1. FY08 –FY10 GOES-R3 Project Title

- Title: GOES-R Applications to Tropical Cyclone Analysis and Forecasting
- Project Type: Product Development Proposal
- Status: Final Year
- Duration: 3 Years
- Leads:
  - » J. Knaff, NESDIS/StAR/RAMMB
  - » M. DeMaria, NESDIS/StAR/RAMMB
- Other Participants:
  - » A. Schumacher, CIRA/CSU
  - » J. Dostalek , CIRA/CSU
  - » K. Micke, CIRA/CSU
  - » D. Watson, CIRA/CSU
  - » R. Brummer, CIRA/CSU

2. Project Summary

- Proxy GOES-R data will be used to develop tropical cyclone applications
- Genesis and Intensity Forecasting
  - » Test existing frameworks with proxy GOES-R data
    - – NCEP/TPC SHIPS statistical intensity prediction model and rapid intensity index (RII)
    - – NESDIS/SAB tropical cyclone formation probability product
      - Uses discriminant analysis
  - » Proxy datasets
    - – World Wide Lightning Location Network (for lightning mapper)
    - – MSG observations (for ABI)
      - Utilize AWG technique to derive ABI from MSG channels
  - » Evaluate predictive signal in lightning data
    - – Intensification relationships may depend on shear
    - – Confirm preliminary studies on TC genesis but with other data present
- Tropical Cyclone Structure Analysis
  - » Generalize GOES inner core wind algorithm to ABI channels
  - » Storm structure analysis with proxy sounder data
    - – AIRS, IASI, COSMIC satellite soundings, NOAA Jet GPS sondes
    - – Eye sounding technique
    - – Nonlinear balance winds
    - – Impact on Dvorak intensity estimation method

3. Motivation

- Ready existing algorithms for ABI/GLM data
  - » Statistical Hurricane Intensity Prediction Scheme (SHIPS)
  - » Rapid Intensification Index (RII)
  - » Tropical Cyclone Formation Product
  - » Dvorak Technique Sensitivities (AWG project with CIMSS)
  - » Inner core IR proxy winds
- Develop GOES Lightning Mapper Proxy
  - » World Wide Lightning Location Network (WWLLN_
  - » Vaisala GL360… proving ground activities
- Determine if the lightning data contains predictive information and develop the methods.
  - » SHIPS/ RII

FY08-FY09
Major Milestones and Accomplishments

- **GOES-R3**
  - » Assemble proxy lightning mapper, ABI and sounding databases
  - » Modify SHIPS, Rapid Intensity Index, TC genesis parameter to use GOES-R inputs
  - » Test eye sounding technique on large sample of cases
  - » Present preliminary results at AMS tropical conference
  - » Expand proxy datasets
  - » Evaluate impact on forecast algorithms
  - » Begin real time web site to demonstrate experimental GOES-R products
  - » Present results at AMS Annual Meeting
  - » Begin publication of results
- **AWG**
  - » Create synthetic ABI imagery and corresponding MSG SEVIRI IR window channel imagery for the seven tropical cyclones from 2006-2008
  - » Documentation for proxy datasets
  - » Inputs to ATBD and Algorithm Implementation and Test Plan documents
  - » Monthly reports

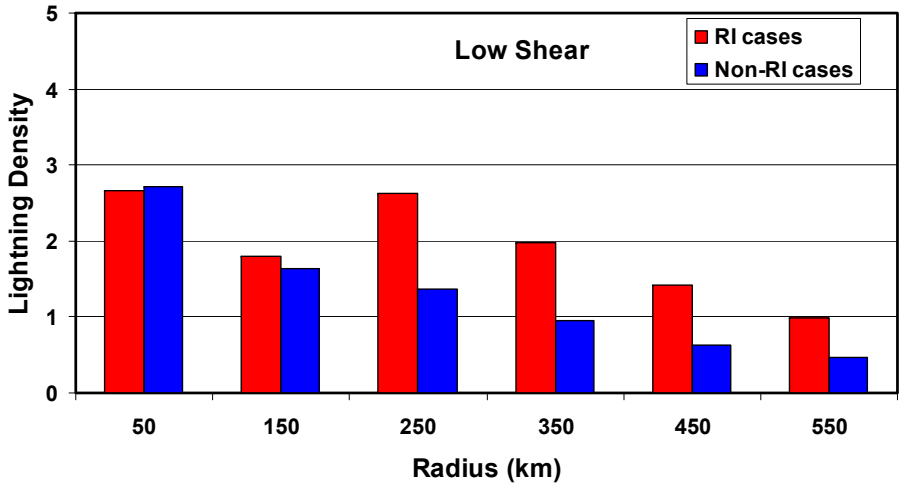
Proxy Dataset (ABI, Sounding, GLM)

