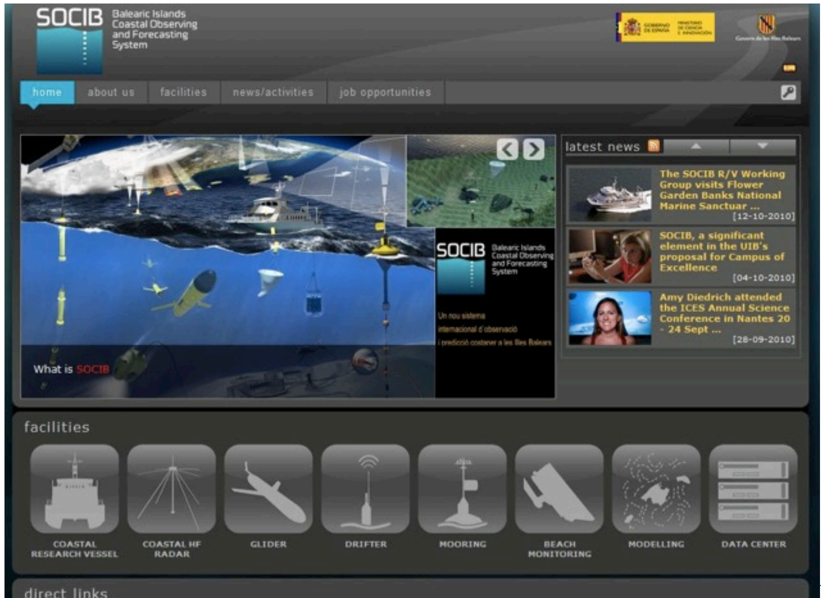
The impact of new multi-platform observing and forecasting systems in science, technology development and response to society needs;

The real challenge for the next decade: "From small to large scales".



Joaquín Tintoré and the SOCIB & IMEDEA (UIB-CSIC)

http://www.socib.es

SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Govern de les Illes Balears

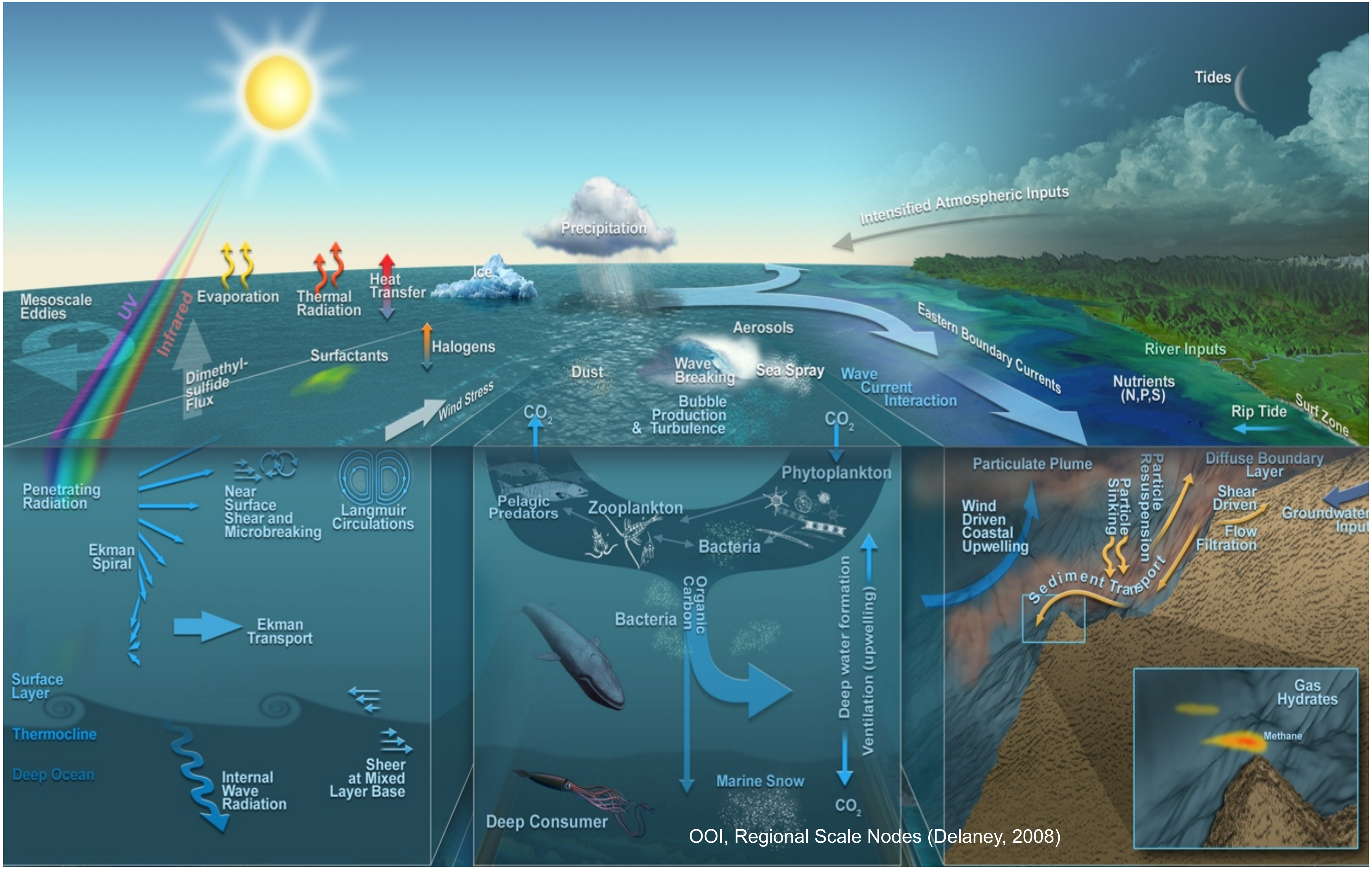
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

SOCIB team

OUTLINE, NARRATIVE; --- "the history to tell"….

