Mesoscale comparison of simulated and observed winds during Sandy's landfall

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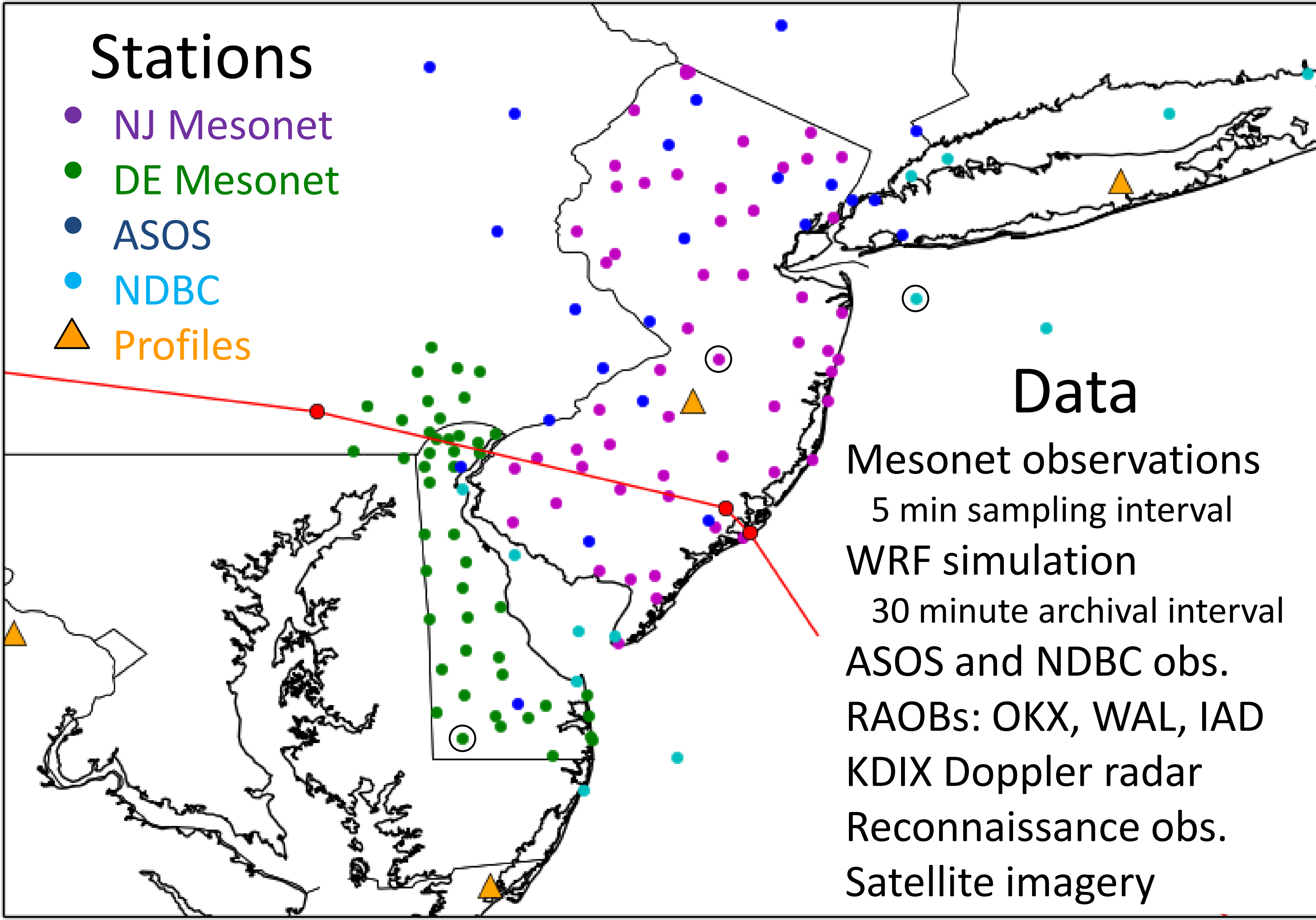
Work Made Possible By . . .

- High resolution mesonet **observations**
  - New Jersey Weather and Climate Network (NJWxNet)
  - Delaware Environmental Observing System (DEOS)
  - NOAA's Automated Surface Observing Systems (ASOS) and National Data Buoy Center (NDBC)
- High resolution WRF **simulation**
  - WRF simulation with Mel Shapiro and Mark Straka on Cray XE6 at NCSA yielded 43 Terabytes
  - NCAR's Dick Valent was instrumental in gaining access to big data set
  - NCAR's VAPOR Visualization and Analysis Platform was vital for studying it

Goal(s)

- Original goal . . .
  - Leverage resilient mesonets and 500-meter resolution WRF simulation to understand the mechanisms that caused the **patchy nature of significant tree-fall** experienced throughout Sandy's landfall region
- Broadened to include
  - Understanding **fine structure of surface wind fields** observed during landfall and mechanisms driving them
  - Characterizing **late-stage extratropical transition** and associated air streams and their evolution
  - **Evaluating performance** of 500-meter resolution WRF simulation during landfall period

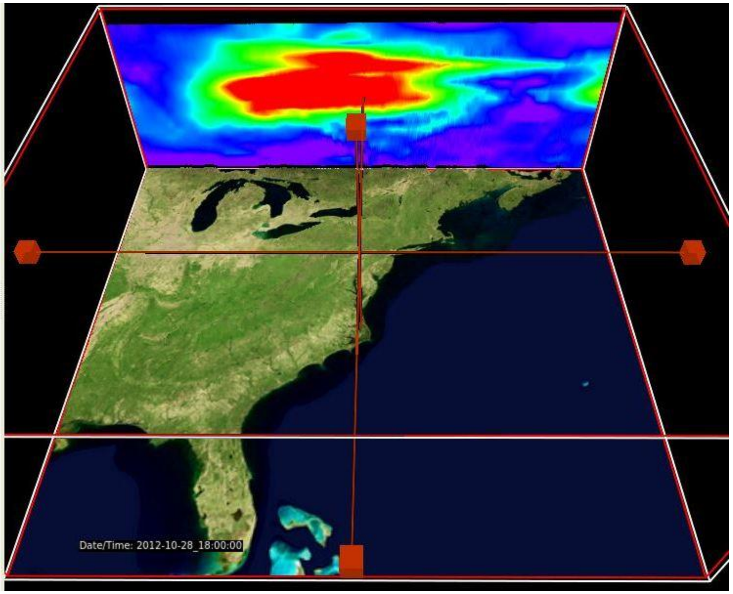


Data

- Mesonet observations
  - 5 min sampling interval
- WRF simulation
  - 30 minute archival interval
- ASOS and NDBC obs.
- RAOBs: OKX, WAL, IAD
- KDIX Doppler radar
- Reconnaissance obs.
- Satellite imagery

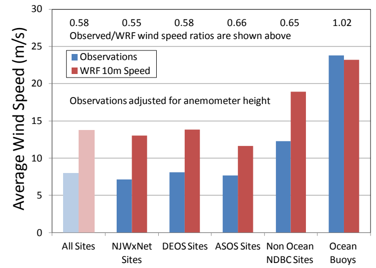
WRF Simulation

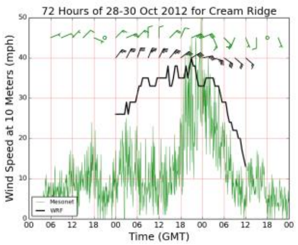
- **WRF version**: Advanced Research WRF version 3.3.1
- **System**: Cray XE6 “Blue Waters” at NCSA
- **Execution**: 58 hours of wall clock using 140,000 cores
- **Grid**: 500 meters, 5320x5000 horizontal, 150 layers
- **Initialization and boundary conditions**: NOAA/NCEP GFS global model output
- **PBL**: Yonsei University (YSU)
- **Simulation period**: 96 hours, 12Z Oct 26 to 12Z Oct 30, 2012
- **Output**: 30 minute interval, 193 files, 224 Gigabytes each, total of 43.2 Terabytes

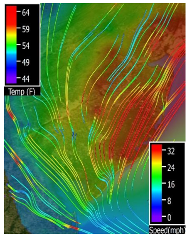


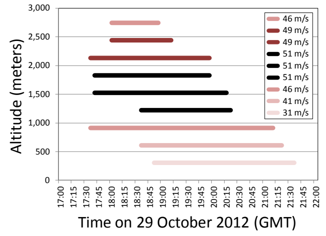
Investigations

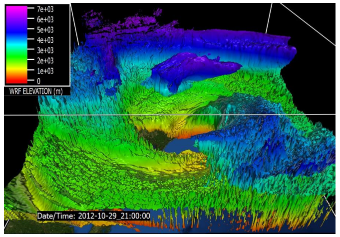
- WRF/observation **comparisons**
  - Quantitative: Statistical summaries
  - Qualitative comparisons
    - Time series of wind and temperature
    - Surface fields of wind and temperature
    - Profiles of WRF/radar/rawinsonde data
- Storm features **characterizations** by fusing WRF and observation data
  - 3-D visualizations of WRF variable fields using NCAR VAPOR
  - 2-D visualizations of gridded surface observations, radar imagery, and WRF variable fields

