NATIONAL WEATHER SERVICE HYDROLOGY PRODUCTS: INFLUENCING FACTORS OF PEOPLE'S EFFECTIVE USE AND OPTIMIZATION SUGGESTIONS

by

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Floods are one of the most destructive disasters in the United States, causing tremendous economic, life, and property losses to human society. Hydrology weather forecast products can be effective tools for preventing hydrological events from becoming disasters and reducing their losses. Yet, there is a lack of research on how people interpret weather forecast products, particularly uncertainty products, and how this varies with different situational factors. Further, rarely has research considered weather forecast product design and characteristics of users as a coherent system.

This study is a part of an ongoing NWS-funded project exploring the influencing factors behind people's use and understanding of National Weather Service Hydrology Products. The influencing factors investigated include situational factors like geographic location, flood experiences, and socio-demographic characteristics, and their relationship with risk perceptions of flooding and product utility. Two structural equation models (SEM) were created in AMOS software to analyze the relationships between situational factors of people, risk perceptions, product characteristics, and user's understanding and use of the products. Spearman's correlation analysis and SEMs were applied to analyze surveys

of focus group participants from Durango, CO, Eureka, CA, Gunnison, CO, and Owego, NY, four locations representing different hydrological regimes. In this project, the NWS hydrology products are the hydrograph, Probability of River Level Forecast, and Briefing Packages, with major emphasis on the Hydrologic Ensemble Forecast System (HEFS).

This research found that no significant relationships between different situational factors and risk perceptions of flooding after using the NWS forecast products, whereas there were significant relationships with some but not all of people's situational factors and their perceived usefulness of NWS products and their elements. Meanwhile, professionals, people with more flood experience and with higher perceived usefulness of NWS products and their elements will significantly have more usage intention of NWS products as well as intended actions. Further, people with more flood experience and higher perceived usefulness of NWS product elements will significantly understand these products better; people with higher risk perceptions of flooding will significantly have more intended actions after using these NWS forecast products, even though they may not significantly have more usage intention of these products. Finally, while people with higher usage intention of NWS forecasts products will significantly have more intended actions after using these products, people who understand these products better will not significantly have more intended actions. The results of this research suggest that, designers of NWS products must recognize the factors that lead to both more and less understanding and use of products. One product, especially those explicitly incorporating uncertainties, will not serve all equally, so taking into account the range of users' situational factors and needs can lead to an optimal, though not perfect, products.

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CHAPTER 1: INTRODUCTION

According to the annual disaster statistics report from Centre for Research on the Epidemiology of Disasters (CRED), there were 315 natural disaster events recorded with 11,804 deaths, over 68 million people affected, and US$131.7 billion in economic losses across the world in 2018. As one of the natural disasters, flooding affected the highest number of people, accounting for 50% of the total affected--a total of 34.2 million people in 2018, and the annual average for 2008 to 2017 is 73.1 million people. In terms of economic losses, floods in 2018 caused about US$19.7 billion and storms US$70.8 billion (Centre for Research on the Epidemiology of Disasters, 2018). From these statistics we can see that the loss brought by natural disasters to human beings is tremendous. Thus it is very important to improve prevention and control of natural events.

As one of the effective tools to prevent events from becoming natural disasters and reduce their losses, weather forecast products play an important role in people's decision-making. They enable meteorologists to evaluate the time and scope of events in advance, so as to prepare a series of corresponding products allowing people to take protective measures and actions. Thus they are imperative for us to reduce the loss of both lives and economy from natural disasters to a large extent. However, due to the complexity of weather systems, it is difficult to accurately predict the specific characteristics of events over long time and space scales, that is to say, they have a certain degree of uncertainty (Ehrendorfer 1997; Schüttemeyer and Simmer 2011). This kind of uncertainty is a critical factor to affecting the user's understanding and use of weather forecast products. Some research has shown that including uncertainty in climate forecasts will make the public more likely to trust and pay more attention to relevant weather forecasts, so as to generate climate friendly behavior (Joslyn and LeClerc 2016; Grounds and Joslyn 2018). However, it may also lead to low efficiency or even wrong use, and correspondingly negatively affect response to the weather forecast products (Joslyn and Savelli 2010). Based on that, many previous studies have explored how to better help users understand the uncertainty in weather forecast products (Sink 1995; Morss et al. 2008, 2010; Zabini et al. 2015). These research studies basically focus on making it easier for people to understand uncertainty from various technical aspects, including the adoption of terms and icons, and the structure of the product.

However, to a large extent, as a key factor influencing people's decision-making and acceptance of information products, few studies start from people's perceptions and the underlying situational and cognitive factors to design and develop special weather forecast products for various user groups with diverse backgrounds to foster better use of these products. Many studies have shown that people's socio-demographic factors like age and culture, economic status, and social factors, especially the place of residence, actually shape their perceptions (Flynn et al. 1994; Slimak and Dietz, 2006; Lee et al. 2015; Landeros-Mugica et al. 2016; Sachdeva 2017; Haeffner et al. 2018; Andrew et al. 2019; Gao et al. 2019; Khan et al. 2020). At the same time, these distinct concepts cause user groups with different characteristics to have corresponding preferences, which affect their ability to understand information provided in the products. These factors and the design of the product itself (picture, text and color) together determine the extent to which the weather forecast products can be understood and used by those who need to act on them

(Mileti and Sorenson, 1990; Jiang and Benbasat, 2007; Shome and Marx, 2009; Severtson and Myers, 2013; Ash et al. 2014; Yi et al. 2015; Hogan Carr et al. 2016).

Based on previous research, three research questions are proposed in this study:

1. What is the relationship between peoples' situational factors, risk perceptions, reviews of the usefulness of the products and elements of products (color, legend, etc.)?

2. To what extent do users' situational factors, risk perceptions, and product type and product elements influence users' understanding and usage intention of weather forecast products?

3. In what aspects of the factors can we optimize the weather forecast product to increase user's understanding and usage intention?

These three questions are all about discovering the relationships among people's situational factors, product characteristics, and people's use and understanding of the weather forecast products. The main goal is to explore the influencing factors and the specific degree of these factors behind the people's use of these products. This research addresses the situational factors including people's geographic locations, flood experience, and socio-demographic factors (age, gender, and educational level) that may affect both product usage and risk perceptions of flooding, through analyzing the surveys of focus group participants from four different geographic areas. Centered on National Weather Service (NWS) weather forecast products, particularly products that indicate the uncertainty in the forecast, or the probability of an event occurring, the research is designed to reveal relationships among users' situational factors, their risk perceptions of flooding, the design and structure of the products, their understanding and use of the products, and their intended actions based on these products, in order to improve the products for the widest use.

This next chapter considers relevant background information about previous research, including the role uncertainty plays in understanding weather forecasts, situational and cognitive factors that influence people's perceptions and product acceptance, the influence of product design and peoples' perceptions on product interpretation, and the relationship between product acceptance and usage intention. The third chapter introduces the methods, including the characteristics of the data, research hypotheses, and analytical methods adopted in this research. The fourth chapter presents results, focusing on the integration of the data, then exploring and analyzing the varying understandings and uses by people with different situational factors for product types and product design (such as structure and color) of the NWS forecast products. The last chapter briefly summarizes the results of the research and the verification of the proposed hypotheses and discusses the research findings and the optimization suggestions including product improvements. The discussion of the contributions and limitations of this project and the work to be done in the future are also included in the last chapter.

The nature of this particular study, may offer a framework for designing other weather information-based products around the world which may be particularly misunderstood by users with different characteristics. Furthermore, it is the hope of this study that the joining of varying user characteristics with suggestions of optimizing weather forecast products may contribute towards the potential development of weather forecast products with direct pertinence to various groups of users in the future.

CHAPTER 2: LITERATURE REVIEW

There are five parts to this literature review. To begin, the key point---the role of uncertainty in the weather forecast products and its influence on users--is discussed. Second, research on how people's perceptions and their acceptance of products and their design are influenced by environmental factors and socio-demographic factors like gender or age is included. The next concern turns to research on how people's perceptions and product design could affect product understanding and interpretation. Last but not least, research on whether users' perceived product usefulness and interpretation of products will affect their usage intention as well as intended actions is discussed. A summary and evaluation of the literature is included in the end. The literature reviewed in this chapter covers a wide range of risks, platforms and products, including non-weather forecast products, in an effort to consider the body of knowledge relating to factors associated with user perceptions, product design, and product usage.

2.1 Uncertainty in Weather Forecast Products

Weather forecast products will lead to a certain degree of misjudgment, the biggest reason being their uncertainty. Some scholars have discussed uncertainty and its causes. During the 1990s, Ehrendorfer (1997) mentioned that the uncertainty in weather forecasts produced with numerical weather prediction (NWP) models is caused by errors in both the specification of the initial state of the model and in the model formulation. Thus, an estimate of the uncertainty in a forecast will increase credibility and utility of it. In addition, Schüttemeyer and Simmer (2011) revealed that uncertainty is the essential problem of weather forecasts, especially precipitation forecasts, because rainfall is only the end of a complex process chain in a large range of space and time scales. It is difficult to achieve accurate forecasts because of the time and space changes and ranges of precipitation. Further, the ensemble forecast prediction is uncertain because ensembles take into account numerous sources of uncertainty.

Uncertainty is an important factor to determine the user's understanding and use of weather forecast products. On the one hand, through two experiments based on a questionnaire that presented climate projections to the public including people with different socio-demographic factors, Joslyn and LeClerc (2016) found that including uncertainty in climate prediction makes it easier for the public to trust and thus pay more attention to relevant weather predictions, resulting in climate-friendly behavior. Grounds and Joslyn (2018) suggested that the estimation of numerical uncertainty may be an effective way to convey the weather danger to the public. Therefore, this kind of weather forecast with numerical uncertainty is more reasonable. On the other hand, uncertainty can also lead to inefficiency or even misuse, which correspondingly negatively affects the weather forecast products. Joslyn and Savelli (2010) pointed out that the public understands the uncertainty in deterministic forecasts based on their background knowledge, but some of their reviews of the forecast products are not verified by data provided by weather forecast offices that issue these products. This is probably caused by some factors like the availability heuristic (people base their prediction of an outcome on the vividness and emotional impact rather than on actual probability), thus peoples' opinions have to be considered carefully before the adjustment of weather forecasts is conducted based on these opinions.

It is important to let users know the uncertainty in weather forecast products; however, to convey the concept of uncertainty in forecasts to the public can be challenging. Several attempts have been made to solve the challenge. Sink (1995) pointed out if people have misconceptions about the details in the forecast, the uncertainty in these precipitation forecasts will be magnified. When the numbers and images used in the prediction are different from the verbal prediction of meteorologists, the prediction will be misinterpreted. She also mentioned that to eliminate misunderstanding of the public on weather forecasts as far as possible, especially for the mismatch between verbal and numerical information, the precise use of precipitation language by meteorologists is required, and education and popularization of basic meteorology terms to the public are also important. Morss et al. (2008; 2010) analyzed the public's view of uncertainty through some nationwide surveys in hydrometeorology and meteorology. They suggested that by inferring the information the public is interested in and asking their probabilistic threshold for taking action to protect themselves from potential risks, people are able to better understand the uncertainty. Thus getting more effective information and corresponding screening and review of the weather information will be easier. Similarly, Zabini et al. (2015) studied the interpretation of weather forecasts by the Italian public and found that people have a common way of understanding and perceiving weather forecasts and a mode of thinking, which stems from the deep-rooted habit of people accepting deterministic forecasts. That is, there is almost no wrong or uncertain information in the forecast, so people's common sense of weather may be produced in the absence of standards and is mixed with their direct experience and perception of the accuracy of a weather forecast. In addition, the public often adds uncertainty when interpreting certain icons. Further, due to the knowledge gap between forecasters and the public, the selection of simplified graphics and maps of forecast products will lead to more misunderstanding, even by those with more experience and education in weather forecasting. Thus it is necessary to convey the uncertainty in the weather forecasts to the public based on their perceptions and preferences as well as local mindsets and cultural heritage.

In summary, given the importance of the uncertainty inherent in weather forecasts and the great influence on peoples' interpretations and use of weather forecasts, the explanation of uncertainty in forecasts (so that people can interpret them correctly to the greatest extent) needs to be fully considered in their design. To do this, forecasters must understand peoples' views about weather forecasts with uncertainty (including the content and form of them), and also how to design weather forecast products according to these views.

2.2 Situational and Cognitive Factors that Influence People's Perception and Product Acceptance

Situational factors including location, social position, people's identities, and cognitive factors like risk aversion and individual values, play significant roles in shaping the perceptions of people, and they can also affect people's acceptance of products as well as satisfaction and use of products, as discussed in two parts below.

2.2.1 Situational and Cognitive Factors and People's Perceptions

Basically, people's perceptions and decision-making are affected by environmental factors, especially space and location. Many scholars have done relevant research. Andrew et al. (2019) have shown the logic of clustering environmental perceptions, through exploring the spatial patterns of public perceptions of water quality and the spatial analysis of perception score semi-variance to determine the range of correlation in values using social data and models. They found that people with different socio-economic status have different perceptions of water quality. The lower the socio-economic status is, the lower their perception of the water quality will be, which means people with lower socio-economic status tend to perceive water quality worse than those with higher status; meanwhile residents with low perception of local water quality may have negative views on the overall local environmental conditions. However, due to the low educational background of the population in the study area, the authors did not find a significant relationship between education level and water quality perception.

People's perceptions are changing around the world. Lee et al. (2015) discussed cross-national climate change risk perceptions, which are relatively less studied. Based on a Gallup world poll conducted in 2007 and 2008 and national representative samples from 119 countries, their findings revealed that widely used national sustainability indicators, such as GDP, have poor predictive power of global climate change and sustainability concepts, and highlight the need to study other social and cultural measures. In addition to strategies to improve basic education, climate knowledge and public understanding of it, each country has its own relatively unique set of related factors, while countries with similar economies or regions will form sub-regional classifications to a certain extent, therefore cross-cultural research is necessary.

Compared to the influence of space and place, the impact of social position determines people's perceptions to some extent too. By using a mixed method approach with survey and interview data from a study of Utah leaders and their constituents in urban water systems in Northern Utah, USA, Haeffner et al. (2018) examined how social position explains variations in water perceptions and concerns between different actors in a socio-hydrological system. Based on the quantitative survey and qualitative interview data, they discovered that residents are most concerned about future water shortages and high water costs, while their leaders are most concerned about the deterioration of local water infrastructure, and have more confidence in the current and future availability of water to meet the needs of their cities. Therefore, information exchange and participation between leaders and voters can predict the direction of perceived water problems better than hydrological differences and geographical location.

In addition to these factors, another factor that shapes people's perceptions is their socio-demographic factors, like gender and experience. Aiming to develop appropriate disaster risk reduction strategies by understanding gender risk perception in a multi-disaster environment, Khan et al. (2020) proposed an index based risk assessment method to interview high school students in the area of Gilgit, Pakistan. The researchers selected a similar number of men and women, collected data through structured questionnaires, and then used Chi-square and t-tests to find out differences between the two genders. Their results showed that there are gender differences in different risk cognitive components and significant differences in their perceptions, especially with floods and landslides. These differences vary with different natural disasters, partly due to the predictability of landslides and floods. In general, the overall risk perception ability of high school boys and girls is poor. Based on that, they suggested that gender must be included in risk perception assessments in order to understand the nature of disaster response better. Flynn et al. (1994) not only focused on the influence of gender on people's perceptions, but they also included race. Through the results of a national survey by telephone in which perceptions of environmental health risks were measured for white and non-white people, one of the common findings of the research is white women are more likely to perceive risk to be higher than white men, but non-white men and women are more similar in risk perception than white men and women. They also noticed that white men tend to differ from others in their attitudes and opinions, and they think the risk is much smaller and more acceptable than others. People's experience can also have an effect on their perceptions, and research undertaken by Landeros-Mugica et al. (2016) focused on this. They paid attention to the relationships among the different parts of landslide risk perception in Mexico. The data is based on the previous experience and involvement with communities of residents and ten key actors from five boroughs of Teziutla´n in Mexico that included direct landslide exposure and experience. They developed a questionnaire survey on different dimensions of landslide risk perception in this area, and they showed that previous experiences and exposure to risk affect perceptions and patterns related to prevention and response, while those who are inexperienced and living in danger perceive the lowest possibility of loss. The residents who have experienced a dangerous landslide have a better understanding of the possibility of material loss than those who have not. The perception of vulnerability is influenced by previous events, and the memory collectivization of past events may improve the risk perception rate. At the same time, the majority of people living in landslide prone areas usually pay attention to disaster related information, such as seeking professional advice, warning and shelter location information.

Meanwhile, cognitive factors like risk aversion and individual values also shape perceptions of people toward environmental events. Gao et al. (2019) established a multi-dimensional path model from environmental risk perception to behavioral response to study how public environmental risk perception affects their environmental behaviors. Data from the 2013 China Social Survey (CGSS 2013) is used for testing. Their results show that information channel factors and cognitive evaluation factors have significant impacts on the process of environmental risk perception and behavioral response. Specifically, media use and environmental values play important roles in the transformation process, while social networks and public evaluation of environmental governance will inhibit the transformation of public risk perception into environmental behavior. At the same time environmental knowledge can link information channel factors and cognitive evaluation factors together. Slimak and Dietz (2006) tested the explanatory power of the value-belief-norm (VBN) theory for risk perception using a mail survey on ecological risk perception. This survey was administered to a randomized sample of the lay public and to selected risk professionals at the U.S. Environmental Protection Agency (US EPA). In order to measure the perception of risk (or the perception of consequences), respondents were asked about their personal values, spiritual beliefs, and world outlook to rank the overall importance of 24 risks (from acid rain to population growth). The researchers found that social structure not only has a direct impact on the perception of risk, but also on the views of individuals. Although non-professionals pay more attention to the risk of low probability and high consequence situations, professionals pay more attention to the risk of long-term impact on the ecosystem. However, individual values, beliefs and world outlook have an impact on all individual perceived ecosystem risks. The results show that the difference in the respondents' perceptions of ecological risk is affected by the VBN to some extent. In addition, Sachdeva (2017) explored how the sacred belief of natural resources weakens the perceived danger of environmental hazards, by examining locals' recognitions toward the Ganges River in northern India through three studies: an online survey using Qualtrics, an experimental design, and one-on-one interview sessions. She found that, compared with secular belief, sacred belief has a greater influence in improving people's perceptions of various environmental hazards, and in some cases, the perception of natural resources as sacred may lead to a decrease of perception of environmental risks (such as pollution), which means sacred beliefs may inure participants to the harmful effects of pollution in the Ganges River.

2.2.2 Situational and Cognitive Factors and Product Acceptance

Situational and cognitive factors can also affect people's acceptance of products and their design in addition to their perceptions. Mileti and Sorenson (1990) reviewed more than 200 studies on warning systems and warning response, trying to explore why the effectiveness of warnings is not constant. They found that the nature and content of warnings have a great impact on whether the public listens to them, such as their source and frequency, their consistency, reliability, accuracy, and the comprehensibility of information, among other factors. In addition, the characteristics of the population also matter: people with different social characteristics like gender and age as well as different psychological characteristics such as risk perception tend to have different attitudes toward certain warnings. They also mentioned that warning methods need to consider regional and social differences in order to effectively provide warnings and notifications to the public. Shome and Marx (2009) combined lab and field studies with actual cases through principles derived from the social sciences to explore ways to make climate change presentations and discussions more effective. Their results show that people's behavioral response to climate change policy depends on the way they deal with information and make decisions, and eight related sociological methods about presentation are proposed to better convey information and make the information understood by people, which basically focuses on individual differences. Ninggar et al. (2020) carried out a series of Covariance Analysis analyses using SPSS to investigate differences in perceptions and intended actions between phenomenon-based weather warning recipients and impact-based weather warnings, by controlling several relevant demographic variables, including gender, age, education, and domicile/residence. The results of their analysis showed that respondents who received impact-based warning information felt it was much easier to understand the possible effects of bad weather, had more trust that the potential impact would be more threatening, and were more concerned about the effects of bad weather compared with respondents who received phenomenon-based warning information. Demographic variables such as gender, age, and experience of respondents who have been affected by bad weather have no significant effect on the responses to impact-based weather forecast and early warning information provided, while the level of education and the vulnerability of the region will have significant influence on the response of the public.

In addition to research relating to weather warnings, it is also important to look at how situational and cognitive factors influence perceptions and actions relating to other environmental and risk issues. Panwar et al. (2010) discussed the understanding of perceptions and expectations of various demographic segments about business performance and relevant social and environmental issues in the forest products industry in the US. They collected a randomly chosen sample of 2000 total residents aged 18 and above within Washington, Oregon, Idaho, and Montana, since forestry is an important socio-economic sector in these states. Their results indicate that varying degrees of differences exist in different demographic categories like gender, education level, place of residence, and age. For example, they found that females are more critical than males in evaluating the US forest products industry's current performance related to both social and environmental issues, but females exceed males only in the area of environmental issues in terms of expectations. They suggested that females place environmental issues higher than social issues because they either consider business activities to harm the environment more than they inflict problems in society, or they simply care more for environmental issues than social issues. And on the other hand, males associate higher social utility (like jobs or community investment) with it than an expectation of environmental stewardship, because the forest industry predominantly employs males. Therefore, they suggested that companies in the US forest products sector consider demographic characteristics when formulating their socio-environmental strategy and communication.

Moreover, Fielding et al. (2021) determined the role of cetacean-based food products in the diet of the Vincentian population as a proxy for exposure to methylmercury (MeHg) using interview surveys. Through in-person individual interviews with 921 adults with different demographic characteristics living in St. Vincent and the Grenadines (four of the country's eight inhabited islands: St. Vincent, Bequia, Mayreau, and Union Island), they found that respondents' gender and geographical home region are the most important factors influencing cetacean consumption. Since the consumption of cetacean-based food products may represent a public health risk, as a large portion of the population may be exposed to high MeHg concentrations, they recommend the government of St. Vincent and the Grenadines to embark upon a demographically and geographically targeted intervention campaign by establishing and communicating dietary recommendations based upon the most recent information available, given the high concentration of environmental contaminants and the high degree of popularity of these food products.

Patnaik (2020) explored the relationship and impact of demographic characteristics on influential factors of eco-buying decisions. The researcher discussed the relationship between gender, occupation and education with factors such as environmental concern, product category and pricing in eco-fast moving consumer goods (FMCG) products. The results indicate that there is an association between gender and environmental concerns. Women are more concerned about whether the products they are buying are eco-friendly than men. A significant relationship was also found between occupation and product category, such that people are more likely to consider consuming products related to their occupation; however, there is no association between education and pricing. Atlason et al. (2017) investigated how end-users perceive three end-of-life (EoL) scenarios (reuse, recycling and remanufacturing) and two disposal methods (door-to-door collection and delivery at point of purchase) for eight household electrical and electronic products (e-products), to identify differences within user segments in terms of demographic (e.g., age, gender, education level) and relevant psychographic variables (e.g., environmental awareness). A quantitative Kano survey was used by researchers to classify product features related to EoL and disposal methods according to users' preferences. Their results show that women were found to prefer all EoL scenarios more than men, and were also more willing to pay a premium price for environmentally friendly e-products. Therefore, they suggested that gender may be the most important basis for user segmentation in the context of product development, and that products targeted towards women are more likely to enter favorable EoL scenarios.

Wang et al. (2020) investigated the impact of demographic factors (age and gender) on design of an effective website. They conducted a survey using electronic media with a total of 340 responses. Their results revealed that age has a significant impact on website design factors: young people look for high quality information in a website while middle and older aged people prefer easy accessibility and navigation quality. They also found that visual appeal and product picture quality attract females more than males. They suggested website designers customize websites as per its target audience’s demographic factors. Likewise, Klein et al. (2010) conducted an anonymous online survey examining general Internet and alcohol and other drugs (AOD) -specific usage, search behaviors, and valued AOD website tools or functions to investigate content and functionality preferences for AOD and other health websites. Surveys were obtained from 1214 drug and alcohol website users. Their results show that robust website design/navigation, open access, and validated content provision were highly valued by both drug and alcohol website users. While attractiveness and pictures or graphics were also valued, high-cost features (videos, animations, games) were preferred by fewer respondents. Additionally, although gender did not affect survey responses, younger respondents were more likely to value interactive and social networking features, whereas downloading of credible information was most highly valued by older respondents. Again, the results suggest that the design and features of AOD websites should target specific audiences' demographic characteristics to have maximal impact. Gefen and Straub (1997) extended the Technology Acceptance Model (TAM) by adding gender to an IT diffusion model. They sampled 392 female and male responses from comparable groups of knowledge workers using e-mail systems in the airline industry in North America, Asia, and Europe, via a cross-sectional survey instrument and tested gender differences that might relate to beliefs and use of computer-based media. They found that women and men differ in their perceptions of e-mail but not their usage intention of it. In the paper, they suggested managers and co-workers to realize that the same mode of communication may be perceived differently by the sexes, and environments should take into account not only organizational contextual factors, but also the gender of users.

In summary, given the numerous situational and cognitive factors including demographic characteristics that can influence people's perceptions and their acceptance of different products, designers of the weather forecast products should also take these situational and cognitive factors into consideration when designing products to enable people to use them more effectively.

2.3 Influence of Product Design and Peoples' Perceptions on Product Interpretation

Given the numerous situational and cognitive factors that can affect people's perceptions and their acceptance of products and their design, it is vital to design forecast products carefully because many previous studies have shown that product design, as well as people's perceptions, will affect their understanding and interpretation of products.

Several studies have addressed the topic of product design and the role it can play in people's interpretations of products. Through a survey on the responses of college students, Ash et al. (2014) explored whether a tornado warning based on visualization technology will affect the level of individual's fear and the possibility of taking protective actions because of its design, color scheme, and structure. They found that the information used for warning is not always the same as the information that people receive, and the efficiency of communication will vary with the interaction between the design of a warning product and the location of each receiver. The design based on the current NWS warning format, which visually represents a simple elevated probability of occurrence of a tornado within a geographic area, tends to generate a stronger response in the geographic centroid of the warning, while the strongest responses of probabilistic design are concentrated in the narrow portion of the warning, which is the nearest to the maximum tornado threat. The decreasing speed of people's fear and intended action also vary with the distance from the warning area and the design of the warning product. Based on this, the authors suggest that the combination of geographical location and visual features can provide reference for future research on visual meteorological communication, and additional cognitive aids such as local base maps with locations may influence the interpretation of warnings. Hogan Carr et al. (2016) conducted a multi-partner project on some NWS products in two flood-prone communities in the Delaware River basin in Pennsylvania and New Jersey, including the use of color and patterning, language and the level of geographic specificity in the products. They found that the use of color is important to help participants understand the message, especially with flood watches and warnings, and the lack of local specificity is a major limitation of the flood products. The combination of graphics and text rather than a single form can quickly provide explanation and detail, providing enhanced visual clarity and easily interpretable representations that also benefit the understanding of user.

Considering a different risk, Severtson and Myers (2013) explored the relationship between map features, user's risk beliefs about cancer risk from air pollution, and the ambiguity of risk beliefs for maps. Changing the map contours, number of colors and a verbal-relative or numeric risk expression in a full factorial experiment with 826 university students, their results show that visual features largely affect conveying information of uncertainty and a dose-response message. In addition, different levels of iconicity of the contour and color shading as well as the iconic and pre-attentive map features influenced people's risk beliefs, while personal characteristics of prior beliefs and numeracy also had substantial influences. Thus, the design of maps can affect users' interpretations of them. Additionally, Yi et al. (2015) investigated the effects of a non-interactive video presentation and two virtual product experience (VPE) presentations (full interaction and restricted interaction), through providing users with an online product experience and engaging them to try the product offline. They found that, because it deprives users of part of the interactive product experience, the restricted interaction presentation is more enticing for users with more product-class knowledge, compared to the non-interactive and fully interactive design. Due to that, the restricted interaction is similar to the one with full interaction in engaging users, since engagement and enticement positively affect users' intentions of products use. Thus less interaction and less costly presentations can be more effective in attracting users toward the products.

Furthermore, people's perceptions can also affect their interpretation and use of products. Through the comparison of four online product presentation formats: static pictures, videos without narration, videos with narration, and virtual product experience (VPE), Jiang and Benbasat (2007) revealed that rather than the actual product knowledge, perceived website diagnosticity (i.e., the extent to which consumers believe a website is helpful for them to understand products) positively influences user's perceived effectiveness of a website, which will affect their intentions to revisit the websites. In addition, they found that users' perceptions of products vary in response to different methods of presenting product information, and the four presentation formats have different effects on consumers' product understanding as well as a moderating role of the complexity of product understanding tasks. Both videos and VPE led to higher perceived website diagnosticity than static pictures, but the four presentation formats are not equally effective in terms of actual product knowledge under different task complexity conditions. Likewise, Bearth & Siegrist (2019) conducted a mixed-design scenario experiment with a large sample of Swiss consumers of eco-friendly cleaning products, to find out if the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) could let the customer know the risk of the product accurately. The results of their research show that consumers' risk perception makes them have a correct risk judgment on cleaning products and led them to correctly identify the problematic scenarios like unsafe storage of drain cleaner. However, at the same time, consumers' low risk perception of a "green" halo effect for eco-friendly cleaning products makes them have wrong risk judgments and treatment measures. Therefore, they suggested that risk perception was also the most important predictor in further research and policy. Additionally, Guelke (1979) proposed that the design and production of better maps is dependent on users' perception of maps. The researcher focused on users' perceptions of maps in designing them because the cultural background and experience of map users will shape their perceptions and thus generally determine the manner in which they are likely to interpret maps and map symbols. Therefore, he suggested that cartographers must take account of the perception characteristics of the map user to design effective maps. Moreover, Lee (2020) conducted hierarchical multiple regression analysis on data collected through random sampling from Korea, in order to examine the impacts of nuclear energy risk perception, benefit perception, and political orientation on nuclear energy consumption behavior from the nuclear energy users' perspectives. The result of the research indicated that users with lower social and personal risk perceptions of nuclear energy and with higher social benefit perception of nuclear energy tend to have more positive attitudes towards nuclear energy, and greater usage intention of nuclear energy. Meanwhile people with different political parties and groups tend to have different risk perceptions towards nuclear energy and thus have different levels of consumer support.

In summary, given that both the product design and peoples' perceptions can influence their interpretations of different kinds of products, weather forecasters should also take the design of the product and peoples' perceptions into consideration to enable people to use them more effectively.

