"Cloud and Rainfall Observations using Microwave Radiometer Data and A-priori Constraints"

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Outline

- *Briefly review the TRMM and GPM Missions*
- *Describe the common database of cloud structures being developed for the passive microwave algorithms associated with these missions.*
- *Review rainfall retrieval capabilities and impact of a-priori cloud profile database information*
- *Compare ECMWF rainfall analysis to retrieved rainfall and relate differences to the a-priori information.*

Tropical Rainfall Measuring Mission (TRMM)

NASDA
NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN

TRMM Sensors

Nov. 1997 launch, 35° inclination; 402 km

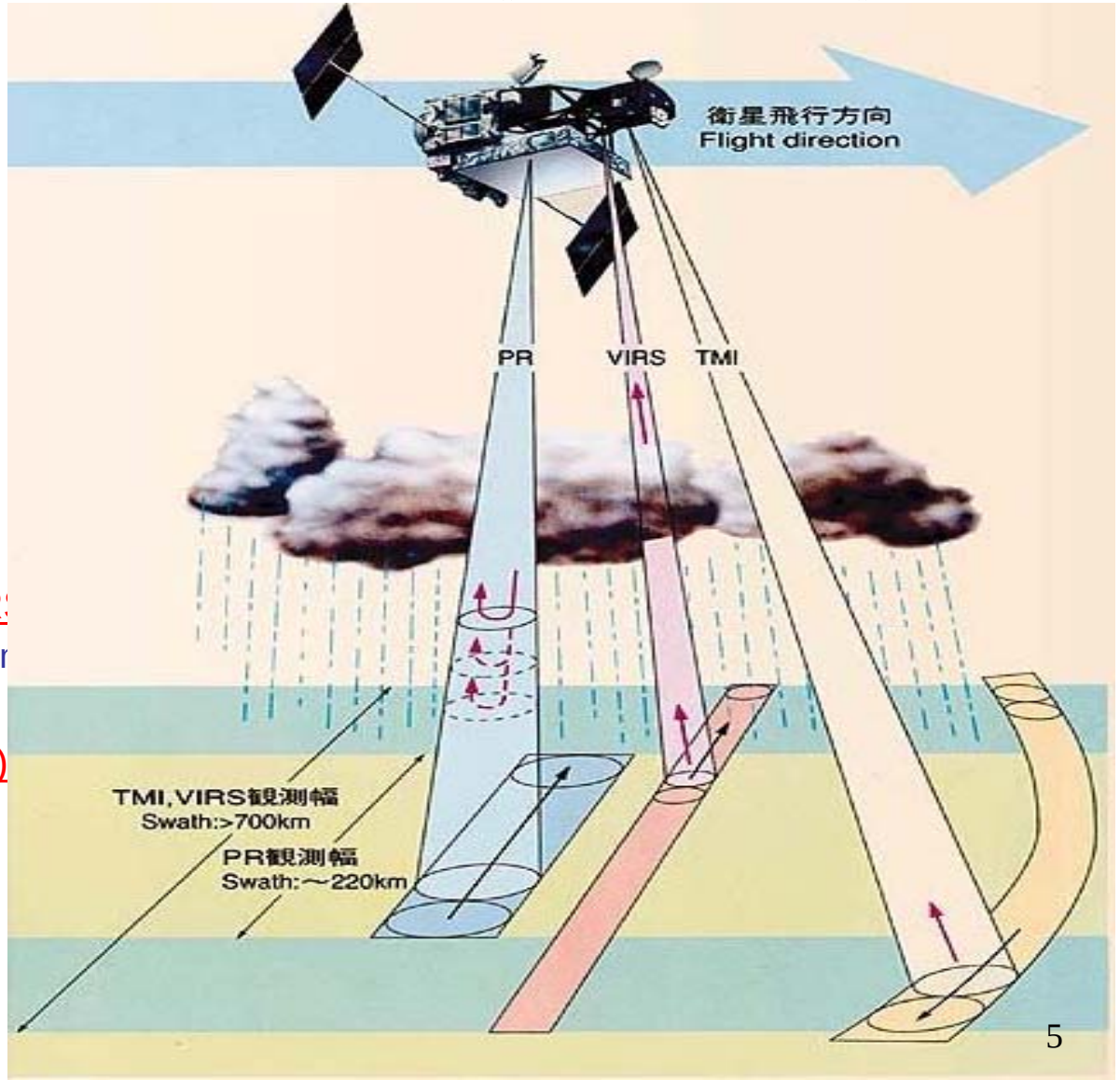
Precipitation radar (PR):
- 13.8 GHz
- 4.3 km footprint
- 0.25 km vertical res.
- 215 km swath

Microwave radiometer (TMI):
- 10.7, 19.3, 21.3, 37.0
- 85.5 GHz (dual polarized except for 21.3 V-only)
- 10x7 km FOV at 37 GHz
- 760 km swath

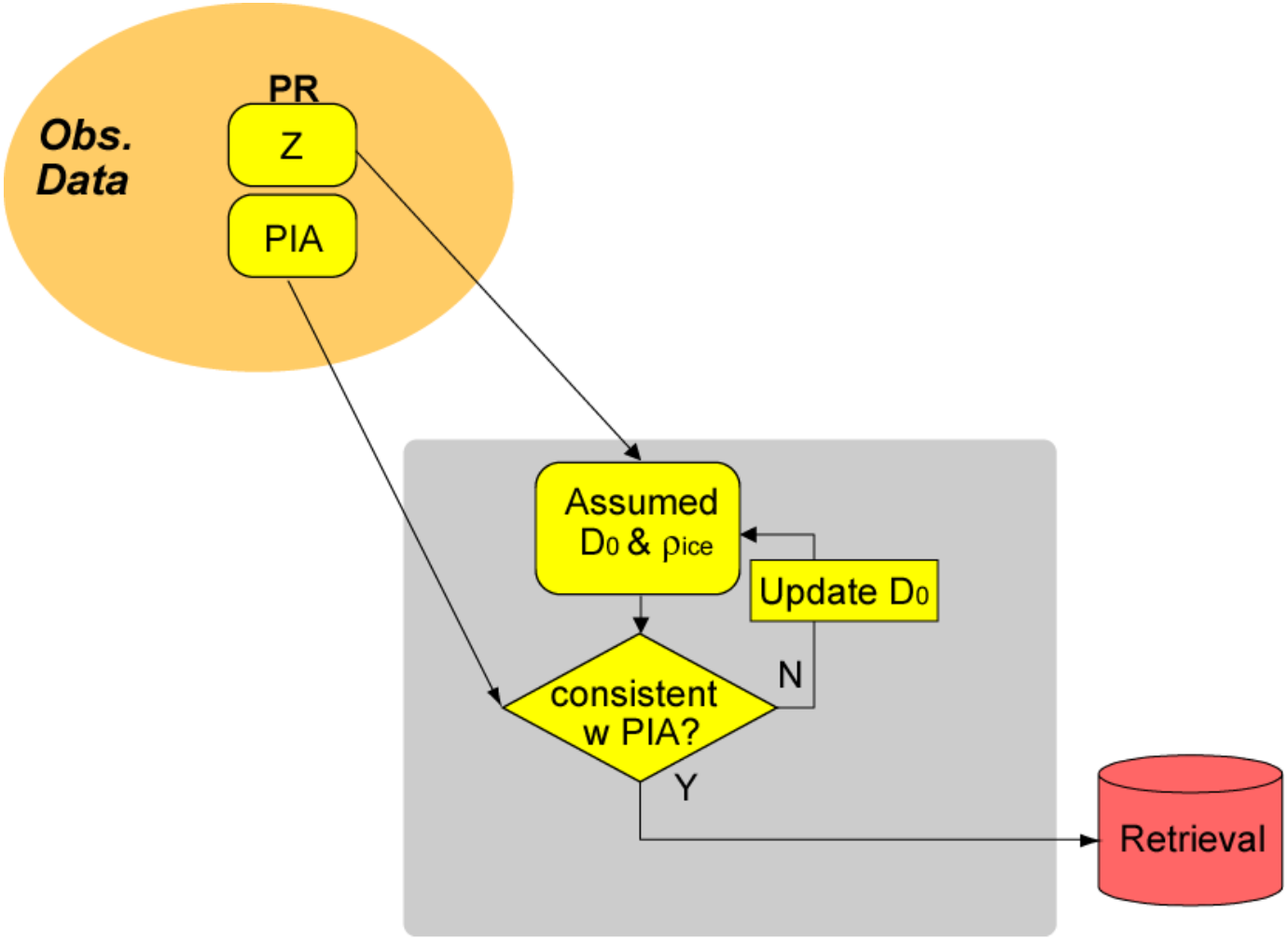
Visible/infrared radiometer (VIR
- 0.63, 1.61, 3.75, 10.8, and 12 :r
- at 2.2 km resolution

Lightning Imaging Sensor (LIS)

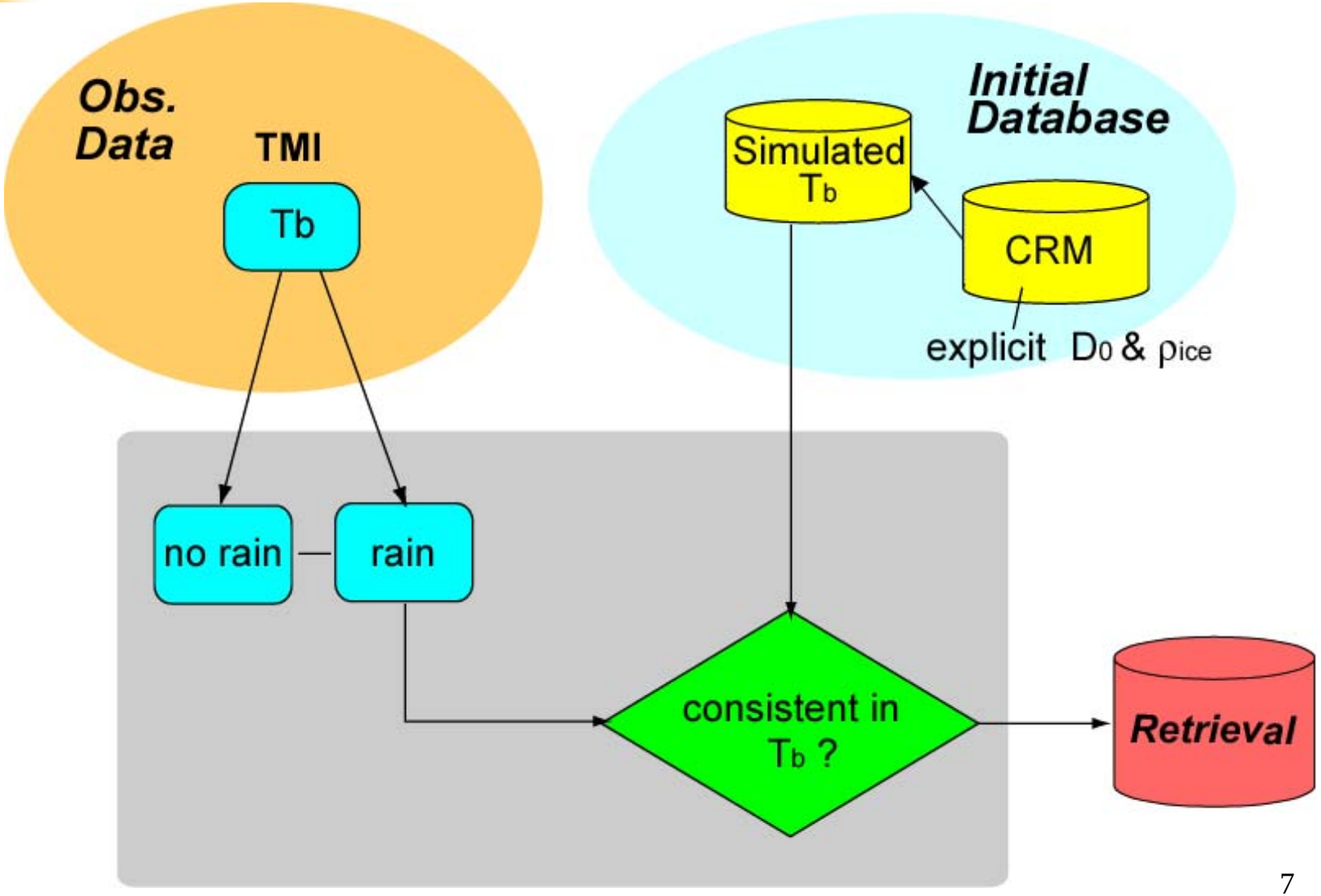
Cloud & Earth Radiant Energy System (CERES)



