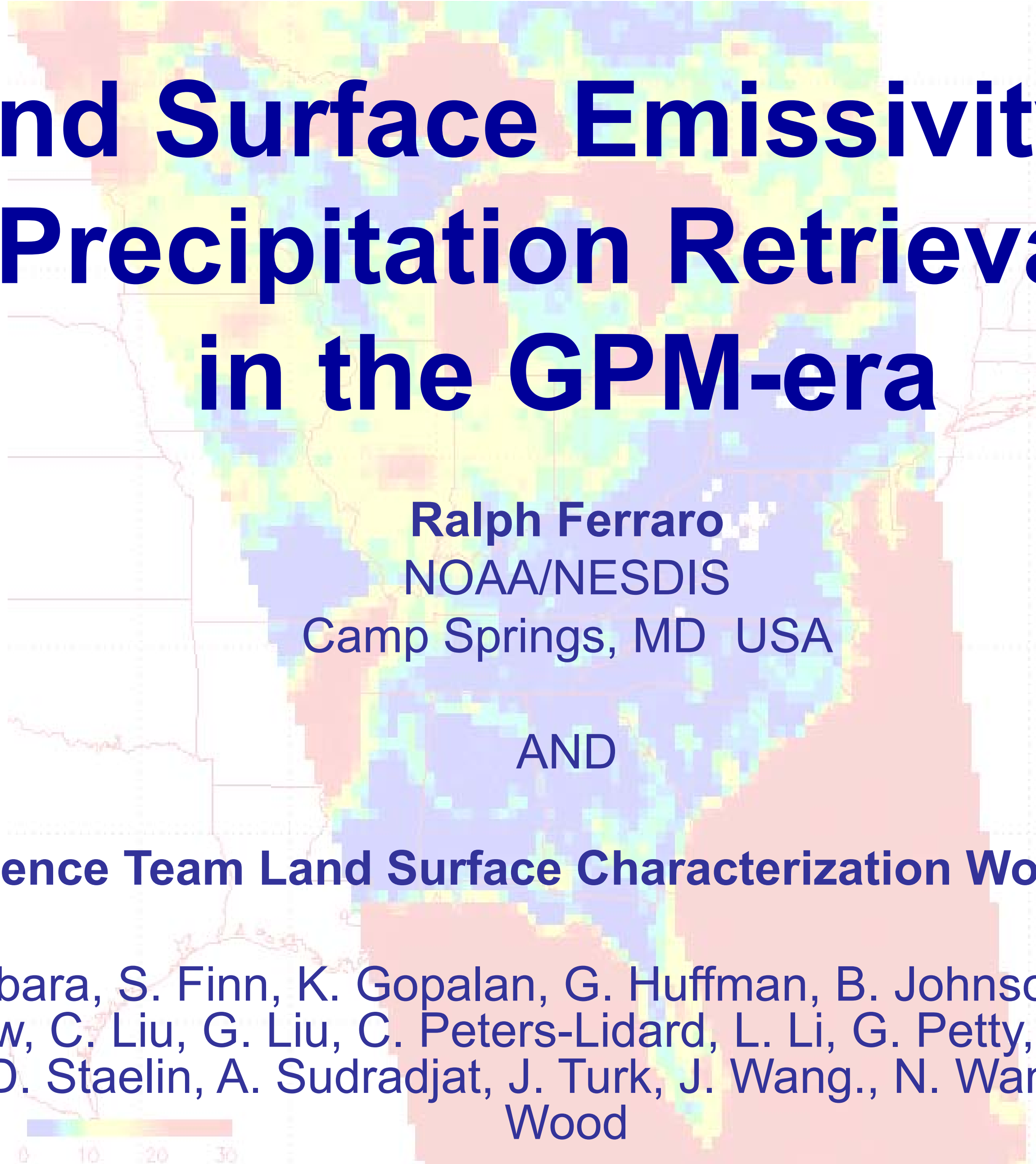


Land Surface Emissivity for Precipitation Retrieval in the GPM-era

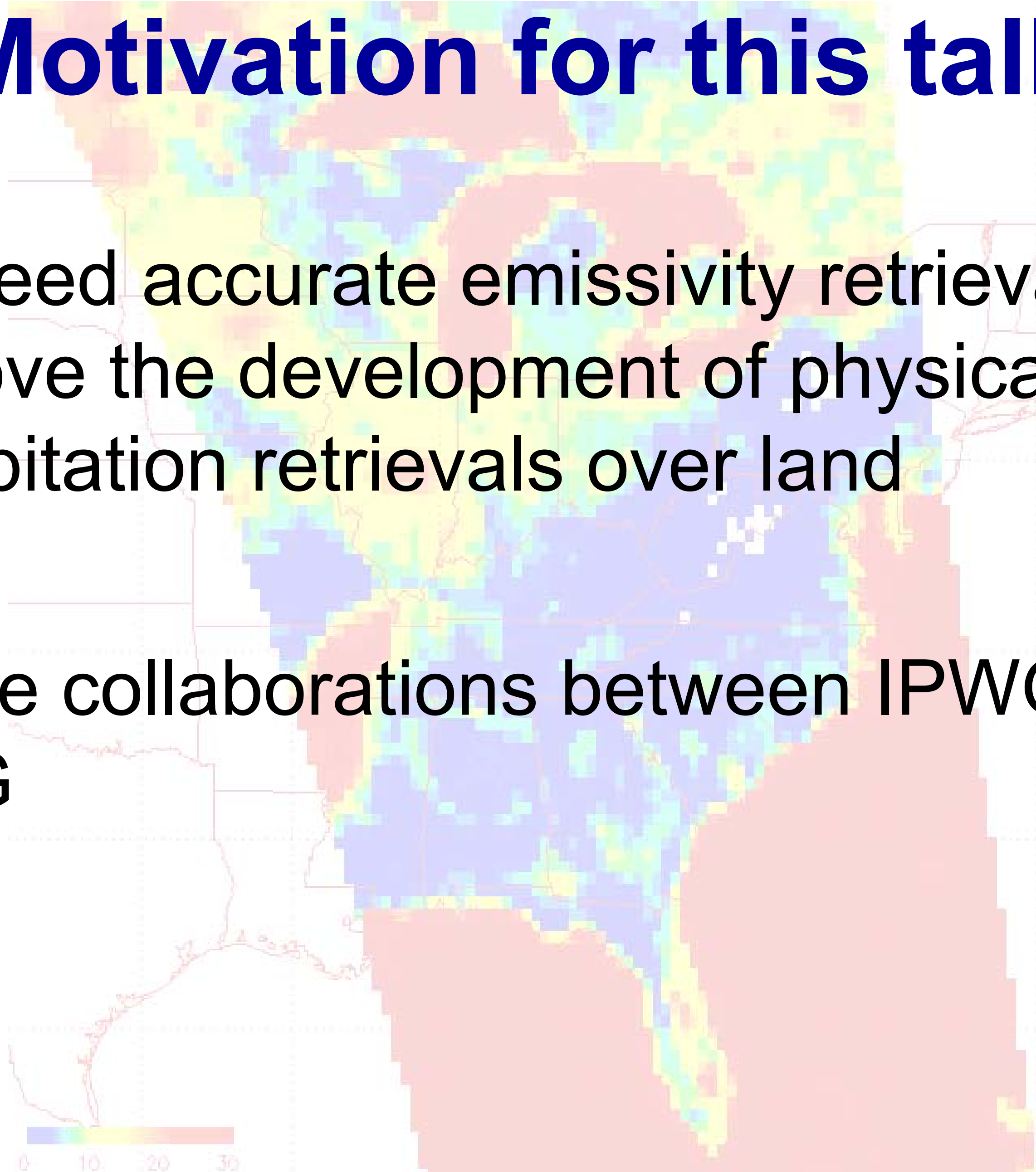
Ralph Ferraro
NOAA/NESDIS
Camp Springs, MD USA

