The impact of new information infrastructures in understanding and forecasting the changing coastal ocean: SOCIB, an international **C**oastal **O**cean Observing and Forecasting **S**ystem based in the **B**alearic **I**slands

Joaquín Tintoré and the SOCIB team

SOCIB and IMEDEA (UIB-CSIC)

http://www.socib.eu

The ICTS SOCIB approach to sustained Marine RI

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

→ **RESPONDING TO 3 KEY DRIVERS**

- Science Priorities
- Strategic Society Needs
- Technology Developments

Similar approach for other Spanish ICTS, UTM (CSIC); PLOCAN

What is SOCIB?

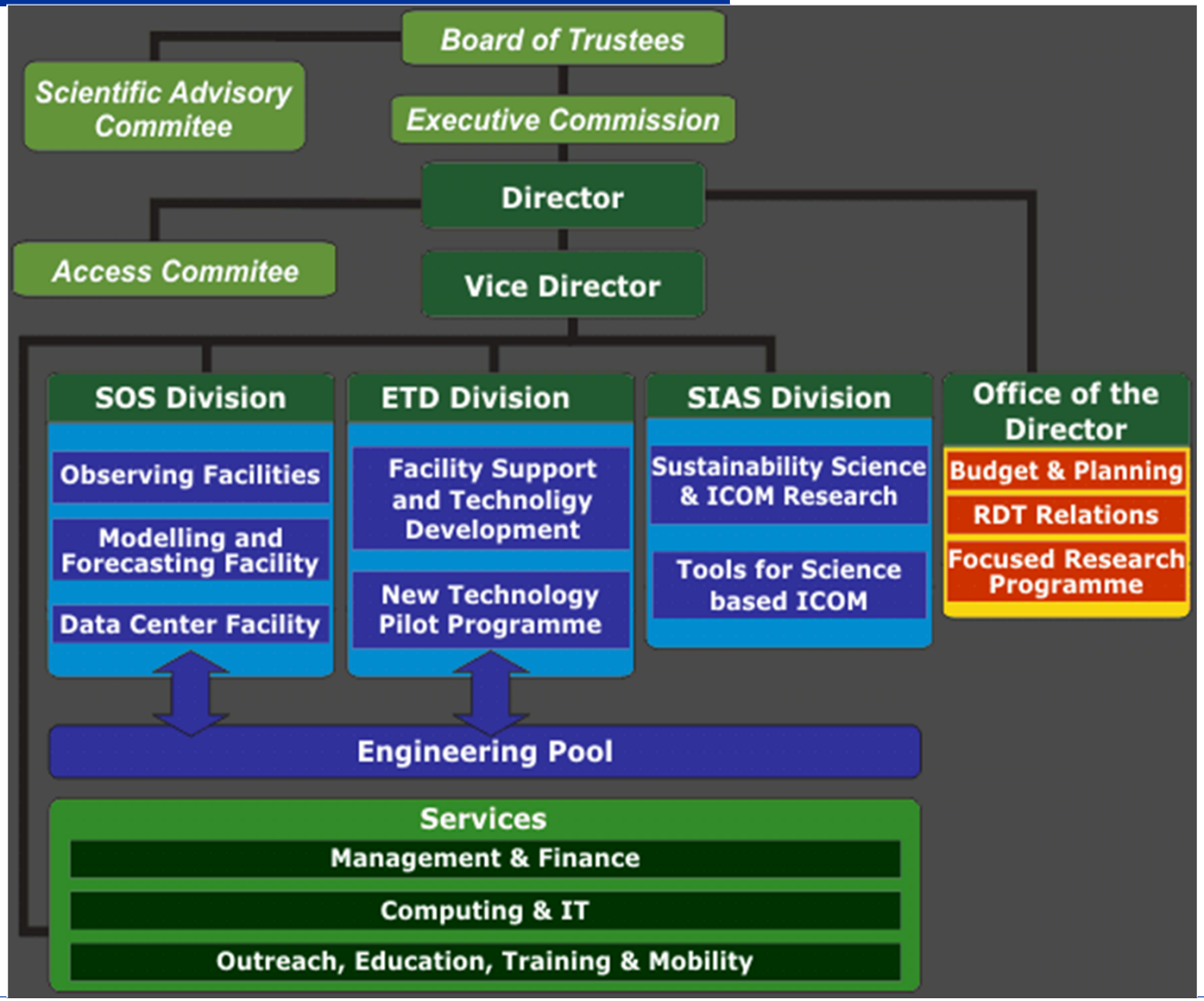
SOCIB is a Coastal Observing and Forecasting System, **a <u>multi-platform</u> <u>distributed</u> and <u>integrated</u> Scientific and Technological** Facility (a facility of facilities…)

- 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.

