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Optimal monitoring of the ocean surface by observing the transport crossroads

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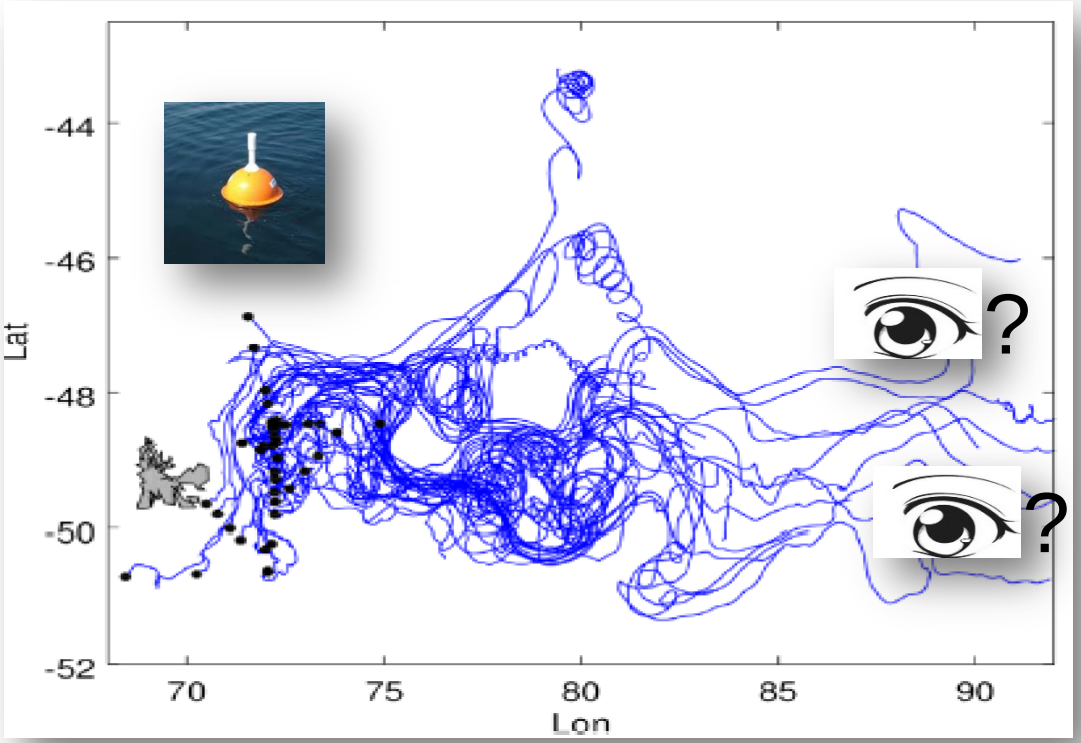
The problem:

Some pollutant, nutrient, larvi, set of drifters, …, are released on the sea and transported by currents



SVP drifters released in the Kerguelen, Keops2 campaign

What are the optimal locations to monitor the spill or release, so that the smallest number of observation stations detects most of the affected water parcels?

