



Close-Up Look at Sandy's Landfall: Mesoscale Modeling and Observations

James A. Schiavone, Kun Gao, David A. Robinson,
Peter Johnsen and Mathieu Gerbush

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Sandy's Impacts

- Sandy's biggest impacts were:
 - Devastating storm surge flooding
 - Extended power outages caused by massive tree-fall
 - 72 direct deaths, *20 of them caused by fallen trees*
- Tree-fall was widespread but patchy – ***Why was it patchy?***
 - Hypothesize that patchiness was caused by *roll vortices*
- Key resources are leveraged in our Sandy landfall study:
 - *Resilient* New Jersey and Delaware state mesonets
 - *500-meter* resolution Weather Research and Forecasting model
 - NOAA radar, surface and rawinsonde observations
- What I will cover:
 - Data resources
 - **Overview of Sandy's landfall**
 - Boundary layer wind and roll vortex concepts
 - **Evidence of roll vortices** – in observations and simulation

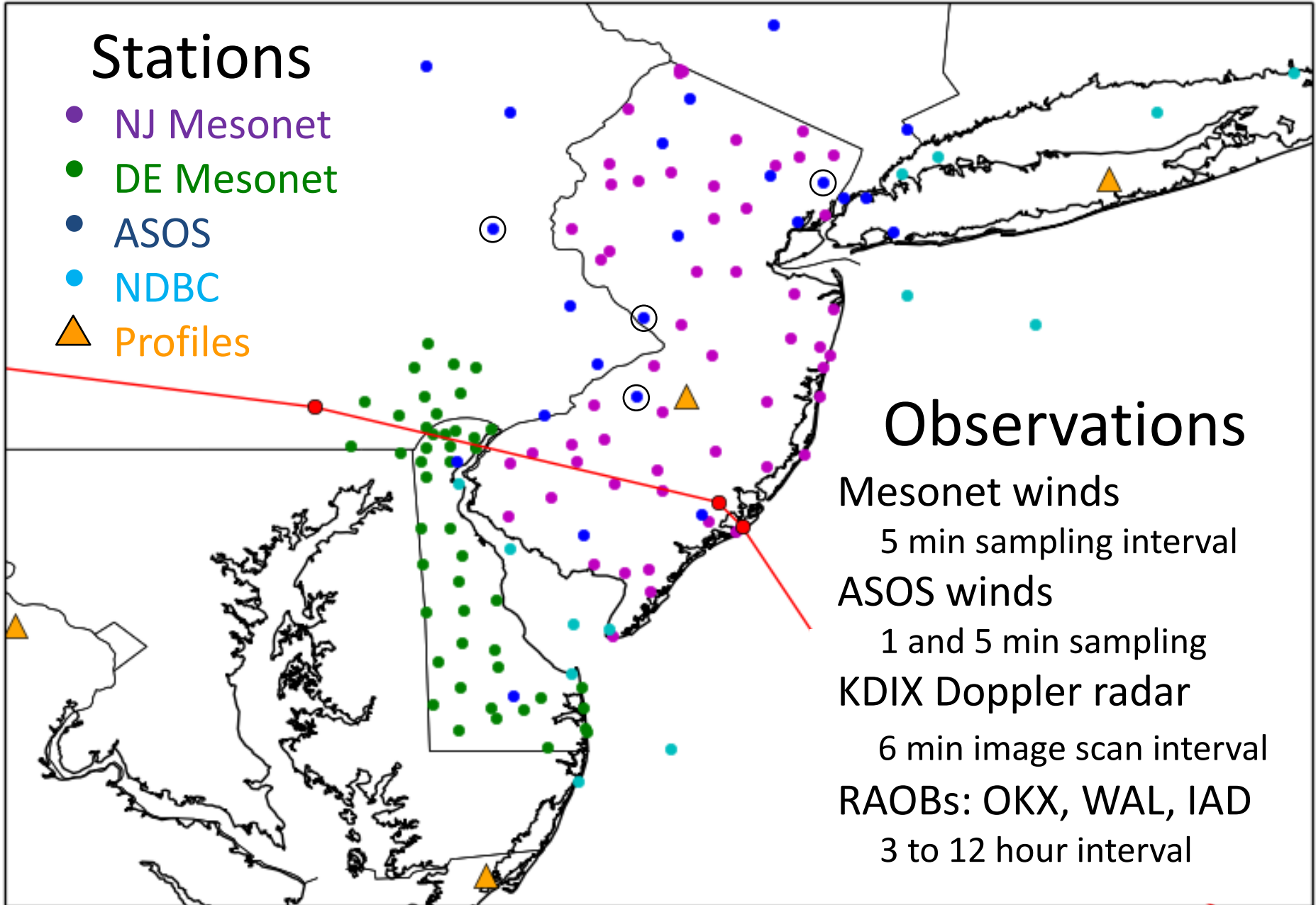


Work Made Possible By . . .

- High resolution surface observations
 - New Jersey Weather and Climate Network (NJWxNet) mesonet
 - Delaware Environmental Observing System (DEOS) mesonet
 - NOAA's Automated Surface Observing Systems (ASOS) and National Data Buoy Center (NDBC)
- High resolution WRF simulation of Sandy
 - Run by Pete Johnsen, Mel Shapiro and Mark Straka on Cray XE6 at NCSA
 - NCAR's Dick Valent was instrumental in gaining access to the large 43 Terabyte data set
 - NCAR's Alan Norton provided invaluable help in using VAPOR Visualization and Analysis Platform

Stations

- NJ Mesonet
- DE Mesonet
- ASOS
- NDBC
- ▲ Profiles



Observations

Mesonet winds

5 min sampling interval

ASOS winds

1 and 5 min sampling

KDIX Doppler radar

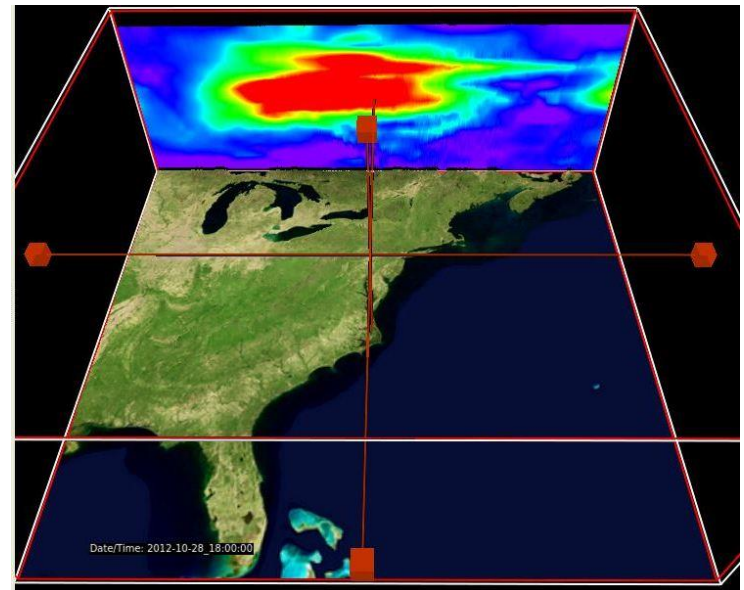
6 min image scan interval

RAOBs: OKX, WAL, IAD

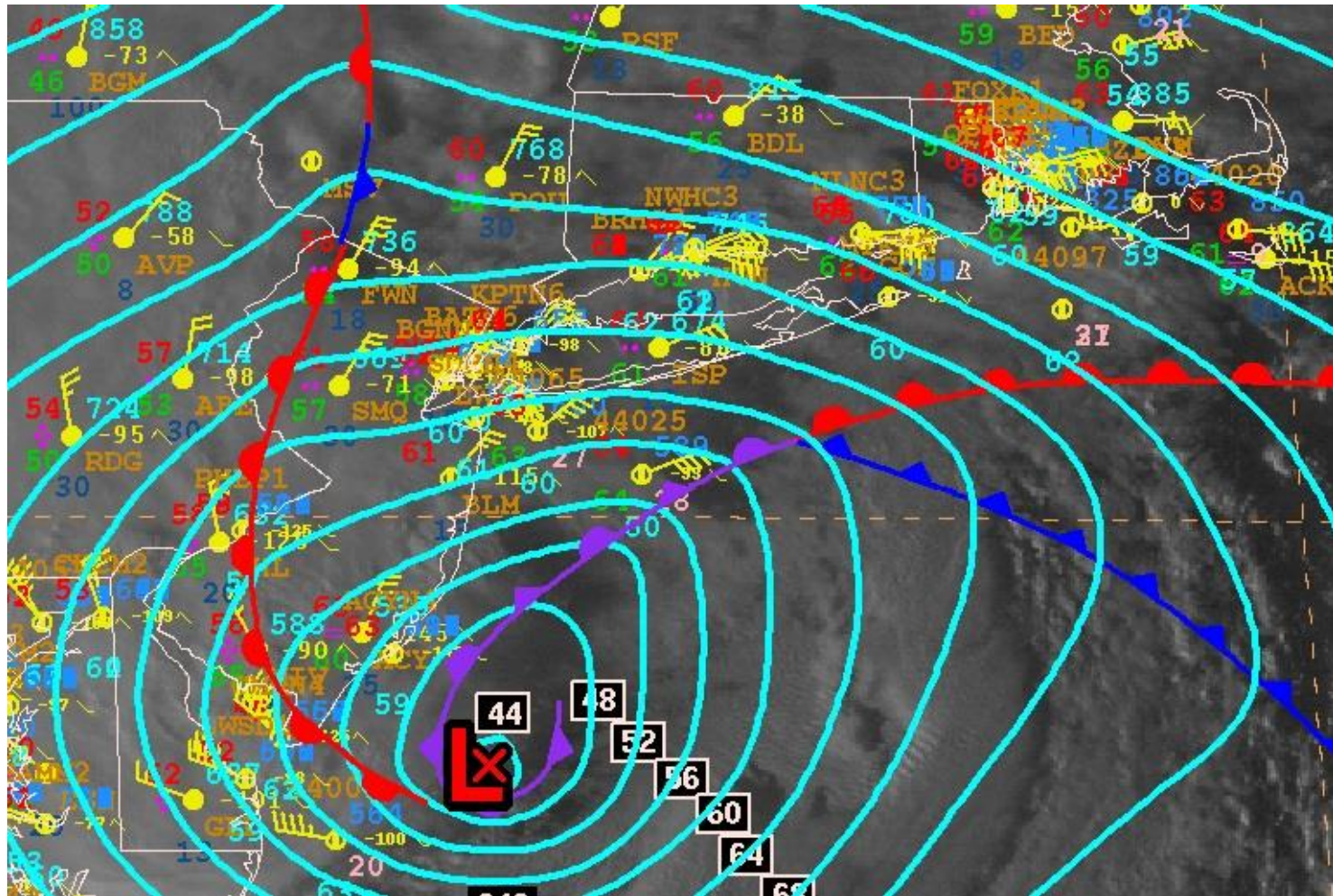
3 to 12 hour interval

WRF Model Simulation

- **Model:** Advanced Research WRF version 3.3.1
- **System:** Cray XE6 “Blue Waters” at National Center for Supercomputing Applications (NCSA)
- **Grid:** *500 meter spacing*, 5320x5000x150 grid, 4 billion grid points
- **Initialization and boundary conditions:** NOAA/NCEP GFS output
- **Simulation period:** 96 hours, beginning 12Z Oct 26, 2012
- **Output:** 30 minute interval, 193 files, 224 GB each, total of 43 Terabytes