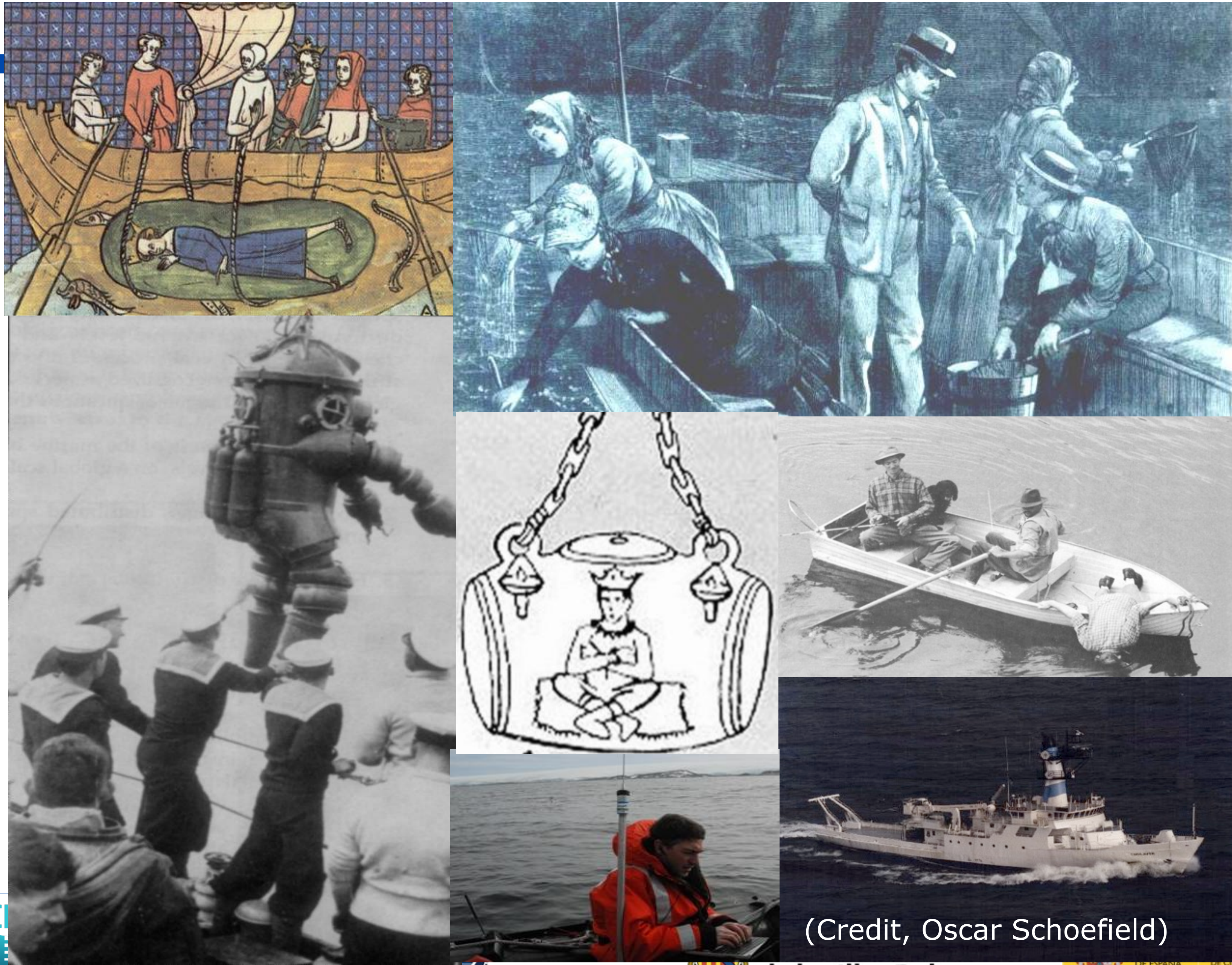
1) **The system & the problem:** we need to characterise ocean state and variability. Ok last decade for the large scale (example the ARGO floats system).
2) **But, now, 2013… new technologies** allow to do this at the really significant scales (for the physics & biogeochemical processes, ecosystem variability), the small scales (meso and submeso), repetitive basis, and in many cases in quasi real time.
3) **How do we do that?:** through multi-platform integrated observing & forecasting systems. Marine Research Infrastructures, Observatories, ….
4) **The SOCIB example in the Mediterranean**; 3 drivers, Science, Technology and Society driven. Mission focus on meso and submesoscale, nearshore-open ocean.
5) **SOCIB, some examples** of science, technology and response to society: It works
6) **Innovation Oceanographic Instrumentation: c**onditions for disruptive innovations
7) **So,...what are the Challenges next decade:** where to concentrate: back to basics… key oceanic scales and monitoring tools: repetitive, sustained, small scales, coastal.
8) **The Key to do this:** concentrate on long term problems, short term successes, work in parallel, big coordinated teams, data availability, integration, so as to respond to 3 drivers…. And communicate, no.. MORE… … involve society since the beginning.

