Precipitation Phase Determination and Impact of Snow Cloud Types on Satellite Snowfall Retrievals

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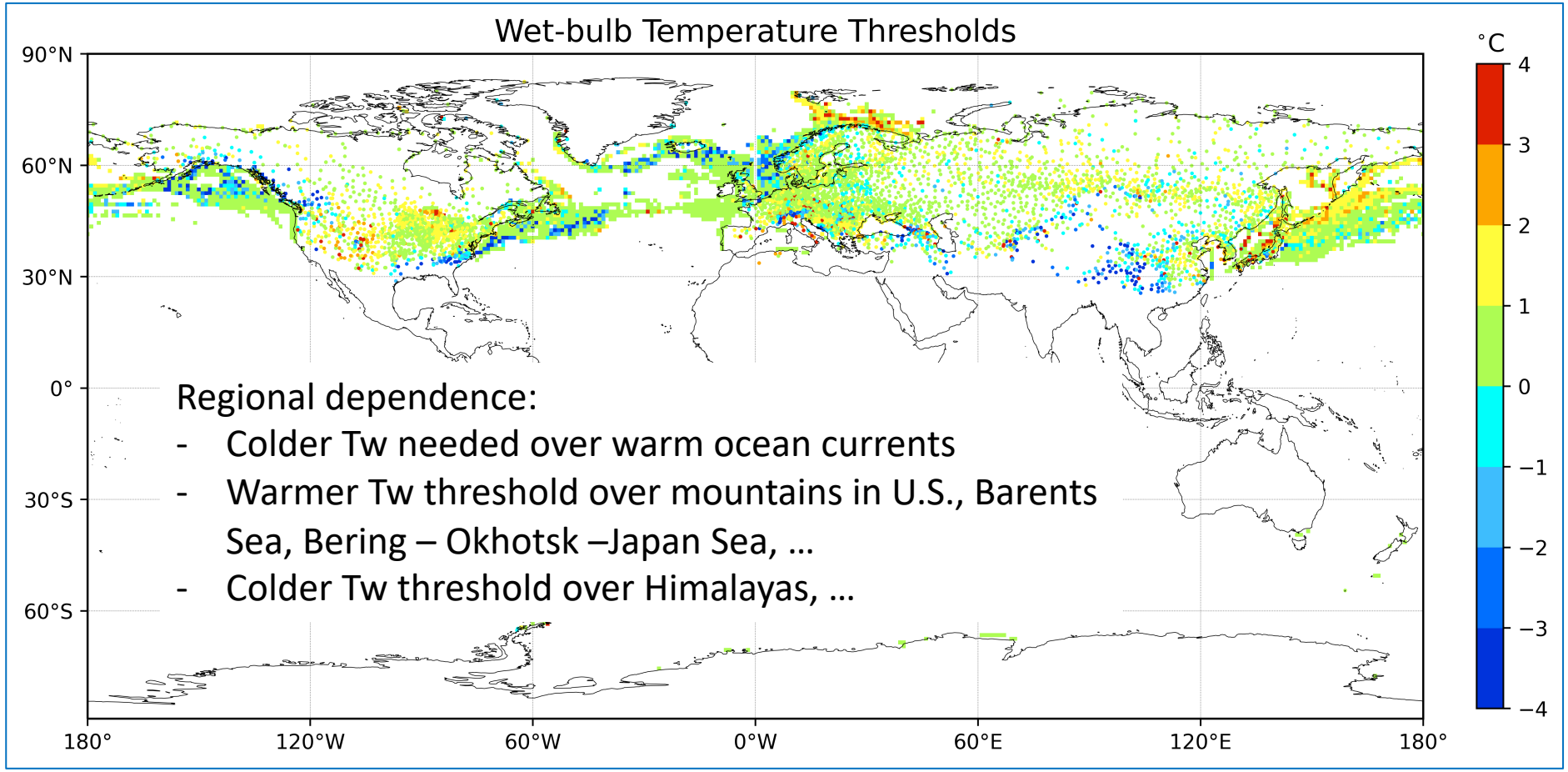
Precipitation Phase Based on Surface Manual Observations

Continued from Sims and Liu (2015), examine the regional dependence of rain-snow transition. This map shows the wet-bulb T at which precip has 50% prob to be solid.