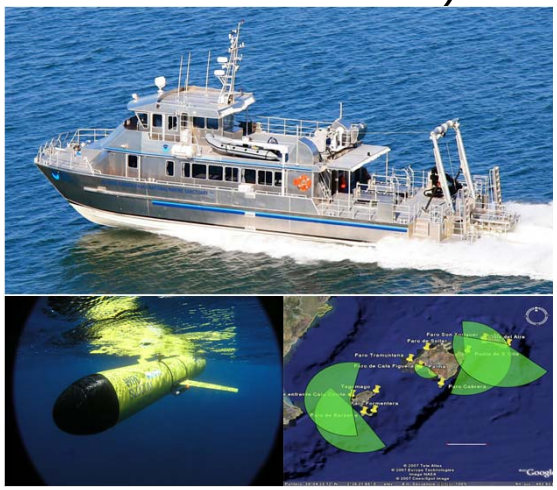
SOCIB Structure



Systems Operations and Support Division

1. Observational Facilities (major elements)

- New Coastal Research Vessel (25 m LOA – 1.200 km coastline in the Islands)
- HR Radar
- Gliders and AUV's
- Moorings, tide gages and satellite products
- ARGO and surface drifters
- Nearshore beach monitoring



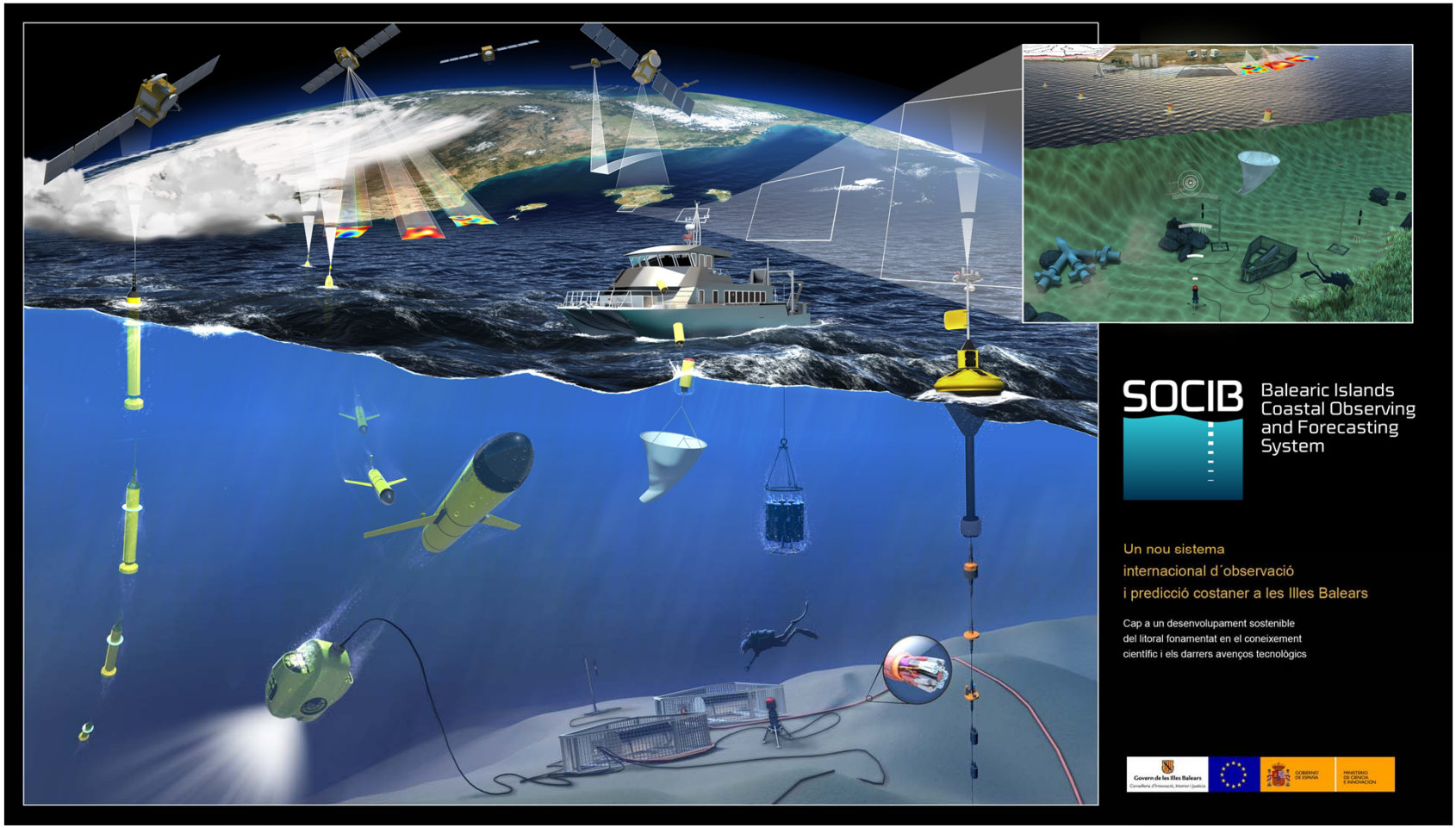
2. Forecasting sub-system

- 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: the view….