AND

PMM Science Team Land Surface Characterization Working Group:

S. Boukabara, S. Finn, K. Gopalan, G. Huffman, B. Johnson, C. Kidd, C. Kummerow, C. Liu, G. Liu, C. Peters-Lidard, L. Li, G. Petty, G. Skofronick-Jackson, D. Staelin, A. Sudradjat, J. Turk, J. Wang., N. Wang, F. Weng, E. Wood

Motivation for this talk…



- We need accurate emissivity retrievals to improve the development of physically based precipitation retrievals over land

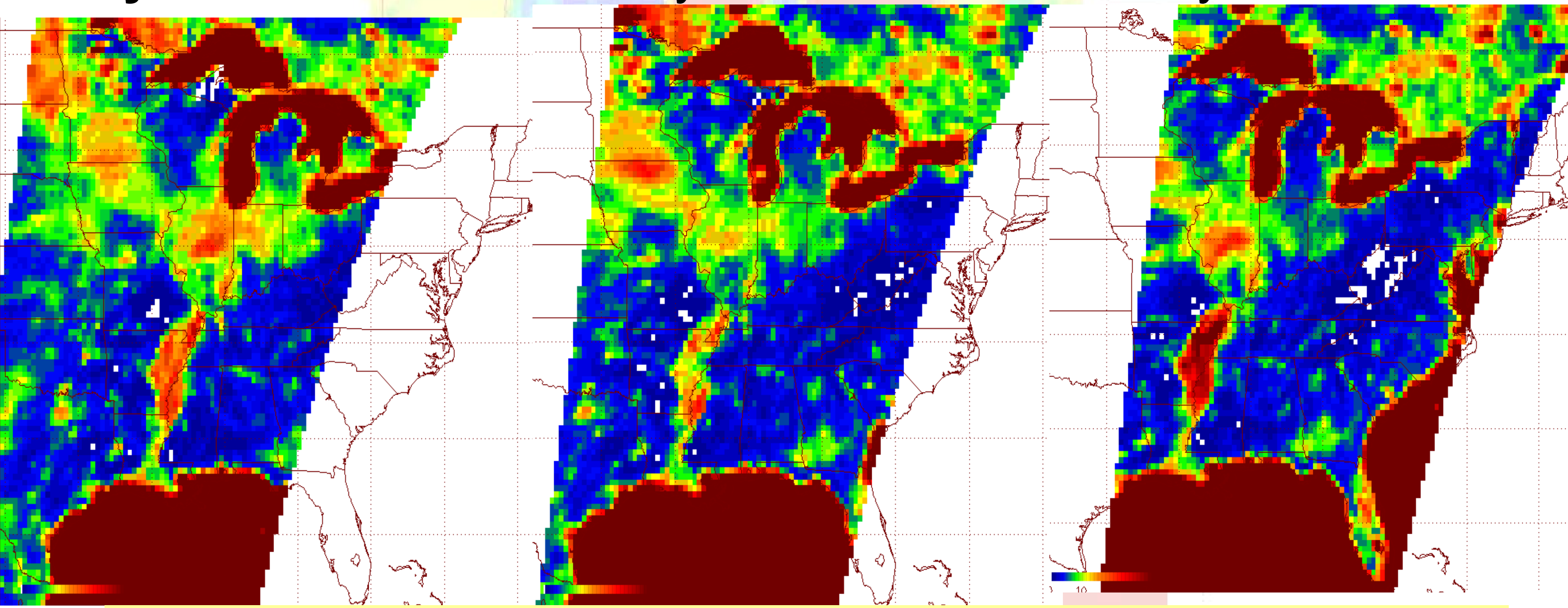
- Initiate collaborations between IPWG and ITWG

Outline

- Scientific need
- What we have and what we don't have
- PMM Science Team emissivity experiment
  - What we are doing
  - Preliminary results
- Summary and next steps

Surface Variations

May 22 – 0753 Z May 24 – 0741 Z May 26 – 0728 Z



AMSR-E sequence of 18V-18H:

- Active period of rainfall
- Surface vegetation/crops emerging
- Polarization differences (related to soil moisture and vegetation cover) are dynamically varying
  - Poses challenge to ϵ retrievals and precipitation retrieval

Scientific Need*

***From PMM Science Team Meeting, July 2008**

- Improved surface characterization is urgently needed to advance the GPM-era precipitation over land algorithms

- PMM algorithm scientists focusing on a wide range of topics, but not necessarily on land surface characterization
  - Land/winter season precipitation microphysics
  - Radiative transfer in precipitating atmospheres
  - Benefits/Utilization of high frequency measurements

- However, much expertise is available through other programs
  - GEWEX
  - JCSDA/CRTM
  - CGMS – ITWG (+Emissivity Workshops), IPWG
    - However, it is not as simple as “plug and play”

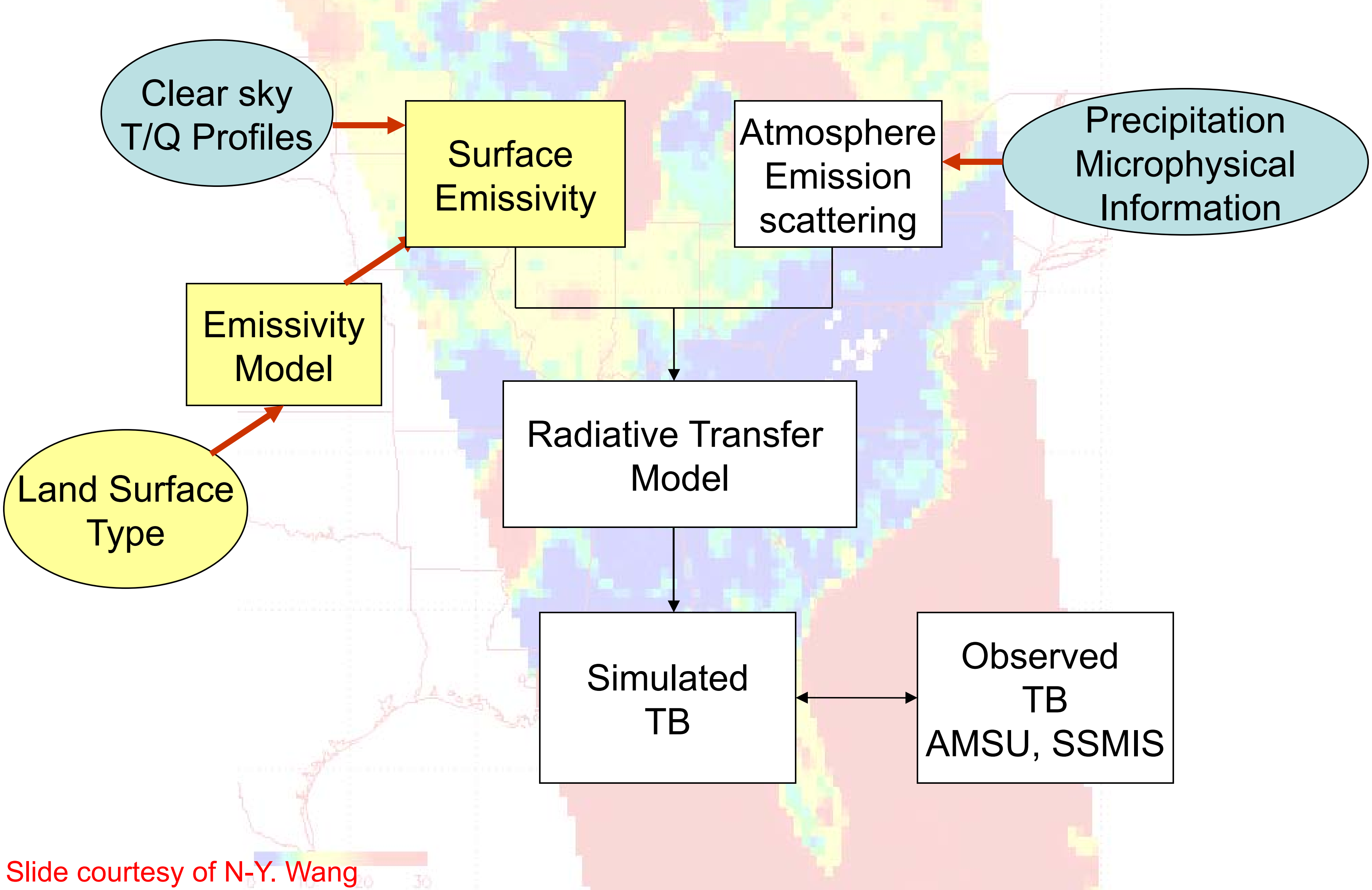
LSWG Objectives and Goals *

***From PMM Science Team Meeting, July 2008**

- Assess the current state of land surface emissivity models/retrievals
  - Must be applicable to all GPM sensors
    - 6 – 200 GHz
  - What happens during active precipitation (if using static data base)?
  - Engage experts external to PMM

