Analysis of the uncertainty in flood predictions of GLoFAS for Piura in the Pacific region of Peru

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Introduction

The northern Pacific region of Peru suffers from flooding, especially due to high rainfall during the El Niño. In March 2017 extreme rainfall across Peru led to flooding and landslides. In Piura 51.3 mm of rainfall was measured, resulting in flooding which affected 12,000 people and resulted in 4 casualties [1]. Flooding in Piura caused by extreme El Niño rainfall is frequent and accurate prediction of the El Niño rainfall extremes and flood peaks can help reduce the impact of the flooding and reduce the loss of life.

In Piura forecast based financing is a project run by the Red Cross that enables early action to be taken using probabilistic forecast information, with the aim of reducing flood impacts [2]. The project uses a combination of forecast models including GLoFAS.

The focus of this poster is to analyse the uncertainty associated with forecasting the flood peaks in GLoFAS for Piura during El Niño events. For this the GLoFAS reforecasts that use ERA-Interim/Land dataset were used. ERA-Interim/Land includes soil moisture, soil temperature and snow-pack. It benefits from an improved parameterization of the land surface scheme [3]. The first section of the poster shows how ERAI Interim/Land precipitation captures the rainfall extremes for Piura during the El Niño events and the second part of the poster shows the performance of the GLoFAS reforecasts for the Piura catchment.

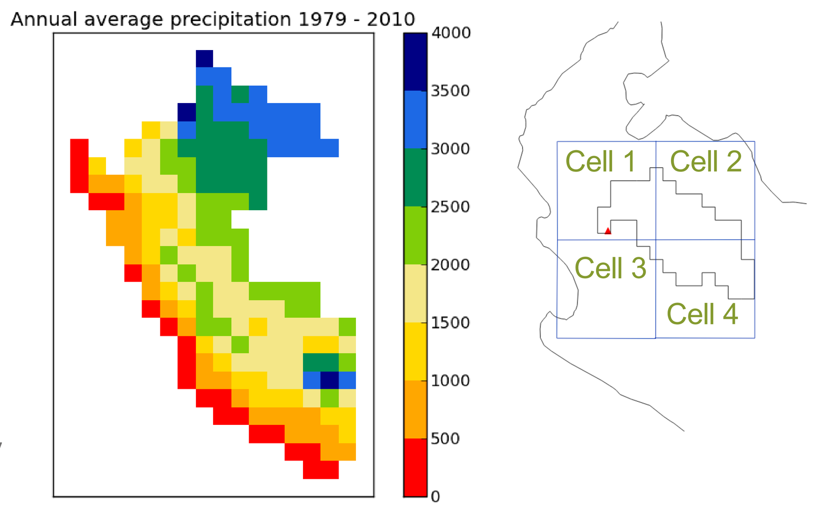

Figure 1: ERA-Interim/Land Average Annual Precipitation, showing low rainfall along the coast and high rainfall towards the Amazon region

Global Flood Awareness System (GLoFAS)

The GLoFAS model has been setup with the aim to provide an overview of upcoming floods in large world river basins. GLoFAS has been setup to forecast using the Variable Resolution Ensemble Prediction System (VarEPS), consisting of a 51 member ensemble with a horizontal grid resolution of ~32 km with a forecast span of 10 days, and ~65 km with a forecast of days 11-15. Twice daily forecasts are available via the GLoFAS website on a 10 km grid and for reporting points around the world, including Piura.

Figure 2: Piura River floods Don Bosco College 29th of March 2017, Source: http://www.infoans.org/en/sections/news-photos/item/2950-peru-the-piura-river-floods-don-bosco-college

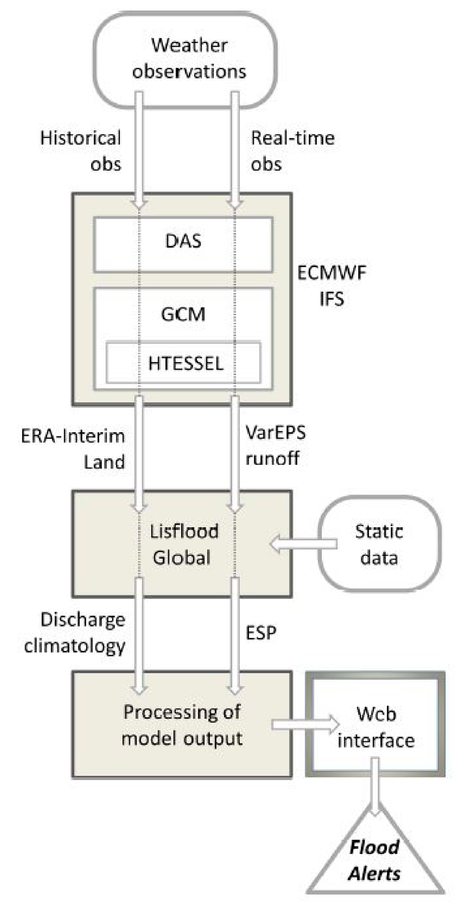

Figure 3: GLoFAS schematic [4]

