



# Airborne SLAP Measurements for Soil Moisture Estimation

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## 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

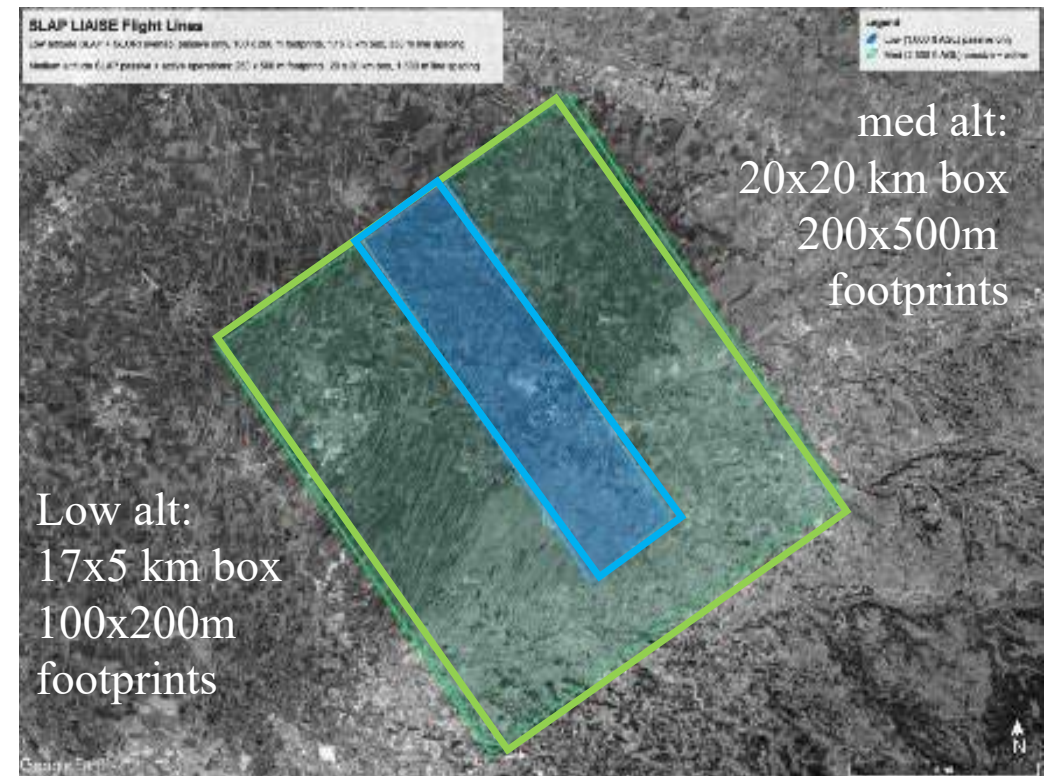


SLAP on bottom of NASA Langley King Air (UC-12) aircraft.