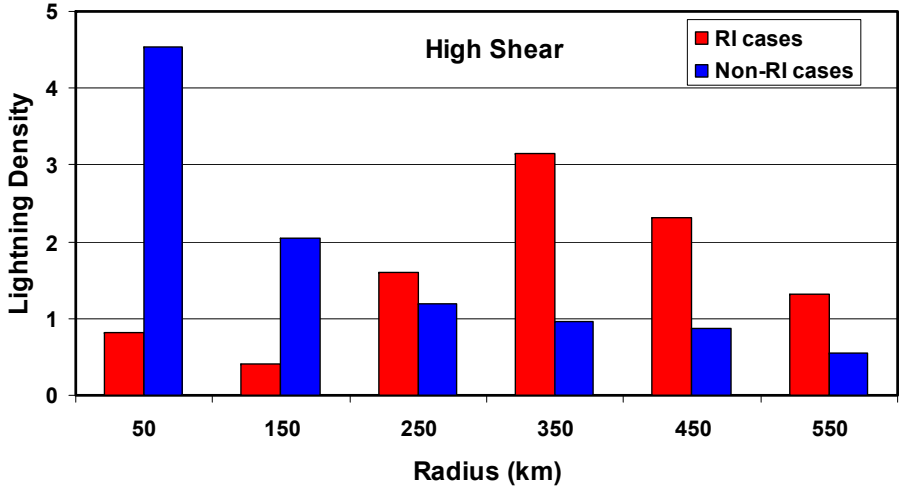
- The collection of MSG data in the tropical Atlantic for use as proxy ABI data continues using an automated procedure
- Algorithm to create simulated ABI channels (7-16) from MSG data
  - » Automated on the web
  - » Seven TC cases created (AWG)
- Note: the collection of soundings from the AMSU instrument has long been automated for global tropical cyclones
- The AIRS sounding database via the AIRS science team for historical storms has also completed
- COSMIC Soundings have been collected from NCAR
- The analysis of the World Wide Lightning Location Network (WWLLN) data (2003-2009)
  - » Calibrated using OTD/LIS annual climatology
  - » Crude correction for detection and conversion from CTG to total
  - » GL360 inter calibration for proving ground activities
- IASI sounding database developed
- 1 km IR archive (MODIS and AVHRR) of Global tropical cyclones.

Testing with Forecast Algorithms

- SHIPS (lightning studies)
  - » Developing lightning proxies using WWLNN data (successful 2005-2009)
- Genesis (impact of ABI imagery)
  - » Test ABI input (successful)
- RII (improvements with lightning)
  - » Diagnostics of where/how lightning may be related to the intensification process
    - – Low shear
    - – High shear

Evaluate GOES-R impact on forecast algorithms (SHIPS, Rapid Intensity Index)





Combination of shear and lightning appears different in the cases of RII

Lightning is transient near the eyewall

The signal seems to be in the rainband region

The rainband signal and vertical wind shear are being investigated in RII discriminant analysis technique and will be supplied during NHC proving ground in 2010

FY10 Milestones and Accomplishments

- **GOES-R3**
  - » Continue data collection and statistical analysis
  - » Expand real time demonstration web page
  - » Write paper on synergistic TC wind structure analysis
  - » Write paper on ABI lightning application to genesis/intensity forecasting
  - » Possible participation in GOES-R Proving Ground at National Hurricane Center in 2010
    - – Demonstration of GLM and proxy ABI products
- **AWG**
  - » Create synthetic ABI imagery and corresponding MSG SEVIRI IR window channel imagery for the seven tropical cyclones from 2006-2008
  - » Documentation for proxy datasets
  - » Inputs to ATBD and Algorithm Implementation and Test Plan documents
  - » Monthly reports

