National Aeronautics and Space Administration

L4_SM

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**NASA/GMAO, +JPL Caltech, #USDA, &Univ. MT*

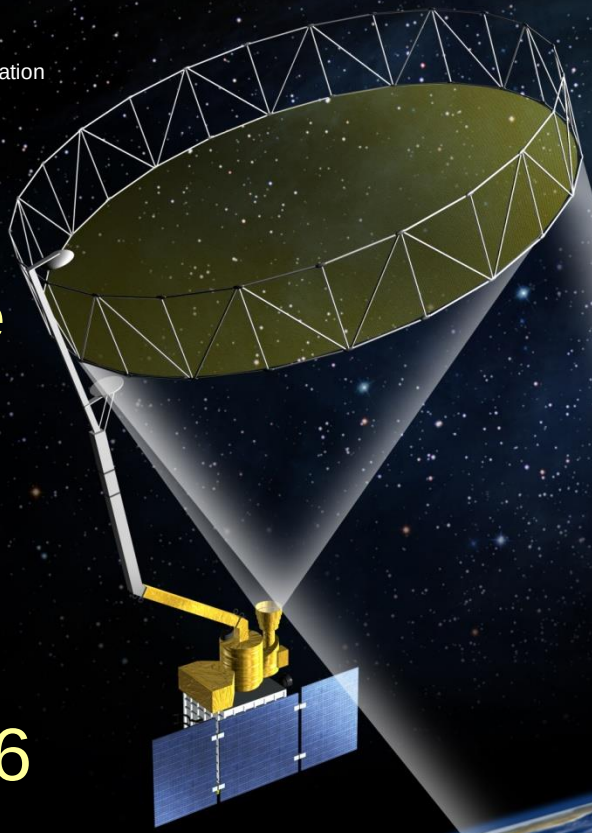
Soil Moisture Active Passive Mission

SMAP

Cal/Val Workshop #6

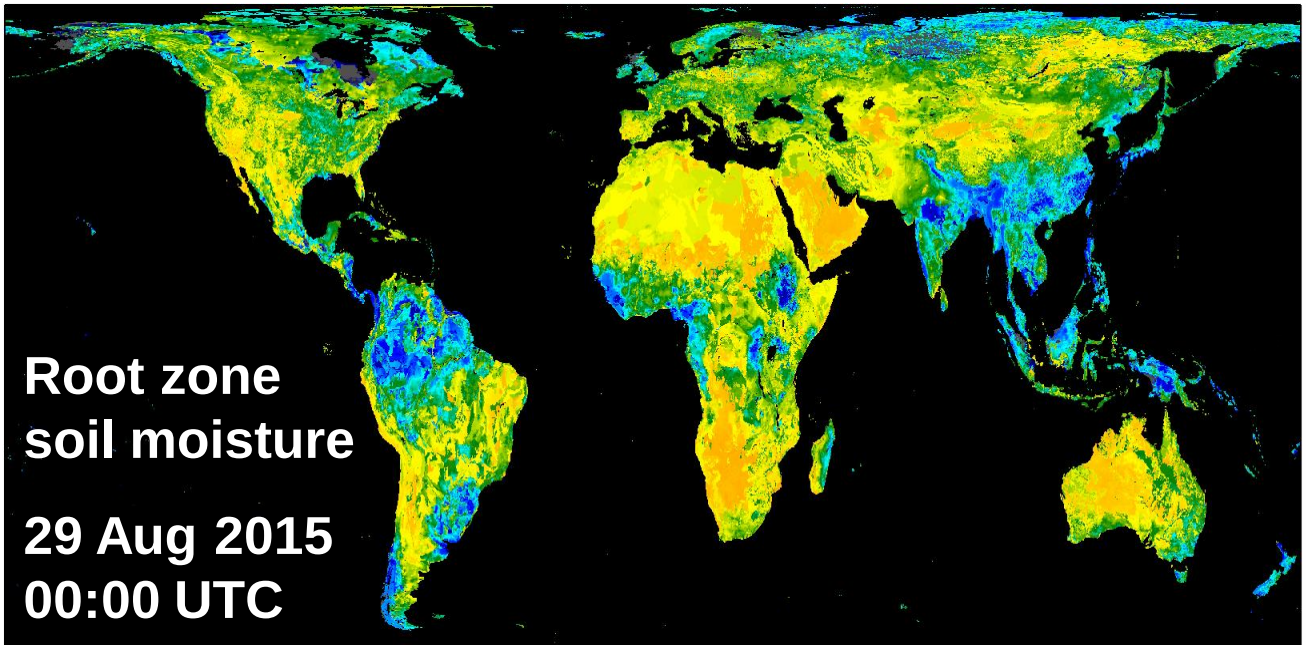
Sep 1-3, 2015

Columbia, MD



L4_SM Product Specifications

- ***Global***
- ***3-hourly***
- ***9-km***
- ***~3-day latency***



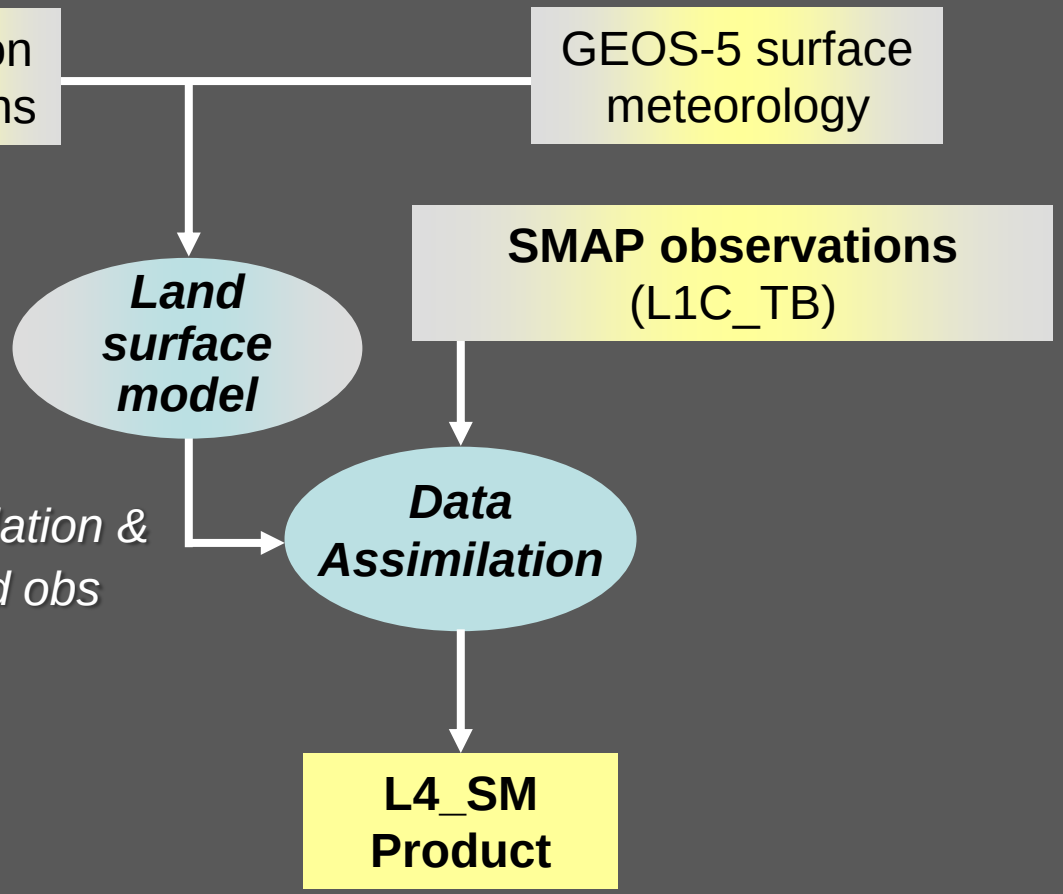
Geophysical Data (“gph”)	**Analysis Update Data** (“aup”)
3-hour time averages	*3-hour instantaneous (snapshots)*
Surface and **root zone** soil moisture, soil temperature, snow, land surface fluxes, surface meteorological forcing data.	Brightness temperatures (observed and modeled), soil moisture and soil temperature (model forecast and analysis), **uncertainty estimates**.

SMAP L4_SM Algorithm

GEOS-5 LDAS

- **Catchment model**
- **3d EnKF**

  spatial extrapolation, interpolation & disaggregation of assimilated obs



SMAP L4_SM Production

Current Operational Product Status

GSFC local time: 20150831 12:02:19 ET UTC: 20150831 16:02:19 Z

JOB NAME	STATUS	RUNNING	COMPLETED
SPL4SM V10002 001	Nominal	20150829	08/28/2015

http://gmao.gsfc.nasa.gov/operations/status.php

SMAP L4_SM Availability

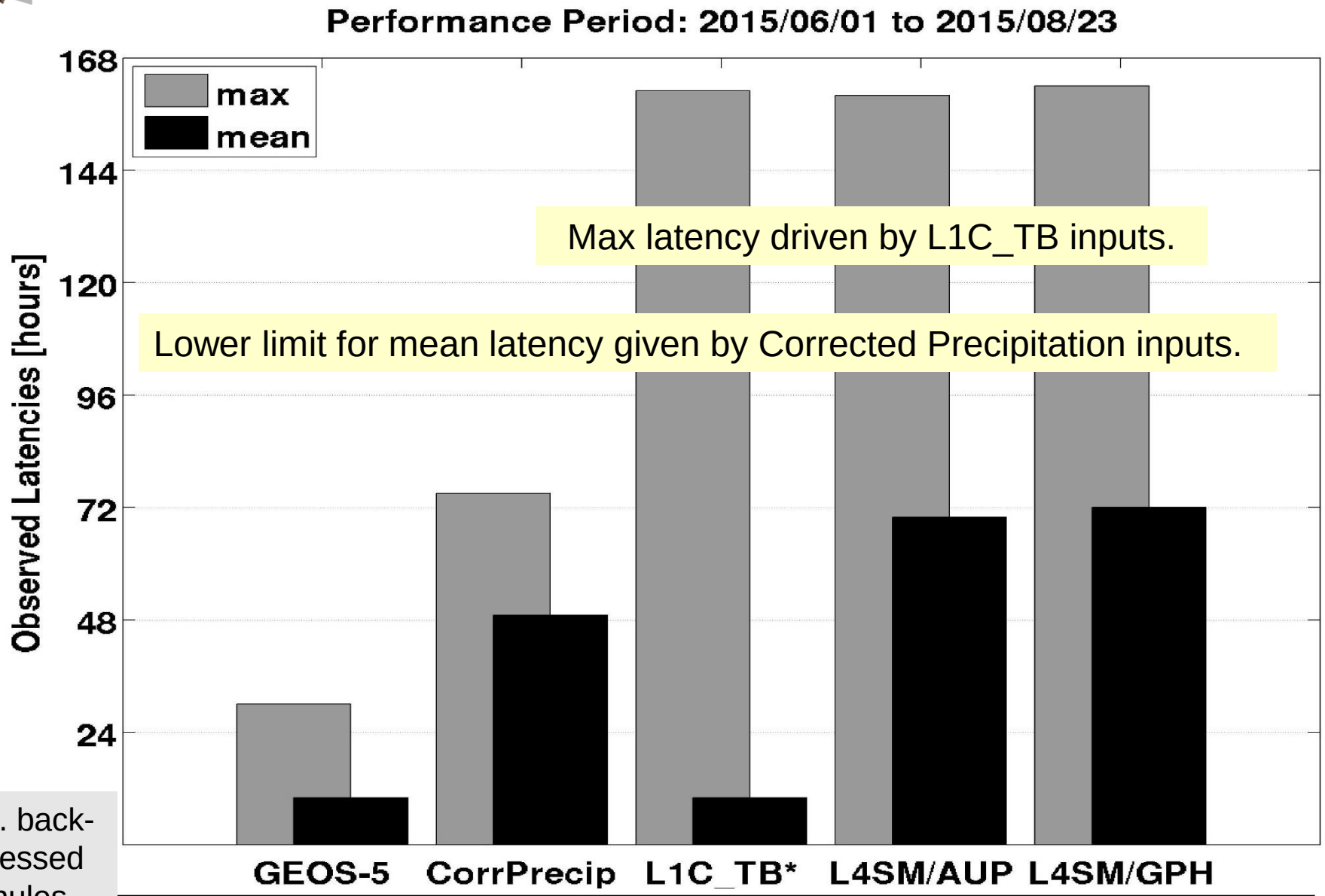
Pre-beta data (V10002) available for 3/31/2015-present from

- JPL (smap-tb.jpl.nasa.gov) and
- NSIDC (for restricted distribution).

V10002 algorithm very close to beta-release version, but operational V10002 stream used pre-beta L1 and L2 inputs.

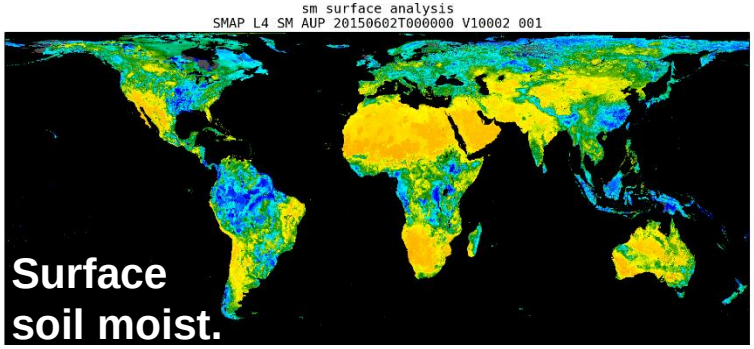
Reprocessing for L4_SM beta-release will fix many of the issues encountered in V10002.

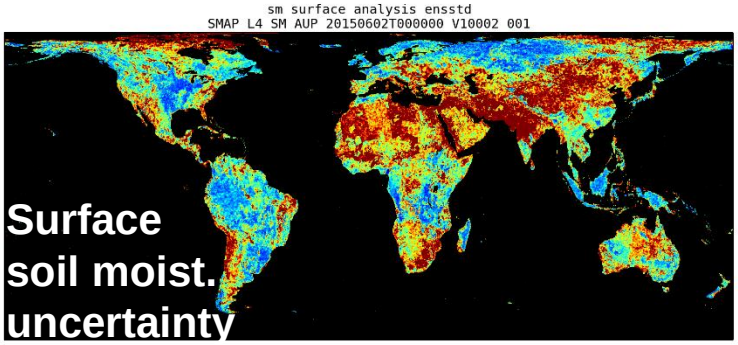
L4_SM Observed Latencies

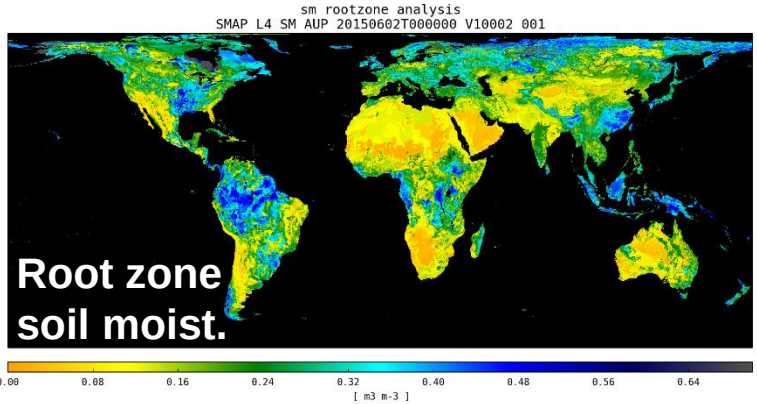


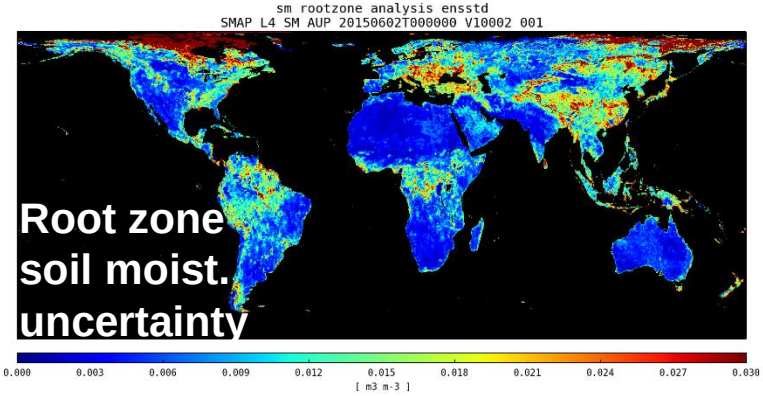
*Excl. back-processed granules.

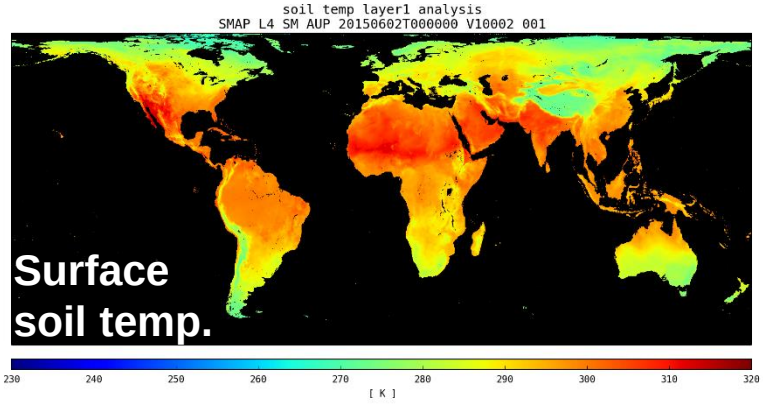
Browse Images
L4_SM V10002, 2 Jun 2015, 0z

