NEW CAPABILITIES FOR SCIENCE BASED OPERATIONAL OCEANOGRAPHY RESPONSE TO OIL SPILL IN COASTAL WATERS

From 2001 to 2011: ten years of experiences…

Joaquín Tintoré and the SOCIB and IMEDEA TMOOS team

IMEDEA (UIB-CSIC) and SOCIB

OUTLINE

1. **IMEDEA – TMOOS: SCIENCE FOR OPERATIONAL OCEANOGRAPHY**
   - **PRE-OPERATIONAL SCIENCE BASED SYSTEMS (Prestige and Don Pedro Oil Spills)**
   - **ONGOING RESEARCH PROJECTS (MyOcean, TOSCA, etc.)**
2. **SOCIB: THE NEW BALEARIC ISLANDS OBSERVING AND FORECASTING SYSTEM**
3. **IN SITU SOCIB VISIT: OPERATIONAL CAPABILITIES FOR SCIENCE BASED TOOLS FOR DECISION MAKING**

Science for... IMEDEA work since 1990 's... - Strategic Plan 2010-2013 – **SCALE INTERACTIONS**

20 years of **peer reviewed 'basic' Research Activity (observations and models)**: 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 (*Operational oceanography*, 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)

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The IMEDEA – Marine Technologies, Operational Oceanography and Sustainability Depart.

SCALE INTERACTIONS: from basin to sub-basin and local scales, to beach morpho-dynamics…

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Research through projects

Spanish and European framework: some examples

MERSEA

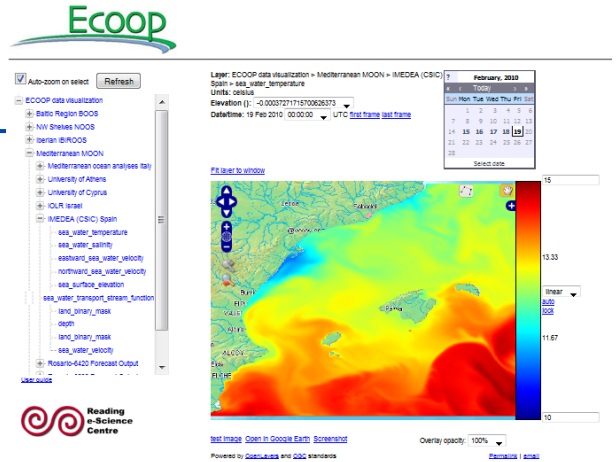
ESEOO ESTABLECIMIENTO DE UN SISTEMA ESPAÑOL DE OCEANOGRAFÍA OPERACIONAL

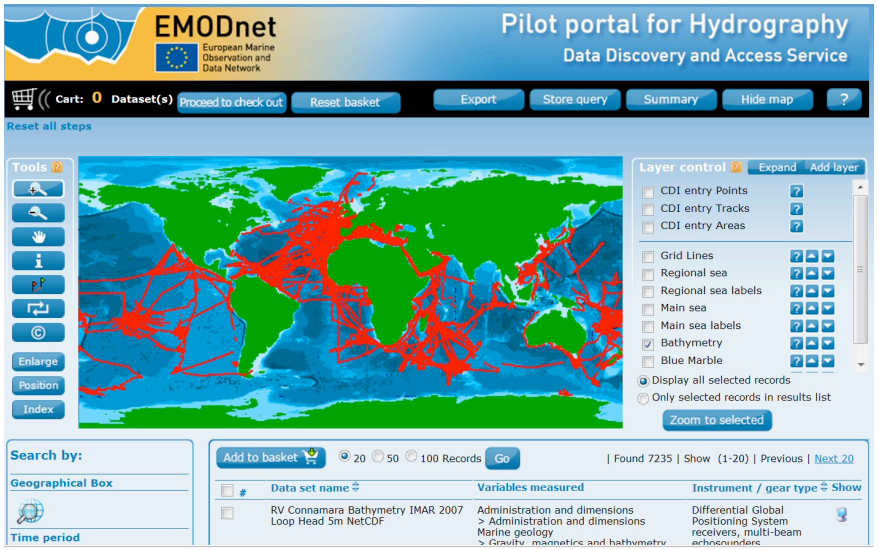
SESAME

myOcean

TOSCA
NETWORK FOR A BETTER RESPONSE TO MARITIME ACCIDENTS

EFFICIENT RESPONSE TO MARITIME ACCIDENTS IN THE MEDITERRANEAN





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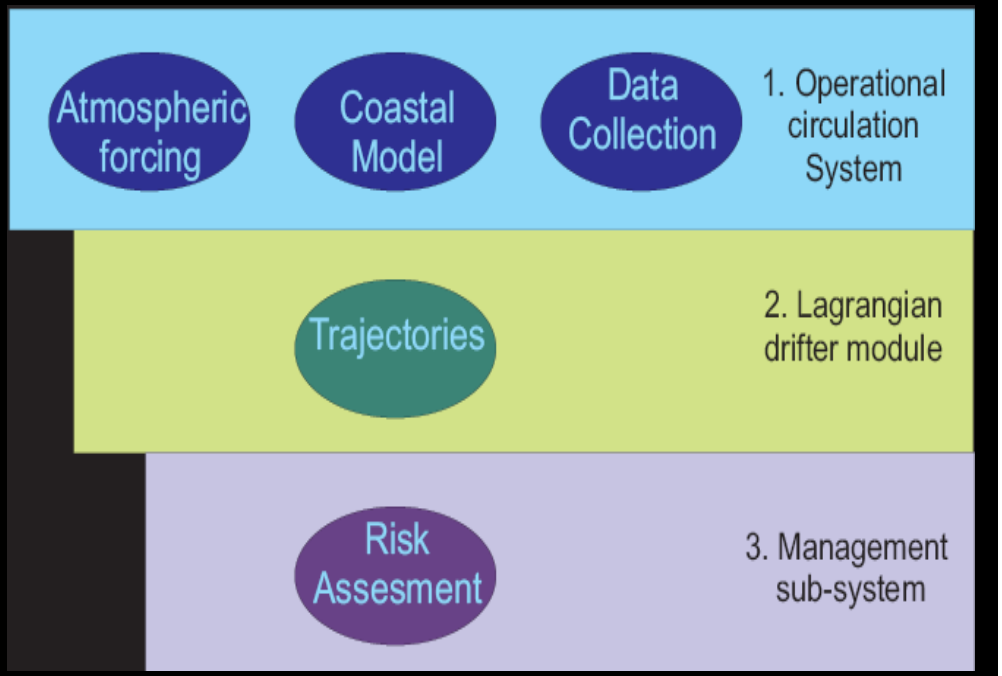
The IMEDEA pre-Operational Forecasting system (2002-2008)

IMEDEA pre-operational circulation system in the Balearic Islands. System based upon three nested domains

Science based support to operational response.

The system is a tool to forecast oil spill trajectories, drifting objects, etc.

It is applied using a management subsystem based on GIS technology which aids for decision support to provide response to SAR operations or oil spill accidents.

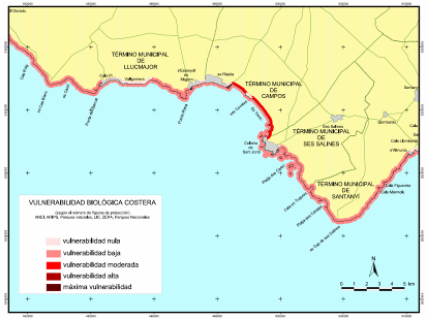


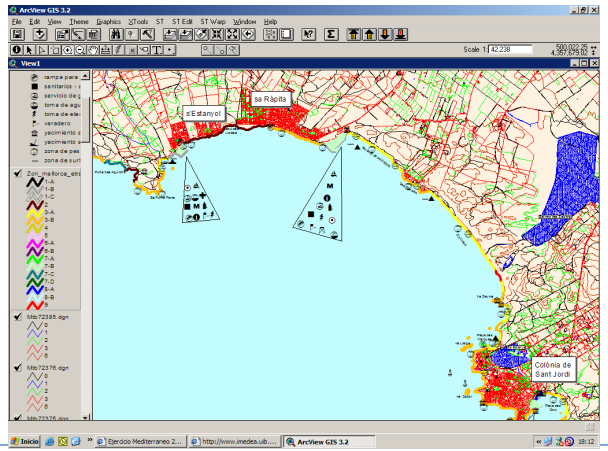
UIB I·M·E·D·E·A Institut Mediterrani d'Estudis Avançats CSIC

