A Semi-Empirical Emissivity Model for use in Physical Precipitation Database Construction

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Construction of Semi-Empirical Emissivity Model

- A method for emissivity estimation that makes use of best info from models, retrievals
- Physical model for 10 GHz emissivity
  - Required inputs: soil type, soil moisture, surface temperature, LAI, antecedent precipitation
  - This is where physical model and retrievals agree (Ringerud et al. 2014)
- Empirical model uses observed covariance relationships to map to other frequencies
  - Bytheway and Kummerow 2010

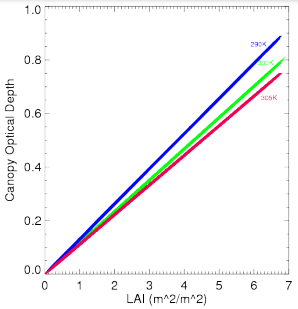
S. Ringerud, C. Kummerow, C. Peters-Lidard, "A Semi-Empirical Model for Computing Land Surface Emissivity in the Microwave Region ", *IEEE Trans. Geosci. Remote Sensing*, accepted

10 GHz Physical Model (based on operational schemes)

2-Stream Radiative transfer solution : emissivity (Weng et al. 2001)

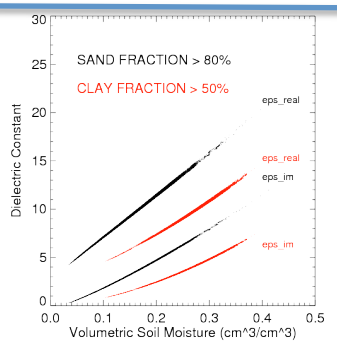
INTERCEPTED WATER (Empirical)

Vegetation Optical Depth: Tau-Omega approach (CMEM, based on Wegmiller et al. 1995, formulated for 1-100 GHz using geometric optics)
LAI: MODIS



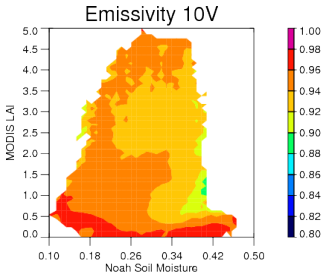
Smooth surface Reflectivity: Fresnel law
Rough reflectance: Wegmuller and Matzler 1999 (1-100 GHz)

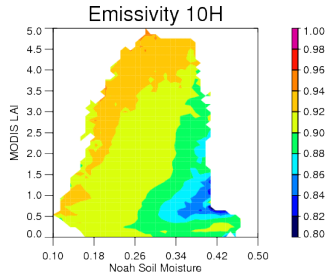
Soil Dielectric Model: Dobson et al. 1985 (1-18 GHz) (SMOS, LandEM)
Texture and Moisture: Noah LSM + STATSGO + NLDAS2

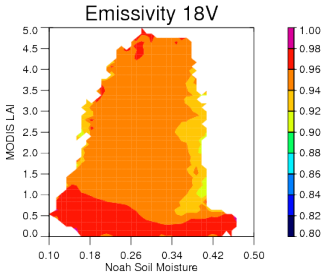


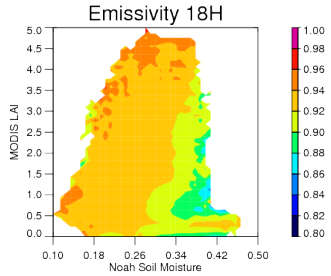
Empirical Model

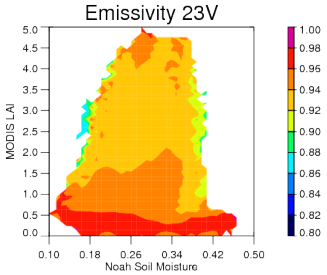
- 5 years of clear sky AMSR-E retrievals, over 2 million pixels
  - Noah-NLDAS2 surface temperature + ERA-Interim atmosphere (MODIS confident-clear)
  - Plane-parallel Eddington radiative transfer scheme
- Retrieved emissivities strong function of soil moisture, particularly at lower frequencies, and LAI, particularly at higher frequencies

