How ocean modeling can inform coral disease management

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Modeling SCTL disease dispersal with SLIM and LPT: Florida reef tract, August 2016 to February 2017

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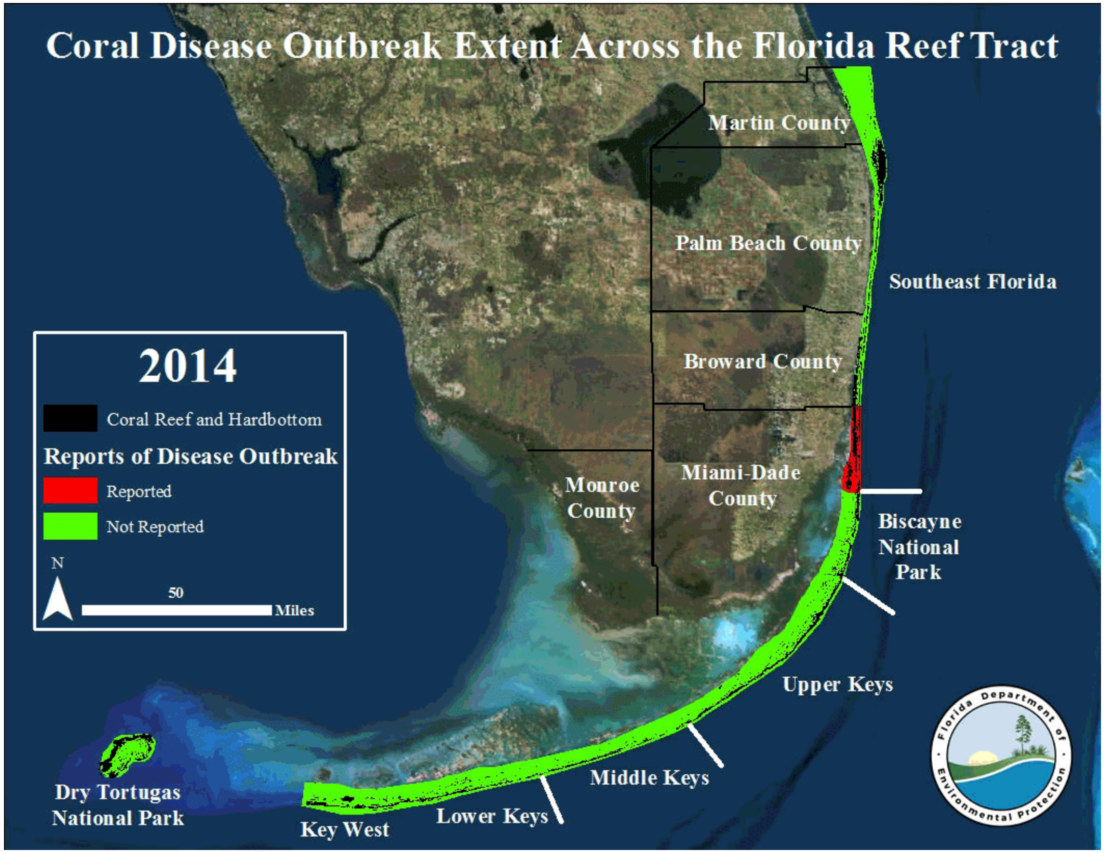
The recent outbreak has spread over more than 388 km² of Florida's reefs since 2014



Since the beginning of the outbreak, many questions remain unanswered

How does it spread ?

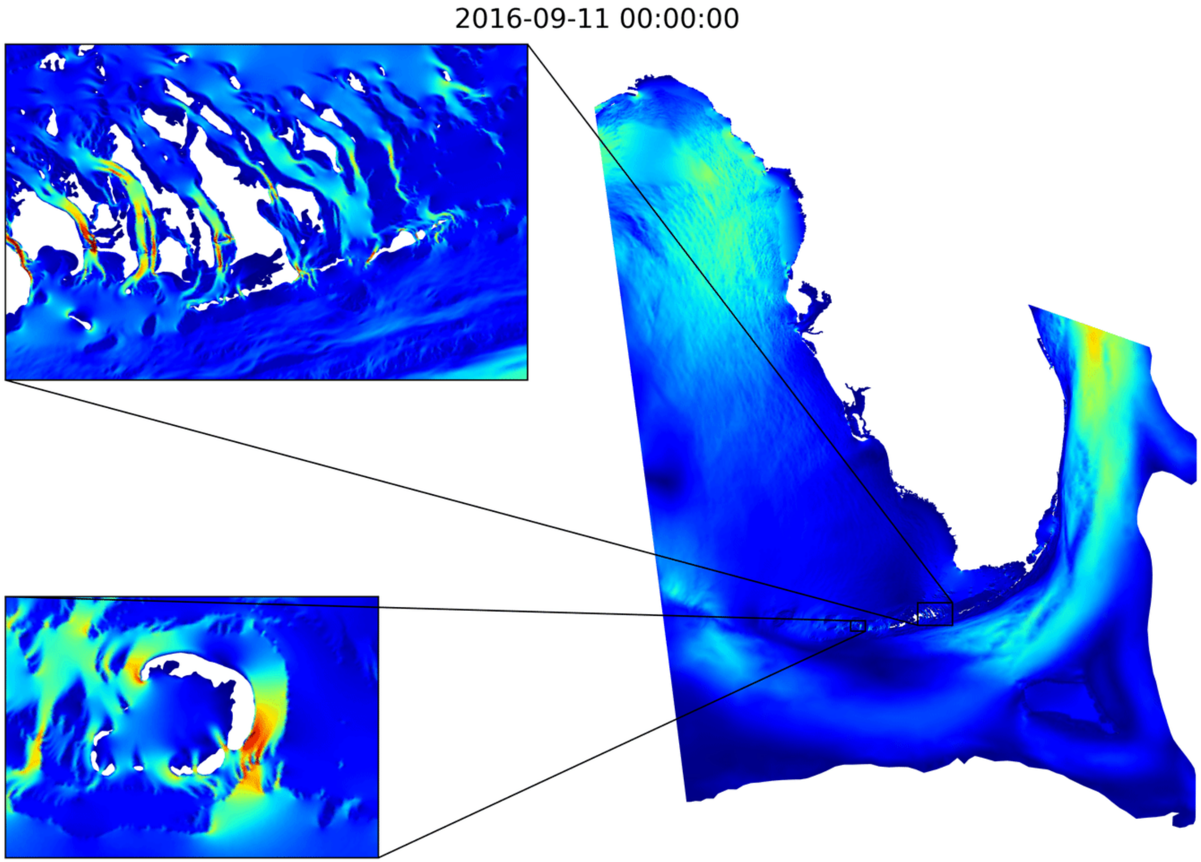
When will the remaining healthy reefs be hit ?

