An Active-Passive Microwave Land Surface Classification from GPM

S. Joe Munchak[1]

*Sarah Ringerud[1,2]

Ludovic Brucker[1,2]

Yalei You[2],

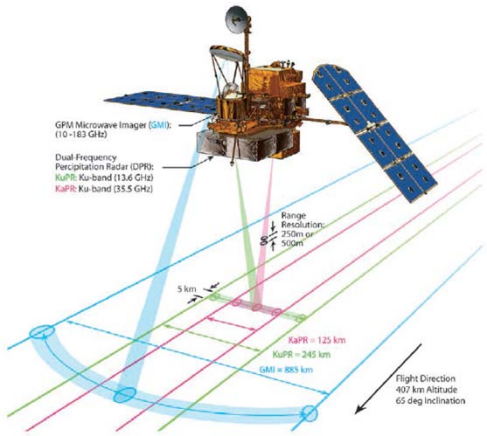
and Catherine Prigent[3]

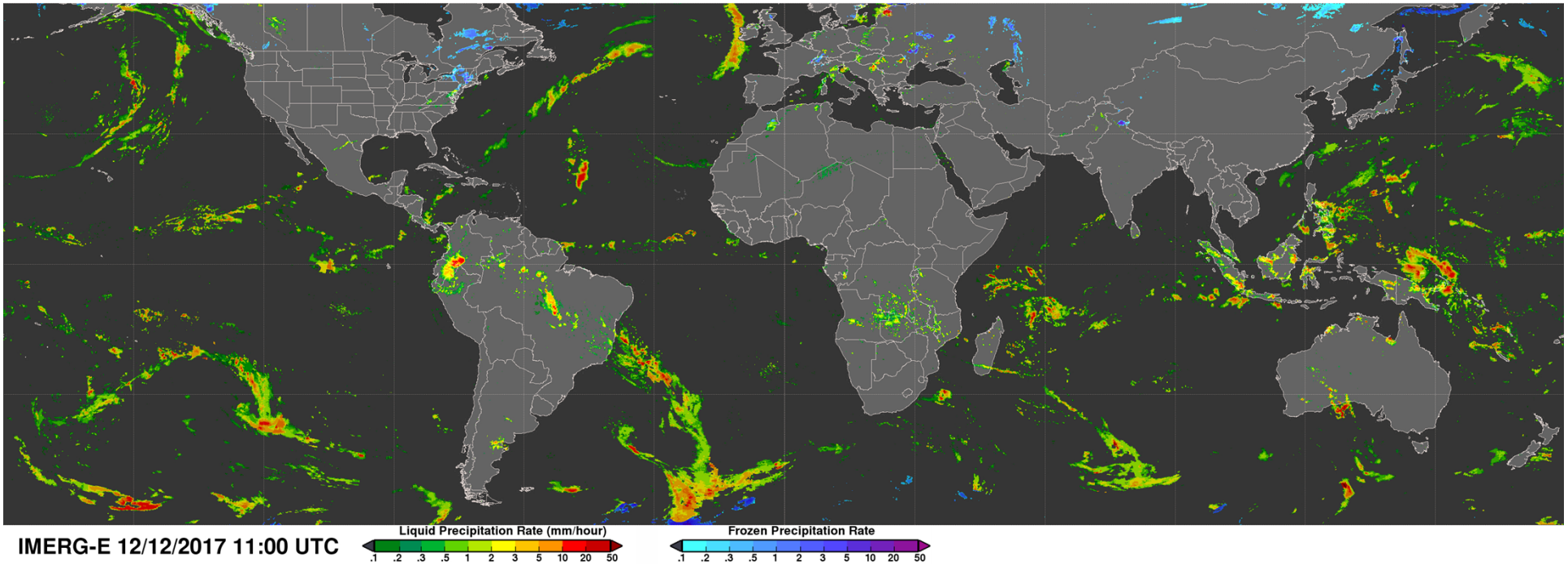
1: NASA GSFC, 2: UMD-ESSIC,
3: l'Observatoire de Paris

