

African Easterly Waves and Atlantic Hurricanes

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Connections: African Sahel and North Carolina



Drought
Niger, West Africa

**When West Africa
gets more rain, we
get more
hurricanes!**



Floyd aftermath
Greenville, NC

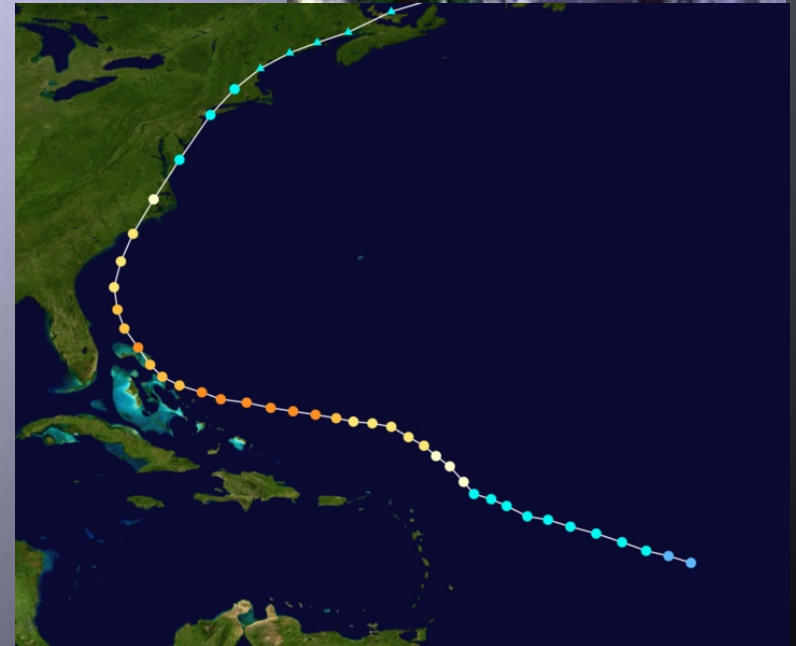
Hurricane Dennis (1999)

- Formed from an African Easterly Wave that left the coast of Africa on Aug 17



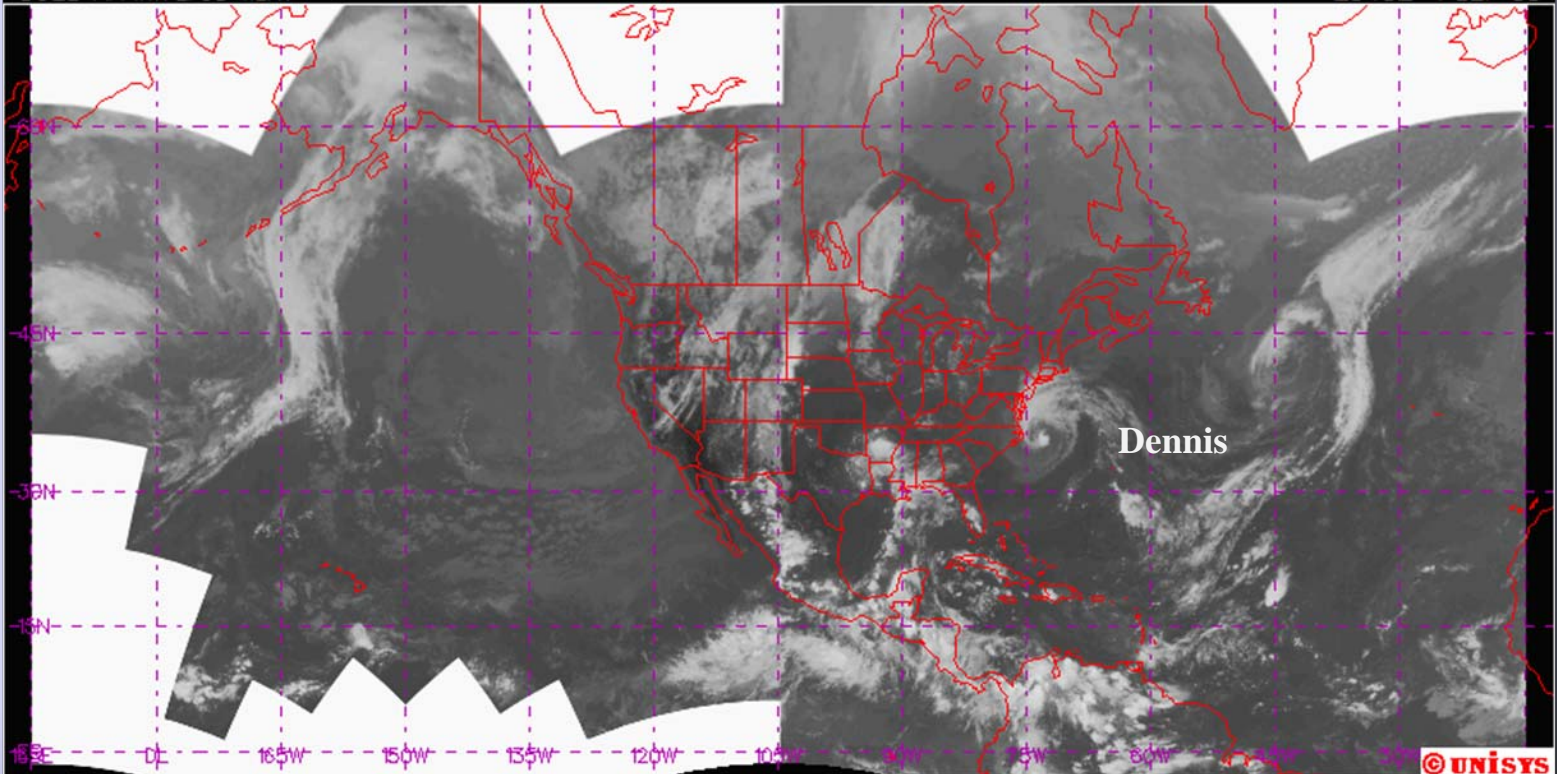
Hurricane Floyd (1999)

- Formed from an African Easterly Wave that left the coast of Africa on September 2



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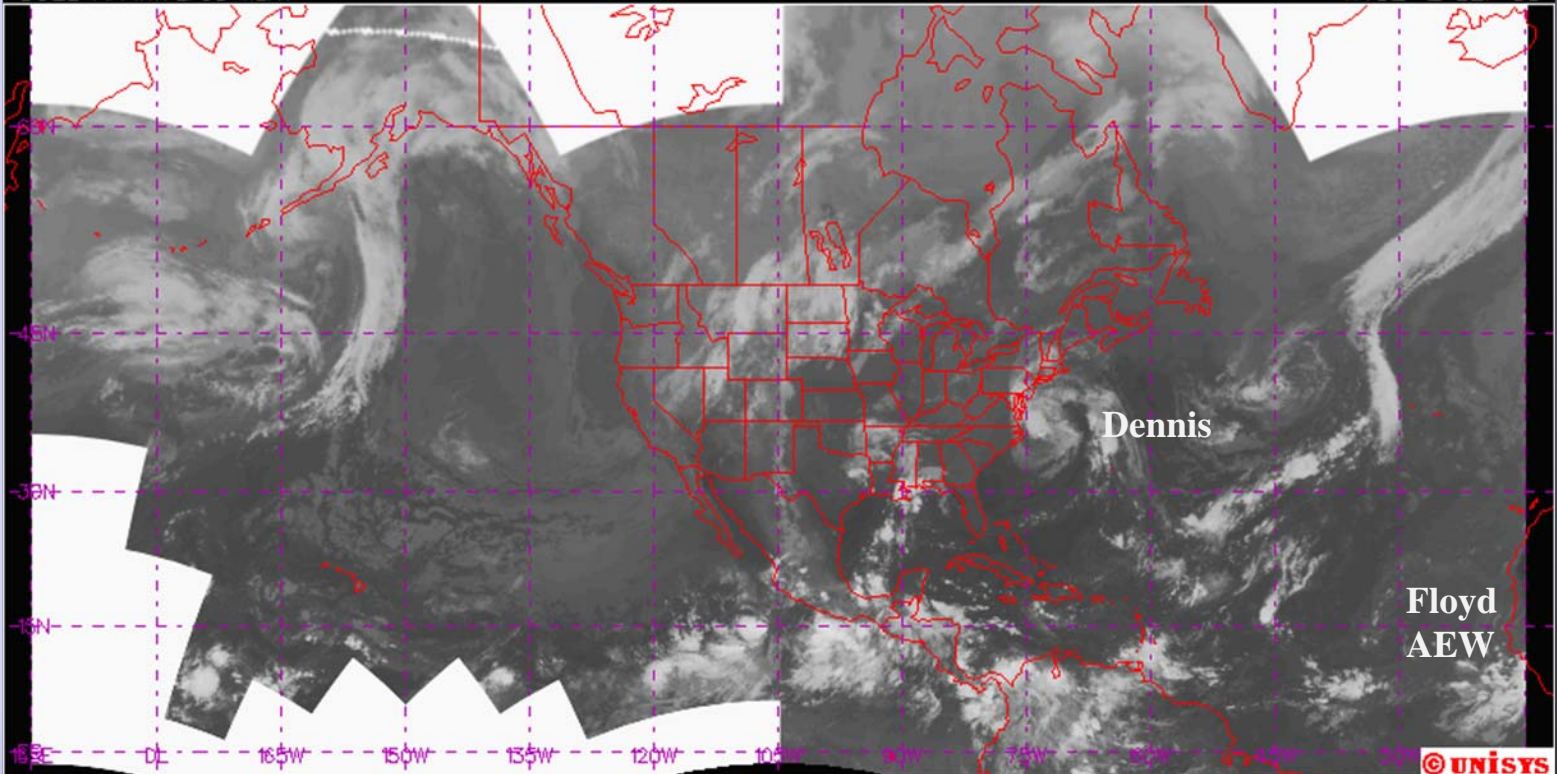


Dennis

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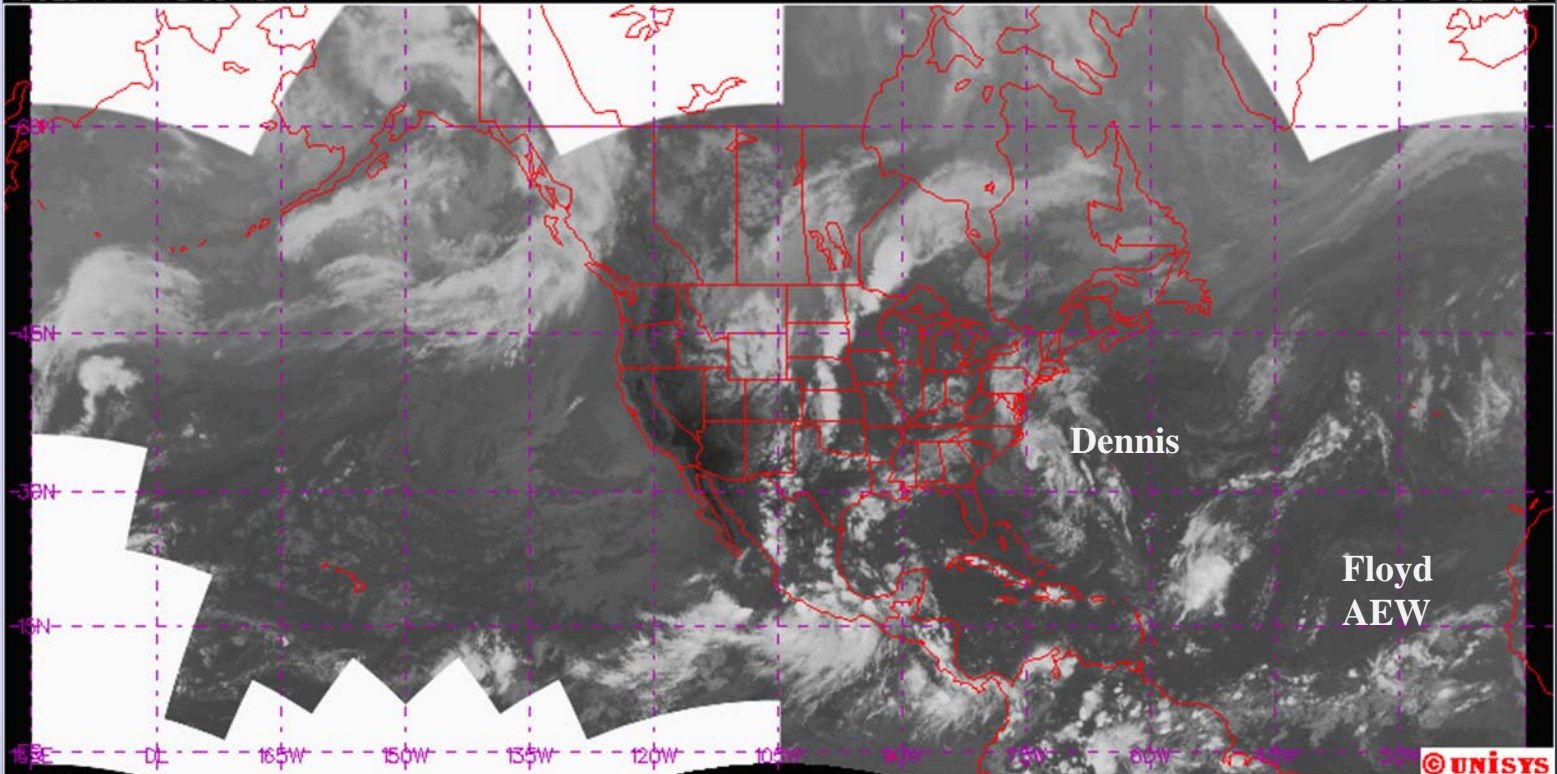
Dennis

Floyd
AEW

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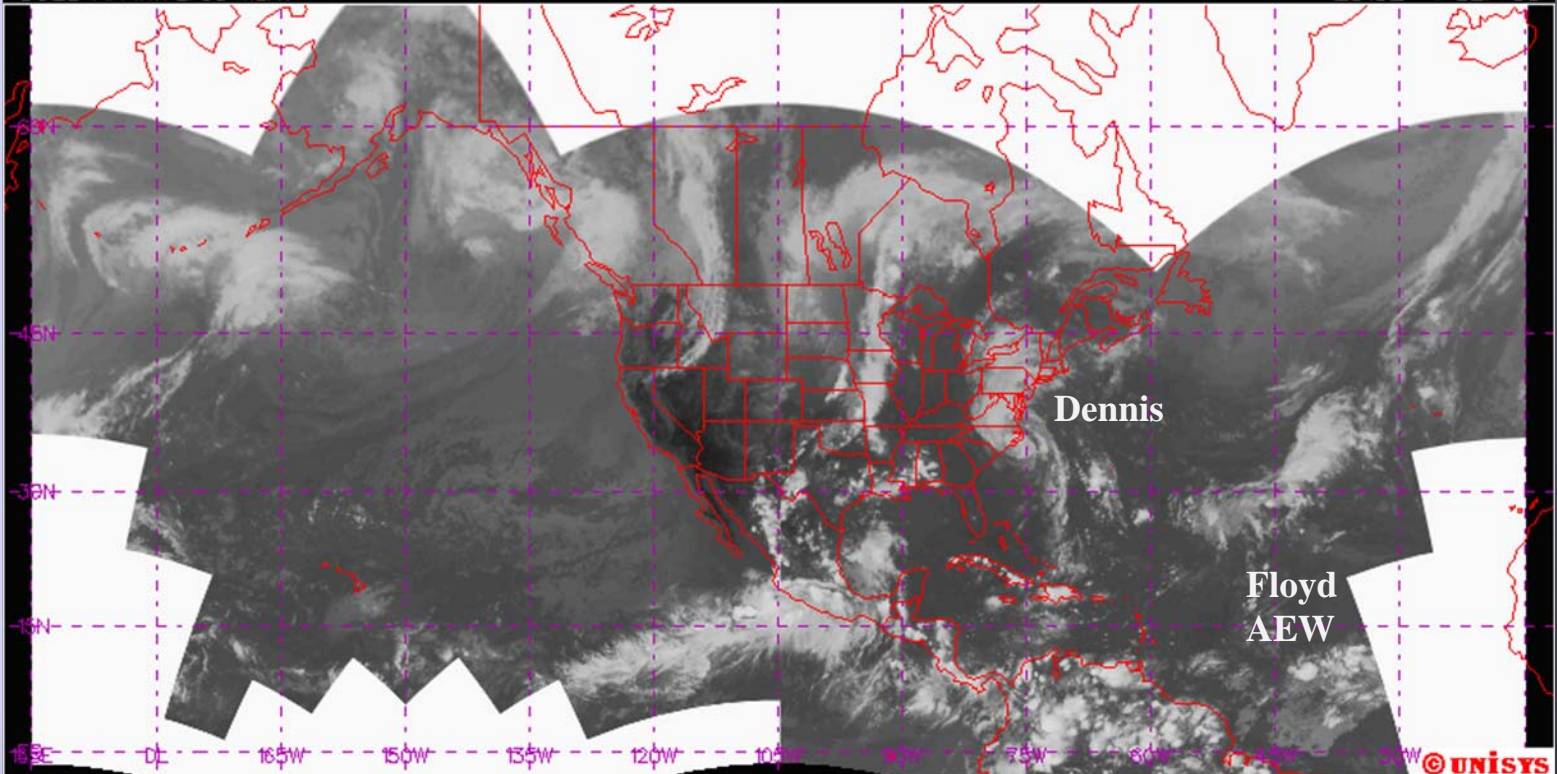
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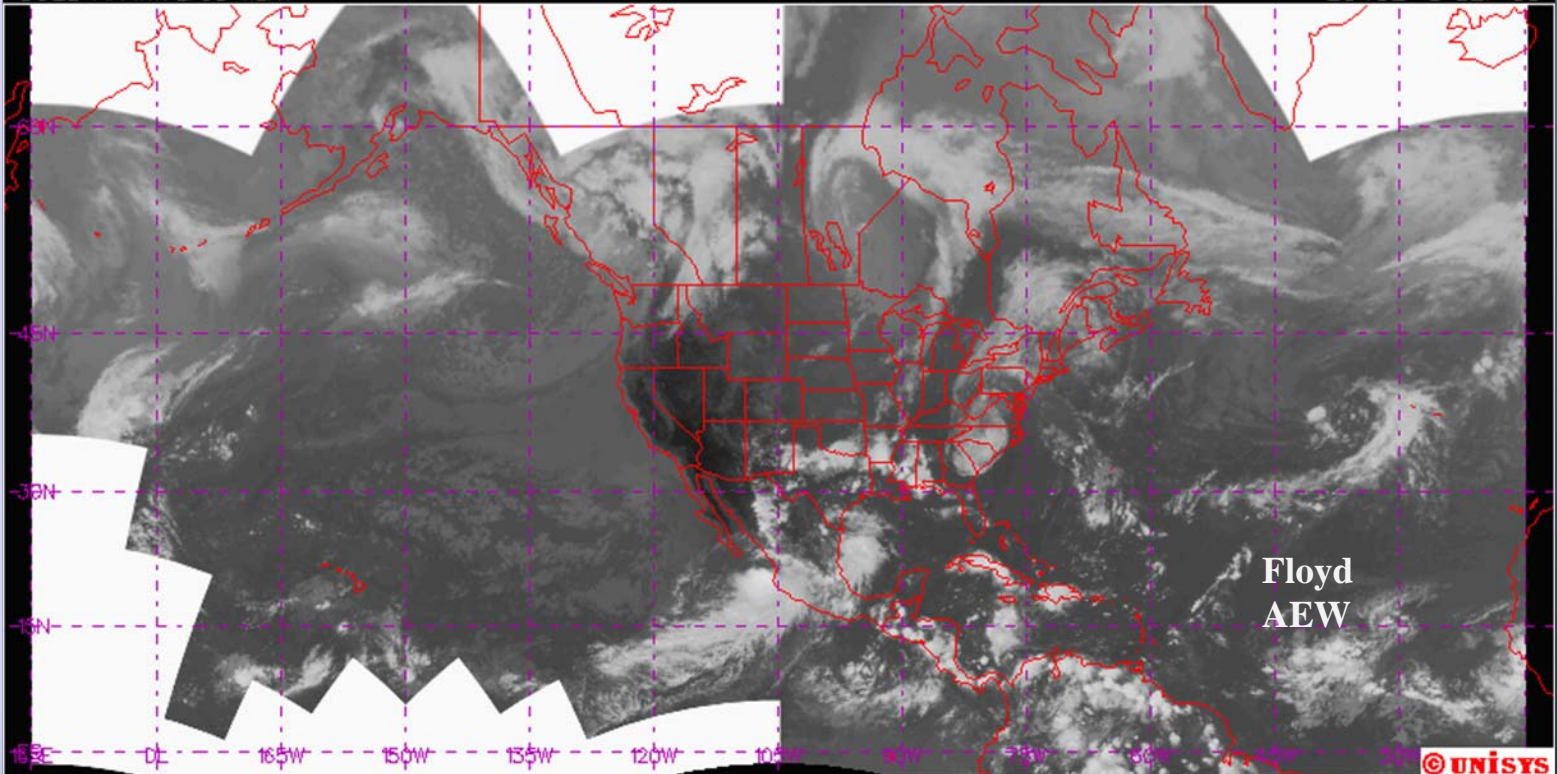
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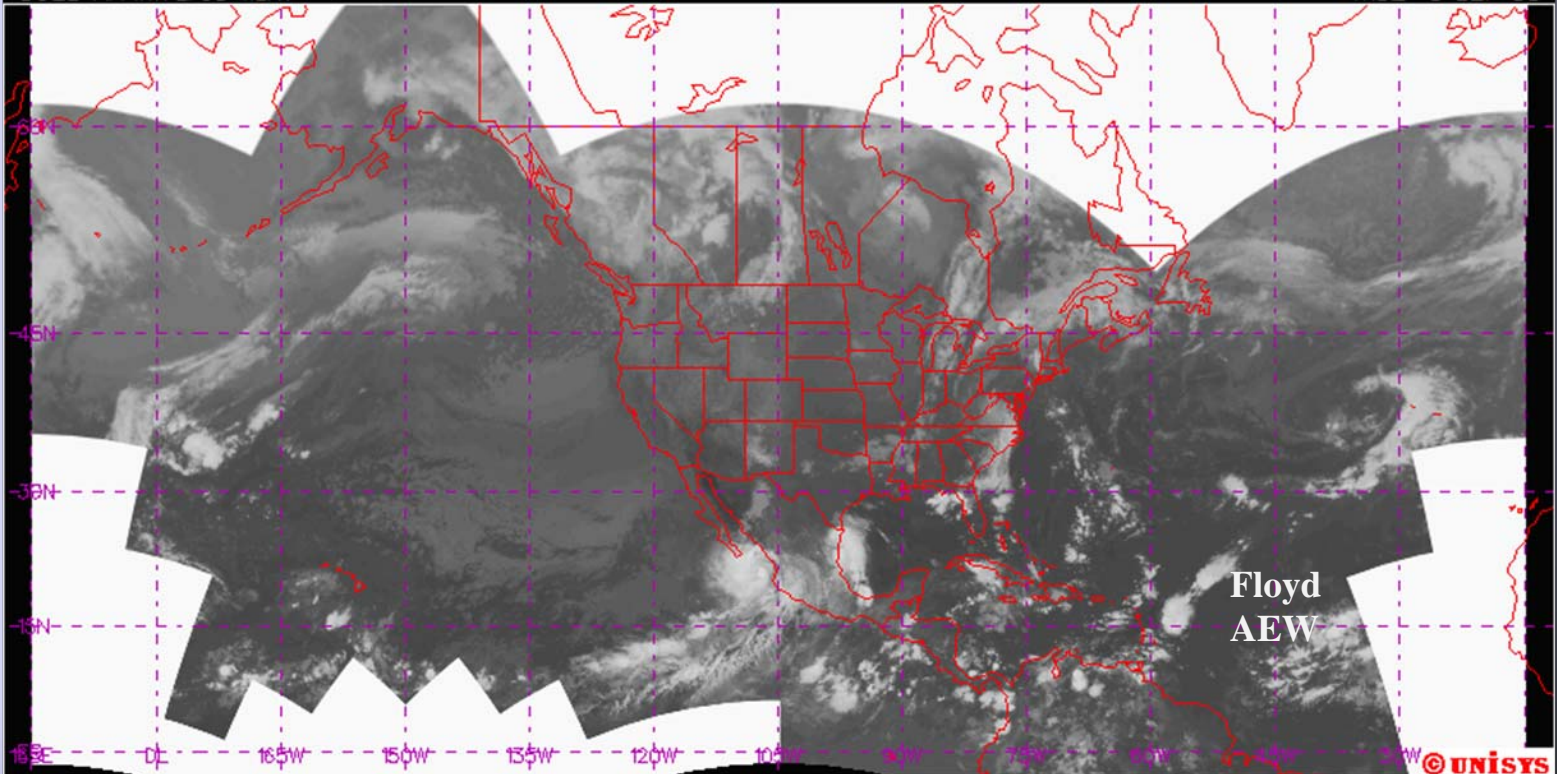
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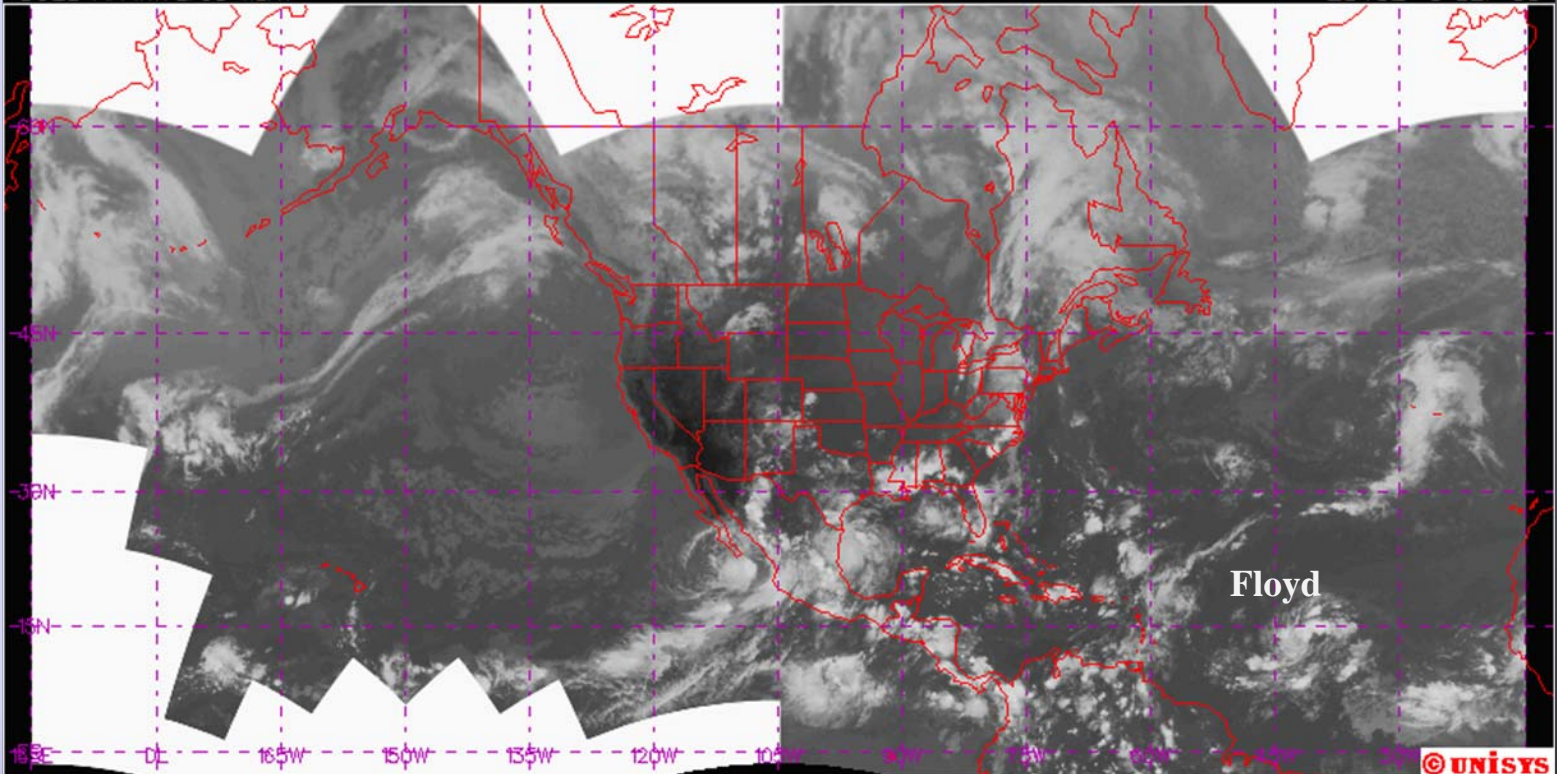


