Utilization of Land Surface Emissivity for Precipitation Retrieval – An Obvious Linkage between ITWG and IPWG – and Implications for GPM-era Algorithms

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AND

PMM Science Team Land Surface Characterization Working Group & Affiliates –
including Gail Skofronick-Jackson, Christa Peters-Lidard, Catherine Prigent, Fatima Karbou, Chuntao Liu, Joe Turk, Li Li, Sarah Finn, Ken Harrison…

17th International TOVS Study Conference - Pacific Grove, CA April 2010

Motivation for this talk…

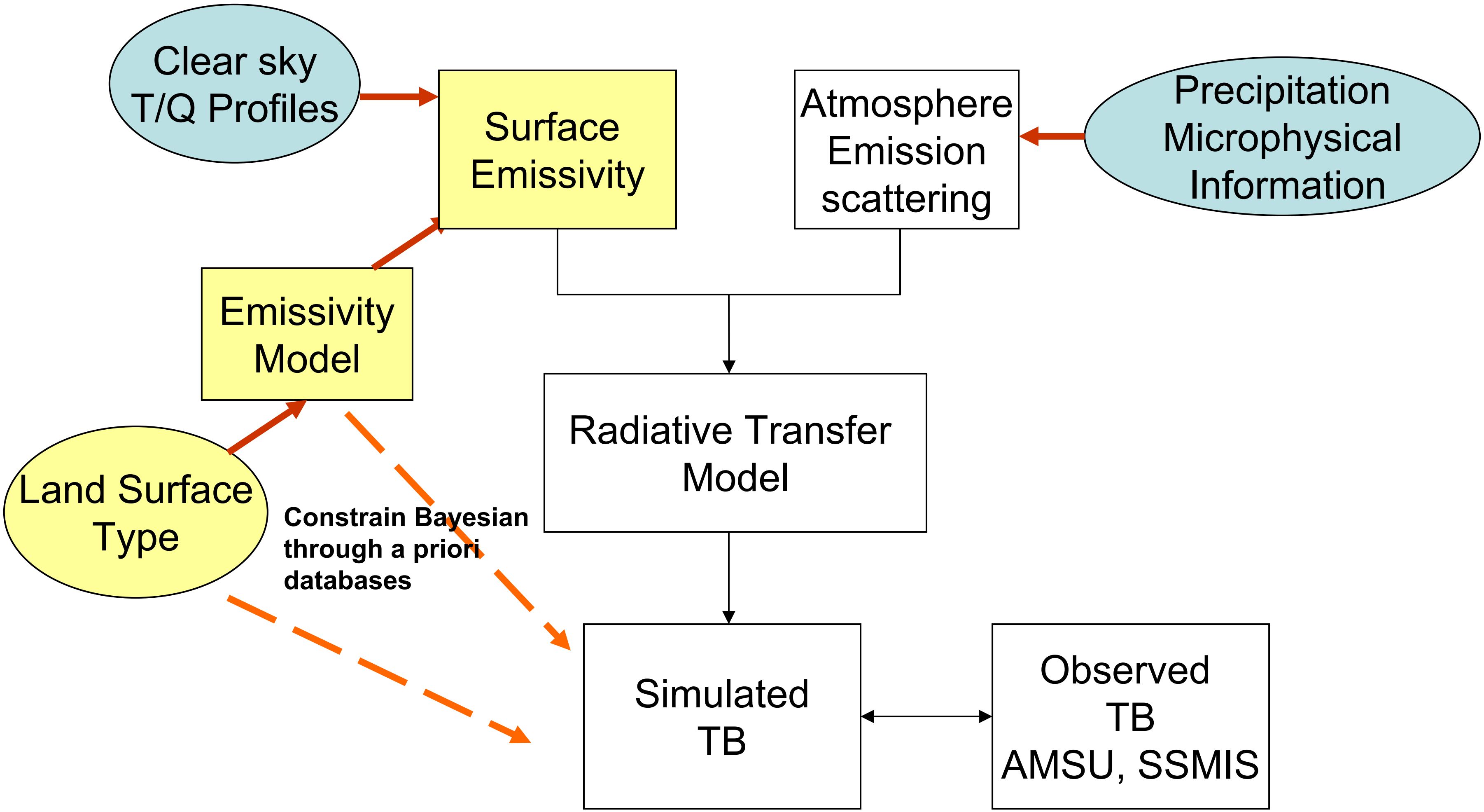
- We need accurate Є retrievals to improve the development of physically based precipitation retrievals over land
  - Q signal (low freq.) over land < Є variability
  - IWP signal (high freq.) over land < Є variability
  - GPM mission focus…international constellation!

- Enhance collaborations between IPWG and ITWG
  - Build off of progress made at 2009 Toulouse workshop and gear towards IPWG-5 (Hamburg, October 2010)
  - IPWG and GPM need Є under cloudy/precipitating conditions from 10 – 190 GHz

Outline

- Scientific need
- PMM Science Team emissivity experiment
  - What we are doing
  - Preliminary results
- Summary and next steps
  - Intercomparison study
  - ITWG/IPWG Synergy

How we can use Є information to improve precipitation retrievals?