When will reefs experience additional exposure from disease agents due to currents ?

A biophysical ocean model can complement field studies to help answer these questions

We have coupled the high resolution ocean model SLIM with an epidemiological model for disease transmission

SLIM has a **100m** resolution near reefs and islands, about 10x higher than the finer models so far.



Models are particularly useful to test assumptions

1. Are disease agents transported within material driven by
   - Bottom currents ? (e.g. sediments, composites, demersal organisms)
   - Mean currents ? (e.g. fines, pelagic organisms)
   - Surface currents ? (e.g. mucus and surfactants)

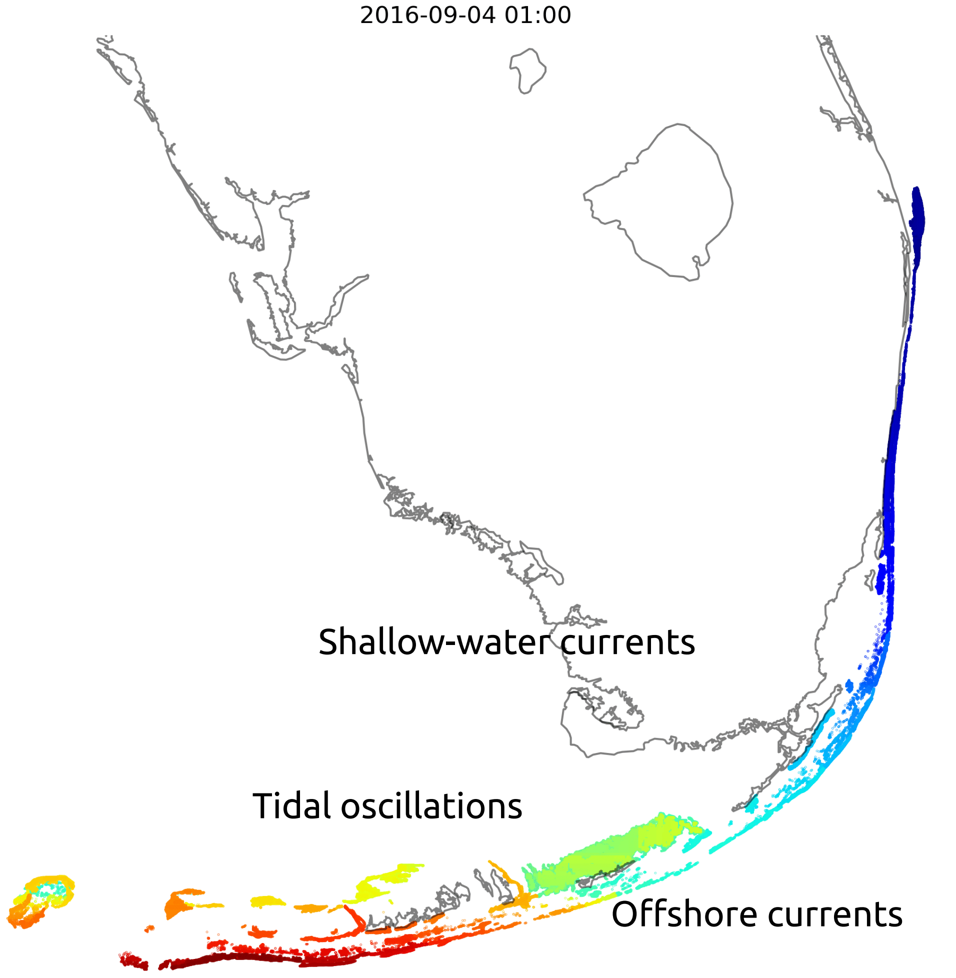
2. How fast do corals get affected once in contact with causative agent ?

