High resolution soil moisture drought monitoring over Luxembourg

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Objectives

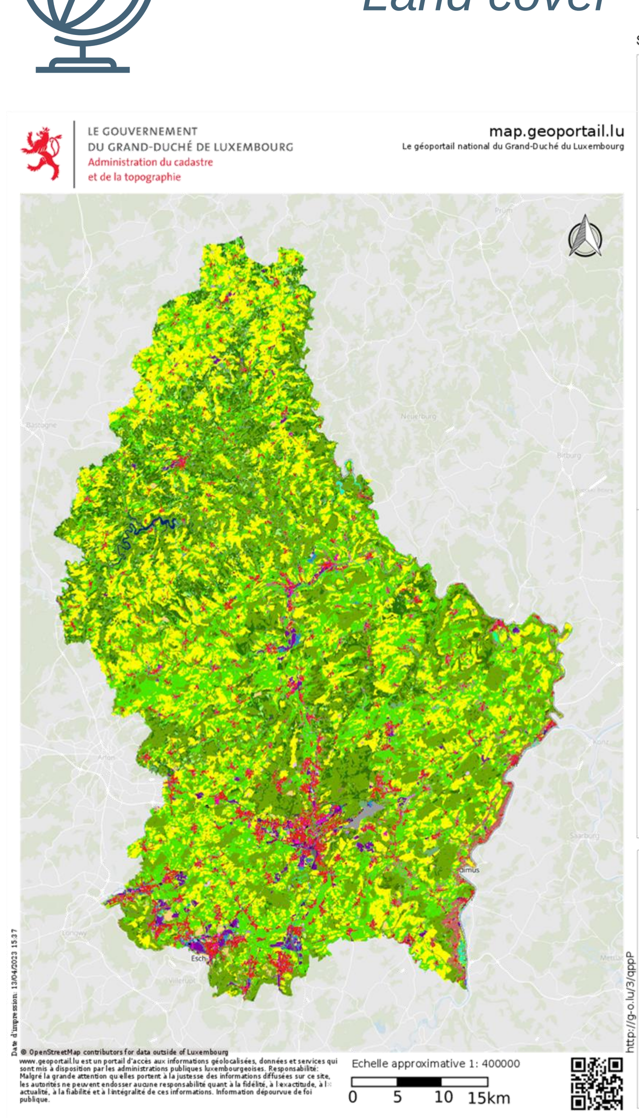
- Intercompare different high and low resolution soil moisture datasets to in situ data
- Compute drought indices from soil moisture datasets to monitor severe droughts over the past decade
- Compare spatial patterns to geology and land use and temporal patterns to precipitation variability
- Determine differences and offsets between soil moisture droughts and impacts on vegetation

Research Question

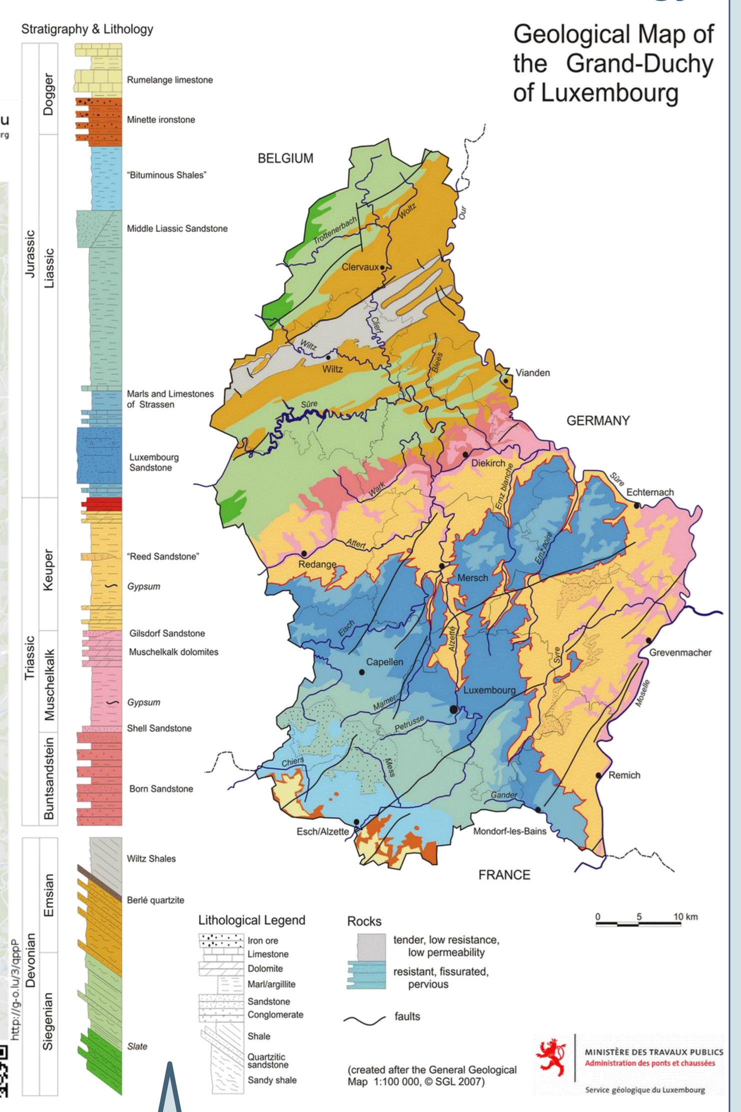
- How do high resolution drought monitoring strategies compare to those on lower resolutions?