ISWG-3 Montréal

July 15, 2019

Introduction: GPM Constellation

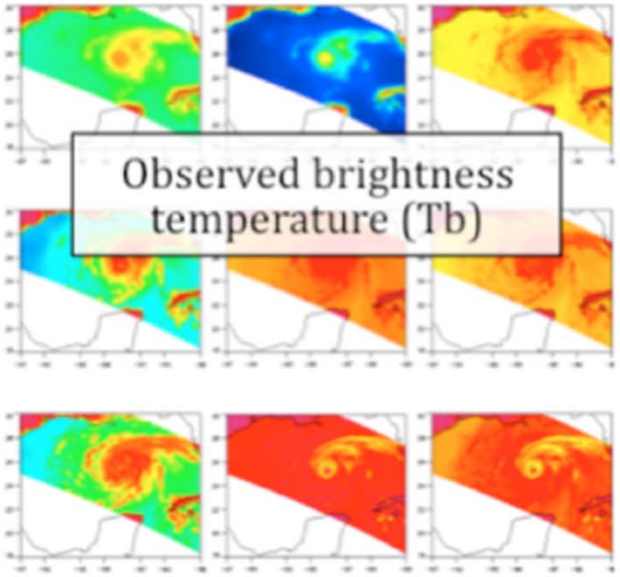


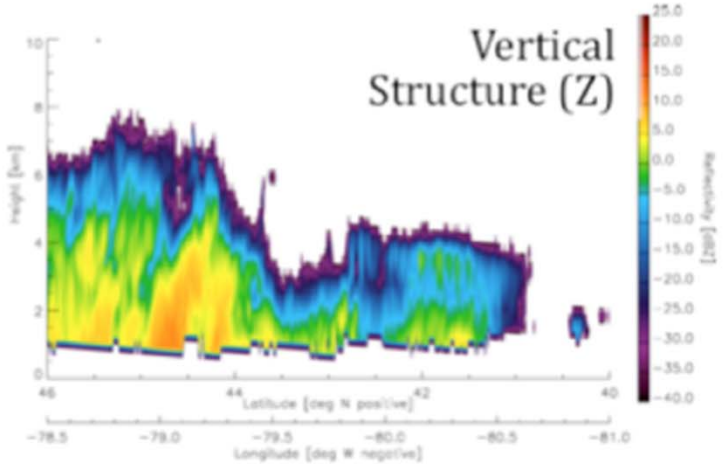


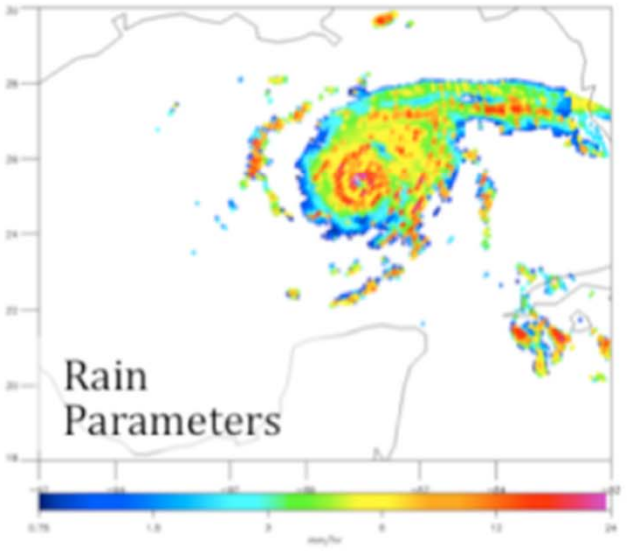
Introduction

GPM's database from DPR+GMI obs.

Observed T_b, Z, & combined retrievals







GPM: GPM Core observations provide database T_b and RR, this transfer standard allows for unified precipitation retrievals.

pmm.nasa.gov/multimedia/images/GPM

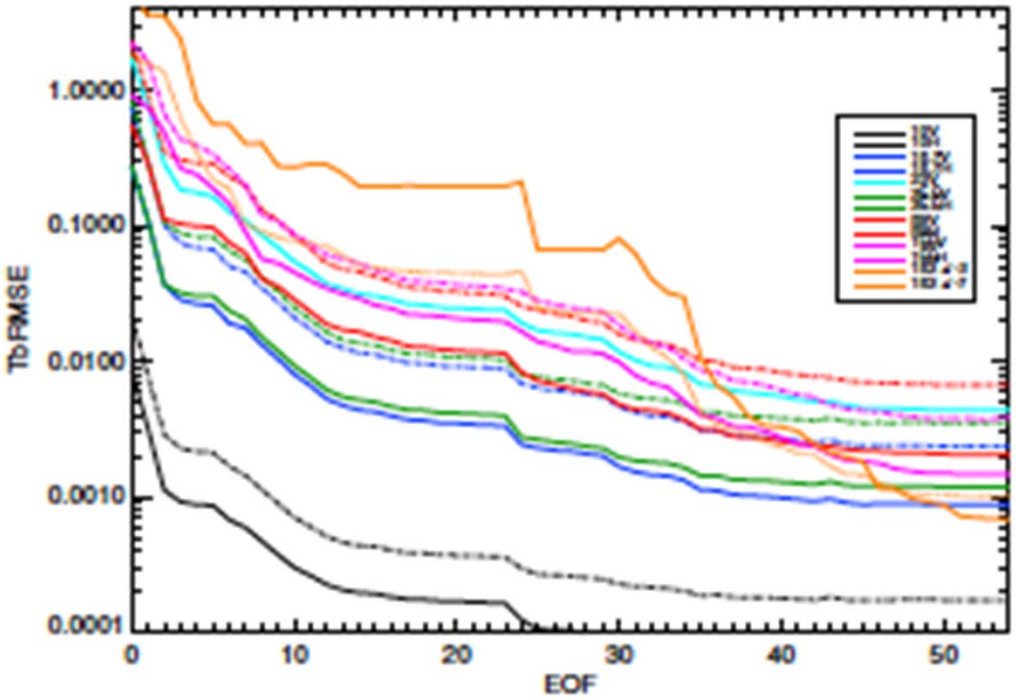
Motivation: Emissivity

- Database construction and retrievals include important forward modeling component
- Existing microwave emissivity atlases (e.g., TELSEM) are useful, but would like the full range of GMI frequencies
- Backscatter at DPR frequencies and incidence angles used in temporal reference component of SRT, but not linked to microwave emissivity
- Superior calibration, resolution, and matched active-passive data from GPM provide uniquely valuable dataset for model developers

In order to provide a dataset relevant to these application areas, we have developed a 5-year database of GPM emissivity and backscatter data

Emissivity Retrieval

- Optimal estimation at each GMI pixel
- Use MERRA2 for T_{skin} and first-guess atmosphere (temperature and water vapor profile)
  - Error covariance matrix constructed from radiosonde comparisons
- Retrieve emissivity vector and EOF representation of MERRA2 error
  - Effective emissivity
- No assumed covariance between emissivity at different channels (except 18V-23V-36V and 166-183) – we want to use output to discover these relationships

