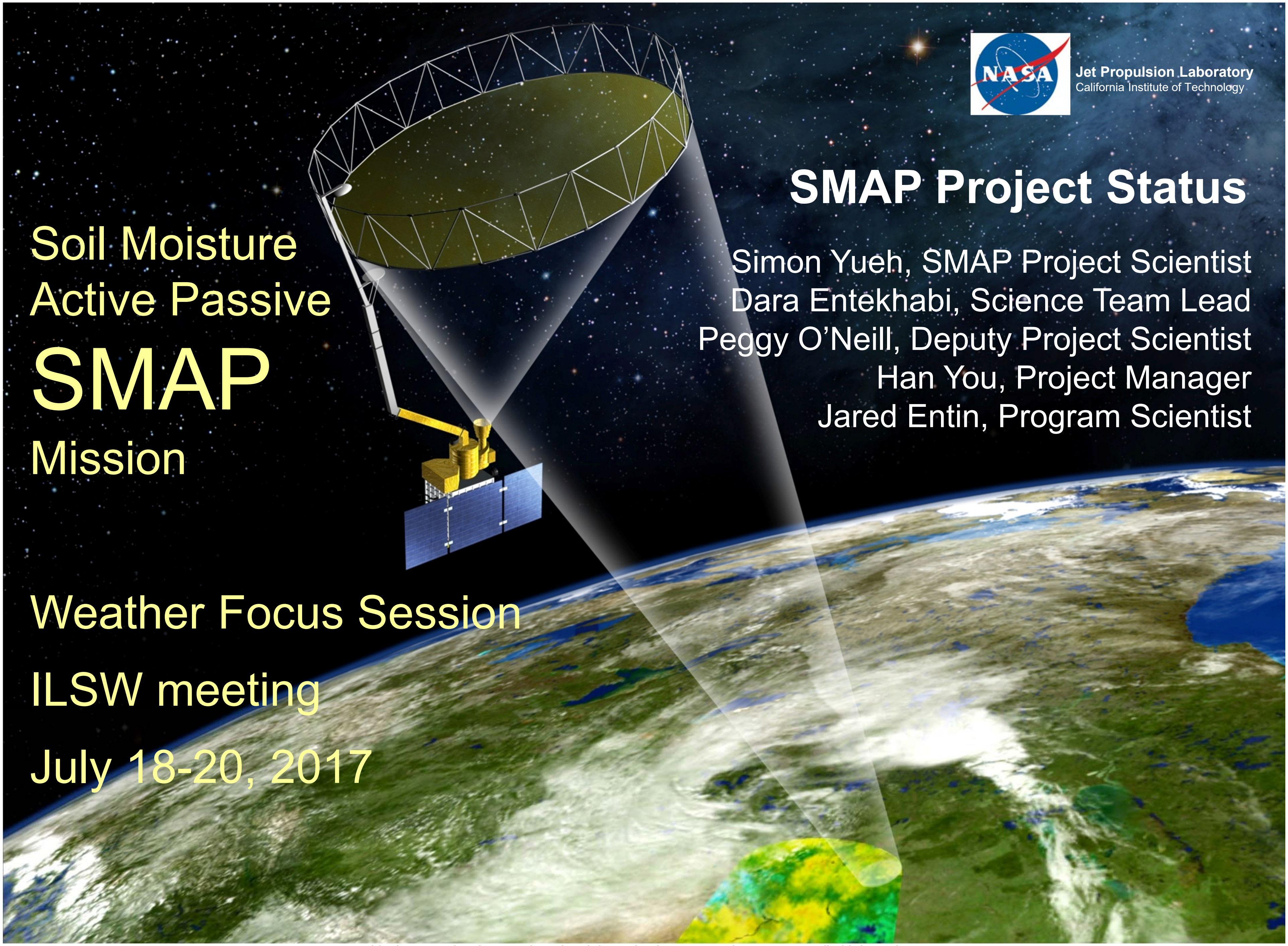


SMAP Project Status

Simon Yueh, SMAP Project Scientist
Dara Entekhabi, Science Team Lead
Peggy O'Neill, Deputy Project Scientist
Han You, Project Manager
Jared Entin, Program Scientist

Jet Propulsion Laboratory
California Institute of Technology

Soil Moisture
Active Passive
SMAP
Mission

Weather Focus Session

ILSW meeting

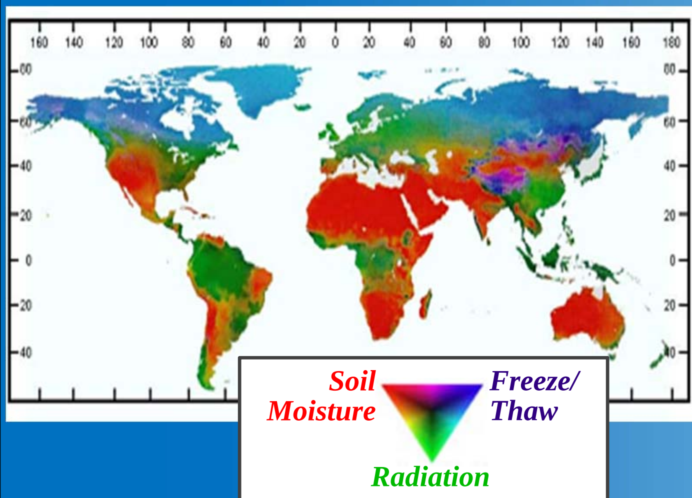
July 18-20, 2017

SMAP Science and Application Returns

Jet Propulsion Laboratory
California Institute of Technology

Science Returns

Soil Moisture *Links* the Global Land Water, Energy, and Carbon Cycles



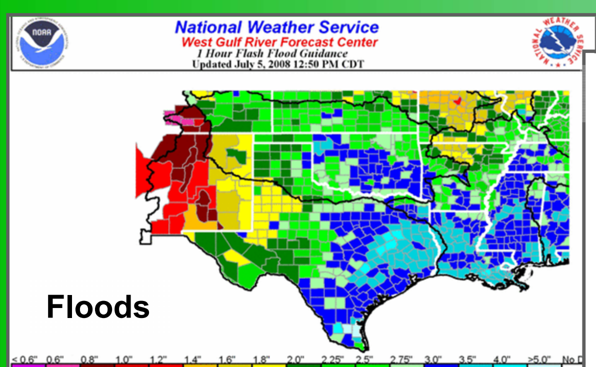
1. Estimating global surface water and energy fluxes
2. Quantifying net carbon flux in boreal landscapes
3. Reduce uncertainty of climate model projections

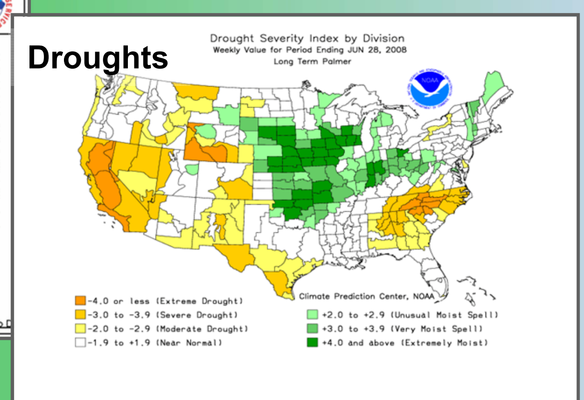
L-band (~21 cm; All-Weather; Canopy Penetration; Sensing Depth)

