National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology

Soil Moisture Active Passive Mission

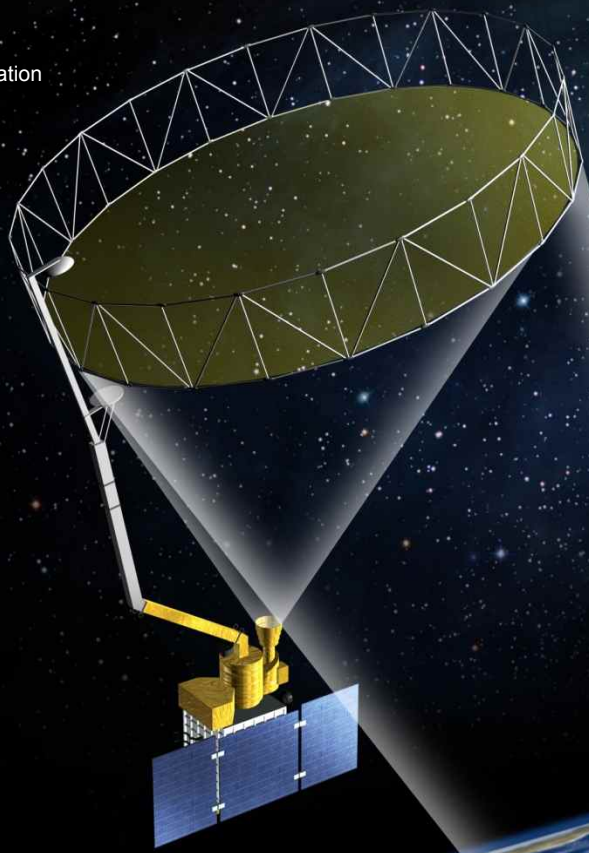
SMAP

Field Experiments

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

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
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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*	

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SMAPVEX12

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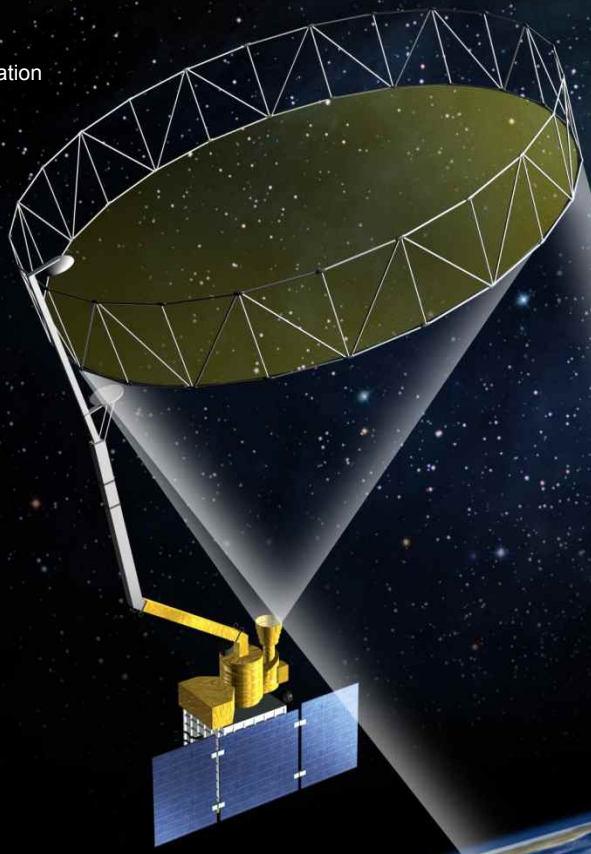

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SMAP Validation Experiment 2012 (SMAPVEX12)

- NASA/SMAP Goals and Overview (T. Jackson)
- Field Campaign Operations and Results (H. McNairn)
- PALS (A. Colliander)
- UAVSAR (S. Kim)
- Data Schedule and Archive Plan (H. McNairn/A. Colliander)
- Summary (T. Jackson)

SMAP Validation Experiment 2012 (SMAPVEX12)

- Collect observational data to support the development and validation of the SMAP active and passive soil moisture retrieval algorithms as well as process modeling and data assimilation methodologies
- SMAPVEX12 is the primary pre-launch field campaign of the SMAP mission
- SMAPVEX12 is conducted as a partnership between U.S. and Canada

