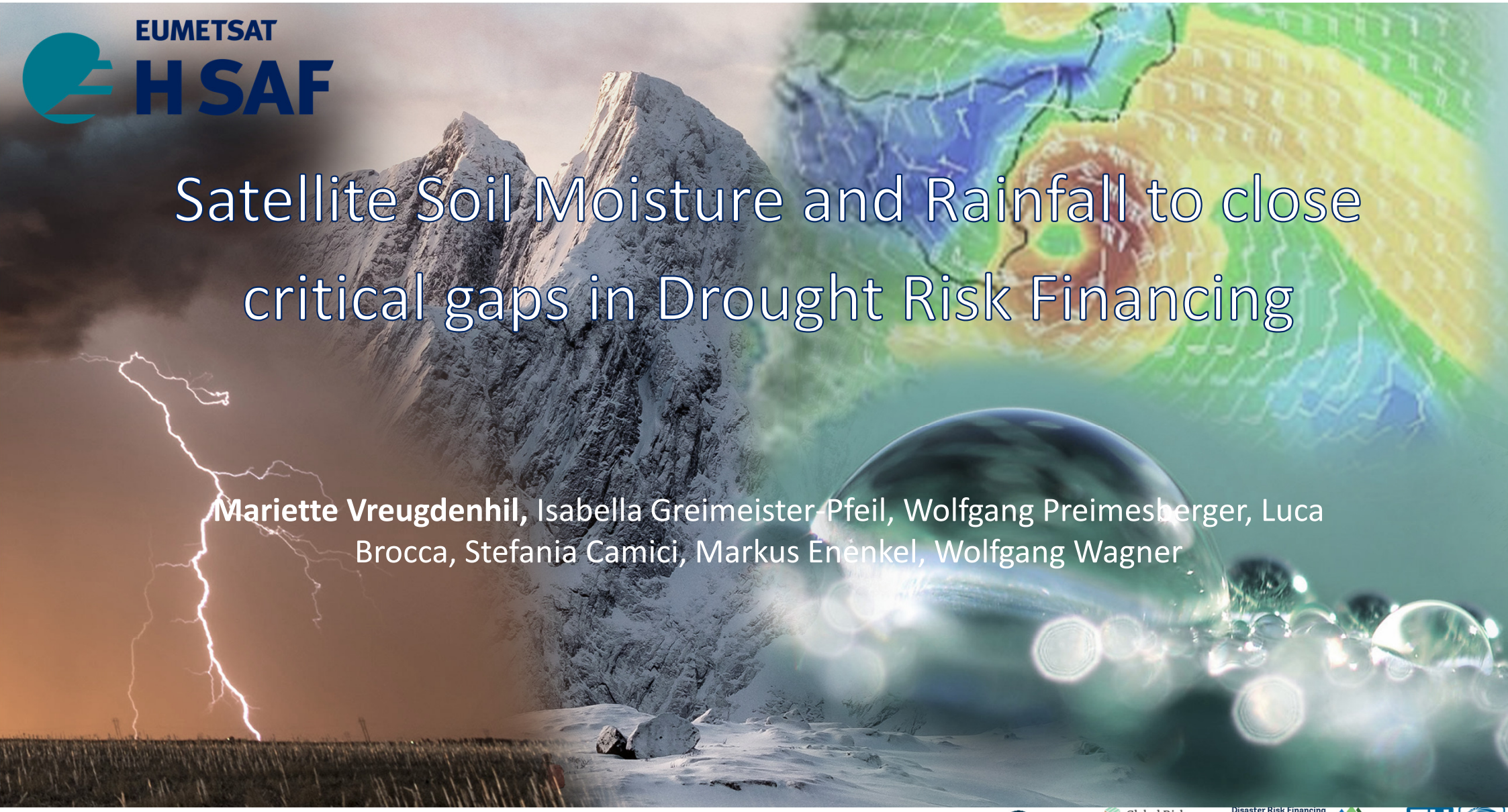


Satellite Soil Moisture and Rainfall to close critical gaps in Drought Risk Financing

Mariette Vreugdenhil, Isabella Greimeister-Pfeil, Wolfgang Preimesberger, Luca Brocca, Stefania Camici, Markus Enenkel, Wolfgang Wagner

5° H SAF User Workshop | 24-28 January 2022

Structure

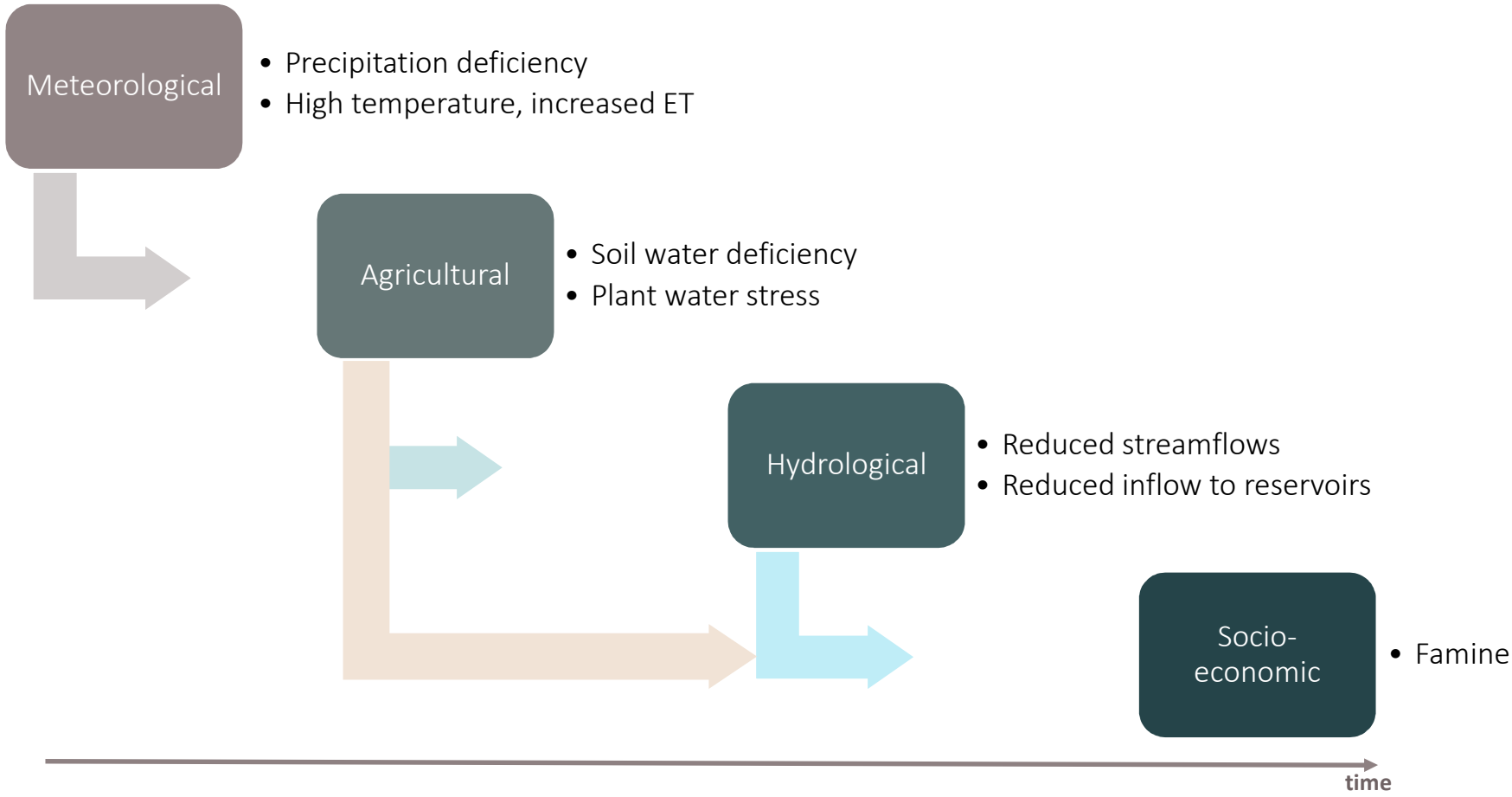
- introduction
  - Drought development
  - Satellite products

1. accuracy assessment
   - What is the best satellite soil moisture product?

2. analysis of the correlation with other satellite variables to lower basis risk
   - Can we track rainfall deficits through the water cycle?

3. relationship between different satellite variables and crop yield
   - Can we predict yield?

