

EO FOR AFRICA SYMPOSIUM 2024

September 25th, 2024

OPERATIONAL H SAF SATELLITE PRECIPITATION AND SOIL MOISTURE PRODUCTS FOR HYDROLOGICAL APPLICATION IN AFRICA



Luca Brocca, Luca Ciabatta, Paolo Filippucci,
Jaime Faona, Usman Liaquat,



Sebastian Hahn,
David Fairbairn,



Simone Gabellani,
Silvia Puca

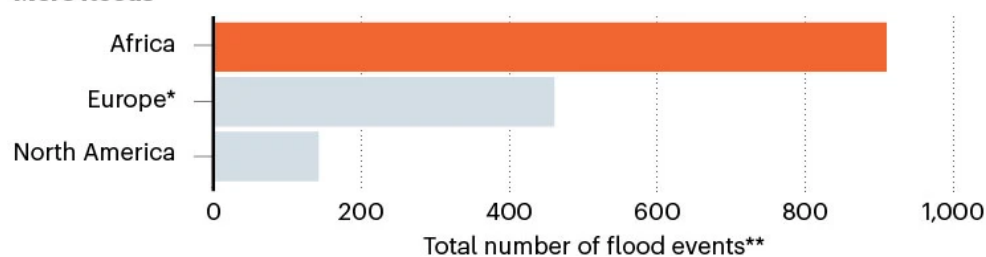


HOW TO REDUCE AFRICA UNDUER EXPOSURE TO CLIMATE RISKS?

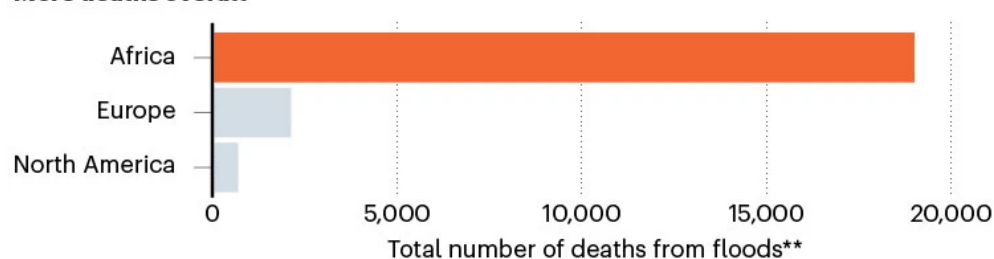
AFRICA'S DISPROPORTIONATE TOLL

Floods are more frequent across Africa than in North America and Europe combined, with four times as many deaths on average owing to a lack of preparedness and warnings.

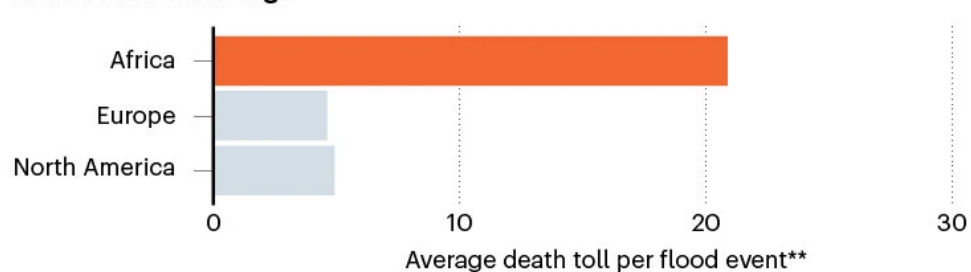
More floods



More deaths overall



More deaths on average



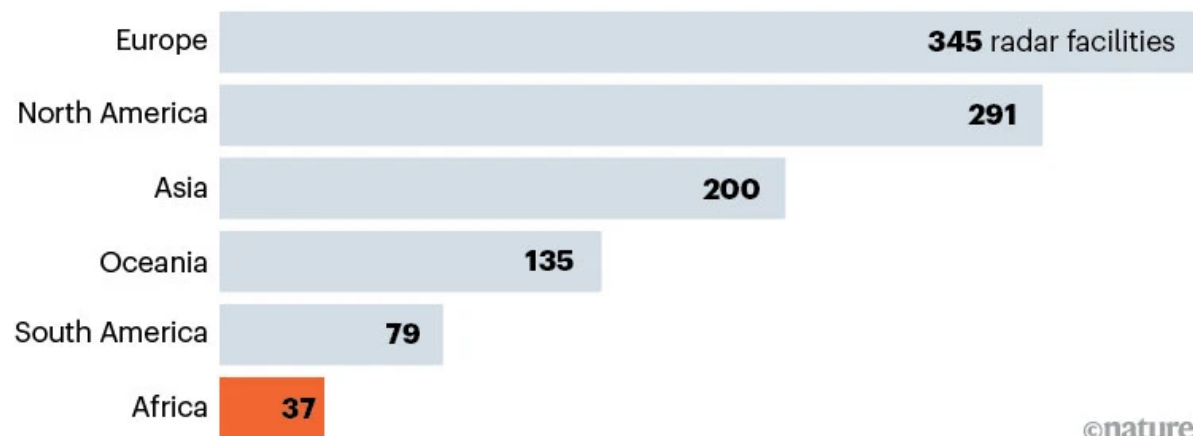
*Europe: EU-27 and United Kingdom.

**Flash, riverine and coastal floods, 2000–22.

©nature

WEATHER STATION DEFICIT

Compared with other continents, Africa has few radar facilities for tracking weather, despite its size.

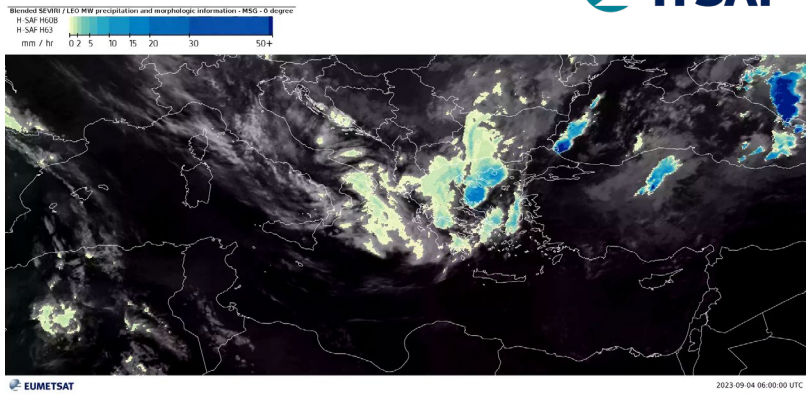


©nature

Africa is disproportionately exposed to catastrophic climate, hydrological and meteorological risks. Well-funded weather monitoring, nowcasting and early-warning systems must become a priority.

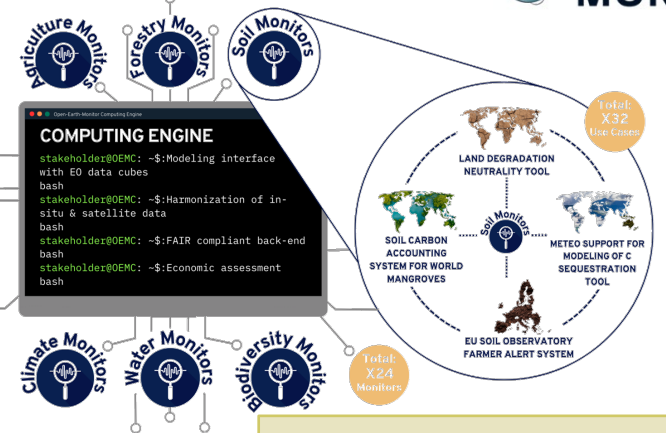
OUR PROJECTS ON EO FOR FLOOD&DROUGHT IN AFRICA

H SAF EUMETSAT



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

OEMC Horizon



<https://earthmonitor.org/>

SEED-FD Horizon



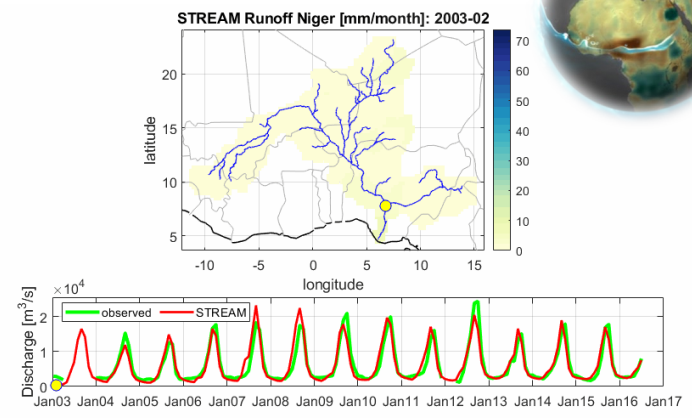
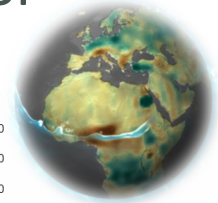
Strengthening Extreme Events Detection for Floods and Droughts

DEVELOPMENT	FLOODS
DANUBE Major transboundary heavily regulated basin - temperate climate	Flood caused by heavy rainfall, melting snow, or a combination of both
BHIMA Heavily managed surface and groundwater system - tropical climate	Monsoon flooding, high inter- and intrannual variability
VALIDATION	FLOODS
NIGER Data scarce semi-arid area with monsoon season and large wetlands	Multiple flash floods in urban areas each year
JUBA-SHEBELLE Data scarce semi-arid area, global hot spot for droughts	Occasional floods due to heavy rains in the headwaters
PARANA Tropical transnational basin, axis for waterway movement	High population density, vulnerable to flash floods

Methodology
The project will be composed of two distinct phases - a scientific development and a scale-up validation phase - linked together by a prototyping stage. On selected Use Cases that are representative examples of worldwide hydrological extremes, plus challenges associated with floods and droughts.