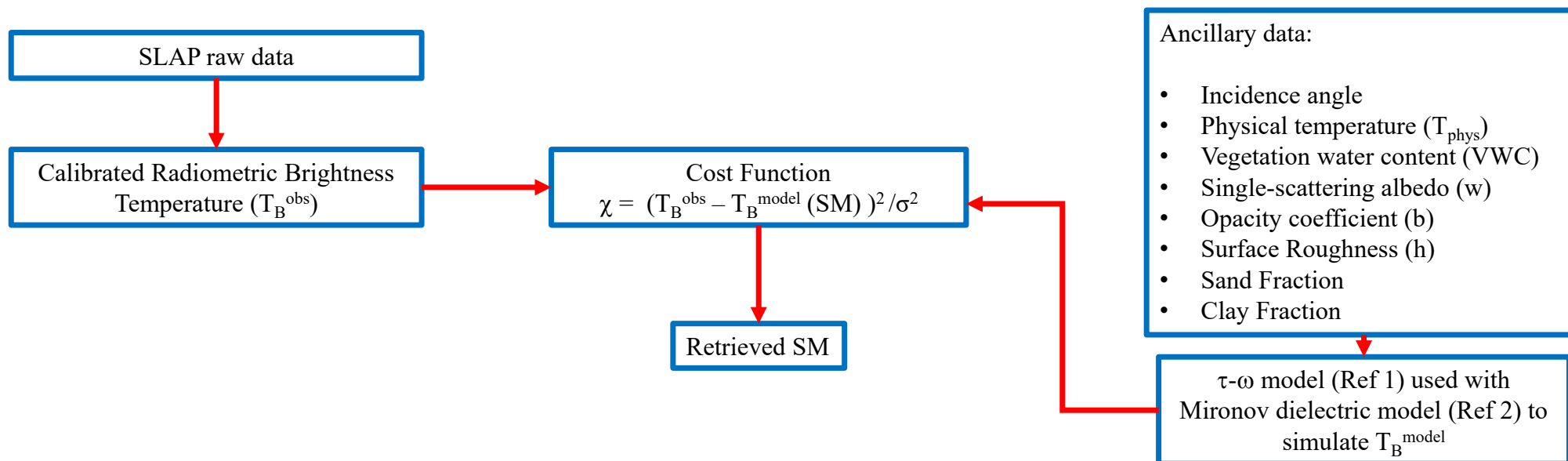
# SLAP in LIAISE 2021

- July 15—29, 2021
- 9 science flights
- Mostly passive hi-res (blue box)
- but 2 times passive + active less hi-res (green box)
- Dry downs after irrigation and precip (July 26) observed





# 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

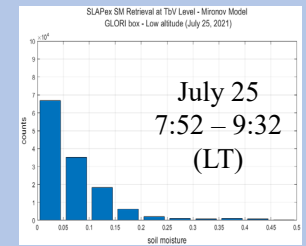
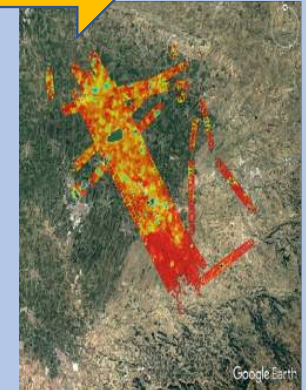
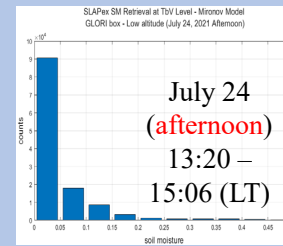
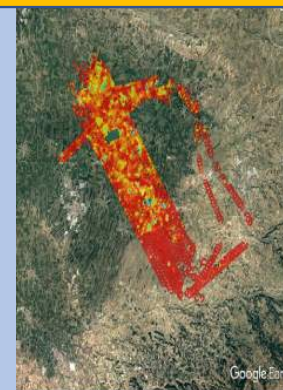
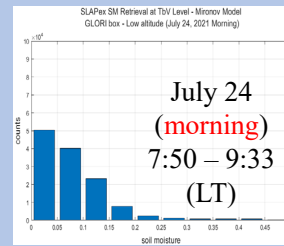
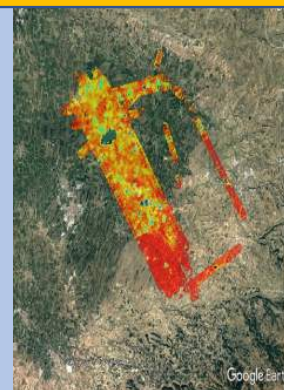
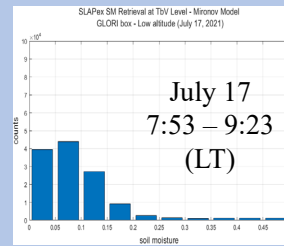
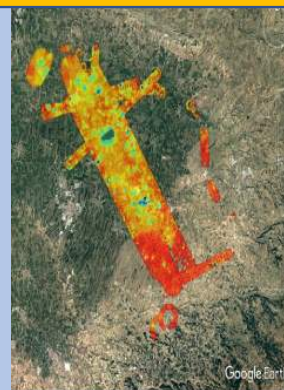
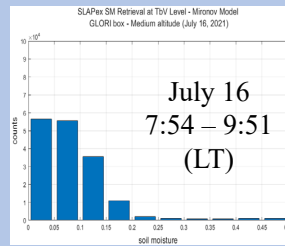
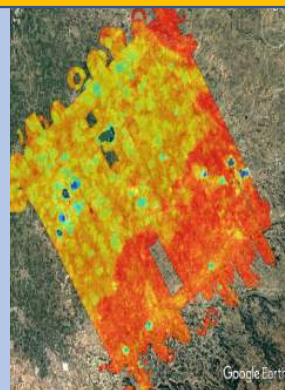
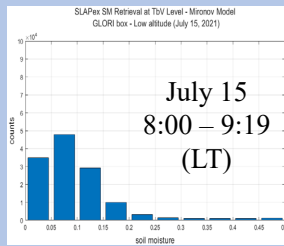


