National Aeronautics and Space Administration

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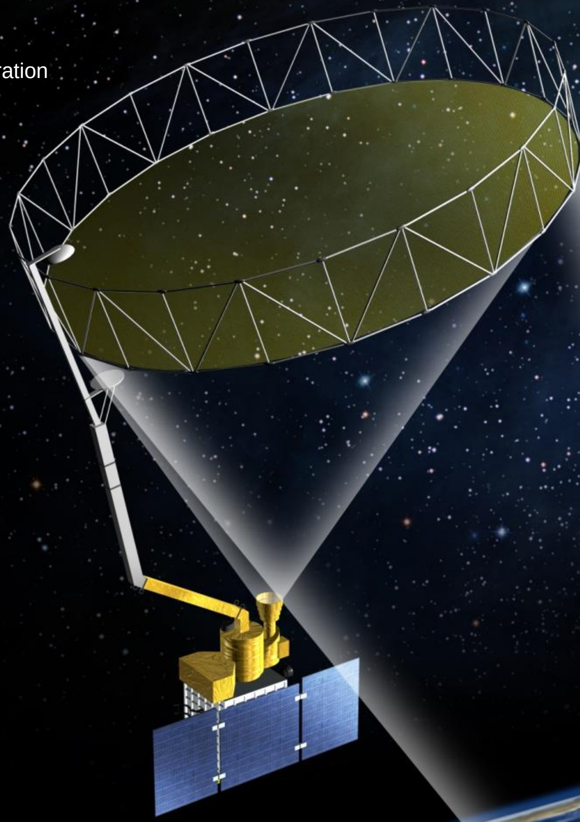
Soil Moisture Active Passive Mission
SMAP



Algorithm Refinement Testing Cal/Val Rehearsal 2

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Objectives for Rehearsal 2

- Exercise the capabilities of the Research & Analysis (R&A) and OASIS environments for doing algorithm parameter and software updates during Cal/Val.
  - *R&A: Validation, parameter/software updates, small-scale reprocessing to test*
  - *OASIS: Large-scale reprocessing to make updates available to DAART*

- Use existing contemporary data sources for realistic validation tests
  - *SMOS Tb at 40 deg incidence angle, reformatted to SMAP L1C_TB*
  - *Aquarius Tb & radar sigma0*
  - *PALSAR2 (if available)*
  - *Glosim radiometer & radar simulations based on contemporary LSM data; can produce controlled anomalous data for discovery & analysis by DAART*

- Main algorithm refinement tasks
  - *Algorithm performance analysis*
  - *Algorithm parameter & threshold optimization*
  - *Bias determination/correction*
  - *Forward model optimization*

L2_SM_A Cal/Val Rehearsal 2 Experiments

Experiment/objective	Analysis	Data required	Environments
Demonstrate consistency with passive and active/passive products	Variation of input parameters & datacube biases to optimize consistency	GloSim radar data; At least one 8-day cycle (117 orbits); At least 10 runs of L2 and L3 SM_A.	OASIS (processing) R&A (analysis)
Identify areas where heterogeneity effects are severe	Analysis of error performance vs landcover heterogeneity.	GloSim radar data; 4 runs of GBTS (35 days), L2/L3_SM_A (8 days)	OASIS (processing) R&A (analysis)
Analysis of L2_SM_A algorithm performance and accuracy	Analyze spatial and temporal patterns of L2_SM_A errors; identify causes; modify algorithm/input data	GloSim radar data; 5 runs of L2/L3_SM_A (at least 8 days)	OASIS (processing) R&A (analysis)
Forward model (datacube) refinement	Construct/refine data cubes using available data	R2: PALSAR HH and UAVSAR data; SMAP data post-launch.	R&A (analysis)

L2_SM_P Cal/Val Rehearsal 2 Experiments

Experiment/objective	Analysis	Data required	Environments
Survey brightness temperature anomalies (residual RFI, non-RFI warm bias) in L1C_TB	RFI: Global maps of (TBH-TBV), feedback to L1 about RFI mitigation performance Warm bias: Collocate SMAP/SMOS/AQ Tb over homo-geneous ocean/ice/forest.	SMOS40 and Aquarius H,V Tb on 36km SMAP grid (L1C_TB format)	R&A (some processing, analysis)
Algorithm performance & validation, baseline and option algorithms	Evaluation of retrieval errors at core sites, triple-collocation for sparse network sites; errors vs. landcover and other ancillary inputs	GloSim and/or SMOS40 Tb data processed to L2_SM_P	OASIS (processing) R&A (analysis)
Forward model parameter refinement	Optimize tau-omega model parameters (b,h,ω) using available data time series	GloSim and/or SMOS40 Tb data processed to L2_SM_P	R&A (analysis)

