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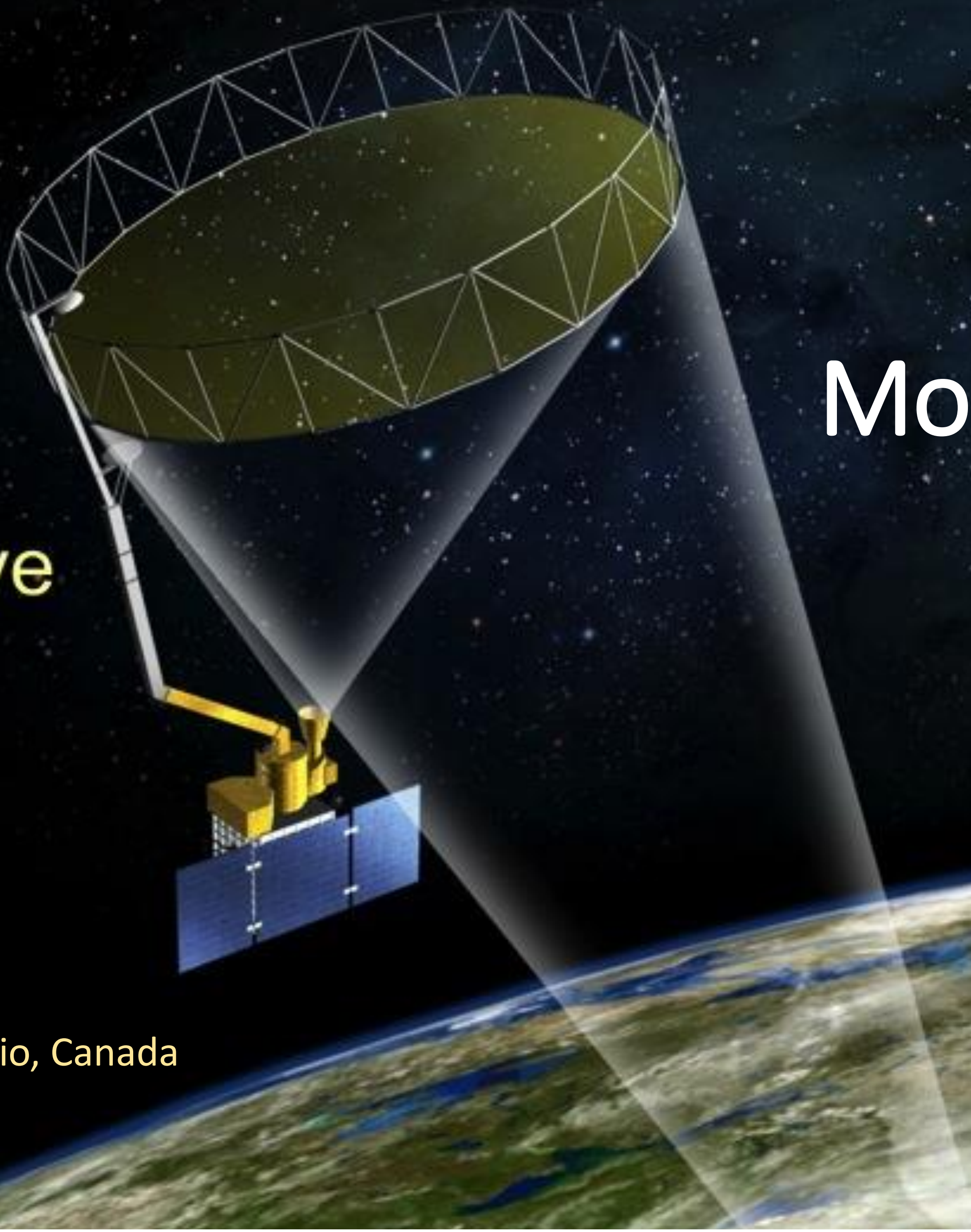
PALS TB and Soil Moisture Data from SMAPVEX16

A. Colliander, S. Misra
JPL/Caltech



Soil Moisture Active Passive
SMAP
Mission

Canadian SMAP Workshop
University of Guelph, Ontario, Canada
May 16-17, 2017

Passive Active L-band Sensor

- PALS functions as SMAP simulator
- L-band frequency
  - Radiometer: 1.41 GHz
  - Radar: 1.26 GHz
- View angle: 40°
- Operating altitude: 1-3 km
  - With 20° beamwidth 600-1500 m footprint
- Scanning operation
  - Swath width ~2 x altitude
- Measurement resolution
  - Radiometer < 0.2 K
  - Radar < 0.2 dB
- Fast sampling digital backend for RFI
- Thermal infrared sensor
  - Nadir pointing, 2° beamwidth

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Hardware problems during SMAPVEX16-MB

