SMAP Algorithms and Cal/Val Workshop

Oxnard, CA, USA

June 9-11, 2009

Overview of DRAFT SMAP Cal/Val Plan

Cal/Val Definitions

- CEOS Working Group on Calibration and Validation (WGCV):
  - *Calibration* is the process of quantitatively defining the system response to known, controlled signal inputs
  - *Validation* is the process of assessing by independent means the quality of the data products derived from the system outputs
    - Recently formed Land Products Validation Group on Soil Moisture (Jackson/Wagner) http://lpvs.gsfc.nasa.gov/
- Definitions from SMOS:
  - *Instrument Calibration*: Verification of the L1 processor
  - *Geophysical Validation*: L2 products
    - "Validation will demonstrate with statistical significance that the derived products satisfy mission requirements"
    - "Data sets used must be of known quality, extend over significant geographical areas, span various geophysical conditions, and have sufficient temporal coverage"

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CEOS WORKING GROUP ON CALIBRATION & VALIDATION

Land Product Validation Subgroup

Home | Landcover | Biophysical | Surface Rad | LST/Emissivity | Fire/Burn | Soil Moisture

Current LPV Chair: Frédéric Baret (INRA)
Vice-Chair: Sebastien Garrigues (CNES)

Announcing...

- The International Conference on Land Surface Radiation and Energy Budgets, Beijing, March 19-20, 2009.
- Mark your calendars!!! 4th Global Vegetation Workshop, Missoula, MT, June 16-18, 2009
- The Globcover product and validation report are now available via the POSTEL web site.
- The proposed satellite Burned Area Validation Protocol is now available for review.
- CEOS CalVal Portal. See Newsletter link under Information section.
- View a summary of current GEO/GEOSS tasks and the LPV contributions here.
- Reports and presentations from the GEO/CEOS Workshop on Calibration and Validation Processes - Geneva, 2007
- TGRS Special Issue on Land Product Validation
- CEOS Publication - Global Land Cover Validation: Recommendations for Evaluation and Accuracy Assessment of Global Land Cover Maps

Subscribe!

LPV subgroup topical mailing lists:

Subscribe: Unsubscribe:

How to use these mailing lists

Data access

- CEOS Validation Core Sites
- WGISS Test Facility (WTF)

Link to current

CEOS Calendar

Organization:

LPV is a subgroup of the Working Group on Calibration and Validation

WGCV is a standing Working Group of the Committee on Earth Observation Satellites

LPV Mission

To foster quantitative validation of higher-level global land products derived from remote sensing data and to relay results so they are relevant to users

Validation is the process of assessing, by independent means, the quality of the data products derived from the system outputs

Background

The subgroup on Land Product Validation (LPV) is one of six subgroups of the Working Group on Calibration and Validation (WGCV), which itself is one of two standing working groups within the Committee on Earth Observation Satellites (CEOS, see also CEOS structure). The six WGCV subgroups are:

- Infrared and Visible Optical Sensors (IVOS)
- Atmospheric Chemistry (AC)
- Microwave Sensors (MS)
- Synthetic Aperature Radar (SAR)
- Terrain Mapping (TM)
- Land Product Validation (LPV)

The Land Product Validation subgroup arose out of the recognition in the late nineties that standardised approaches to global product validation were essential for wide acceptance and use of proposed global land products. Several programs at the time were aimed at global monitoring of Earth processes, many with plans to distribute higher level data products. A common approach to validation would encourage widespread use of validation data, and thus help us to move toward standardised approaches to global product validation. With the high cost of in-situ data collection, the potential benefits from international cooperation are considerable and obvious.
Previous requests for assistance from the original International Global Observing Strategy (IGOS) pilot projects and two subsequent ad hoc meetings of the WGCV identified a clear need for improved international collaboration concerning the validation of land products derived from Earth observing satellites. A new subgroup within the WGCV was proposed to the CEOS Plenary in Stockholm at the end of 1999, receiving full support. The LPV was officially adopted as a subgroup at the WGCV-17 meeting in October of 2000.
A general consensus now exists within the CEOS community to identify the three stages of validation for satellite products. The guidelines for the CEOS Hierarchy of Validation are:

Stage 1 Validation	Product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods and ground-truth/validation program effort.
Stage 2 Validation	Product accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.
Stage 3 Validation	Product accuracy has been assessed, and the uncertainties in the product well-established via independent measurements made in a systematic and statistically robust way that represents global conditions.

