II. Natural Hazards and Climate Change Conference

Session 1: Advancing Hydroclimatic Hazard Assessment

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Evaluating unusual weather conditions in the past – a methodology and a visualisation platform

Márk Zoltán Mikes, Roland Hollós, Zsuzsanna Dezső, Rita Pongrácz
Eötvös Loránd University, Institute of Geography and Earth Sciences, Department of Meteorology, Budapest, Hungary

We present a methodology that can be used to evaluate past weather conditions and is based on the following principles: (1) the definitions of unusual phenomena must be based on relative thresholds and take into account seasonality; (2) the reference climatology must be spatially relevant; (3) the results should not be bound to specific calendar years or months; (4) unusual phenomena should be visualised simultaneously (to provide a compound framework). The expression “unusual” is used to describe anomalous values in contrast to the more commonly used “extreme”, because we aim to highlight periods with non-absolute weather extremes. As input, daily meteorological data available at 70 stations across Hungary from 2002 to 2024 are used to create the methodology, where a total of 9 unusual weather phenomena are defined using temperature, precipitation and wind gust as basic variables. The methodology serves as the meteorological basis for a science communication platform that combines complex information with simplicity through interactive visualisations. The described approach can serve as inspiration for further studies aiming to evaluate weather extremes in the past and for applications where specific information (regarding location or season) is required.

What can we learn about hail from laboratory studies?

Miklós Szakáll[1], Alexander Theis[2]
[1]*University of Mainz, Germany;*
[2]*Max Planck Institute for Chemistry, Mainz, Germany*

Severe weather events including hail are responsible for damages in residential, industrial, and agricultural goods and cause hundreds of injuries and fatalities every year in Europe and worldwide. Furthermore, according to ICCP, extreme precipitation events are very likely to increase in rate and frequency in the next decades in Europe due to climate change. In spite of its importance, most of the atmospheric processes related to hail are not well understood. We have carried out laboratory studies in the vertical wind tunnel of the University of Mainz to explore the kinetics of hailstones and their melting behavior. Special focus was placed on the fall speed and its dependency on hailstone shape, size, and density. For that, a large set of hailstone replica of natural shapes has been printed out using 3D printing technique. Furthermore, the melting of hail was studied using spherical and natural hailstone shapes, which provided valuable information on whether hail reaches the ground in solid form or as rain.

Using ESA CCI Soil Moisture Data for Drought Characterization: Applications and Scientific Perspectives

Johanna Lems, Pierre Laluet, Nirajan Luintel, Wouter Dorigo
Vienna University of Technology Department of Geodesy and Geoinformation, Vienna, Austria

Droughts are among the most challenging natural hazards to monitor, due to their slow onset, spatial heterogeneity, and far-reaching impacts across multiple sectors. Soil moisture is a key variable in understanding and detecting drought conditions, as it reflects the interplay between precipitation, evapotranspiration, and vegetation water uptake.

The ESA Climate Change Initiative (CCI) Soil Moisture dataset provides harmonized global observations dating back to 1978, derived from multiple passive and active microwave satellite sensors. It offers three main products—ACTIVE, PASSIVE, and COMBINED—each based on different sensor types and retrieval methods, and associated with specific uncertainty profiles. With daily observations at a 0.25° spatial resolution, it is a valuable and widely used resource for drought monitoring and analysis at multiple scales.

We have leveraged this dataset across several European reserch project, advancing both applied and methodological developments. Our findings demonstrate the strong potential of ESA CCI Soil Moisture data for drought research and early warning applications. However, challenges remain—particularly regarding spatial resolution and representativity in heterogeneous landscapes.

In our presentation, we provide an overview of the ESA CCI Soil Moisture product and show how it has been used in various drought applications developed at TU Wien, such as Clim4Cast. Additionally, we outline future developments aimed at aligning the dataset more closely with user needs, further enhancing its applicability for drought research.

OPTRAM model based plot-level soil moisture mapping using Sentinel-2 imagery

Gábor Mátyás Gubucz[1], Boudewijn Van Leeuwen[2], Ferenc Kovács[1]
[1]*University of Szeged Department of Physical and Environmental Geography, Szeged, Hungary,*
[2]*Bay Zoltán Nonprofit Ltd. for Applied Research, Szeged, Hungary*

The OPTRAM (Optical Trapezoid Model) utilizes remotely sensed data to accurately deter-mine soil moisture by analyzing the linear relationship between the Normalized Difference Vegetation Index and transformed short-wave infrared values. Using this model, our aim was to map topsoil moisture at the plot-level on different soil surfaces. First, in situ measurements were carried out in spring 2020 with Spectrum FieldScout TDR 350 instrument on ground sur-faces at the same time of Landsat-8, Sentinel-2, PlanetScope satellite image acquisitions. The sentence related to the spectral indexes was adapted: Spectral index values were initially compared with in situ measurements collected concurrently to identify correlations and to determine the ratios of spectral bands for soil moisture estimation, but correlation coefficients were typically low (0.1-0.2), which indicates that none of the individual indices is sufficient for accurate soil moisture estimation. Using OPTRAM, the correlations significantly improved (0.7-0.8), particularly on bare soil surfaces. Model was then applied to Sentinel-2 data and compared with in situ data from three soil moisture monitoring stations in autumn 2023, re-sulting in a strong correlation (0.8-0.85). The OPTRAM based methodology demonstrates sig-nificant potential for remote sensing-based soil moisture determination and illustrates well time series variation improving the scalability and accuracy of drought monitoring while emphasizing the need for integrating soil properties context to enhance accuracy in plot-level analyses.

Impact of drought on the sustainable development of the border area of Serbia with Bulgaria

Marko Sedlak, Nemanja Josifov, Vladimir Malinić
Faculty of Geography University of Belgrade, Belgrade, Serbia

The problem of drought is a big challenge and one of the problems, primarily in less developed and developing countries. The paper presents the theoretical framework of the effect of aridization on regional development, as well as the spatial aspect of its influence at the global level. The changes in the drought index and the differences in the border area between Serbia and Bulgaria were analyzed. In the paper, the methods of Lang's rain factor, De Marton's drought index and Pina combined index were used to obtain drought index values and identify regional differences based on available data at the meteorological stations of this territory (Negotin, Zaječar, Knjaževac, Pirot, Dimitrovgrad, Babušnica). The time frame of the research includes the period 1961–2020. By applying the standard deviation method, the ranking of dry and wet years was performed for each meteorological station individually. These data are related to the realization of certain goals of sustainable development: climate action (SDG 13), life on land (SDG 15), affordable and clean energy (SDG 7), zero hunger (SDG 2), good health and well-being (SDG 3), clean water and sanitation (SDG 6). In this context, their current and future impact on the economy, life and work of the population of this area was considered.