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European Drought Observatory

User Meeting, 9-10 November 2017

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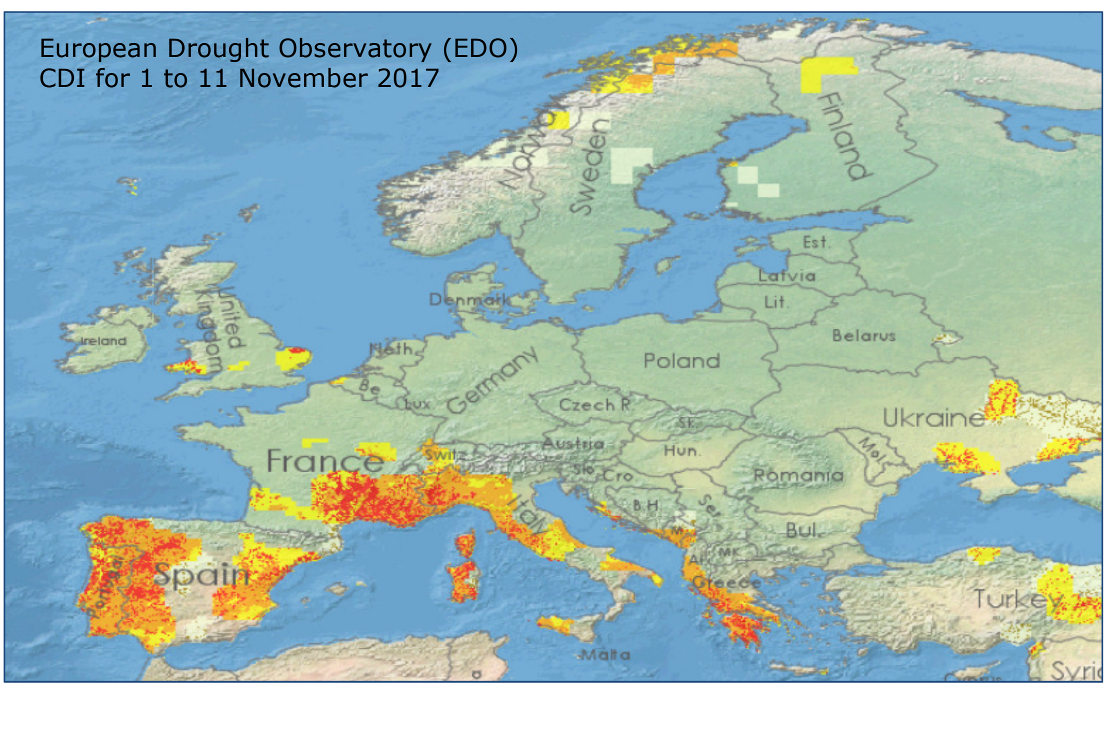

Joint Research Centre

JRC Science Hub
https://ec.europa.eu/jrc

European Drought Observatory (EDO)
http://edo.jrc.ec.europa.eu

Global Drought Observatory
http://edo.jrc.ec.europa.eu/gdo

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Contents

Abstract

The first European Drought Observatory (EDO) User Meeting was held on 9 and 10 November 2017, at the Joint Research Centre (JRC) in Ispra, Italy. The meeting gathered together experts from river basin commissions, national and international meteorological services, national water boards, regional and national drought management centres, private entities, and the JRC, to discuss the development, status and future evolution of the European Drought Observatory, and the related Global Drought Observatory (GDO). Regional, national and local drought monitoring and forecasting systems were presented at the meeting, and the potential for links to the EDO system was discussed. Besides the technical and scientific aspects of drought monitoring and forecasting, the discussions centred on the stakeholders' requirements and expectations, and their involvement in the continued development of EDO, for example, through a network of partners and experts. The need to develop sustainable monitoring and forecasting systems at various scales, their inter-linkages and synergies, as well as important existing gaps in available data and information (e.g. a lack of standardised information on drought impacts) were highlighted. This report provides a short summary of the presentations and discussions that took place during the meeting.

1 Introduction

The European Drought Observatory (EDO) was developed as a response to the need to better understand, monitor, and forecast water scarcity and drought in Europe and to provide input for the development of evidence-based policies in the field. A first attempt to address the water scarcity and drought problem in the European Union was included in the European Water Framework Directive (WFD, 2000), which requires drought management plans to be developed in all river basin districts prone to prolonged droughts. In 2007, the European Commission then published a specific Communication to the European Parliament and the Council on "Addressing the challenge of water scarcity and droughts in the European Union" (European Commission, 2007). This communication explicitly asks for the development of EDO and acknowledges its use for the enhancement of the knowledge on droughts. It further underlines the fact that efficient alert systems are an essential dimension of risk management and that an early warning system will help to improve the drought preparedness of the relevant authorities. It details the need for a system that "will integrate relevant data and research results, drought monitoring, detection and forecasting on different spatial scales, from local and regional activities to a continental overview at EU level, and will make it possible to evaluate future events" (European Commission 2007, p. 9).

This communication and the general lack of harmonized drought information at the European level led the European Commission's Joint Research Centre (JRC) to start the development of EDO in close collaboration with the EU Member States, the European Environment Agency, Eurostat, and representatives from the electricity and water industries. EDO targets efficient methods to monitor and forecast meteorological, agricultural, and hydrological droughts at European scale and at the same time foresees the possibility to link to national to subnational information systems. It is a distributed system, where data and indicators are handled at each spatial scale by the responsible authorities (stakeholders) and visualized through Web Mapping Services. This requires calculation of a suite of core indicators according to defined standards at all scales. With increasing detail, additional locally important indicators can be added by the responsible authorities. While JRC handles data and computes indicators at the continental level (so-called awareness-raising indicators), national, regional, and river basin authorities add more detailed information for their area of interest. As detail increases, indicators become more relevant for day-to-day water management. EDO can be accessed through JRC's web portal at http://edo.jrc.ec.europa.eu/ and at the same time it serves as the European node in the first prototype of a distributed Global Drought Information System (GDIS) hosted by NOAA at https://www.drought.gov/gdm/ and developed as part of the Group on Earth Observation (GEO) work plan. EDO provides a suite of drought indicators at different spatial and temporal scales, including 10-daily and monthly updated maps on the occurrence and evolution of drought events, as well as a 7-day forecast of soil moisture. Medium- to long-term forecasting is under development using probabilistic ensemble methods. On the continental scale, EDO includes meteorological indicators, snow pack indicators, soil moisture indicators (output of a distributed hydrological model), indicators on the photosynthetic activity of the vegetation cover (based on satellite measurements), and indicators on river low flows. At the more detailed levels it includes selected indicators relevant for the respective authorities.

The variety of indicators proved useful for the expert user and, in case of severe drought events, for the production of drought reports by the JRC drought team. Policymakers, however, require synthetic high-level combined indicators, showing different alert levels, to be used for awareness raising as well as for policy and decision-making. Such combined indicators need to be developed by sector (e.g., for agriculture, public water supply, energy production, and waterborne transport). As a consequence, the EDO team developed a first Combined Drought Indicator (CDI) for agriculture and natural ecosystems, providing information on the drought propagation within the hydrological cycle and the resulting impacts on the vegetation cover. The CDI provides easy-to-understand sector-specific information for decision makers in the form of alert levels. More recently, EDO has been extended to the global level in order to provide information to the Emergency Response Coordination Centre (ERCC) of the EC, which supports and coordinates a wide range of prevention and preparedness activities in the area of natural and man- made disasters. This extended system, called the Global Drought Observatory (GDO; http://edo.jrc.ec.europa.eu/gdo) adds the component of risk and impact assessment. A first drought risk assessment for agricultural impacts has been implemented and a Likelihood of Drought Impact (LDI) indicator has been developed that serves as a high-level alert indicator combining the hazard with exposure and vulnerability to evaluate the evolving drought risk for that sector. More details on the systems can be found in Vogt et al., 2017.