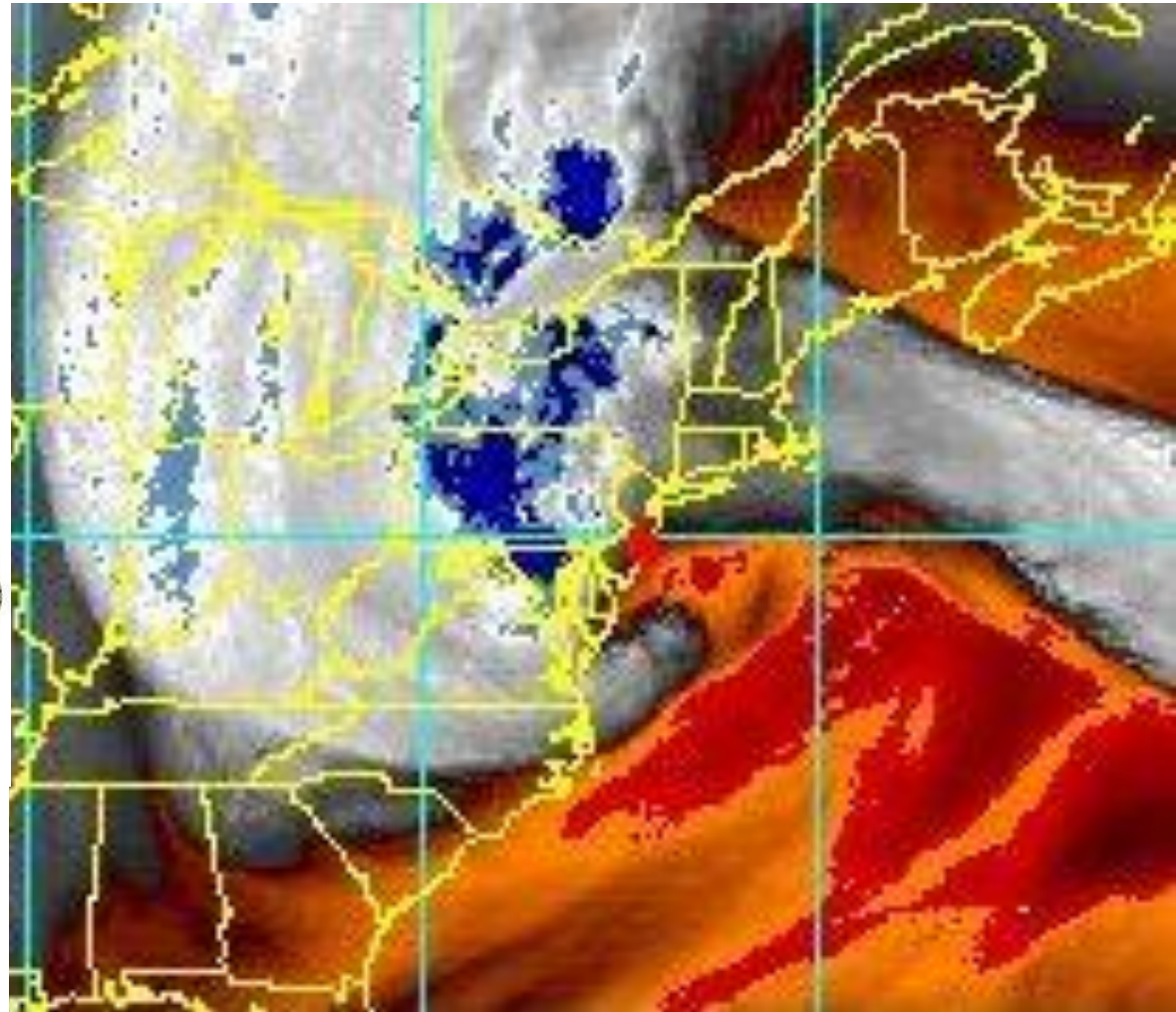
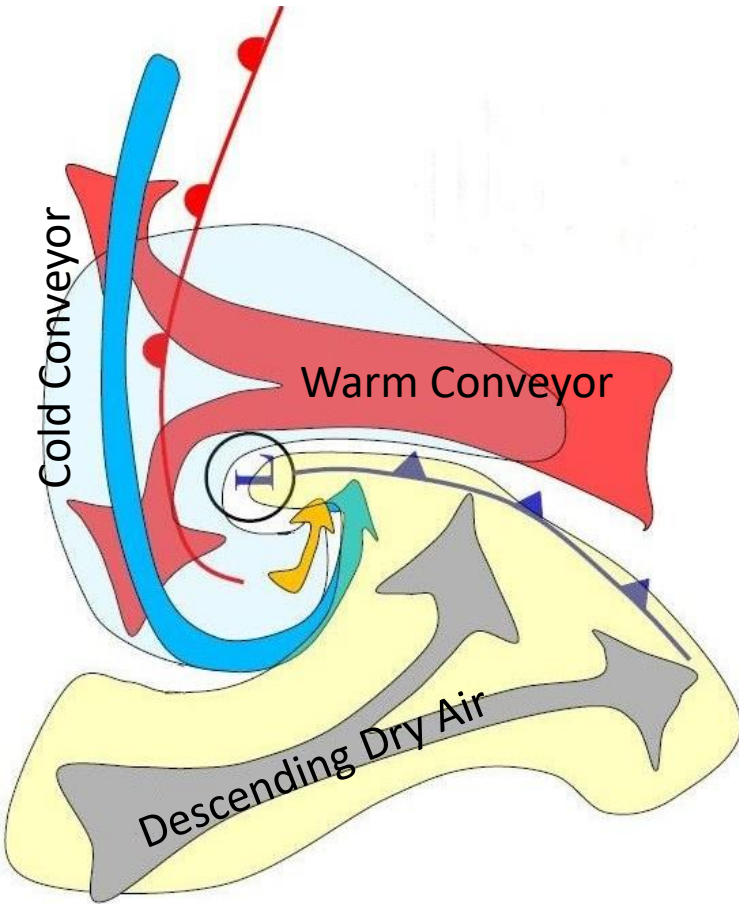
Sandy Overview – Observations



NHC Analysis at 21Z on 29 October 2012

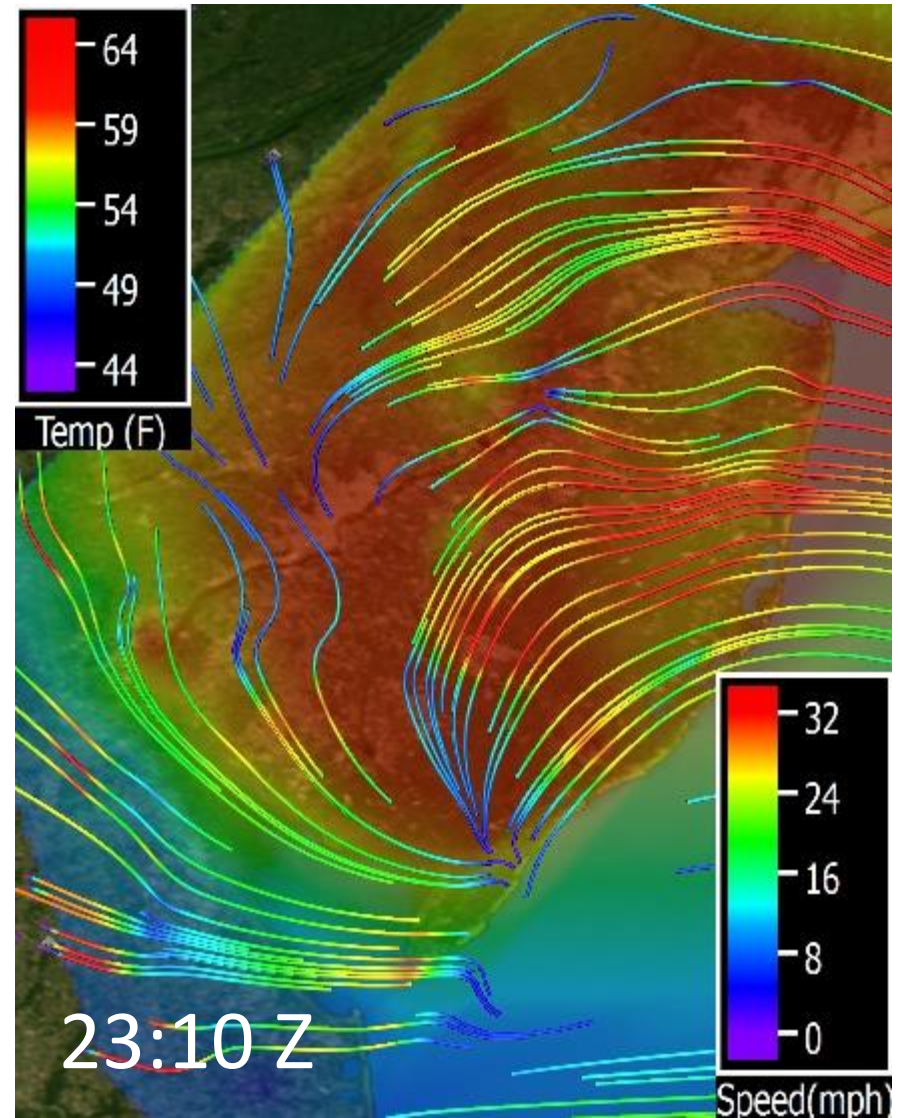
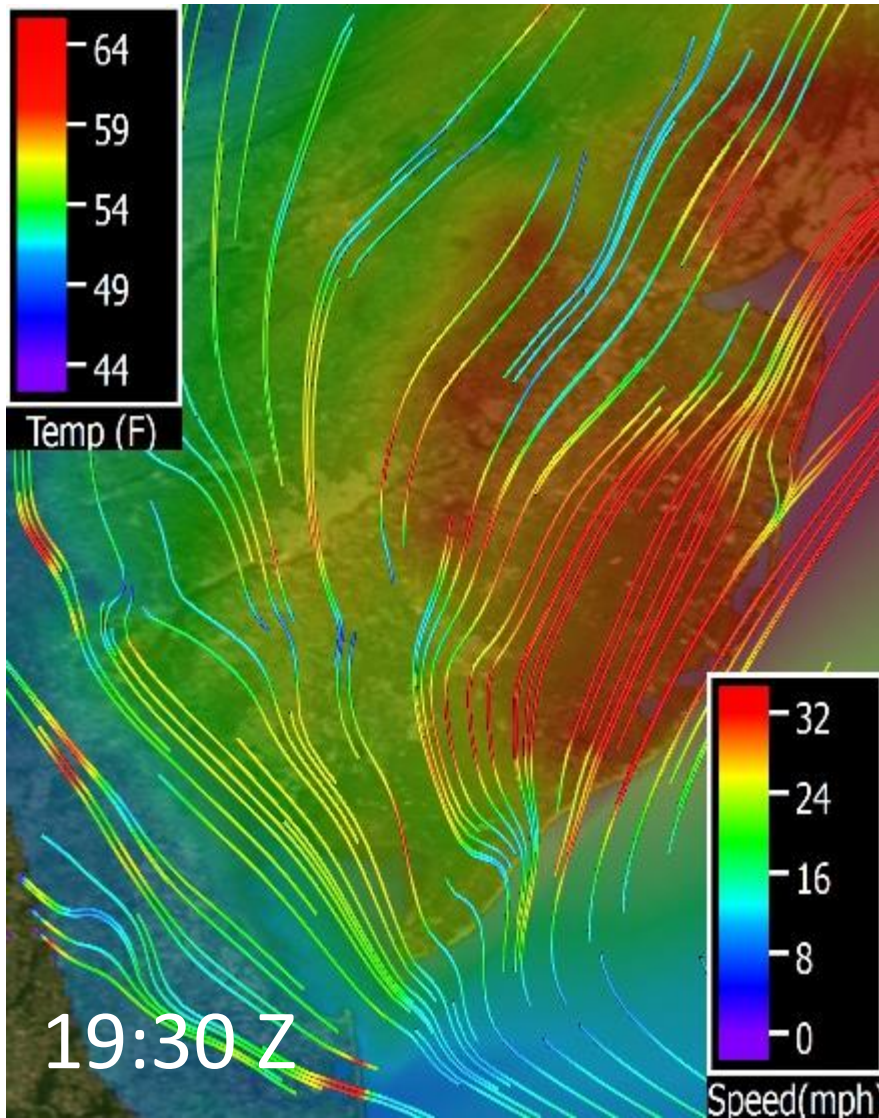
Sandy's Extratropical Airstreams

