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SMAP Radar Soil Moisture Algorithms

JAKOB VAN ZYL

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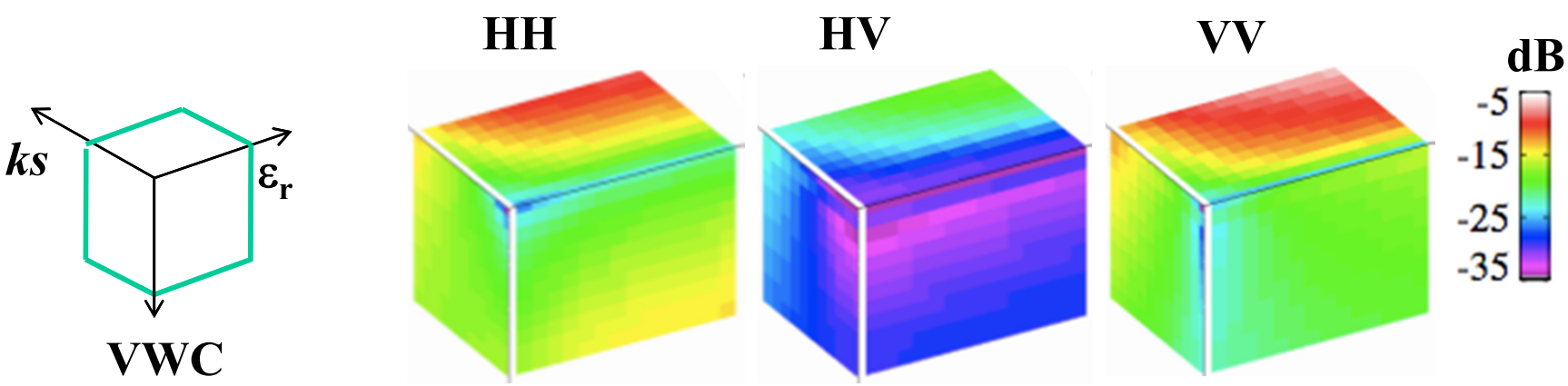
SMAP Radar Baseline Algorithm-1

- The current baseline retrieval algorithm is an optimization process applied to a robust physical forward model and time-series data.
  - Optimizing a robust forward model is computationally challenging. A solution may be a search of its lookup table (datacube).
  - Radar observation error is not small for SMAP (0.5 to 0.7dB after fore+aft look synthesis). The time-series input constrains the solution search against the noise presence. Experiments showed the required length of the time-series is at least 6.



[Datacubes for pasture vegetation, L. Tsang]

