AMSR-E Algorithm Development Work

- First part of proposal:

    Support Production
    Combined w. TRMM, continue improving ocean algorithm

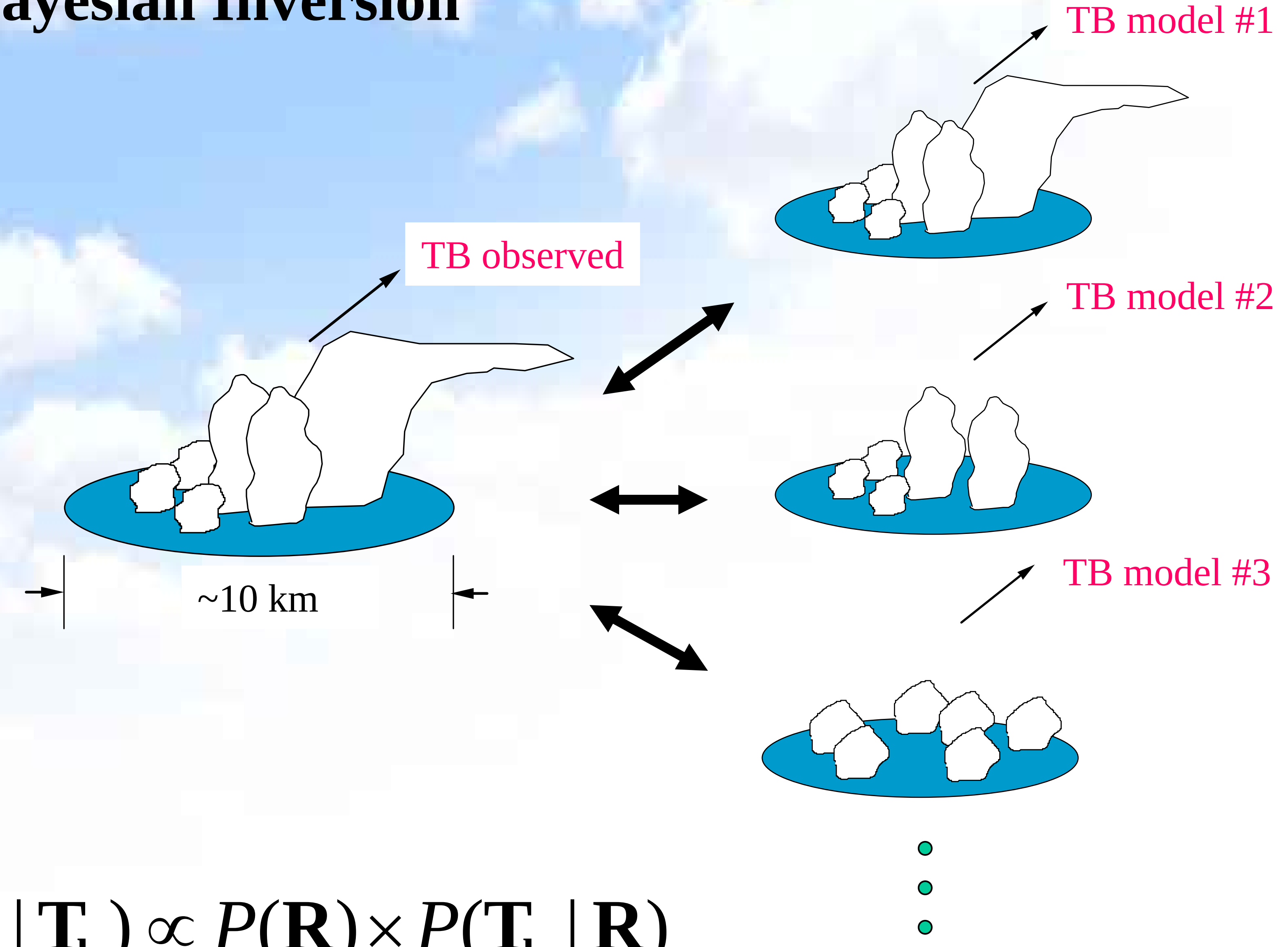
- Second part of proposal

    Work on a more physical land algorithm

~~Cloud resolving Model Database~~

TRMM PR & Model Database

Bayesian Inversion



$$P(\mathbf{R}\,|\,\mathbf{T}_\mathbf{b}) \propto P(\mathbf{R}) \times P(\mathbf{T}_\mathbf{b}\,|\,\mathbf{R})$$

GPROF2008 Algorithm
(All sensors)

Create Data base

Start with observed PR rain profiles and non-raining background

Compute Tb at TMI channels and resolution and compare to observations

Adjust rain profiles to be consistent with PR and TMI

Use adjusted 4 km rain profiles to compute Tb for any sensor

Create Database (raining and non-raining) pixels in 1K SST and 2 mm TPW bins.