Oceans are complex, central to the Earth system Management is needed. Oversimplification dangerous…



OOI, Regional Scale Nodes (Delaney, 2008)

The oceans are chronically under-sampled



(Credit, Oscar Schoefield)

de les Illes Balears

Technology development and innovations are needed for sound knowledge based ICOM management…

Rationale:

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

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

Needs:

Improvements in tools capabilities

Increase understanding

Major practical benefits

Why is it important? : we need synoptic coverage to really characterise Ocean State and Variability…

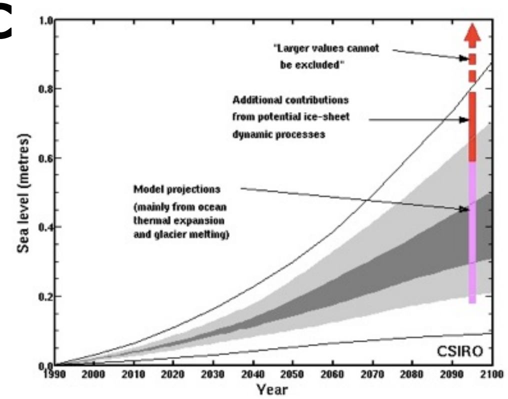
"Every time a new instrument has arrived,
new key findings"…

Examples of innovations:

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

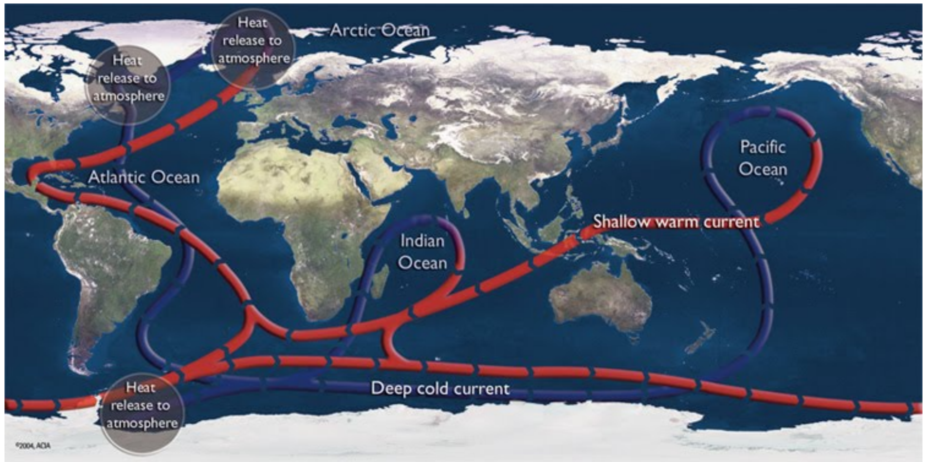
Scientific challenges: key hot topics, long term monitoring

IPCC



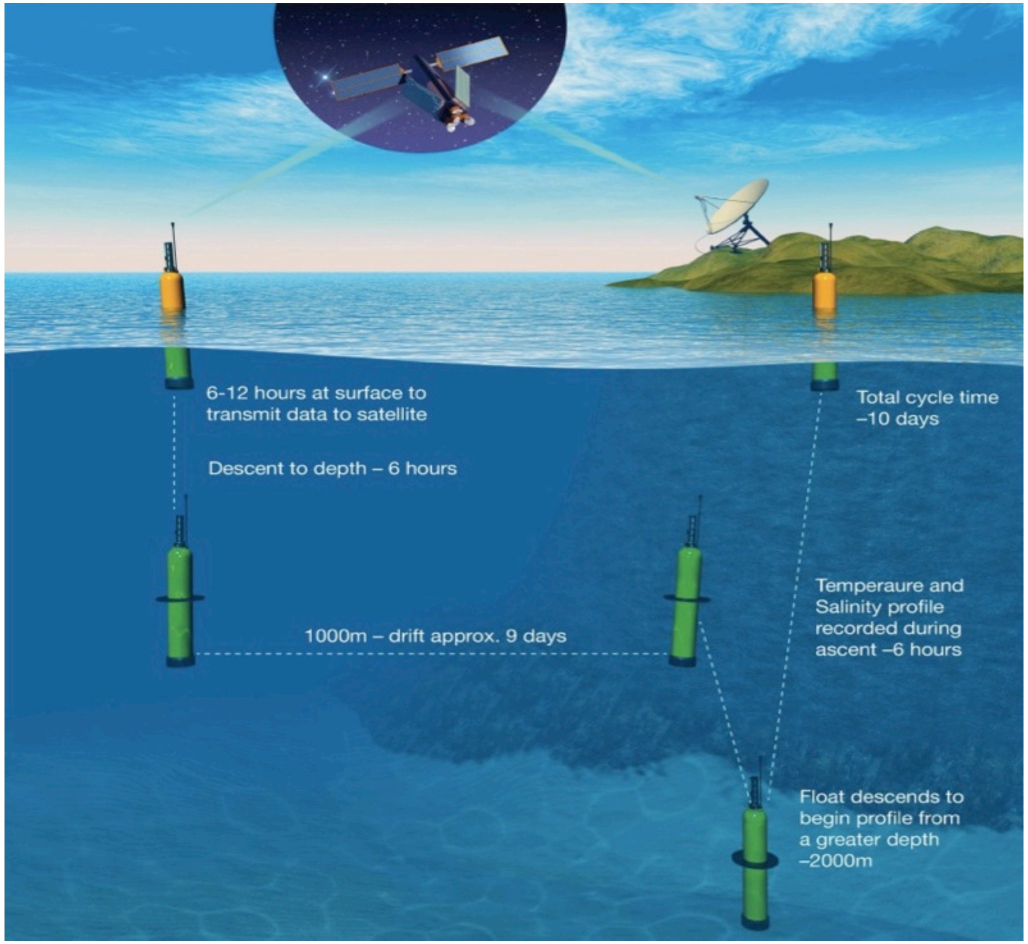
<u>Climate change in *Europe:* </u>*Increased risk of inland flash floods; more frequent coastal flooding and increased erosion from storms and sea level rise; glacial retreat in mountainous areas; reduced snow cover and winter tourism; extensive species losses; reductions of crop productivity in southern Europe*

HOT TOPICS: *Eastern and Western boundary Currents,*
Straits exchanges, Coastal ocean variability, Shelf/slope exchanges,
Meso and submesoscale eddies, mean flow – eddies interactions,
fronts, upper ocean exchanges
extreme events, ecosystem response,
…

