Report
on the "Satellite enhanced snowmelt flood and drought predictions for Kabul River basin with surface and groundwater modeling" project

Mohammad Tayib Bromand

Initial statement on Flood Monitoring and forecasting

According to the instruction of Dr. Jay Sagin Principal Investigator Initiating communication with the UK experts for work methodology development for the Kabul River Basin Flood Monitoring and forecasting was giving to Mr. Masoud Ghulami as a team leader and other members such as Mr. Zaryab, Ms. Samira Burhani and myself would be research member in order to fulfill the objective of related activities. Unfortunately, this issues ignored, However, for better understanding of GloFAS products and services, I was involved since August, 2018 in this topic and started basic research in order to obtain required information and knowledge about this important website and will share the findings briefly as bellow.

Introduction to the Global Flood Awareness System – GloFAS

The Global Flood Awareness System (GloFAS), jointly developed by the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF), is a global hydrological forecast and monitoring system independent of administrative and political boundaries. It couples state-of-the art weather forecasts with a hydrological model and with its continental scale set-up provides downstream countries with information on upstream river conditions as well as continental and global overviews.

GloFAS produces daily flood forecasts (since 2011) and monthly seasonal streamflow outlooks (since November 2017). GloFAS has been fully operational as a Copernicus Emergency Management Service since April 2018. Fortunately, this system produce daily hydrological forecast for Afghanistan, particularly Kabul River Basin. As we conducted research and investigation in this regard, we have found that the production of this system can be used for preparedness and prevention plans in order to mitigate the negative impact of flood.

GloFAS modelling chain overview

GloFAS real-time initial states (atmosphere and land surface) are the conditions from which to start the ensemble discharge forecast. They are provided by a daily update of the atmosphere, land-surface and river states, every day for the past 5-day period based on a monitoring analysis of the latest observations. Because of the latency in the availability of real-time reanalysis data, day-1 forecasts from a deterministic run of the ECMWF Integrated Forecast System (IFS) are used as fill-up when necessary for GloFAS 30-day initialization.

