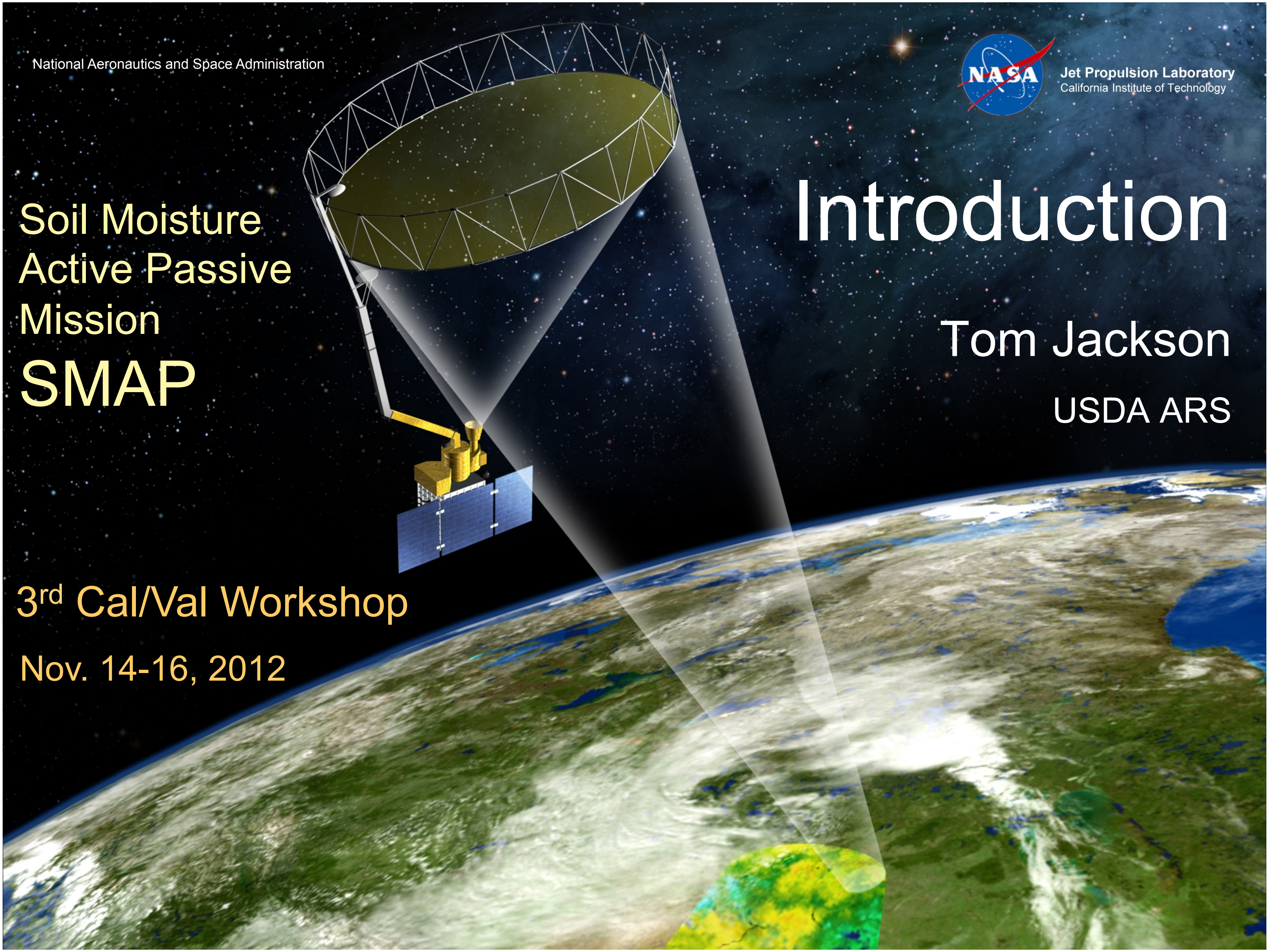
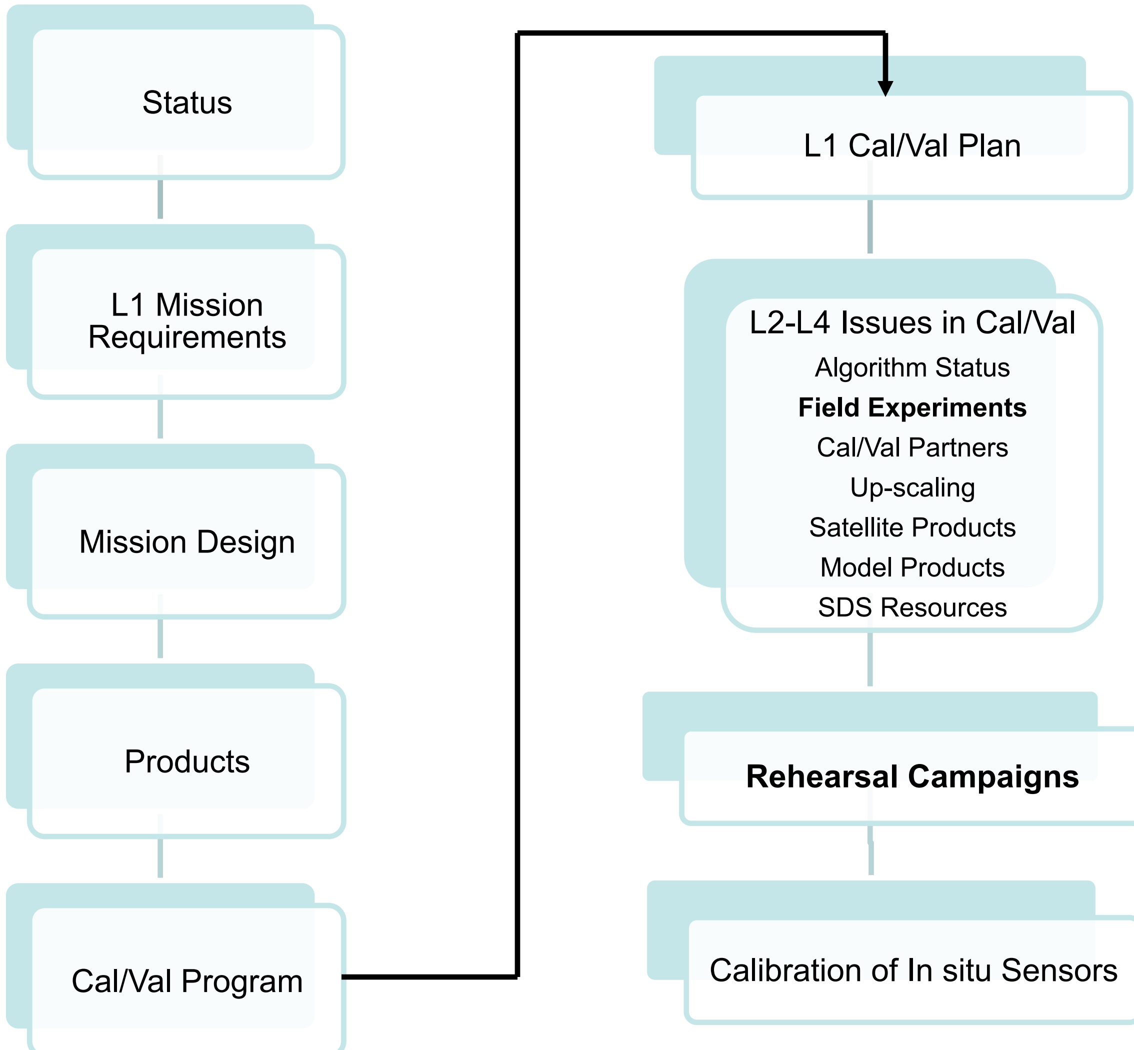