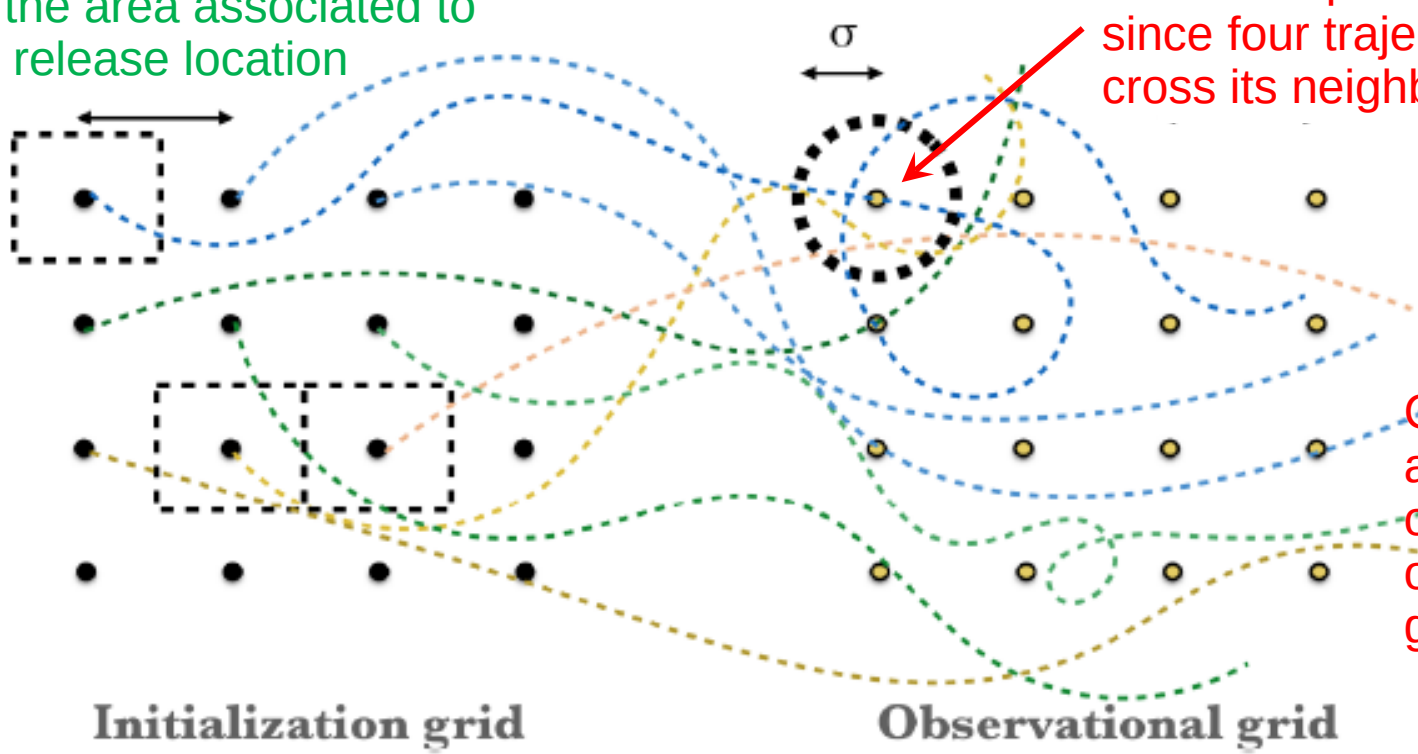
The solution:

CROSSROADNESS at point **x** during an interval of time τ: CR(**x**,τ,σ)

Is the volume or surface area of water crossing a neighborhood of size σ around observation location **x** during time τ.

Δ^2 is the area associated to each release location

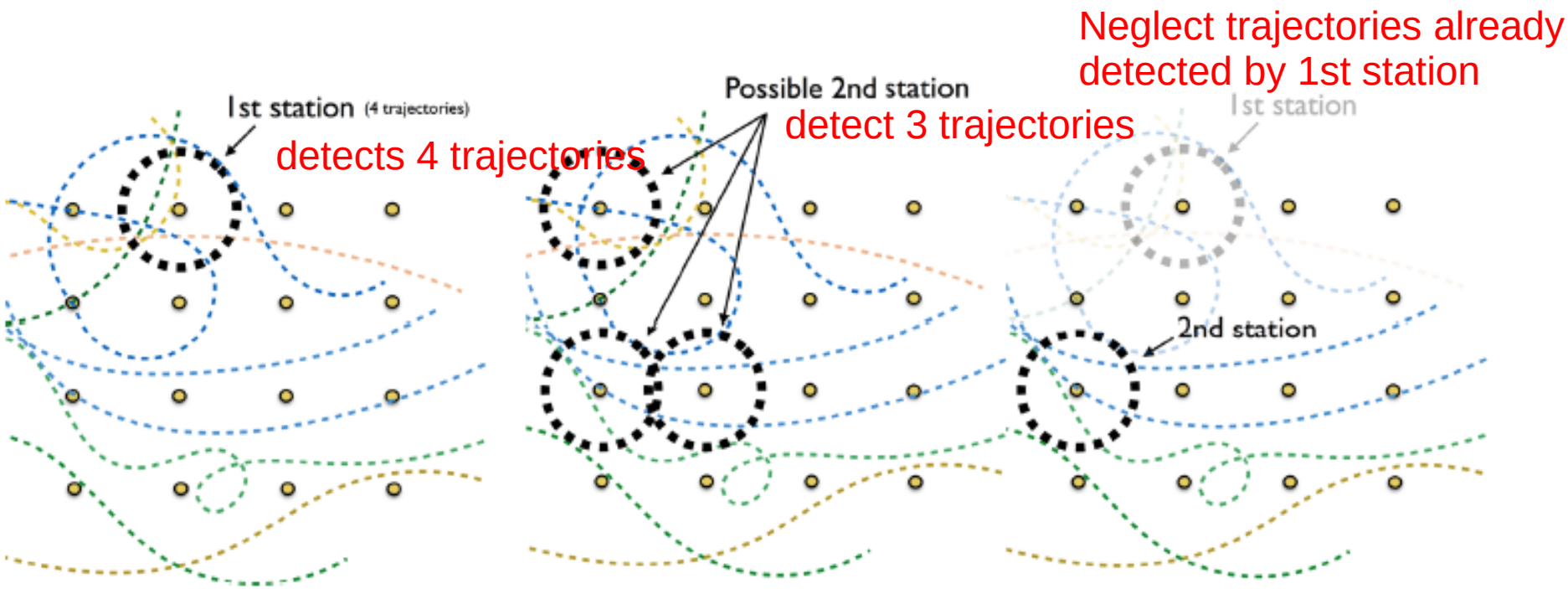
CR at this point is 4 Δ^2, since four trajectories cross its neighborhood



