

Synergetic analyses of Earth observation time series on land surface dynamics in large river basins

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Researchgate:



Knowledge for Tomorrow



Increasing availability of Earth observation (EO)-based time series data

Geophysical variables (physical units)

- e.g. DLR Bethy NPP, Climate Research Unit (CRU), TerraClimate, ESA CCI SM, ERA5, ...

Index variables (dimensionless)

- e.g. vegetation indices (AVHRR, MODIS, Landsat, Sentinel), drought indices, teleconnection indices, ...

Thematic variables (i.e. binary or multiclass)

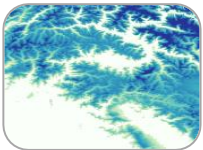
- e.g. DLR WaterPack, DLR SnowPack, DLR World Settlement Footprint, JRC Global Human Settlement Layer, JRC Surface Water Layer, Hansen Global Forest Change, ESA CCI LC, ...



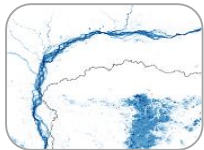
Objectives

- Joint analyses of **multivariate** & **multidecadal** feature space, including EO-based land surface variables
- Development of methodological **framework** for data preparation, harmonization, and statistical analysis
- Explore **trends** and **interdependencies** using time series analysis techniques to quantify **land surface dynamics**
- Focus on land surface variables:

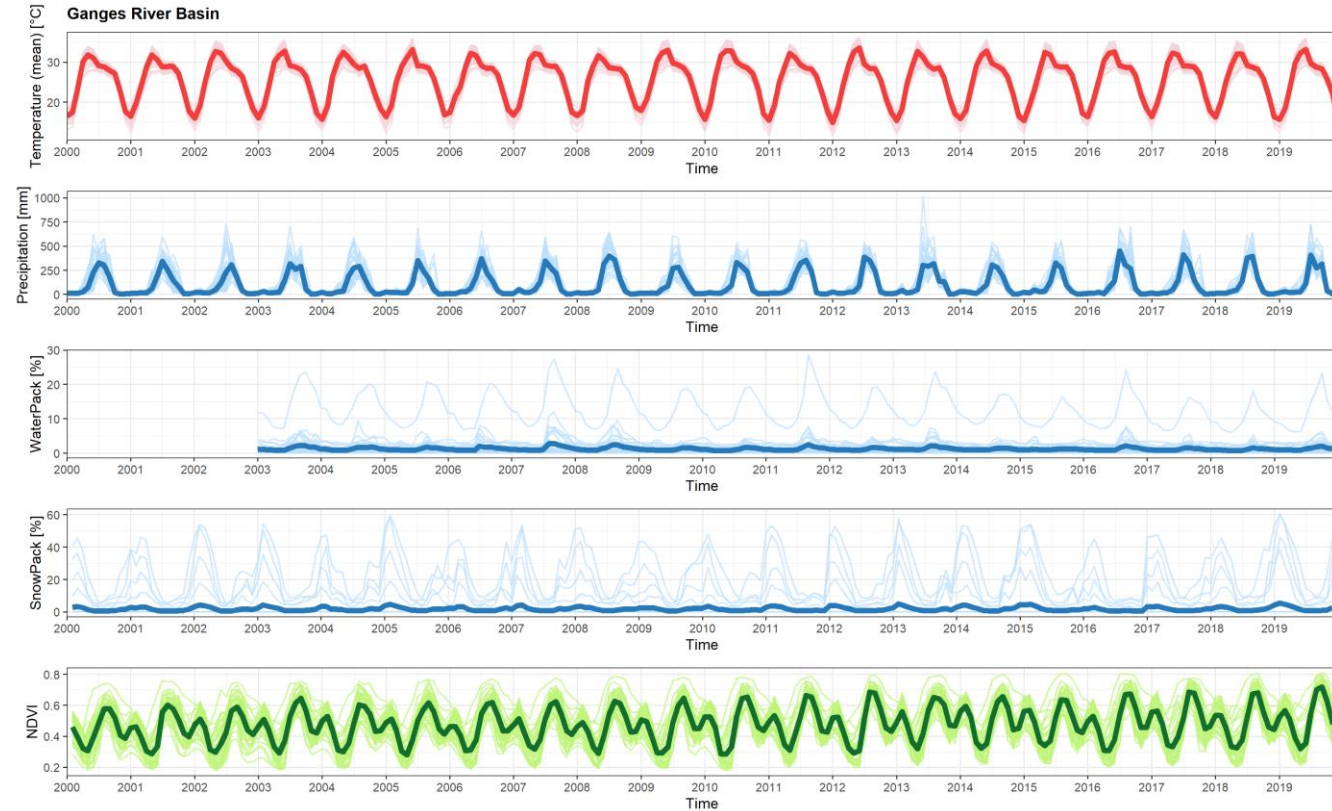
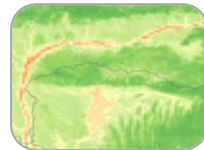
DLR SnowPack



