From small to large scales: the real challenges for the next decade: the impact of new information infrastructures in understanding and forecasting the world's oceans

Joaquín Tintoré and the SOCIB/IMEDEA team

SOCIB and IMEDEA (UIB-CSIC)

http://www.socib.eu

OUTLINE

1. The Oceans' Challenges for Science, Technology and Society

2. Ocean Information for Society,… what we learned (scientific motivation and some examples of global problems addressed in a Lab. Ocean)

3. SOCIB, Ocean Observatories, a new multi-platform approach

4. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

Or… what do we do, and why?...

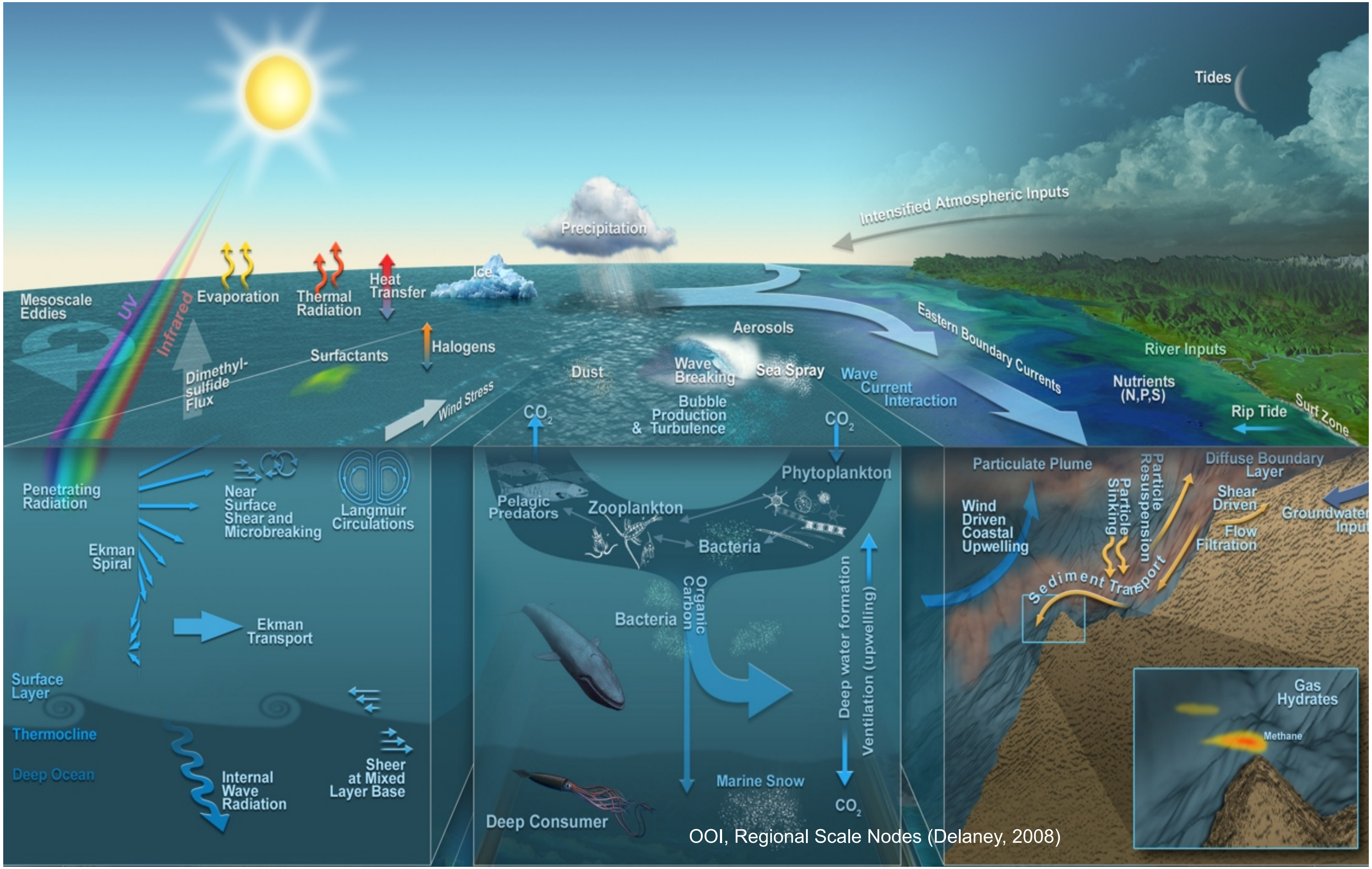
Previous work… the origins

Jewish cartographer, Cresques Abraham of Mallorca (d.1381)

"Catalán Atlas", 1375, made with his son, Jafuda Cresques

(Bibliothèque Nationale de Paris)

Oceans are complex and central to the Earth system

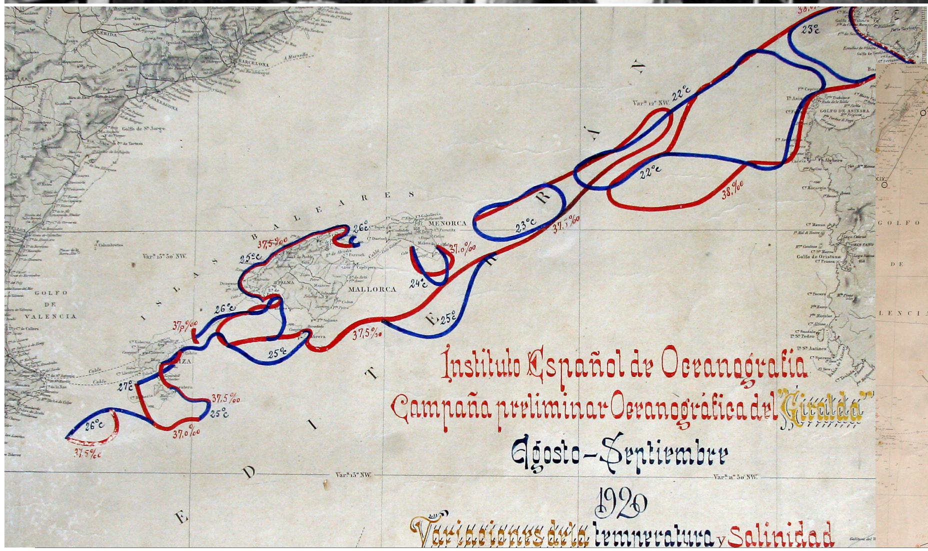


OOI, Regional Scale Nodes (Delaney, 2008)

The oceans are chronically under-sampled (1)

(Credit, Oscar Schoefield)

The oceans are chronically under-sampled (2)



(Credit, Pere Oliver)

Balearic Islands Coastal Observing and Forecasting System

Govern de les Illes Balears

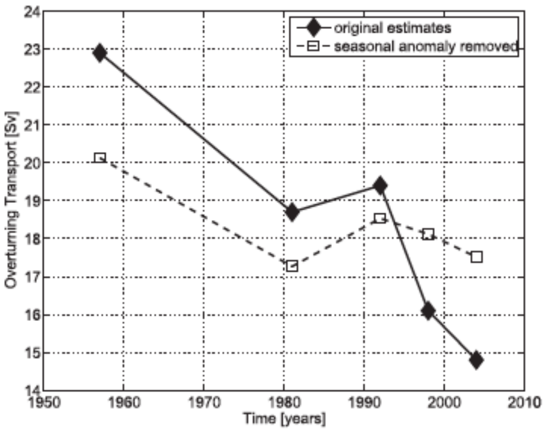
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

2012 Oceans' Challenges for Science, Technology and Society

- **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"

An example: …. AMOC, Atlantic Ocean Meridional Circulation seasonal biases,…



1 NOVEMBER 2010 KANZOW ET AL.

FIG. 16. The Ψ^{MAX} inferred from five hydrographic snapshot estimates between 1957 and 2004 (solid diamonds), as reproduced from Bryden et al. (2005b). The hydrography cruises were carried out in different seasons, namely, in October 1957, August–September 1982, July–August 1991, February 1998, and April 2004. The open squares represent the historical estimates of Ψ^{MAX} with seasonal anomalies of T_{UMO} (Fig. 10c; Table 2) subtracted.

TABLE 2. S
historical esti
been applied
et al. used con
give the cruise
Fig. 16, Bryde
10c) correspo
cruises were c
mates of Ψ^{MA}

Cruise
Oct 1957
Aug–Sep 1981
Jul–Aug 1992
Feb 1998
Apr 2004

dominate
ern bound
5.4 Sv.
- The resp

Balearic Islands Coastal Observing and Forecasting System

CSIC

Universitat de les Illes Balears

Instituto Mediterráneo de Estudios Avanzados

Govern de les Illes Balears

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

2012 Oceans' Challenges for Science, Technology and Society

- **The Oceans; a complex system, changing, under-sampled but that still needs to be managed…**

•Scientists have a role but…

- Recognize GAPS in data and in knowledge, but also in GAPS in procedures such as in some cases data availability, optimization of resources, etc.

- Recognize we are part of society, managing and understanding the oceans is a global enterprise: we need more than just coordination --- > Partnership

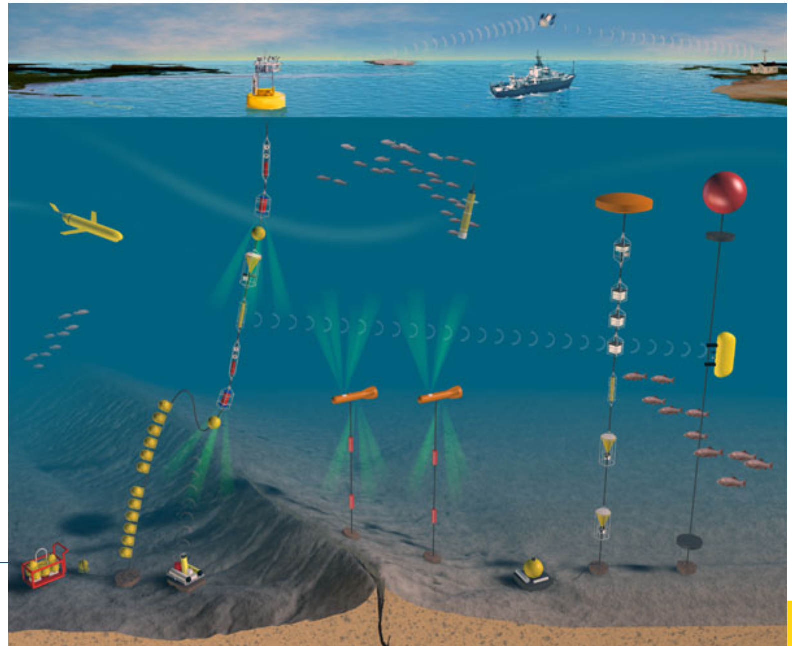
- Marine Infrastructures (OO) can help and must help to fill theses gaps and Governing bodies should adapt to the new global situation.

Paradigm Shift in Ocean Observation

From: Ship based observation
To: Multi-platform observing systems

Platform-centric Sensing Systems

Net-centric, Distributed Sensing Systems



(Adapted from Steve Chien, JPL-NASA)

Paradigm Shift in Data Availability

From: Data only available xx months/years after cruises….
To: Quasi-real time quality controlled data available

Inter-comparison

Models ⟷ **Data**

…. For ….At sea mission re-definition, new models setup…

With… huge increase in human potential for analysis

NEW CHALLENGES, TOOLS DEVELOPMENT, etc…

What is SOCIB? – Balearic Islands Coastal Observing System -

SOCIB is an Observing and Forecasting System, **a multi-platform distributed and integrated Scientific and Technological** Facility (a facility of facilities…)

- providing streams of oceanographic data and modelling services in support to operational oceanography
- contributing to the needs of marine and coastal research in a global change context.

The concept of Operational Oceanography is here understood as general, including traditional operational services to society but also including the sustained supply of multidisciplinary data and technologies development to cover the needs of a wide range of scientific research priorities and society needs.

In other words, SOCIB will allow a quantitative increase in our understanding of key questions on oceans and climate change, coastal ocean processes and ecosystem variability.

Why SOCIB, why Ocean Observatories, and **why now?**

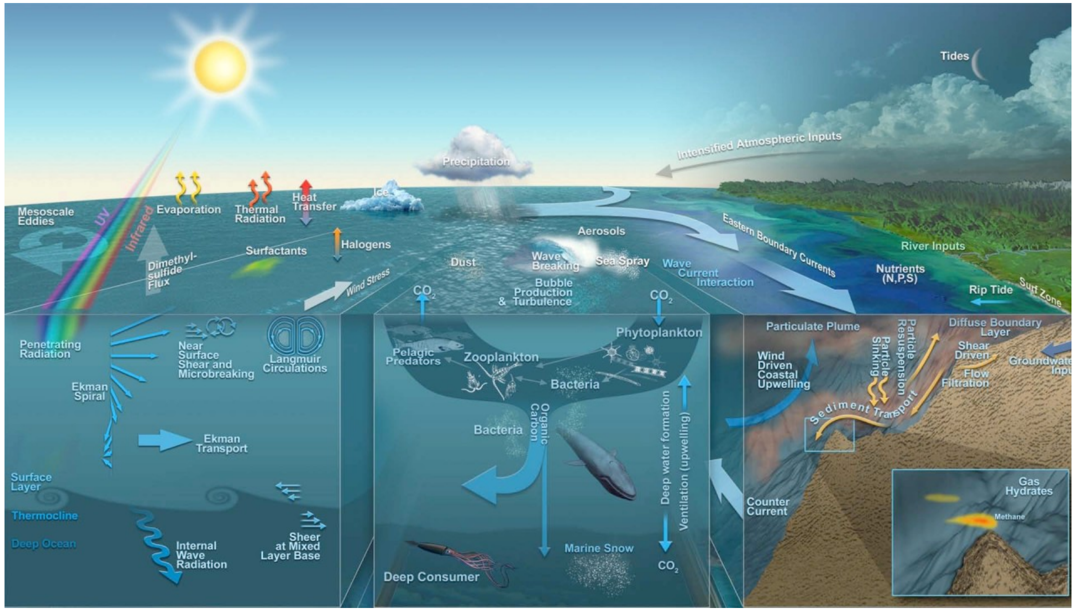
A New Approach to Marine and Coastal Research

New technologies now allow three-dimensional real time observations, that combined with forecasting numerical models, and data assimilation, …

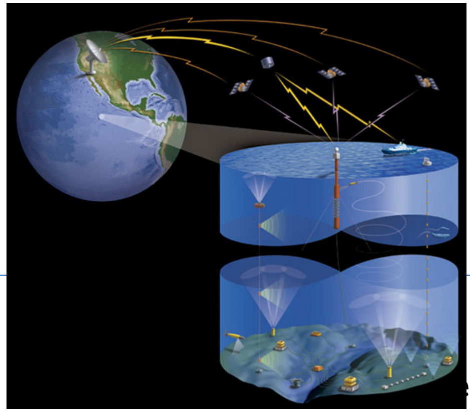
A quantitative major jump, in scientific knowledge and technology development

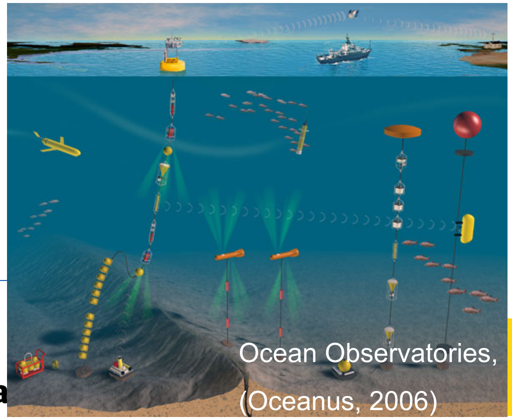
The development of a new form of Integrated Coastal Zone Management, based on recent scientific and technological achievements,

on a global change context (where climate change is one of the most important, but not the only one…), and following sustainability principles



OOI, Regional Scale Nodes (Delaney, 2008)





Ocean Observatories, (Oceanus, 2006)

The SOCIB approach to sustained Marine RI

To assure the real sustainability of the seas and oceans and of the observing systems, in 2007 we designed SOCIB:

→ **RESPONDING TO 3 KEY DRIVERS**

- Science Priorities
- Strategic Society Needs
- Technology Developments

OUTLINE

1. The Oceans' Challenges for Science, Technology and Society

2. Ocean Information for Society,… what we learned (scientific motivation & examples of global problems addressed in Med Sea; a Lab. Ocean)

3. SOCIB, Ocean Observatories, a new multi-platform approach

4. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

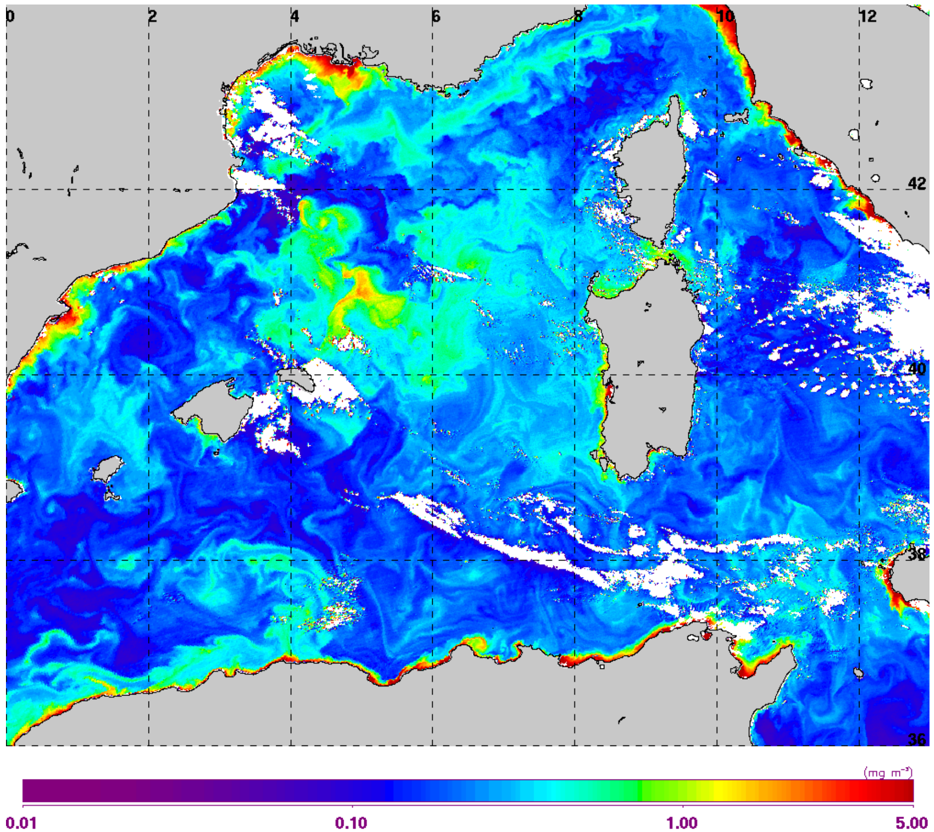
Scientific motivation

From Large Scale Picture --→

Mesoscale/eddy-mean flow interactions, heat, nutrient and/ or carbon fluxes, etc… : 1990’s onwards…

Vertical motion associated with mesoscale features plays a major role in the exchanges of properties between the surface and the ocean interior (Klein-Lapeyre 2008).

Mesoscale and Submesoscale impacts on physical variability and ecosystem variability.



SeaWiFS chlorophyll image. Unites are mg m^{-3} . Mesoscale dynamics modulates biological responses.

Regional Problems (of global interest)

- Mesoscale variability / characteristics, eddies and filaments (Balearic & Alborán sub-basins).
- Mesoscale vaiabili3d dynamics of mesoscale structures, w estimations using QG Omega and SQG, assimilation PE models, models experiments, induced vertical biogeochemical exchanges. Ecosystem response.
- Mesoscale effects on sub-basin and basin scale circulation (Balearic Sea/ Algerian sub-basin) and on shelf/slope exchanges (canyons).

- Transient forcing episodes and its effects on sub-basin and basin scale circulation (Water Masses and also MLD) and beaches (!)

- New Technologies, for addressing the “scales and scales interaction problem” as well as the “synopticity problem”…: gliders

Motivation: the background... IMEDEA work since 1990 's… - Strategic Plan 2010-2013

20 years of **peer reviewed 'basic' Research Activity**: fronts, mesoscale eddies, shelf/slope exchanges, shelf dynamics, satellite altimetry, waves, sediments, beach variability, etc…

that evolved incorporating …

Technology Development (both transfer of technological products –spin off AMT- and transfer of management technologies –beach management, recreational boating carrying capacity, tools for decision support; ESI/NOAA, sustainability indicators-)

that evolved as requested by society…

Applications to respond to society needs (beach erosion, beach response extreme events, sand re-nourishment, socio-economic valuation, ICZM, ICOM, MSP).

(Available pdf file at:

http://imedea.uib-csic.es/tmoos)

Eastern Alborán Sea dynamics and basin scale interactions

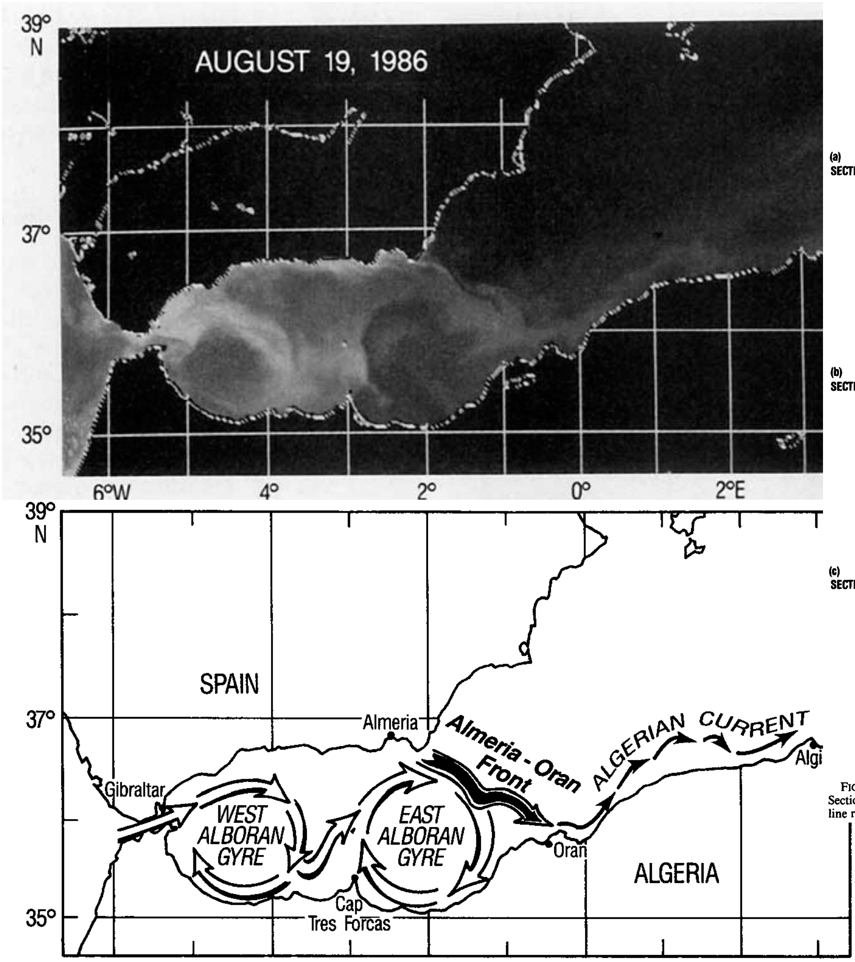


FIG. 1. (Top) A satellite thermal image of the Alboran Sea, showing the continuity of the regional circulation. As with the other satellite imagery in this paper, this NOAA AVHRR-IR image was registered to a Mercator projection and enhanced to show the ocean features. (Bottom) A schematic drawing of the circulation identifying the features displayed in the satellite thermal image (after Arnone et al. 1988).

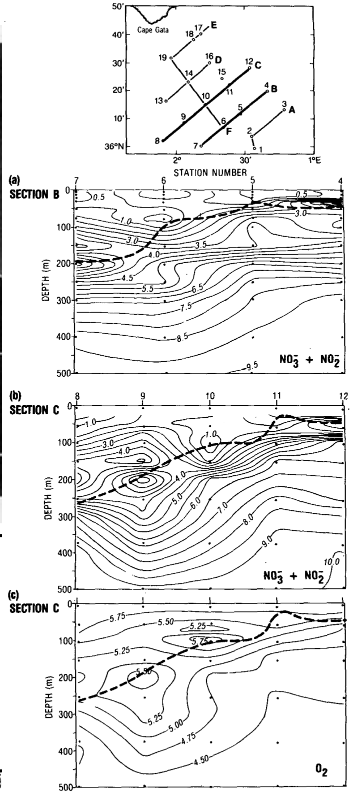
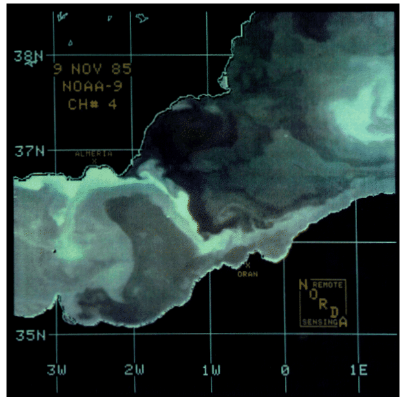
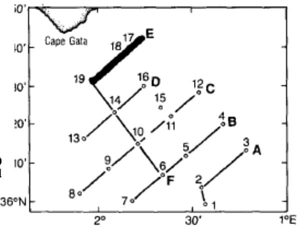


FIG. 8. Vertical nitrogen distribution for (a) Section B, and (b) Section C. Vertical oxygen distribution for Section C (c). The dashed line represents the depth of the 28.4 isopycnal.





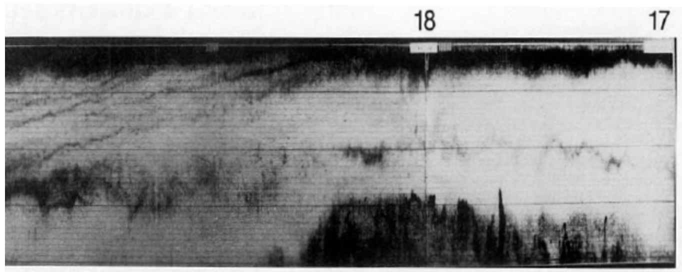


FIG. 10. Echosounder chart for Section E.

Mesoscale dynamics, vertical motions, size structure of phytoplankton, biogeochemical fluxes

(Viúdez, Tintoré, Haney, 1996)

MAY 1996 VIÚDEZ ET AL.

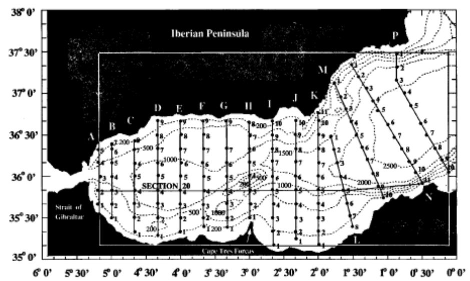


FIG. 1. The Alboran Sea (bottom topography in m). The different vertical CTD sections are referenced.

