Soil Moisture Active Passive Mission
SMAP

Cal/Val Rehearsal

Tom Jackson, USDA

3rd Cal/Val Workshop
Nov. 14-16, 2012
Workshop Overview

- Status
  - L1 Mission Requirements
  - Mission Design
  - Products
  - Cal/Val Program

- L1 Cal Val Plan
  - L2-L4 Issues in Cal/Val
    - Algorithm Status
    - Field Experiments
      - Cal/Val Partners
      - Up-scaling
      - Satellite Products
      - Model Products
      - SDS Resources
  - Rehearsal Campaigns
  - Calibration of In situ Sensors
SMAP Cal/Val Rehearsals

• Review of key background items
  – Product List
  – Post-launch Cal/Val Timeline
  – Methodologies and Tools
• Why Conduct a Cal/Val Rehearsal?
• Phase 1 Planning
• Phase 2 Planning (Barry)
## SMAP Science Products

There are a lot of products! (Organization)

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Resolution</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1A_Radiometer</td>
<td>Radiometer Data in Time-Order</td>
<td>-</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1A_Radar</td>
<td>Radar Data in Time-Order</td>
<td>-</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1B_TB</td>
<td>Radiometer $T_B$ in Time-Order</td>
<td>(36x47 km)</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1B_S0_LoRes</td>
<td>Low Resolution Radar $\sigma_o$ in Time-Order</td>
<td>(5x30 km)</td>
<td>12 hrs</td>
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<tr>
<td>L1C_S0_HiRes</td>
<td>High Resolution Radar $\sigma_o$ in Half-Orbits</td>
<td>1 km (1-3 km)</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1C_TB</td>
<td>Radiometer $T_B$ in Half-Orbits</td>
<td>36 km</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L2_SM_A</td>
<td>Soil Moisture (Radar)</td>
<td>3 km</td>
<td>24 hrs</td>
</tr>
<tr>
<td>L2_SM_P</td>
<td>Soil Moisture (Radiometer)</td>
<td>36 km</td>
<td>24 hrs</td>
</tr>
<tr>
<td>L2_SM_AP</td>
<td>Soil Moisture (Radar + Radiometer)</td>
<td>9 km</td>
<td>24 hrs</td>
</tr>
<tr>
<td>L3_FT_A</td>
<td>Freeze/Thaw State (Radar)</td>
<td>3 km</td>
<td>50 hrs</td>
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<tr>
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<td>Soil Moisture (Radiometer)</td>
<td>36 km</td>
<td>50 hrs</td>
</tr>
<tr>
<td>L3_SM_AP</td>
<td>Soil Moisture (Radar + Radiometer)</td>
<td>9 km</td>
<td>50 hrs</td>
</tr>
<tr>
<td>L4_SM</td>
<td>Soil Moisture (Surface and Root Zone )</td>
<td>9 km</td>
<td>7 days</td>
</tr>
<tr>
<td>L4_C</td>
<td>Carbon Net Ecosystem Exchange (NEE)</td>
<td>9 km</td>
<td>14 days</td>
</tr>
</tbody>
</table>

* Over outer 70% of swath.

** The SMAP project will make a best effort to reduce the data latencies beyond those shown in this table.
Science Data Validation and Delivery Timeline

Only ~ 1 year to complete! (Meeting the Schedule)

- Pre-launch Preparation
- Launch
- In-Orbit Checkout (3 months)
  - Formal start of SMAP Science Mission
  - Beta release of L1 products and start of routine delivery
- L1 validation (6 months)
  - Delivery of validated L1 products to Data Center
- L2-L4 validation (12 months)
  - Delivery of validated L2-L4 products to Data Center

- L-3 mo
- L-6 mo
- L-9 mo
- L-15 mo
Cal/Val Methodologies and Tools

• Methodologies
  – Practices, procedures, and rules used by those who work in a discipline or engage in an inquiry; i.e. comparing retrievals to a dense and representative network of in situ observations using RMSE, bias, and R as metrics.
  – For L2-L4: Comparisons to Core Validation Sites, Sparse Networks, Satellite Products, Model Products, and Field Campaigns

• Tools
  – Software-based routines used to construct statistical and visual products to facilitate the methodologies; i.e. a program that routinely extracts SM products over a validation site.
Why Have a Cal/Val Rehearsal?