DLR WaterPack



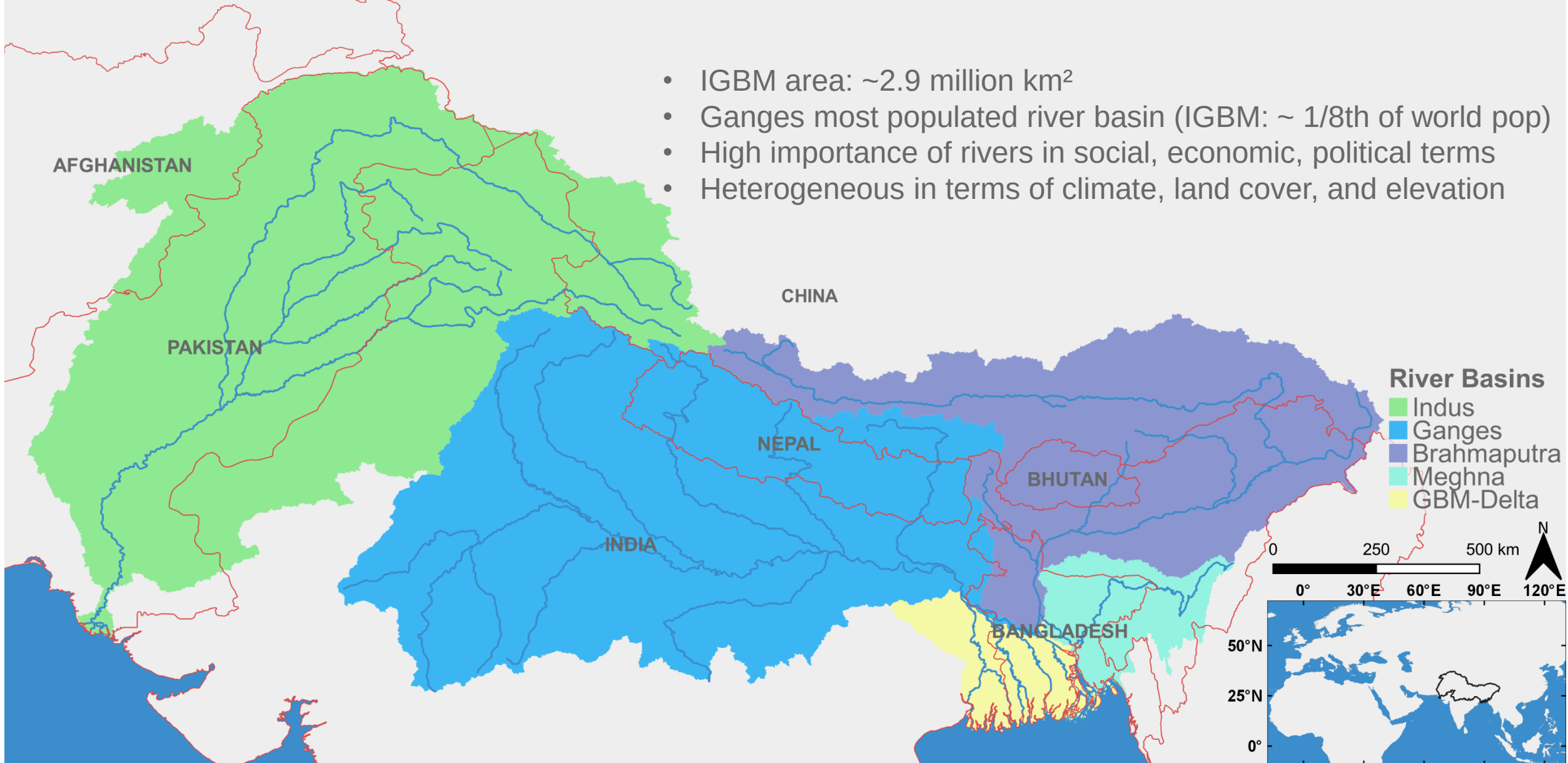
MODIS NDVI



Case study

Indus-Ganges-Brahmaputra-Meghna (IGBM) river basins

- IGBM area: ~2.9 million km²
- Ganges most populated river basin (IGBM: ~ 1/8th of world pop)
- High importance of rivers in social, economic, political terms
- Heterogeneous in terms of climate, land cover, and elevation