L2_SM_AP Cal/Val Rehearsal 2 Experiments

Experiment/objective	Analysis	Data required	Environments
Algorithm performance & validation	Evaluation of retrieval errors at core sites, triple-collocation for sparse network sites; errors vs. landcover and other ancillary inputs	L2_SM_AP outputs derived from GloSim L2_SM_A radar data, GloSim or SMOS40 Tb data processed to L2_SM_P	OASIS (processing) R&A (analysis)
Active-passive disaggregation algorithm parameter refinement (beta, gamma)	Regression of aggregated sigma0 and Tb to re-determine parameters; optimize temporal windows	GloSim L2_SM_A radar data; GloSim or SMOS40 Tb data processed to L2_SM_P	OASIS (processing) R&A (analysis)
Forward model parameter refinement	Optimize tau-omega model parameters (b,h,ω) using available data (coordinate with L2_SM_P)	GloSim or SMOS40 Tb data processed to L2_SM_P	OASIS (processing) R&A (analysis)

L3_FT_A Cal/Val Rehearsal 2 Experiments

Experiment/objective	Analysis	Data required	Environment
Assess performance of L3_FT and L3_SM (FT flag) retrievals at core sites	Collocation with core sites; analysis of landcover, Tsoil, and Tair sensitivities	GloSim radar data processed to L3_FT_A and L3_SM_A with “pre-launch” (old Glosim) and updated FT parameters	OASIS (processing) R&A (analysis)
Re-parameterize FT algorithm reference states & thresholds using “contemporary” data	Starting from January data, build up new reference states and threshold maps, compare with “pre-launch” parameters.	GloSim radar data; Aquarius radar data @36km?	OASIS (processing) R&A (analysis)
Assessment of classification accuracy over boreal and global domains for 6-month period (Jan-June) including rehearsal	Look at classification skill during thaw transition period as well as average over full time period; does accuracy improve with updated parameters?	GloSim radar data processed to L3_FT_A and L3_SM_A with “pre-launch” (old Glosim) and updated FT parameters	OASIS (processing) R&A (analysis)

Data Simulation Approach for Rehearsal 2

- “NRT” GloSim based on contemporary model products (GMAO, ECMWF?)
  - *GloSim produces simulated L1B_TB and L1C_S0 radiometer and radar data using SMAP orbit, instrument noise models, land surface models, and static ancillary inputs to the respective Tb and sigma0 forward models.*
  - *Run orbit-by-orbit as the dynamic model data becomes available on SMAP TB*
  - *Change of input SM, Tsoil fields requires minor modifications to existing radiometer and radar simulations used for algorithm development since 2009.*
  - *Simulation allows us to control the instrument noise characteristics & biases injected into the sensor data.*
  - *Level 1 data are converted on the back-end to HDF5, ready for input to L2/L3 processing.*
- Alternative approach is to provide “true” forward sensor measurements from GloSim to Level 1 radiometer and radar teams
  - *Revert (as far as possible) sensor measurements to raw “counts”, including noise and anomalies – try to get close to end-to-end test.*
  - *Run the reverted data back through the L1B_TB and L1C_S0 processors to produce HDF files directly.*
  - *Introduction of known anomalies, biases, and “RFI” by L1 teams in blind test datasets, to be “discovered” by DAART during rehearsal.*

Data Simulation Approach for Rehearsal 2

Test Datasets

- Noise-free (closed-loop) test
  - *Set instrument noise to zero for radiometer and radar*
  - *Input geophysical "truth" should be reproduced by retrieval processing --* ***(if not, why not?)***
  - *Small (~8-day cycle or less) set of data from standard GloSim codes*
- Data with nominal instrument noise models (no anomalies/biases)
  - *6-12 month standard GloSim data set*
  - *"NRT" GloSim data set generated during rehearsal*
- Data with calibration biases & anomalies (made from GloSim+L1)
  - *Use to determine quantity of SMAP data that will be required to assess/correct biases*
  - *Use to test ability to detect anomalies (excess RFI, pointing errors, etc.) in downstream processing*

Backup slides

Simulation Upgrades

- Radiometer simulation
  - *Make use of current operational inputs (SM, Tsurf, precip, snow, Tair, ocean wind)*
  - *Introduce ocean wind forward model for simulation of open-water Tb with wind?*
  - *Coordinate with L1 team to work out generation of simulation with L1 sensor processing*
    - Can GloSim Tb be reverted to L1A or L0 radiometer data?
  - *L1 team: Create anomalous data from GloSim truth inputs?*
    - Geolocation errors (attitude anomalies/biases, etc.)
    - Noise diode calibration
    - RFI?
- Radar simulation
  - *Make use of current operational inputs (SM, Tsurf, precip, snow, Tair, ocean wind)*
  - *Introduce ocean wind forward model for simulation of open-water backscatter*
  - *Add fore/aft azimuths (function of cross-track location) to simulation data output*
  - *Coordinate with L1 team to work out generation of simulation with L1 sensor processing*
  - *L1 team: Create anomalous data from GloSim truth inputs?*
    - Complete reversion of backscatter to ‘counts’ not feasible for SAR
    - Reversion to L0/L1A may be possible for low-res L1B_S0 radar data
    - Pointing errors, calibration biases, RFI?