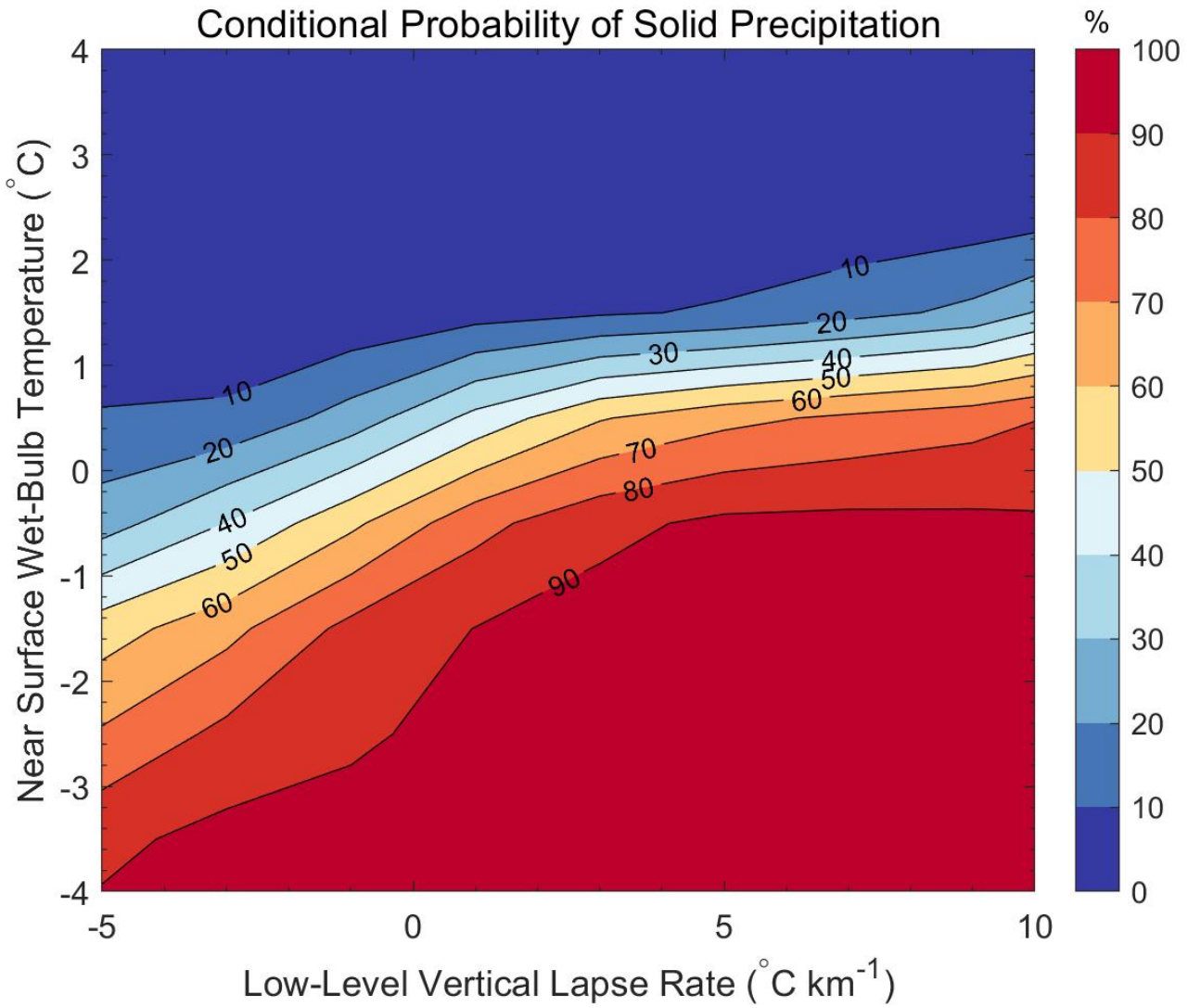
While on average the rain-snow transition occurs around 0.5℃ wet-bulb temperature, regional variation can be as large as ± 3 ℃ !

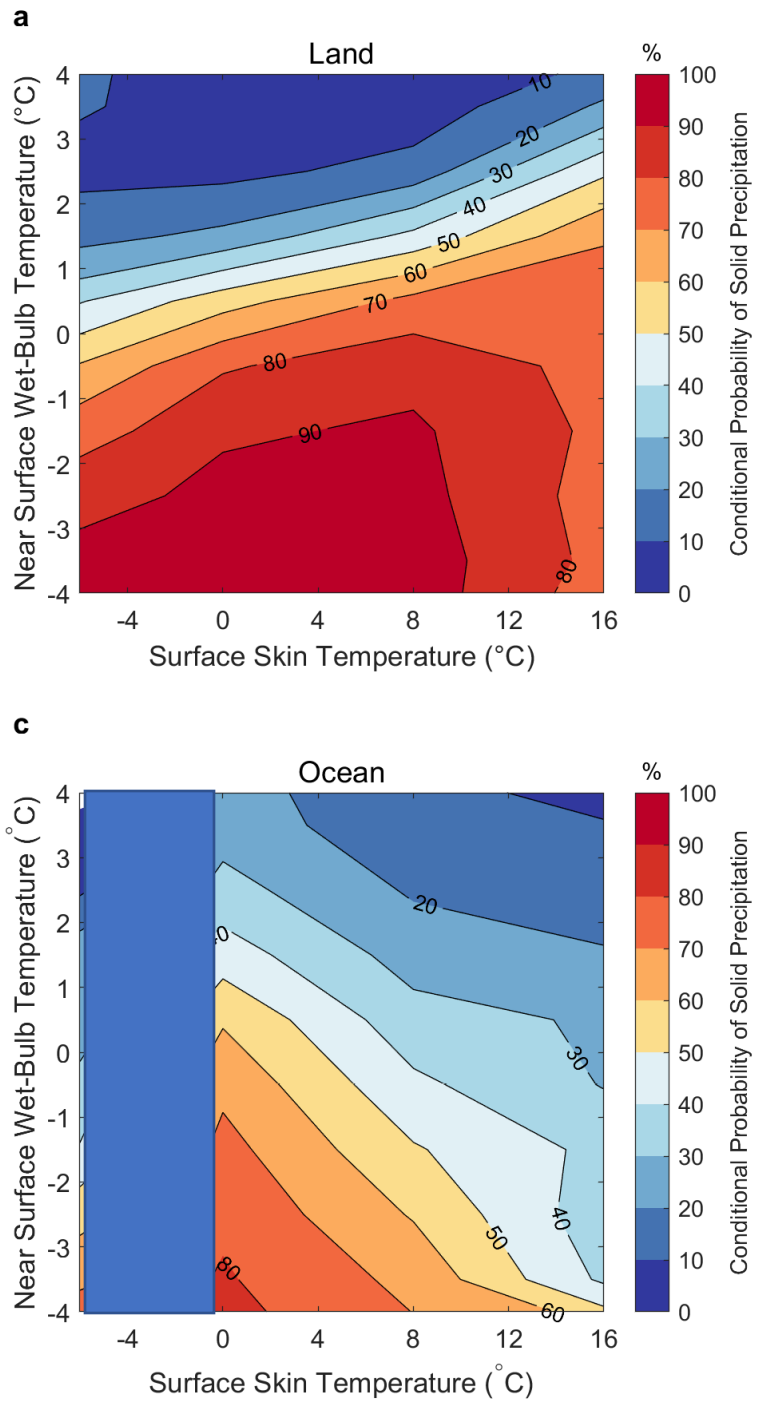
We are studying the causes/physics of the variation, and attempt to include the factors in a new parametrization.