2.4 Product Acceptance and Usage Intention

A number of previous research studies have investigated relationships between people's product acceptance and their usage intention toward the product. In order to study whether consumer satisfaction before and after consumption will affect the occurrence of continued purchase behavior, Oliver (1980, 1993) proposed an Expectation-Confirmation Theory (ECT) which contains five factors: Expectation, Confirmation, Perceived Performance, Satisfaction, and Repurchase Intention. Oliver believed that consumers' confirmation and expectation can influence their satisfaction with a certain product and thus affect repurchase intention. ECT has great influence and has been widely used in the study of consumers' continuous use behavior since then. For example, Anderson and Sullivan (1993) developed a model to link explicitly the antecedents and consequences of customer satisfaction based on ECT. They analyzed the dataset of a nationally representative survey of 22,300 customers of a variety of major products and services in Sweden in 1989–1990. Their results show that expectations do not directly affect satisfaction, while quality that falls short of expectations has a greater impact on satisfaction and repurchase intentions than quality which exceeds expectations. They also found that confirmation is less likely to occur when quality is easy to evaluate and the elasticity of repurchase intentions with respect to satisfaction will be lower for firms that provide high satisfaction. Therefore, they believe that a long-run reputation effect insulates firms which consistently provide high satisfaction. Moreover, also based on ECT, Patterson et al. (1996) empirically examined the determinants of customer satisfaction or dissatisfaction (CS/D) in the context of business professional services, and the data were obtained from a survey of client organizations. They examined the simultaneous effect of CS/D constructs (including expectations, performance, and disconfirmation) and several variables: fairness (like equity), purchase situation, and individual-level variables (like decision uncertainty and stakeholding) in a causal path framework. Their results show that the effect of purchase situation and individual-level variables rivals that of disconfirmation and expectations in explaining CS/D, and performance was found to affect CS/D directly but not as powerfully as disconfirmation. In summary, studies based on the ECT indicate that there is a strong relationship between people's product acceptance and their usage intention of the product.

Meanwhile, Bhattacherjee's research (2001) played an important role among research based on ECT. He applied the five main variables of the ECT to research on information systems, put forward the Expectation Confirmation Model (ECM), and introduced the theory into research on the continuous use behavior of information systems. His ECM includes four variables: Perceived Usefulness, Satisfaction, Confirmation, and Continual Usage Intention. In this model, continual usage intention is mainly affected by users' satisfaction and perceived usefulness; satisfaction indirectly affects continual usage intention. Users' perceived satisfaction is mainly affected by users' confirmation and perceived usefulness; and perceived usefulness is also directly affected by the user's confirmation. Continued usage is a concept relative to initial use or initial acceptance, also known as post acceptance. In Bhattacherjee’s ECM, he thinks that users' continuous usage behavior of information systems is the same as consumers' repurchase behavior, and the continuous usage behavior of users to information systems has similar psychological cognition and psychological reaction processes to the repeated consumption and purchase behavior of consumers. He proposed that there are significant positive relationships between user’s perceived usefulness, satisfaction, and continual usage intention of the information system. Like ECT, there are also studies by other researchers based on ECM, and the hypotheses Bhattacherjee proposed have been proved by these studies. For example, Hayashi et al. (2004) blended Computer Self-Efficacy (CSE) and ECM, and assessed their applicability on the intention of online learners who were continuing users of an e-learning system as a vehicle to assimilate IT skills, to theorize the causal relationship of the factors of Perceived Usefulness, Confirmation, Satisfaction, and IS Continuance in the e-learning context. Their results showed that there is not a significant relationship among the CSE of online learners and their perceived usefulness, confirmation, and satisfaction level, which means CSE does not have a significant influence on learning outcomes. However, they found that for long-term knowledge transfer, social presence was shown to have an effect in different virtual learning environments. Their study suggests that ECM is effective in checking relationships between user's perceived usefulness, satisfaction, and continual usage intention in the online learning system. Likewise, Lee (2010) synthesized the ECM, the technology acceptance model (TAM), the theory of planned behavior (TPB), and flow theory to hypothesize a theoretical model to explain and predict users' intentions to continue using e-learning. The researcher analyzed a sample collected from 363 users of a Web-based learning program designed for continuing education, and the results demonstrated that satisfaction has the most significant effect on users' continuance intention, followed by perceived usefulness, attitude, concentration, subjective norm, and perceived behavior. Moreover, He and Wei (2009) conducted a study of continued knowledge sharing through an ECM-based model they proposed. The data was collected through online questionnaires of 500 eligible system users in an international IT company. Their results showed that habit exhibits a strong moderating effect on the relationship between intention and behavior, and organizational resources and facilitating conditions are very important for continued knowledge-contribution behaviors. Besides, in the need-driven behaviors such as knowledge-seeking, usage intention is still the main causal mechanism explaining people's continuing usage behavior of an IS. Their study proved that ECM is also effective in finding influencing factors that drives continued knowledge sharing among knowledge management system (KMS) users.

In 1985, Davis proposed the TAM, which is composed of six variables: External

Variables, Perceived Usefulness, Perceived Ease of Use, Attitude Towards Using, Behavioral Intention to Use, and Actual System Use. It is mainly used to explain and predict the acceptance of people’s continuous use of information systems. In the model, perceived ease of use mainly refers to users' subjective ease of use of the information system. Perceived usefulness mainly refers to the subjective performance improvement of users using the information system. Davis (1985) found that the user's behavior intention is determined by the user's attitude and perceived usefulness; at the same time, perceived usefulness and perceived ease of use have a direct impact on the user's attitude to some extent. In addition, perceived usefulness is directly affected by perceived ease of use, because it takes time for users to perceive the usefulness of it. If the system is not easy to use, it may cause people to stop using the system so they cannot perceive the usefulness of the system. TAM has been used by many researchers. For example, Chau (1996) reviewed the concept of perceived usefulness in the field of the information technology and psychology literature and then modified TAM to include the two types of perceived usefulness. Data was collected from 285 administrative/clerical staff in a large organization and TAM was tested against the modified model using the structural equation modeling approach. The results showed that even though perceived near-term usefulness had the most significant influence on the behavioral intention to use a technology, perceived long-term usefulness also exerted a positive and lesser impact. There was no significant direct relationship found between ease of use and behavioral intention to use a technology. Pikkarainen et al. (2004) developed a model based on focus group interviews with banking professionals, TAM literature and e-banking studies, to indicate online-banking acceptance among private banking customers in Finland. Their data was collected by means of a survey consisting of questions that related to background, possible factors affecting acceptance of online banking and use of online banking services. The findings indicated that perceived usefulness and information on online banking on the website were the main factors influencing online-banking acceptance. They found that perceived usefulness, perceived ease of use, perceived enjoyment, information on online banking, and security and privacy have an impact on the acceptance of online banking, while perceived usefulness and the amount of information on online banking were found to be the most influential factors explaining the use of online banking services. They suggested that the finding refers to the fact that consumers use online banking for the benefits it provides in comparison to other banking delivery channels, and perceived ease of use impinges on acceptance through perceived usefulness.

In summary, given that the models mentioned above had all proved effective in analyzing the relationships among people's perceived usefulness of a product, product characteristics, and their continuing usage behavior of the product in many different systems (like knowledge management system and online-banking system), models similar or based on ECT, ECM, and TAM can be created and used to analyze the influencing factors (including people's perceived usefulness of the product, product design, and user characteristics) in people's continuing usage behavior of weather forecast products.

2.5 Conclusion

Optimizing weather forecast products by revealing the role of individual and environmental factors in interpretation and understanding is challenging, not only because of various and complex influencing factors, but also because of many gaps not covered by previous research. From the previous research literature, we can see the following trends:

a) Numerous researchers have found that uncertainty has an important impact on the public's acceptance and understanding of weather forecast products. The solution is to focus on making it easier for people to understand uncertainty from various technical aspects, including the use of terms and icons, and the structure of products, among others. However, there are significant complexities relating to understanding how people under the influence of different situational and cognitive factors such as location, gender and age interpret forecasts and their design, as well as the most effective optimization of corresponding weather forecast products.

b) Studies of people’s perceptions indicate the influences of situational and cognitive factors while the recent trend of these studies is moving from specific disciplines to multiple disciplines, from simple to in-depth and from local to global. However, due to the many kinds and wide range of influences of these factors, it is very difficult and complex to conduct a comprehensive and in-depth study on them. For example, people's perceptions are revealed by previous research to be influenced by socio-demographic factors and environmental factors. Yet, although previous studies have found that situational and cognitive factors will affect the user's perceptions and understanding of products and their design, the nature of the influences (direct or indirect, for example) is unclear.

Perception is multi-faceted, including risk perception and product perception, among others, and the specific reasons that affect people's perceptions are numerous and complicated. Previous research about people's perceptions often only involves part of the situational and cognitive factors rather than in a more comprehensive way. Therefore, it is imperative to conduct a comprehensive and in-depth study of the situational and cognitive factors behind the specific practical problems, especially in those areas greatly affected by people's perceptions, such as the interpretation and application of uncertainty in weather forecast products.

c) Many previous studies have shown that product design can significantly affect people’s understanding and use, while product presentation based on this largely determines whether the information in the product can be effectively and correctly conveyed. Therefore, the environmental and social factors that influence people's perceptions and determine their interpretation of a product's information, led by the differences of subject and region, need to be considered in the design and communication of a product. At present, there is much research on finding effective methods to accurately and quickly deliver the information in the product to the user. However, these studies and applications tend to concentrate more on product design from a technical aspect, rather than designing the product based on the corresponding situational or cognitive factors of the user, resulting in the information that the product tries to convey not being understood accurately or accepted quickly by users with different characteristics, thus affecting their actions. Therefore, it is necessary for future research (such as the research on weather forecast products) to conduct more interviews and experiments to obtain enough data about products and their elements that are most acceptable to users with various characteristics (such as risk perception level and flood experience).

d) Despite the research that has been done, there remain gaps with respect to conveying the information in weather forecast products more effectively and accurately to users with different perceptions. For example, it is revealed by studies that product design and user's perceptions will affect their interpretations of products and their usage intention. However, there are few studies on whether user's perceptions, including risk perceptions, directly or indirectly impact the use intention of the product or intended actions based on the product. People's perceptions vary greatly due to numerous environmental factors. These different perceptions cause people's interpretations to vary, due in part to the type and format of products, such as structure and details, as well as uncertainties associated with weather forecast products. All of these factors make it a challenge to convey the information correctly. Although previous scholars have established many models and theories about analyzing affecting factors of the perceived usefulness and usage of products, such as Expectation Confirmation Theory (ECT), Expectation Confirmation model (ECM), and Technology Acceptance Model (TAM), few studies have applied or created their own models based on these theories and models to the analysis of weather forecast products. Moreover, previous studies mostly focused on the relationship between one or two links but rarely considered all links as a coherent system. Therefore, starting from the situational and cognitive factors that affect people's perceptions to the role uncertainty plays in weather forecast products, it is of great significance to systematically study the degree of interaction between each link so as to formulate corresponding product design for improving the efficiency of information transmission to the public. In summary, the main goal of this research is to explore the influencing factors and the specific degree of these factors behind people’s use of weather forecast products, including the quantitative recognition of product types and components by people with different situational factors and perceptions, as well as their usage intention of the products as related to these factors.

CHAPTER 3: METHODOLOGY

This chapter introduces the data, methods and procedures used in this study. A discussion of the data collection methods and sample sources, research variables, research design, statistical analysis models and processes is provided within this chapter.

3.1 Data Collection

3.1.1 Research Study Areas

The study is a part of an ongoing NWS-funded project that centers on focus groups from Durango, CO, Eureka, CA, Gunnison, CO and Owego, NY, four locations representing different hydrological regimes recommended for analysis by NWS. Locations are shown in Figure 3.1 below.

Figure 3.1: Study Area Locations. Used with Permission, Nurture Nature Center, Easton, PA

The study areas represent regions with different flood risks and people with distinct flood experiences, which are shown in Figures 3.2 to 3.5 below (Federal Emergency Management Agency (FEMA) Flood Map Service Center, 2010, 2017, 2013, 2012).

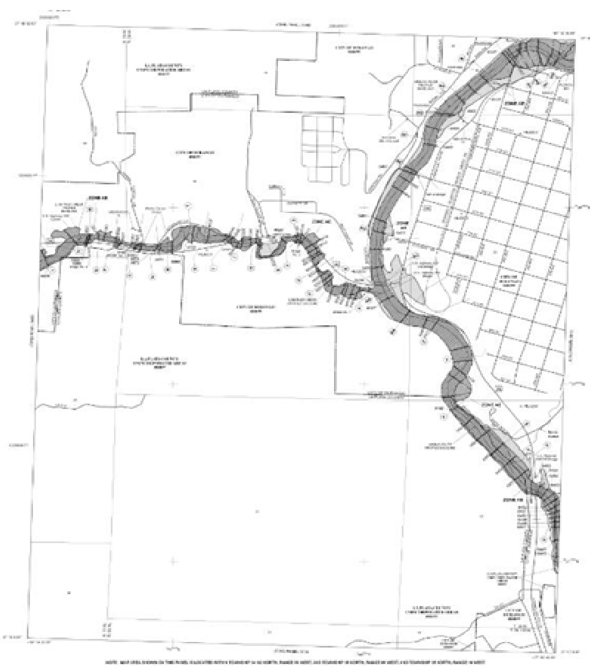

Figure 3.2: Floodplain Map of Durango, CO (FEMA, 2010)

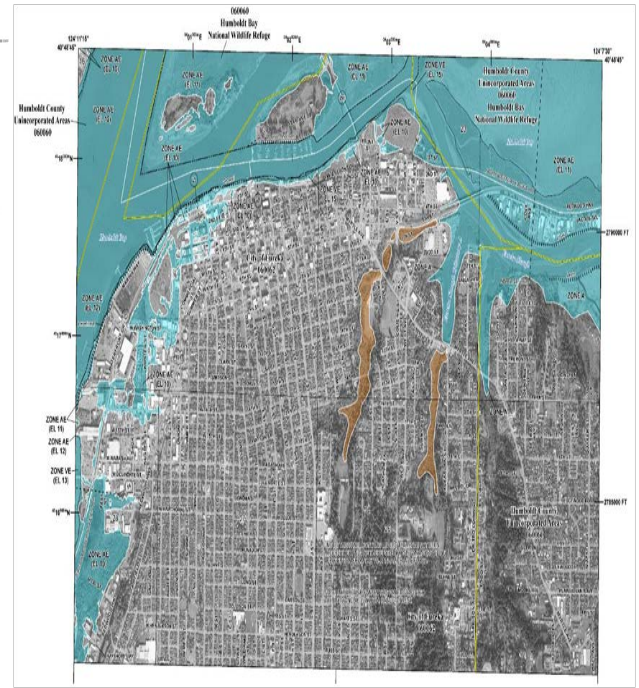

Figure 3.3: Floodplain Map of Eureka, CA (FEMA, 2017)

Figure 3.4: Floodplain Map of Gunnison, CO (FEMA, 2013

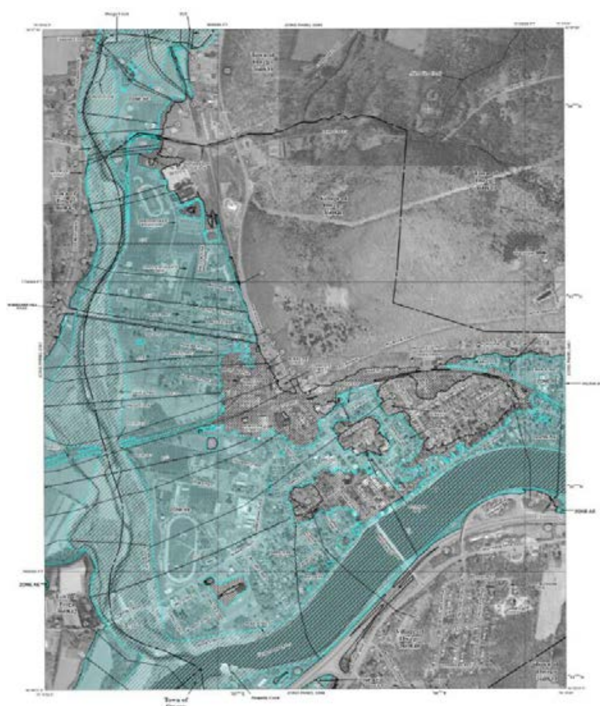

Figure 3.5: Floodplain Map of Owego, NY (FEMA, 2012)

The black shaded area in Figure 3.2 and teal shaded areas in Figures 3.3 to 3.5 are the areas where the flood has a 0.2%-1% chance of being equaled or exceeded in any given year. From these maps, it is quite clear they are regions with different flood risks and area. Owego is most likely to have flooding in almost the entire city. In Eureka, a large part of the area near the river is likely to be flooded and Durango's flood area is concentrated along the river that crosses the city. As for Gunnison, despite the large flood area in the south, only a small part of the city is under the risk of flooding, and thus has a minimum flood risk in the urban area. As a result, for the purposes of this study, flood risk is defined as the proportion of the community in the designated floodplain. Thus, the flood risk of the geographic locations in the study from highest to lowest is Owego, Eureka, Durango, and Gunnison.

Sixteen focus groups were held in all, with eight in each of two rounds. A professional group of NWS partners and a resident group were held in each location in each round. In order to ensure that each focus group contained enough interested participants, volunteers were recruited through local environmental and community groups, as well as social media like Facebook (see Appendix A for IRB approval). A pre-session survey was administered to every participant to get their demographic characteristics and flood experiences at the beginning of each focus group meeting, and at the end of the meeting, the participants also completed a post-session survey without personal background information to assess the experience of the focus group and put forward their personal suggestions on the deficiencies and improvements of the products. In the first round, the scenario that was presented used the respective River Forecast

Center's Hydrologic Ensemble Forecast (HEFS) graph (see Figure 3.6 for the product used in Eureka). In the second round, the graph (see Figure 3.7) was revised based on the results of the focus groups and post session surveys from the first round. After the second round, the graphs (see Figure 3.8) were revised once again and were included in an online survey sent to all participants in the 16 focus groups to obtain the views of all participants on the revised products. Following are some details in each survey. Complete surveys are in Appendix B.

3.1.2 Product Type and Survey Composition

The NWS hydrology products in this project are the Hydrograph, Probability of River Level Forecast and Briefing package, but the major emphasis is on the Probability of River Level Forecast, that is the Hydrologic Ensemble Forecast System (HEFS), with examples for Eureka shown in Figures 3.6, 3.7, and 3.8 below.

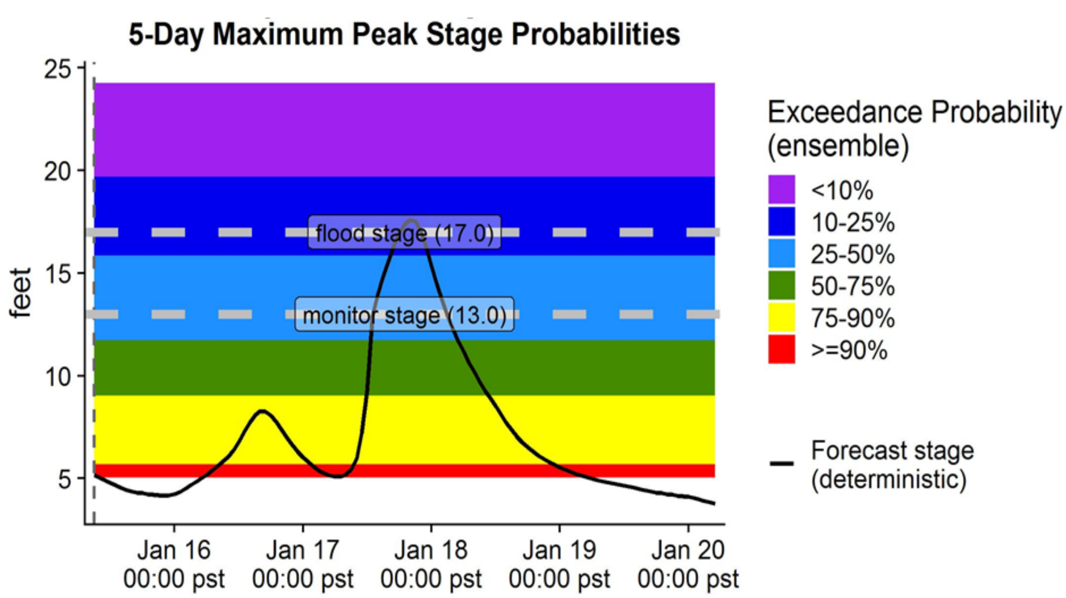

Figure 3.6: River Level Probabilities Product of Eureka, CA used in Round One Focus Group

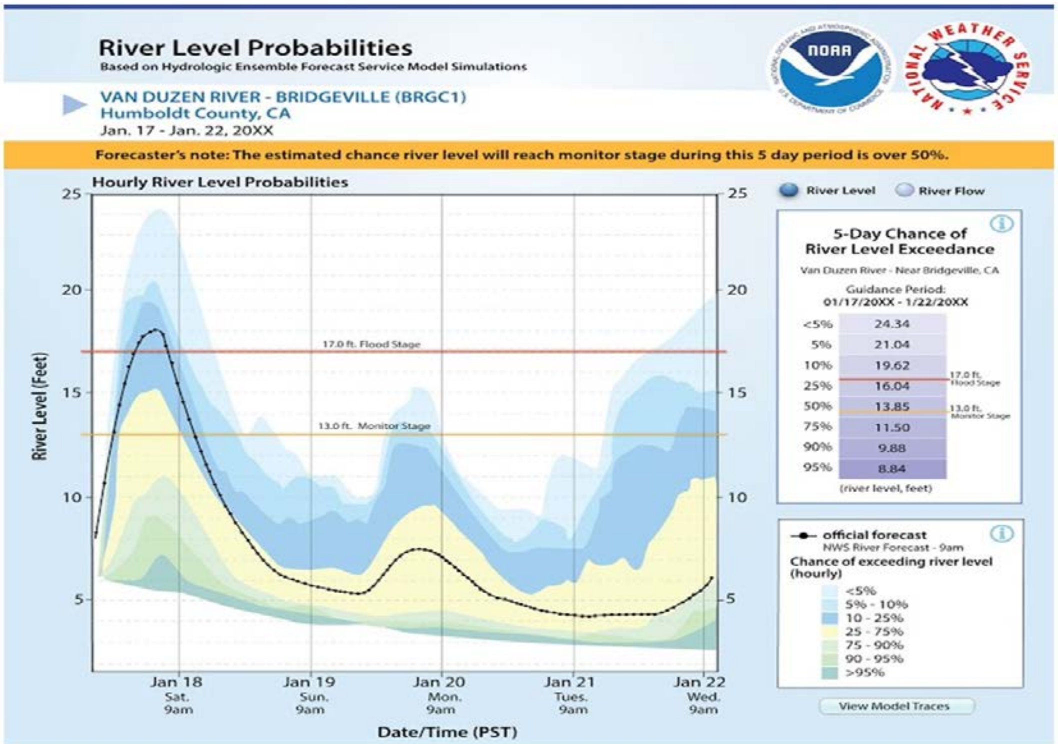

Figure 3.7: River Level Probabilities Product of Eureka, CA used in Round Two Focus Group

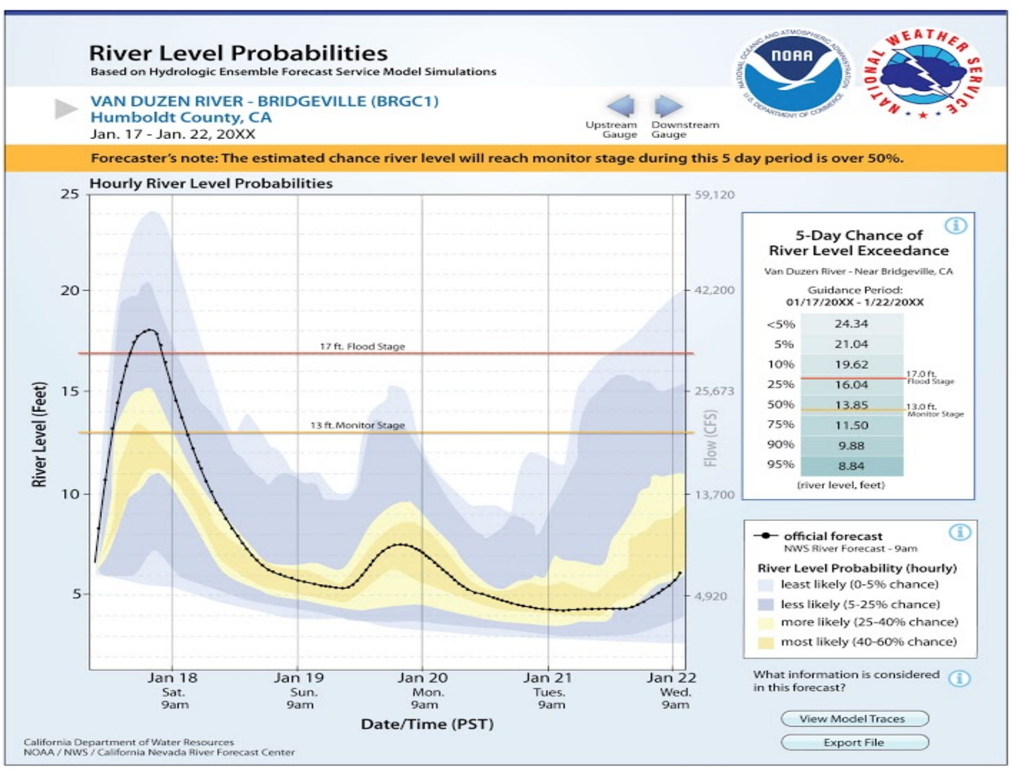

Figure 3.8: River Level Probabilities Product of Eureka, CA used in Online Survey

Questions in the pre-session survey are almost the same for each location. Every pre-session survey included the following topics: reason for attending, access to information about extreme weather events, personal background like age, gender, education level and place of residence as well as flood experience and preparation. It is slightly different between the professional group and the resident group; there are two more questions focusing on professionals' positions. This survey is designed to acquire the basic background information of participants.

As for the post-session survey, questions are mainly focused on participants' understanding and use of weather forecast products, as well as corresponding opinions and suggestions. Questions related to their reviews about the NWS resources, how they will use and share the products, usefulness and confusion relating to the content and format of each product, digital platform and social media preferred to acquire the information and the suggested improvements to foster the effectiveness of the products.

The final follow-up survey combines a number of questions from the pre-session survey and the post-session one, including background information of the participants in the focus groups and their understanding of the product (after a second revision) but puts more weight on the anticipated actions of the participants after using the products, and their preferences for changes to the product (modified colors, added percentiles, and clarified wording) based on the feedback from the focus group surveys and conversations.

It is important to note that this study is part of an ongoing NWS-funded project and thus the surveys were designed to meet the needs of the project as a whole rather than around the research questions investigated here.

3.2 Data Analysis Method and Procedure

This section presents hypotheses, definitions of variables and the questionnaire items used to undertake the analyses that will be used in this study. Analytical methods used in this study are descriptive statistical analysis, Spearman's correlation analysis, reliability and validity analysis and path analysis of Structural Equation Modeling (SEM).

The data obtained from the focus groups in rounds 1 and 2 and the online survey were both tested for their validity and reliability to verify the effectiveness of the scales. According to Awang (2015), the assessment of the reliability and validity for the SEMs is required before testing the relationships between constructs. The reliability and validity analysis is required only for latent variables of multiple-item measurement. Additionally, correlation analyses were undertaken to study the relationship between variables. The methodology of using SPSS and AMOS for Structural Equation Model simulation and Correlation analysis like Pearson correlation analysis and Spearman's correlation analysis has been widely applied in safety research that explores the influence among constructs (Meng et al., 2019; Li et al., 2020). It was proved to be effective and feasible for examining the inter-correlation and influence significance among SEMs in safety research (Ong and Puteh, 2017; Civelek, 2018). In this study, because the data used are all ordinal, a Spearman's correlation analysis was conducted in order to verify the hypotheses proposed in this paper preliminarily. However, factor analysis of latent variables is needed before the correlation analysis can be conducted.

3.2.1 Hypotheses

Twenty-seven hypotheses in terms of the assumed correlation between variables based on previous literature in the study are listed in Table 3.1. The large number of hypotheses is needed to set up the model used in the analyses, as described in the next section.

Table 3.1: Hypothesized Correlation between Variables in the Study

Number	Content
H1	Professionals will have significantly higher risk perception levels than residents.
H2	There is a significant difference in the usefulness of products (UOP) between professionals and residents
H3	There is a significant difference in the usefulness of products elements (UOPE) between professionals and residents
H4	People living in areas with a higher chance of flooding will have a significantly higher risk perception level .
H5	People living in areas with a higher chance of flooding will report NWS forecasts products (UOP) to be significantly more useful.
H6	People living in areas with a higher chance of flooding will report NWS forecasts products elements (UOPE) to be significantly more useful.
H7	People's flood experience will have a significantly positive influence on their risk perception level.
H8	People's flood experience will have a significantly positive influence on their reports of the usefulness of NWS forecasts products (UOP).
H9	People's flood experience will have a significantly positive influence on their reports of the usefulness of NWS forecasts products elements (UOPE).
H10	People's age will have a significant influence on their risk perception level.
H11	People's age will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).
H12	People's age will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).
H13	People's gender will have a significant influence on their risk perception level.
H14	People's gender will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).
H15	People's gender will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).
H16	People's educational level will have a significant influence on their risk perception level.

H17	People's educational level will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).
H18	People's educational level will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).
H19	People's risk perception level will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).
H20	People's risk perception level will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).
H21	People's risk perception level will have a significant influence on their usage intention of NWS forecasts products.
H22	People's risk perception level will have a significant influence on their intended actions after using NWS forecasts products.
H23	People's reports of the usefulness of NWS forecasts products (UOP) will have a significant influence on their usage intention of NWS forecasts products.
H24	People's reports of the usefulness of NWS forecasts products elements (UOPE) will have a significant influence on their usage intention of NWS forecasts products.
H25	People's reports of the usefulness of NWS forecasts products elements (UOPE) will have a significant influence on their product understanding of NWS forecasts products.
H26	People's product understanding of NWS forecasts products will have a significant influence on their intended actions.
H27	People's usage intention of NWS forecasts products will have a significant influence on their intended actions.