6m conically scanning (14 rpm) antenna for 1000 km swath

Global coverage every 2-3 days

Applications Returns





4. Enhancing weather forecasts
5. Improving flood prediction and drought monitoring

SMAP Project Status

- SMAP radiometer has been operating more than 2 years
  - To complete the prime mission in June 2018
  - Excellent radiometer calibration stability and soil moisture products
  - Data distributed through NSIDC and ASF
- Released enhanced and AM/PM soil moisture products in Dec 2016
- Completed NASA Senior Review of proposal extension through 2023
- **Near Real Time L1 latency with some simplifications in processing: <3 hours (median) – data distribution through JPL**

SMAP Project Status
Short Term Improvements

- Plan to release the SMAP+Sentinel-1 soil moisture soon: 3/9 km soil moisture products every 12 days
- Improving waterbody correction algorithm
- Developing algorithm to reduce bias, due to vegetation and so on

L1 Brightness Temperature Calibration Stability

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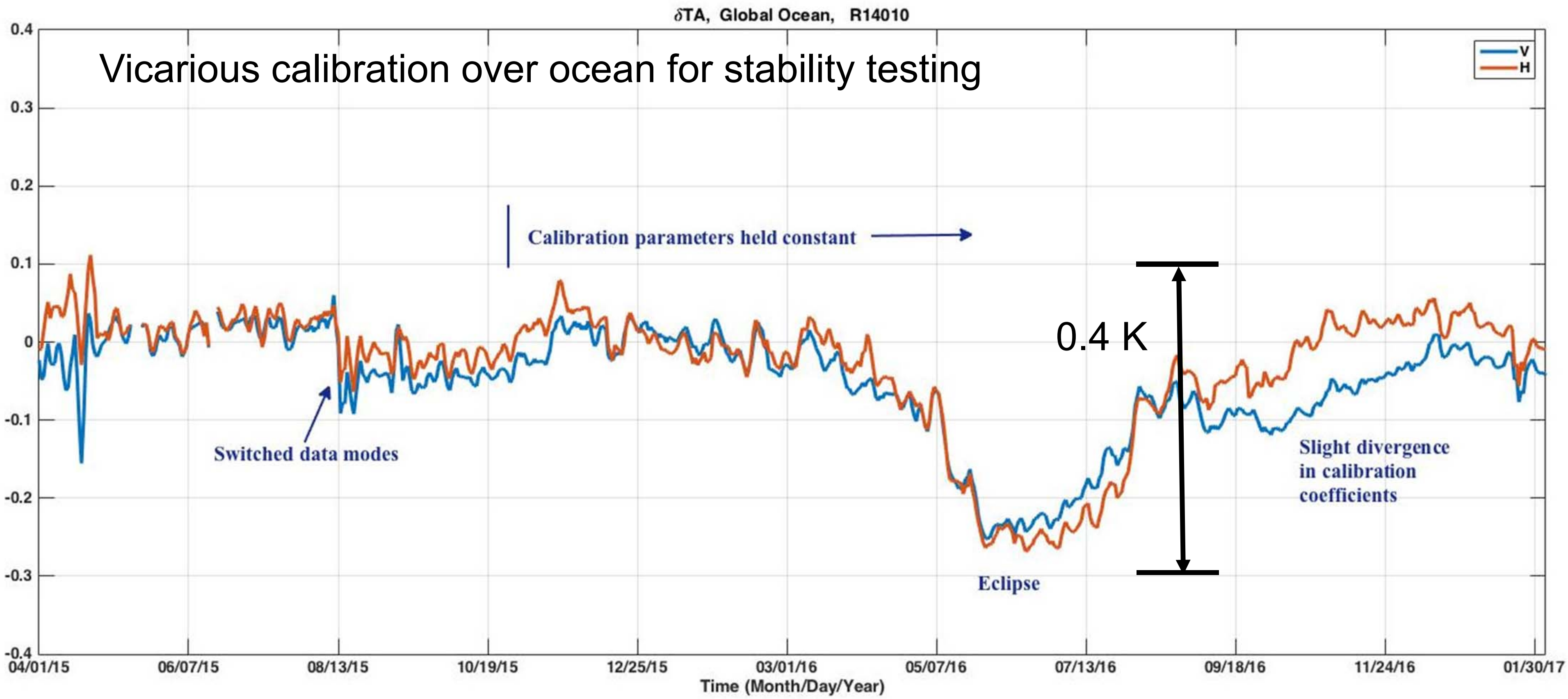
- Very stable long-term calibration over two years <0.4 K or ~0.1 K RMS
- Remaining bias~1K to 2K



Two years

Latencies from Begin of Observation

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Product Type	Requirement	min	max	avg	median
L0B_RADAR	12 hours	01:34:45	129:31:38	10:51:13	04:39:24
L1A_RADAR	12 hours	02:19:45	129:58:55	13:45:50	05:35:31
L0B_RADIOMETER	12 hours	01:10:58	124:49:48	04:51:50	02:06:57
L1A_RADIOMETER	12 hours	02:13:42	125:09:19	08:29:07	03:49:44
L1B_TB	12 hours	03:48:17	126:37:42	10:23:42	05:34:59
L1B_TB_E		06:00:27	128:55:48	13:09:19	08:19:27
L1C_TB	24 hours	03:48:57	126:38:22	10:24:24	05:35:39
L1C_TB_E		06:01:37	128:56:50	13:10:24	08:20:32
L2_SM_P	24 hours	05:18:28	126:39:34	15:54:23	13:09:32
L2_SM_P_E		07:47:48	128:59:05	16:50:50	13:45:35
L3_SM_P	50 hours	14:19:34	92:01:29	37:02:38	32:10:23
L3_SM_P_E		14:20:14	92:02:08	37:03:16	32:10:58
L3_FT_P		06:19:44	92:02:02	33:49:57	28:24:23
L3_FT_P_E		08:20:30	92:02:45	35:17:02	29:58:58

- Radar forward processing only to L1A_Radar

Reduction of median from 5:34 to 2:51

Latency Type	Min	Max	Ave	Median
Total Latency **(from observation to product creation)**	00 00:28:00	05 06:05:08	00 04:12:48	00 02:50:56
Latency at SDS **(from telemetry arrival at SDS to product creation)**	00 00:08:47	00 01:40:25	00 01:18:34	00 01:33:40
Total Processor Run time **(Processor run times at SDS)**	00 00:04:56	00 01:33:55	00 01:12:43	00 01:28:48
Pipeline Overhead **(Latency at SDS minus the program run times)**	00 00:02:42	00 00:08:31	00 00:05:51	00 00:05:51