National Aeronautics and Space Administration
NASA
Jet Propulsion Laboratory
California Institute of Technology
Soil Moisture
Active Passive
Mission
SMAP
Introduction
Tom Jackson
USDA ARS
3rd Cal/Val Workshop
Nov. 14-16, 2012

3rd SMAP Cal/Val Workshop

- Logistics (Register, release form, posters,....)
- Review the SMAP Cal/Val Plan and specific issues that benefit from the input of the Cal/Val Working Group
  - *SMAP Project (SDS, ADT), SDT, Cal/Val Partners, and collaborating scientists*
- Launch 10/14
- Cal/Val Plan has matured and survived a project review
- Progress has been made on several important Cal/Val issues
  - *In situ calibration, Cal/Val Partners, and up-scaling*
- Transitioning from pre- to post-launch concerns
  - *New issues included 2015 field campaign and Cal/Val readiness*

Workshop Overview



Cal/Val Workshop Agenda-Day 1

Wednesday (November 14)		
0815	Welcome and Overview of Workshop	Jackson
0830	SMAP Project Status	Kellogg/Njoku
0900	SMAP Cal/Val Plan and Project Review	Jackson/Njoku
0945	*Break*	
	L1 Products	*Spencer (Lead)*
1000	Overview of Approach	Spencer
1015	Radiometer	Kim/Piepmeier
1045	Radar	West/Spencer
1115	ESA Dome-C Plans	Skou
1125	Discussion (and short presentations)	Spencer/Colliander
1200	*Lunch*	
	L2-L4 Products	
1300	Algorithm Status Overview	O'Neill/Moghaddam
	Field Experiments and Instruments	*Jackson (Lead)*
1330	SMAPEx	Walker
1400	SMAPVEX12	McNairn/Colliander/Kim/Jackson
1500	*Break*	
1515	ComRAD	O'Neill
1530	AirMOSS	Moghaddam
1545	Discussion: Future Campaigns and SMAPVEX15	Jackson
1700	*End*	

