Background document on extreme climate- and weather - related events

Background

Extreme weather and climate events (e.g. pluvial floods, droughts, heavy precipitation and heat/cold waves) can lead to major impacts on natural and managed systems and are thus an important driver for developing management plans, national and local adaptation actions, and disaster responses.

Data collected from different sources show an increase in damages from extreme weather events due to increases in infrastructure and people in risk prone areas, a general increase in wealth and also to some extent due to increases in number and frequency of extreme events (see EEA climate change impact indicators for damages from weather and climate related events[1]), for extreme temperatures and health[2], the 2011 EEA Technical Report on "Mapping the impacts of natural hazards and technological accidents in Europe"[3] and 2012 EEA report on "Climate change impacts and vulnerability in Europe"[4]

EEA also compiles indicators on extreme climate and weather events. The indicators on temperature extremes[5], precipitation extremes[6], and storms[7] are regularly updated (either annually or every two years), while the indicator on droughts (abnormally low soil moisture) is planned for redesign and improvement during 2015. In addition to those listed here, the EEA is considering the merits of developing an indicator for hail.

EEA intends to publish an updated and improved report on climate change, impacts and vulnerability (CCIV) in 2016. The report will include indicators on changes in the climate (including extremes), impacts on ecosystems, socio-economic sectors and human health and information on vulnerability and risks.

As an important element of this 2016 CCIV report, the EEA wishes to assess current scientific knowledge on frequency and intensity of extreme weather and climate events in Europe including trends, changes in trends over recent decades, and future projections of these events.

Objectives

To strengthen the knowledge on extreme climate and weather related events and to improve the content of selected EEA indicators, EEA together with ETC is preparing a technical paper on extreme weather and climate related events. The objective of the paper are understanding the nature of extremes in the context of climate change and describing extremes such us extreme temperature, heavy precipitation, drought, and hail in the form of indicators.

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[1] http://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-1/assessment
[2] http://www.eea.europa.eu/data-and-maps/indicators/heat-and-health-1/assessment-1
[3] http://www.eea.europa.eu/publications/mapping-the-impacts-of-natural/mapping-the-impacts-of-the.pdf/view
[4] http://www.eea.europa.eu/publications/climate-impacts-and-vulnerability-2012
[5] http://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature/global-and-european-temperature-assessment-8
[6] http://www.eea.europa.eu/data-and-maps/indicators/precipitation-extremes-in-europe-2
[7] http://www.eea.europa.eu/data-and-maps/indicators/storms-1/assessment-1

1. To understand weather and climate related extreme events

It is important to understand the nature of weather and climate related extreme events. Specifically the paper aims to address the following points:

- From observation of the climate variable to detection of extreme events
  - How important is the selection of the baseline period?
  - How the interpolation influences the detection?
  - What are the regional differences across European land areas?
- The availability of timeseries
  - What is the minimum acceptable length of a timeseries for analysis of extreme events?
  - What are the minimum data frequencies needed for analysis (hourly, daily, monthly)?
  - What statistical techniques can be of use to better understand data or allow use of incomplete data?
- Spatial scale and regional differences
  - What is the optimal spatial resolution to capture extremes?
  - What are the advantages of station data versus interpolated datasets?
  - What are the limitations in assessing extremes at the continental level (local versus large scale events)?
  - What statistical techniques can be of use to better understand spatial patterns?
- Representation of extremes in climate models
  - Are existing observational datasets adequate for model validation?
  - How to account for inter-model variability in projections?
  - How biases are influencing the detection of extremes in the models?
  - Is the statistical bias correction the right approach?
- Linking climate- and weather-related extreme events indicators to adaptation and other areas
  - Are existing indicators and metrics useful in adaptation and other applied research?