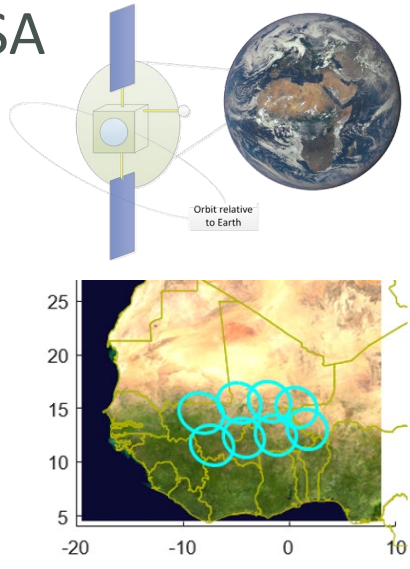
<https://www.seed-fd.eu/>

NGGM-MAGIC ESA+ASI



Hydroterra+ ESA

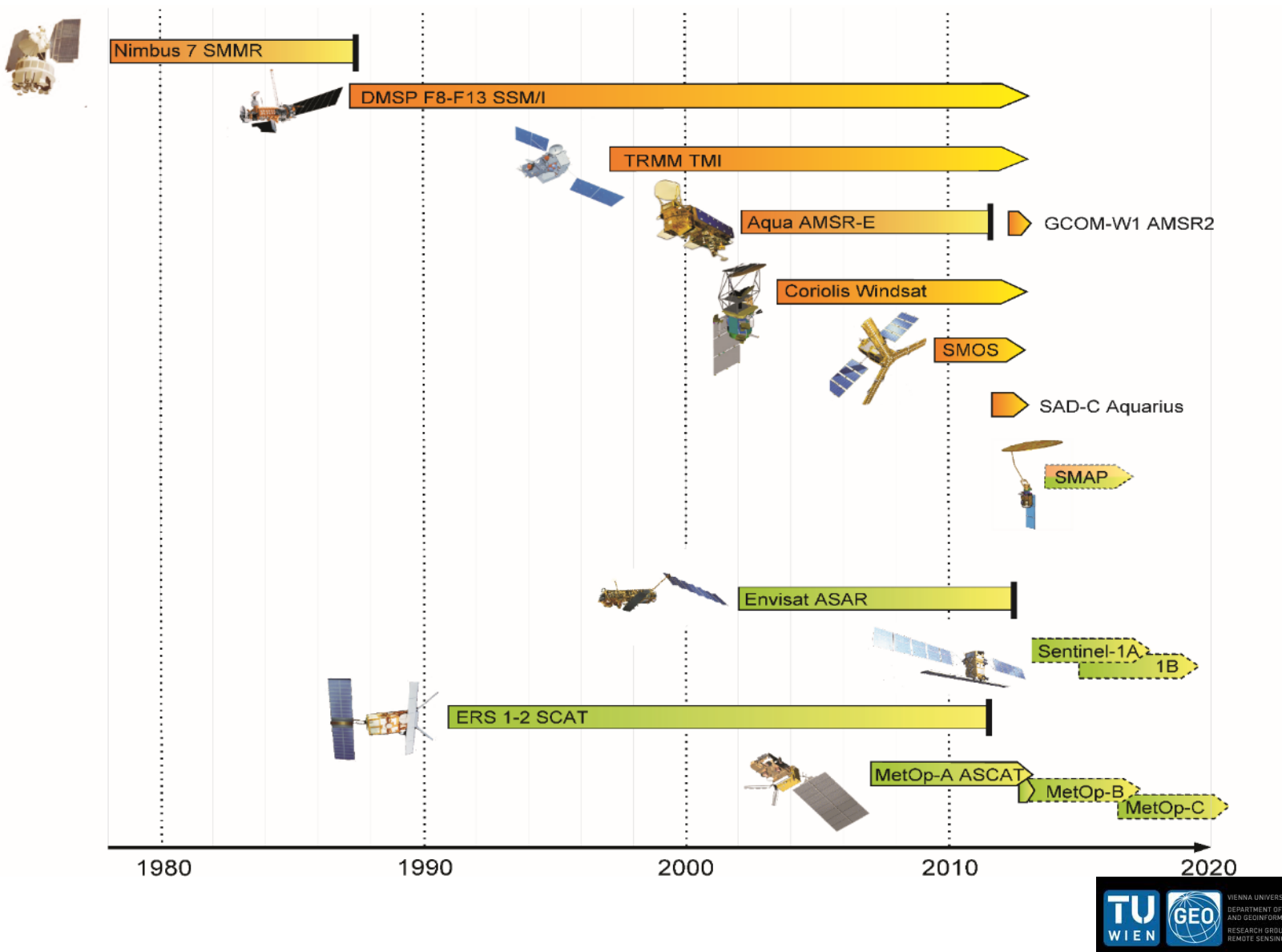
Geosynchronous SAR for measuring sub-daily changes in the water cycle (e.g., precipitation)



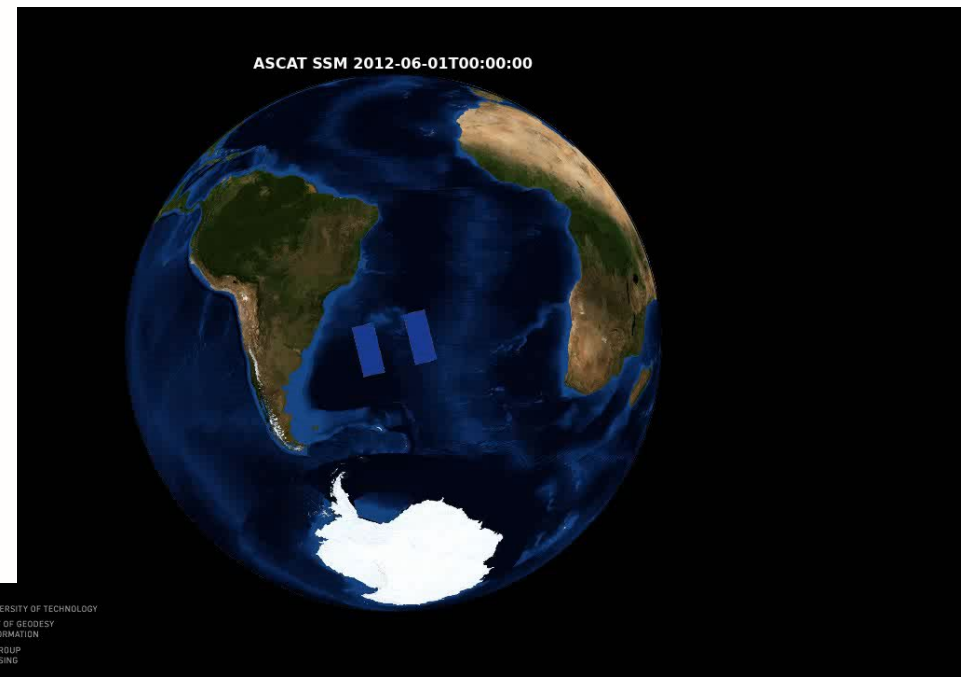
And much more...

...**STREAM-NEXT** (runoff and river discharge from GRACE/-FO for the whole Africa)...**DEMETRAS** (river discharge for Northern Africa test sites)...**4DHYDRO** (flood prediction in South Africa)...submitted\starting projects (**EO Africa – ESA**, **DTE Hydrology Next – ESA**)

REMOTE SENSING OF SOIL MOISTURE



Satellite soil moisture products have been available since November 1978... in fact exactly when I was born... and I look old!

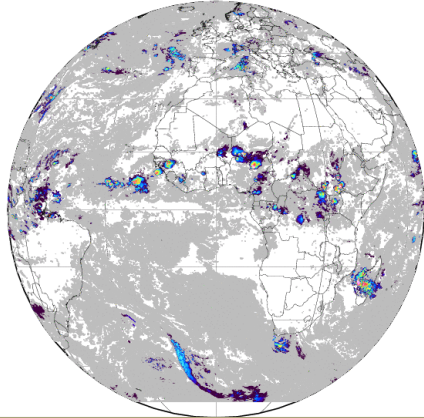


OPERATIONAL SOIL MOISTURE PRODUCTS

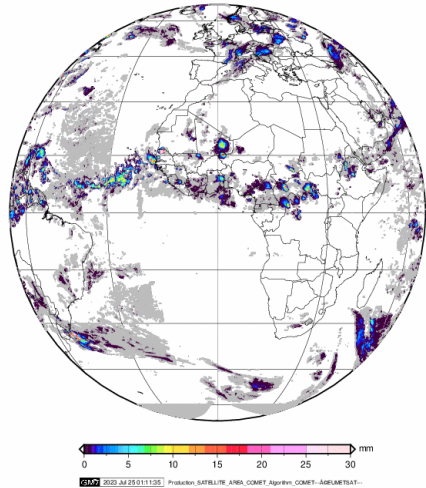
Satellite / Product	Temp. Cov.	Temp. res.	Latency	Spatial sampling	Spatial coverage	Organisation	Access
H SAF ASCAT SSM CDR	2007-	1-2 d	Year	12.5 km	Global	EUMETSAT H SAF	Free
H SAF ASCAT SSM NRT	2007-	1-2 d	1 d	12.5 km	Global	EUMETSAT H SAF	Free
ESA CCI SSM	1978-	1-2 d	Year	0.25°	Global	ESA	Free
C3S SSM	1978	10 d	10d	0.25°	Global	Copernicus	Free
CGLS ASCAT SWI	2007-	Daily	3 d	0.1°	Global	CGLS	Free
SMOS L2 SSM	2010-	1-2 d	1 d	36 km	Global	ESA	Free
SMAP L3 SSM	2015-	1-2 d	1 d	36 km	Global	NASA	Free
CGLS S-1 SSM	2015-	3-24 d	1 d	0.5 km	Europe	CGLS	Free
CGLS SCATSAR SWI	2015-	1-2 d	3 d	0.5 km	Europe	CGLS	Free
VanderSat	2002-	Daily		100m	request	VanderSat	Paid

REMOTE SENSING OF PRECIPITATION

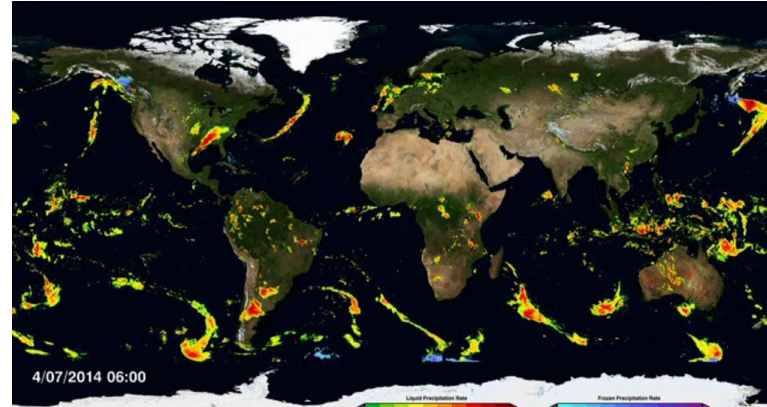
H SAF H60: 2020 to present
Rain Rate, 15-min, 0.05-degree



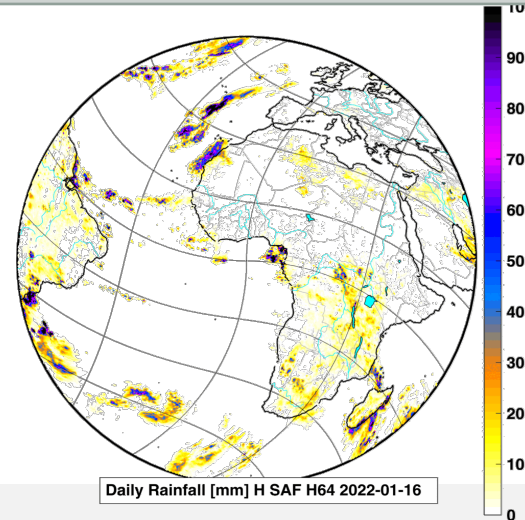
H SAF H61: 2020 to present
Accum. Prec., 1-24 h, 0.05-degree