- Establish methodology to accurately characterize the land surface for GPM core and constellations sensors
  - Must consider sensor and orbital characteristics
    - Frequency/FOV
    - Sensitivity to surface
  - Must be both static and dynamic in nature
    - Static – Land/Water/Terrain/Є Climatology
    - Dynamic - snow cover, Tsfc, Є, changing water boundaries (e.g., Aral Sea)

How we can use Є information

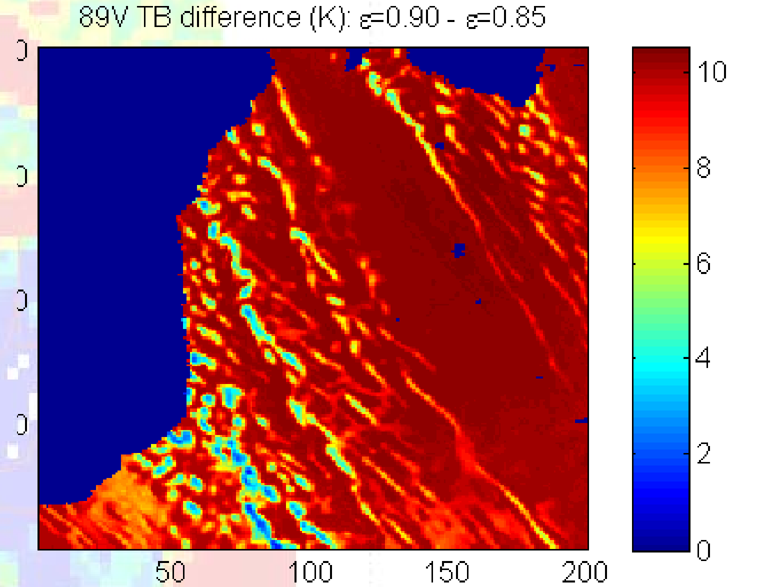


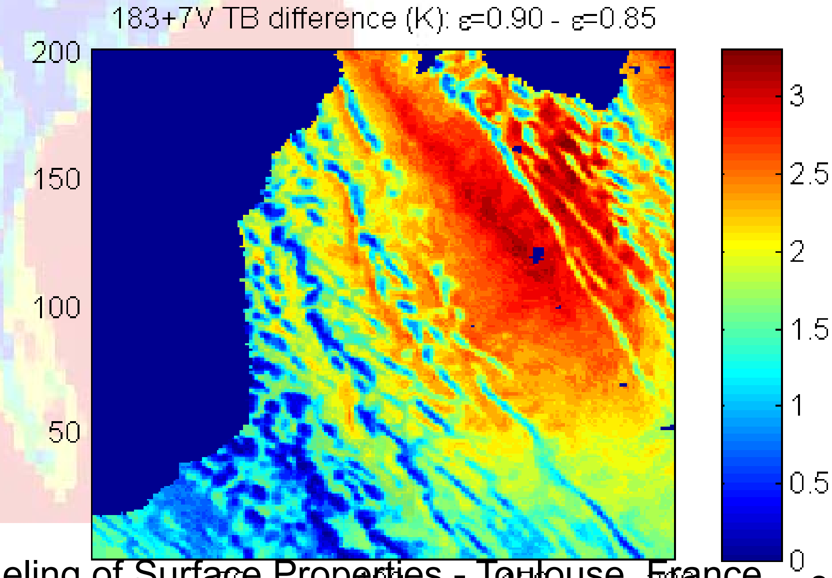
Slide courtesy of N-Y. Wang

Sensitivity on Retrievals

Results courtesy of B. Johnson/G. Skofronick-Jackson

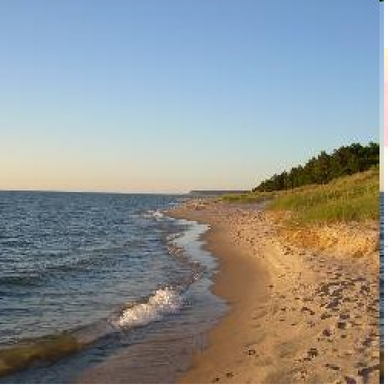
- Examination of lake effect snow bands from C3VP
- Impacts of incorrect emissivity
  - 5-10 K @89 GHz
  - 1 – 3 K @ 183+7 GHz
- This translates up to 100% error in retrieved snowfall rates (0-2 mm/hr)





Study Parameters

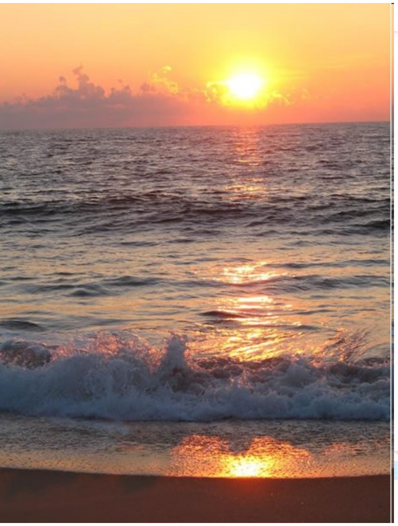
- 12 Targets/9 types of surfaces
- 1 Year: 1 July 06 – 30 June 07
- Assemble data sets:
  - Satellite
    - AMSR-E, SSMI, SSMIS, TMI, AMSU, WindSat
  - Ancillary satellite
    - ISCCP, PR/VIRS, CloudSat
  - Model
    - GDAS, LSM, JCSDA Emissivity
- Participants generate emissivity "their way" but:
  - Must use only the data sets supplied
  - Make results freely accessible by others (post on web)
- Results to be stratified by site, cloud mask, etc.

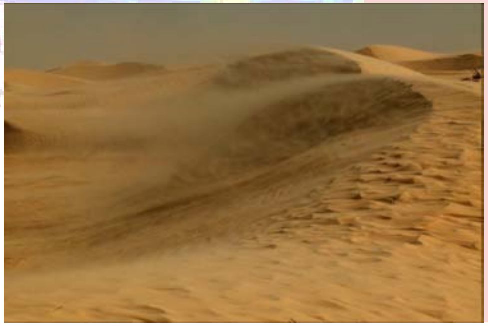


Study Domain

A diverse set of targets were selected:

- **C3VP –** 44 N, 80 W
- **Amazon(2) –** 7 S, 70 W and 2 N, 55 W
- **Open Ocean(3) –** 0 N, 150 W; 35 N, 30 W; 45 S, 35 W
- **Desert –** 22 N, 29 E
- **SGP** – 35 N, 97 W
- **Inland Water –** 48 N, 87 W
- **SE US (HMT-E)** - 34 N, 81 W
- **Wetland surface** - 18 S, 57 W
- **Finland –** 60 N, 25 E





Study Web Page

http://cics.umd.edu/~rferraro/LSWG.html

This is the web page for the PMM Science Team Land Surface Characterization Working Group (LSWG).
Details of the study are found here LSWG Study Summary.
Meeting minutes from April 28, 2009 are found here Latest Meeting Minutes.

