



EUMETSAT H SAF PRODUCTS APPLICATION IN AGROMETEOROLOGY

H SAF Team

Presenter: Simone Gabellani

16th EUMETSAT User Forum in Africa, Cotonou, September 20th, 2024



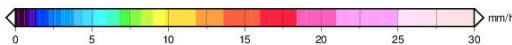
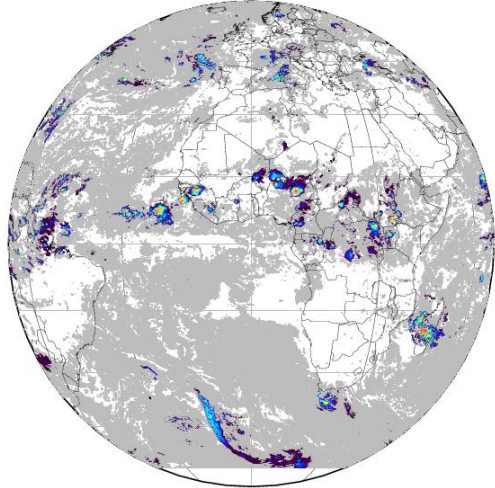
H SAF

Satellite Application Facilities in Support to Operational Hydrology and Water Management

PRECIPITATION rate
and accumulated

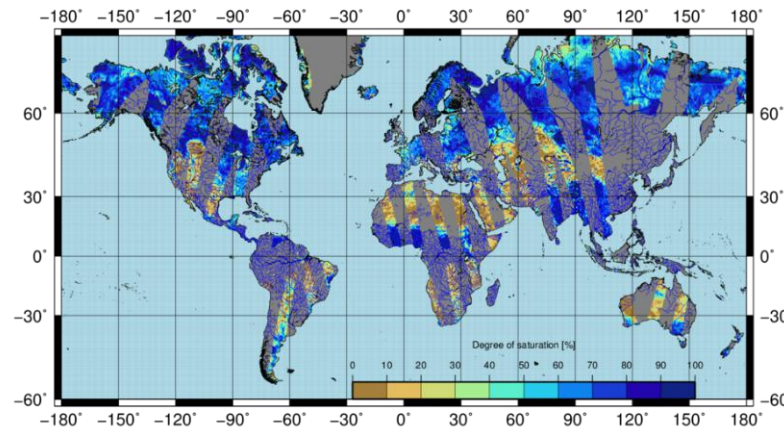
EUMETSAT H-SAF P-IN-SEVIRI

Instantaneous Rain Rate retrieved from IR-MW blending data
 Blending of: SEVIRI IR + SSM/I-SSMIS MW + AMSU MW: 20190622 0000



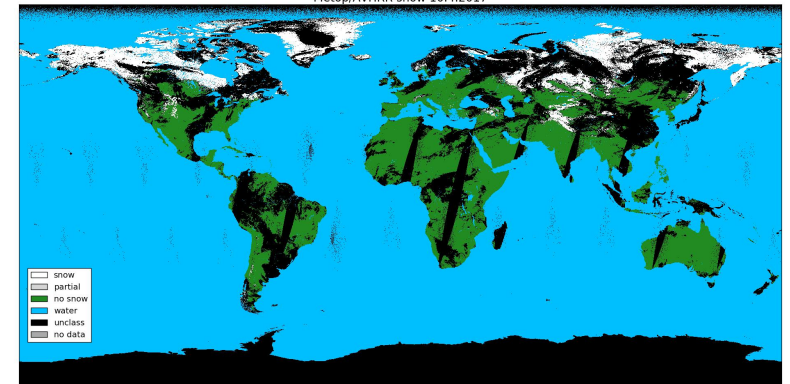
SOIL MOISTURE
Surface and root zone

ASCAT soil moisture 20230818_0210, Metop-B, 125



SNOW
cover, melting condition,
water equivalent

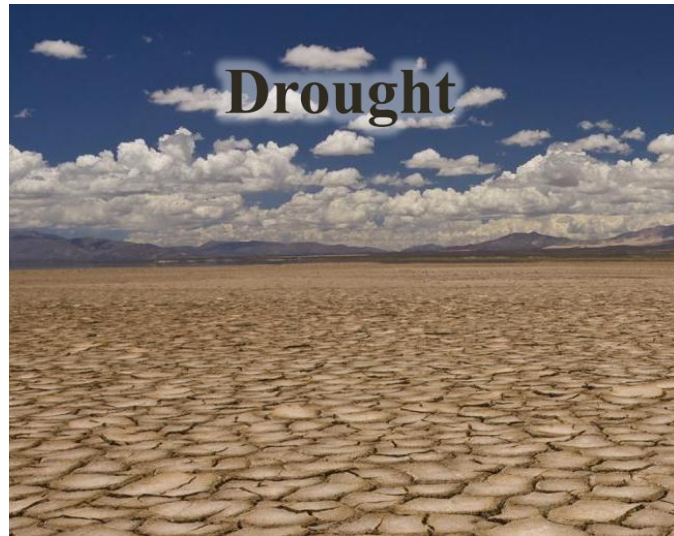
Metop/AVHRR snow 10.4.2017



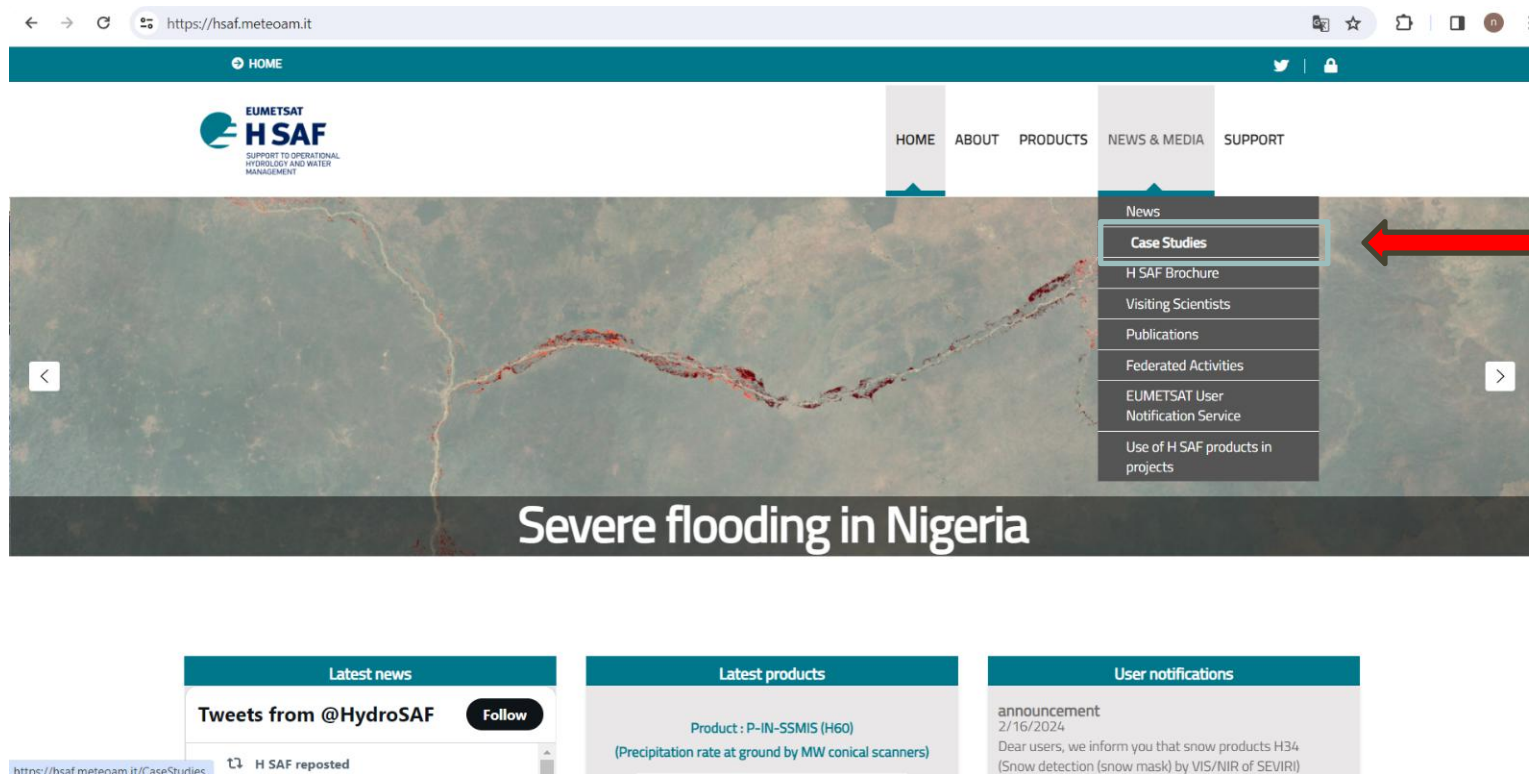
NRT products (EUMETCAST and H SAF ftp)

Data record for soil moisture are available from 1997

EXTREME EVENTS



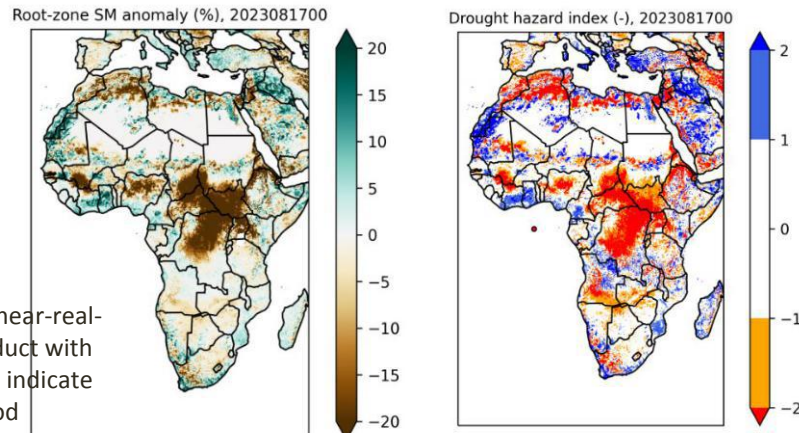
Case Studies



<https://h-saf.eumetsat.int>

Case Studies

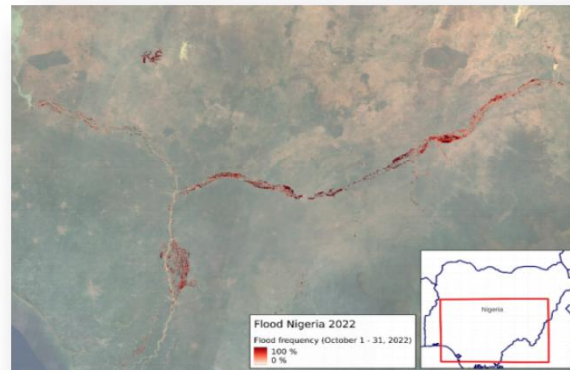
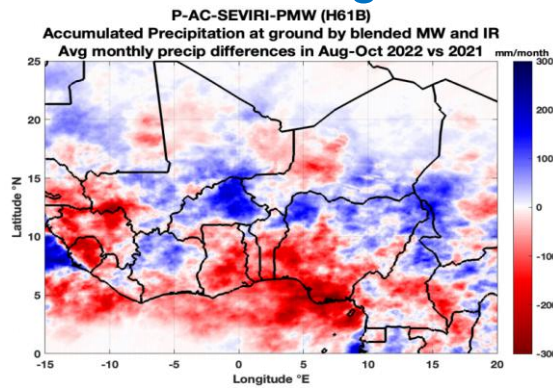
African drought condition 2023



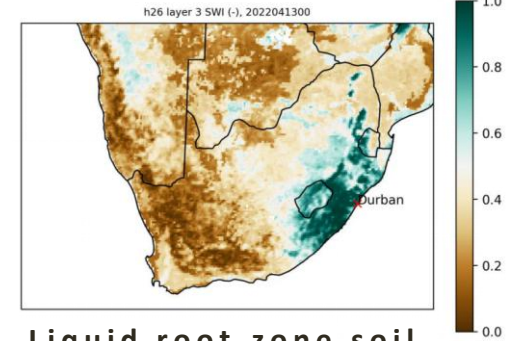
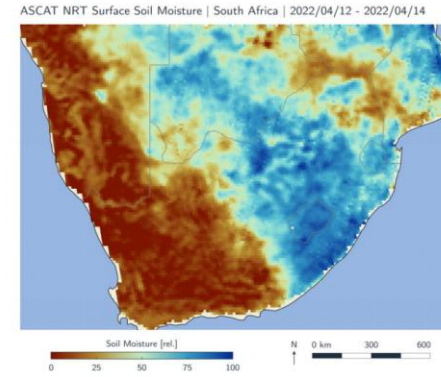
Comparison of near-real-time (NRT) product with data record can indicate droughts or flood

Severe drought present over parts of central and eastern Africa

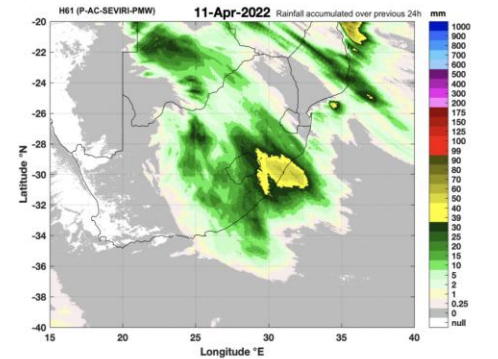
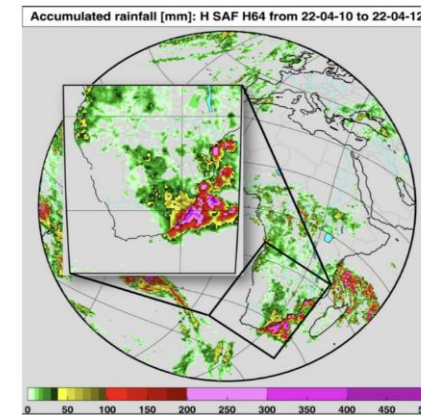
Nigeria –October 2022



South Africa (11-13 April 2022)



Liquid root-zone soil wetness index. Saturated soil moisture conditions are present around Durban during the flooding events.