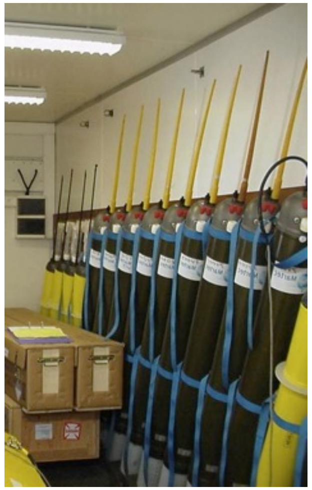


→ New sensors gaps and needs:….In situ temperature and salinity profiles
Measures of PCO2 (physical and biological pumps)

The successful Argo programme: Large Scale Ocean monitoring

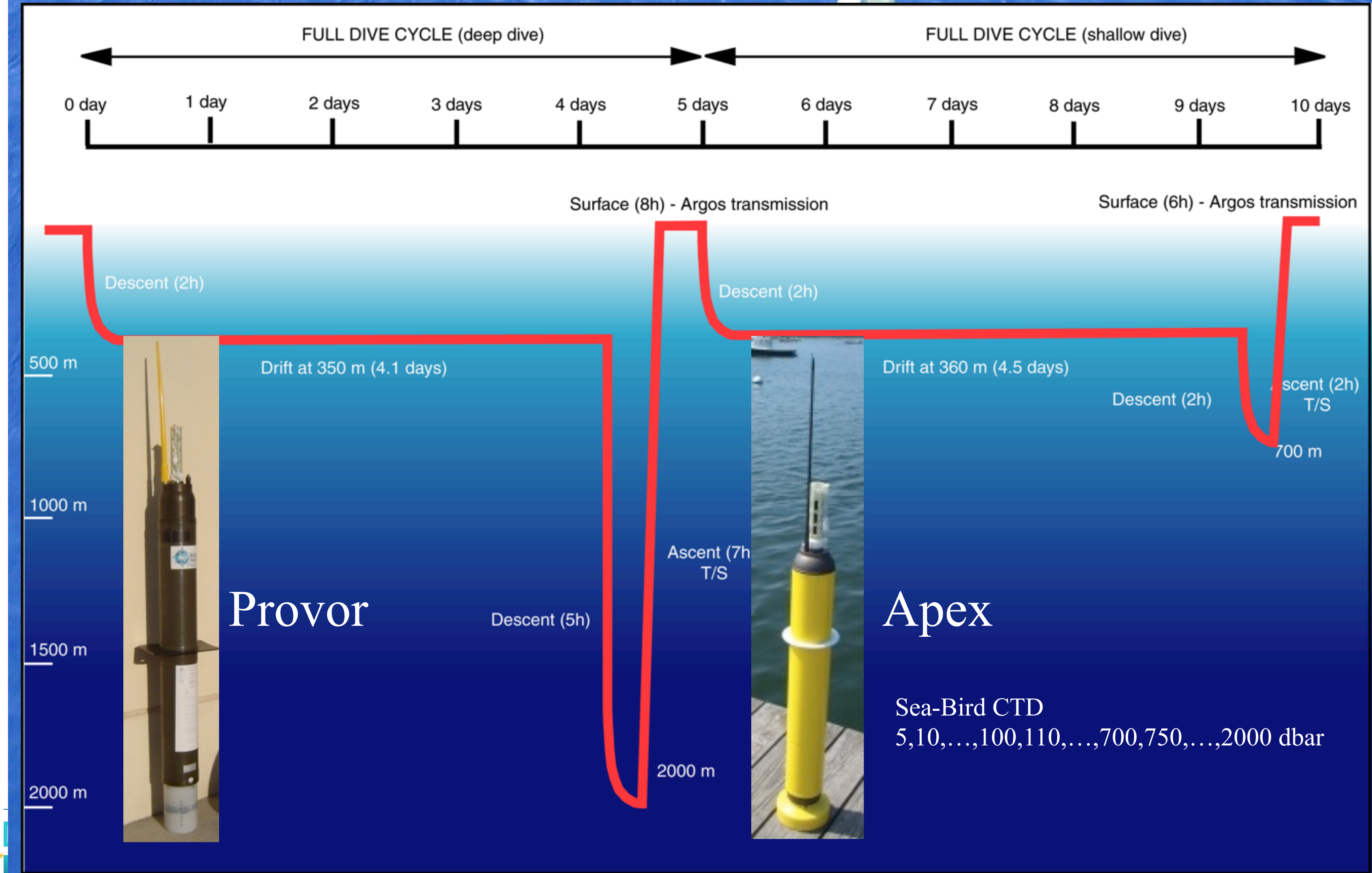


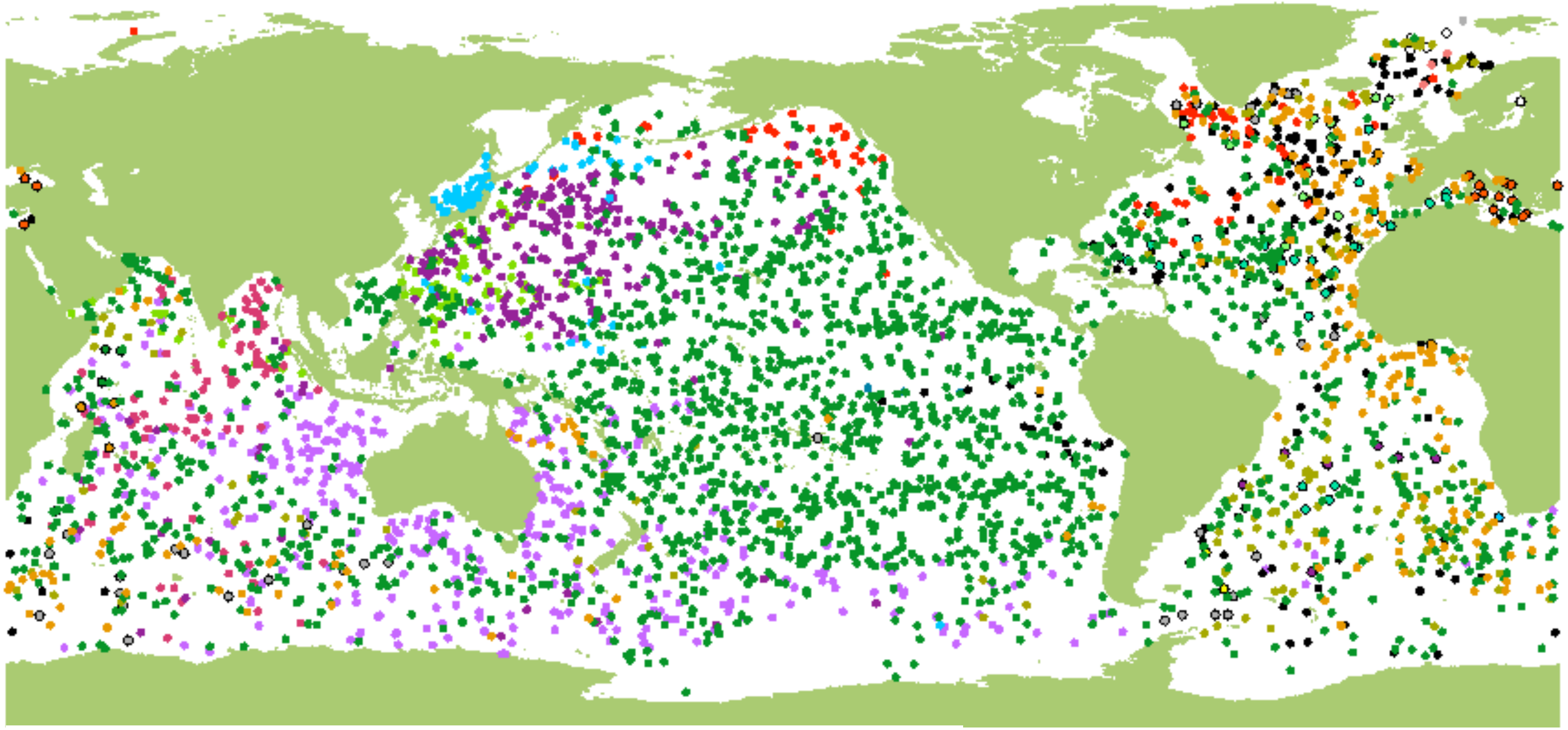
Schematic diagram of a single Argo float cycle



http://www.argo.ucsd.edu/

MEDARGO Sampling cycle characteristics





Location of 3623 active Argo floats in February 2012, color –coded by nation. Source: Argo Information Centre

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

Our Goal: … To characterize ocean state, variability & ecosystem response

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

- Walter Munk-2001- “The last century of oceanography is marked by the degree of under-sampling”,
- Carl Wunsh 2010: “We need data, … models are becoming untestable”
- An Example: AMOC, Atlantic Ocean Meridional Circulation seasonal biases, …