CR computed at each point of the observational grid

High crossroadness values identify hotspots with maximum incoming flux in the considered time window

Ranking of observation sites according to their crossroadness:

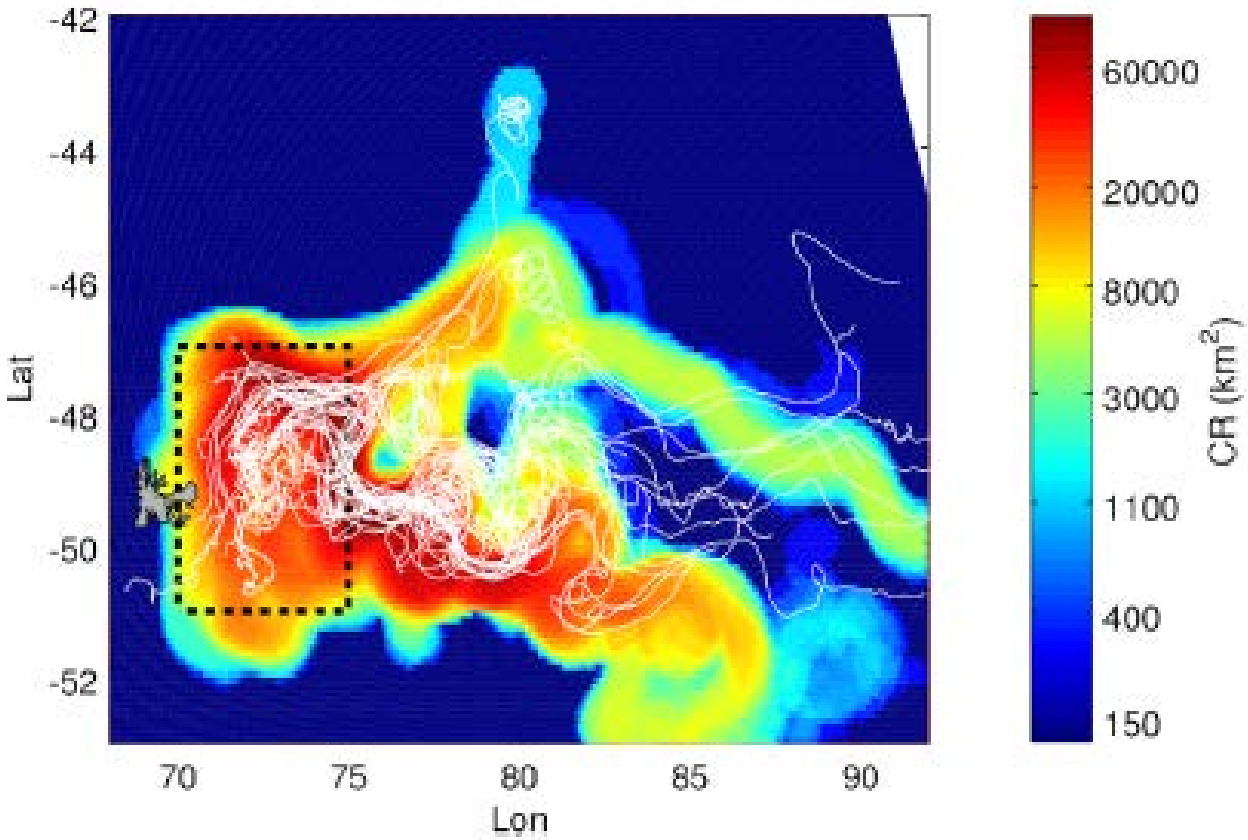


First station: maximum crossroadness

Second station: second maximum crossroadness but considering only