29 October 2012



Right:
GOES water vapor
at 23:45Z

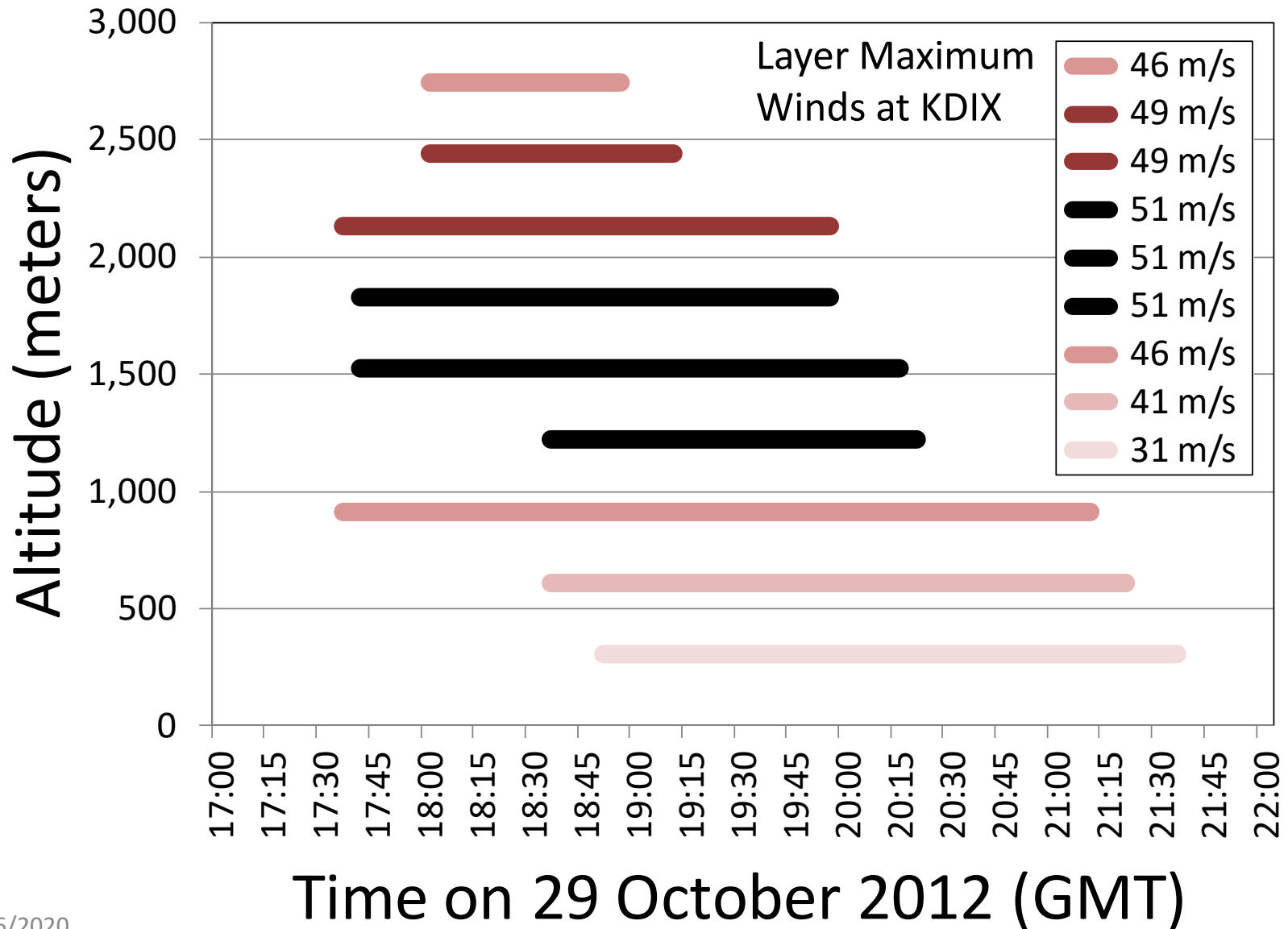
Warm Sector Traversal of NJ Mesonet



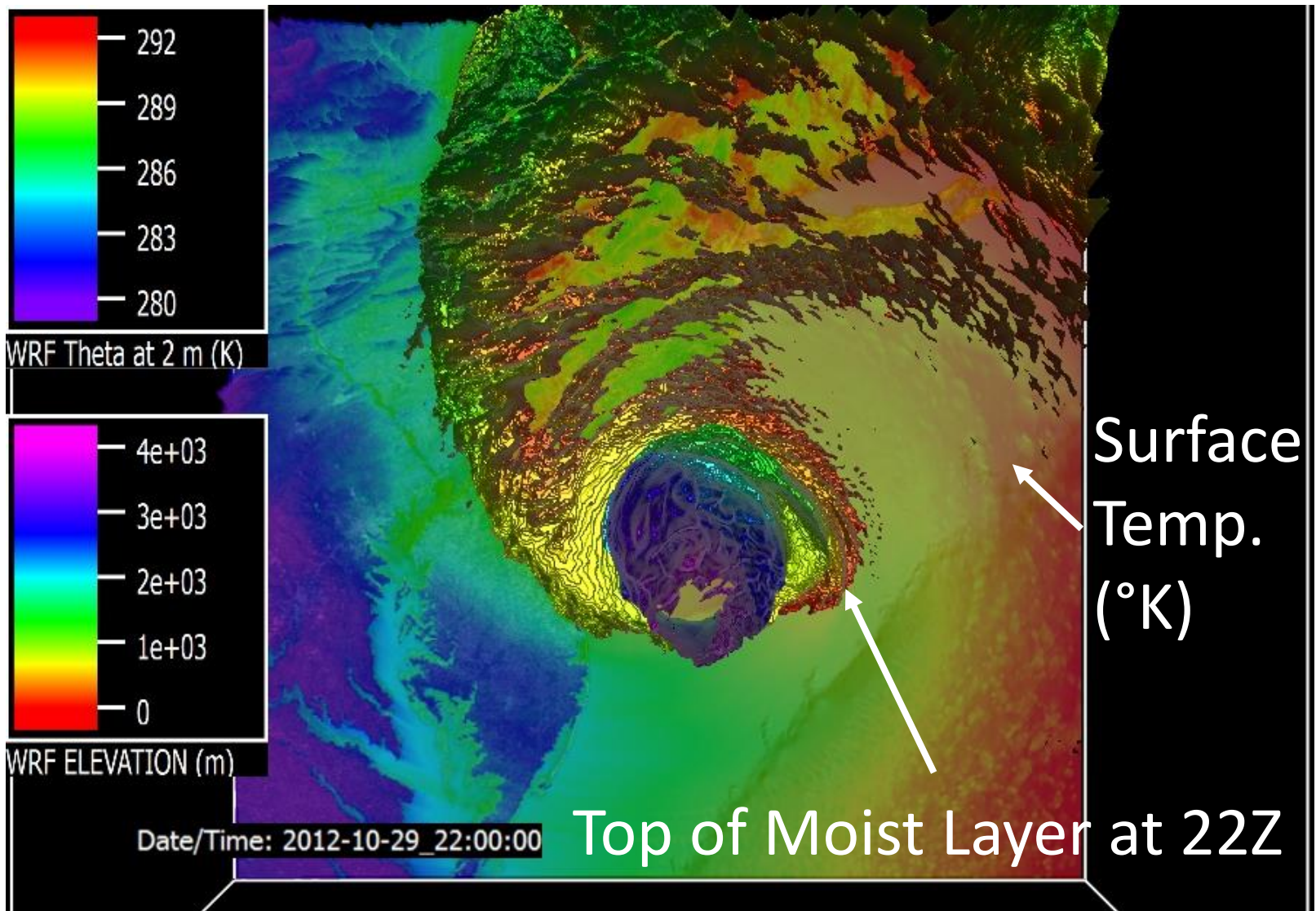
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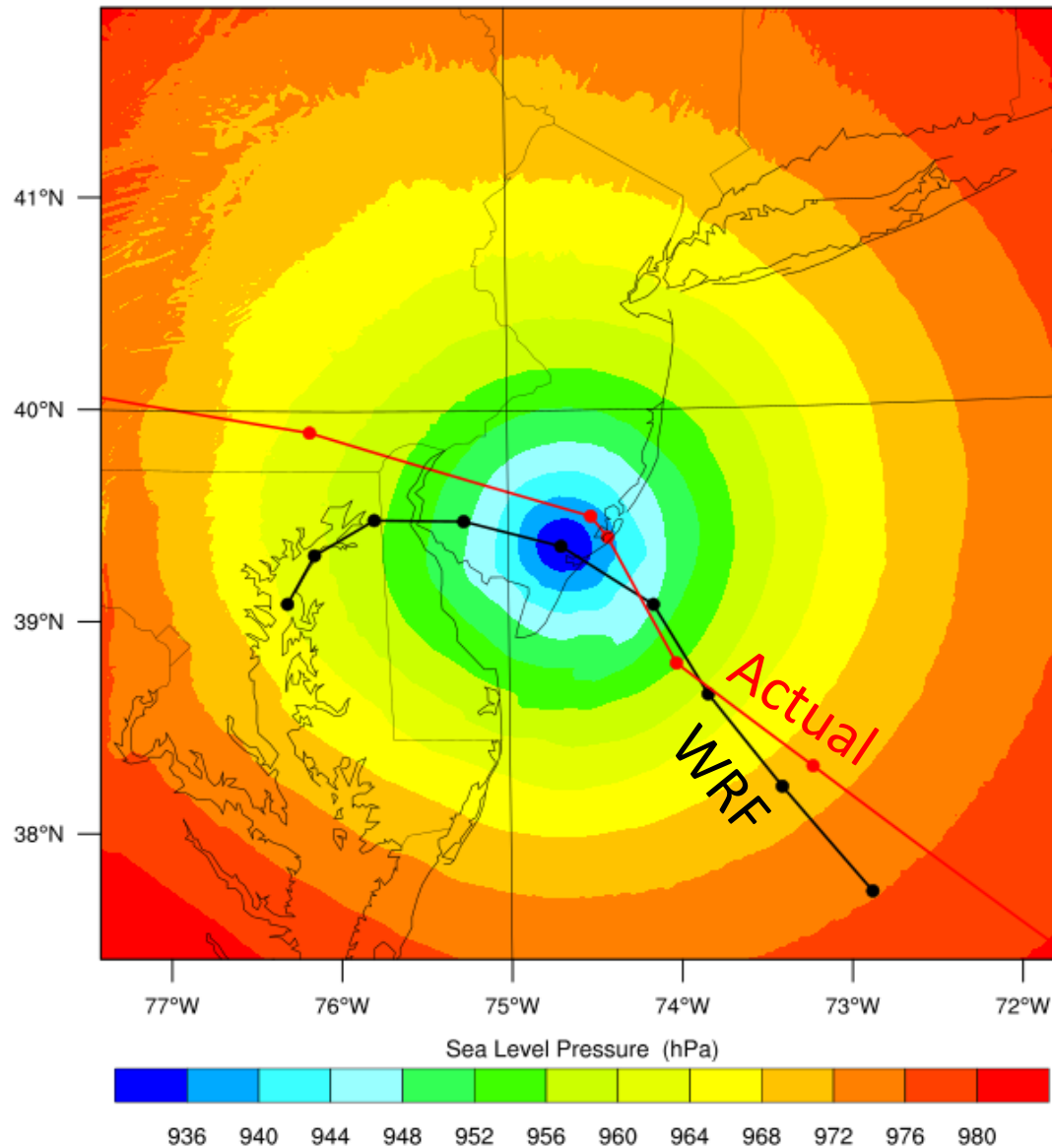
Fort Dix Radar Wind Speed Profiles



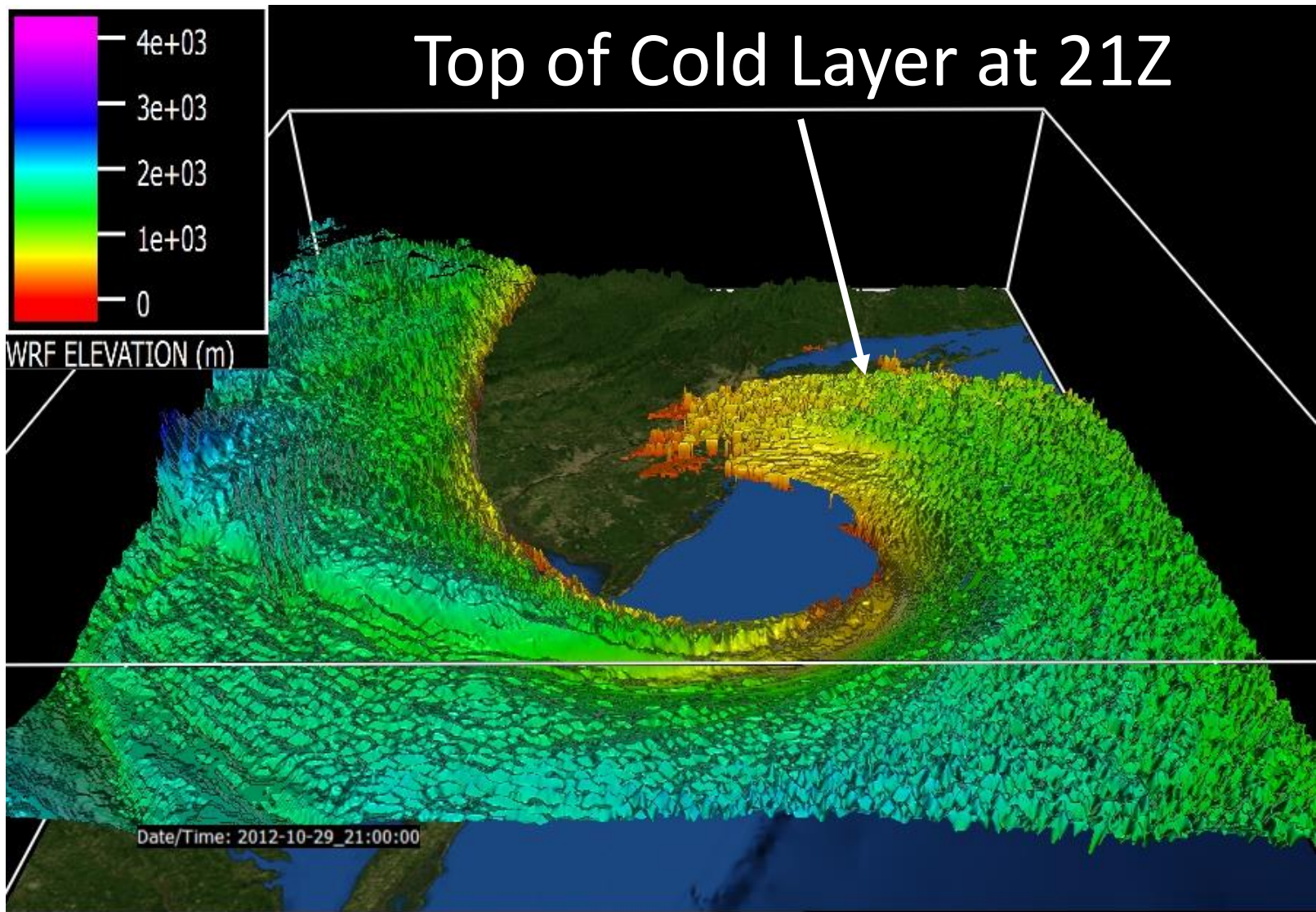
Sandy Overview – Model



Storm Track Comparison



WRF Cold Air Encirclement of Sandy

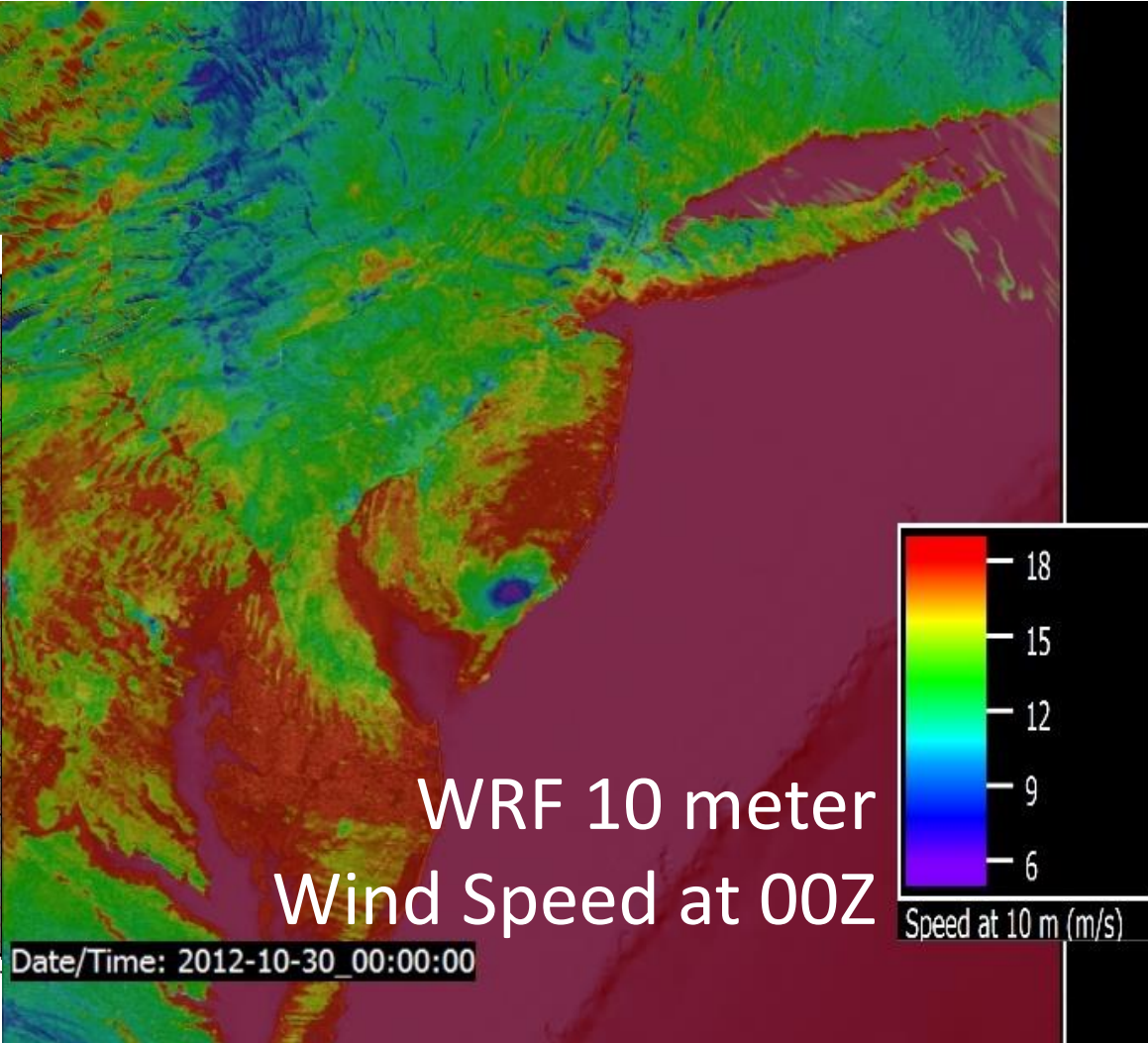
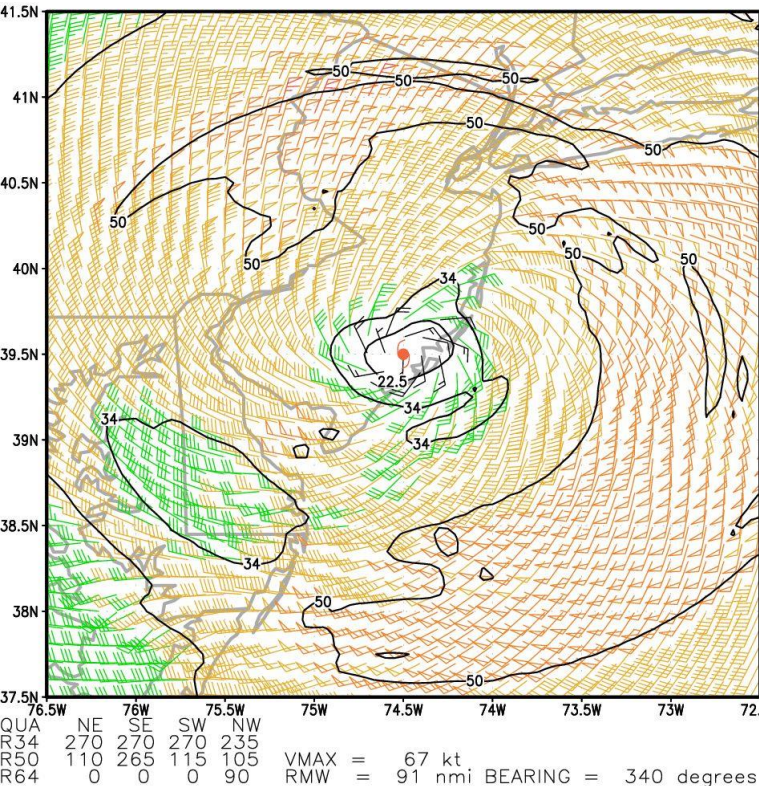


