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# *Interactive comment on* "GloFAS – global ensemble streamflow forecasting and flood early warning" *by* L. Alfieri et al.

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GENERAL COMMENT:

This manuscript presents a global flood forecast system, the Global Flood Awareness System (GloFAS), aiming to assess the feasibility of transferring the methods from the "European Flood Awareness System" to the global scale and to evaluate the system performance. The paper is generally well written and presents a research of great importance. The development of global flood forecast systems is a very important issue for optimizing actions of mitigating flood impacts, especially at developing countries. That's why I would be pleased to see this research published at HESS. Meanwhile, I have some comments/suggestions that hopefully will help the authors to improve this



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Interactive Discussion

Discussion Paper

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MAJOR COMMENTS:

1) Objective and conclusion:

The authors claim that the “aim of this study is to assess the feasibility of transferring methodologies and concepts from the EFAS system to the global scale and . . . ”. However, there is no discussion at the “Discussions and Conclusion” section explicitly comparing the EFAS and GloFAS systems. How the performance of the GloFAS system compares with the EFAS’s? What methods and concepts that worked well at European scale (or region) were successful or unsuccessful on the global scale? Why? What should be improved in the EFAS system to useful on the global scale? This kind of questions should be answered at the discussion and conclusion section.

2) Performance evaluation:

- Page 12307, line 7: Why have you performed a hindcast test of only 2 year length? It seems that with the methods used by the authors, it would be possible to do the same tests for the 1990-2010 period. Also, as explained in the manuscript (Page 12311, lines 23-25), a longer test period would allow the evaluation of the system performance using warning thresholds based on discharges related to 2, 5 and 20-yr return periods, as it is actually used in the GloFAS. Please justify the option for a 2 year test period in the manuscript.

- Page 12309, line 10: Why not testing the system performance against discharge observations? It would be interesting to see Figures of CRPSS and AROC (or max lead time where AROC > 0.7) for each gauging station, similar to Fi. 2 and 6.

- Page 12309, lines 5-21: The approach of testing the system performance against results from a reference run considers that the only source of errors is the weather forecasts. But it is not true, important errors can arise from imperfect model structure and parameters and also wrong model initial states at the beginning of a forecast.



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That is why it would be important to test the system performance against discharge observations too.

-Page 12314, line 22 to Page 12315, line 5 and Page 12315, lines 17-29 In my view, the analysis performed in the manuscript is too weak to conclude, for example, that it is possible to detect flood events with forecast horizon as long as 1 month. The methods used in this paper do not consider all source of uncertainty such as errors in model structure and parameters or errors in model initial states. For example, aiming at studying the sources of prediction uncertainty in the Amazon River basin, Paiva et al. (2012b) showed that initial conditions of model states (e.g. river discharge and water levels, groundwater storage, among others) play an important role for discharge predictability even for large lead times ($\sim$ 1 to 3 months) on main Amazonian Rivers. These analyses indicated the feasibility of hydrological forecasts based mostly on optimal model initial states, while the weather forecasts would have a secondary importance. Also, development of data assimilation methods was encouraged to estimate the optimal initial states. Also, figures 7, 8 and 9 can show an incorrect good performance of the GloFAS system where the model can't represent observed discharges at the climatology simulation. In my view, to perform a stronger analysis, it would be necessary to evaluate forecast results against discharge observations.

-Section 4.1.: The manuscript brings some explanations for model errors at some regions of the globe, including dam regulation, water withdrawals for irrigation, incorrect modelling of snow processes or biased input temperatures. In my view, it should be added some references or analysis to support these explanations, otherwise it seems only speculation.

3) Timing errors:

- Figure 3: The large timing errors between simulations and observations presented in figure 3 opens room to the following discussion. The authors claim that, since the goal of the GloFAS system is to provide warnings based the exceedance of warning thresholds (developed based on simulation results), it is much more important that the simulation model reproduce discharges in terms of percentile ranks rather than quantitative values. Consequently, errors related to bias between simulations and observations wouldn't cause problems in the flood forecasts. That is actually a very interesting idea. However, how does this method deals with timing-related errors? In the case of advanced hydrographs, during the operational monitoring of the system results, I would expect first an advanced false warning followed by a miss of a flood event. That can have important implications in the performance of this system. The timing errors between simulated and observed discharge series could be easily evaluated using the "Delay Index" presented in Paiva et al. (2012a) or using more complicated metrics as the one presented by Liu et al. (2011). It would be interesting to include a discussion on the implications of timing errors in the performance of the flood forecasts system.

4) Simulation model:

-Page 12301, lines 16 - 18: Is the storage and flow of water in floodplains taken into account for streamflow rounting? There is some recent advances in regional / global modeling of surface waters flow, moving to diffusive and full hydrodynamic modeling of channel flow to consider backwater effects (e.g. Paiva et al, 2011, 2012a,b; Yamazaki et al. 2011) and floodplain store of water volumes exchanged with the river (e.g. Paiva et al, 2011, 2012a,c; Yamazaki et al. 2011; Decharme et al. 2008). The Fig. 3 shows results in the Amazon basin, where simulated discharges are very advanced in comparison to observations. On the other hand, Paiva et al. (2012a,c) and Yamazaki et al. (2011) showed that not representing backwater effects and mainly floodplains in simulations can lead to very advanced hydrographs. Possibly, the delay errors shown in Fig. 3 are due to the same reasons. It would be interesting mentioning these recent advances and relating it to the model and results from this manuscript.

