Development and Evaluation of a Great Lakes Surface Temperature Product for use in Modeling and Analysis

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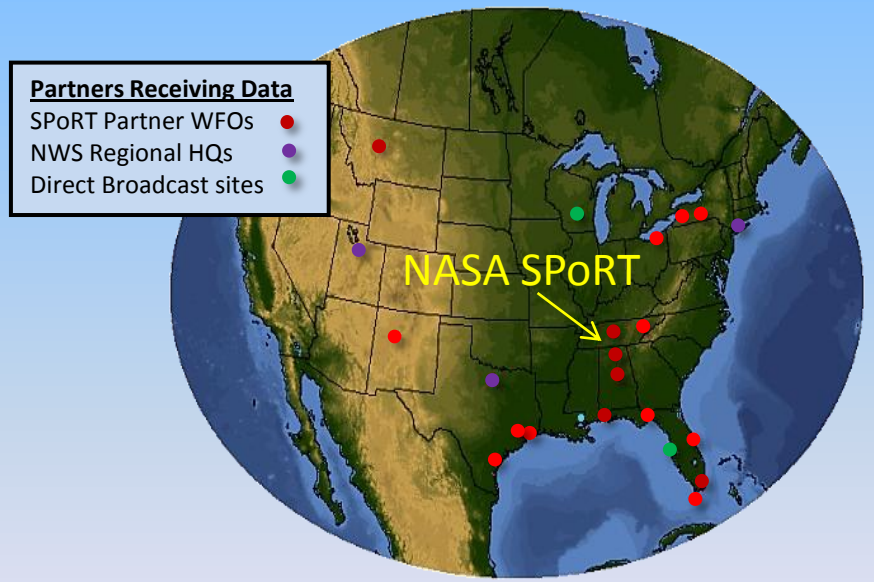
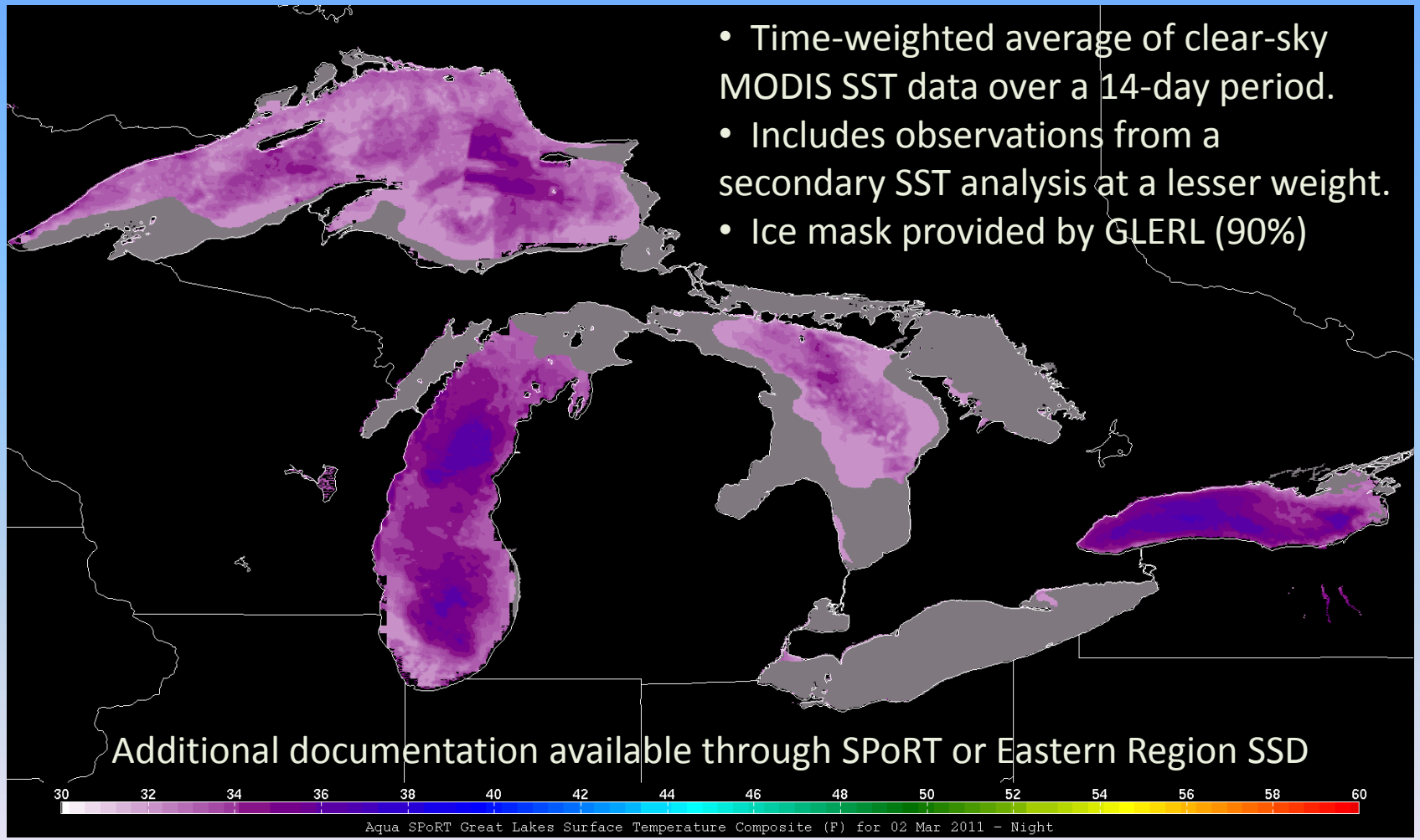
The SPoRT Center

