CEOS WGCV Land Product Validation Plenary

Soil Moisture

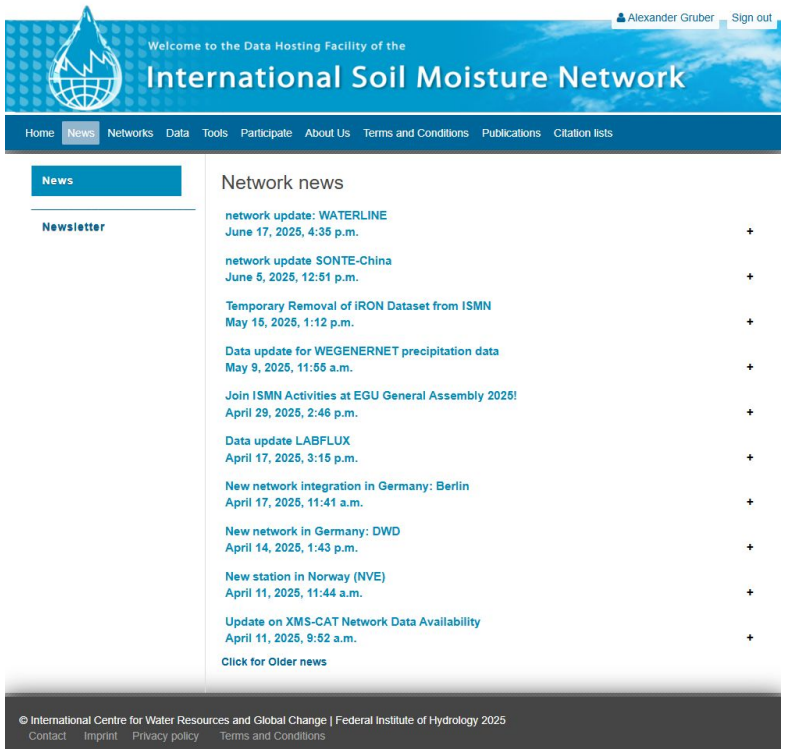
Alexander Gruber, John Bolten

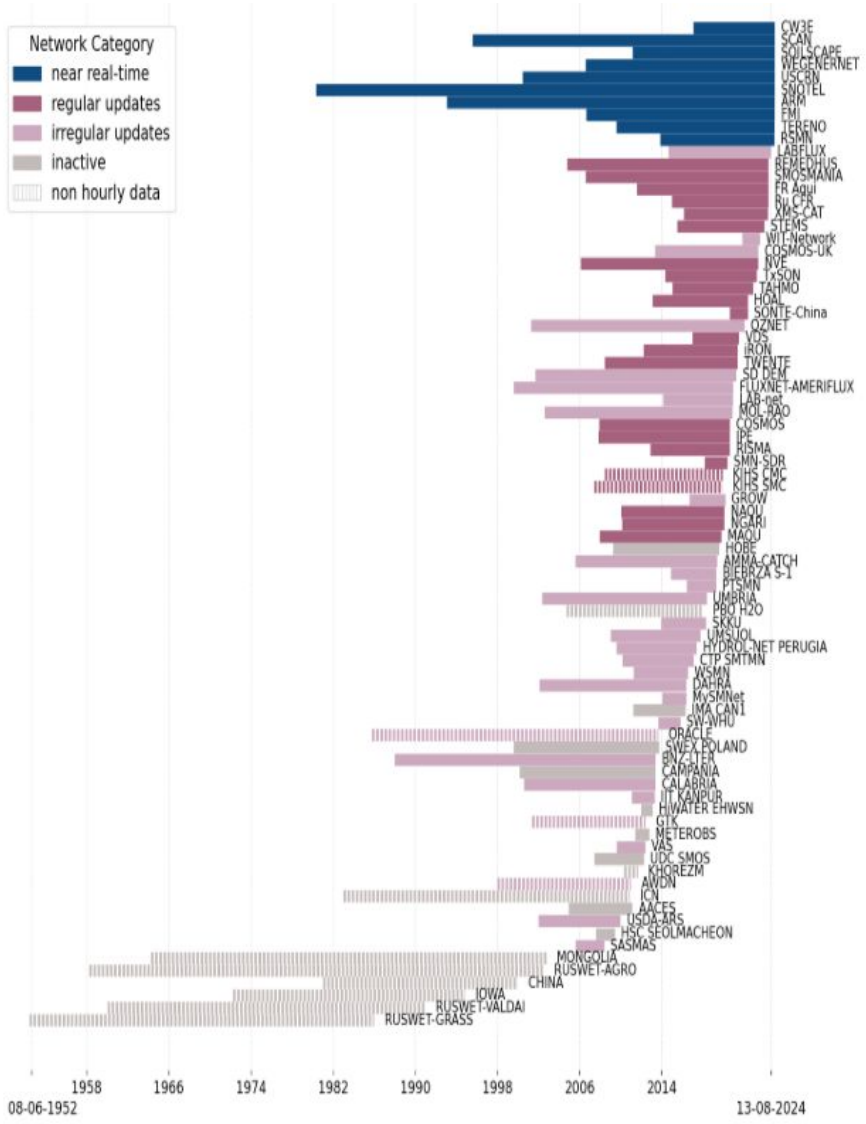
26th June 2025

Reference data updates

- ISMN: regular + NRT updates
  - Currently hosting 85 networks, 3278 stations
- QA4SM: ISMN-based FRM subset w. additional quality indicators updated ~1-2 per year