The LPV subgroup activities are divided up into four themes that compliment the research agendas of the Global Observations of Forest and Land Cover Dynamics (GOFC/GOLD) program, namely biophysical products, fire/burn scar detection, and land cover mapping. In addition to the GOFC/GOLD themes, the LPV subgroup includes an Albedo/Surface Radiation thematic group. Working with GOFC/GOLD, who seek the common goal of coordinated validation of land cover and fire products by standardized protocols, LPV aims for similar coordination for all land products.

More on LPV: background, previous reports, and it relationship with WGCV and CEOS.....

- LPV Leads Meeting June 15th prior to the Long term global monitoring of vegetation variables using moderate resolution satellites: June 16-19, 2009 in Missoula, MT

Cal/Val Definitions

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Calibration Definitions

- *Calibration* is the process of quantitatively defining the system response to known, controlled signal inputs
- *Instrument Calibration*: Verification of the L1 processor
- *Vicarious calibration:* In orbit calibration of a satellite sensor by a method independent of that used to perform the initial laboratory calibration.
  - Targets with known properties
    - Internal
    - External
      - Highly reliable (Deep space, open ocean)
      - Requiring additional information (Deserts, Dome-C, Amazon forest)
  - Data from the satellite sensor are compared with measurements by a sensor on an aircraft (or other) platform and or another well-calibrated satellite system

SMAP Cal/Val

- The objective of SMAP Cal/Val is to calibrate and validate Level 1 through Level 4 algorithms and products relative to the mission requirements.
- The purpose of the Cal/Val plan is to describe the process that will be used for calibrating and validating Level 1 through Level 4 science data products of the SMAP Mission. The SMAP Cal/Val Plan is the basis for implementation of the detailed set of calibration and validation activities that take place during the SMAP mission lifetime The SMAP Cal/Val plan has the following role in completion of the SMAP Cal/Val program.
- *Clarification of terms*: There are Level 1 and 2 mission requirements and Level 0, 1, 3, and 4 mission products.