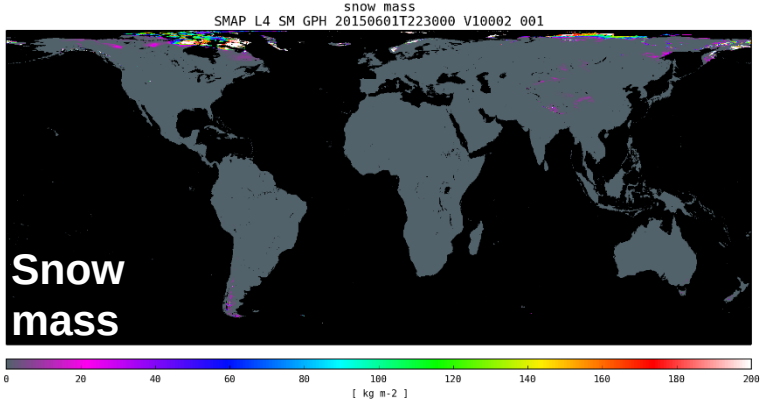




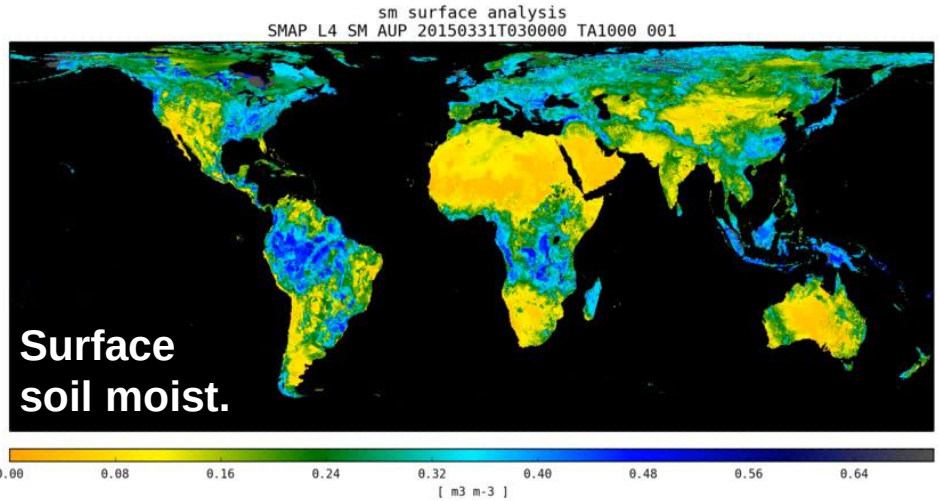


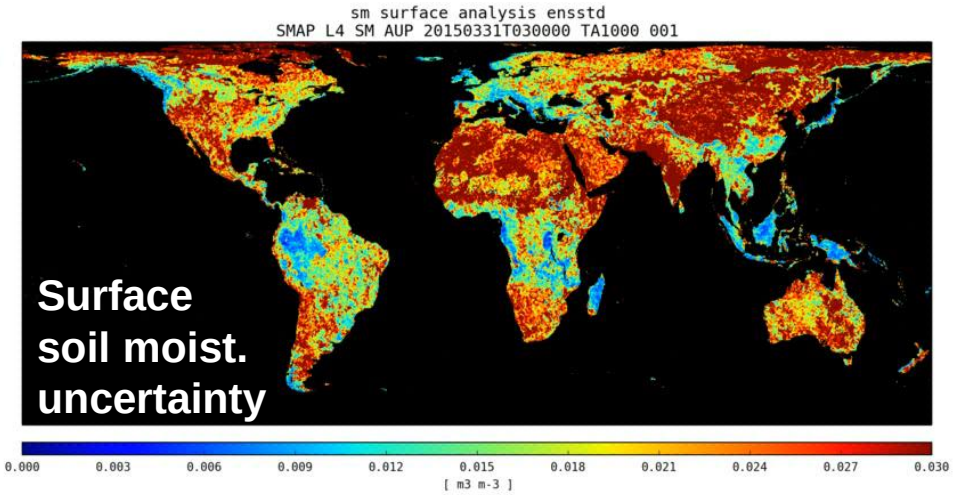


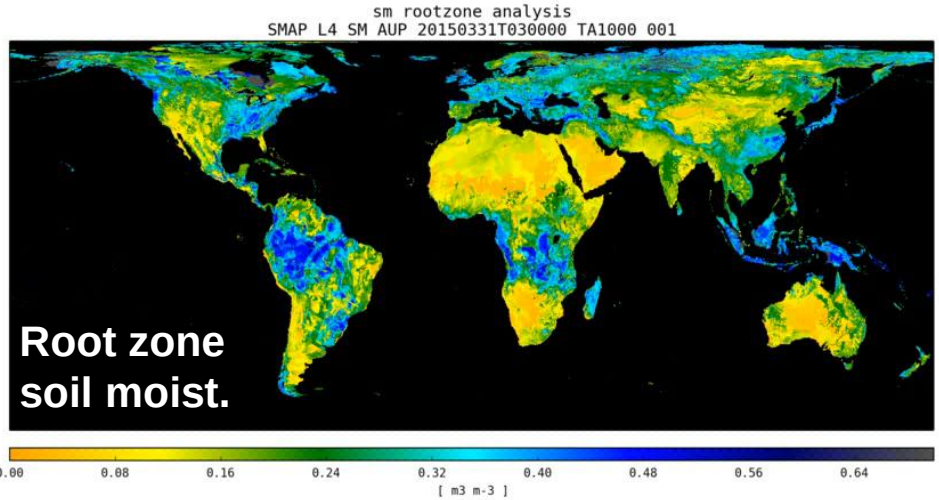


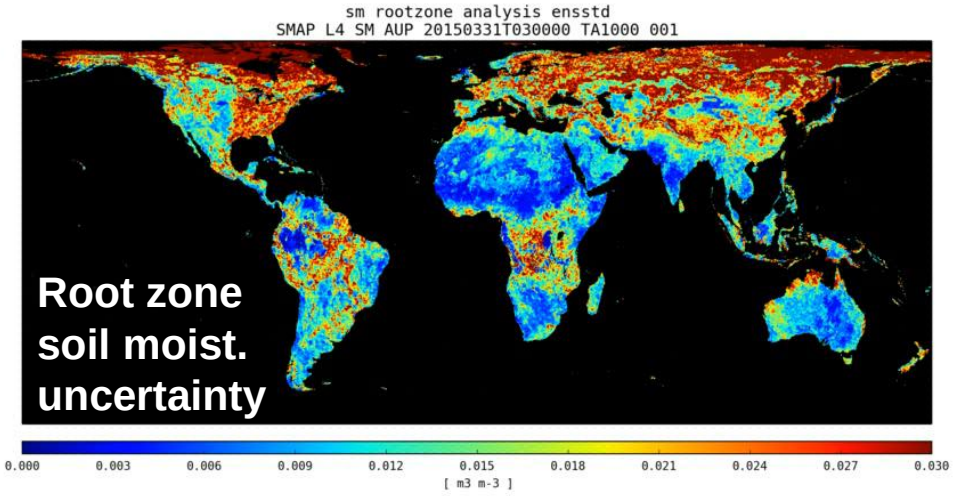


L4_SM Movie


sm surface analysis
SMAP L4 SM AUP 20150331T030000 TA1000 001
Surface soil moist.
0.00 0.08 0.16 0.24 0.32 0.40 0.48 0.56 0.64
[m3 m-3]


sm surface analysis ensstd
SMAP L4 SM AUP 20150331T030000 TA1000 001
Surface soil moist. uncertainty
0.000 0.003 0.006 0.009 0.012 0.015 0.018 0.021 0.024 0.027 0.030
[m3 m-3]


sm rootzone analysis
SMAP L4 SM AUP 20150331T030000 TA1000 001
Root zone soil moist.
0.00 0.08 0.16 0.24 0.32 0.40 0.48 0.56 0.64
[m3 m-3]

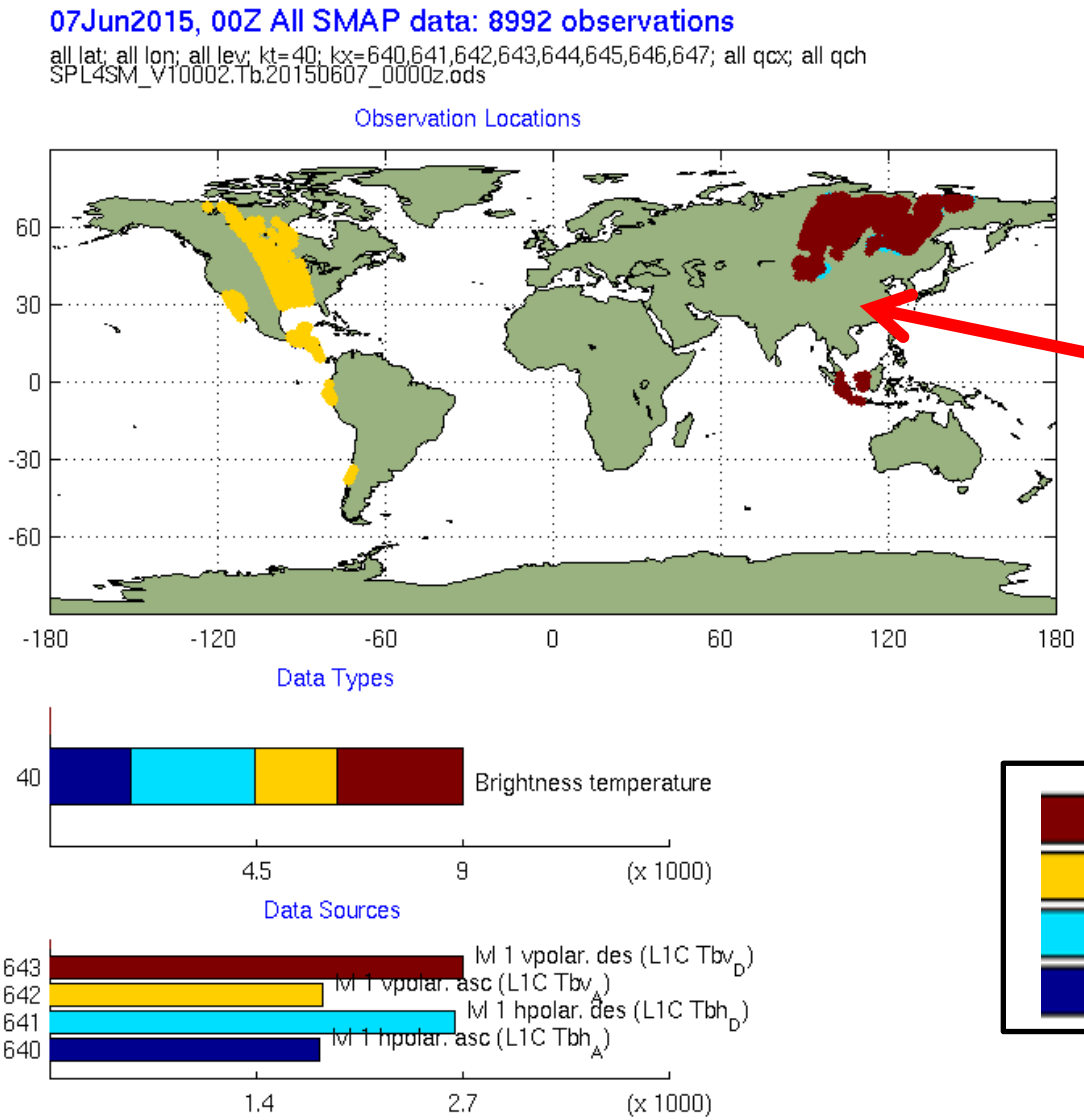

sm rootzone analysis ensstd
SMAP L4 SM AUP 20150331T030000 TA1000 001
Root zone soil moist. uncertainty
0.000 0.003 0.006 0.009 0.012 0.015 0.018 0.021 0.024 0.027 0.030
[m3 m-3]

L4_SM as Cal/Val Tool

L4_SM algorithm routinely confronts SMAP Tbs with model forecasts:

- Data coverage
- Data counts
- Observation-minus-forecast residuals (O-F; a.k.a. “innovations”)
- Observation-minus-analysis residuals (O-A)

Coverage of Assimilated Tb Observations



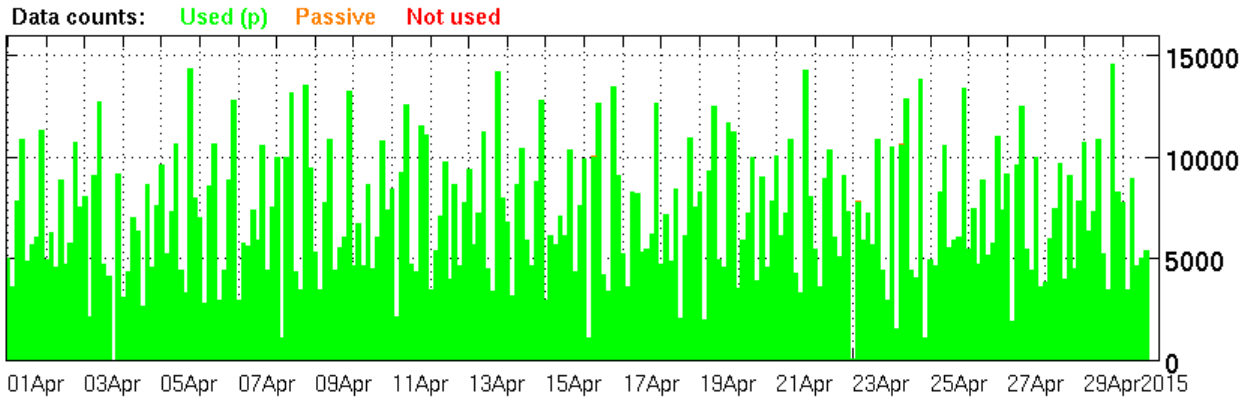
Gaps in SMOS-based rescaling files (because of RFI in SMOS)

- L1C_TB, V-pol, desc
- L1C_TB, V-pol, asc
- L1C_TB, H-pol, desc
- L1C_TB, H-pol, asc

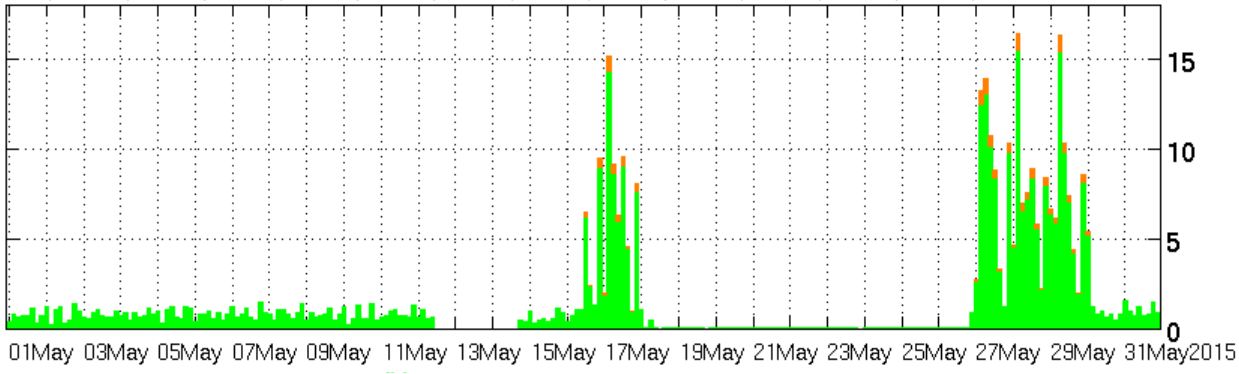
Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global

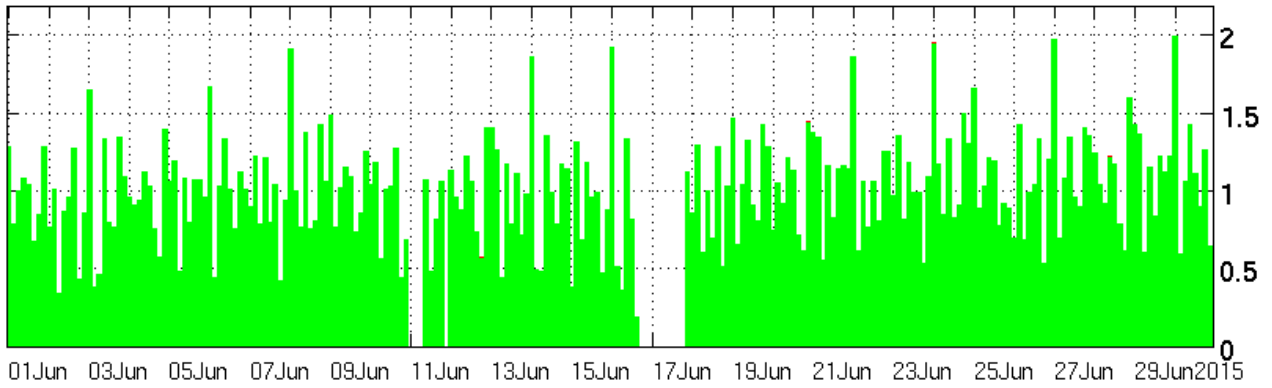
April



May

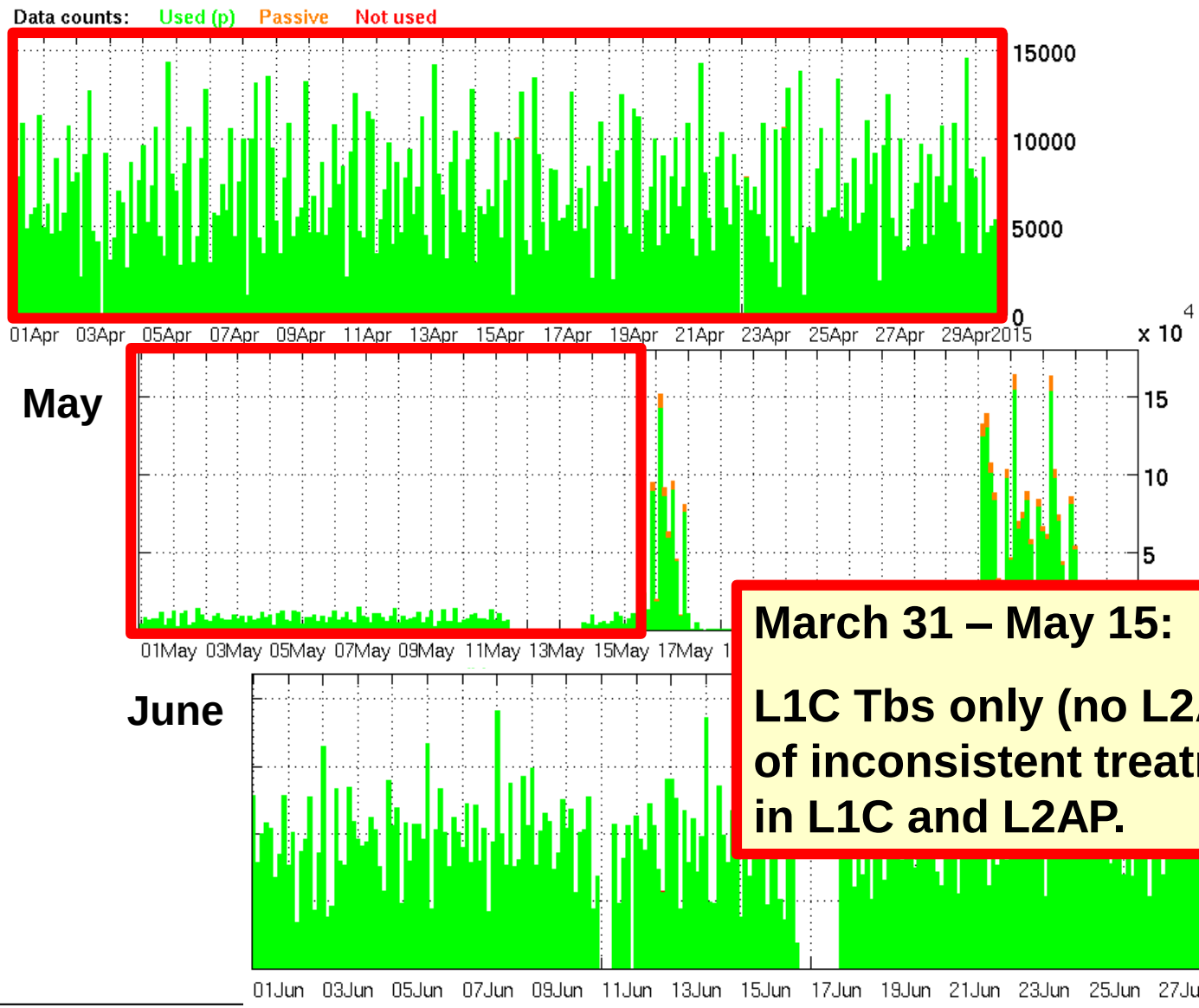


June



Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global

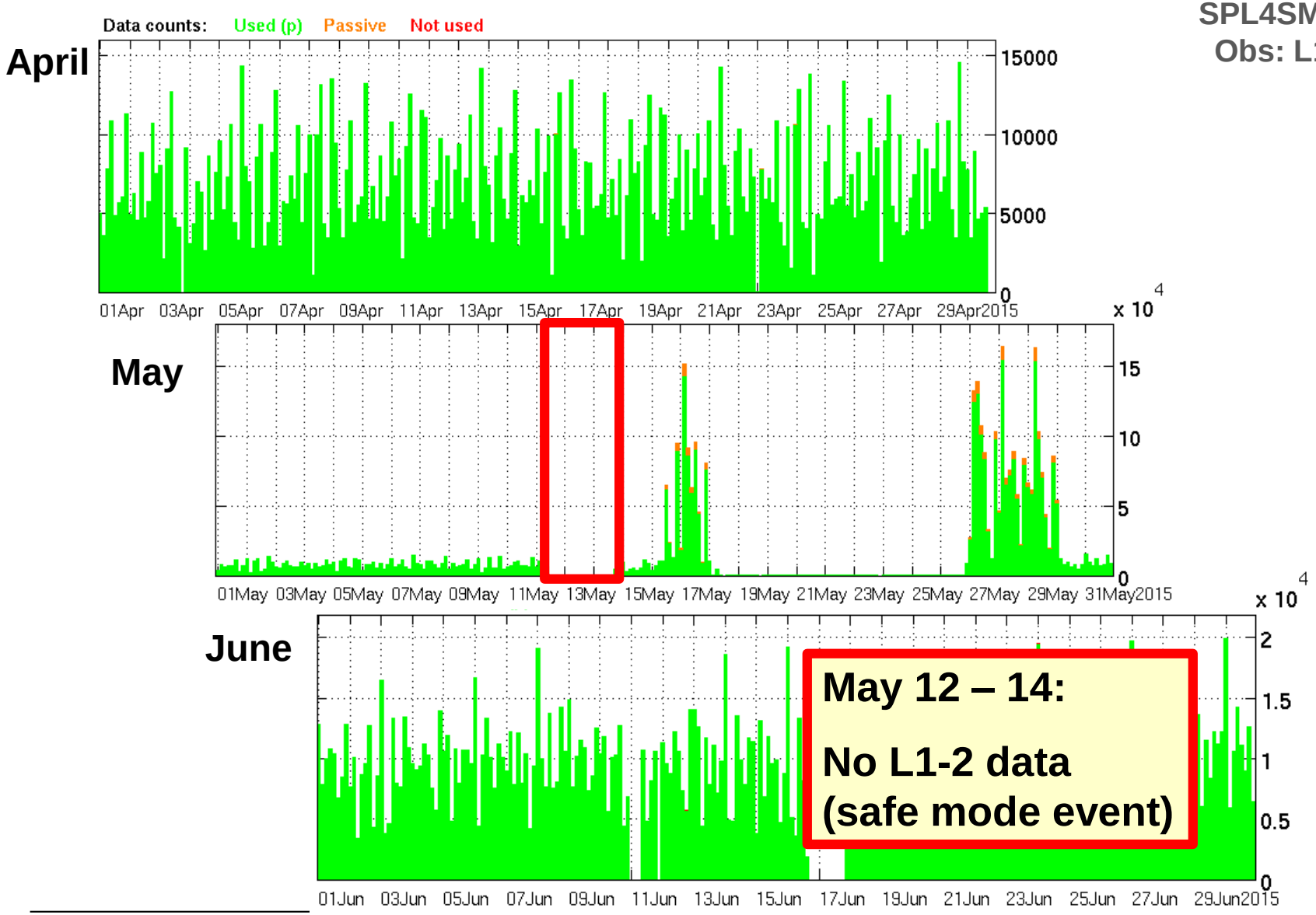


March 31 – May 15:

L1C Tbs only (no L2AP) because of inconsistent treatment of flags in L1C and L2AP.

Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global



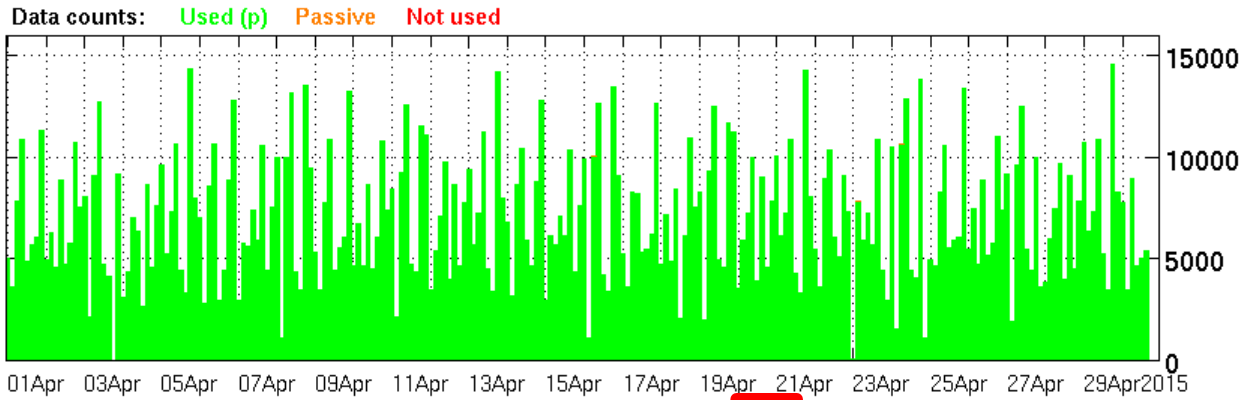
May 12 – 14:

No L1-2 data (safe mode event)

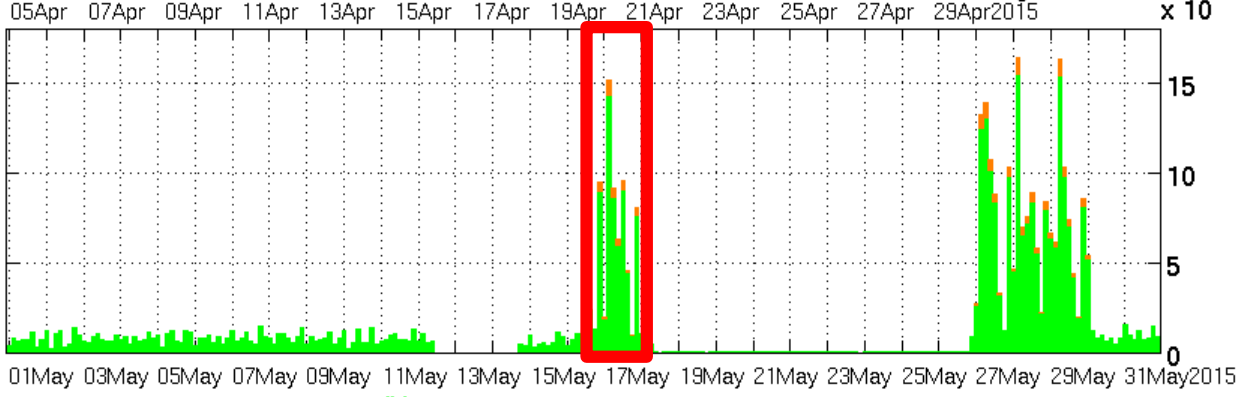
Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global

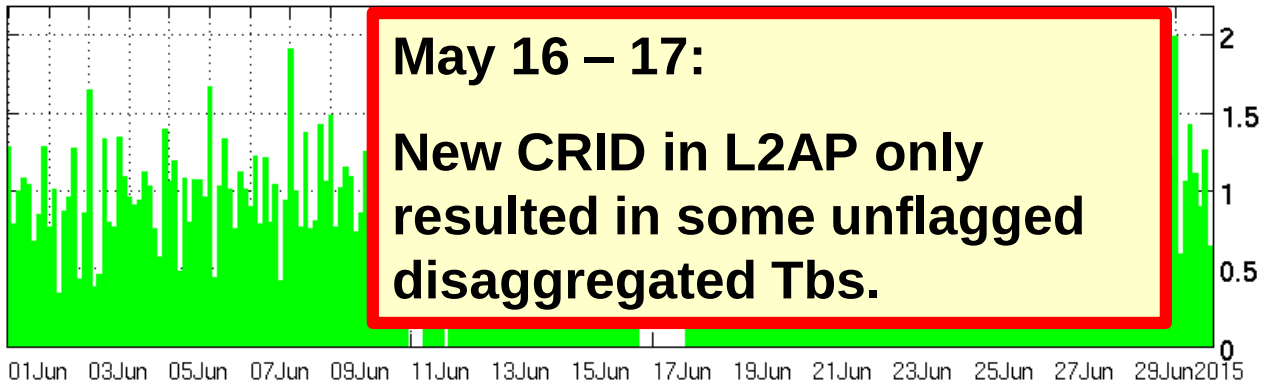
April



May



June



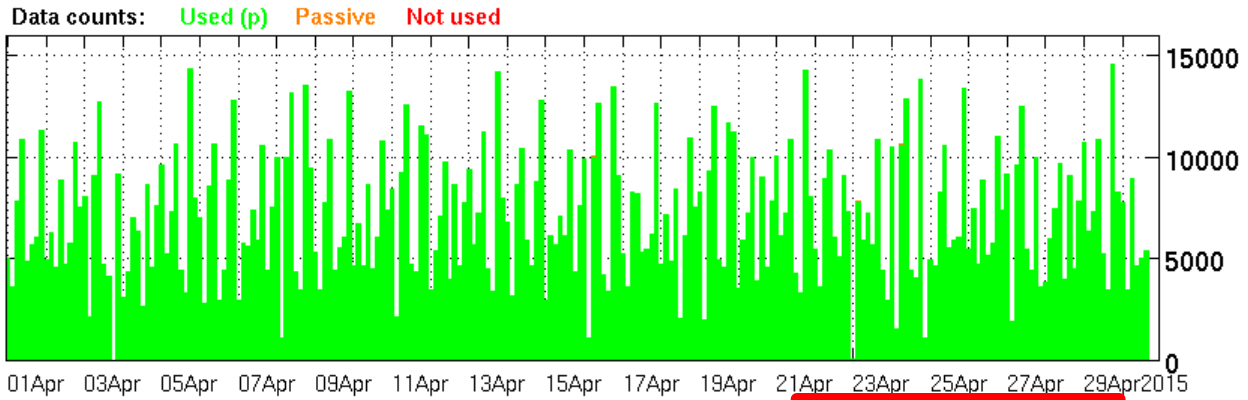
May 16 – 17:

New CRID in L2AP only resulted in some unflagged disaggregated Tbs.

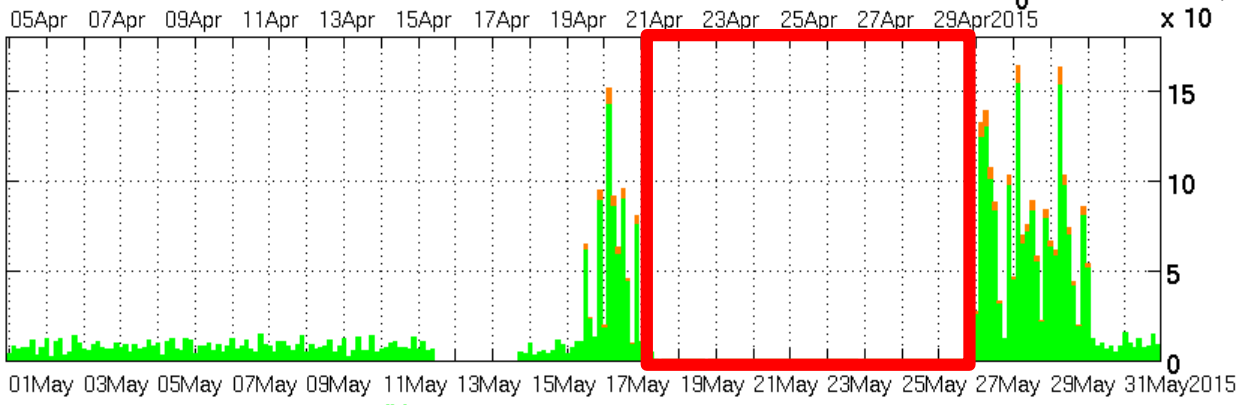
Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global

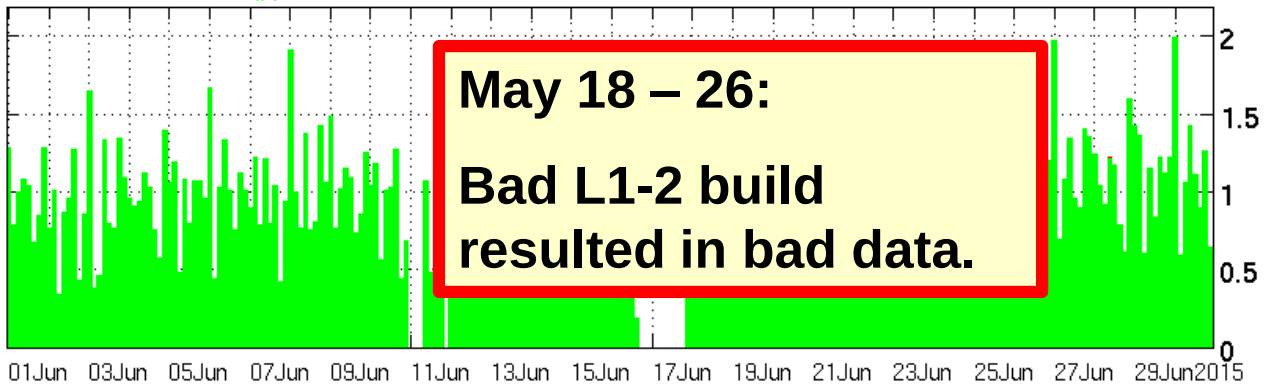
April



May



June



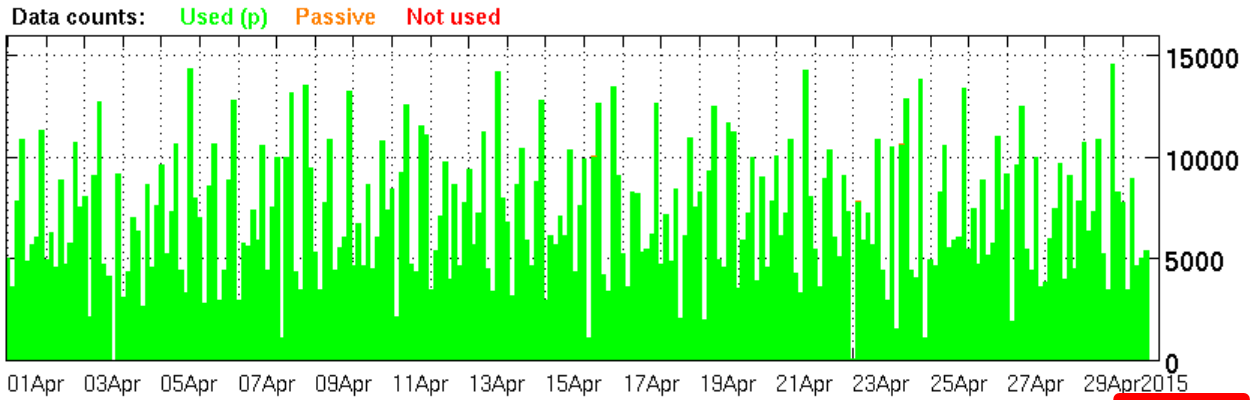
May 18 – 26:

Bad L1-2 build resulted in bad data.

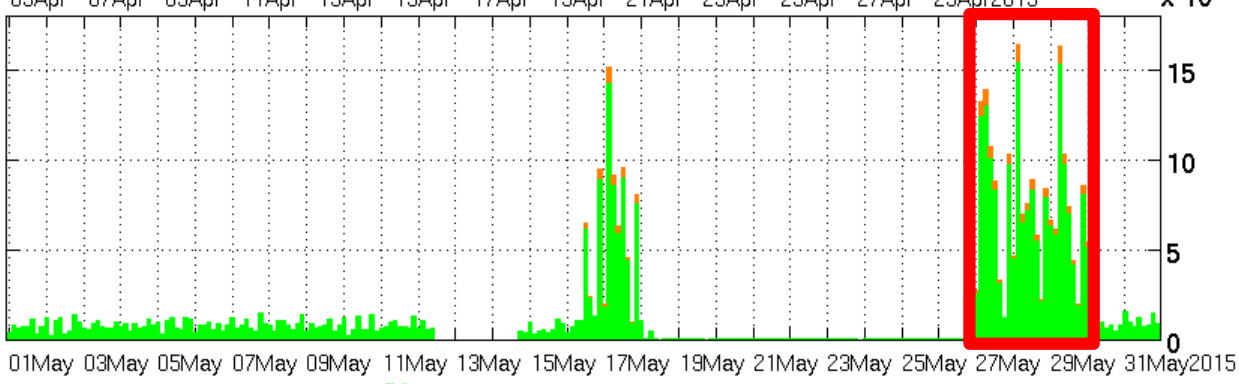
Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global

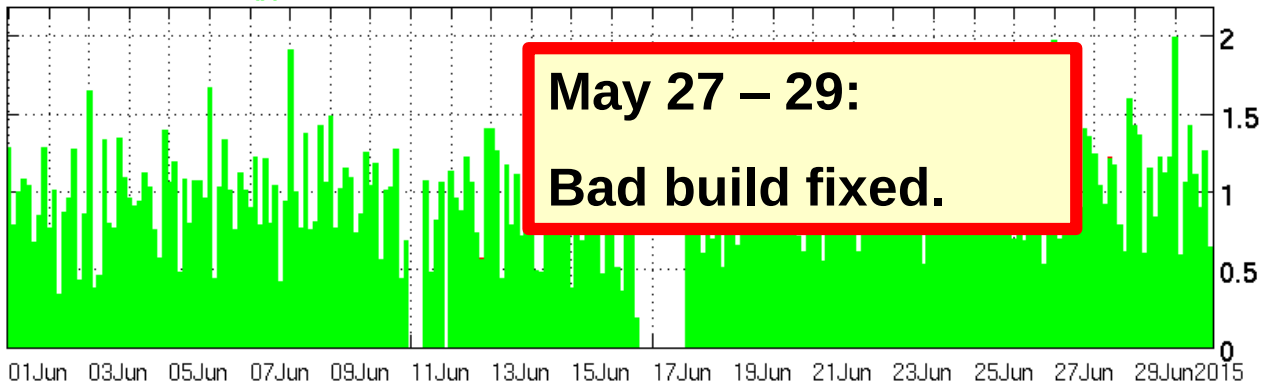
April



May



June

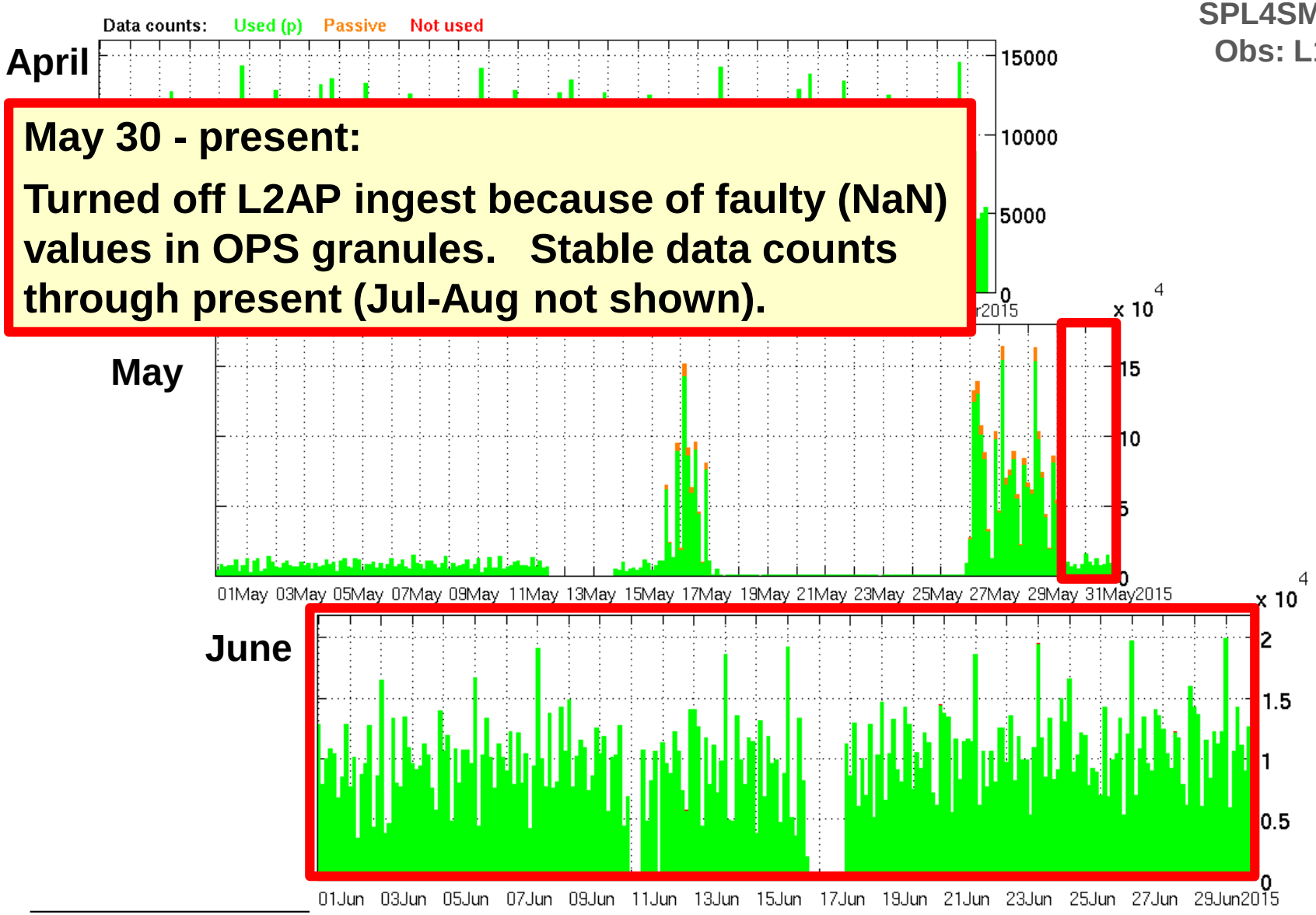


May 27 – 29:

Bad build fixed.