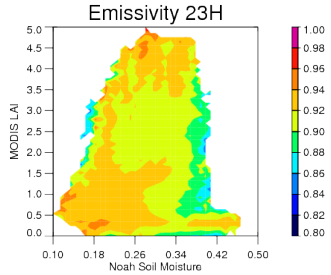


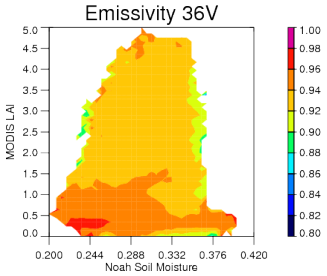


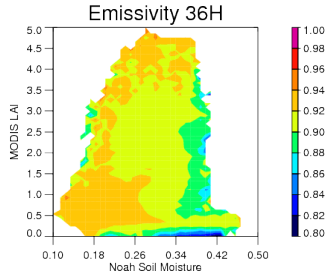


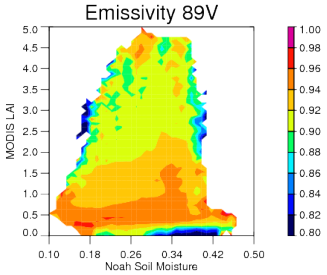


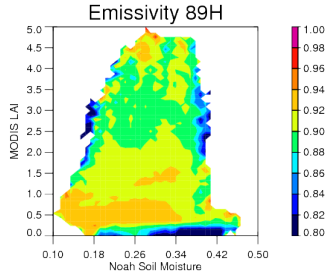


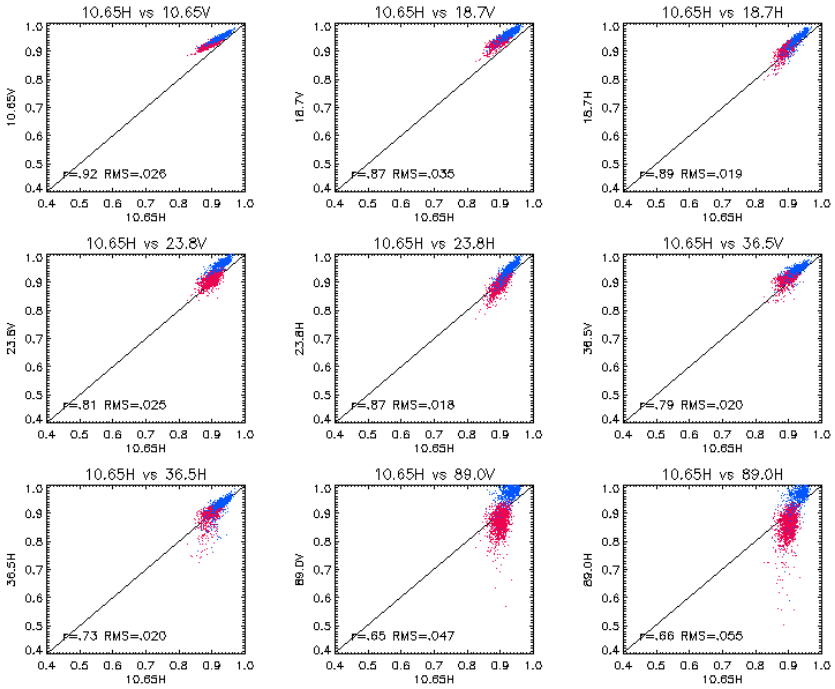


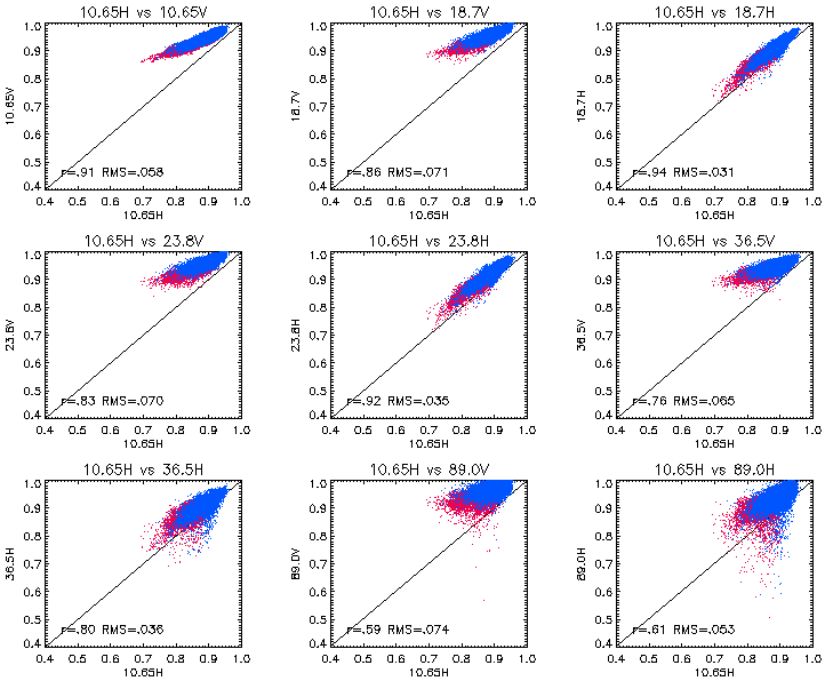








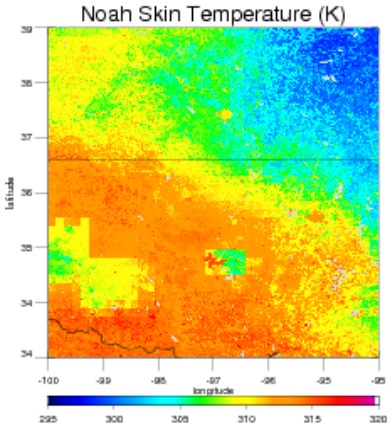