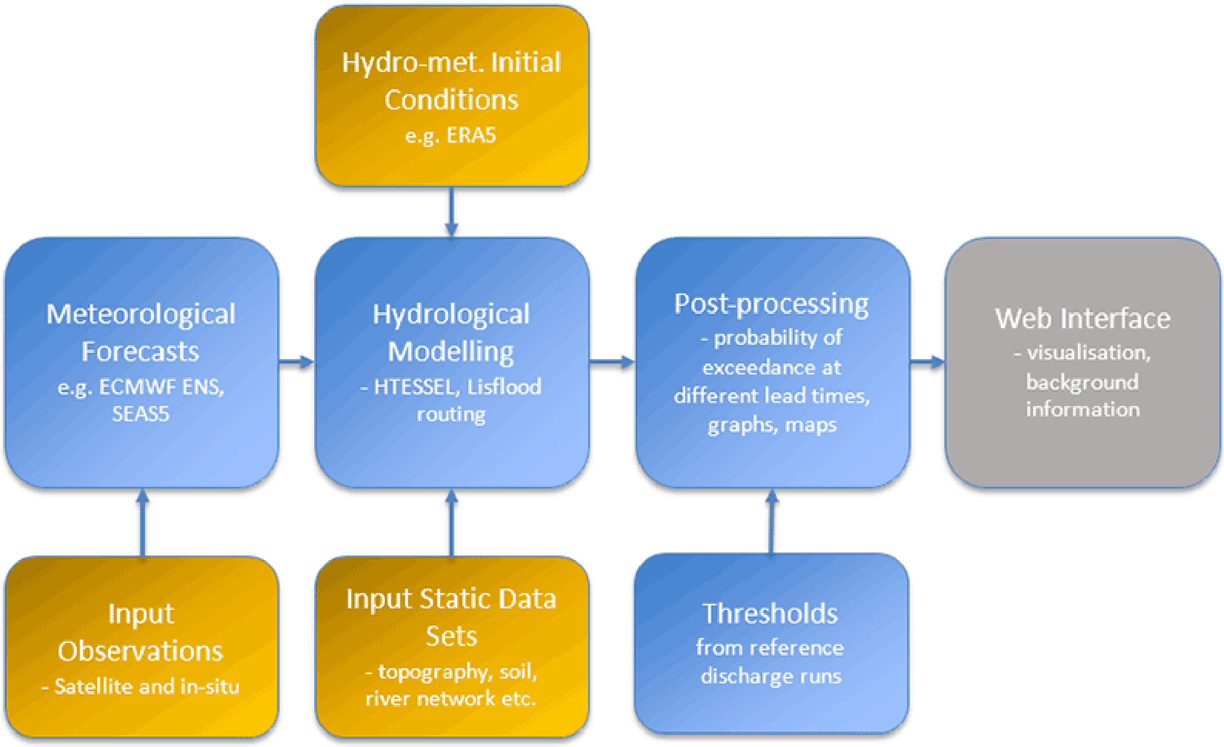

Figure 1: GloFAS modeling layout for flood forecasting and monitoring

GloFAS forecasts are produced using the latest ensemble of Numerical Weather Prediction (NWP) forecasts of the ECMWF IFS. Surface and sub-surface runoff outputs are routed with the Lisflood hydrological model over the GloFAS river network. The runoff is computed with the HTESSEL land-surface model of ECMWF. The medium- and extended-range ensemble runoff outputs are used for GloFAS 30-day, and the long-range SEAS5 ensemble runoff is used for GloFAS Seasonal. In order to analysis the hydrological flood, It is a long deterministic hydrological simulation based on a configuration as close as possible to that of the operational system, providing modelled hydrological variables, including daily river discharge, as close as possible to observation, over the GloFAS river network. It is used to evaluate GloFAS hydrological skill, and also as initial conditions to the forecast reruns and to define the discharge.

GloFAS available data

A number of GloFAS simulated discharge products are available to access, summarised in the table below. Note GloFAS 30-day forecasts over European domain are currently not publicly available. The detail explanation elaborated in the table below.

		Data set	Period	Frequency	Ensemble members
GloFAS 30-day	V2.0	Real-time forecasts	1 Jul 2018 - real-time	Daily	51
		Reanalysis	1981-2017	Daily	1
		Forecasts reruns	Jan 1997 - Dec 2016	Twice weekly	11
			1 Jan 2017 - 30 Jun 2018	Twice weekly	51
	V1.0	Real-time forecasts	23 Apr 2018 - 13 Nov 2018	Daily	51
		Reanalysis	ERAI-Land: Jan 1980 - Jun 2016	Daily	1
			HRES: Jul 2016 - Apr 2018	Daily	1
		Forecasts reruns	Jan 1997 - Dec 2016	Twice weekly	11
GloFAS Seasonal	V2.0	Real-time forecasts	Jan 2018 - real time	Once a month	51
		Forecasts reruns	Jan 1981 - Dec 2017	Once a month	25

Table 1 : GLoFAS vailbale data demonestrated in the table one

There are three ways to access GloFAS Data, all being subject to the terms and conditions of the Copernicus Emergency Management Service – flood early warning and monitoring systems.

Access to real-time river flow forecasts and forecast reruns from GloFAS (both GloFAS 30-days and GloFAS Seasonal) is possible through a dedicated ftp service set-up by the GloFAS team upon request. Data is provided either as point time series or 2D grid series, both in netCDF format. Request of real-time forecasts or forecast reruns, or any other inquiry and feedback on the service can be made to info@globalfloods.eu. The team endeavours to respond to all requests as soon as possible within 10 working days. Please provide the following information when sending a request for data, including the period of simulation requested (real time or forecast reruns):

Hydrological flood forecasting in the Kabul River Basin

GloFAS provides flood forecasts and hydrological outlooks at sub river basins, river basins, national, regional bases in the form of layers, data and information. The layers are organized in four categories such as meteorological, hydrological, static and external WMS. GloFAS has 11 point stations in order to forecast real time to real-time river flow at the main rivers and streams of Afghanistan. The majorities of these points located in the most appropriate location for monitoring. Out of 11, four points have been located in the Kabul river basin. These four points crossed Panjshir river, Laghman river, Kabul river, and Kuner rivers which are properly sited and forecasting daly, weekly, monthly and seasonal streamflow including flood forecasting. Monitoring points have shown in the figure.2