TRMM radar retrieval

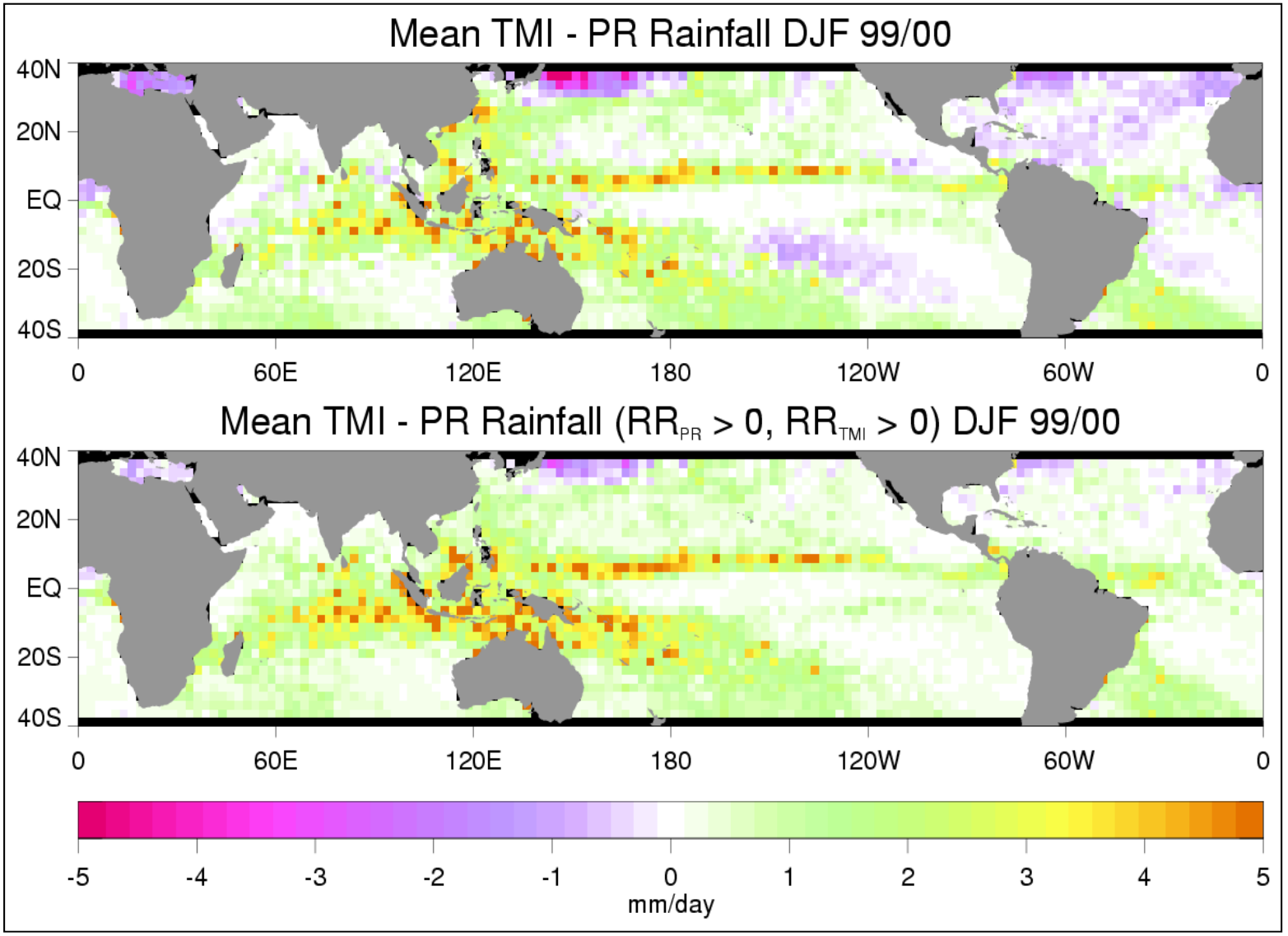


Radiometer retrieval - V6



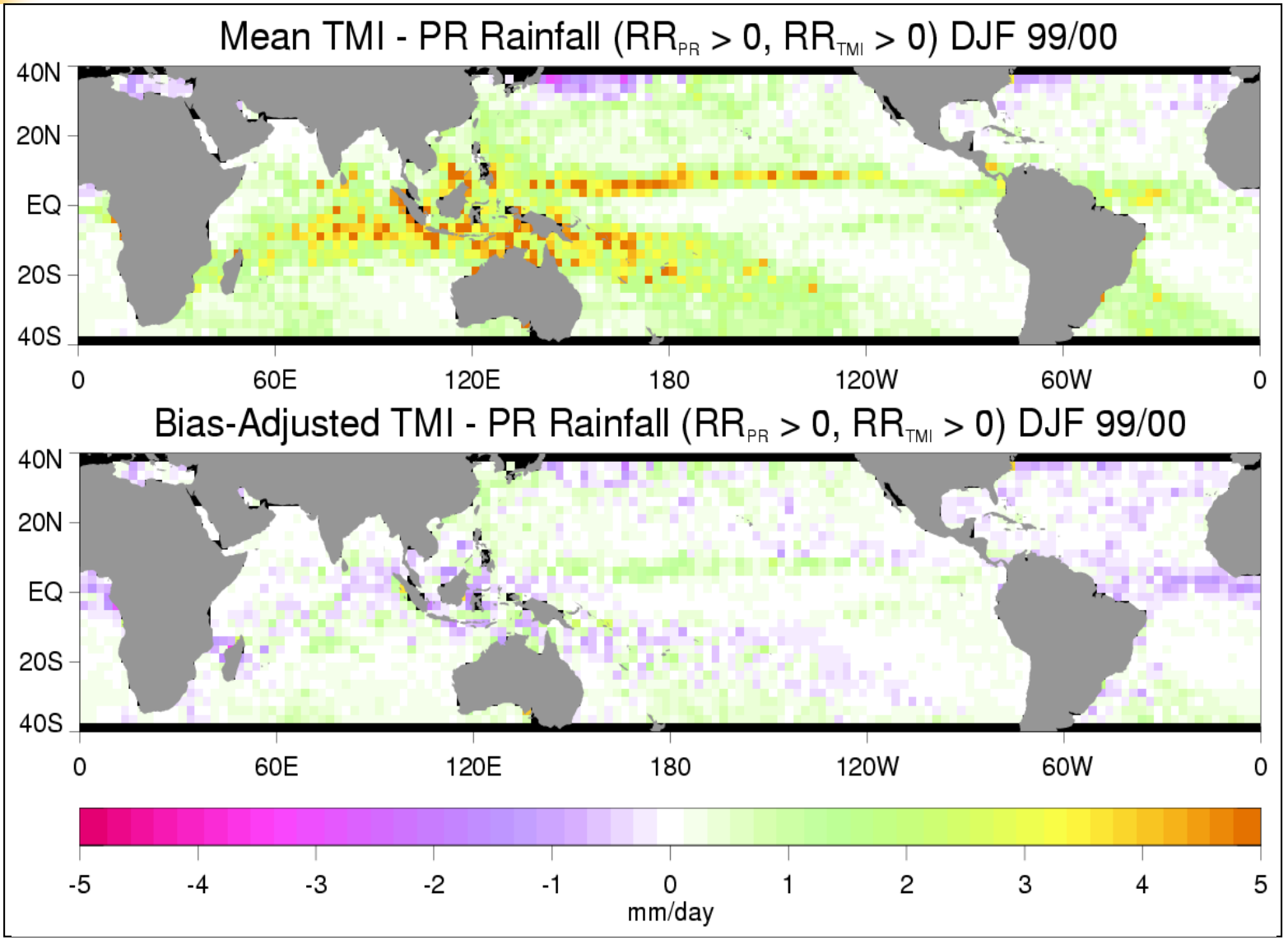
Rainfall Detection Errors

Impact on TMI/PR Differences

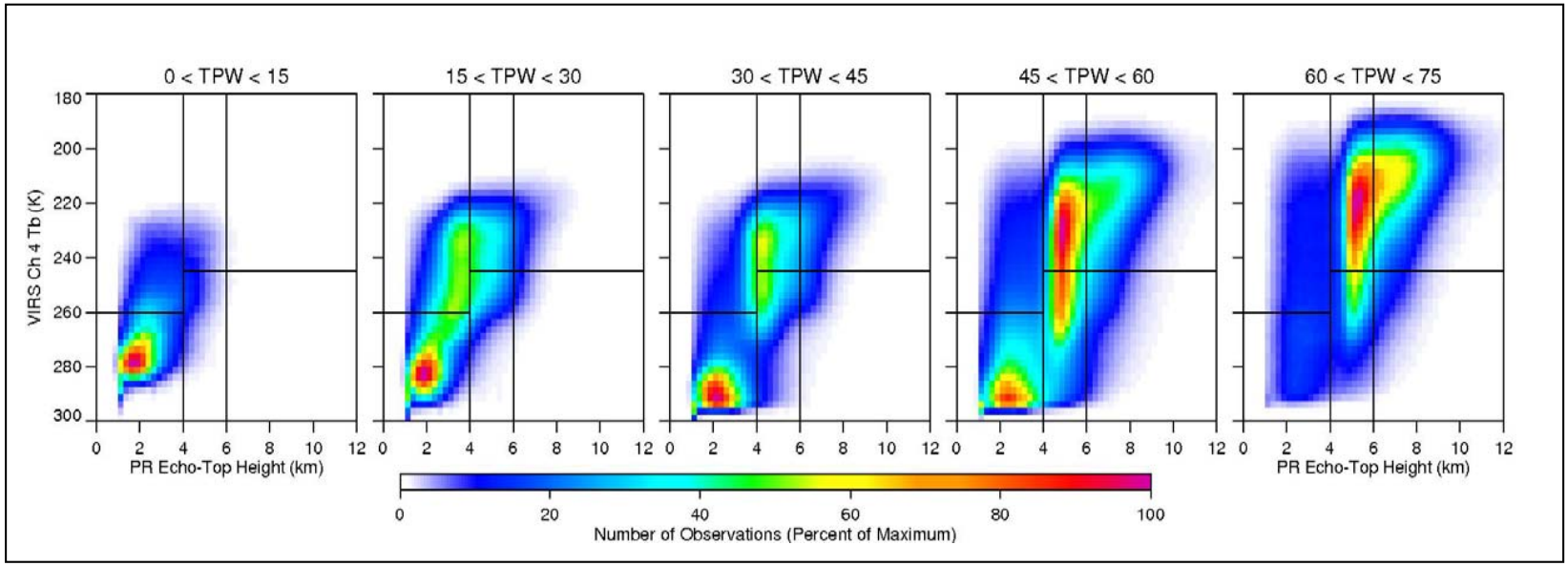


Rainfall Bias Removal

Based on Column Water Vapor



Cloud Profiles Partitioned by TPW



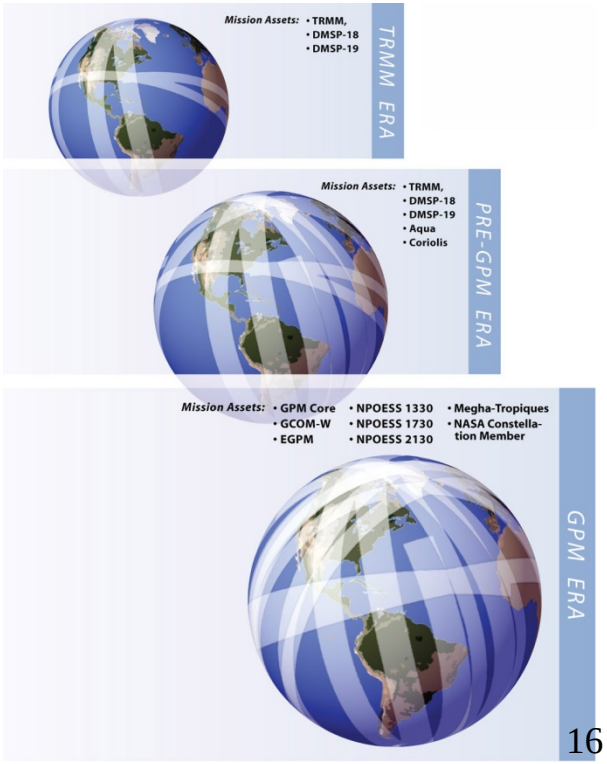
The GPM Concept

Everyone contributes constellation of dedicated and operational PMW radiometers for frequent sampling

