Fine-resolution SLAP Soil Moisture Observations During LIAISE

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Outline

- SLAP background
- Overview of LIAISE flights
- Soil moisture algorithm
- Example data
- Preliminary soil moisture validation
- Summary

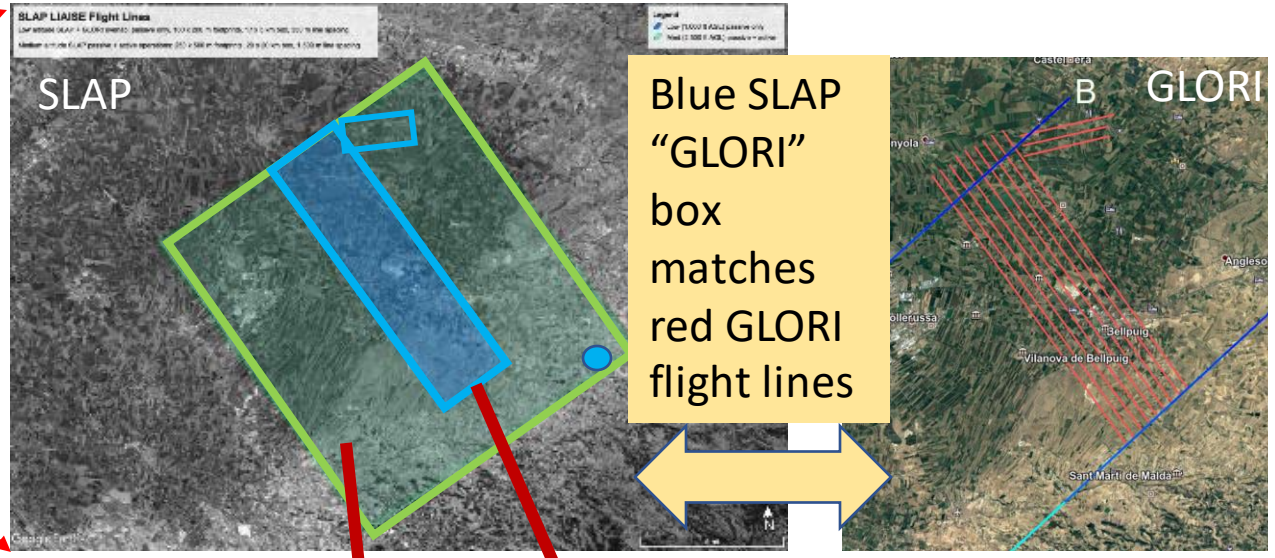
NASA Goddard's Scanning L-band Active Passive (SLAP) is…

- …an airborne SMAP simulator with both passive (1.4 GHz) and active (1.2 GHz) microwave imaging capability
- Radiometer is 4-Stokes w/SMAP's digital backend + RFI processor + enhancements; footprints 100x200m from 1000 ft AGL
- Radar is a quad-pol scatterometer; footprints 350m from 2500 ft AGL (radar minimum altitude)
- Swath widths up to 8km/4.2nm (at 11500 ft AGL)
- Single-pixel thermal IR
- Compatible with several aircraft, currently on a King Air
- 1400km range in 4.5 hrs; day/night/VFR/IFR
- Capable of worldwide deployment

SLAP on bottom of NASA Langley King Air (UC-12) aircraft.

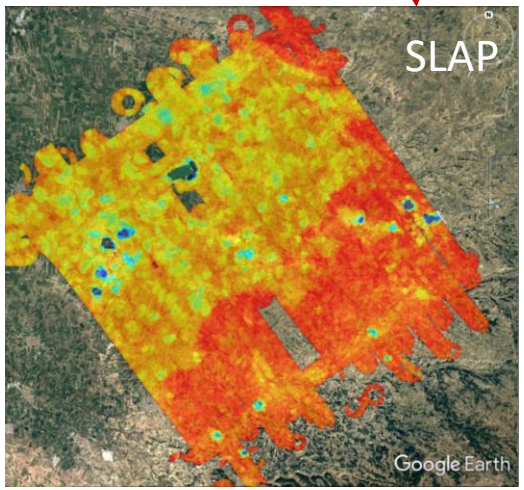
SLAP Flights Overview

July 15—29, 2021
9 science flights

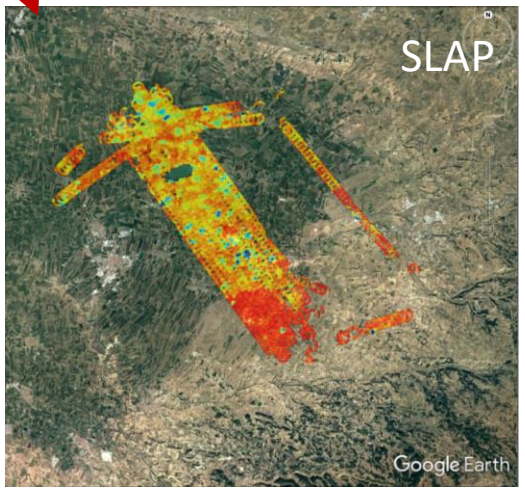


Flight date	Target area start time	Flight altitude	Footprint size
July 15	0800	Low	100×200m
July16	0754	Med	200×500m
July 17	0753	Low	100×200m
July 24	0750	Low	100×200m
July 24	1320	Low	100×200m
July 25	0752	Low	100×200m
July 27	0814	Low	100×200m
July 28	0808	Low	100×200m
July 29	0803	Med	200×500m

