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The Global Flood Partnership Conference 2016

Linking global flood information with local needs

Salamon P., Hirpa F., Andredakis I., de Groeve T., Brakenridge R., Coughlan de Perez, E., Rudari R., Wu H., Policelli F., Amarnath G., Trigg M., Green D.

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GFP
global flood partnership

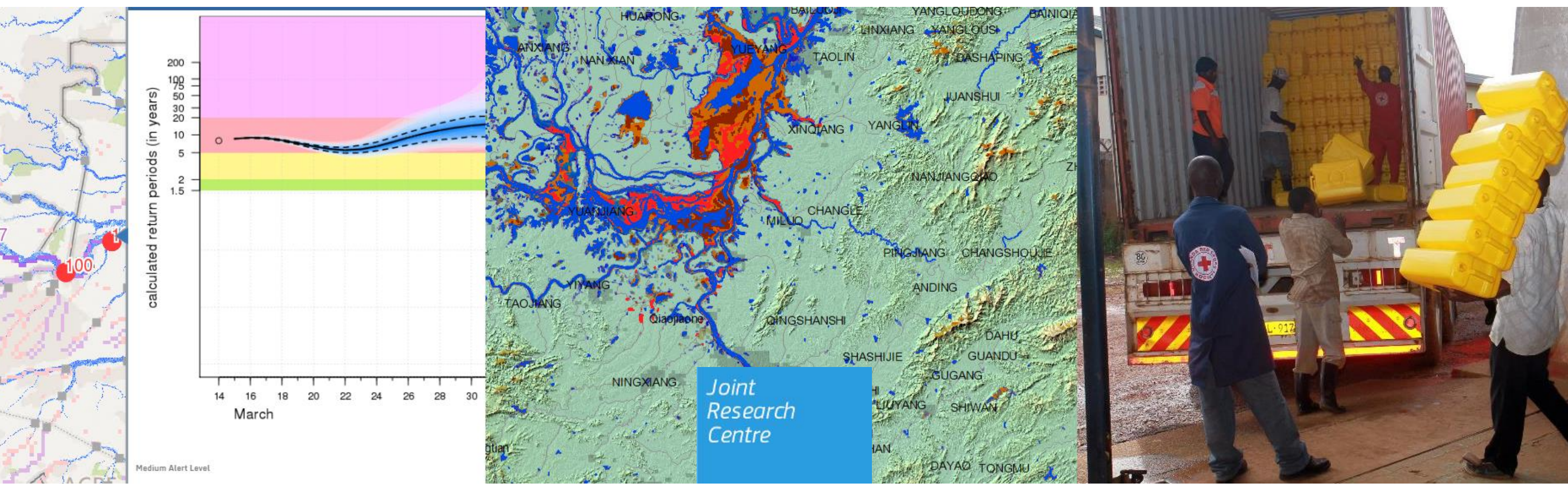

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Table of contents

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1 Introduction

From 29 June – 1 July 2016, the 2016 Global Flood Partnership Conference was held at the Joint Research Center of the European Commission in Ispra, Italy. Fifty participants attended the conference coming from 15 different countries in 5 continents. They represented 38 institutions including international organisations, the private sector, national authorities, universities, governmental research agencies and non-profit organisations.

The organising committee of the 2016 conference consisted of Robert Brakenridge (University of Colorado, Dartmouth Flood Observatory), Erin Coughlan de Perez (Red Cross/Red Crescent Climate Center), Ioannis Andredakis, Tom de Groeve, Feyera Hirpa and Peter Salamon (Joint Research Centre of the European Commission). Logistic and organisational support was provided by the Joint Research Center.

1.1 Objectives of the conference

Each year, floods cause devastating losses and damage across the world. Growing populations in ill-planned flood-prone coastal and riverine areas are increasingly exposed to more extreme rainfall events. With more population and economic assets at risk, governments, banks, international development and relief agencies, and private firms are investing in flood reduction measures. However, in many countries, the flood risk is not managed optimally because of a lack of scientific data and methods or a communication gap between science and risk managers.

The Global Flood Partnership is a multi-disciplinary group of scientists, operational agencies and flood risk managers focused on developing efficient and effective global flood tools that can address these challenges. Its aim is to establish a partnership for global flood forecasting, monitoring and impact assessment to strengthen preparedness and response and to reduce disaster losses. It is building an operational global flood observational and risk modelling infrastructure: for better predicting, monitoring and measuring large flood events and their impacts, worldwide.

The objective of the 2016 conference was to review the advances and success stories of the Partnership, to assess the challenges and opportunities ahead, and to discuss steps needed to address user needs effectively.

The first day focused on the Partnership's achievements and the activities of its included different pillars. The second day focused on discussing research advances, and the third on plans for the coming years. The conference was organized in an interactive way to accommodate discussions and interaction through presentations, posters, workshops, market places, ignite talks, and doctor-patient sessions.

2 Conference proceedings

2.1 Opening session

Tom De Groeve, acting Head of the Joint Research Centre (JRC) Disaster Risk Management Unit, opened the GFP 2016 conference by warmly welcoming the participants to the JRC. He presented briefly the history of the GFP, starting with its first meeting in 2011 hosted also by JRC, and subsequent meetings at Deltares (2012), the University of Maryland Earth System Science Interdisciplinary Center (ESSIC, 2013), the European Center for Medium Range Weather Forecasting (ECMWF, 2014) - where the GFP was formally established - and the U.S. National Center for Atmospheric Research (NCAR, 2015). He highlighted the main objective of the partnership ("partnering for global flood forecasting, monitoring and impact assessment to reduce flood risk and strengthen preparedness for response") and presented some of the more recent advances with regards to global tools for flood monitoring and forecasting. Besides the recently adopted global political frameworks such as the Sendai Framework for Disaster Risk Reduction, the 2015 United Nations Climate Change Conference (COP21) and the Sustainable Development Goals, which all recognize the need to reduce the impact of natural disasters and specifically floods, Tom De Groeve illustrated how the GFP links to other related activities. Such activities include the UNISDR Global Assessment Report and Loss Data collection, the WMO MHEWS initiative, CEOS Disaster IWG-SEM, Copernicus Emergency Management Service, the Disaster Risk Knowledge Management Center and the Global Disaster Alert and Coordination System (GDACS) for example.

Finally, he presented a series of science and technology questions as well as questions regarding the partnership to be examined during the conference and that will help to shape the future of the GFP.

In addition, Robert Brakenridge, Director of the Dartmouth Flood Observatory and co-founder of the GFP, highlighted the need of a strong network such as the GFP and underlined that the GFP should ensure links and synergies to other relevant activities but that it should make a unique contribution by providing inter-operable data products and services at the global scale that can be used also at the local level.

2.2 Ignite Talks: Global Flood Partnership in action

A total of seven ignite talks were presented to demonstrate achievements of the Global Flood Partnership in action or potential new topics.

Global Flood Forecasts: Triggering action in Uganda (Flavio Monjave, Red Cross/Red Crescent Climate Center)

Forecast-based financing (FbF) aims at mainstreaming of early warning information to trigger early humanitarian action. An example of FbF for Uganda where GloFAS was successfully used to trigger pre-flood humanitarian action illustrated the concept and the on-going work.

An intercomparison of 6 flood hazard maps (Mark Trigg, U. Leeds)

In order to undertake the recent GFP model intercomparison project, many model groups have freely shared their model output. It has led to a new understanding of how well the models agree and also how they could be improved. It has also resulted in a new anonymous aggregated dataset for Africa that will be shared freely and could be used for many purposes by GFP partners and others.