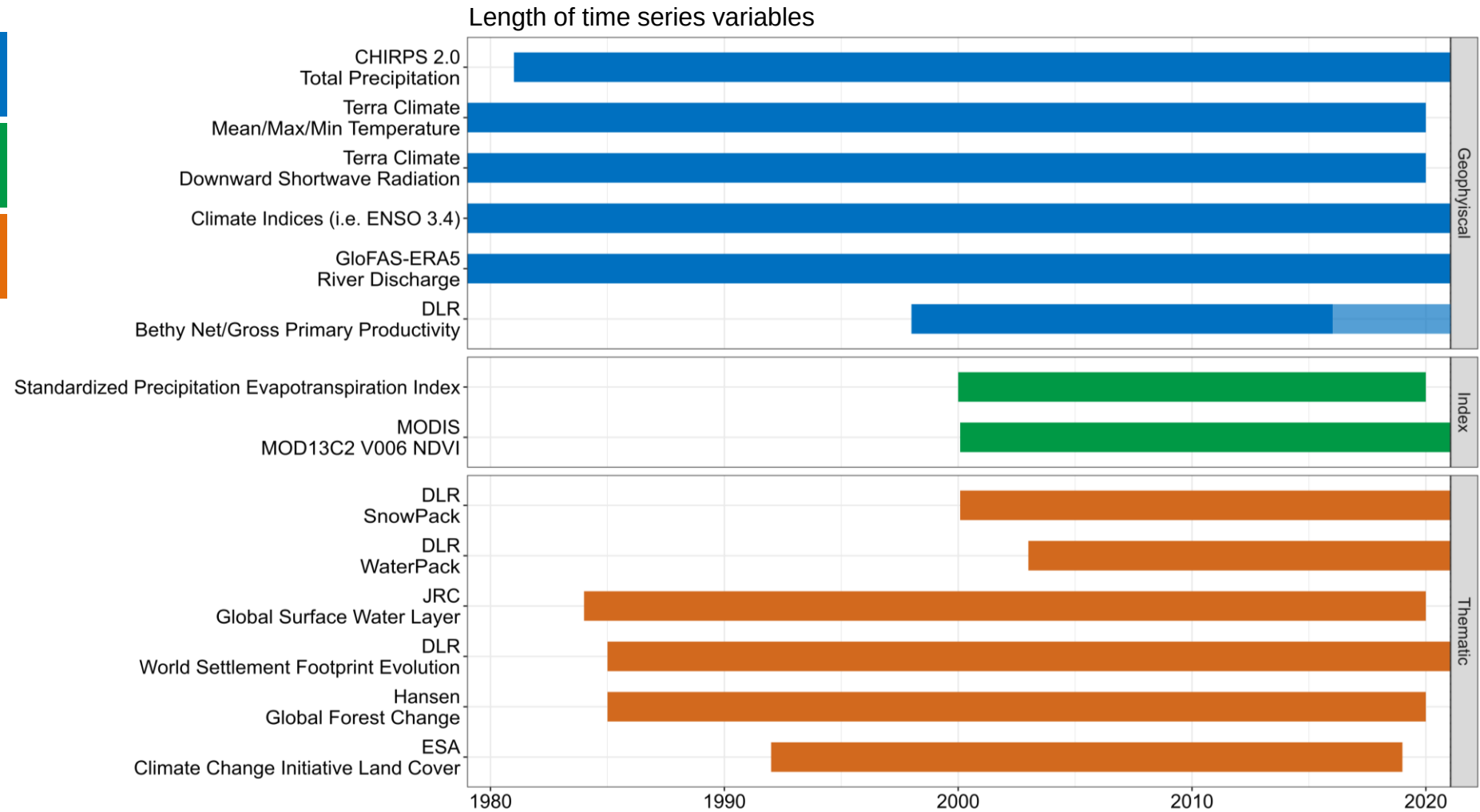


Data base

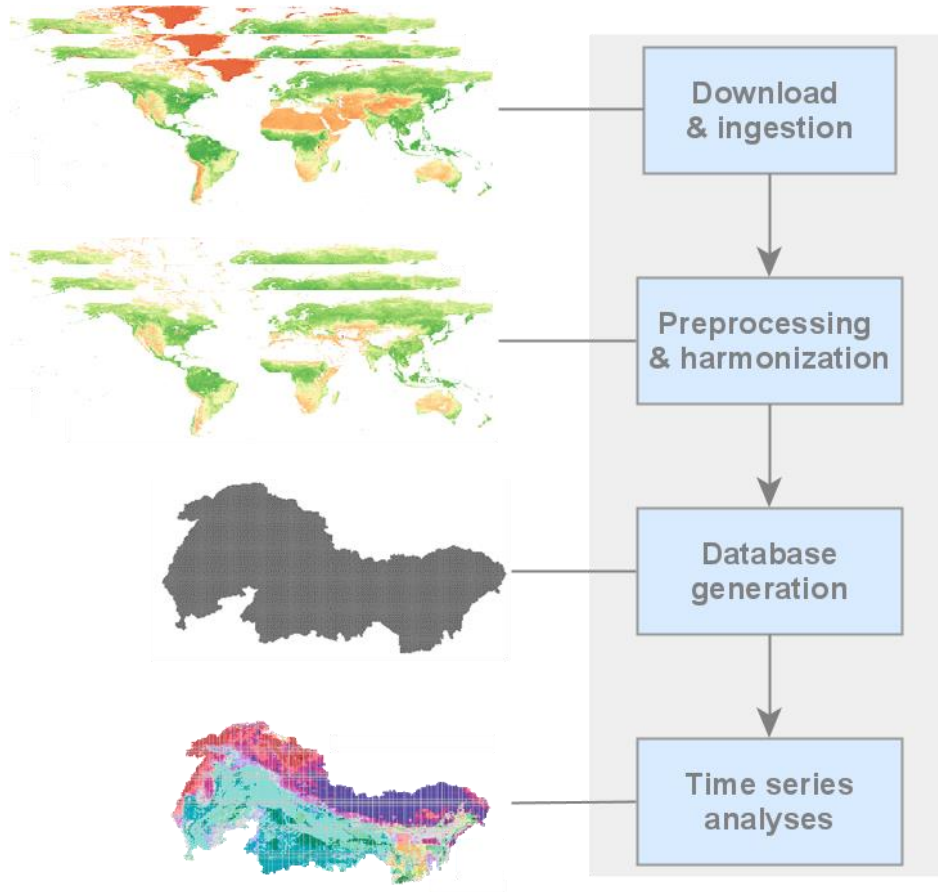
Geophysical
variables

Index
variables

Thematic
variables



Methods



➤ Trend tests

- Mann-Kendall significance test
- Theil-Sen slope estimator

➤ Phenological parameters

- TIMESAT to quantify changes of land surface variables (Jönsson & Eklundh 2004)