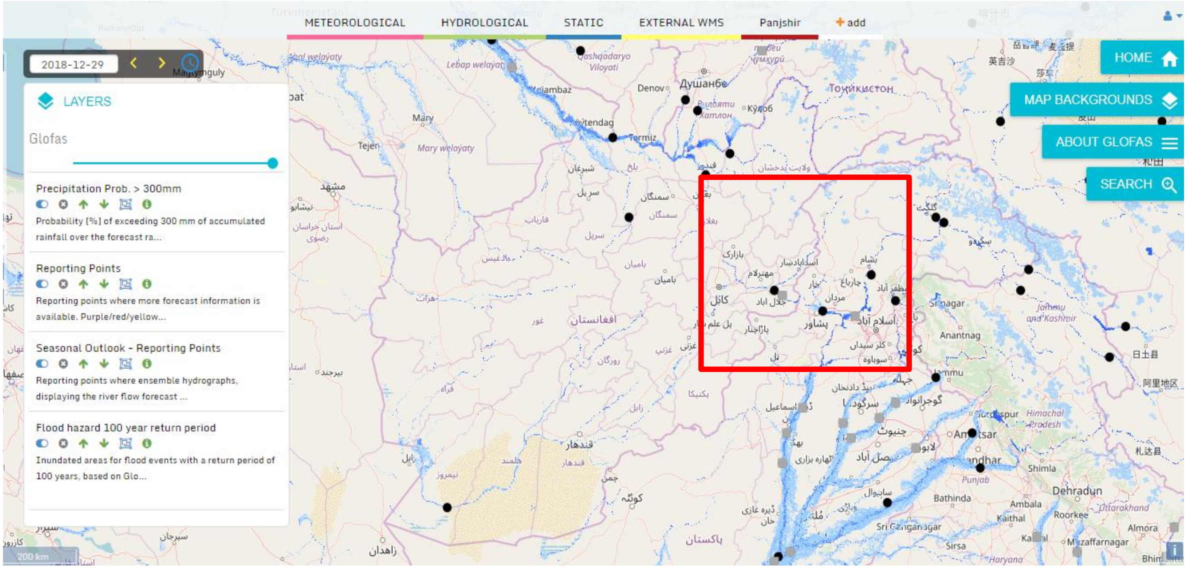

Figure 2: Monitoring ponts in The Kabul River Basin, Afghanistan

These monitoring points are shown at the outlet of four major sub river basins in different climatic regions, for forecast lead times of 15 and 25 days. Outlets location and name initials of eacch river are shown with red rectengal in