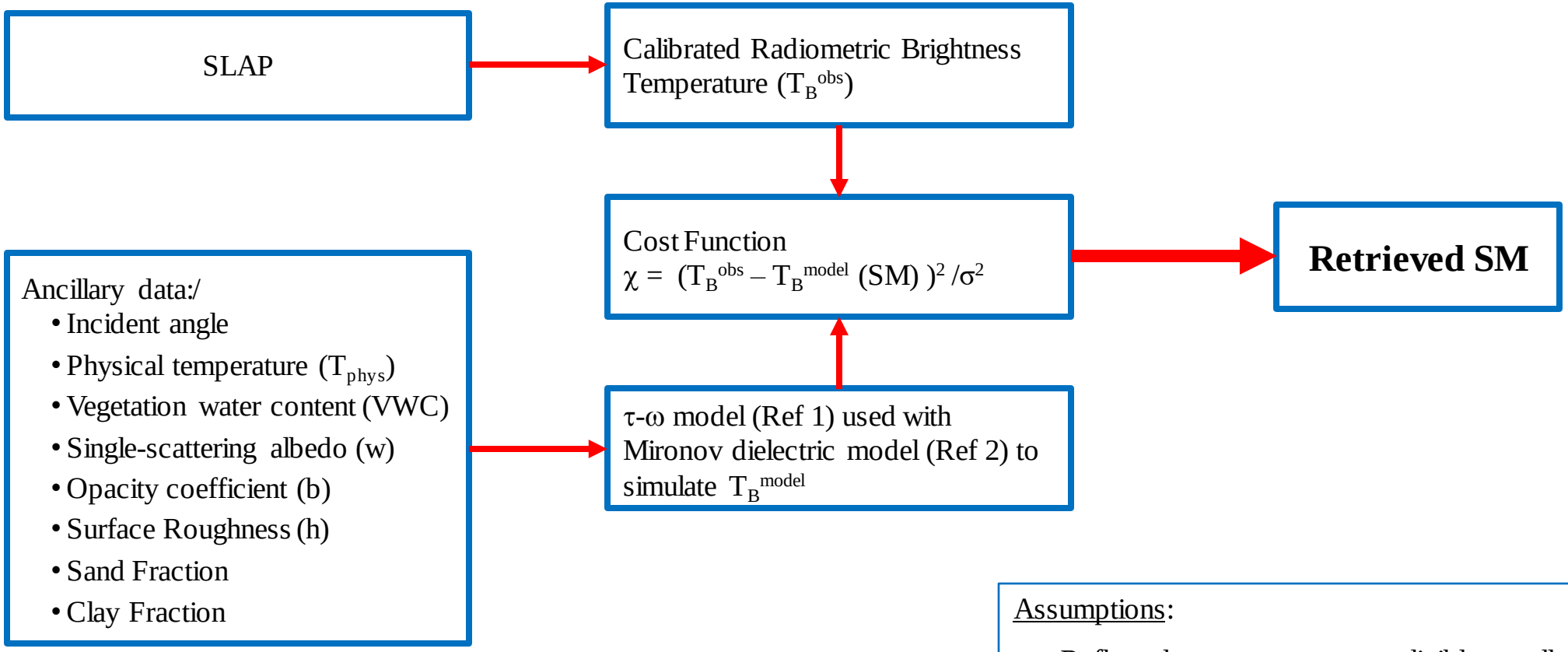
med altitude:
20×20 km box
passive+active



low altitude (GLORI box):
17×5 km box
passive only



SLAP Soil Moisture Algorithm



Assumptions:

- Reflected components are negligibly small
- Atmospheric emission and attenuation neglected
- $T_{veg} \approx T_{soil}$

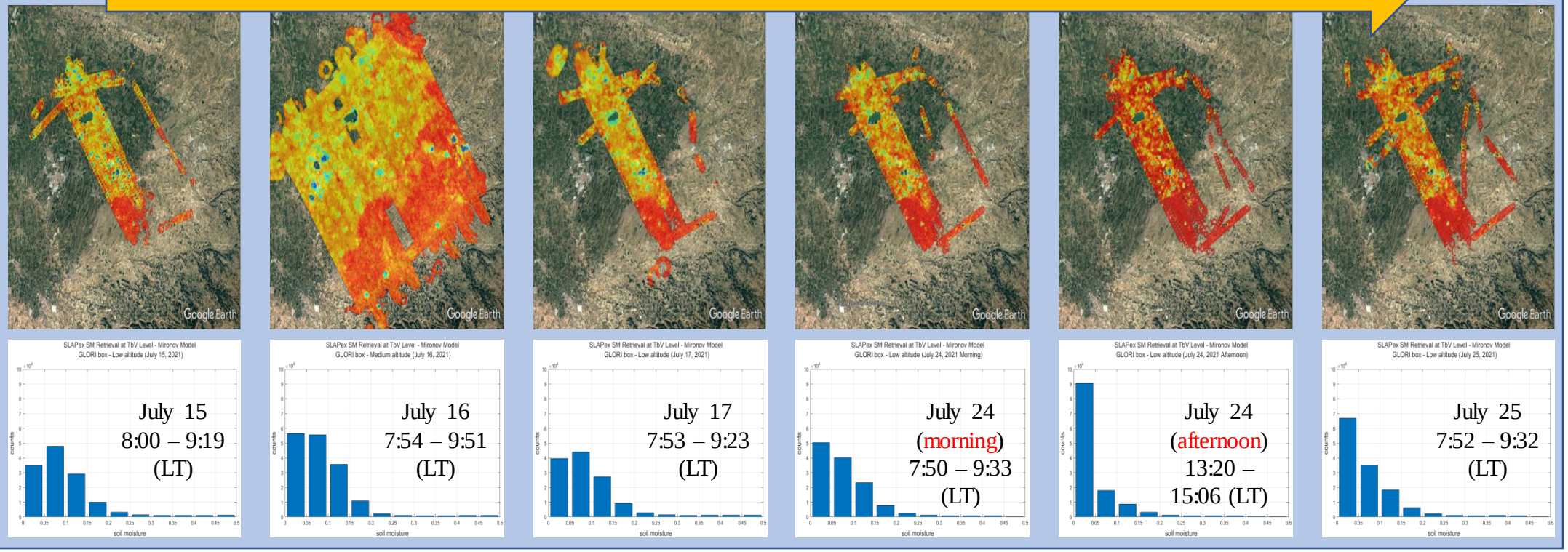
Ref 1: Mo et al. (1982) JGR VOL. 87, NO. 11
Ref 2: Mironov et al.(2013), IEEE GRL VOL. 10, NO.3

Soil Moisture Before Precip Event

TIME SERIES

SOIL MOISTURE BEFORE PRECIP

Caveat: some areas observed multiple times during a flight (by design) → histograms contain replicated data

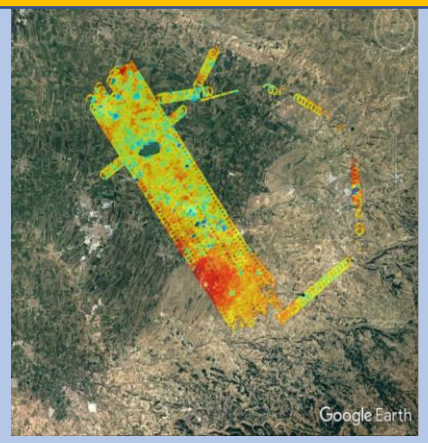


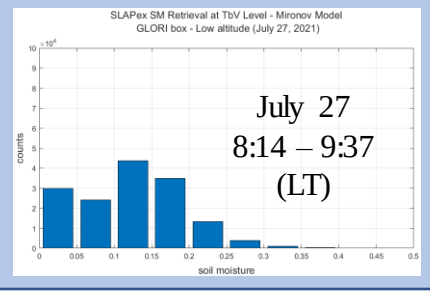
Soil Moisture after Precip + Irrigation

TIME SERIES CONTINUED

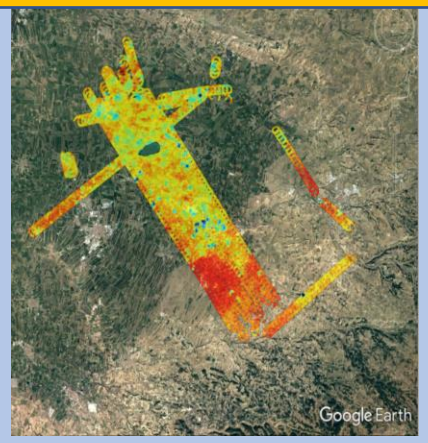
July 26
Large precip over northern 2/3 of area (no flight)