In order support the further development of EDO and GDO and in order to foster networking of institutions and authorities involved in drought management, it was decided to establish a user and expert network that should meet yearly in order to discuss the status and evolution of drought monitoring, forecasting and risk assessment in Europe and globally. This report results from the first EDO User Meeting held at the JRC Ispra on 9 and 10 November 2017. It details the programme of the meeting, the main points of the presentations and discussions as well as the main conclusions from the meeting.

- Participants in the EDO User Meeting 2017 (9/11/2017)

2 Meeting Programme

Thursday 09/11/2017:

09:00 – 09:30: Arrival and Registration

Session 1: Current Status of EDO

(Chair: J. Vogt, Rapporteur: C. Cammalleri)

09:30 – 09:45: Welcome and scope of the meeting (J. Vogt)

09:45 – 10:15: EDO: History, status and planned evolution (J. Vogt)

10:15 – 11:00: EDO Portal and Tools – online demo and discussion (A. de Jager and D. Magni)

11:00 – 11:30: Coffee/Tea

Session 2: National and Regional Activities, Needs and Expectations

(Chair: P. Barbosa, Rapporteur: J. Spinoni)

11:30 – 12:30: National and Regional Systems

1. The Integrated Drought Management Programme for Central and Eastern Europe (IDMP CEE) and the Drought Management Centre for Southeastern Europe (DMCSEE): Cooperation with EDO and follow-up in the DriDanube project (A. Susnik and S. Bokal)
2. Central European drought monitoring efforts (M. Trnka)
3. The Spanish system for drought monitoring and its application in the Segura River Basin (J. Fraile)
4. Past and present experiences in drought monitoring in Italy (S. Mariani)

12:30 – 13:45: Lunch & Group Photo

13:45 – 15:30: Experiences, Needs, and Perspectives

1. Needs and experiences of the Po River Basin authority (C. Vezzani)
2. Handling of drought events in the Netherlands: Information used, developments and challenges (V. Beijk)
3. The perspective of the International Commission for the Protection of the Danube River (Z. Major)
4. The perspective from the International Sava River Basin Commission (M. Sarac)
5. Greek experiences in drought monitoring and management (M. Kossida)
6. Data and drought monitoring activities at the German Weather Service, DWD (K. Rehfeldt)

15:30 – 16:00: Coffee/Tea

16:00 – 17:00: Discussion: Needs and expectations/Common way forward
(Chairs: J. Vogt/P. Barbosa)

17:00 – 17:15: Wrap-up of Session 1

17:30: Transfer to Hotel dei Tigli in Angera

19:00: Social Dinner at Hotel dei Tigli in Angera

Friday 10/11/2017:

Session 3: Planned improvements and additions: The way forward

(Chair: N. McCormick, Rapporteur: A. de Jager)

08:45 – 09:00: Arrival to JRC

09:00 – 09:20: European Drought Events (J. Spinoni)

09:20 – 09:40: Drought Impact Data (V. Blauhut and G. Naumann)

09:40 – 10:00: Developing Sectorial Impact Indicators: The example of energy production (D. Masante)

10:00 – 10:20: Forecasting Droughts (and Heatwaves) in Europe (Ch. Lavaysse)

10:20 – 10:40: Coffee/Tea

10:40 – 11:00: Drought Trends and Projections for Europe (J. Spinoni)

11:00 – 11:20: Drought Risk Assessment (H. Carrao, G. Naumann, V. Blauhut, C. Cammalleri)

11:20 – 12:30: Discussion on way forward

12:30 – 14:00: Lunch

14:00: Closure of the meeting

3 Meeting Presentations and Discussions

Day 1 (Thursday, 09/11/2017)

Roundtable presentation of participants

Welcome and scope of the meeting (J. Vogt)

EDO: History, status, and planned evolution (J. Vogt)

- Drought in Europe, impacts in different sectors, damages and losses, policy framework.
- History of the development of the European Drought Observatory (EDO) and the Global Drought Observatory (GDO) and the stakeholders and expert groups involved. From 2018 EDO & GDO will be included in the Copernicus Emergency Management Service (EMS). Links with other global activities and programs (e.g., GEO-GIDIS, IDMP).
- Current status: web-based platform, multi-scale approach, partner network, indicators, maps and factsheets, indicator examples.
- Ongoing activities: development of a database of drought events, analysis of trends and projections, forecasting, testing of damage functions for selected sectors, exploring the possibilities to develop a database of drought impacts based on the European Drought Impact report Inventory (EDII, Universities of Freiburg and Oslo).
- Keeping up collaborations with partners requires commitment from both sides.
- GDO: likelihood of drought impact indicator, analysis of drought hazard, exposure, vulnerability and risk, media monitor and possible feedbacks, generation of semi-automatic reports, preparation of analytical reports in case of severe events.

Q[1]: Is the media monitor effective? R: Yes, but needs well prepared queries and quality checks of the results.

EDO Portal and Tools – online demonstration and discussion (A. de Jager – D. Magni)

- Introduction on the portal and its background technology.
- Open system, data input, updates, forecasting, large archive, data providers, data pre-processing and checks.
- Available indicators: indicators for precipitation, soil moisture, vegetation vigour, river flows, snow pack, groundwater, temperatures, heat waves, and a combined indicator.

[1] Q: Question, C: Comment, R: Response

- Available tools: side by side maps, identifier, time series graphs, geographic background, metadata catalogue, animations.
- Possibility to download EDO maps for example as ArcGIS map project
- How to join EDO (steps, registration, how to become a data provider).
- Participants are invited to frequently check the system and provide feedback

Q: Is the definition/value of the heat wave threshold the same throughout Europe? Could users work with their own definition in EDO? How many tools can be added? R: The same definition is used across Europe; however, the threshold is percentile based and therefore variable across Europe. The user currently cannot work with own definitions, but in principle, this is possible. We can add as many tools as needed; the ideal situation, however, is to avoid too many tools.

C: In the Segura basin the monitoring approach is more hydrological rather than meteorological or agricultural. How can this link to EDO? R: The current choice of indicators in EDO is based on discussions in the Water Scarcity and Drought Expert Group under the WFD. It covers all aspects of drought. A low flow indicator is included. At lower levels regionally and locally important indicators can be added. This poses no problem.

Q: How dynamical is EDO? Can we download data and map layers from EDO? Are the data public? R: All the data visible in EDO are publicly available, and download is in principle possible. The underlying source data (e.g. meteorological data) are copyright protected and therefore not accessible. All visible data are derived data, which underlie no restrictions.

C: Do we need to inform you if we download data? R: No. But we appreciate feedback on the use and quality of the data.