Factors that impacts rain-snow transition

- Lapse rate

Large impact – inversion will lower the Tw threshold, i.e., need low Tw for solid precipitation.

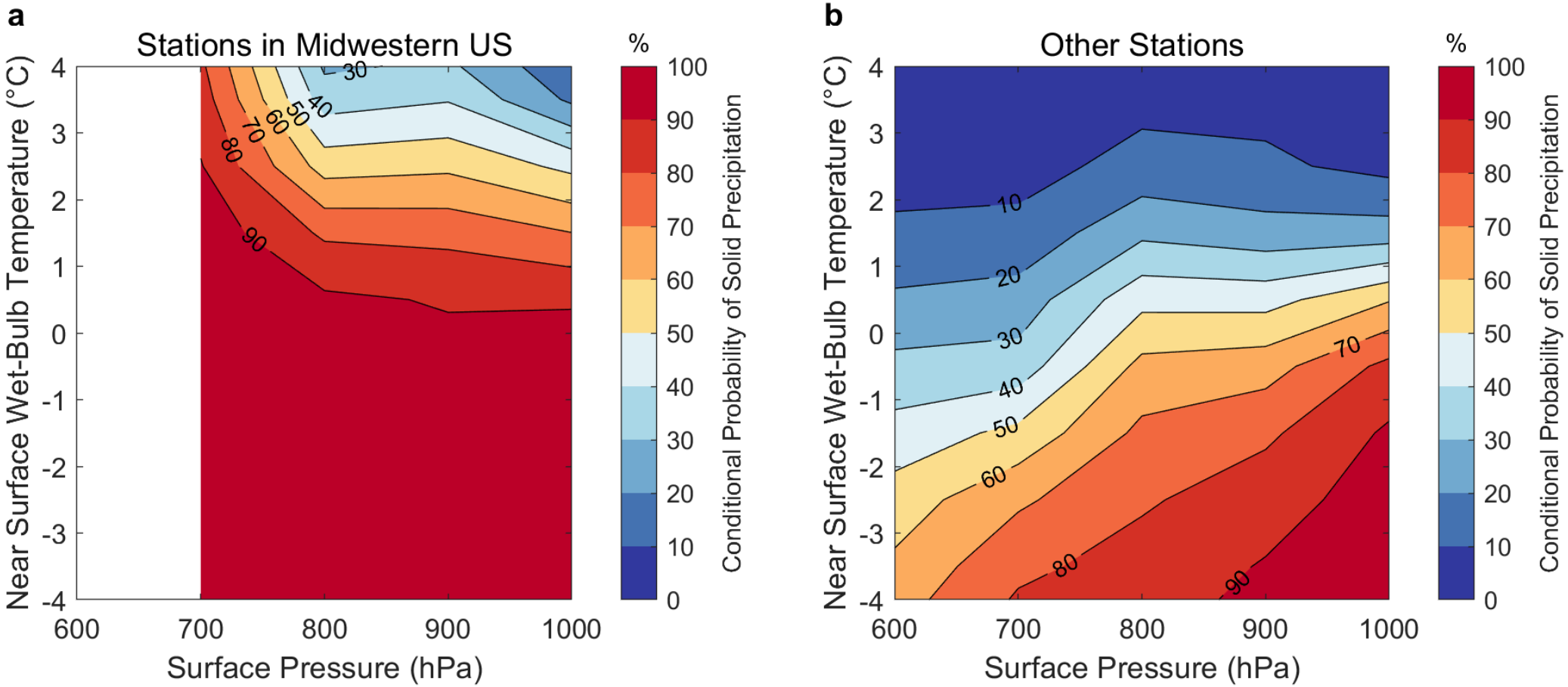




Surface "skin" temperature

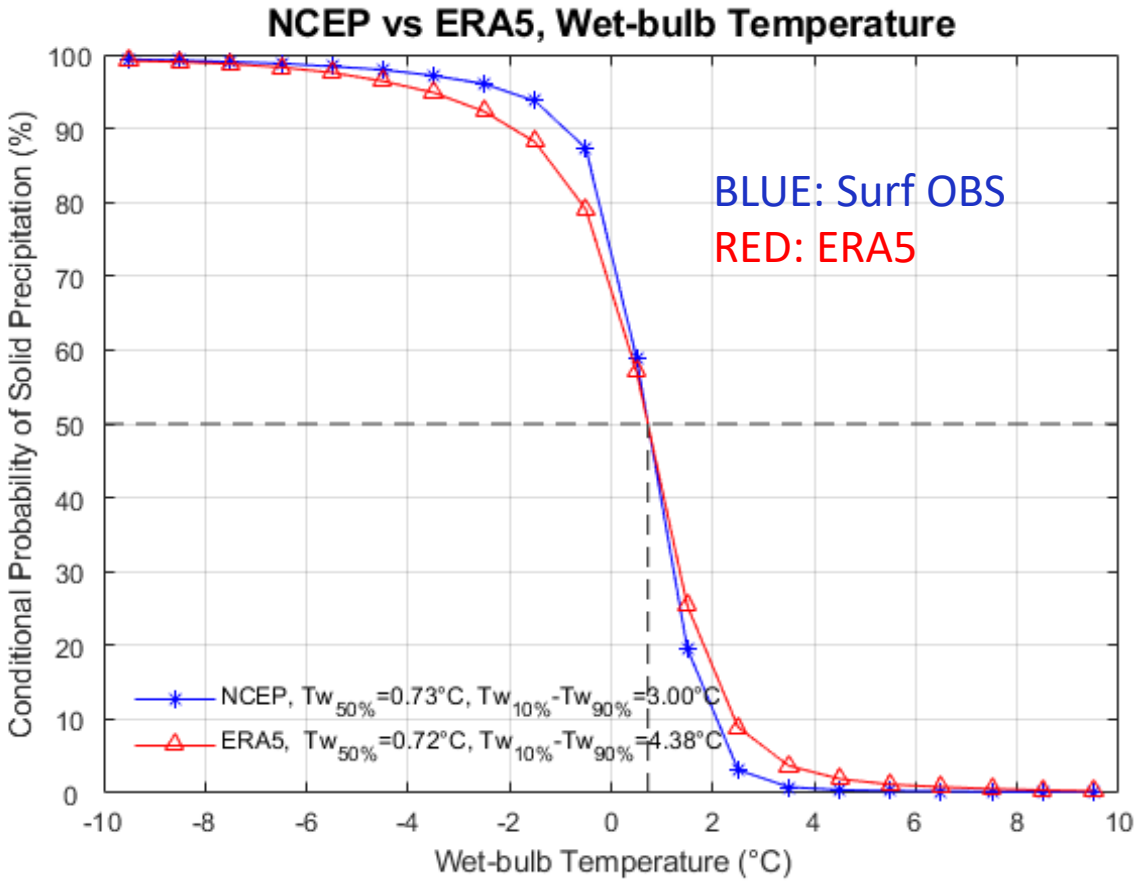
- Ocean: higher Ts → lower Tw threshold, explains low Tw threshold values over warm ocean currents: Gulf stream, Kuroshio, …
- Land: have opposite trend compared to over ocean, explains low Tw threshold over Himalayas, …
- Physical explanations not clear yet.

