BADAN INFORMASI GEOSPASIAL

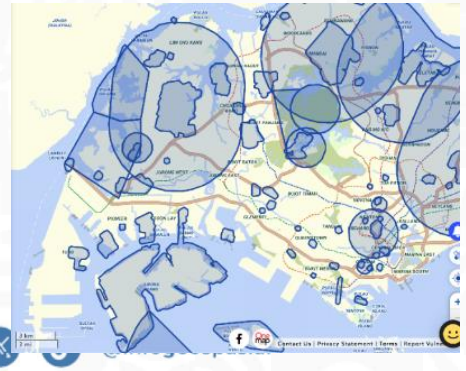
Gathering and using data for coastal flood models – datums, models and resolution.

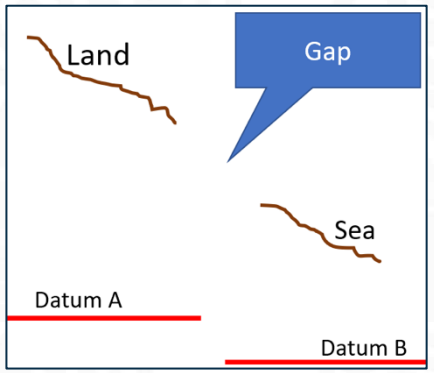
UN GGCE International Workshop (Bogor, Indonesia)
3 December 2024

Dr. Ooi SK, TMSI, National University of Singapore.

Need and challenges

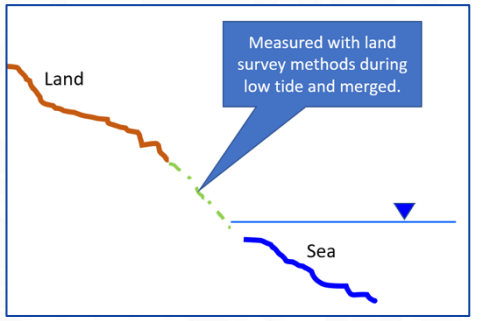
- The need …
  - Rising sea levels, potential of land subsidence
  - Increasing risk of pluvial as compared to fluvial flooding.
  - Intense storms → waves (coupled with ship wakes in heavy marine traffic areas)
- Nearshore topography / bathymetry data becomes even more important
  - A key parameter that influences nearshore (shallow-water) wave evolution
  - Needed for engineering design of coastal protection structures
  - Required to assess combined flooding (coastal and rain-induced)
- Challenges (some are local):
  - Equipment data resolution in the different domains
  - No entry (fly / sail) zones
  - Datums and timing of data collection
  - Are models able to utilize the data?



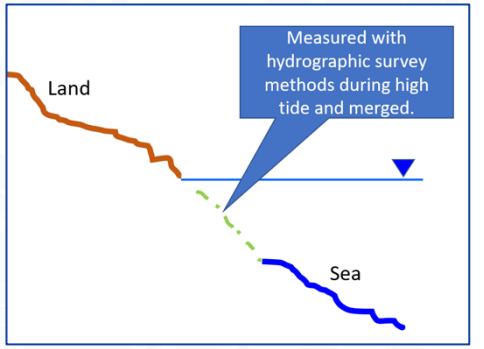


Present state of data gathering

- Some typical data gathering methods to gather data at this gap location include:
  - Extending land survey methods towards the sea at extreme low tides
  - At some locations it's possible to extend hydrographic survey methods towards the shore at high tides.
  - Typically there will be some gaps.



- To minimize these gaps will require both methods to be carried out. But this may result in different timing of the surveys and could potentially result in large differences in the measurements if:
  - The inter-tidal area has sediment with characteristics that allow it to become easily mobile
  - The data gathering windows for both methods are separated over a large period of time particularly if they are separated by a spring or a neap tide. There is a potential for more bed sediment movement during spring tides due to the slightly higher tidal velocities in that period and longer time window for wave action to mobilize the bed during neap tides, as the tidal range is smaller in that period.