3.2.2 Data Analysis: Structural Equation Modeling

The method of structural equation modeling (SEM) was applied to analyze surveys of focus group participants (professionals of NWS partners and residents in four locations in the US), with respect to their perceived usefulness, and understanding and use of NWS hydrology products (see Figures 3.9 and 3.10). SEM analysis was conducted by using AMOS 27.0.

SEM is a powerful multi-stage/multi-equation model that allows for the testing of latent variables, posits a hypothesized model of direct and indirect relations, and tests the plausibility of that model. The many arrows in the model, with their directionality, each reflects a hypothesis bearing on the causal structure of the variables in the model (Byrne, 1994). SEM also allows for the integration of latent (or unobservable) and observed variables in a single model; it explains how the observed and latent variables are related to one another. It is an especially appropriate design because it allows for the analysis of both direct and indirect effects and the analysis of both mediating and moderating variables. It is also capable of handling issues of auto-correlation resulting from the entry of the same factor at multiple times. The most commonly used method for estimation and testing in SEM is the maximum likelihood estimation (MLE). In MLE, parameter estimates are obtained by maximizing the likelihood function derived from the multivariate normal distribution, and it attempts to maximize the likelihood that obtained values of the criterion variable will be correctly predicted (Hayashi et al. 2011). The Department of Statistics and Scientific Computation at the University of Texas (2012) provides details on SEM and how it is structured in AMOS. The greatest benefits of the SEM are its flexibility in testing, use of multiple measures, accommodation of varying distributional assumptions, and capacity for handling many kinds of data (Fassinger 1987).

There were two SEMs used in this analysis due to the structural differences between the first post-session survey and the final follow-up survey. The first, Hypothetical Model 1, is designed for analyzing the first and second round pre-session and post-session surveys whereas Hypothetical Model 2 is made for analyzing the final follow-up survey. Figures 3.9 (Hypothetical Model 1) and 3.10 (Hypothetical Model 2) below depict the layout of the hypothetical research model with all hypotheses (H#) proposed. Specific variable descriptions are listed in Tables 3.2 and 3.3.

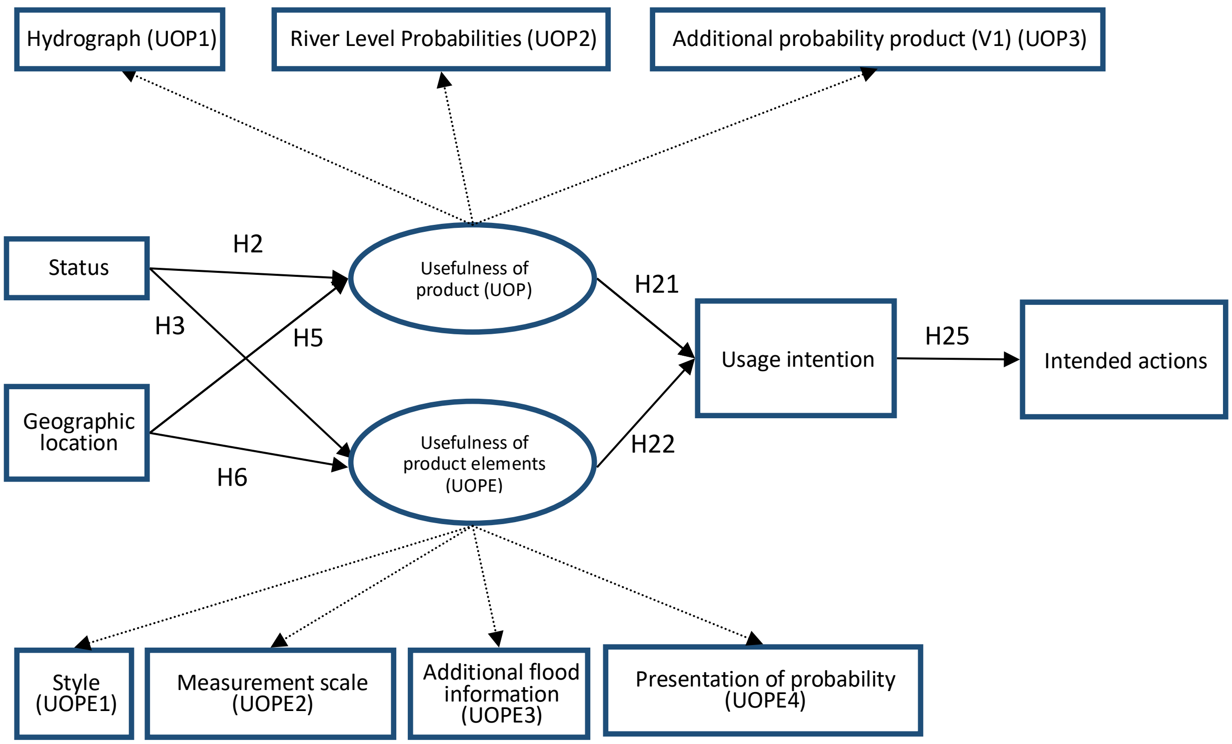

Figure 3.9: Hypothetical Structural Equation Model 1 for Round 1 and 2 Surveys

Table 3.2: Measures by Variables, Indicators and Geographic Location in Hypothetical Model 1

Variables	Indicators（V#s）	Geographic location
Usefulness of product (UOP)	Hydrograph (UOP1)	Owego
	River Level Probabilities (UOP2)	
	5 Day River Flood Outlook (V1) (UOP3)	
Usefulness of product (UOP)	Hydrograph (UOP1)	Eureka
	River Level Probabilities (UOP2)	
	River Flow Probabilities (V1) (UOP3)	
Usefulness of product (UOP)	Hydrograph (UOP1)	Durango
	River Level Probabilities (UOP2)	
	Weekly Chance of Exceeding (V1) (UOP3)	
Usefulness of product (UOP)	Hydrograph (UOP1)	Gunnison
	River Level Probabilities (UOP2)	
	Weekly Chance of Exceeding (V1) (UOP3)	
Usefulness of product elements (UOPE)	Style (UOPE1)	Owego, Eureka, Durango and Gunnison
	Measurement scale (UOPE2)	
	Additional flood information (UOPE3)	
	Presentation of probability (UOPE4)	

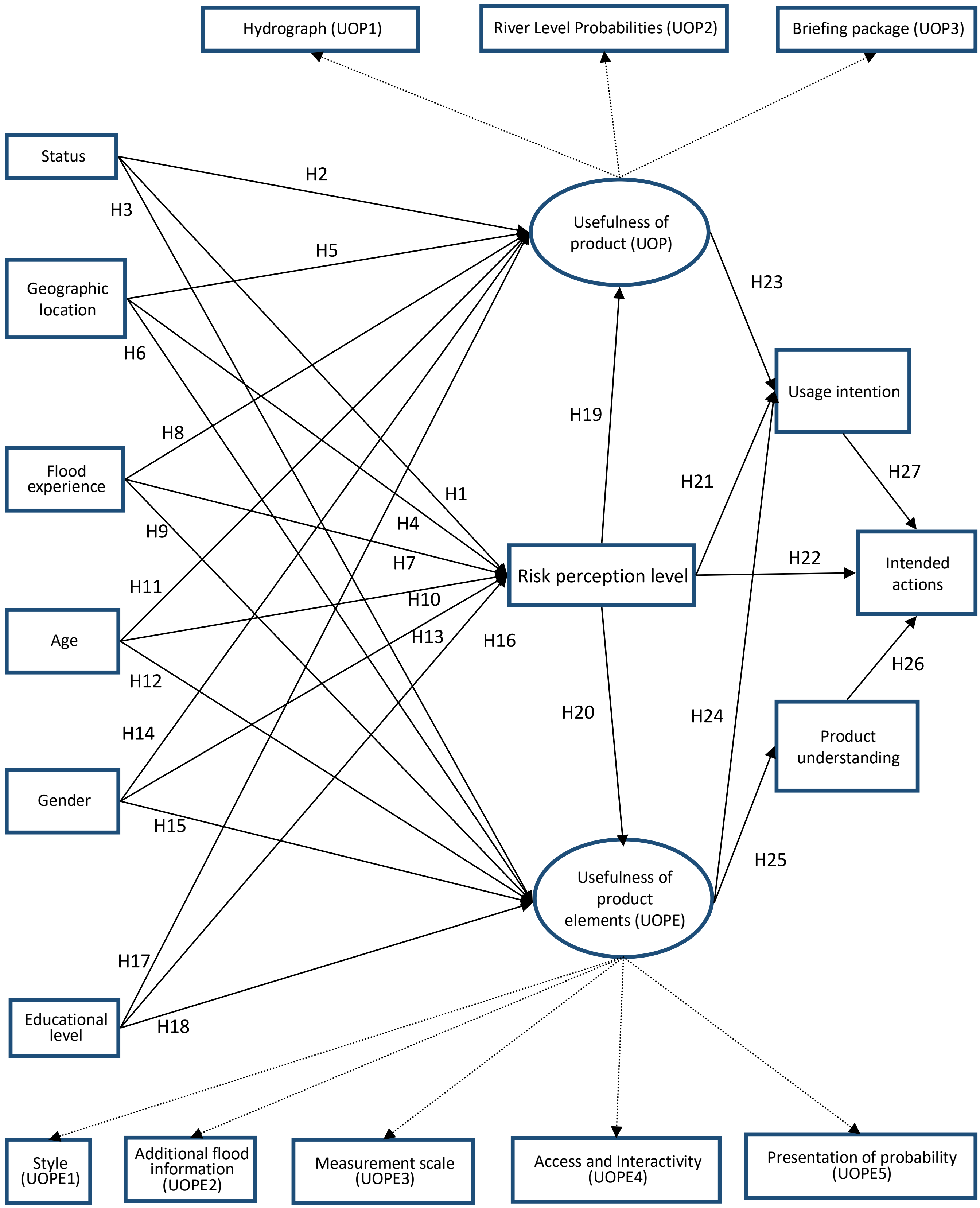

Figure 3.10: Hypothetical Structural Equation Model 2 for Online Survey

Table 3.3: Measures by Variables, Indicators and Geographic Location in Hypothetical Model 2

Variables	Indicators	Geographic location
Usefulness of product (UOP)	Hydrograph (UOP1)	Owego, Eureka, Durango and Gunnison
	River Level Probabilities (UOP2)	
	Briefing Package (UOP3)	
Usefulness of product elements (UOPE)	Style (UOPE1)	
	Measurement scale (UOPE2)	
	Additional flood information (UOPE3)	
	Presentation of probability (UOPE4)	
	Access and Interactivity (UOPE5)	

All variables in the two hypothetical models can be categorized as either exogenous or endogenous variables. In the hypothetical model diagrams, the exogenous variables have arrows pointing to other variables and endogenous variables have arrows pointing to themselves. Exogenous variables in the study are status, geographic location, flood experience, age, gender, and educational level. Variables that can be used as both endogenous and exogenous variables in the study are risk perception level, usefulness of product, usefulness of product elements, product understanding, and usage intention. Intended actions is an endogenous variable. Variables in the square frames are observable variables, while variables in the ellipses are latent or unobservable variables, which need to be measured by indicators. Various NWS forecasts like hydrographs and probability forecasts are the indicators of the latent variable "Usefulness of product", while the product elements like style and measurement scale are the indicators of the latent variable "Usefulness of product elements". These latent variables and their indicators are connected by the dashed line in Figures 3.9 and 3.10.

3.2.3 Model Measures Definitions

Measures and definitions of the variables and indicators are listed below. Due to the low number and variety of responses for the "other" category in questions in the surveys, they were not included in any of the analyses.

Exogenous variables:

The exogenous variables were determined from the surveys and are presented in Table 3.4. Status was determined by whether the participant is a professional or a resident. The geographic location of participants indicates where they attended the focus group, while flood experience refers to the number of times a person and the people that person knows have experienced floods. Various demographic variables including age, educational level, and gender are known to be important to understanding perceptions and thus are included in the analysis as shown in the table 3.4.

Table 3.4: Exogenous Variables and their Measures used in the Analysis

Variable	Measure	Survey and Survey question
Status	1=Resident 2=Professional	
Geographic location	1=Gunnison 2=Durango 3=Eureka 4=Owego	
Flood Experience	# of times 1=never 2=1-5 times 3=6-10 times 4=11-20 times 5=20+ times	Pre-session #4 Online #4,5,6
Age	1=under 20 2=20-29 3=30-39 4=40-49 5=50-59 6=60-69 7=70+	Pre-session #12 Online #1
Gender	1=Male 2=Female	Pre-session #13 Online #2

Educational level	1=High school/GED 2=Associate's/2-yearDegree 3=Bachelor's/4-year Degree 4=Post graduate work	Pre-session #17 Online #3

Several endogenous variables were determined from the surveys and are presented in Table 3.5 below. Risk perception level refers to the level of subjective judgment that people make about the characteristics and severity of a risk, including potential harm or the possibility of a loss. It is an endogenous variable only in Hypothetical Model 2, and in the online survey it was measured by individual questions in that survey (Table 3.5). The scale of measurement is from 1 (Very low) to 5 (Very high). Product understanding is the degree of overall understanding of NWS weather forecast products by the participants in the focus groups. It is an endogenous variable only in Hypothetical Model 2, and in the online survey it was measured by individual questions in that survey (Table 3.5). For the questions addressing this variable (refer to Table 3.5 and Appendix C), the scale of measurement is from 1 (don't understand) to 5 (understand extremely well). Every correct answer checked among four boxes was coded as 1, while each wrong answer checked was scored as -1. Final scores were the sum score of two questions: more right and fewer wrong answers checked, the higher the score will be, so higher scores indicate better understanding of the product. Intended actions refers to the activities relating to flooding prevention participants say they will undertake as a result of the NWS weather forecast products they saw. It indicates the extent to which people report the products will influence their actions, thus revealing people's acceptance of products. In the post-session survey, it was measured by item 4: "After attending today's session, how likely are you to" for every possible response except "Use uncertainty forecasts in your decision-making". The overall score is the average value of answers reported to all the possible responses (again, except "Use uncertainty forecasts in your decision-making"). The scale of measurement is from 1 (Unlikely) to 4 (Very likely), and the higher score indicates products have more influence on people's actions. In the online survey, it was measured by various questions, depending on the location (Table 3.5). The measurement scale is from 0 (No intended actions) to 5 (All intended actions), depending on how many boxes presented in the questions were checked. The higher score indicates products have more influence on people's actions. Usage intention explains the ultimate willingness of participants to use the NWS weather forecast product in the future. In the post-session survey, it was measured by item 4: "After attending today's session, how likely are you to…use uncertainty forecasts in your decision-making". The scale of the measurement was from 1 (Unlikely) to 4 (Very likely), and the higher score indicates participants are more likely to use the product in the future. Again, in the online survey, it was measured by different questions depending on the location, and the scale of the measurement was from 1 (Very unlikely) to 5 (Very likely), with the higher score indicating participants are more likely to use the product in the future.

Table 3.5: Several Endogenous Variables and their Measures used in the Analysis

Variable	**Measure**	**Survey and Survey question**
Risk perception level	1=Very low 2=Somewhat low 3=Neutral (neither high nor low) 4=Somewhat high 5= Very high	Online #14, 25, 39, 50

Product understanding	# of correct answers checked -# of wrong answers checked -2=Don't understand at all -1=Somewhat don't understand 0=Understand fairly well 1=Understand well 2=Understand extremely well	Online #13, 24, 38, 49
Intended actions	For model 1 1=Unlikely 2=Somewhat unlikely 3=Somewhat likely 4=Very likely For model 2 # of options checked 0=No intended actions 1=One intended actions 2=Two intended actions 3=Three intended actions 4=Four intended actions 5=All intended actions	Post-session #4 Online #15, 16, 26, 27, 40, 41, 51, 52
Usage intention	For model 1 1=Unlikely 2=Somewhat unlikely 3=Somewhat likely 4=Very likely For model 2 1=Very unlikely 2=Somewhat unlikely 3=Neutral (neither likely nor unlikely) 4=Somewhat likely 5=Very likely	Post-session #4 Online #19, 30, 44, 55

The latent variables and their indicators were determined from the surveys and are presented in Table 3.6. The latent variable, usefulness of products, refers to the overall evaluation of the usefulness by the participants in the focus groups of several specific NWS weather forecast products. This endogenous variable was measured by several indicators, depending on the geographic location of the focus group. The specific indicators of the variable and their measures for each focus group are shown in Tables 3.1, 3.2 and 3.6. The scale of the measurement was from 1 (Very unlikely) to 4 (Very likely) for the post-session surveys and from 1 (Very unlikely) to 5 (Very likely) for the online survey. The higher score indicates a higher evaluation of the product. Similarly, the usefulness of product elements refers to the overall evaluation by the participants in the focus groups of the usefulness of each product element in the NWS weather forecast products. This endogenous variable was also measured by several indicators, the same for all focus groups. The specific indicators of the variable and their measures for each focus group are shown in Tables 3.1, 3.2, and 3.6. Options were categorized as five indicators: Style (title, legends, color), Measurement Scale (time period, river level, river flow, and discharge), Additional Flood Information (flood levels, forecaster's note, USGS historic river levels comparison, and historic river levels hover box), Presentation of Probability (percentages, likely categories, range of probable levels, 5-Day chance of exceedance, percent chance of exceedance, median line, and river level probability lines), and Access and Interactivity (option to click for upstream and downstream gauge data, information pop-ups, option to view model traces, option to export file, and scale to flood stage option). These indicators were measured by two questions (7 and 8) in the post-session survey: for question 7, each option selected by respondents was scored as 1, while each option selected by respondents for question 8 was scored as -1. Final scores were the sum score of the two questions divided by each element's total number of components, so that higher scores indicated higher evaluation of the usefulness of the product elements. The online survey applies the same measurement method.

Table 3.6: Latent Variables, Indicators, and Measures used in the Analysis

Variable	Indicator	Measure	Survey and Survey question
Usefulness of product (UOP)	Hydrograph	For Model 1 1=Not at all useful 2=Slightly useful 3=Very useful 4=Extremely useful	Post-session #6 Online #8
	River Level Probabilities	For Model 2 1=Not useful 2=Somewhat not useful 3=Neutral (neither useful nor not useful) 4=Somewhat useful 5=Very useful	Post-session #6 Online #9, 18, 29, 43, 54
	5 Day River Flood Outlook	1=Not at all useful 2=Slightly useful 3=Very useful 4=Extremely useful	Post-session #6
	River Flow Probabilities	1=Not at all useful 2=Slightly useful 3=Very useful 4=Extremely useful	
	Weekly Chance of Exceeding	1=Not at all useful 2=Slightly useful 3=Very useful 4=Extremely useful	
	Briefing Package	1=Not useful 2=Somewhat not useful 3=Neutral (neither useful nor not useful) 4=Somewhat useful 5=Very useful	Online #10
Usefulness of product elements (UOPE)	Style	# of options checked -1 to -0.5=Very confusing -0.5 to 0 =Slightly confusing 0=Neutral (neither useful nor confusing)	Post-session #7, 8 Online #20, 21, 31, 32, 45, 46, 56, 57
	Measurement scale		
	Additional flood information		
	Presentation of probability		

	Access and Interactivity	0 to 0.5=Slightly useful 0.5 to 1=Very useful	

In order to get a better model fit and make the model reflect the actual situation more accurately, SEMs in the study were iterated and optimized many times. The objects of iteration and optimization of the model include model fit, indicators of latent variable, and influence relationship between variables.

Based on the results of the model, the format of some variables has been changed to make the data able to reflect its distribution characteristics more accurately. For example, the value of the variable Flood Experience has been changed from a simple counting method to a scale-based counting method to reduce the reduction of model matching caused by extreme numbers. Indicators of latent variables have been reduced, and indicators with low factor loadings were removed to improve the model fit. Several relationships between variables have been removed because the results of SEMs in iterations indicated these relationships were insignificant and therefore could decrease the model fit.

The approach used in this study is exploratory, given the complexities in the relationships that are being tested and the direct and indirect influences of various factors that can influence risk perception, product understanding, and ultimately action. The next chapter presents the results of the various models and SEM iterations to test the hypotheses.

CHAPTER 4: RESULTS

This chapter is divided into six parts. First is the descriptive statistics analysis of the collected data. Second is the reliability and validity analysis of the measurement items of the latent variables. Third is the correlation analysis of the variables carried out to verify the hypotheses of the hypothetical models preliminarily. After that, path analysis was used to figure out the direct and indirect influence relationship within the SEM, to further verify the hypotheses. Furthermore, the SEMs were modified according to the model fit and relationship significance of the previous results. Last, the overall result of model hypothesis verification is provided. The analysis results of this study are described in detail and briefly discussed.

4.1 Descriptive Statistical Analysis

The descriptive statistical analysis of this study describes the percentage, frequency, average, standard deviation, maximum and minimum values of the data, including demographic variables of the respondents (such as gender, age, status, education level, geographic location, flood experience, and risk perception level), as well as the model-related variables (Usefulness of Product (UOP), Usefulness of Product Elements (UOPE), Product Understanding, Usage Intention, and Intended Actions). The questionnaires collected in this study were divided into two parts: the first part had 144 valid questionnaires from rounds 1 and 2 used for Hypothetical Model 1; the second part includes 107 valid online surveys used for the Hypothetical Model 2. Valid questionnaires refer to those whose questions have all been answered.

4.1.1 Descriptive Statistical Analysis of Demographic Characteristics

Tables 4.1 and 4.2 describe the demographic information of the sample. For round 1 and 2 surveys, the results showed that overall there were more residents than professionals with almost 32% of all participants in Eureka, while the respondents with Gunnison residence had the lowest number, about 17%. Overall, the proportion of Colorado respondents was relatively low. The proportion of respondents with flood experience (72.22%) was much higher than that of respondents without experience (27.78%). Although the respondents were generally evenly distributed by age, more than half were over 50 years old. There were more men than women participating in the focus groups, and almost all except 15% had some college education. Finally, most of the participants had a relatively low (36.11%) to medium (31.25%) risk perception level, despite the fact that most of the respondents had experienced floods.

Table 4.1: Personal Characteristics of Participants in Round 1 and 2 Surveys for Hypothetical Model 1 (N= 144)

Variables	Categories	Frequency	Percentage
Status	Resident	82	56.94%
	Professional	62	43.06%
Geographic location	Gunnison	25	17.36%
	Durango	30	20.83%
	Eureka	46	31.94%
	Owego	43	29.86%
Flood experience	Yes	104	72.22%
	No	40	27.78%
Age	under 20	2	1.39%
	20-29	14	9.72%
	30-39	22	15.28%
	40-49	28	19.44%
	50-59	36	25.00%
	60-69	28	19.44%
	70-79	14	9.72%

Gender	Male	74	51.39%
	Female	70	48.61%
Educational level	High school/GED	21	14.58%
	Associate's/2-yearDegree	15	10.42%
	Bachelor's/4-year Degree	56	38.89%
	Post graduate work	52	36.11%
Risk perception level	No risk	13	9.03%
	Very little risk	52	36.11%
	Some risk	45	31.25%
	Somewhat high risk	23	15.97%
	Extremely high risk	11	7.64%

For the online survey, which is a follow-up survey of respondents who previously participated in rounds 1 and 2 of the focus groups, the results in Table 4.2 show that more than twice the number of residents responded to the survey than did professionals. From the geographic location perspective, the online survey results were similar to the results of the round 1 and 2 surveys with almost 40% of the respondents being from Eureka. Again, Gunnison had the lowest number, even lower than the previous results. As before, the proportion of respondents living in the Colorado study sites was relatively low.

The online follow-up survey further quantifies the specific flood experience of the respondents. Although the vast majority of people (91.59%) had relevant flood experience, nearly half experienced few floods (0-5 times). Since the number included the respondents themselves and their relatives' flooding experiences, it indicates that most of the respondents had not experienced many floods. Further, the number of those who had experienced more than 10 flood events is not large, less than 25%.

The participants' age distribution in the follow-up survey was basically the same as those of the rounds 1 and 2 surveys. Most of the respondents were also between 50 and 69 years old (49.53%), and the proportion of respondents under the age of 29 and over the age of 70 was quite low. The data was generally evenly distributed by age. The proportion of men and women (51.40% and 48.60%, respectively) was almost identical to the results of rounds 1 and 2 surveys. There were more men than women in the online survey, but there was no big deviation in the proportion of gender. Further, the level of education was also very similar to the results of rounds 1 and 2 surveys with a large majority having some college education.

Unlike the previous results of round 1 and 2 where most of the participants indicated a relatively low (36.11%) to medium (31.25%) risk perception level), the results of the online survey showed that, although there was still a large proportion of the participants with a relatively low (32.71%) risk perception level, the number of respondents with a high risk perception level increased significantly compared with the previous results. The proportion of respondents who perceive themselves to be at "somewhat high risk" was as high as 36.45%. Compared to the previous results of round 1 and 2, this value increased from 15.97% to 36.45%, which suggests that the introduction and explanation of the weather forecast products to focus groups may have led to an increase in participants' risk perception levels.

Table 4.2: Personal Characteristics of Participants in Online Survey for Hypothetical Model 2 (N= 107)

Variables	Categories	Frequency	Percentage
Status	Resident	74	69.16%
	Professional	33	30.84%
Geographic location	Gunnison	12	11.21%
	Durango	23	21.50%
	Eureka	41	38.32%
	Owego	31	28.97%
Experienced Flood Times	0	9	8.41%
	0-5	51	47.66%

Experienced Flood Times	6-10	23	21.50%
	10-20	13	12.15%
	>20	11	10.28%
Age	under 20	2	1.87%
	20-29	9	8.41%
	30-39	13	12.15%
	40-49	21	19.63%
	50-59	26	24.30%
	60-69	27	25.23%
	70-79	9	8.41%
Gender	Male	55	51.40%
	Female	52	48.60%
Educational level	High school/GED	12	11.21%
	Associate's/2-yearDegree	17	15.89%
	Bachelor's/4-year Degree	43	40.19%
	Post graduate work	35	32.71%
Risk perception level	No risk	12	11.21%
	Very little risk	35	32.71%
	Some risk	10	9.35%
	Somewhat high risk	39	36.45%
	Extremely high risk	11	10.28%

4.1.2 Descriptive Statistical Analysis of Variables in Models

In this study, the model variables were also analyzed, including their maximum, minimum, mean, skewness, kurtosis, and standard deviation. Since this study uses SEMs to test the research hypotheses, and in this study the Maximum Likelihood method was used for data analysis of SEMs, samples must obey a normal distribution. Skewness and kurtosis are useful indexes to test normal distribution. Each variable's descriptive statistical results are shown in Tables 4.3 (Hypothetical Model 1) and 4.4 (Hypothetical Model 2). Since the Hypothetical Model 1 does not include demographic characteristics other than status and geographic location, this part does not include the analysis of these data.

As seen in Table 4.3, variables in the Hypothetical Model 1 include Status, Geographic Location, Usefulness of Product (UOP), Usefulness of Product Elements (UOPE), Intended Actions, and Usage Intention. Among them, the variables UOP and UOPE are latent variables constructed by indicators UOP1, UOP2, UOP3, and UOPE1, UOPE2, UOPE3, UOPE4, and UOPE5, respectively. (See Tables 3.2, 3.3, and 3.6 above for the specific names and value of relevant indicators.)

Table 4.3: Results of the Descriptive Statistical Analysis of Variables in Hypothetical Model 1

Variables	Indicators	N	Minimum	Maximum	Mean	Std.D	Skewness	Kurtosis
Status	/	144	1	2				
Geographic location	/	144	1	4				
Intended actions	/	144	0	4	2.31	1.35	-0.176	-1.785
Usage intention	/	144	1	4	3.25	0.76	-0.746	0.028
Usefulness of product (UOP)	UOP1	144	1	4	3.34	0.76	-0.856	-0.08
	UOP2	144	1	4	3.12	0.88	-0.545	-0.782
	UOP3	144	1	4	3.06	0.85	-0.383	-0.874
Usefulness of product elements (UOPE)	UOPE1	144	-1	1	0.39	0.57	-0.769	-0.088
	UOPE2	144	-1	1	0.65	0.44	-0.943	-0.188
	UOPE3	144	-1	1	0.69	0.50	-1.517	1.722
	UOPE4	144	-1	1	0.37	0.59	-0.627	-0.469

As shown in Tables 4.3 and 4.4, the absolute values of skewness of all variables were less than 3, and the absolute values of kurtosis were less than 8, indicating that the sample data conform to the normal distribution, making it suitable to use the SEM for analysis. Similarly, the standard deviations of all latent variables were less than 1, indicating that the respondents' evaluation of these structures was consistent.

Table 4.4: Results of the Descriptive Statistical Analysis of Variables in Hypothetical Model 2

Variables	Indicators	N	Minimum	Maximum	Mean	Std.D	Skewness	Kurtosis
Status	/	107	1	2				
Geographic location	/	107	1	4				
Flood experience	/	107	1	5	2.68	1.12	0.74	-0.305
Age	/	107	1	7	4.65	1.49	-0.426	-0.542
Gender	/	107	1	2				
Educational level	/	107	1	4	2.94	0.97	-0.646	-0.508
Risk perception level	/	107	1	5	3.02	1.25	-0.065	-1.284

Product understanding	/	107	-2	2	0.61	1.03	-0.376	-0.56
Intended actions	/	107	0	5	3.02	1.63	-0.336	-0.964
Usage intention	/	107	1	5	4.27	0.92	-1.317	1.369
Usefulness of product (UOP)	UOP1	107	1	5	4.05	0.98	-1.122	1.146
	UOP2	107	1	5	4.33	0.67	-1.139	1.509
	UOP3	107	1	5	4.44	0.75	-1.602	3.594
Usefulness of product elements (UOPE)	UOPE1	107	-1	1	0.64	0.42	-0.783	-0.615
	UOPE2	107	-1	1	0.55	0.41	-0.706	0.03
	UOPE3	107	-1	1	0.63	0.38	-0.542	-0.808
	UOPE4	107	-1	1	0.33	0.52	-0.332	-0.607
	UOPE5	107	-1	1	0.19	0.49	-0.162	0.418

4.2 Reliability and Validity Analysis

4.2.1 Reliability Analysis

Reliability reflects the extent to which the scale avoids random errors and ensures the consistency and predictability of research results, and the index of reliability is mostly the correlation coefficient. Internal consistency is a general term used for estimating the reliability of a measure by evaluating the within-scale consistency of the responses to the measure items (indicators). Cronbach’s coefficient is often used to test the internal consistency reliability, which reflects the consistency of multiple items for measuring the same construct (Tavakol and Dennick, 2011). In recent years, scholars in social science research have taken 0.7 as the threshold. When Cronbach's Alpha value is greater than 0.7, they believe the data has high credibility; when Cronbach's alpha value is less than 0.7, they think the data has poor credibility. However, according to Ramayah (2011), Cronbach’s Alpha coefficient values of more than 0.7 are considered good, but more than 0.5 are acceptable. In this research, Cronbach’s coefficient was tested by SPSS 26.0 software. The reliability of each latent variable is shown in Tables 4.5 (Hypothetical Model 1) and 4.6 (Hypothetical Model 2).