Drought

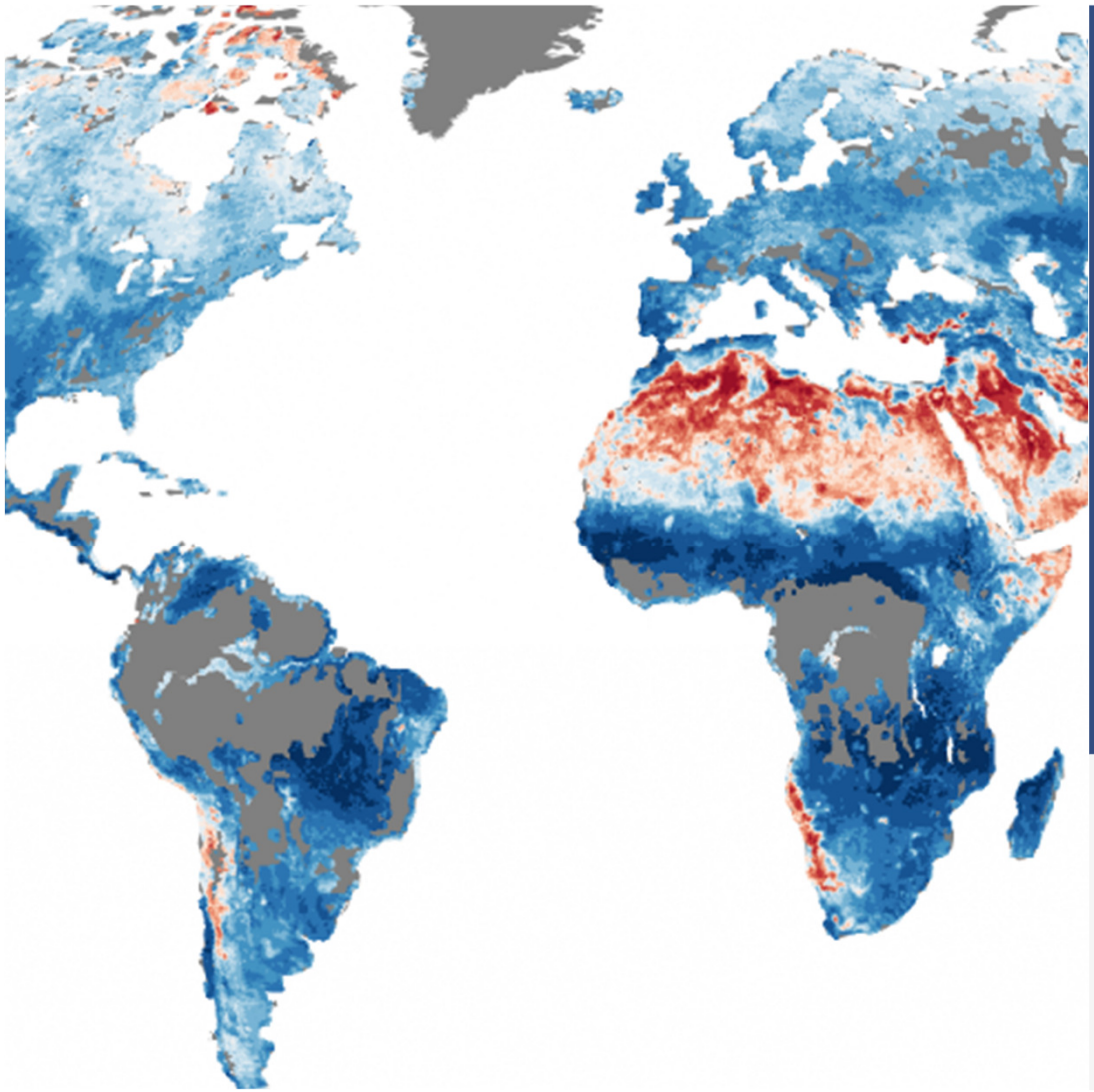

Meteorological
• Precipitation deficiency
• High temperature, increased ET
Agricultural
• Soil water deficiency
• Plant water stress
Hydrological
• Reduced streamflows
• Reduced inflow to reservoirs
Socio-economic
• Famine
time

Datasets and pre-processing

- HSAF SM2RAIN
  - 12.5 km
- HSAF SSM CDR H116
  - 12.5 km
- CGLS NDVI
  - 1km

- ERA5-Land Soil Moisture
  - 9 km

- Resampled
  - Spatial: 0.1°
  - Temporal: Dekadal



What are the strengths and weaknesses?

Accuracy assessment

Graphic by S. Hahn, TU Wien

Validation of satellite soil moisture products

Temporal correlation analyis

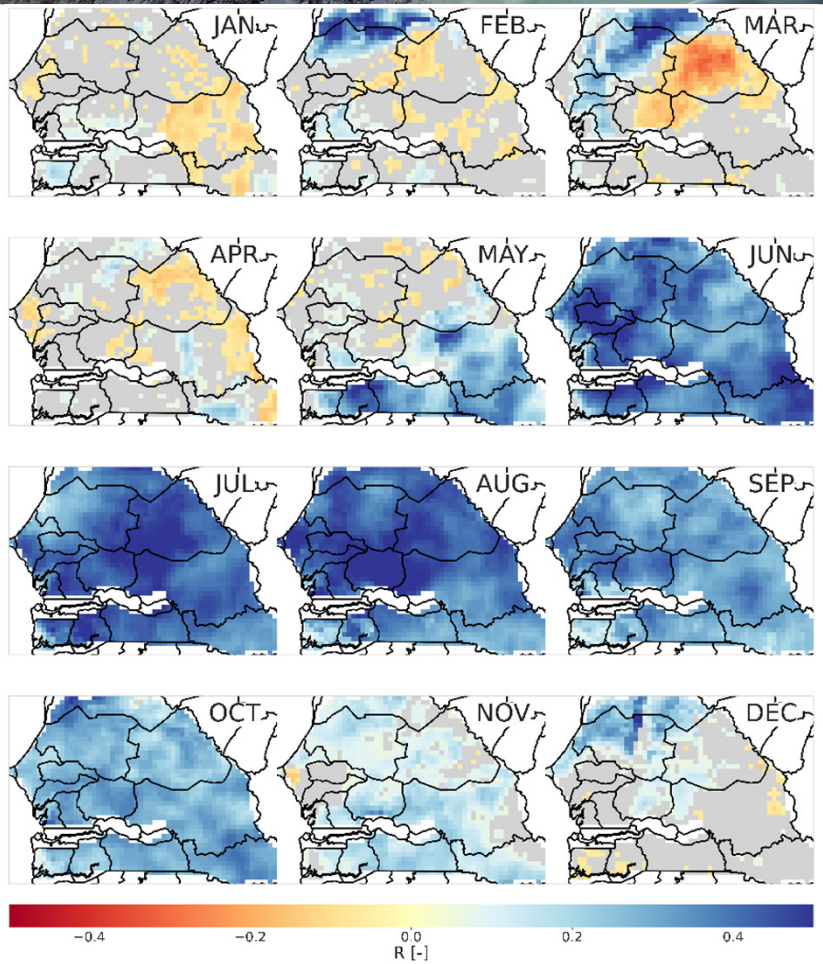
- Reference dataset
  - ERA5-Land soil moisture from different layers

Soil Water Index analyis

- Relating T-value to soil depth
- Temporal correlation analysis over different soil layers of ERA5-Land

Accuracy assessment of HSAF H116 SM (Pearson R with ERA5-Land)

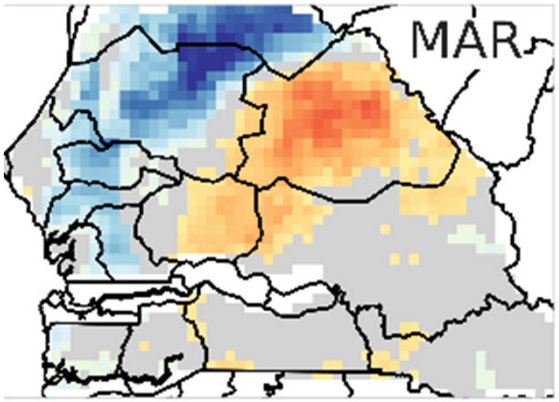
HSAF ASCAT Soil Moisture (12.5 km)