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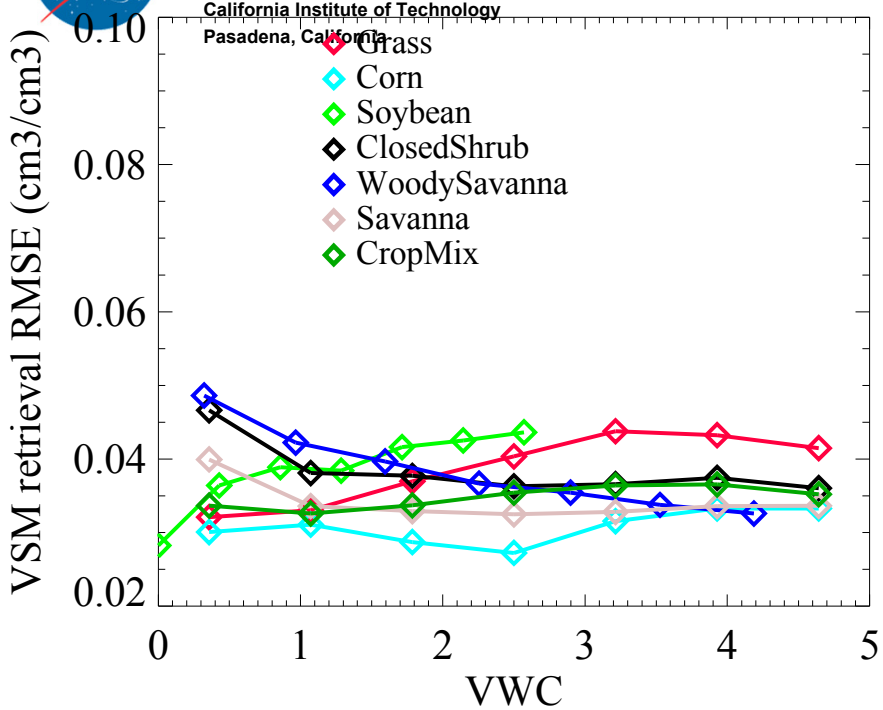
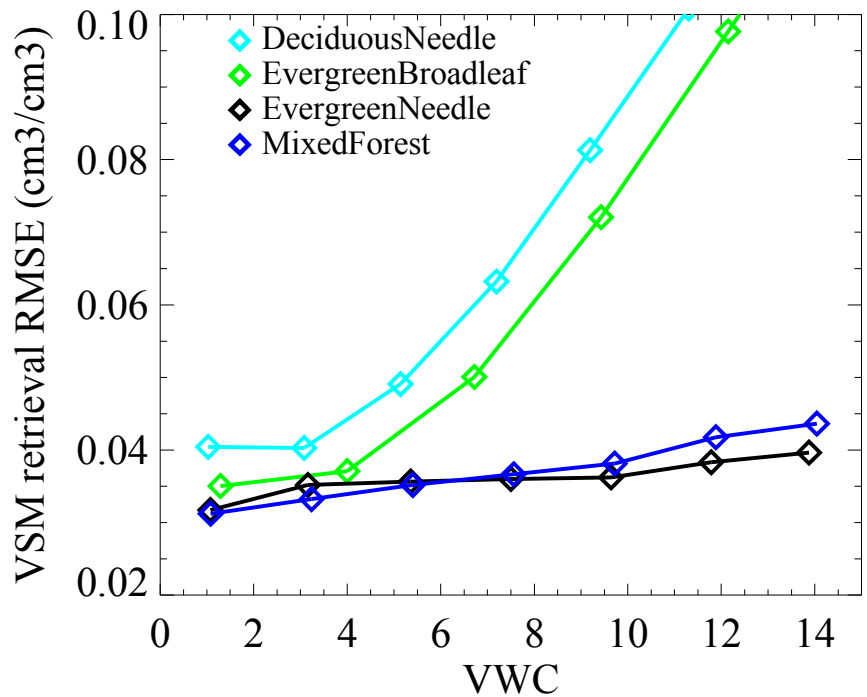
SMAP Radar Baseline Algorithm-2





- Datacubes were trained using in situ data for 16 land cover classes according to the IGBP scheme (International Geosphere-Biosphere Programme).
- The curves are averages of Mv RMSE from the Monte-Carlo simulations, over roughness values of 0.5 to 4 cm, and dielectric constant values of 3.5 to 27. 6 time-series input were used.
- With the total Kp of 0.5 dB (fore+aft), the Mv RMSE is 0.05 cm^3/cm^3 or less, for the non-forest cases up to 5 kg/m^2 vegetation water content (VWC).