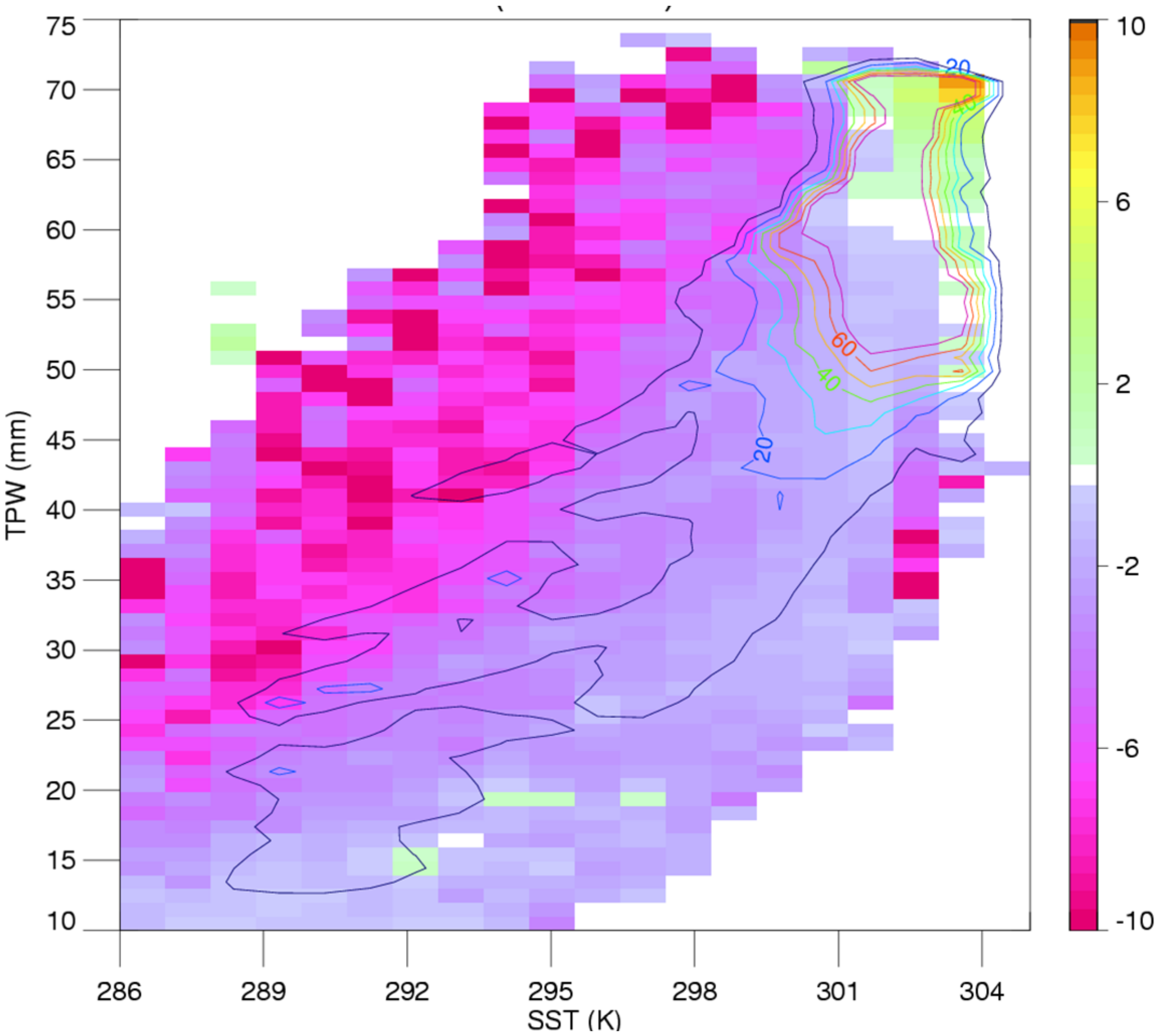
Run Retrieval

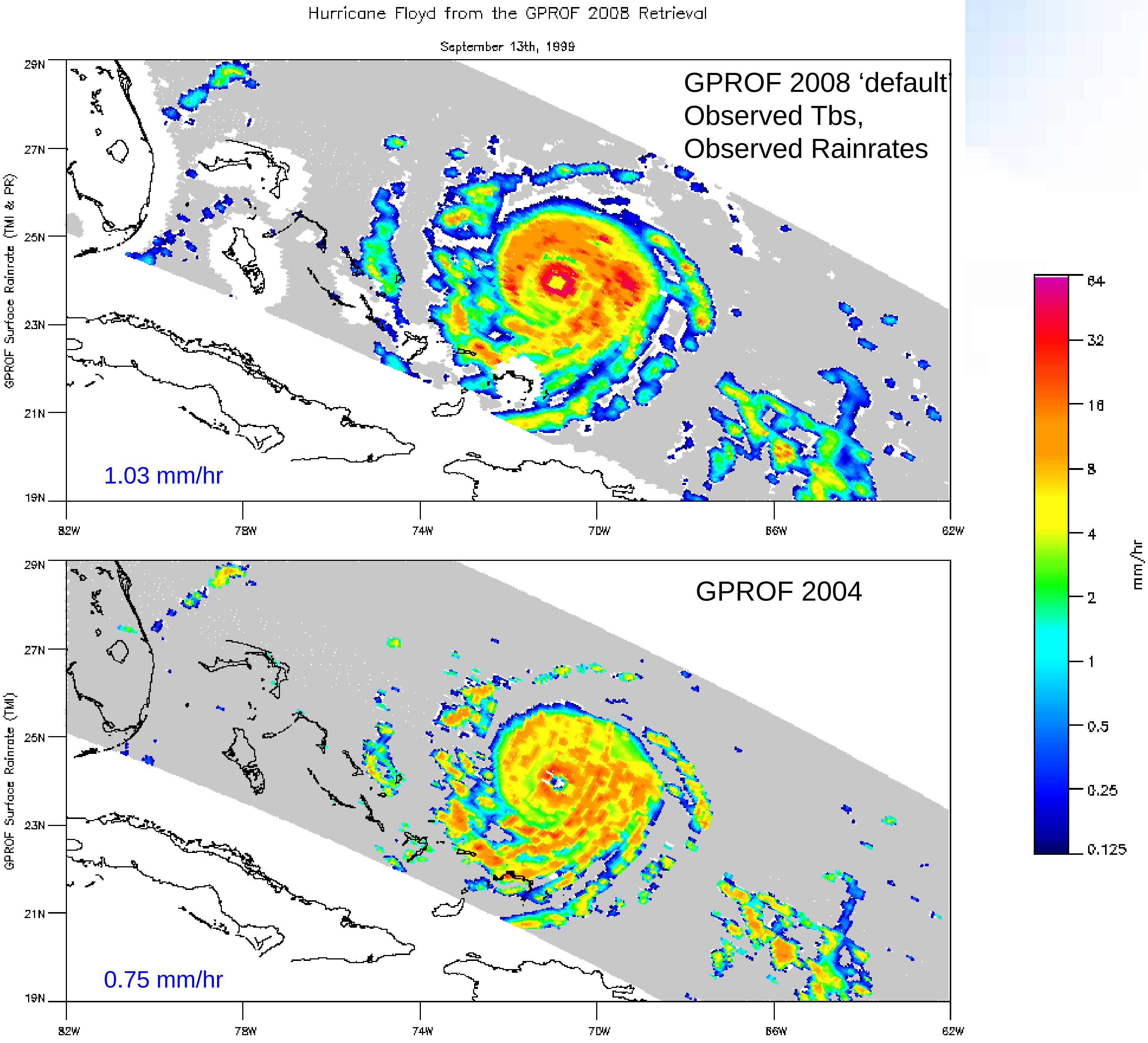
Determine SST & TPW

Compare observed Tb to dbase entries within ±1K (SST) and ±2 mm (TPW)

Weight of profile depending upon rms of channel difference.

19V Tb (Sim-Obs) “default”





GPROF 2008 'default'
Observed Tbs,
Observed Rainrates

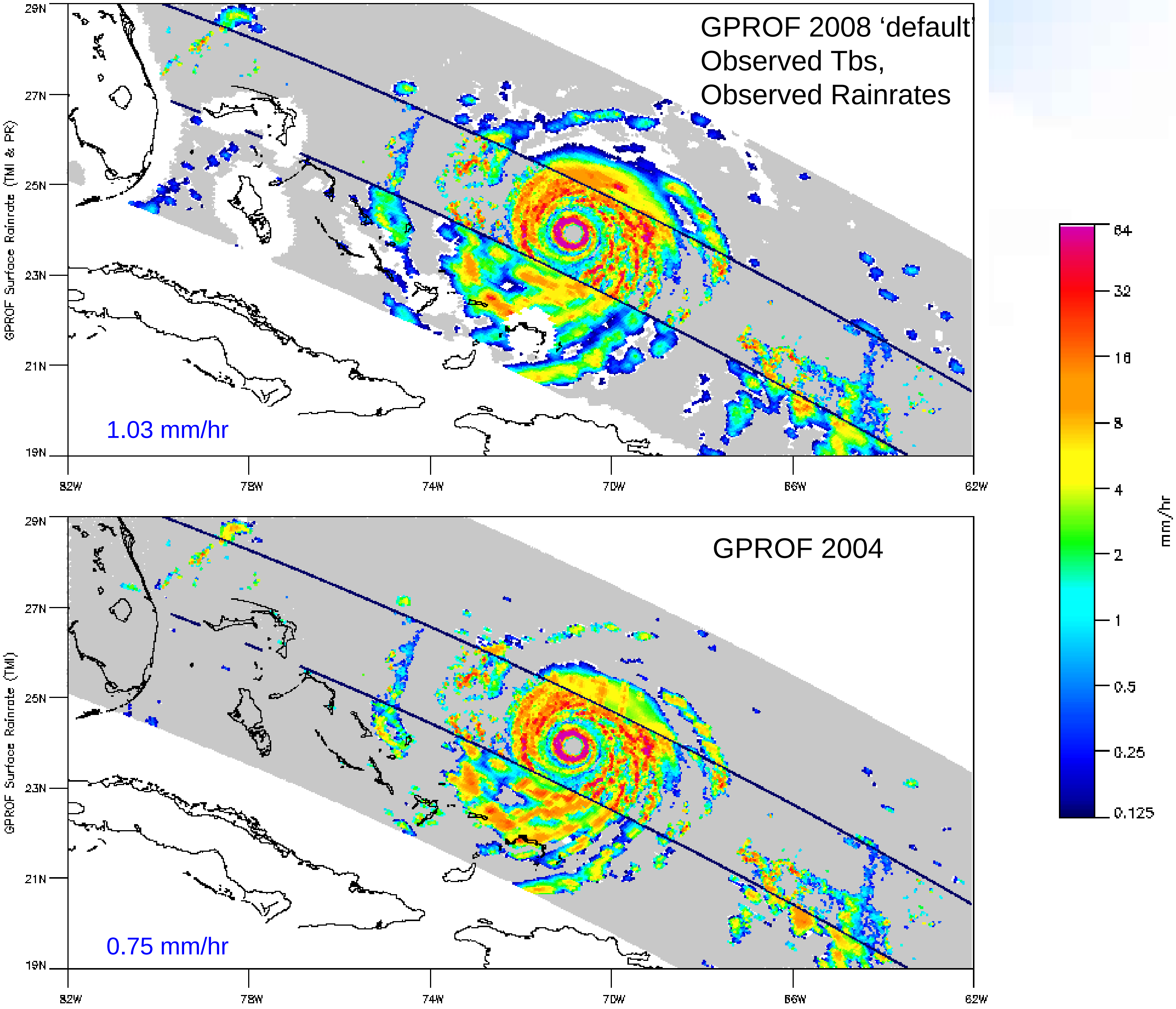
1.03 mm/hr

GPROF 2004

0.75 mm/hr

Hurricane Floyd from the GPROF 2008 Retrieval

September 13th, 1999



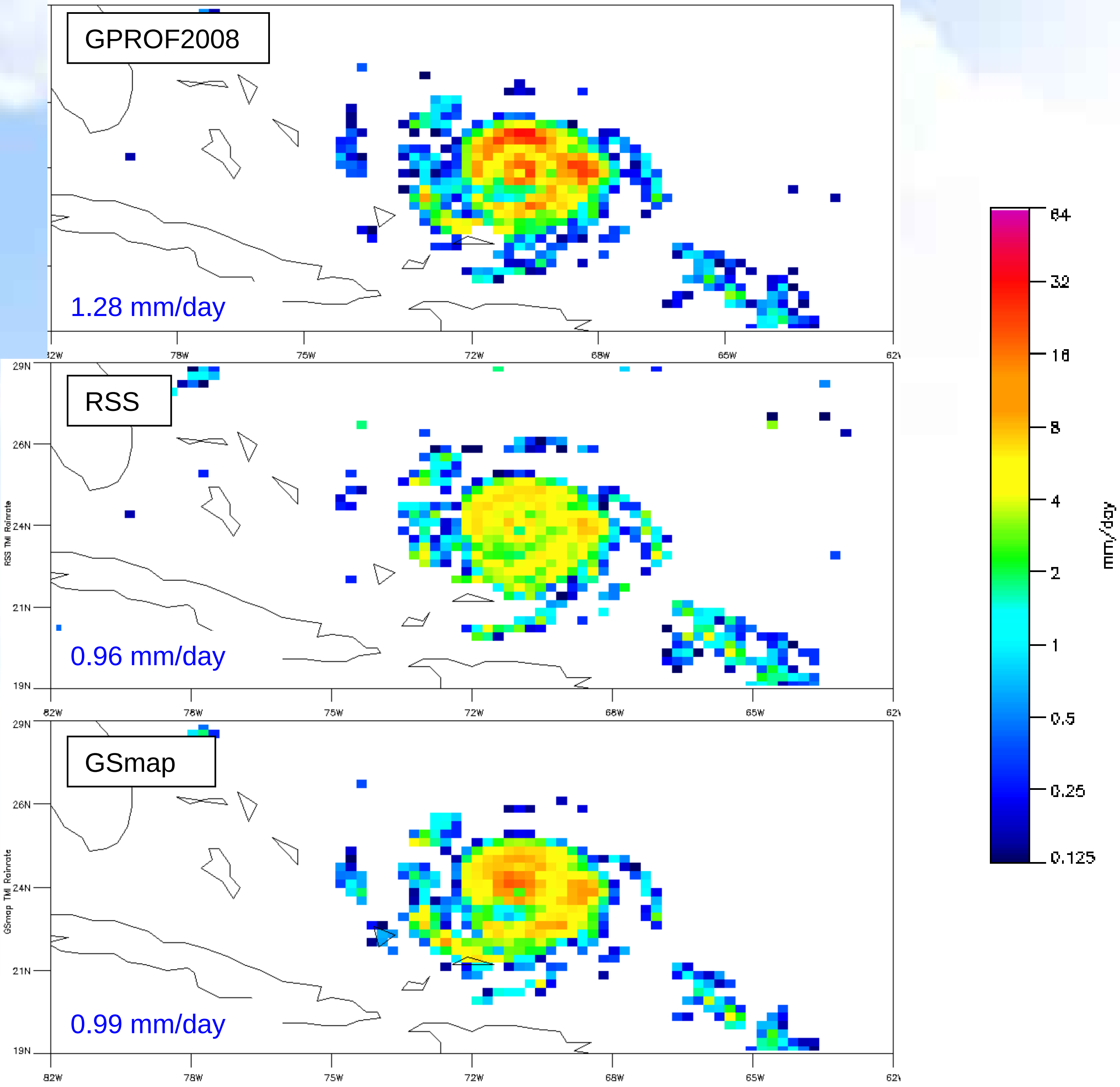
GPROF 2008 ‘default’
Observed Tbs,
Observed Rainrates

