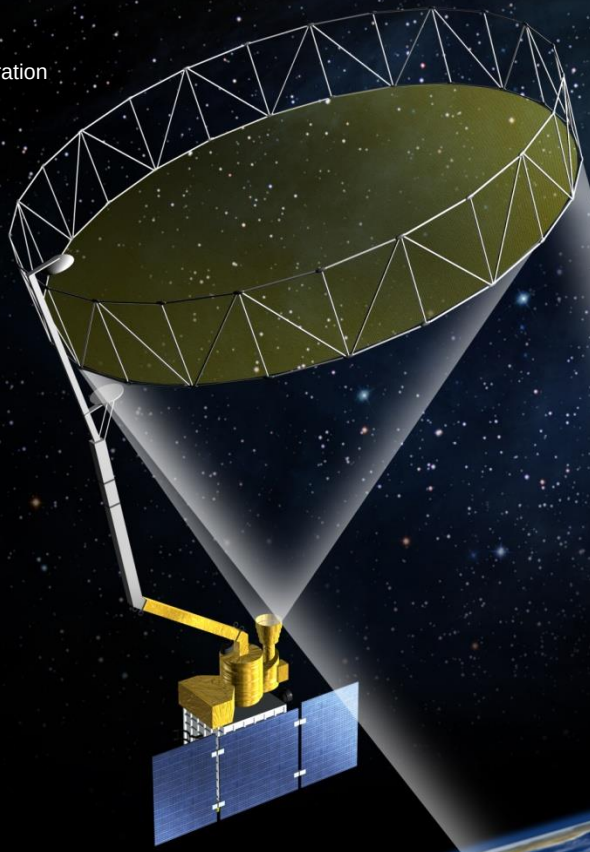
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology

Soil Moisture Active Passive Mission

SMAP



4th Cal/Val Workshop

Nov. 5-7, 2013

4th SMAP Cal/Val Workshop

- Logistics (Register, release form, posters,....)
- WIFI: shrpasa/jan1196 (lowercase!)
- Review the SMAP Cal/Val activities and specific issues that benefit from the input of the Cal/Val Working Group
  - *SMAP Project (SDS, ADT), SDT/ST, Cal/Val Partners, and collaborating scientists*
- Cal/Val is the first phase after launch
- Progress has been made on several important Cal/Val issues
  - *L1 Cal/Val Plan*
  - *In situ calibration, Cal/Val Partners, and up-scaling*
  - *Phase 1 Cal/Val Rehearsal*

4th SMAP Cal/Val Workshop: Objectives

- Closure on Phase 1 of the Cal/Val Rehearsal and lessons learned.
- Increased engagement of the Cal/Val Partners and provide them with a better understanding of the Project needs.
- Feedback on the L1 Cal/Val Plan
- Establish a relationship with the L-band inter-calibration working group
- Feedback on the plans for post-launch field campaigns
- Feedback on the Phase 2 Cal/Val Rehearsal plan

Workshop Overview

Project Status

Cal/Val Overview

Phase 1 Rehearsal

Cal/Val Partners

L1 Cal/Val Plan
- Overview
- Topics
- Inter-calibration/satellite programs

L2-L4 Topics
- In situ sensors
- Sparse networks
- Field experiments
- Triple Co-location

Phase 2 Rehearsal

Cal/Val Workshop Agenda-Day 1

Tuesday (November 5)		
0800	Welcome and Overview of Workshop	Jackson
0830	SMAP Project Status	Kellogg/Yueh/Entekhabi
	Phase 1 Cal/Val Rehearsal	*Jackson (Lead)*
0900	Cal/Val Timeline and Overview of Approach	Jackson
0915	Review of Activities	Colliander
1000	*Break*	
	Reports from Algorithm Leads on Rehearsal 1	Njoku
1015	L2/L3_SM_P	Chan
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1105	L4_SM	Reichle
1120	L4_C	Yi
1135	*Lunch*	
	Reports from Cal/Val Partners	Jackson
1245	Feedback to Cal/Val Partners from Rehearsal	
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1450	*Break*	
1505	Twente Watershed (NL) and Tibet Sites	Su
1520	CREST (NY)	Lakhankar
1535	EURAC (IT)	Notarnicola
1550	OCO-2 Cal/Val Site	Schwandner
1605	GPS Network	Small
1620	Lessons Learned Discussion	Colliander/Jackson
1700	*End*	

Cal/Val Workshop Agenda-Day 2

Wednesday (November 6)		
	Level 1 Cal/Val Plan and Activities	*Spencer (Lead)*
0815	Project Level 1 Cal/Val Plan Overview	Spencer
0845	Radiometer Cal/Val Activities	Kim
0915	Radar Cal/Val Activities	West
0945	*Break*	
	L1 Cal/Val Topics and Discussion	Spencer
1000	Radiometer Cal/Val Techniques/Targets	Misra
1020	Dome-C Aircraft Experiment	Skou
	Inter-Calibration and Satellite Updates	Spencer
1040	SMOS/Aquarius Working Group Status	LeVine
1110	SMOS/Aquarius Inter-Calibration Results	Bindlish
1130	Aquarius Radar Inter-calibration	Fore
1150	*Discussion*	
1200	*Lunch*	
	L2-L4 Topics: In Situ Sensors and Networks	*Cosh (Lead)*
1300	Marena OK In Situ Sensor Testbed (MOISST)	Cosh
1330	CRN	Bell
1345	OK Mesonet	Basara
1400	NEON	Ayres
1415	Canadian FT Sites	Belair
1430	*Posters/Break*	
	L2-L4 Topics: Field Experiments	*Jackson (Lead)*
1530	SMAPVEX12 Archive	Colliander
1545	ComRAD	O'Neill
1600	Future Field Campaigns	Jackson
1630	Discussion	
1700	*End*	

Cal/Val Workshop Agenda-Day 3

Thursday (November 7)		
	L2-L4 Topics	
0815	Triple Co-location and Sparse Networks	Crow
0845	Model-based Validation of Soil Moisture Products	Crow
0915	Discussion	
0930	*Break*	
	Phase 2 Cal/Val Rehearsal	*Yueh (Lead)*
0945	Scope, Roles, and Responsibilities	Yueh
1000	L1 Plan	Spencer
1020	L2-L4 Algorithms Plan	Dunbar
1045	L2-L4 Validation Plan	Colliander
1110	Science Data System Plan	Weiss
1130	Schedule and Summary (Discussion)	
1200	***Workshop Summary and Actions***	Jackson/Yueh/Entekhabi/Njoku
1300	*End*	

Cal/Val Workshop Agenda-Day 1

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	Reports from Cal/Val Partners	Jackson
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1700	*End*	

SMAP Project Status

- Next: A review of some important components of the SMAP Project/Mission that guide and define the SMAP Cal/Val program.

Level 1 Science Requirements

- The NSF Decadal Survey identified numerous potential applications for SM/FT observations.
- These were grouped into three categories with a spatial resolution, refresh rate, and accuracy.

Requirement	Hydro-Meteorology	Hydro-Climatology	Carbon Cycle	Baseline Mission		Threshold Mission	
				Soil Moisture	Freeze/ Thaw	Soil Moisture	Freeze/ Thaw
Resolution	4–15 km	50–100 km	1–10 km	10 km	3 km	10 km	10 km
Refresh Rate	2–3 days	3–4 days	2–3 days[a]	3 days	2 days	3 days	3 days
Accuracy	0.04-0.06 [c]	0.04-0.06 [c]	80–70% [b]	0.04 [c]	80%[b]	0.06 [c]	70%[b]
Mission Duration				36 months		18 months	

[a] North of 45N latitude, [b] Percent classification accuracy (binary freeze/thaw), [c] Volumetric water content, 1-σ in [cm^3/cm^3] units

- These are the L1 priority products and requirements. Other product accuracies derive from L2 requirements. Defines the baseline mission.
- The SMAP Project proposed the active-passive approach for meeting these requirements.