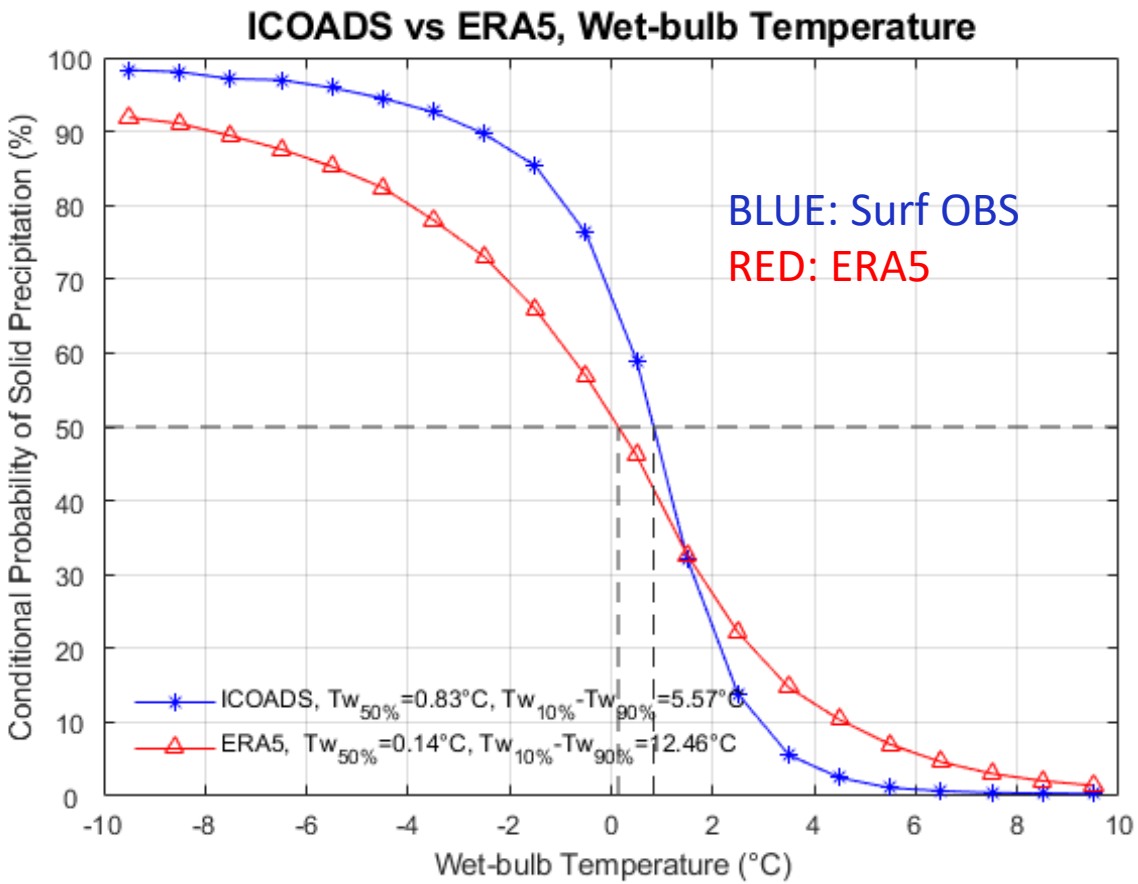
Elevation (surface pressure)



Clear trend over Midwestern US, but opposite trend over stations elsewhere. Possibly several factors are tangled together. For example, frozen surface induced T inversion over high mountains, etc.