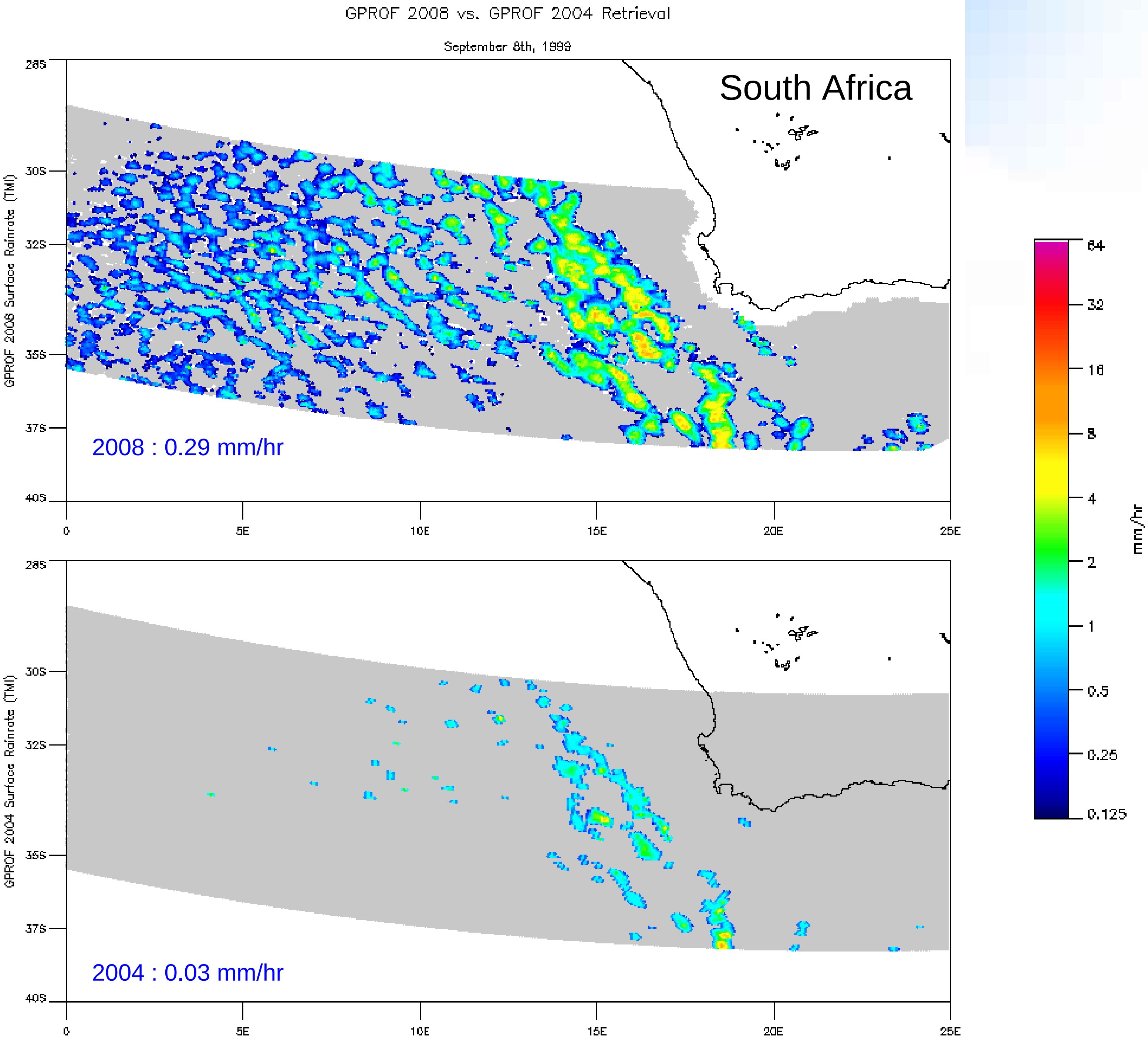
1.03 mm/hr

GPROF 2004

0.75 mm/hr

Hurricane Floyd Sep 3, 1999 TMI Algorithm Comparison 0.25 x 0.25 gridded

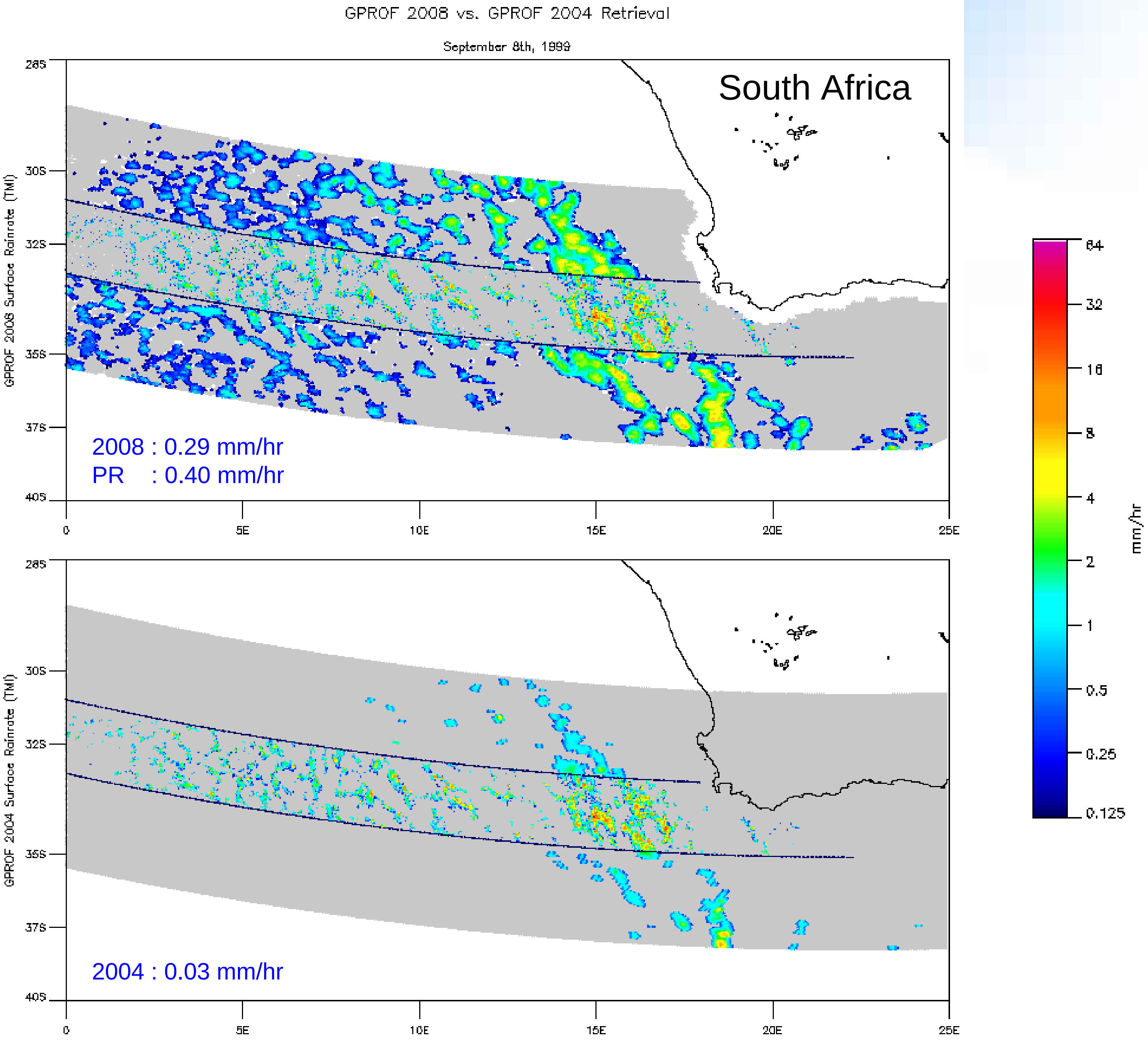




South Africa

2008 : 0.29 mm/hr

2004 : 0.03 mm/hr



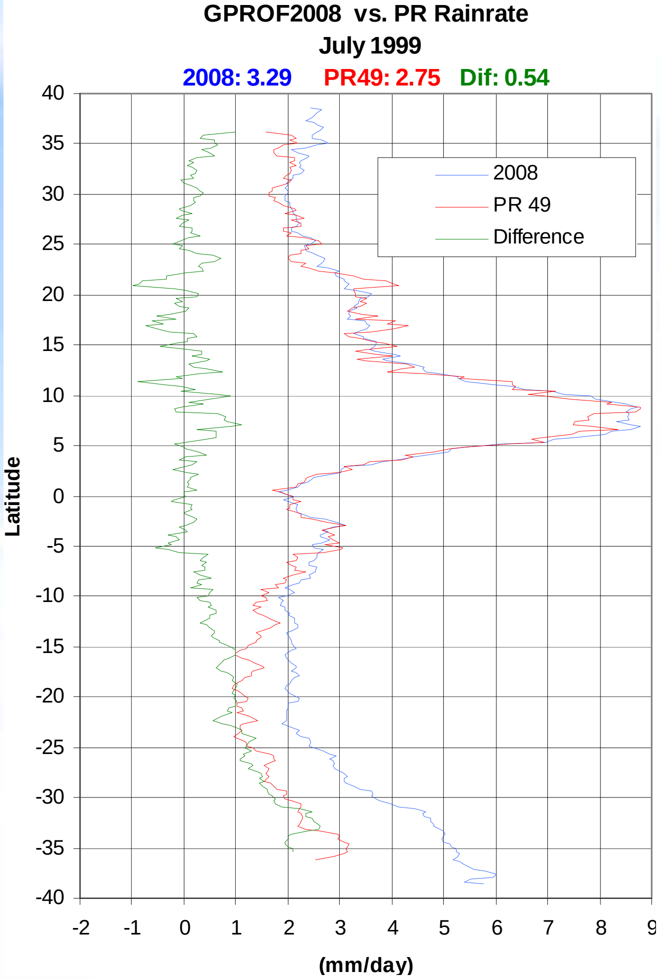
GPROF 2008 vs. GPROF 2004 Retrieval

September 8th, 1999

South Africa

2008 : 0.29 mm/hr
PR : 0.40 mm/hr

2004 : 0.03 mm/hr


GPROF2008 vs. PR Rainrate
July 1999
2008: 3.29
PR49: 2.75
Dif: 0.54
2008
PR 49
Difference
Latitude
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-2
-1
0
1
2
3
4
5
6
7
8
(mm/day)

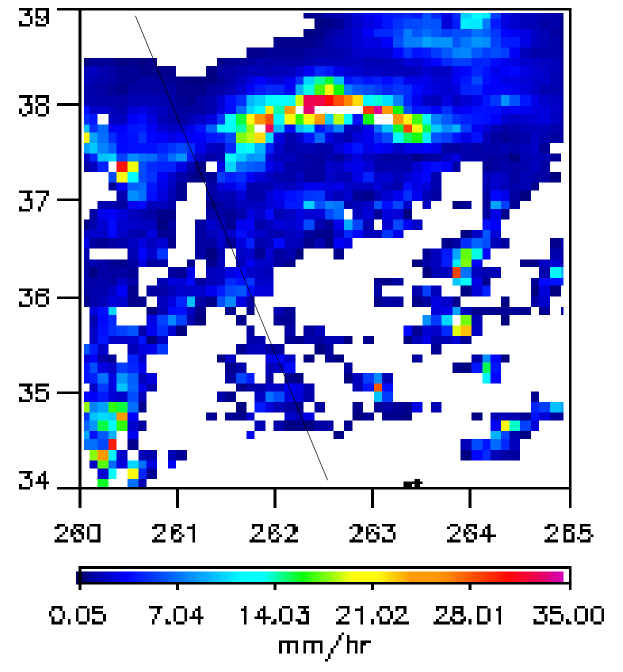
Oceans (Gprof 2008)

- Will finish Dbase adjust by 9/1/08