SLIM currents serve as inputs for a particle tracker

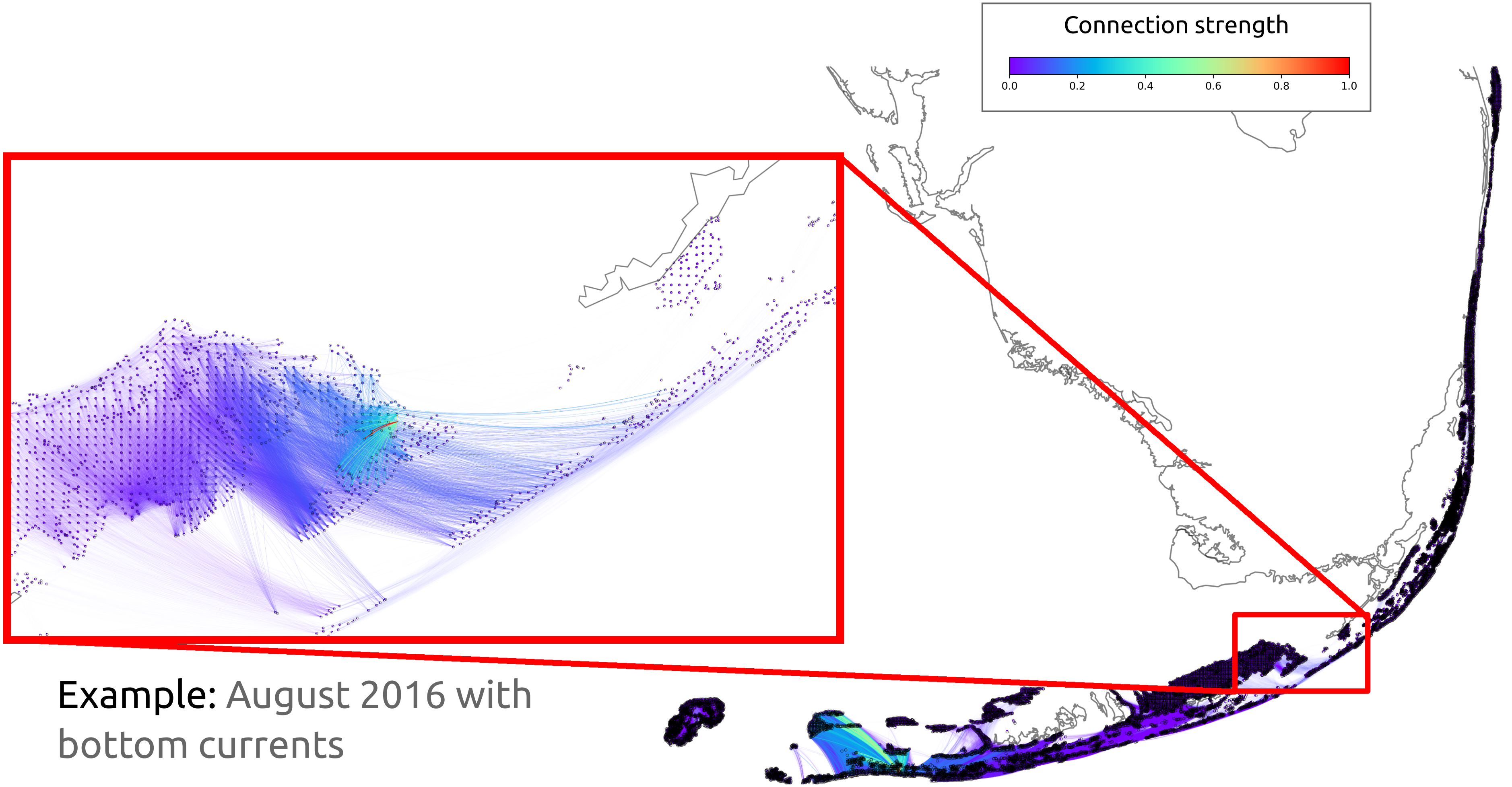
We release > 1e5 particles over all the reefs of the FRT.

When particles pass over a reef, they lose material (“mass”) on that reef.

Exchanges of material between reefs are recorded in a **connectivity matrix**.



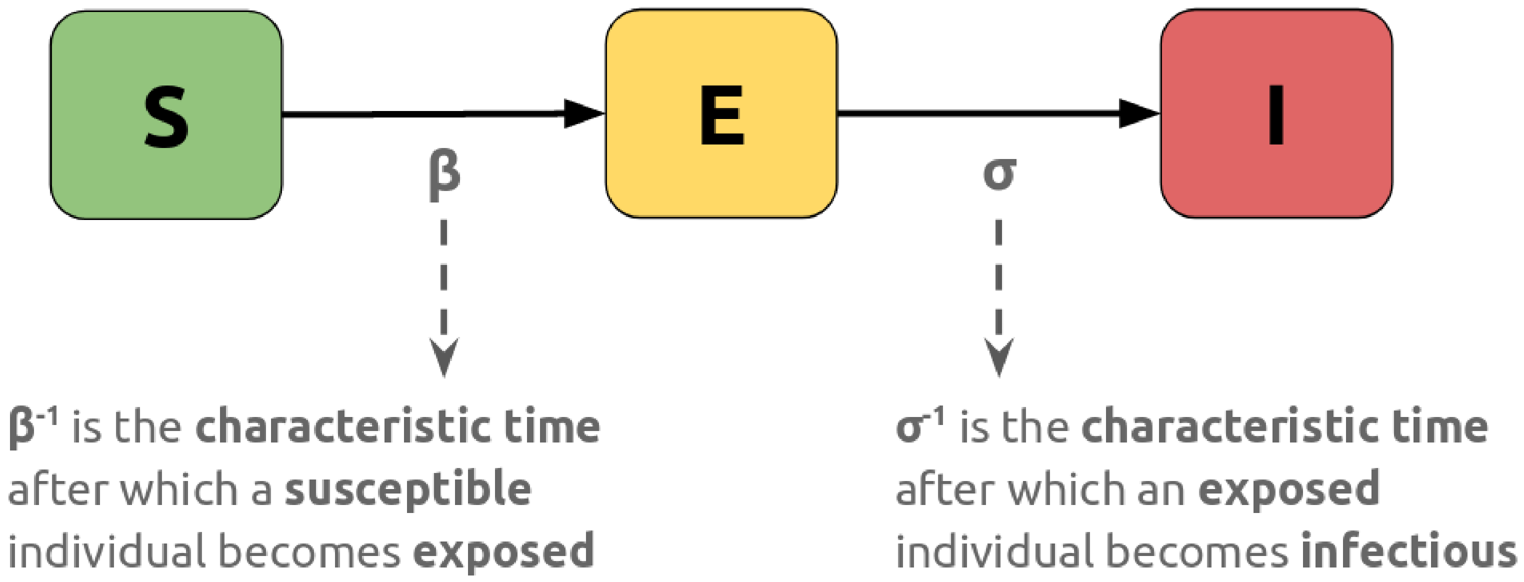
The resulting connectivity matrix represents a reef network



