SMAP Cal/Val

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Caveats

• The original Hydros Validation Plan was written > 5 years ago….things change.
• SMOS is establishing useful validation resources; insitu soil moisture, tower and aircraft sensors, and eventually the mission $T_B$s.
• Timeline of SMOS-Aquarius-SMAP will influence SMAP Cal/Val.
• Evolution of GEOSS may impact potential insitu resources
Topics

• *Soil Moisture Mission Roadmap*
• Cal/Val Elements
  – Level 1B/1C Products
  – Soil Moisture Products
  – Freeze/Thaw (other talks)
• Modeling (other talks)
• SMOS, ALOS, Aquarius Considerations
Goals:

- Understand the processes linking water, energy, and carbon cycles at scales of 10 km or better
- Data and models that result in improved weather and climate prediction
- Models capable of predicting the water cycle, including floods and droughts, at scales of 10’s of km or better
- Demonstrate user applications

Soil Moisture Mission Roadmap (2007v2)

Knowledge Base

Define Observation Requirements

TODAY:

- Data denial experiments show influential role of soil moisture in severe weather forecasting, in seasonal water cycle predictability, and in linking water, energy, and biogeochemical cycles over land
- Extensive heritage using ground-based and airborne instruments in field experiments which have demonstrated the need for low frequency active and passive microwave remote sensing to accurately map soil moisture fields at relevant scales
- Complete lack of in situ networks and inadequacy of current spaceborne sensors to meet soil moisture mapping requirements

US Soil Moisture Networks

Int. Soil Moisture Working Group (GEOSS)

Analyses & Studies Demonstrating Value of Soil Moisture Information

- SMEX Science Support
- AP Aircraft and Ground-Based Simulators
- Enhance active/passive algorithms for soil moisture retrieval
- Evaluation of operational AMSR soil moisture algorithms
- Characterize role of soil moisture in linking water, energy, and carbon cycles
- Improve understanding of vegetation effects on remote sensing of soil moisture

Soil moisture products limited by spatial resolution and vegetation attenuation

Hydros ESSP Proposal

Hydros Risk Reduction

Hydros Formulation Phase

Funded

Unfunded

Non-US

Field Campaign

SMAP

Aquarius

SMOS (ESA)

ALOS (JAXA)

SMAP C/V

SMOS (ESA)

Hydros

Risk Reduction

Formulation Phase

SMAP C/V

Hydros

Risk Reduction

Formulation Phase

CLASIC

HEX/CLASIC II
Aquarius/SMOS

SMAP C/V

Non-US

US Soil Moisture Networks

AMSRE/Windsat

PALS, AIRSAR, ESTAR, 2DSTAR

SMEX02 SMEX03 SMEX04 SMEX05

SMEX Science Support

Hydros ESSP Proposal

Hydros Risk Reduction

Hydros Formulation Phase

TODAY:

- Data denial experiments show influential role of soil moisture in severe weather forecasting, in seasonal water cycle predictability, and in linking water, energy, and biogeochemical cycles over land

Topics

• Soil Moisture Mission Roadmap
• *Cal/Val Elements*
  – Level 1B Products
  – Soil Moisture Products
  – Freeze/Thaw
• Modeling
• SMOS, ALOS, Aquarius Considerations
Level 1B/1C Brightness Temperature and Backscatter

- Sensor calibration
- SMOS, Aquarius, and ALOS PALSAR data can establish baseline records
  - Regional and seasonal statistics on $T_B$ and $\sigma^o$
  - Refine vicarious calibration plans
  - Merge data into longer records
- Tower and aircraft based measurements
- Modeling
Level 1B/1C Brightness
Temperature and Backscatter: Satellite Resources

- SMOS: Global $T_B$ H&V $\sim 40^\circ$
- Aquarius: Simultaneous $T_B$ and $\sigma^o$, other potential resources include 37 GHz and TIR
- ALOS PALSAR: Multiple resolution $\sigma^o$
- Options and value of data increase with mission overlap
Soil Moisture Validation Goal

