HIGH-RESOLUTION SURFACE CURRENTS FROM SATELLITE OBSERVATIONS IN THE NORTH-WESTERN MEDITERRANEAN SEA: EDDIES ALONG THE IBERIAN COAST

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UCM MED 2018, December 11-12 2018, Frascati, Italy
OCEAN CURRENTS ARE...

...THE HOLY GRAIL OF PHYSICAL OCEANOGRAPHY
Holly grail... why?

1. Central for the investigation of ocean dynamics
   - Ocean processes: vorticity, divergence, ...
   - Turbulence theory: statistics of velocities, ...

2. Need for most (non-physical) fields of oceanography

3. Needed for almost all human activities in the sea
   - Navigation
   - Search & rescue
   - Maintenance, towing, ...

   However, at present there isn’t direct observations of high-resolution currents!
WHAT DOES IT MEANS HIGHER SPATIAL RESOLUTIONS?

\[ \Delta x \leq 20 \text{ km} \]
FROM SCIENCE TO REAL-WORLD

➢ Beyond the understanding of ocean upper layers...

➢ ... movement of people across the Mediterranean has a strong impact on the Search & Rescue services

➢ Tight collaboration with the Spanish Search & Rescue service:
  ➢ Use of their facilities
  ➢ Software development
  ➢ Training
  ➢ Operational currents (on going)
AREA OF STUDY
DATA

- **Satellite**: AHRR SST (infrared) from ICM’s EumetCast station

- **In situ**: everything that can float and provide its position
  - Use of ‘exotic’ instruments as well as standard
  - Depth < 1 m

- **Experimental conditions:**
  - Low wind conditions
  - No swell
METHODOLOGY(I): BACKGROUND

- For a non-divergent flow it is possible to define a stream-function, such that

\[ \vec{u}_s(\vec{x}) = \vec{e}_z \times \nabla \psi_s(\vec{x}) \]

- The reconstruction of surface currents from SST can be formulated in terms of a transfer function

\[ \hat{\psi}_s(\vec{k}) = C F_n(k) e^{i\Delta \theta(\vec{k})} \hat{T}_s(\vec{k}) \]

- The transfer function and phase shift can be theoretically derived from GFD

_Isern-Fontanet et al. JPO 2014_
Surface Quasi-Geostrophic (SQG) equations predicts that

\[ \Delta \theta(\vec{k}) = 0 \quad ! \quad F_n(k) \propto k^{-1} \]

Many other solutions can be found imposing different stratifications.

- They have in common that they only depend on \( k \).

It can also be empirically determined using altimetry

\[ CF_n(k) \approx \frac{\langle |\hat{\eta}(\vec{k})| \rangle_k}{\langle |\hat{T}_s(\vec{k})| \rangle_k} \]

EXAMPLES: SMALL EDDIES ~15 KM
COMPARISON WITH DRIFTERS

- Interior PV, salinity, large-scale contributions

\[ \vec{v} = C\vec{v}_{ssq} + \vec{v}_{LS} \]

- Gradient flow correction

- No correction: correlations in the range 0.7-0.8

- Correction: correlations up to 0.9
LIMITATIONS

- The strongest limitation is the assumption that
  \[ \Delta \theta(k) = 0 \]

- Contributions to phase shift:
  - Vertical structure
  - Surface processes
  - Salinity
    \[ \nabla T \approx c \nabla S \]
    \[ \nabla T \approx \pm c \nabla S \]
EXAMPLE: ALGERIAN VORTICES

- Inhomogeneities in the alignment between SST and SSS can induce the wrong sing of vorticity
  - e.g. Western Mediterranean Sea (Algerian basin)

- If SSS is available, it can be used to correct it
  - New SMOS-BEC SSS products (available very soon)
EXAMPLE: ALBORAN SEA (GLOBCURRENT CS)

- Correction of salinity contribution
  - Regional approach: image processing + oceanography

*Isern-Fontanet et al. JGR 2018*
EXAMPLE: ALBORAN SEA (GLOBCURRENT CS)

- Comparison with altimetry:
  - SST + SQG outperforms altimetry East to Gibraltar Strait
  - Similar performance in the central part of the vortex
  - Better performance of altimetry in the Easternmost part (due to the SSS correction?)

_Isern-Fontanet et al. JGR 2018_
A NATURAL LABORATORY FOR OCEAN CURRENTS

- Casablanca Oil Platform
  - Platform for instruments
  - ADCP profiler
- Regional model (ROMS)
- Dynamical/environmental
  - Small Rossby radius
  - Cloud-free (~40 %)
- Easy (= ‘cheap’) to access
- Different approaches have been already implemented, others are under implementation

Isern-Fontanet et al. NPG 2017
CURRENT WORK ON SST

- Problems under study/development:
  - Characterization of turbulence regimes (intermittency/topology)
  - New generation of cloud masks
CURRENT WORK ON SST

- Global Infrared SST:
  - from ATSR-1 to AATSR
  - SLSTR
- Effective noise determination
SUMMARY AND CONCLUSIONS

- Existing IR radiometers have the capability to observe structures shorter than 20 km in terms of spatial and temporal sampling.

- IR SST derived velocities have the potential to capture the motion associated to structures as small as 10 km very close to the coast.

- Difficulties:
  - Role of salinity (can be corrected regionally)
  - SST processes

- We have developed the tools for estimating currents from a single SST image, which we will released soon (License, bugs, ...)

- We are setting up a laboratory for testing and validating satellite-based methods and instruments for estimating velocities.
Q1: Who are the users to be addressed and how to involve them as stakeholders?
   - Shipping companies, energy, ...
   - Search & Rescue: formation/co-working, ...

Q2: What are the key scientific gaps, application areas and data exploitation infrastructures to be considered and addressed?
   - Quality indices/flags for ocean currents products
   - Salinity gradients (for phase based methods of OC)

Q3: What large scientific/applicative projects can support the initiative?
   - Safety in the sea
   - Plastics
   - Climate Change

Q4: Would a Mediterranean Regional Office help in structuring, managing and supporting the various ideas, projects and stakeholders?
   - Probably, yes.
Thank you

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