National Aeronautics and Space Administration

New Directions for SMAP

SMAP Status and Product Enhancement

Soil Moisture
Active Passive
Mission

SMAP

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with contributions by
Cal/Val Partners

Early Adopter Telecon
Date: 06-16-2016

Outline

1. Status of SMAP Mission
1. L2SMAP Product
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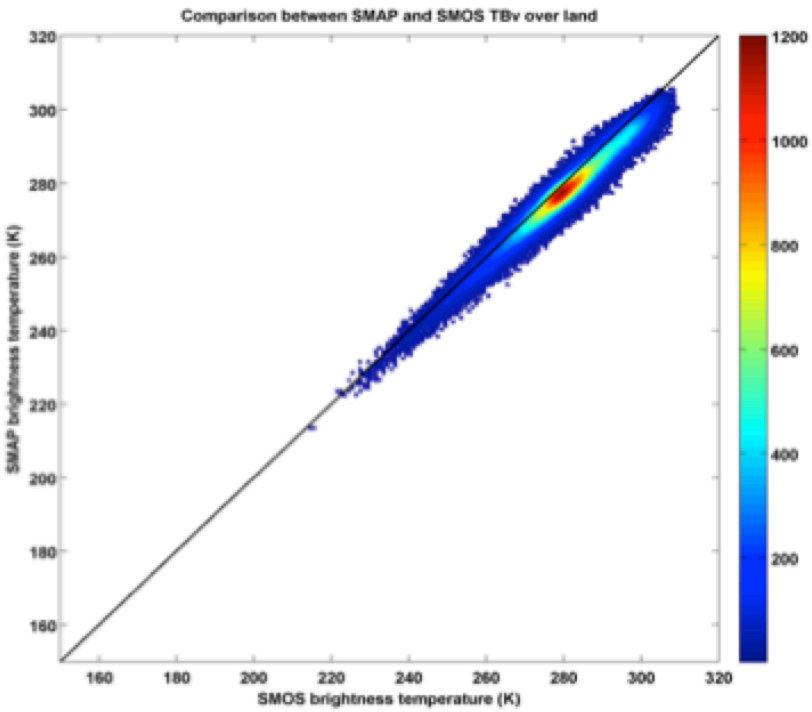
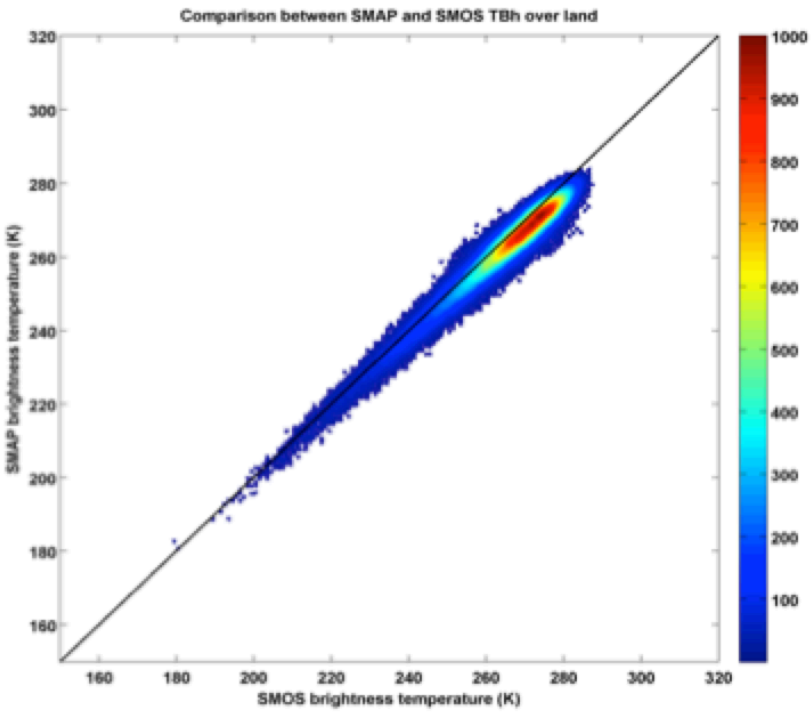
1. SMAP Post-Radar Period
1. SMAP Radiometer Resolution Enhancement
2. SMAP Fine Grid Processing For Radiometer
1. SMAP-Sentinel Active-Passive Product for Fine Resolution Soil Moisture
2. SMAP Radiometer-based F/T Product
3. Conclusion

Status of SMAP Mission

- SMAP launched on Jan 31st, 2015
- Science data acquisition started in April, 2015
- SMAP Radiometer and Radar worked in tandem with great success
- SMAP Radar malfunctioned on July 7th, 2015
- SMAP Radar is currently inoperable
- SMAP released Beta-Product to public on October 31st, 2015
- SMAP science data acquisition operation finished one year in April 2016
- SMAP released Validated-Product on April 30th, 2016
- SMAP data is now freely available to public through the NASA DAAC at NSIDC

SMAP L2SMP Product



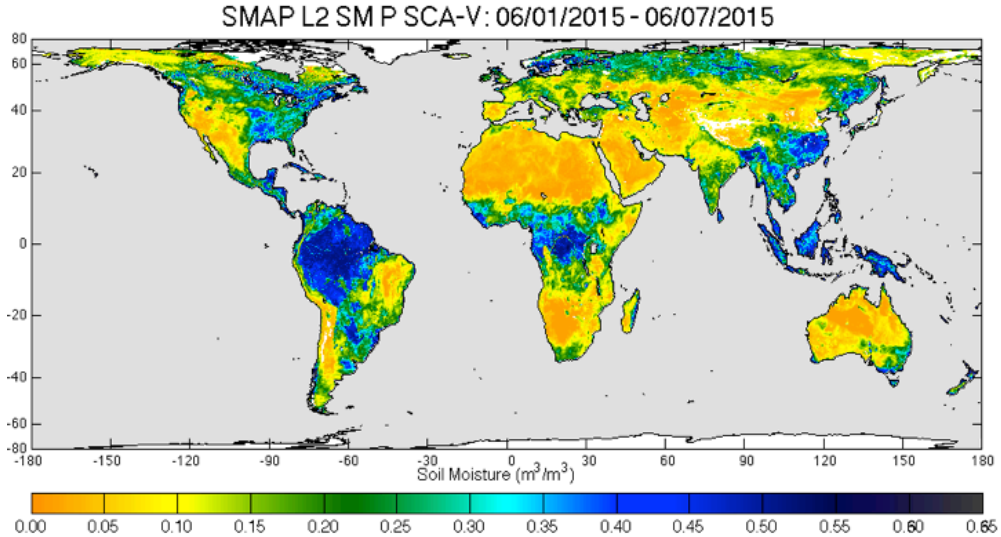


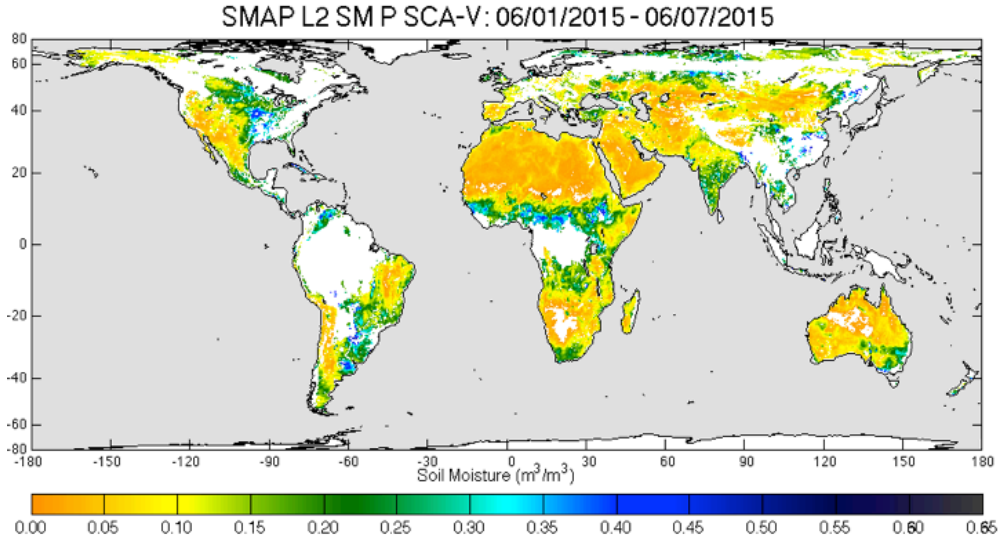
Density plot of the L1 brightness temperature comparison (top of the atmosphere) between SMAP and SMOS observations over land targets for V-pol (left) and H-pol (right)

Summary statistics of the brightness temperature comparison between SMOS and SMAP observations.