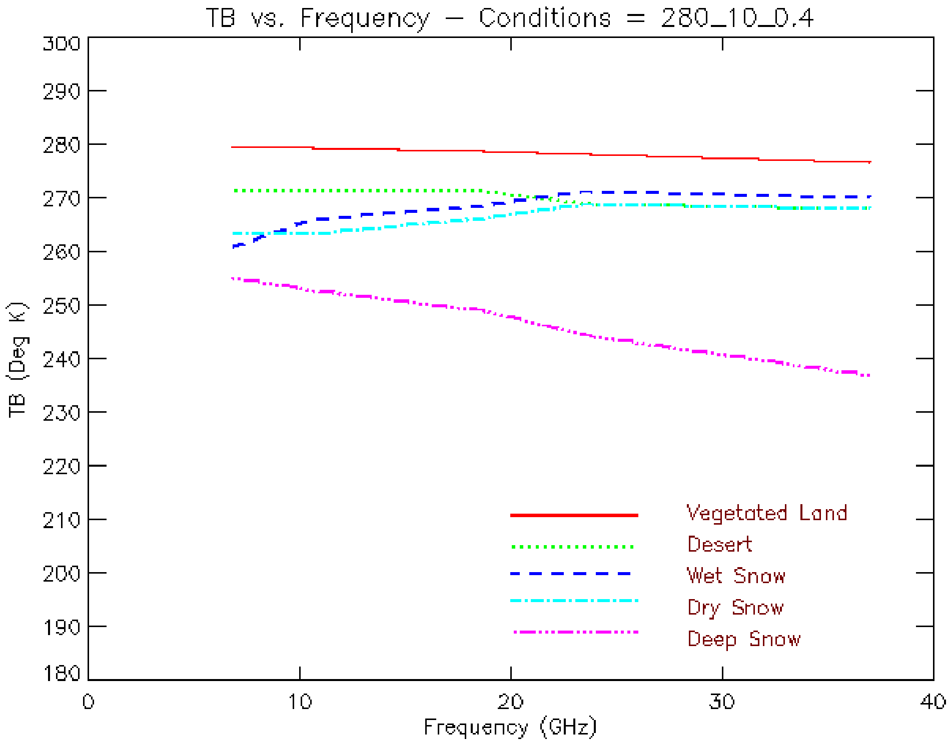


Slide courtesy of N-Y. Wang

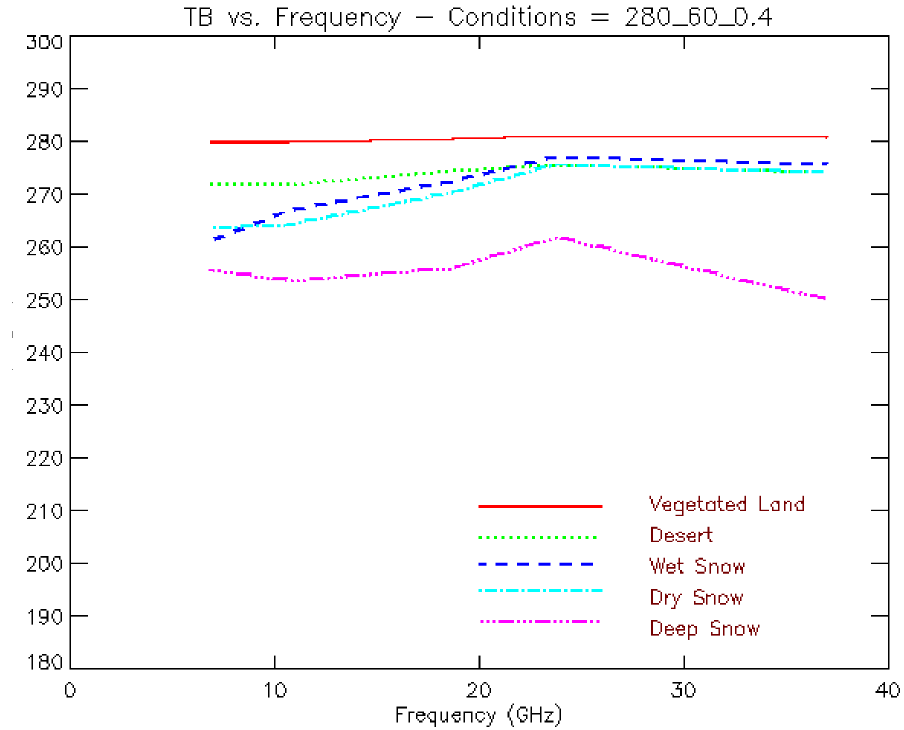
Sensitivity of Surface to Q and V

Ts = 280 K, RAIN (Q=0.40), no-scattering

Dry: V = 10 mm



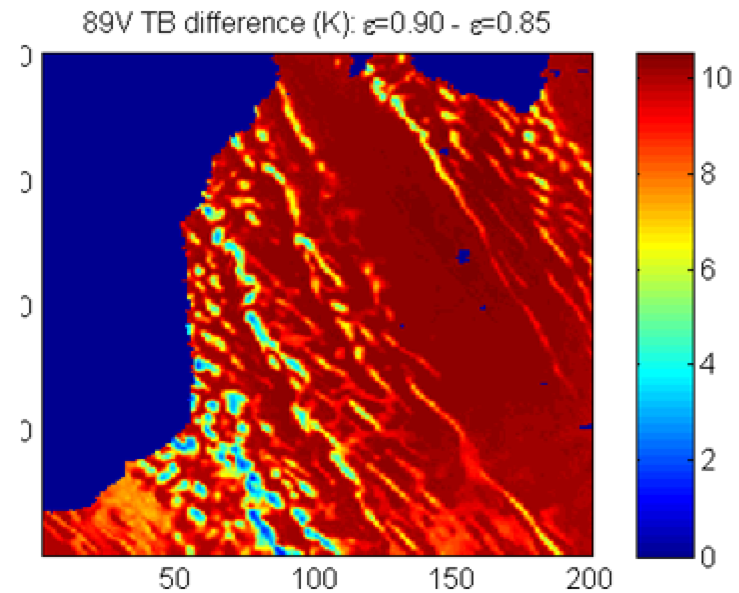
Moist: V = 60 mm

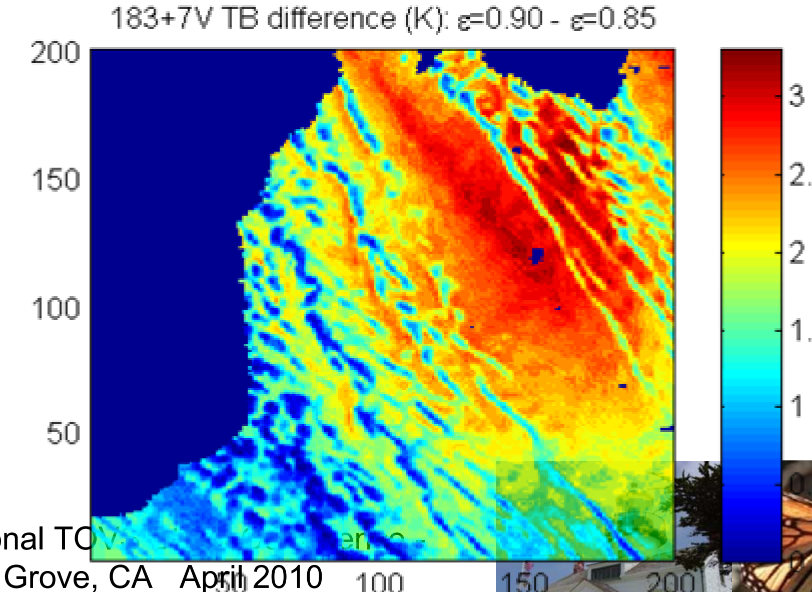


Sensitivity on Retrievals

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

- Examination of lake effect snow bands from C3VP
- Impacts of incorrect є
  - 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)

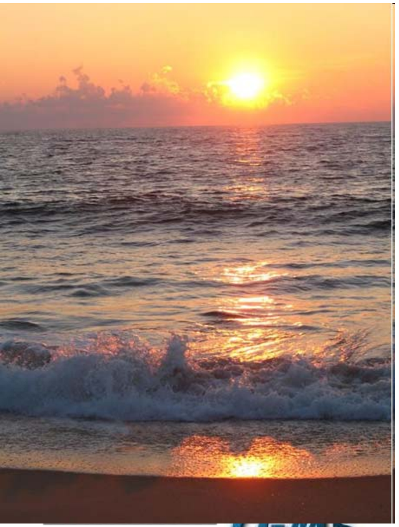


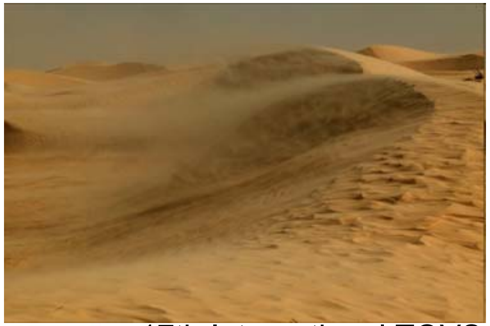


Study Domain

A diverse set of targets were selected:

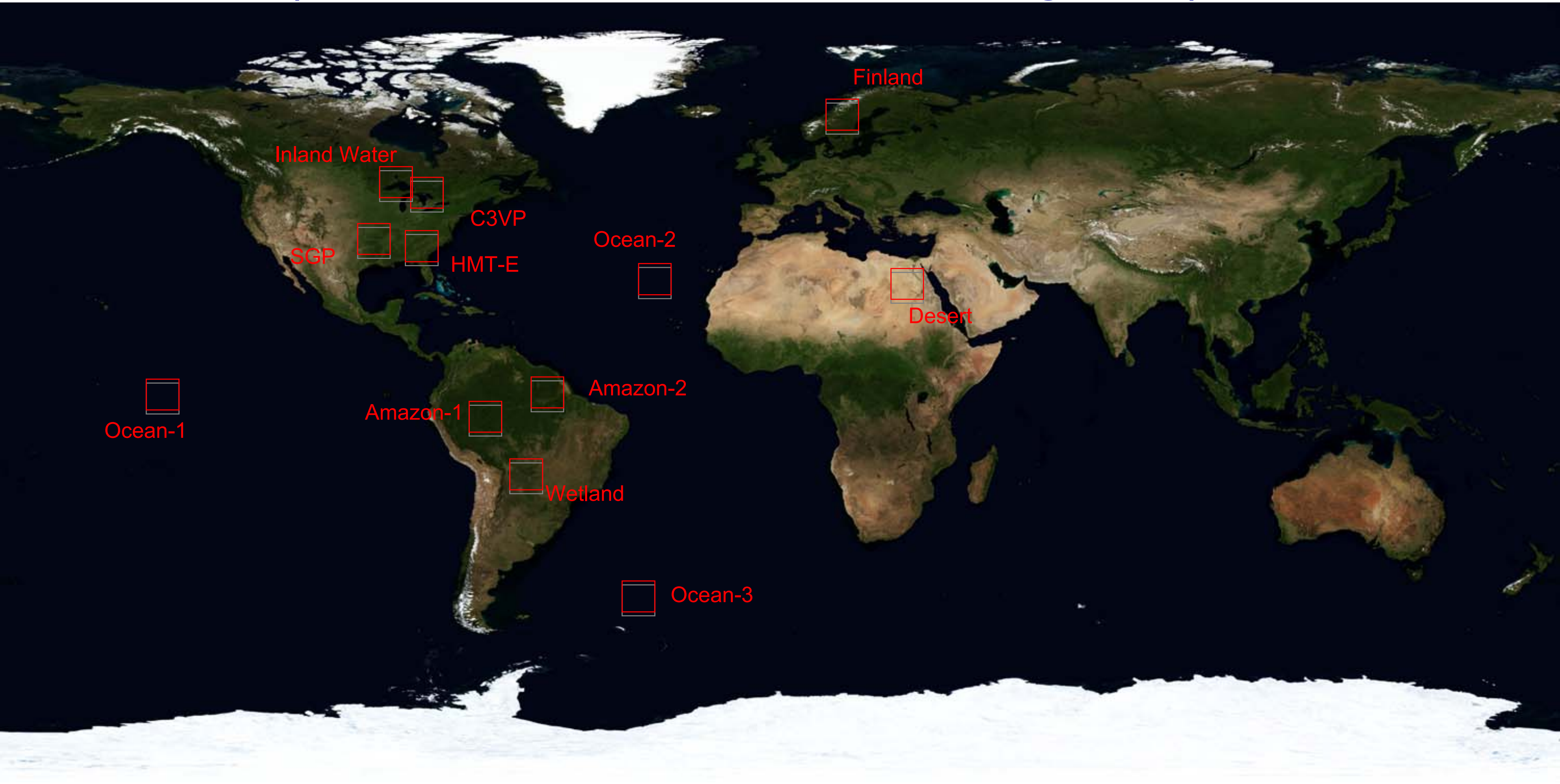
- **C3VP –** 44 N, 80 W
- **Amazon(2) –** 7 S, 70 W and 2 N, 55 W
- **Open Ocean(3) –** 0 N, 150 W; 35 N, 30 W; 45 S, 35 W
- **Desert –** 22 N, 29 E
- **SGP** – 35 N, 97 W
- **Inland Water –** 48 N, 87 W
- **SE US (HMT-E)** - 34 N, 81 W
- **Wetland surface** - 18 S, 57 W
- **Finland –** 60 N, 25 E





GPM Land Surface Working Group (LSWG) Study Sites

(Some obtained from ITWG Land Working Group)

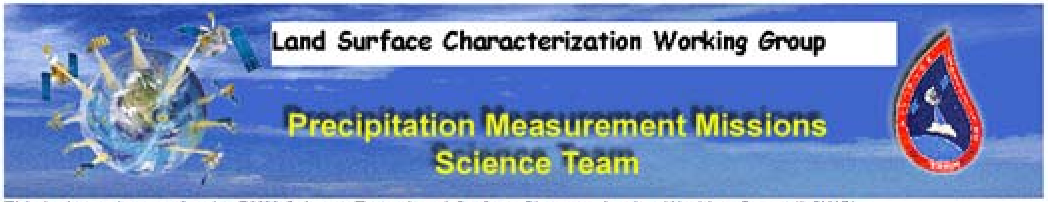


Study Parameters

- 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, CMORPH
  - Model
    - GDAS, LSM, JCSDA Emissivity
- Participants generate ϵ “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, rain, etc.

Study Web Page

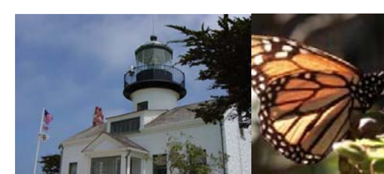
http://cics.umd.edu/~rferraro/LSWG.html



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



Emissivity Estimates Received

Algorithm	Sensor(s)	Targets	Algorithm Type
NESDIS (Boukabara)	AMSR-E; AMSU/MHS	All	1DVAR
GSFC (Wang & Skofronick-Jackson)	AMSU/MHS SSMIS	C3VP	Physical (remove atm.)
CICS (Wang/Gopalan)	AMSR-E; TMI	Amazon	Physical (remove atm.)
LSM/CRTM (Peters-Lidard/Harrison)	AMSR-E; AMSU SSM/I	All	Physical – surface from LSM, GDAS and CRTM
NRL (Turk/Li)	WindSat	All	Physical – surface from satellite, MLE
CNRS (Prigent)	AMSU; SSM/I	All	Physical (remove atm.)
Meteo-France (Karbou)	AMSU; SSM/I	All	Physical (remove atm.)