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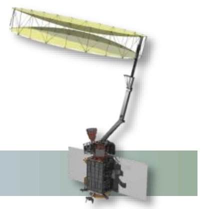
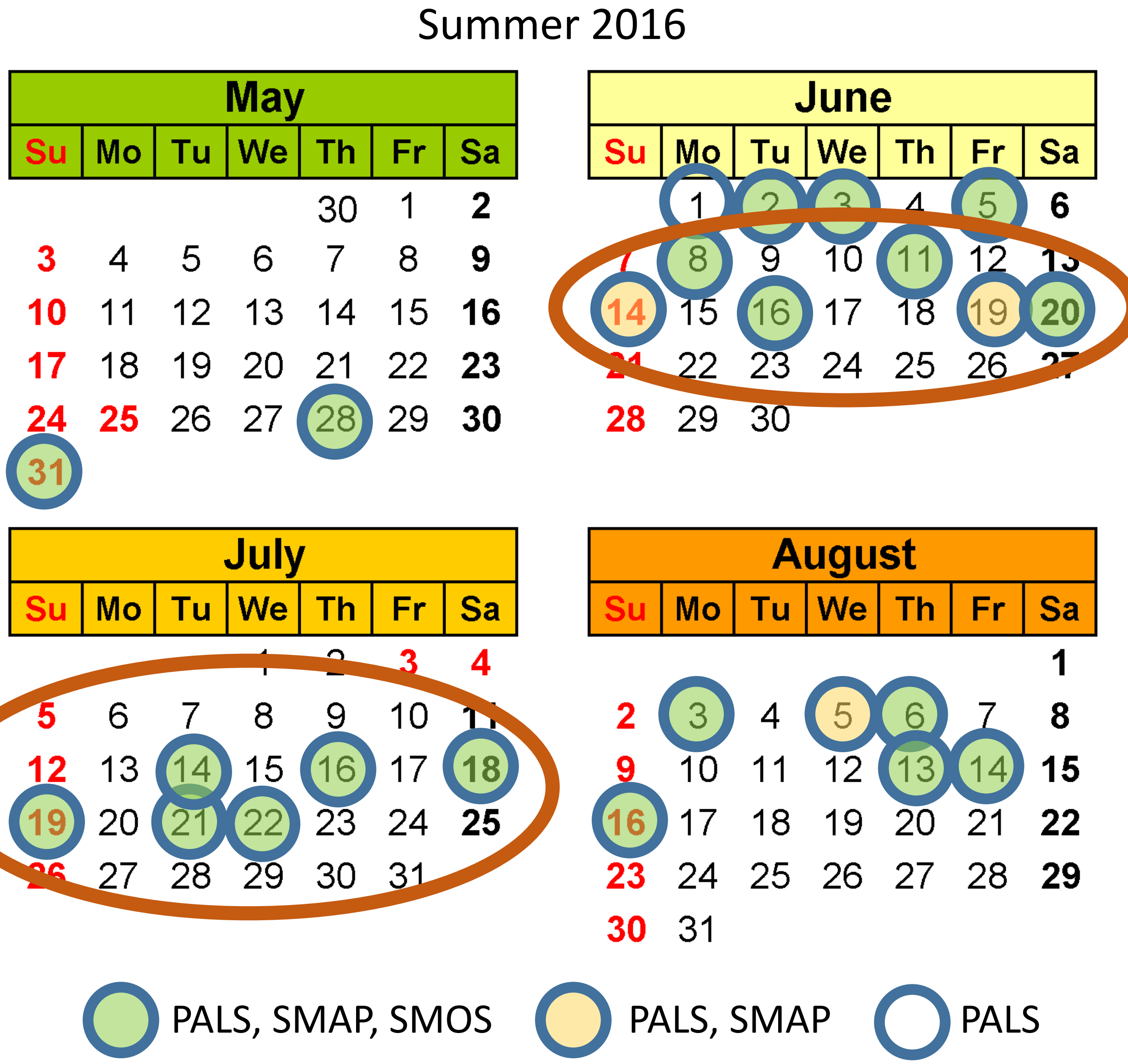
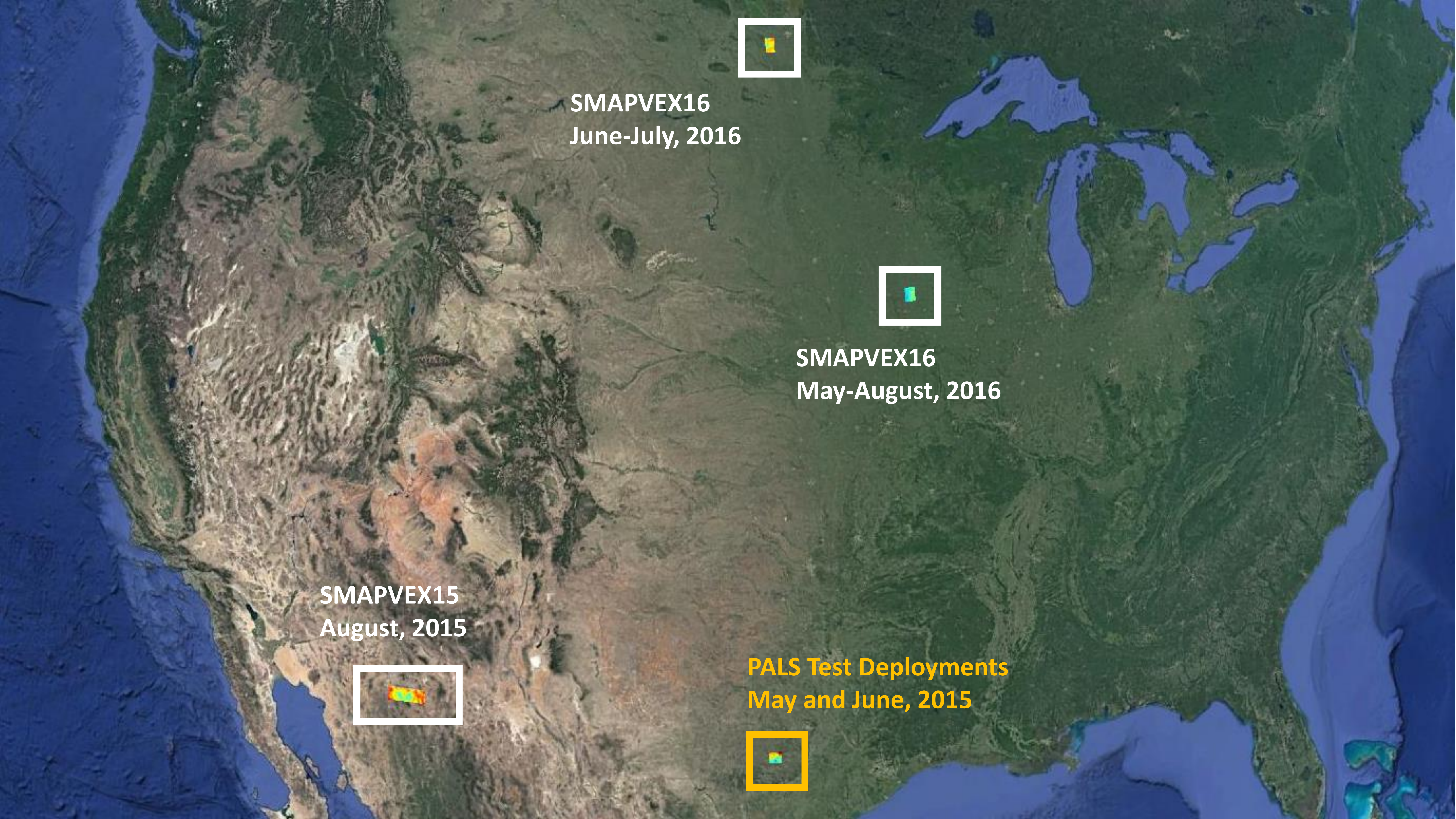
Calendar of Flights and Overpasses



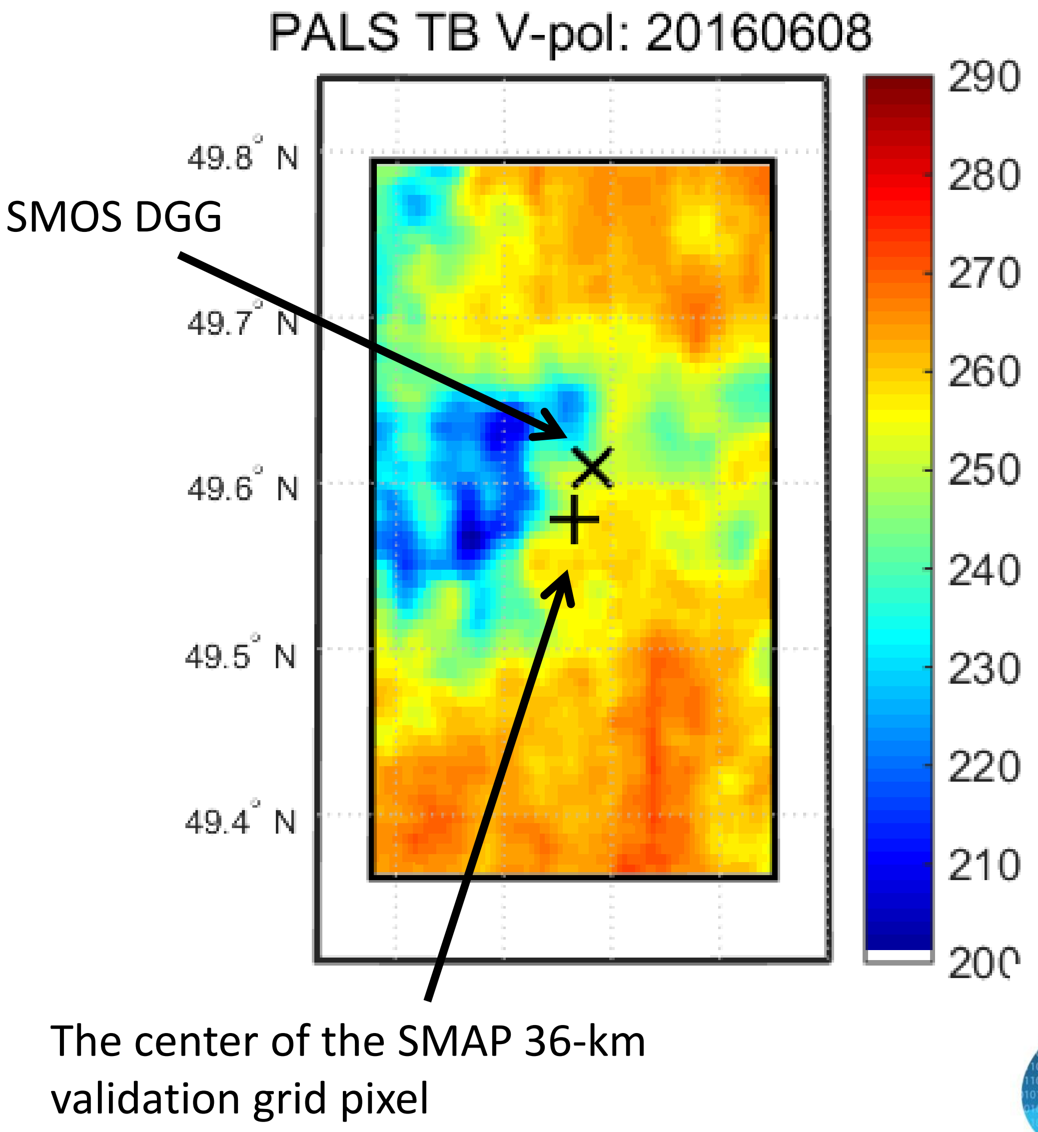
- SMAPVEX16-MB flights in June and July
- The 12 PALS flights during SMAP overpasses
  - Also 10 SMOS overpasses captured
- IOP1 and IOP2 separated by about three weeks
- DC-3 flew back to Texas during the break
- PALS was partially removed and then re-installed between the IOP1 and IOP2




SMAPVEX16
June-July, 2016
SMAPVEX16
May-August, 2016
SMAPVEX15
August, 2015
PALS Test Deployments
May and June, 2015