- Will develop dbase for higher latitudes by lowering freezing level (i.e. simultaneously lowering SST and TPW).
- Implement and test algorithm for TMI, AMSR-E and SSMI by end of 2008
- Do extensive beta-testing in house before distribution to data systems.
- Reprocess AMSR-E internally (summer of 2009)

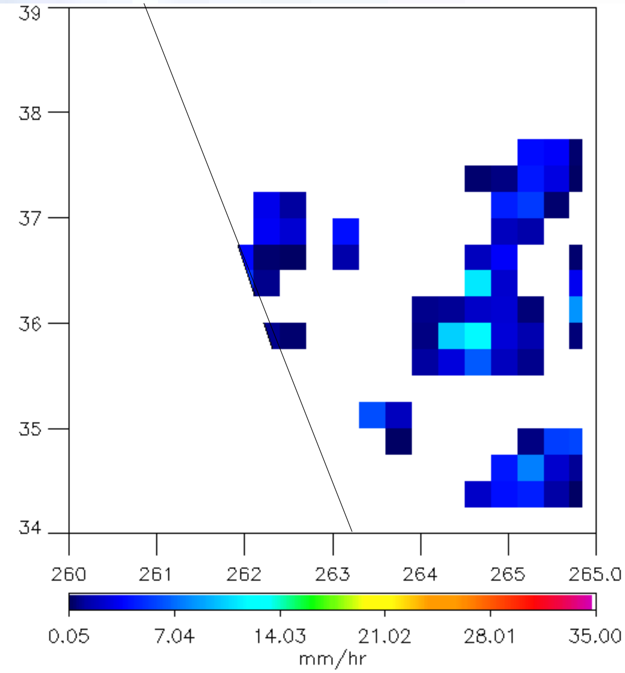
Land (Gprof 2012?)

Rainfall Errors over Land

Radar composite



GPROF



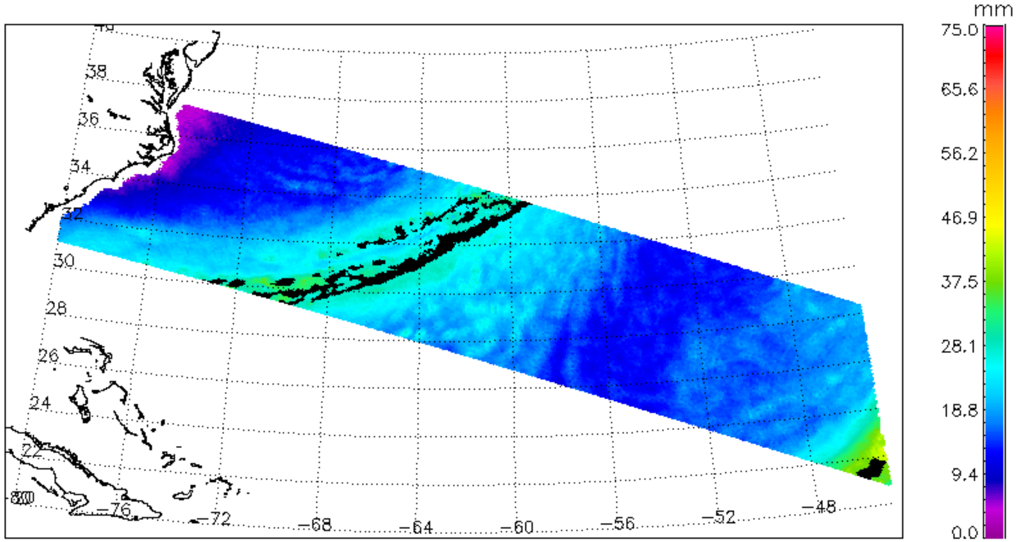
Optimal Estimation Retrievial

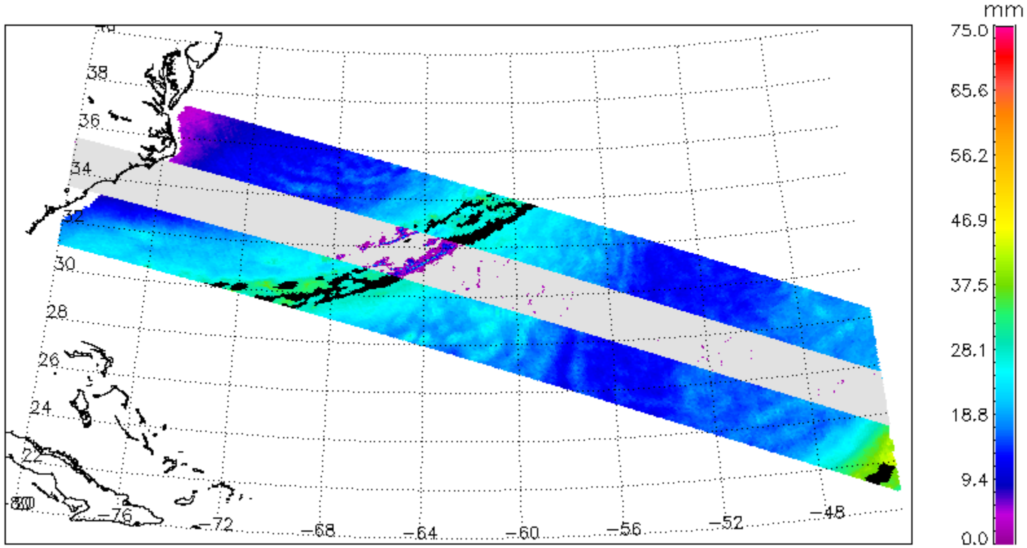
$$\mathrm{P}(\mathbf{x} \mid \mathbf{y}) = \frac{\mathrm{P}(\mathbf{y} \mid \mathbf{x})\mathrm{P}(\mathbf{x})}{\mathrm{P}(\mathbf{y})}$$