Study area

Land cover



Geology



Methods

Data preparation

An exclusion map for insensitive backscatter pixels was derived using Zhao et al., 2020. Over these pixels, the MULESME algorithm does not retrieve soil moisture.

Data X (NDVI, soil moisture) were normalized using:

$$z = \frac{X - \bar{X}}{\sigma_X}$$

With a reference period between 2015 and 2022.

SPI1 was computed for each station according to McKee et al., 1993, and spatial maps were created using Voronoi polygons.

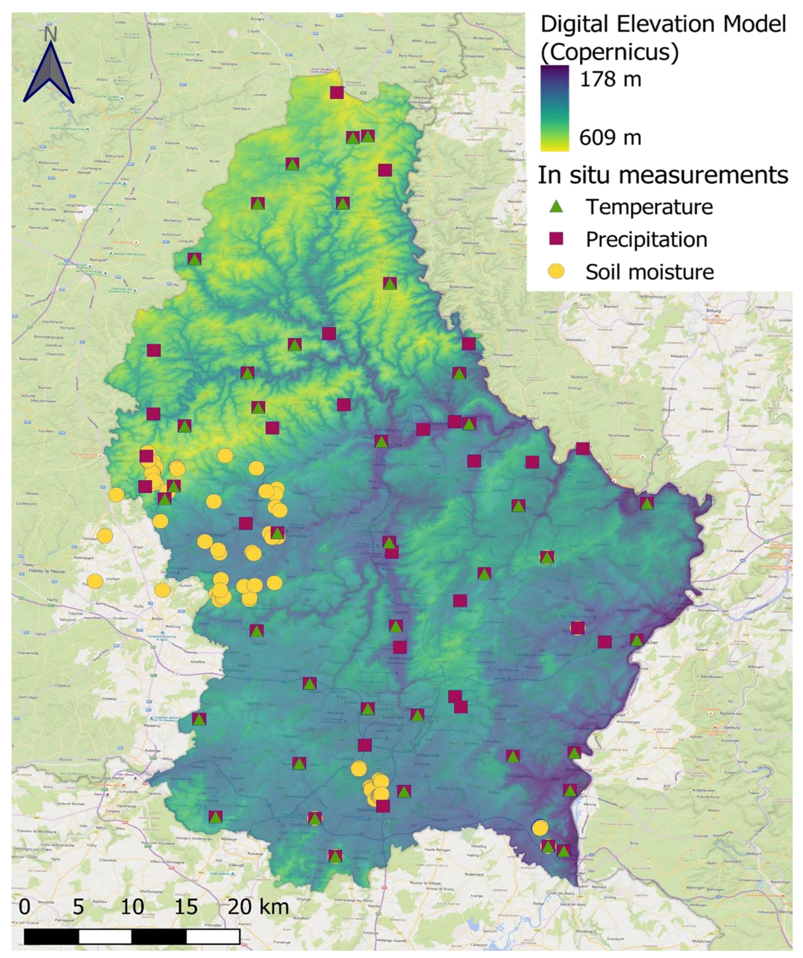
Data

Satellite datasets

- **CCI** active soil moisture data
  Spatial resolution: 0.25°