# Soil Moisture Before Precip Event

TIME SERIES

SOIL  
MOISTURE  
BEFORE  
PRECIP

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





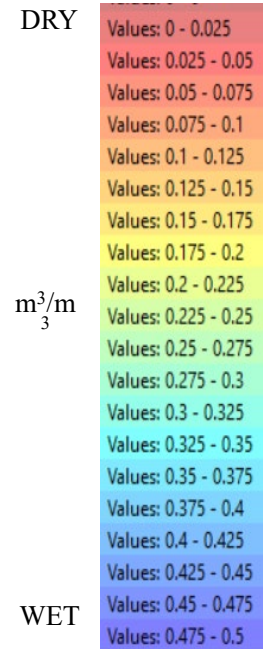
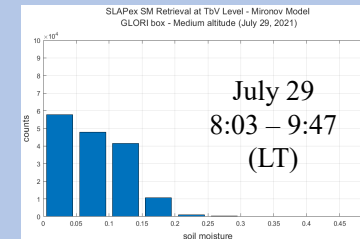
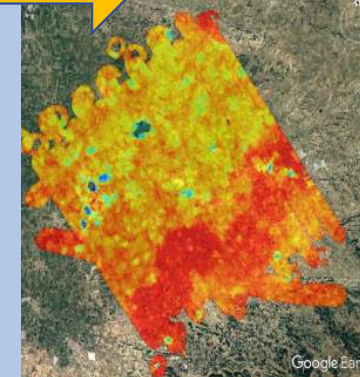
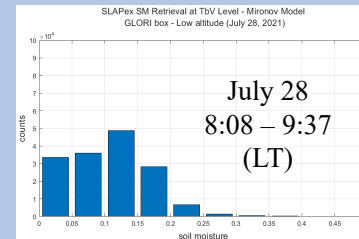
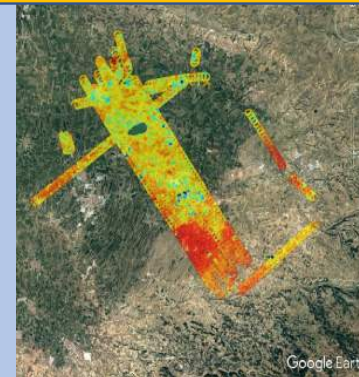
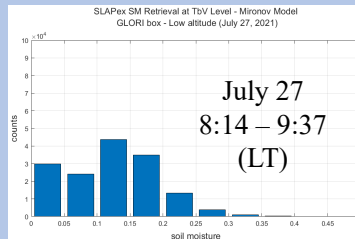
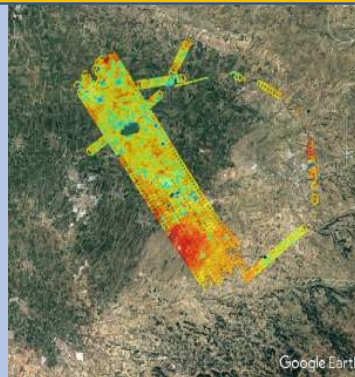


