# EO4Multihazards

Transferability study to Senegal

## Earth Observation for high-impact multi-hazard science


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GMV

Carlos Domenech

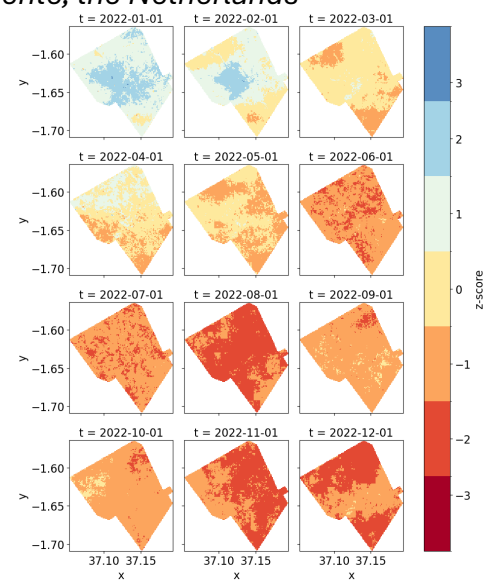

NP1.3 6 May 15:00

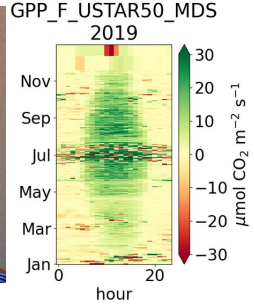
# Egor Prikaziuk: 9 years in remote sensing and Earth Observation

UNIVERSITY OF TWENTE. | ITC

- **2021-... – Assistant professor** - *ITC, University of Twente, the Netherlands*
  - drought monitoring
  - evapotranspiration modelling
  - SCOPE model development
  - eddy-covariance data collection and processing
  - carbon accounting in Africa
  - water quality monitoring in Central Asia

- **2021-2022 R&D** – *eLEAF B.V.*
  - Sugarcane and grape wine yield prediction with EO
  - FAO WaPOR water accounting

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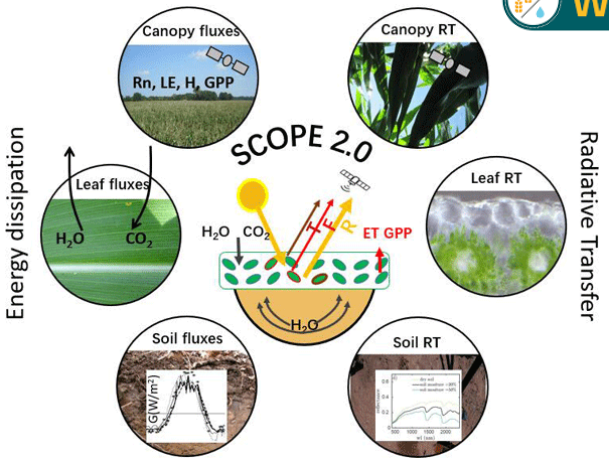
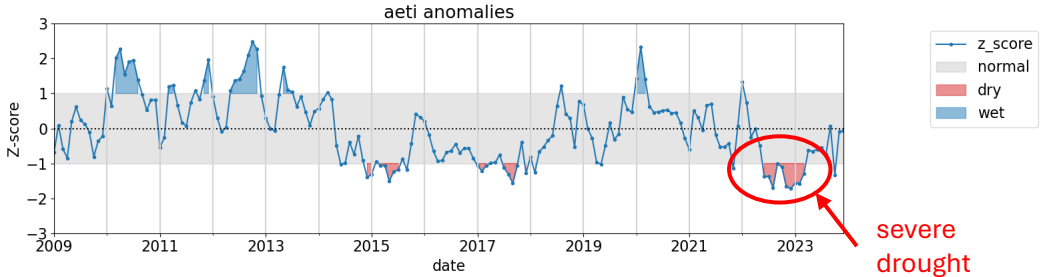
EO AFRICA




**S**oil **C**anopy **O**bservation, **P**hotochemistry and **E**nergy fluxes SCOPE model (Van der Tol et al., 2009, Yang et al., 2021)

Time series of actual evapotranspiration (AETI) anomalies over Kapiti rangeland farm, Kenya. The severe drought was in 2022 (Marshall et al, 2026, RSE)



# Multi-hazards are co-occurring hazards

MYRIAD-HESA 2004-2017

| Hazard class | Hazard type | Acronym |
|---|---|---|
| Geophysical | Earthquake | eq |
| | Volcanic eruption | vo |
| | Landslide | ls |
| Meteorological | Tropical cyclone | tc |
| | Coldwave | cw |
| | Heatwave | hw |
| | Extreme wind | ew |
| Hydrological | Tsunami | ts |
| | Flood | fl |
| Climatological | Drought | dr |
| | Wildfire | wf |

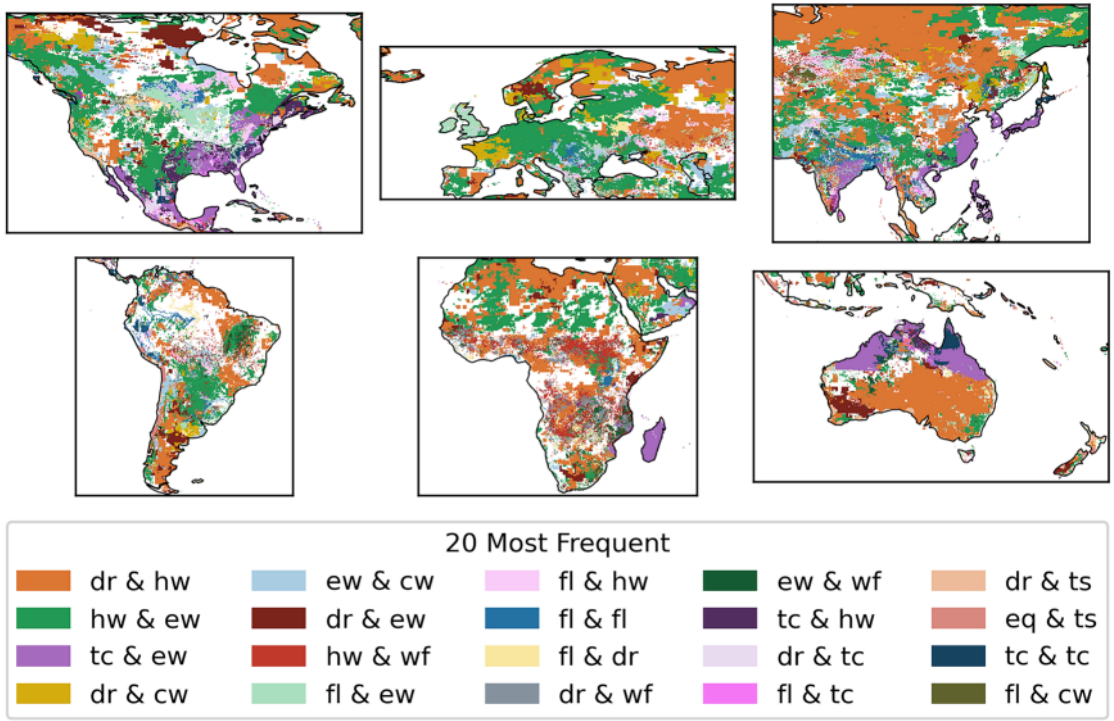



**Figure 5.** The most frequent hazard pair globally. Here, there is no distinction which hazard occurs first in the pair, for example, 'dr & hw' could be a drought followed by a heatwave as well as a heatwave followed by a drought. The acronyms for each hazard are inlcuded in Table 1. White areas are the ocean or a place with no hazard pairs.

Claassen, J.N., Ward, P.J., Daniell, J. *et al.* A new method to compile global multi-hazard event sets. *Sci Rep* **13**, 13808 (2023). https://doi.org/10.1038/s41598-023-40400-5

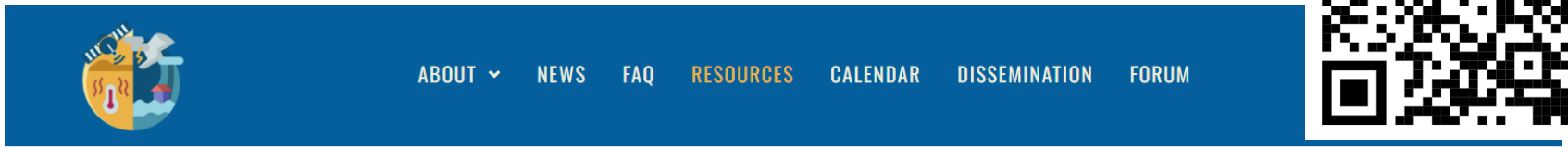
# Earth Observation for high-impact multi-hazard science

2023-2025

- developed a multi-hazard event database
- analyzed hazards (4 case studies)
- quantified risks = f(hazard, exposure, vulnerability)

# Project output

https://eo4multihazards.gmv.com/




## Resources

This repository serves as a comprehensive hub offering easy access the resources and results produced during the EO4MULTIHAZARDS project.

### Publications

Collection of the white papers and peer-reviewed publications published during the project.

### Documentation

This page encompasses the technical documentation, reports, presentations, and dissemination materials generated within the framework of the EO4MULTIHAZARDS project

### Events-database

Adhering to Open Science standards, this platform ensures reliable data for the scientific community and promote comprehensive research efforts on multi-hazard events.

