Operational oceanography helps understand the behavior of marine animals

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PRESENT SITUATION WITH BIO-LOGGING AND OCEANOGRAPHY

- Knowledge on marine top predators is moving from statistical information based on sparse data to very detailed biological/physical information based on individual tracking

- To obtain **matching oceanographic information** we have to move from a general description of the mean circulation to quantitative estimation of the **mesoscale ocean circulation** and its **temporal evolution**

- This recently became possible thanks to progress in
  - Satellite oceanography
  - Operational ocean modeling

AN EXAMPLE WITH LEATHERBACK TURTLES IN THE ATLANTIC

- **Goal** :understand the influence of the oceanic mesoscale circulation of the migration trajectories of the leatherback turtles in the North Atlantic

Turtle data (June 00 – April 01):

From CEPE (Sandra Ferraroli, J.Y. Georges and Y. Le Maho)

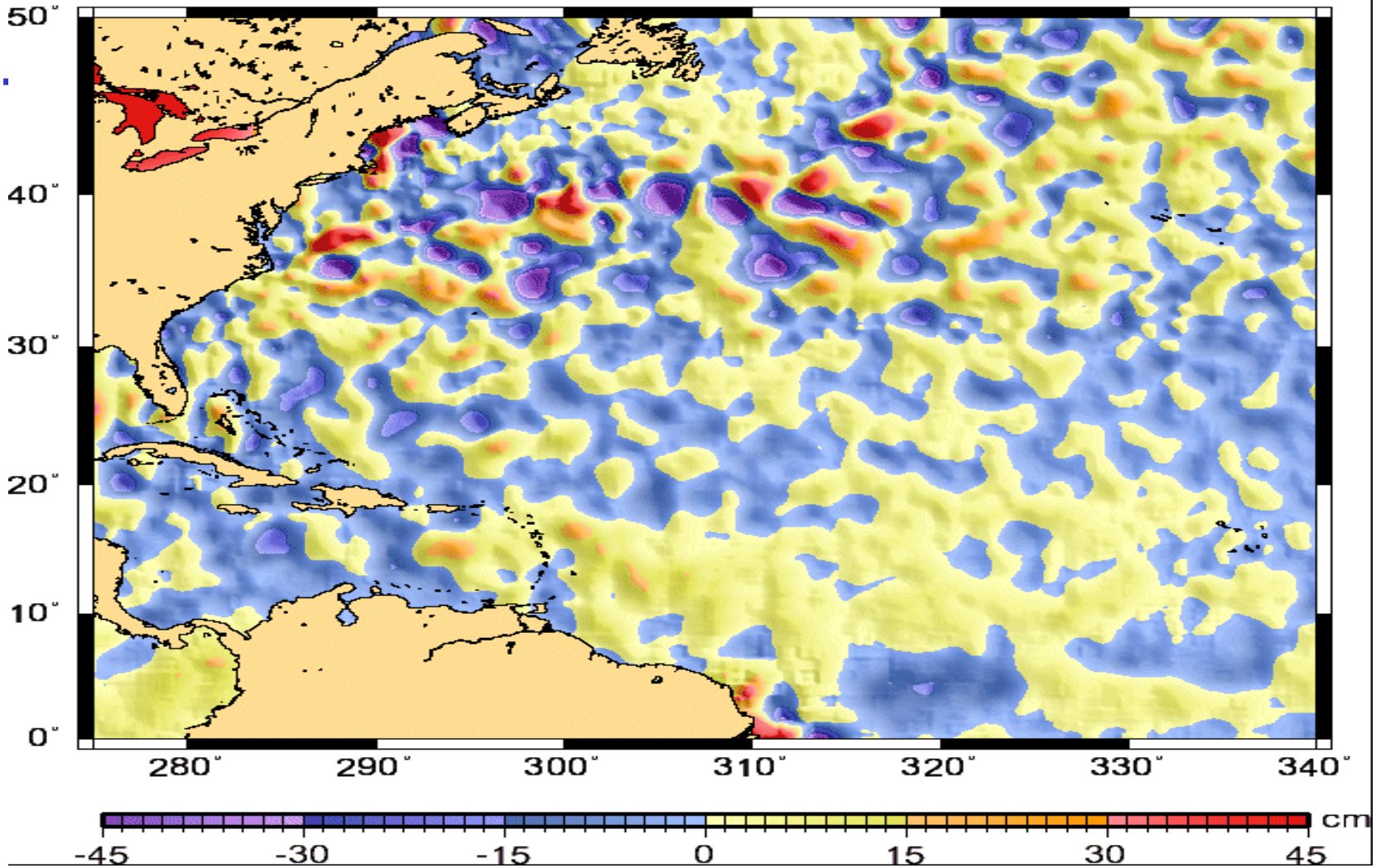
Oceanic data :

CLS maps of sea level anomalies deduced from combined altimetric measurements of TOPEX-POSEIDON and ERS-2

Spatial Resolution : $\frac{1}{4}$ degree

Sampling : 1 map every 10 days

22 juin 2000



QUESTIONS ???

