HORIZON 2020

Hydrologic Extremes at the Global Scale: teleconnections, extreme-rich/poor periods, climate drivers and predictability

Berichterstattung

Projektinformationen

HEGS

ID Finanzhilfevereinbarung: 835496

Projektwebsite

DOI
10.3030/835496

Projekt abgeschlossen

EK-Unterschriftsdatum
11 April 2019

Startdatum
17 Mai 2019

Enddatum
16 Mai 2022

Finanziert unter
EXCELLENT SCIENCE - Marie Skłodowska-Curie Actions

Gesamtkosten
€ 281 827,20

EU-Beitrag
€ 281 827,20

Koordiniert durch
INSTITUT NATIONAL DE RECHERCHE POUR L'AGRICULTURE, L'ALIMENTATION ET L'ENVIRONNEMENT
France

Periodic Reporting for period 2 - HEGS (Hydrologic Extremes at the Global Scale: teleconnections, extreme-rich/poor periods, climate drivers and predictability)

Berichtszeitraum: 2021-05-17 bis 2022-05-16

Zusammenfassung vom Kontext und den Gesamtzielen des Projekts

Hydrologic extremes (floods and heavy precipitation events) are among Earth’s most common natural hazards and cause considerable loss of life and economic damage. Despite this, some of their key characteristics are still poorly understood at the global scale. The IPCC thus reports that “confidence about peak flow trends over past decades on the global scale is low”. More generally, the space-time variability of hydrologic extremes is yet to be thoroughly described at the global scale. As a striking illustration, the recent initiative “23 unsolved problems in Hydrology” includes questions such as: Is the hydrological cycle regionally accelerating/decelerating under climate and environmental change? How do extremes around the world teleconnect with each other and with other factors? How do flood-rich and drought-rich periods arise, are they changing, and if so why?

It is vital to fill these knowledge gaps to inform design, safety and financial procedures and to improve hazard preparedness and response. The project’s ambition is hence to better understand the global space-time variability of hydrologic extremes, using a three-pillar research strategy based on methodological innovation, extensive data analysis and proof-of-concept case studies. The specific objectives are to:
1. Develop a statistical framework to describe the global-scale variability of extremes in relation to climate;
2. Analyze global precipitation/streamflow datasets with the aim of quantifying teleconnections, spatial clustering, trends and extreme-rich/poor periods, along with their climate drivers;
3. Explore practical applications such as past reconstruction, future projection or seasonal forecasting of global hydrologic extremes, and their interest for understanding natural variability, adapting to climate change or improving disaster preparedness.

The work performed during the project allowed delivering new tools to analyze extremes at the global scale, along with a 100-year analysis and a 180-year reconstruction of floods and heavy precipitation probabilities at the global scale.

Arbeit, die ab Beginn des Projekts bis zum Ende des durch den Bericht erfassten Berichtszeitraums geleistet wurde, und die wichtigsten bis dahin erzielten Ergebnisse

We developed a very general statistical framework to describe how environmental data vary in Space, Time or other Dimensions (it has hence been named STooDs). This of course includes data describing hydrologic extremes such a floods and heavy precipitation, but it is not limited to it. The computing code implementing STooDs has been released as an open-source software. It has also been extensively tested on several case studies, including: the hidden climate patterns controlling flood occurrences in France and Eastern Australia; the co-occurrence of hot-and-dry fire-prone conditions in Australia.

Datasets describing floods and heavy precipitation at the global scale have also been analyzed jointly using the STooDs framework. These datasets include more than 1800 hydrometric stations and more than 1700 raingauges located in most regions of the world. Results of a 100-year analysis highlight interesting teleconnection patterns at the global scale: distant regions of the world are in phase or sometimes in anti-phase in terms of probabilities of flood and heavy precipitation occurrence. In terms of time variability, we found evidence for global-scale increases affecting heavy precipitation, but no such evidence was found for floods. We did not find any strong evidence for the existence of extreme rich/poor periods at the global scale. However, we highlighted several modes of climate variability that were important in explaining the variability of heavy precipitation and floods, as well as their co-variability.

Applications focused on building past reconstructions of hydrologic extremes. Using the 20CR long-term reanalysis of atmospheric variables, we built a 180-year long reconstruction (1836-2015) of flood and heavy precipitation probabilities at the global scale. This reconstruction allows identifying hot spots and hot moments in the distant past corresponding to abnormally high flood / heavy precipitation probabilities. At the smaller national scale of France, we built a similar 311-year long reconstruction (1705-2015) of flood probabilities, based on a database collecting historical flood marks. These two applications illustrated the versatility of the STooDs framework and its ability to integrate several sources of information coming from various measurement networks and periods.

Results have been disseminated to the research community through several articles and publications in conferences. An important effort was made to release open-source and reusable codes: it is an important medium of dissemination to the research, engineering and operational communities. Likewise, the reconstructions describe above have been released as open datasets. Finally, we communicated on the project's activities by means of musical videos created by animating and sonifying the data we used during the project (https://globxblog.inrae.fr/).