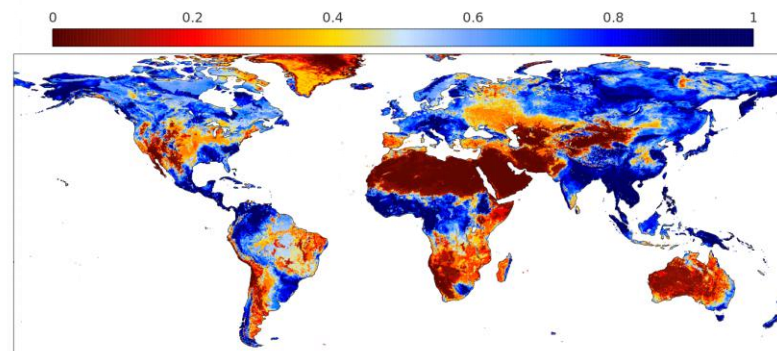


RZSM-ASCAT-NRT-10 (H26)

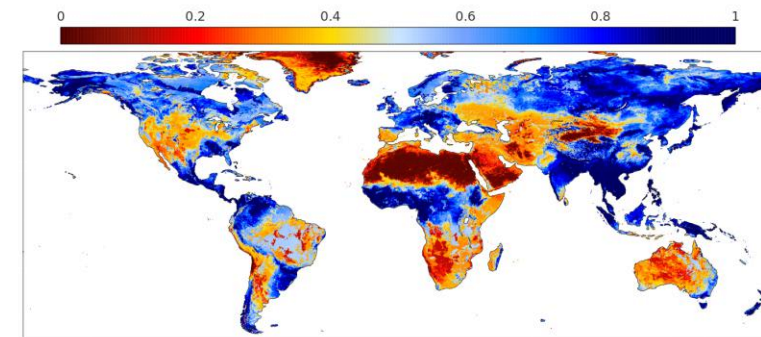
Metop ASCAT NRT Root Zone Soil Moisture Profile Index 10 km resolution

Analysed liquid soil moisture profile index at 10 km spatial sampling for four different soil layers (covering the root zone from the surface to ~ 3 metres) generated at ECMWF by the dedicated H SAF soil moisture assimilation system at 24 hour time steps.

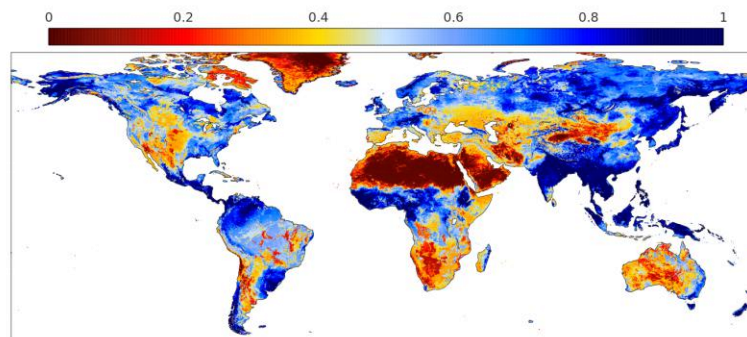
RZSM-ASCAT-NRT-10km Layer 1 (0-7 cm) - Copyright © Eumetsat 20240918



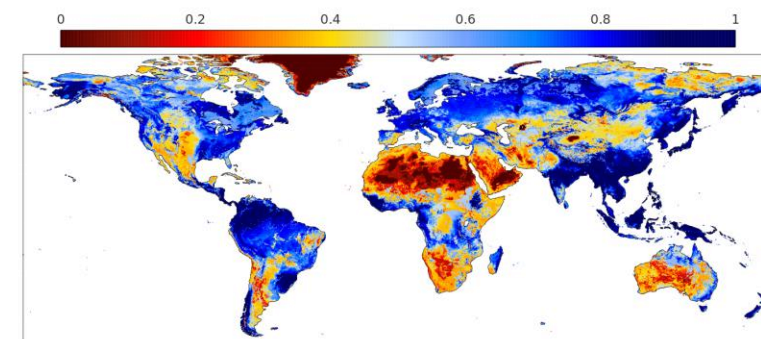
RZSM-ASCAT-NRT-10km Layer 2 (7-28 cm) - Copyright © Eumetsat 20240918



RZSM-ASCAT-NRT-10km Layer 3 (28-100 cm) - Copyright © Eumetsat 20240918



RZSM-ASCAT-NRT-10km Layer 4 (100-289 cm) - Copyright © Eumetsat 20240918



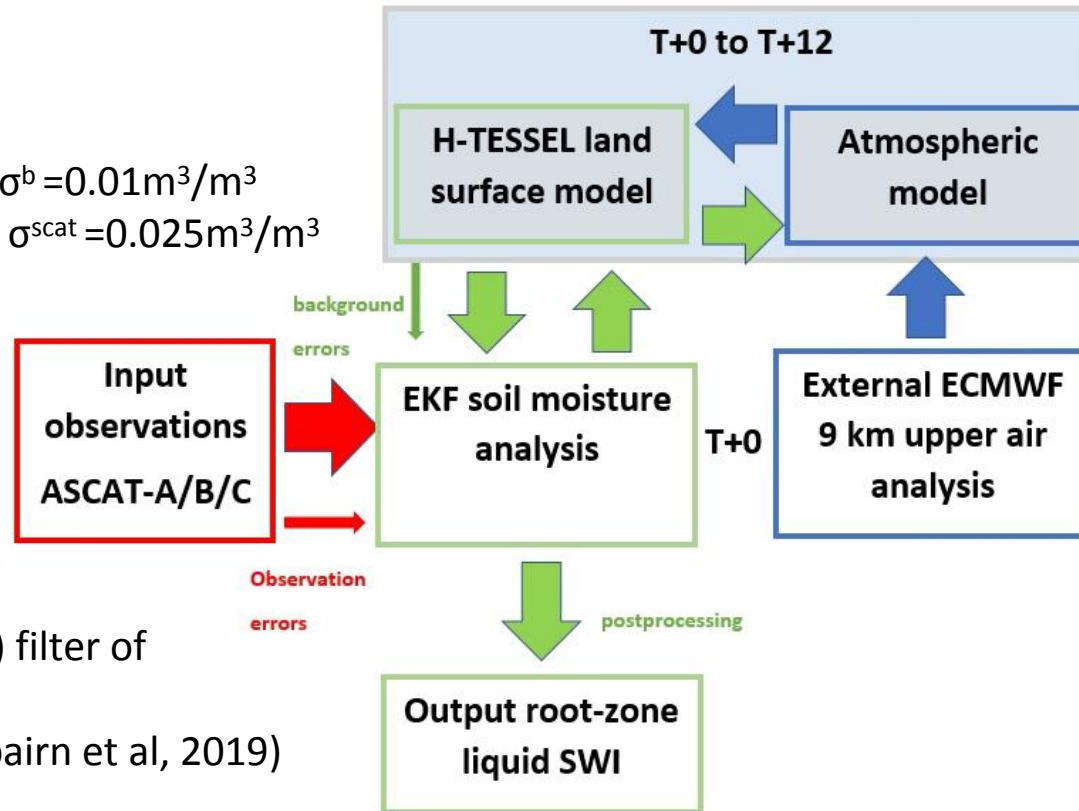
RZSM-ASCAT-NRT-10 (H26)



SSM derived from change-detection approach (Wagner et al., 1999)

$$\sigma^b = 0.01 \text{m}^3/\text{m}^3$$

$$\sigma^{\text{scat}} = 0.025 \text{m}^3/\text{m}^3$$



Simplified EKF analysis

$$\mathbf{x}^a(t_i) = \mathbf{x}^b(t_i) + \mathbf{K}_i [\mathbf{y}^o(t_i) - \mathcal{H}_i(\mathbf{x}^b)],$$

$$\mathbf{K}_i = [\mathbf{B}^{-1} + \mathbf{H}_i^T \mathbf{R}^{-1} \mathbf{H}_i]^{-1} \mathbf{H}_i^T \mathbf{R}^{-1},$$

$$\mathbf{H}_{m,i} = \frac{\mathcal{H}_{m,i}(\mathbf{x}^b + \delta \mathbf{x}_n^b) - \mathcal{H}_{m,i}(\mathbf{x}^b)}{\delta x_n}.$$

SM analysed over first 3 layers in H-TESEL:
 Layer 1: 0-7 cm
 Layer 2: 7-28 cm
 Layer 3: 28-100 cm
 Layer 4 (not analysed): 100-289 cm

- Simplified Extended Kalman (SEKF) filter of de Rosnay et al., 2013
- Stand-alone surface analysis (Fairbairn et al, 2019)

- Daily (00 UTC) global root-zone liquid soil wetness index at 10 km sampling
- Operational since 23rd March 2022 with 12-hour latency
- Near-real-time product (identifier): RZSM-ASCAT-NRT-10km (H26)

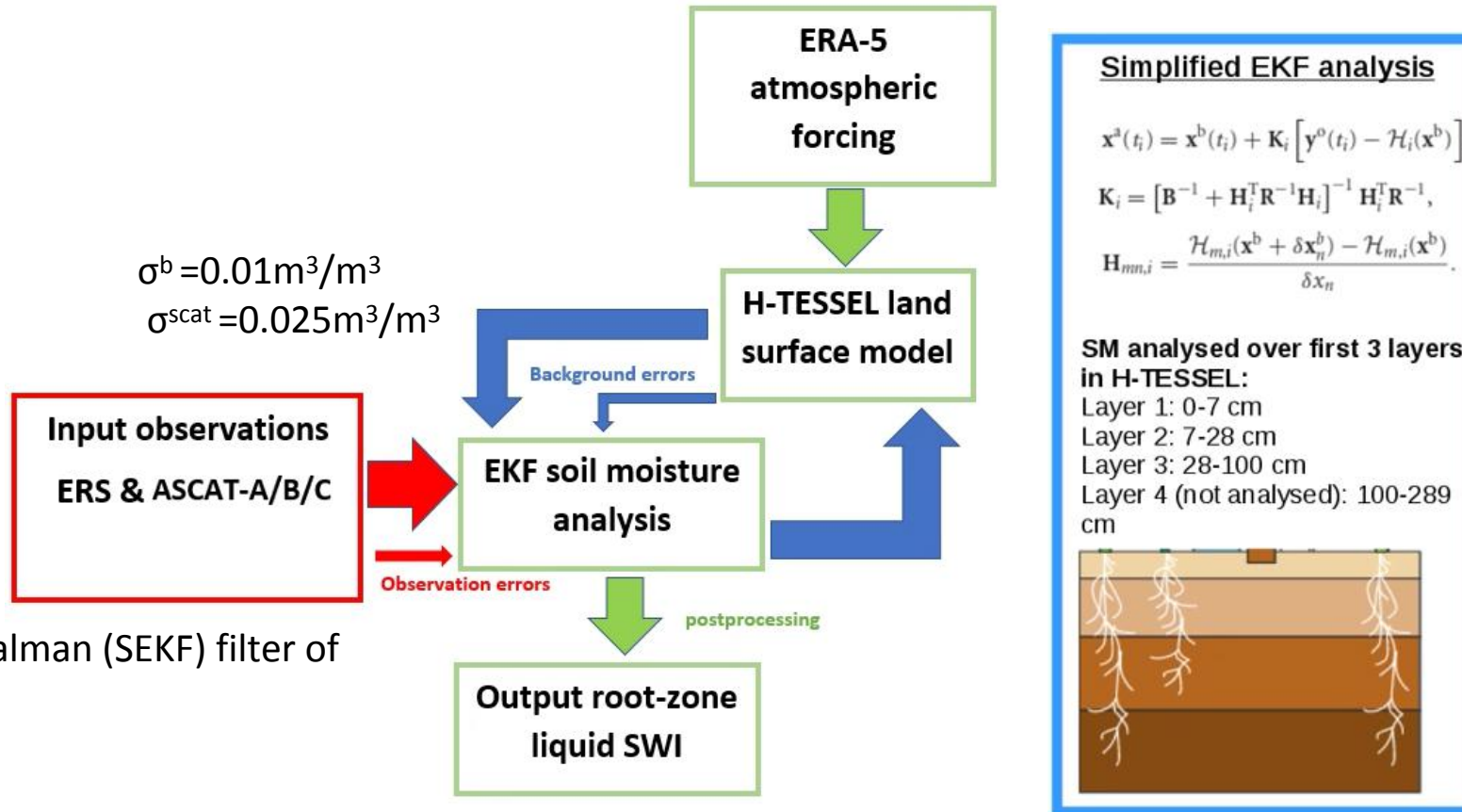
RZSM-DR2019-10km (H141)