➤ Causal networks

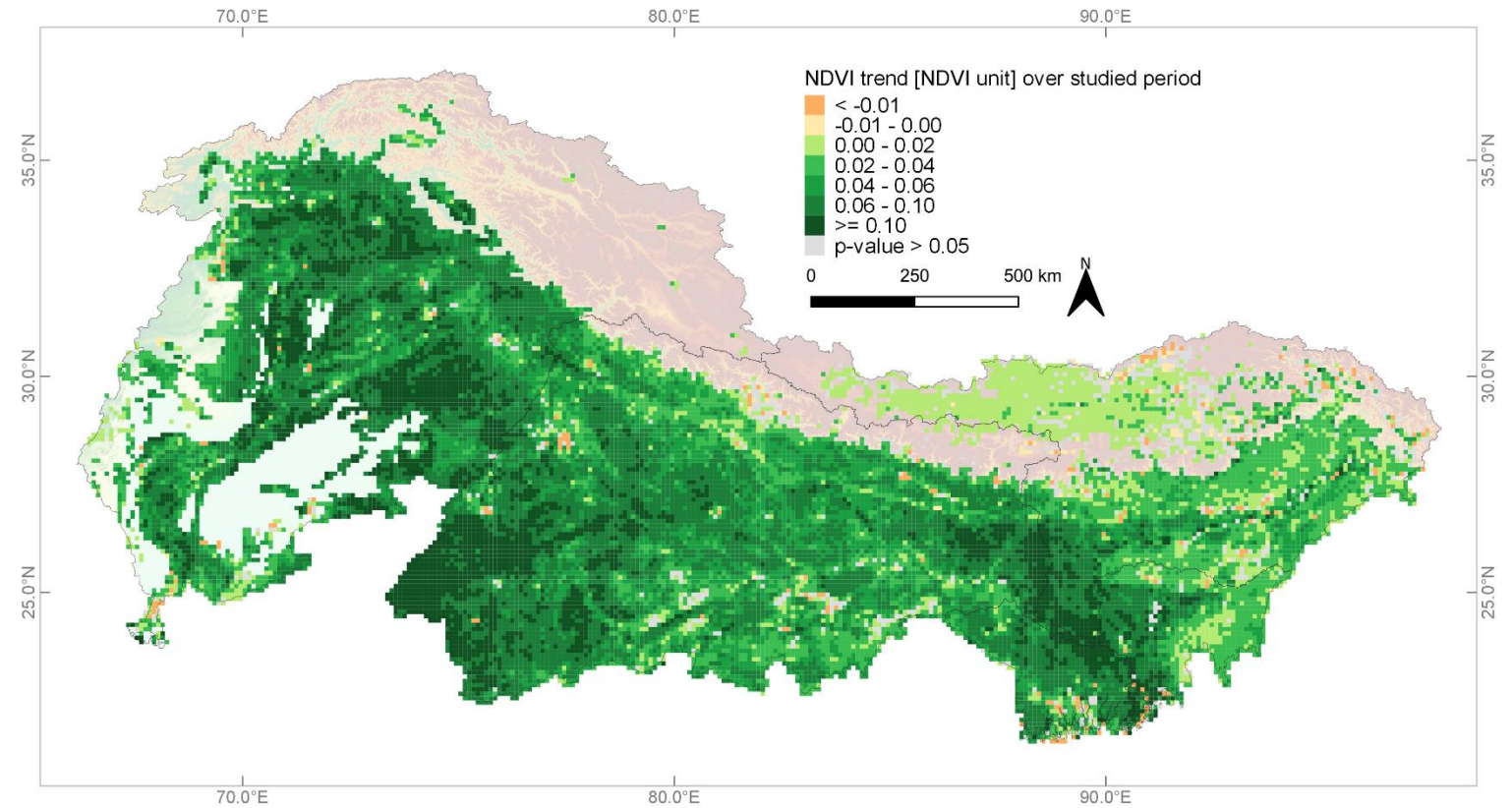
- PCMCI (Runge 2018, Runge et al. 2019)
- Target variables: land surface variables
- Drivers: Climatological & hydrological variables

- Uereyen et al. Exploitation of multidecadal and multivariate time series for large scale analysis of land surface dynamics. [in prep.]
- Jönsson, P. & Eklundh, L. (2004). Timesat—a program for analyzing time-series of satellite sensor data. Computers & Geosciences 30, 833–845.
- Runge, J. (2018). Causal network reconstruction from time series: From theoretical assumptions to practical estimation. Chaos 28, 075310.
- Runge, J., Nowack, P., Kretschmer, M., Flaxman, S., & Sejdinovic, D. (2019). Detecting and quantifying causal associations in large nonlinear time series datasets. Science Advances, 5(11), eaau4996.