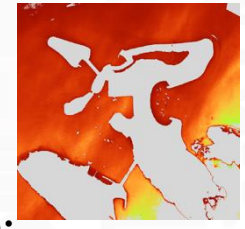


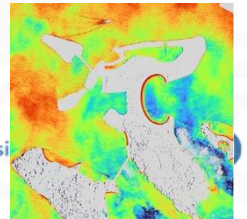
Approach

- Multi-modal instrumentation:
  - Conventional Approach:
    - Survey + LiDAR on land;
    - Vessel / USV with MBES

  - Multi-sensor shallow-draft Unmanned Surface Vessel (USV)
    - Purchased USV with LiDAR and Single Beam Echo Sounder (SBES)

  - Aerial and Satellite (Remote Sensing)
    - Drone(s) with multi-spectral camera (RGB, R, B, G, RE, NIR, NR)
    - Multi / hyper-spectral satellite imagery e.g. Worldview-3 or equivalent (8 band minimum)





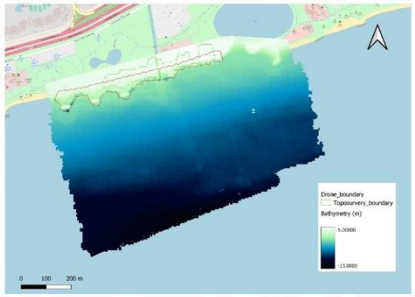
- Multiple terrain type
  - Marine clay / mud

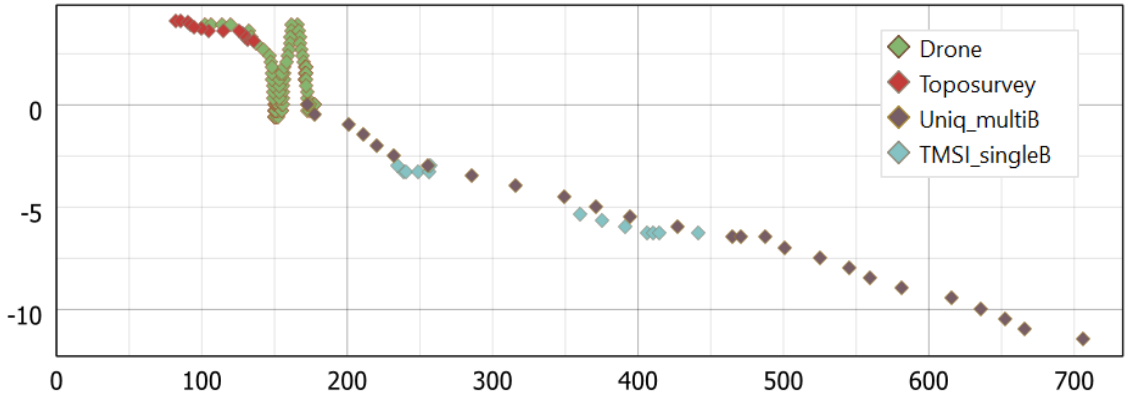
  - Sandy

  - Coastal structures

Comparison of the various methods:

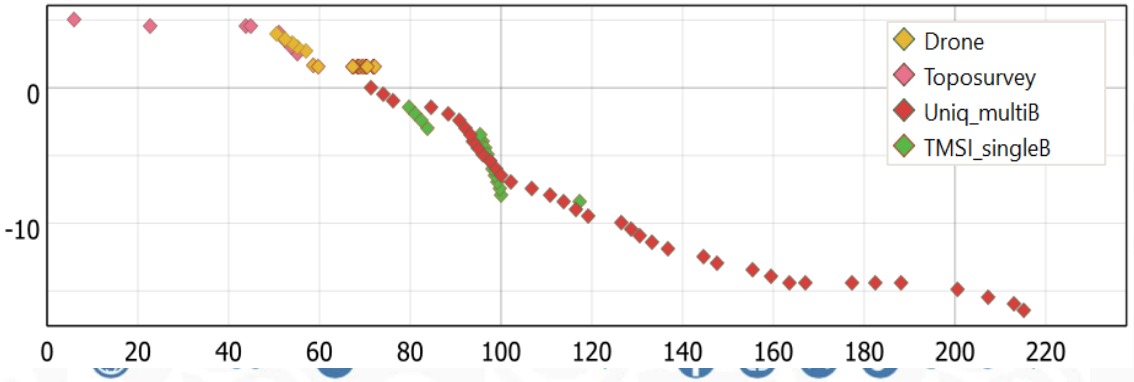
- Results at two locations:
  - ❑ ECP





- Overall the drone compares well with ground truth profile across water and land.
- USV bathy profile compares reasonably well with vessel bathy profile

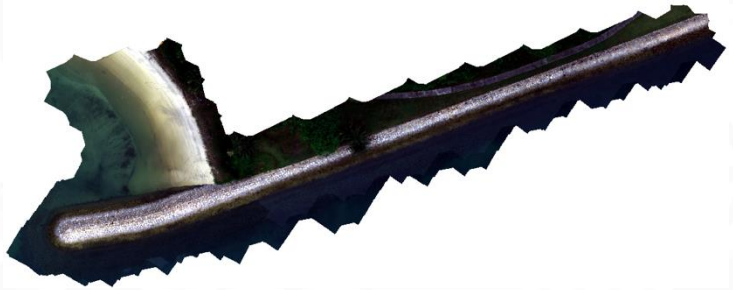
  - ❑Seringat



- Drone extract (topo+bathy) compares well with ground truth profile.
- USV bathy result compares well with ground truth.

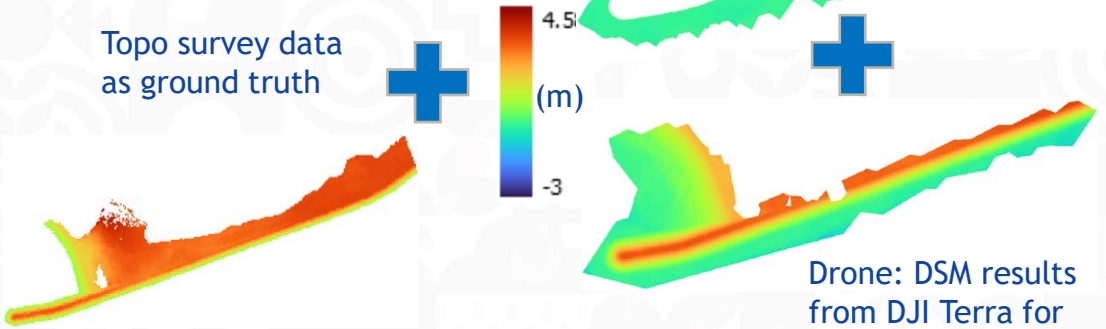
Suggested approach for shallow areas:

- Integration of drone with ground truth



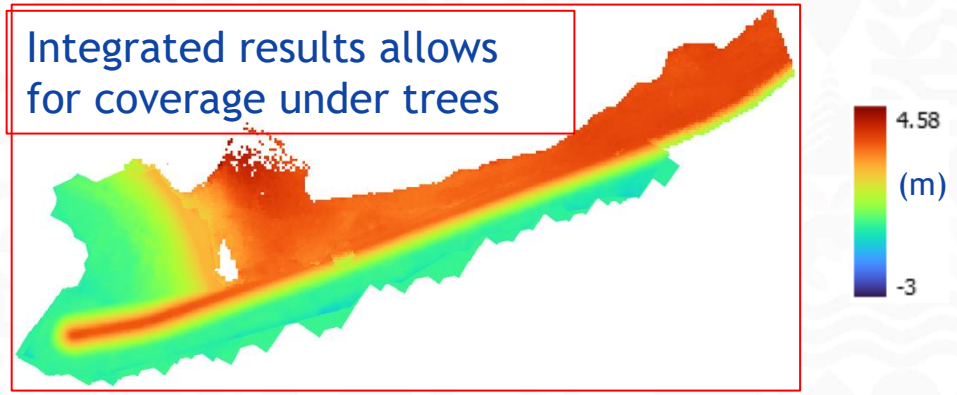
Drone: Water depth results from DJI Terra & WASI