SMAPVEX12 Specific Objectives

- Collect an extended times series of concurrent active and passive microwave observations
  - *Capture a wide range of soil moisture conditions*
  - *Observe a wide range of vegetation conditions that include the type of vegetation and growth stages*
  - *Multiple resolution observations for scaling*
- Find ways to better mitigate low-level RFI effects observed in North America
- Improve the parameterization of vegetation (and its water content)
- Inter-compare soil dielectric models
- Improve transient water body detection
- Establish an in situ Cal/Val site for SMAP post-launch validation

SMAPVEX12 Key Components

- PALS (Passive Active L-band System): JPL
  - *Provides concurrent observations of Active & Passive (AP) surface signatures for AP soil moisture algorithm*
- UAVSAR: JPL
  - *Provides high spatial resolution active data to enhance radar algorithm development and multiple scales needed for the AP algorithm*
- Soil Moisture
  - *~55 quarter-section (800 m by 800 m) sites*
- Vegetation
  - *6 crop types, grassland and forest*
  - *Crop conditions covered emergent to mature*
- Duration: 45 days

SMAPVEX12 Flight Plans and Ground Sites

- Plan included flights ~ 2.5 days
- PALS Flight lines
  - *Low altitude (4) covered the 55 fields at 400 m resolution to provide high quality data for both the passive and the active soil moisture algorithms,*
  - *High altitude (8) covered a 70 km by 12 km domain to support the AP algorithm and retrievals under heterogeneous vegetation.*
- UAVSAR Flight lines
  - *Matched the high altitude PALS domain to support the relative scales of SMAP*
  - *Provided high resolution observations of the 55 fields that were sampled.*
- Ground Soil Moisture-on all flight days
- Vegetation and roughness-multiple times over the campaign

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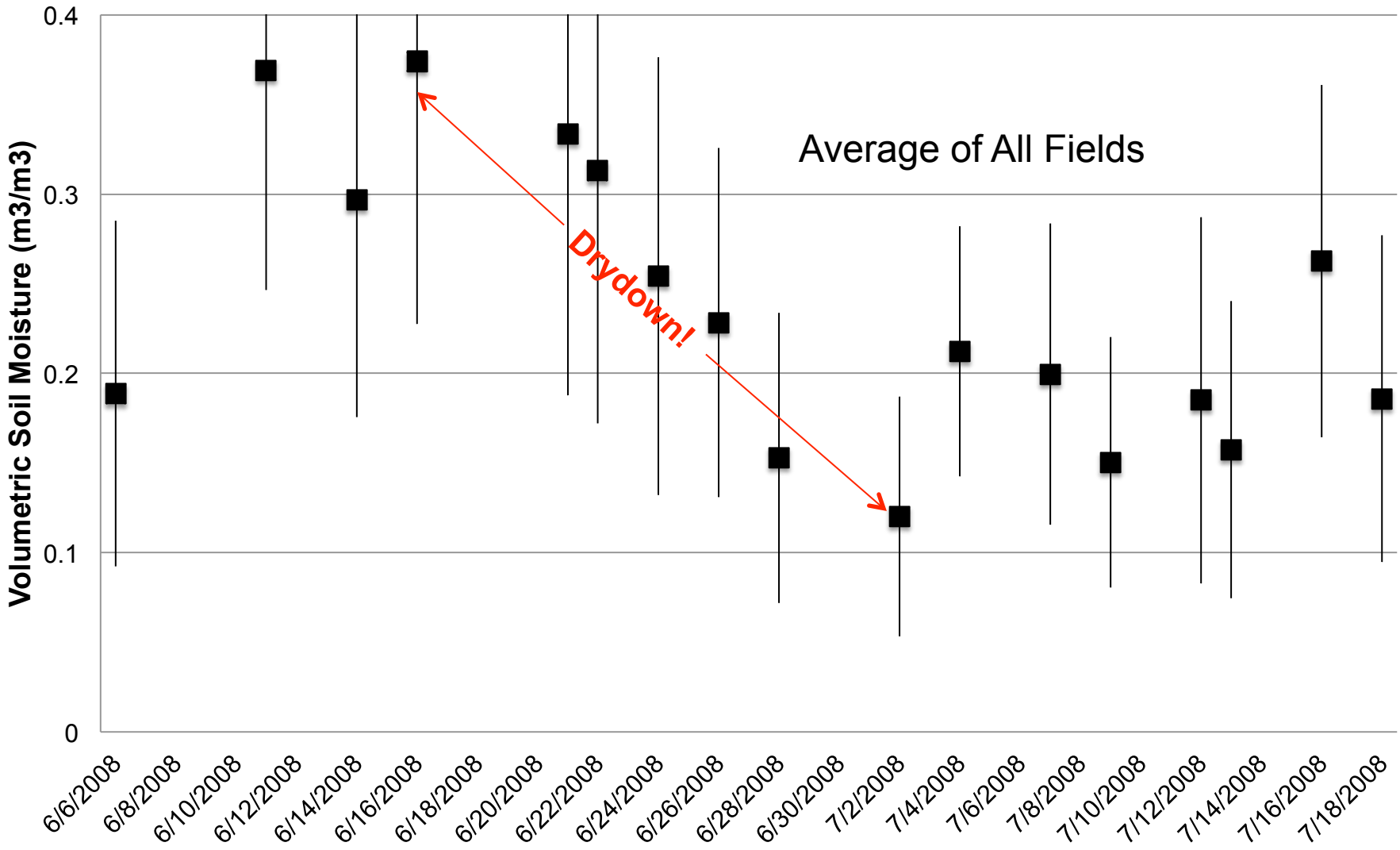
SMAPVEX12 Summary and Plans