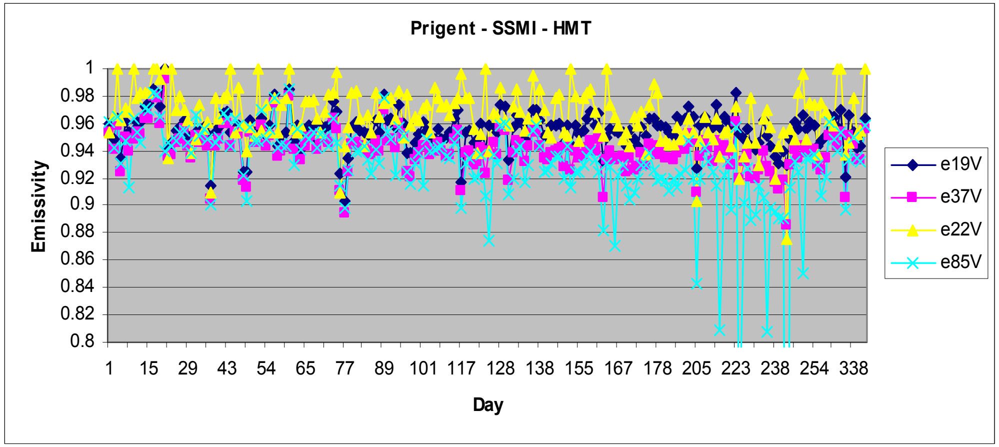
Some results…caveats

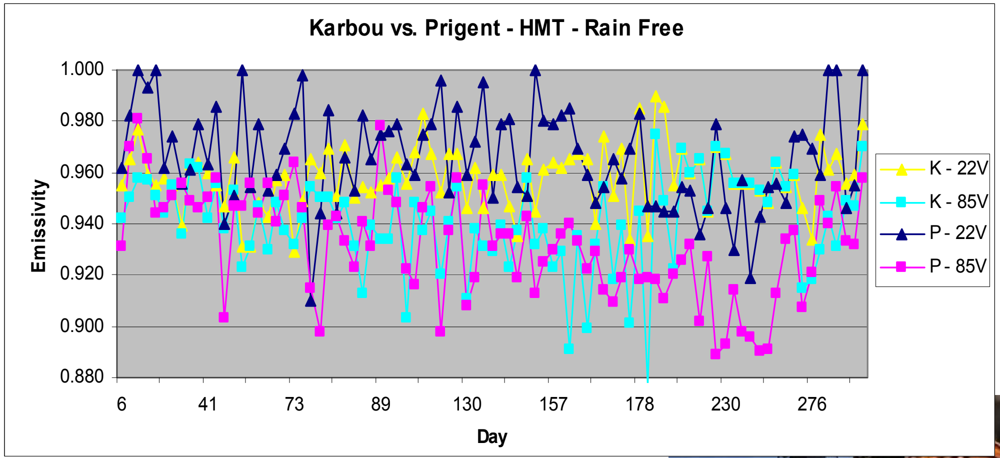
- Not truly an "apples to apples" comparison
  - Not all estimates used exactly the same set of satellites or our input data
  - Some estimates are 1 degree areal average some are center of the box
  - Some give exact observation time, some 12 hour increments, …
    - Did daily averages for all sensor types
- My inefficiencies in computer programming and database management
- Goal - NOT trying to determine which estimate is the best, rather, where they are similar and where they are not

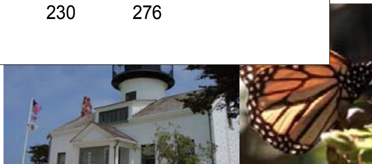
HMT-E Site – SSM/I

		PRIGENT							KARBOU						
		e19V	e19H	e22V	e37V	e37H	e85V	e85H	e19V	e19H	e22V	e37V	e37H	e85V	e85H
HMT (ALL)	MEAN	0.955	0.935	0.965	0.941	0.924	0.929	0.913	0.956	0.938	0.957	0.949	0.935	0.941	0.925
HMT (ALL)	STD	0.013	0.013	0.020	0.015	0.014	0.049	0.054	0.012	0.019	0.014	0.013	0.022	0.023	0.037
HMT (No Rain)	MEAN	0.954	0.934	0.966	0.939	0.923	0.932	0.915	0.956	0.938	0.958	0.949	0.934	0.941	0.924
HMT (No Rain)	STD	0.013	0.013	0.019	0.014	0.014	0.021	0.022	0.010	0.017	0.012	0.012	0.021	0.018	0.029

- This is a site with annual cycle in vegetation, some winter snowfall
- All data
  - Similarity 19VH & 37VH
  - Prigent saturation @ 22V
  - Response to rain evident
- Rain free data
  - Data are in closer agreement, mean & Std.
  - Still see daily variations up to 5%



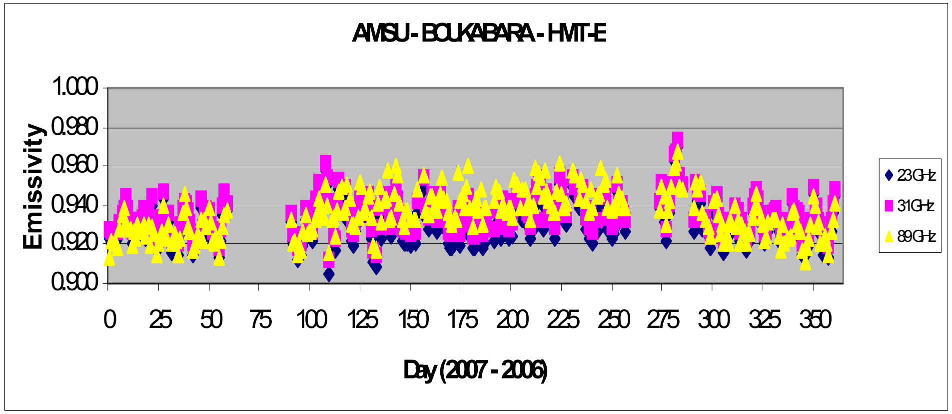


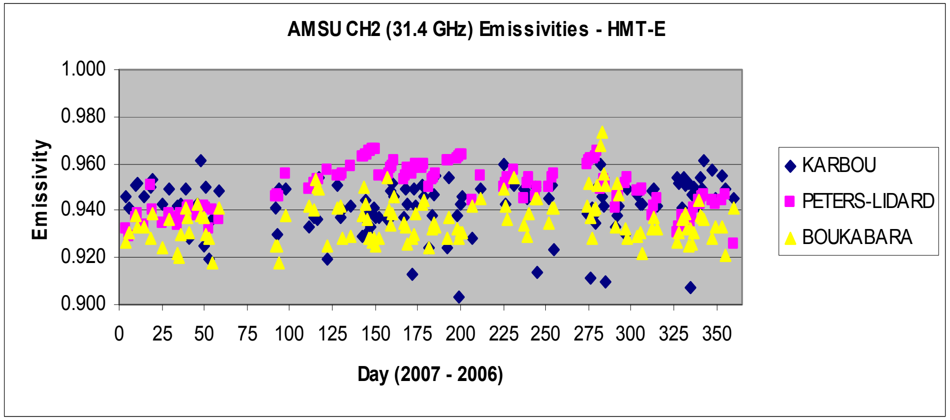


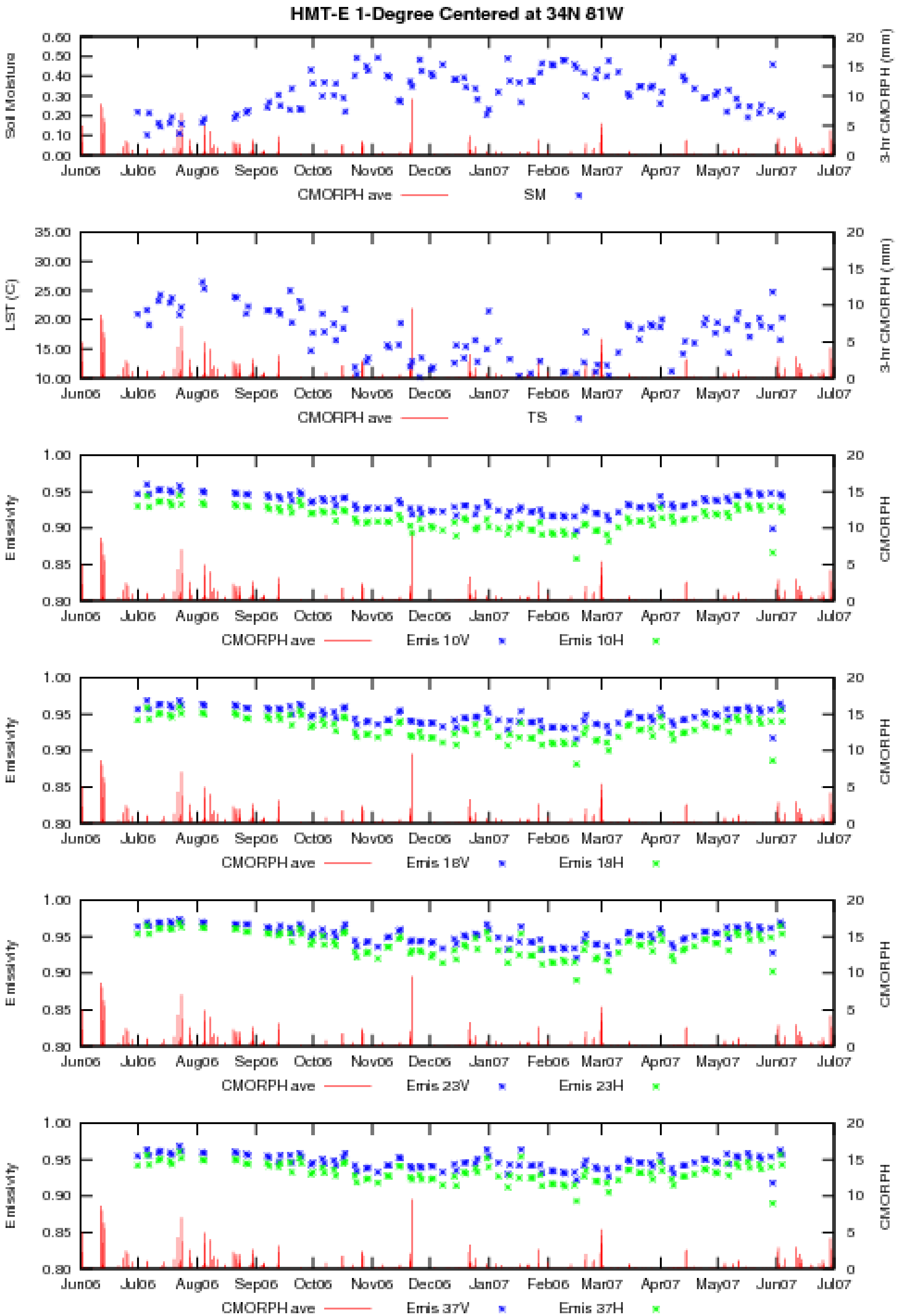
HMT-E Site – AMSU

		KARBOU				PETERS-LIDARD				BOUKABARA			
		e23	e31	e50	e89	e23	e31	e50	e89	e23	e31	e50	e89
HMT (ALL)	MEAN	0.942	0.943	0.943	0.944	0.942	0.948	0.958	0.950	0.930	0.935	0.930	0.935
HMT (ALL)	STD	0.012	0.011	0.016	0.028	0.012	0.010	0.008	0.003	0.010	0.010	0.011	0.011
HMT (No Rain)	MEAN	0.941	0.942	0.945	0.951	0.944	0.950	0.959	0.950	0.931	0.936	0.931	0.936
HMT (No Rain)	STD	0.012	0.011	0.013	0.011	0.011	0.010	0.007	0.001	0.010	0.009	0.011	0.011

- All data
  - K and P-L similar at 23 and 31 GHz
  - B lower than K and P-L
  - Other differences noted
- Rain free data
  - Not much difference in P-L and B (and K, accept at 89 GHz)