  Input: ERS and ASCAT
- **Copernicus** surface soil moisture data
  Spatial resolution: 1 km
  Input: Sentinel-1
  (TU Wien algorithm)
- C-band **Van der Sat** soil moisture data
  Spatial resolution: 100 m
  Input: AMSR2, AMSRE
  (van der Sat algorithm)
- **MULESME** soil moisture data
  Spatial resolution: 60 m
  Input: Sentinel-1
  (MULESME algorithm)
- **NDVI** vegetation data
  Spatial resolution: 10 m
  Input: Sentinel-2

In situ datasets

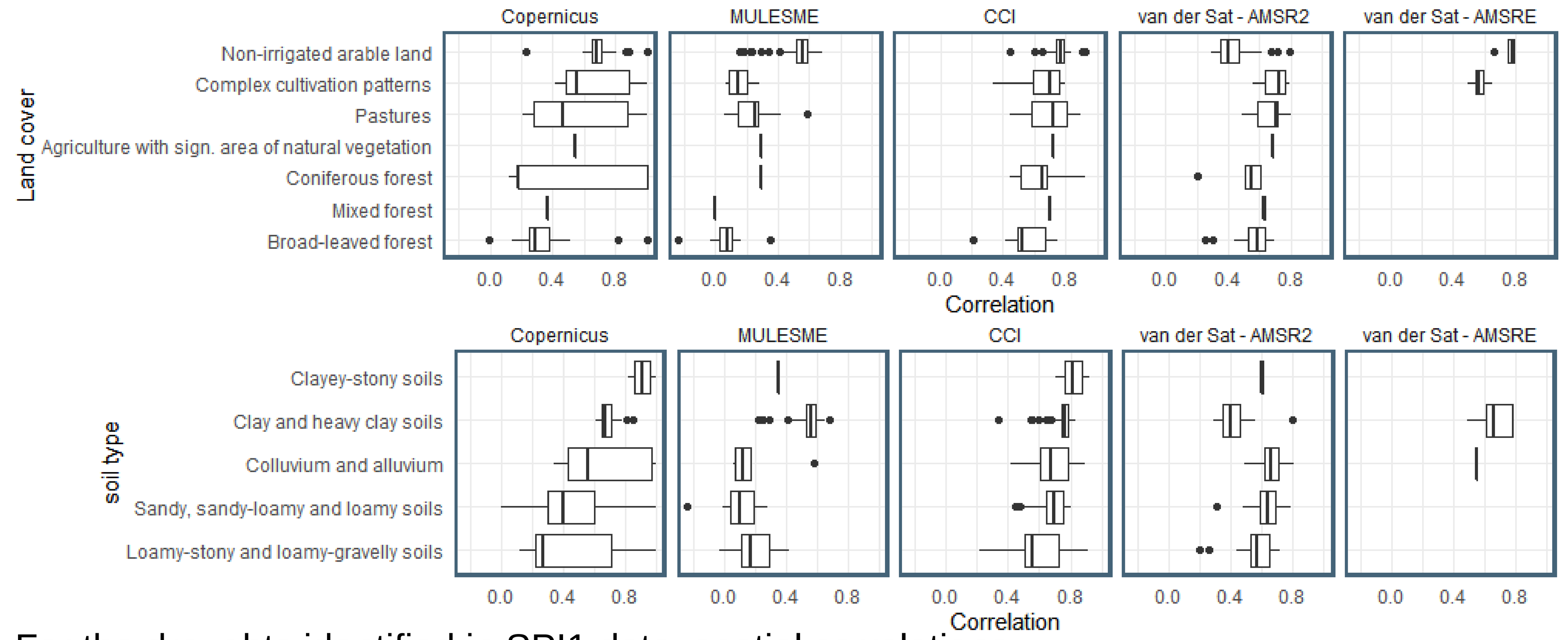
- Precipitation and temperature from LIST and ASTA
- Soil moisture from LIST; ASTA; Blume & Weiler; van Hateren et al.; Foets et al.