- All SMAPVEX12 experiment objectives were satisfied including
  - *Observing a wide range of soil moisture conditions*
    - Bonus: Extended drydown
  - *Observing a wide range of vegetation types and vegetation water content levels*
    - Fortunately not located in the US Midwest!
- Dataset will provide a basis for the calibration and scaling of an in situ network that will support SMAP Cal/Val post launch
- Excellent aircraft and instrument performance
  - *No days lost due to repair!*
- Data still to be processed
  - *Archive being established*
  - *Workshops in March 2013 will focus on the campaign results*

SMAPVEX12 Soil Moisture Conditions



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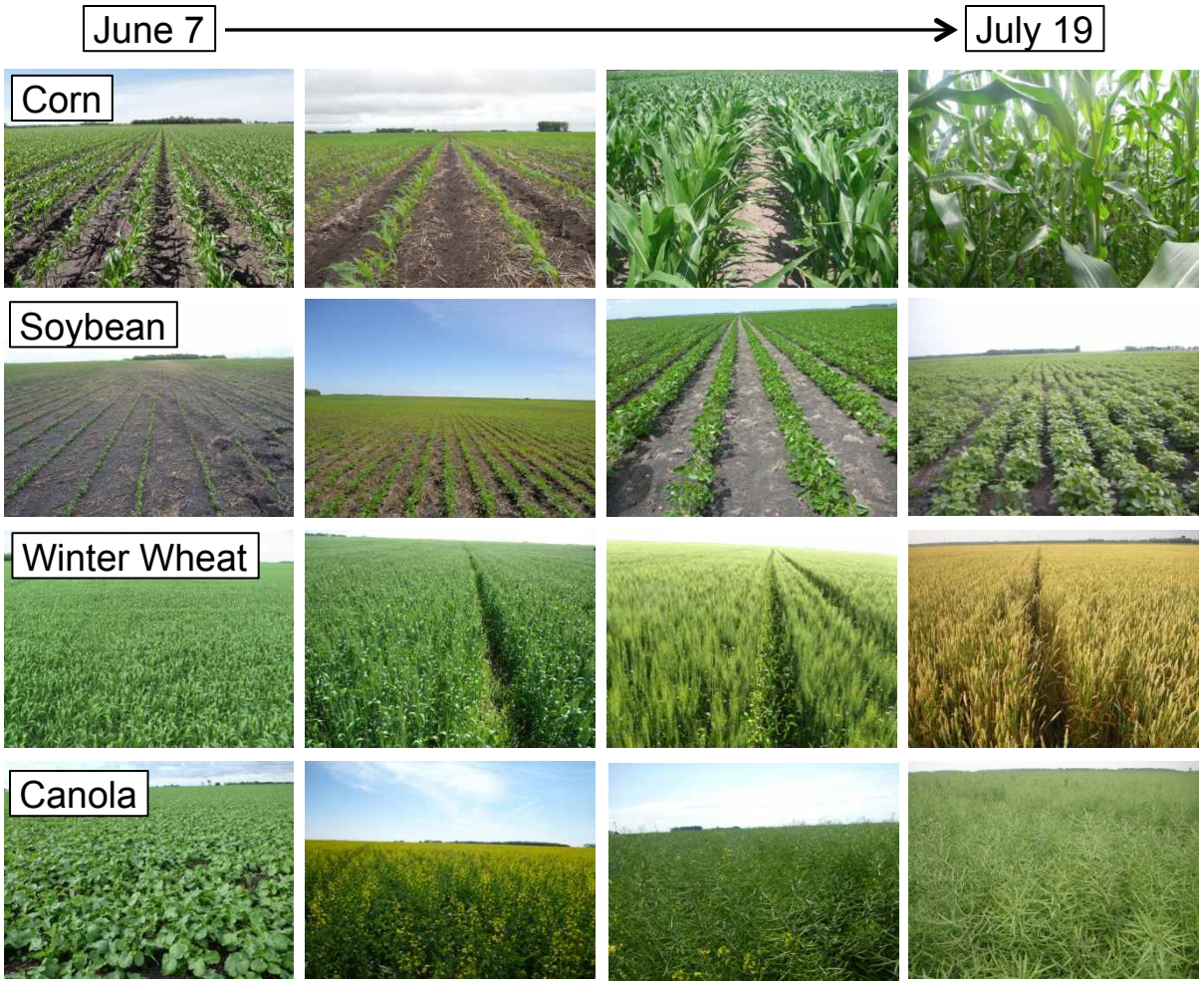