- The format is - DAY HH:MM:SS

SMAP L1B_TB: JPL NRT vs NSIDC
Xiwu Zhan

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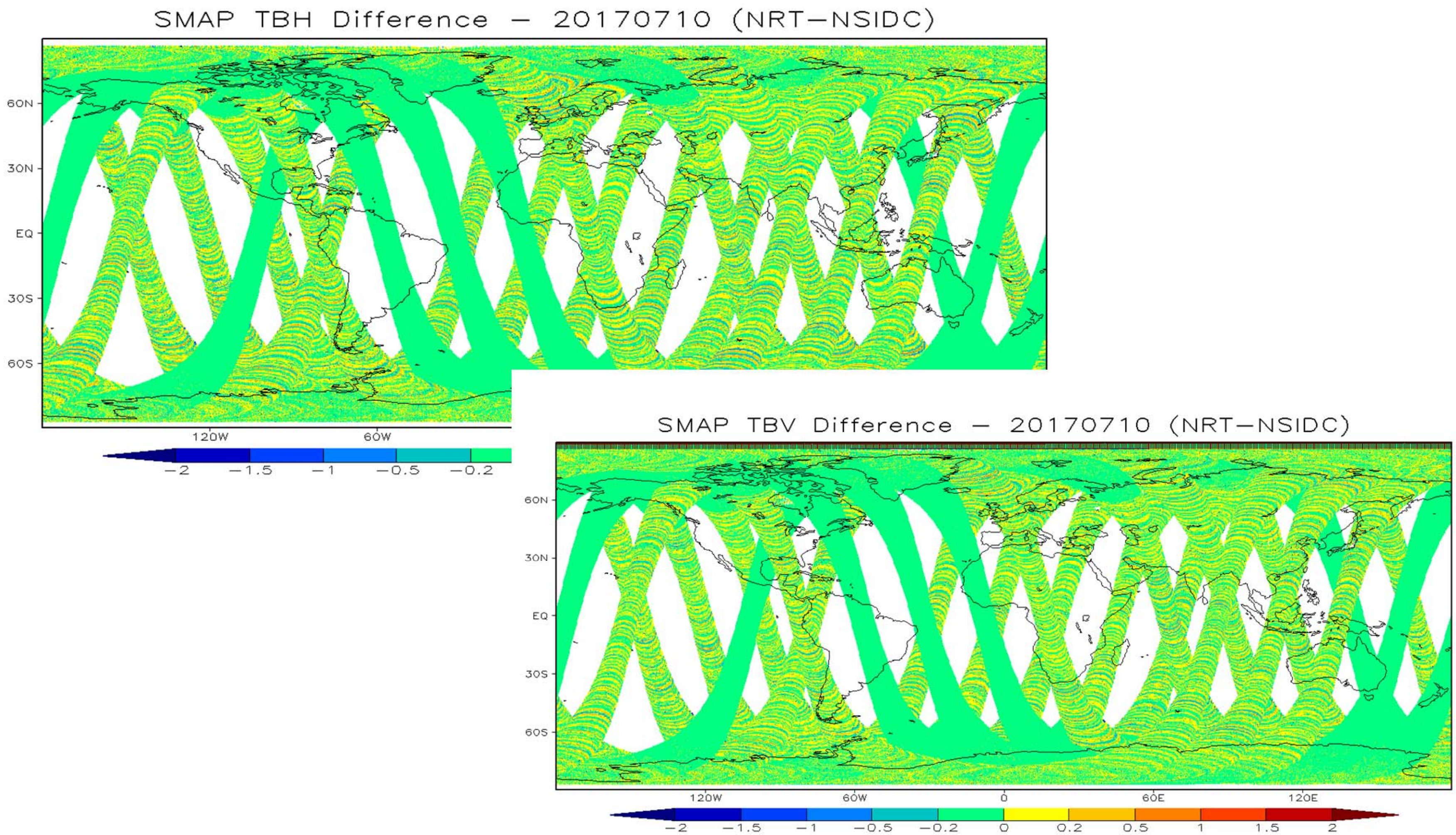

More than 99% of footprint TBs have difference smaller than 0.2 Kelvin.

SMAP Radiometer Soil Moisture Performance at Core Validation Sites (April 2015-Feb 2017)

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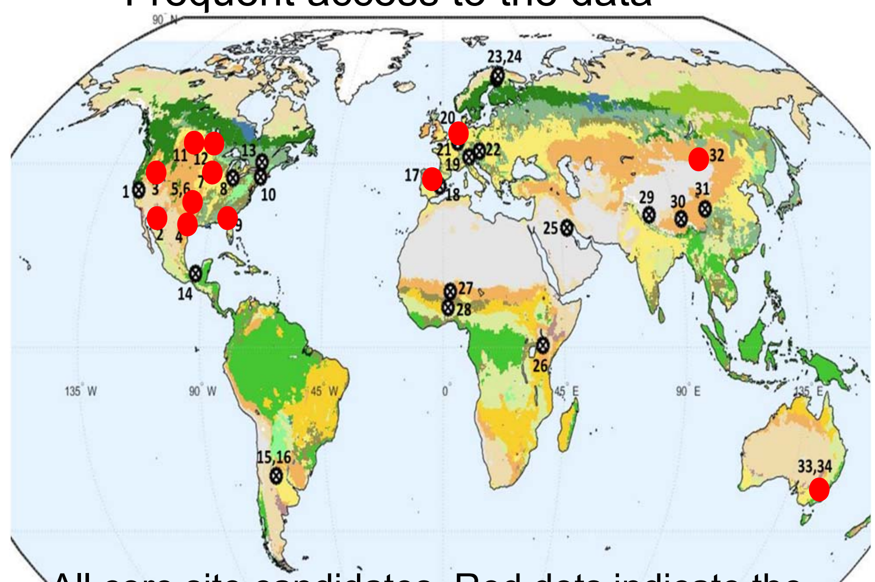
Performance Metrics

Site Name	ubRMSE (m3/m3)	Bias (m3/m3)	RMSE (m3/m3)	R
Reynolds Creek	0.037	-0.021	0.043	0.646
Walnut Gulch	0.024	0.007	0.025	0.789
TxSON	0.030	-0.015	0.034	0.929
Fort Cobb	0.028	-0.056	0.062	0.877
Little Washita	0.021	-0.028	0.035	0.915
South Fork	0.051	-0.057	0.076	0.645
Little River	0.022	0.079	0.083	0.884
Kenaston	0.022	-0.039	0.045	0.848
Carman	0.055	-0.090	0.105	0.599
Monte Buey	0.050	-0.025	0.056	0.864
REMEDHUS	0.039	-0.002	0.039	0.877
Twente	0.054	0.019	0.057	0.872
HOBE	0.037	-0.007	0.038	0.836
MAHASRI	0.036	-0.006	0.037	0.726
Yanco	0.040	0.016	0.043	0.957
Mean	0.036	-0.015	0.052	0.818

***This performance meets the SMAP requirement of 0.04**

SMAP Core Validation Site Program

- Core Site Definition:
  - Multiple in situ sensors within satellite footprint
  - Well-calibrated in situ sensors
  - Spatial up-scaling to footprint scale established
  - Frequent access to the data



All core site candidates. Red dots indicate the sites that meet the criteria above. These sites are used for the metrics computation on the left.