Results

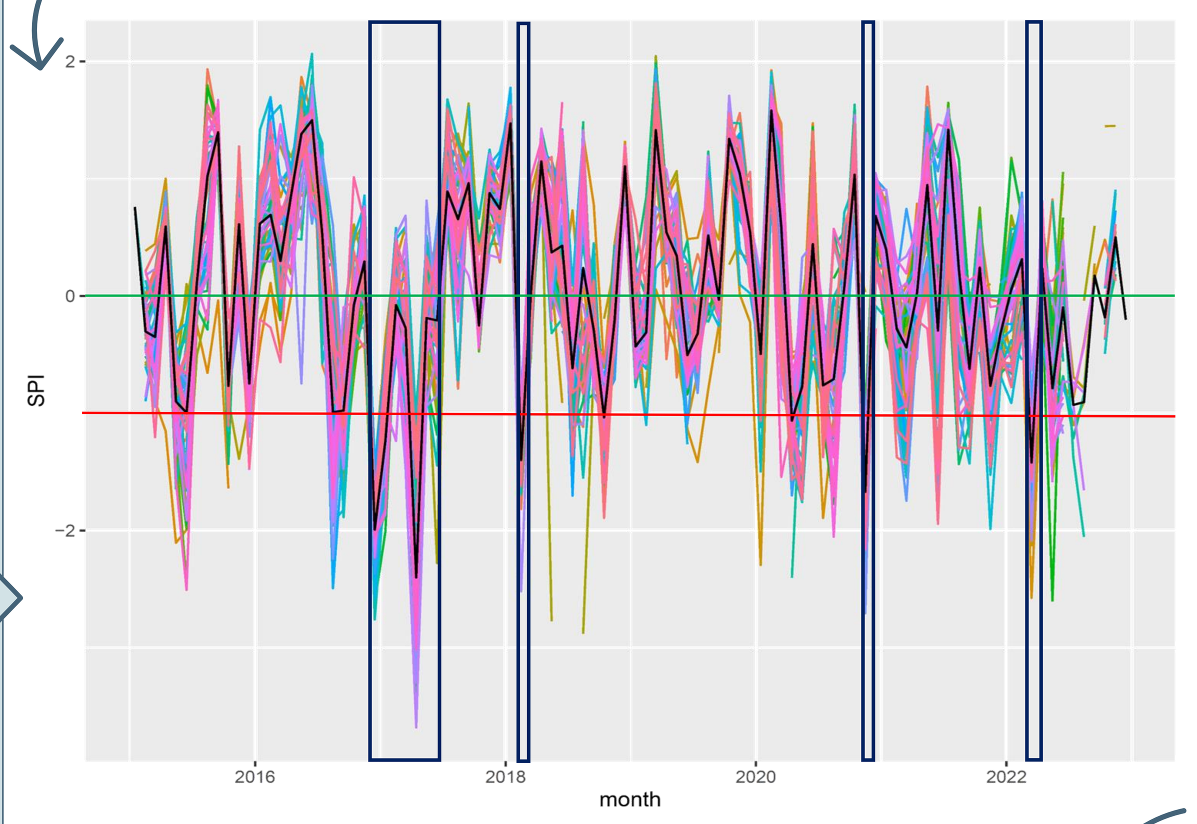
The temporal correlation between satellite and in situ data depends on land cover and soil type. Stations located on non-irrigated arable land and/or clayey-stoney soils show the highest correlations with satellite data.

Temporal correlation between satellite and in situ data



The time series of SPI1 at in situ stations show summer droughts in the median (black line) in 2017, 2020 and 2022 (boxes).