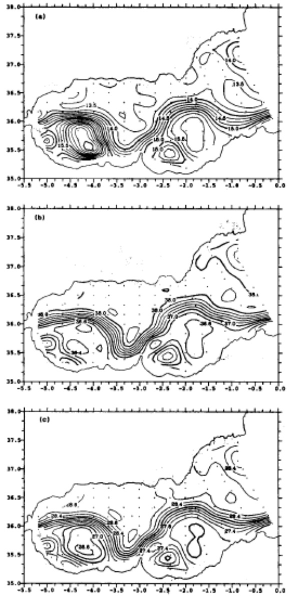
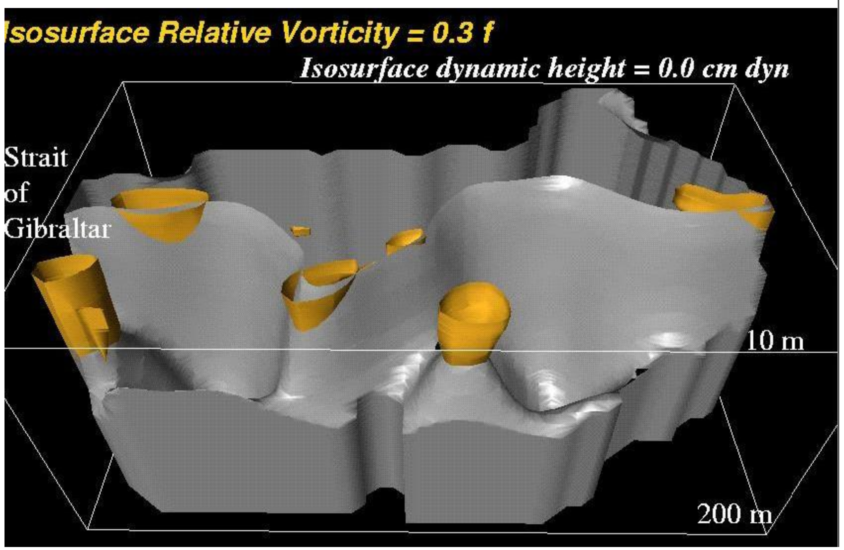


FIG. 2. (a) Temperature (Δ = 0.25°C), (b) salinity (Δ = 0.2 psu), and (c) σ_t (Δ = 0.2 σ_t) horizontal distributions at 100 m. Interpolation method: successive corrections (referenced in the text).

17 Sept to 7 Oct. 1992, R/V García del Cid



letters to nature

floras, angiosperms typically constitute only a very small percentage of the total diversity[15,17,29]—perhaps reflecting low pollen production and poor dispersal abilities associated with insect pollination. Similarly, with one strongly disputed exception angiosperm wood has not been recorded from Aptian or older rocks, and angiosperm leaves in Aptian or earlier floras are also extremely rare. However, exceptionally preserved whole plants reported from the Lower Cretaceous Crato Formation, Brazil, document that diverse herbaceous water plants were present by the Aptian–Albian and were a prominent part of the angiosperm assemblage of this flora[21]. These observations suggest that the apparent discrepancy between the diversity of angiosperm reproductive structures and the diversity of leaves and wood during the earliest phases of angiosperm diversification may in part be explained by the low potential of leaves and stems of herbaceous plants, including water lilies and monocots, to be preserved.

Received 20 October; accepted 15 December 2000.

1. Qiu, Y.-L. *et al.* The earliest angiosperms: evidence from mitochondrial, plastid and nuclear genomes. *Nature* **402**, 404–407 (1999).
2. Qiu, Y.-L. *et al.* Phylogeny of basal angiosperms: analyses of five genes from three genomes. *Int. J. Plant Sci.* **161** (Suppl. 6), S3–S27 (2000).
3. Soltis, P. S., Soltis, D. E. & Chase, M. W. Angiosperm phylogeny inferred from multiple genes as a tool for comparative biology. *Nature* **402**, 402–404 (1999).
4. Kuzoff, R. A. & Gasser, C. S. Recent progress in reconstructing angiosperm phylogeny. *Trends Plant Sci.* **5**, 330–336 (2000).
5. Friis, E. M., Pedersen, K. R. & Crane, P. R. Angiosperm floral structures from the Early Cretaceous of Portugal. *Pl. Syst. Evol.* **8** (Suppl.), 31–49 (1994).
6. Magallón, S., Crane, P. R. & Herendeen, P. S. Phylogenetic pattern, diversity and diversification of eudicots. *Ann. Missouri Bot. Gard.* **86**, 297–372 (1999).
7. Frumin, S. & Friis, E. M. Magnoliid reproductive organs from the Cenomanian–Turonian of northwestern Kazakhstan: Magnoliaceae and Illiciaceae. *Plant Syst. Evol.* **216**, 265–288 (1999).
8. Gandolfo, M. A., Nixon, K. C. & Crepet, W. L. in *Monocots: Systematics and Evolution* (eds Wilson, K. L. & Morrison, D. A.) 44–51 (CSIRO, Melbourne, 2000).
9. Friis, E. M., Pedersen, K. R. & Crane, P. R. Early angiosperm diversification: the diversity of pollen associated with angiosperm reproductive structures in Early Cretaceous floras from Portugal. *Ann. Missouri Bot. Gard.* **86**, 259–296 (1999).
10. Friis, E. M., Pedersen, K. R. & Crane, P. R. Reproductive structure and organization of basal angiosperms from the Early Cretaceous (Barremian or Aptian) of Western Portugal. *Int. J. Plant Sci.* **161** (Suppl. 6), S169–S182 (2000).
11. Zbyszewski, G., Manupella, G. & Da Veiga Ferreira, O. *Carta geológica de Portugal na escala de 1/50 000. Notícia explicativa da folha 27-A Vila Nova de Ourém* (Serviços Geológicos de Portugal, Lisbon, 1974).
12. Doyle, J. A. & Hickey, L. J. in *Origin and Early Evolution of Angiosperms* (ed. Beck, C. B.) 139–206 (Columbia Univ. Press, New York, 1976).
13. Penny, J. H. J. An Early Cretaceous angiosperm pollen assemblage from Egypt. *Special Papers Palaeontol.* **35**, 121–134 (1986).
14. Doyle, J. A. Revised palynological correlations of the lower Potomac Group (USA) and the Cocobeach sequence of Gabon (Barremian–Aptian). *Cretaceous Res.* **13**, 337–349 (1992).
15. Hughes, N. F. & McDougall, A. B. Barremian-Aptian angiospermid pollen records from southern England. *Rev. Palaeobot. Palynol.* **65**, 145–151 (1990).
16. Doyle, J. A. & Robbins, E. I. Angiosperm pollen zonation of the continental Cretaceous of the Atlantic Coastal Plain and its application to deep wells in the Salisbury Embayment. *Palynology* **1**, 43–78 (1977).
17. Hughes, N. F. *The Enigma of Angiosperm Origins* (Cambridge Univ. Press, Cambridge, 1994).
18. Rey, J. Recherches géologiques sur le Crétacé inférieur de l'Estremadura (Portugal). *Serviços Geológicos de Portugal, Memórias (Nova Série) 3* **21**, 1–477 (1972).
19. Endress, P. K. & Igersheim, A. Gynoecium structure and evolution in basal angiosperms. *Int. J. Plant Sci.* **161** (Suppl. 6), S211–S223 (2000).
20. Saporta, G. D. *Flore fossile du Portugal. Nouvelles contributions à la flore Mésozoique. Accompagnées d'une notice stratigraphique par Paul Choffat* (Imprimerie de l'Academie Royale des Sciences, Lisbon, 1894).
21. Mohr, B. & Friis, E. M. Early angiosperms from the Aptian Crato Formation (Brazil), a preliminary report. *Int. J. Plant Sci.* **161** (Suppl. 6), S155–S167 (2000).
29. Brenner, G. J. & Bickoff, I. S. Palynology and the age of the Lower Cretaceous basal Kurnub Group from the coastal plain to the northern Negev of Israel. *Palynology* **16**, 137–185 (1992).

Acknowledgements

We thank P. K. Endress and J. Schönenberger for valuable comments and help; and P. von Knorring for preparing the reconstruction of the fossil flower. The work was supported by grants from the Swedish Natural Science Foundation (to E.M.F.), the Carlsberg Foundation (to K.R.P. and E.M.F.), the Danish Natural Science Research Council (to K.R.P.) and the US National Science Foundation (to P.R.C.).

Correspondence and requests for materials should be addressed to E.M. Friis (e-mail: else.marie.friis@nrm.se).

Mesoscale vertical motion and the size structure of phytoplankton in the ocean

Jaime Rodríguez*, Joaquín Tintoré†, John T. Allen‡, José Mª Blanco*, Damià Gomis†, Andreas Reul*, Javier Ruiz§, Valeriano Rodríguez*, Fidel Echevarría§ & Francisco Jiménez-Gómez*‖

* *Departamento de Ecología, Universidad de Málaga, Campus de Teatinos, 29071-Málaga, Spain*
† *Institut Mediterrani d'Estudis Avançats (CSIC-UIB), 07071 Palma de Mallorca, Spain*
‡ *Southampton Oceanography Center, J. Rennell Division, Southampton SO14 3ZH, UK*
§ *Departamento de Biología Animal, Biología Vegetal y Ecología, Facultad de Ciencias del Mar, Universidad de Cádiz, 11510 Puerto Real, Cádiz, Spain*

Phytoplankton size structure is acknowledged as a fundamental property determining energy flow through 'microbial' or 'herbivore' pathways[1]. The balance between these two pathways determines the ability of the ecosystem to recycle carbon within the upper layer or to export it to the ocean interior[1]. Small cells are usually characteristic of oligotrophic, stratified ocean waters, in which regenerated ammonium is the only available form of inorganic nitrogen and recycling dominates. Large cells seem to characterize phytoplankton in which inputs of nitrate enter the euphotic layer and exported production is higher[2–4]. But the size structure of phytoplankton may depend more directly on hydrodynamical forces than on the source of available nitrogen[5–7]. Here we present an empirical model that relates the magnitude of mesoscale vertical motion to the slope of the size–abundance spectrum[8–10] of phytoplankton in a frontal ecosystem. Our model indicates that the relative proportion of large cells increases with the magnitude of the upward velocity. This suggests that mesoscale vertical motion—a ubiquitous feature of eddies and unstable fronts—controls directly the size structure of phytoplankton in the ocean.

ELSEVIER

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Progress in Oceanography 66 (2005) 321–340

Progress in Oceanography

www.elsevier.com/locate/pocean

Mesoscale, seasonal and interannual variability in the Mediterranean Sea using a numerical ocean model

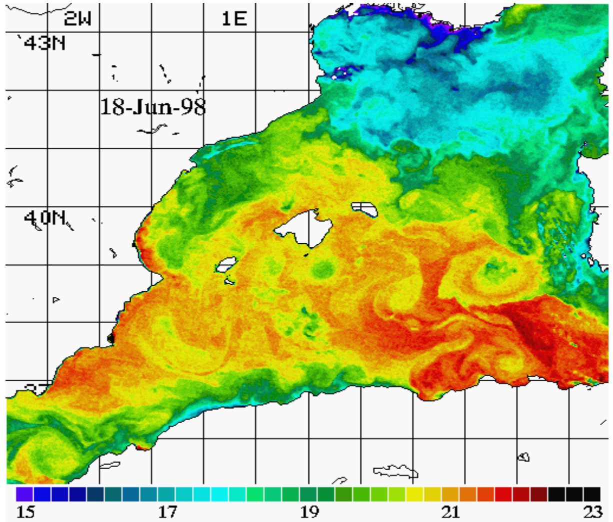
Vicente Fernández [a,*], David E. Dietrich [a], Robert L. Haney [b], Joaquín Tintoré [a]

[a] IMEDEA (CSIC-UIB), Instituto Mediterráneo de Estudios Avanzados, Spain
[b] Department of Meteorology, Naval Postgraduate School, Monterey, CA, USA

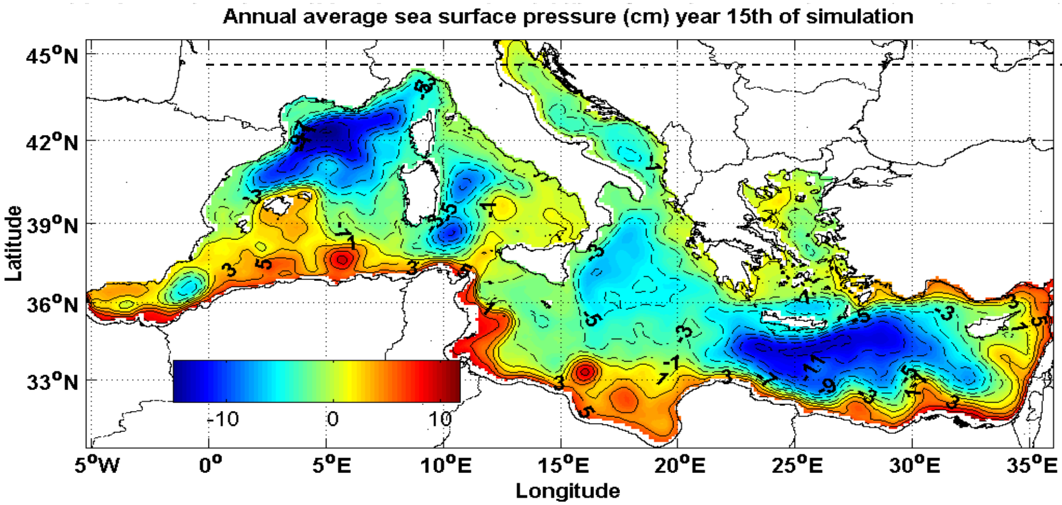
Received 4 November 2002; received in revised form 17 February 2003; accepted 2 July 2004
Available online 10 May 2005

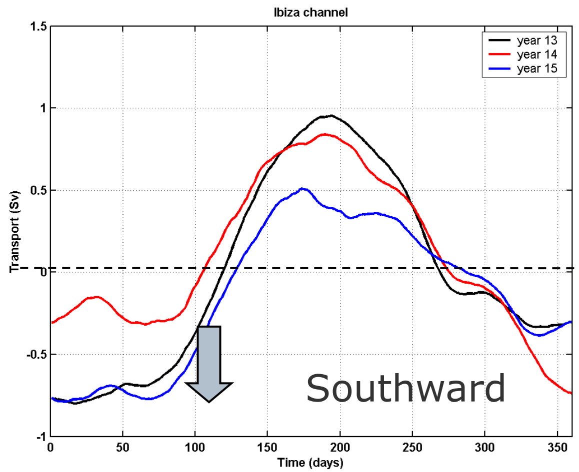
Abstract

In this paper, we present the results from a 1/8° horizontal resolution numerical simulation of the Mediterranean Sea using an ocean model (DieCAST) that is stable with low general dissipation and that uses accurate control volume fourth-order numerics with reduced numerical dispersion. The ocean model is forced using climatological monthly mean winds and relaxation towards monthly climatological surface temperature and salinity. The variability of the circulation obtained is assessed by computing the volume transport through certain sections and straits where comparison ...el simulations. More ..., is also found in the ...pheric forcing), is an ...ms to be very signif... ...g the last decade.



Observations: Northward intrusion of 0.2 to 0.7 Sv in summer. Southward transport of 1 to 1.5 in winter. *Pinot et al., 2002.*





SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Instituto Mediterráneo de Estudios Avanzados

Universitat de les Illes Balears

Govern de les Illes Balears

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

Shelf/slope exchanges – canyons interactions – mean flow/frontal instabilities

ELSEVIER
Available online at www.sciencedirect.com
SCIENCE DIRECT®
Progress in Oceanography 66 (2005) 120–141
Progress in Oceanogra
www.elsevier.com/loca

Shelf-slope exchanges by frontal variability in a steep submarine canyon

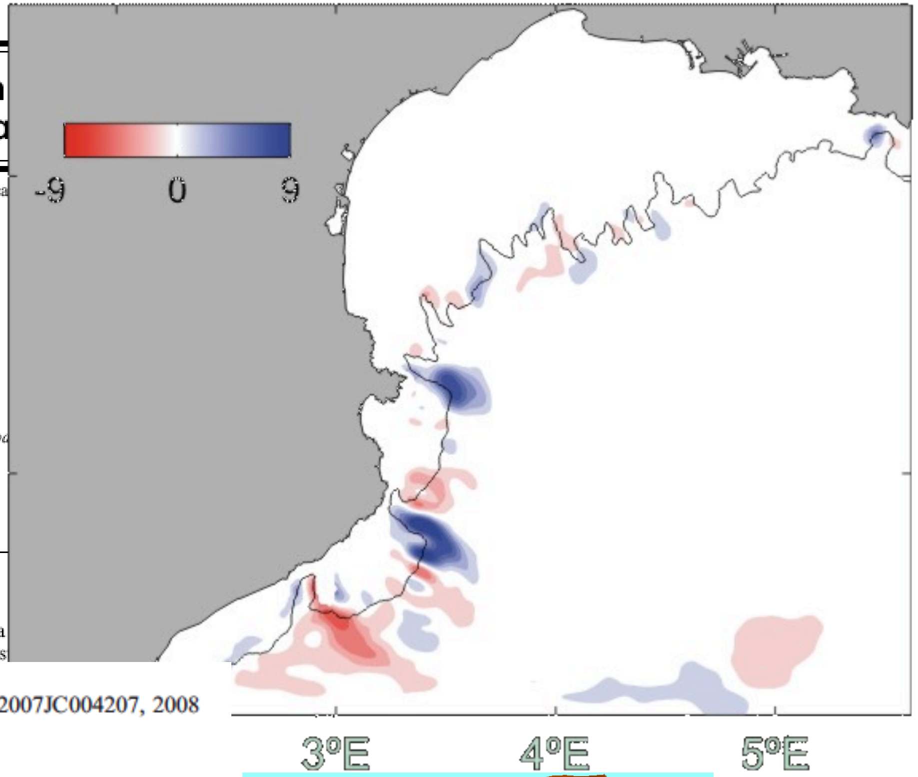
A. Jordi *, A. Orfila, G. Basterretxea, J. Tintoré

IMEDEA, Instituto Mediterráneo de Estudios Avanzados (CSIC-UIB), C/ Miquel Marqués, 21, 07190 Esporles, Spa

Received 9 October 2002; received in revised form 25 March 2003; accepted 29 July 20
Available online 13 May 2005

Abstract

We study the dynamics of a frontal jet and its short-timescale variability generated by the interaction with a
ine canyon using a limited-area fine-resolution three-dimensional coastal ocean model. The focus is on the s



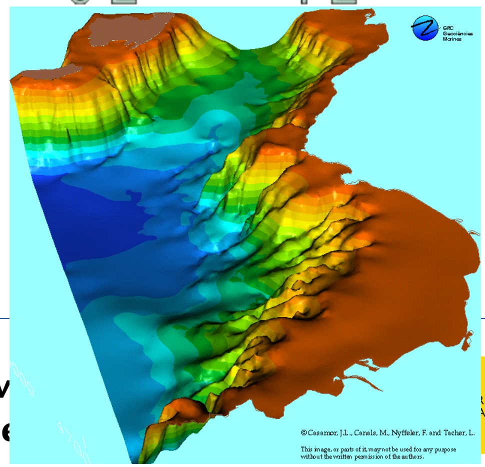
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, C05016, doi:10.1029/2007JC004207, 2008

Click Here for Full Article

Estimation of shelf-slope exchanges induced by frontal instability near submarine canyons

A. Jordi,[1] J. M. Klinck,[2] G. Basterretxea,[3] A. Orfila,[3] and J. Tintoré[3]

Received 9 March 2007; revised 29 August 2007; accepted 3 January 2008; published 13 May 2008.



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC Universitat de les Illes Balears Instituto Mediterráneo de Estudios Avanzados

Gov de l

RNO AÑA MINISTERIO DE CIENCIA E INNOVACIÓN

Residence time, coastal–open ocean exchanges, eutrofication

Available online at www.sciencedirect.com
SCIENCE DIRECT•
Continental Shelf Research 25 (2005) 1339–1352
CONTINENTAL SHELF RESEARCH
www.elsevier.com/locate/csr
ELSEVIER

Residence time and *Posidonia oceanica* in Cabrera Archipelago National Park, Spain

A. Orfila[a,*], A. Jordi[b], G. Basterretxea[b], G. Vizoso[b], N. Marbà[b], C.M. Duarte[b], F.E. Werner[c], J. Tintoré[b]

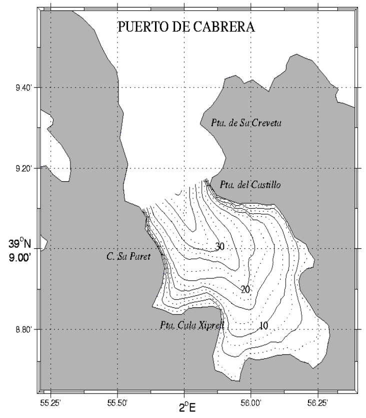
[a]*School of Civil and Environmental Engineering, Hollister Hall, Cornell University, 14853 Ithaca, NY 14853, USA*
[b]*IMEDEA. Instituto Mediterráneo de Estudios Avanzados (CSIC-UIB), Miquel Marquès, 21, 07190 Esporles, Spain*
[c]*Department of Marine Sciences, University of North Carolina, 27599 Chapel Hill, NC, USA*

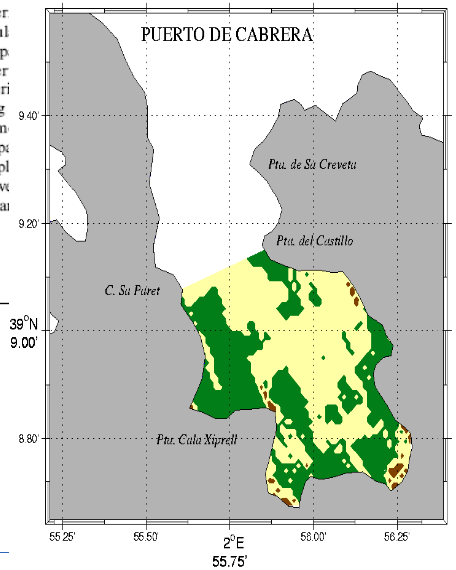
Received 20 April 2004; received in revised form 22 January 2005; accepted 25 January 2005
Available online 19 March 2005

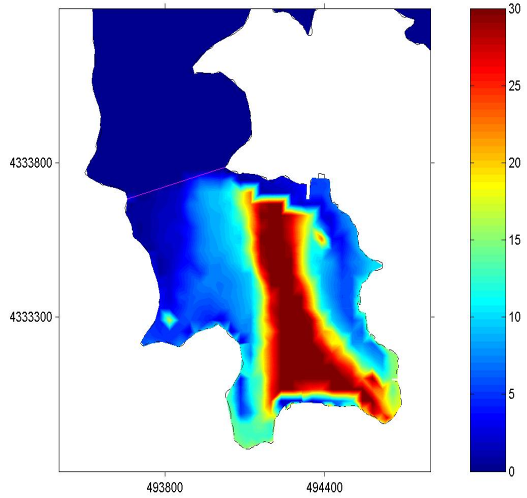
Abstract

Flushing time and residence time are studied in a small inlet in Cabrera National Park, Western Mediter
Flushing time is studied using ADCP in situ data. Observed flushing time data are compared with the simul
a three-dimensional coastal ocean numerical model. Residence time is assessed using virtual lagrangian p
studying the number remaining within the analyzed domain. Results show a good agreement between obser
modeling estimations of the flushing time (i.e. 6 days from the ADCP data and 5.6 days from the numeri
Residence time estimations yield a broad range of values, from 1 h in the Bay to over 30 days depending
horizontal and vertical position where particles were released. A continuous stirred tank reactor (CSTR) m
Port yields a value of 8.7 days. Results obtained for the residence time appear to have a determinant impa
meadows of the seagrass *Posidonia oceanica*, present inside the Port. Recirculation patterns and compl
coastal environments create a non-uniform distribution of the areas of accumulation of non-conservative
that indicate that residence time concept is the correct approach when studying the impact of water tra
biological communities.