GloFAS-IS 2.0: New ways of exploring global flood forecasting data (Milan Kalas, Valerio Lorini and Davide Muraro, JRC)

GloFAS-IS 2.0 aims at improving user experience by delivering efficient web services that supports smooth data visualization, interactive interface and on demand processing. These can be achieved through advanced technologies such as storing data for optimizing data fetching, back/front end integration, distributed task scheduler, and effortless scalability with docker.

Forecast-based Integrated Flood Detection System for Emergency Response and Disaster Risk Reduction (FloodFINDER) (Roberto Rudari, CIMA)

UNITAR-UNOSAT has developed together with USGS and CIMA Foundation a prototype Global Flood EWS called "Flood-FINDER". The Flood-FINDER system is a modelling chain, which includes meteorological, hydrological and hydraulic models that are accurately linked to enable the production of warnings and forecast inundation scenarios up to three weeks in advance. The system is forced with global satellite derived precipitation products and numerical weather prediction outputs. The modelling chain is based on the "Continuum" hydrological model and risk assessments produced for GAR2015. In combination with existing hydraulically reconditioned SRTM data and 1D hydraulic models, flood scenarios are derived at multiple scales and resolutions. Climate and flood data are shared through a Web GIS integrated platform.

Flood risk assessment in Europe at 4ºC global warming (Lorenzo Alfieri, JRC)

Ensemble projections of river stream flow based on seven EURO-CORDEX RCP 8.5 scenarios are combined with recent advances in European flood hazard and risk mapping to assess changes in flood risk in Europe for the current century. A number of novelties are presented that address issues pointed out in previous flood risk assessments at continental scale: 1) flood hazard maps are derived by a 2D hydraulic model rather than through simplified approaches; 2) the frequency of extreme peak discharges is assessed through a peak over threshold approach; 3) a new methodology is proposed to bias correct the impact of climate projections, which does not modify the atmospheric variables nor the energy balance; 4) the risk assessment is based on high resolution (100 m) estimates of flood hazard, exposure and on updated flood vulnerability information.

Under a 4°C global warming scenario and by the end of the century flood risk in Europe is projected to increase by an average 220%. When coherent socio-economic development pathways are included, central estimates of population annually affected by floods range between 500,000 and 640,000 in 2050, and between 540,000 and 950,000 in 2080, as compared to 216,000 in the current climate. A larger range is foreseen in the annual flood damage, currently of 5.3 B€, which is projected to rise to 20 - 40 B€ in 2050 and 30 - 100 B€ in 2080, depending on the future economic growth.

El Nino as a Predictor of Flooding (Rebecca Emerton, U. Reading)

The use of El Nino as a predictor of flooding at the global scale, and its use for early humanitarian action in regions such as Peru, was presented. ERA-20CM-R (110 years, 1901-2010 which included 30 El Niño years) was used as input to the GloFAS hydrological modelling framework to estimate the probability of flow above a given threshold. It was concluded that El Niño can be used as an early indicator of increased flood hazard, but there are also other considerations when using such information for decision-making.

Usefulness and limitations of global flood risk models (Philip Ward, IVM U. Amsterdam)

Global flood risk models were developed to identify risk hotspots in a world with increasing flood occurrence. In this presentation we assess the ability and limitations of the current models and suggest what is needed to move forward.

2.3 Keynote

David Green (Manager for Disasters Focus Area at NASA Applied Sciences Program) delivered a keynote on the role of NASA in disaster response.He raised several discussion questions with regards to the GFP's focus and NASA's potential role in achieving GFP's goal. These include: what is the GFP trying to achieve? What has the GFP done collectively (by combining the individual projects)? What is the focus of the GFP? What outcomes can the GFP deliver? How can NASA engage with the GFP? Can the GFP tools contribute to open-access data?

He concluded his remark with the following points: i) Hazards need to be translated to impacts. Forecasting is not enough, as emergency managers want to know the RISK! ii) GFP may need a formal governance structure for decision making; and iii) NASA is on board with disaster support, and wants to work with GFP.

2.4 Marketplaces (also known as pillar booths)

There were seven market places where the presenter(s)

This year conference also included Marketplace sessions, where the participants were split into seven discussion groups (booths) with a host (or multiple hosts) leading the discussions and answering questions from the participants. The discussions at each booth lasted for a maximum of 10 minutes after which the participants rotated from one booth to the other, exchanging experiences and ideas.

The booths were arranged under 3 GFP pillars as follows:

Global Flood Record

- Integration of existing Global Flood Records services: what are the challenges and ways forward? Roberto Rudari, CIMA Research Foundation
- Flood magnitude vs impact: Bo Holst, Swedish Meteorological and Hydrological Institute, SMHI

Global Flood Service and Toolbox

- Global Flood Impact Predictability: David Lavers, ECMWF and Daniel Twigt, Deltares & Wageningen University & Research
- Current status of flood model development: what are recent achievements, remaining limitations, and requirement from users? Dai Yamazaki, JAMSTEC - Japan Agency for Marine-Earth Science and Technology
- Global Flood Awareness System: Feyera Hirpa, JRC

User Forum

- Disaster Risk Financing: Giriraj Amarnath, International Water Management Institute
- Forecast-based Financing: Erin Coughlan de Perez Red Cross Red Crescent Climate Centre

2.5 Workshops

What Defines A "Flood Event" (Led by Robert Brakenridge & Roberto Rudari)

The thresholds and criteria for flood disaster response and flood event definition differ among different responders. Depending on their timing, relatively small hydrologic floods may trigger major disruptions to food supplies; major extreme floods in remote areas are of less concern to many disaster response agencies. Insurance companies and Earth Observation facilities such as the International Charter for Space and Major Disasters and ESA's Copernicus, also, have various activation criteria determining whether a response is warranted, or not. This workshop brought together a diverse collection of data providers and end-users to determine if there are certain in-common criteria capable of defining a "major damaging flood event".

Workshop outcomes and discussion points

The audience agreed that defining an event is not trivial and different datasets might have different needs and therefore use different definitions of Flood event. However, a strong starting point to is to set a COMMON NUMBER describing an event so that different sources of information can be linked. GFP strongly takes on board this challenge through the GFO. For now, the proposal is to use an EVENT ID that is given by the GFO operator. The Event ID is a serial number that serves as a unique identifier, in addition now it is possible to indicate GLIDE, Copernicus EMS activation number, DFO serial number. The GFO serial number should be always mandatory while the others would be optional to facilitate searches within relevant data bases.

The GFO web application was presented. Now a rough polygon identifying the area affected by flood can be inserted and saved from the web portal. Such polygons should be also serviced through an API. The portal allows also the characterization of the event in terms of the severity index 1, 1.5, 2 based on the DFO methodology. Although severity can be defined also in terms of return periods/quantiles, this is a difficult task especially for large scale floods and the problem increases in complexity when compound effects are considered (e.g. in case of coastal flooding events with multiple causing).

There is a need to capture at least major events to create confidence in the system. In order to do that it would be proper to set a threshold above which an event is considered/recorded.

How to define a flood and how to set a threshold is not a trivial problem and was extensively discussed in the workshop.

There are different ways to identify/define a flood:

- from new media or government reports
- from geophysical observations
- from the humanitarian perspective (aid needed, in-country capacity exceeded)
- from the socio-economic perspective (e.g. damage and losses)

All of the above point to different needs.

The intensity of a flood is however a relative concept and the flood maps/events could be redefined on the basis of big departures from frequently observed values.

Flood maps are produced from models of observed from EO but in many cases surface flooding is not taken into account.