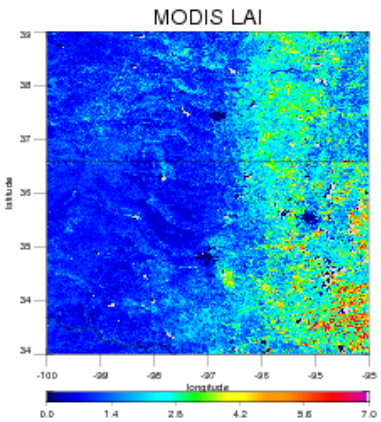


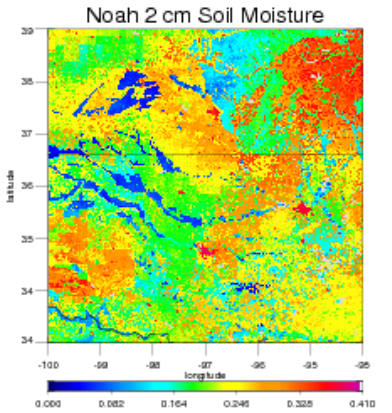
Empirical Model AMSR-E

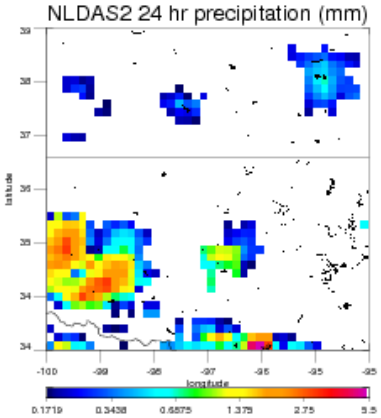
Channel	r-NO BINS	r-BINS
10.65V	0.84	0.91
18.7V	0.74	0.87
18.7H	0.91	0.91
23.8V	0.60	0.83
23.8H	0.81	0.89
36.5V	0.56	0.80
36.5H	0.68	0.77
89.0V	0.32	0.67
89.0H	0.40	0.68