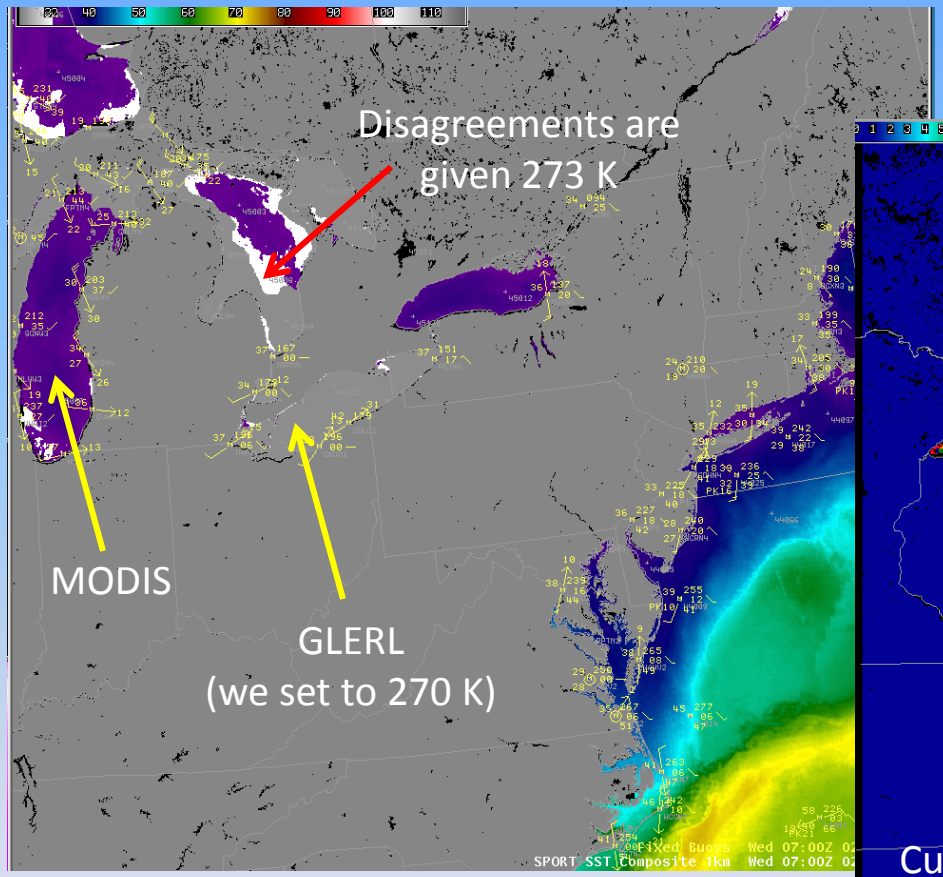
- SPoRT is a NASA project to transition unique observations and research capabilities to the operational weather community, to improve short-term forecasts on a regional scale.
- Located at NASA Marshall Space Flight Center
  - Huntsville, Alabama
  - Within the MSFC Earth Science Office
  - Collocated with the NWS WFO in Huntsville, AL, the University of Alabama in Huntsville (UAH).
  - Combination of NASA scientists, UAH employees, contractors, graduate students and staff.

