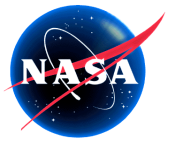
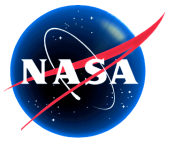


Multiple Scatterometer Hurricane Winds: Year 1, QuikSCAT

Bryan Stiles, Svetla-Hristova Veleva, and Michael Brennan

May 9-11, 2011



Overview

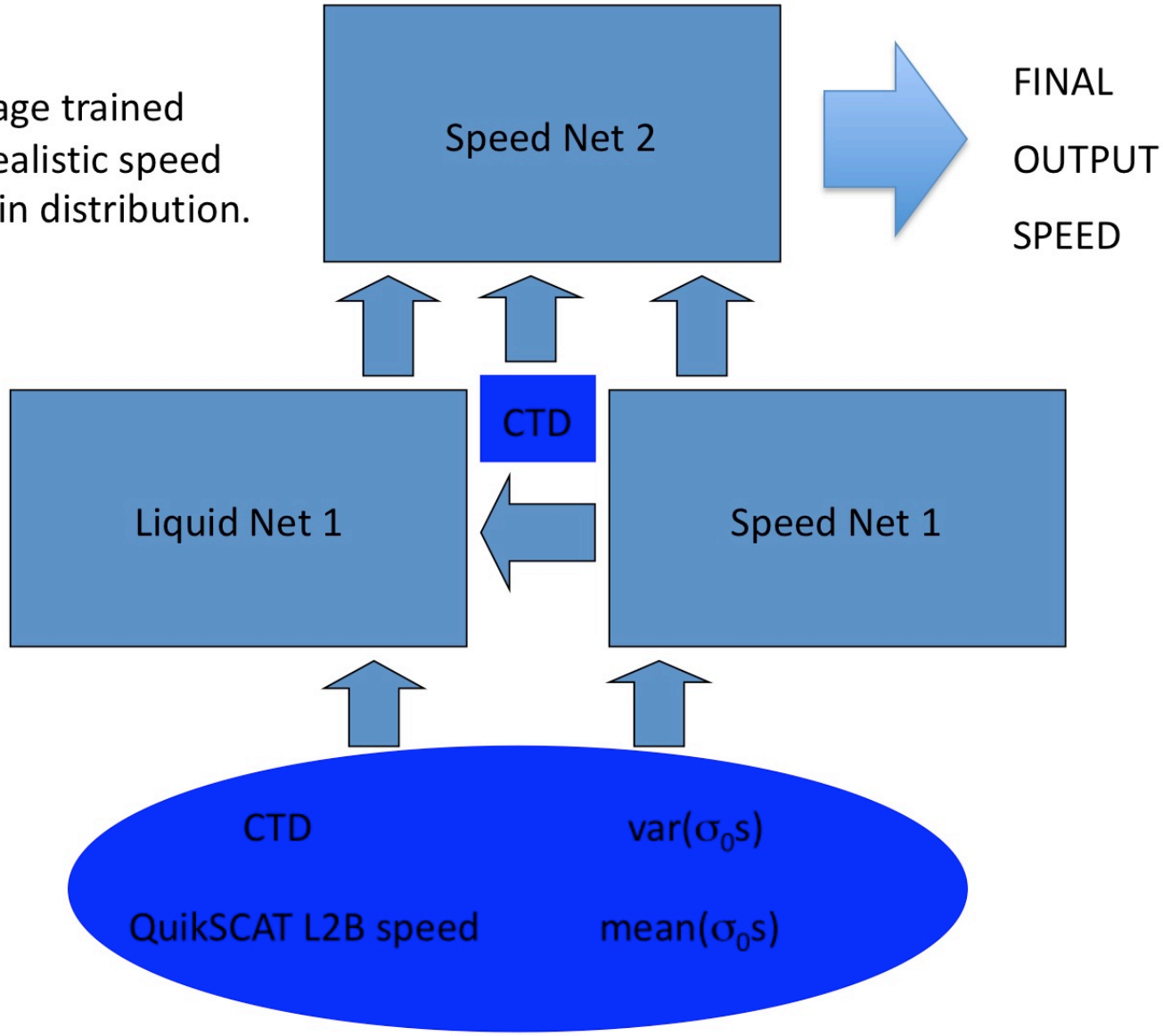
- Concept
- Training Data Set Description
  - Co-located H*Winds and QuikSCAT data from 2005.
- Comparison of H*WINDS with QuikSCAT data
  - Current 12.5 km QuikSCAT wind speed performance
  - NRCS vs. H*WINDS speed and relative azimuth scatter plots
- Neural Network Wind Retrieval
  - Block Diagram
  - Performance statistics
  - Example wind, NRCS,and rain impact fields
- Summary of Current Status

Concept

- Use neural networks to retrieve accurate wind speeds from 3 different scatterometer data sets.
  - QuikSCAT
  - ASCAT
  - OceanSAT-II
- The neural networks will be trained and validated for wind speed accuracy using a combination of models (HWINDS), in situ data (P-3 overflights of hurricanes), and simulated data.
- The retrieved wind data will be validated for usefulness by Michael Brennan at the National Hurricane Center.
- In the first year we will concentrate on developing the QuikSCAT high wind retrieval algorithm.
- In subsequent years, we will extend the technique to ASCAT and OceanSAT-II.

Planned Neural Network Structure

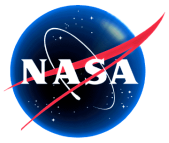
Top stage trained with realistic speed and rain distribution.



Bottom stage trained with exaggerated high wind distribution

Modifications in Current Structure

1. An additional rain impact estimator network is added.
2. Speed Net 2 is duplicated with one network used for rain impact <= 2.5 and another for rain impact > 2.5
3. Liquid Network is omitted as it has not yet been trained.
4. Speed Net 1 is replaced with 4 smaller networks that each input only one of the four NRCS values. (Allows smaller training set.)
5. CTD input is left out to avoid biasing due to non-uniform wind speed vs. CTD distribution in training set.
6. L2B wind speed input is omitted pending completion of QuikSCAT reprocessing.

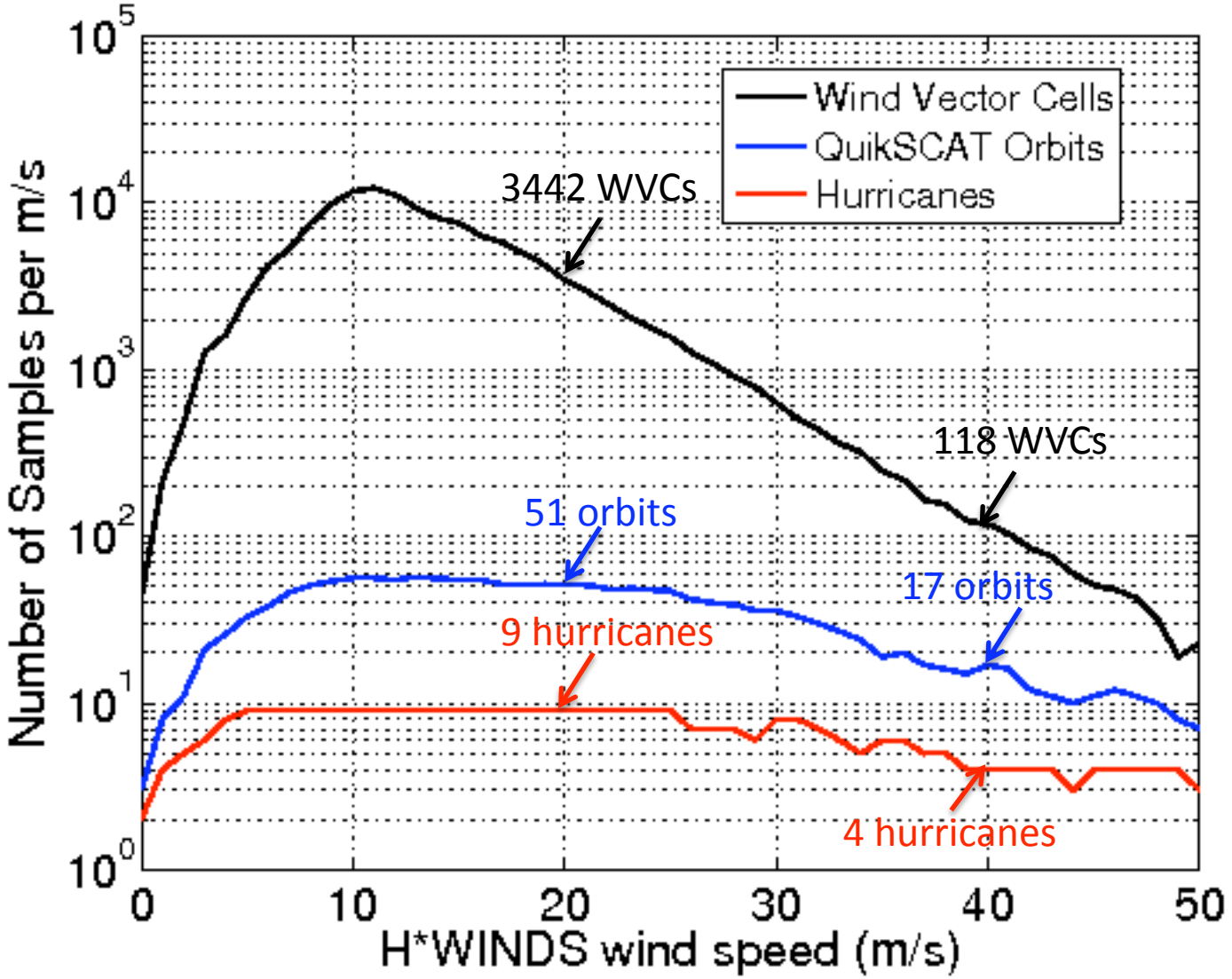


Ground Truth Data Set

- Data: 67 QuikSCAT observations of the 9 hurricanes in 2005 for which both QuikSCAT and H*WINDS data was available.
  - 33 observations with 127522 wind vectors total were used for training
  - 34 other observations with 129175 wind vectors total were used as a test set for validating the performance.
  - Temporal mismatches up to 10 hours were included in the data set.
  - To reduce mis-colocation error, H*WINDS wind fields were translated based upon best track hurricane centers.