Cal/Val Workshop Agenda-Day 2

Thursday (November 15)		
0815	Cal/Val Partners Status Report	Jackson
0915	Posters and Break	
	Implementing Sparse Networks in Validation	*Crow (Lead)*
1000	Sparse Network Up-Scaling	Crow
1030	Discussion: How to Implement in Validation?	Crow
	Satellite Validation Updates	*Njoku (Lead)*
1045	SMOS	Kerr/Walker
1100	SAOCOM	Thibeault
1115	Aquarius	Le Vine
1130	Satellite Products in SMAP Validation	Bindlish
1215	*Lunch*	
1315	Model-based Products in Validation	Reichle
1400	SMAP SDS Resources for Data Product Validation	Weiss/Cruz/Cuddy
1445	Break	
1500	***Validation Rehearsal Discussion and Planning***	***Jackson (Lead)***
1700	*End*	

Cal/Val Workshop Agenda-Day 3

Friday (November 16)		
	Calibration and Scaling of In Situ Resources	***Cosh (Lead)***
0815	MOISST	Cosh
0840	GPS	Small
0850	CRN	Bell
0900	COSMOS	Zreda
0915	COSMOS Rover/SMAPVEX11	Ochsner
0930	Discussion: Lessons Learned and Implementation	Cosh
1015	*Break*	
1030	Breakout Sessions	
1130	Workshop Issues, Actions, and Summary	Njoku
1200	*End*	

- This is a workshop and not a conference. We want your input!

SMAP Project Status

- Kent/Eni
- 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

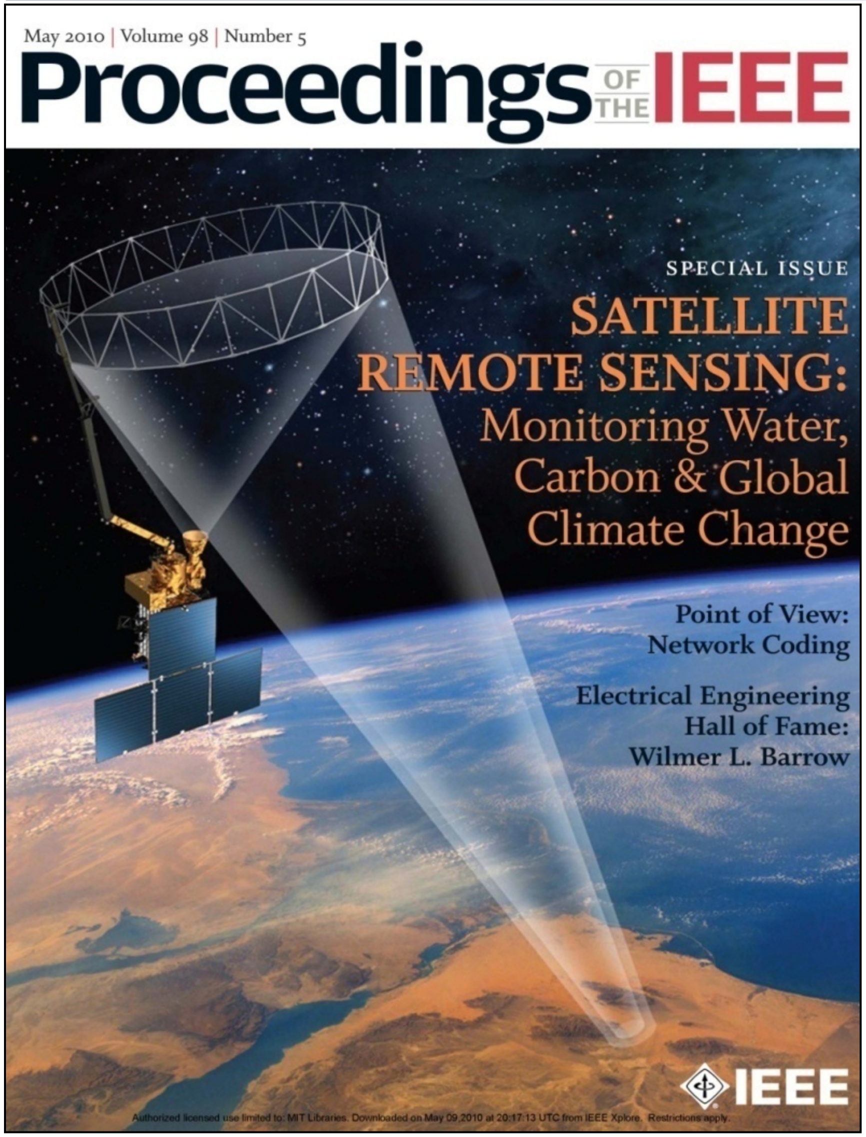
- The NSF Decadal Survey identified numerous potential applications for SM/FT observations.
- These were grouped into three categories with a spatial resolution, refresh rate, and accuracy.

