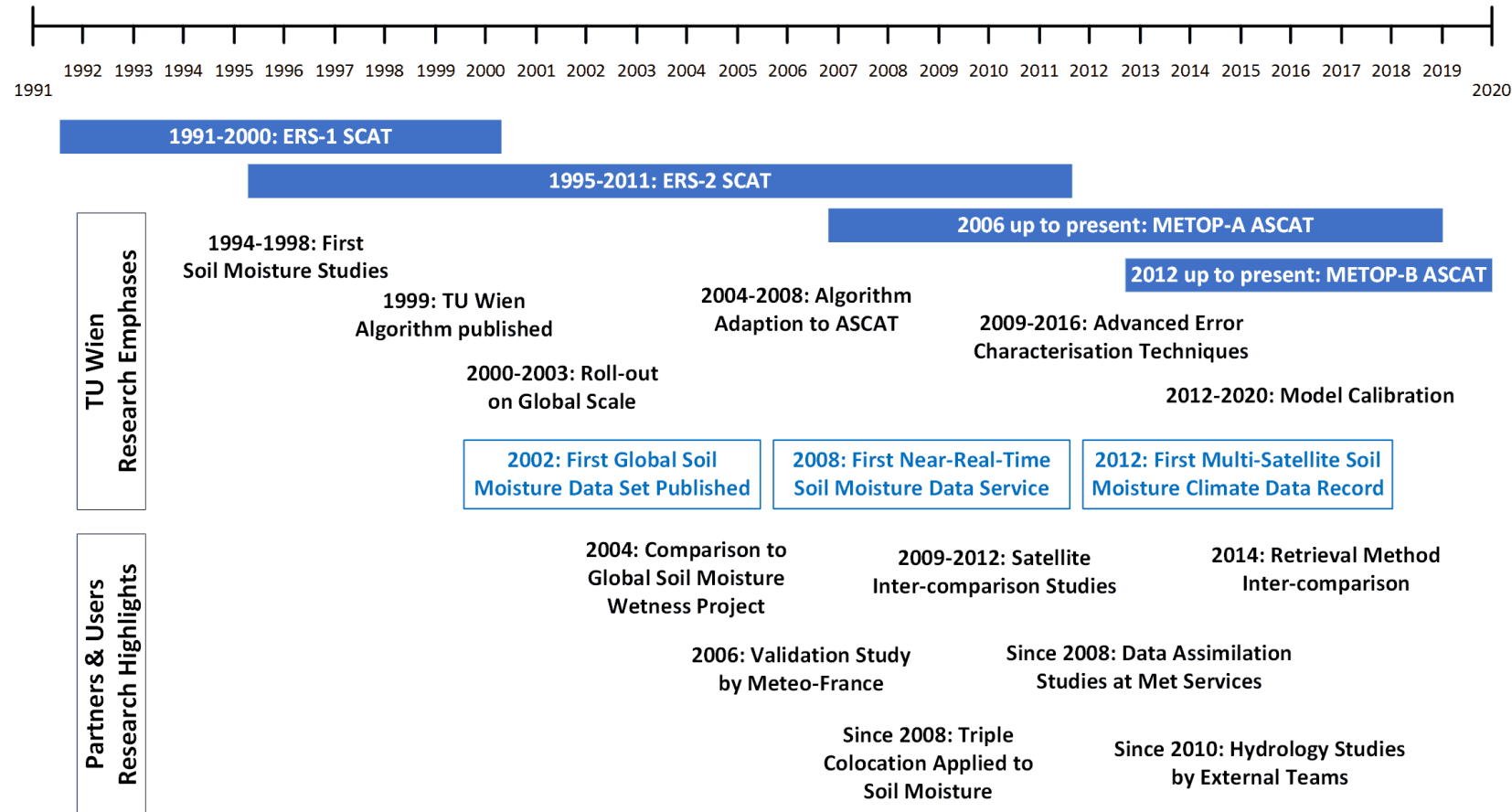# Enhancing Drought Early Warning through Satellite Soil Moisture Data
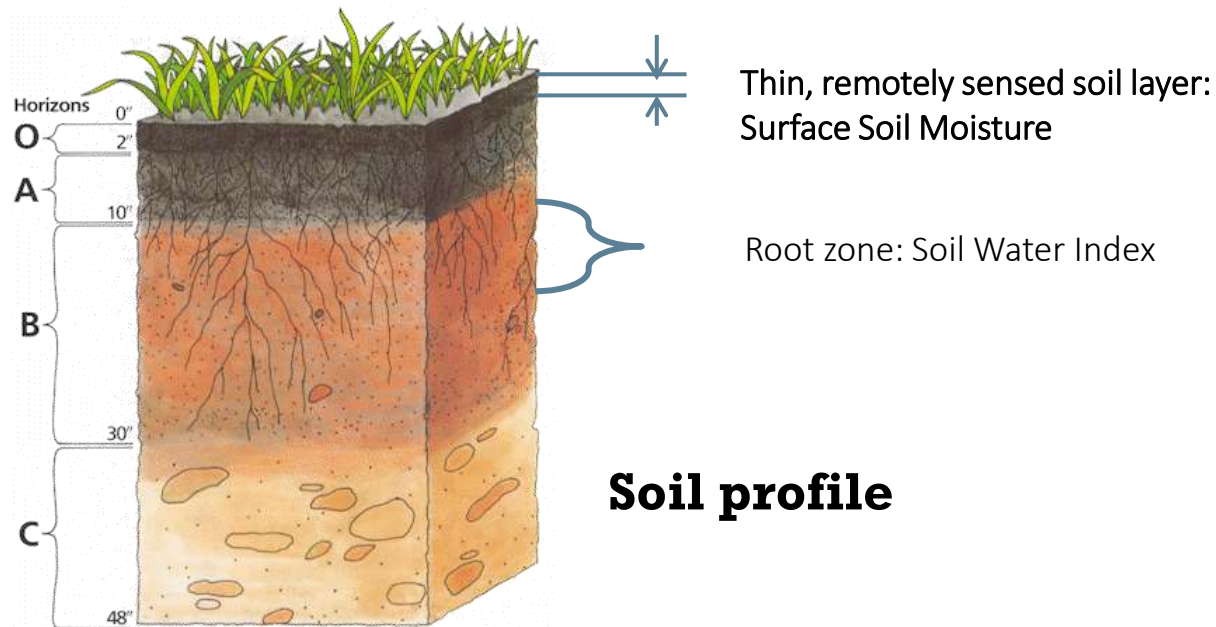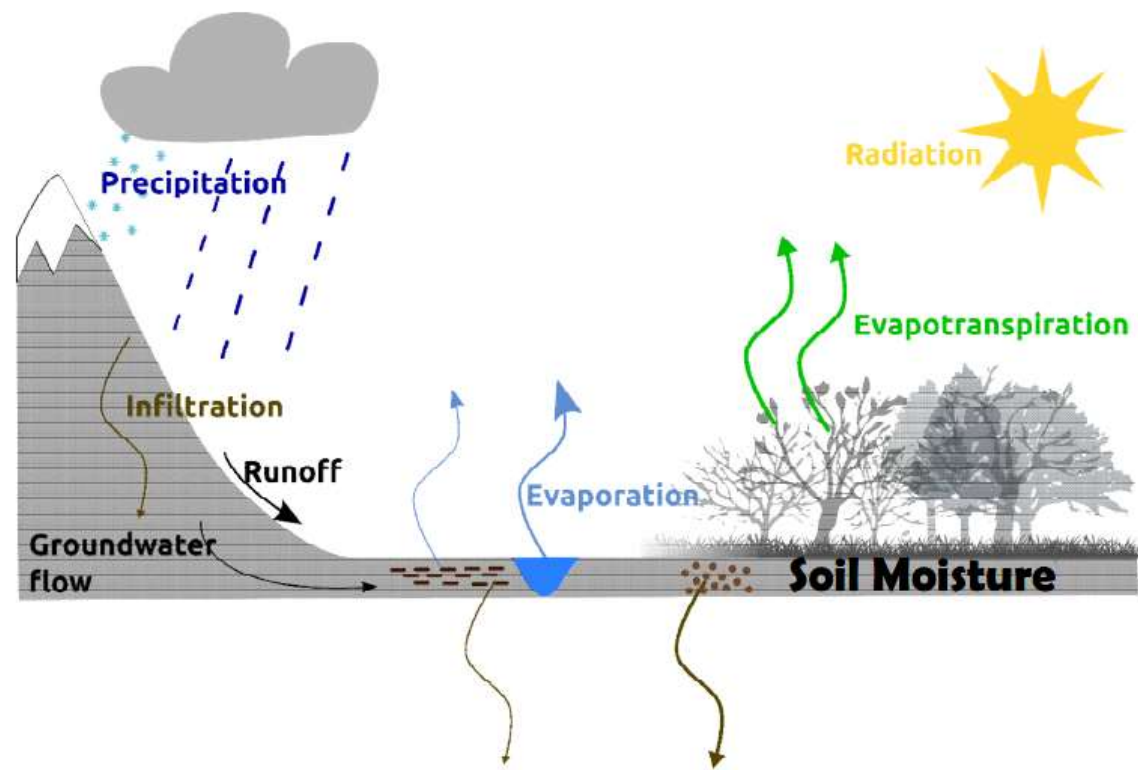
Dr. Mariette Vreugdenhil, Isabella Greimeister-Pfeil, Wolfgang Preimesberger, Luca Brocca, Stefania Camici, Markus Enenkel, Wolfgang Wagner

