# GOES-R Geostationary Lightning Mapper (GLM)

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**GOES-R OCONUS Proving Ground Meeting**

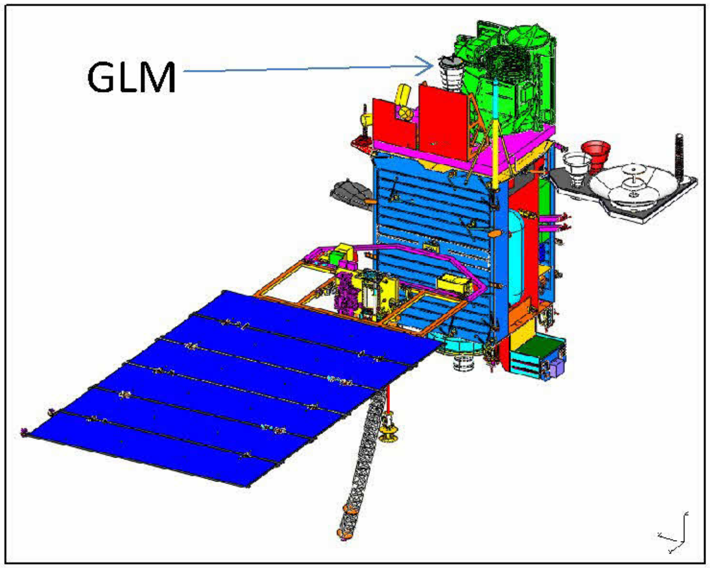
Honolulu, Hawaii

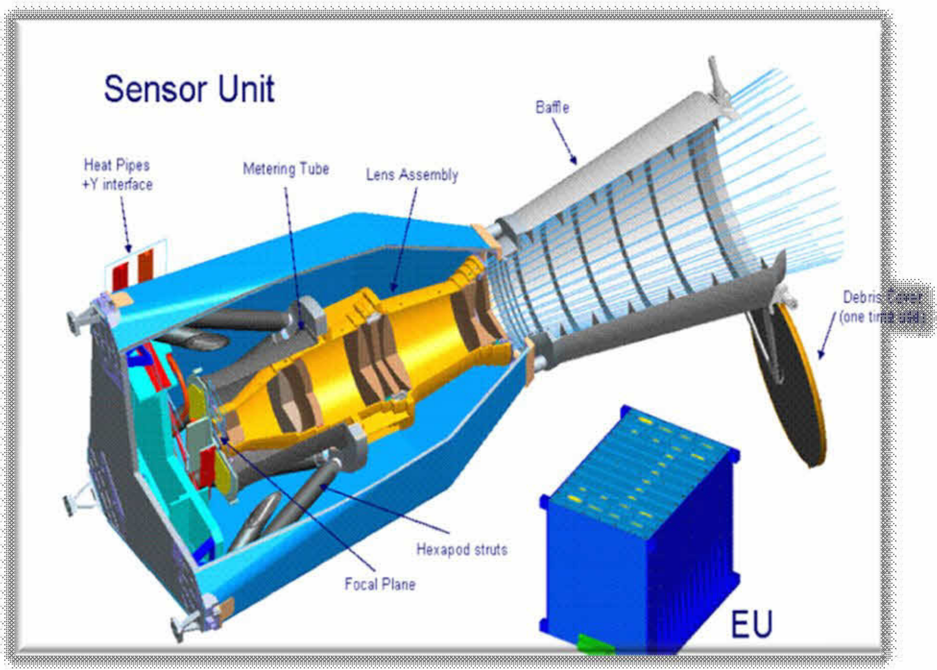
July 28, 2010

# Natural Hazards and Lightning

- Tornadoes
- Hailstorms
- Wind
- Thunderstorms
- Floods
- Hurricanes
- Volcanoes
- Forest Fires
- Air Quality/NOx