According to table 4.5, for the Hypothetical Model 1, the Cronbach's Alpha of the variable UOP and UPOE were all above 0.5, which indicates barely acceptable consistency reliability of these variables. The data in the "Corrected Item-Total Correlation" column refers to the Pearson correlation coefficient of each specific item with other items, which is of each UOP indicator with the total UOP and of each UOPE indicator with the total UOPE. Generally speaking, if the index is less than 0.3, the item is not closely related to other items and can be eliminated. If the total correlation coefficient of the revised item is less than 0.3 and the Cronbach Alpha increases after the item was deleted, the reliability increases when the item is deleted for reanalysis. In this research, for the Hypothetical Model 1, the indicator UOP3 in the column "Corrected Item-Total Correlation" was below 0.3, and when it was deleted, the Cronbach's Alpha of the latent variable it represents increases from 0.568 to 0.637, which achieves better reliability. Therefore, this indicator may not accurately reflect the changes of potential variables and should be deleted to enhance the overall reliability of the analysis. However, for indicator UOPE4, although its Corrected Item-Total Correlation was below 0.3, Cronbach's Alpha decreases if this item is deleted. Meanwhile, it is worth mentioning that Cronbach's Alpha of variable UOP reduces dramatically (from 0.568 to 0.145) if indicator UOP2 is deleted, which means this indicator has a dominant influence over any other variable on the latent variable it represents.

Table 4.5: Cronbach's Alpha Test Results of Latent Variables in the Hypothetical Model 1

Variables	Indicators	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
Usefulness of product (UOP)	UOP1	0.339	0.524	0.568
	UOP2	0.558	0.145	
	UOP3	0.264	0.637	
Usefulness of product elements (UOPE)	UOPE1	0.353	0.468	0.553
	UOPE2	0.388	0.452	
	UOPE3	0.354	0.469	
	UOPE4	0.279	0.539	

For the results of the Hypothetical Model 2 (see Table 4.6), the Cronbach's Alpha of latent variable UOP was near the borderline, but the Cronbach's Alpha of latent variable UOPE meets the recommended acceptable criteria standard (above 0.7). This may be because the respondents came to know more about the products' elements after the first and second rounds of product introductions, which led them to provide more meaningful answers to the questionnaire, or the revised weather forecast product elements and questionnaire were more accurately understood by the respondents. Similar to the results of the reliability analysis of the Hypothetical Model 1, the indicator UOP3 in the column "Corrected Item-Total Correlation" of the Hypothetical Model 2 was below 0.3. And when it was deleted, the Cronbach's Alpha of the latent variable it represents increases from 0.554 to 0.680, which achieves better reliability. Therefore, this indicator may not accurately reflect the changes of potential variables and should be deleted to enhance the overall reliability of the analysis. Similarly, indicator UOP2 of latent variable UOP also has a dominant influence over any other variable on the latent variable it represents.

Table 4.6: Cronbach's Alpha Test Results of Latent Variables in the Hypothetical Model 2

Variables	**Indicators**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**	**Cronbach's Alpha**
Usefulness of product (UOP)	UOP1	0.414	0.390	0.554
	UOP2	0.555	0.215	
	UOP3	0.195	0.680	
Usefulness of product elements (UOPE)	UOPE1	0.518	0.687	0.738
	UOPE2	0.452	0.710	
	UOPE3	0.477	0.703	
	UOPE4	0.639	0.633	
	UOPE5	0.439	0.720	

In summary, the overall weak Cronbach's Alpha of two hypothetical models may be because of the questionnaire design or classification criteria.

4.2.2 Validity Analysis

Validity is the authenticity and accuracy of measurement; it refers to the degree that the measurement process is not affected by systematic and random errors and reflects whether the questionnaire's measurement items measure the actual situation of its intended observation accurately. The main types of validity include face validity, content validity, criterion validity, and construct validity. Among them, construct validity is the most commonly used method in the existing research, which refers to the degree that the measurement items represent and logically connect the observed phenomena and constructs through the basic theory, to evaluate whether the results of measurement and observation can truly support the terminology or hypothesis of a particular theory. It includes convergent validity and discriminant validity.

Composite reliability was tested to measure the degree of reliability of the compositional constructs (Ammerlaan et al., 2017), which was further applied together with the average variance extracted (AVE) and factor loading to evaluate the degree of convergent validity (Cheung and Wang, 2017). Discriminant validity was tested by contrasting the square root of AVE with its largest inter-construct correlations for a certain factor or construct (Hair et al., 2010). This study focuses on construct validity, and both convergent validity and discriminative validity of the construct validity are discussed. They were tested using AMOS 27.0. The convergent validity is shown in Tables 4.7 (Hypothetical Model 1) and 4.8 (Hypothetical Model 2), and the discriminant validity is shown in Tables 4.9 (Hypothetical Model 1) and 5.0 (Hypothetical Model 2).

4.2.2.1 Convergent Validity Analysis

In the measurement model of SEM, composite reliability and average variance extracted (AVE) are important indexes to evaluate the convergent validity of variables. The composite reliability refers to the reliability of latent variables added by all indicators. The AVE refers to the average size of the observed variance explained by latent variables, thus, the larger the value is, the smaller the random measurement error is, and the more the indicators are qualified to represent the latent variable. As existing studies have pointed out, a factor loading greater than 0.6 or one that is statistically significant indicates that the variable has high convergent validity, however, if it is exploratory research, the criteria standard for factor loadings can be lower, down to 0.5 (Harrington, 2009). When the composite reliability is higher than 0.7 (0.6 is acceptable for exploratory research) and the AVE is greater than 0.5, the questionnaire's convergent validity is good. The factor loadings of measure items (indicators) reflect the level of convergent validity of each variable, and the factor loading is the correlation coefficient between the latent variable and its indicators.

For the Hypothetical Model 1 (see Table 4.7), only the factor loadings of UOP2 are above 0.6, UOPE2 and UOPE3 have factor loadings above 0.5, and UOP1 and UOPE4 have factor loadings lower but close to the borderline (0.5 for the exploratory analysis). Because of the low factor loadings, it is possible that two indicators (UOP1 and UOPE3) should be considered separately in the SEM.

Table 4.7: Results of Convergent Validity Analysis for the Hypothetical Model 1

Variables	**Indicators**	**Factor Loading**	**Square of Factor Loadings (SMC)**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Usefulness of product (UOP)	UOP1	0.473	0.224	0.669	0.450
	UOP2	1.000	1.000		
	UOP3	0.355	0.126		
Usefulness of product elements (UOPE)	UOPE1	0.382	0.146	0.573	0.256
	UOPE2	0.558	0.311		
	UOPE3	0.582	0.339		
	UOPE4	0.477	0.228		

The convergent validity analysis results of the Hypothetical Model 2 are better than the first one. Three indicators (UOP2, UOPE1, UOPE4) have factor loadings above 0.6; only the factor loadings of UOP3 and UOPE5 (near the borderline) are below 0.5. This means an overall acceptable convergent validity for the Hypothetical Model 2. It is worth mentioning that the factor loading of UOP2 was very high in both hypothetical models; this may be because there was a problem of collinearity among three indicators of the latent variable UOP, because the three weather forecast products tested are quite similar to some extent.

Table 4.8: Results of Convergent Validity Analysis for the Hypothetical Model 2

Variables	Indicators	Factor Loading	Square of Factor Loadings (SMC)	Composite Reliability	Average Variance Extracted (AVE)
Usefulness of product (UOP)	UOP1	0.553	0.306	0.663	0.454
	UOP2	0.999	0.998		
	UOP3	0.244	0.060		
Usefulness of product elements (UOPE)	UOPE1	0.780	0.608	0.744	0.375
	UOPE2	0.531	0.282		
	UOPE3	0.544	0.296		
	UOPE4	0.679	0.461		
	UOPE5	0.479	0.229		

One interesting thing for the convergent validity analysis results is that the composite reliabilities (CR) for the two hypothetical models were all larger than the Cronbach's Alpha of them. The Cronbach's Alpha of latent variable UOP and UOPE in the Hypothetical Model 1 was 0.568 and 0.553, but the composite reliability for them was 0.669 and 0.573. It is also the same for the latent variables in the Hypothetical Model 2. CR is often advocated as an alternative option due to the usual violation of the tau-equivalency assumption by Cronbach's Alpha; it does not assume essential tau-equivalence, that is, equal loadings. Therefore, it is a more significant index of questionnaire reliability than Cronbach's Alpha during SEM research. The big difference between CR and Cronbach's Alpha may be that the more factor loadings fluctuate among items, the higher the discrepancy between the values of CR and Cronbach's Alpha. As a study relying on SEM, composite reliability may be more representative than Cronbach's Alpha in this study.

However, although the AVE of variable UOP in the two hypothetical models was near the borderline, not a single variable in the two hypothetical models meets the criteria (>0.5). This means the existing indicators in the hypothetical models may not fully represent the latent variables they were in, so it may be necessary to delete some indicators to obtain better convergent validity. An AVE value higher than 0.5 is good, but we can still accept 0.4. According to Fornell and Larcker (1981), if AVE is less than 0.5, but composite reliability is higher than 0.6, the construct's convergent validity is still adequate. In this research, therefore, since all latent variables in the two hypothetical models (except for the UOPE in the Hypothetical Model 1, which has a CR value of 0.573 near the borderline) have CR that was above 0.6, the reliability and convergent validity of the two hypothetical models are acceptable. Again, since it is exploratory research, it cannot always be "perfect."

4.2.2.2 Discriminant Validity Analysis

Discriminant validity refers to the low degree of association between different latent variables and the measurement items (indicators) that measure them. When the questionnaire's discriminant validity is good, the correlation between various measures of different constructs should not be higher than the score obtained when various measures were used to measure the same trait. In this study, Amos 27.0 software was used to test the discriminant validity of the data. Tables 4.9 and 5.0 reveal the acceptability of discriminant validity in the two hypothetical models by showing that the largest correlation between a particular construct and other constructs was less than its square root of AVE.

Table 4.9: Results of Discriminant Validity Analysis for the Hypothetical Model 1

	Usefulness of product (UOP)	**Usefulness of product elements (UOPE)**	**AVE**
Usefulness of product (UOP)	**0.671**		0.450
Usefulness of product elements (UOPE)	0.132	**0.506**	0.256

Notes: Square root of AVE in bold on diagonals. Off diagonals are Pearson correlation of constructs.

Table 4.10: Results of Discriminant Validity Analysis for the Hypothetical Model 2

	Usefulness of product (UOP)	**Usefulness of product elements (UOPE)**	**AVE**
Usefulness of product (UOP)	**0.674**		0.454
Usefulness of product elements (UOPE)	0.572	**0.613**	0.375

Notes: Square root of AVE in bold on diagonals. Off diagonals are Pearson correlation of constructs.

It can be seen from Tables 4.9 and 4.10 that in both hypothetical models, the square root of AVE of each latent variable is greater than its correlation coefficient with other variables, which indicates that there is a good discrimination between the observable values of different latent variables. Therefore, the discriminant validity of the questionnaire used in this study meets the criteria.

4.3 Correlation Analysis

4.3.1 Factor Analysis

According to the literature (Grice, 2001; Holgado-Tello et al., 2010), factor scores extracted from factor analysis can be used for regression analysis and correlation analysis. The measure of Sampling Adequacy from Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used to judge whether the sample data is suitable for factor analysis. In this study, SPSS 26.0 software was used for this analysis.

KMO is an indicator of simple correlation and the partial correlation between variables, representing the ratio of all correlation coefficients and net correlation coefficients related to the measurement item. When KMO is not less than 0.5 (Kaiser 1974) and the significance of Bartlett's Test of Sphericity is less than 0.01, it means that there is a significant correlation between measures, which can be used for factor analysis. The test results are shown in Tables 4.11 and 4.12. These results show that the KMO values of each potential variable in the two hypothetical models are not less than 0.5 and were significant at a 99% confidence level (the significance level of Bartlett's Test of Sphericity was close to 0). Therefore, it is suitable for factor analysis to extract factor scores from latent variables for correlation analysis.

Table 4.11: Results of Factor Analysis for Latent Variables in the Hypothetical Model 1

Variables	**KMO**	**Approx. Chi-Square**	**df**	**Sig.**
Usefulness of product (UOP)	0.50	56.42	3	.000
Usefulness of product elements (UOPE)	0.64	48.04	6	.000

Table 4.12: Results of Factor Analysis for Latent Variables in the Hypothetical Model 2

Variables	**KMO**	**Approx. Chi-Square**	**df**	**Sig.**
Usefulness of product (UOP)	0.53	44.43	3	.000
Usefulness of product elements (UOPE)	0.75	109.62	10	.000

4.3.2 Spearman’s Correlation Analysis

Spearman’s correlation analysis was conducted to verify the significance of the influences in the hypothetical models. This study used SPSS 26.0 software to study whether there is a significant dependency among the hypothetical models' variables to verify the relevant hypotheses preliminarily. Factor scores of latent variables extracted from factor analysis were used for correlation analysis. The results were divided into three parts: (1) the relationships between exogenous variables and latent variables, (2) the relationships between latent variables and endogenous variables, and (3) the relationships between endogenous variables.

4.3.2.1 Correlation Analysis of Exogenous Variables and Latent Variables

The analysis results are shown in Tables 4.13 and 4.14. Table 4.13 indicates that the latent variable UOP in the Hypothetical Model 1 was significantly affected by Status (0.05 level). In comparison, the latent variable UOPE was clarified to be positively influenced by both Status (0.01 level) and Geographic Location (0.05 level).

Table 4.13: Spearman's Correlation Analysis of Exogenous Variables and Latent Variables for the Hypothetical Model 1

		Usefulness of product (UOP)	**Usefulness of product elements (UOPE)**
Status	Correlation Coefficient	$.199^{*}$	$.347^{**}$
	Sig. (2-tailed)	.017	.000
	N	144	144
Geographic Location	Correlation Coefficient	.017	$.213^{*}$
	Sig. (2-tailed)	.844	.011
	N	144	144

*: Significant correlation at the 0.05 level. **: Significant correlation at the 0.01 level.

As for the Hypothetical Model 2, we can see from Table 4.14 that the latent variable UOP was only significantly affected by Status (0.01 level). In comparison, the latent variable UOPE was clarified to be positively influenced by both Status (0.01 level) and Flood Experience (0.01 level). Still, there was no significant relationship between any variable and the Risk Perception Level variable.

Table 4. 14: Spearman's Correlation Analysis of Exogenous and Latent Variables for the Hypothetical Model 2

		Risk perception level	**Usefulness of product (UOP)**	**Usefulness of product elements (UOPE)**
Status	Correlation Coefficient	-.140	$.251^{**}$	$.304^{**}$
	Sig. (2-tailed)	.152	.009	.001
	N	107	107	107
Geographic Location	Correlation Coefficient	.149	.005	-.055
	Sig. (2-tailed)	.125	.962	.577
	N	107	107	107
Flood experience	Correlation Coefficient	.071	.151	$.341^{**}$
	Sig. (2-tailed)	.467	.121	.000
	N	107	107	107
Age	Correlation Coefficient	.002	.024	-.046
	Sig. (2-tailed)	.983	.803	.641
	N	107	107	107
Gender	Correlation Coefficient	.017	-.150	-.101
	Sig. (2-tailed)	.861	.124	.301
	N	107	107	107
Educational level	Correlation Coefficient	-.101	.151	.072
	Sig. (2-tailed)	.299	.121	.461
	N	107	107	107
Risk perception level	Correlation Coefficient	1.000	.005	-.018
	Sig. (2-tailed)	.	.960	.852
	N	107	107	107

*: Significant correlation at the 0.05 level. **: Significant correlation at the 0.01 level.

Meanwhile, through comparing the results of the two hypothetical models, only relationships between exogenous variable Status and two latent variables were tested for significance among both hypothetical models.

4.3.2.2 Correlation Analysis of Latent Variables and Endogenous Variables

The analysis results are shown in Tables 4.15 and 4.16. Table 4.15 indicates that the endogenous variable Usage Intention in the Hypothetical Model 1 was significantly affected by both latent variable UOP (0.01 level) and latent variable UOPE (0.01 level) in a positive direction.

Table 4.15: Spearman's Correlation Analysis of Latent Variables and Endogenous Variables in the Hypothetical Model 1

		Usefulness of product (UOP)	**Usefulness of product elements (UOPE)**
Usage intention	Correlation Coefficient	$.467^{**}$	$.237^{**}$
	Sig. (2-tailed)	.000	.004
	N	144	144

**: Significant correlation at the 0.01 level.

As for the Hypothetical Model 2, we can see from Table 4.16 that the endogenous variable Product Understanding was only significantly affected by the latent variable UOPE (0.01 level). In comparison, the endogenous variable Intended Actions was found to be positively influenced by both the Risk Perception Level (0.01 level) and the latent variable UOPE (0.05 level). Further, the endogenous variable Usage Intention was significantly affected by both latent variables at the 0.01 level.

Table 4.16: Spearman's Correlation Analysis of Latent Variables and Endogenous Variables in the Hypothetical Model 2

		Risk perception level	**Usefulness of product (UOP)**	**Usefulness of product elements (UOPE)**
Product understanding	Correlation Coefficient	-.116	.062	$.380^{**}$
	Sig. (2-tailed)	.235	.523	.000
	N	107	107	107
Intended actions	Correlation Coefficient	$.382^{**}$	.142	$.216^{*}$
	Sig. (2-tailed)	.000	.145	.025
	N	107	107	107
Usage intention	Correlation Coefficient	.128	$.502^{**}$	$.392^{**}$
	Sig. (2-tailed)	.188	.000	.000
	N	107	107	107

*: Significant correlation at the 0.05 level. **: Significant correlation at the 0.01 level.

Meanwhile, through comparing the results of the two hypothetical models, relationships between endogenous variable Usage Intention and two latent variables were found to be significant in both hypothetical models, which indicates a significant correlation between participants' usage intention and their evaluation of products and elements.

4.3.2.3 Correlation Analysis of Endogenous Variables

The results of the two hypothetical models reveal that the endogenous variable Intended Actions in all hypothetical models is significantly positively affected by endogenous variable Usage Intention (0.01 level) (Table 4.17), while there is no significant relationship between the endogenous variable Product Understanding and Intended Actions (Table 4.18).

Table 4. 17: Spearman's Correlation Analysis of Endogenous Variables in the Hypothetical Model 1

		Usage intention
Intended actions	Correlation Coefficient	$.427^{**}$
	Sig. (2-tailed)	.000
	N	144

**: Significant correlation at the 0.01 level.

Table 4. 18: Spearman's Correlation Analysis of Endogenous Variables in the Hypothetical Model 2

		Product understanding	**Usage intention**
Intended actions	Correlation Coefficient	.022	$.311^{**}$
	Sig. (2-tailed)	.825	.001
	N	107	107

**: Significant correlation at the 0.01 level.

The results of Spearman's Correlation analysis indicate that most of the hypotheses about participants' situational factors and their evaluations of UOP and UOPE proposed in the paper were found, at least preliminarily, to be not supported. Only exogenous variables Status, Geographic Location, and Flood Experience have significant effects on latent variables, that is, hypotheses H2, H3, H6, and H9 were supported by the first part of the correlation analysis.

Meanwhile, the latent variable UOPE was found to have a positive significant influence on all endogenous variables in both hypothetical models. On the other hand, only the endogenous variable Usage Intention was found to be significantly affected by the latent variable UOP in both hypothetical models. The second part of the correlation analysis has supported the hypotheses H22, H23, H24, and H25.

Last but not least, the third part of the results showed that there is only one significant relationship among endogenous variables: Intended Actions were significantly affected by Usage Intention rather than Product Understanding. Therefore, hypothesis H27 was proved by the correlation analysis.

Although the correlation analysis shows some significant correlations between variables and preliminarily supports some hypotheses of this study, the relationships' causality still needs to be further verified. The subsequent hypothesis verification analysis is carried out to study the degree of influence and significance level among all variables as described next.

4.4 Structural Equation Modeling Analysis

This section discusses the verification of model assumptions through SEMs. Although the correlation analysis had pointed out some significant correlations between some variables, it was not clear about the causal relationship and internal influence between variables. Therefore, two versions of SEM were applied to rounds 1 and 2 and an online survey of the focus groups to test the influence mechanism among all exogenous and endogenous variables. Moreover, the Bootstrap method in AMOS 27.0 was applied for testing inferences about the indirect effects among variables in the SEMs, which was suggested by Domínguez-Escrig et al. (2018).

4.4.1 Model Fit

There are numerous different fit statistics researchers use to evaluate their SEMs' goodness of fit (Hooper et al., 2008): the goodness-of-fit index (GFI), the standardized root mean square residual (SRMR), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), the Chi-Square divided by degree of freedom (x2/df), and the comparative fit index (CFI). According to Kline (2005), four indices should be reported at a minimum: The Model Chi-Square, RMSEA, CFI, and SRMR. In order to evaluate the goodness of the model fit more comprehensively, this paper adopted other indicators besides those four. These indexes and recommended criteria that indicate a good fit are listed and described in Table 4.19.

Table 4. 19: Common Index Fitting Table of Structural Equation Model and Recommended Criterions

Index	**Name**	**Description**	**Criteria of good fit**
X^2	Model Chi-Square	This assesses overall fit and the discrepancy between the sample and fitted covariance matrices. Sensitive to sample size, sample size more than 50 can easily lead to a poor fit. The chi-square value and model degrees of freedom can be used to calculate a p-value to evaluate the fit of the model	p-value> 0.05

		(done automatically by AMOS software).	
X^2/ df	Model Chi-Square Divided by the Degree of Freedom	An index is obtained by dividing the test statistic value by the degree of freedom (df). It is known as parsimony and stand-alone fit index. The value of this ratio gives information on the fit between data and model. It is said that with smaller index value of χ^2/v ratio, the consistency will be better.	<3
GFI	Goodness of Fit	GFI is a measure of fit between the hypothesized model and the observed covariance matrix. Also known as gamma-hat or $\hat{\gamma}$, it is the proportion of variance accounted for by the estimated population covariance. Analogous to R^2.	>0.90
CFI	Comparative Fit Index	CFI is an incremental fit index. It is a corrected version of relative non-centrality index. The extent to which the tested model is superior to the alternative model established with manifest covariance matrix is evaluated. Not very sensitive to sample size. Compares the fit of a target model to the fit of an independent, or null, model.	>0.90
RMSEA	Root Mean Square Error of Approximation	The RMSEA is an index of the difference between the observed covariance matrix per degree of freedom and the hypothesized covariance matrix which denotes the model. It is a parsimony-adjusted index. Values closer to 0 represent a good fit.	< 0.08
SRMR	Standardized Root Mean Square Residual	The Standardized Root Mean Square Residual (SRMR) is an index of the average of standardized residuals between the observed and the hypothesized covariance matrices.	<0.08

Table 4.20 below lists the model fit statistics of the SEMs in this research. We can see the model fits for the two hypothetical models were not as good as the recommended

criteria in Table 4.19, but most of them were acceptable according to many studies. First, according to Iacobucci (2010), it is not necessary to be overly concerned with χ2 —it simply will not fit if the sample size is 50 or more. Instead, a χ2 /df value about 3 or under was considered a good model fit. Values of X^2/ df for the two hypothetical models in this research were all under 3 and thus exhibit considerable fitness. Second, Doll et al. (1994) suggested that although GFI or AGFI scores of 0.90 or higher are considered evidence of good fit, scores in the 0.80 to 0.89 range can be considered as a reasonable fit. The GFI values for the two hypothetical models in this research were all above 0.80, and thus exhibit considerable fitness. Meanwhile, Bentler (1990) suggested that 0.9<CFI indicates a good fit while 0.8<CFI<0.9 indicates adequate fit. In this research, the CFI of the Hypothetical Model 2 meets the criteria, but that of the Hypothetical Model 1 was too low. According to Kenny et al. (2015), RMSEA < 0.08 is considered good fit, while 0.08 < RMSEA < 0.1 indicates adequate fit. In this research, the RMSEA of the Hypothetical Model 2 was considered a good fit (0.073), while the RMSEA of the Hypothetical Model 1 was a little above the borderline (0.104). However, in terms of SRMR, as that value was not less than the provided measurement standard of 0.08, the results indicate a poor fit for both the conceptual and refined model. Perhaps this could be due to its sensitivity towards sample size (144 for the Hypothetical Model 1 and 107 for the Hypothetical Model 2).

Table 4.20: Model Fit Indexes for Two Hypothetical Structural Equation Models

	X^2	X^2/ df	GFI	CFI	RMSEA	SRMR
Hypothetical Model 1	104.022 (p= 0.000)	2.537	0.893	0.712	0.104	0.101
Hypothetical Model 2	163.183 (p= 0.000)	1.569	0.863	0.834	0.073	0.092

In summary, most of the model fits of the two hypothetical models in the research meet the fundamental criteria, except for the CFI of the Hypothetical Model 2 and the SRMR. However, this is exploratory research, which means the structures of the questionnaires and SEMs of this research were not tested and proved repeatedly by previous studies. Further, just like Marsh et al. (2004) said: “Do not take the rules-of-thumb too seriously”. Thus, the results demonstrate that both hypothetical models exhibit considerable fitness to corresponding data.

4.4.2 Path Analysis

Following model fit, path analysis is used to study the correlation strength of multi-level causal relationships among multiple variables. Its primary purposes are to test: (1) whether there is a correlation between variables in the hypothetical model; (2) if there is a significant correlation, whether there is a causal relationship between variables, and which variable is the cause and which variable is the result; and (3) if causality is established, it is necessary to determine whether the influence mechanism is directly affected or indirectly affected.

4.4.2.1 Direct Path Analysis

Figures 4.1 and 4.2 graphically present the SEM with the structures and direct coefficients of influence paths for the two hypothetical models after the analysis. Latent variables and their indicators are connected by the dashed line, whereas arrows in red refer to significant correlation among variables. (* significant at the 0.05 level. ** significant at the 0.01 level. *** significant at the 0.005 level. **** significant at the 0.001 level.)

Figure 4.1 indicates there are four significant relationships (arrows in red) between variables in the Hypothetical Model 1. To begin, Status has a very significant influence at the 0.001 level on UOPE, which means professionals will report the elements of NWS forecast products to be more useful than residents. Second, Geographic Location also has a very significant influence at the 0.005 level on UOPE, which means people living in areas with a higher chance of flooding will report NWS forecasts products elements (UOPE) to be more useful. Moreover, UOP has a very significant influence at the 0.001 level on Usage Intention, which means people with reports of higher usefulness of NWS forecasts products will have more usage intention of these products. Last, Usage Intention has a very significant influence at the 0.005 level on Intended Actions, which means people's higher usage intention of NWS forecasts products will lead to more actions based on these products.

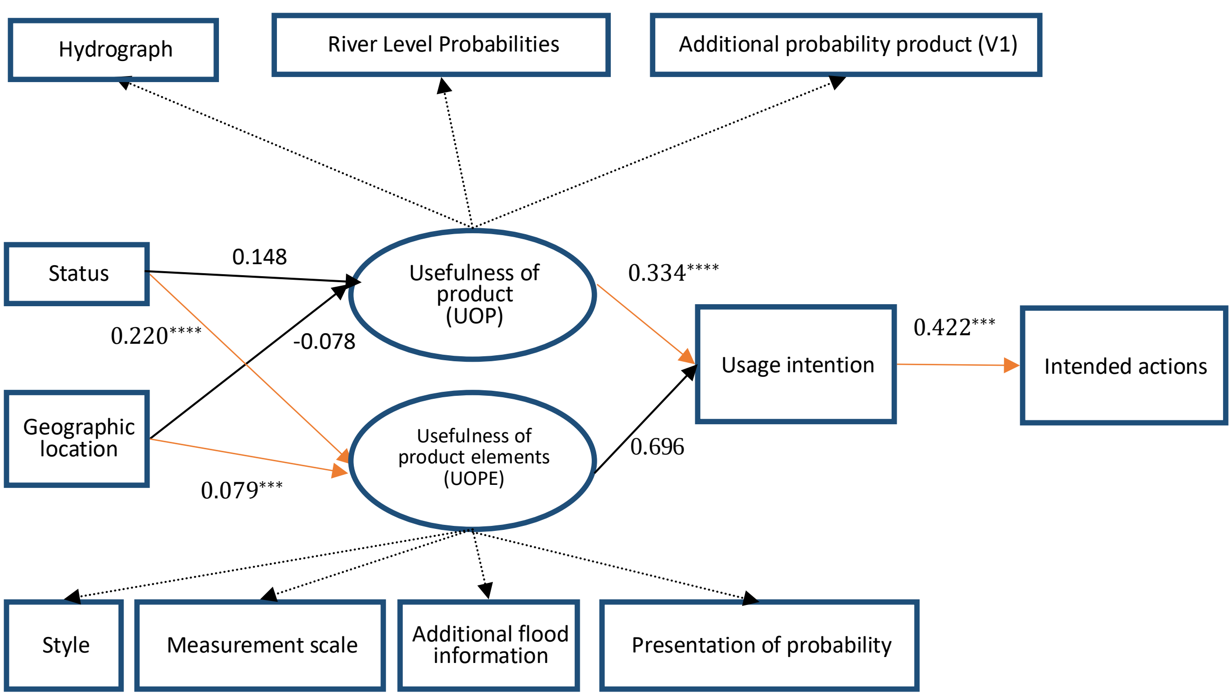

Figure 4.1: Hypothetical Structural Equation Model 1 with Coefficients of Influence Paths for Round 1 and 2 Surveys

At the same time, Figure 4.2 indicates there are eight significant relationships (arrows in red) between variables in the Hypothetical Model 2. To begin with, as with the Hypothetical Model 1, Status has a very significant influence at the 0.005 level on UOPE, which means professionals will report the elements of NWS forecast products to be more useful than residents. Second, Flood Experience has a very significant influence at the 0.001 level on UOPE, which means people with more experience with flooding will report NWS forecasts products elements to be more useful. Moreover, Risk Perception Level has a significant influence at the 0.05 level on UOP, which means people with higher risk perceptions of flooding will report NWS forecasts products to be more useful. Similarly, Risk Perception Level also has a very significant influence at the 0.001 level on Intended Actions, which means people with higher risk perceptions of flooding will be more likely to take actions after using these products. Meanwhile, as in the Hypothetical Model 1, UOP has a very significant influence at the 0.001 level on Usage Intention, which means people with reports of the higher usefulness of NWS forecasts products will be more likely to use these products. Likewise, UOPE also has a significant influence at the 0.05 level on Usage Intention, which means people with reports of the higher usefulness of elements of NWS forecasts products will be more likely to use these products. Besides, UOPE has also a very significant influence at the 0.005 level on Product Understanding, which means people with reports of the higher usefulness of elements of NWS forecasts products will understand these products better. Finally, Usage Intention has a very significant influence at the 0.001 level on Intended Actions, which means people’s higher usage intention of NWS forecasts products will lead to more actions based on these products.