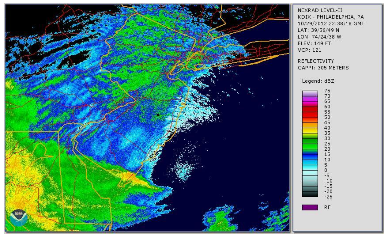




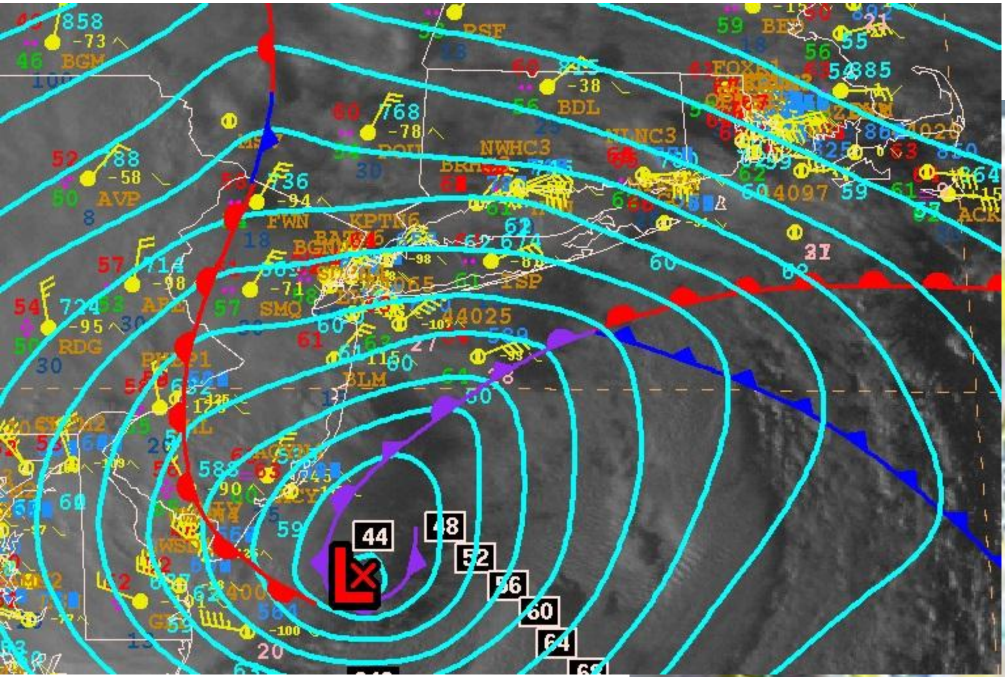




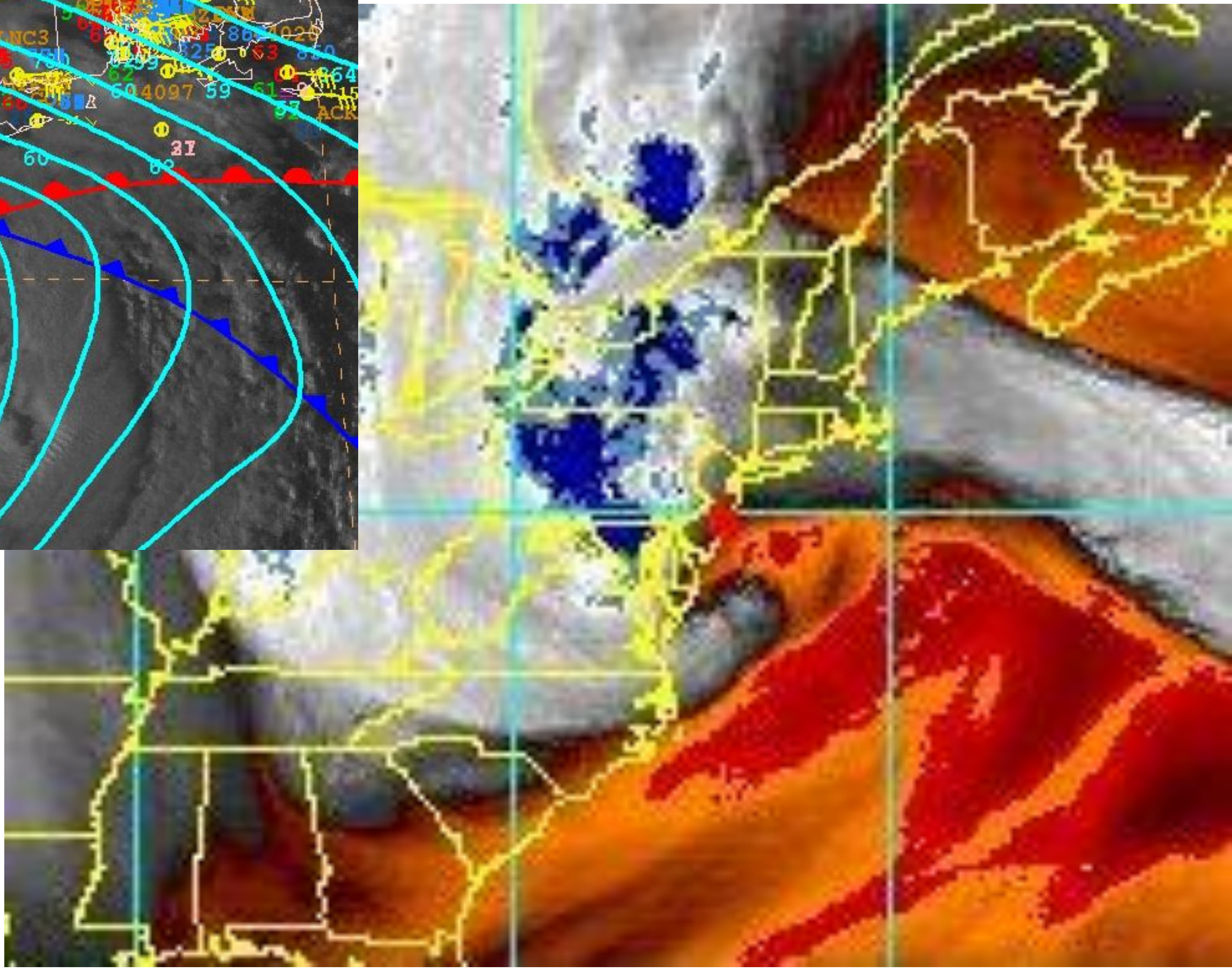




Sandy Overview



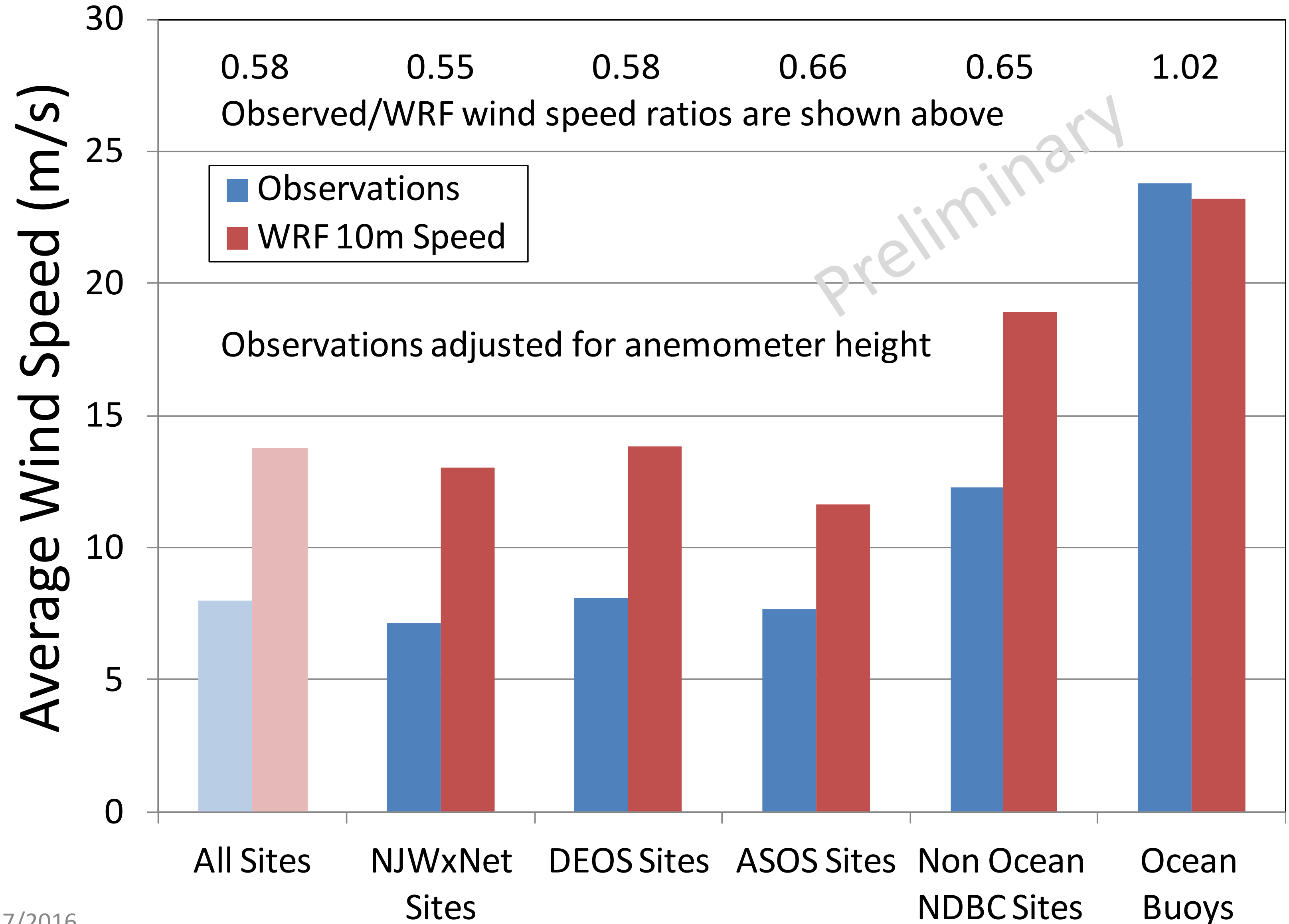
29 October 2012



Above:
NHC Analysis at 21Z

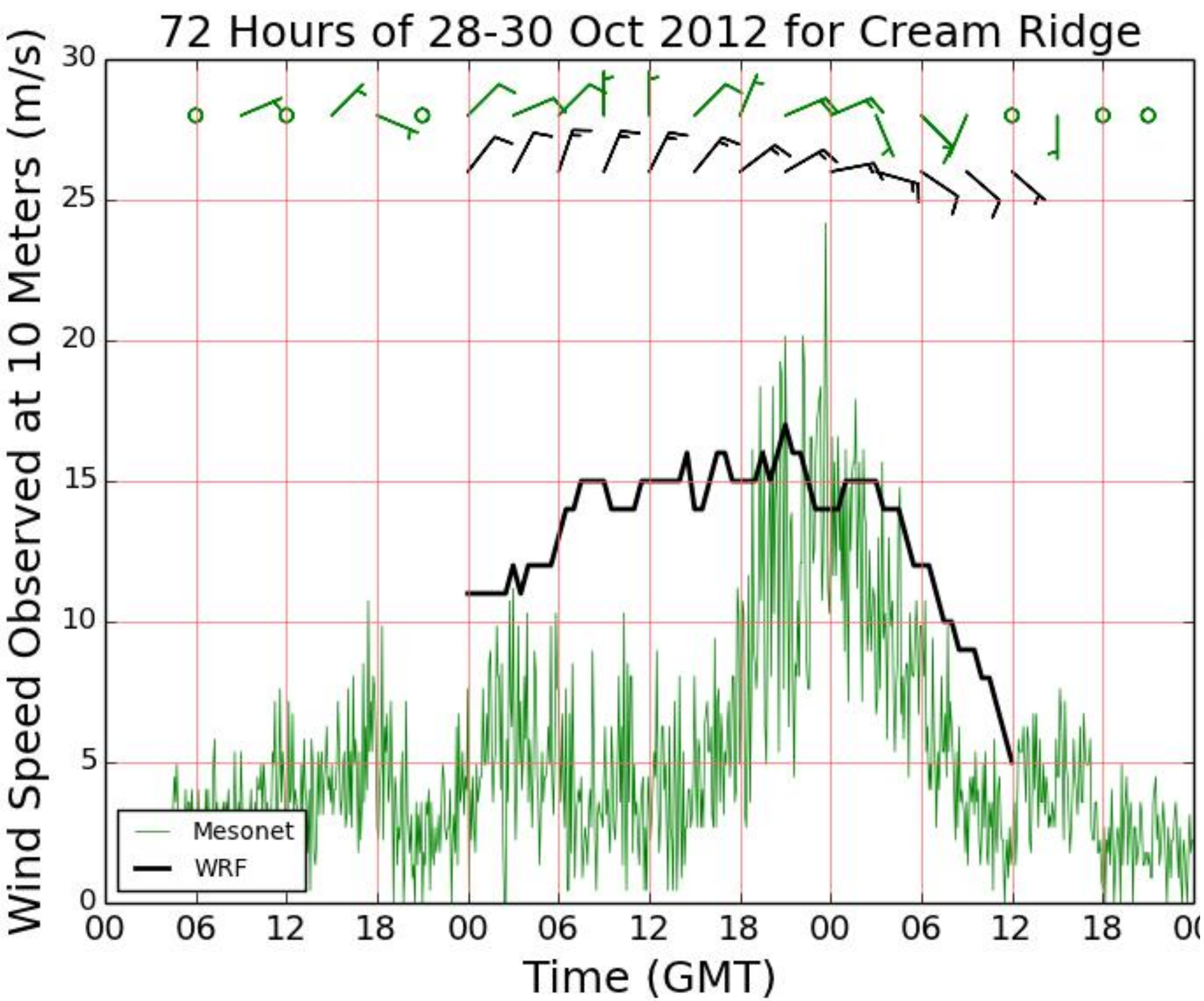
Right:
GOES water vapor
at 23:45Z

Average Wind Speeds Comparison

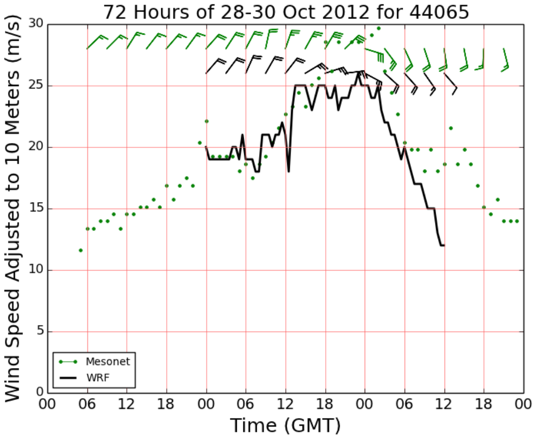


Time Series Comparison Sample

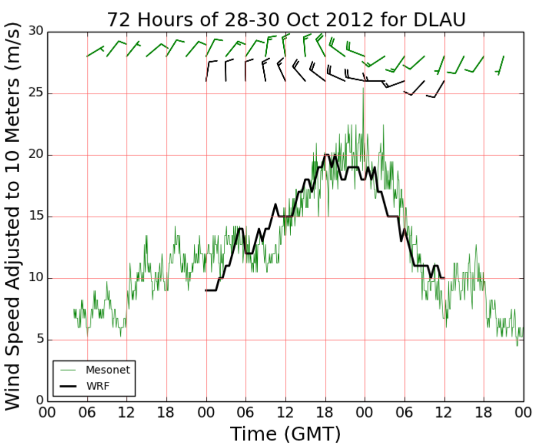
Inland NJ – 10m



Oceanic – 5m



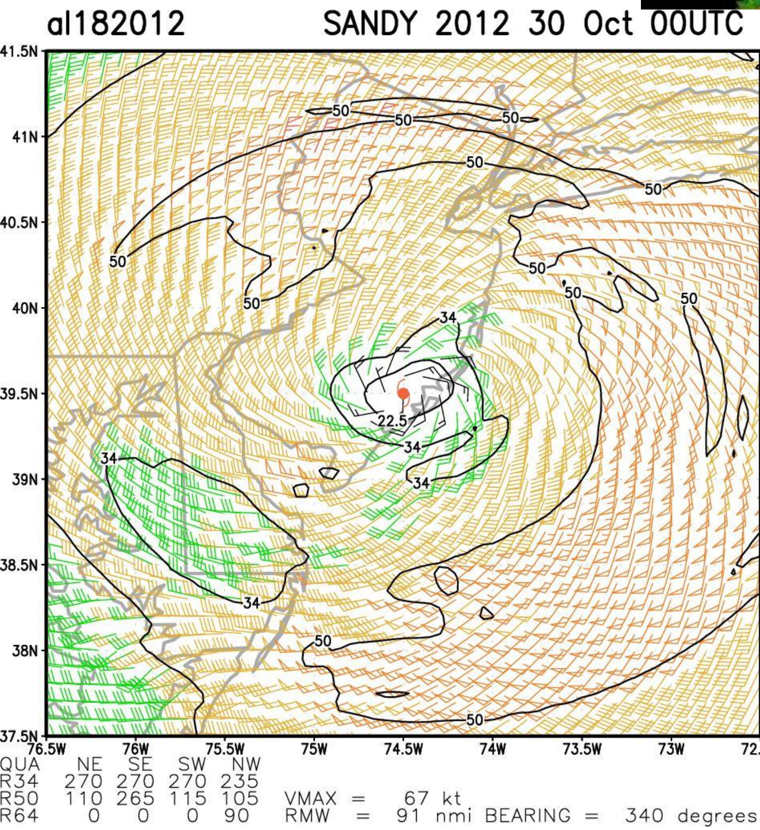
Inland DE – 3m