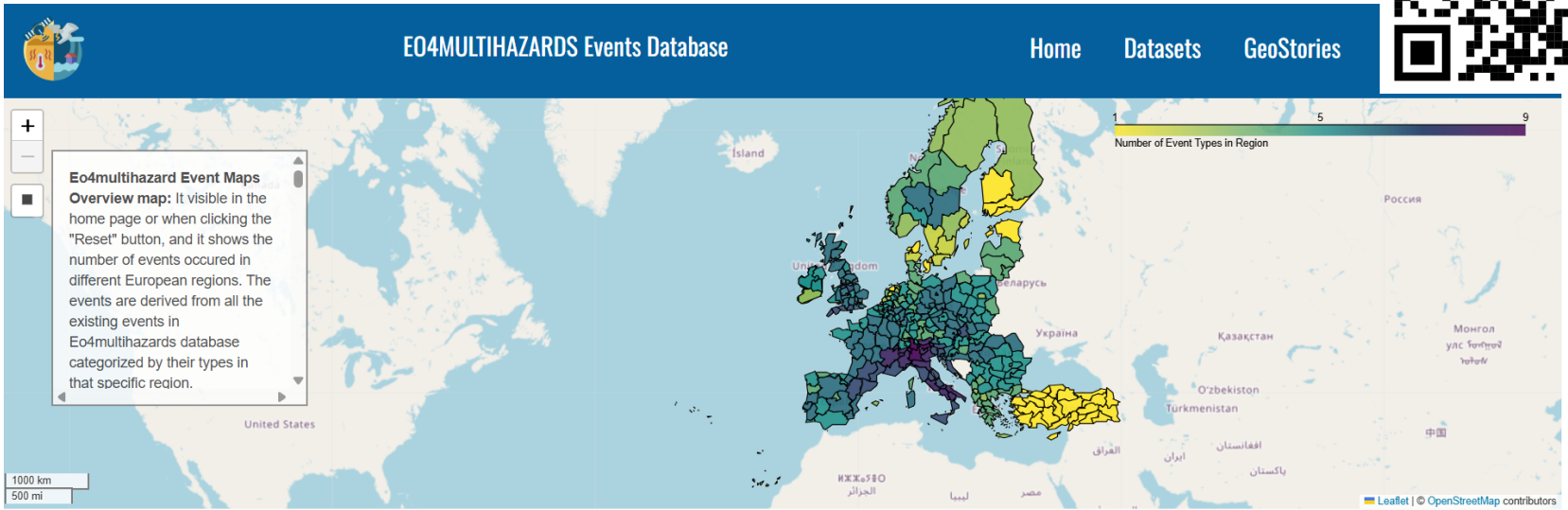
### Definitions

This link redirects you to the definitions of multi-hazard, multi-risk terminology adopted by the MYRIAD-EU project

### Repository of research datasets

Collection of the datasets generated in the case studies developed in the project

# Events database http://eo4multihazards.eurac.edu/




**Filtering Tools: Use it to query event records**

**Start Date** 01-Jan-2020

**End Date** 05-May-2026

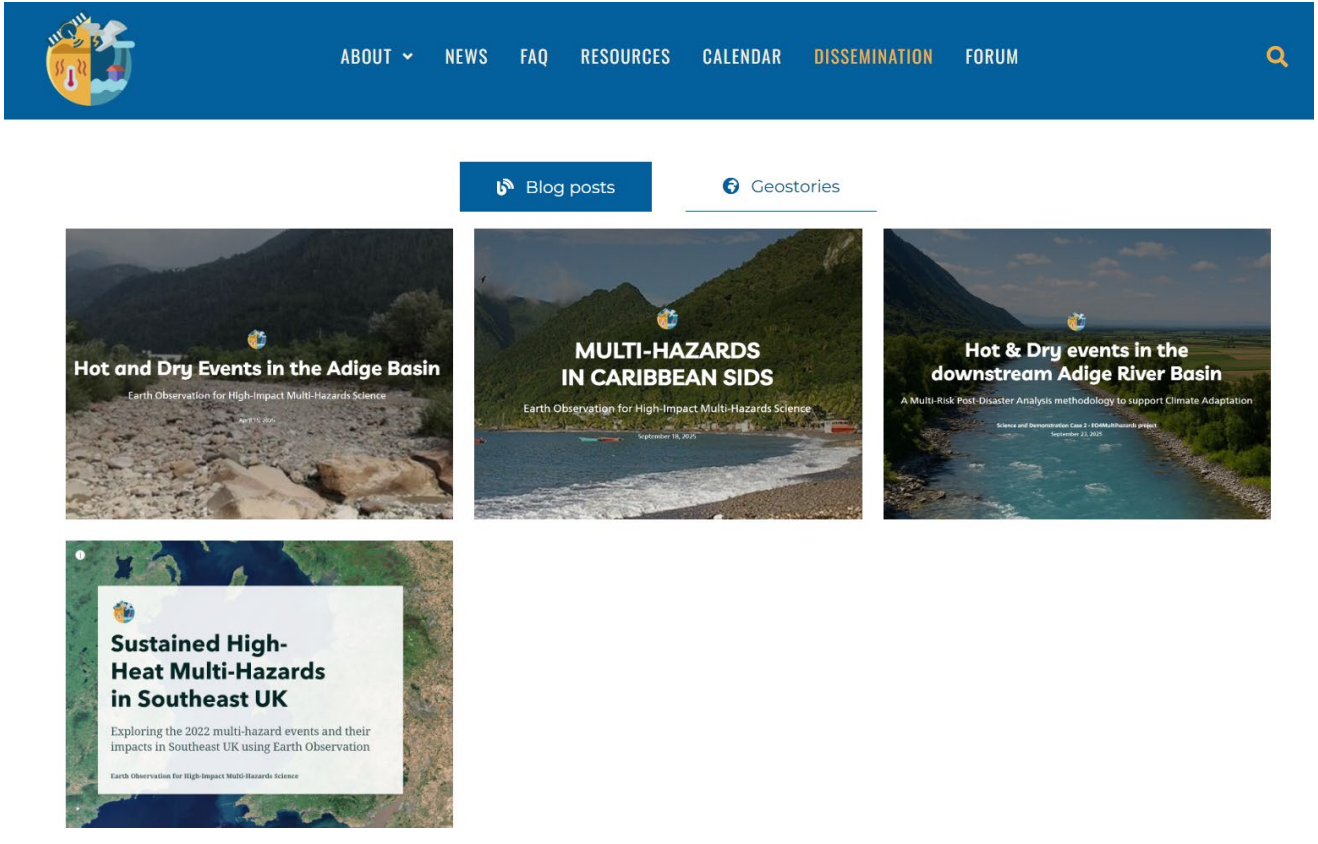
search reset

**Select the Event Type**
- Drought
- Flash flood
- Heatwave
- Landslide

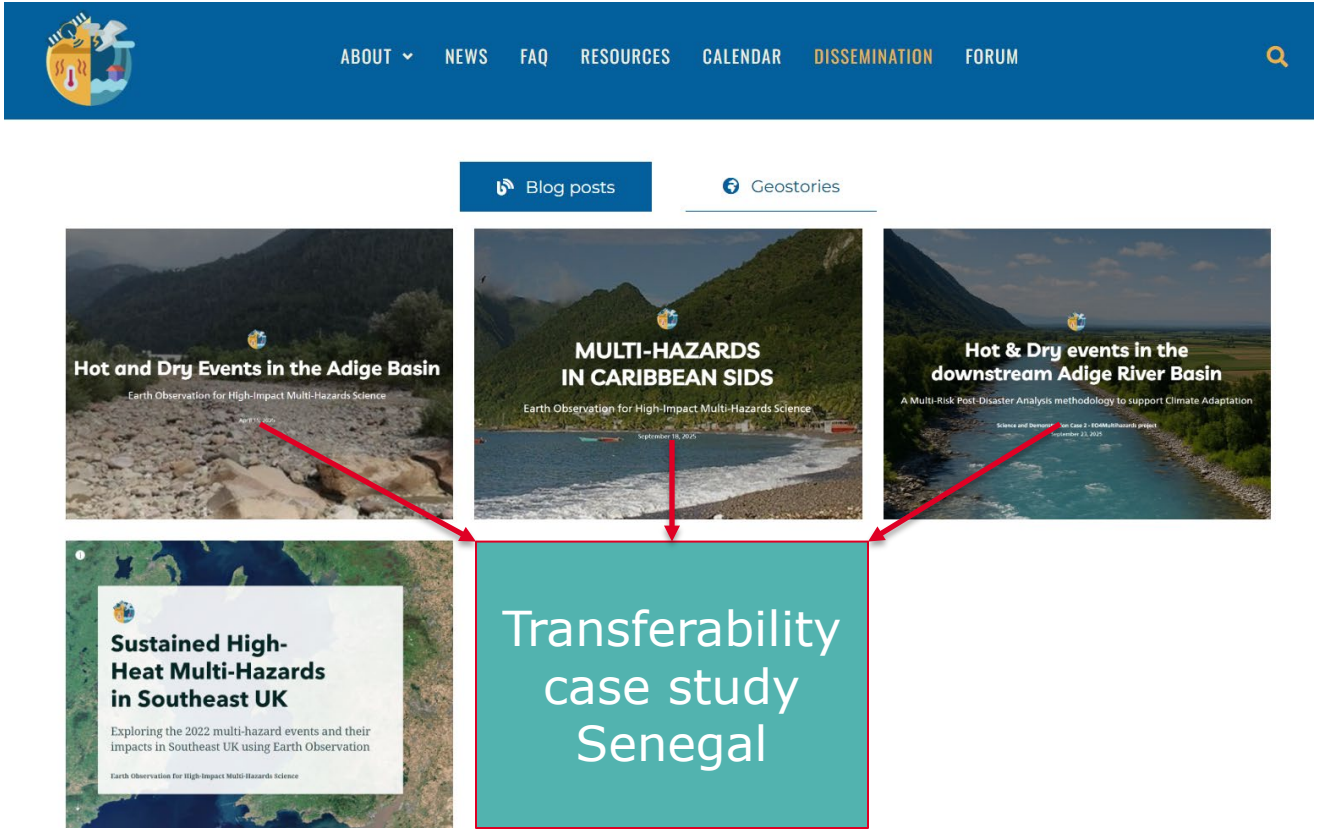
**Select the Event Country**
- Austria
- Belgium
- Bulgaria
- Cyprus