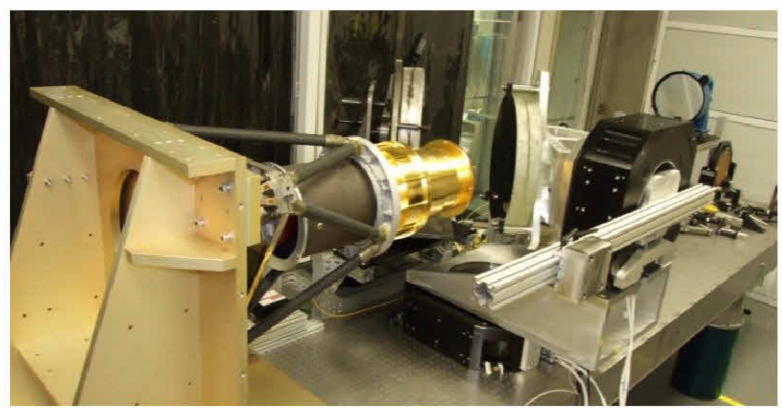
# GOES-R Geostationary Lightning Mapper (GLM)



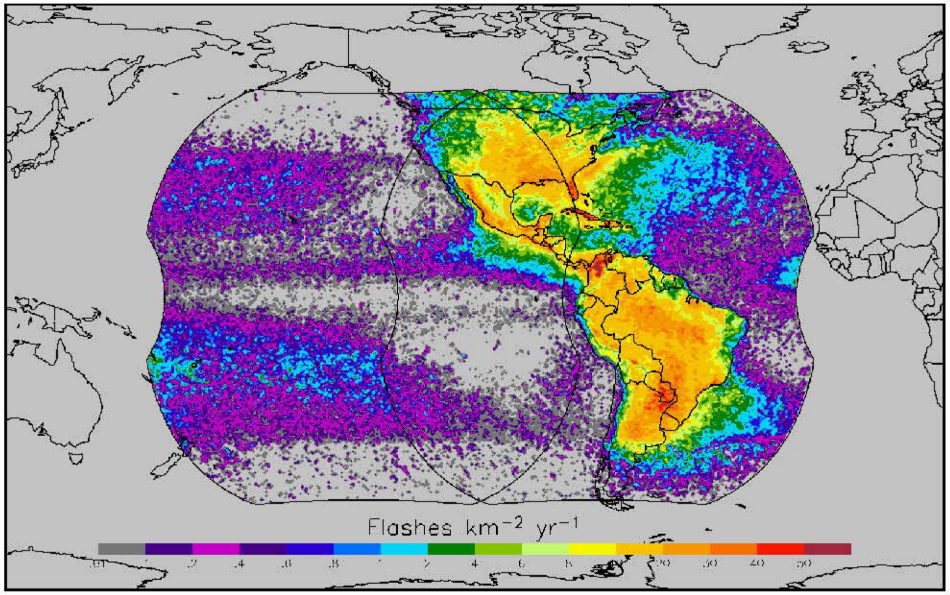

## GLM Characteristics

- Staring CCD imager (1372x1300 pixels)
  - Single band 777.4 nm
  - 2 ms frame rate
  - 7.7 Mbps downlink data rate
  - Mass: 114 kg- SU (66 kg), EU (48 kg)
  - Avg. Operational Power: 290 W
  - Volume w/ baffle ($cm^3$): 81x66x150
- Near uniform spatial resolution/ coverage of total lightning (IC, CG) up to 52 deg lat
  - 8 km nadir to 14 km at edge
  - 70-90% flash detection
- L1 and L2+ products produced at Wallops for GOES-R Re-Broadcast (GRB)
- < 20 sec product total latency