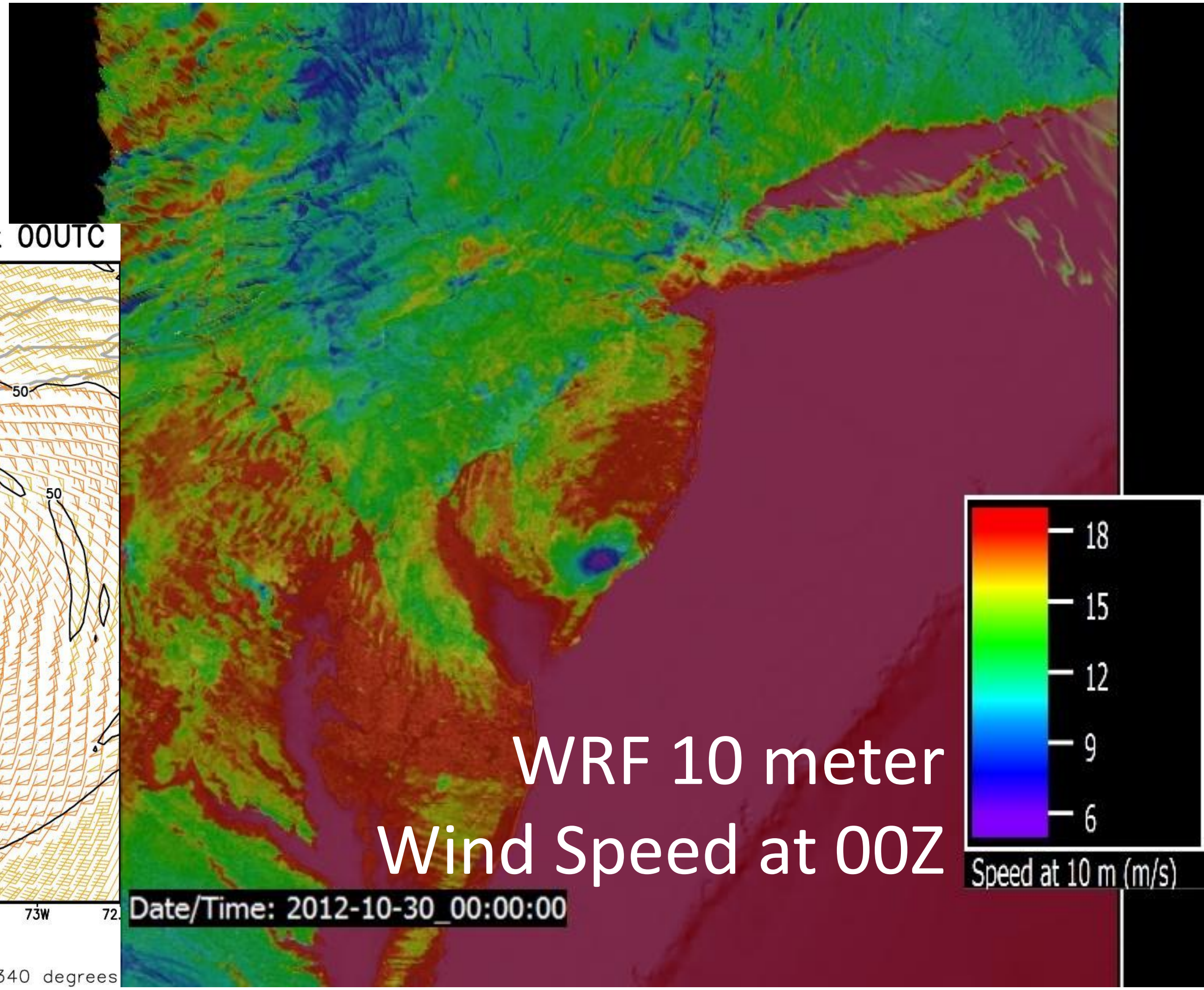


Surface Wind Field Comparison

Aircraft-based Surface Wind Analysis at 00Z

↓

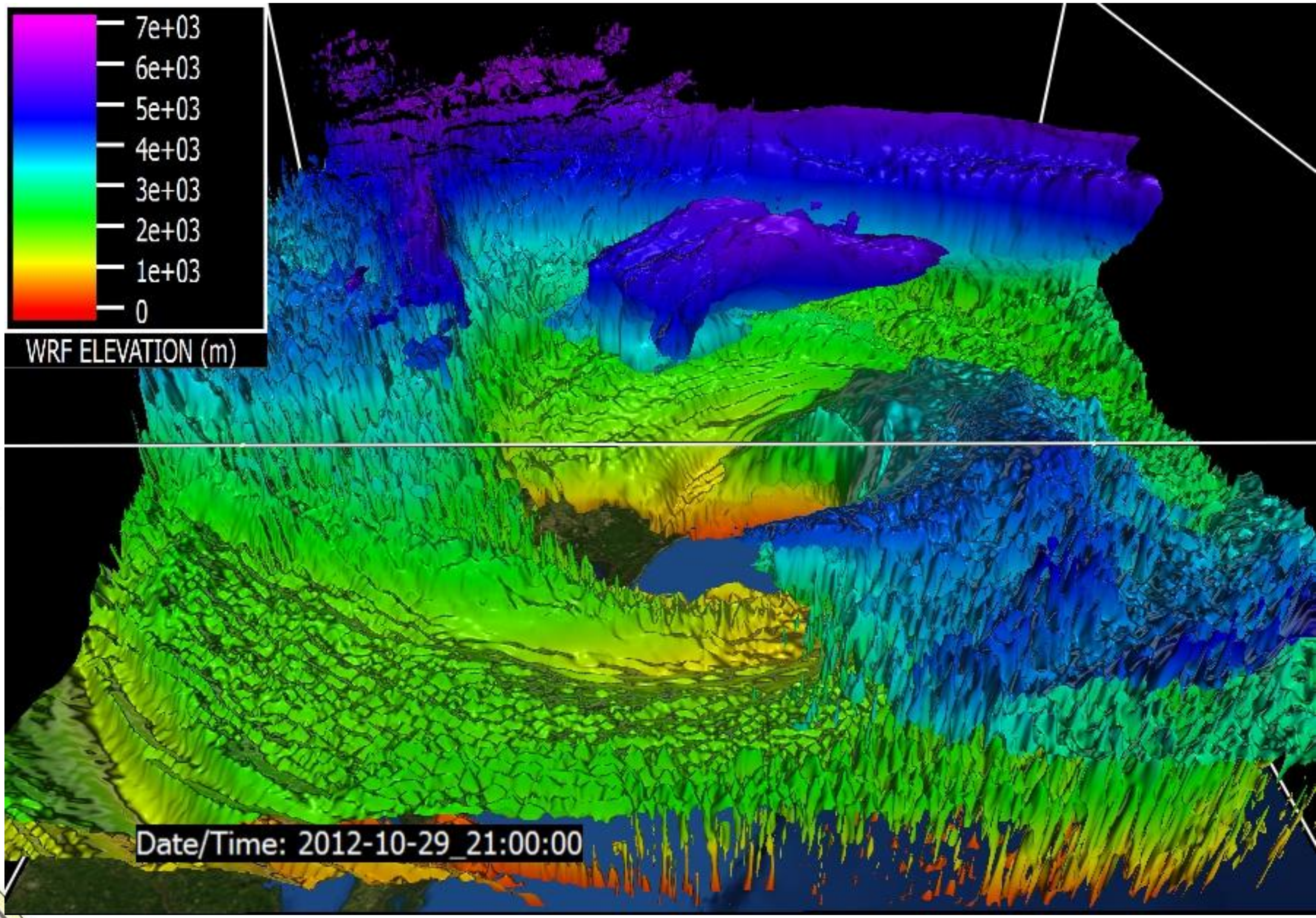


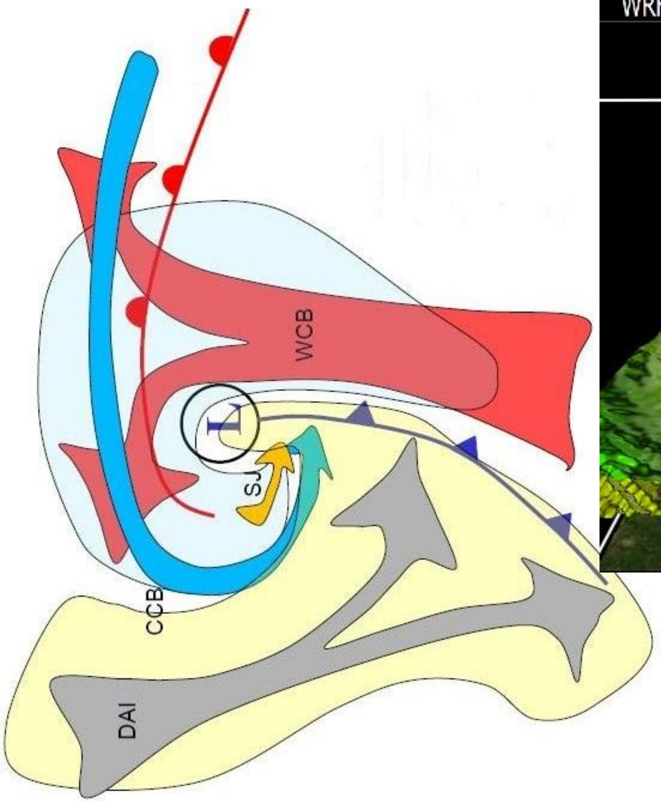


WRF 10 meter Wind Speed at 00Z

Storm Features: Low Level Winds

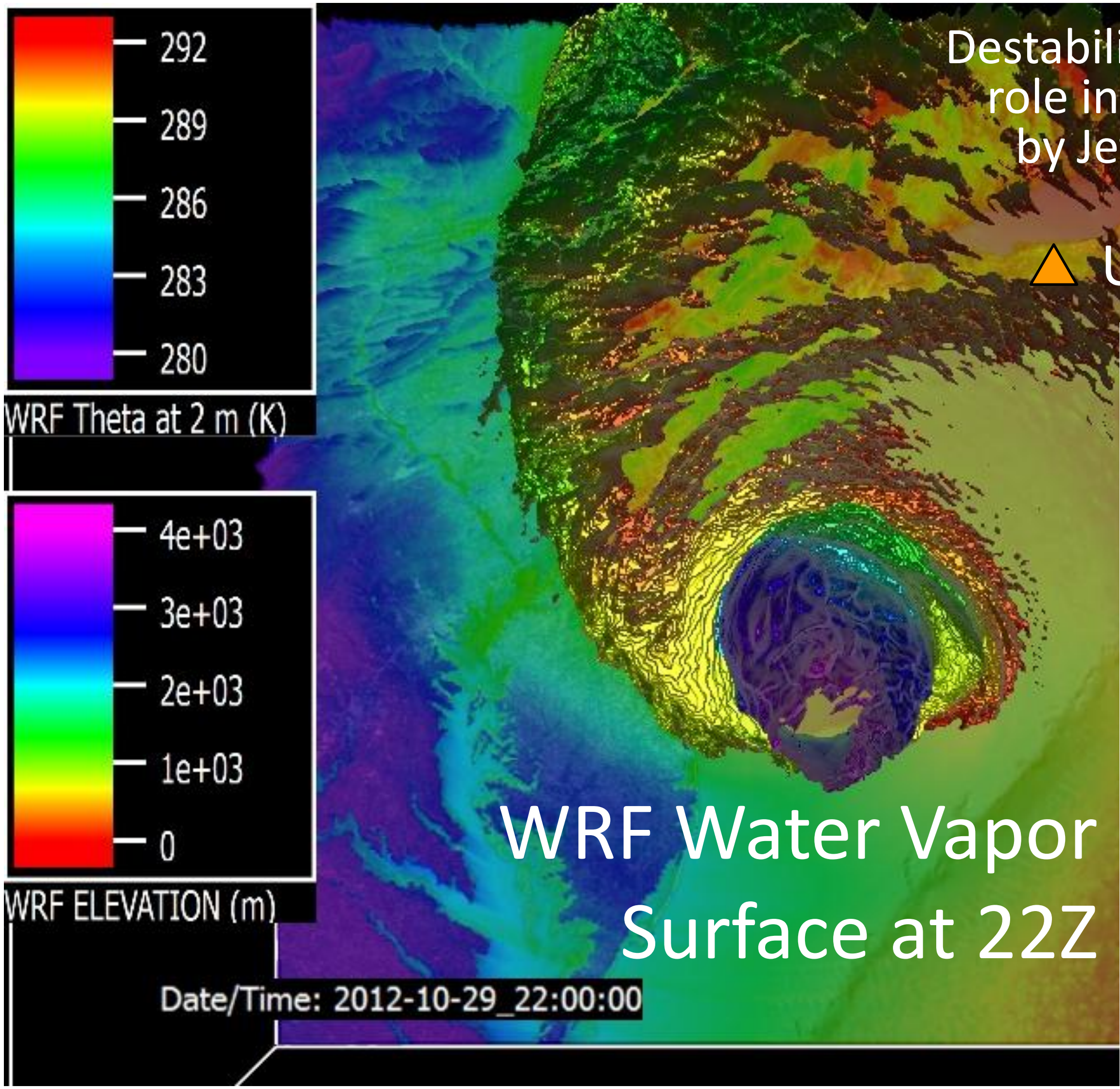