Ground Truth Data: Wind Speed Distribution

co-locations within 5 hours

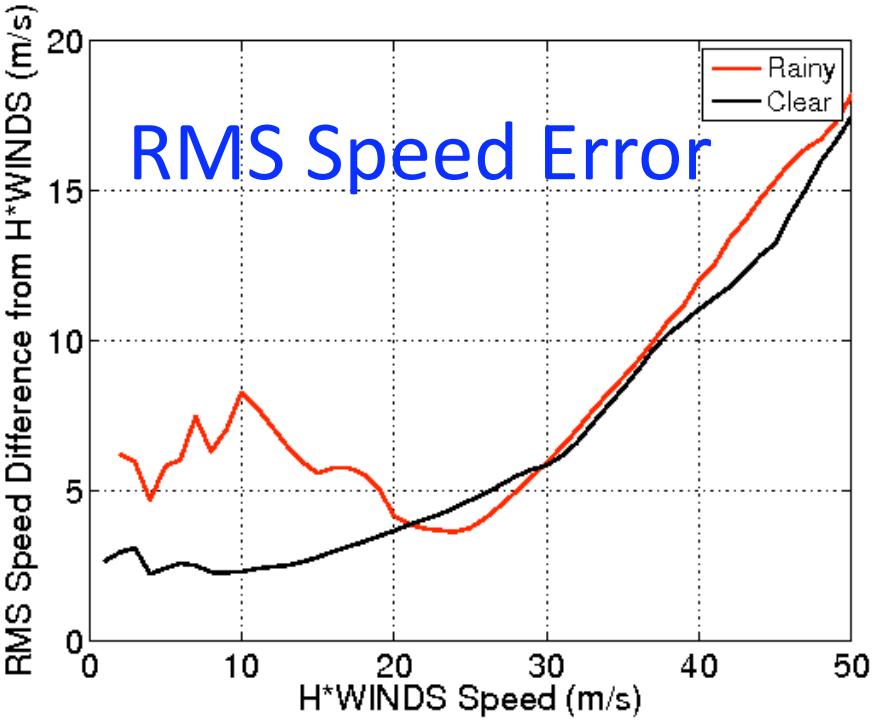


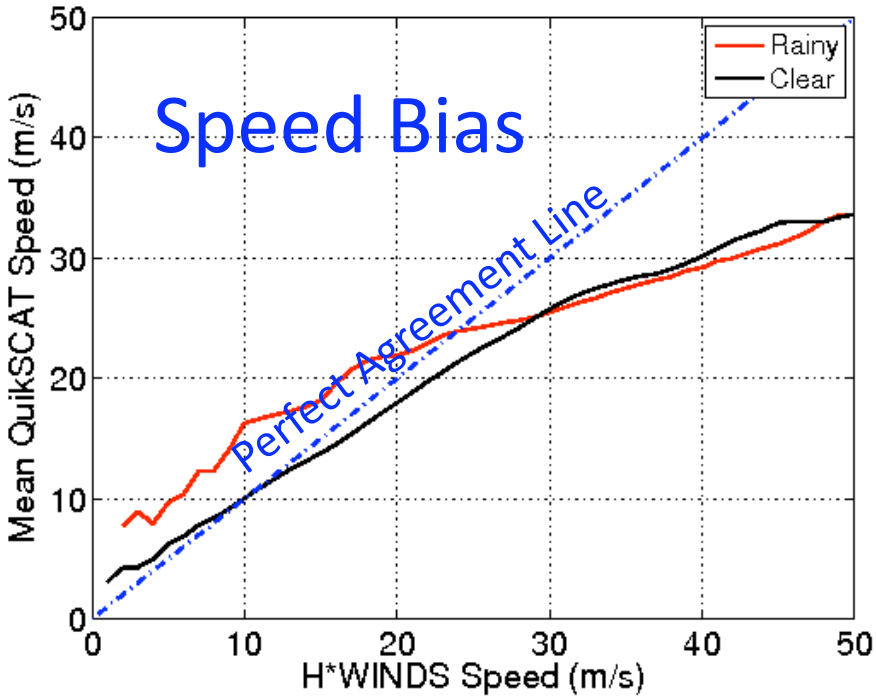
Because of the rapid decline in samples with speeds, we weighted high wind samples more heavily during network training.

JPL QuikSCAT 12.5 km L2B performance

(QuikSCAT/H*WINDS matched within 2 hours)

- In rain (rain impact quantity > 2.5), QuikSCAT data is biased high at low speeds with large RMS values.
- Rainy and rain-free QuikSCAT data is biased high at high winds with large RMS values.



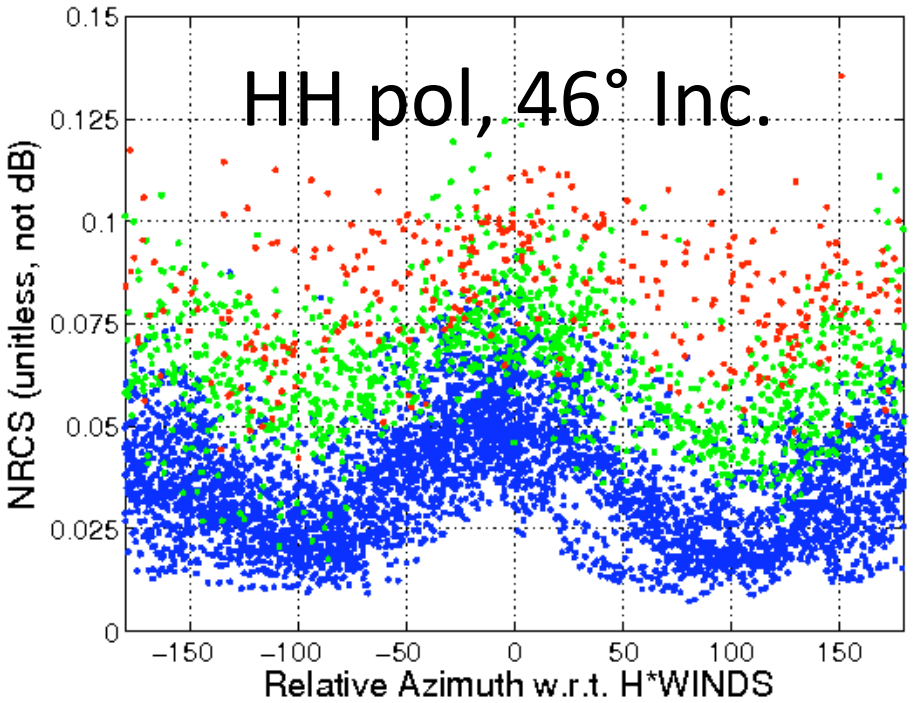


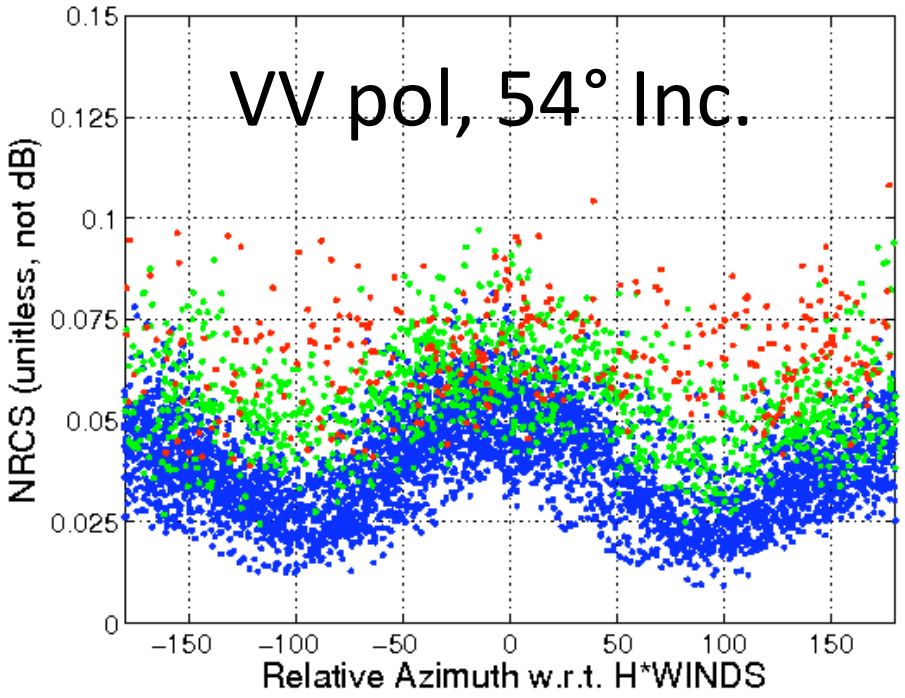
NRCS scatterplots for 20,30, and 40 m/s H*WINDS

(QuikSCAT/H*WINDS matched within 2 hours, *Clear conditions*)

- In *rainfree* conditions (rain impact quantity <= 2.5), QuikSCAT HH pol 46 degree incidence NRCS values are sensitive to wind speed and direction in the 20-40 m/s range.
- QuikSCAT VV 54 degree incidence values have less sensitivity.