The use of GLOFAS as an added value for GFO was also discussed and its use to direct the observational data collection into certain target areas was perceived as a strong advantage.

The criteria of defining thresholds to include an event in the data base was felt as a priority as recording everything is not good for the database consistency: the higher the threshold, the more reliable the data base may be. And even though is clear that the parameters to be considered and the threshold to be used depend on the end users, it was proposed to try nevertheless to establish easy and commonly accepted criteria.

Since from the experience acquired in GDACS it is almost impossible to set objective thresholds to define a flood that needs to be entered in the GFO/GFR database, a discussion on possible guidelines has been undertaken. The following list summarizes the ideas from the workshop participants:

1. Use affected people as a reference metric.

2. Use a matrix that combines intensity and impact (e.g. as they do at the UK Met Office).

3. Along the lines of above, return period is a good parameter to be used with an impact-related parameter.

4. Again along the same lines, the use of just one parameter was not considered proper, but instead best to use a combination of parameters.

5. Define the flood in terms of action needed (e.g. response). If there is no action triggered by observing that or no use of the monitoring data, no need to record that event

6. Use Glide Numbers directly. However, the GLIDE listing is clearly not complete; relying only on it means not ourselves determining what to accept as an event.

Additional comments were made on the possible uses of the data base to improve the forecast model capabilities: to allow skill verification in reforecast mode. In order to do that we need to include the forecast information in the event as it is entered.

Integration of Remote Sensing-based Flood Information for Enhanced Flood Mapping (led by Huan Wu and Fritz Policelli – discussion notes by Giriraj Amarnath)

Remote sensing, *in-situ* observation and numerical modelling using remote sensed and in-situ observed information are the major sources for providing timely information of hazardous flood events, e.g., stream flow and inundation. Both remote sensing and model technologies advance rapidly nowadays while each has its own strengths and weaknesses. The limitations in current flood mapping products raise the challenges in the integration of these complementary sources of flood information. The discussion among the participants including flood mapping producers and data users was focused on questions such as (1) how can we compare and integrate multisource flood information? (2) How can we integrate multisource information to determine flood events and how good are these datasets? (3) How do we compare the models? (4) How do we validate/optimize remote sensed based flood algorithms? (5) What are the challenges in model integration?

In order to enhance flood mapping for humanitarian and government agencies in their efforts to prepare, mitigate, and manage responses to disaster to save lives and limit damage, the comparison of different products was agreed to be the first important step.

The inter-comparison and evaluation of the multiple products in different geographic regions and the usability of the model results are relevant to GFP's objectives. There is no best model at global scale. The comparisons are needed to understand the disagreements as well as in-common results. Regarding the comparison, good ideas and suggestions were made by participants during the discussion, such as:

- Compare products at the same resolution
- Store all flood data both models and remote sensing data in one portal (also for wider dissemination)
- Integrate reservoir information
- Input data quality and individual components of the existing models need to be checked carefully, as differences among the GFP flood products exist in a wide range of aspects, e.g., model physics, inputs rainfall-runoff forcing, topography, channel geometry, human intervention.
- High resolution DEM and flood data (e.g. Sentinel-1 10m) is desirable and very helpful
- Event-based comparisons and integration experiments with group efforts will be an efficient way to make progress.

The GFP could establish a research group or an evaluation committee to implement the above activities. Some other points were also raised on the integration of flood products. Integration can be performed for both retrospective archive and real-time responses (e.g. GloFAS, GFMS) for tasking radar/satellites by using model information. A good flood database of historical data will be valuable to have for impact assessments. User oriented products integrated with geospatial information (e.g. areas disconnected from roads due to floods, quick flood loss estimates in 48hrs after flood disasters), will be helpful for aid agencies. Ensemble hydrological models are considered very useful.

A framework for model testing and validation (led by Mark Trigg)

Workshop abstract: The GFP global flood model inter-comparison project highlights an urgent need for better model testing and validation. In addition, as these models gain acceptance we have a duty to ensure they are fit for use. Flood hazard is a very location-specific phenomenon, with climate, topography, geomorphology and anthropogenic factors all playing a part in the manifestation of excess water in a particular flood. Thus, validation of a model in one location and climate does not demonstrate that the model will be equally valid elsewhere. There are efforts underway to collate flood observations globally (e.g. DFO), but these rely on remote sensing datasets from a relatively short period and therefore are hard to quantify in terms of return period and use for probability validation directly. In addition, on-the-ground data to validate the remote sensing and the models is lacking for much of the globe, further challenging our ability to undertake this task. Finally, the scale of the validation means that many of the methods developed for local catchment level validation (which rely on good monitoring networks) may not be applicable to these new models. Due to the scale of the validation challenge, this exercise needs to be undertaken in a coordinated and comprehensive manner so that maximum advantage can be gained for all parties in the efforts. If we have a clear strategy going forward and well defined synergies between the GFP partners, we will also position ourselves more strongly in applying for future research support. The aim of this workshop was to begin to define this strategy and identify research funding and sponsors that could support the efforts.

The workshop was organised into four sessions.

(1) Brief summary of the GFP model intercomparison project by Mark Trigg, who has been conducting the comparison on behalf of the partnership, with contributions from six of the GFP modelling groups. The study compared multi-probability flood hazard maps for Africa from six global models and shows wide variation in their flood hazard, economic loss and exposed population estimates, which has serious implications for model credibility. While there is around 30-40% agreement in flood extent, the results show that even at continental scales, there are significant differences in hazard magnitude and spatial pattern between models, notably in deltas, arid/semi-arid zones and wetlands. The study is an important step towards a better understanding of modelling global flood hazard, which is urgently required for both current risk and climate change projections. The study is due to be published in Environmental Research Letters: "The credibility challenge for global fluvial flood risk analysis". The remaining sections of the workshop focused on trying to identify what should be the next step in comparing, testing and validating global flood models.

A discussion on access followed the presentation. Are the models open source/are results open? Response from Mark Trigg: The paper will be open access and the aggregated dataset used in the comparison will be made available with the paper for anyone to download and compare their own models or undertake their own tests. Many of the models included in the comparison are available open access and have their data access websites.

(2) Sticky note session. All participants were asked to contribute one or more sticky notes on "what elements/components/outputs of global flood models needed testing and why, as well as what would enhance the credibility of models". Responses were grouped into the following five areas;

Usability/access; How to access the model outputs and visualize their meaning easily? How reliable/accurate is a particular model and how does it compare to others? Is it helpful, visual and can be understood in 10 seconds? Why can I trust it and how well do you know the certainty/uncertainty?

Region/scale of application; Regional consistency and appropriate scale of application? How does the model perform in my watershed/region/gauging station? How does it compare to historical flooding at users point of interest? Focus on testing where it matters.

Validation/testing; Models versus historical data and field observations. Validate the validation by using a variety of different methods and approaches. Ensure we are getting the right results for the right reasons. Validate against independent data sources. GFP can define/agree on common methods linked to scale and type of application. Historical databases are needed and at different spatial aggregation levels.

Flood warning/forecasting; where is the water and where is it going? Need to test predicted stage, flow, inundation extent. What users need versus what is possible. Added value to what already exists? Quantify Hits, Misses and False Alarm Ratio (FAR) etc.. Identify longest forecast horizon of usefulness.

Model components; Compare subcomponents of the models such as discharge, flooded area, water levels/depths, precipitation input. Examine what processes are included/excluded, e.g. snow melt, flood defences, human activities that affect discharge.

(3) Discussion session on "What data/ideas/methods can we use for model testing?"