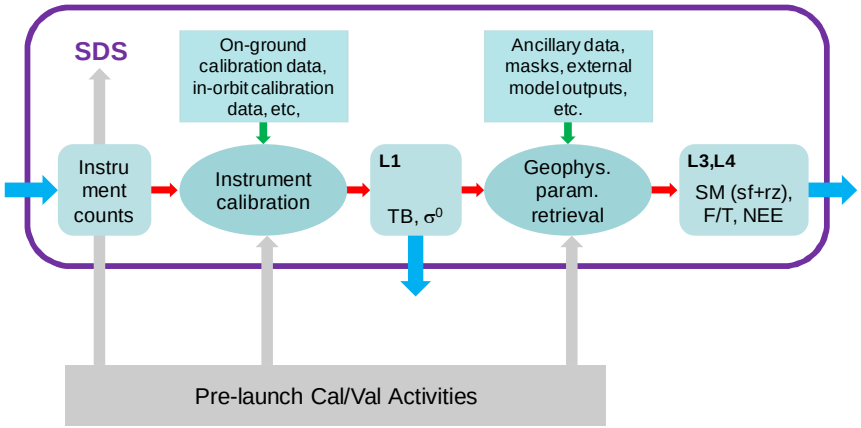
SMAP Product Requirements

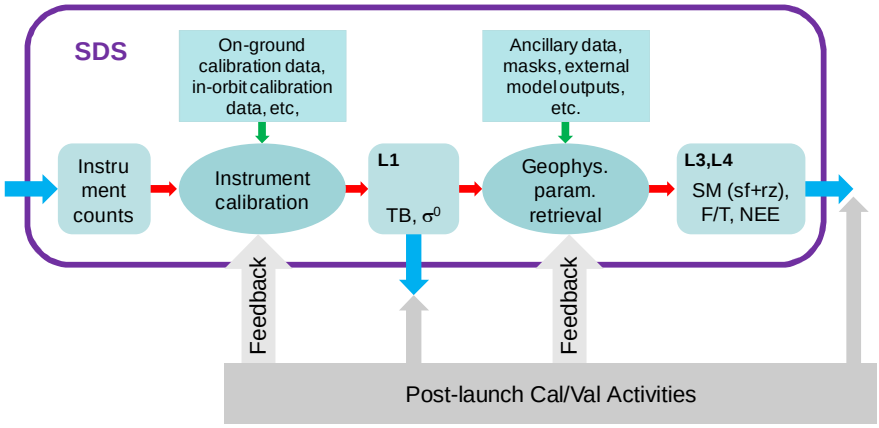
- The objectives of the mission are quantified at the product level in the Level 2 mission requirements
- Level 2 mission requirements for the baseline mission are:

Product		Accuracy	Reso [km]	Refresh [d]	Latency	Notes
L1B	TB	1.3 [K]	40		12 [h]	Fore/aft combined, Time ordered
	σ_0	1 [dB]	30		12 [h]	Real aperture
L1C	TB	1.3 [K]	40		12 [h]	Fore/aft combined, Earth grid
	σ_0	1 [dB]	1-3		12 [h]	Synthetic aperture processing
L3	SM	0.04 [m^3/m^3]	10	3	24 [h]	Surface soil moisture (0-5 cm), Mask applies
		0.04 [m^3/m^3]	40	3	24 [h]	Surface soil moisture (0-5 cm), Mask applies
	F/T	80 [%]	3	2	24 [h]	Freeze/thaw, Mask applies (> 45°N)
L4	SM	0.04 [m^3/m^3]	10		7 [d]	Root-zone soil moisture (0-100 cm)
	NEE	30 [$gC/m^2/yr$]	10		14 [d]	Net ecosystem exchange (> 45°N)