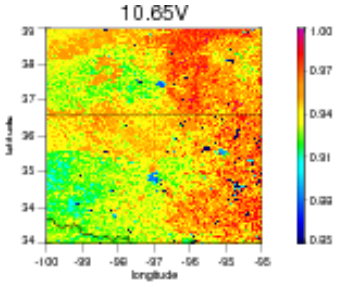
Emissivity

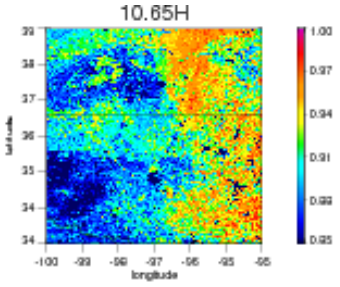

Noah Skin Temperature (K)
latitude
longitude
295
300
305
310
315
320

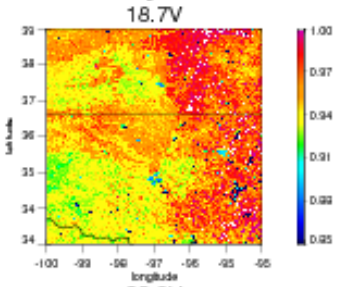

MODIS LAI
latitude
longitude
0.0
1.4
2.8
4.2
5.6
7.0

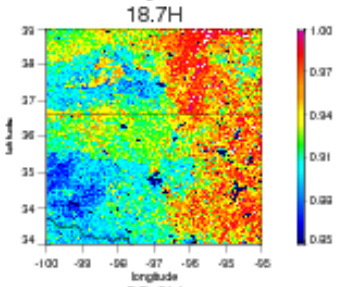

Noah 2 cm Soil Moisture
latitude
longitude
0.000
0.082
0.164
0.246
0.328
0.410

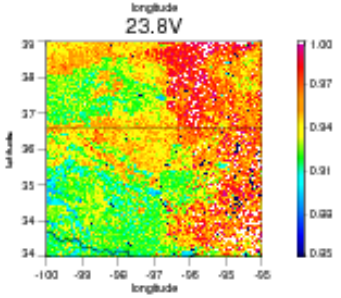

NLDAS2 24 hr precipitation (mm)
latitude
longitude
0.1719
0.3438
0.6875
1.375
2.75
5.5