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

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]

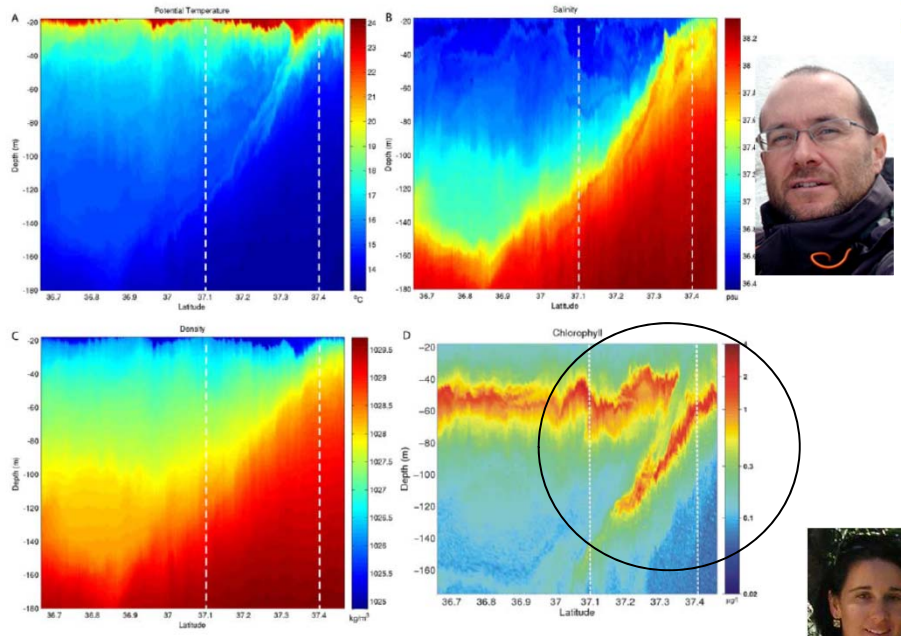


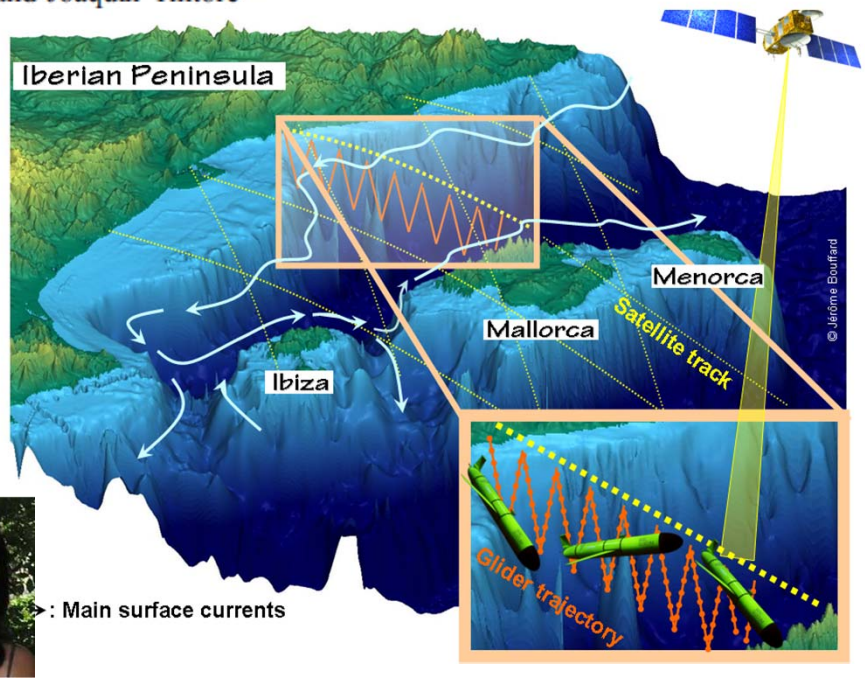
Figure 2. Vertical section of temperature (°C), salinity (PSU), density (kg/m^3) and chlorophyll (μg/l) from glider section 2 (dashed magenta in Figure 1). White dashed lines define sub-section in the northern part of the domain.

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 Universitat de les Illes Balears

Govern de les Illes Balears

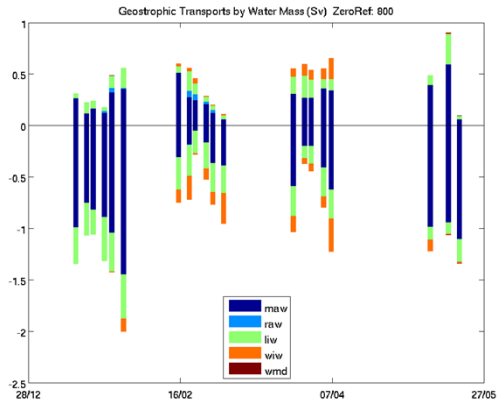
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