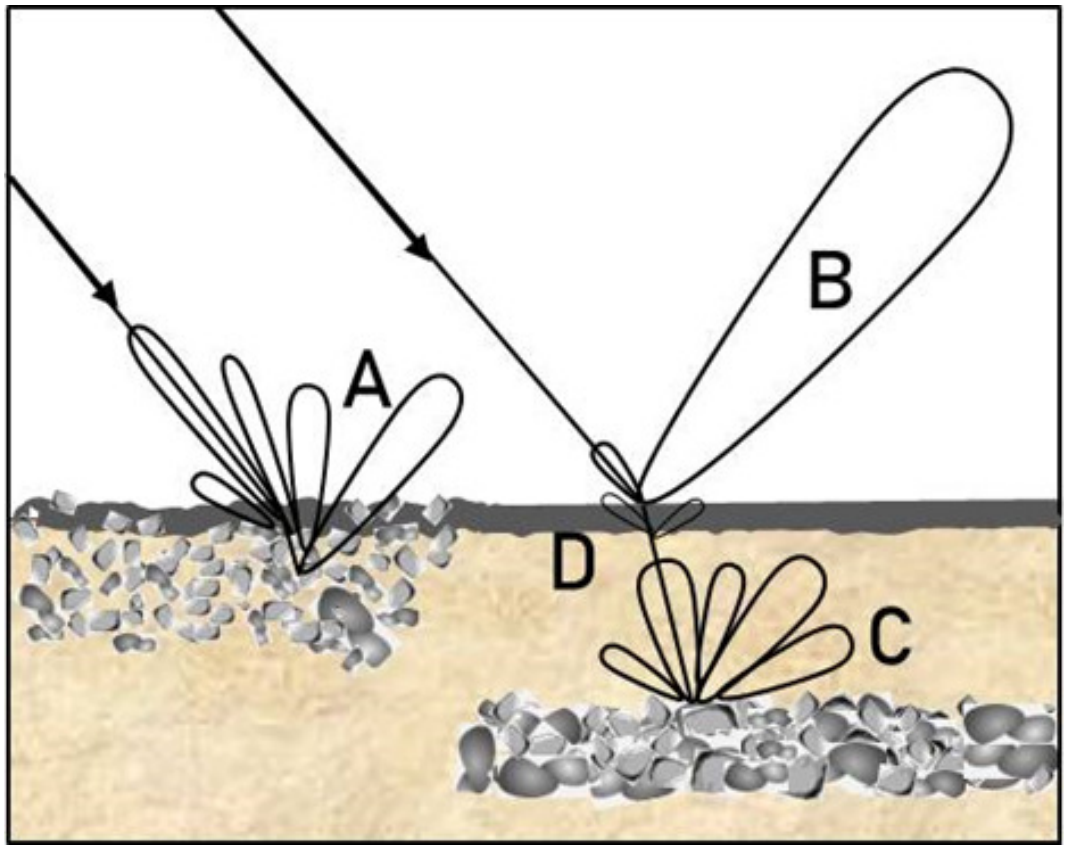


Sub-surface scattering

- Rocks in the sub-surface lead to higher return to the satellite

- Rocks only “visible” during dry season due to higher penetration depth



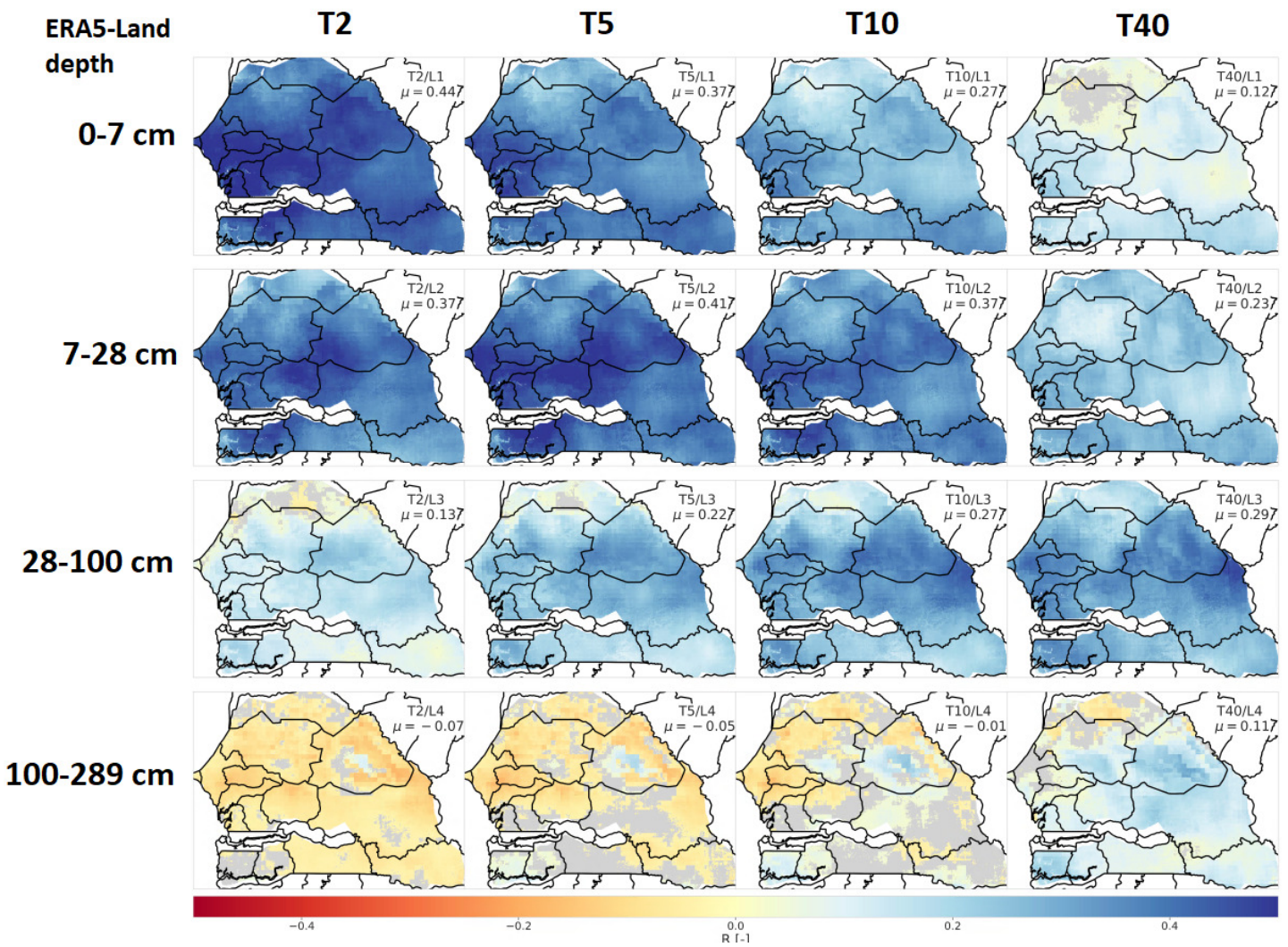


EUMETSAT
H SAF

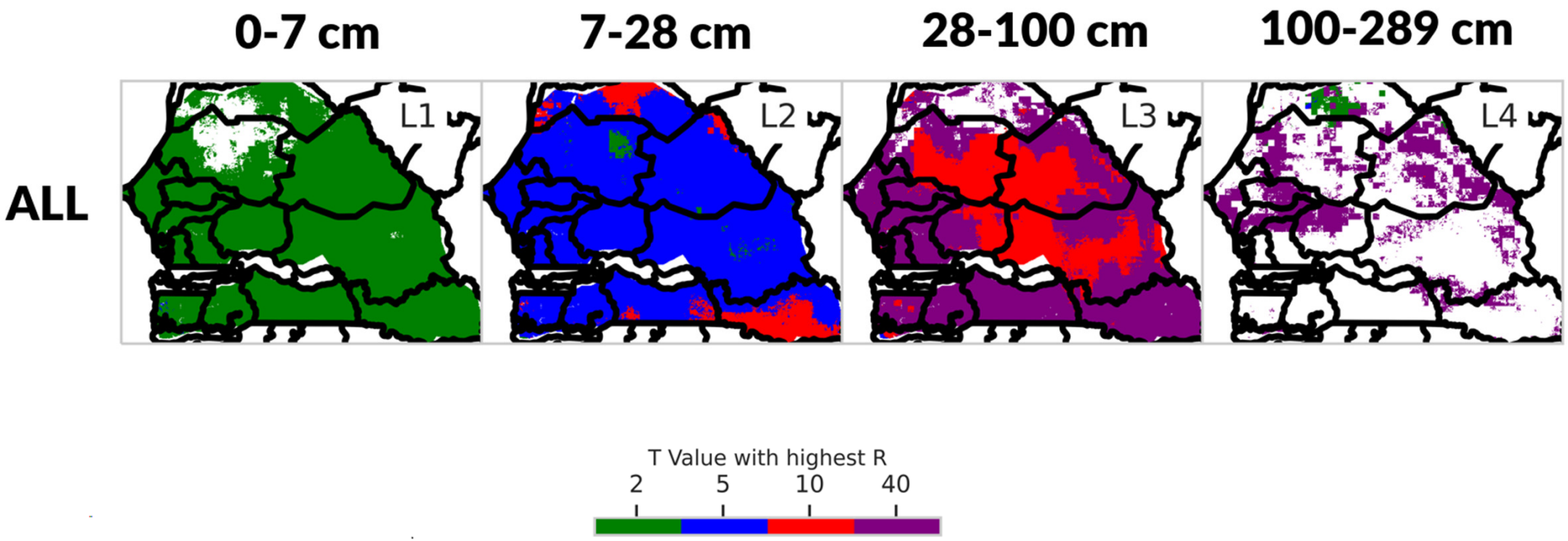
Root zone soil moisture

Higher t-values are related to deeper soil moisture dynamics

Good correspondence up to 100cm.