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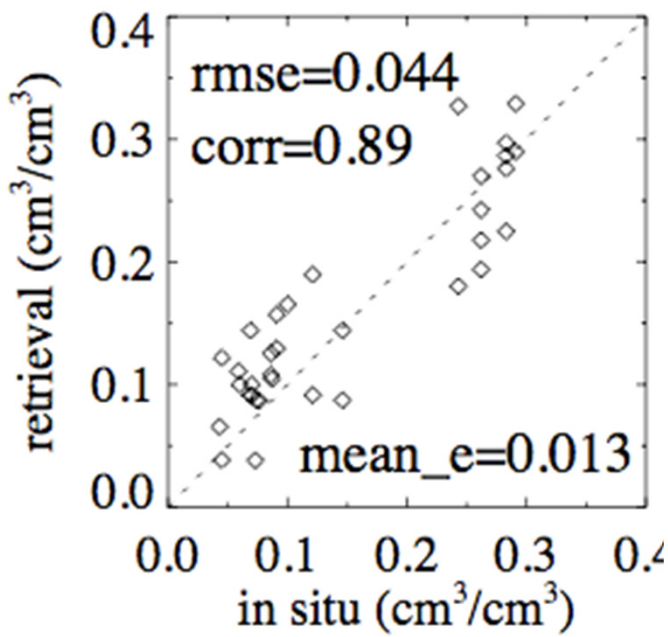
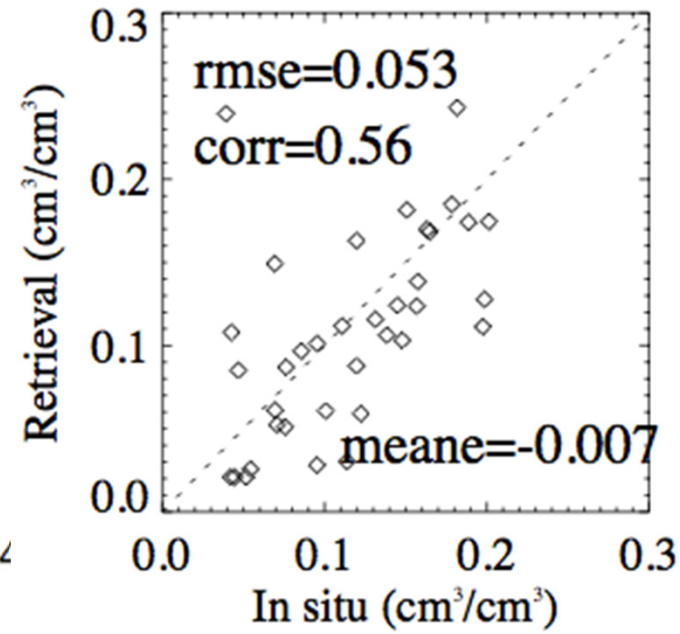
SMAP Radar Baseline Algorithm-3

- (Left) RMS errors in soil moisture retrieval using the data-cube time-series method, assessed with (a) the Yipsilanti bare surface data and (b) the SGP99 pasture surface data.
- (Bottom) The error budget based on the above analysis.





Error Sources	Budget (cm^3/cm^3)
A) Total Kp noise (0.5dB, 1sigma, fore+aft)	0.04
B) Vegetation Water Content (10%, 1 sigma, unbiased)	
C) Datacube error (2 dB)	0.053
D) Dielectric conversion (0.02 cm^3/cm^3)	
E) Scalling and heterogeniety	TBD
Total Error: RSS of A, B, C, D (up to TBD VWC)	0.067