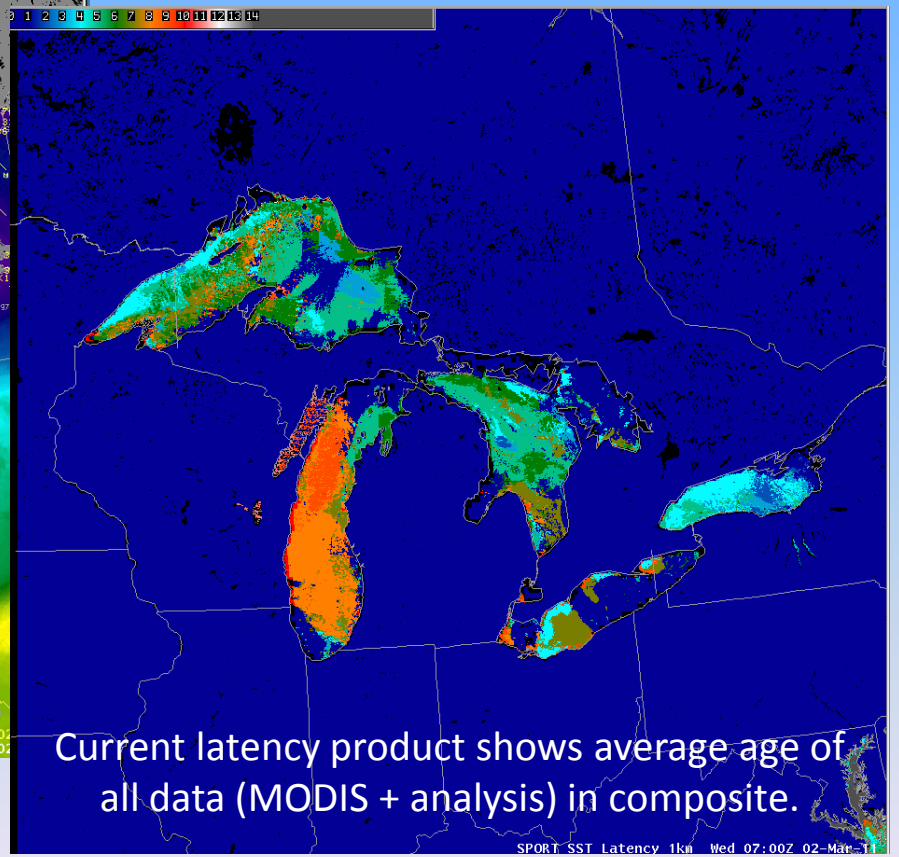


Great Lakes Temperature Product



Displays in AWIPS



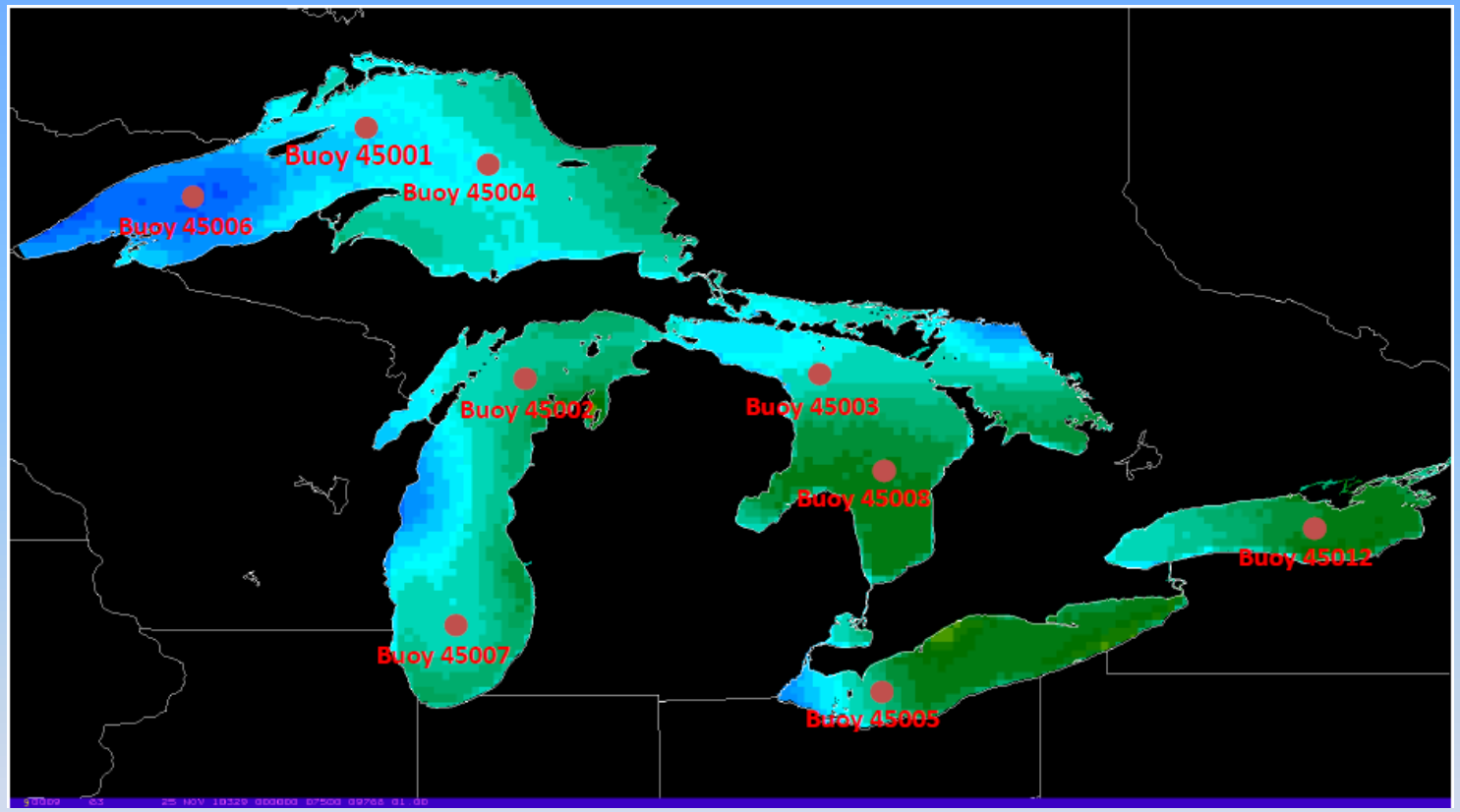


Modeling Applications

- The Great Lakes product is distributed as part of a larger SPoRT SST product for use in modeling and analysis.
- We have made configuration changes to accommodate use in the WRF-EMS

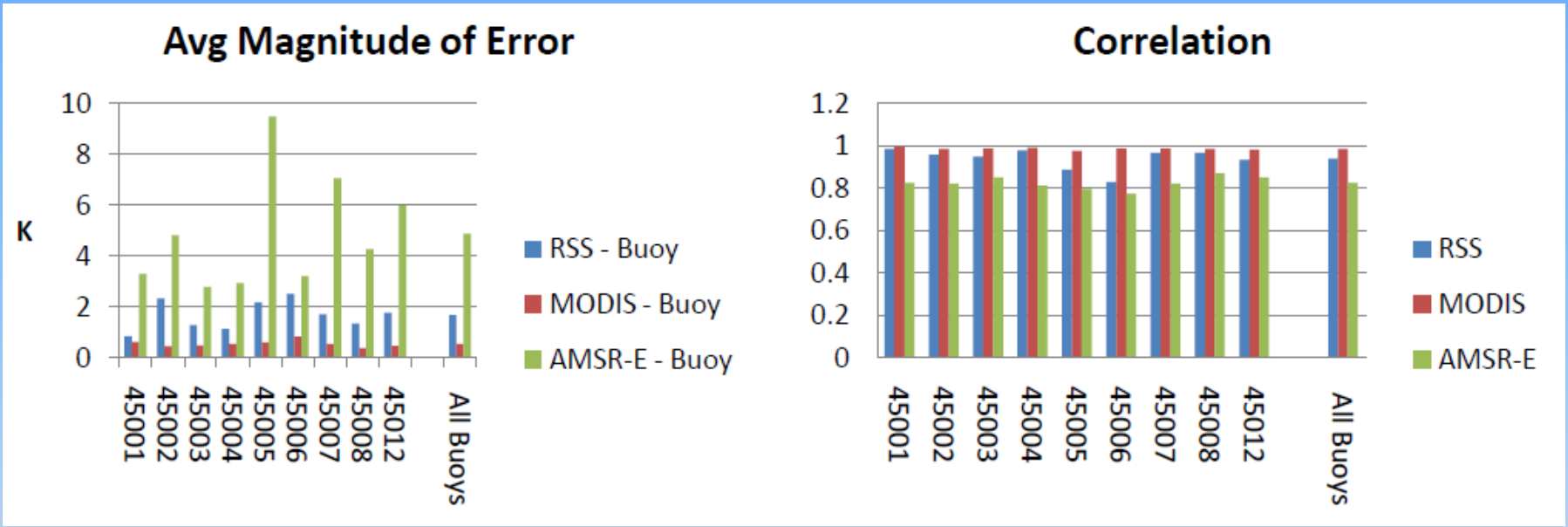
- ARW core
  - Users select the SPoRT SST product.
  - Ice points of 270 K are less than ice threshold (273 K) and become ice.
- NMM core
  - Users select the SPoRT SST product and ice mask.
  - Combined temperatures and ice mask are used.

Product Evaluation



Goal: Use available buoys in the summer of 2010 (June, July, August) to evaluate various satellite estimates of surface temperature and various analysis products.