- *NASA/JAXA contribute Core Satellite Precipitation Physics*

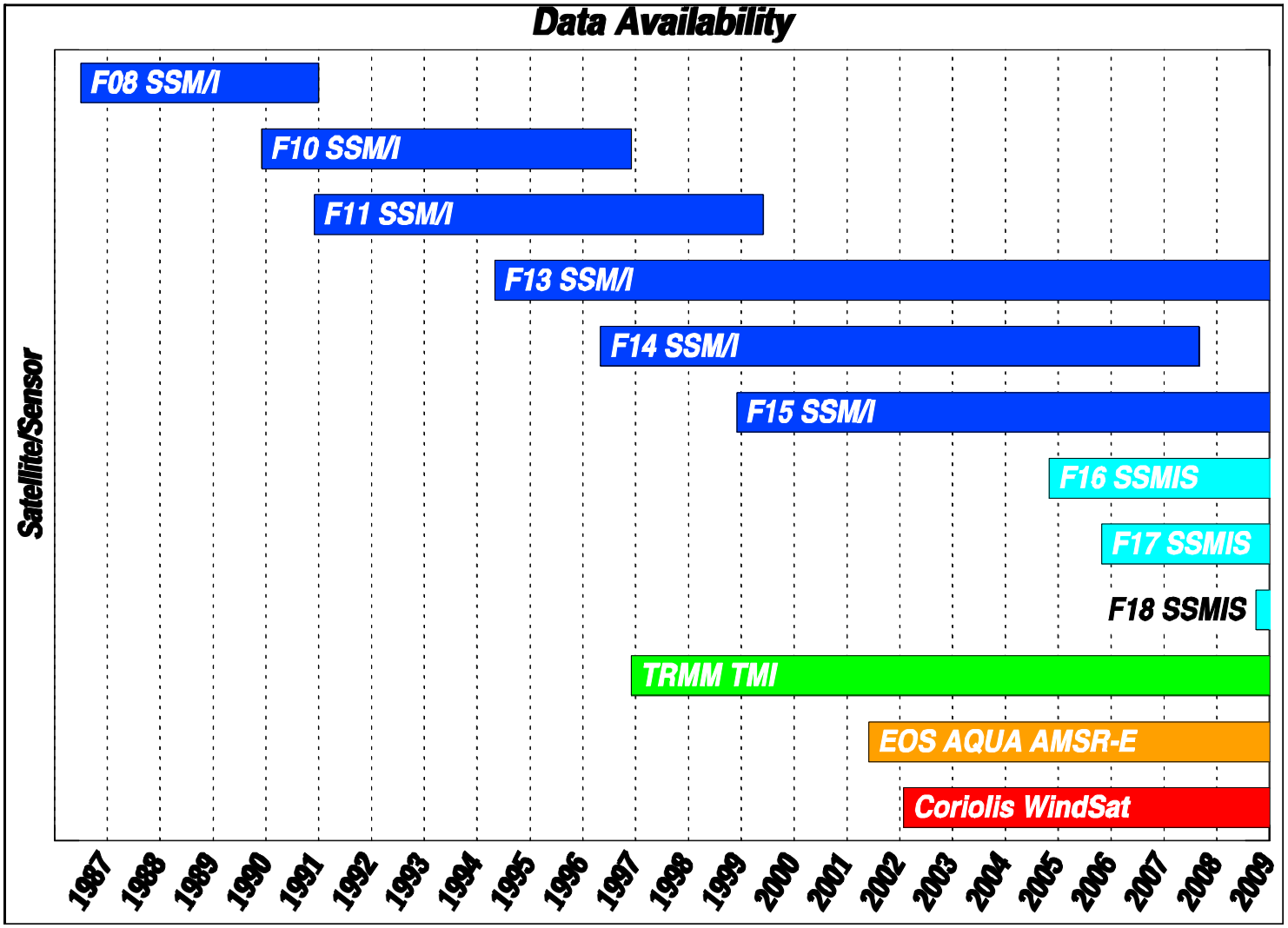
GPM Core Satellite carries:

- *a dual-frequency radar &*
- *a passive microwave imager with high-frequency capabilities*

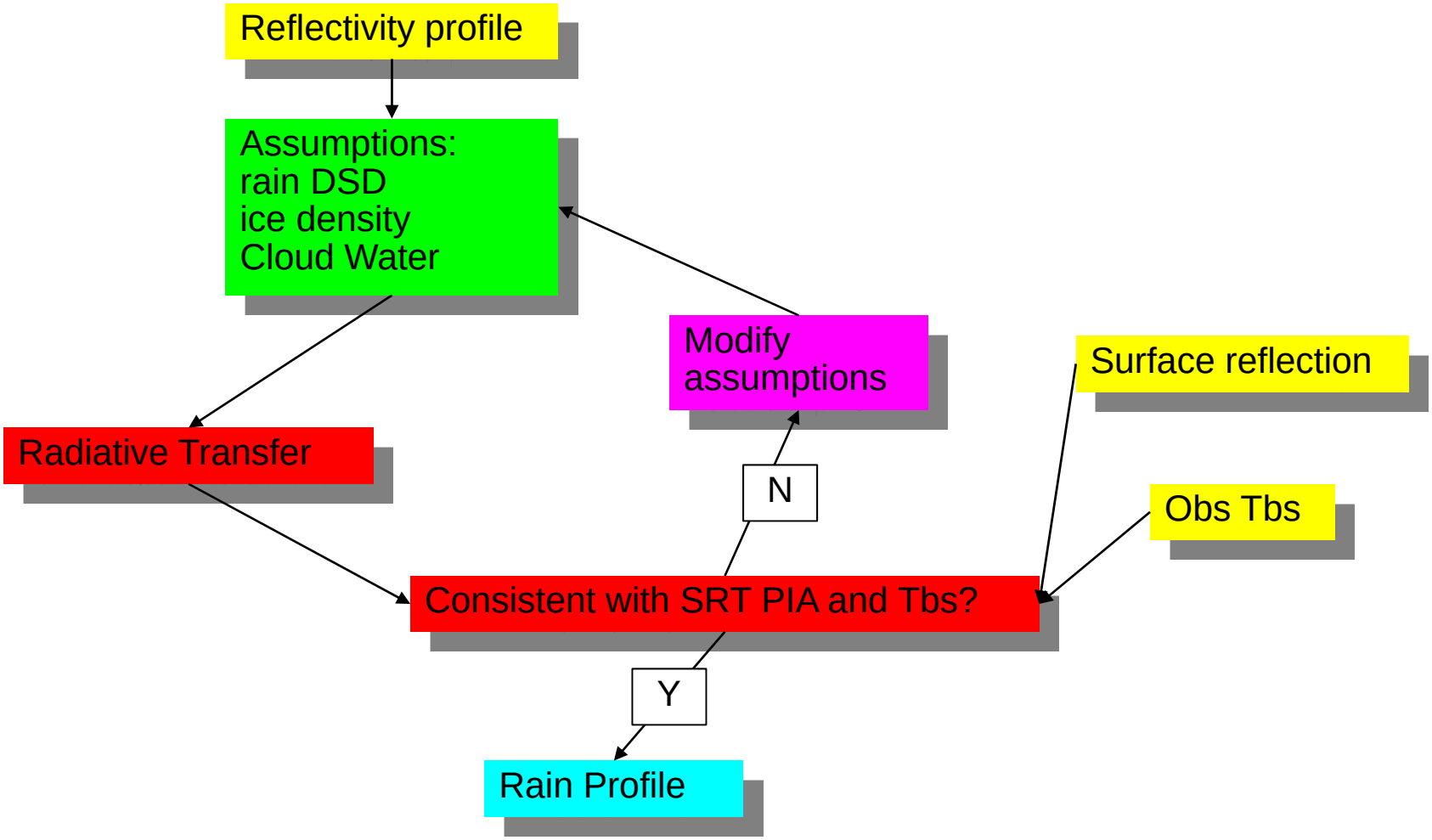


Philosophy is to use Core satellite to build a-priori database of observed profiles that less capable sensors can exploit in their algorithms