Surface Wind Field Comparison

Aircraft-based Surface
Wind Analysis at 00Z

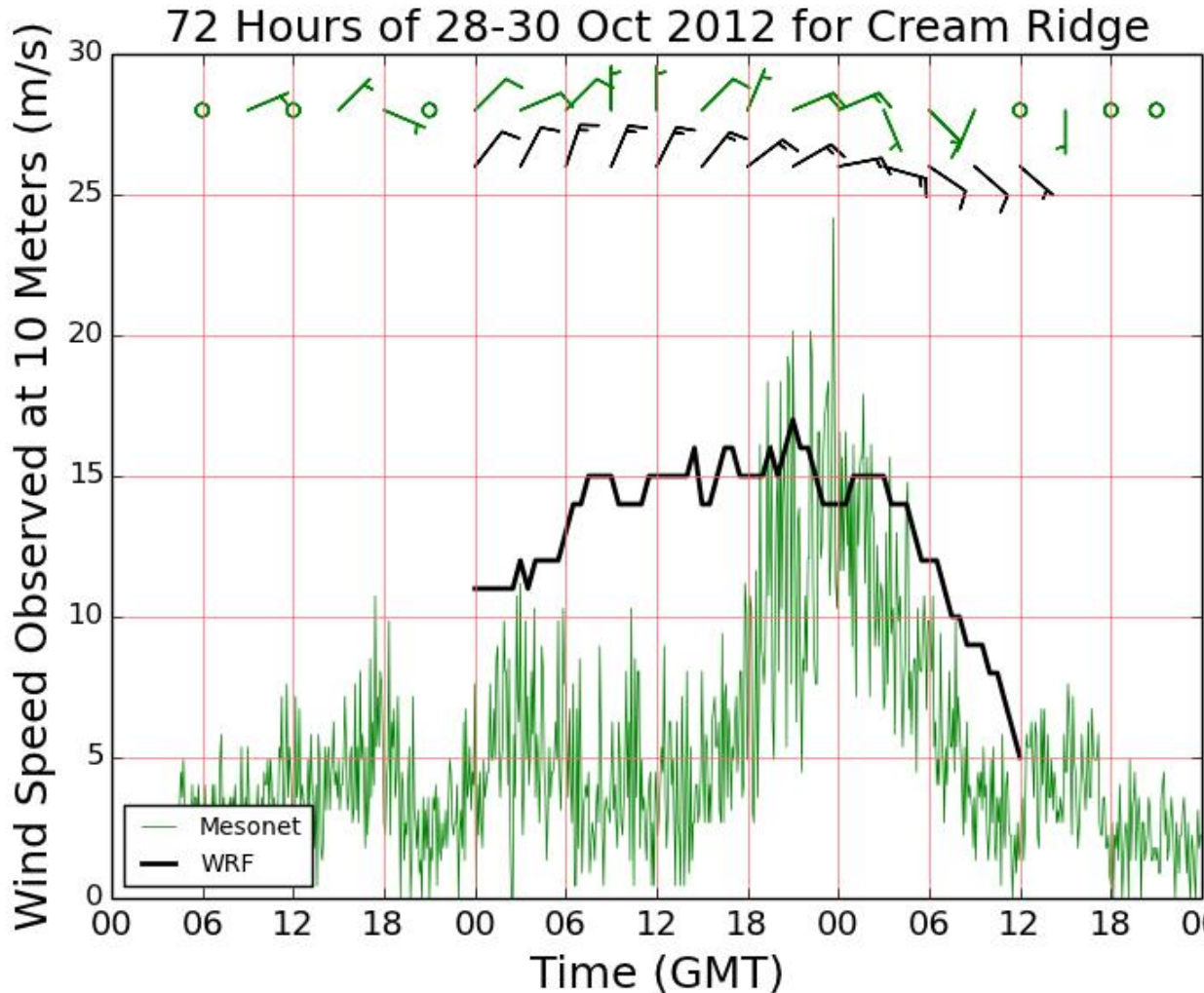


al182012 SANDY 2012 30 Oct 00UTC

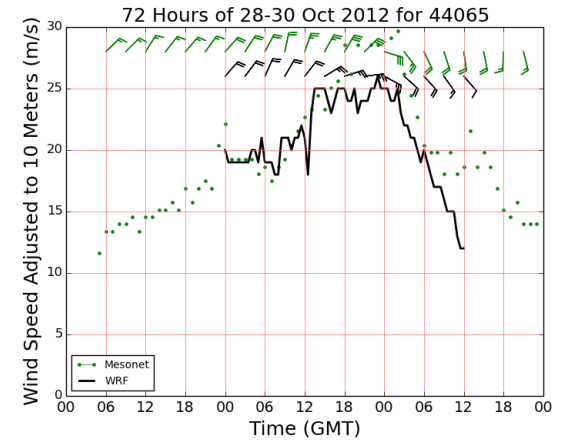


Time Series Comparison Sample

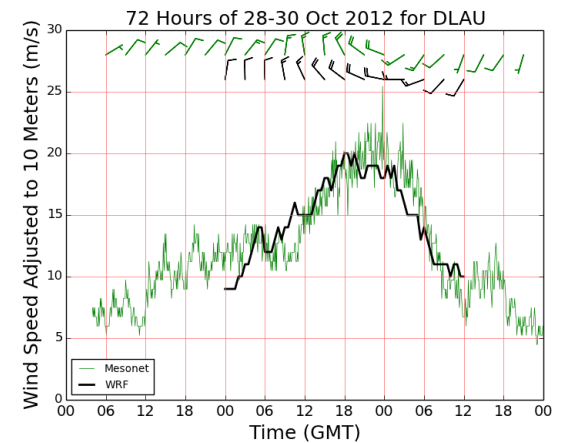
Inland NJ – 10m



Oceanic – 5m



Inland DE – 3m

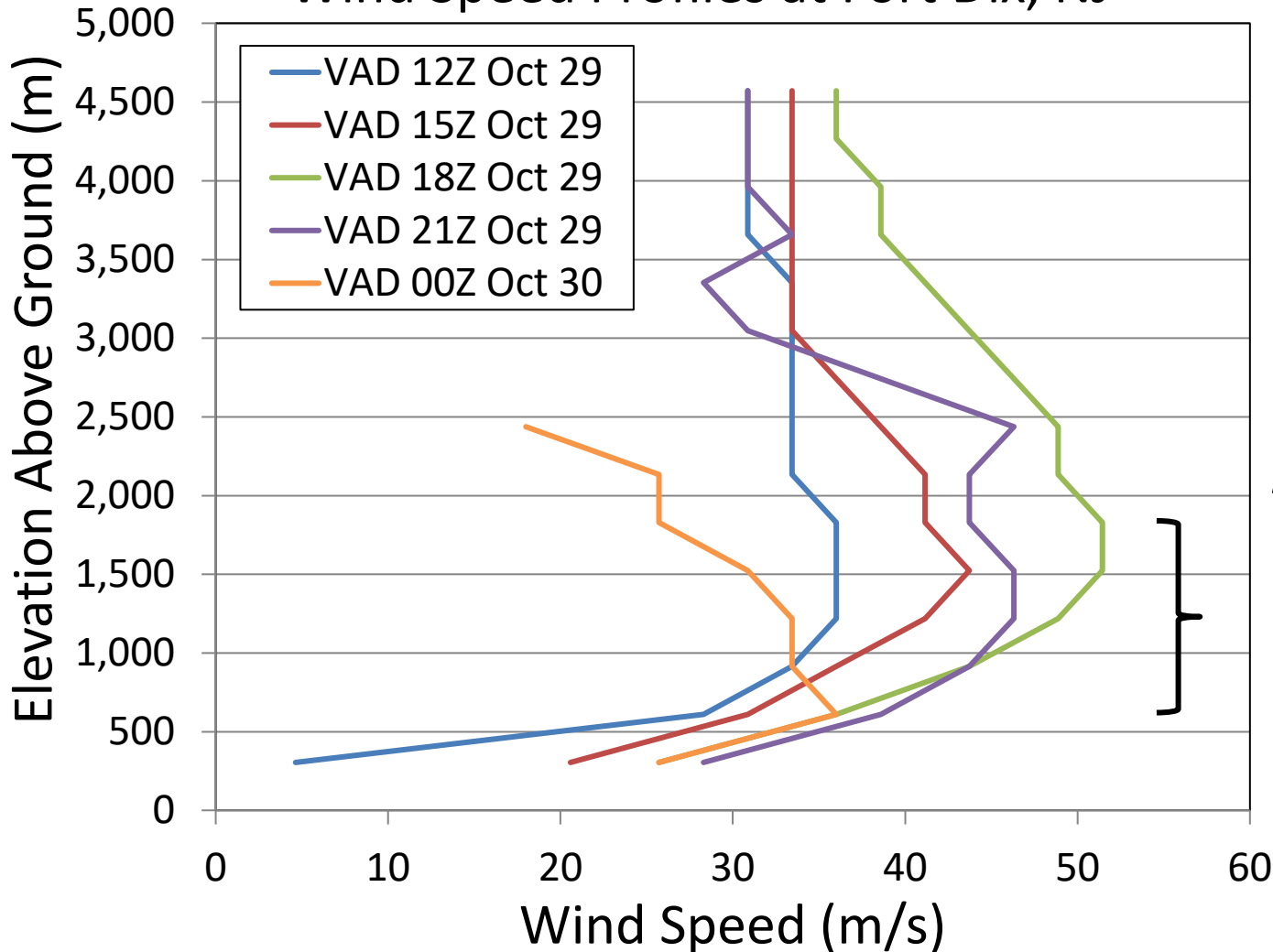


Roll Vortices

- **Concepts**
- *Radar* roll vortex signatures
- *Model* roll vortex signatures
- *Wind observation* roll vortex signatures
- Impact on wind and trees

Concepts – Boundary Layer and Winds

Wind Speed Profiles at Fort Dix, NJ

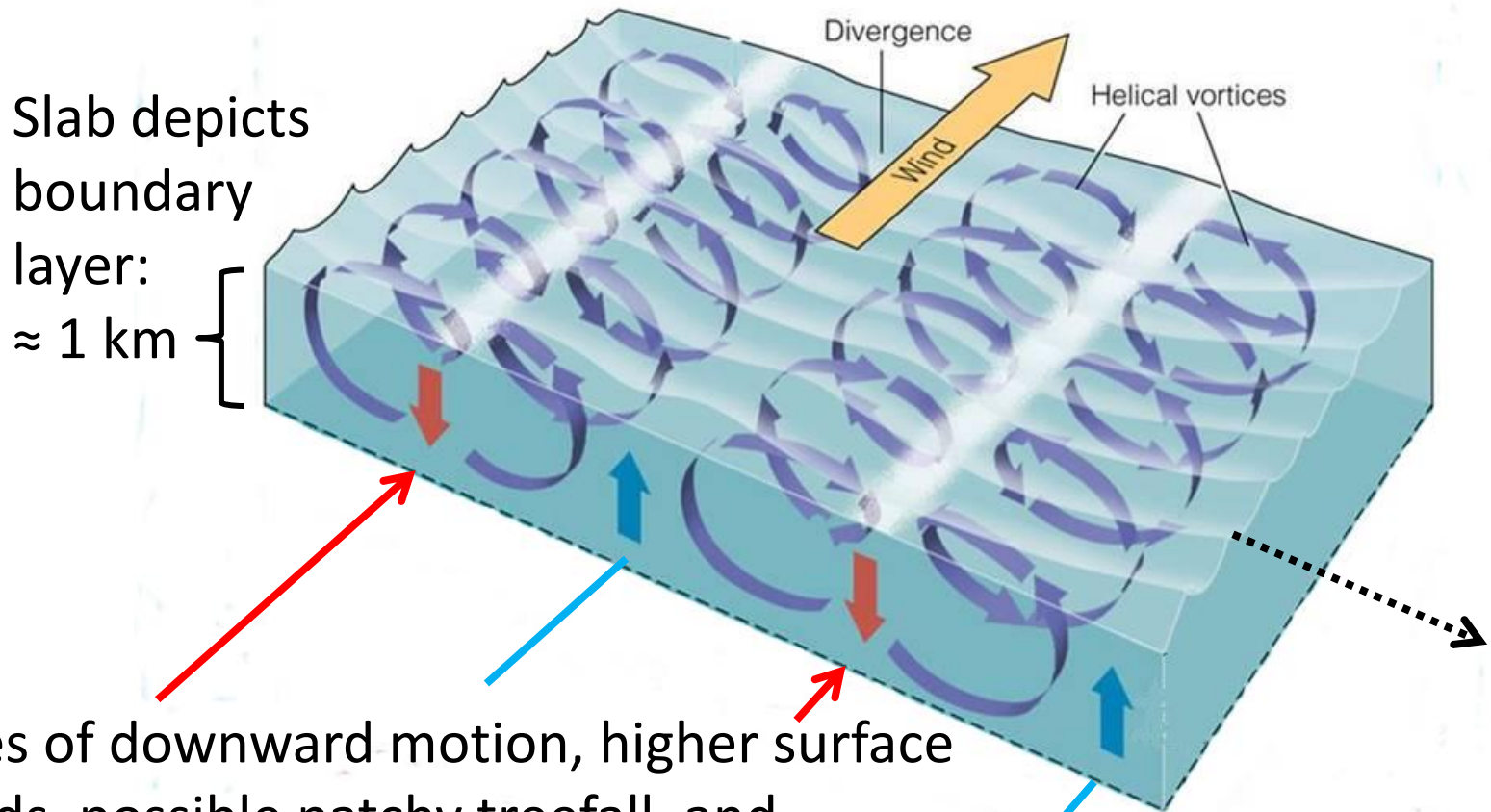


Boundary layer:
Air layer most affected by earth's surface

Hurricane winds peak near top of boundary layer:
600-1,800 m for Sandy

Concepts – What Are Roll Vortices?