Number of Assimilated Tb Observations

SPL4SM_V10002
Obs: L1C, L2AP
Global



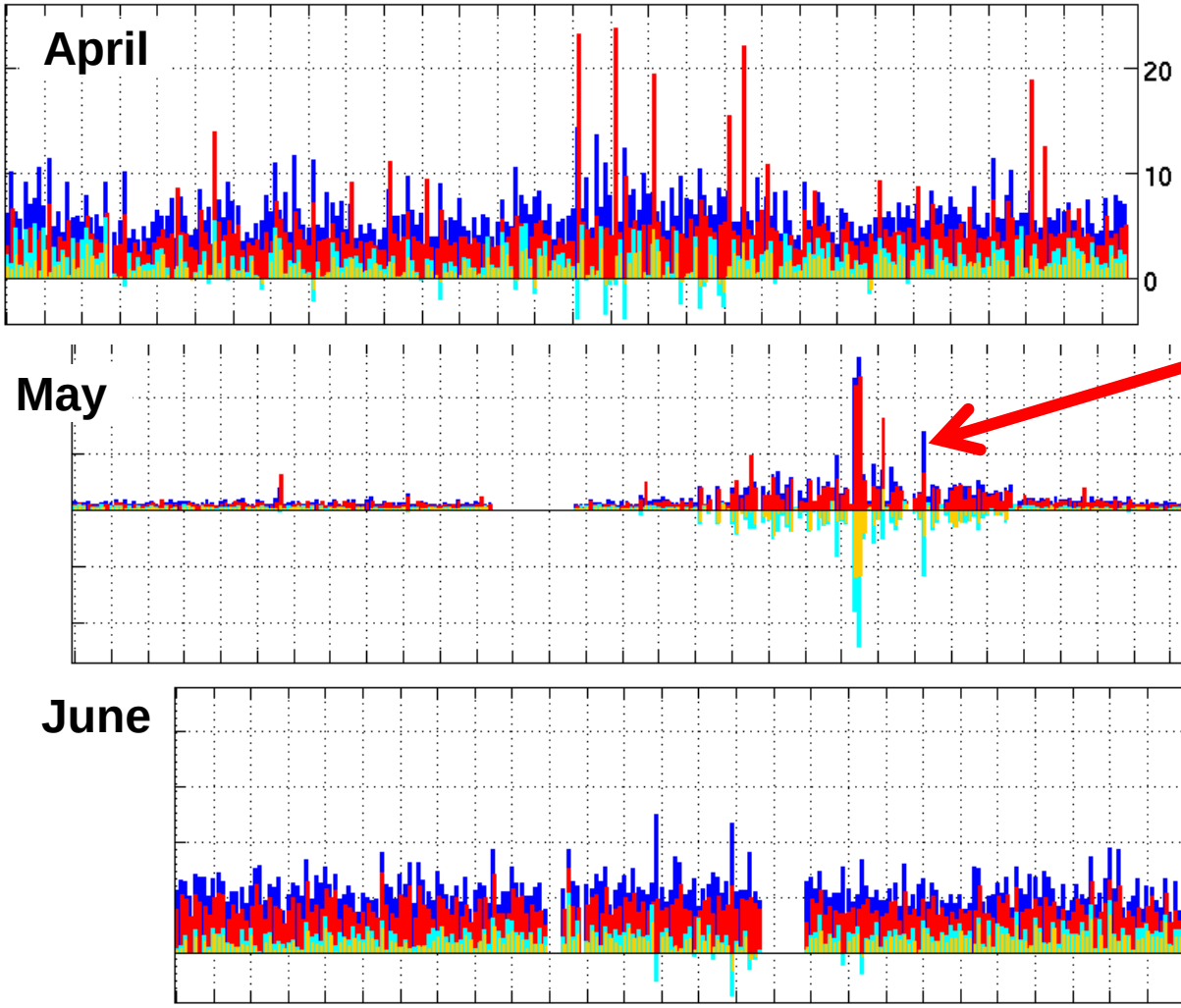
May 30 - present:

Turned off L2AP ingest because of faulty (NaN) values in OPS granules. Stable data counts through present (Jul-Aug not shown).

Data Residuals

rms(O-B) rms(O-A) mean(O-B) mean(O-A)

SPL4SM_V10002
Obs: L1C, L2AP
Global



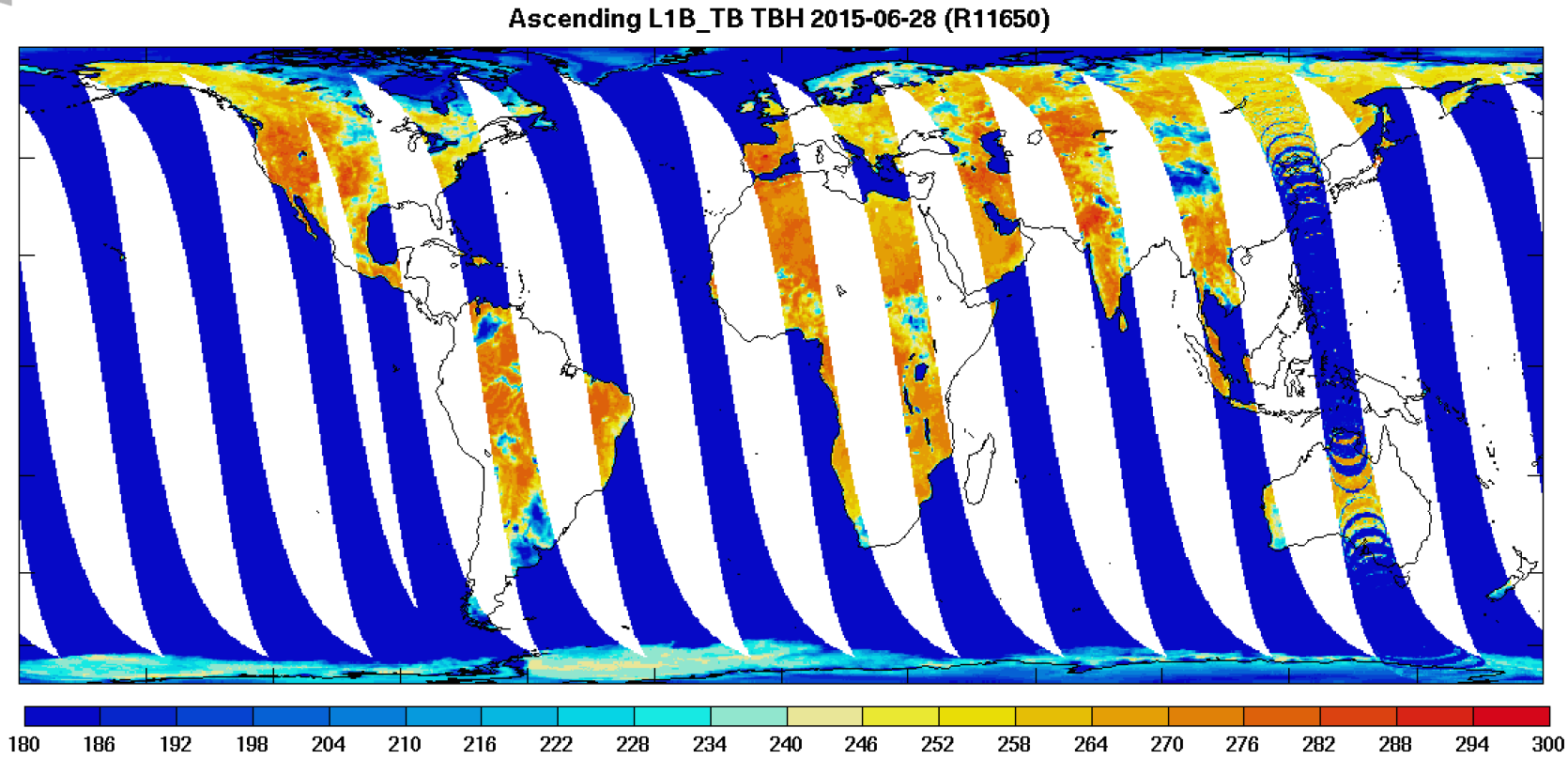
May 18 – 26:

Bad L1-2 build resulted in bad L1-2 data.

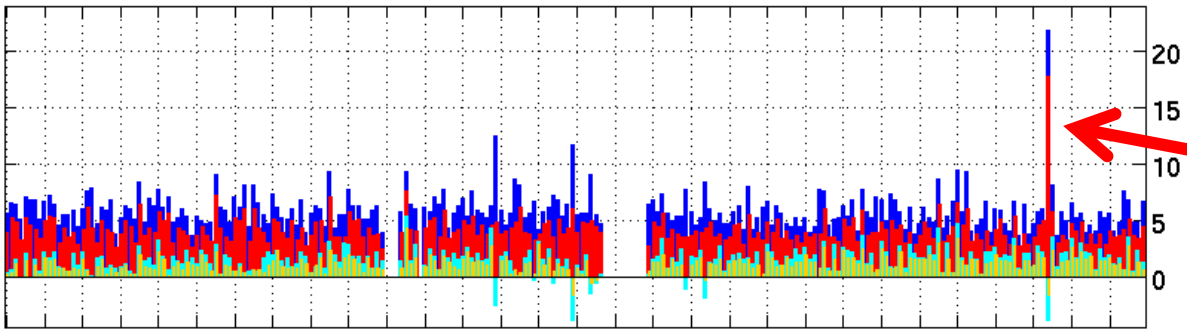
***Occasional outliers*:**

Half-orbits with bad data.

Data Residuals



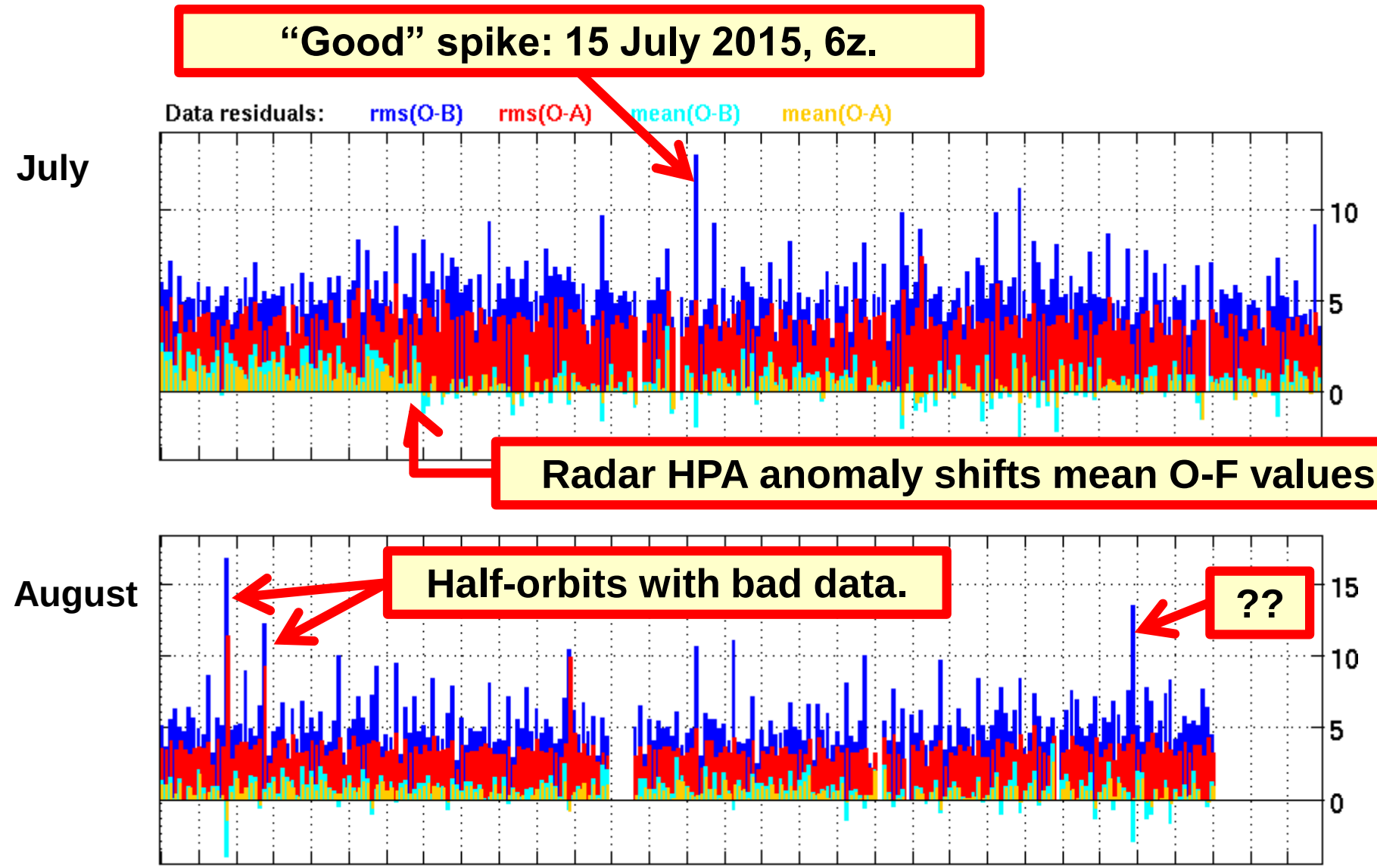
June



***Occasional outliers*:**

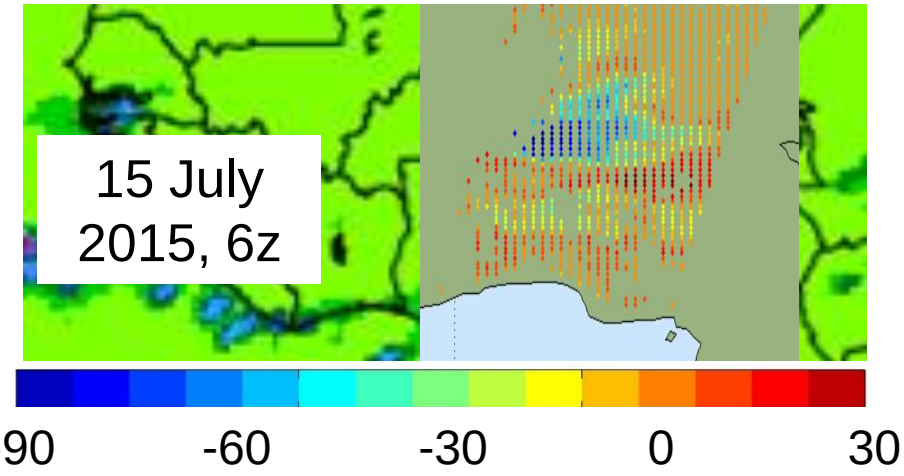
Half-orbits with bad data.

Data Residuals



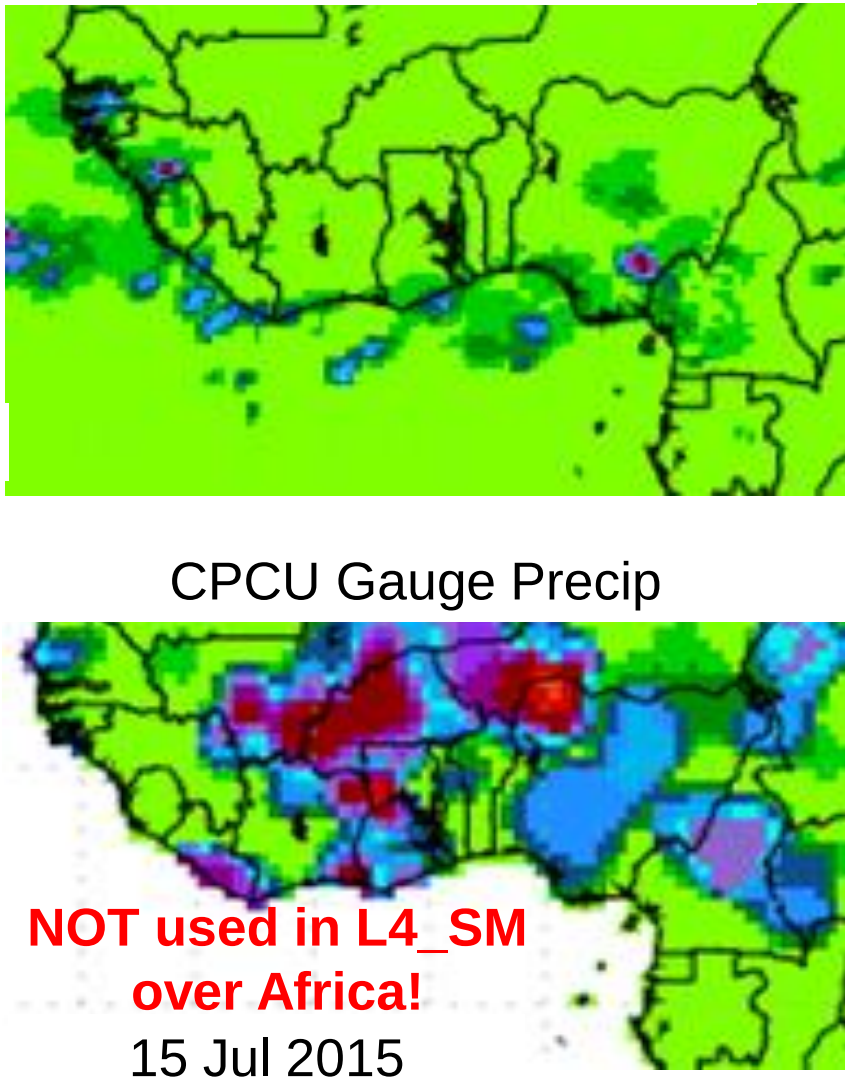
Data Residuals

L4_SM O-F [K], 15 July 2015, 6z

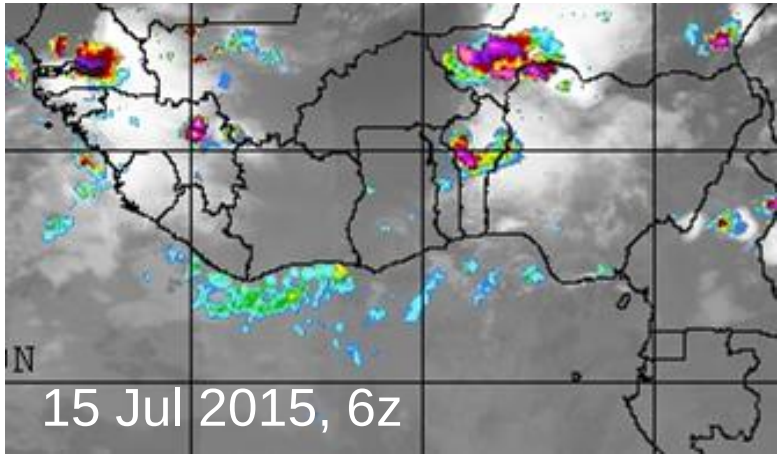


-90 -60 -30 0 30

Precip Forcing (GEOS-5) [mm d^{-1}]