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)





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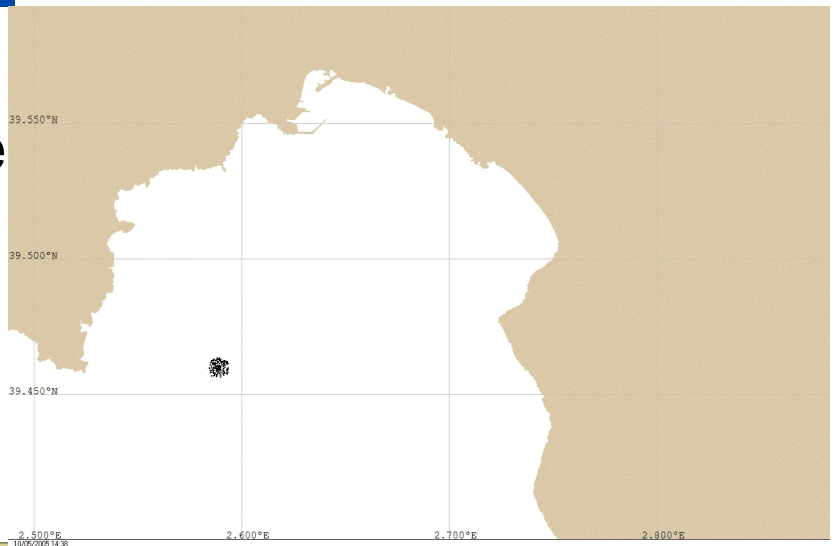
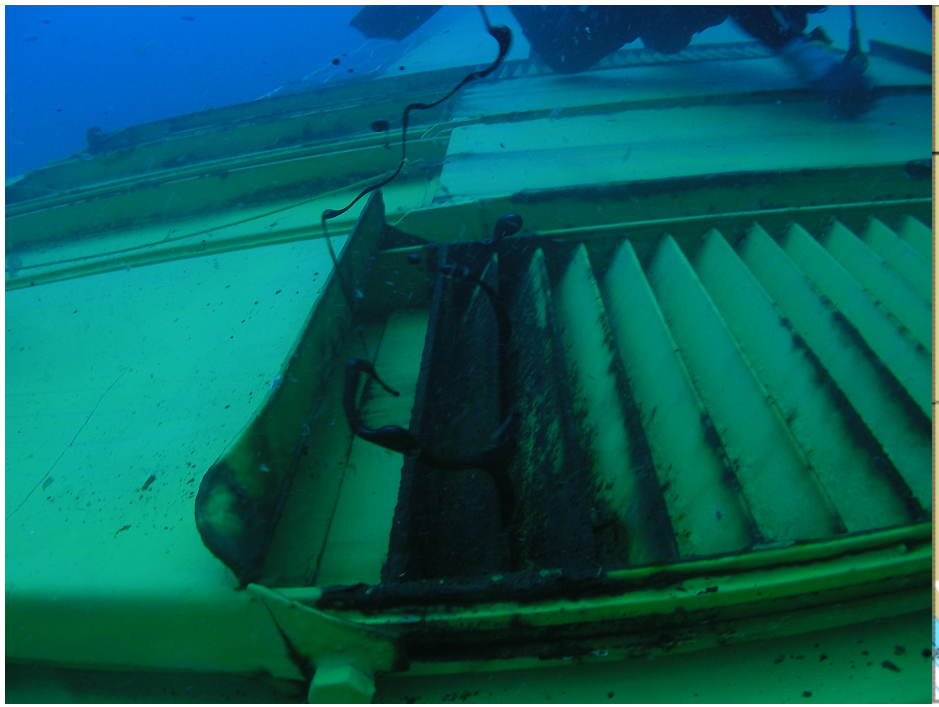
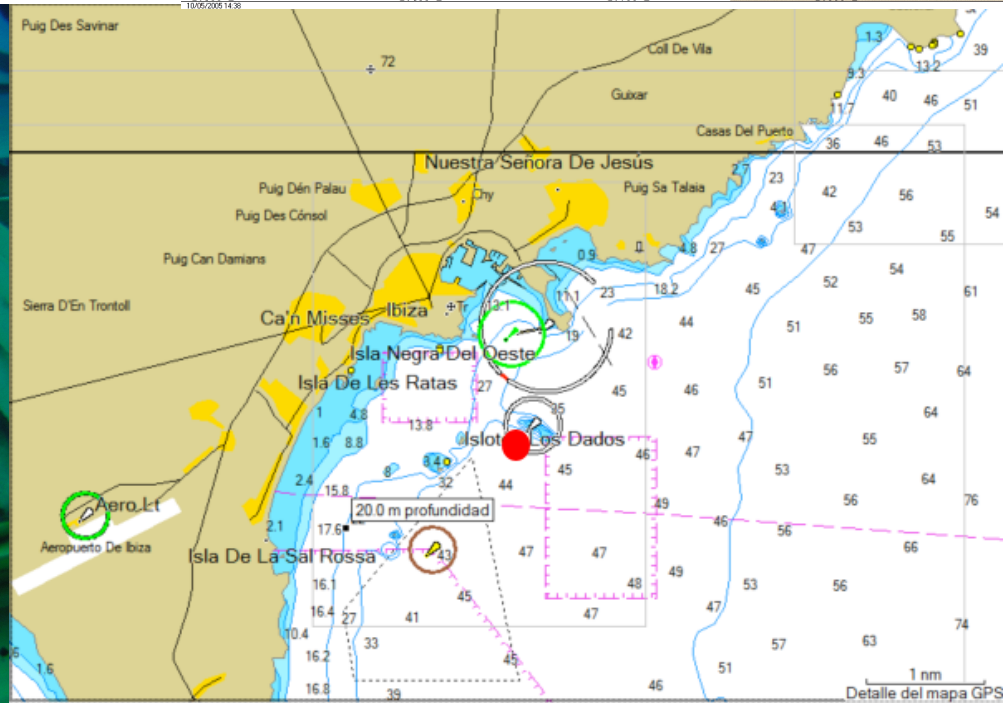
Don Pedro Oil Spill - Ibiza

Scientific support for oil spill response and damage assessments

In close coordination to D. G. Emergencies, Balearic Government



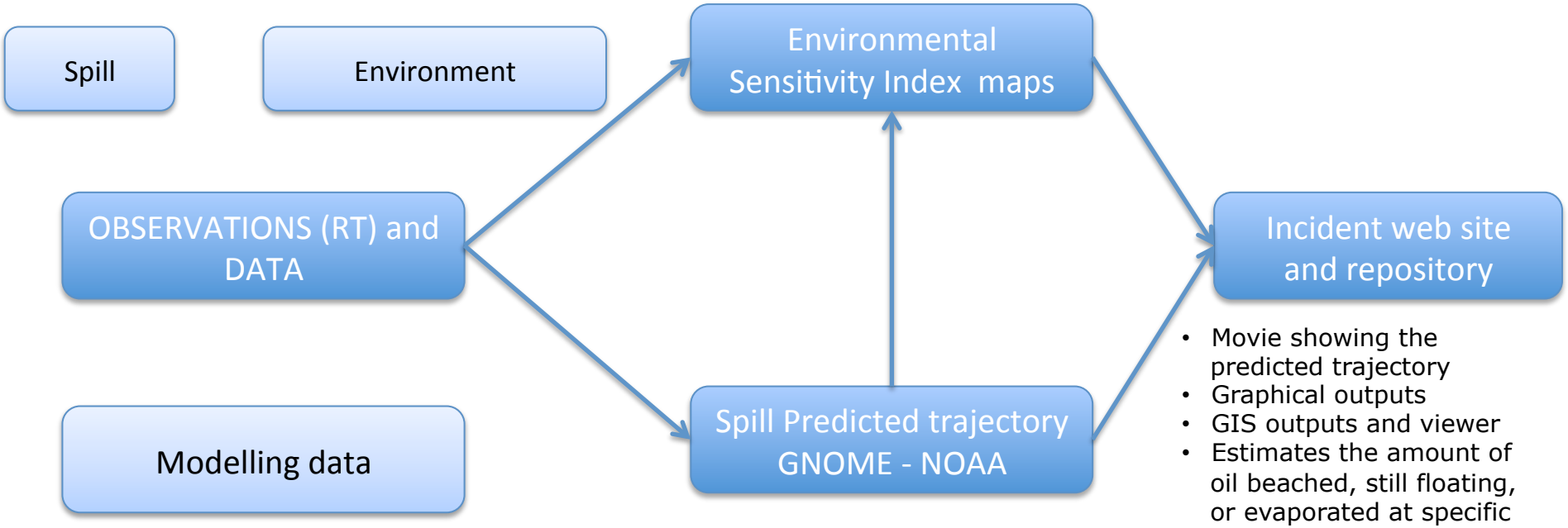




The IMEDEA pre-Operational Forecasting system (2002-2008)

