

Active/Passive Surface Characteristics from GPM: Physical Insights and Algorithm Applications

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With contributions from:
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Yalei You, Ludovic Brucker, and Sarah Ringerud

~90% of the time, GPM is not observing precipitation

What can these observations tell us about surface properties, including the recent accumulation of rain or snow?

How can we use these observations to improve assumptions about the surface that are needed by combined algorithm (and GPROF database generation)?

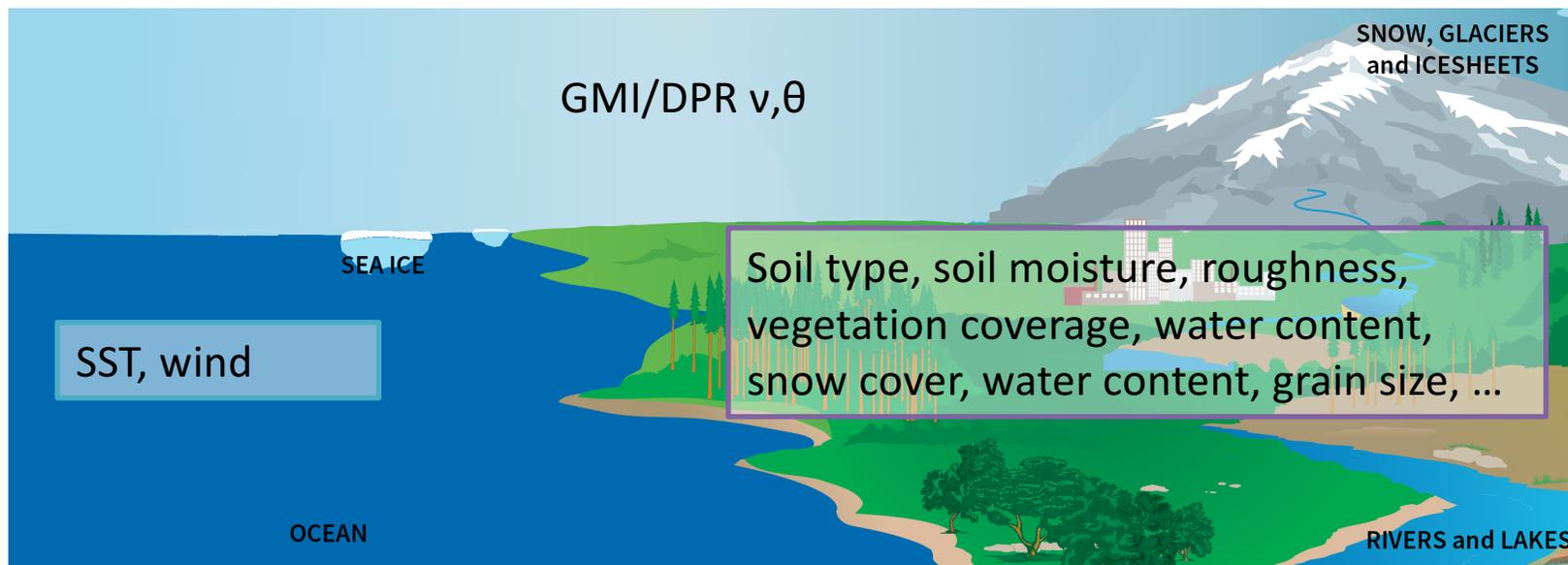
Different Surfaces, Different Strategies

Water

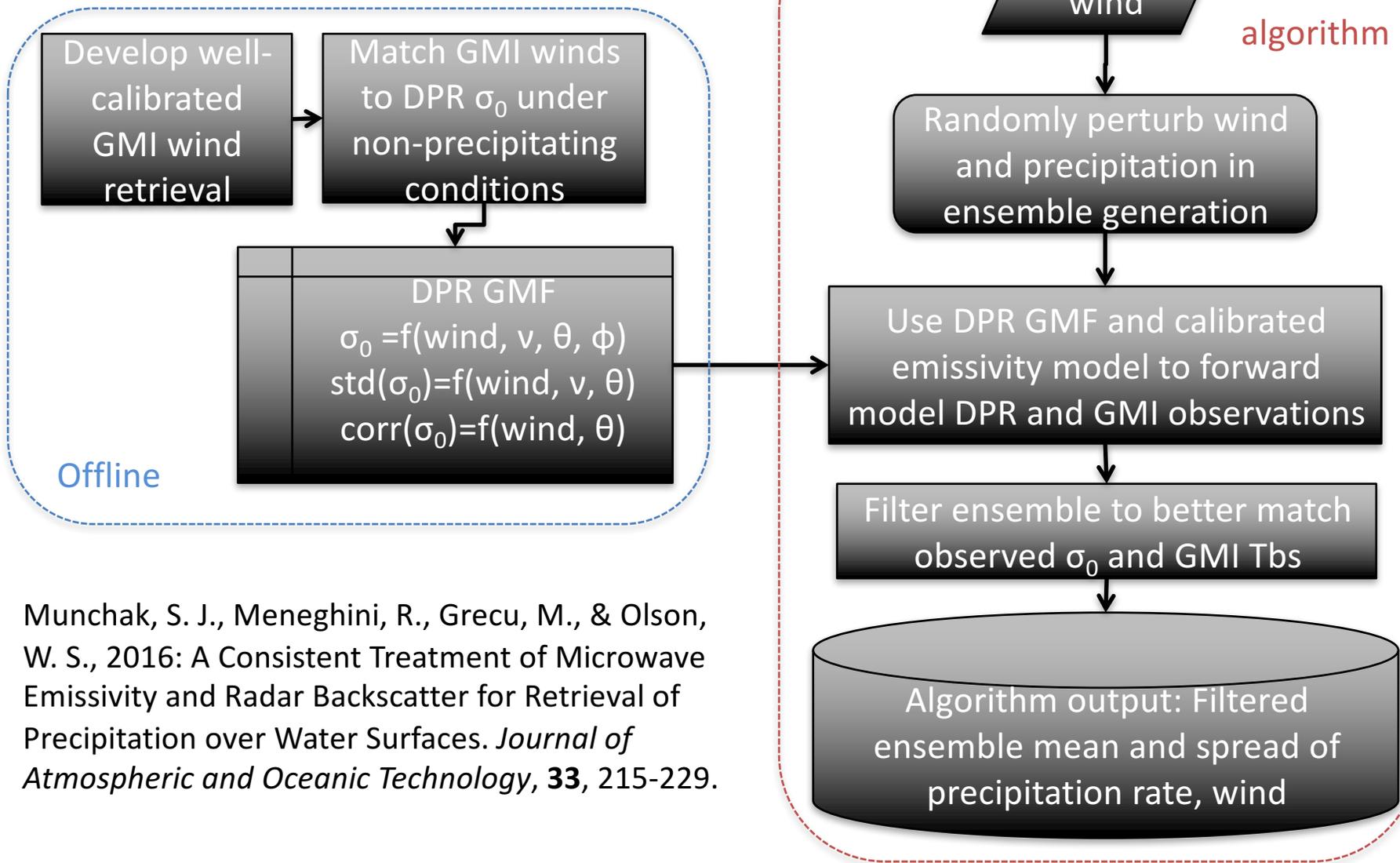
- Emissivity and σ_0 depend on relatively few parameters
- Develop calibrated surface emissivity and σ_0 Geophysical Model Function (GMF)
- Use calibrated GMF in DPR-GMI combined algorithm

Land/Other (incl. coastlines)

- Emissivity and σ_0 depend on many parameters
- Develop empirical relationships from clear-sky data over self-similar surface types
- Use EOFs in DPR-GMI combined algorithm



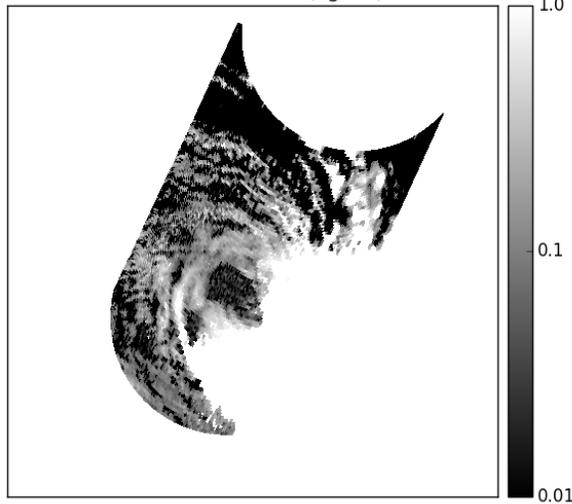
Water Surfaces in the Combined Algorithm



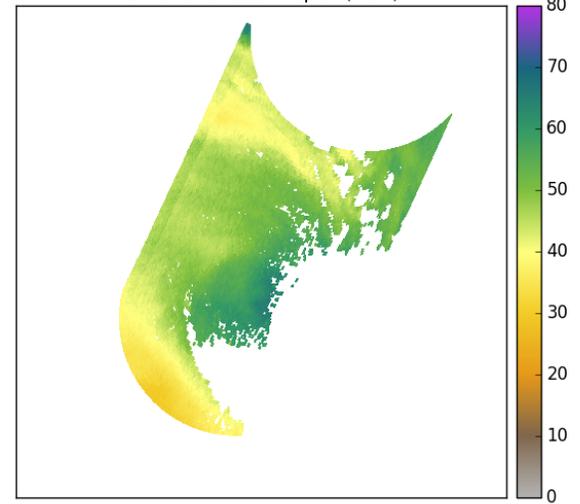
Munchak, S. J., Meneghini, R., Grecu, M., & Olson, W. S., 2016: A Consistent Treatment of Microwave Emissivity and Radar Backscatter for Retrieval of Precipitation over Water Surfaces. *Journal of Atmospheric and Oceanic Technology*, **33**, 215-229.

GMI 1DVAR Retrievals

Cloud Water Path (kg/m^2)

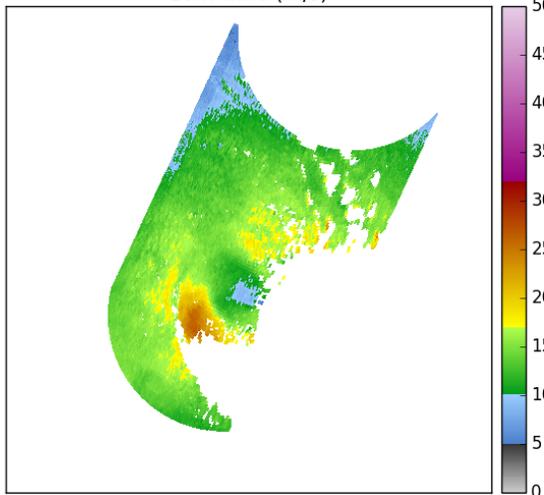


Column Water Vapor (mm)

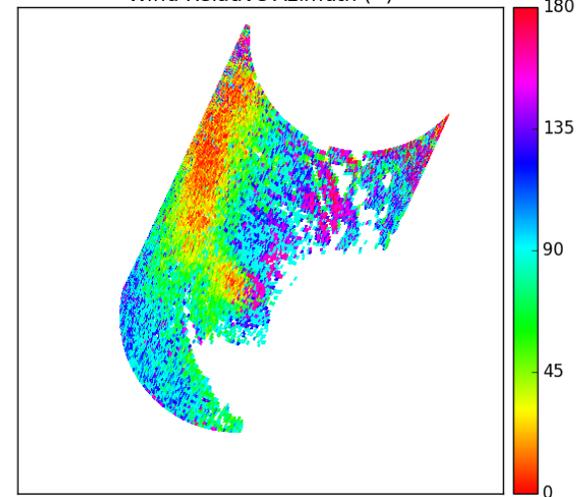


Tropical
Cyclone
Corentin (24
January 2016)