• Cal/Val rehearsal reduces the risk of not meeting checkpoints by identifying and correcting issues encountered in the exercises.
  – Organization
  – Schedule
  – Functioning

• Based upon initial discussions of the SMAP SDT and SDS, there are different but complementary objectives that led to an overall approach consisting of two phases.
SMAP Cal/Val Rehearsal Phases

- **Phase 1** Now
  - *Emphasizes development of validation methods*
    - Test calibration and validation methods that the team plans to use during mission cal/val
    - Resolve external validation resource issues
  - *Researchers run code on available hardware (SDT and CV)*

- **Phase 2** Later
  - *Emphasizes effective use of tools in an operational setting*
    - Ensure that the tools function in the operational environment
    - Ensure that tools operate on selected input appropriately
    - Ensure that tools generate anticipated output
  - *Team members run code on same hardware that will be used during cal/val (SDS)*
Prototype View of Post-Launch L2-L4 Cal/Val Science Operations and Processing Flow

- **Data storage for all sites**
- **Scaling function to represent footprint**
- **Data sets matching other data sources**
- **Data sets corresponding to SMAP products**
- **Time and space collocation wrt other data sources (cal/val products)**
- **Time and space collocation wrt validation sites (cal/val products)**
- **Mean RMSE**
- **Model products**
- **Other satellite data products**
- **Field experiment data**
- **In situ data Core and Sparse**
- **In situ data**
- **Production and data storage**
- **Cal/Val Reporting**
- **Analyze results**
- **Cal/Val Community**
- **Compare data sets**
- **Triple-collocation**

Feedback flow:
- Data sets matching other data sources
- Data sets over the sites
- Data sets corresponding to SMAP products
- SDS

SDS:
- Mean RMSE
- Compare data sets
- Triple-collocation

Prototyping View of Post-Launch L2-L4 Cal/Val Science Operations and Processing Flow

IN SITU DATA: Core and Sparse

Field experiment data

Data storage for all sites

Scaling function to represent footprint

Data sets matching other data sources (cal/val products)

Data sets corresponding to SMAP products

Data sets over the sites

Data sets corresponding to SMAP products

Cal/Val Community

Analyze results

Feedback

Model products

Other satellite data products
What Should Be Included in Phase 1?

- Products?
- Methodologies?
- Tools?
- What data resources?
- Schedule?
### Which Products Should Be Included in Phase 1?

<table>
<thead>
<tr>
<th>Product Level</th>
<th>Product</th>
<th>Cal/Val Heritage</th>
<th>Dependence on Outside Data Resources</th>
<th>Concerns over Outside Data Resources</th>
<th>Concerns over Methodology</th>
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<tbody>
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<td>L1</td>
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</table>
What Should Be Included in Phase 1?

- **Products?**
  - (1) All, (2) L2-L4, (3) L2-L3, (4) L2-L3 SM, or (5) L2-L3 SM-
    Passive
  - Heritage: Lacking for active-based products
  - Dependence: L2-L4 are more dependent
  - Concerns: SM more than FT and NEE
  - Methodologies: Most

- **Recommendation**
- **Methodologies?**
- **Tools?**
- **What data resources?**
- **Schedule?**
## Which Methodologies Should Be Included in Phase 1?

### L2-L4 Validation Methodologies

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Role</th>
<th>Constraints</th>
<th>Resolution</th>
</tr>
</thead>
</table>
| Core Validation Sites   | Accurate estimates of products at matching scales for a limited set of conditions | • In situ sensor calibration  
• Limited number of sites       | • In Situ Testbed  
• Cal/Val Partners      |
| Sparse Networks         | One point in the grid cell for a wide range of conditions            | • In situ sensor calibration  
• Up-scaling  
• Limited number of sites       | • In Situ Testbed  
• Scaling methods  
• Cal/Val Partners      |
| Satellite Products      | Estimates over a very wide range of conditions at matching scales    | • Validation  
• Comparability  
• Continuity       | • Validation studies  
• Distribution matching |
| Model Products          | Estimates over a very wide range of conditions at matching scales    | • Validation  
• Comparability       | • Validation studies  
• Distribution matching |
| Field Campaigns         | Detailed estimates for a very limited set of conditions              | • Resources  
• Schedule conflicts       | • Airborne simulators  
• Partnerships         |
Methodology Concerns

- Core Sites
  - Data delivery
    - Formatting
    - Transmission
    - Latency
  - Up-scaling
  - Data Quality
- Sparse Networks
  - Data delivery (not as much of an issue)
  - Up-scaling
  - Data Quality
- Satellite Products
  - Data delivery and processing
  - Metrics
- Model Products
  - Same as satellite products
- Field Campaigns
  - Many concerns discussed earlier
  - SMAPVEX12 was a rehearsal
What Should Be Included in Phase 1?

• Products?
  – *Recommendation:*

• Methodologies?
  – *Recommendation: All expect Field Campaigns*

• Tools?

• What data resources?

