The Advanced Technology Microwave Sounder (ATMS): New Capabilities for Weather and Climate Study

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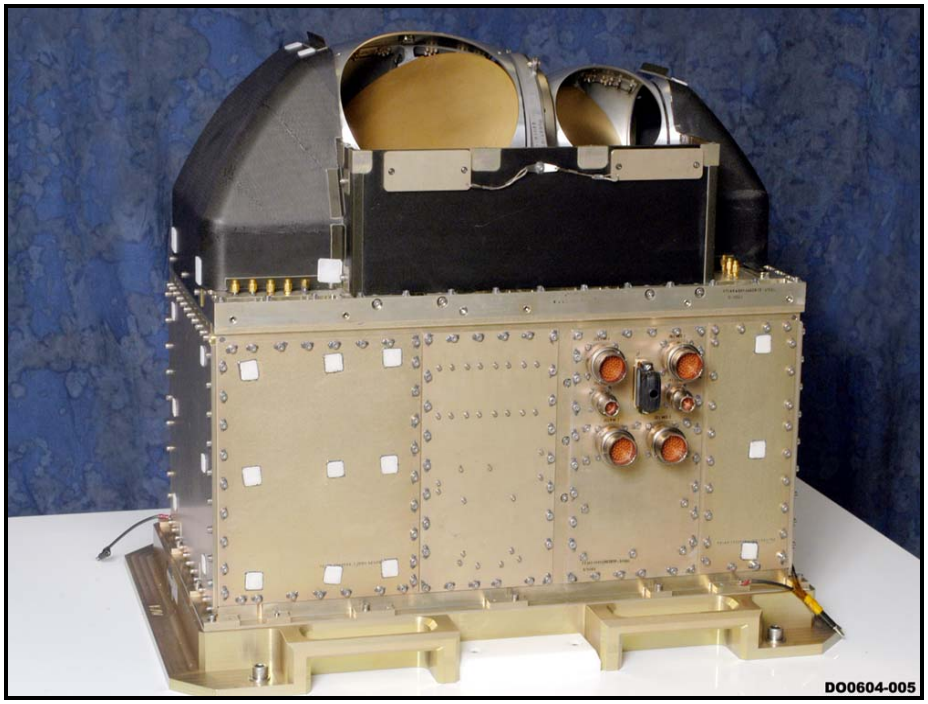
Outline

- Overview
- Performance Validation for Earth Science & Climate Study
- New Capabilities
  - Severe Weather and Disaster Management
    - Tropical cyclones
    - Floods and flash floods
    - Aviation decision support
  - All weather data assimilation
  - Climate signatures
- Summary

Advanced Technology Microwave Sounder (ATMS)

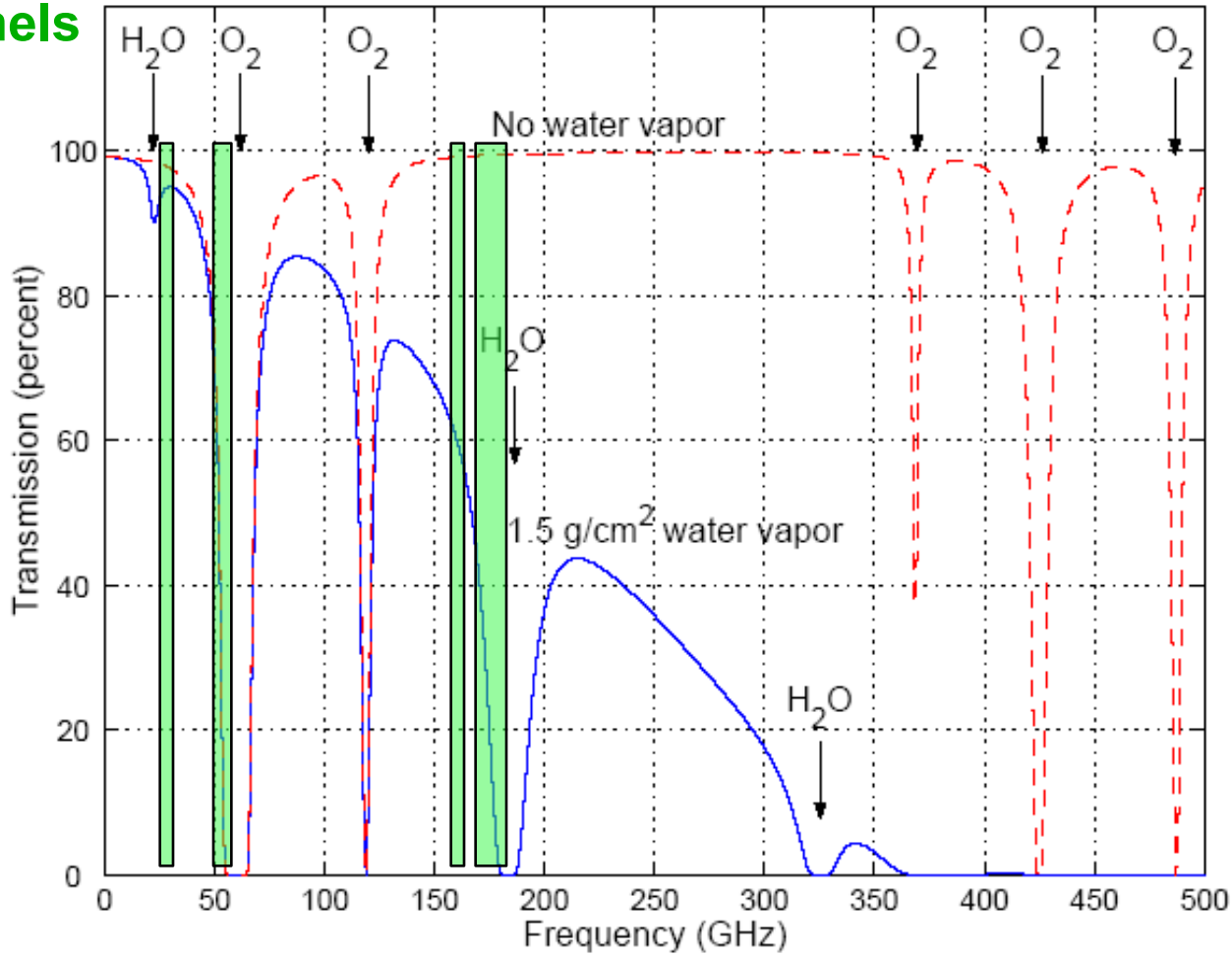
- ATMS is a 22 channel MW sounder
- Frequencies range from 23-183 GHz
- Total-power, two-point external calibration
- Continuous cross-track scanning, with torque & momentum compensation
- Orbits: 833 km (JPSS); 824 km (NPP); sun-synchronous
- Thermal control by spacecraft cold plate
- Contractor: Northrop Grumman Electronics Systems (NGES)



70 cm

Atmospheric Transmission at Microwave Wavelengths

ATMS channels



The frequency dependence of atmospheric absorption allows different altitudes to be sensed by spacing channels along absorption lines