- In terms of Bayes’ Theorem, the optimal solution maximizes P(**x**|**y**) for a given **y.**
- Maximize P(**y**|**x**)P(**x**) when the cost function is minimized:

$$\Phi = \underbrace{(\mathbf{x} - \mathbf{x}_{\mathbf{a}})^T \mathbf{S}_a^{-1} (\mathbf{x} - \mathbf{x}_{\mathbf{a}})}_{\textit{Minimize the differences between the retrieved and a priori states}} + \underbrace{(\mathbf{y} - \mathrm{f}(\mathbf{x},\mathbf{b}))^T \mathbf{S}_y^{-1} (\mathbf{y} - \mathrm{f}(\mathbf{x},\mathbf{b}))}_{\textit{Minimize the differences between observed and simulated Tbs}}$$

Rodgers (2000)


38
36
34
32
30
28
26
24
22
−80
−76
−72
−68
−64
−60
−56
−52
−48
mm
75.0
65.6
56.2
46.9
37.5
28.1
18.8
9.4
0.0


38
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−76
−72
−68
−64
−60
−56
−52
−48
mm
75.0
65.6
56.2
46.9
37.5
28.1
18.8
9.4
0.0

Methodology

1. Retrieve surface emissivities in the absence of clouds. Use values from previous land emissivity retrievals for validation.

2. Use the correlations between emissivities at different channels to create an empirical emissivity model.

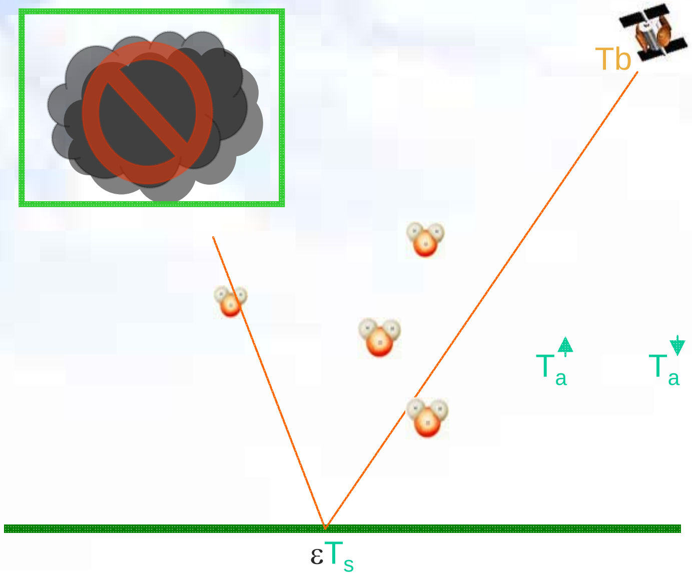
3. Use empirical emissivity model in an optimal estimation retrieval for the 10.7 GHz horizontally polarized emissivity, column water vapor (CWV) and cloud liquid water (CLW).

4. Evaluate the usefulness as a precipitation screen over land.

Surface Emissivity Retrieval

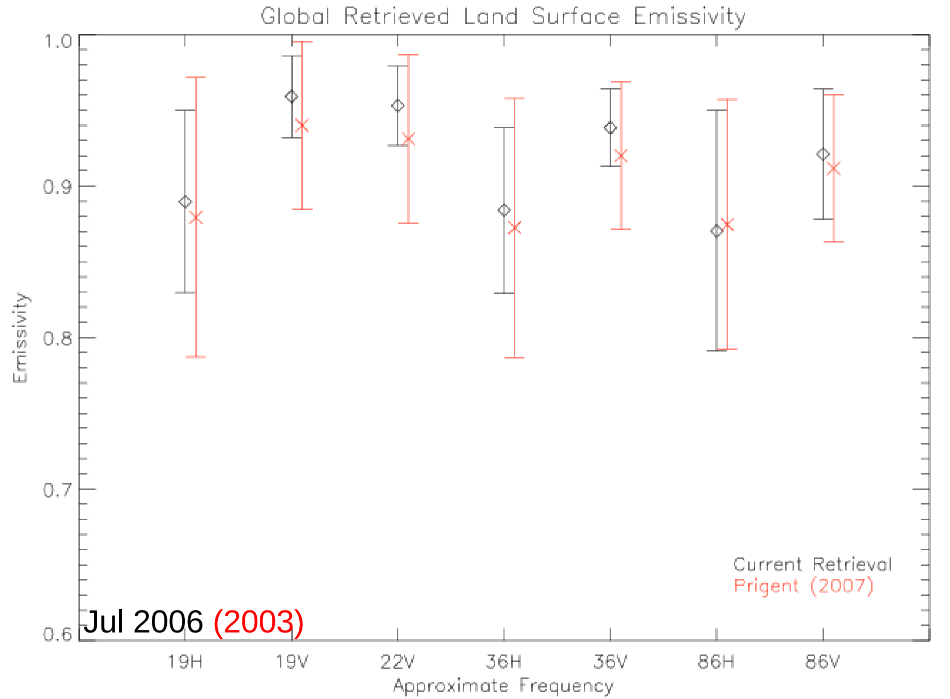
$$Tb = T_s \varepsilon e^{\frac{-\tau(0,H)}{\mu}} + T_{a\downarrow}(1-\varepsilon)e^{\frac{-\tau(0,H)}{\mu}} + T_{a\uparrow}$$

$$\varepsilon = \frac{Tb - T_{a\uparrow} - T_{a\downarrow} \times e^{\frac{-\tau(0,H)}{\mu}}}{e^{\frac{-\tau(0,H)}{\mu}} \times \left(T_s - T_{a\downarrow}\right)}$$



- Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E)
  - Level 1 Brightness temperatures
  - 10.65, 18.7, 23.8, 36.5, and 89.0 GHz
  - Horizontal and Vertical polarization
  - Deconvolved to 23.8 GHz footprint
- Atmospheric Infrared Sounder (AIRS)
  - Level 2 Standard Retrieval product
    - Surface temperature, pressure
    - Temperature, pressure, and humidity profiles
- Moderate Resolution Infrared Spectroradiometer (MODIS)
  - 5 km cloud mask product