Time series of SPI1 at in situ stations



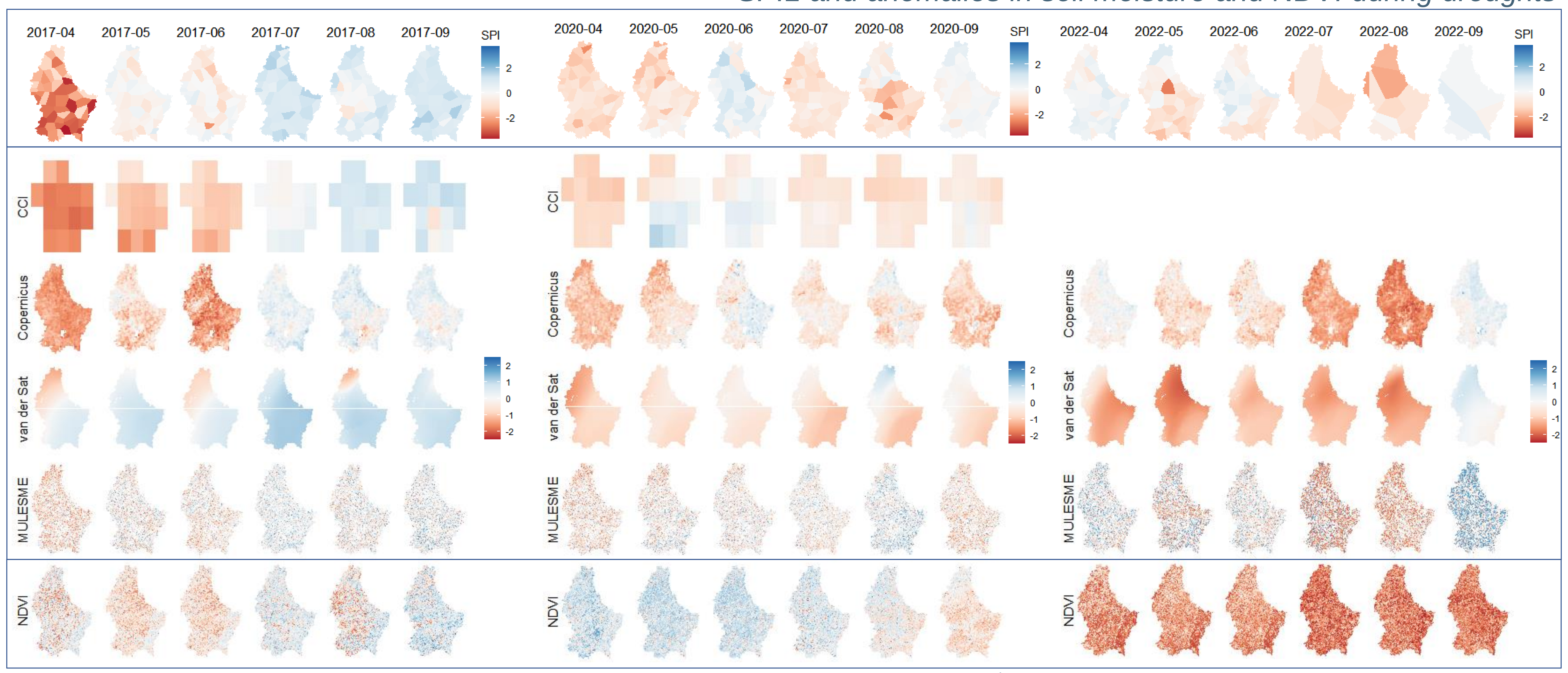
For the droughts identified in SPI1 data, spatial correlations between SPI1 and soil moisture maps are shown here per month.

Correlation between SPI1 and soil moisture anomalies during droughts

Year	2017						2020						2022					
Month	4	5	6	7	8	9	4	5	6	7	8	9	4	5	6	7	8	9
CCI	0.49	0.21	0.04	0.10	-0.05	0.12	0.16	0.62	0.18	0.23	-0.35	-0.14	-	-	-	-	-	-
Copernicus	0.01	0.49	0.34	-0.15	0.01	0.15	0.29	0.60	0.08	0.39	0.37	0.43	-0.10	0.25	0.50	0.62	0.41	-0.45
Van der Sat	-0.52	-0.20	0.09	-0.11	-0.31	-0.15	0.30	-0.37	0.03	-0.24	0.42	0.03	-0.36	-0.45	-0.24	0.04	0.43	0.47
MULESME	-0.34	0.33	0.07	-0.04	0.28	0.24	0.53	0.62	0.12	-0.03	-0.19	0.33	-0.28	-0.11	0.39	0.38	0.58	0.12

For the droughts identified in SPI1 data, maps of SPI1 and anomalies in soil moisture and vegetation are shown here.