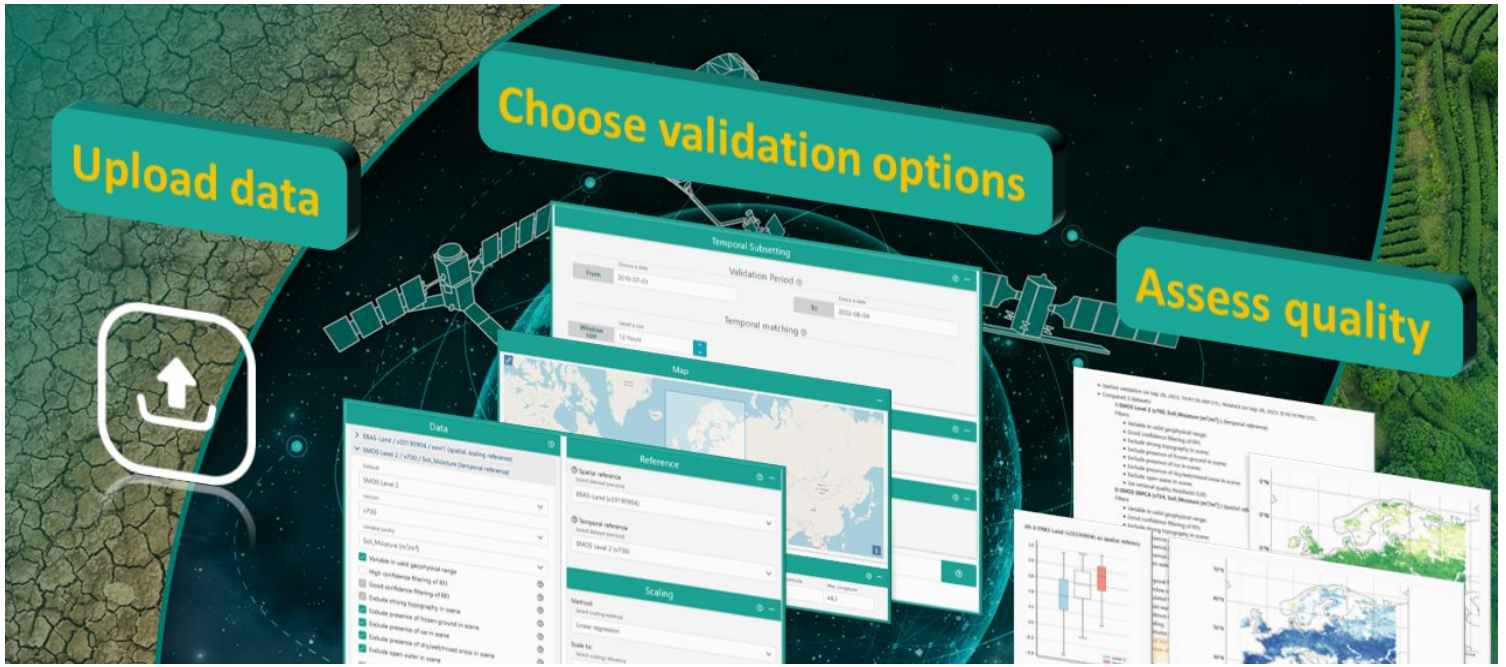
https://ismn.earth/en/news/





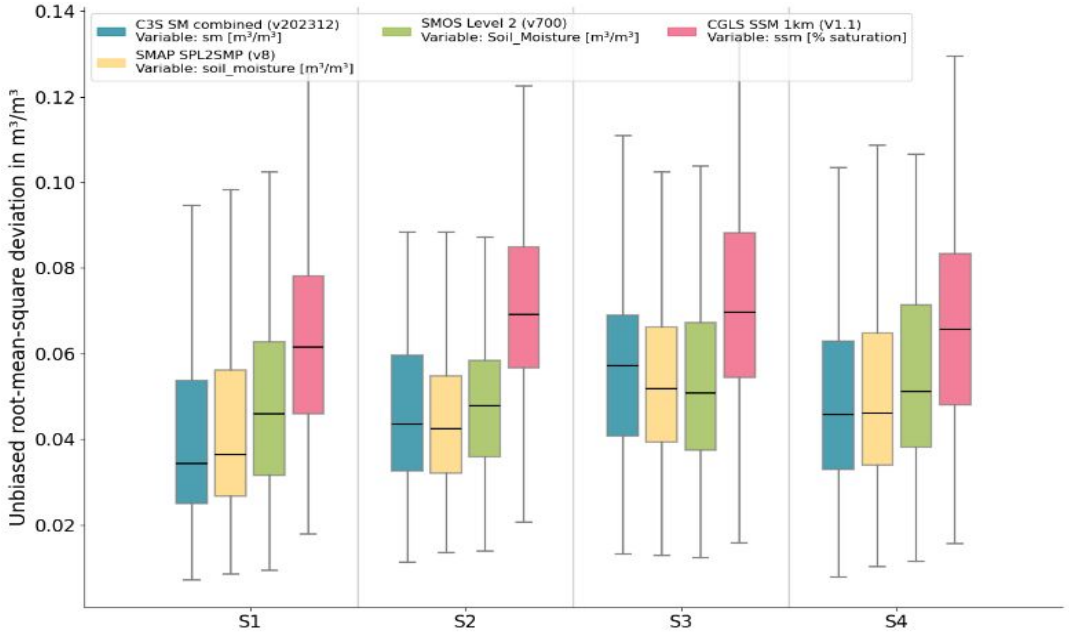
Quality Assurance for Soil Moisture

- QA4SM Version 3 released in May 2025
  - Implemented new features to calculate inter/intra-annual validation metrics
  - Enabled regular, automated extension of satellite + reference data sets
  - Released public API for greater flexibility
  - Started developent of automated validation reports

