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Enabling Delta Life

Simulation of flooding during Typhoon Bopha with the SFINCS model

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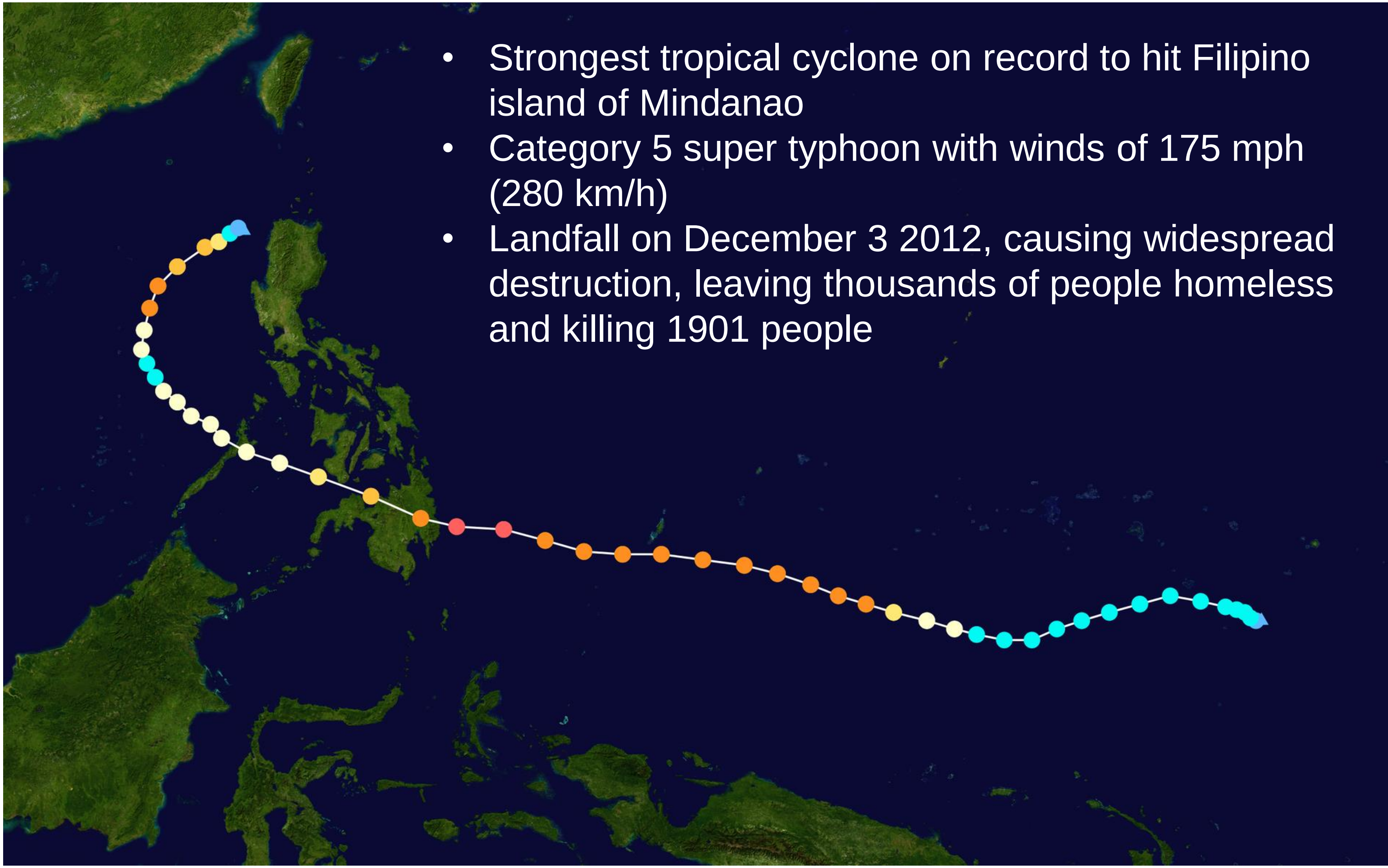
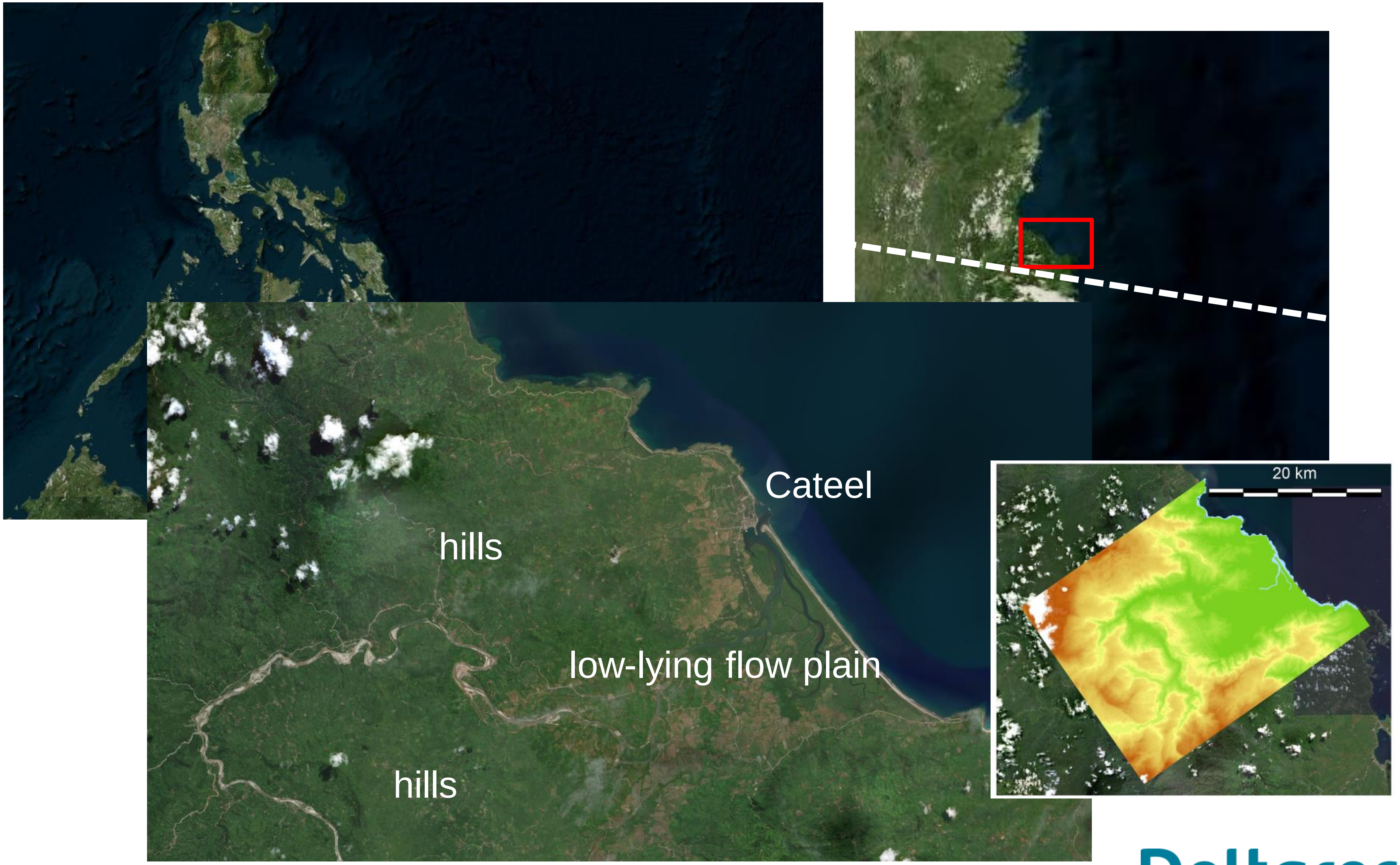
Typhoon Bopha