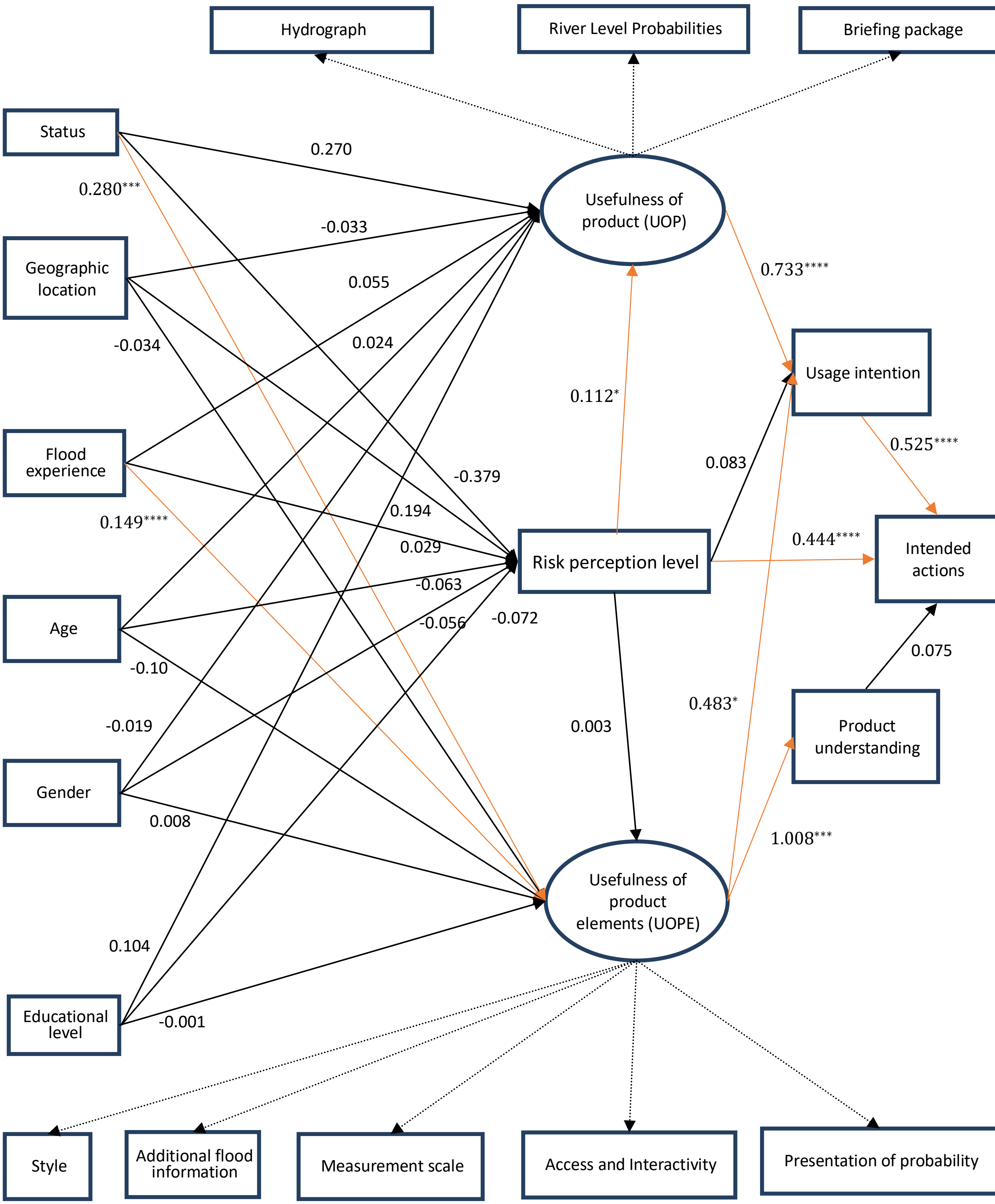

Figure 4.2: Hypothetical Structural Equation Model 2 with Coefficients of Influence Paths for Online Survey

All the specific verification results of the hypotheses after the SEM test are shown in Table 4.21. For the direct effects between variables, the research models show that although most of the proposed hypotheses were rejected, some of them were supported: H3, H23, and H27 were supported by both hypothetical models; H9, H19, H22, and H25 (not tested by the Hypothetical Model 1) were supported by the Hypothetical Model 2. H6 was supported by the Hypothetical Model 1 but rejected by the second one. This may be due to the differences in some product elements between round 1 and 2 surveys and the online survey, or because of the imbalanced proportion of participants from different geographic locations in the online survey. H24 was rejected by the Hypothetical Model 1 but supported by the second one (this may due to the borderline p-value of H24 in the Hypothetical Model 1, which is 0.052).

Moreover, based on SEMs' results, most of the verified direct significant relationships in the SEMs were in line with the above-mentioned Spearman's correlation analysis. However, H2 was supported by Spearman's correlation analysis but rejected by path analysis, and H19 was rejected by Spearman's correlation analysis but supported by path analysis.

Table 4.21: Direct Path Analysis Results of the Hypothetical Structural Equation Models

Hypothesis	Path	Coefficients (Model 1)	Result	Coefficients (Model 2)	Result
H1	Status → Risk perception level	/	/	-0.379	Rejected
H2	Status → Usefulness of product (UOP)	0.148	Rejected	0.270	Rejected
H3	Status → Usefulness of product elements (UOPE)	0.220****	Supported	0.280***	Supported
H4	Geographic location → Risk	/	/	0.194	Rejected

	perception level				
H5	Geographic location → Usefulness of product (UOP)	-0.078	Rejected	-0.033	Rejected
H6	Geographic location → Usefulness of product elements (UOPE)	0.079***	Supported	-0.034	Rejected
H7	Flood experience → Risk perception level	/	/	0.029	Rejected
H8	Flood experience → Usefulness of product (UOP)	/	/	0.055	Rejected
H9	Flood experience → Usefulness of product elements (UOPE)	/	/	0.149****	Supported
H10	Age → Risk perception level	/	/	-0.063	Rejected
H11	Age → Usefulness of product (UOP)	/	/	0.024	Rejected
H12	Age → Usefulness of product elements (UOPE)	/	/	-0.10	Rejected
H13	Gender → Risk perception level	/	/	-0.056	Rejected
H14	Gender → Usefulness of product (UOP)	/	/	-0.019	Rejected
H15	Gender → Usefulness of product elements (UOPE)	/	/	0.008	Rejected
H16	Educational level → Risk perception level	/	/	-0.072	Rejected
H17	Educational level → Usefulness of product (UOP)	/	/	0.104	Rejected
H18	Educational level → Usefulness of product elements (UOPE)	/	/	-0.001	Rejected
H19	Risk perception level → Usefulness of product (UOP)	/	/	0.112*	Supported
H20	Risk perception level → Usefulness of product elements (UOPE)	/	/	0.003	Rejected
H21	Risk perception level → Usage intention	/	/	0.083	Rejected
H22	Risk perception level → Intended actions	/	/	0.444****	Supported
H23	Usefulness of product (UOP) → Usage intention	0.334****	Supported	0.733****	Supported
H24	Usefulness of product elements (UOPE) → Usage intention	0.696	Rejected	0.483*	Supported
H25	Usefulness of product elements (UOPE) → Product understanding	/	/	1.008***	Supported

H26	Product understanding → Intended actions	/	/	0.075	Rejected
H27	Usage intention → Intended actions	0.422***	Supported	0.525****	Supported

Two-tailed significance. * Significant at the 0.05 level. ** Significant at the 0.01 level. *** Significant at the 0.005 level. **** Significant at the 0.001 level.

4.4.2.2 Indirect Path Analysis

In order to seek a more accurate explanation of effects among variables, this research also measured the mediating effects of factors by using the Bootstrap method in AMOS 27. Davidson and MacKinnon (2000) examined the case of bootstrapping p-values and suggested that for tests at the 95% level of confidence intervals, the minimum number of sampling frequency is about 400, while it is 1500 for a test at the 0.01 level. The sampling frequency of this study was set at 2000 because it is sufficient to conduct the analysis, and the confidence intervals of both percentile and bias-corrected methods were set at 95% to ensure reliability.

The indirect effect of exogenous variables Status, Geographic Location, Flood Experience, Age, Gender, and Educational Level on latent variables UOP and UOPE in both hypothetical models was computed through mediating variable Risk Perception Level, while other paths were overall indirect effects from one variable to another (through one or more mediating variables). The results are shown in Table 4.22. The “Effect coefficients” of the indirect path analysis in the Table 4.22 below is what Preacher and Hayes (2008) called the “index of mediation.” It is computed by taking the unstandardized indirect effect coefficient and multiplying it by the ratio of the standard deviation of X to the standard deviation of Y. In AMOS, only the total but not the specific indirect effects are provided (Mallinckrodt et al., 2006). For the data here for instance, variable Status’s indirect effect on Usage Intention is computed as the total indirect effects of Status to Usage Intention through variable UOP and through variable UOPE. The indirect effect of Status to Usage Intention through variable UOP is calculated as the product of the path coefficient from Status to UOP and the path coefficient from UOP to Usage Intention, which is .148 × 0.334 = .050; similarly, the indirect effect of Status to Usage Intention through variable UOPE is calculated as the product of the path coefficient from Status to UOPE and the path coefficient from UOPE to Usage Intention, which is .220 × 0.696 = .153. Therefore, the total indirect effects of Status to Usage Intention is the sum of two indirect effects above, which is .050 + .153 = .203. This means Usage Intention increases by .203 standard deviations for every one standard deviation increase in Status, as shown in the Table 4.22 below.

Table 4.22 reveals that in the Hypothetical Model 1, variable Status has significant indirect effects on variable Usage Intention as well as Intended Actions through mediating variable UOP and UOPE and, variables UOP and UOPE have significant indirect effects on variable Intended Actions through mediating variable Usage Intention. In the Hypothetical Model 2, variables Status and Flood Experience have significant indirect effects on variable Product Understanding and Usage Intention through mediating effects, and variables Risk Perception Level and UOP have significant indirect effects on variable Intended Actions through mediating effects.

Table 4.22: Results of Mediating Effects in Both Hypothetical Models

	Indirect path	Effect coefficients	Effect Std. Error	Percentile 95% CI			Bias-corrected 95% CI		
				Lower bounds	Upper bounds	Sig (Two tailed)	Lower bounds	Upper bounds	Sig (Two tailed)
Hypothetical Model 1	Status → Usage intention	0.203	0.112	0.017	0.47	0.027*	0.022	0.48	0.024*
	Status → Intended actions	0.086	0.057	0.006	0.225	0.029*	0.011	0.243	0.016*
	Geographic location → Usage intention	0.029	0.039	-0.05	0.105	0.54	-0.037	0.119	0.355
	Geographic location → Intended actions	0.012	0.017	-0.022	0.046	0.54	-0.013	0.062	0.272
	Usefulness of product (UOP) → Intended actions	0.141	0.054	0.044	0.25	0.002***	0.051	0.264	0.001****
	Usefulness of product elements (UOPE) → Intended actions	0.294	0.359	-0.005	1.011	0.054	0.02	1.306	0.027*
Hypothetical Model 2	Status → Usefulness of product (UOP)	-0.043	0.039	-0.134	0.025	0.224	-0.169	0.007	0.096
	Status → Usefulness of product elements (UOPE)	-0.001	0.017	-0.035	0.041	0.989	-0.046	0.031	0.741
	Status → Usage intention	0.270	0.164	-0.03	0.606	0.077	-0.045	0.591	0.091
	Status → Product understanding	0.281	0.147	0.051	0.634	0.012*	0.049	0.625	0.013*
	Status → Intended actions	-0.006	0.195	-0.399	0.372	0.98	-0.404	0.37	0.964
	Geographic location → Usefulness of product (UOP)	0.022	0.02	-0.008	0.072	0.197	-0.004	0.088	0.101
	Geographic location → Usefulness of product elements (UOPE)	0.001	0.009	-0.02	0.019	0.969	-0.017	0.022	0.805
	Geographic location → Usage intention	-0.008	0.078	-0.161	0.14	0.962	-0.17	0.13	0.865
	Geographic location → Product understanding	-0.034	0.046	-0.11	0.079	0.499	-0.122	0.059	0.316
	Geographic location → Intended actions	0.079	0.09	-0.089	0.271	0.328	-0.085	0.281	0.305
	Flood experience → Usefulness of product (UOP)	0.003	0.014	-0.027	0.035	0.852	-0.021	0.04	0.631
	Flood experience → Usefulness of product elements (UOPE)	0.000	0.005	-0.01	0.01	0.991	-0.009	0.012	0.88
	Flood experience → Usage intention	0.117	0.065	-0.002	0.253	0.05*	0.007	0.263	0.012*
	Flood experience → Product understanding	0.150	0.051	0.05	0.254	0.003***	0.062	0.268	0.001****

	Flood experience → Intended actions	0.086	0.085	-0.067	0.264	0.278	-0.063	0.275	0.239
	Age → Usefulness of product (UOP)	-0.007	0.011	-0.03	0.015	0.523	-0.041	0.008	0.268
	Age → Usefulness of product elements (UOPE)	0.000	0.004	-0.011	0.007	0.893	-0.011	0.006	0.855
	Age → Usage intention	0.003	0.053	-0.095	0.111	0.913	-0.105	0.102	0.984
	Age → Product understanding	-0.01	0.038	-0.089	0.061	0.792	-0.092	0.056	0.74
	Age → Intended actions	-0.027	0.059	-0.137	0.094	0.659	-0.141	0.088	0.598
	Gender → Usefulness of product (UOP)	-0.006	0.033	-0.077	0.062	0.838	-0.084	0.052	0.713
	Gender → Usefulness of product elements (UOPE)	0.000	0.01	-0.024	0.023	1	-0.027	0.02	0.886
	Gender → Usage intention	-0.019	0.14	-0.269	0.288	0.918	-0.291	0.266	0.796
	Gender → Product understanding	0.008	0.097	-0.173	0.21	0.896	-0.182	0.2	0.976
	Gender → Intended actions	-0.035	0.158	-0.326	0.296	0.861	-0.347	0.285	0.783
	Educational level → Usefulness of product (UOP)	-0.008	0.017	-0.046	0.025	0.625	-0.059	0.015	0.374
	Educational level → Usefulness of product elements (UOPE)	0.000	0.006	-0.011	0.016	0.866	-0.016	0.009	0.692
	Educational level → Usage intention	0.064	0.068	-0.075	0.19	0.377	-0.068	0.2	0.325
	Educational level → Product understanding	-0.001	0.053	-0.087	0.128	0.949	-0.085	0.138	0.986
	Educational level → Intended actions	0.001	0.082	-0.162	0.168	0.935	-0.179	0.156	0.968
	Risk perception level → Usage intention	0.084	0.061	-0.025	0.212	0.161	-0.022	0.214	0.146
	Risk perception level → Product understanding	0.003	0.041	-0.098	0.068	0.961	-0.094	0.07	0.915
	Risk perception level → Intended actions	0.088	0.049	0.001	0.195	0.047*	0.012	0.218	0.023*
	Usefulness of product (UOP) → Intended actions	0.385	0.137	0.126	0.656	0.003***	0.131	0.661	0.003***
	Usefulness of product elements (UOPE) → Intended actions	0.329	0.215	-0.035	0.809	0.079	-0.034	0.812	0.076

Note: Table shows overall indirect effects from one variable to another. * Significant at the 0.05 level. ** Significant at the 0.01 level. *** Significant at the 0.005 level. **** Significant at the 0.001 level.

Based on the indirect path analysis results, H22 was supported. In addition, some significant relationships beyond the hypotheses were also found through indirect path analysis：

1) Professionals will have significantly more usage intention of NWS products as well as intended actions than residents, through their higher reports of the usefulness of products and elements.
2) Professionals and people who had experienced more floods will significantly understand NWS product better and have more usage intention, through their higher reports of the usefulness of products.
3) People who report higher usefulness of NWS product and their elements will have significantly more intended actions through their higher usage intention.
4) People with higher risk perception level will have significantly more intended actions through their higher reports of the usefulness of products.

4.5 Model Modification

Based on the previous results of the Hypothetical Model 1 and Model 2, this study removed some variables that were not significant or that will reduce the model fit, in order to improve the reliability and validity of the model. Since the main NWS product used in this study was River Level Probabilities, this indicator of latent variable UOP has the dominant factor loading (0.99) among the other two indicators (variables Hydrograph and Briefing Package). Therefore, the modified SEMs replaced the latent variable UOP with this indicator and removed other indicators of this latent variable. Some indicators (presentation of probability for the Hypothetical Model 1, style and additional flood information for the Hypothetical Model 2) of latent variable UOPE with low factor loadings were also removed. Several runs were done to optimize the model so that the best goodness of fit could be obtained. The goodness of fit summary of modified SEMs is presented in Table 4.23.

We can see that the model fits of the two modified models are far better than the hypothetical models. Most of them now meet the recommended criteria. Although the CFI (0.840) and RMSEA (0.084) of the Modified Model 1 were a little beyond recommended criteria, they were improved from the hypothetical models and are acceptable.

Table 4.23: Model Fit Indexes for Two Modified and Hypothetical Structural Equation Models

		X^2	X^2/ df	GFI	CFI	RMSEA	SRMR
First model	Hypothetical model	104.022 (p= 0.000)	2.537	0.893	0.712	0.104	0.101
	Modified model	34.094 (p= 0.008)	2.006	0.945	0.840	0.084	0.067
Second model	Hypothetical model	163.183 (p= 0.000)	1.569	0.863	0.834	0.073	0.092
	Modified model	69.286 (p= 0.15)	1.506	0.921	0.899	0.069	0.073

Modified structures and direct coefficients of influence paths for the two modified models after the analysis are shown in Figures 4.3 and 4.4. The dashed line connects latent variables and their indicators, whereas arrows in red refer to the significant correlation among variables. (* Significant at the 0.05 level. ** Significant at the 0.01 level. *** Significant at the 0.005 level. **** Significant at the 0.001 level.)

Figure 4.3 indicates there are four significant relationships (arrows in red) between variables in Modified Model 1. Status has a very significant influence at the 0.001 level on UOPE, which means professionals will report the elements of NWS forecast products to be more useful than residents. Second, Geographic Location also has a very significant influence at the 0.001 level on UOPE (significance was increased compared to the Hypothetical Model 1), which means people living in areas with a higher chance of flooding will report NWS forecasts products elements (UOPE) to be more useful. Moreover, Usefulness of River Level Probabilities has a very significant influence at the 0.001 level on Usage Intention, which means people with reports of higher usefulness of the River Level Probabilities product will have more usage intention of the NWS forecasts products. Finally, Usage Intention has a very significant influence at the 0.005 level on Intended Actions, which means people's higher usage intention of NWS forecasts products will lead to more actions based on these products. Overall, the significant relationships in the Modified Model 1 are the same as the Hypothetical Model 1.

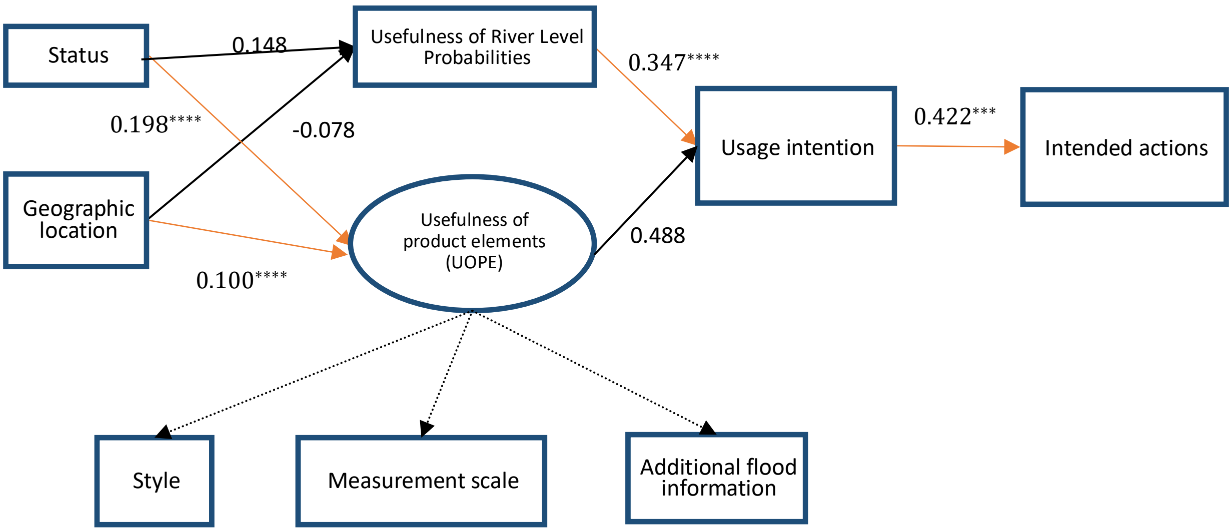

Figure 4.3: Modified Structural Equation Model 1 with Coefficients of Influence Paths for Round 1 and 2 Surveys

At the same time, Figure 4.4 indicates there are eight significant relationships (arrows in red) between variables in Modified Model 2. To begin with, as in the

Modified Model 1, Status has a very significant influence at the 0.005 level on UOPE, which means professionals will report the elements of NWS forecast products to be more useful than residents. Second, Flood Experience has a very significant influence at the 0.001 level on UOPE, which means people with more experience with flooding report NWS forecasts products elements to be more useful. Moreover, Risk Perception Level has a significant influence at the 0.05 level on the Usefulness of River Level Probabilities product, which means people with higher risk perceptions of flooding will report the River Level Probabilities product to be more useful. Similarly, Risk Perception Level also has a very significant influence at the 0.001 level on Intended Actions, which means people with higher risk perceptions of flooding will intend to take more actions after using NWS forecasts products. Meanwhile, as with the Modified Model 1, Usefulness of River Level Probabilities has a very significant influence at the 0.001 level on Usage Intention, which means people with reports of the higher usefulness of the River Level Probabilities product will have more usage intention of NWS forecast products. Likewise, UOPE also has a significant influence at the 0.005 level on Usage Intention (significance was increased compared to the Hypothetical Model 2), which means people with reports of a higher usefulness of elements of NWS forecasts products will have more usage intention of these products. Besides, UOPE also has a very significant influence at the 0.005 level on Product Understanding, which means people with reports of higher usefulness of elements of NWS forecasts products will understand these products better. Last, Usage Intention has a very significant influence at the 0.001 level on Intended Actions, which means people's higher usage intention of NWS forecasts products will lead to more actions based on these products. Overall, the significant relationships in the Modified Model 2 are the same as the Hypothetical Model 2.

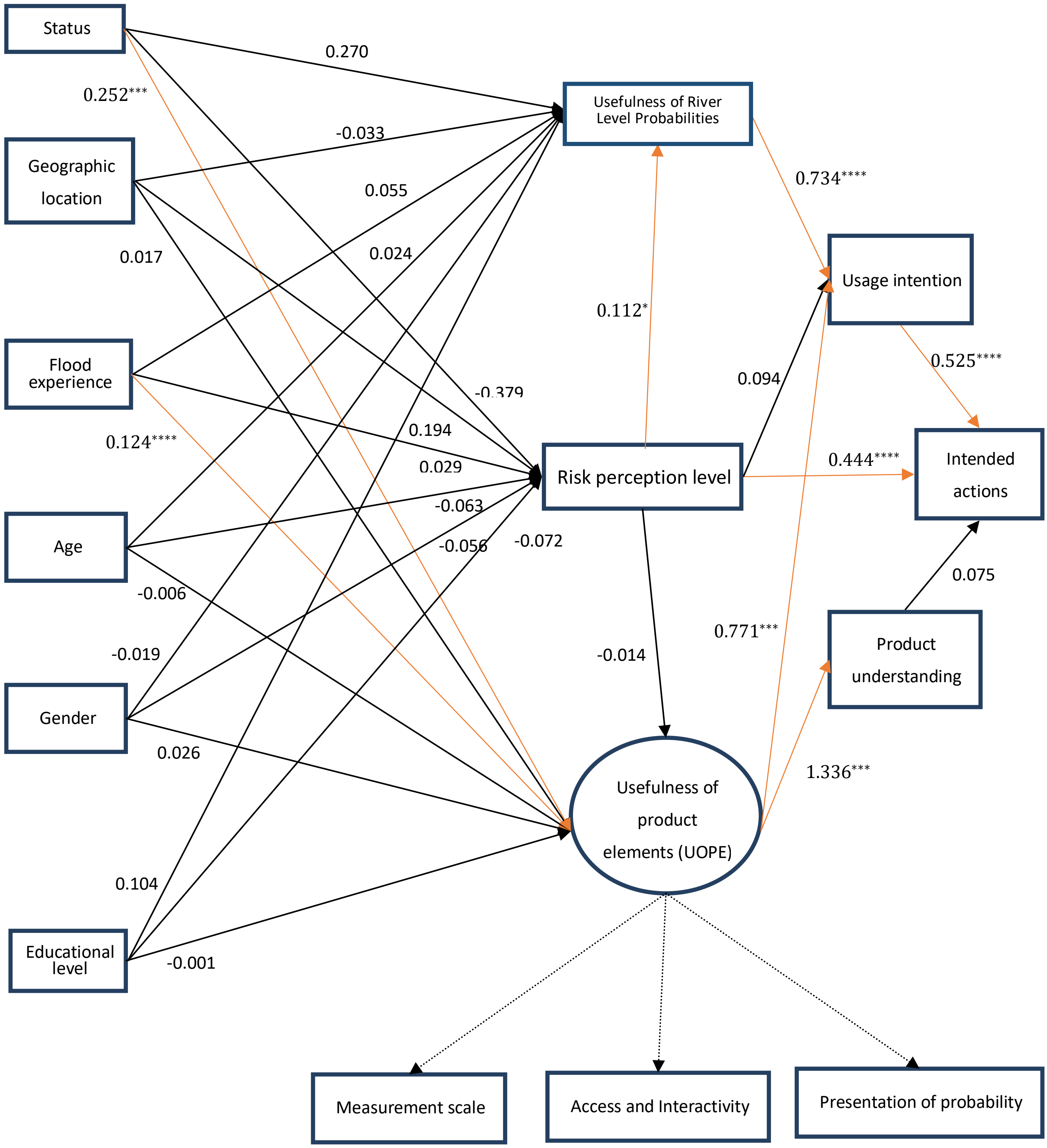

Figure 4.4: Modified Structural Equation Model 2 with Coefficients of Influence Paths for Online Survey

In summary, through the comparison of the hypothetical models and the modified models, we can see that the significant relationships in both modified models are the same as both hypothetical models, respectively.

All the specific verification results of the hypotheses tested by the modified structural equation models are shown in Table 4.24. Through the comparison of Tables 4.21 and 4.24, it is obvious that both modified models support exactly the same hypotheses as the hypothetical models, therefore the hypothesis verification results of SEMs remain unchanged.

Table 4.24: Direct Path Analysis Results of Modified Structural Equation Models

Hypothesis	Path	Coefficients (Model 1)	Result	Coefficients (Model 2)	Result
H1	Status → Risk perception level	/	/	-0.379	Rejected
H2	Status → Usefulness of product (UOP)	0.148	Rejected	0.270	Rejected
H3	Status → Usefulness of product elements (UOPE)	0.198****	Supported	0.252***	Supported
H4	Geographic location → Risk perception level	/	/	0.194	Rejected
H5	Geographic location → Usefulness of product (UOP)	-0.078	Rejected	-0.033	Rejected
H6	Geographic location → Usefulness of product elements (UOPE)	0.100****	Supported	0.017	Rejected
H7	Flood experience → Risk perception level	/	/	0.029	Rejected
H8	Flood experience → Usefulness of product (UOP)	/	/	0.055	Rejected
H9	Flood experience → Usefulness of product elements (UOPE)	/	/	0.124****	Supported
H10	Age → Risk perception level	/	/	-0.063	Rejected
H11	Age → Usefulness of product (UOP)	/	/	0.024	Rejected
H12	Age → Usefulness of product elements (UOPE)	/	/	-0.006	Rejected
H13	Gender → Risk perception level	/	/	-0.056	Rejected
H14	Gender → Usefulness of product (UOP)	/	/	-0.019	Rejected
H15	Gender → Usefulness of product elements (UOPE)	/	/	0.026	Rejected
H16	Educational level → Risk perception level	/	/	-0.072	Rejected
H17	Educational level → Usefulness of product (UOP)	/	/	0.104	Rejected
H18	Educational level → Usefulness of product elements (UOPE)	/	/	-0.001	Rejected
H19	Risk perception level → Usefulness of product (UOP)	/	/	0.112*	Supported
H20	Risk perception level → Usefulness of	/	/	-0.014	Rejected

	product elements (UOPE)				
H21	Risk perception level → Usage intention	/	/	0.083	Rejected
H22	Risk perception level → Intended actions	/	/	0.444^{****}	Supported
H23	Usefulness of product (UOP) → Usage intention	0.347^{****}	Supported	0.734^{****}	Supported
H24	Usefulness of product elements (UOPE) → Usage intention	0.488	Rejected	0.771^{***}	Supported
H25	Usefulness of product elements (UOPE) → Product understanding	/	/	1.336^{****}	Supported
H26	Product understanding → Intended actions	/	/	0.075	Rejected
H27	Usage intention → Intended actions	0.422^{***}	Supported	0.525^{****}	Supported

Two-tailed significance. *: Significant correlation at the 0.05 level. **: Significant correlation at the 0.01 level. ***: Significant correlation at the 0.005 level. ****: Significant correlation at the 0.001 level.