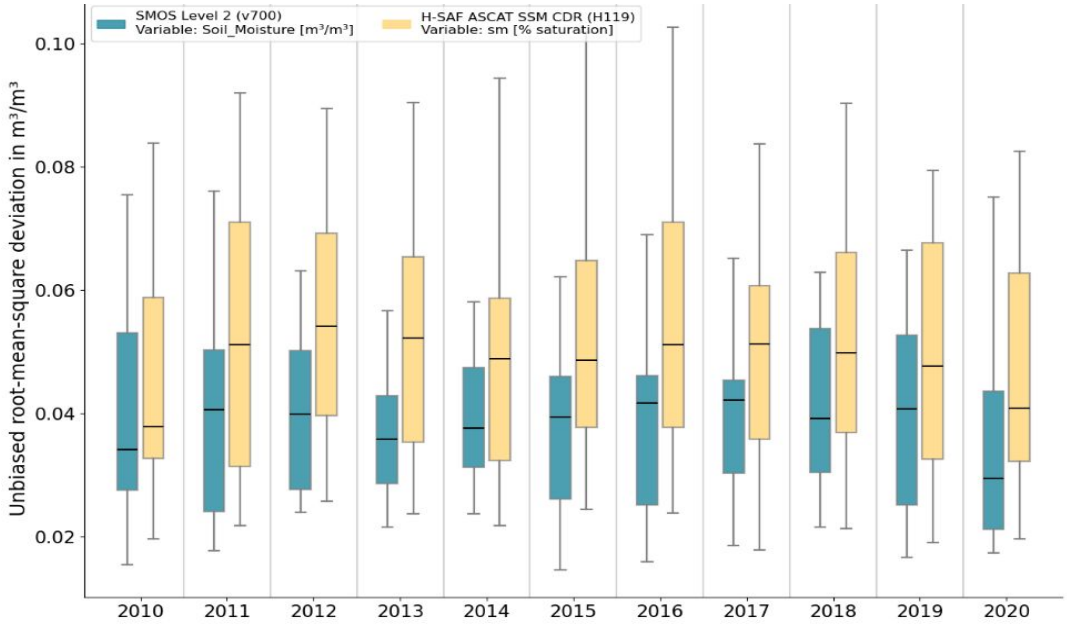


Quality Assurance for Soil Moisture

- New features: Inter/Intra-annual metrics



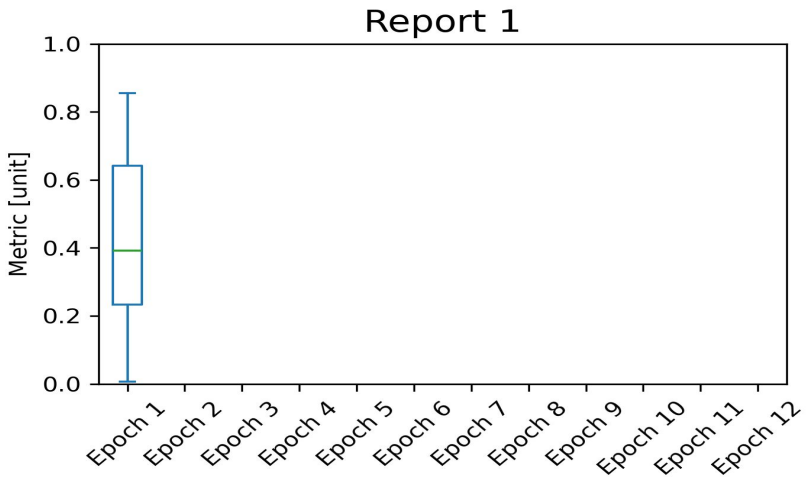
- Seasonal skill comparison



- Annual skill comparison

Quality Assurance for Soil Moisture

- Under development: Automated validation reports w. customizable information



SMOS_L2_v700_202301_epoch1_report.pdf
SMOS_L2_v700_202302_epoch2_report.pdf
SMOS_L2_v700_202303_epoch3_report.pdf

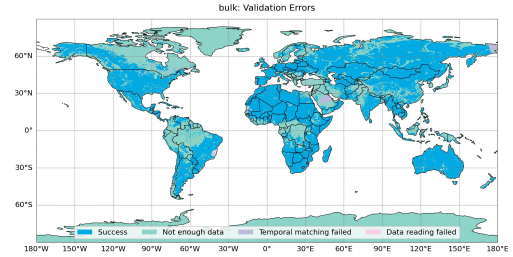
Validation Results (last Epoch): 2025-03-01 to 2025-05-31