SMAP Science Products

- Goal of Cal/Val: provide the information for both the assessment and improvement of all products. program.

L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1B_S0_LoRes	Low Resolution Radar σ_o in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_o in Half-Orbits	1 km (1-3 km)	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L3_FT_A	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

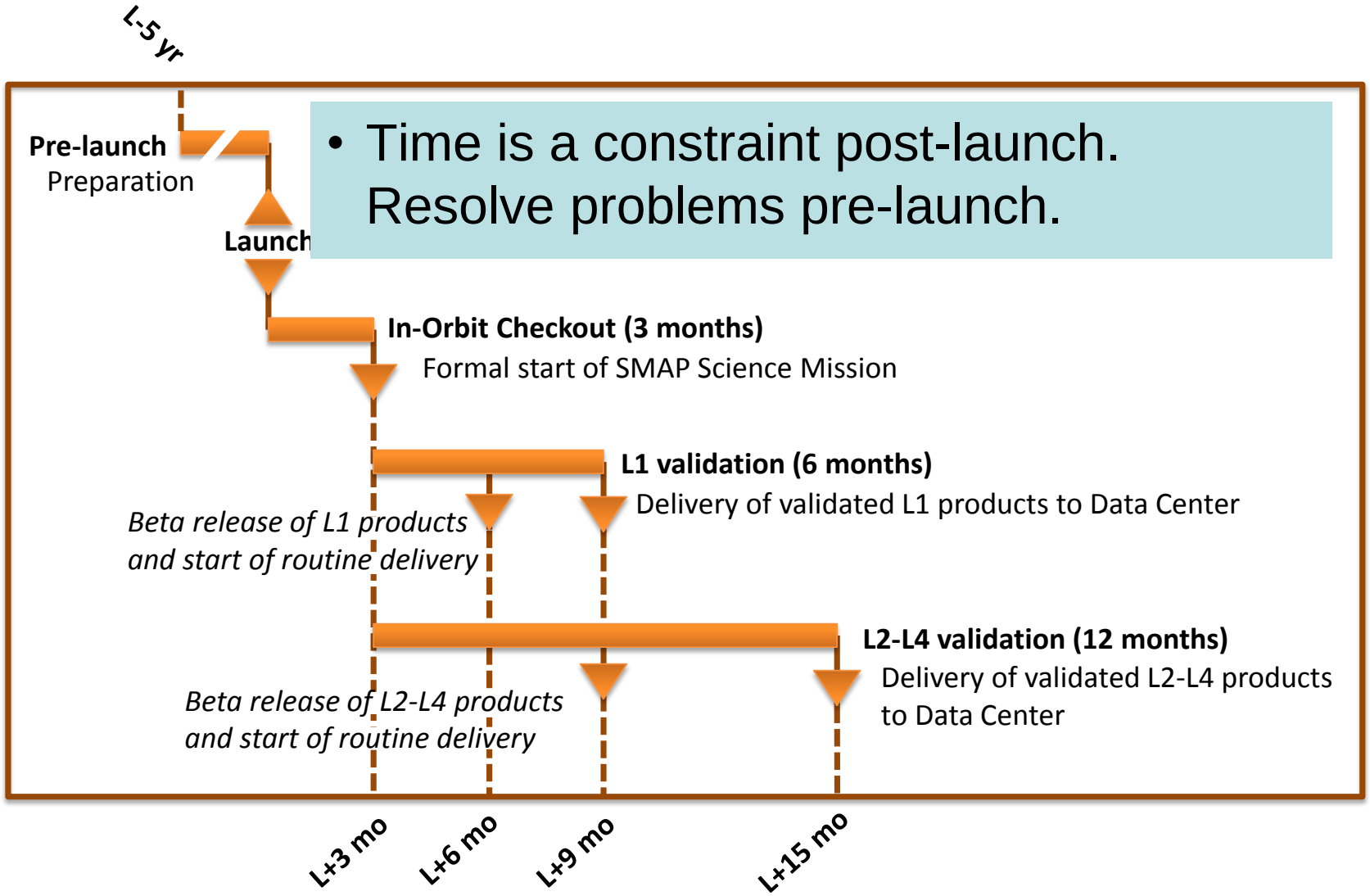
* Over outer 70% of swath.

** The SMAP project will make a best effort to reduce the data latencies beyond those shown in this table.

Something to Remember for L2/L3 Soil Moisture Cal/Val

- Brightness temperature observed by a satellite sensor originates from a varying depth of soil. (A similar statement can be made for radar)
- The variation depends upon the distribution of water as well as temperature in the near surface layers of soil and that this contributing depth increases as the moisture decreases.
- All very interesting but not very useful for operational product development.
  - *We need some standardization……*
- Theory suggests that the contributing depth of the soil is about 25% of the wavelength, which for L-band will be ~ 5 cm.
- Even if you don't agree with this theory, there is ample experimental evidence that soil moisture estimated under the assumption of a uniform surface layer is well correlated with 0-5 cm soil moisture as determined by gravimetric sampling (the standard).
- What SMAP is providing is an estimate of the 0-5 cm soil moisture.
  - *This is what we need to validate and*
  - *There may be some error we can NEVER remove due to this simplification of reality.*
- Regardless of what methodology we use for validation, it must also be referenced to the same layer we are estimating using remote sensing.

Science Data Validation and Delivery Timeline



SMAP Cal/Val Approach: Changing Focus

Pre-launch

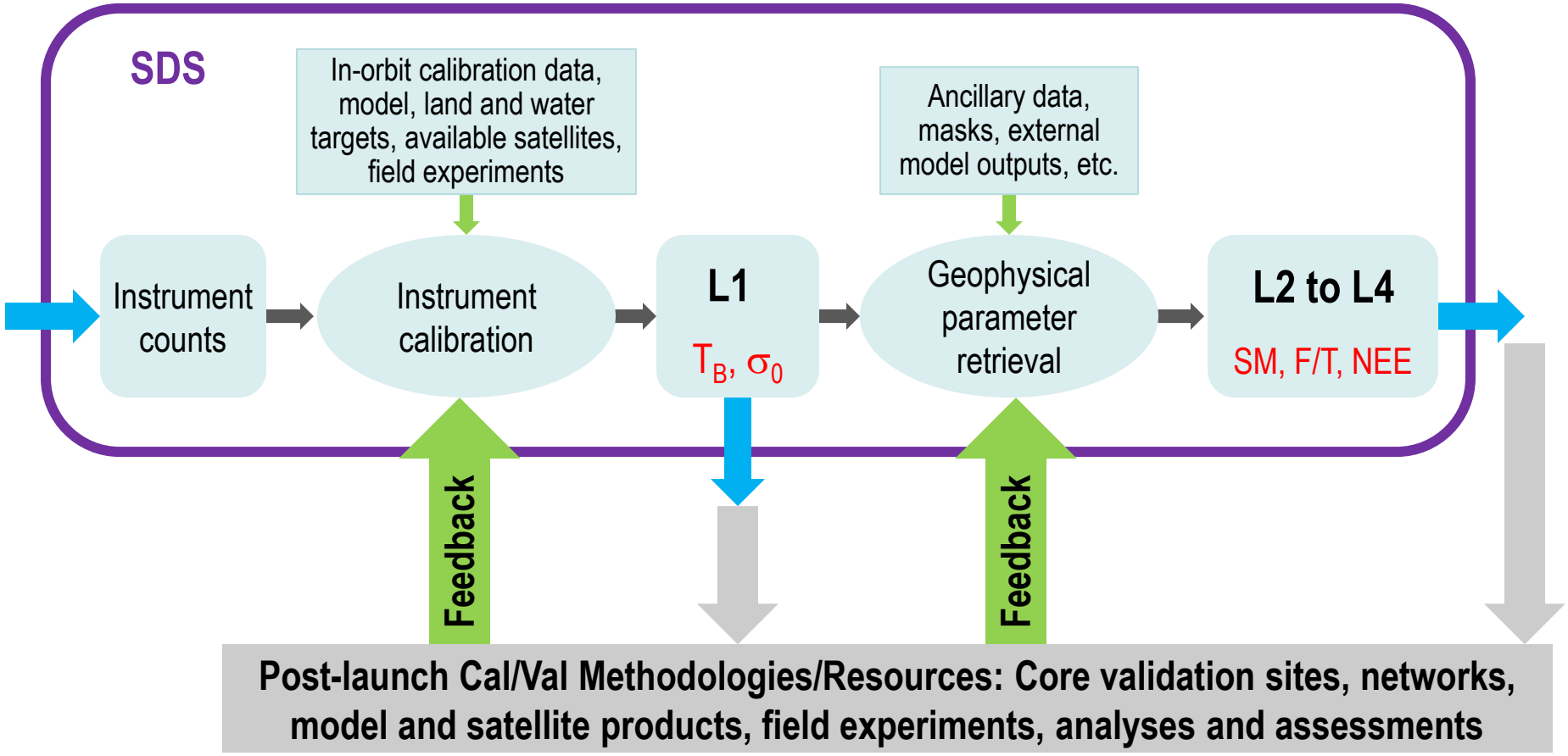
- Insuring that there are means in place to fulfill the mission objectives
  - *Acquire and process data with which to calibrate, test, and improve models and algorithms used for retrieving SMAP science data products*
  - *Develop and test the infrastructure and protocols for post-launch validation*