4.6 Hypothesis Verification Results

Based on all analyses in this chapter, the verification results of 27 hypotheses proposed in this study are shown in Table 4.25. From the table we can see that hypotheses H3, H9, H22, H23, H25, and H27 are supported by all analyses including SEMs and correlation analysis, which means these hypotheses proposed are valid and tenable in the study. Combined with the coefficients from the path analysis, the hypotheses that are supported indicate that: 1) professionals will report NWS forecasts products elements to be more useful than residents; 2) people with more flood experiences will report NWS forecasts products elements to be more useful; 3) people with higher risk perceptions of flooding will be more likely to take actions after using NWS forecasts products; 4) people who report NWS forecasts products to be more useful will have more usage intention of these products; 5) people who report NWS forecasts products elements to be more useful will understand these products better; and 6) people with more usage intention of NWS forecasts products will be more likely to take actions based on these products.

Meanwhile, hypotheses supported by either but not both Spearman's analysis or one of the SEMs were marked as “Partially supported”. Hypotheses H2, H6, H19, and H24 are partially supported in the study which suggests that these hypotheses are valid but not always tenable in the study. Combined with the coefficients of the path analysis, hypotheses partially supported indicate that: 1) professionals will report NWS forecasts products to be more useful than residents; 2) people living in areas with a higher chance of flooding will report NWS forecasts products elements to be more useful; 3) people with higher risk perceptions of flooding will report NWS forecasts products more useful; and 4) people who report NWS forecasts products elements more useful will have more usage intention of these products.

Other unmentioned hypotheses are all rejected in the study, which means no other significant relationships were founded.

Table 4.25: Overall Verification Results of Proposed Hypotheses in the Study

Number	Content	Result
H1	Professionals will have significantly higher risk perception levels than residents.	Rejected
H2	There is a significant difference in the usefulness of products (UOP) between professionals and residents	Partially Supported
H3	There is a significant difference in the usefulness of products elements (UOPE) between professionals and residents	Supported
H4	People living in areas with a higher chance of flooding will have higher risk perception level significantly.	Rejected
H5	People living in areas with a higher chance of flooding will report NWS forecasts products (UOP) to be significantly more useful.	Rejected
H6	People living in areas with a higher chance of flooding will report NWS forecasts products elements (UOPE) to be more useful significantly.	Partially Supported
H7	People’s flood experience will have a significantly positive influence on their risk perception level.	Rejected
H8	People’s flood experience will have a significantly positive influence on their reports of the usefulness of NWS forecasts products (UOP).	Rejected

H9	People's flood experience will have a significantly positive influence on their reports of the usefulness of NWS forecasts products elements (UOPE).	Supported
H10	People's age will have a significant influence on their risk perception level.	Rejected
H11	People's age will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).	Rejected
H12	People's age will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).	Rejected
H13	People's gender will have a significant influence on their risk perception level.	Rejected
H14	People's gender will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).	Rejected
H15	People's gender will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).	Rejected
H16	People's educational level will have a significant influence on their risk perception level.	Rejected
H17	People's educational level will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).	Rejected
H18	People's educational level will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).	Rejected
H19	People's risk perception level will have a significant influence on their reports of the usefulness of NWS forecasts products (UOP).	Partially Supported
H20	People's risk perception level will have a significant influence on their reports of the usefulness of NWS forecasts products elements (UOPE).	Rejected
H21	People's risk perception level will have a significant influence on their usage intention of NWS forecasts products.	Rejected
H22	People's risk perception level will have a significant influence on their intended actions after using NWS forecasts products.	Supported
H23	People's reports of the usefulness of NWS forecasts products (UOP) will have a significant influence on their usage intention of NWS forecasts products.	Supported
H24	People's reports of the usefulness of NWS forecasts products elements (UOPE) will have a significant influence on their usage intention of NWS forecasts products.	Partially Supported
H25	People's reports of the usefulness of NWS forecasts products elements (UOPE) will have a significant influence on their product understanding of NWS forecasts products.	Supported

H26	People's product understanding of NWS forecasts products will have a significant influence on their intended actions.	Rejected
H27	People's usage intention of NWS forecasts products will have a significant influence on their intended actions.	Supported

Notes: Hypothesis supported by either Spearman's analysis or one of the SEM was marked as "Partially supported".

In summary, although most of the proposed hypotheses were rejected by the analyses in the study, hypotheses supported and partially supported indicate that people's situational factors including status, flood experience, geographic location, and risk perception of flooding will influence their reports of the usefulness of the NWS forecast products and their elements. At the same time, people's reports of the usefulness of the NWS forecast products and their elements will influence their usage intention of these products and thus affect their actions based on them.

Detailed discussion of the results found by the study, innovations and limitations of the study, as well as future prospects are provided in the next chapter.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

The ready availability of information on the Internet and the diversity of communication methods (TV, radio, smartphone, Internet) make the dissemination of weather forecast information increasingly efficient and convenient. Because of the complexity of weather related events, it is often difficult for people to predict and prepare corresponding actions by themselves. Weather forecast products have increasingly become a very effective means for people to obtain and interpret meteorological processes, especially natural events (such as floods), so that they can prepare for disasters in advance. Therefore, it is critical to study the influencing factors relating to use and intended actions based on the weather forecast products (such as NWS weather forecast products), especially the uncertainty within those products which often creates great differences in understanding.

By combining previous research results and the design and content of NWS weather forecast products, this project constructs two theoretical and modified models of influencing factors behind people's continuing usage behavior of weather forecast products. By analyzing the views of participants in focus groups from different geographic regions on these weather forecast products, statistical analysis methods including SEM and correlation analysis were used to test the theoretical model and 27 proposed research hypotheses. This chapter includes the following parts: first, discussion of the research results; second, the contributions and limitations of the research; and finally, the prospects for future research.

5.1 Discussion of Results

The influencing factors behind people's continuing usage behavior of the products are complex and multifaceted. Based on the review of the previous literature, this study identified factors that affect continuing usage behavior of products by different people such as: situational factors including location and people's socio-demographic factors, and cognitive factors like risk aversion and individual values; risk perceptions; perceived usefulness of the product, product design and its elements; understanding of the product; and action intention based on the product. These factors are related to the characteristics of the product itself and the characteristics of users. In this research, based on the results of the above literature, two SEMs were created to study influencing factors behind users' continuing usage behavior and intended actions of the NWS weather forecast products. SEMs and Spearman's correlation analysis have shown that the characteristics of both the products and users will have different degrees of influence on individuals' use intention and intended actions based on the product. The following is a detailed summary of the research hypotheses and the direct and indirect significant effects of the factors considered in this research.

5.1.1 Situational Factors and Risk Perception

All situational factors of people studied in this research (including people's status, flood experience, geographic location, age, gender, and educational level) do not have a significant influence on people's risk perception of flooding. Spearman's correlation analysis showed that none of the coefficients among situational factors of people in this study and their risk perceptions of flooding were significant (see Table 4.14). Further, the causality verification studies based on SEMs also found no significant causal relationship between people's situational factors in this study and their risk perceptions of flooding (see Tables 4.21 and 4.24). Combining the results of both correlation analysis and path analysis, hypotheses H1, H4, H7. H10, H13, H16 are all rejected.

Overall, these results indicate that people with different situational factors (including status, flood experience, geographic location, age, gender, and educational level) will not have significant differences in their risk perception of flooding after using the NWS forecast products. Therefore, it may not be necessary to consider the influences of people's situational factors on their risk perceptions when designing weather forecast products, as these results suggest that the products all do not have significant impacts on risk perceptions of flooding.

5.1.2 Factors Influencing Perceived Product Usefulness

People's geographic location and their socio-demographic factors including status, flood experience, and risk perception of flooding were found to significantly influence their reports of the usefulness of the NWS forecast products or their elements, or both. This aligns with Mileti and Sorenson (1990) who found that the nature and content of information in a warning have different impacts on whether the public listens to them, and people with different situational characteristics like gender, age, and risk perceptions tend to have different attitudes toward certain information products. This project has found a significant relationship between Status and UOP and between Status and UOPE. Spearman's correlation analysis showed Status has a significant relationship with both UOP and UOPE in both hypothetical models (see Tables 4.13 and 4.14). However, the direct path analysis of SEMs showed that there is no significant causal relationship between Status and UOP in all hypothetical and modified models, while there is a significant causal relationship between Status and UOPE in all hypothetical and modified models (see Tables 4.21 and 4.24). The results of both correlation analysis and path analysis support hypotheses H2 and H3 indicating that, not surprisingly, professionals report significantly higher usefulness of the NWS forecast products as well as product elements than residents.

Geographic Location also has a significant relationship with UOPE but not UOP. Spearman's correlation analysis showed Geographic Location has a significant relationship with UOPE only in the Hypothetical Model 1, whereas it does not have a significant relationship with UOP in both hypothetical models (see Tables 4.13 and 4.14). The same was found with the direct path analysis where there is a significant causal relationship between Geographic Location and UOPE in the Hypothetical Model 1 and the Modified Model 1 but insignificant in the Hypothetical Model 2 and the Modified Model 2 (see Tables 4.21 and 4.24). Thus, hypothesis H5 is rejected while H6 is supported. These results suggest that people living in areas with a higher chance of flooding will significantly report NWS forecasts products elements to be useful, while they will not significantly report NWS forecasts products to be useful. It appears that there are elements in the products that garner the attention of those in higher risk areas, but that is not the case with the overall product.

Flood Experience also has a significant relationship with UOPE but not UOP. Spearman's correlation analysis showed Flood Experience has a significant relationship with UOPE in the Hypothetical Model 2, whereas it does not have a significant relationship with UOP (see Table 4.14). However, the direct path analysis of SEMs showed there is a significant causal relationship between Flood Experience and UOPE but not UOP in both Hypothetical Model 2 and Modified Model 2 (see Tables 4.21 and 4.24). Thus, hypothesis H8 is rejected while H9 is supported. The results suggest that people with more flood experience will significantly report NWS forecasts products elements to be more useful, while they will not significantly report NWS forecasts products to be more useful. The implications of this are similar to those stated above.

Risk Perception Level has a significant relationship with UOP but not UOPE. Spearman's correlation analysis showed Risk Perception Level does not have a significant relationship with either UOP or UOPE in the Hypothetical Model 2 (see Table 4.14). However, the direct path analysis of SEMs showed that there is a significant causal relationship between Risk Perception Level and UOP but not UOPE in both Hypothetical Model 2 and Modified Model 2 (see Tables 4.21 and 4.24). Thus, hypothesis H19 is supported while H20 is rejected. The results indicate that people with higher risk perceptions of flooding will significantly report NWS forecasts products to be more useful, while they will not significantly report NWS forecasts products elements to be more useful.

However, despite those significant relationships mentioned above, we can see from Tables 4.13, 4.14, 4.21, and 4.24 that neither Spearman's correlation analysis nor the direct path analysis of SEMs showed other socio-demographic factors of people studied in this research, including age, gender, and educational level to have significant influences on their perceived usefulness of the NWS forecast products or their elements. This also shows that these factors will not significantly influence people's continuing usage behavior of or intended actions based on NWS forecast products. Therefore, hypotheses H11, H12, H14. H15, H17, H18 are all rejected. These results suggest that people with different age, gender, or educational levels will not significantly report NWS forecasts products or the elements of these products to be more useful, again suggesting that the utility (or lack of utility of some elements) of the products cuts across groups.

In summary, based on the research results, the first research question "What is the relationship between peoples' situational factors, risk perceptions, reviews of the usefulness of the products and elements of products (color, legend, etc.)?" has been answered to some extent. Although peoples' situational factors will not have a significant influence on their risk perceptions of flooding, some people's situational factors (status, flood experience, and geographic location) but not with others (age, gender, and educational level) will have significant influences on their perceived usefulness of NWS forecast products and their elements. Similarly, people's risk perceptions of flooding will have a significant influence on their reviews of the usefulness of the products. Additionally, these results suggest, first, that one design does not meet all needs, as indicated by, for instance, the differences by geographic location, and second, more importantly, different individual elements of a product play an important role in understanding and use of a product. For example, in order to improve usefulness of products for those with less flood experience, including past record floods on products may provide the kind of information needed.

5.1.3 Influencing Factors of Usage Intention and Intended Actions

As shown in the results chapter, people's risk perceptions of flooding and their product acceptance, including perceived usefulness of the product and its elements, will significantly influence their usage intention and product understanding of the NWS forecast products, thus affecting their intended actions based on the product. Simultaneously, the indirect path analysis shows that people's status and flood experience will have a significant indirect influence on their usage intention and product understanding of the NWS forecast products; and people's status, their perceived usefulness of the product and its elements, and their risk perceptions of flooding will respectively have a significant indirect influence on their intended actions based on the NWS forecast products.

To be specific, Spearman's correlation analysis showed that Risk Perception Level has a significant relationship with Intended Actions but not Usage Intention in the Hypothetical Model 2 (see Table 4.16). The same was found with the direct path analysis of SEMs where there is a significant causal relationship between Risk Perception Level and Intended Actions but not Usage Intention in both the Hypothetical Model 2 and Modified Model 2 (see Tables 4.21 and 4.24). Additionally, the indirect path analysis shows that Risk Perception Level has a significant indirect influence on Intended Actions in the Hypothetical Model 2 through the mediating variables UOP, UOPE, or Usage Intention (see Table 4.22 and Figure 4.2). Thus, hypothesis H21 is rejected and H22 is supported. The results indicate that people with higher risk perceptions of flooding will significantly have more intended actions after using NWS forecasts products, even though they will not significantly have more usage intention of the product. This is similar to the research of Landeros-Mugica et al. (2016) and Bearth & Siegrist (2019), the former finding that people with higher risk perceptions due to some situational factors usually pay more attention to disaster-related information, and the latter finding that consumers with different levels of risk perception tend to have different abilities to make correct risk judgments on products and take proper actions.

A significant relationship was also found between UOP and Usage Intention and between UOPE and Usage Intention. Spearman's correlation analysis showed both UOP and UOPE have a significant relationship with Usage Intention in both hypothetical models (see Tables 4.15 and 4.16). However, the direct path analysis of SEMs showed that there is a significant causal relationship between UOP and Usage Intention in all hypothetical and modified models, and there is a significant causal relationship between UOPE and Usage Intention only in the Hypothetical Model 2 and Modified Model 2 (see Tables 4.21 and 4.24). Additionally, the indirect path analysis shows that Status has a significant indirect influence on Usage Intention only in the Hypothetical Model 1 through the mediating variables UOP, UOPE, or Risk Perception Level (see Table 4.22 and Figure 4.1). It also shows that Flood Experience has a significant indirect influence on Usage Intention in the Hypothetical Model 2 through the mediating variables UOP, UOPE, or Risk Perception Level (see Table 4.22 and Figure 4.2). Similarly, Flood Experience has a significant indirect influence on Product Understanding in the Hypothetical Model 2 through the mediating variable UOPE (see Table 4.22 and Figure 4.2). Thus, hypotheses H23 and H24 are supported. Similarly, as Davis (1985), Chau (1996), and Pikkarainen et al. (2004) found, user's behavior intentions are determined by their perceived usefulness and the acceptance of the product. These results suggest that people with higher perceived usefulness of NWS forecasts products and their elements will significantly have more usage intention towards NWS forecasts products. Further, some significant relationships found through indirect path analysis suggest that professionals and people with more flood experience will significantly have more usage intention of the NWS forecast product, and people with more flood experience will also significantly understand these products better. Thus, it is important for NWS to consider the needs of those with less flood experience in product design.

Spearman's correlation analysis showed UOPE has a significant relationship with Product Understanding in the Hypothetical Model 2 (see Table 4.16). The same was found with the direct path analysis where there is a significant causal relationship between UOPE and Product Understanding in both the Hypothetical Model 2 and Modified Model 2 (see Tables 4.21 and 4.24). Thus, hypothesis H25 is supported. The results show, not surprisingly, that people with higher perceived usefulness of the elements of the NWS forecasts products will significantly understand these products better, suggesting that additional design features may be needed for people to understand the elements and thus the products. Just like Ninggar et al. (2020), Ash et al. (2014), and Hogan Carr et al. (2016a) found in their research, some features or characteristics of information products will create different levels of difficulty for user understanding.

Last, Spearman's correlation analysis showed that Usage Intention but not Product Understanding has a significant relationship with Intended Actions in all hypothetical models (see Tables 4.17 and 4.18). The same was found in the direct path analysis where there is a significant causal relationship between Usage Intention but not Product Understanding and Intended Actions in all hypothetical models (see Tables 4.21 and 4.24). Thus, hypothesis H26 is rejected and H27 is supported, indicating that people with higher usage intention of NWS forecasts products will significantly have more intended actions after using these products, whereas people with a better understanding of the NWS forecasts products will not significantly have more intended actions after using these products. Additionally, the indirect path analysis shows that Status has a significant indirect influence on Intended Actions only in the Hypothetical Model 1 through the mediating variables UOP, UOPE, or Risk Perception Level (see Table 4.22 and Figure 4.2). It also shows that UOP has a significant indirect influence on Intended Actions in both hypothetical models through the mediating variable Usage Intention (see Table 4.22 and Figures 4.1 and 4.2). Similarly, UOPE has a significant indirect influence on Intended Actions in the Hypothetical Model 1 but not the Hypothetical Model 2 through the mediating variable Usage Intention (see Table 4.22 and Figure 4.1). Therefore, these significant relationships found through indirect path analysis suggest that professionals and people with higher perceived usefulness of NWS products and their elements will significantly have more intended actions after using these products.

In summary, the results of influencing factors of usage intention and intended actions answered the second proposed research question "To what extent do users' situational factors, risk perceptions, and product type and product elements influence users' understanding and usage intention of weather forecast products?" in four aspects below:

1) Professionals, people with more flood experience, and people with higher perceived usefulness of NWS products and their elements will significantly have more usage intention of NWS products as well as intended actions based on them.
2) People with more flood experience and higher perceived usefulness of the elements of these NWS products will significantly understand these products better.
3) People with higher risk perceptions of flooding will significantly have more intended actions after using these NWS forecast products, even though they may not significantly have more usage intention of these products.
4) While people with higher usage intention of NWS forecasts products will significantly have more intended actions after using these products, people who understand these products better will not significantly have more intended actions.

Finally, according to all results of this research, the last research question "In what aspects of the factors can we optimize the weather forecast product to increase user's understanding and usage intention?" that is proposed in this research has been answered: when developing NWS products, it is important to take into consideration in product design and content characteristics and perceptions of those who do not use the products and to recognize the reasons for their lack of understanding and use. For example, since this study has shown that professionals, people with more flood experience, and people with higher perceived usefulness of NWS products and their elements will significantly have more usage intention of NWS products and intended actions based on them, this means residents or people with less flood experience or less perceived usefulness of NWS products and their elements will significantly have less usage intention of NWS products. These groups are more difficult to accept the same NWS forecast products than the above groups (professionals, etc.), which may lead them to not take enough prevention measures to deal with natural events. Therefore, when designing NWS forecast products to also reach those with low usage intention or intended actions (like residents or people with little flood experience), without distorting the correct information, it may be important to add some product components such as descriptive forecaster's notes, to highlight the flood hazard. As mentioned in Chapter 5, the most important thing is to design weather forecast products that are most acceptable to users with different characteristics (such as risk perception level and flood experience). However, the results of this research suggest that this will require additional surveys and interviews to obtain a large enough and diverse enough sample to provide sufficient information to design NWS forecast products correspondingly. It is worth mentioning that this experiment found that a better understanding of NWS forecast products does not necessarily mean that more actions will be generated. Therefore, when designing NWS forecast products, providing products that are readily accessible, both in terms of content and availability, may lead to people being more willing (and able) to use products. After all, people with higher usage intention of NWS forecasts products will significantly have more intended actions after using them. However, this research also suggests that those who design NWS forecast products should also pay attention to insuring the product is more easily understood by users because if they do not understand the product, they may not use it or may misuse or misunderstand it.

5.2 Contributions and Limitations

5.2.1 Contributions

Since this research is an exploratory cross-sectional analysis designed to develop a framework of the relative importance of various factors behind people's continuing usage behavior of flood-related weather forecast products, two primary contributions are attained through the extension and integration of the analysis of these influencing factors in understanding and use of weather forecast products. The first contribution relates to theory. Based on prior relevant research discussed in the literature review, this project creatively investigated and examined the factors influencing people's understanding, use, and intended actions of the NWS weather forecast products from a comprehensive perspective, which includes people's situational factors (status, geographic locations, age, gender, risk perception, etc.) and the content and form of the forecast products. This project proposed two theoretical models of the influencing factors of user's continuous use behavior based on their characteristics and the forecast product and its design, which enriches the theoretical research on the transmission and reception of weather forecast information to the user (for example, the influence of users' risk perceptions of flooding on their use of the product). Also, from an empirical level, this project provides new ideas and examples for the development and improvement of other products based on weather forecast information.

The second contribution relates to the research method and model. In this study, SEM is used to construct and verify a model of the influencing factors of people's use and intended actions of the NWS weather forecast products, which is rare in the current research field of weather forecast products. Meanwhile, this study proposed and verified two multi-factor structural models incorporating the influencing factors of user behavior relating to NWS weather forecast products, including the specific structure of the model, the influence strength (factor loading) of each indicator on the corresponding latent factors, and the relationships and their strength between all the variables in the model. This research method combined with SEM is shown to be effective in researching weather forecast information-based products, which provides methodological reference value for future related research. Further, the variables included in the model and the relationship between the variables can also provide a reference for future research.

5.2.2 Limitations

As with all research, despite the contributions, there are limitations to this project. The first relates to the sample that completed the surveys. Sample size is small because the survey respondents attended focus groups which are intentionally limited to foster discussion. Because of the focus group structure, the respondents are not necessarily representative of the population as a whole given the voluntary nature of participation in a two-hour focus group. In addition, not all the respondents who completed the round 1 and 2 surveys took the follow-up online survey. Further, there is an imbalance in number of participants by geographic location, and geographic locations studied in this project are not enough to represent regions with different hydrological characteristics, although they do represent very different flood situations. These factors may well have affected the research results.

The second is the limitation in the design of questionnaires and SEMs. To begin with, since this study is a part of an ongoing NWS-funded project, the surveys were designed by the project principal investigators to meet specific goals of the project. As a result, the design of the questionnaires does not fully fit the method and goal of this study and thus may not be sufficient to explore the influencing factors of people's use of the NWS forecast products to the maximum extent. For example, the most obvious point is that the questionnaire does not contain questions about the participants' cognitive factors like individual values or attitudes toward flooding. Moreover, perception factors involved in the questionnaires only include risk perceptions of flooding instead of other factors like product perceptions. Additionally, because the previous theoretical research on use behavior and intended actions of the weather forecast products is not rich (especially the research using SEM), this research mainly refers to the existing research model and findings of other non-weather forecast products such as information technology. However, previous research models including ECT, ECM, and TAM on which this project is based do not sufficiently consider the influence of cognitive factors (including emotional and psychological factors) on people’s continuing usage behavior. For the above reasons, it was impossible for this project to take all the situational and cognitive factors that might affect people’s continuing usage behavior on weather forecast products into consideration. As a result, the design of the questionnaire and SEMs (including the design of the SEMs’ structures, selection of observable and latent variables, and the selection of the indicators of the latent variables) in this project only include the situational factors which were easy to measure and quantify in both the questionnaires and models. All of this may lead to less reliability of the questionnaire and weaker model fit of the SEMs. However, since it is a “new” measure, which is not a well-established one, then an initial validity test should be viewed as largely "exploratory." A new measure cannot always be "perfect" because it has to be tested and improved in numerous studies.

5.3 Prospect of Future Research

Influencing factors behind peoples’ use of a weather forecast product has always been an important and complex research topic. It is an important topic because, to a large extent, the value of a product depends on whether it is effectively accepted and used; and it is a complex topic because there are many factors with varying degrees of influence that could affect the acceptance and use of products by individuals. The nature of weather forecast products has created a particular challenge to product design and user acceptance. The uncertainty that the product conveys can be difficult to interpret and therefore can influence effective use of the product. Further, the content and design of the product itself will also significantly affect user acceptance. Therefore, it is difficult to grasp all the specific factors that influence use of weather forecast products, which also provides more possibilities for further research. Various suggestions for future research derive from the present findings. From this study's perspective, two main fields are worth more attention in future research.

The first field is to improve the theoretical research system of influencing factors behind people's continuing usage behavior of weather forecast products. This study has shown that some situational factors, including status, flood experience, and geographic locations, affect peoples' perceived usefulness of the NWS forecast product and its elements to varying degrees. Some of these factors like status and flood experience may even affect their usage intention and intended actions based on the product through mediating effects, as shown in the indirect path analysis results. On the other hand, some situational factors like age, gender, or educational level were shown to not significantly influence people's perceived usefulness of the product or their usage intention. Meanwhile, this study has also indicated that the characteristics of the NWS forecast products themselves can influence peoples' use of the product. However, many other factors are not considered in this study. A broader question that needs to be addressed is, despite the situational factors included in this research, what other specific situational or cognitive factors will significantly impact people's perceived usefulness of NWS forecast products or other weather forecast information-based product or their usage intention? It may not be challenging to expand the research of situational factors like social position, but it may be a difficult problem to collect and analyze the cognitive factors like personal values that are difficult to quantify. Similarly, in addition to the research indicators (UOP and UOPE) relating to the characteristics of NWS forecast products included in this research, what other specific characteristics of products could significantly affect people's perceived usefulness of the NWS forecast products or other weather forecast information-based product or their usage intention? Overall, this study suggests that in the study of the influencing factors behind use of weather forecast products, researchers need to consider other factors, including additional situational and cognitive factors, to enrich and improve the theoretical research system. In future research, we should also consider in greater detail the influence of weather forecast products' characteristics on users' usage intention, such as the availability and ease of access of these products, or whether people can effectively contact product developers and get feedback.

The second field is to optimize the research method and model of influencing factors behind users' continuing usage behavior of weather forecast products. This study adopted SEM as a powerful research method to reveal the causal relationships among factors in the model, which suggests that this research method could be used in similar studies. However, the application conditions and standards of criterion of this method are numerous and complex, making the threshold of acquiring effective and convincing results higher. SEM should be used in studies of influencing mechanisms behind people's use of weather information-based products or other relevant studies because it allows for revealing the causal mechanisms among the whole system and not just the relationships between several factors. Further, researchers should also realize the necessity of optimizing the steps from data acquisition to data analysis to acquire the most appropriate data and to design the most appropriate SEMs, in order to obtain the most reliable and valid results. At the same time, researchers can learn from the design or ideas of other related research that include SEM, and carry out simulation research on the mechanisms of the influencing factors behind user's continuing usage behavior of weather forecast products, so as to improve the relevant SEM further and make it more reasonable and extensive. In summary, this study proved the powerful and efficient ability of SEM to reveal causal relationships among influencing factors behind user's continuing usage behavior of weather forecast products. However, given the complexity of the use conditions and criteria of the SEM, future research needs to improve the reliability and model fit of SEM in all aspects as far as possible to obtain effective and convincing results.

In this project, by using a number of statistical methods and applying SEM to the complex relationships associated with continuing usage behavior of weather forecast products by users with different experiences and characteristics, we have found that people's situational factors, including their status, geographic locations, and flood experience, will affect their perceived usefulness of the NWS forecast products, and thus affect their usage intentions of these products and the actions adopted based on them. The results of this project suggest that future studies should explore and discover other situational and cognitive factors in addition to the factors involved in this study, that may affect user's continuing usage behavior of the weather forecast products and other weather information-based products. This would enable developers of these products to understand more clearly the factors that influence people’s use of their products in a broader and more diverse view and develop widely applicable products for people with varying characteristics and circumstances.

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APPENDIX A

IRB Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** ·
www.ecu.edu/ORIC/irb

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: Burrell Montz Covey
CC:

Date: 8/15/2018
Re: UMCIRB 18-001777
Making Sense of Uncertainty

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 8/15/2018 to 8/14/2019. The research study is eligible for review under expedited category #6, 7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
Example recruitment flyer professionals.pdf	Recruitment Documents/Scripts
Example recruitment flyer residents.pdf	Recruitment Documents/Scripts
Informed-Consent(2).doc	Consent Forms
On-line survey 8 2018.docx	Surveys and Questionnaires
PostSurvey_082018.docx	Surveys and Questionnaires
Pre-survey 082018.docx	Surveys and Questionnaires
Script.docx	Interview/Focus Group Scripts/Questions
Social media text.docx	Recruitment Documents/Scripts

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418

APPENDIX B

QUESTIONNAIRES

Rounds One and Two Pre-Session Survey (Residents and Professionals)

Thank you for participating in this focus group. Please take a few minutes to answer some questions before we get started.

* Required

1. How did you learn about this focus group? *

2. What was your reason for attending? *

3. Do you live in a floodplain?

Yes
No
Unsure

4. Please tell us about your experience with extreme weather/flood events. Have you, a family member, or close friend experienced one or more significant flood events (e.g., experienced damage, loss, evacuation)? *

Yes
No

4a. If yes, please indicate:

within the last 2 years
2-5 years ago
more than 5 years ago

5. If you have experienced a flood, did you respond to official flood warning messages? *

Yes
No
Not applicable

6. How do you rate your own chance of being flooded at your home or business? *

Extremely High Risk
Somewhat High Risk
Some Risk
Very Little Risk

No Risk

7. Have you ever prepared for an anticipated flood? *

Yes
No

8. How much advance notice do you need to prepare for an extreme event (i.e. flooding)? *

1 day
2 days
3-4 days
5 or more days
Other:

9. How do you get information about imminent extreme weather events, such as flooding? Please check all that apply and identify sources in the blank 'Other' line. *

TV
Radio
Smartphone
Internet
Twitter
Facebook
Other:

10. How do you get information about how to prepare for extreme weather events? Please check all that apply and identify sources. *

TV
Radio
Smartphone
Internet
Twitter
Facebook
Other:

11. If you learn that a significant weather hazard is approaching your area, what do you typically do with that information? (Please check all that apply.) *

Discuss with friends and family
Seek further information
Contact local officials

Other:
Required

12. What is your age? *

Under 20
20-29
30-39
40-49
50-59
60-69
70+

13. What is your gender? *

Female
Male
Prefer not to say
Other:

14. In what Municipality do you live? *

15. In what County do you live? *

16. How long have you lived at your current residence? *

under 1 year
1-2 years
3-5 years
6-8 years
8 or more years

17. What is your highest level of education completed? *

High School/GED
Associate's degree or 2-year college degree
Bachelor's degree or other 4-year college degree
Post graduate work

18. What is the title of your current position? *

19. How long have you been in your current position? *

1 year or less

2-4 years
5-7 years
8 years or more

Rounds One and Two Post-Session Survey (Residents and Professionals)

* Required

1. Please rate your agreement with the following statements about the forum. *

Strongly Agree
Agree
Disagree
Strongly Disagree

The information was clearly presented.
I felt comfortable voicing my opinion.
I know more about the National Weather Service (NWS) resources.
I feel I could use NWS resources to judge my risk in an extreme weather event.
I understand the difference between probabilistic and deterministic forecast products.