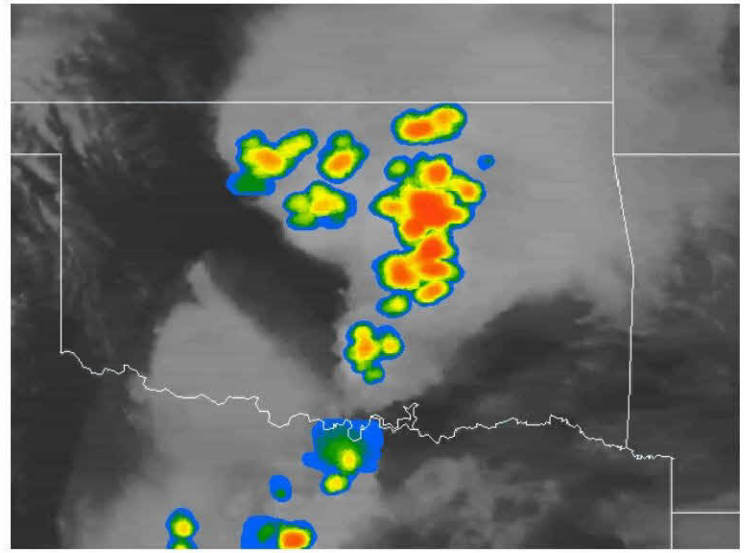


# GOES-R Geostationary Lightning Mapper (GLM)

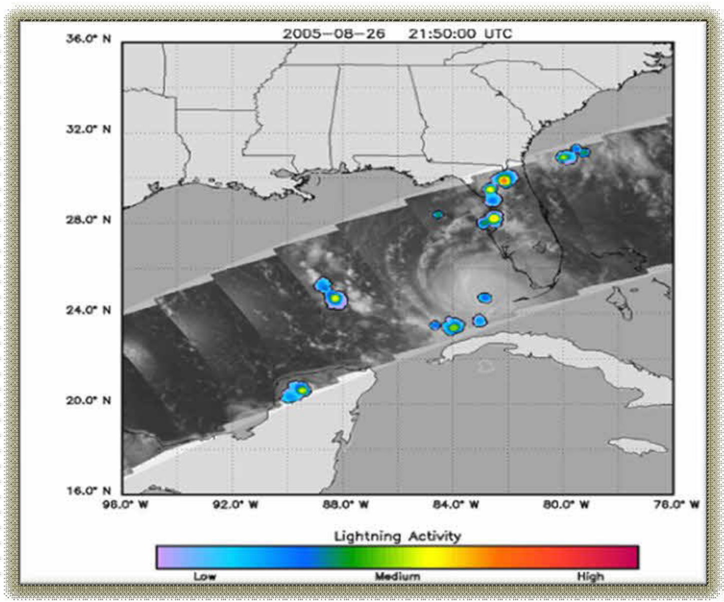
**GLM Combined E-W Coverage**

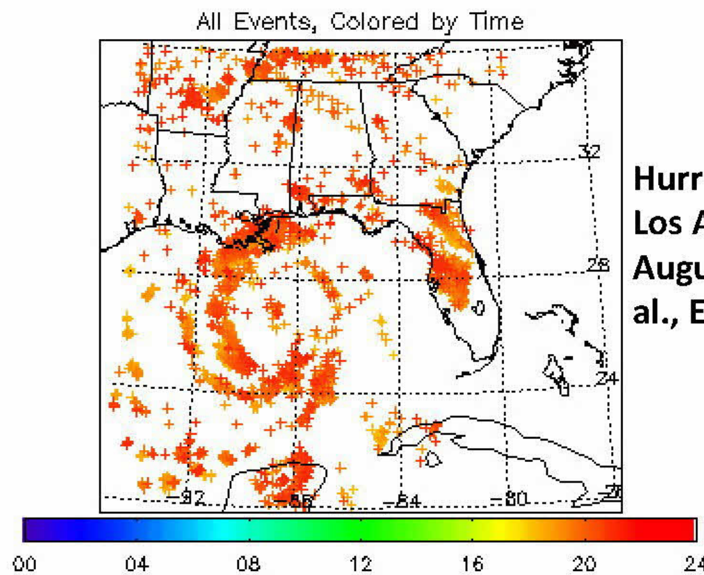



**May 3 1999 Oklahoma Tornado Outbreak**



**1-minute of observations from TRMM/LIS**




**Hurricane Katrina**
**Los Alamos Sferics Array, August 28, 2005, Shao et al., EOS Trans., 86**

# Physical Basis:

## Lightning Connection to Thunderstorm Updraft, Storm Growth and Decay

- Total Lightning —responds to updraft velocity and concentration, phase, type of hydrometeors, integrated flux of particles
- WX Radar — responds to concentration, size, phase, and type of hydrometeors- integrated over small volumes
- Microwave Radiometer — responds to concentration, size, phase, and type of hydrometeors — integrated over depth of storm (85 GHz ice scattering)
- VIS / IR — cloud top height/temperature, texture, optical depth

