Dynamic Emissivity Estimates to Support Physical Precipitation Retrievals for GPM

Poster #207

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INTRODUCTION

- Over-land, the land surface emission needs to be accurately estimated as it obscures the precipitation signal
- The land surface emissivity is highly variable, reflecting the pronounced dynamics in soil moisture and vegetation
- Here, three alternative methods for capturing the land surface emissivity dynamics over the SGP are compared

Method 1: Semi-empirical model (Ringerud et al. 2015)

Models are relied upon for prediction at one low frequency, and then associated co-variances are used to predict at higher frequencies.

Forward model

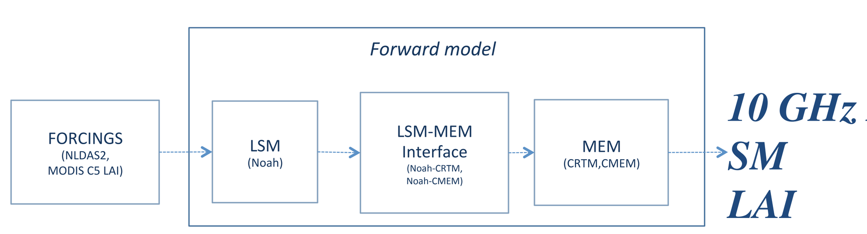
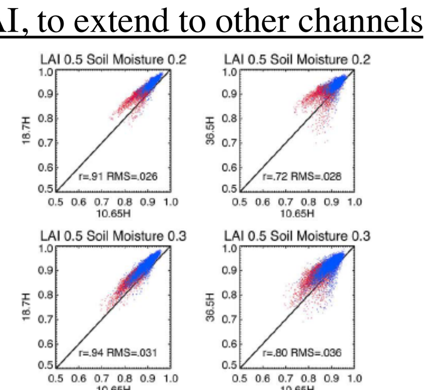


Figure 1: Semi-empirical framework

Co-variances, binned by SM & LAI, to extend to other channels



Semi-Empirical	10.65V	10.65H	18.7V	18.7H	23.8V	23.8H	36.5V	36.5H	89.0V	89.0H
Correlation	0.93	0.85	0.93	0.87	0.94	0.90	0.93	0.86	0.88	0.85
Mean bias (K)	0.71	-0.060	0.51	0.20	0.78	0.45	0.87	0.66	1.25	1.25
RMS	0.009	0.010	0.005	0.004	0.002	0.0006	0.0007	0.003	0.009	0.013

CRTM LandEM	10.65V	10.65H	18.7V	18.7H	23.8V	23.8H	36.5V	36.5H	89.0V	89.0H
Correlation	0.91	0.81	0.92	0.84	0.93	0.88	0.91	0.83	0.87	0.85
Mean bias (K)	-0.92	-1.76	-3.67	-4.60	-1.01	-0.82	0.82	1.00	1.24	0.82
RMS	0.013	0.015	0.012	0.017	0.006	0.010	0.002	0.007	0.007	0.006

Figure 2: Error statistics for (top) the semiphysical model and (bottom) the CRTM LandEM model relative to observed AMSR-E brightness temperatures for all SGP cloud-free pixel matches during the period 2009-2010

Method 2: Calibrated physical forward model (Harrison et al. 2015)

The predictive power of forward models for microwave emissivity estimation is severely limited (e.g., Ringerud et al., 2014). Here, the models are calibrated to address the widely recognized problem of poor parameter specification.