- *In addition, there is the internal L3 SM Radar product*

SMAP Cal/Val Pre-launch and Post-launch



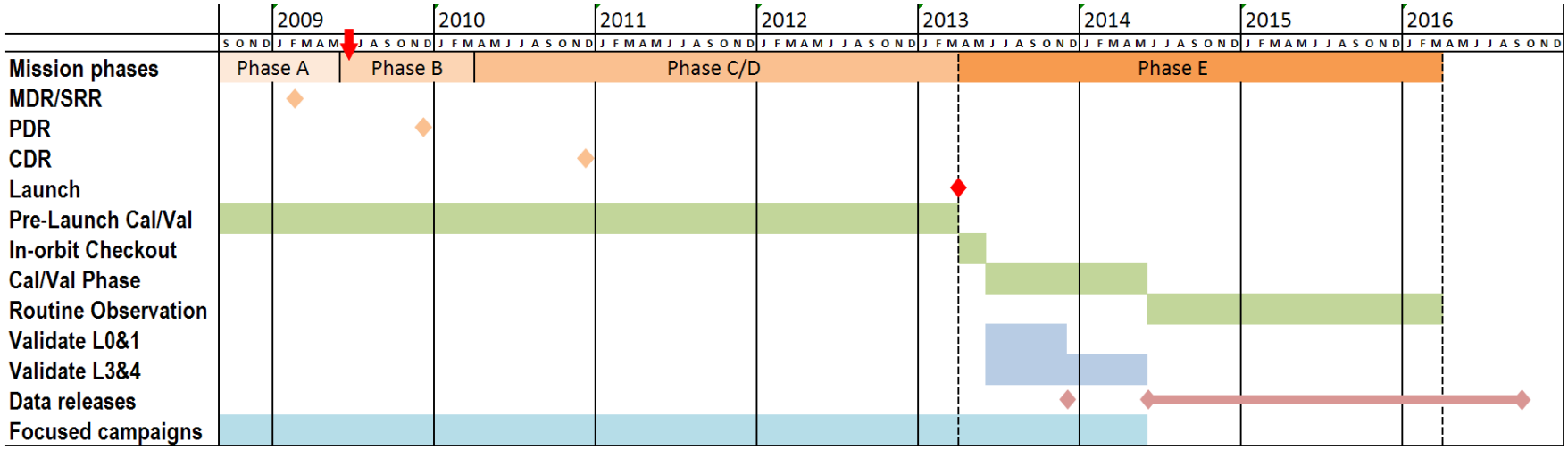


- Pre-launch Cal/Val is focused on validating that there are means in place to fulfill the mission objectives. In particular
  - ATBD identified activities that will improve algorithms and products
  - Establish infrastructure necessary for post-launch calibration and validation
- Post-launch Cal/Val is focused on validating that the science products meet their quantified requirements, and on improving the algorithms and quality of products over the mission life.

(schematic diagram of data processing flow; SDS = Science Data System)

SMAP Cal/Val Timeline

- Important milestones for Cal/Val planning (and algorithm development) before launch are the Preliminary Design Review (PDR) and Critical Design Review (CDR)
  - Updated draft Cal/Val Plan after the Workshop
  - Preliminary Cal/Val Plan in place by PDR, Final by CDR
- The Post-launch Mission is divided into In Orbit Check, Cal/Val, and Routine Observation phases
- Brightness temperature and backscatter products are to be validated and released in **6 months**. Soil moisture (surface and root-zone), freeze-thaw state and net ecosystem exchange within **12 months**.
- Final consistency checked processing of the data will be performed 6 months after the end of primary science mission



SMAP Cal/Val Plan Document

The SMAP Cal/Val Plan document is structured in the following main sections:

1. Introduction
2. Science and Mission Overview
3. Calibration and Validation Overview
4. Cal/Val Requirements of SMAP Products
   a) What are the specific/primary items required for the cal/val of each product?
   b) Prioritization of issues
5. Pre-Launch Activities
   a) Activities carried out for the cal/val of sensor products and geophysical parameters
   b) Timeline for these activities
6. Post-Launch Activities
   a) Activities carried out for the cal/val of each product
   b) Identify quantified references for each product
   c) Coordinated field campaigns
   d) Timeline for these activities
7. International Contributions
8. Activities related to other relevant missions

SMAP Pre-Launch Cal/Val

- Instruments
  - Characterization of the instruments and their components to show compatibility with requirements and to support post-launch calibration
  - Performance analysis and simulations based on in orbit environment scenarios
- Geophysical Algorithms
  - Modeling and analysis using the SMAP Testbed
  - Field campaigns to support the development of algorithms and to resolve critical algorithm issues
  - Algorithm tests with equivalent data from other satellite resources
  - Assimilation trials with synthetic and other satellite data products
  - Establishment and verification of post-launch resources: installation, calibration, and scaling of ground based networks, integration of operational validation data resources, and evaluation of complementary satellite products
- Validation of Science Data System (SDS) operation and data production

Post-launch Level 1 Products Cal/Val (1/2)

Radiometer

- Cold sky maneuvers
  - Sky in regions with low galactic background.
  - Possible to execute one to several times a year
  - Track inter-seasonal changes in the calibration
- Ocean modeled TB's
  - No impact on observatory operations.
  - Buoy matchups with, e.g., TOGA-TAO and ARGO arrays
  - Regional averages based on environmental reanalysis models
  - Approximately monthly tracking of gain calibration
- Dome-C observations
  - Studies predict 0.1-K stability in TB's
  - Currently being verified by ESA ground-based radiometer measurements
  - Potential vicarious calibration of on-board reference load
- RFI mitigation
  - Compare RFI detection flags with known RFI sites (e.g., FAA radars)
  - Compare with aircraft underpasses