# Soil Moisture after Precip + Irrigation

TIME SERIES CONTINUED

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

SOIL  
MOISTURE  
AFTER PRECIP

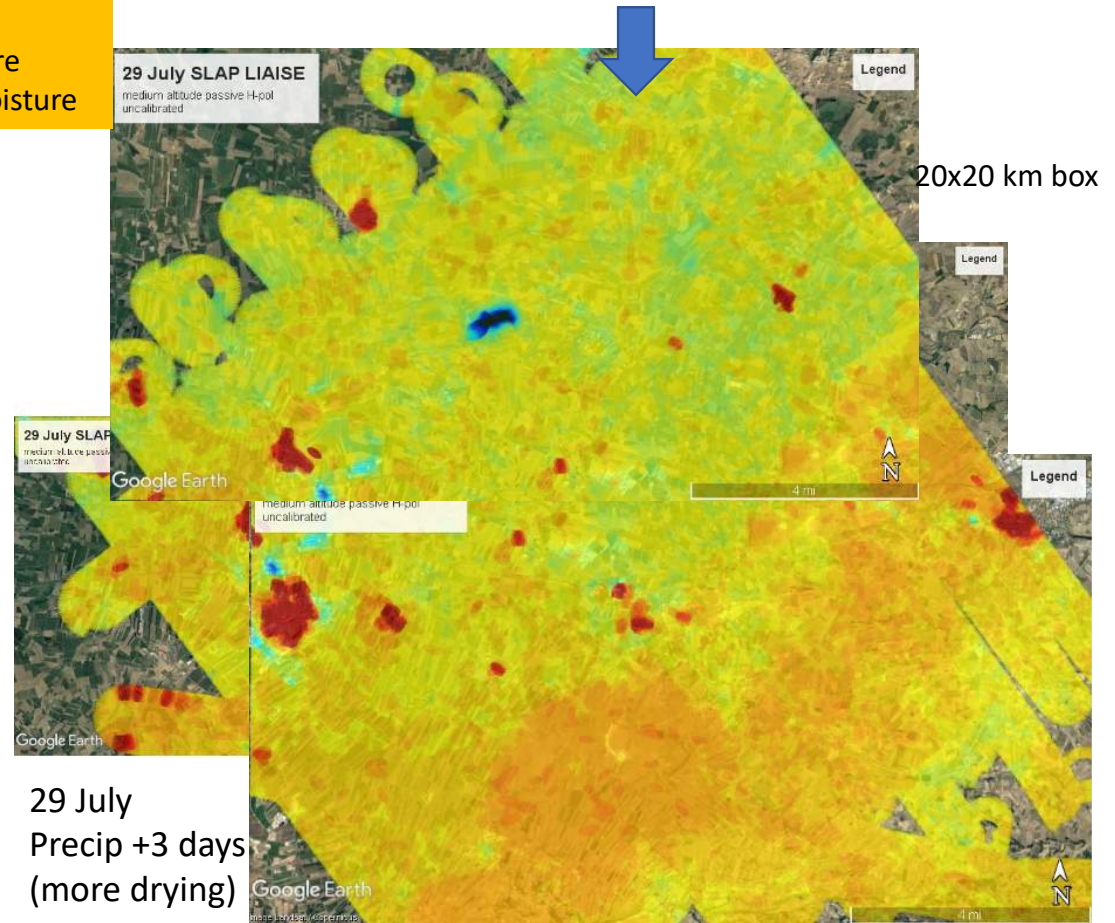
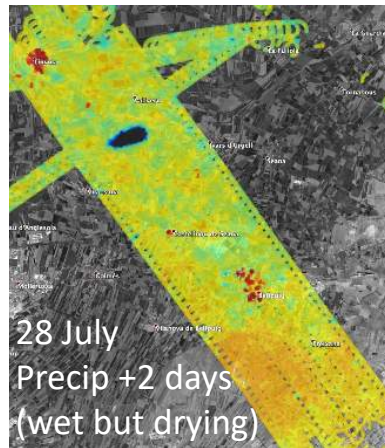
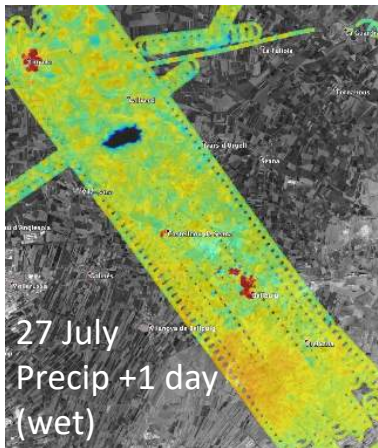
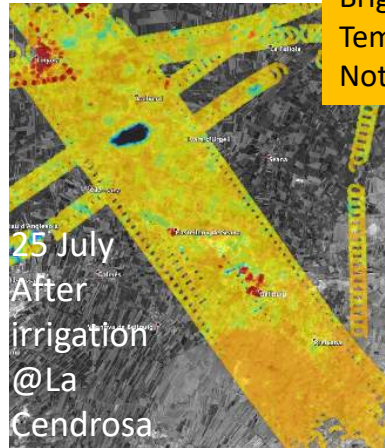
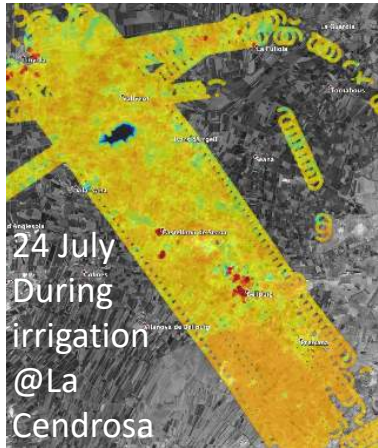