Post-launch

- Validating that the products meet their quantified requirements
  - *Calibrate, verify, and improve the performance of the science algorithms*
  - *Validate accuracies of the science data products as specified in L1 science requirements according to Cal/Val timeline*

Post-Launch Cal/Val Approach

- Calibrate, verify, and improve the performance of the science algorithms
- Validate accuracies of the science data products as specified in L1 science requirements according to Cal/Val timeline



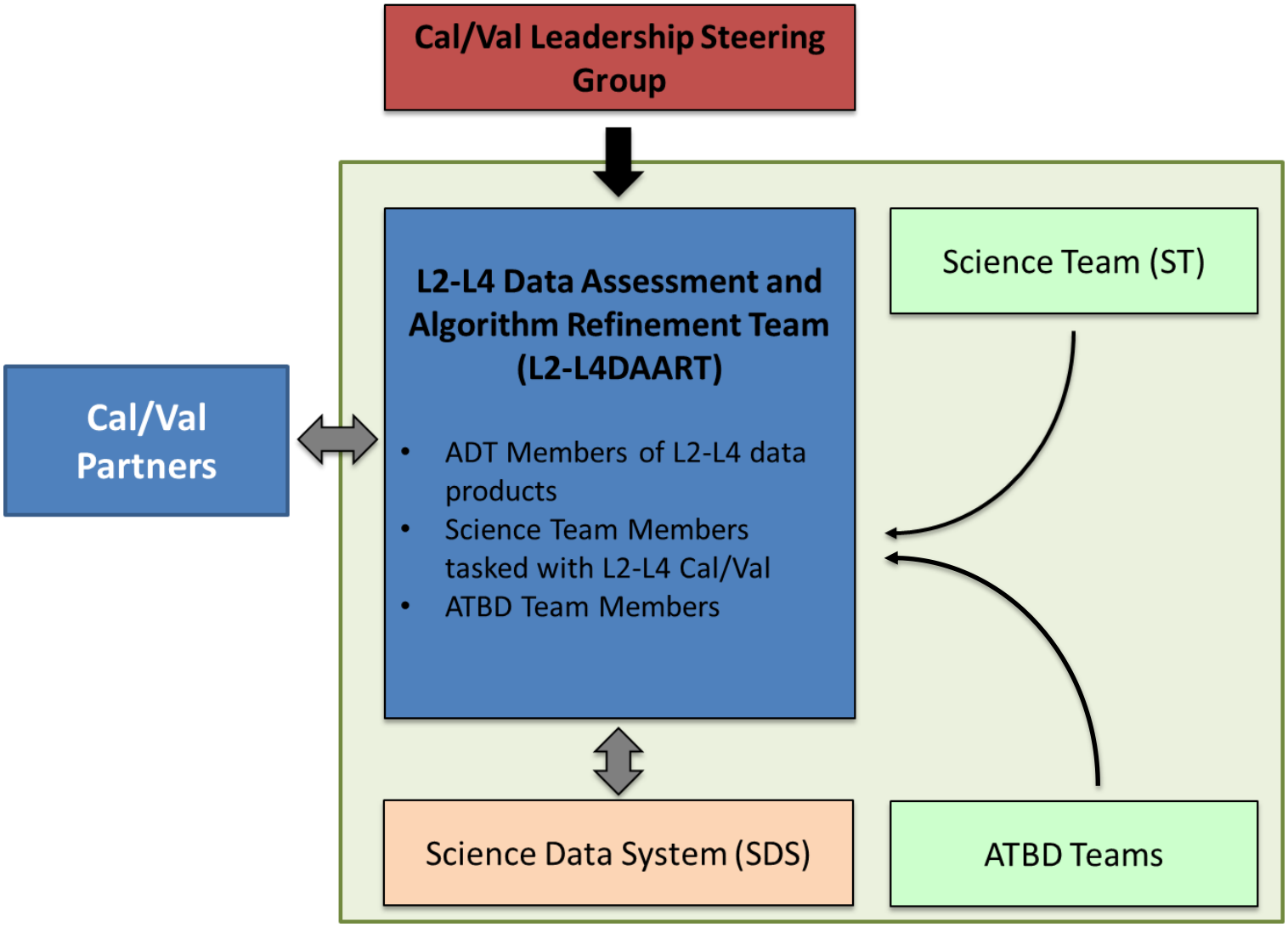
L2-L4 Validation Methodologies

Methodology	Role	Constraints	Resolution
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

DAART Objectives and Composition

- Post-launch Calibration and Validation is performed by the Data Assessment and Algorithm Refinement Team (DAART) under the direction of the Cal/Val Leadership Steering Committee.
- Objectives of Post-Launch Cal/Val
  - *Calibration. Adjust algorithm parameters and coefficients to yield data products that agree with associated external calibration standards.*
  - *Validation and Verification. Assess the performance of the SMAP measurements relative to independent standards, and verify that science requirements for data products are met.*
  - *Algorithm Refinement. As necessary to meet calibration and/or validation objectives, modify baseline algorithms and recommend changes to the operational processing system.*
- The DAART is composed of members of the pre-launch Algorithm Development Teams, Science Team, as well as Instrument and Mission Systems Teams.
- DAART prelaunch activities are currently ongoing to develop necessary Cal/Val tools, including focused Cal/Val process rehearsals.