The Integrated Drought Management Programme in Central and Eastern Europe (IDMP CEE) and the Drought Management Centre for South-Eastern Europe (DMCSEE): Cooperation with EDO and follow-up in the DriDanube project (A. Susnik and S. Bokal)

a) DMCSEE

- The DMCSEE promotes a web-based platform with information from various sources to monitor and detect droughts throughout SEE. The consortium consists of 13 countries in SEE. DMCSEE was established in 2006. The mission of the DMCSEE is to coordinate and facilitate the development, assessment and application of drought risk management tools and policies in South-Eastern Europe with the goal of improving drought preparedness and reducing drought impacts.
- Basic information on drought is summarized in a drought bulletin for SEE. Bulletin contains short summary (“Hot spot”). It aims at very short insight of possible circumstances of drought at the time of issue. Information is extended with further information on temperature and water balance situation, including most relevant maps and other monitoring products. Report on impacts based on information available in electronic media on the internet. Remote sensing derived vegetation indices are a particularly helpful and complementary tool to classical station-data derived drought indices, mainly for monitoring agricultural drought.

- Project work – recent project DriDanube (point c)
- More info: http://dmcsee.org/.

b) IDMP CEE

- In 2013, the Global Water Partnership Central and Eastern Europe (GWP CEE) initiated the Integrated Drought Management Programme (IDMP CEE) within the framework of the joint, global WMO/ GWP Integrated Drought Management Programme. Focus of the IDMP CEE is to increase the capacity of the CEE region to adapt to climate variability by enhancing resilience to drought.
- An essential part of the 1st phase of the Programme was the involvement of the key policy makers to discuss the current status of drought management in each country, identify strong and weak areas, and increase their capacity to prepare Drought Management Plans/Policies.
- During the 1st phase also link with EDO was made and integration of 26 additional products from CEE countries.
- 2nd phase of the programme (2017-2019) focus on four main areas: improvement of the drought monitoring; unification of drought impacts and risk assessment; overcoming gaps in decision-making processes in drought management; improve dialogue between the scientific and policy-making communities.
- More info: http://www.gwp.org/en/GWP-CEE/WE-ACT/Projects/IDMPCEE/

c) DriDanube

- Project funded by the Danube Transnational Programme; duration: January 2017 – June 2019 (www.interreg-danube.de/dridanube/).
- Main objective of DriDanube project is to increase the capacity of the Danube region to manage drought related risks.
- Main outputs:

  a) Drought User Service, (DUS) which will enable more accurate and efficient drought monitoring and timely early warning (the service will integrate all the available data, including large volume of the most recent remote sensing products. Drought user service will become major DMCSEE monitoring tool and data hub, including map service for international data exchange.

  b) Methodologies for drought risk and impact assessment;

  c) Strategy to improve drought emergency response and better cooperation among operational services and decision making authorities in a Danube region on national and regional level.

d) General considerations

- Connect different initiatives, projects, programmes which are working on drought indicator systems, classification of drought stages, thresholds, early warning, etc.

- Harmonize data collection, methodologies (INSPIRE directive – protocols), impact & risk on EU level;
- Ensure sustainability (project to operational work);
- Briefings EDO-DMCSEE-IDMP - other initiatives;
- Integrate drought monitoring into drought management – stronger link with EC and support with the preparation of an EU Drought Policy or other regional policy like the EU Strategy for the Danube Region (EUSDR)?

Q: How do you manage the feedback by users? Is there an established feedback mechanism? R: There is a responsible for each country/region, but people change their job and duties. As a consequence, it is sometimes difficult to keep-up connections with countries.

C: What about the mentioned lack of monitoring systems in some countries? The Sava River Basin Commission and Bosnia could help with near-real time data and products and also with historical data. R: Input would be welcome.

C: The nested approach is interesting and in-line with EDO, data and indicator harmonizing is important, the projects and perspectives shown could fit EDO and be useful at EU level. R: Visibility through EDO and involving countries with no national or regional monitoring in the process are important aspects.

Central European Drought Monitoring Efforts (M. Trnka)

- PDSI and SPEI time series demonstrate trends towards increasing in dryness in parts of the Czech Republic (CZ). Also relatively local droughts can have significant impacts on agricultural production.
- Examples of drought and flood impacts on yields in CZ (e.g. May 2012).
- Ensemble projections indicate increasing hazard of drying in CZ → increasing drought impacts to be expected.
- CZ drought monitoring system (www.intersucho.cz; www.drought.cz): real-time drought monitoring (meteorological indicators, soil moisture model, vegetation indices from EO data); high-resolution daily to weekly update; regular communications with ca. 300 farmers providing weekly feedbacks on general situation, impacts on crops and data from soil moisture measurements; yield data available at district level; forecasts based on ensembles up to 9 days ahead but also statistical up to 2 months ahead; link to cadastral data, which allows farmers use the data for managing their property.
- Collaboration with and coverage for Slovak Republic since 2017.
- Interest to join EDO and provide drought impacts on forecasted yields, also as possible input to the MARS bulletin. Aim is providing high-resolution data and maps.

Q: Are your data protected? R: Data are freely available.

Q: Soil moisture and vegetation are important variables, but is irrigation considered in the analysis? What about river low flows and groundwater levels? R: Intersucho is an operational system, including climatic water balance and reservoir storage. Irrigation is *not a big factor in the Czech Republic and therefore not included. Using more dams could be an option for the future as less water resources will be available due to climate change.*

Q: How do models and farmer feedbacks match? Do you compare them? Do you also ask to quantify impacts in monetary losses? R: Agreement is really good. Farmers are trained to report. The number of reports allows for cross-checking as quality control. We prefer 300 farmers that report weekly as compared to 3000 which report only randomly. We ask to report yield reduction (in %), not losses of profit.

Q: Is there a questionnaire for farmers? Do you collect statistics about reported impacts? R: Yes, there is a questionnaire. We do not report statistics, but maps. Data are available since 2014.

The Spanish System for Drought Monitoring and its Application in the Segura River Basin (J. Fraile)

The Spanish system for drought monitoring and management is concerned with hydrological droughts, so the relevance of meteorological droughts is relative to its effect on available resources and, perhaps, the more direct effect on rainfed crops. A great deal of the Spanish territory can be deemed as arid or semi-arid according to the Aridity Index, taking into account not only rainfall but also evapotranspiration (UNESCO 1979; UNEP 1992, Spanish White Book on Water 2000). Spain is a country that is particularly affected by droughts. The main tools of the Spanish administration for drought management and planning are basically three:

- Hydrological status index systems,
- Emergency plans for urban supply in every town over 20.000 people,
- Special Drought Plans for each individual basin, including their own subsystems and indicators for each of these subsystems.

The targets of such a plan are very straight-forward: To guarantee water availability in order to ensure life and health of the population; to avoid or minimize environmental effects on the ecological status of water bodies; to minimize the effects on urban supply; to minimize effects on economic activities, under the preference order set in planning instruments and the Water Act

To achieve those specific targets, we have instrumental targets: To define mechanisms for the prediction and detection of droughts, to set thresholds defining different stages of progressive severity in drought events; to define what measures we can take to achieve the aforementioned specific targets in each stage of drought; and to ensure public participation and transparency in the drafting and application of the Plan.

One of the key issues in the Drought plans for basins is the System of indicators. The indicators should give an idea of the status of the key elements of the supply system, so the choice of control points will be dependent of the nature of the system to monitor.

Since every subsystem in every basin has a different indicator, we have to transform indicators into indices in order to make standardization and comparison possible. The index adopts a value between 0 and 1, and we set levels and thresholds that express the “risk of drought happening”. The levels are four: Normal, Pre-alert, Alert and Emergency.