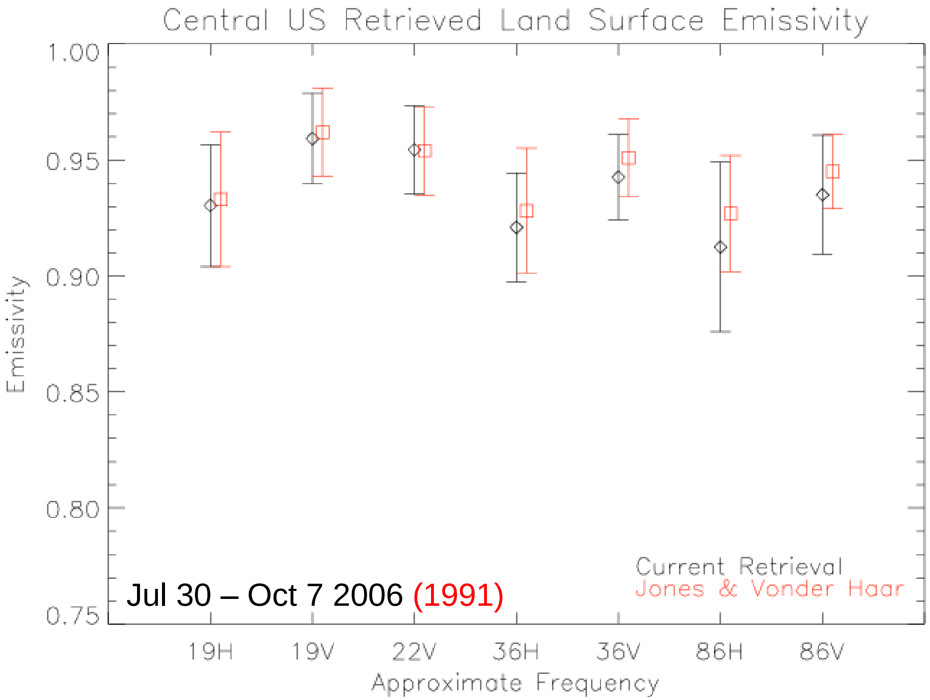
Emissivity Retrieval Validation



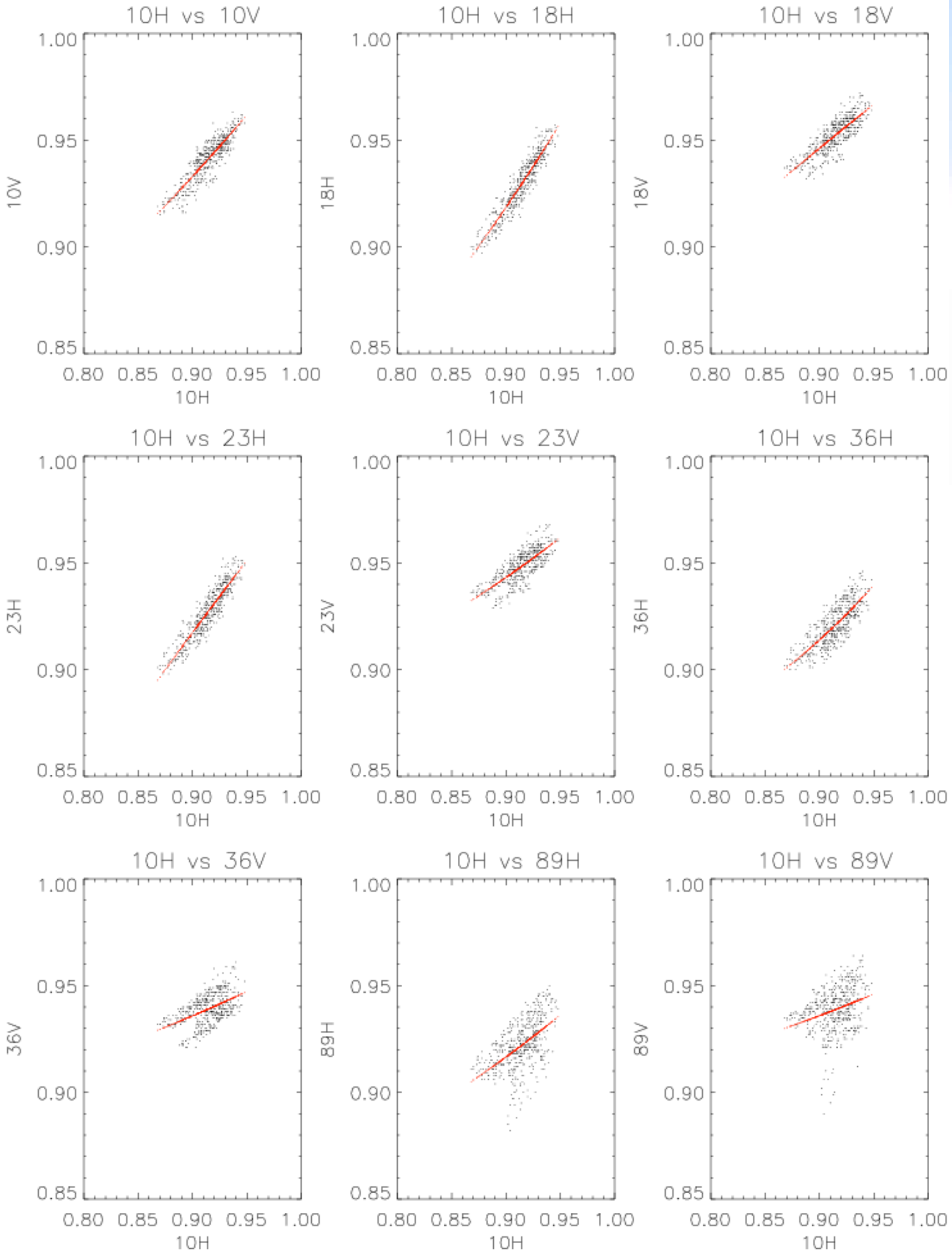
Jul 2006 (2003)

Retrieved surface emissivities over 1 year (2006).

Used results from multiple studies to verify that average retrieved land emissivity values over given periods of time were comparable to previous results.



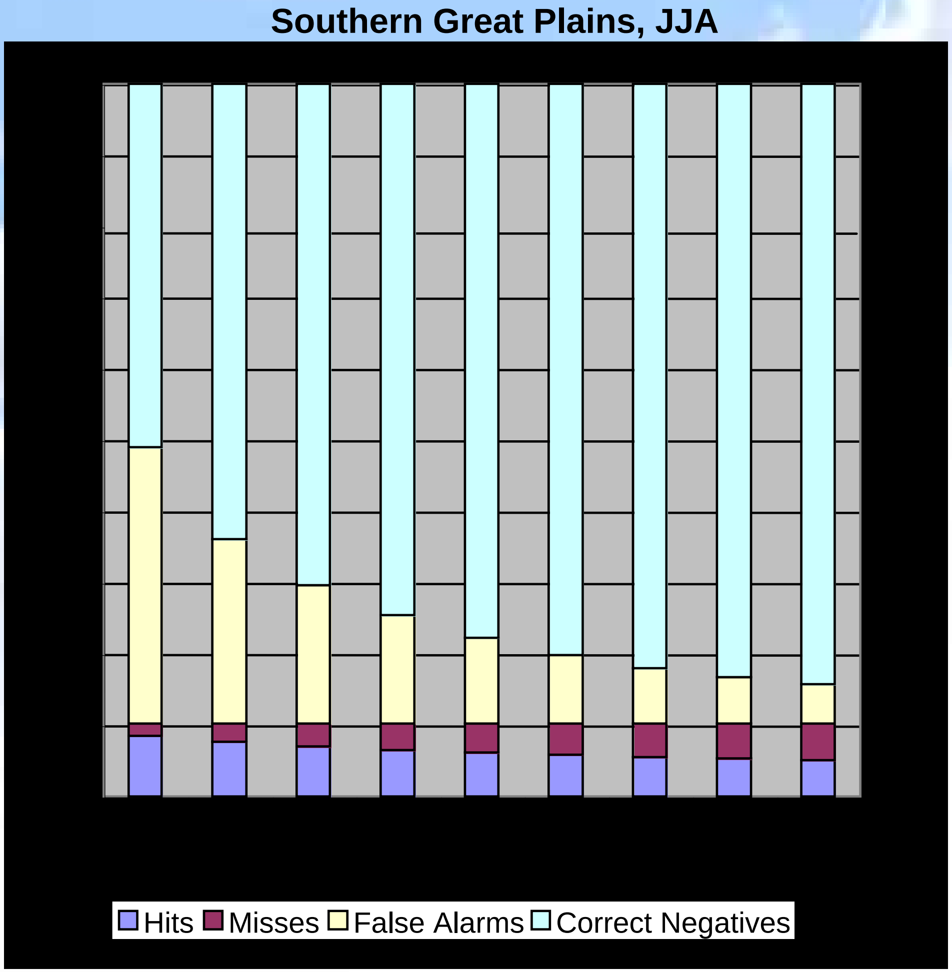
Jul 30 – Oct 7 2006 (1991)


10H vs 10V
10H vs 18H
10H vs 18V
10H vs 23H
10H vs 23V
10H vs 36H
10H vs 36V
10H vs 89H
10H vs 89V
10V
18H
18V
23H
23V
36H
36V
89H
89V
10H
1.00
0.95
0.90
0.85
0.80
0.85
0.90
0.95
1.00

Selected Study Areas

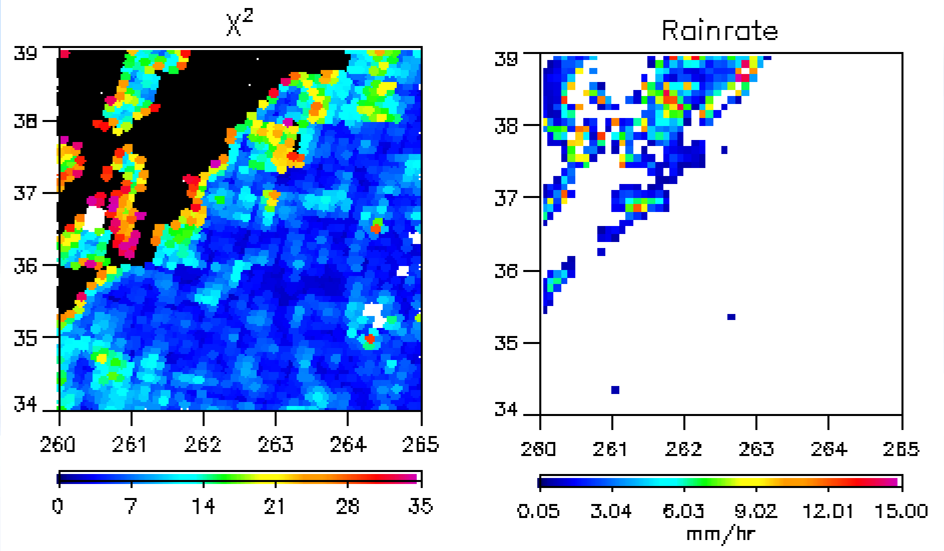
Location Number	Description	Lat/Lon Boundaries	General Surface Type
1	Southern Great Plains	34-39 N, 95-100 W	Cropland
2	Southeastern United States	31-35 N, 82-88W	Deciduous forest
3	Southwestern United States	32-37 N, 105-110 W	Semi-arid/ desert