Processing statistics

- Processing took 20 minutes wall time (-10% to previous epoch)

Error rate was 20%

(+3% compared to previous epoch)

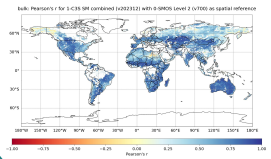


Selection of Summary Statistics

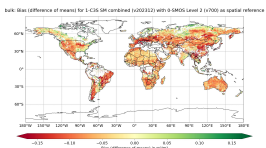
Metric	N.Obs	Pearson R	Bias	ubRMSD	Etc...
Mean	1360	0.68	0.25	0.03	Metrics are taken from the summary statistics table
Median	1350	0.74	0.22	0.03	
IQ Range	623.75	9.39e-02	0.02	0.012	

Selection of Plots

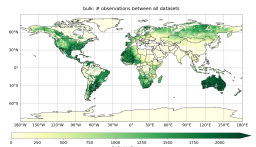
Pearson's R



Bias



#obs

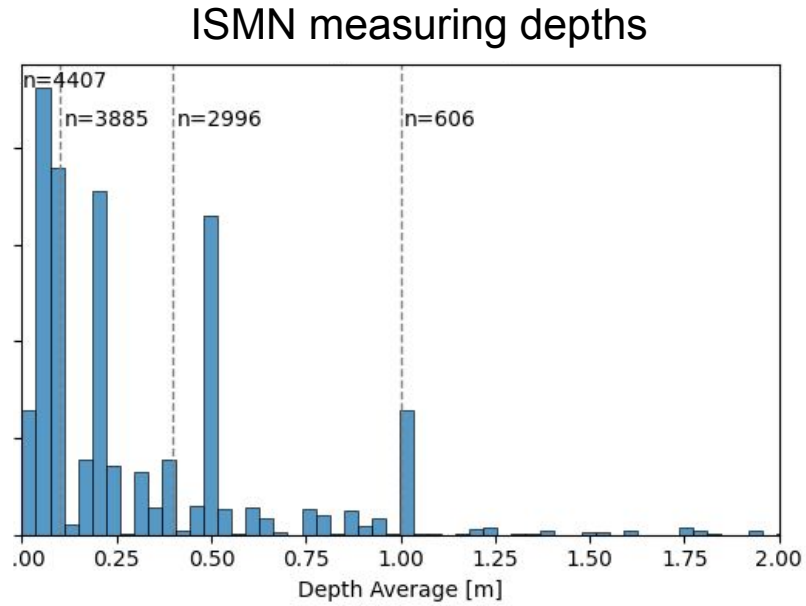


Trends in the community

- Trend toward higher spatial resolution
  - Technology driven (SAR/GNSS-R)
  - Downscaling
  - Machine learning approaches
  - Current validation methods inapt to assess *spatial* skill