- Localizations (helicopter, aircraft. In situ)
- Type and characteristics (NOAA methodology)

- Winds (Shore stations, ships,…)
- Sea temp. (in situ)



- Movie showing the predicted trajectory
- Graphical outputs
- GIS outputs and viewer
- Estimates the amount of oil beached, still floating, or evaporated at specific times.
- Reports and assesments

- Winds (HIRLAM AEMET)
- Sea breeze (analytical model)
- Currents (IMEDEA IFOSY)
- Waves (PE)

Response agency
Local decision makers

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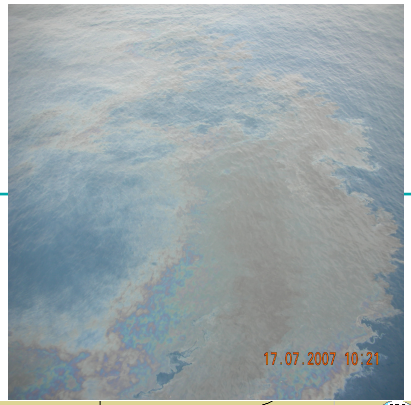
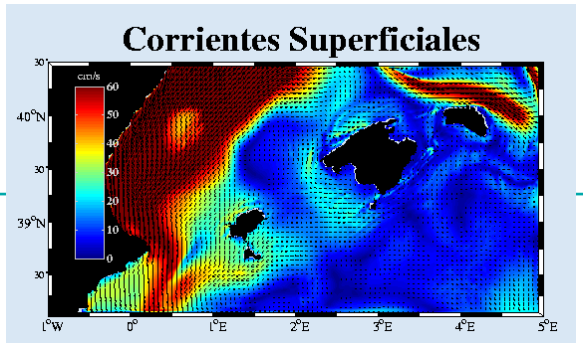
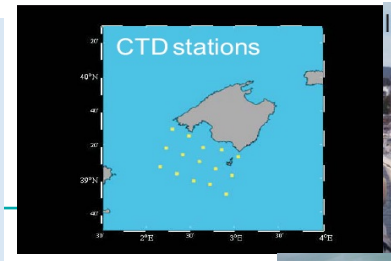
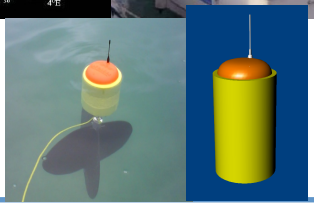


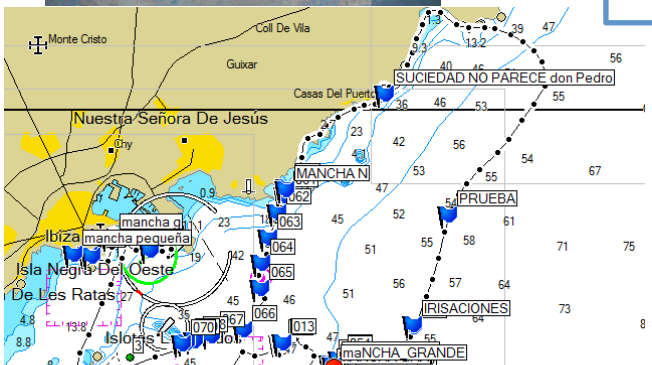


Imedea currents forecasting



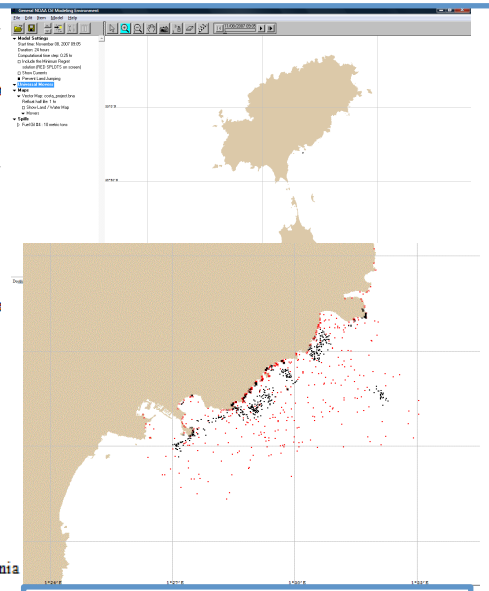


REA capability

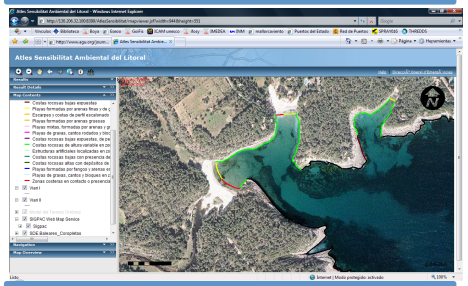


Reguero entrada puerto y manchas fragmentadas
Directos hasta wp4
Mancha
Wp 12
Pasado cala llonga limpio
Riu sta Eulalia limpio hay convergencias posidonia
Pto sta Eulalia limpio
Después sta Eulalia, limpio
Convergencia espumas, no parece del dp
Mancha dudosa junto cosrta en roca expuesta 5 m2 wp5
Wp6 mancha irisación 15 m
Wp7 manchas fragmentadas junto roca expuesta acumulaciones con posidonia
Wp8 en barrera pequñas acumulaciones galletas a confirmar
wp9 regueros 60 m
wp 10 pequeños regueros y galletas
wp 11 acumulacion en entrante mezcla con suciedad (no fuel)
wp 12 acumulacion pequeña en barrera
wp 13 regueros 2009 m a lo largo costa en saliente y entrante
wp 14 iriaciones 100m
wp15 acumulación en entrante mezcla co po
wp 16regueros junto costa rocosa baja expuesta
wp 17 acumulacion extremo N barrera
wp 18 reguros a 50 m barrera
Wp 20 barrera limpia
Wp 21 acumulacion en entrante con un fondo guijarros