Keywords: Residence time; Flushing time; *Posidonia oceanica*







Balearic Islands Coastal Observing and Forecasting System
Govern de les Illes Balears
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

Coastal ocean forecasting, pre-operational Systems: Oil spill, Search and Rescue, etc…

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of Marine Systems 71 (2008) 79–98

JOURNAL OF MARINE SYSTEMS

www.elsevier.com/locate/jmarsys

A forecast experiment in the Balearic Sea

Reiner Onken [a,*], Alberto Álvarez [b], Vicente Fernández [b], Guillermo Vizoso [b], Gotzon Basterretxea [b], Joaquín Tintoré [b], Patrick Haley Jr. [c], Elvio Nacini [d]

[a] Institute for Coastal Research, GKSS Research Centre, Max-Planck-Straße 1, 21052 Geesthacht, Germany
[b] IMEDEA, C/ Miquel Marquès 21, 07190 Esporles, Mallorca, Spain
[c] Harvard University, 29 Oxford Street, Cambridge, MA 02138-2901, USA
[d] NATO Undersea Research Centre, Viale San Bartolomeo 400, 19138 La Spezia, Italy

Received 20 October 2005; received in revised form 16 January 2007; accepted 10 May 2007
Available online 5 June 2007

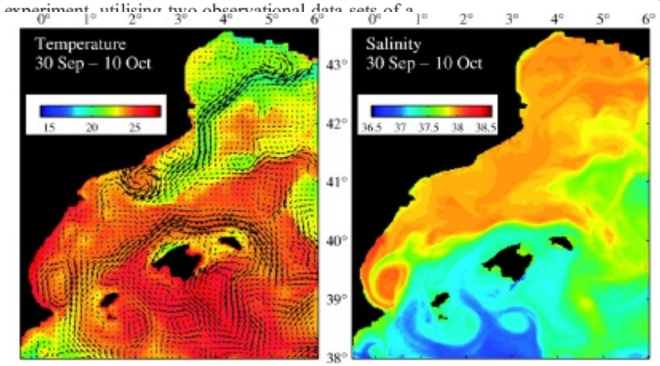
Abstract

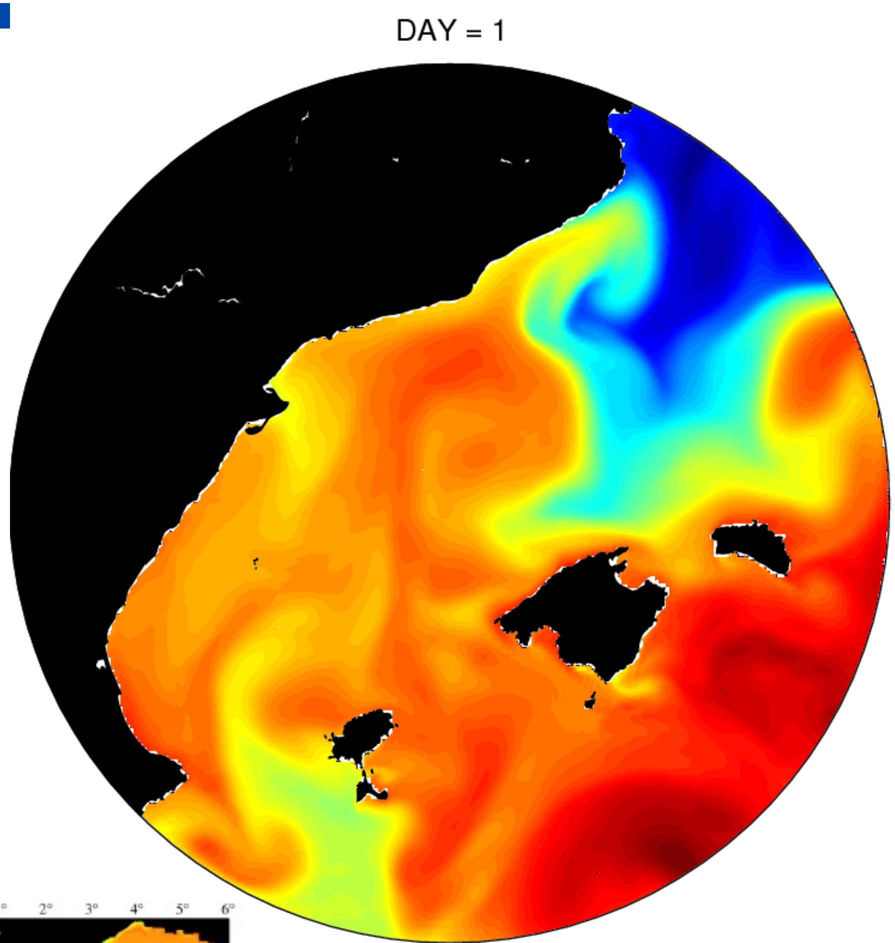
A forecast experiment in the Balearic Sea is presented which is based on the Harvard Ocean Prediction System (HOPS). HOPS is modular, containing a high-resolution primitive equations model, packages for objective analysis and data assimilation (Optimum Interpolation), an interface to implement atmospheric forcing and another interface for one-way nesting of HOPS into any other larger-scale circulation model. Here, to prevent false advection from open boundaries, HOPS is nested into the basin-scale DieCAST model [Dietrich, D.E., Haney, R.L., Fernández, V., Josey, S.A., Tintoré, J., 2004. Air–sea fluxes based on observed annual cycle surface climatology and ocean model internal dynamics: a non-damping zero-phase-lag approach applied to the Mediterranean Sea. J. Mar. Syst., 52, 145–165] and atmospheric forcing fields were provided in terms of HIRLAM fields by the Spanish National Institute of Meteorology.

The forecast capability of HOPS is demonstrated in terms of a hindcast experiment utilising two observational data sets of a subregion of the Balearic Sea which were acquired in mid September and used for model initialisation, that of the second survey serves for validation is evaluated quantitatively by three different objective methods, comparii fields, and pattern correlations, both for temperature and salinity. In five validation data set than the fields used for initialisation, i.e. the forecast

Taking into account further available options of HOPS (implementatio biological modules, two-way nesting), the system is operational for a wi

Keywords: Mediterranean Sea; Balearic Sea; Operational model; Forecast model; l





SST from 11/2008

System

lles Balears

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

Pre-operational systems being implemented; coastal ocean and beaches

Journal of Coastal Research	26	3	503–509	West Palm Beach, Florida

A Nearshore Wave and Current Operational Forecasting System

Amaya Alvarez-Ellacuria[†], Alejandro Orfila[†], Maitane Olabarrieta[‡], Raul Medina[‡], Guillermo Vizoso[†], and Joaquin Tintoré[†]

[†]Instituto Mediterraneo de Estudios Avanzados (CSIC-UIB)
07190 Esporles, Spain
a.orfila@uib.es

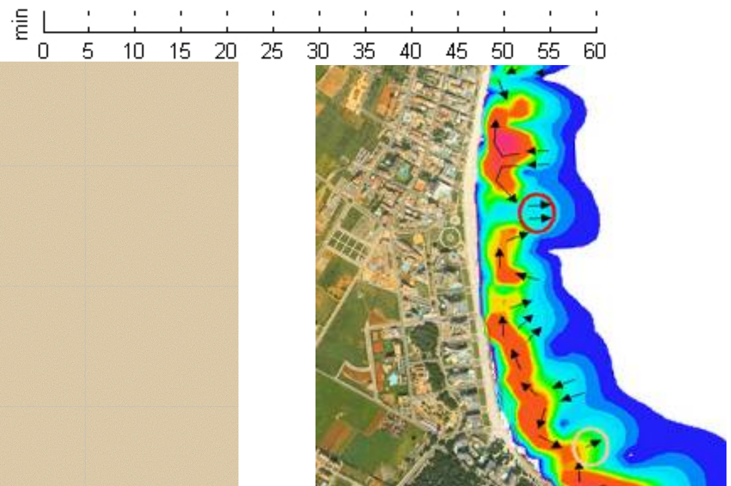
[‡]Environmental Hydraulic Institute
IH Cantabria
Universidad de Cantabria
39005 Santander, Spain

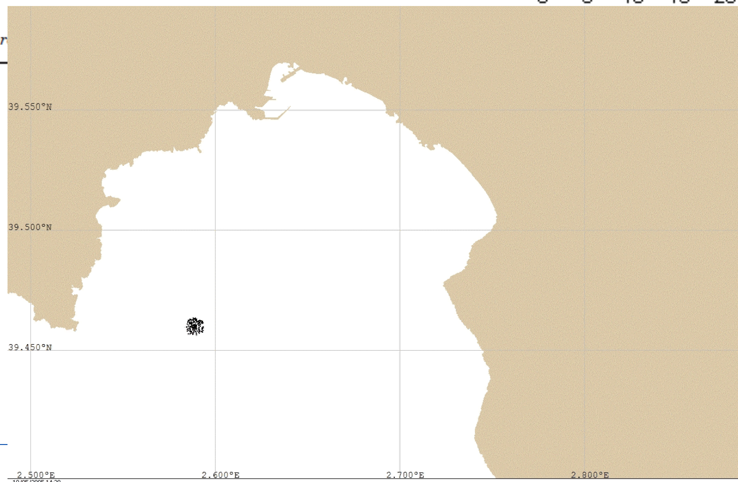
ABSTRACT

ALVAREZ-ELLACURIA, A.; ORFILA, A.; OLABARRIETA, M.; MEDINA, R.; VIZOSO, G., and TIN
A nearshore wave and current operational forecasting system. *Journal of Coastal Research*, 26(3), 503–
Beach (Florida), ISSN 0749-0208.

An operational forecasting system for nearshore waves and wave-induced currents is presented. The
tem (FS) has been built to provide real time information about nearshore conditions for beach safet
system has been built in a modular way with four different autonomous submodels providing, twice
wave and current forecast, with a temporal resolution of 1 hour. Making use of a mild slope paral
system propagates hourly deep water wave spectra to the shore. The resulting radiation stresses are
depth-integrated Navier-Stokes model to derive the resulting current fields. The system has been in
beach located in the northeastern part of Mallorca Island (western Mediterranean), characterized by i
pressure during summer season. The FS has been running for 3 years and is a valuable tool for loca
beach safety management.

ADITIONAL INDEX WORDS: *Rip currents, wave pr*





Oil-spill mapping

Land vulnerability

Security in beaches – rip currents

Prediction of trajectories from Tsunamis.

SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Instituto Mediterráneo de Estudios Avanzados

Universitat de les Illes Balears

Govern de les Illes Balears

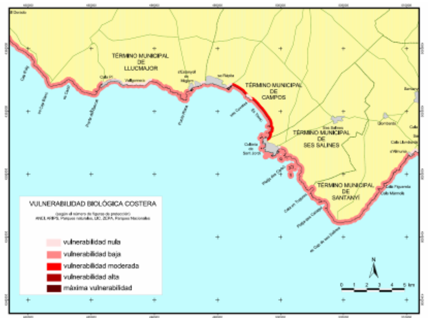
GOBIERNO DE ESPAÑA

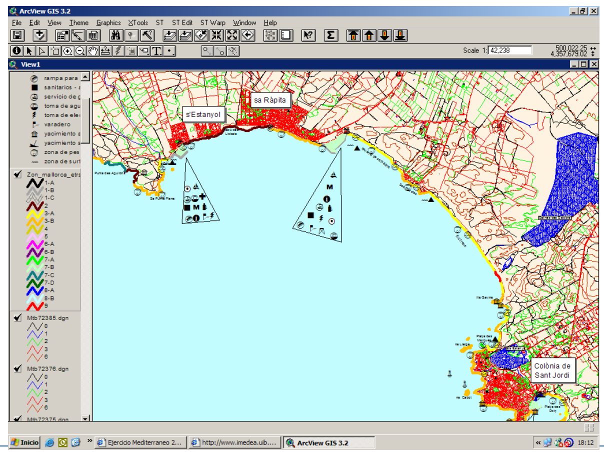
MINISTERIO DE CIENCIA E INNOVACIÓN

Tools for decision support under oil spill: ESI for all Balearic coast (1.200 km coastline)

This system incorporates all the available information and identifies resources at risk, establishing protection priorities and identifying appropriate response.

ESI (Environmental Sensitivity Index)





SOCIB Balearic Islands Coastal Observing and Forecasting System

Instituto Mediterráneo de Estudios Avanzados

CSIC

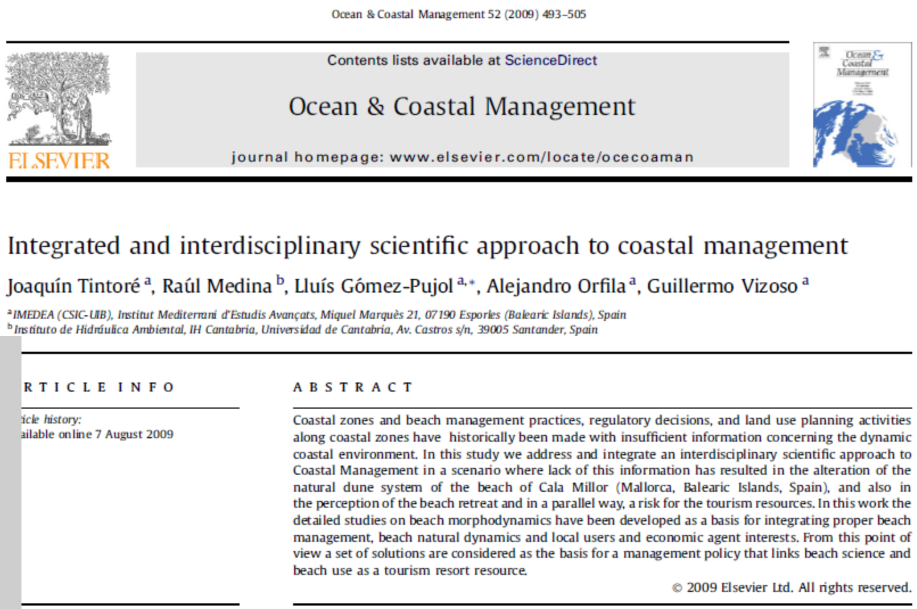
Universitat de les Illes Balears

Govern de les Illes Balears

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

Results at local scale, beach and coastal infrastructures, harbours…


Ocean & Coastal Management 52 (2009) 493–505

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

ELSEVIER

Integrated and interdisciplinary scientific approach to coastal management

Joaquín Tintoré [a], Raúl Medina [b], Lluís Gómez-Pujol [a,*], Alejandro Orfila [a], Guillermo Vizoso [a]

[a] IMEDEA (CSIC-UIB), Institut Mediterrani d'Estudis Avançats, Miquel Marquès 21, 07190 Esporles (Balearic Islands), Spain
[b] Instituto de Hidráulica Ambiental, IH Cantabria, Universidad de Cantabria, Av. Castros s/n, 39005 Santander, Spain

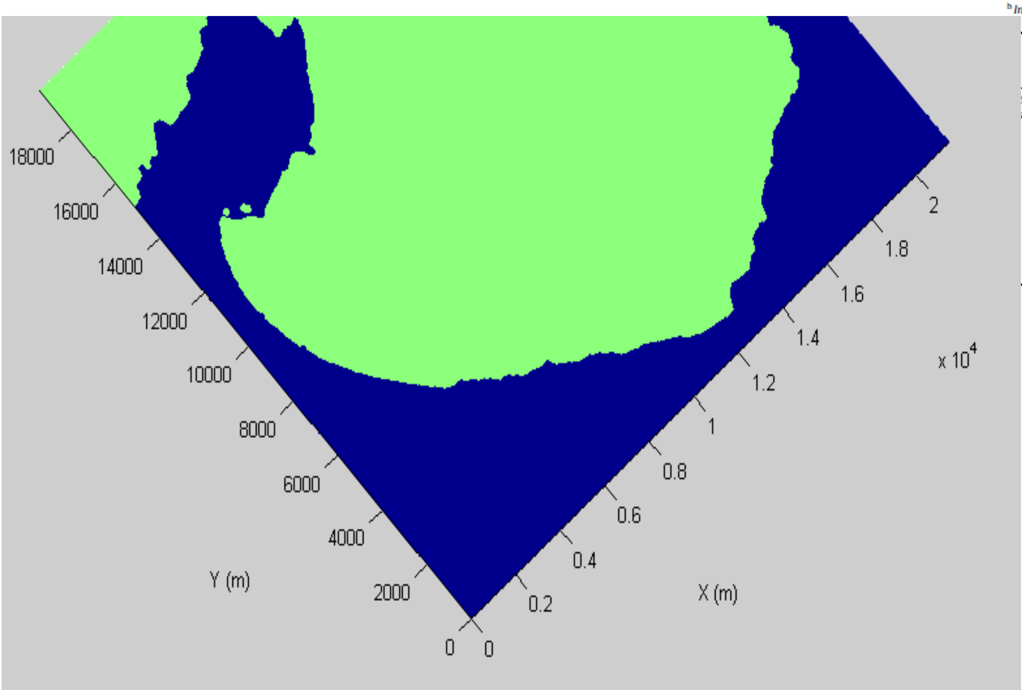
RTICLE INFO

icle history:
ailable online 7 August 2009

ABSTRACT

Coastal zones and beach management practices, regulatory decisions, and land use planning activities along coastal zones have historically been made with insufficient information concerning the dynamic coastal environment. In this study we address and integrate an interdisciplinary scientific approach to Coastal Management in a scenario where lack of this information has resulted in the alteration of the natural dune system of the beach of Cala Millor (Mallorca, Balearic Islands, Spain), and also in the perception of the beach retreat and in a parallel way, a risk for the tourism resources. In this work the detailed studies on beach morphodynamics have been developed as a basis for integrating proper beach management, beach natural dynamics and local users and economic agent interests. From this point of view a set of solutions are considered as the basis for a management policy that links beach science and beach use as a tourism resort resource.

© 2009 Elsevier Ltd. All rights reserved.



We know that with today's knowledge, actions undertaken in the past would be done differently

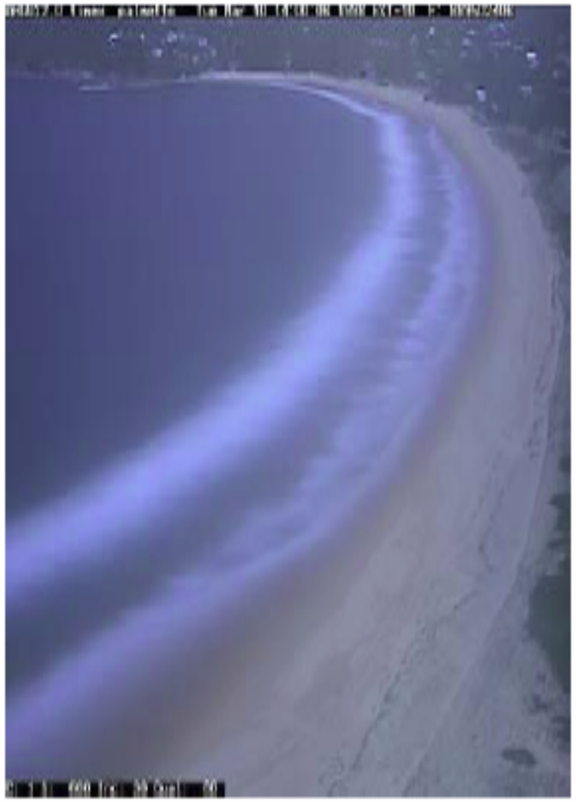
(extreme storms Nov. 2001)

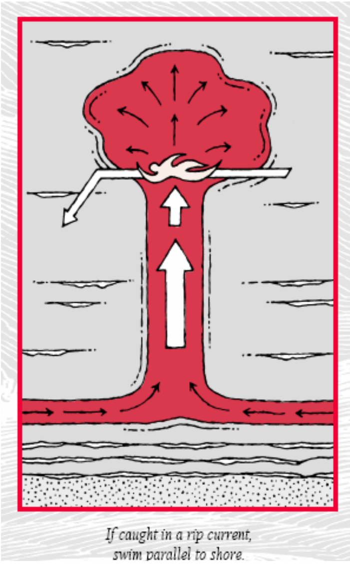
Balearic Islands Coastal Observing and Forecasting System

Govern de les Illes Balears

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN

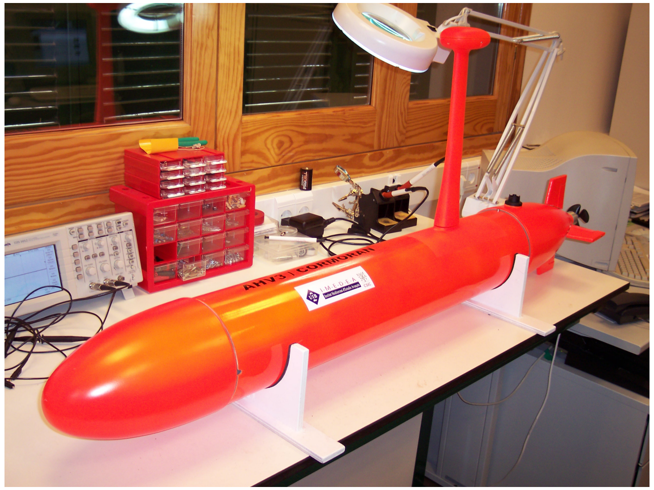
Technology development, Rip currents… Beach Safety





Beach monitoring using cameras and models,
breakers, rips, bathymetry changes, etc.

Technology Development, IMEDEA transfer to new spin off company AMT, UIB-CSIC / 2005)

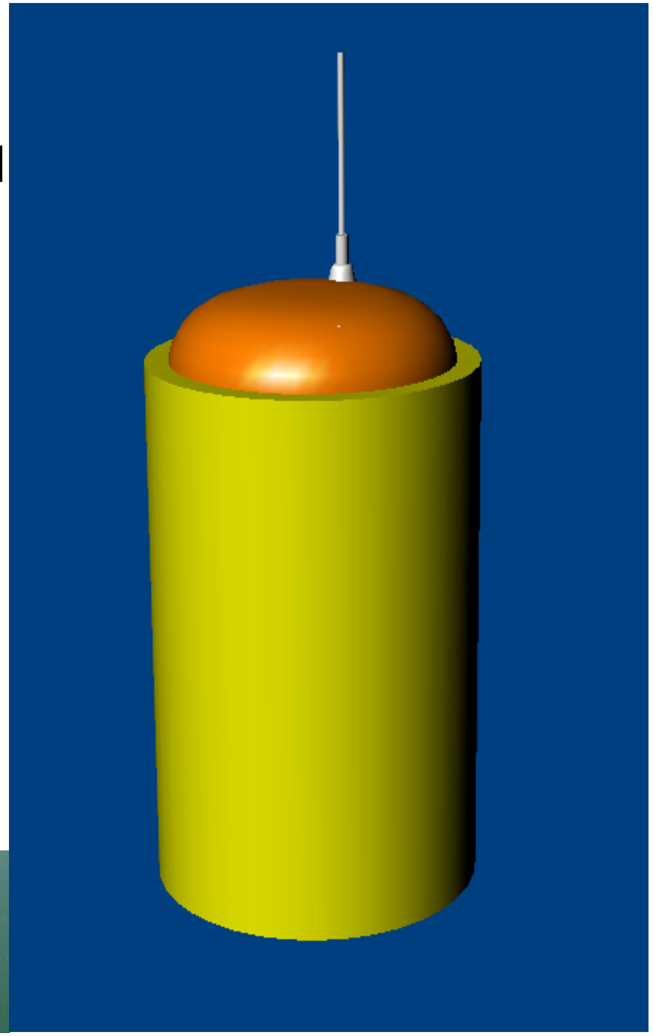


AUV's

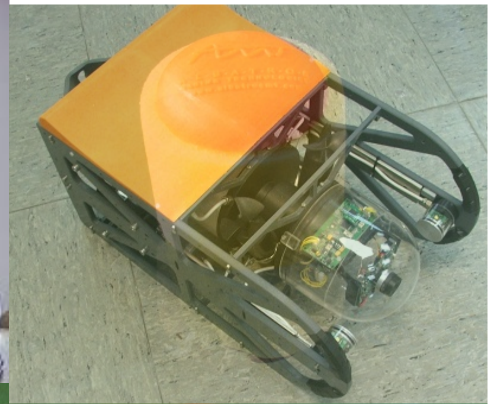
GSM and New Iridium drifters

Albatros Marine Technologies – Spin off -

ROV's



Technology Development, IMEDEA transfer to new spin off company AMT, UIB-CSIC / today 2011)



http://www.albatrosmt.com

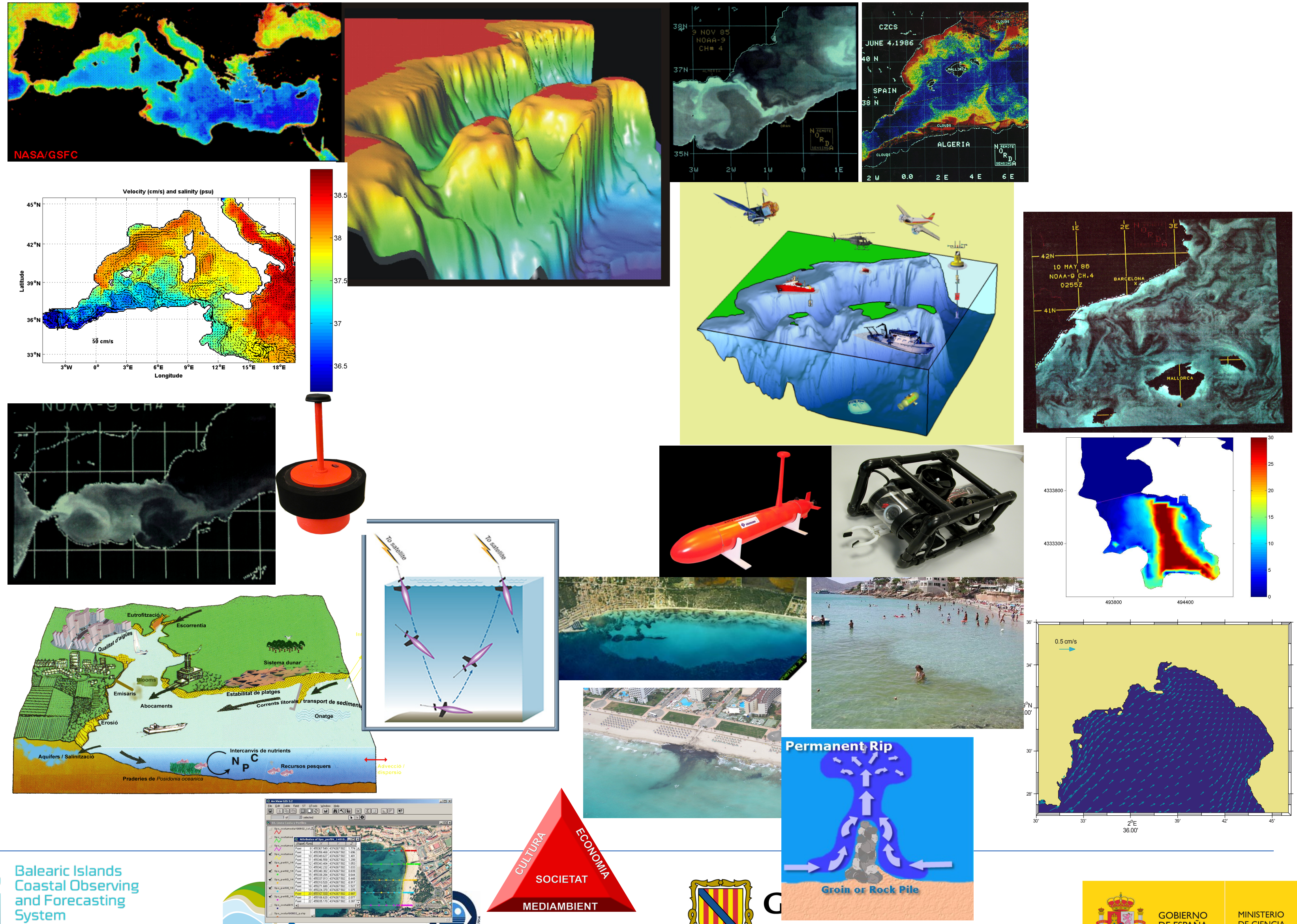
SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

In summary, background…



SOCIB Balearic Islands Coastal Observing and Forecasting System

Instituto Mediterráneo de Estudios Avanzados

Universitat de les Illes Balears

de les Illes Balears

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

In summary… addressed **regional issues of global interest**

Examples from **SCIENCE, TECHNOLOGY DEVELOPMENT AND APPLICATIONS FOR SOCIETY:**

Example… SCIENCE:

Strait's outflow (Alborán Sea), MAW-MW convergences, interactions, fronts (AO front).

Mesoscale and sub-mesoscale variability / characteristics, eddies and filaments (Balearic & Alborán sub-basins).

3d dynamics of mesoscale structures, w estimations using QG Omega and SQG, assimilation PE models, models experiments, induced vertical biogeochemical exchanges. Ecosystem response.

Mesoscale effects on sub-basin scale circulation (Balearic Sea/Algerian sub-basin) and on local circulation (canyons).

Mesoscale/sub-basin interactions with basin scale circulation: blocking effects, recirculation and with shelf / slope exchanges…

Transient forcing episodes and its effects on sub-basin and basin scale circulation (Water Masses and also MLD) and beaches (!)

New Technologies, for addressing the "scales and scales interaction problem" as well as the "synopticity problem"…: gliders

nature

www.nature.com/nature Vol 450 | Issue no. 7171 | 6 December 2007

Patching together a world view

Data sets encapsulating the behaviour of the Earth system are one of the greatest technological achievements of our age — and one of the most deserving of future investment.