For more information, please contact Ralph Ferraro

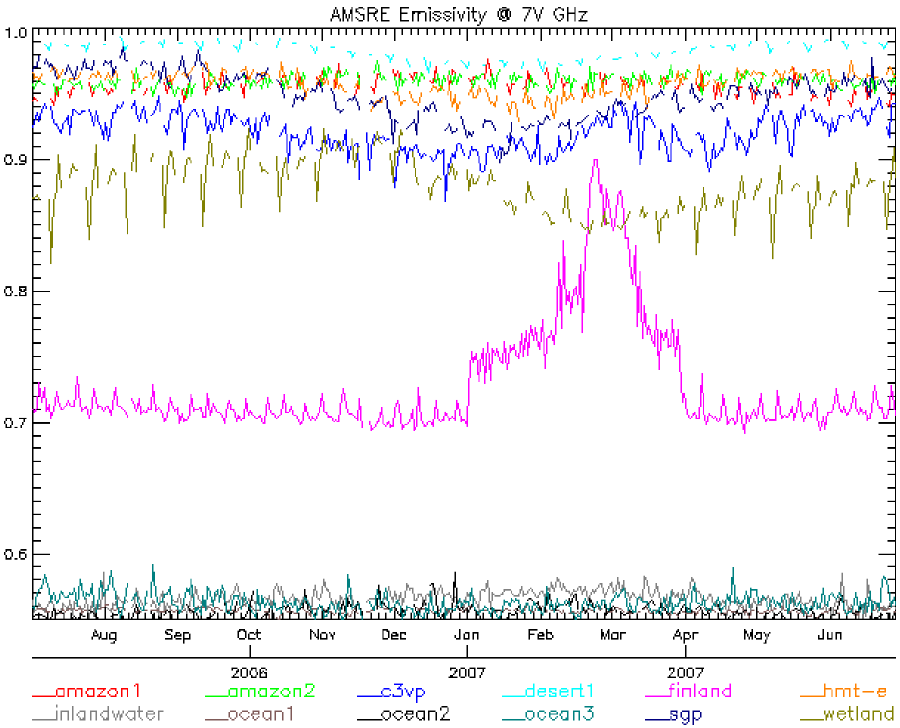
Data Type	Readme	ASCII Data	Comments	Focal Point
GDAS	GDAS Readme	GDAS data	1 Degree Data	Fuzhong Weng
Emissivity Model				Fuzhong Weng
LSM Input	LSM Readme	LSM data	GLDAS 1 deg, 3 hr, using 4 LSMS: NOAH, CLM, VIC, MOSAIC	Christa Peters-Lidard
ISSCP Cloud Mask	ISCCP Readme	ISCCP Data	Data Set is compressed	Chuntao Liu
Colocated TMI, PR and VIRS	TMI/PR/VIRS Readme	TMI/PR/VIRS data	VIRS cloud mask with colocated TMI; Data Set is compressed	Chuntao Liu
AMSR-E	AMSR-E Readme	Jul06 Aug06 Sep06	AMSR-E, TMI, SSMI and SSMIS data sets are combined into monthly files	Sarah Finn
SSMI	SSMI Readme	Oct06 Nov06 Dec06	AMSR-E,TMI, SSMI and SSMIS data sets are combined into monthly files	Sarah Finn
SSMIS	SSMIS Readme	Jan07 Feb07 Mar07	AMSR-E, TMI, SSMI and SSMIS data sets are combined into monthly files	Sarah Finn
TMI	TMI Readme	Apr07 May07 Jun07	AMSR-E, TMI, SSMI and SSMIS data sets are combined into monthly files	Sarah Finn
CloudSat	CloudSat Readme	CloudSat Data	Data Set is compressed	Guosheng Liu

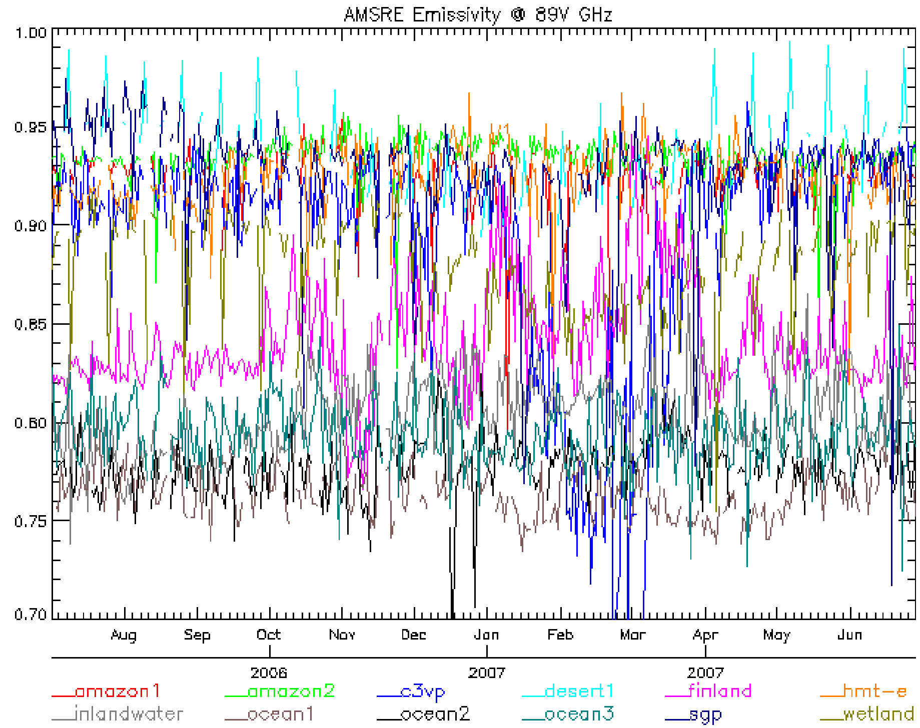
Preliminary Results

- MIRS 1DVAR (Boukabara)
  - AMSU, AMSR-E, SSMIS
- CICS - Direct computation – remove atmosphere (Wang)
  - AMSR-E, TMI
- NASA - Direct computation – knowing surface type and atmosphere (Skofronick-Jackson)
  - AMSU
- NRL - Direct computation (Li)
  - WindSat