GLoFAS simulation of El Niño at Piura

The lower limit of catchment size advised for using GLoFAS is 10,000 km² [5]. Piura's catchment area of 7,435 km² is below this lower limit and therefore higher uncertainty is expected. Figure 4 shows the flows in the El Niño year of 2016 as modelled by GLoFAS compared to the monthly average modelled flows in the period 2008-2017. The El Niño year is clearly picked up as an anomaly for the average.

El Niño event			
Weak	Moderate	Very strong	Non
1979	1986	1982	1981
1980	1987	1983	1984
1994	1988	1997	1985
1995	1991	1998	1989
2004	1992	2015	1990
2005	2002	2016	1993
2006	2003		1996
2007	2009		1999
	2010		2000
			2001
			2008

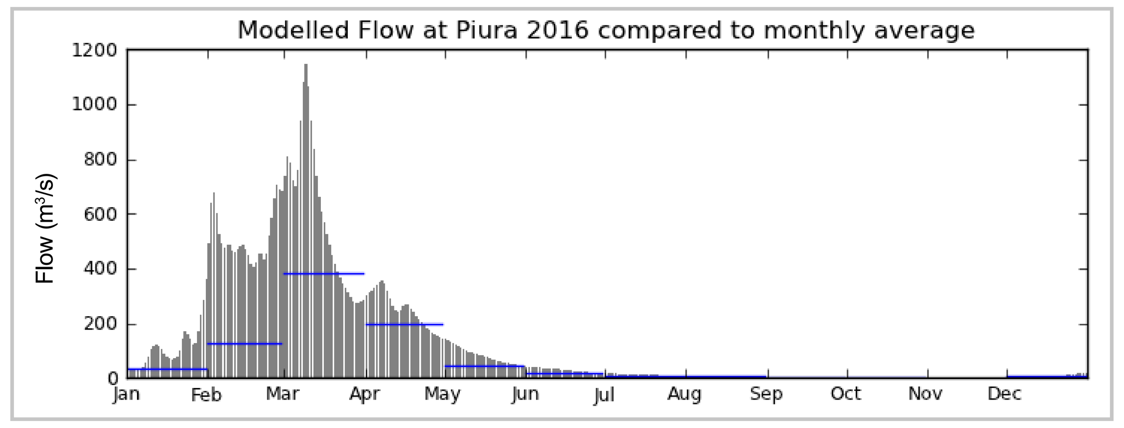

Figure 4: Modelled flows during the El Niño year 2016 (grey bars) compared to the monthly average flows of 2008-2017 (blue lines)

ERA-Interim and ERA-Interim/Land

ERA-Interim/Land reanalysis dataset has global coverage, a horizontal resolution of 80 km and is available from 1979 to 2010. The surface runoff produced by HTESSEL as part of ERAI-Interim/Land was used to force the Lisflood component of GLoFAS for the reforecasts (Figure 3). The atmospheric forcing used in ERAI-Interim/Land experiment is from ERAI-Interim atmospheric reanalysis [5] with rainfall adjustments based on monthly GPCP v2.1.

		Mann Whitney U Test		Kolmogorov Smirnov Test	
		U(XX)	P value	D	P value
Cell 1	Wet Season (Jan – June)	437	0.0026	0.830	0.009
	Dry Season (July – Dec)	664	0.2910	0.217	0.354
Cell 2	Wet Season (Jan – June)	533	0.0324	0.380	0.012
	Dry Season (July – Dec)	408	0.0010	0.400	0.006
Cell 3	Wet Season (Jan – June)	369	0.0003	0.400	0.006
	Dry Season (July – Dec)	619	0.1598	0.192	0.509
Cell 4	Wet Season (Jan – June)	456	0.0045	0.358	0.018
	Dry Season (July – Dec)	295	0.00001	0.483	0.0004