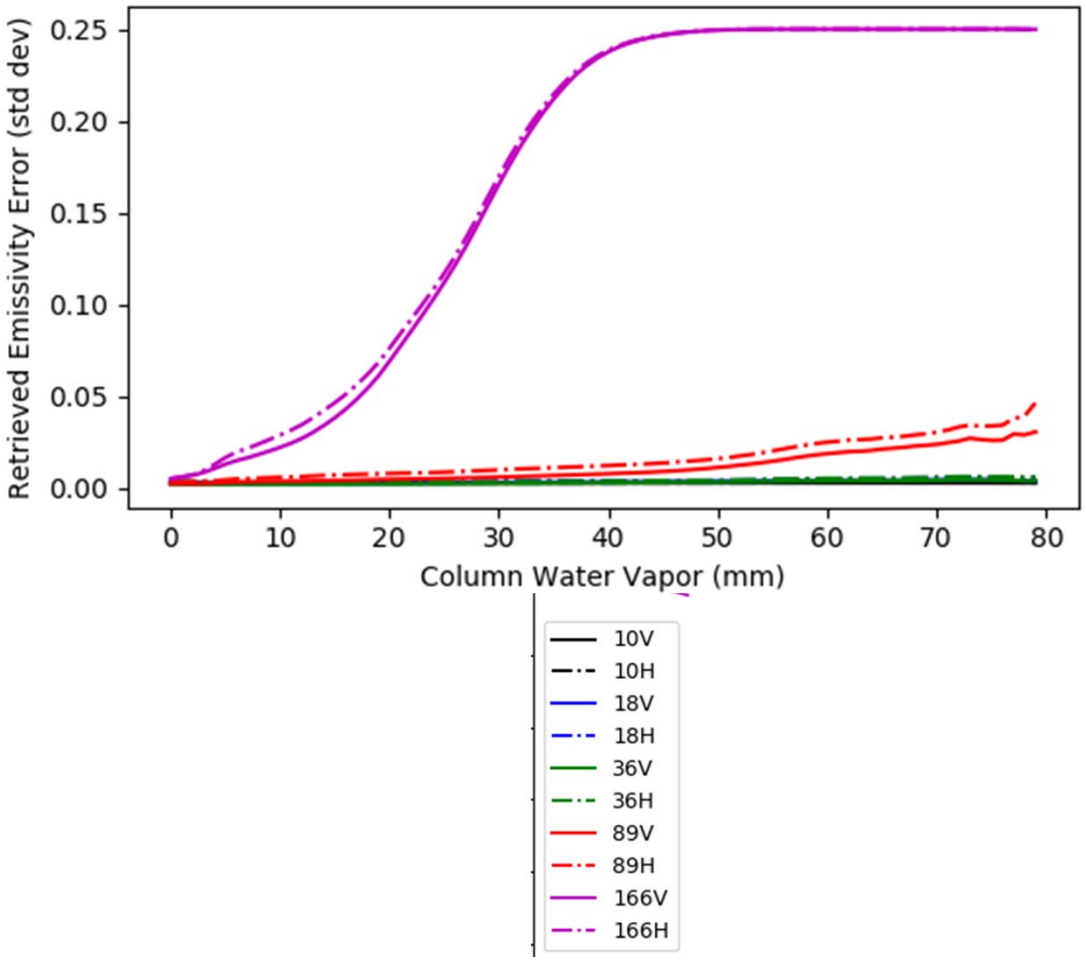


Information Content

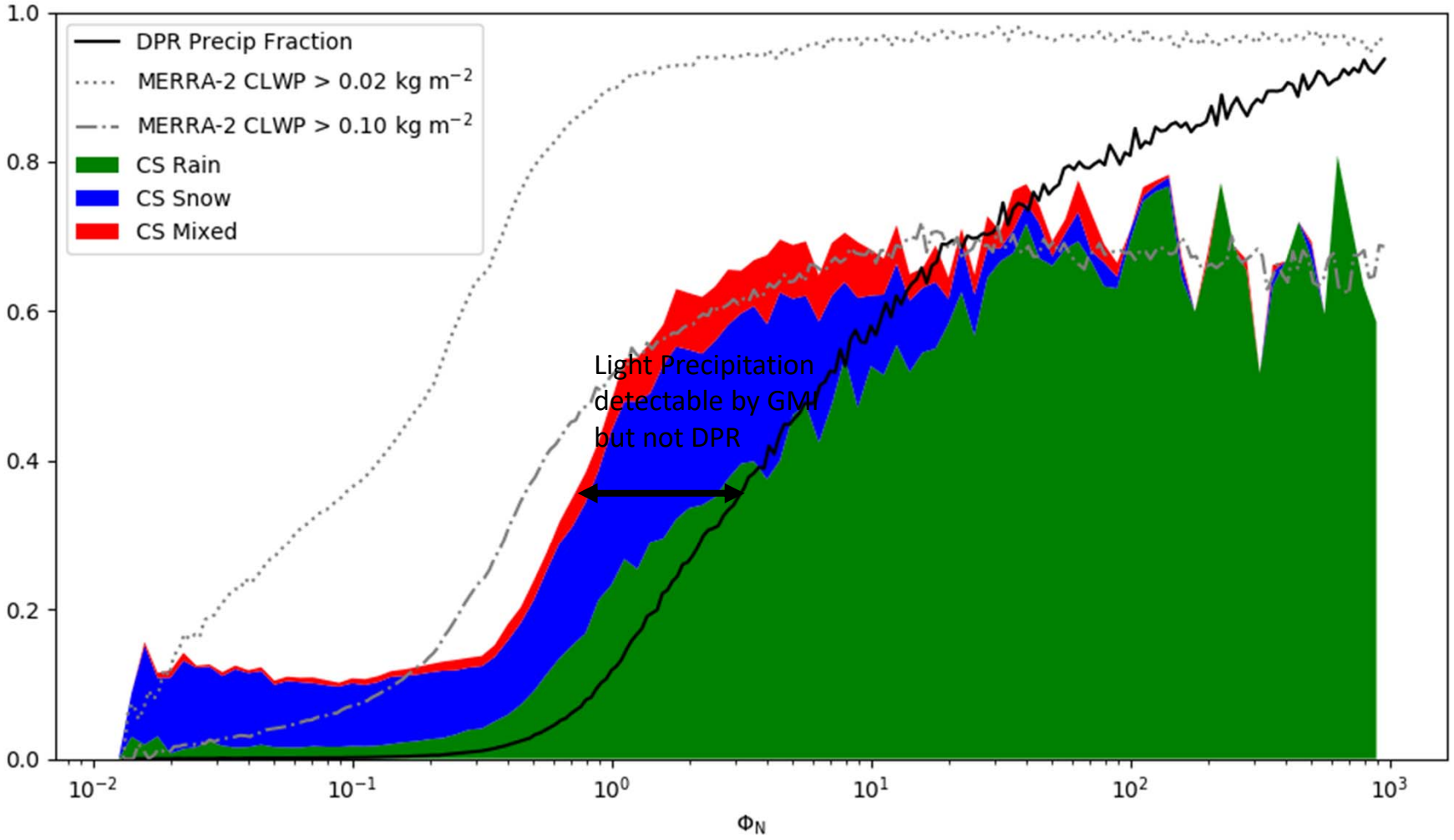
As column water vapor increases, GMI Tb becomes less sensitive to surface emissivity, therefore it becomes difficult to retrieve and can be influenced by errors in water vapor profile.

Effect is not significant below 89 GHz, and even there only for very high column water vapor (> 50 mm). At 166 GHz the impact is much larger. Retrievals not reliable above 10-20mm column water vapor.