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Remote Sensing at TU Wien

- Development and production of operational soil moisture datasets:
  - ESA CCI Soil Moisture
  - C3S Soil Moisture
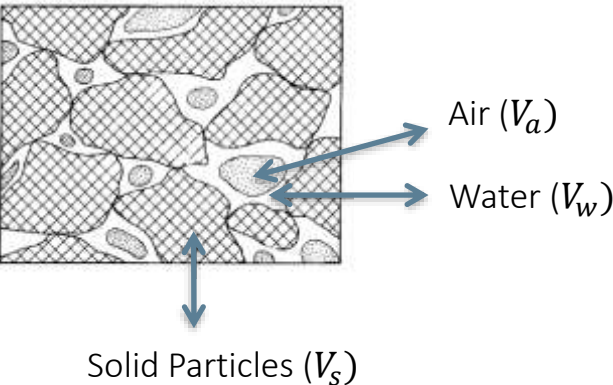 - CGLS 1km Sentinel-1 Soil Moisture
  - H SAF NRT Soil Moisture

1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

1991-2000: ERS-1 SCAT

1995-2011: ERS-2 SCAT

2006 up to present: METOP-A ASCAT

2012 up to present: METOP-B ASCAT

TU Wien Research Emphases

1994-1998: First Soil Moisture Studies

1999: TU Wien Algorithm published

2000-2003: Roll-out on Global Scale

2004-2008: Algorithm Adaption to ASCAT

2009-2016: Advanced Error Characterisation Techniques

2012-2020: Model Calibration

2002: First Global Soil Moisture Data Set Published

2008: First Near-Real-Time Soil Moisture Data Service

2012: First Multi-Satellite Soil Moisture Climate Data Record

Partners & Users Research Highlights

2004: Comparison to Global Soil Moisture Wetness Project

2009-2012: Satellite Inter-comparison Studies

2014: Retrieval Method Inter-comparison

2006: Validation Study by Meteo-France

Since 2008: Data Assimilation Studies at Met Services

Since 2008: Triple Colocation Applied to Soil Moisture

Since 2010: Hydrology Studies by External Teams

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Microwave Remote Sensing of Soil Moisture

Thin, remotely sensed soil layer: Surface Soil Moisture

Root zone: Soil Water Index

Soil profile

Cross-section of a soil

Air (V_a)
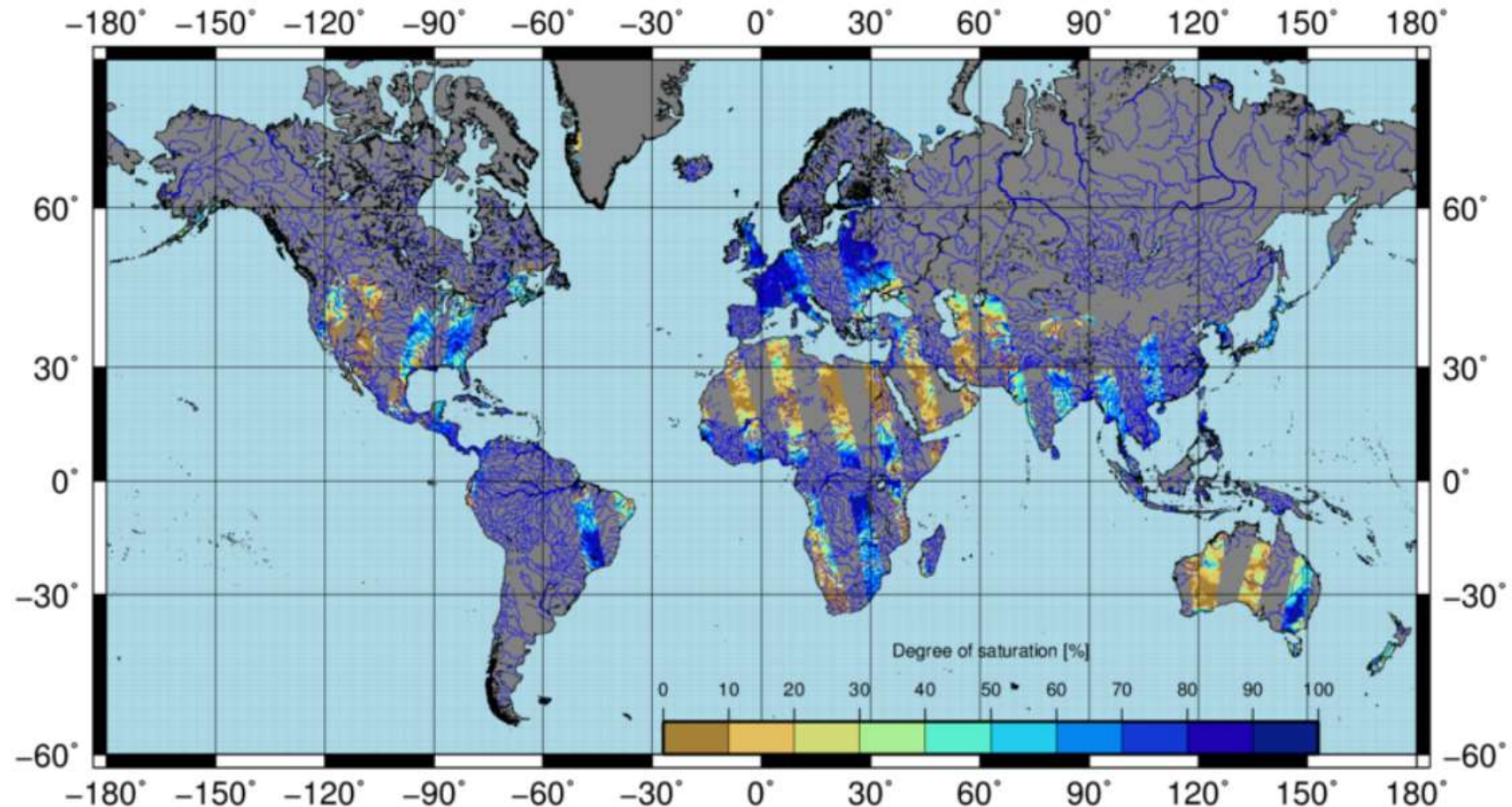
Water (V_w)

Solid Particles (V_s)

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Microwave Remote Sensing of Soil Moisture

- Global coverage
  - 1-2 days

- 1 km – 36 km

- Operational products
- Available at no cost

- Surface Soil Moisture
- Root Zone Soil Moisture
- Rainfall

ASCAT soil moisture 20221116_0210, Metop–B, 125

Degree of saturation [%]

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Datasets and pre-processing

Can we use satellite observations for drought assessment and early warning?