L2-L4 DAART Organization and Composition



Workshop Overview

Project Status

Cal/Val Overview

Phase 1 Rehearsal

Cal/Val Partners

L1 Cal/Val Plan
- Overview
- Topics
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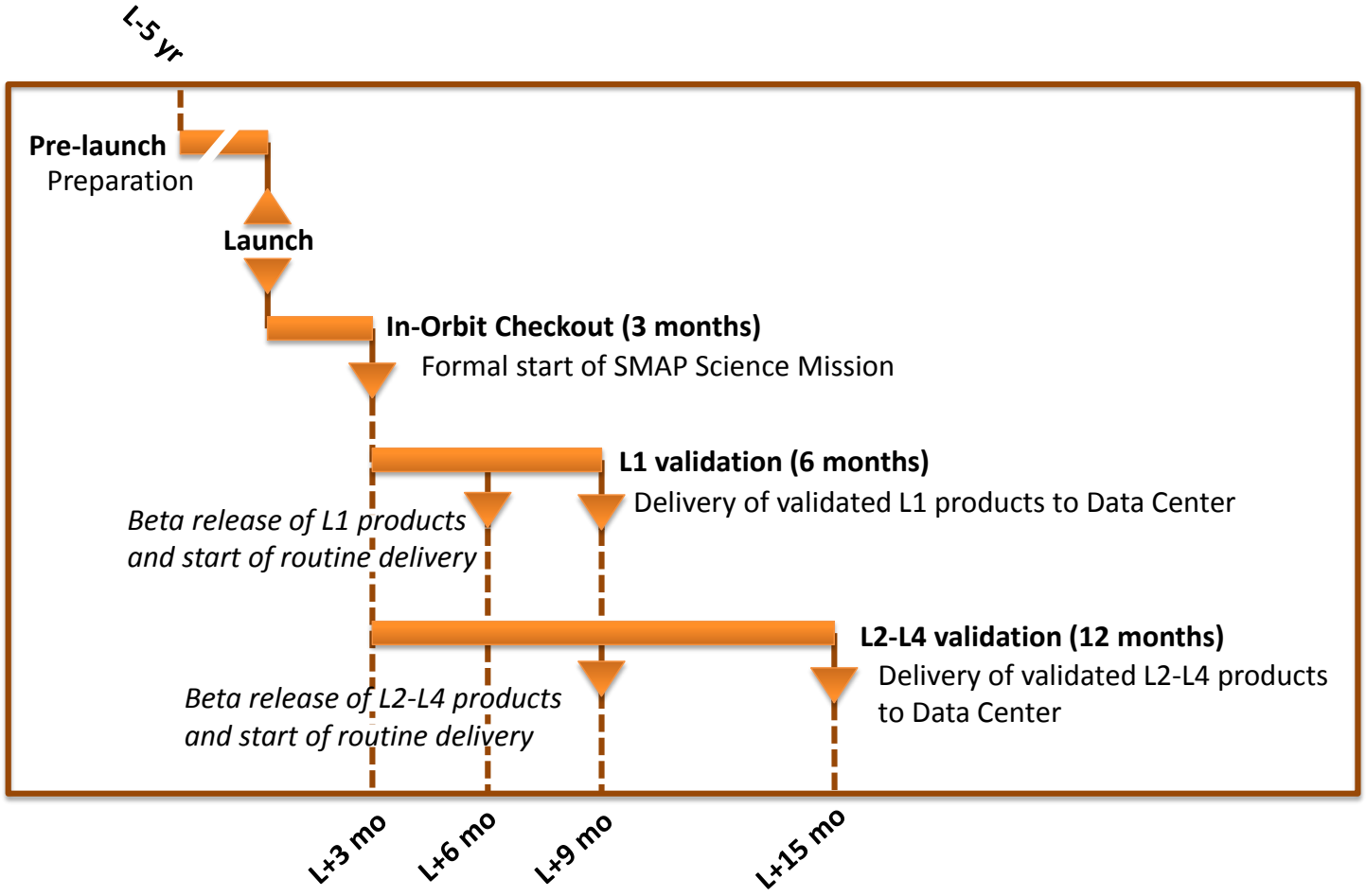
L2-L4 Topics
- In situ sensors
- Sparse networks
- Field experiments
- Triple Co-location

Phase 2 Rehearsal

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.



SMAP Cal/Val Rehearsal Phases

- Phase 1
  - *Emphasizes development of validation methodologies and tools*
    - 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
  - *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
  - *Continue Phase 1 activities and expand to all products*
  - *Team members run code on same hardware that will be used during cal/val (SDS)*

SMAP Cal/Val Rehearsals Schedule

November 2012	3rd Cal/Val Workshop (Planning for Phase 1)
June 17 - August 23, 2013	Phase 1 Rehearsal
September 24, 2013	Rehearsal review
November 5-7, 2013	4th Cal Val Workshop (Review and feedback, planning for Phase 2)
January 2014	Collect operational description of all cal/val tools
May 2014	Complete cal/val procedure document
May 1 – July 1, 2014	Phase 2 Rehearsal
Sept., 2014	5th Cal Val Workshop review and feedback
November 5, 2014	Launch

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
- Assessing the quality of the data supplied by the Cal/Val partners
- Defining the up-scaling functions for the core sites
- 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

Phase 1 Rehearsal Overview

- Timeline
  - *Duration: 10 weeks*
  - *Phase 1 Rehearsal start: Monday, June 17*
  - *Phase 1 Rehearsal end: Friday, August 23*
- Basic concept for L2-L4 data products
  - *Weekly updates of the match-ups and validation metrics*
  - *Analysis, design and development of updates and algorithm refinement tools*
  - *Keep automated parts on after the end of the rehearsal*

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Provision of SMAP Data Products to Cal/Val Partners

- During the cal/val period, the SMAP SDS will distribute data products to the Data Centers
  - NSIDC will distribute Radiometer Level 1 Products as well as Level 2, Level 3 and Level 4 Products will appear at NSIDC
  - ASF will distribute Radar Level 1 Products
- During the cal/val period, access to a special distribution site at the Data Centers will be restricted to SMAP Cal/Val partners
  - Site will be password protected
- Level 1 Products will become available to general public at 6 months after launch
  - At that time, the Level 1 products will only be available at the public site
  - Level 2, Level 3 and Level 4 products will continue to be available at the restricted, password protected site
- Level 2 through 4 Products will become available to the general public at 9 months after launch
  - At that time, all products will be available at the public site

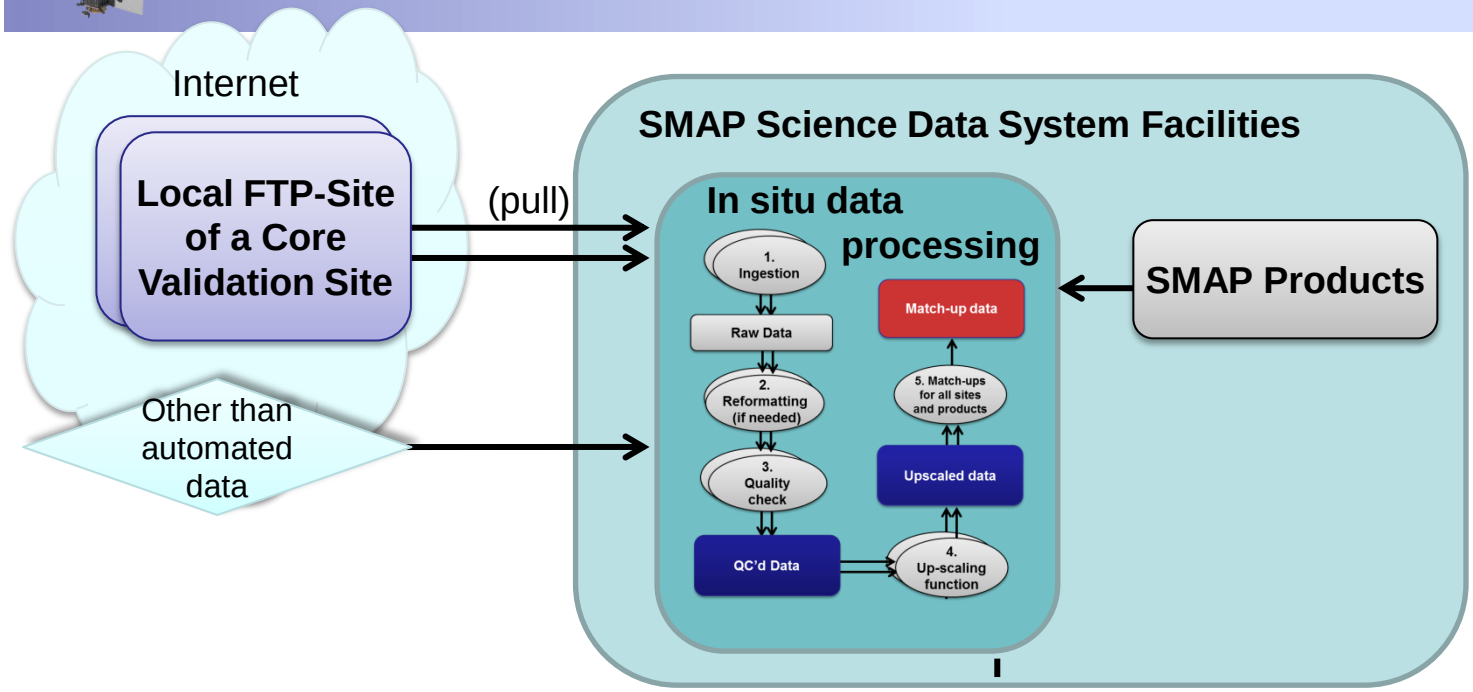
(Source: Barry Weiss)