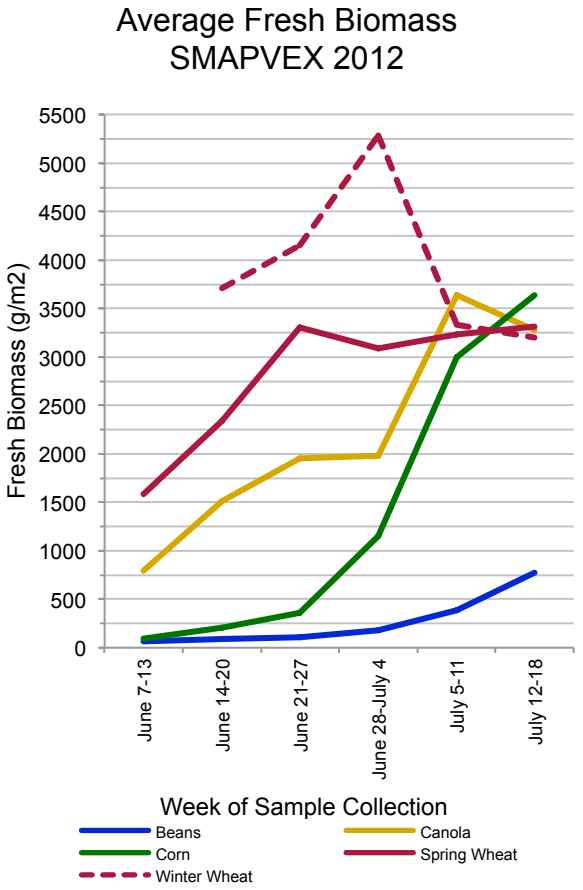

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SMAPVEX12 Summary of Data Acquisitions

Date (June-July)	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PALS																																												
UAVSAR																																												
Soil Moisture																																												
Vegetation																																												

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Soil Moisture
Active Passive
Mission

SMAP

SMAPVEX15

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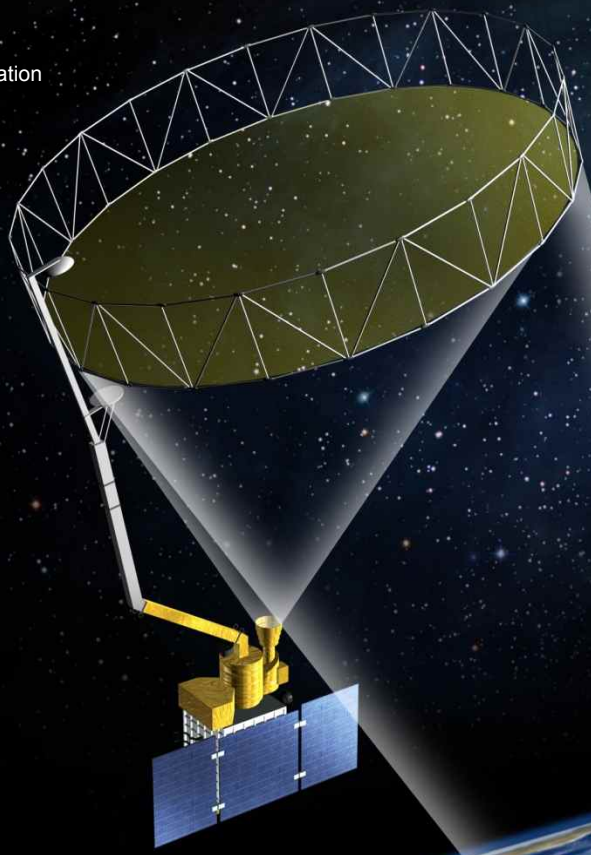

3rd Cal/Val Workshop

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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*