Exemplary results

Trend tests

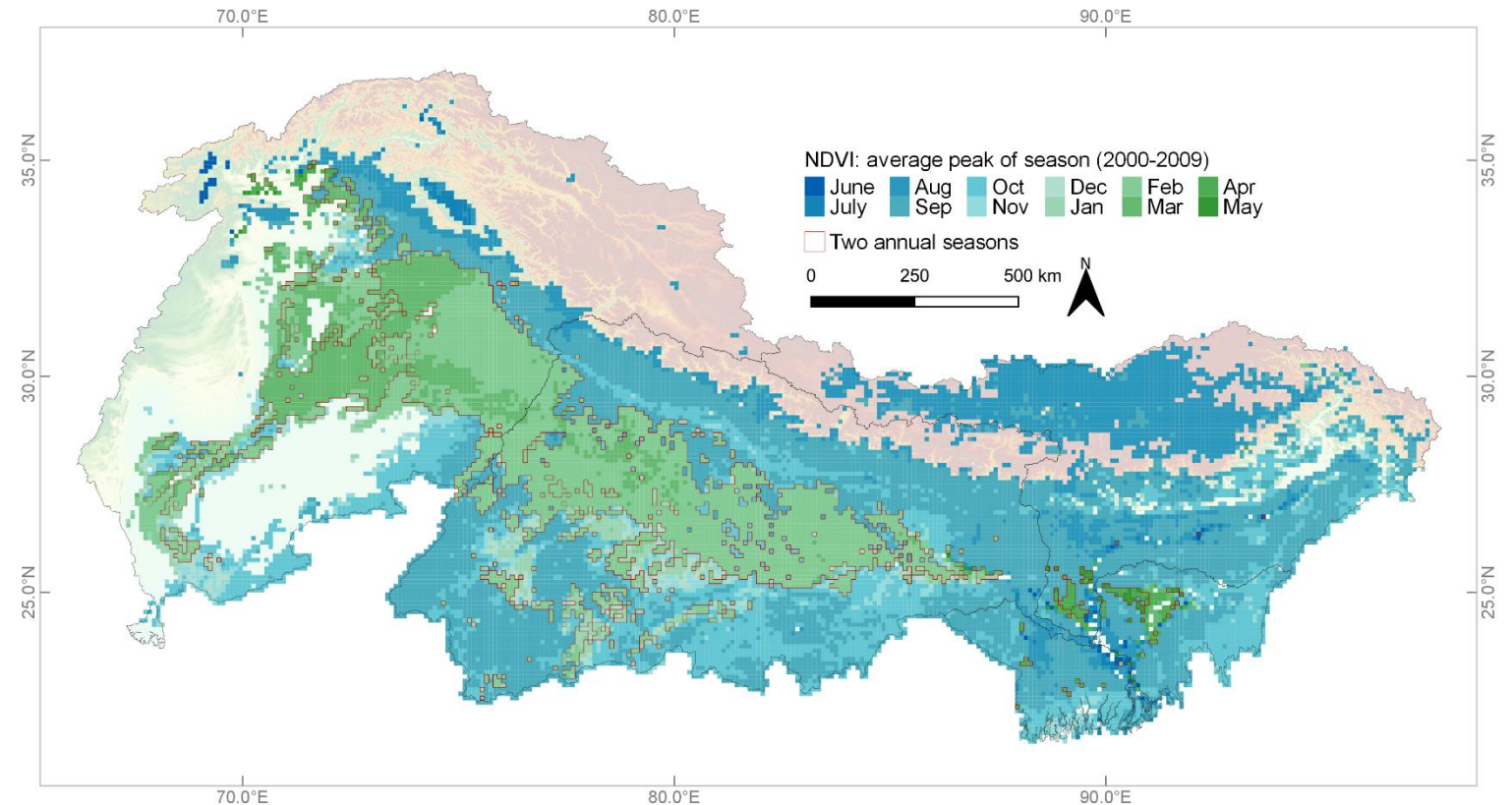
- Testing existence of statistically significant trends
- Prewhitening, if lag-1 autocorrelation is significant
- Tests at monthly and seasonal scale



Exemplary results

Phenological parameters

- Quantification of peak and duration of season using TIMESAT
- Calculation of changes between two decades
- Example illustrates average peak of season for NDVI (area with red outline characterized by two annual seasons, here peak of first annual season is illustrated)