		RMSD (K)	R	Bias [SMAP-SMOS] (K)
H pol	Land	4.32	0.9753	-2.20
	Ocean	2.48	0.7035	0.01
	Overall	3.05	0.9994	-0.54
V pol	Land	4.17	0.9737	-2.27
	Ocean	2.55	0.7767	-0.34
	Overall	3.04	0.9994	-0.82

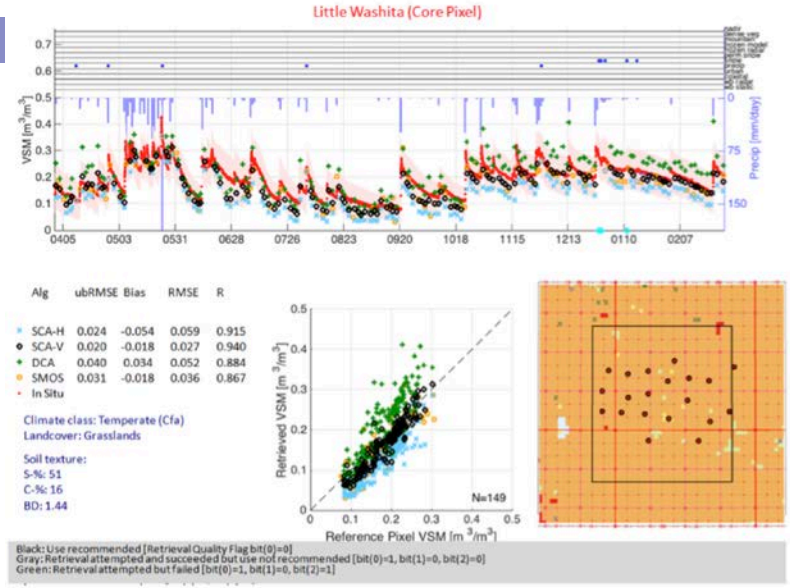
SMAP L2SMP Product



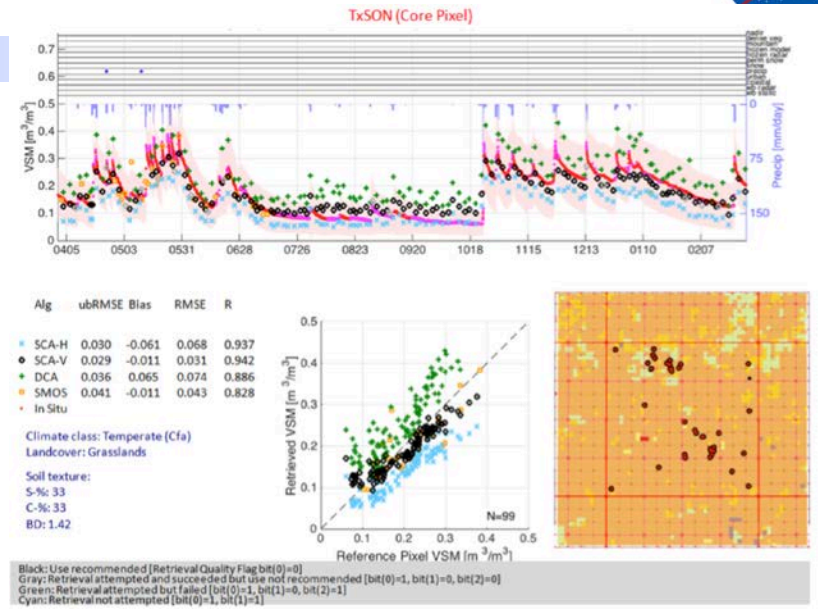


SMAP L2SMP global images of soil moisture including (top) or excluding (bottom) flagged data.

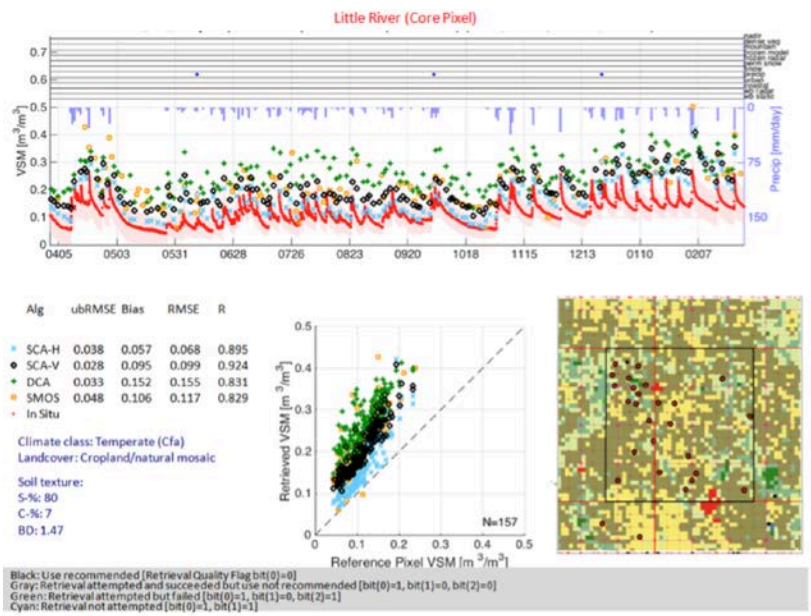
SMAP L2SMP Product Validation



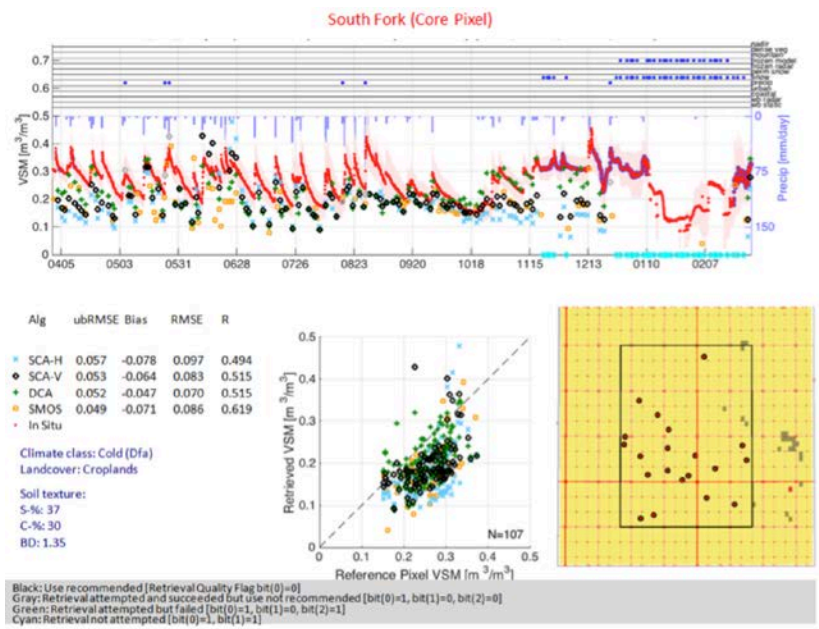
L2SMP Assessment Tool Report for Little Washita, OK.



L2SMP Assessment Tool Report for TxSON, TX.



L2SMP Assessment Tool Report for Little River, GA.



L2SMP Assessment Tool Report for South Fork, IA.