**Select the Data Provider**
- BGS
- EFFIS
- EMDAT

# Geostories of the case studies



# This talk is about transferability, case 5



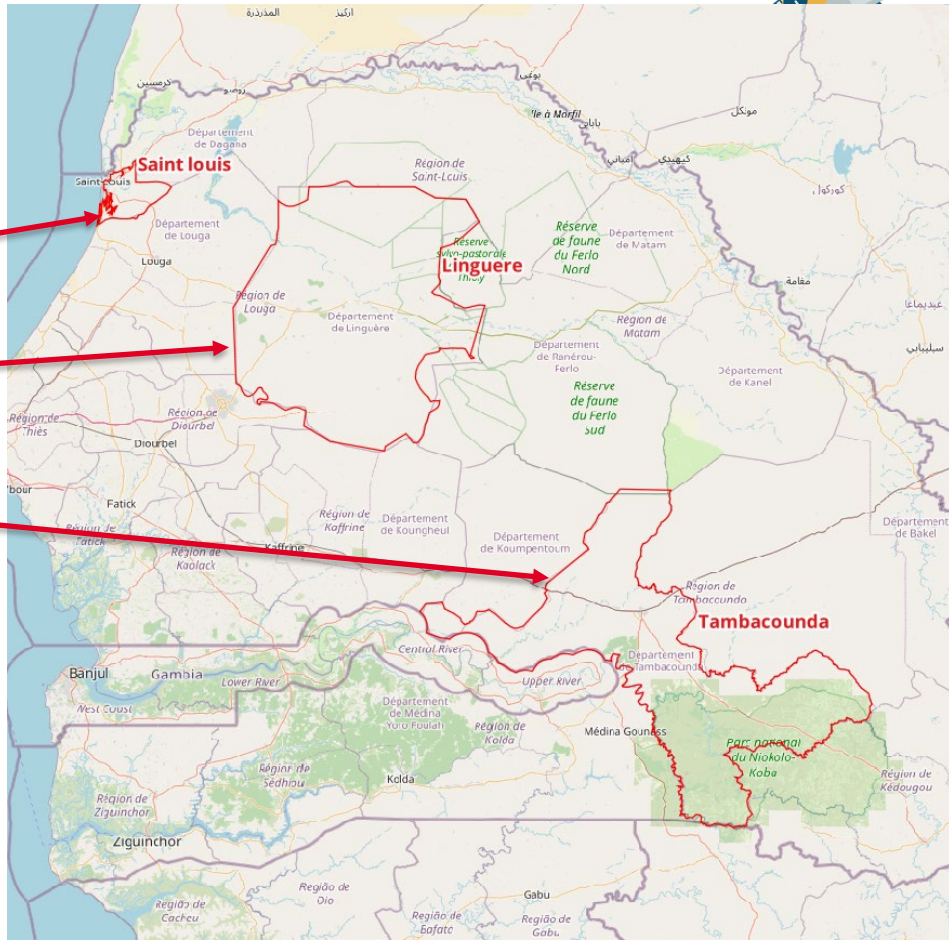
# Senegal study areas

**based on CSE information**

**Flood: in the cities**

**Droughts: over pastures**

**Fires: forest + pastures**




CSE

Centre de Suivi Ecologique

# Heatwaves

- the number of heatwaves, their duration and severity are growing
- the growth of duration increased after 2013
- lower Adige method detects more events (due to lower quantile)

| case | MA period | Ta max quantile | shortcut |
|---|---|---|---|
| upper Adige | 31 days | 0.90 | MA31-Q90 |
| lower Adige | 15 days | 0.95 | MA15-Q95 |

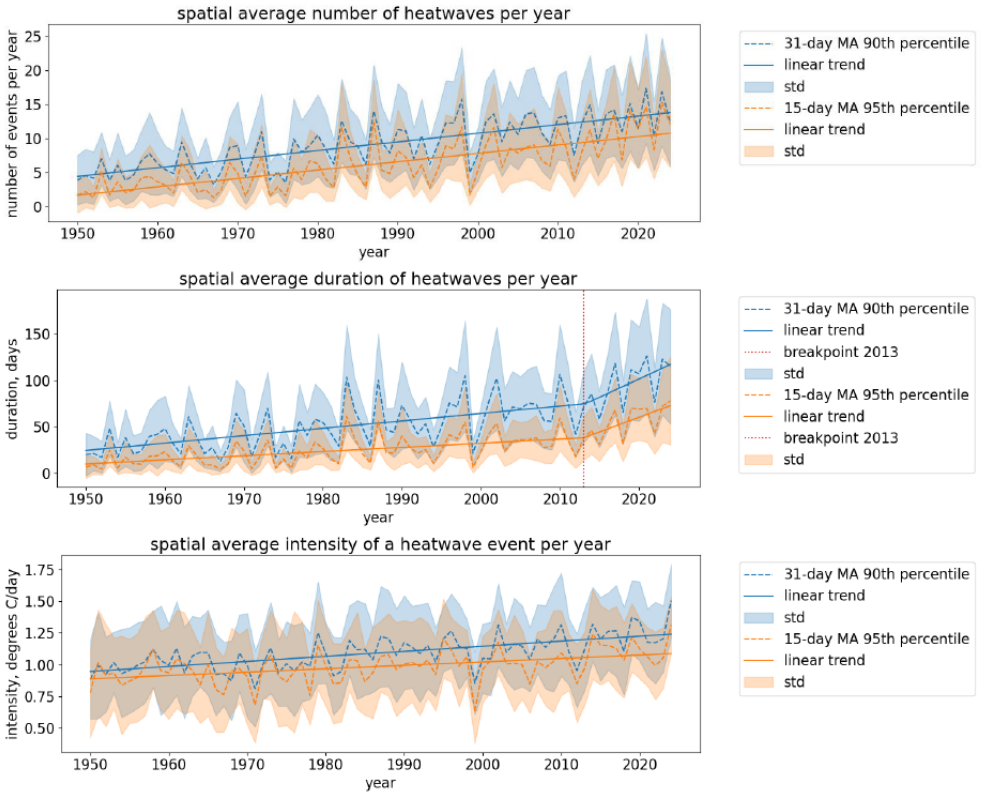



**Figure 7-4 - Spatial average number of heatwaves, their duration and intensity computed with two methods HW31 (SC1, blue) and HW15 (SC2, orange) over Senegal.**

# Droughts

- **droughts are becoming milder in Senegal**
- **upper Adige method detects a smaller number of events (max 12 per year)**

| case | indicator | distribution |
|---|---|---|
| upper Adige | SPI-6 month | normal |
| lower Adige | SPEI-90 days | gamma |