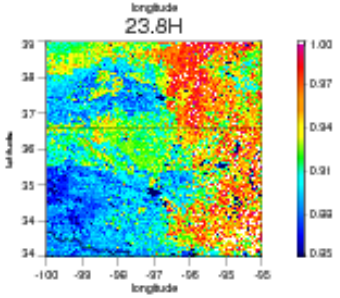

10.65V
latitude
longitude

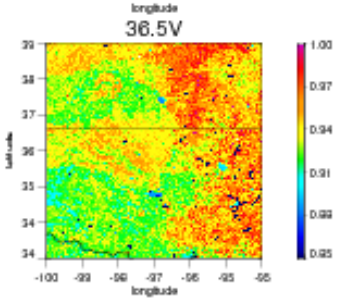

10.65H
latitude
longitude

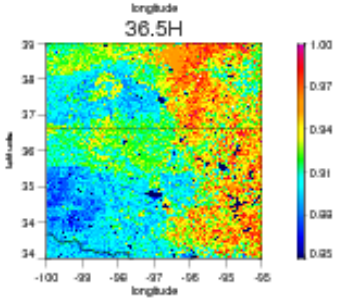

18.7V
latitude
longitude

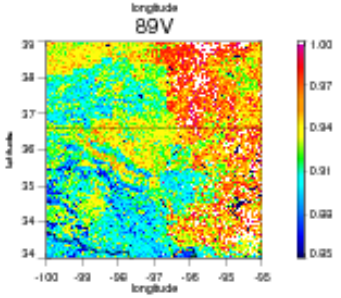

18.7H
latitude
longitude

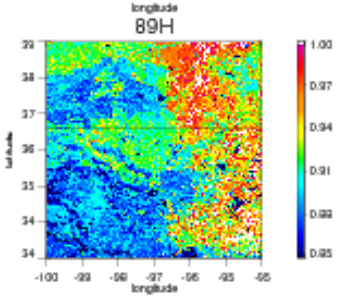

23.8V
latitude
longitude


23.8H
latitude
longitude


36.5V
latitude
longitude


36.5H
latitude
longitude

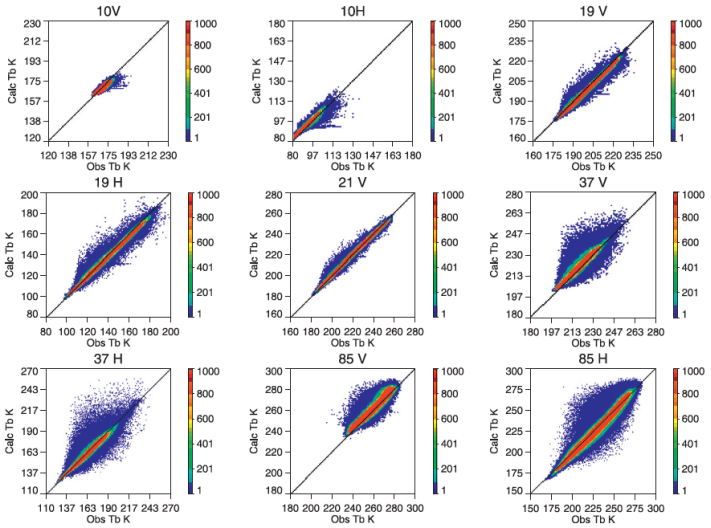

89V
latitude
longitude

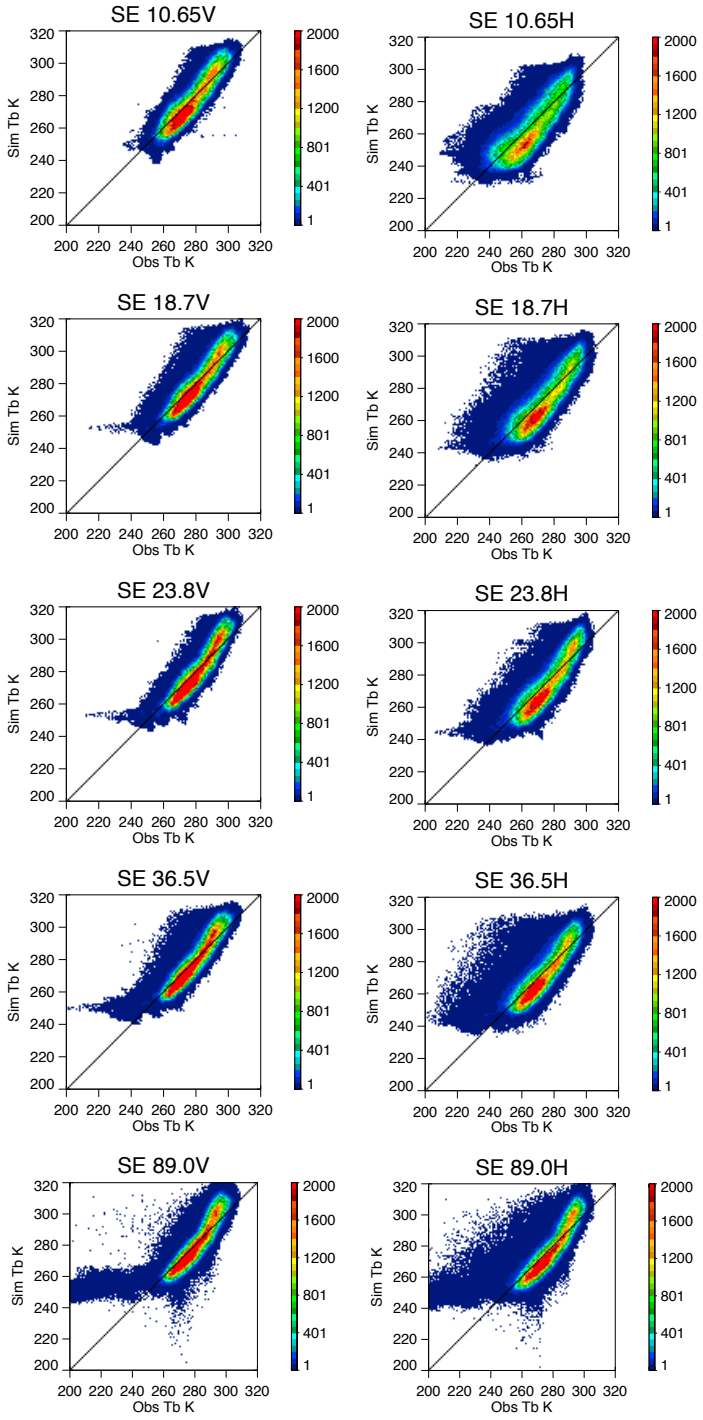

89H
latitude
longitude

AMSR-E Tb Results Comparison to Observed

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

TMI Non-Raining Ocean (Kummerow et al. 2011)