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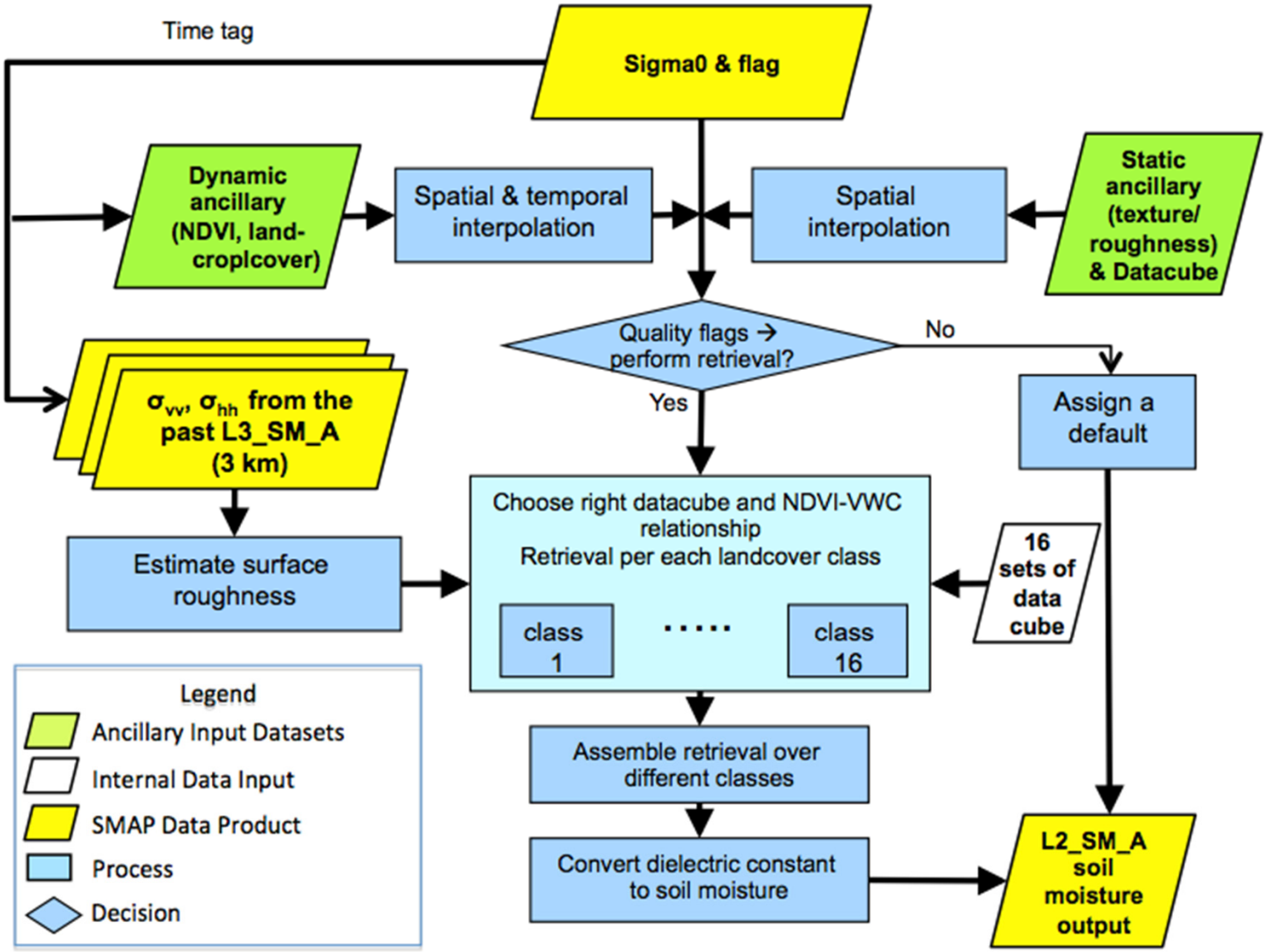
SMAP Radar Baseline Algorithm-4