- Good to have an overall idea of performance around globe, but may be useful to identify different classes of areas, e.g. how well do the models perform in urban areas? In agricultural areas? Land cover types? Already looking at agreement in climate zones.
- Is it just a comparison, or is also an ensemble? And could that then be a weighted ensemble?
- This exercise is a GFP highlight – shows that we actually have added value. Future outcome/next step could be probabilistic / multi-model hazard map. Could help to quantify risk, and also gives added value as few national authorities have probabilistic risk maps.
- Is there a systematic difference between models? There are some obviously differences, but the aim is not to say what is best model, but what we can learn from them. Maybe a metric could be used to look how much of observed floods is captured by each model.
- An absolute must is to start comparisons to observed data…this will be facilitated by making data available.
- Running models with same forcing would allow better understanding of where the differences are coming from – separate the different uncertainties
- CIMA model can ingest climate data to make a flood frequency analysis based on the same climate forcing data
- Stream flows: NASA use N&S, bias, etc., until there is good data on water extent
- Why do some models have higher GDP exposure for lower flood extents? Related to the cells that are flooded, and shows the importance of looking at specific regions
- The Africa application is in a region with little data. A next useful step may be to do another case study region where there are more data.
- ECMWF provided an ensemble output from 1 climate model – the uncertainty around that did not even come close to the next nearest model. An ensemble approach may be a good next step – but needs to be broader than just a climate ensemble
- Comparison to truth information is needed to add credibility – e.g. which model performs best in a particular region – it is important to note that nothing is "truth", even gauge data.
- A lot of users are okay with difference between models and their "truth", but they want consistency from the models. An incomplete understanding is ok, but what is not okay is when datasets don't match up over space.

- To assess this, you could maybe look at "jumpiness" (discontinuities) between countries.
- Other potential datasets: soil moisture, mass change from GRACE, precipitation radar or space based radar to check precipitation input (order of magnitude)
- A perfect representation of the "100 year flood" will never exist. Therefore maybe concentrate on what we already have and how we can use it. Perhaps on an automatic framework that would allow to generate model agreement maps (etc.) when they update their simulations. Also so that others can upload their own map, e.g. a national level map with very high quality data. This could be something in which GFP could actually provide added value. This would allow users to be able to evaluate the data themselves and see where models agree. This tool could also contain something in which users can add a "quality statement".
- Roberto: already useful, it highlights the very large uncertainty. The question it raises is, what does the uncertainty mean for applications?
- The current maps already show areas/regions that need effort for improvement (e.g. deltas).
- Comparison difficult due to non-existence of flood protection in models. But can be used to show importance of the flood protection, and how it reduces hazard
- From a user's point of view, the kind of maps shown (agreement map between models) is an indication of the level of confidence. Coming up with one metric is rather difficult, but a set of parameters may offer more information that is useful to different users. Including the regional classification mentioned earlier. Metadata is required.
- Flood hazard community could provide guidance to other kinds of hazard.

(4) Discussion session on "Who is interested in involvement in the next stage of model testing and how to resource it and take it forward."

- Perhaps useful to come in as a consortium, instead of individual model owners, when tendering for projects. A "partnership strategy" as a means of practice.
- Useful to include commercial models from user perspective.
- Useful to get confidence level.
- How reliable are extents, e.g. is it likely that I am over/underestimating extents, or more or less correct?
- For users, the comparison framework described earlier would be useful for checking quality of licensed products.
- There are some intercomparison models going on (of cat models?) for other natural hazards. It would be interesting to discuss the comparison of aggregated information from reinsurance models.
- Bob: 25-year floodplain is quite easy to test against remote sensing data. Mark believes that it is difficult to agree on what is a 25-year event.
- Report in US comparing different atmospheric models. Now looking to do a crowdsourcing activity. Could we do a kind of "user analysis"?
- If we could get a very good DEM, with a flood fill, and include dams, and then simulate the top-500 floods, that would be very useful.
- Nice opportunity in H2020 in merging satellite data with community data (?). Perhaps could be used to develop a consistent satellite based map – could be a useful opportunity
- For a H2020 proposal, it could be framed to show the usefulness of all the money that has been spent on the satellites.
- Idea to develop a "one-pager" on a project idea, so that it is ready when a chance arises.

Forecast-based Financing Led by Erin Coughlan de Perez

This workshop focused on the use of forecasts by humanitarian agencies in the context of Forecast-based Financing (FbF). FbF programmes develop Standard Operating Procedures that trigger automatic action and funding when pre-defined forecast triggers are exceeded. The goal is to systematically act before extreme events happen, reducing humanitarian impacts.

At the beginning of the session, the RCCC team led a new interactive exercise, which allowed the participants, largely physical science researchers, to see what is like to be a decision maker in the context of FbF. The groups of 4-5 were tasked with 'acting out' FBF, from development of danger levels at the National Level Met Services to taking action. Groups were asked to model the chain from forecast through intermediaries to action, and reflect on how this would be different in different contexts of lead-time and hazard.

Given these specific examples of potential use of such forecasts, participants were tasked with identifying available forecasts for specific lead-times and hazards. The discussion focused on the availability of local hydrological forecasts, as well as the limitations to the usefulness of existing seasonal forecasts, which give little to no hydrological information. Further, leveraging the knowledge of the participants relative to climate and weather data, these products and ideas were pasted onto a world map, and will be used as a basis for the development of a practitioner resource in the future.

2.6 Presentations

2.6.1 Oral presentations

There were a total of 14 oral presentations on diverse topics related to global-scale flood modelling, forecasting, detection and risk assessments. The titles and abstracts of the talks along with the names and affiliations of the presenters are as follows.

Spatial-temporal characteristics of vulnerability of flood at the global scale (Yukiko Hirabayashi, The University of Tokyo) Flooding is one of the main natural hazards that cause adverse effect to humanity. As projecting climate change and socioeconomic growth would increase damage of flooding, understanding of the historical spatial-temporal patterns of risk drivers (exposure, damage, and flood protection level) is an important to conduct effective adaptation measure against the change. This study tried to investigate historical change in flood vulnerability at global scale by comparing modelled flood exposure and disaster statistics at country level. Following similar study by Jongmann et al. (2015), mortality rate (percentage of fatalities in modelled exposed population) and loss rate (percentage of losses in modelled exposed GDP) to fluvial river flooding across the world were calculated using a state-of-the-art river and inundation model, CaMa-Flood, and flood damage statistics taken from the International Emergency Disasters Database (EM-DAT). Obtained mortality rate globally reduced from 1990 to 2005 at all income level between 1960 and 2014, which may reflect the improvement in flood protection level in the past. Loss rate in the past also showed negative trend mainly after the 1990s, while that in the former period showed both positive and negative change, depending on the improvement of flood protection level and increase of exposed asset associated with economic growth. Evaluation of the spatial displacement of population within country revealed that mortality rate is increased at several countries such as in Congo, Burkina Faso and Botswana, where increase in population is high in flood affected areas.