trajectories that have not already detected by the first station

Third station, etc.

Example:



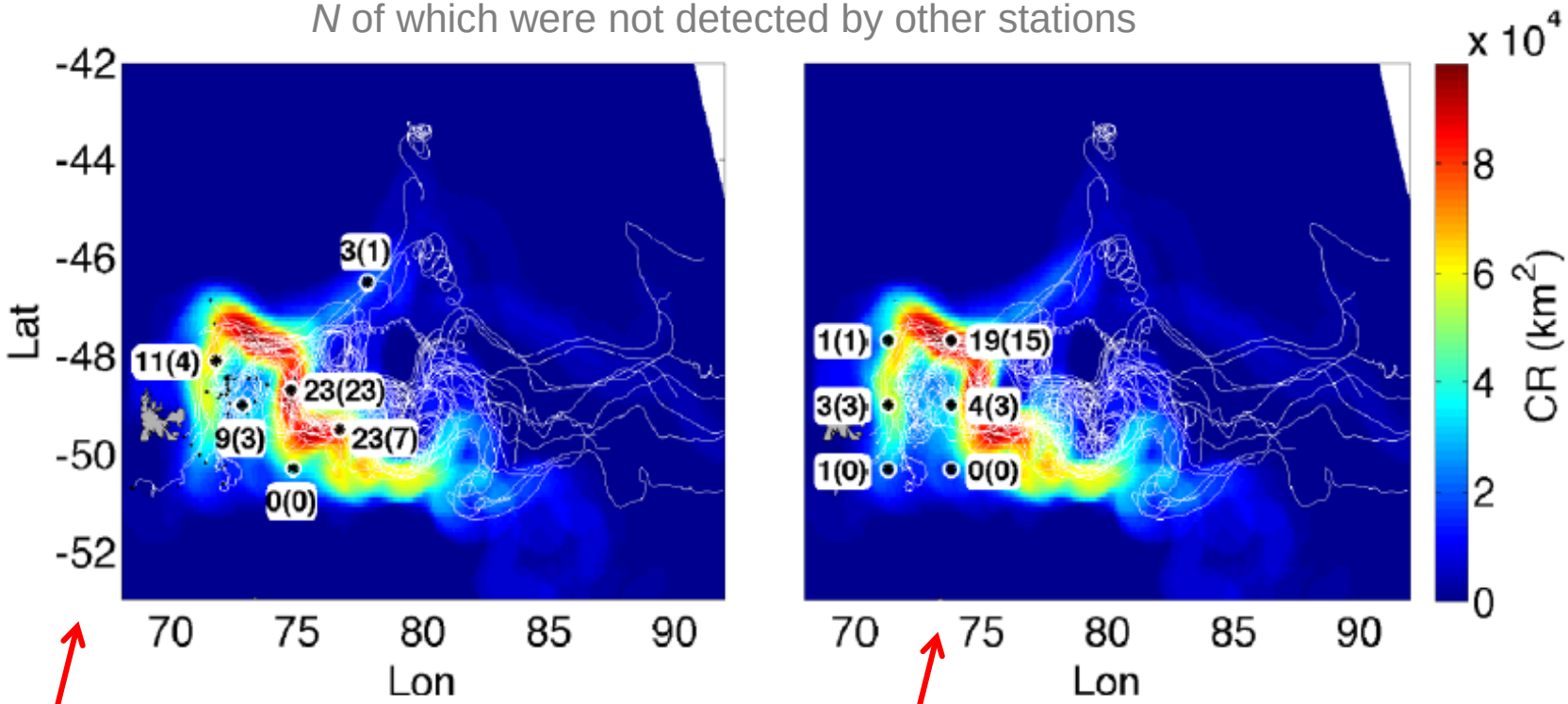
Crossroadness field in the Kerguelen region from altimetry-derived velocities. τ=60 days, σ=4º, release points in the dotted rectangle, each representing an area of 0.1º x 0.1º

White lines: drifters released during the Keops2 campaign.