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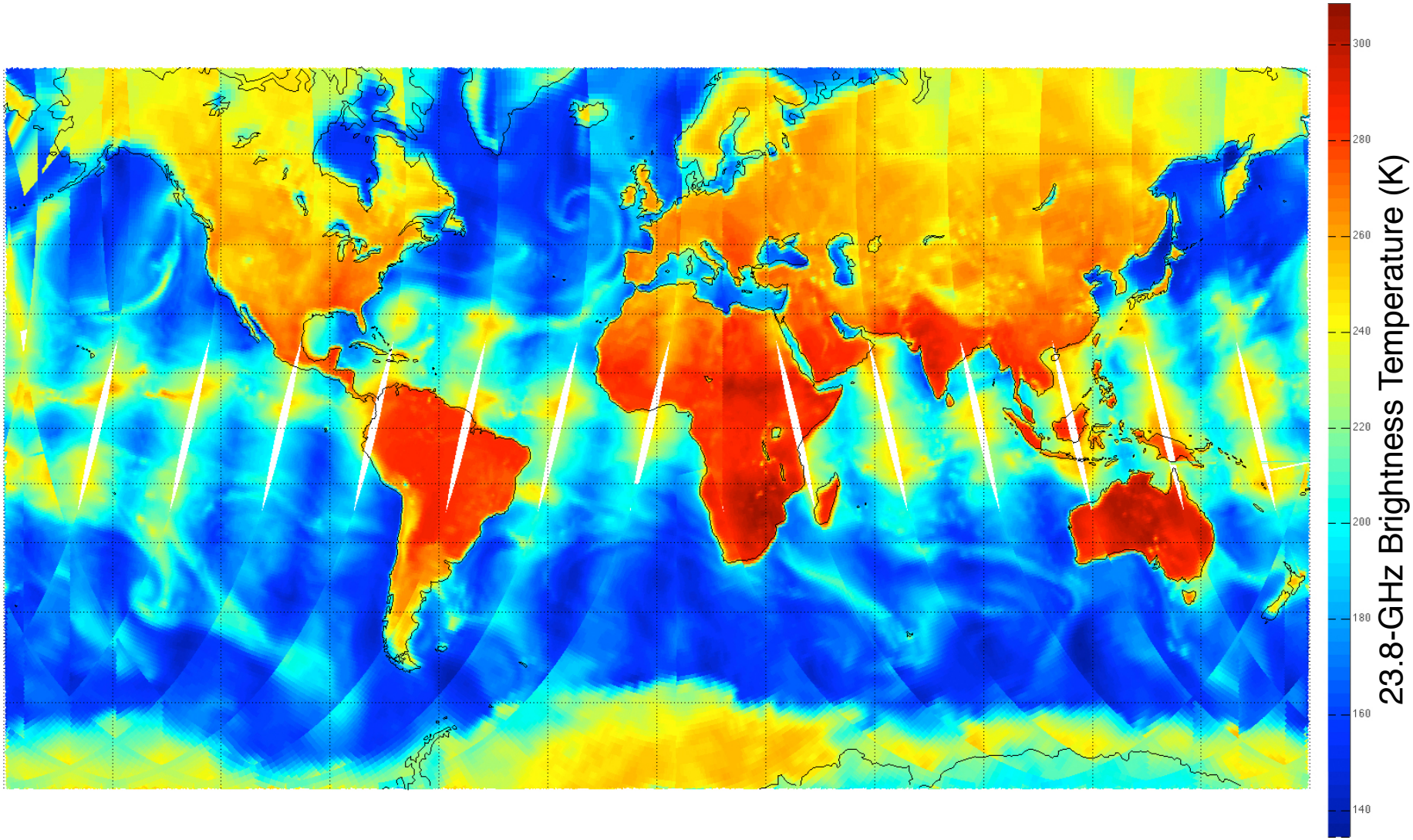
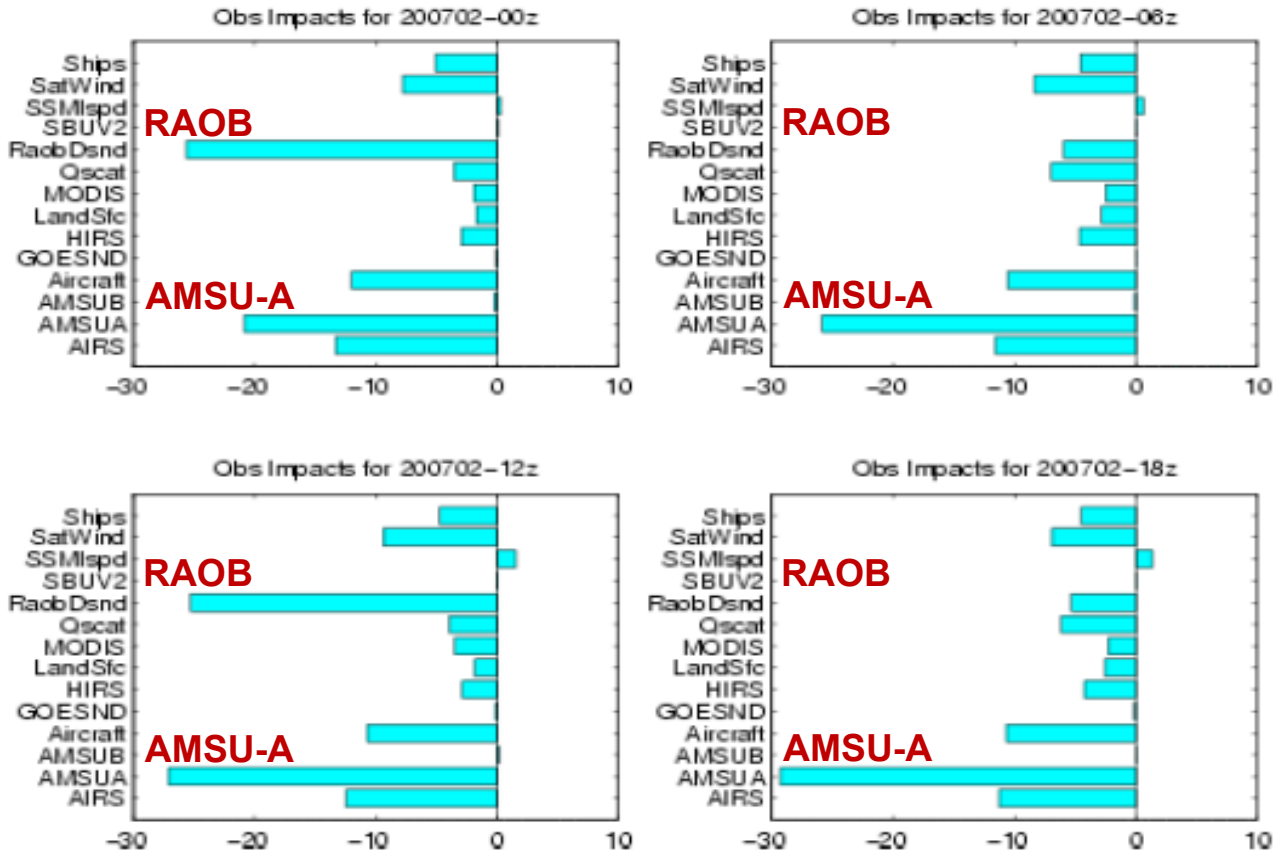
ATMS 23.8-GHz Channel



