Validation of the SMAP L2_SM_AP Product

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Soil Moisture Active Passive Mission

SMAP

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The baseline science mission shall provide estimates of soil moisture in the top 5 cm of soil with an error of no greater than 0.04 cm$^3$/cm$^3$ (one sigma) at 10 km spatial resolution and 3-day average intervals over the global land area excluding regions of snow and ice, frozen ground, mountainous topography, open water, urban areas, and vegetation with water content greater than 5 kg/m$^2$ (averaged over the spatial resolution scale)
Regions Where SMAP is Expected to Meet Science Requirements

At 9 km:
VWC ≤ 5 kg m⁻²
Urban Fraction ≤ 0.25
Water fraction ≤ 0.1
Elevation Slope Standard Deviation ≤ 3 deg
L2_SM_AP Algorithm Overview

Baseline Algorithm
$T_B$ disaggregation
(Das et al., ATBD)
(TGARS, Published in 2013)

$nc = 1$

$L2_{-}SM_{-}P \quad T_B$

$C$

$nm = 16$

$M_{nm}$

$nf = 144$

$L2_{-}SM_{-}AP$

$C = \text{Coarse (\sim 36 km Radiometer)}$

$M_{nm} = \text{Medium (~} F_{nf} \text{~Merged Product)}$

$F_{nf} = \text{Fine (\sim 3 km, Radar)}$
Evaluate \( T_{B_p} = \alpha + \beta \cdot \sigma_{pp} \) at scales \( C \) and \( M \):

\[
T_{B_p} (C) = \alpha(C) + \beta(C) \cdot \sigma_{pp} (C)
\]

\[
T_{B_p} (M) = \alpha(M) + \beta(M) \cdot \sigma_{pp} (M)
\]

Subtract one from another:

\[
T_{B_p} (M) - T_{B_p} (C) = [\alpha(M) - \alpha(C)] + \beta(M) \cdot \sigma_{pp} (M) - \beta(C) \cdot \sigma_{pp} (C)
\]

Add and subtract \( \beta(C) \cdot \sigma_{pp} (M) \) to rewrite as:

\[
T_{B_p} (M) = \]

\[
T_{B_p} (C) + \beta(C) \cdot [\sigma_{pp} (M) - \sigma_{pp} (C)] + [\alpha(M) - \alpha(C)] + [\beta(M) - \beta(C)] \cdot \sigma_{pp} (M)
\]

Disaggregated brightness temperature

Parent scale-\( C \) brightness temperature

Scale-\( C \) sensitivity parameter \( \beta \) times smaller scale-\( M \) variations in \( \sigma_{pp} \)

Contribution of scale-\( M \) variations of the parameters
L2_SM_AP Algorithm Overview

Test of Baseline Algorithm Using SMEX02 PALS Data

PALS $T_B$
and $\sigma$

$\downarrow$

L3_SM_A/P
Algorithm

SCA $\tau$-o
Passive Retrieval

Disaggregated $T_B$ (0.8 km)

Estimated Soil Moisture (0.8 km)

Baseline Algorithm
RMSE: 0.033 [cm$^3$ cm$^{-3}$]
RMSE: 0.033 [cm$^3$/cm$^2$]

Minimum Performance Test
RMSE: 0.056 [cm$^3$ cm$^{-3}$]
Sample of L2_SM_AP Data

Disaggregated Tbv at 9 km K

Aggregated S0vv at 9 km

Retrieved Soil Moisture at 9 km

From Global Simulation
SMAP L2_SM_AP Cal/Val Approach

- **Pre-launch objectives are to:**
  - Acquire and process data with which to calibrate, test, and improve models and algorithms used for retrieving SMAP science data products;
  - Develop and test techniques and protocols used to acquire validation data and to validate SMAP science products in the post-launch phase.

- **Post-launch objectives are to:**
  - Verify and improve the performance of the science algorithms;
  - Validate the accuracy of the science data products with respect to the requirements.
# SMAP L2_SM_AP Cal/Val Approach

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SMAP L2_SM_AP Cal/Val Approach

- Primary calibration and validation approach is utilization of dense in situ soil moisture measurement networks (means multiple soil moisture measurement within the 3-km to 36-km SMAP footprint)

- Secondary approach will utilize large-scale sparse networks (one measurement within footprint), and global remote sensing and model-based soil moisture data products

[Map showing global distribution of core validation sites]
SMAP L2_SM_AP Cal/Val Approach

- Simulated L2_SM_AP product using land surface parameters from 2001
  - i.e. not comparable to in situ or other products
- Surface flag to be included

Black: Use recommended ($b0 = 0$)
Magenta: Retrieval attempted and succeeded but use not recommended ($b0 = 1, b1 = 0, b2 = 0$)
Green: Retrieval attempted but failed ($b0 = 1, b1 = 0, b2 = 1$)
Cyan: Retrieval not attempted ($b0 = 1, b1 = 1$)
SMAP L2_SM_AP Cal/Val Approach

QC and scaling of in situ soil moisture data to 9 km grid cell

Core Site in situ Soil moisture data

Comparison and evaluation of L2_SM_AP against scaled in situ data

Computation of Bias, RMSE and aRMSE

Optimization of algorithm and model parameters

Ancillary Data
Plan – Rehearsal 2

• **Core validation sites**
  – Classify sites most suitable for validation at 9 km
  – Use displaced pixel technique to encompass most of the in situ observations for Cal/Val
  – Use of relevant scaling function for comparison against L2_SM_AP

• **Sparse network**
  – Identify feasible sites
  – Use triple collocation

• **Model and Algorithm Parameters Optimization**
  – Optimize tau-omega model parameters \((b, h, \omega)\) using available data (collaborate with L2_SM_P team)
  – Optimize the L2_SM_AP algorithm parameter over different landcovers and temporal window

• **Tools and Other Data**
  – Use of in-house developed tools for Cal/Val
  – Field Campaign data, Satellite Data (Aquarius), Model data
## Postlaunch SMAP L2_SM_AP Cal/Val Approach

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Thanks