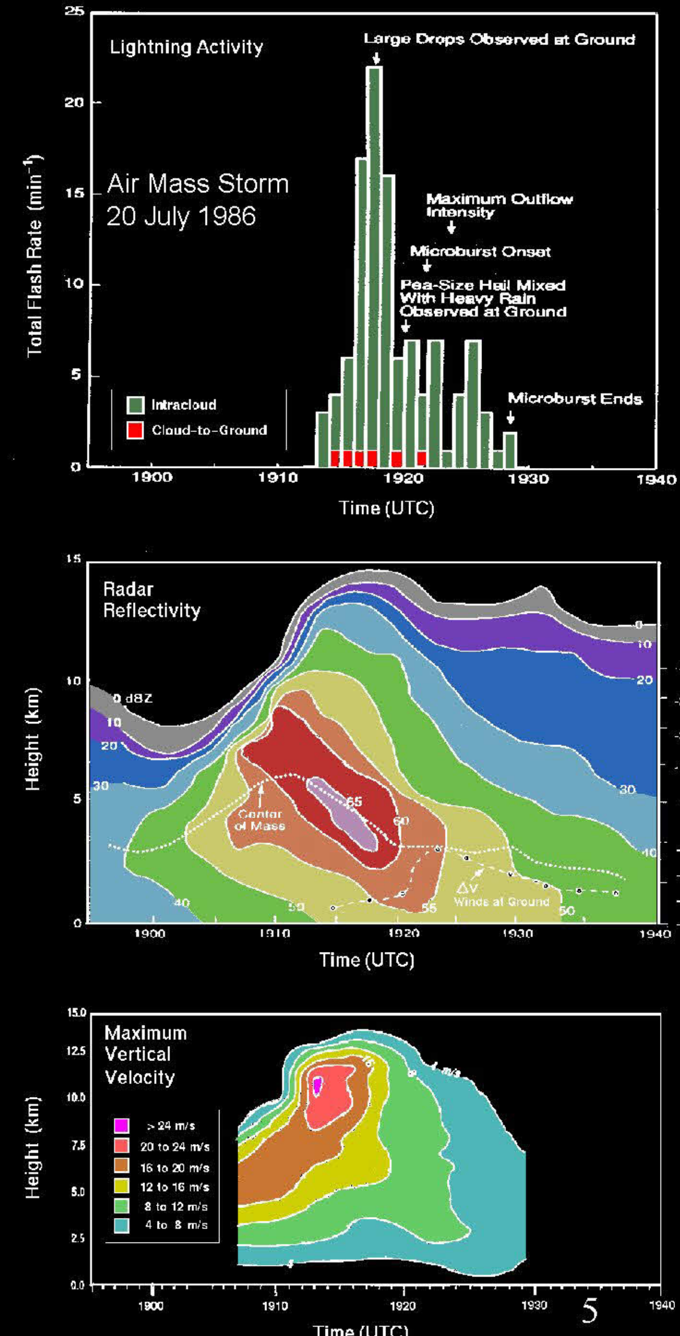


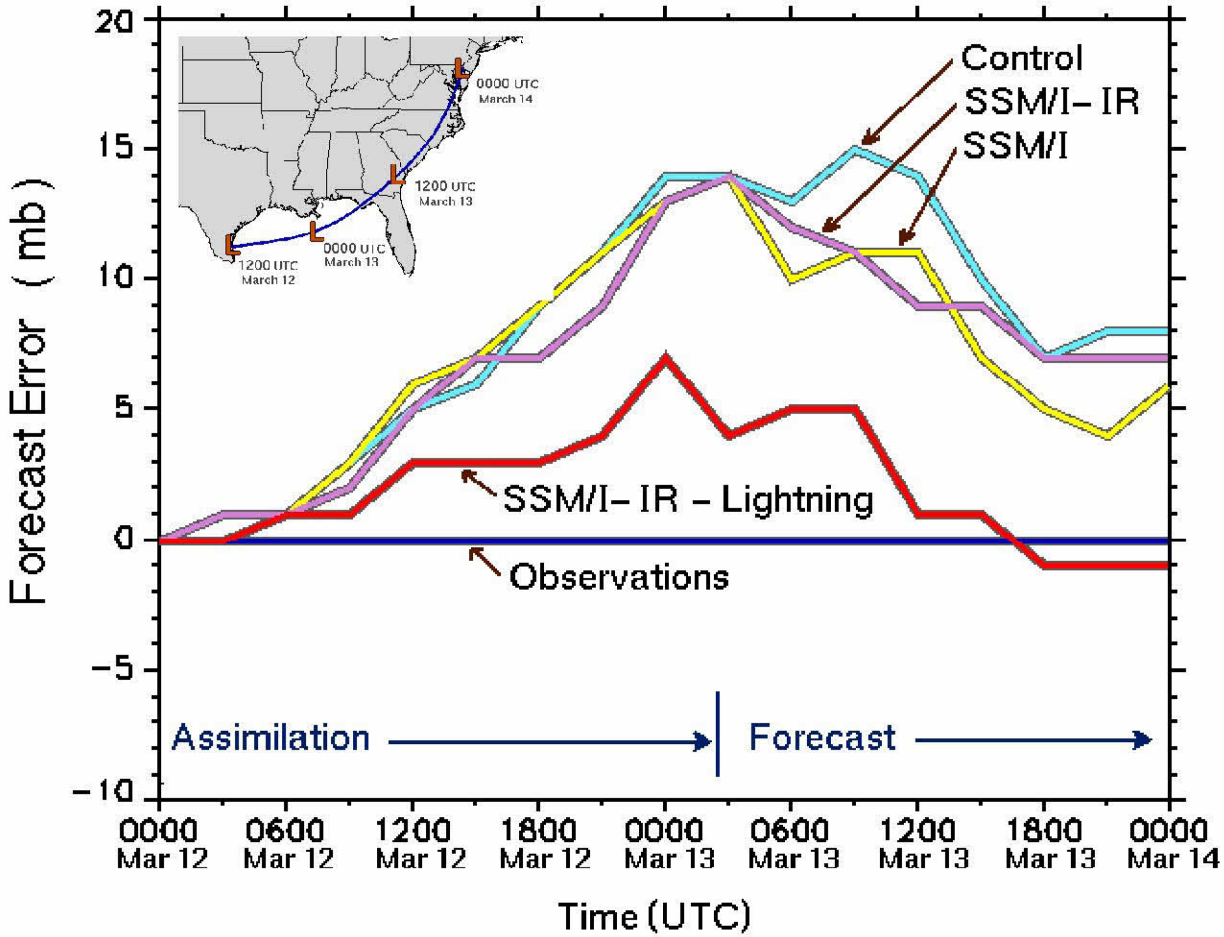

Figure from Gatlin and Goodman, JTECH, Jan. 2010- adapted from Goodman et al, 1988; Kingsmill and Wakimoto, 1991