Passive Microwave Sounders Have Very High Forecast Impact

Observation impact: 3dVar DAS & Forecasts

Accumulated forecast error reduction due to various observing instruments for the 24-forecasts for February 2007 - 1/2degree system



Source: Gelaro, Rienecker et al., 2008, NASA GMAO

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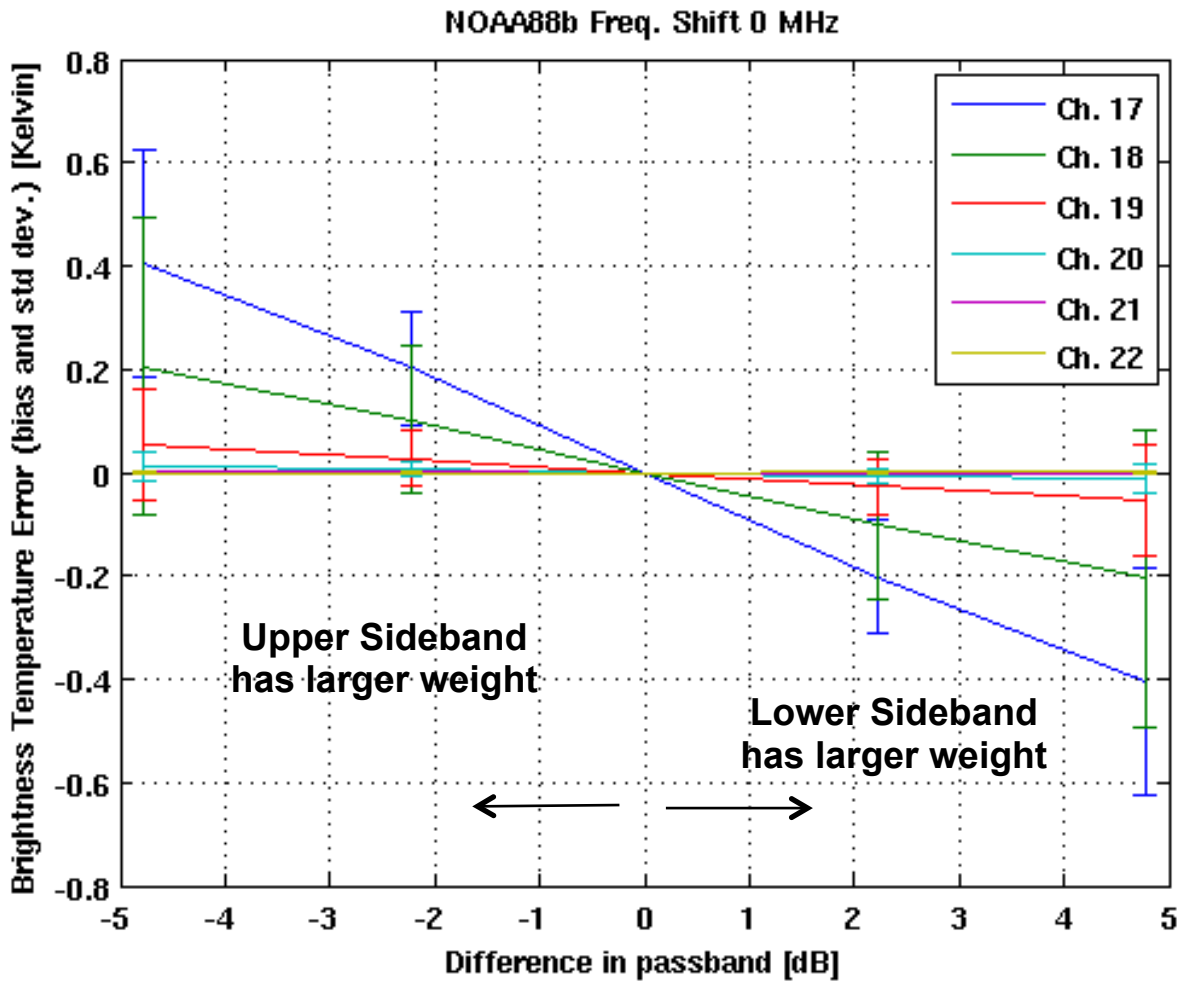
Beyond "Operational Assimilation" to "Climate Optimized" Observations

- Operational Validation Objectives
  - Characterization of sensor transfer functions to levels consistent with sensor error budget
    - Spatial response (antenna sidelobes)
    - Spectral response (filter bandpass)
    - Radiometric response (linearity)
  - SDR corrections implemented based on above

- Research/Climate Validation Objectives
  - Detection/mitigation subtle and perhaps localized anomalies that negligibly impact global assimilation
  - NASA JPSS Level 1B requirements call out 0.05K stability
  - Example issues currently under investigation:
    - Antenna reflector emissivity
    - Filter sideband imbalance
    - Internal calibration target heating through solar intrusion
    - Cold space calibration spillover

Simulation Example #1: Sideband Imbalance (water vapor channels)