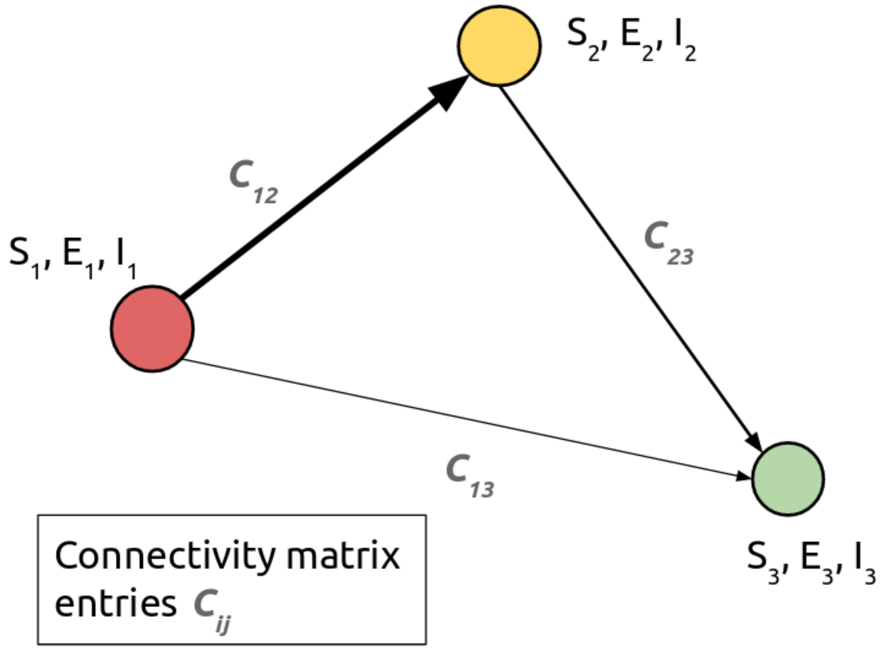
Example: August 2016 with bottom currents

Connectivity is then used to spatialize an epidemiological model

<u>3 states:</u> S susceptible, **E** exposed (infected but not infectious yet), **I** infectious



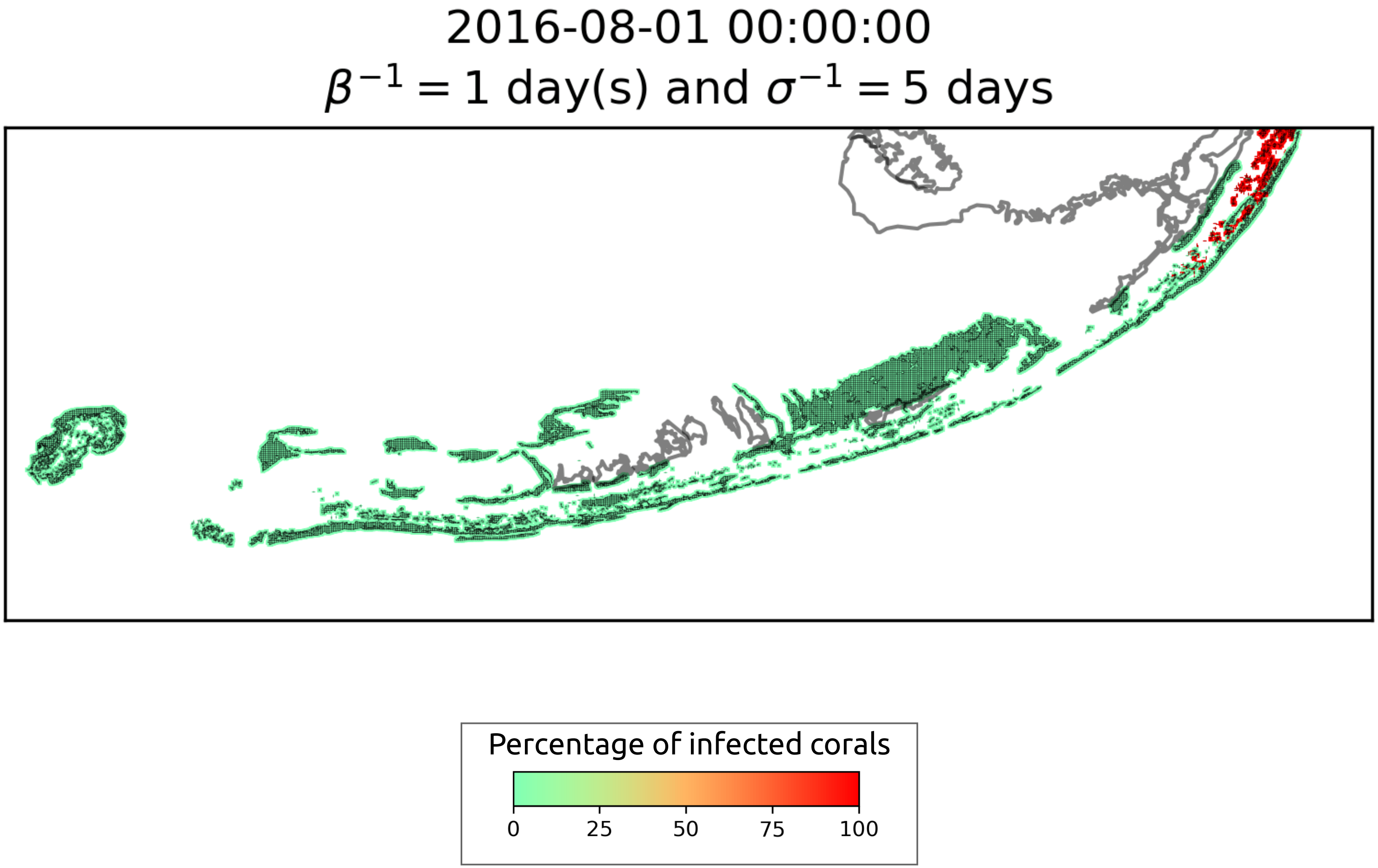
Connectivity is then used to spatialize an epidemiological model