# Lightning Data Assimilation into NWP Models

- Previous lightning data assimilation work:
  - Alexander et al., 1999; Chang et al. 2001 (latent heating)
  - Papadopoulos et al., 2005 (moisture profiles)
  - Mansell et al., 2006, 2007 (BL moisture and updraft speed; NLDN/LMA convective trigger switch for Kain-Fritsch)
  - Weygandt et al., 2006, 2008 (cloud and moisture fields-lightning-reflectivity relationship to create a latent heating-based temperature tendency field, applied to RUC /HRRR during a pre-forecast diabatic digital filter initialization)
  - Pessi and Businger, 2009 (Vaisala Pacnet long-range lightning data over the open ocean- tropical cyclones, oceanic storms)
- Workshop on Lightning Modeling and Data Assimilation (Mar. 15)
  - http://www.nssl.noaa.gov/research/forewarn/lt_workshop/

# Lightning Data Assimilation: Reduces Forecast Error

March 13, 1993 Superstorm (Alexander et al., 1999 MWR)






Lightning assimilated via latent heat transfer functional relationship

# WRF Lightning Threat Forecasts
# Background

- High-resolution explicit convection WRF forecasts can capture the character and general timing and placement of convective outbreaks well;

- Traditional parameters used to forecast thunder, such as CAPE fields, often overestimate LTG threat area; CAPE thus must be considered valid only as an integral of threat over some ill-defined time;

- No forward model for LTG available for DA now; thus search for model proxy fields for LTG is appropriate;

- Research results with global TRMM data agrees with models (e.g., Mansell) that LTG flash rates depend on updraft, precip. ice amounts.

# WRF Lightning Threat Forecasts
# Objectives

*(McCaul, E. W., Jr., S. J. Goodman, K. LaCasse and D. Cecil, 2009: Forecasting lightning threat using cloud-resolving model simulations. Wea. Forecasting, 24, 709-729).*

1. Create WRF forecasts of **Total Lightning** threat (1-24 h), based on two proxy fields from explicitly simulated convection:
   - graupel flux near -15 C (captures LTG time variability)
   - vertically integrated ice (captures anvil LTG area)

2. Calibrate each threat to yield accurate quantitative peak flash rate densities based on VHF Lightning Mapping Array (LMA) total LTG

3. Evaluate threats for areal coverage, time variability

4. Blend threats to optimize results for amplitude, area

5. Examine sensitivity to model mesh, microphysics

# WRF Lightning Threat Forecasts Methodology

1. Use high-resolution 2-km WRF simulations to prognose convection for a diverse series of selected case studies

2. Evaluate graupel fluxes in the mixed-phase charging zone at -15C level; vertically integrated ice (VII=cloud ice+snow+graupel); dBZ also considered, but set aside because of nonlinearities

3. Calibrate WRF LTG proxies using peak total LTG flash rate densities from North Alabama LMA (NALMA) vs. strongest simulated storms; relationships ~linear; regression line passes through origin

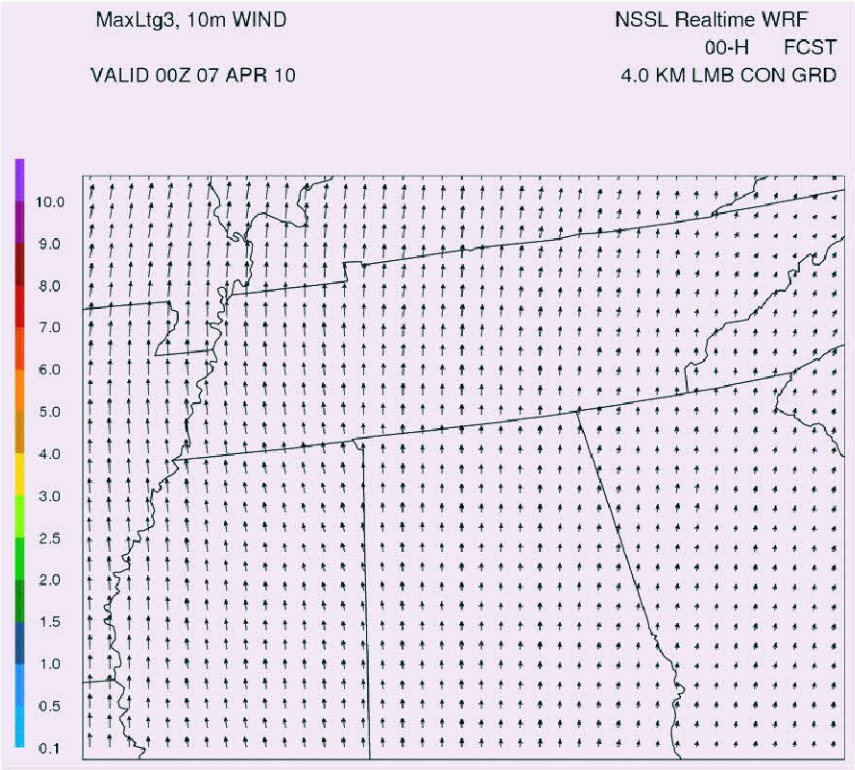
4. Truncate low threat values to make threat areal coverage match NALMA flash extent density obs