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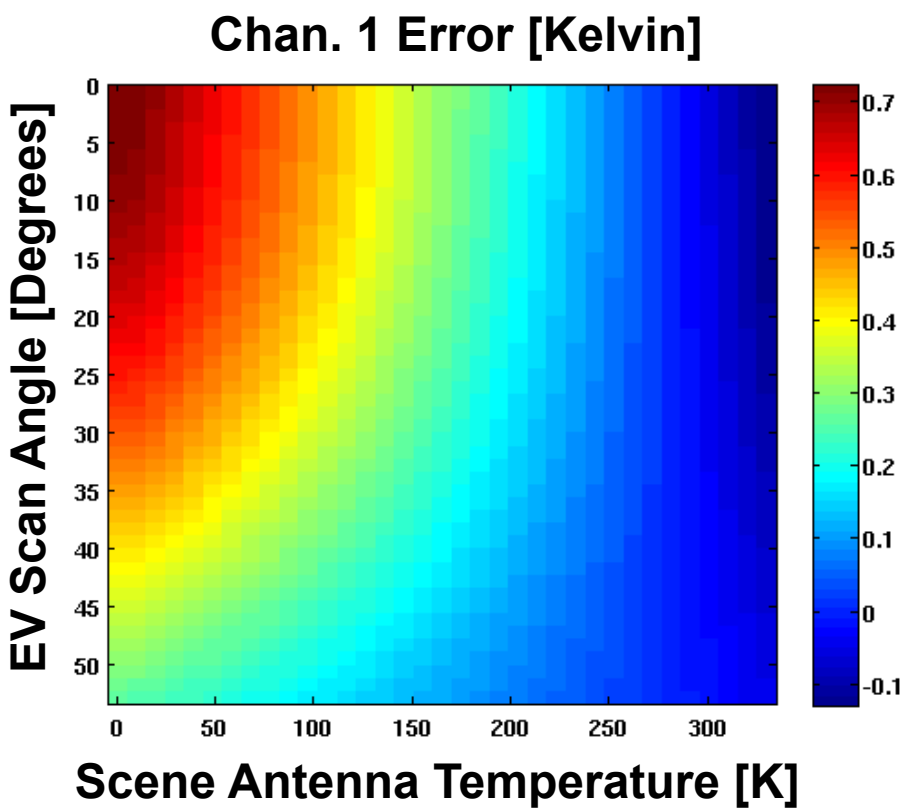
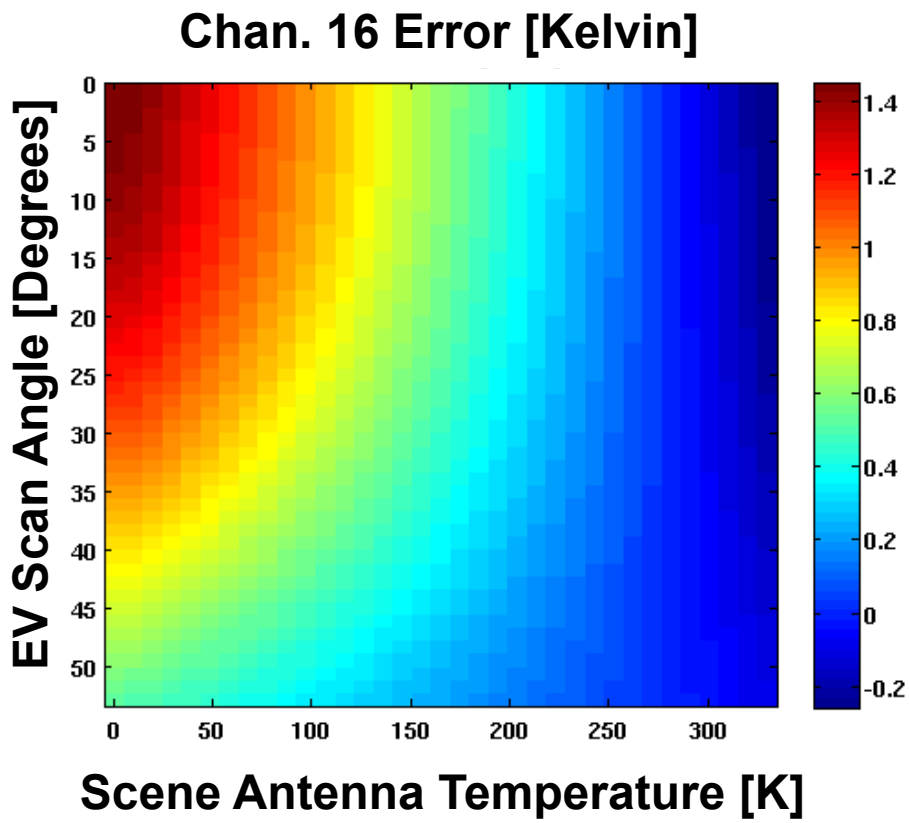
Simulation Example #2: Imperfect (Emissive) Antenna Reflector



ICVS TDR Histogram ranges from 140 to 240 K
(no strong peak)
Worst case: ~0.4 K at nadir



ICVS TDR Histogram ranges from 200 to 280 K
(no strong peak)
Worst case: ~0.4 K at nadir

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  - **Climate signatures**
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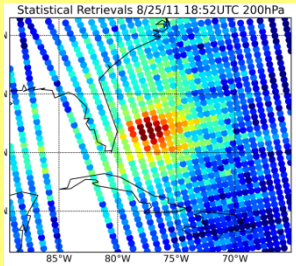
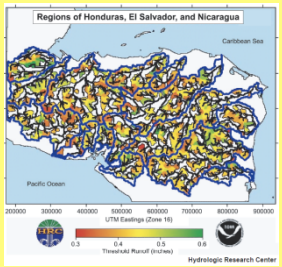
Some Science Focus Areas for Passive Microwave Sounder Observations

Severe Weather 1: Hurricanes and Tropical Cyclones

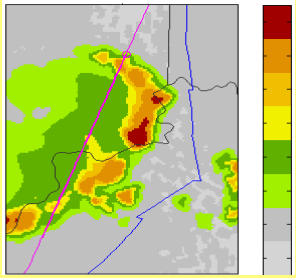


Severe Weather 2: Floods and Flash Floods

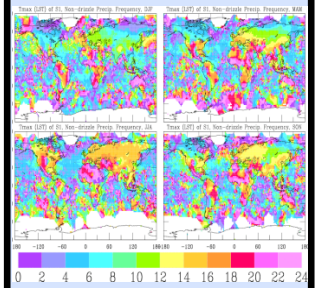


Severe Weather 3: Remote and Data Sparse Regions

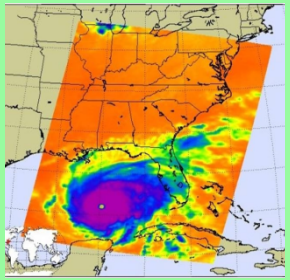
Severe Weather 4: Aviation Decision Support



Climate Fingerprinting



Data Assimilation



Level 1 and 2A/2B Products (and Derived Products)

Product Validation

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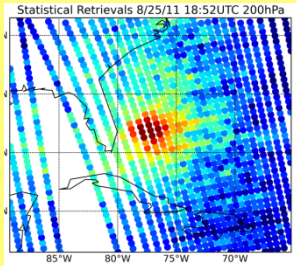

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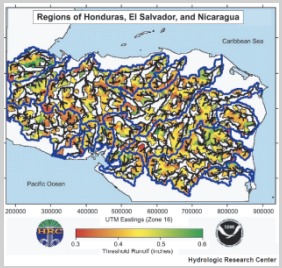
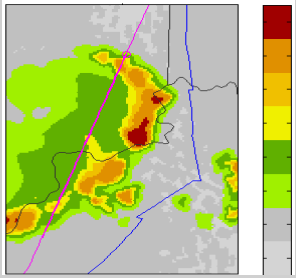


Severe Weather 3: Remote and Data Sparse Regions

Severe Weather 4: Aviation Decision Support



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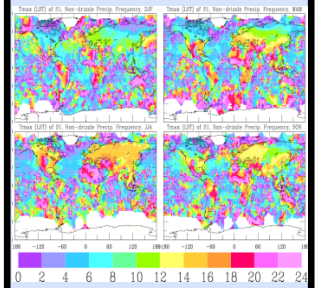