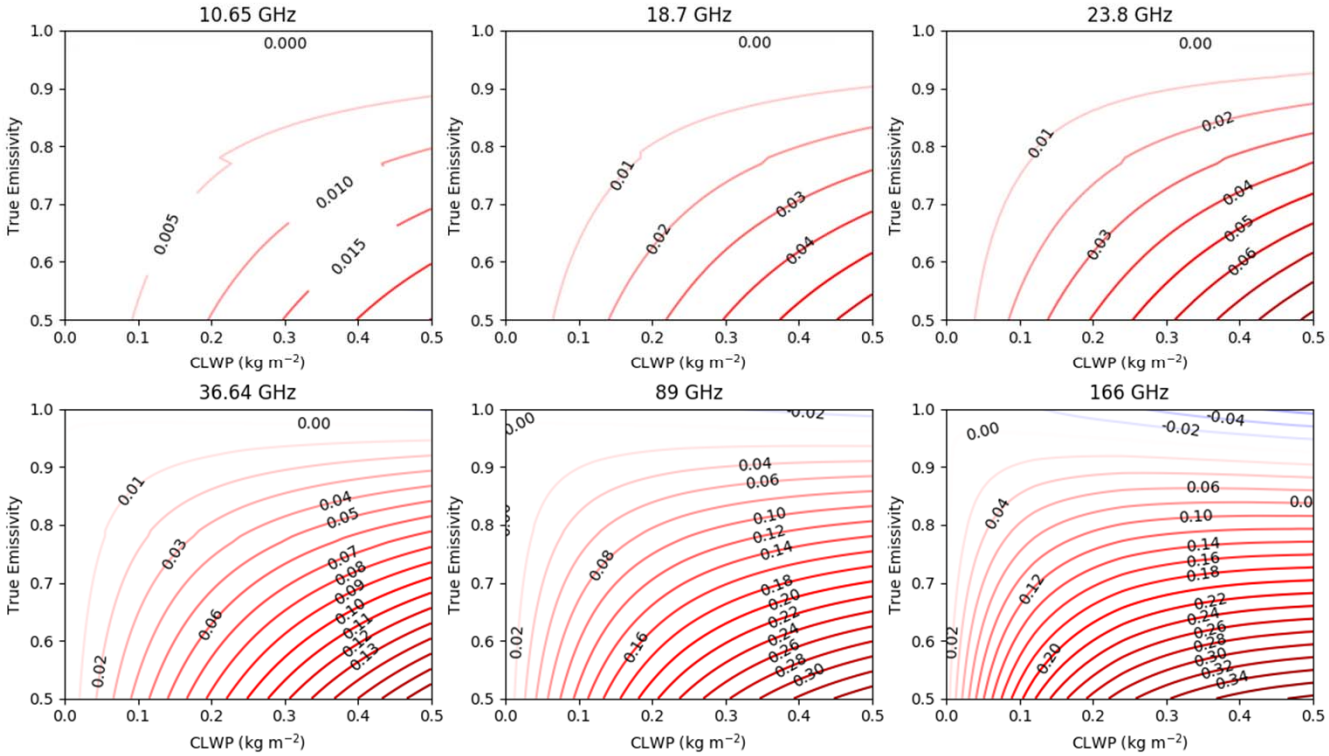
Clouds and precipitation also impact retrievals significantly and must be screened, as these are not accounted for in the forward model.



Precipitation Screening by Normalized Cost Function



Influence of Liquid Clouds on Retrieved Emissivity



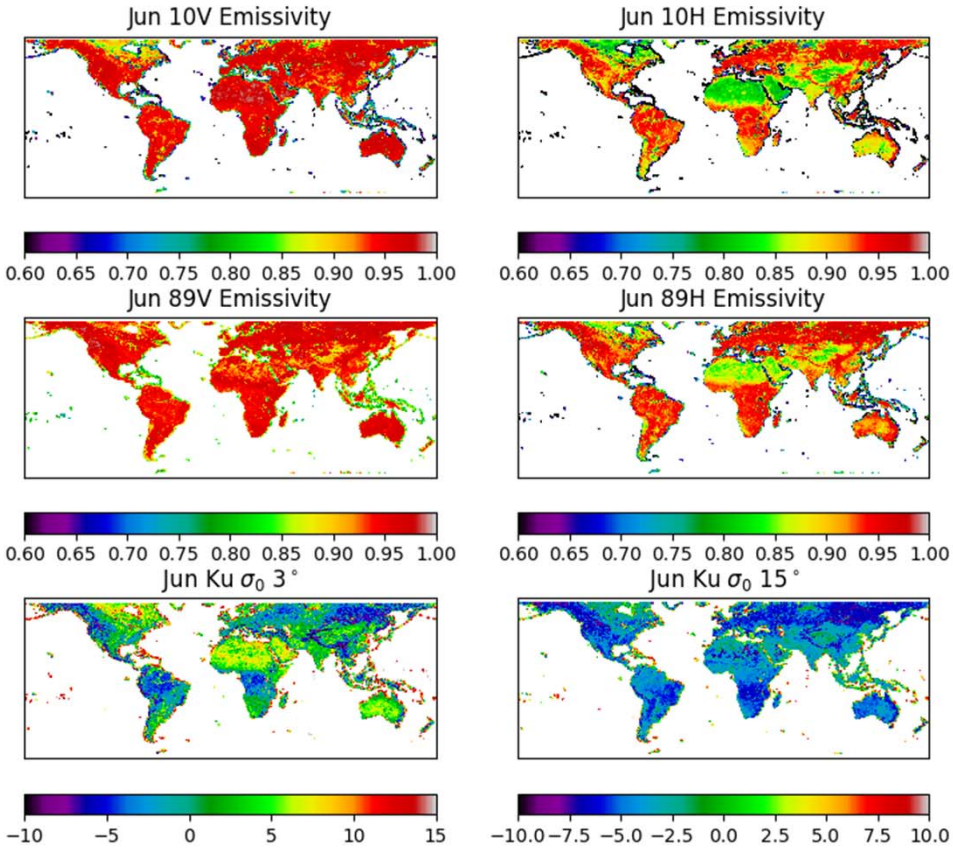
Contours are retrieved emissivity error (retrieved minus true). Error can be significant, yet difficult to retrieve cloud unless emissivity is already strongly constrained. Solution: Use ancillary data (MERRA2) to screen clouds.