(Blue, Green, Red) = (20,30,40) m/s +10% H*WINDS



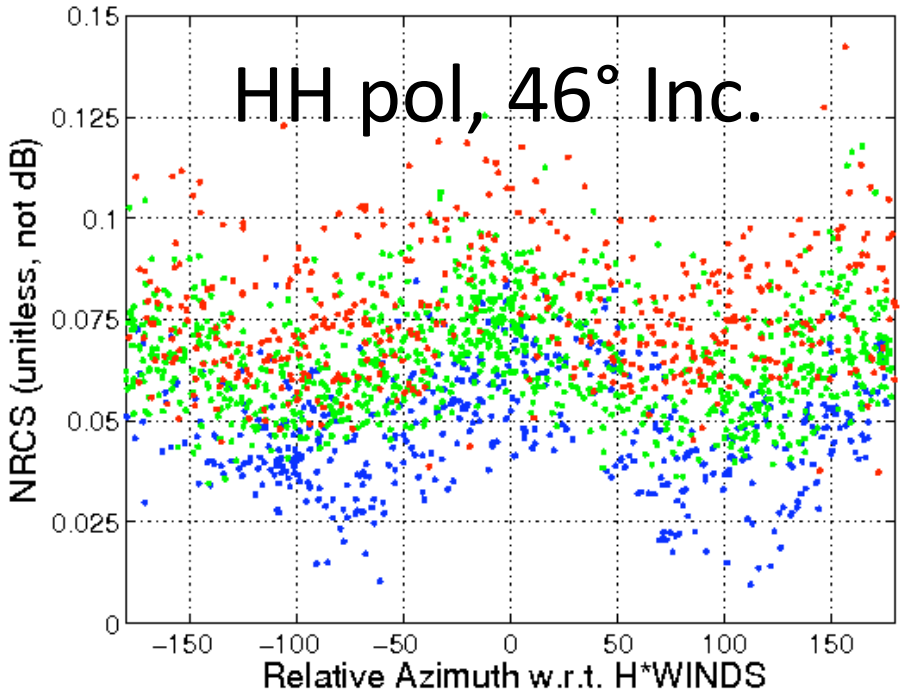


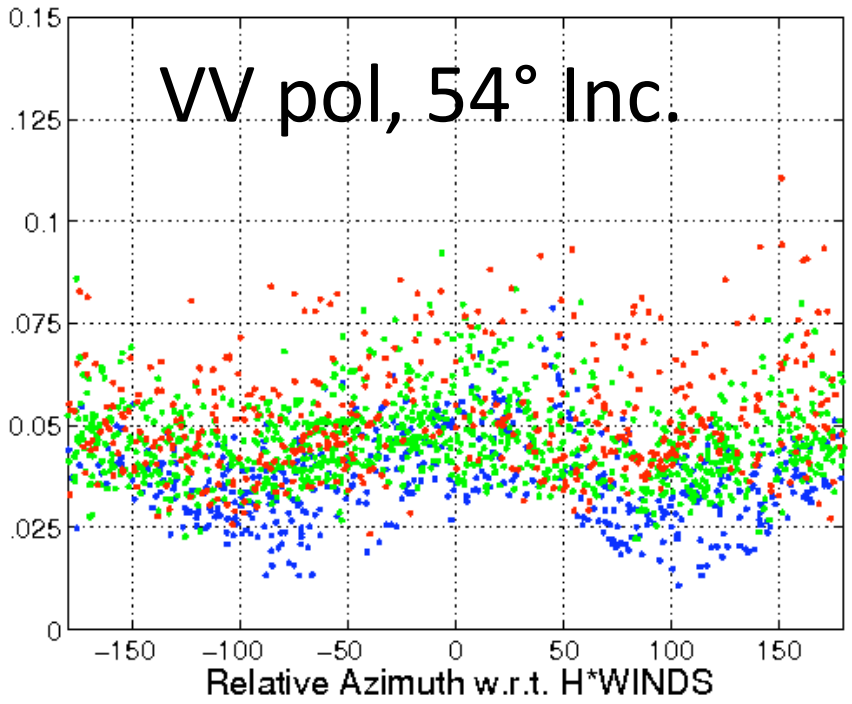
NRCS scatterplots for 20,30, and 40 m/s H*WINDS

(QuikSCAT/H*WINDS matched within 2 hours, *Rainy conditions*)

- In *rainy conditions* (rain impact quantity > 2.5), the wind sensitivity of both polarizations are reduced especially for VV pol, but still apparent at least for moderate rain.

(Blue, Green, Red) = (20,30,40) m/s +10% H*WINDS



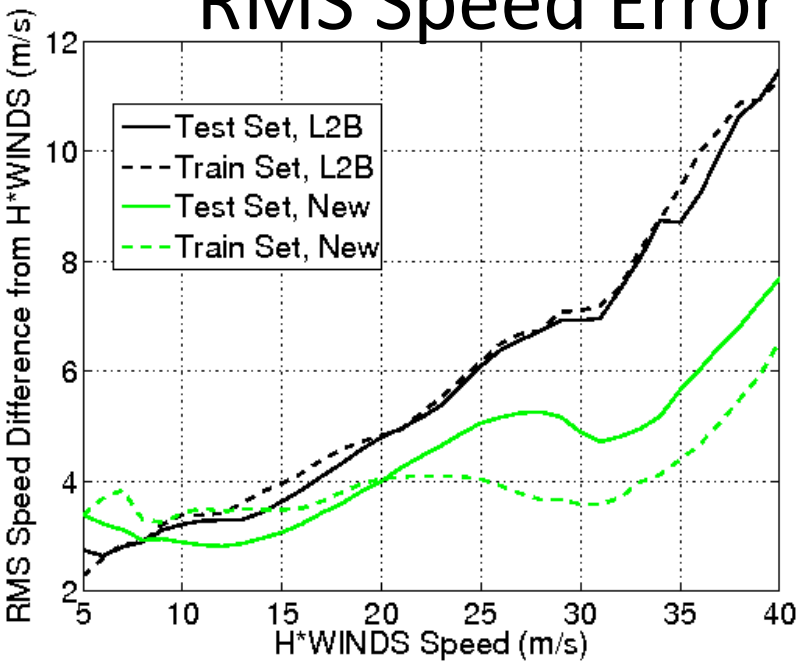


Neural Net Results:

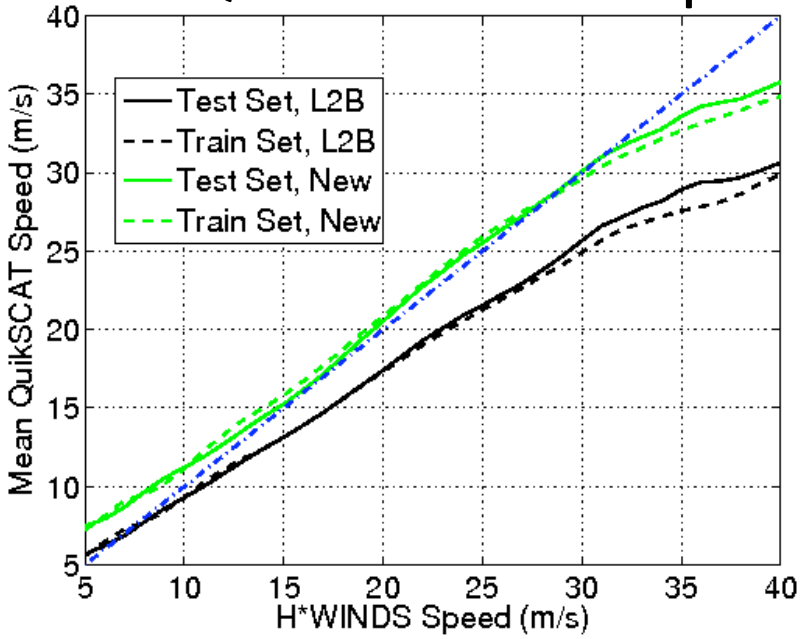
Error on training and test sets *in clear conditions*, within 5 hours

- A neural network was trained to map QuikSCAT NRCS values to HWINDS wind speeds for clear data (rain impact quantity <= 2.5).
  - A set of storm 33 scenes from 2005 were used for training.
  - A different set of 34 scenes from 2005 was used to test performance.
- The plots below illustrate the RMS differences and biases w.r.t HWINDS for the neural network (green) and the standard 12.5 km L2B product (black) on the training (dashed) and test set (solid).