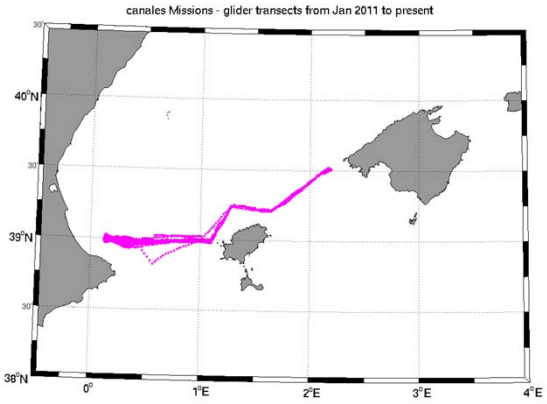
Gliders Facility: Operational

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

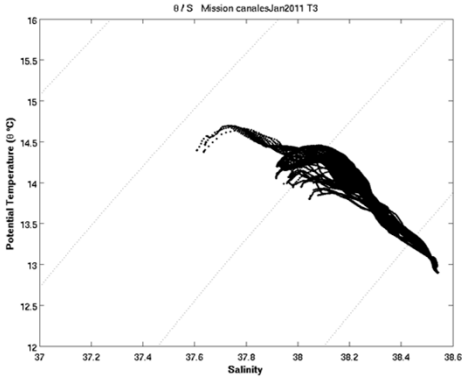
NEED DEFINE KEY CONTROL SECTIONS EU

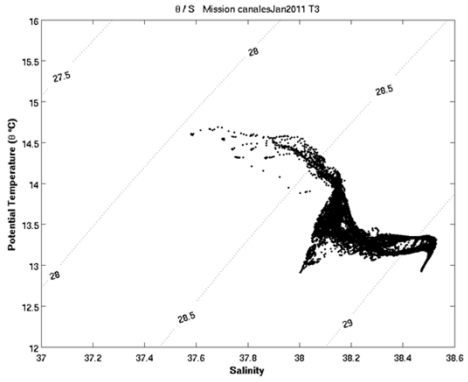
Major transport changes





TS diagrams ROMS / Glider





SOCIB Balearic Islands Coastal Observing and Forecasting System

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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…

Multi-platform integration: altimeter - tide gauge

OBJECTIVE: Assess the benefit of combining tide gauge measurements with altimetry (Saraceno et al 2008) to improve surface currents estimation along the Balearic coast.

Data and methodology

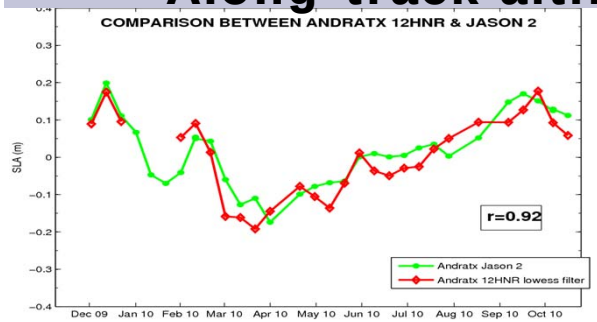
Tide Gauge

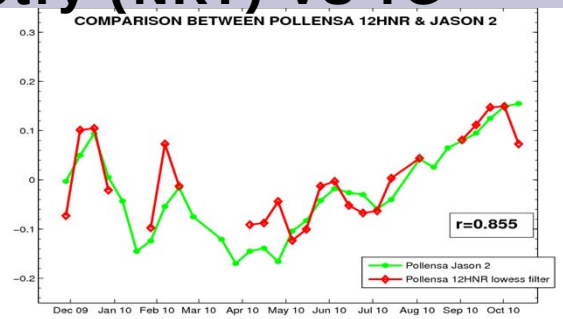
SSH corrected by HIRLAM (20 days Filtered)