# 29 July SLAP medium-altitude Quicklook



Uncalibrated  
Brightness  
Temperature  
Not soil moisture



Same color scale for all images

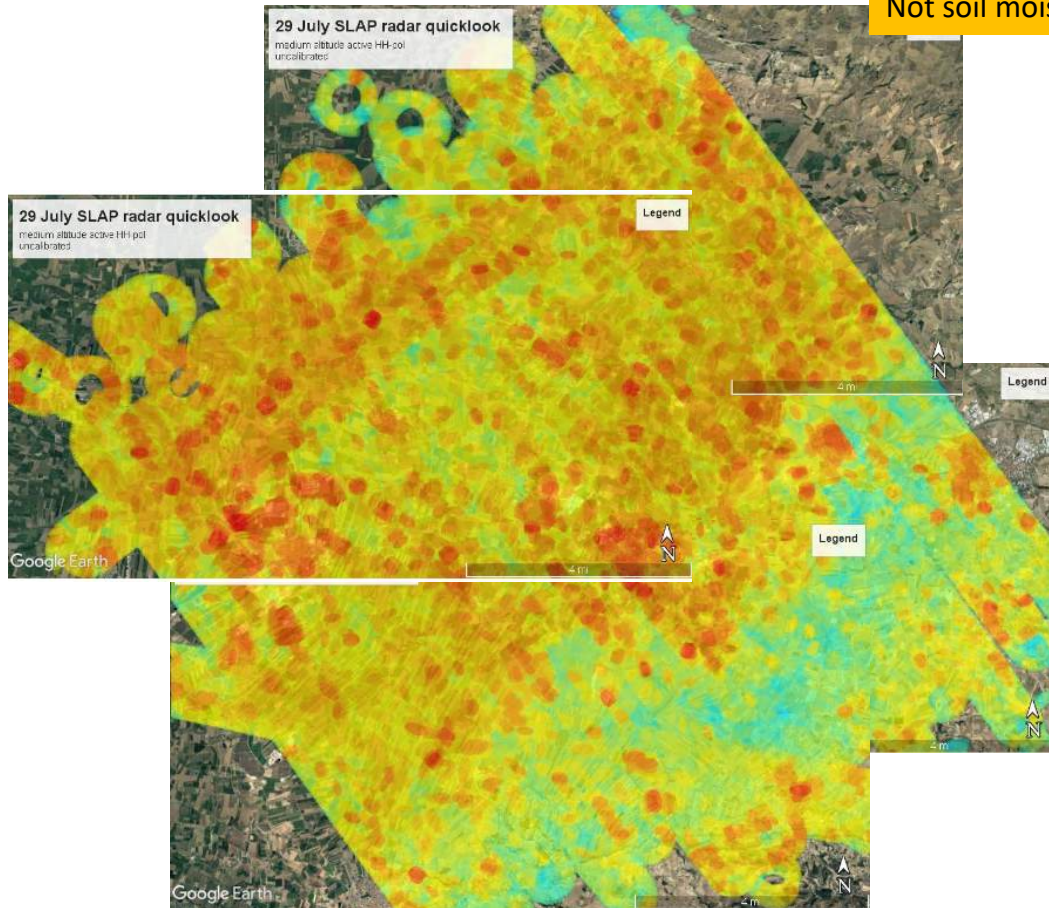




# SLAP Passive vs. Active 29 July medium altitude Quicklooks

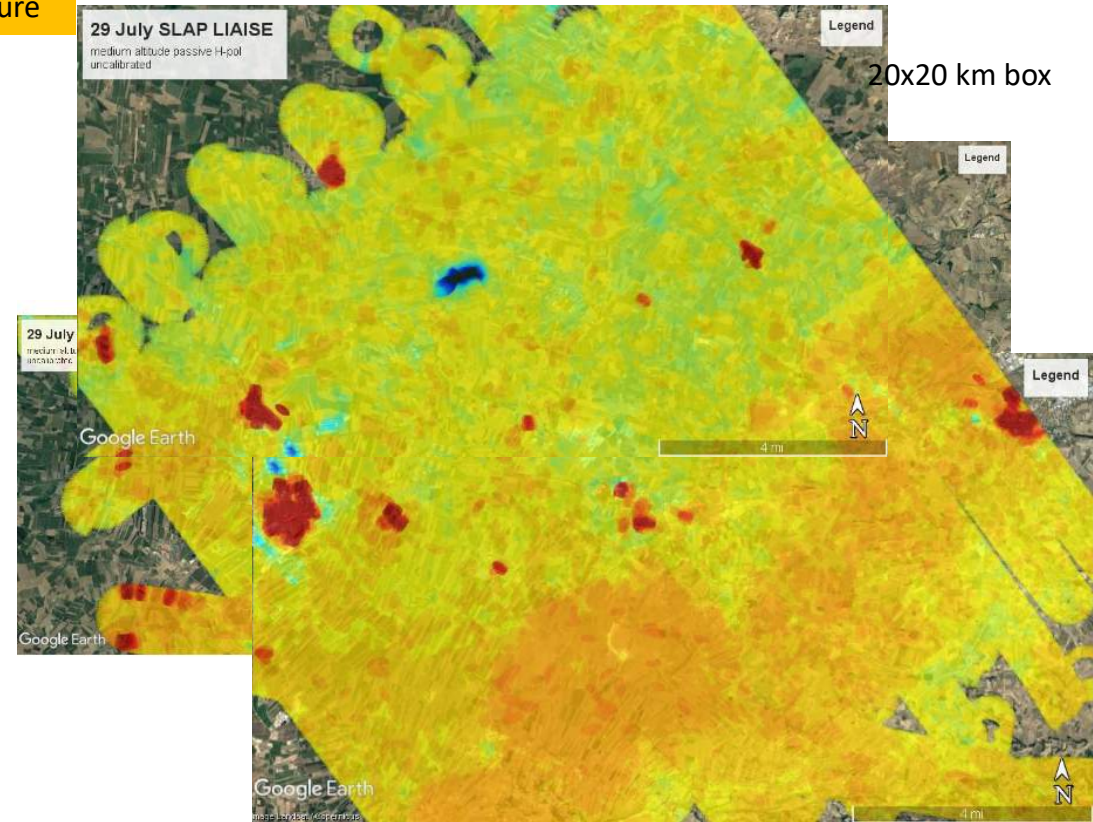