SSM derived from change-detection approach (Wagner et al., 1999)

$$\sigma^b = 0.01 \text{m}^3/\text{m}^3$$

$$\sigma^{\text{scat}} = 0.025 \text{m}^3/\text{m}^3$$



Simplified Extended Kalman (SEKF) filter of de Rosnay et al., 2013

- Daily (00 UTC) global root-zone liquid soil wetness index at 10 km sampling over 1992-2022
- Data record product (identifier): RZSM-DR2019-10km (H141) covers 1992-2022
- Available as demonstrational product on H SAF ftp

DROUGHT MONITORING WITH ROOT-ZONE SM

- Comparison of near-real-time (NRT) product with data record can indicate droughts or floods

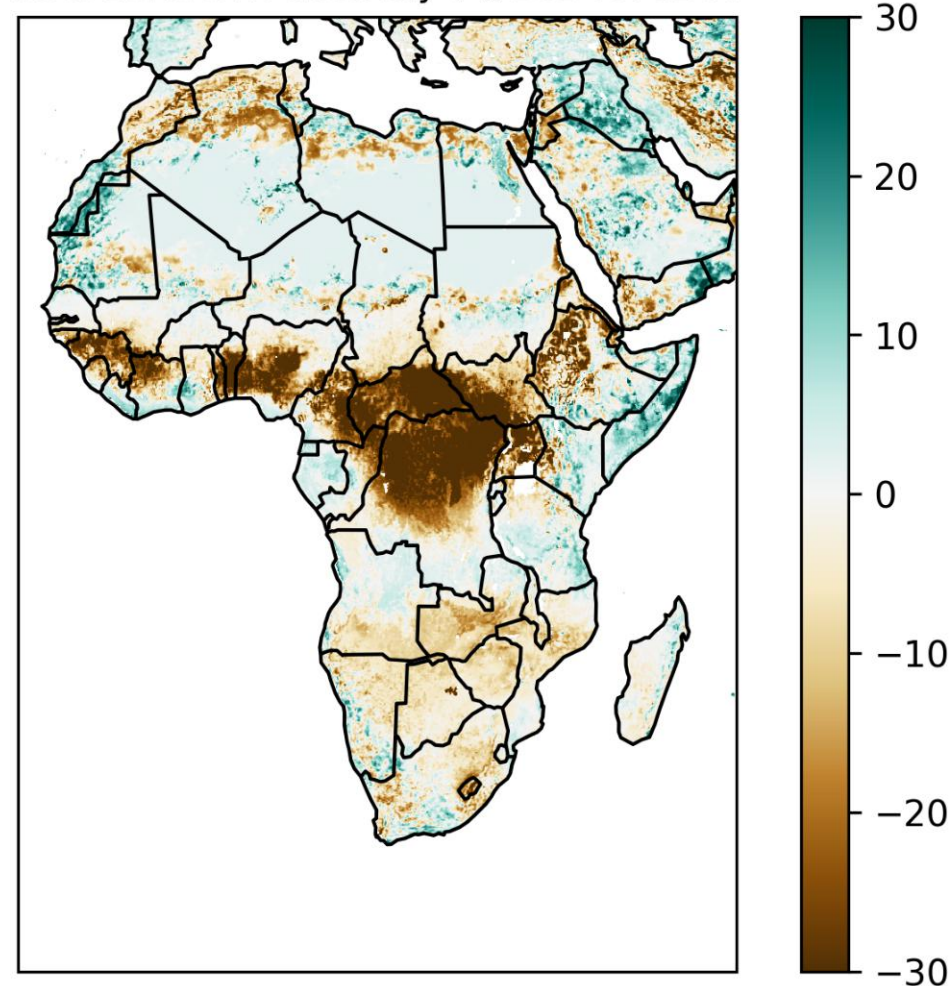
- H26 anomaly (%) relative to monthly H141 mean (1992-2021):

$$(SM_i - \overline{SM}) * 100.0$$

- Extremely dry anomalies over parts of central and western Africa (<-20%)

H26 layer 3 (28-100 cm depth) anomaly, 2nd July 2024

Root-zone SWI anomaly (-), 2024070200



DROUGHT HAZARD INDEX

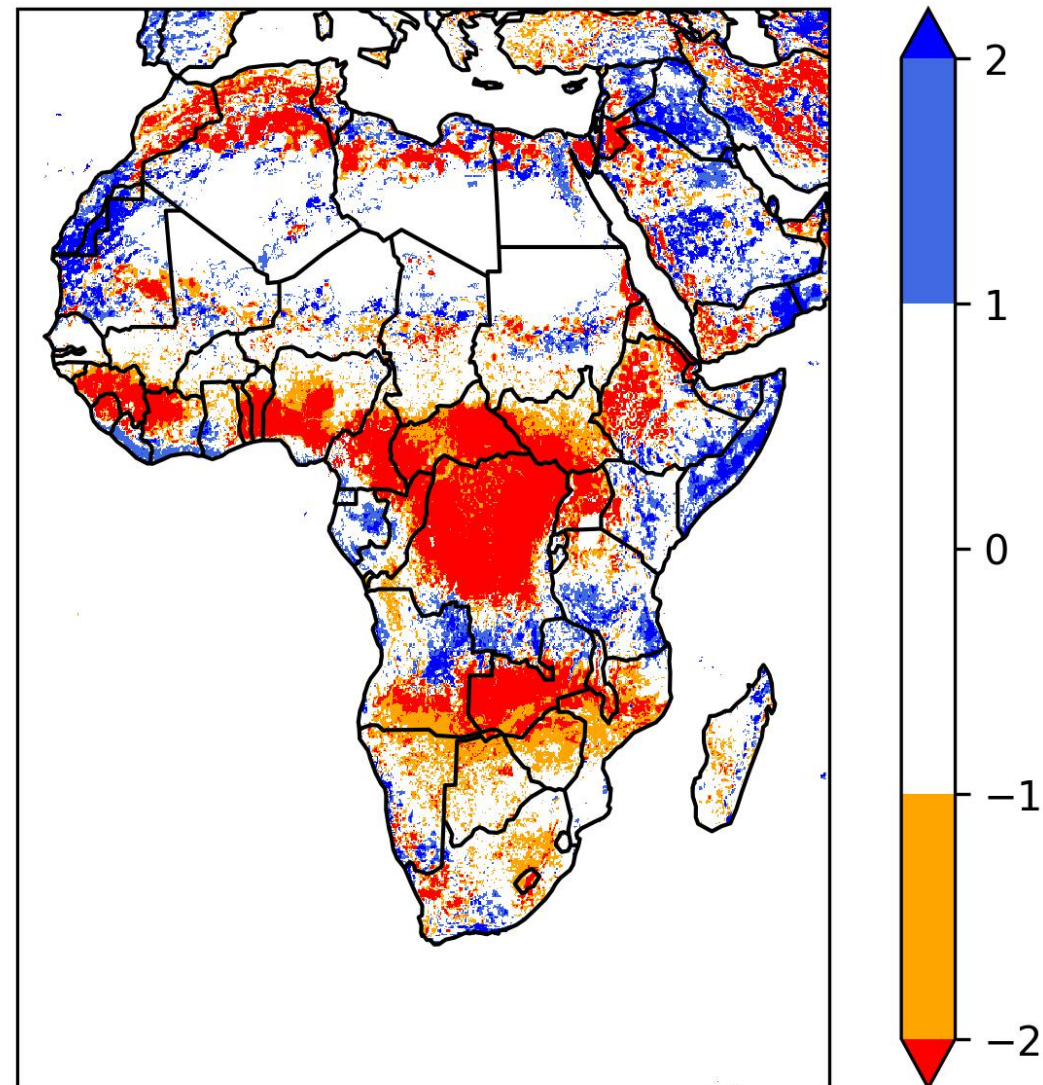
- Drought hazard index (DHI) measures the severity of drought conditions
- Drought hazard index based on anomaly divided by standard deviation:

$$\frac{SM_i - \overline{SM}}{\sigma}$$

- Drought conditions (<-1), Severe drought (<-2)
- Severe drought present over parts of central and eastern Africa (02 July 2024)

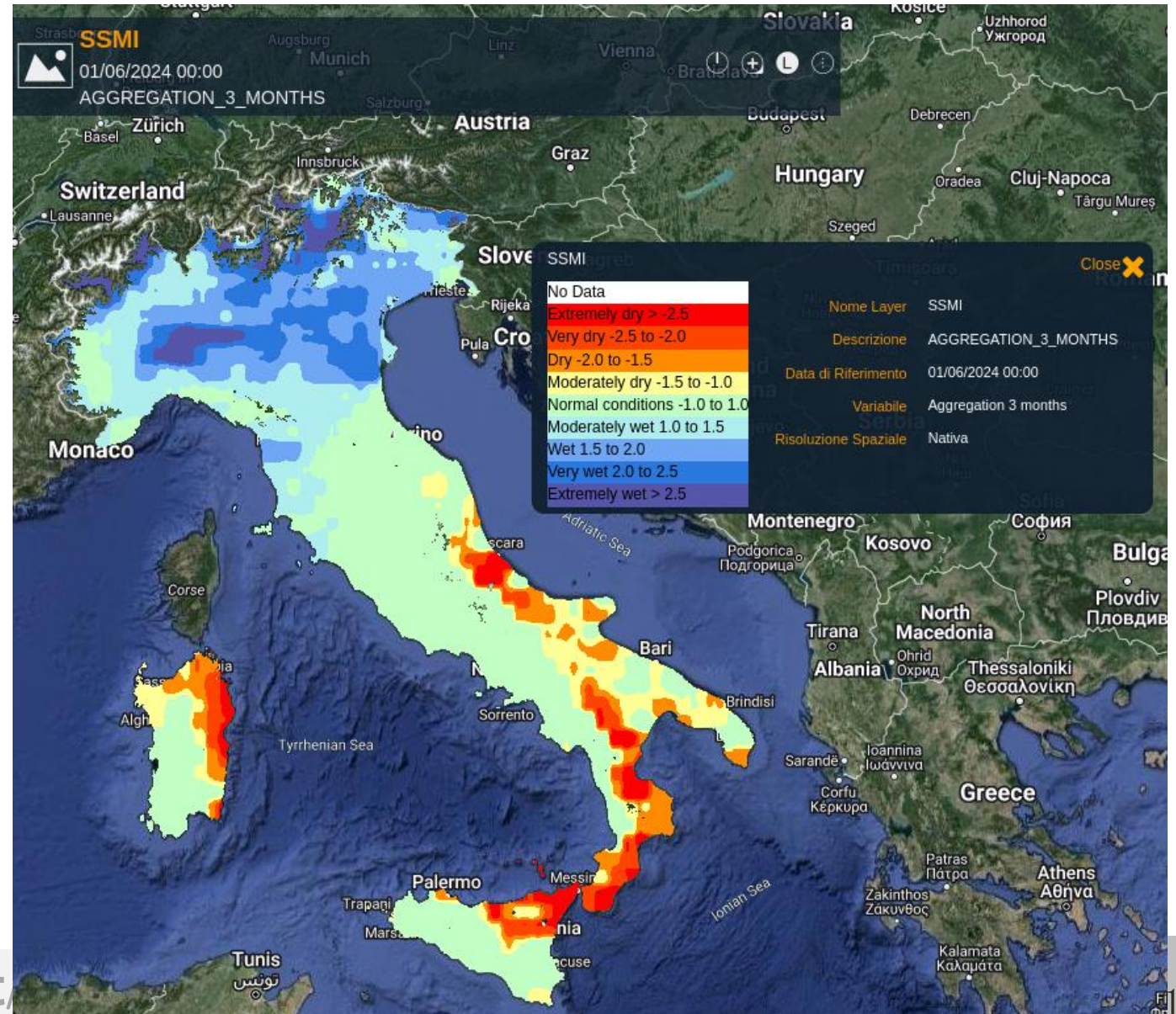
H26 layer 3 (28-100 cm depth) drought hazard index, 2nd July 2024