Southern Great Plains



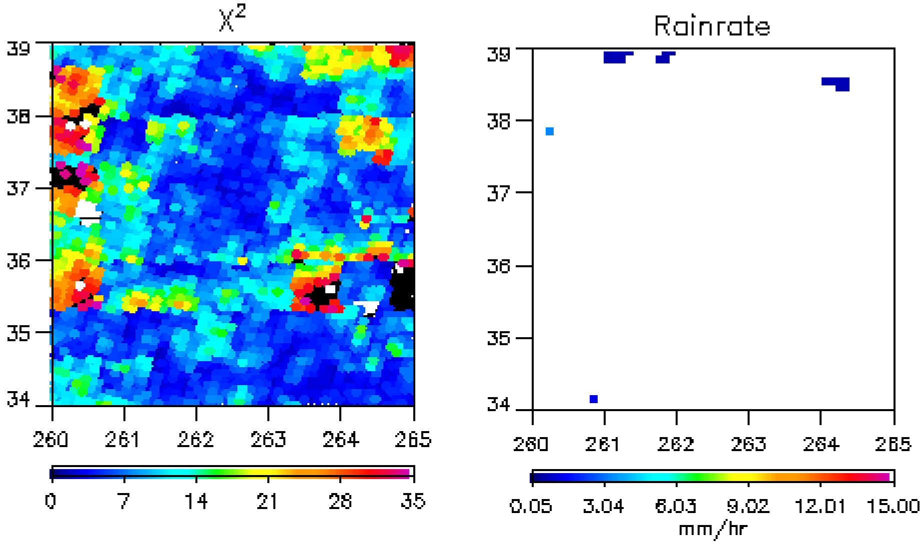
Season		Precip Detected	No Precip Detected	Success Rate
DJF	$\chi^2 > 35$	1761	3905	80.36%
	$\chi^2 < 35$	673	16975	
MAM	$\chi^2 > 35$	1707	3895	86.81%
	$\chi^2 < 35$	806	29228	
JJA	$\chi^2 > 35$	3625	5974	85.99%
	$\chi^2 < 35$	2781	50142	
SON	$\chi^2 > 35$	2852	6123	84.34%
	$\chi^2 < 35$	2305	52523	