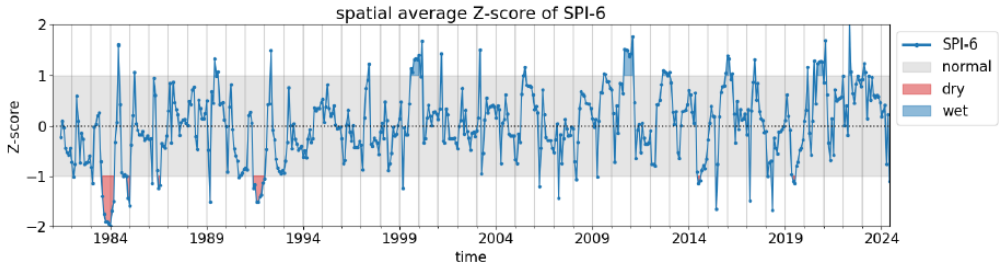



**Figure 7-5 - Spatial average Z-score of SPI-6.**

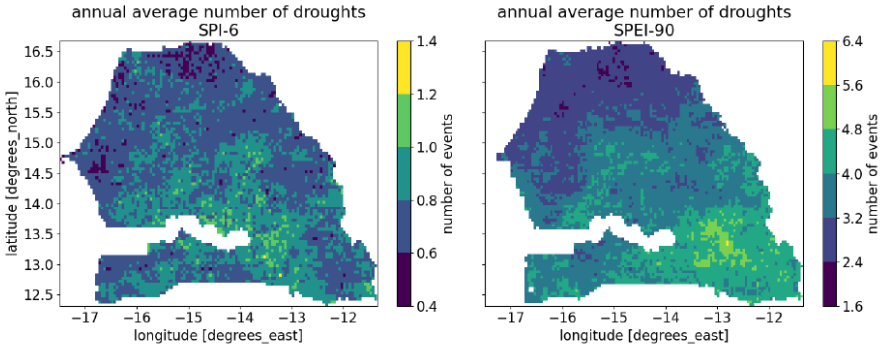



**Figure 7-12 - Drought number temporal average.**

# Compound drought-heatwave events (CDHW)

## CDHW in the Linguere (pasture) region of Senegal are less frequent but more intense

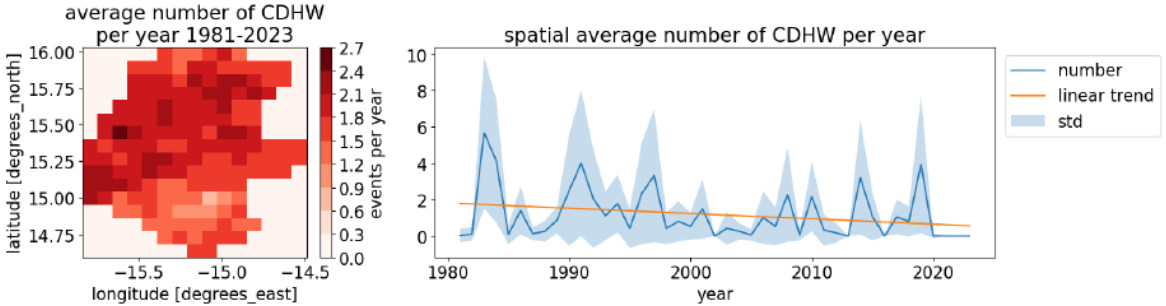



**Figure 7-13 - Average number of CDHW in time.**

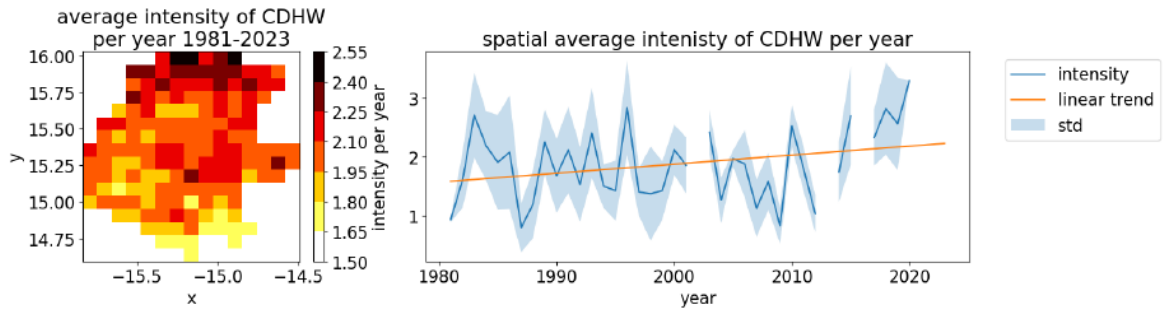
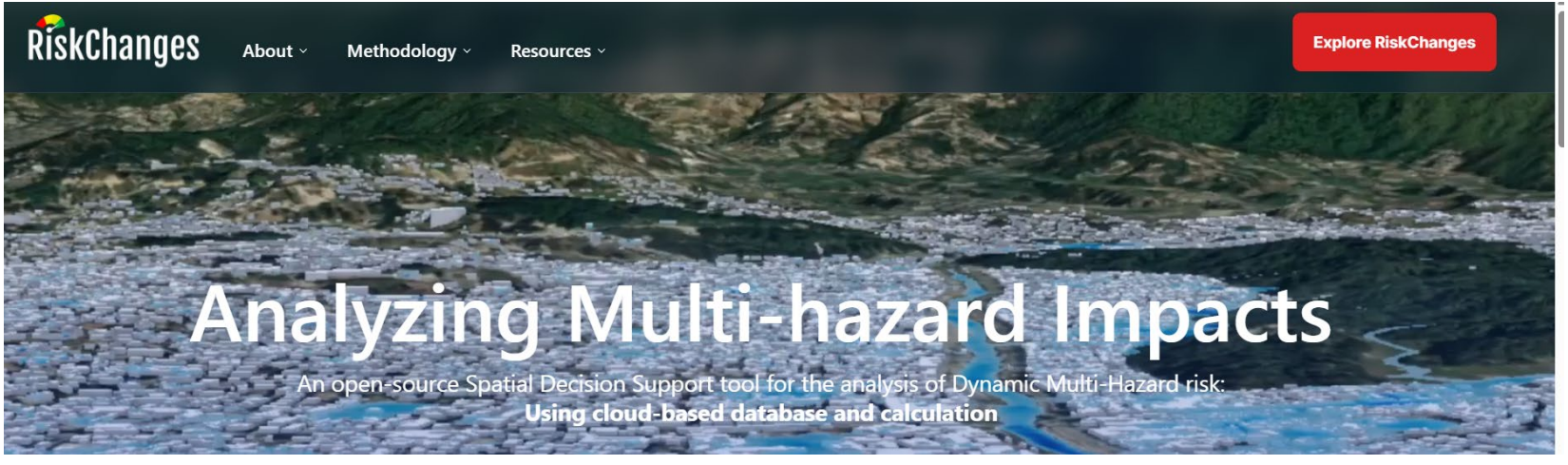
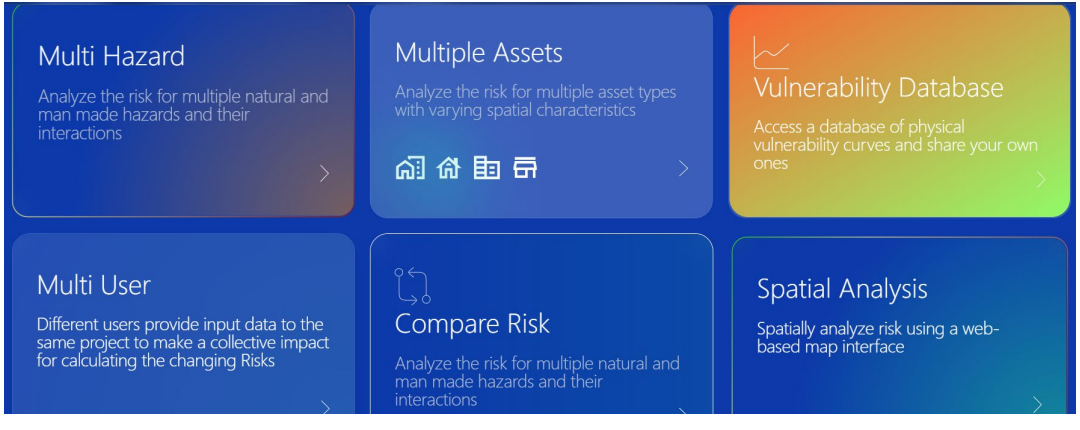