MIRS Results – AMSR-E

Results courtesy of S. Boukabara/W. Chen



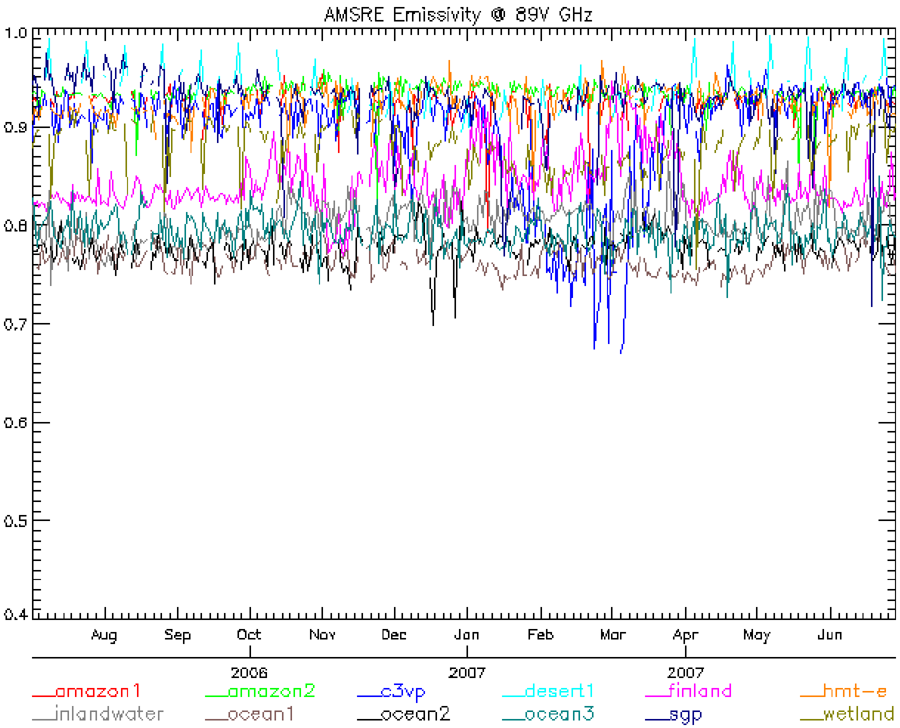


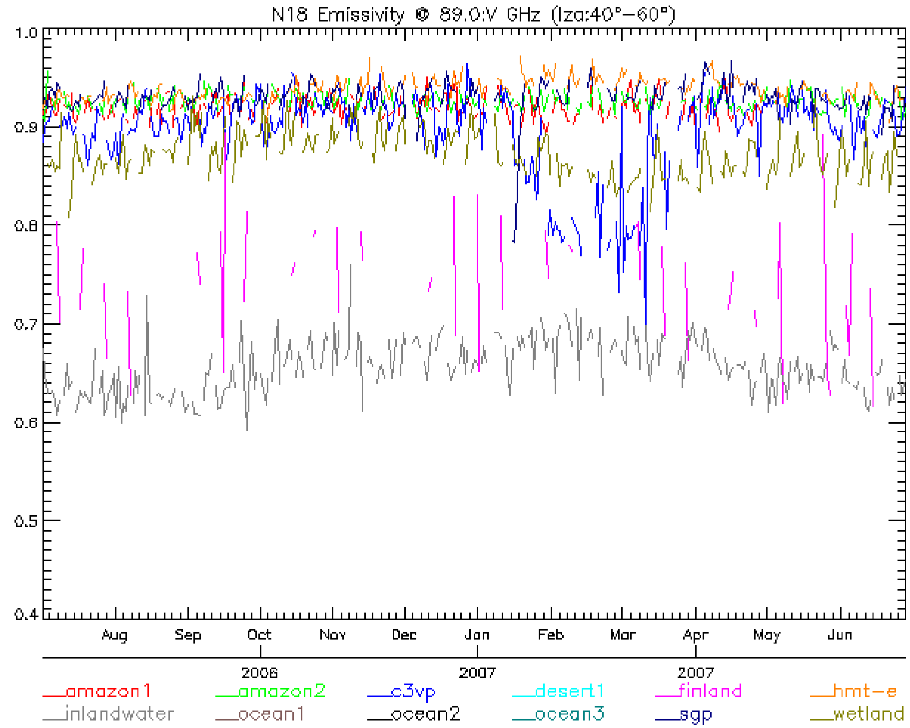
- 6.9V: relatively small interannual Variability EXCEPT:
  - Finland in winter
  - C3VP in winter
  - SGP due to vegetation/lack of it
  - Wetlands in fall

- 89V: highly variable for most sites

MIRS Results – AMSU vs. AMSR-E

Results courtesy of S. Boukabara/W. Chen





- AMSR-E ~50 deg incidence angle, AMSU shown here between 40-60 deg.
- AMSU is also mixed polarization
- Only 5 targets of AMSU data were made available to date
- Similarities:
  - Large annual cycle changes at C3VP and wetland (and magnitudes)
  - Finland is clearer lower than other targets
- Differences:
  - Water targets (mixed polarization?)