Post-launch Level 1 Products Cal/Val (2/2)

Radar

- Post-Launch external calibration goals
  - Remove channel-to-channel and pixel-to-pixel biases to high accuracy
  - Remove absolute bias to best capability
- Post-Launch external calibration approach (man-made targets are insufficient[1])
  - Characterize receiver with space view maneuver and pre-launch calibration parameters (similar to radiometer calibration)
  - Statistical analysis of large, uniform, isotropic, well-characterized, stable scenes (such as Amazon)
  - Cross-calibration with other contemporaneously flying radars: ALOS PALSAR, Aquarius, UAVSAR, etc.[2]
  - Natural target calibration demonstrated to be very accurate[3]
  - Utilize polarimetric backscatter reciprocity
  - SAR image formation: check for scan oriented brightness variation (scalloping) indicating antenna, attitude, and/or ephemeris offsets => tweak processing parameters and derive attitude from radar data as needed
  - Occasional receive only data collections to survey RFI conditions

1) Pixel size too large for corner reflectors (however, they are cheap and may be helpful in geo-location validation) and transponder accuracy insufficient

2) Over distributed targets and over targets where comparison sensors can be calibrated with corner reflectors

3) JPL Ku-Band scatterometers removed channel-to-channel and pixel-to-pixel biases to 0.2 dB JERS-1 demonstrated that Amazon is stable to < 0.2 dB at L-Band

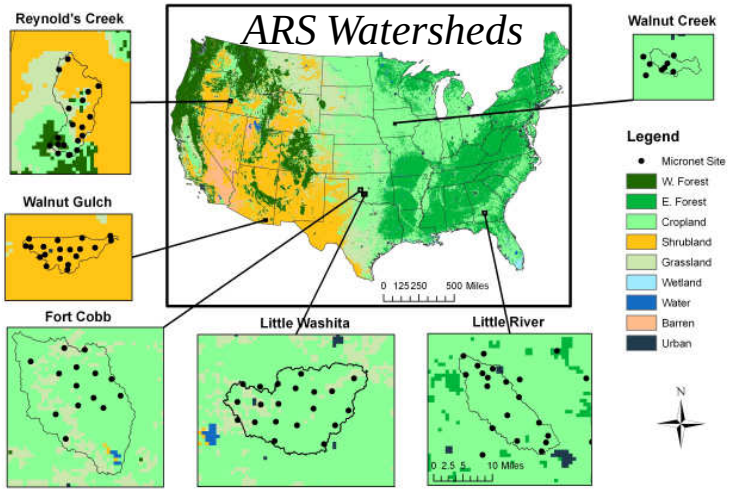
Post-launch Level 3 Products Cal/Val (1/4)

- Approach
  - Provide verified estimates over an area and depth equivalent to the derived products throughout the project life
  - Provide a robust set of cover conditions and geographic/climate domains for validation
  - Provide continuous, consistent, and long term records with minimal latency. Available without restrictions.
- Elements
  - Ground based observations that represent the footprint/grid cell either by replication or scaling, which has been verified
  - Field experiments
  - Satellite product comparisons
  - Model product comparisons

Post-launch Level 3 Products Cal/Val (2/4)

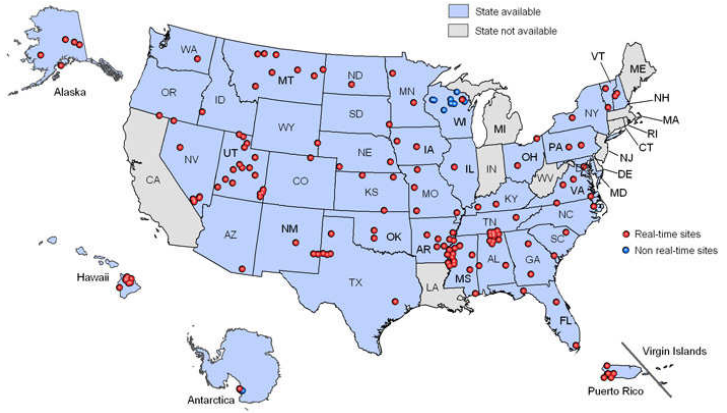
Ground-based Soil Moisture

- Soil moisture validation will reply on ground-based soil moisture observations made by dedicated networks, climate networks, and field campaigns.
- Pre-launch activities will have verified all sites and established scaling functions