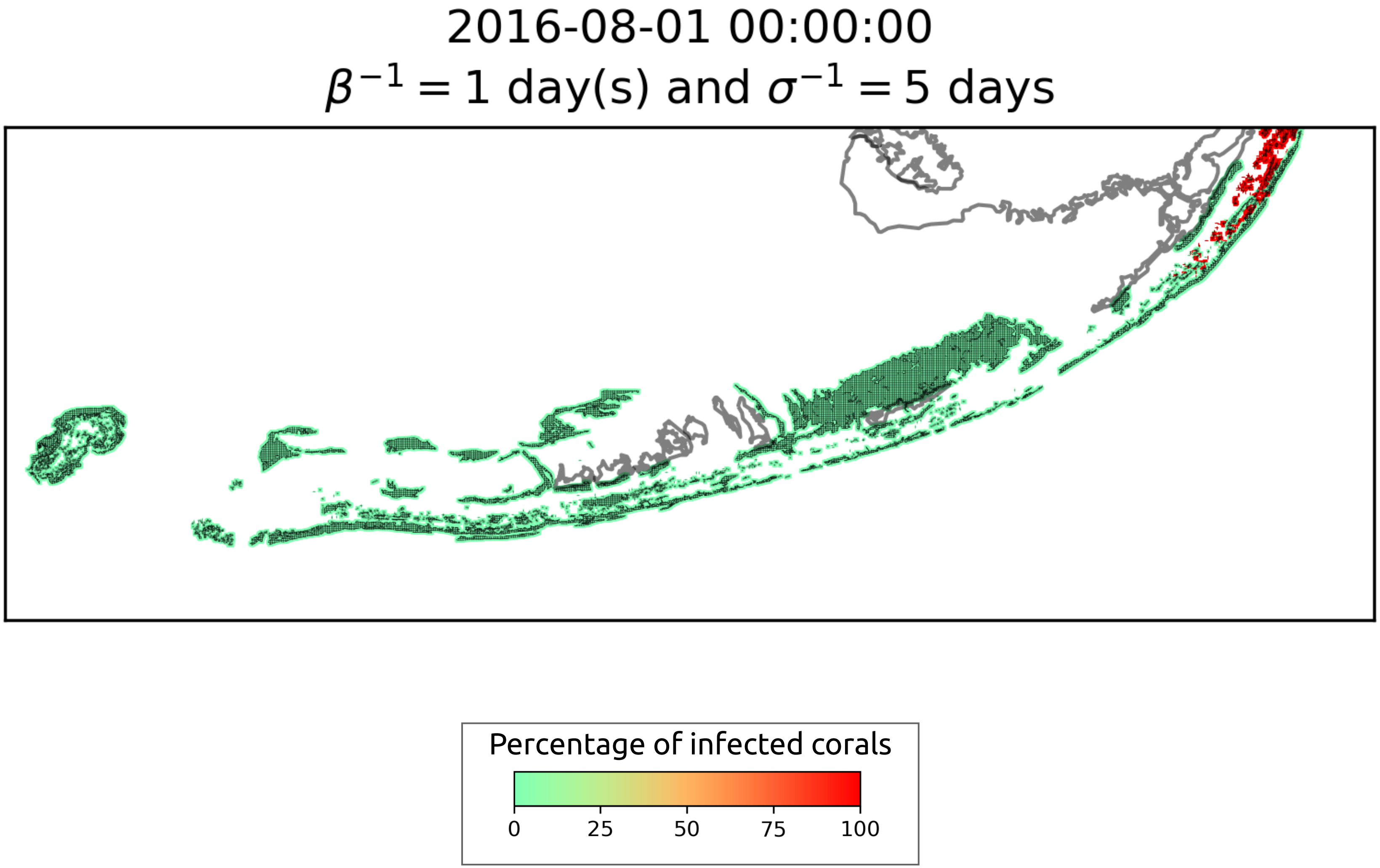
Infectious individuals can infect susceptible individuals from other reefs through the connections of the connectivity matrix

$$\frac{dS_j}{dt} = -\beta \sum_i \frac{A_i}{A_j} I_i C_{ij} S_j - \beta I_j S_j$$
$$\frac{dE_j}{dt} = \beta \sum_i \frac{A_i}{A_j} I_i C_{ij} S_j + \beta I_j S_j - \sigma E_j$$
$$\frac{dI_j}{dt} = \sigma E_j$$