Floyd
AEW

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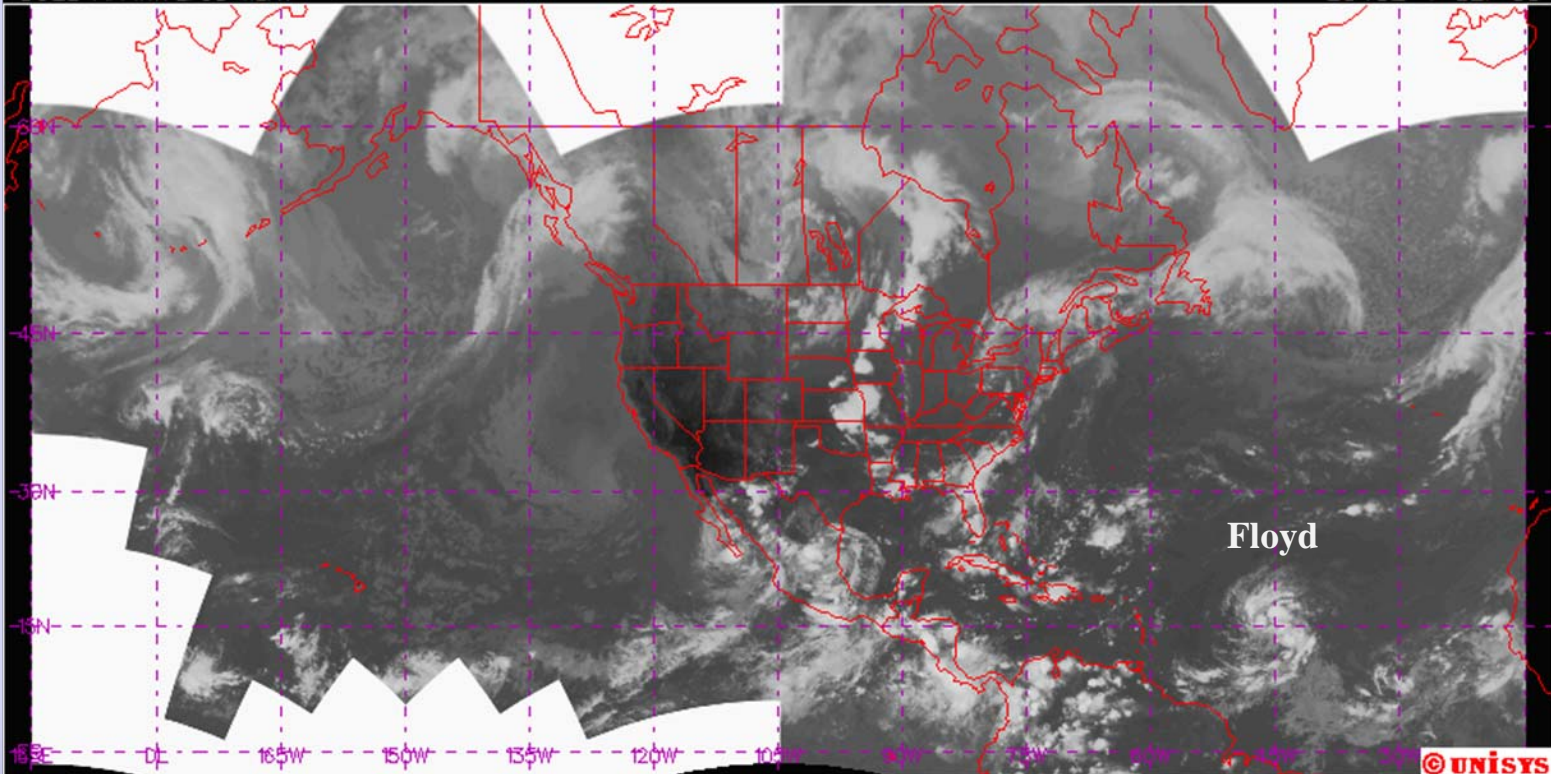
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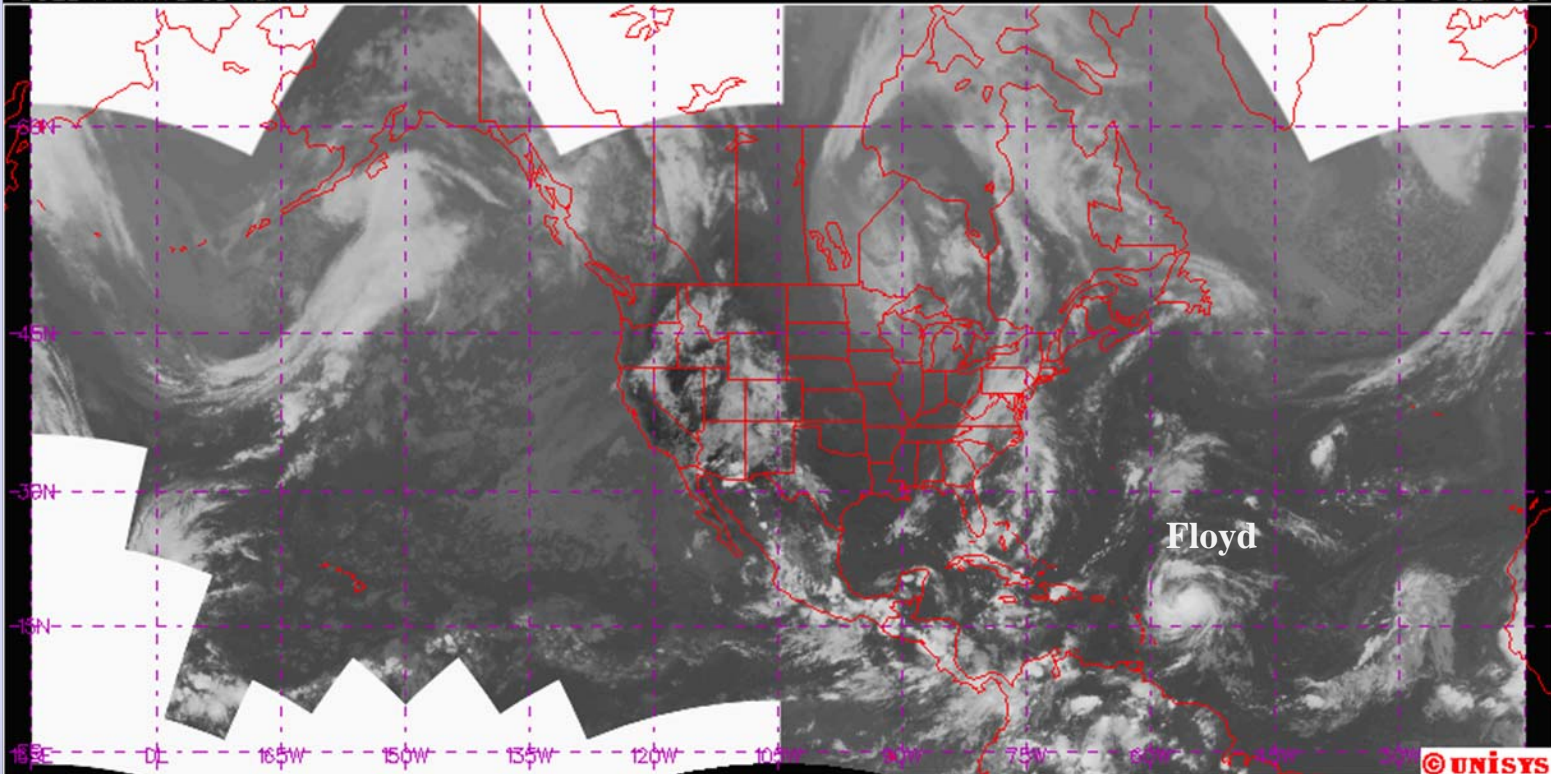
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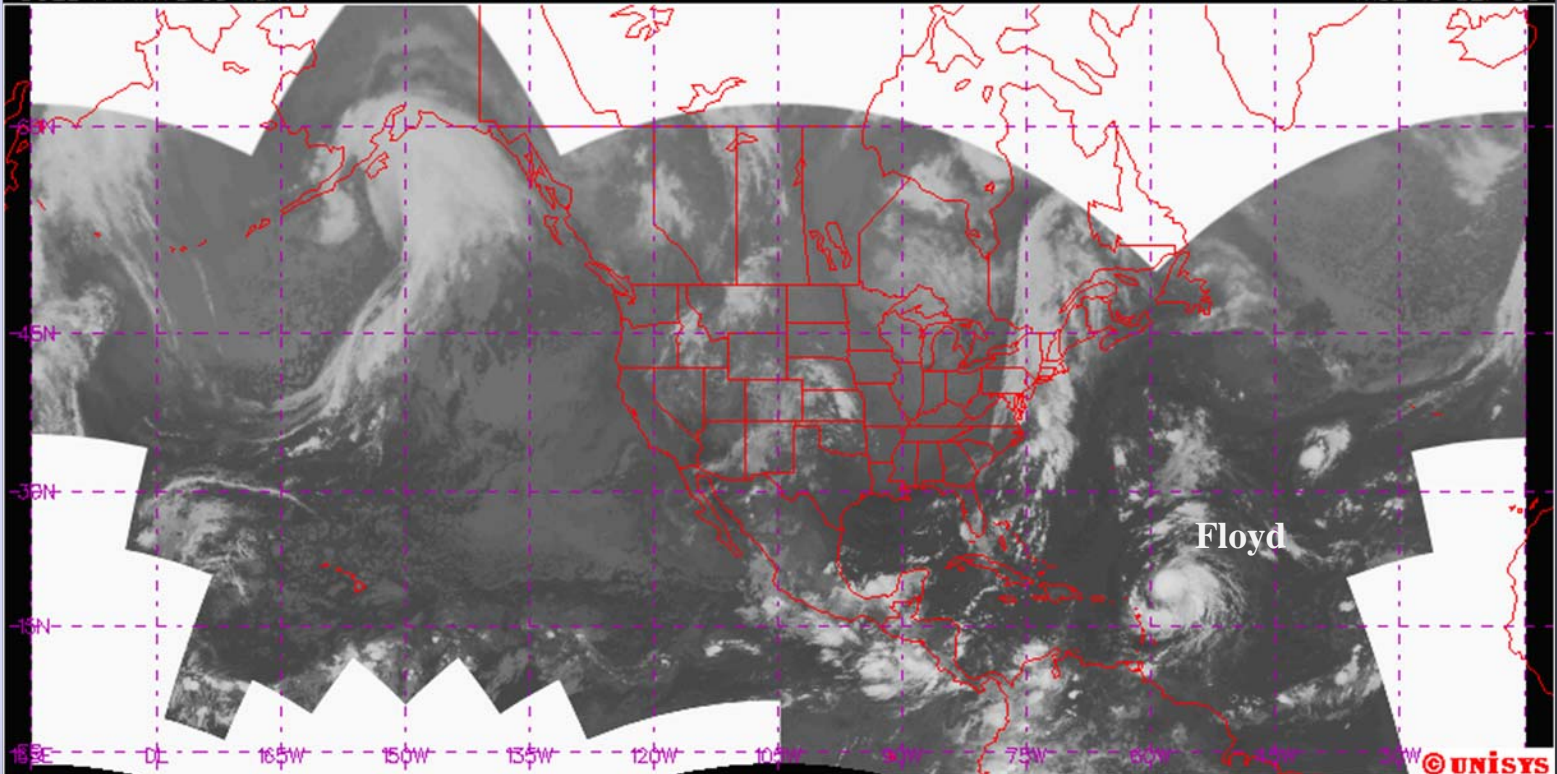