Scientists have to recognize ….

- GAPS & NEEDS in knowledge
- GAPS & NEEDS in technologies, new sensors (Ph, etc.)
- GAPS & NEEDS in responding to society needs (MSFD,WFD…)

- GAPS & NEEDS in data and procedures such as in some cases data availability, sharing, joint work, optimization of resources, etc.

- GAPS in science-society / society-science; … we are part of society, managing and understanding the oceans is a global enterprise: we need more than just coordination > Partnership

And … we need to work in order to fill the “**Science-Policy Gap**”

1 NOVEMBER 2010 KANZOW

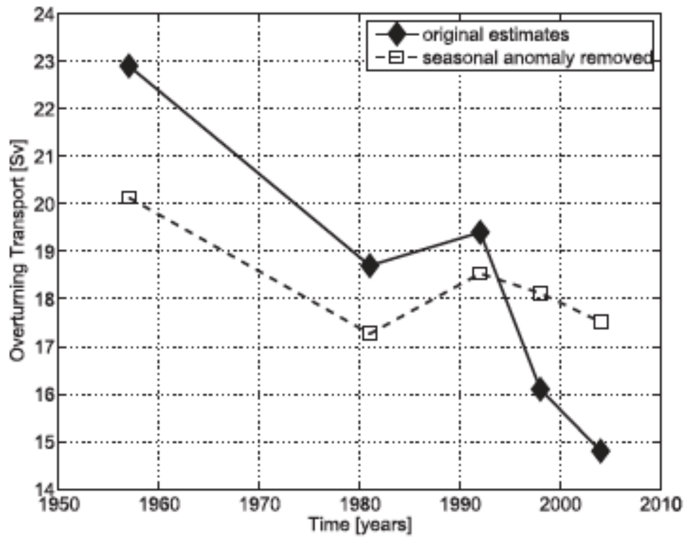


FIG. 16. The Ψ^{MAX} inferred from five hydrographic snapshot estimates between 1957 and 2004 (solid diamonds), as reproduced from Bryden et al. (2005b). The hydrography cruises were carried out in different seasons, namely, in October 1957, August–September 1982, July–August 1991, February 1998, and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