NRL 3-hr satellite precip

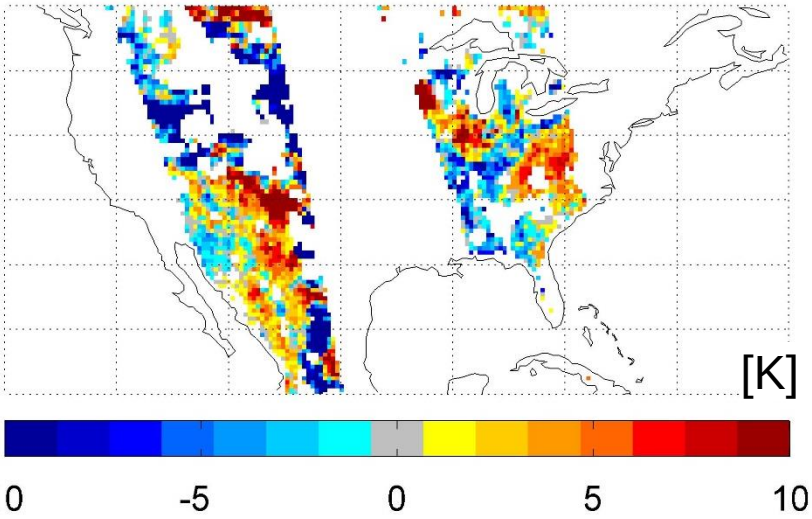


CPCU Gauge Precip

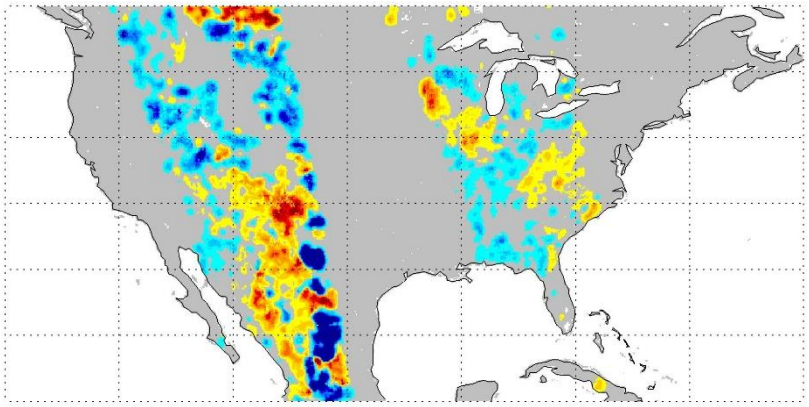
15 Jul 2015

Soil Moisture and Temperature Analysis
29 May 2015, 0z

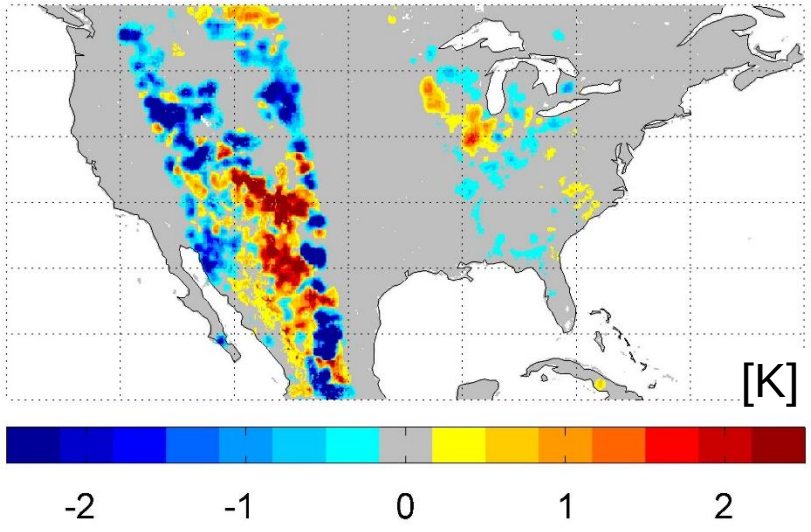
tb_h_obs_assim-tb_h_forecast



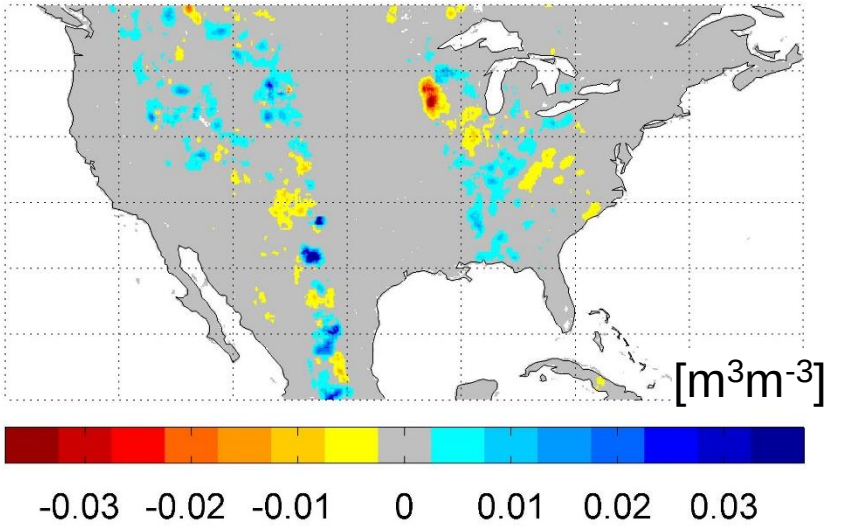
sm_surface_analysis-sm_surface_forecast



soil_temp_layer1_analysis-soil_temp_layer1_forecast

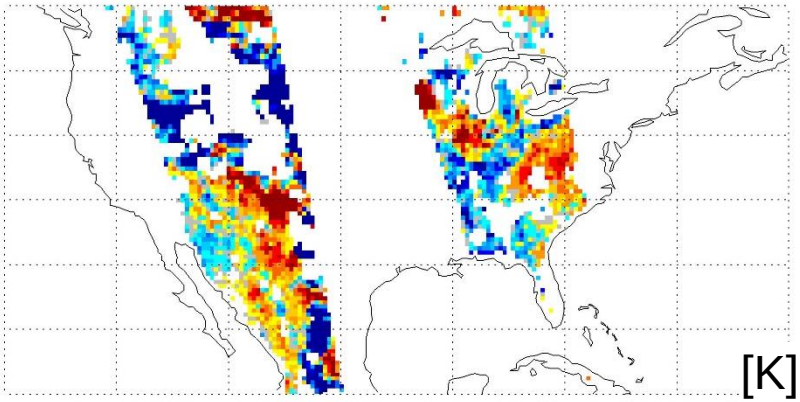


sm_rootzone_analysis-sm_rootzone_forecast

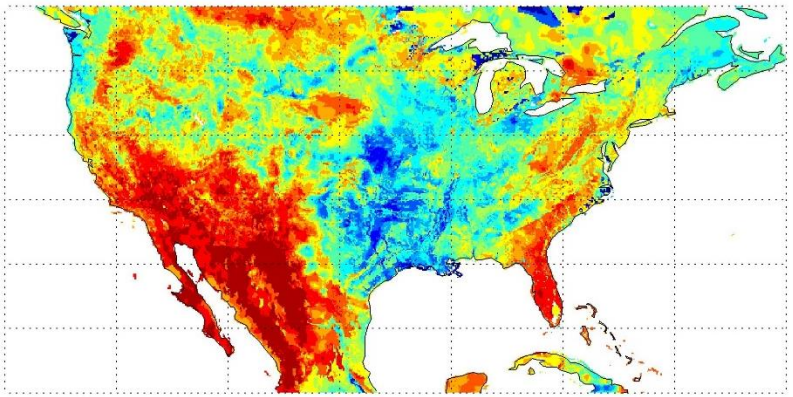


Soil Moisture and Temperature Analysis
29 May 2015, 0z

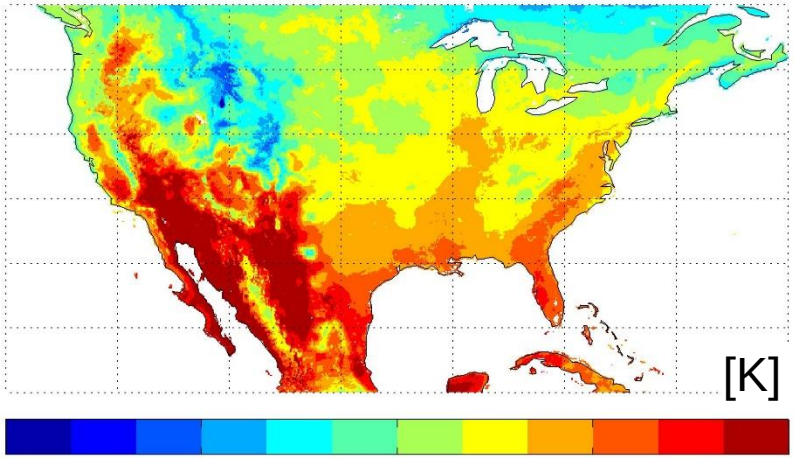
tb_h_obs_assim-tb_h_forecast



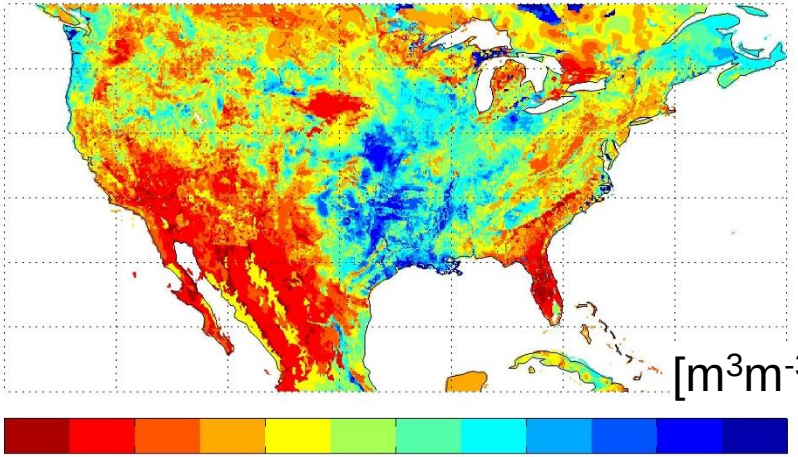
sm_surface_analysis



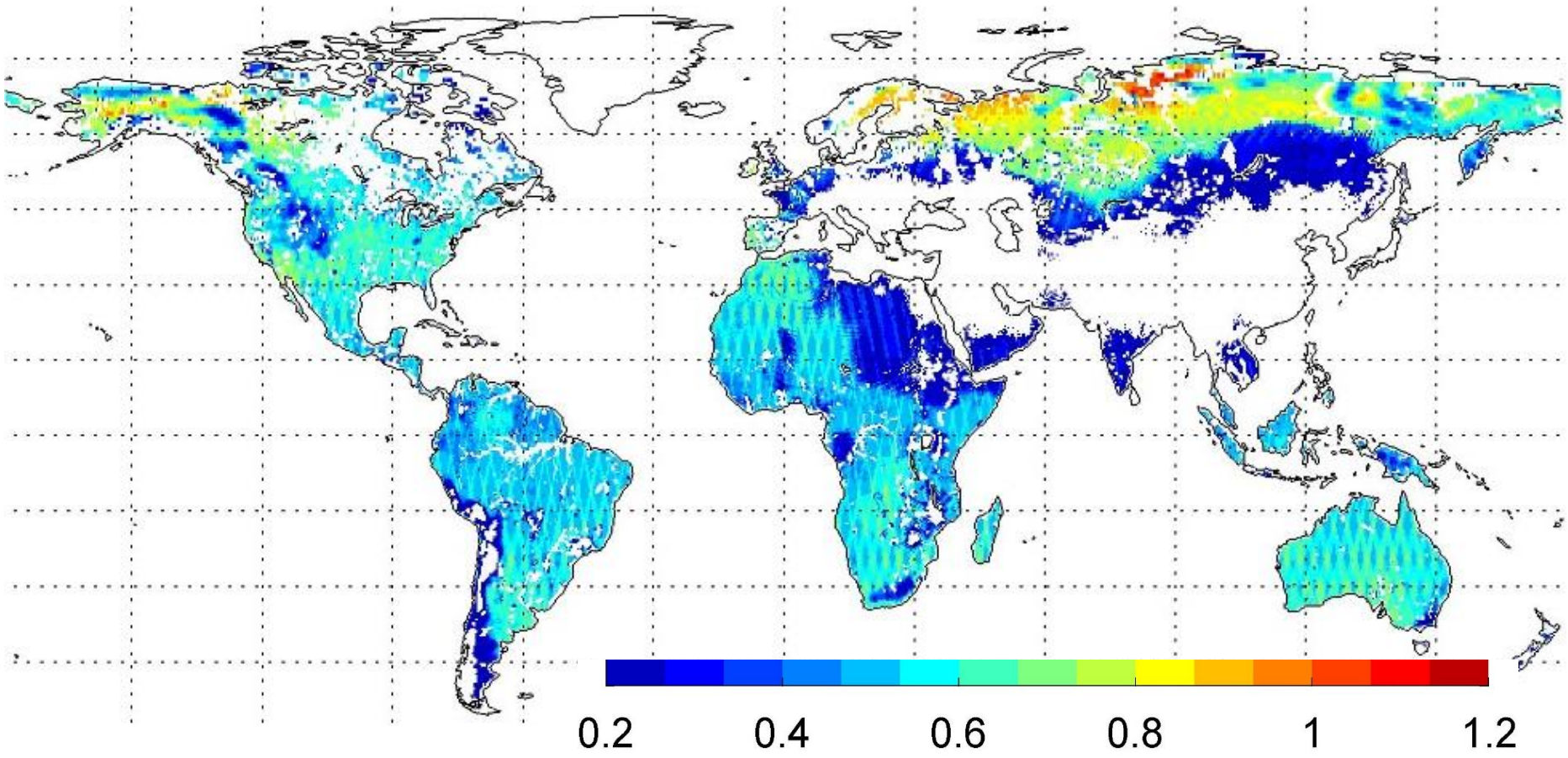
soil_temp_layer1_analysis



sm_rootzone_analysis



Number of Assimilated Data (L1C_TB)



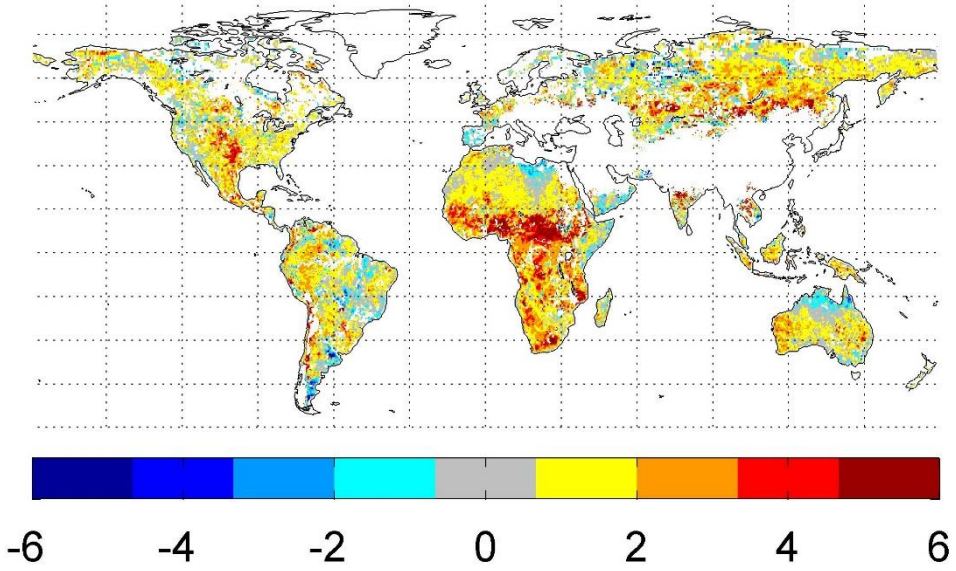
Number of assimilated L1C_TB obs per day (avg=0.49)

H- & V-pol, ascending & descending, 3/31-8/23/2015

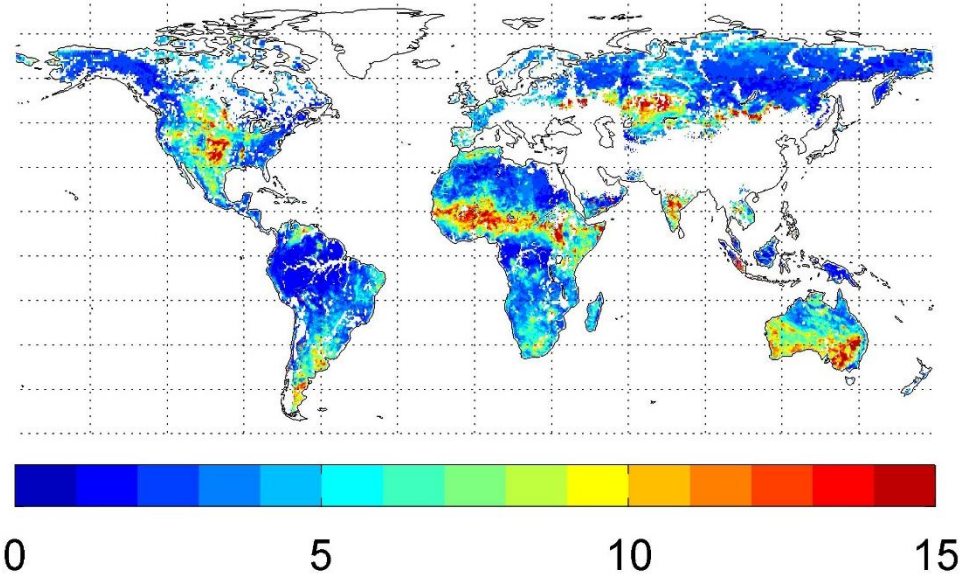
Observation Minus Forecast Residuals (L1C_TB)

31 Mar – 23 Aug 2015

Mean O-F (avg=1.3 K)



Std-dev O-F (avg=6.0 K)