Floyd

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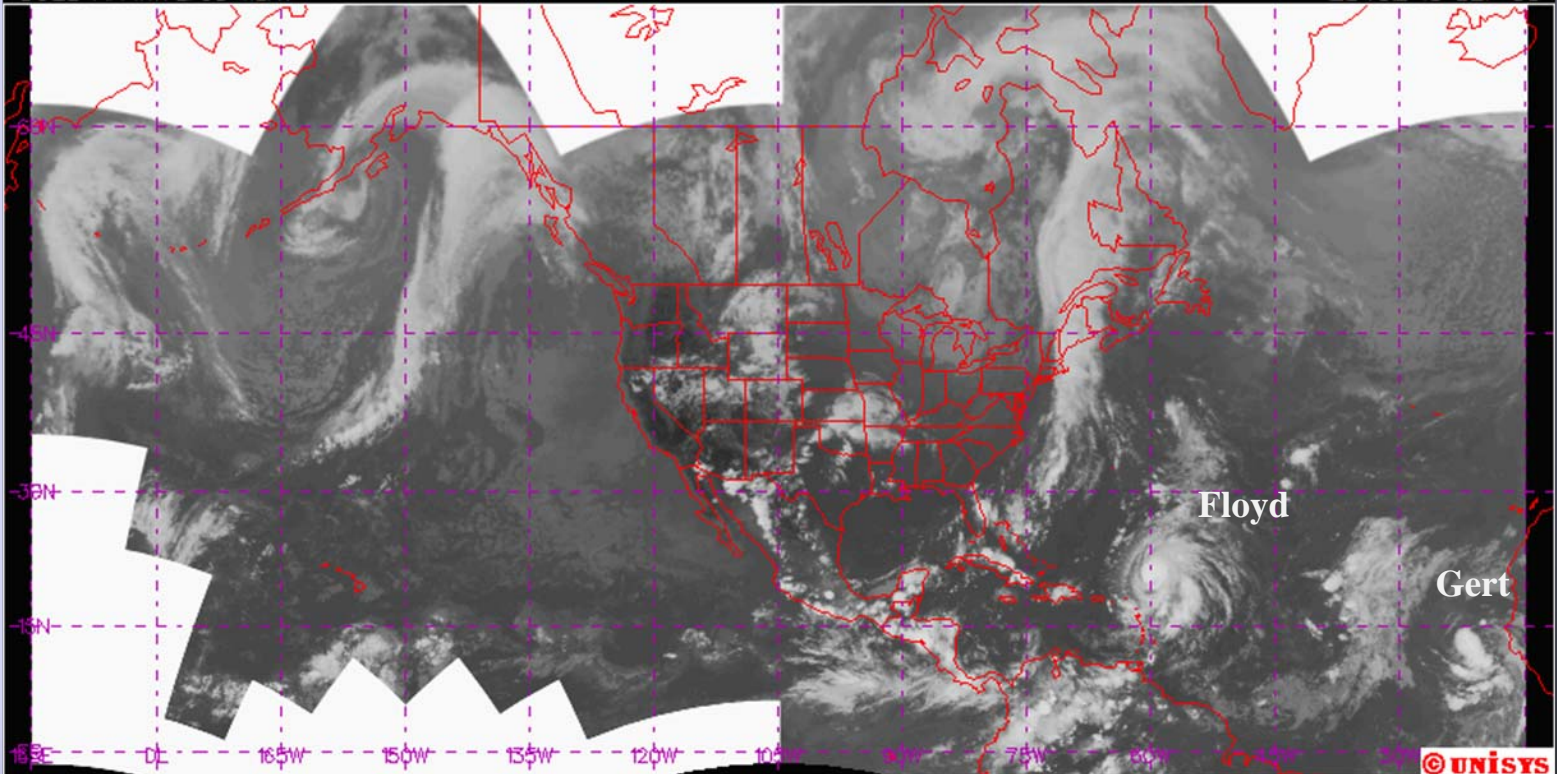
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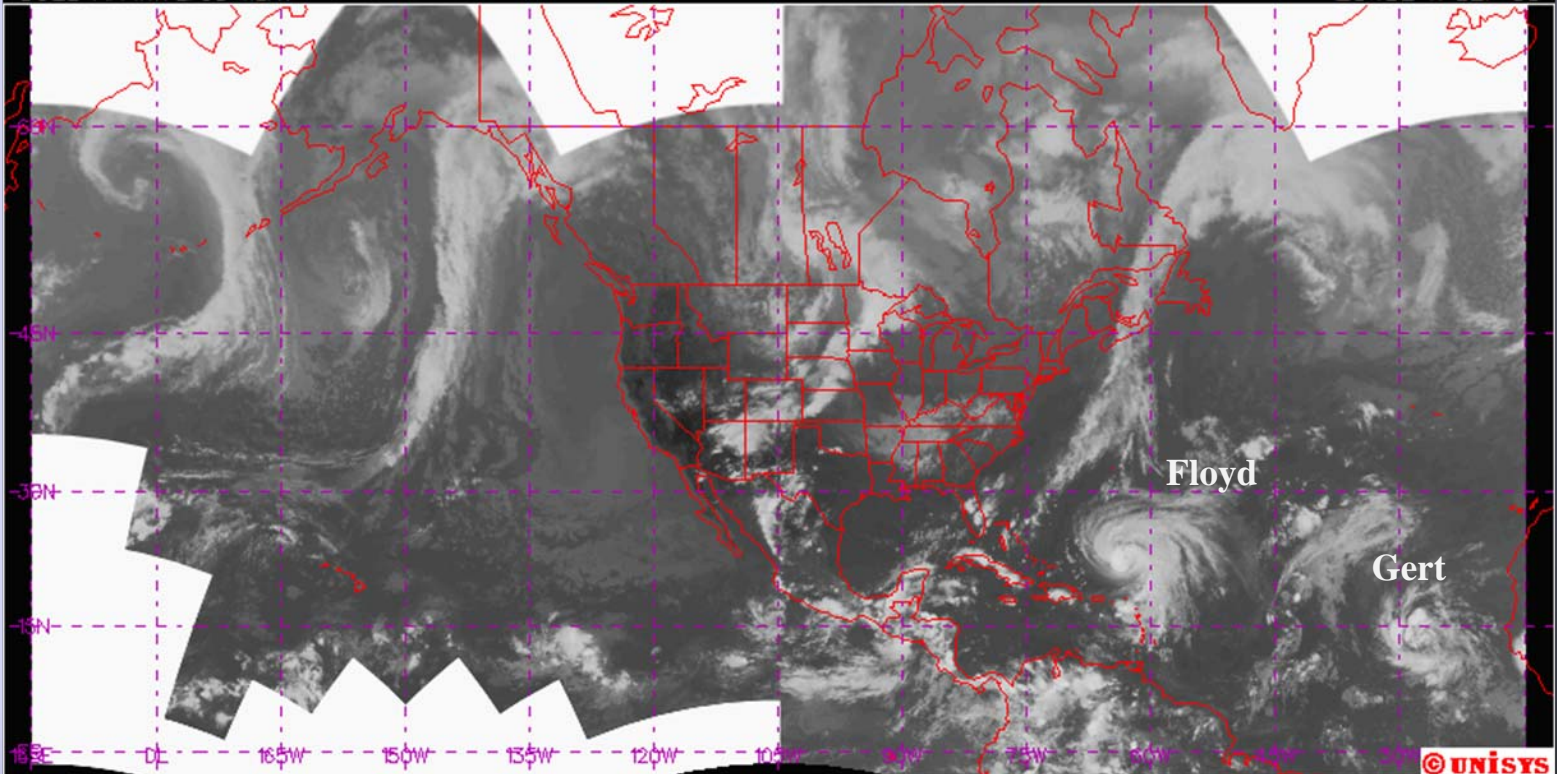
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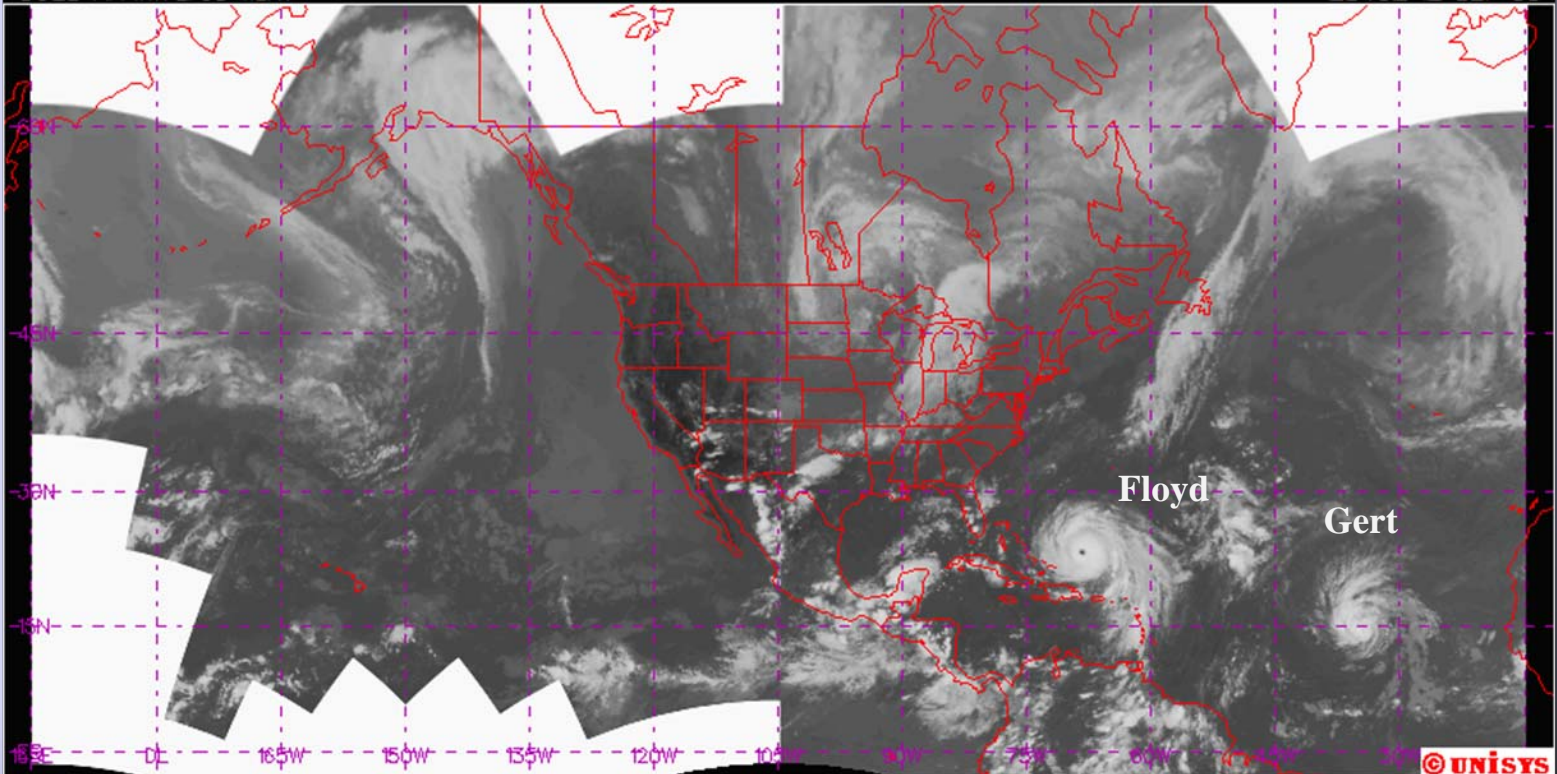
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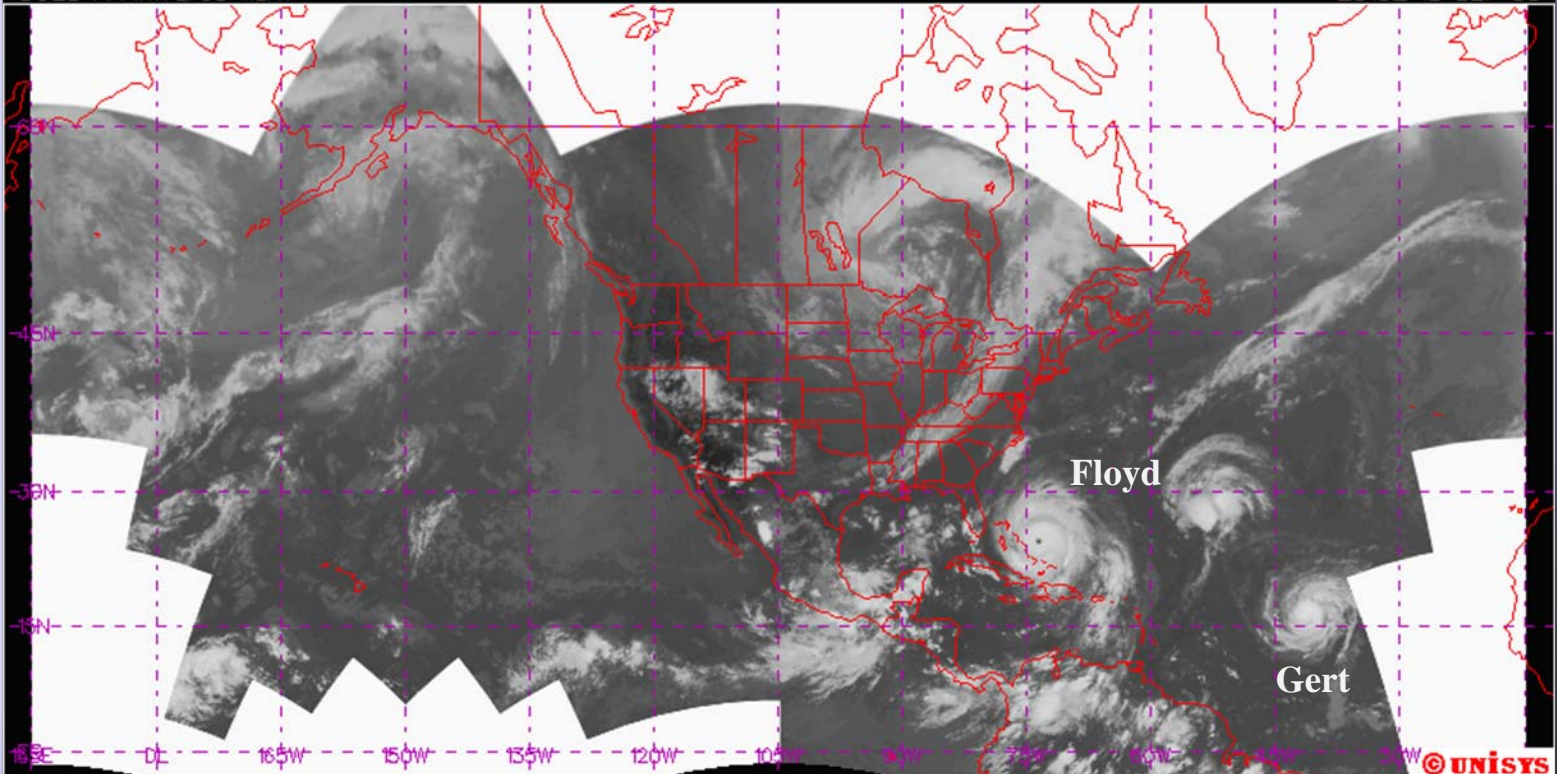
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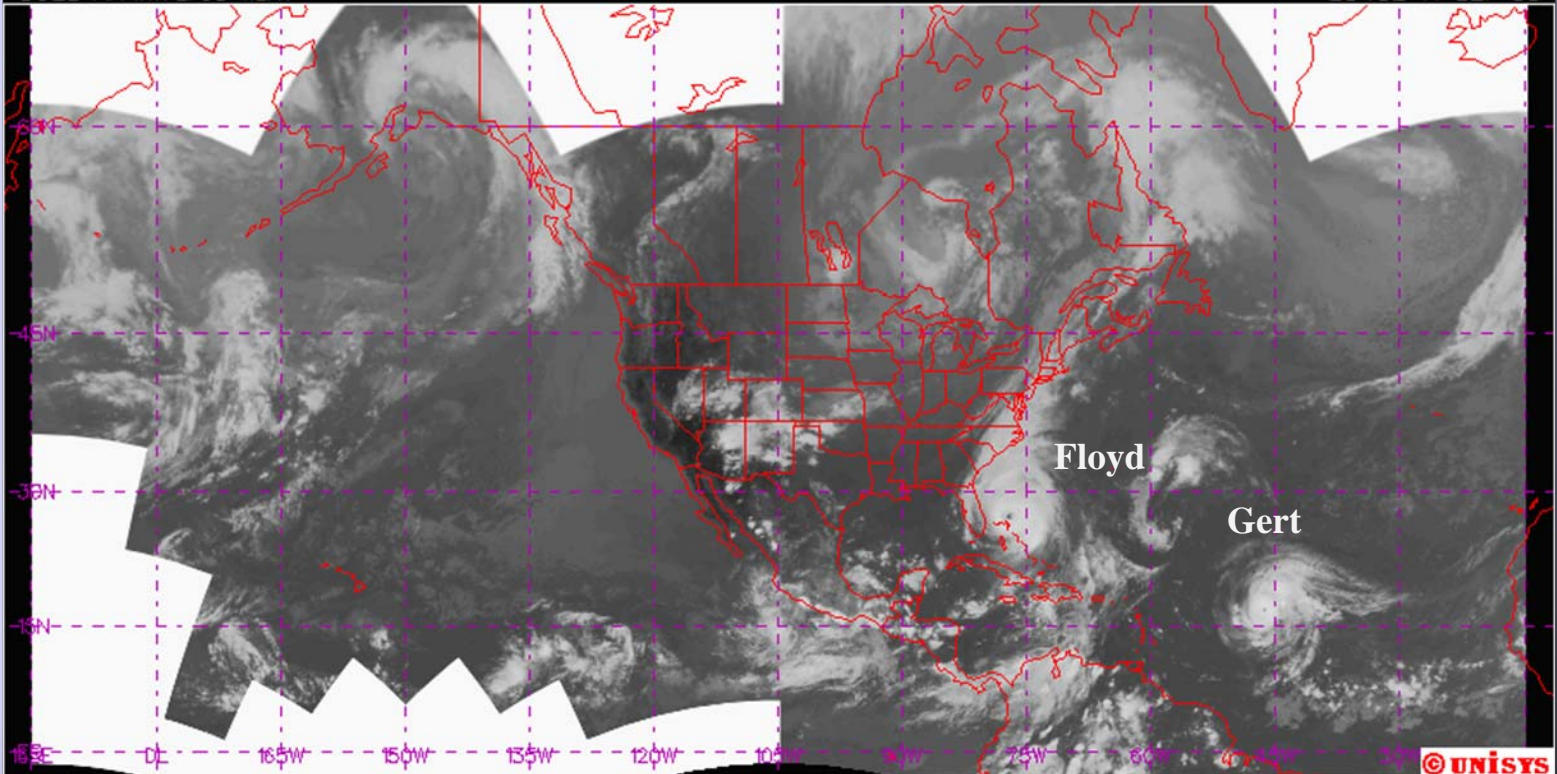
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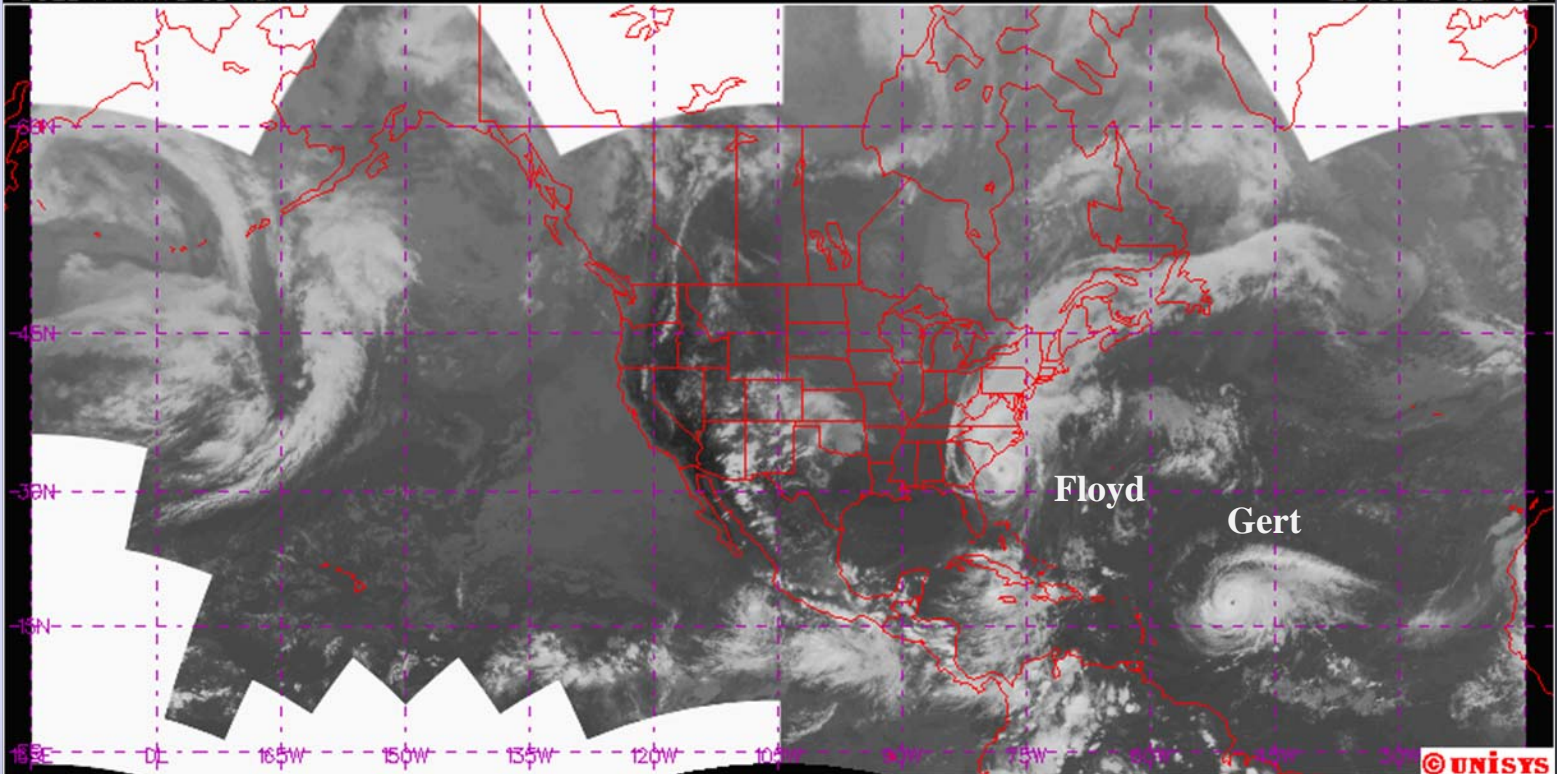
Floyd