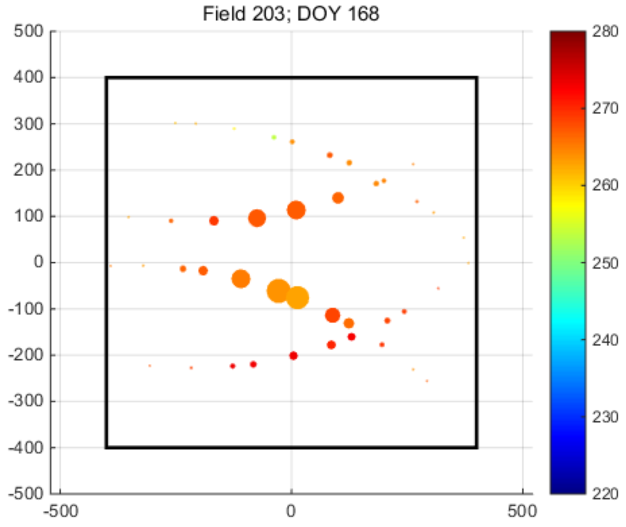
High Altitude Flights

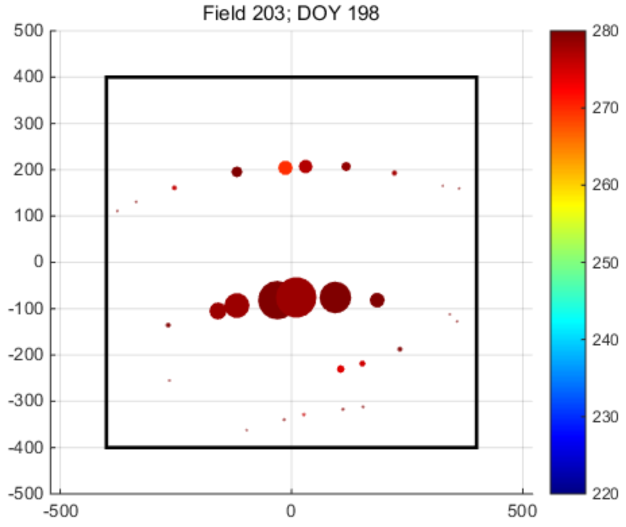
- PALS TB mapping
  - 1500 m spatial resolution
  - 1.3 hr mapping time in SMAPVEX16
  - Mean of the measurement time usually within 1 hour of SMAP overpass
  - Gaussian weighting used in the gridding
- PALS TB averaged for SMAP/SMOS comparisons
  - Gaussian weighted average starting from the respective pixel center
  - Mapped domains do not cover the entire footprint necessarily
- Difference on SMAP and SMOS pixel center locations
  - Based on TB variability measured with PALS it should not be statistically significant (but case by case could introduce some effects)

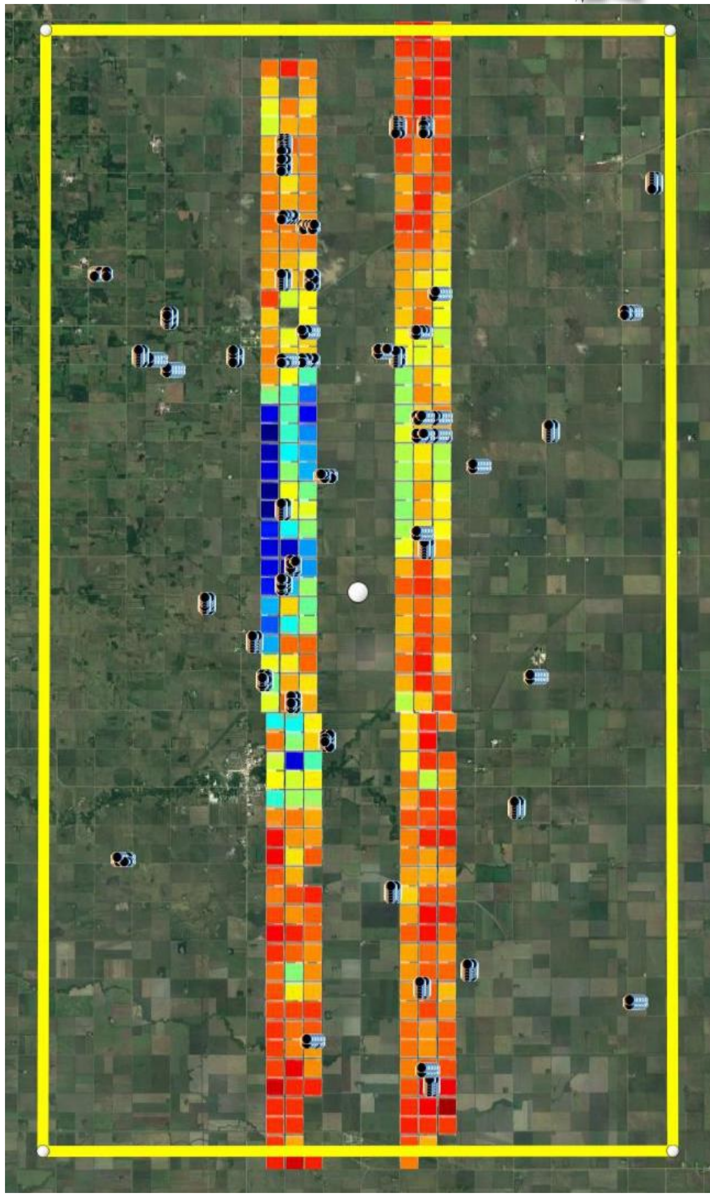


Low Altitude Flights

- PALS low altitude flights
  - Two lines
  - 600 m spatial resolution
- Field matchups
  - Gaussian weighting over all fields under swath







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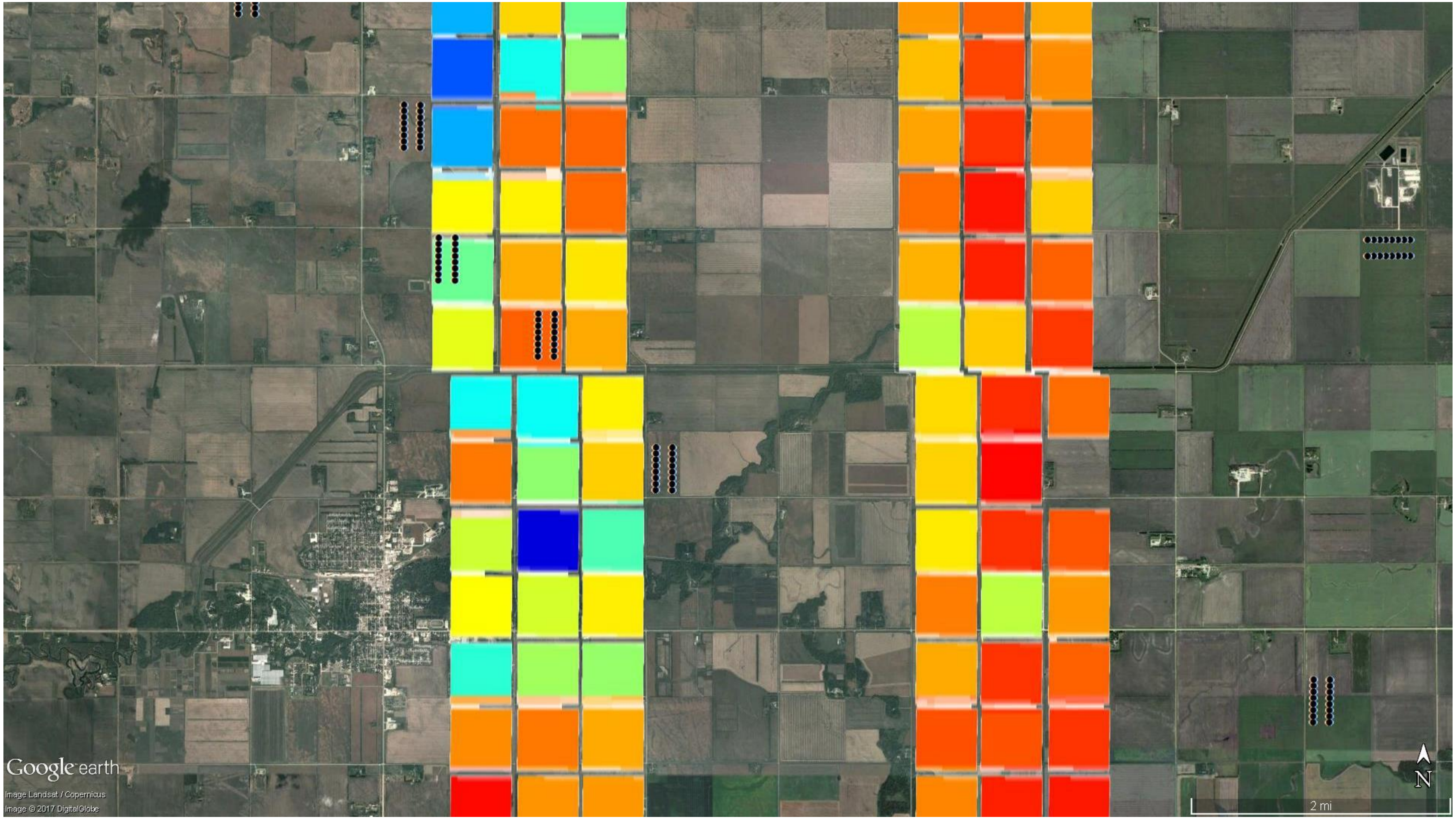
Low Altitude Flights