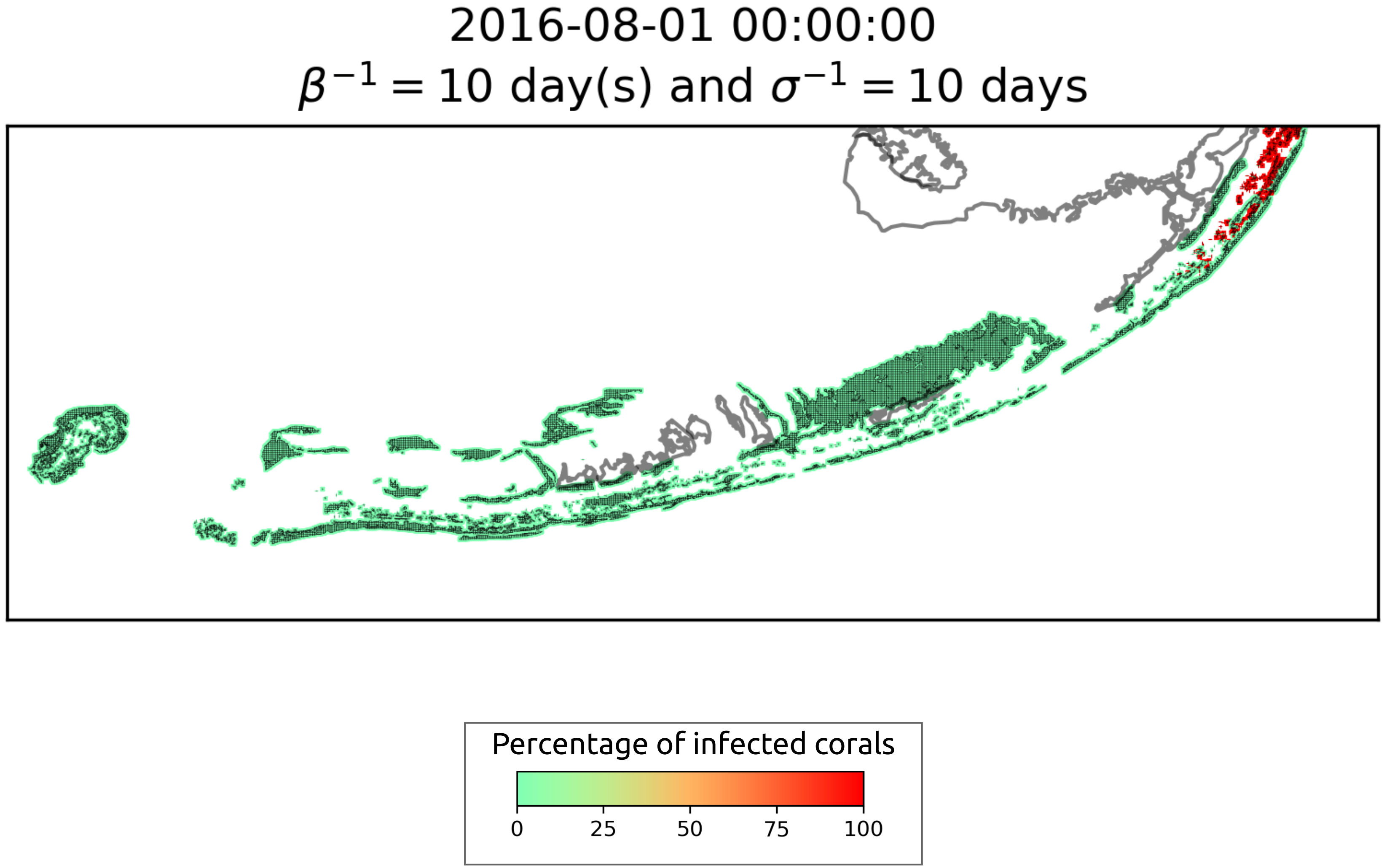
The mean currents transport the disease too fast