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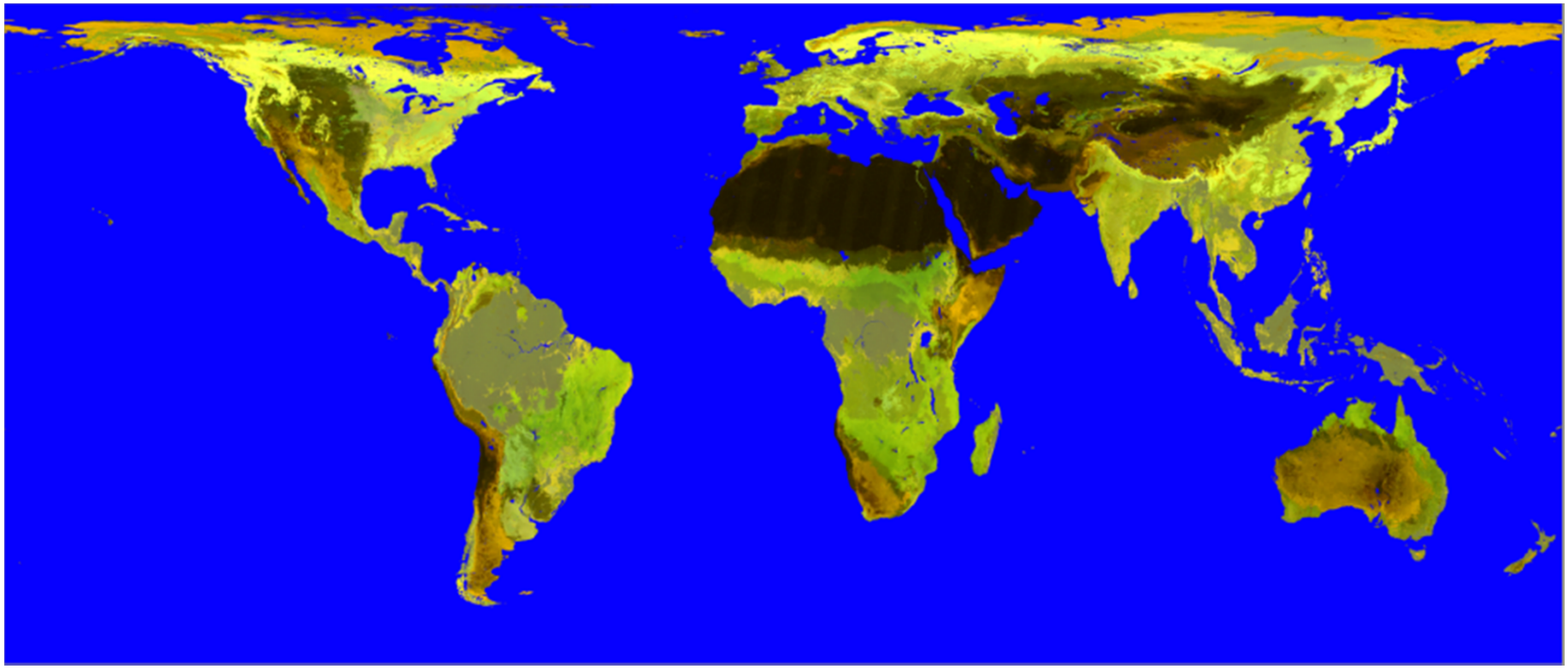
SMAP Radar Baseline Algorithm-5

- Prior to launch, retrieval algorithms need to be tested and evaluated using both airborne field experiment data as well as end-to-end simulation systems 'SAMP algorithm Testbed'.



Simulated global radar backscatter in the Testbed: False-Color R,G,B = VV,HH,HV

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SMAP Algorithms: Optional Time-series Approach-1

- The time-series algorithm of Kim and van Zyl (2009) relies on the linear relationship between soil moisture and radar backscatter.
- The coefficients (Ci) depend on land cover class and vegetation amount.

$$m_v = C_0 + C_1 \frac{\sigma_{hh} + \sigma_{vv}}{2}$$

- The change detection algorithm by Wagner et al. produces a wetness index based on the linear relationship between soil moisture and radar backscatter.
- The reference states (radar backscatter for wet and dry conditions) need to be determined.

$$M_S = \left(\sigma^0(t) - \sigma^0_{dry}\right) / \left(\sigma^0_{wet} - \sigma^0_{dry}\right)$$