GPM IMERG: 2000 to present,
Rain Rate, 30-min, 0.1-degree

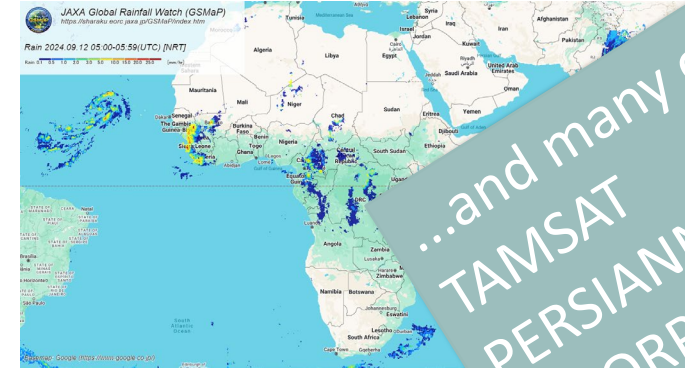


H SAF H64: 2020 to present,
Accum. Prec., 24-h, 0.25-degree

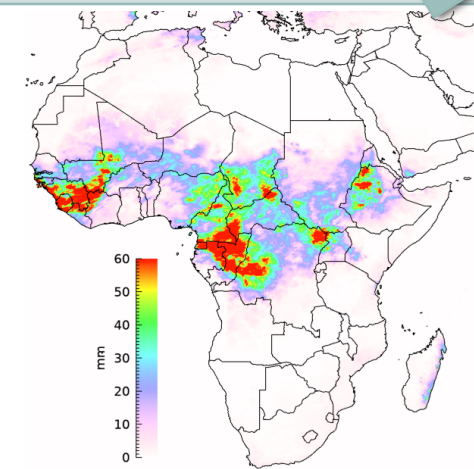


Daily Rainfall [mm] H SAF H64 2022-01-16

GSMaP: 2000 to present
Rain Rate, 1-h, 0.1-degree



CHIRPS: 1981 to present,
Accum. Prec., 24-h, 0.05-degree

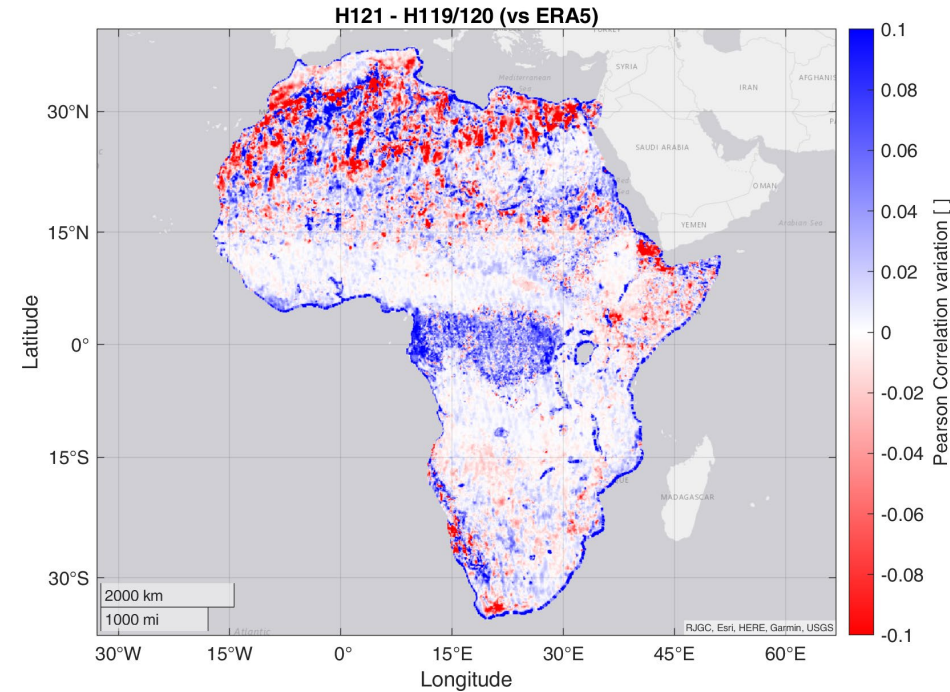
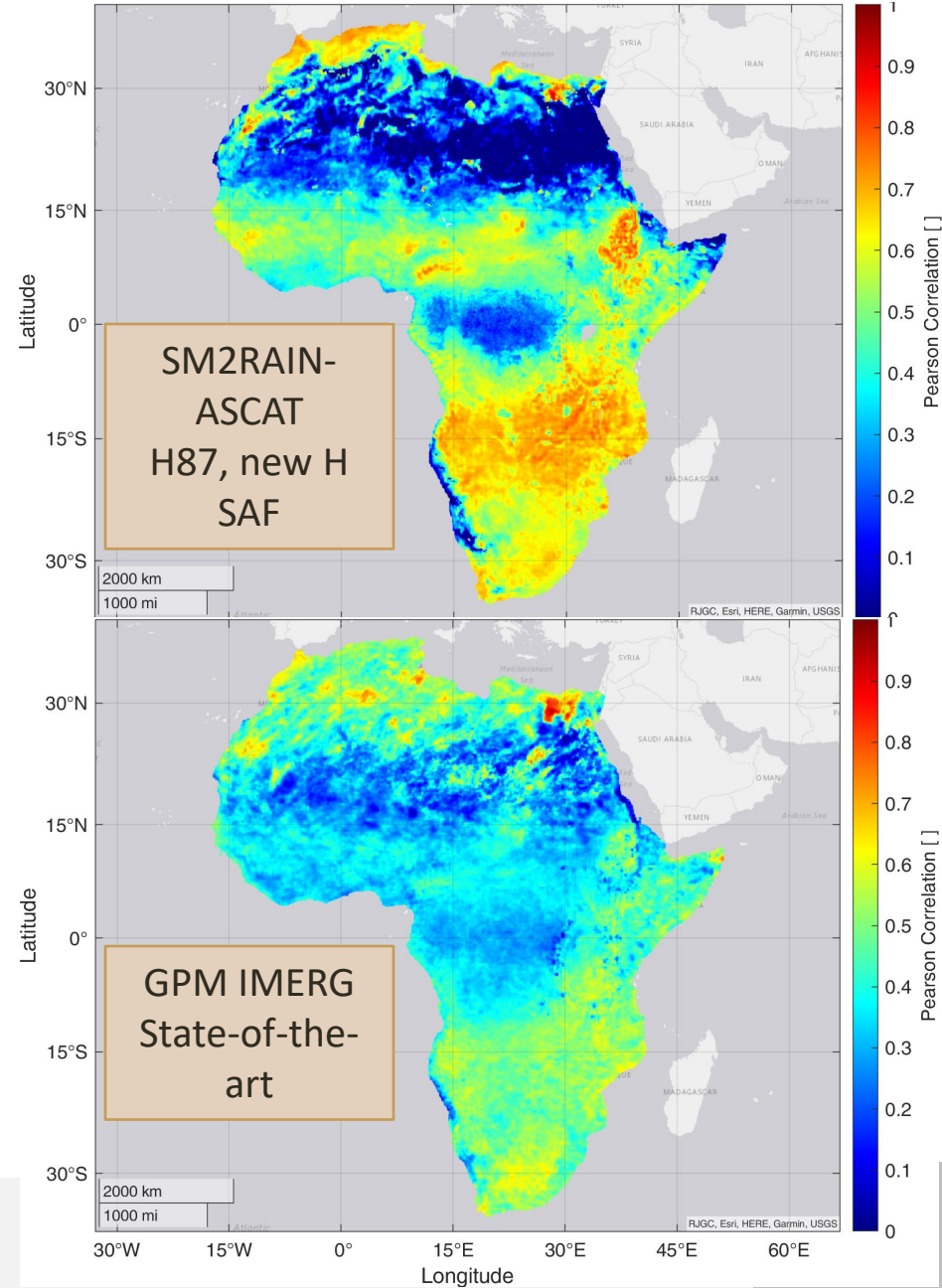


...and many others:
 TAMSAT
 PERSIANN
 CMORPH

IMPROVING H SAF PRECIPITATION OVER AFRICA

Correlation improvement (blue) and deterioration (red) of the new precipitation product.

The new precipitation product performs very well where it rains (not in the desert) and better than state-of-the-art products (reference ERA5...to be improved, see the poster)



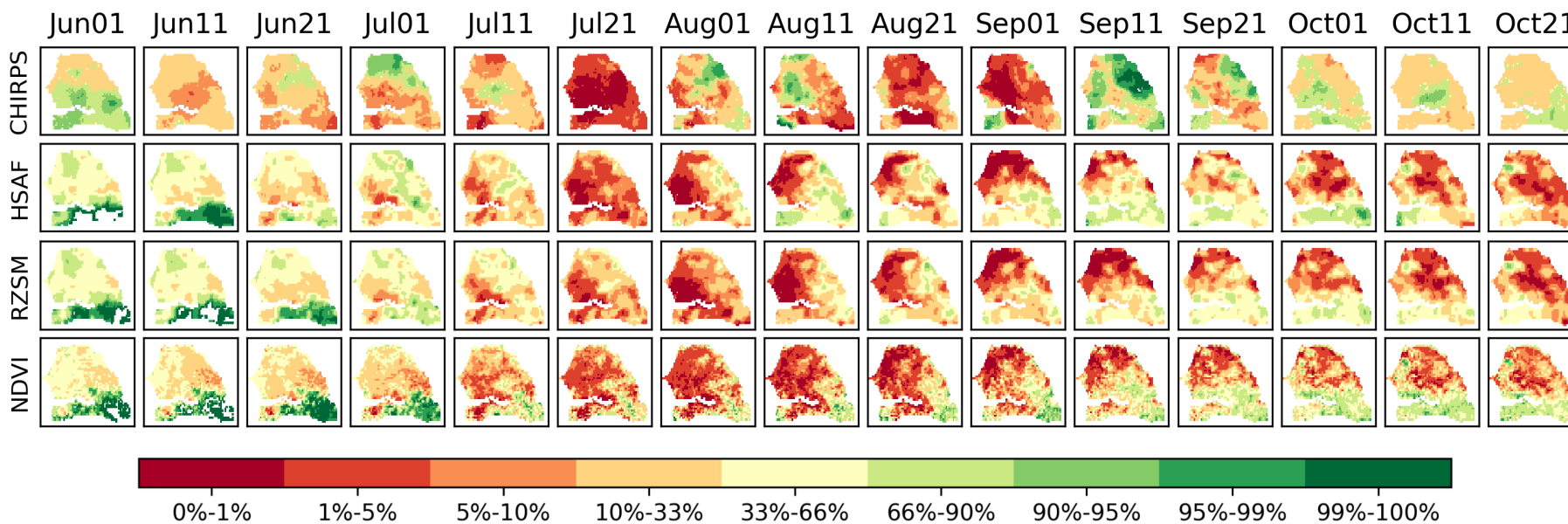
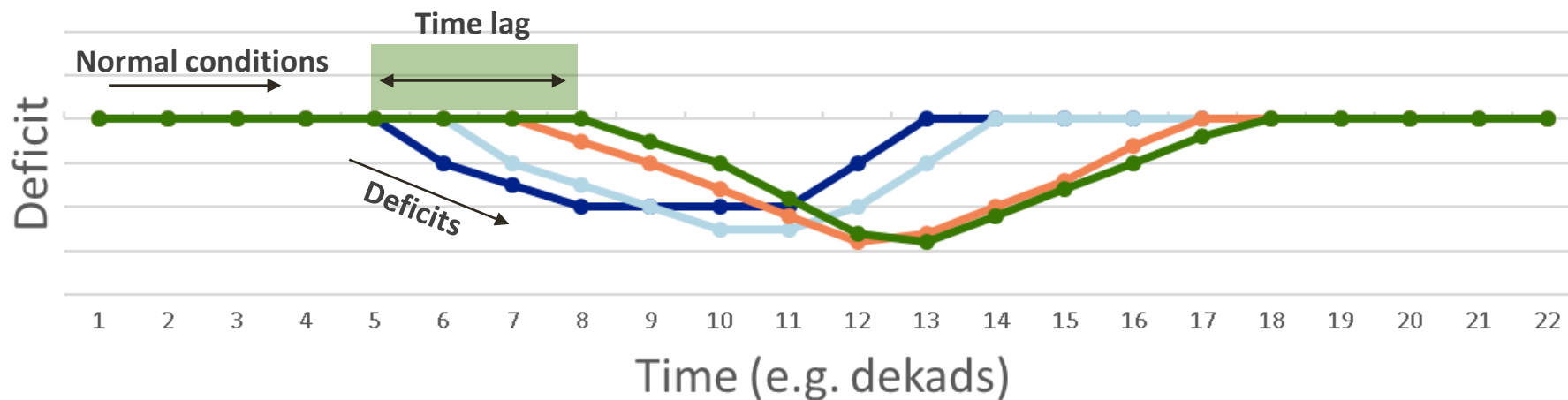
#39: Poster presentation by Filippucci P.
 “Rainfall estimation in the African continent:
 an optimized integrated product”

DROUGHT

Drought monitoring and
yield prediction with H SAF
soil moisture and
precipitation products