Topo survey data as ground truth

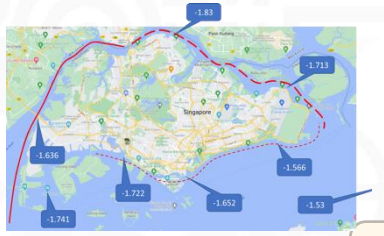


Drone: DSM results from DJI Terra for above water elevations

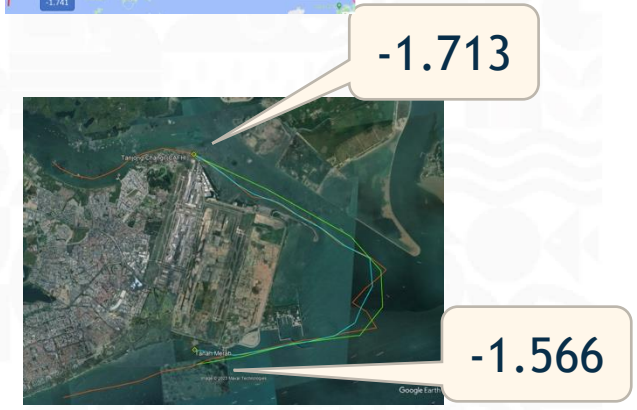
Integrated results allows for coverage under trees



Datum integration for models –Potential solutions?

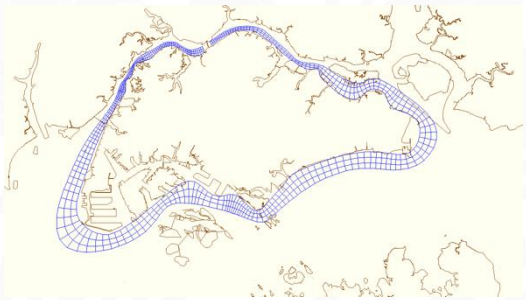


- Present method (in Singapore):
  - Utilize a single value for conversion provided by MPA based on location, date and need
- Based on the data and methods, there are at least two alternatives:
  - Island-focused.
    - Linear interpolation between stations which can be converted to one based on splines / curves at complicated areas as shown in this picture:
    - This spline interpolation can be further extended as shown here through a gridded interpolation method to a limited distance off the main island. This method has issues as our offshore islands have different SHD-CD differences at the same gridded distance away from main island.



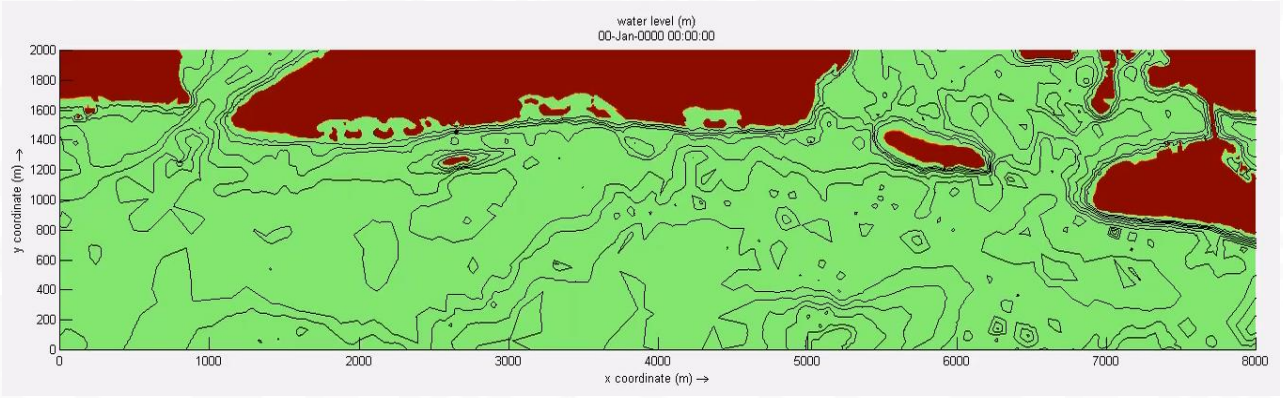
  - Domain-focused.
    - Extend the SGeoid09 of SLA to create a surface that extends through all the known points and interpolate from that surface.
    - Requires transfer of both **mean sea level and tidal range** to all offshore islands before this can be properly utilized.