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.
  - *Accuracy is based on the average over all sites meeting core site requirements over the full period of record.*
- The SMAP Project proposed the active-passive approach for meeting these requirements.

SMAP Project Approach



- L-band unfocused SAR and radiometer system, offset-fed 6 m light-weight deployable mesh reflector. Shared feed for
  - 1.26 GHz HH, VV, HV
    <u>Radar</u> at 1-3 km (30% nadir gap)
  - 1.4 GHz H, V, 3rd and 4th Stokes
    <u>Radiometer</u> at 40 km
- Conical scan, fixed incidence angle (40°) across swath
- Contiguous 1000 km swath with 2-3 days revisit (8 day repeat)
- Sun-synchronous 6am/6pm orbit (680 km)
- Launch October 20, 2014 (now in Phase C/D)
- Mission duration 3 years

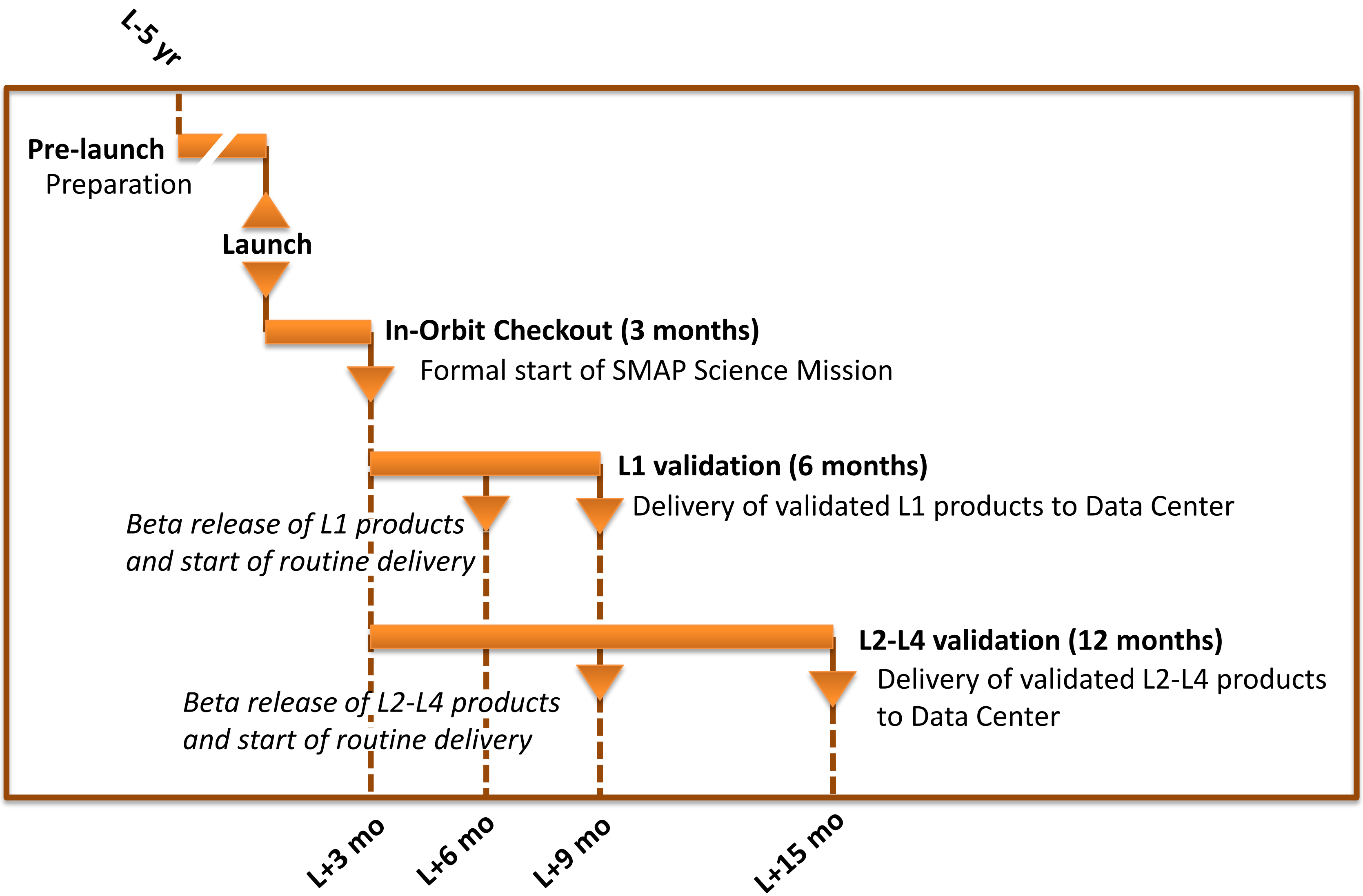
SMAP Science Products

Product	Description	Gridding (Resolution)	Latency**	
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	