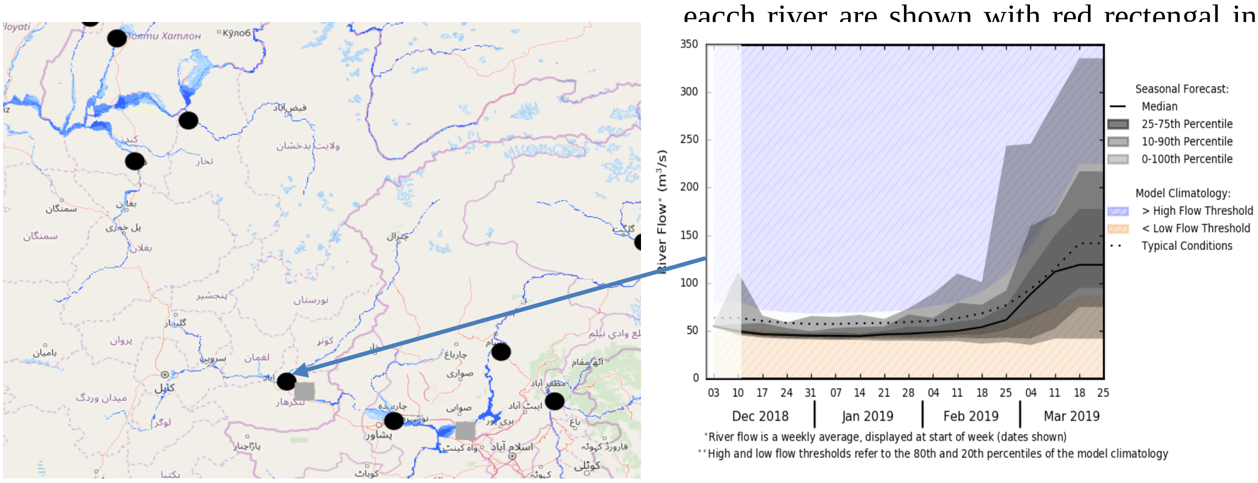

Figure 3: Seasonal forecast graph for the Kabul river

locations the ensemble spread is larger for the longest lead time shown, increases. However, graphs with longer forecast lead time (not shown in the article) suggest that, after reaching its maximum, the ensemble spread tends to reduce after the predicted rainfall has drained througth the basin outlet. This is the consequence of using 15 days of ranfall but simulating a longer lead time, which means that the ESP spread is increasingly underestimated of simulation. In four ou eleven statins in the figure 2, the runoff regime follows a clear seasonal trend, with peak flows always in the same range of months, depending on the rainfall regime and on the timing of snow and ice accumulation and melting. Differently, in the other river, the runoff regime is more variable and high flows occurred in different seasons. This partly explains the results shown in figure. 3. Where the ESP performs quantitatively better than a persistent forecast also for long lead times (i.e., 25 days). Graphs in Fig. 4 show that the ESP spread is higher when the hydrographs have increasing trend because of the uncertainty of forecast rainfall

Probability of exceeding low flow threshold.

Forecast Day	03	10	17	24	01	08	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04	11	18	25	04	11	18
2018-09-01	57	94	80	57	57	57	51	43	63	51	53	67	75	80	80	80													
2018-10-01							8	14	25	41	53	65	61	59	63	75	78	69	82	78									
2018-11-01										96	84	65	69	57	53	75	65	59	65	71	76	84	78	65	53				
2018-12-01															75	84	78	82	75	78	63	59	59	59	49	41	31	27	20

Probability of exceeding high flow threshold.

Forecast Day	03	10	17	24	01	08	15	22	29	05	12	19	26	03	10	17	24	31	07	14	21	28	04	11	18	25	04	11	18
2018-09-01				4	2	8	2	16	10	16	8	6	4	4	6	6													
2018-10-01						8	27	18	8	10	4	4	6	10	8	4	4	10	4	4									
2018-11-01											2	6	8	14	4	4	8	6				2	2	6	16				
2018-12-01															2							2	2	10	4	2	14	10	10