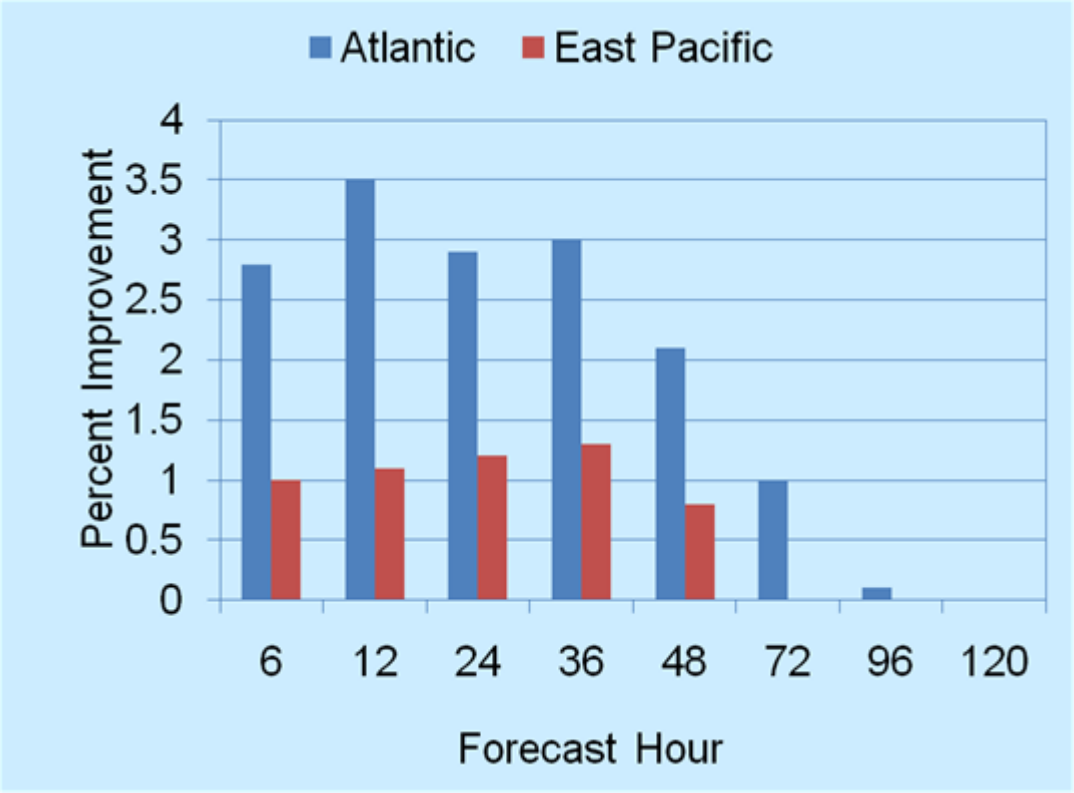
Statistical Analysis with SHIPS

Lightning Predictor

Combination of

1. Lightning density
2. Initial intensity
3. Vertical wind shear

Can significantly improve SHIPS forecasts



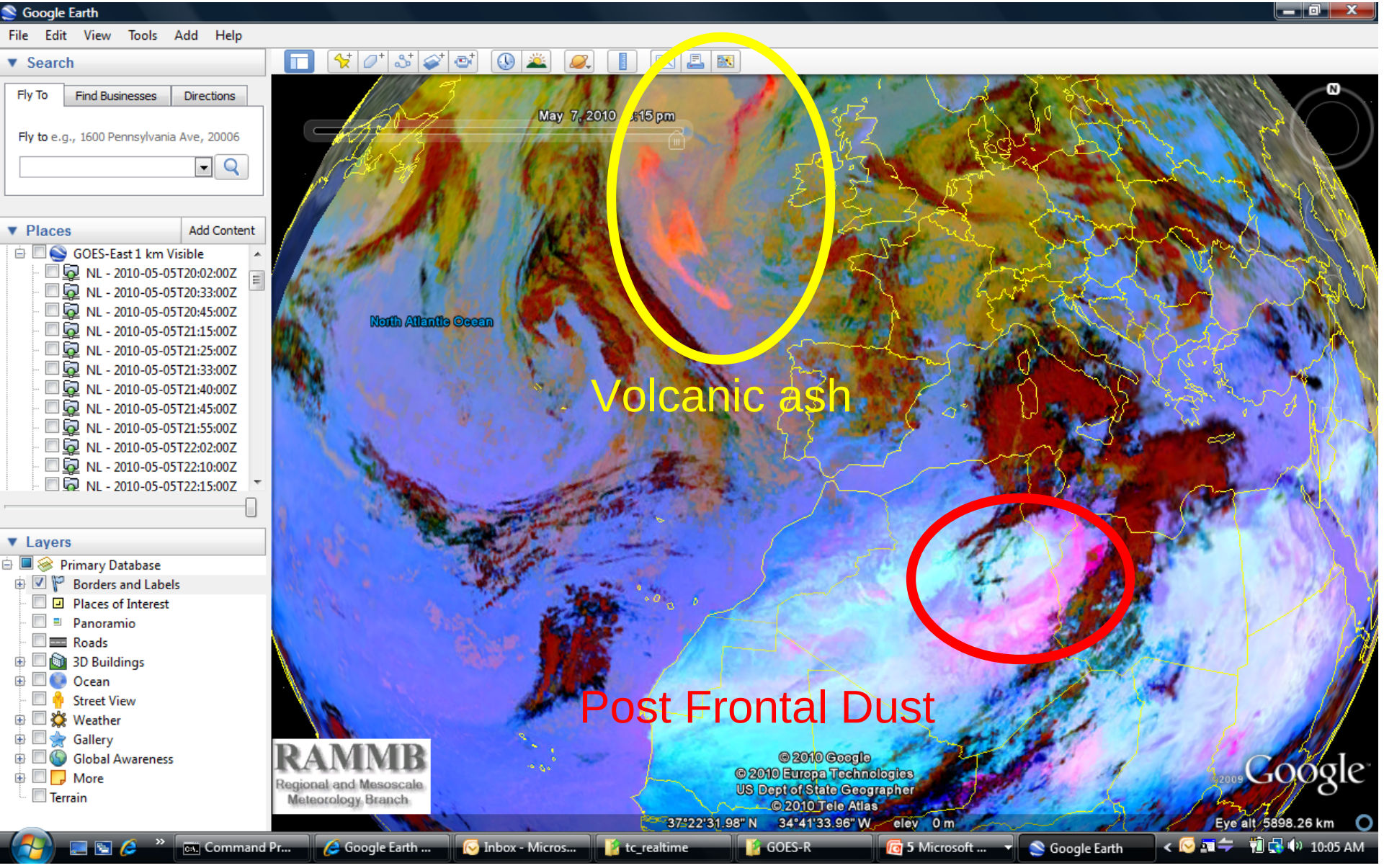
Proving Ground Participation

- Two MSG-based RGB products – Display in Google Earth
  - » Dust Product
    - Ch 7 (8.7 µm), 8 (9.66 µm), 9 (10.8 µm), 10 (12.0 µm)
    - **R = Difference IR10.8 – IR12.0 (-2 to 4 K)**
    - **G = Difference IR10.8- IR8.7 (0 to +15 K, γ=2.5)**
    - **B = Channel IR10.8 (261 to 289 K)**
  - » Air Mass Product
    - Ch 5 (6.25 µm), 6 (7.35 µm), 8 (9.66 µm), 9 (10.8 µm)
    - **R = Difference WV6.25 - WV7.35 (-25 to 0 K)**
    - **G = Difference IR9.66 - IR10.8 (-40 to +5 K)**
    - **B = Channel WV6.25 (243 to 208 K)**
- RII with lightning component has been combined into a discriminant analysis-based experimental index.
  - » Rainband (300-400 km) lightning is related to RI.
  - » Also to use TPW data (supported by JHT)

Google Earth and the Web

- Free software that provides a way to explore the world without leaving your computer
  - » Detailed satellite imagery, street maps, etc.
  - » NWS approved technology
  - » Links with most web browsers (Firefox, IE, Chrome, etc.)
- Users can add their own images to Google Earth
- Ability to accurately geolocate where objects are placed, including satellite imagery
- Using KML files users can share data
- Large image files
  - » Have been tiled to increase loading speed
- Google Earth supports 24+ bit imagery and transparency factors and may provide a dissemination method for GOES-R products if similar capabilities in AWIPS II are unavailable.