- Precipitation
  - Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) 0.05°
- **Soil Moisture**
  - **HSAF H116** Surface Soil Moisture 12.5km
- **Root Zone Soil Moisture**
  - Copernicus Global Land Service 0.1°
- Copernicus Global Land Service NDVI
  - 1km

June-August 2019
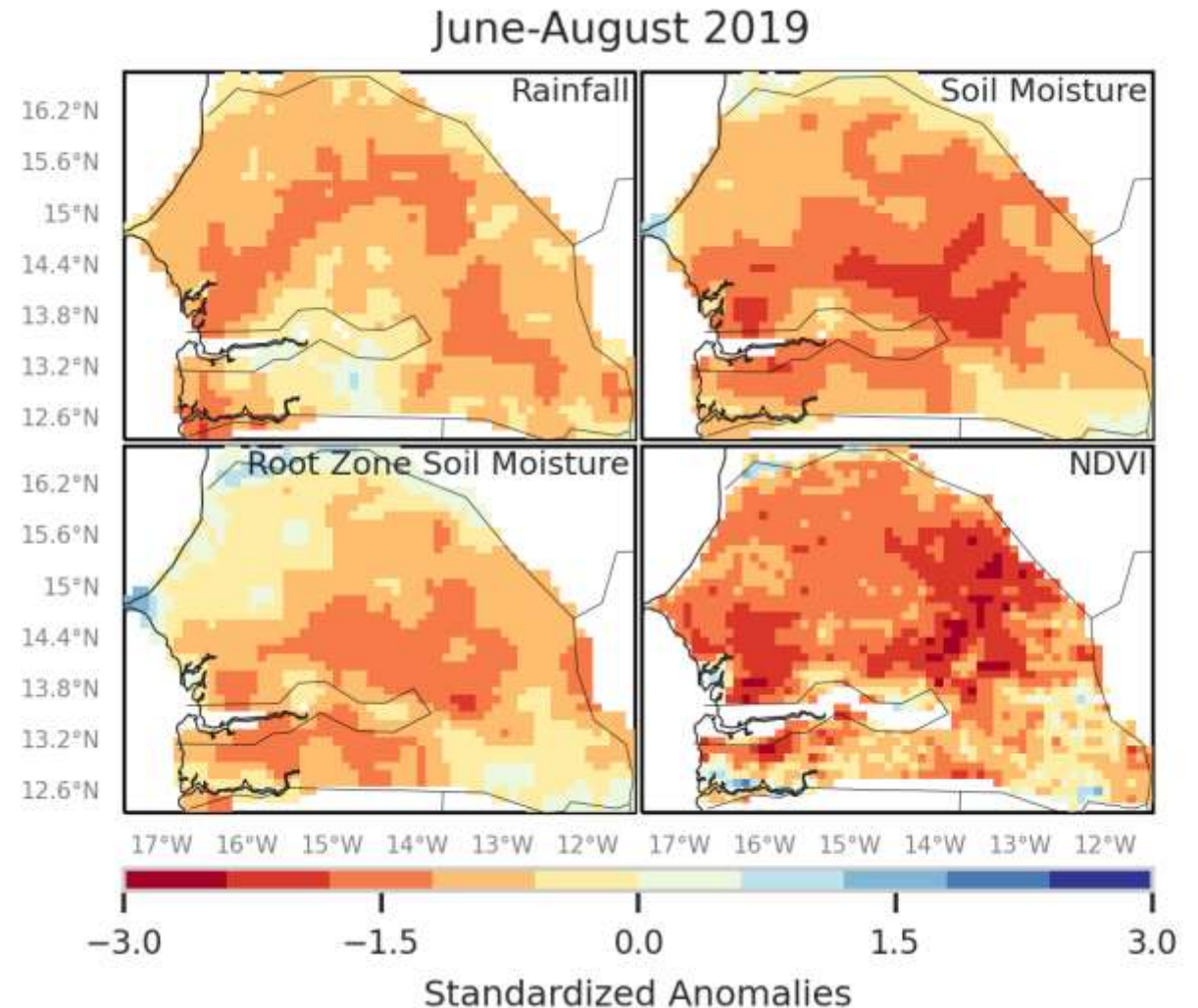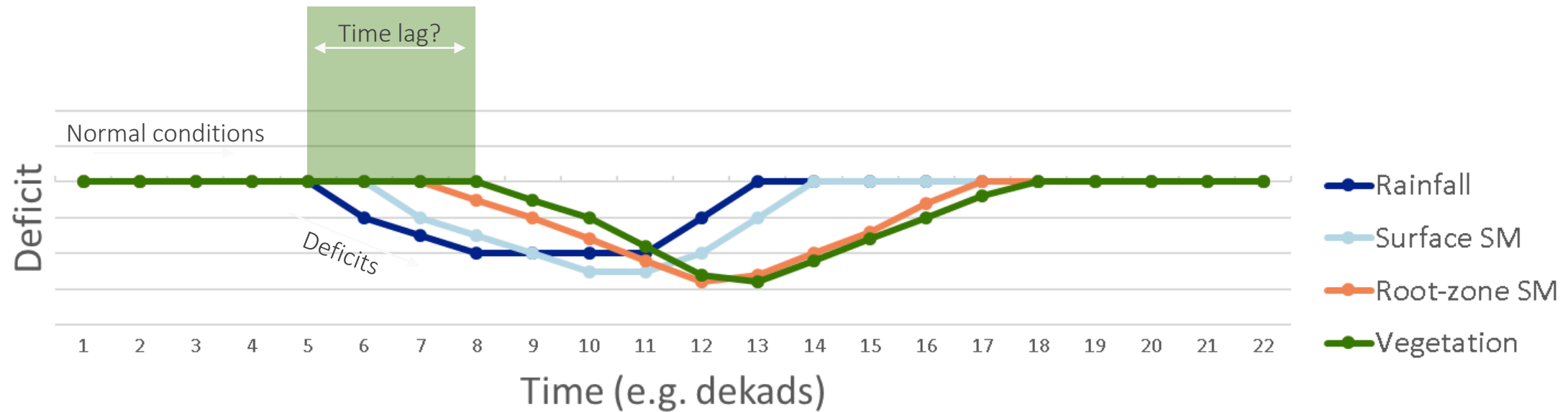
Drought development
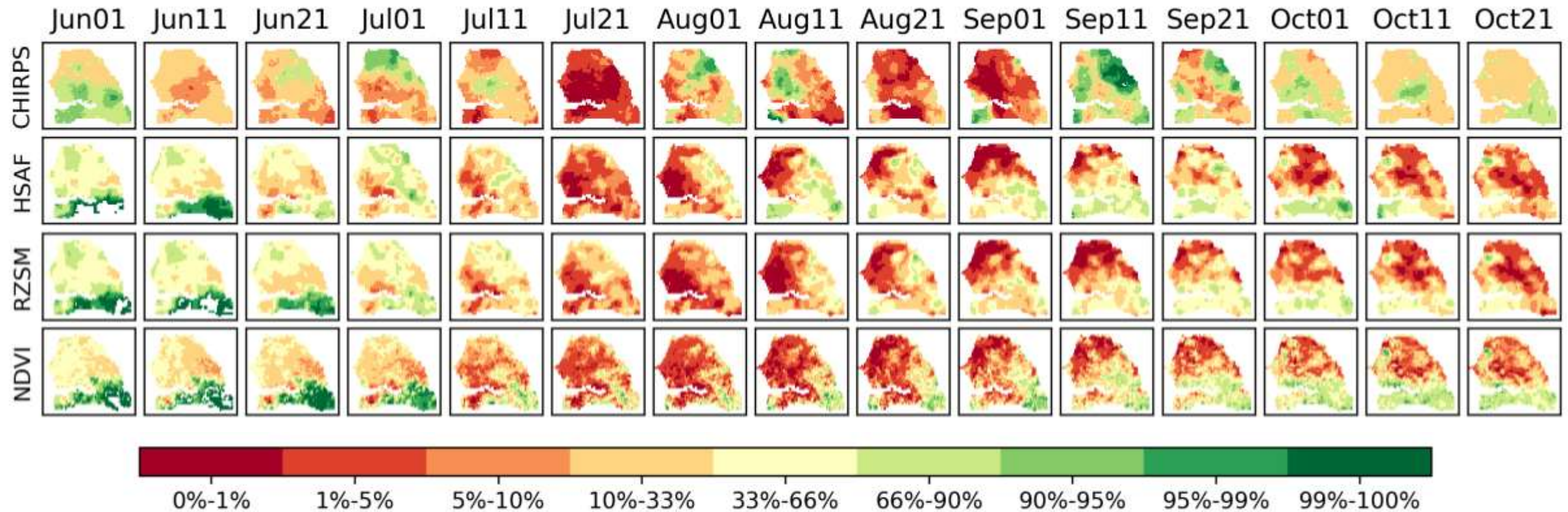
EO data as proxy for yield