ACTIVE, HH-pol, uncalibrated



Uncalibrated  
Radiometer +  
Radar radiances  
Not soil moisture

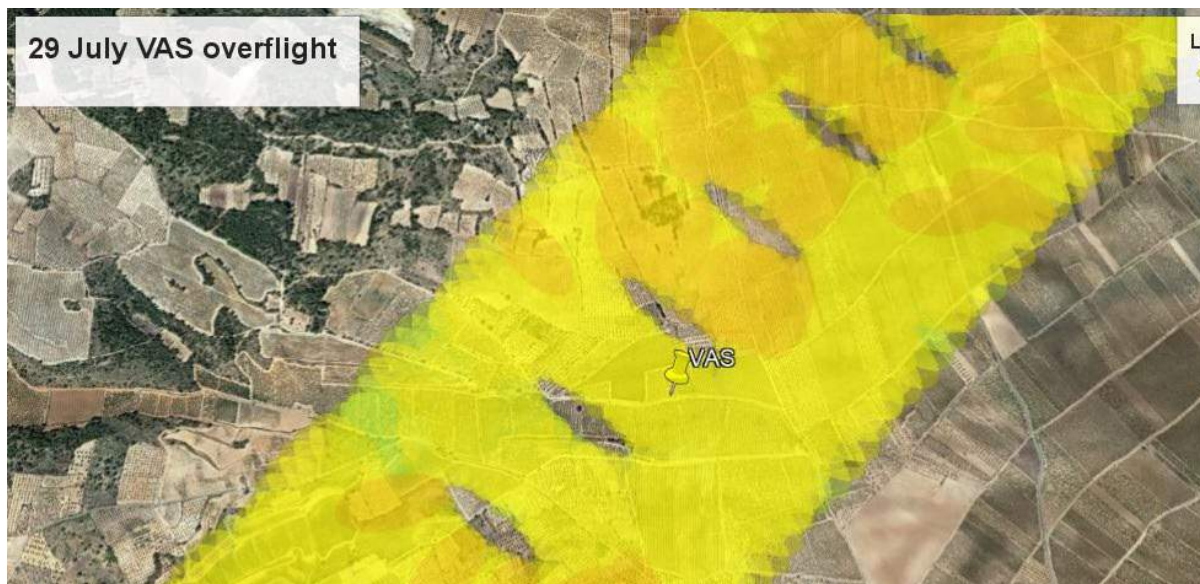
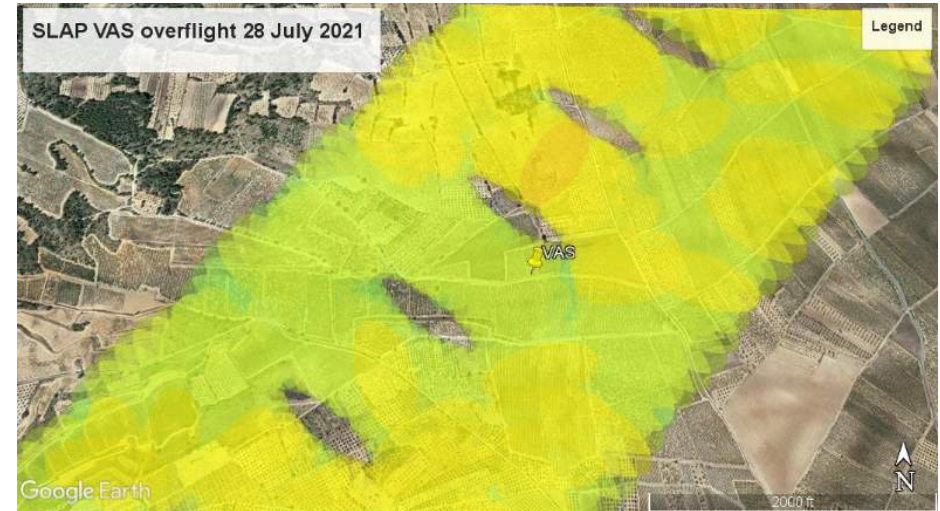
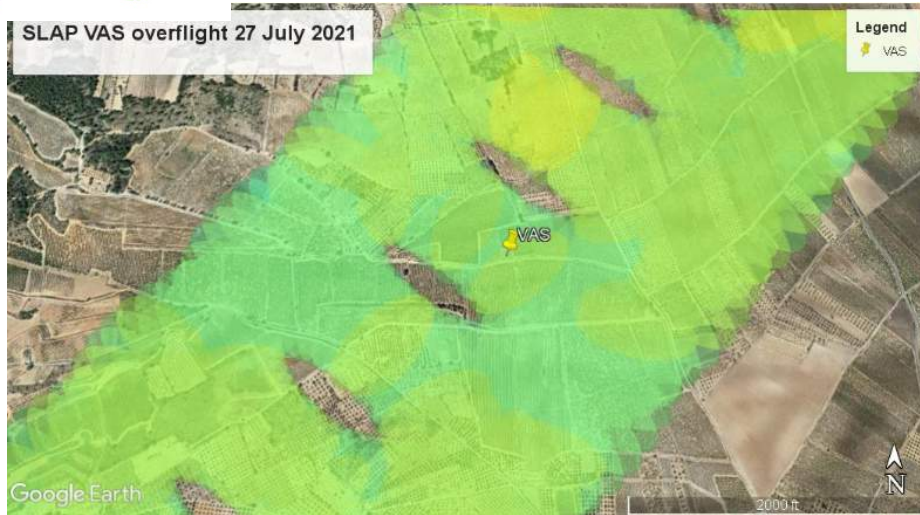
PASSIVE, H-pol, uncalibrated