DROUGHT MONITORING IN SENEGAL



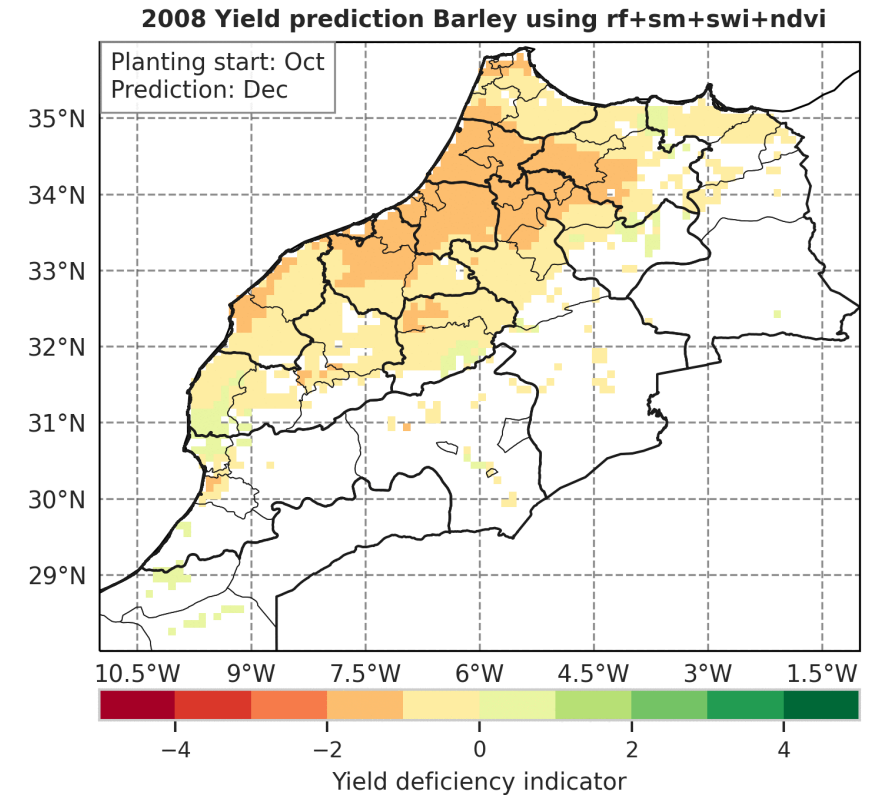
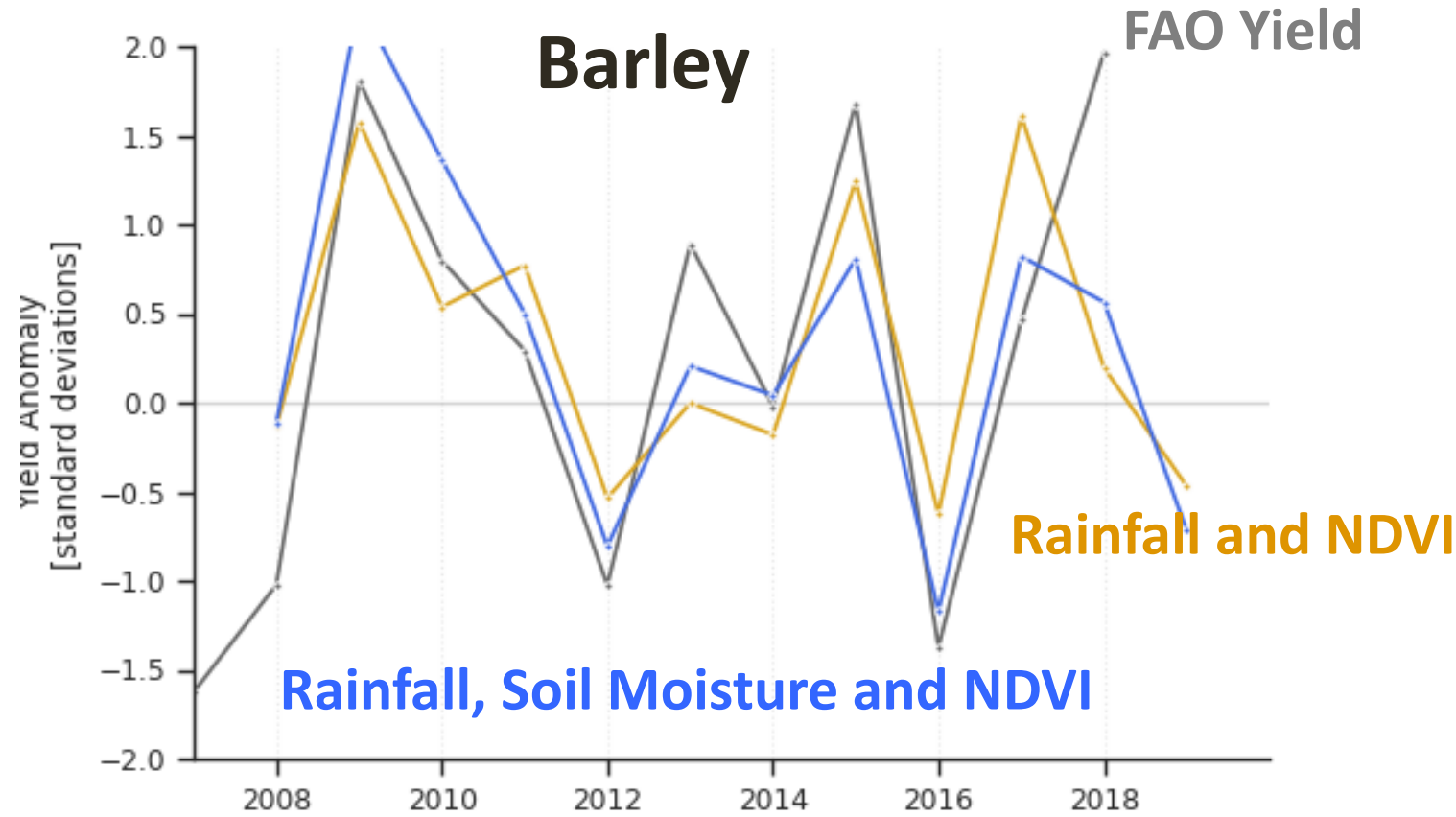
2014 drought in Senegal

By exploiting multiple variables (rainfall, surface and root-zone soil moisture, vegetation) we can monitor drought in time

Vreugdenhil et al. 2022 (Frontiers in Water)

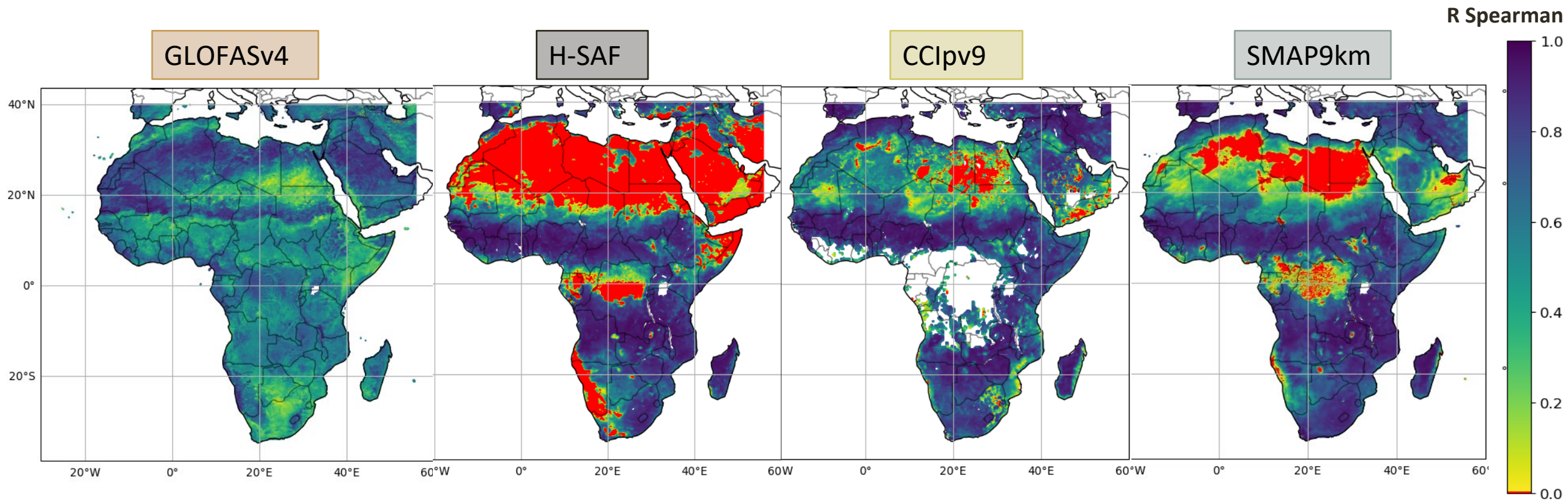
YIELD PREDICTION IN MOROCCO

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



Vreugdenhil et al. 2022 (Frontiers in Water)

DROUGHT MONITORING IN AFRICA



#43: Poster presentation by Gaona J.
"Intercomparison of remote sensing and soil moisture modelling products for operational drought monitoring over Africa"

FLOOD

Extreme events monitoring
and **flood prediction** with H
SAF soil moisture and
precipitation products

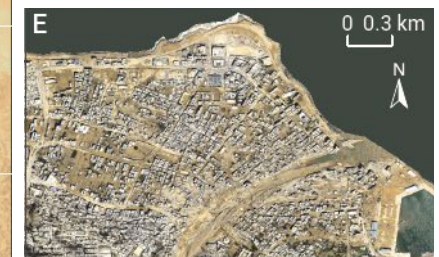
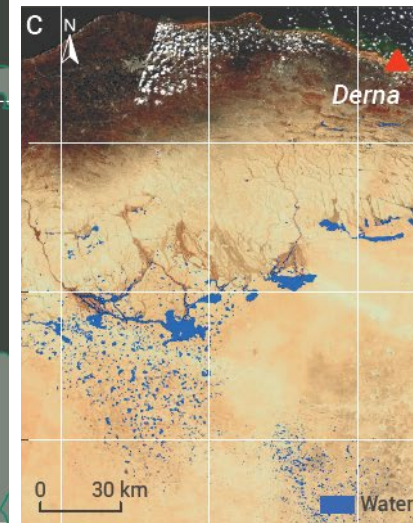
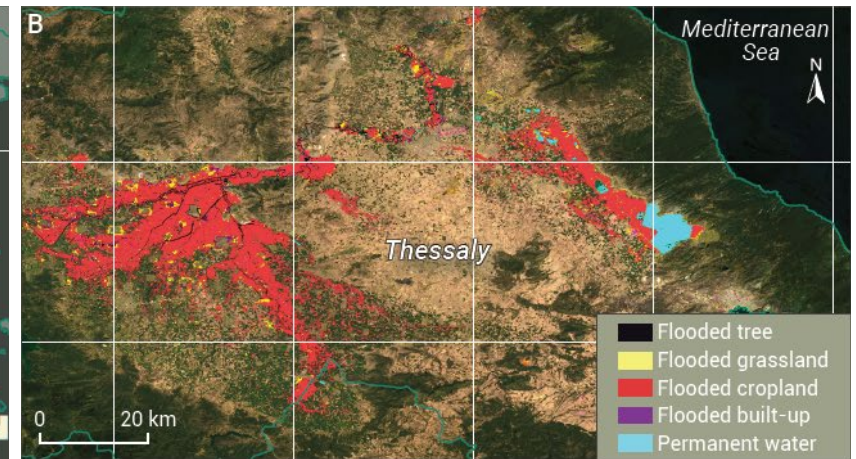
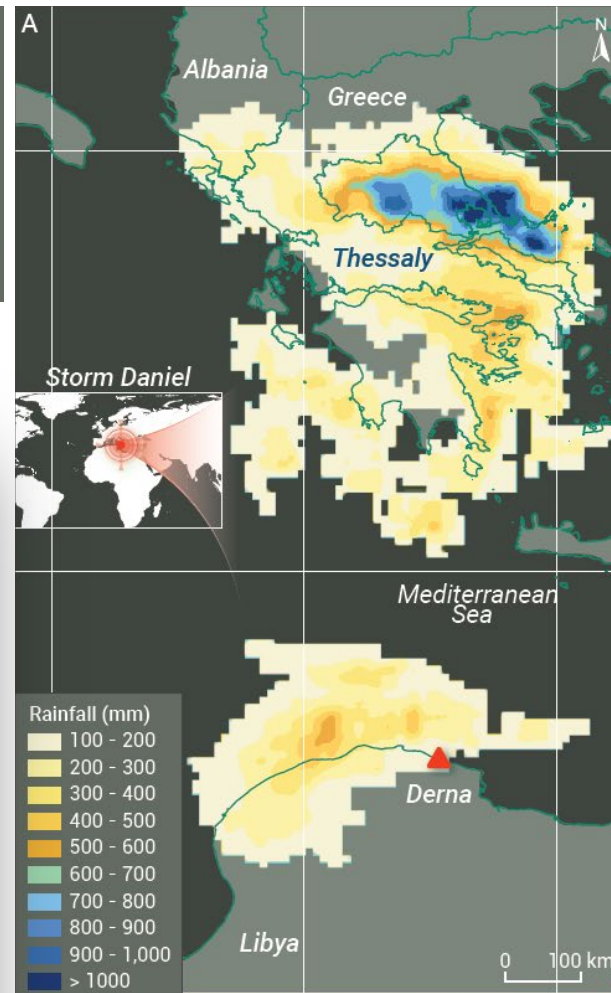
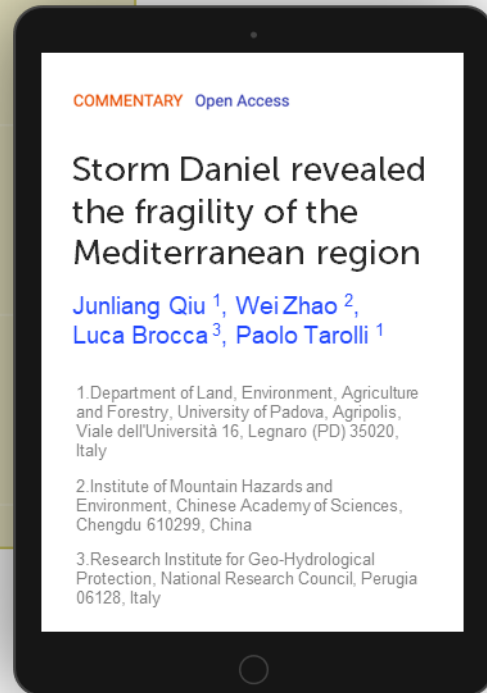