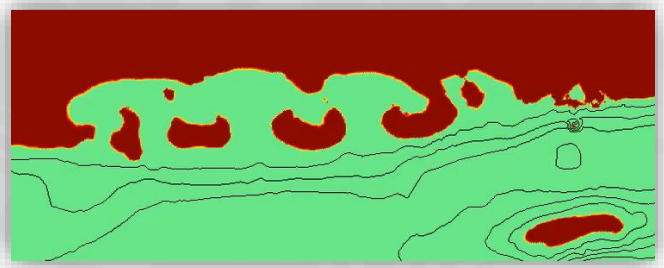
A form of this is used by UKHO

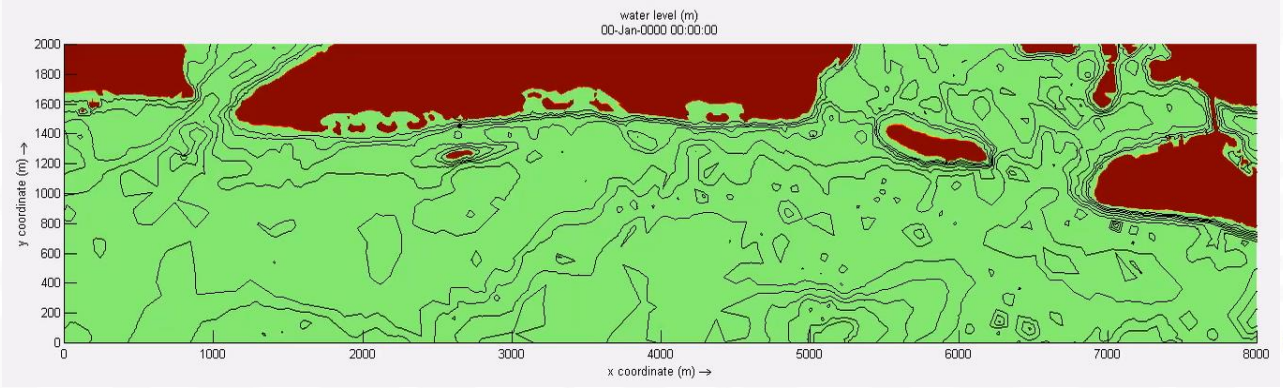


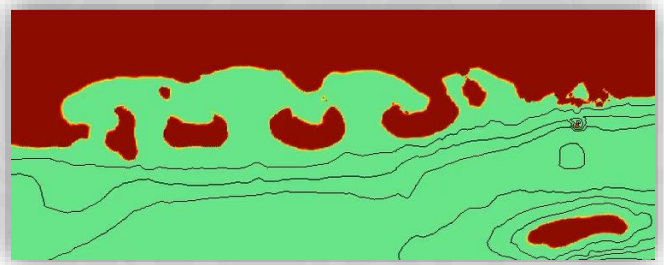
Applications for models - coastal

- Can we utilize high resolution topo/bathy data in the coastal areas and do we always need them?



