Identifying drivers of extreme impacts

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Extreme impacts are often related to multiple compounding conditions in the weather and climate system. For instance, unfortunate combinations of temperature and precipitation can lead to crop failure (e.g. Ben-Ari et al., 2018) or vegetation mortality. Identifying which combination of weather conditions lead to extreme impacts is challenging and often made even more difficult due to the small sample size of such extreme events in observational datasets.

In this training school project, we will work with very long impact model simulations and explore approaches to identify multivariate climate conditions that are associated with extreme impacts. Our aim will be to test and develop different methods of exploring multivariate, potentially temporally compounding, drivers leading to an extreme impact. The impact dataset will be used as a testing dataset, it is useful for its large sample size and the fact that we know exactly what meteorological data is forcing the crop model.

Data

Meteorological data:

- 2000 years of simulated climate data from the EC-Earth model representing present-day conditions (Van der Wiel et al., 2019, GRL).
- Bias corrected towards the daily climatology of AgMERRA (Ruane et al., 2015, AFM).
- Variables: minimum temperature, maximum temperature, dewpoint temperature, precipitation, near surface wind, incoming solar radiation (daily resolution).

Impact data:

- 1600 years of simulated spring and winter wheat yields from the APSIM model (Zheng et al., 2014, online), forced with the bias corrected meteorological data.
- Variables: total yield, sowing date, growing season length (yearly values).

Initially we will focus on a few point locations (e.g. in France, China, USA), with the possibility to extend to a gridded global analysis at a later stage.

Methods

Methods to be explored may include

- Correlation analysis based on a small number of potential predictors
- Classification (e.g. Zscheischler et al., 2016, JGR)
- Temporal composite analysis (e.g. Nicolai-Shaw et al., RSE)
- Feature selection from a large range of predictors (e.g. Ben-Ari et al., NComm)
- ...

Required software

R, CDO, ncview, shell scripting

Suggested literature

- Ben-Ari et al. (2018): Causes and implications of the unforeseen 2016 extreme yield loss in the breadbasket of France. *Nature Communications*, 9, 1627: **example of an analysis of an extreme low crop yield season**
- Nicolai-Shaw et al. (2017): A drought event composite analysis using satellite remote-sensing based soil moisture. *Remote Sensing of Environment*, 203, 216-225: **example of temporal composite analysis based on extreme soil moisture**
- Van der Wiel et al. (2019): Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall. *Renewable & Sustainable Energy Reviews*, 111, 261-275: **example of a spatial composite analysis based on renewable energy extremes**
- Zscheischler et al. (2016): Short-term favorable weather conditions are an important control of interannual variability in carbon and water fluxes, *Journal of Geophysical Research: Biogeosciences*, 121, 2186-2198: **example of classifying environmental conditions related to extremes in carbon fluxes**

Expected outcome

The outcome of the project is to provide the basis for a research paper to be published a few months after the training school. The students are expected to draft the skeleton of this paper (detailed outline + planned figures) by the end of the second week and to distribute roles between themselves to ensure the submission of this paper a few months after the training school. The project supervisors will be available for support also after the training school.