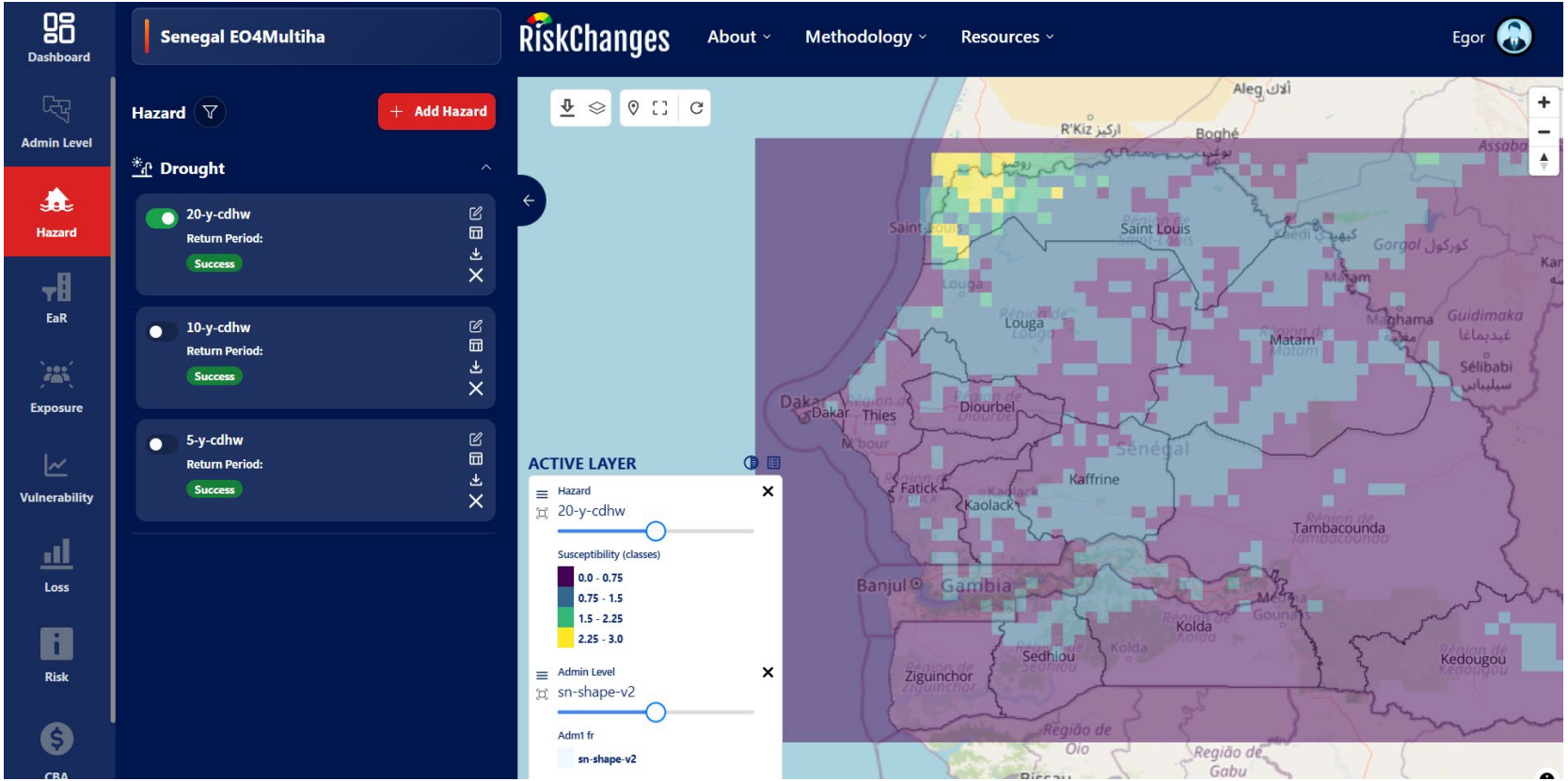

**Figure 7-14 - Average intensity of CDHW in time.**

# RiskChanges.org



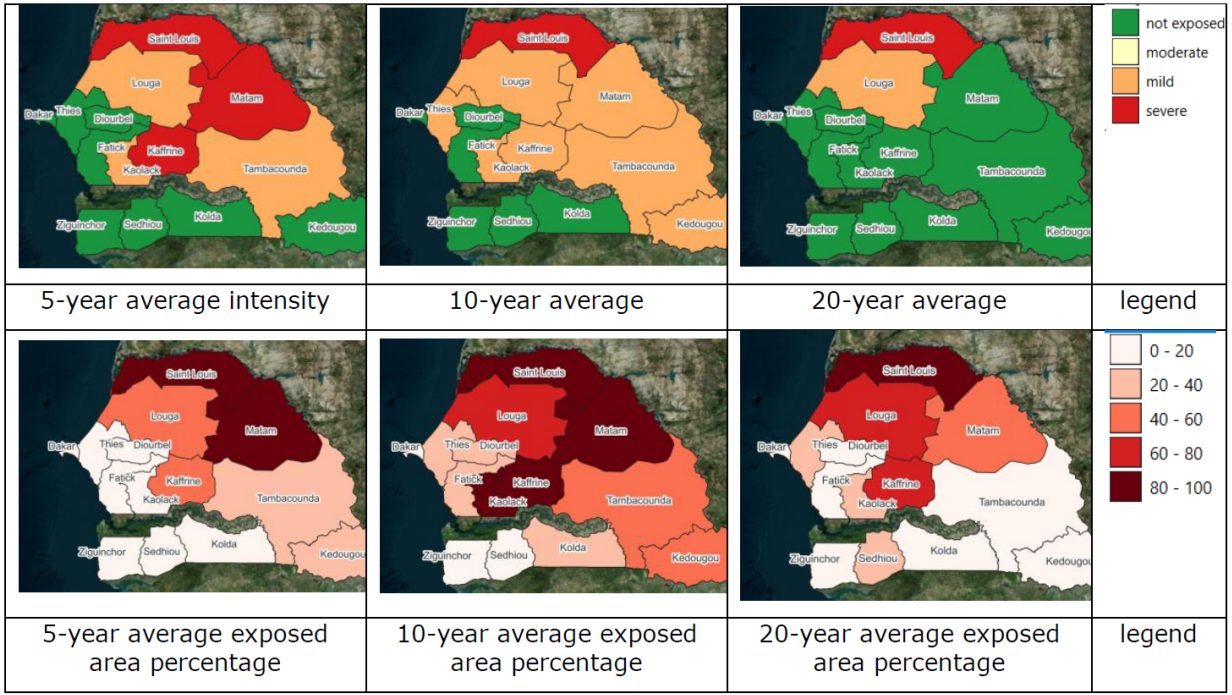
# RiskChanges.org



# Exposure analysis

## Compound drought-heatwave events

**Figure 7-8 - Exposure assessment of the population to CDHW, aggregated over administrative units. Color codes: green -not exposed, yellow – moderate, orange – mild, red - severe.**




| 5-year average intensity | 10-year average | 20-year average | legend |
|---|---|---|---|
| 5-year average exposed area percentage | 10-year average exposed area percentage | 20-year average exposed area percentage | legend |

# Floods

## transferability from Dominica (SC4)

Deltares

Impact Expertise Research facilities Software and data News Stories

Home • Reliable expertise • Projects • Saint-Louis, caught between two threats

### • Saint-Louis, caught between two threats

Saint-Louis, Senegal, is caught between two threats. The coastal town in northern Senegal is located on a sand spit at the mouth of the Sénégal River, where high river levels cause flooding during the wet season. At the same time, the city borders on the sea, which means that storms and waves also cause flooding and coastal erosion on the narrow, vulnerable coast where many people live.

# Floods + drought indices

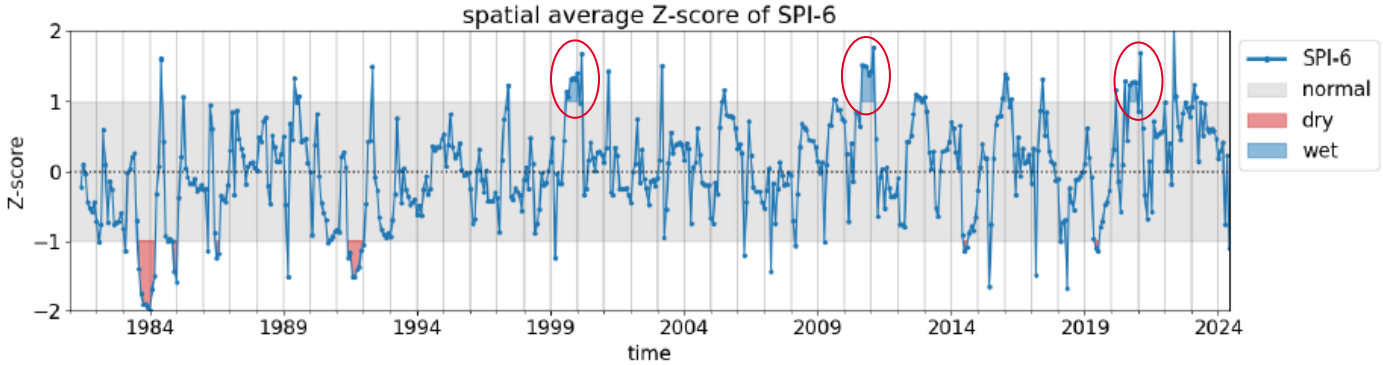
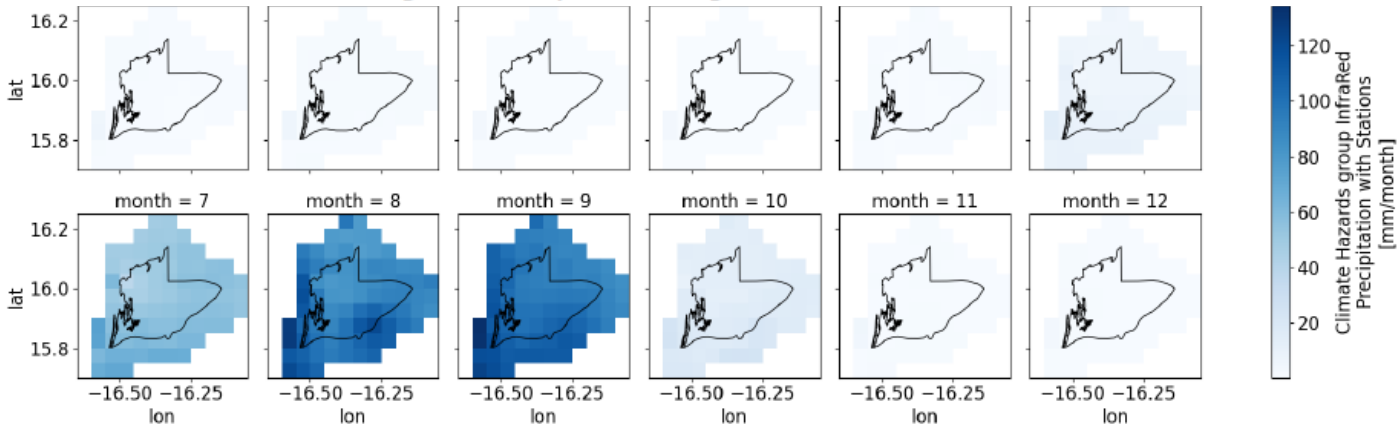
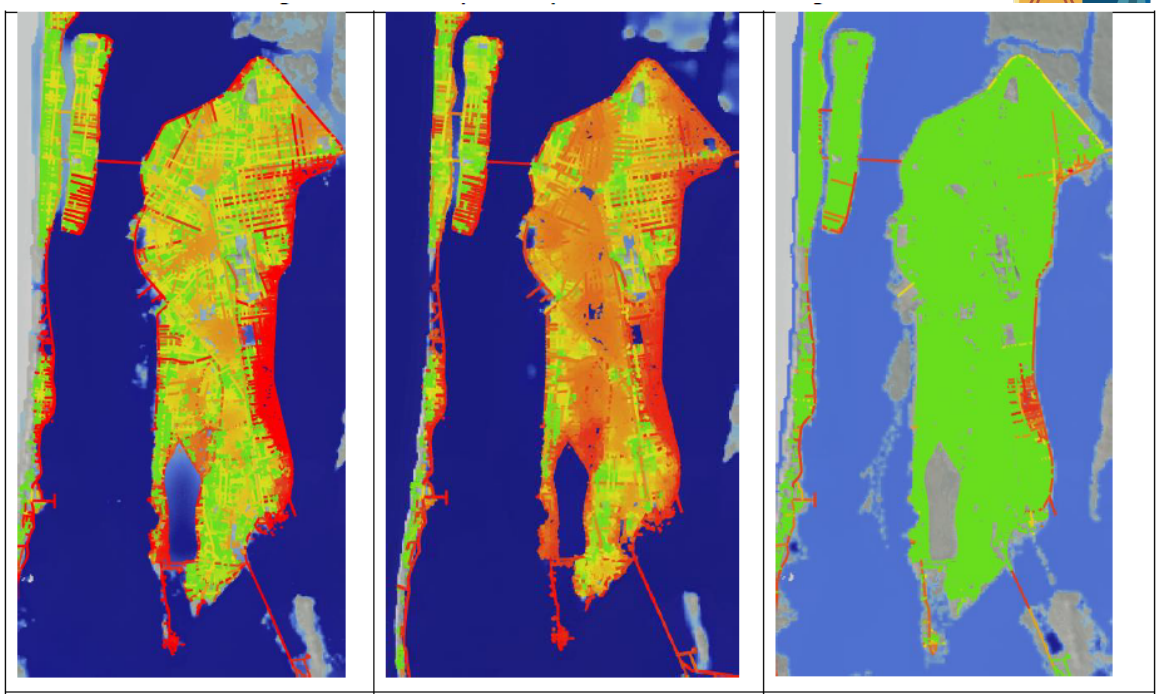



Figure 7-5 - Spatial average Z-score of SPI-6.