Dust product for the Proving Ground @ NHC



Air mass product will also be displayed like this

Publications and Reports (FY08 –FY10)

DeMaria, M., 2008: A simplified dynamical system for tropical cyclone prediction. *28th AMS Conference on Hurricanes and Tropical Meteorology,* 28 April-2 May, Orlando, FL.

Knaff, J.A., 2008: Rapid tropical cyclone transitions to major hurricane intensity: Structural evolution of infrared imagery. *28th AMS Conference on Hurricanes and Tropical Meteorology,* 28 April-2 May, Orlando, FL.

DeMaria, M., 2009: Tropical cyclone applications of NPOESS and GOES-R. *5th AMS Annual Symposium on Future Operational Environmental Satellite Systems - NPOESS and GOES-R*, 11-15 January, Phoenix, AZ.

DeMaria, M., and **R. DeMaria**, 2009: Applications of lightning observations to tropical cyclone intensity forecasting. *16th AMS Conference on Satellite Meteorology and Oceanography*, 11-15 January, Phoenix, AZ.

Knaff, J.A., D.W. Hillger, M. DeMaria, J. Gurka, 2009: Developing GOES-R Tropical Cyclone Products via Proxies. *63rd Interdepartmental Hurricane Conference*, 2-5 March, St. Petersburg, FL.

Knaff, J., M. DeMaria, J. Kaplan, J. Dunion, **R. DeMaria**, 2010: Assessing the impact of total Precipitable water and lightning on SHIPS forecasts. *29th Conference on Hurricanes and Tropical Meteorology*, 8-12 May 2010, Tucson, AZ.

Knaff, J.A., and **M. DeMaria**, 2010: An automated objective satellite-derived surface wind analysis for monitoring tropical cyclones. (in preparation).