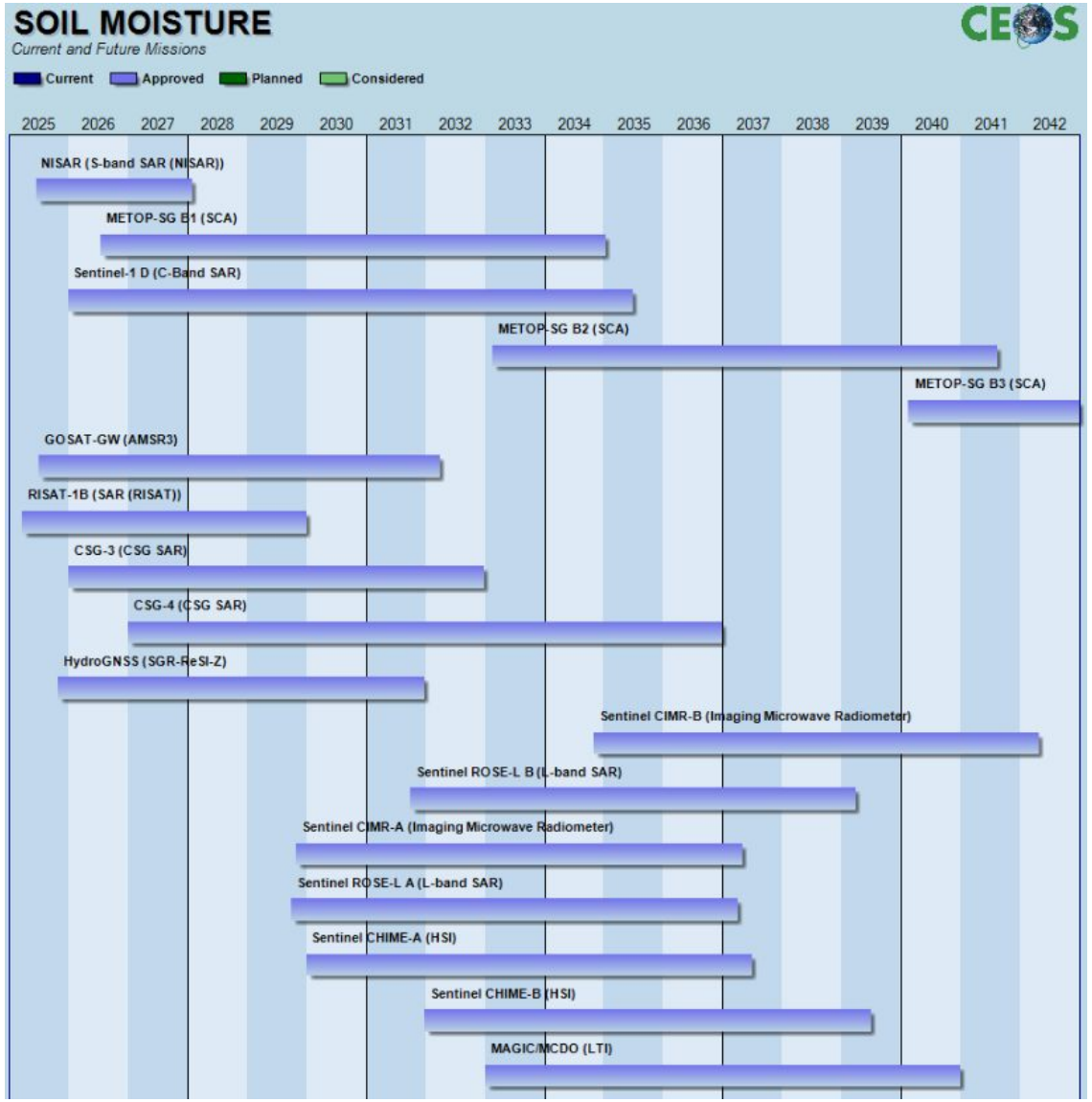
- Increasing interest in root zone soil moisture
  - Data assimilation (e.g., SMAP L4)
  - Exponential filtering (e.g., ESA CCI root-zone soil moisture)
  - Vertical resolution ill-defined, issues w. reference data distribution

- Validation good practice protocol update planned end 2025 (draft) – end 2026 (final)
  - Incl. implementation of relevant features / data sets in QA4SM



New missions

Approved missions (CEOS/ESA, https://database.eohandbook.com/)



New missions

NISAR

- NASA – ISRO Synthetic Aperture Radar Mission
- Integration and Testing is completed.