875 km² flooded area in Greece

¼ agricultural production wiped out

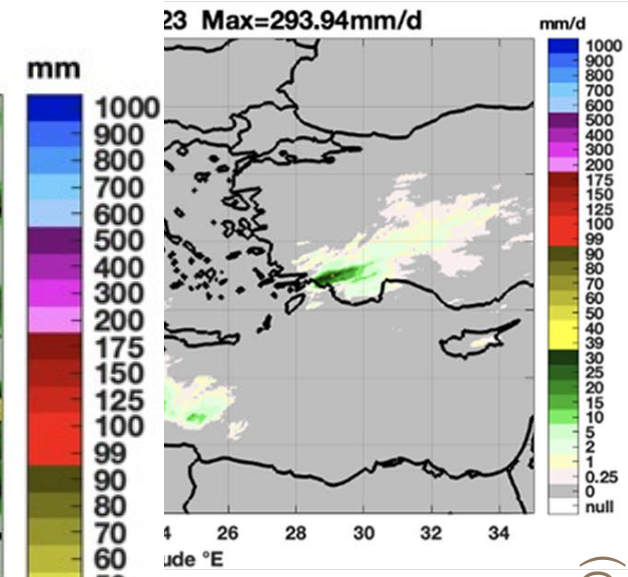
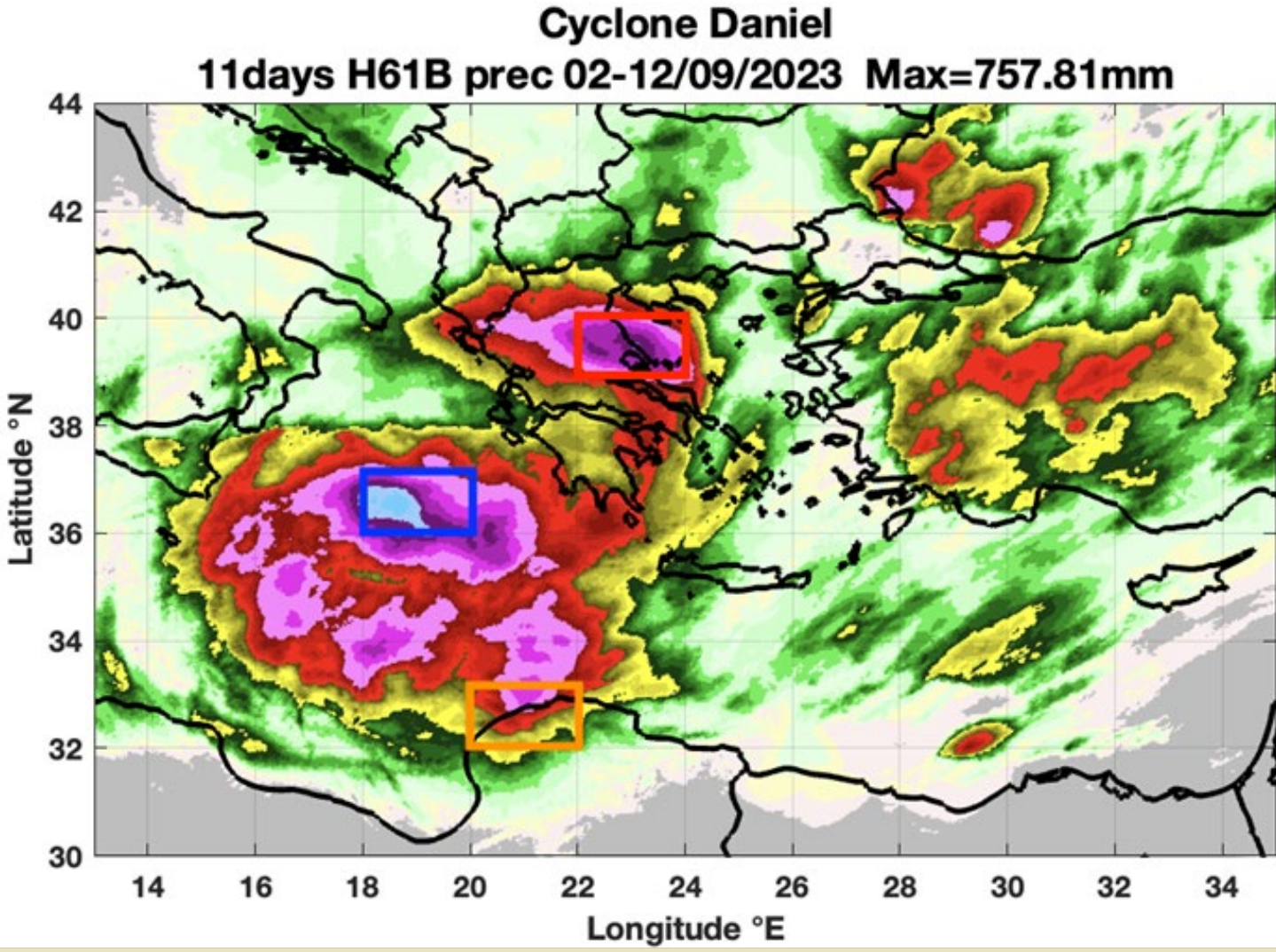
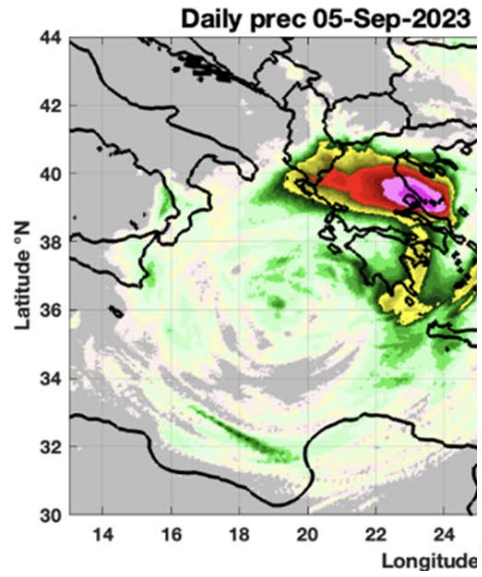
Flooding in the desert

11,000 casualties (18-20,000 estimated)



EXTREME EVENT MONITORING – STORM DANIEL

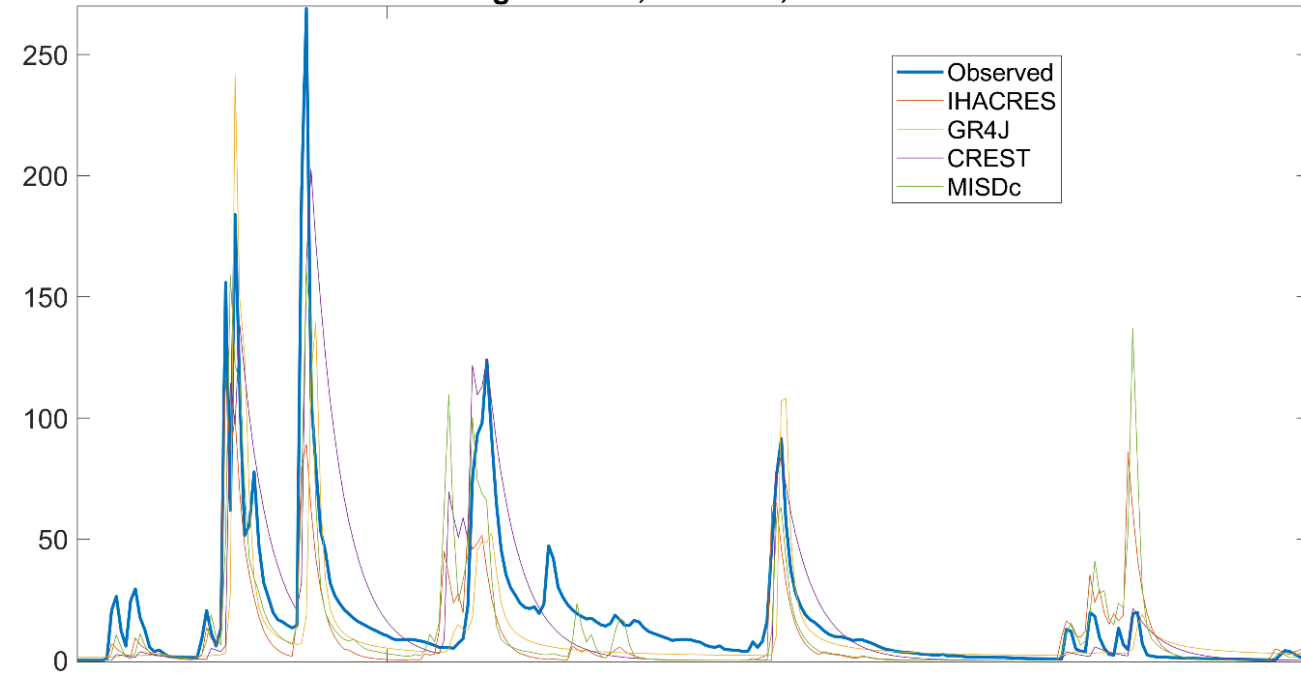
September 2023



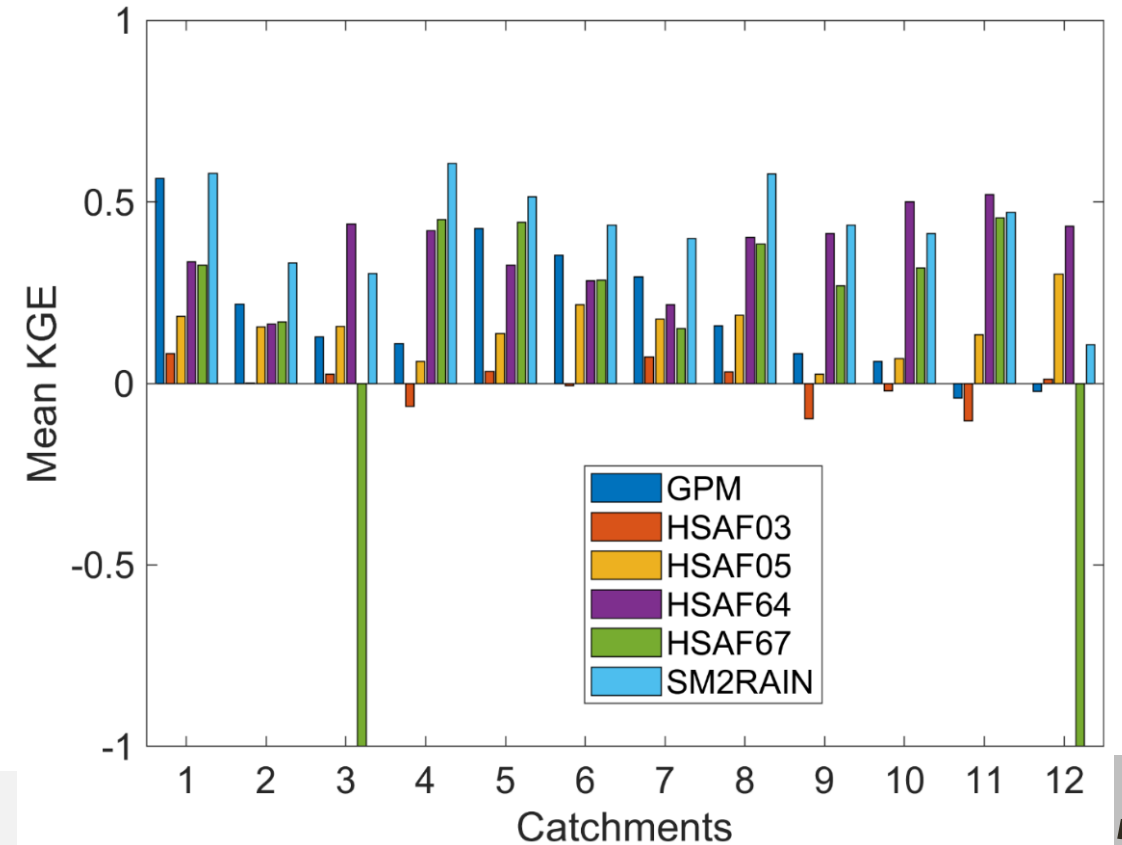
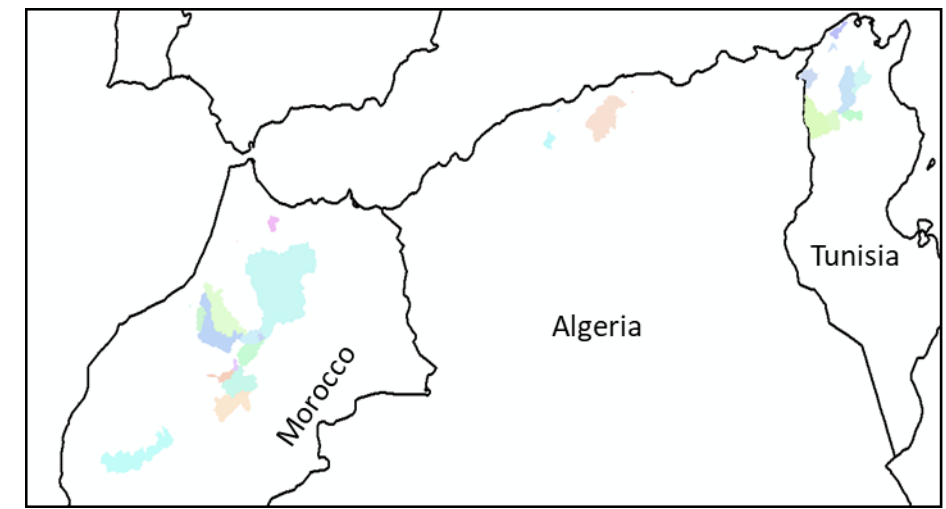
<https://user.eumetsat.int/resources/case-studies/extreme-floods-in-libya-and-central-greece>