Now or never

Monitoring the Earth system requires great expertise, not just to build the instruments but to use them properly and interpret their output. Many scientists are, however, far from enthused by projects that do not involve the forming and testing of hypotheses. At worst, monitoring is traduced as stamp collecting and looked down on as drudgery.

Such attitudes must not be allowed to prevail. Testing hypotheses about how the world works requires not just information on the current state of the three-dimensional globe, but on its progress through the fourth dimension of time. Data on the colour of the seas that are not gathered today can never be gathered in the future — gaps left in the record cannot be filled (see page 782). And continuous data sets are going to be vital to the validation of the ever more informative models of the Earth system that we need.

This is why operational systems for data collection in which scientists play key roles are so important. Only they can give us multiscale and multifactor ways of seeing the world that are up to the challenges of the twenty-first century. When the expenditure needed to maintain these data flows conflicts with the funds needed to support fresh scientific research, researchers must acknowledge that there is a strong case for preferring continuous, operational monitoring. An accurate and reliable record of what is going on can trump any particular strategy for trying to understand it.

There is only one Earth, with only one history, and we get only one chance to record it. Ideas not followed through can be taken up again later. A record not made is gone for good. Long zooms in and out of our ever more detailed images of Earth will delight and inform us for years to come. But no digital trickery can replace the steady, fateful pan from past to future. ■

Responding Science… and Society issues

Project based – 3 years - Can be done!!

But is inneficient

Next Step

SOCIB

Eos, Vol. 92, No. 25, 21 June 2011

NEWS

Determining Critical Infrastructure for Ocean Research and Societal Needs in 2030

PAGES 210–211

The United States has jurisdiction over 3.4 million square miles of ocean—an expanse greater than the land area of all 50 states combined. This vast marine area offers researchers opportunities to investigate the ocean's role in an integrated Earth system but also presents challenges to society, including damaging tsunamis and hurricanes, industrial accidents, and outbreaks of waterborne diseases. The 2010 Gulf of Mexico Deepwater Horizon oil spill and 2011 Japanese earthquake and tsunami are vivid reminders that a broad range of infrastructure is needed to advance scientists' still incomplete understanding of the ocean.

The National Research Council's (NRC) Ocean Studies Board was asked by the National Science and Technology Council's Subcommittee on Ocean Science and Technology, comprising 25 U.S. government agencies, to examine infrastructure needs for ocean research in the year 2030. This request reflects concern, among a myriad of marine issues, over the present state of aging and obsolete infrastructure, insufficient capacity, growing technological gaps, and declining national leadership in marine technological development; these issues were brought to the nation's attention in 2004 by the U.S. Commission on Ocean Policy.

increasing fundamental scientific understanding (10 questions). Many of the questions in the report (e.g., sea level rise, sustainable fisheries, the global water cycle) reflect challenging, multidisciplinary science issues that are clearly relevant today and are likely to take decades of effort to solve. As such, U.S. ocean research will require a growing suite of ocean infrastructure for a range of activities, such as high-quality, sustained time series observations or autonomous monitoring at a broad range of spatial and temporal scales. Consequently, a coordinated national plan for making future strategic investments becomes an imperative for addressing societal needs. Such a plan should be based on known priorities and be reviewed every 5–10 years to optimize the federal investment, the report states.

The committee examined the past 20 years of technological advances and ocean infrastructure investments (such as the rise in the use of self-propelled, uncrewed, underwater autonomous vehicles), assessed infrastructure that would be required to address future ocean research questions, and characterized ocean infrastructure trends for 2030. One conclusion was that ships will continue to be essential, especially because they provide a platform for enabling other infrastructure, such as autonomous and remotely operated vehicles; samplers and

The committee also provided a framework for prioritizing future investments in ocean infrastructure. It recommends that development, maintenance, or replacement of ocean research infrastructure assets be prioritized in terms of societal benefit, with particular consideration given to addressing important science questions; affordability, efficiency, and longevity; and the ability to contribute to other missions or applications. These criteria are the foundation for prioritizing ocean research infrastructure investments by estimating the economic costs and benefits of each potential infrastructure investment and funding those investments that collectively produce the largest expected net benefit over time. While this

ars

increasing fundamental scientific understanding (10 questions). Many of the questions in the report (e.g., sea level rise, sustainable fisheries, the global water cycle) reflect challenging, multidisciplinary science issues that are clearly relevant today and are likely to take decades of effort to solve. As such, U.S. ocean research will require a growing suite of ocean infrastructure for a range of activities, such as high-quality, sustained time series observations or autonomous monitoring at a broad range of spatial and temporal scales. Consequently, a coordinated national plan for making future strategic investments becomes an imperative

—Deborah Glickson, Ocean Studies Board, National Research Council, Washington, D. C.; E-mail: dglickson@nas.edu; Eric Barron, Florida State University, Tallahassee; and Rana Fine, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Fla.

OUTLINE

1. The 2012 Oceans' Challenges for Science, Technology and Society

2. Ocean Information for Society,… what we learned in the Mediterranean

3. SOCIB, a new multi-platform approach

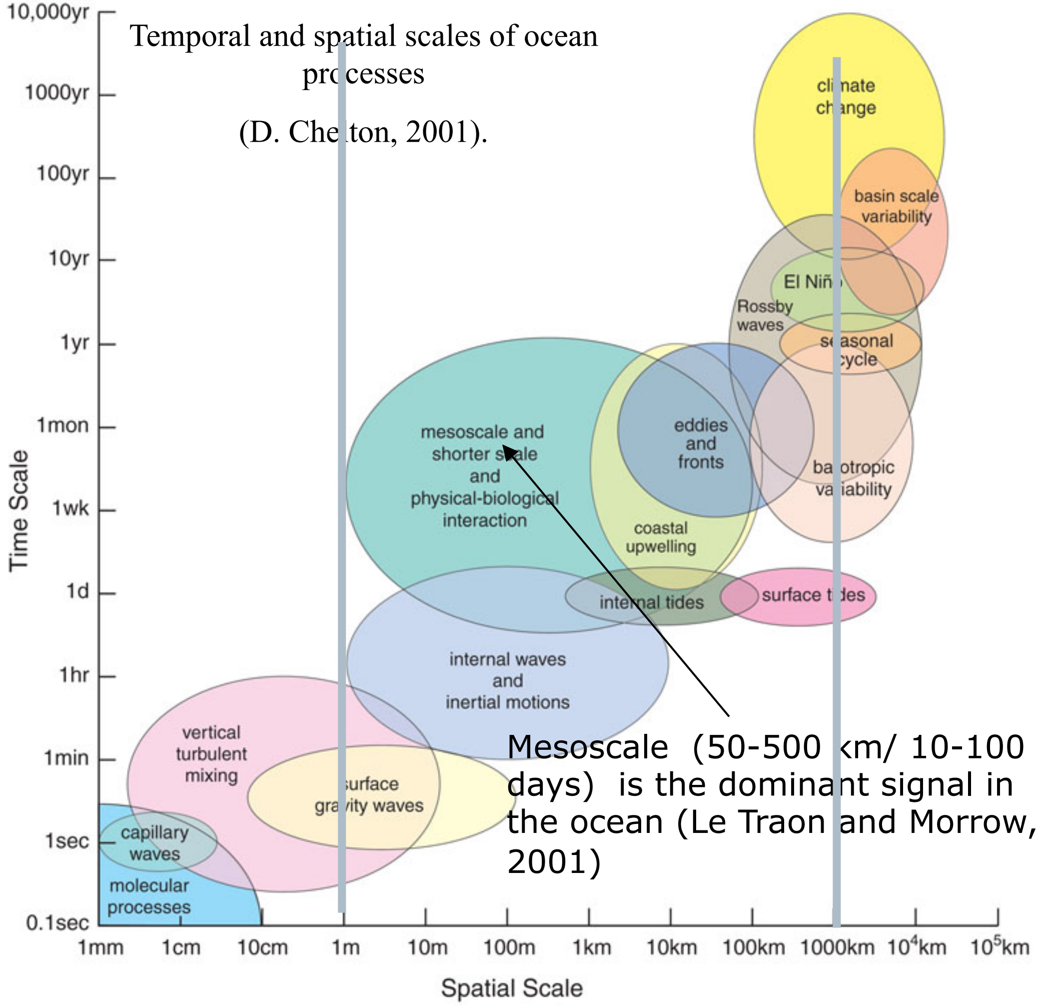
4. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

SOCIB Scales Focus: ocean variability at mesoscale/sub-mesoscale, interactions and ecosystem response

Theory and observations have shown that there is a maximum energy at the mesoscale (include fronts and eddies ~10-100km),

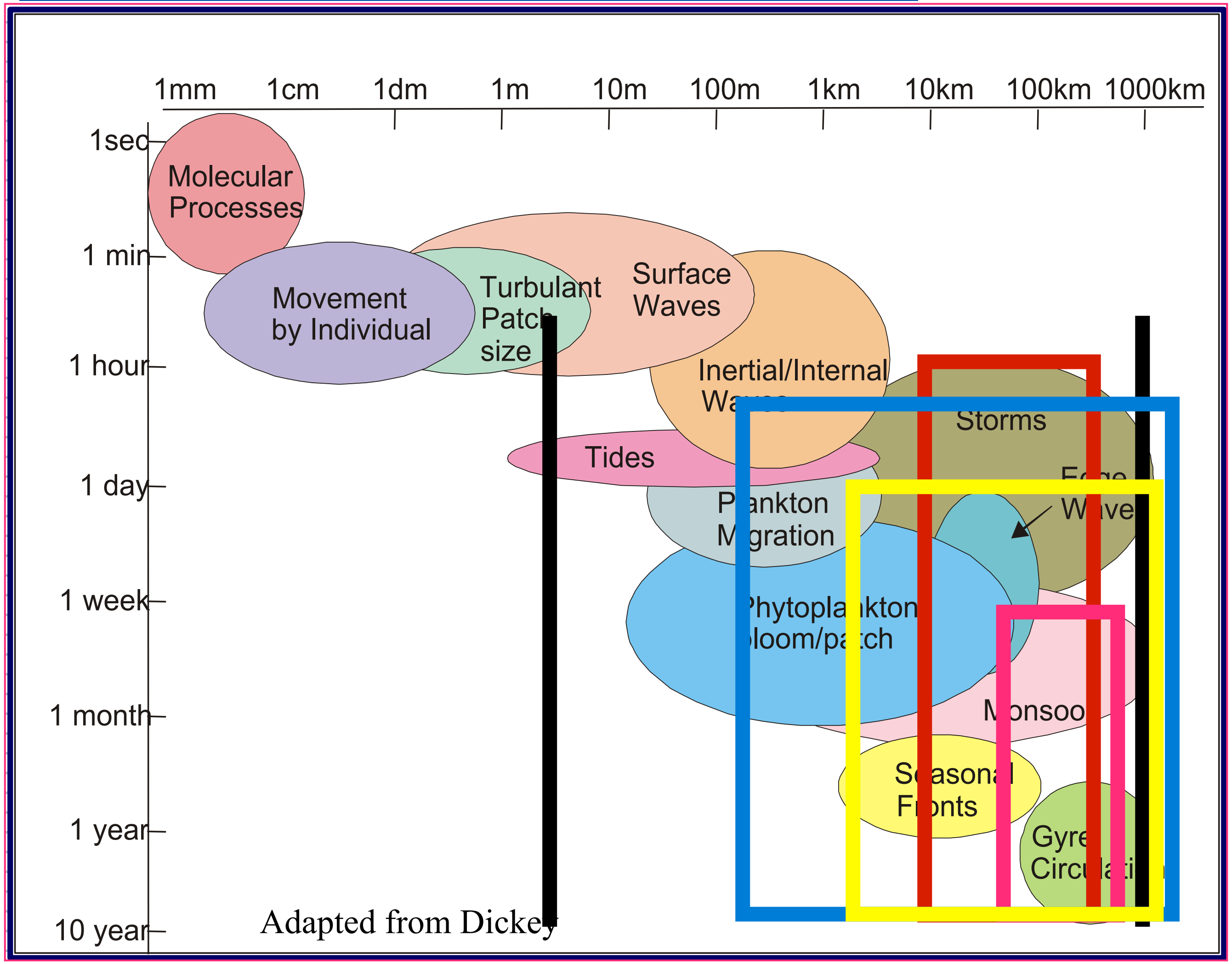
<u>SOCIB focus:</u> mesoscale & submesoscale and their interactions with general circulation and their effects on vertical motions, impact on ecosystem variability.

<u>With inputs from 'both sides'....</u>
(nearshore and coastal ocean and also seasonal/inter-annual and decadal variability)



SOCIB scales

SOCIB scales and monitoring tools



Gliders

Fixed Platforms

HF radar

24 m R/V Catamaran

Satellite

SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Instituto Mediterráneo de Estudios Avanzados

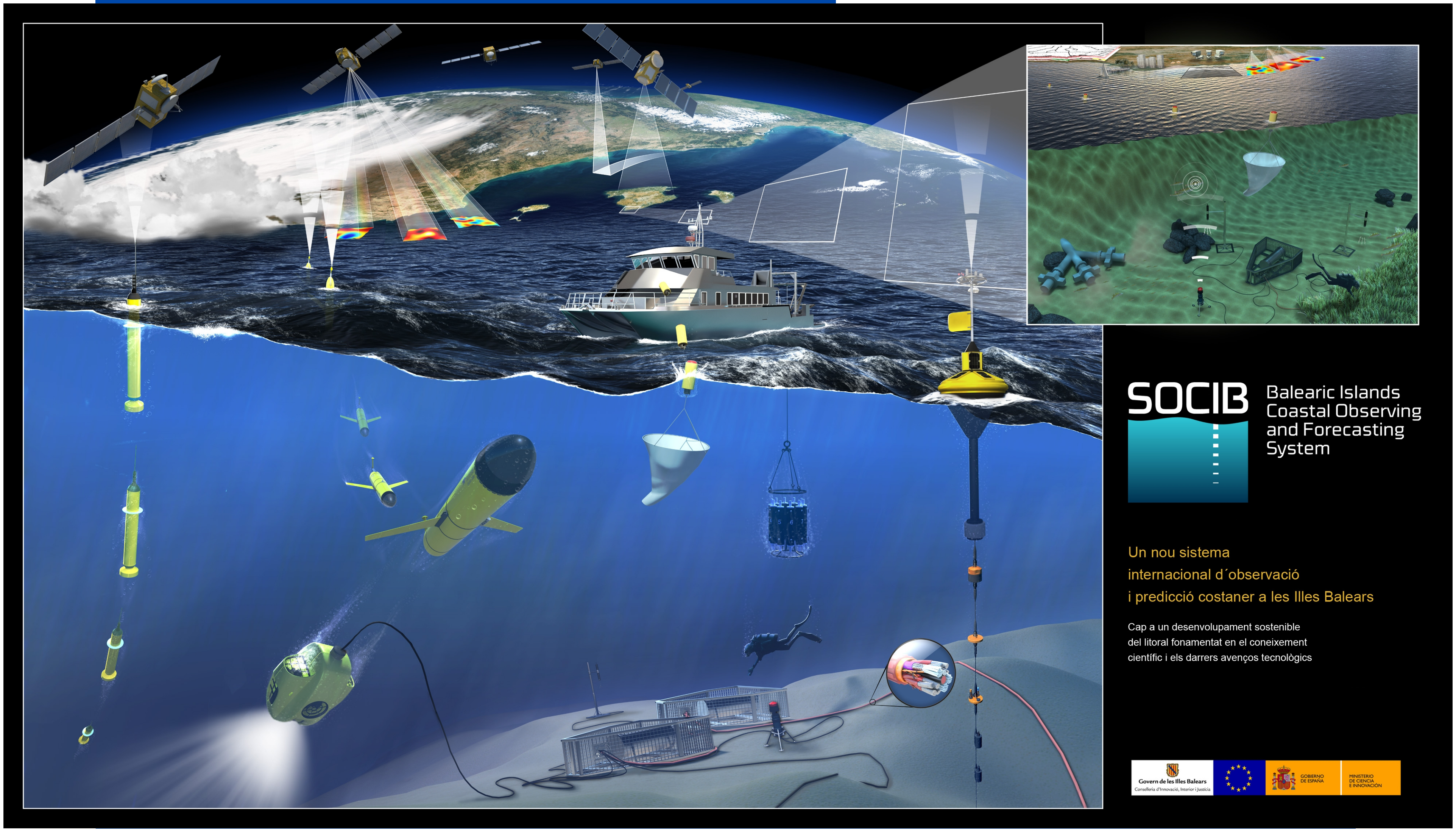
Universitat de les Illes Balears

Govern de les Illes Balears

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

SOCIB: the view….



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

The real challenge at SOCIB for the next decade…:

<u>To use and integrate </u>these new technologies 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 by this
- Establish the decadal variability, understand the associated biases and correct them …

Implementation

	2009		2010				2011				2012		2013	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1/Q2	Q3/Q4	Q1/Q2	Q3/Q4
Systems, Operations and Support Division														
Observing Facilities:														
Coastal Research Vessel	CD	CD	PDP	LP	LP	C	C	C	C	C	IOC	OM	FOC	FOC
Coastal HF Radar	CD	CD	PDP	LP	LP	C	C	IOC	FOC	FOC	FOC	FOC	FOC	FOC
Gliders	CD	CD	PDP	LP	IOC	IOC	OM	OM	OM	OM	FOC	FOC	FOC	FOC
Drifters	CD	CD	PDP	PDP	PDP	PDP	LP	IOC	IOC	OM	FOC	FOC	FOC	FOC
Moorings	CD	CD	PDP	LP	C	IOC	OM	OM	FOC	FOC	FOC	FOC	FOC	FOC
Marine and Terrestrial Beach Monitoring	CD	CD	PDP	LP	C	C	C	C	C	C	IOC	FOC	FOC	FOC
Data Centre Facility	CD	CD	CD	PDP	PDP	IOC	IOC	OM	FOC	FOC	FOC	FOC	FOC	FOC
Modelling and Forecasting Facility	CD	CD	PDP	PDP	LP	C	C	IOC	IOC	OM	FOC	FOC	FOC	FOC
Engineering and Technology Development Division														
Facility Support and Technology Development	CD	CD	PDP	LP	IOC	IOC	OM	OM	FOC	FOC	FOC	FOC	FOC	FOC
Near Shore Station	CD	CD	CD	CD	PDP	LP	PDP	C	C	IOC	OM	FOC	FOC	FOC
Ships of Opportunity/Fishing Fleet Monitoring	CD	CD	LP	PDP	IOC	IOC	OM	OM	FOC	FOC	FOC	FOC	FOC	FOC
Strategic Issues and Application to Society Division	CD	PDP	IOC	IOC	OM	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC
Services														
Management & Finance	PDP	IOC	OM	OM	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC	FOC
Computing & IT	CD	C	OM	PDP	LP	C	IOC	OM	FOC	FOC	FOC	FOC	FOC	FOC
Outreach, Education, Training & Mobility	CD	CD	PDP	PDP	PDP	PDP	IOC	IOC	OM	FOC	FOC	FOC	FOC	FOC

Project Stages:

CD	Concept Development
PDP	Planning, Design and Pilots
LP	Legal Procedure/Purchase
C	Construction
IOC	Achieve Initial Operational Capability
OM	Operation and Maintenance
FOC	Final Operational Capability

Table 2: Implementation Schedule Summary for the major SOCIB elements, detailed schedules are available in Annex 3. All available at www.socib.es

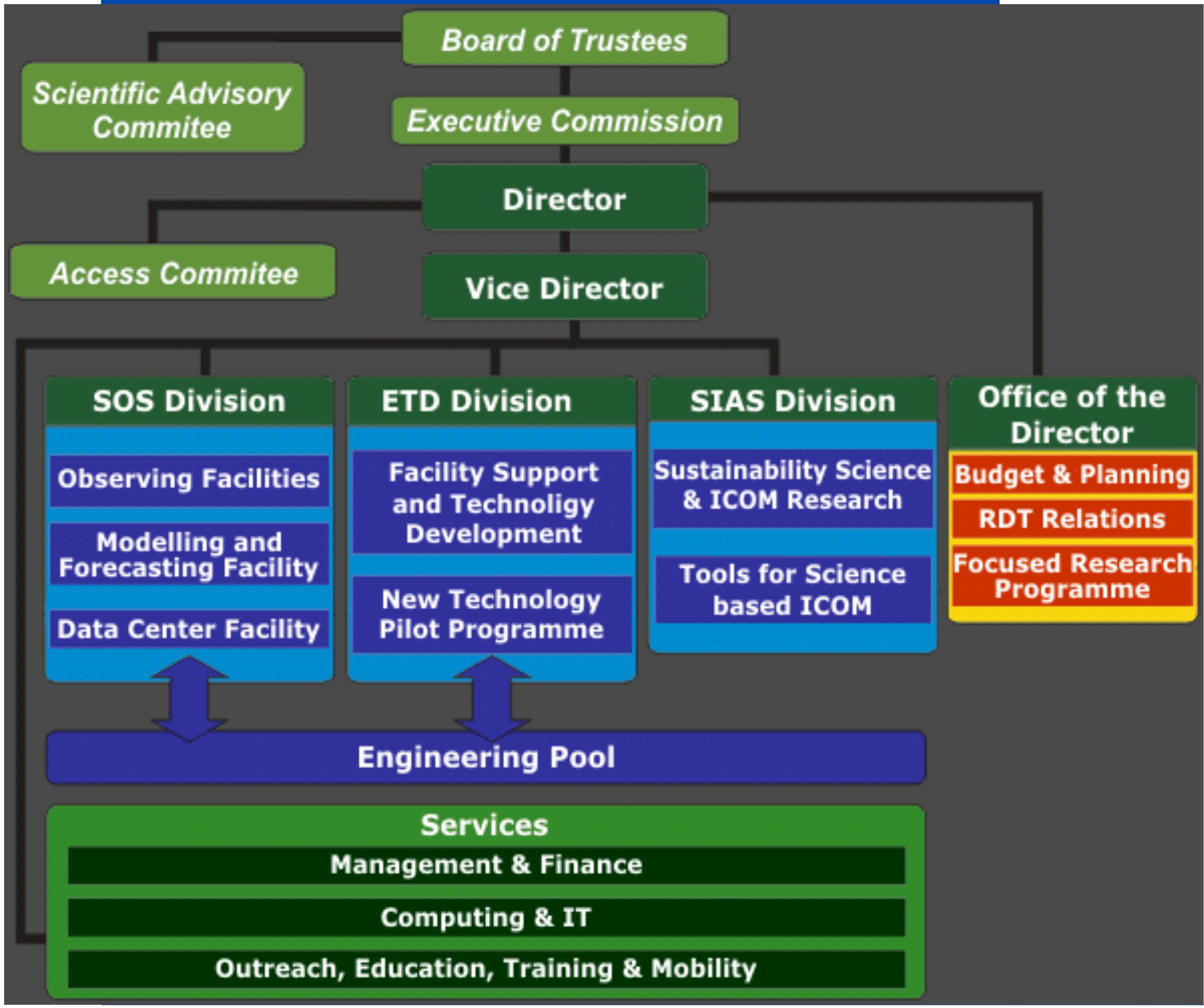
SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

SOCIB Structure and Implementation Plan



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Instituto Mediterráneo de Estudios Avanzados

Universitat de les Illes Balears

Govern de les Illes Balears

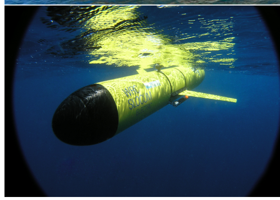
GOBIERNO DE ESPAÑA

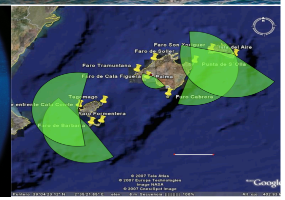
MINISTERIO DE CIENCIA E INNOVACIÓN

Systems Operations and Support Division

1. Observational Facilities (major elements)

- New Coastal Research Vessel (24 m LOA – 1.200 km coastline in the Islands)
- HR Radar
- Gliders
- Fixed Platforms and Satellite products
- ARGO and surface drifters
- Nearshore beach monitoring





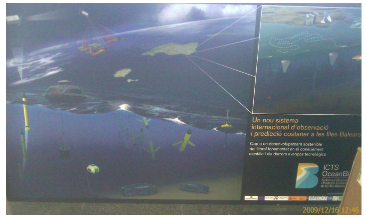
2. Forecasting sub-system

- Ocean currents (ROMS) and waves (SWAN) at different spatial scales, forced by Atmospheric model (WRF) and ecosystem coupling (NPZ)

3. Data Centre

- Quality control and Web access in open source
- Effective data archiving, internationally accepted protocols, delivery and communication

SOCIB Facilities and Services – 2012 www.socib.es



Already from SOCIB and/or in kind from CSIC, IEO and UIB and agreement with PE:

SYSTEMS OPERATIONS AND SUPPORT DIVISION

OBSERVING:

- Glider Facility (7 Slocum + 2 iRobot gliders)
- Satellite remote sensing products
- ARGO profiles and Surface drifters Facility (pilot)
- Coastal Buoys real time Facility (pilot)
- Nearshore beach monitoring Facility (pilot)

MODELLING

- Numerical Forecasting Facility

DATA CENTER

- Data Center

- •Proven capability
- •Pilot projects
- •Non sustained

APPLICATIONS AND STRATEGIC ISSUES SOCIETY DIVISION

- ICZM and Science based sustainable coastal and ocean management

Bluefin Tuna target project

ENGINEERING AND TECHNOLOGY DEVELOPMENT DIVISION

- New technologies

Parc Bit – office –
Since August 2009

SERVICES

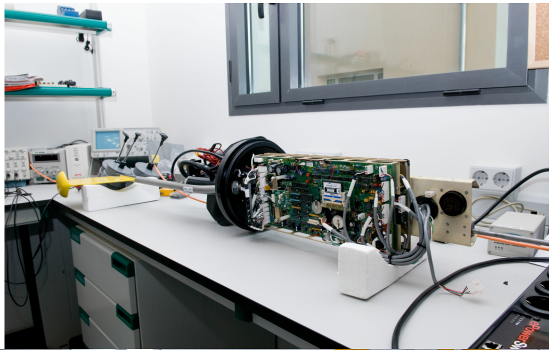
- Management and Finances
- Computing and IT's
- Outreach and Education

IMPLEMENTATION PLAN; approved July 2010

SOCIB Glider Facility

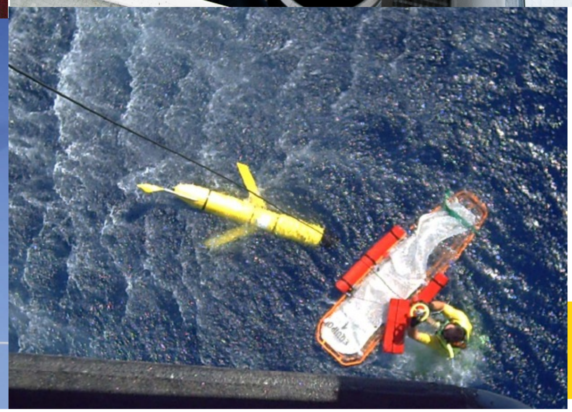
We have established new facilities for glider operations at IMEDEA