RMS Speed Error



Mean QuikSCAT wind speed

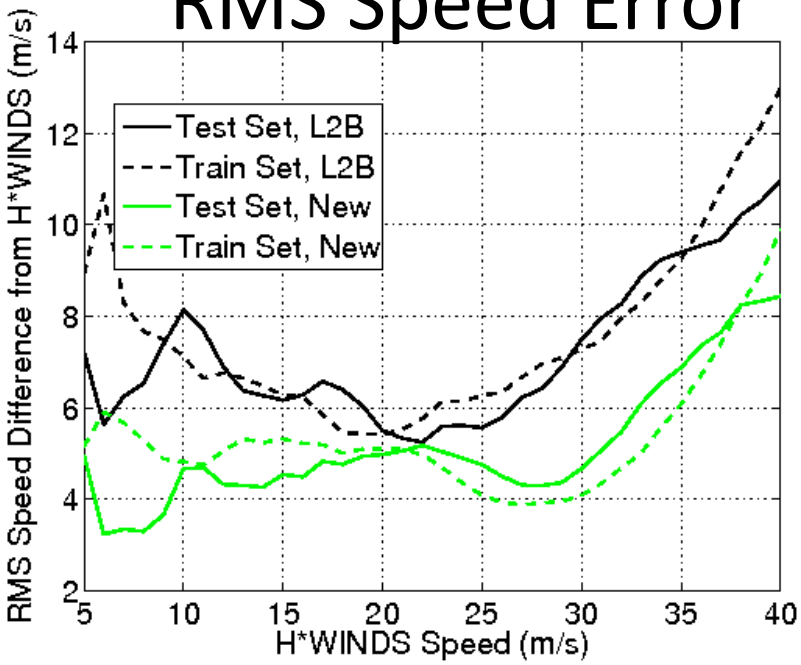


Neural Net Results:

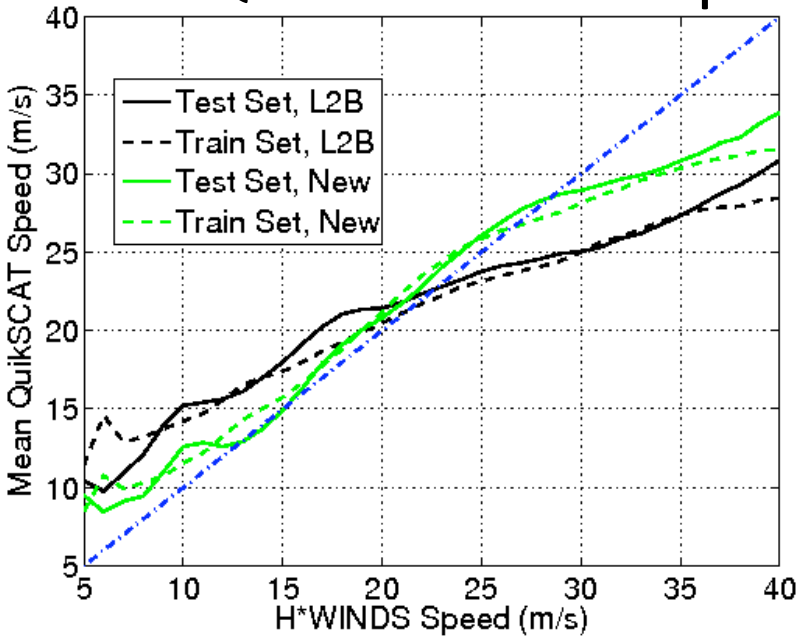
Error on training and test sets *in rainy conditions*, within 5 hours

- A neural network was trained to map QuikSCAT NRCS values to HWINDS wind speeds for rainy data (rain impact quantity > 2.5).
  - A set of storm 33 scenes from 2005 were used for training.
  - A different set of 34 scenes from 2005 was used to test performance.
- The plots below illustrate the RMS differences and biases w.r.t HWINDS for the neural network (green) and the standard 12.5 km L2B product (black) on the training (dashed) and test set (solid).