FLOOD PREDICTION IN NORTH AFRICA

AguibatZiar, Morocco, 3650km²



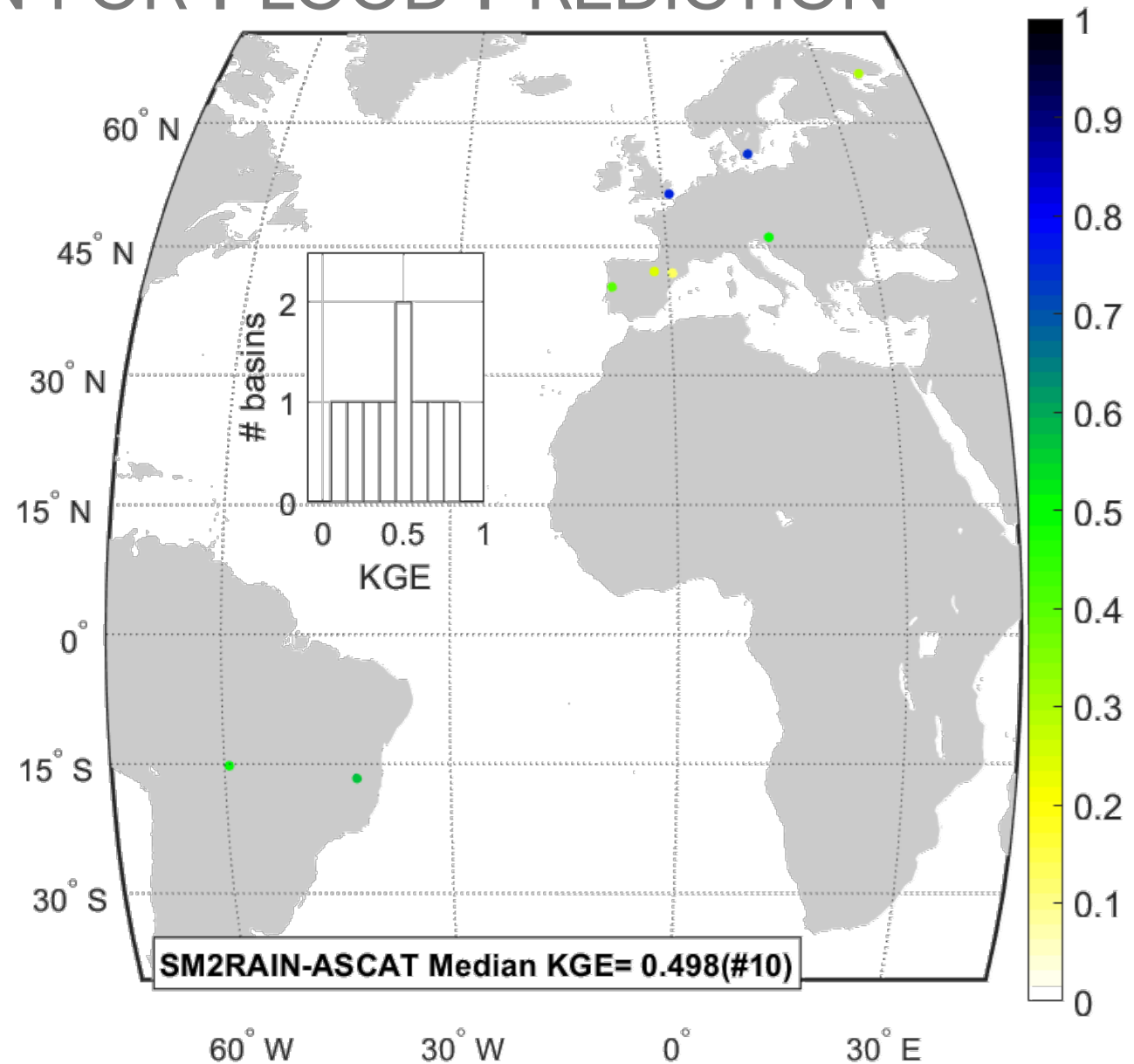
During an H SAF visiting scientist activity, different H SAF precipitation products were tested in 12 basins in northern Africa highlighting their good prediction capabilities in most of the basins.



Tramblay et al. 2023 (HSJ)

SATELLITE PRECIPITATION FOR FLOOD PREDICTION

Integration of rainfall obtained from satellite soil moisture measurements with state-of-the-art rainfall observations allows significant improvement in flood forecasting. A total of 2273 basins were analysed on a global scale with good results particularly in south Brazil, west Africa, and in the Mediterranean region.

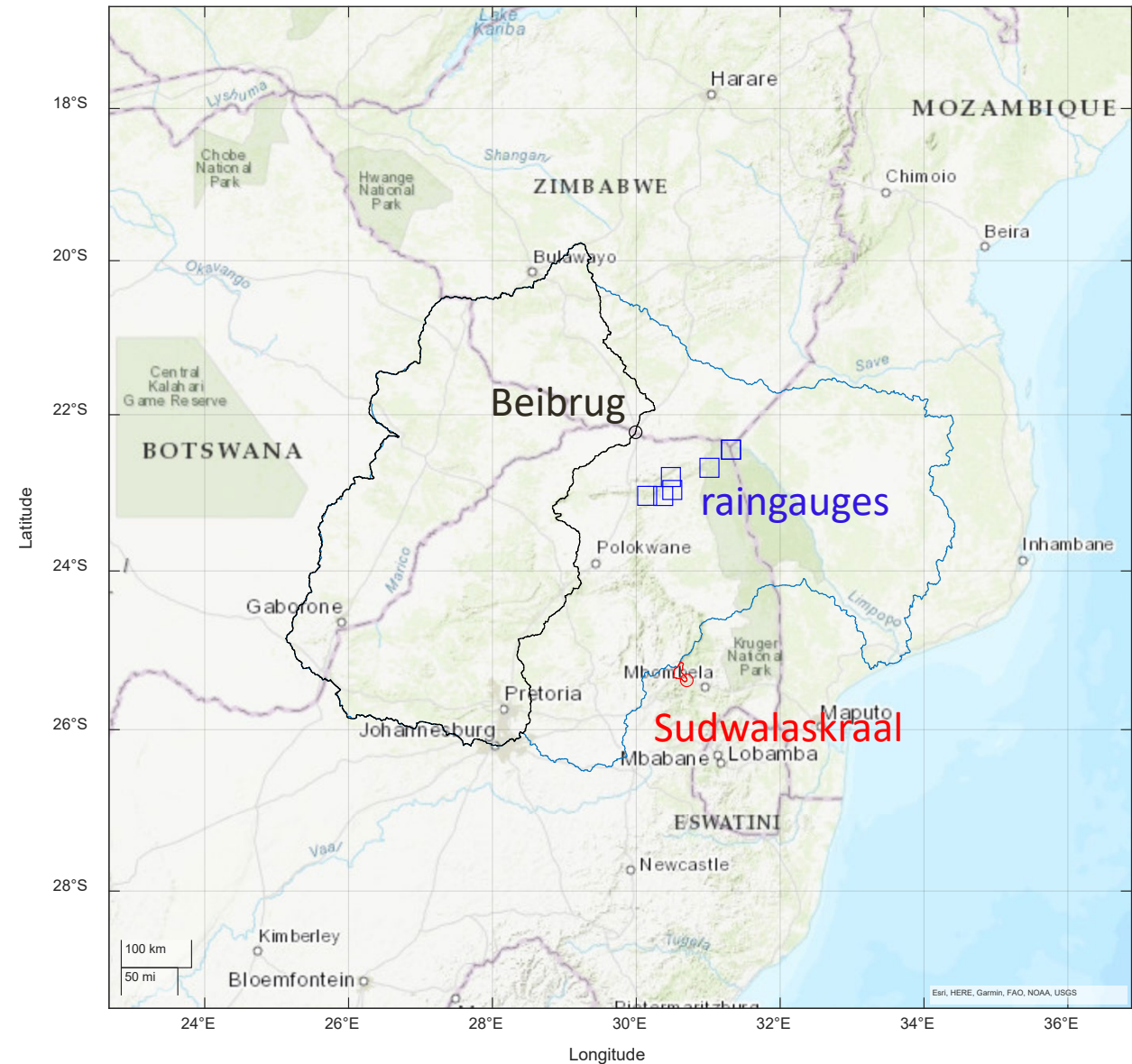


Camici et al (2018 JoH; 2020 HESS)
Brocca et al (2020 SREP); Almagro et al (2021 JoH)

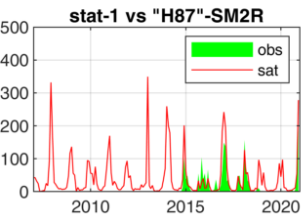
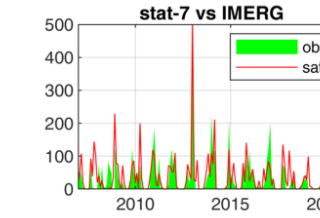
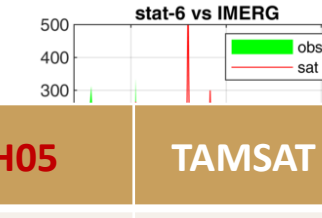
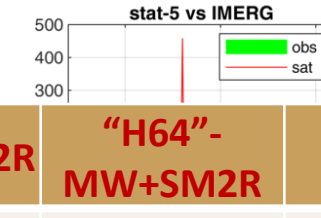
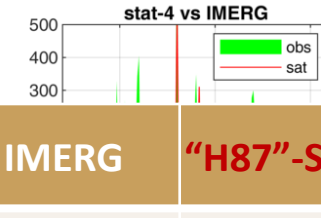
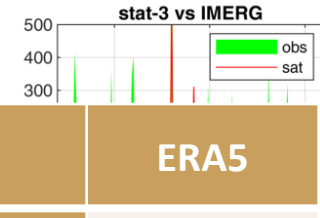
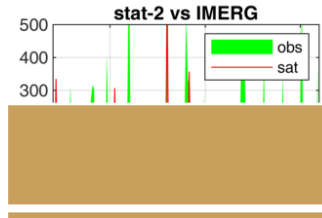
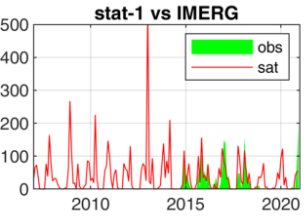
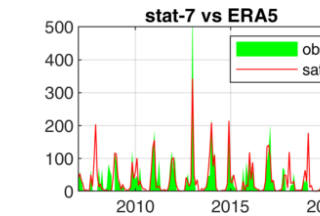
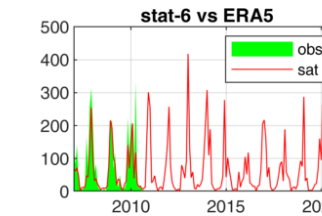
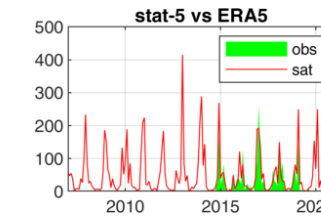
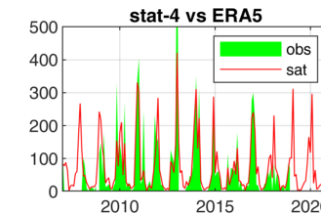
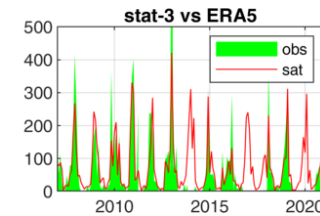
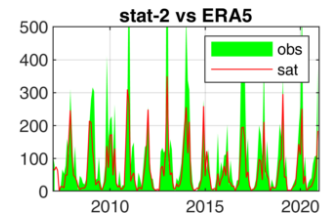
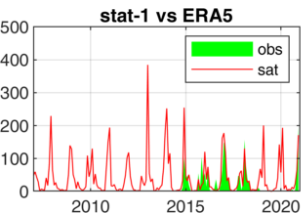
LIMPOPO BASIN

Professor Timothy Dube provided us rain gauge data over the Limpopo Basin that we have just compared with different satellite precipitation products.