Altimetry: JASON 1 / 2

AVISO (NRT) at nearest points

Along-track altimetry (NRT) VS TG



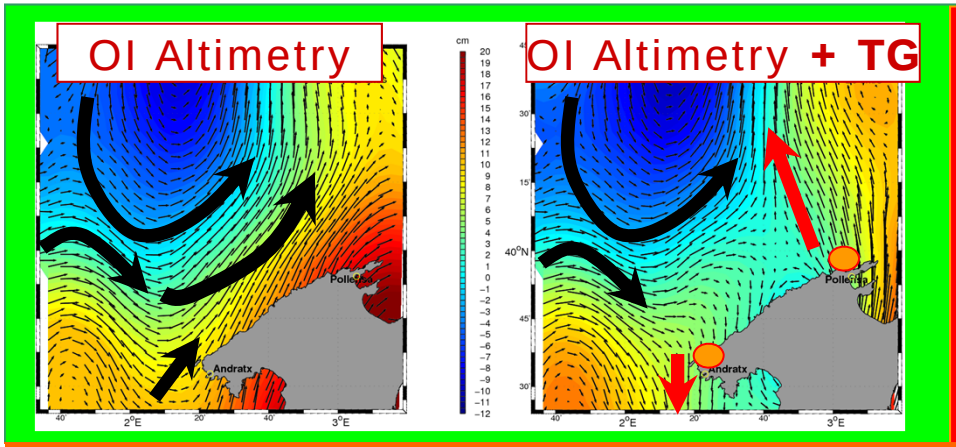


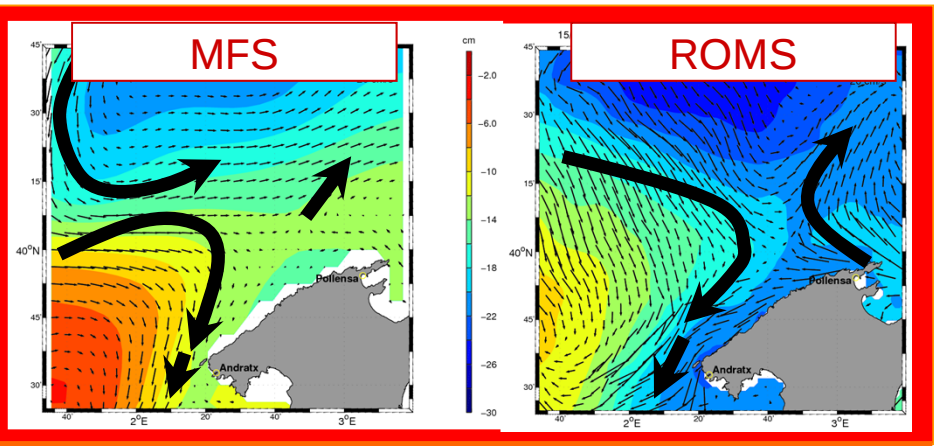
Good TG-altimetry agreement (corr >0.8 with J1 / J2)...

OPTIMAL INTERPOLATION

Several tests (Grid definition, Spatial / temporal correlation scales, error covariances ...)