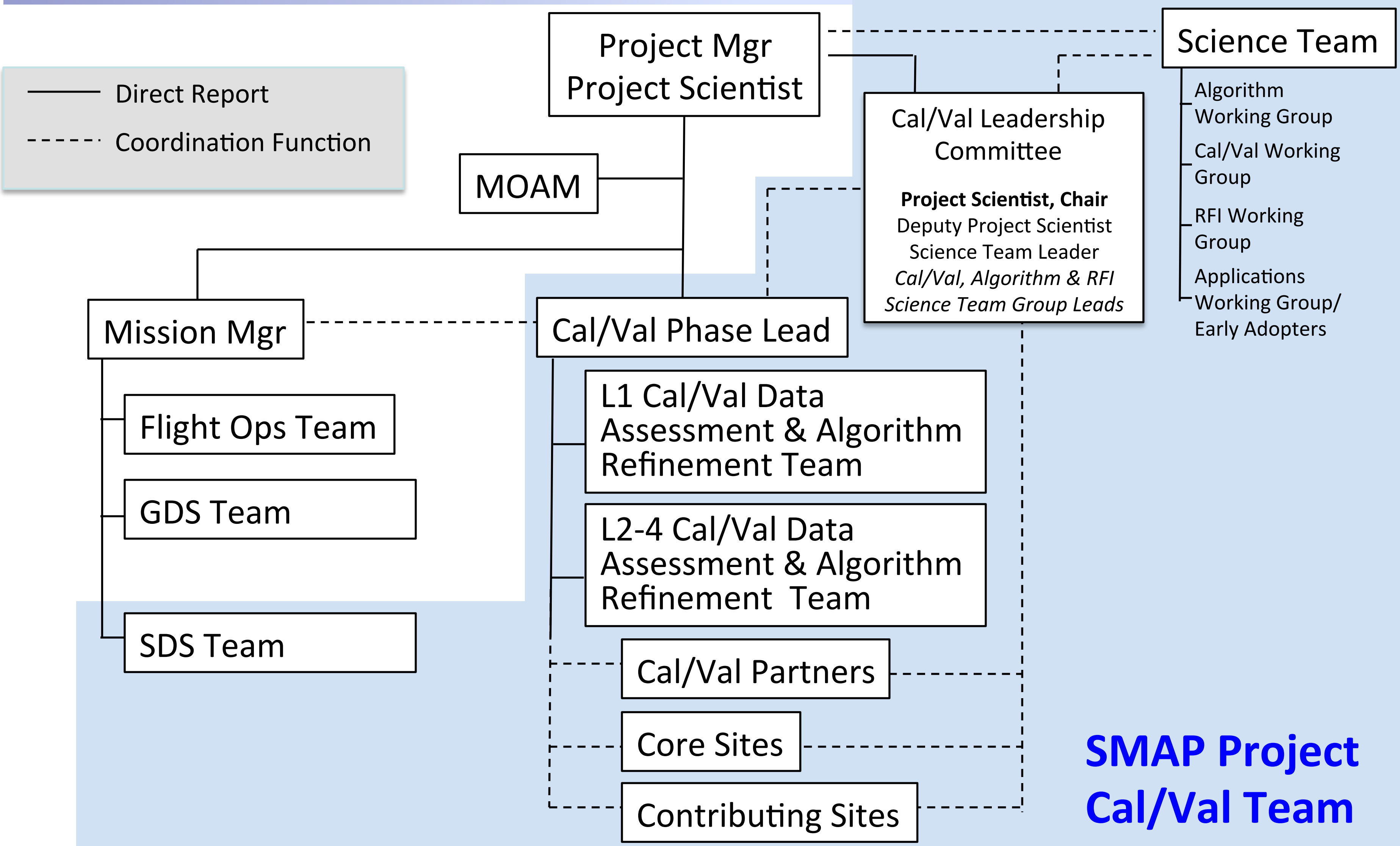
* Over outer 70% of swath.

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

Science Data Validation and Delivery Timeline



Commissioning Cal/Val Organization
(will transition 12-6 months before launch)



SMAP Cal/Val Plan

- Documents
  - *SMAP Science Cal/Val Plan*
  - *L1 Data Products Cal/Val Plan*
  - *L2-L4 Data Products Cal/Val Plan*
- Definitions
- Approach
- Deliverables
- Lessons Learned
- Methodologies

CEOS Cal/Val Definitions

Calibration

- The process of quantitatively defining the system responses, under specified conditions, to known, controlled signal inputs. The result of a calibration permits either the assignment of values of measurands to the system output or the determination of corrections with respect to the system output.