Yield Deficiency Indicator

Drought monitoring and vegetation impact

Monitoring and impact assessment often done with crop models and meteorological data

Rainfall
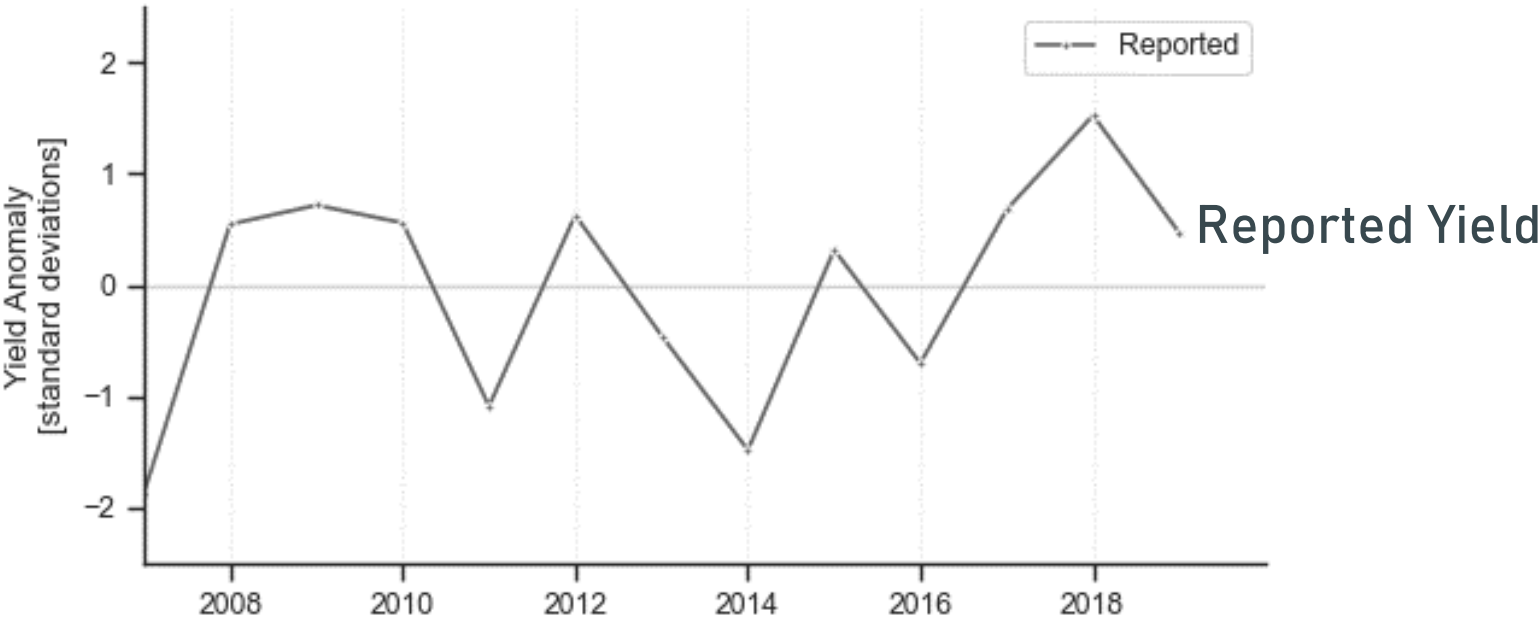
Driver of crop development

Excludes evaporation

Soil Moisture

Missing link…?

NDVI

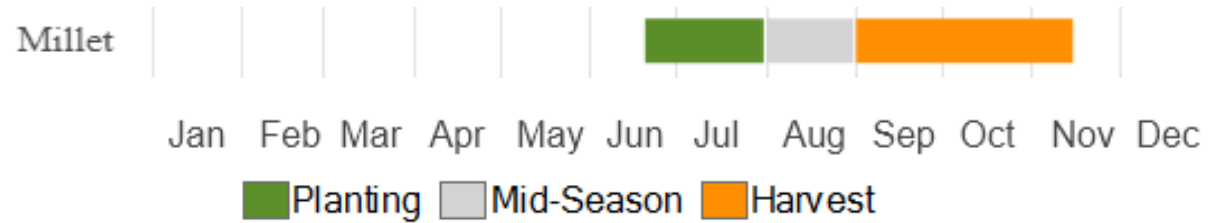**Indicator** of crop development
Late response