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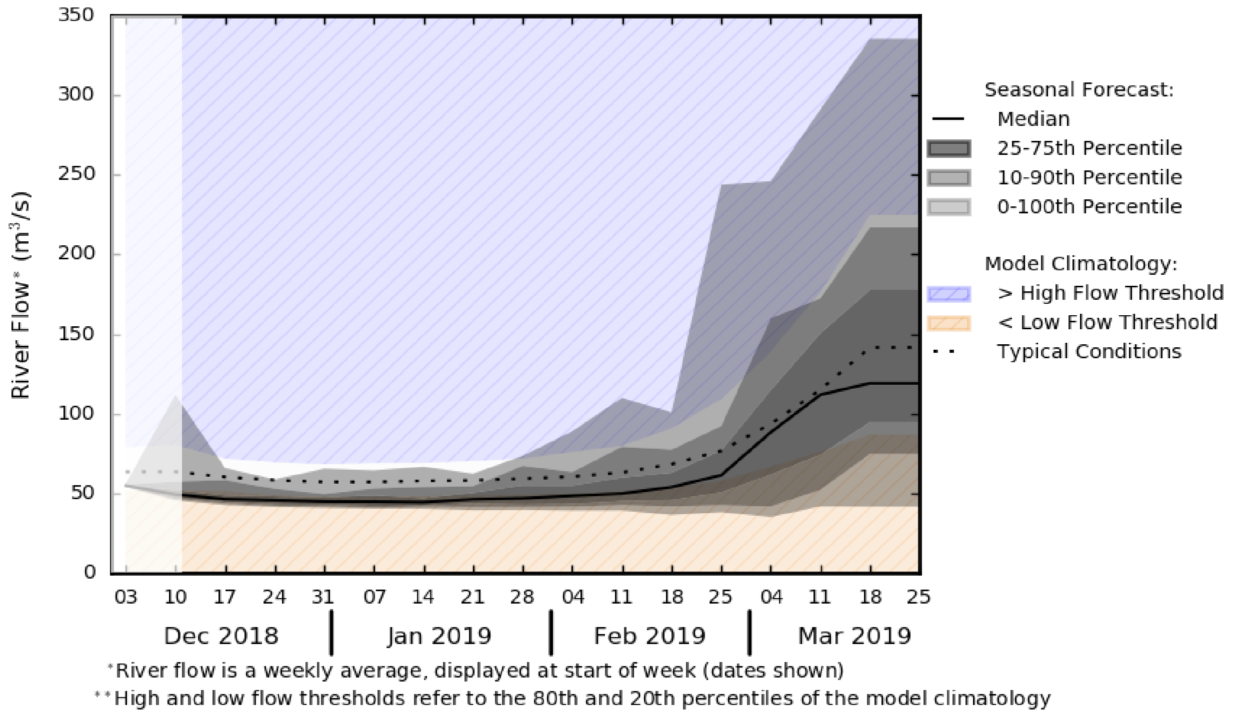
Figure 4: Persistence diagrams of the forecasts shown in figure. 3, showing the probability of exceeding the high and server alert level over Kabul river consecutive forecasts issued from3 to 18 December, 2018



River, few kilometer downstream the of Kabul, in the Kabul province of Afghanistan, geographic location of the area is shown in table-contoured rectangle in figure.4. Forecasts show a sharp rise of discharge in the river, with expected peak of the ensemble mean on the 31 days after the prediction was issued. The uncertainty range increases with the lead time, though it almost completely excessed the sever alert level from the 25 December and later.

Discussions and Conclusions

In this report we present a probabilistic flood early warning system running at global scale, aimed at forecasting the threshold exceedance of ensemble streamflow predictions on the basis of a model-consistent discharge climatology. The system has been set up following similar structure as in EFAS, through on specific comparison has been carried out (in Europe) between the two systems. GloFAS now has been running on a daily basis since December, 2018. Results are shown on in the figures.3.4. and being monitored to assess qualitatively the system skills for flood events in large river basin. Quantitative performance has been assessed for one year of daily handcarts starting on 03 December and predicted till 25 March 2019 using simulated climatology as reference run. Although it is a relatively short time window to assess the system performance in the detection of extreme events, it represents a useful experiment to test the overall behavior of the uncalibrated system after its initial setup, and to help identify the main components where to address the main future development efforts. Findings of this analysis show that current ensemble weather predictions can enable skillful detection of hazardous events with forecast horizon as long as 1 month in large river basins, providing that the initial conditions are estimated correctly. This anticipation depends on the skill of input weather forecasts and on the delay between the meteorological forcing and the hydrological response in the river basin. Interestingly, the uncertainty range of ensemble weather predictions has a reduced effect when propagated to discharge predictions in large river basins. Indeed, flood events in major rivers are mostly caused by large-scale weather systems that are skillfully predicted by state-of-theart global forecasting models. In addition, when weather systems have smaller or similar size as that of the river basin, spatial shifts of predicted rainfall fields have limited effect on the resulting streamflow at the outlet.

There is no doubt that the system performance is great in the large scale river basin, In order to improve the functionality of the system at the sub river basin, we most downscale the performance at the regional level and validate the result with the observed climatologically and hydrologically. To do so, the researchers and scientists of each state should contribute in sharing the observed data particularly, streamflow and precipitation of the accuracy checking of the system outputs. It is highly required to extend joint researches with the system experts in the Kabul river basin and compare the observed records with the system outputs in order to enhance the performance of system forecasting in the coming future.