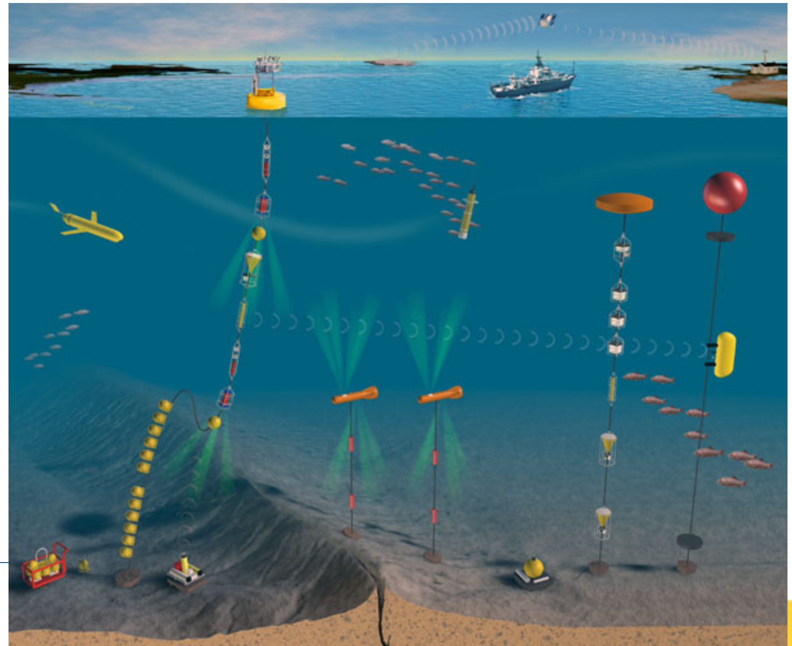
New Ocean Observatories can help to fill theses gaps; importance of their critical mass to address multiple goals.

Paradigm Shift (1) 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)

and Forecasting
System
CSIC
de les Illes Balears
DE ESPAÑA
DE CIENCIA
E INNOVACIÓN

Paradigm Shift (2) in Data Availability

From: Data only available 12-24 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…

A 2020 Vision for Ocean Science

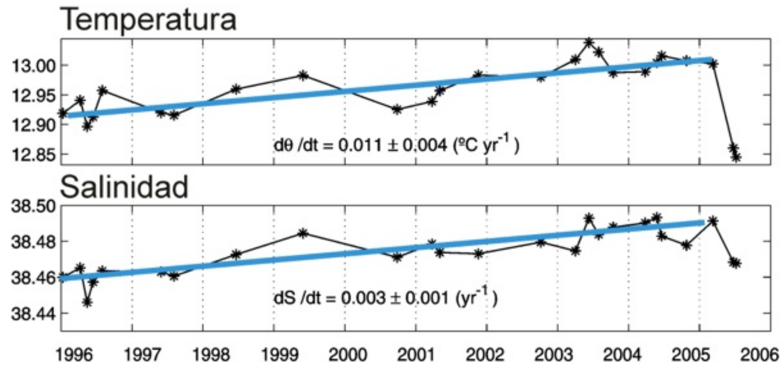
JOHN R. DELANEY
University of Washington
ROGER S. BARGA
Microsoft Research

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

Motivation:

- Mediterranean unique ecosystems, ecosystem services, fluxes, regional and global impacts, changes, etc
- Causes and consequences still unknown in many cases….
- Conflicts of use in the marine and coastal zone

Changes in world's oceans and in the Mediterranean…



López-Jurado, J.-L. et al. (2005), *Geophys. Res. Lett.*,

Detecting Changes Imply monitoring.

Need of reliable baseline data

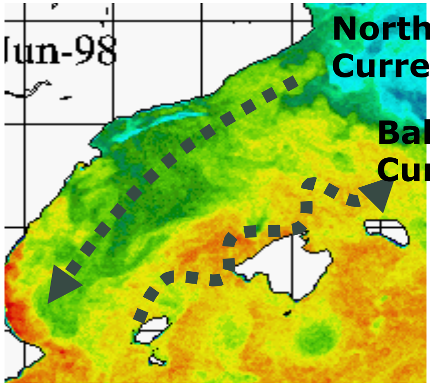
Key questions: example; How the interactions between the physical, biogeochemical and ecological variability in the Mediterranean can be best described and how it will evolve in the future.

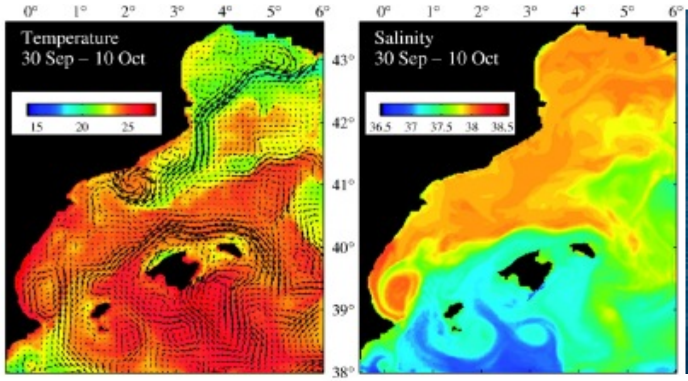
Careful monitoring is needed with traditional and with new infrastructures, new tools, new technologies...

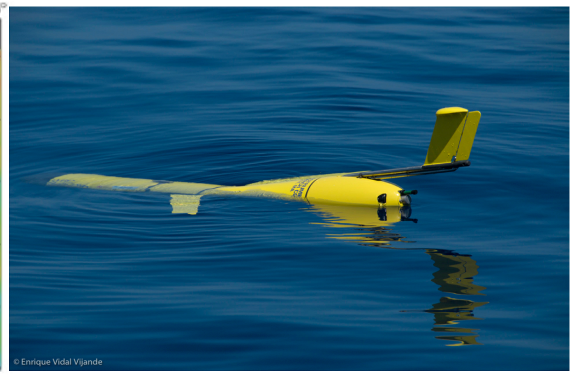
Why SOCIB, why Coastal Ocean Observatories, and **why now?**

New monitoring technologies are being progressively available for coastal ocean 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, <u>used together</u>, are delivering new insight into coastal ocean variability, which in turn will trigger new theoretical developments, increasing our understanding 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?**

