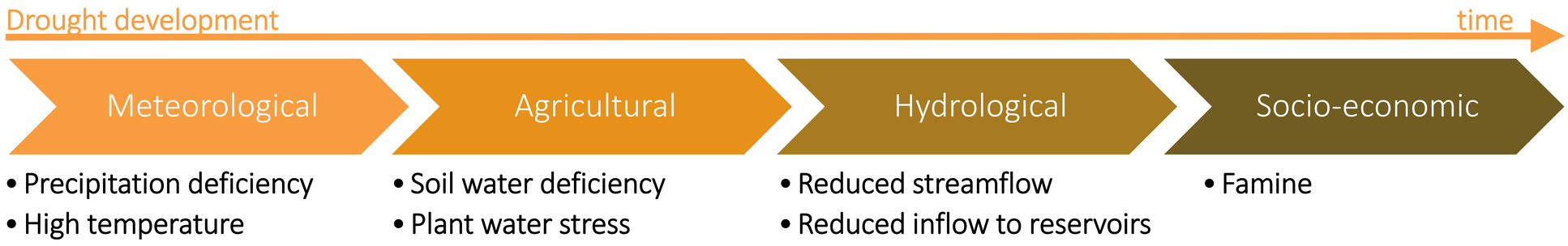
Satellite soil moisture for drought risk insurance

Mariette Vreugdenhil[1], Isabella Greimeister-Pfeil[1,2], Wolfgang Preimesberger[1], Stefania Camici[3], Markus Enenkel[4], Luca Brocca[3], and Wolfgang Wagner[1]

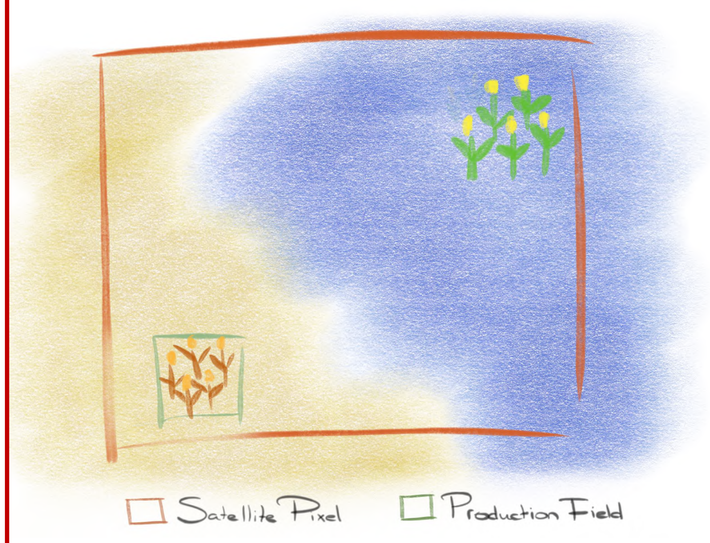
1 TU Wien, Remote Sensing Research Area, Department for Geodesy and Geoinformation, Austria, 2 Umweltbundesamt, Austria, 3 Research Institute for Geo-Hydrological Protection, National Research Council, Italy , 4 Disaster Risk Financing and Insurance Program, World Bank, Washington DC, USA

Motivation

Can we improve drought monitoring and yield prediction using satellite data?



Challenge 1: Basis Risk



Drought insurance based on precipitation and temperature are subject to errors related to distance to the nearest weather station or pixel size of the dataset. This may lead to missing payouts.

Challenge 2: Used Indicators

Meteorlogical indicators: Satellite and station rainfall and temperature
Excludes evaporation and runoff. Depends on station network density.

Vegetation indicator: Satellite Normalized Difference Vegetation Index (NDVI)
Affected by cloud cover
Late indicator of stress

Solution: Use Soil Moisture

Direct indicator of soil water deficiencies and thus direclty related to plant available water. Can be retrieved from satellite data.

High spatial resolution (1-25 km), all-weather observation capacity, 1-2 day revisit time, near-real-time.