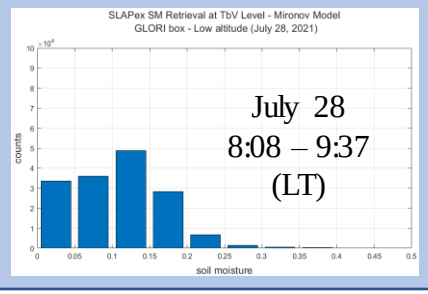
SOIL MOISTURE AFTER PRECIP



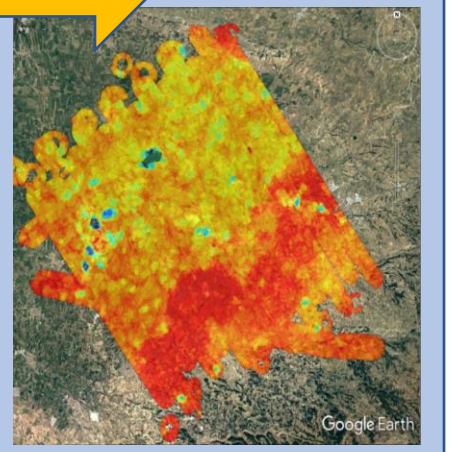


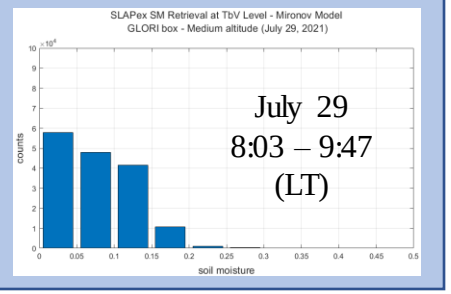
July 27
8:14 – 9:37
(LT)





July 28
8:08 – 9:37
(LT)





July 29
8:03 – 9:47
(LT)

DRY

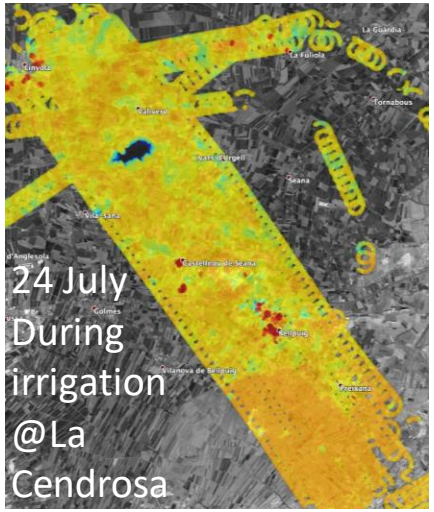
m^3/m^3

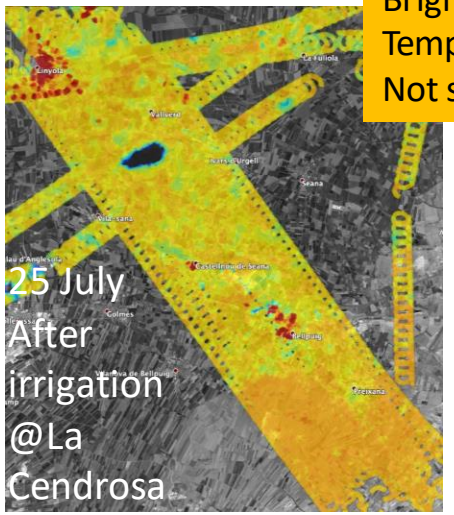
WET

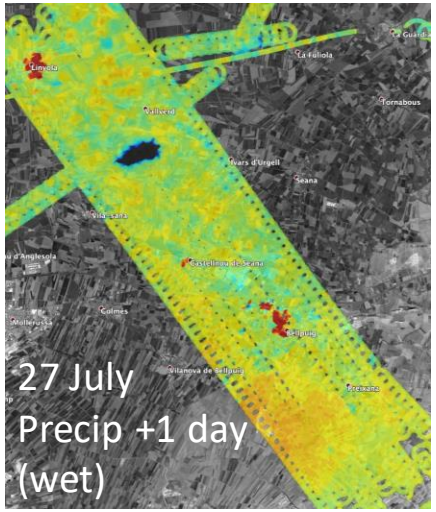
Values: 0 - 0.025
Values: 0.025 - 0.05
Values: 0.05 - 0.075
Values: 0.075 - 0.1
Values: 0.1 - 0.125
Values: 0.125 - 0.15
Values: 0.15 - 0.175
Values: 0.175 - 0.2
Values: 0.2 - 0.225
Values: 0.225 - 0.25
Values: 0.25 - 0.275
Values: 0.275 - 0.3
Values: 0.3 - 0.325
Values: 0.325 - 0.35
Values: 0.35 - 0.375
Values: 0.375 - 0.4
Values: 0.4 - 0.425
Values: 0.425 - 0.45
Values: 0.45 - 0.475
Values: 0.475 - 0.5