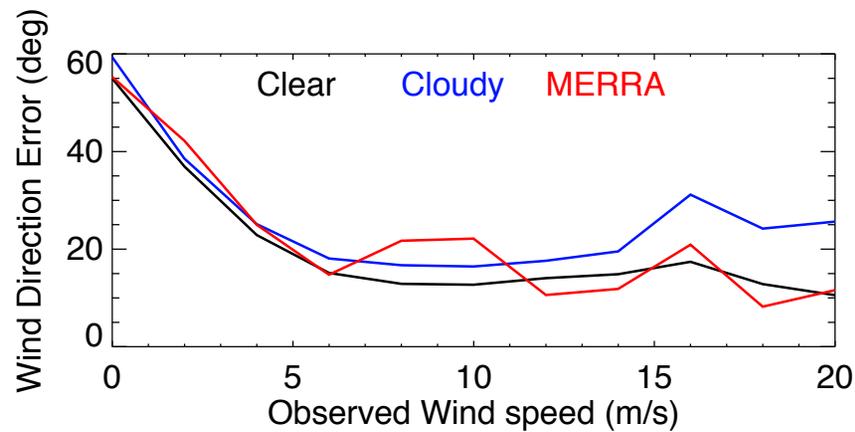
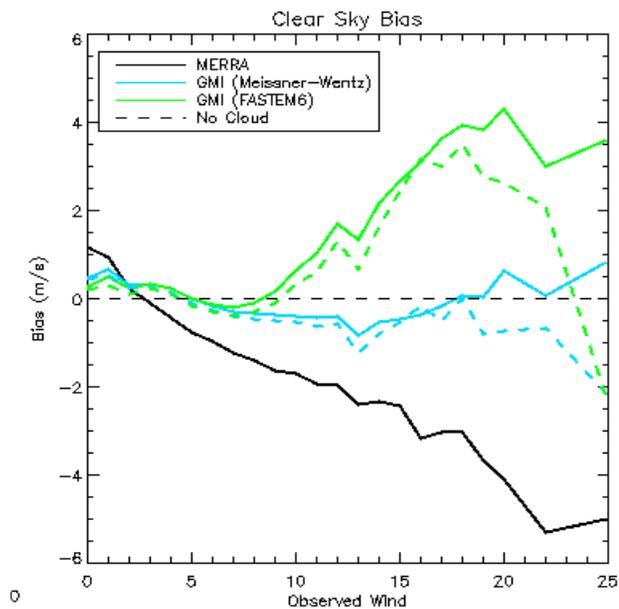
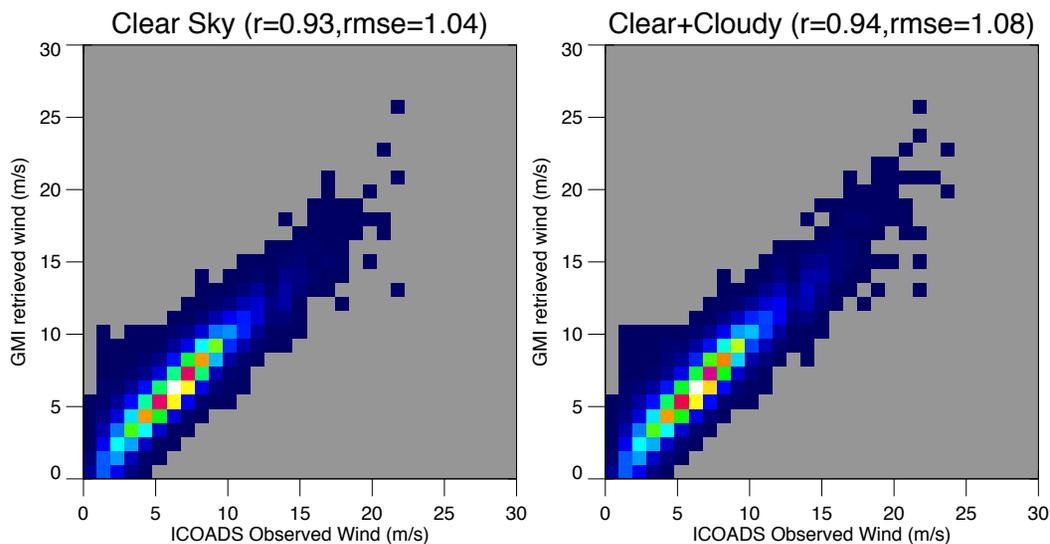
10m wind (m/s)



Wind Relative Azimuth ($^\circ$)

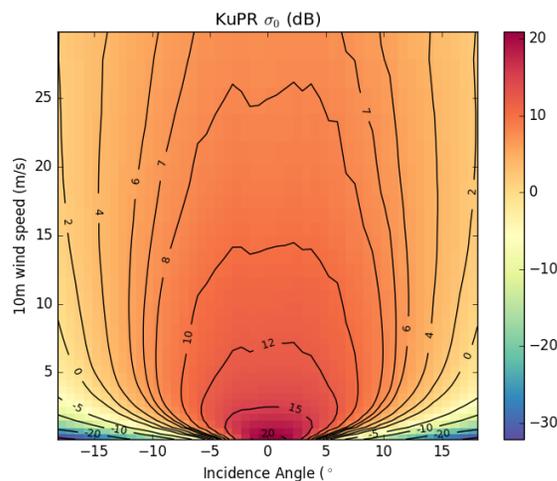


GMI wind retrieval accuracy

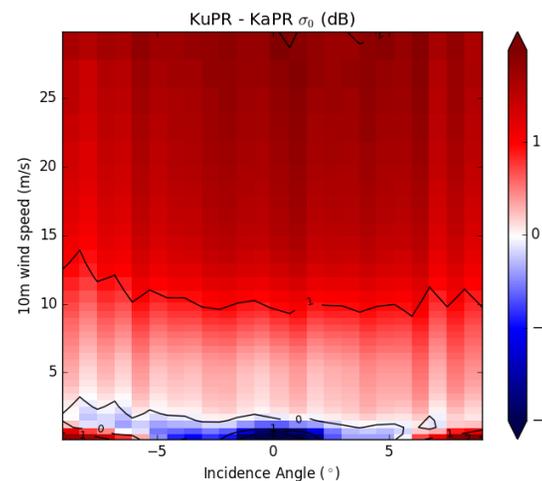


GMI-derived wind- σ_0 Geophysical Model Function for DPR

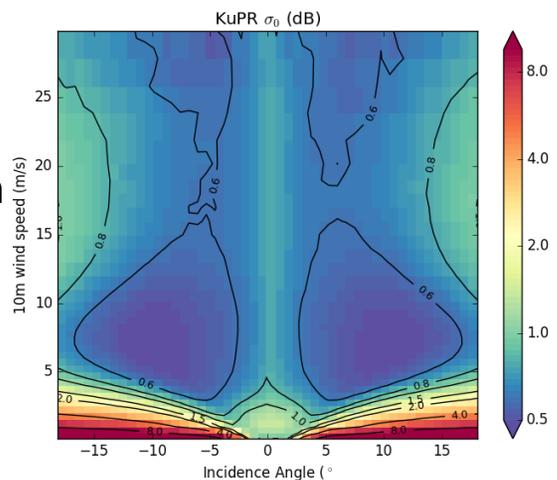
Mean σ_0 (Ku)



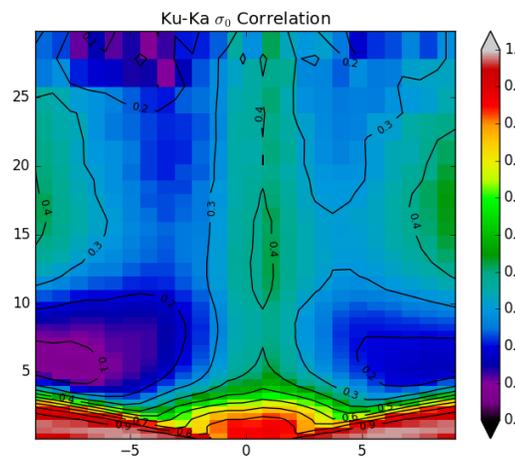
Ku - Ka



Standard Deviation
of σ_0 (Ku)

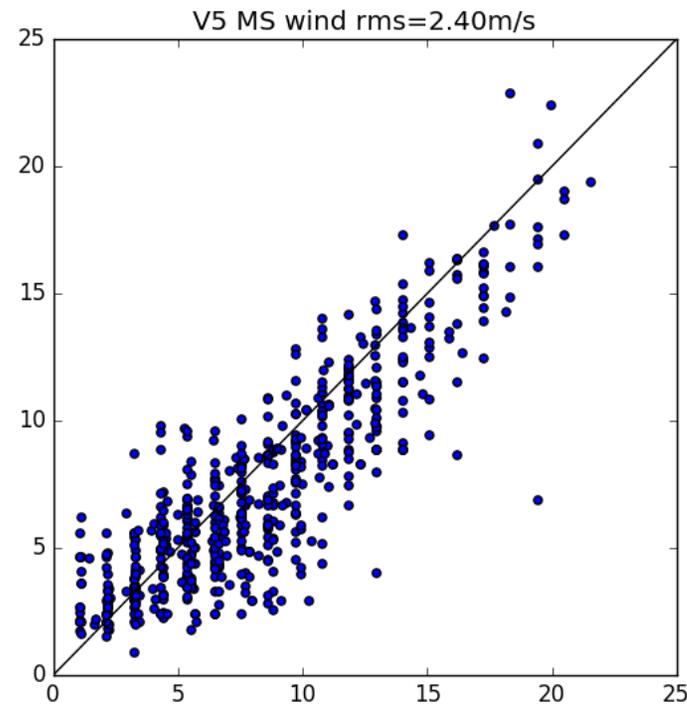
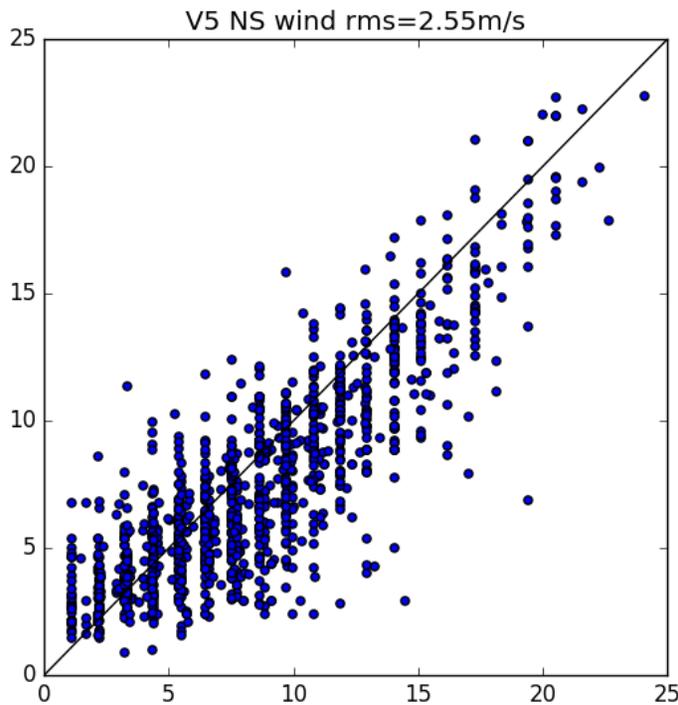


Ku-Ka
Correlation



Wind Error in Precipitating Pixels

Alg. Version	2A-ENV	NS	MS
V4	2.66 m/s	2.75 m/s	2.59 m/s
V5 prototype	2.66 m/s	2.55 m/s	2.40 m/s