Gert

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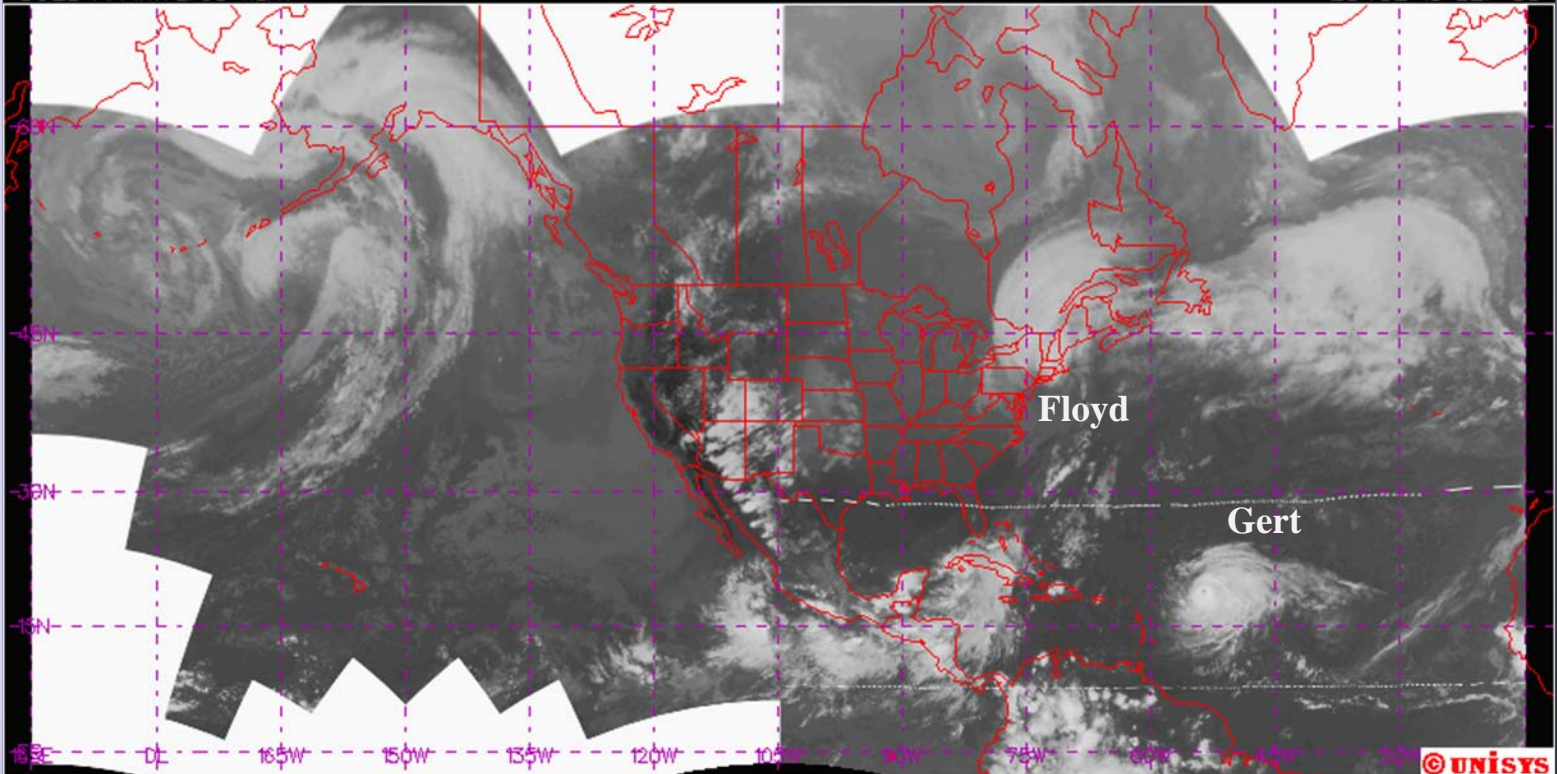
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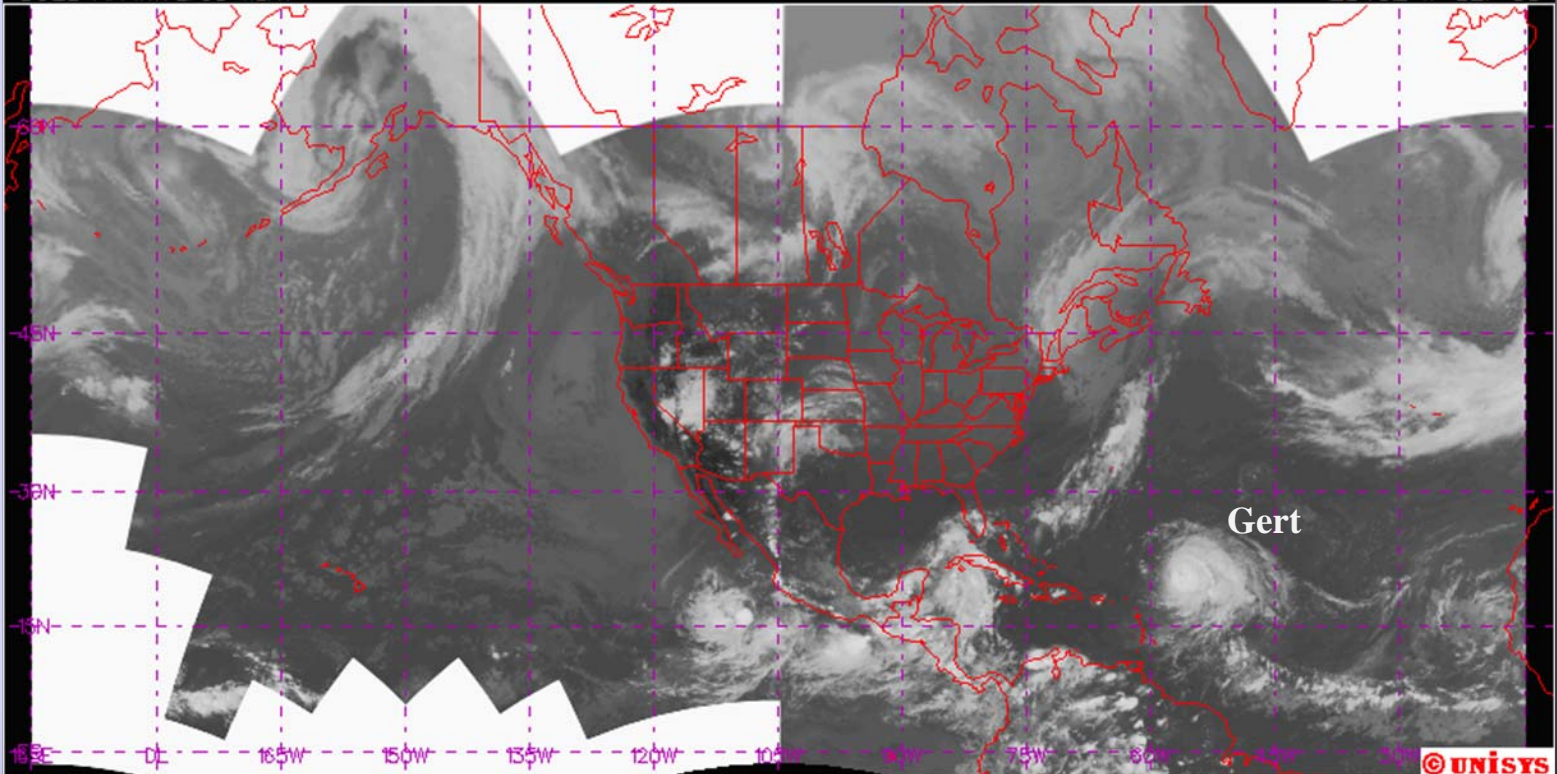
Floyd

Gert

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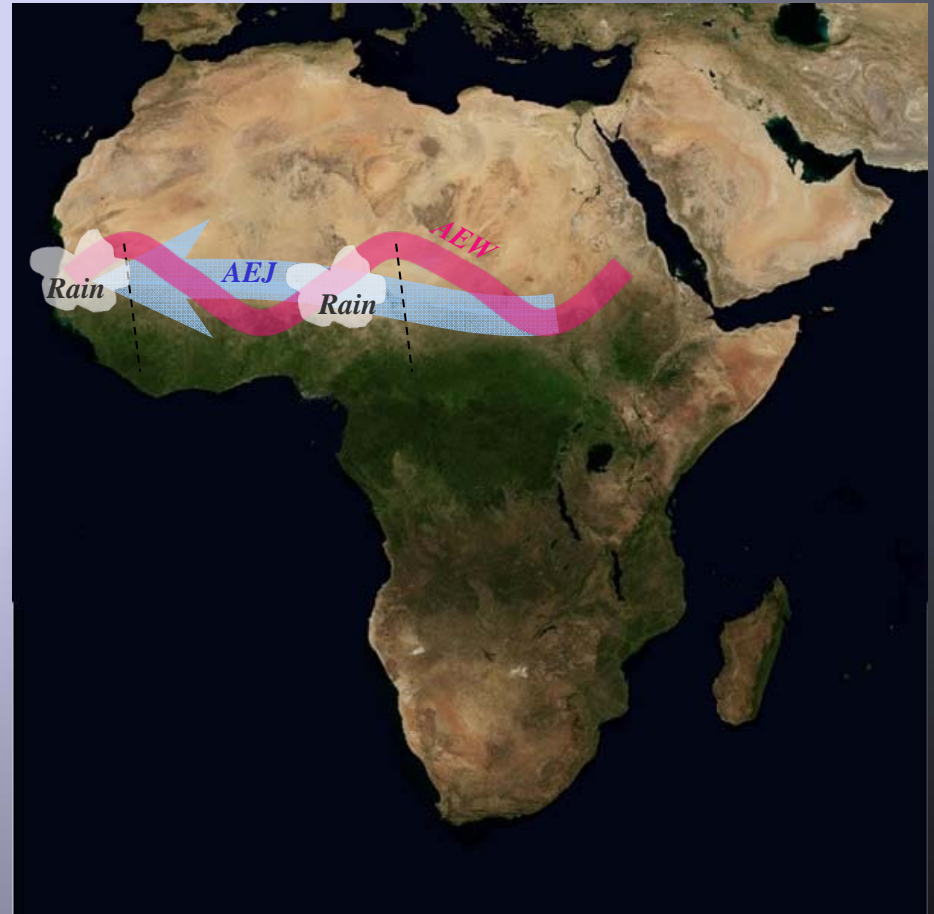
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Atlantic Tropical Cyclones and African Easterly Waves

- More than half of all Atlantic tropical cyclones, including Dennis and Floyd, form in African Easterly Waves
- African Easterly Waves form in the African Sahel.

What is an African Easterly Wave?

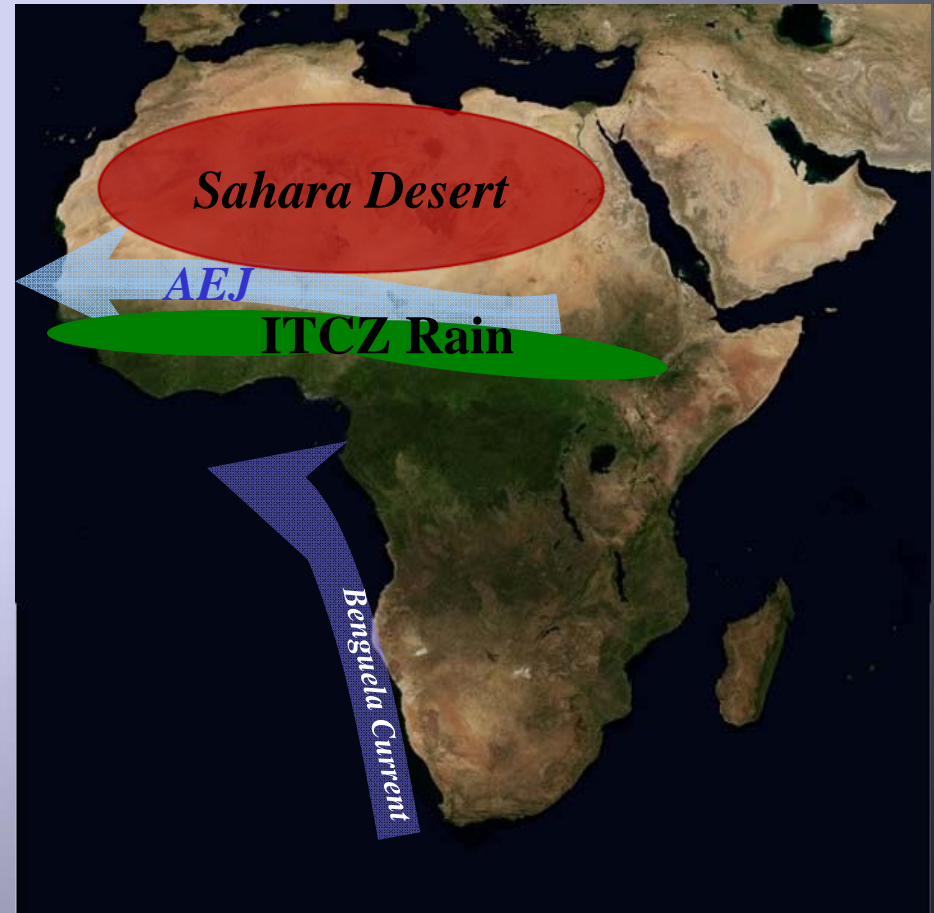
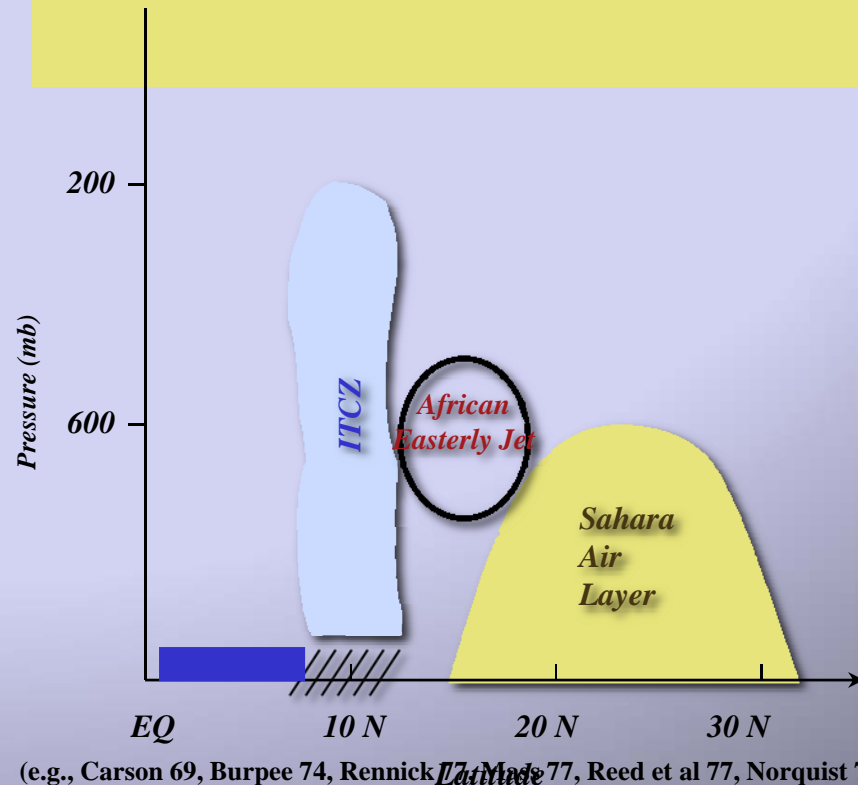
Like our own Jet Stream, cyclonic meandering in winds over the African Sahel favors the formation of storms



African Easterly Jet - AEJ

Formation Mechanisms

- Reversed meridional temperature gradient between warm Sahara and cool Gulf of Guinea
- Intertropical convergence zone (ITCZ) convection



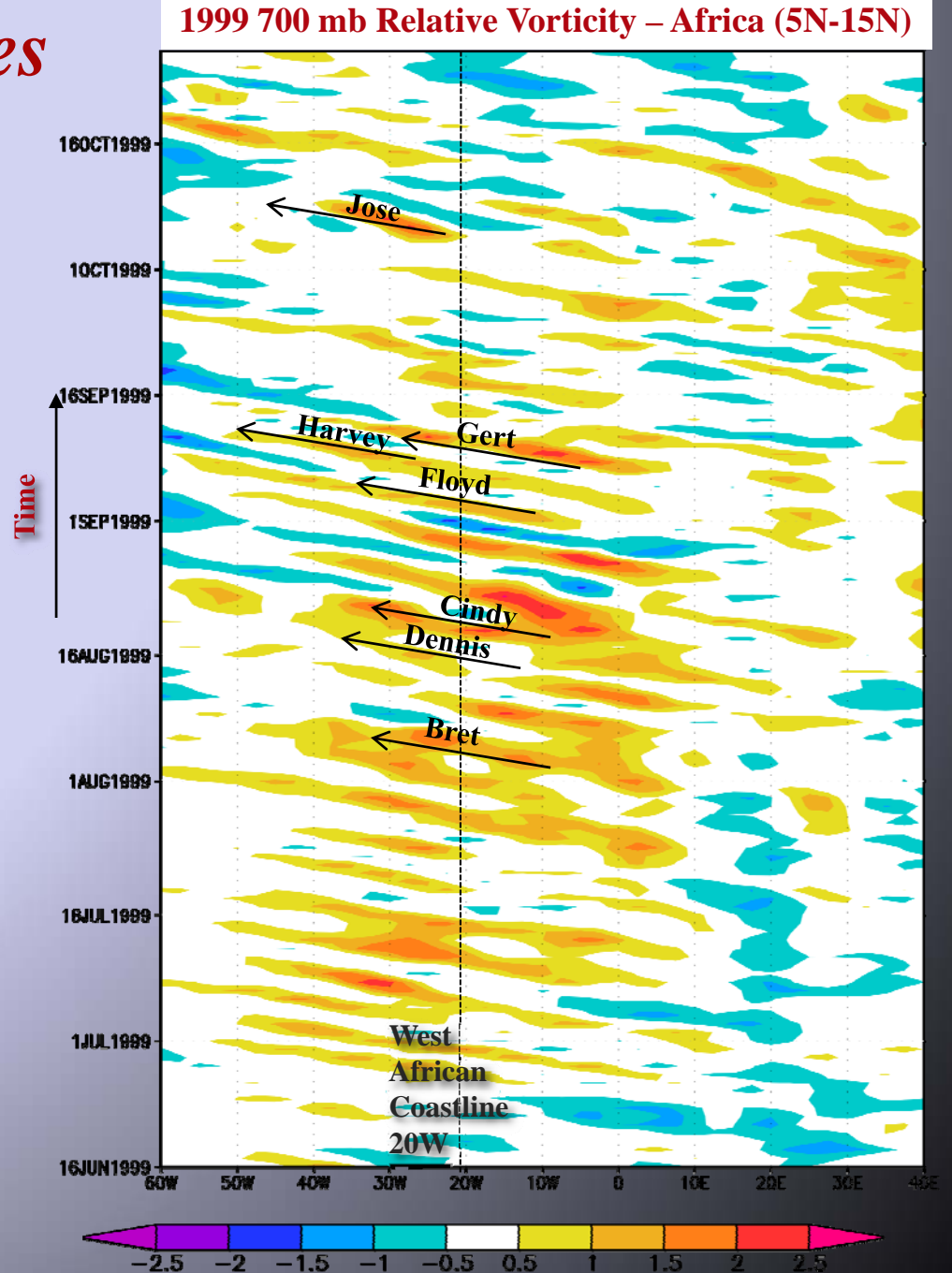
African Easterly Waves

1999

~20 AEW passed through Niamey

8 of 12 Atlantic Tropical Cyclones
Formed in African Easterly Waves

including Hurricanes Dennis and Floyd



AMMA

Field Campaign - Summer 2006

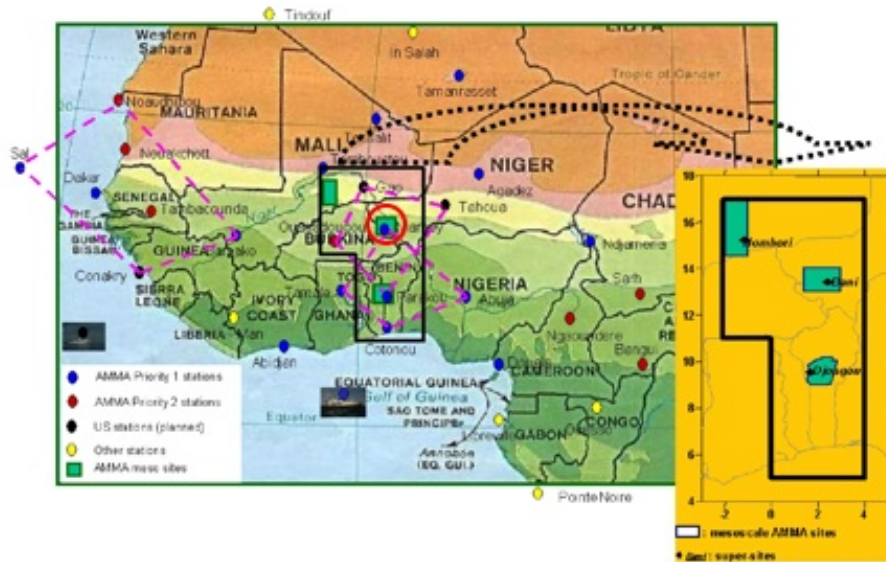


Figure 1. AMMA implementation region in the Sahel region of West Africa. Location of MIT radar (below) shown as red circle.