Provision of Calibration Data

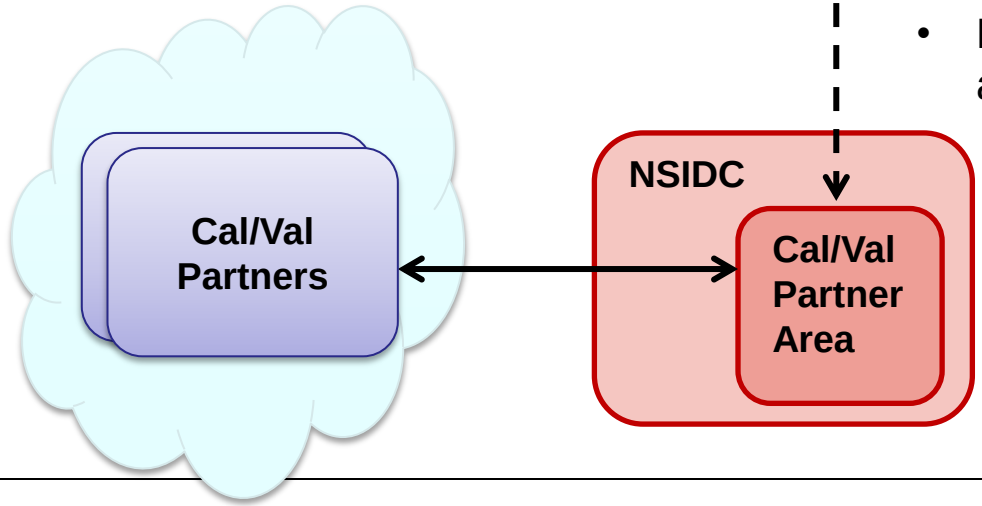
- Data Centers will also provide additional materials for Cal/Val Partners
- These will include:
  - Matchup results
  - Cal/Val reports and analyses
- Details are TBD

(Source: Barry Weiss)