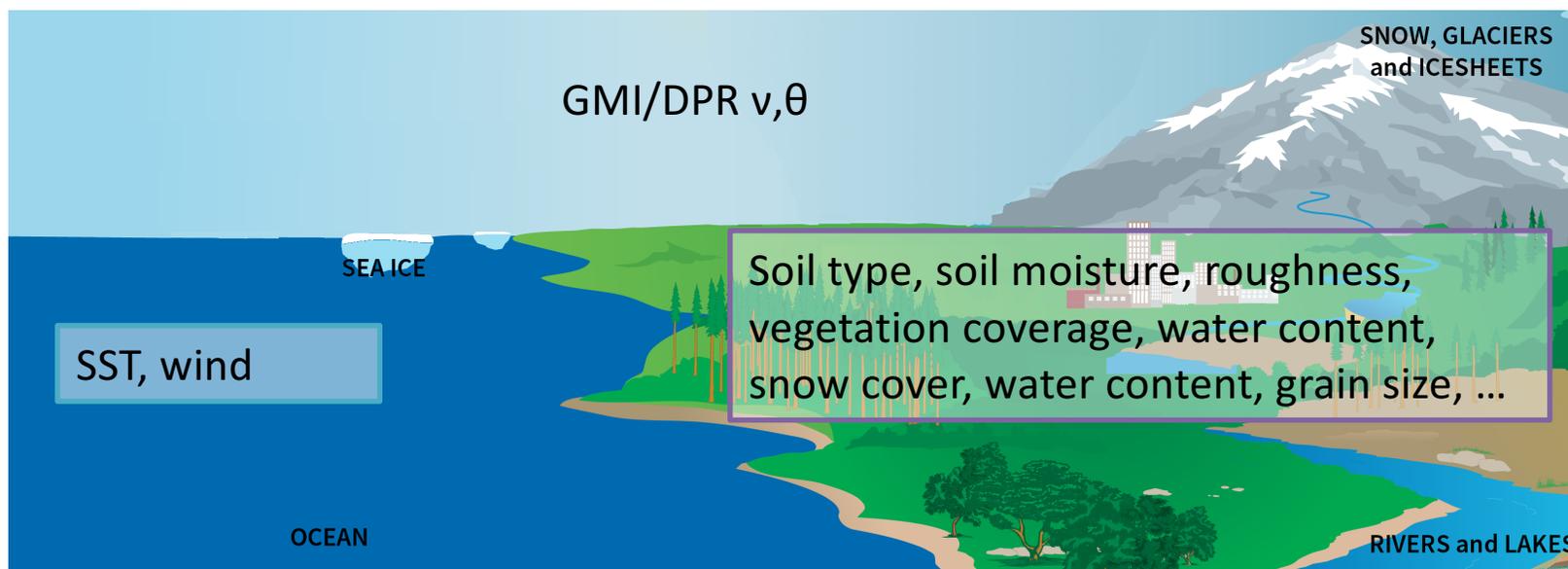
Different Surfaces, Different Strategies

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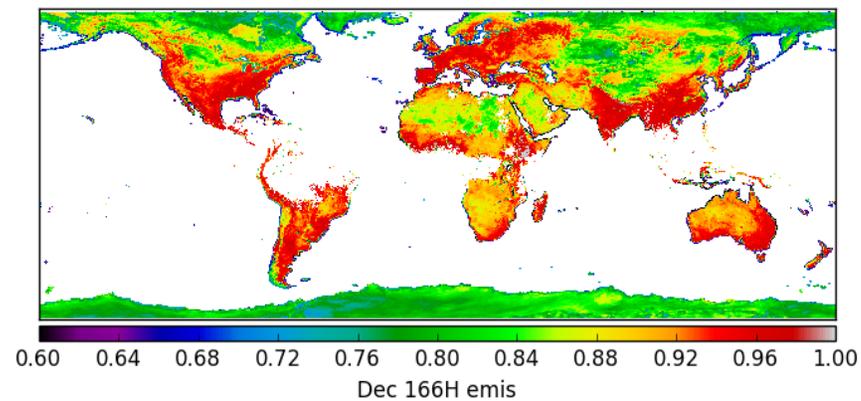
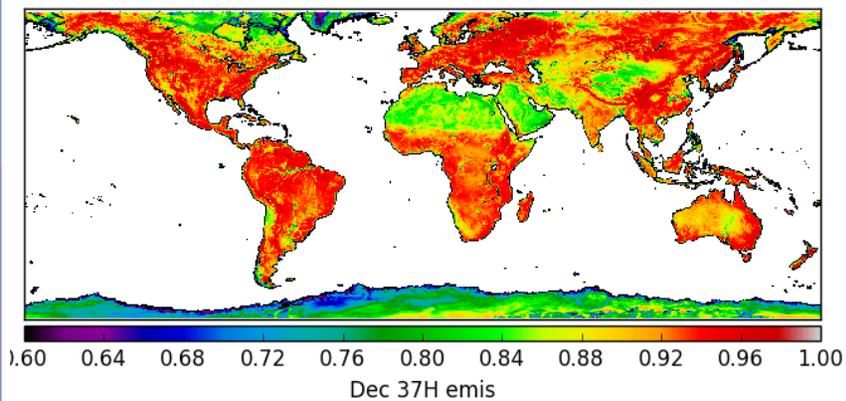
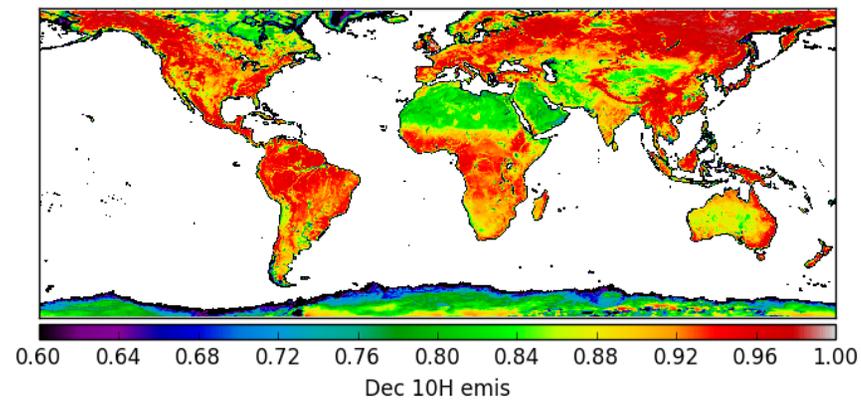
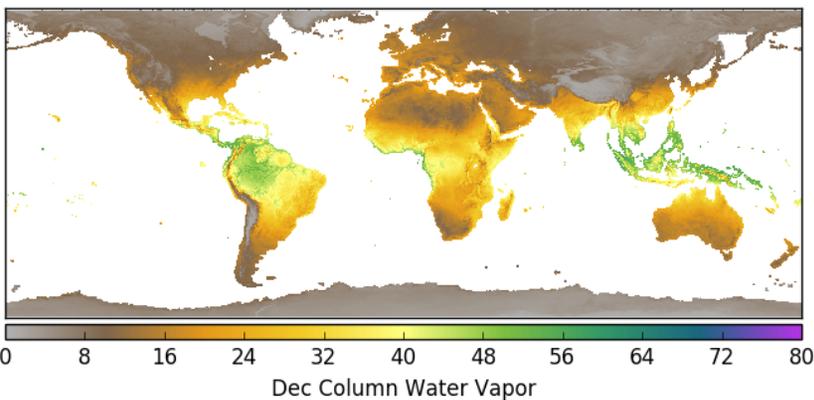
Land/Other (incl. coastlines)

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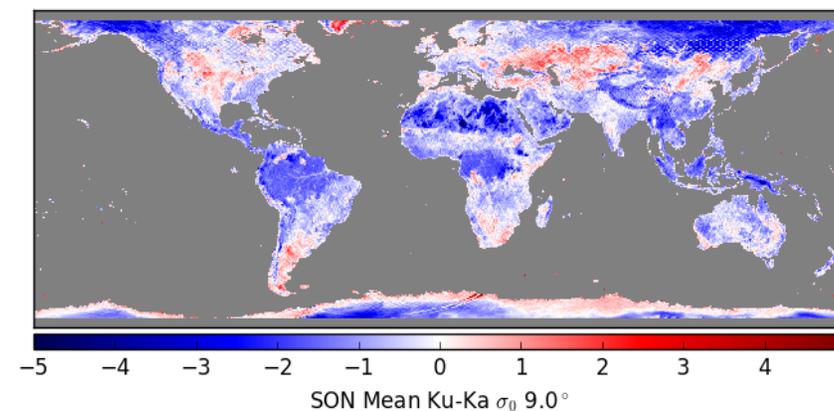
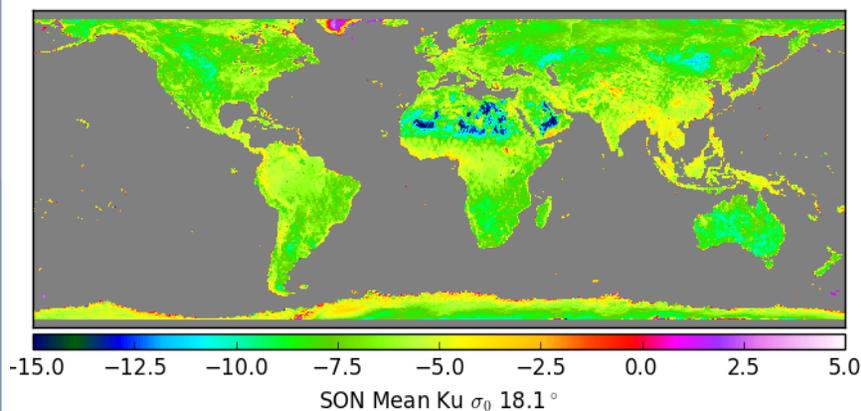
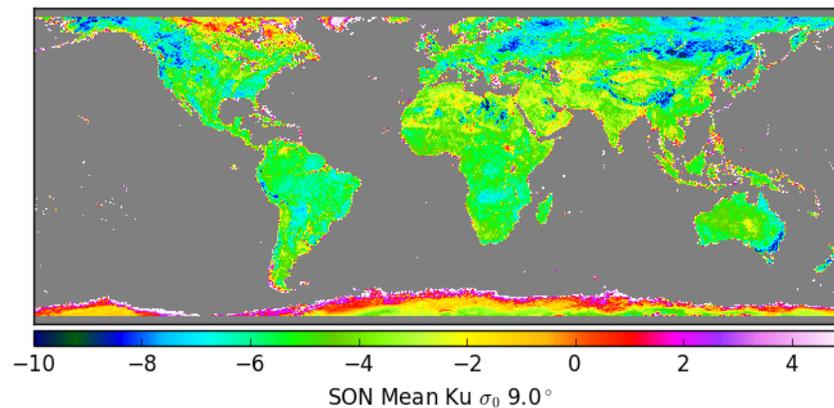
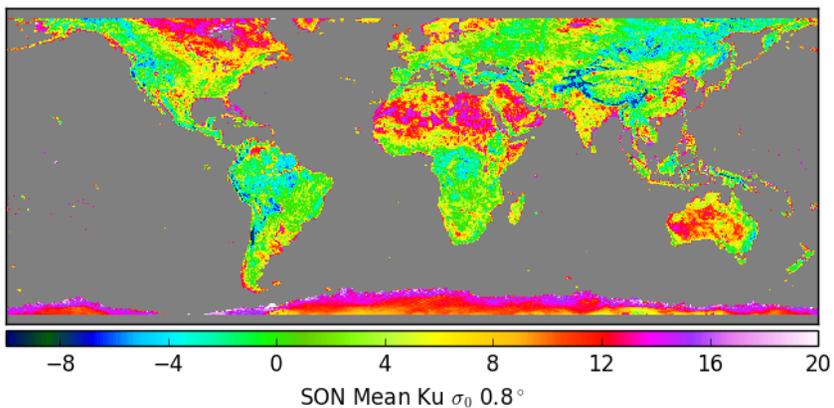
Land/Other Emissivity Database

