SWOT and hydrodynamic modelling
Flooding as a global problem

- According to UNESCO in 2004 floods caused …..
  - ~7k deaths
  - affected ~116M people
  - 7.5Bn USD of damages
- Flooding is the major natural hazard worldwide
  - 107 out of 305 UNESCO-listed natural disasters in 2004 were floods
  - Always the largest category each year
Flood dynamics

• Large low amplitude waves
  – 1-1000km in length
  – <1 hour to 6 months duration
  – Low slope 1-100cm km\(^{-1}\)
  – Gradually varied flow
  – Above bankfull stage waves spread in 2D over floodplains
  – Complex shallow water inundation dynamics
  – Major control on wetland biogeochemistry and carbon cycling
Hydrodynamic models

- Principal tool for assessing flood risk
- Provide dynamic predictions of water depth and velocity
  - Horizontal scales of ~1-1000 m
  - Temporal scales of ~1-60 s over events lasting up to 1 year
  - Domain sizes of ~1-100,000 km²
  - Can be 1, 2 or 3 dimensional (but consensus that floodplain inundation is at least a 2D process)
Model data needs

- Boundary conditions
  - Discharge and stage at river gauging stations

- Topography
  - Ideally LiDAR (<10m spatial resolution, <10cm rmse vertical accuracy), but can also use SRTM for large rivers

- Calibration/validation data
  - Measurements of water height and flood extent
  - Used to calibrate model friction parameters
Current measurements of surface water dynamics

- Limited to:
  - Point gauging stations
  - Very small numbers of consistent inundation images
  - Satellite altimetry (=gauges)
Data limitations to modelling

• When we have distributed cal/val data we can do great modelling

• But …..
  – Existing gauges only test bulk flow routing
    • Allows modellers to ‘get away with’ 1D codes
  – We only have data to test 2D model performance at ~10-15 sites globally
    • Even here often only 1 flood extent image per event
    • Doesn’t allow us to test 2D model dynamics
  – Lack of sufficient cal/val data means that many flood models suffer from high uncertainty
Carlisle, UK – 10m model vs. ground survey

RMSE on water depth = 0.32 m
Upton on Severn, UK – 18m model vs airborne SAR

Model fit = 89%
What data do we want?

• Must have ....
  – Flood images at $O(1-2)$ more sites than we currently have
    • Need flood extent at $\sim 100$m or less
    • Water elevations to centimeter level accuracy
    • Will make 2D modelling routine globally
  – For a smaller number of sites we need multiple SWOT images through events
    • Test model dynamic predictions
    • Will lead to the development of better modelling tools

• Would be nice
  – Discharge measurements in ungauged rivers accurate to $\pm 25\%$
  – Better global floodplain terrain data
    • SRTM is all we have, but this has $\sim 5$m scale vertical noise at 3 arc-second resolution
    • Ideally need a global floodplain DEM with decimeter scale vertical errors
Will SWOT do this?

Yes

– Don’t need to image all floods, just a sufficient number
– Dealing with whole river reaches (10-1000km) so exact orbit repeat may not be necessary to image a single flood multiple times
– Pixel size and water height/slope accuracy within specification
– Can recover discharge for ungauged rivers
– Better floodplain terrain data may be a fantastic side product of the mission
  • But may incur additional processing costs
Hydrodynamic modelling – key message

• Routine application of hydrodynamic models appropriate to simulating floodplain inundation is currently prevented by a lack of observed 2D flood extent and water height data that can be used to calibrate such schemes. SWOT will provide these data and allow a step change in our ability to model floods.