Improved Soil Moisture Retrieval Algorithm to Reduce Bias

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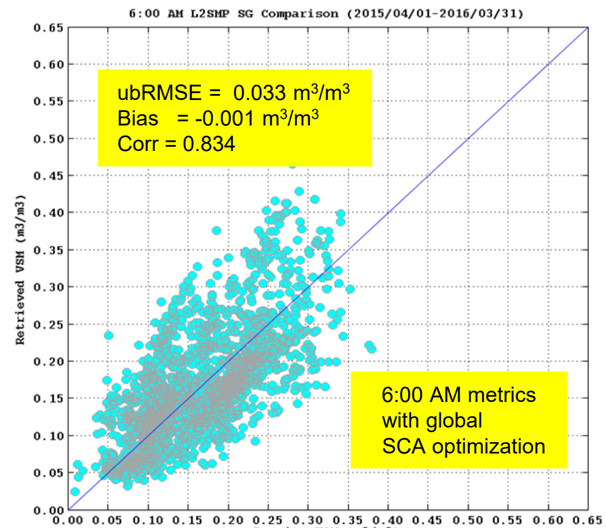
California Institute of Technology

- Time-series algorithm accumulate 5 passes (~12 days) of dual-pol (T_B's): 10 observations to retrieve 5 soil moisture values and the values of 4 surface and vegetation parameters
- Preliminary results show that global mean ubRMSE and bias (across the CVS) are reduced while correlation increases, but bias for some individual agricultural sites remains
- Refinements to / analysis of this algorithm and its use in calibration is continuing
- The research algorithm at MIT is also being investigated.

Improvement to 6 AM baseline algorithm performance

Retrieval Performance with Temporal Optimized Model Coefficients

	ubRMSE	Bias	RMSE	corr	N
ReynoldsCreek_04013602	0.037	-0.017	0.041	0.603	49.000
WalnutGulch_16013604	0.026	0.016	0.031	0.635	45.000
TxSON_48013601	0.030	-0.020	0.037	0.928	108.000
FortCobb_16033603	0.024	-0.045	0.051	0.873	136.000
LittleWashita_16023603	0.025	-0.028	0.038	0.889	150.000
SouthFork_16073603	0.036	-0.085	0.092	0.713	95.000
LittleRiver_16043603	0.031	0.092	0.097	0.901	162.000
Kenaston_27013603	0.030	0.011	0.031	0.835	86.000
Carman_09013602	0.051	-0.030	0.059	0.758	97.000
MonteBuey_19023602	0.030	-0.017	0.034	0.883	72.000
REMEDHUS_03013604	0.040	0.036	0.054	0.835	97.000
Twente_12043604	0.041	0.067	0.079	0.938	162.000
Yanco_07013603	0.034	-0.001	0.034	0.930	112.000
Kyeamba_07023602	0.030	0.014	0.034	0.950	121.000
****** AVERAGE ******	0.033	-0.001	0.051	0.834	106.571



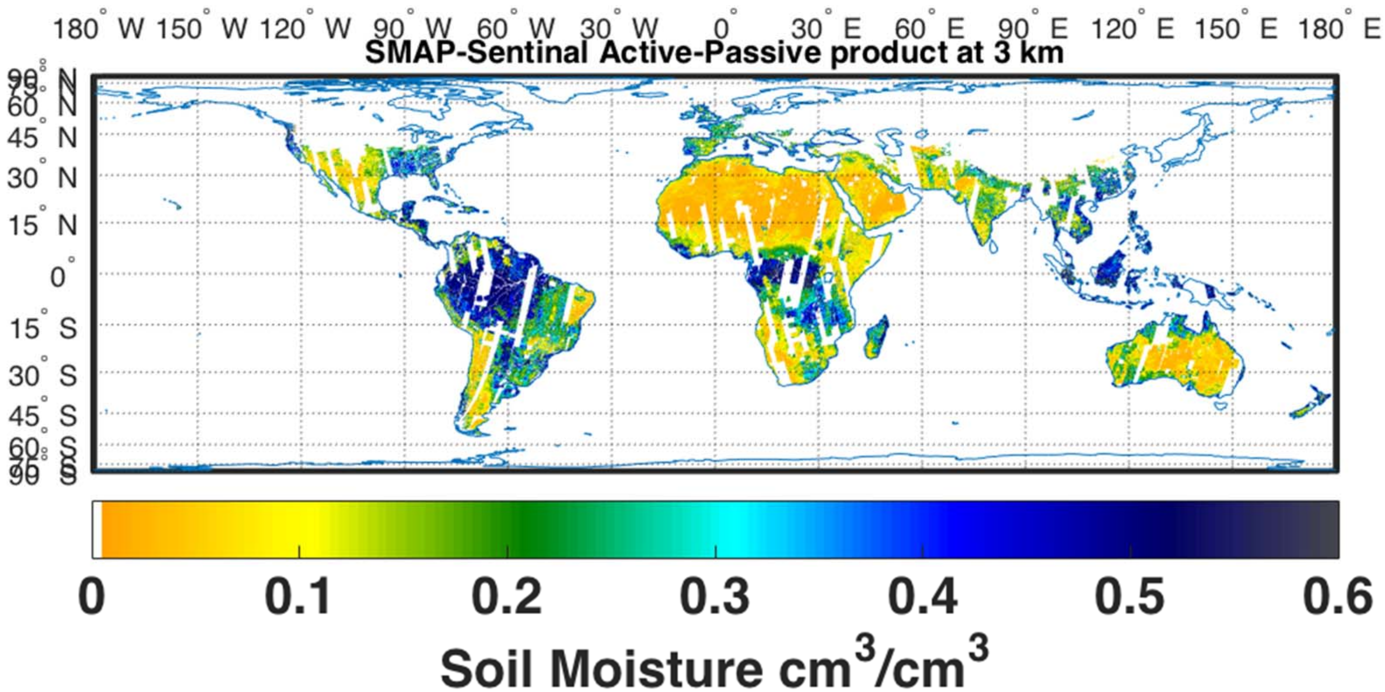
This document has been reviewed and determined not to contain export-controlled information..

SMAP Soil Moisture at 3 Km Resolution Disaggregated Using ESA Sentinel-1 Radar Data

Narendra Das el .al.