WRF 34 m/s
Wind Speed
Surface at 21Z

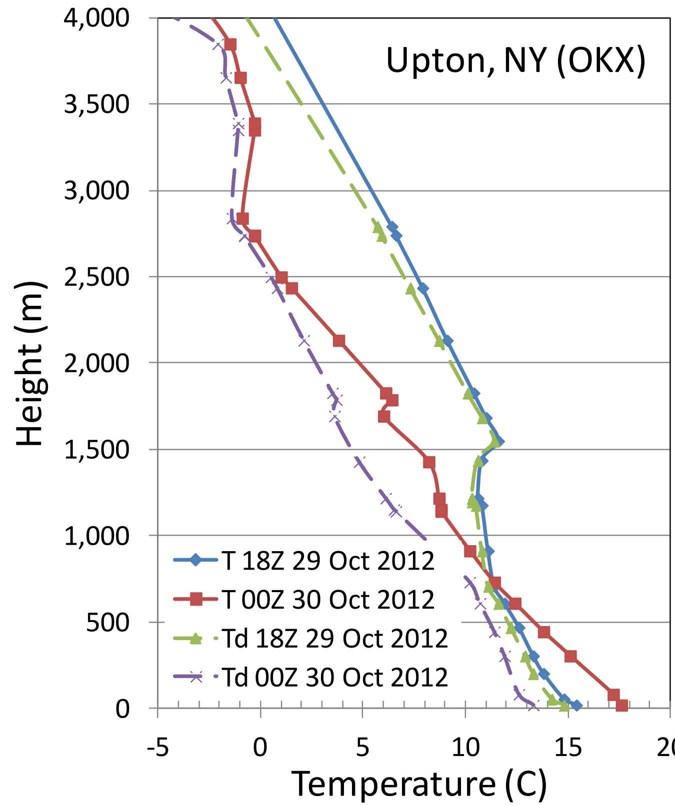




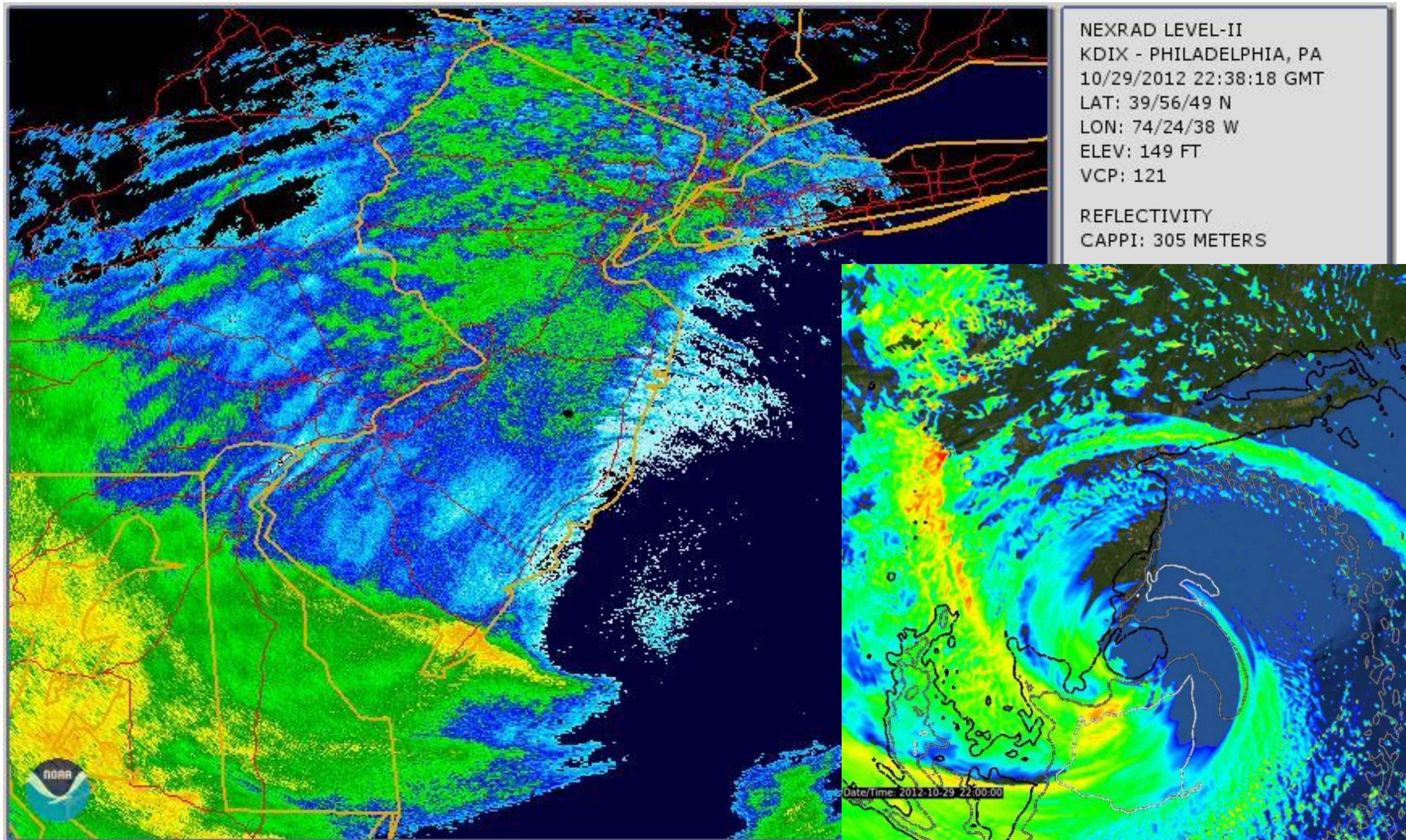
Shira Raveh-Rubin and Heini Wernli, 31 August 2015, "Climatology of dry air intrusions and their relation to strong surface winds in extratropical cyclones"

