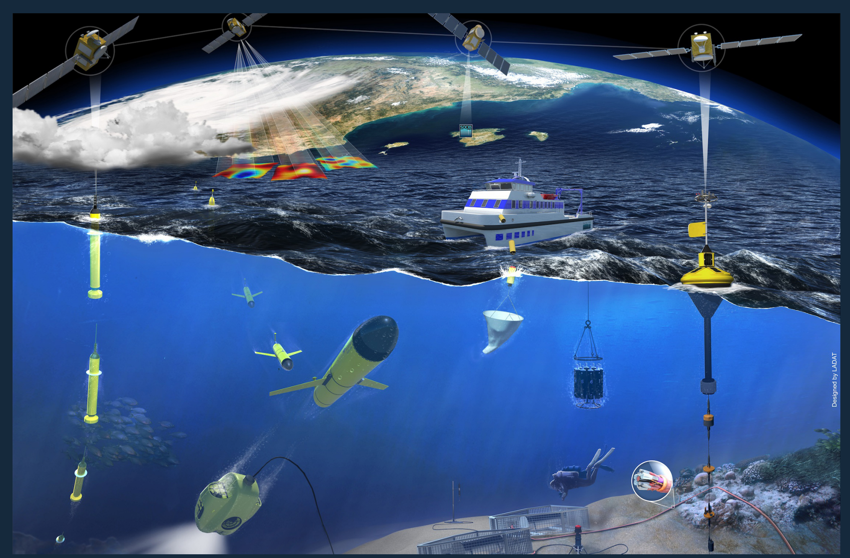
Sub-seasonal and mesoscale variability in oceanic circulation at a key ‘choke’ point

An example from the Western Mediterranean

Authors: E. Heslop, J. Allen, S. Ruiz, J-L. López-Jurado, J. Tintoré

contact: eheslop@socib.es

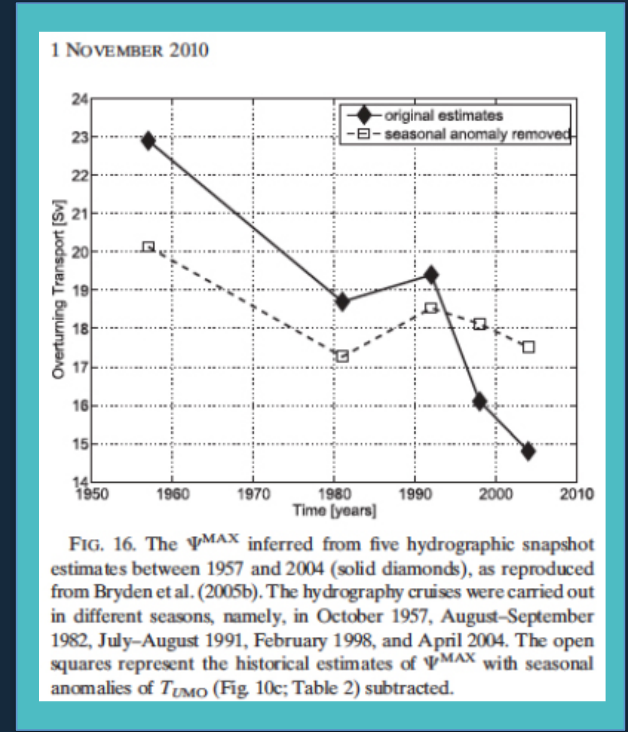
01 SOCIB Goal: characterize Ocean state, variability & ecosystem response



The Oceans; a complex system, changing, under-sampled

- Walter Munk-2001- *“The last century of oceanography is marked by the degree of under-sampling”*,
- Carl Wunsh 2010: *“We need data, … models are becoming untestable”*