Issues related to using ERA5

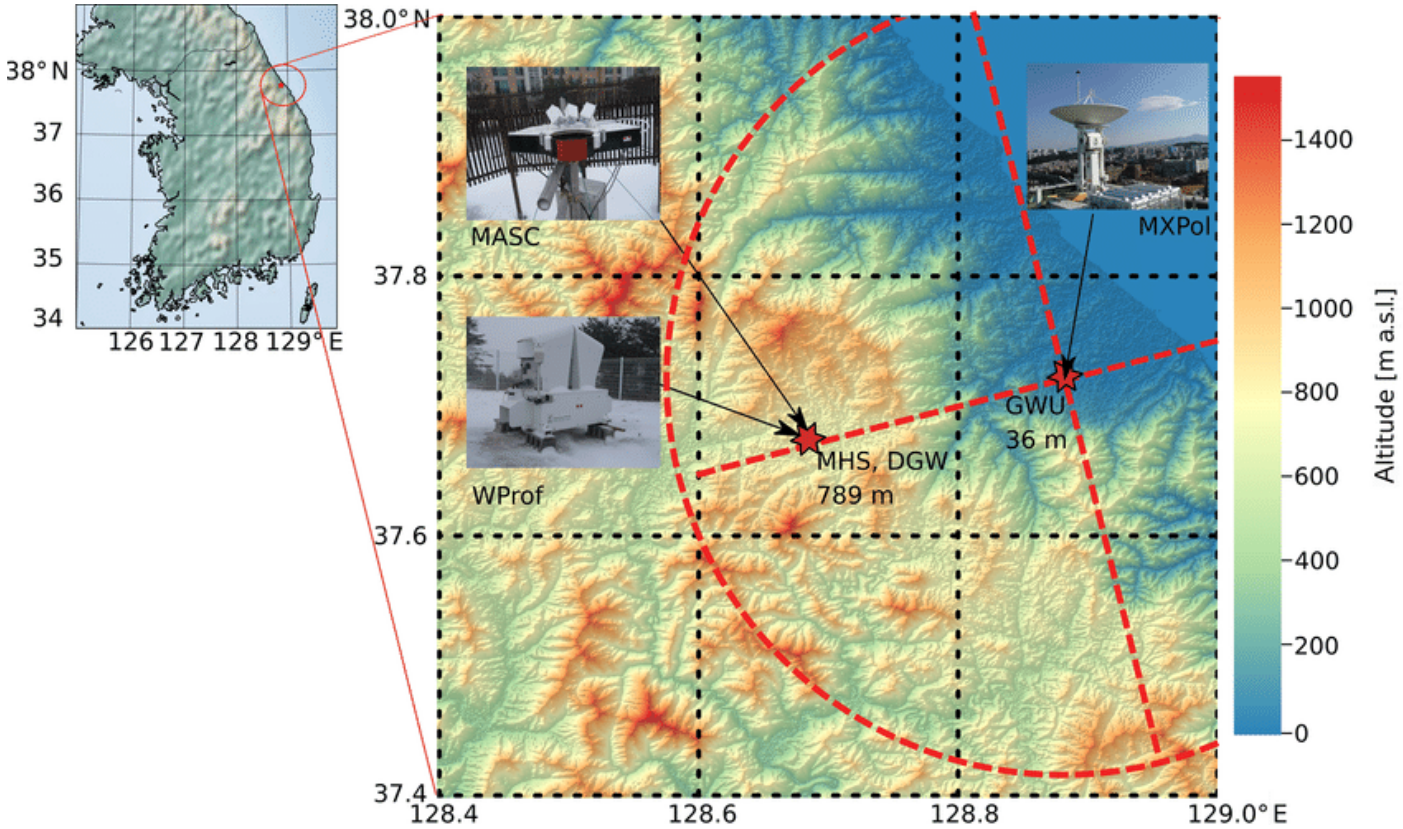




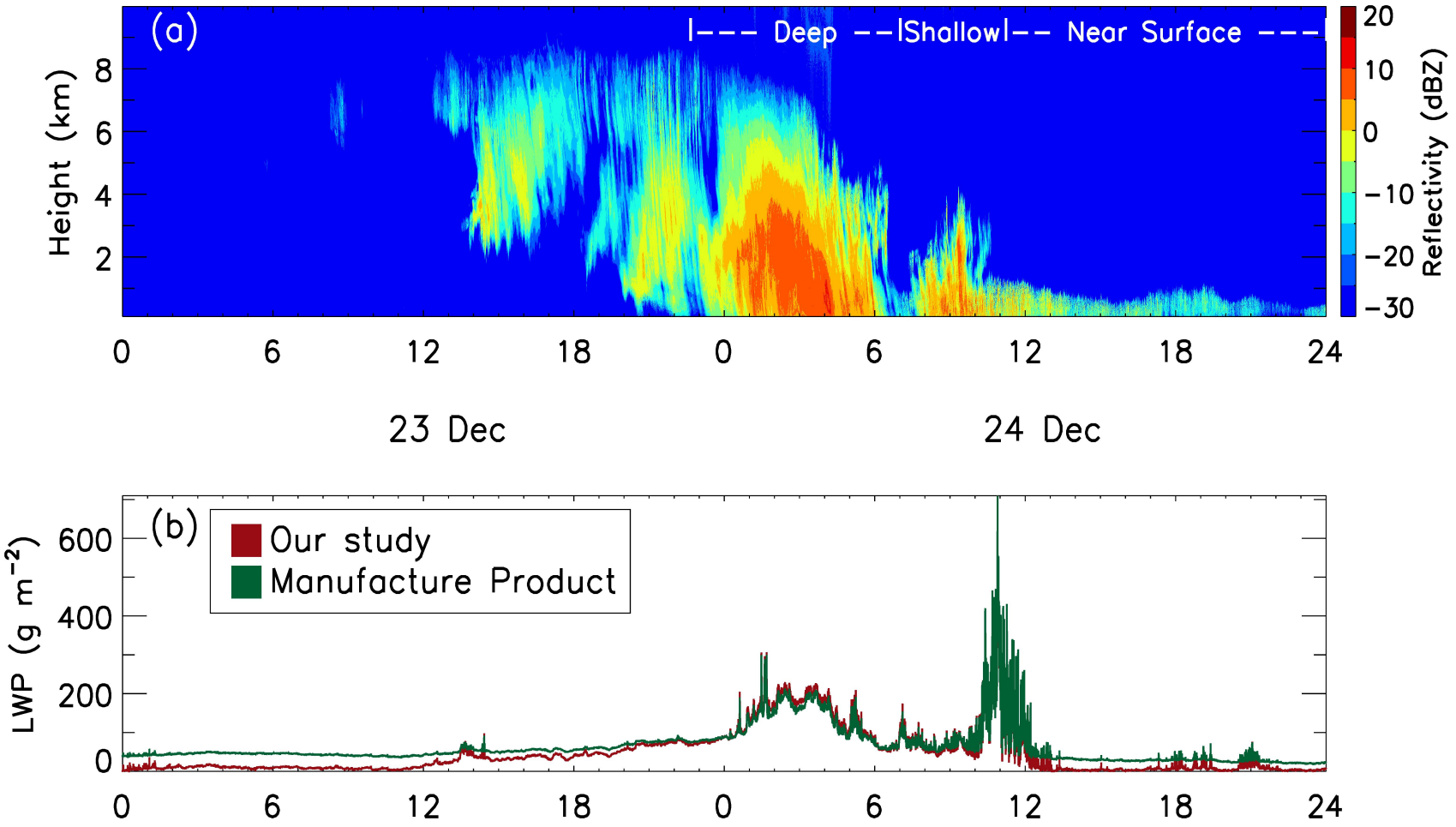
Over land, similar to results based on surf obs, but over ocean, large discrepancy.