Root-zone SWI z-score (-), 2024070200

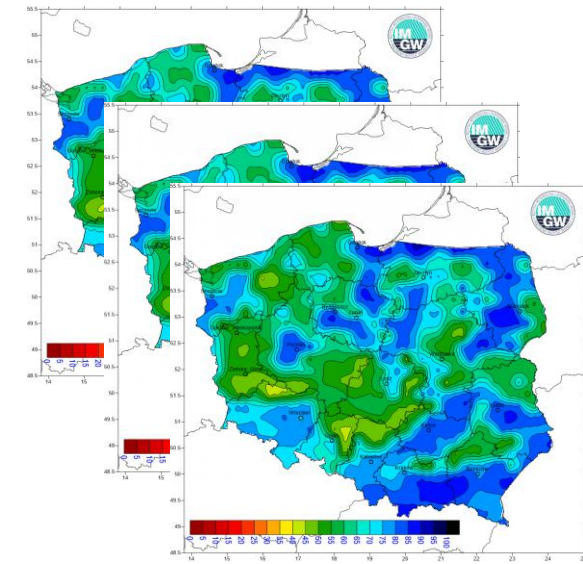


DROUGHT MONITORING WITH ROOT-ZONE SM

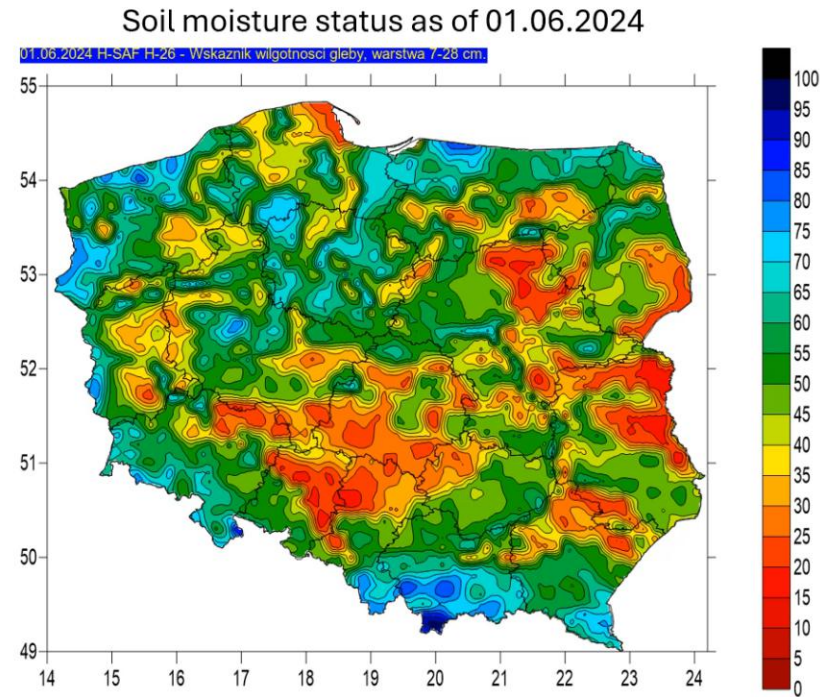
Monthly bulletin for Water resources in Italy to support national Civil Protection (Standardized Soil Moisture Index based on RZSM-ASCAT-NRT-10, H26)



Soil moisture index (H26) from the past three days and ensemble weather forecasts from IFS model (ECMWF) are used to make a soil moisture forecast



P and T forecast, IFS
model (ECMWF)

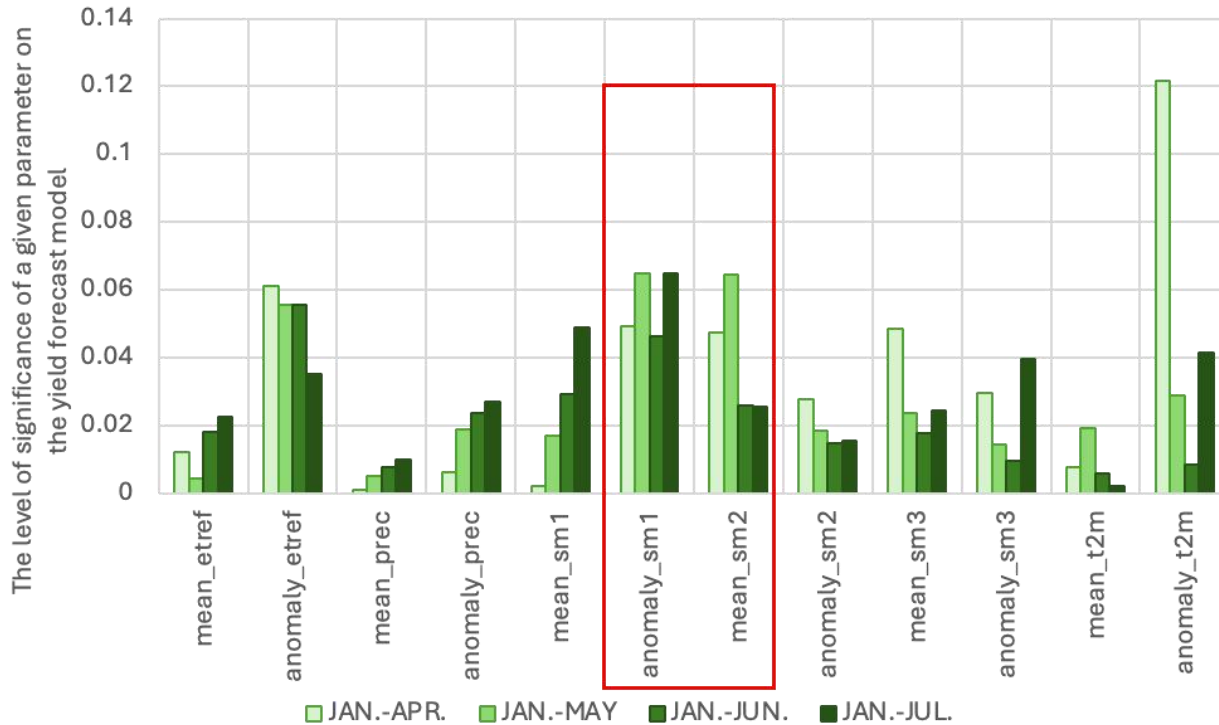


The model is developed for two soil depth layers
7-28 cm and 28-100 cm

Forecast of crop yields



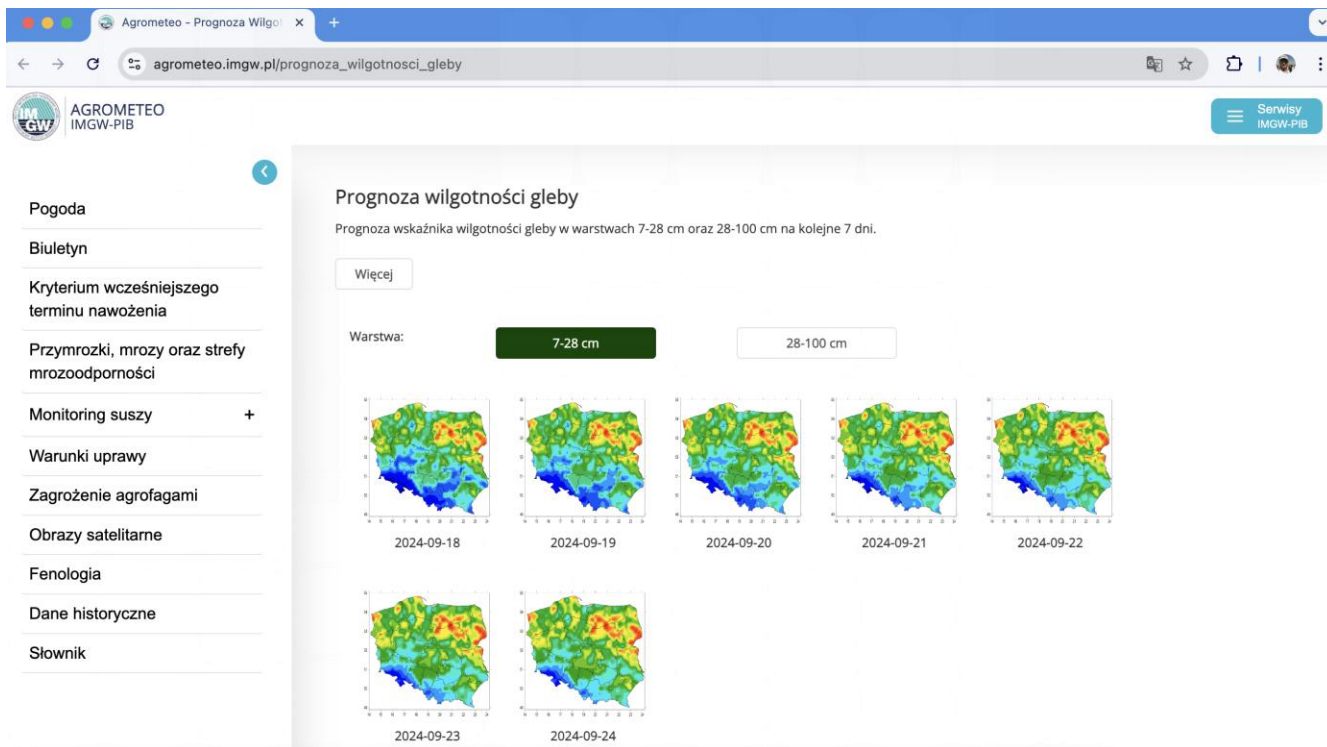
Based on selected parameters and indicators derived from satellite data and the anomalies calculated for them, a model for forecasting the yield of selected crops was created. The model was developed for consecutive months starting with data from January to April, ending with data from January to July



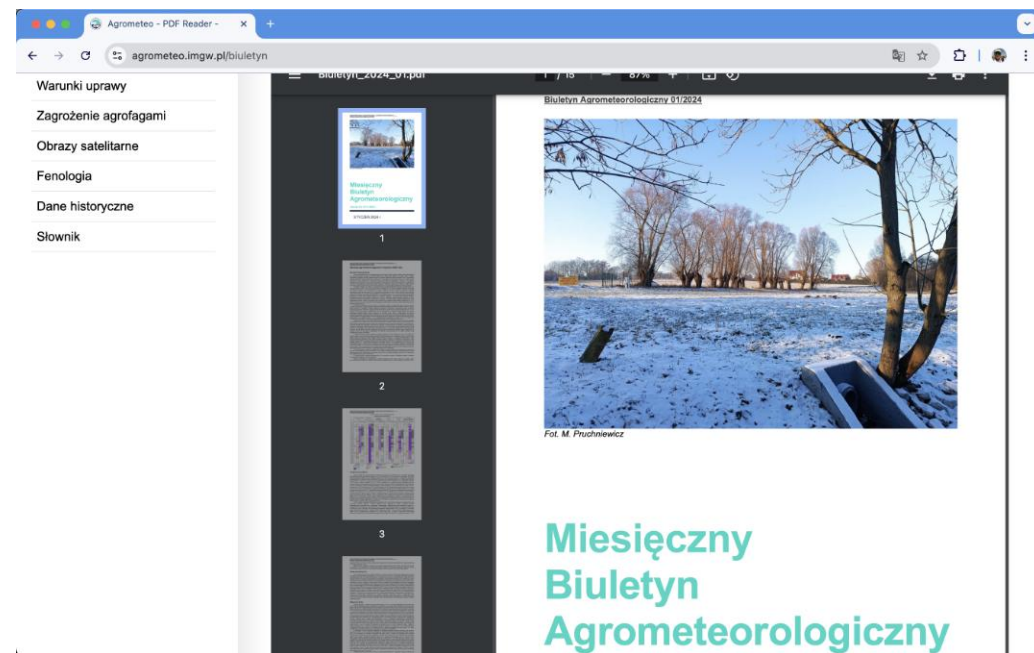
Sample model results for 2023.