Bottom currents yield a slower and more realistic spread

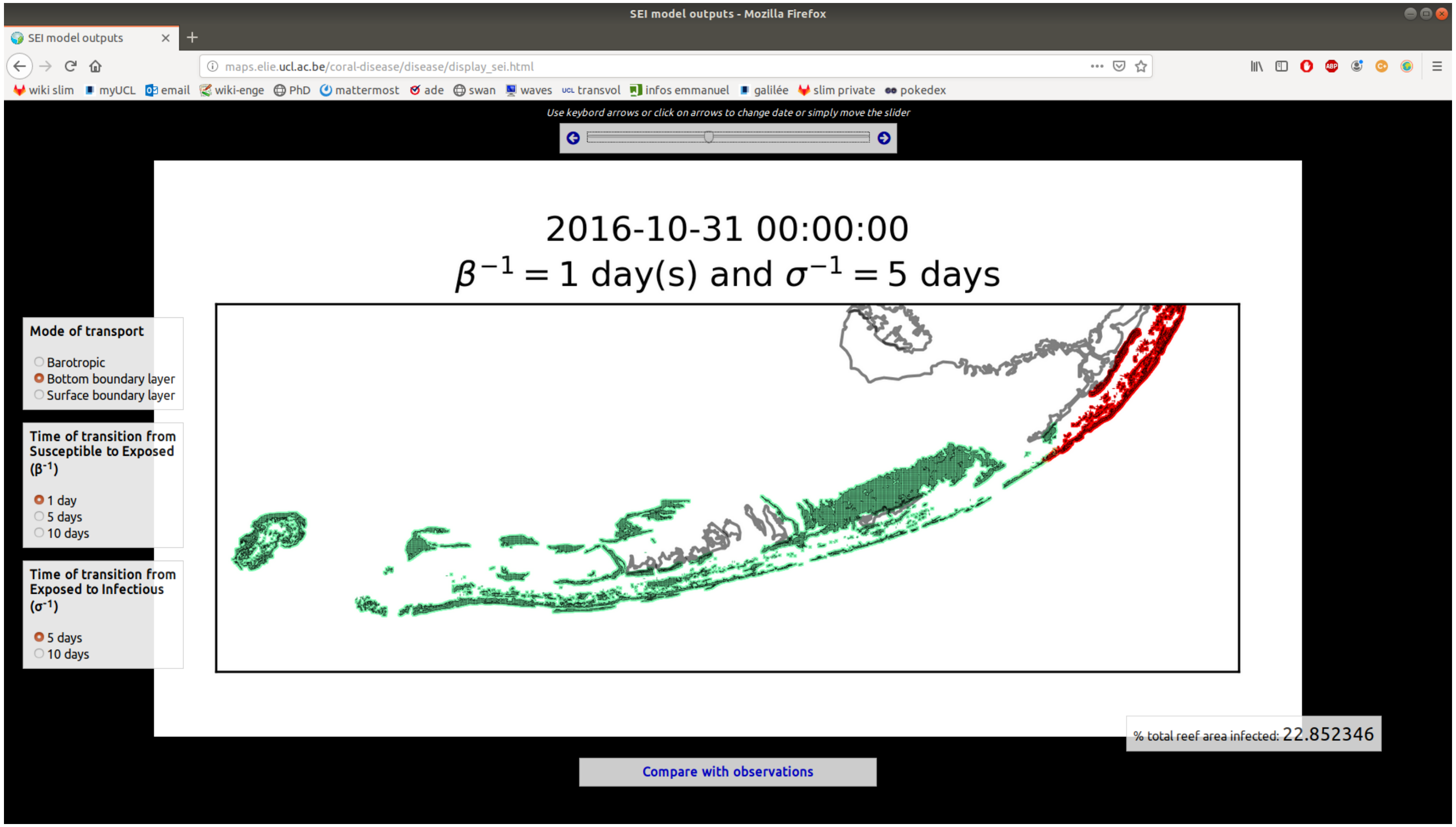


Once we have the right mode of transport, we can look at the other disease parameters...