02 Why variability?

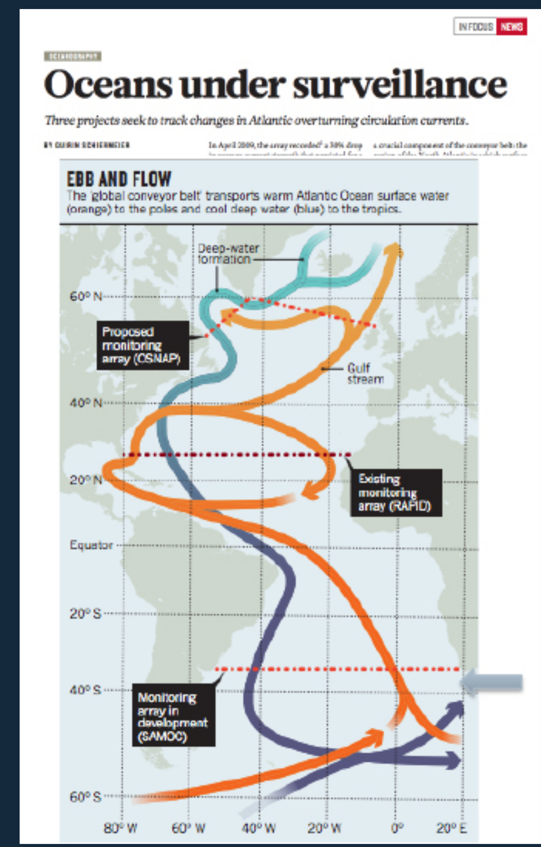


(Kanzow et al., 2010)

Marine research in the past 20 years has focused on defining the present day ocean circulation. From these measurements of ocean circulation, we begin to understand how biogeochemical distributions are set and how the ocean and atmosphere interact to determine the present climate.

The key issue for the next 20 years is to understand how the ocean circulation varies across inter-annual to decadal time scales.

In April 2009, the RAPID array recorded a 30% drop in average current strength that persisted for a year, reducing the amount of heat transported in the North Atlantic



(Nature, May 2013)

03 Two paradigm changes

Ocean observation:

1. **From:** ship based observation
   To: multi-platform observing systems

Data availability:

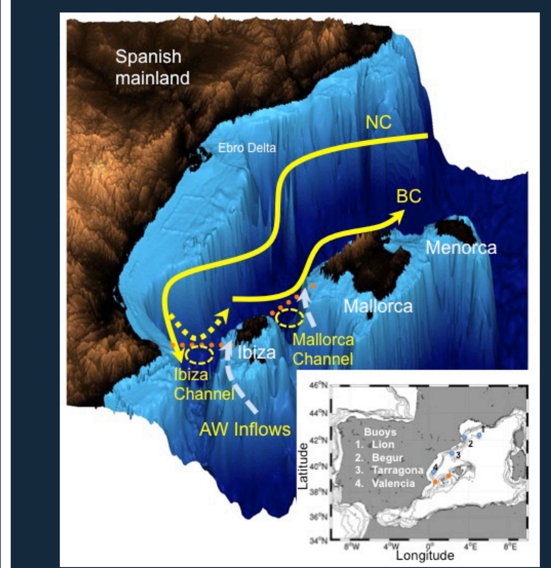
2. **From:** data only available 12-24 months after cruises
   To: quasi real time quality controlled data available