HMT-E Site
34N 81W

Soil Moisture

1 Jun 2006-1 Jul 2007

Land Sfc Temperature

Red impulses indicate 3-hourly CMORPH accumulated precipitation average

10V 10H Emissivity

18V 18H Emissivity

23V 23H Emissivity

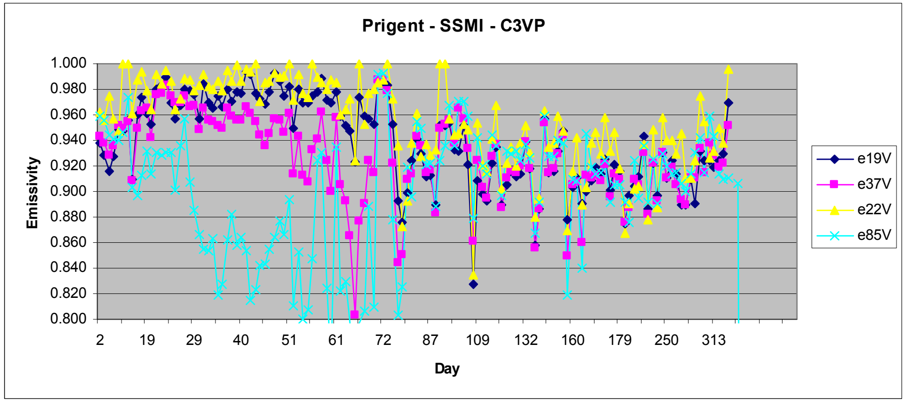
37V 37H Emissivity

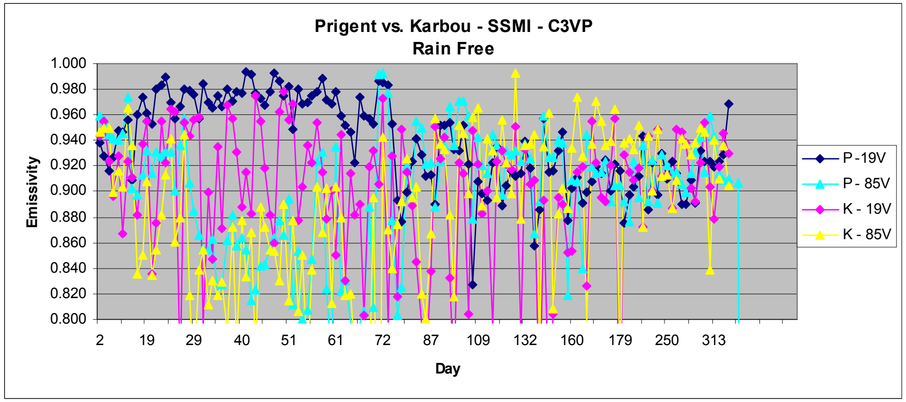
ational TOVS Study Conference -
ific Grove, CA April 2010

C3VP Site – SSM/I

		PRIGENT							KARBOU						
		e19V	e19H	e22V	e37V	e37H	e85V	e85H	e19V	e19H	e22V	e37V	e37H	e85V	e85H
C3VP(ALL)	MEAN	0.914	0.861	0.932	0.912	0.870	0.916	0.879	0.893	0.830	0.901	0.903	0.848	0.912	0.862
C3VP (ALL)	STD	0.020	0.027	0.030	0.022	0.031	0.026	0.044	0.062	0.113	0.062	0.057	0.122	0.053	0.118
C3VP (No Rain)	MEAN	0.924	0.861	0.939	0.914	0.867	0.906	0.868	0.891	0.809	0.896	0.893	0.825	0.897	0.837
C3VP (No Rain)	STD	0.031	0.032	0.034	0.031	0.039	0.049	0.060	0.058	0.101	0.059	0.059	0.113	0.066	0.117

- This is a site with long periods of snowcover and annual vegetation changes
- Snow cover evident in 37 and 85 GHz by P and K
- K tends to be lower and more variable – Great Lakes influence in my processing; needs to be redone correctly…

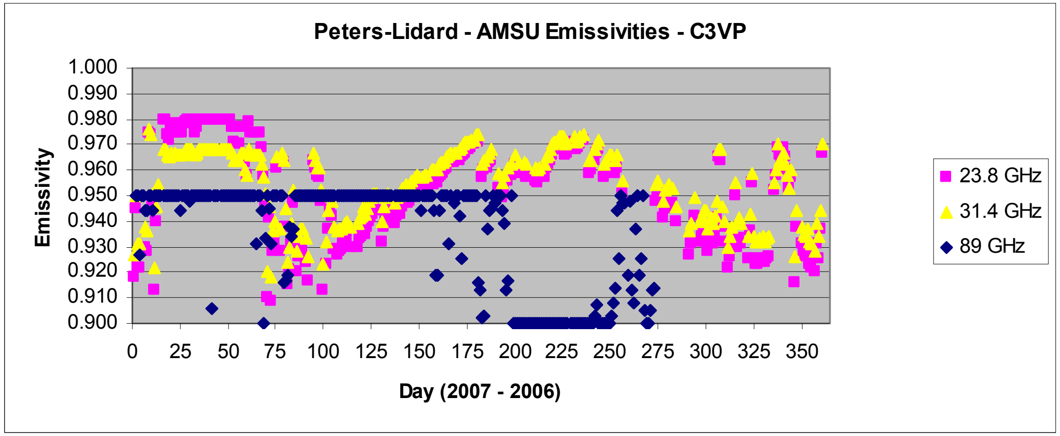


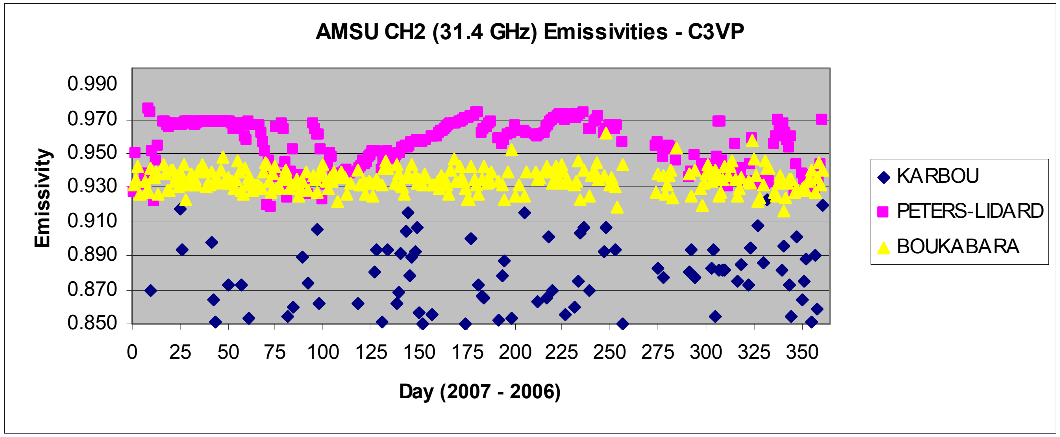


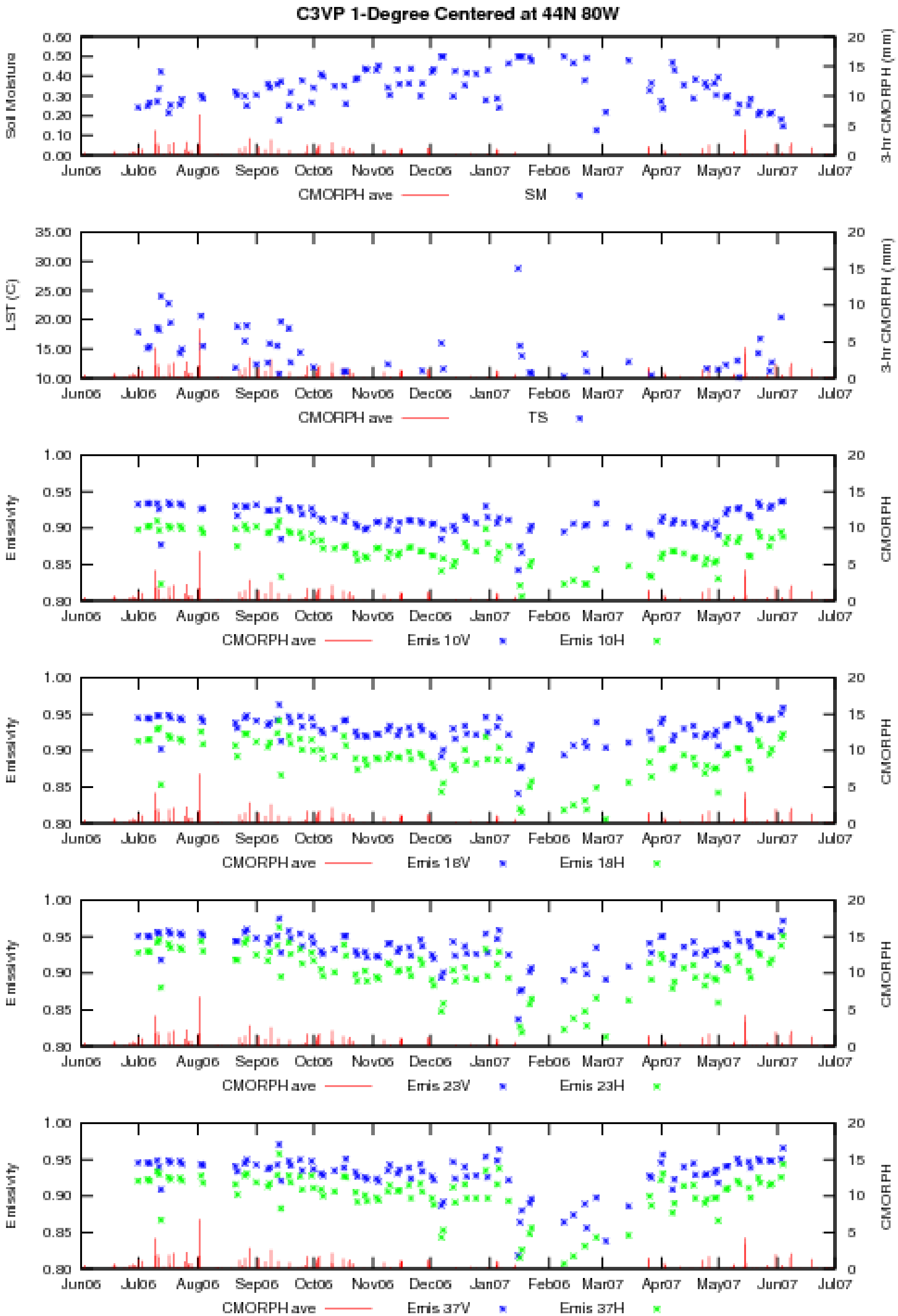
C3VP Site – AMSU

		KARBOU				PETERS-LIDARD				BOUKABARA			
		e23	e31	e50	e89	e23	e31	e50	e89	e23	e31	e50	e89
C3VP(ALL)	MEAN	0.830	0.839	0.866	0.888	0.946	0.952	0.959	0.944	0.932	0.936	0.921	0.915
C3VP (ALL)	STD	0.060	0.058	0.049	0.042	0.017	0.015	0.010	0.013	0.008	0.008	0.008	0.008
C3VP (No Rain)	MEAN	0.813	0.821	0.842	0.847	0.955	0.954	0.943	0.920	0.931	0.935	0.921	0.916
C3VP (No Rain)	STD	0.059	0.057	0.051	0.057	0.023	0.015	0.012	0.022	0.007	0.006	0.007	0.008

- Large variations between estimates
  - View angle handling?
  - B is N18 only
  - Water/Ice contamination in K
- B shows least variability
- Some issue with P-L 89 GHz