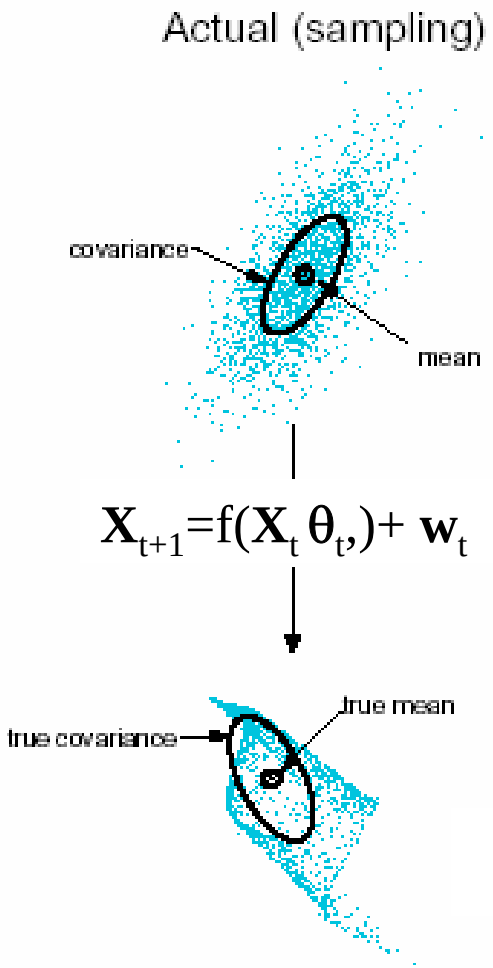
- How can turtles maintain nearly straight trajectories to the North while crossing the subtropical gyre and thus encountering currents nearly perpendicular to their tracks ??
- What is going on (in the ocean ?) to trigger the switch between the straight northward motion and the "loops" off NewFundland
- The turtle apparently follow the mean current in her eastward leg. Passive drifting ??
- What is going on (in the ocean ?) to trigger the recirculation to the south and then west ???

A USE OF OCEAN MODEL OUTPUTS : HELPING INCREASE GEOLOCATION ACCURACY

- Geolocation errors (>> 1°) are insufficient to allow detailed analysis of how tracked animals (tunas,…) exploit mesoscale oceanic features
- First attempts to reduce errors trough Kalman filtering of observations with a simple drift + random walk models (Sibert et al.) . Interesting results but filtered locations are still largely uncertain as models add little additional information
  - ⇒ Several groups work on the use of the temperature records to reduce uncertainties on locations
- Basic idea : given a temperature field , reconstruct the track that is consistent with light AND temperature record

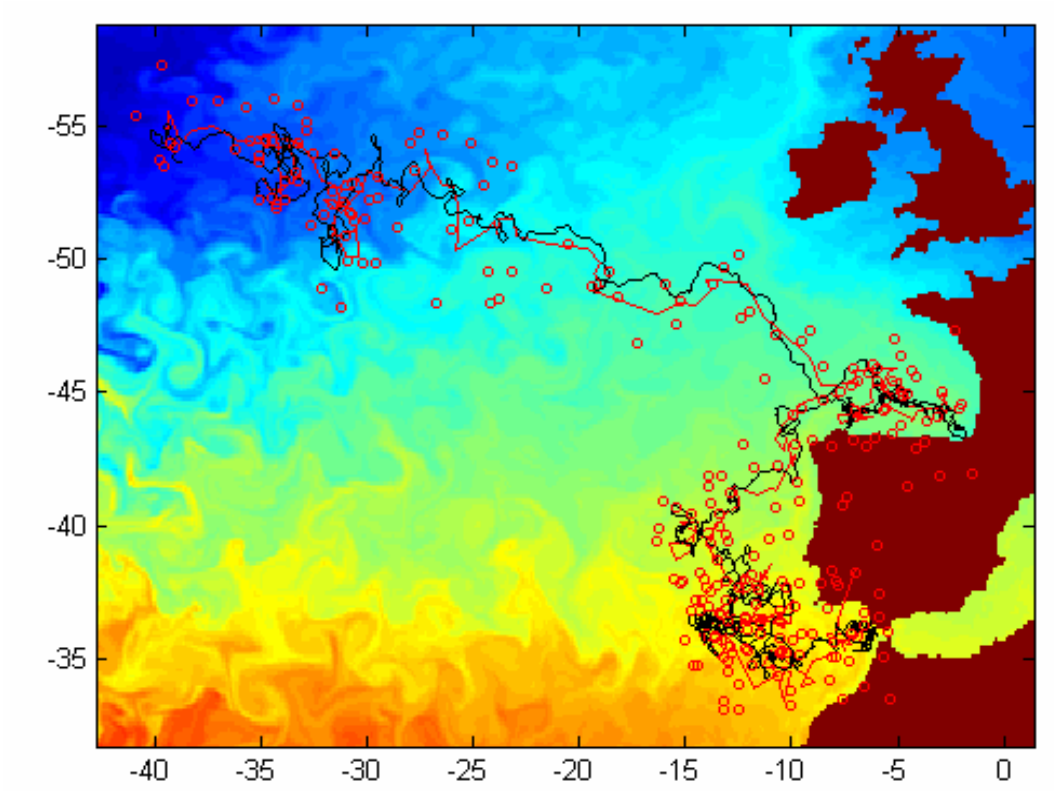
THE PARTICLE FILTER APPROACH TO USE TEMPERATURE AND GEOLOCATION (Royer, Fromentin and Gaspar)