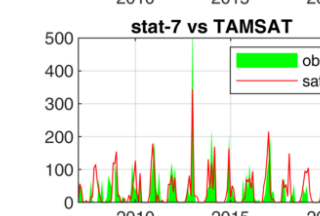
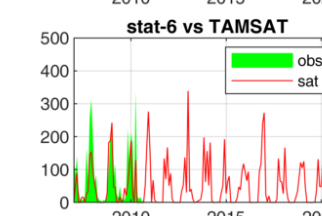
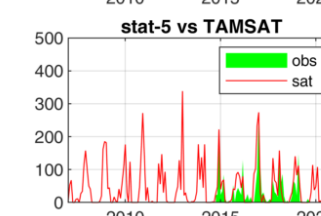
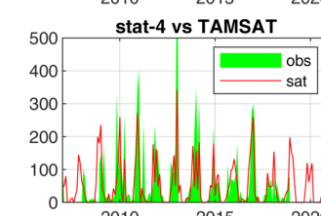
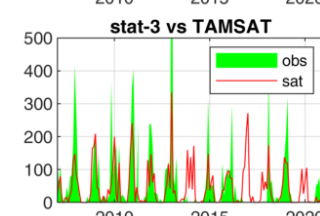
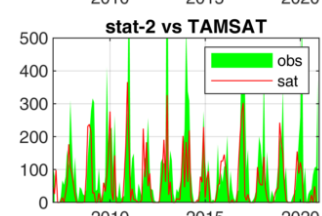
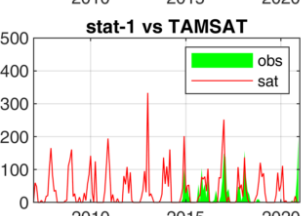
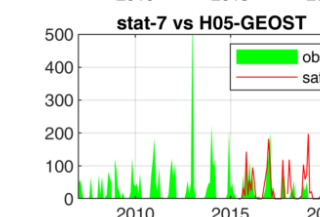
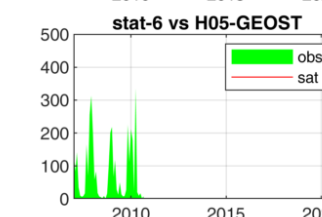
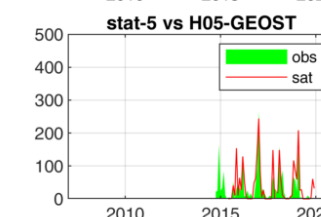
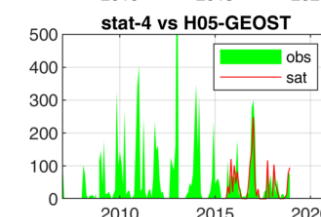
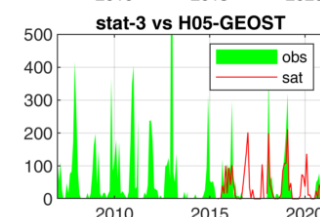
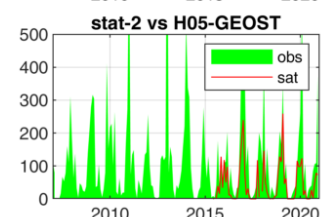
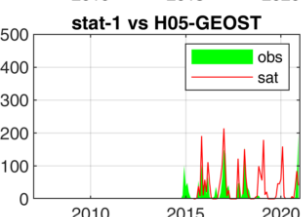
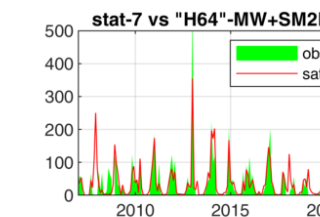
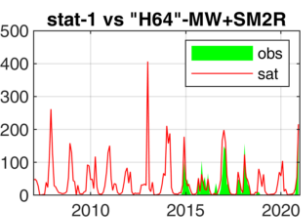
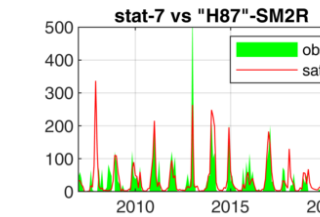
Moreover, we carried out the hydrological validation for the Limpopo basin @ Beibrug by using GRDS river discharge data and different satellite precipitation products.



SATELLITE VS GAUGE-BASED PRODUCTS @ LIMPOPO BASIN

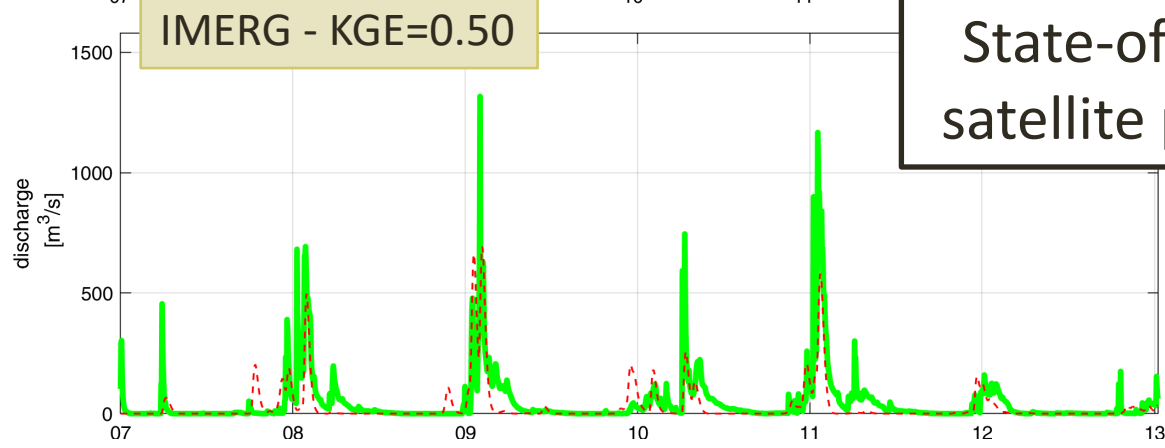
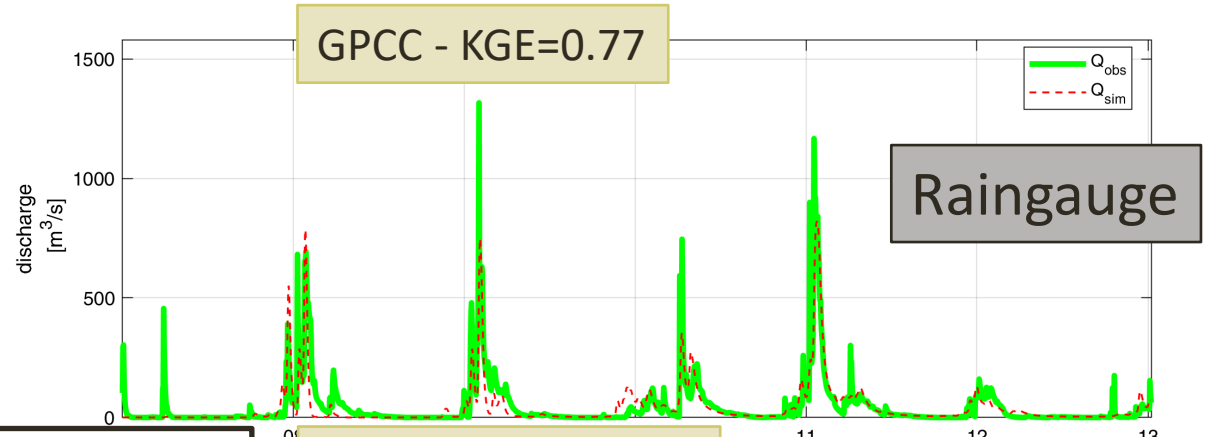
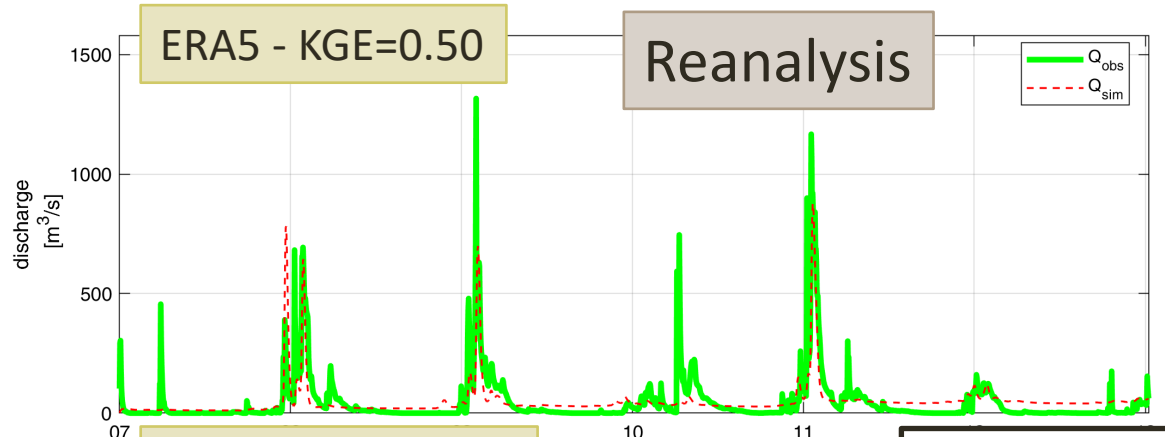


	ERA5	IMERG	"H87"-SM2R	"H64"-MW+SM2R	H05	TAMSAT
MUTELE	0.60	0.61	0.80	0.82	0.57	0.49
LEVUBU - CITIMBA	0.87	0.76	0.88	0.91	0.78	0.63
UNIVERSITY OF VENDA	0.71	0.72	0.61	0.68	0.61	0.64
LWAMONDO	0.84	0.84	0.79	0.86	0.80	0.71
SUMBANA	0.80	0.70	0.83	0.87	0.81	0.74
TSHIOMBO	0.88	0.86	0.86	0.93	n.a.	0.78
SIGONDE	0.75	0.80	0.64	0.77	0.61	0.72
MEAN	0.78	0.76	0.77	0.83	0.70	0.67