Database construction and availability

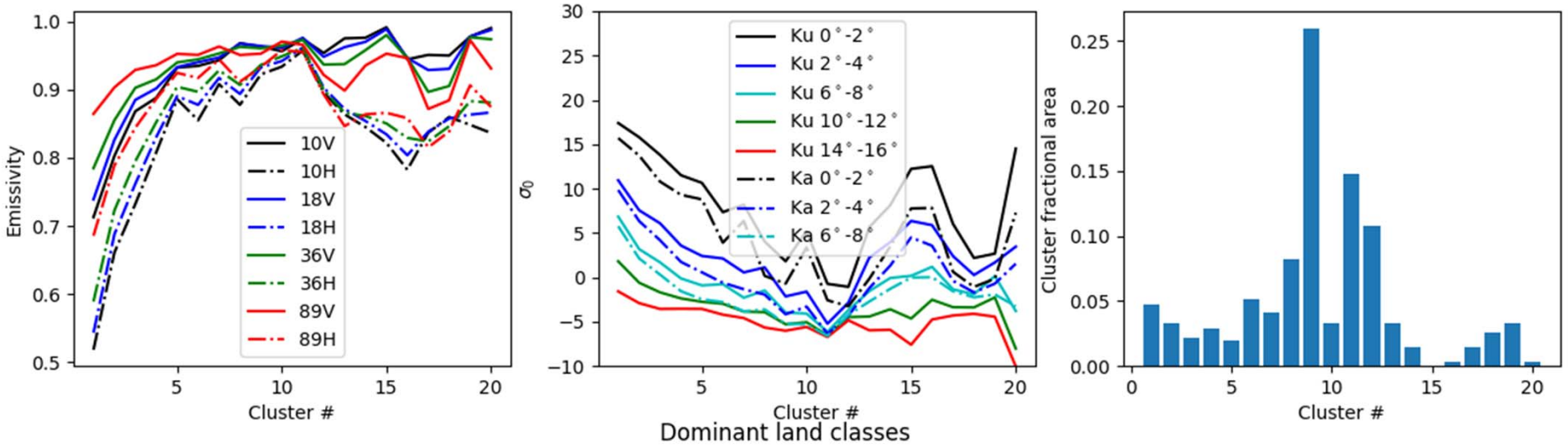
- Retrieval run for full GMI swath at GMI resolution (GMI.*.HDF5 files)
  - Contains retrieved emissivities, column water vapor, GMI observed and simulated Tbs, retrieval cost function, MERRA2 fields (Tskin, cloud LWP, column water vapor)
- Match to DPR resolution (nearest neighbor) (GPM.*.HDF5 files)
  - All the data in the GMI files, plus several fields copied from DPR files (incl. GANAL Tskin, precip flags, snow flags, sigma_zero, PIA from gas attenuation)
- Files for March 2014 – February 2019 available at ftp://meso-a.gsfc.nasa.gov/pub/munchak/gpm/emis/
  - Switching to ftps in near future
  - Anticipated to be part of GPM combined algorithm V7

Gridded Database Construction

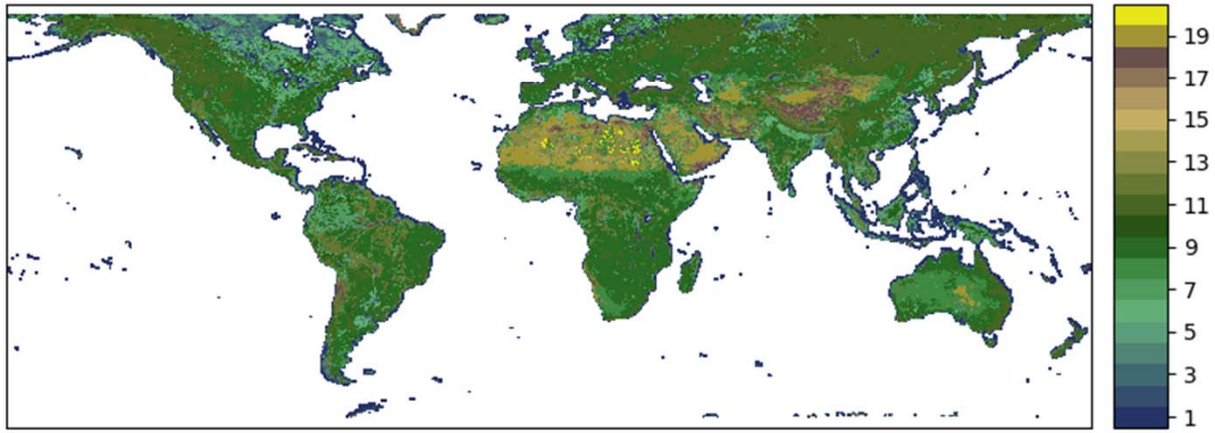
- 0.25˚ -resolution grids of the following statistics compiled:
  - Mean emissivity
  - Mean sigma_zero
  - Emissivity covariance matrix
  - Sigma_zero covariances
  - Emissivity-sigma_zero covariances
- Separate grids for each month
- Separate grids for snow/sea ice
- Form basis of self-similar classification