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

Post-Launch SMAPVEX15

- Objectives
  - Validation of L2 soil moisture and L3 freeze/thaw products
    - Scaling from field to SMAP footprint scale; assessment of heterogeneity, bias
  - Cal/Val of L1 radar and radiometer data and assessment of RFI
- Considerations
  - Availability of aircraft sensors/platforms
  - Diversity of conditions and seasonality
  - Cal/Val timeline
    - Begins Feb 2015 and ends Feb 2016

Post-Launch SMAPVEX15: Design Options

- What design is best suited to SMAP post-launch Cal/Val of L2 (and L1) products?
  - Long time series of a single site (1 site-45 days)
  - Snapshots of many sites (i.e. Core Validation Sites) (10 sites-3 days)
  - Something in between (3 sites-14 days)
- Considerations
  - Budget impacts of alternatives
  - How much ground data is needed in a post-launch campaign?
  - Can we get permissions and supply people at each site?
  - Launch delays
- Impacts on other Cal/Val activities

Post-Launch SMAPVEX15: 3 Design Options

Soil Moisture

Long Time Series

- Manitoba
- Option A: Continuous
  - *June 15-August 1, 2015*
- Option B: Split
  - *May 15—June 1, and July 1-15, August 15-30, 2015*
- SMAPVEX12 provided and excellent rehearsal

Snapshots

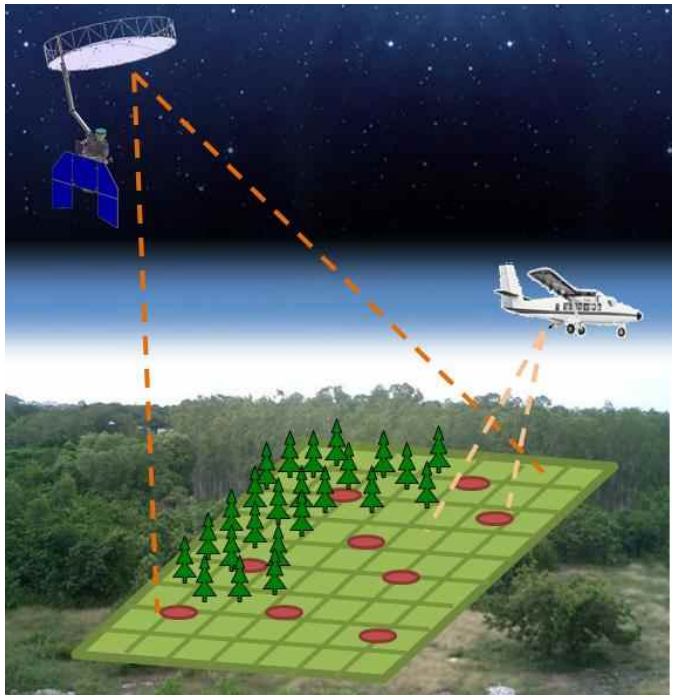
- Core Validation Sites (9)
- Two flights over each site
- July 15-August 30, 2015

Mix

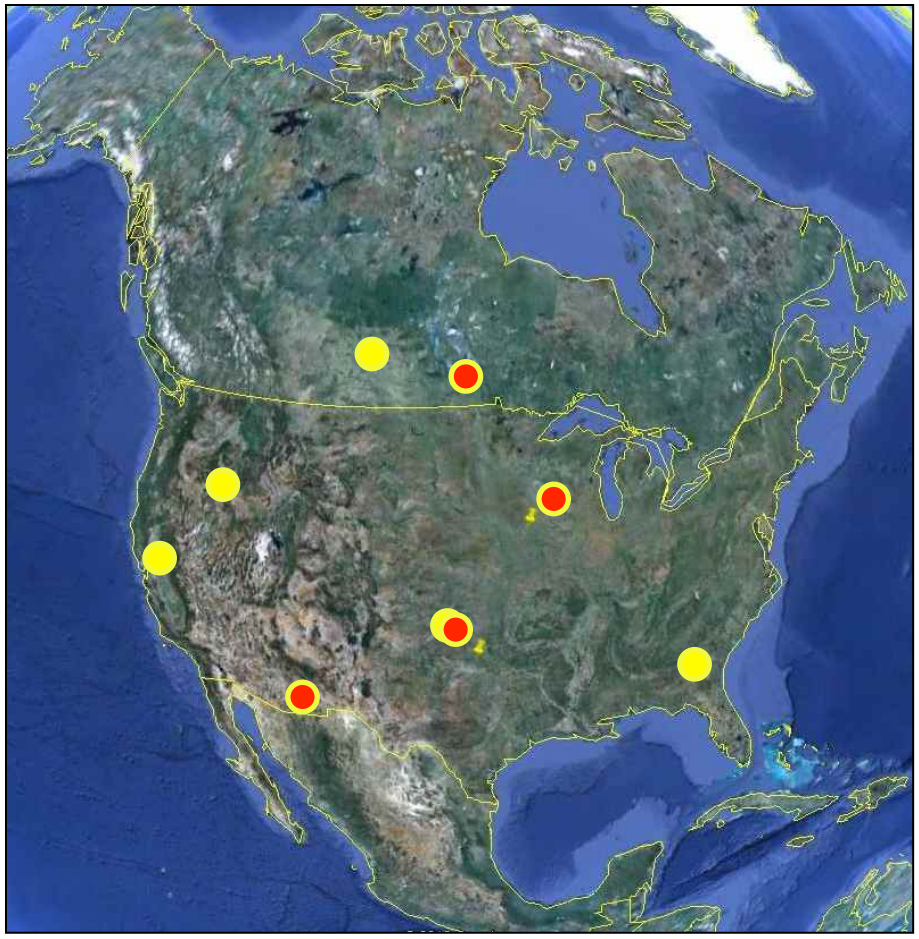
- Subset of Core Validation Sites (3)
- Six flights over each (~2 weeks)
- July 15-August 30, 2015