Root zone soil moisture

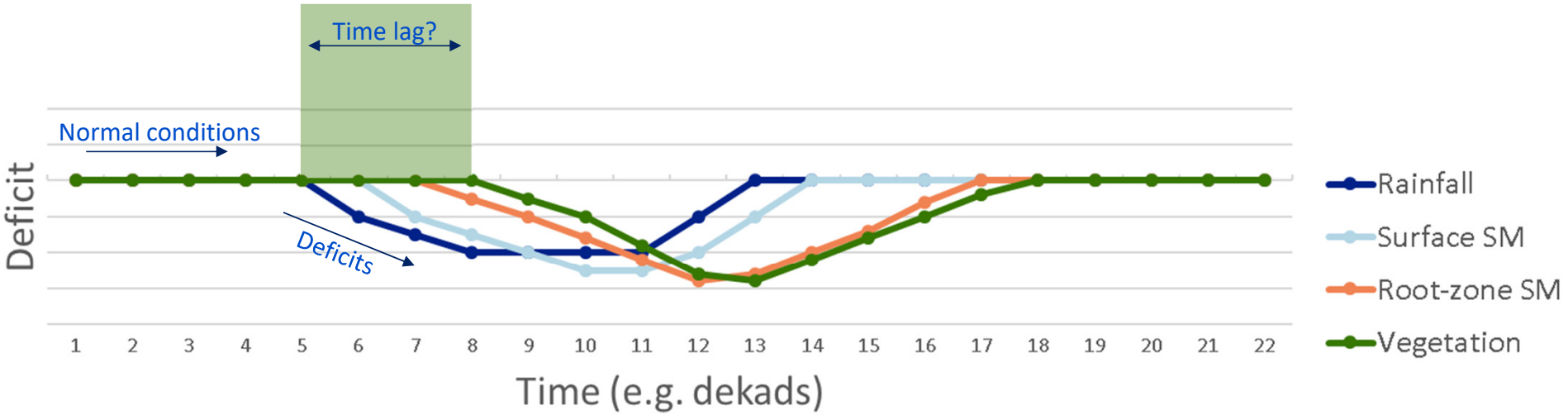


Tracking rainfall deficits through the water cycle

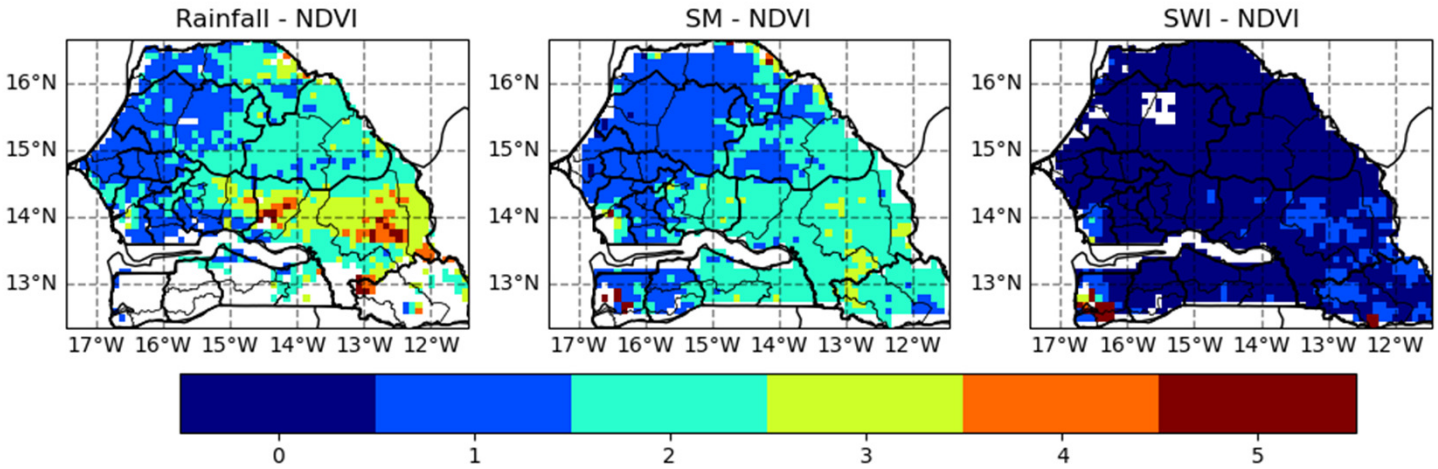
Convergence of Evidence

esa · Global Risk Financing Facility · Disaster Risk Financing & Insurance Program · WORLD BANK GROUP · irpi · TU WIEN · GEO

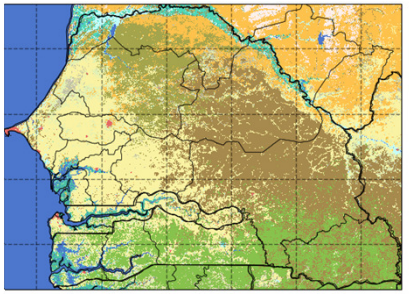
Tracking rainfall deficits through the water cycle



When does vegetation respond?



Time lag to NDVI [dekads]



ESA CCI Land Cover (v2.0.7)

How is a drought captured by different variables?

Rainfall [mm/day]

Surface SM [m^3/m^3]

Root-zone SM [%]

Vegetation [-]

Standardize

DHI Rainfall

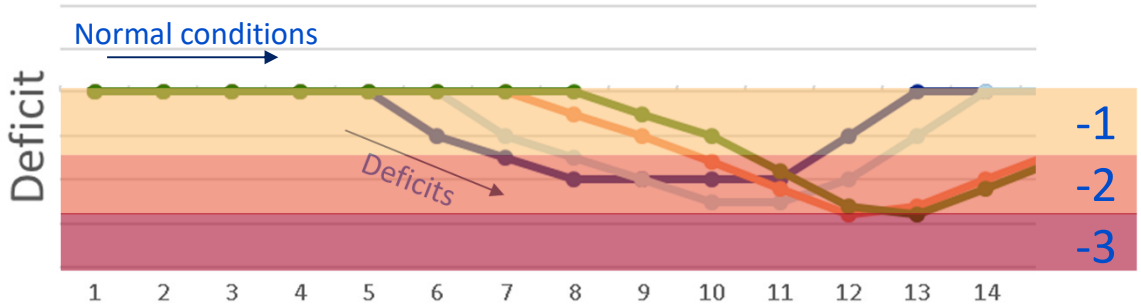
DHI Surface SM

DHI Root-zone SM

DHI Vegetation

Development of a standardized drought hazard indicator

- DHI: express deficits in **categories**



- Big advantage: we can **directly compare four different drought indicators**

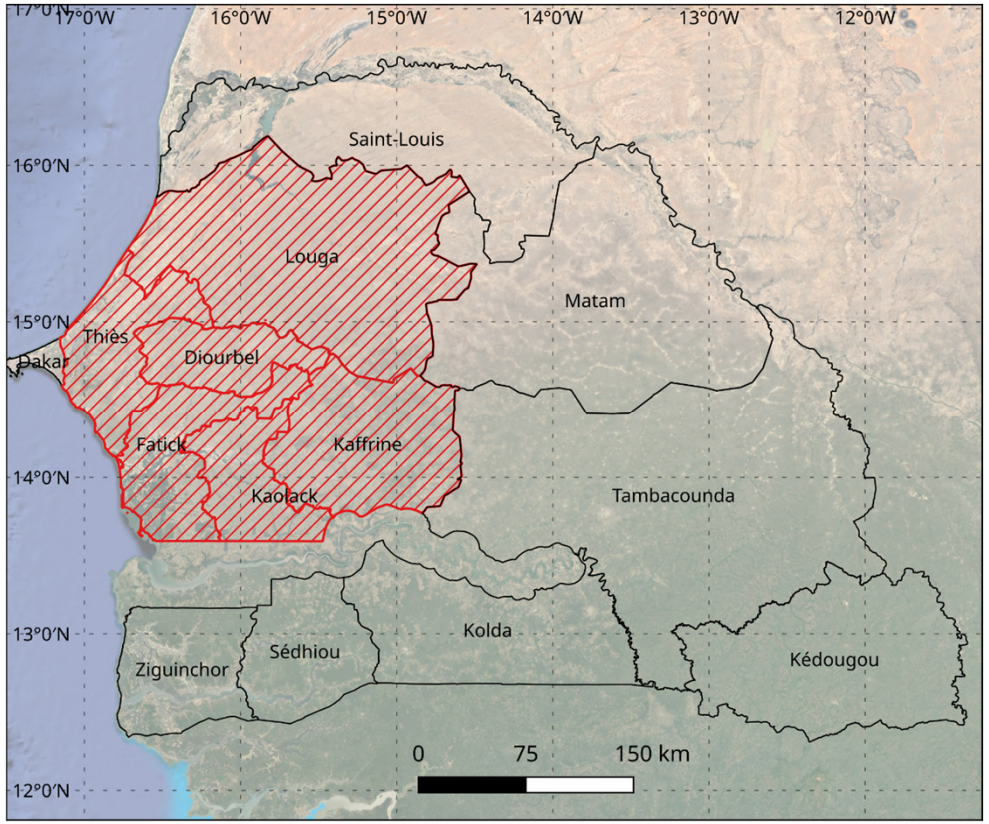
2019 Senegal Drought

Late start of season

Very bad harvest

968.000 people affected

US$23.1m payout



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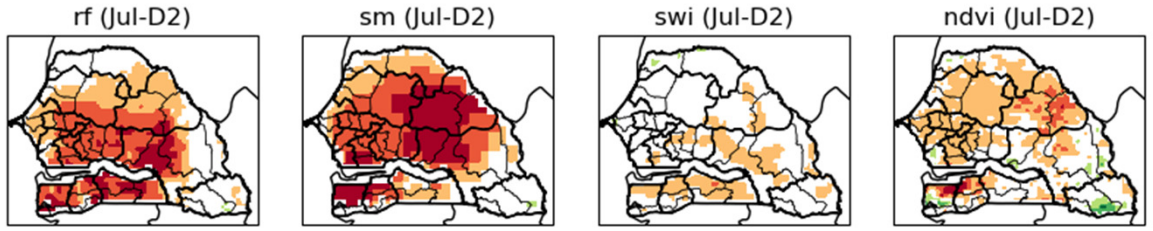
Drought Hazard Indicator – Senegal 2019