Each level is linked to a different management target and a different set of possible measures to be adopted, and the types of measures are more drastic as the risk of drought impacts increases. They include things like pumping groundwater from emergency wells, more seawater desalination, enabling trading rights to the use of water between users of the same and/or different basins, tariff modification and, eventually restrictions to the amount of water available for every user.

Periodically the Ministry publishes an updated map showing the status for every different subsystem in the inter-community basins, managed by the state administration.

A large part of the Segura RB (www.chsegura.es) demands are satisfied with the resources provided by the Tagus Segura Water transfer, while own resources, mainly surface waters but also groundwater, provide a large part of the remaining demands. We do not consider non-conventional resources in the indicator systems because both desalinated seawater and reclaimed wastewater have a very high stability in supply.

So we have an indicator for the Tagus Segura Water transfer and a different one for the Segura Basin System. They both combine into a global indicator and index that expresses the overall status of the basin. Each of the indicators adopts an absolute value that then is transformed into an index ranging from 0 to 1, 0 being the worst situation recorded and 1 the best.

The global index here shown is calculated as a linear combination of both, where the proportion of each one of them is determined taking into account the range of the value of their respective indicators, the total range adding both indicators and the proportion each one of them represents over the total.

We are currently in Emergency status, with an Index Value of less than 0.03 over 1. The reservoirs at the headwaters are currently holding only 13% of their overall capacity, and the Tagus Segura Water transfer stopped delivering water in May 2017 because the reservoirs at the Tagus basin headwaters have reached the threshold that prevents additional transfers to be delivered.

The basin and the transfer sub-systems also have their own graph. Their value is 0.180 for the Basin System and a blunt 0 for the Tagus-Segura transfer that has been hitting a new historical minimum month after month for the past 6 months.

The system described for the Segura RB operates in theory for the whole country, but some exploitation systems in other basins may go into emergency state without adopting a drought decree because they have little demands, so impacts are not severe. A standardization of indexes to take into account this type of factors is currently in progress.

On a more technical note, the State index does not show actual trends when bouncing back from a very wet or very dry period, since it reaches a new low or a new high. This may lead to situations where the index goes into pre-alert but the water stock at the Segura RB is still good.

We can also point out that although droughts are not caused by climate change, their frequency and severity can be increased by climate change.

Q: How do you manage priorities? R: There is a priority list, generally urban, minimum environmental flow, industries, and irrigation.

Q: What are the political priorities? R: We follow a legal regulation for water saving and reduction during crises. The main priority is on long-term planning.

Q: What is the Status of dams? Are you building new ones? In Italy this is difficult nowadays. R: Every month a report is send to the ministry about the stored volume of dams as well as an annual report. Dams are considered buffers, not the solution for

Spain. Currently the Segura situation is -12% compared to the average for the same period of the year. In general, reservoirs are never full, even though, in 2012 we had an overflow.

Q: Which measures do you use to cope with drought? Have you applied for support from the EU solidarity fund? R: When the water scarcity is high, we close all the irrigation systems in winter to save water for next spring. Desalinization is an expensive option, so farmers usually don't use it. Solidarity fund and EU measures can be requested at national level only. We just got support from the Spanish government as an exceptional measure for the current drought crisis.

Past and Present Experiences in Drought Monitoring in Italy (S. Mariani)

- The Italian Istituto Superiore per la Ricerca e la Protezione Ambientale (ISPRA) in Rome coordinates environmental services in Italy and supports policy implementation. The national system for environmental protection (Sistema nazionale per la protezione dell'ambiente, SNPA) is formed by ISPRA and 21 Territorial Environmental Agencies.
- In addition, ISPRA coordinates the national committee for operational hydrological services that represents a federal system with the goal to promote at national scale a homogenous quality of the operational hydrological services, in agreement with the WMO resolutions. It aims at developing guidelines and common meteorological data sharing platforms, as well as tools such as, for instance, for water budget monitoring at national scale.
- Drought bulletin: SPI-based, 2.5° resolution, some examples shown (Italy, Bracciano lake). Italian territorial agencies provide maps and other hydro-meteorological indicators (incl. SPI) at local and river basin level. Other indicators are also used and SPI point series are sometimes available. See http://www.isprambiente.gov.it/pre_meteo/siccitas/index.html.
- ISPRA Hydrological Info System (ISPRA HIS Central) is the tool for data access at national level (http://www.hiscentral.isprambiente.gov.it/hiscentral/). The data bases present in the ISPRA HIS Central catalogue are managed by the territorial agencies that are responsible for the hydro-meteorological monitoring.
- A network of Observatories for the use of water resources was established in 2016 (7 river basin districts, according to WFD). Frequent meetings and special meetings during extreme droughts and water scarcity events. Aim: Supporting the water resource governance by coordinating all the key players at the level of a river basin district and monitoring and forecasting droughts and water scarcity events, as well as managing the consequences on the territory of these events, under the Water Framework Directive - Common Implementation Strategy (WFD-CIS). Example: drought 2017 and data in the observatories.

Q: Are the data about the exceptional 2017 drought accessible? R: Not through the HIS Central platform, where, at the moment, there are historical data until 2015. Data have to be requested to the territorial agencies responsible for the hydro-meteorological monitoring.

Needs and Experiences of the Po River Basin Authority (C. Vezzani)

- Po River Basin characteristics. Difficulties for Italian River Basins to connect with European activities. Website: http://www.adbpo.gov.it.
- Drought Early Warning System for the Po River Basin (DEWS-PO). Meteorological data, rain gauges, reservoir level data. Meteorological components (ECMWF, ensemble forecasts, meteorological services of EU), distribution models (TOPKAPI and RIBASIM). Some info on RIBASIM (groundwater, salt intrusion, water withdrawal).
- During water scarcity events: monitoring and forecasting, meetings to define severity scenarios, taking action (iteration), final reporting and statistics, discussion about improvements and what went wrong.
- Example of summer drought 2017, now "prolonged drought" is included in protocols (art. 4, WFD) for exceptional events, but it is difficult to deal with this drought.
- Possible improvements: analyse natural causes, withdrawal not enough limited during droughts, observatory still voluntary, restoration, strengthen the action, collaborate with EDO, better definitions of thresholds, evaluate impacts (users ask for this information), harmonization.

C: EDO can provide overview with different resolutions (soil moisture, vegetation vigour). Harmonization is important; having high-resolution maps would be an added value.

Handling of Drought Events in the Netherlands: Information used, Developments and Challenges (V. Beijk)

- Drought in the Netherlands, river Rhine as main fresh water source for low-lying areas, higher areas depend on rainfall and groundwater, sea water intrusion major issue during summer months.
- The National Coordination Committee on Water Allocation assesses drought and advises on possible measures. Water authorities remain in charge of the actual measures to be taken.
- Priority sequence for water allocation during droughts foresees 4 main use categories: (1) safety/prevention of irreversible damage (e.g. to dikes), (2) public water use, (3) small-scale users with high added value, (4) other water demands.
- Information used: long-term river flow and discharge, flow and weather forecasts, soil moisture, dams/freshwater, agriculture/industrial use.
- Produces during droughts a weekly drought report, including forecast up to 4 weeks ahead, maps, charts, thresholds, and a water balance map. A groundwater map used in the evaluation of situation but not published.
- Future developments: continuous validation/calibration of models, improved groundwater map, evapotranspiration, optimization of tools, preparation for future weather under a changing climate.