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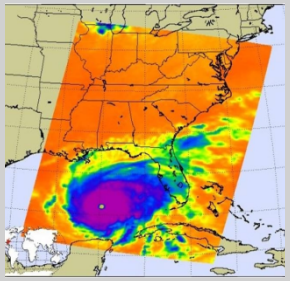
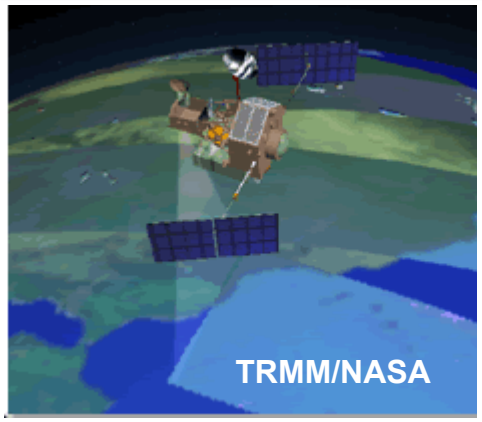


Level 1 and 2A/2B Products (and Derived Products)

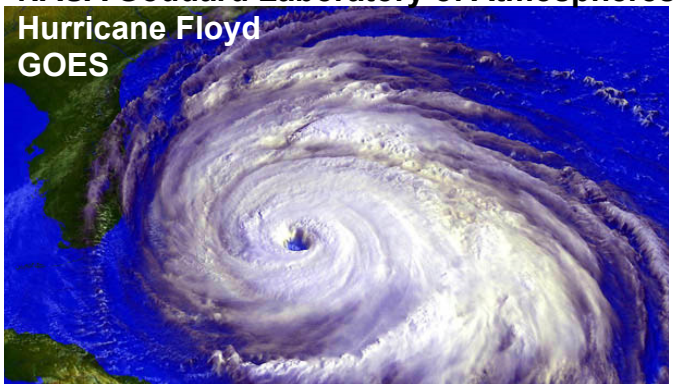
Product Validation

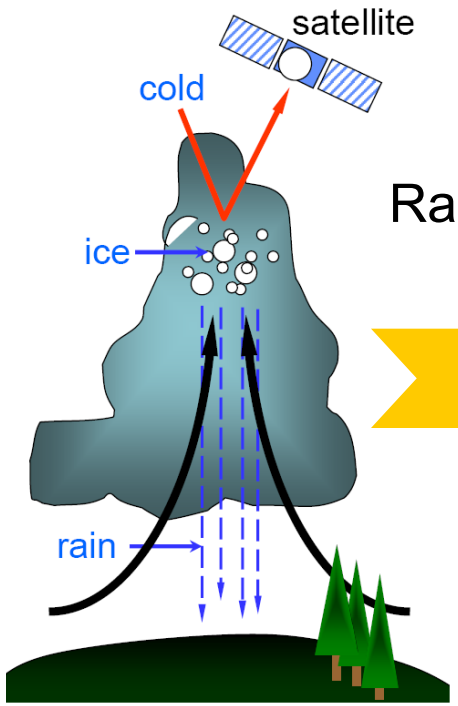
Passive Microwave Radiation & Precipitation



Satellite microwave sensors can penetrate storm clouds and reveal precipitation with global coverage