Crops	Data from Statistic Poland (dT/ha)	Data from model (dT/ha)
Winter wheat	54,5	50,6
Spring wheat	40,3	39,5
Winter rye	35	33,8
Winter barley	50,1	44,9
Spring barley	37,7	37,4
Oats	30,5	31,9
Winter triticale	45,2	42,7
Spring triticale	33	33,9

The importance of the soil moisture index and the anomalies of this value in the different layers were often more important to the model than, for example, the average daily temperature.



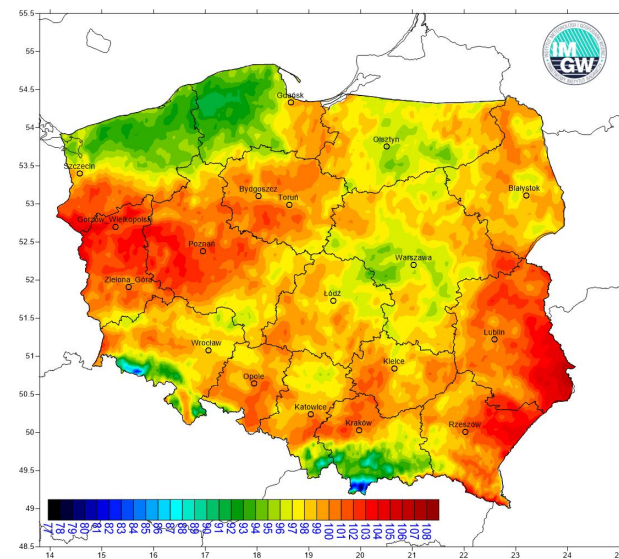
https://agrometeo.imgw.pl/prognoza_wilgotnosci_gleby



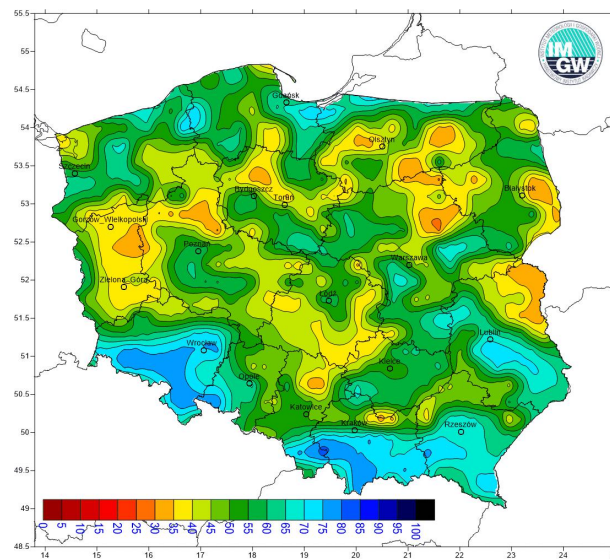
Miesięczny
Biuletyn
Agrometeorologiczny

Agrometeorological bulletins are prepared monthly, based on measurement data and phenological observations from selected synoptic stations of Institute of Meteorology and Water Management, and based on EUMETSAT H-SAF and Land-SAF satellite products. The maps and charts presented here concern those meteorological elements and agrometeorological indicators that play an important role for crop production.

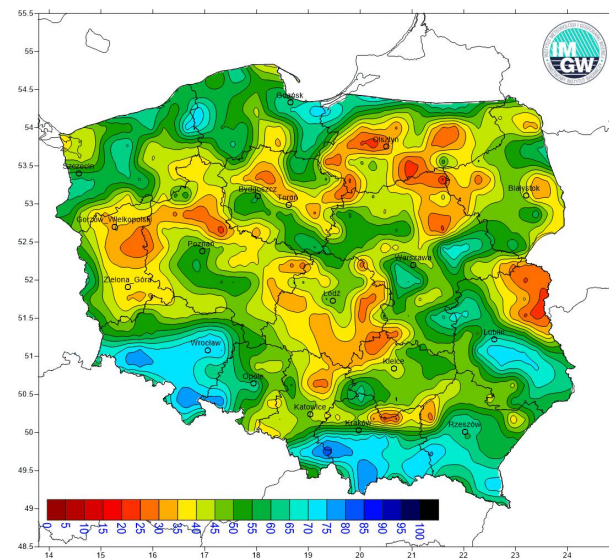
EUMETSAT satellite products:



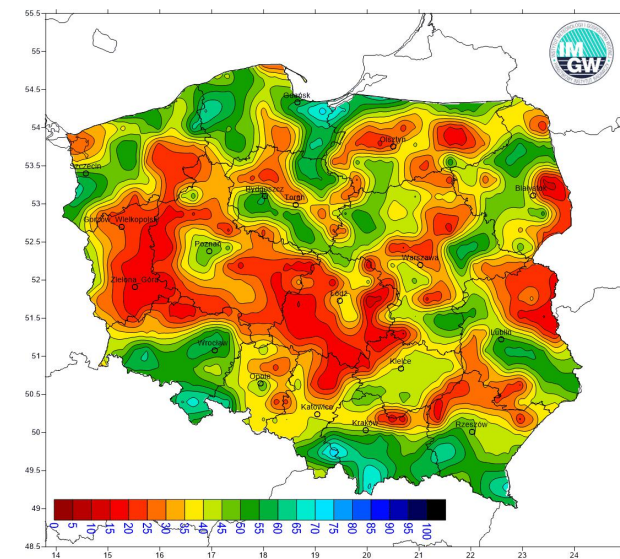
Reference Evapotranspiration
[LSA-303]



Soil moisture profile index:
layer-1 (0-7cm) [H26]

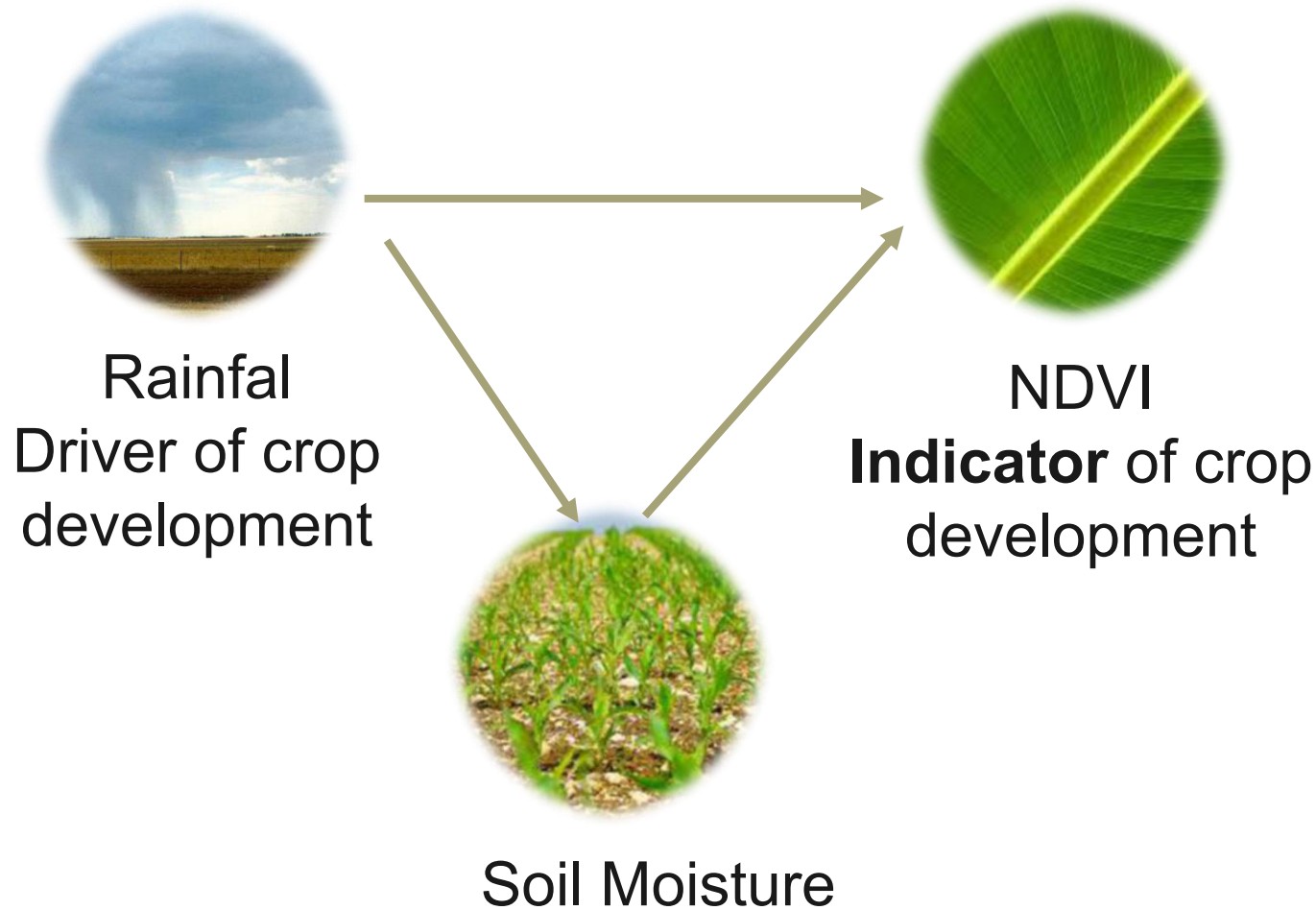


Soil moisture profile index:
layer-2 (7-28cm) [H26]



Soil moisture profile index:
layer-3 (28-100cm) [H26]

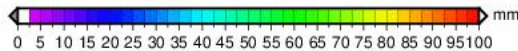
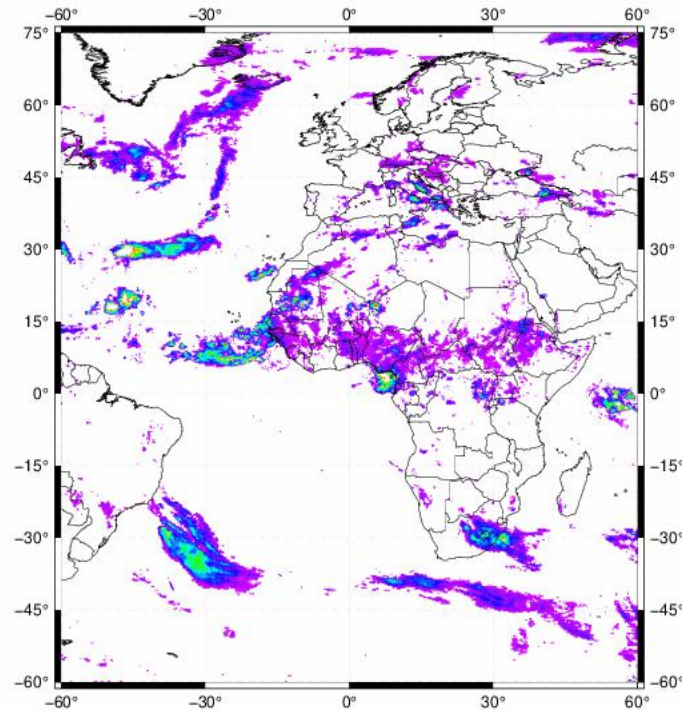
Yield prediction in Morocco



Explore the contribution of satellite soil moisture (and satellite precipitatin) in Yield deficiency

P-AC-SM2R-PMW (H64)

EUMETSAT H SAF P-AC-SM2RAIN-PMW (H64)
Gridded 24h accumulated precipitation at ground
Based on the integration of soil moisture-derived rainfall and PMW estim.
h64_20240918_0000_24_heg



GM7 2024 Sep 18 15:20:02 Production_SATELLITE_AREA_COMET_Algorithm_ISAC_CNR-AGEUMETSAT--