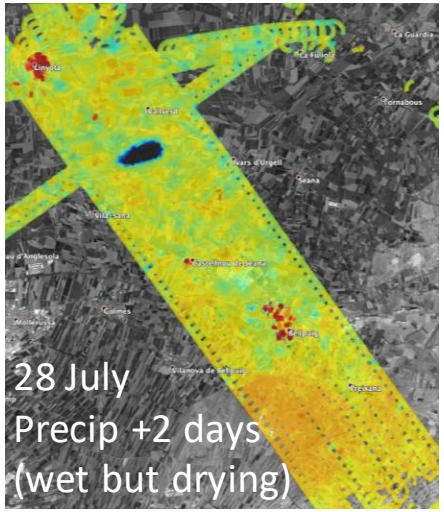
29 July SLAP medium-altitude Quicklook

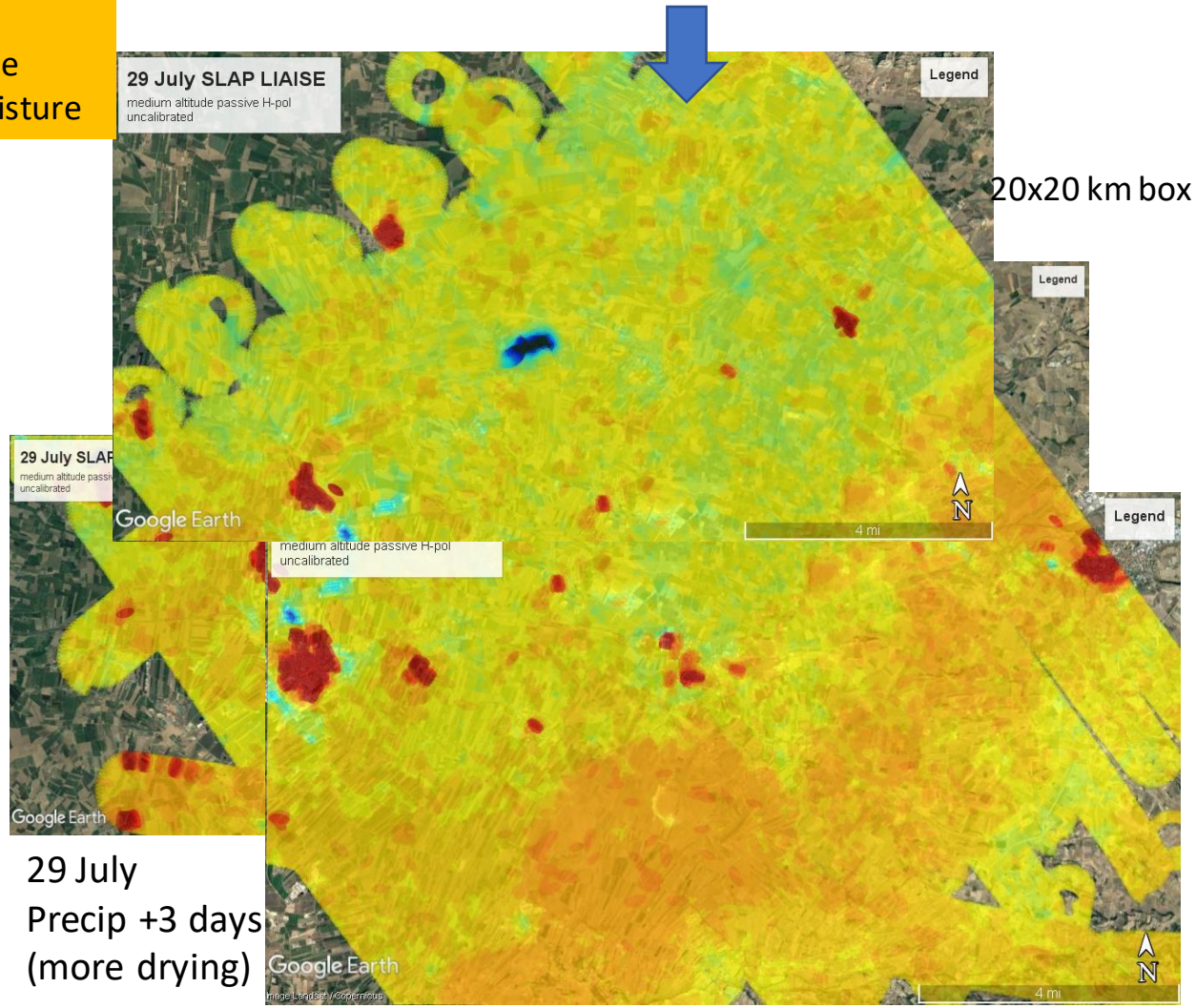
Uncalibrated
Brightness Temperature
Not soil moisture











20x20 km box

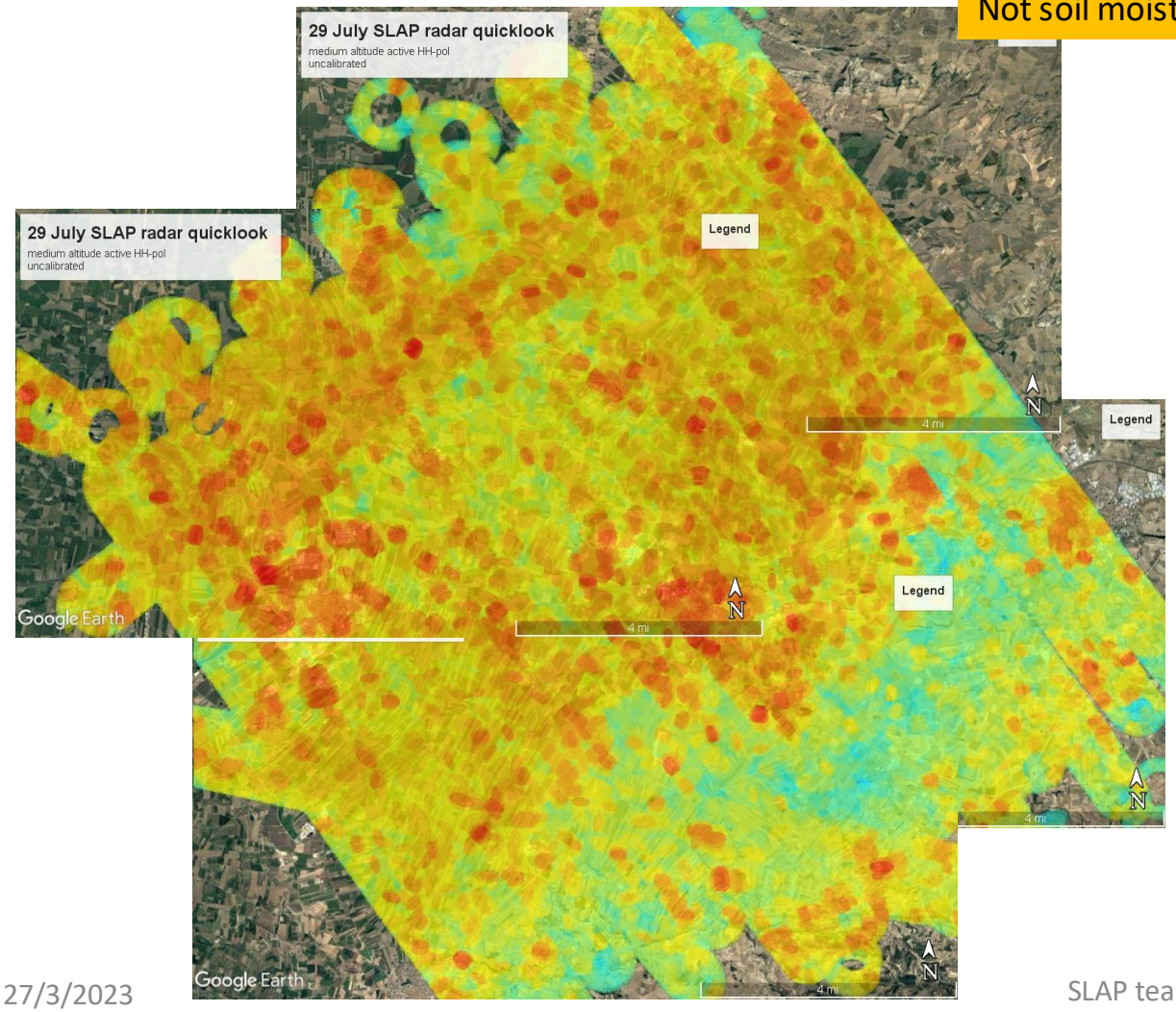
29 July
Precip +3 days (more drying)