Validation

- The process of assessing, by independent means, the quality of the data products derived from the system outputs. The quality is determined with respect to the specified requirements.

http://www.ceos.org/index.php?option=com_content&view=category&layout=blog&id=75&Itemid=113

NASA Earth Science Data Maturity Levels

Beta

- Products intended to enable users to gain familiarity with the parameters and the data formats.

Provisional

- Product was defined to facilitate data exploration and process studies that do not require rigorous validation. These data are partially validated and improvements are continuing; quality may not be optimal since validation and quality assurance are ongoing.

Validated

- Products are high quality data that have been fully validated and quality checked, and that are deemed suitable for systematic studies such as climate change, as well as for shorter term, process studies. These are publication quality data with well-defined uncertainties, but they are also subject to continuing validation, quality assurance, and further improvements in subsequent versions. Users are expected to be familiar with quality summaries of all data before publication of results; when in doubt, contact the appropriate instrument team. Four stages to be described later.

CEOS Validation Stages Adopted for SMAP

Validation: The process of assessing, by independent means, the quality of the data products derived from the system outputs. The quality is determined with respect to the specified requirements.

Validation Stage	Description
Stage 1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with *in situ* or other suitable reference data.
Stage 2	Product accuracy is estimated over a significant set of locations and time periods by comparison with reference *in situ* or other suitable reference data. *Spatial and temporal consistency of the product and with similar products have been evaluated over globally representative locations and time periods.* Results are published in the peer-reviewed literature.
Stage 3	Uncertainties in the product and its associated structure are well quantified from comparison with reference *in situ* or other suitable reference data. *Uncertainties are characterized in a statistically robust way over multiple locations and time periods representing global conditions.* Spatial and temporal consistency of the product and with similar products have been evaluated over globally representative locations and periods. Results are published in the peer-reviewed literature.
Stage 4	Validation results for stage 3 are *systematically updated* when new product versions are released and as the time-series expands.

SMAP Cal/Val Approach

Pre-launch

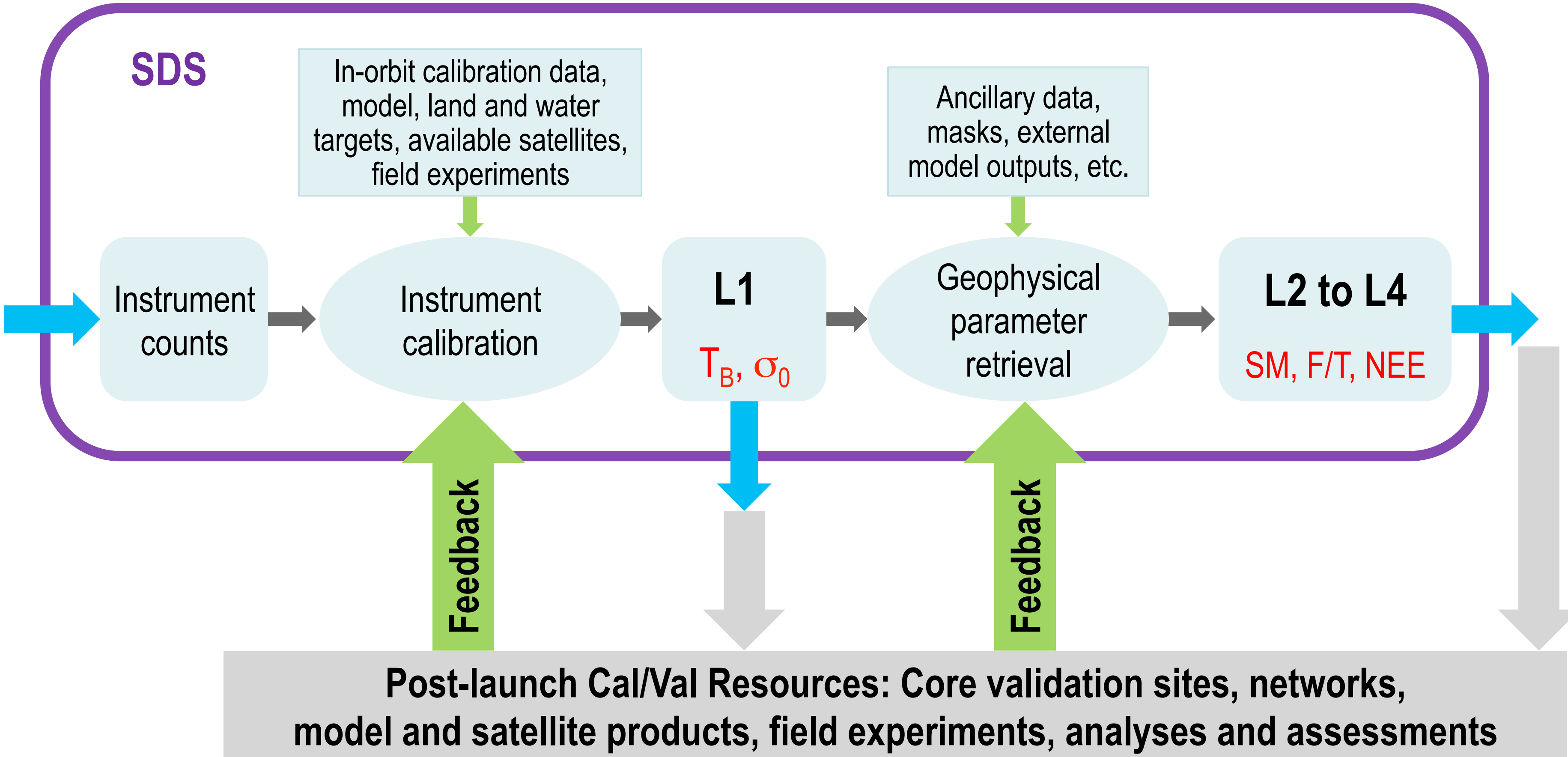
- Focus on insuring that there are means in place to fulfill the mission objectives
  - *Acquire and process data with which to calibrate, test, and improve models and algorithms used for retrieving SMAP science data products*
  - *Develop and test the infrastructure and protocols for post-launch validation*