Post-Launch SMAPVEX15: Questions

- Will there be an aircraft campaign? (Yes)
- Will budget constraints and priorities impact scope? (Most likely – yes)
- From a science POV, which option is most desirable?
- Based on tradeoffs of science and budget, which option is most desirable?
- What instruments are required?
- Will PALScan be completed and available?
- Will there be schedule constraints due to competing programs?
- Where?
- Next Steps
  - *Based on Cal/Val Workshop recommendations, develop baseline plan.*
  - *Resolve instrument, aircraft, and support issues identified.*

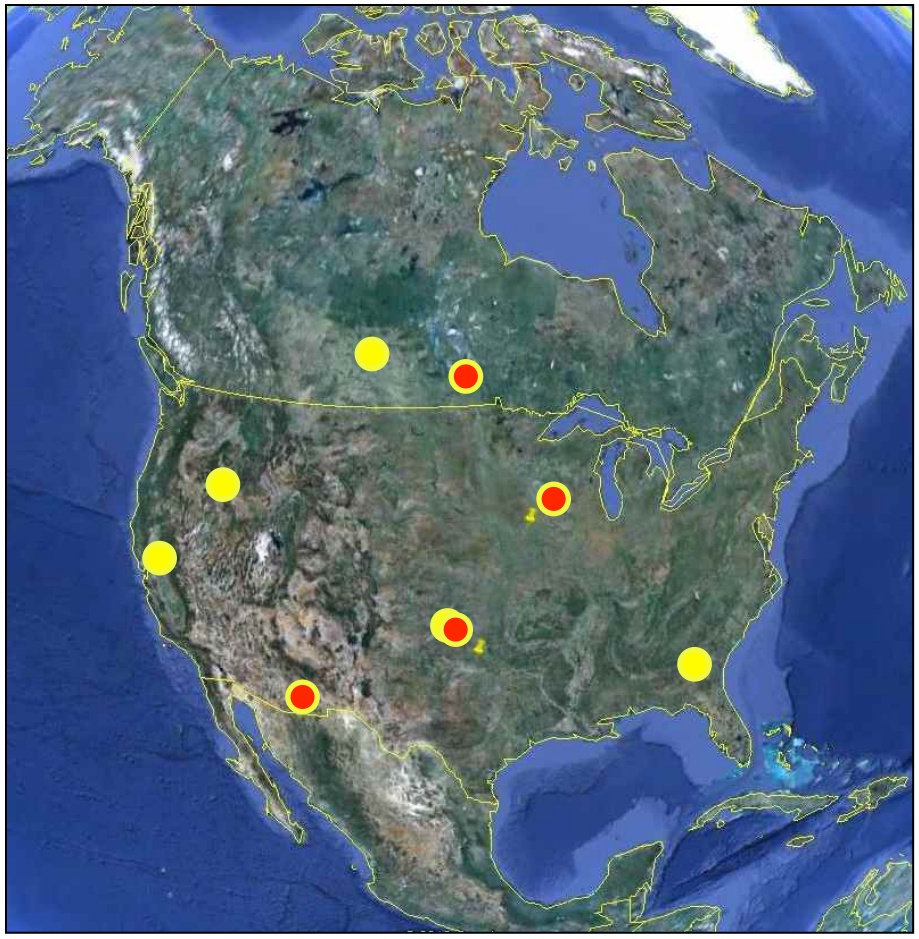


Post-Launch SMAPVEX15: Where?