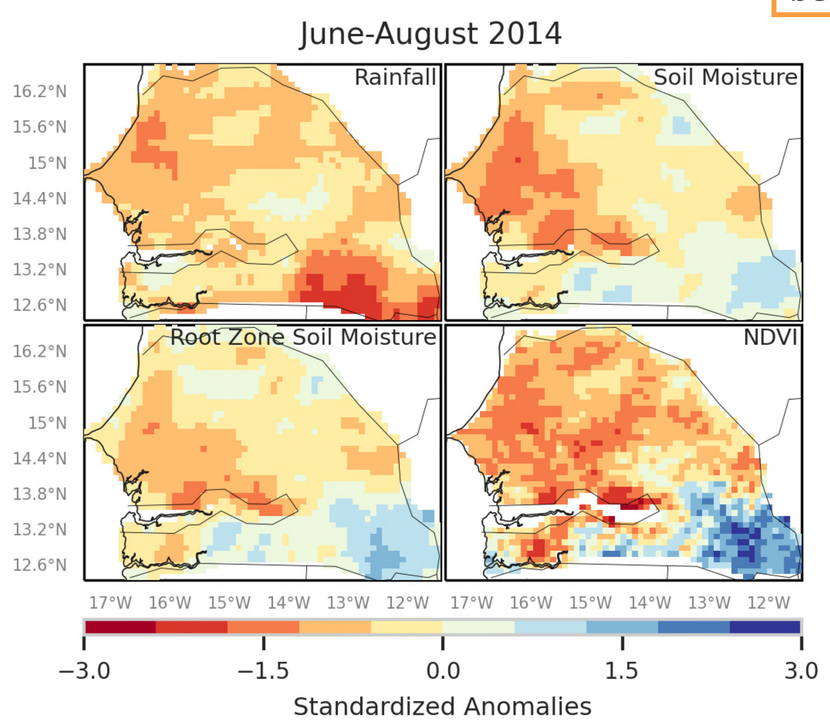
Drought monitoring for Food Security

With drought monitoring we want to **identify areas where crop growth is affected by drought**: which product shows the best correspondence to vegetation indicator NDVI?

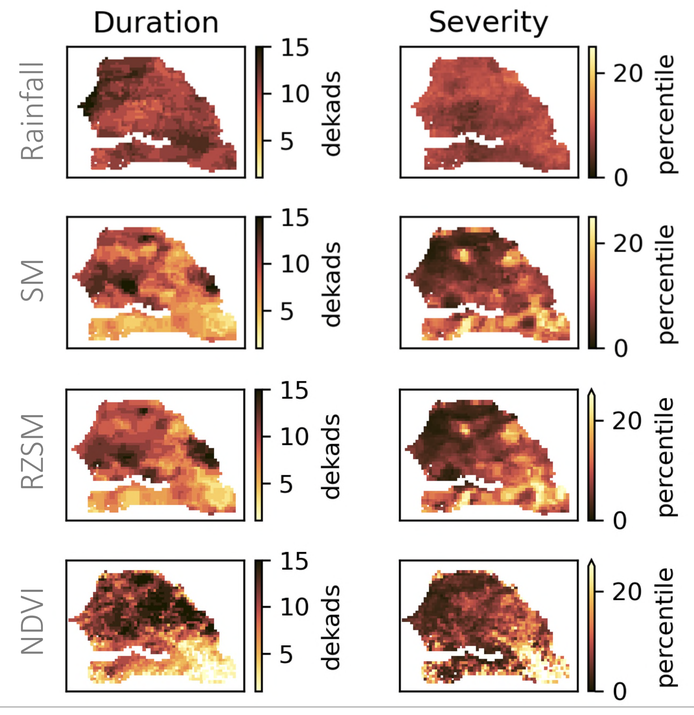
Case study: Senegal

- Rainfall — Station & Satellite
- Surface Soil Moisture — Satellite
- Root Zone Soil Moisture — Satellite
- NDVI — Satellite

Calculate decadal or monthly anomalies from climate normal (long-term climatology) per gridpoint for all datasets



Set thresholds for drought levels (from mild to extreme) to calculate drought duration and severity

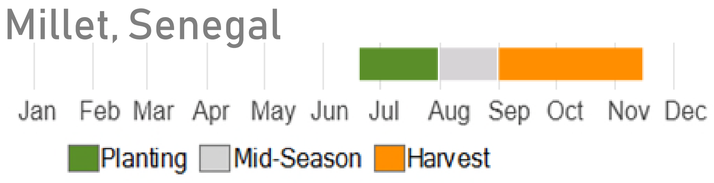


Take Home Message 1

Compared to rainfall **spatial patterns of soil moisture correspond better to NDVI**, providing reliable information on drought.

Early warning: Yield Deficiency Prediction

We want to **predict future yield deficiencies as early and as accurate as possible** (start of season) in order to take early action and provide reliable drought risk insurance.