Millet

Yield data reported at district level from Senegal

Yield early warning

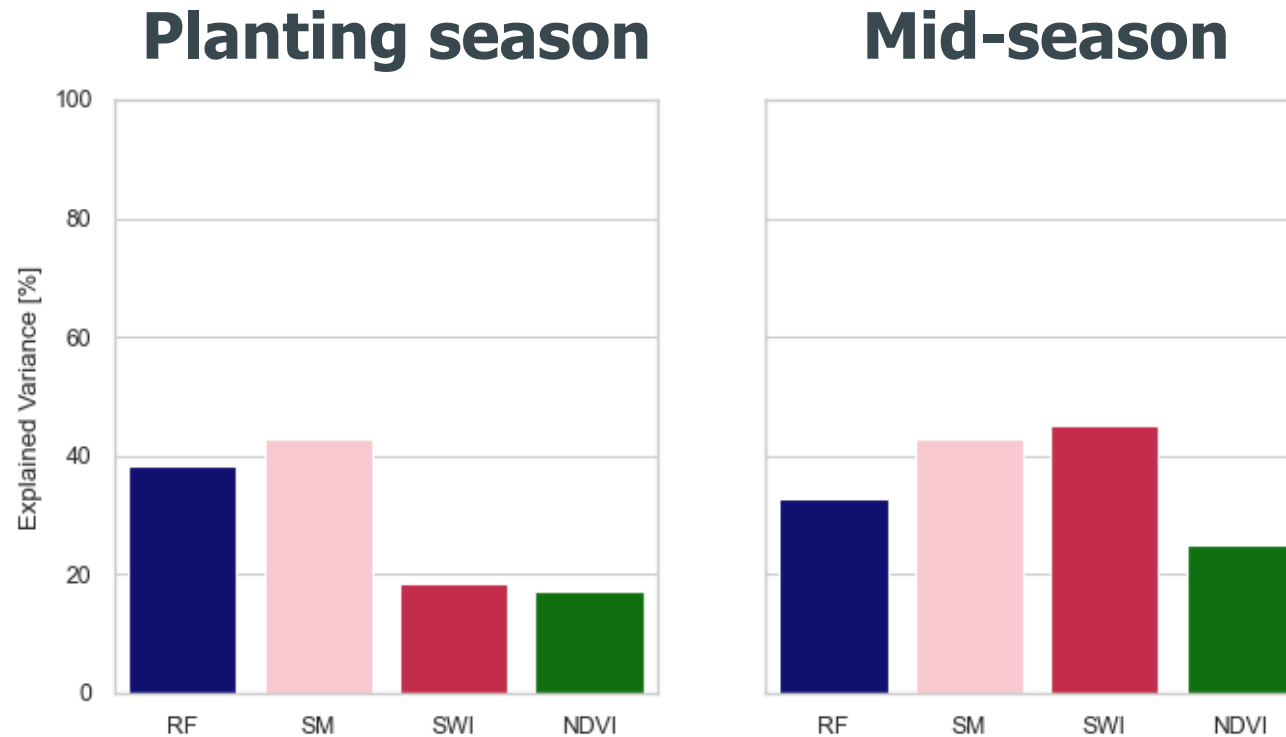Use early season satellite data to model spatial and temporal variability in yield anomalies

USDA

Millet

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |

■ Planting ■ Mid-Season ■ Harvest

Source: FAS/GMA/IPAD

With two input scenarios:

1. Satellite based **rainfall** and NDVI

2. Satellite based **soil moisture** and NDVI

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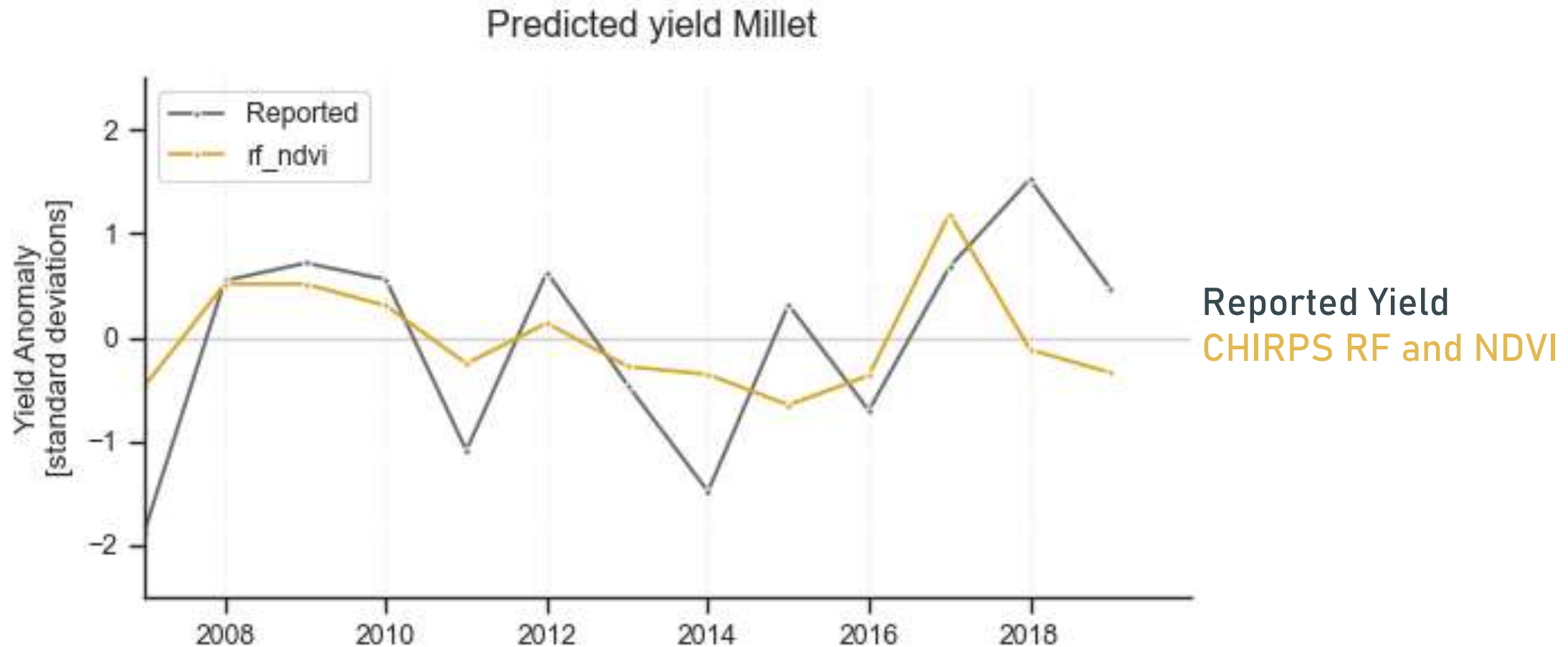
Sensitivity of observations to yield