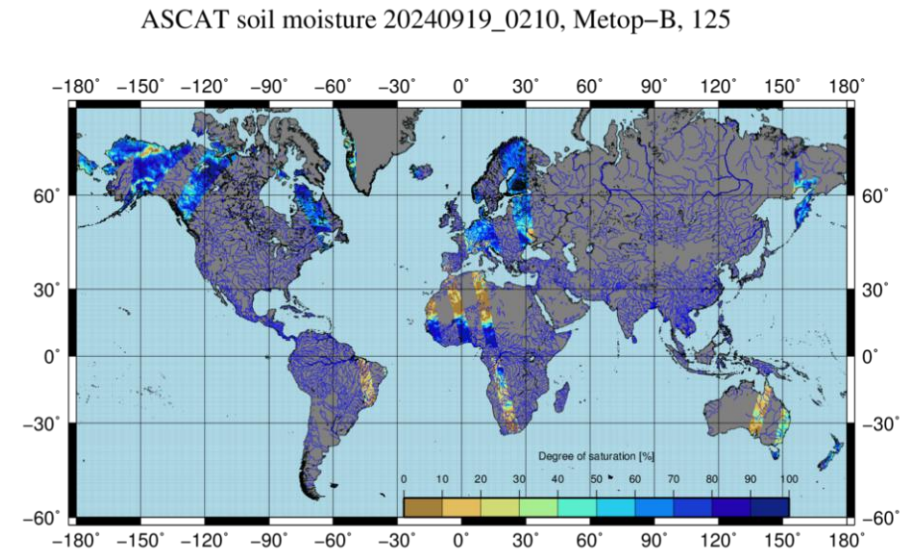
Gridded daily precipitation obtained by merging soil moisture-derived rainfall with Passive Microwave (PMW) rainfall estimates,

Main Features:

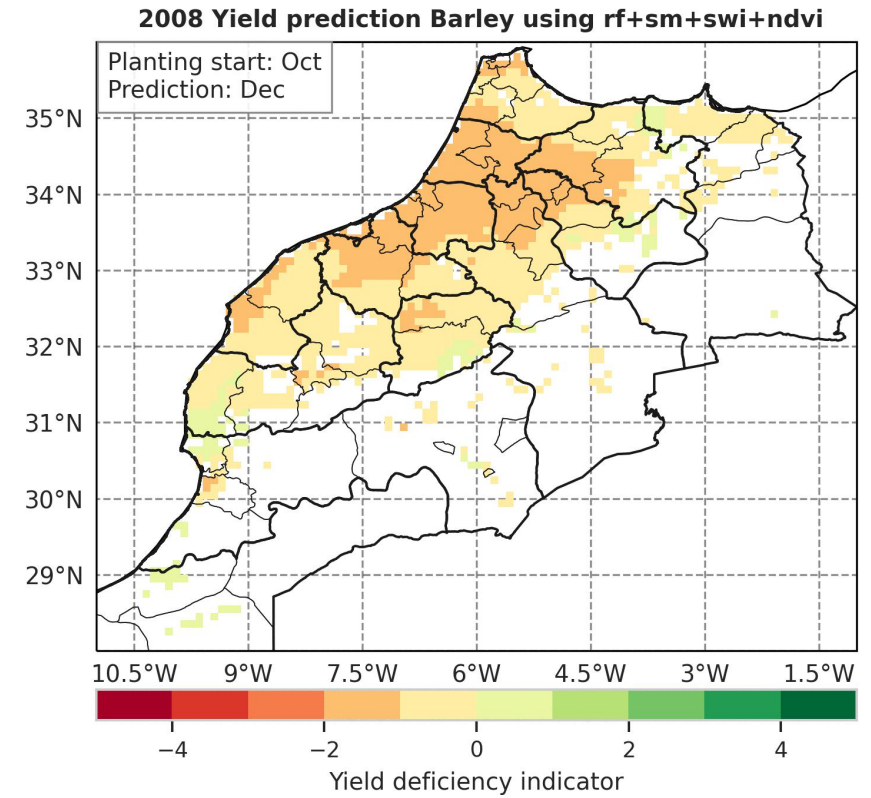
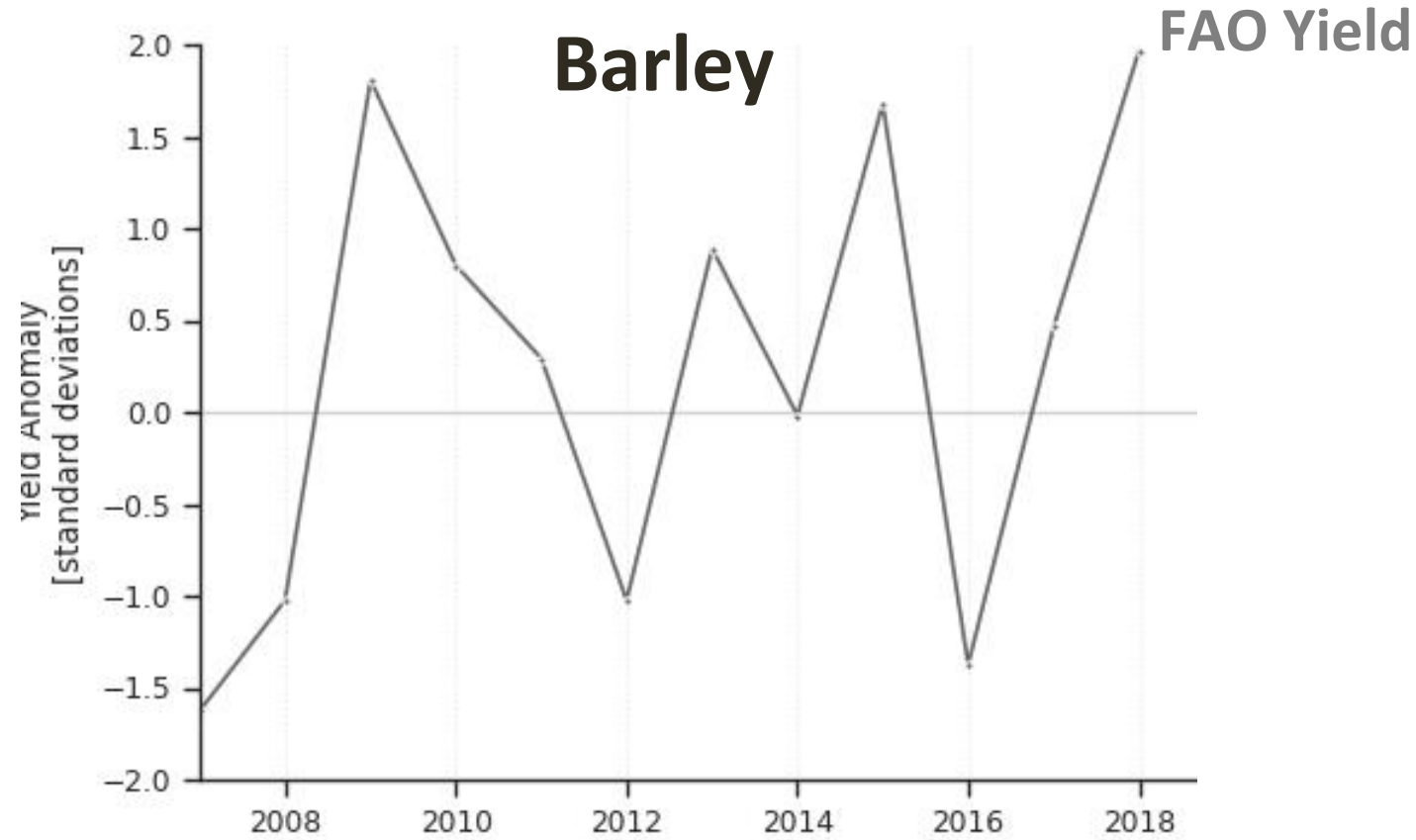
- Daily temporal resolution;
- 0.25° spatial resolution;
- 1 day latency;

SSM-ASCAT-B-NRT-O12.5 (H16)

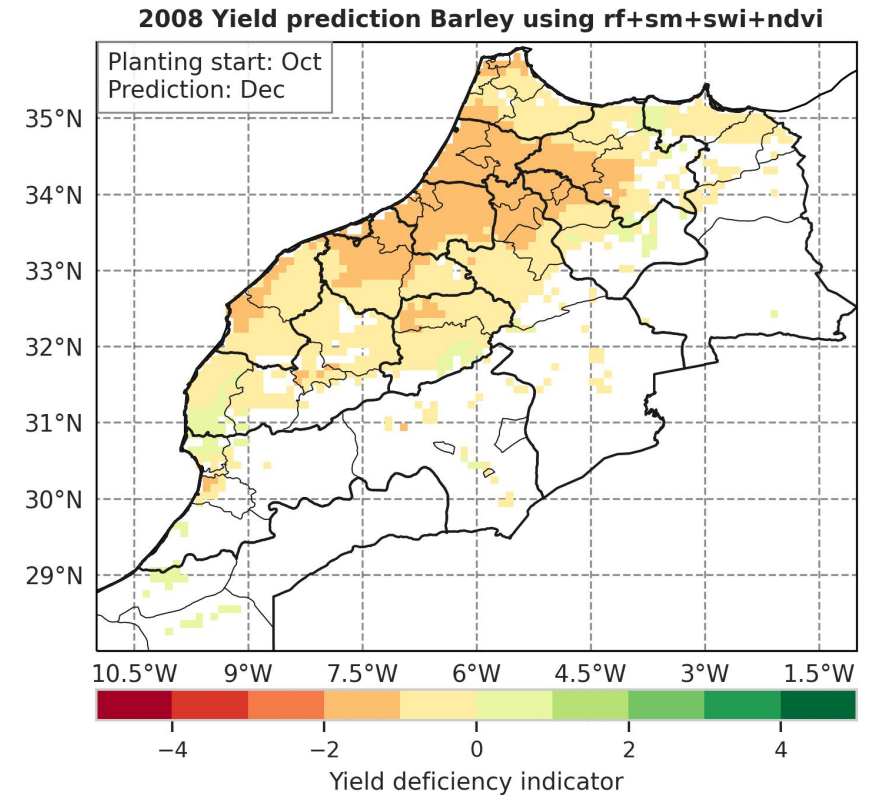
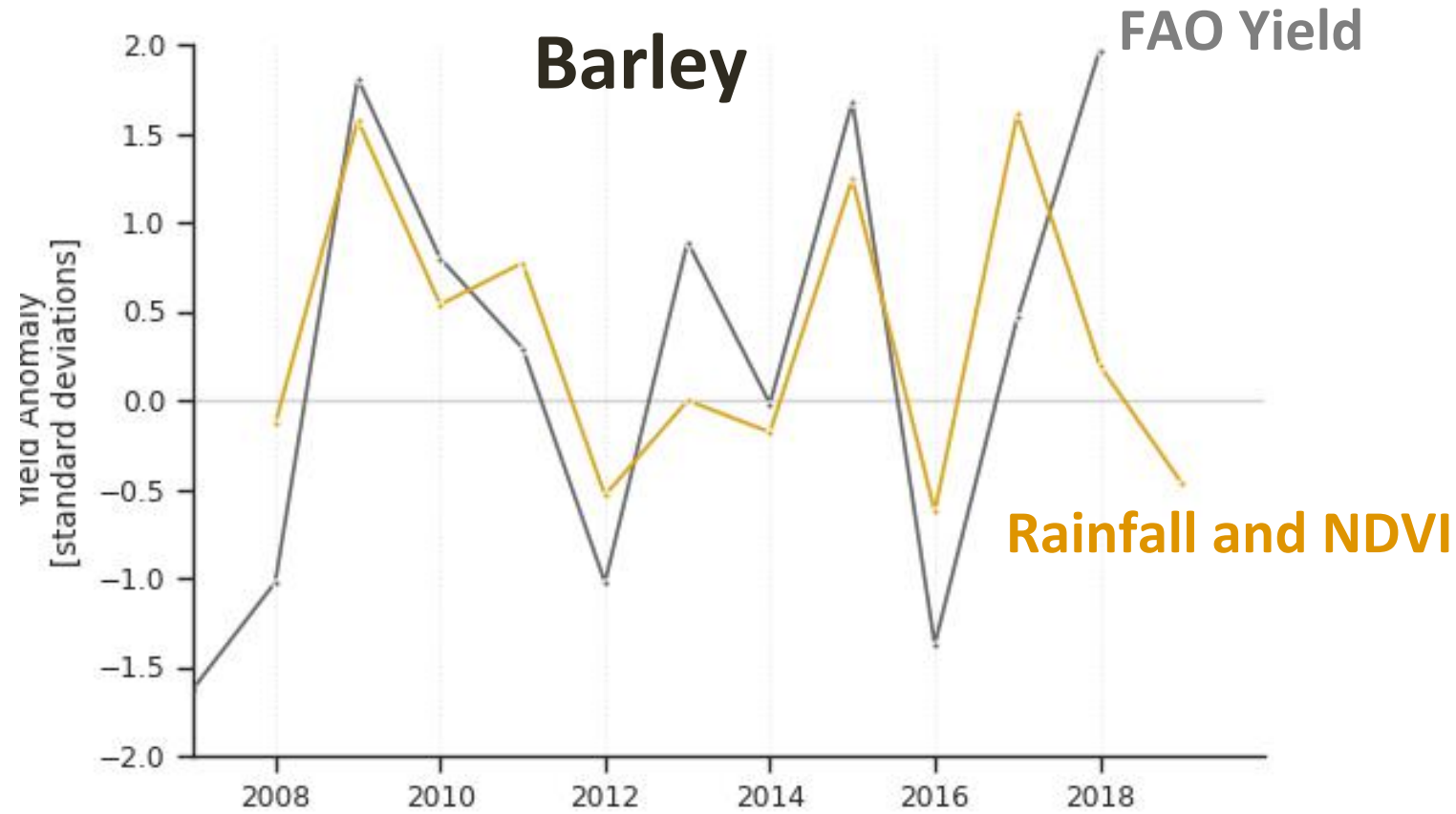
- Surface Soil Moisture (SSM) products from backscatter observations from the Advanced Scatterometer (ASCAT) on-board the series of Metop satellites
 - Spatial resolution: 12.5 km
 - Vertical resolution: Top SM content, 0-2 cm