NASA Goddard Laboratory of Atmospheres



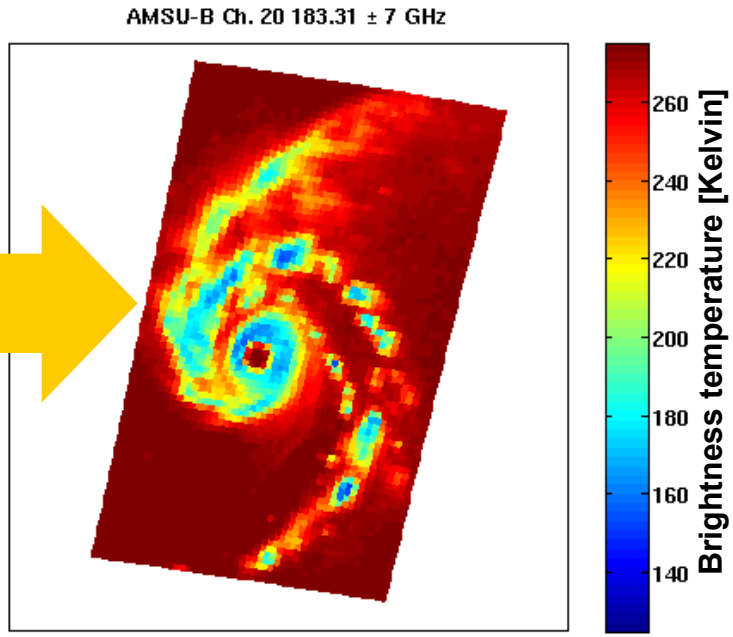


Radiance

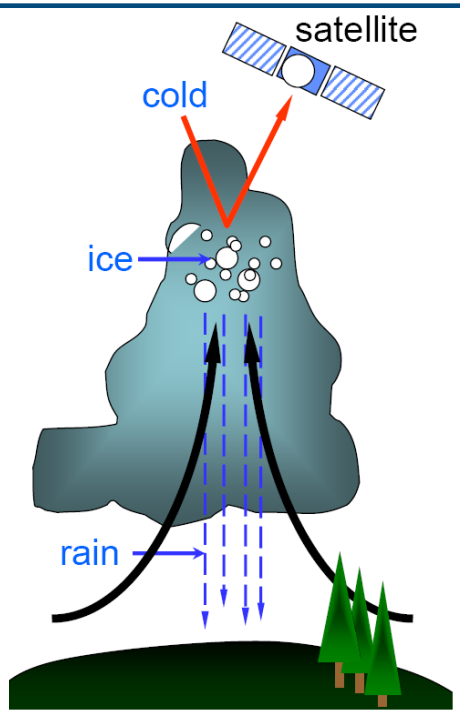
Precipitation Parameters

$$R = F(P)$$

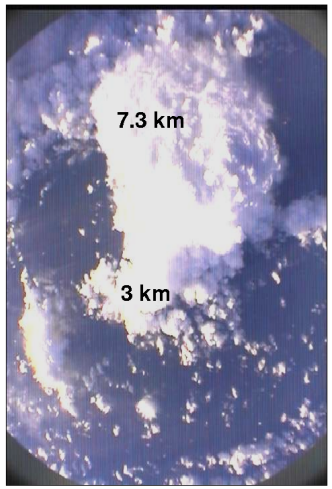
"forward model"
or radiance simulation

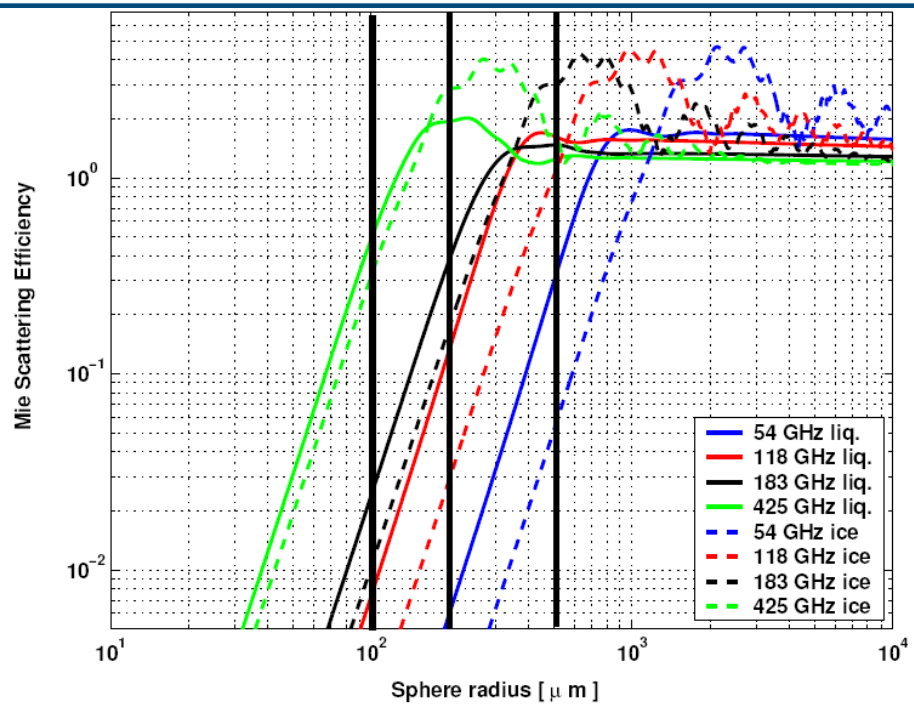


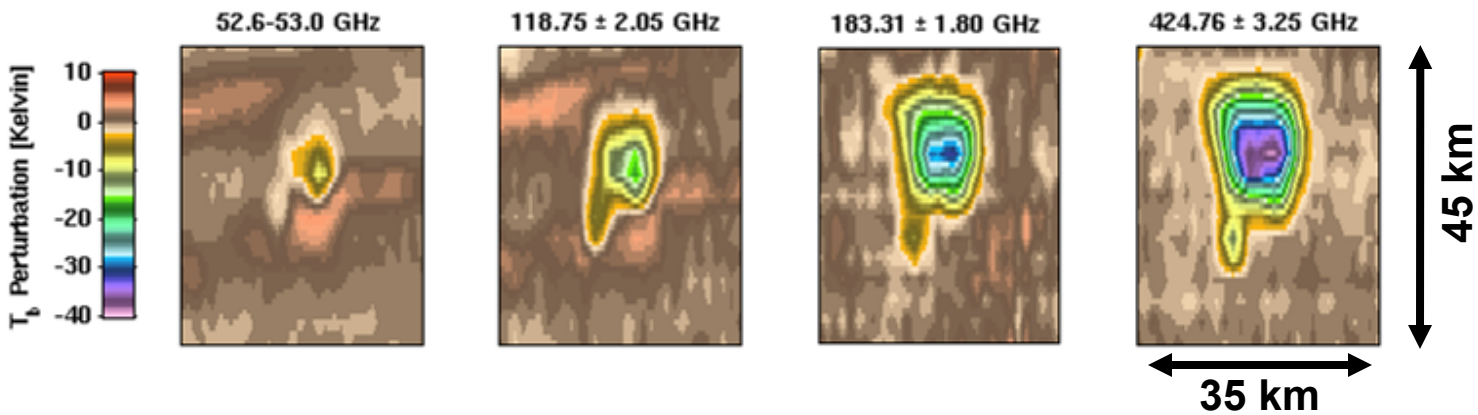
Frequency Dependence of Precipitation



Visible







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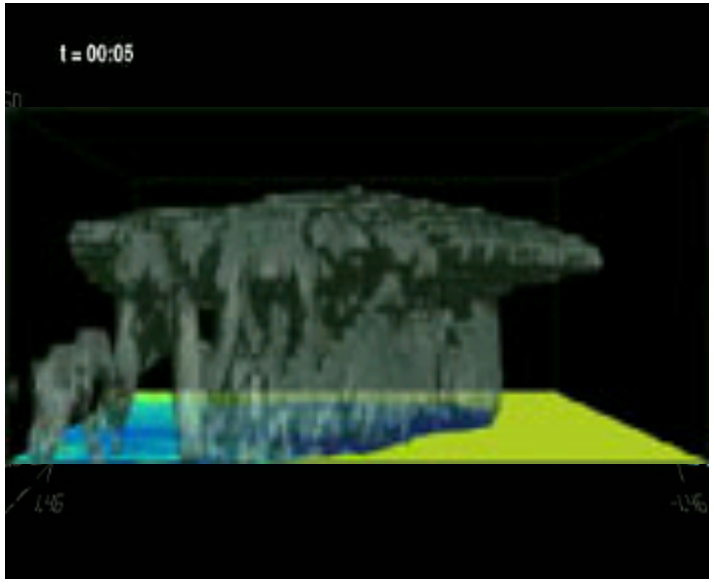
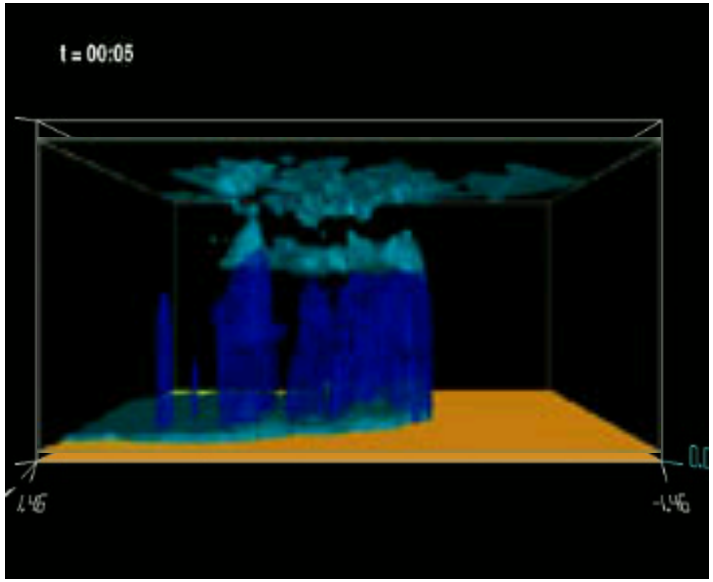
Precipitation Modeling

- **Cloud Resolving Models (CRMs) explicitly represent the time-varying thermodynamic properties of storms at high spatial and temporal resolution**
- **The WRF mesoscale model was used with initial conditions at a grid spacing of 20 to 40 km**