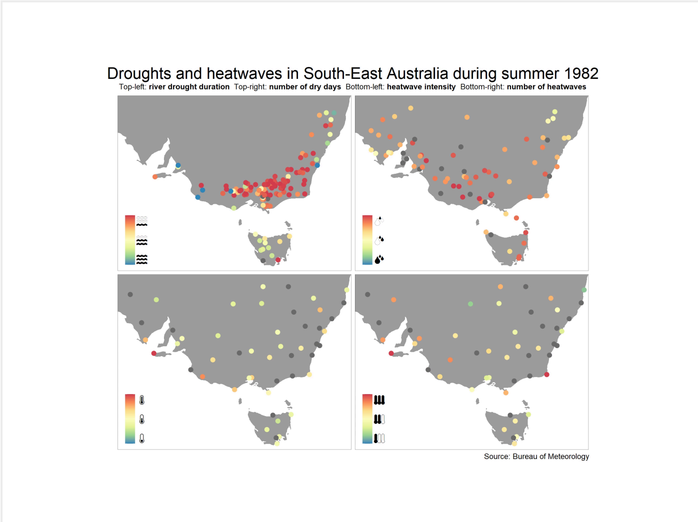
Fortschritte, die über den aktuellen Stand der Technik hinausgehen und voraussichtliche potenzielle Auswirkungen (einschließlich der bis dato erzielten sozioökonomischen Auswirkungen und weiter gefassten gesellschaftlichen Auswirkungen des Projekts)

The STooDs framework corresponds to a significant methodological innovation. In particular, it builds on the recent concept of "hidden climate indices", and it implements the following new functionalities: (1) handling of thousands of stations and hence global-scale applicability; (2) joint analysis of several environmental variables and hence applicability to compound hazards; (3) flexible specification of the probabilistic model; (4) ability to deal with varying data availability, missing or censored values, etc. These new functionalities make STooDs a very general probabilistic framework that can be reused beyond the particular case studies of this project. This has the potential to induce new advances in hydroclimatology (e.g. by analyzing other variables such as droughts, extreme wind, etc.) and beyond.

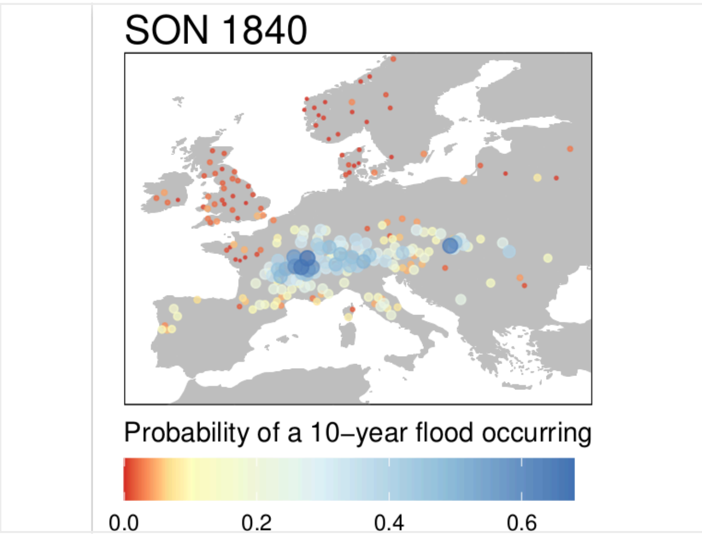
The extensive 100-year analysis is delivering important insights on the historical variability of hydrologic extremes at the global scale, which may contribute to future IPCC assessments. More specifically, the latest IPCC report (recently released in 2021) indicates that “the frequency and intensity of heavy precipitation events have increased since the 1950s”, but that at the same time “confidence about peak flow trends over past decades on the global scale is low”. Our analysis mostly confirms these conclusions, and put them on firmer ground by extending the analysis in at least three directions: (i) a long analysis period (100-year vs. the typical 50-to-60-year used in the literature); (ii) a joint analysis of floods and extreme precipitation; (iii) a seasonal analysis, accounting for different flood-generation processes across seasons.

The 180-year reconstruction of flood and heavy precipitation probabilities also contributes to an improved characterization of the natural hydroclimatic
variability at the global scale. This is a much-needed improvement since hydrologic extremes have major socio-economic impacts yet remain incompletely understood at the global scale. This reconstruction also constitutes an important proof of concept for a “bottom-up” approach that starts from hydrologic extremes observed on operational station networks and attempts to uncover sources of predictability from the larger-scale climate. While we restricted to past reconstructions during this project, applications to seasonal forecasting or future projections also have a strong impact potential in terms of disaster preparedness or climate change adaptation strategies.

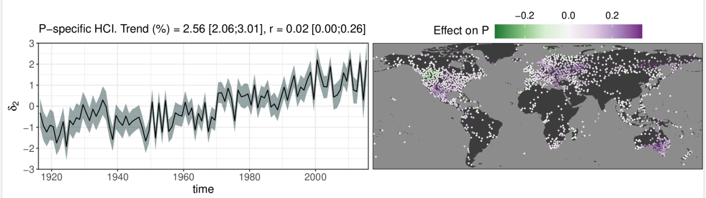
Project's logo



Droughts and Heat Waves in South-East Australia



Example of a reconsructed flood probability map



Letzte Aktualisierung: 11 September 2022

Permalink: https://cordis.europa.eu/project/id/835496/reporting/de