Examples of possible dedicated validation sites for soil moisture that utilize replication

SCAN



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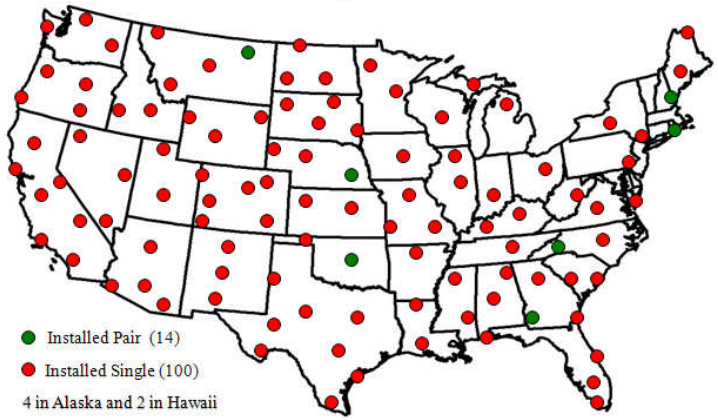


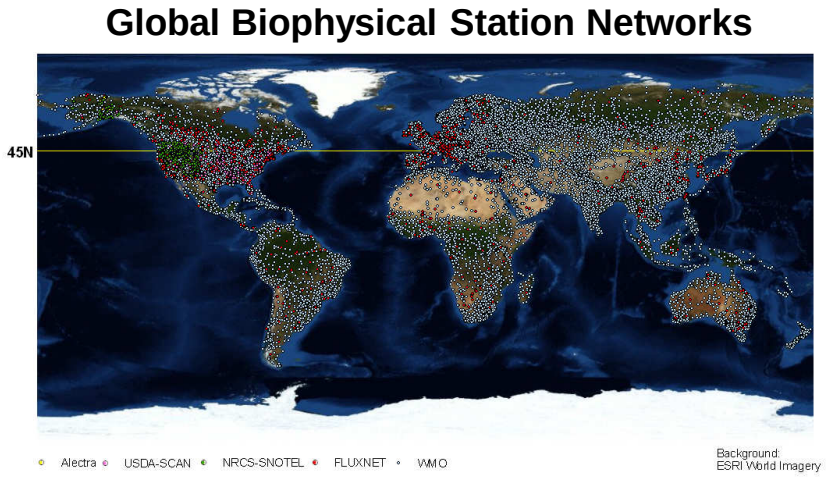
Examples of possible networks for soil moisture that require scaling

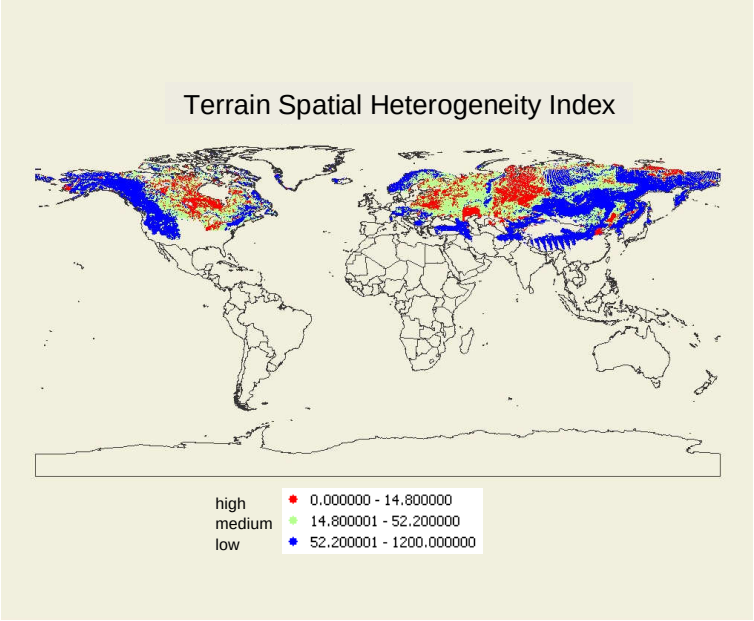
Post-launch Level 3 Products Cal/Val (3/4)