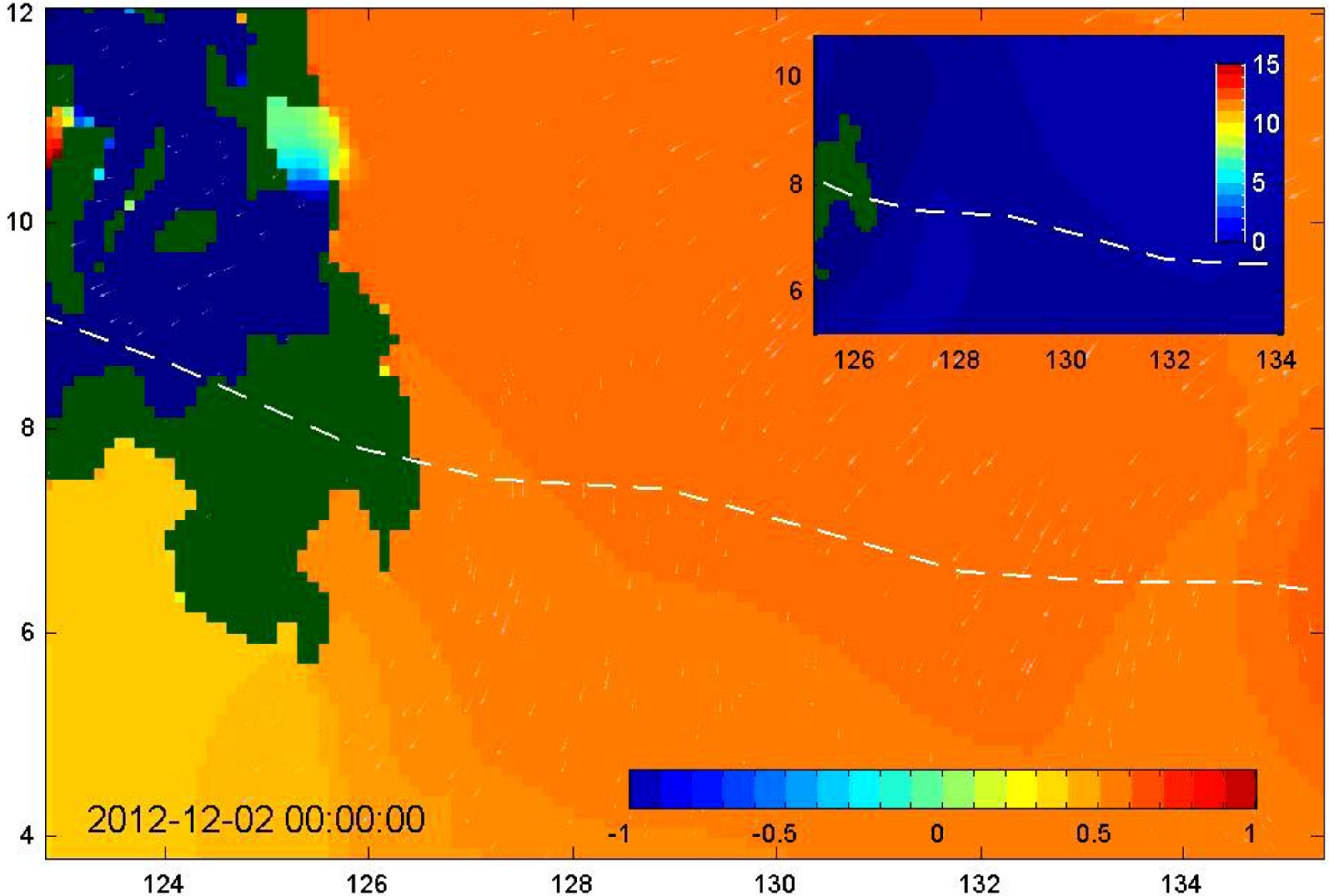
- Strongest tropical cyclone on record to hit Filipino island of Mindanao
- Category 5 super typhoon with winds of 175 mph (280 km/h)
- Landfall on December 3 2012, causing widespread destruction, leaving thousands of people homeless and killing 1901 people