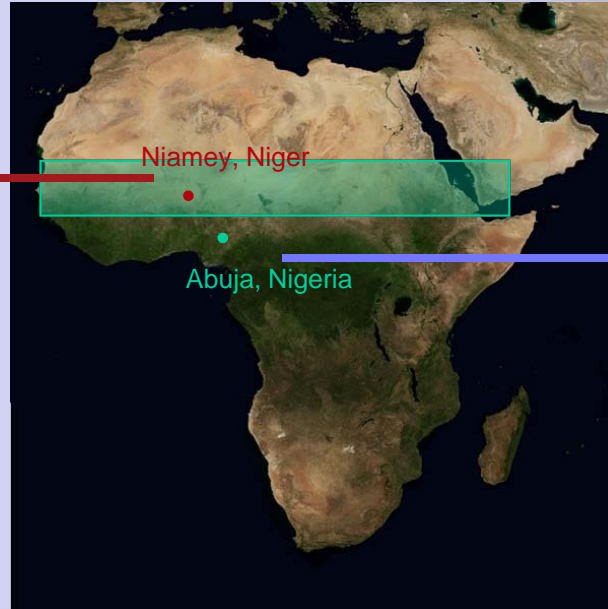
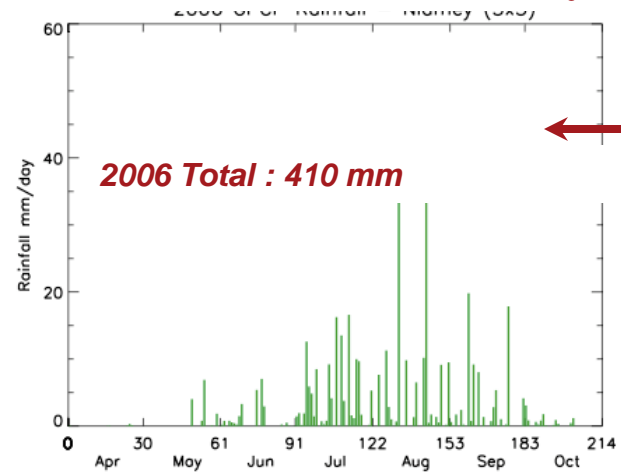


Goal: Study the connections between Sahel Rainfall and Atlantic Hurricanes

Two different regimes of rainfall in Equatorial Africa

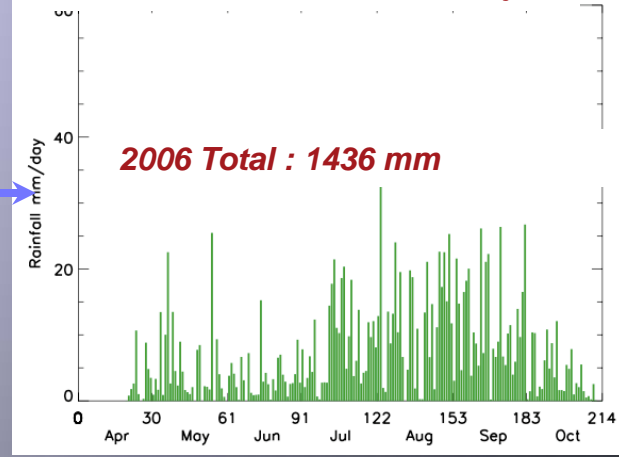
AEW Regime

2006 GPCP 1dd Rainfall - Niamey



ITCZ Regime

2006 GPCP 1dd Rainfall - Abuja



At the peak of the rainy season (JAS),

- It rains every 3-4 days in Niamey.
- About 12 mm per rainy day

At the peak of the rainy season (JAS),

- It rains every day in Abuja.
- About 12 mm per rainy day

African Easterly Waves

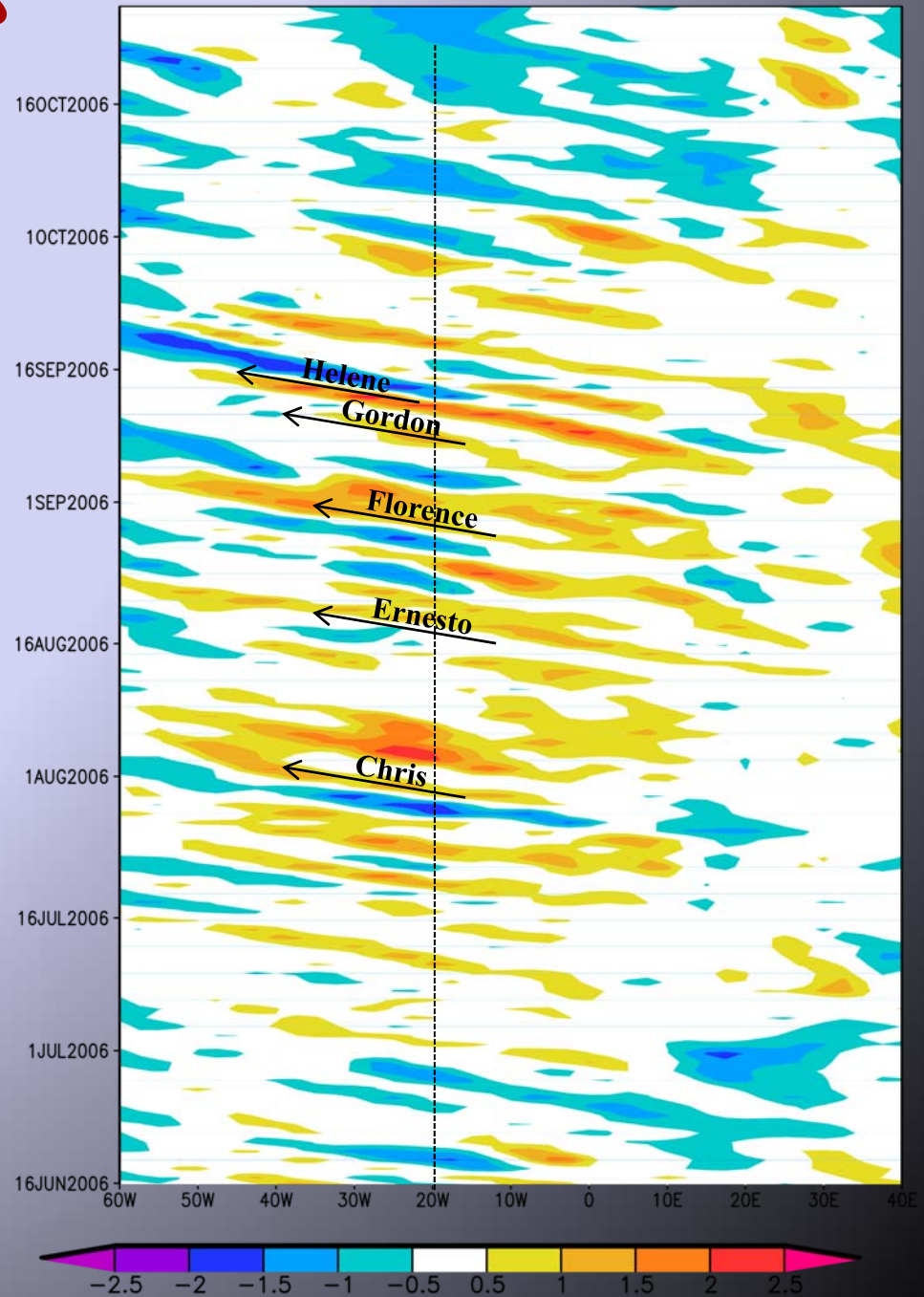
2006

~21 AEW passed through Niamey

**7 of 8 Atlantic Tropical Cyclones
Formed in African Easterly Waves**


*including Hurricane Ernesto and
Tropical Storm Alberto that affected NC*

2006 700 mb Relative Vorticity, Africa (5N-15N)



West African 'Rainmakers'

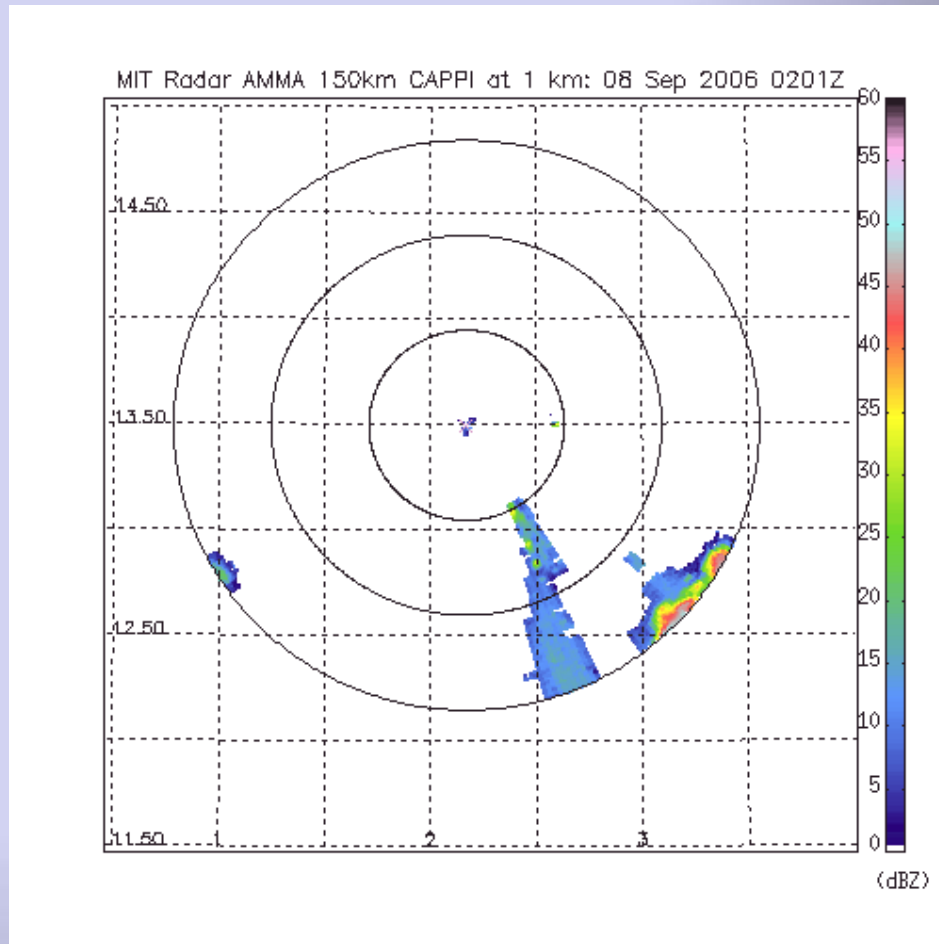
Organized as *squall lines*: the largest, rainiest systems observed over land

- African Easterly Waves  African Squall Lines
- Squall lines produce most of the monsoon rain vital to subsistence agriculture in West Africa

MIT Radar - Niamey, Niger, West Africa

Squall line precursor to Hurricane Helene

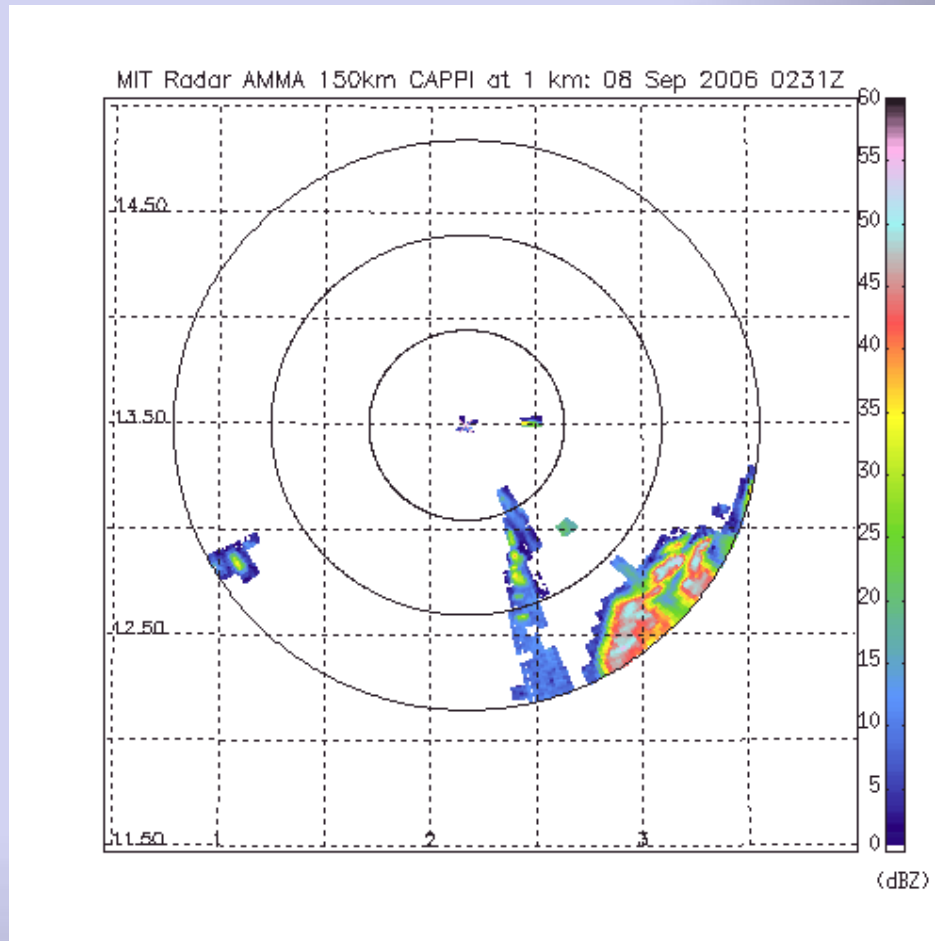
8 September 2006



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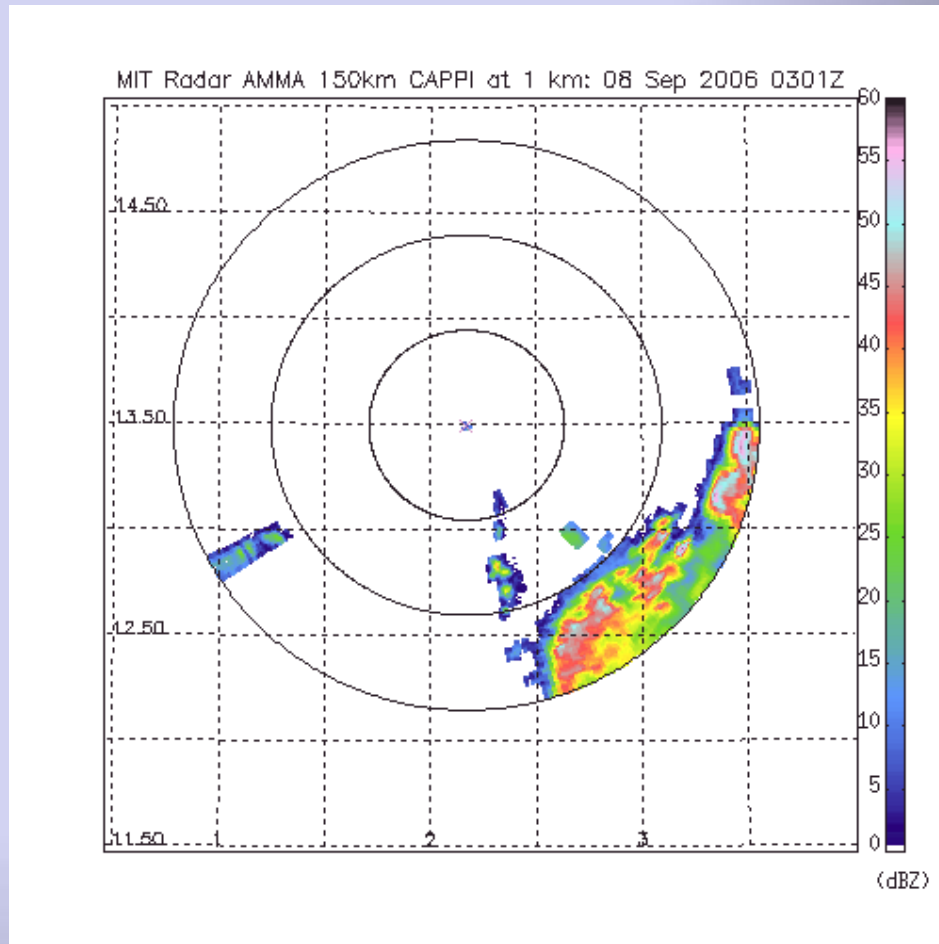
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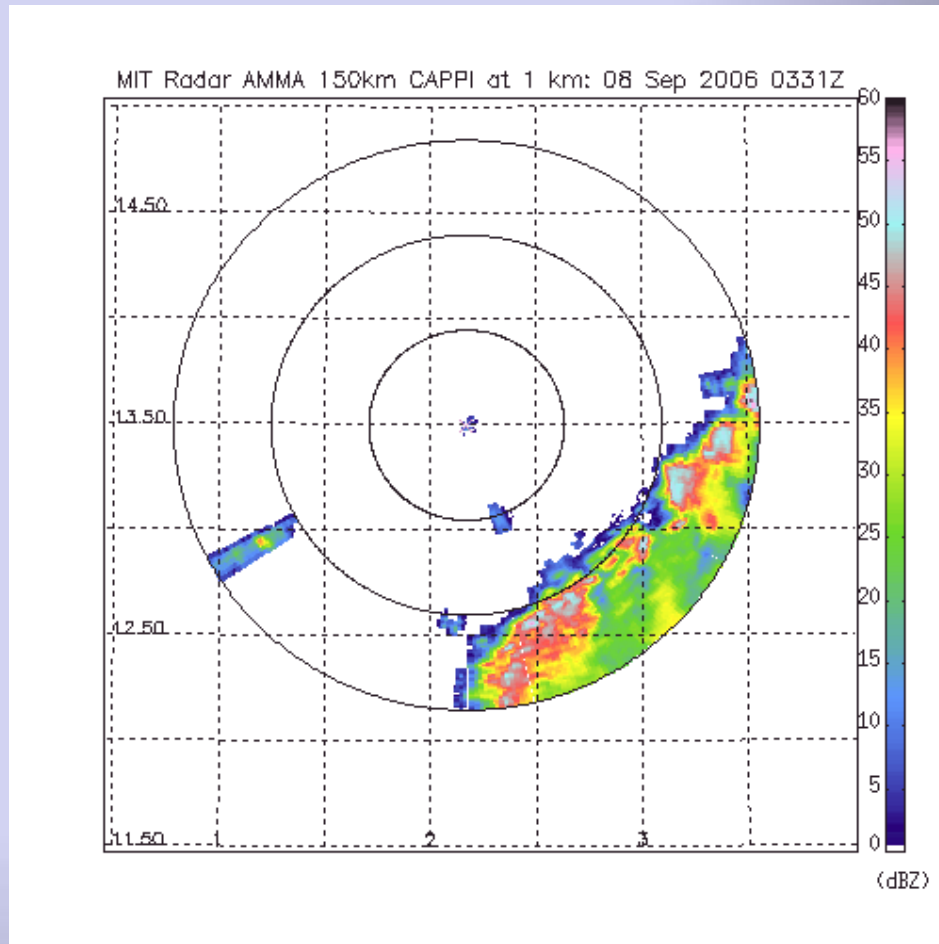
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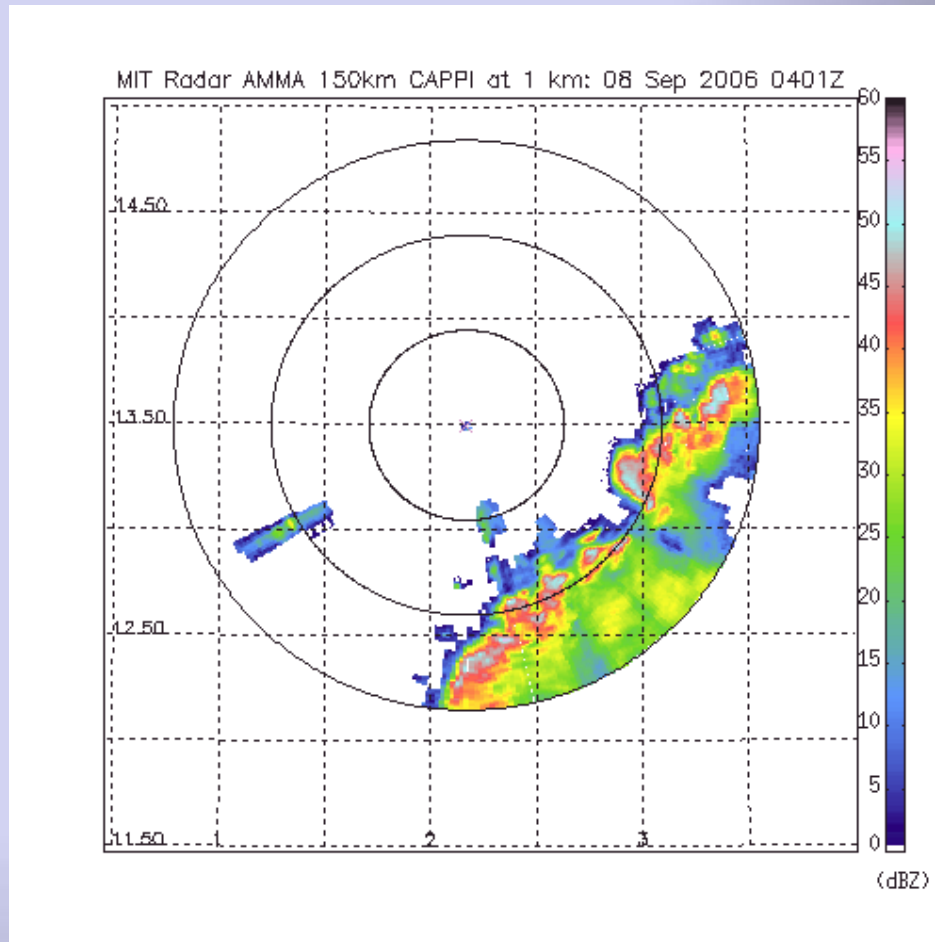
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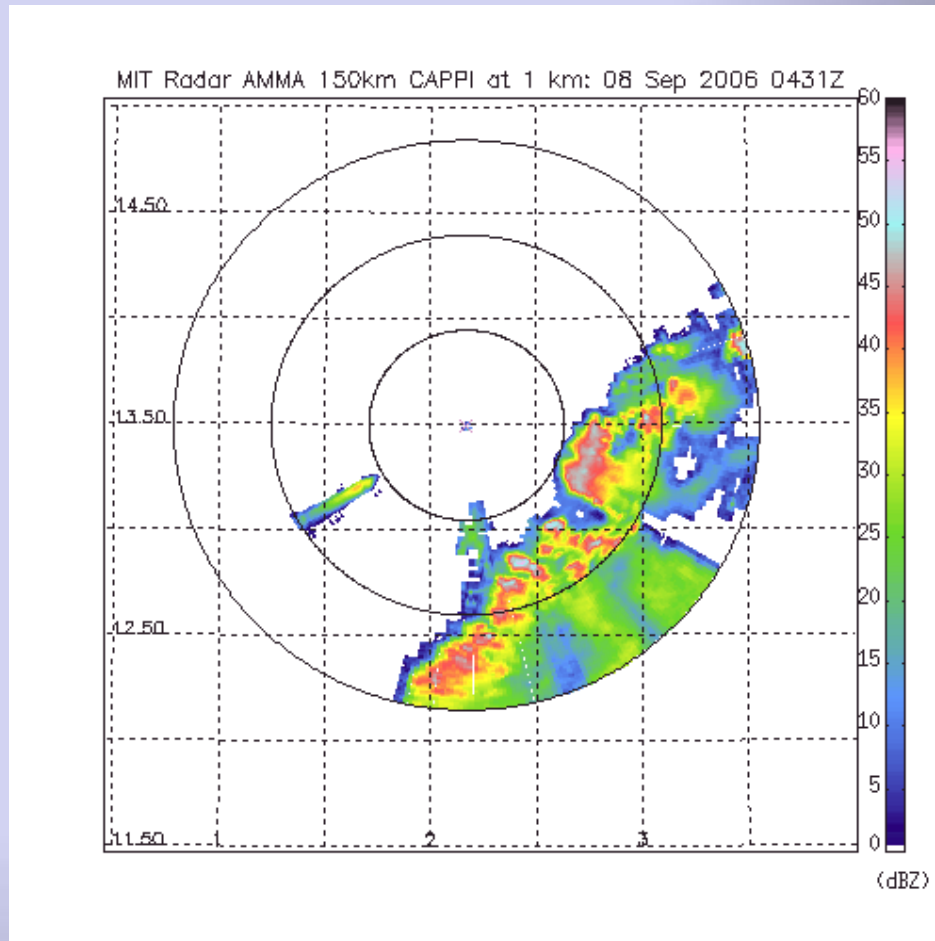
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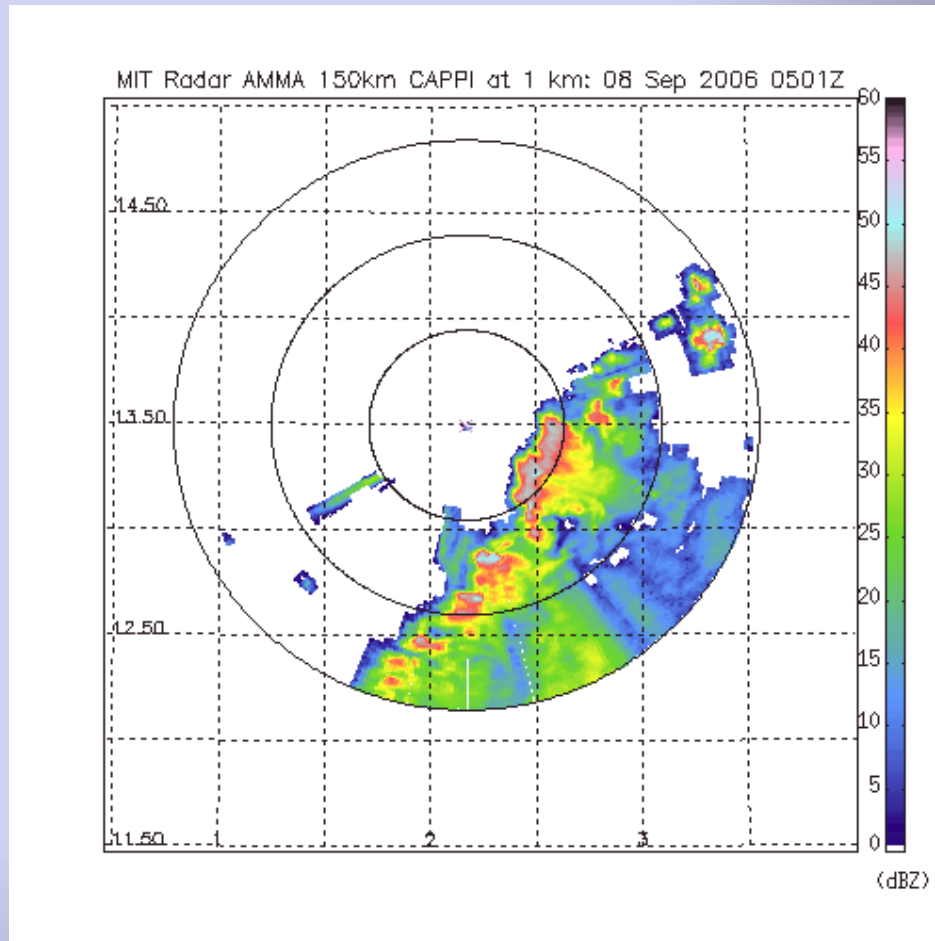
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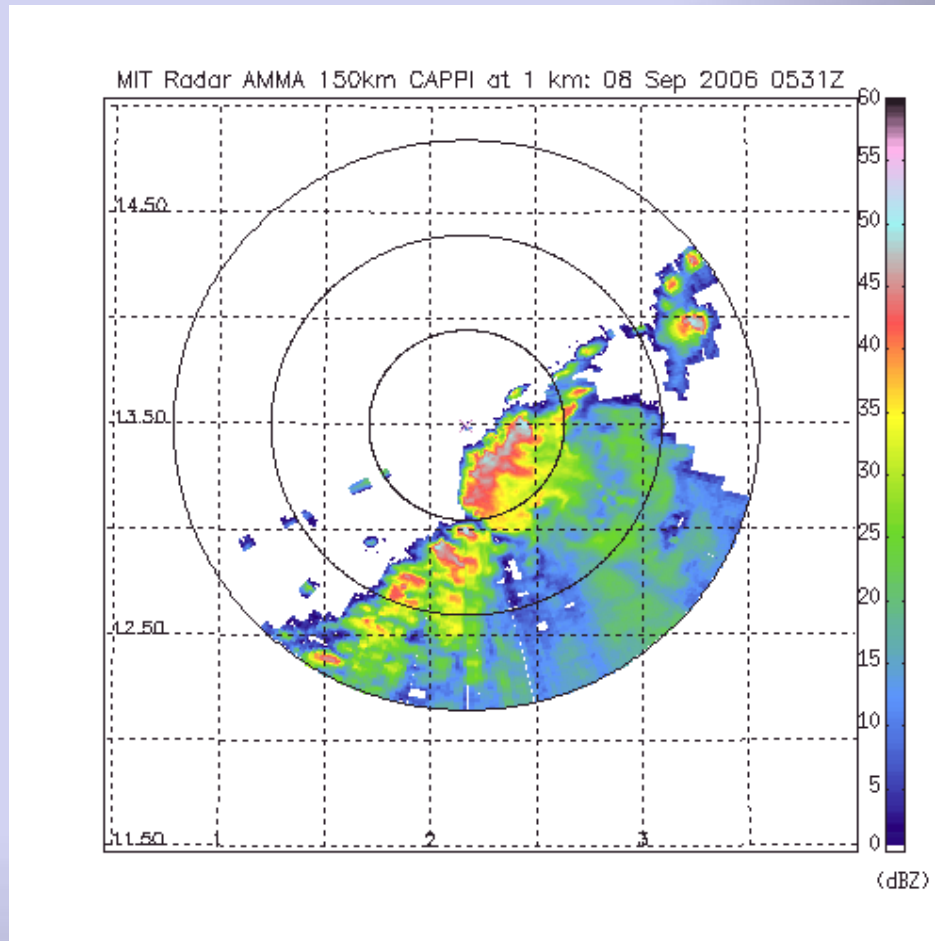
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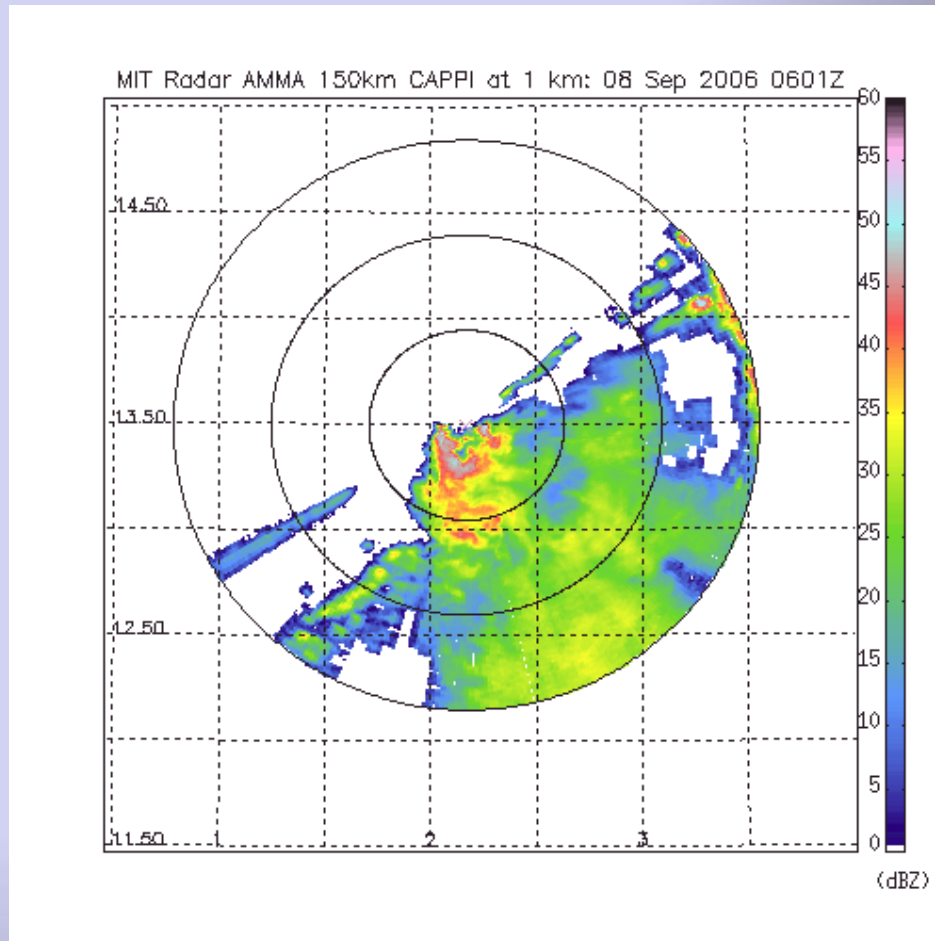
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Squall line precursor to Hurricane Helene