Crossroadness at each point measures how many drifters will detect a station at that point.

Example (contd):

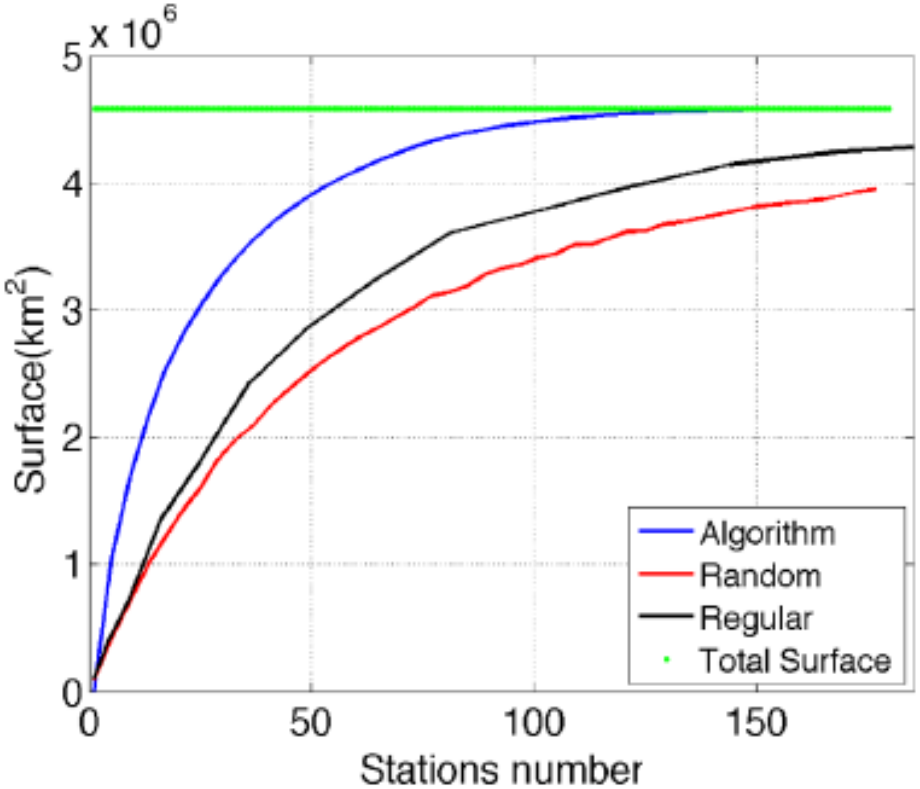
M(N) means *M* drifters detected by that station,
N of which were not detected by other stations



Optimal locations for the first 6 stations from the CR algorithm. In 60 days 69 detections of 38 different drifters.

For comparison, detection by a regular observation grid: In 60 days 28 detections of 22 different drifters.

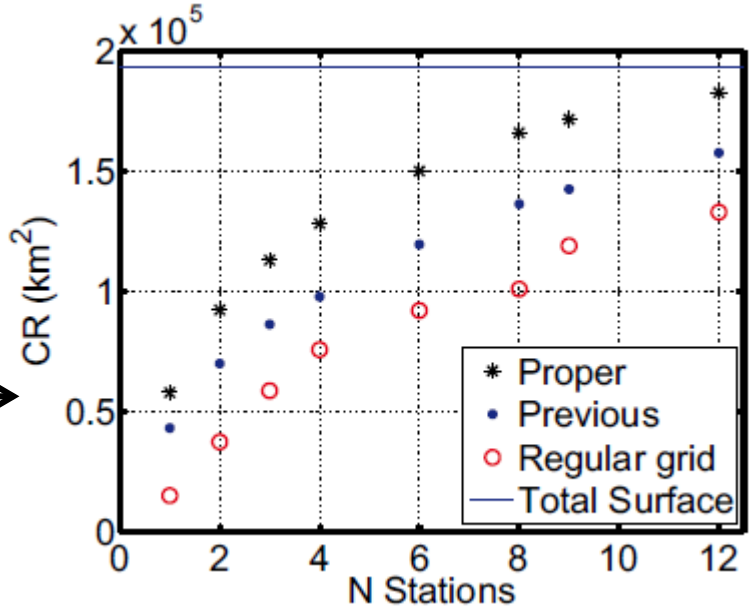
Example (contd):