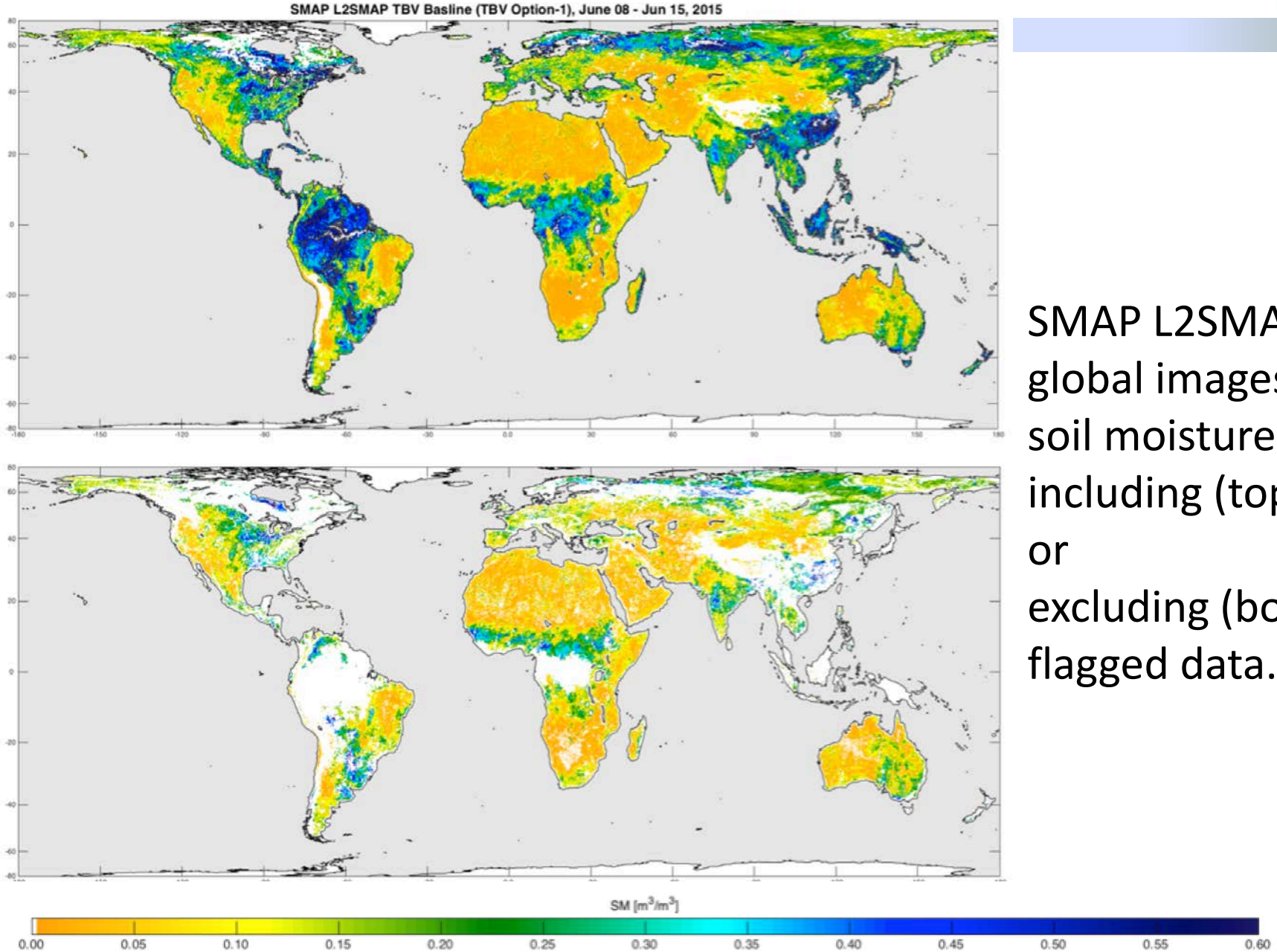
SMAP L2SMP Product Validation

SMAP L2SMP Release 2 CVS Assessment

CVS	ubRMSE (m^3/m^3)			Bias (m^3/m^3)			RMSE (m^3/m^3)			R			N		
	SCA-H	SCA-V	DCA	SCA-H	SCA-V	DCA	SCA-H	SCA-V	DCA	SCA-H	SCA-V	DCA	SCA-H	SCA-V	DCA
Reynolds Creek	0.041	0.041	0.055	-0.065	-0.030	-0.003	0.077	0.051	0.055	0.638	0.670	0.650	86	93	93
Walnut Gulch	0.026	0.028	0.041	-0.028	-0.006	0.015	0.038	0.028	0.043	0.587	0.688	0.674	86	101	97
TxSON	0.030	0.029	0.036	-0.061	-0.011	0.065	0.068	0.031	0.074	0.937	0.942	0.886	99	99	97
Fort Cobb	0.033	0.029	0.042	-0.069	-0.040	-0.003	0.076	0.049	0.042	0.870	0.883	0.815	137	137	137
Little Washita	0.024	0.020	0.040	-0.054	-0.018	0.034	0.059	0.027	0.052	0.915	0.940	0.884	149	149	148
South Fork	0.057	0.053	0.052	-0.078	-0.064	-0.047	0.097	0.083	0.070	0.494	0.515	0.515	104	107	107
Little River	0.038	0.028	0.033	0.057	0.095	0.152	0.068	0.099	0.155	0.895	0.924	0.831	157	157	157
Kenaston	0.037	0.026	0.039	-0.061	-0.035	0.008	0.071	0.043	0.040	0.661	0.774	0.584	76	76	76
Carman	0.084	0.058	0.055	-0.088	-0.085	-0.075	0.121	0.103	0.093	0.570	0.620	0.471	101	102	102
Monte Buey	0.072	0.056	0.045	0.004	0.013	-0.010	0.072	0.058	0.047	0.776	0.885	0.682	74	87	88
REMEDHUS	0.034	0.039	0.050	-0.031	-0.013	0.004	0.046	0.041	0.050	0.908	0.897	0.882	142	138	132
Twente	0.070	0.054	0.047	0.021	0.035	0.049	0.073	0.064	0.068	0.909	0.919	0.847	153	157	157
MAHASRI	0.030	0.037	0.034	-0.007	-0.008	-0.005	0.031	0.037	0.034	0.788	0.765	0.782	63	47	51
Yanco	0.040	0.037	0.038	-0.012	0.013	0.034	0.042	0.039	0.051	0.923	0.936	0.930	104	105	105
Kyeamba	0.056	0.054	0.043	-0.019	0.004	0.017	0.059	0.054	0.046	0.918	0.948	0.942	99	116	122
SMAP Average	0.045	0.039	0.043	-0.033	-0.010	0.016	0.067	0.054	0.061	0.786	0.820	0.758			
SMOS Average	0.048			-0.023			0.066			0.750					

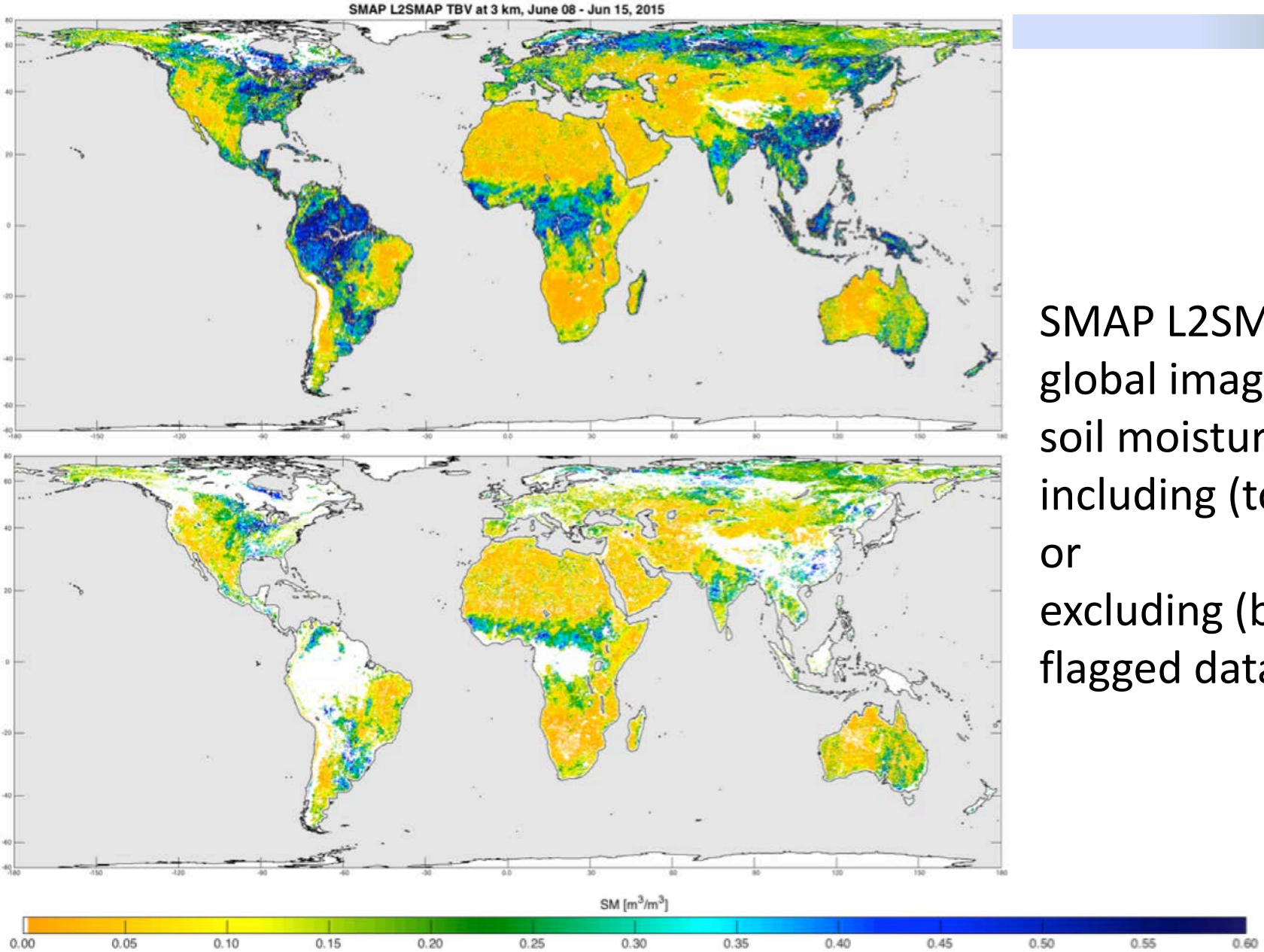
ubRMSE: 0.039 m^3/m^3

SMAP L2SMAP Product at 9 km



SMAP L2SMAP global images of soil moisture including (top) or excluding (bottom) flagged data.

SMAP L2SMAP Product at 3 km



SMAP L2SMAP global images of soil moisture including (top) or excluding (bottom) flagged data.

National Aeronautics and
Space Administration

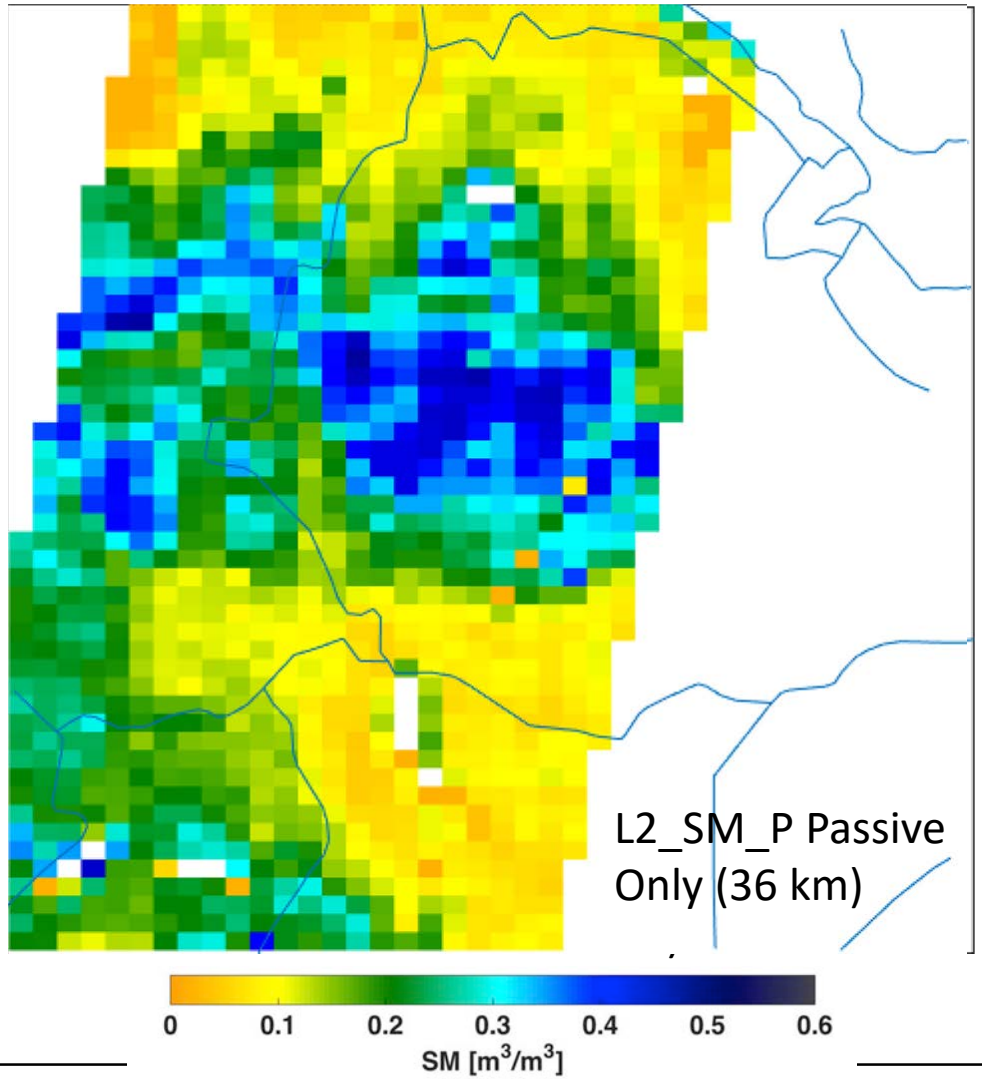
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