Typhoon Bopha



Typhoon Bopha

Typhoon Bopha



Delft3D / SWAN

Tide + surge + waves

Storm track from JTWC

Holland (2010) parametric winds

Boundary conditions for SFINCS model

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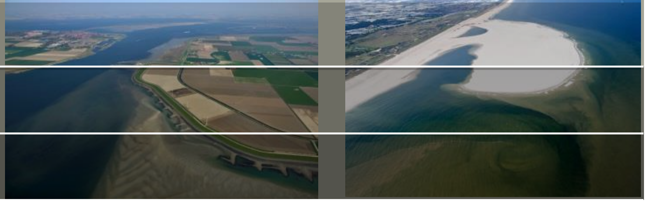
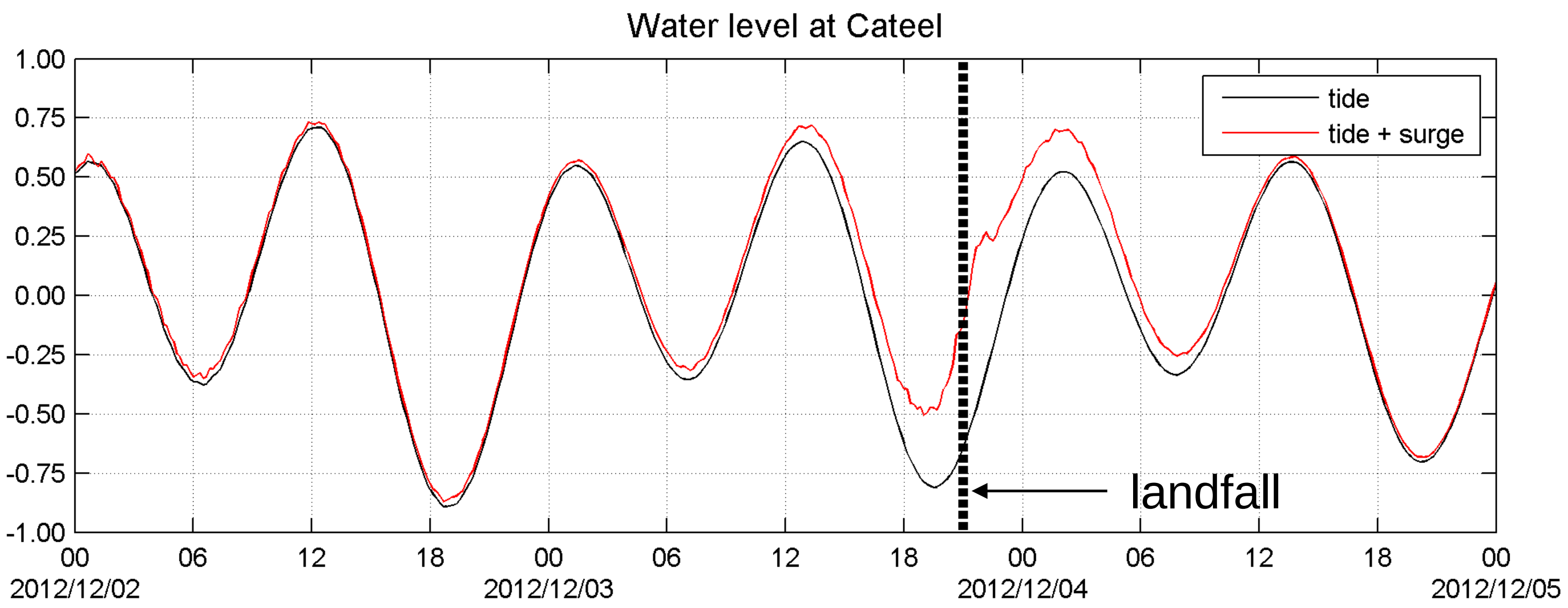
Typhoon Bopha – at Cateel