# FastFlood results

- Pluvial floods cause intermediate damage (aggravated by the sewage system blockage)
- Fluvial floods could cause the most damage
- Coastal floods are not an issue for the city of Saint-Louis



| Pluvial flood with 8 mm/h for 3 hours. | Fluvial flood with 10,000 m3/s discharge rate. | Coastal flood with water elevation 0.5 m a.s.l. |
|---|---|---|

**Figure 7-23 - Flood simulation in the Senegal river delta, city of Saint-Louis with the FastFlood app. The overlay represents open street maps building and road, colored green (unaffected) and red (submerged under 1 meter of water).**

# Building occupancy type characterization

- open street map (OSM) data + enhancement with tags
- 52% - unclassified
- 46% - residential

**To be followed up with building material type => vulnerability**

**Figure 7-7 - Exposure assessment of buildings to flood (water height level) in the city of Saint Louis, zoomed in on the central part.**

Building classification (white – unclassified, red – residential, blue – commercial, orange – industrial, green – educational). OSM background.

Building classification (white – unclassified, red – residential, blue – commercial, orange – industrial, green – educational). Google Satellite background.

# Datasets are on Zenodo

September 14, 2025 (v2) | Dataset | Restricted | View

### HDBSCAN Clusters Rice Crop Stress - Senegal River Delta, 2019-2020

Prikaziuk, Egor; University of Twente; Van Westen, Cees

Demonstration Case Name Multi-hazards in Senegal (transferability case) Dataset Name/Title HDBSCAN Clusters Rice Crop Stress - Senegal River Delta, 2019-2020 Dataset Description The dataset contains HDBSCAN (Hierarchical Density-Based Spatial Clustering of…

Part of Earth Observation for high impact multi-hazards science (EO4Multihazards)
Uploaded on September 14, 2025

85 0

September 14, 2025 (v1) | Dataset | Restricted | View

### Exposure to CDHW - Senegal, 5-, 10-, 20-year RP

Prikaziuk, Egor; University of Twente; Van Westen, Cees

Demonstration Case Name Multi-hazards in Senegal (transferability case) Dataset Name/Title Exposure to CDHW - Senegal, 5-, 10-, 20-year RP Dataset Description Exposure analysis of administrative units and population Key Methodologies The Severity of Compound Drought an…

Part of Earth Observation for high impact multi-hazards science (EO4Multihazards)
Uploaded on September 15, 2025

10 0

September 14, 2025 (v1) | Dataset | Restricted | View

### Exposure of buildings to flood – Saint-Louis, Senegal

Prikaziuk, Egor; University of Twente; van den Bout, Bastian

Demonstration Case Name Multi-hazards in Senegal (transferability case) Dataset Name/Title Exposure of buildings to flood - Saint-Louis, Senegal Dataset Description Exposure analysis of buildings Key Methodologies Flood water heights were simulated with the FastFloodApp.…

Part of Earth Observation for high impact multi-hazards science (EO4Multihazards)
Uploaded on September 15, 2025

6 0

# Thank you

PANGEOS COST action funded my participation at the EGU2026 with the Young Researcher and Innovator Conference Grant (YRIG)

Funded by the European Union

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

FutureMed TRANSDISCIPLINARY NETWORK

We acknowledge support from the EO4Multihazards project (Earth Observation for high-impact multi-hazards science), contract number 4000141754/23/I-DT, funded by the European Space Agency and launched as part of the joint ESA-European Commission Earth System Science Initiative.

# Conclusions on transferability

- **Exposure analysis via riskchanges.org:** Technically straightforward overlays, but hazard severity and Exposure at Risk (EaR) definitions are subjective, especially for multi-hazards like CDHW events.

- **Building characterization:** OSM data incomplete (missing tags, fewer polygons than visible roofs); Google/Microsoft ML buildings add limited value; fieldwork is needed to capture materials, vulnerability, and replacement cost.

- **EO data strengths and limits:** Valuable for vegetation health and hazard mapping (droughts, heatwaves), but limited in urban resolution (3–10 m); exposure/vulnerability analysis also relies on non-EO datasets (population, buildings, crop types), requiring fieldwork to improve EO-derived products.

# Supplementary material

## 7.7.1.IMPACT CHAINS

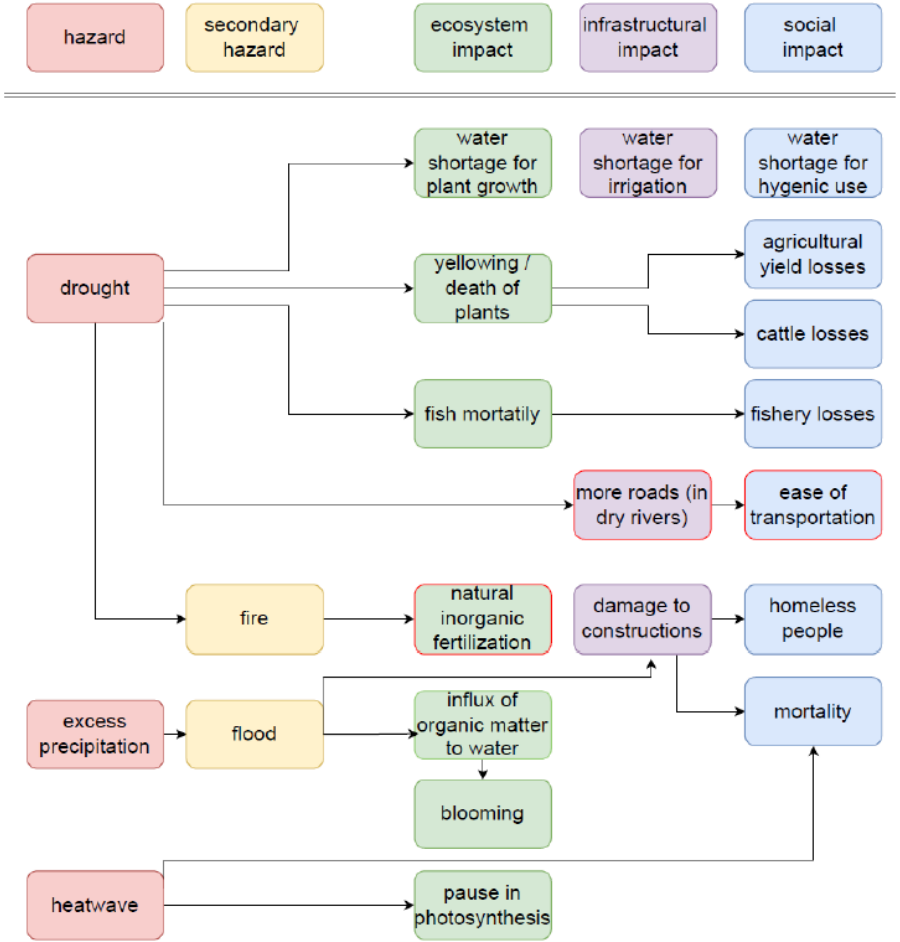


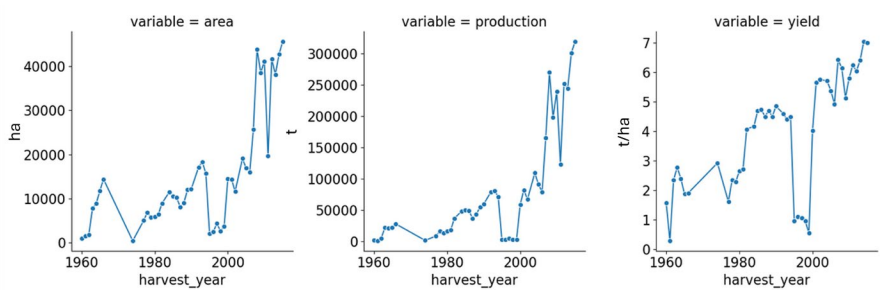

Figure 7-2 - Impact chain of SC5 hazards.

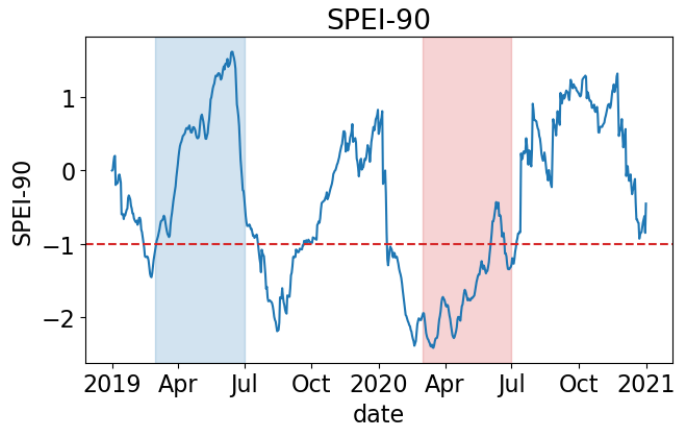
# Impact of CDHW on an irrigation scheme