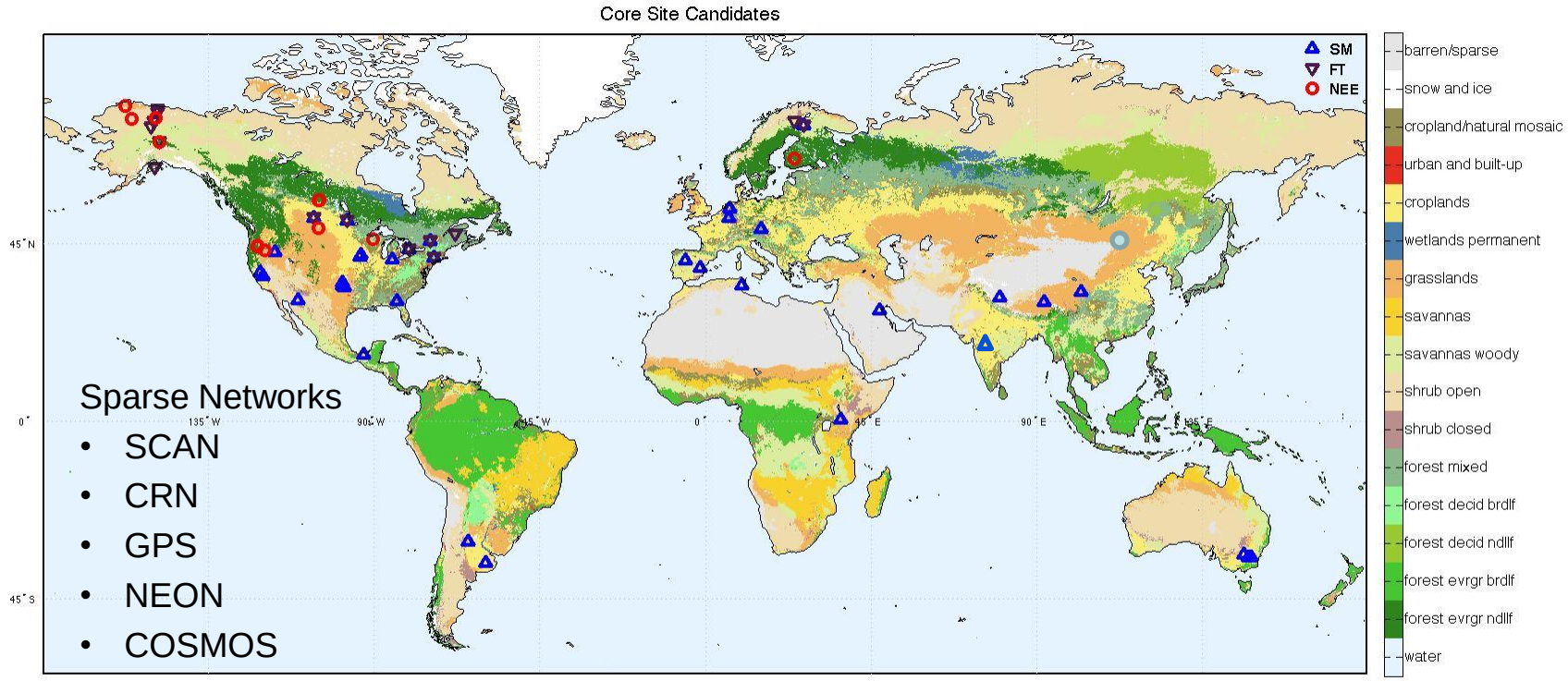
In situ cal/val data flow



- Match-ups between SMAP products and reference pixels



SMAP Core Validation Site Candidates

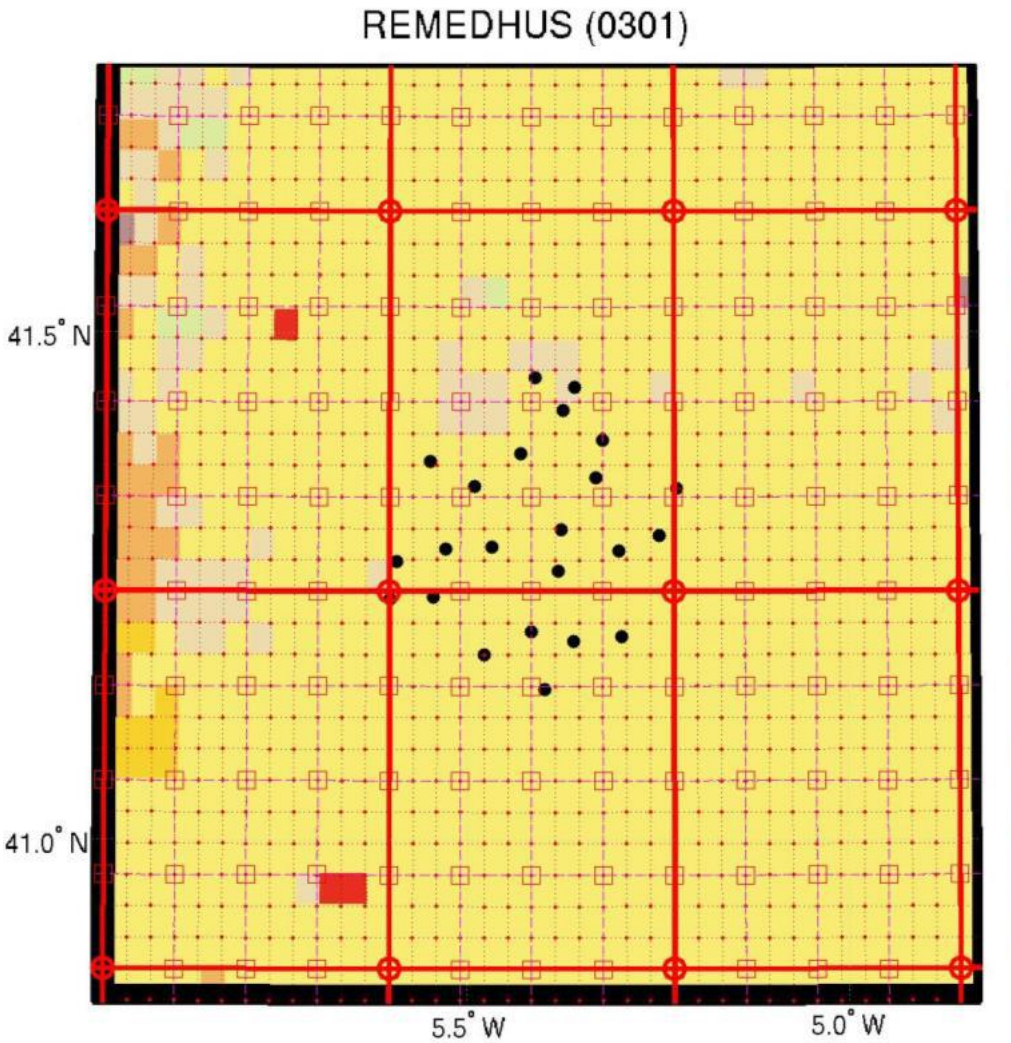


Ongoing efforts to formally engage more Partners.

We ❤ Cal/Val Partners

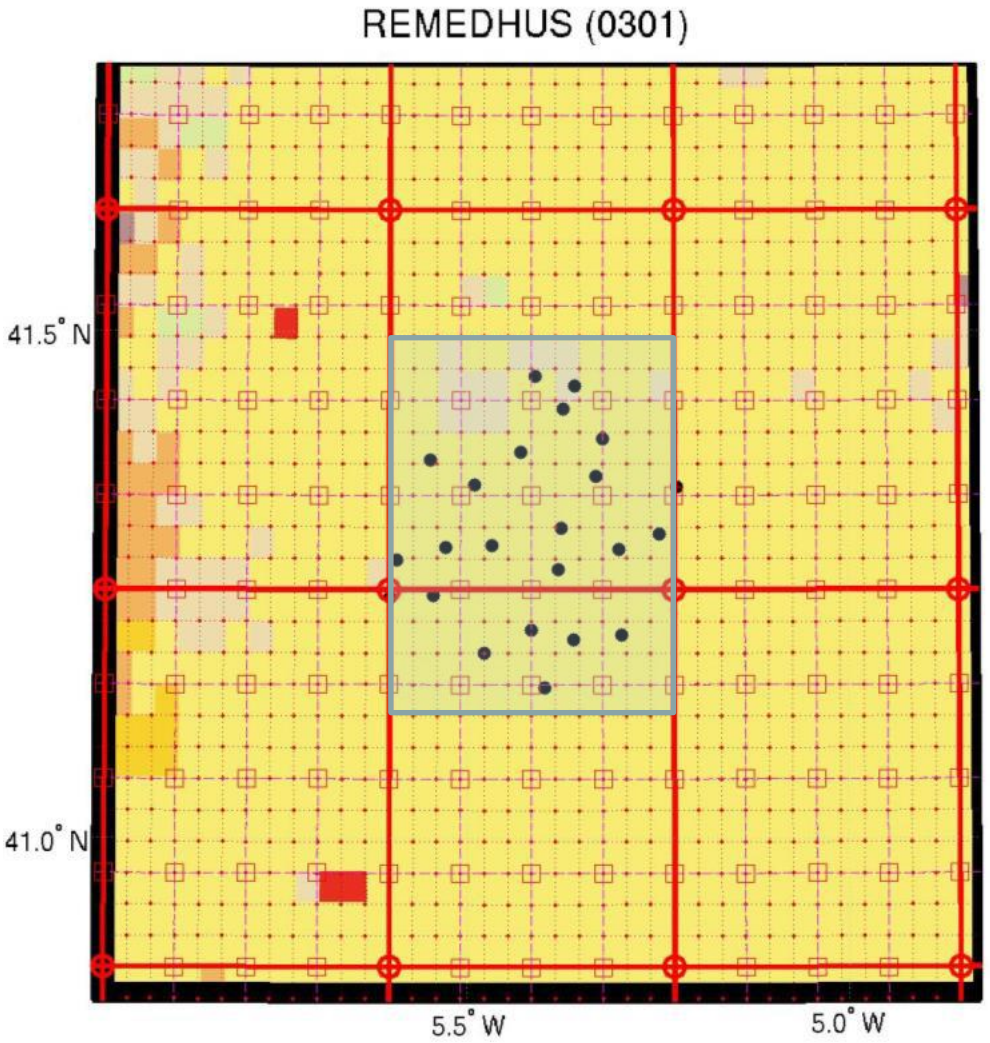
- In situ data are critical in the assessment of products
- This comparison provides error estimates and a basis for modifying algorithms and/or parameters
- We want to believe that the scaled soil moisture provided from each site is close to the true average 0-5 cm soil moisture (or other variable)
- What convinces us? Evidence that
  - *Sensors are calibrated*
  - *Relationship established between the sensor measurement and the satellite reference (i.e. 0-5 cm soil moisture)*
  - *A reasonable basis for the scaling function (i.e. n is large)*
- If we are convinced of the above, the cause of the difference can be assumed to be in the satellite retrieval (not the in situ) and is the basis for making adjustments.
- Comments
  - *Core Validation Sites and Scaling*
  - *Field Campaigns*

Core Validation Sites and Scaling (1/4)