Soil Moisture

C3VP Site

44N 80W

Land Sfc Temperature

1 Jun 2006-1 Jul 2007

Red impulses indicate 3-hourly CMORPH accumulated precipitation average

10V 10H Emissivity

18V 18H Emissivity

23V 23H Emissivity

37V 37H Emissivity

Summary and Future

- The advancement of precipitation over land in GPM-era must consider
  - Accurate surface characterization 6 – 200 GHz under all weather conditions
  - Understanding of the sensitivity of the retrievals over all surface types and frequency range
- PMM Science Team intercomparison study
  - Preliminary results indicate similarities and differences between the different methods
    - Early hope that they will all be “about the same” is likely not true – we have a lot of work to do!
- Future
  - A lot more work to do - we need your help!
  - How can ITWG work with IPWG and GPM communities?
    - Let’s try to develop a joint emissivity model for 6 – 200 GHz under all weather conditions
    - Come to IPWG#5 - Hamburg, Germany, 11-15 October 2010
    - Come to GPM algorithm team meeting – May 2010, College Park, MD

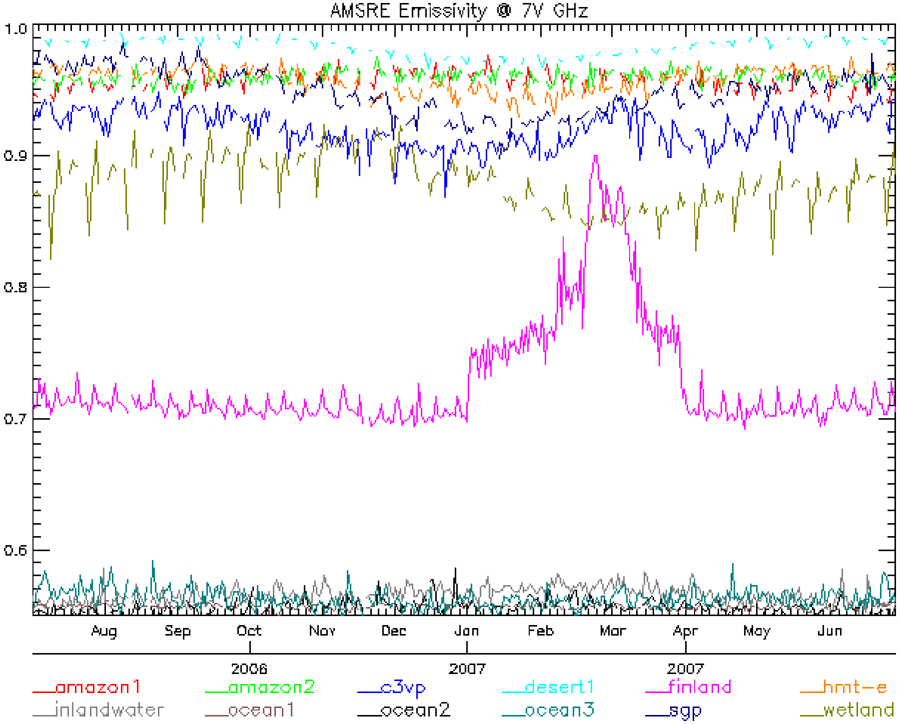
Backup Slides

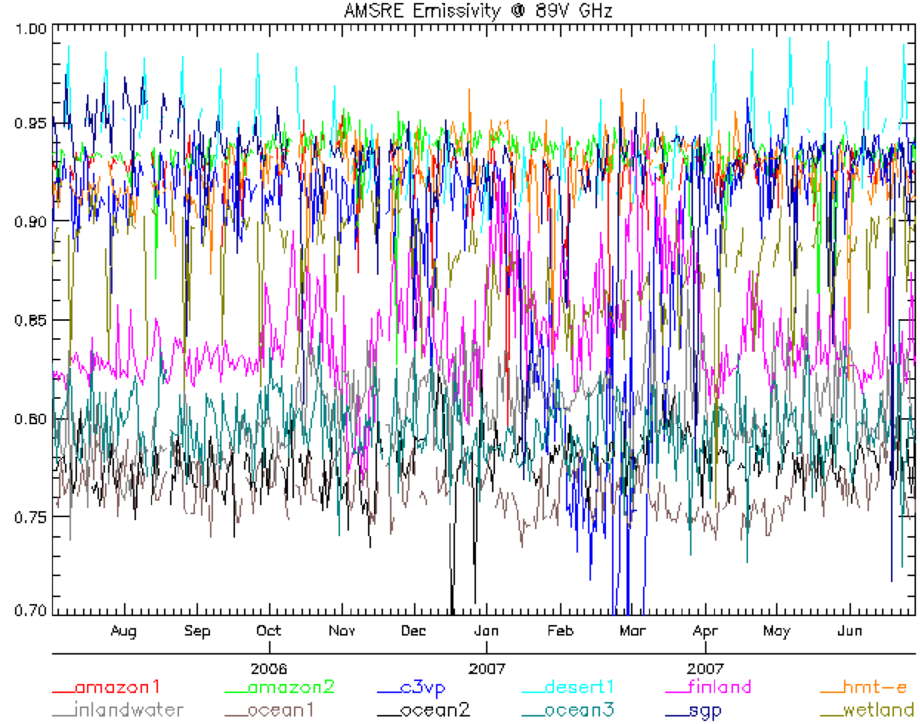
Further results not shown due to time constraints

Credits – Turk (JPL), Peters-Lidard (NASA), Boukabara (NOAA), J. Wang (NASA), N. Wang (ESSIC)

MIRS Results – AMSR-E

Results courtesy of S. Boukabara/W. Chen



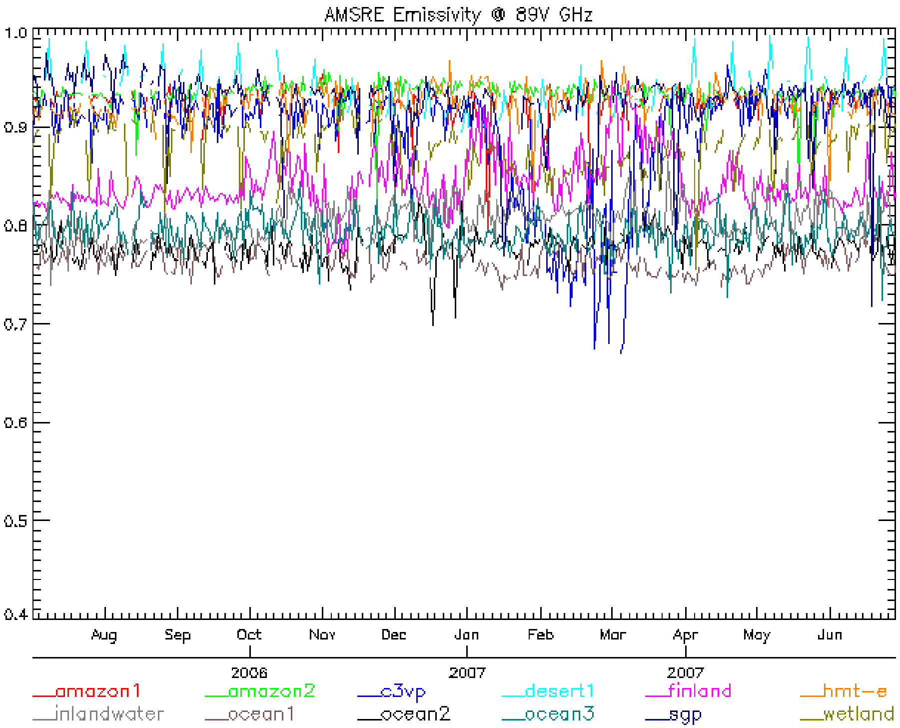


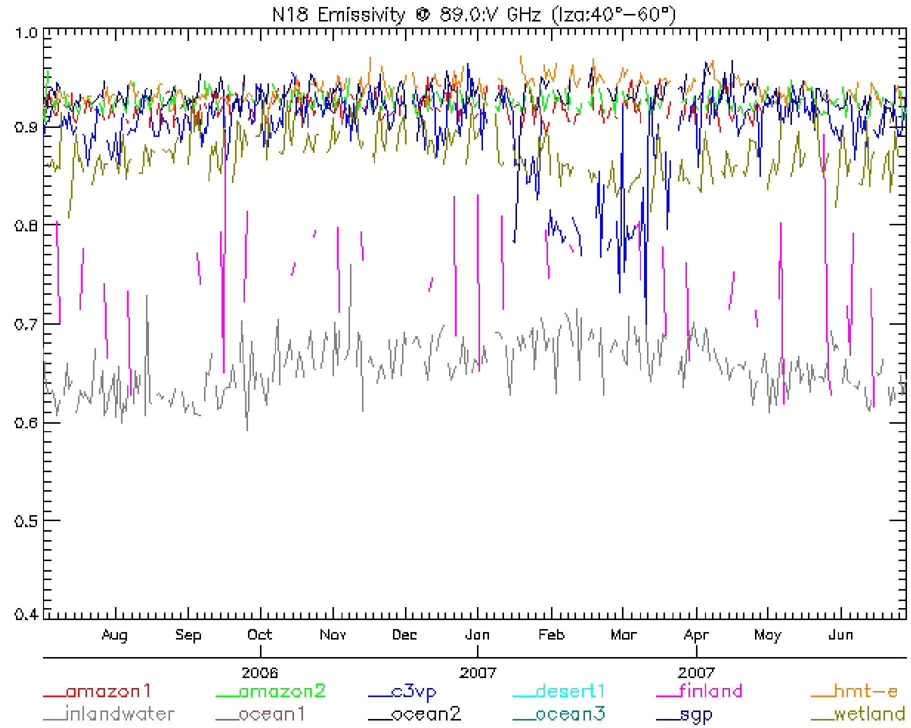
- 6.9V: relatively small interannual Variability EXCEPT:
  - Finland in winter
  - C3VP in winter
  - SGP due to vegetation/lack of it
  - Wetlands in fall