Electronics & Gliders Laboratory



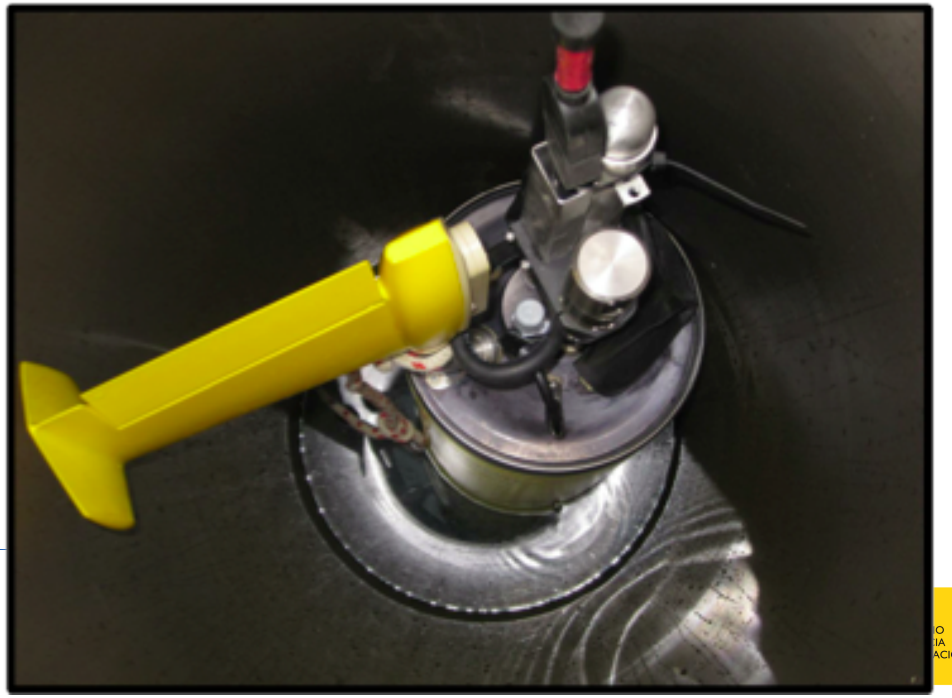
Ballasting Lab & Pressure Chamber

Collaboration:
Search and Rescue
801 Squadron
and local authorities



SOCIB Balearic Islands Coastal Observing and Forecasting System

Instituto Mediterráneo de Estudios Avanzados CSIC UIB Universitat de les Illes Balears ity



de Estudios Avanzados

O
IA
ACIÓN

Gliders Facility: Science

Mesoscale – Submesoscale / Vertical motions - biogeo effects

GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L14607, doi:10.1029/2009GL038569, 2009

Vertical motion in the upper ocean from glider and altimetry data

Simón Ruiz,[1] Ananda Pascual,[1] Bartolomé Garau,[1] Isabelle Pujol,[2] and Joaquín Tintoré[1]

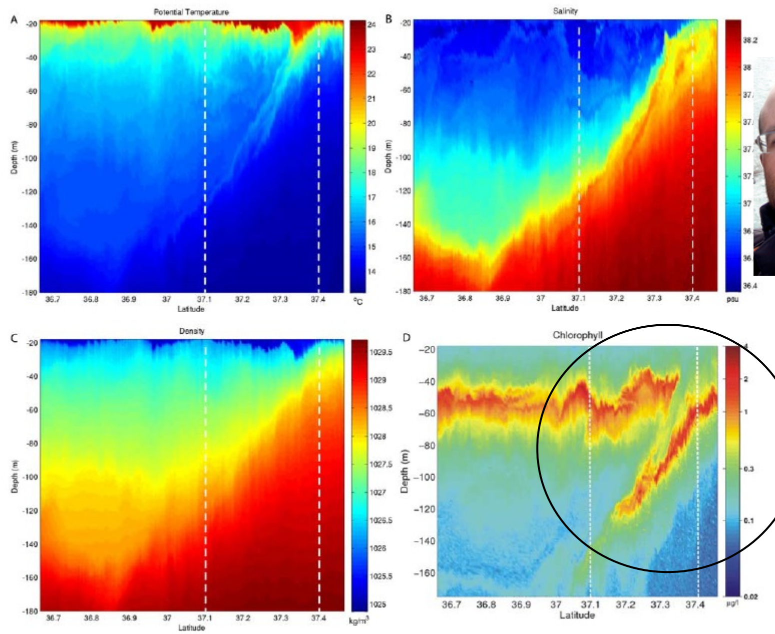
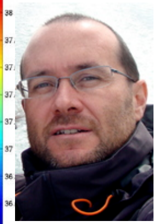


Figure 2. Vertical section of temperature (°C), salinity (PSU), density (kg/m^3) and chlorophyll (μg/l) from glider section 2 (dashed magenta in Figure 1). White dashed lines define sub-section in the northern part of the domain.

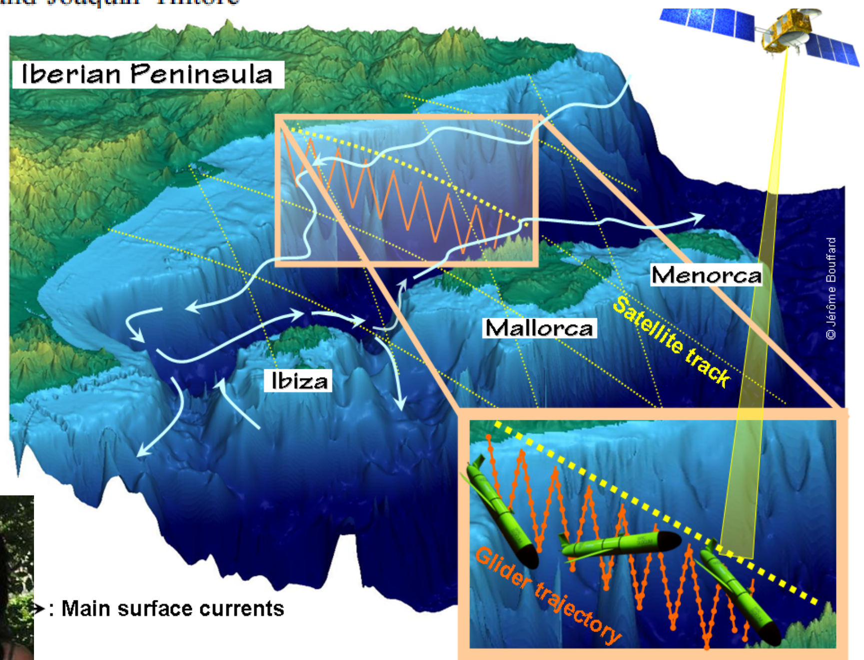


Eddy/mean flow interactions – Blocking effects General Circulation

JGR, 2010

Coastal and mesoscale dynamics characterization using altimetry and gliders: A case study in the Balearic Sea

Jérôme Bouffard,[1] Ananda Pascual,[1] Simón Ruiz,[1] Yannice Faugère,[2] and Joaquín Tintoré[1,3]



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

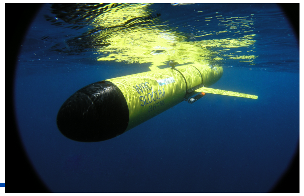
Instituto Mediterráneo de Estudios Avanzados

Universitat de les Illes Balears

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

Gliders Facility: Science



Heat content and MLD

GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L01603, doi:10.1029/2011GL050078, 2012

Underwater glider observations and modeling of an abrupt mixing event in the upper ocean

Simón Ruiz,[1] Lionel Renault,[2] Bartolomé Garau,[2] and Joaquín Tintoré[1,2]

Received 20 October 2011; revised 1 December 2011; accepted 2 December 2011; published 13 January 2012.

Main results:

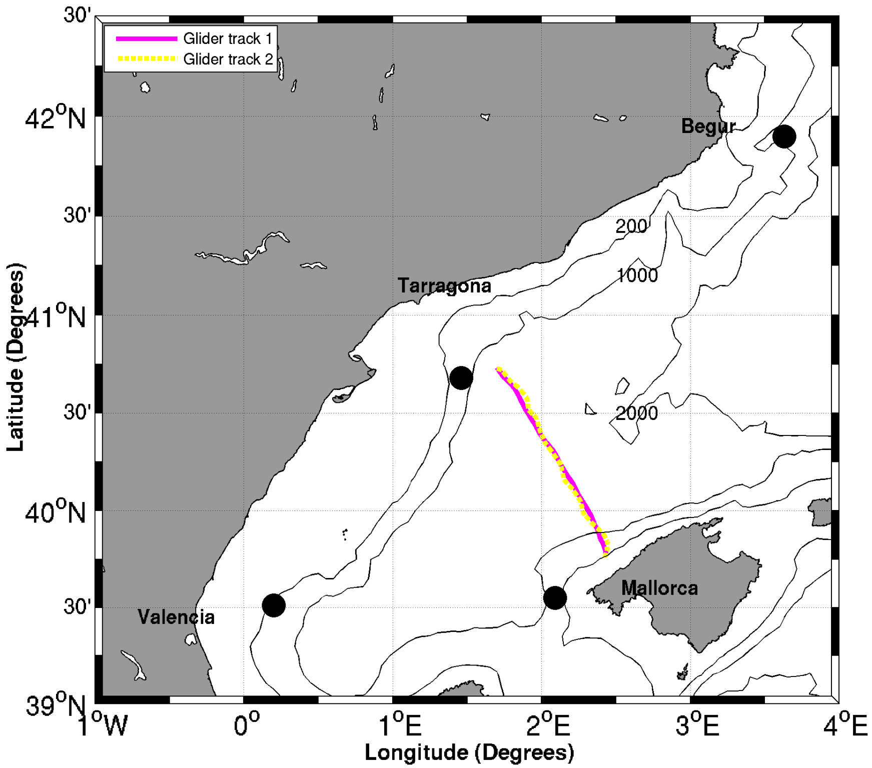
-Intense winds (up to 20 ms-1) and buoyancy forcing during December 2009 induced strong vertical mixing of the upper ocean layer in the Balearic Sea.

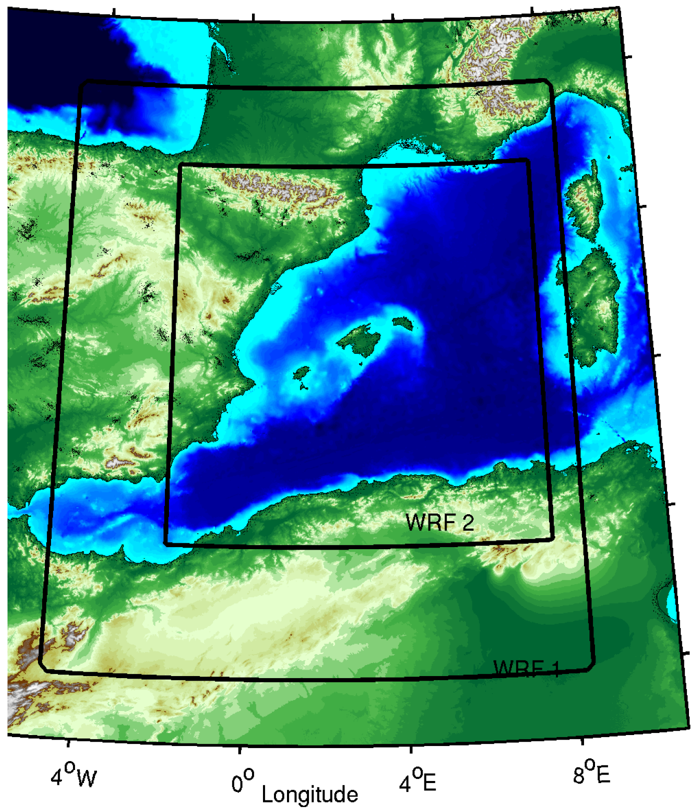
- High resolution glider data from a coastal glider reveal a surface cooling of near 2ºC and the deepening of the Mixed Layer Depth by more than 40 meters in the center of the basin.

- The heat content released to the atmosphere by the upper ocean during this mixing event exceeds 1000Wm-2. Consistent WRF estimates.

Gliders Facility: Science, MLD

Study area and sampling

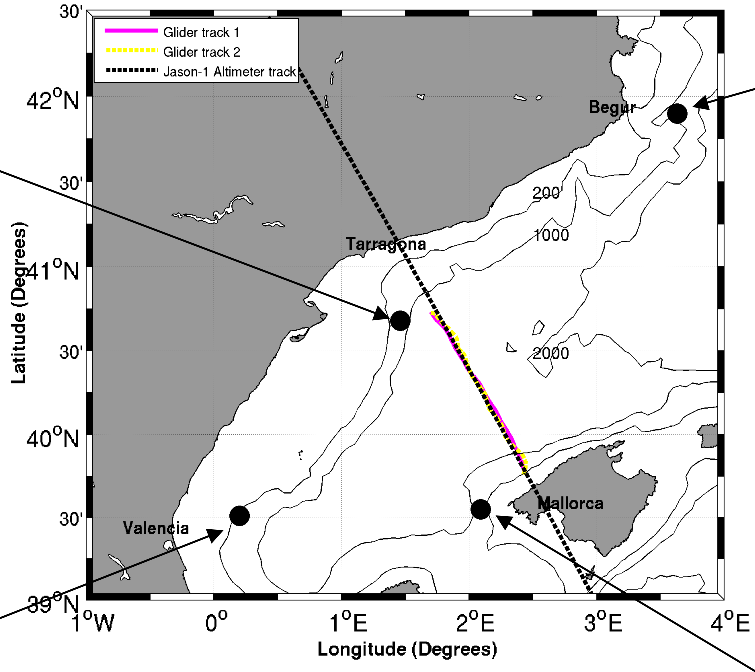


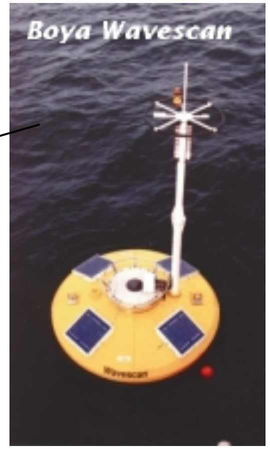


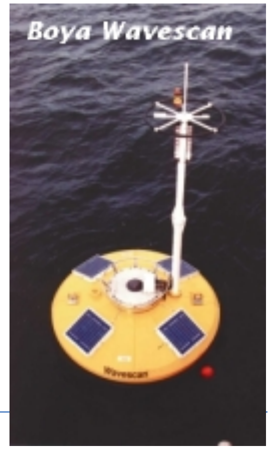
(left) Map of the study area in the Northwestern Mediterranean Sea. Glider tracks (magenta and yellow lines) are indicated. Black dots correspond to locations of the 4 oceanographic/ meteorological deep-buoys. (right) Model domains for the WRF model implementation.

Gliders Facility: Science, MLD

Data set: Puertos del Estado Deep buoys network in the WMED







- Meteorologic, oceanographic and waves

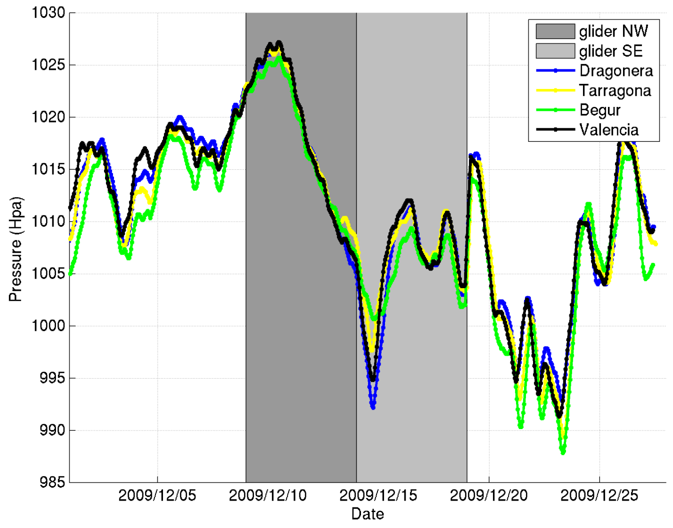
- Hourly data

- Northwestern Mediterranean Sub-basin

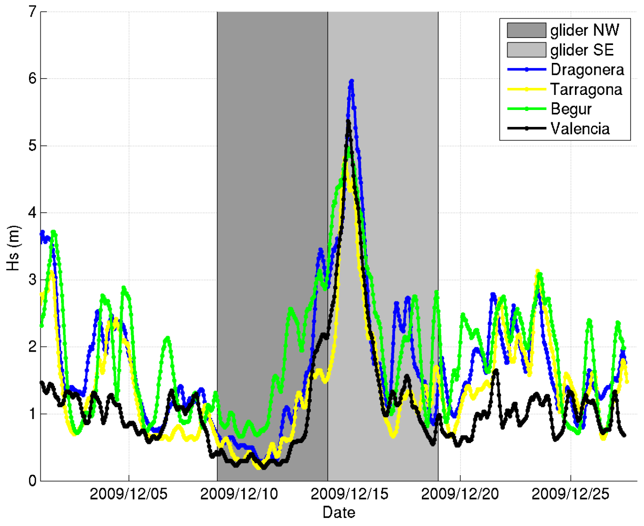
Gliders Facility: Science, MLD

Results: Buoys PdE network

Atmospheric pressure

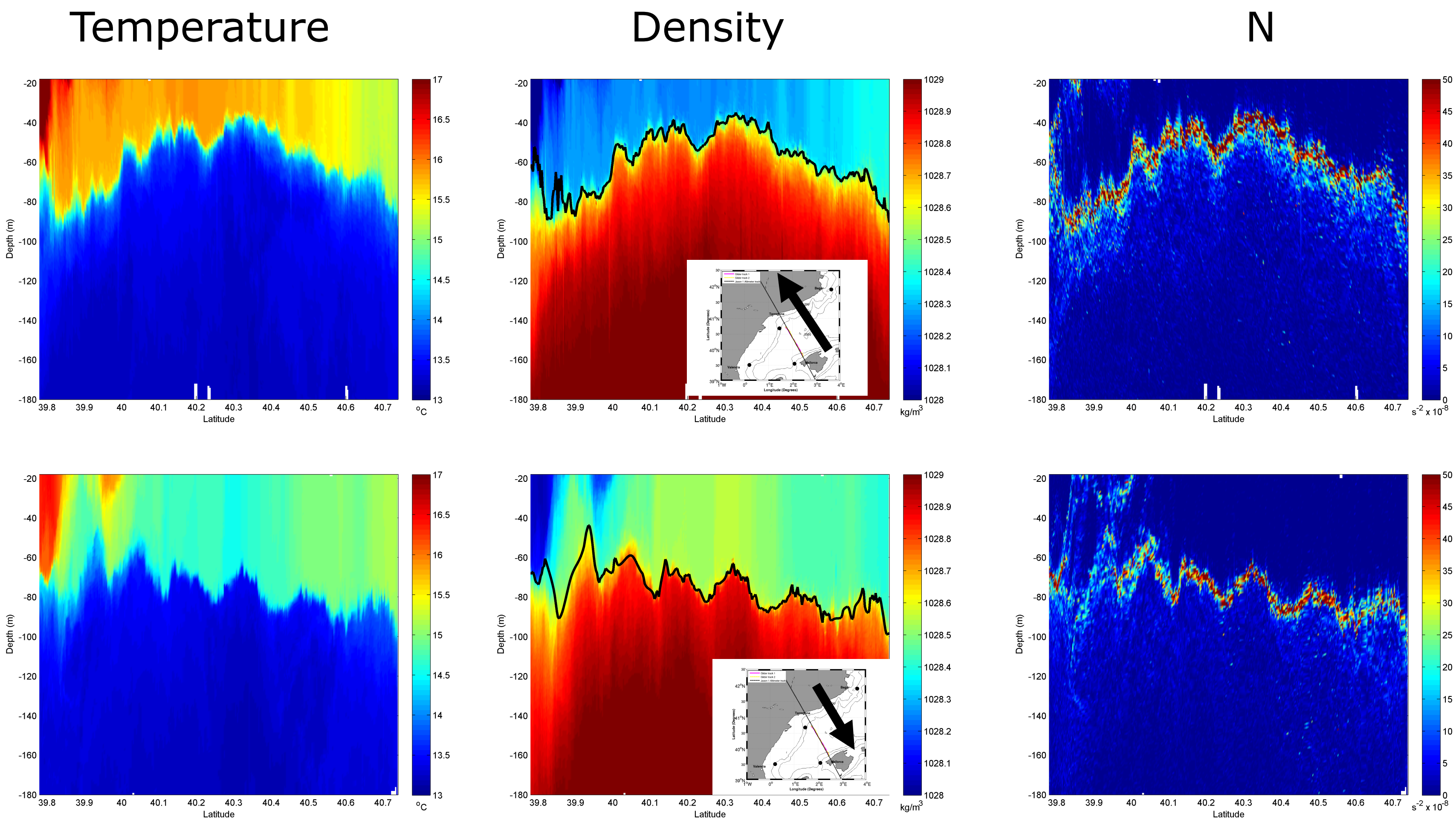


Significant wave height



Atmospheric pressure and significant sea surface height measured during glider mission. Gray shadow colour indicates coincident period between glider and buoy measurements.

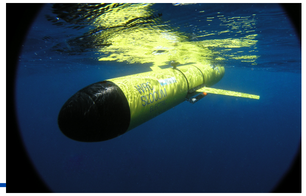
Gliders Facility: Science, MLD



Vertical sections of high-resolution temperature , density and Brunt-Väisälä frequency obtained from glider (top) 'go' and (bottom) 'return.' The black line on the density field correspor

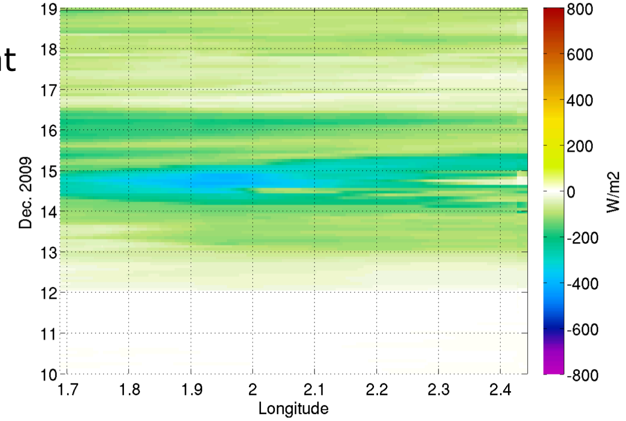
Ruiz et al., 2012, GR

Gliders Facility: Science, MLD

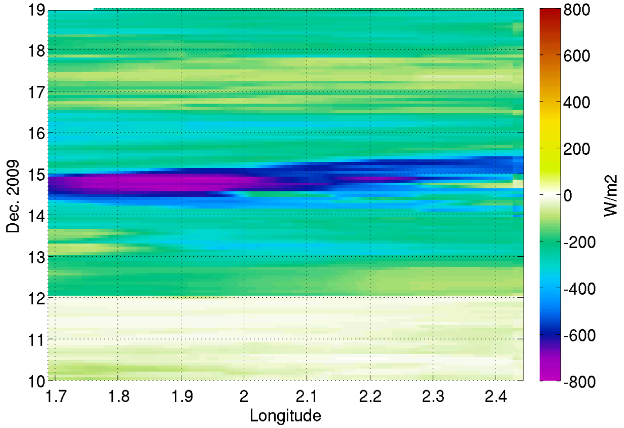


Results; Heat content, modelling and glider data

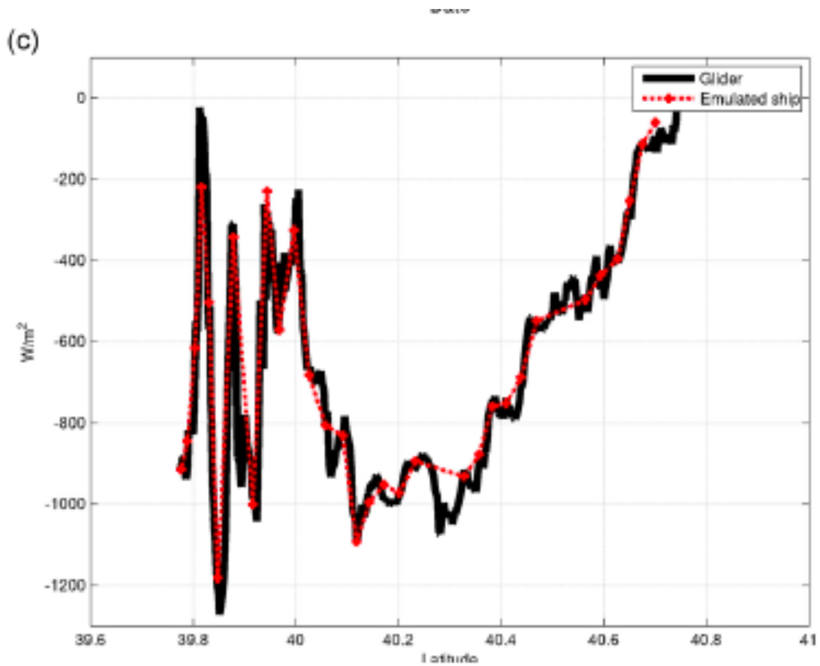
Sensible Heat



Latent Heat



From the WRF model



Heat content from glider data

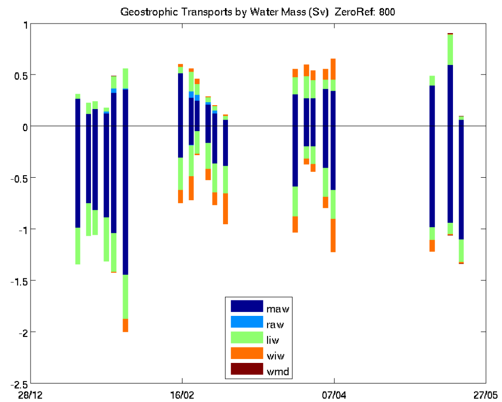
Ruiz et al., 2012, GR

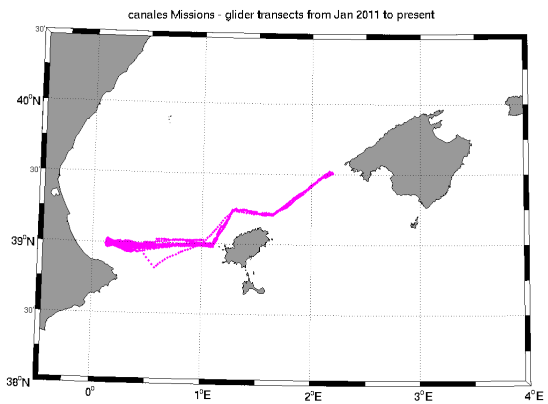
Gliders Facility: Operational

- **After 28 glider missions (started in 2006), + 10.000 profiles**
- **Since January 2011; routine operations in Ibiza and Mallorca Channels (150 miles section)**