• Provide a close approximation of soil moisture within the area and depth measured by low frequency passive microwave sensors that would result in a robust data set for quantitative validation of retrieval algorithms
• Challenging due to spatial scale mismatch and variability
SMAP Soil Moisture Validation

• Ground based networks are a core component: provide actual quantitative soil moisture observations to evaluate algorithm performance
  – Continue/Establish a number of dedicated soil moisture validation sites
  – Promote the development of and exploit existing networks providing soil moisture (partnerships…follow SMOS approach…data for data)

• Field experiments that address mission specific algorithm issues and/or applications

• Model based validation techniques

• Prelaunch studies with SMOS, Aquarius and ALOS
Soil Moisture Networks

- There are only a few available that provide the right kind of data
- SMAP core effort: long term networks in the US (SCAN, ARS, other?)
- Integrate with GEOSS (ISMWG), SMOS, and AMSR/GCOM-W efforts
- Standardization and 5 cm!
Selected Soil Moisture Networks

Point       Local      Regional       Global

Frequency

Density

Extent

Hourly

Real Time

Archival

USDA Watersheds (4)
REHMEDES
Oklahoma and Mongolia
SCAN
???

Low

High

Crop

Monthly
Soil Climate Analysis Network (SCAN)

- 100+ sites
- Web based real time
- Public access
- Hourly observations
- Standard Configuration
  - Air temperature
  - Relative humidity
  - Wind speed and direction
  - Solar radiation
  - Barometric pressure
  - Snow water content and depth
  - Soil moisture and temperature (5, 10, 20, 50, 100 cm)

http://www.wcc.nrcs.usda.gov/scan/
Selected Soil Moisture Networks

Point       Local      Regional       Global

Extent

Hourly     Monthly

Density

Low        High

Frequency

Real Time

Archival

Hourly

Real Time Archival
Validation of AMSR-E Soil Moisture Products Using Watershed Networks

- Standards
- Infrastructure
- Diverse Conditions
- Replication
- Installation
- Calibration
- Scaling
- Archive
- Algorithm Validation

Lessons Learned

SMEX+

Complete
Incomplete
AMSR-E Soil Moisture Validation

AMSR-E U.S. Soil Moisture Validation Sites

- Little Washita, OK
- Little River, GA
- Walnut Gulch, AZ
- Reynolds Creek, ID

Longitude W (Degrees)
Latitude N (Degrees)

+ Rain gage
Existing SM Site

AMSR-E Soil Moisture Validation
Little Washita Vitel Network

Little Washita River Washita

5 cm

3-7 cm

111

NOAA

136

144

146

144

146

159

Berg

111

133 134

149

151

149

154

162
Validation of AMSR-E Soil Moisture Products Using Watershed Networks

Lessons Learned
Standards
Infrastructure
Diverse Conditions
Replication
Installation
Calibration
Scaling
Archive
Algorithm Validation

SMEX+

Complete
Incomplete
Online Real-Time Network Products

Range of products and archive

http://ars.ocs.ou.edu/public/

5 cm Soil Moisture

45 cm Soil Moisture
AMSR-E Algorithm Validation

Little Washita, OK (Asc)

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>SEE (m3/m3)</th>
<th>Bias (m3/m3)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.044</td>
<td>-0.009</td>
<td>800</td>
</tr>
<tr>
<td>B</td>
<td>0.100</td>
<td>0.079</td>
<td>306</td>
</tr>
<tr>
<td>C</td>
<td>0.051</td>
<td>0.024</td>
<td>832</td>
</tr>
</tbody>
</table>

- Very good range of soil moisture observed
- B overestimates soil moisture and anomalous behavior
- C response is <50% of observed
- A had the overall best performance
Field Experiments and Validation