Post-launch

- Focus on 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



SMAP Cal/Val Deliverables

- SMAP Science Cal/Val Plan, and
  - *L1 Data Products Cal/Val Plan*
  - *L2-L4 Data Products Cal/Val Plan*
- Cal/Val Workshop Reports
- Field Campaign Plans
- Cal/Val Reports documenting data acquired, processing and analysis performed, results, algorithm enhancements, and quality assessments
- Improved L1-L4 product algorithms based on Cal/Val analyses
- Beta and Validated data products for delivery to the DAACs
- Beta and Validation reports accompanying release of each level of SMAP data products to the DAACs (Levels 1-4)

Cal/Val Lessons Learned: SMOS, Aquarius, Aqua, and GCOM-W (1/3)

- Calibration teams should consider the **full range of response** of the instrument and recognize that data may be used for other applications (specifically, both land and ocean studies).
- **External calibration** targets can play an important role; however there are very few that are unambiguous. Recent results over Antarctica by SMOS and Aquarius should be exploited.
- **Cross calibration** of L1 mission products from different instruments / satellites is worthwhile -- the mission team should work to resolve any issues as early as possible.

Cal/Val Lessons Learned: SMOS, Aquarius, Aqua, and GCOM-W (2/3)

- **In situ resources** are one of the most valuable Cal/Val methodologies; however, issues in data quality and latency must be resolved before launch or shortly after.
  - *The presence of RFI over an in situ site makes it useless in Cal/Val assessment. Preliminary screening with SMOS and aircraft observations would reduce the probability of this occurring. Also, having more sites in diverse locations is desired.*
  - *Dealing with specific site instrument and scaling issues post-launch introduces delays and uncertainty into the Cal/Val assessment. These must be addressed pre-launch through rehearsal campaigns.*
  - *Informal arrangements for providing Cal/Val data can result in latency and standardization problems, which impact Cal/Val assessment.*
  - *Well-characterized dense networks covering a footprint/grid are more valuable than single points.*
  - *When sparse (single point) network data are available, analyses tend to "cherry-pick" without rigorous assessment. Assessments should be conducted pre-launch to qualify/disqualify sites and establish scaling methodologies.*