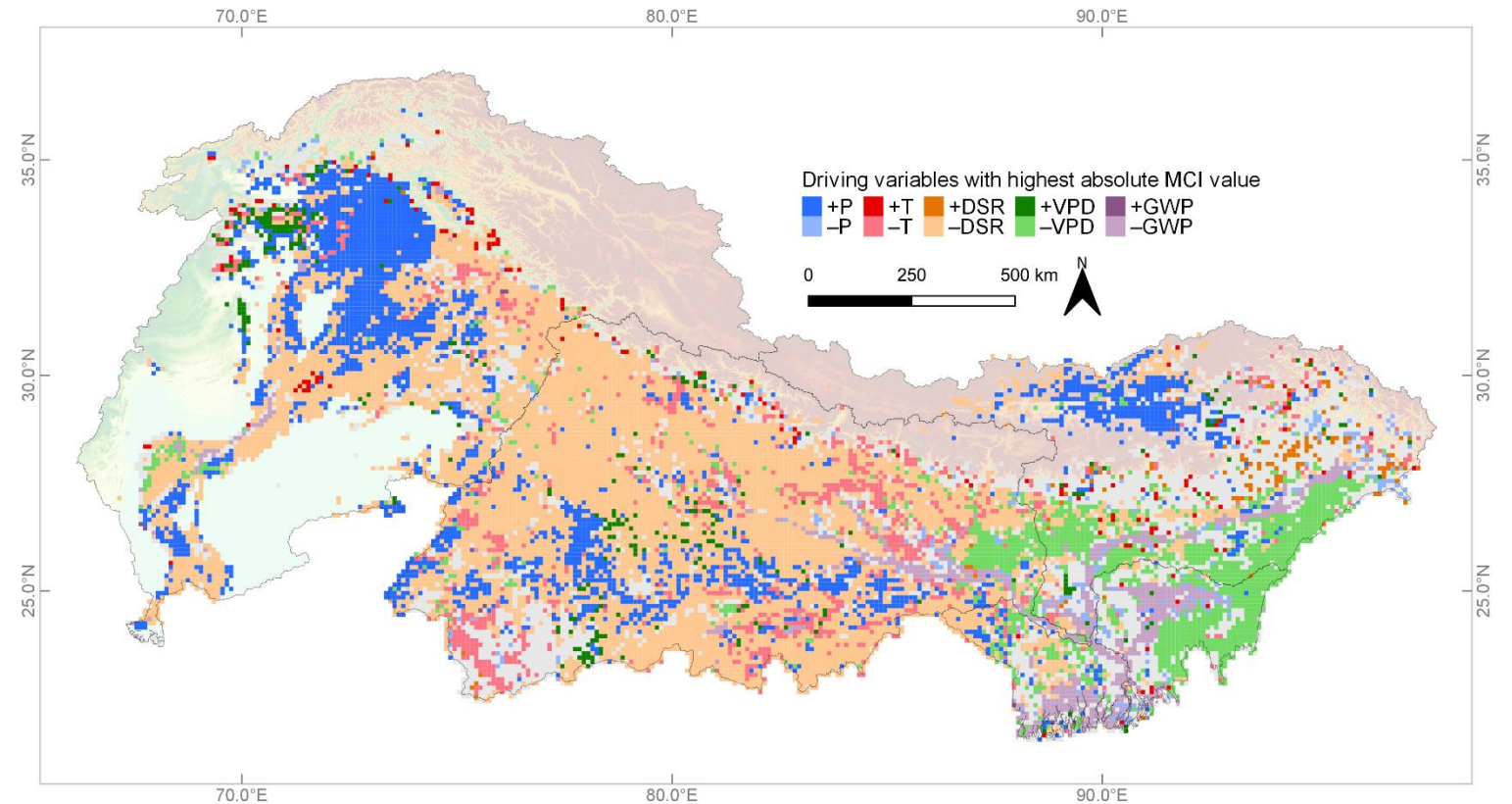
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Exemplary results

Causal maps (PCMCI)

- Quantification of interdependencies based on causal networks using partial correlation framework
- Testing at different temporal scales (i.e. season, month) with temporal lags
- Targets: land surface variables
- Drivers: climate and hydrological variables



P: Precipitation, T: Temperature, DSR: Radiation, VPD: Vapor pressure deficit, GWP: DLR WaterPack

