SMAP L4_SM Version 5

Rolf Reichle*¹, Qing Liu¹, Joseph Ardizzone¹, Wade Crow², Gabrielle De Lannoy³, Weiyuan Jiang¹, John Kimball⁴, & Randal Koster¹

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¹NASA Global Modeling and Assimilation Office, NASA/GSFC, Greenbelt, MD
²Hydrology and Remote Sensing Laboratory, USDA/ARS, Beltsville, MD
³Division of Soil and Water Management, KULeuven, Leuven, Belgium
⁴College of Forestry & Conservation, University of Montana, Missoula, MT

*Rolf.Reichle@nasa.gov
Outline

1. Overview and Status
2. Model and Analysis Changes
3. Climatology
4. In Situ Validation
5. Assimilation Diagnostics
6. Summary
L4_SM Streams

<table>
<thead>
<tr>
<th>L4_SM Stream</th>
<th>Data Period</th>
<th>Production Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vv5012</td>
<td>31 Mar 2015 – 26 Aug 2020</td>
<td>Complete</td>
<td>Version 5 ops (&quot;preliminary&quot; reprocessing) using L1C_TB inputs from &quot;OASIS&quot; R17 test data (T16[516,518,700])</td>
</tr>
<tr>
<td>Vv5014</td>
<td>27 Aug 2020 – …</td>
<td>On-going</td>
<td>Version 5 ops (initial forward processing stream)</td>
</tr>
<tr>
<td>Vv5030</td>
<td>31 Mar 2015 – …</td>
<td>Planned, starting ~Sep 2020*</td>
<td>Version 5 ops (&quot;official&quot; reprocessing) using R17 ops Tb; once caught up to present (~Nov 2020*), Vv5030 replaces Vv5012 &amp; Vv5014</td>
</tr>
</tbody>
</table>

*TBD, pending decision on updates in scaling parameters or mwRTM parameter calibration.
L4_SM Documentation

- Product Specs  
  *(unchanged)*

- User Guide  
  *(delivered to NSIDC)*

- ATBD  
  *(unchanged)*

- Validation Report
  - Slides  
    *(complete; this presentation)*
  - Written Report  
    *(in progress)*
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Changes in L4_SM Modeling System ("NRv[x]")

<table>
<thead>
<tr>
<th>Experiment</th>
<th>NRv7.2</th>
<th>Vv4030</th>
<th>NRv8.3, Vv5012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L4_SM Version</strong></td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Software Version</strong></td>
<td>LDASsa m3-16_6</td>
<td>GEOSIdas v17.9.0</td>
<td></td>
</tr>
<tr>
<td><strong>Boundary conditions</strong></td>
<td>Icarus NL (&quot;v003&quot;)</td>
<td>Icarus NLv2 (&quot;v003a&quot;)</td>
<td>Icarus NLv4</td>
</tr>
<tr>
<td><strong>Greenness, NIRDF, &amp; VISDF fix</strong></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>“Mali” bug fix</strong></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>z0 formulation</strong></td>
<td>3</td>
<td>4</td>
<td>(increased z0\textsubscript{min}, stem area index)</td>
</tr>
<tr>
<td><strong>Zenith angle revision</strong></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>Climatology (for percentile output)</strong></td>
<td>2001-2017</td>
<td>2001-2019</td>
<td></td>
</tr>
</tbody>
</table>

Revised aerodynamic roughness length (z0) formulation represents minor science change.
Rejected change in vegetation height (explored to achieve consistency with recent GEOS FP upgrade).
Greenness and “Mali” bug fixes, zenith angle revision, and s/w version have minimal impact on science.
(Small everywhere and/or limited to a small fraction of grid cells.)
Changes in L4_SM Tb Analysis

Re-calibrated Tb analysis in Version 5.

- **Assimilate R17 L1C_TB Tbs.**
  (Different from R16 Tbs by a couple of K owing to revised L1 calibration.)
- **Reinstated check for excessive std-dev in fore-minus-aft Tbs.** (After problems in L1 processing resurfaced.)
- **RTM parameters** calibrated using NRv7.2 modeling system based on 7 yrs of multi-angular SMOS v620 data.
  (New calibration using NRv8.3 has been completed; testing in progress for future version upgrade.)
- **Tb scaling parameters** based on SMAP only:

<table>
<thead>
<tr>
<th>L4_SM Stream</th>
<th>SMOSv620 Period</th>
<th>SMAP Period and Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vv5012, Vv5014</td>
<td>n/a</td>
<td>Apr 2015 – Mar 2020 (5 yrs; T16[516,518] OASIS) (1-yr, discontinuous streams)</td>
</tr>
<tr>
<td>Vv5030</td>
<td>n/a</td>
<td>Apr 2015 – Mar 2020 (5 yrs; R17 ops) [TBD*] (continuous integration)</td>
</tr>
</tbody>
</table>

*Requires completion of R17 L1C_TB reprocessing and Version 5 Open-Loop before Vv5030 production can start.