Jet Propulsion Laboratory
California Institute of Technology

- Validation effort ongoing – improved spatial resolution while maintaining the accuracy (preliminary findings)
- Beta level products to be released in Aug-Sept 2017



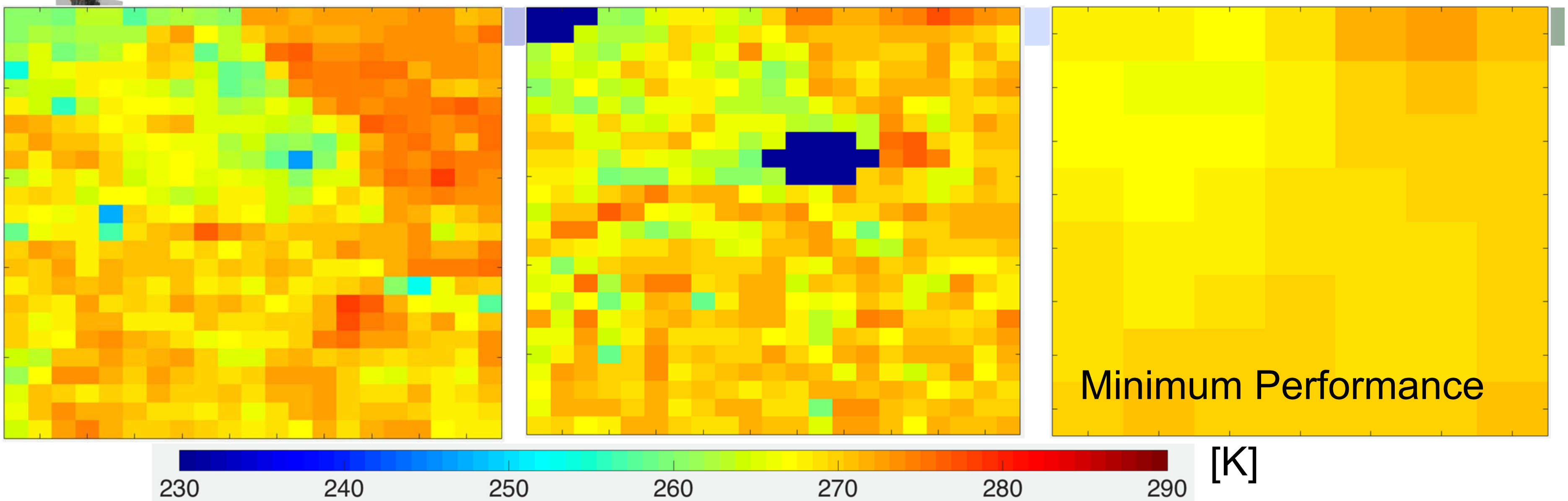
Twelve Days Coverage of SMAP Sentinel from 1st Feb, 2017 to 12th Feb, 2017

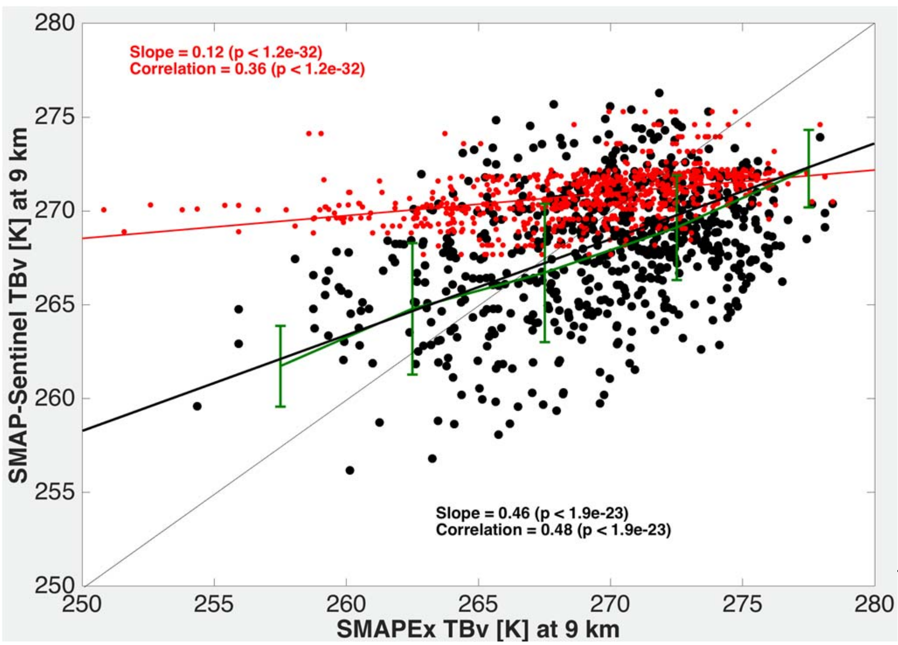
3 and 9 km resolution soil moisture products every 12 days

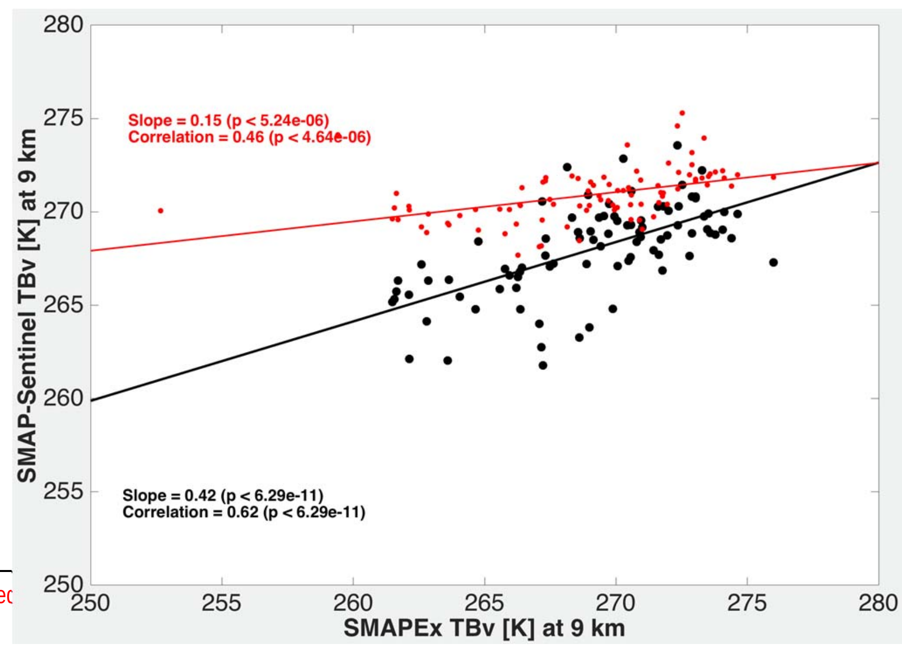
SMAP TB Disaggregated Using ESA Sentinel-1 Radar Data

Narendra Das el .al.

SMAPEx TBv Obs at 3 km | SMAP_Sentinel TBv at 3 km | L2_SM_P_E Gridded at 9 km





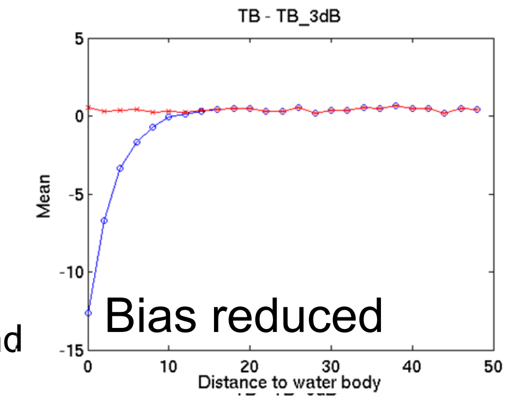


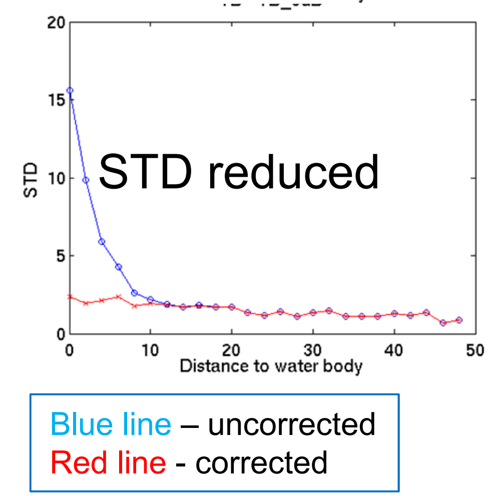
Backus-Gilbert OI and Waterbody Correction