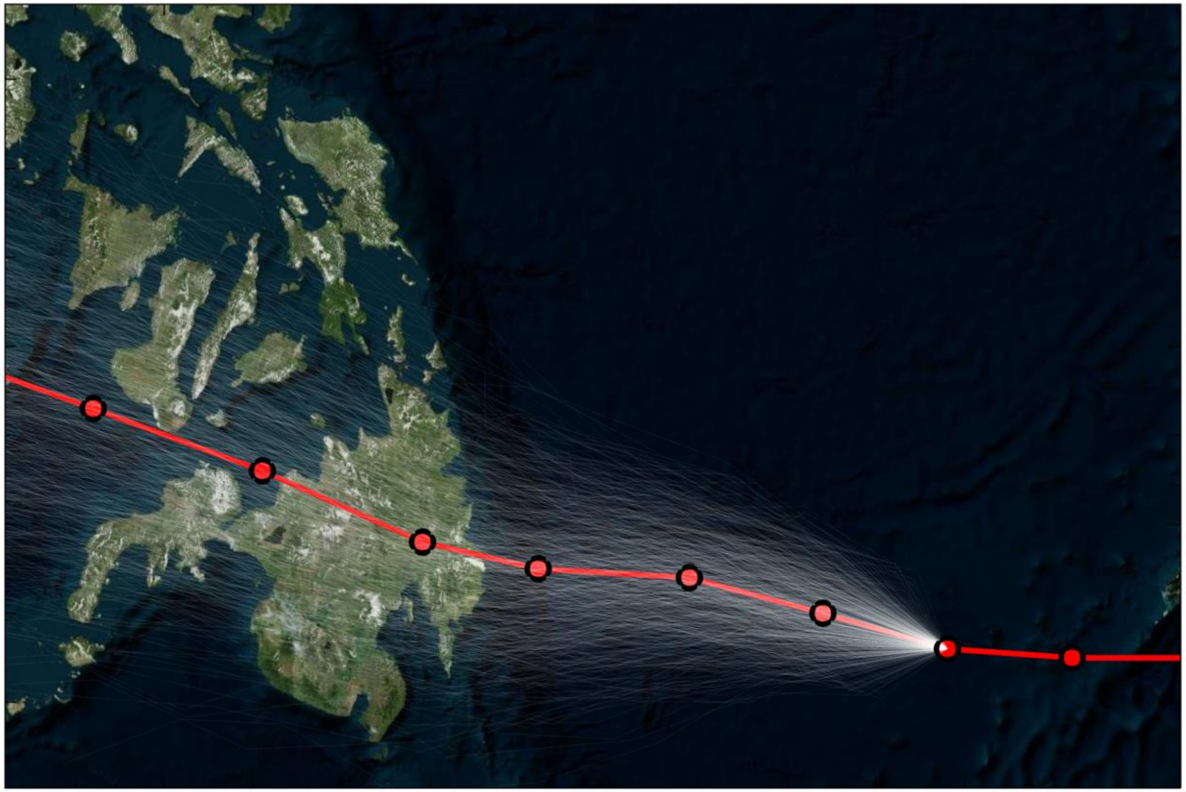
Wind set-up is limited! (no continental shelf, h>200 m just 3 km offshore)

Other processes responsible for flooding:

1. wave set-up and (infragravity) wave run-up
2. rainfall

Can existing models simulate compound flooding?

Bouss
Xbeac
Delft3I



Bathtu

SFINCS model, an attempt to overcome these limitations
(Super Fast INundation of CoastS)

SFINCS model

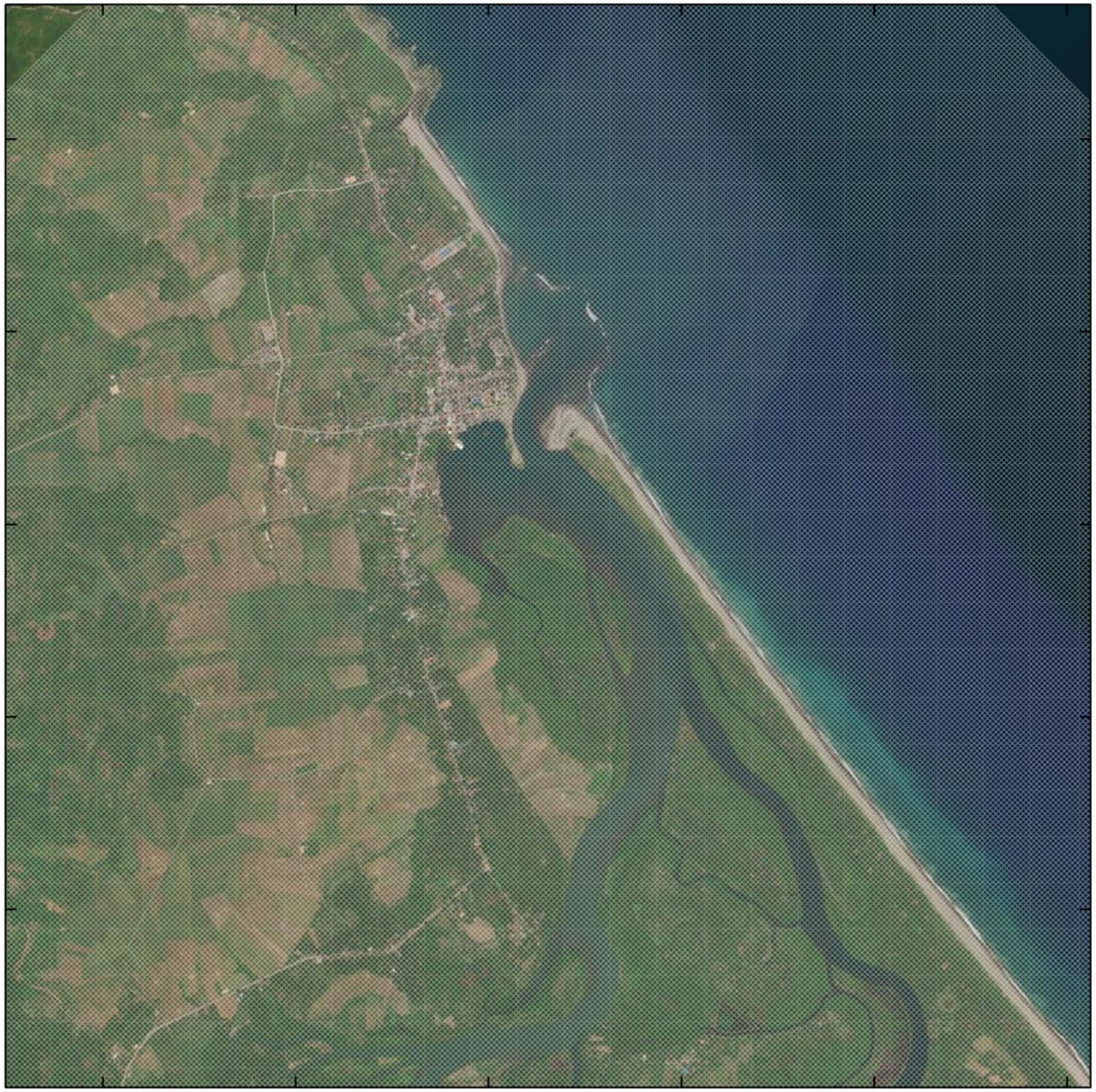
- 2D flood solver on a regular (1D or 2D) mesh
- Bates et al. (2010) i.e. LISFLOOD-FP