SMAP L2SMAP Product Validation

Detail Captured by SMAP Active-Passive Approach, July 1st, 2015

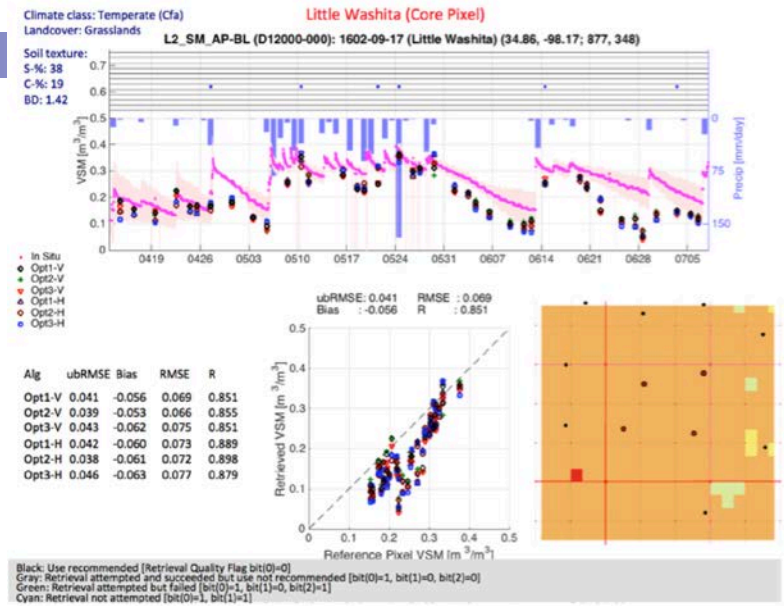
Comparison of SMAP Active-Passive Soil Moisture (3 km and 9 km) with the Passive-Only (36 km) soil moisture

Finer Details of Soil Moisture Captured in Increasing Spatial Resolution

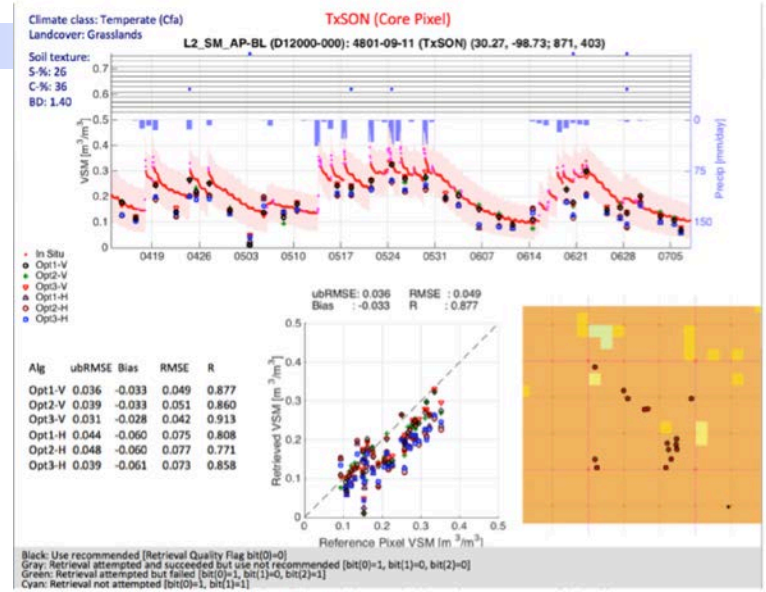


Example over Ethiopia, East Africa

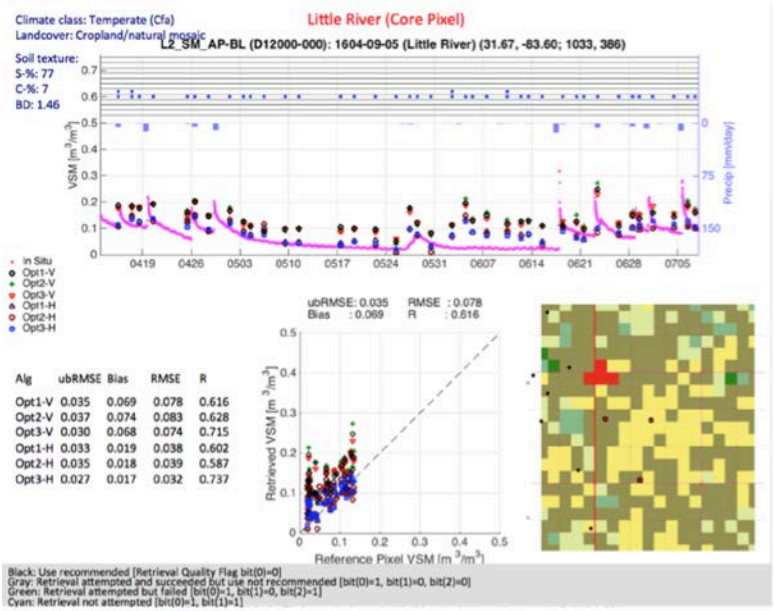
SMAP L2SMAP Product Validation



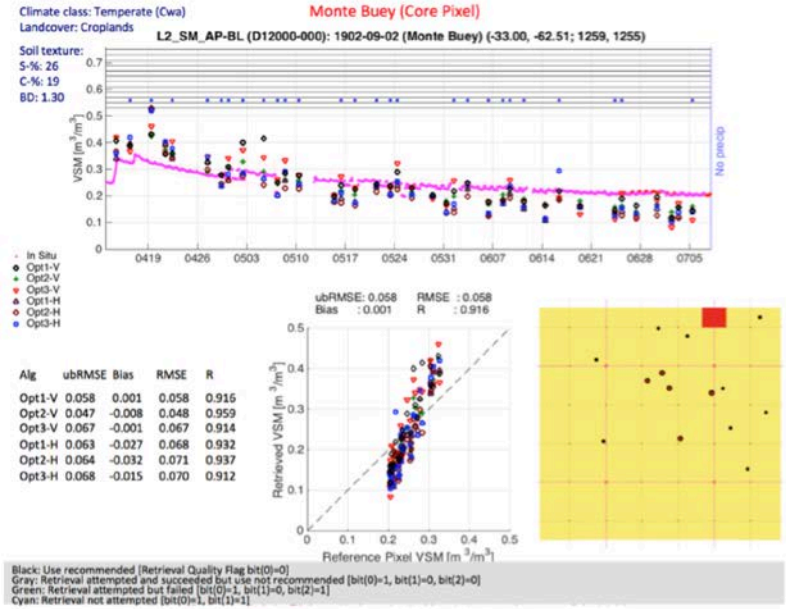
L2SMAP Assessment Tool Report for Little Washita, Oklahoma, USA.



L2SMAP Assessment Tool Report for TxSON, Texas, USA.