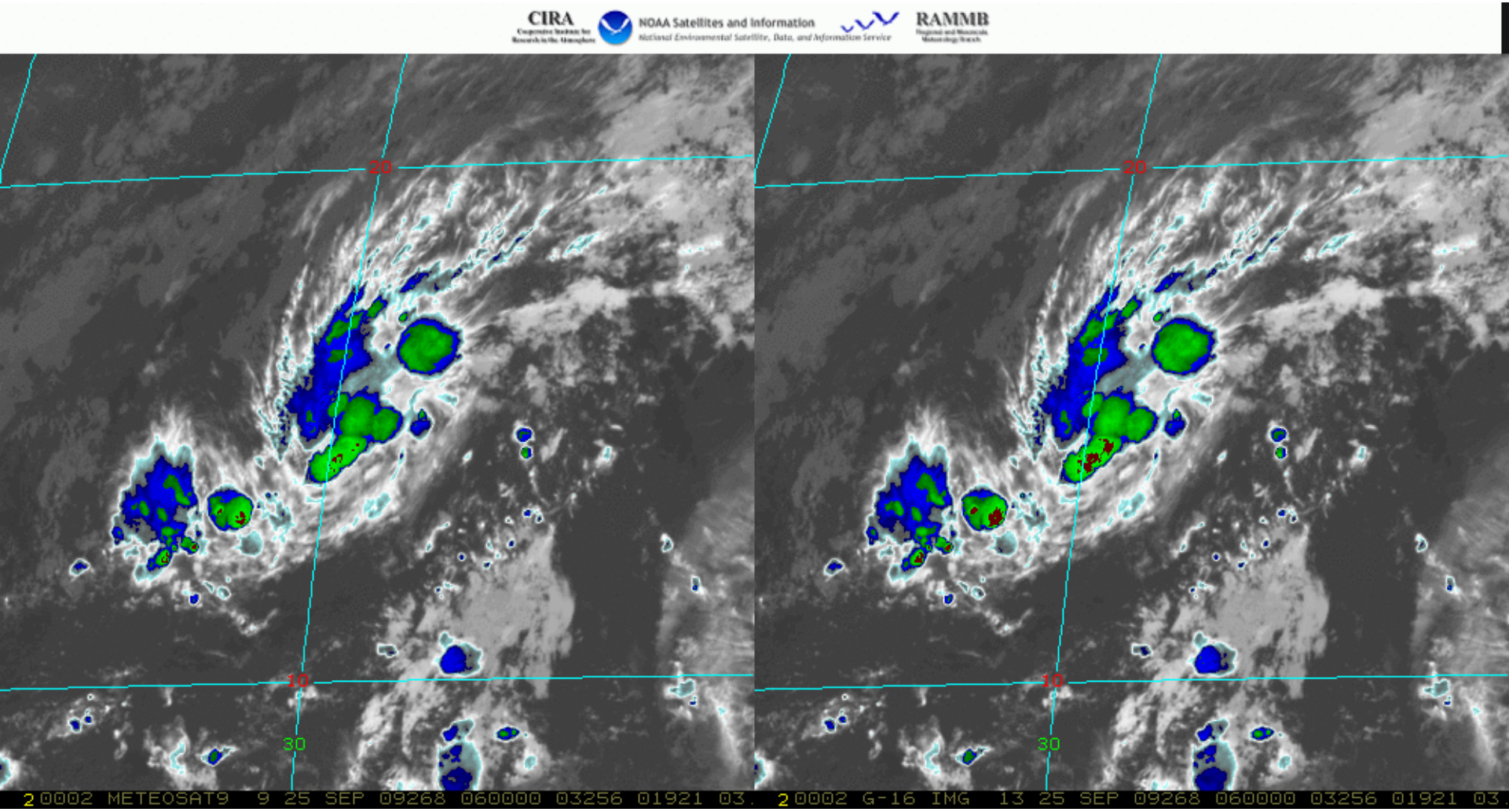
Gurka J., **M. DeMaria**, S. Goodman, and T. Schmit 2010: Preparing for Improved Monitoring of Tropical Cyclones in the GOES-R Proving Ground. *Interdepartmental Hurricane Conference*, 1 -4 March 2010, Savannah, Ga.

Schumacher A.S, M. DeMaria, J. Knaff, and D. Brown, 2010: The NESDIS Tropical Cyclone Formation Probability Product: An Overview of Past Performance and Future Plans. *Interdepartmental Hurricane Conference*, 1 -4 March 2010, Savannah, Ga.

AWG portion of the project

1. Development of Proxy Datasets for four 2006-2008 Tropical Cyclone Cases
2. Development of Proxy Datasets for four 2009 Tropical Cyclone Cases
   - » Synthetic ABI 10.35 µm imagery and corresponding MSG SEVIRI IR window channel imagery for eleven 2006-2009 tropical cyclones
   - » Documentation for proxy datasets
   - » Monthly reports on progress, which is ongoing for the second project

TD08 Example



SEVIRI Ch 9

Simulated ABI Ch 13

Unexpected Results

- Inner core lightning activity generally being a negative for TC intensification in the large (all cases) SHIPS database.
- Interaction with AWIPS II … 24+-bit image capabilities.

Additional Activities Leveraged

- GOES-R Proving Ground demonstrations
  - » Real-time product generation
  - » Google Earth display capability
- Joint Hurricane Testbed
  - » Continued improvements of the Rapid Intensity Index
    - – Real-time TPW
    - – Improved use of GOES information
    - – Ocean mixing thermodynamic parameterizations
- GOES-R (new start FY10 with CIMSS)
  - » Rapid Intensity Index
    - – Lightning
    - – Microwave imagery
- GIMPAP
  - » Rapid weakening
  - » Extra-tropical Transitions

Recommendations for follow on research

- Continued lightning studies with tropical cyclone intensification and genesis
  - » Rapid Weakening
  - » Extra tropical transition
  - » Initial formation
- Improving satellite estimates of tropical cyclone structure
  - » Multi-Channel estimates of wind structure
    - – Emphasis on the radius of maximum winds
- Environmental TPW affects on storm structure (formation and evolution)
- Cloud top microphysics and storm tendencies