$$q_{t+\Delta t} = \frac{q_t - g h_t \Delta t \frac{\partial (h_t + z)}{\partial x}}{\left(1 + g h_t \Delta t n^2 q_t / h_t^{10/3}\right)}$$

- Wave set-up and (infragravity) wave run-up
  - Empirical relations using offshore waves and bottom slope
- Forced along ~2 m depth contour
- Added advection term (optional)
- Spatially and temporally varying winds
- Spatially and temporally varying rainfall

- ~ Two orders of magnitude faster than Delft3D or Xbeach !

SFINCS wave boundary conditions



SFINCS wave boundary conditions

Cut off grid to 2 m depth contour

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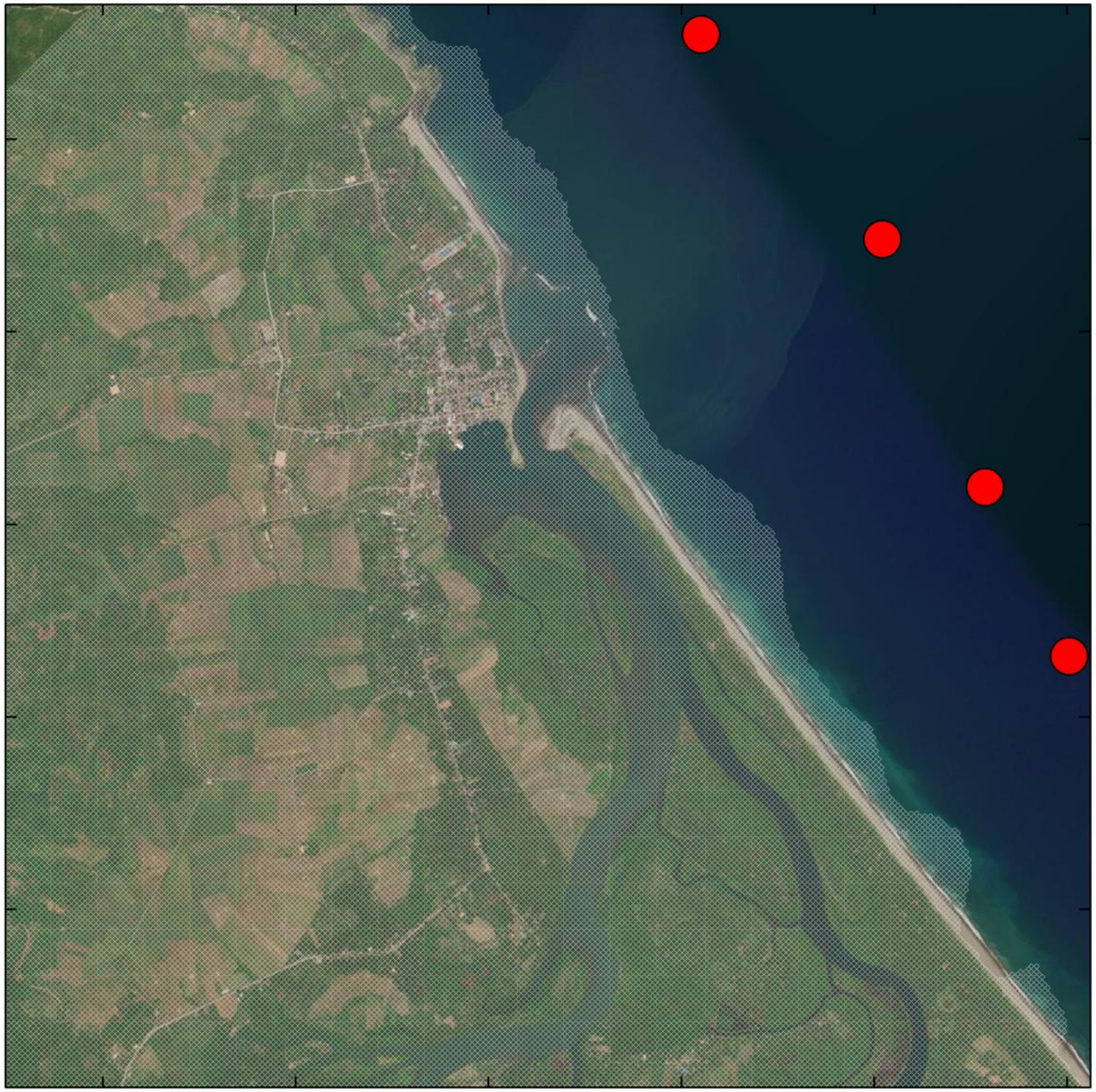
SFINCS wave boundary conditions