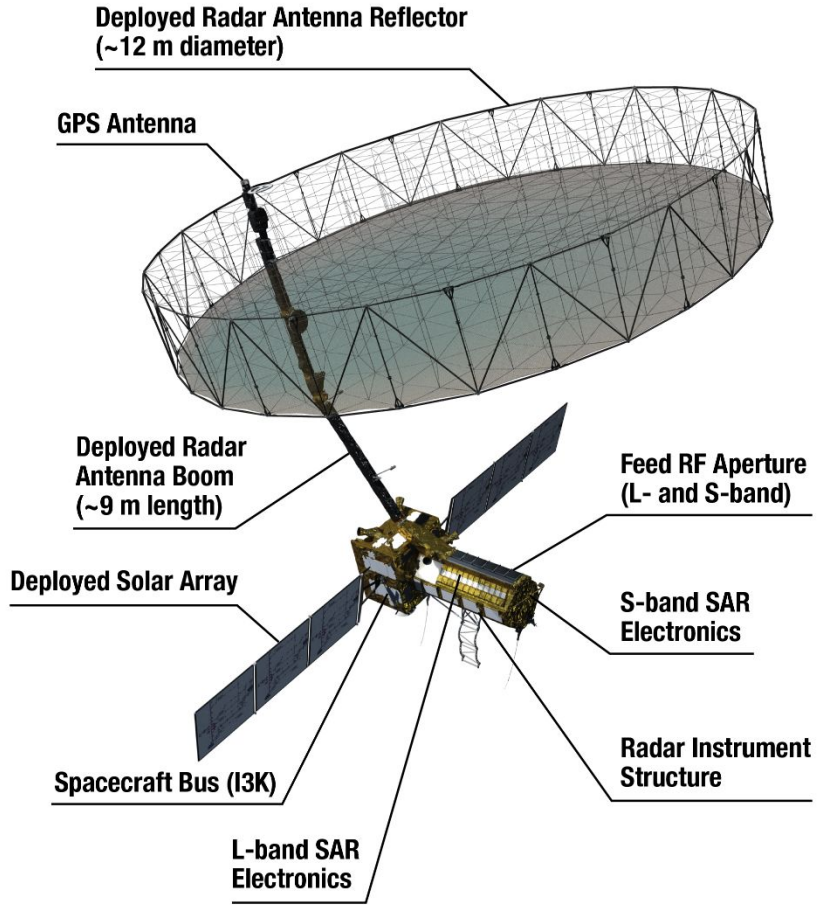
•Projected launch planned in June, 2025

•Commissioning for three months

•First data available after commissioning

•Soil moisture product will have 200 m resolution

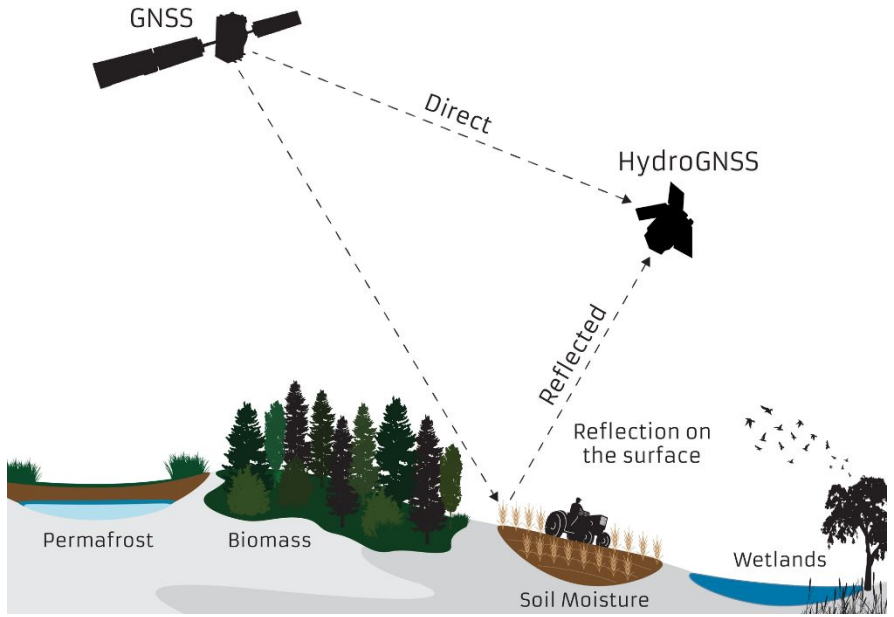
•Global 6 day repeat (asc/desc)