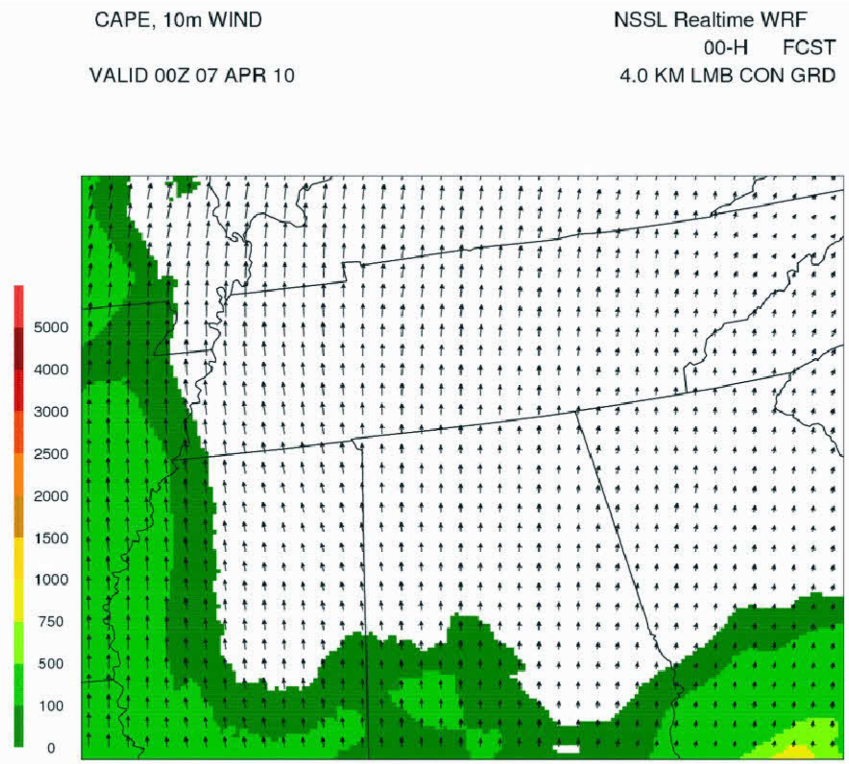
5. Blend proxies to achieve optimal performance