Deep water wave points

Time series of:

Hs

Tp

wave direction

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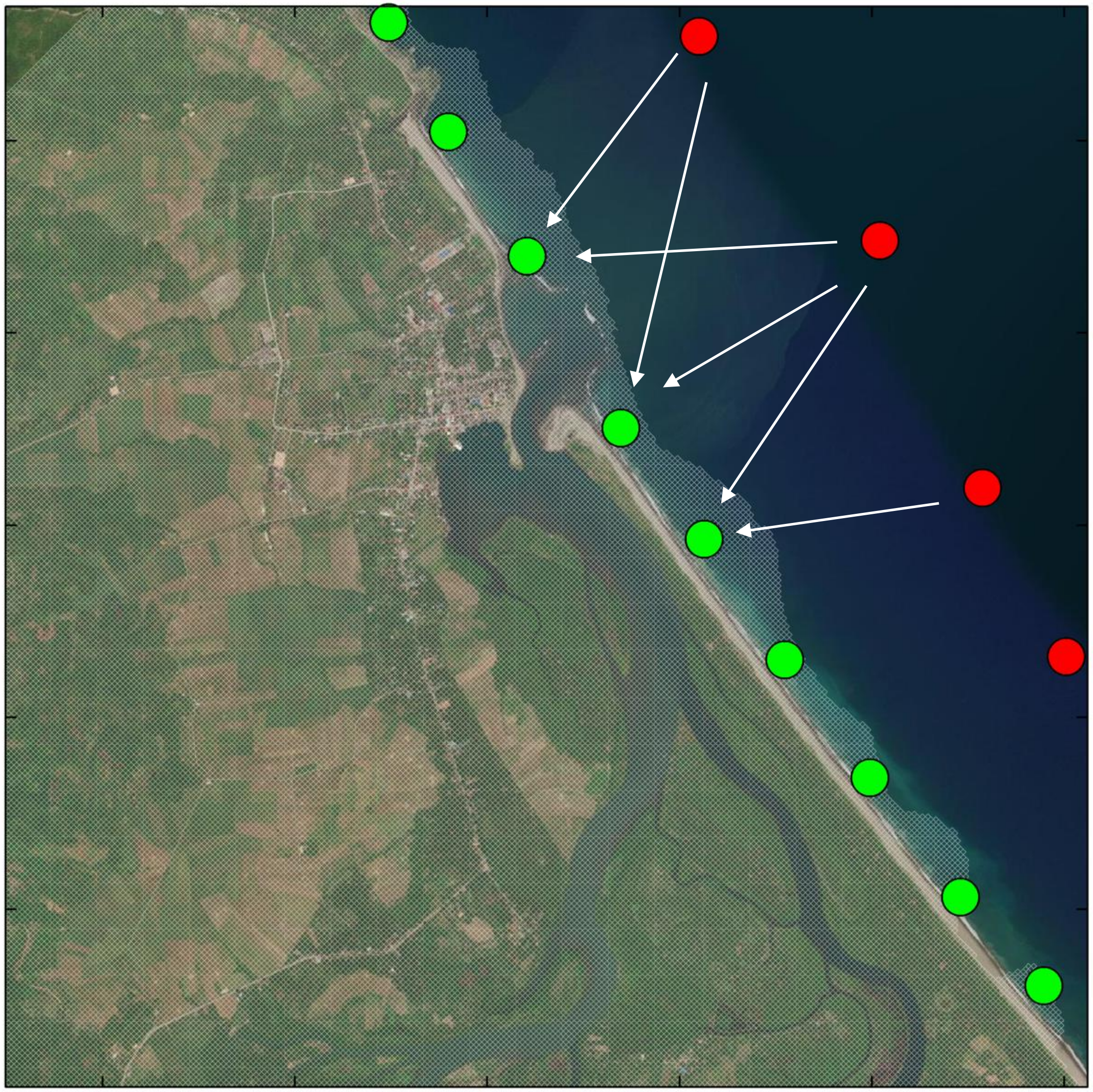
SFINCS wave boundary conditions

Coastal points

Orientation

Bottom slope

SFINCS wave boundary conditions



At the coast points:

obtain Hs, Tp, and dir

Determine:

wave set-up
(IG) wave height

using empirical relation

f(Hs, Tp, dir, slope, orientation)

WL time series at coast points

SFINCS wave boundary conditions

At all model boundary points:

Obtain WL timeseries by

interpolating

WL time series

from coast points

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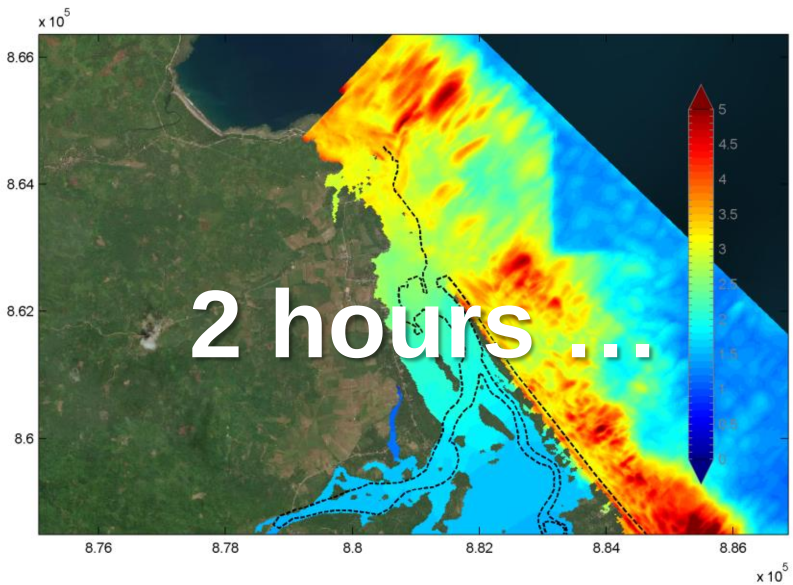
XBeach vs SFINCS