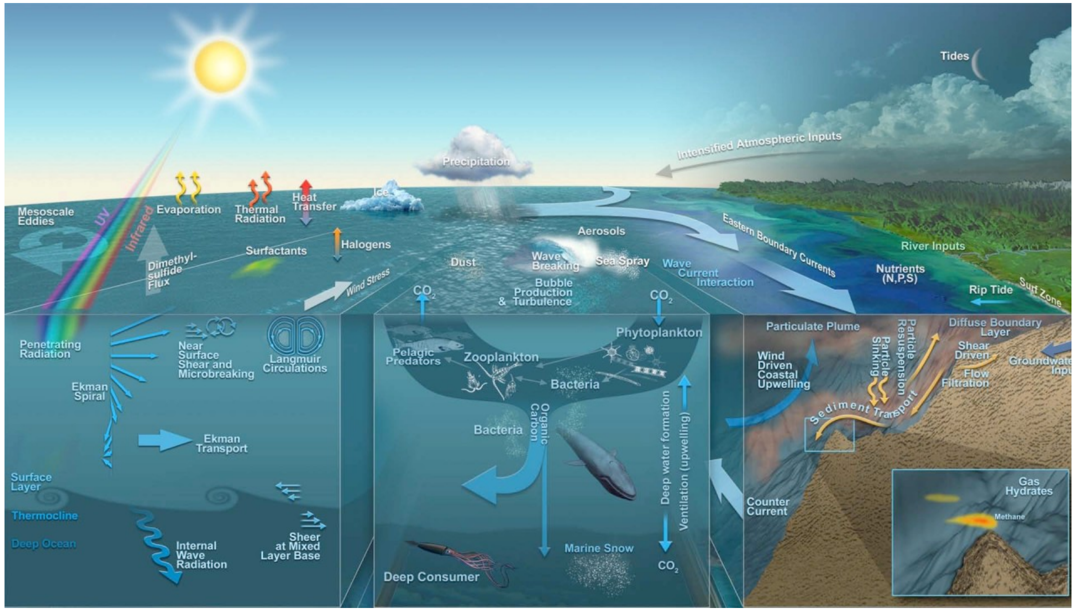
A New Approach to Marine and Coastal Research

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

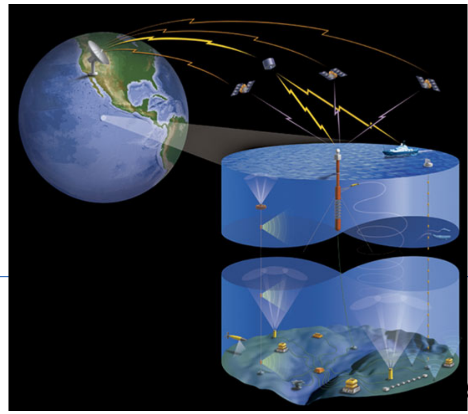
A quantitative major jump, in scientific knowledge and technology development

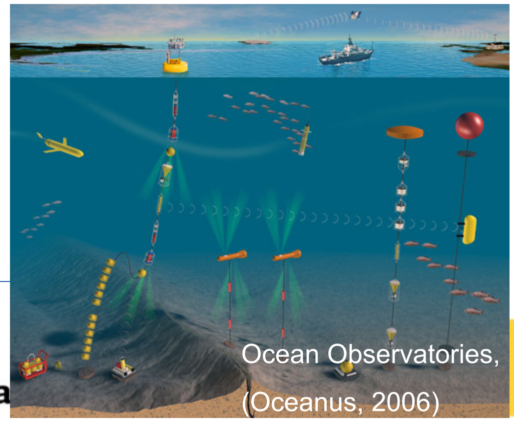
The development of a new form of Integrated Coastal Zone Management, based on recent scientific and technological achievements,

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)