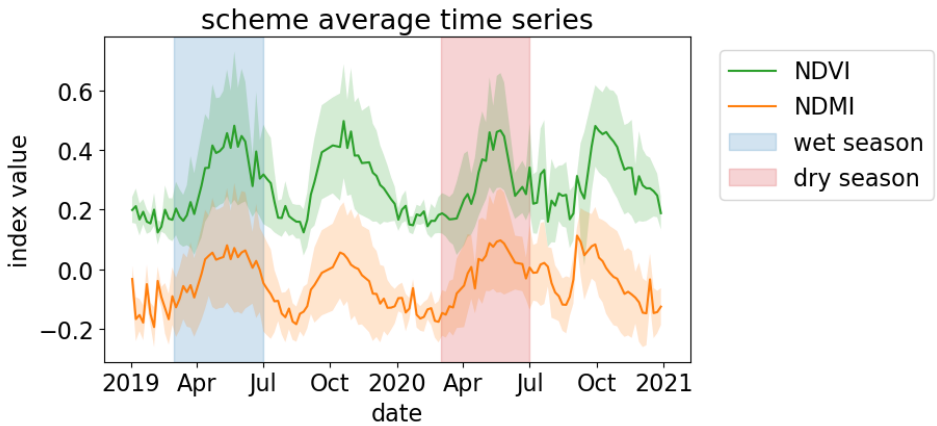
# Irrigation scheme performance in dry and wet years

## DC2 transfer

- irrigation takes place along the Senegal river
- the irrigated (dry) season is April to July
- the major crop in Dagana region is rice (320 kt, 95%)

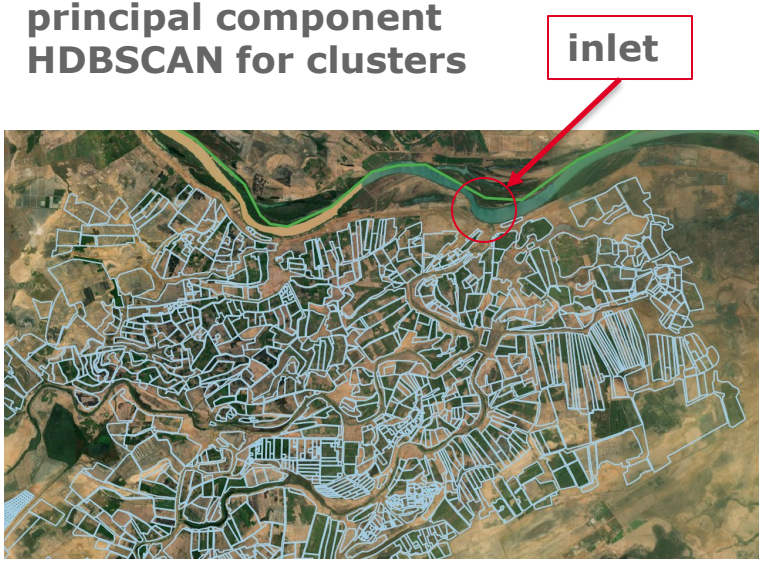


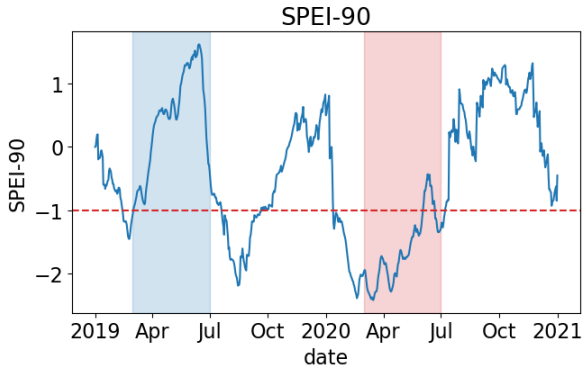



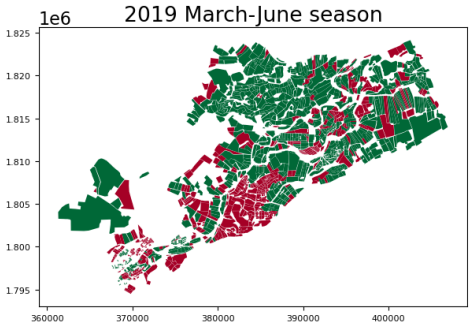



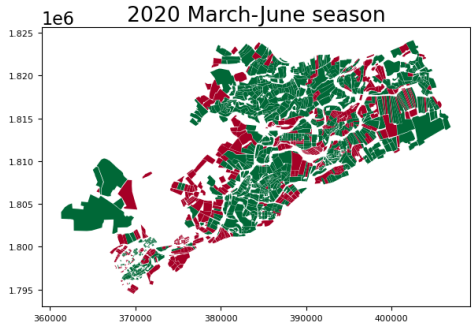
# Steps

- filtering of vegetated field based on BSI value at the peak of the season (May-June)
- distance from the inlet computation
- NDVI and NDMI composition to a principal component
- HDBSCAN for clusters



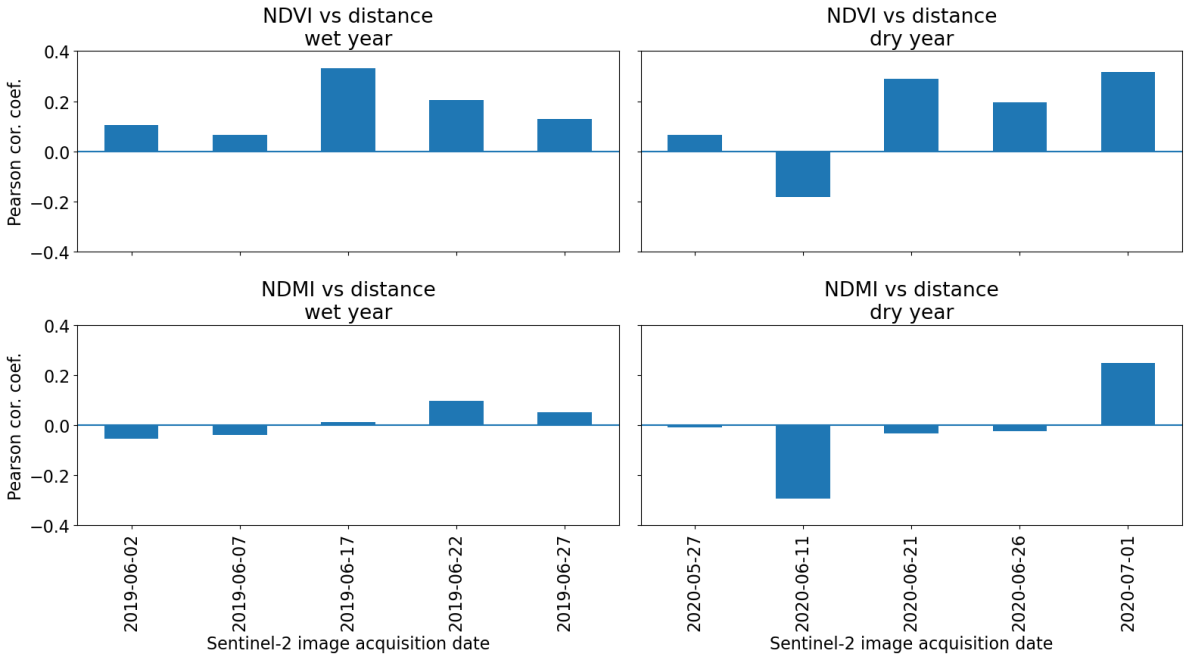



# Results: correlation with distance

**Expected**

- **decline in NDVI and NDMI with the distance from the inlet**
  - not confirmed
  - too few fields?
  - too strong flow?



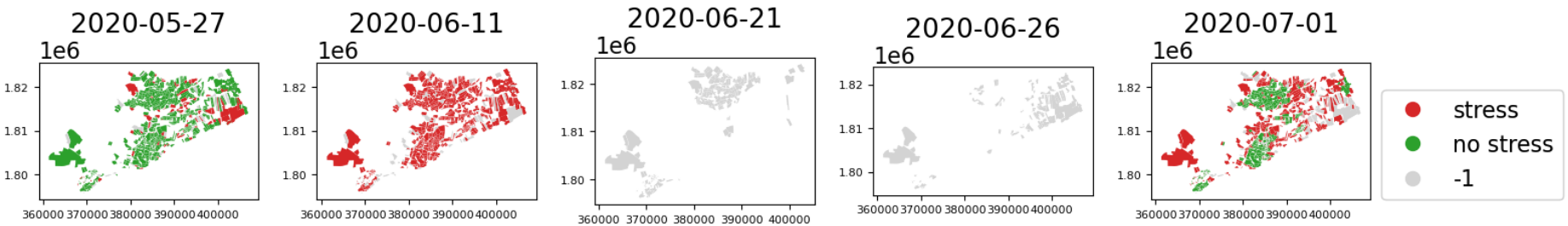
# Results: HDBSCAN

**Expected**

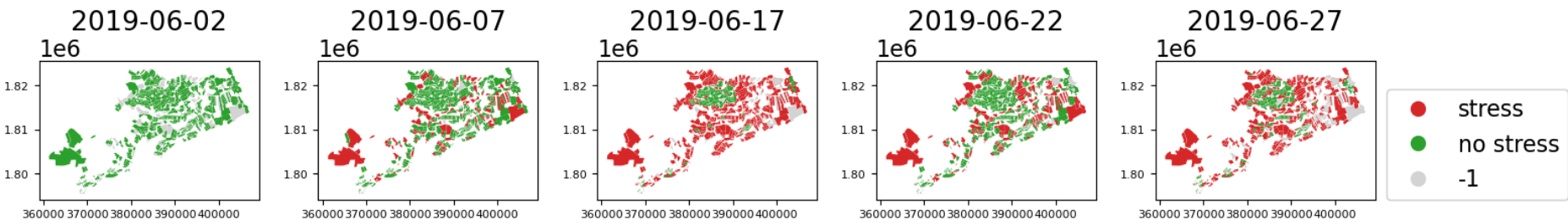
- **more stress clusters in the dry year**
  - not confirmed

- **stress cluster was redefined as**
- **NDVI < 0.45 and NDMI < 0.15**
  - original methodology 0.8 & 0.2