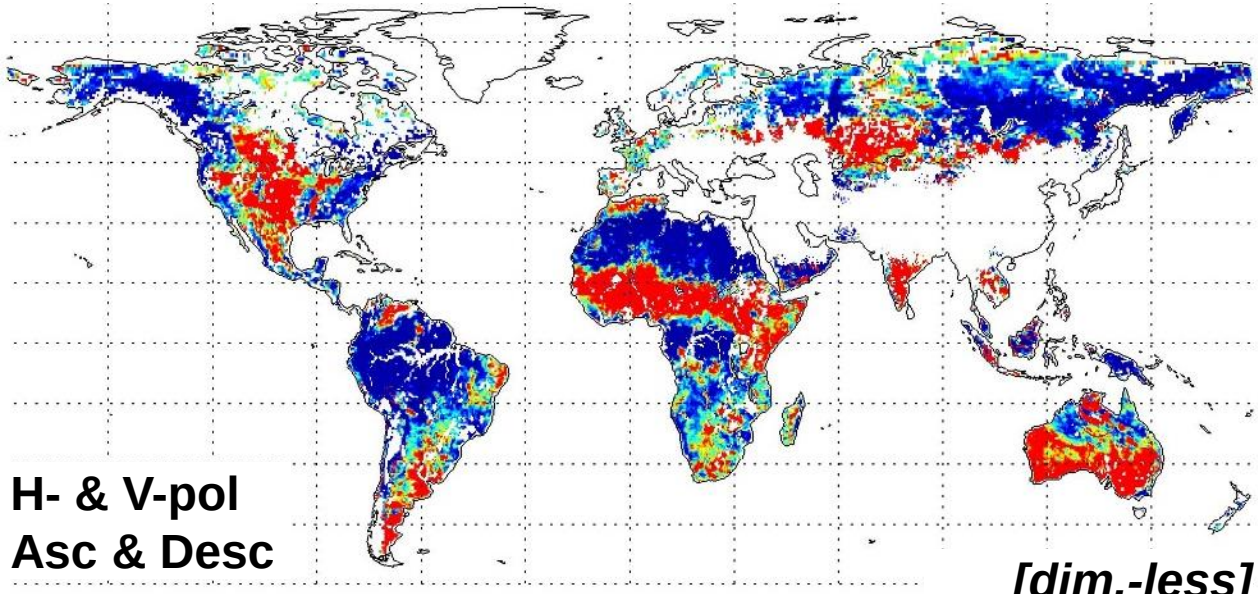


H- & V-pol, ascending & descending

Observation Minus Forecast Residuals (L1C_TB)

31 Mar – 23 Aug 2015

Std-dev normalized O-F ~ $\frac{\text{Actual Uncertainty}}{\text{Assumed Uncertainty}}$



0.5 | 1 | 1.5

Target value = 1

DA system

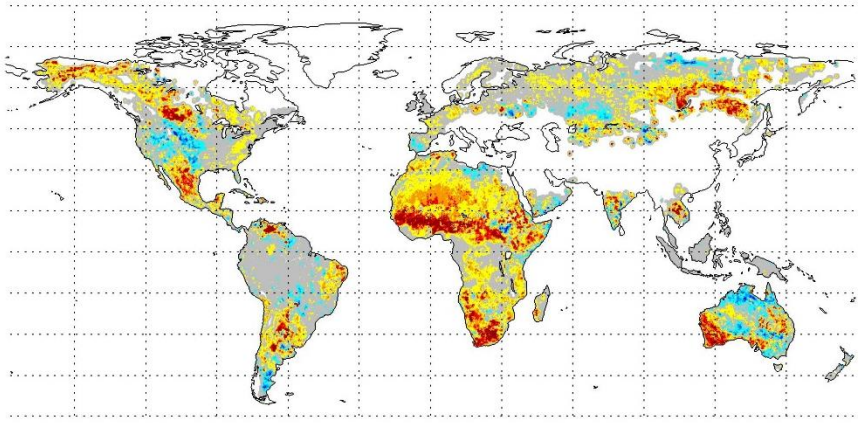
← **over**estimates

underestimates →

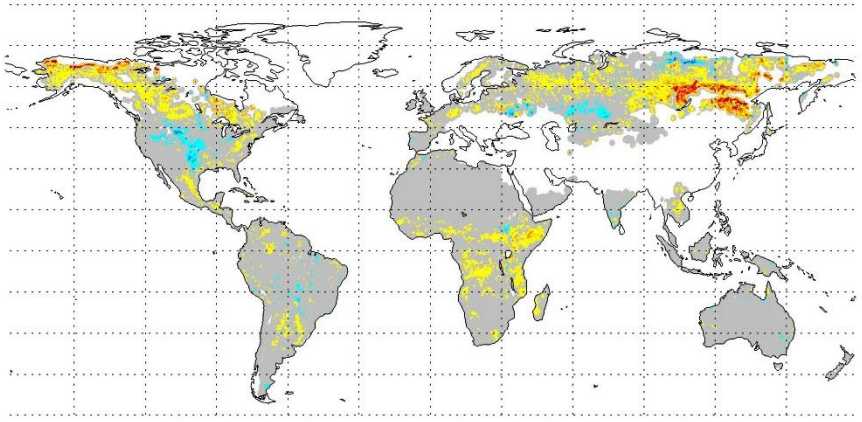
actual uncertainty

Mean Increments (Analysis Minus Forecast)
31 Mar – 6 Jun 2015

mean Δsm_surface; m=-0.002 [m^3/m^3]

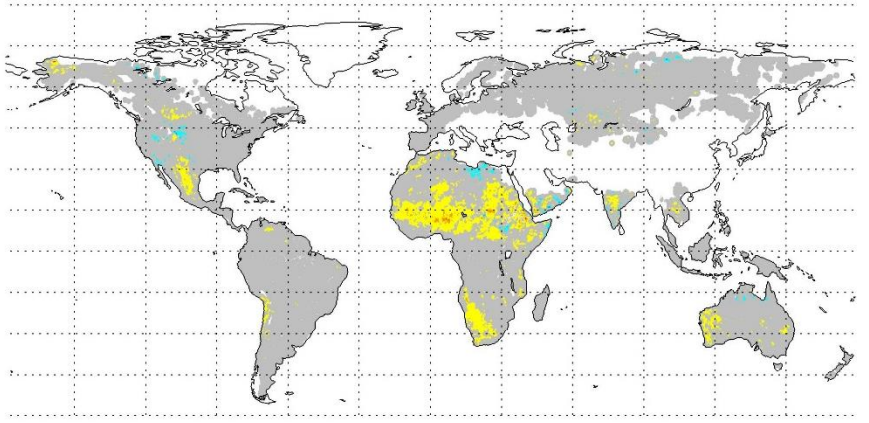


mean Δsm_rootzone; m=-0.001 [m^3/m^3]



-0.015 -0.01 -0.005 0 0.005 0.01 0.015

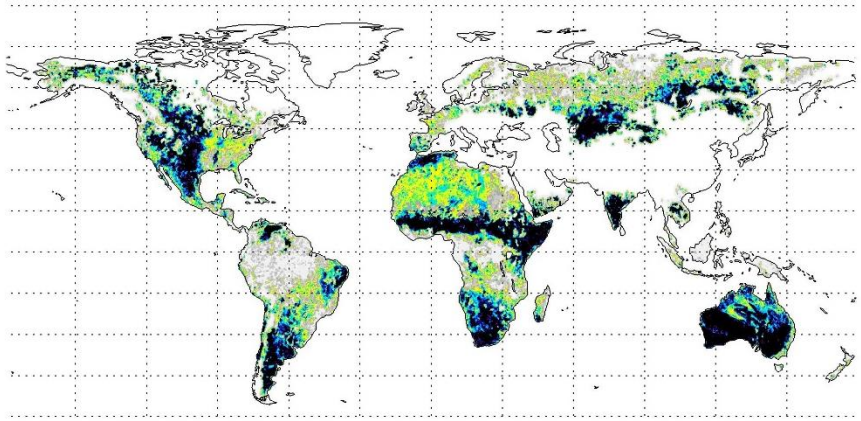
mean Δsoil_temp_layer1; m=0.093 [K]



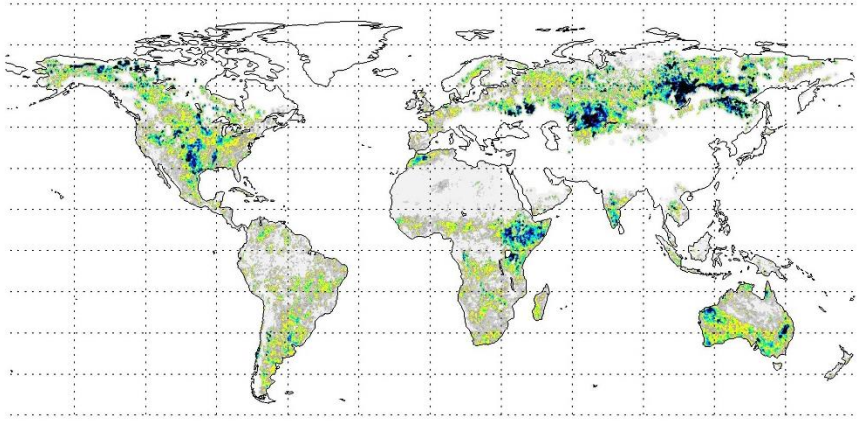
-3 -2 -1 0 1 2 3

Std-dev Increments (Analysis Minus Forecast)
31 Mar – 6 Jun 2015

stdv Δsm_surface; m=0.014 [m^3/m^3]

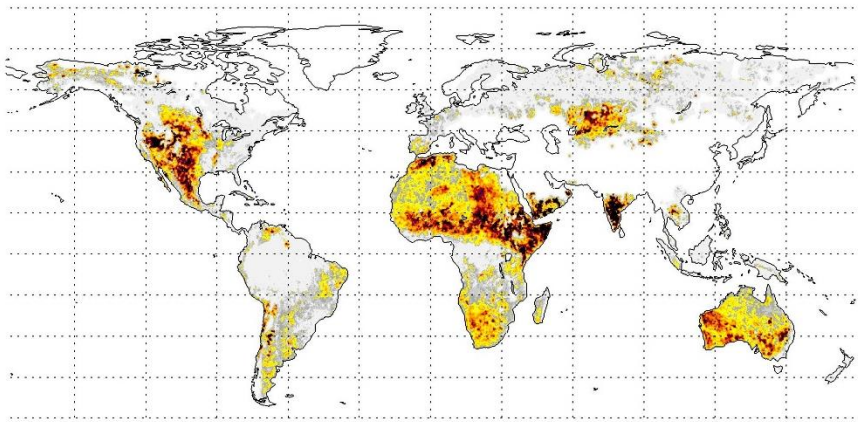


stdv Δsm_rootzone; m=0.006 [m^3/m^3]



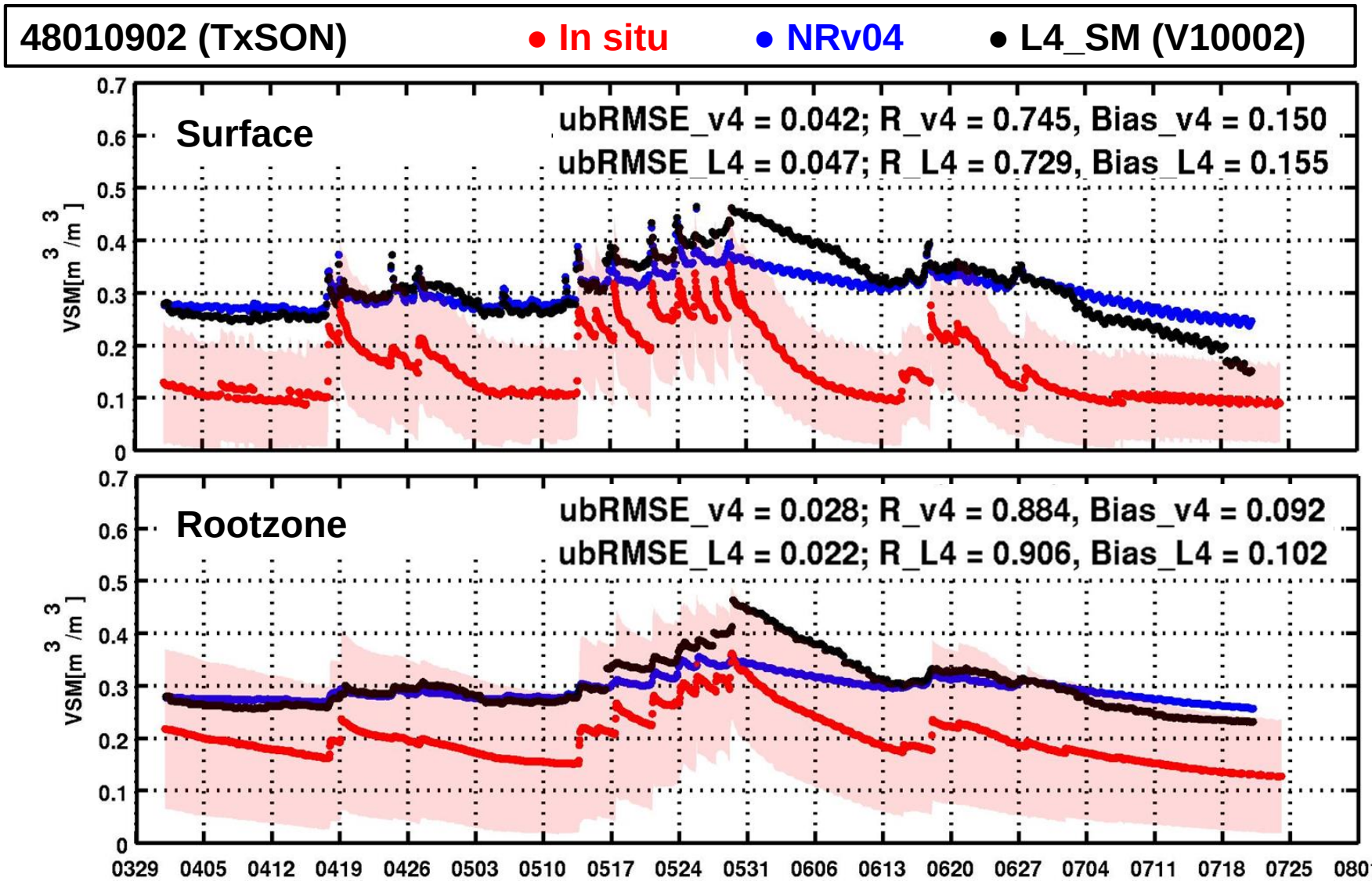
0 0.005 0.01 0.015 0.02

stdv Δsoil_temp_layer1; m=0.596 [K]

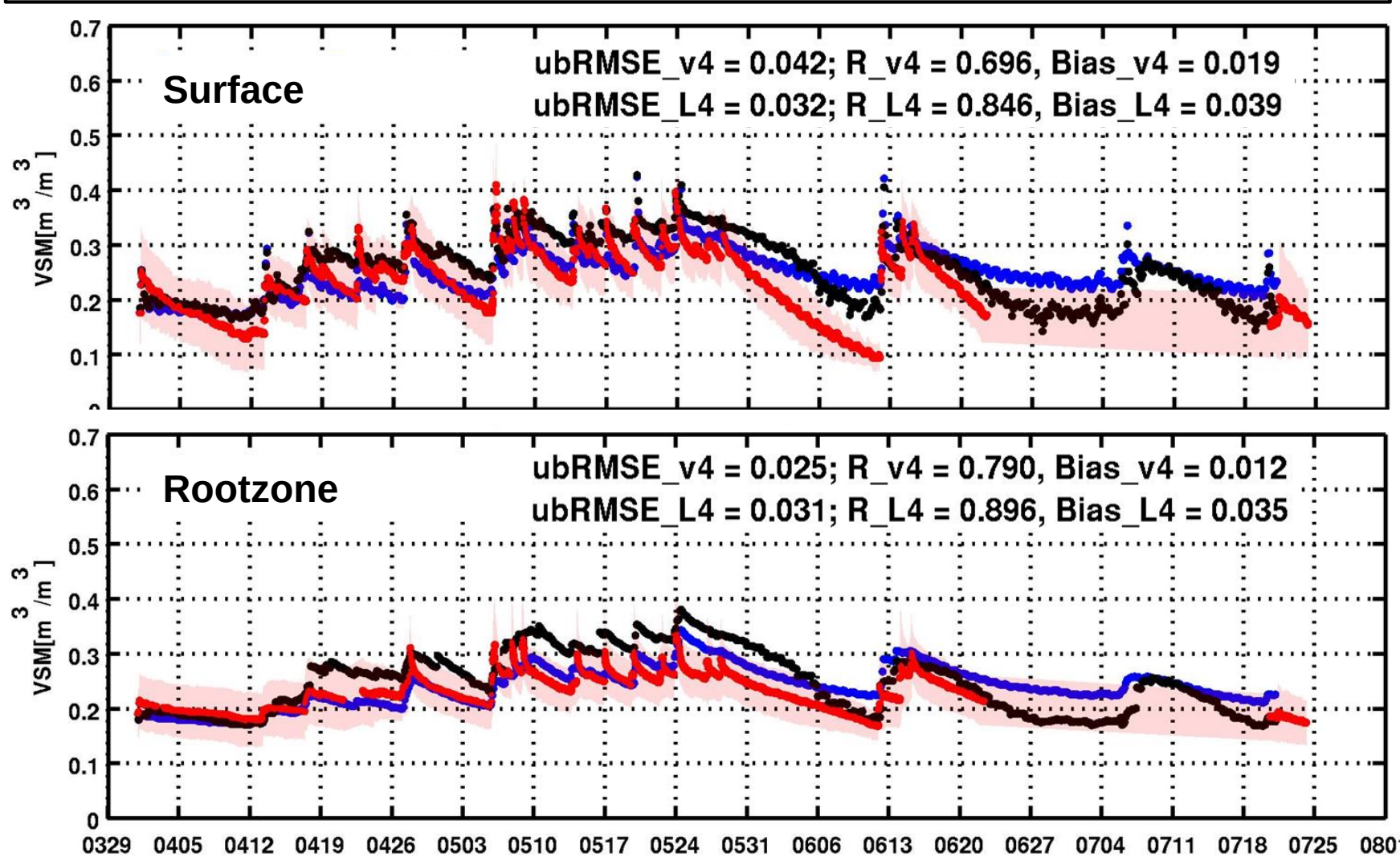


0 0.5 1 1.5

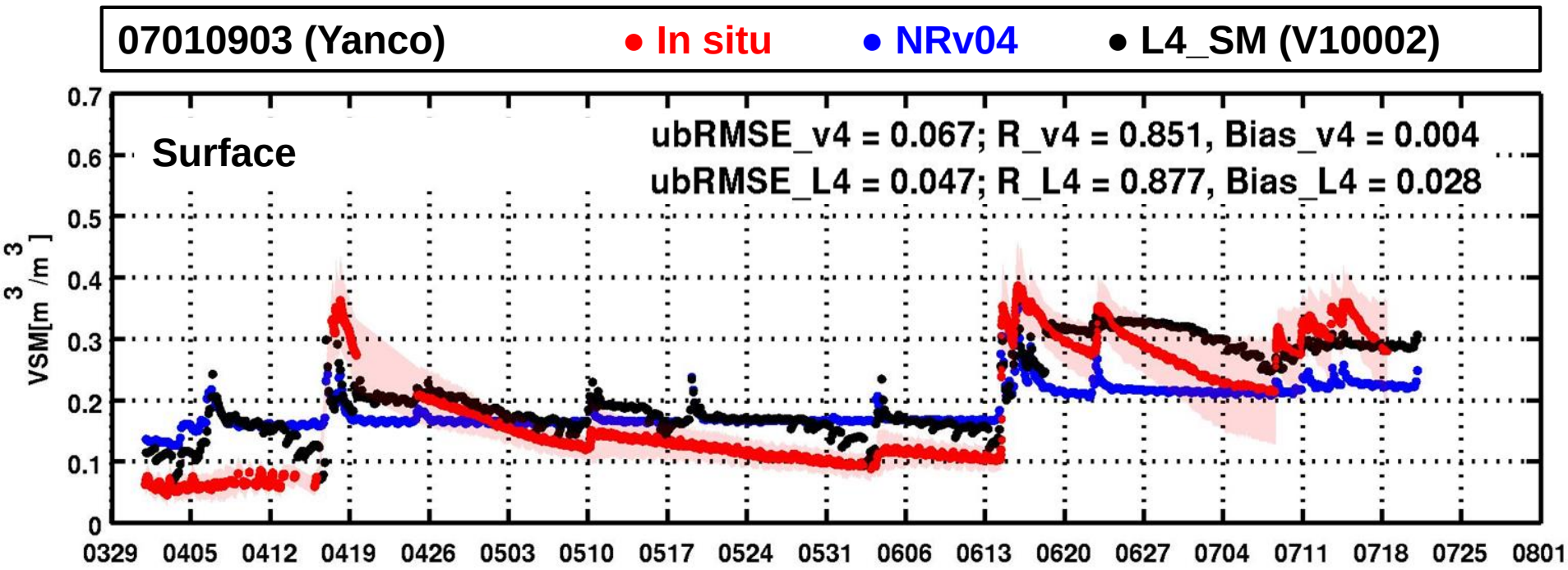
Core Site Validation – Sample Time Series