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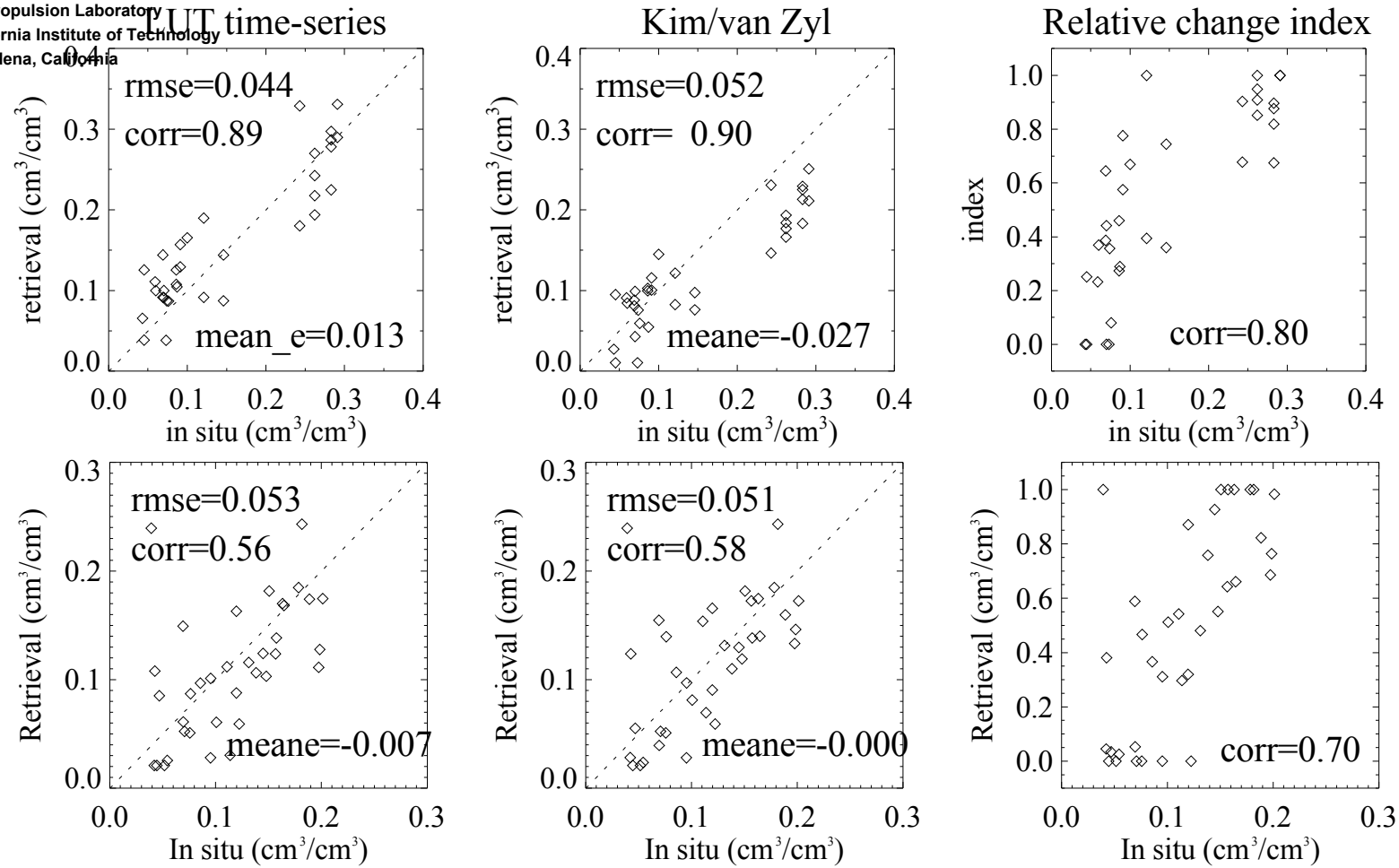
SMAP Algorithms: Optional Time-series Approach-2

[Bare Surface]

[Pasture Surface]



- The baseline and two optional algorithms were evaluated using the Ypsilanti and SGP99 data. The Kim/van Zyl algorithm was constrained using the retrievals of the baseline method. The baseline performs the best for the bare surface. Wagner method has the best correlation for the pasture surface but does not provide absolute soil moisture.