SPECIFIC COMMENTS:

-Page 12294, lines 21-24: Is the 230% increase in economic damage computed com-



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paring the 2011 year with the 2000-2010 decade? If yes, I am not sure that such comparison is appropriate, considering the natural interanual variability of climate.

-Page 12296, lines 17-20: Data assimilation methods can also be used to derive optimal estimates of model initial states based on observations.

-Page 12300, line 27: "... hydrodynamic channel routing model..." This term is usually related to full (or close to full) Saint Venant equations, where the flow in channels is modeled considering all inertia, gravitational, friction and pressure forces. Indeed, as described in the manuscript (Page 12301, line 18), Lisflood simulates the flow in the river network using a simpler kinematic wave approach, that considers only gravitational and friction forces. It would be better to remove the term "hydrodynamic routing model" for the Lisflood model to avoid confusion.

-Page 12301, lines 11-16: How the parameters of subsurface and groundwater reservoirs were estimated? How river parameters (e.g. river width, Manning coefficient) were estimated? Is there another publication describing the global application of the Lisflood model? If not, it would be important to provide more details about model parameters.

-Page 12301, lines 18 - 19: Was any upscaling method used to derive flow directions at the 0.1 degree resolution?

-Page 12302, lines 5 - 8: What does it mean? Does it mean that the model is forced with null precipitation between 15 to 45 days lead time? At some regions, null precipitation may not be the best guess. Have you considered using an ensemble of historical precipitation data from past years, such as used in the "Ensemble Streamflow Prediction" method from Day (1985) ? Maybe you could mention this idea at the conclusion section. And what about the other meteorological forcings, such as surface temperature or solar radiation? Do you consider a persistence criterion?

-Page 12302, lines 5 - 8: What about the initial states of the hydrological model Lisflood



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(River discharge, surface, subsurface and groundwater volumes) ?

-Page 12302, line 19: “the 5 and 20-yr” = “the 2, 5 and 20 yr”?

-Page 12302, lines 4-15: Do you assimilate data from observations to update the initial sates of HTESSEL or Lisflood model?

-Page 12302, line 24: Have you considered using fixed reporting points located at the world most populated cities?

-Page 12303, line 15: “Persistence diagrams”. These diagrams were not present in the manuscript.

-Page 12304, line 10: How can you be sure that a visual check can remove all problems related to discharge regulation in stream flow data from gauging stations? For example, Fig. 2 show lots of gauges used in this manuscript located at Paraná River basin (southeast Brazil), where there are lots of reservoirs from hydropower plants. The discharge time series of these gauges are possibly affected by reservoir regulation and hydropower operation. Have you considered using a database of world large reservoirs?

-Page 12306, line 16: Please provide a reference for the Peirce’s skill score.

-Page 12306, line 17: Why have you choose to use a threshold equal to the 90th percentile of discharges? It would be better to use thresholds equal to the discharge values corresponding to 2, 5 and 20-yr return period, since these are the values actually used in the warning system.

-Page 12307, line 22 to Page 12308, line 5: This paragraph is not very clear. For example, how do you deal with Lisflood state variables in the bias correction?

-Page 12308, lines 17-19: Not clear, please rephrase it.

-Page 12309, line 6: What threshold value was used? I guess it was the 90th percentile. Please clarify it here.



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-Page 12310, line 6: "... model performance is often substantially affected by dam regulation... " How can you tell that the model performance is affected by dam regulation, if you claim (Page 12304, line 10) to have removed all gauging stations affected by discharge regulation using the visual check?

-Page 12310, line 11-12: You could add regressions lines (e.g. PCC = a0 + a1*Area or PCC = a0 + a1*log(Area) ) for different latitude ranges at Fig. 5 to support this affirmation.

-Section 4.1.: Please, also provide ranges, mean, median or any percentile value for Nash and Suttcliffe index values. -Page 12312, line 29: In large rivers that usually have marked seasonal regimes, a better reference forecast would be the climatological value of discharge for each Julian day.

-Page 12314, line 8: "MODIS Rapid Response" Please provide a reference for this dataset. Is is one of the products mentioned in Page 12295, lines 25-26?

-Page 12315, lines 25-29 It could be mentioned the use of data assimilation methods to update model states.

-Page 12315, lines 6-16 The authors should present some Area x Skill Scores figures to support these conclusions (maybe using regression lines too).

-Page 12316, lines 7-9 You could also mention that there is room for improving the representation of river- floodplain flow to consider effects of backwatering and floodplain storage in flood wave traveling along the river network.

TECHNICAL CORRECTIONS:

-Sections 2. and 3. : The names of sections "2. Data and Methods" and "3. Methods" are confusing.

-Page 12300, line 10: "Orography" = Topography?

-Figures 2 and 6. Maybe some gauges were hidden behind the ones with large



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upstream area represented by large circles. An alternative would be to represent gauges with different ranges of upstream area using different symbols, such as circles, squares, triangles.

-Figure 9. caption: “see red markers in Fig. 7” = “see red markers in Fig. 8”

-Figure 10: It would be easier for the reader if the location of the area presented in Figure 10 was shown as a rectangle in one of the figures showing the globe (e.g. Fig. 8).

-Figure 11: It would be easier for the reader if the location of the area presented in Figure 11 was shown as a rectangle in Fig. 9.

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