Daily Prediction of Flood Inundation From Microwave Remote Sensing (Robert Brakenridge and Albert Kettner, Dartmouth Flood Observatory University of Colorado) Near real-time mapping of flood disasters is severely constrained by the inability of optical satellite sensors to image the ground through cloud cover. Emergency responders require information as to where flooding has cut-off communities, broken road connections, or affected critical facilities, but a common scenario is that they must wait for a combination of available satellite orbit over-flights and clear sky conditions: days to weeks delay may occur. The new generation of synthetic aperture radar satellites (e.g., ESA's Sentinel 1) image through cloud cover, but again there may still be significant delay while the satellite is re-tasked to acquire the area affected (if such can be accomplished at all). Meanwhile, freely available passive microwave radiometry images the Earth's surface daily, without strong hindrance by cloud cover (sensors aboard GCOM-w and GPM). The pixel dimensions (~ 10 km) are far too large to allow detailed flood mapping, but they do allow accurate estimation of percent in-pixel water coverage and thus flood detection and magnitude characterization. The Flood Observatory has linked these incoming, daily, microwave data to libraries of previously imaged and mapped flood extent. When a numeric flood threshold is reached by the microwave data (for example, the 5-year recurrence interval flood), the end user can access detailed maps showing what land areas should now be under water at that location. Published formats include online, mobile device-friendly maps, and geotif and Google Earth kmz files for importing into other mapping systems. Finally, this approach can also make use of predictive flood modelling. Thus, with the model input that the 5-year threshold will be exceeded some days hence, the look-up libraries allow prediction of what land areas will be under water. Validation of such predictions then occurs, once detailed satellite imaging of the current event is obtained.

Sharing experiences from the winter 2015-16 flooding. (Crystal Moore, Flood Forecasting Centre - Environment Agency, Met Office). The Flood Forecasting Centre (FFC) is a partnership between the UK Met Office and the Environment Agency, established in 2009, to provide an overview of flood risk across England and Wales. Based at the Met Office in Exeter, the FFC provides flood-warning services covering England and Wales, primarily for the emergency response community. Severe flooding affected northern England in early December; and again through the Christmas period. Our experience and recommendations following severe floods of winter 2015-16 will be shared.

GFMS on the recent flood events in southern United States (Huan Wu University of Maryland) Severe flood occurred in southern states of USA in early/mid-March, 2016 caused significant damage. This work investigated the performance of the real-time GFMS on this event in stream flow and inundation mapping by comparing the model results with in-situ observations and satellite inundation mapping etc., with particular interests in interpretation and understanding of the difference in the results derived by hydrologic/hydraulic model and remote sensing approaches. Such understanding is important for integration of the two complementary approaches to maximize the flood information of on-going events for hazard mitigation activities.

Building a multi-model flood prediction system with the TIGGE archive. (Ervin Zsoter ECMWF) This study presents a multi-model approach to building a global flood prediction system using multiple atmospheric reanalysis datasets for river initial conditions and multiple TIGGE ensemble forcing inputs, to the ECMWF land-surface model. A sensitivity study is carried out to clarify the effect of using archive ensemble meteorological predictions and uncoupled land-surface models. The probabilistic discharge forecasts derived from the different atmospheric models are compared with those from the multi-model combination. The potential for further improving forecast skill by bias correction and Bayesian Model Averaging is examined.

Multi-model global flood forecasting (Daniel Twigt, Deltares & Wageningen University & Research) Flood (and storm surge) forecasting at the continental and global scale has only become possible in recent years (Emmerton et al., 2016; Verlaan et al., 2015) due to the availability of meteorological forecast, global scale precipitation products and global scale hydrologic and hydrodynamic models. Deltares has setup GLOFFIS a research-oriented multi model operational flood forecasting system based on Delft-FEWS in an open experimental ICT facility called Id-Lab. In GLOFFIS both the W3RA and PCRGLOB-WB model are run in ensemble mode using GEFS and ECMWF-EPS (latency 2 days). GLOFFIS will be used for experiments into predictability of floods (and droughts) and their dependency on initial state estimation, meteorological forcing and the hydrologic model used. Here we present initial results of verification of the ensemble flood forecasts derived with the GLOFFIS system.

The NASA Global Flood Mapping System (Fritz Policelli NASA) The NASA Global Flood Mapping System has provided near real time surface water extent and flood maps for most of the Earth's land surface since 2011. The system uses data from the MODES instruments on the NASA AQUA and Terra satellites, which each provide near global coverage each day. Recent work has focused on product evaluation, mitigating false positives due to misidentification of cloud and terrain shadows as water, and a new web portal to improve ease of data access and use. Additional work is focused on bringing new products into the system, including near real time surface water extent maps derived from NASA/USGS Landsat data.

Enhancing the benefits of remote sensing data and flood hazard model in development of index based insurance product (Giriraj Amarnath, International Water Management Institute) Index-based flood insurance (IBFI) is an innovative approach to developing effective pay-out schemes for low-income, fl-ood-prone communities. This project aims to integrate hi-tech modelling and satellite imagery with other data to predetermine fl-ood thresholds, which could trigger speedy compensation payouts. Effective end-to-end solutions will be developed in collaboration with a range of organizations and experts from central and state government bodies, private insurance firms, community-based organizations (CBOs) and nongovernmental organizations (NGOs).

Funes: A model-less model. (Herman Dolder Aquaveo LLC) "Funes" is a method to estimate the value of a dependent variable using historical records that connect that dependent variable with a set of independent variables. Its main asset is its simplicity, which usually translates into low implementation and operation costs. Provided with good data and forecasts, Funes' predictions can be quite good. This makes Funes a very good Cost/Benefit ratio alternative, especially for developing countries.

Global Flood Prediction Activities at The University of Oklahoma (Zac Flamig CIMMS/NSSL). The Hydrometeorology and Remote Sensing Laboratory at the University of Oklahoma has been working on a global flood prediction system utilizing satellite and model precipitation forcing. This talk will detail the hydrologic modelling framework, EF5, and how we derived apriori parameter estimates for the globe. A brief evaluation will be shown highlighting differences between satellite based precipitation estimates and GFS model analyses. We will also showcase our work with capacity building using EF5, particularly in Africa. A second portion of this talk will focus on our method for predicting environments suitable for flash floods and floods using NWP model output. A random forest algorithm was trained over flood reports in the U.S. and then applied globally. Real time output is currently available on http://weather.capital.

Global sea levels reanalysis dataset and its application for coastal flood risk assessment (Philip Ward IVM - Vrije Universiteit Amsterdam) Extreme sea levels, caused by storm surges and high tides, can have devastating societal impacts. The global coastal population is faced with an increasing trend in flood risk, induced by socio-economic development and climate change. Without action, the increasing trends in flood hazard and exposure will be associated with catastrophic flood losses in the future. The adequate allocation of global investments in adaptation requires an accurate understanding of the current and future coastal flood risk on a global-scale.

Here we present the first global reanalysis of storm surges and extreme sea levels (GTSR dataset) based on dynamical modelling. GTSR covers the entire world's coastline and consists of time series of tides and surges and estimates of extreme values for various return periods. The dataset is based on two different hydrodynamic models: FES2012 for modelling tides, and GSTM for modelling storm surges. GTSM is forced by meteorological fields from ERA-Interim to simulate storm surges for the period 1979-2014. Validation showed that there is very good agreement between modelled and observed sea levels. Only in regions prone to tropical cyclones, extreme sea levels are severely underestimated due to the limited resolution of the meteorological forcing. This will be resolved for future updates of GTSR.

As a first application of GSTR, we estimate that 99 million people are exposed to a 1 in 100 year flood. This is almost 40% lower than estimates based the DIVA dataset, another global dataset of extreme sea level. We foresee other applications in assessing impacts of climate change and risk management, such as assessing changes in storminess, estimating the impacts of sea level, and providing warning levels to operational models.

Predictability of variables relevant for extreme hydrological events in the mid-latitudes (David Lavers, ECMWF) A large proportion of extreme hydrological events in the mid-latitudes are associated with high water vapour transport in extra tropical cyclones, in a region now known as an atmospheric river. To provide awareness of these types of events, precipitation forecasts are commonly used. Here a predictability assessment of the precipitation and water vapour transport forecasts will be shown over Europe and the western United States to determine which variable may provide the earliest warning. The interannual variability of the predictability will also be considered.