• Schedule?
• What data will drive the exercise?
• Setting up the acquisition and processing of the outside data resources (in situ, SMOS, model) and examining their quality is a very important aspect of the Phase 1 Rehearsal.
  – If we use simulated L1 data to drive the production of L2-L4 that is based on some period in the past (GLOSIM), comparisons between the simulated products and current in situ, etc. data will not be quantitative, it will only support establishing the methodology and associated tools.
  – For instance, evaluating the utility of TCL in Cal/Val is important. However, statistical assessments based on the scenario above would not be representative.
• Do we need to simulate delivery of satellite data or treat it as a batch?
<table>
<thead>
<tr>
<th>Product Level</th>
<th>Product</th>
<th>Data Source Options for Simulating SMAP Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Radiometer</td>
<td>GLOSIM or SMOS</td>
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<tr>
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<td>Radar</td>
<td>GLOSIM</td>
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<tr>
<td>L2/3</td>
<td>SM Passive</td>
<td>GLOSIM, SMOS, GCOM-W, Aquarius</td>
</tr>
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<td></td>
<td>SM Active</td>
<td>GLOSIM</td>
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<tr>
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What Should Be Included in Phase 1?

- **Products?**
  - (1) All, (2) L2-L4, (3) L2-L3, (4) L2-L3 SM, or (5) L2-L3 SM-Passive
  - *Recommendation:*
- **Methodologies?**
  - *Recommendation: All expect Field Campaigns*
- **Tools?**
- **What data resources?**
  - *Recommendation:*
- **Schedule?**
SMAP Cal/Val Rehearsals Schedule
Considerations

• Can’t start too soon
  – *Organizing the infrastructure to conduct a rehearsal will take time.*
    • Phase 1 –
    • Phase 2 -
  – *Conditions should be representative of the primary cal/val period.*

• Can’t wait too long
  – *If the feedback from the exercise is to be of value and if corrections are necessary, time is needed for analyses and implementation*
    • Phase 1 -
    • Phase 2 -
  – ...
## SMAP Cal/Val Rehearsals Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>November 2012</td>
<td>Cal/Val Workshop planning for Phase 1</td>
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<tr>
<td>February 2013</td>
<td>Collect initial description of all cal/val tools, data required to run tools</td>
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<tr>
<td>June 2013</td>
<td>Start Phase 1 rehearsals</td>
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<tr>
<td>September 2013</td>
<td>End Phase 1 rehearsals</td>
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<tr>
<td>October 2013</td>
<td>Cal Val Workshop review and feedback</td>
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<tr>
<td>January 2014</td>
<td>Collect operational description of all cal/val tools</td>
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<tr>
<td>May 2014</td>
<td>Complete cal/val procedure document</td>
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<tr>
<td>May 2014</td>
<td>Start Phase 2 Rehearsals</td>
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<tr>
<td>July 2014</td>
<td>End Phase 2 Rehearsals</td>
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<tr>
<td>Fall 2014</td>
<td>Rehearsal review</td>
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</table>

![Timeline Diagram]

TJJ–24
Soil Moisture (L2 Passive) Validation
Rehearsal Processing Flow for 2013

Data storage for all sites
Production and data storage
Time and space collocation wrt validation sites (cal/val products)
Time and space collocation wrt other data sources (cal/val products)
Data sets matching other data sources
Data sets over the sites
Data sets corresponding to SMAP products
Data sets corresponding to SMAP products

In situ data Core and Sparse
Field experiment data

SDS
Compare data sets
Triple-collocation

Current Testbed
Mean RMSE

Other satellite data products
Model products

SMOS
ECMWF

Feedback
Cal/Val Community
Analyze results

TJJ-25
SMAP Cal/Val Phase 1 Rehearsal Goals

- The process and procedures of getting Cal/Val partner data to the Project and resolving any ambiguous issues the two sides might have
- Defining the up-scaling functions for the core sites
- Assessing the quality of the data supplied by the Cal/Val partners
- Formalizing and implementing the up-scaling approach and analysis procedures that will be used for sparse networks
- Assessment and qualification of specific points in the available sparse network data
- Providing feedback to the Cal/Val partners, which might be implemented before launch
- Exercising the procedures for acquisition and analysis of satellite products from SMOS, Aquarius, and GCOM-W
- Exercising the procedures for acquisition and analysis of model products from ECMWF, NCEP, GMAO
- Formalizing tools and analysis procedures used by the Cal/Val team
SMAP Cal/Val Phase 2 Rehearsal Goals