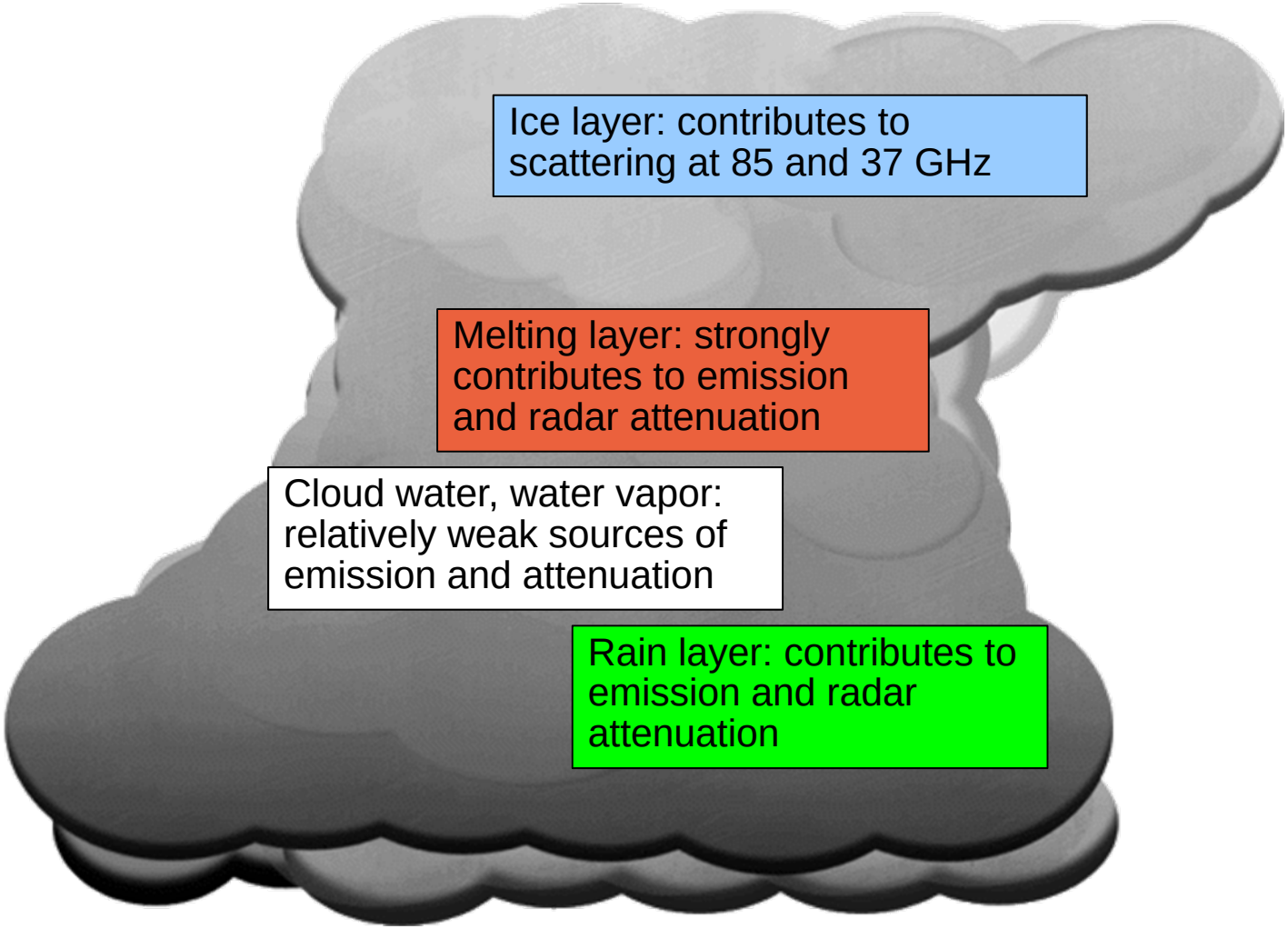
Available Microwave Imagers



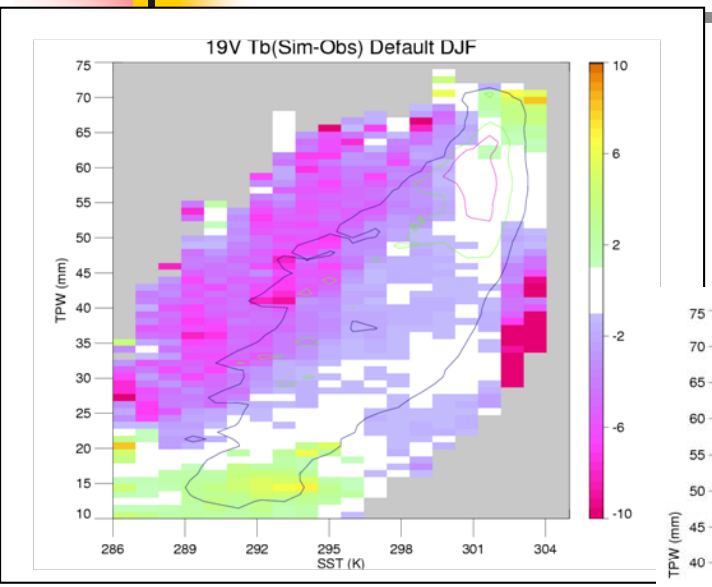
Radar/radiometer algorithms define the a-priori database.



Retrieval of Precipitation Parameters

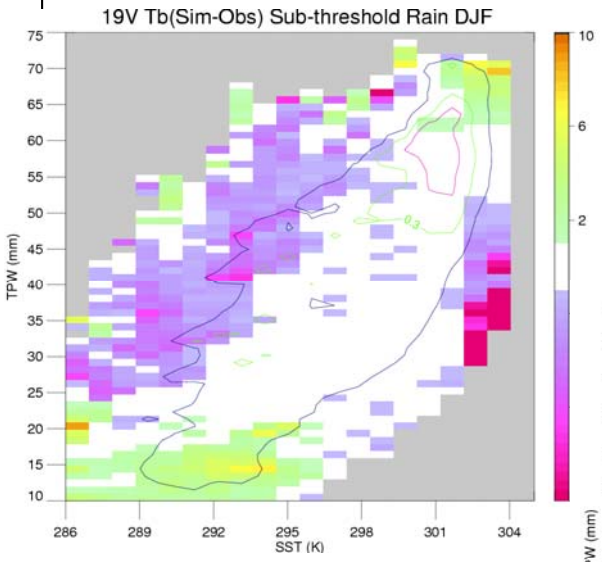


Database Adjustments

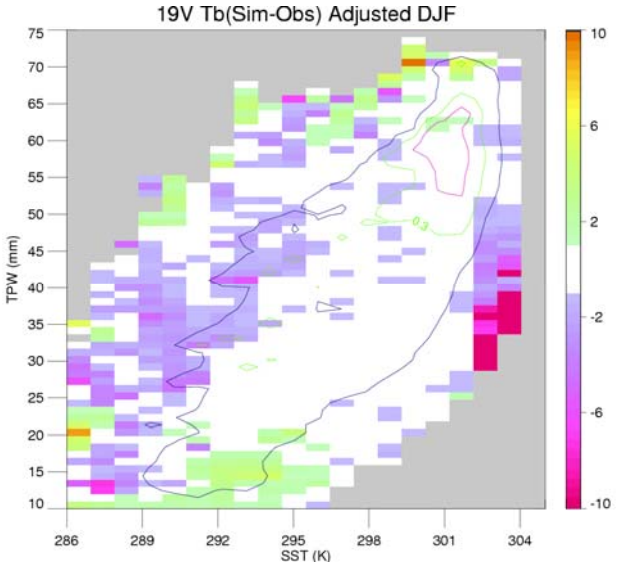


Original Tb differences

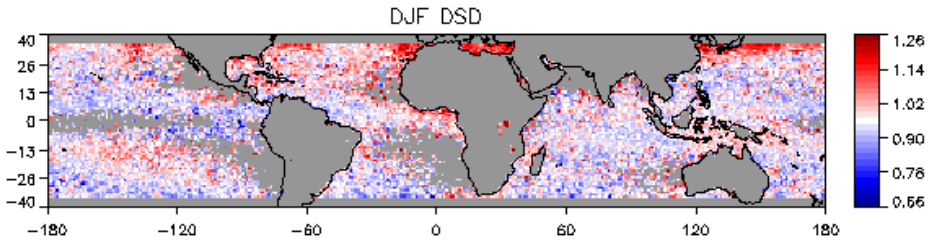
19 GHz differences after
Cloud water adjustment

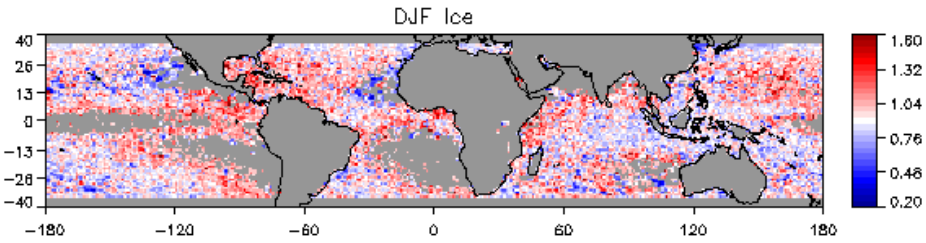


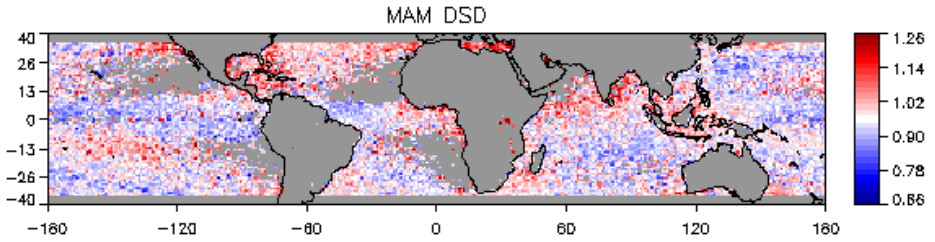
19 GHz differences after
DSD modification

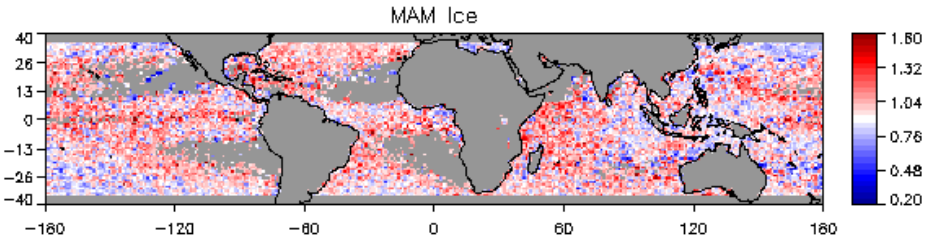


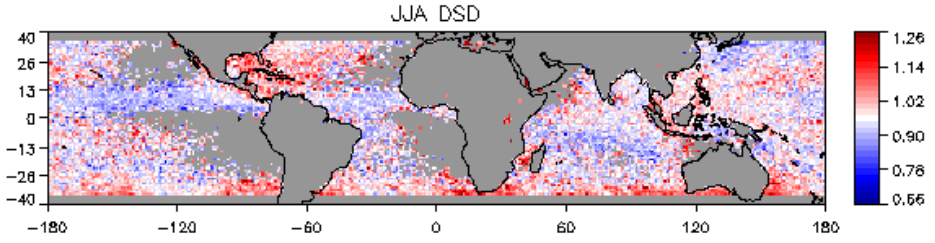
Radar/Radiometer Combined Algorithm Adjustment of DSD