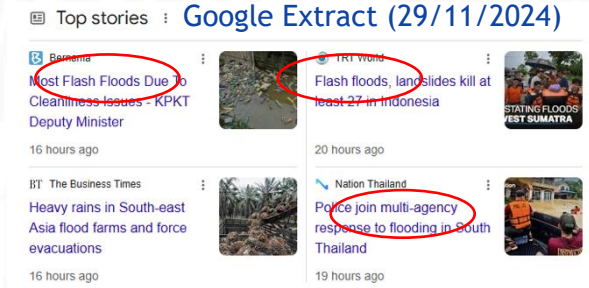






Application for models – rain induced

- What about rain-induced flooding?
  - Most flooding models tend to be based on fluvial flooding concepts.
    - Rain is collected at points in the model domain.
    - Pushed to the river or drain at some location.
    - Only when the river or drain is full then only does the DEM come into play.
  - This means they don't actually model how water gets into the drains which is the issue that impacts a lot of our situations now.
  - There are some models that challenge the traditional model paradigm (next 2 slides).

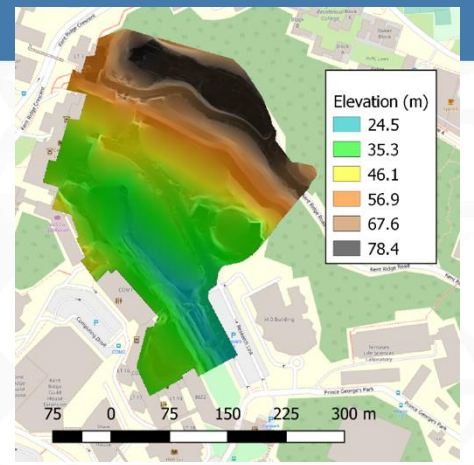


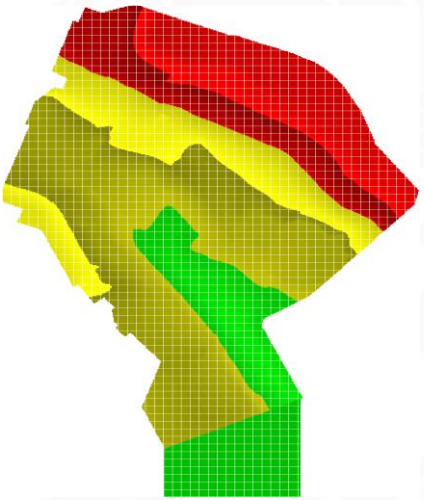
51% of average November rain in 2.5 hours. (127.7 mm)

Youtube Image Extract (22/11/2024)

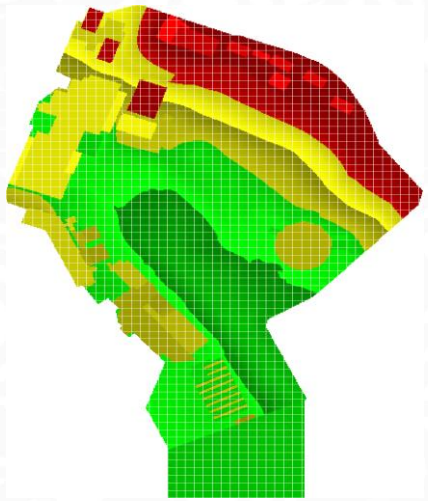
High resolution pluvial flood model

- Model only uses the DEM; 2D calculations only.