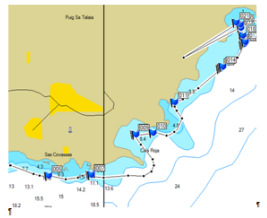
Visual observations



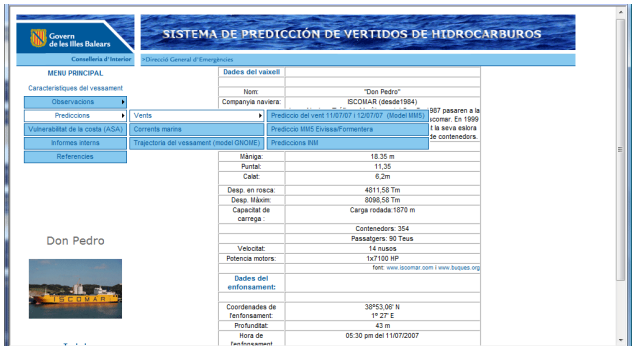
GNOME



ESI



Reports and incident web site for decision makers



Any operational system needs amelioration, upgrades through research projects

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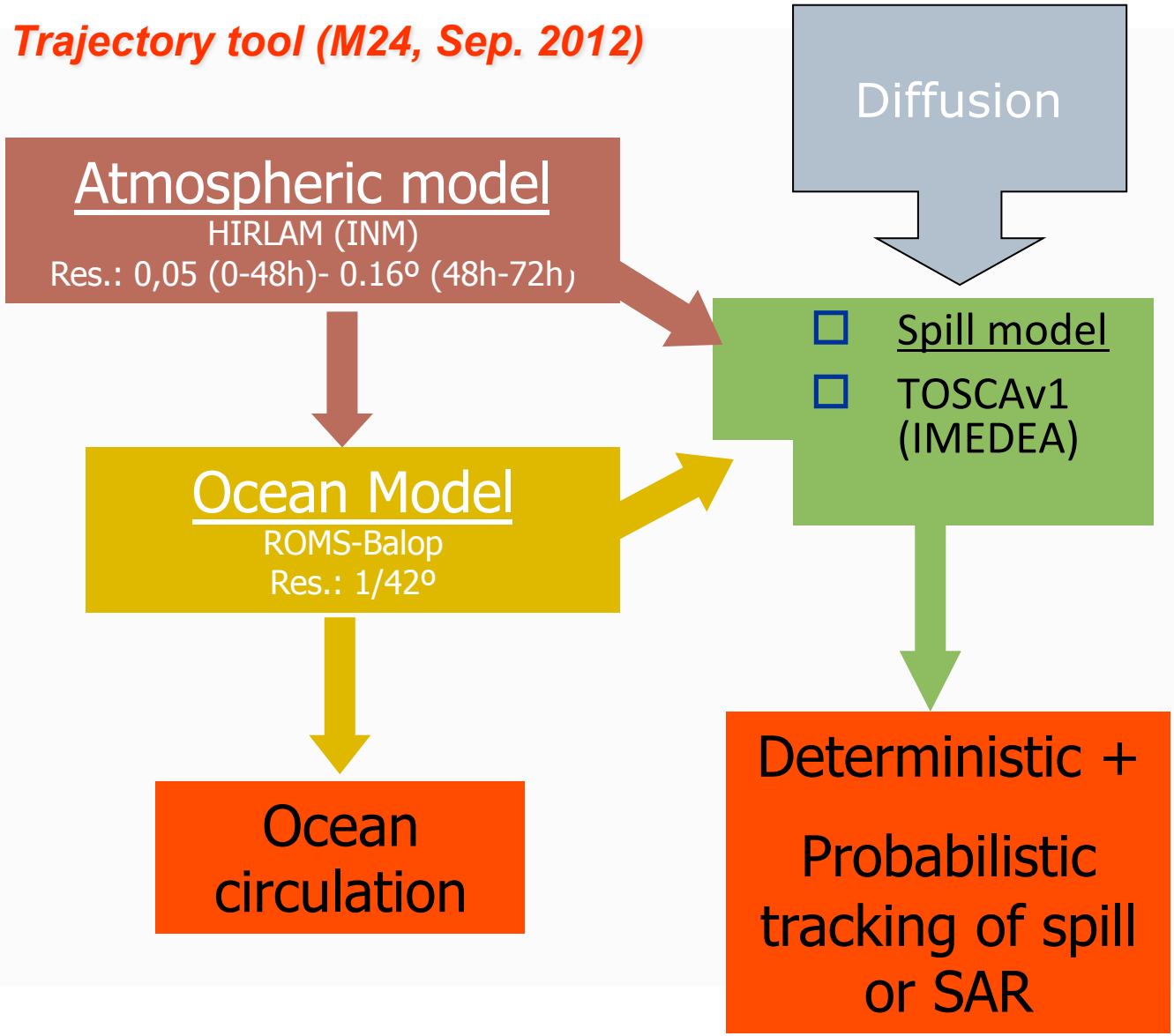
D.5.1.1. Trajectory tool (M24, Sep. 2012)



What is ToscaV1

….An Oil spill and trajectory model ……

But …why? Since we have many (GNOME, TESEO, OILMAP…)

An open tool (in the wide sense), multi-platform mixing the deterministic kind of models and the stochastic approach to build a trajectory tool in the probability domain based on the advection diffusion of the kernel of probability.

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

http://www.albatrosmt.com

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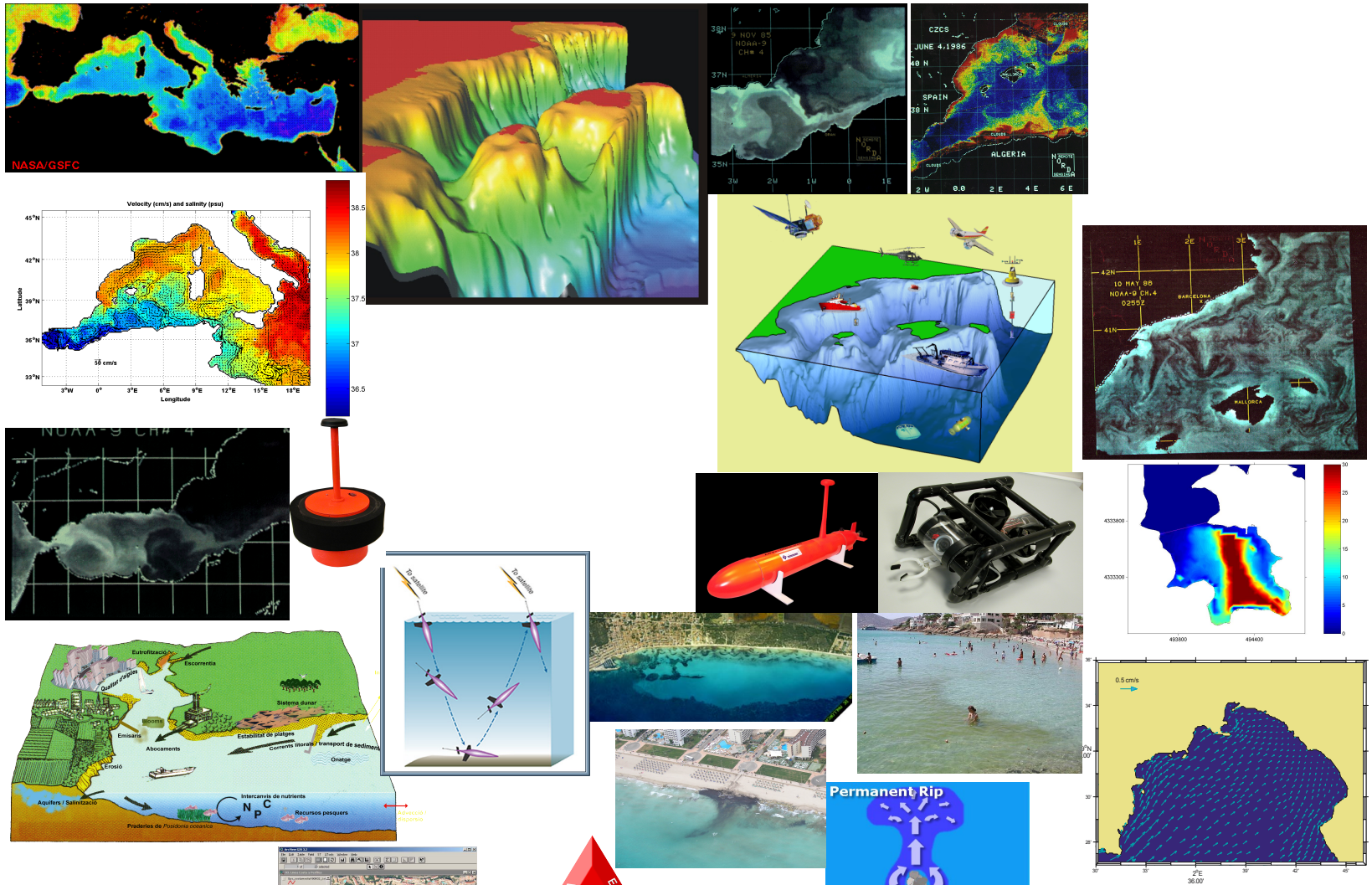
In summary, background…



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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 ineficient

Next Step

SOCIB

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.

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

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

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

—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.