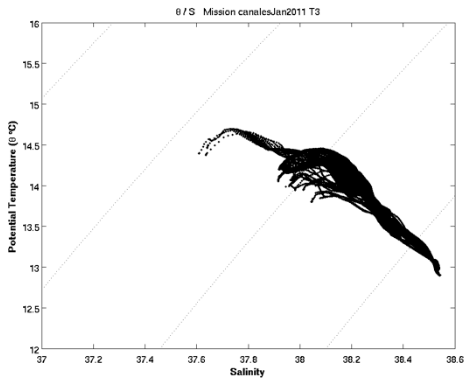
<u>NEED DEFINE KEY CONTROL SECTIONS EU</u>

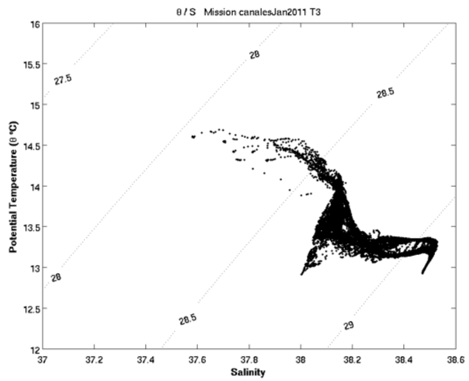
Major transport changes

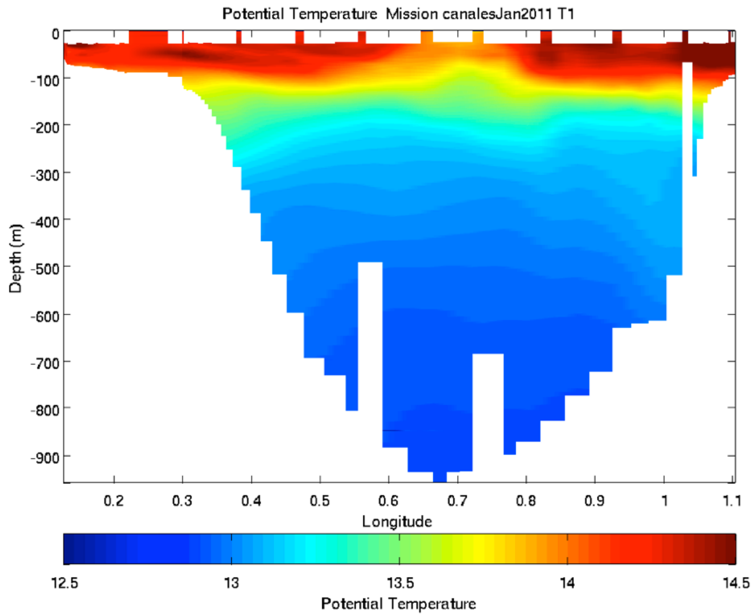


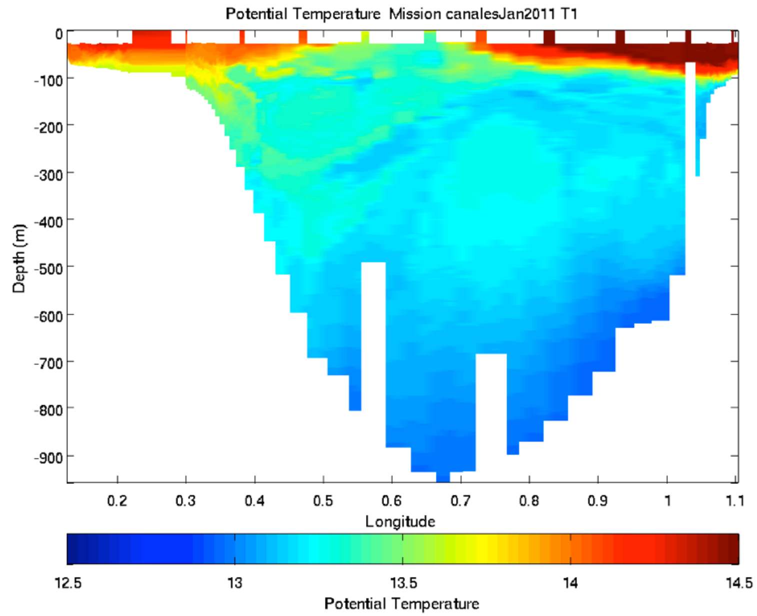


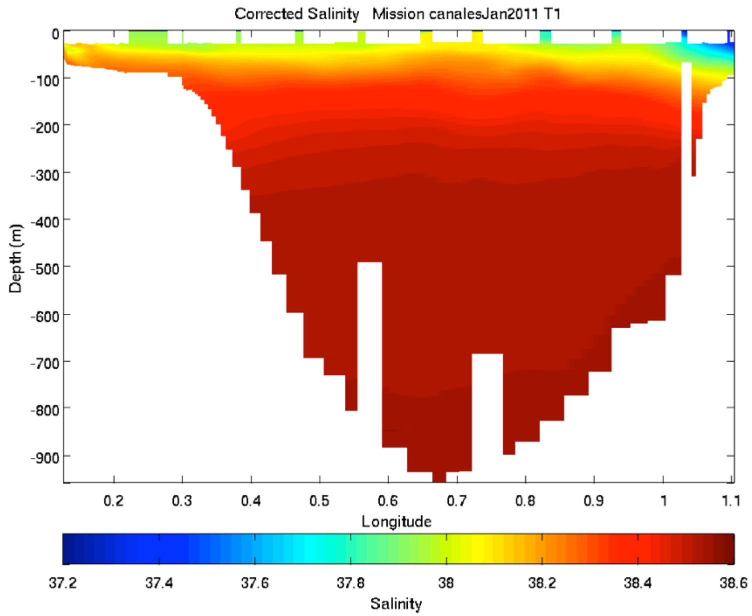
TS diagrams ROMS / Glider

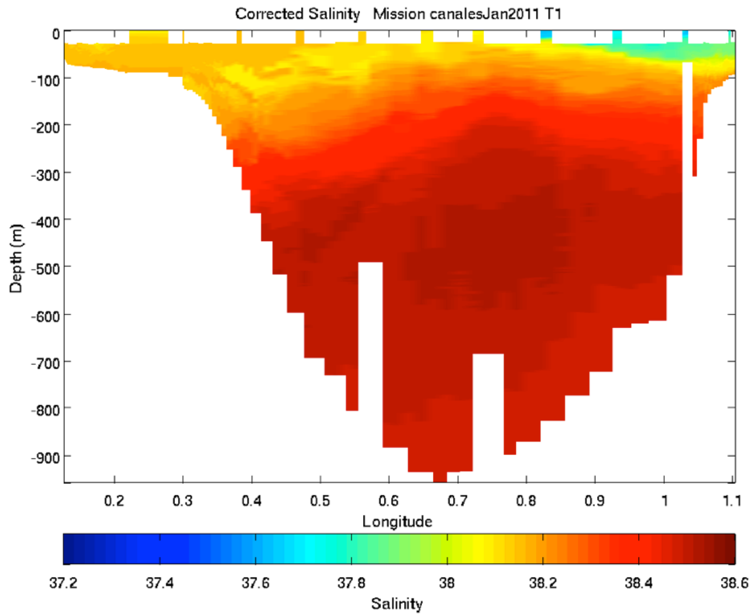


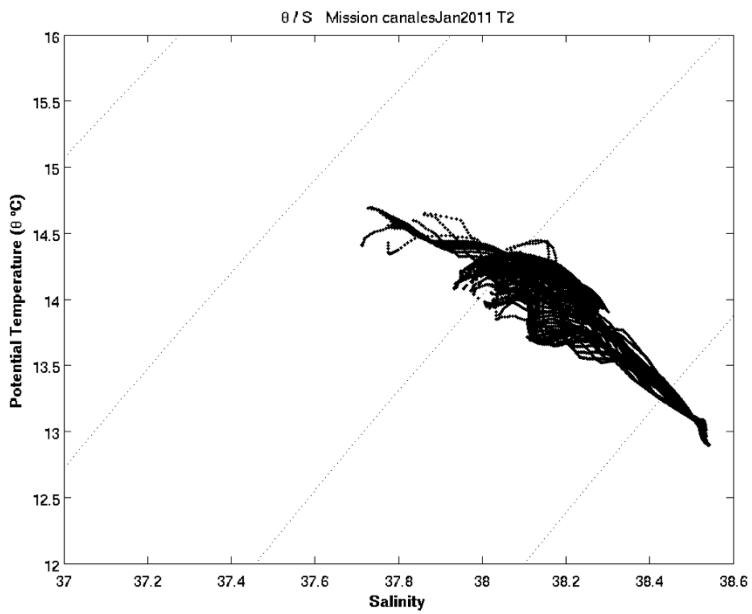


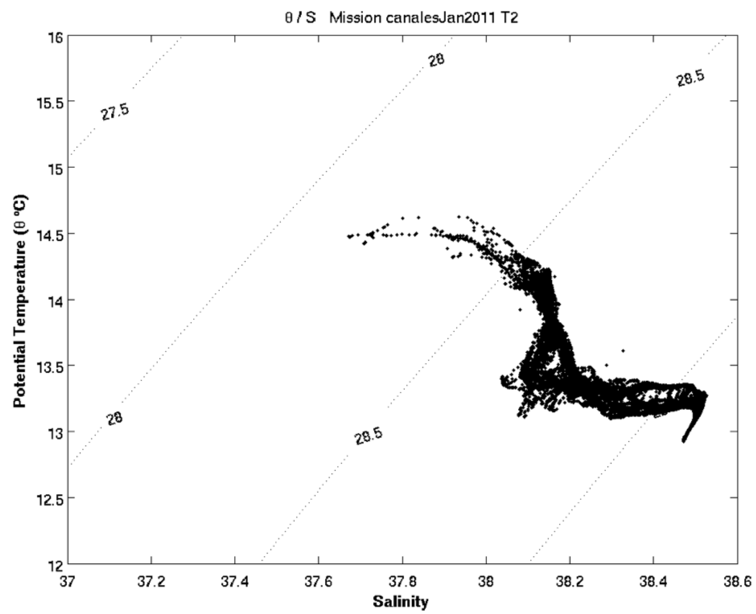

Potential Temperature Mission canalesJan2011 T1
Depth (m)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
Longitude
12.5
13
13.5
14
14.5
Potential Temperature


Potential Temperature Mission canalesJan2011 T1
Depth (m)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
Longitude
12.5
13
13.5
14
14.5
Potential Temperature


Corrected Salinity Mission canalesJan2011 T1
Depth (m)
Longitude
Salinity


Corrected Salinity Mission canalesJan2011 T1
Depth (m)
Longitude
Salinity

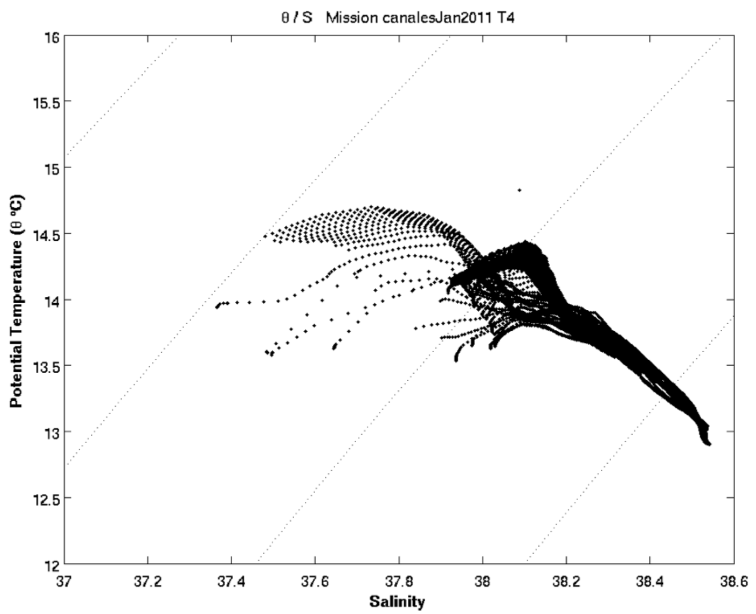


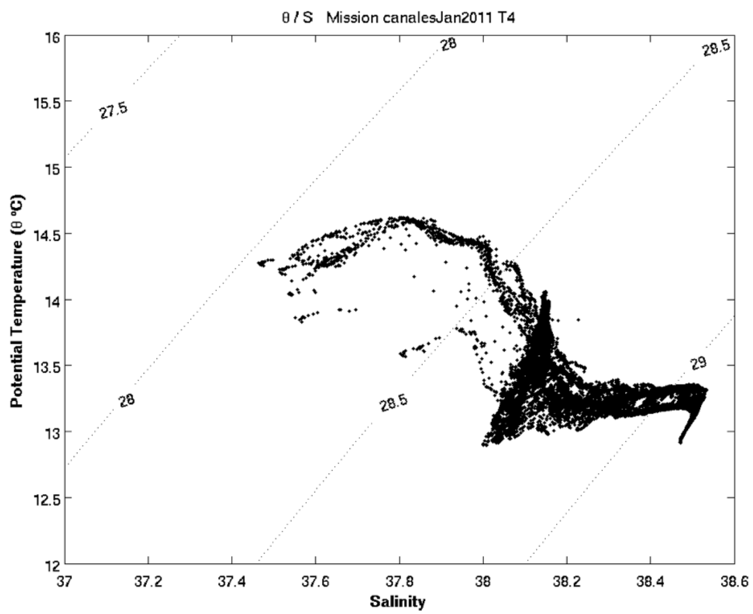


Balearic Islands Coastal Observing and Forecasting System

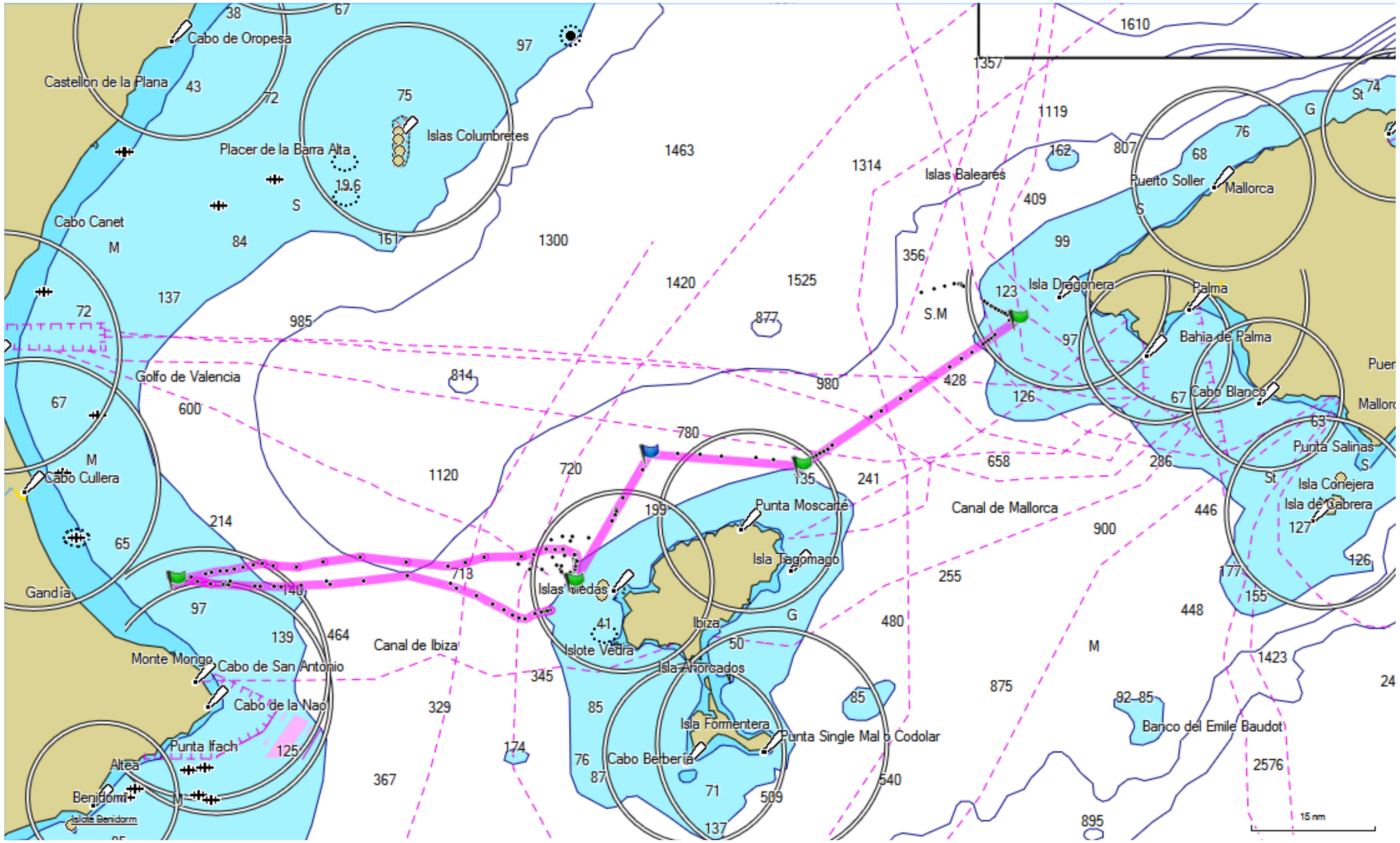
Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN


θ / S Mission canalesJan2011 T4
Potential Temperature (θ °C)
Salinity
16
15.5
15
14.5
14
13.5
13
12.5
12
37
37.2
37.4
37.6
37.8
38
38.2
38.4
38.6


θ / S Mission canalesJan2011 T4
Potential Temperature (θ °C)
Salinity
27.5
28
28.5
29
16
15.5
15
14.5
14
13.5
13
12.5
12
37
37.2
37.4
37.6
37.8
38
38.2
38.4
38.6

1st SOCIB Seaglider mission (ongoing, April 23 reaching Mallorca, back)



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC Universitat de les Illes Balears Instituto Mediterráneo de Estudios Avanzados

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

SOCIB Glider Facility (Summary)

Gliders (a fleet of …) ?:

- They allow long term, sustained, multidisciplinary monitoring of the coastal ocean for example at key control sections.

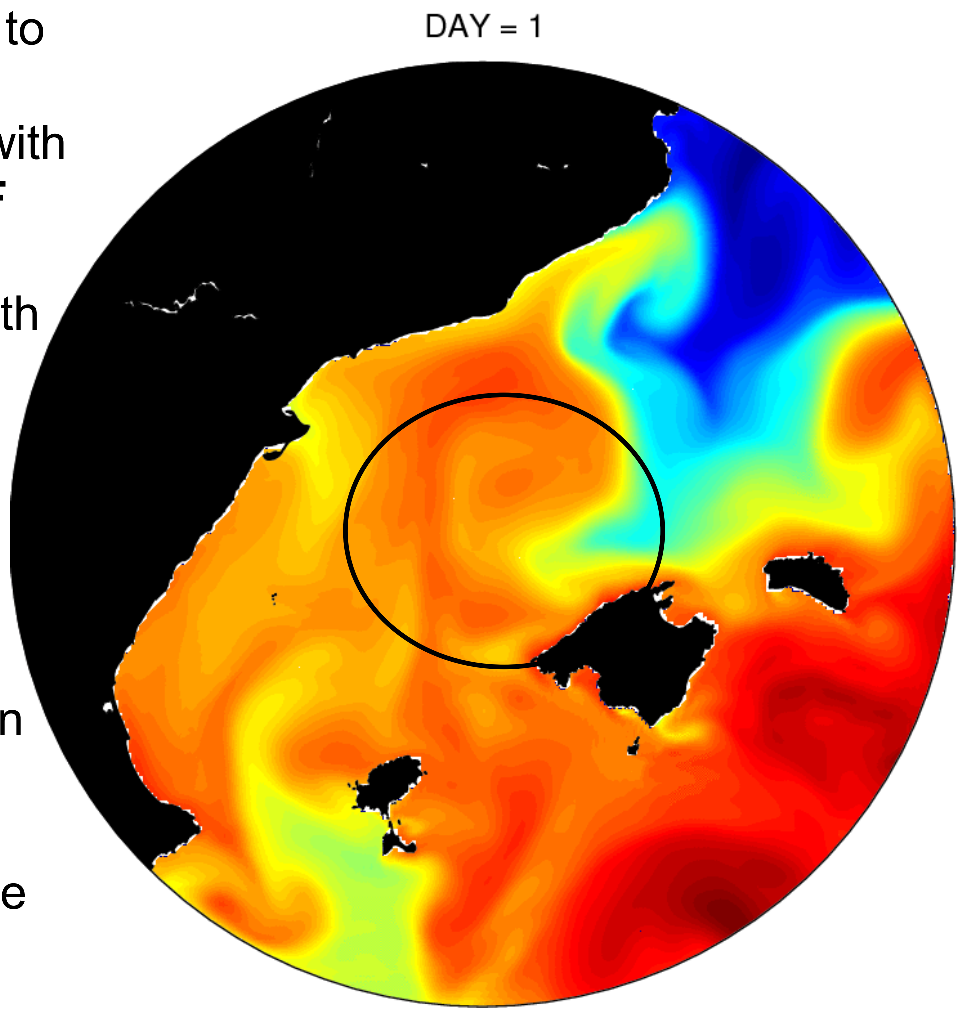
- They are providing new evidences of the complexity of the coastal ocean, by resolving tridimensional mesoscale and submesoscale instabilities **never fully observed before**, showing the intrinsic dynamical relevance of theses instabilities, their interactions and effects on the mean circulation, and their role on the response of the ecosystem.
  - **A major observational breakthrough is appearing upfront**. It will trigger theoretical and numerical developments…
  - Examples from Balearic and Alborán Seas have been shown, suggesting the capabilities that will soon arise from monitoring with fleets of gliders, physical variability and ecosystem response at meso and submesoscale…

Modelling Facility

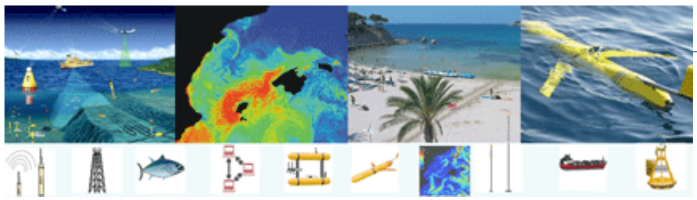
Operational Modeling: **ROMS,** 2km, to reproduce and maintain mesoscale features, interactions. In collaboration with PE and in the frame MFS/MOON. **WRF** Atmospheric Model. **SWAN** for coastal ocean wave Dynamics and Habors (with PE)

Aim :

- Validate the model with measurement (gliders, ...)
- From available data and model simulation (5 years), study the formation of mesoscale structures.
- Understand impact of meso/ submesoscale on circulation and on the ecosystem



SST from 11/2008



ICTS OceanBit

Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB

I·M·E·D·E·A

CSIC

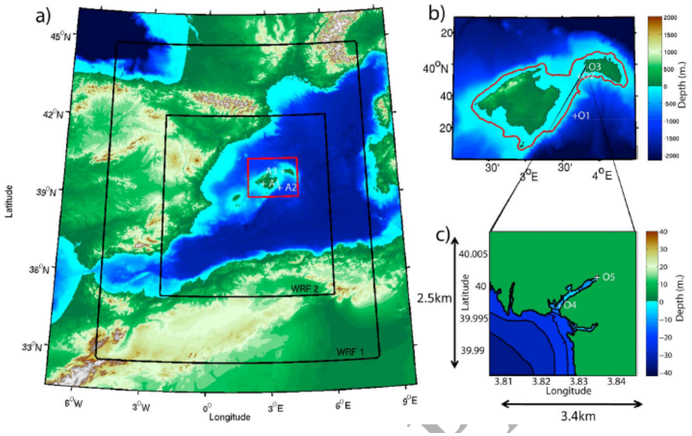
Modelling Facility; Meteotsunamis forecasting

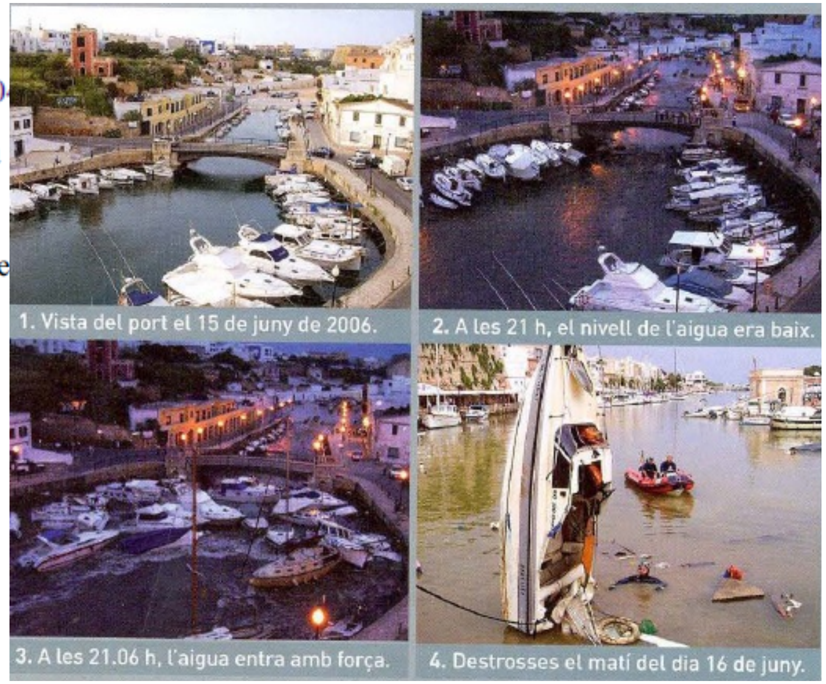
GEOPHYSICAL RESEARCH LETTERS, VOL. 38, LXXXXX, doi:10.1029/2011GL0

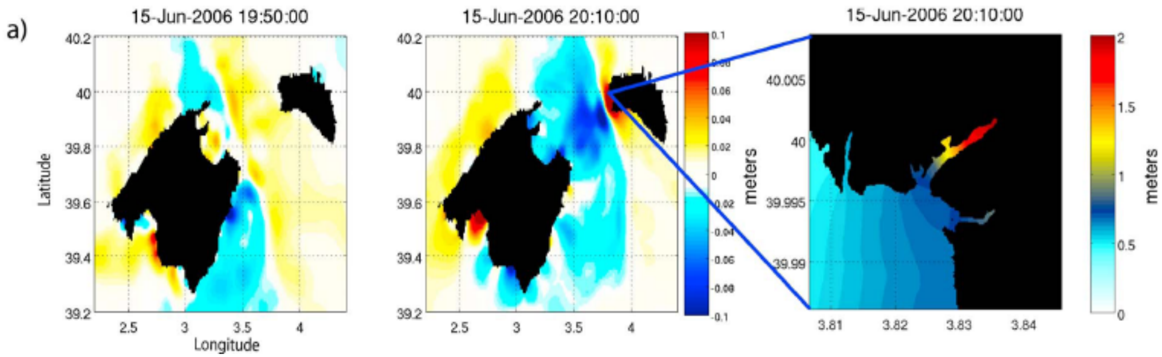
1 **Toward the predictability of meteotsunamis in the Balearic Sea**
2 **using regional nested atmosphere and ocean models**