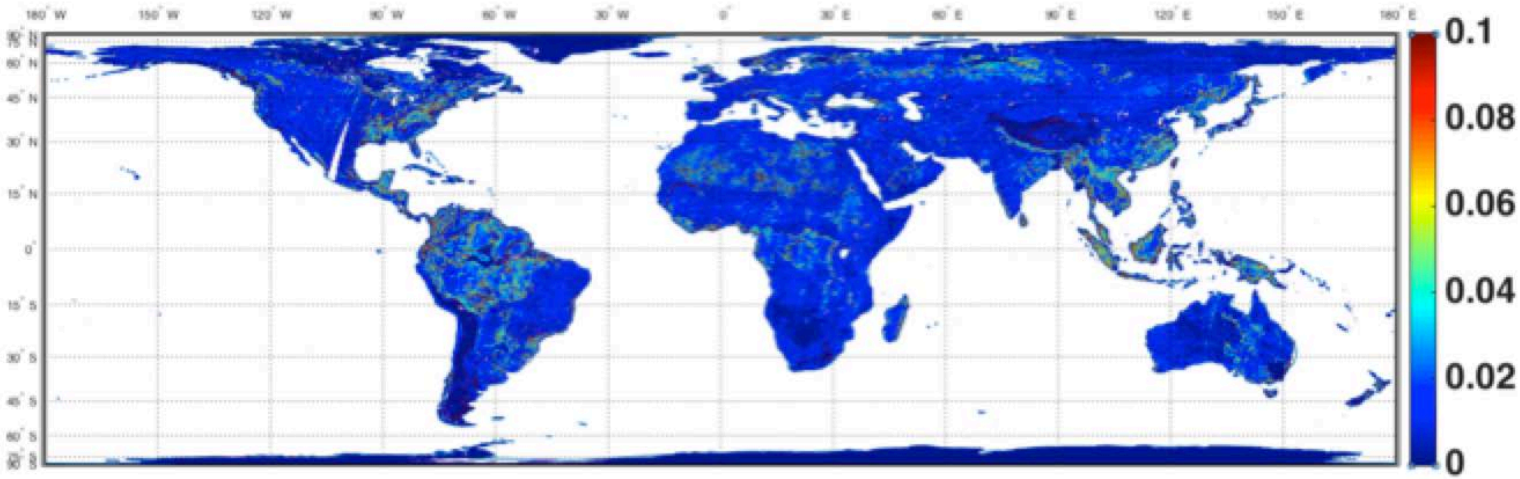


L2SMAP Assessment Tool Report for Little River, Georgia, USA.

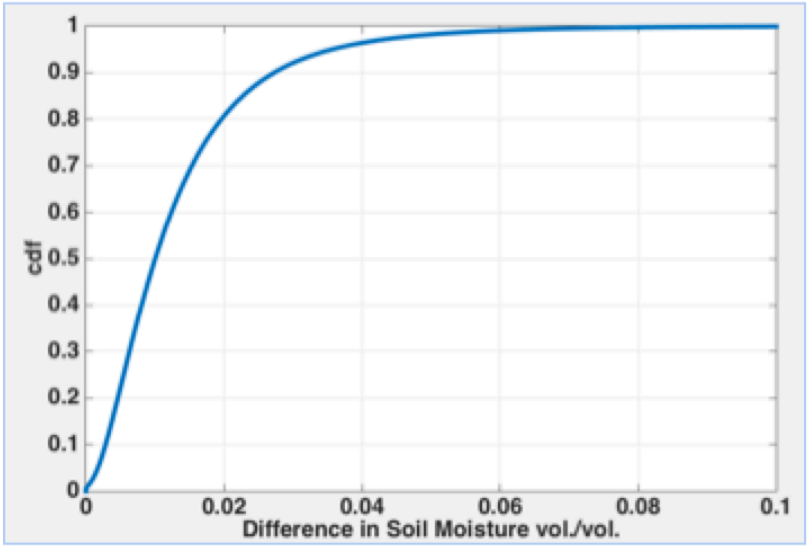


L2SMAP Assessment Tool Report for Monte Buey, Argentina.

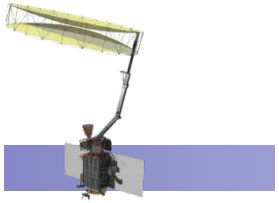
SMAP L2SMAP Product Validation



Comparison of L2SMAP and L2SMP soil moisture without using retrieval quality flags.



CDF of comparison of L2SMAP and L2SMP soil moisture without using retrieval quality flags.



SMAP L2SMAP Product Validation

SMAP L2SMAP Beta Release CVS Assessment for Disaggregated TBVs at 9 km

	ubRMSE (m^3/m^3)			Bias (m^3/m^3)			RMSE (m^3/m^3)			R		
Site name	**Opt-1**	**Opt-2**	**Opt-3**	**Opt-1**	**Opt-2**	**Opt-3**	**Opt-1**	**Opt-2**	**Opt-3**	**Opt-1**	**Opt-2**	**Opt-3**
Walnut Gulch	0.030	0.039	0.027	-0.015	-0.007	0.012	0.034	0.035	0.029	0.894	0.870	0.907
TxSON	0.036	0.039	0.030	-0.033	-0.033	-0.028	0.05	0.055	0.043	0.870	0.860	0.910
Tonzi Ranch	0.026	0.031	0.025	-0.067	-0.036	-0.072	0.072	0.048	0.077	0.814	0.670	0.814
Little Washita	0.041	0.039	0.043	-0.056	-0.053	-0.062	0.069	0.066	0.075	0.851	0.855	0.851
Little River	0.028	0.032	0.031	0.050	0.060	0.065	0.067	0.075	0.073	0.752	0.675	0.735
Kenaston	0.055	0.062	0.053	-0.026	-0.033	-0.021	0.061	0.070	0.057	0.651	0.591	0.512
Monte Buey	0.058	0.047	0.067	-0.001	-0.008	-0.001	0.058	0.048	0.067	0.915	0.959	0.914
Valencia	0.034	0.034	0.034	-0.037	-0.025	-0.046	0.050	0.042	0.057	0.537	0.500	0.510
Yanco	0.069	0.072	0.064	0.040	0.060	0.044	0.089	0.102	0.089	0.825	0.830	0.850
SMAP Average	**0.0418**	**0.043**	**0.041**	**-0.016**	**-0.008**	**-0.015**	**0.061**	**0.060**	**0.063**	**0.789**	**0.757**	**0.778**
Averages are based on the values reported for each CVS												

ubRMSE:
0.0418 m^3/m^3

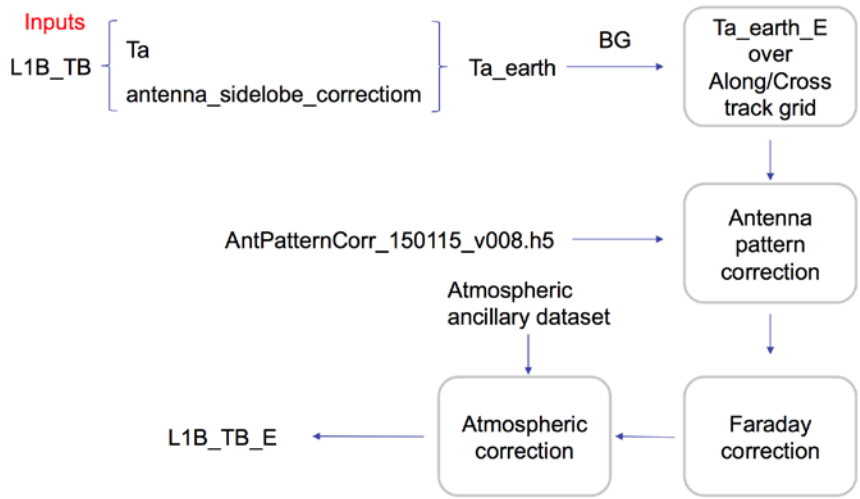
SMAP L2SMAP Beta Release CVS Assessment for Disaggregated TBV and TBH at 3km

	ubRMSE (m^3/m^3)		Bias (m^3/m^3)		RMSE (m^3/m^3)		R	
Sites	TBV	TBH	TBV	TBH	TBV	TBH	TBV	TBH
Walnut Gulch	0.029	0.044	-0.010	-0.023	0.037	0.058	0.324	0.10
TxSON	0.034	0.044	-0.063	-0.013	0.070	0.046	0.921	0.828
Tonzi Ranch	0.034	0.049	-0.050	-0.059	0.061	0.076	0.773	0.640
St Josephs	0.109	0.098	0.053	0.018	0.122	0.100	0.508	0.334
Little River	0.043	0.044	-0.014	0.027	0.046	0.051	0.673	0.658
Kenaston	0.057	0.076	-0.064	-0.032	0.086	0.082	0.281	0.421
Monte Buey	0.065	0.100	-0.053	-0.031	0.084	0.105	0.817	0.693
Valencia	0.042	0.047	-0.064	-0.029	0.077	0.056	0.267	0.446
Yanco	0.071	0.074	0.005	0.027	0.071	0.079	0.728	0.682
SMAP Average	**0.054**	**0.064**	**-0.029**	**-0.013**	**0.072**	**0.073**	**0.59**	**0.54**
L2SMAP 9km	**0.042**	**0.044**	**-0.016**	**-0.036**	**0.061**	**0.069**	**0.79**	**0.72**

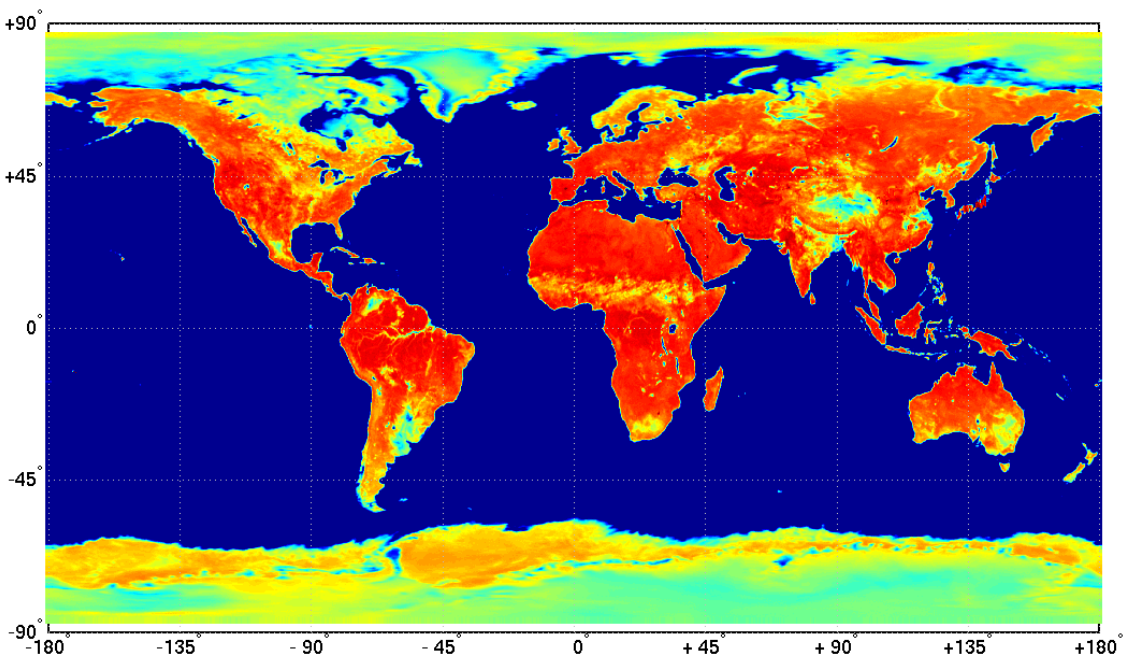
SMAP Post-Radar Period

- Lead to many research to recover the lost capabilities of the SMAP mission due to the radar failure.
- Two Approaches are followed:
  - -- Enhancing the SMAP radiometer resolution
  - -- Fine Grid processing of SMAP L2SMP data
  - -- Ingesting SAR data from different satellite for high resolution soil moisture