6. Experiments to study CAPS 4-km ensembles to evaluate sensitivities

# HWT Blog

http://goesrhwt.blogspot.com/



# HWT Blog

**EWP ready to go... 5/19/2010**

*Some notes from the briefing...*

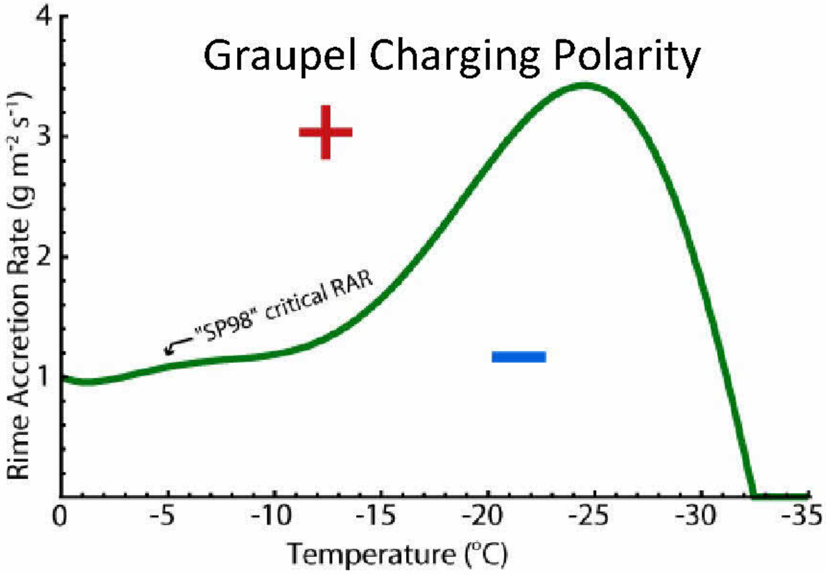
The NSSL-WRF lightning threat forecast was shown to the forecasters for this evening and it helped us identify which storms may have stronger updrafts because of their increased lightning output, which we couldn't necessarily determine from the synthetic satellite or radar output.

**Thursday, May 20, 2010**

- At 1:30 PM, the the North Alabama Lightning Mapping Array (NALMA) showed lightning activity along the northern Mississippi-Alabama border. The 00Z 20 May NSSL-WRF run in support of the NSSL/SPC EFP shows continued evolution of this convection toward central Alabama by 00-02Z this evening.
- The lightning threat field in the NSSL-WRF using the McCaul blended vertically integrated ice / graupel flux method shows lightning activity extending north-south through Alabama at 1Z. The predicted flash rates are somewhat less over the far northern part of the domain.

# RESEARCH NEEDED TO ASSIMILATE LIGHTNING FLASH RATES DIRECTLY IN ENSEMBLES

(MacGorman, Mansell, Ziegler et al., NSSL/CIMMS)




(SP98 = Saunders, C.P.R., & S.L. Peck, 1998: *J. Geophys. Res.*, **103**, 13949).

- Determine grid resolution (<4 km) at which storm updraft similitude adequate
- Improve model microphysics (particularly ice)
- Add simplified electrification parameterization to forecast model
- Develop simple flash parameterization, such as:
  - determine threshold of charge for first flash at grid point
  - estimate subsequent flash rates from charging rates
- Determine how to map GLM data to model grid in space and time
- Assimilate GLM flash rates
  - assimilate where there is existing model convection
  - determine how to initiate missing convection

# Summary

- GLM instrument development on schedule
  - EDU risk reduction completion summer 2010
  - FM 1 optical component long lead items in procurement
  - Full CDR November 2010
- Ver. 1 of ATBD, Val Plan, Proxy Data, L2 Prototype S/W
  - Product demonstrations at NOAA Testbeds
    - Hazardous Weather Testbed (2010 Spring Program with VORTEX-II IOP, Summer Program)
    - Joint Hurricane Testbed (NASA GRIP, NSF PREDICT)
    - Aviation Weather Testbed (NextGen)
    - Continue Regional WFO demonstrations (Norman, Huntsville, Sterling, Melbourne, …)
- New Risk Reduction/Advanced Product Initiatives
  - Data Assimilation: JCSDA FFO 2010 funding two new GLM investigations
  - High Impact Weather Working Group- GOES-R DA focus on short-range NWP
  - Combined sensors/platforms (e.g., ABI/GLM ; ABI/GLM/GPM)
  - NASA GPM - GLM proxy data 12-mo. campaign in Sao Paulo in partnership with InPE and CHUVA GPM pre-launch ground validation program
  - NSF Deep Convective Cloud and Chemistry (DC3) Experiment 2012