	OK	MB	AZ	IA
Infrastructure				
Vegetation Range				
SM Range				
Seasonal Limitations				
Cost Sharing				
Heritage				

Post-Launch SMAPVEX15: Where?



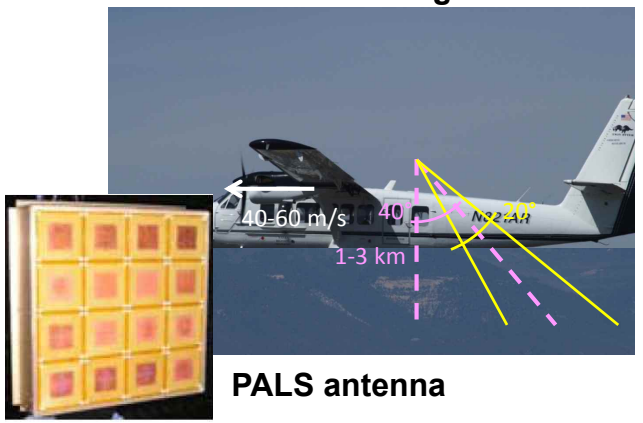
	OK	MB	AZ	IA
Infrastructure	M	H	H	L
Vegetation Range	M	H	L	H
SM Range	H	H	M	H
Seasonal Limitations	M	M	L	M
Cost Sharing	L	H	L	L
Heritage	H	H	H	L

Post-Launch SMAPVEX15: Plan?

PALScan

- Passive Active L-band System (PALS)
- Currently PALS is a fixed-pointing system, most recently operated on Twin Otter and P-3
- There is a plan to re-configure the system to enable conical scanning on C-23 aircraft
  - *Same antenna*
  - *40-45 deg view angle; to be confirmed*
  - *Covered with radome*
  - *Scan mechanism exists*
- Objective is to enable coverage of large areas quicker for matching SMAP footprint and more reliable coverage and ground referencing
  - *Change of temperature and moisture during mapping*
  - *Overlap between flight lines*
  - *Hitting the in situ sampling locations*
- PALScan to be implemented for 2013 CARVE deployments