Yield prediction in Morocco

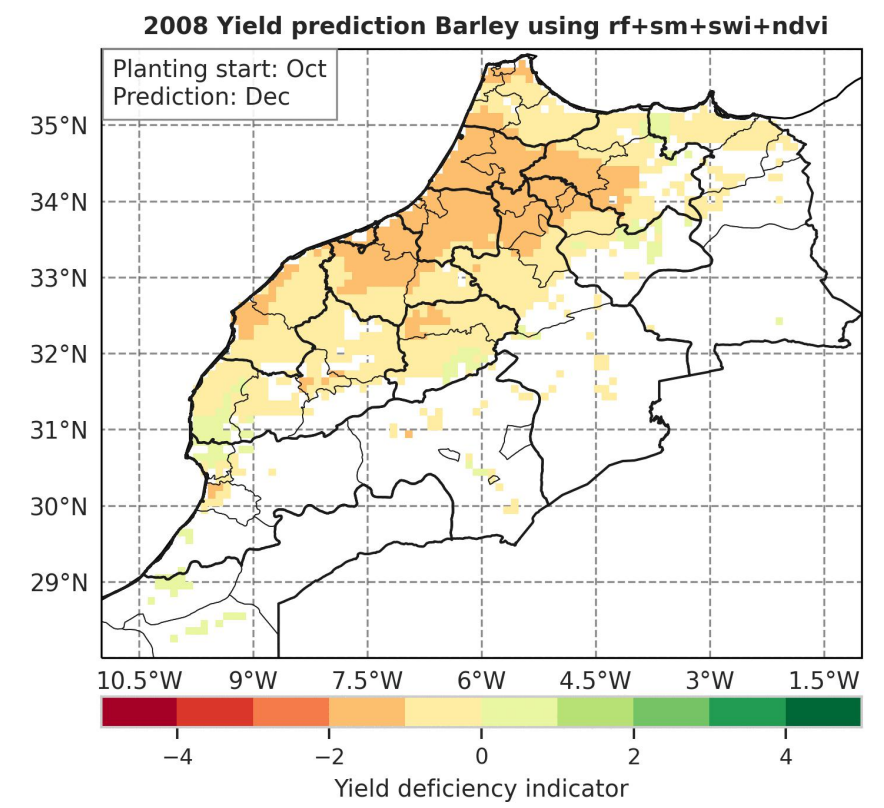
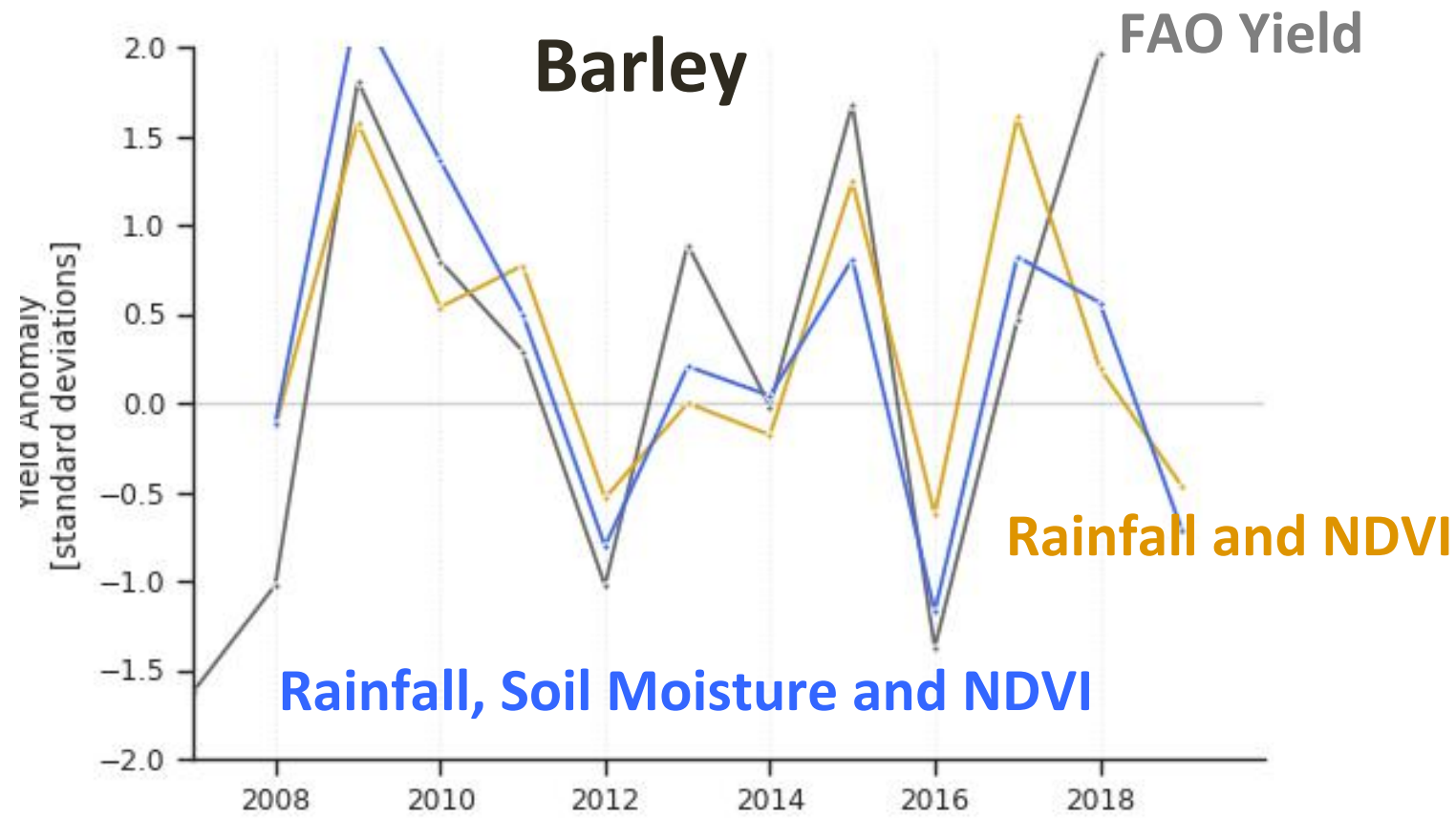


Yield prediction in Morocco



Yield prediction in Morocco

Including soil moisture significantly improves yield prediction in Morocco, particularly in drought conditions

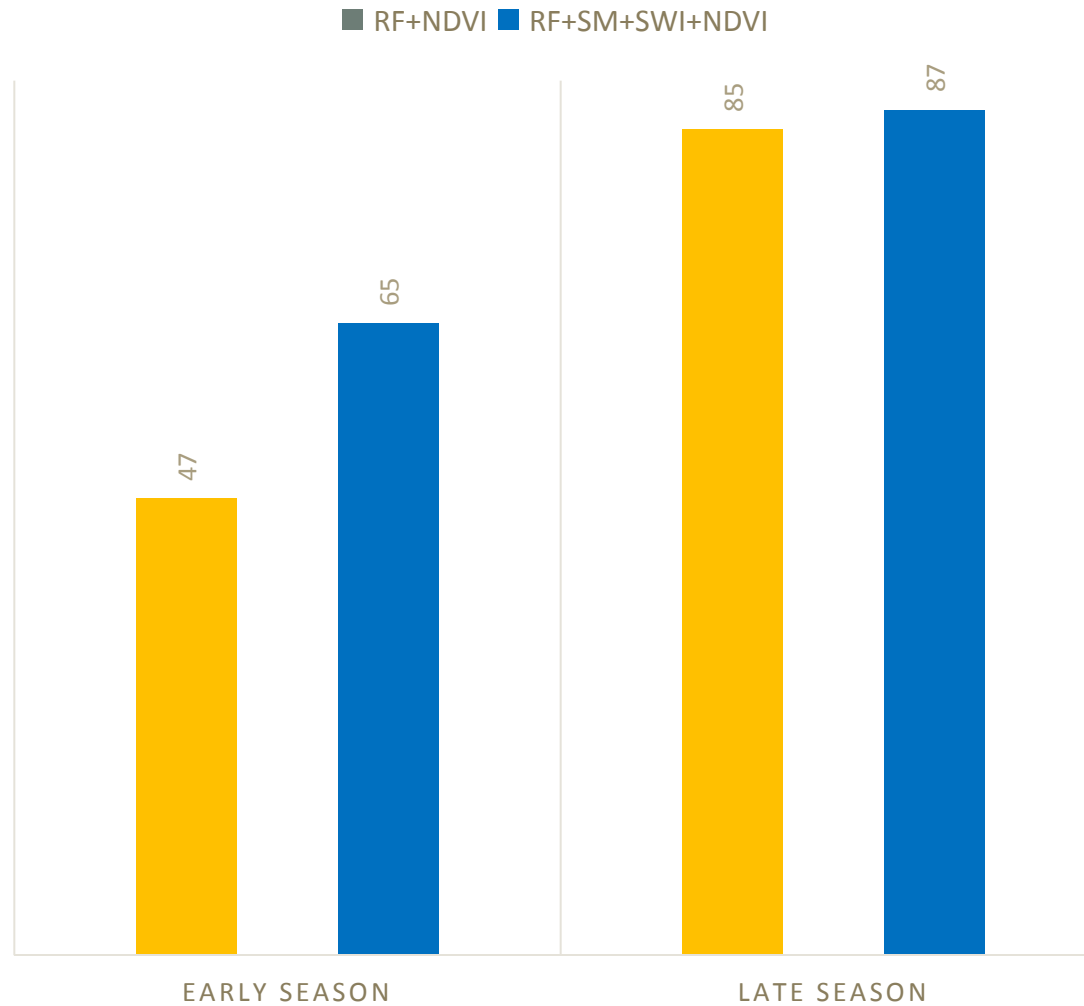


Vreugdenhil et al. 2022 (Frontiers in Water)