Huge increase in human potential for analysis: open science, open for society

Glider monitoring at a circulation ‘choke’ point: results

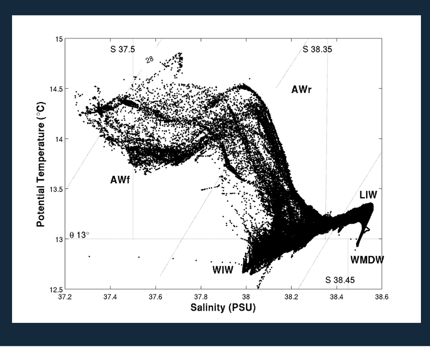
04

4.1 Ibiza Channel ‘choke’ point

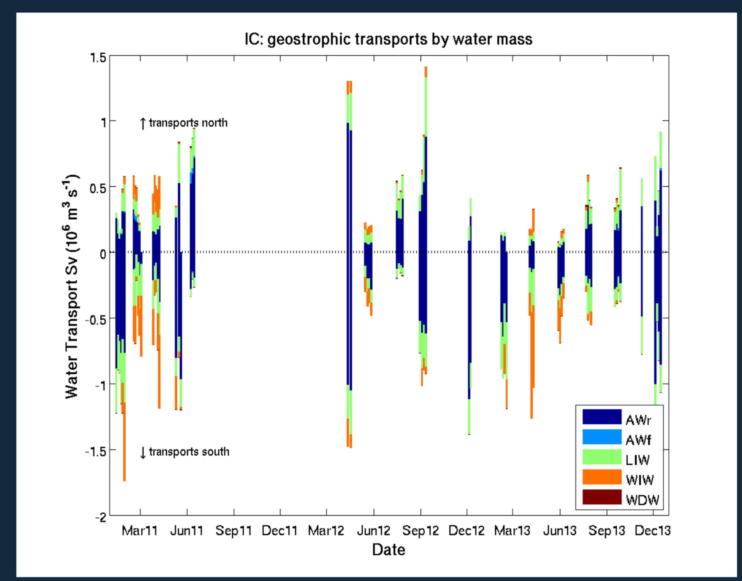


Location of the Ibiza Channel in the Western Mediterranean Sea; major components of the circulation are the Northern Current (NC), Balearic Current (BC) and AW inflows. A ‘blocking’ eddy (yellow dashed circle) and the re-circulation of the NC above the eddy (yellow dashed line) are shown. Approximate position of the glider transects are shown as orange dots.

- Narrow ‘choke’ point in circulation
- Governs important north/south exchange of watermass
- Mesoscale eddies ‘block’ flows
- Fresher inflows affect spawning grounds of bluefin tuna
- To capture variability at different scales:
  - ✧ Glider transects: 63 in 3 years
  - ✧ R/V transects: 53 in 18 years



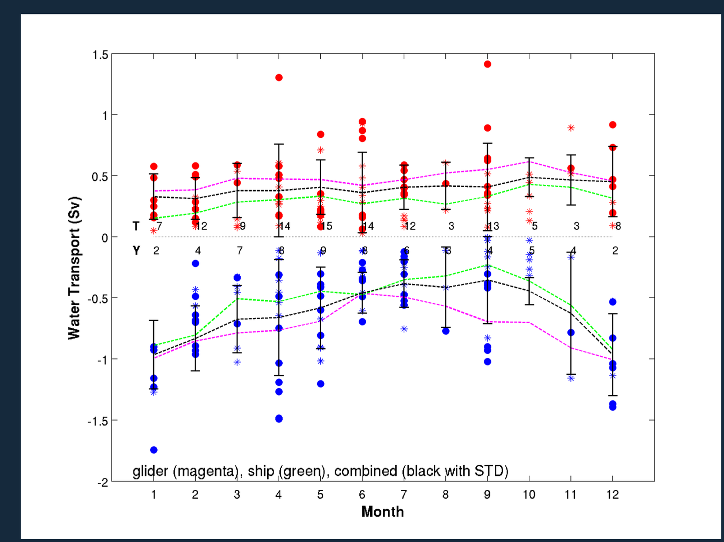
4.2 High frequency variability



Geostrophic transports by watermass in the Ibiza Channel from glider missions: Each bar represents the water transports for a single (2-day) glider transect of the deep (central) part of the channel, total bar height is the total volume of water transported, transports north are positive, transports south are negative, and the different watermasses are indicated by colour.

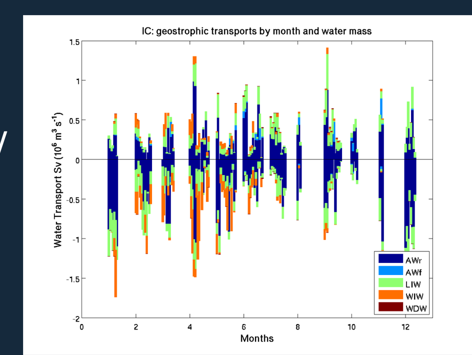
- Glider high-resolution transects show
- Changes in transports of 0.8-0.9 Sv in days, southwards
- Changes of 0.4-0.5 Sv in days, northwards
- High variability of the same order as the seasonal range
- Caused by: WIW, eddies, inflows

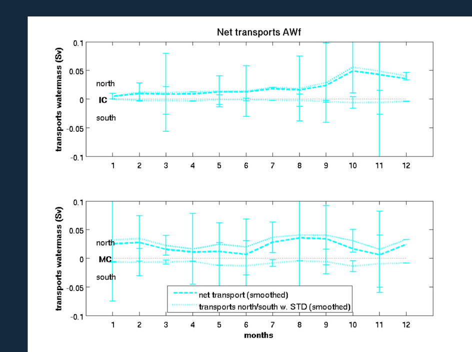
4.3 Seasonal variability: circulation



Seasonal cycle of transports from 18 year glider and ship dataset: Seasonal cycles (dashed lines) are the mean transports per month with a 3-month moving average applied, glider (magenta), ship (green), combined data (black with STD). Plotted over the per transect transports for gliders (dots) and ships (stars). Ships CTD data provided by IEO-COB (IBAMar DATABASE), University of Valencia and SOCIB.