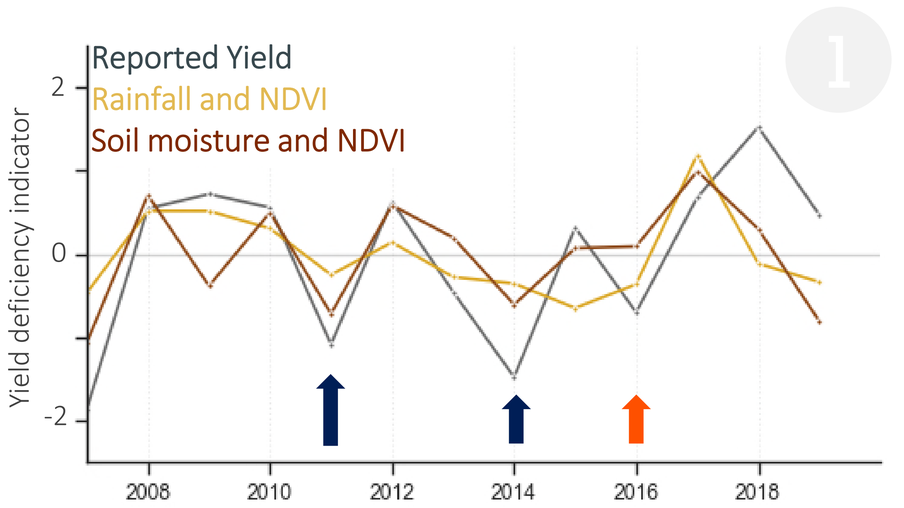
Reference Data:
Yearly yield data: FAO Yield data per country and per crop
Water Requirement Satisfaction Index: FewsNet maps of end of season WRSI

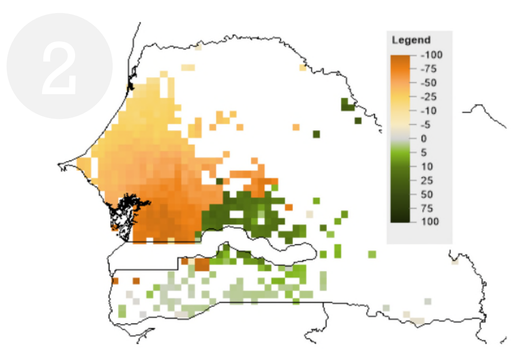
Method: Detrended and standardized yield and EO datasets. Multiple linear regression using rainfall or soil moisture with NDVI from July (start of season) to predict yield.

Take Home Message 2

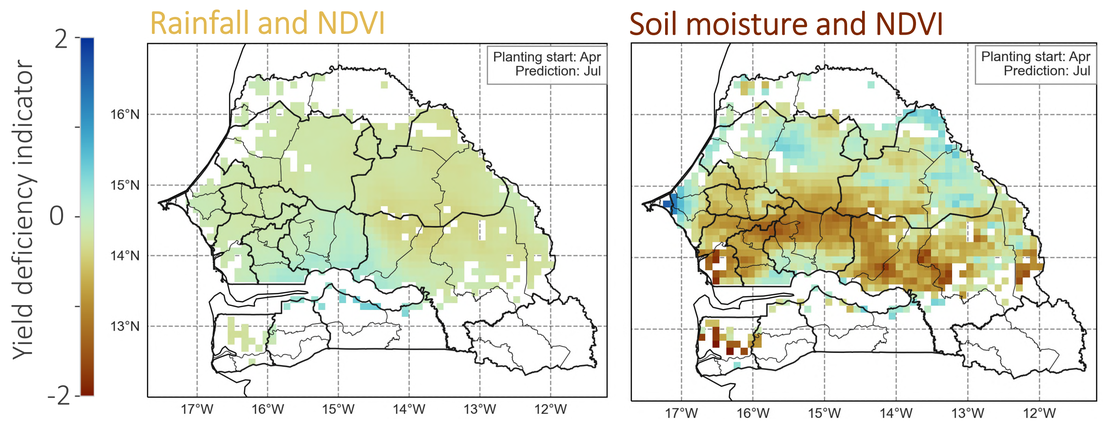
Satellite **soil moisture and NDVI** improve predictions of end-of-season yield deficiencies compared to using rainfall and NDVI. Also for other crops in Senegal.

And compare better to **end of season** FAO reported yield (1) and Water Requirement Satisfaction Index (2) which is used in the parametric drought insurance of African Risk Capacity.





Water Requirement Satisfaction Index available at the end of the growing season.



Vreugdenhil, M., Greimeister-Pfeil, I., Preimesberger, W., Camici, S., Dorigo, W., Enenkel, M., Van Der Schalie, R., Steele-Dunne, S., Wagner, W., 2022. Microwave remote sensing for agricultural drought monitoring: Recent developments and challenges. Frontiers in Water 4, 205.