Core Site Validation – Sample Time Series

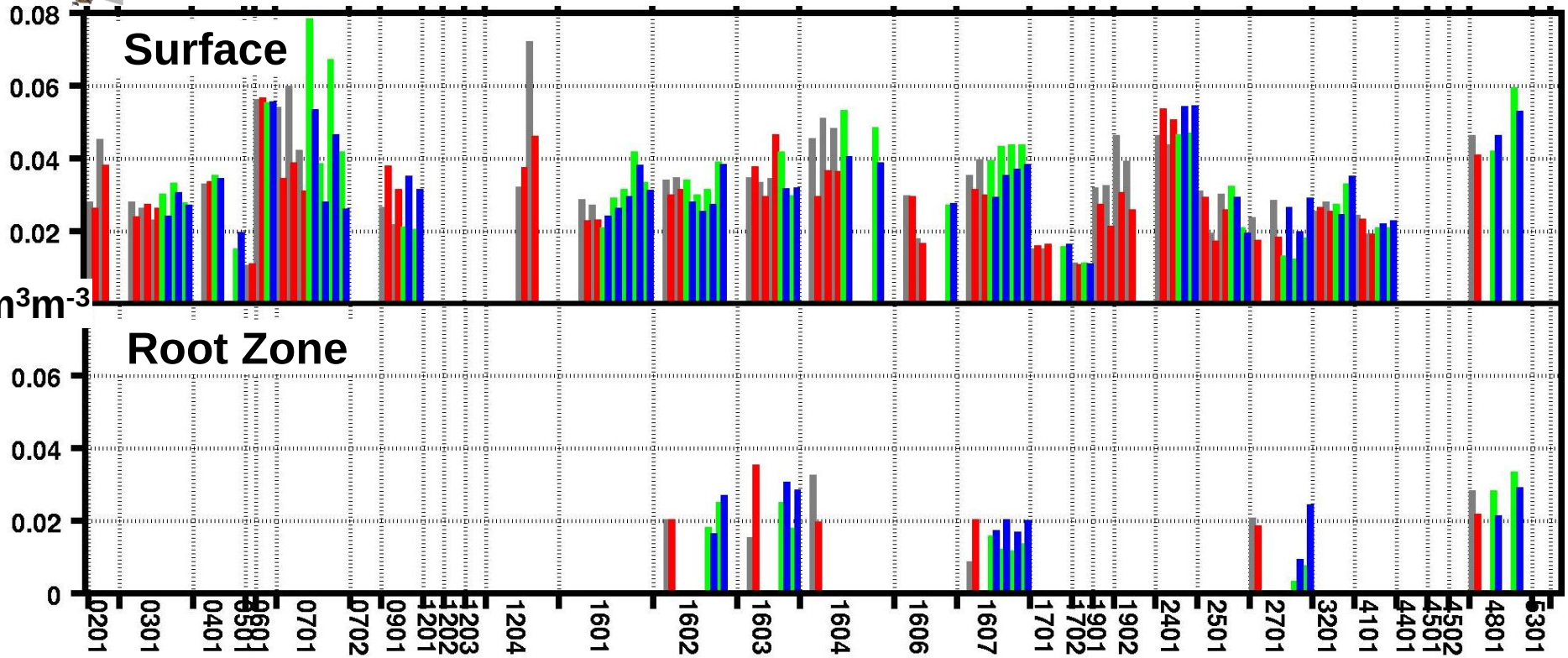


Core Site Validation – Sample Time Series



Core Site Validation – **ubRMSE**

L4_SM V10002, 31 Mar – 25 Jul 2015

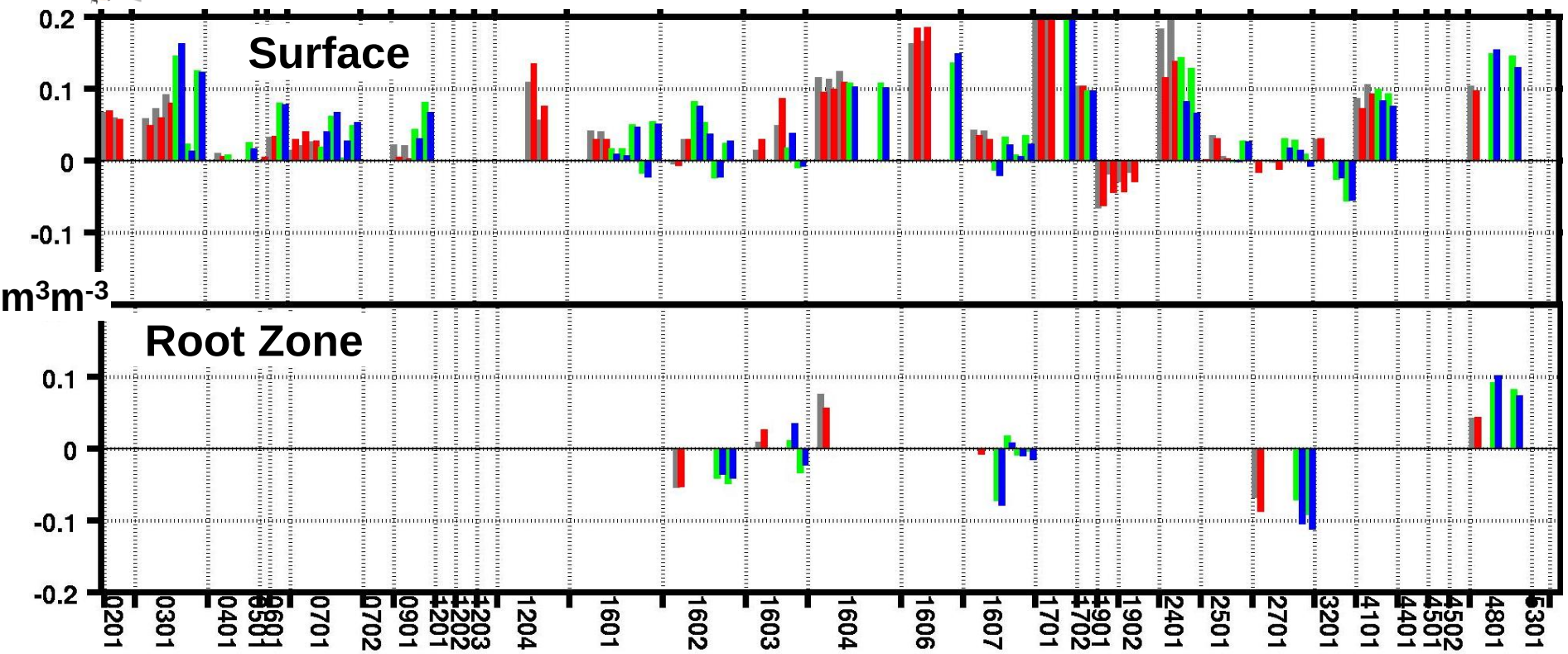


Product	*CVS Scale*	***ubRMSE** [m3/m3]*	
		Surf.	*Root.*
NRv04	36 km	.034	.020
L4_SM	**36 km**	**.029**	***.023***
NRv04	9 km	.034	.014
L4_SM	**9 km**	**.031**	***.021***

Average metrics are for core sites only (excl candidate sites).

Core Site Validation – **Bias** (model minus in situ)

L4_SM V10002, 31 Mar – 25 Jul 2015

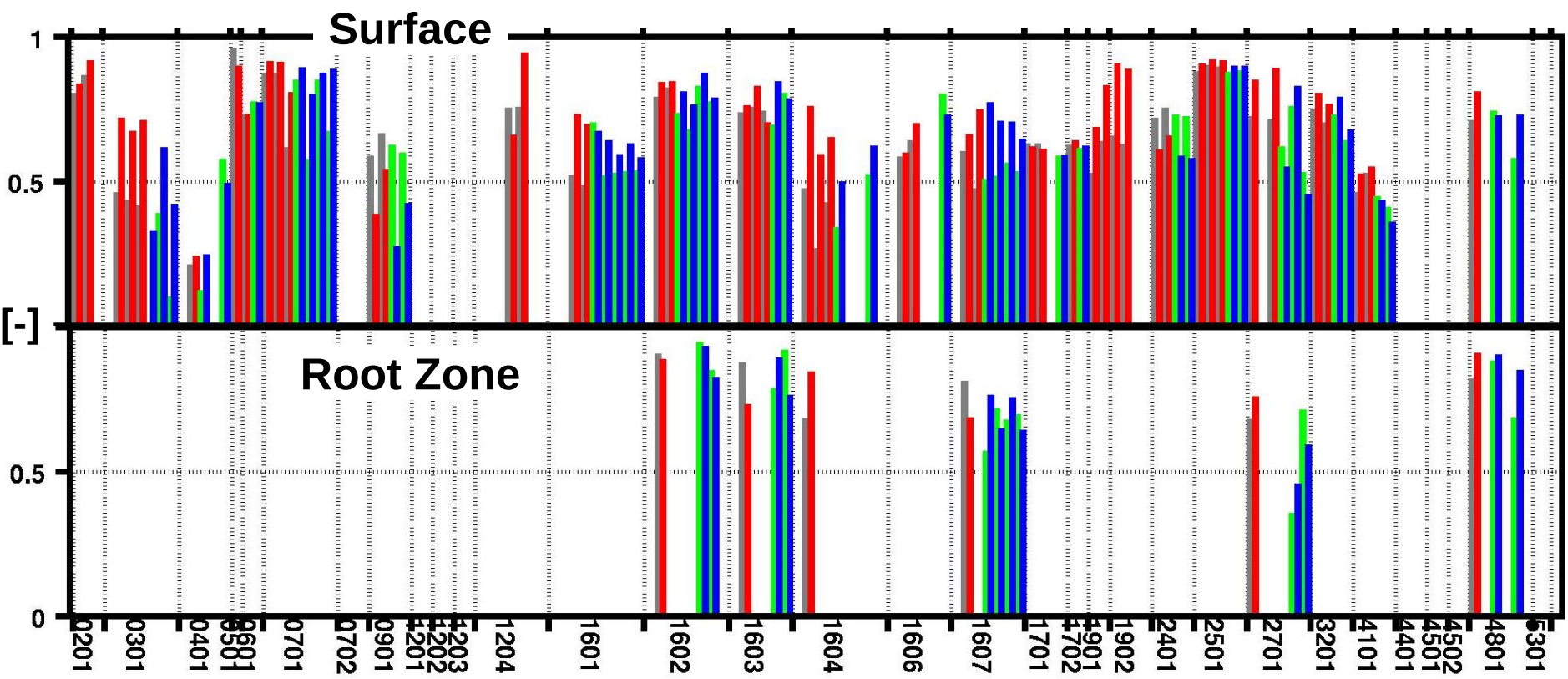


Product	*CVS Scale*	***ubRMSE** [m3/m3]*		***Bias** [m3/m3]*	
		Surf.	*Root.*	*Surf.*	*Root.*
NRv04	36 km	.034	.020	.062	.042
L4_SM	**36 km**	**.029**	***.023***	**.059**	***.047***
NRv04	9 km	.034	.014	.065	.040
L4_SM	**9 km**	**.031**	***.021***	**.061**	***.048***

Average metrics are for core sites only (excl candidate sites).

Core Site Validation – Time Series Correlation (**R**)

L4_SM V10002, 31 Mar – 25 Jul 2015



Product	CVS Scale	ubRMSE [m3/m3]		Bias [m3/m3]		R [-]	
		Surf.	Root.	Surf.	Root.	Surf.	Root.
NRv04	36 km	.034	.020	.062	.042	.633	.795
L4_SM	**36 km**	**.029**	***.023***	**.059**	***.047***	**.737**	***.784***
NRv04	9 km	.034	.014	.065	.040	.585	.712
L4_SM	**9 km**	**.031**	***.021***	**.061**	***.048***	**.648**	**.719**

Average metrics are for core sites only (excl candidate sites).

Core Site Validation – Summary

L4_SM V10002, 31 Mar – 25 Jul 2015

L4_SM V10002 surface and root zone soil moisture estimates meet the validation requirement at 9 km:

ubRMSE = 0.031 m^3m^{-3} (surface)

ubRMSE = 0.021 m^3m^{-3} (root zone)

Comparison with skill of Nature Run v04 estimates suggests mixed impact of assimilated SMAP Tbs.

Reprocessing against beta version of L1 observations should further improve L4_SM.

On schedule for L4_SM beta-release (~1 Nov 2015).

L4_SM Science Issues (Beyond Beta-Release)

- **L4_SM calibration**
  - Forcing climatology (*MERRA-2; revised precipitation corrections*)
  - RTM parameters (*recalibrate to SMOS v620*)
- **Refined assessment of SMAP impact in assimilation system**
  - Single-member (no perturbations) with precip. corr. (Nature Run)
  - Ensemble open-loop with precipitation corrections (*new*).
  - Ensemble open-loop without precipitation correction (*new*).
- **Improved precipitation corrections during reprocessing?**
  - Forward-processing (OPS) data trade quality vs. latency.
  - Reprocessing could use GPCP, GPM, and/or CMAP data, but
    - Requires re-calibration of the system
    - Difficult to transition into forward-processing (OPS)
- **Other algorithm enhancements**
  - Waterbody correction (not just screening)
  - Freeze-thaw analysis
  - Improved utilization of flags in L1C.

Thanks for listening.

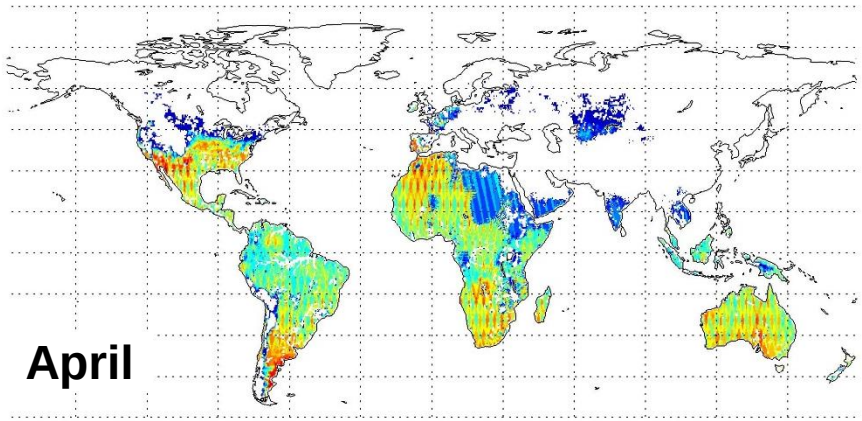
EXTRA SLIDES

Assimilated Data (L1C_TB, H&V-pol)

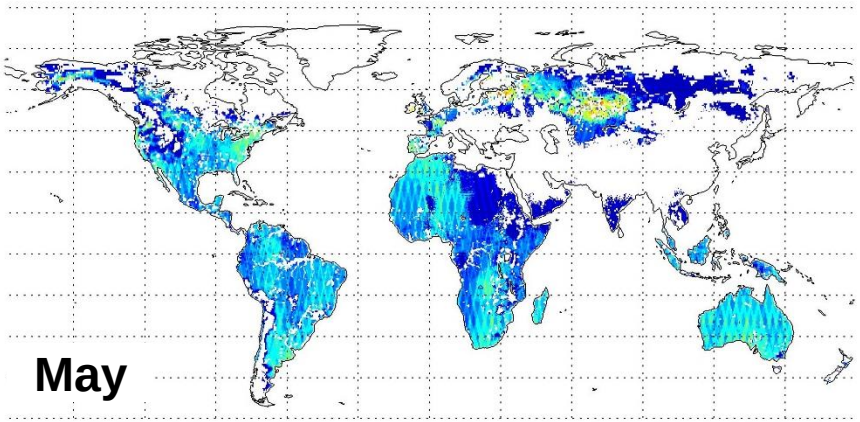
O-F = obs minus forecast residuals

Number of data per day

N_data_per_day ΔTbL1C; m=0.66, s=0.22

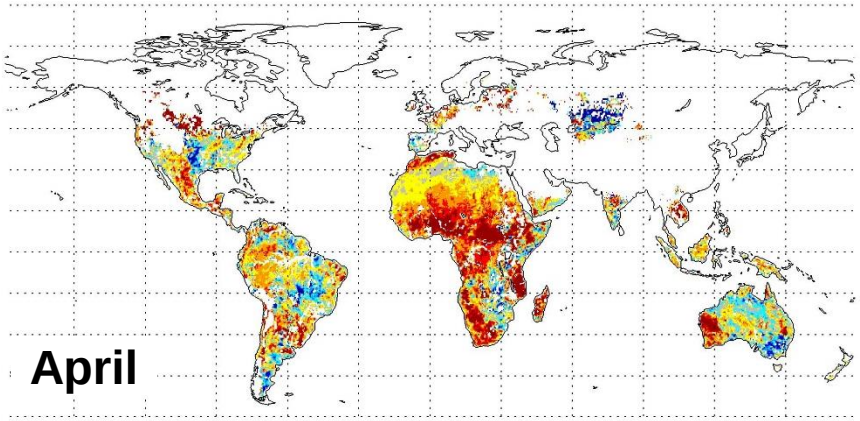


N_data_per_day ΔTbL1C; m=0.43, s=0.16

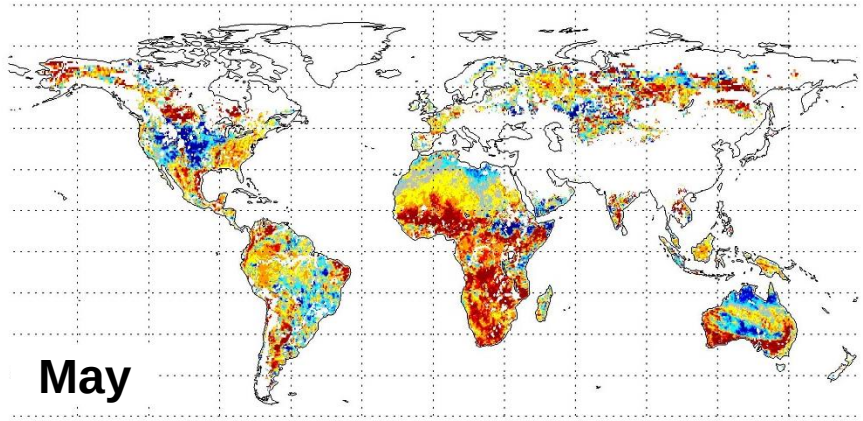


Mean O-F

mean ΔTbL1C; m=1.85, s=3.10 [K]