DHI	Classification
+3	Extreme surplus
+2	Severe surplus
+1	Moderate surplus
0	**Normal**
-1	Moderate drought
-2	Severe drought
-3	Extreme drought



Drought hazard throughout the growing season

DHI Rainfall

DHI Surface SM

DHI Root-zone SM

DHI Vegetation

Combined DHI

Development of a drought event over time

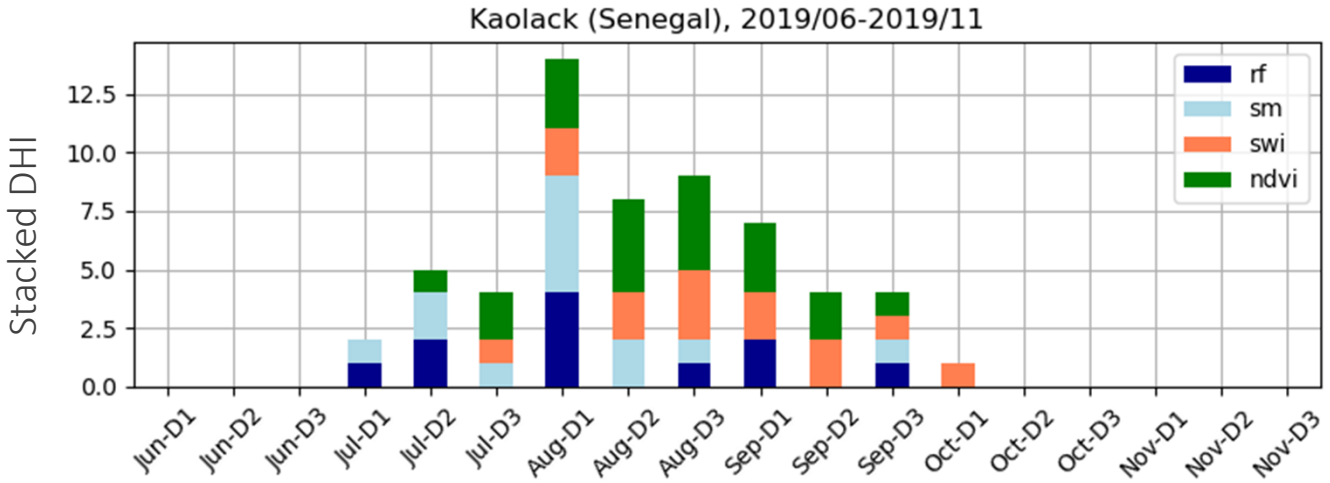
Drought hazard throughout the growing season

DHI Rainfall

DHI Surface SM

DHI Root-zone SM

DHI Vegetation



EO data as proxy for yield

Yield Deficiency Indicator

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How to predict yield?

?

- Rainfall

- **Driver** of crop development
- **Excludes evaporation**

- NDVI

- **Indicator** of crop development

How to predict yield?

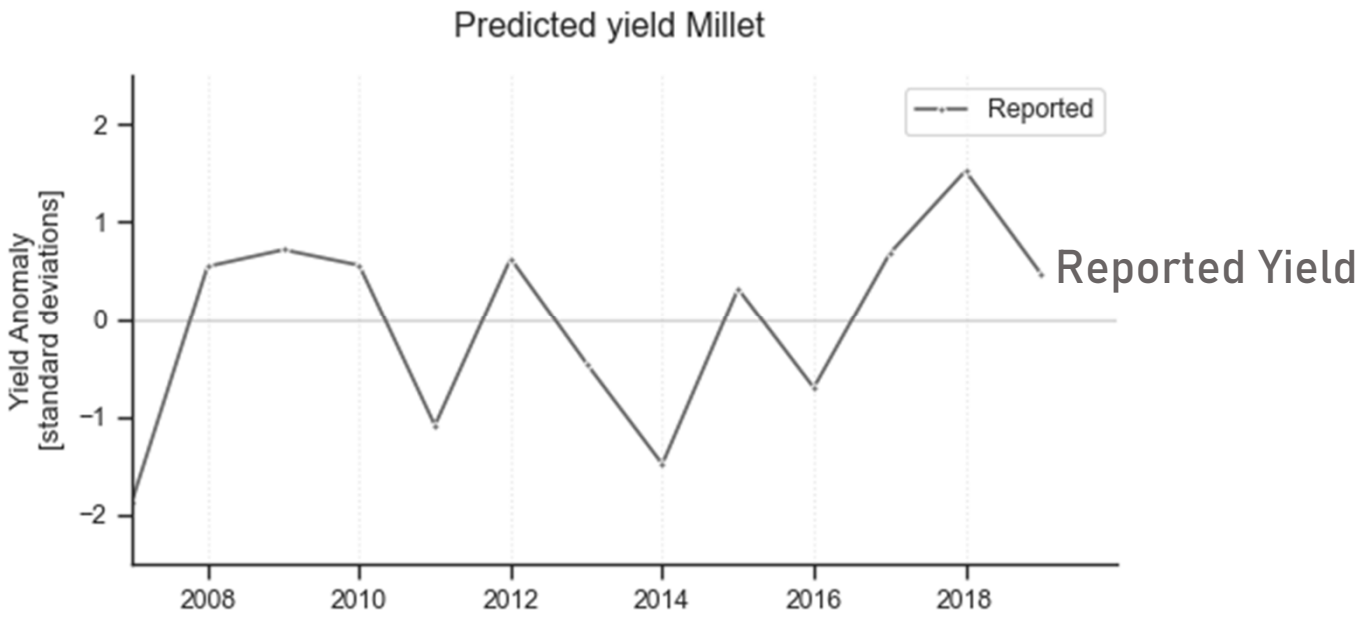
- Rainfall
- **Driver** of crop development
- **Excludes evaporation**

- Soil Moisture
- Missing link…?

- NDVI
- **Indicator** of crop development

Yield Prediction

Millet



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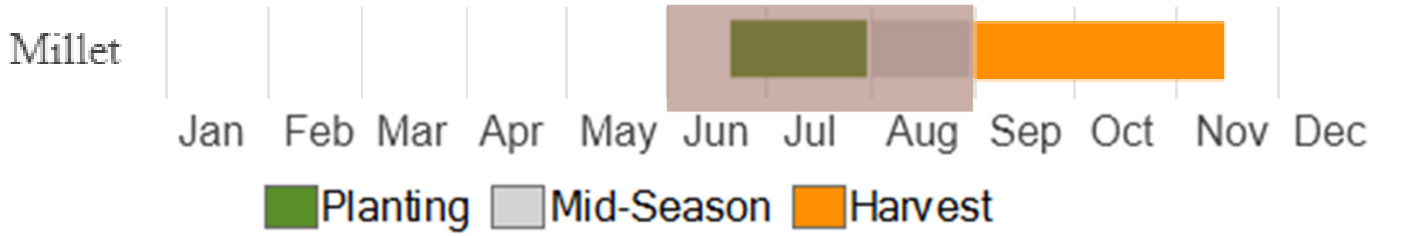
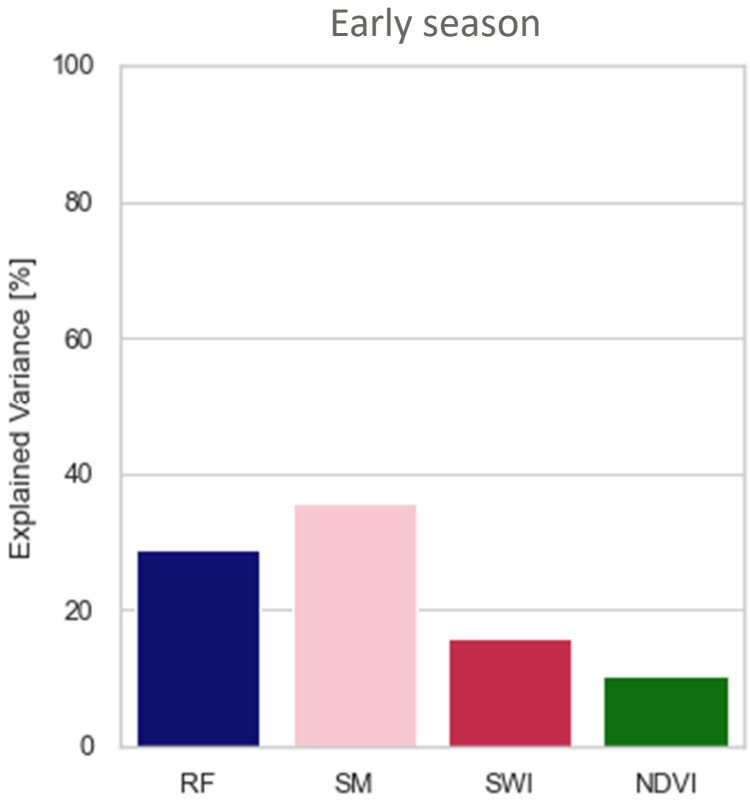