Key publications which serve as background literature:

- *Trends in extreme weather events in Europe*: implications for national and European Union adaptation strategy: http://www.easac.eu/fileadmin/PDF_s/reports_statements/Easac_Report_Extreme_Weather_Events.pdf
- Extreme Weather Events in Europe: http://www.easac.eu/fileadmin/PDF_s/reports_statements/Extreme_Weather/Extreme_Weather_full_version_EASAC-EWWG_final_low_resolution_Oct_2013f.pdf
- Explaining Extreme Events of 2013 from a Climate Perspective: http://www2.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-of-2013-from-a-climate-perspective/
- Chapter 3 in: Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX): http://ipcc-wg2.gov/SREX/report/
- Weather and climate extremes: Pacemakers of adaptation? http://www.sciencedirect.com/science/article/pii/S2212094714000693

- Bias correction of the ENSEMBLES high-resolution climate change projections for use by impact models: Evaluation on the present climate http://onlinelibrary.wiley.com/doi/10.1029/2011JD015934/abstract
- Review of trend analysis and climate change projections of extreme precipitation and floods in Europe http://www.sciencedirect.com/science/article/pii/S0022169414008889

2. To contribute to improvements of four EEA indicators

It is important to understand what are the possibilities and limitations for development and revision of the EEA's indicators related to extreme weather and climate events. The paper will focus on presenting following indicators:

- Hail
- Heavy precipitation
- Drought
- Heat waves

For each topic several key questions will be addressed.

2.1 Hail

Questions

- Is the data underlying the recently developed European hail climatology robust and complete enough to justify the addition of a new EEA indicator on hail?
- Is the data sufficient for reporting past trends for hail across Europe or for specific regions?
- Are projections for future changes in hail across Europe or for specific regions available, and are they robust enough to be included in an EEA indicator?

Scientific context

In the context of the HARIS-CC Project "Hail Risk and Climate Change", several experts have recently assessed changes in hail potential over past and for future decades for Europe. Recently also a new catalogue for hail event across Europe has been compiled

Key publications

- A new physically based stochastic event catalogue for hail in Europe (http://dx.doi.org/10.1007/s11069-014-1161-0)
- Changes in Hail Potential Over Past and Future Decades (http://www.oeschger.unibe.ch/events/conferences/hail/presentations/24_Mohr.pdf)

2.2 Drought

Questions:

- Currently aspects of meteorological, hydrological, agricultural and socio-economic droughts are covered by various CLIM indicators: CLIM004 (Standardized Precipitation Index (SPI) and dry-spell length), CLIM018 (River flow drought), CLIM029 (Soil moisture) and to some degree CLIM033 (Irrigation water requirement). What are the pros and cons of combining different aspects of drought-related information in EEA indicators?

- How to define hydrological droughts? What are the pros and cons of the choice of different return periods for minimum river flow (e.g. socio-economic relevance, robustness)?

- How is the data availability regarding observations of further indices on hydrological drought (e.g. drought duration, deficit volume)? Could these indices provide substantial additional information for development of the drought indicator?

- What are the causes for substantial differences in drought projections (e.g. assumptions regarding thresholds and hydrological regimes), and what are the implications for decision-makers?

- In Europe, ground based measurements of soil moisture are not available for many regions. Measurements are also not harmonised and they are also not available for sufficiently long time periods. However, satellite derived soil moisture data are now available for Europe.

- Currently studies about drought climatology for Europe use mainly drought indices, like SPI or the Palmer Drought Severity Index (PDSI). What are the limitations of using these indices for assessing drought climatology in Europe?

- For what past time period can the combined drought indicator (CDI) be calculated? Is it possible to combine the CDI with information on agricultural droughts from the revised soil moisture indicator?

- What are the links between heat waves and droughts?

Scientific context

Drought is one of the most costly climate related extreme event with impacts across many systems and sectors. There are many definitions of drought and there are many aspects of droughts (like meteorological, hydrological, soil moisture/agricultural and socio-economic droughts). Proxy indicators for drought such as SPI and PDSI are frequently used for assessing drought climatology. Soil moisture is a useful indicator in the study of drought, but apart from satellite derived data information across Europe is incomplete.

Recently several experts from JRC have developed a Combined Drought Indicator (CDI), an index for agricultural drought that combines the Standardized Precipitation Index, the anomalies of soil moisture and

the anomalies of the fraction of Absorbed Photosynthetically Active Radiation. Other researchers from the same JRC apply the LISFLOOD model for projecting changes in hydrological droughts (i.e. minimum river flow).