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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

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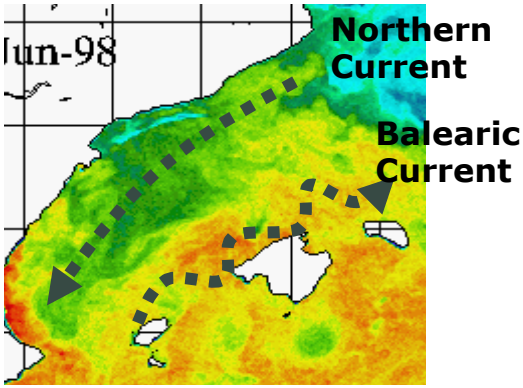
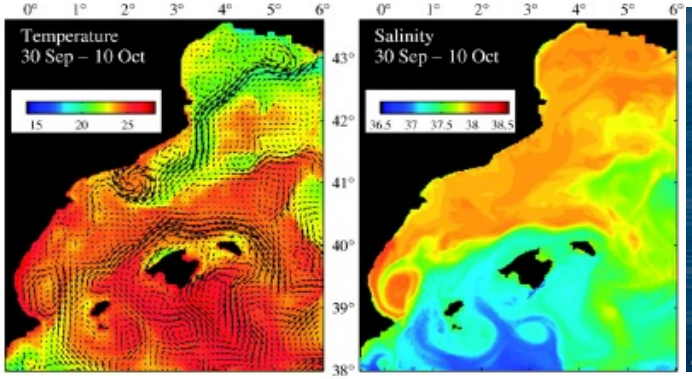
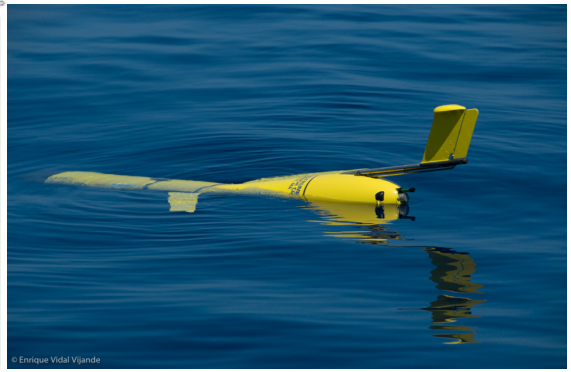
Why SOCIB, why Ocean Observatories, and **why now?**

New monitoring technologies are being progressively available for near real time coastal ocean 4D studies:

For example, **gliders** allow high-resolution sampling showing the existence of new features, such as submesoscale eddies with intense vertical motions that significantly affect upper ocean biogeochemical exchanges, an issue of worldwide relevance in the context of climate change (***Klein-Lapeyre, Ann Rev, 2008***).







These new technologies, integrated and used together, are delivering new insight into **coastal ocean variability,** which in turn will trigger **new theoretical developments**, increasing our u**nderstanding** of coastal and nearshore processes and contributing to a more science based and sustainable **management** of the coastal area.

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

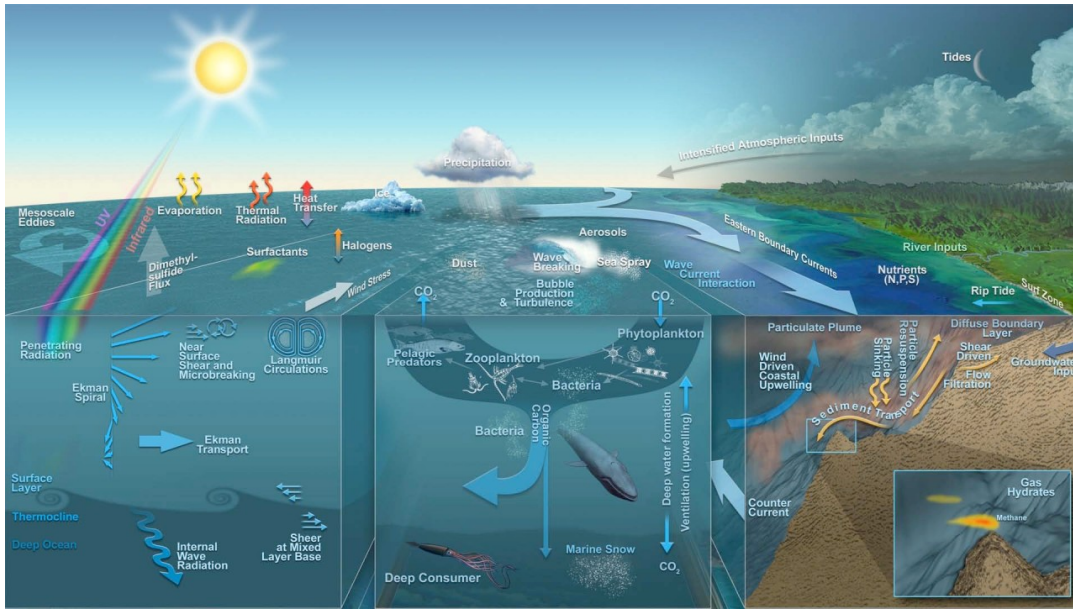
A New Approach to Marine and Coastal Research

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

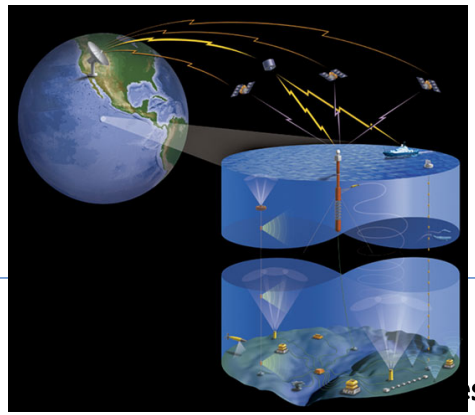
A quantitative major jump, in scientific knowledge and technology development

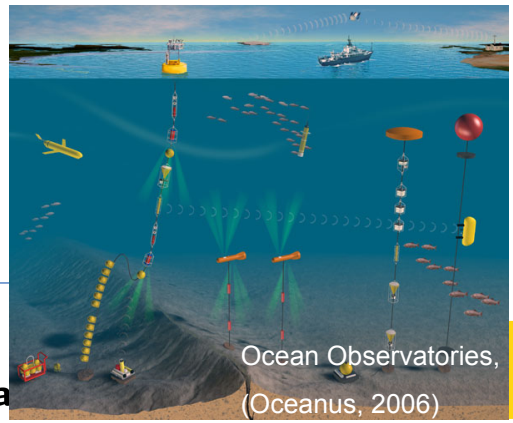
The development of a new form of Integrated Coastal Zone Management, based on recent scientific and technological achievements,

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)

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.

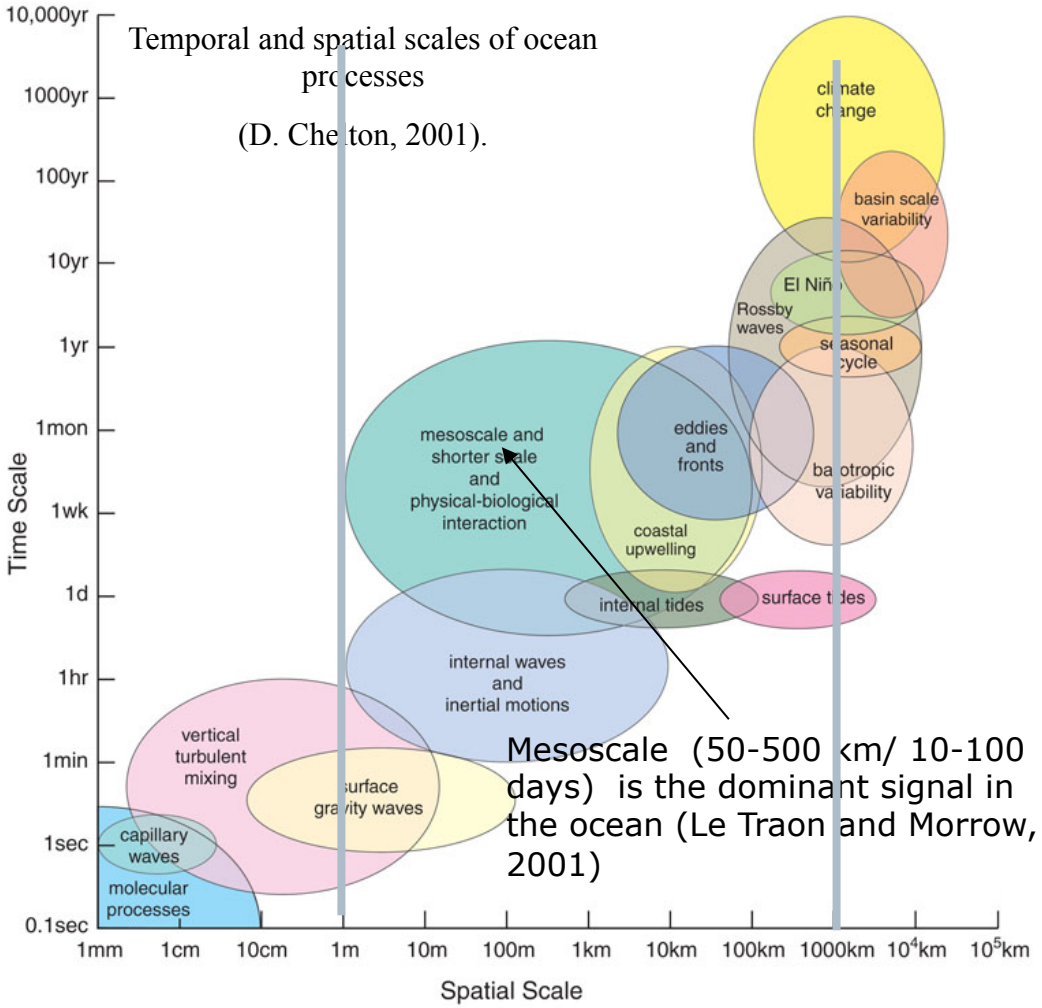
In other words, SOCIB will allow a quantitative increase in our understanding of key questions on oceans and climate change, coastal ocean processes and ecosystem variability.