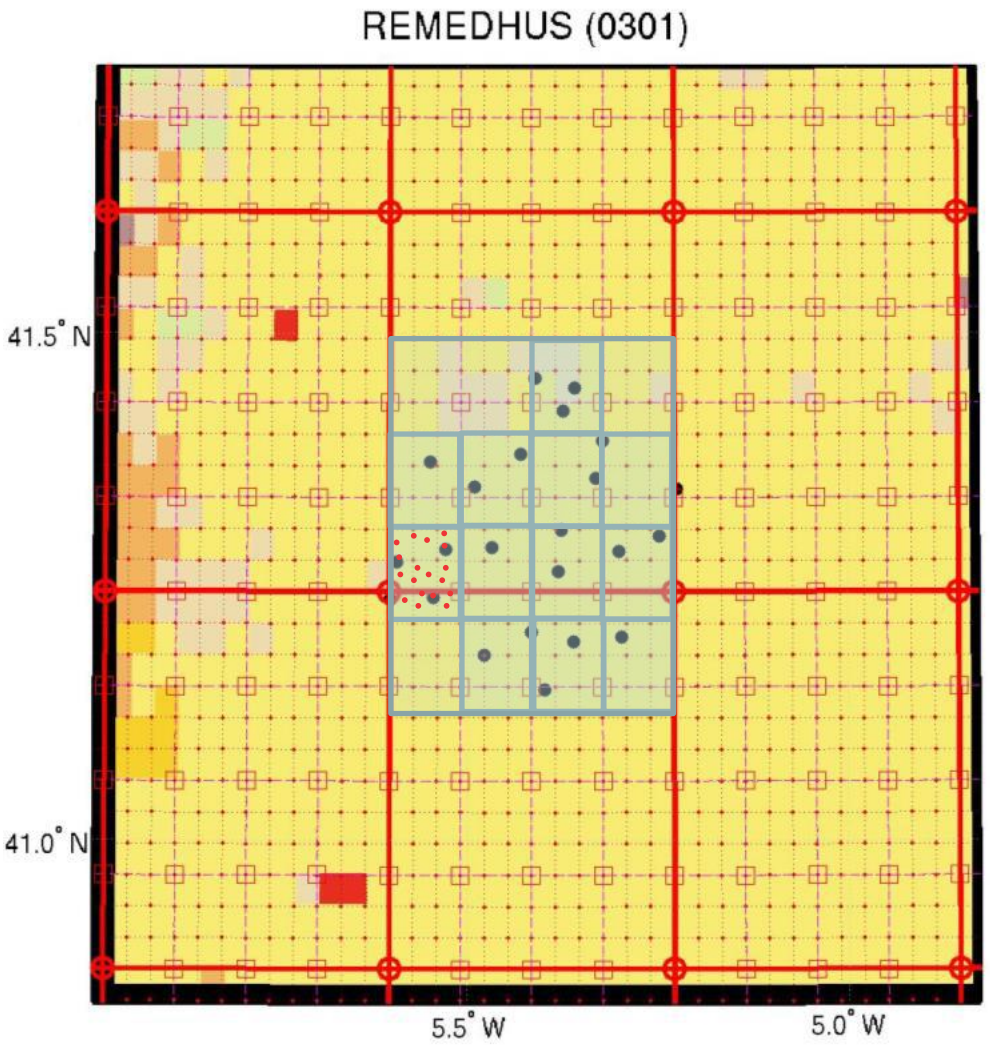
- We have a good set of sites to support the validation of the 36 km product using standard statistical methods (N large).
- In most cases, the distribution of the points at a site does not match the grid products.
- Rather than have poorly distributed and small (N) data sets, we decided to shift the grid … just for validation.

Core Validation Sites and Scaling (2/4)



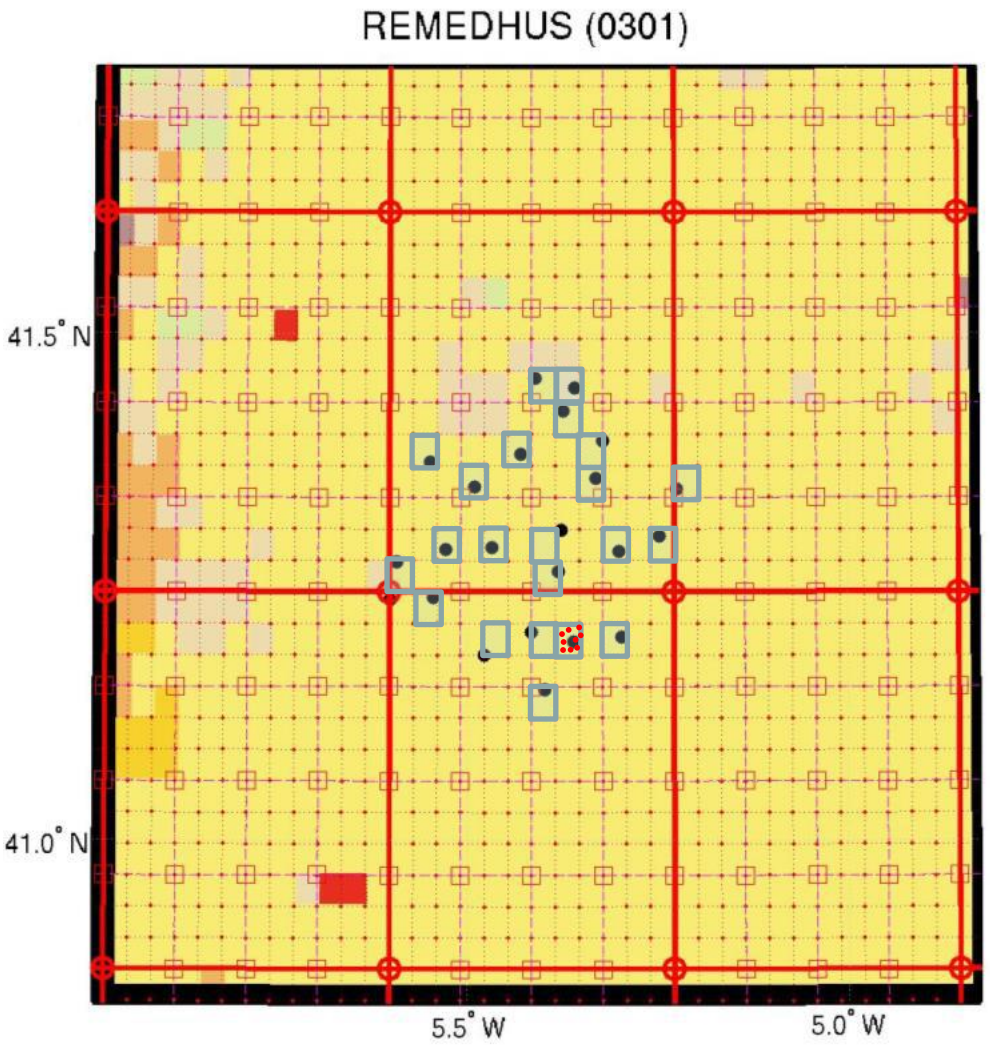
- We have a good set of sites to support the validation of the 36 km product using standard statistical methods (N large).
- In most cases, the distribution of the points at a site does not match the grid products.
- Rather than have poorly distributed and small (N) data sets, we decided to shift the grid … just for validation.
- In most cases, the average of these points will provide a statistically significant estimate of the surface soil moisture.
  - *I would then be confident in challenging the algorithm product if they do not match up.*
- Not all sites will look this good!
- New challenge: higher resolution products.

Core Validation Sites and Scaling (3/4)



- New challenge: higher resolution products.
- For the 9 km product there are fewer sites with enough points to support a standard statistical analyses.
- Some options
  - *Ignore: 1 or two points in a grid cell is just fine!*
  - *Up-scale*
    - Model
    - Field campaigns combined with temporal stability (Focus on a subset of grids?)

Core Validation Sites and Scaling (4/4)