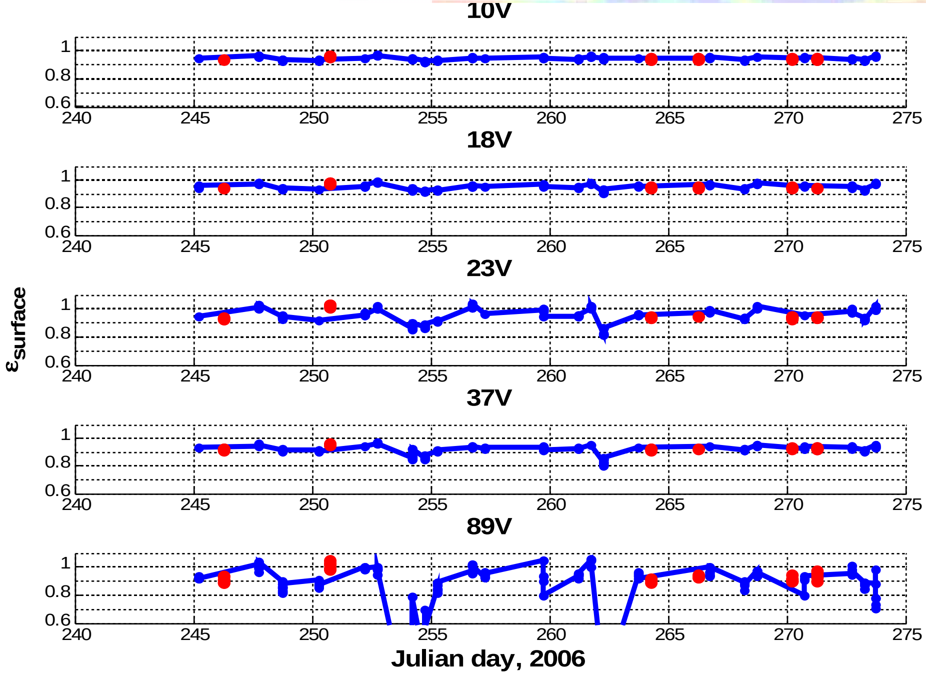
CICS - Amazon Target

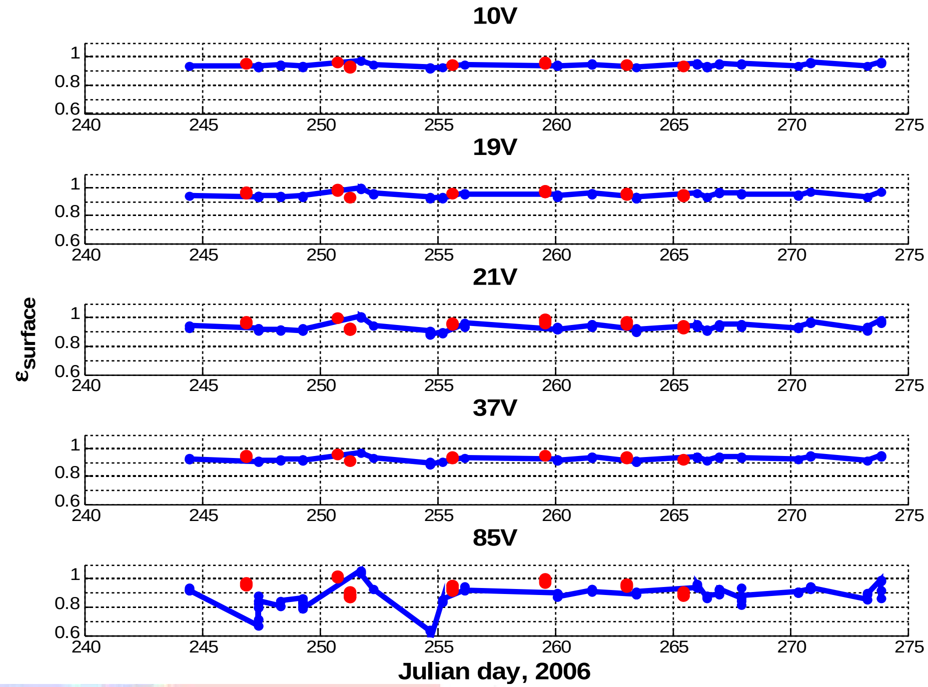
Clear Sky
Cloudy

AMSR-E

Results courtesy of N-Y. Wang/K. Gopalan

TMI

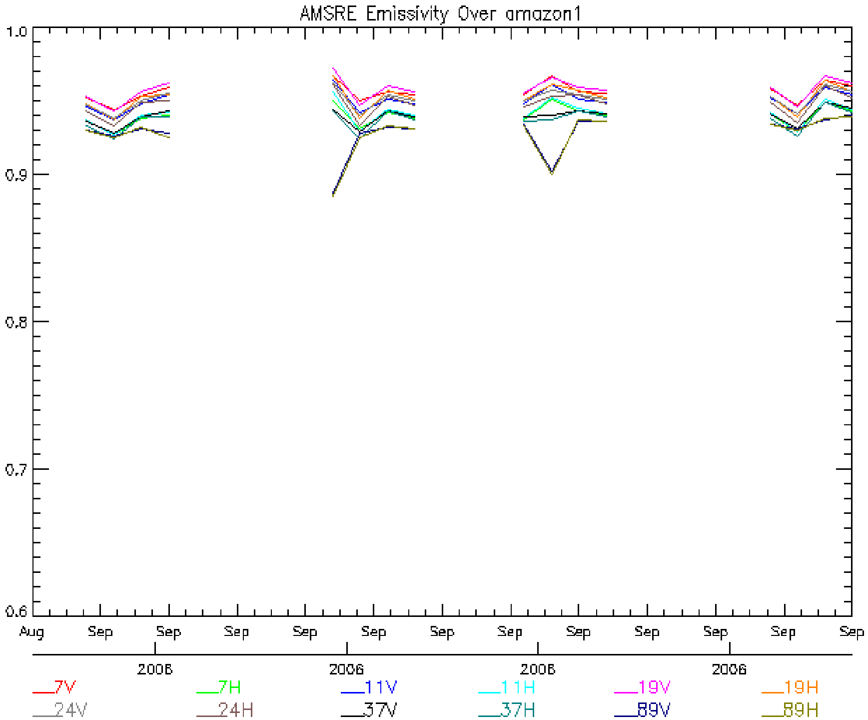


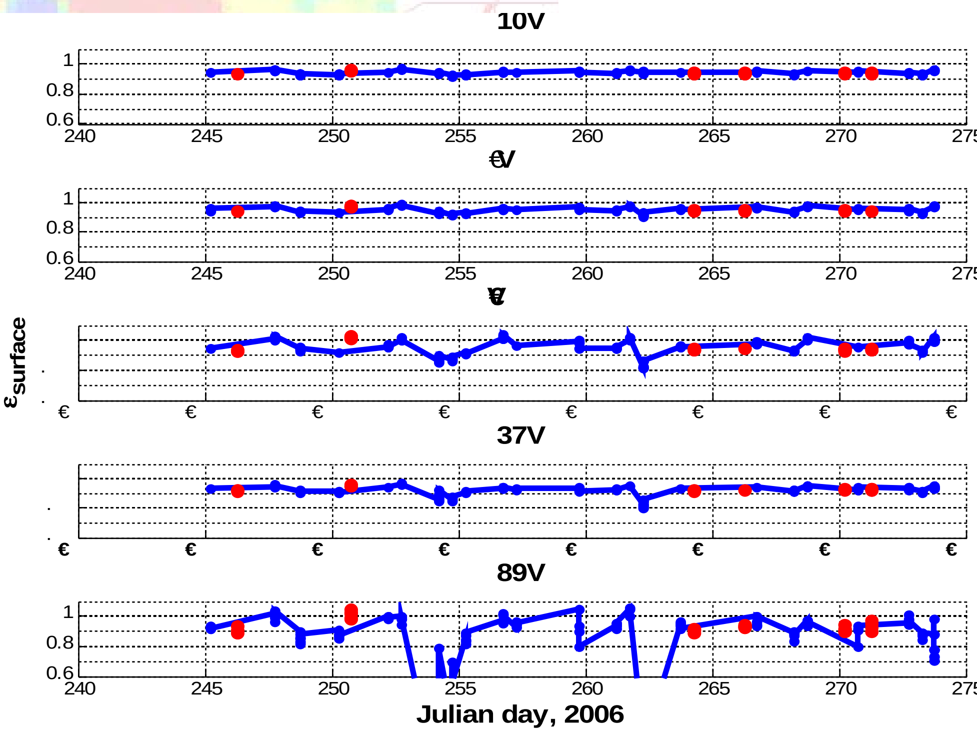


- 37 GHz or less
  - Reasonable stability of Є over vegetated target
  - Cloud affects minimal
- 89 GHz
  - Cloud and precipitation affects dramatic
  - Similar values during clear conditions

MIRS vs. CICS - Amazon

Results courtesy of S. Boukabara/W. Chen





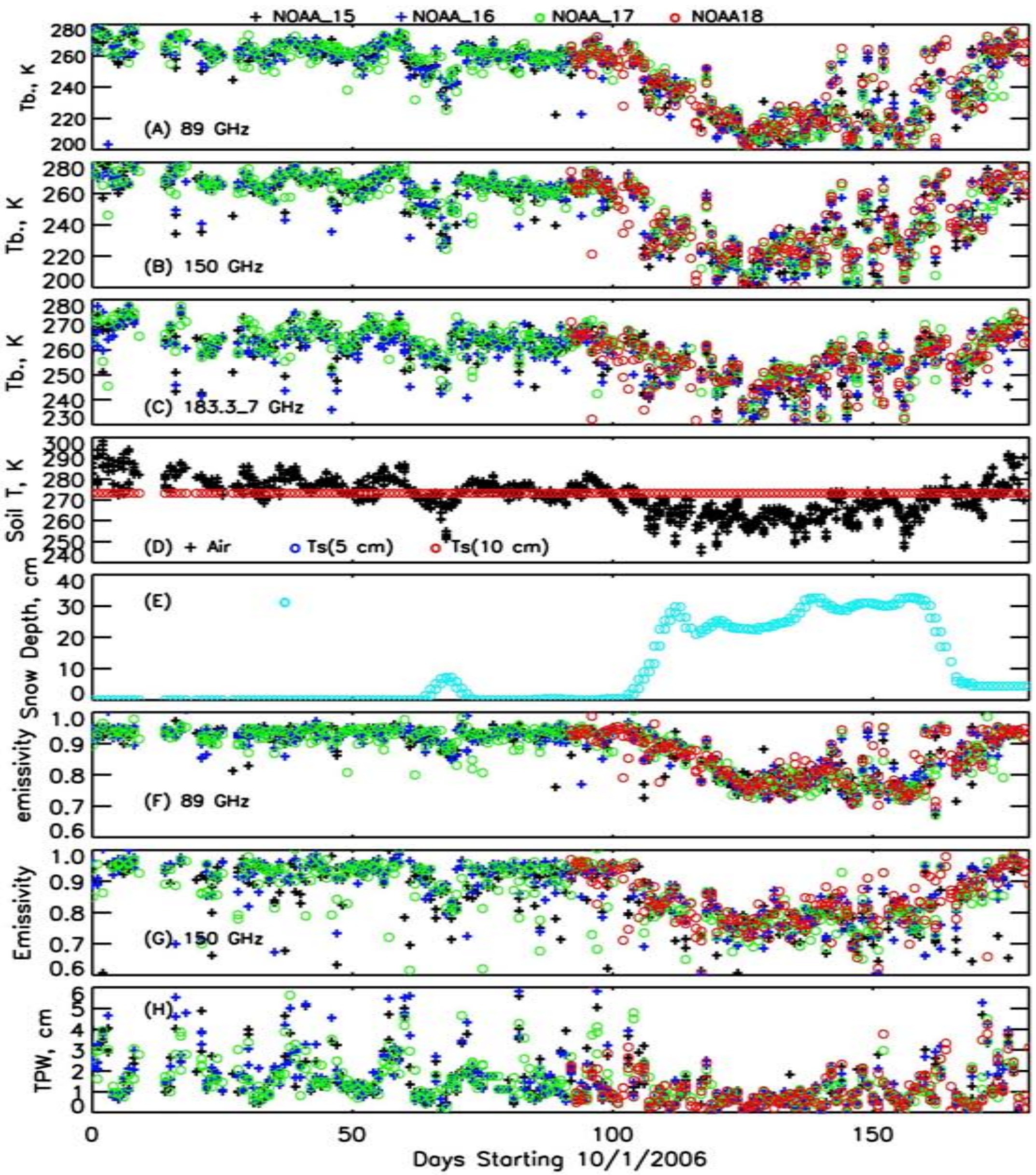
- Very limited data to compare at this time….
- Seems like reasonable agreement in ranges of values – clear sky