Extreme Weather in Future Decades (Alan Gadian, NCAS, University of Leeds) WISER (Weather Climate Change Impact Study at Extreme Resolution) is a project designed to analyse changes in extreme weather events in a future climate, using a weather model (WRF) which is able to resolve small scale processes. Use of a weather model is specifically designed to look at convection, which is of a scale, which cannot be resolved by climate models. The regional meso-scale precipitation events, which are critical in understanding climate change impacts will be analysed. A channel domain outer model, with a resolution of ~ 20km in the outer domain drives an inner domain of ~ 3 km resolution. Results from 1989-1995 and 2020-2025 and 2030-2035 will be presented to show the effects of extreme convective events over Western Europe. This presentation will provide details of the project. It will present data from the 1989-1995 ERA-interim and CCSM driven simulations, with analysis of the future years as defined above. The representation of pdfs of extreme precipitation, Outgoing Longwave Radiation and wind speeds, with preliminary comparison with observations will be discussed. It is also planned to use the output to drive the EFAS (European Flood model) to examine the predicted changes in quantity and frequency of severe and hazardous convective rainfall events and leading to the frequency of flash flooding due to heavy convective precipitation.

MSWEP: a high-resolution global precipitation dataset by blending gauge, satellite, and reanalysis data. (Hylke Beck, Joint Research Centre) Multi-Source Weighted-Ensemble Precipitation (MSWEP) is a global P dataset (1979–2014) with a 3-hourly temporal and 0.25° spatial resolution designed for the purpose of hydrological modelling. The design philosophy of MSWEP is to optimally merge the highest quality precipitation data sources available at different time scales and locations. The long-term mean of MSWEP was based on the CHPclim dataset supplemented with more accurate regional datasets and bias corrected using stream flow observations from ~15,000 stations. The temporal variability of MSWEP was determined by weighted averaging of precipitation anomalies from two gauge-based datasets, three satellite-based datasets, and two reanalysis-based datasets.

2.6.2 Poster Presentations

Similarly, there were several poster presentations and discussion points on different topics related to global-scale flood modelling, forecasting, detection and risk assessments.

RASOR - Rapid Analysis and Spatialisation of Risk Platform (Roberto Rudari CIMA Research Foundation) RASOR Platform aims at enabling easy computation of the impacts caused by Natural disasters including Floods and other weather related perils. the Platform can be easily rolled out globally if supported by proper exposure data and hazard information. As such it could be used as a final like to the tools included in the Global Flood Toolbox to go from flood maps to impact maps. The platform is Open source and free to be used in the context of GFP.

The credibility challenge for global flood models (Mark Trigg University of Leeds) I have been undertaking an intercomparison of 6 of the current global flood models for the African continent. Findings show that while there is some encouraging agreement, there are also still many areas where there is only moderate agreement, presenting a credibility challenge for the use of these models. The intercomparison has also been useful in highlighting some more obvious areas of model improvement and allows us to propose a more comprehensive framework for validation of the models. I have also been involved with a project applying one of the global models at a national scale in Belize (with World Bank and the Government of Belize). We have done a lot of work on application scales, value and limitations.

Link Global warning to local danger level (AHMADUL HASSAN, Red Cross Red Crescent Climate Centre) How global/National level forecast can be packaged into local Danger levels

El Nino as a Predictor of Flood Hazard (Rebecca Emerton, University of Reading) I would be discussing my work on using El Nino as a predictor of flood hazard at the global scale, looking at answering the question of "What is the probability of increased river flow or flooding during an El Nino, in any given month?". This research makes use of the ECMWF ERA-20C 110-year reanalysis dataset to evaluate the use of El Nino as an early indicator of flooding, and how this can be used for humanitarian action.

Use of medium spatial resolution satellite imagery for the study of water bodies expansion-contraction, exposed to drought and flooding during ENSO events in Colombia. (Sergio Alejandro Rojas Barbosa, Geographic Institute Agustín Codazzi) The ENSO events affects periodically Colombia, just as the equatorial region, causing seasonal events of drought and flooding; this leads to important economic losses from the negative effects these have on the agricultural landscape of the country, and of course, to human lives. A methodology that consisted on satellite images processing and spatial analysis form RapidEye imagery and secondary data –land cover, basic and thematic cartography– was designed and successfully implemented. The results consisted of the mapped areas where the different water bodies presented a multitemporal change – flooding where there was expansion and indications of drought when contraction. The obtained results were considered and included in the "Agro-climatic adaptation models and Prevention" project of the Colombian Agricultural Research Corporation – CORPOICA.

Tropical cyclone manual of trigger (Flávio Monjane, Jonas Aurélio Monjane & Filomena Jaime Muchave, Bairro das Mahotas, Maputo – Mozambique) In Mozambique, Red Cross Red Crescent Climate Centre (RCCC), together with German Red Cross implements Forecast Based Financing (FbF) project which aims to minimize impacts of hydro meteorological hazards, particularly tropical and floods. The manual of trigger is a template which presents essential parameters/elements analysed to trigger preparedness action before event striking.

ARISTOTLE: All Risk Integrated System TOwards Trans‐boundary hoListic Early‐warning/DG-ECHO (Bo Holst, Swedish Meteorological and Hydrological Institute, SMHI) The European Commission's DG ECHO (Humanitarian Aid & Civil Protection) did in early 2016 launch a Pilot Project in the area of Early Warning System for natural disaster. The objective is to give the Emergency Response Coordination Centre (ERCC) in Brussels better basis for decision-making in connection with natural disasters, and response to member countries possibly activating the EU Civil Protection Mechanism. A 15 member Consortium has recently been contracted to carrying through the work. The hazards to be dealt with are Volcanoes, Earthquakes incl. tsunamis, severe weather and Flooding. The multi-hazard aspects are very important, e.g. need for weather forecast in an area where the rescue operation is needed after an earthquake. The project is scheduled for two years. The first phase during 2016 includes knowledge inventories, creation of a multi-hazard scientific partnership etc. The Pilot operational phase, when information shall be provided to ERCC in the case of Hazard events, starts approximately February 2017 and lasts for another 12 months. The operational EFAS-IS will provide much of the information needed for the Flooding component of the project

New topography datasets for global flood modelling (Dai Yamazaki JAMSTEC - Japan Agency for Marine-Earth Science and Technology) Now we are developing new global topography datasets (SRTM DEM improved by ICESat-bias-correction + tree height removal; brand-new hydrography map to replace HydroSHEDS; Landsat-based water body + river width maps). All of these datasets are developed to improve the global-scale flood modelling, and designed to keep the consistency between each layers. These datasets will be distributed free of charge for academic research and education purposes when their development is completed.

Modelling the impact of storm surge on fluvial flooding in a mega-delta region (Hiroaki Ikeuchi The University of Tokyo) Mega-delta regions in Southeast Asia are vulnerable to flood risks such as fluvial flood inundation and cyclonic storm surge. Furthermore, global warming induced by climate change would augment the risk, for instance frequent fluvial floods and sea level rise. Thus, it is indispensable to analyse fluvial flood under the condition of storm surge and sea level rise. However, studies dealing with river and coastal floods are limited to relatively small scale, and large-scale (continental- or global- scale) studies have not handled both of them explicitly.