USDA

Source: FAS/GMA/IPAD

Yield Prediction

Millet



SM improves early prediction of yield deficiencies

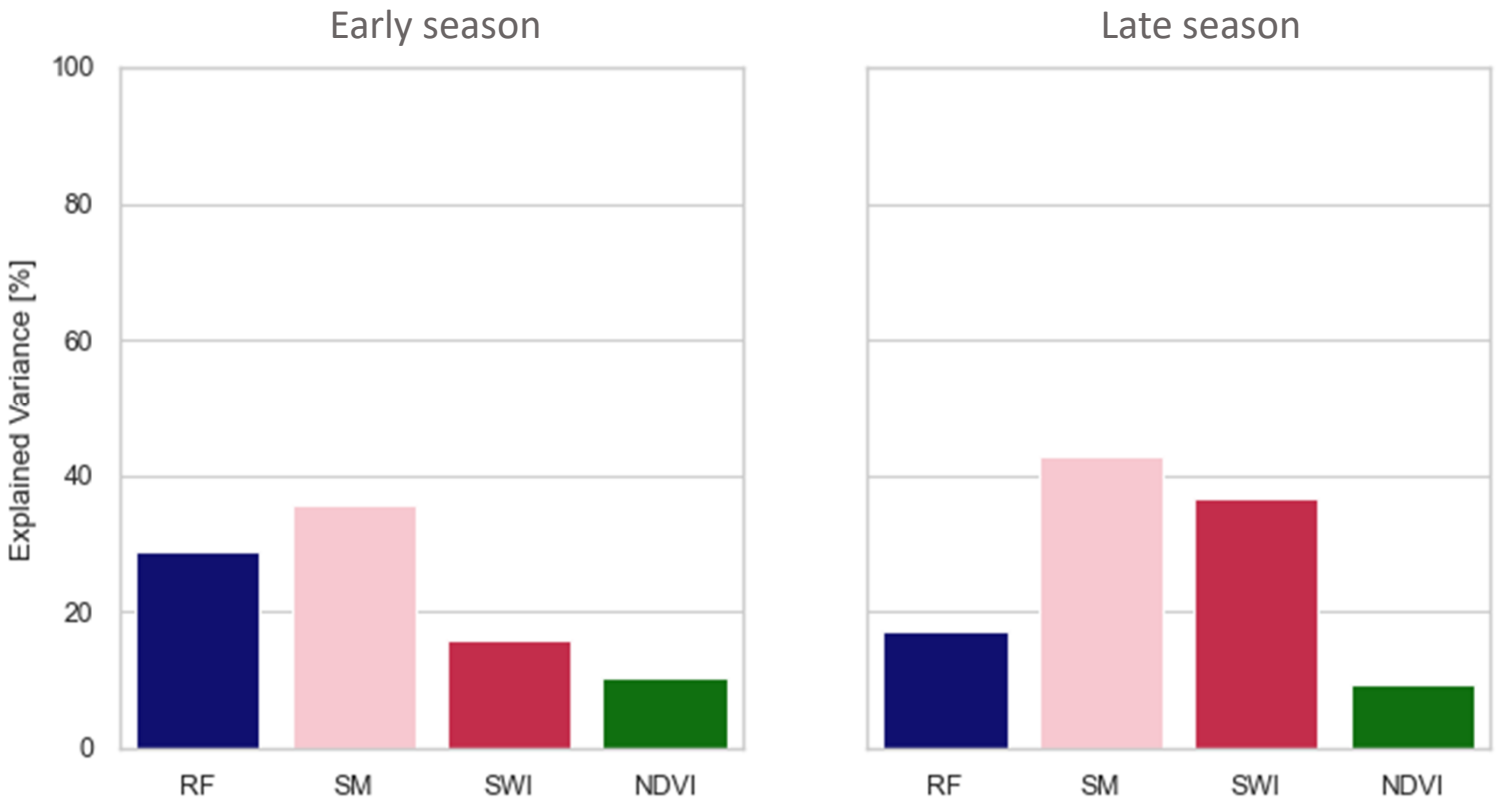
Millet

USDA

Source: FAS/GMA/IPAD

Yield Prediction

Millet



Yield Prediction

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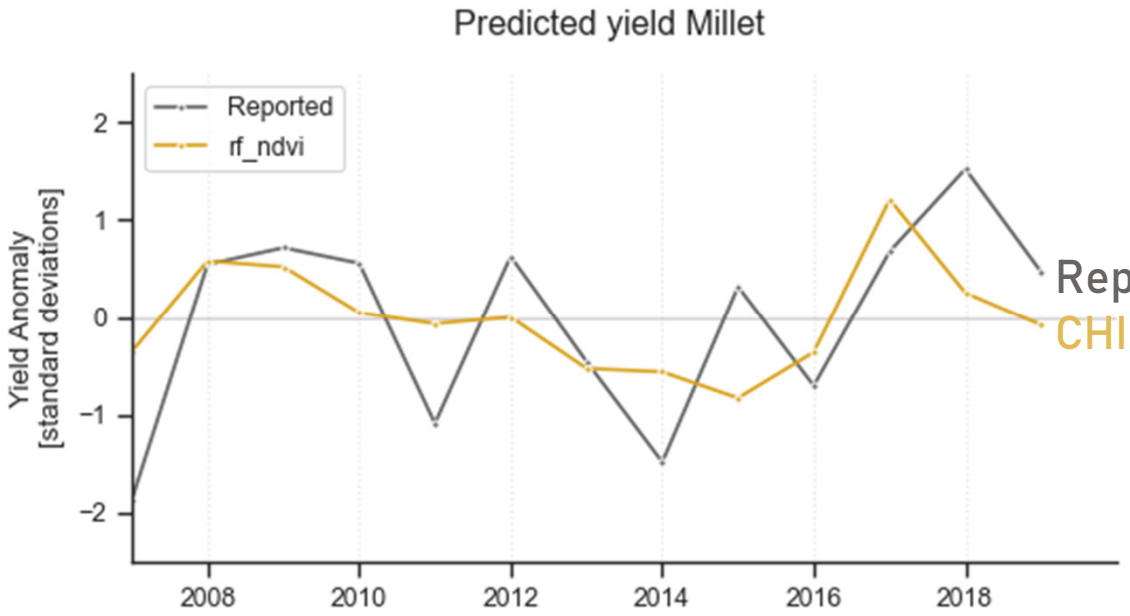
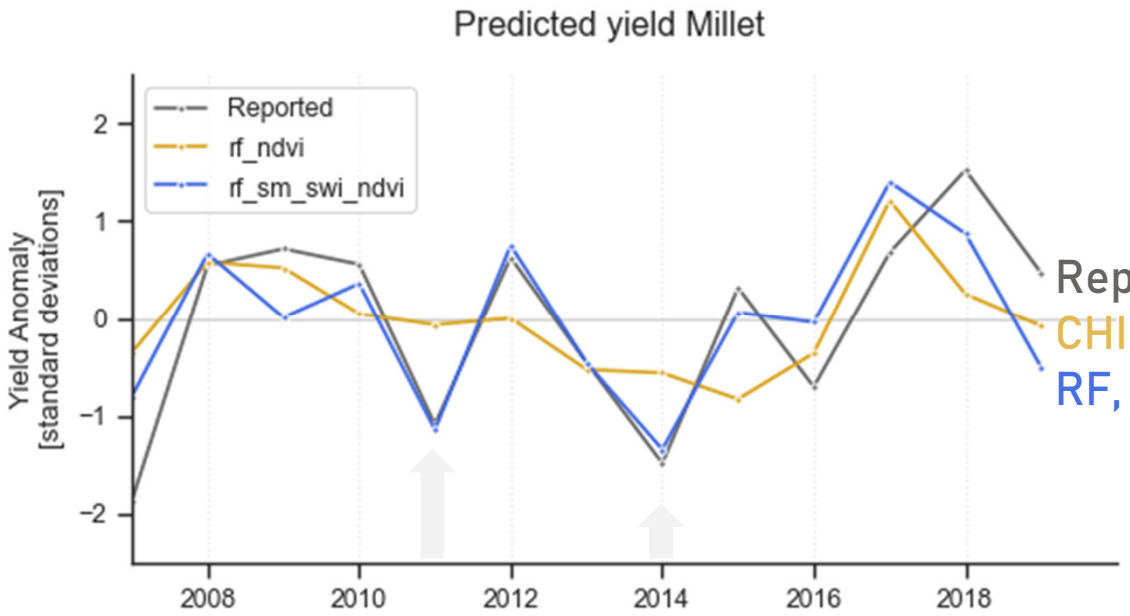