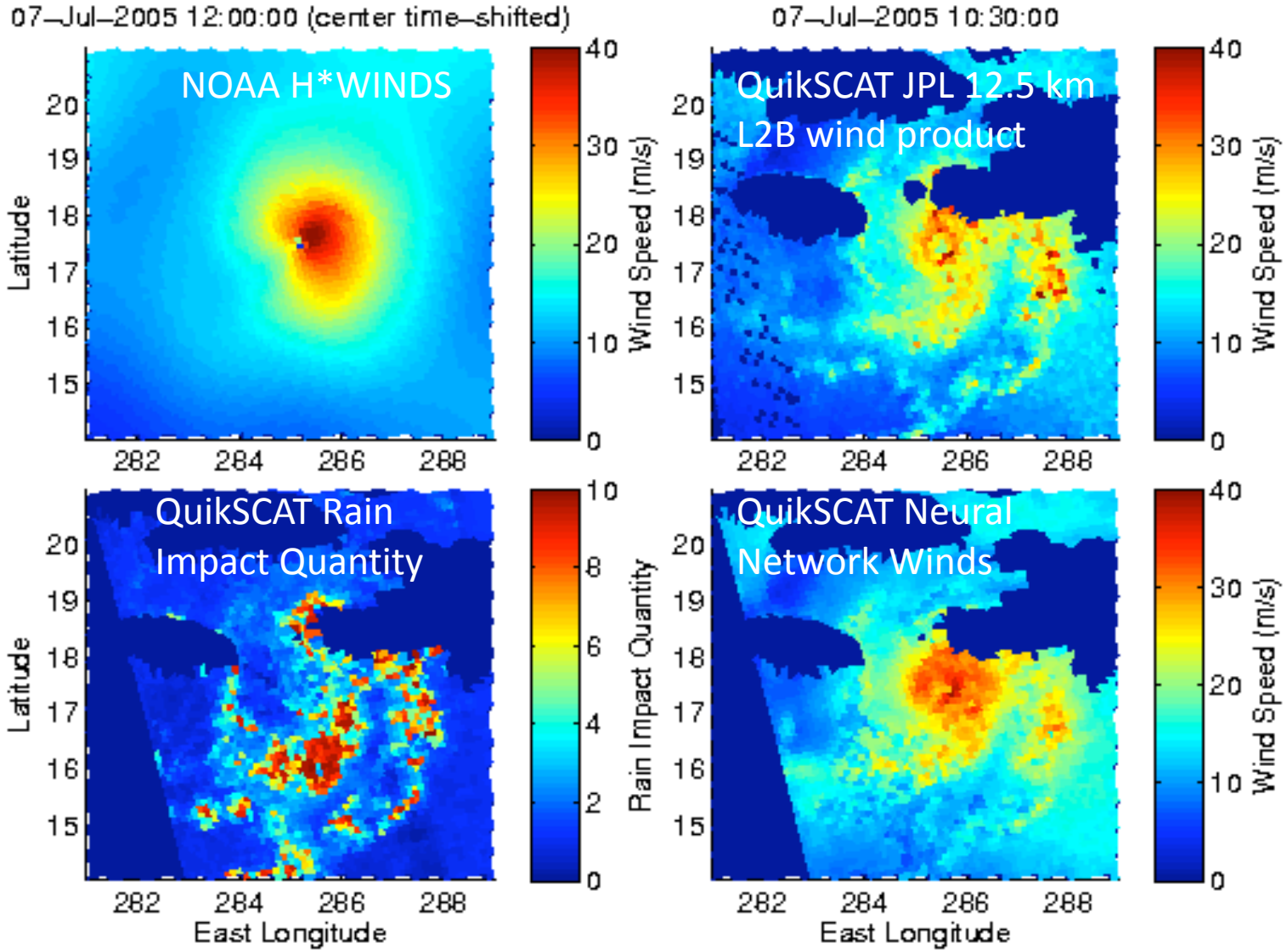
RMS Speed Error



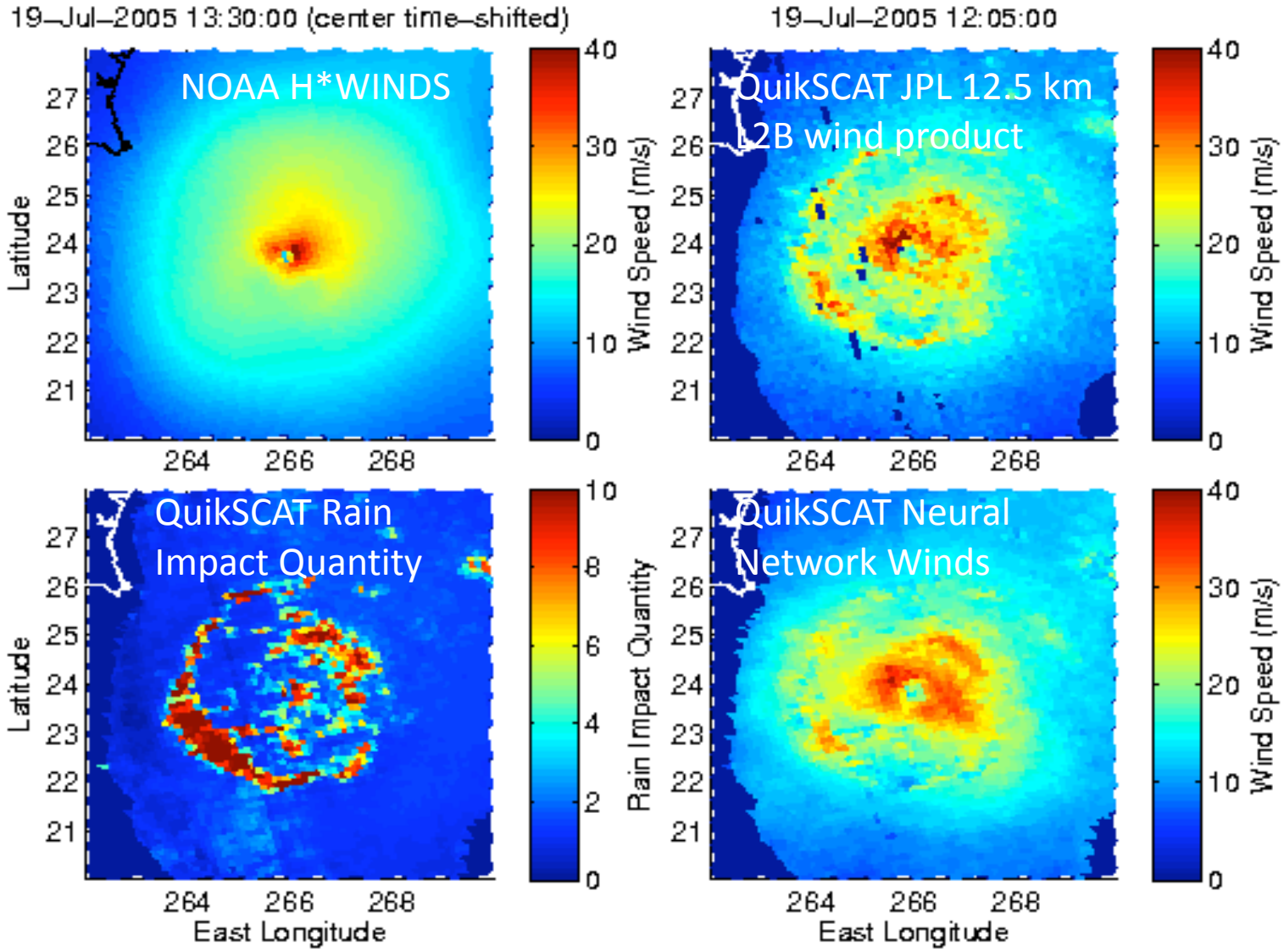
Mean QuikSCAT wind speed



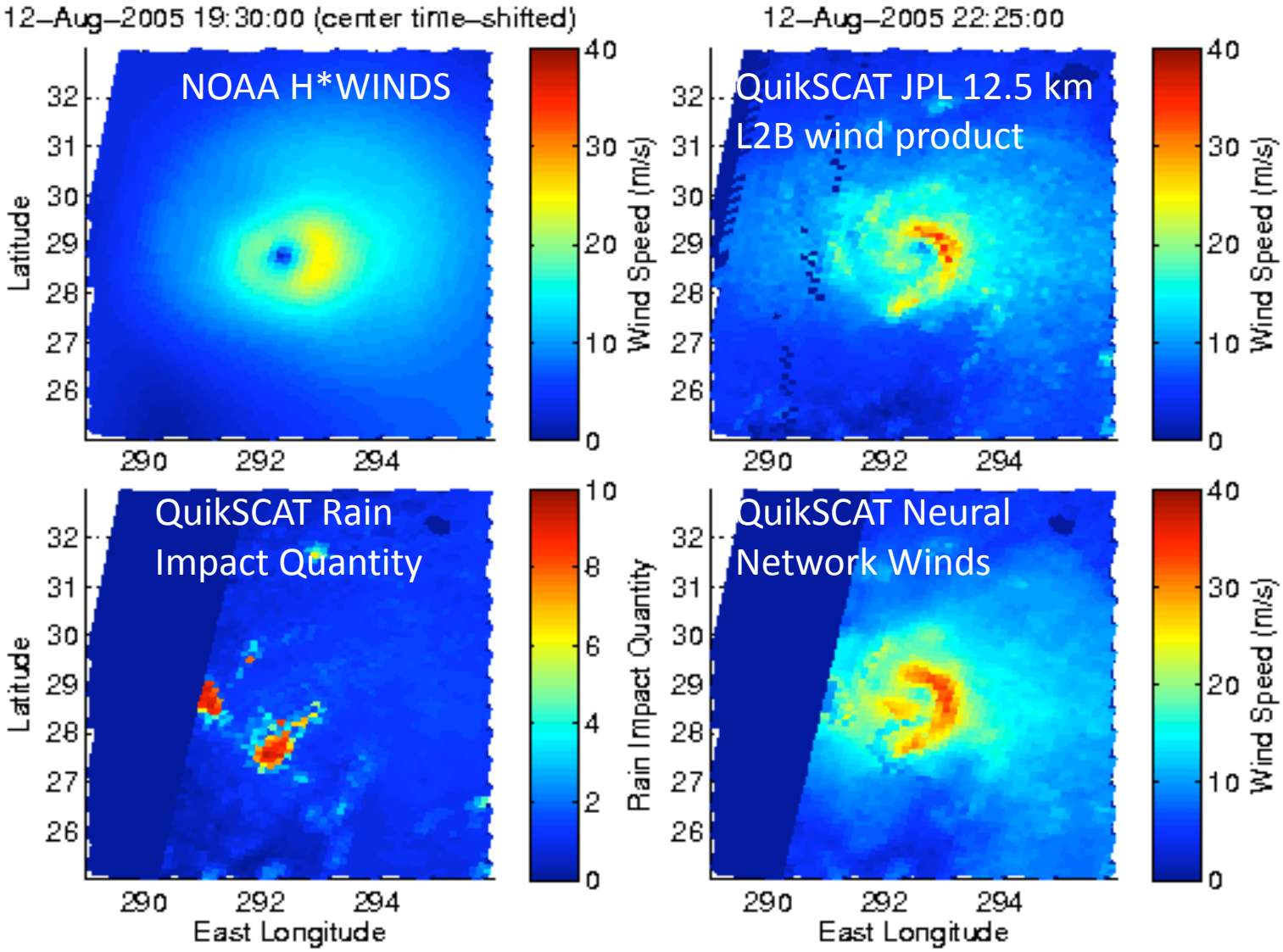
Hurricane Dennis Example from Test Set



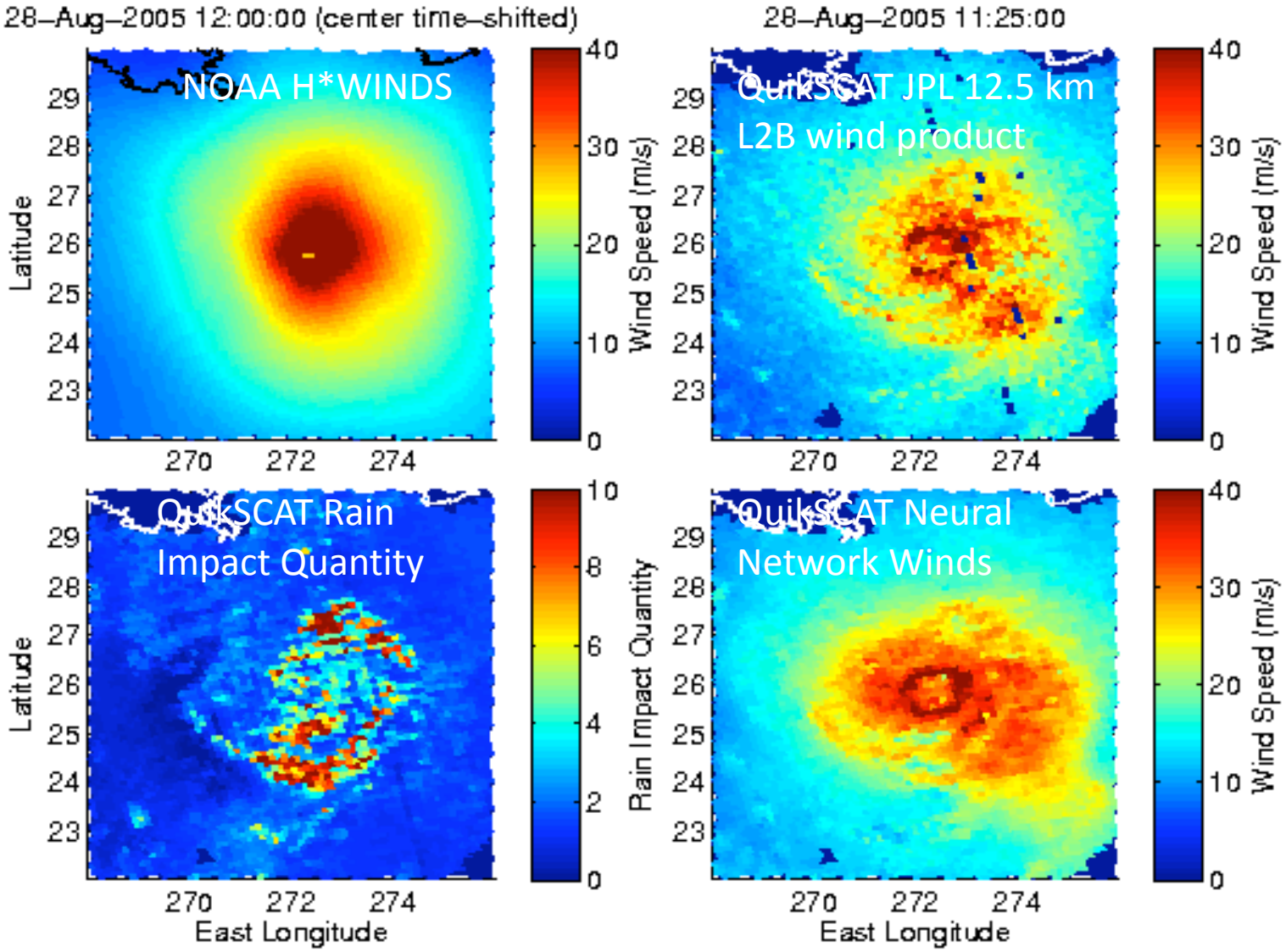
Hurricane Emily Example from Test Set



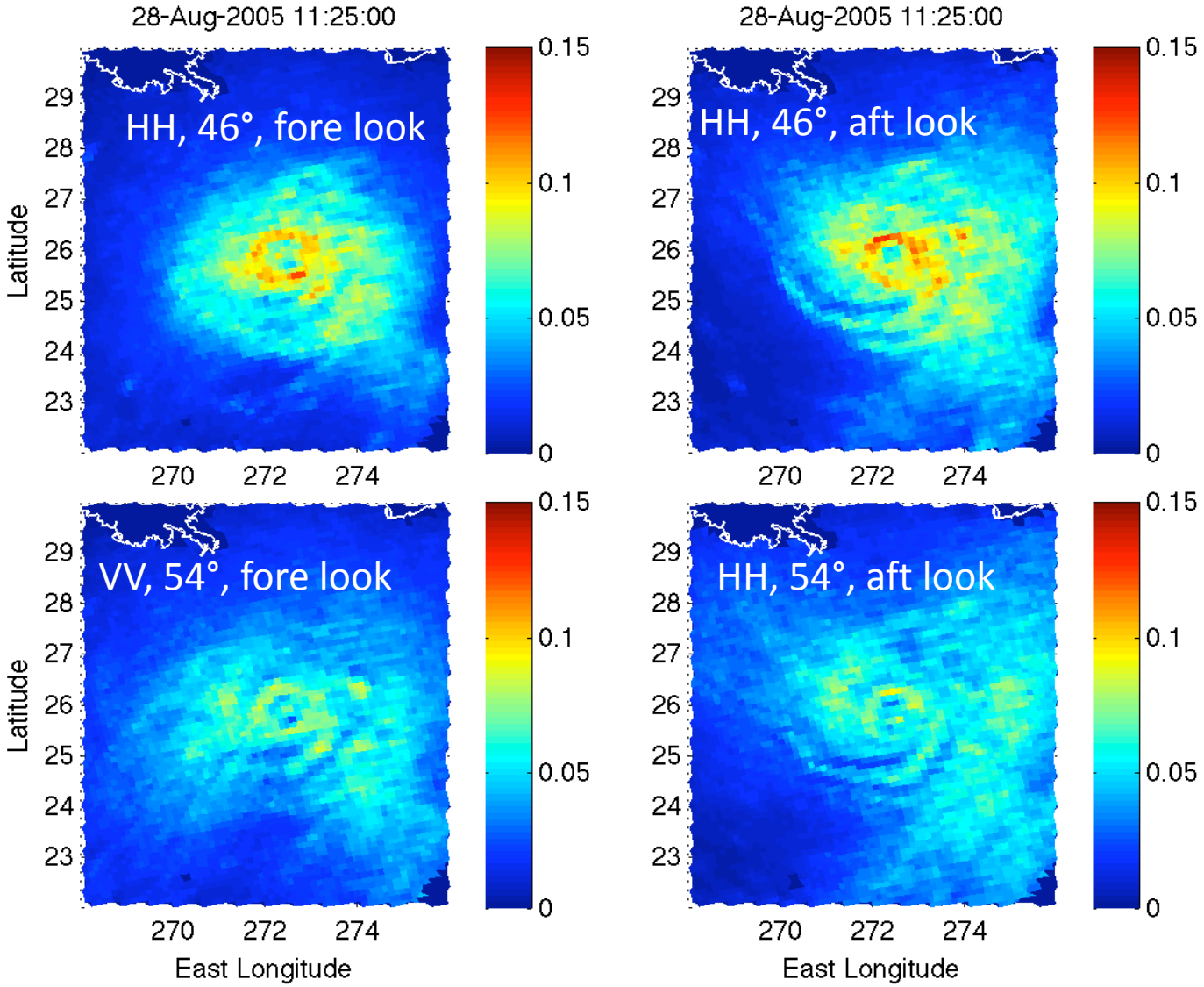
Hurricane Irene Example from Test Set



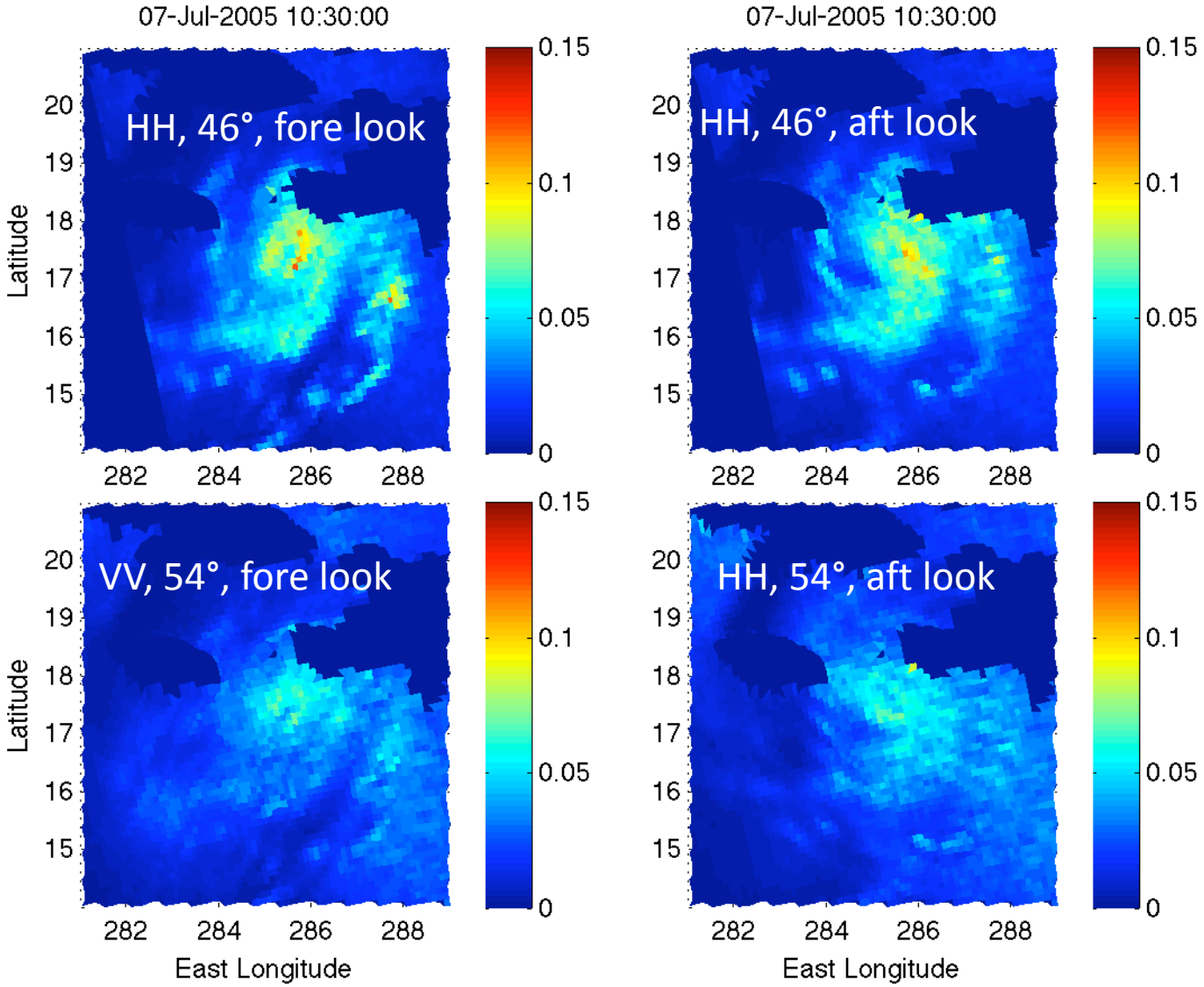
Hurricane Katrina Example from Test Set



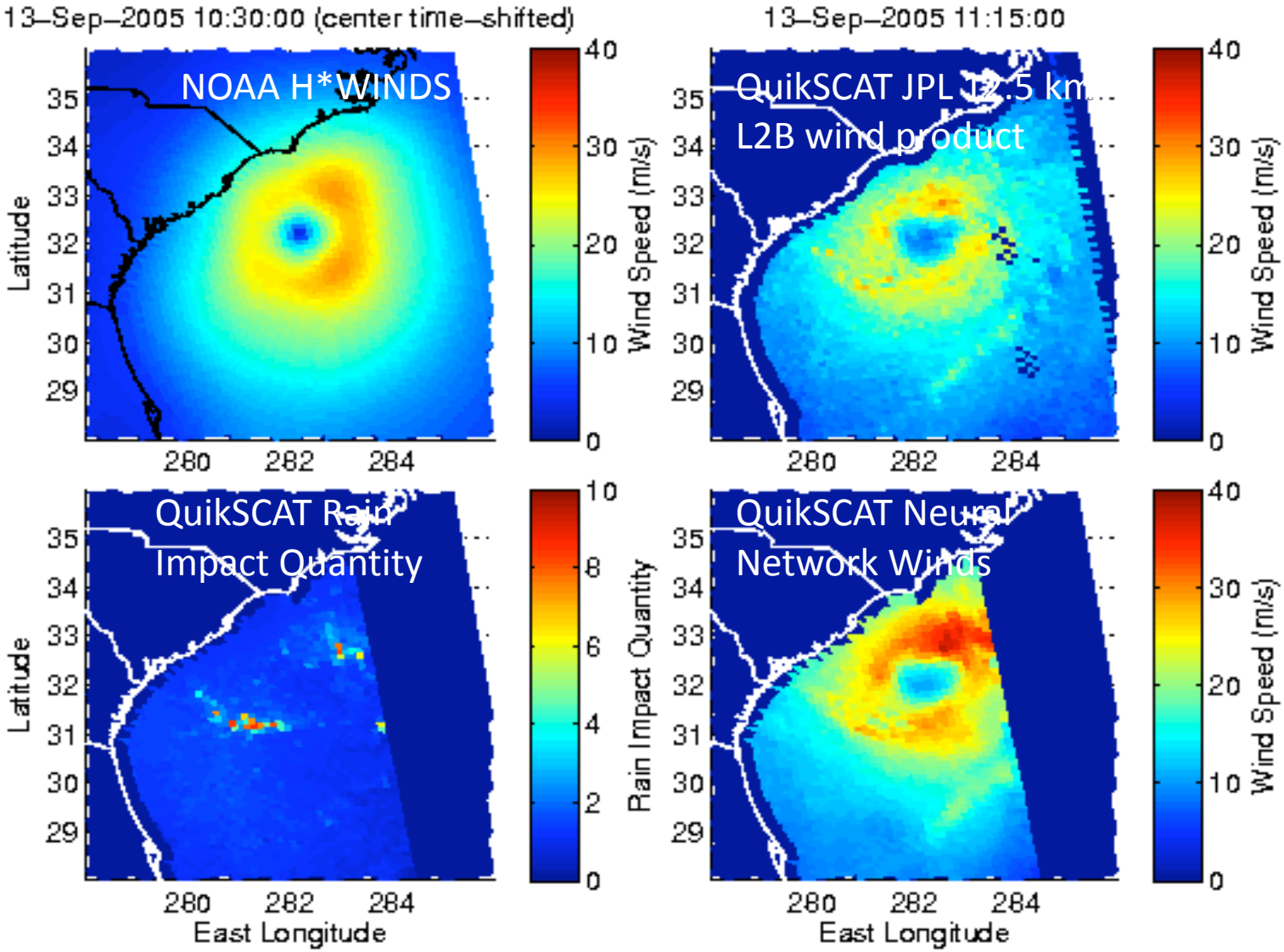
Hurricane Katrina Example –NRCS values



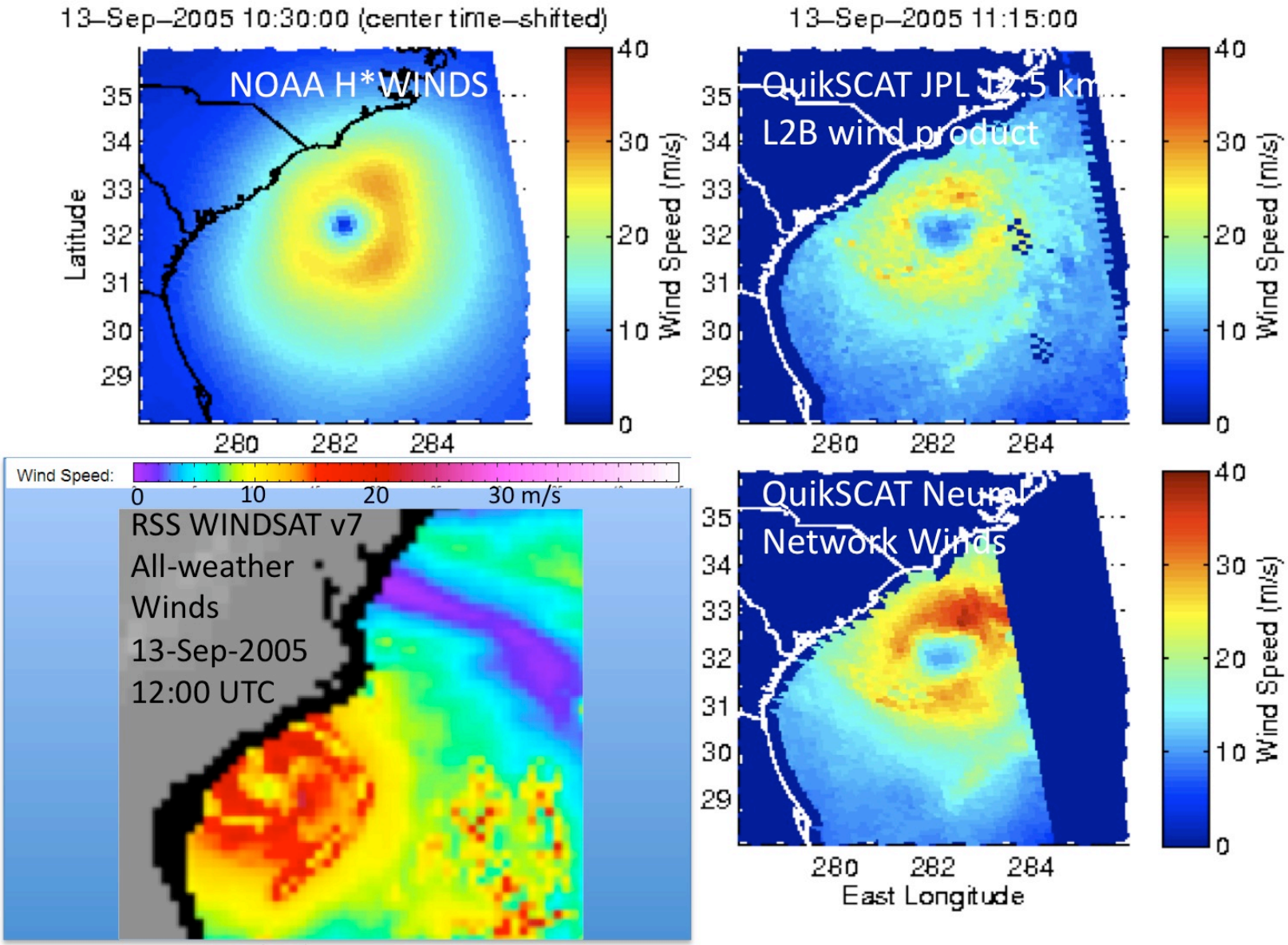
Hurricane Dennis Example –NRCS values



Hurricane Ophelia Example from Test Set

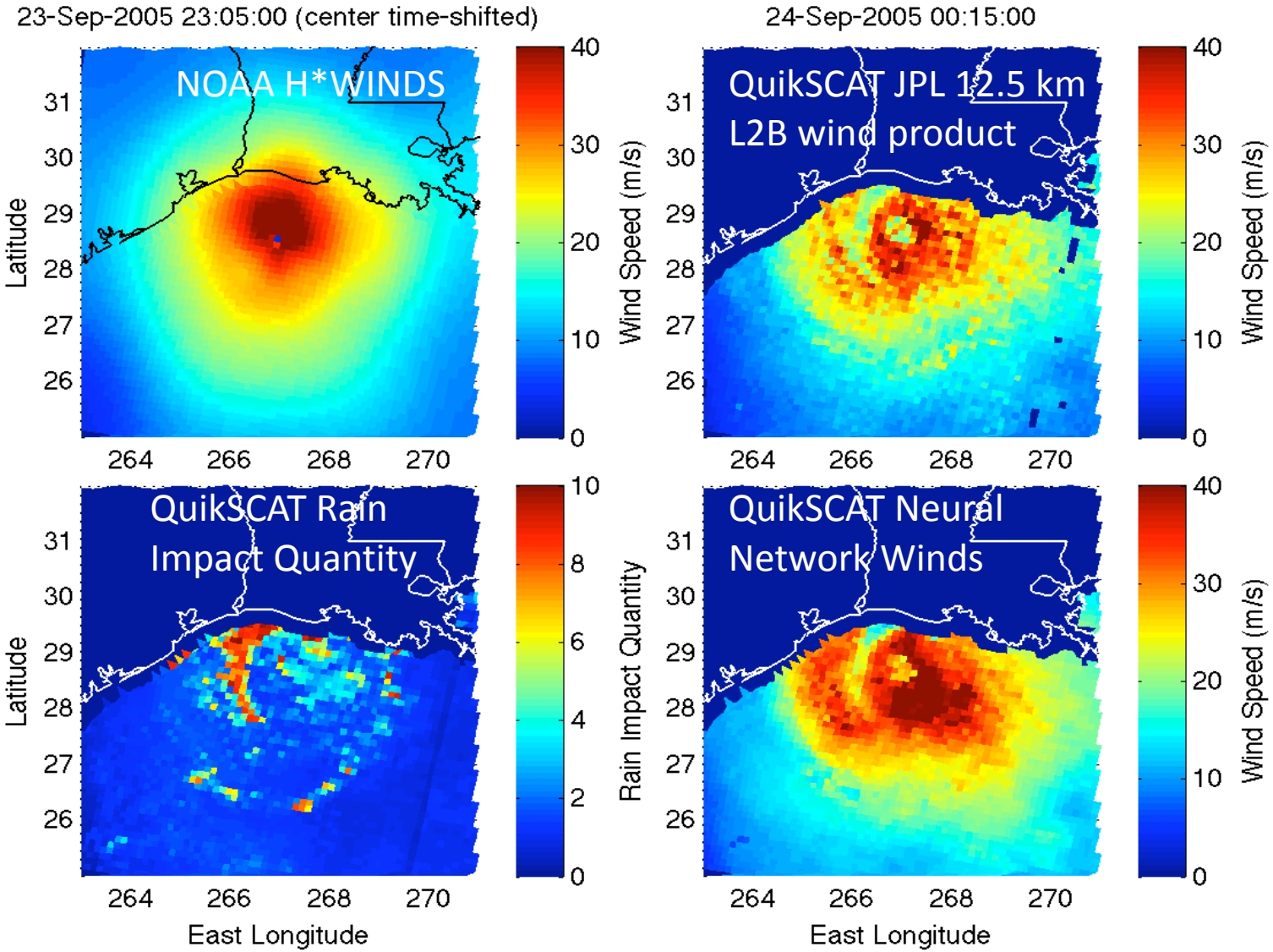


Hurricane Ophelia Compared with WINDSAT

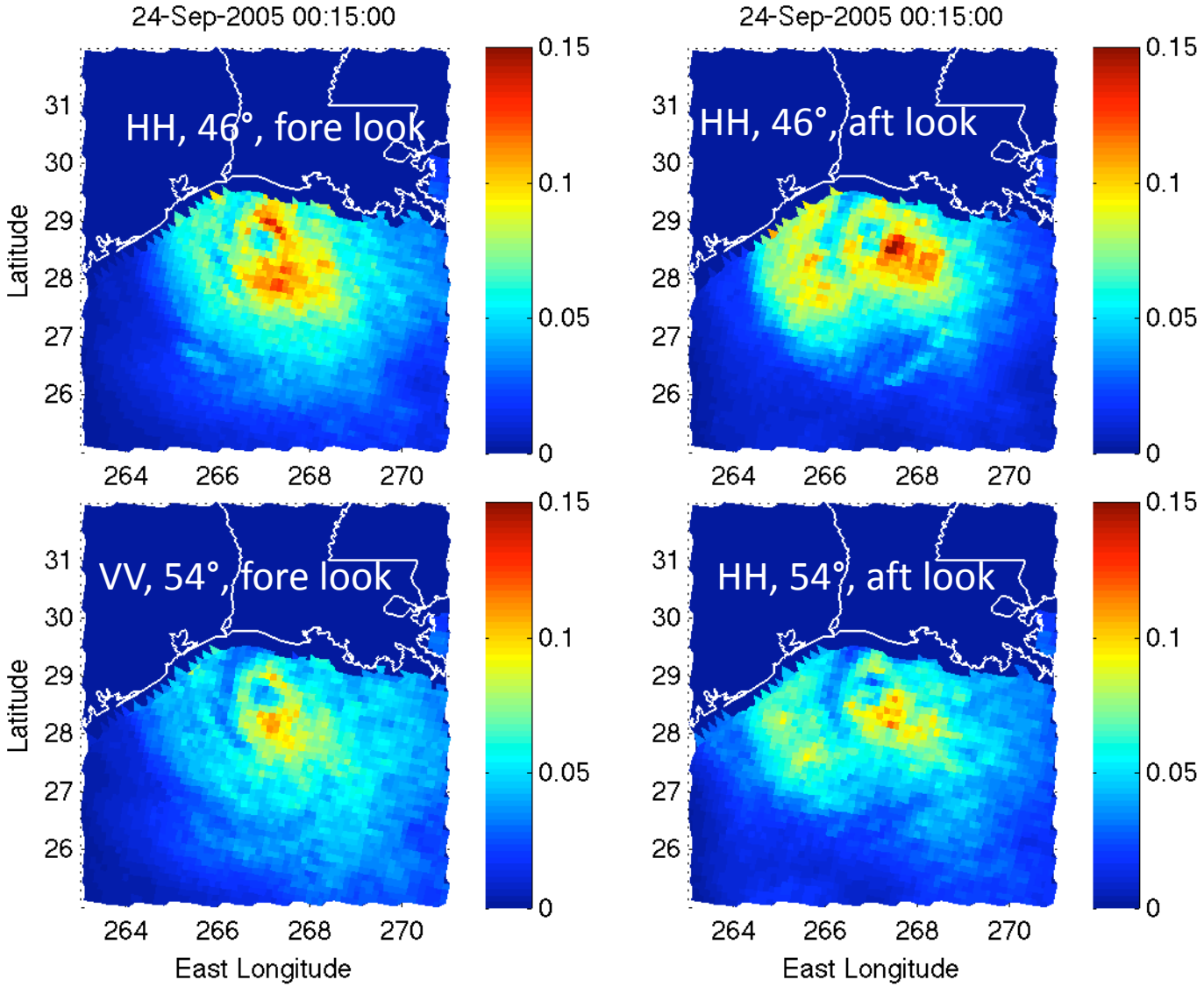


Downloaded on 05/09/2011 from www.remss.com