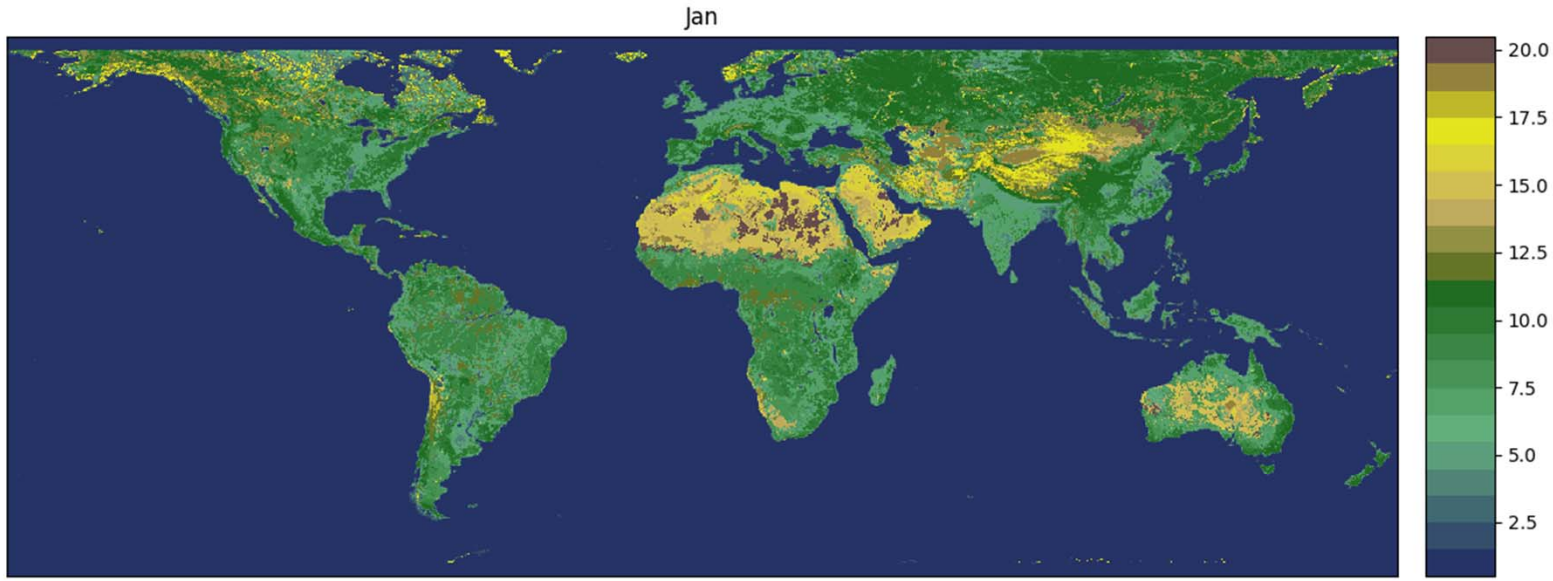


Kohonen Self-Organizing Map Clustering Method: Snow-free land

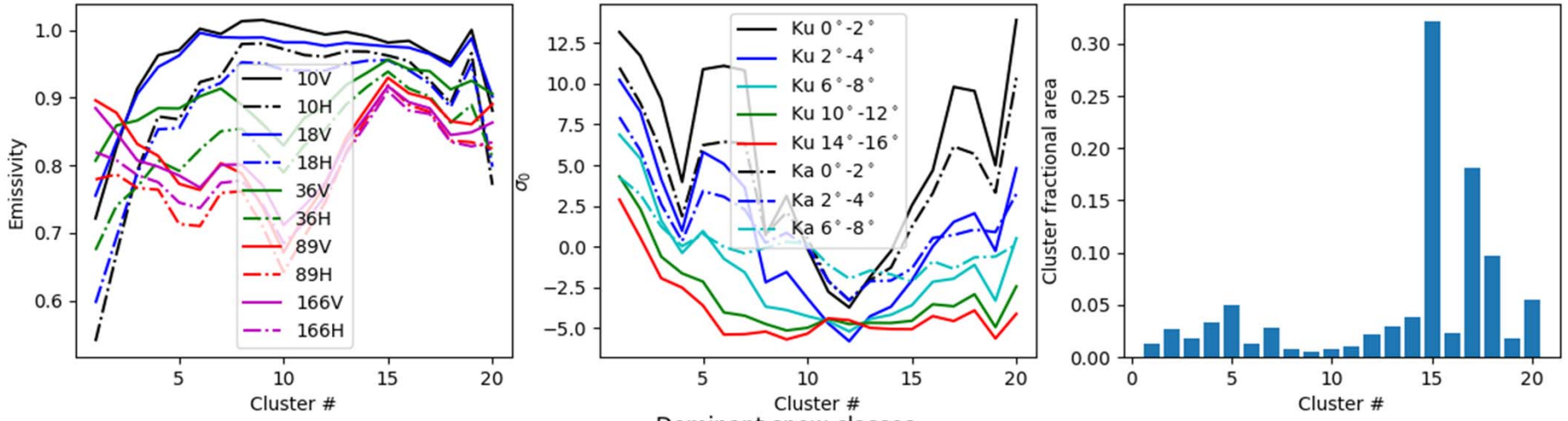


1-4: coastal, wetlands, river flood plains
5-10: increasing vegetation
7-11: dense vegetation
12-14: Decreasing vegetation
15-20: Sandy deserts