Reported Yield

CHIRPS RF and NDVI

Yield Prediction

Millet



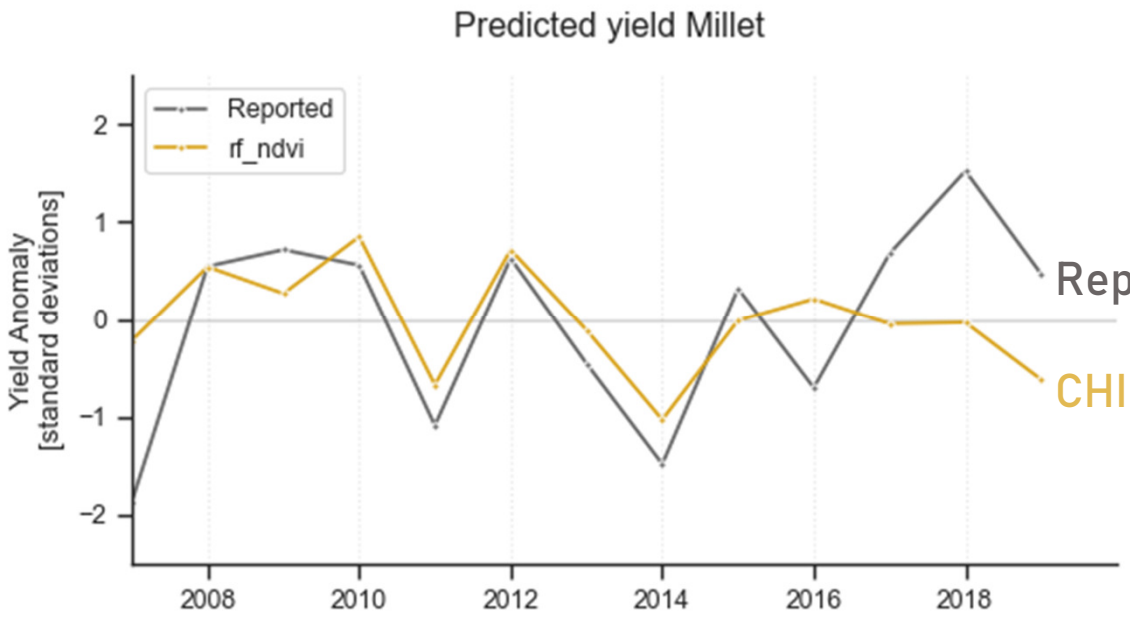
Reported Yield

CHIRPS RF and NDVI

RF, SM, SWI and NDVI

Yield Prediction

Millet

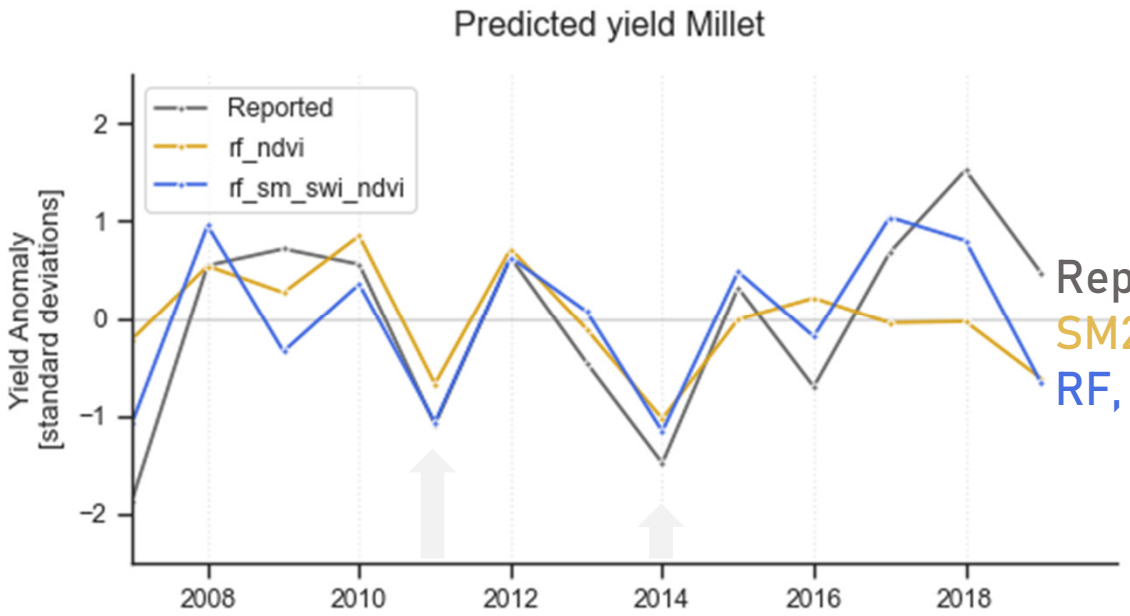


Reported Yield

CHIRPS RF and NDVI

Yield Prediction

Millet

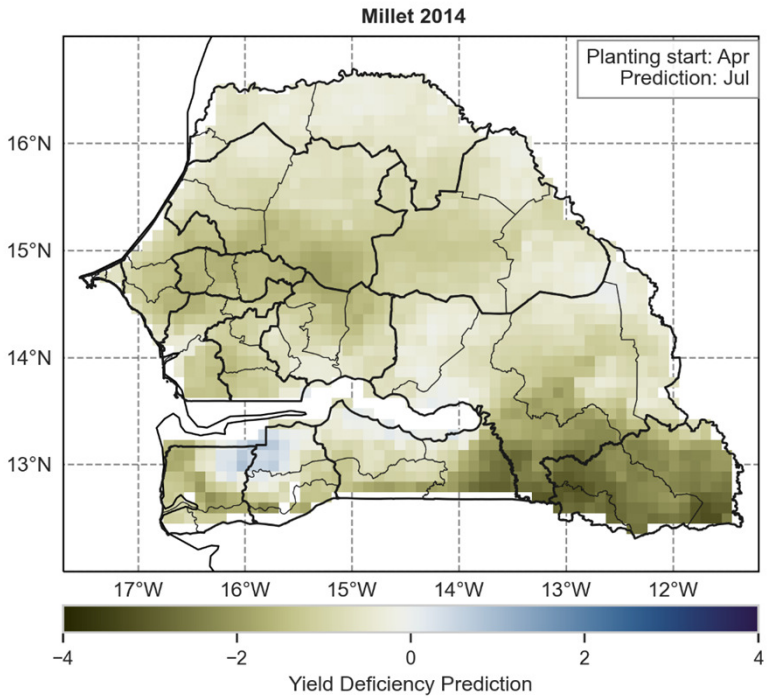


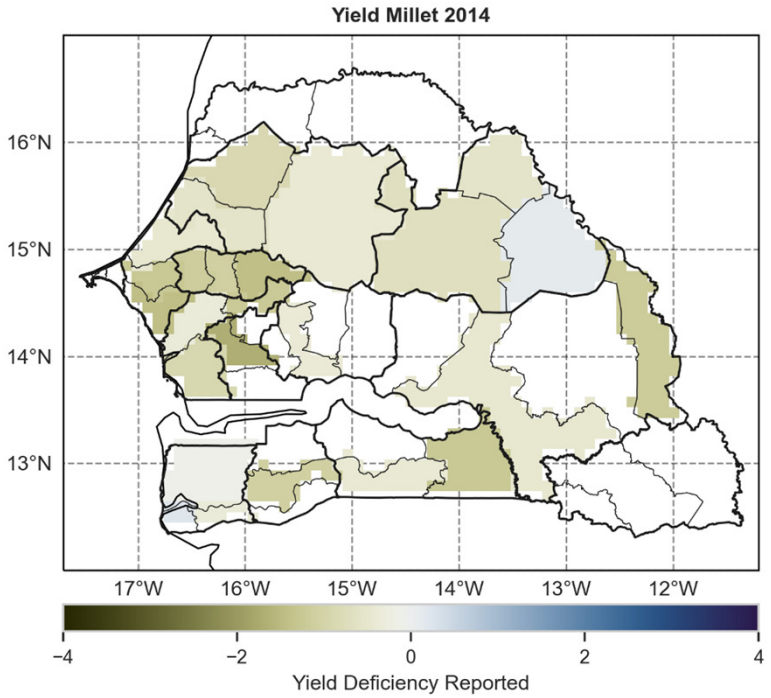
Reported Yield

SM2RAINand NDVI

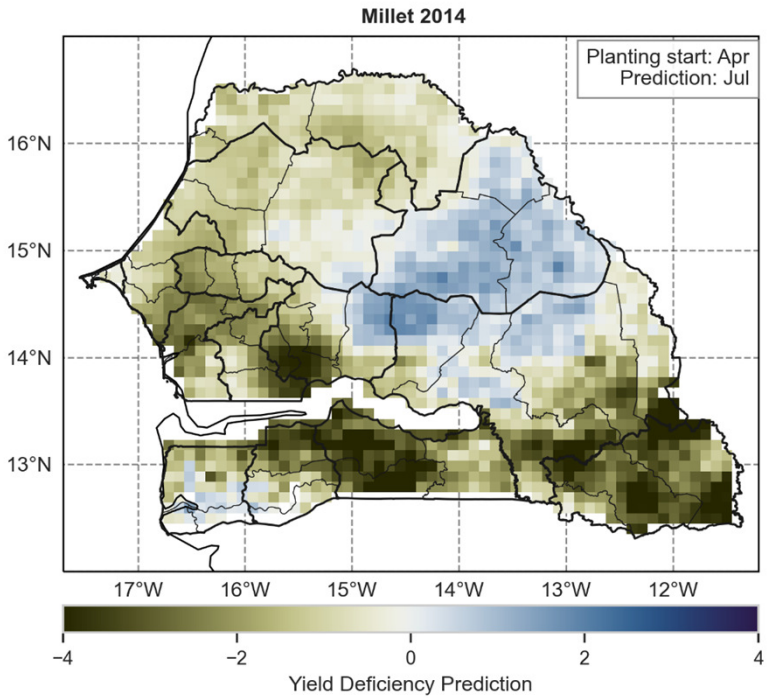
RF, SM, SWI and NDVI

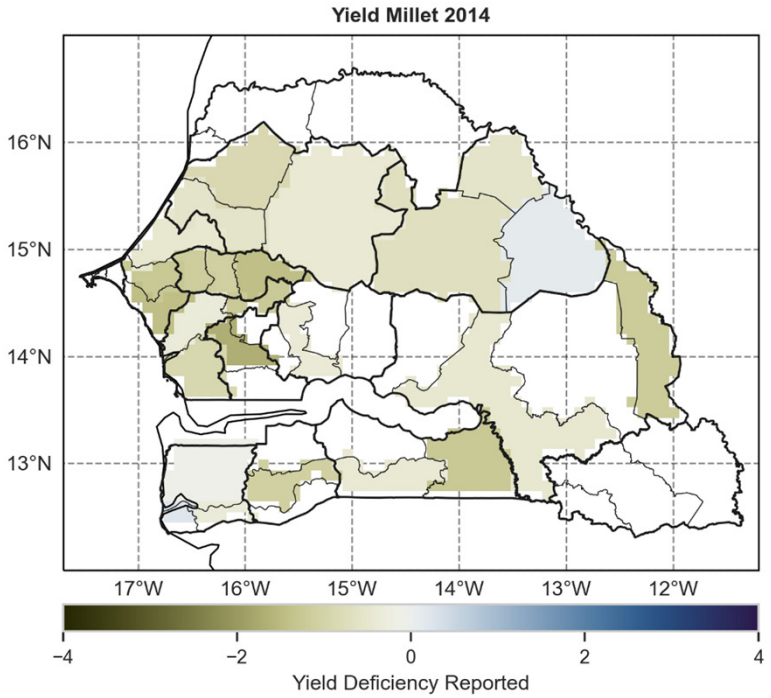
Yield Prediction