Millet
Senegal

Explained variance in end of season yield for rainfall, soil moisture, root zone soil moisture and NDVI using EO data from the planting season or mid-season.
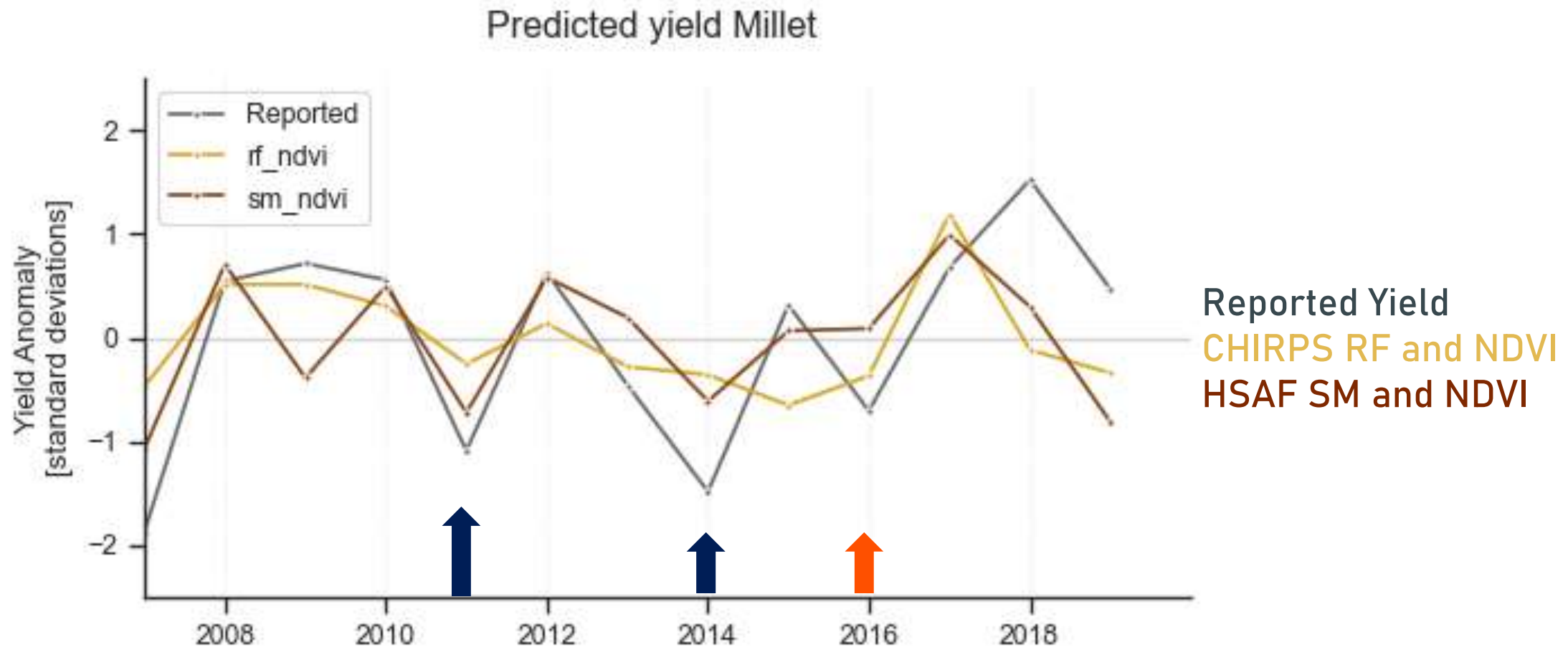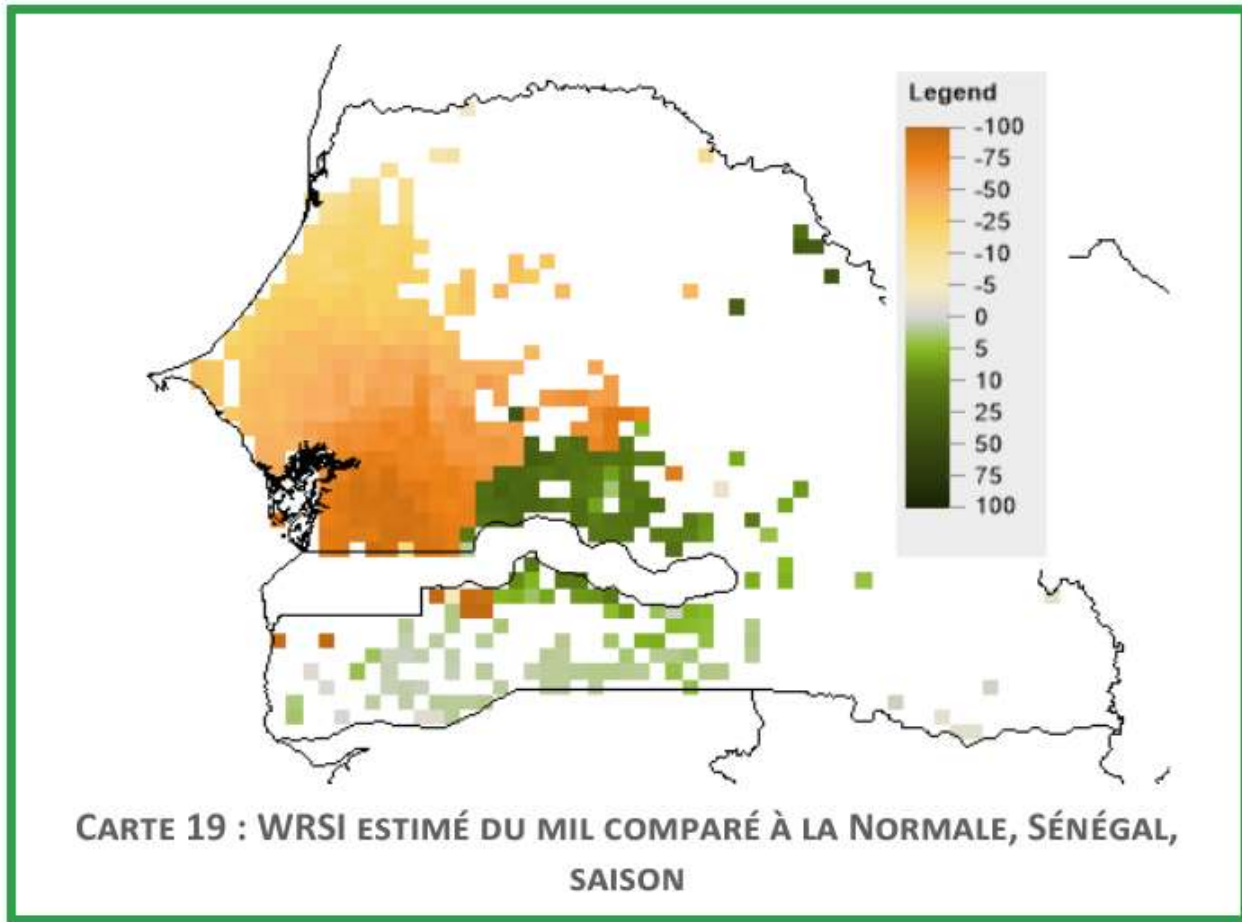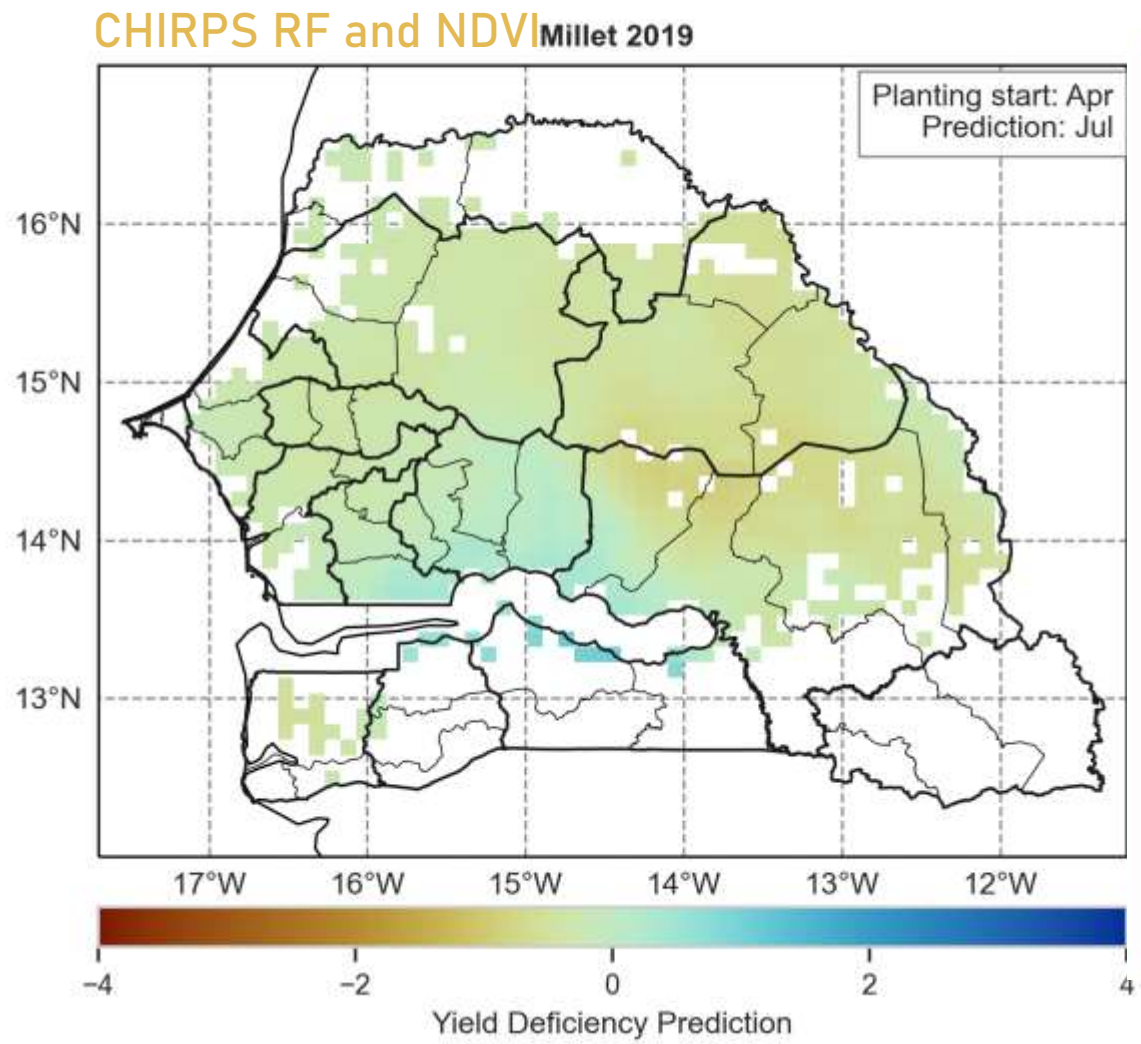
Yield deficiency indicator