3 hours, wave boundary conditions at peak of storm

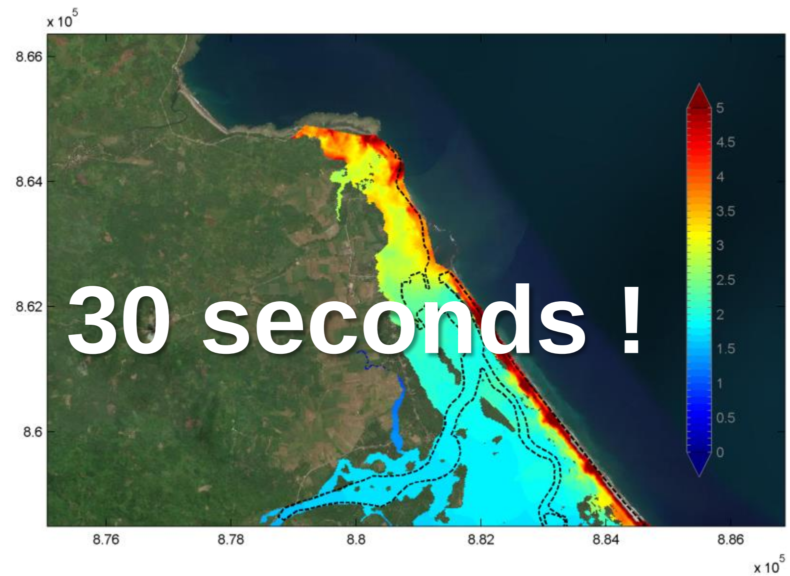
No rain, no tides, no surge

20 m grid spacing, 10 km coastline

Xbeach



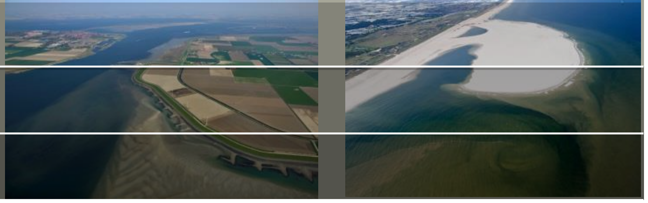
SFINCS



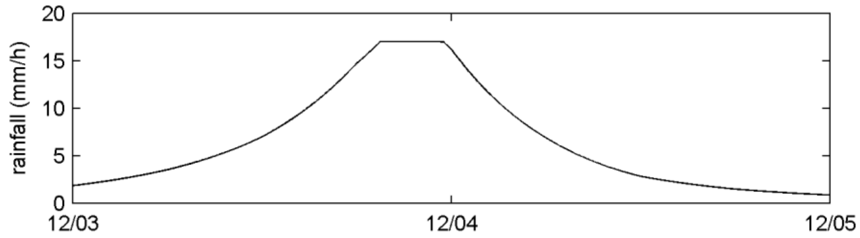
SFINCS animation

SFINCS animation

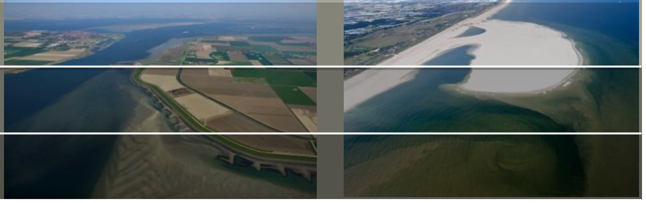
SFINCS, adding rainfall

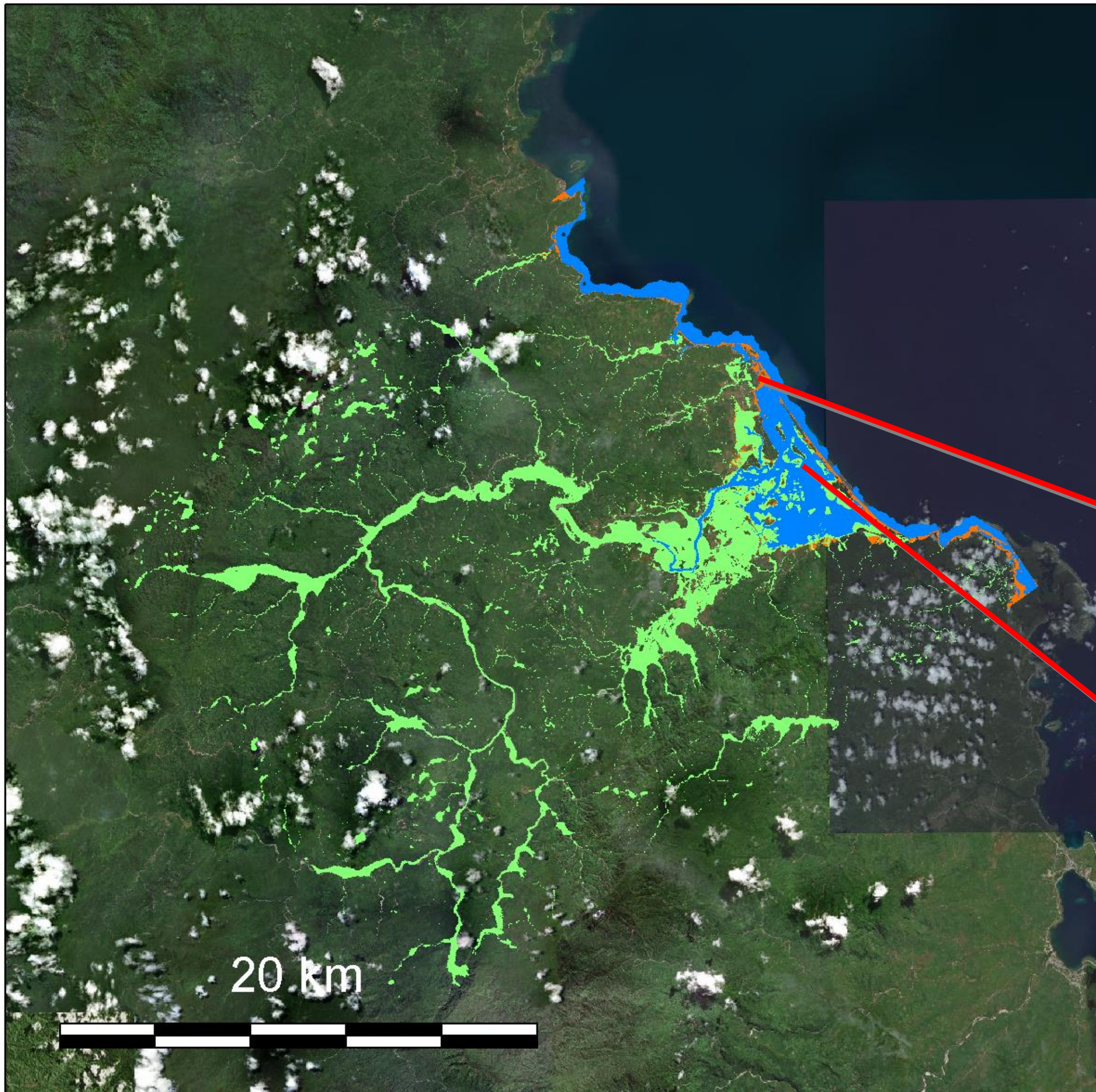


240 mm of rain fell over 48 hour period (NASA)



Effects of rain and waves

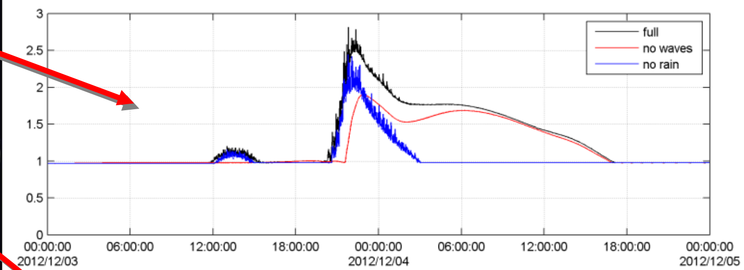


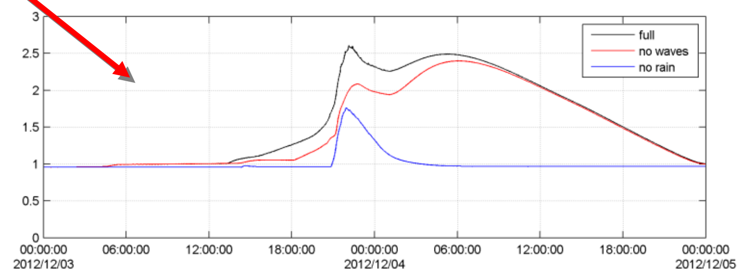


Green: only with rain

Orange: only with waves

Blue: both with rain and waves





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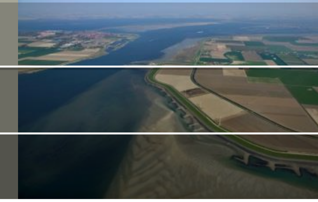
What’s next for SFINCS?



- Further testing

- Improvement of empirical relations for boundary conditions
  - e.g. for different coasts (reefs)
- Hydraulic structures
- Infiltration

- GPU
- Sub-grid approach

- Large-scale surges
- Tsunami’s?

- Paper in preparation (Leijnse, et al. ????)

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Questions?