Low Altitude Flights



PALS Radiometer Calibration

- PALS calibration relies heavily on internal calibration and proven repeatability during 2012
- Internal noise diode calibration
  - SMAP and Aquarius adopted similar scheme
- Pre- and post-flight absorber and sky calibration as a repeatability test
- Two lake calibration flights, one during each IOP
- Radome characterization is the key in this configuration
  - The radome is not ideal in terms of scattering coefficients
- A simple statistical method was used to remove the radome azimuthal effect on daily basis
  - After a lot of analysis by Sid Misra this seems to be the best approach

Brightness Temperature

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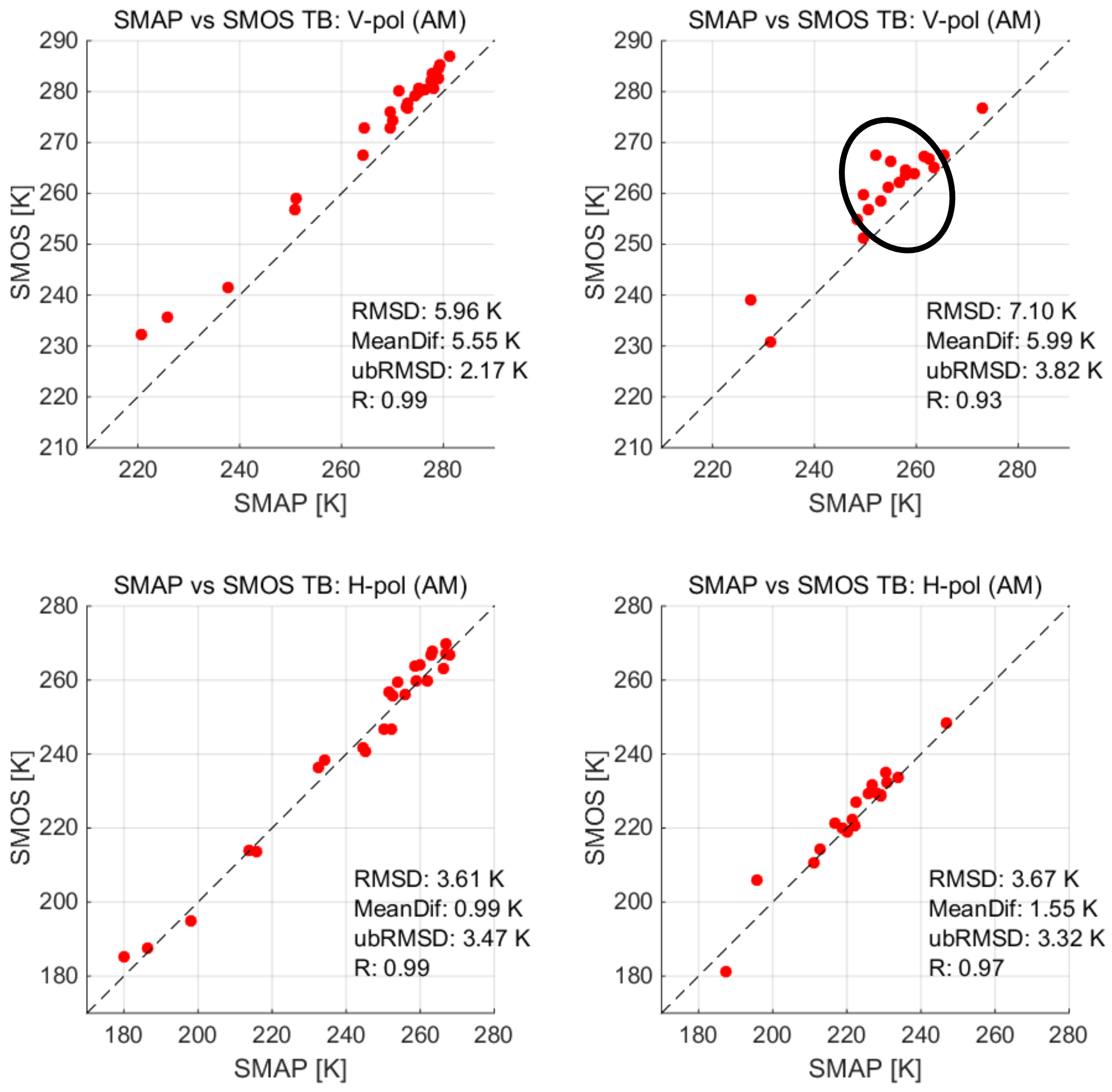
SMAP TB vs SMOS TB

- Data from the soil moisture products:
  - SMAP: L2SMP, R13080
  - SMOS: L2SM UDP, v620
- Processing of each product includes various corrections
  - Shows differences in TB that goes into the algorithms
- Observations:
  - Consistent difference in V-channels
  - Possibly smaller difference in H-channels
  - Possible RFI in Manitoba
  - (Larger comparison area could be used but here we focus on the campaigns with PALS data)

South Fork (Iowa) / Carman (Manitoba)



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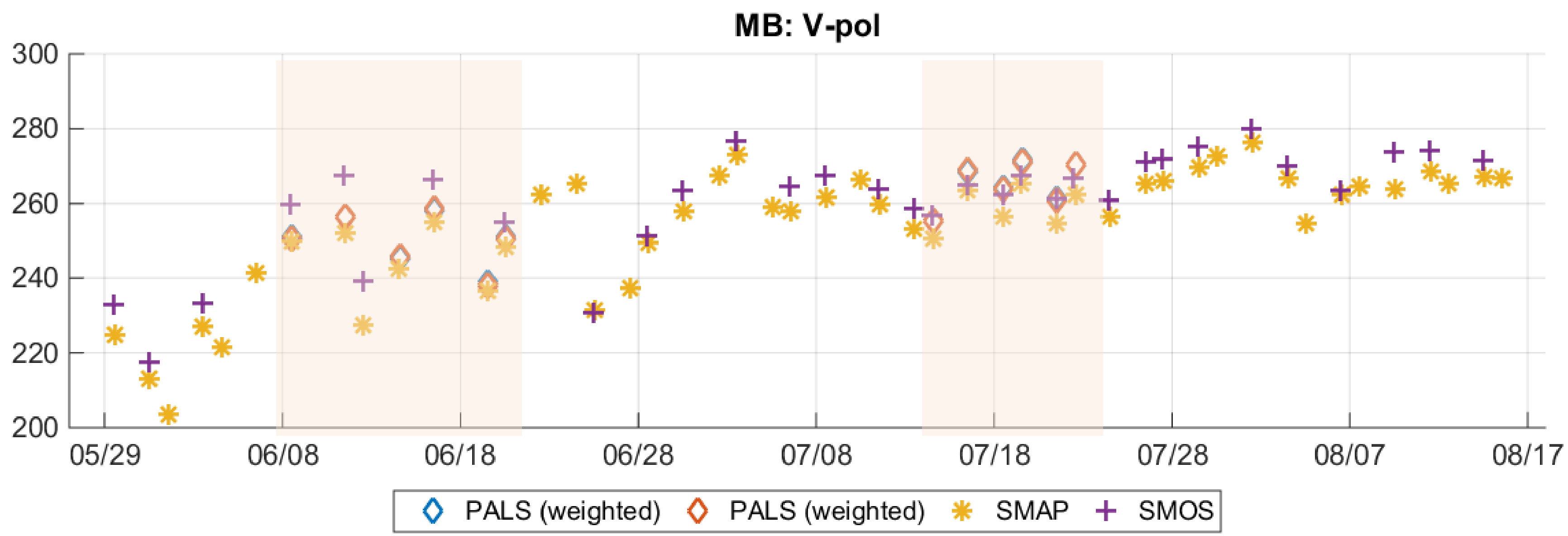
SMAP TB vs SMOS TB