Ground-based Freeze-thaw

Freeze-thaw validation activities will rely heavily on existing global biophysical station networks including WMO weather stations, FLUXNET, Snotel, SCAN & ALECTRA site networks.

Pre-launch activities will include terrain and land cover based scaling studies to establish regional representation and scaling relationships of in situ validation sites.





Post-launch Level 3 Products Cal/Val (4/4)

Satellite-based Soil Moisture

- SMOS
- GCOM-W
- EUMETSAT

Model-based Soil Moisture

Two potential approaches:

- Evaluate improvement in model output realized upon assimilation of SMAP products into a land model (Crow et al., 2009).
- Use model-based soil moisture as one of three independent estimates of soil moisture and apply “triple co-location” techniques (Scipal et al., 2008).

Requirements:

- Must be robust to inevitable error in model-based soil moisture.
- Methods must be verified using more direct validation techniques.

Post-launch Level 4 Products Cal/Val

- Approach
  - Provide products of other models for comparison
  - Provide internal diagnostic indicators of the assimilation process
  - Provide verified estimates over an area and depth equivalent to the derived products throughout the project life
- Elements:
  - Model products (like GMAO L4 SM)
  - Long term network data on e.g. CO2 flux, root-zone soil moisture

Approach to Field Campaign Design

- Pre-Launch
  - ATBD teams identify needs that can be addressed by field campaigns utilizing tower and/or aircraft SMAP simulators
  - Cal/Val WG identifies field campaigns that would contribute to establishing post-launch infrastructure
  - SMAP SDT prioritizes activities
  - Campaigns are planned and executed to satisfy these needs to the extent possible with resources available
- Post-Launch
  - ATBD teams identify specific test activities that can be addressed by field campaigns utilizing tower and/or aircraft SMAP simulators
  - Cal/Val WG identifies field campaigns that would contribute to establishing mission performance
  - Campaigns are planned and executed to satisfy these needs to the extent possible with resources available

Objectives of the Cal/Val Portion of Workshop

- Review C/V plan status
- Synopsize linkages between the ATBDs and C/V plan
- Identify critical development needs in algorithms
- Prioritize pre-launch activities
- Establish post-launch validation infrastructure
- Review existing networks
- Review methods for scaling points to grids
- Design and plan the implementation of validation sites
- Strategies for exploiting other satellite missions for SMAP
- Consensus for near term field experiments with airborne and/or tower instruments (2010/2011)
- Strategy for longer term (Pre- and post-launch)

Some Specific Questions

- How to incorporate existing in situ networks into SMAP Validation?
  - Technique
  - Depth
  - Latency
  - Testbed
  - How do we use sparse networks in validation?
- What should our core validation sites look like and where should they be?
- What are the options for engaging international cooperators in validation?
- What should the near-term SMAPVEX include?

CEOS Hierarchy of Validation (Post-Launch)

- Stage 1: Product accuracy has been estimated using a *small number* of independent measurements obtained from selected locations and time periods and ground-truth/field program effort. *(Core Sites; field campaigns within first 12 months)*
- Stage 2: Product accuracy has been assessed over a *widely distributed* set of locations and time periods via several ground-truth and validation efforts. *(Core sites; networks, cooperators, model products)*
- Stage 3: Product accuracy has been assessed, and the uncertainties in the product well-established via independent measurements made in a systematic and statistically robust way that represents global conditions. *(All resources over the mission life)*