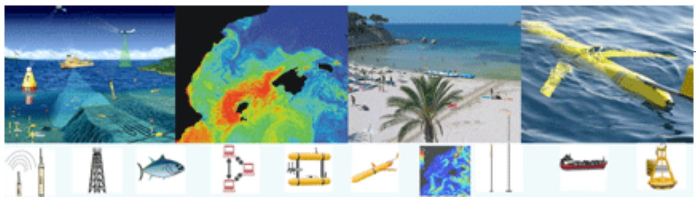
3 Lionel Renault,[1] Guillermo Vizoso,[2] Agustin Jansá,[3] John Wilkin,[4] and Joaquin Tintore

4 Received 4 March 2011; revised 29 March 2011; accepted 30 March 2011; published XX Month 2011.









ICTS OceanBit

Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB

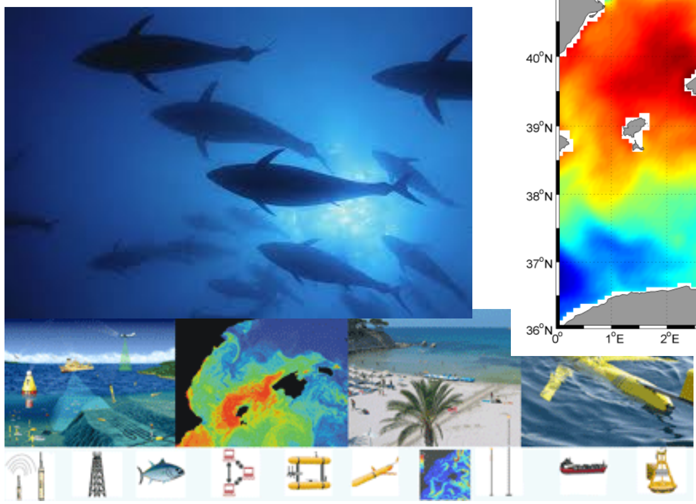
I·M·E·D·E·A

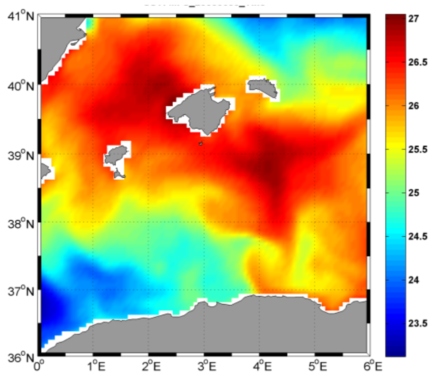
CSIC

Bluefin Tuna Target Project: scientific problem solving for sustainable fisheries: at SOCIB since 2011

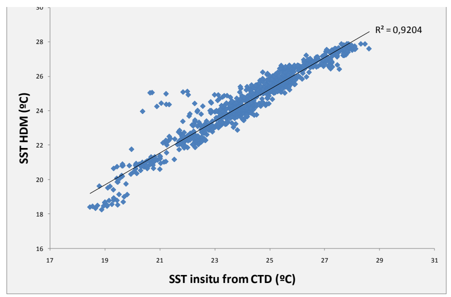
Initial Activities and First Results:

- Compilation of historical larvae data from various projects at IEO
- Link fishing data with ROMS, remote sensing and in situ hydrography
- Validate ROMS historical hydrographic data (SST and SSS) in the study area
- Development of an analysis framework and tools for modelling habitat-species relations.
- Development of field campaigns for studding specific key ecological questions
- Organize a inter-institutional working framework for data management and project flow control





ROMS derived SST vs CTD



ICTS OceanBit

Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

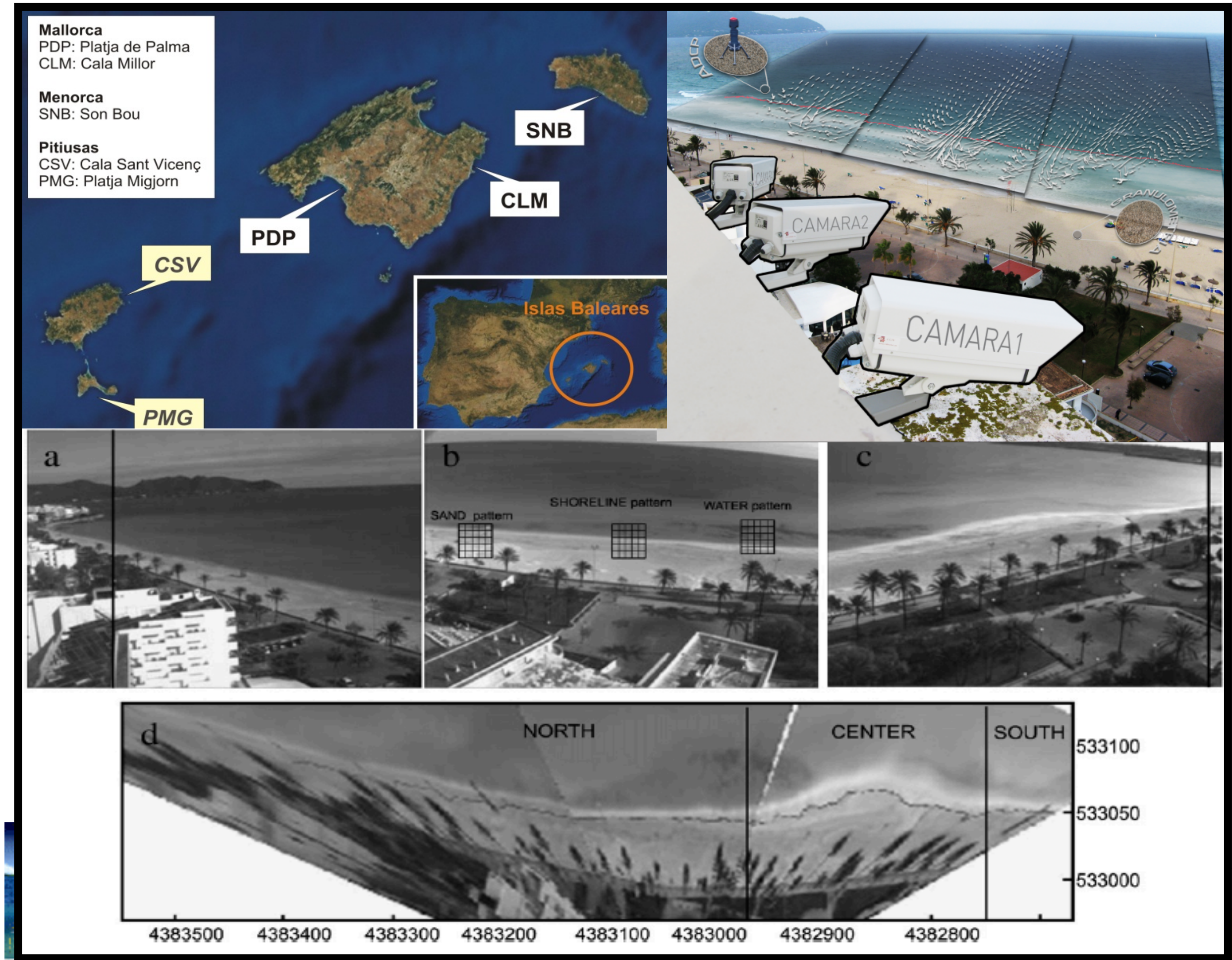
UIB

I·M·E·D·E·A

CSIC

Marine and Terrestrial Beach Monitoring Facility

TMTBMF is a MODULAR SYSTEM designed to monitor continuously and in an autonomous way short and long term physical beach hydrological and morphological parameters.



MOBIMS

- Beach videomonitoring (SIRENA)
- Waves and currents (ADCPs)
- Bathymetry and beach profiles surveys
- Sediment parameters

PRODUCTS & SERVICES FOR BEACH MORPHODYNAMICS RESEARCH, BEACH SAFETY & COASTAL MANAGEMENT

SOCIB Strategic Issues and Applications for Society

Sustainability Science and Integrated Coastal and Marine Management, MSP

SYSTEM OF INDICATORS
for Integrated Coastal Zone Management in the Balearic Islands

We are…

- Developing and evaluating science-based decision-making tools and methods to support ICMM, with particular emphasis on the integration of environmental and social dimensions

- Identifying and implementing indicators to assess, monitor, and predict limits to growth and critical thresholds,

- Integrating research with environmental governance and management systems to assure sound transfer two sides science to society and back!.

Marine Policy 34 (2010) 772–781

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Balancing science and society through establishing indicators for integrated coastal zone management in the Balearic Islands

A. Diedrich [a,*], J. Tintoré [a], F. Navinés [b]

[a] IMEDEA (CSIC-UIB), Mediterranean Institute of Advanced Studies, Calle Miquel Marqués, 21, 07190 Esporles, Mallorca, Balearic Islands, Spain

[b] CES, Economic and Social Council of the Balearic Islands, Palau Reial, 19, 07001 Palma, Mallorca, Balearic Islands, Spain

ARTICLE INFO

Article history:
Received 24 November 2008
Received in revised form
18 January 2010
Accepted 18 January 2010

Keywords:
Indicators
ICZM
Science-policy gap
Balearic Islands
Spain

ABSTRACT

This paper explores the process by which indicators may be developed as tools for communicating science to decision-makers using the participatory approach demonstrated by the Balearic Indicators Project. This initiative reflects a series of compromises considered necessary to achieve the objective of generating an indicator system that is scientifically viable, comparative internationally yet locally relevant, and to facilitate its implementation. The article highlights questions regarding the utility of science for addressing current global issues related to sustainability and why science often fails to promote change at the societal level.

Ocean & Coastal Management 52 (2009) 493–505

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Integrated and interdisciplinary scientific approach to coastal management

Joaquín Tintoré [a], Raúl Medina [b], Lluís Gómez-Pujol [a,*], Alejandro Orfila [a], Guillermo Vizoso [a]

[a] IMEDEA (CSIC-UIB), Institut Mediterrani d'Estudis Avançats, Miquel Marquès 21, 07190 Esporles (Balearic Islands) Spain

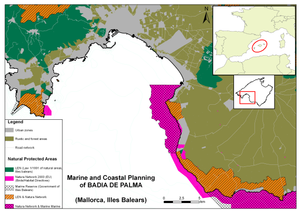
[b] Instituto de Hidráulica Ambiental, IH Cantabria, Universidad de Cantabria, Av. Castros s/n, 39005 Santander, Spain

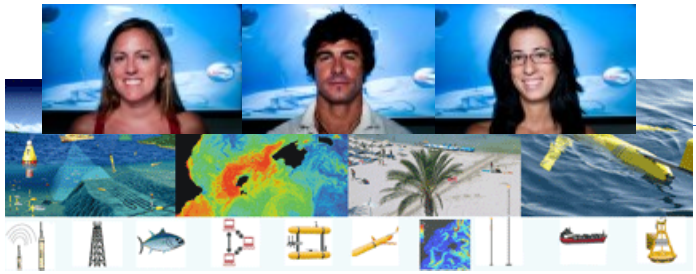
ARTICLE INFO

Article history:
Available online 7 August 2009

ABSTRACT

Coastal zones and beach management practices, regulatory decisions, and land use planning activities along coastal zones have historically been made with insufficient information concerning the dynamic coastal environment. In this study we address and integrate an interdisciplinary scientific approach to Coastal Management in a scenario where lack of this information has resulted in the alteration of the natural dune system of the beach of Cala Millor (Mallorca, Balearic Islands, Spain), and also in the perception of the beach retreat and in a parallel way, a risk for the tourism resources. In this work the detailed studies on beach morphodynamics have been developed as a basis for integrating proper beach management, beach natural dynamics and local users and economic agent interests. From this point of view a set of solutions are considered as the basis for a management policy that links beach science and beach use as a tourism resort resource.





ICTS OceanBit

Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB

I·M·E·D·E·A

CSIC

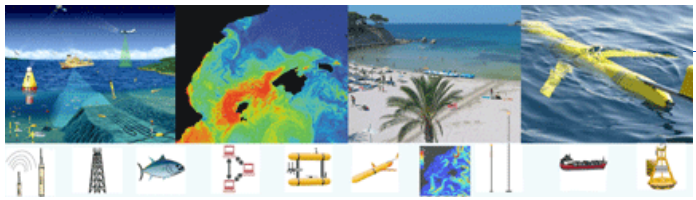
Data Centre Facility

A crucial element for real multi-platform integration, a pilot element for a Spanish Data Management strategy.

Goal: to provide researchers and users with a **system** that allow to **locate and download the data** of interest (near real time and delayed mode) to **visualize, analyze** and manage the information.

Principles of SOCIB Data Center: the data are,

- Discoverable, accessible, 'collect once, use many' (data and metadada)
- Freely available
- Interoperability, standardization and sharing guarantee



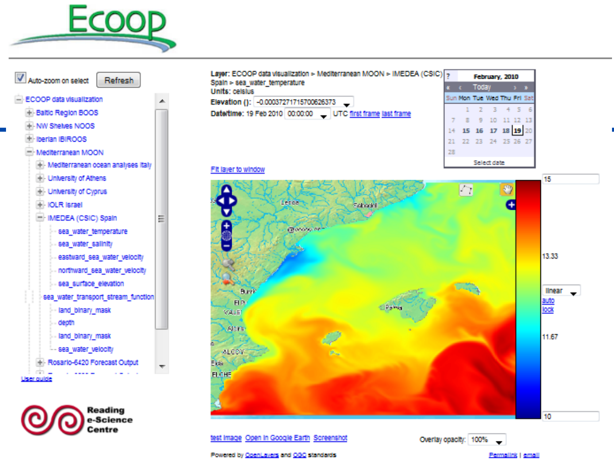
Data Centre Facility

The European framework

MERSEA

SESAME

myOcean



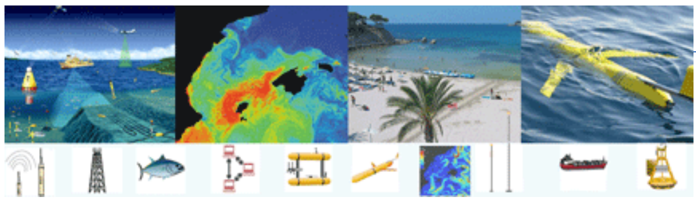
The international framework

IMOS

OCEAN OBSERVATORIES INITIATIVE

IOOS

NEPTUNE Canada



ICTS OceanBit

Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB

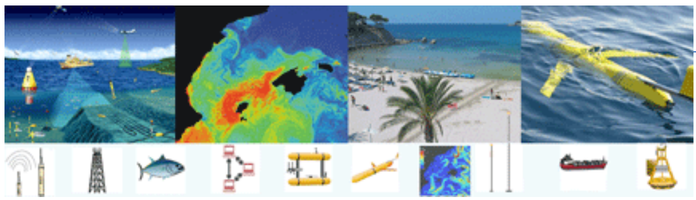
I·M·E·D·E·A

CSIC

Data Center: Science and Technology

To accomplish the full lifecycle data (from the modeling and observing systems ingestion up to the user), the data center has defined seven steps for the Data Management Process:

1. Platform management and communication
2. Quality Control assurance
3. Metadata Aggregation and Standardization
4. Data Archive
5. Data Search and Discovery
6. Data Policy and distribution
7. Data Viewing



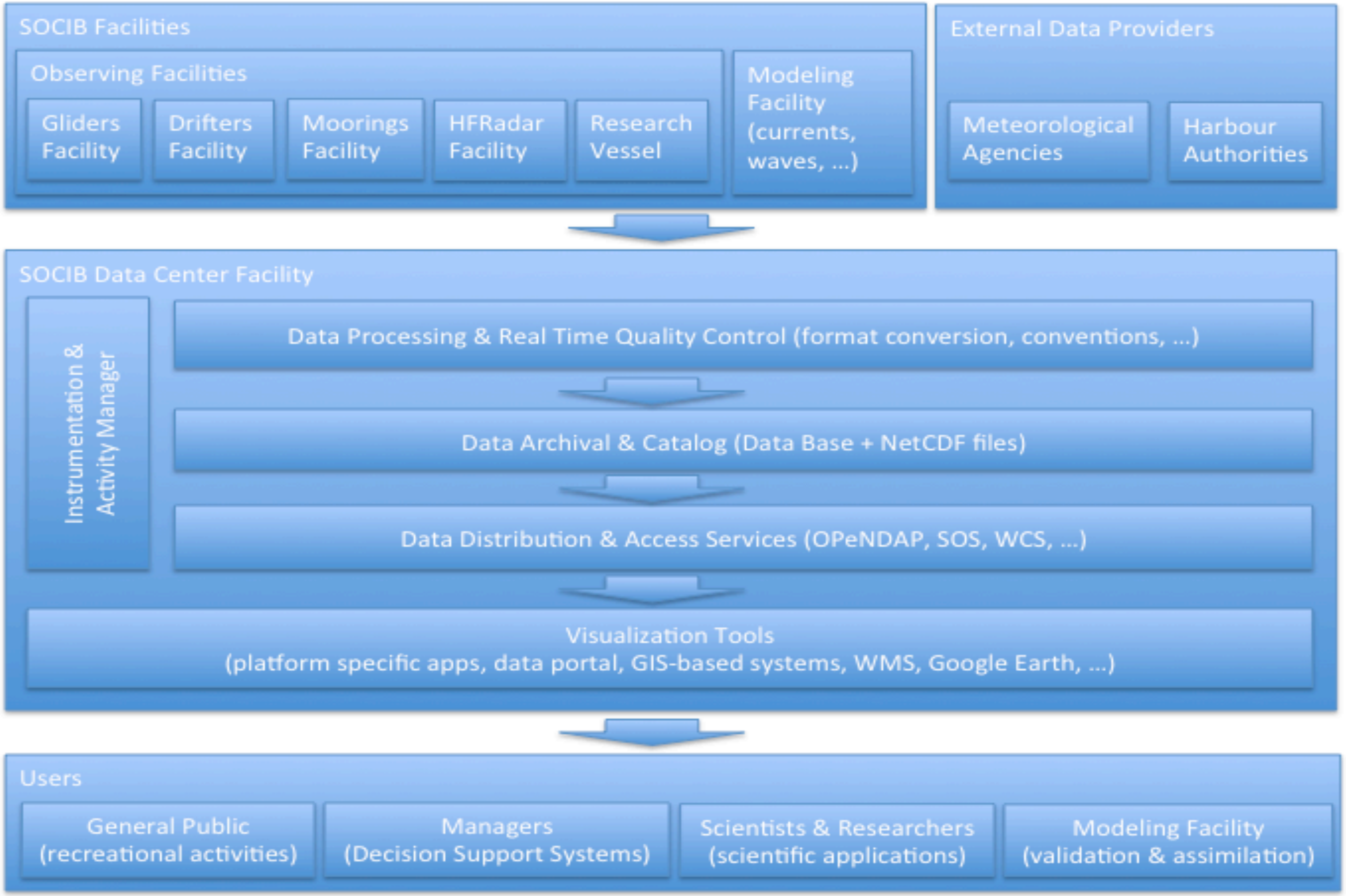
MERSEA SESAME myOcean IOOS OOI OCEAN OBSERVATORIES INITIATIVE NEPTUNE Canada IMOS

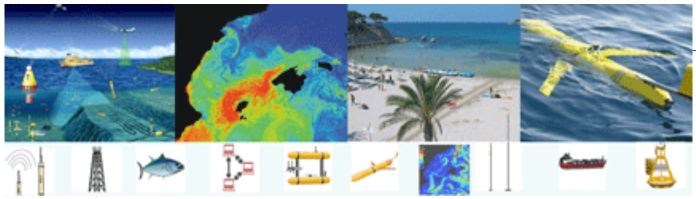
ICTS OceanBit

Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB I·M·E·D·E·A CSIC

Data Centre


SOCIB Facilities
Observing Facilities
Gliders Facility
Drifters Facility
Moorings Facility
HFRadar Facility
Research Vessel
Modeling Facility (currents, waves, ...)
External Data Providers
Meteorological Agencies
Harbour Authorities
SOCIB Data Center Facility
Instrumentation & Activity Manager
Data Processing & Real Time Quality Control (format conversion, conventions, ...)
Data Archival & Catalog (Data Base + NetCDF files)
Data Distribution & Access Services (OPeNDAP, SOS, WCS, ...)
Visualization Tools
(platform specific apps, data portal, GIS-based systems, WMS, Google Earth, ...)
Users
General Public (recreational activities)
Managers (Decision Support Systems)
Scientists & Researchers (scientific applications)
Modeling Facility (validation & assimilation)



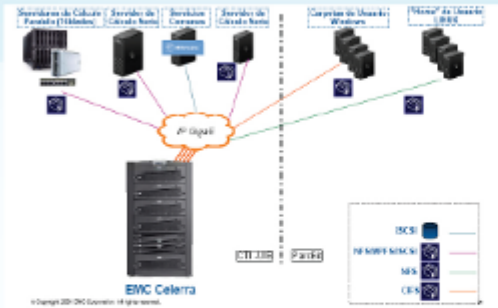
Data Centre: Technologies

The main technologies used are: OPeNDAP / THREDDS server hosting CF-compliant NetCDF; the open-source RAMADDA as a content management system and collaboration services for Earth Science data. Those technologies permit the distribution, cataloging and discovery over the oceanographic data.

1. Multi Platform Management

Alredyavailable:glidersdrifters,moorings,adcp, beach monitoring cameras, ... Real time monitoring and wide descriptions of data sets (standardscompliant).

2. Data Archive



Informatic infraestructure: to securely archive data and metadata and retrieve them on demand.

3. Distribution

OPeNDAP, WCS, WMS, HTTP, FTP, ... to access the data in an interoperable manner from client applications.

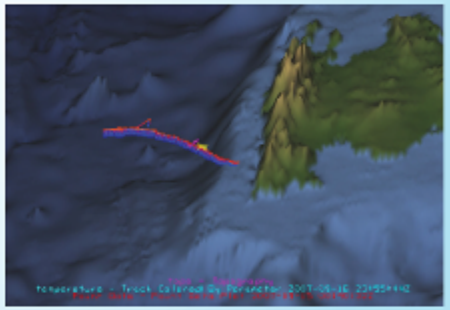
4. Catalog

THREDDS to organize data and Metadata to automatic harvesting.

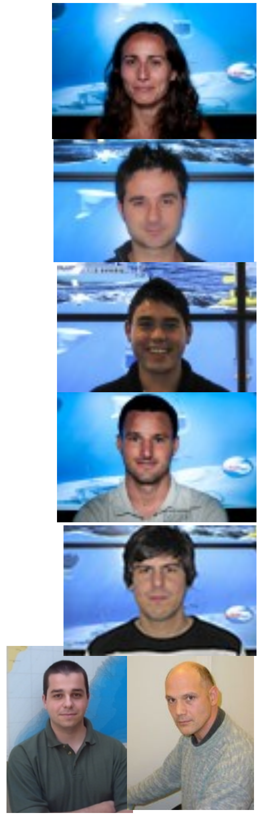
5. Discovery

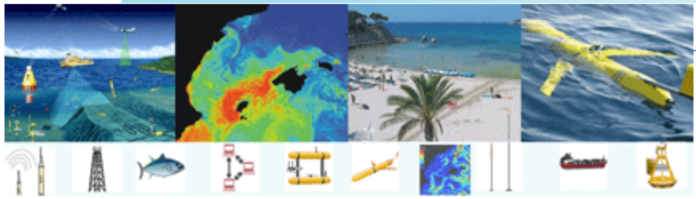
RAMADDA to search for and find data sets of interest for human interaction.

6.Analisis and Visualization



IDV, own Web Aplications, GODIVA, LAS,... capability to provide an integrated viewing service.