NASA – AMSU-B at C3VP

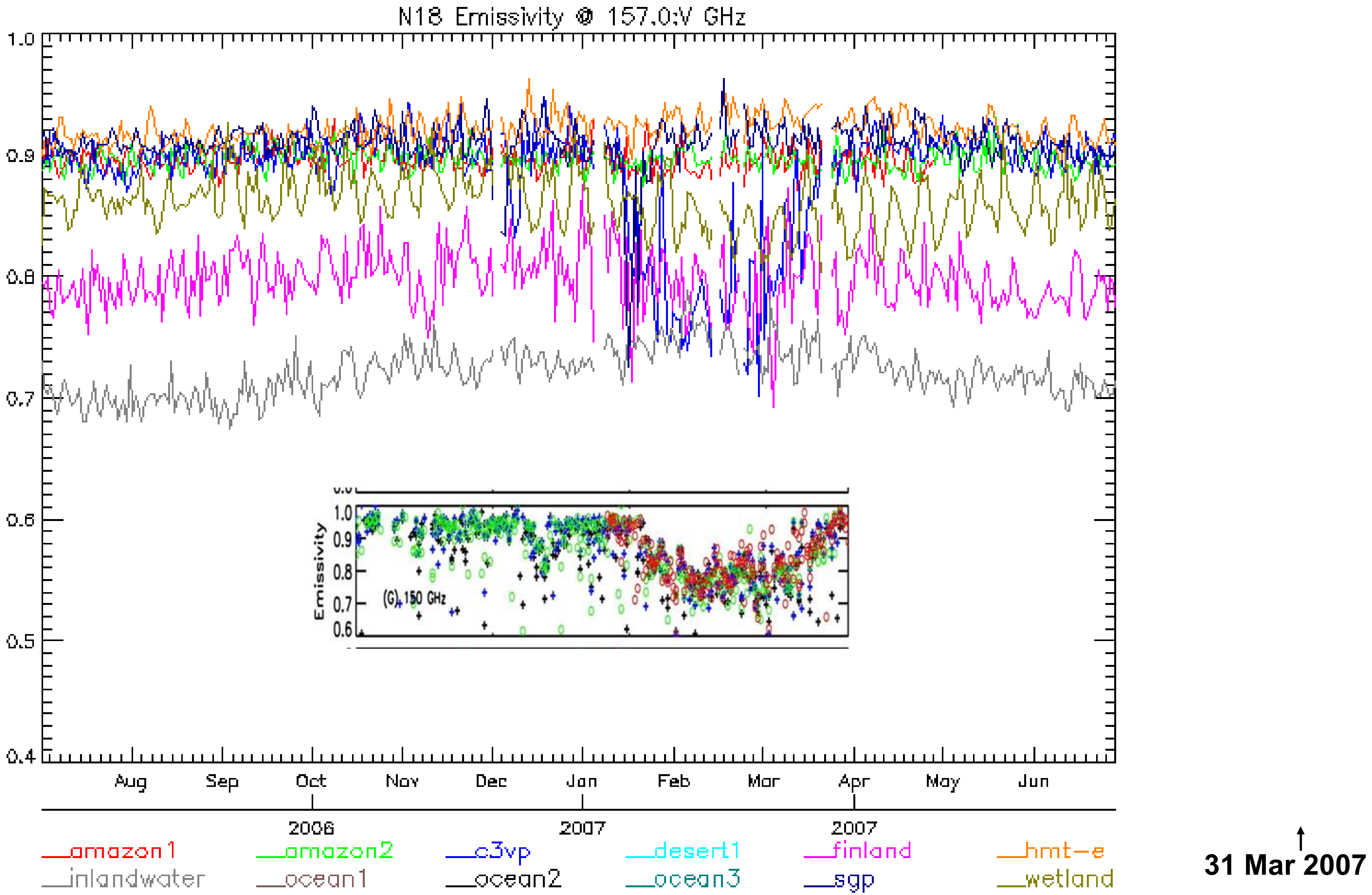
Results courtesy of J. Wang/G. Skofronick-Jackson