GLOBAL PRECIPITATION MEASUREMENT



Conditional Subsets – Impact of Seasonal Cycle on DPR Backscatter

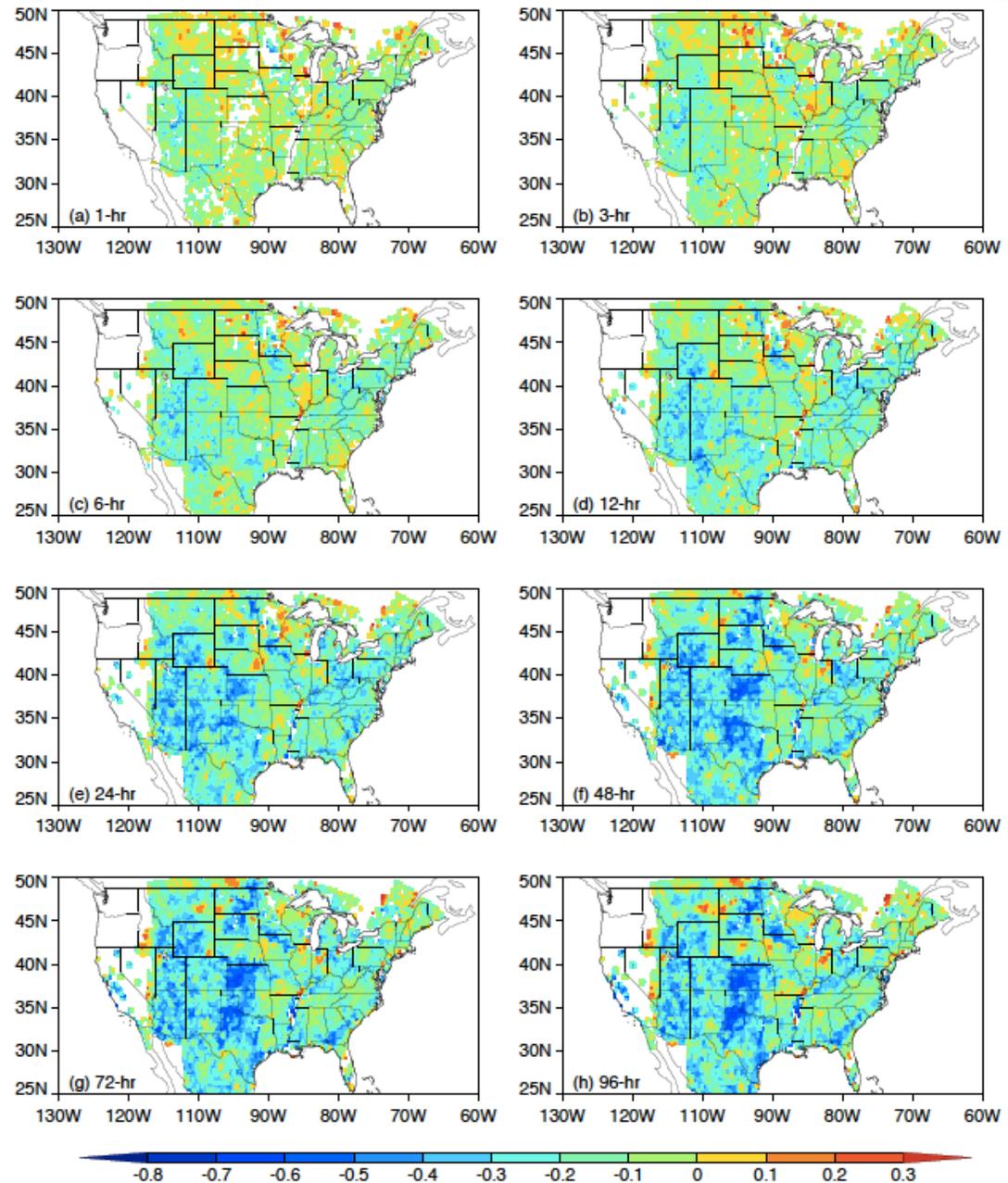
GLOBAL PRECIPITATION MEASUREMENT



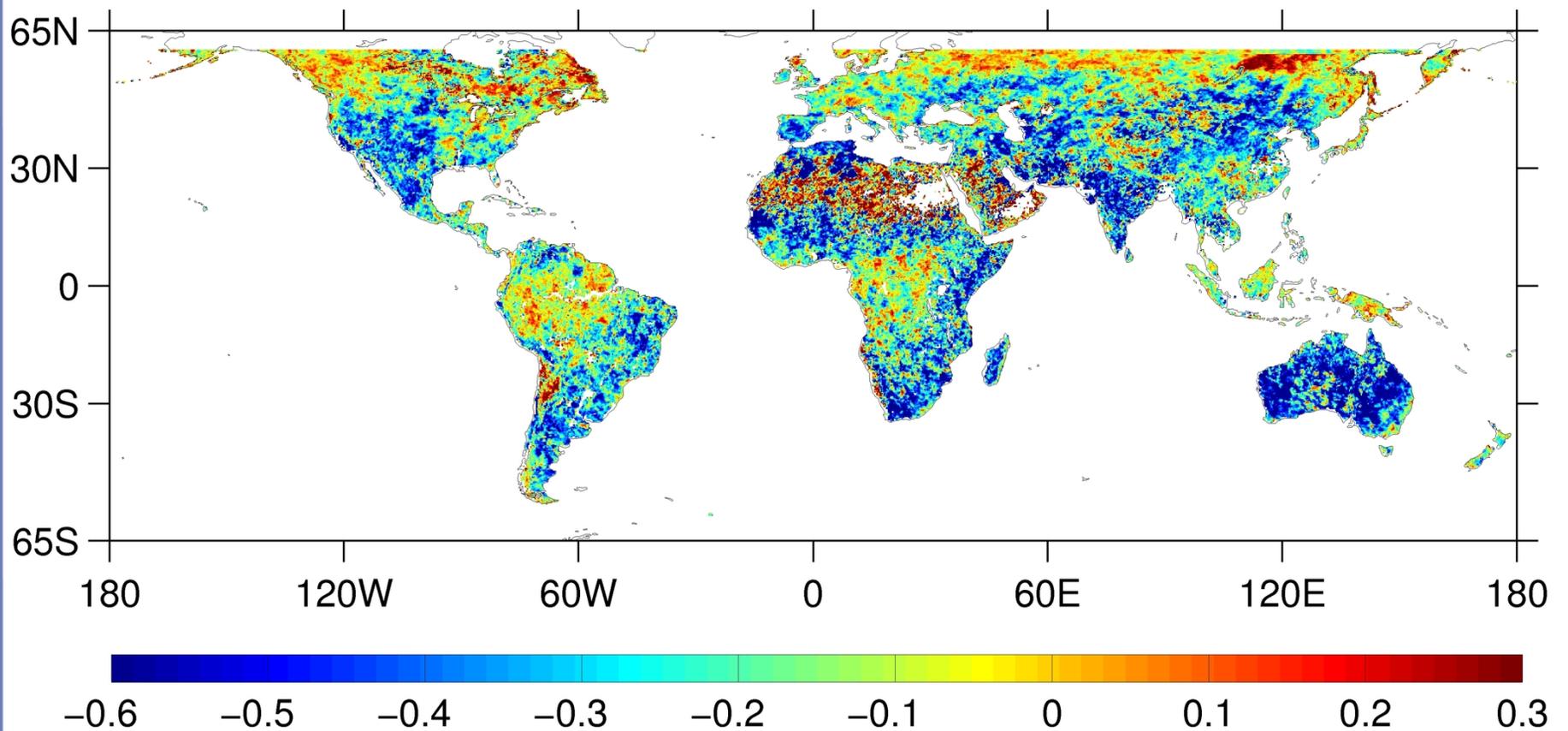
MRMS was used to evaluate the relationship between emissivity and previous rainfall on different timescales. We observed:

- Largest emissivity response (decrease) over western US.
- Magnitude of correlation was maximum at 48-hours
- Positive correlations were noticed in the winter season

Courtesy of Yalei You



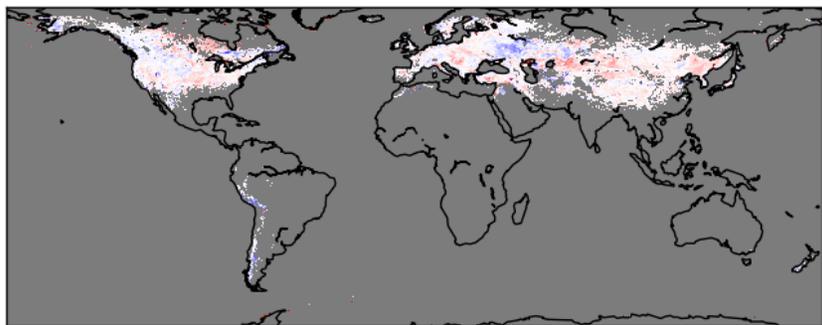
IMERG data used to construct global maps of emissivity correlation to 48hr rainfall



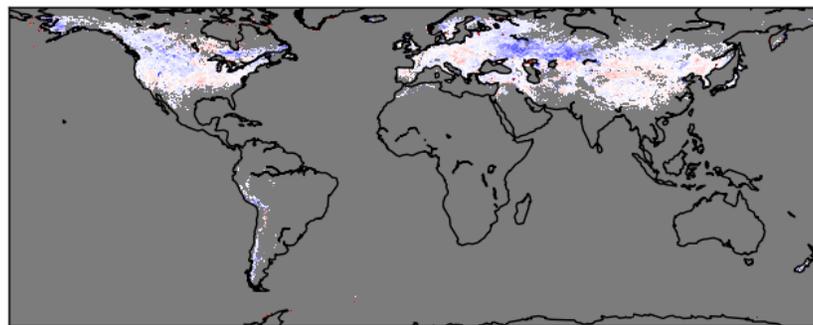
Courtesy of Yalei You

Effect of Snow Cover on Emissivity

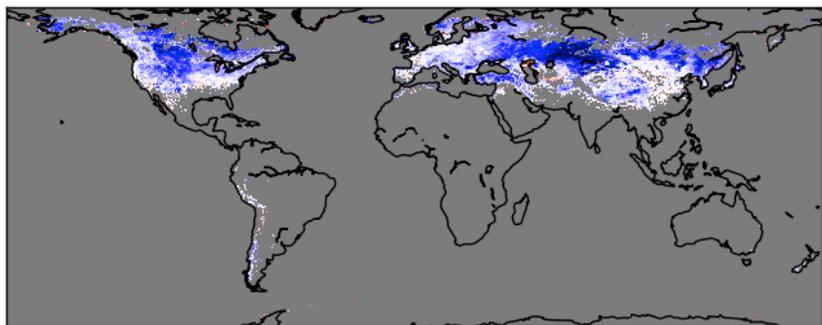
GLOBAL PRECIPITATION MEASUREMENT



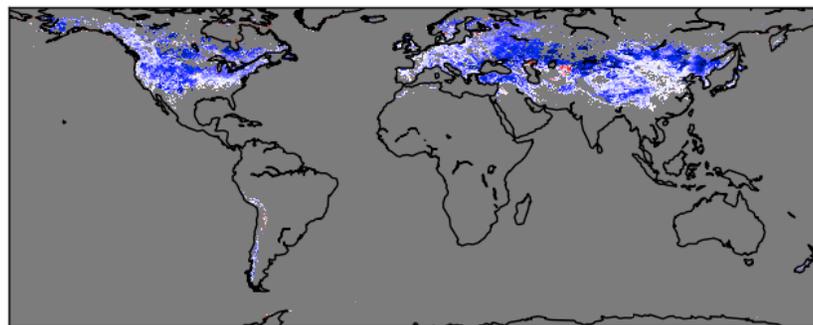
-0.30 -0.24 -0.18 -0.12 -0.06 0.00 0.06 0.12 0.18 0.24 0.30
DJF Snow-Bare Emissivity 10H



-0.30 -0.24 -0.18 -0.12 -0.06 0.00 0.06 0.12 0.18 0.24 0.30
DJF Snow-Bare Emissivity 18H