Q: How is nature treated (appears in two priority categories)? How can the State intervene with respect to nature? R: Nature can be in more than one category, but usually is in category 4. The State can force distribution of water in different directions. It never happened yet to have to prioritize in the first 3 categories.

Q: Do the farmers ask to take water? What about salt water intrusion? R: The quality of water is important for farmers and we check it. Salinity in general (includes chlorine) can become too high for agricultural purposes during low flows due to intrusion of seawater. However, the decision can be made to let high salinity water into the regional water system to prevent instability of secondary dikes/levees.

Q: Is the priority system a top-down one? Why is agriculture in level 4 (lowest)? R: Priority in level 4 is flexible depending on the actual situation (time of year, forecast, etc.); during emergencies, some sectors can be prioritized and also test periods in different levels are allowed.

The perspective of the International Commission for the Protection of the Danube River Basin (ICPDR) (Z. Major)

The characteristics of the Danube River Basin and the Convention for the Protection of the Danube River (1994) were presented. ICPDR includes 14 countries. ICPDR is interest in extreme events, especially droughts and floods. ICPDR countries are developing National Adaptation Strategies (NAS). ICPDR has reported on climate change impacts (Report on 2015 droughts), partly based on information from EDO and DMCSEE.

- The revision and update of the ICPDR Climate Change Adaptation Strategy is ongoing (to be completed in 2018).
- Climate adaptation measures are incorporated in cyclic (every 6 years) management plans for the Danube basin, according to requirements of the EU Water Framework and EU Floods Directives.
- The Danube area is divided into three regions (upper, middle, lower DRB). Predictions show that regional differences may increase.
- Lessons learned: joint understanding is needed for joint decision making in trans-boundary basins; climate change is a cross-cutting issue requiring an inter-disciplinary approach; a stepwise cyclical adaptive approach is needed.
- Main interest: access to and analysis of information, participation in meetings, teaming-up with experts, improving technical competences and services. Interested to participate to future EDO meetings and to share information both ways. Forthcoming workshop on climate change in Vienna in 2018.
- Website: http://www.icpdr.org.

Q: Do you have connections with the International Commission for the Rhine? R: We have open contacts, and we collaborate with other river basins if possible. Currently we have the capacity to share data and map services, and we are planning to expand our systems with near-real time data. The example that was presented for Po River may be of interest for us.

Q: Do you have data on the long-term climatology? Do you use high-resolution satellite data? You could relate to the CARPATCLIM and DANUBECLIM projects and their experience in data collection and harmonization. R: We are still considering how to utilise

Remote Sensing data (Copernicus programme); we have expert group meetings twice a year, where we have the opportunity to consider various experiences, and to foster technical exchange. We are also interested in collaborating more with DMCSEE.

The perspective from the International Sava River Basin Commission (ISRBC) (M. Sarac)

- The ISRBC is linked with the national institutions, officially nominated by the governments (mostly ministries), as well as National Hydro-Meteorological services, Water Agencies and other institutions.
- ISRBC manages plans, integrates systems, deals with legal and economic issues and protocols.
- Main goal: to prevent and limit impacts from hazards such as droughts, floods, and ice storms. Floods are frequent (2014 devastating, 10 in 10 years), droughts are increasing (2012, 2015 also coinciding with flood in other part of basin).
- Forecasting/Warning: for floods and low flows, a lot of initial steps, use of the US Army Corps of Engineers software tools (HEC-HMS and HEC-RAS), which became the ISRBC reference platform for the hydrological and hydraulic modelling along with the Delft FEWS for forecasting.
- Other activities: data exchange, river basin management planning (Sava RBMP) climate change (WATCAP).
- Current projects: Flood Risk Management Plan; flood forecasting and warning system (Sava FFWS); low flow analysis within the Sava FFWS as a first step to the drought forecasting is almost ready. Expected to be fully operational in 2018, but Sava GIS is already available.
- Sava FFWS developments: Currently, a consultation process on the regular maintenance of the System is ongoing as a very important step towards the post-project sustainability. Simulation models for flood and low flow forecasting and warnings are already run in a pre-release version. Drought will be considered in further developments.
- Websites: http://www.savagis.org (Sava GIS Geoportal), http://www.savahis.org (Sava HIS (Hydrological Information System) Real-time data), using standards such as OWS (OGC (Open Geospatial) Consortium Web Service), INSPIRE, WMO, WaterML 2.0 (Water Markup Language).

Q: Which communication system do you use to share/receive data? Satellite, mobile, web? R: It depends on the national system, but, in general, data are sent using GSM and GPRS mobile networks to country agencies and from them to the ISRBC.

Greek Experiences in Drought Monitoring and Management (M. Kossida)

- Drought in Greece. Complex geography and hydrology of Greece (14 river basins). Data available from 1950 to 2006. Overview of worst droughts (1989-91, 1992-94, 2000-02, 2004, 2007-08).
- Policy context with respect to drought and water scarcity, plans need to be harmonized and improved.
- Greek Drought and Water Scarcity Management Plan (GDWSMP) main goals: historical events based on SPI, SPEI, SRI, mapping drought and water scarcity for stakeholders, find impact data, define vulnerability and assess risk (incl. land cover, DHI, WEI, surface waters, ground water)), analyse zones at risk, early warning.
- Examples: Peloponnese 2002-03, Eastern Greece 2008-09 (DHI – Drought hazard indicator - with four parameters to define vulnerability zones, good also for prediction), Crete Island (ongoing, interest to join EDO, analyses of past droughts, focus on leakage losses and meteorological indicators).
- Future developments for Crete: implement response and mitigation at regional level, municipality level, implement regional directorates responsible for data, analyses, and indicators. Publish monthly bulletins so the single municipalities can directly implement measures.
- Future general steps: harmonize river basins, develop common indicators, collect impact data (now nothing available), update GDWSMP, go to more operational level, ask for public participation, and improve transparency in decision making levels.

Q: Why are no impact data available? R: They are not registered in Greece.

Data and Drought Monitoring Activities at the German Weather Service (DWD) (K. Rehfeldt)

The German drought monitoring is based on the Standardized Precipitation Index (SPI), Standardized Temperature Index (STI), Standardized Combination Index (SCI), Standardized Precipitation Evapotranspiration Index (SPEI) and flash droughts. A combination of the SPI with adaptations from Deutscher Wetterdienst (SPI-DWD) and the SPEI (using Thornthwaite evapotranspiration parameterization) provides estimations of water supply anomalies in respect to long-term statistics and is known as the Global Precipitation Climatology Centre Drought Index (GPCC-DI). Its main advantage is that it combines two existing indices that can both be used in an optimal way without the need for arbitrary settings for evapotranspiration. As a result a nearly global coverage is achieved, except for particularly cold and dry regions like the southern Andes, Himalayas and parts of Tibet. The gridded precipitation data is taken from the Global Precipitation Climatology Centre (GPCC), with a 1° spatial resolution, and gridded monthly mean temperature data from NOAA’s Climate Prediction Center (CPC), with 0.5° spatial resolution. It is finally calculated on a regular grid with 1° spatial resolution. Since January 1952 the GPCC-DI is available with several accumulation periods of 1, 3, 6, 9, 12, 24 and 48 months for different applications. Depending on the availability of the input data it is typically released on the 10th day of the following month. All accumulation periods are integrated into one netCDF file per month. The real-time data set is referenced by the doi:10.5676/DWD_GPCC/DI_M_100 and is available from the GPCC website ftp://ftp.dwd.de/pub/data/gpcc/html/gpcc_di_doi_download.html free of charge, the non-real-time data set is referenced by the doi: 10.5676/DWD_GPCC/DI_M_V1.1_100.