- TB difference between SMAP and SMOS remains constant over the summer
  - This will be significant for the soil moisture comparisons

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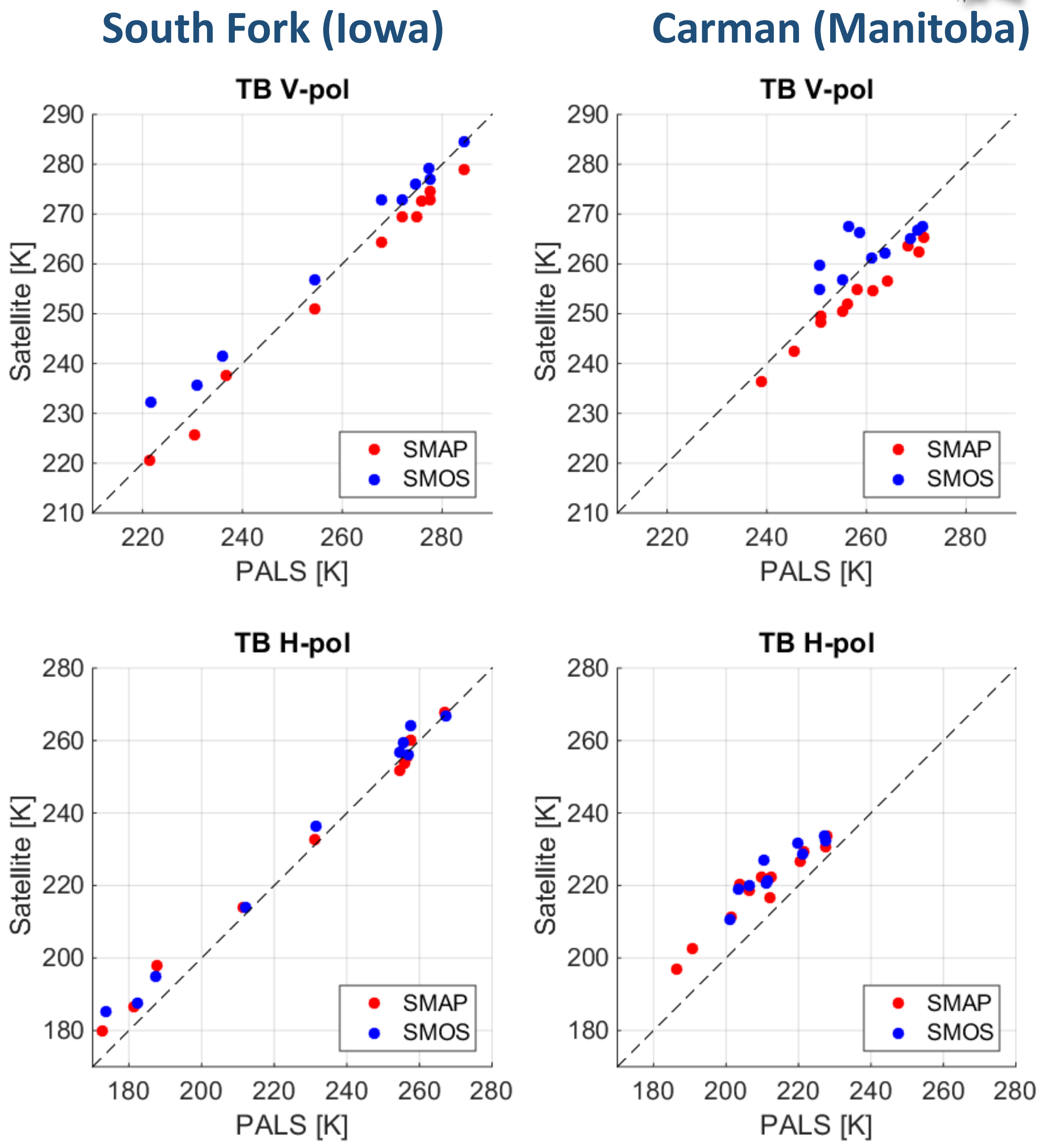
Comparisons to PALS

- PALS brightness temperature averages show general correspondence with SMAP and SMOS with different bias consistent with comparisons between SMAP and SMOS
- SMOS V-pol may be experiencing RFI over the site
- PALS mean difference to SMAP during SMAPVEX16-MB:
  - V-pol: PALS 5.5 K higher
  - H-pol: PALS 8.5 K lower