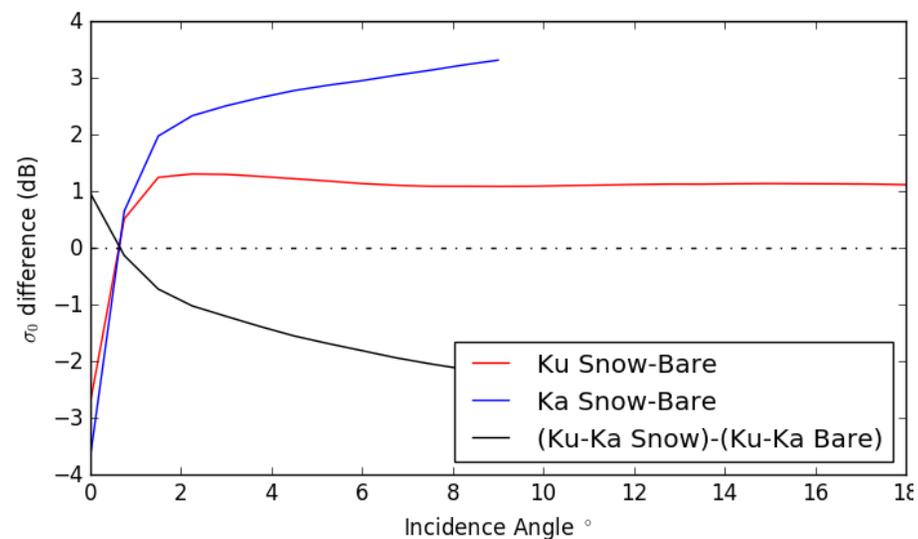
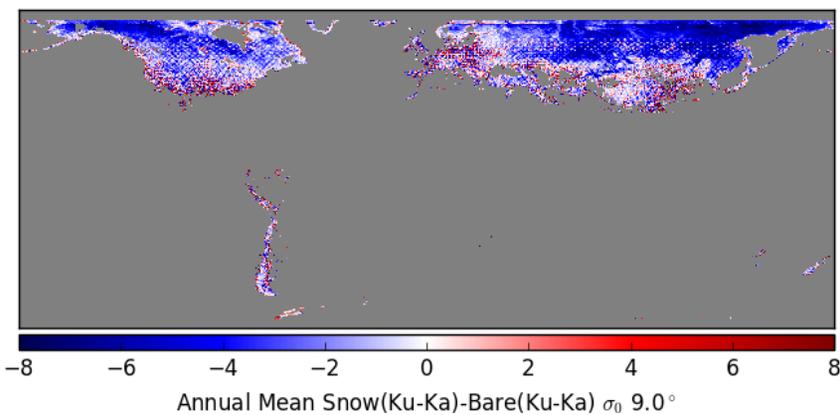
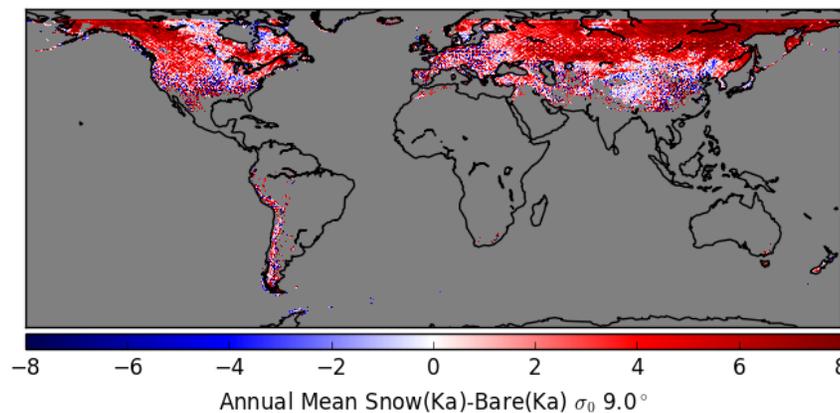
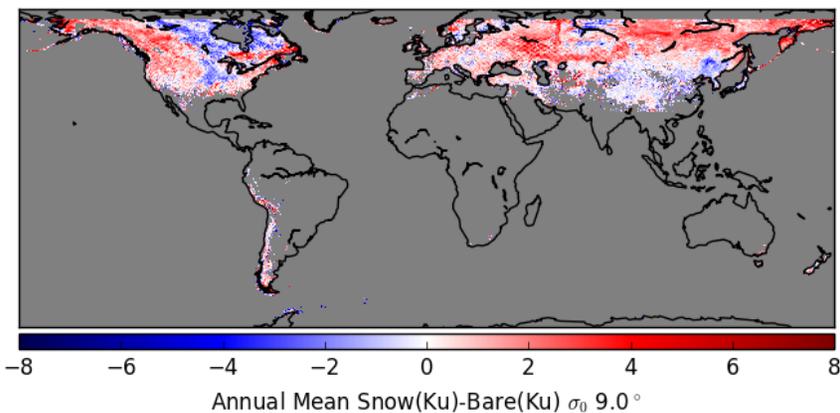
-0.30 -0.24 -0.18 -0.12 -0.06 0.00 0.06 0.12 0.18 0.24 0.30
DJF Snow-Bare Emissivity 89H



-0.30 -0.24 -0.18 -0.12 -0.06 0.00 0.06 0.12 0.18 0.24 0.30
DJF Snow-Bare Emissivity 166H

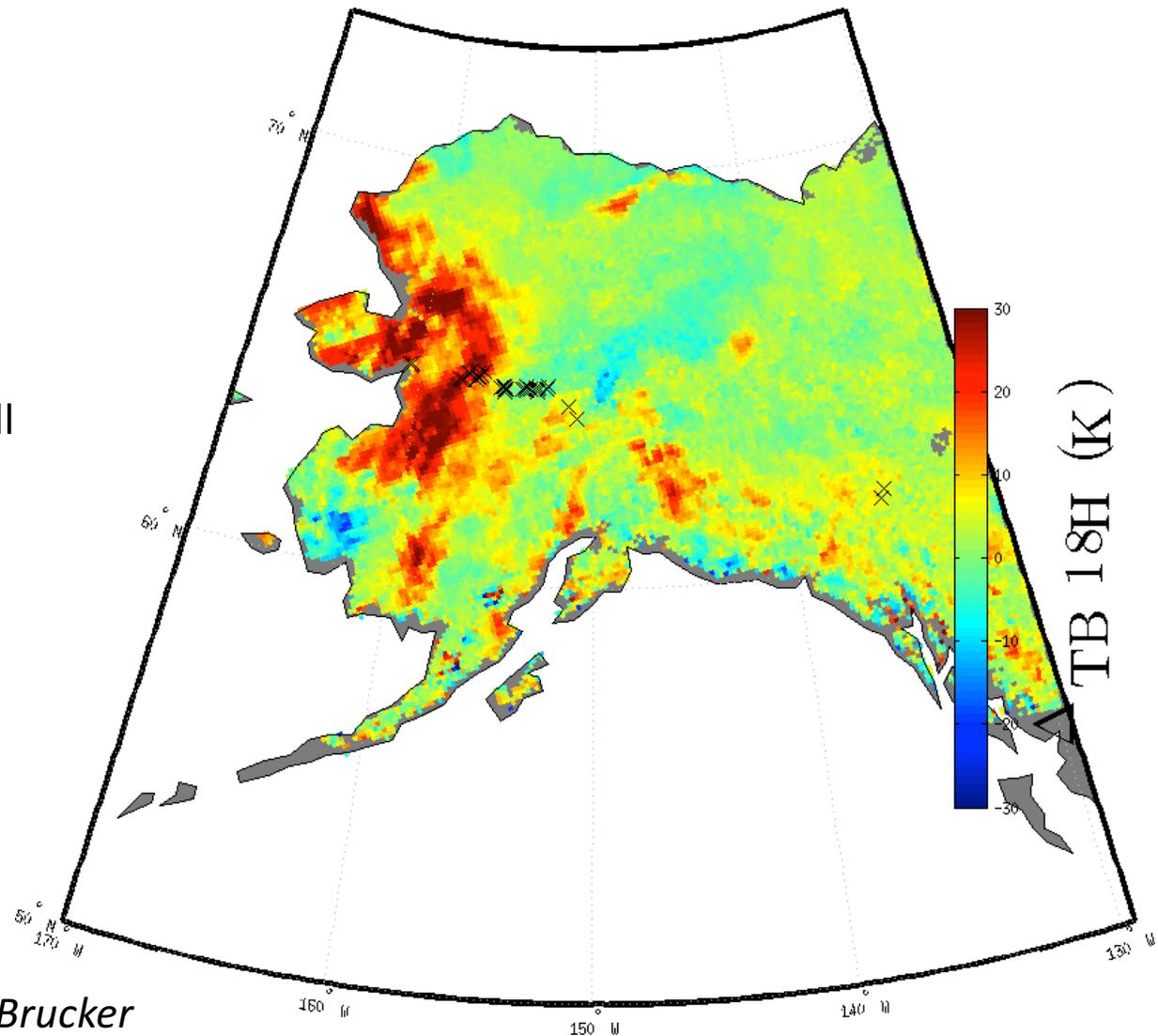
Effect of Snow Cover on DPR Backscatter

GLOBAL PRECIPITATION MEASUREMENT



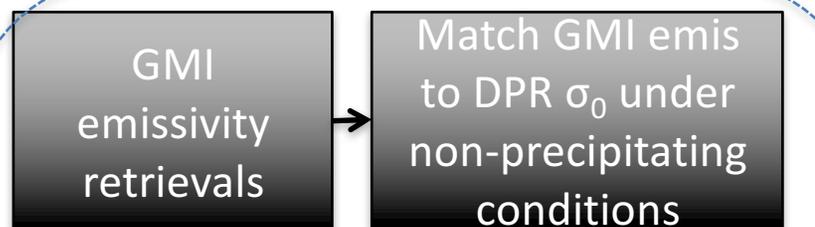
Rain-on-Snow Events

1-day change in
AMSR2 18H Tb after
DPR-detected rainfall
event (up to 30K
increase!)