All our results are available online

The web interface can be adapted to the needs of the reef managers

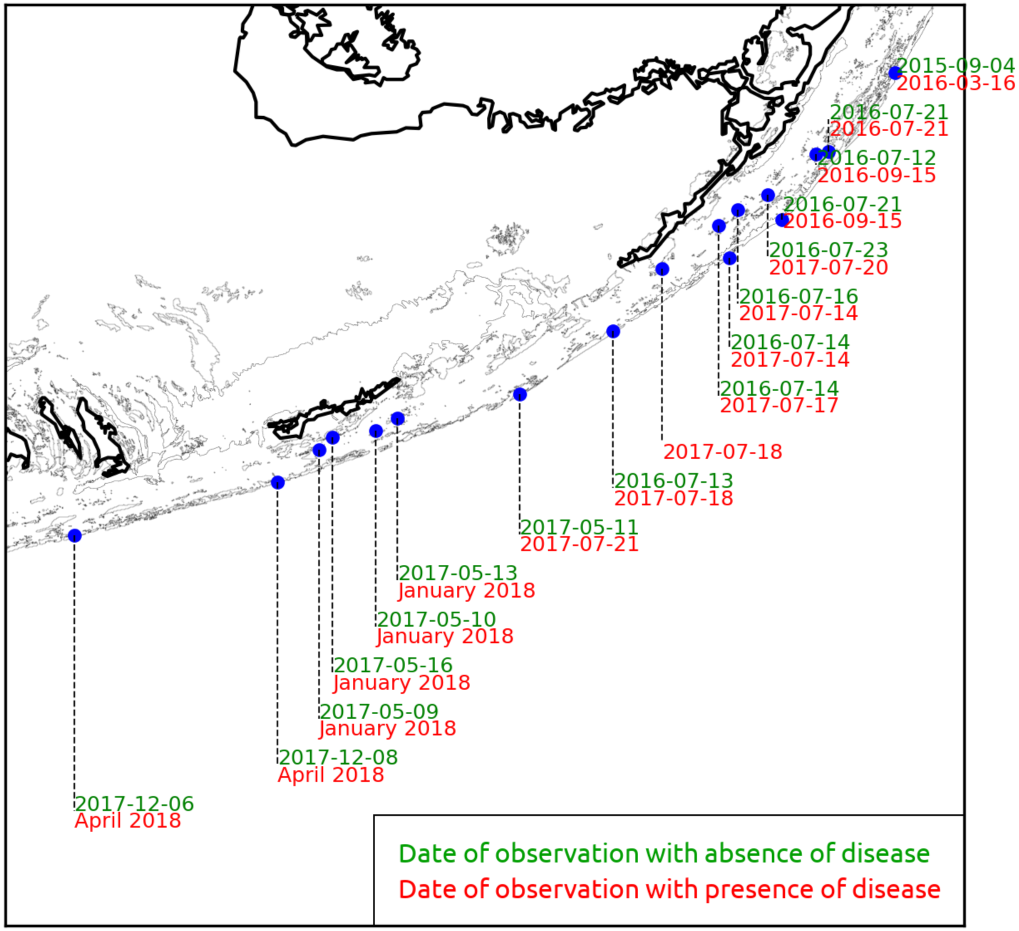


http://maps.elie.ucl.ac.be/coral-disease/disease/display_sei.html

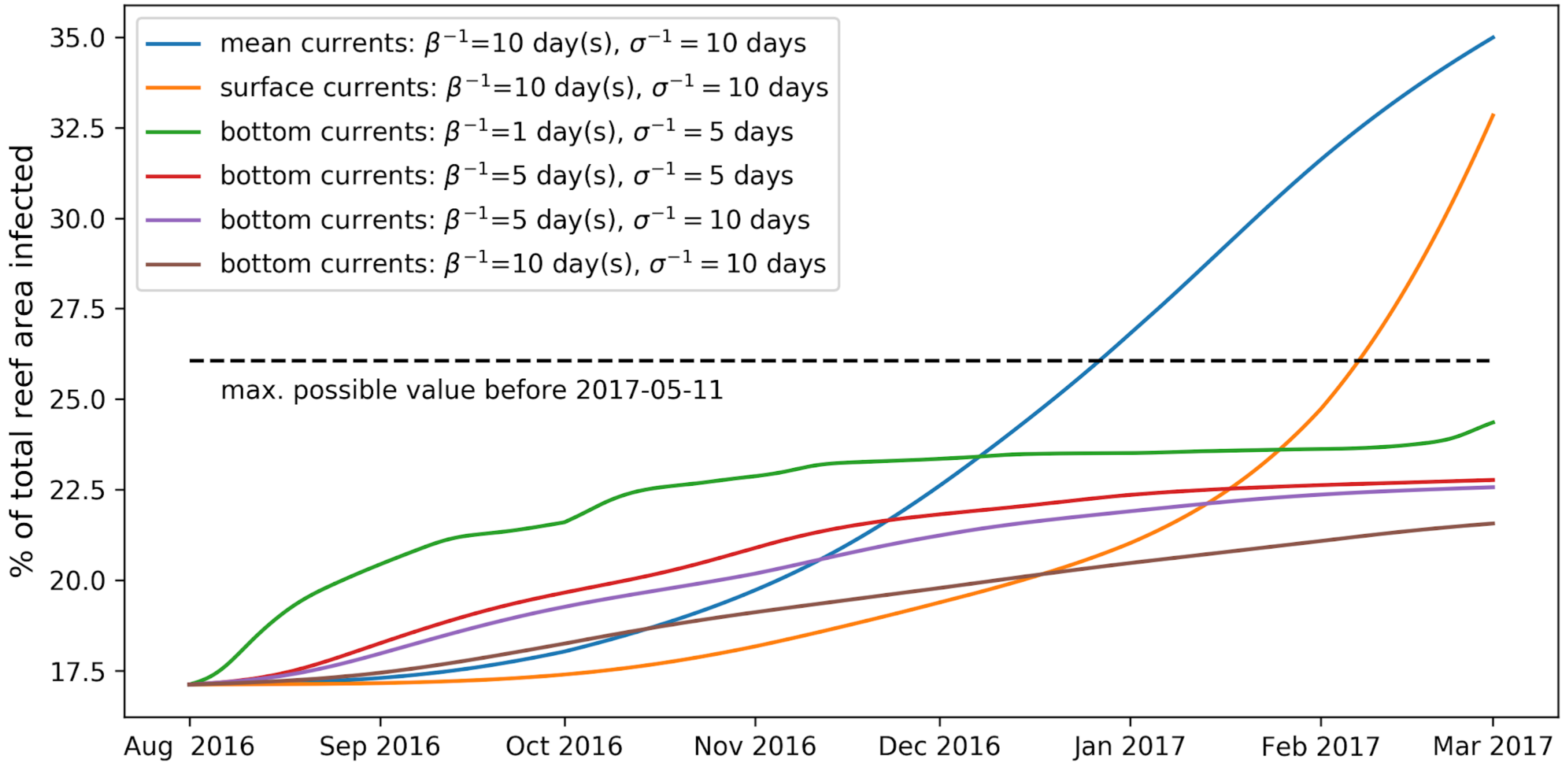
We will use the following data to further validate our model

Observations from:

- FRRP
- FWC
- DAC members



Summary of our experiments so far....



Surface and mean currents propagate the disease too fast and should be discarded.

Bottom currents seem to drive the epidemics at the right pace. Epidemiological parameters still have to be determined.

What's next ?

We could:

- Extend the simulated period to the whole outbreak
  - 1 simulated month = 2 days of set up and 2 days of computation on 100 CPUs + 4 days of reanalysis ⇒ support needed
- Backtrack the disease propagation
- Improve the epidemiological model

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