Impact of Snow Cloud Types on Satellite Snowfall Retrievals

- Snow cloud properties based on simultaneous obs by W-band radar and microwave radiometer – snow + liquid water. ICE-POP 2018

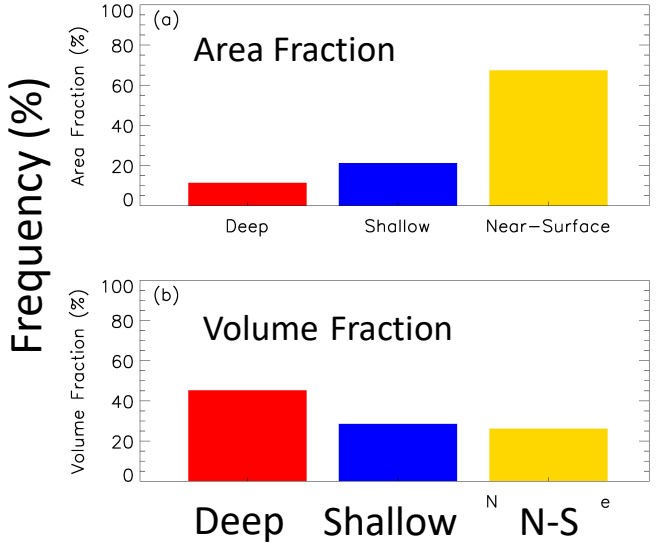


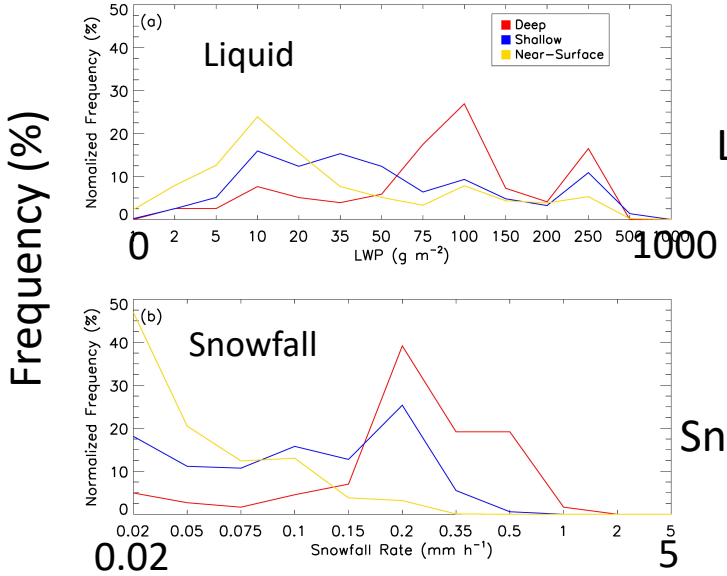
Simultaneous Obs of Snowfall and Liquid Water by W-band Radar and 89 GHz Radiometer over Korea for 6 months