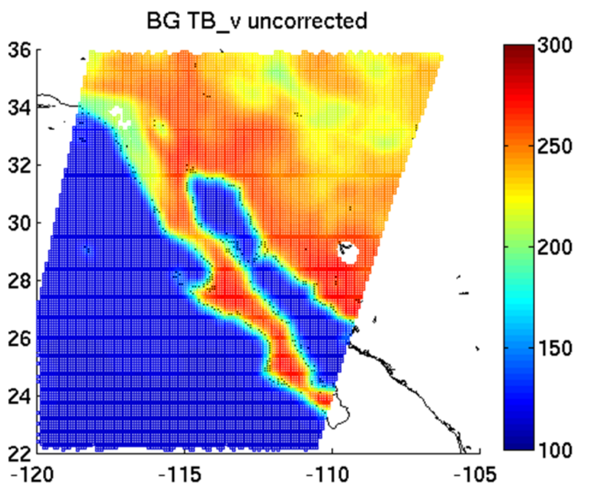
- We are investigating a waterbody correction algorithm using the SMAP antenna gain-weighted waterbody fraction (f) to correct land surface brightness temperatures.

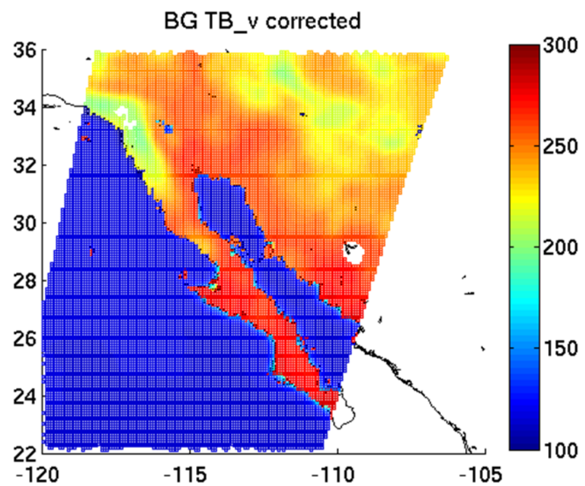
$$T_B^{corr} = T_B - \frac{f}{1-f} T_B^{water}$$

- Simulation tests confirm excellent performance of the algorithm.
- To work on look-up-table to reduce processing time.
  - Release the improved waterbody corrected products (L1/L2/L3) by the end 2017









Waterbody Correction

Example: Lake Victoria

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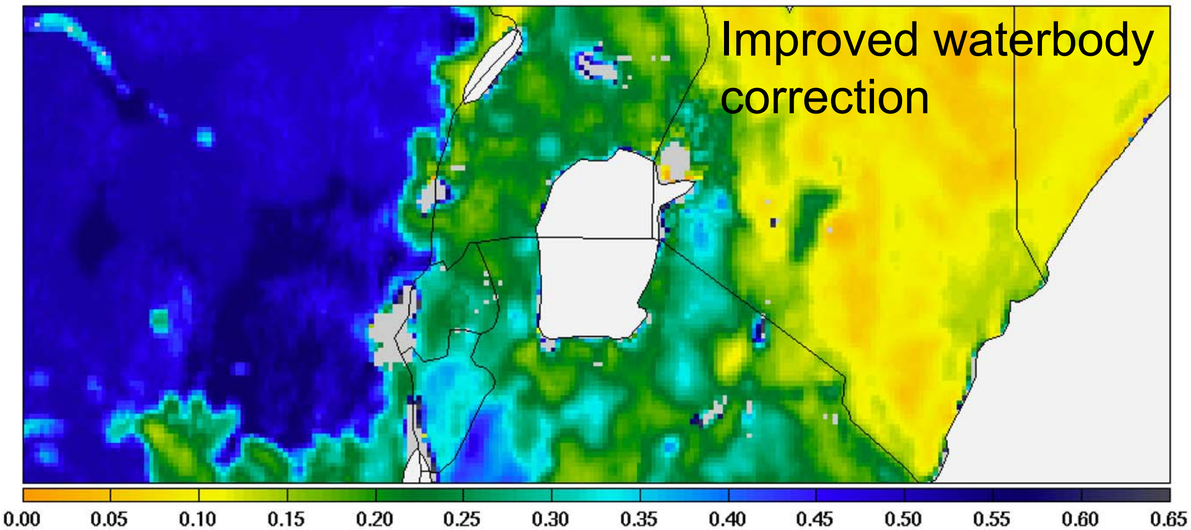
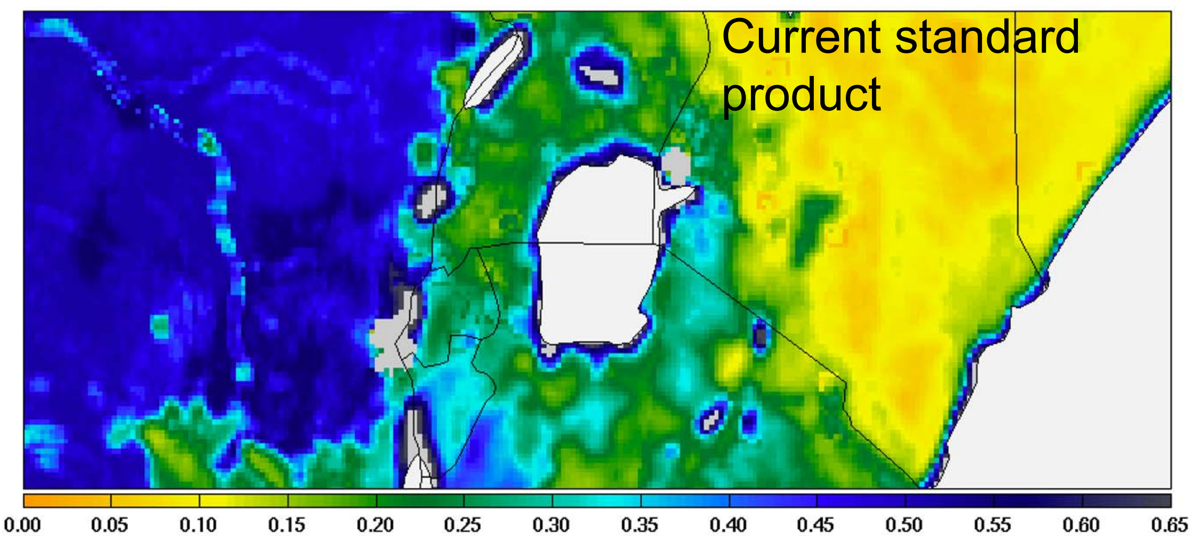
OAS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3



OPS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3



Observations:

- Non-existent near-saturation soil moisture bands around OWB and coastlines in XP visually more pleasing than BP.
- Forest right-hand boundaries better defined in XP than in BP. Real features?
- Forest retrievals in XP and BP hard to interpret. It is likely that BP is over-correcting TB and XP is about right.
- BP's occasional water TB over-correction (dashed circles) addressed quite well in XP.
- BP and XP converge wherever water fraction is zero (i.e., no water TB correction performed).