2. What is the biggest barrier you face in using NWS flood forecast and warning products? *

3. Our goal today was to gather feedback to improve NWS flood forecast and warning tools, including the River Level Probabilities. Beyond the questions asked today, what else would be important for us to know about how you gather information about extreme weather risks and your intended actions? *

4. After attending today's session, how likely are you to: *

Very likely
Somewhat likely
Somewhat unlikely
Unlikely

Create or revise plans to deal with extreme weather events.
Share what I learned today with others.
Seek NWS information about extreme weather risks.
Seek out uncertainty information
Use uncertainty forecasts in your decision-making

5. Which do you prefer in trying to understand your level of risk from flooding? *

Text-based products
Graphic/visual products

Combined text and graphics

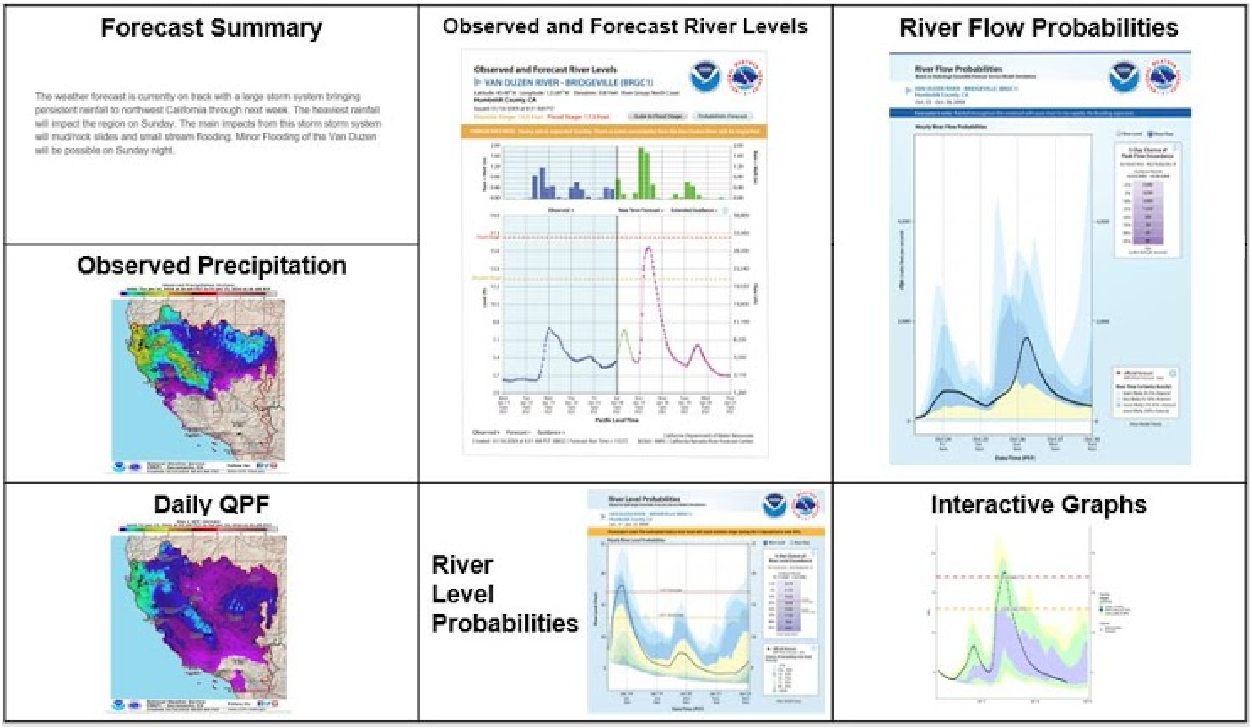
5a. Please explain why: *

6. Please rate the weather products discussed today based on their usefulness to you in assessing your water level situation. See thumbnail images below for reference. *

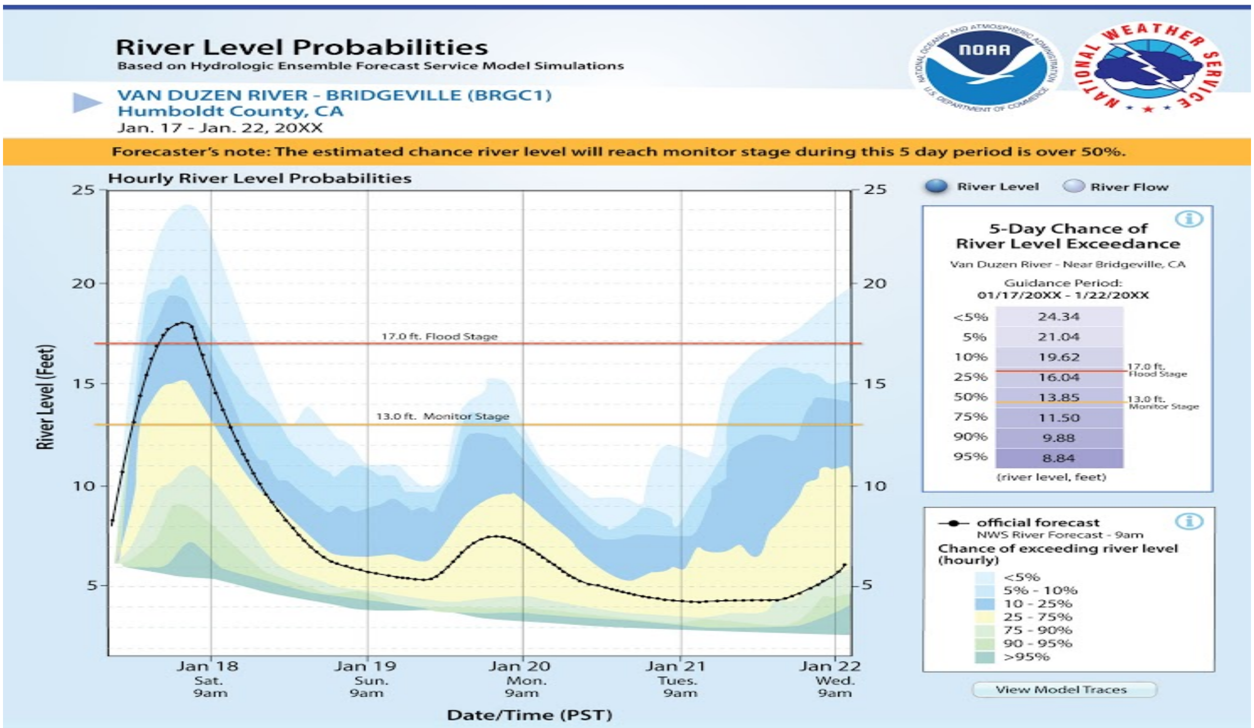
Extremely useful
Very useful
Slightly useful
Not at all useful

Forecast summary
Observed Precipitation
Daily QPF
Observed and Forecast River Levels
River Level Probabilities
River Flow Probabilities
Interactive graphs

Thumbnails for Question 6



For Questions 7 and 8



7. What elements of the River Level Probabilities product shown above are most useful in understanding the situation? (check all that apply) *

Title
Legends
Colors
Percentages
Time Period
Flood levels (monitor, flood stage)
River Level (left axis/side)
Range of probable levels (different shades/colors)
5-Day Chance of River Level Exceedance (Box on Right Side)
Ability to toggle between river level and peak flow
Forecaster's note
Other:
Required

8. What elements of the River Level Probabilities product are not useful or are confusing to you in understanding the situation? (check all that apply)

Title
Legends
Colors

Percentages
Time period
Flood levels (monitor, flood stage)
River level (left axis/side)
Range of probable levels (different shades/colors)
5-Day Chance of River Level Exceedance (Box on Right Side)
Ability to toggle between river level and peak flow
Forecaster's note
Other:

How useful are the probability products you saw today for understanding and making decisions regarding a high flow situation?

Not at all useful

1
2
3
4
5

Very useful

How useful are the probability products you saw today for understanding and making decisions regarding a low flow or transition situation?

Not at all useful

1
2
3
4
5

Very useful

9. If a probabilistic forecast is different from a deterministic forecast, how does that affect your perception of the forecast given? (check all that apply) *

I would have less confidence in both forecasts
I would have less confidence in the deterministic forecast
I would have less confidence in the probabilistic forecast
I would not trust future forecasts from this source
I would seek out more information to understand why they differed
I would ask a forecaster/expert for their opinion
I would ignore the forecast
Other:

Required

10. Which social media would you use to find information about the risk of extreme weather/flooding near you? Please check all that apply: *

Facebook
Twitter
Weather app
Other:

11. Which digital platform are you most likely to use to access NWS resources? *

Smartphone
Tablet
Computer
Other:

12. Was anything in the session confusing? *

Yes
No

12a. If yes, please explain:

13. What improvements could be made in the format or content? *

Focus Group Follow-up Survey

Thank you for participating in an earlier focus group for our project testing the understandability and usefulness of National Weather Service (NWS) hydrology products. We have taken your suggestions into consideration and made revisions to the Probability of River Levels product. We modified colors, added percentiles, and clarified wording. Now, we ask you to once again provide us your feedback by answering the questions below. It will help us determine how helpful the revisions are for improving understanding and usability.

As a reminder, this project focused on probabilistic forecast products. The forecasts are assembled from a variety of meteorological models that show a range of possible scenarios of differing location, timing and amounts of precipitation. The ensemble river forecasts show what the river would be for different precipitation scenarios. The NWS would like to understand how these tools can be helpful to individuals who need to be aware of the possibility of flooding where they live.

Please note we are asking demographic and flood experience information again because we need to identify whether there are differing needs for information and opinions about the products, as that will inform our recommendations to the NWS.

* Required

1. What is your age? *

Check all that apply.

- [ ] <20
- [ ] 20-29
- [ ] 30-39
- [ ] 40-49
- [ ] 50-59
- [ ] 60-69
- [ ] 70+

2. What is your gender? *

Mark only one oval.

- ( ) Female
- ( ) Male
- ( ) Prefer not to say
- ( ) Prefer to self describe

3. What is the highest level of education completed? *

Mark only one oval.

- ( ) High school/GED
- ( ) Associate's/2-year Degree
- ( ) Bachelor's/4-year Degree
- ( ) Post graduate work
- ( ) Other: ____________________

4. We are interested in your experience with extreme weather/flood events. How many times have you been directly affected by flooding (property affected)? Please put a number. *

____

5. About how many times were you inconvenienced by flooding (had to change plans/travel)? Please put a number. *

____

6. How many times have family or friends experienced flooding? Please put a number. *

____

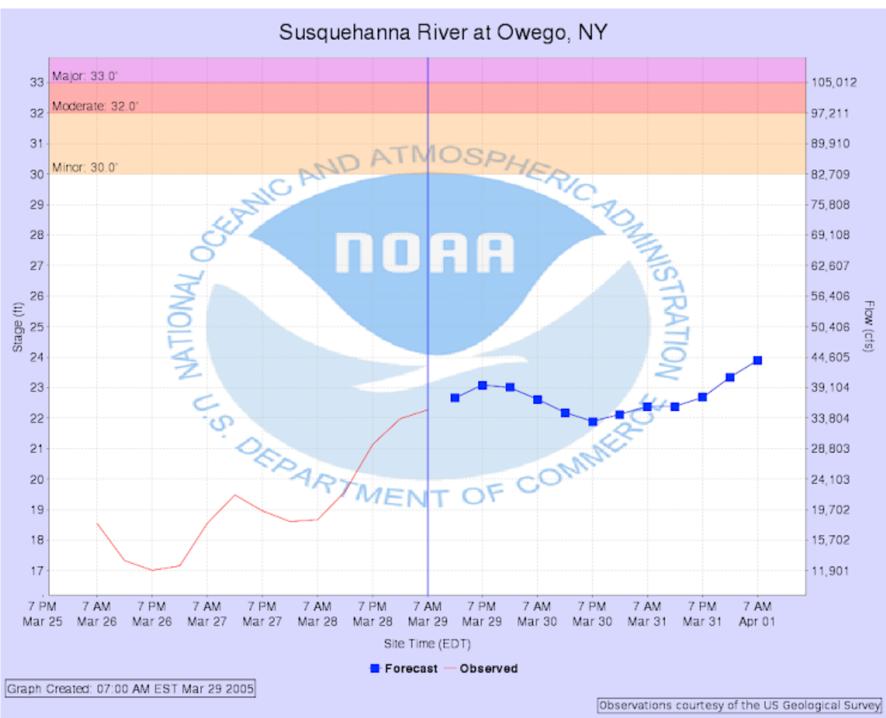
Interest in flood related products

7. Are you interested in forecasts of river levels? *

Mark only one oval.

- ( ) Yes, definitely
- ( ) Somewhat
- ( ) Not really
- ( ) Definitely not
- ( ) Other: _______________________

Example of Hydrograph (APHS)

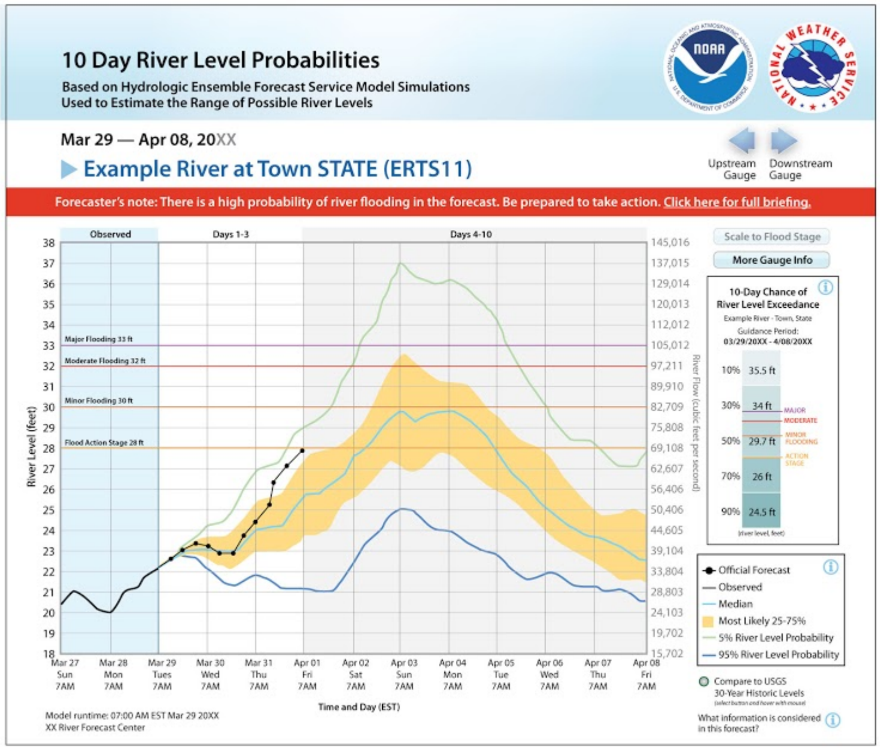


8. Is the Hydrograph (APHS) useful to you? *

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

Example of Probability of River Level Forecast

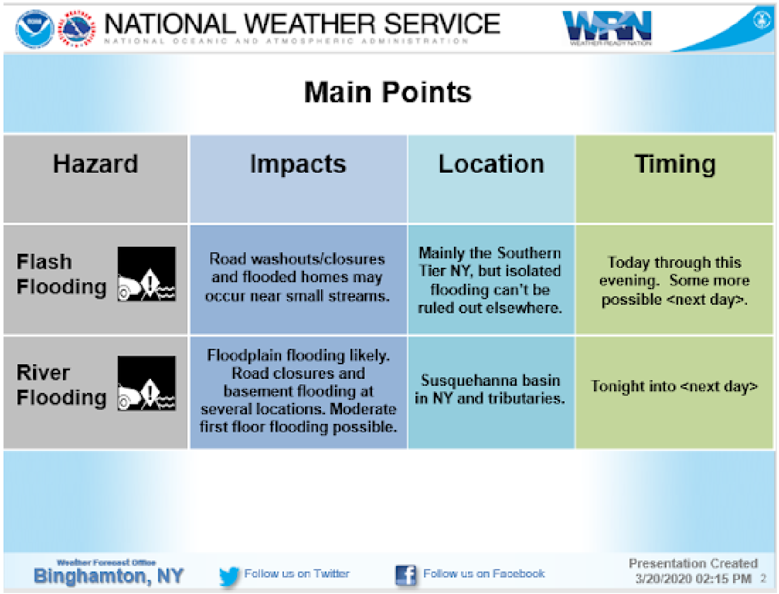


9. Is the Probability of River Level Forecast product useful to you? *

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

Example of part of a Briefing package.



10. Is the briefing package (multiple products packaged together with text/information from local Weather Forecast Office) useful to you? *

Mark only one oval.

	1	2	3	4	5	
Not at all useful	◯	◯	◯	◯	◯	Very useful

Focus Group participation

11. When did you participate in a focus group *

Mark only one oval.

◯ Spring 2019
◯ Fall 2019
◯ Other: ______________

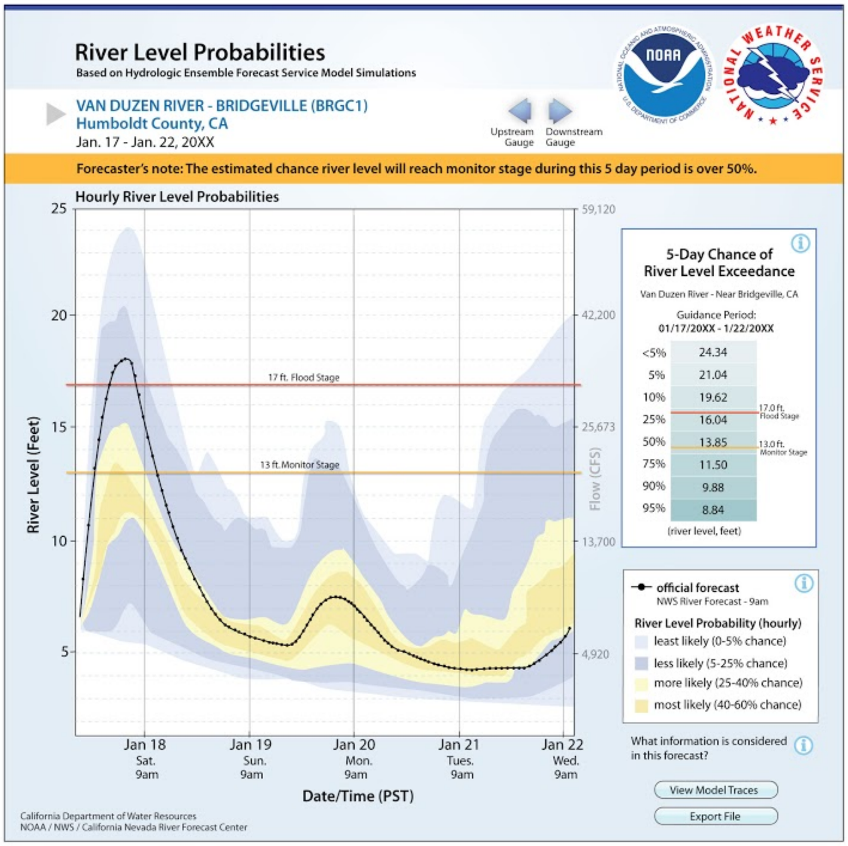
12. What focus group location did you participate in? *

Mark only one oval.

◯ Eureka, CA *Skip to question 13*
◯ Owego, NY *Skip to question 24*
◯ Gunnison, CO *Skip to question 38*
◯ Durango, CO *Skip to question 49*

Eureka, CA

Use the product below to answer the following questions.



13. What is this product telling you (check all that apply)? *

Check all that apply.

- [ ] It is most likely (40-60% chance) that river levels will stay below flood stage from Jan 17 to 22
- [ ] There is a small possibility that flood stage could be reached on Jan 22
- [ ] Flooding will occur Jan 17
- [ ] No flooding will happen Jan 17 to Jan 22

Other: [ ] ______________________

14. After viewing this product how do you view the risk of flooding from Jan 17-22? *

Mark only one oval.

- ( ) Very high
- ( ) Somewhat high
- ( ) Neither high nor low
- ( ) Somewhat low
- ( ) Very low
- ( ) Other: ______________________

15. Would you take any actions as a result of this product? *

Mark only one oval.

- Yes
- No
- Maybe

16. If yes, what actions would you take as a result of this product (check all that apply).

Check all that apply.

- [ ] Seek out more information
- [ ] Talk to family, friends, and neighbors.
- [ ] Take action to secure outdoor property and reduce property loss from flooding
- [ ] Make sure to have an emergency preparedness kit/stock up on food, water, and batteries
- [ ] Keep an eye on the river

Other: [ ] ______________________

17. If no, why (check all that apply)?

Check all that apply.

- [ ] I'm not concerned about flooding risk
- [ ] The information in this product doesn't tell me enough
- [ ] I don't believe the forecast
- [ ] I don't know what actions to take

Other: [ ] ______________________

18. How useful is this product (select one)? *

Mark only one oval.

- Very useful
- Somewhat useful
- Neutral (neither useful nor not useful)
- Somewhat not useful
- Not useful

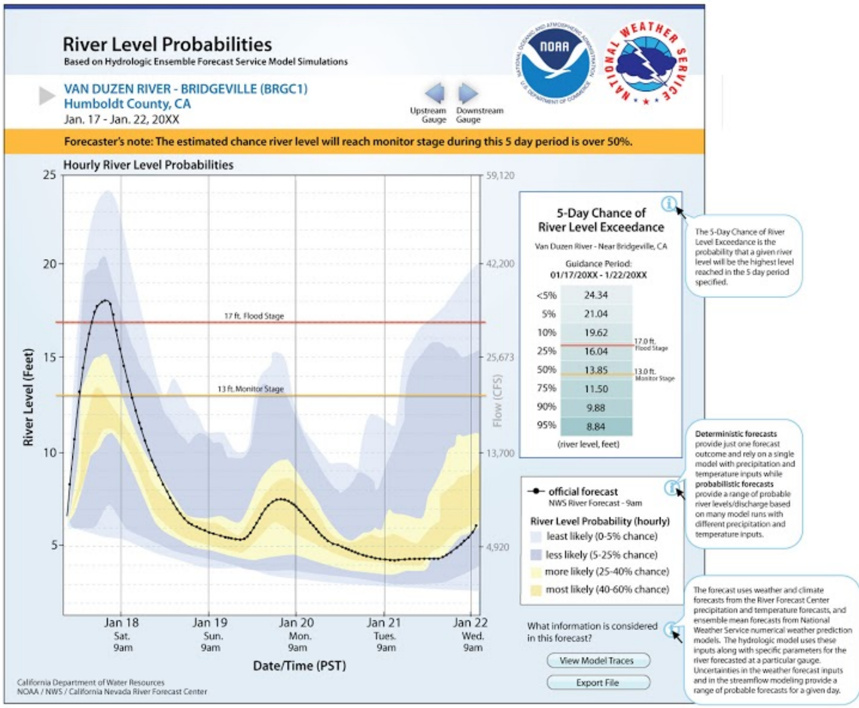
19. How likely are you to use this product in the future? *

Mark only one oval.

- Very likely
- Somewhat likely
- Neutral (neither likely nor unlikely)
- Somewhat unlikely
- Very unlikely

River Level Probabilities

Use the product below to answer the following questions.



20. What elements of this product are most useful in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legends
- [ ] Colors
- [ ] Percentages (0-5%, 5-25%, 25-40%, 40-60%)
- [ ] Likely categories (least, less, more, most)
- [ ] Time period
- [ ] Flood levels (monitor and flood stage)
- [ ] River level (left axis)
- [ ] Flow (right axis)
- [ ] Range of probable levels (different shades/colors)
- [ ] Forecaster's note
- [ ] 5-Day chance of exceedence (box on right side)
- [ ] Option to click upstream and downstream gauge (top arrows)
- [ ] Information pop-ups (i)
- [ ] Option to view model traces
- [ ] Option to export file
- [ ] None

Other: [ ] ______________________

21. What elements of this product are not useful or confusing to you in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legends
- [ ] Colors
- [ ] Percentages (0-5%, 5-25%, 25-40%, 40-60%)
- [ ] Likely categories (least, less, more, most)
- [ ] Time period
- [ ] Flood levels (monitor and flood stge)
- [ ] River level (left axis)
- [ ] Flow (right axis)
- [ ] Range of probable levels (different shades/colors)
- [ ] Forecaster's note
- [ ] 5-Day chance of exceedence (box on right side)
- [ ] Option to click upstream and downstream gauge (top arrows)
- [ ] Information pop-ups (i)
- [ ] Option to view model traces
- [ ] Option to export file
- [ ] None

Other: [ ] ____________________

22. What additional information or elements would make this product more useful or understandable to you (if any)? *

____
____
____
____
____

23. The official/deterministic forecast is higher than the probabilistic forecast on Jan 17, how does that affect your perception of the forecast given? (check all that apply) *

Check all that apply.

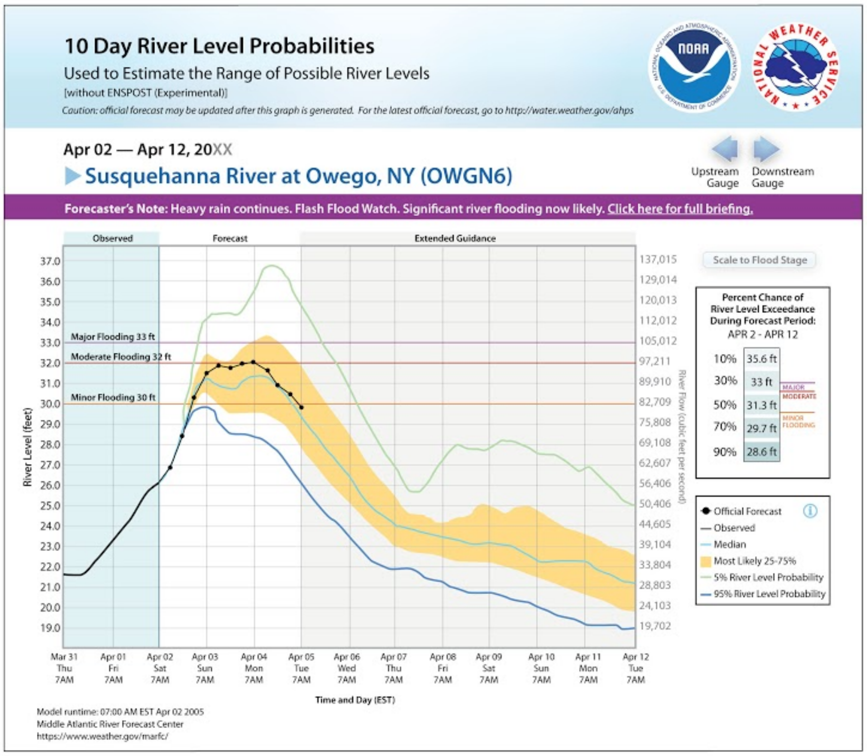
- [ ] I would have less confidence in both forecasts
- [ ] I would have less confidence in the deterministic forecast
- [ ] I would have less confidence in the probabilistic forecast
- [ ] I would not trust future forecasts from this source
- [ ] I would seek out more information to understand why they differed
- [ ] I would ask a forecaster/expert for their opinion
- [ ] I would ignore the forecast

Other: [ ] ____________________

Skip to question 60

Owego, NY

Use the product below to answer the following questions.



24. What is this product telling you (check all that apply)? *

Check all that apply.

- [ ] Minor flooding is likely on April 3rd.
- [ ] Major flooding is not at all likely from April 2nd to April 12th
- [ ] There is a chance of minor flooding on April 6th
- [ ] Moderate flooding is likely to occur on April 5th

Other: [ ] ____________________

25. After viewing this product how do you view the risk of flooding from April 2nd to 12th? *

Mark only one oval.

- ( ) Very high
- ( ) Somewhat high
- ( ) Neither high nor low
- ( ) Somewhat low
- ( ) Very low
- ( ) Other: ____________________

26. Would you take any actions as a result of this product? *

Mark only one oval.

- ⬭ Yes
- ⬭ No
- ⬭ Maybe

27. If yes, what actions would you take as a result of this product (check all that apply).

Check all that apply.

- ☐ Seek out more information
- ☐ Talk to family, friends, and neighbors.
- ☐ Take action to secure outdoor property and reduce property loss from flooding
- ☐ Make sure to have an emergency preparedness kit/stock up on food, water, and batteries
- ☐ Keep an eye on the river

Other: ☐ ______________________

28. If no, why (check all that apply)?

Check all that apply.

- ☐ I'm not concerned about flooding risk
- ☐ The information in this product doesn't tell me enough
- ☐ I don't believe the forecast
- ☐ I don't know what actions to take

Other: ☐ ______________________

29. How useful is this product (select one)? *

Mark only one oval.