ICTS OceanBit

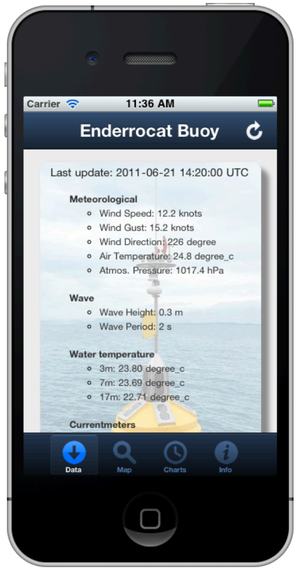
Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

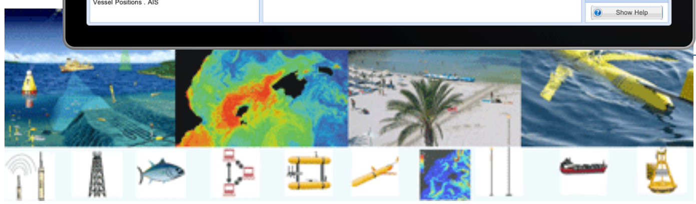
UIB

I·M·E·D·E·A

CSIC

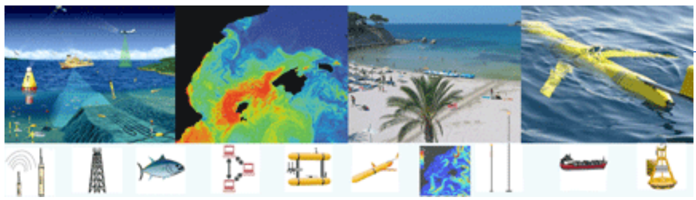
Data Centre (Technologies; example of Apps)

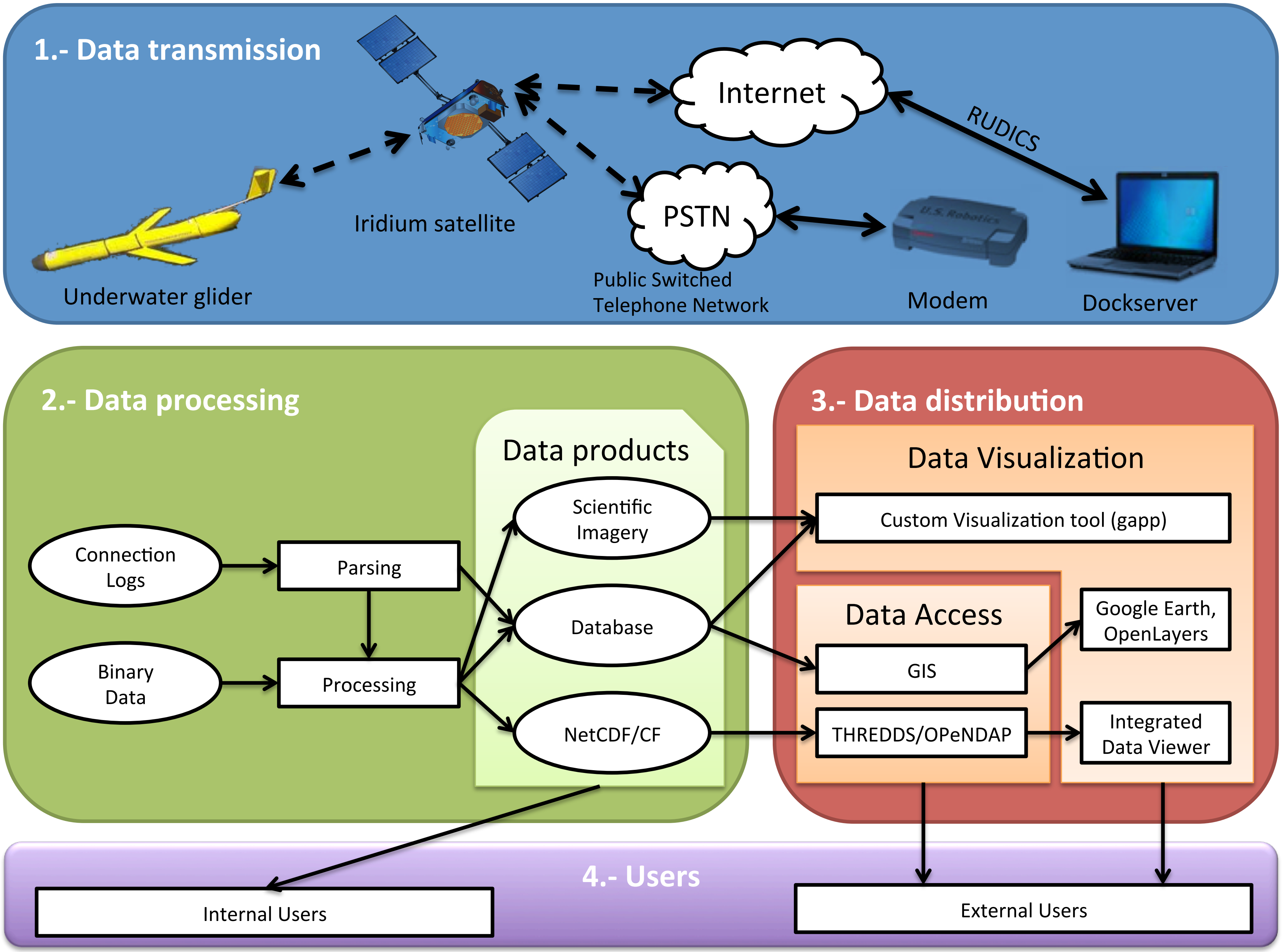




Glider Data Management at SOCIB

A paradigmatic case of observing system management goals and issues being addressed at SOCIB

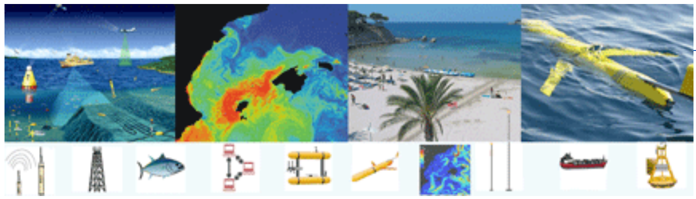




1.- Data transmission
Internet
RUDICS
PSTN
Iridium satellite
Underwater glider
Public Switched
Telephone Network
Modem
Dockserver
2.- Data processing
Data products
Connection
Logs
Parsing
Binary
Data
Processing
Scientific
Imagery
Database
NetCDF/CF
3.- Data distribution
Data Visualization
Custom Visualization tool (gapp)
Data Access
GIS
Google Earth,
OpenLayers
THREDDS/OPeNDAP
Integrated
Data Viewer
4.- Users
Internal Users
External Users

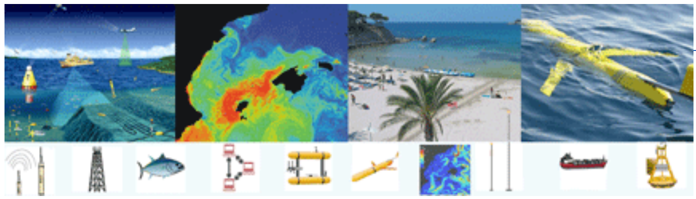
Goals

- Platform management
  - Deployments’ information
  - Mission planning tools
- Data management
  - Ingestion
  - Processing
  - Distribution
  - Visualization



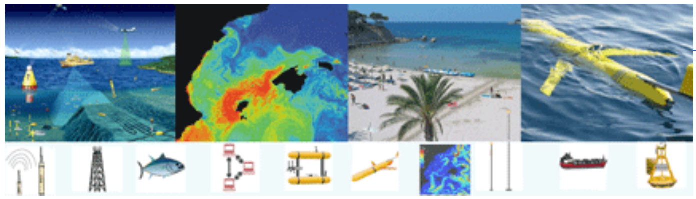
Main issues I

- Manage two different platform types (Slocum and Seaglider)
  - Issues in platform management, ingestion and processing
- Real-Time data requirements
  - Platform tracking
  - Technical and scientific data monitoring, Quality Control procedures
- Interoperability
  - Metadata: information regarding platform, deployment, and variables. Goal: obtain a self-describing dataset
  - Data sharing: provide data discovery, standard distribution protocols and formats (ISO and OGC standards)



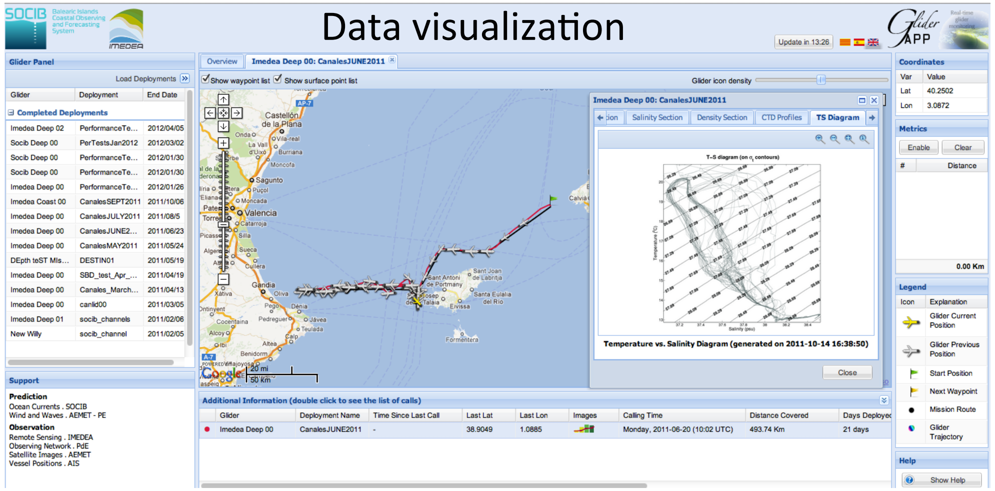
Main issues II

- Setup as a service for different users
  - Internal users:
    - Modelling facility: validation and assimilation
    - Fixed stations and drifters facilities: intercomparison and QC
    - Risk assessment: AIS ship collision, environmental conditions…
  - External users
    - Provide tools and support for ICTS users
    - Adaptive to user requirements
- International relations (EGO, MyOcean, ...)
  - Adopt common standards among glider users community (formats, access protocols, descriptions, etc.) (enforce usage of ISO and OGC standards)
  - Data distribution policy (approved for public release or limited to partners, RT or DM timeliness)

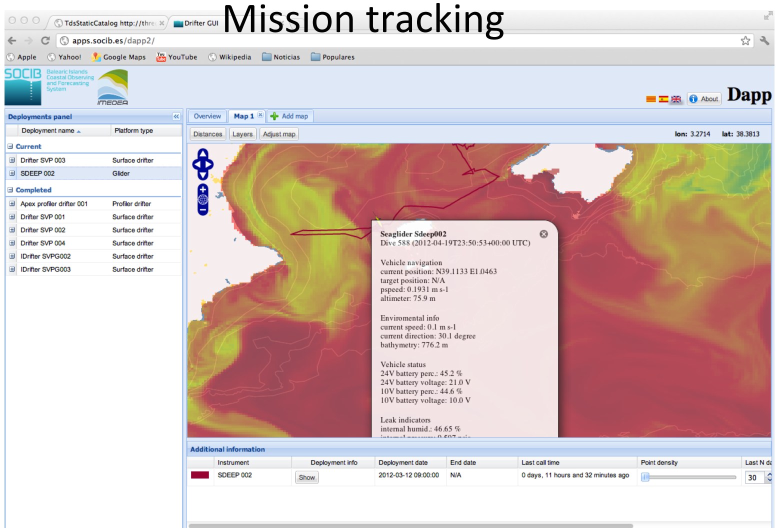


Some products tools (examples)

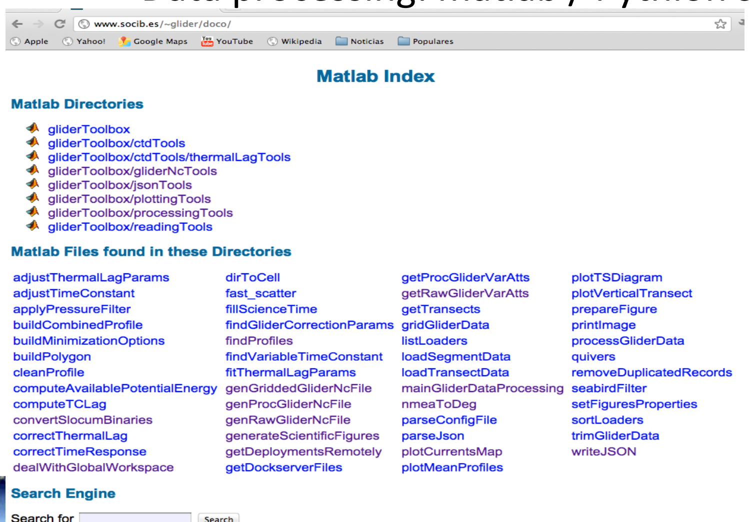
Data visualization



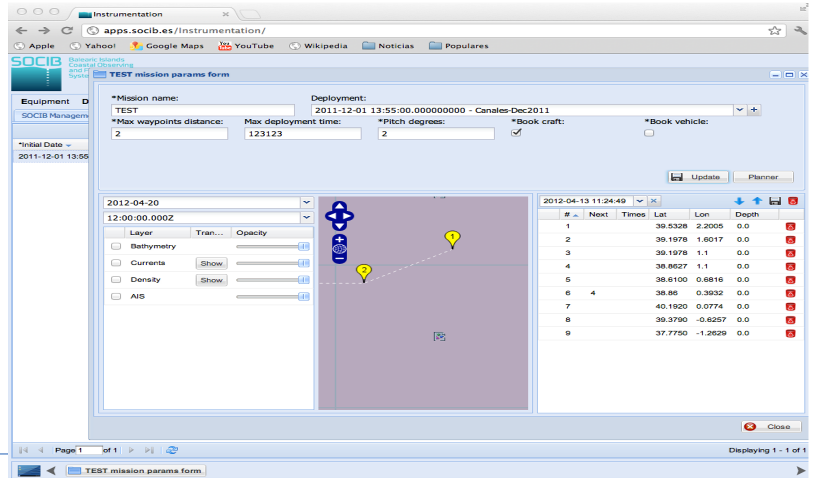
Mission tracking



Data processing: matlab / Pythion scripts

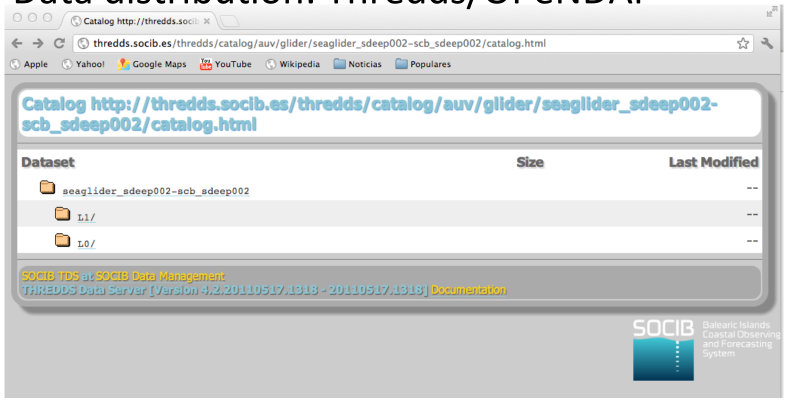


Platform management: mission planning

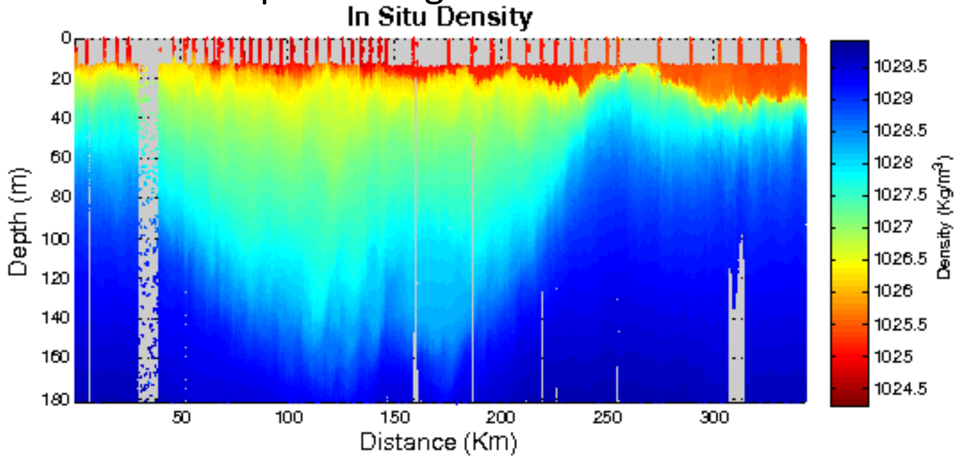


Some products tools (examples)

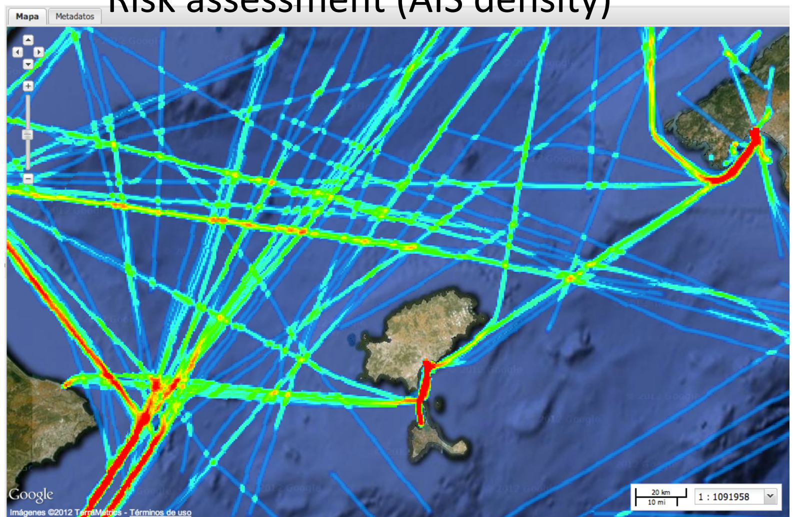
Data distribution: Thredds/OPeNDAP



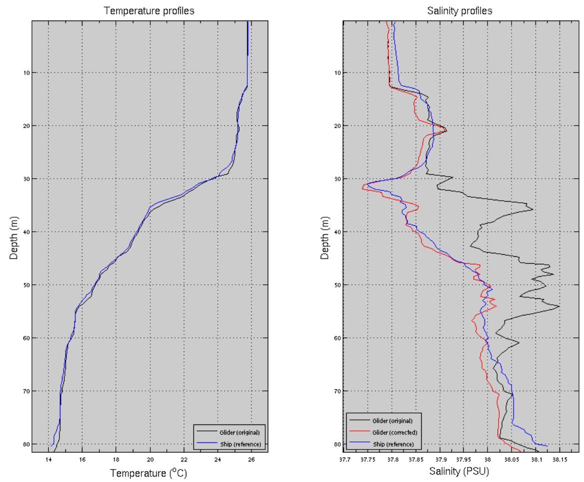
Postprocessing: visualization tools

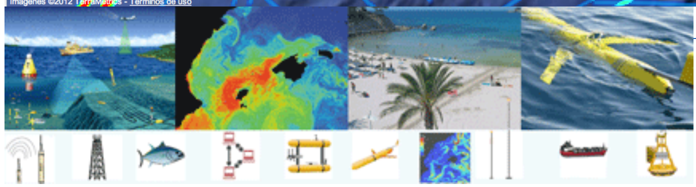


Risk assessment (AIS density)



Postprocessing: thermal lag corrections





ICTS OceanBit

Govern de les Illes Balears
Conselleria d'Economia, Hisenda i Innovació
Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB

I·M·E·D·E·A

CSIC

OUTLINE

1. The 2012 Oceans' Challenges for Science, Technology and Society

2. Ocean Information for Society,… what we learned in the Mediterranean

3. SOCIB, a new multi-platform approach

4. SOCIB and the new role of Marine Research Infrastructures to respond to Science, Technology and Society needs

Innovation in oceanographic instrumentation

3 elements:

- Oceans complexity imply and drive a need for improvement of instrumental capacities

- The innovation process, complexity and incubation time

- The key to success

(Curtin and Belcher, TOS, 2008)

Innovation in
Oceanographic
Instrumentation

BY THOMAS B. CURTIN AND EDWARD O. BELCHER

INTRODUCTION

The tools of oceanography include instruments that measure properties of the ocean and models that provide continuous estimates of its state. Major improvements in tool capabilities lead to leaps in understanding, and this increased knowledge has many practical benefits. Advances in tool capabilities are sometimes viewed as an objective of basic research, a viewpoint reflected in the basic research funding category of "science and technology" (S&T).

The complexities of and incubation times for advancing instrumentation are often not fully appreciated, resulting in unrealistic expectations and discontinuous support. Greater understanding of the process of innovative instrument development can contribute to sustaining it. Innovation can be incremental or radical depending on performance gains (Utterback, 1994), stimulated or suppressed depending on institutional factors (Van de Ven, 1989; Office of Technology Assessment, 1995), and sustaining or disruptive depending on value propositions (Christensen, 1997). For example, going from a Nansen to a Niskin bottle was an incremental innovation, whereas going from bottle casts to CTD profiles was a radical innovation. Moored current meters incrementally advanced from film recording of gauges, to mechanically digitized signals on reel-to-reel tape, to solid-state analog, to digital conversion and memory. Radical innovation of current-field measurement came with the acoustic Doppler current profiler.

In large organizations, stimulated innovation often occurs in research departments, particularly when the projects have champions: "the new idea either finds a champion or dies" (Schon, 1963). In other parts of the same organization, innovation may be suppressed by the costs associated with re-integrating a system and minimal perceived competition. The incubation time of the computer mouse from inception to wide use was 30 years. In oceanographic observation, where synoptic coverage is an objective, a sustaining innovation would be a sampling platform with improved propulsion that doubles its speed. A disruptive innovation would be a new platform with much *slower* speed, but with much longer duration and a low enough cost to be deployed in great numbers. Here, we will focus on radical, stimulated, disruptive innovation that involves both science and engineering.

To motivate continued investment in basic research, the histories of many radical innovations, ranging from the transistor to radar to the Internet, have been documented (Bacher, 1959; Hetrick, 1959; Becker, 1980; Hove and Gowen, 1979; Allison, 1985; Abbate, 2000. The Defense Acquisition History Team at the US Army Center of Military History is also preparing a document on this subject.). These cases clearly demonstrate that "rapid" innovation in

SOCIB Balearic Islands Coastal Observing and Forecasting System

Instituto Mediterráneo de Estudios Avanzados · CSIC · Universitat de les Illes Balears

Govern de les Illes Balears

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN

Oceans complexity, needs for improvement of instrumental capacities

Rationale:

The Oceans; a complex system, changing, under-sampled: tools to study them include

- Instruments to measure properties
- Models for continuous estimates of states and evolution

Improvements in tools capabilities

↓

Increase understanding → **Major practical benefits**

The innovation process (for advancing oceanographic instrumentation)

Complexity of innovation process: needs to be known, to avoid unrealistic expectations and/or discontinuous support.

Incubation time: 15-30 years (computer mousse, 30 years). Gliders 10 years. ¿?

Innovation can be incremental or radical, stimulated or suppressed.

The innovation process (for advancing instrumentation)

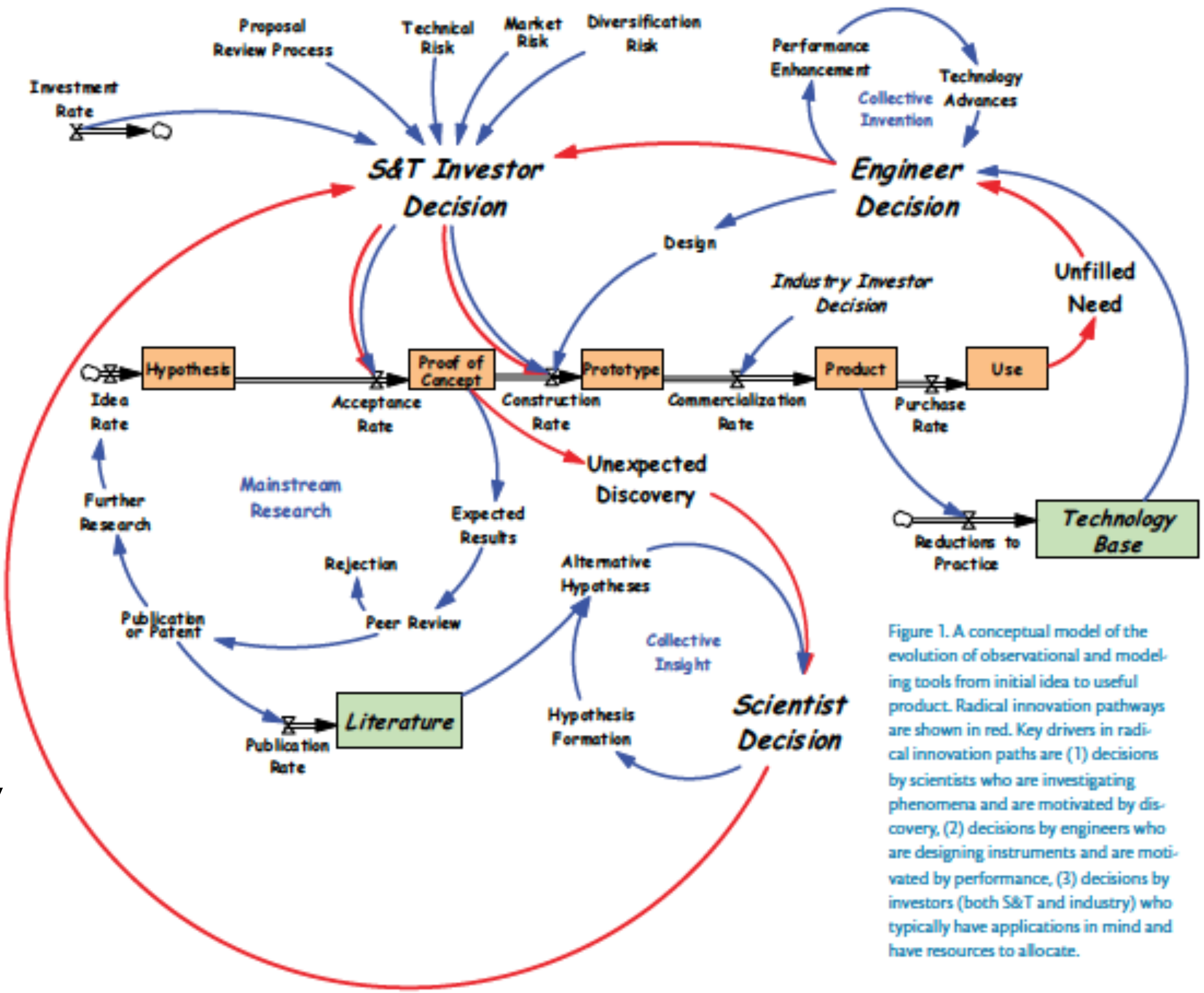


Figure 1. A conceptual model of the evolution of observational and modeling tools from initial idea to useful product. Radical innovation pathways are shown in red. Key drivers in radical innovation paths are (1) decisions by scientists who are investigating phenomena and are motivated by discovery, (2) decisions by engineers who are designing instruments and are motivated by performance, (3) decisions by investors (both S&T and industry) who typically have applications in mind and have resources to allocate.

(Curtin and Belcher, TOS, 2008)

The innovation process (for advancing instrumentation)

Why is it important? : we need synoptic coverage

And… "Every time a new instrument has arrived,

new key findings"…

Examples of innovations:

- Ships → Public – Private transfer
- Satellites → Ocean Weather…
- CTD → Micro-structure,
- Buoys- ARGO profilers →
- Currentmeters (rotor to ADCP) → Spectrum…
- Gliders → Submesoscale - …

The real challenge for the next decade…:

To use and integrate these new technologies 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 by this**
- **Establish the decadal variability, understand the associated biases and correct them …**

The innovation process (disruptive, gliders)

Incubation time for gliders; ½

Why?:

… "A coherent set of scientists, engineers, and investors that envisioned the scientific goal, understood the technology potential and sustained the funding" (Curtin and Belcher, TOS; 2008).

The key to success for radical innovation in oceanographic instrumentation

1. Visionary leadership
2. Close coupling between science and engineering
3. A coherent investment strategy based on distributed, coordinated resources
4. Effective processes for communication, feedback, and contingency planning.
5. Incentive to assume responsibility for risky instrumentation development projects without undue career jeopardy.

In summary: work in collaborative, multidisciplinary teams, be tenacious and focused on long term objectives while producing short-term success, and find creative champions among funding agencies and investor organizations.

The role of new marine research infrastructures (MRI/ ICTS/Ocean Observatories….)

→ Need to…: **RESPOND TO THE 3 KEY DRIVERS**

- Science Priorities – (ok!)
- Strategic Society Needs (more listening!, policy makers&managers endorsement), MSFD (GES); Energy, Tourism, etc.
- New Technology Developments (companies, social society endorsement)

Observing and Forecasting Systems are particularly well placed

AND → Need to define a **JOINT STRATEGY** (international level, more than coordination, Partnership…between Observing and Forecasting Systems !!!

SUMMARY… From small to large scales…

1. **Respond to 3 drivers: science, technology, society needs**

2. **Use and integrate new technologies to:**

- Monitor the variability at small scales, e.g. mesoscale/week, to

- Resolve the sub-basin/seasonal and inter-annual variability and by this

- Establish the decadal variability, understand the associated biases and correct them …

3. **Select key control sections for routine monitoring 'choke or control points' to characterise ocean variability**

Thank you!!!