Near-surface: top <1.5 km
Shallow: top 1.5 – 4.5 km
Deep: top > 4.5 km

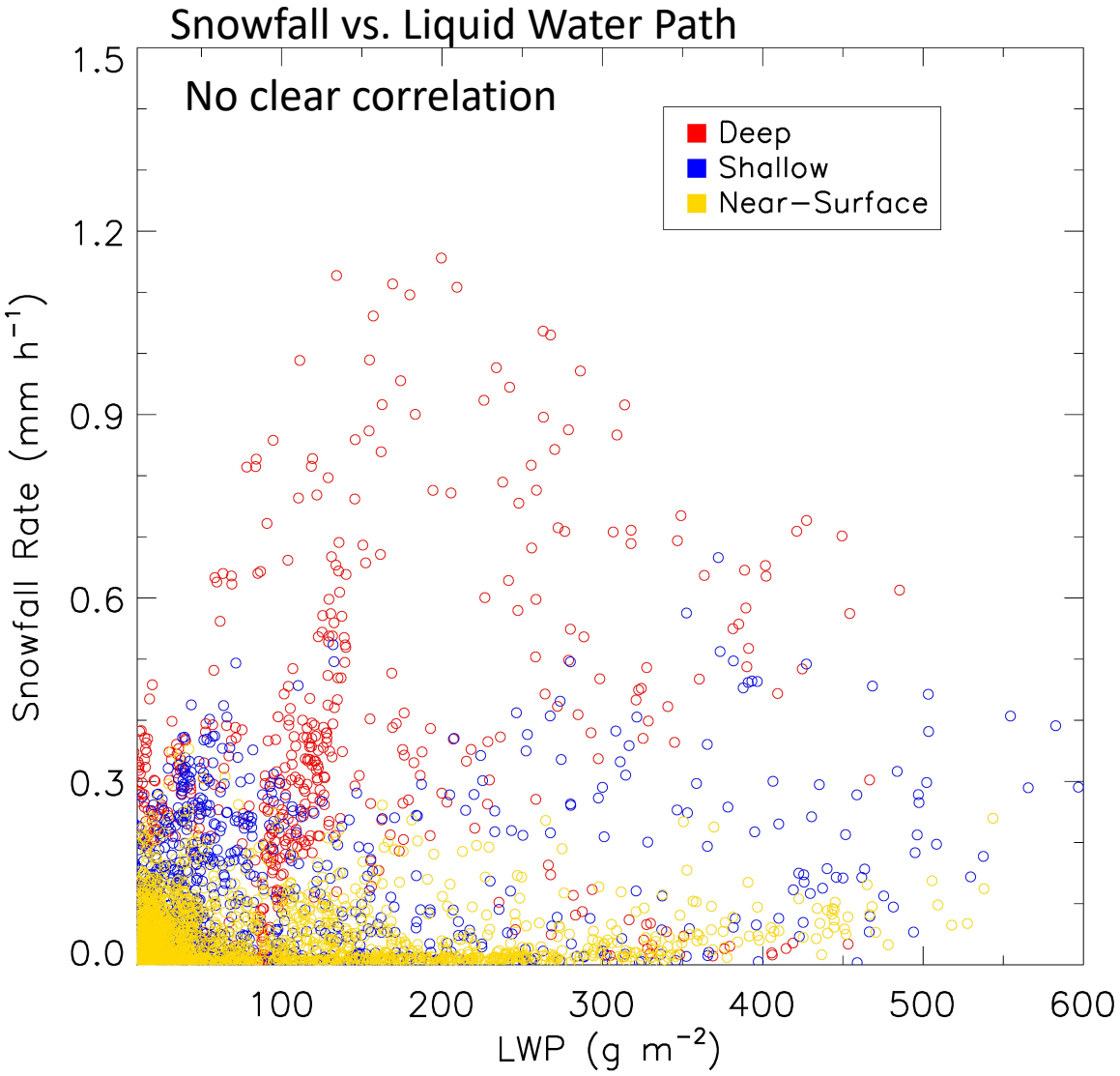
Microphysical properties





LWP (g m^{-2})

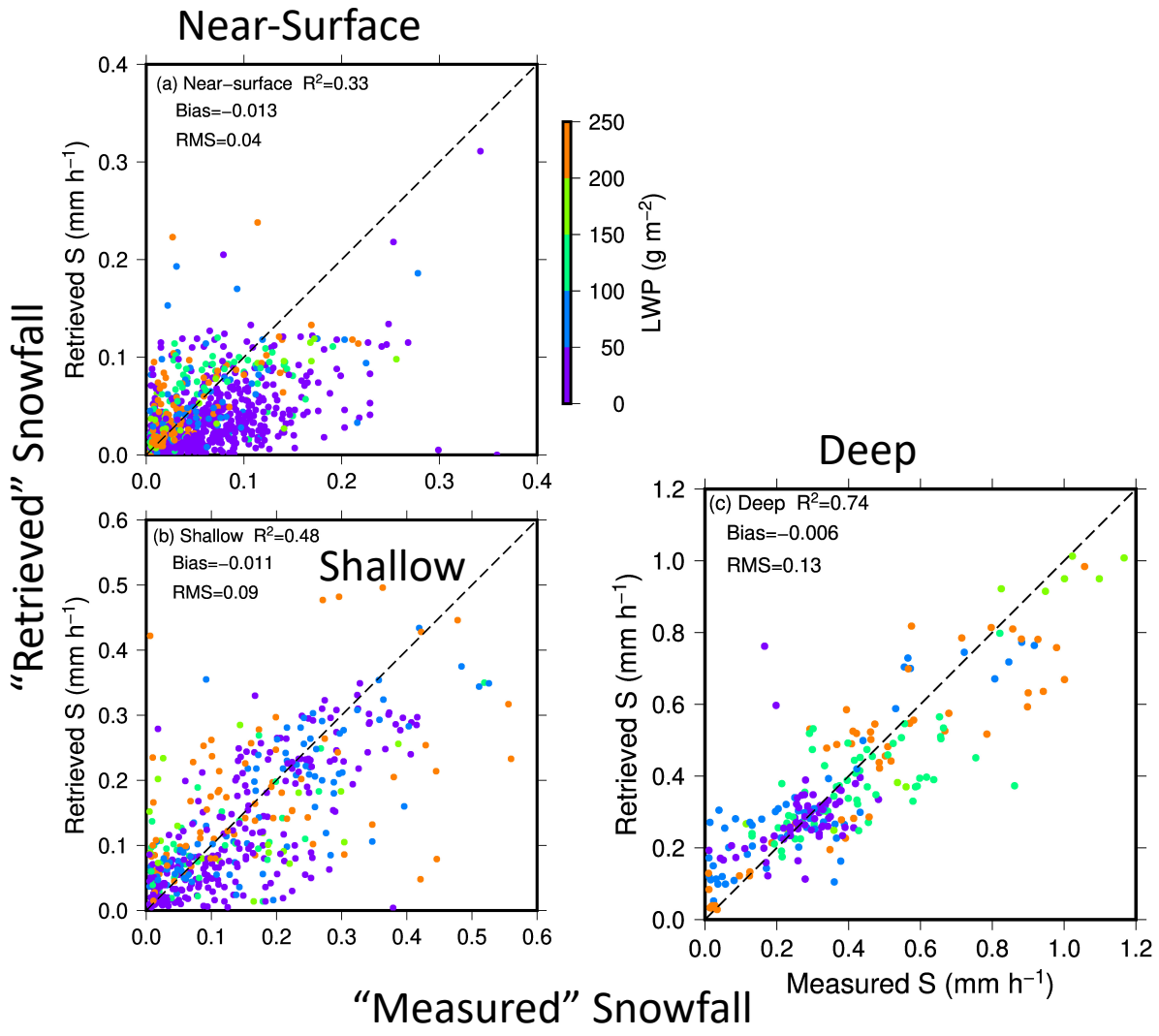
Snowfall (mm h^{-1})