- 89V: highly variable for most sites

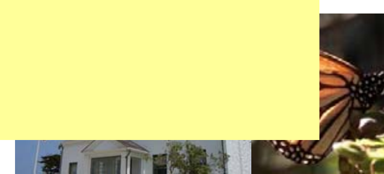
MIRS Results – AMSU vs. AMSR-E

Results courtesy of S. Boukabara/W. Chen

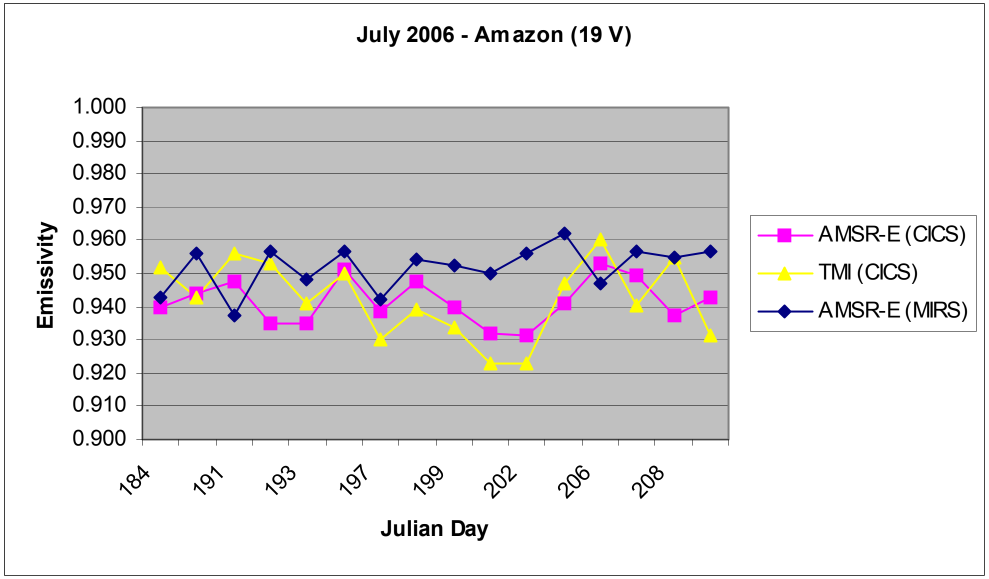




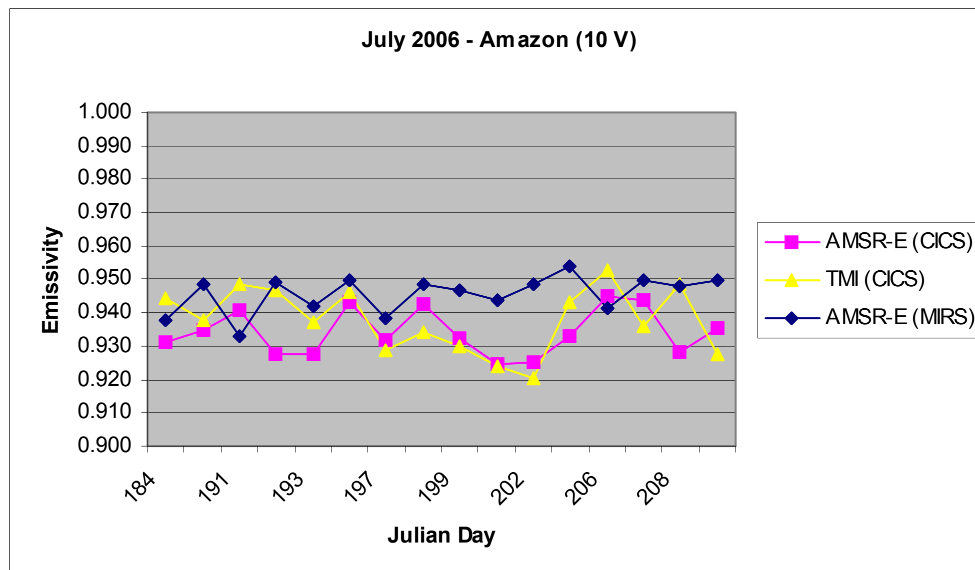
- AMSR-E ~50 deg incidence angle, AMSU shown here between 40-60 deg.
- AMSU is also mixed polarization
- Only 5 targets of AMSU data were made available to date
- Similarities:
    - Large annual cycle changes at C3VP and wetland (and magnitudes)
    - Finland is clearer lower than other targets
- Differences: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



Amazon Comparison



Means:
AMSR-E (CICS)=0.942
TMI (CICS)=0.942
AMSR-E (MIRS)=0.952

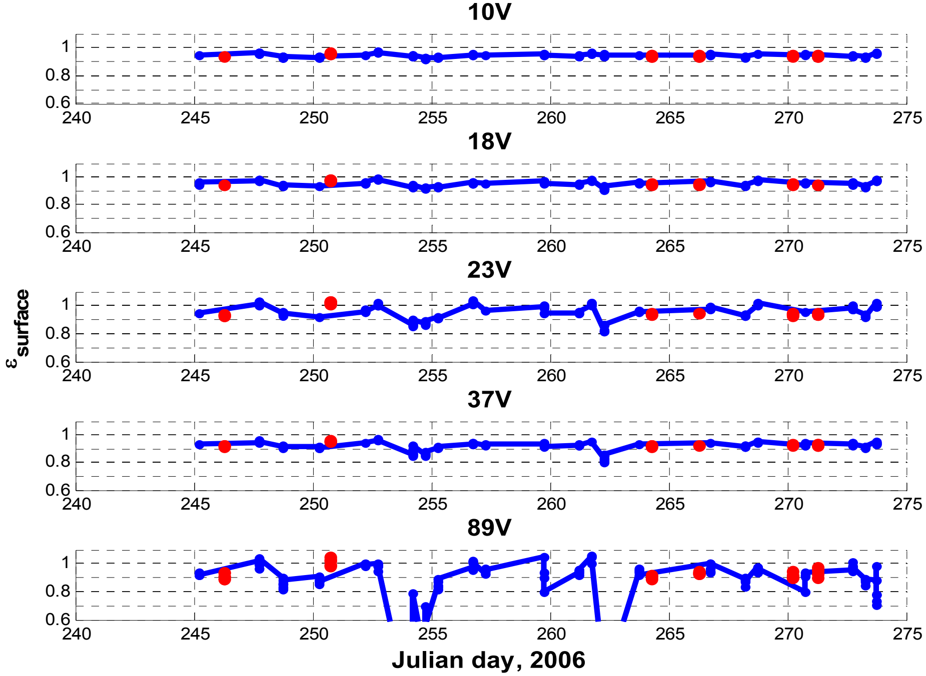


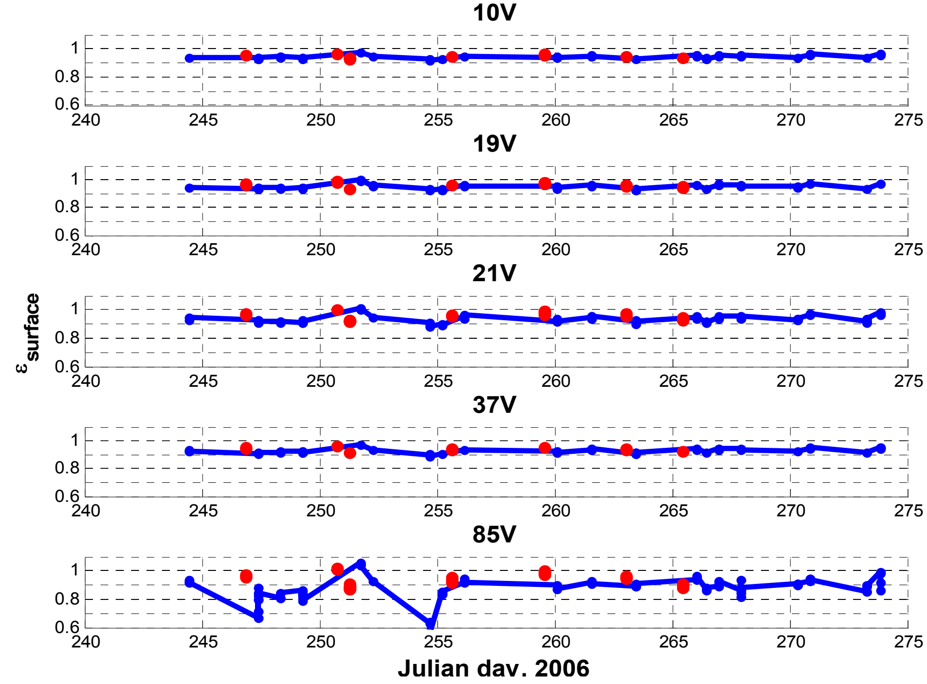
Means:
AMSR-E (CICS)=0.934
TMI (CICS)=0.938
AMSR-E (MIRS)=0.946

CICS - Amazon Target

Clear Sky
Cloudy

AMSR-E | Results courtesy of N-Y. Wang/K. Gopalan | TMI

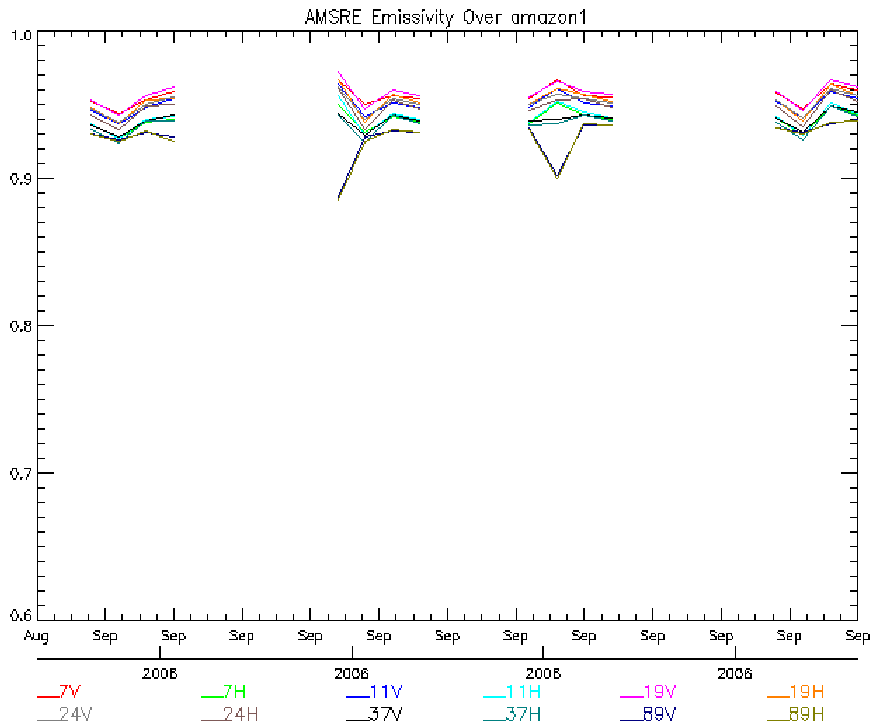


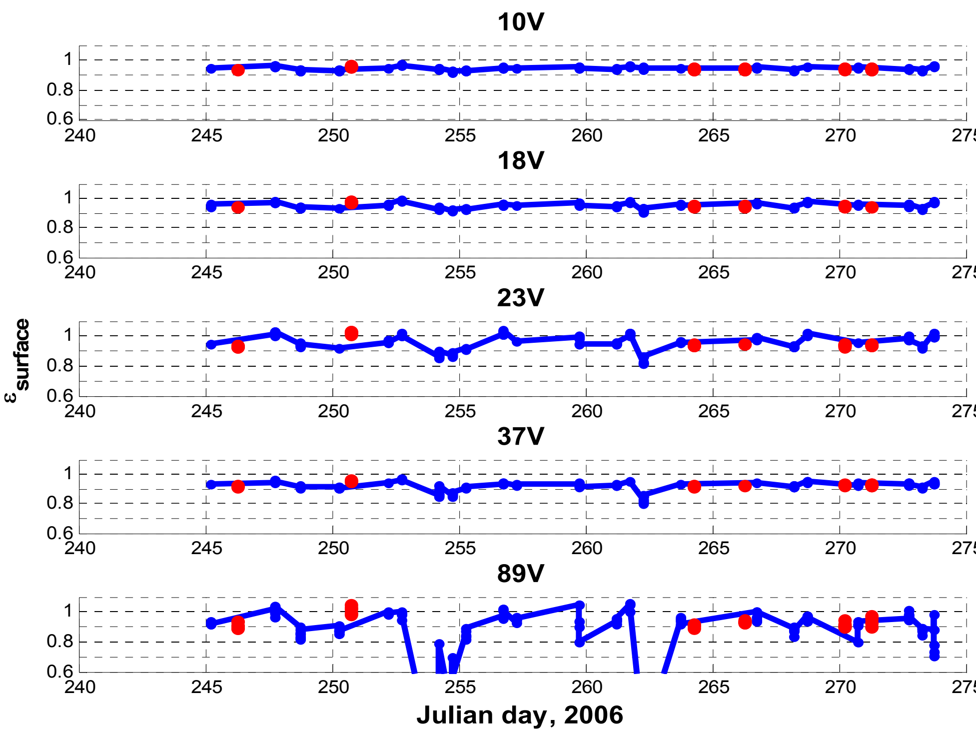


- •37 GHz or less
    - •Reasonable stability of Є over vegetated target
    - •Cloud affects minimal
- •89 GHz
    - •Cloud and precipitation affects dramatic
    - •Similar values during clear conditions