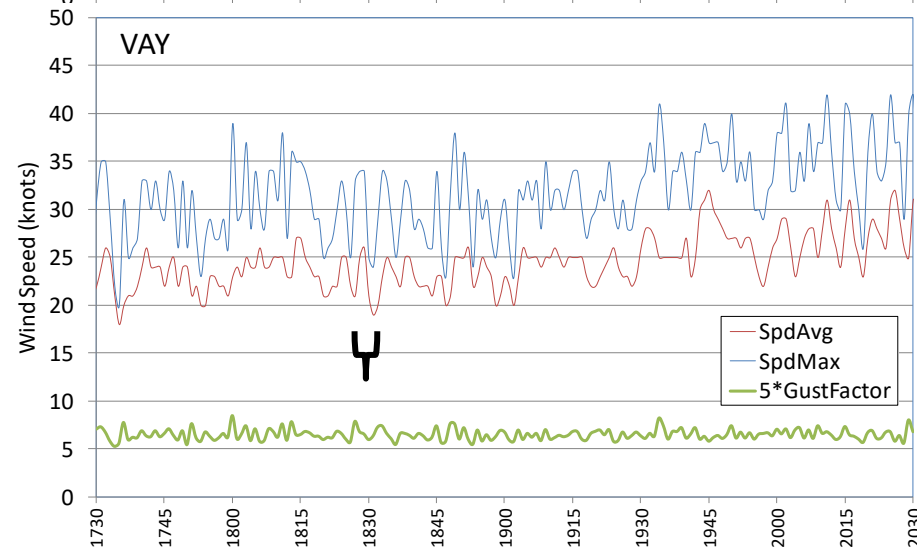
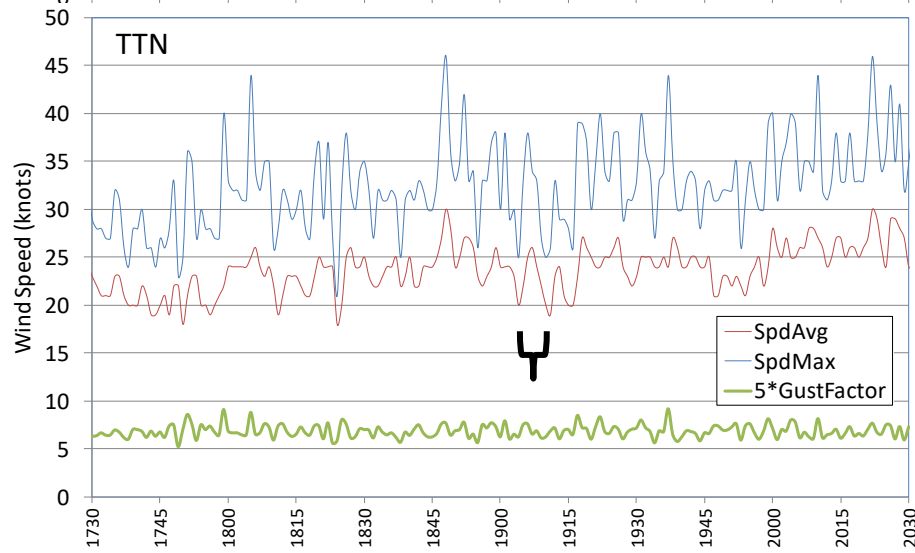
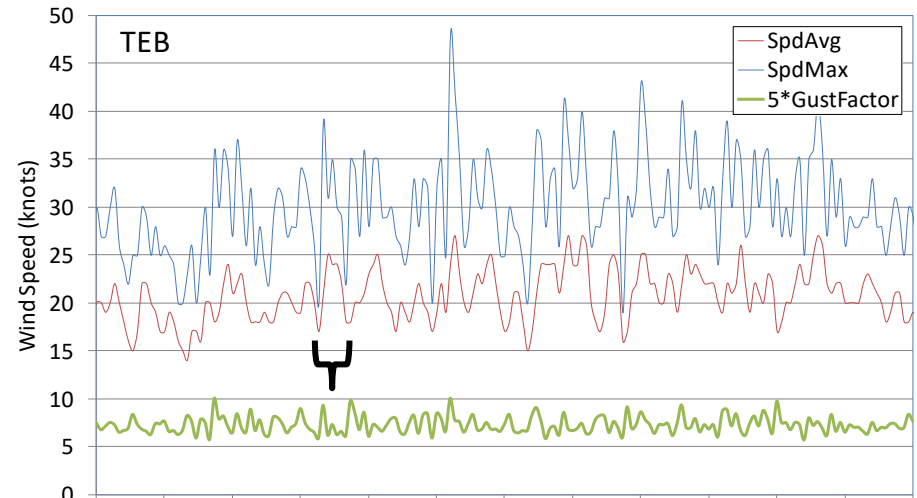
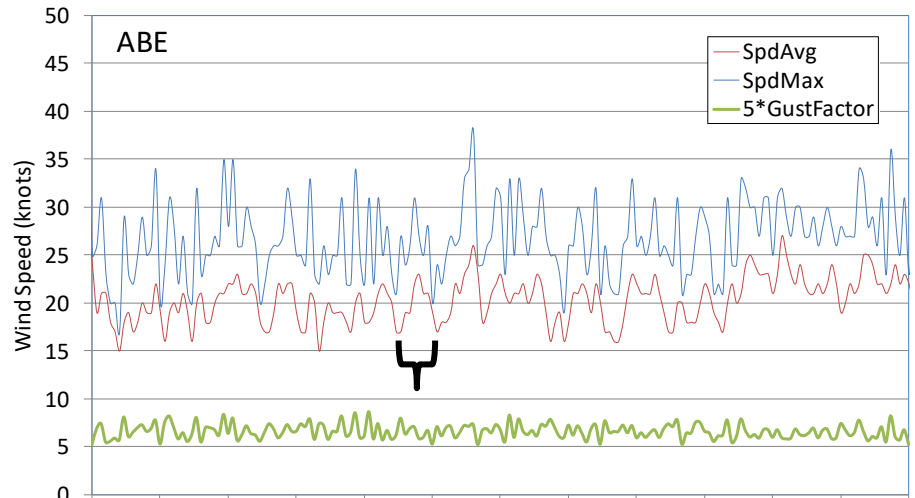
Observed in 12 prior hurricanes but mostly over open waters



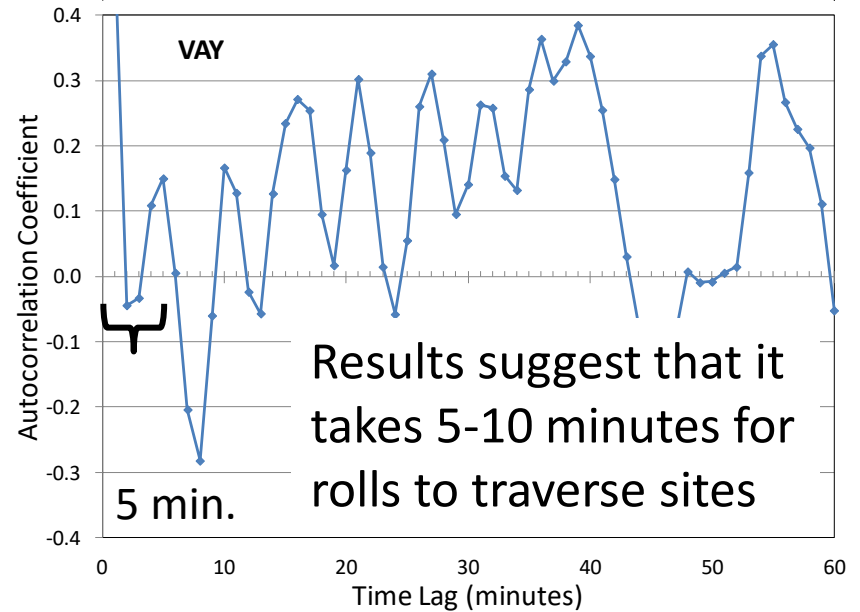
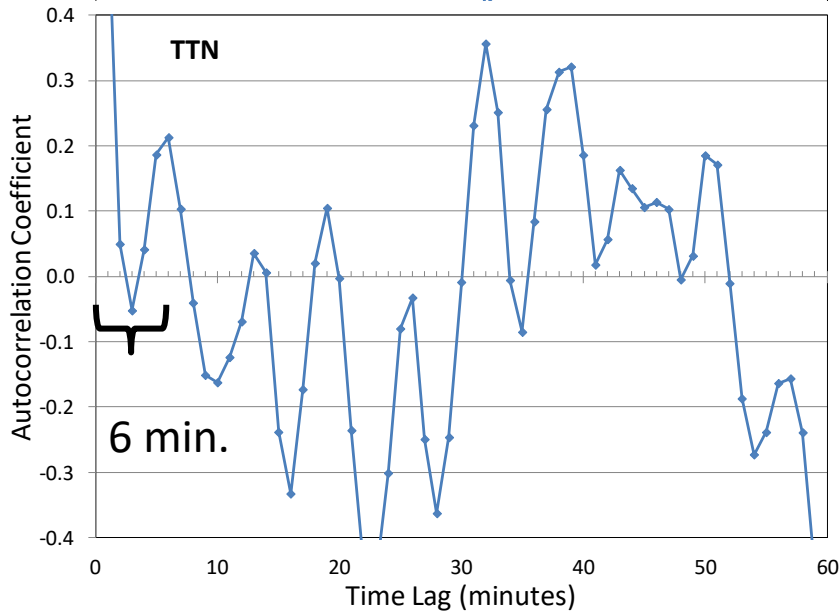
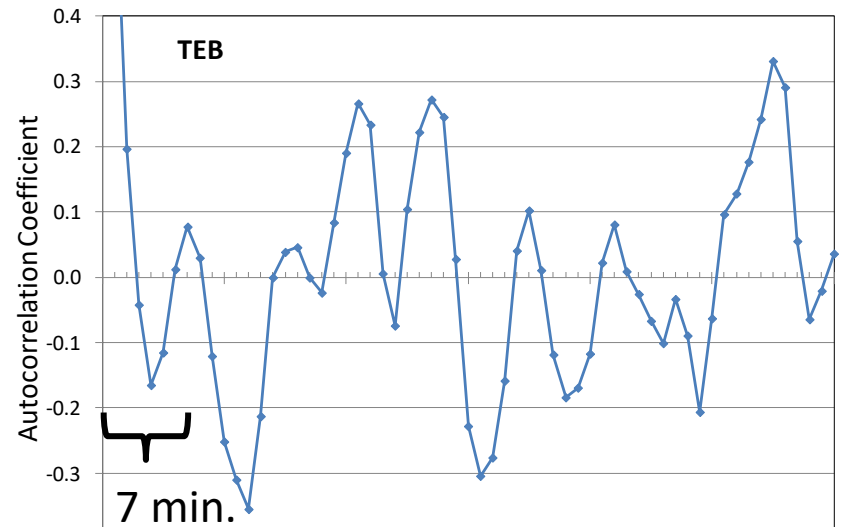
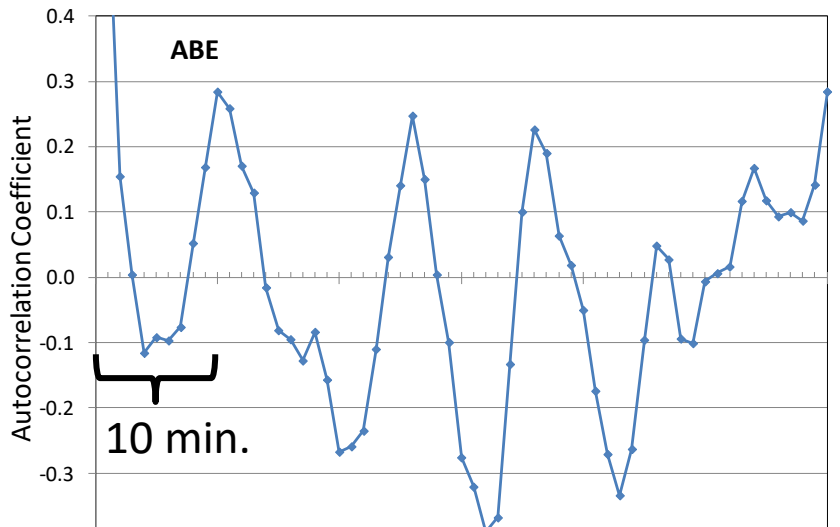
- Lines of downward motion, higher surface winds, possible patchy treefall, and diminished precipitation
- Often propagate sideways