• Demonstrates the use of the operational environments and facilities and all of the tools required for the cal/val effort
  – *Effective use of tools in an operational setting*
    • Tools function in the operational environment
    • Tools operate on selected input data sets
    • Tools generate anticipated output
    • Tools run on same hardware that will be used during cal/val
  – *Effective use of the available data*
    • Incorporates SMAP data products
    • Incorporates validation data sets
    • Incorporates QA products and analysis products
  – *Effective use of communication channels and process tools*
    • Employ all established means that the team will use to communicate issues and results and exercise tools for changes
Phase 2 Cal/Val Rehearsal Procedures

• Prerequisites
  – Mission hardware is configured for cal/val
  – Data repositories are configured for cal/val
  – Software tools and applications are configured for cal/val
  – Software tools and applications reside where they will be used during cal/val

• Exercises
  – Schedule specific time periods in May/June 2014 to run test cases
  – Assign team members to execute specific parts of the exercise
  – Run all tools with available data with resources intended for mission use
  – Employ all report mechanisms and repositories
  – Evaluate results and, if necessary, modify procedures accordingly

• Some exercises will test the use of procedures and tools under anomalous conditions
• Demonstrate mission readiness in time for ORR in August
Phase 2 Cal/Val Rehearsal Planning

- Generate cal/val use cases
  - The full set of use cases covers all planned cal/val activities
  - Use cases will ensure that
    - The data storage plan provides necessary data sets
    - The tool development plan covers necessary functions

- Document procedures that are common to all cal/val activities.
  - Those procedures will specify:
    - Facilities in use and how to access them
    - Location of various data sets
    - Communication methods the cal/val team will use to share information and prepare reports

- Document cal/val procedures that are specific to each use case.
  - Those procedures will specify:
    - Prerequisite conditions for each use case
    - Specific sequence of activities
    - Alternatives for expected anomalous conditions
# SMAP Cal/Val Phase 1 Rehearsal Tasks

<table>
<thead>
<tr>
<th>Date</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/14/12</td>
<td>Scope and schedule defined</td>
</tr>
<tr>
<td>11/15/12</td>
<td>Prioritization of tasks, follow-up comments</td>
</tr>
<tr>
<td></td>
<td>Organizational chart</td>
</tr>
<tr>
<td></td>
<td>Agreements with Cal/Val Partners completed</td>
</tr>
<tr>
<td></td>
<td>Tools identified and development initiated</td>
</tr>
<tr>
<td></td>
<td>Priority core site data acquisition process established</td>
</tr>
<tr>
<td></td>
<td>Sparse network data acquisition process established</td>
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<tr>
<td></td>
<td>Satellite product acquisition process established</td>
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<tr>
<td></td>
<td>Model product acquisition process established</td>
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<tr>
<td></td>
<td>All core site data acquisition process established</td>
</tr>
<tr>
<td></td>
<td>Simulated SMAP data set available</td>
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<tr>
<td>QC Procedures</td>
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<tr>
<td></td>
<td>Stage 1 test case</td>
</tr>
<tr>
<td></td>
<td>Stage 2 with sparse networks</td>
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<tr>
<td></td>
<td>Stage 2 with satellite and model products</td>
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<tr>
<td></td>
<td>Monthly reviews</td>
</tr>
<tr>
<td></td>
<td>Workshop, Report, Feedback</td>
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</table>
SMAP Cal/Val Tools

• Examples or List
## Cal/Val Workshop Agenda-Day 3

**Friday (November 16)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Leader</th>
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<tbody>
<tr>
<td>0815</td>
<td>MOISST</td>
<td>Cosh</td>
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<tr>
<td>0840</td>
<td>GPS</td>
<td>Small</td>
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<tr>
<td>0850</td>
<td>CRN</td>
<td>Bell</td>
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<td>COSMOS</td>
<td>Zreda</td>
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<tr>
<td>0915</td>
<td>COSMOS Rover/SMAPVEX11</td>
<td>Ochsner</td>
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<td>0930</td>
<td>Discussion: Lessons Learned and Implementation</td>
<td>Cosh</td>
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<tr>
<td>1015</td>
<td>Break</td>
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<tr>
<td>1030</td>
<td>Breakout Sessions</td>
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<tr>
<td>1130</td>
<td>Workshop Issues, Actions, and Summary</td>
<td>Njoku</td>
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<tr>
<td>1200</td>
<td><strong>End</strong></td>
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</tbody>
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Summary and Actions

• Cal/Val Program Status
• Progress on Cal/Val activities
• Field Experiments
  – SMAPVEX12
  – SMAPVEX15: Decide?
• Cal/Val Rehearsals
  – Phase 1
  – Phase 2
• Future Cal/Val Workshops
  – Fall 2013: SMAP ST will likely hold its first meeting Oct/Nov?
    • Same time or separate?
    • Logistics