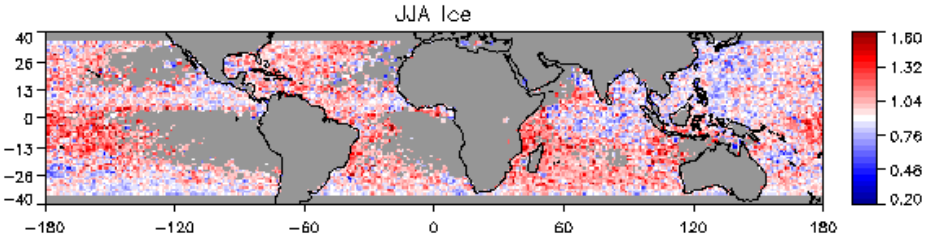


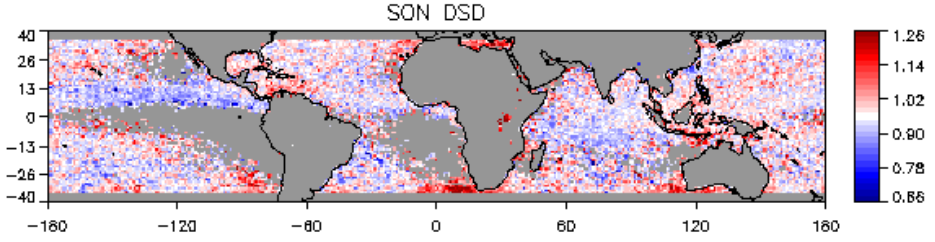


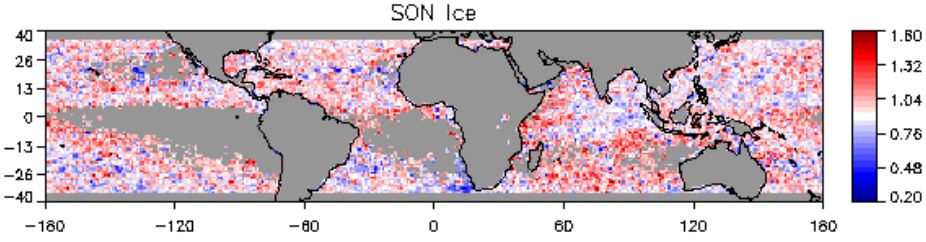






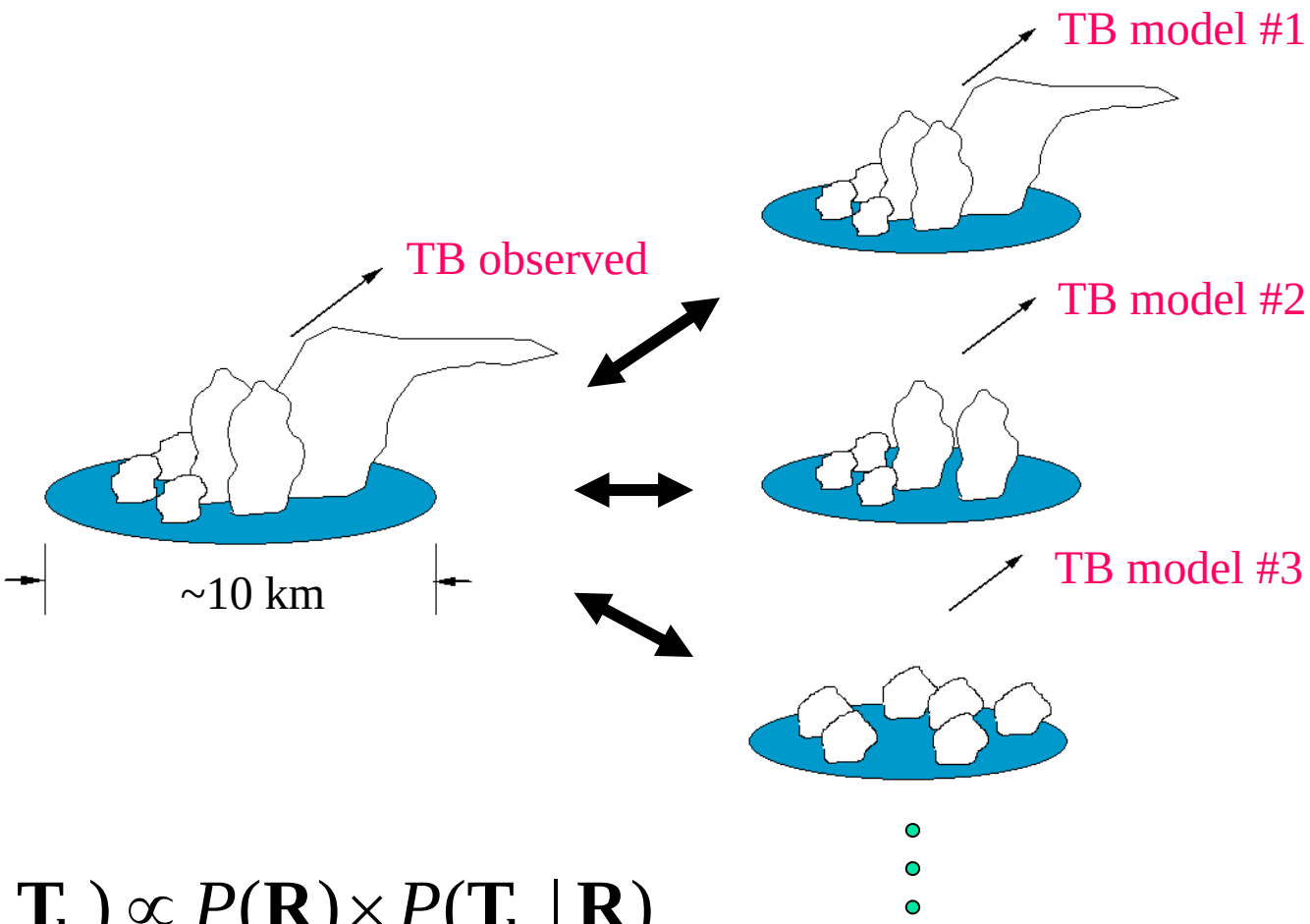






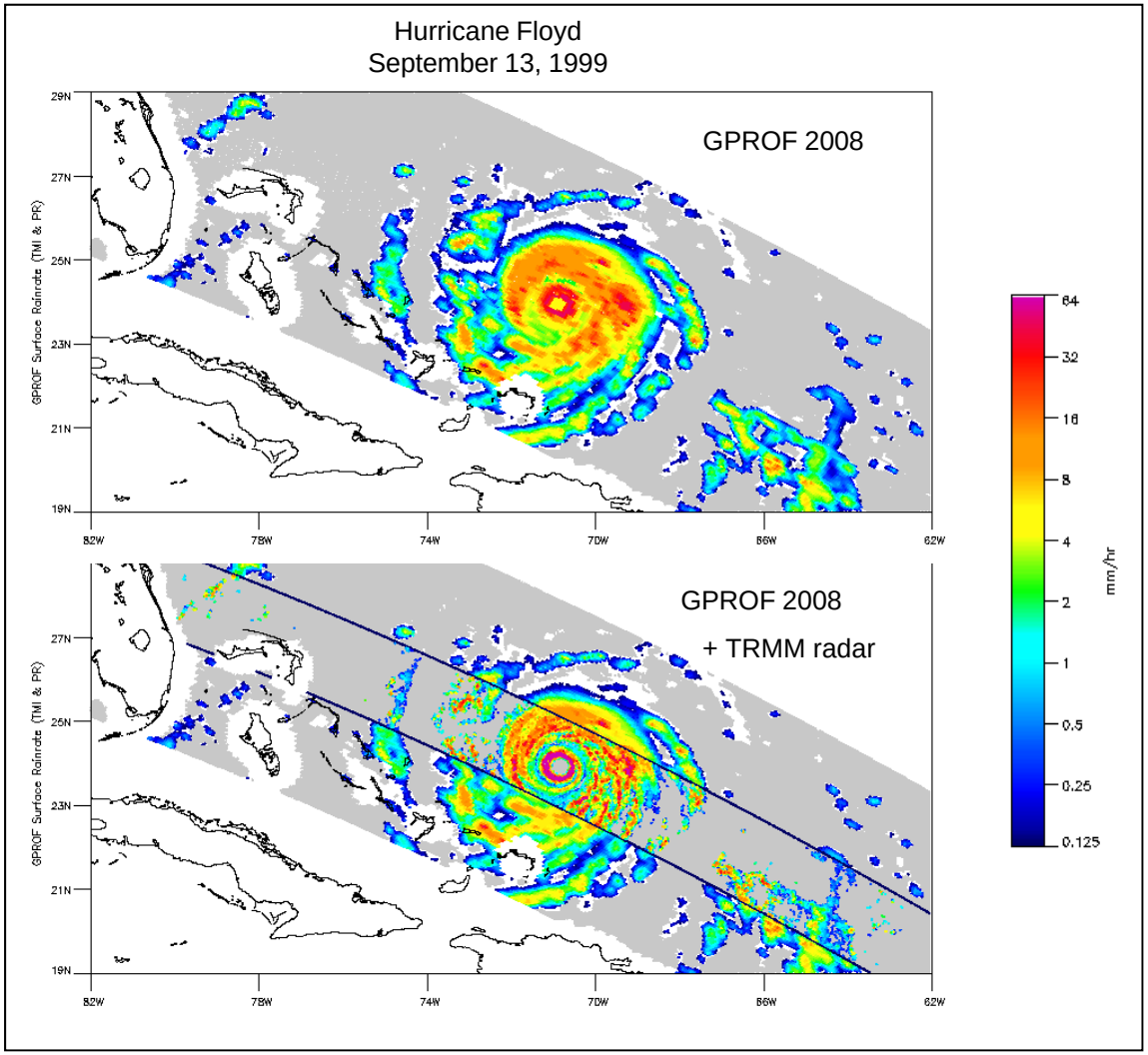
Bayesian Inversion

TRMM Radar & Model Database

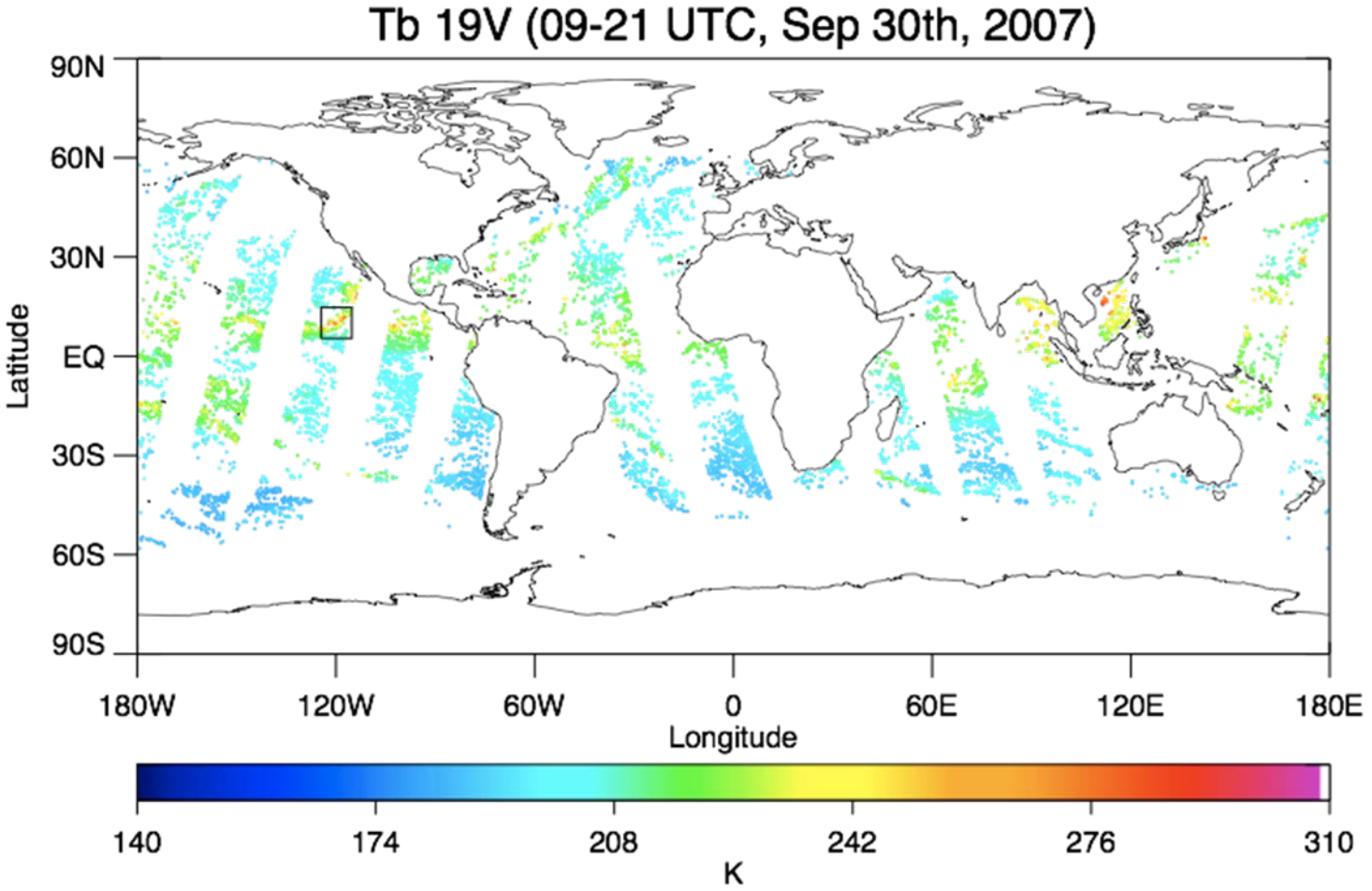