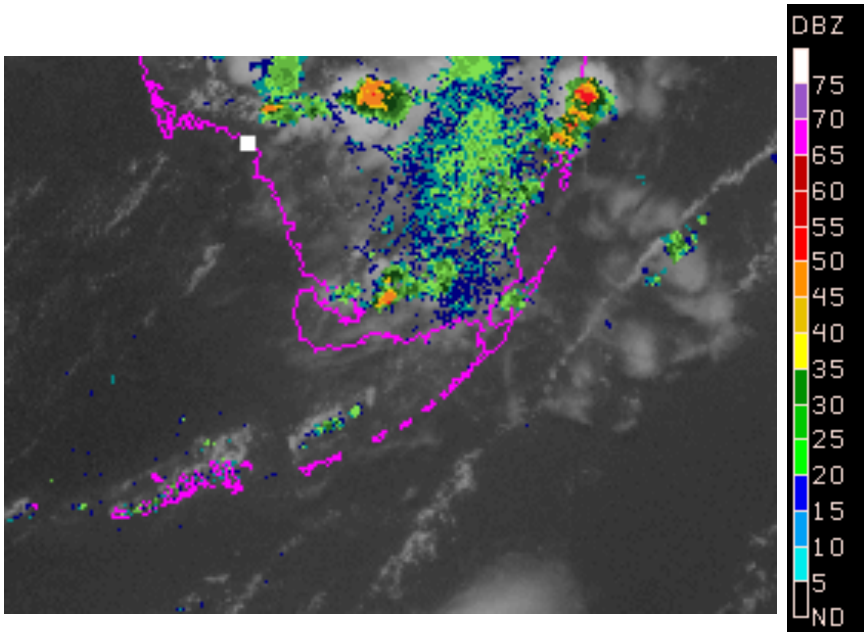




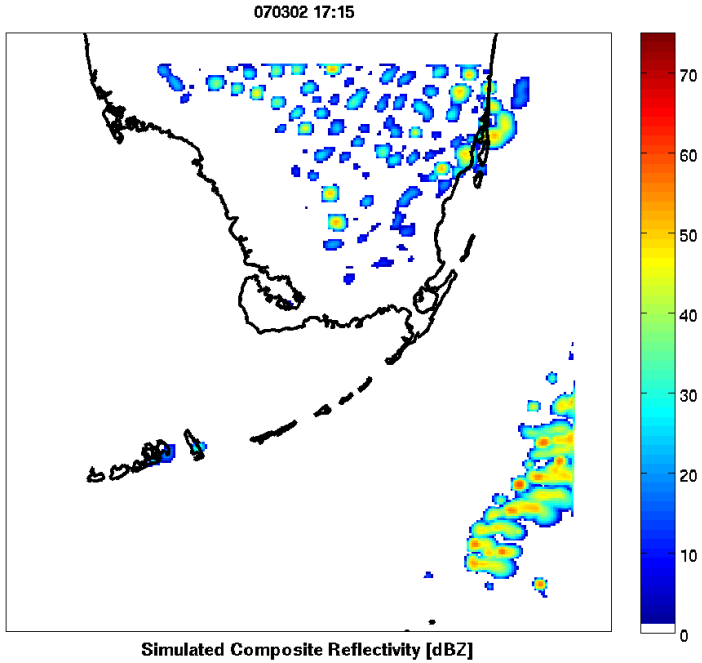
Movies: Klemp-Wilhelmson numerical model – squall line

Credits: Morris Weisman, Chris Davis, Bill Skamarock, Joe Klemp, and Tim Scheitlin from UCAR

Qualitative Radar Validation

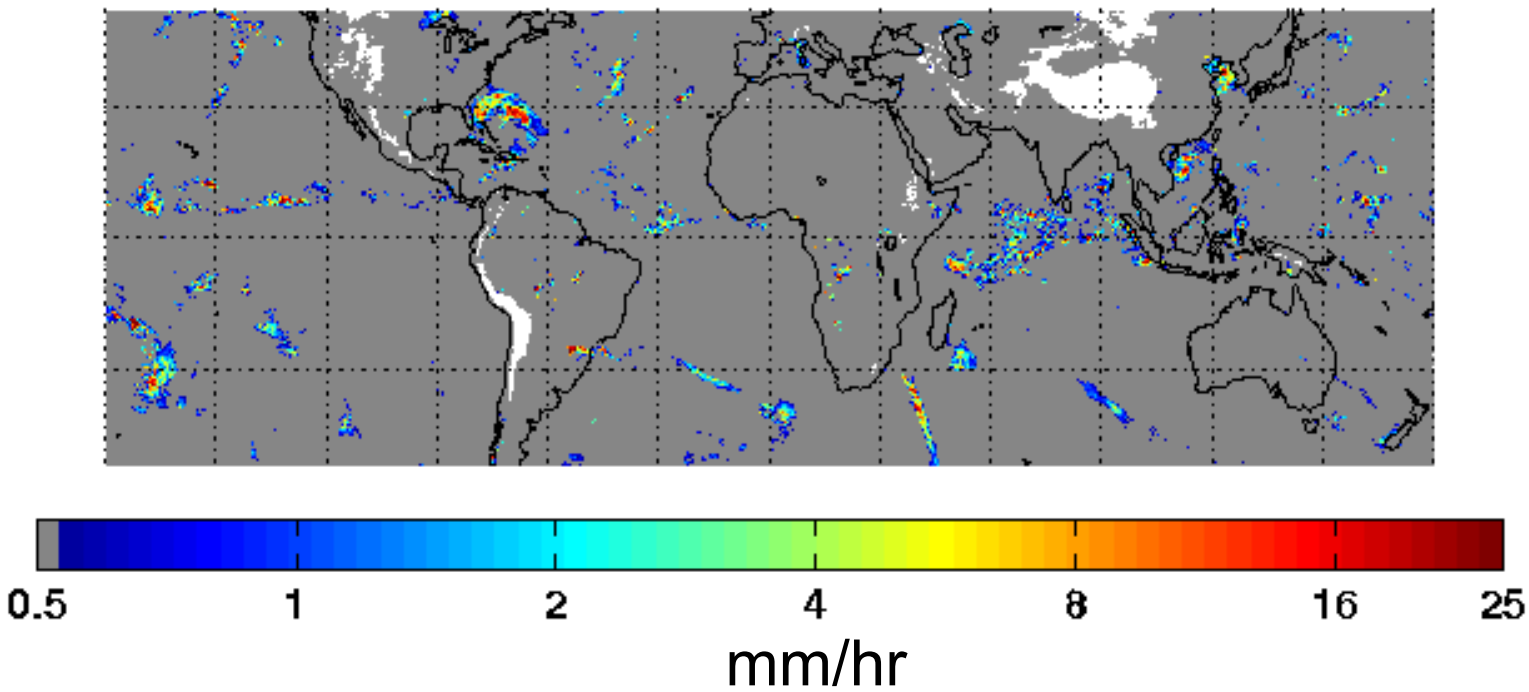


Composite radar over GOES visible image



Simulated composite radar Using WRF output data

ATMS Surface Precipitation Rate
Hurricane Sandy (10/26/2012)