- **PAR perturbations bug fix** (removes inconsistency in latent & sensible heat flux between NR and L4_SM).
  (PAR = Photosynthetically Active Radiation)
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Revised $z_0$ formulation for consistency with Jan 2020 GEOS FP upgrade. Roughness increased by factor of 10 in deserts (increased minimum $z_0$). New dependency on stem area index and revised equation result in minor changes elsewhere.
Only minimal climatology changes in surface and root-zone soil moisture, snow, and latent heat flux.
NRv8.3 minus NRv7.2 (Energy Variables)

Soil temperature climatology changes by ~1-2 K in deserts, with corresponding changes in sensible heat flux.
Bug resulted in larger differences between Open-Loop (OL) ensemble simulation (with perturbations) and single-member, unperturbed simulation.

Version 5 OL minus NRv8.3

Version 5 has improved consistency between single-member, unperturbed model and ensemble simulations.
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Core Validation Sites (9 km)

Version 5 meets requirement:
ubRMSE $\leq 0.04$ m$^3$/m$^3$

ubRMSE and root-zone R slightly worse in Version 5.
(Within 95% conf. interval.)

Bias better in Version 5.

On balance, the performance of Version 5 is the same as that of Version 4.
At 33-km core sites:

Same relative performance of Versions 4 and 5.

Metrics generally better.

(W.r.t. metrics at 9-km sites.)
No meaningful change in performance between Versions 4 and 5.

(Same for NRv7.2 and NRv8.3; not shown.)
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Number of Assimilated SMAP L1C_TB Observations

On average, Vv5012 assimilates slightly fewer L1C Tb obs. Performance may change slightly for Version 5 ops and (possibly) with revised mwRTM calibration.

Light blue shading: Incomplete OASIS Tb processing. Will be fixed w/ R17 ops (Vv5030).

Dark red “filling”: Calibration of mwRTM parameters in Vv5012 based on simulation with newer land mask.

Dark blue “holes”: Minor processing issue during mwRTM parameter calibration (some ancillary data on old land mask).

Light yellow shading: Better coverage of Tb scaling parameters.
Mean of observation-minus-forecast (O-F) Tb residuals.

Version 5 has better calibration of the Tb analysis, likely because only SMAP data are used to derive Tb scaling parameters.
O-F Tb Residuals (Std-Dev)

Typical magnitude of O-F Tb residuals.

Version 5 has slightly better model forecasts of SMAP Tb observations that are about to be assimilated.
Version 5 has slightly better consistency between actual and assumed errors.

Std-dev of normalized O-F Tb residuals.
Analysis Increments (Number)

Changes in number of increments reflect changes in number of assimilated Tb observations.
Analysis Increments (Mean)

Version 5 has slightly smaller mean absolute increments than Version 4, likely because only SMAP data are used to derive Tb scaling parameters.
Minimal differences in typical magnitude of soil moisture increments.

Typical surface soil temperature increments in deserts are smaller by ~0.3 K in Version 5 than in Version 4.
Uncertainty Estimates

Minimal differences in uncertainty estimates (analysis ensemble spread) for soil moisture. Surface soil temperature uncertainty estimates in deserts are smaller by ~0.3 K in Version 5 than in Version 4.
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Summary

Vv5012 meets minimum requirements for new Version:

- Soil moisture ubRMSE $\leq 0.04$ m$^3$ m$^{-3}$ (vs. in situ measurements from 9-km core site reference pixels).
- Vv5012 is at least as good as Vv4030 (on balance across in situ metrics & assimilation diagnostics).

Compared to Vv4030, Vv5012 has:

- Revised aerodynamic roughness length calculations;
- Catchment model bug fixes;
- Better calibration of the Tb analysis based only on SMAP observations;
- Improved software framework to support future science development;
- Slightly worse ubRMSE and but better bias metrics;
- Slightly smaller O-F Tb residuals and soil temperature increments;
- Slightly better consistency between actual and assumed errors.

Official reprocessing (Vv5030):
- Considering using NRv8.3-based mwRTM calibration (improved spatial coverage).