Waterbody Correction

Example: The Great Lakes

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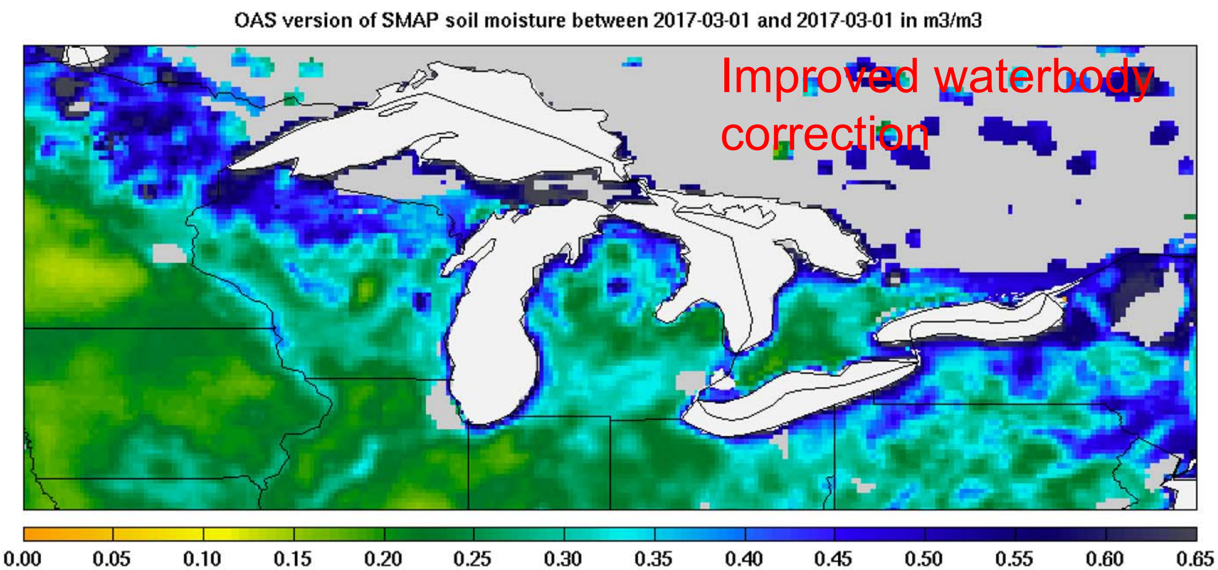
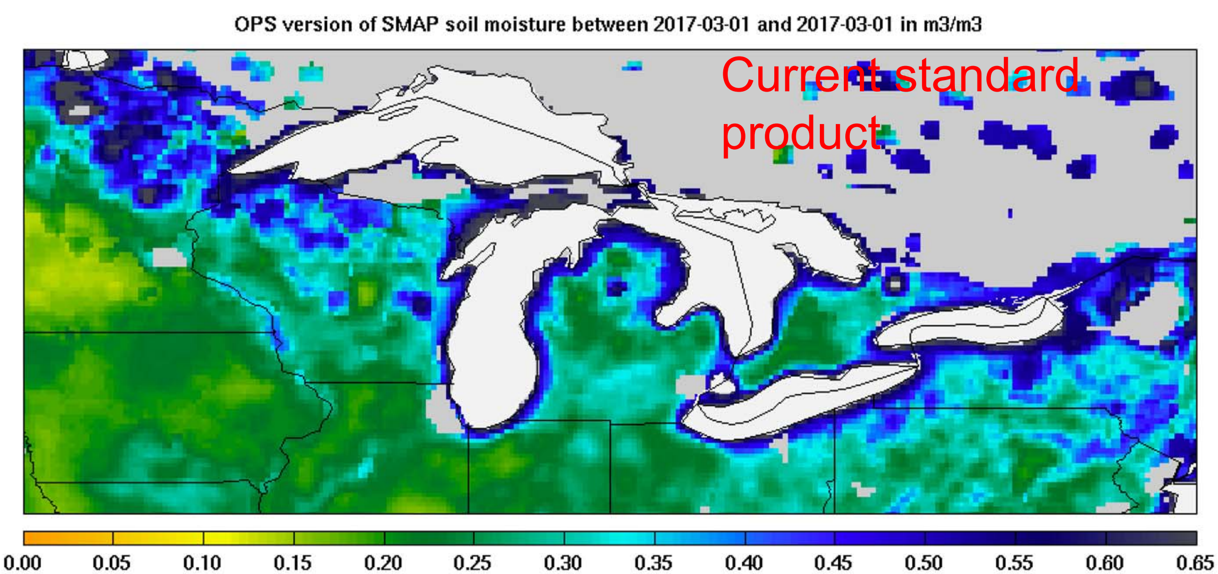
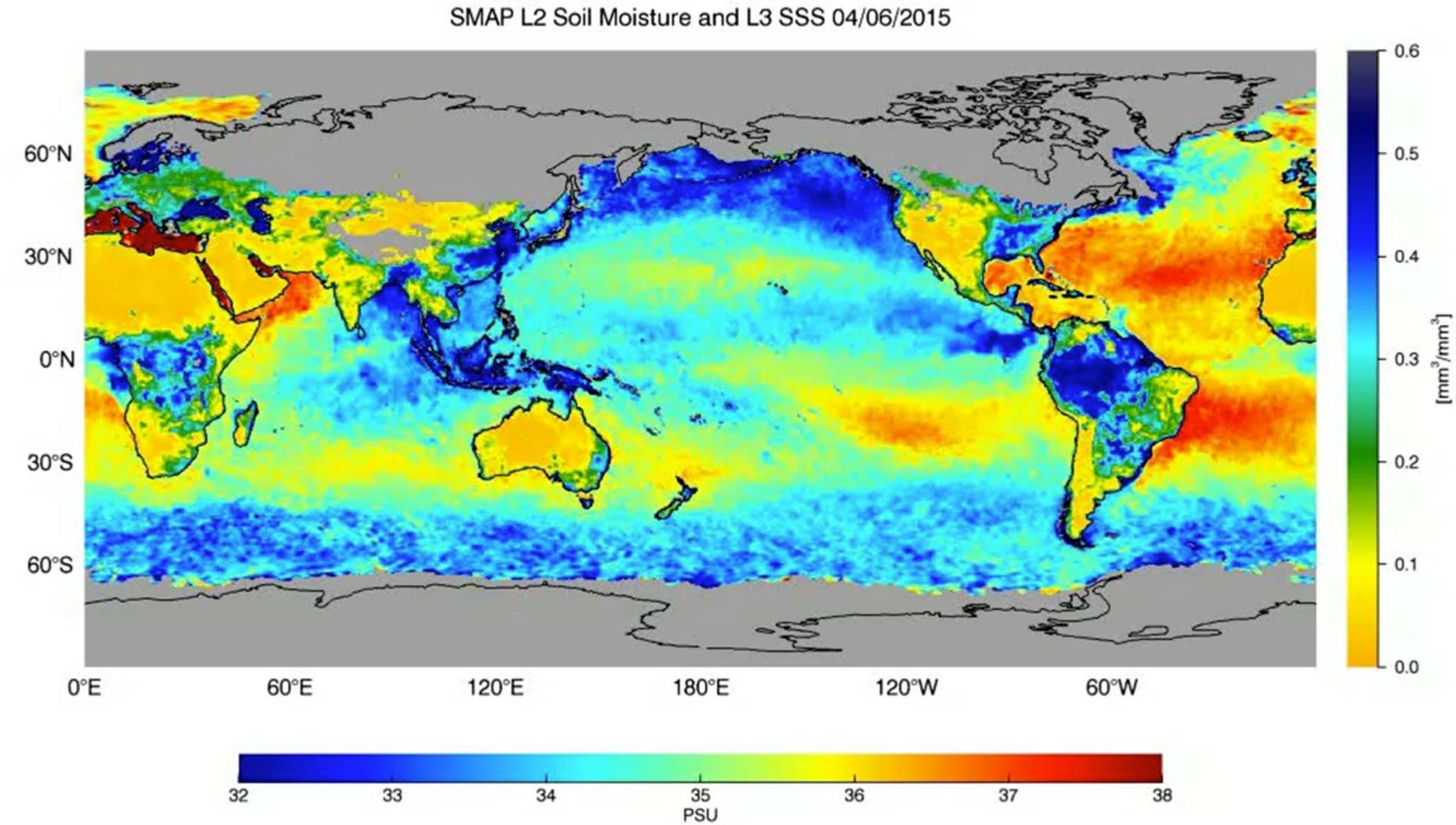