The objective of this study is to quantify current and potential risks of fluvial flooding and storm surges in the Ganges-Brahmaputra-Meghna Delta, which is one of the largest mega-deltas in Southeast Asia. A state-of-the-art global hydrodynamic model was utilized. Forced by dynamic variation of water level boundary condition at river mouths, the model could represent storm surge effects on river flooding.

One major cyclone event, Sidr, was focused in this study because of its severe damage to Bangladesh. Results demonstrated that the surge height of 6 m along coastlines was simulated to propagate 200 km upstream with 1 m increase in water level in rivers. Water level increase was larger in case of larger discharge upstream. Finally, sensitivity experiments were conducted under different scenarios with regard to storm surge and sea level rise. In addition to the actual landfall season (dry season), the same extent of cyclone in flood season was investigated. Water level increase due to storm surge was 1 m larger in flood seasons than dry seasons.

David Maréchal Guy Carpenter & Company GmbH (Re-insurance) Insurance is an important tool for the management of flood risk through, for instance, a faster recovery of the society by the dissemination of information by the insurance companies or the rapid payment of insurance claims. As a global reinsurance intermediary, Guy Carpenter acts as a practitioner for flood risk management by providing its clients a wide range of services to better understand, manage and transfer flood risk. Guy Carpenter would thus like to contribute with its practical experience in natural catastrophe modelling and risk management to improving the design and implementation of flood risk management at the global scale."

Developing a new global flash flood forecasting tool (Fatima Maria Pillosu ECMWF)

Education and capacity building on flood forecasting and early warning (Schalk Jan van Andel UNESCO-IHE)

Updates on ITHACA Extreme Rainfall Detection System (Franca Disabato ITHACA)

The contribution describes the updates in ITHACA Extreme Rainfall Detection System (ERDS), including the new data visualization capabilities, such as aggregated alerts and graphs representing the forecasted precipitation related to the alerts. In addition a methodological approach for data validation, based on available disaster losses databases, is described.

Lower Zambezi River Basin - Zambezi Delta (Herminio Elias, Mulungo Elias Ernesto Mulungo and Jaquelina Alexandre Nguenha Maputo, Mozambique) The Marromeu Complex (11,272 km²) covers the southern half of the Zambezi Delta and the adjacent Cheringoma escarpment. The Complex includes the Marromeu Special Reserve (Reserva Especial de Marromeu) and two forest reserves (Reserva Florestal de Nhampacué and R.F. de Inhamitanga), four hunting concessions (Coutada Oficial no. 10, 11, 12, and 14), large commercial agricultural lands (notably the Sena Estates, the largest sugar plantation in Mozambique), and community lands A proposed buffer zone (an additional 2,300 km2) includes forest concessions, game farms, and community lands that are contiguous with the forest and woodland ecosystems of the Marromeu Complex and drain directly from the Cheringoma escarpment catchment to the Marromeu floodplains.

The Complex has lately been showing signs of being stressed. These stresses have a direct negative impact not only on the biodiversity of the system, but also on the many valuable ecosystem services provided to the people of the Marromeu Complex and the regional and national economy. The most severe stress to the Marromeu Complex at present is its reduced water availability and other adverse changes in the timing, volume, duration, and frequency of runoff. Of particular concern is the reduction in water availability for wildlife in pans, drainage lines, and floodplain water bodies, especially in the late dry season, and the encroachment of open pans and floodplains grasslands with woody species. This, coupled by land use changes, might accelerate the negative impacts on biodiversity and ecosystem goods and services. A good understanding of the hydrological processes that sustain the complex and climate change impacts on wetland hydrology is necessary to inform strategic interventions and management of the wetlands

Flood Response in Malawi (Andrew Kruczkiewicz IRI-Columbia University/Red Cross Red Crescent Climate Centre) In January 2015, extended periods of extreme rainfall caused a series of flood events throughout Malawi resulting in the displacement of over 230,000 residents and caused 276 fatalities. In order for local authorities and humanitarian agencies to provide post-disaster relief, these organizations often rely on remotely sensed satellite data to evaluate initial disaster impact and design response programs. In partnership with the Malawi Red Cross, this project aimed to expand on the findings from Spring 2015 by adding enhanced ground-truth data (locations of shelter sites of internally displaced people (IDPs) and origins of IDPs) into the initial analysis from the previous research, second using knowledge gained by communication with project partners, local authorities and from a visit to the study region to define regions by predominate flood type and third, by integrating European Space Agency (ESA) remotely sensed data to explore the potential predictive capabilities of soil moisture for flash flood detection. In addition to data from NASA sensors (MODIS, TRMM, SSM-I and AMSU-A data), this project incorporated ASCAT data from ESA and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The results of this study will increase the ability to forecast and monitor flood events, benefiting organizations involved with disaster preparedness and relief efforts in Malawi and potentially allowing for more efficient action, including prepositioning of pre-flood resources, response operations and allocation of emergency flood relief efforts.

Integration of flood hazard maps in the Global Flood Awareness System (Francesco Dottori European Commission - Joint Research Centre) We present the development of a novel framework for global flood hazard mapping, based on the most recent advances in large scale flood modelling and integrated in the Global Flood Awareness system (GloFAS). Stream flow data provided by GloFAS climatology are processed to provide the input for local flood inundation simulations, performed with a two-dimensional hydrodynamic model. All flood-prone areas identified along the river network are then merged to create continental flood hazard maps for different return periods at 30" resolution. We evaluate the performance of our methodology in several river basins in Europe, South America, Africa and Asia by comparing simulated flood maps against both official hazard maps and satellite-derived flood maps. In addition, we compare the results with other global flood hazard models. We further investigate the sensitivity of the flood modelling framework to different parameters and modelling approaches and identify strengths, limitations and possible improvements of the methodology.

Flood risk assessment in Europe at 4ºC global warming (Lorenzo Alfieri European Commission - Joint Research Centre) In this work, ensemble projections of river stream flow based on seven EURO-CORDEX RCP 8.5 scenarios are combined with recent advances in European flood hazard and risk mapping to assess changes in flood risk in Europe for the current century. A number of novelties are presented that address issues pointed out in previous flood risk assessments at continental scale: 1) flood hazard maps are derived by a 2D hydraulic model rather than through simplified approaches; 2) the frequency of extreme peak discharges is assessed through a peak over threshold approach; 3) a new methodology is proposed to bias correct the impact of climate projections, which does not modify the atmospheric variables nor the energy balance; 4) the risk assessment is based on high resolution (100 m) estimates of flood hazard, exposure and on updated flood vulnerability information. Under a 4°C global warming scenario, by the end of the century flood risk in Europe is projected to increase by an average 220% due to climate change. When coherent socio-economic development pathways are included, central estimates of population annually affected by floods range between 500,000 and 640,000 in 2050, and between 540,000 and 950,000 in 2080, as compared to 216,000 in the current climate. A larger range is foreseen in the annual flood damage, currently of 5.3 B€, which is projected to rise to 20 - 40 B€ in 2050 and 30 - 100 B€ in 2080, depending on the future economic growth.

Global projections of extreme coastal wave energy flux (Lorenzo Mentaschi, JRC) In this study we examine on global scale the changes in frequency and magnitude of extreme wave events in coastal areas projected for the 21st century. The analysis was performed using an ensemble of global wave simulations carried out with the wave model Wavewatch III forced by six CMIP5 models and five CMIP5 global atmospheric downscales operated by the Swedish Meteorological and Hydrological Institute (SMHI), for the Representative Concentration Pathways (RCP) scenarios 8.5. This analysis is focused on the wave energy flux, which is particularly important in coastal applications, because it can be related to wave setup and to wave contribution to coastal inundation. A non-stationary Extreme Value Analysis (EVA) was carried out on energy flux along the coasts on global scale, using the Transformed Stationary (TS) EVA methodology. Ensemble results show a general decrease of the extremes in the Northern hemisphere, although in many areas there is disagreement between the different members of the ensemble. Conversely for the Southern hemisphere an increase of extremes is generally projected. In particular under the RCP8.5 scenario the projected increase of extreme energy fluxes is more than 15% in about 10% of the considered locations, and more than 20% in many areas of the Southern hemisphere, locally reaching up to 30% with respect to current conditions. The analysis shows also that the increase is higher for more intense events.