SMAP Radiometer Resolution Enhancement



BACKUS GILBERT Approach

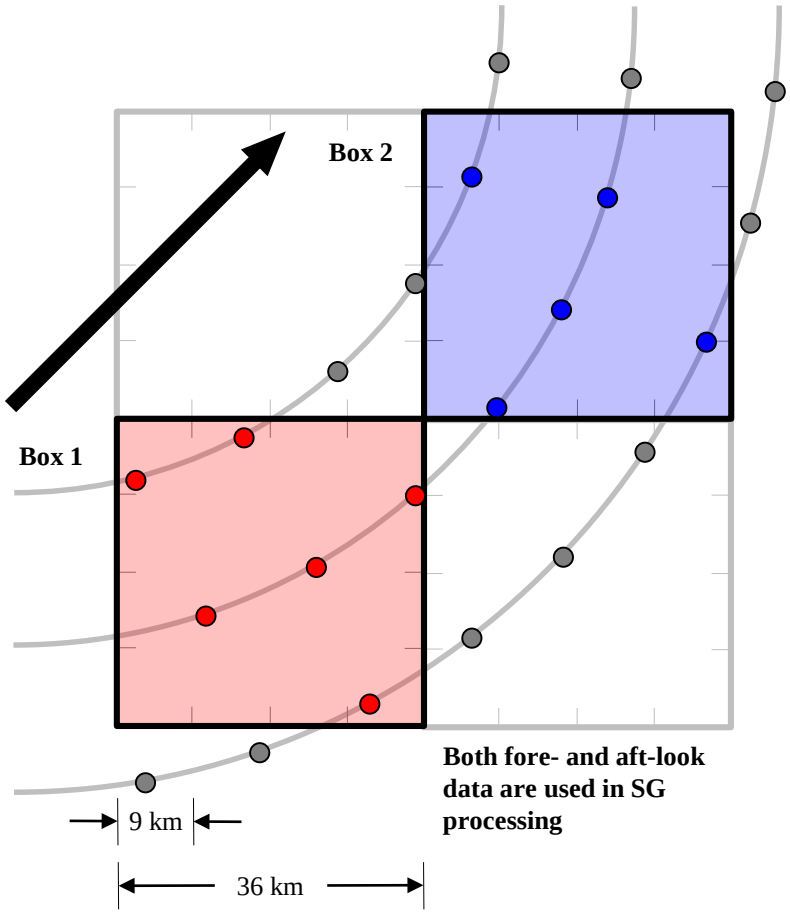


Three days simulation
Expected resolution ~25 km
Gridded at 9 km

SMAP Fine Grid Processing For Radiometer

Existing
Standard Grid (SG) Processing

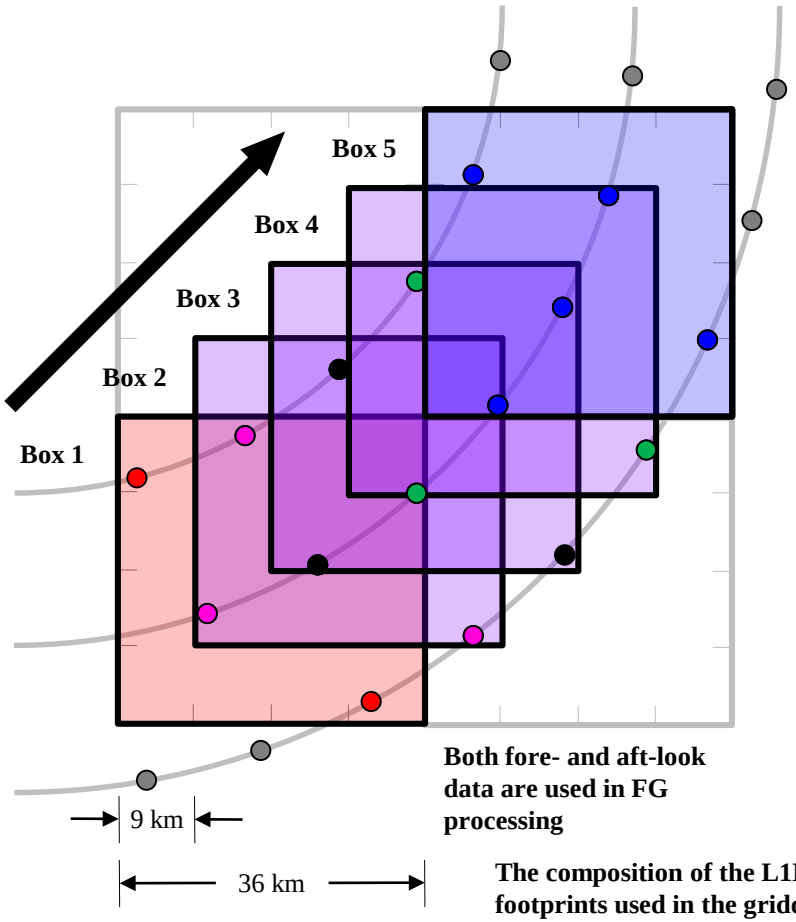
On SG, radiometer data transition is not fully captured from one box to another offset by 36 km



Both fore- and aft-look data are used in SG processing

Proposed
Fine Grid (FG) Processing

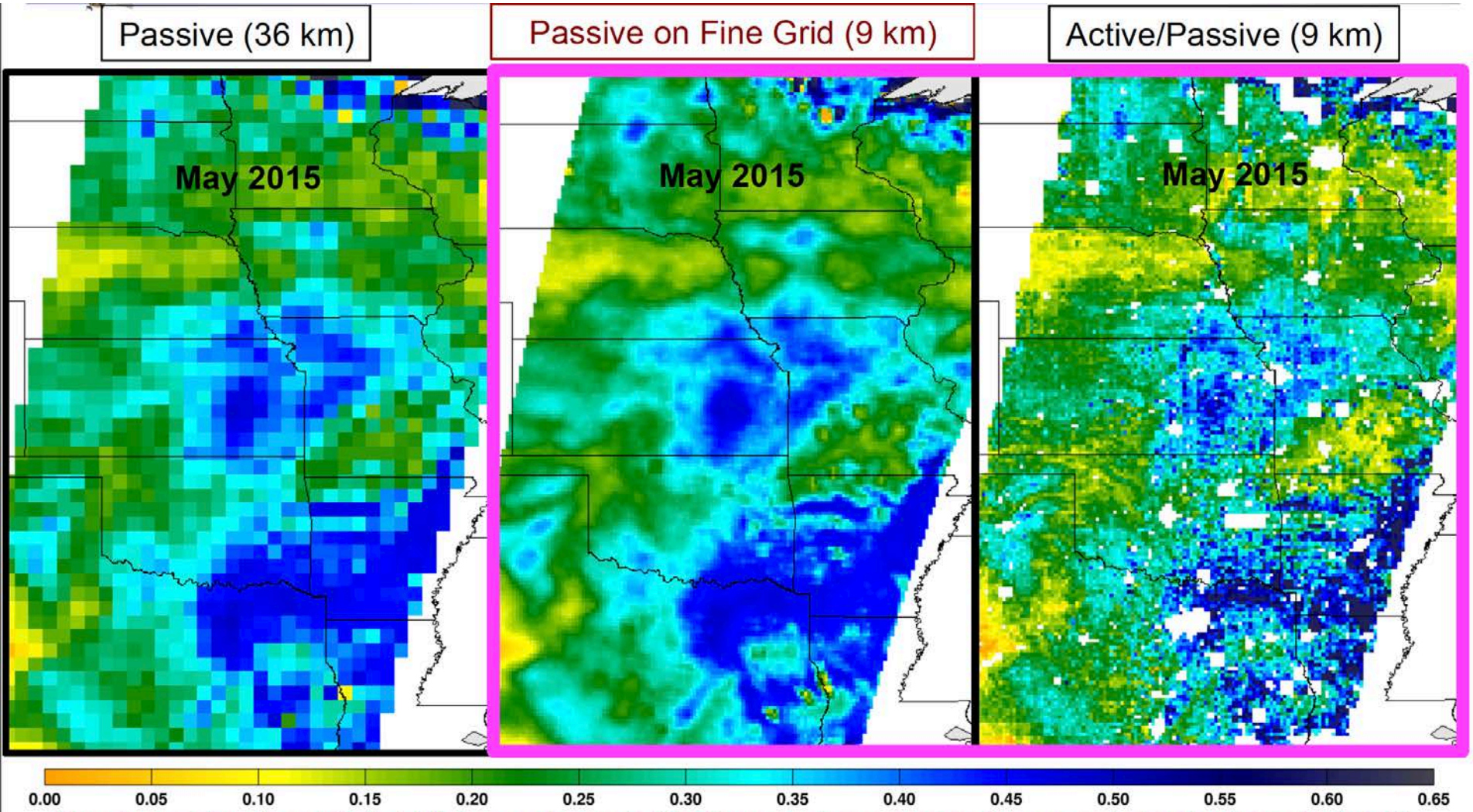
On FG, radiometer data transition is **more fully captured** from one box to another offset by 9 km