Є89

Є150



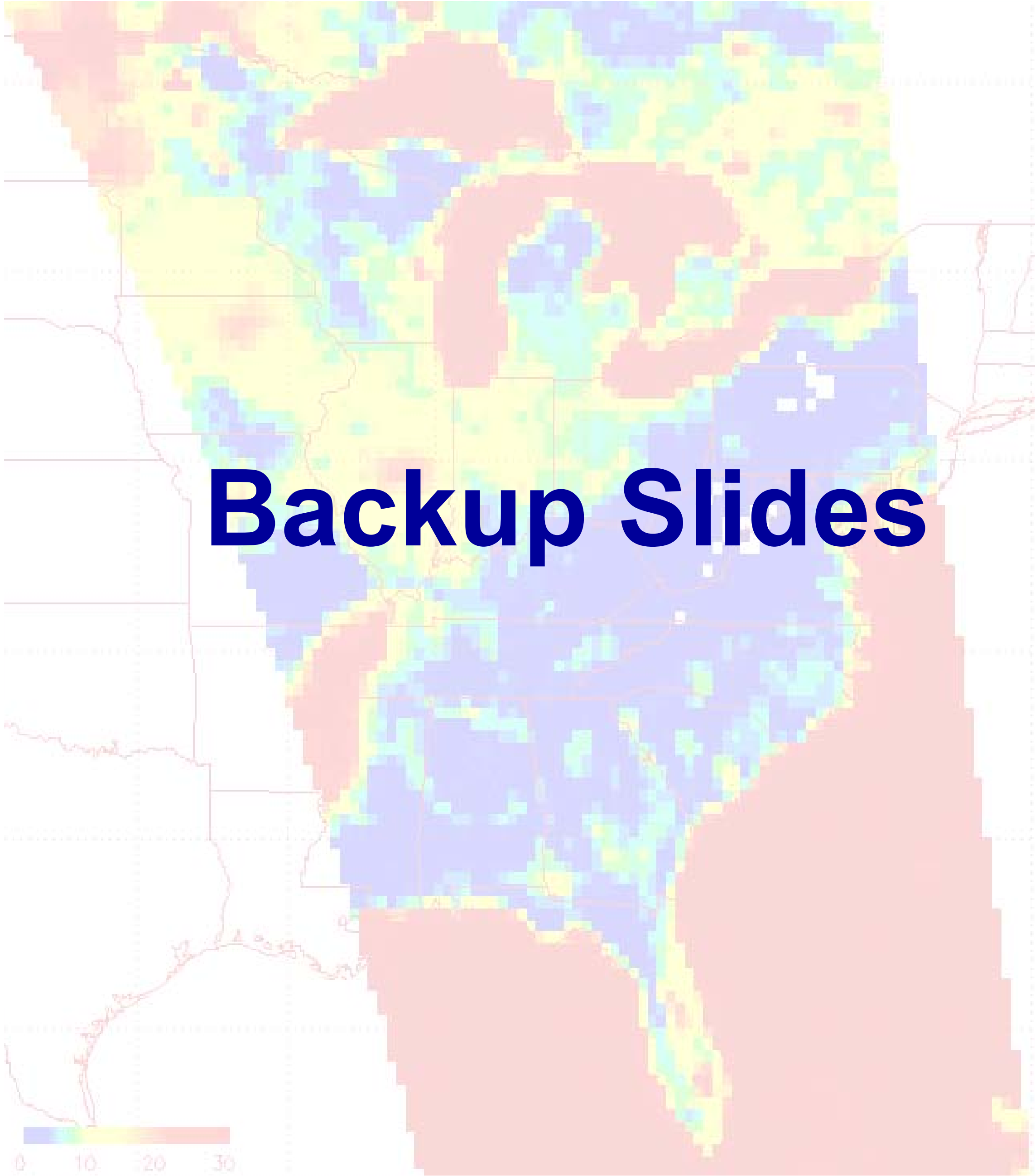
MIRS vs. NASA – C3VP @ 157 GHz



Summary and Future

- The advancement of precipitation over land in GPM-era must consider
  - Accurate surface characterization 6 – 200 GHz
  - Understanding of the sensitivity of the retrievals over all surface types and frequency range
- PMM Science Team **just starting** in this area with a very simple intercomparison study
  - Preliminary findings very interesting and perhaps encouraging
- Future
  - We need your help!
  - PMM emissivity workshop with ITWG interested parties?
    - Learn more at PMM Science Team Meeting, Salt Lake City, UT, USA, October 2009
  - ITWG engagement at next IPWG
    - Hamburg, Germany in fall of 2010?

Backup Slides



Methodology

- Emissivities inferred from passive microwave observed Tb and clear sky* computations

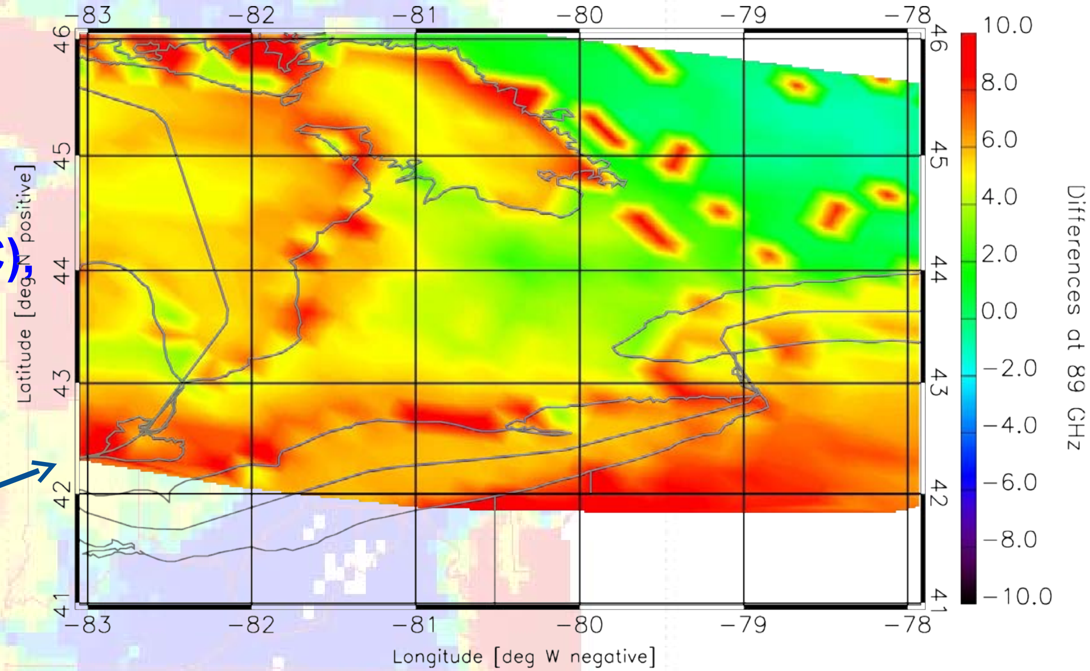
$$\varepsilon = (T_{obs} - T_{up} - e^{-\tau}.T_{down}) / e^{-\tau}(t_s - T_{down})$$

  - where ε is the inferred surface emissivity
  - T_{obs} is the observed Tb and t_s is the surface temperature
  - T_{up} (T_{down}) is the upwelling (downwelling) emission from the atmosphere
  - τ is the opacity of the atmosphere

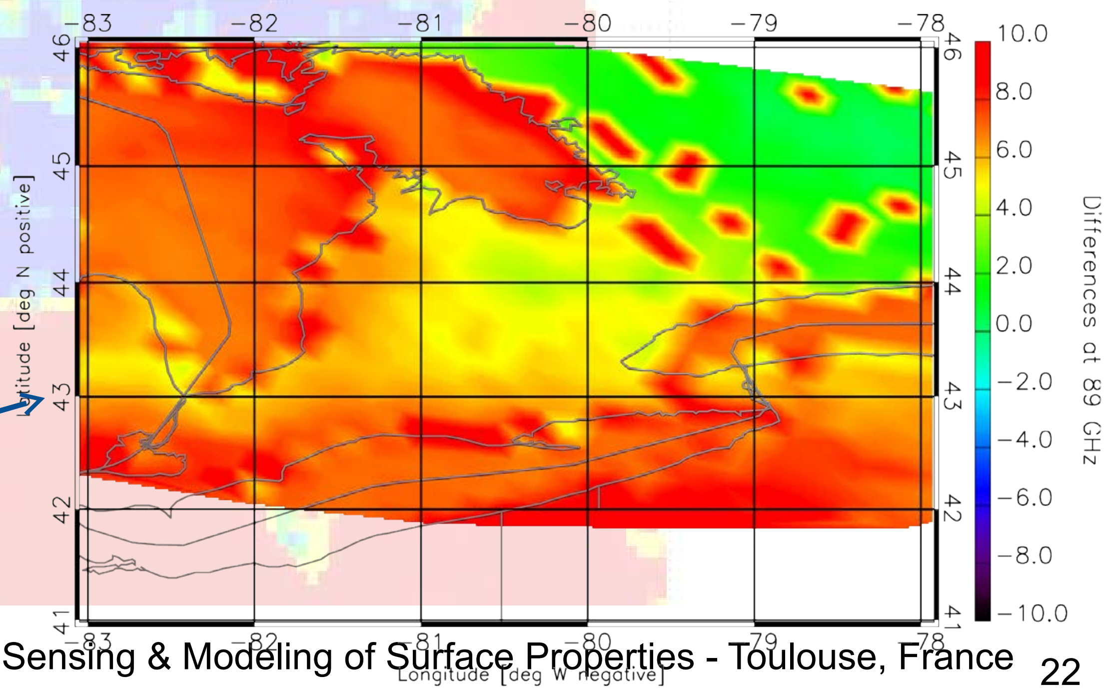
* Assumes no cloud for all RTM calculations

Retrieved Emissivity -> forward model cf. observed TBs
AMSU-B Overpass at 11:31 UTC

Figures from Gail Jackson (GSFC), Jim Wang (GSFC), and Anne Kramer (UMBC)



89 GHZ Observed – Simulated Using CARE-derived TPW [looks decent, but still issues]
[TB diff. range: -1 to +9 K]



89 GHZ Observed – Simulated Using GOES-derived TPW [simulated TBs a bit too cold]
[TB diff. range: 0 to +10 Ks]

Emissivity: 21 Jan 2007 (Clear Air)

NOAA-15 AMSU-B Overpass at 11:31 UTC (150 GHz)

Differences when surface emission (emissivity) assumptions change.

Non-forested areas=

Deep Dry Snow (fixed depth)

Wet Snow (fixed depth)

Deep Dry (WRF variable depth)