Cool, Dry Air Encirclement

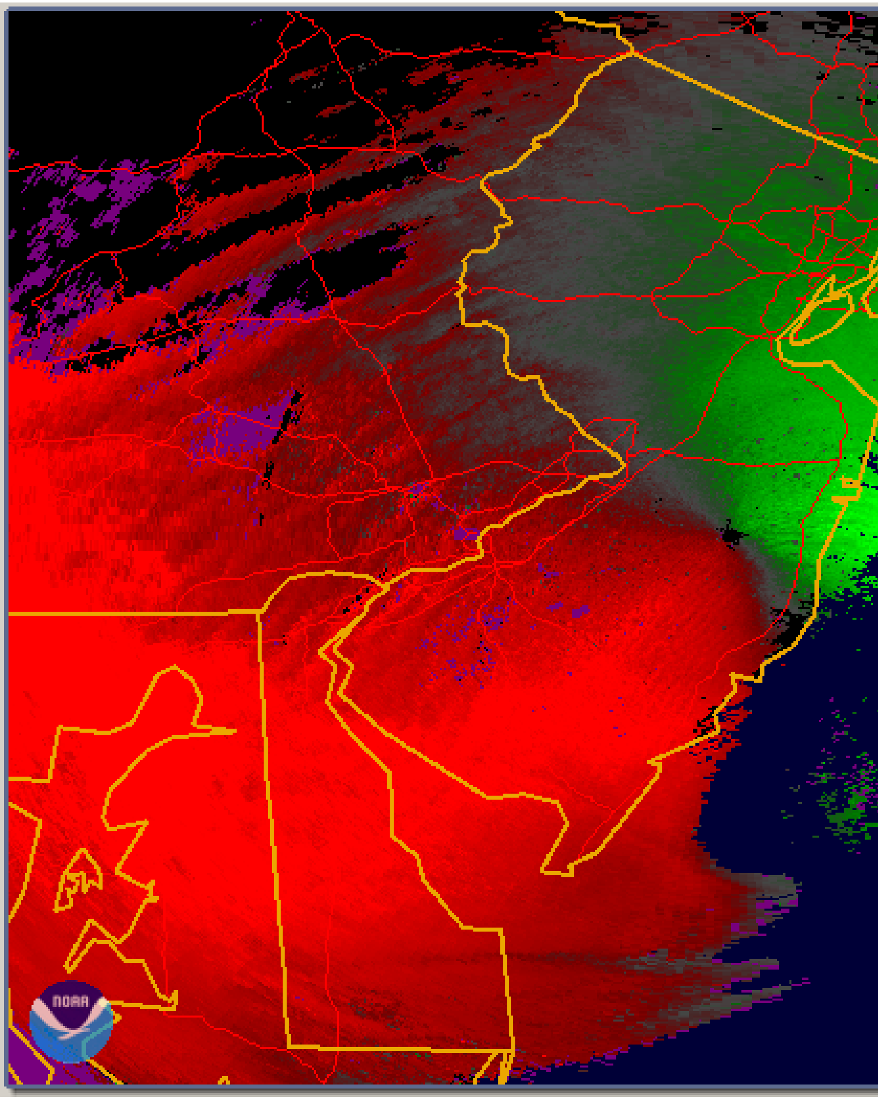




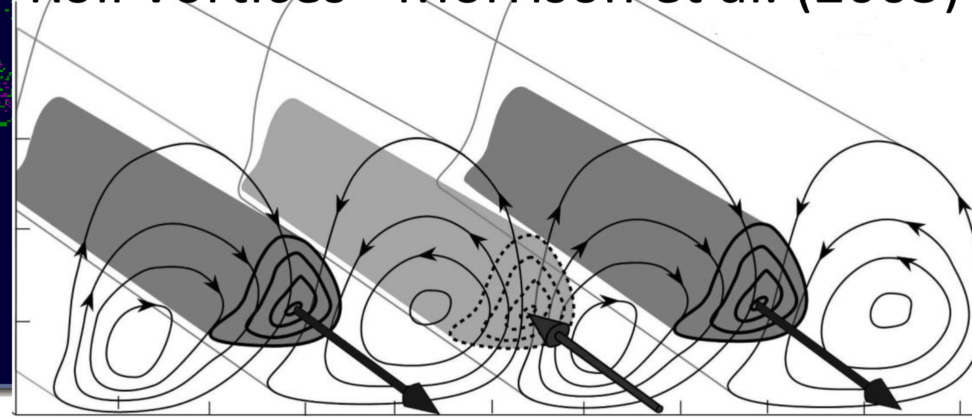
Radar and WRF Reflectivity at ≈22Z



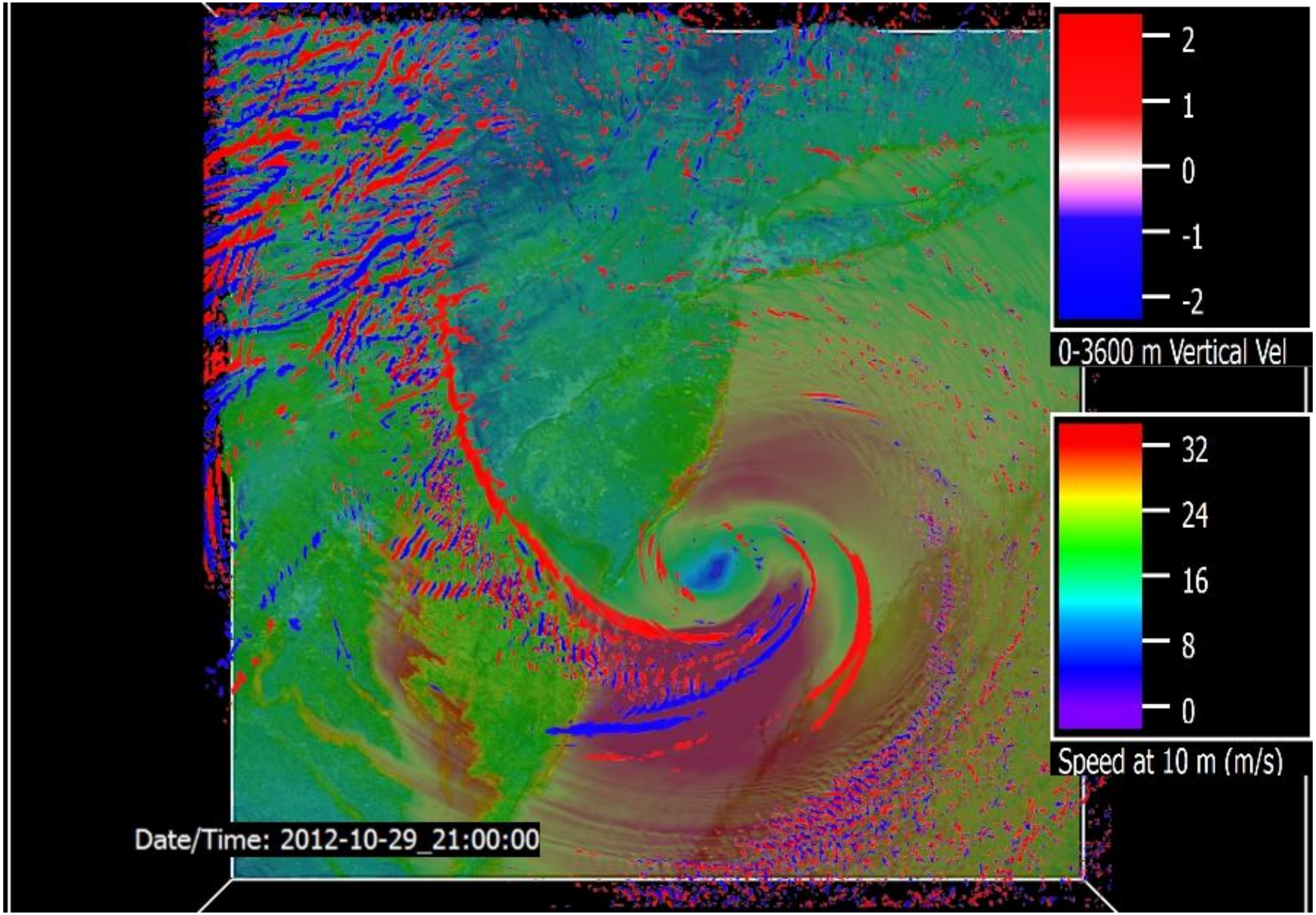
Radar Base Velocity at 22:38Z



Roll Vortices - Morrison et al. (2005)



WRF Vertical Velocity at 1 km and 21Z



WRF/Mesonet Comparison Summary

- Many aspects agree well . . .
  - Surface warm and cool air intrusions and their structures
  - Roll vortices’ and their dimensions
  - **Pre**-landfall track and timing
  - Rapid 3-hour pre-landfall storm symmetry collapse
  - Low level jets’ heights and speeds and PBL height and profiles
- Others not so much
  - Location of maximum winds over land
  - WRF exhibits less wind speed variability on multi-hour time scale
  - **Post**-landfall track, timing and storm core size
- Bottom line
  - Being able to fuse the **fine-resolution** observations and WRF output was an excellent enabler to identify and investigate the storm structures that produced the observed surface wind fields

Questions to be Addressed

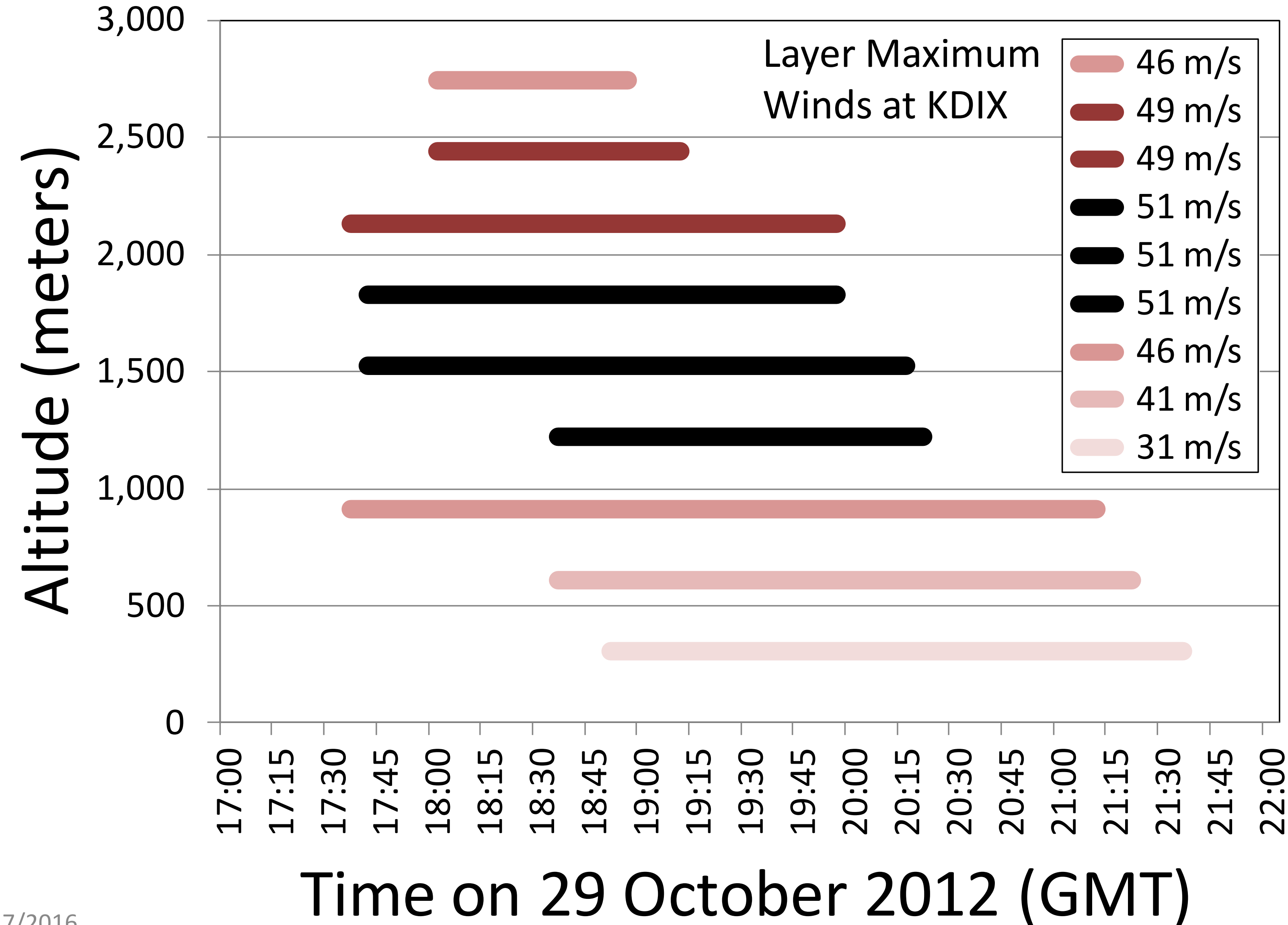
- Spotty tree-fall across landfall region
  - Is it caused by **wind bursts** not resolvable by WRF PBL scheme, such as downward momentum transport from LLJs driven by roll **vortices**?
  - Is this why WRF wind speeds do not peak as sharply as observed during landfall period?
  - Would a WRF **LES** PBL scheme improve wind burst representation?
- WRF storm features: Are they detectable in observations?
  - Roll vortices
  - Oceanic surface wind dart
  - Mesoscale pressure troughs
  - Coastal estuary thermal "shadows" far offshore
- 3-hour storm symmetry collapse: What is key mechanism?