Both fore- and aft-look data are used in FG processing

The composition of the L1B footprints used in the gridding process changes for each FG box

SMAP Fine Grid Processing For Radiometer



Passive retrieval on FG (middle) reveals spatial features not apparent in the current standard product (left); these features are nonetheless consistent with what the A/P product (right) demonstrated prior to radar failure

SMAP-Sentinel Active-Passive Product

Why Sentinel for AP Algorithm

Sensor Name	RADARSAT-2	Sentinel-1A	RISAT-1
Agency	Canadian Space Program (CSP)	European Space Agency (ESA)	Indian Space Research Organization (ISRO)
Instrument	C-band SAR (5.4 GHz)	C-band SAR (5.4 GHz)	C-band SAR (5.35 GHz)
Incidence Angle	Side-looking, 15-45° off-nadir	Side-looking, 15-45° off-nadir	36.85 deg.
Polarization	HH, HV, VV and VH	(VV and VH) or (HH and HV)	HH an HV
Sensor Height at Equator	798 km	693 km	542 km
Orbit	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)
Revisit time (Orbit Repeat cycle)	24 days	12days	25 days
Resolution	100 m	5 m X 20 m	~25 meters
Swath Width	500 km (ScanSAR mode)	250 km (IWS mode)	115 km (MRS)
Mean local time	6:00 AM Descending	6:00 AM Descending	6:00 AM
Launch	Dec 14th, 2007	April 3rd, 2014	April 26th, 2012
Planned Lifetime	7 years minimum	7 years	5 years

SMAP-Sentinel Active-Passive Product

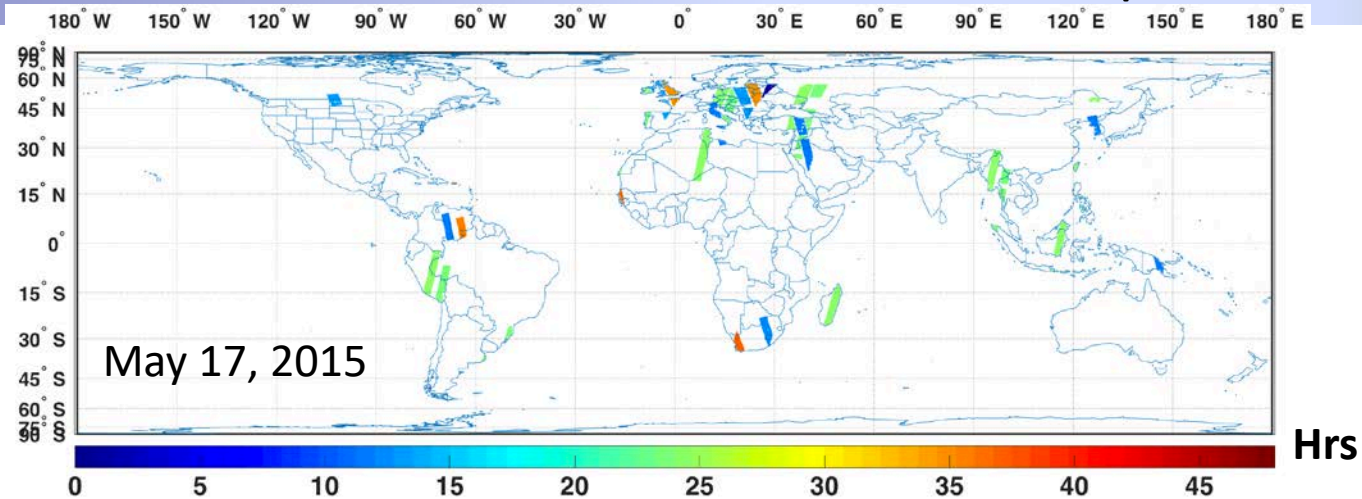
Why Sentinel for AP Algorithm cont'd

Sensor Name	RADARSAT-2	Sentinel-1A	RISAT-1
Current Data Access	Cost $$$	**Free**	Cost $$$
Future addition to mission	No	Yes, (Sentinel-1B to be launched in 2016)	No

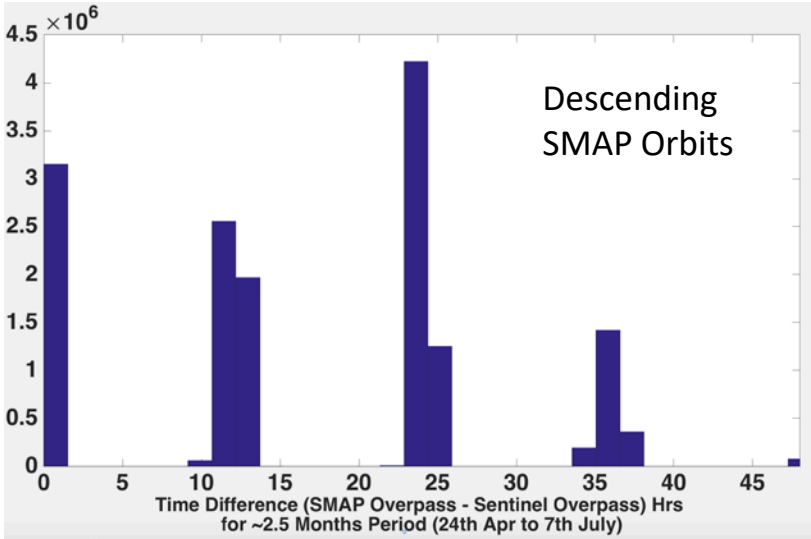
Recommendation: Is to use Sentinel data because it is free, has better revisit interval, and has the required co-pol and x-pol measurements. With Sentinel-1B, the revisit interval will improve further.

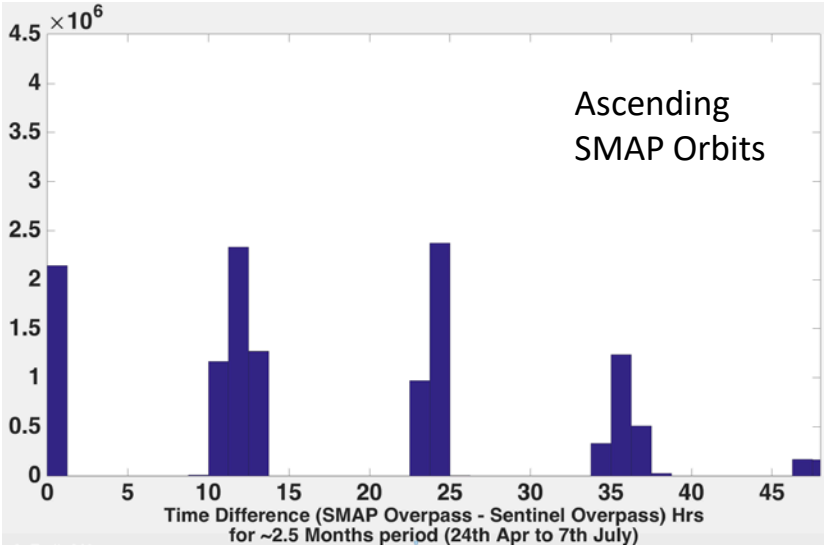
SMAP-Sentinel Active-Passive Product

SMAP and Sentinel Global Overlap



With the current orbits characteristics of SMAP and Sentinel the average time difference is ~18 hours that includes the Sentinel Asc. and Des. Overpasses for any given SMAP swath.