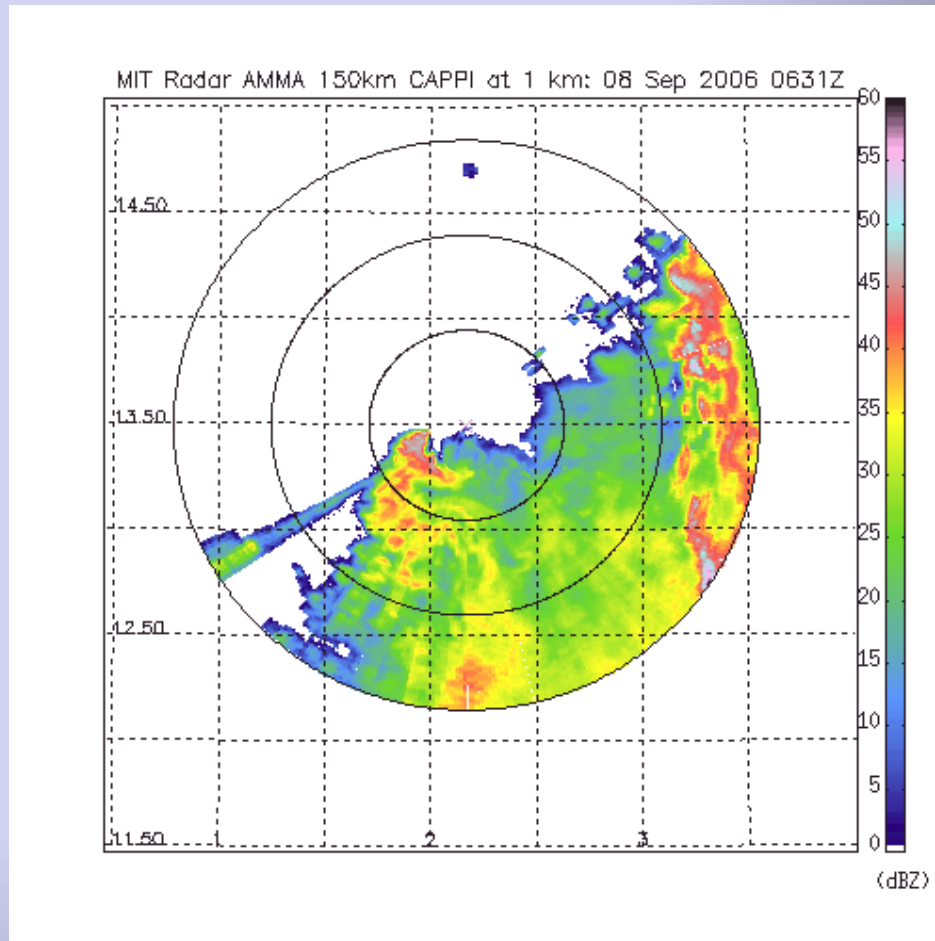
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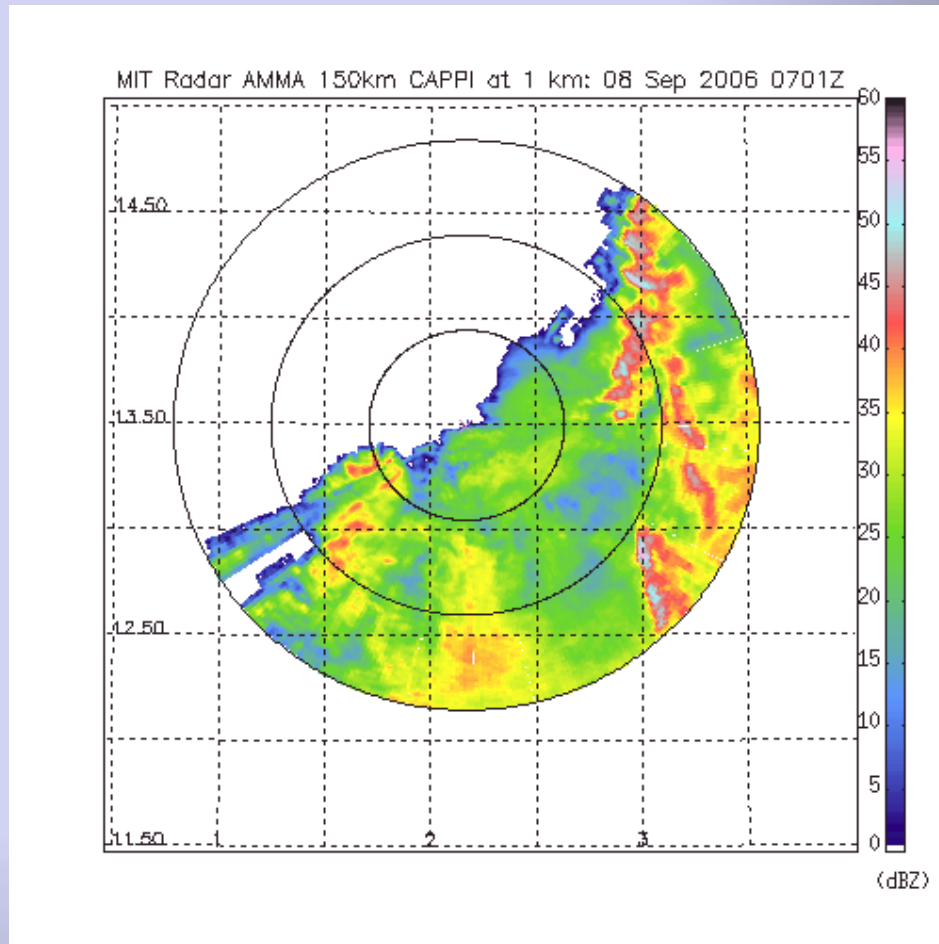
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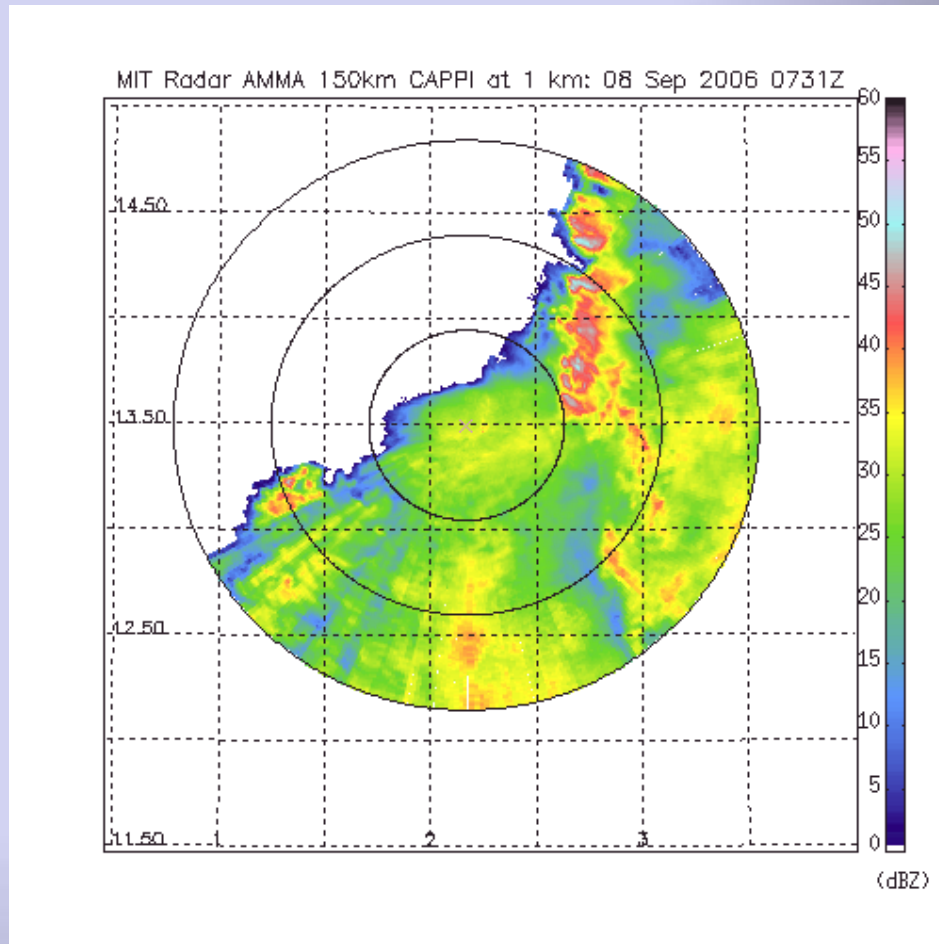
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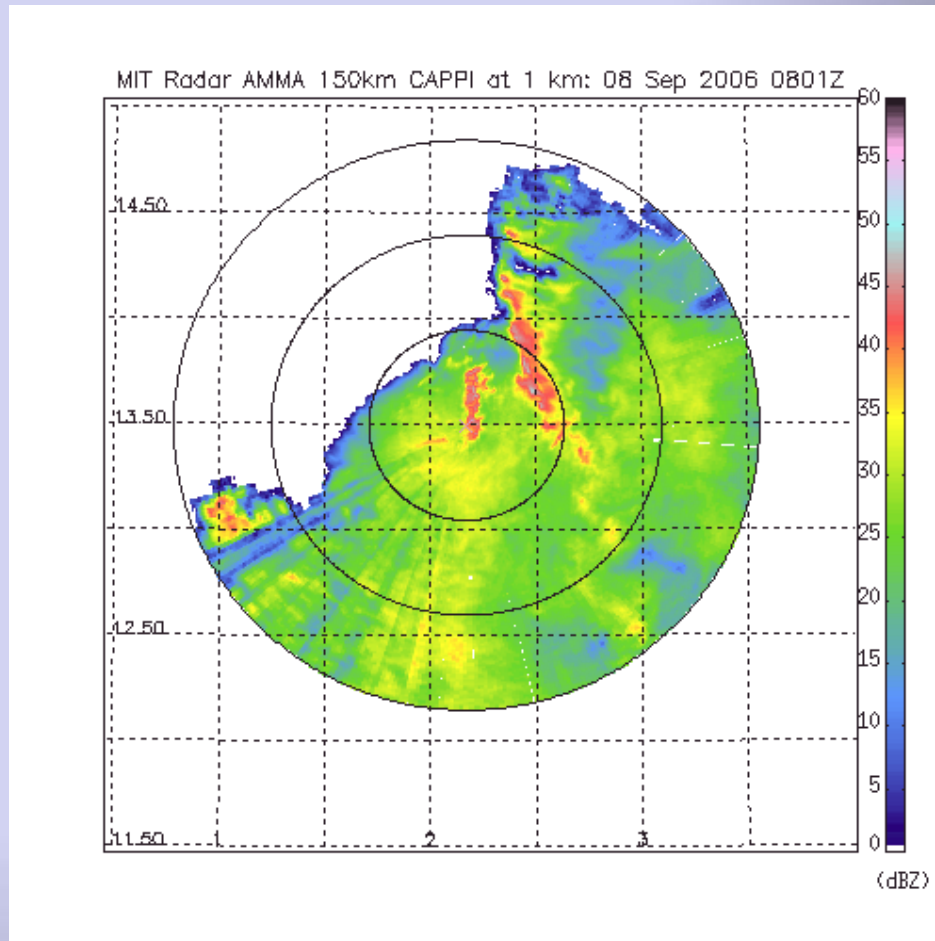
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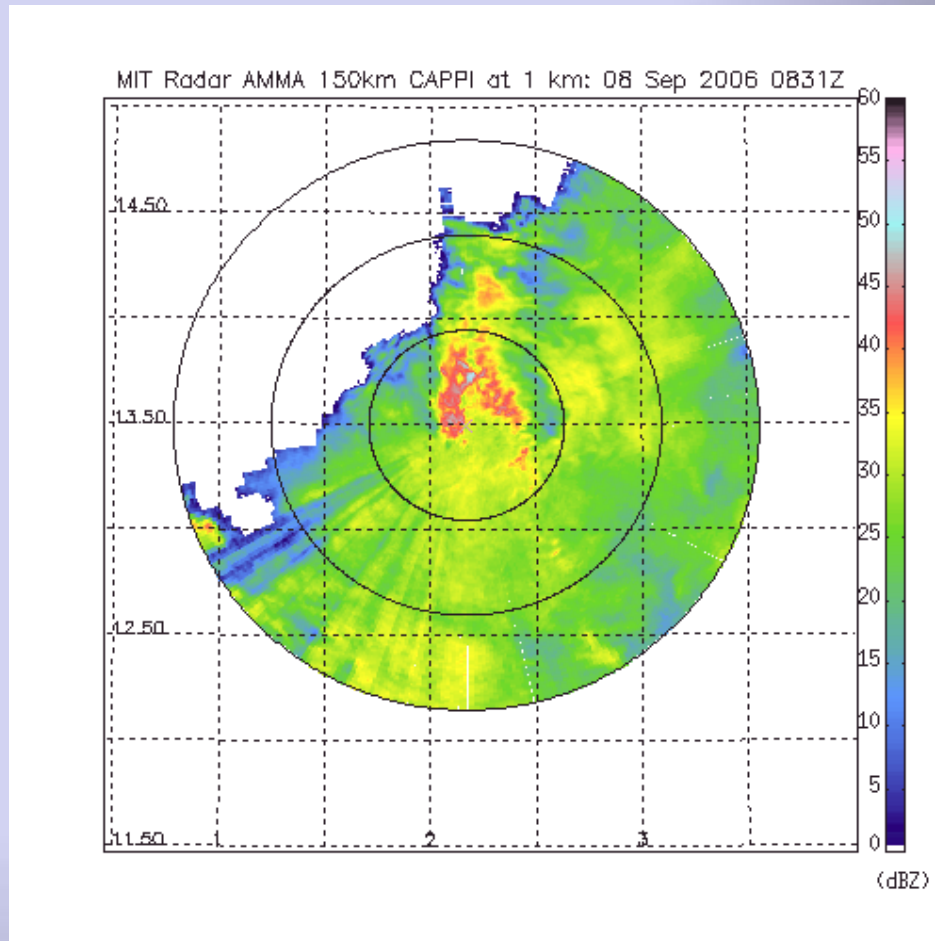
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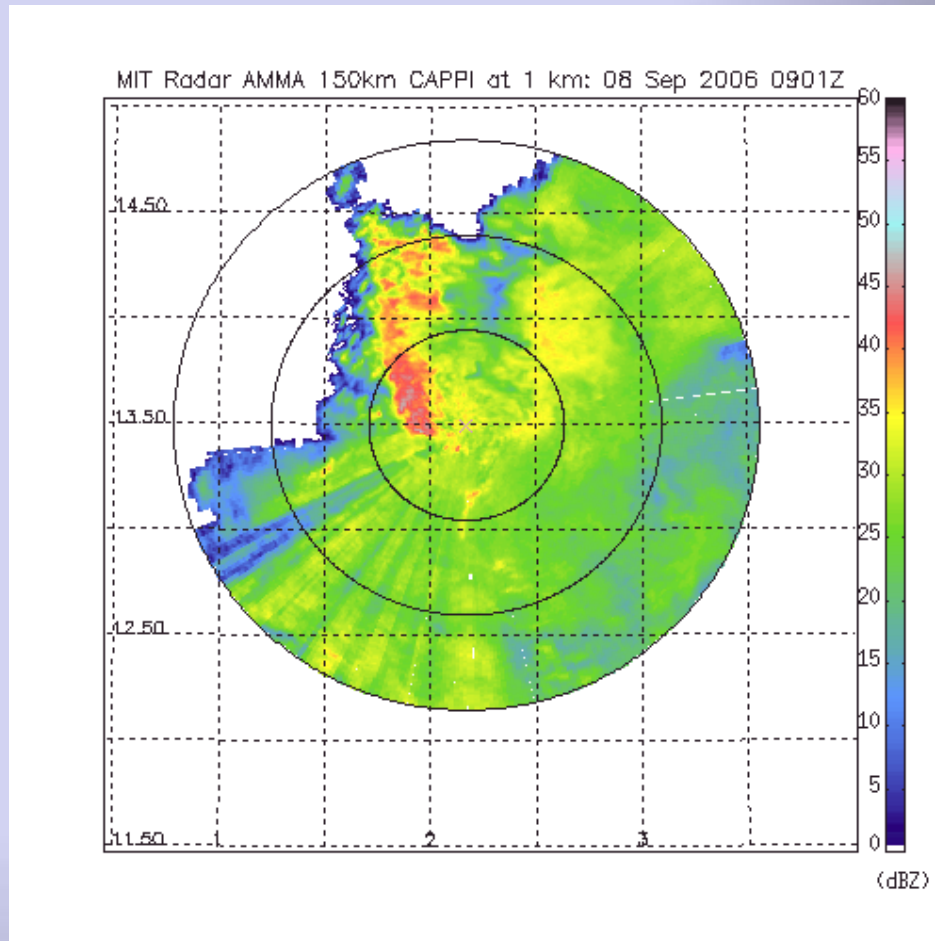
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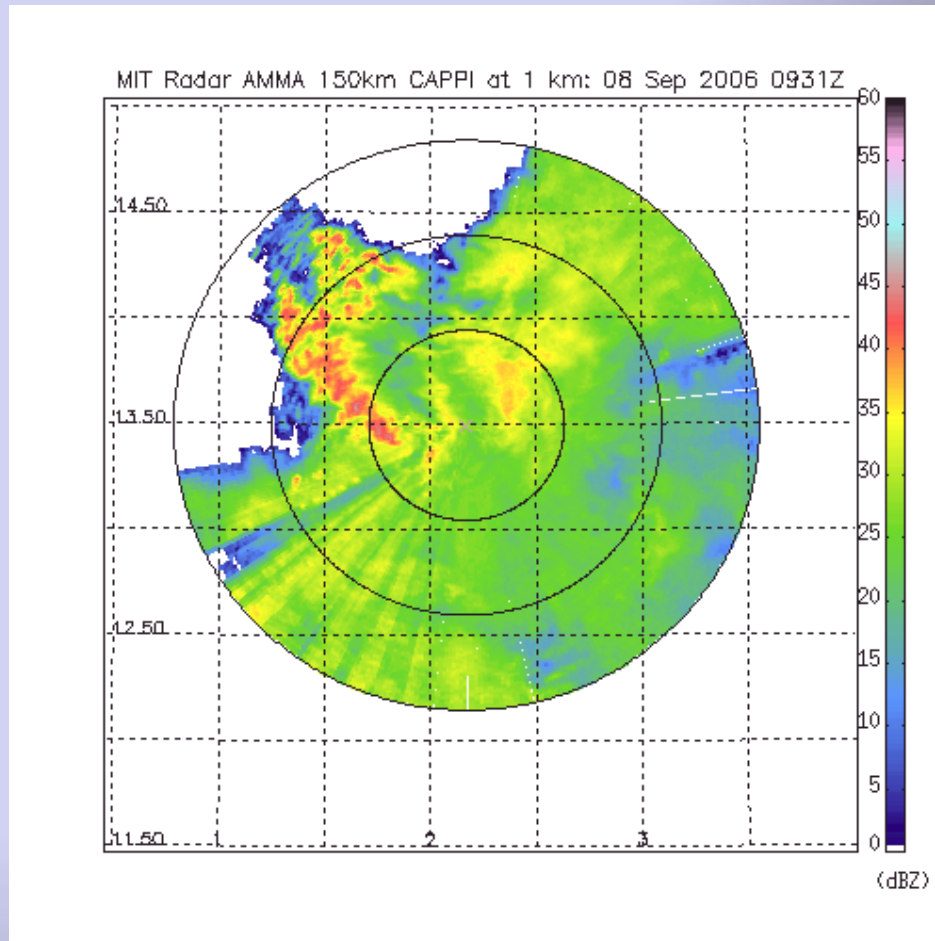