# NASA SLAP quicklook H-pol uncalibrated comparison of 27 & 28 July overflight of Valencia Anchor Station (west of Valencia)



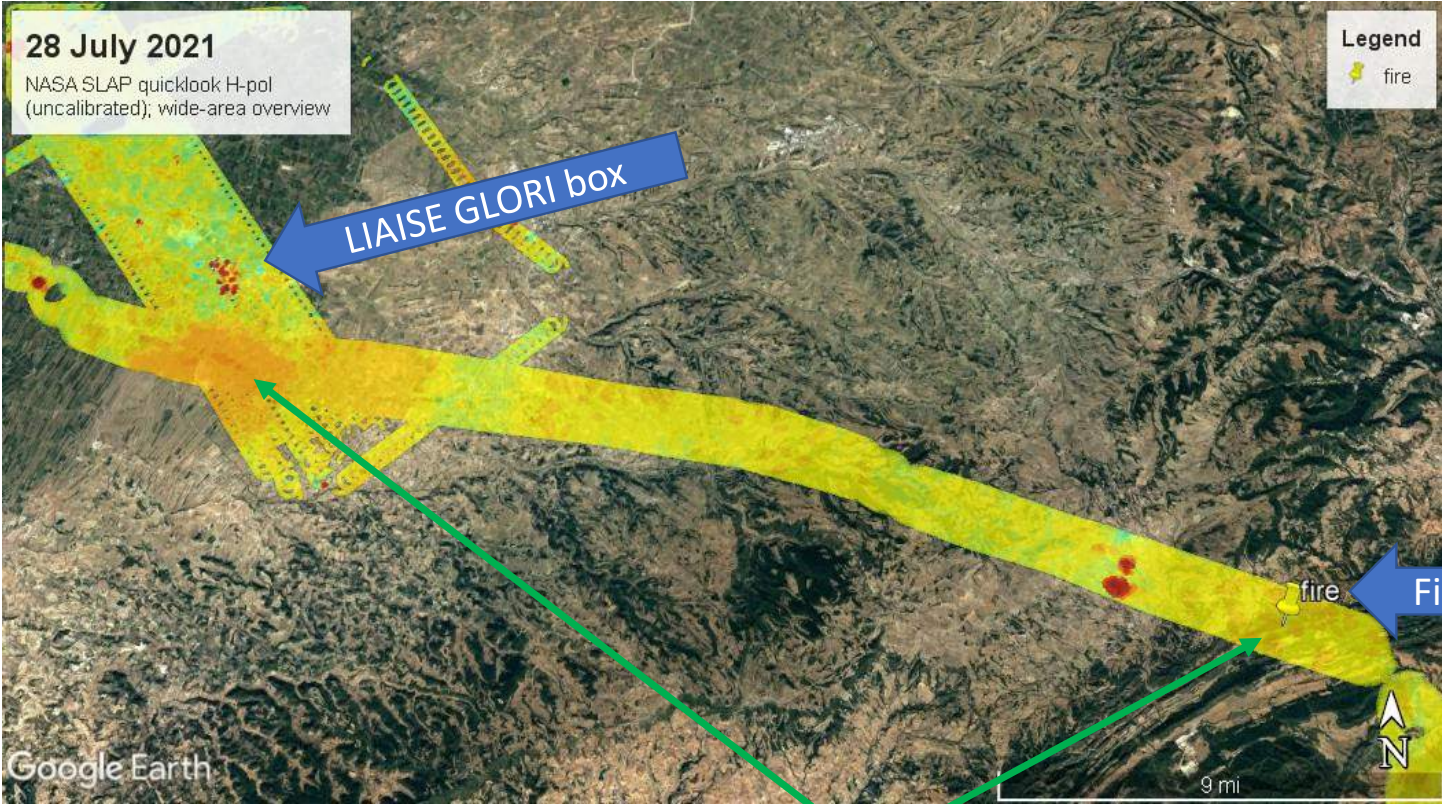
Uncalibrated  
Brightness  
Temperature  
Not soil moisture

Definite drying!