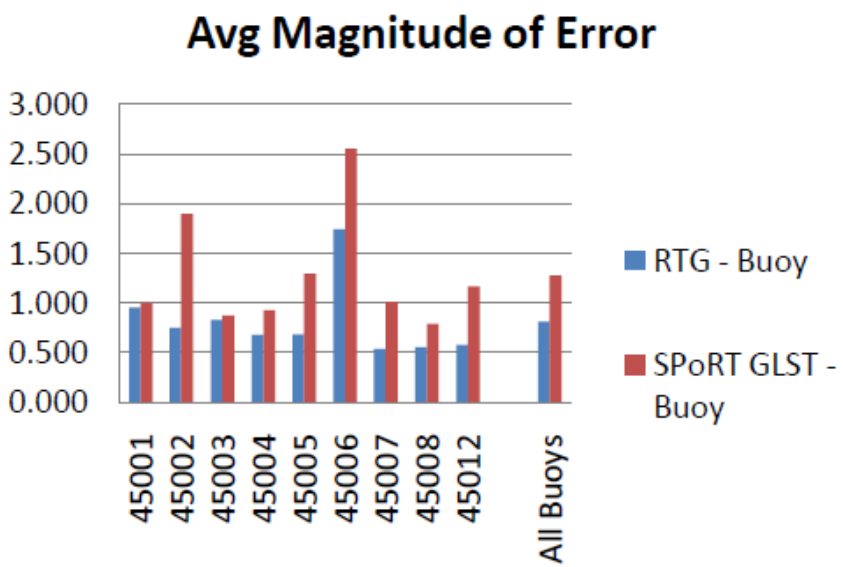
Product Evaluation

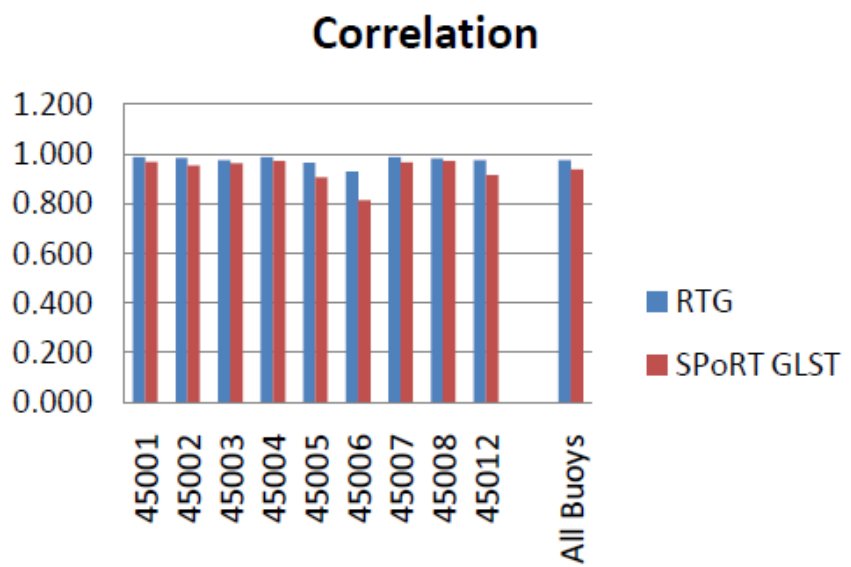


Satellite and Composite Product Results:

- Passive microwave observations from AMSR-E would penetrate cloud cover, but would introduce large errors into composite values.
- The Remote Sensing Systems composite, which is included in the composite but given a very small weight, is a reasonable depiction of temperatures.
- MODIS observations provide the minimum error versus coincident buoy observations.