Millet
Senegal

Reported Yield
CHIRPS RF and NDVI

Millet
Senegal

Predicted yield Millet

Reported Yield
CHIRPS RF and NDVI
HSAF SM and NDVI

Spatial yield deficiency prediction made in July
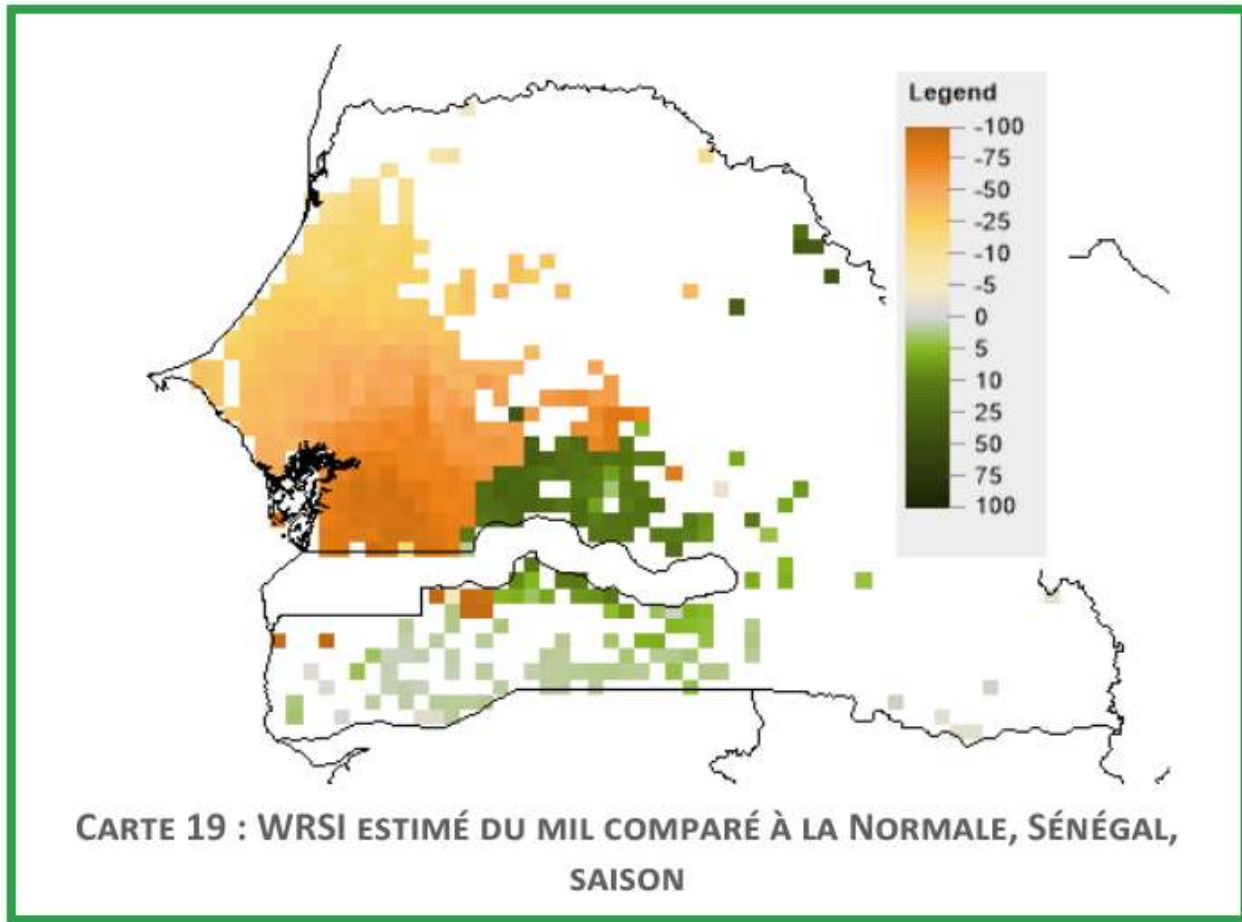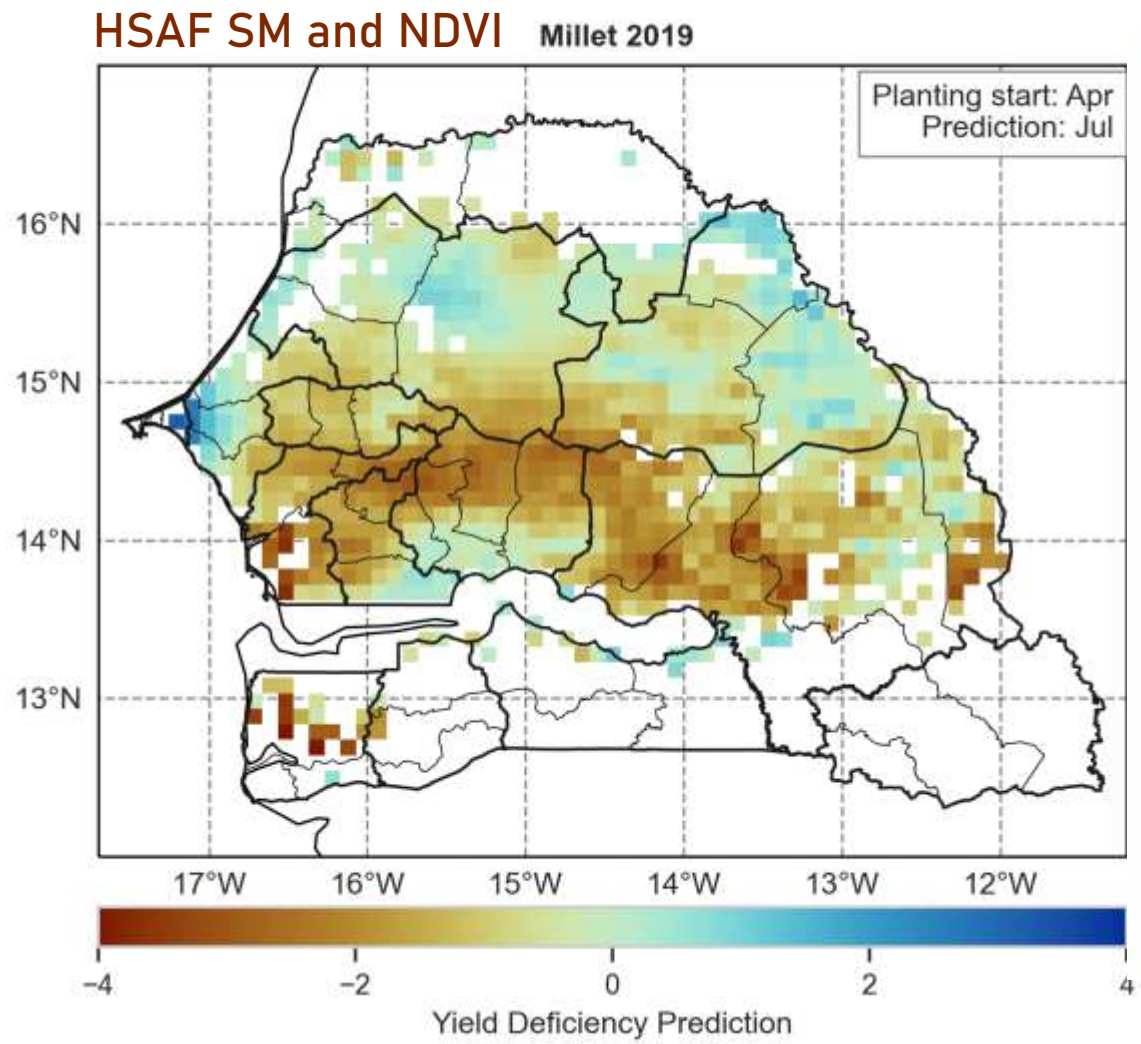
CHIRPS RF and NDVI — Millet 2019