Further developments are the recalculation of the GPCC-DI parameters with the same time period for the climatology and monitoring after the updated version of GPCC Full Data Monthly Product is released in the beginning of 2018. Regarding the seasonal forecast system (GCFS), which is based on MPI-ESM, the high resolution of the Ensemble should be available and used in 2018. Because the calculation of the model for the first month (spin-off) increased the uncertainty, the second to the fourth month are used for the aggregation.

All aforementioned capacities are provided at operational service level with the potential to contribute to systems at national, regional, European and global scale.

For further information see Ziese et al. (2014).

Q: Why do you remove the first month from the forecast? How can you have a better forecast for the second month or later when the skill normally falls significantly after the first month? R: We remove the first month due to increased uncertainty. This leads to overall better results.

Discussion on Needs and Expectations (J. Vogt)

Key points arising from the foregoing presentations and discussions:

- Different monitoring and/or forecasting systems are currently under development.
- Forecasting droughts is still a key issue.
- Drought impact data are missing and needed.
- A harmonized approach for indicator calculation would be useful.
- The spatial resolution and information content is varying between different systems.
- Data sharing between organizations and countries is often difficult.
- Establishing and maintaining collaborations is a key issue (often linked to project life-times).
- The nested approach implemented by EDO is widely supported.
- Networking for data and information sharing should be fostered.
- Which indicators, tools, and information to be provided at EU level should be further discussed.

C: The WMO platform and recommendations for data sharing are good.

C: It would be important to help harmonizing data sharing and provide EDO tools and scripts to local providers. This way, if a country is not included, local providers will want to participate.

C: The experience of the CARPATCLIM project regarding sharing the same tools was positive.

C: Meetings should be set to share tools and follow the same routines.

C: The nested approach is nice, but how much is nesting already happening? What about solar radiation data? R: It depends on the variable/indicator, e.g., snow is provided by the Finnish Met Service, BRGM in France provides groundwater information, DMCSEE provides meteorological indicators, and the Ebro RB provides different drought indicators at management level. Solar radiation not included so far.

C: Tools and indicators are important. One should be able to compute SPI and SPEI with the same method, the same reference period, harmonization over EU. For example, the US Drought Monitor and Brazil also use human checks. We should know what the users ask, this is the real challenge. Also the choice of indicator is important, there are agreed lists, but then every country does its calculations following its rules and choices.

C: Currently we have 6 commonly agreed core indicators in EDO and we are working on harmonizing the factsheets. Following the standards is important. The Copernicus services are increasingly helping to provide continent-wide harmonized data and indicators.

C: The nested approach is interesting. However, in a nested approach drought indicators may depend too much on the local approaches, tools, and the local point of view. The resilience of drought can be hardly captured with a nested approach.

C: Different users are interested in different levels of detail of information and in different information types (e.g. awareness raising indicators at high level vs. management indicators at local level). Politicians require the global picture while river basin managers need indicators for managing the water resources. Therefore, we have to filter requests or give the opportunity to users to filter the information, which is possible in EDO. The big picture provided in EDO and the possibility to explore more detailed information other scales can be very interesting, for example, for "local" users that depend on the upstream situation (e.g. the Netherlands depend to a large degree on water inflow from the Rhine, which is influenced by the snow pack in the Alps and water abstractions along the river).

C: A problem in DMCSEE and generally is that the users are not "in the boat" from the beginning, we need to inform and teach them about what they can expect from our services. They don't even know if and what they can ask. Another main issue is how to reach commitment from stakeholders for cooperation, but also for data sharing and nesting. We need to attract stakeholders providing input and discuss with them on the organisation of a sustainable collaboration.

C: From the Po river basin experience, it is important to think as users or stakeholders and ask ourselves what we would need. Moreover, we should have a specific focus and interest to impacts. Different users need different kind of impact data and studies. We need to arrive at the end to platforms which are useful instruments for stakeholders.

C: US is doing well with impacts, Europe is not. Maybe using social media could help.

C: The University of Freiburg has been working in this direction with the European Drought Impact report Inventory (EDII), collecting also mobile information, but it is difficult and time-consuming.

C: In Spain the Ministry asks volunteers to send information about the use of water.

C: Also schools could be engaged.

C: How to collect inputs is important. In Slovenia agricultural stakeholders are asked to join and constantly check if the drought tools and information are good. A question is whether a phenology service could help. The problem is once again the standardization.

C: The US Drought Monitor combines different indicators based on standards, and then corrects the indicator maps based on expert judgments. This requires a strong network and commitments.

Day 2 (Friday, 10/11/2017)

European Drought Events (J. Spinoni)

- Presentation of published databases and needs for a global database of drought events.
- The developed global database is based on SPI and SPEI, definition of a drought event, characteristics of a drought event included in the database: Start and end date, duration, extent, severity, intensity, peak month, extent at peak month.
- Results: Drought events per country, WMO region, rank scores, global picture.
- Future developments, link between events and impacts.

C: A conference on impact data with private companies will take place in Venice in the next weeks, this might help.

C: How do you validate the database? R: using published papers, scientific reports, books, and information from reliable media sources, we checked the top-50 events and found confirmation for 47.

C: The scoring system is important. We can offer our experience from two study basins in Greece to discuss the parameters

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Drought Impact Data (V. Blauhut)

- European Drought Reference database (EDR): covers selected major EU drought events, currently no human resources to expand the database. Example: 2003, history of this drought, connection with impacts.
- European drought Impact report Inventory (EDII): Collection of impact reports. Many information sources (e.g. government reports, web information, published papers, news articles), focus on reliable info, time consuming extraction of high-quality and quantitative information.
- Archive includes: information source, location (NUTS, level 3), time of occurrence, impact categorization (15 classes). EDII currently has about 6000 reported impacts (38 countries), mostly about agriculture. How to connect to events? There are some biases in the database: many reports for some countries, few for others
- EDII is a text-based archive, visualization of impact distribution possible, impact profiles included, also some temporal profiles (example: UK 2011-12).
- Possibilities of joining the system with the DRMKC and EDO are currently investigated. Important to connect with citizens.

C: Agricultural and water supply impacts are important, but you should try to include also low flow and groundwater impacts.

Q: How could data for the Danube region be inserted? How can your data be included in our observatory? R: A feasibility study on the implementation of EDII in EDO is ongoing. Implementing and updating such a database will require resources. The EDO User *network is important in this respect as it could ensure quality-checked inputs from national experts and high profile contributors.*

Q: Do you have 6000 reports or events documented? R: We talk about reported impacts.

Developing sectorial impact indicators: the example of energy production (D. Masante)

- Drought risks are different for different sectors. So different indicators are needed and should be suitable for monitoring (good frequency and coverage).
- Power plants: water requirements, info and data needed. Drought risk for power production. Conceptually: exposure = demand, vulnerability = water withdrawal/MWh, hazard = in-flow water volume.
- In practice: exposure = power capacity, vulnerability = class of water withdrawal/MWh (i.e. type of cooling system), hazard = a proxy for water inflow.
- Data: many sources but fragmented, more than 5000 power plants in the database currently studied, resources for monitoring and trade-offs. Problem: how much water is really in the plant?
- Communicating the risk: maps, aggregation, to go online in 2018.
- Conclusions: sectorial indicators move closer to impacts. Data collection is difficult, so incremental improvements are required. Next steps: low flow data, other sectors, how to get more data from private sectors?