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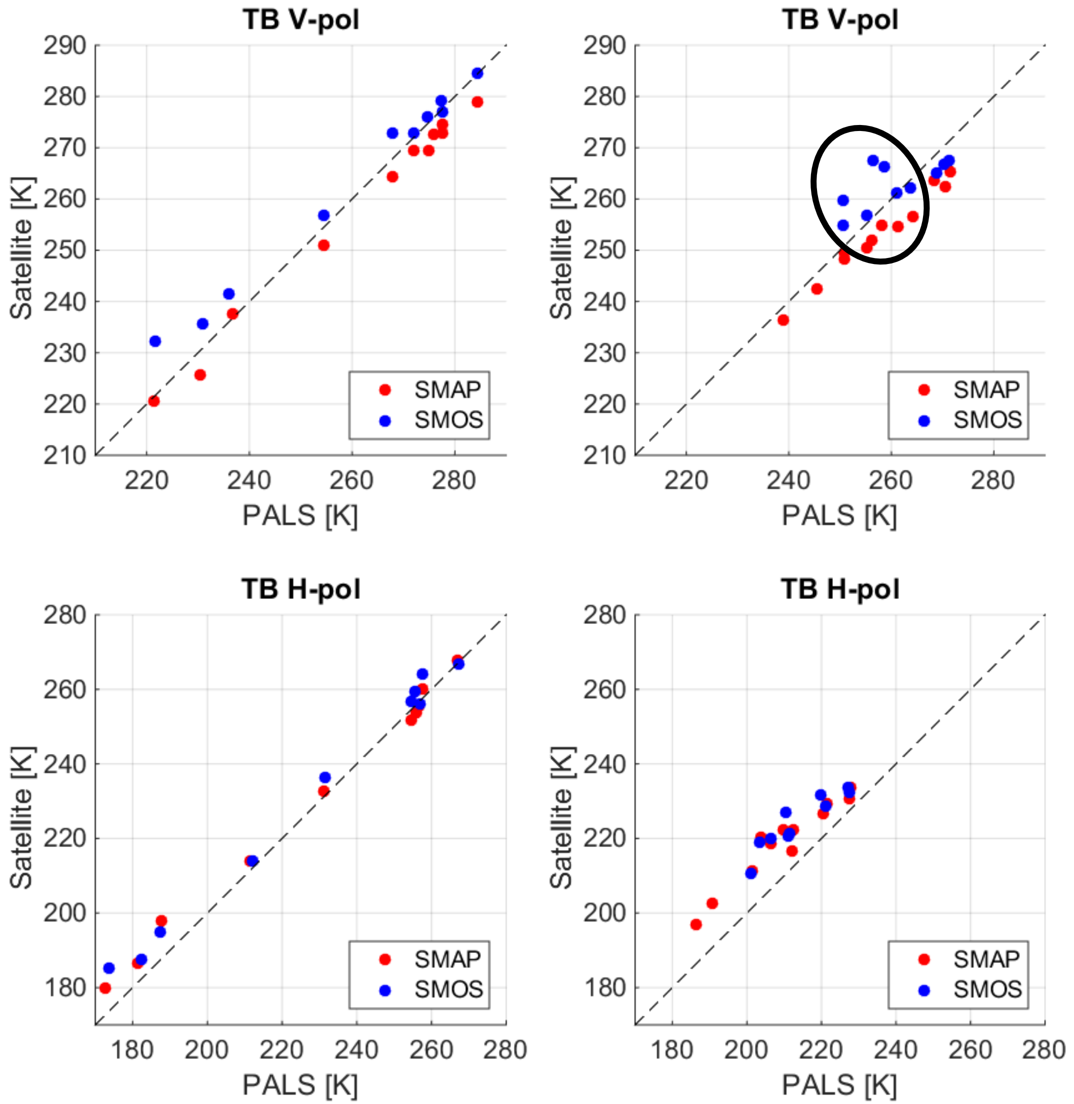
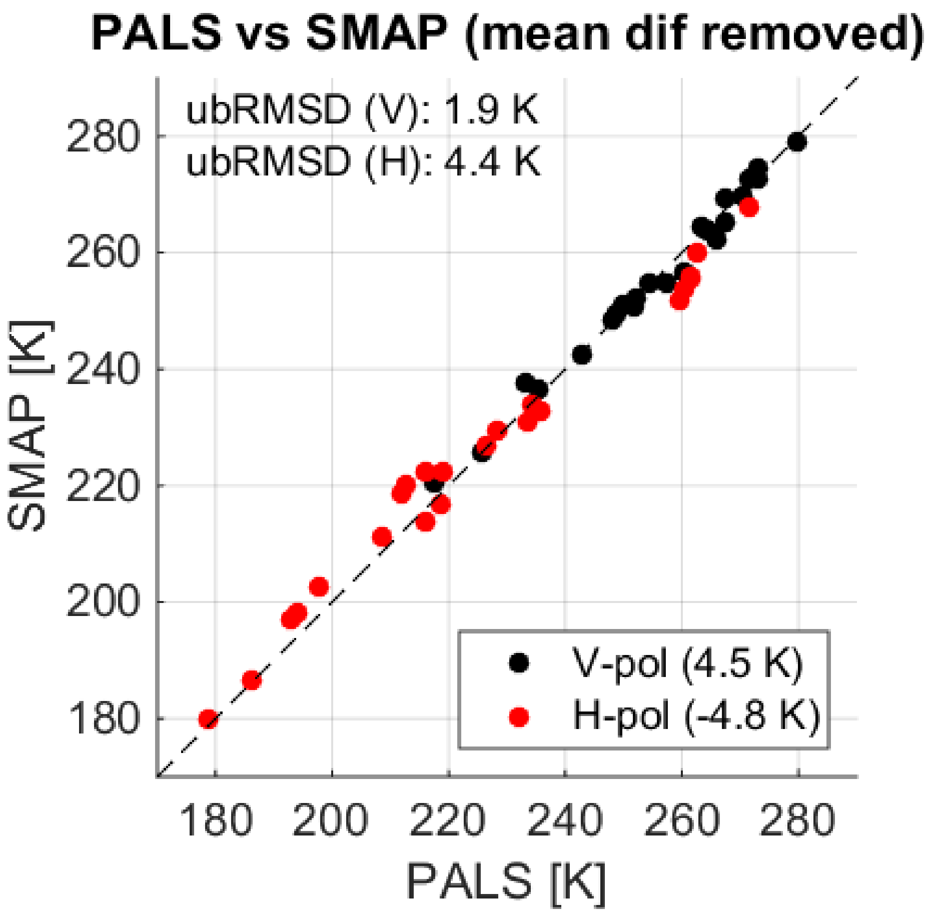
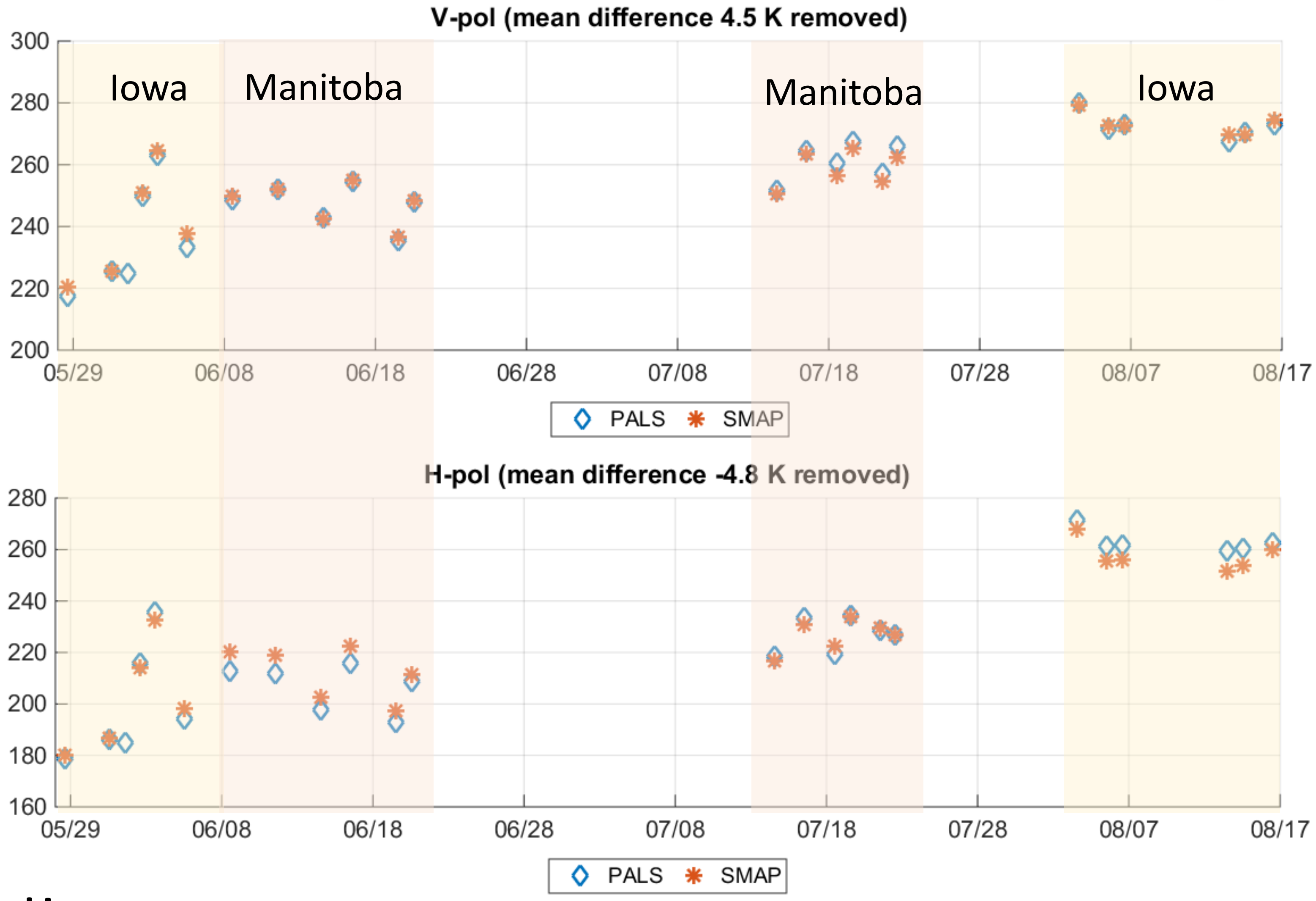


Manitoba and Iowa combined





General consistency confirmed!

Soil Moisture
(work in progress)