Planting start: Apr
Prediction: Jul

Yield Deficiency Prediction

CARTE 19 : WRSI ESTIMÉ DU MIL COMPARÉ À LA NORMALE, SÉNÉGAL, SAISON

Water Requirement Satisfaction Indicator from African Risk View end of season report 2019

HSAF SM and NDVI

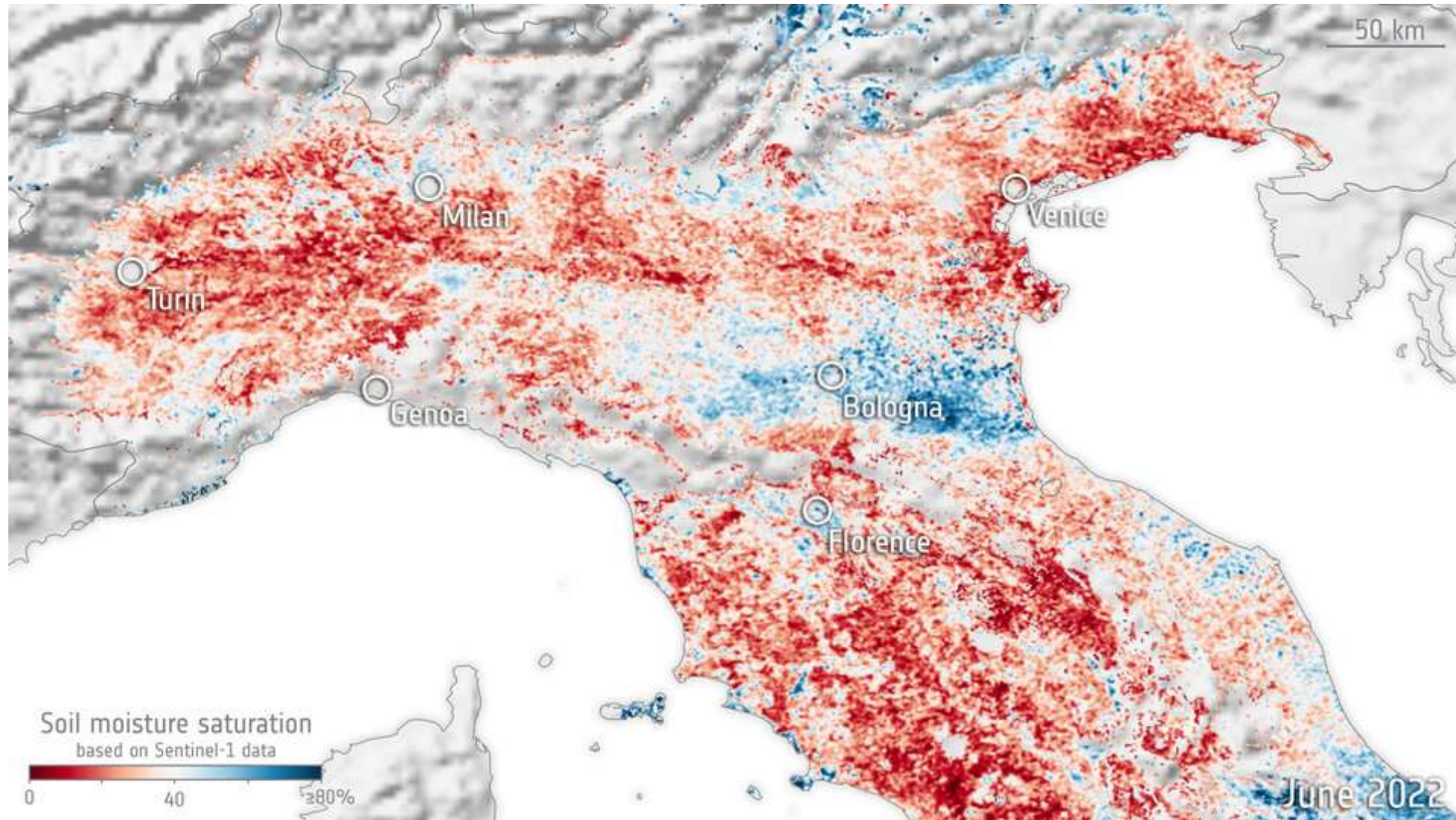Water Requirement Satisfaction Indicator from African Risk View end of season report 2019

Enhancing Drought Early Warning in Mozambique through Satellite Soil Moisture Data to support food security in the context of climate change

Research and Capacity building project

TU Wien and Eduardo Mondlane University

ADA project

- High resolution soil moisture for improved drought monitoring and early warning
  - Improve agricultural practice and tools
  - Increased capacity for drought interventions and mitigation
  - Investment in people, education, science, technology on use of freely available remote sensing data

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Drought monitoring

Soil moisture saturation
based on Sentinel-1 data

0   40   ≥80%

50 km

June 2022

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Work plan

User needs and data collection

1.1 Baseline and synergies

1.2 Stakeholder mapping and requirements

1.3 National data collection

•Inputs from MADER, INGC, Red Cross, WFP

Satellite soil moisture based drought and crop indicators

2.1 EO data cube,

2.2 Soil moisture retrieval and calibration

2.3 (Root zone) soil moisture retrieval

2.4 Accuracy assessment

3.1 Convergence of evidence

3.2 Drought indicator development

3.3 Crop yield indicator development

3.4 Evaluation historical drought and yield data

Integration and exploitation of drought early warning products in existing platforms

4.1 International technical working group

4.2 Exploitation: Integration in WaPOR, WFP PRISM, EAP

4.3 Exploitation for MADER, Use of SM for irrigation mapping

Gender sensitive capacity development of project beneficiaries

5.1 Capacity development stake-holders

5.2 Joint graduate course and training, master theses

5.3 Mentoring programme

5.4 Dissemination: policy briefs, publications

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