SOCIB Science Focus: coastal 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),

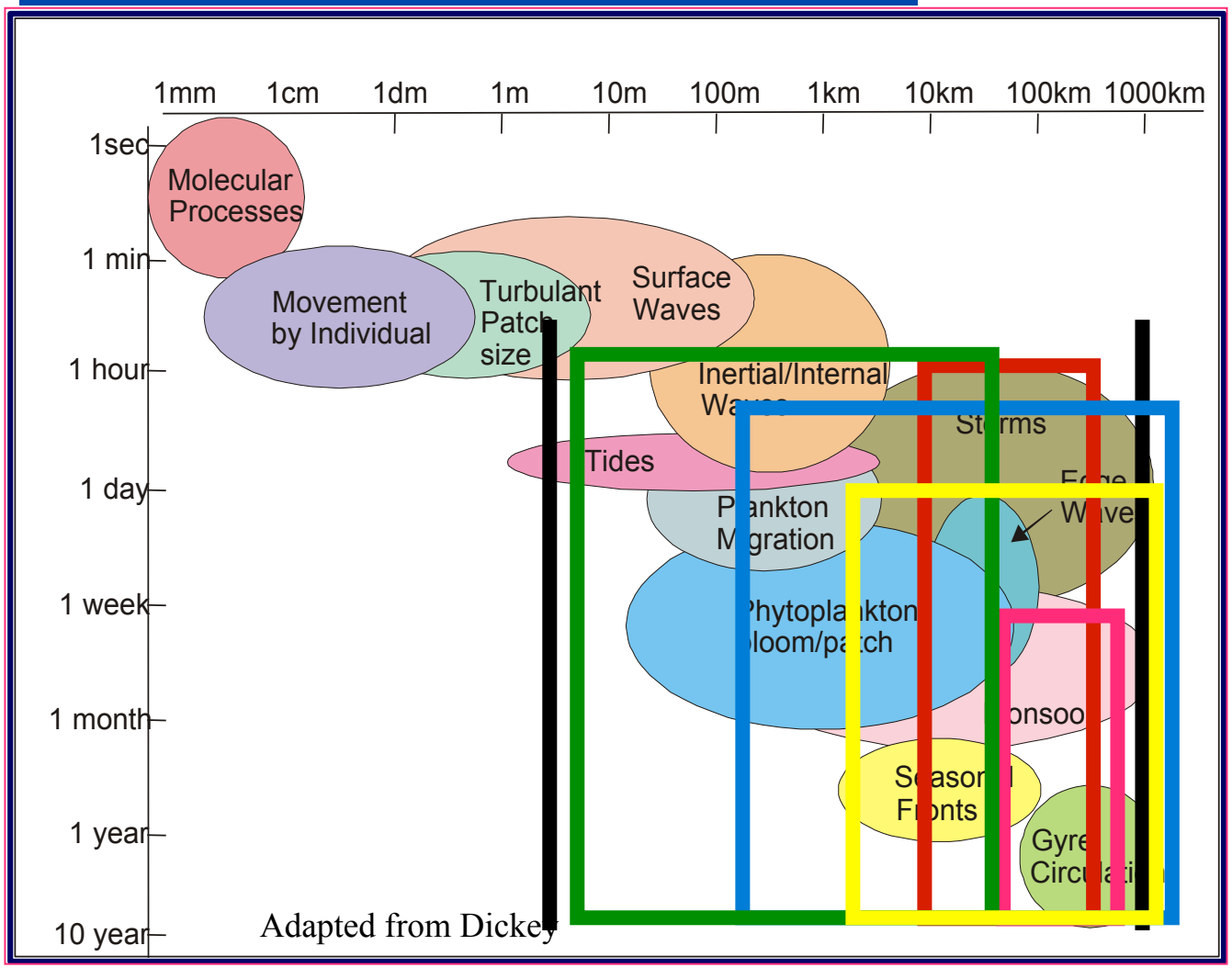
SOCIB focus: mesoscale & submesoscale and their effects on vertical motions, impact on ecosystem variability.