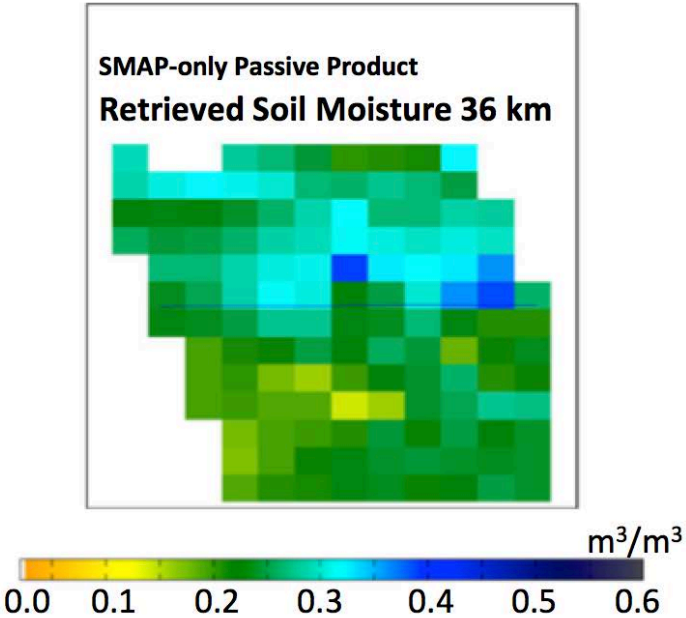


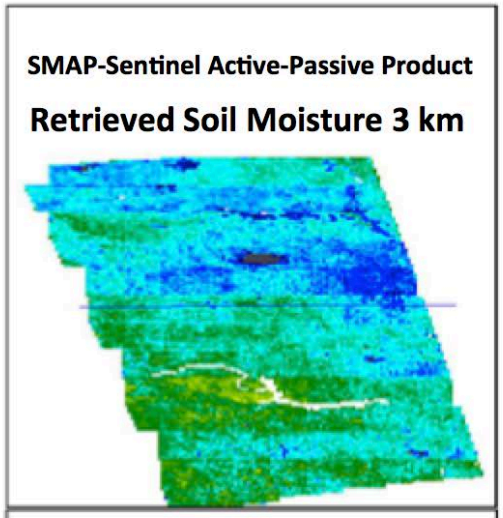


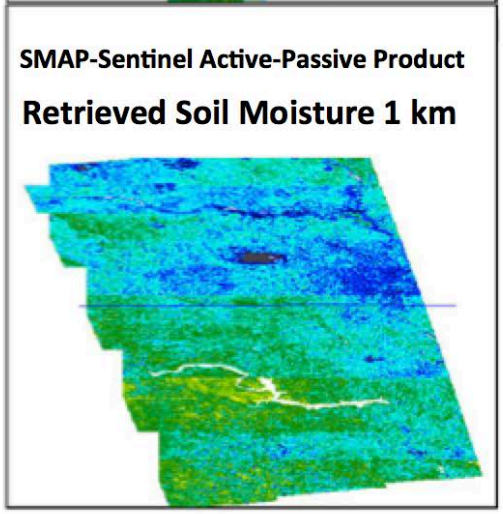
SMAP-Sentinel Active-Passive Product

SMAP Active-Passive Algorithm

$$T_{B_p}(M) = T_{B_p}(C) + \beta(C) \cdot \{ [\sigma_{pp}(M) - \sigma_{pp}(C)] - \Gamma(C) \cdot [\sigma_{pq}(M) - \sigma_{pq}(C)] \}$$





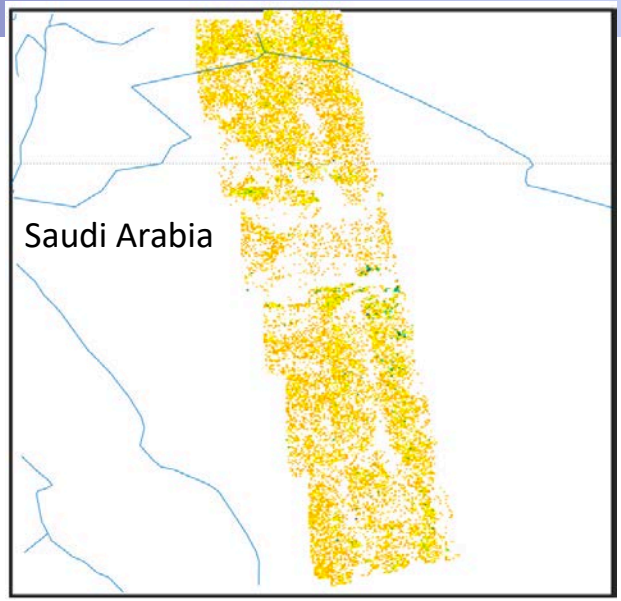


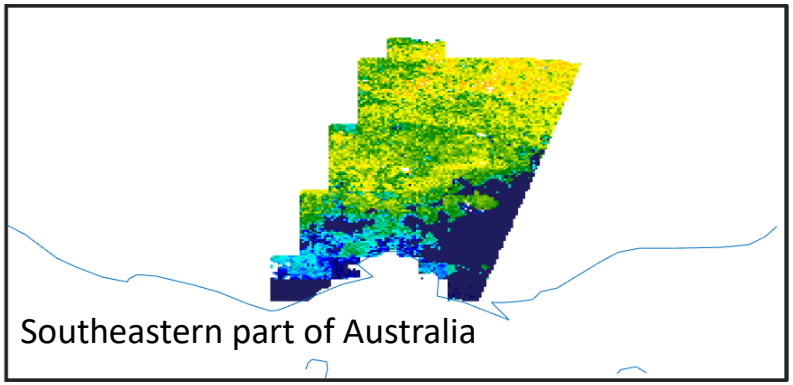
Soil Moisture at Different Resolutions Retrieved for May 17th, 2015 Over Manitoba region Canada

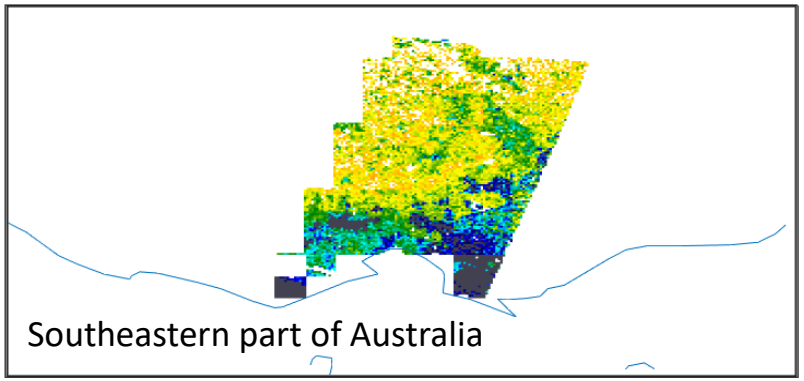
SMAP-Sentinel Active-Passive Product

SMAP_Sentinel-based 3 km

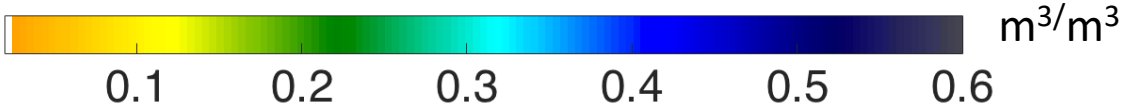
SMAP-based 3 km







Retrieved Soil Moisture

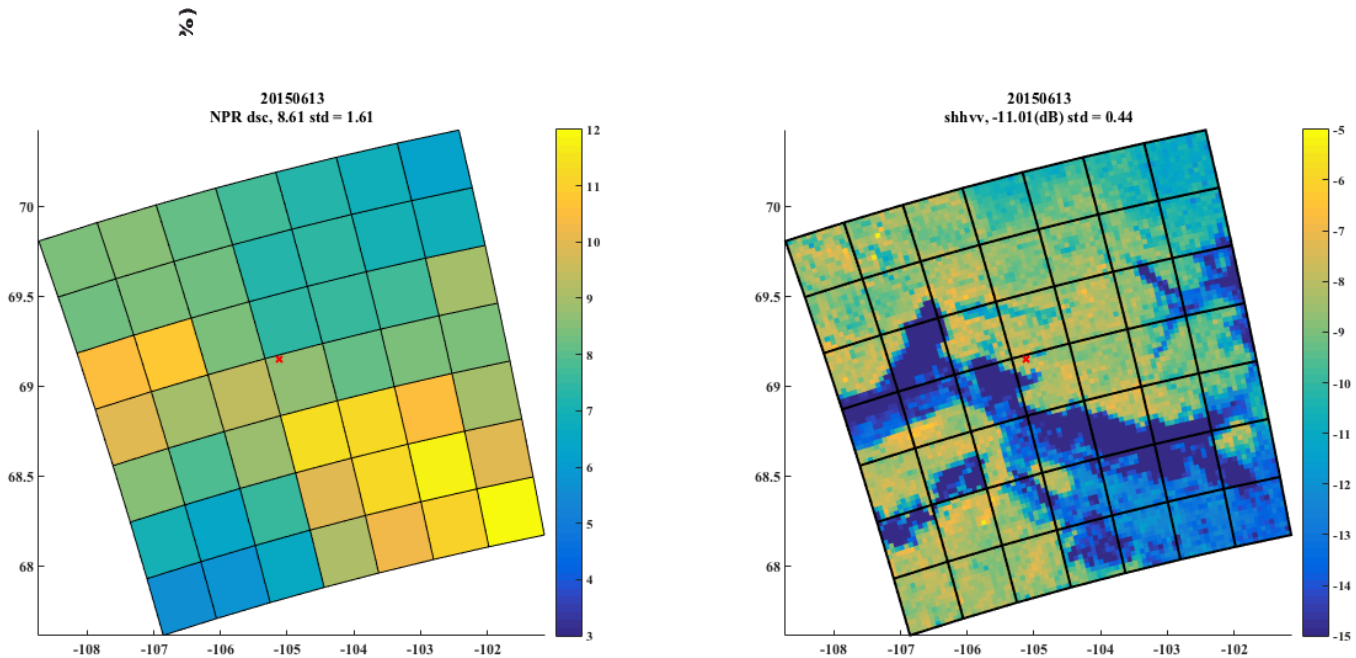


m^3/m^3

SMAP Radiometer-based F/T Product

Comparison with Active ProductL3-FT-A vs. L3-FT-P

- Expected impacts on retrieval performance compared to L3_FT_A are related to:
  - -change in sensitivity from the active to passive case (will assess during period of radiometer and radar overlap, including low res s0
  - -increased spatial classification error due coarser resolution (36 vs 3 km)



Conclusion

- The SMAP Validated-Products are already released and the products met the mission requirements
- The SMAP mission finished one year in April’16
- SMAP-Enhanced Products are being tested and look promising. As per proposed schedule, the SMAP-Enhanced products will be released by April’17.