Yield prediction in Morocco

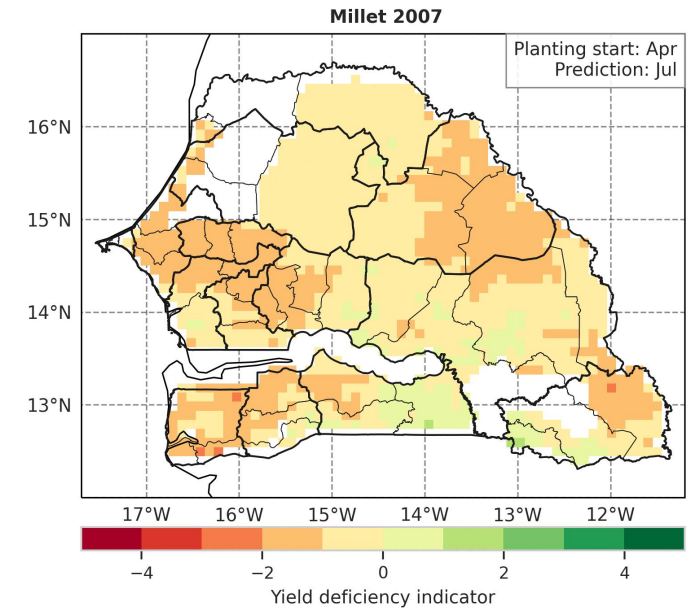
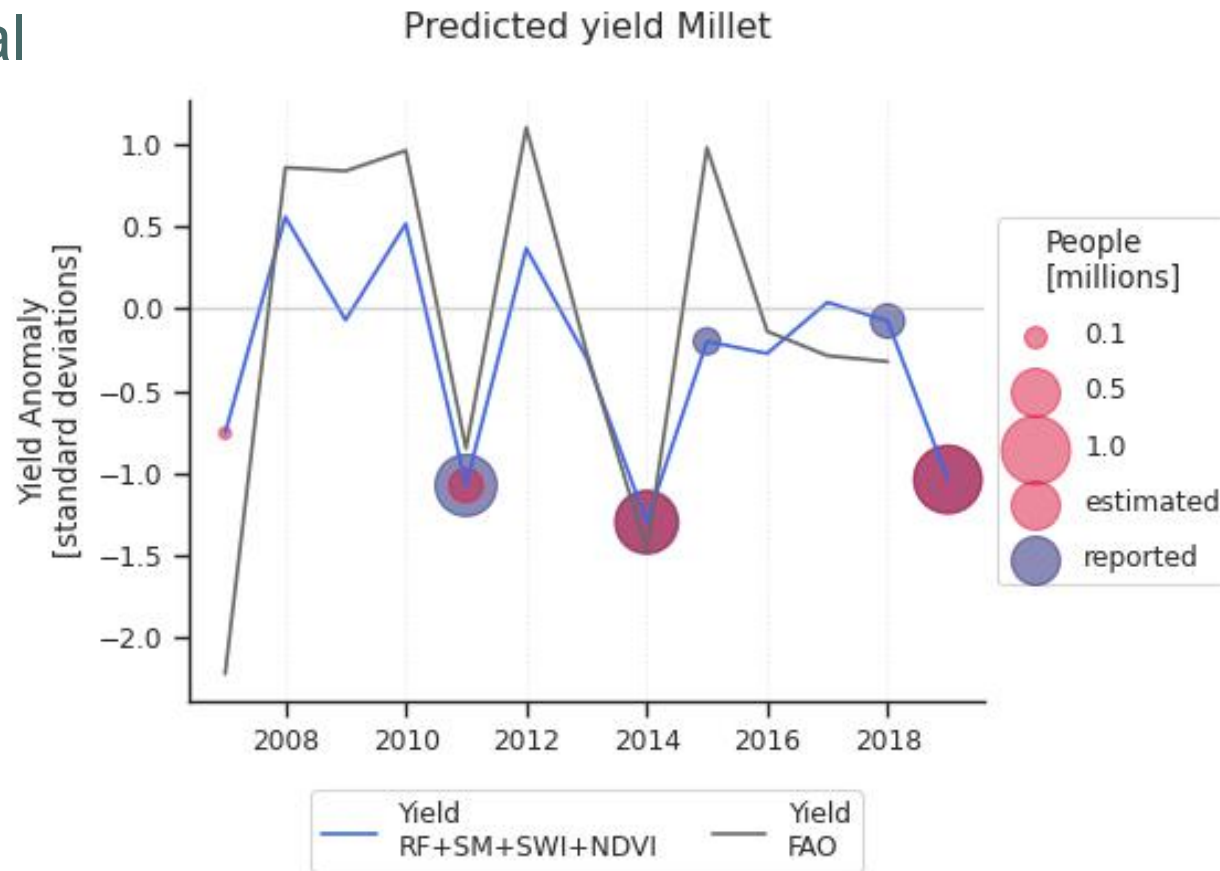
Barley
Morocco

EXPLAINED VARIANCE [%]



YIELD DEFICIENCY AND PEOPLE AFFECTED

Millet Senegal



How to download and visualize data

<https://h-saf.eumetsat.int>

EUMETCAST

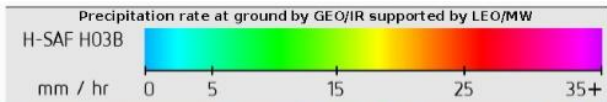
EUMETSAT DATA CUBE

H SAF ftp server (last 60 days)

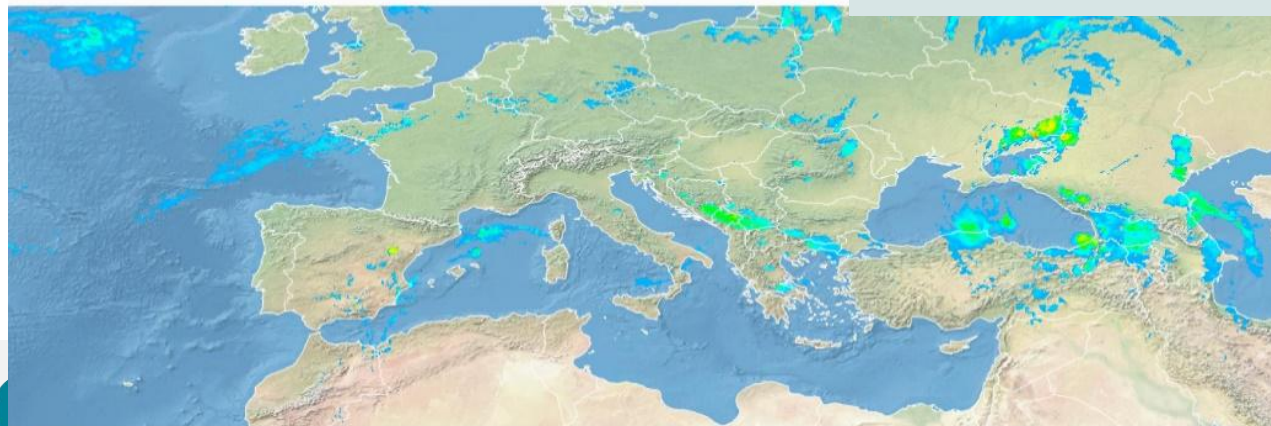
<ftp://h-saf.meteoam.it>

**Order archived products,
instructions on the web site**

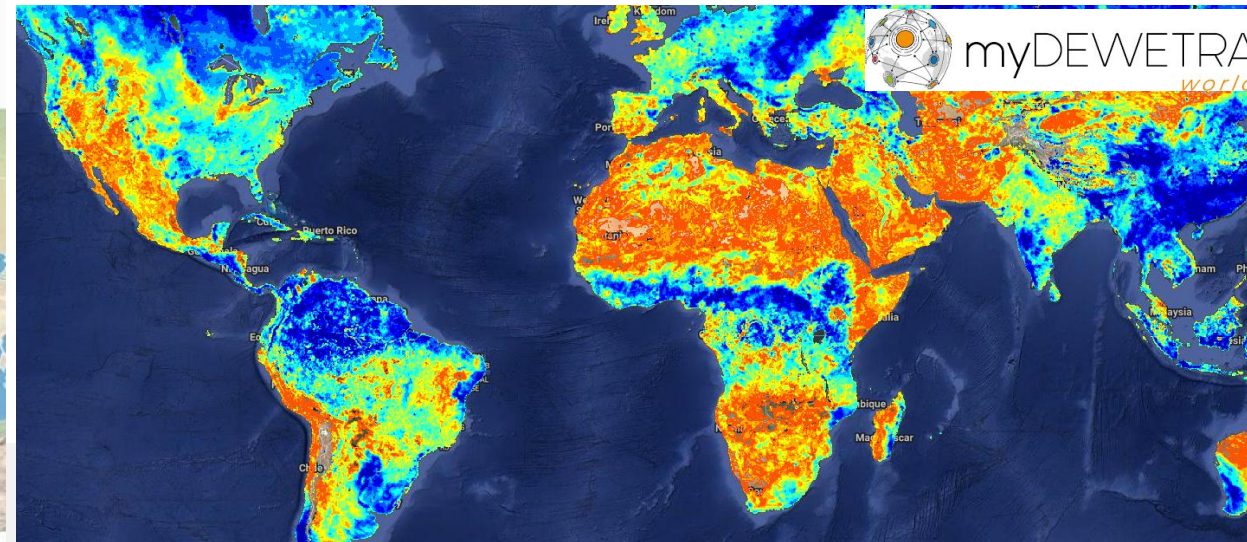
<https://view.eumetsat.int/productviewer?v=default>



EUMETview



<https://www.mydewetra.world/>



H SAF E-LEARNING PLATFORM



It is hosted on the CIMA Foundation moodle platform
edu.cimafoundation.org

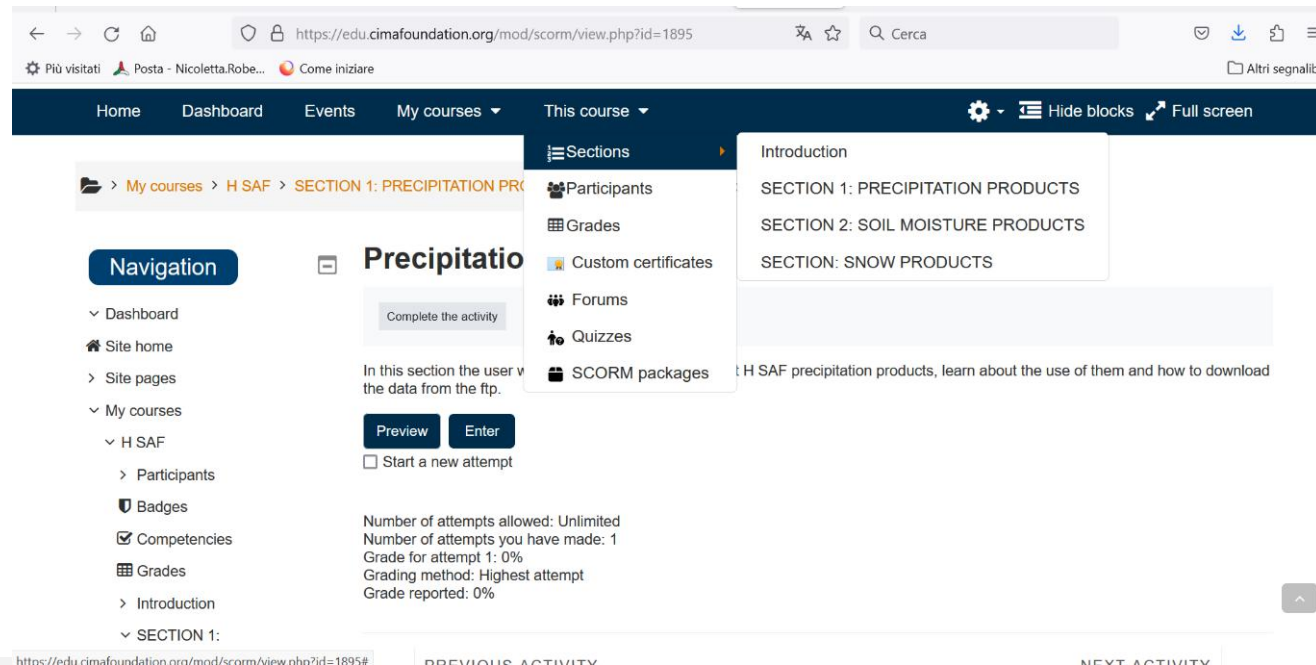
4 SECTIONS

INTRODUCTION

PRECIPITATION PRODUCTS

SOIL MOISTURE PRODUCTS

SNOW PRODUCTS



Each section includes **CASE STUDIES** and applications

H SAF e-learning Platform

FOR EACH SESSION THERE ARE

- **1 module explaining main products** (containing 1 video from cluster leader or representative)
- **1 test with exercises on the use of one or more products** that requires the student to provide an accurate answer
- **1 certificate of participation** that can be unlocked by the participant only if the exercise performed is correct
- **1 dedicated forum** where participants can pose questions to experts



A screenshot of the H SAF e-learning platform interface. The top navigation bar includes "Home", "Dashboard", "Events", "My courses", and "This course". Below the navigation, there's a "Quiz navigation" section with a progress indicator (1-7) and a "Start a new preview" button. The main content area displays "Question 5" with a map of precipitation over Durban, South Africa, and a "CERTIFICATE OF ACHIEVEMENT" section stating "HAS SUCCESSFULLY COMPLETED THE COURSE H SAF / PRECIPITATION PRODUCTS". A bottom navigation bar includes "Home", "Dashboard", "Events", "My courses", "This course", and utility icons. A "Navigation" sidebar on the left lists "Dashboard", "Site home", "Site pages", "My courses", "H SAF", "Participants", "Badges", "Competencies", "Grades", "Introduction", "SECTION 1: PRECIPITATION PRODUCTS", and "Precipitation products". A "Precipitation products Forum" section is visible, featuring a search bar, "Add discussion topic", "Subscribe to forum", and a table of discussions with columns for "Discussion", "Started by", "Last post", "Replies", and "Subscribe".



Take home message

H SAF Satellite soil moisture and precipitation products are available in near real-time, and long-term

Their use for **yield prediction** (**drought**, **extreme event** monitoring and **flood** prediction) represent an advance in knowledge and is relevant for real-world operational applications.



silvia.puca@protezionecivile.it
simone.gabellani@cimafoundation.org
luca.brocca@irpi.cnr.it



<http://hsaf.meteoam.it/>



@HydroSAF
@HydrologyNext