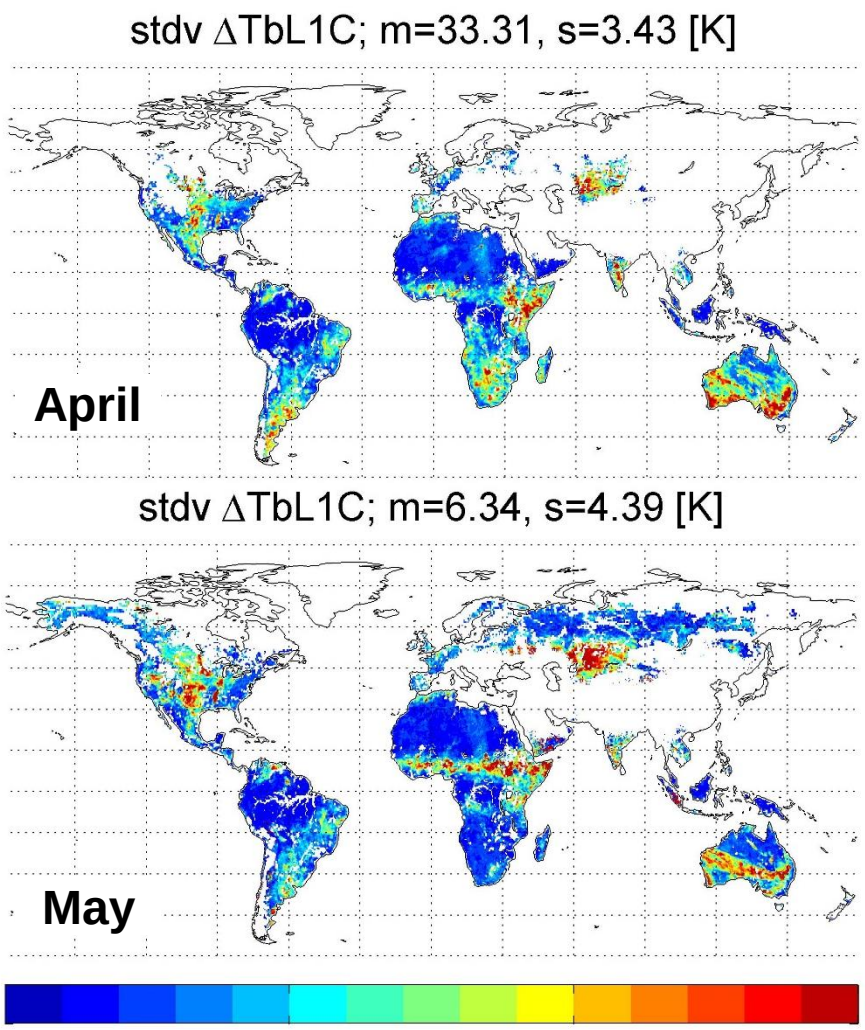


mean ΔTbL1C; m=1.41, s=3.46 [K]

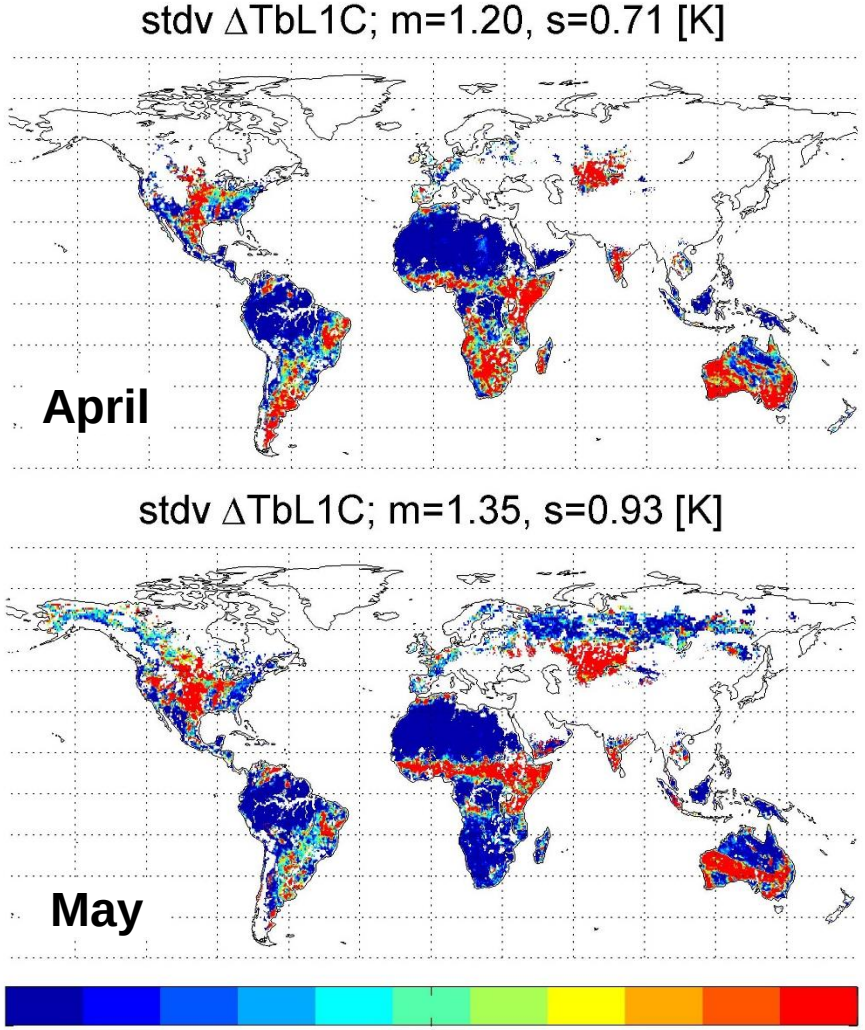


Assimilated Data (L1C_TB, H&V-pol)

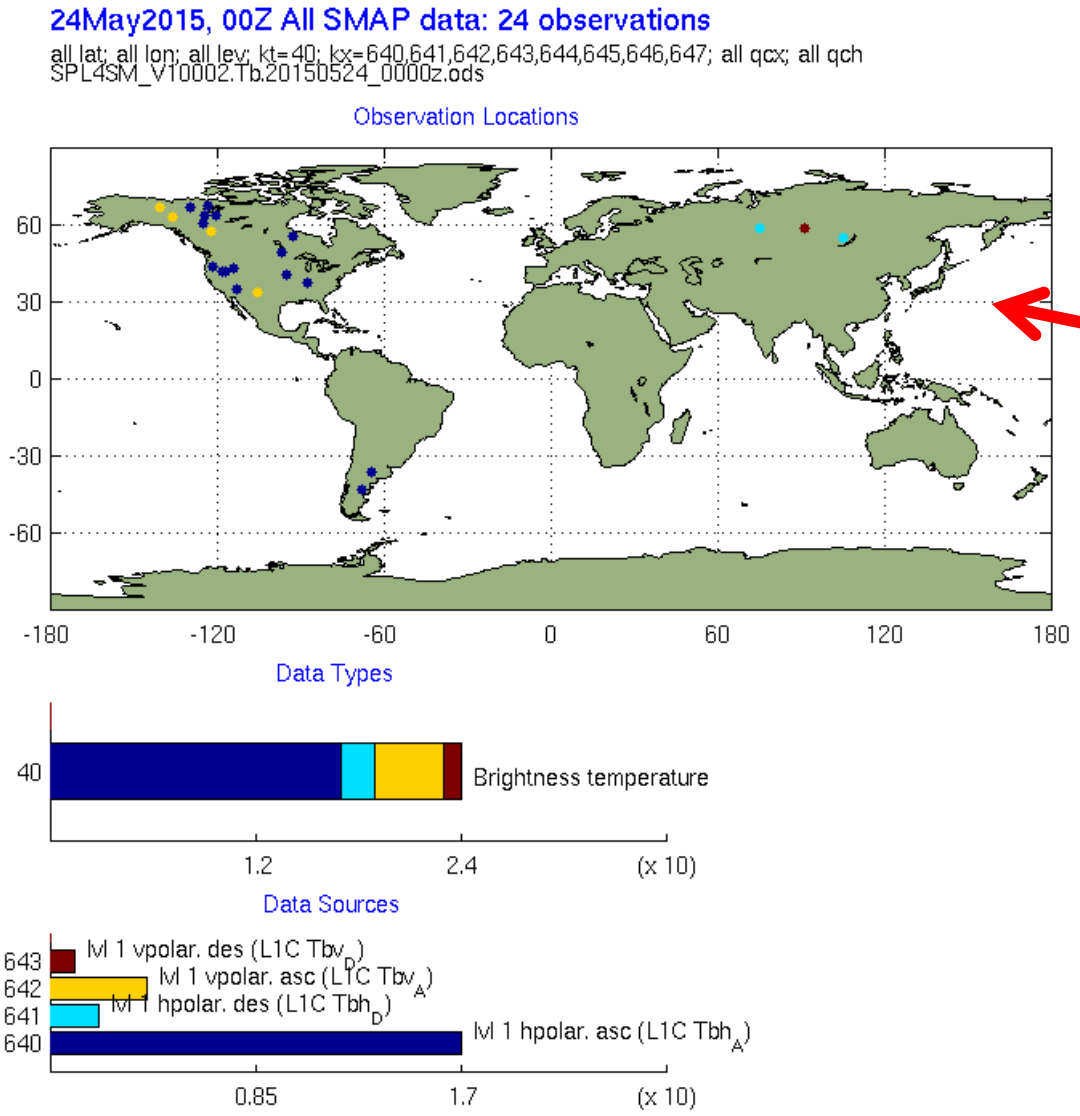
Std-dev O-F



Std-dev normalized O-F



Coverage of Assimilated Tb Observations



Bad L1-2 build: Just 24 Tb observations assimilated…

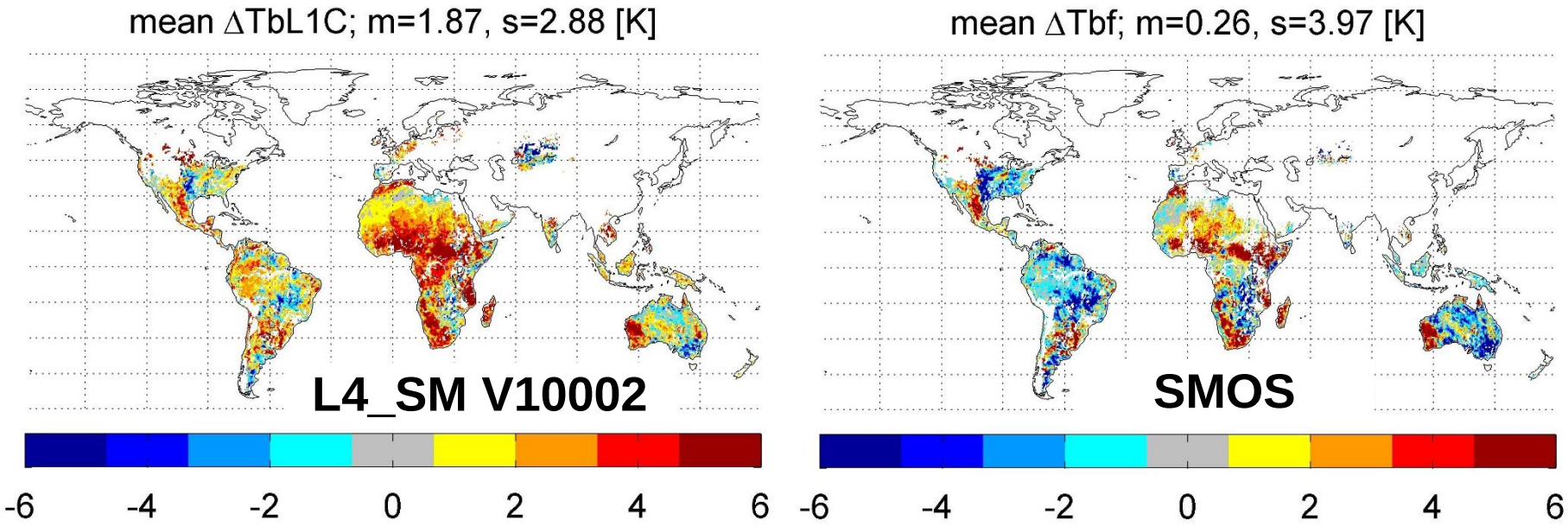
L1C_TB, V-pol, desc
L1C_TB, V-pol, asc
L1C_TB, H-pol, desc
L1C_TB, H-pol, asc

Compare L4_SM to science experiment using SMOS:

- Assimilate SMOS v5 Tb interpolated to 40° inc angle.
- Otherwise configuration identical to L4_SM V10002.
- April 2015 only.

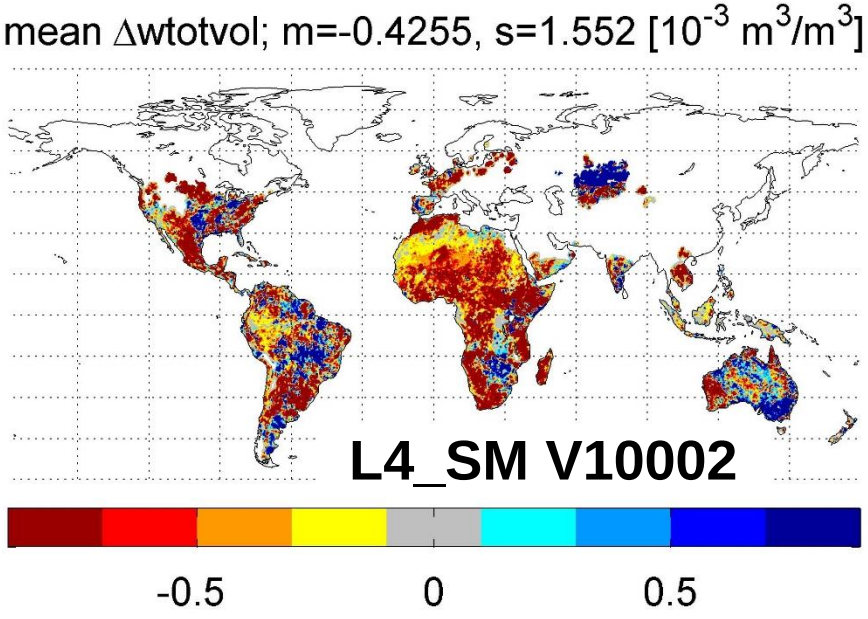
SMAP and SMOS
April 2015

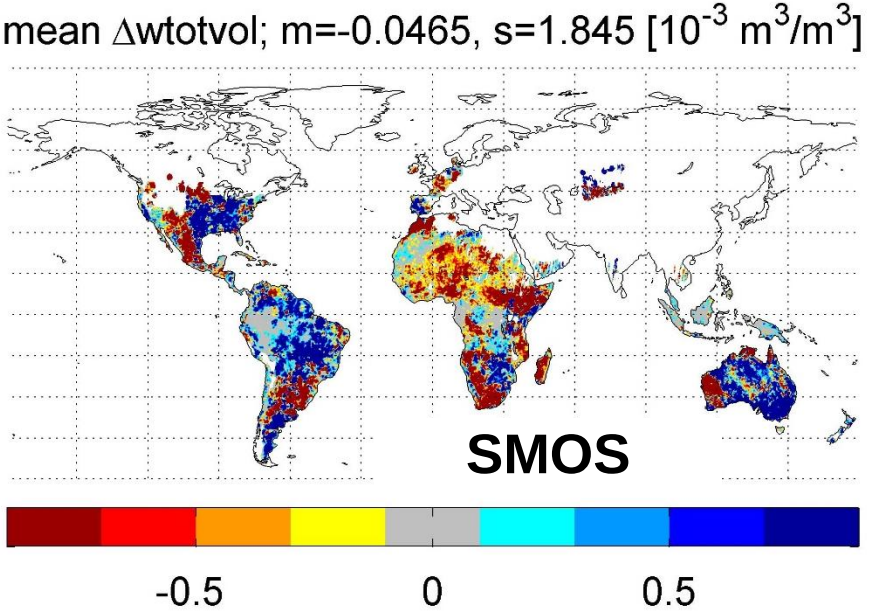
Mean innovations (observations minus forecast)



SMAP warmer on average than SMOS? Not expected.

Total profile soil moisture increments (mean)

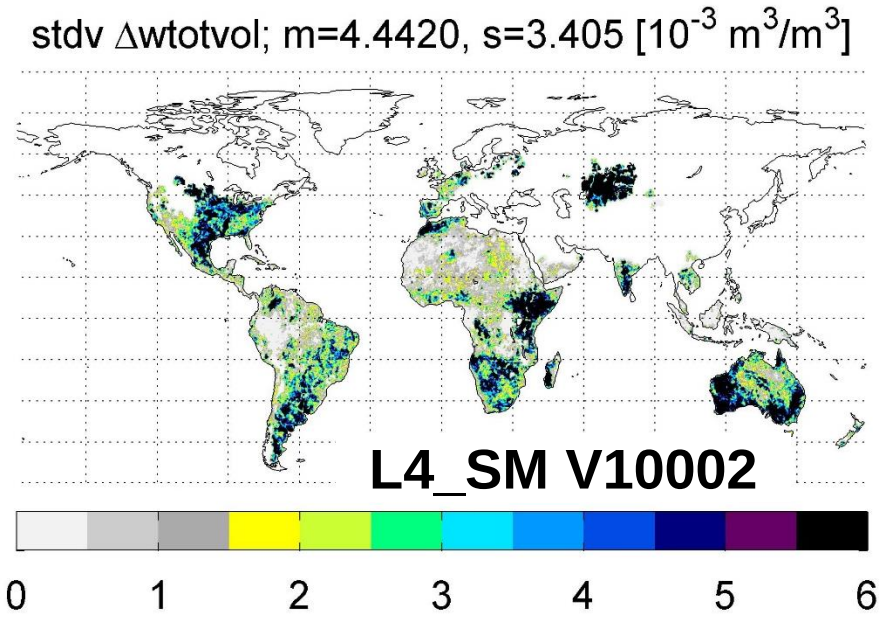


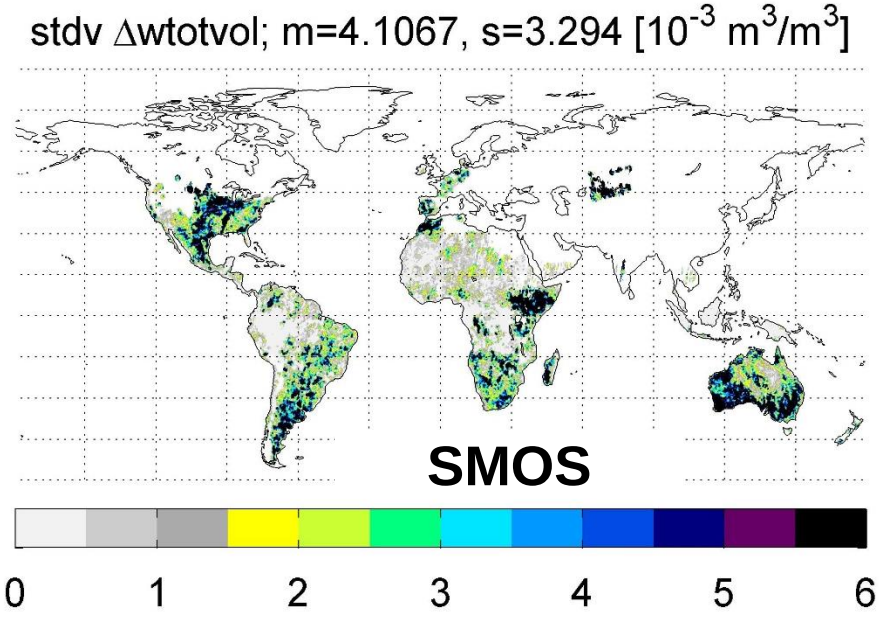


Mean increments larger for SMAP (but still small.)

SMAP and SMOS
April 2015

Total profile soil moisture increments (std-dev)





Increments from SMAP and SMOS are of similar size on average.

(As measured by the time series std-dev of the increments.)