- Long term (18 year) record of glider and R/V transects
- Clear seasonal variability in southward flows, driven by events to the north
- No seasonal variability in northward flows, episodic, likely driven by events to the south
- Fresher surface layer inflows also show no seasonal variability, however need to capture more events

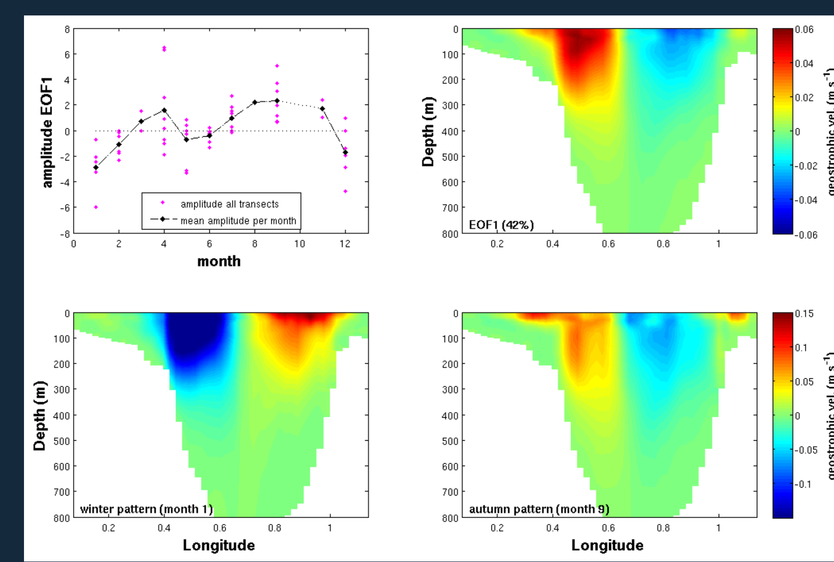




Seasonal cycles for fresher AW inflows (S < 35.5 PSU) combined dataset

4.4 Mesoscale variability

- EOF analysis (glider transects) indicates annual interplay between basin scale and mesoscale
- Seasonal cycle for eddy activity



First EOF of geostrophic velocity, top left mean seasonal cycle of amplitudes (black dashed line), top right EOF1, bottom panels EOF1 for winter (LHS) indicating a strong NC with AW inflows and autumn (RHS) a large anticyclonic eddy

05 Characterising complexity

North/South Exchange:

- High frequency sub-seasonal variability characterised
- Seasonal cycle in southward flows characterised
- Seasonal cycle in mesoscale activity characterised
- AW Inflows episodic, linked to circulation modes in the Alboran Sea
- 5 patterns or modes proposed, periods of greater stability

Characterisation will aid:

Ocean model assessment in Western Mediterranean, 1996 - 2013
Operational modelling forecast capability
Ecosystem prediction

Gliders: part of a revolution in ocean observation

06 The challenge for next decade

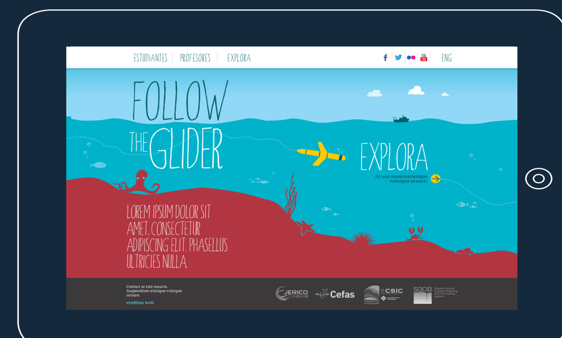
To integrate new technologies and to carefully and systematically:

- Monitor the variability at small scales, e.g. mesoscale/weeks, to
- Resolve the sub-basin/seasonal and inter-annual variability, and
- Establish the decadal variability, understanding the associated biases

To expand data usage, science open to and for society

SOCIB Data

Real Time,
Free Access & Download,
Quality Controlled
www.socib.es



Heslop, E., Ruiz, S., Allen, J., López-Jurado, J-L., Renault, L., and Tintoré, J., (2012), Autonomous underwater gliders monitoring variability at “choke points” in our ocean system: A case study in the Western Mediterranean Sea. Geophys. Res. Lett., 39.

SOCIB Balearic Islands Coastal Observing and Forecasting System · Gobierno de España, Ministerio de Economía y Competitividad · Govern de les Illes Balears · PERSEUS · GROOM · JERICO · myOcean