Same color scale for all images

SLAP Passive vs. Active 29 July medium altitude Quicklooks

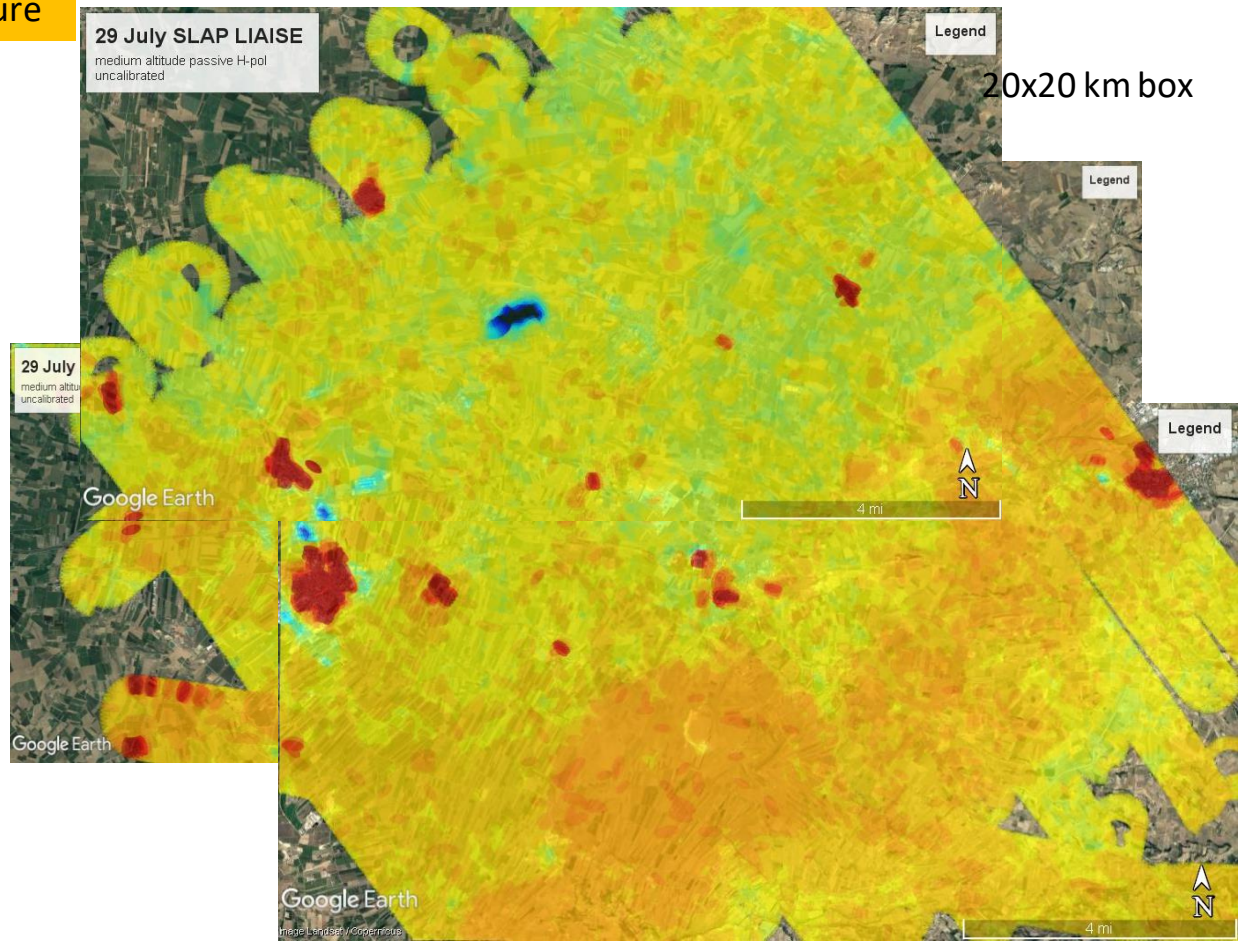
Uncalibrated
Radiometer +
Radar radiances
Not soil moisture

ACTIVE, HH-pol, uncalibrated



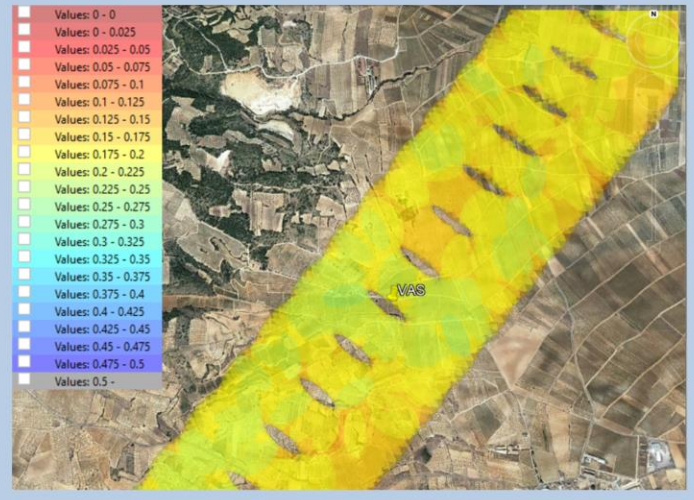
PASSIVE, H-pol, uncalibrated

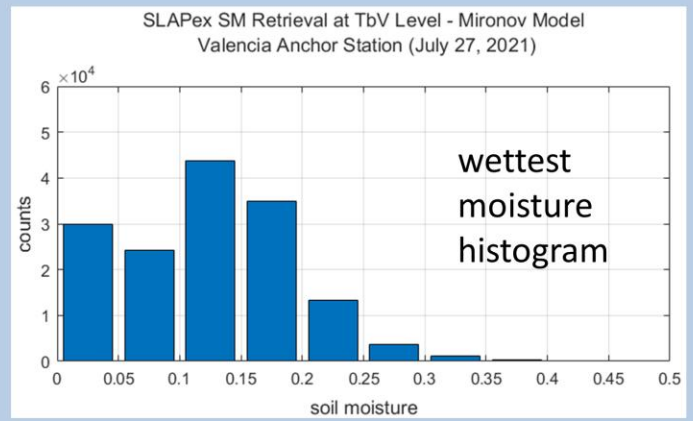
20x20 km box



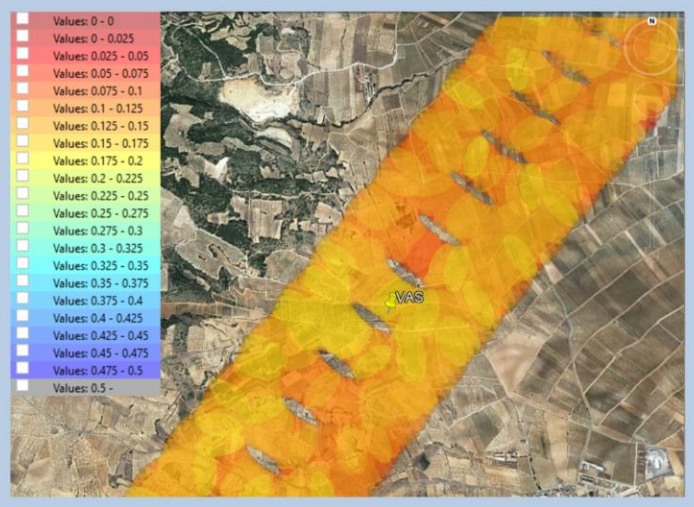
SLAP overflight of Valencia Anchor Station (west of Valencia) July 27, 28, 29 (3 days after rain)