Two further modelling groups have modelled future changes in droughts at a global level, using different modelling approaches and assumptions. Both groups include European researchers involved with the (virtual) European Drought Centre (http://www.geo.uio.no/edc/). The EURO-CORDEX initiative has recently completed RCM-based projections for various climate indicators, including dry spell length, in Europe.

Key publications

- A spatio-temporal structure-based approach to drought characterisation (http://onlinelibrary.wiley.com/doi/10.1002/joc.2280/abstract)
- Development of a Combined Drought Indicator to detect agricultural drought in Europe (http://dx.doi.org/10.5194/nhess-12-3519-2012)
- Ensemble projections of future streamflow droughts in Europe (http://dx.doi.org/10.5194/hess-18-85-2014)
- Global hydrological droughts in the 21st century under a changing hydrological regime (http://dx.doi.org/10.5194/esd-6-1-2015)
- Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment (http://dx.doi.org/10.1073/pnas.1222473110)
- EURO-CORDEX: new high-resolution climate change projections for European impact research (http://dx.doi.org/10.1007/s10113-013-0499-2)

2.3 Heavy precipitation

Questions:

- What are the relative advantages of various indices (such as extreme daily precipitation, R95, and wet spell length, WSL) for presenting observed and projected changes in heavy precipitation?
- Are data on observed changes in R95 easily available for Europe, and for which time period?
- What are the observed trends in heavy precipitation and how precipitation extremes are represented in gridded (low spatial resolution) datasets?
- Is data on projected changes in WSL from GCMs and/or RCM ensembles easily available for Europe?
- How relevant and important is the bias correction of climate models?

Scientific context

Studies at the continental level give inconclusive results regarding the trends in heavy precipitation. The reasons can be insufficient data availability and low spatial resolutions in datasets. Several experts have recently assessed observations and projections for various extreme precipitation indices (including R95 and WSL).

Key publications

- A consistent picture of the hydroclimatic response to global warming from multiple indices: Models and observations (http://dx.doi.org/10.1002/2014JD022238)

- Changes in extremes and hydroclimatic regimes in the CREMA ensemble projections (http://dx.doi.org/10.1007/s10584-014-1117-0)
- Global changes in extreme events: regional and seasonal dimension (http://dx.doi.org/10.1007/s10584-011-0122-9)

2.4 Heat waves

Questions:

- What are the relative advantages of the different indices for presenting observed and projected changes in extreme high temperature?
- Is the Heat Wave Magnitude Index (HWMI) suitable for use as an indicator about temperature extremes?
- Has the HWMI or another heat wave index been systematically linked to observed impacts from heat waves in Europe (e.g. on human health or agricultural crop yields)?
- How useful are the spatial and temporal projections of heatwaves from climate models?

Scientific context

Extreme temperatures have become more frequent. Since 1880 an average length of summer heat waves in western Europe doubled and the frequency of hot days almost tripled.

There are also many heat wave definitions. In the EEA climate change indicators different approaches are used for assessing trends than for analysing projected changes. Projections of heat waves often require prior bias correction of temperature, which require additional step in data processing.
Several experts from JRC have recently used heat waves defined in relative terms and applied it to climate observations and projections. Several experts have recently assessed projections for the Heat Wave Day Index (as well as extreme precipitation indices). A more comprehensive assessment of various heat wave indices has been conducted earlier by various experts.

Key publications

- Magnitude of extreme heat waves in present climate and their projection in a warming world (http://dx.doi.org/10.1002/2014JD022098)
- A new index to quantify the magnitude of Heat Waves in present and future climate (http://adsabs.harvard.edu/abs/2013AGUFMNH51B1608R)
- Extreme heat waves in present climate and their projection in a warming Mediterranean region (http://meetingorganizer.copernicus.org/EGU2014/EGU2014-1927-1.pdf)
- Changes in extremes and hydroclimatic regimes in the CREMA ensemble projections (http://dx.doi.org/10.1007/s10584-014-1117-0)
- Global changes in extreme events: regional and seasonal dimension (http://dx.doi.org/10.1007/s10584-011-0122-9)
- Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset (http://dx.doi.org/10.1002/jgrd.50150)
- Criteria for heat and cold wave duration indexes (http://dx.doi.org/10.1007/s00704-011-0495-8)