Adapted from
Brooks/Cole –
Thomson (2005)

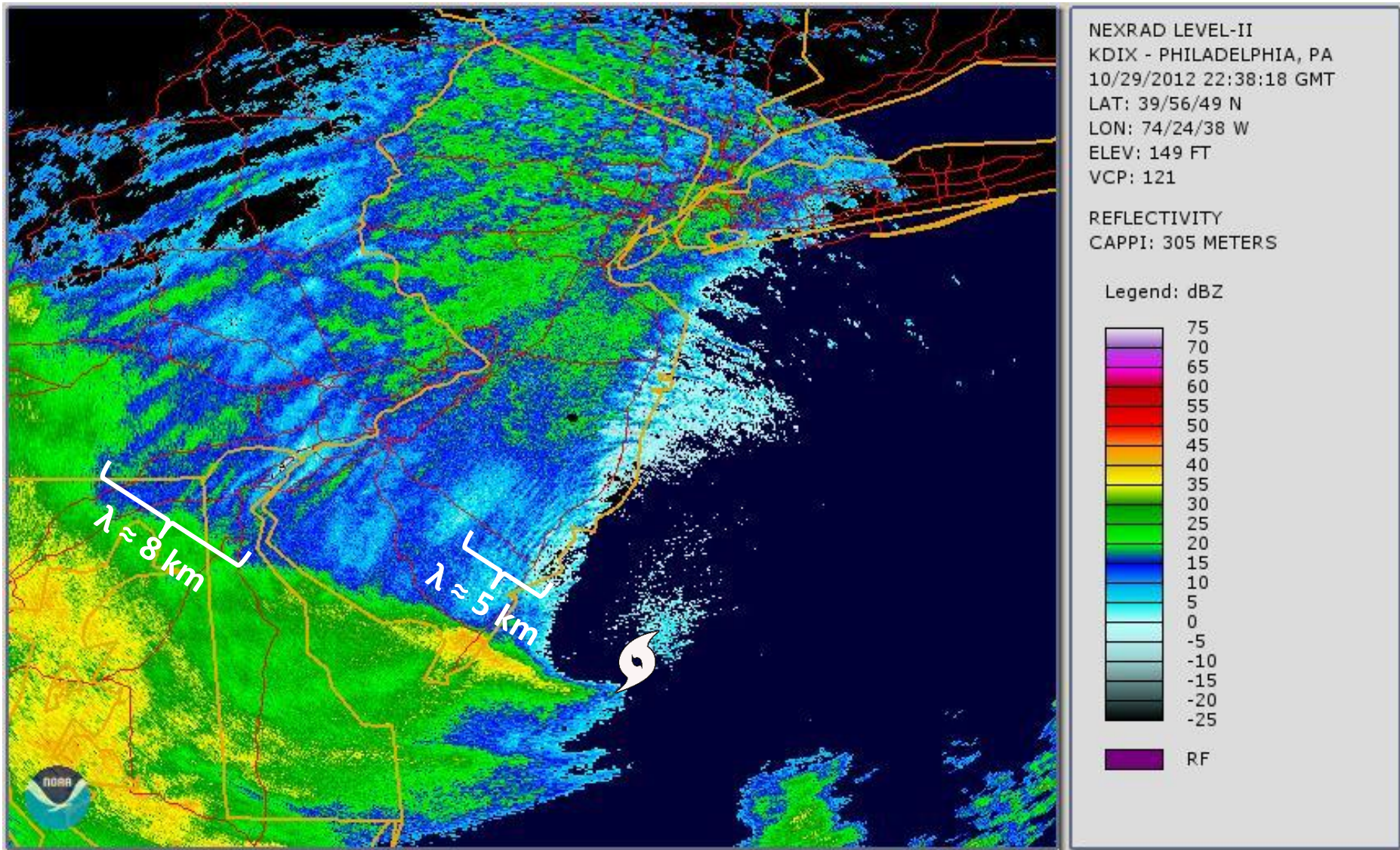
1-Minute Speed Time Series



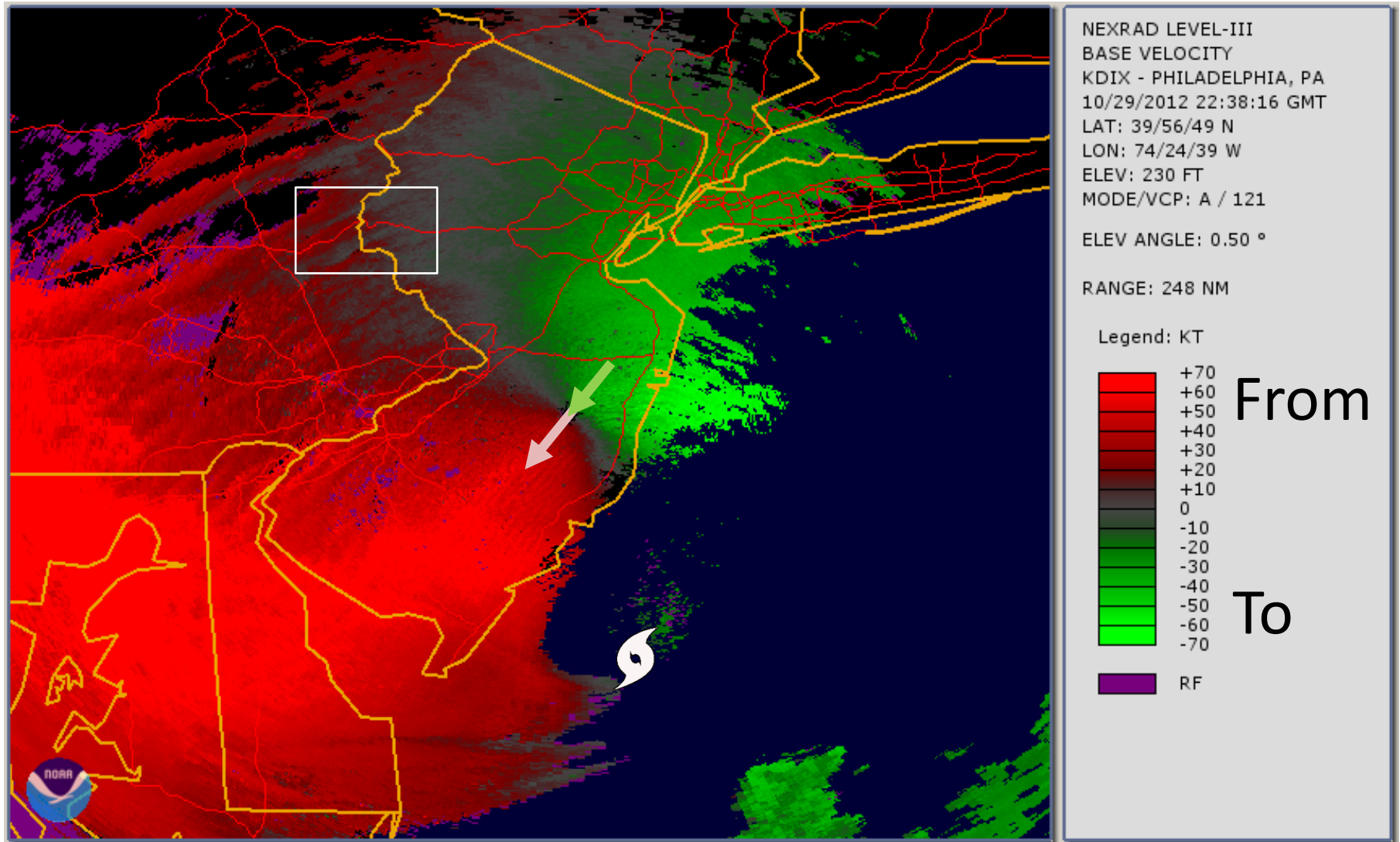
Wind Speed Autocorrelation



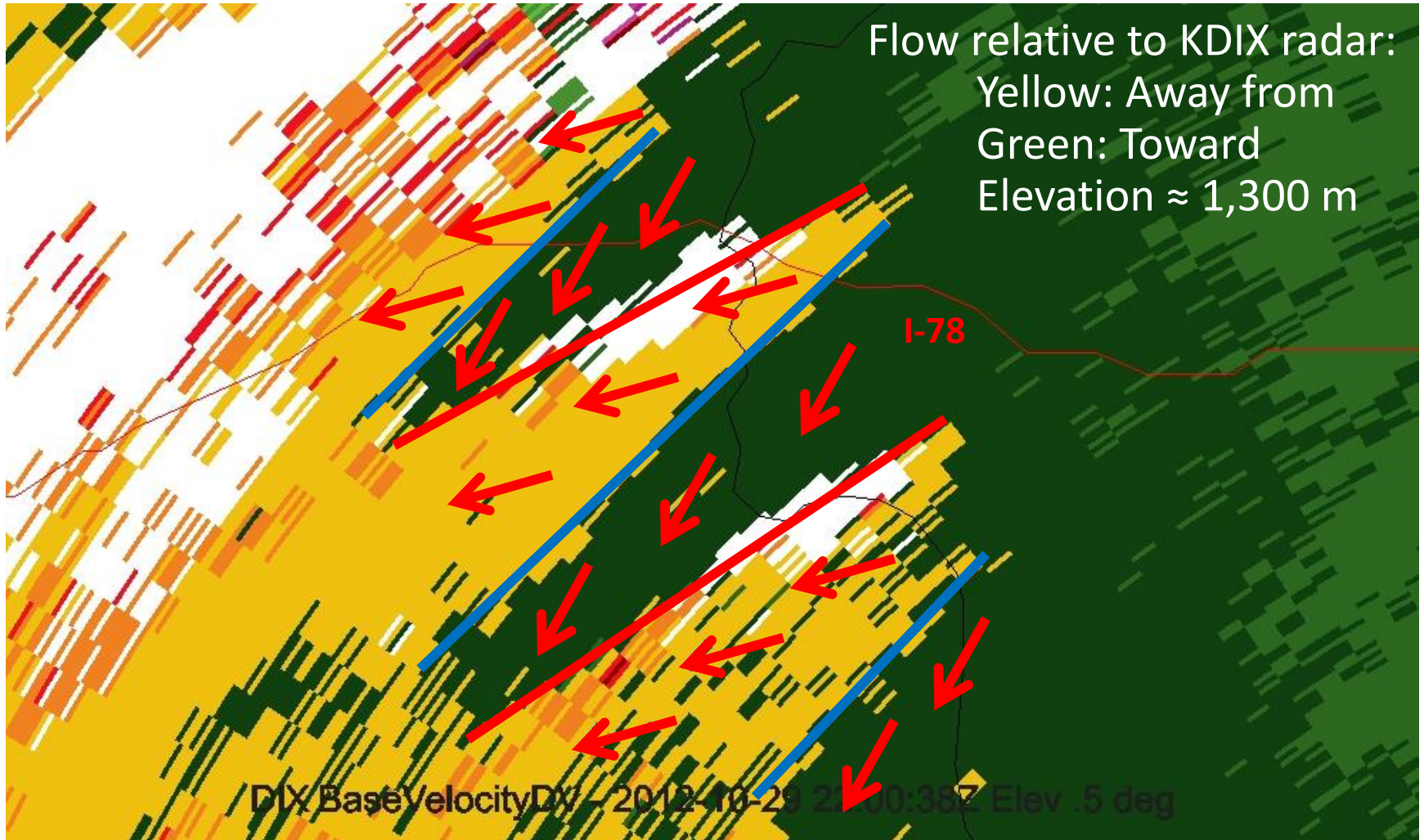
Roll Signatures in Radar Precipitation



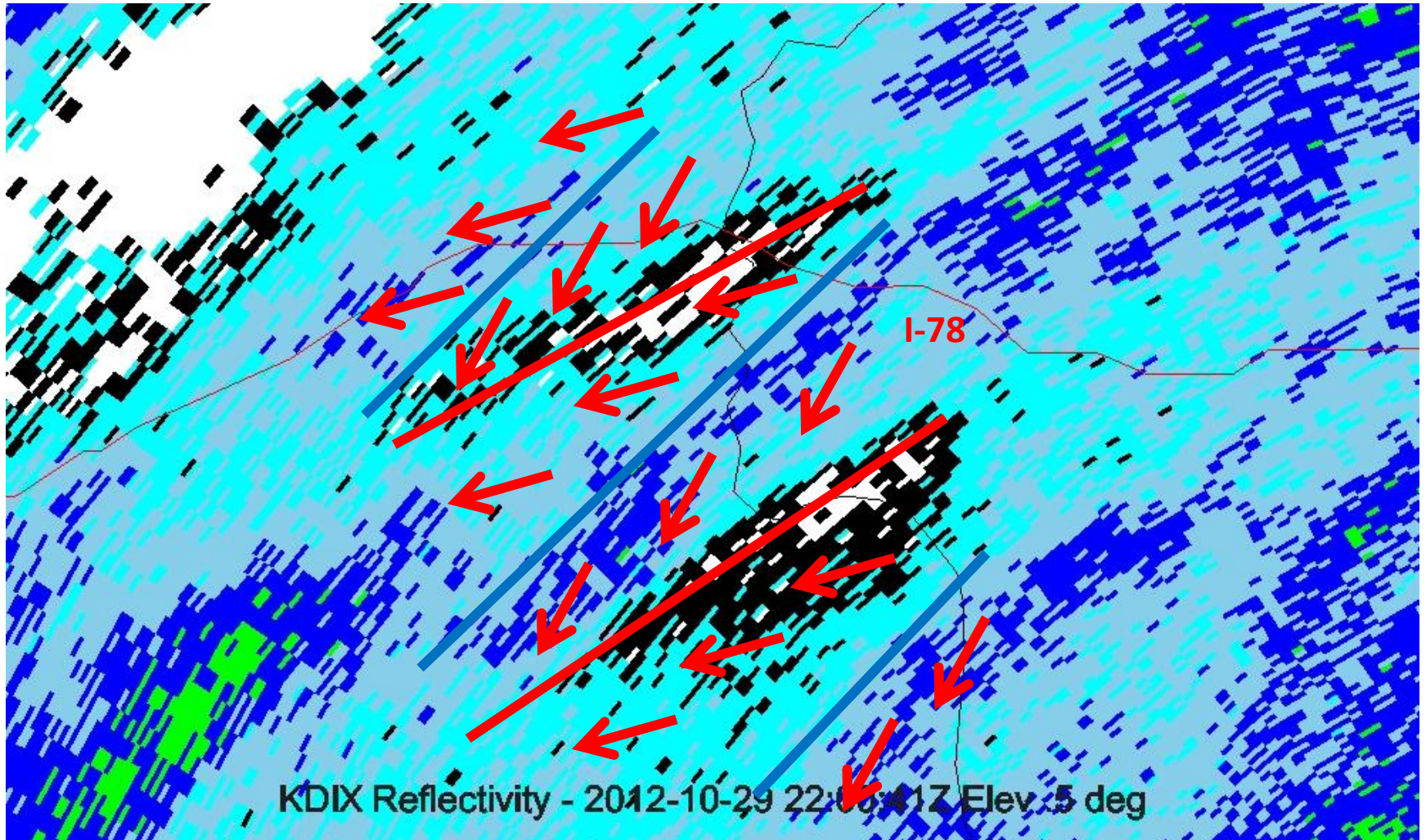
Roll Vortex Signatures in Radar Velocity