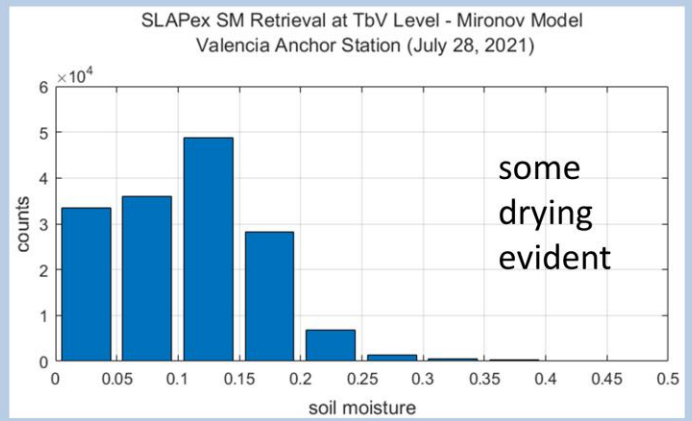
1 day after 148 mm rain →WET!



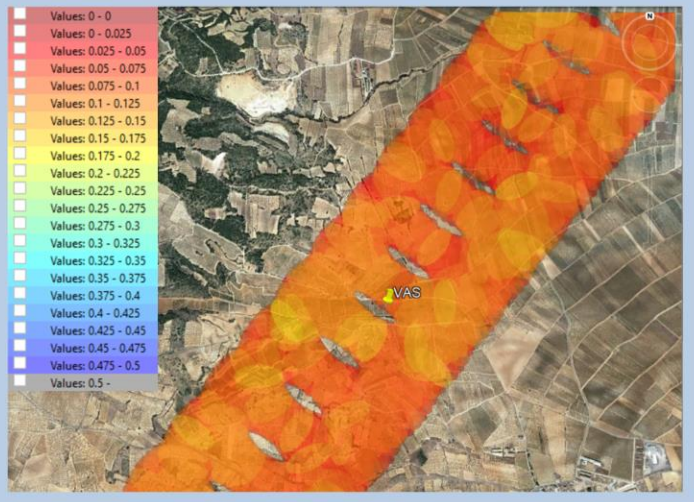


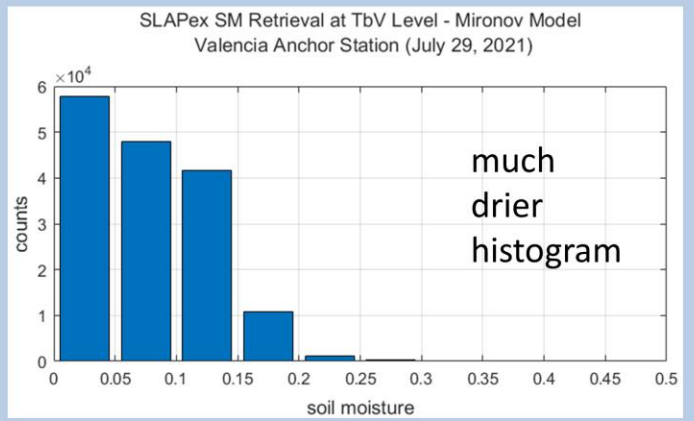
2 days after rain → some drying





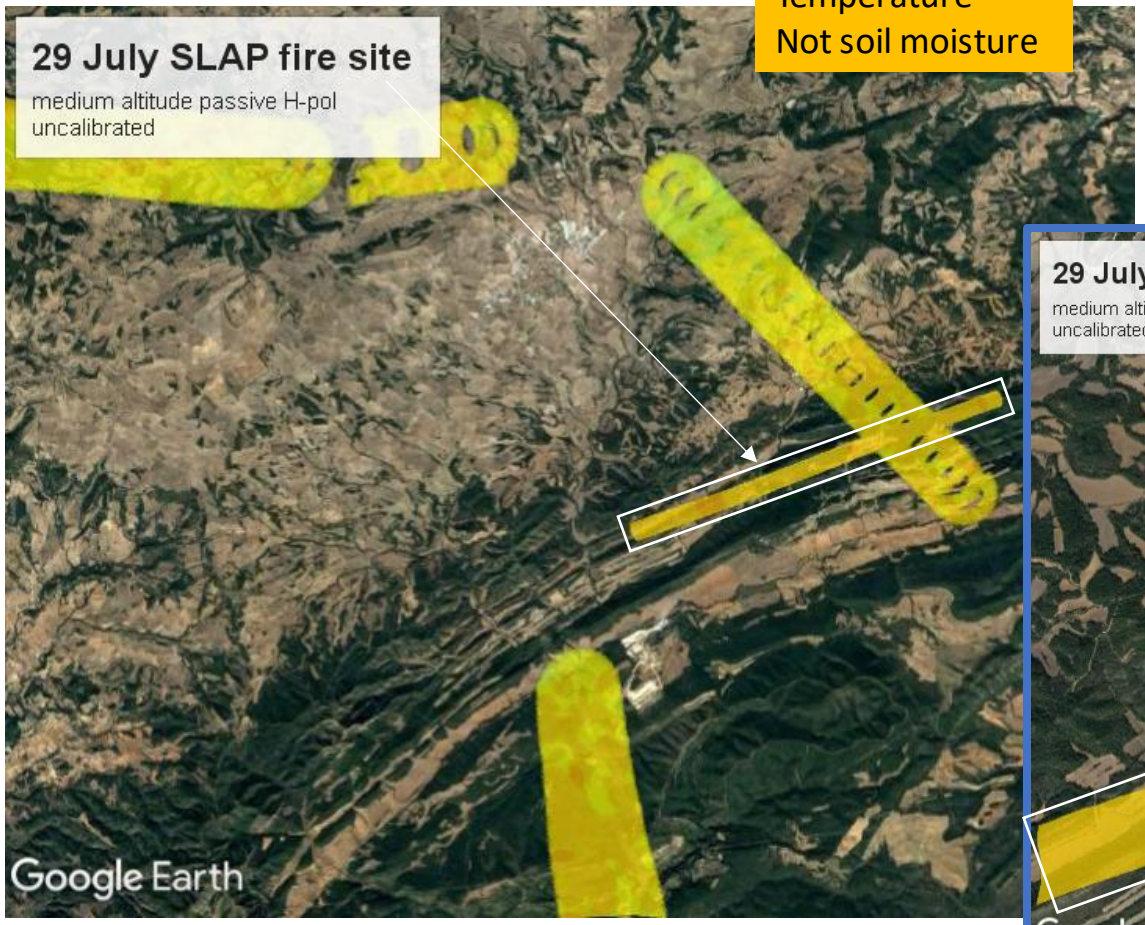
3 days after rain → even drier



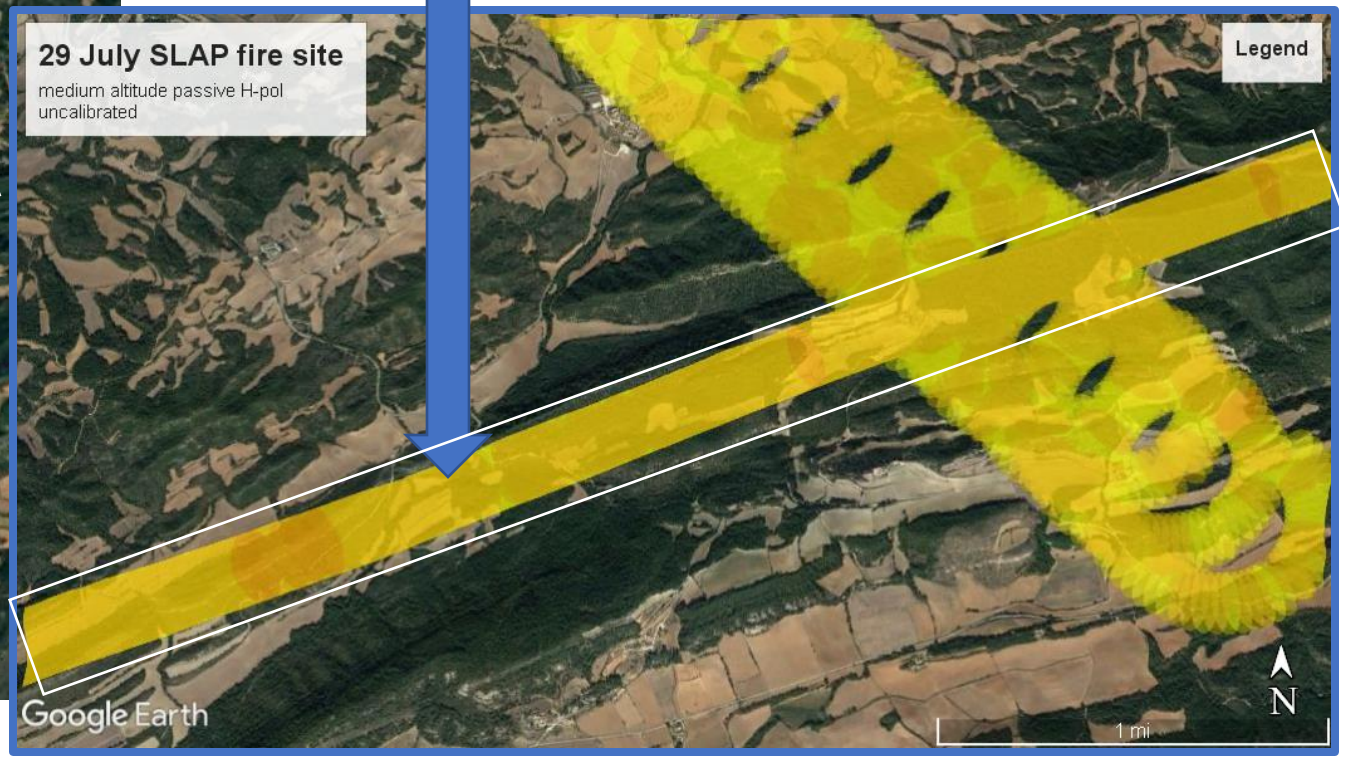


29 July SLAP quicklook of fire site

Uncalibrated
Brightness
Temperature
Not soil moisture



Attempt to observe the burned side of the ridge better by turning off scanning→just a line of pixels