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



SOCIB scales

SOCIB scales and monitoring tools



Gliders

AUV's

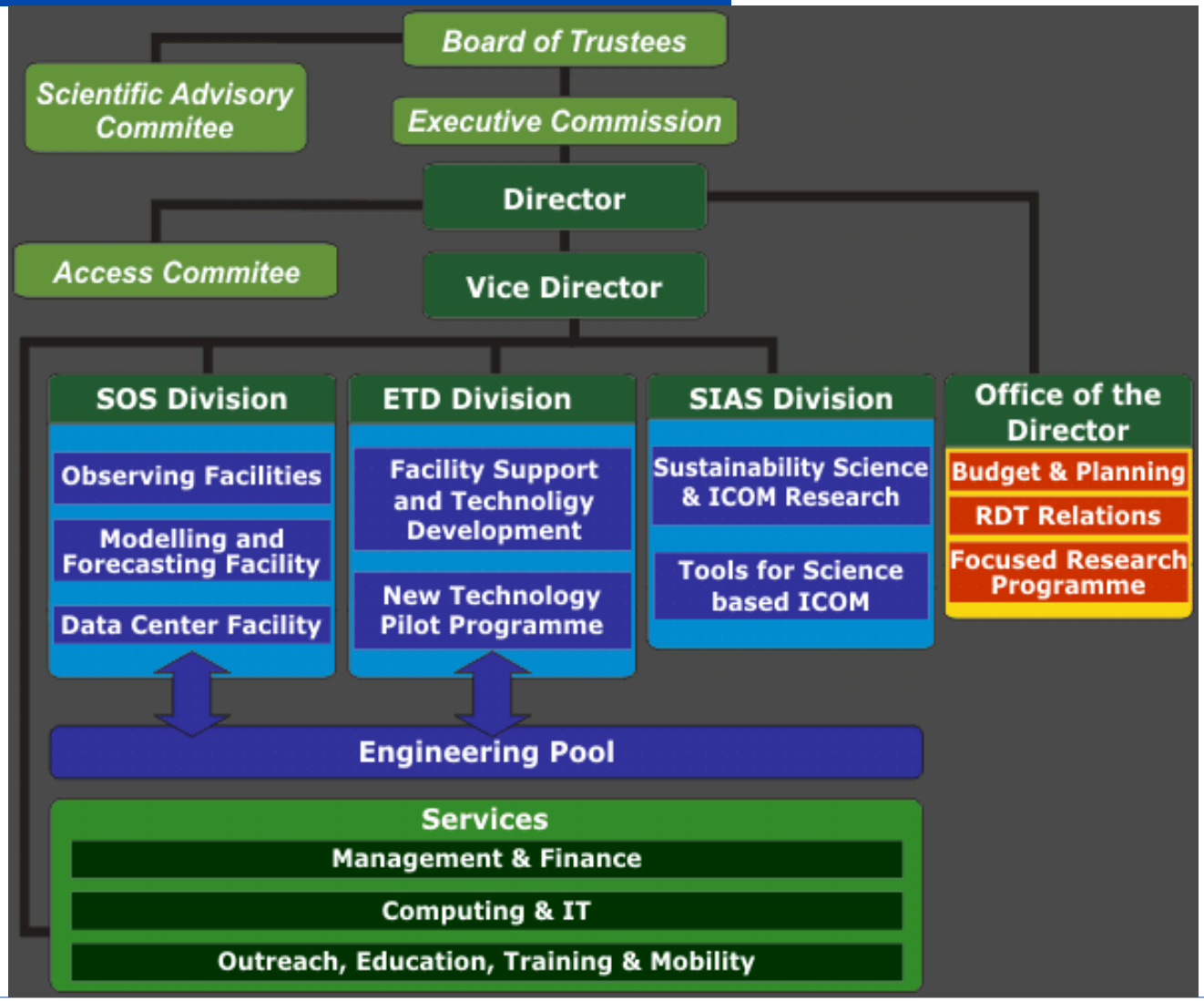
Time series

HF radar

Spatial survey

Satellite

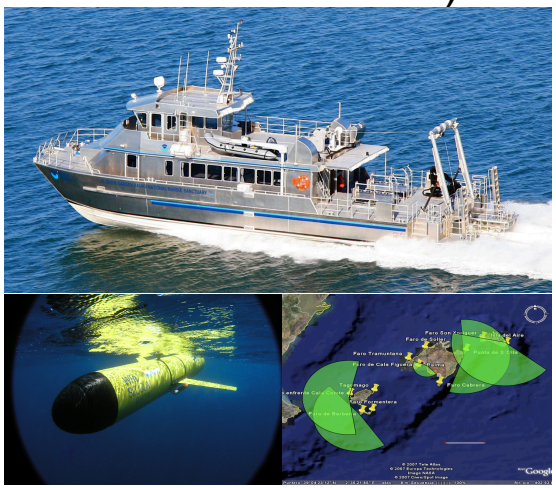
SOCIB Structure



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



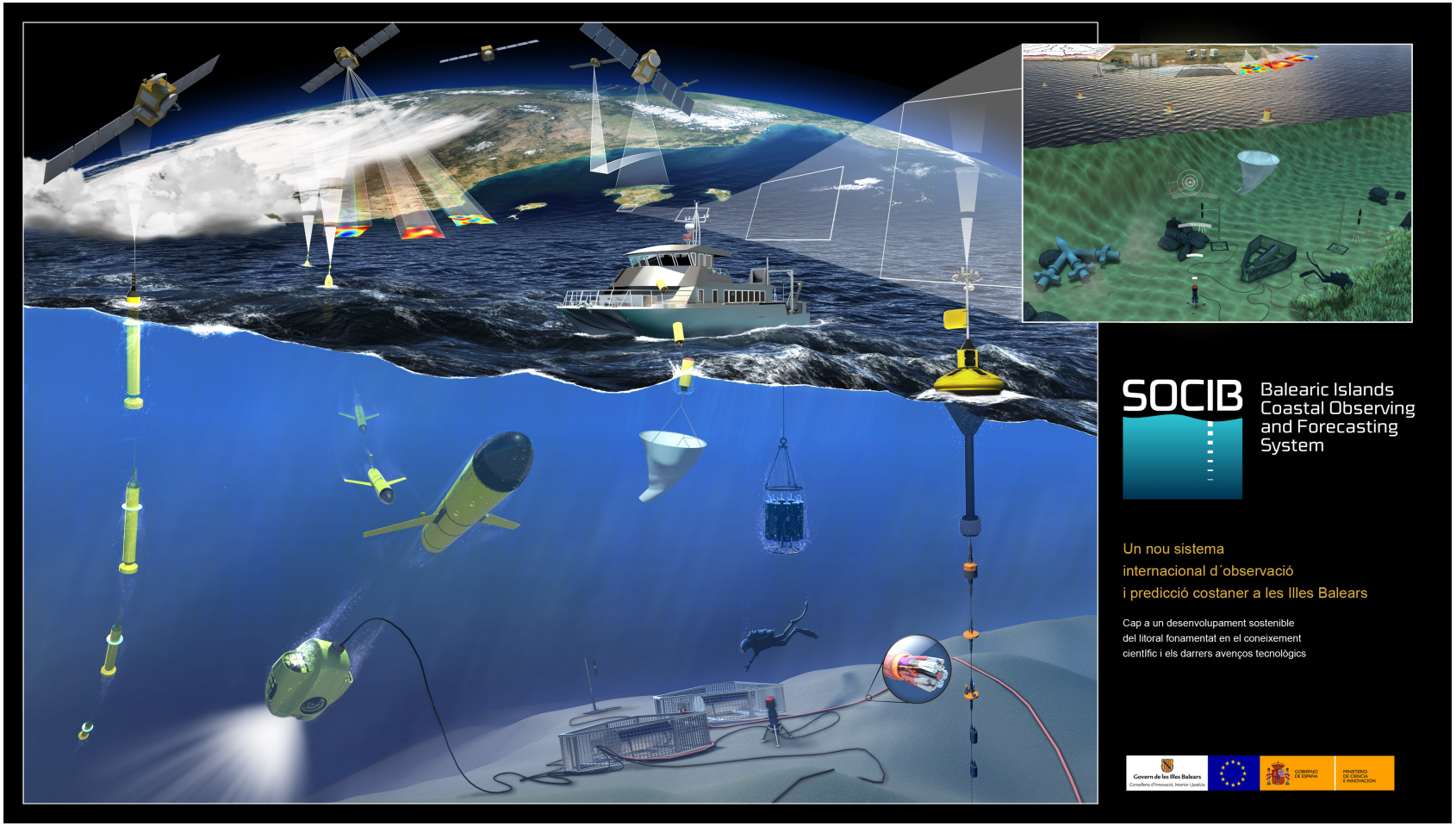
2. Forecasting sub-system

- 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….



SOCIB Facilities and Services – 2011

www.socib.eu

Already from SOCIB and/or in kind from CSIC and IEO and UIB:

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

APPLICATIONS AND STRATEGIC ISSUES SOCIETY DIVISION

- ICZM and Science based sustainable coastal and ocean management

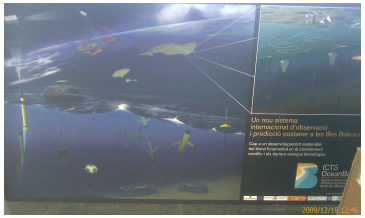
ENGINEERING AND TECHNOLOGY DEVELOPMENT DIVISION

- New technologies

SERVICES

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

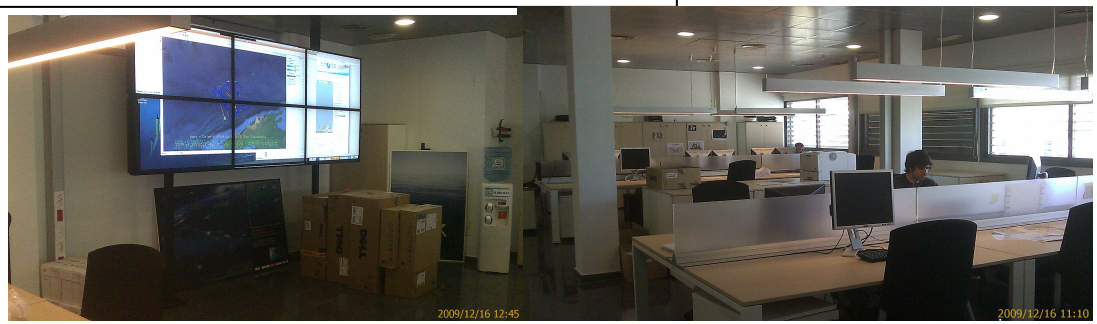
IMPLEMENTATION PLAN; approved July 2010



- Proven capability
- Pilot projects
- Non sustained

Bluefin Tuna target project

Parc Bit – office – August 2009



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC Universitat de les Illes Balears