Studies based on 4500 snowfall and 14500 no-snowfall profiles

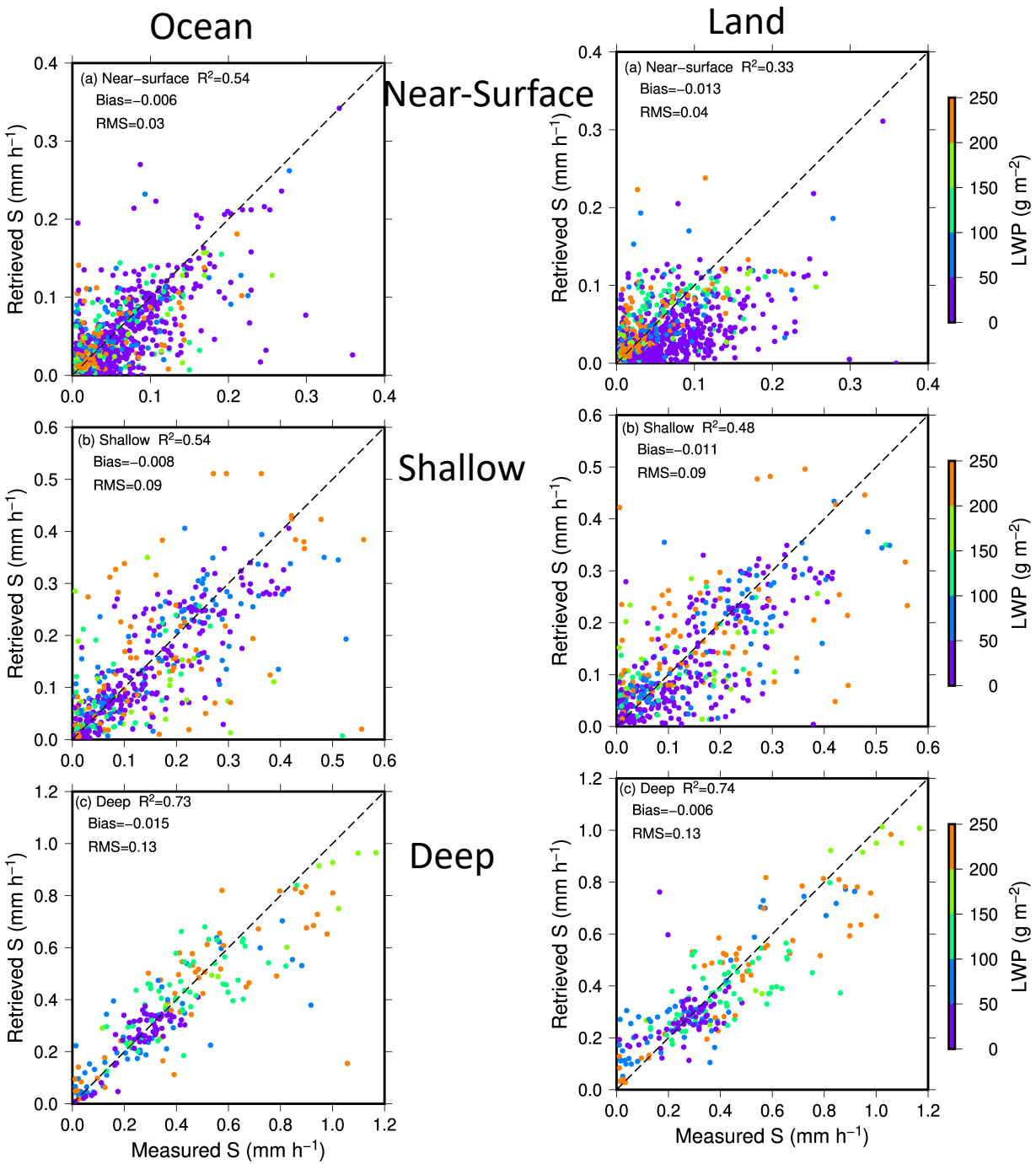
- Use RT Model generate GMI Tbs
- Separate profiles into training set and testing set.
- Test how a Bayesian algorithm would perform

Under ideal conditions (know surface emissivity, particle size distribution, etc), how good a Bayesian algorithm can do (upper limit) – error only due to the randomness of cloud structure, liquid – ice composition.



What if over ocean?

Over ocean, due to liquid water info can be resolved by lower frequency channels. Snowfall retrieval can be improved compared to over land. But major improvement is only seen in the near-surface cloud types.



Conclusions

- Found regional dependence of rain-snow Tw threshold
  - Lower threshold Tw over warm ocean currents, Himalayas, …
  - Warmer threshold Tw over midwestern U.S., Barents Sea, Bering Sea – Sea of Okhotsk – Sea of Japan, …
  - Studying factors that cause the regional dependence
    - Lapse rate
    - Surface skin temp.
    - Surface pressure
    - …
- Cloud types' impact on snowfall retrieval
  - Observed cloud microphysics during ICE-POP 2018
    - Contributions to total snowfall by 3 cloud types: near-surface, shallow & deep
    - No clear correlation between snowfall and cloud liquid water
    - Large liquid water amount can be found in any of the 3 types of clouds
  - How good a Bayesian algorithm can perform, a simulation study (best scenario) :
    - Best for "deep" clouds (R^2=0.75), followed by shallow (R^2=0.5) and near-surface (R^2=0.3) clouds
    - If over ocean, greatest improvement occurs for near-surface clouds (R^2 from 0.3 to 0.5)