**dry year**




**wet year**



# CDHW with DBSCAN

# DBSCAN (SC2)

**spatio-temporal collocation of droughts (SPEI-90 < -1) and heatwaves (MA15-Q95)**

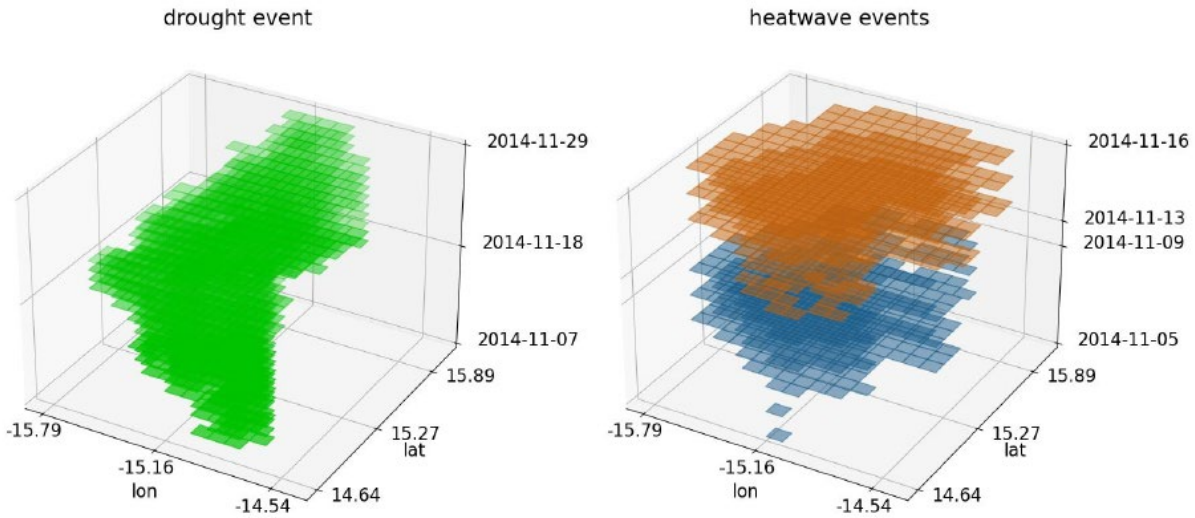



**Figure 7-18 - Overlapping drought and heatwave event clusters identified with DBSCAN in Linguere region in November 2014.**

# Fires

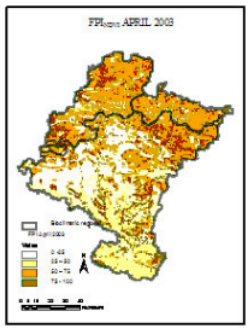
# Fires

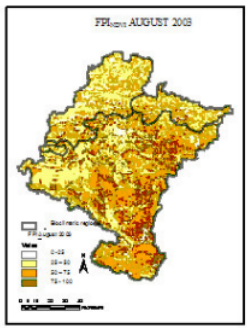
## Forest fire risk modeling

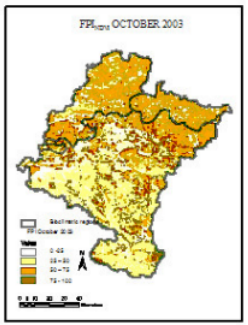
Margarita Huesca

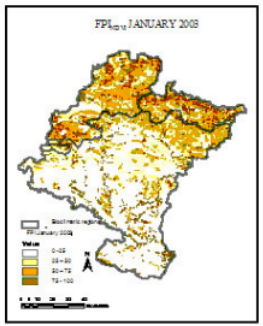
**The Fire Potential Index (FPI)** (Burgan et al., 1998), designed to estimate the susceptibility of vegetation to ignition, integrates meteorological factors (i.e. temperature and relative humidity), land use variables (fuel maps), and live vegetation status (derived from vegetation indices from satellite information).

FPI has been successfully validated in California and Nevada (Burgan et al., 1998), four Mediterranean countries (Sebastián-López et al., 2002), Kalimantan Island, Indonesia (Sudiana et al., 2003) and  Navarre in Spain (Huesca et al. 209 and 2014)



# Wildfires

- SC1 methodology for mountainous region and calibration data was not applicable for flat Senegal
- wildfires are a topical hazard for Senegal
- the fire probably index (FPI) uses higher resolution products than droughts (300 m NDVI)
- the worst (extinction moisture 40%) and the best (15%) scenarios were computed

7.7.4. WILDFIRES

Tambacounda region consists of primarily grasslands and croplands in the north, shrublands in the middle and forest in the south.

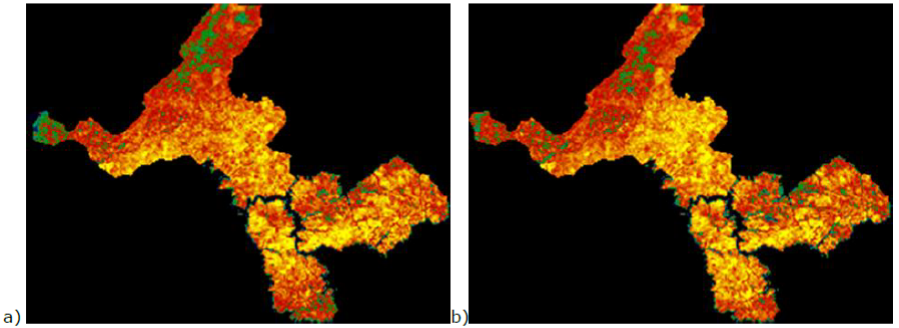



**Figure 7-24 - FPI spatial pattern during dry season using a) 15 % extinction moisture and b) 40 % extinction moisture. More yellow areas indicate higher FPI.**

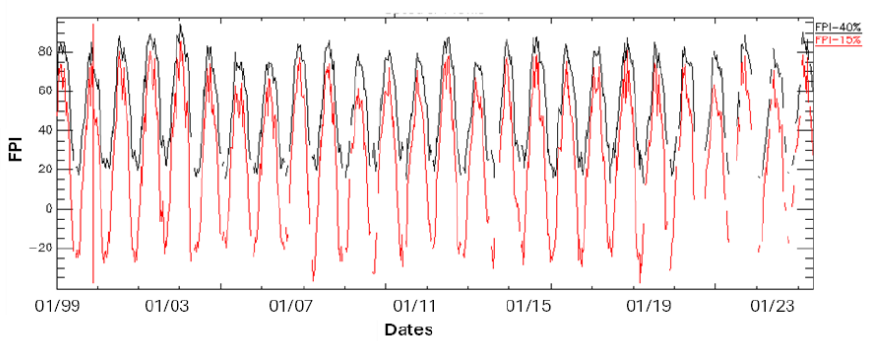
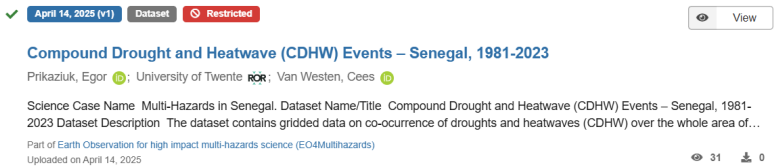


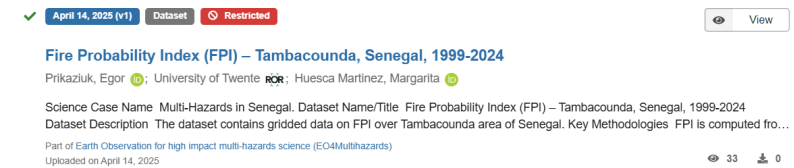

**Figure 7-25 - FPI temporal pattern of a pixel located in the central part of the study area. Red line shows FPI calculated with 15% of extinction moisture and the black line shows FPI calculated with 40% of extinction moisture.**

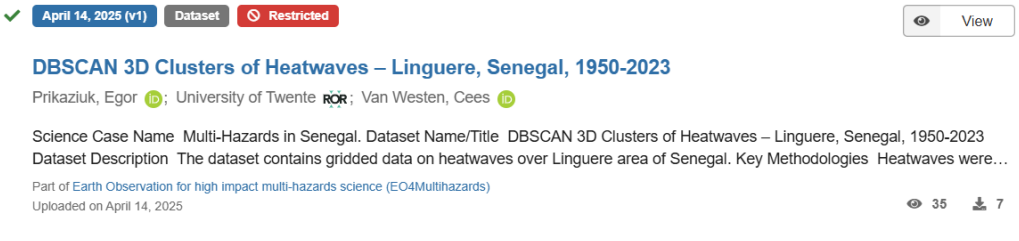
# Hazard datasets

# SC5 Zenodo datasets (D3.4)

1. Compound Drought and Heatwave (CDHW) Events – Senegal, 1981-2023
2. DBSCAN 3D Clusters of SPEI-90 days – Linguere, Senegal, 1981-2023
3. DBSCAN 3D Clusters of Heatwaves – Linguere, Senegal, 1950-2023
4. Fire Probability Index (FPI) – Tambacounda, Senegal, 1999-2024




# SC5 summary

- Senegal differs from Italy in terrain, climate, and ground data availability, affecting data calibration and validation for weather analysis.
- Precipitation is essential but difficult to measure due to its variability; CHIRPS was chosen for this study over other datasets, with alternatives like GPCP and PERSIANN-CDR suggested for benchmarking.
- The CDHW method was easier to adapt than DBSCAN due to lower granularity needs; interpolation of SPI data remains a challenge, with potential for daily SPI-180 to better capture short-term extremes.
- The SC1 fire model was unsuitable for Senegal due to data gaps and topography differences, but a multi-dataset approach could still assess fire risk with further ground validation.
- Multi-hazard EO-based methodologies are transferable across regions but require ground validation for accuracy, and method selection should align with the specific hazard impact being assessed.