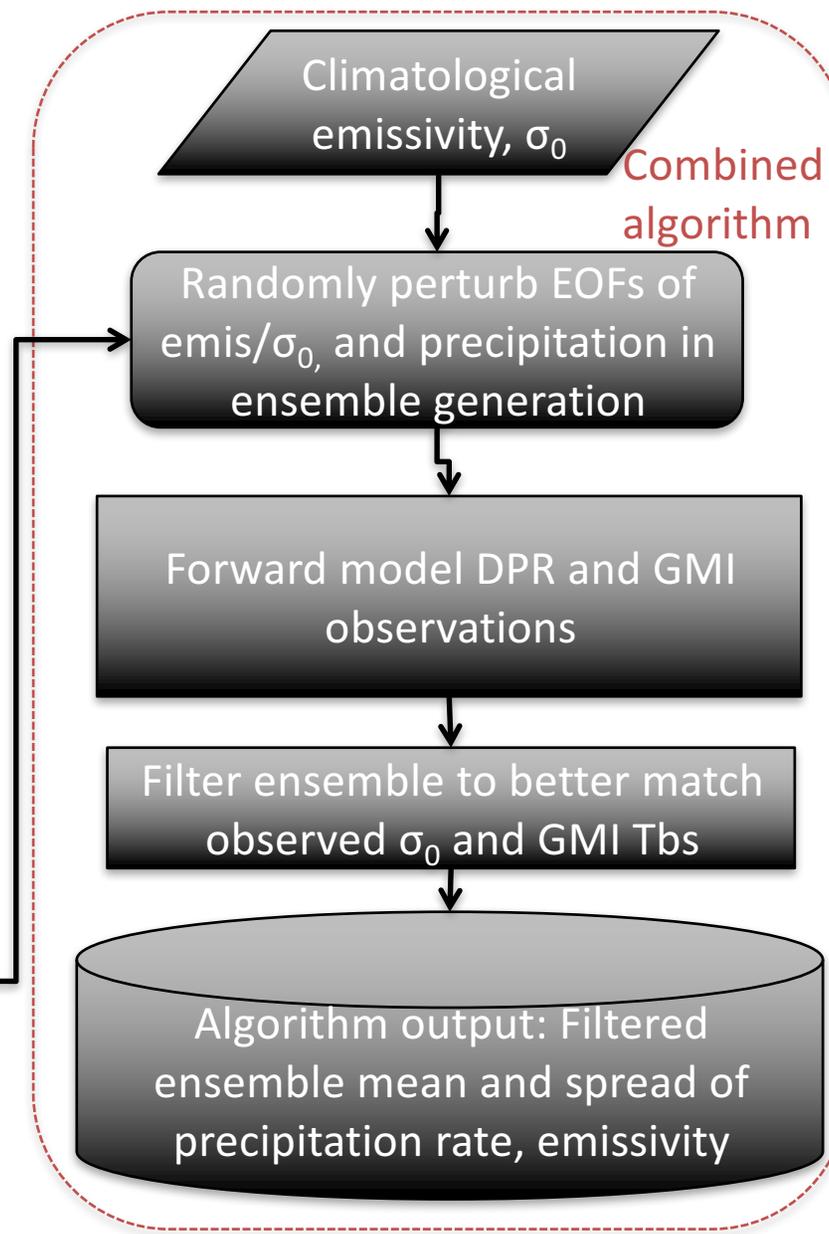


Courtesy of Ludovic Brucker

Land Surfaces in the Combined Algorithm



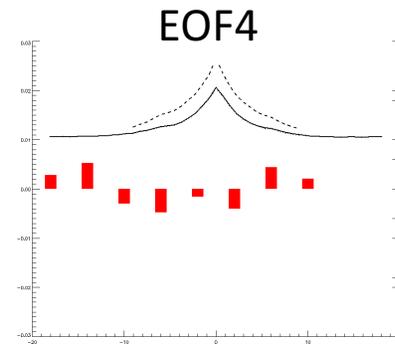
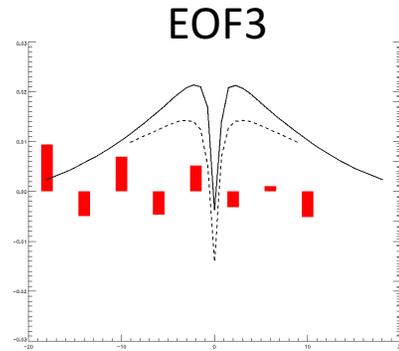
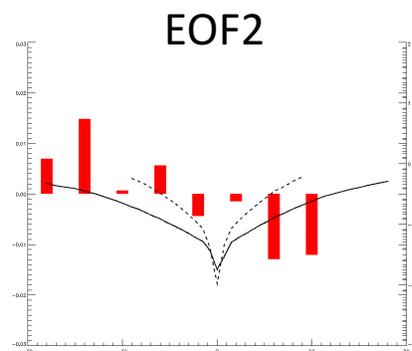
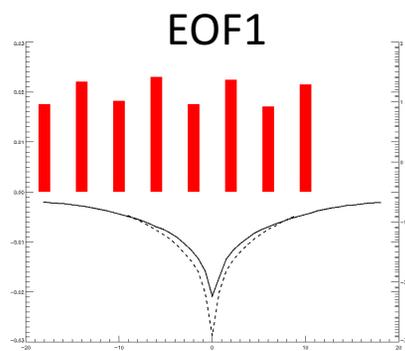
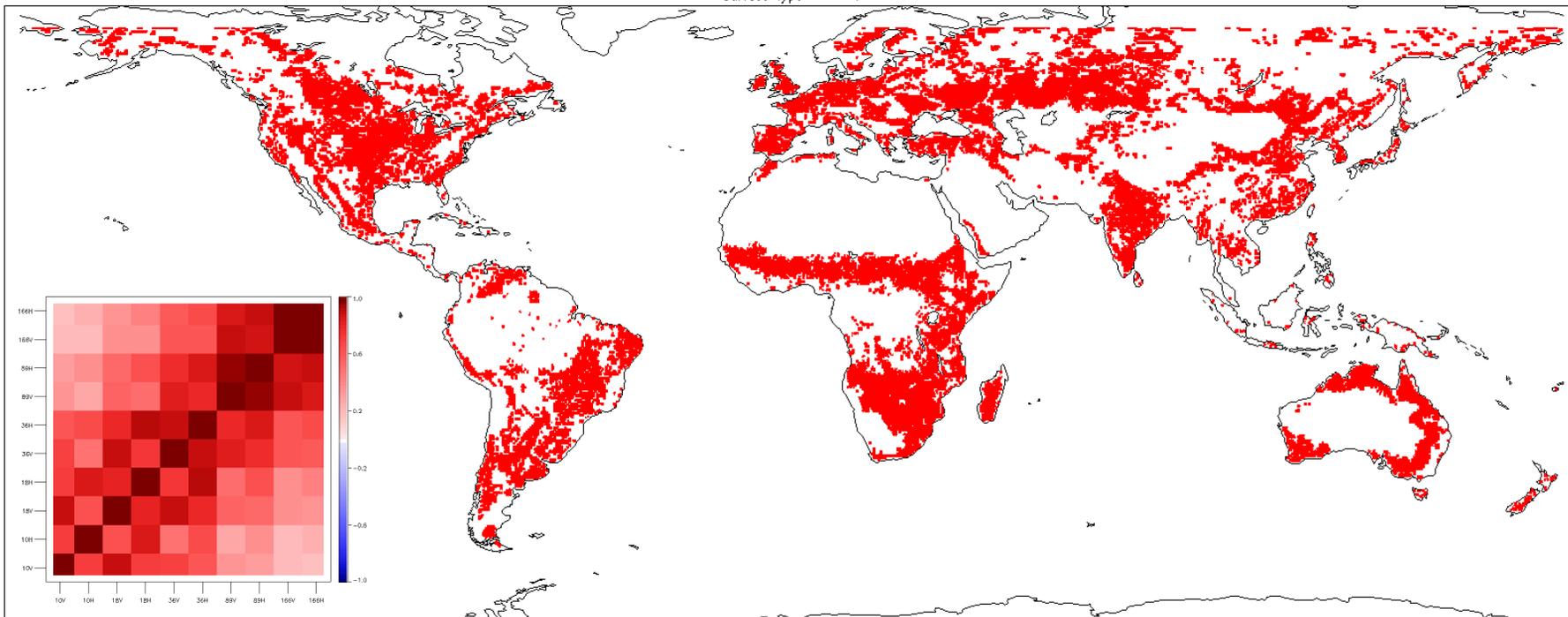
Offline