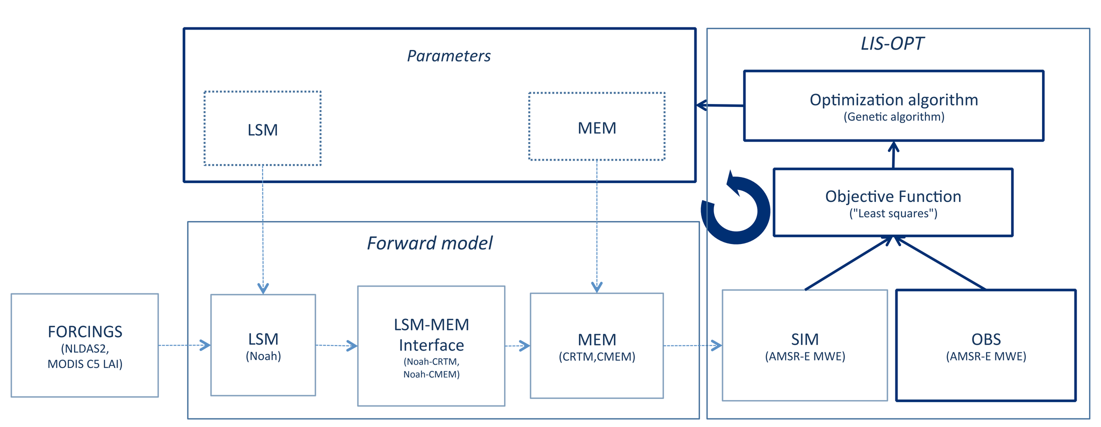


Figure 3: Calibration framework

10.65 GHz H emissivity after SGP storms (up to 12 inches) Sept. 11-15 2008…

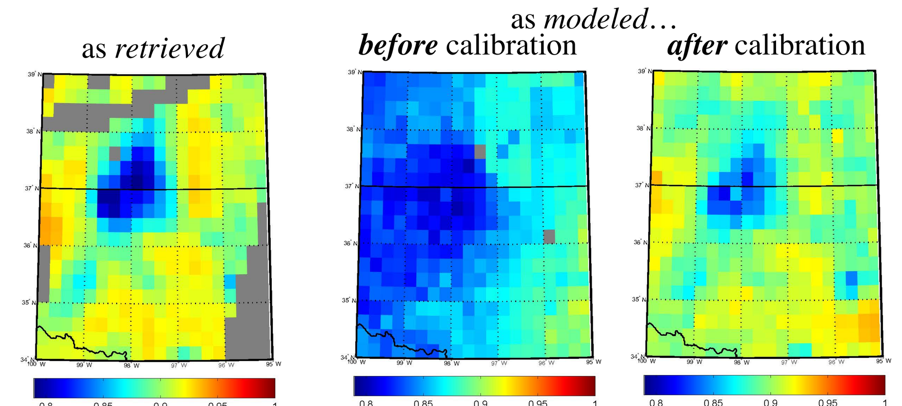


Figure 4: The initially poor match of retrieved (left) and modeled (middle) estimates is greatly improved with calibration (right), as illustrated here following a major storm in the SGP.

Method 3: Regression (Tian et al. 2015)

Satellite-observed brightness temperatures (Tb's) and Tb-derived quantities such as MPDI are dependent upon emissivity. Here, simple linear relationships are explored.

$$e_i = a_0 + a_1 \cdot P_{1,i} + a_2 \cdot P_{2,i} \ldots + a_m \cdot P_{m,i} + \ldots + a_M \cdot P_{M,i} + \varepsilon_i$$