Product Evaluation

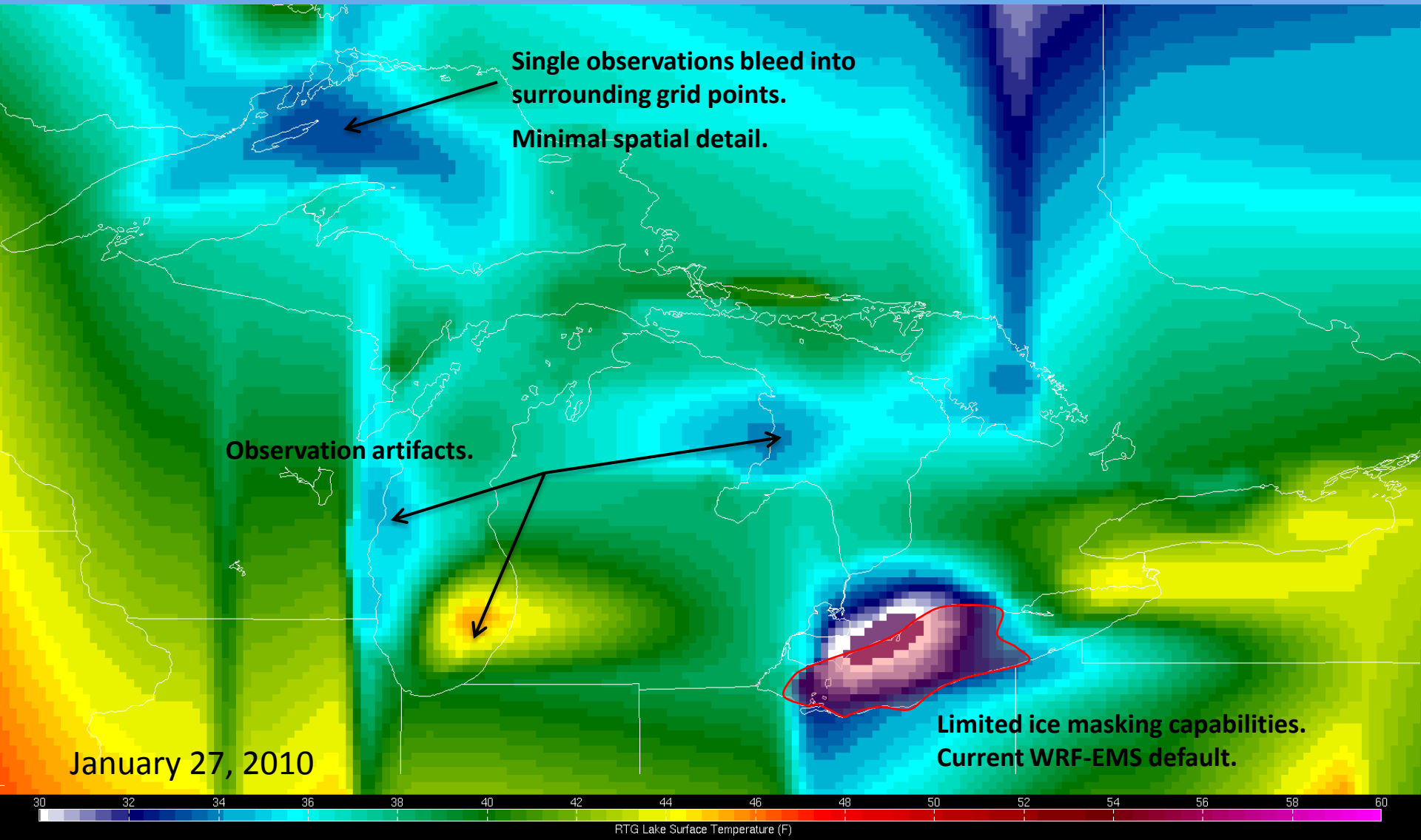




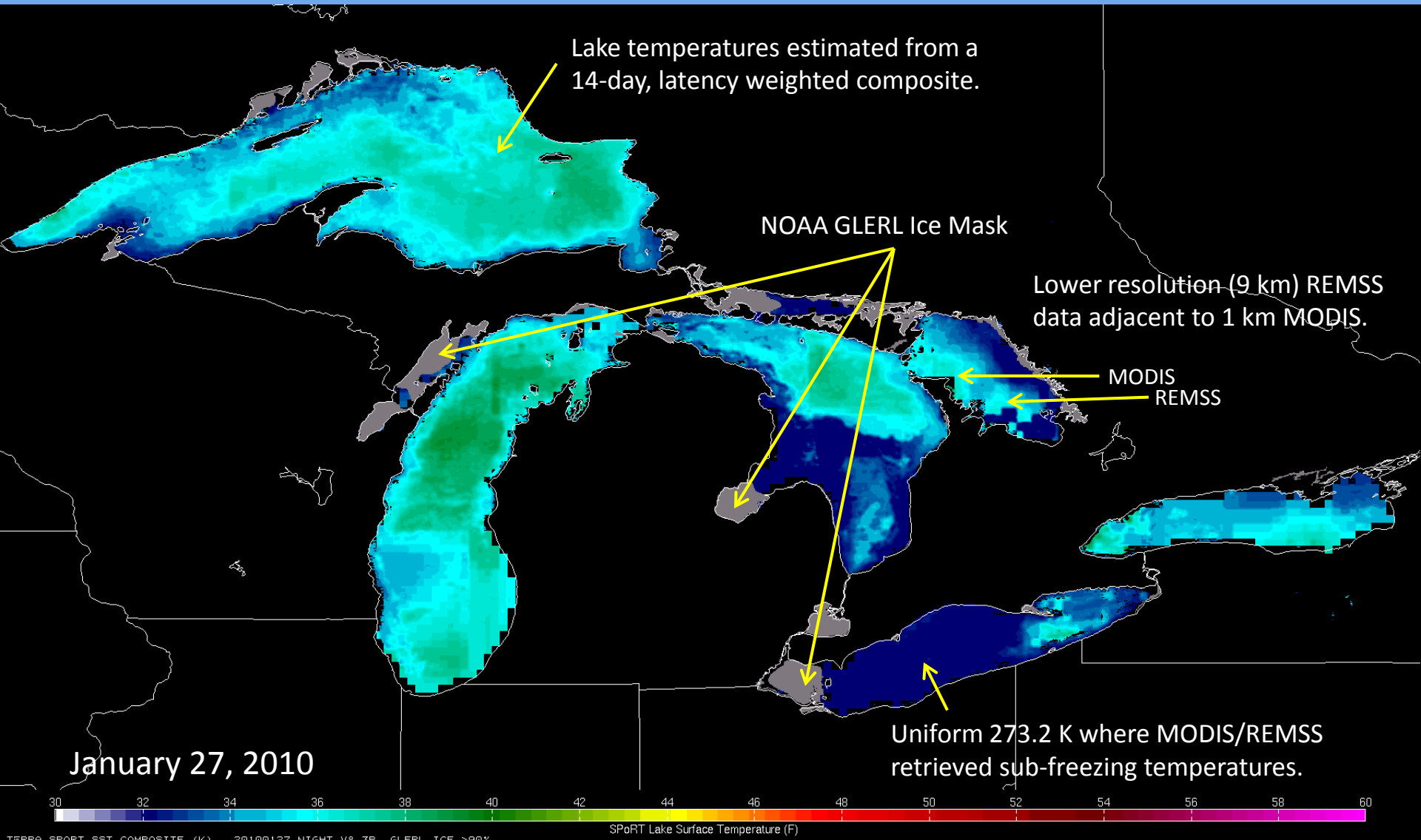
Comparing our GLST Product to the Default RTG:

- The current SPoRT GLST is comparable to the RTG (usually within 0.5 K) but during the summer season, has an average magnitude of error greater than the RTG.
- Caveat: The RTG includes buoy observations in the analysis. The SPoRT GLST product does not. Validation is performed *against the buoy observations*.
- Both products are similar in correlation and their ability to represent seasonal cycle.