Algorithm and image courtesy of C. Surussavadee

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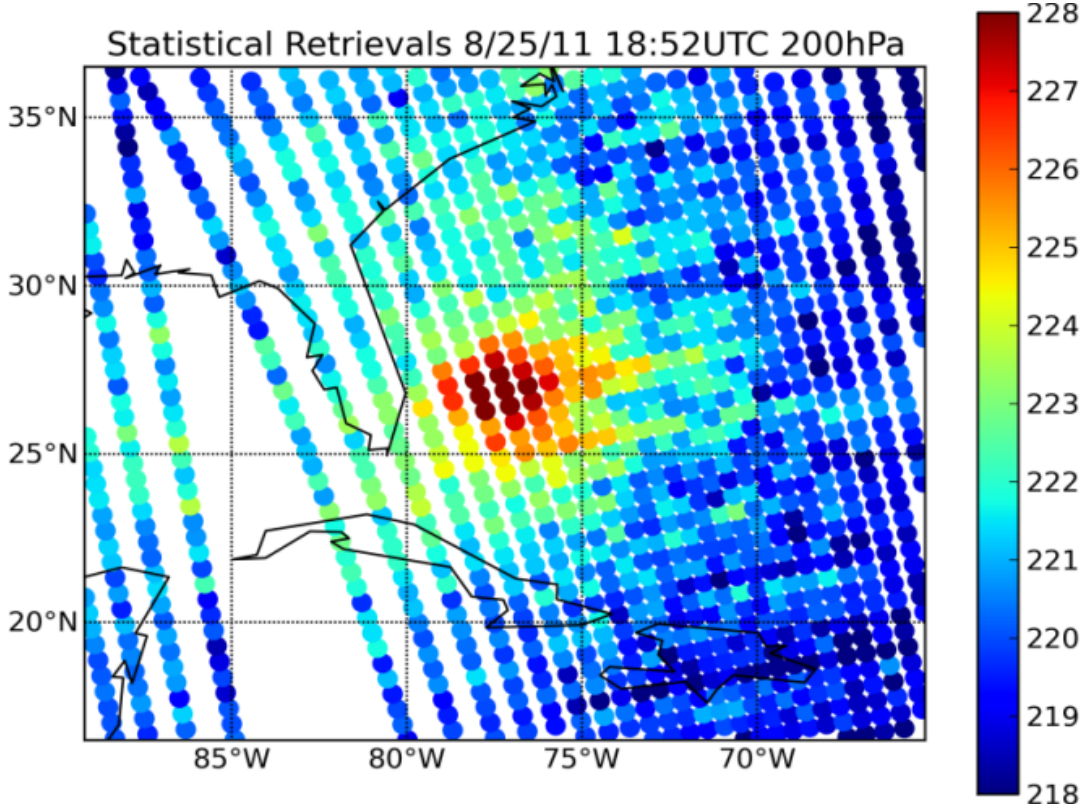
Tropical Cyclone Analysis and Forecasting

AMSU-A observations of Hurricane Wilma in 2005 clearly reveal the harm core



Tropical cyclone products

- Intensity
- Wind structure estimation

Intensity prediction

- Maximum Potential Intensity
- Tropical Vertical Instability

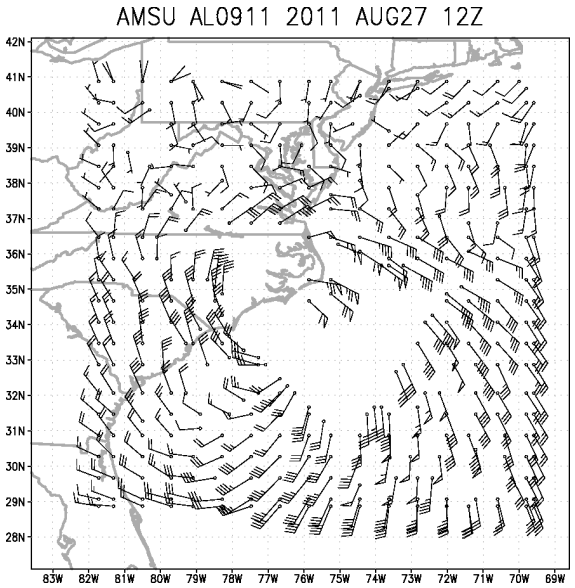


Image credits:
Mark DeMaria and John A. Knaff (NOAA/NESDIS/STAR)
Andrea Schumacher, Jack Dostalek, Robert DeMaria and Dan Welsh (CIRA/CSU)

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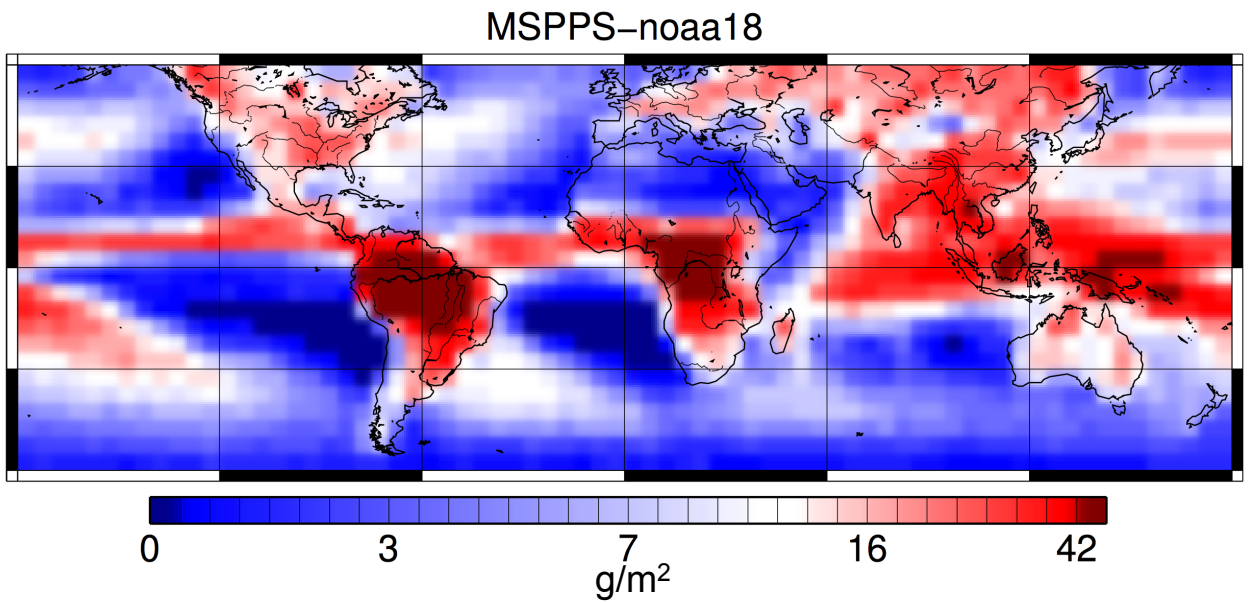
Climate "Fingerprint" Example: Cloud Ice Water Path (CIWP)

- Cloud IWP is an essential climate variable describing the vertically integrated mass of ice suspended in the atmosphere.
- Cloud IWP is a fundamental cloud-related parameter in climate models, governed by total water mass continuity equations.
- The current global observing system for IWP is poor, with both observations and models showing large discrepancies.
- ATMS observations at 183 GHz allow for the derivation of IWP.



Eliasson, S., et al. 2011, Atmos. Chem. Phys., Vol. 11, pp. 375-391

Summary

- ATMS on-orbit performance has been excellent
- Cal/val activities in progress to optimize calibration for high-fidelity earth science and climate applications
- AMSU capabilities will be continued and expanded
- New and improved precipitation and severe weather products further exploit microwave sounding observations