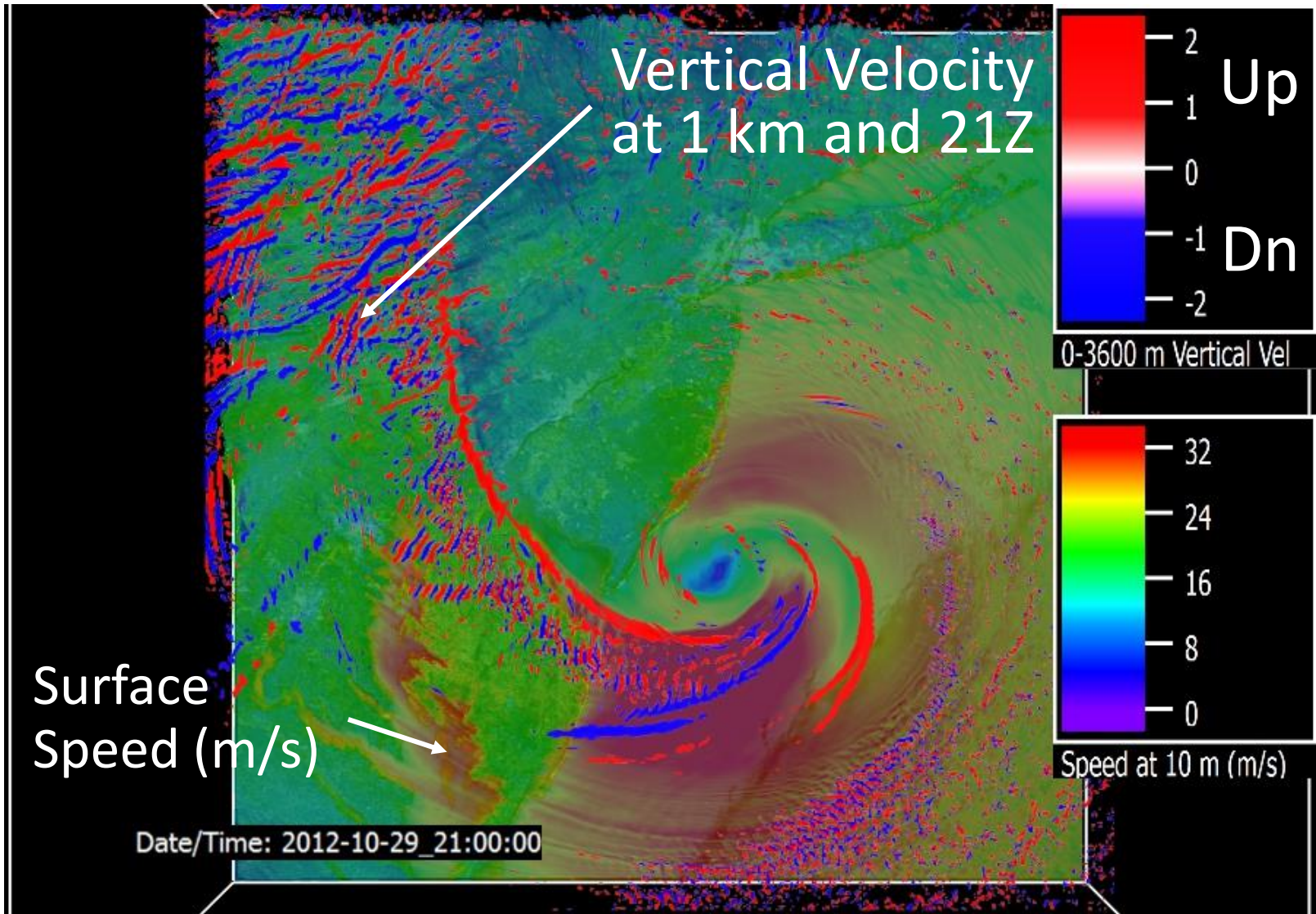
Radial Velocity Confluence Lines



Reflectivity With Confluence Lines

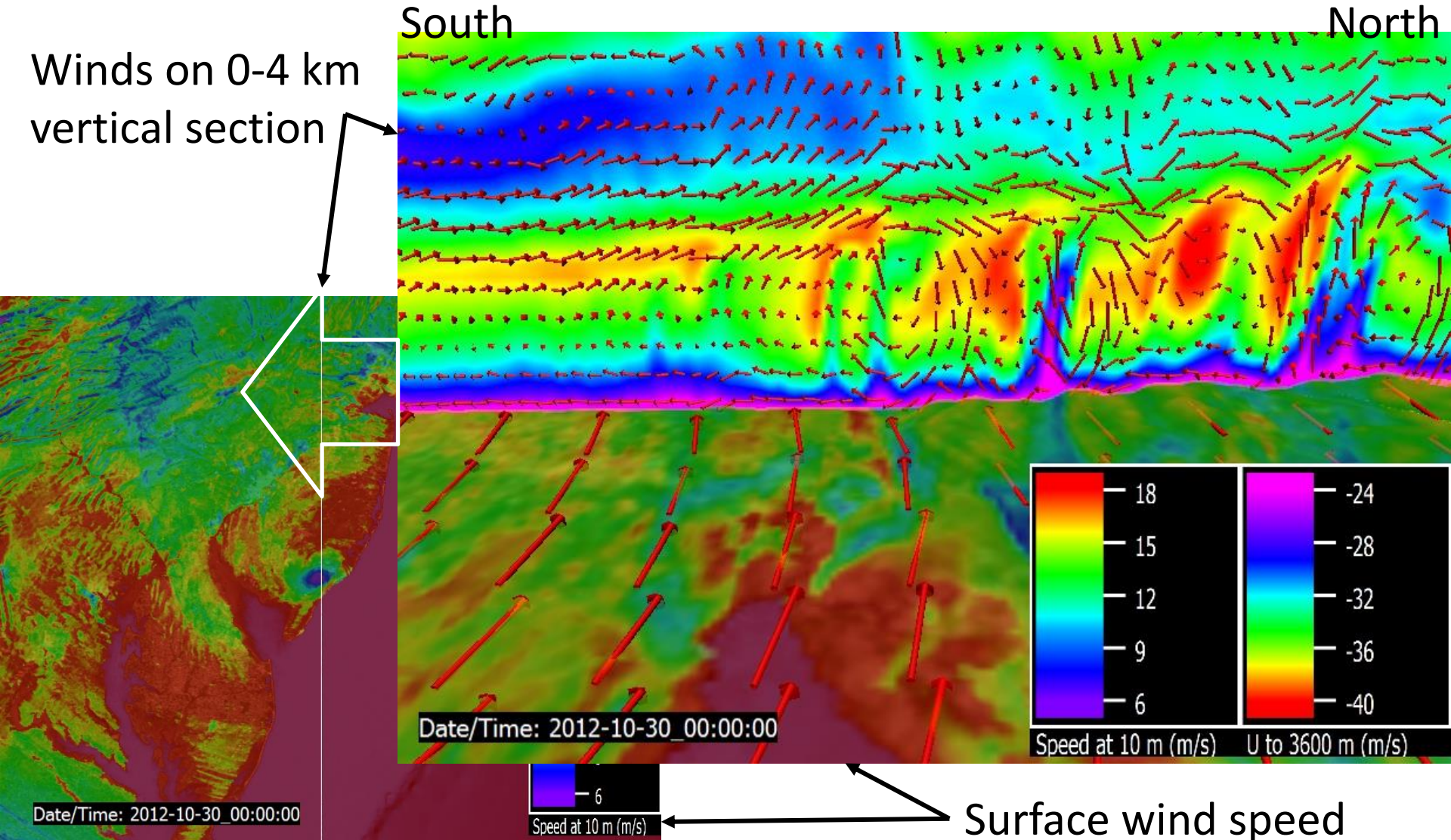


Roll Vortex Signatures in Model

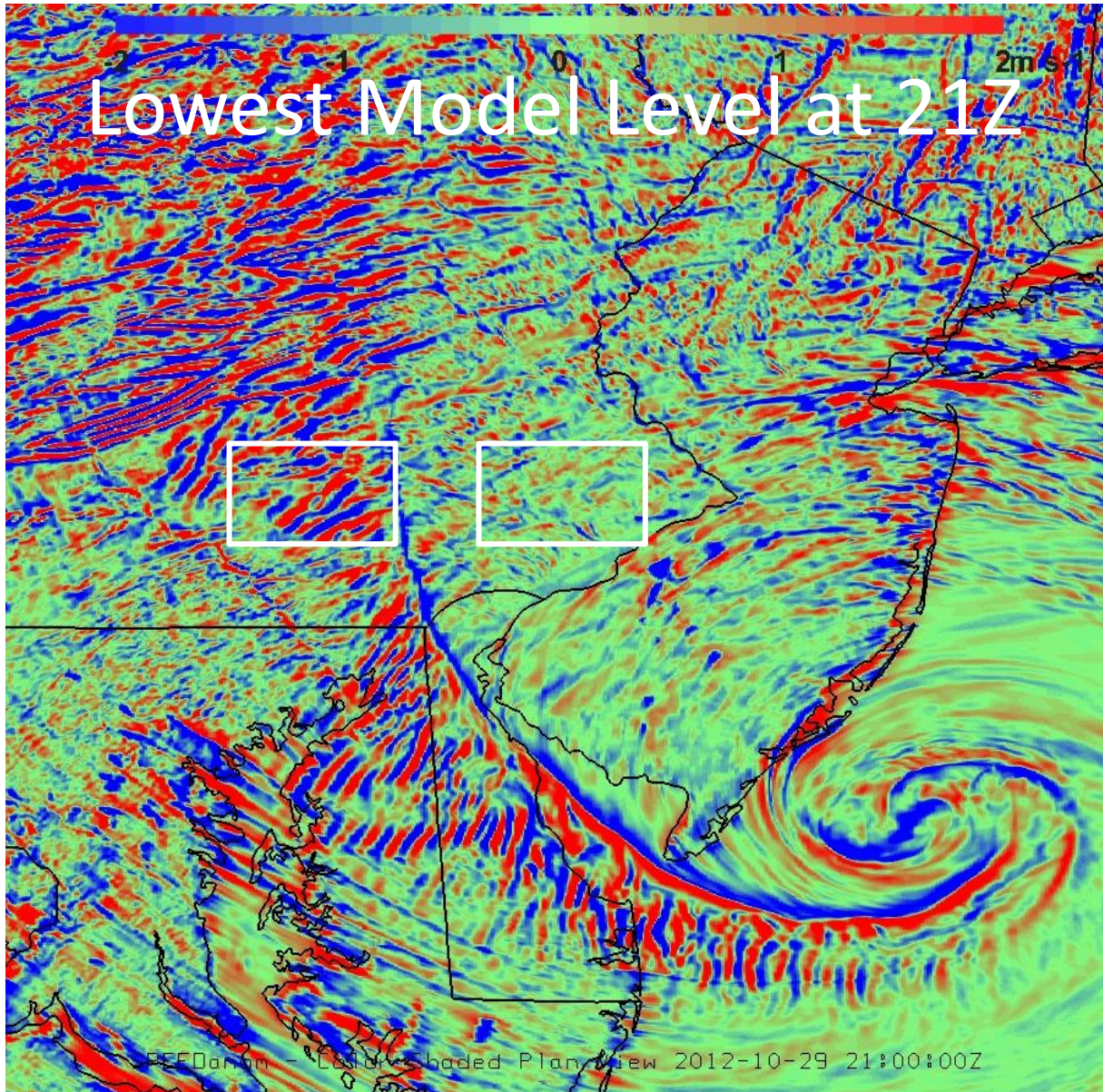


Wind Speed Vertical Section - Model

Winds on 0-4 km vertical section

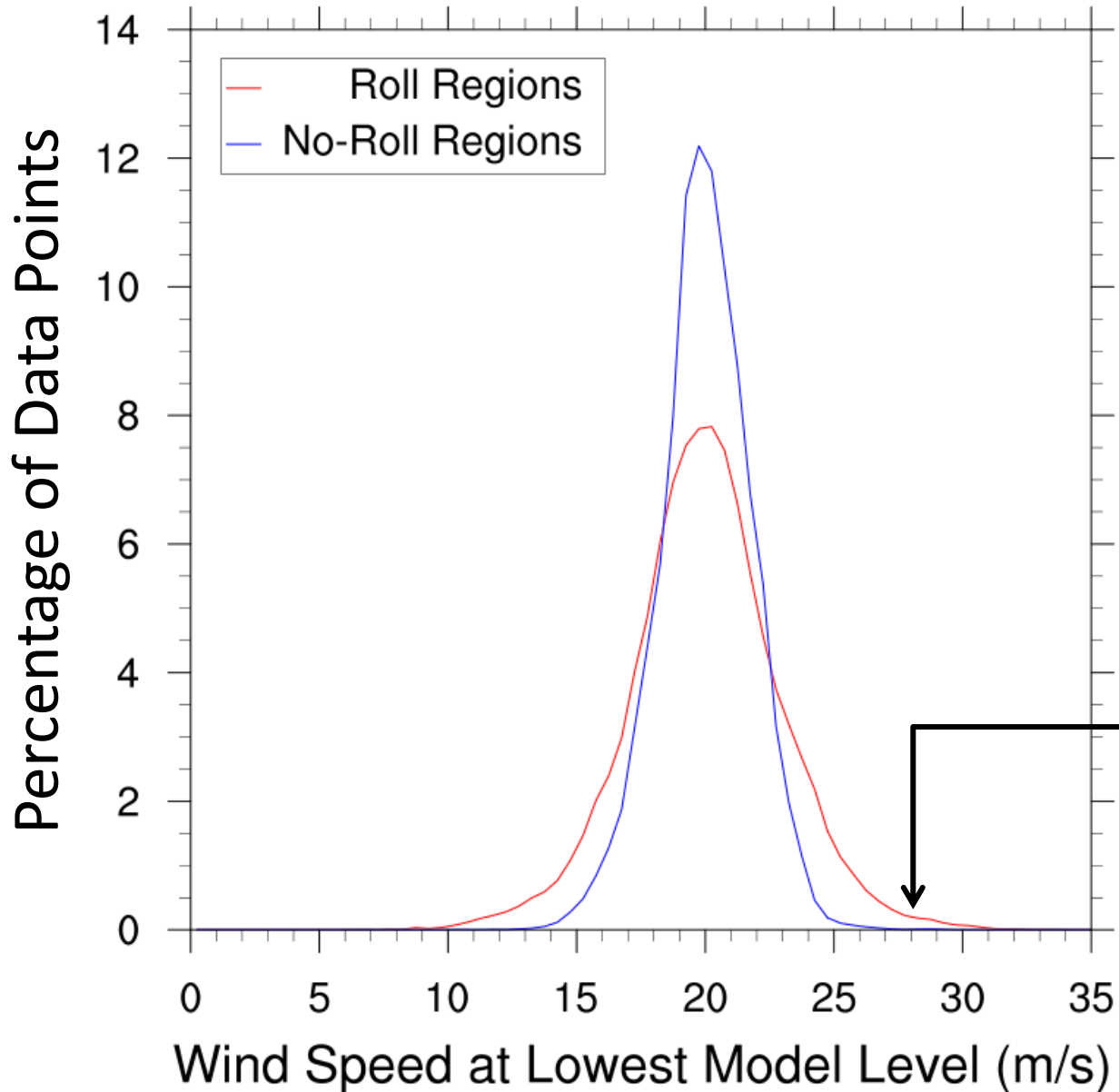


WRF Wind Speed “Footprints”



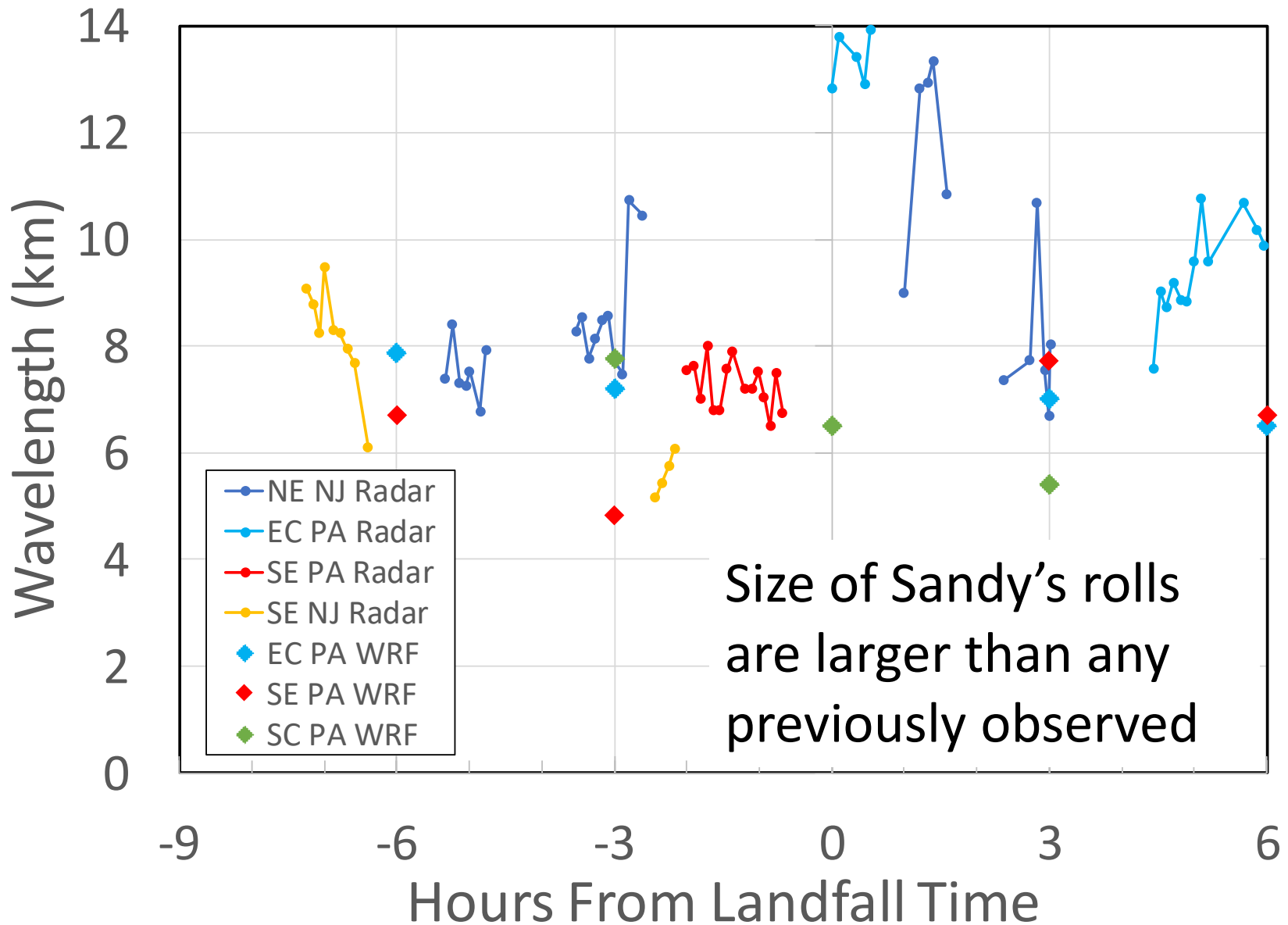
- Spatially *smooth* wind speed and subtract it from *raw* wind speed
- This yields wind speed *deviation* from local mean wind speed:
Red = high
Blue = low
- Speed deviation exhibits roll “footprints” of alternating lines of high and low wind speed

Roll Excess Wind Risk



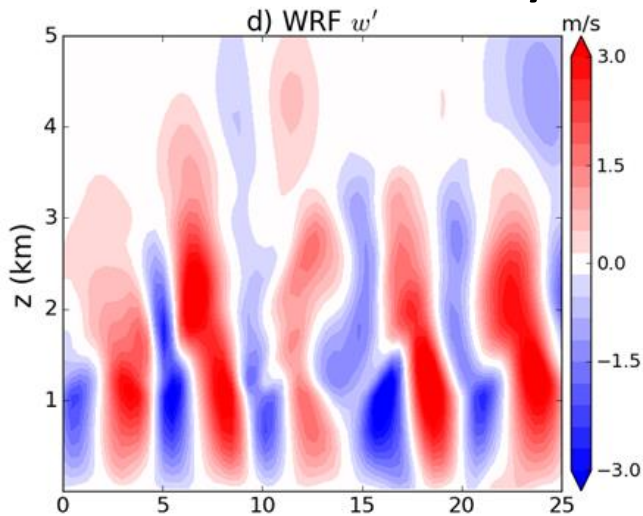
25 times
more likely to
experience
winds ≥ 28 m/s
if rolls are
present

Roll Vortex Sizes and Clusters

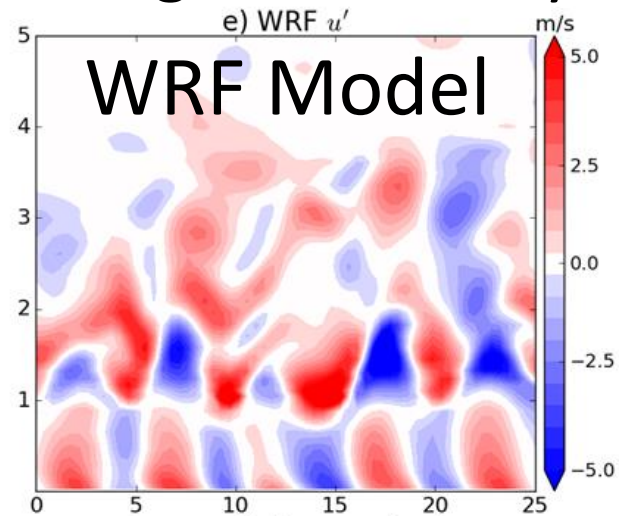


Kun Gao's Roll Model vs. WRF

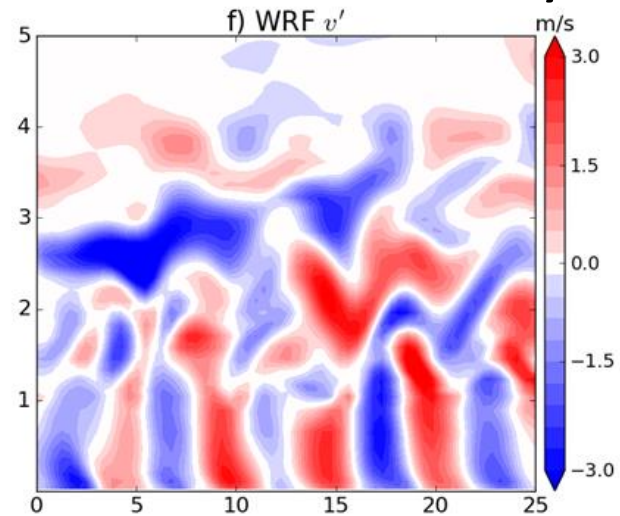
Vertical Velocity



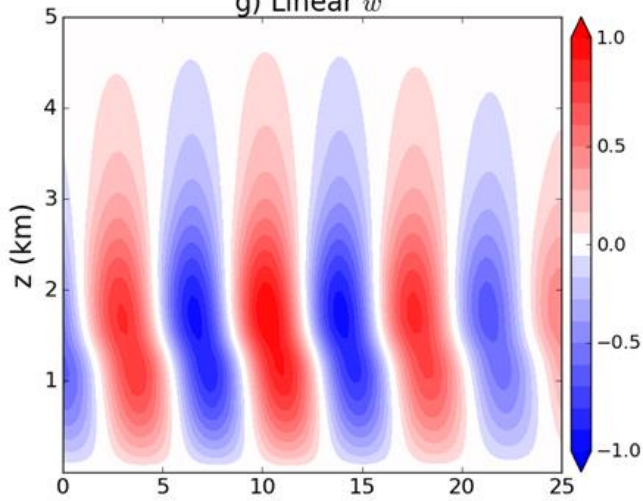
Along Roll Velocity



Outward Velocity

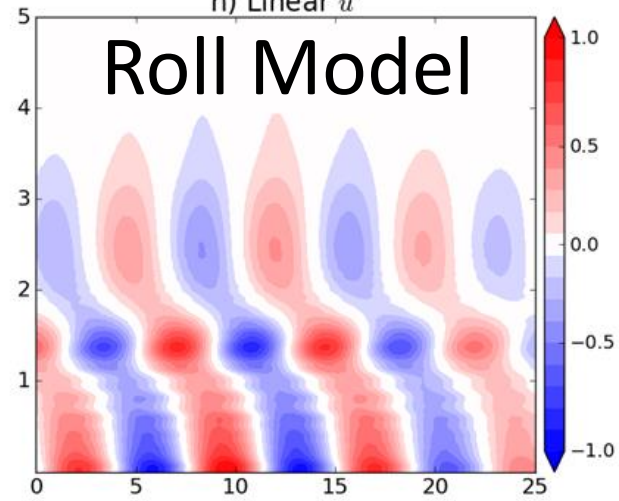