For More Information

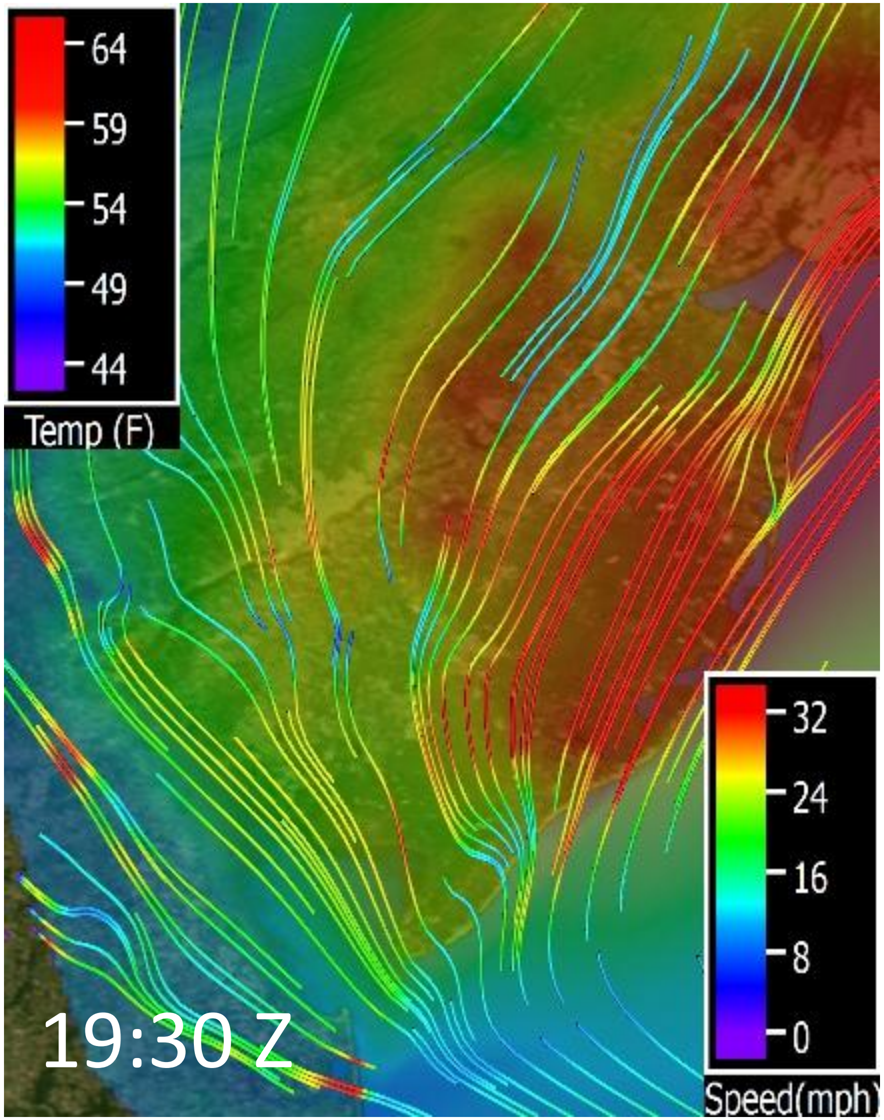
- Email me
  - jimschiavone@gmail.com
- VAPOR visualizations for this presentation
  - seedme.org/node/70880
- VAPOR visualizations of different storm features from exploratory study of WRF
  - seedme.org/node/47360
- New Jersey Mesonet
  - njweather.org
- Delaware Mesonet
  - deos.udel.edu

