EDITORIAL

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While flash floods have deadly impacts worldwide they are poorly observed relative to large-scale river floods. Following the recent paper by Gaume and Borga (2008) that provides detailed guidelines for postflood field investigations we ask: 'What is the status of current flash flood observation capabilities and what are some specific strategies to expand our databases?'

For several reasons scientific understanding of flash flood impacts is limited. Short lead times, localized areas of impact, and confusion over what events are defined as flash floods (debris flows, landslides, intense posthurricane rainfalls, river response < 6 h from intense rainfall), our flash flood knowledge is primarily based on detailed postevent investigations to estimate flood magnitude, timing, and sediment transfer. Case studies improve our scientific understanding of rainfall–runoff processes, but are limited in scope to the specificity of the extreme magnitude of the events, the geomorphology of the region impacted, and antecedent conditions of the atmosphere, land surface, streams, soils, and underlying aquifers.

Much remains to be known about the spatial extent, frequency, and magnitude, i.e. *climatology*, of flash floods. Maddox *et al*. summed up the state of flash flood climatologies in 1979 and his words still apply: 'Unfortunately, reports of flash floods are often vague, many flash flood events are probably never reported, and there is no national [US] database for collecting flash flood reports'. A statistical understanding of flash flood frequencies can be used to improve the skill of prediction models. Moreover, we need to know the state of flash flood climatologies in today's world to anticipate the societal impacts of flash floods in future scenarios of climatic, demographic, and land use changes. What kind of data can be used to derive flash flood climatology maps?

Flood hydrograph reconstruction is possible through field investigations *ex post facto* as discussed by Gaume and Borga and also with instruments that report in real time, situated in or near streams and onboard satellites. *In situ* stream velocity and stage measurements have the benefits of providing a quantitative metric of stream discharge, are taken at high temporal resolution, i.e. on the order of minutes, and as such can be used to compute flash flood frequency statistics. These instruments are rather limited in their spatial coverage and they require regular maintenance, support, and a means to communicate or store their data. More cost-effective methods of measuring stream discharge through remote sensing include acoustic Doppler profilers. The use of these instruments for field studies has been demonstrated, and their deployment in operational networks will improve the spatial density of discharge measurements at the flash flood scale.

In the last decade, remote sensing of surface water has been demonstrated through satellite-based retrievals. Observations are available with a spatial resolution on the order of tens of kilometers with a near-daily frequency, depending on cloud conditions. The major advantages of space-borne water surface area detection is the possibility for global coverage, data formatting is standard, and there is real-time data access without regard to political boundaries. The utility of space-borne measurement of floods will certainly increase with future missions and better spatio-temporal resolution, but for the time being, the near-daily satellite passes is insufficient for estimating peak flows associated with flash floods.

Another option for collecting data about flash flooding involves surveys. Many operational weather agencies, such as the US National Weather Service, regularly collect spotter reports of flash flooding and publish them annually in the National Climatic Data Center's *Storm Data* report. The intent of these observations is to validate warnings, most of which span an entire county on the order of 1000 km^2, issued by local forecast offices. In this sense, they are conditioned on the issuing of a warning, include no null reports, and as such are insufficient to describe the climatology of flash floods.

We need to build on Gaume and Borga's recommendations by introducing novel methods to improve our understanding of the spatial and temporal characteristics of flash floods, ultimately leading to flash flood climatologies, and also by gathering social science data in surveys to gain a more comprehensive understanding of flash floods. When posing data needs of flash flood observations, *societal impacts* must be assessed. We reinforce recent calls for an end-to-end approach to assure that we learn as much as possible about the physical and human impacts of flash floods (Ruin *et al*., 2008). New methods need to be broadly used, such as conducting interviews after flash floods and cognitive mapping exercises where people are asked to map their perceptions of vulnerability along roads. By contacting people affected by flash floods through telephone or internet surveys we can learn more about the human as well as the physical impacts. Eyewitness accounts fill in gaps where there are no instruments to detect flooding, and they provide more complete and richer pictures of all aspects of flash floods.

We call on researchers, national weather services, emergency management agencies, local governments, and others to develop coordinated data collection strategies for flash floods that consider physical, societal, and process impacts in the questionnaires. These survey-based databases could greatly expand our knowledge of the temporal and spatial characteristics of flash floods, ultimately leading to global climatologies of flash floods.

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