- ⬭ Very useful
- ⬭ Somewhat useful
- ⬭ Neutral (neither useful nor not useful)
- ⬭ Somewhat not useful
- ⬭ Not useful

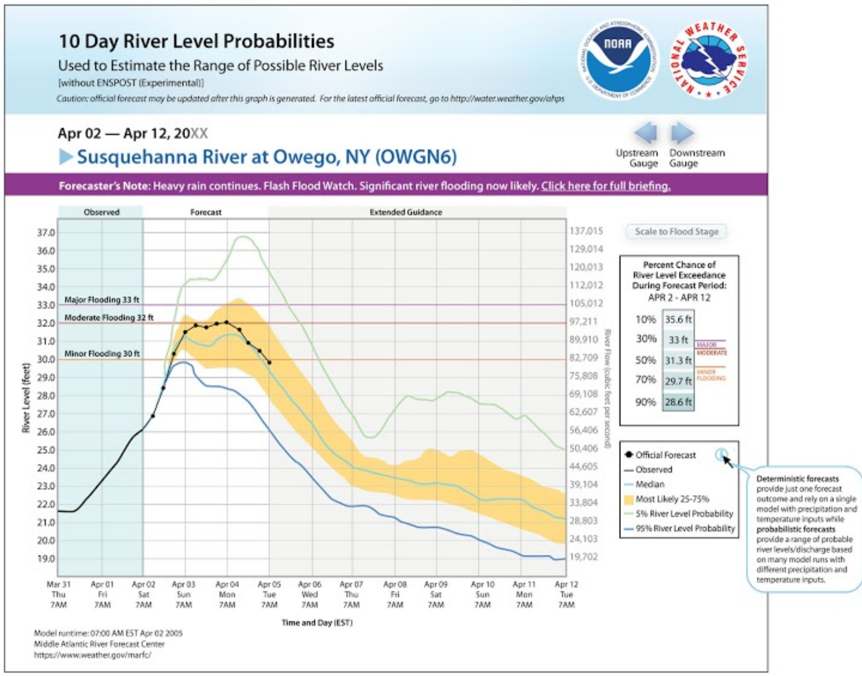
30. How likely are you to use this product in the future? *

Mark only one oval.

- ⬭ Very likely
- ⬭ Somewhat likely
- ⬭ Neutral (neither likely nor unlikely)
- ⬭ Somewhat unlikely
- ⬭ Very unlikely

River Level Probabilities

Use the product below to answer the following questions.



31. What elements of this product are most useful in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legends
- [ ] Colors
- [ ] Percentages(25-75%)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] River flow (right axis)
- [ ] Median line
- [ ] 5% and 95% River Level Probability lines
- [ ] Forecaster's note
- [ ] Percent chance of exceedence (box on right side)
- [ ] Option to move upstream or downstream (arrows at the top)
- [ ] Information pop-up box
- [ ] Scale to Flood Stage option (button at the top right)
- [ ] None

Other: [ ] ____________________

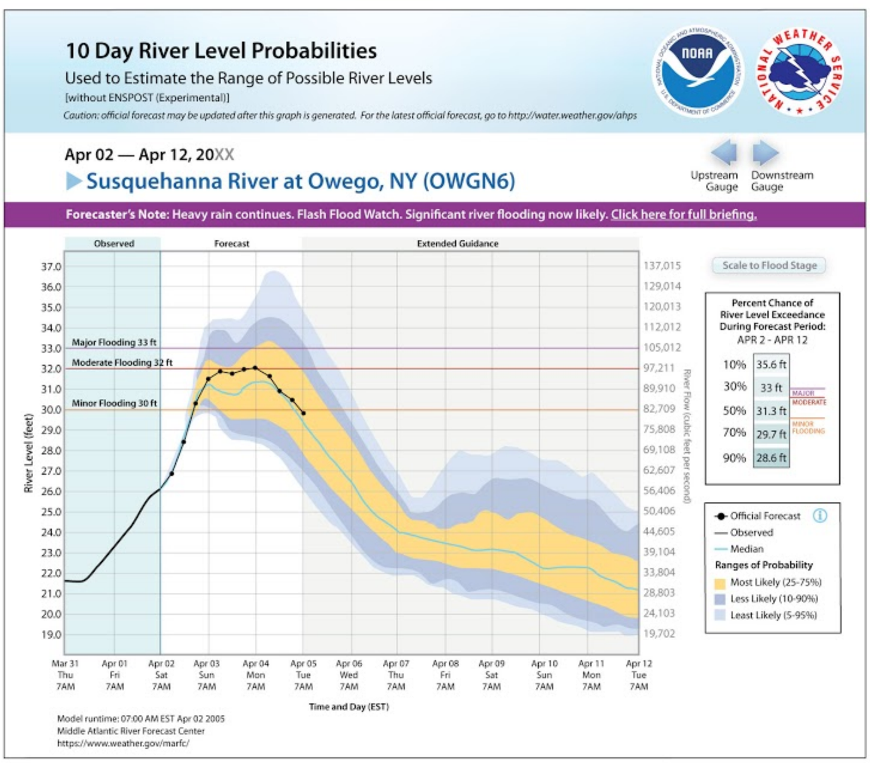
32. What elements of this product are not useful or confusing to you in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legends
- [ ] Colors
- [ ] Percentages (25-75%)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] River flow (right axis)
- [ ] Median line
- [ ] 5% and 95% River Level Probability lines
- [ ] Forecaster's note
- [ ] Percent chance of exceedence (box on right side)
- [ ] Option to move upstream or downstream (arrows at the top)
- [ ] Information pop-up box
- [ ] Scale to flood stage option (button at the top right)
- [ ] None

Other: [ ] ______________________

Below is another way to represent probabilities - using shaded probabilities. Please respond to the following questions with this graphic in mind.



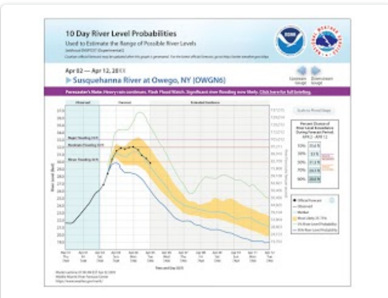
33. Do the shaded ranges of probabilities make the product easier for you to understand? *

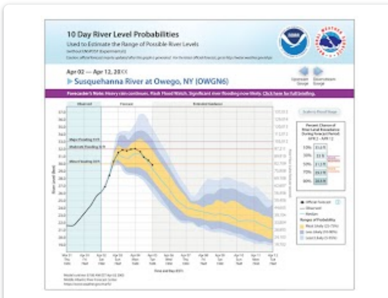
Mark only one oval.

( ) Yes
( ) No
( ) Maybe

34. Which of these products do you prefer? *

Check all that apply.





☐ Option 1 ☐ Option 2

35. Why do you prefer this product? *

36. What additional information or elements would make these products more useful or understandable to you? *

37. If a probabilistic forecast is different from a deterministic/official forecast, how does that affect your perception of the forecast given? (check all that apply) *

Check all that apply.

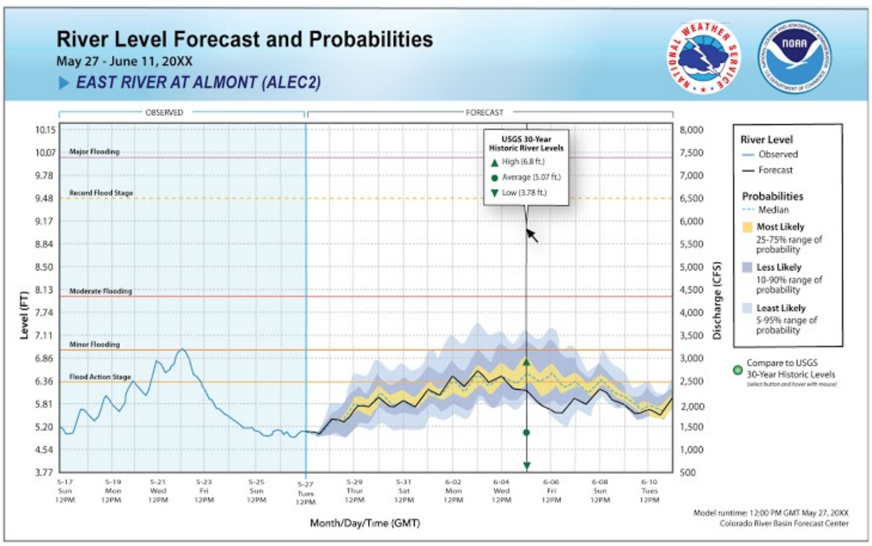
- [ ] I would have less confidence in both forecasts
- [ ] I would have less confidence in the deterministic forecast
- [ ] I would have less confidence in the probabilistic forecast
- [ ] I would not trust future forecasts from this source
- [ ] I would seek out more information to understand why they differed
- [ ] I would ask a forecaster/expert for their opinion
- [ ] I would ignore the forecast

Other: [ ] ____________________

Skip to question 60

Gunnison, CO

Use the product below to answer the following questions.



38. What is this product telling you (check all that apply)? *

Check all that apply.

- [ ] Minor flooding is likely to occur on June 2nd
- [ ] River levels will be above action stage on June 8th
- [ ] River levels will be above average on June 5th
- [ ] No flooding is likely to occur on June 6th

Other: [ ] ____________________

39. After viewing this product how do you view the risk of flooding in the time period May 27 to June 11? *

Mark only one oval.

- ( ) Very high
- ( ) Somewhat high
- ( ) Neither high nor low
- ( ) Somewhat low
- ( ) Very low
- ( ) Other: ____________________

40. Would you take any actions as a result of this product? *

Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) Maybe

41. If yes, what actions would you take as a result of this product (check all that apply).

Check all that apply.

- [ ] Seek out more information
- [ ] Talk to family, friends, and neighbors.
- [ ] Take action to secure outdoor property and reduce property loss from flooding
- [ ] Make sure to have an emergency preparedness kit/stock up on food, water, and batteries
- [ ] Keep an eye on the river

Other: [ ] ____________________

42. If no, why (check all that apply)?

Check all that apply.

- [ ] I'm not concerned about flooding risk
- [ ] The information in this product doesn't tell me enough
- [ ] I don't believe the forecast
- [ ] I don't know what actions to take

Other: [ ] ____________________

43. How useful is this product (select one)? *

Mark only one oval.

- ⬭ Very useful
- ⬭ Somewhat useful
- ⬭ Neutral (neither useful nor not useful)
- ⬭ Somewhat not useful
- ⬭ Not useful

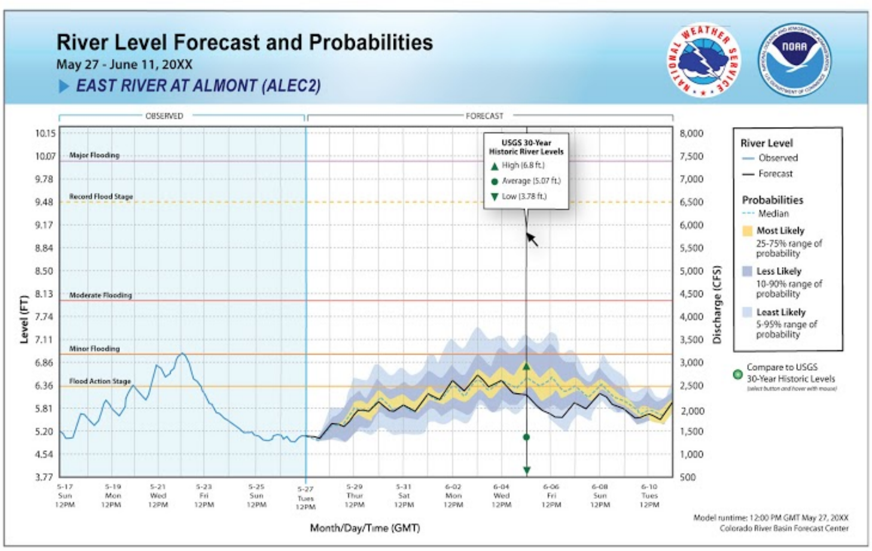
44. How likely are you to use this product in the future? *

Mark only one oval.

- ⬭ Very likely
- ⬭ Somewhat likely
- ⬭ Neutral (neither likely nor unlikely)
- ⬭ Somewhat unlikely
- ⬭ Very unlikely

River Level Probabilities

Use the product below to answer the following questions.



45. What elements of this product are most useful in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legend
- [ ] Colors
- [ ] Percentages (5-95%, 10-90%, 25-75%)
- [ ] Likely categories (most, less, least)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] Discharge (right axis)
- [ ] Median line
- [ ] Range of probable levels (different shades/colors)
- [ ] Forecaster's note
- [ ] USGS Historic River Levels Comparison
- [ ] None

Other: [ ] ____________________

46. What elements of this product are not useful or confusing to you in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legend
- [ ] Colors
- [ ] Percentages (5-95%, 10-90%, 25-75%)
- [ ] Likely categories (most, less, least)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] Discharge (right axis)
- [ ] Median line
- [ ] Range of probable levels (different shades/colors)
- [ ] Forecaster's note
- [ ] USGS Historic River Levels Comparison
- [ ] None

Other: [ ] ____________________

47. What additional information or elements would make this product more useful or understandable to you? *

48. On June 6th the deterministic forecast (black line) is different from the probabilistic forecast, how does that affect your perception of the forecast given? (check all that apply) *

Check all that apply.

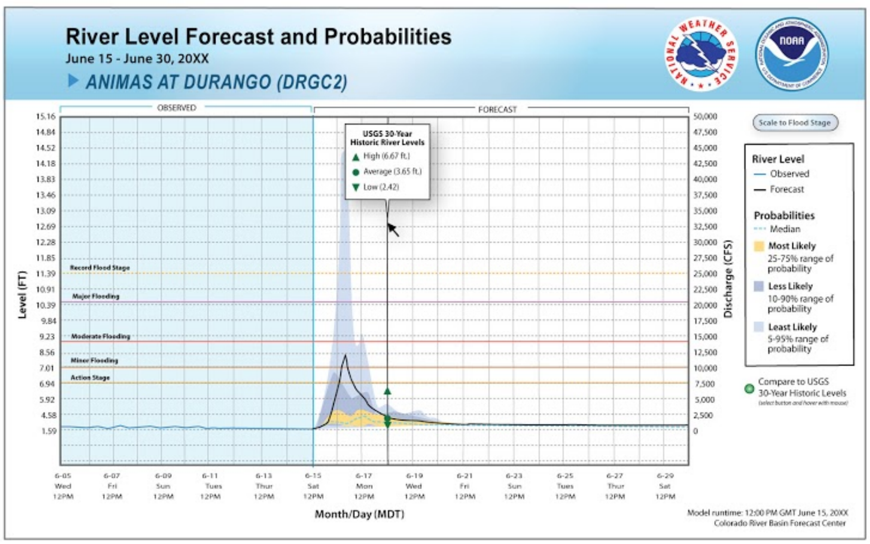
- [ ] I would have less confidence in both forecasts
- [ ] I would have less confidence in the deterministic forecast
- [ ] I would have less confidence in the probabilistic forecast
- [ ] I would not trust future forecasts from this source
- [ ] I would seek out more information to understand why they differed
- [ ] I would ask a forecaster/expert for their opinion
- [ ] I would ignore the forecast

Other: [ ] ____________________

Skip to question 60

Durango, CO

Use the product below to answer the following questions.



49. What is this product telling you (check all that apply)? *

Check all that apply.

- [ ] No moderate or major flooding is likely to occur June 15-30th
- [ ] Minor flooding is likely on June 16th.
- [ ] Action stage and minor flooding will not be reached June 15-30th
- [ ] River levels will be at average on June 18th

Other: [ ] ____________________

50. After viewing this product how do you view the risk of flooding in the time period June 15th-30th? *

Mark only one oval.

- Very high
- Somewhat high
- Neither high nor low
- Somewhat low
- Very low
- Other: ______________________

51. Would you take any actions as a result of this product? *

Mark only one oval.

- Yes
- No
- Maybe

52. If yes, what actions would you take as a result of this product (check all that apply).

Check all that apply.

- [ ] Seek out more information
- [ ] Talk to family, friends, and neighbors.
- [ ] Take action to secure outdoor property and reduce property loss from flooding
- [ ] Make sure to have an emergency preparedness kit/stock up on food, water, and batteries
- [ ] Keep an eye on the river

Other: [ ] ______________________

53. If no, why (check all that apply)?

Check all that apply.

- [ ] I'm not concerned about flooding risk
- [ ] The information in this product doesn't tell me enough
- [ ] I don't believe the forecast
- [ ] I don't know what actions to take

Other: [ ] ______________________

54. How useful is this product (select one)? *

Mark only one oval.

- Very useful
- Somewhat useful
- Neutral (neither useful nor not useful)
- Somewhat not useful
- Not useful

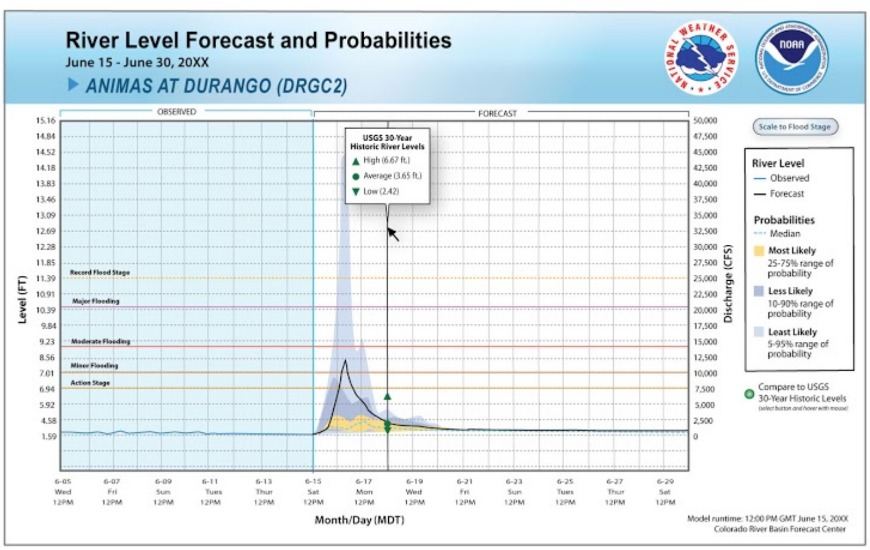
55. How likely are you to use this product in the future? *

Mark only one oval.

- Very likely
- Somewhat likely
- Neutral (neither likely nor unlikely)
- Somewhat unlikely
- Very unlikely

River Level Probabilities

Use the product below to answer the following questions.



56. What elements of this product are most useful in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legends
- [ ] Colors
- [ ] Percentages (5-95%, 10-90%, 25-75%)
- [ ] Likely categories (most, less, least)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] Discharge (right axis)
- [ ] Median line
- [ ] Range of probable levels (different shades/colors)
- [ ] Forecaster's note
- [ ] USGS Historic River Levels Comparison
- [ ] Scale to flood stage option (button at top right)
- [ ] None

Other: [ ] ____________________

57. What elements of this product are not useful or confusing to you in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legends
- [ ] Colors
- [ ] Percentages (5-95%, 10-90%, 25-75%)
- [ ] Likely categories (most, less, least)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] Discharge (right axis)
- [ ] Median line
- [ ] Range of probable levels (different shades/colors)
- [ ] Forecaster's note
- [ ] USGS Historic River Levels Comparison
- [ ] Scale to flood stage option (button at top right)
- [ ] None

Other: [ ] ____________________

58. What additional information or elements would make this product more useful or understandable to you? *

____
____
____
____
____

59. On June 16th the deterministic forecast (black line) is different from the probabilistic forecast, how does that affect your perception of the forecast given? (check all that apply) *

Check all that apply.

- [ ] I would have less confidence in both forecasts
- [ ] I would have less confidence in the deterministic forecast
- [ ] I would have less confidence in the probabilistic forecast
- [ ] I would not trust future forecasts from this source
- [ ] I would seek out more information to understand why they differed
- [ ] I would ask a forecaster/expert for their opinion
- [ ] I would ignore the forecast

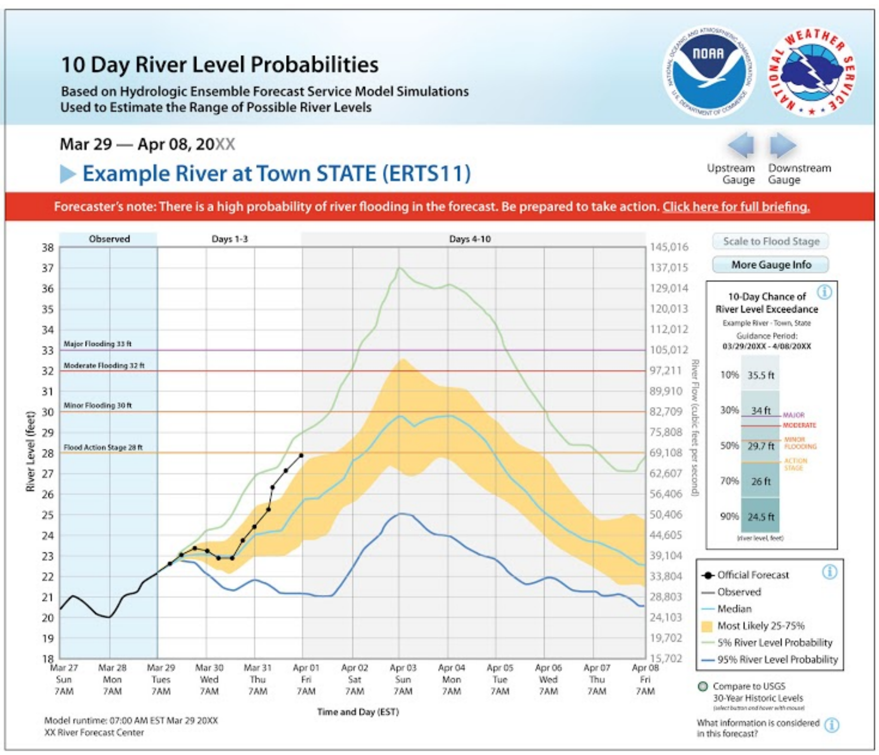
Other: [ ] ____________________

Skip to question 60

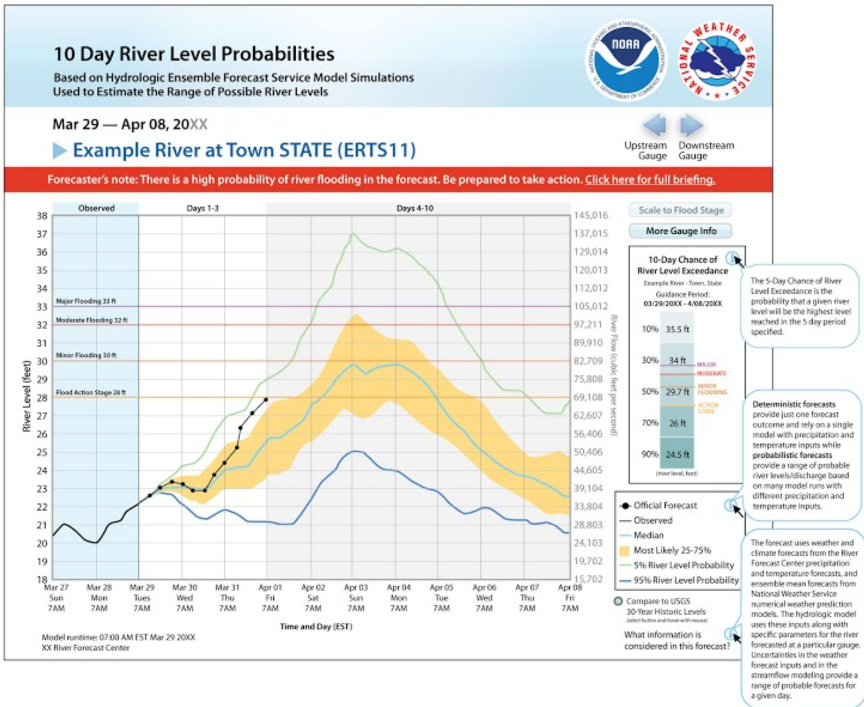
National Product

NOAA is considering developing a national flood level probability product that would have the same features across all forecasting areas. Your input on this possible graphic will help inform that development. Please note that this is an example gauge site of a hypothetical flood situation. The product is shown multiple times with different elements added to reflect the options that would be available on an interactive graph.

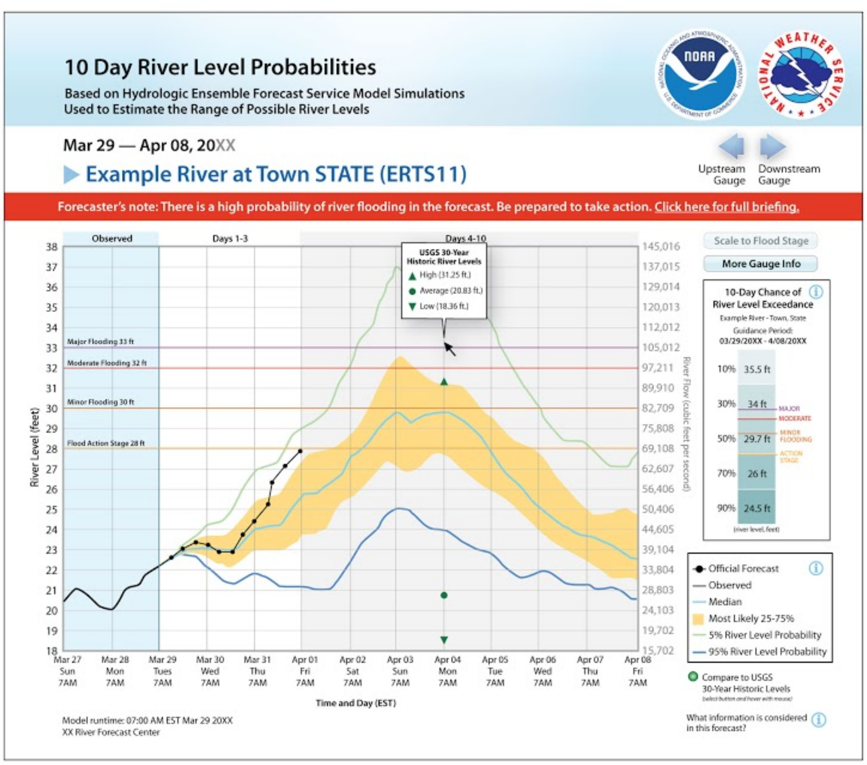
National Product prototype example



National Product example with information (i) boxes expanded



National Product example with USGS Historic River Level Comparison shown



60. What elements of this product are most useful in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legend
- [ ] Colors
- [ ] Percentages (25-75%)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] River Flow (right axis)
- [ ] Median line
- [ ] 5% and 95% River Level Probability Lines
- [ ] Forecaster's note
- [ ] 10 Day Chance of River Level Exceedance (box on the right side)
- [ ] Option to move to upstream and downstream gauges (arrows at the top)
- [ ] USGS Historic River Level Comparison
- [ ] Information boxes (i)
- [ ] Scale to flood stage option (button at top right)
- [ ] None

Other: [ ] ______________________

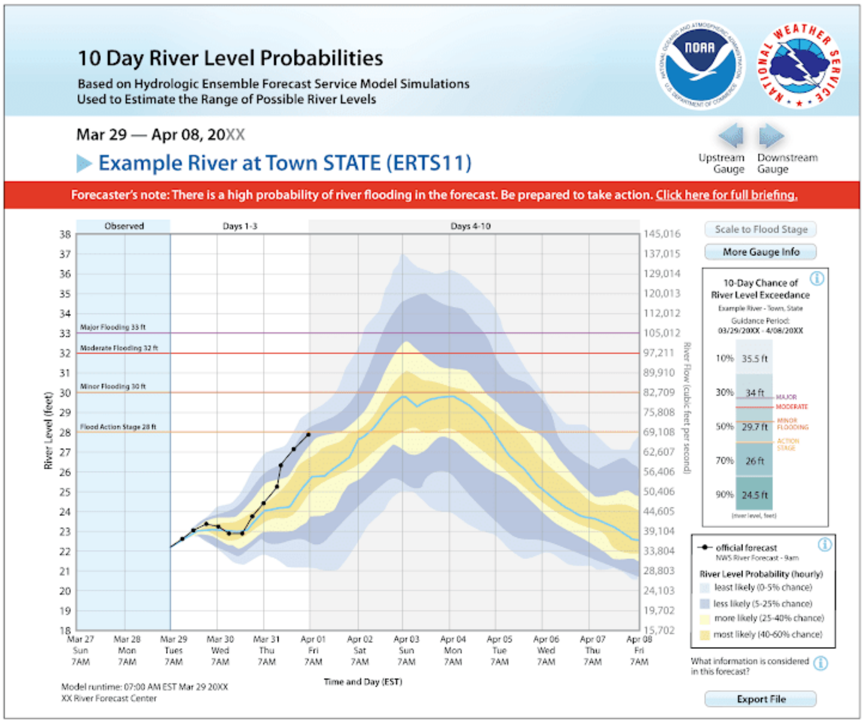
61. What elements of this product are not useful or confusing to you in understanding the situation (check all that apply). *

Check all that apply.

- [ ] Title
- [ ] Legend
- [ ] Colors
- [ ] Percentages (25-75%)
- [ ] Time period
- [ ] Flood levels (minor, moderate, and major)
- [ ] River level (left axis)
- [ ] River Flow (right axis)
- [ ] Median line
- [ ] 5% and 95% River Level Probability Lines
- [ ] Forecaster's note
- [ ] 10 Day Chance of River Level Exceedance (box on the right side)
- [ ] Option to move to upstream and downstream gauges (arrows at the top)
- [ ] USGS Historic River Level Comparison
- [ ] Information boxes (i)
- [ ] Scale to flood stage option (button at top right)
- [ ] None

Other: [ ] ______________________

Alternate National Product example with Shaded Probabilities



62. Are the likely categories (least, less, more, most)... *

Mark only one oval.

	1	2	3	4	5	
Confusing (I don't understand what they are telling me)	◯	◯	◯	◯	◯	Easy to understand (they help me assess the situation)

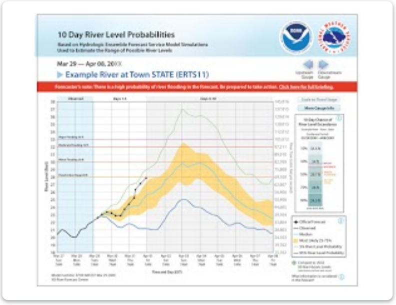
63. Are the percentages (0-5%, 5-10%, 25-40%, 40-60%)... *

Mark only one oval.

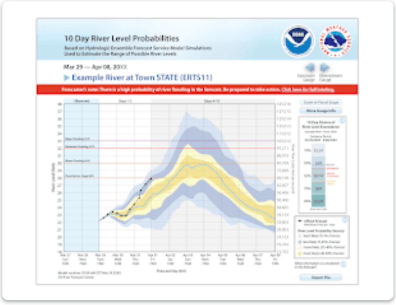
	1	2	3	4	5	
Confusing (I don't understand what they are telling me)	◯	◯	◯	◯	◯	Easy to understand (they help me assess the situation)

64. Which product do you prefer? *

Mark only one oval.



Option 1



Option 2

65. Why did you select that option? *

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