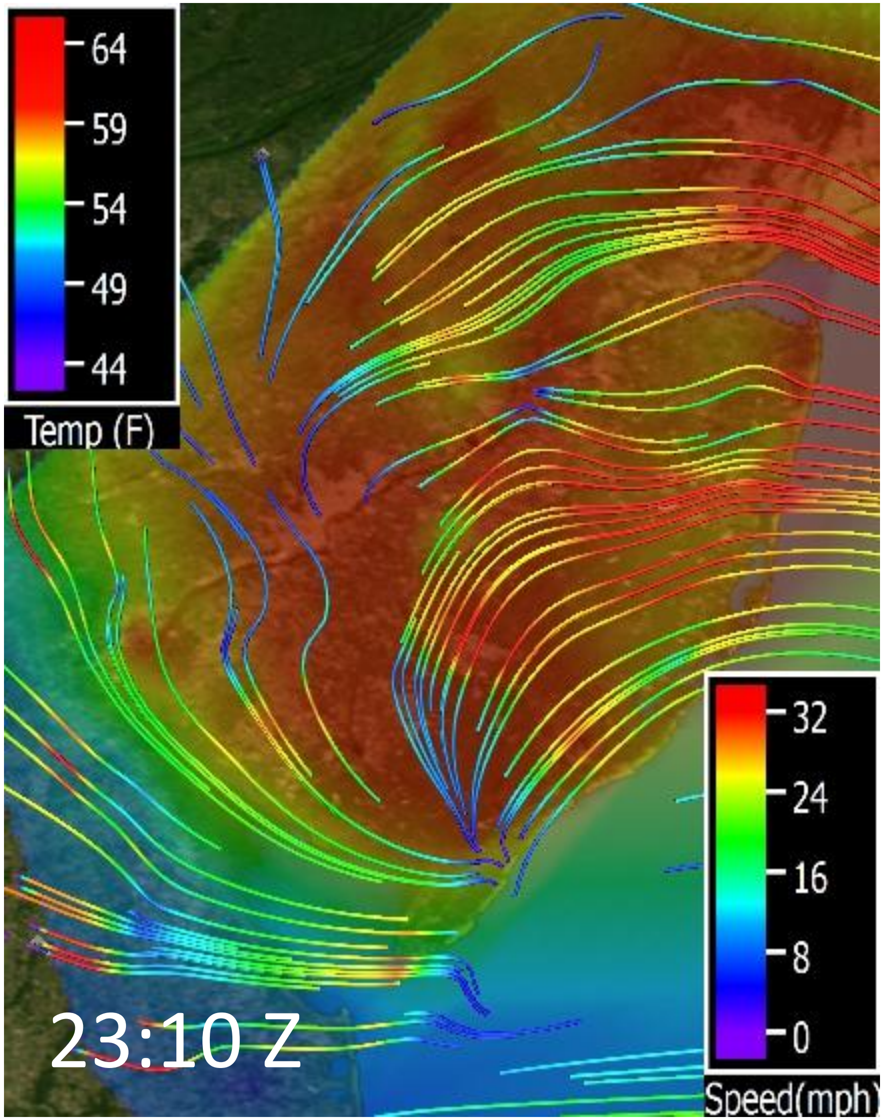
Backups

Qual. Comparisons – Radar Profiles

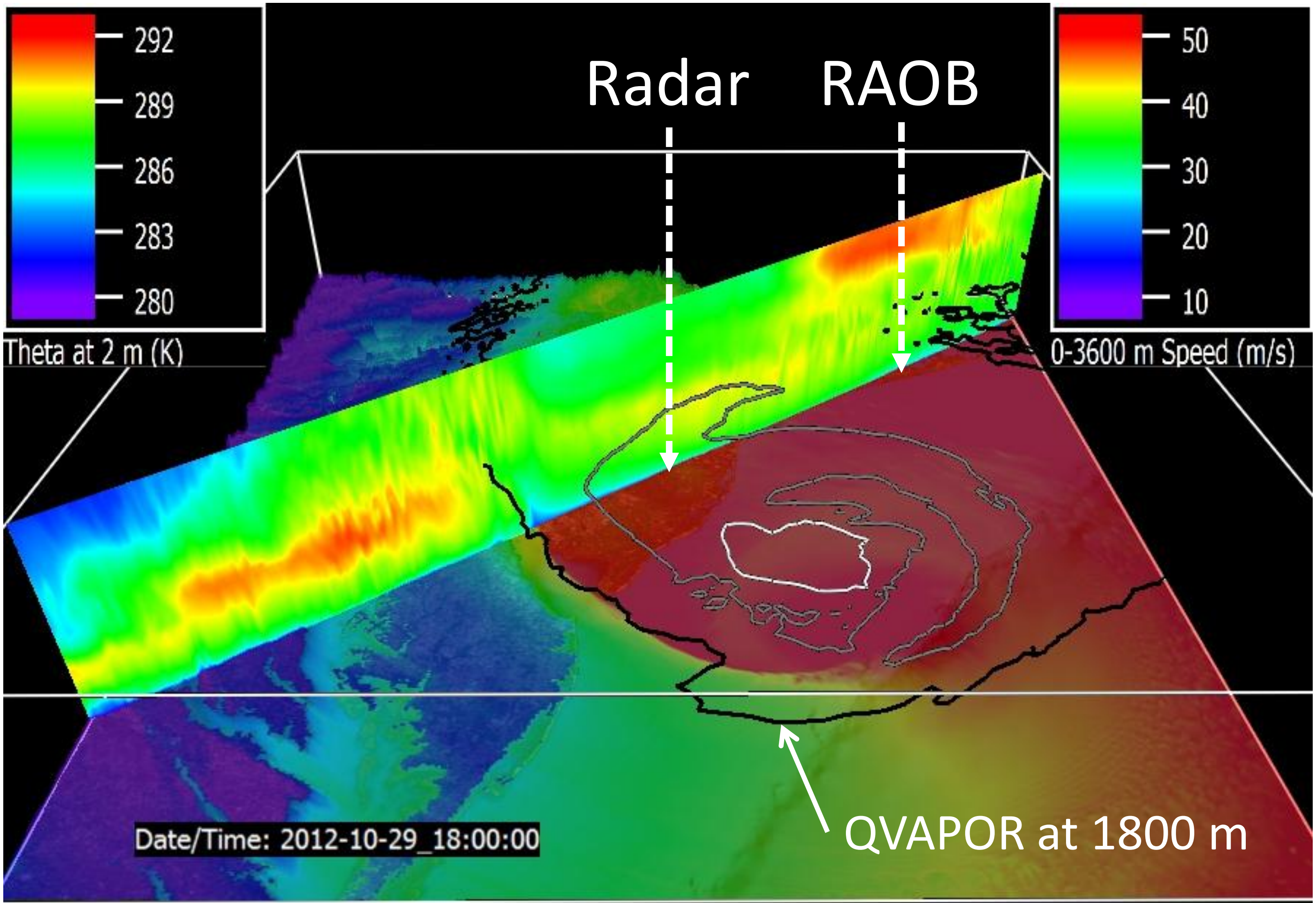


Mesonet Warm and Cool Intrusions

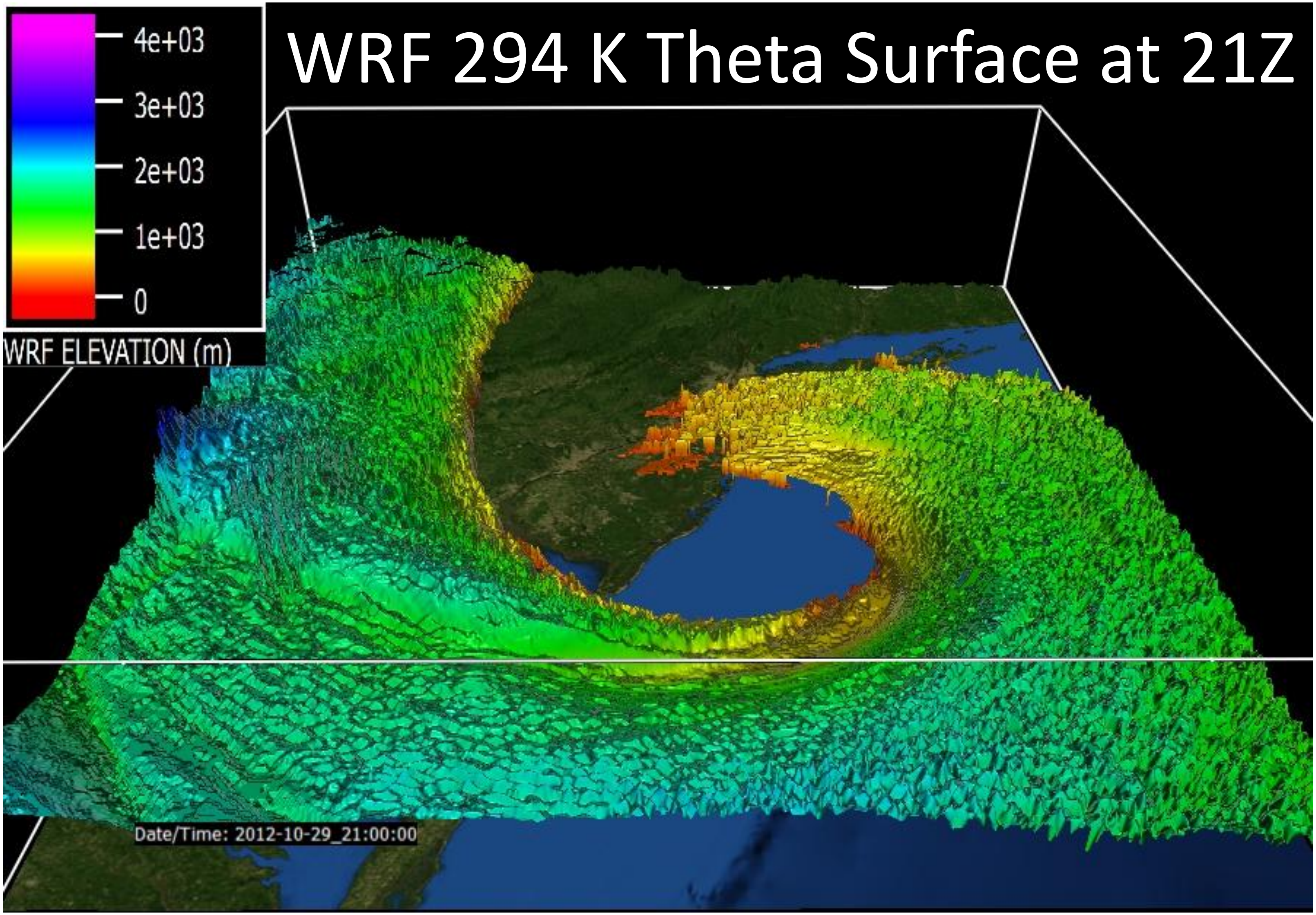




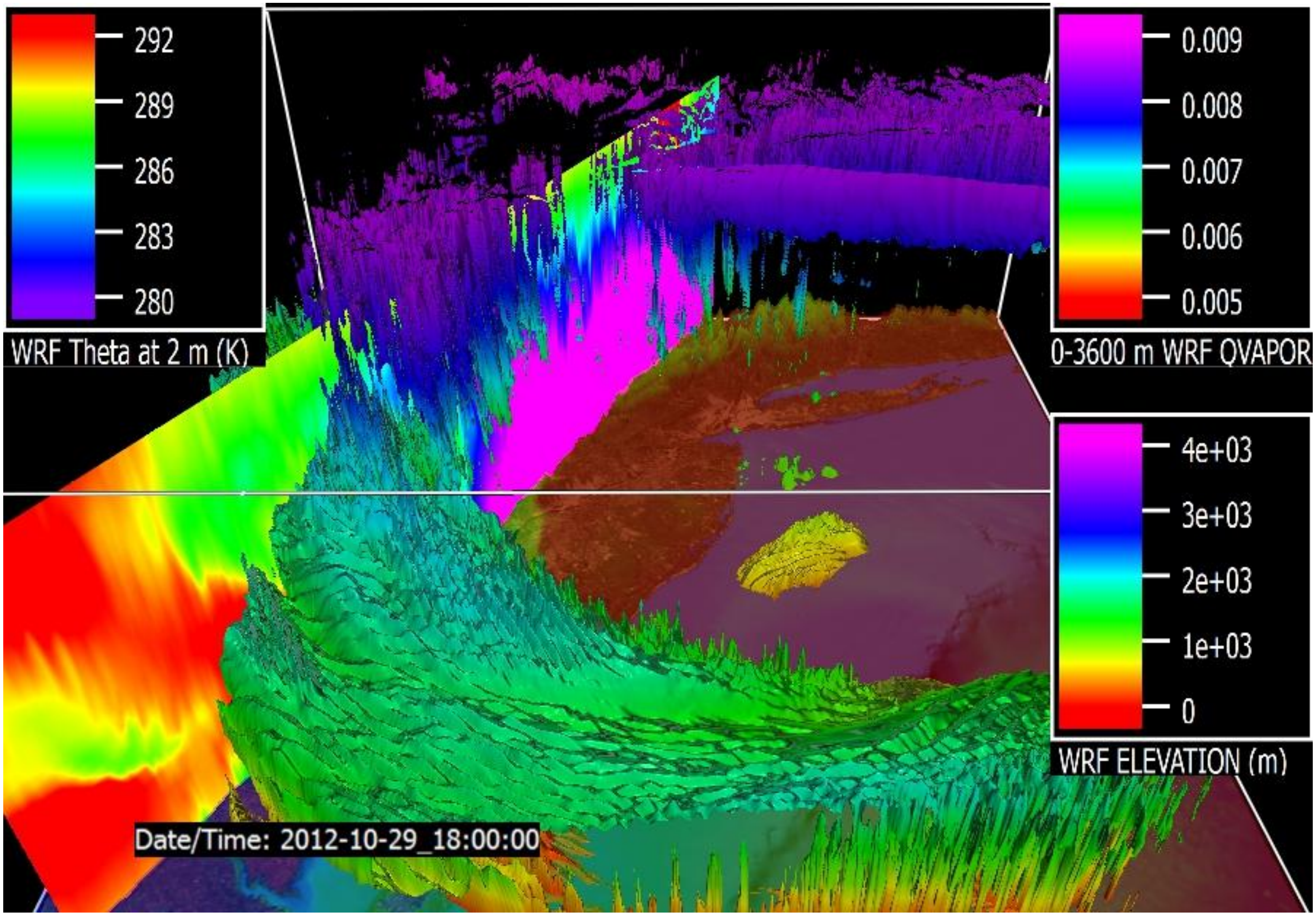
WRF Wind Speed Cross Section at 18Z



Warm and Cool Intrusions per WRF



Warm and Cool Intrusions per WRF 18Z



WRF Wind Cross Section at 21Z