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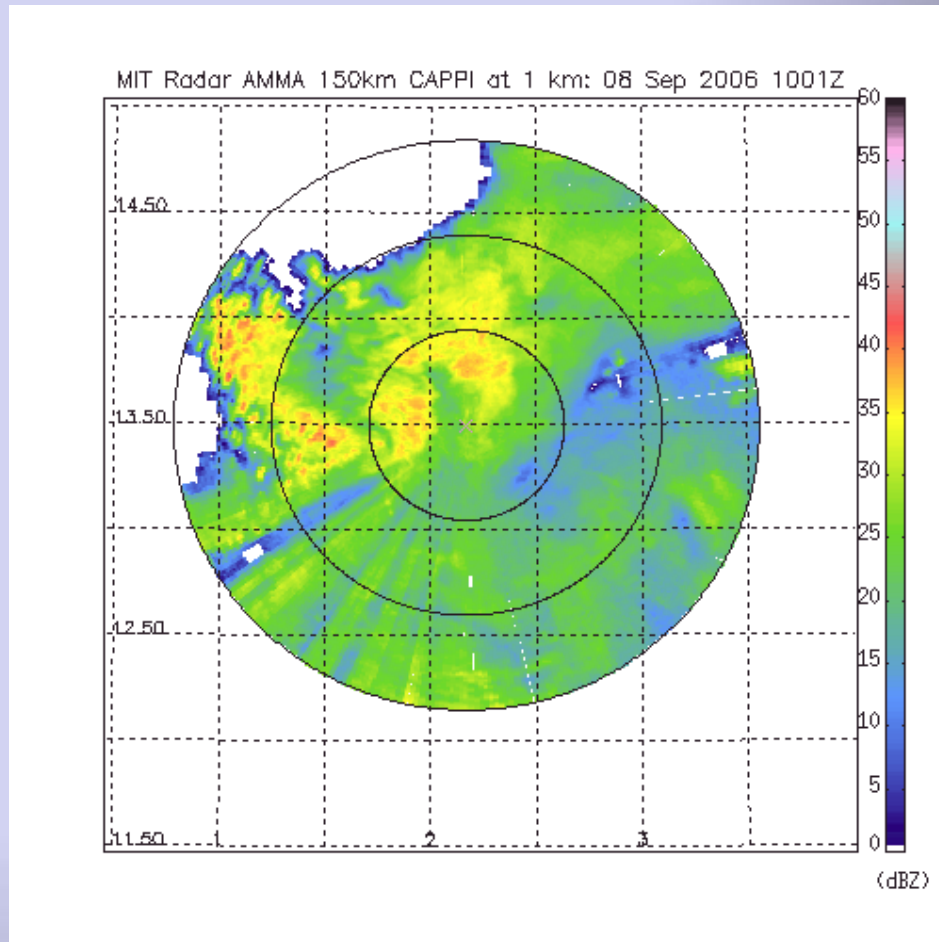
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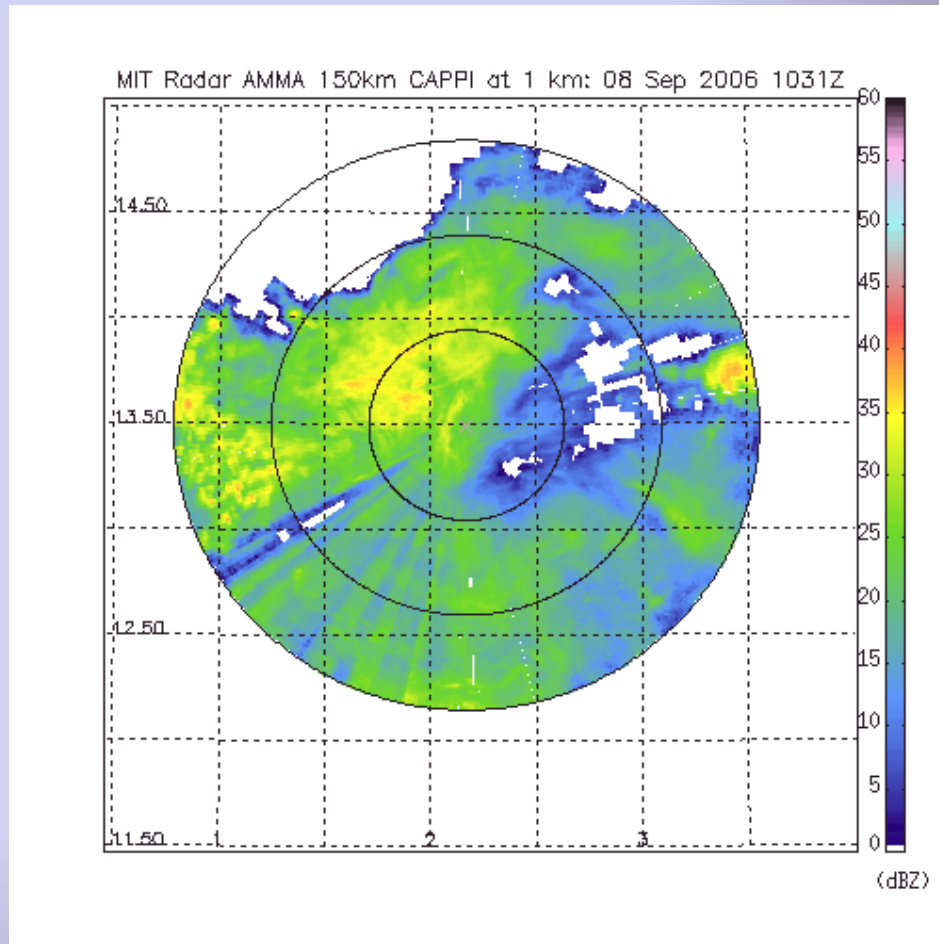
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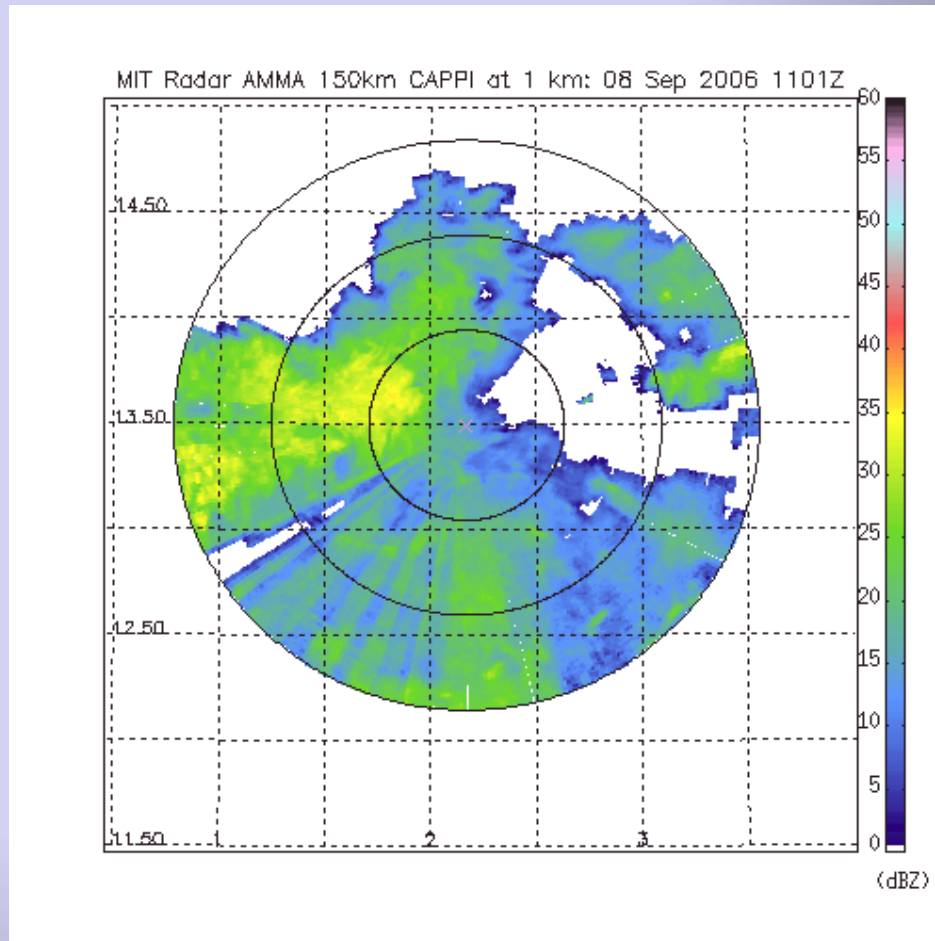
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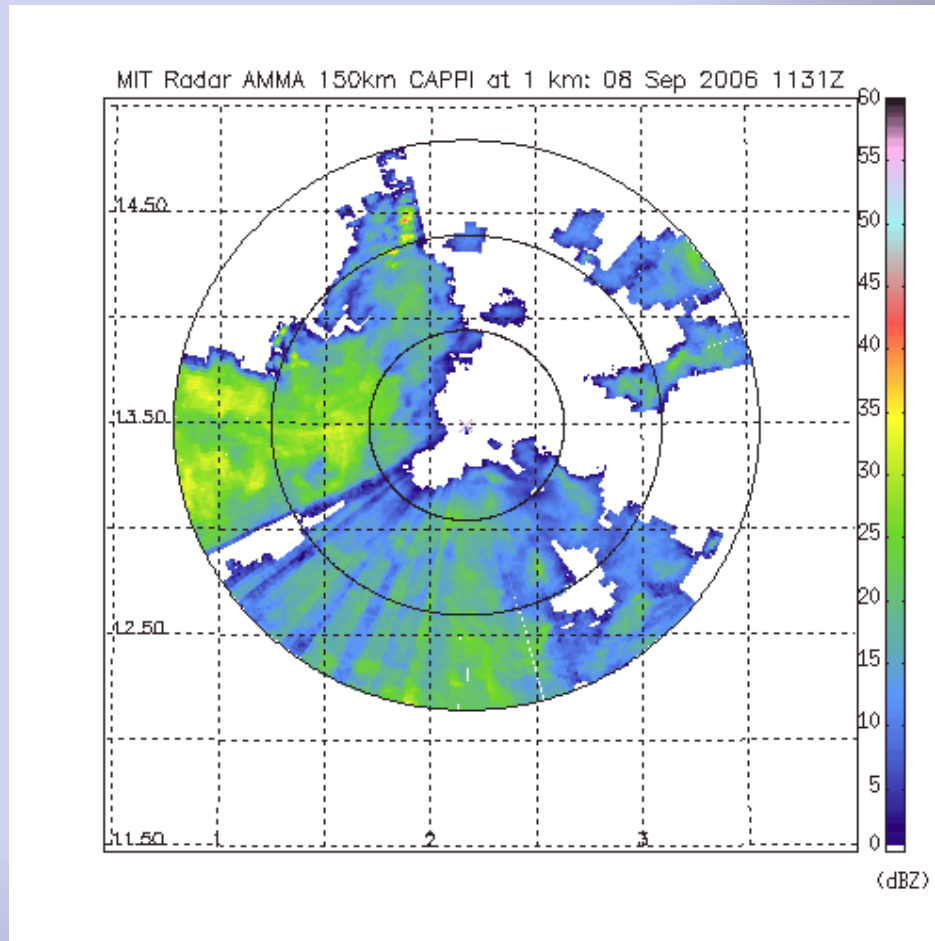
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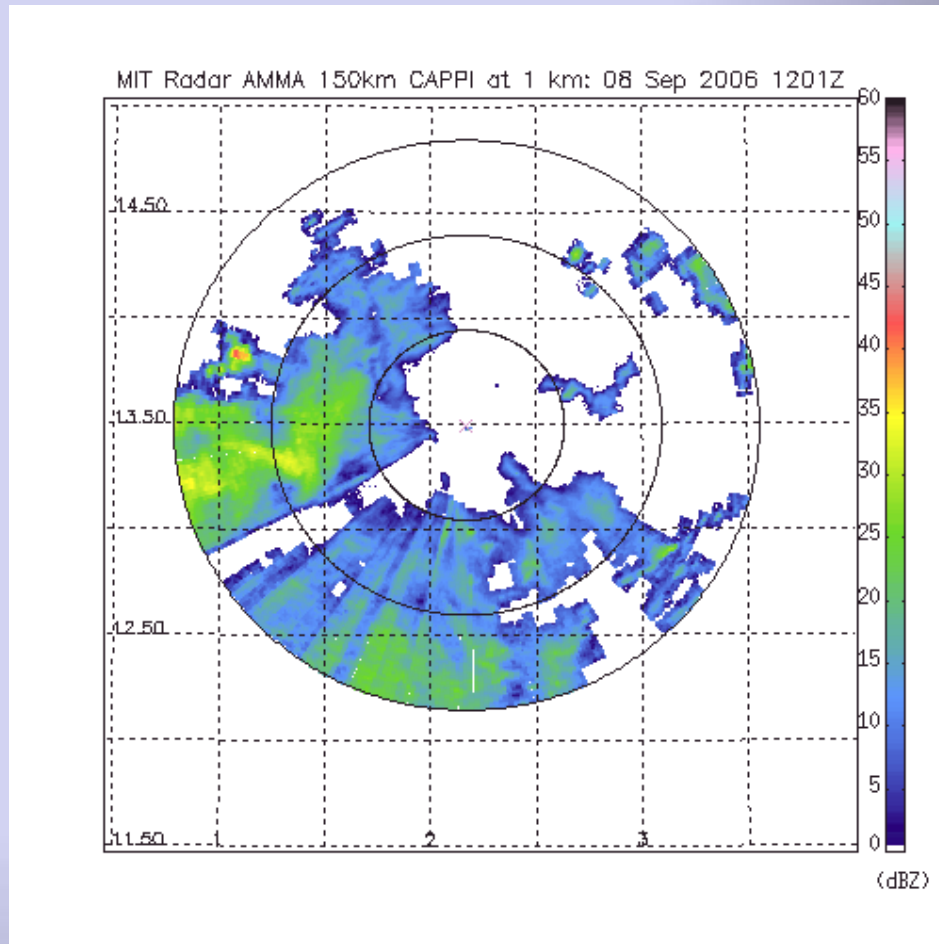
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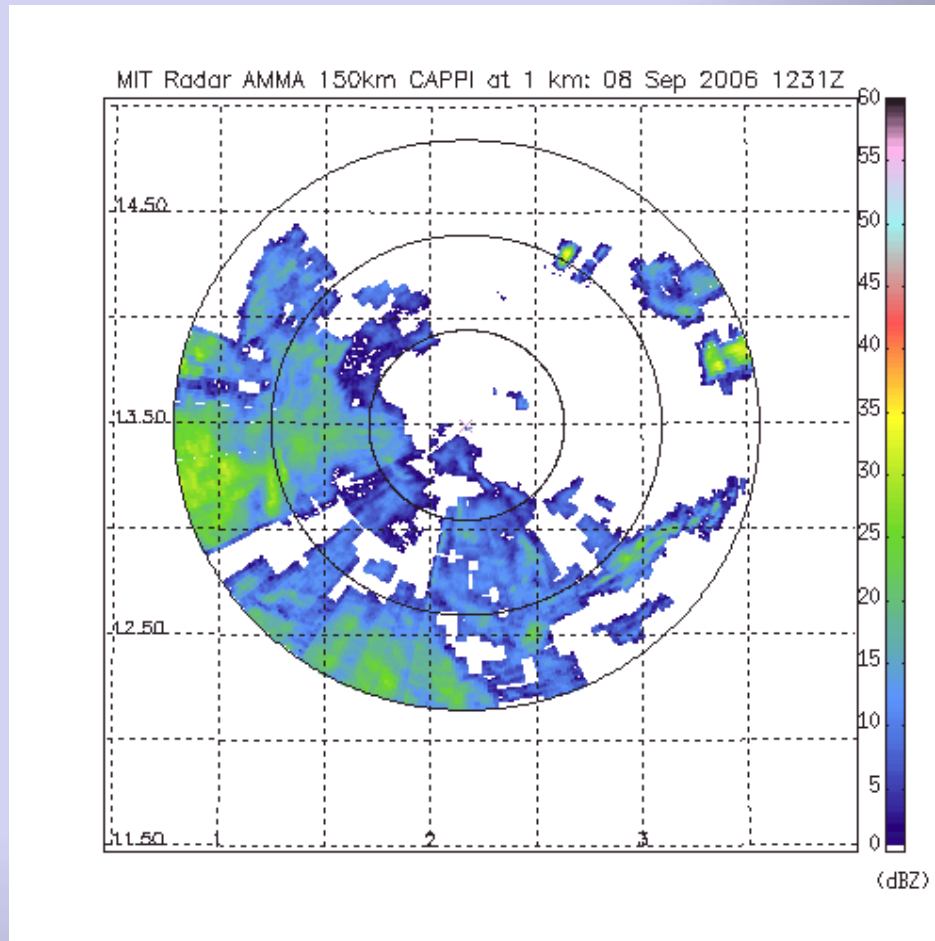
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MIT Radar - Niamey, Niger, West Africa