Area of surface water monitored by a number of stations located according to the **CR algorithm**, on **random locations,** or on a **regular grid**.
Green line is the total release surface.

Persistence of the good properties of the CR-based monitoring network:

Performance of the monitoring task during 60 days when optimizing the observing network for the velocity field from the **previous** 60 days, as compared with the **proper** optimization, and with a **regular** observation grid

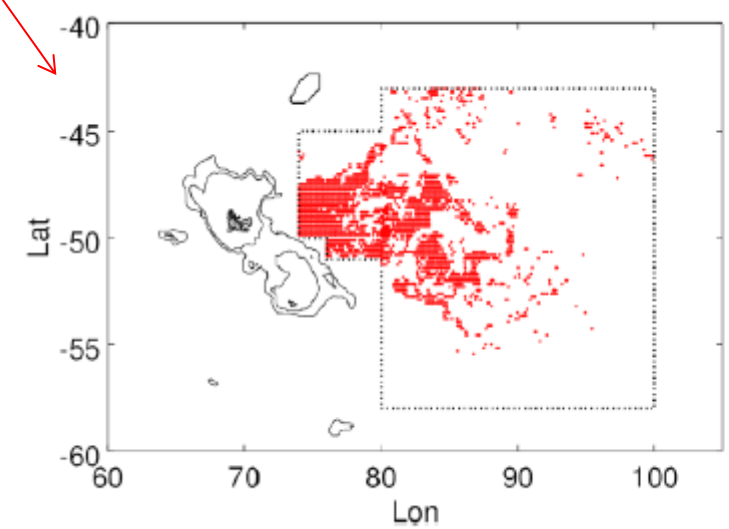


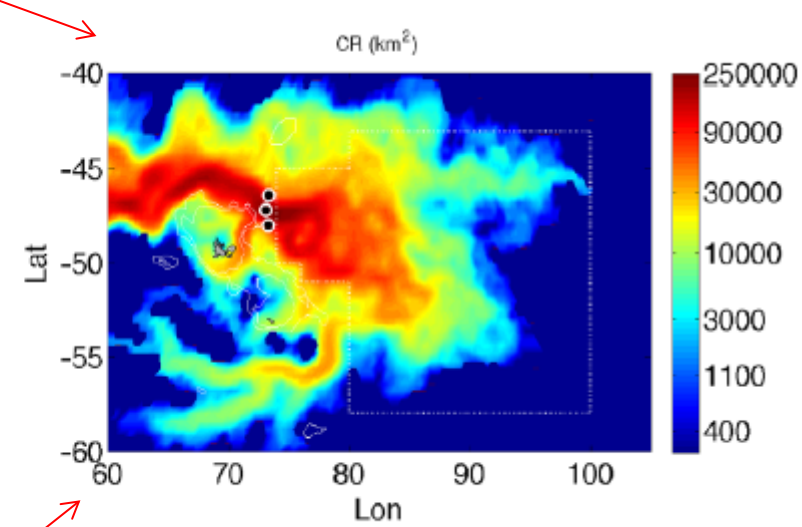
Time-backwards CR:

Integrating the trajectories backwards in time allows identification of places outflowing the largest amount of tracers

Example:

- Initialization locations at the red points, where satellite-derived chlorophyll is larger than 1 mg/m^3
  - Integration backwards in time for 180 days
    - Calculation of the crossroadness





High values of crossroadness indicate the major sources of water with conditions (large iron content) suitable to produce later high chlorophyll values (plankton bloom). The three dots are the three 'optimal stations', meaning major sources of iron (located in the Kerguelen plateau, where it is crossed by the Antarctic Circumpolar Current)

More details in

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Crossroads of the mesoscale circulation

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