Southern Great Plains

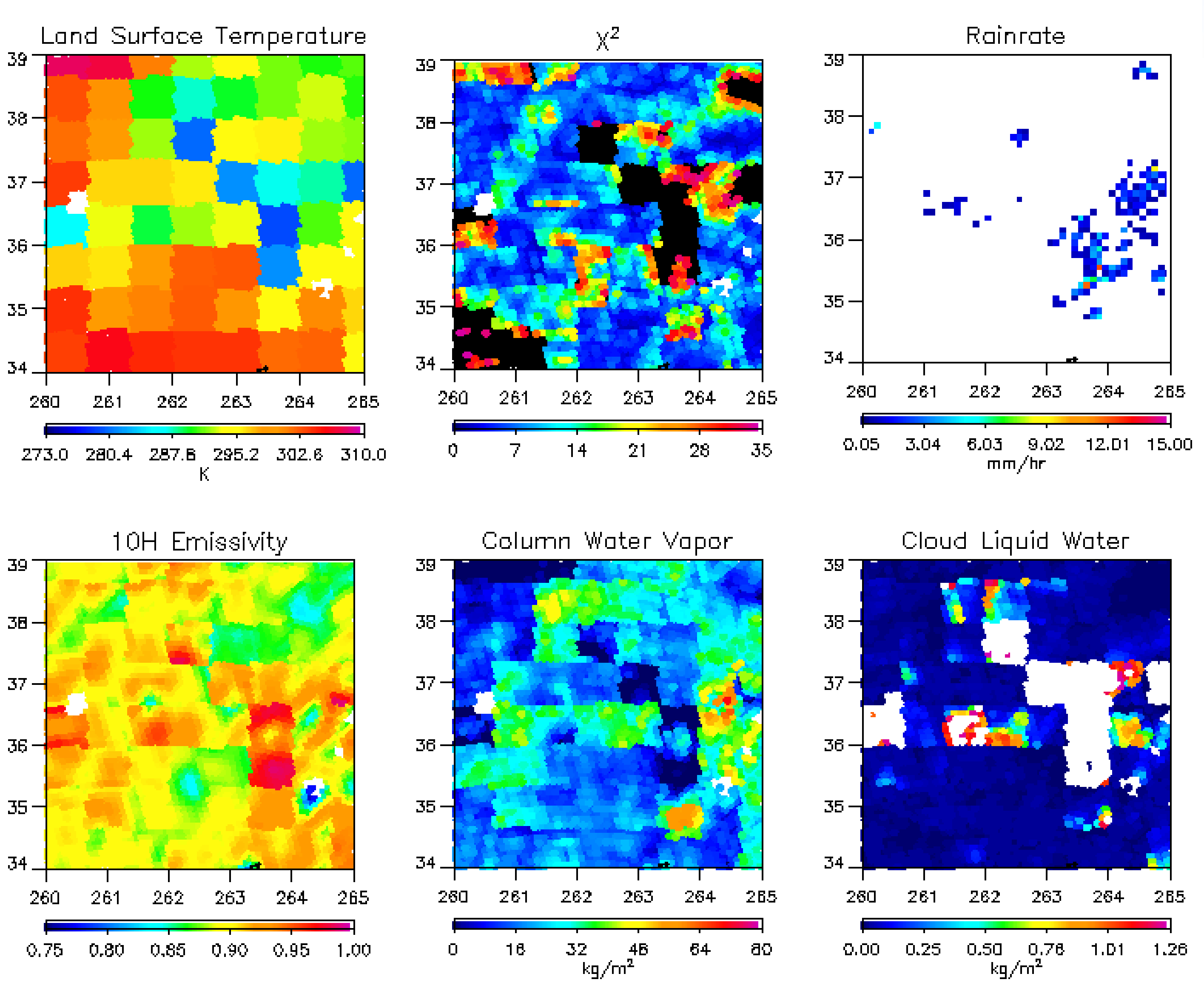


Successful Precipitating Case

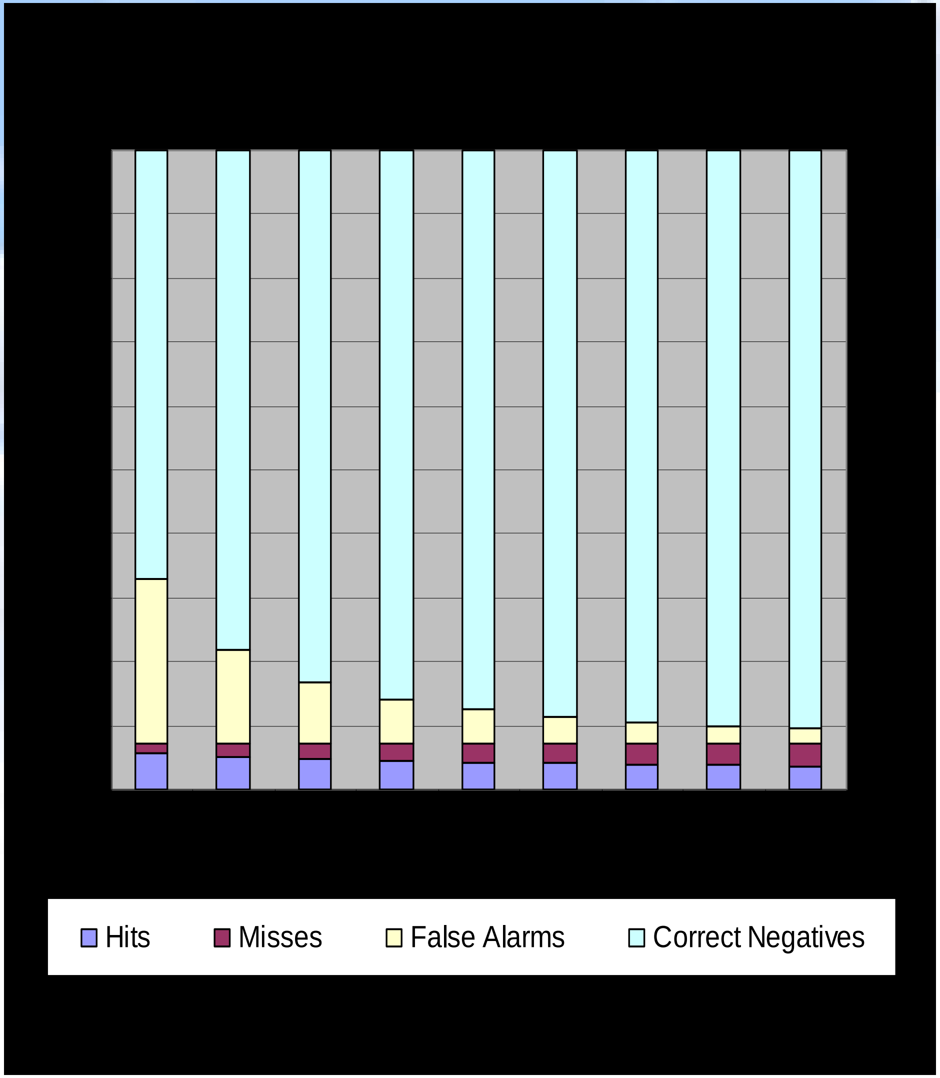
Successful Non-precipitating case



Bad Surface Temperature Input



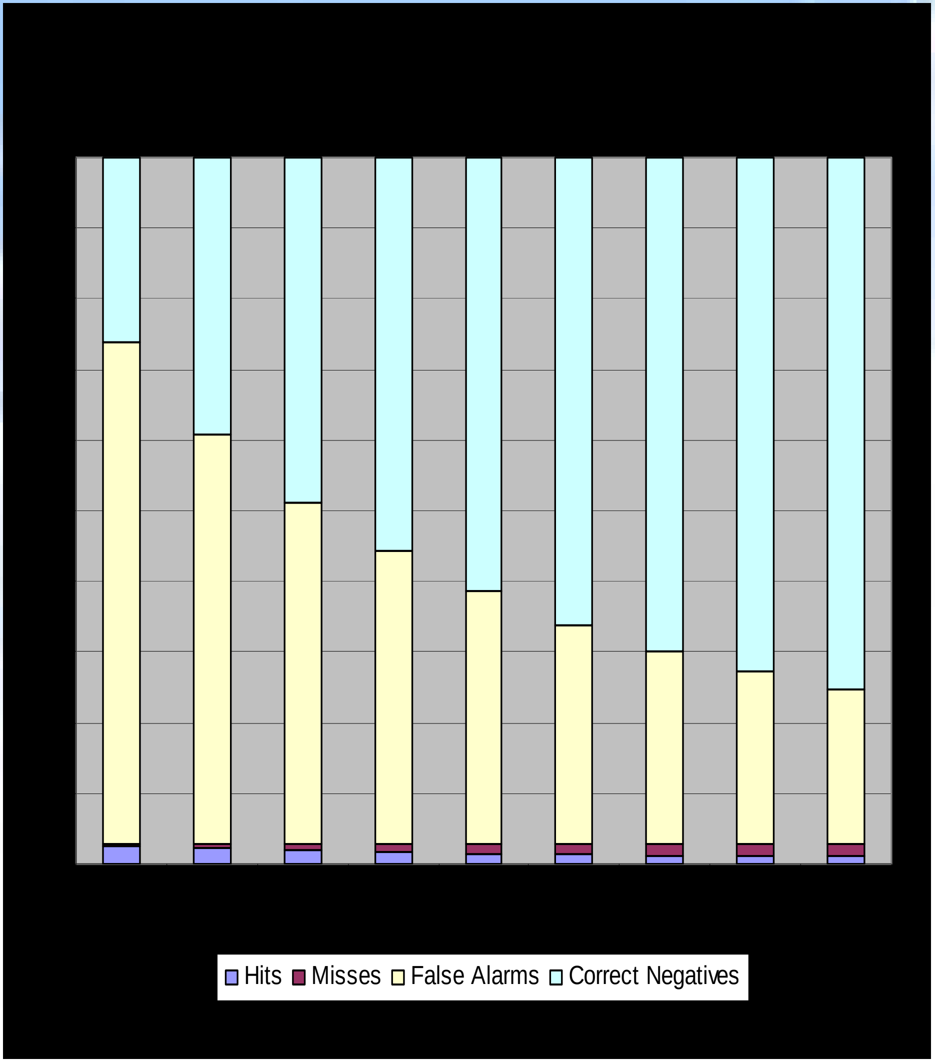
Southeastern United States

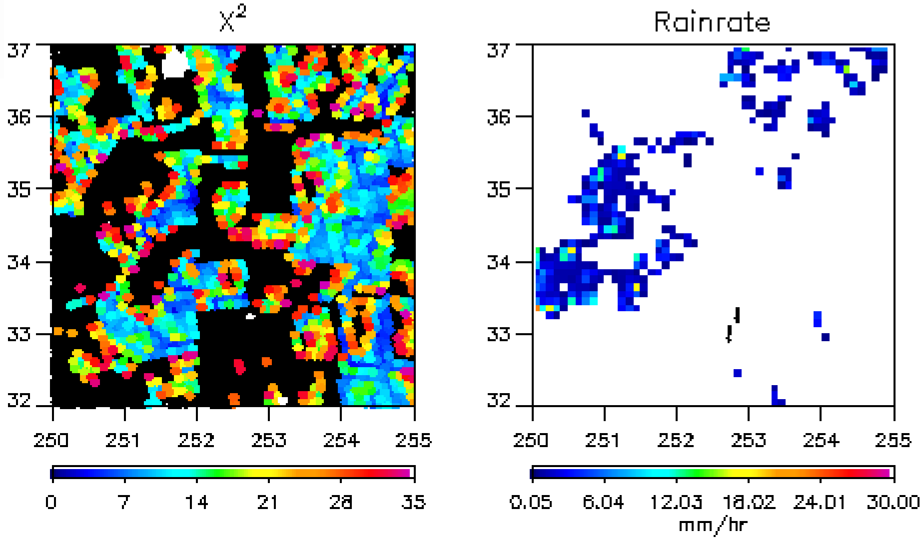


Season		Precip Detected	No Precip Detected	Success Rate
DJF	$\chi^2 > 35$	1673	1570	89.60%
	$\chi^2 < 35$	1261	22705	
MAM	$\chi^2 > 35$	1650	1709	92.62%
	$\chi^2 < 35$	1284	35888	
JJA	$\chi^2 > 35$	1263	1426	93.50%
	$\chi^2 < 35$	1736	44236	
SON	$\chi^2 > 35$	1696	2710	86.68%
	$\chi^2 < 35$	2346	31204	

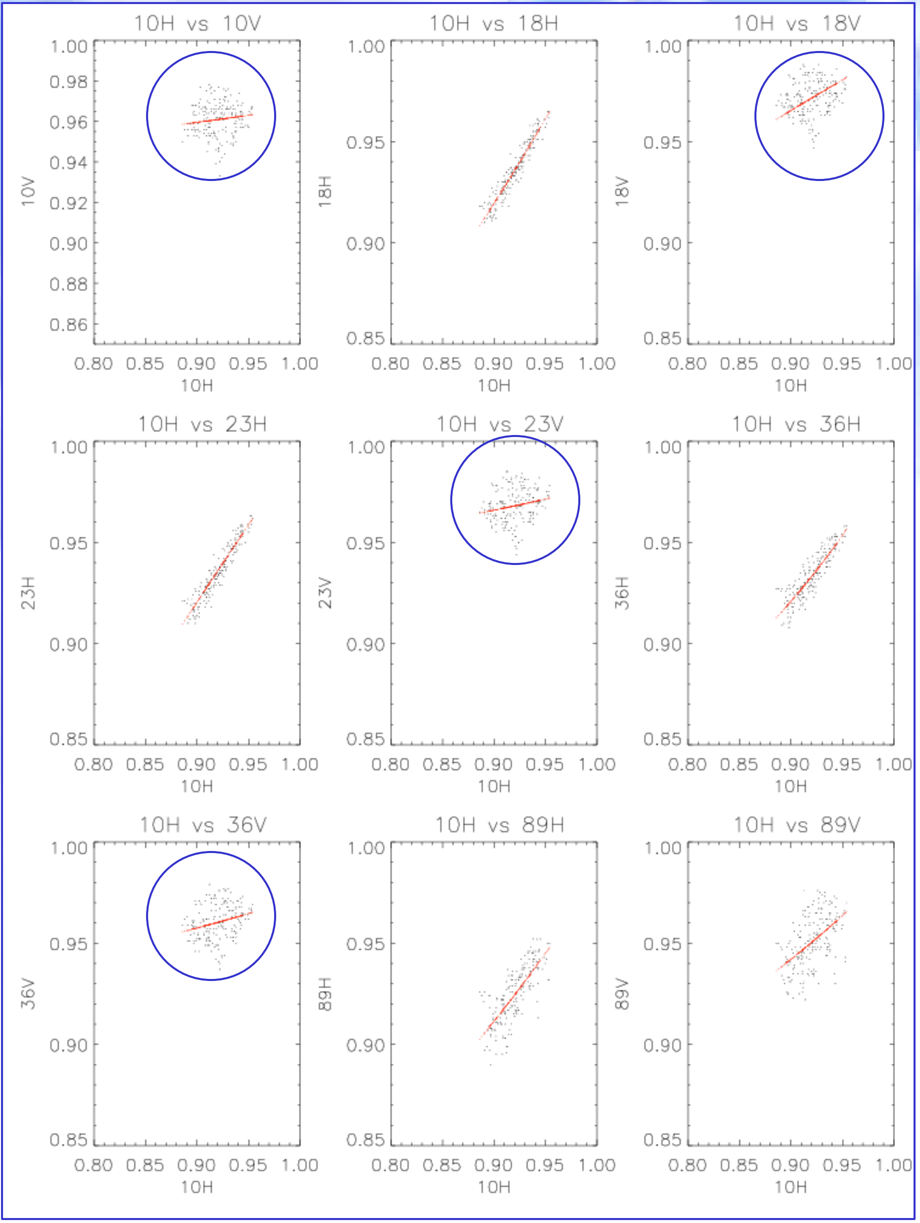
Southwest United States

Season		Precip Detected	No Precip Detected	Success Rate
DJF	$\chi^2 > 35$	396	9176	67.54%
	$\chi^2 < 35$	474	19686	
MAM	$\chi^2 > 35$	1125	9637	76.51%
	$\chi^2 < 35$	801	32865	
JJA	$\chi^2 > 35$	2212	15712	61.37%
	$\chi^2 < 35$	1574	25252	
SON	$\chi^2 > 35$	810	6370	69.78%
	$\chi^2 < 35$	301	14596	





Low Correlations



[redacted]

Season = JJA		Precip Detected	No Precip Detected	Success Rate
All Channels	$\chi^2 > 35$	2212	15712	61.37%
	$\chi^2 < 35$	1574	25252	
4 Channels	$\chi^2 > 35$	326	389	91.40%
	$\chi^2 < 35$	3460	40575	
5 Channels	$\chi^2 > 35$	859	1618	89.84%
	$\chi^2 < 35$	2927	39346	

Conclusions

- Retrieved surface emissivities match well to previous study values and exhibit correlations between channels.
- The correlations between channels can be used to create an empirical emissivity model valid for all surface characteristics.
- The empirical emissivity model can be used in a parametric retrieval to screen for precipitation.
- Over land, there are several factors that need to be improved before model is operational.