Gridded currents VS models



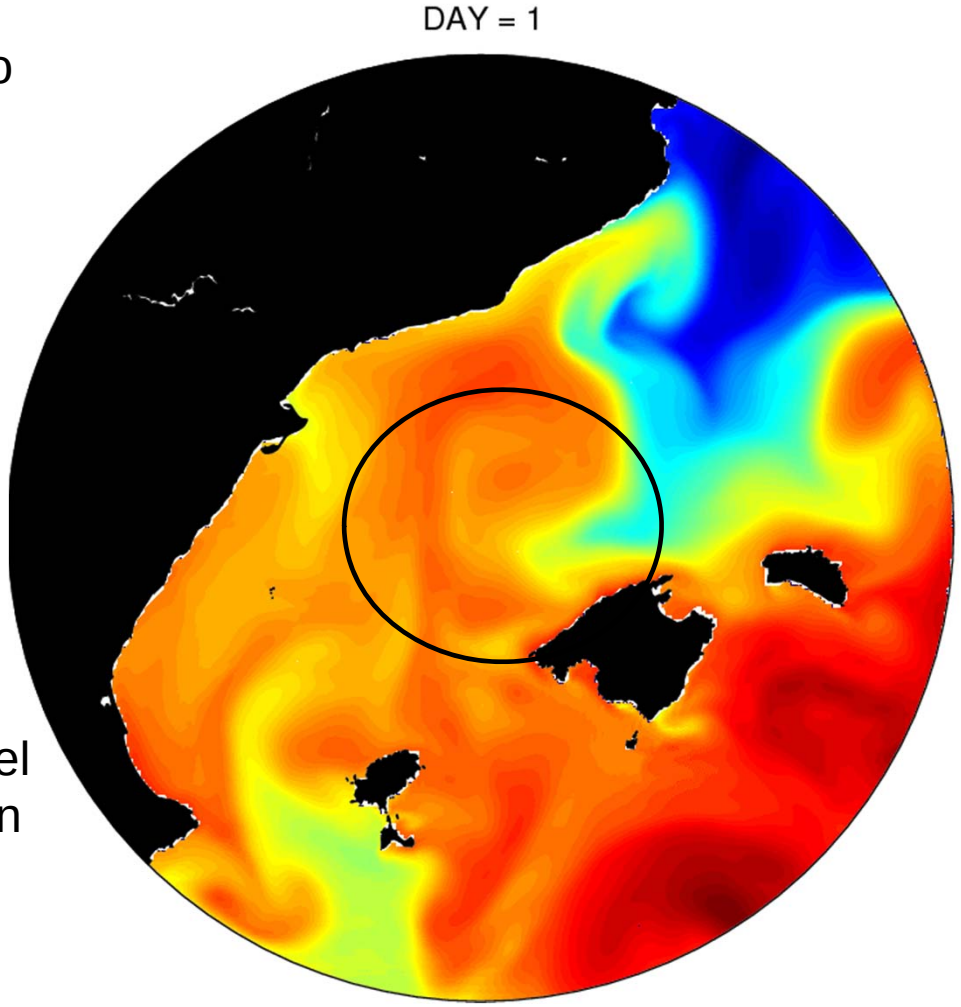


Preliminary results show good qualitative agreements with numerical

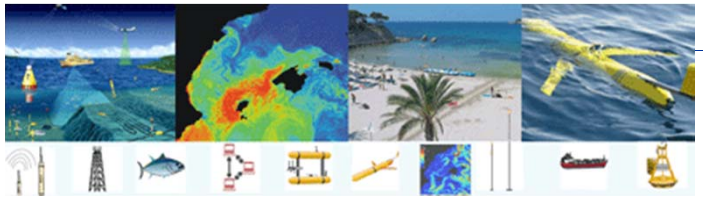
Modelling Facility

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

The aim :
- Validate the model with the measurement (gliders, ...)
- From the available data and the model simulation (5 years), study the formation of mesoscale structures.
- Understand impact on the ecosystem



SST from 11/2008



ICTS OceanBit

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Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

UIB

I·M·E·D·E·A

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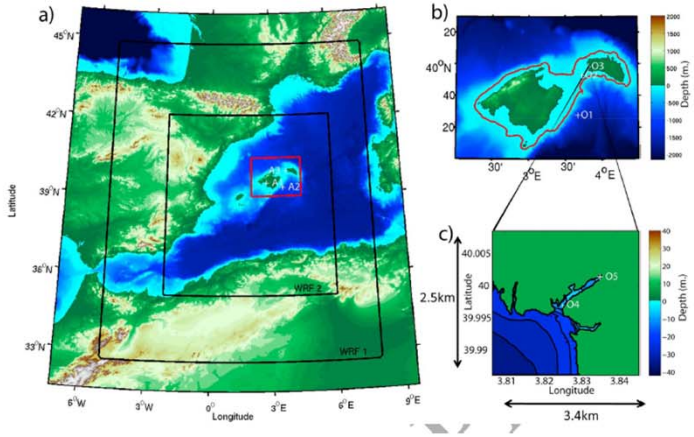
Modelling Facility; Meteotsunamis forecasting

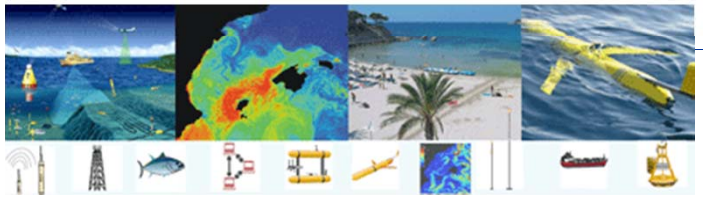
GEOPHYSICAL RESEARCH LETTERS, VOL. 38, LXXXXX, doi:10.1029/2011GL0

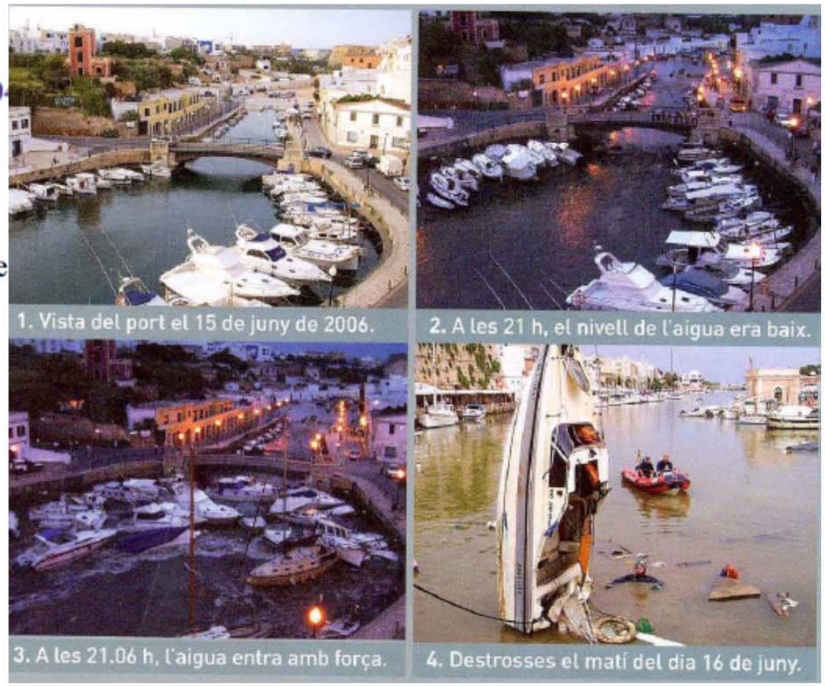
1 Toward the predictability of meteotsunamis in the Balearic Sea
2 using regional nested atmosphere and ocean models