# (Natural) fire site 28 July quicklook



Uncalibrated  
Brightness  
Temperature  
Not soil moisture

Approximately similar color values,  
Implying similar temperature/dryness



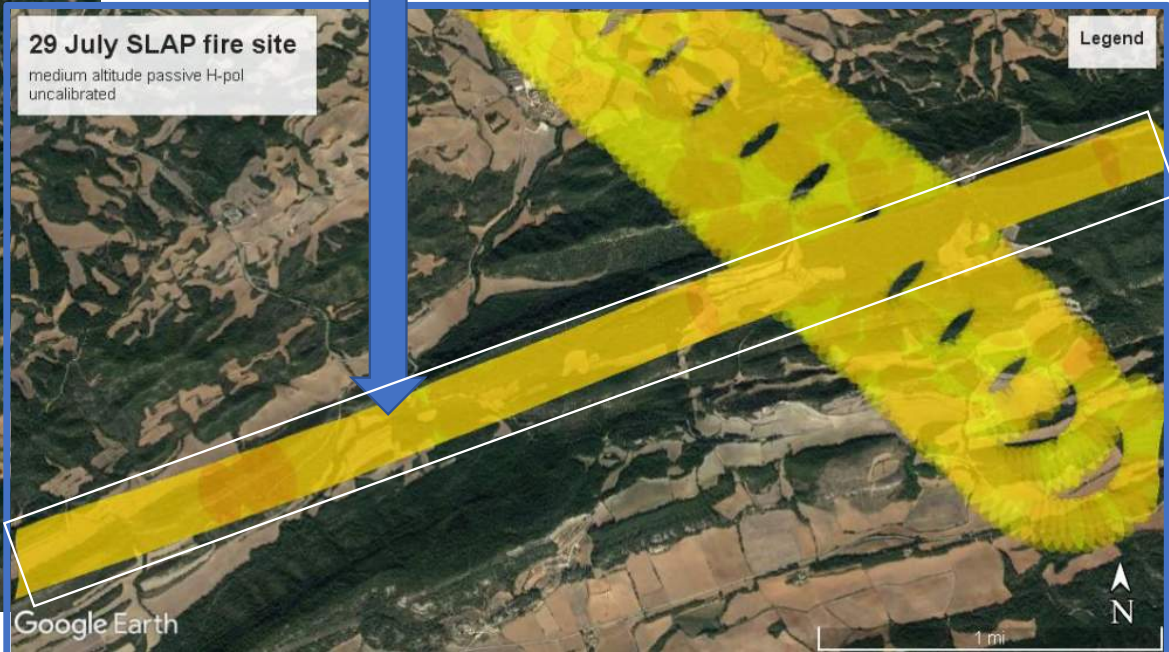


# 29 July SLAP quicklook of fire site



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 28<sup>th</sup> → smaller footprints



Same color scale for images from 28 July





# Preliminary Findings

- Boundary between irrigated and non-irrigated areas is very clear
- Boundary of areas that received precip July 26 is also very clear
- Drydown following precip event is visible
- Farm field-scale spatial variations at ~200m resolution are clearly visible across a range of wetness and vegetation conditions
- Preliminary soil moisture images shown today use generic ancillary data values over whole domain; more localized ancillary data will allow more accurate soil moisture retrievals at/near those places
- Need assistance finding such localized or hi-res ancillary data
- Scattered RFI around some towns, but not enough to impact science in other areas



# Summary

NASA's airborne SLAP sensor measured soil moisture during July 2021 as part of the European LIAISE campaign in Spain, providing a valuable opportunity to assess the advantages and limitations of potential higher-resolution observations from future satellite soil moisture missions or downscaled products over a well-understood and well-characterized environment. The preliminary soil moisture results presented here are at very high resolution (100x200 m footprints) compared with satellite soil moisture observations, and fine-scale spatial variations are clearly visible across a range of wetness and vegetation conditions.



# Acknowledgement

We wish to thank the dedication of all those at NASA HQ, Langley, and Goddard and from Europe who made this deployment possible during the global pandemic!