RTG Product Example



GLST Product Example



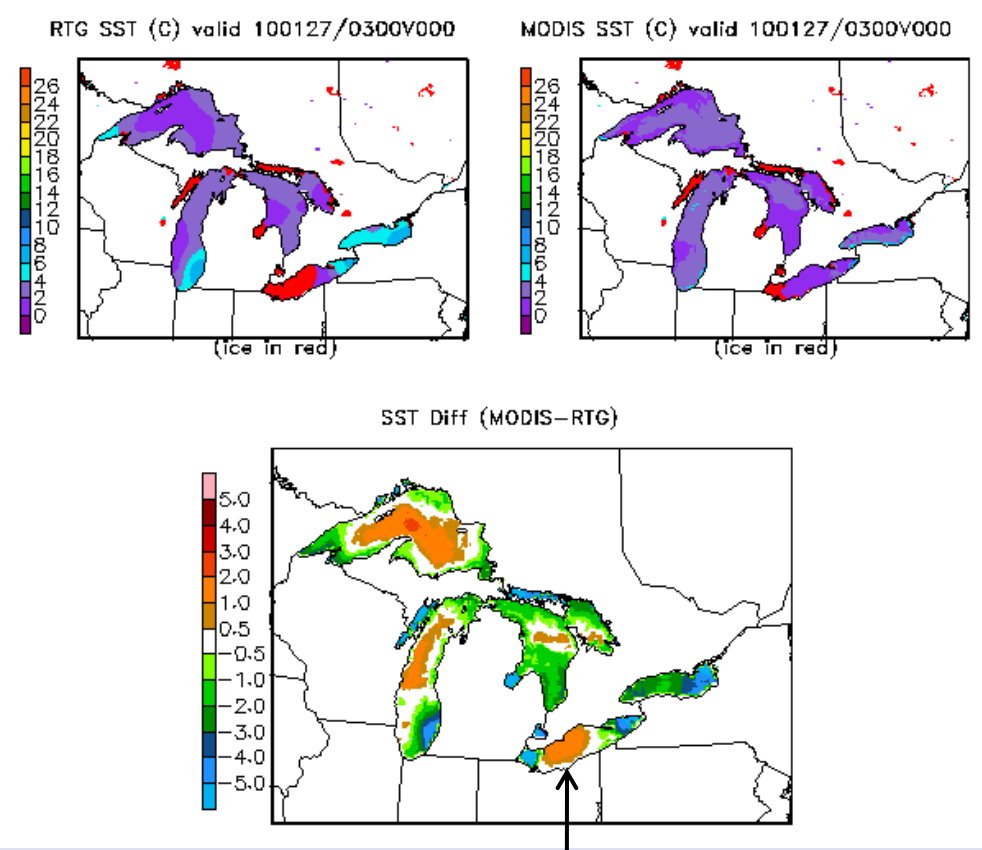
Applications

- Examples of modeling applications using the SPoRT Great Lakes Temperature Product
- Two cases have been examined thus far:
  - Lake Effect Storm “Echinacea”
    - January 27-29, 2010 off of Lake Erie and Lake Ontario
  - Lake Effect Storm “Bluegill”
    - December 1-3, 2010 primarily off of Lake Ontario, but also Erie.
  - Storms were named and analyzed by WFO Buffalo, NY
- Demonstrate model capabilities at fairly high resolution (4 km) and sensitivity to initial conditions.

Lake Effect Storm Echinacea

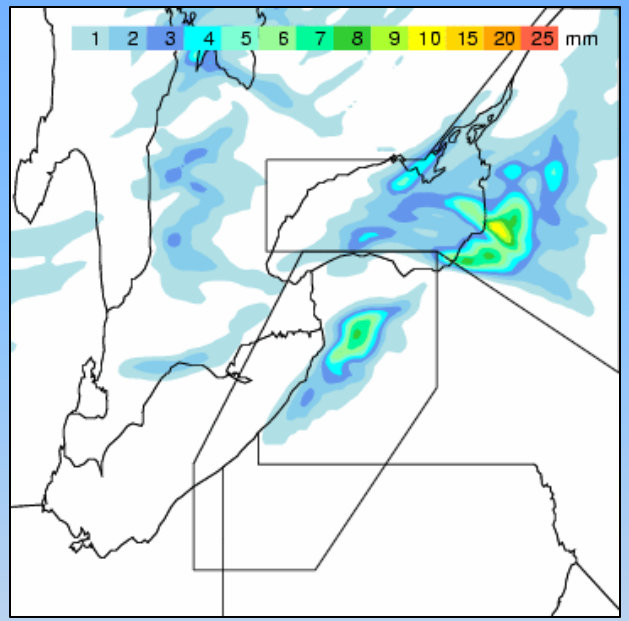
- Emphasis on examining differences in simulated event as they relate to GLST changes.
- Large areas of temperature increase (decrease) within each lake versus default model product (RTG).

January 27-28, 2010: "Lake Effect Storm Echinacea"