Not sure how well we aimed, but no clouds, so we
Were able to fly lower than 28th → smaller footprints



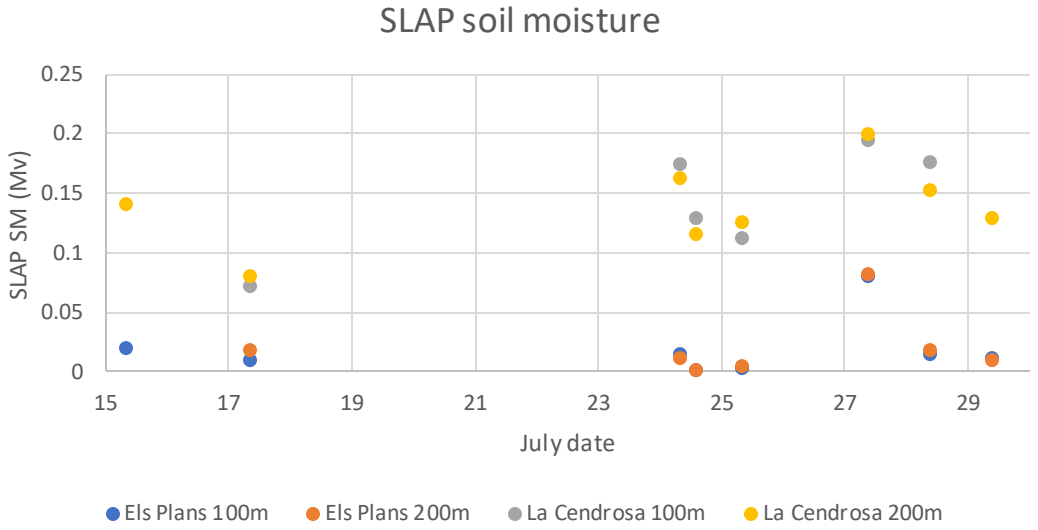
Same color scale for images from 28 July

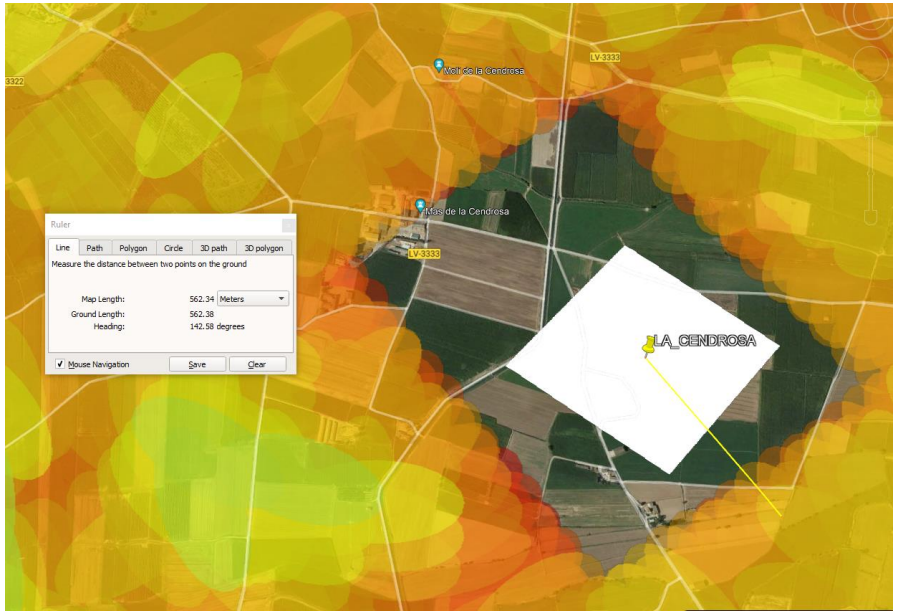
The Validation Challenge

- As the sensor footprint size decreases, more natural variability is resolved
- Spatial averaging no longer smooths the maxima and minima toward the middle → dynamic range expands
- Ground truth at points can see an even wider dynamic range vs. sensor footprints of ~100-200m size