$$P(\mathbf{R}\,|\,\mathbf{T_b}) \propto P(\mathbf{R}) \times P(\mathbf{T_b}\,|\,\mathbf{R})$$

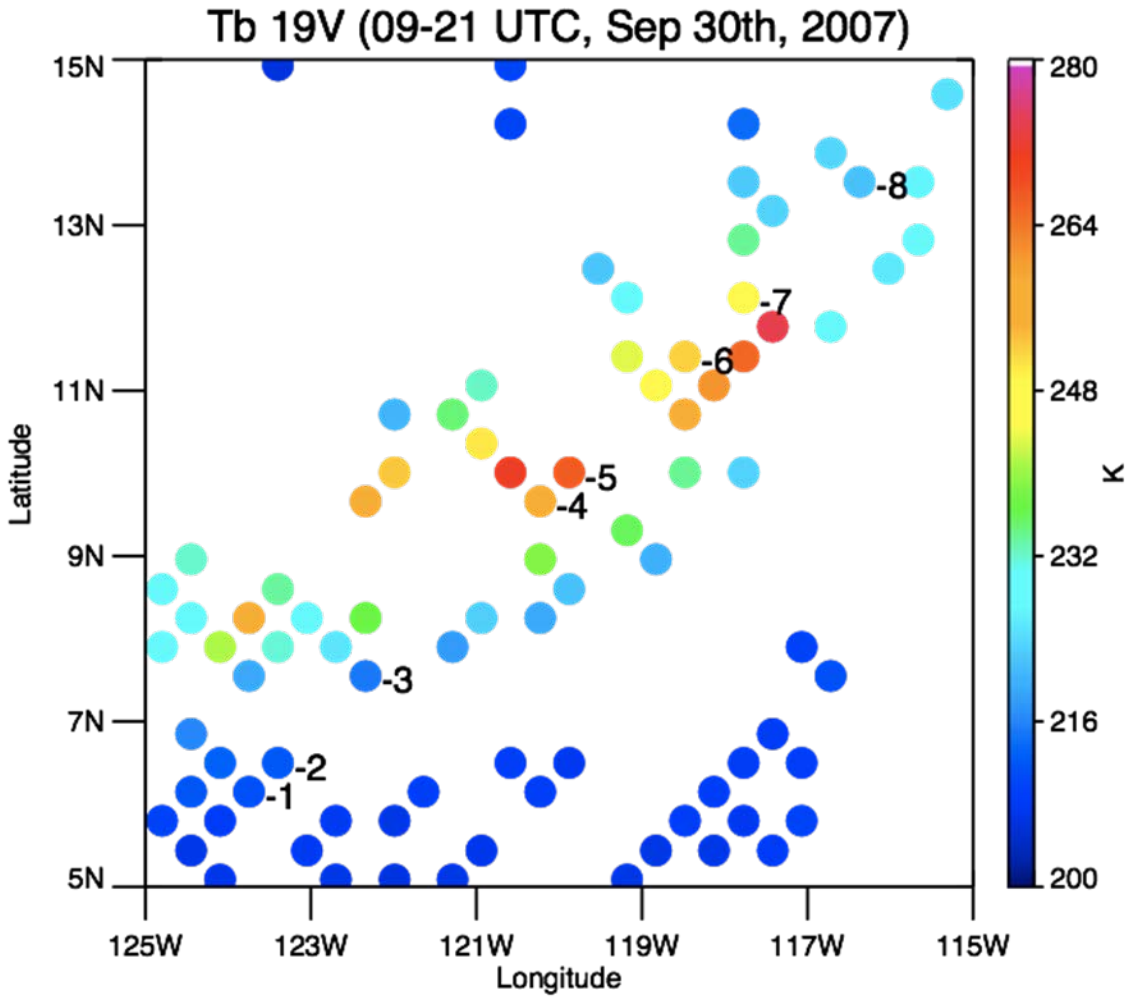
GPROF w. Empirical Database



ECMWF Assimilated Pixels (SSMI)

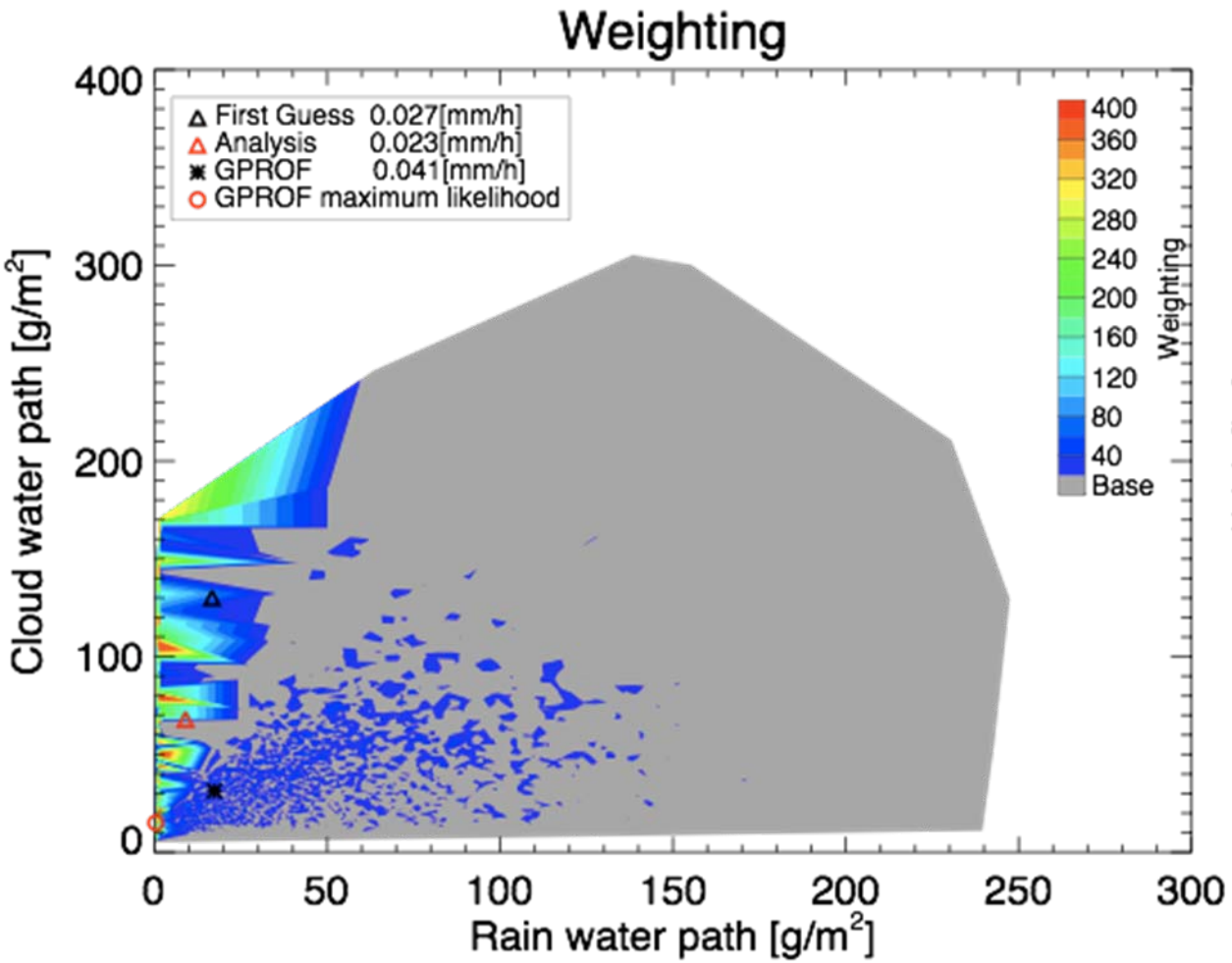


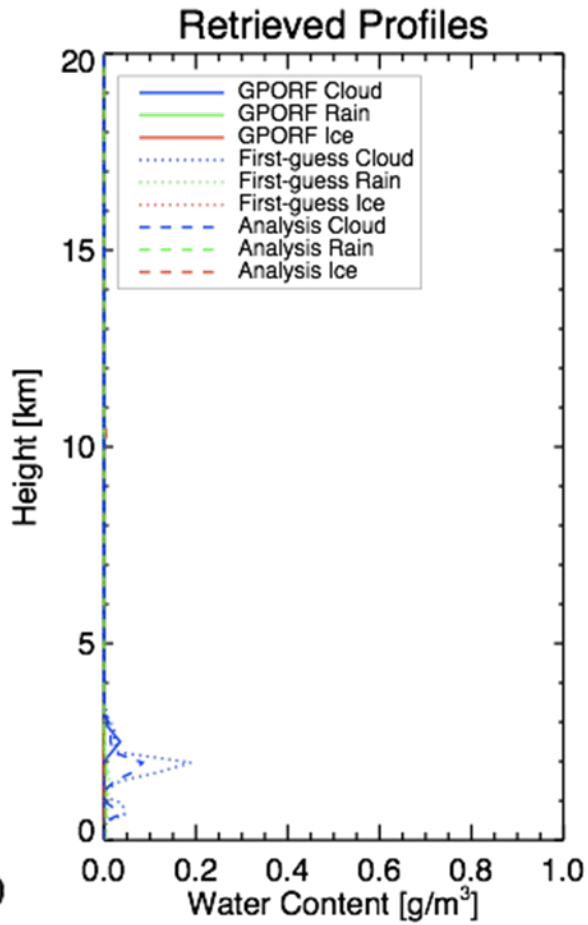
ECMWF Assimilated Pixels (SSMI)