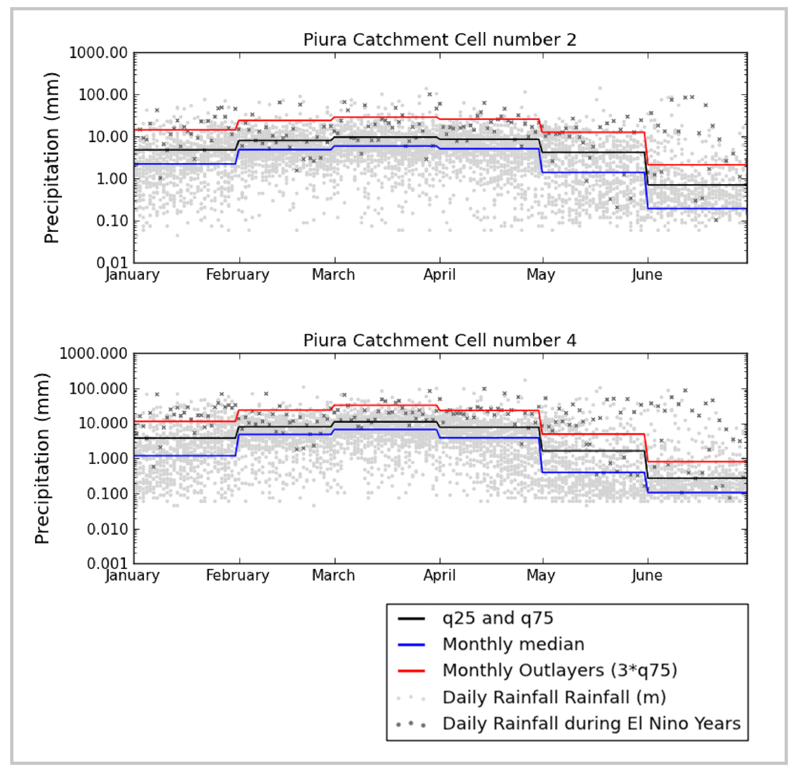

Figure 5: ERA-Interim/Land precipitation 1979-2010, showing that precipitation in very strong El Niño years are extremes, however not all extremes are due to the very strong El Niño

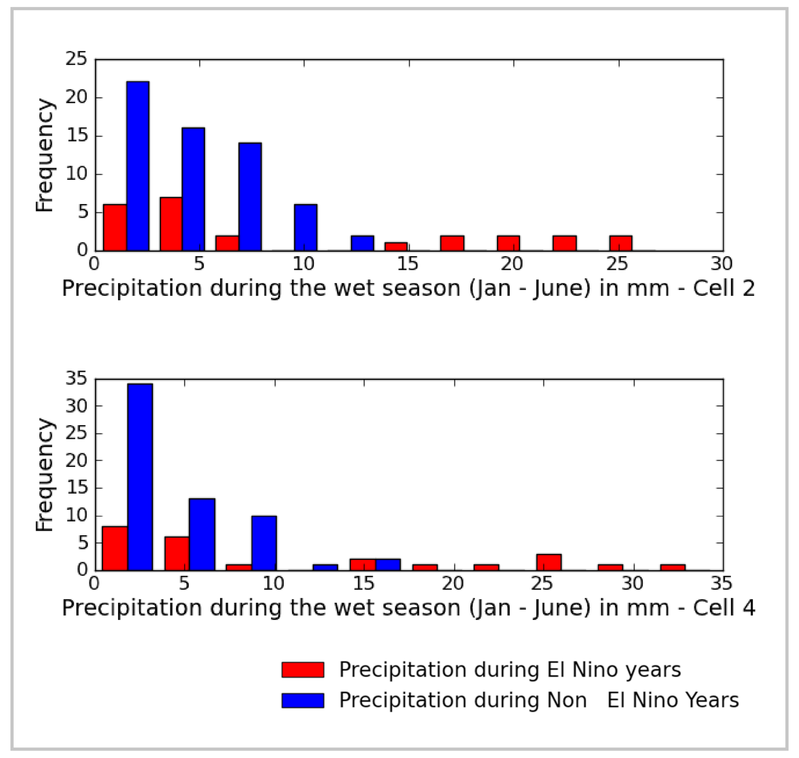

Figure 6: Histogram of frequency of precipitation events comparing the non El Niño years to the very strong El Niño years

Modelled GLoFAS flow compared to observed flows at Piura

To analyse if GLoFAS is able to model the flow regime of the Rio Piura the flow exceedance curves were produced for both the observed data and the modelled data (times series of daily data with observed data 1992-2015 and modelled data 2008-2015). Figure 7 shows that GLoFAS underestimated the flow in Rio Piura for most of the flow regime, except for the dry periods, where GLoFAS overestimates the flow.

During the moderate El Niño of 2010 the observed maximum discharge was 2009 m³/s which has a 1.42 % change of exceedance. The equitant modelled maximum flow during this event is 109 m³/s and has a 6.29 % change of exceedance. The issues regarding the modelling of absolute flows are known, but this analysis shows that for this catchment, the comparable magnitude of this event was not captured.