• Ties together point and footprint observations
• Intensive observing periods
  ✓ Establish the representativeness of sparse networks
  ✓ Characterize spatial variability
• Tower and aircraft sensors
  ✓ Critical link between scales
  ✓ Establish retrieval accuracy for homogeneous targets
• Test bed for new algorithms
• Limited resources require broader science programs
• Exciting!…Strengthen the science and the community
Field Experiment Infrastructure Requirements

- Controlled condition experiments: Tower based AP
- Mapping of large domains: Aircraft based scanning AP, UAVSAR, (SMOS merge-STAR)
- Algorithm issue resolution: Flexible platform and AP sensor (PALS)
- Insitu sampling: Deployable networks
Mobile “MiniNet” Stations

Easily installed and removed soil moisture sensor networks with local communications. Frequent soil moisture and temperature at 5 cm depth.
Large Scale Field Experiment Possibilities

- HEX
- CLASIC-II
- SMOS and/or Aquarius Validation
- SMAP Validation
**Goals:**

- Understand the processes linking water, energy, and carbon cycles at scales of 10 km or better
- Data and models that result in improved weather and climate prediction
- Models capable of predicting the water cycle, including floods and droughts, at scales of 10’s of km or better

**Soil Moisture Mission Roadmap (2007v2)**

- Data denial experiments show influential role of soil moisture in severe weather forecasting, in seasonal water cycle predictability, and in linking water, energy, and biogeochemical cycles over land
- Complete lack of in situ networks and inadequacy of current spaceborne sensors to meet soil moisture mapping requirements

**Today:**

- Improved understanding of vegetation effects on remote sensing of soil moisture
- Characterize role of soil moisture in linking water, energy, and carbon cycles
- Evaluation of operational AMSR soil moisture algorithms
- Improve understanding of vegetation effects on remote sensing of soil moisture

**Knowledge Base**

- Hydros ESSP Proposal
- Hydros Risk Reduction
- Hydros Formulation Phase

- Analyses & Studies Demonstrating Value of Soil Moisture Information
  - SMEX Science Support
  - AP Aircraft and Ground-Based Simulators
  - US Soil Moisture Networks
  - Int. Soil Moisture Working Group (GEOSS)

- AMSR-E/Windsat

- SMAP
- Aquarius
- SMOS (ESA)
- ALOS (JAXA)

- Hydros
- Risk Reduction
- Formulation Phase

- Define Observation Requirements

- Smex Science Support

- Ground based networks and satellite mission coordination

- SMAP C/V
- SMOS (ESA)
- Aquarius

- Analyses & Studies Demonstrating Value of Soil Moisture Information

- PALS, AIRSAR, ESTAR, 2DSTAR

- SMEX02, SMEX03, SMEX04, SMEX05

- SMEX02 Science Support

- SMEX03 Science Support

- SMEX04 Science Support

- SMEX05 Science Support

- soil moisture products limited by spatial resolution and vegetation attenuation

- Extensive heritage using ground-based and airborne instruments in field experiments which have demonstrated the need for low frequency active and passive microwave remote sensing to accurately map soil moisture fields at relevant scales
SMAP Validation Baseline Requirements

- SMOS, Aquarius and ALOS satellite data and supporting studies
- Long term soil moisture networks in the US
- Int. partnerships (GEOSS-ISMWG–SMOS) or data exchange for additional soil moisture resources
- Pre launch field experiments to exploit SMOS and Aquarius for SMAP
- Post launch field experiments to validate SMAP Level 1-3 products
- Insitu, tower and aircraft resources to support SMAP
Summary-Key Points

• Validation program will evolve and adapt as other satellite programs mature
• Soil moisture networks must be established and continued throughout the various missions
• Field experiments will remain an important component of SMAP; pre launch (SMOS/Aquarius) and post launch
• Tower and aircraft based simulators are critical
• Partnerships (data for data) are a valuable component