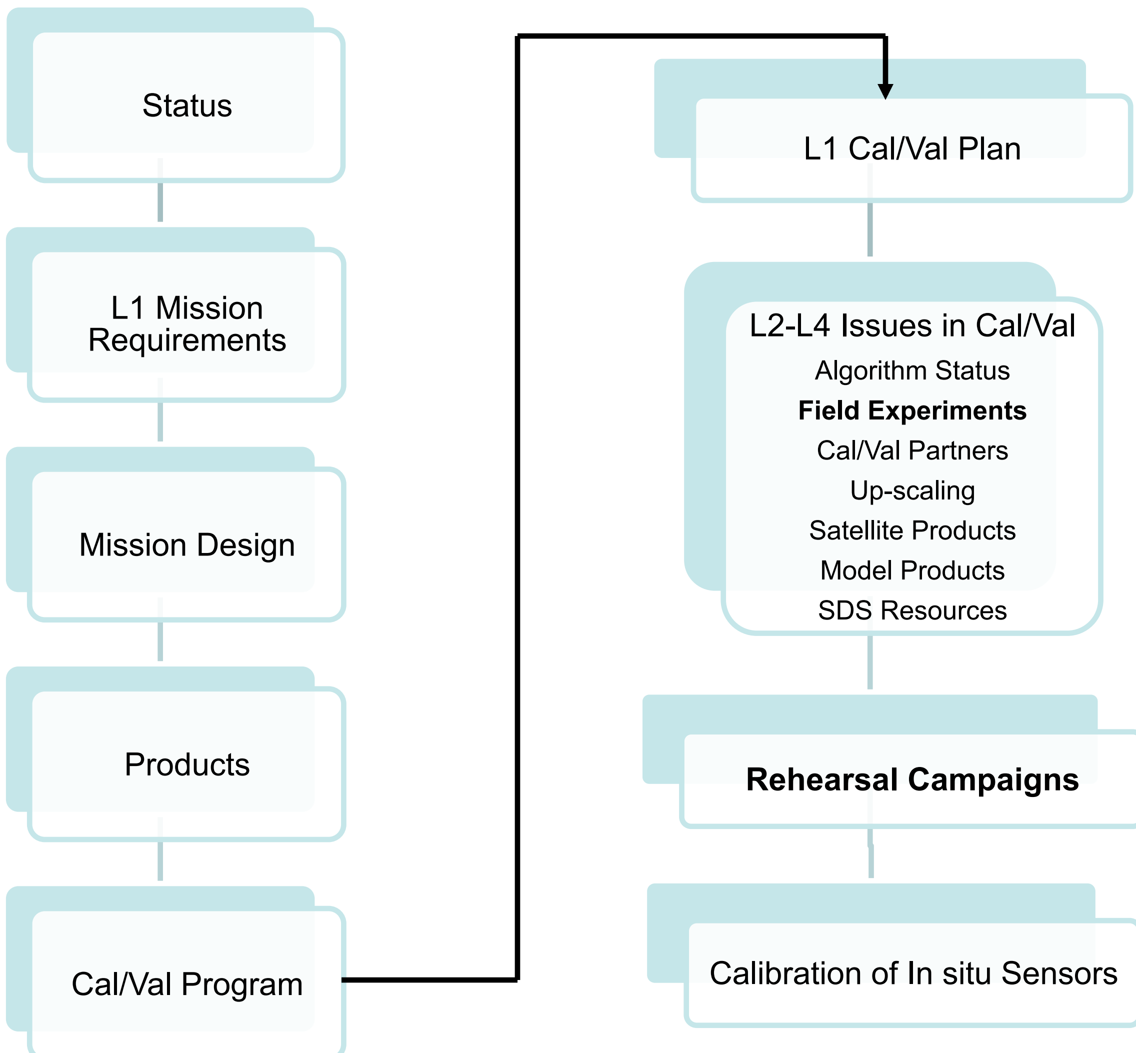
Cal/Val Lessons Learned: SMOS, Aquarius, Aqua, and GCOM-W (3/3)

- **Field campaigns** must be rigorously planned, utilize well-established aircraft instruments and sites, have a dedicated team, and be conducted early in the Post-launch Cal/Val phase if they are to be of value in the Cal/Val assessment.
- If mission data are in the public domain, independent teams will conduct assessments using their available resources. These can result in mixed messages on mission performance, especially early on when there is a limited time series and possible calibration changes. **Engaging these groups as Cal/Val partners** would broaden the scope of Cal/Val and minimize misinterpretation.
- **Comparison with L2/L3 products** from other instruments/satellites is a valuable methodology for Cal/Val assessment (assuming that these have been validated) because they provide a wide range of conditions. In addition, it is highly desirable that all products be integrated.
- **Value of rehearsals.**

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

Workshop Overview



Cal/Val Workshop Agenda-Day 1

Wednesday (November 14)		
0815	Welcome and Overview of Workshop	Jackson
0830	SMAP Project Status	Kellogg/Njoku
0900	SMAP Cal/Val Plan and Project Review	Jackson/Njoku
0945	*Break*	
	L1 Products	*Spencer (Lead)*
1000	Overview of Approach	Spencer
1015	Radiometer	Kim/Piepmeier
1045	Radar	West/Spencer
1115	ESA Dome-C Plans	Skou
1125	Discussion (and short presentations)	Spencer/Colliander
1200	*Lunch*	
	L2-L4 Products	
1300	Algorithm Status Overview	O’Neill/Moghaddam
	Field Experiments and Instruments	*Jackson (Lead)*
1330	SMAPEx	Walker
1400	SMAPVEX12	McNairn/Colliander/Kim/Jackson
1500	*Break*	
1515	ComRAD	O’Neill
1530	AirMOSS	Moghaddam
1545	Discussion: Future Campaigns and SMAPVEX15	Jackson
1700	*End*	