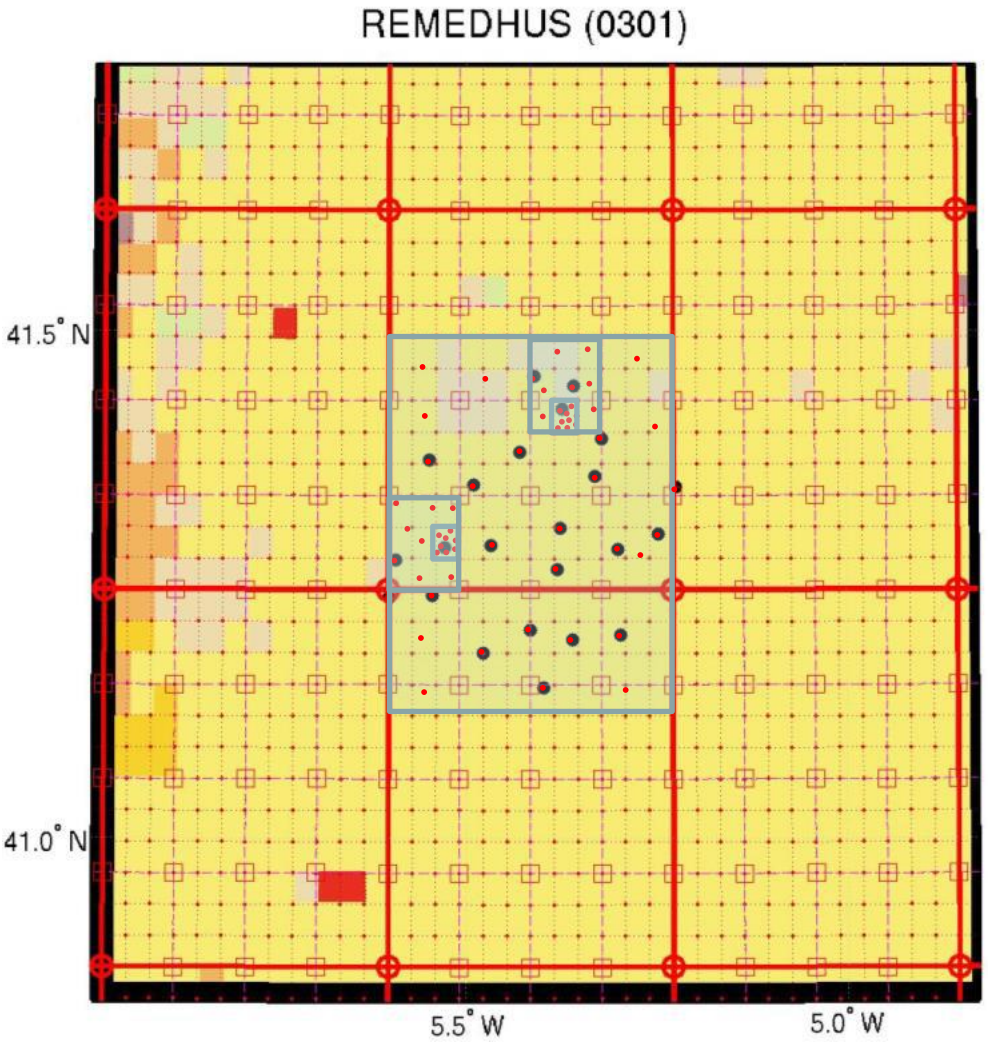


- New challenge: higher resolution products.
- For the 3 km product there are very few sites with enough points to support a standard statistical analyses.
- Some options
  - *Ignore: 1 point in a grid cell is just fine! (But we have lots of them)*
  - *Up-scale*
    - Model
    - Field campaigns combined with temporal stability (Focus on a subset of grids?)

We ❤ Cal/Val Partners

- Our confidence in your data will depend on the quality of the calibration, representation, and up-scaling.
- Some CV Partners have addressed this in their research programs; however, even the most comprehensive have not considered all the elements and scales (except Yanco!).
- One way to address this is with field experiments.

How Would I Design a Campaign?



- Attempt to satisfy all 3 products (if site is large enough)
- Link to gravimetric sampling of the 0-5 cm layer.
- Example
  - *2: 3 km grids (9 each = 18)*
  - *2: 9 km grids ((9 + 8) each = 34)*
  - *1: 36 km grid (34 + 17 + 9 = 60)*
    - Includes sampling at each station for calibration
- How long would it take?
  - *Assume 4 teams: 4 hours*
- Duration
  - *2/week for 8 weeks*
- Pre- or Post-launch?
- What do we want?
  - More points with higher uncertainty
  - Fewer well characterized and reliable points

CV Partners Presentations

- Requested the following set of slides (and no more). (Posters available)

Slide	Content
1.	*Title, Team, Affiliations, Define Acronyms*
2.	*SMAP Grid Cell and station map (Andreas will provide)*
3.	*Photos of landscape and/or stations*
4.	*Approach to calibration (Minimum: i.e.I believe the manufacturer)*
5.	*Approach to representing the SMAP product (Minimum: i.e. for 0-5 cm SM; I believe that the sensor installed at 5 cm depth provides a good estimate of the 0-5 cm SM)*
6.	*Approach to up-scaling for SMAP products (For SM; 36, 9, and 3 km) (Minimum: Our n points can be averaged)*
7.	*Your thoughts on pre-launch field campaigns (ground-based only) that would improve the items in slides 4, 5 and 6.*

Cal/Val Workshop Agenda-Day 1

Tuesday (November 5)		
0800	Welcome and Overview of Workshop	Jackson
0830	SMAP Project Status	Kellogg/Yueh/Entekhabi
	Phase 1 Cal/Val Rehearsal	*Jackson (Lead)*
0900	Cal/Val Timeline and Overview of Approach	Jackson
0915	Review of Activities	Colliander
1000	*Break*	
	Reports from Algorithm Leads on Rehearsal 1	Njoku
1015	L2/L3_SM_P	Chan
1035	L2/L3_SM_AP	Das
1050	L2/L3_SM_A	Kim
1105	L4_SM	Reichle
1120	L4_C	Yi
1135	*Lunch*	
	Reports from Cal/Val Partners	Jackson
1245	Feedback to Cal/Val Partners from Rehearsal	
1300	USDA Watersheds	Cosh/Seyfried
1320	Tonzi Ranch (CA)	Moghaddam
1335	Valencia (ES)	Lopez-Baeza
1350	Mexico	Hernández
1405	FMI (FI)	Ryyppo
1420	Winnipeg SM (CA)	McNairn
1435	Saskatchewan SM (CA)	Berg
1450	*Break*	
1505	Twente Watershed (NL) and Tibet Sites	Su
1520	CREST (NY)	Lakhankar
1535	EURAC (IT)	Notarnicola
1550	OCO-2 Cal/Val Site	Schwandner
1605	GPS Network	Small
1620	Lessons Learned Discussion	Colliander/Jackson
~~1700~~	~~*End*~~	

Phase 1 Rehearsal and CV Partners

- Overall, we were very pleased with the SMAP Phase 1 Rehearsal. We were able to demonstrate that we could acquire and process in situ data and conduct meaningful analyses.
- As we expected, the exercise also revealed some things that needed improvement before the actual SMAP Cal/Val Phase (hopefully before the Phase 2 Rehearsal).
- From the SMAP side of the program, we will continue to acquire data and finish integrating the data sets that were not ready for Phase 1. Our goal is to complete this as soon as possible with a deadline of the start of Phase 2.
  - *If we are unable to fully integrate a site by this time it will likely not be used in the SMAP CV Phase of the program. As we have learned from our recent activities, there are a number of labor and time intensive activities associated with this process and we will not have these available post-launch. So, we will be pressing to resolve these issues soon.*

Message to ADT

- In situ data are one of several methodologies used for assessment of products
- Comparisons of in situ and algorithm products provides error estimates and a basis for modifying algorithms and/or parameters
- If we are convinced that the in situ data is reliable, the cause of the difference can be assumed to be in the satellite retrieval
- You can’t cherry-pick data; the basis for using or rejecting in situ data must be established a priori and not after comparison

Next Activities

- What needs to be done with CV Partners
  1. *MOU*
  2. *Test data set evaluation by SMAP*
  3. *Data transfer operational*
  4. *QC of individual sites*
  5. *Rehearsal feedback and action*
  6. *Calibration*
  7. *Referencing to satellite measurement*
  8. *Scaling for multiple resolutions*
  9. ***Field experiments***
- Sites must participate in Phase 2 Rehearsal if they are to qualify as CVS. (Will remain Supplemental)
- Begin the process of CVS selection from candidates
- Making sense of statistical CV and Triple co-location
  - *Sparse*
  - *Core*
  - *Satellite and model products*
- What can we tolerate in terms of latency?
- Between now and Phase 2
  - *ADT and CV Partners-continue to add and advance sites*
  - *CV Partners: address the issues of calibration, referencing, and scaling.*
  - *Field campaigns?*