Observations:

- Narrower near-saturation soil moisture bands around open water bodies (OWB) in XP intuitively more reasonable than BP.
- Harder to interpret their relative merits elsewhere in the absence of ground truth – is XP over-correcting or BP under-correcting?
- BP and XP converge wherever water fraction is zero (i.e., no water TB correction performed).
- **Some apparent residual bias might be be due to lake ice**

SMAP Soil Moisture+Sea Surface Salinity Revealing Land and Ocean Water Cycle



Extreme Ocean Surface Winds from SMAP

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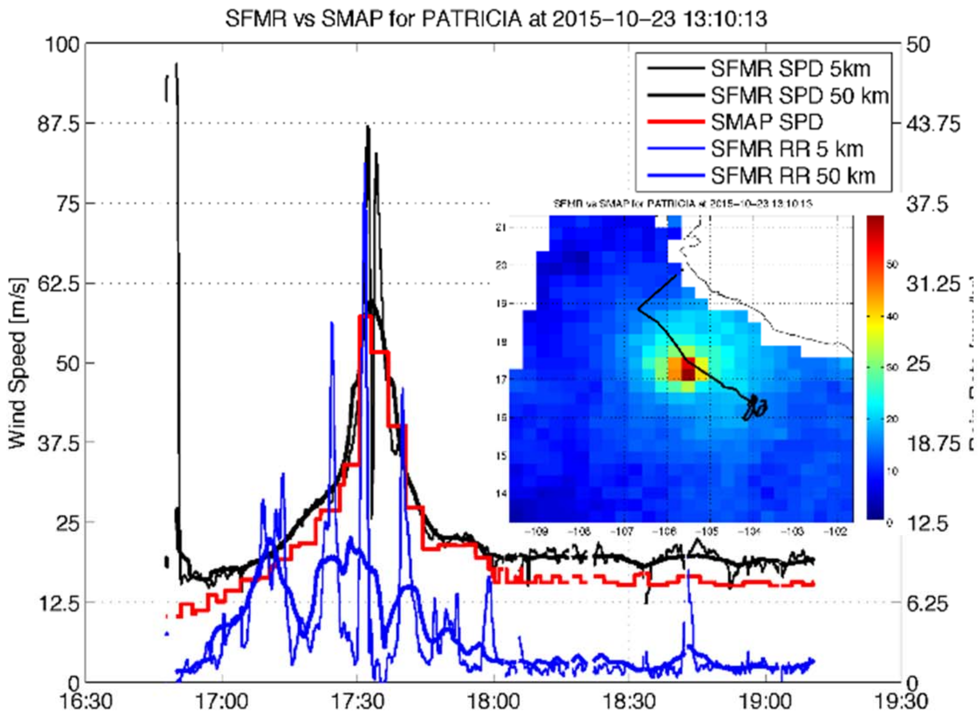

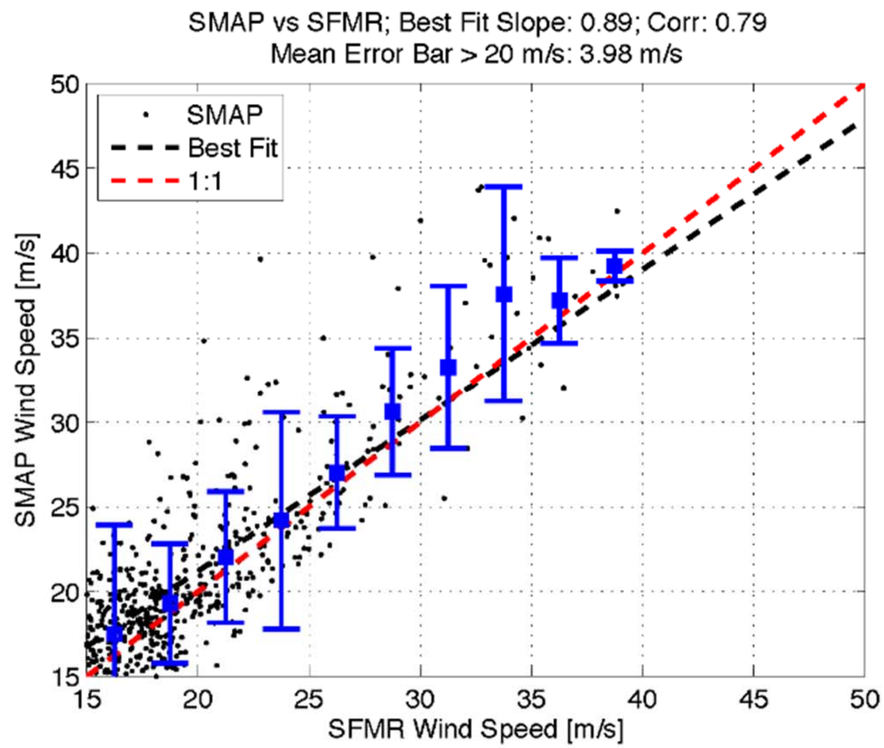

Summary

- Exceptional quality global L-band radiometry – science acquisition ongoing
- Science uses in characterizing land, terrestrial biosphere and ocean water cycle branches
- **Continuous effects for algorithm/product improvement**
  - **Waterbody correction**
  - **Bias reduction**
  - **Disaggregation**
- **Reducing Near Real Time L1 latency**
- **Any need for NRT L2 soil moisture?**