Database, 1st guess, analysis and retrieved rainfall

Pixel #1





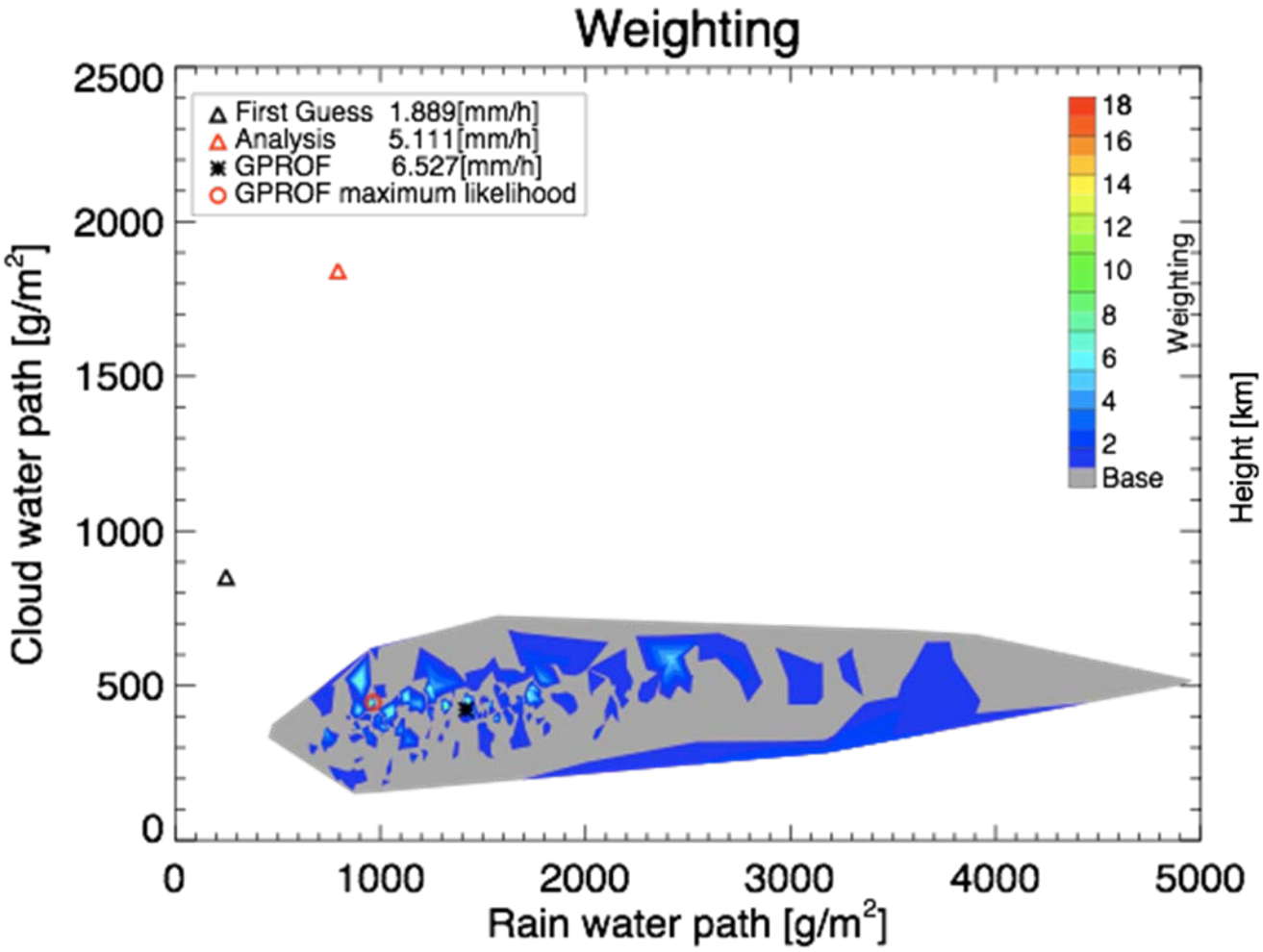
Retrieval and Model Biases

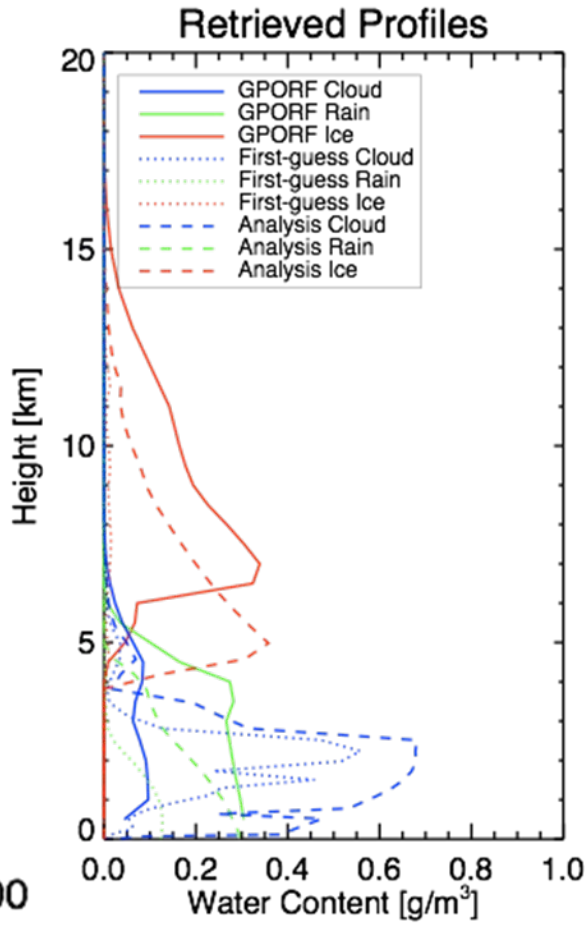
Pixel #1

Tb biases	**19V**	**19H**	**22V**	37V	37H	85V	85H
GPROF maximum likelihood	2.177	0.471	0.546	1.417	5.109	0.354	-4.56
ECMWF 1DVAR First Guess	1.662 (1.706)	5.583 (5.546)	1.739 (-0.246)	0.061 (4.704)	1.990 (6.446)	0.748 (3.064)	2.414 (5.362)
ECMWF 1DVAR Analysis	-0.236 (-0.192)	2.104 (2.067)	-0.204 -2.207)	-3.461 (1.182)	-4.904 (-0.447)	-1.628 (0.688)	-3.790 (-0.842)