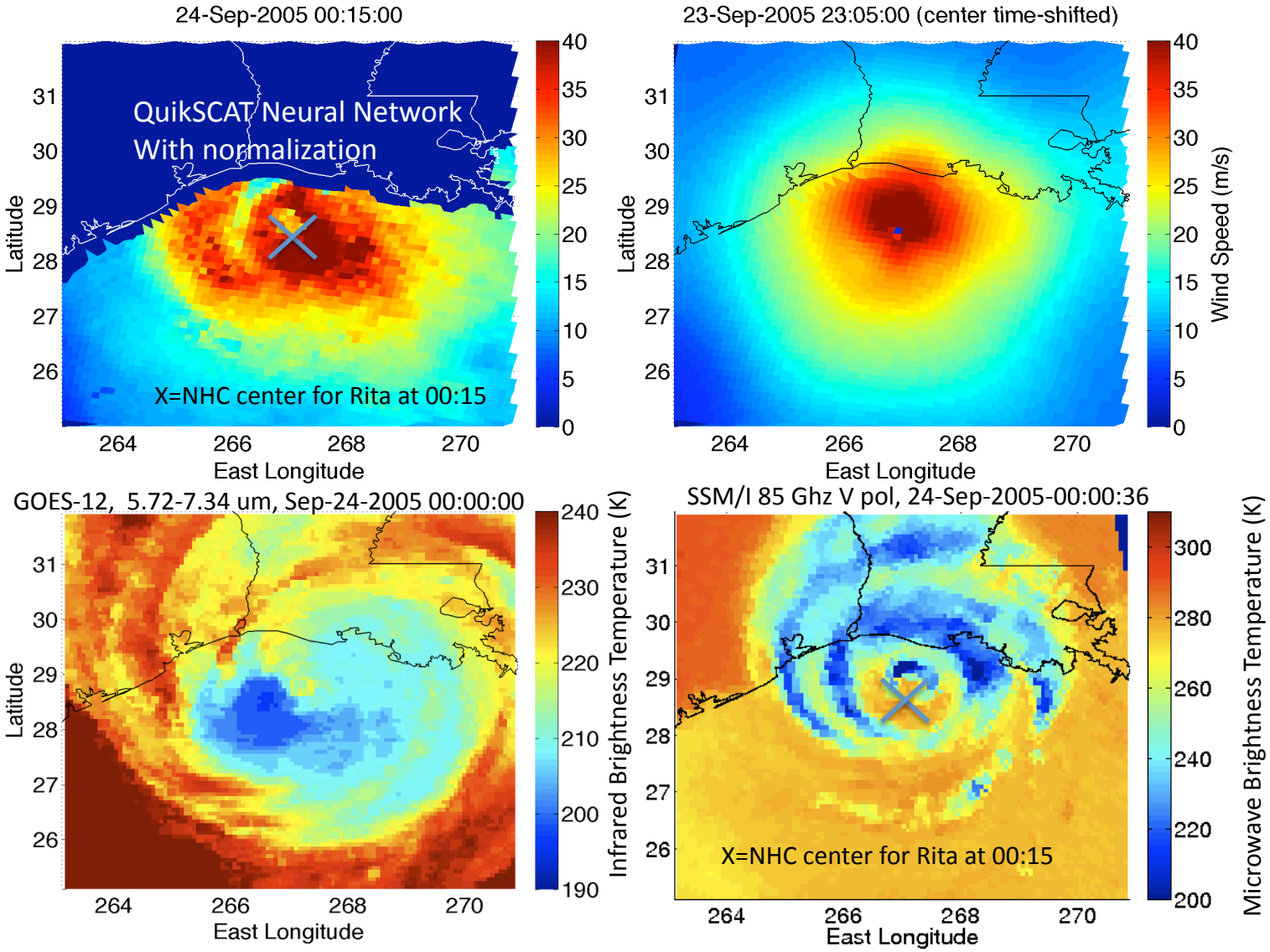
Hurricane Rita Example from Test Set



Hurricane Rita Example –NRCS values



Hurricane Rita Example with GOES and SSM/I



Summary and Future Work

- Completed Work
  - Trained and validated neural network on all coincident H*WINDS and QuikSCAT data from 2005.
  - Neural network achieves significantly reduced bias and RMS error up to 40 m/s when compared with standard 12.5 km L2B product.
- Plan for rest of fiscal year
  - Retrain neural networks using co-located SSM/I data.
    - As was done for rain correction of global ocean surface winds in Stiles and Dunbar 2010, we plan to include an intermediate stage in the network that estimates precipitation. The output of this stage will be used as an input for the final speed estimation network.
  - Compare with new RSS WINDSAT hurricane winds