Soil Moisture Algorithms

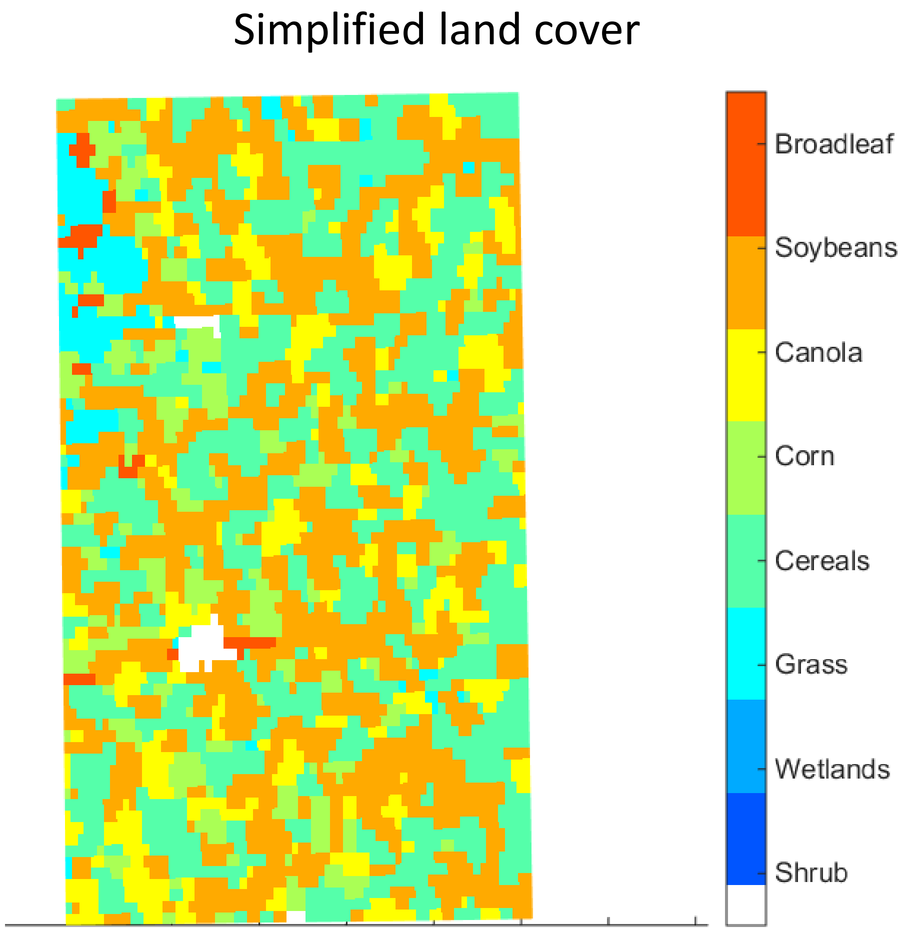
- All soil moisture algorithms based on some formulation of the τ-ω-h model
- SMAP
  - Single channel algorithm; single incidence angle
- SMOS
  - Dual polarization algorithm; a range of incidence angles
- PALS
  - Single channel algorithm; single incidence angle
  - Differences
    - Soil temperature estimated from actual measurements (SMAP and SMOS use models)
    - High resolution vegetation water content from concurrent observations (SMAP uses climatology)

$$T_B = T_{soil}(1 - r_{soil,p})e^{-\tau_p} + T_{veg}(1-\omega_p)(1-e^{-\tau_p}) + T_{veg}(1-\omega_p)(1-e^{-\tau_p})r_{soil,p}e^{-\tau_p}$$

$$r_{soil,p} = r_{0,p}e^{-h_p cos^2(\theta)}$$

High Altitude Soil Moisture Maps

- Soil moisture maps generated for the domain from the PALS high altitude flights
- The parameters obtained from the low altitude flights applied
- Ancillary data sources
  - Soil and vegetation temperature: From RISMA network (Tsoil = Tveg)
  - Land cover: simplified from the geodatabase land cover
  - Vegetation water content: Mike Cosh's product
  - Clay and sand fraction: Harmonized world soil database
- Subpixel modeling used to mitigate the effect of heterogeneity within the footprint
- Cost function based on RMS of both polarizations



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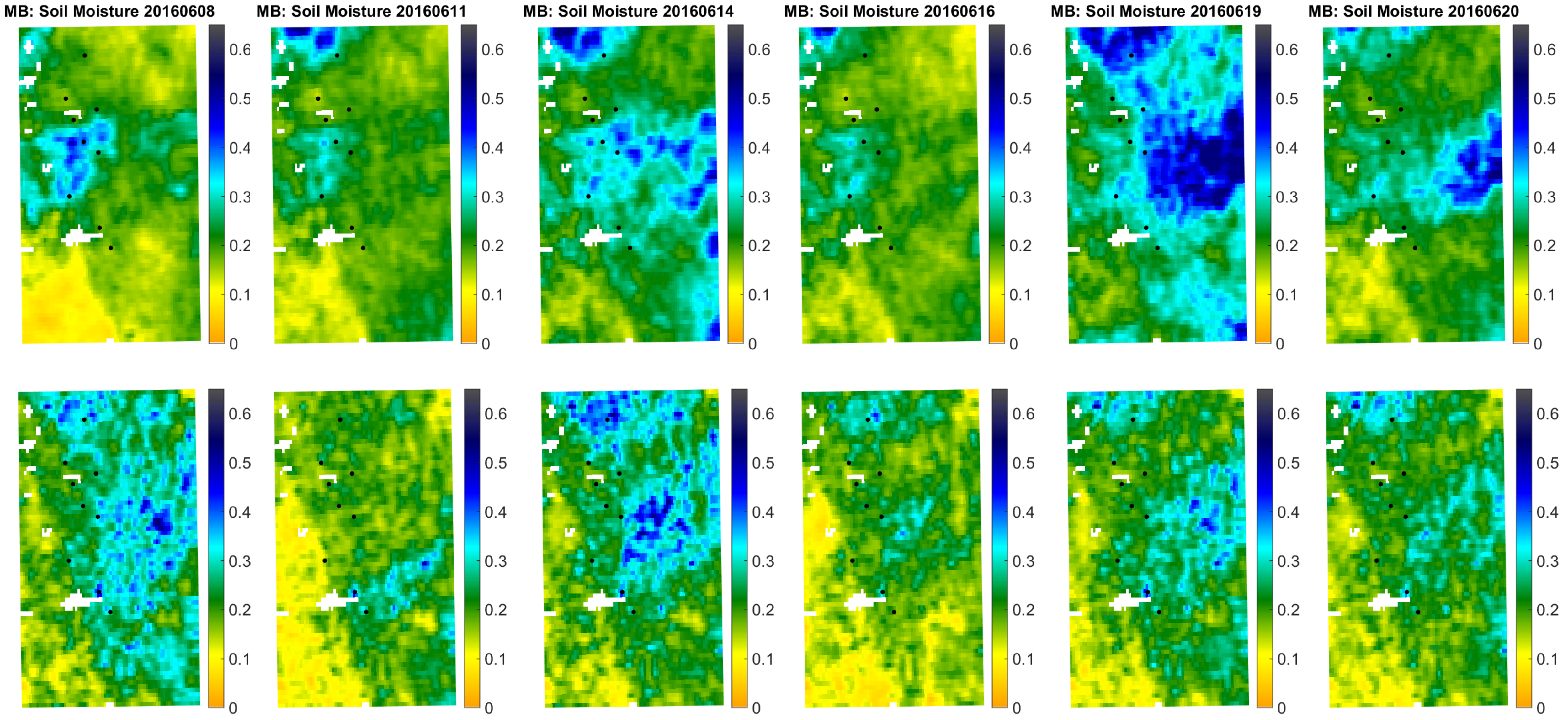
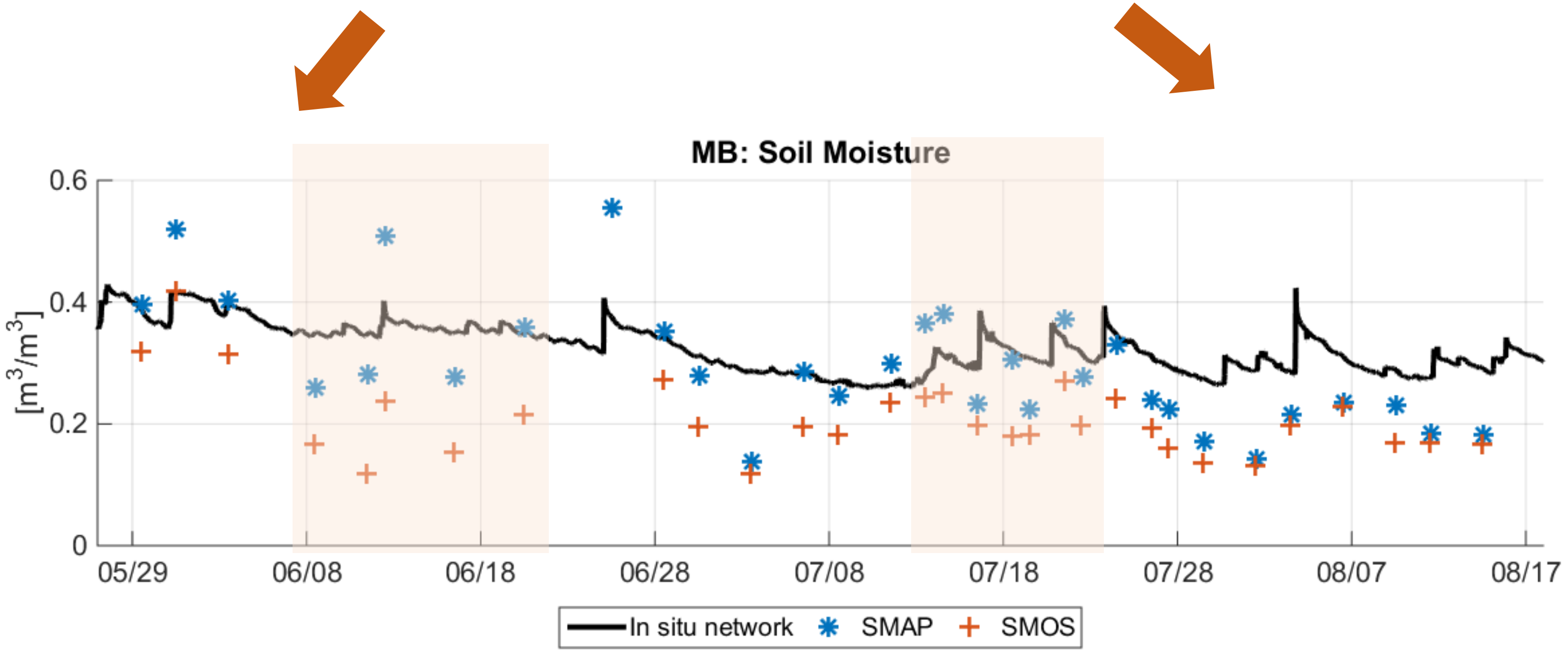
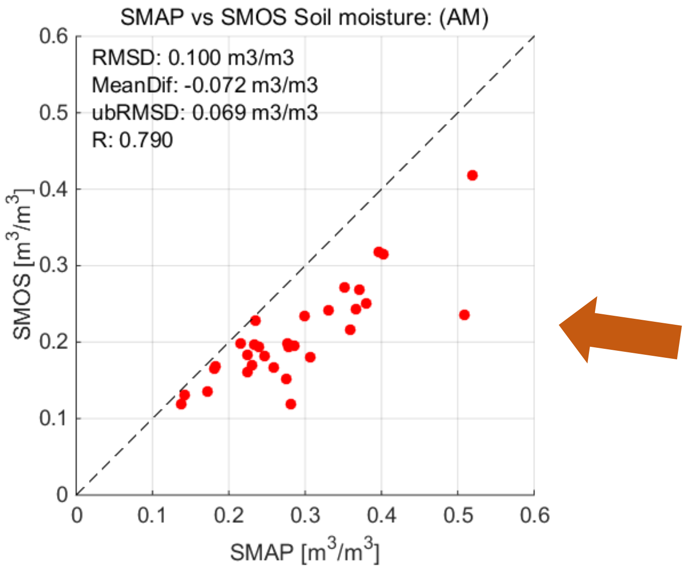
High Altitude Soil Moisture Maps



