Dynamically-coupled hydrologic-hydrodynamic modeling in data-poor regions

A SWOT-ready model

(NASA JPL/Caltech, PNNL, University of Bristol)

Guy.J.Schumann@jpl.nasa.gov
Flooding is one of the most devastating natural disasters

- Floods are regular and devastating in many regions
  - Exposure of people, infrastructures, crops, habitats,...
  - Flood risk, food/crop security, health issues, ecosystem services sustainability,...

Mozambique is known to be a flood-prone country (hotspot region)
- >130,000 people evacuated and >30 people killed (2007 event, modeled here)
- Food security at risk (regular flooding of crops)
- Water supply infrastructure under-developed / unsustainable due to devastating floods (e.g. 2000 event)

Proposed way forward in terms of science

- Short-to-long term flood modeling/forecasting, esp. over large domains in data-sparse regions (UN WFP hot spot zones)
- Such a model, if ultimately rolled out globally, would be highly valuable to the SWOT mission (and many other missions)
- Could be used to generate a whole suite of highly useful SWOT mission spin-off products

What we have (for the Mozambique Delta)

- Designed a flood model for large scale applications to forecast inundation extent, level and wave propagation (utilizes globally available input & boundary data sets; no gauge or any other field data available)
- Calibrated and evaluated on a 700 km stretch of the Zambezi River in SE Africa (Mozambique delta). Cal. against altimetry water level: 27 cm RMSE. Val. against Landsat flood: 86%
A first large-scale flood inundation forecasting model

G. J.-P. Schumann,1,2 J. C. Neal,1 N. Voisin,3 K. M. Andreadis,2 F. Pappenberger,4,5 N. Phanthuwongpakdee,6 A. C. Hall,1 and P. D. Bates1,7
Hydrologic Model (cal/forecast)

**Calibration**

- VIC + routing model
- Simulated flow calibrated with GRDC at Matundo-Cals (1976-79; post-dam period) and verified at other locations and over different periods with naturalized observed long-term mean monthly flow climatology

**Ensemble flow forecast system**

1) Derivation of initial conditions; near real-time nowcast

- ECMWF Analysis temperature and wind + TMPA precipitation (satellite obs adjusted for gage gridded obs)
- VIC + routing model
- Hydrological initial conditions and upstream flow contribution

2) Flow forecasts

- ECMWF temperature and wind ensemble forecasts, ECMWF ensemble precipitation forecasts adjusted with respect to TMPA, i.e. gage based gridded obs
- VIC + routing model
- Ensemble flow forecasts at Chiromo and Tete

Consistent meteorological forcing throughout the forecast system
Hydraulic Model (2007 event)

Simulates/predicts the variables that SWOT will see and many more
• Demonstrated a first complete modeling system including inundation dynamics simulation/forecasting

• Satellite data already added (TRMM, Landsat, ICESat) and will add great value (SMAP & SWOT future potential)

• Follow-on work will develop a more extensive hydrology model (including dams, reservoirs & wetlands) and also full dynamic coupling between VIC-WM (water resources model)-LISFLOOD-FP

• We will also use assimilation of existing/future satellite products (ICESat-1, -2 altimetry, radar altimetry, SMAP & SWOT)
• Between VIC-LISFLOOD-FP-WRM (submitted THP proposal)
  – VIC: hydrology model (handles hydrological processes operating in a basin)
  – LISFLOOD-FP: hydrodynamic model (handles flood wave behavior in channels and water flow across floodplains)
  – WM: water management model (handles water abstraction, irrigation, reservoir links, etc.)

• General idea: there is useful information in all model components that, if these were fully dynamically coupled, can stream seamlessly between components and improve model output
• Such a fully coupled model would be better suited to accommodate SWOT measurements via assimilation or other model-data integration techniques than existing models to date

• Hydrodynamic variables (inundation depths, area, contours, volume, etc.) will be output at a sensible 1 km resolution but can be downscaled to a more SWOT-friendly resolution (using SRTM in data-poor areas either to a 90 m version or even a 30 m version since these will be SRTM-derived outputs)