New missions

HydroGNSS

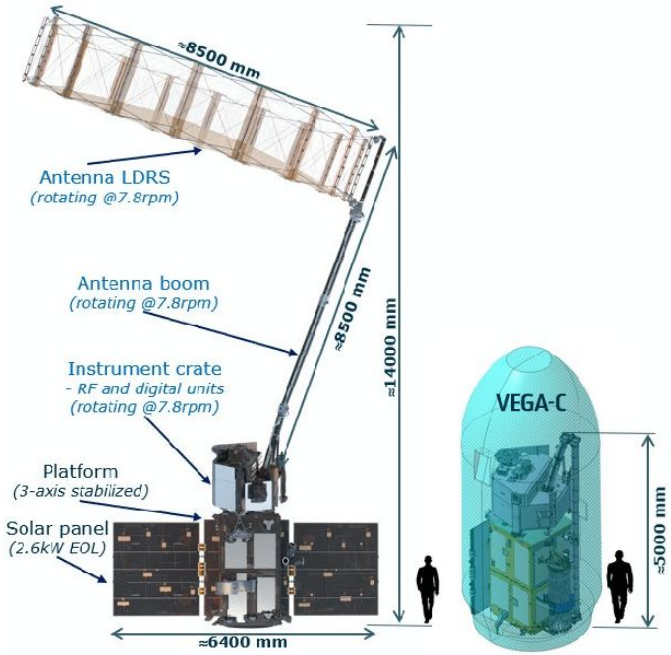
- ESA Scout framework / FutureEO programme
- Two-satellite constellation
- GNSS reflectometry (L-band) to measure climate variables related to the water cycle
- Provide continuity for SMOS, complement Biomass mission
- Soil moisture at 25 km, 1 day repeat cycle
- Launch planned 2025
- Relation with CYGNSS, SPIRE, etc. unclear!



New missions

CIMR

- Copernicus Imaging Microwave Radiometer
- Two-satellite mission (Planned 2029/2035)
- Multi-frequency instrument (1.5, 6.9, 10.65, 18.7, 36.5 GHz)
- Spatial resolution: 5 – 15 km; potentially sub-daily sampling
- Focus on Arctic / sea and ice;
- Soil moisture as secondary product
- Planned SM + L-VOD @ 9 and 36 km (SMAP-like)



New missions

ROSE-L

- Copernicus Radar Observing System for Europe L-band SAR
- Two-satellite mission (Planned 2028/2030)
- L-band multi-purpose SAR instrument
- 5-10 m spatial resolution, 3-6 days revisit
- Feasible soil moisture product resultion unclear yet

Beyond soil moisture

ISSI community workshop on ECV uncertainties

- Springer Surveys in Geophysics Special Issue in preparation:
  "Remote Sensing In Climatology – ECVs and their Uncertainties"

– Observations fit for climate science: accounting for uncertainty and handling covariance; Mittaz et al. (submitted)
– Building uncertainty trees and informing uncertainty across multiple data levels; Mittaz et al. (in prep)
– Assessment of estimating trends from (selected) remotely-sensed Essential Climate Variables time series data; Hohensinn et al., (submitted)
– Confidently uncertain: Validating satellite ECV measurement uncertainty estimates; Verhoest et al. (submitted)
– Making sense of uncertainty – Ask the right question; Gruber et al. (in press)
– A practical introduction to utilising uncertainty information in the analysis of Essential Climate Variables; Povey et al. (submitted)
– The importance of scale in the definition of uncertainties: how do we best communicate this to data users?; Bulgin et al. (submitted)
– Stability in climate data records of ECVs; Merchant et al. (in prep)
– The challenges and limitations of evaluating satellite-derived datasets using independent measurements: lessons learned from Essential Climate Variables; Langsdale et al. (submitted)
– What is the uncertainty of the uncertainty and (why) does it matter? Improving the uncertainty estimates of merged multi-satellite soil moisture data sets; Formanek et al. (submitted)
– Lost in translation: The need for common vocabularies and an interoperable thesaurus in Earth sciences; Strobl et al. (submitted)