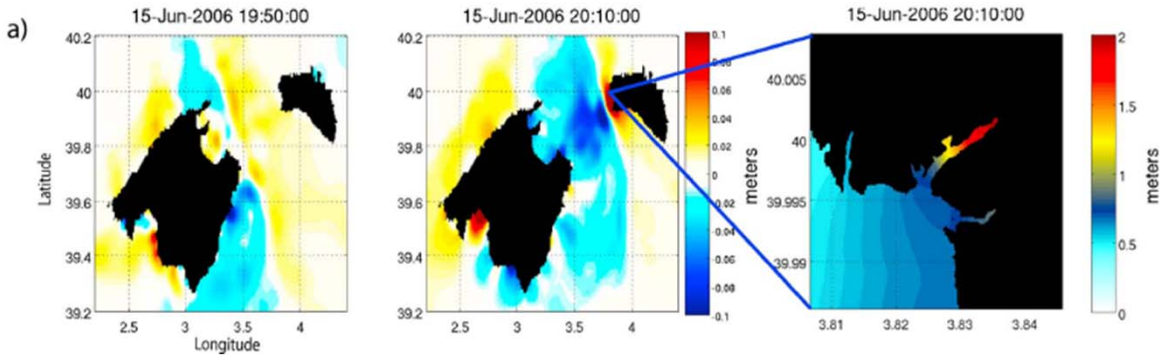
3 Lionel Renault,[1] Guillermo Vizoso,[2] Agustin Jansá,[3] John Wilkin,[4] and Joaquin Tintore

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









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I·M·E·D·E·A
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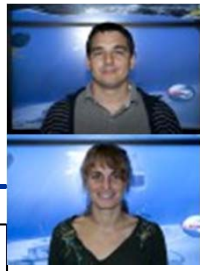
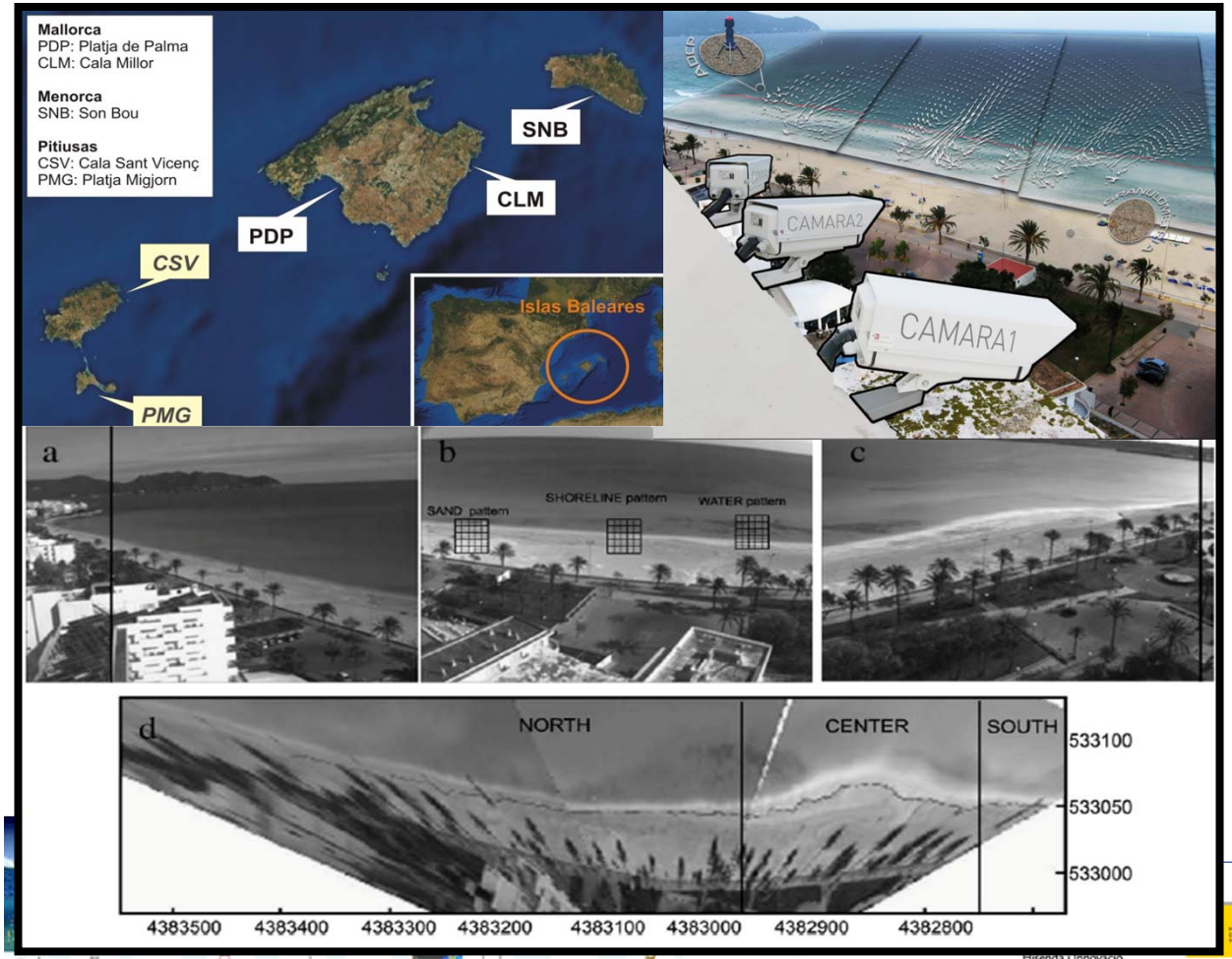
Marine and Terrestrial Beach Monitoring Facility