MIRS vs. CICS - Amazon

Results courtesy of S. Boukabara/W. Chen

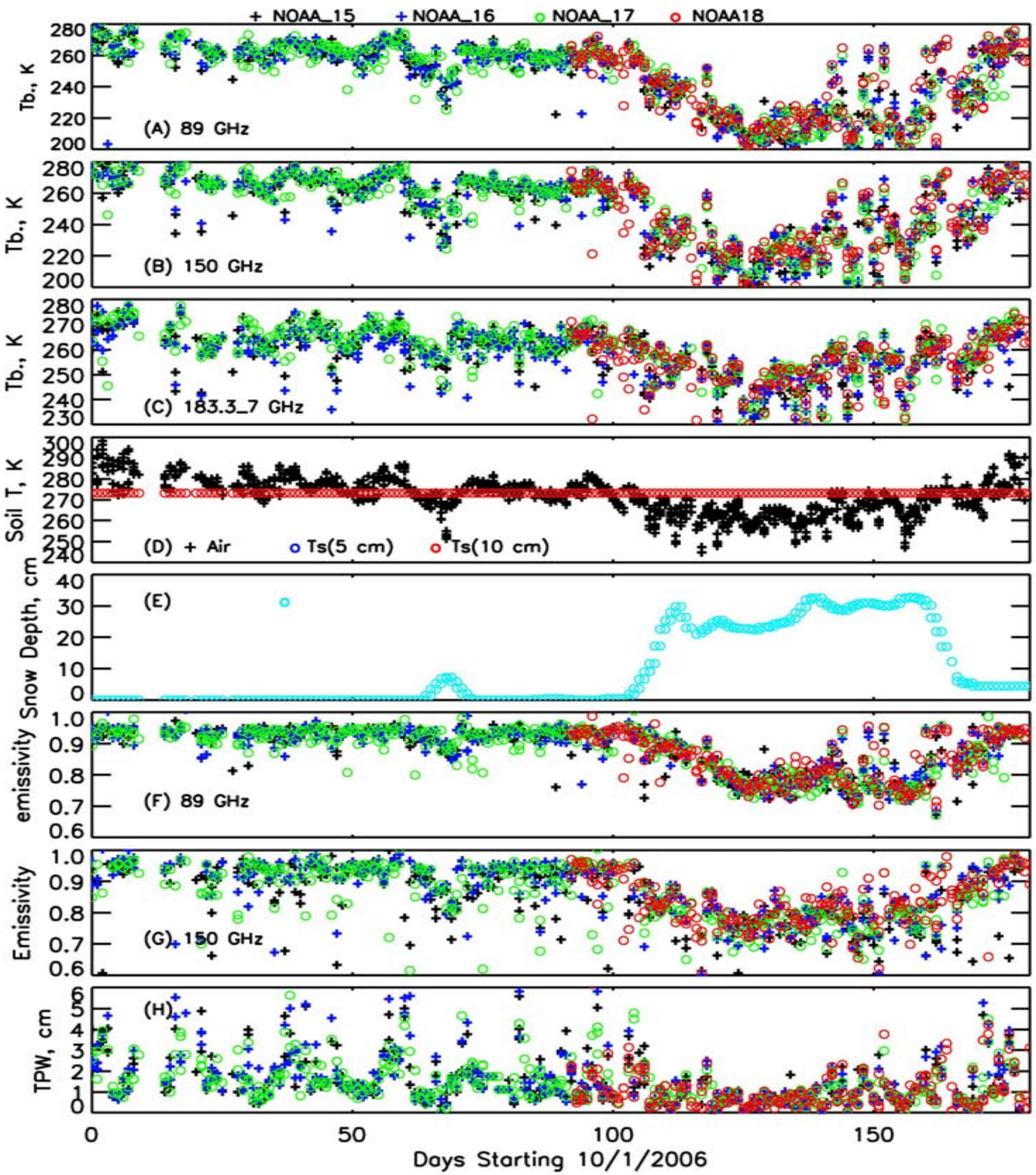




- Very limited data to compare at this time….
- Seems like reasonable agreement in ranges of values – clear sky

NASA – AMSU-B at C3VP

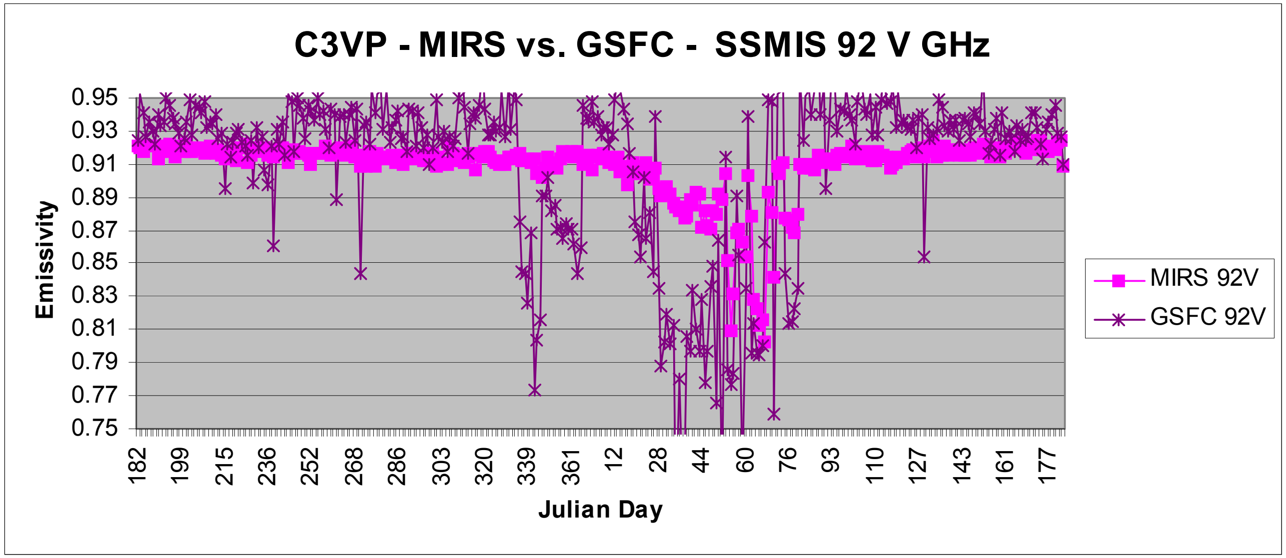
Results courtesy of J. Wang/G. Skofronick-Jackson



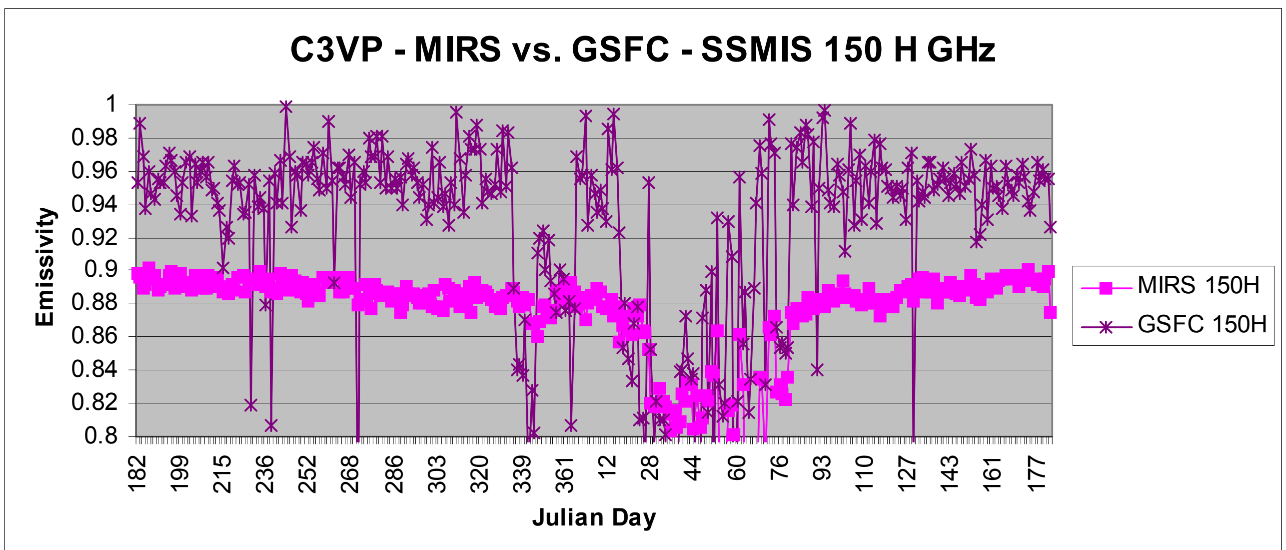
Є89

Є150

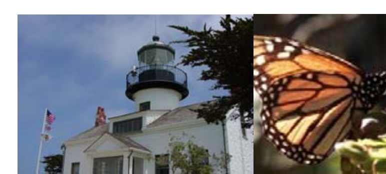
C3VP Comparison



Means:
MIRS=0.913
GSFC=0.911



Means:
MIRS=0.883
GSFC=0.930



C3VP Forward Modeling

AMSU-A 31.4 GHz

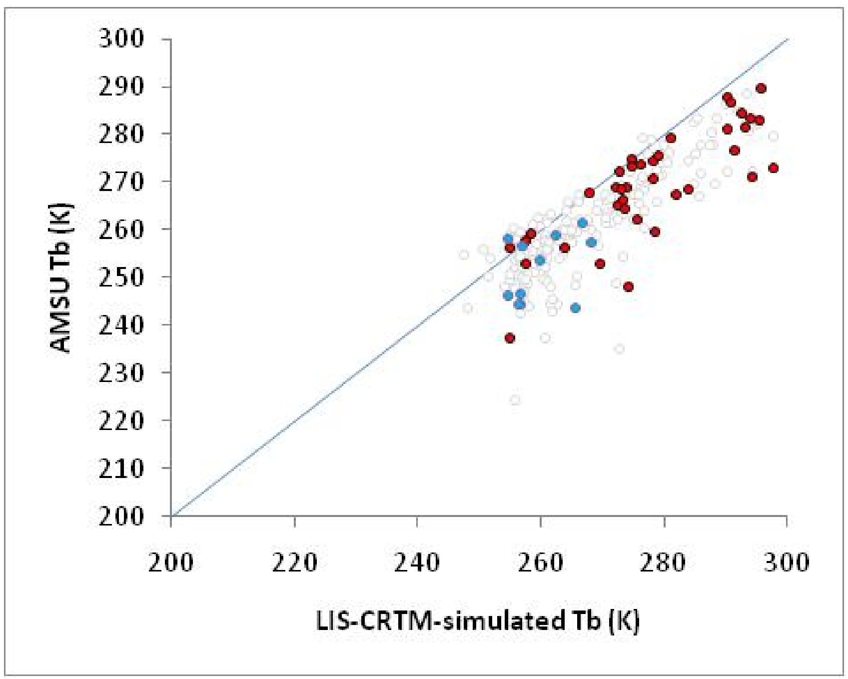
Slide courtesy of
Peters-Lidard, Harrison & Mocko
NASA/GSFC