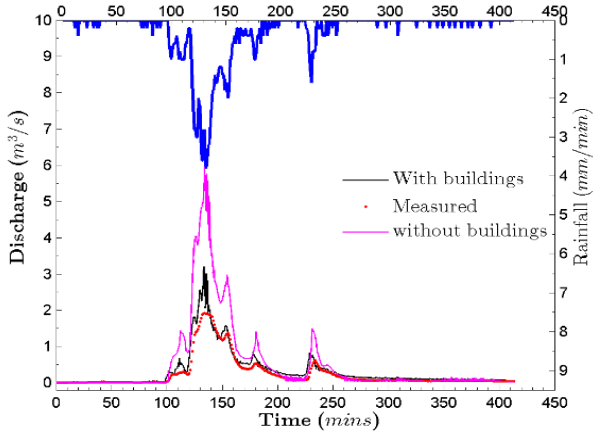


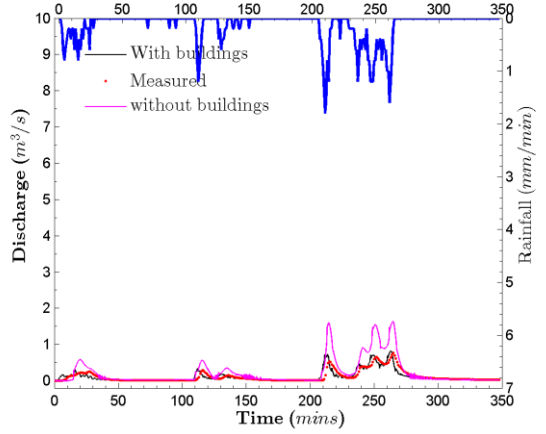


Just DEM



DEM with Buildings



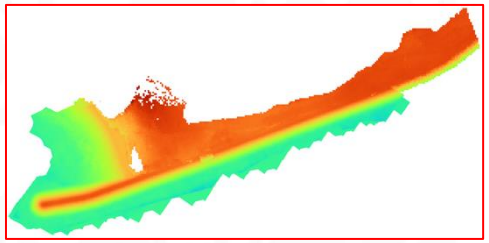


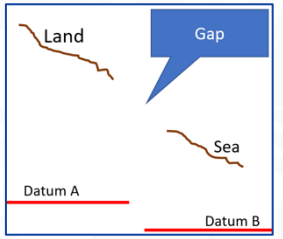
Purely 2D grid with
relatively coarse grid size
(dx = 8 m)

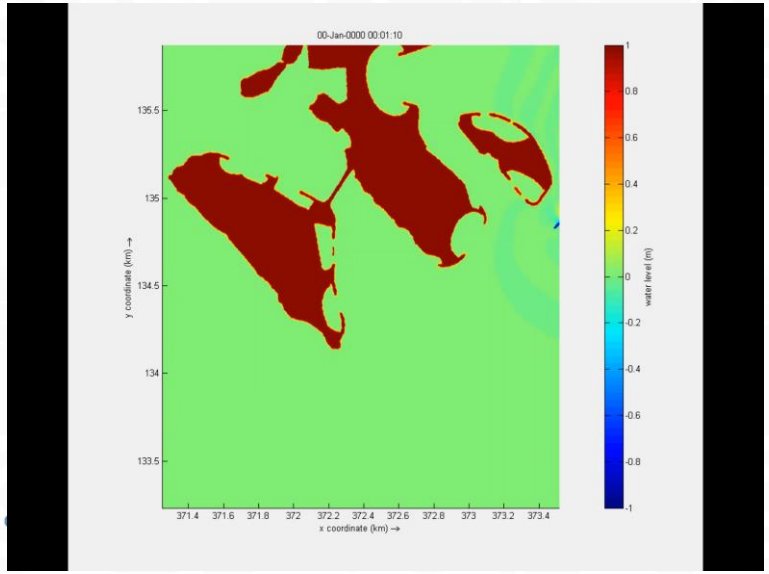
2D only results → Very good!
Obstructions matter!
→ Hydraulically relevant DEM surface required.

A possible outcome:

- To use such high resolution data properly we need:
  - To collect and integrate data across the vertical plane efficiently
  - To efficiently integrate the datums (land and sea)
  - To generate hydraulically appropriate surface from the data
  - To continue developing models that can efficiently use the data







BADAN INFORMASI GEOSPASIAL

THANK YOU!