SHORT-RANGE AND NOWCASTING-SCALE FLOOD PREDICTION

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ABSTRACT

This paper presents some of the areas that are being studied at IBM Research as part of the implementation of a scalable flood prediction tool, which is expected to deliver short-range forecasts and to provide means for validating and processing the data required to deliver such predictions as well as nowcasting.

1. INTRODUCTION

IBM Research is developing a flood prediction tool which digests quantitative precipitation estimates (QPEs), which may originate from instrumentation such as high-resolution weather radars or the output of numerical weather prediction (NWP) codes. The QPE is used as an input to a numerical kernel that calculates and routes the runoff on a digital elevation model (DEM). The prediction needs to be calibrated against the observed water heights in the areas affected by the storm, which may be identified from different sources. Preliminary evaluations of these techniques has been made operationally in the city of Rio de Janeiro (Brazil) [MELLO] [TREINISH]. That approach is being improved to support more general flood forecasting applications.

2. FLOOD MODELS AND THEIR INPUT

High-resolution radars are typically able to observe current atmospheric conditions in the range of a few hundred kilometers, depending on their power and siting such as local topography, obstructions like buildings and wind turbines, etc. State-of-the-art systems provide high resolution volume scans of reflectivity, which can be used to estimate the total mass of liquid after proper calibration. Empirical models like the reflectivity to rainfall relationship are commonly used, such as $Z=aR^b$, where Z is the reflectivity factor (mm^{-6}/m^3), R is the rainfall intensity (mm/hr) and a and b are empirical coefficients. [DOVIAK]

Even with high quality QPEs from radar and a dense mesonet of surface observations, there can be a large gap to enable consistent input with DEMs of the O(1m) resolution. Similarly, the ability to calibrate the flood model with streamflow measurements at such scale may not be feasible. Hence, alternative or proxy data sources need to be identified and evaluated. For instance, the popularity of social networks and surveillance systems provided by government agencies are potential sources of qualitative information. The task of processing data from such systems can be automated by delegating it to text mining software which operates on live streams and on the results returned by special web crawlers. Flood levels can be estimated through the analysis of videos and still image data during and after significant storms.

The conditions of surface runoff, driven mostly by land/vegetation properties and by a soil model, can be modeled with a probability distribution [MOORE]. Consider ARNO, for example [TODINI]. It has two components: a soil moisture balance, derived from the Xinanjiang model [REN-JUN] and augmented with drainage and percolation losses in the moisture balance, and a component which does the transfer of runoff to the outlet of the basin.

Interest in determining potential landslides in short-range forecasts (up to 12 hours) and nowcasting (between 0-2 hours) can be achieved via specialization, given that some elements from the soil model such as evapotranspiration have a very small role on such a small time scale, especially for flash floods driven by high rates of precipitation. However, such elements are still relevant for longer range forecasts (i.e.: beyond 12 hours).

The development of techniques to model river flow is also essential for many cities. Stream networks provide quick conduits to transport flood water and the lack of capacity could cause flooding in the surrounding areas. High-resolution DEM data can be used to extract the characteristics of river streams. A fully dynamic routing method can be applied to provide detailed information on the river stage, with the benefit that it can accurately capture the backwater phenomena due to tidal effects, which could be an important factor in coastal areas. [LIU]

3. APPLICATION

The aforementioned approaches are being used for improving a flood prediction model and will be evaluated for the city of Rio de Janeiro. These will also be applied in parallel for predicting floods in the country of Brunei Darussalam, located in the Borneo island.

The observing infrastructure of Brunei includes a dual-polarization Doppler weather radar system which has the ability to provide QPEs in near real time for use in potential nowcasting applications. However, the radar still requires calibration to ensure that the QPEs are reliable. In addition, Brunei has a network of rain gauges with sufficiently dense coverage and good spatial distribution across the country. The data from these gauges can potentially be used for the calibration.
With an observing and prediction infrastructure in place, a scalable mechanism to deliver short-range flood predictions and nowcasting is feasible.

4. REFERENCES

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