- **Dynamical model :** correlated speed and angle (Bovet et al., 1988) with time-varying correlation allowing time-varying behavior (migration/foraging)
- **Filter** : implementation of a particle filter (PF), a general class of Bayesian filters that can be used with **non-linear** dynamical models and observation equation and **non-gaussian** model and observation noise
- **Based on Monte-Carlo simulations**, i.e. simulation of trajectories of numerous particles, among which one selects, for the next time step, those ending at locations with T closest to T_{obs}

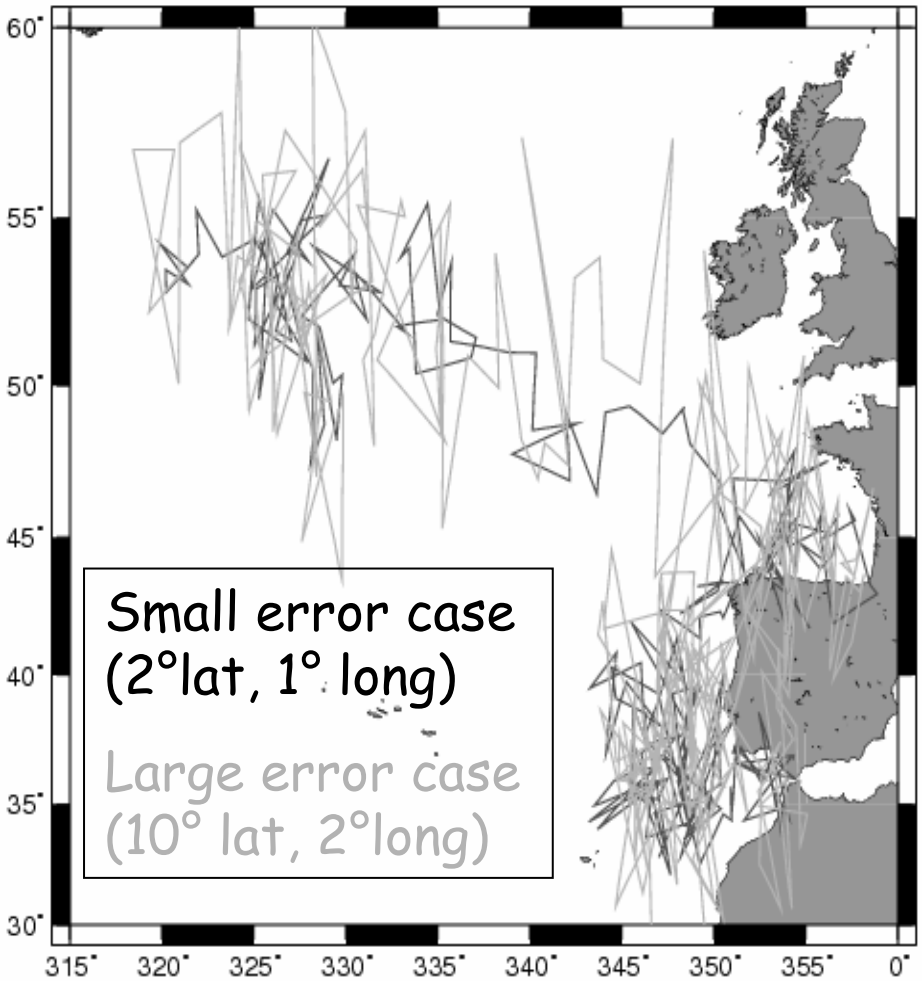


TEST WITH A SIMULATED TRACK

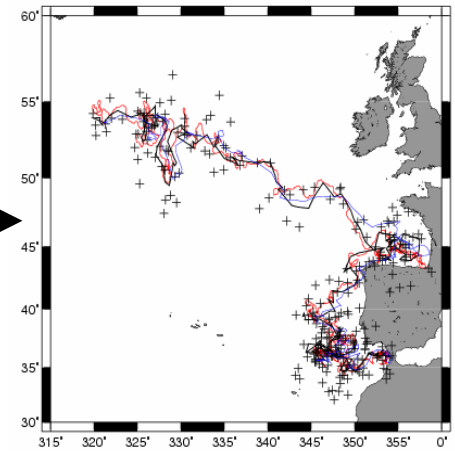
- **Simulate a track** with the correlated speed/angle model
- **Simulate T record** by sampling modeled SST (Mercator 1/15°) along the track
- **Simulate geolocations** using one track position per day + large noise



FIRST RESULTS



Small error



Large error