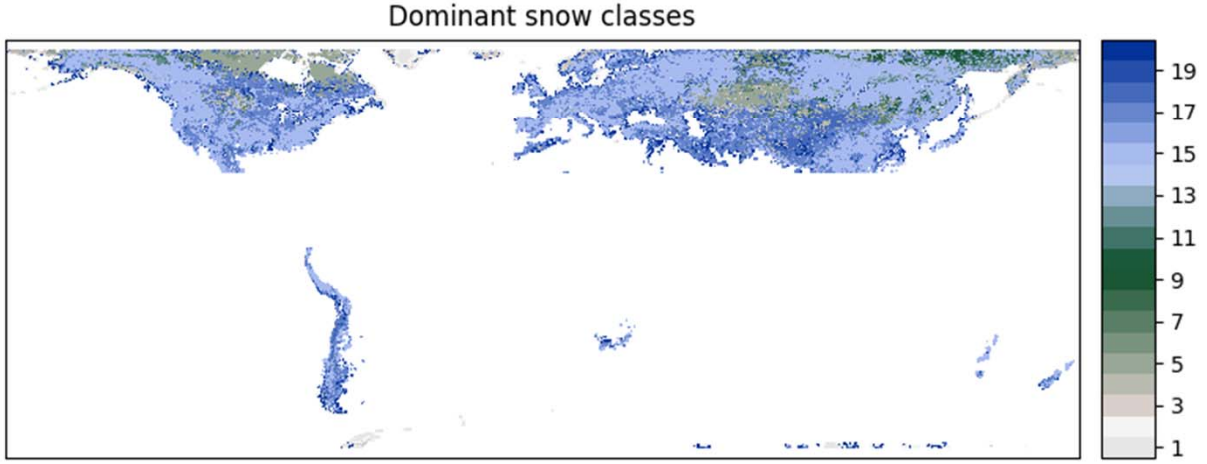


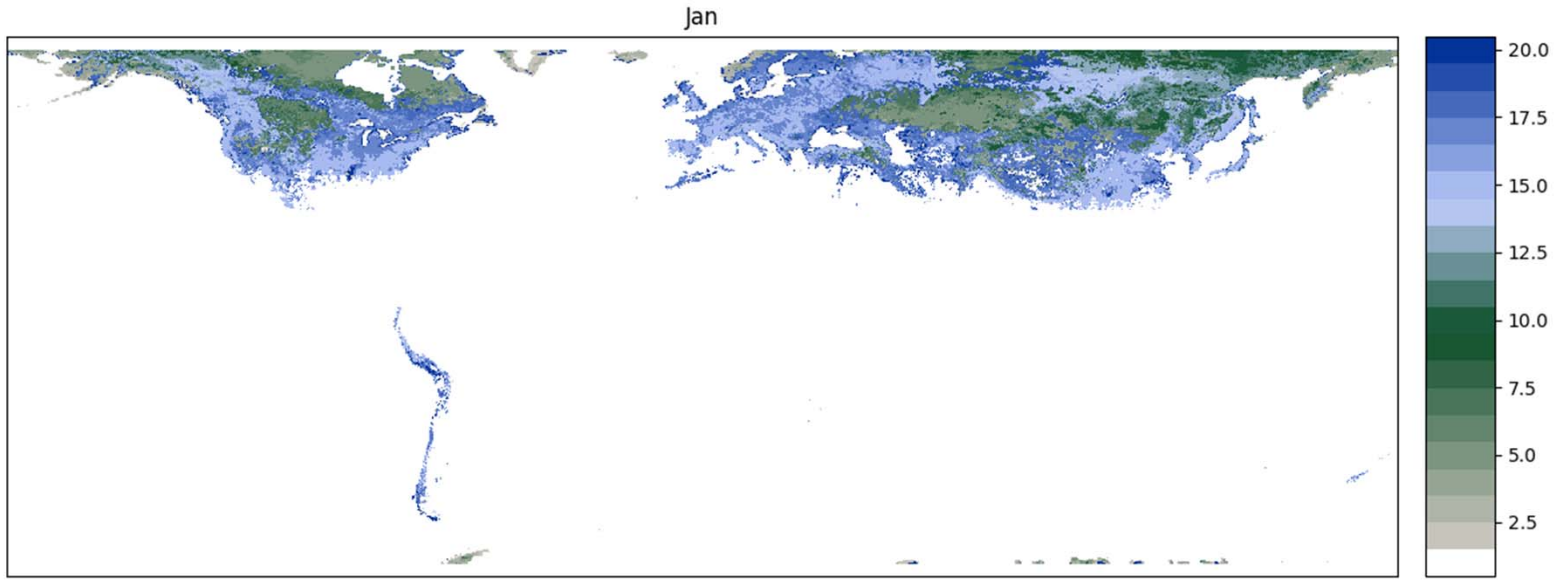

Jan
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5

Kohonen Self-Organizing Map Clustering Method: Snow-covered land



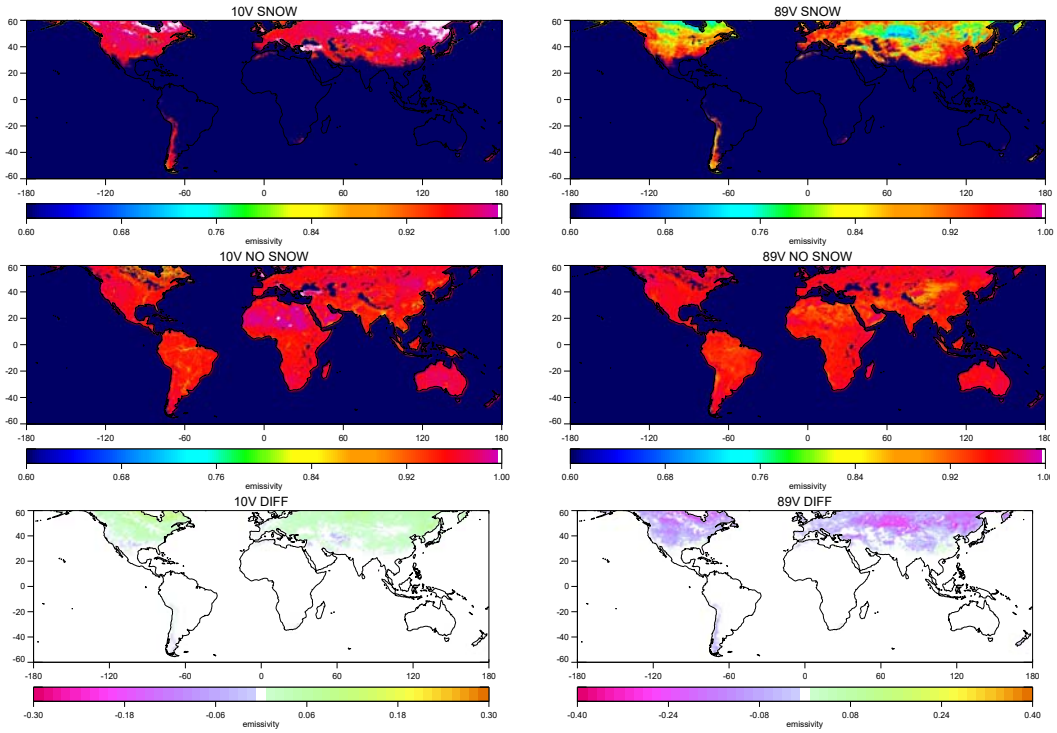
1-2: ice sheets
3-10: cold, dry snow
10-14: mountain or maritime snow
15-20: early season, low latitude

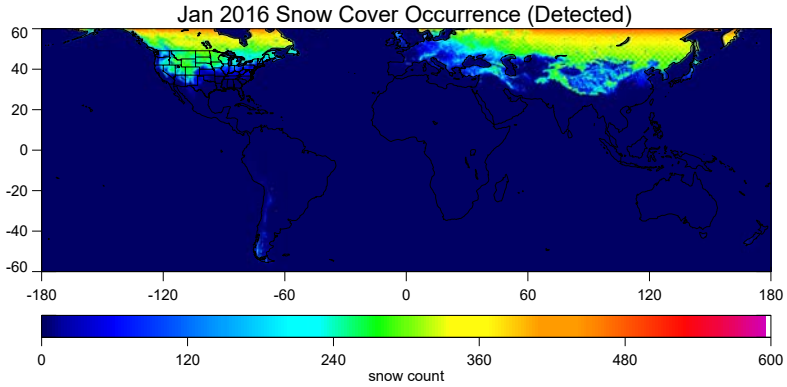


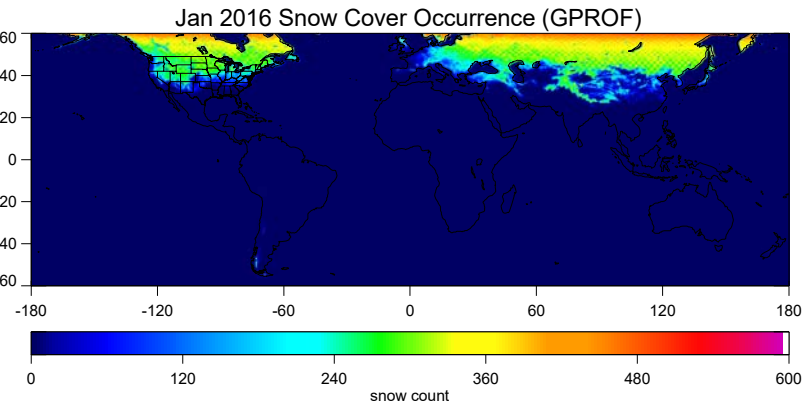

Jan
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5

Applications: Snow Cover

- Physical basis: emission signal at low frequency + scattering signal in high frequency
  - Compare to snow-free emissivity for that location