SPI1 and anomalies in soil moisture and NDVI during droughts



Precipitation (SPI1)

Low Resolution

Soil moisture anomaly

High Resolution

Vegetation anomaly

Conclusions

- The **accuracy** of satellite soil moisture data depends on land cover & soil type
- **Drought conditions** as identified in SPI1 are reflected in most satellite soil moisture datasets
- The **spatial correlation** between satellite soil moisture and SPI1 varies temporally and per dataset
- High resolution soil moisture datasets show more **spatial variation** in drought conditions than low resolution datasets
- Geology (van der Sat) and land use (Copernicus) influence the soil moisture estimates

References

Zhao et al., 'Deriving Exclusion Maps from C-Band Sar Time-Series: An Additional Information Layer for Sar-Based Flood Extent Mapping', ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences V-1–2020 (**2020**): 395–400, http://dx.doi.org/10.5194/isprs-annals-V-1-2020-395-2020
Foets et al., 'Temporal and Spatial Variability of Terrestrial Diatoms at the Catchment Scale: Controls on Communities', PeerJ 8 (**2020**): e8296, https://doi.org/10.7717/peerj.8296
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Blume & Weiler, Soil moisture data resulting from the CAOS project (**2022**)

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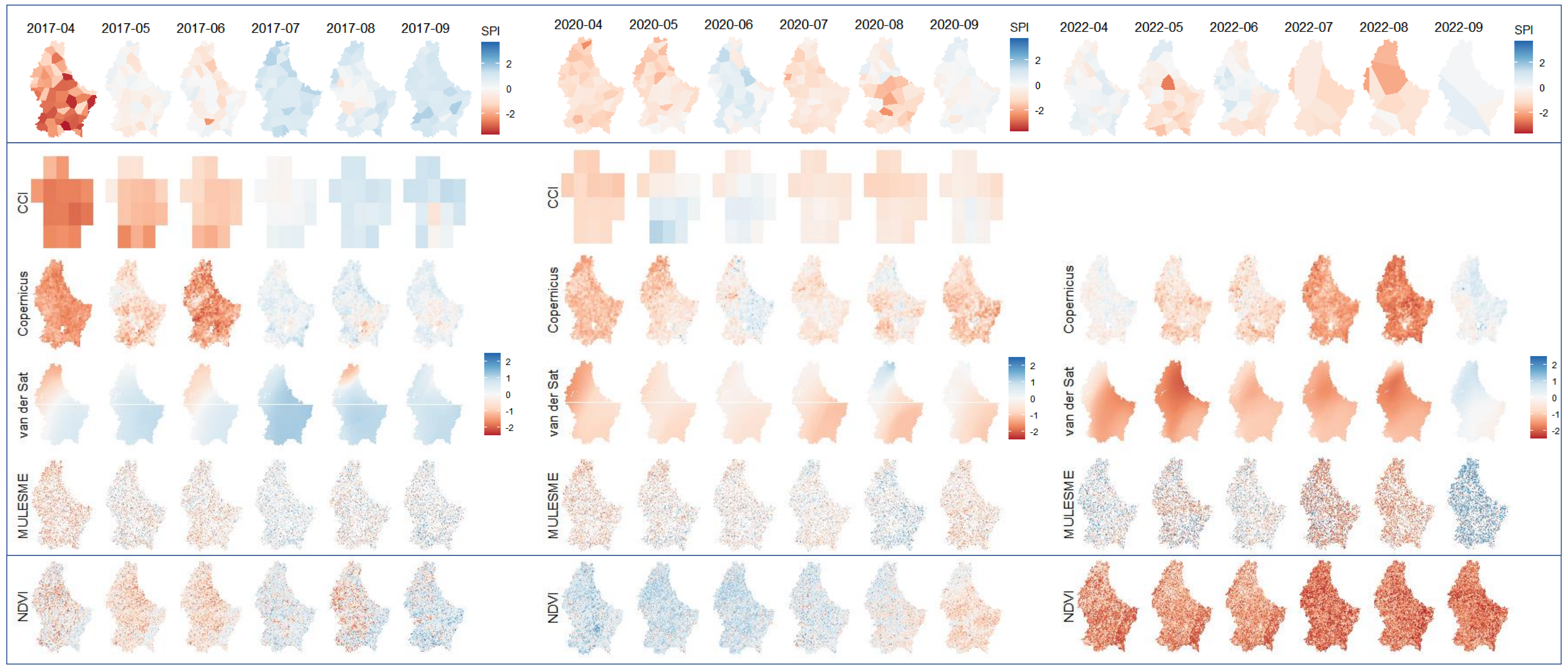

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CCI
Copernicus
van der Sat
MULESME
NDVI