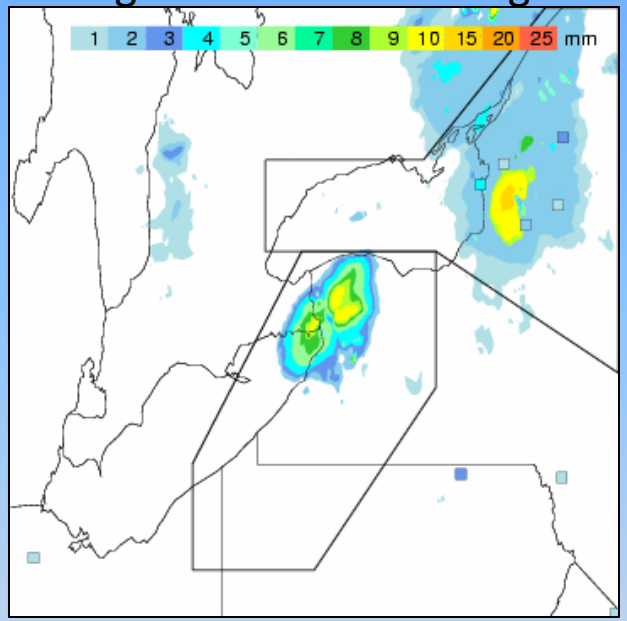


Lake Effect Storm Echinacea

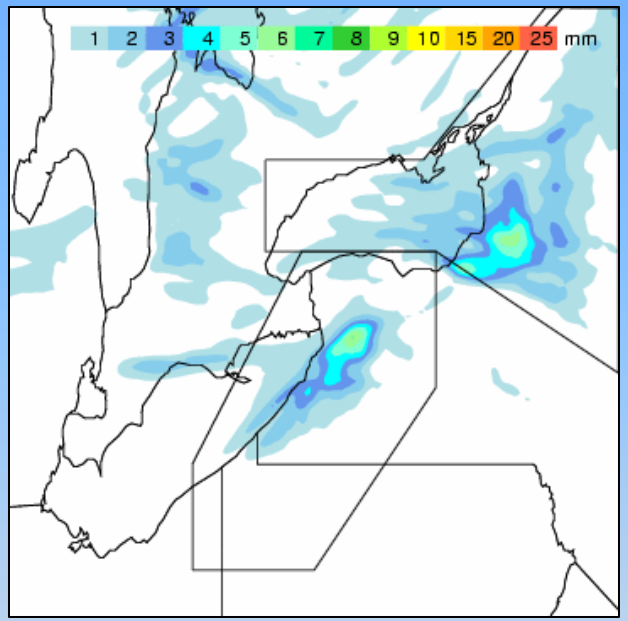
RTG



Stage IV and NCDC Gauges



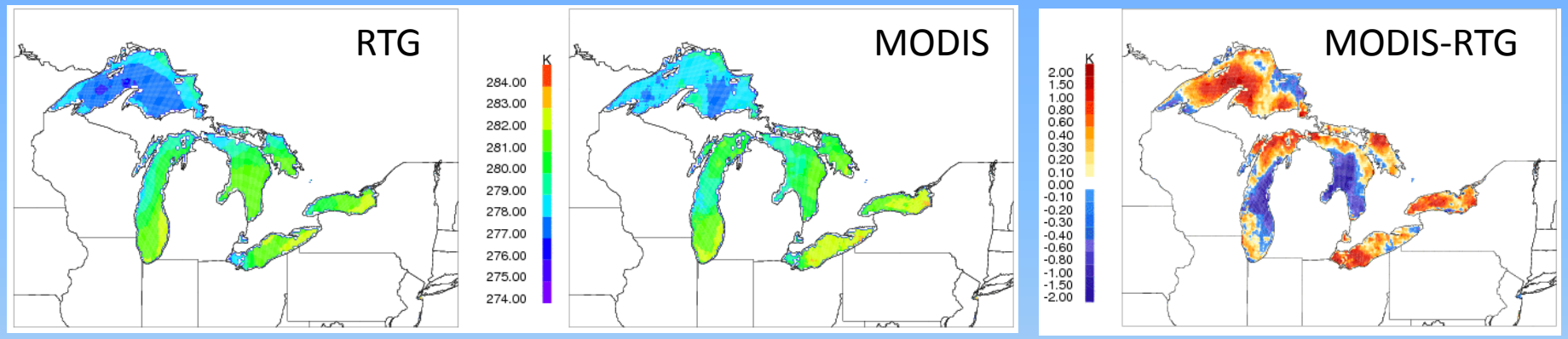
GLST



In this case, use of the SPoRT product decreases downwind precipitation owing to the cooler surface water temperatures. Both forecasts are displaced southward due to model bias.

For more information, please see paper by Cipullo, et al. 2011 (91st AMS, WAF/NWP)

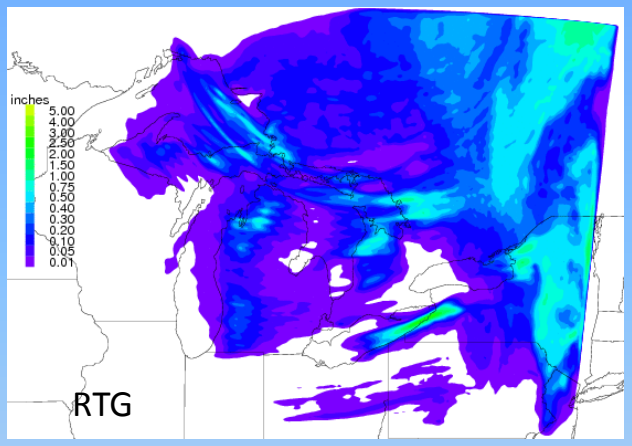
Lake Effect Storm Bluegill

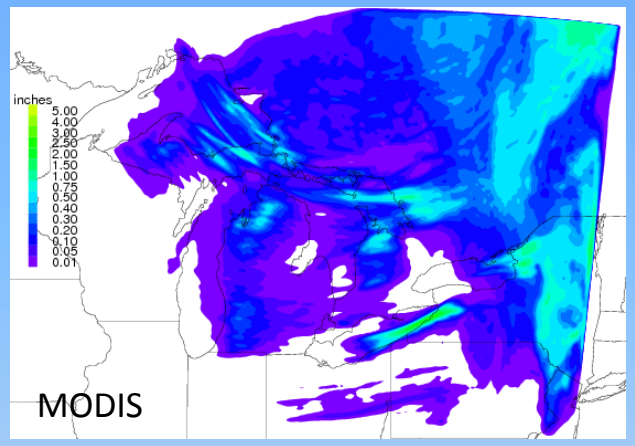


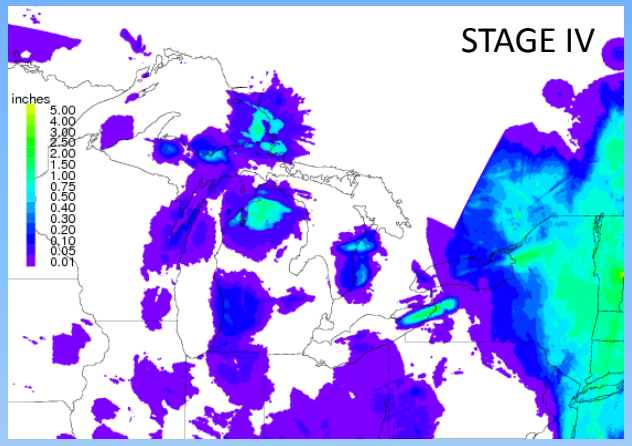
- For Lake Effect Storm Bluegill, temperature differences over Lake Ontario and Lake Erie were not as large (Δ~1 K) as in Lake Effect Storm Echinacea (Δ~3-4 K).

- Caveat: Cloud cover over the Great Lakes preceding and during the event limits clear sky views of lake surface temperature, contributing to latency in the MODIS composite.

Lake Effect Storm Bluegill





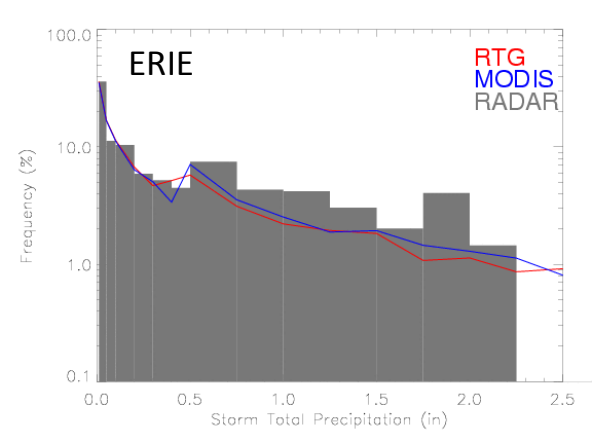


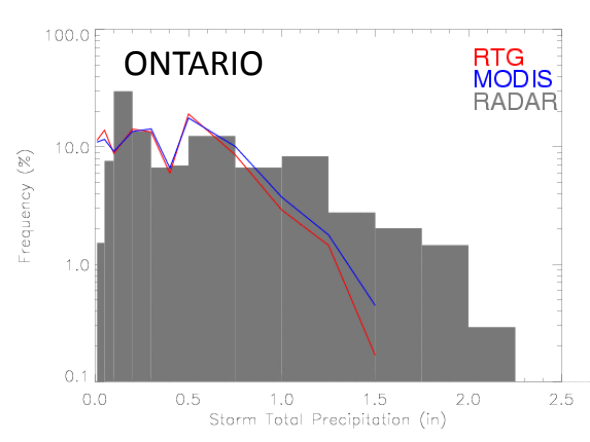
- Storm total precipitation (liquid) is compared between WRF model results and estimates acquired from the NCEP Stage IV precipitation.