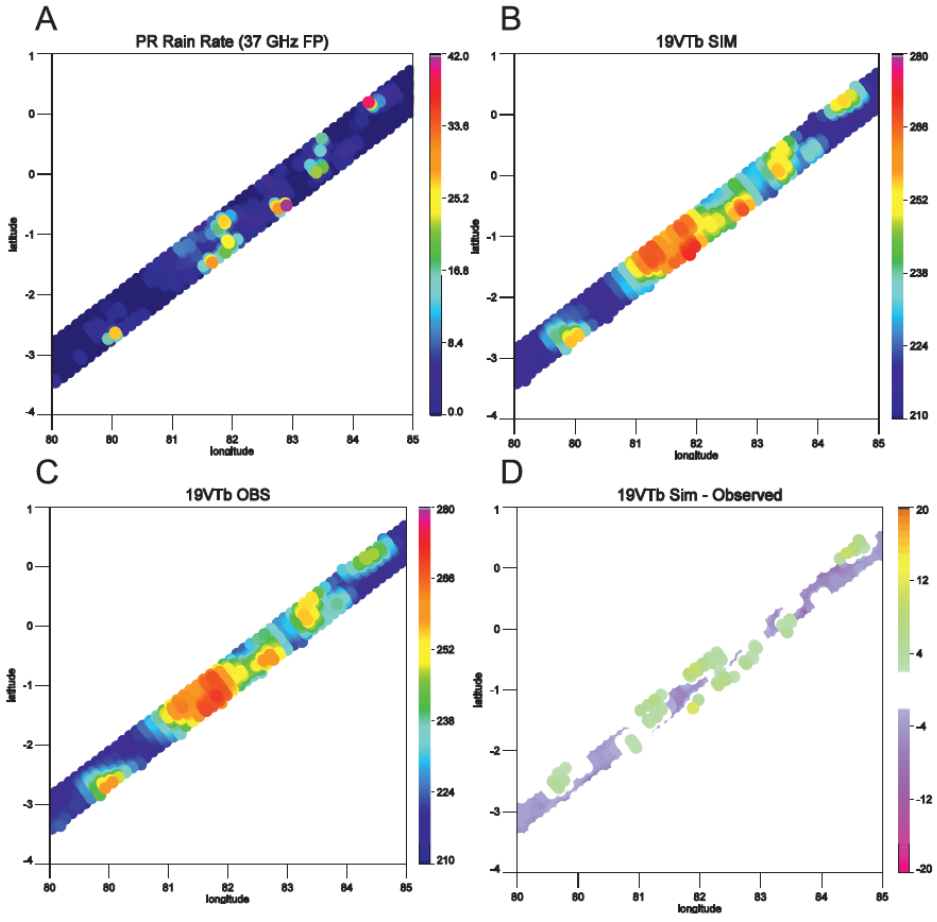


Hydrometeor Database and Ancillary Atmospheric Data

- Hydrometeors: profiles over CONUS for 1 yr. of CRM running in Goddard MMF (Thank you Toshi Matsui!) (every 5th profile: 958,927)
  - Bin to 250 m height res (match PR)
  - Determine conv/strat based upon Lang et al. 2003 (JAM)
  - Calculate DSD 2A25
  - Compute reflectivity using mie-codes
  - Ice is spherical with assumed density (for now)
- Atmosphere: ERA-Interim
- Profiles are matched (with atmospheric constraints) to near-nadir PR profiles and Tb computed

Construct Database

- Empirical Model currently being recalculated using clear-sky retrievals from TRMM TMI
- Semi-Empirical Model serves as background emissivity for physical database following procedure of Kummerow et al. 2011 (ocean)
- Adjustment procedures for rain over land TBD



Next Up

- Ice radiative transfer will be updated
  - Ideally oriented non-spherical particles
- Use higher freq Tb differences to adjust ice (amount? density? size?)
- Run retrieval using this test database
  - Look at emissivity effect on retrieval
  - Is signal good enough to make this work?
  - Study database indexing: soil moisture/LAI/ surface T (ocean is SST/TPW)