- Ground truth obs are limited in space and/or time
- Ideally, would have many ground truth sample locations over a sensor footprint
- Difference time of day may create a diurnal offset

SLAP soil moisture at La Cendrosa, Els Plans





Flight data and time	7/15/2021 (morning)	7/16/2021 (morning)	7/17/2021 (morning)	7/24/2021 (morning)	7/24/2021 (afternoon)	7/25/2021 (morning)	7/27/2021 (morning)	7/28/2021 (morning)	7/29/2021 (morning)
100x100m box									
Els-Plans	0.0187	NaN	0.0082	0.014	0	0.0021	0.0802	0.0132	0.011
La-Censdrosa	NaN	NaN	0.0712	0.1735	0.1279	0.112	0.1934	0.175	NaN
200x200m box									
Els-Plans		NaN	0.0166	0.0105	0.00096	0.0037	0.0811	0.0181	0.0094
La-Censdrosa	0.1406	NaN	0.0802	0.1621	0.1149	0.1257	0.1989	0.151	0.129

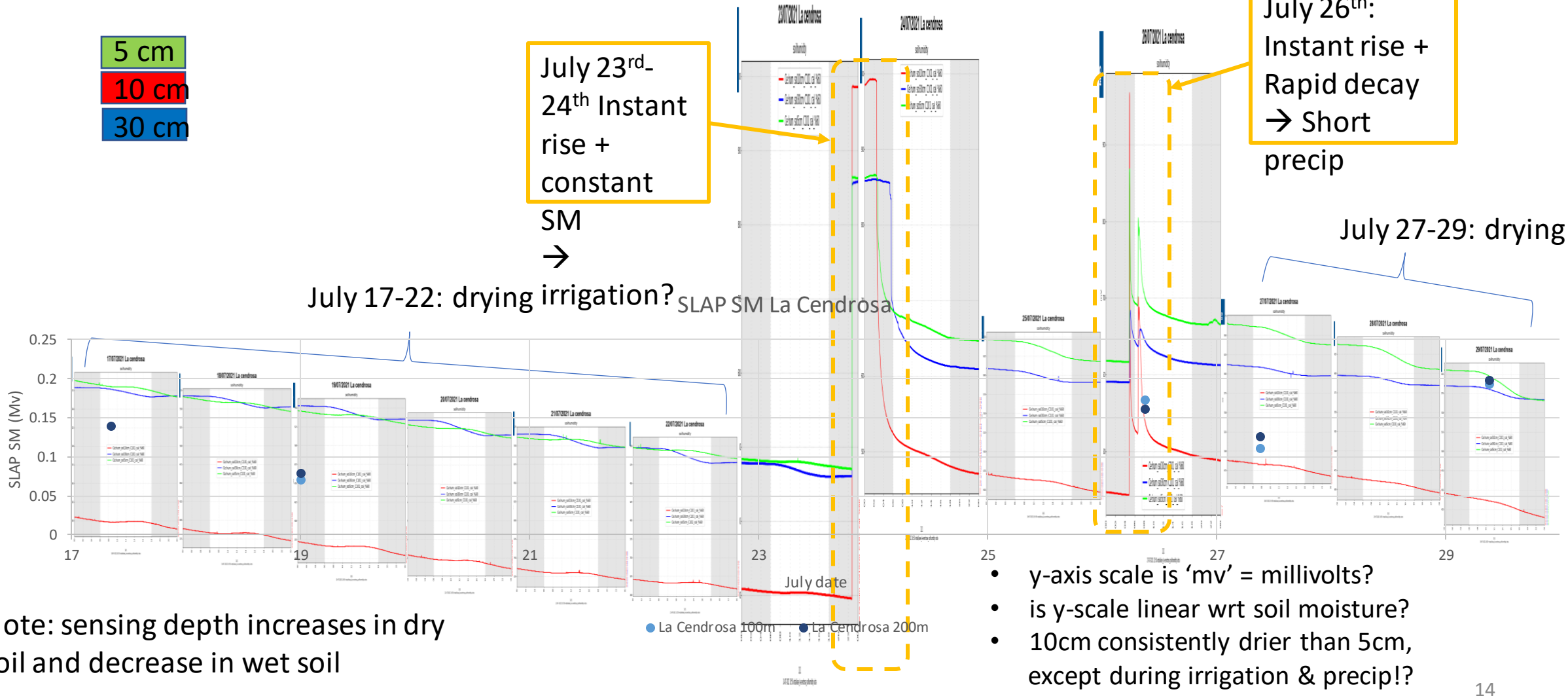
La Cendrosa samha soil moisture (ground truth)

5 cm
10 cm
30 cm

July 23rd-24th Instant rise + constant SM → July 17-22: drying irrigation?

July 26th: Instant rise + Rapid decay → Short precip

July 27-29: drying



Note: sensing depth increases in dry soil and decrease in wet soil

- y-axis scale is 'mv' = millivolts?
- is y-scale linear wrt soil moisture?
- 10cm consistently drier than 5cm, except during irrigation & precip!?

Vegetation Effects on Soil Moisture Retrieval

- SM is derived from TB
- Total TB = soil TB + veg TB
- SM = f(soil TB, veg opacity, veg temp, soil texture, etc)
- Veg TB effect on SM is nonlinear

- Using a constant veg opacity for entire region → can have strong impact on SM accuracy
- Need plot-scale veg and soil info
- Next version of SM product will incorporate veg and soil ancillary data

Soil Moisture Ground Truth Data Needs

- Looking for lat/lon of exact soil moisture samples locations, if available
- Allows better match to SLAP footprints (100x200m)
- Received ancillary data (soil type, roughness, LAI); will take time to incorporate into next version of soil moisture data set

22 test fields during GLORI measurements

Summary

- Fine-resolution (100x200m and 200x500m) microwave observations were made by SLAP during LIAISE
- SLAP L1B (passive microwave TB) data files and metadata are available at https://earth.gsfc.nasa.gov/hydro/instruments/slap/data
- L2 soil moisture data files will be added shortly
- Beware: these L2 SM data files use uniform ancillary data characteristics! Expect some strange values until we re-process with better ancillary data
- Validation against ground truth soil moisture at ~100m scale is challenging and ongoing
- Thermal IR data files will be added shortly
- Active microwave data are awaiting calibration

- Contact: ed.kim@nasa.gov