Combined algorithm

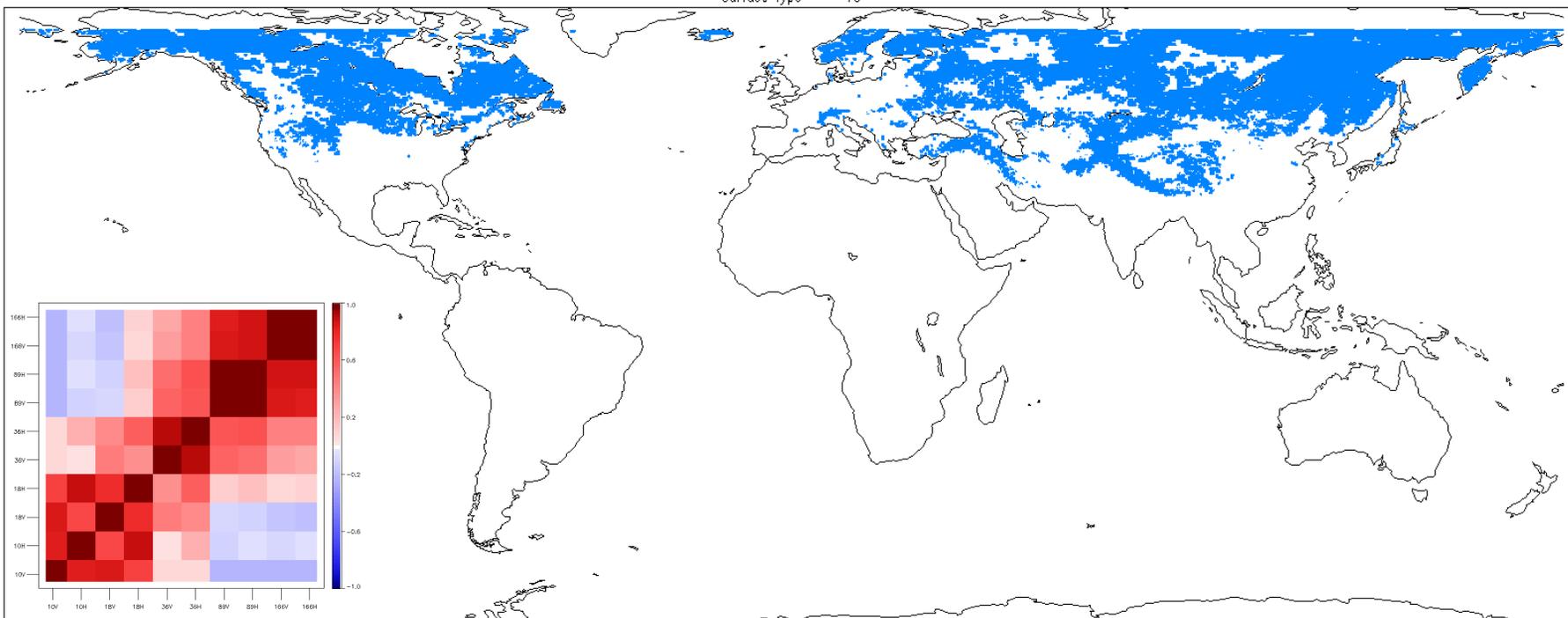
Vegetation Class Example

Surface Type 4

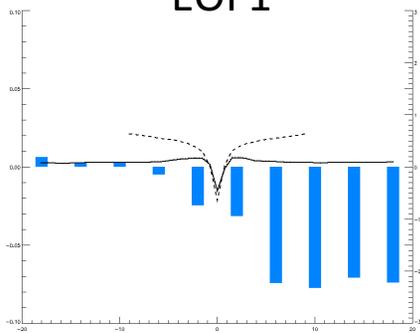


Snow Class Example

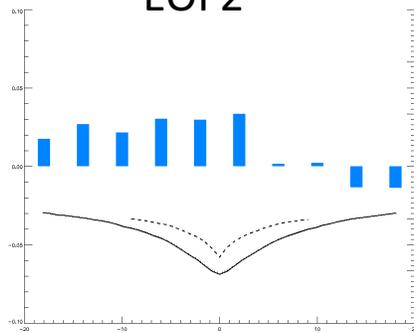
Surface Type 10



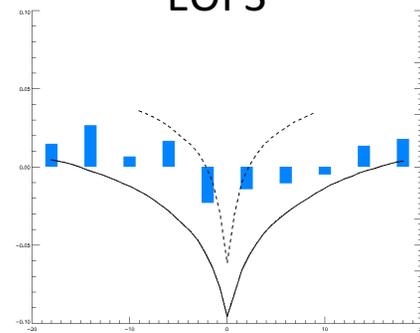
EOF1



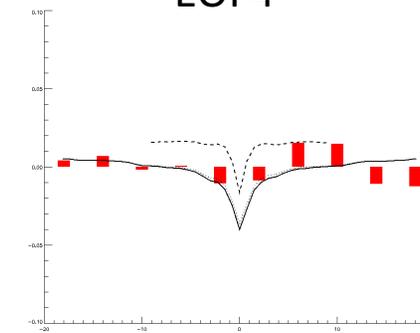
EOF2



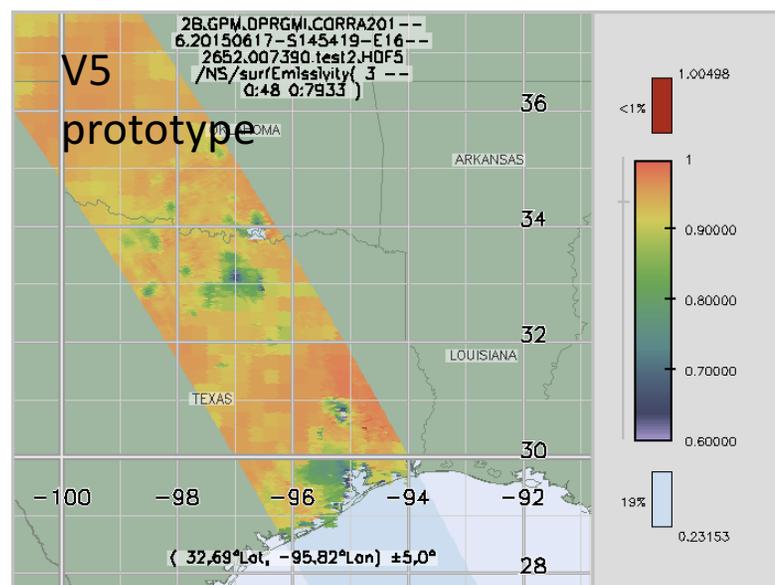
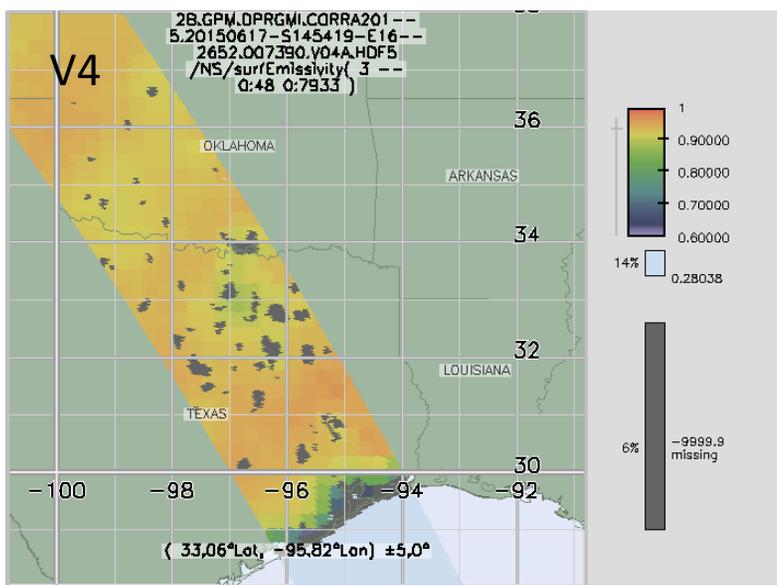
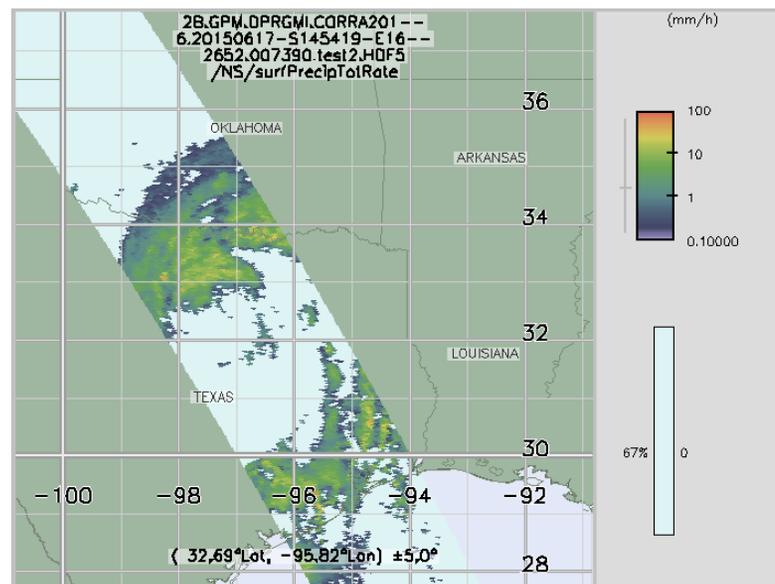
EOF3



EOF4



V5 prototype now includes retrieved surface emissivity within regions of precipitation and eliminates missing data near lakes and coastlines in V4.



Summary

- A 2-year database (June 2014-May 2016) of co-located DPR backscatter, GMI emissivity, and retrieved parameters (e.g., wind) has been created (available upon request)
- Over water, wind and precipitation are retrieved simultaneously by combined algorithm (version 4 and 5)
- Over land, snow cover is the most dominant variable affecting backscatter and emissivity at a given location, but soil moisture/surface water and vegetation changes also have an effect
- Plan to produce all-sky emissivity estimates and use database-derived covariances in next version (5) of GPM products
- Research Topics:
 - How to use ancillary data (snow cover/depth/SWE, soil moisture, vegetation data, ...) to optimize EOF selection
 - Can we move towards physically-based instead of statistical emissivity/backscatter models?
 - Quantify impact of recent or ongoing precipitation (rain or snow) on surface properties – can we perform accurate accumulated precipitation retrievals?



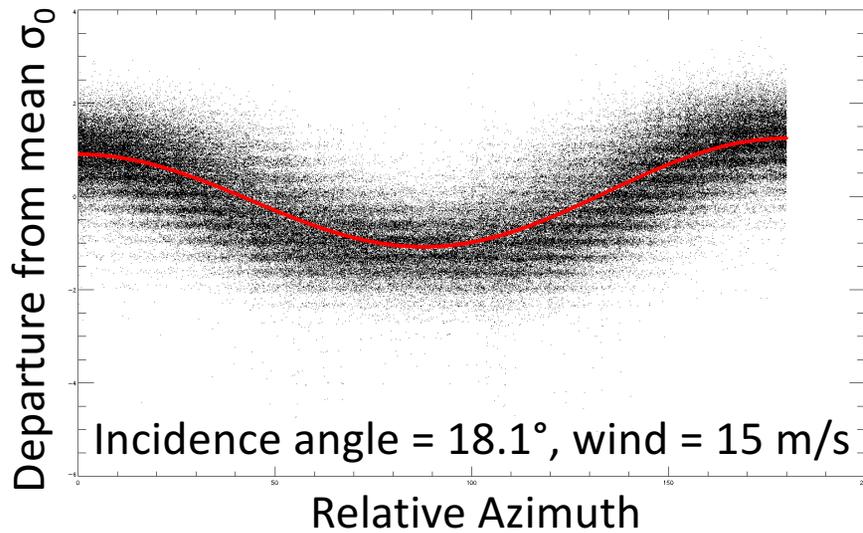
*PMM Science Team Meeting
Houston, TX 24-26 October 2016*



GLOBAL PRECIPITATION MEASUREMENT

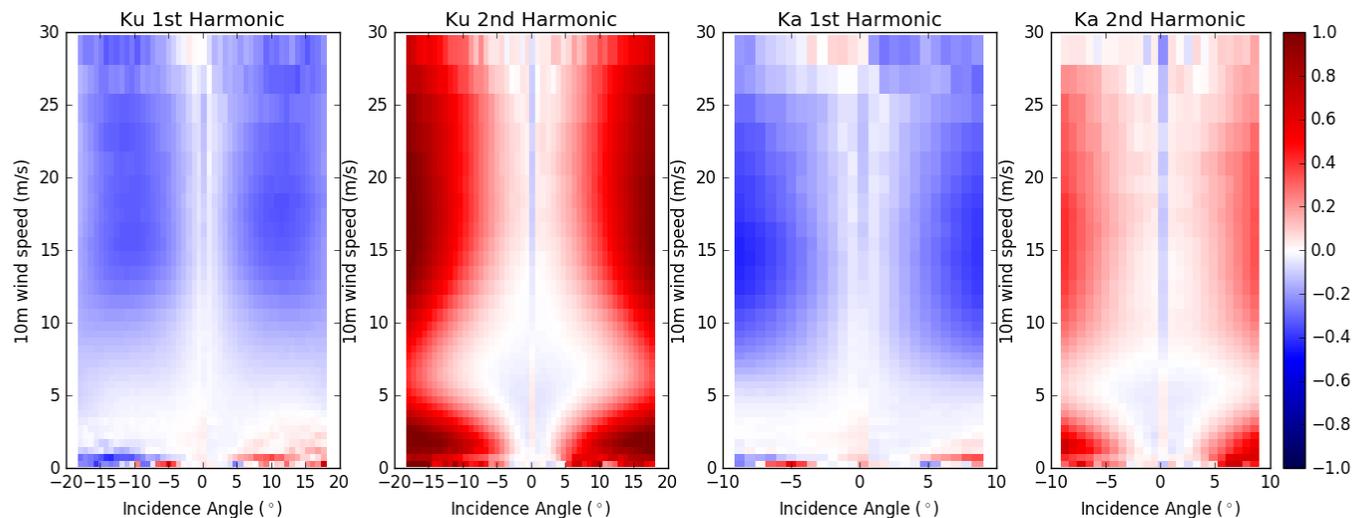
Backup Slides

Wind Direction Harmonics

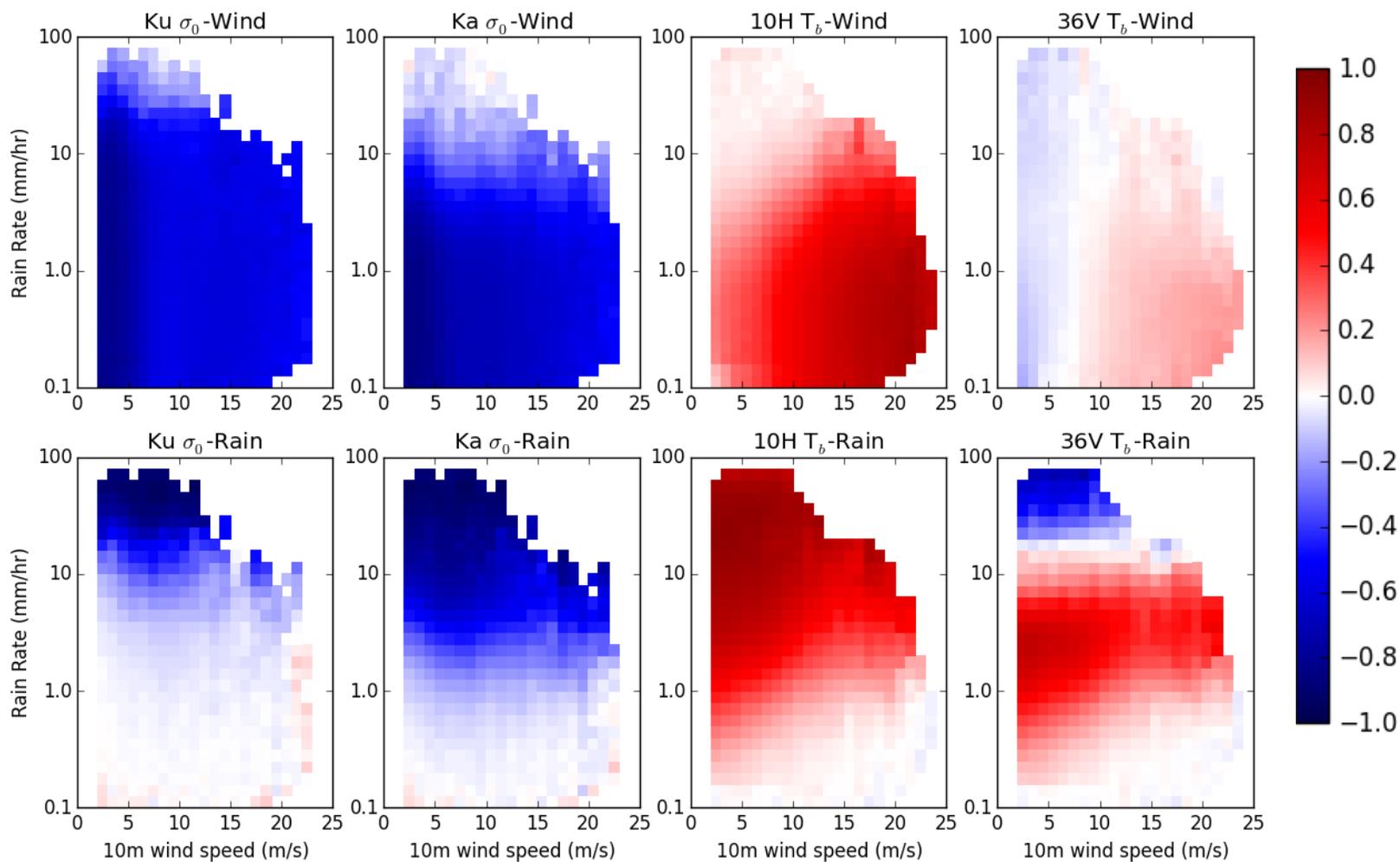


The wind direction dependence of σ_0 can be modeled with a second-order harmonic series:

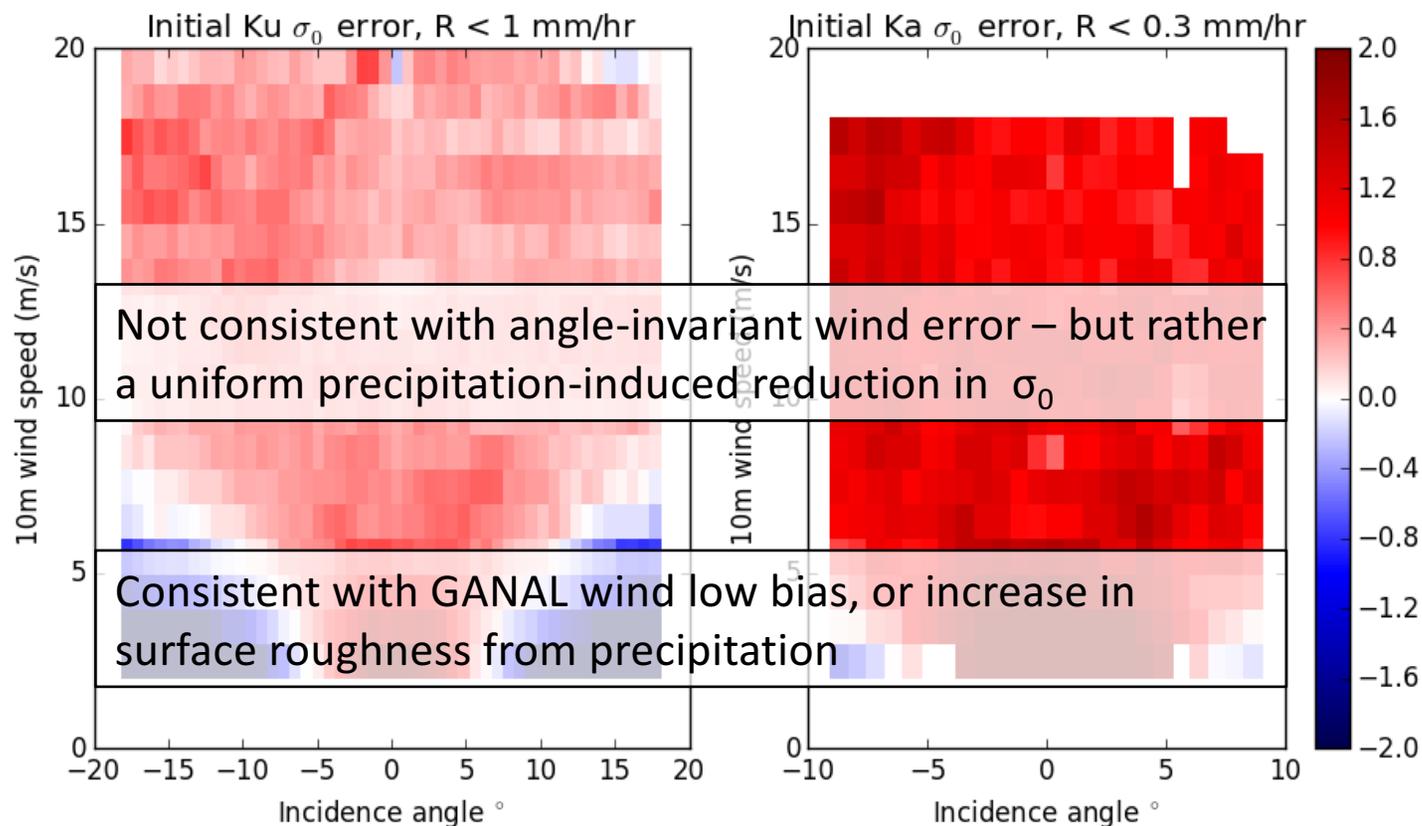
$$\Delta\sigma_0 = a_1 \cos(\varphi) + a_2 \cos(2\varphi)$$



Relative Observation Sensitivity to Wind and Rain



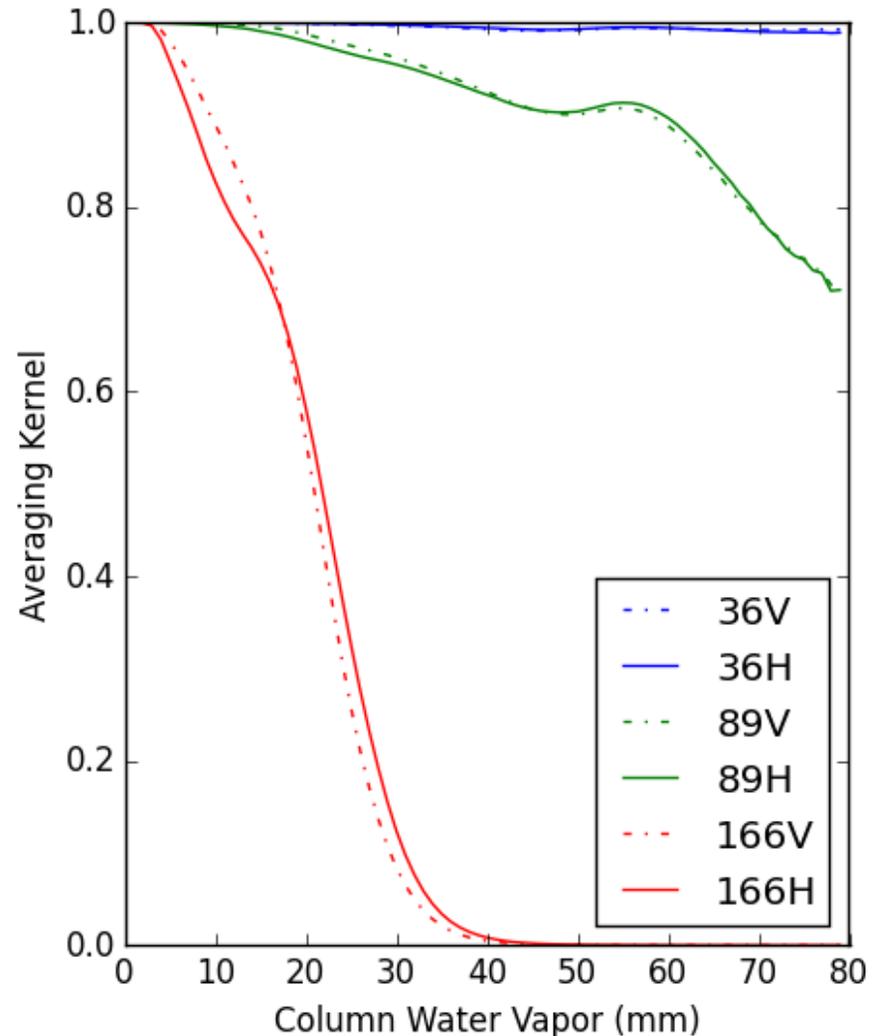
Effect of Precipitation on σ_0 – Inferred from Average of Initial σ_0 Error



Land/Other Surface Emissivity Retrievals from GMI

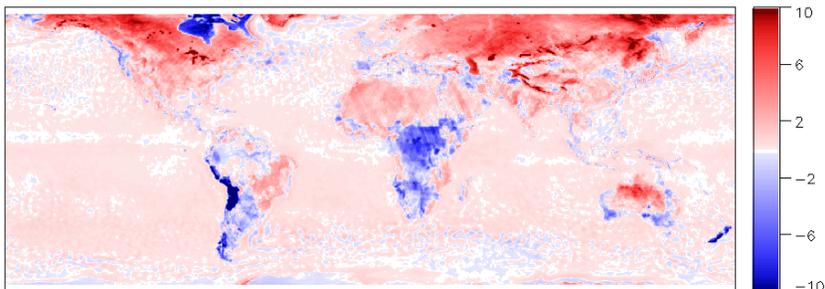
Key assumptions:

- Skin temperature from ancillary data (MERRA/GANAL)
- All channels considered independent, except:
 - 23.8V (interpolated from 18.7V and 36.6V)
 - 183 ± 3 and 183 ± 7 : Use same as 166V
- Adjust water vapor EOFs from analysis state
- No cloud liquid (ancillary data can be used to screen in post-processing)
- No post-1C RFI screening

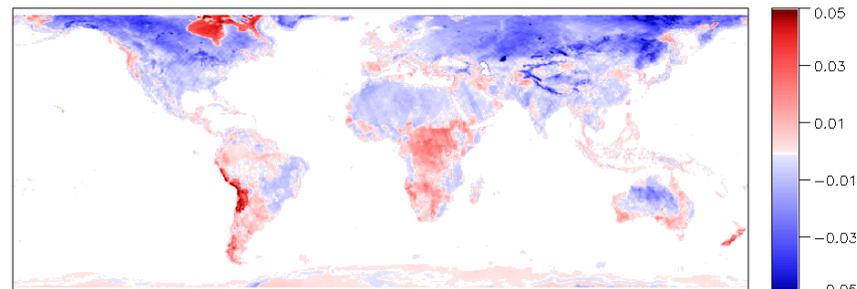


Retrieval Issues: Dependence on Skin Temperature Source

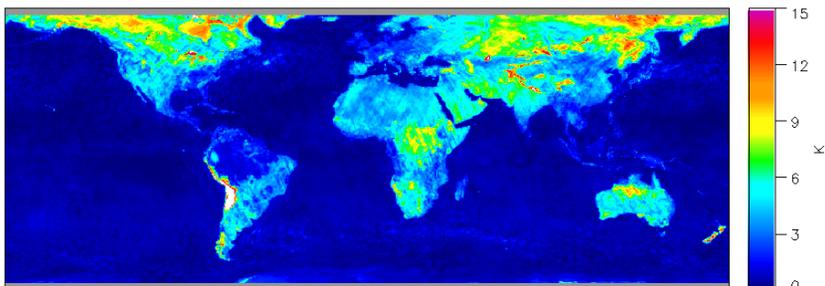
GANAL-MERRA initial Tskin Dec-Jan



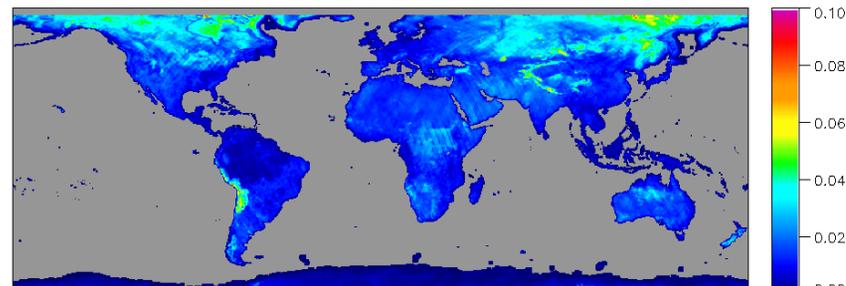
GANAL-MERRA emis Dec-Jan 10V



GANAL-MERRA initial Tskin rms difference Dec-Jan



GANAL-MERRA emis rms difference Dec-Jan 10V



DPR sampling

GLOBAL PRECIPITATION MEASUREMENT