C: Copernicus is investing much in energy studies; you could use it as source. Add low flow indicator. R: Low flow data are available for EU, but global data are hard to validate.

Q: Networks of power plants are usually interconnected. Do you consider this? One (local) impact could impact different other power plants in the network. R: True, but it is very difficult to model for us at global scale and focus is on major events. We, therefore, focus on plant-scale impacts at the moment.

C: Also the water temperature is important, in Germany the plants must shut down if temperature is too high. At global level I don't know how it works. R: Some models include this factor, but it is very difficult to include policies at global level. However, some threshold could be included in future steps, perhaps based on our heatwave indicator.

Forecasting Droughts (and Heatwaves) in Europe (C. Lavaysse)

- How to detect and forecast extreme events operationally? Observations + variables used + ECMWF forecasts.
- Forecasting droughts: first approach uses SPI-1 for droughts, Example: 2011. Second approach includes weather regimes. Example and comparison with SPI-1. Depending on the region, one or the other approach performs better. Statistical metrics, important are initial conditions. More extreme droughts are difficult to be predicted with SPI, good with weather regimes.
- Forecasting heat/cold waves: adapted Heat Wave Duration Index (HWDI) and Heat Wave Magnitude Index (HWMI). Example of drought and heatwave 2003 in

France, evolution of predictions, model is spatially good, temporally only up to 2-3 weeks, onset and intensity are more difficult duration and end to be forecasted correctly.

- Conclusions: drought forecasting with SPI-1 or weather regimes, heat waves can be predicted well 2 weeks in advance, cold waves 3 weeks in advance.
- Next steps: multi-model approach, seasonal forecasts (ECMWF), including impacts.

Drought Trends and Projections (J. Spinoni)

- Known past trends and future projections at European and global scale.
- Indicators, methods, drought quantities at European and global scale.
- Results: EU past trends and future projections, Global past trends. Description of data, approach, and tendencies.
- Analyses of global future projections with CORDEX data is ongoing (results expected in 2018).
- Next steps: mapping global drought, investigate the link between drought and desertification, analyse climate shifts until 2100.

Drought Risk Assessment (H. Carrao, G. Naumann, V. Blauhut, C. Cammalleri)

- Approaches to drought management: change from crisis management to risk management and preparedness.
- Drought risk is a function of hazard (probability of an event of certain severity), exposure (population and assets), and vulnerability (susceptibility to suffer impacts). Need for a multi-scale approach and normalization of data. Different drought types to be considered: agricultural, hydrological and socioeconomic.
- Different approaches: (1) Linking drought characteristics to number of reported impacts or to quantitative measures of impacts, (2) Conceptual approach to assess exposure and vulnerability and link them to hazard for estimating the risk, (3) Combined approach: linking impacts to hazard and vulnerability to obtain risk. Different approaches might need to be used for different scales and sectors.
- Conclusions and next steps: it is important to include updated and improved socio-economic data, improve the communicating of risk and the science-policy interface, drought management depends on national regulations, which might require specific risk assessments, impact data are needed for different sectors.

C: At EU scale quantitative impact data still missing. Tests linking reported national statistics on crop yield and hydropower generation through damage functions showed mixed results. At global scale the situation is even more complex. We therefore use a conceptual approach at global scale. Quality and resolution of socio-economic input data is the critical point at this scale.

Discussion on Way Forward (J. Vogt)

Status:

- Much information is already available (e.g. events, sectorial impacts), but scattered and often not easily accessible. It should be harmonized/standardized, brought together.
- Many monitoring and forecasting systems are available or in development (on different scales).
- A harmonized approach to the calculation of (core) indicators (e.g. algorithms, data quality, reference period) is important.
- Standardized and quantitative impact data are lacking at EU scale.
- Impact data collection and standardization is needed.
    - To calibrate monitoring systems
    - To evaluate damages and losses
- Information on hydrological drought has been implemented in EDO with the low-flow index.
- No European-wide groundwater-based info are yet included in EDO.
- Ongoing Activities: forecasting, trends, projections, risk assessment (depending on user/audience).
- Data sharing between organizations, countries is often difficult.

Key questions:

- Which information, indicators and tools should be provided at European level?
- Are there any indicators or tools missing in EDO?
- Which EDO tools are most useful?
- At which scale(s) should information be provided? Is a nested approach useful?
- Should information on trends, projections, and evolving risk be included?
- How to develop and implement (seasonal) forecasting?
- Any other proposed improvements and future developments?
- How to move from hazard to sectorial risk and impact assessment?
- Any specific needs for and expectations to a European system?
- How to extend the partner network (requires commitment from both sides)?
- Different networks exist (at different levels). How to connect them?
- How to best establish and maintain collaborations?
- What are the needs and expectations for networking, data sharing, etc.?
- How to ensure sustainability of the drought activities and networking?
- Do we need a European drought policy?

C: The nested approach is interesting. How to include predictability? What about uncertainty? Also groundwater should be considered, as well as low flow rates at small *scale. Other indicators, such as the Water Exploitation Index (WEI and WEI+), should be tested and compared to those already in use for assessing vulnerability. R: Low flow data for Europe are included in EDO. Groundwater data are not available at European scale and satellite estimations (e.g. GRACE data) are of low spatial resolution and need to be tested for their accuracy. In the WFD Water Scarcity and Drought Expert Group some countries did not agree on the Water Exploitation Index. This needs to be re-discussed.*

C: EDO is already good. But including WEI and information on water use and water consumption would be interesting, though for Greece this is difficult, surely for Europe even more. In Greece there is a huge debate on how to compute WEI and also there's no 100% transparency on how the water is used for environment/industries/private uses.

C: Using hydrological models is suggested as a solution, but don't forget that they use meteorological variables as input and all models have uncertainties. We must use skill scores when using models.

C: Agreement on the need to consider the uncertainties of hydrological models.

C: Data just on the river flow could be enough for many applications.

C: For many users it is difficult to correctly interpret the indicators and to extract information from indicator series and maps. We should support and train users in this. R: Uncertainty is really important. The users are flooded with information; reports should contain clear messages. On the other hand side, we also receive requests from specific user groups (e.g. industries) for tailor-made indicators. Including too many new indicators would, however, make the system too complex.

C: Vulnerability is studied by UNDP and other institutes which focus on the Mediterranean region, specifically studying El Niño and La Niña events, this could help EDO. At Global and EU level there are meteorological alarm platforms (e.g. MeteoAlarm), but drought is not represented there. We see many regional drought monitoring systems, but they are not linked towards a global picture. The GEO-GIDIS activity is working in that direction, trying to link continental drought observatories, including EDO, the North American Drought Monitor and information from Australia. Latin America, Africa, China and Russia are missing.

C: A nested approach is generally appreciated and GDIS is trying to implement that at global level. GDO is complementary in that it provides a global overview and can provide information on exposure, vulnerability and sectorial impacts to GDIS. We should be aware of the fact that systems at different scales (global, continental, national, and river basins) target different user groups and serve different purposes (e.g. awareness raising vs water management). Therefore not all information fits a global unique platform.