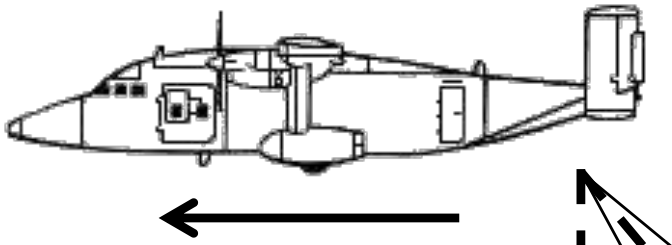
Current configuration



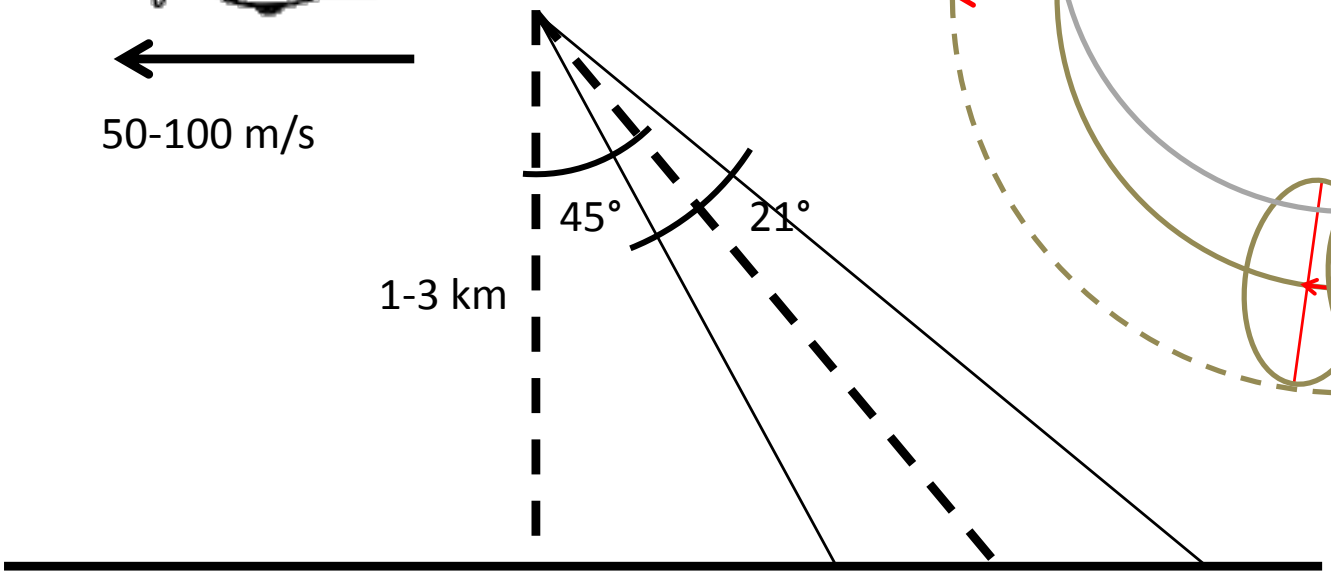
PALS antenna

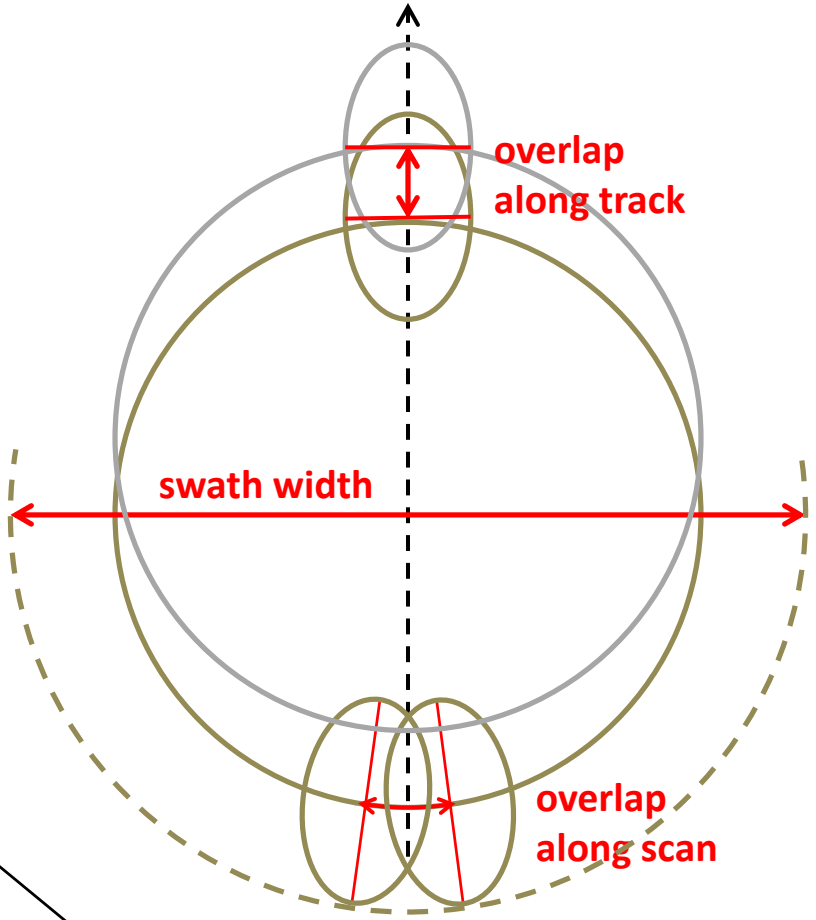
PALScan

- Scanning geometry



50-100 m/s





PALScan

- Scanning parameters
  - *Swath width*

Parameter	Low-slow	Low-fast	High-slow	High-fast
Altitude (m)	1000		3000	
Groundspeed (knots)	100	190	100	190
Groundspeed (m/s)	51	98	51	98
View angle (deg)	45			
PALS sampling rate (ms)	54			
Rotation rate (rpm)	16.7			
Footprint (m)	520x770		1570x2300	
Swath width (m)	2770		8300	
Distance per rotation (m)	190	350	190	350
Overlap along scan	82%			
Overlap along track (fore and aft)	76%	54%	92%	85%
Scan radius on ground (m)	1000		3000	
Scan circumference (m)	6300		18900	
Scan rate on ground (m/s)	1750		5240	
Footprint interval on ground along scan (m)	94		283	

PALScan

- Scanning parameters
  - *Coverage*

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PALScan

- Noise performance of the radiometer versus sampling in the scanning mode: meets requirements for soil moisture measurements
- **Bottom line: PALScan enables coverage of SMAP pixel in about one hour on C-23**