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Summary

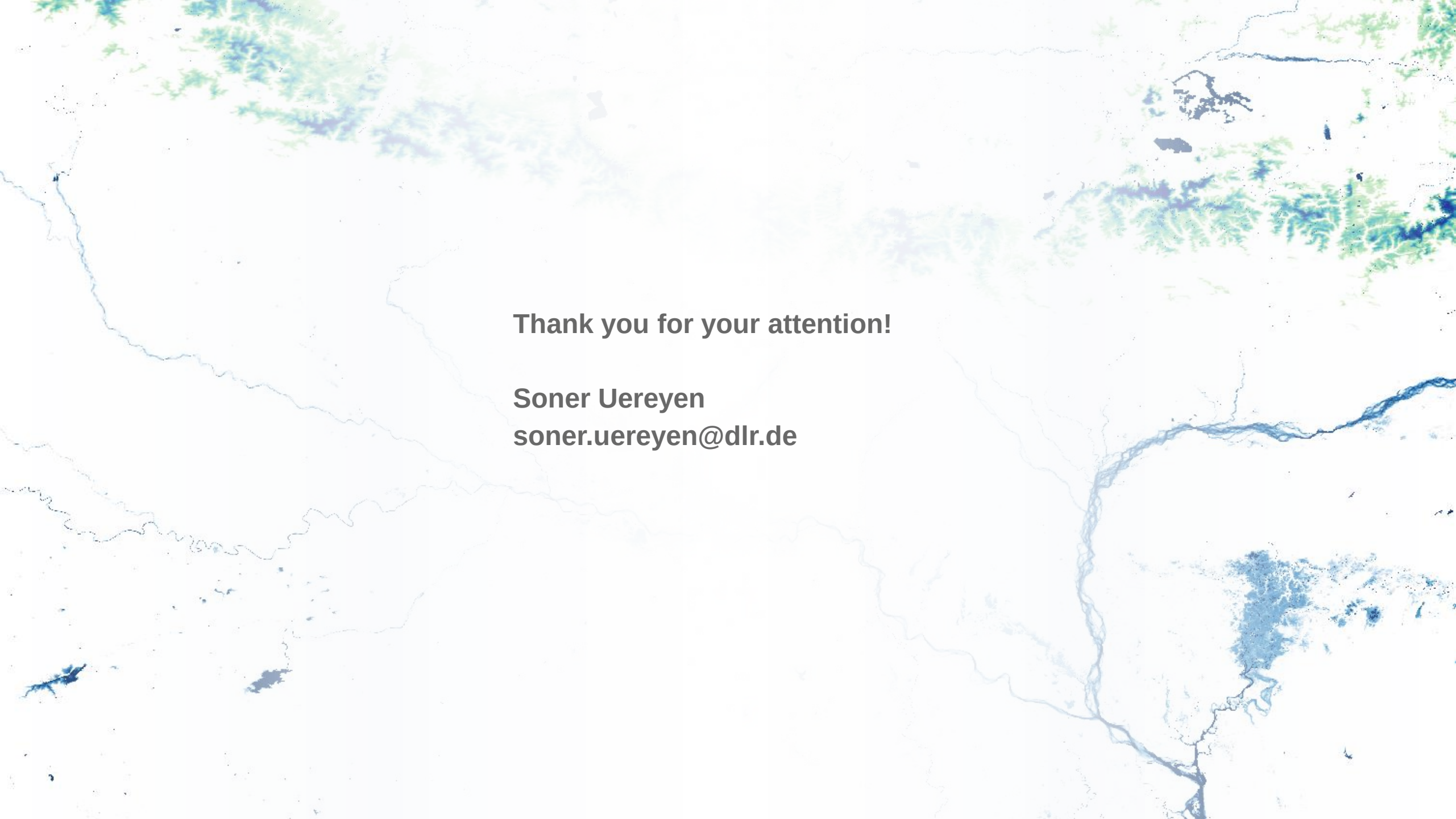
- Long-term time series provide valuable data for analysis of land surface dynamics at large scale
 - We analyze vegetation condition, snow cover extent, and surface water extent
- Trend tests highlight regions with statistically significant trends
- Phenological parameters indicate whether seasonal properties are changing over the last two decades
- Causal network approach supports attribution of statistically significant driving parameters and reduce spurious effects
- Methodological framework is flexible in terms of space time transferability
- Future work involves further detailed geoscientific analyses of land surface dynamics over the last two decades and their attribution, i.e. the inclusion of anthropogenic influences is also envisaged



References

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Thank you for your attention!

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