C: Vulnerability is a complex issue and we have to put emphasis on such analysis, also at EU level. We need to inform stakeholders from local to high level on the ongoing work and tools and ask for feedback and comments.

C: It is difficult to find impact data. Crowd sourcing could be one source of information, but quality checking is important and time intensive.

C: The ICPDR has a database of past data and indicators, nesting this information into EDO would be useful. We aim at high-resolution results for the entire Danube region as DMCSEE does for Slovenia and other areas.

C: Terminology is important. We must distinguish between information systems (awareness rising) and decisional support systems (management). Monitoring and forecasting systems at continental and global scales usually belong to the first group. R: JRC supports this differentiation, which was also discussed in the former Water Scarcity and Drought Expert Group under the water Framework Directive.

C: In the UNISDR framework drought is currently not covered. At policy level, the EC is reorganizing the civil protection mechanism, so it might be the occasion to foster the inclusion of drought. It is important to also address the vulnerability of ecosystems and *societies, especially as severity and frequency of drought events are likely increasing under climate change. Conflict is another important issue. Recent discussions underline drought as one of the causes for migration, civil unrest and conflicts.*

C: Whom to contact for linking our products in EDO? Having info at national level is important, but we also need information on what happens around us and at EU level. Can data for specific units (e.g. river basins, countries) be downloaded from EDO? Comparisons between regional and continental products are important and can give us visibility. R: Contact points and related documents should be placed more prominent on the EDO website. National boundaries and boundaries of river basins and river basin districts are included in EDO. Downloading data for such entities, however, is currently not foreseen, but can be discussed.

Q: Which data can be downloaded from EDO? R: All data in EDO can be downloaded; the technical implementation needs to be improved, if this is an interesting feature for stakeholders.

C: We would be interested in regular information on data availability and ongoing activities at EDO, ECMWF, DWD, etc. Where we can obtain such information? R: The Disaster Risk Management Knowledge Centre (DRMKC) may be the best place to follow-up on this (www.drmkc.jrc.ec.europa.eu).

C: We encourage having these types of meetings on a regular basis and sharing information and communicating about droughts and operational systems inside your own country. The indicators should be used for the development of strategies and policies. At the same time we need to strengthen the legal background (e.g. through the European civil protection mechanism) and push for decisions at policy level. Finally, we need to push for including drought in the MeteoAlarm system.

4 Conclusions

The first EDO User Meeting demonstrated the availability of a huge amount of drought-related expertise, data and information across the European continent. At the same time the meeting highlighted the scattered nature of much of the information, gaps in existing data, and the need for better coordination and information exchange. The high level of interest of various stakeholders in a system which can provide both a European overview as well as the possibility to access more detailed information through a nested approach, was apparent, and the necessary cooperation and networking to implement and maintain such a system was seen as an opportunity to foster the exchange of information and experiences across Europe, and to build a strong stakeholder community.

Important aspects discussed during the meeting included the need to monitor ALL components of the hydrological cycle (i.e. precipitation, evapotranspiration, soil moisture, river flow, reservoirs, and groundwater storage), as well as impacts in different economic sectors and the environment. This requires the analysis of in-situ measurements, model outputs, and Earth observation (EO) data, and of qualitative and quantitative impact information (i.e. damages and losses). Which type of data is mainly used depends on the scale of analysis and the availability and quality of the data. The communication of related uncertainties in the data, models and resulting maps, is considered a key aspect for ensuring the acceptance and uptake of such a system.

The EDO User Meeting also highlighted the wide range of different user communities, from local water managers, decision-makers at regional and national levels, and right up to policy-makers at national and European levels, and the general public. In this context the difference between awareness-raising and water management indicators was underlined, the latter becoming more important as the level of detail increases.

Improving our capabilities to forecast droughts was recognised as an important aspect for all stakeholders, since information on the occurrence of droughts, and their evolution and likely duration, is important for triggering management actions and mitigation measures. Long-term adaptation to droughts requires further studies on the likely evolution of drought characteristics (e.g. frequency, duration, intensity, severity) under a changing climate. Standardization of the calculation of (core) indicators (e.g. algorithms, reference period) was considered to be a further important aspect, in order to improve the quality of the available information and its comparability across scales.

The public availability of the information and data shown within the EDO system, was seen as an important aspect for furthering the understanding of the drought phenomenon, and the acceptance of EDO as a useful tool, as well as fostering the involvement of different stakeholder communities. The lack of standardized drought impact information was identified as an important gap in the available knowledge base. It was agreed that better impact information will improve our understanding of the links between these natural phenomena and society, and will be particularly useful for calibrating models and evaluating damages and losses resulting from droughts, which is considered as being essential for raising public awareness and for triggering policy action.

Finally, the EDO User Meeting concluded that building a strong network and organising regular meetings to exchange experiences and information are of fundamental importance in strengthening our resilience against droughts.

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List of acronyms

CDI	Combined Drought Indicator
CEE	Central and Eastern European Countries
CORDEX	COordinated Regional Downscaling EXperiment
CPC	Climate Prediction Center (NOAA)
DHI	Drought Hazard Indicator
DI	Drought Indicator
DMCSEE	Drought Management Centre for South-Eastern Europe
DRMKC	Disaster Risk Management Centre
DUS	Drought User Service
DWD	Deutscher Wetterdienst (German Weather Service)
ECMWF	European Centre for Medium-range Weather Forecast
EDO	European Drought Observatory
EDII	European Drought Impact report Inventory
EDR	European Drought Reference database
EMS	Emergency Management Service (Copernicus)
ERCC	Emergency Response Coordination Centre
EU	European Union
EUSDR	EU Strategy for the Danube Region
GCFS	German Climate Forecasting System
GEO	Group on Earth Observation
GDIS	Global Drought Information System
GDO	Global Drought Observatory
GDWSMP	Greek Drought and Water Scarcity Management Plan
GIS	Geographical Information System
GPCC	Global Precipitation Climatology Centre
GWP	Global Water Partnership
HIS	Hydrological Information System
HWDI	Heat Wave Duration Index
HWMI	Heat Wave Magnitude Index
ICPDR	International Commission for the Protection of the Danube River Basin
IDMP	Integrated Drought Management Programme
INSPIRE	Infrastructure for Spatial Information in Europe
ISPRA	Italian Istituto Superiore per la Ricerca e la Protezione Ambientale (Rome)
ISRBC	International Sava River Basin Commission
LDI	Likelihood of Drought Impact
LIO	Likelihood of Impact Occurrence

MARS	Monitoring Agricultural Resources
MPI-ESM	Max-Planck-Institute for Meteorology - Earth System Model
NAS	National Adaptation Strategies
NOAA	US National Oceanic and Atmospheric Administration
NUTS	Nomenclature des unités territoriales statistiques
OGC	Open Geospatial Consortium
OWS	OGC Web Service
PDSI	Palmer Drought Severity Index
RBMP	River Basin Management Plan
SCI	Standardized Combination Index
SEE	South-Eastern Europe
SPI	Standardized Precipitation Index
SPEI	Standardized Precipitation Evapotranspiration Index
STI	Standardized Temperature Index
SRI	Standardized Runoff Index
SWMI	Sustainable Water Management Initiative
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEI	Water Exploitation Index
WFD-CIS	Water Framework Directive – Common Implementation Strategy
WaterML	Water Markup Language
WMO	World Meteorological Organisation

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