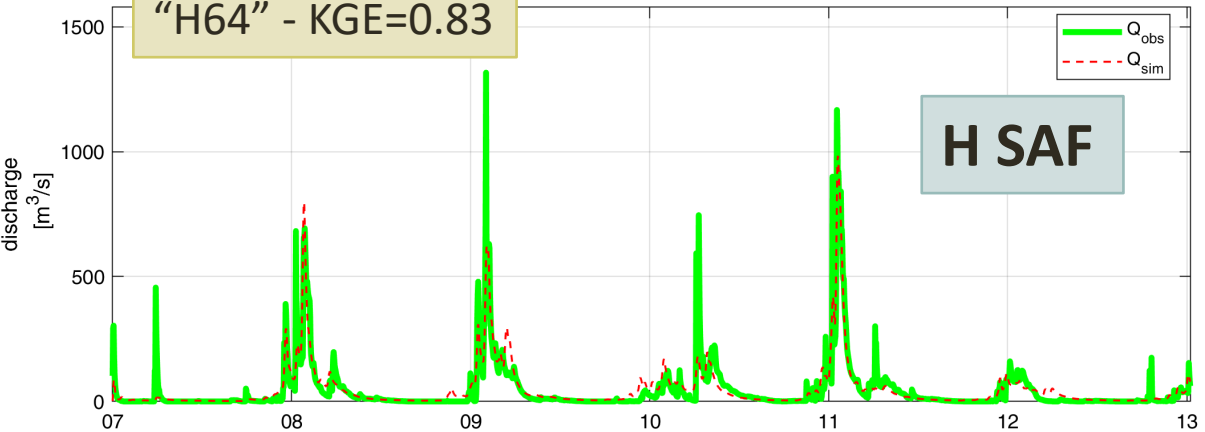
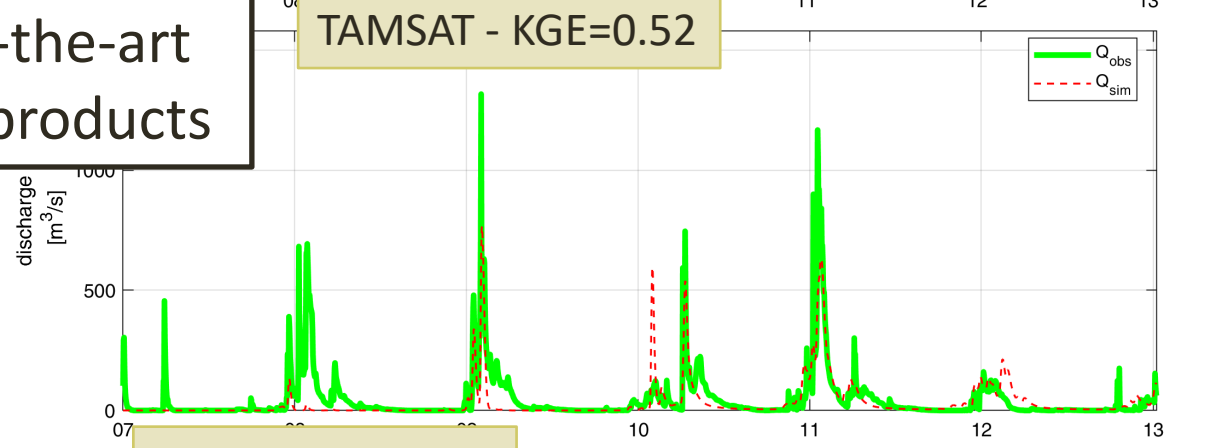


FLOOD PREDICTION @ LIMPOPO BASIN

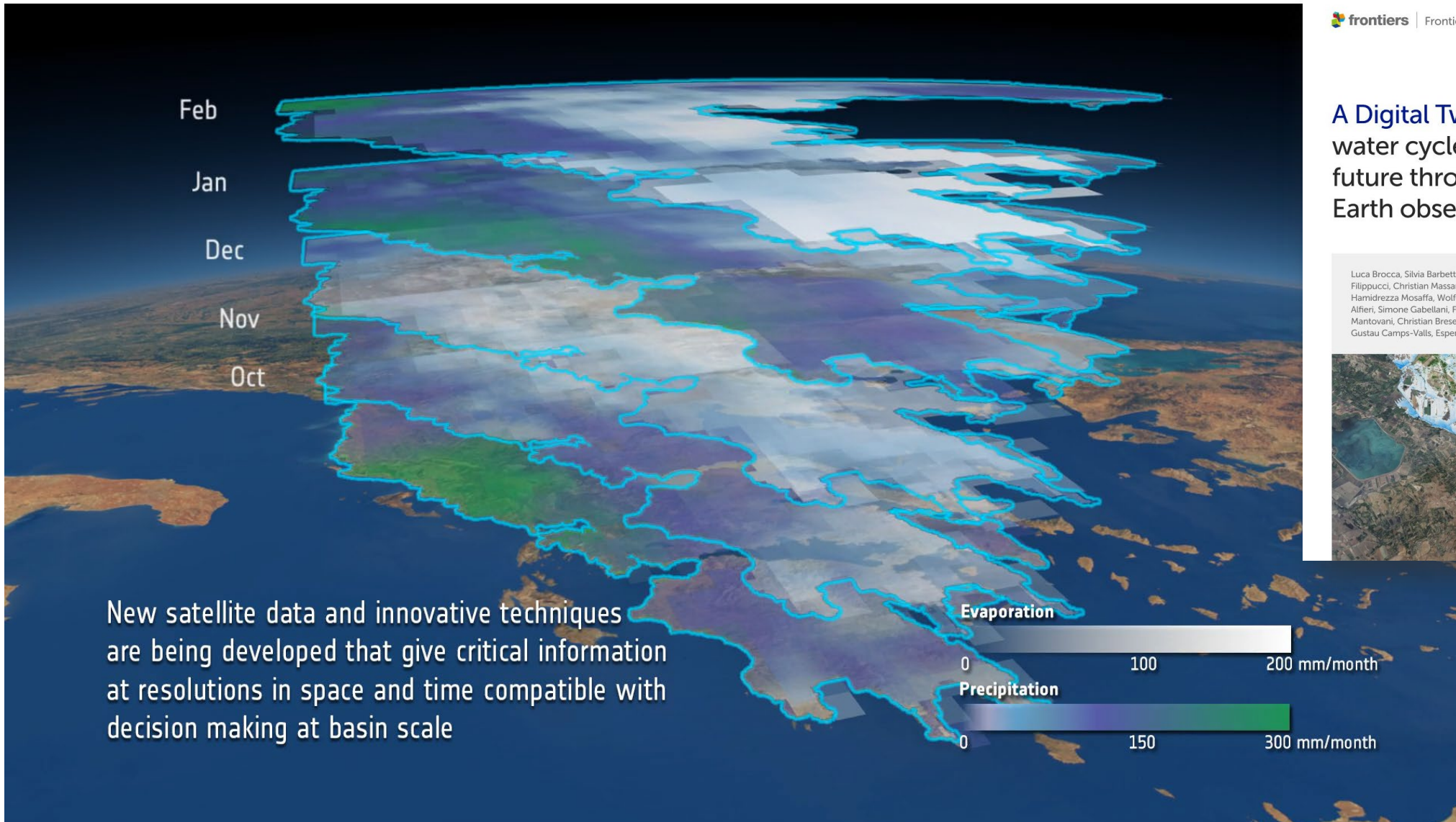
LIMPOPO @ BEIBRUG



State-of-the-art satellite products



HIGH-RESOLUTION HYDROLOGY FROM SPACE



frontiers | Frontiers in Science

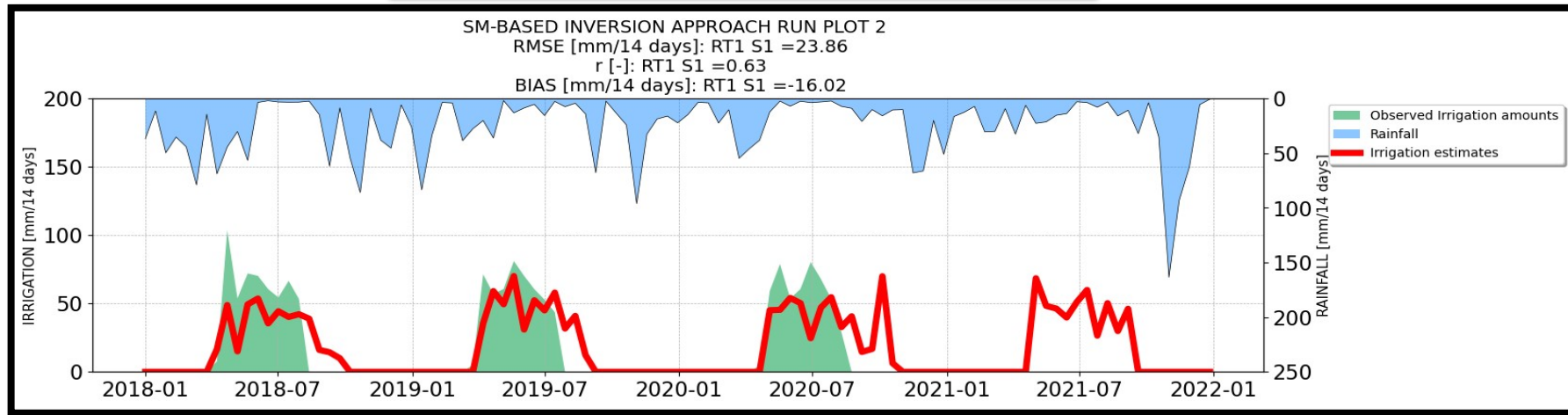
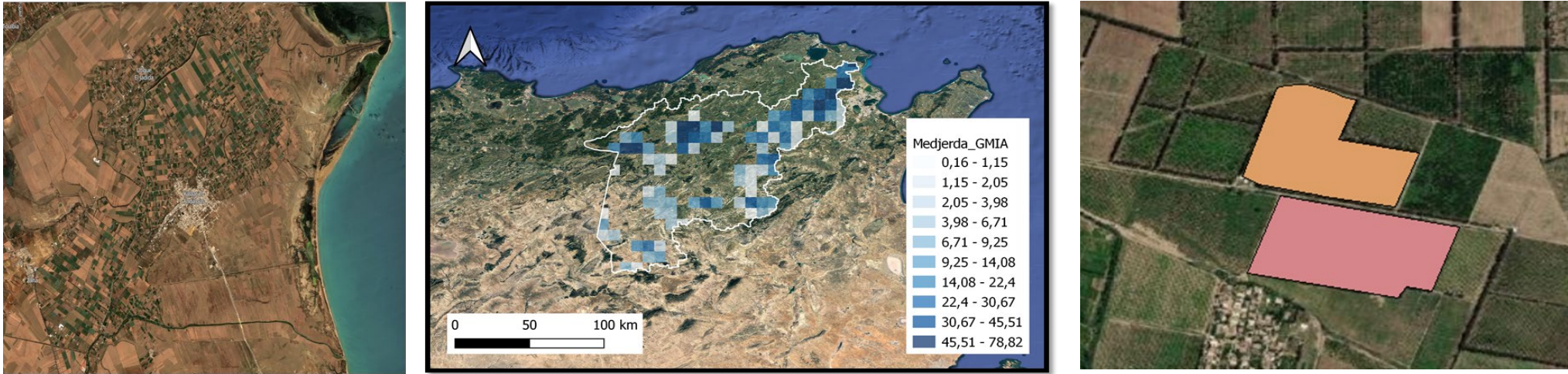
A Digital Twin of the terrestrial water cycle: a glimpse into the future through high-resolution Earth observations

Luca Brocca, Silvia Barbeta, Stefania Camici, Luca Ciabatta, Jacopo Dari, Paolo Filippucci, Christian Massari, Sara Modanesi, Angelica Tarpanelli, Bianca Bonaccorsi, Hamidreza Mosaffa, Wolfgang Wagner, Mariette Vreugdenhil, Raphael Quast, Lorenzo Alfieri, Simone Gabellani, Francesco Avanzi, Dominik Rains, Diego G. Miralles, Simone Mantovani, Christian Brese, Alessio Domeneghetti, Alexander Jacob, Mariapina Castelli, Gustau Camps-Valls, Espen Volden and Diego Fernandez



Brocca et al. (2024; FSCI)

HIGH-RESOLUTION IRRIGATION WATER USE IN AFRICA



#63: Poster presentation by Liaquat U.
“High resolution remotely sensed irrigation estimates in Africa”

TAKE HOME MESSAGE(S)

- H SAF Satellite soil moisture and precipitation products are available in near real-time, and long-term
 - Their use for **drought** monitoring, **yield prediction**, **extreme event** monitoring and **flood** prediction in South Africa will certainly represent an advance in knowledge and will be extremely relevant for real-world operational applications. In some cases, **satellite products performed even better than ground and model (reanalysis) data.**
- Data availability from space for hydrological application is not an issue!
 - **Capacity building** will play a big role for the exploitation of satellite observations (data access, data reading, data understanding, data use, school, lectures, on site training, ...)



luca.brocca@irpi.cnr.it



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



@HydroSAF
@HydrologyNext