g) Linear w'

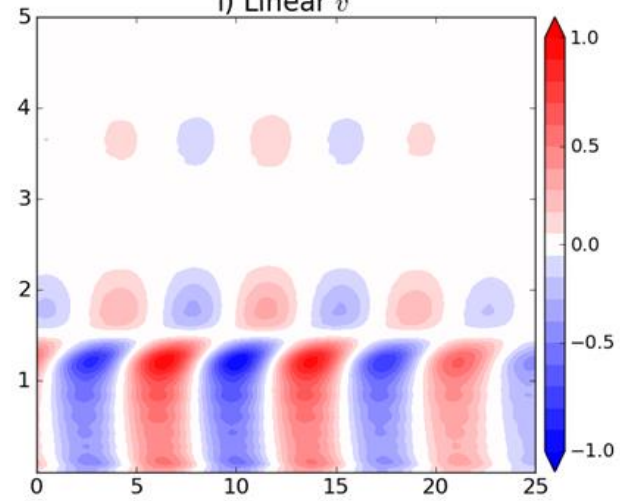


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h) Linear u'



i) Linear v'



29

Sandy's Wind Impact on Tree-fall





Summary

- **Data analyzed**
 - Radar and surface wind speed observations, WRF simulation, specialized roll vortex model
- **Key findings**
 - Observations exhibit many characteristics expected of rolls
 - WRF simulation and roll vortex model corroborate many aspects of observations
 - Therefore, confirm presence of roll vortices during Sandy's landfall
 - First time that roll vortices this large are reported under a landfalling hurricane
- **Yet to be done**
 - Can it be shown that tree-fall patches are indeed caused by roll vortices?
 - Why were roll vortices so large in Sandy?

Thank you!

- More visualizations
 - Mesoscale Analysis of Sandy's Landfall Winds
seedme.org/node/163591
 - WRF Users' Workshop 2016 Visualizations
seedme.org/node/70880
 - Sandy WRF Discovery Paper
seedme.org/node/47360
- A paper on Sandy's roll vortices is nearing completion
- My contact
 - jimschiavone@gmail.com