GloSim2 Radiometer Simulation Flow

MATLAB LINE INPUT

Specify orbit ID range (1-5,400)

Run Sim Cycle

Run orbit/instrument sampling

- **Read SMAP time in UTC @ 12-ms interval**
- **Read 3-dB FOV arrays of lat/lon's, antenna gain, and incidence**

Read global 1-km semi-static data

- **Read annual max NDVI**
- **Read NDVI at two adjacent 10-day periods**
- **Interpolate NDVI for a given DOY; interpolate again within a single half orbit if necessary**

Read global 1-km static data

- **Sand Fraction**
- **Clay Fraction**
- **Bulk Density**
- **IGBP Dominant Land Cover**
- **Surface RMS Roughness**

Read global 9-km dynamic data

- **Read GMAO hourly 10-cm soil moisture; read two files within a single half orbit if necessary**
- **Read GMAO hourly 10-cm surface temperature; read two files within a single half orbit if necessary**

Static Data

Dynamic Data

STEP 1: Sample at FOV lat/lon's

- **246,575-by-338 elements per half orbit**

STEP 2: Water pixels within FOV

- **Compute dielectric constant using Klein-Swift model**
- **Compute water TB using Fresnel equations, along with FOV incidence**

STEP 3: Land pixels within FOV

- **Compute dielectric constant using Mironov model (thawed state)**
- **Compute dielectric constant using modified Dobson model (frozen state)**
- **Construct VWC array using (a) interpolated NDVI, (b) annual max NDVI, and (c) IGBP-based stem factor**
- **Construct 'b' and 'omega' arrays from IGBP-based lookup table**
- **Construct 'h' array from 's' array using the h = 0.1 * s relationship**
- **Compute land TB using Fresnel equations, along with FOV incidence and tau-omega model**

STEP 4: Antenna synthesis

Radiometer Level 1B File

Noise-free time-ordered radiometer H- and V-polarized TB observations output at every 12 ms

TB Calculations

Integrate water TB and/or land TB according to FOV antenna gain.
Result: one TB per boresight location

GloSim2 Radar Simulation Flow

CMD LINE INPUT
Start Cycle
Number of Cycles

Run Sim Cycle

FOR EACH ORBIT:
- Generate Truth File
- Generate L1C File
- Generate Header files

Make SMAP Truth

Make L1C Radar

Static Data

Initialize Radar Forward Model
- Read Datacube cubeset configuration file
- Allocate memory for N cubes
- Read datacubes
- Set up landcover->datacube mapping

Read Global Static Ancillary Data
(1 km resolution)
- Soil Texture Maps
  - Sand Fraction
  - Clay Fraction
  - Bulk Density
- Water Body Fraction
- MODIS Dominant Landcover
- Crop type Map
- Surface Roughness

Dynamic Data

Read NDVI Climatology (10-day, 1km resolution)
- Initialize NDVI data structure
- Get first NDVI map pair based on starting date of simulation
- Read maxNDVI map needed for VWC algorithm

Read GMAO Nature Run LSM Data (hourly, 9km resolution)
- Initialize LSM data structure at simulation start date/hour
- Soil Moisture (sfmc)
- Surface Temperature (Tsurf)

* Update NDVI & LSM data structures as needed

ORBIT SWATH SETUP
- Shift swath template for orbit
- Get data start/end times
- Compute 1-km and 9-km EASEgrid coordinates for swath cells

FOR EACH SWATH CELL:
- Collocate with ancillary data
- Collocate & interpolate NDVI*
- Collocate LSM data*
- Determine landcover type
- Compute VWC
- Run Radar Forward Model
- Compute Kp

SMAP Truth File
1-km cells of collocated ancillary data and true σ_0 measurements

Make Swath Arrays From Truth Data
- Cell Lat/Lon
- 1-km EASEgrid col/row
- Flags
- True Sigma0/Kp

BLUR RADAR
- Variable-length window as function of cross-track location
- Average true sigma0 along row

AT EACH CELL:
Generate fore & aft realizations of noisy sigma0 for HH,VV,HV channels

Radar Level 1C File
High resolution σ_0 on a 1 km SWATH Grid