SMAPVEX16 Soil Moisture Comparisons





- Stark evolution of the difference between SMAP and SMOS from early summer to late summer
- RFI may play a role

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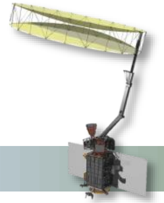

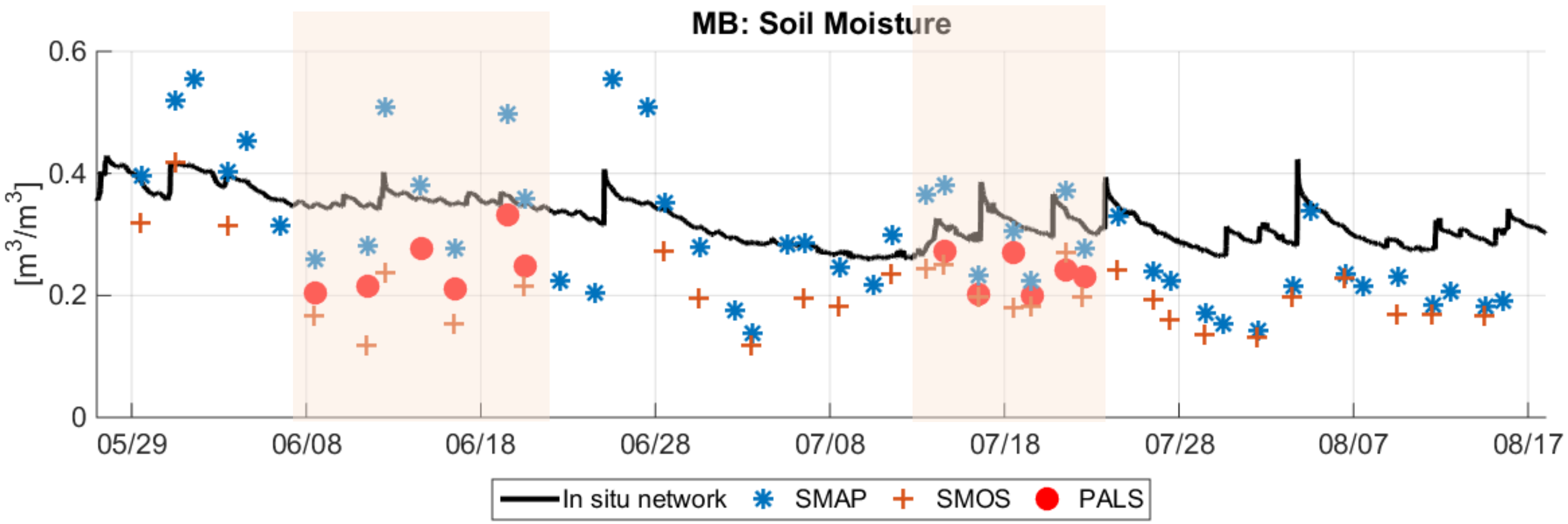

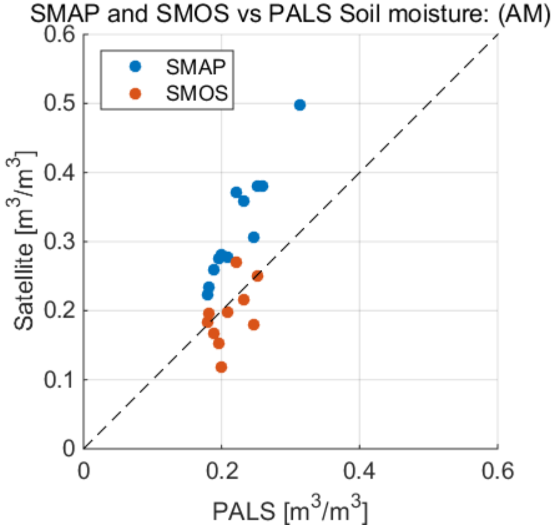

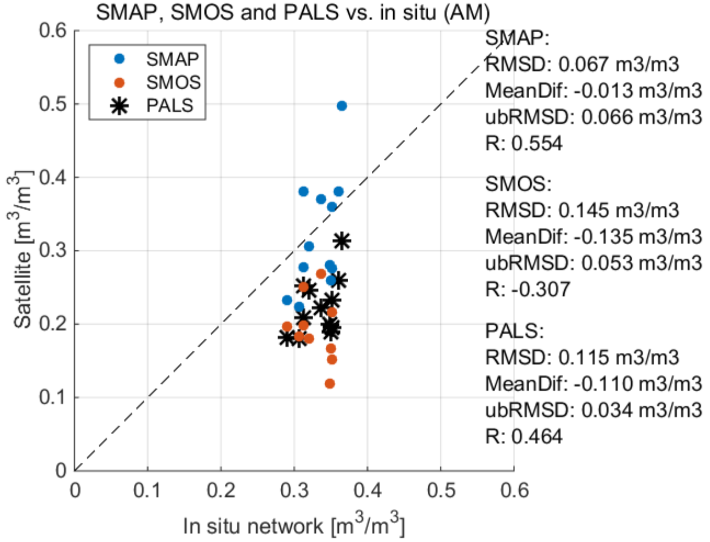

- PALS soil moisture different from SMAP and SMOS
  - Variable bias but string correlation with respect to SMAP
- PALS and SMAP follow the dry-downs after rain events, SMOS sometimes hard to explain (RFI?)

Conclusions

- General consistency in brightness temperature good but some biases detected
  - SMAP and PALS agree pretty closely, SMOS and SMAP difference notable but constant
  - SMOS experiences anomalies in Carman not seen with SMAP or PALS (RFI?)
  - Footprint location differences should play a minor role in the differences

- Soil moisture observations have relative large deviations between SMAP, SMOS and in situ
  - Carman and South Fork show a trend in difference from early summer to late summer
  - PALS shows a (too?) complex spatial structure over Carman
  - PALS clearly different from SMAP and SMOS
- Lots of work remaining…