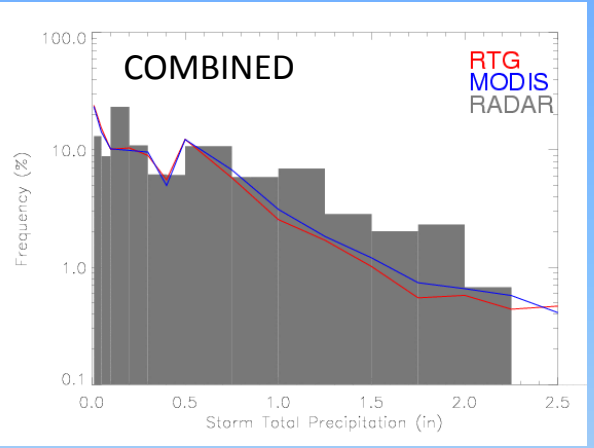
- Model forecasts displace Lake Erie precipitation southward and split Lake Ontario precipitation into a series of banded structures that drift north and south.

- Only subtle changes in surface temperature within regions upwind of the bands, limiting the apparent impact of product difference in forecast precipitation.

Lake Effect Storm Bluegill







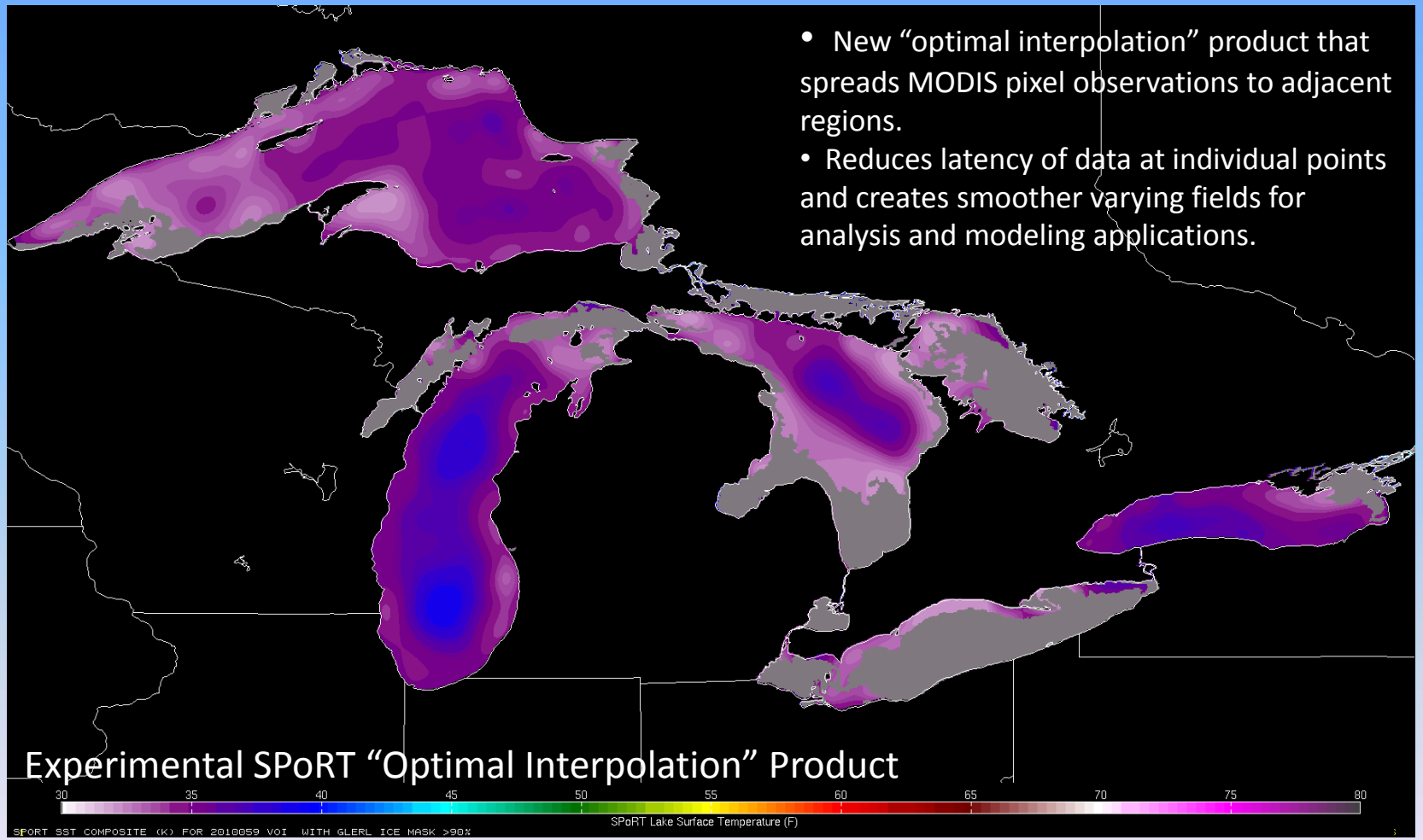
- Storm total precipitation analyzed within boxed regions encompassing individual lakes.

- Analysis repeats graphical findings that there are limited, subtle differences in storm total precipitation, but individual lakes and their combination indicate some increase in heavy precipitation amounts with slightly warmed temperatures.

Summary

- SPoRT has developed a Great Lakes Surface Temperature composite for use in modeling and analysis applications.
- The product mimics seasonal trends in buoy observations and is comparable to RTG.
  - Validation limited to available buoy data
  - Limited observations during extensive cloud cover
- Applications for local modeling:
  - Incorporates GLERL ice mask
  - Higher spatial resolution than other products
  - Could be used in ensemble approaches to contribute variability in assumed lake temperatures

Future Work



- New "optimal interpolation" product that spreads MODIS pixel observations to adjacent regions.
- Reduces latency of data at individual points and creates smoother varying fields for analysis and modeling applications.

Questions?

- Contact information:
  - andrew.molthan@nasa.gov
- SPoRT always seeks feedback from WFOs on how to improve the use of NASA data within weather forecasting applications.
- We also seek to develop collaborative projects investigating and evaluating the use of NASA data.