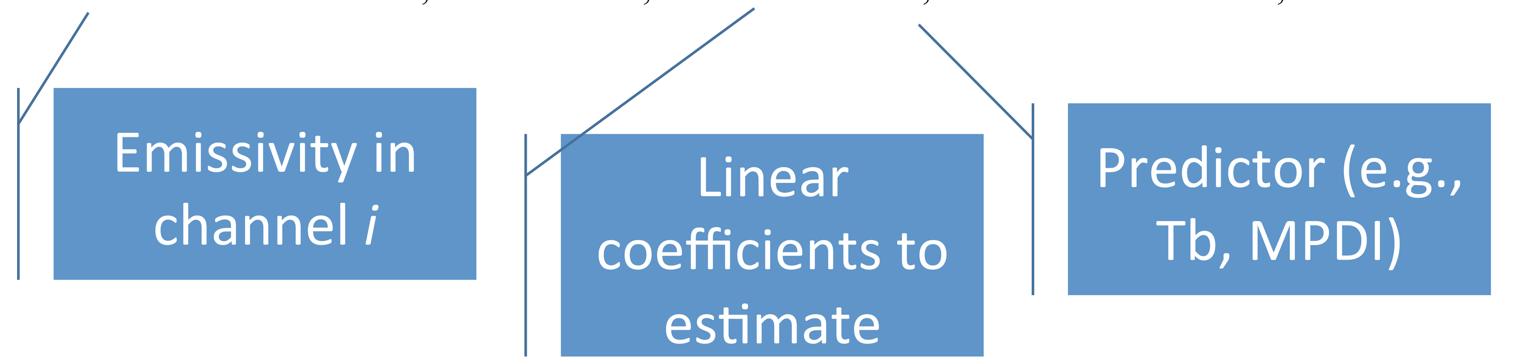


Figure 5: Linear regression framework

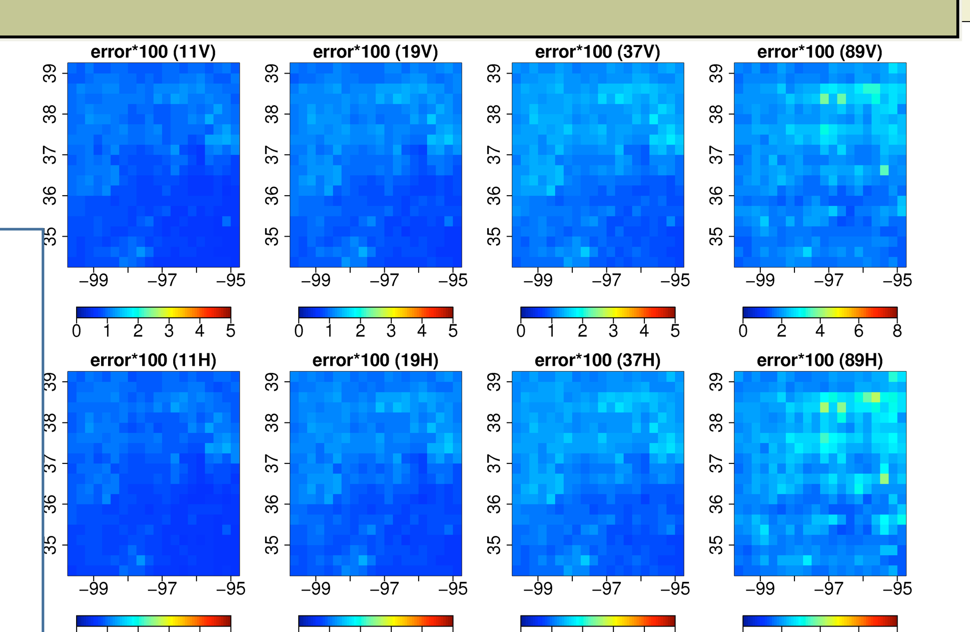


Figure 6. Prediction errors over the SGP for each channel from application of the STAT model M4 (10-channel Tbs and 5-frequency MPDIs)

Inter-comparison of methods (Tian et al., 2015)

Overview: Assess various approaches to the modeling and prediction of emissivity

Spatial domain: the "SGP" site -- a 0.25-deg, 20x20 grid: (-99.875, -95.125)x(34.125, 38.875).

Temporal domain: 1JAN2009-31DEC2010.

Reference data: CSU AMSR-E emissivity retrievals over SGP (Ringerud et al., 2014). Here, limited to descending-pass. (No snow/frozen ground screening)

Other data: Each approach free to use other datasets as needed, including CSU's emissivity retrievals before the study period, which are available from 1AUG2002 through 31DEC2008 (e.g., for model calibration, regression, etc.)

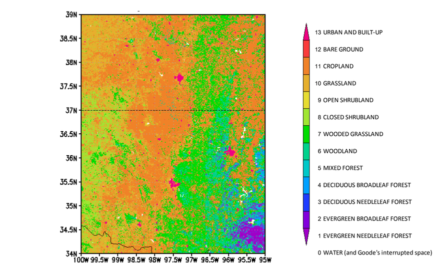


Figure 7: SGP land cover

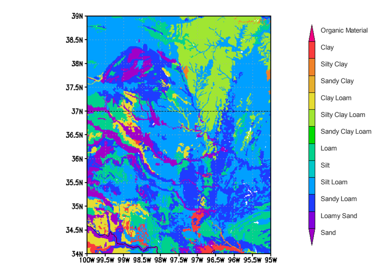


Figure 8: SGP soils

Table 1. Comparison of model performances for predicting clear-sky emissivity, as measured by spatial mean of the room-mean-square-difference (RMSD) between each method's estimate and the retrieved emissivity, multiplied by 100.

Method name	11V	11H	19V	19H	37V	37H	89V	89H
Semi-empirical	1.66	2.51	1.72	2.51	1.89	2.64	3.82	4.21
Forward model[1]	1.43	2.52	1.50	2.81	1.72	2.55	3.58	3.72
Calibrated forward model[2,3,4]	1.25	2.04	1.37	2.45	1.83	2.22	3.63	3.74
Regression[5]	0.90	0.86	1.01	1.00	1.14	1.13	1.94	2.09

[1]Noah-CRTM, after bias correction

[2]Noah-CRTM, after calibration to 2008 warm season Ringerud (2014) AMSR-E retrievals, and after bias correction (see Harrison et al., 2015 for details)

[3]Caveat: calibration of soil-vegetation system only, i.e., snow and frozen-ground overpasses were excluded and therefore cold-season performance not optimized

[4]Caveat: calibration conducted using both ascending and descending retrievals; therefore any biases (e.g., related to surface temperature, dew, day/night differences) in emissivities will increase descending pass simulation error

[5] 15 Tb-based predictors: 10-channel Tbs and 5-frequency MPDIs

CONCLUSIONS

Simple statistical models proved reliable in predicting clear-sky emissivities over the SGP (Table 1), better than alternatives involving forward modeling (though with some caveats as noted in table footnotes). The approach is relatively easy to implement but needs testing globally.

Gains in forward model performance, particularly at lower frequencies, can be secured with calibration. As the semi-empirical approach draws on un-calibrated forward modeling at low frequencies, we anticipate such gains but this, too, needs to be tested.

References

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ACKNOWLEDGEMENTS

NASA Precipitation Science Program NNH09ZDA001N (PI: C. D. Peters-Lidard)