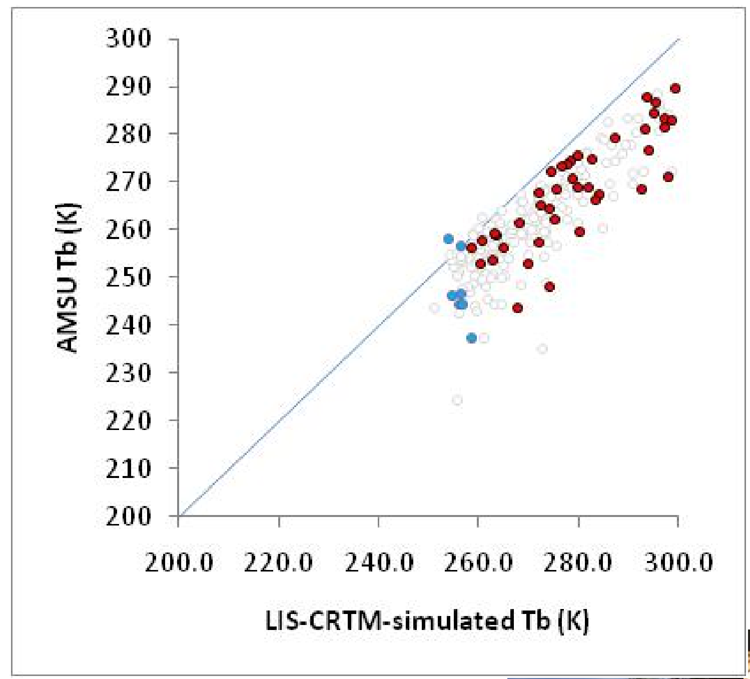
LIS-Catchment-RTM Tb simulation

Std-error (linear regression)	6.00K
Std-error (linear regression)--no snow	6.75K
Std-error (linear regression)--snow	6.69K
Correlation	0.86
Correlation--no snow	0.86
Correlation--snow	0.38

LIS-Noah-CRTM Tb simulation

Std-error (linear regression)	5.68K
Std-error (linear regression)--no snow	6.49K
Std-error (linear regression)--snow	5.68K
Correlation	0.87
Correlation--no snow	0.86
Correlation--snow	-0.70





C3VP Forward Modeling

AMSU-A 31.4 GHz

LIS-Noah-CRTM Time Series

Slide courtesy of
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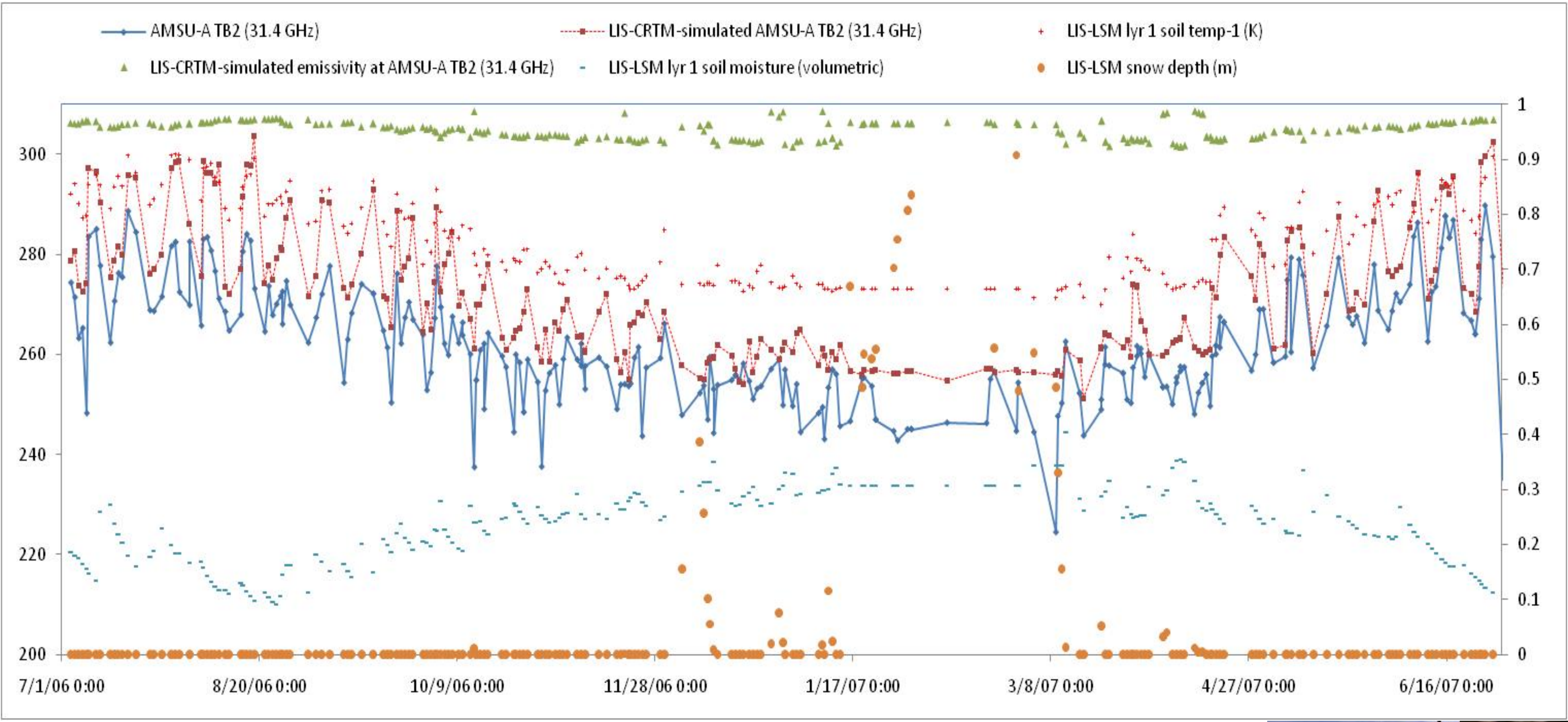


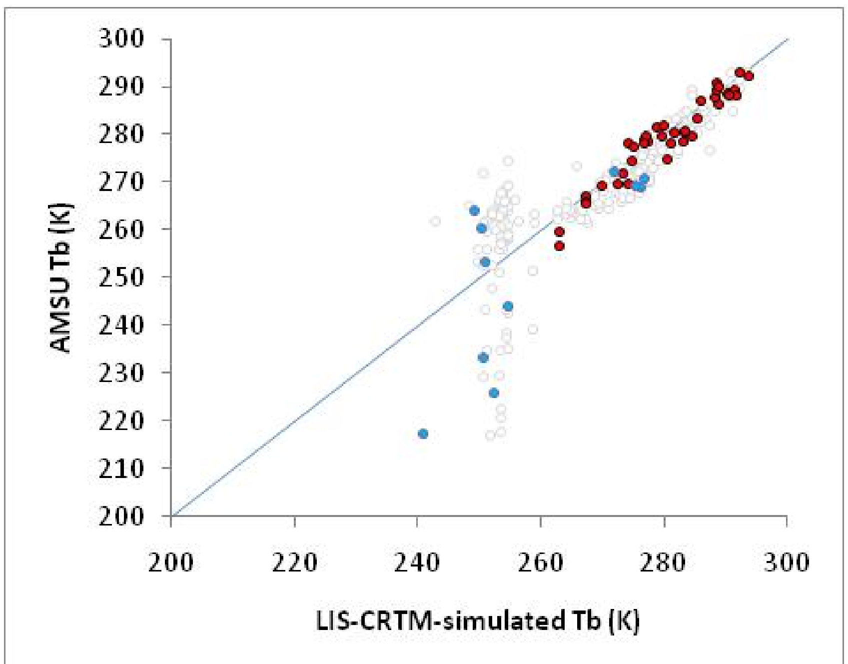
C3VP Forward Modeling

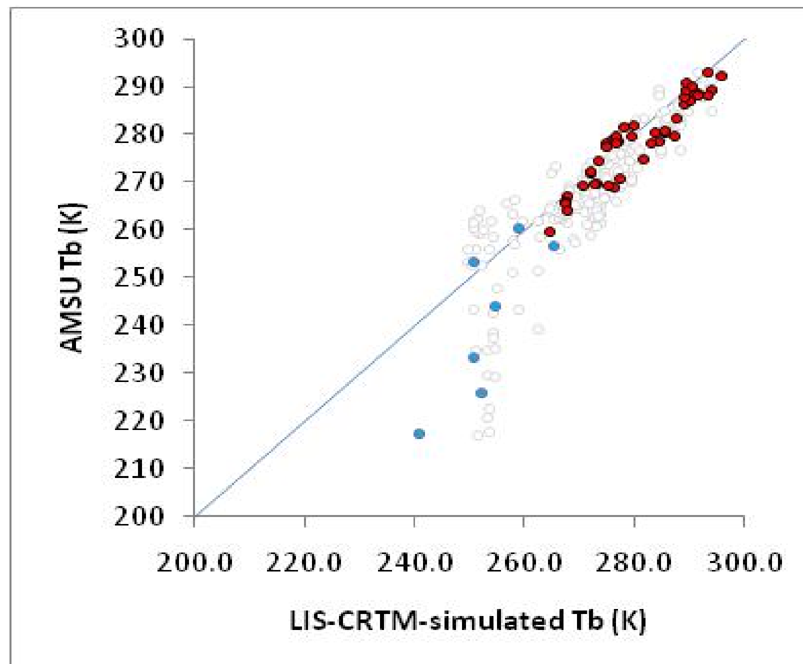
AMSU-B 89 GHz

Slide courtesy of
Peters-Lidard, Harrison & Mocko
NASA/GSFC

LIS-Catchment-CRTM Tb simulation	
Std-error (linear regression)	8.16K
Std-error (linear regression)--no snow	2.58K
Std-error (linear regression)--snow	13.58K
Correlation	0.82
Correlation--no snow	0.92
Correlation--snow	0.75

LIS-Noah-CRTM Tb simulation	
Std-error (linear regression)	7.02K
Std-error (linear regression)--no snow	3.15K
Std-error (linear regression)--snow	10.73K
Correlation	0.87
Correlation--no snow	0.94
Correlation--snow	0.80





C3VP Forward Modeling

AMSU-B 89 GHz

LIS-Noah-CRTM Time Series

Slide courtesy of
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