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

Direcció General de Recerca, Desenvolupament Tecnològic i Innovació

Data Center process

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

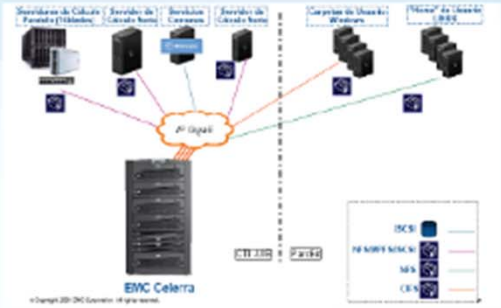
Data Centre. Technologies

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.

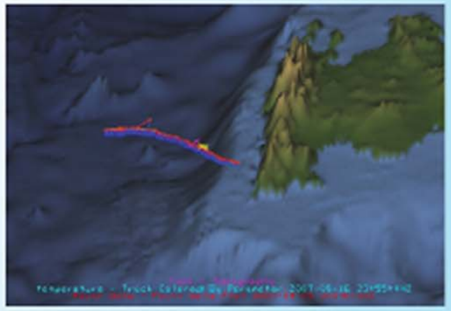
4. Catalog

THREDDS to organize data and Metadata to automatic harvesting.

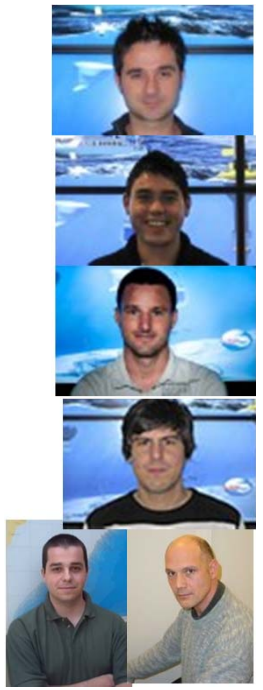
5. Discovery

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

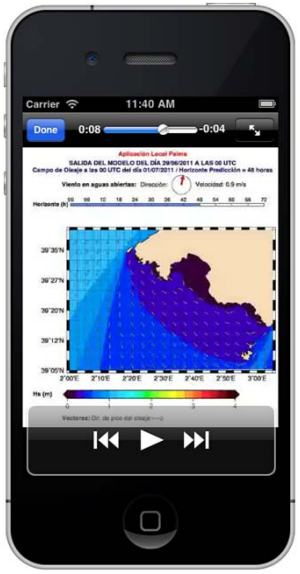
6.Analisis and Visualization



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



Data Centre (example of Apps)



SOCIB Strategic Issues and Applications for Society

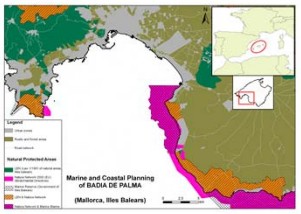
Sustainability Science and Integrated Coastal and Marine Management, MSP

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!.



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

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

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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 53 (2010) 451–468

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Integrated and interdisciplinary scientific approach to coastal management

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

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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 in 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.

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

Summary

THE FACTS: Oceans and Coasts, Research, Research Infrastructures

- The Oceans; a complex system, changing, under-sampled (Walter Munk-2001- "The last century of oceanography is marked by the degree of under-sampling", cited by Chris Barnes/NEPTUNE yesterday; Carl Wunsh 2010: "We need data, … models are becoming untestable" and examples from Martin Visbeck Atlantic Ocean meridional circulation yesterday), 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 can help and must help to fill theses gaps and Governing bodies should adapt to the new global situation.

But we have another **BIG GAP**: …. **"The Science-Policy Gap"**

Summary

To assure the real sustainability of the oceans and of the observing systems, we need to address **the Science – Policy GAP**.

HOW?

→ **RESPONDING TO THE 3 KEY DRIVERS**

- Science Priorities (ok!)
- Strategic Society Needs (more listening!, policy makers&managers endorsement)
- New Technology Developments (social society endorsement)

This implies deep structural changes of 'our' scientific system. Changes imply risk, but we cannot probably avoid it if we want endorsement from Society.

AND → **DEFINING A JOINT STRATEGY** (European/national level in the international framework, more than coordination, Partnership…)

It is time for action. Are we ready? YES!!!!

Merci!!!

Summary

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

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SOCIB Balearic Islands Coastal Observing and Forecasting System

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SOCIB: the impact of new marine infrastructures in understanding and forecasting the coastal oceans

some examples from the Balearic Islands, in the Mediterranean Sea

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The problems – The approaches