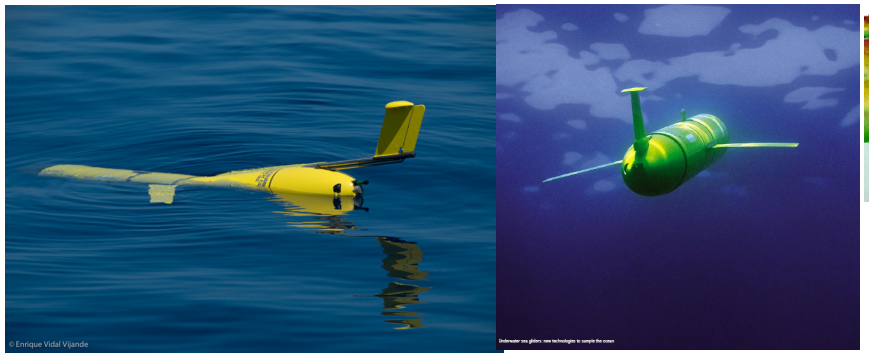
Govern de les Illes Balears

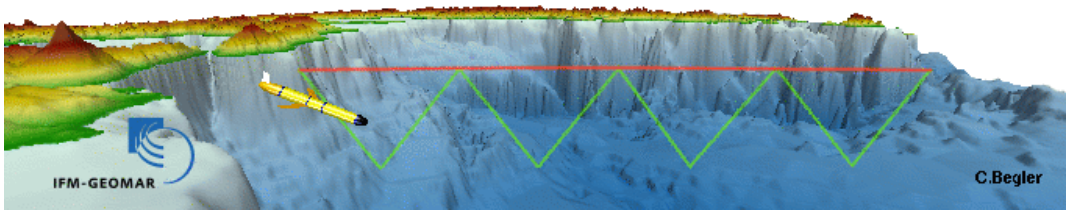
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

Glider Facility Activities

Glider data

- Variables: P, T, S
- Vertical extension: 10-180 m
- Horizontal resolution: 1km





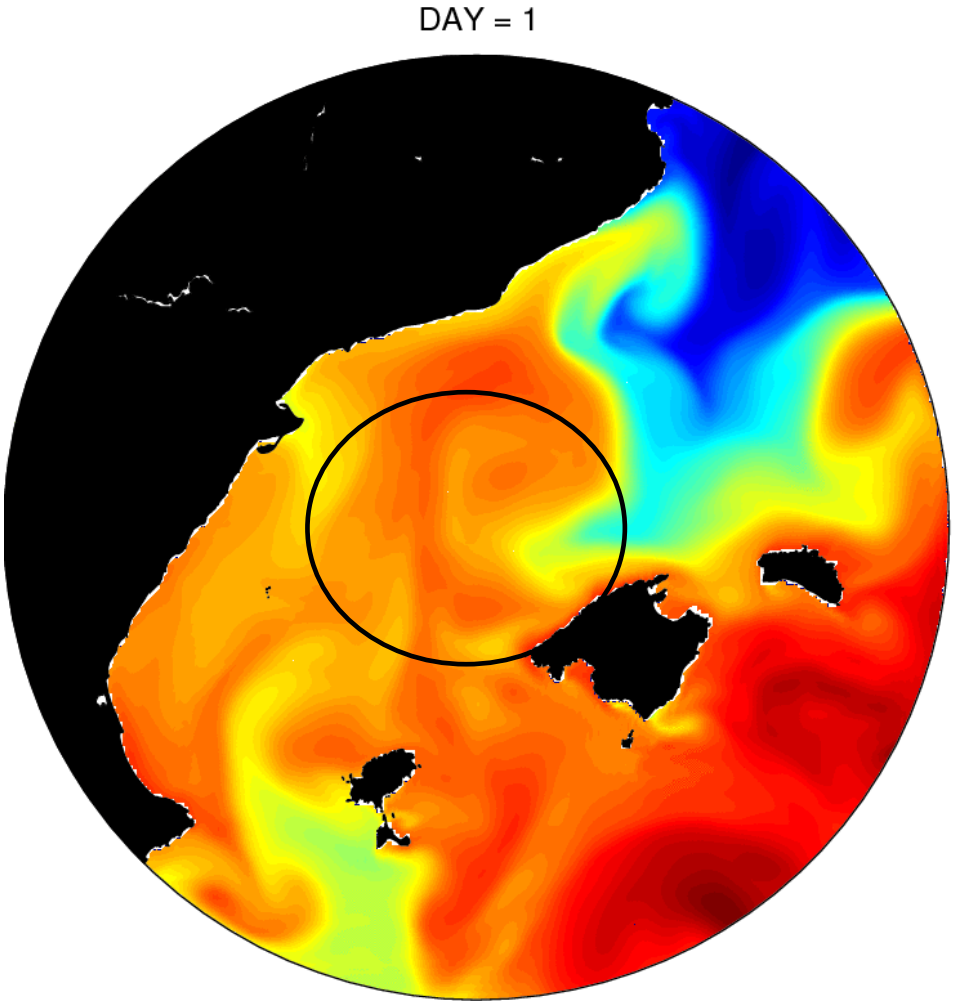
Envisat data

- Along track SLA (AVISO/CLS) + MDT (Rio et al.)
- Delayed time product
- Mediterranean product
- Horizontal resolution: 7 km

Modelling Facility: Science

<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

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

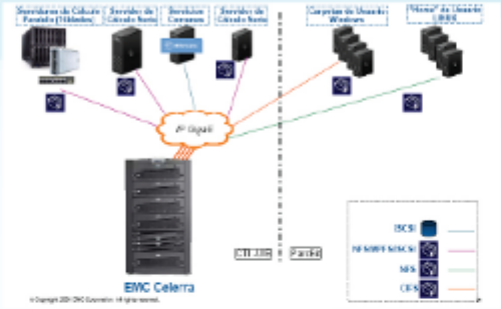
Data Centre. Technologies

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.

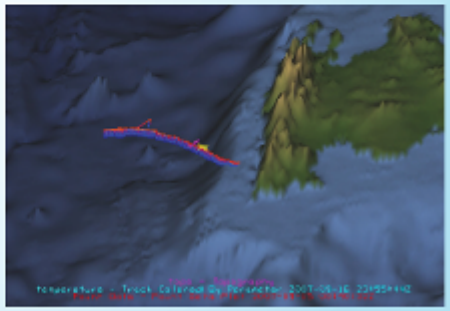
4. Catalog

THREDDS to organize data and Metadata to automatic harvesting.

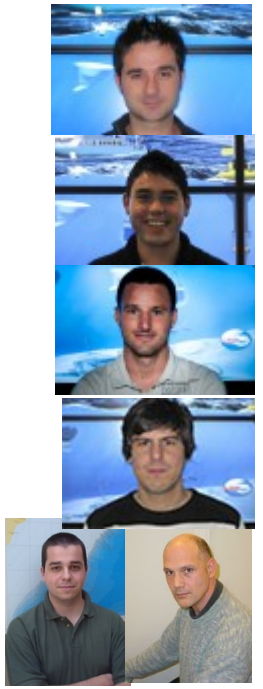
5. Discovery

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.



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

SOCIB Summary

- Consortium: a new way to fund marine research infrastructures, along lines of international initiatives such as OOI, IOOS, IMOS, etc.
- scientific excellence, science, technology and society needs driven.
- Partners and main actors: MICINN-ICTS & Balearic Islands Gov. and later, CSIC, IEO, UIB, etc. IMEDEA, IEO, specific crucial role.
- Initial Proposal: 2006 and formal start: 12/2007, published officially BOE-5 April 2008 (SGPT-MEC)
- Total investment 36 M€ (2008-2021). 14 M€ equipments. 2M€ running costs for 11 years. Equal investments
- is/will be the main facility supporting the R&D activity in Operational oceanography in Balearic Islands.
- Is the first and only existing Large Scale ICTS Facility in the Balearic Islands.
- will be an open access facility for any other R&D institution with similar concepts and focus.
- has management, administration, budget and services autonomy and has own staff.
- Strong and active involvement and partnership with key Science and Technology institutions is a must for success of this initiative.
- Director: Joaquín Tintoré, 12/2008 (Agreement CSIC-SOCIB)
- Still many unknowns, but we are working on them….

OUTLINE

1. **IMEDEA – TMOOS: SCIENCE FOR OPERATIONAL OCEANOGRAPHY**
   - **PRE-OPERATIONAL SCIENCE BASED SYSTEMS (Prestige and Don Pedro Oil Spills)**
   - **ONGOING RESEARCH PROJECTS (MyOcean, TOSCA, etc.)**
2. **SOCIB: THE NEW BALEARIC ISLANDS OBSERVING AND FORECASTING SYSTEM**
3. **IN SITU SOCIB VISIT: OPERATIONAL CAPABILITIES FOR SCIENCE BASED TOOLS FOR DECISION MAKING**

THANK YOU VERY MUCH!

All the IMEDEA and SOCIB team…