Developing a river geometry and hydraulic parameter table database (Solomon Vimal, Floodlite Technology) The shallow water equations that help predict water depth and flow at any given point in a river network can be solved using highly efficient parallelized solvers that borrow concepts from circuit design, where the voltage-resistance relationship is analogous to the flow-roughness in hydraulics. One such efficient solver is the Simulation Program for River Networks, SPRNT (Ben and Hodges, U. Texas, Austin). At each segment in the river network, the solver requires a hydraulic property table that captures the area to wetter perimeter to depth relationship. For this, a large database is created by extracting data from several thousand models in existing flood risk information systems. This may help improve real time flood forecasting at a continental scale.

GloFAS as a flood preparedness tool in the Amazon Basin (Conrado Rudorff, National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN)) Given the serious nature of the growing flood issues in the Amazon Basin, there is a clear need for risk-based information in order to adapt to both current and future hydroclimatic and socio-economic conditions. Flood impact assessment and flood awareness system are important components of the flood risk management actions to improve preparedness to extreme events. The Global Flood Awareness System (GloFAS), jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF) provides daily flood forecasts with lead time of up to one month at continental scale. Based on a case study of the recent floods in Porto Velho, Rondônia, Brazil, we point to potential applications and further development needs for GloFAS as an operational tool for water resource managers and civil protection agents at the local and regional scales in the Amazon Basin.

3 Discussion on the future of the GFP and main outcomes

The Global Flood Partnership is a unique forum linking interdisciplinary teams at global level across multiple policy fields. There was consensus amongst the participants with the overall aim of the partnership. In addition, all agreed upon the added value of the GFP which has been illustrated by unique contributions (see for example the intercomparison of global flood hazard maps), scientific advancements for forecasting and monitoring floods at the global scale (for example the set up of the Global Flood Observatory) and the creation of a well working interdisciplinary network of different stakeholders ranging from scientists to decision makers and emergency responders.

However, not all objectives set in 2015 have been reached and future challenges lie ahead of the partnership. The formal arrangement to register partners has not advanced as legal obstacles prevent some partners to sign despite the fact that the arrangement has no legal force. Participants also pointed out that the partnership currently cannot be used to attract funding for new proposals. Agreed objectives have therefore to be covered by the resources of the individual partners which makes it often difficult to turn the outcomes of the partnership into actions. Some participants also highlighted the need to involve the partnership in more on-going programs (CEOS, GEO) and more key partners (World Bank, UNISDR, etc.) to highlight and better communicate the contributions of the GFP to these activities and the added value to the key partners. Finally, all partners agreed that end user needs should be taken more into account (bottom up approach). This could be done by focusing more on disaster impact and response as well as through ways to better integrate local information into the global tools.

Added note: in middle 2016, the GFP was formally accepted by the GEO Plenary as a Participating Organization.

To address these future challenges for an evolving Global Flood Partnerhsip, a series of actions have been discussed by the participants:

Improve the visibility and communication of the GFP

Re-organize and update the GFP website to better communicate relevant news and successes of the partnership.

Become a recognized partner in on-going programs or initiatives (e.g. GEO).

Organize side events at key meetings (e.g. AGU or EGU)

Continue scientific progress on global flood risk management tools

Foster the scientific development of global flood risk management tools especially with regard to (1) improving the link between existing global products, (2) the intercomparison of global models, (3) the further development of the Global Flood Observatory, (4) the focus on flood impact and response, and (5) ways to link local knowledge and data better with global tools.

Enable the participation of the GFP to attract funding

Establish a governance plan for the GFP by setting up a steering group of the GFP. Representatives of the steering group could then develop and sign a standard letter of support for proposals that contribute to the objectives of the GFP. The steering group would be composed by a series of interested organizations including the JRC and the Dartmouth Flood Observatory. The following participants had expressed interest: David Green (NASA), Roberto Rudari (CIMA), Mark Trigg (University of Leeds), Erin Coughlan de Perez (Red Cross/Red Crescent Climate Center), Jesse Mason (UN WFP)

Better integrate and link to end users

Establish a help desk (through a mailing list) for partners to collaborate and share information on severe floods and to facilitate feedback on the global tools. An example on how this help desk could work is the information requested by the UN WFP on the Malawi 2015 floods.

Based on the presentations, workshops and proceeding discussions during this year’s conference, all participants agreed to summarize the main outcomes of the conference as a statement of intent.

4 Statement of Intent and Invitation

The Global Flood Partnership (GFP) has brought together the scientific community and key stakeholders, from 15 different countries in 5 continents and representing 38 institutions including international organisations, the private sector, national authorities, universities, governmental research agencies and non-profit organisations. We as the Partnership recognize the progress that has been made in scientific understanding and tools for global flood forecasting, monitoring, and assessment. We also recognize the need for the Global Flood Partnership to convene researchers and practitioners in this space.

For example, during this meeting of the Global Flood Partnership, attendees debated the definition of a flood event, applicability and relevance of different global modelling products, and identified specific forecast products that could be used to trigger humanitarian action before a potential flood disaster. The Partnership evaluated the potential impact of existing flood tools for forecasting and monitoring, and where improvements can be made going forward.

In light of this progress, the opportunity exists to make a greater impact in strengthening preparedness and response and reducing disaster losses. This will only be achieved by strengthening our engagement with users of flood risk information. Given the urgent needs of the global community, this will become a greater priority for the Partnership in coming years.

Giving these identified capabilities, The Global Flood Partnership commits to better align research and modelling efforts with the objectives identified by practitioners working on flood preparedness and response. We see the potential for this to amplify research results, through co-developing research priorities and tools with the flood risk management community.

Finally, the Partnership has agreed that there is a need to establish a more mature governance structure for the group, and therefore to develop a “Steering Group” to ensure a sustainable and successful effort towards the identified strategic objectives. The group members will be drawn from academia, flood response and preparedness organizations, and the remote sensing and modelling community at large. It will help the GFP to interface with or contribute to:

- Sendai Framework for Disaster Risk Reduction

- Community of Earth Observing Satellites (CEOS)

- Group on Earth Observing System of Systems (GEO)

- Sustainable Development Goals

The steering group will furthermore reach out to flood risk management stakeholders by:

- seeking the participation in dialogues, meetings, and fora of such stakeholders

- convening the 2017 Global Flood Partnership meeting with a main focus on the sharing of stakeholder priorities and consultation on solutions through participatory scenario building

- establishing a two-way communication channel with stakeholders by soliciting and recording questions from stakeholders on flood risk management through a "helpdesk" mechanism, responding to these questions, and using them to identify future research priorities.

Such stakeholders include but are not necessarily limited to:

- disaster management organizations, including governmental (e.g. civil protection), non-governmental (e.g. START Network), and inter-governmental (e.g. UNOCHA)

- organizations working on development activities that use flood risk information for planning and intervention design

- flood insurance and reinsurance groups; and

- donor organizations looking to assess developing nation flood risks (spatially and temporally) to make funding decisions

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