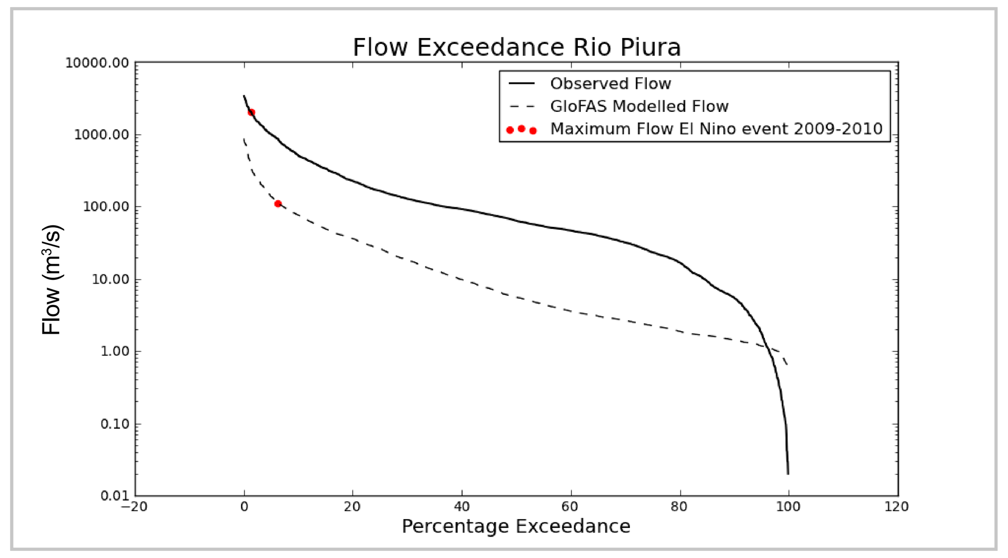

Figure 7: Flow exceedance curves of modelled and observed flow at Piura

The comparison of high flow events shows that the model is unable to simulate absolute flows. As GLoFAS is uncalibrated and the Piura catchment is below the lower limit of catchment size, this is not unexpected. However, figure 8 also shows that GLoFAS is unable to capture the observed pattern of magnitude, in other words there is no relationship between the highest observed events and the highest modelled flow events.

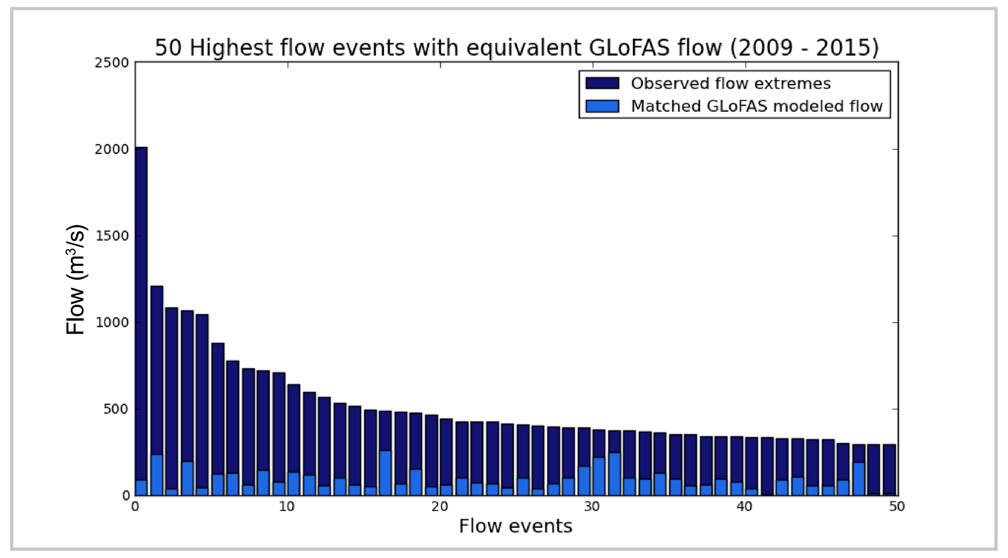

Figure 8: Bar chart comparing the modelled flow to observed flow during periods of high flow

Conclusions

> El Niño precipitation extremes are captured in the ERA-Interim/Land precipitation dataset for the Piura region.

> Modelled GloFAS flow in the Piura catchment shows the expected high flow anomalies during the El Niño year of 2016.

> GLoFAS is not able to fully capture the flow regime of the Piura river.

> The relative magnitudes of modelled and observed flow events are not found to be comparable.

Discussion

> Work is ongoing to update the climatology with ERA-Interim/LAND with the new ERAI 5 datasets which will increase accuracy and resolution and the rainfall and runoff used in the GLoFAS climatology.

> More research is needed to look into the Lisflood components and the forecasting chain to see how they are affecting the discrepancy between observed extremes and modelled extremes.

> More information is needed on the gauged measurements to understand the uncertainty within the observed flood peak.

> More guidance is required on dealing with the uncertainty related to interpreting and using forecast results of an uncalibrated global model like GLoFAS on a regional scale like Piura which is below the lower limit of basin size.

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