Squall line precursor to Hurricane Helene

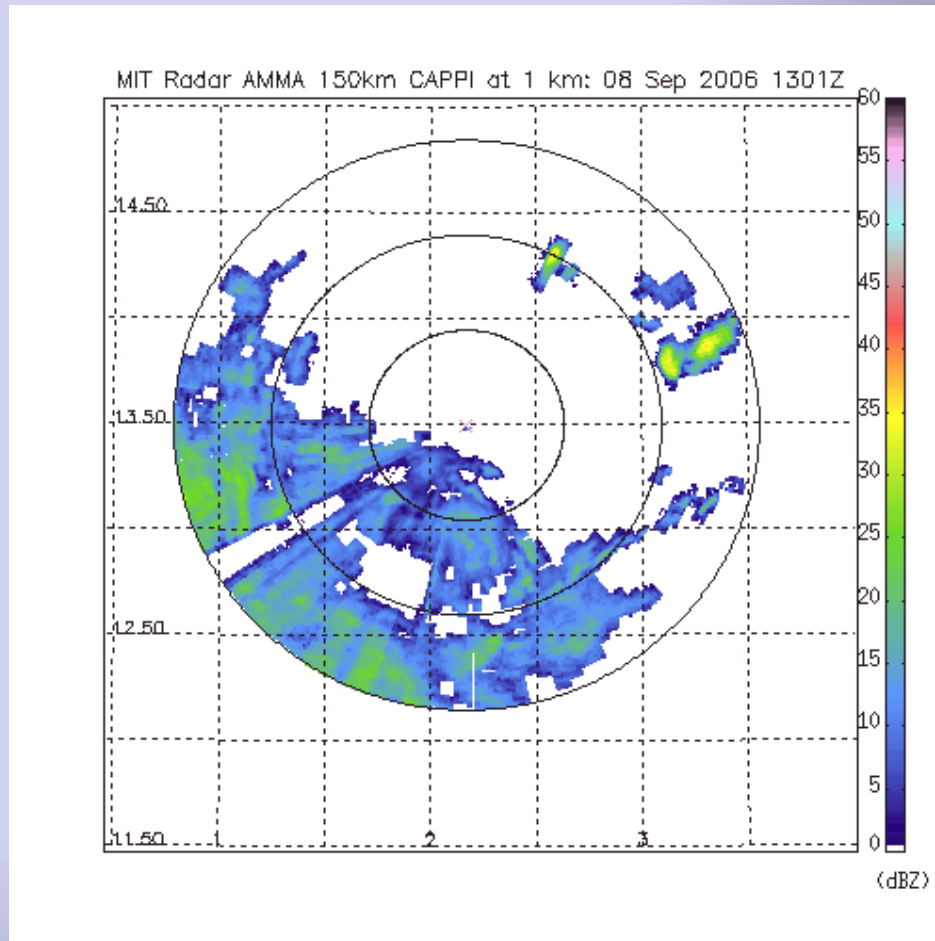
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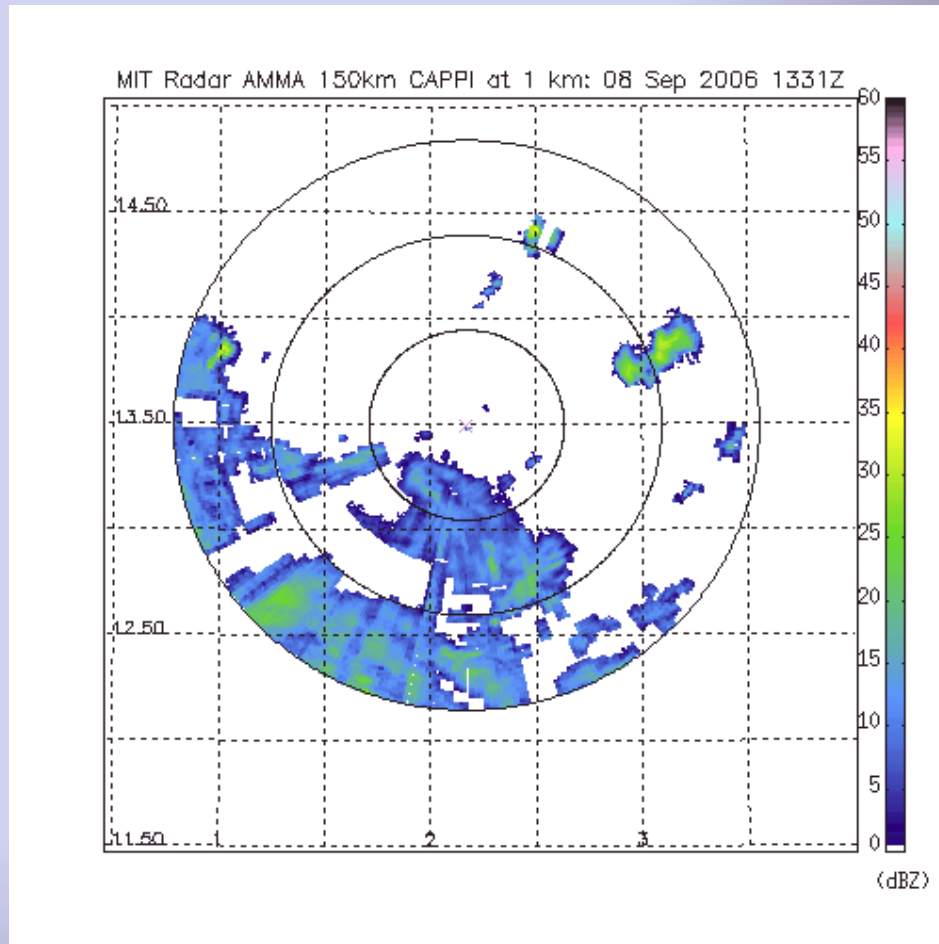
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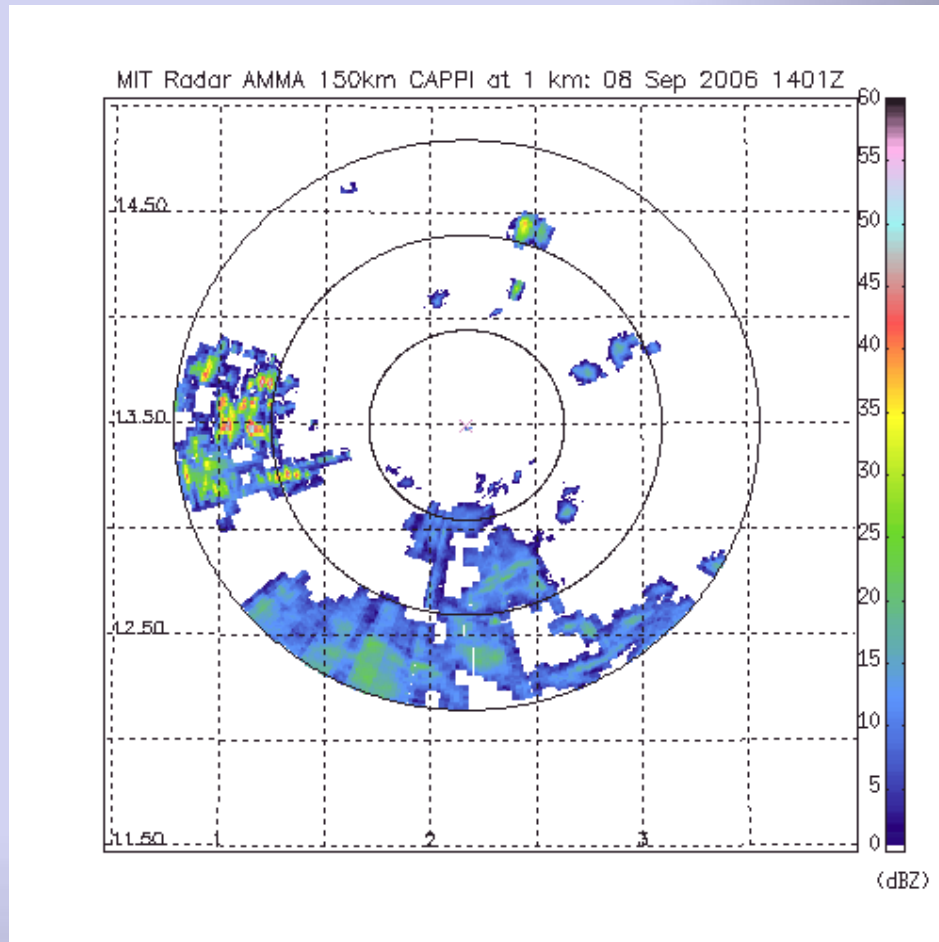
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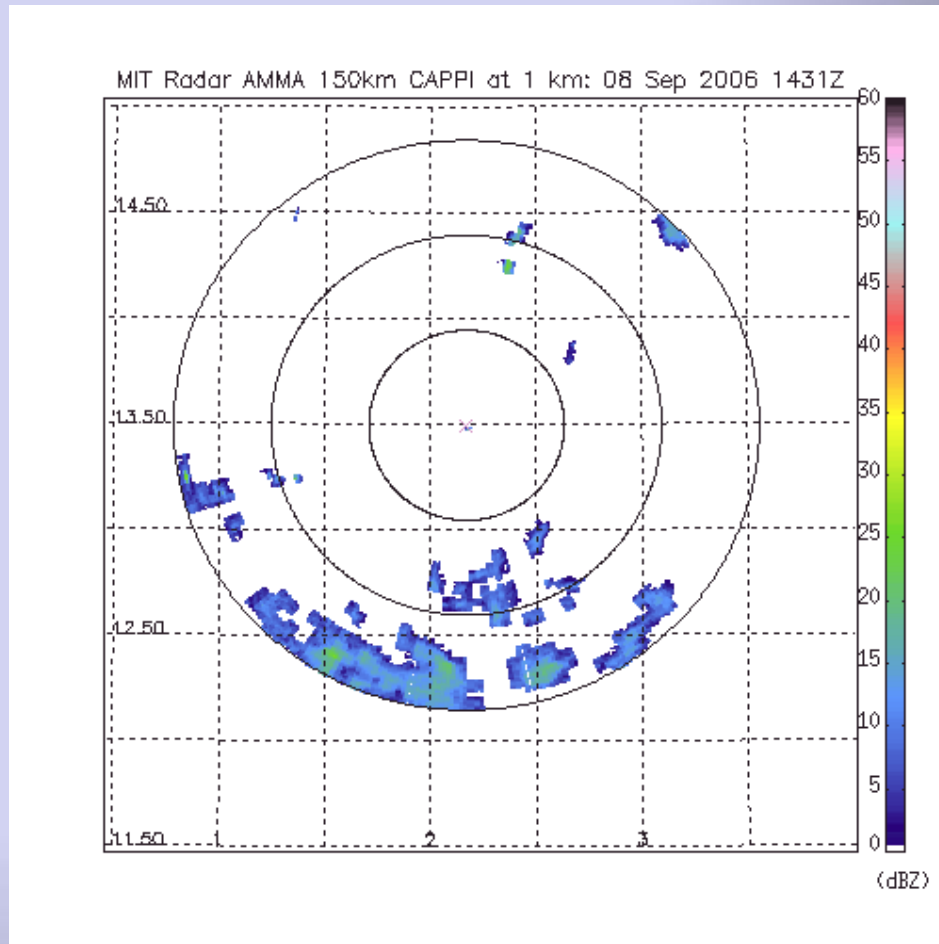
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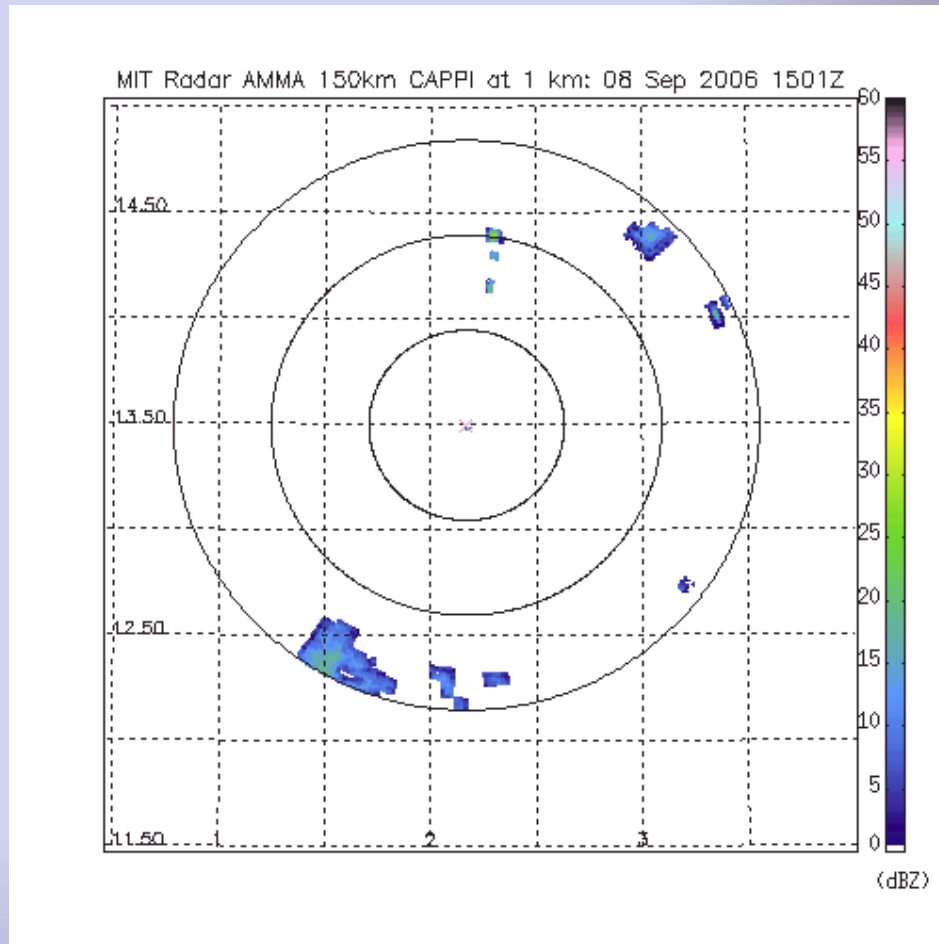
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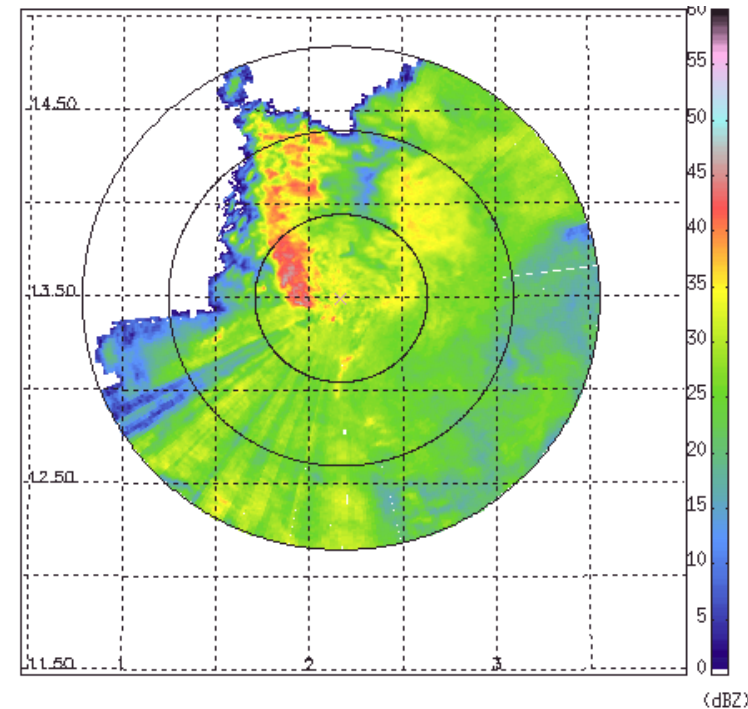


Hurricane Precursors: The Squall Line

Squall lines are the largest, rainiest systems observed over the Sahel

- A total of 28 squall lines
- Squall lines produced 82% of the 2006 rainfall in Niger

MIT Radar - Niamey, Niger, West Africa
8 September 2006



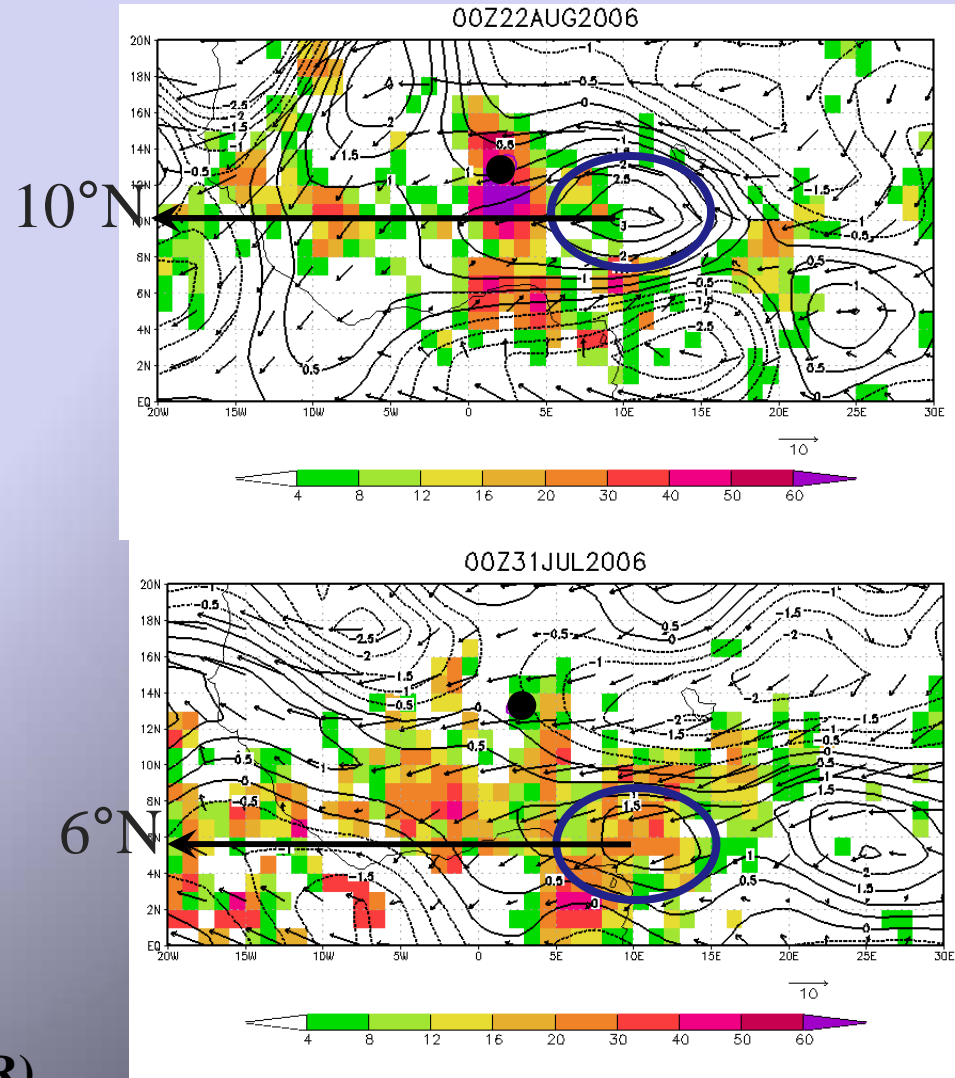
(Rickenbach et al. 2009, GRL)

Relation between squall lines and African Easterly Waves

Two Tracks

- 15 squall lines were associated with AEW troughs that propagated along 10-16°N (Northern Track)
- 13 squall lines were associated with AEW troughs that propagated along 2-6°N (Southern Track)

700 mb relative vorticity (contours), winds and rainfall (shaded)



(Niето Ferreira et al. 2009, MWR)

Structural differences in northern vs. southern track squall lines

The rainfall produced by northern track and southern track squall lines is very similar but the mode of delivery of rainfall is very different:

	Stratiform Rain Fraction	Convective Rain Fraction
Northern	47%	53%
Southern	35%	65%

Hypothesis: AEW troughs present near Niamey in northern track squall lines favor stratiform rain production

Conclusion

There is a direct relationship between Sahel rain and Atlantic hurricanes

Squall lines are the main rainmakers in the Sahel

Distinct types of squall line form ahead of AEW troughs along two different AEW tracks

Understanding the interaction between squall lines and AEWs in the African Sahel may lead to improved Atlantic hurricane prediction

Sahel Rainfall, African Easterly Waves and Atlantic Tropical Cyclone Activity

Normalized Indices