Database, 1st guess, analysis and retrieved rainfall

Pixel #5





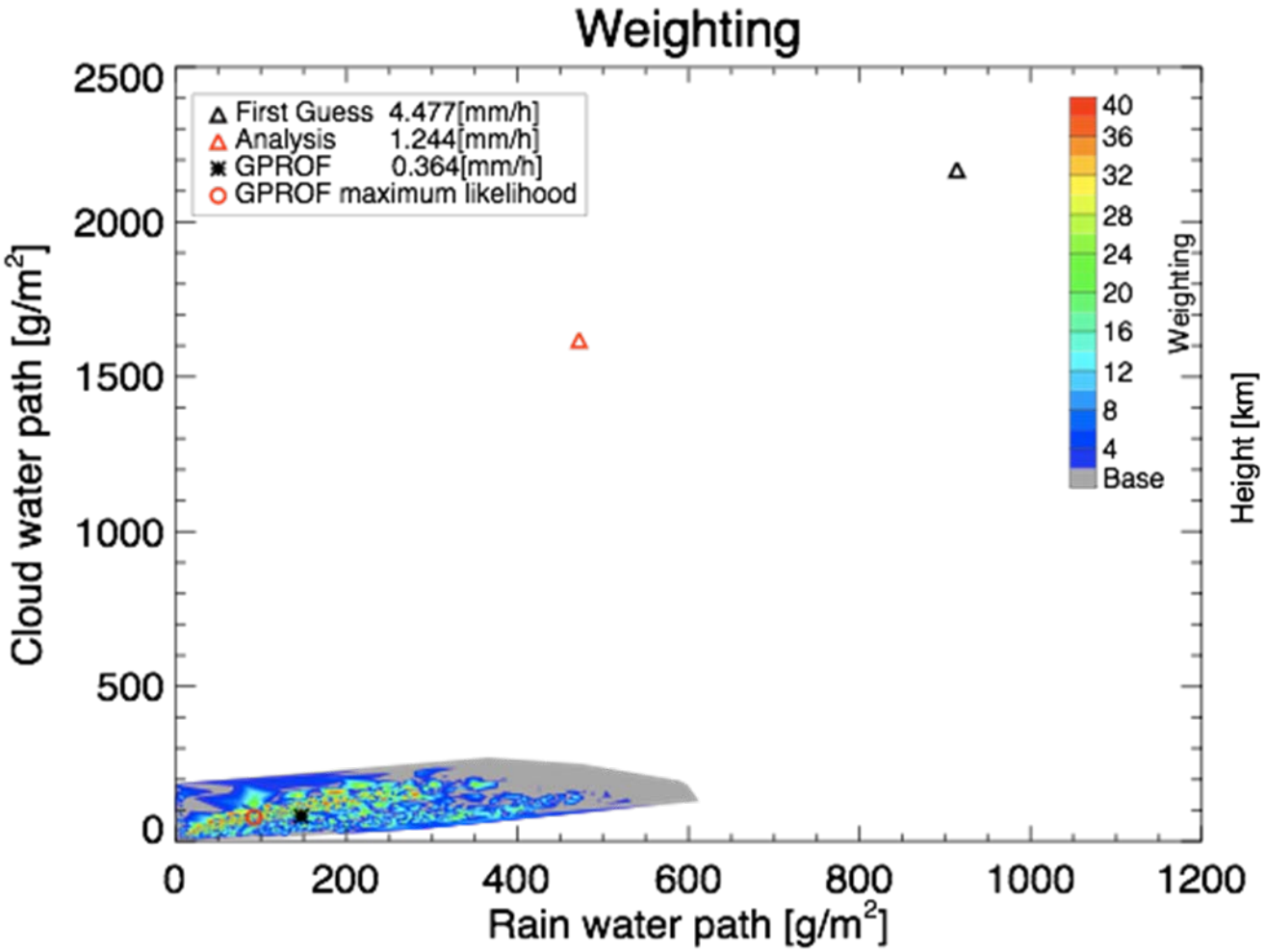
Retrieval and Model Biases

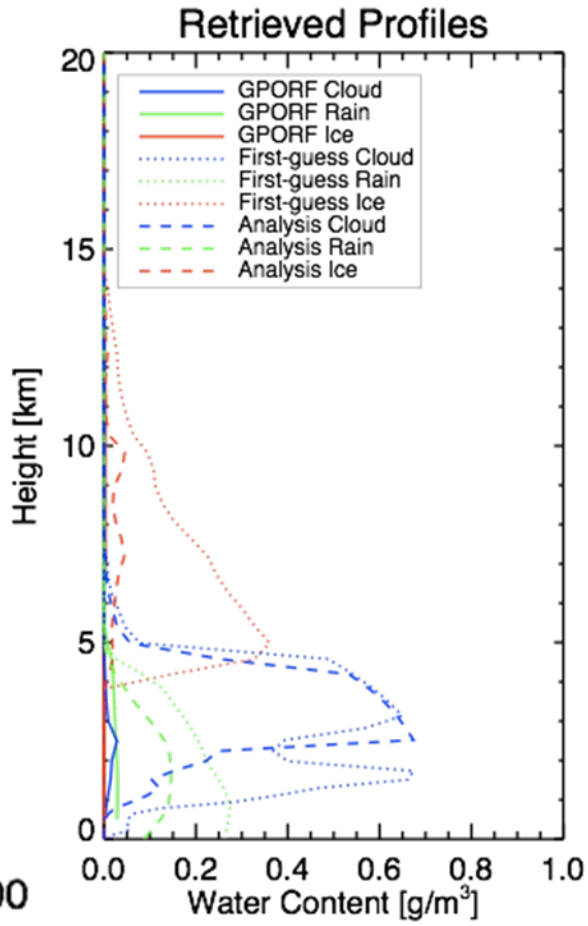
Pixel #5

Tb biases	**19V**	**19H**	**22V**	37V	37H	85V	85H
GPROF maximum likelihood	0.041	-0.912	-0.843	-1.224	0.001	-1.971	5.356
ECMWF 1DVAR First Guess	-30.448 (-21.418)	-57.784 (-40.638)	-9.600 (-7.899)	-13.397 (0.218)	-38.077 (-11.516)	41.604 (41.055)	40.655 (47.649)
ECMWF 1DVAR Analysis	-9.190 (-0.160)	-19.011 (-1.866)	-2.200 (-0.499)	-9.310 (4.305)	-19.629 (6.932)	13.160 (12.611)	12.515 (19.509)

Database, 1st guess, analysis and retrieved rainfall

Pixel #7

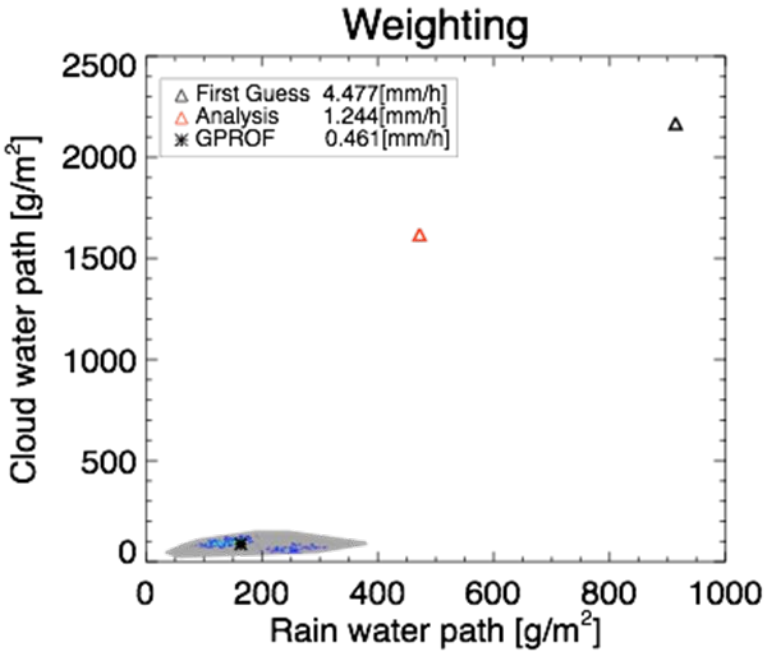


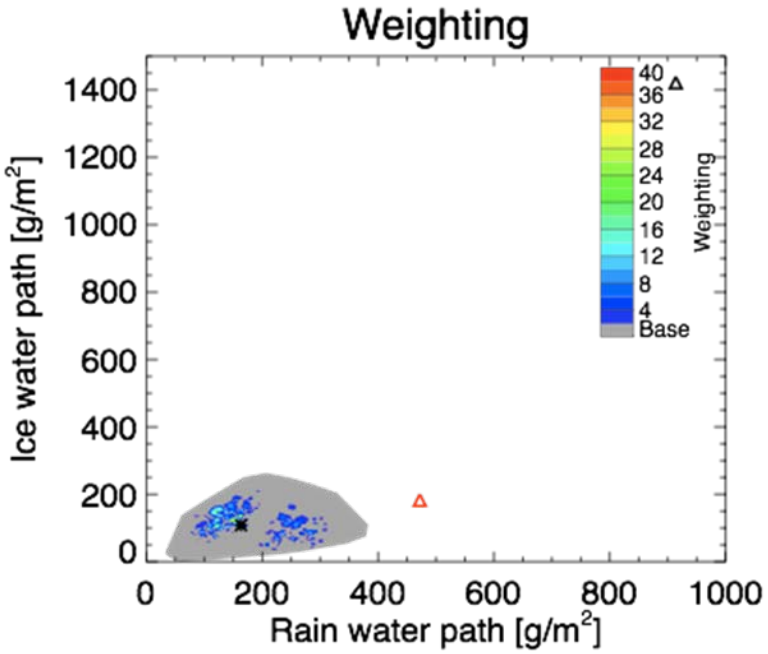


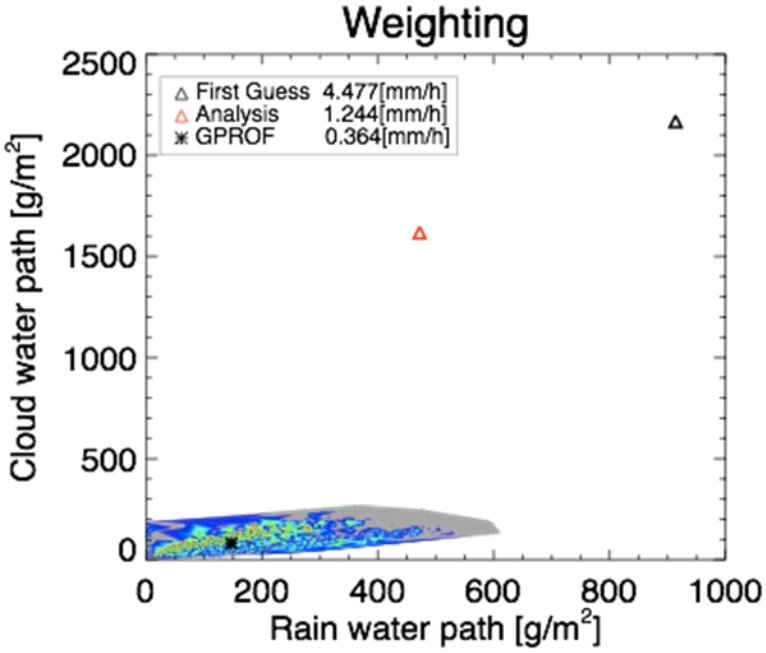
Retrieval and Model Biases

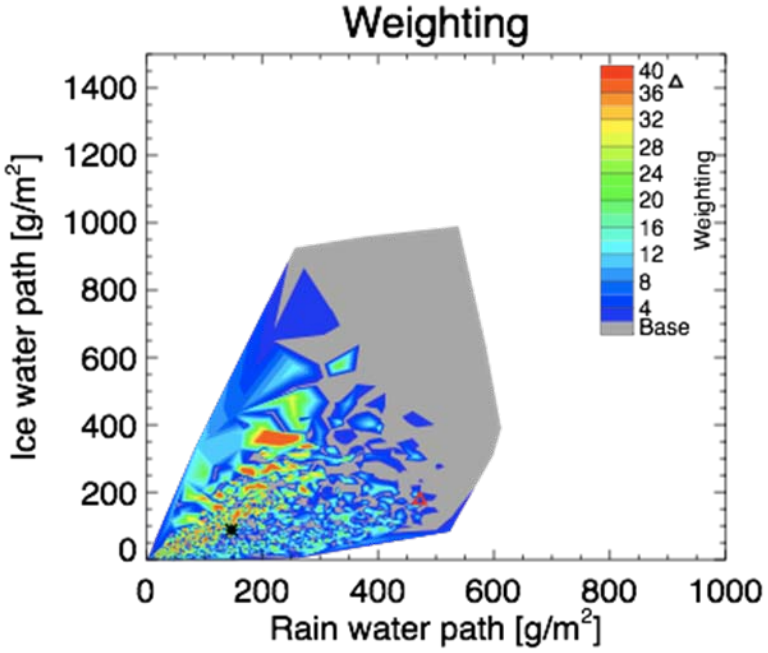
Pixel #7

Tb biases	**19V**	**19H**	**22V**	37V	37H	85V	85H
GPROF maximum likelihood	0.191	1.105	0.222	-1.719	-6.165	4.629	4.288
ECMWF 1DVAR First Guess	13.212 (35.615)	23.246 (64.634)	4.788 (11.749)	6.430 (29.608)	13.467 (64.657)	-12.303 (-20.530)	-15.873 (-12.230)
ECMWF 1DVAR Analysis	0.684 (23.087)	-0.603 (40.785)	1.809 (8.770)	10.979 (34.158)	13.266 (64.456)	6.872 (-1.355)	3.283 (6.925)


Weighting
First Guess 4.477[mm/h]
Analysis 1.244[mm/h]
GPROF 0.461[mm/h]
Cloud water path [g/m2]
Rain water path [g/m2]


Weighting
Ice water path [g/m2]
Rain water path [g/m2]
Weighting
Base


Weighting
First Guess 4.477[mm/h]
Analysis 1.244[mm/h]
GPROF 0.364[mm/h]
Cloud water path [g/m2]
Rain water path [g/m2]


Weighting
Ice water path [g/m2]
Rain water path [g/m2]
Weighting
Base

Conclusions

The a-priori databases constructed from radar/radiometer (and potentially other sensors by algorithm developers) also serves as a nice tool to verify 1D cloud schemes use