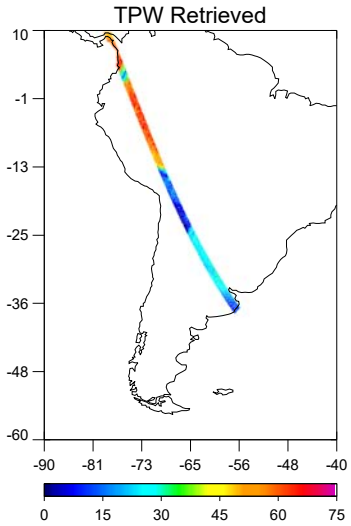


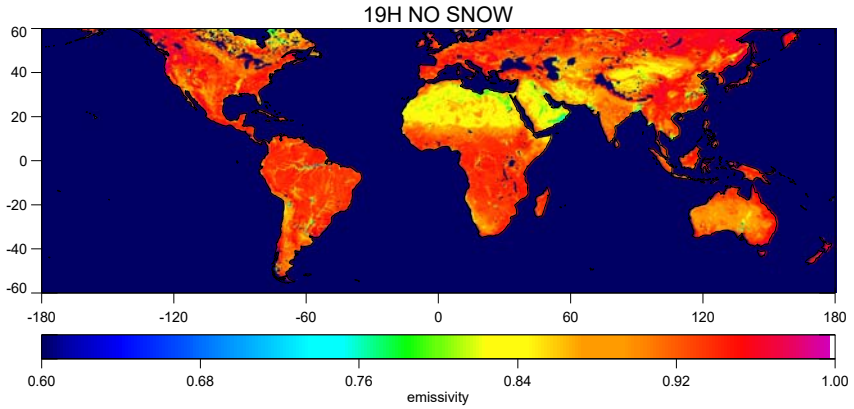


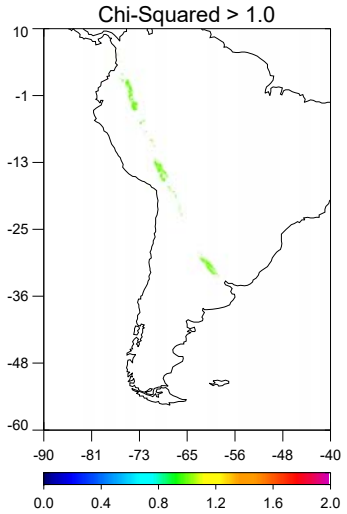


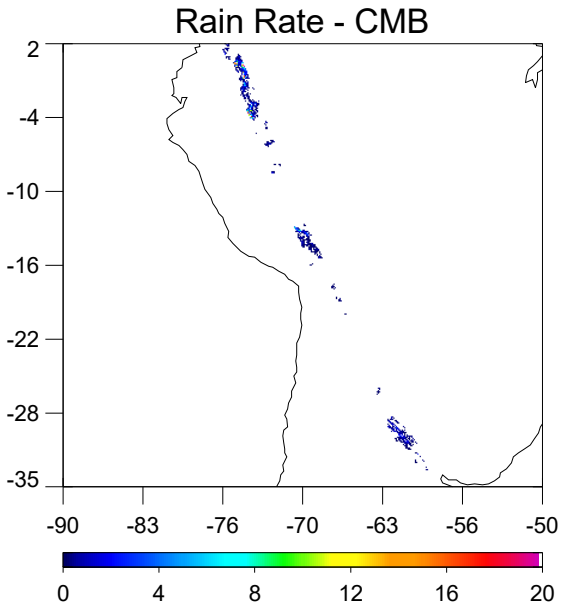
Autosnow: NOAA Blended optical-microwave retrieval algorithm – daily (used by GPROF)

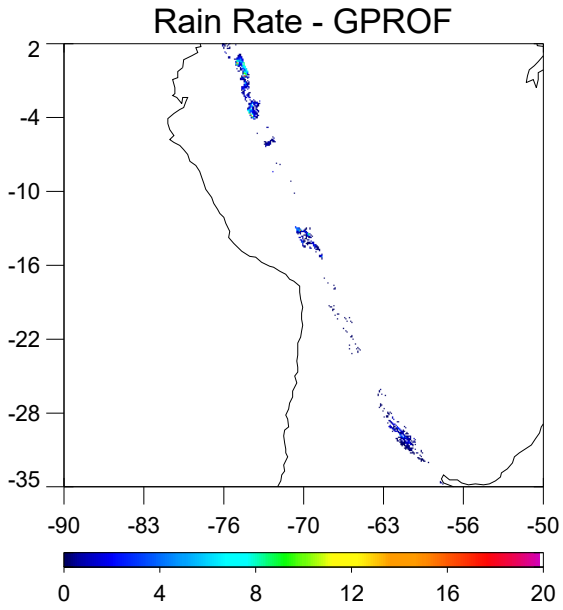
Applications: Hybrid Precipitation Retrieval

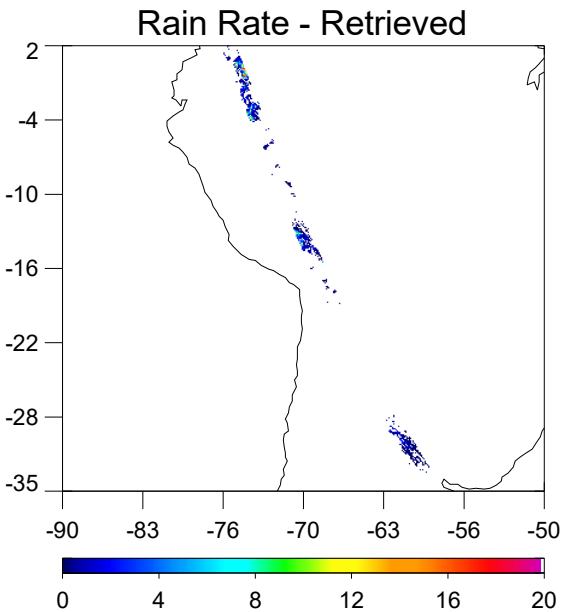












Summary and Conclusions

- A land surface emissivity database has been created using the GPM core satellite active and passive observations along with an Optimal Estimation type retrieval
  - Retrievals available as swath data for all GPM orbits or monthly gridded
- Cluster analysis has been used with the database for creation of snow/no snow surface classification using both emission and backscatter
- Many possible applications of this database
  - Retrieve snow cover
  - Rain/no-rain determination
  - Climatology first guess, model evaluation
  - *Will be available via 2BCMB in V7 GPM product release
- While immediate application is for precipitation retrieval, it is our hope that this extensive database will motivate further study of semi-empirical and fully physical emissivity modeling