  - Optimize simulation of NRCS using Isabel QuikSCAT/H*WINDS/SFMR co-locations.
    - Current simulation uses wind to radar cross section model that was derived from IWRAP data that has a calibration bias when compared with QuikSCAT.
    - Current simulation uses a radiative transfer function and mie-scattering model for rain that overestimates radar cross section around the eye of storms.
    - Eventually when the simulation matches reality well enough, it will be used to generate a larger more uniformly distributed training set for the neural network.
  - Try higher resolution wind retrievals.
  - Produce a preliminary 1-year QuikSCAT hurricane wind product for Michael Brennan at HRD to evaluate.

References

- Global Correction of QuikSCAT Wind Speeds in Rain
  - Bryan W. Stiles and R. Scott Dunbar, "A Neural Network Technique for Improving the Accuracy of Scatterometer Winds in Rainy Conditions," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 48, No. 8, pp 3114-3122, August 2010.
- Dual Frequency Scatterometer Wind Retrieval in Hurricanes
  - Bryan W. Stiles, Svetla M. Hristova-Veleva, R. Scott Dunbar, Samuel Chan, Stephen L. Durden, Daniel Esteban-Fernandez, Ernesto Rodriguez, W. Lee Poulsen, Robert W. Gaston, and Philip S. Callahan, "Obtaining Accurate Ocean Surface Winds in Hurricane Conditions: A Dual-Frequency Scatterometry Approach," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 48, No. 8, pp 3101-3113, August 2010.
- Description of H*WINDS
  - Mark D. Powell*, Sam H. Houston, Luis R. Amat, Nirva Morisseau-Leroy, "The HRD real-time hurricane wind analysis system," *Journal of Wind Engineering and Industrial Aerodynamics 77&78* pp 53-64, 1998.