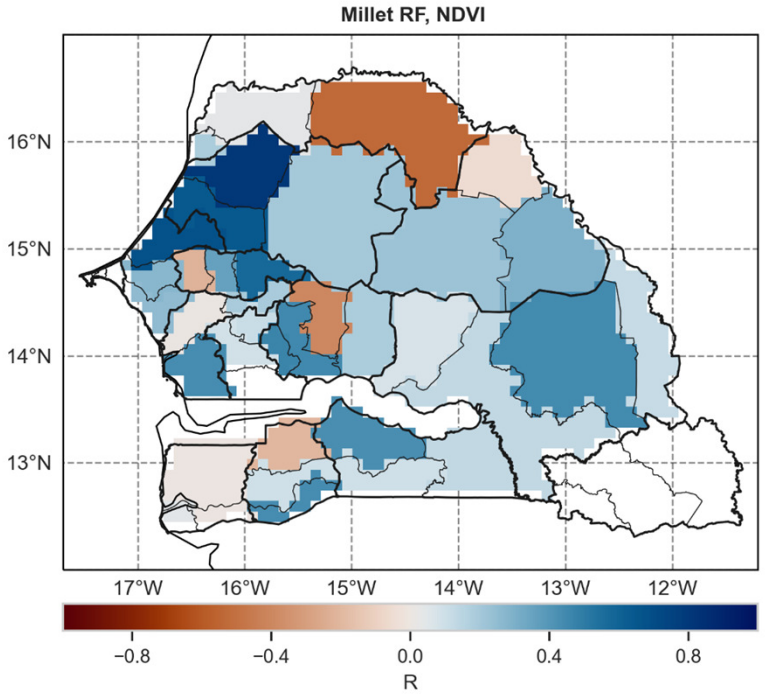


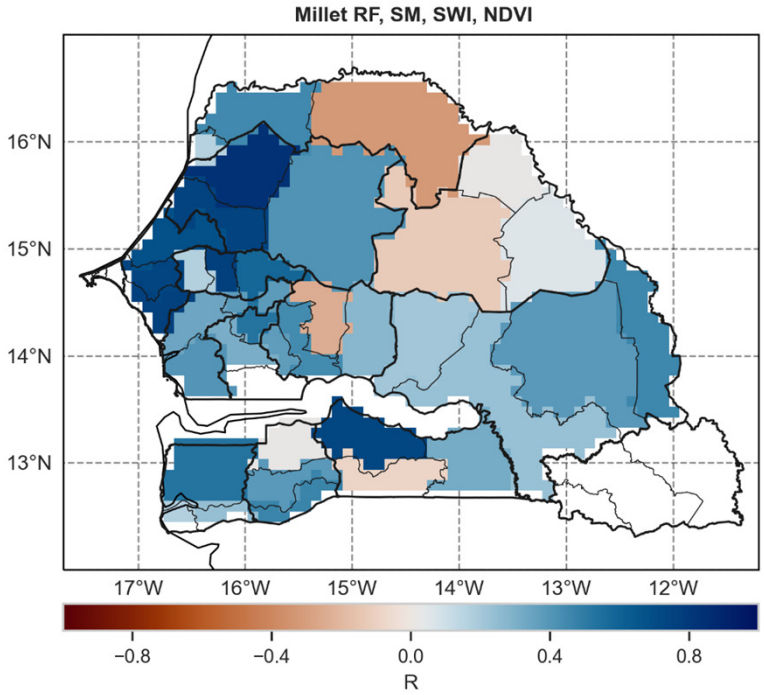
Yield Prediction



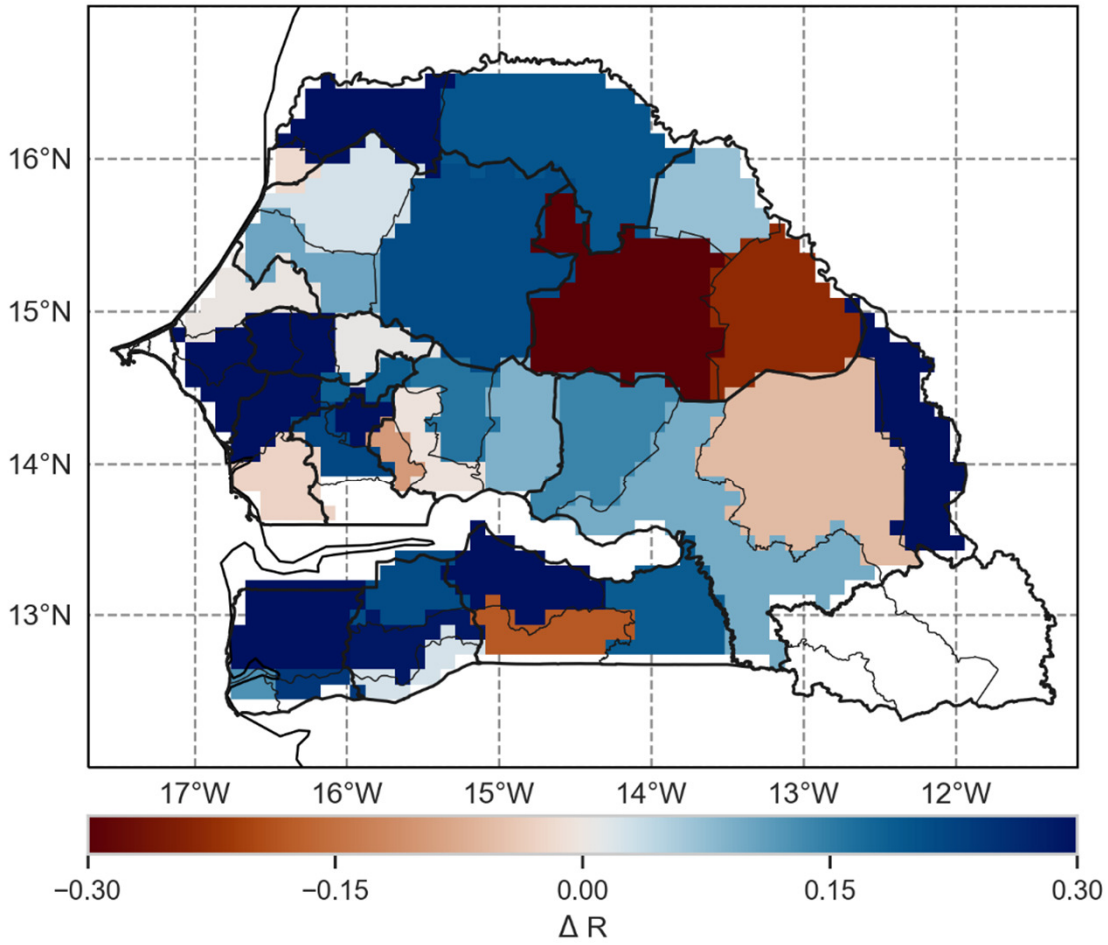


Yield Prediction





Yield Prediction



Conclusions

- Reliable soil moisture during the growing season
  - Impact of sub-surface scattering during dry season
- Corresponds to soil moisture from WRSI

- Rainfall and soil moisture capture main droughts
- A delayed response is observed in NDVI

- Soil moisture and SM2Rain are more capable of explaining yield variability
  - Variations between districts