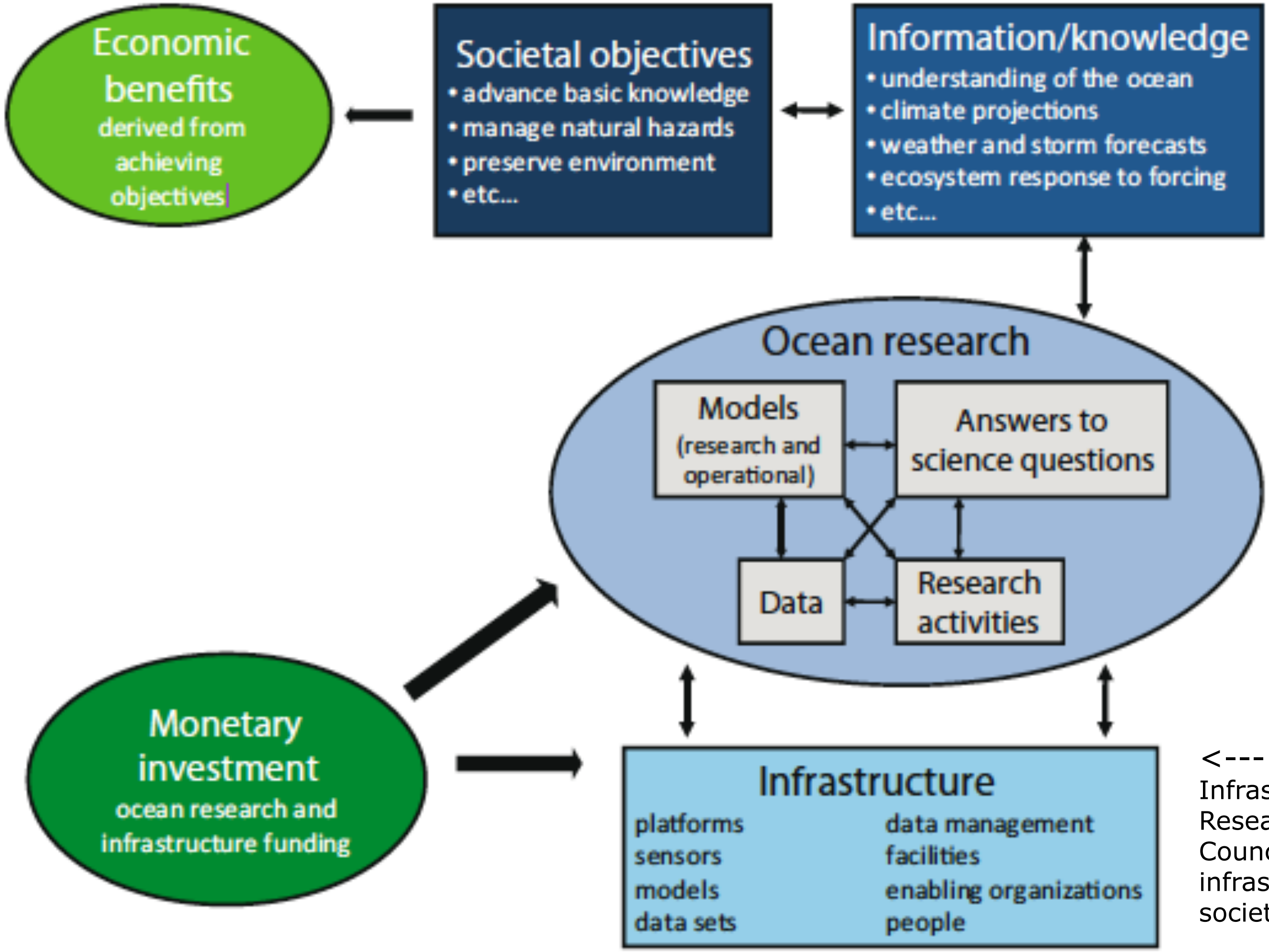


Ocean Observatories, (Oceanus, 2006)

SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

SOCIB and Marine Research Infrastructures

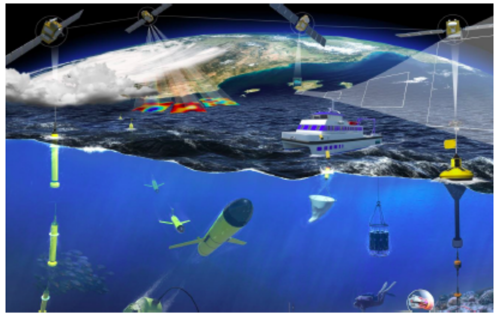


EUROPEAN COMMISSION

Towards European Integrated Ocean Observation

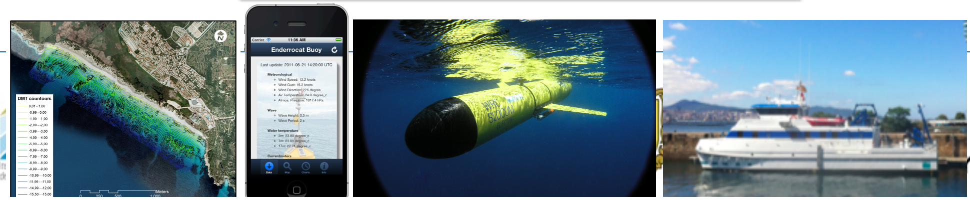
Expert Group on
Marine Research Infrastructures
Final Report

January 2013



Directorate-General for Research and Innovation
EU Marine and Maritime Research Strategy
EN

<--- (Committee on an Ocean Infrastructure: Strategy for U.S. Ocean Research in 2030; National Research Council; 2011: Critical infrastructure for ocean research and societal needs in 2030).



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)

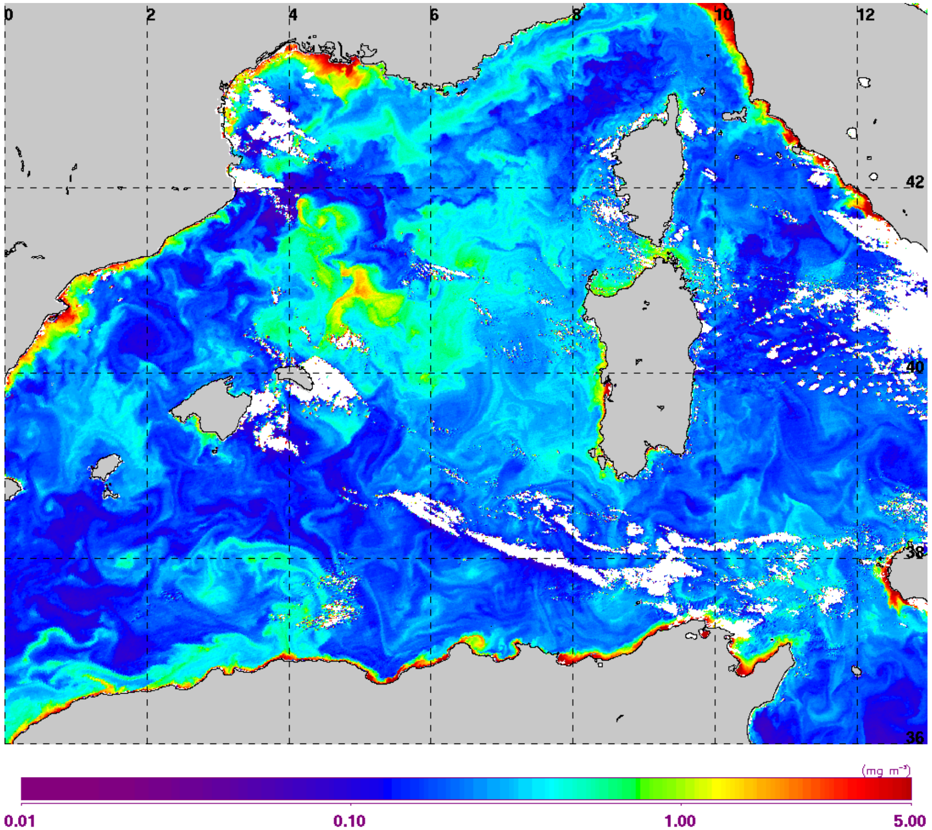
Scientific motivation

From Large Scale Picture --→

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

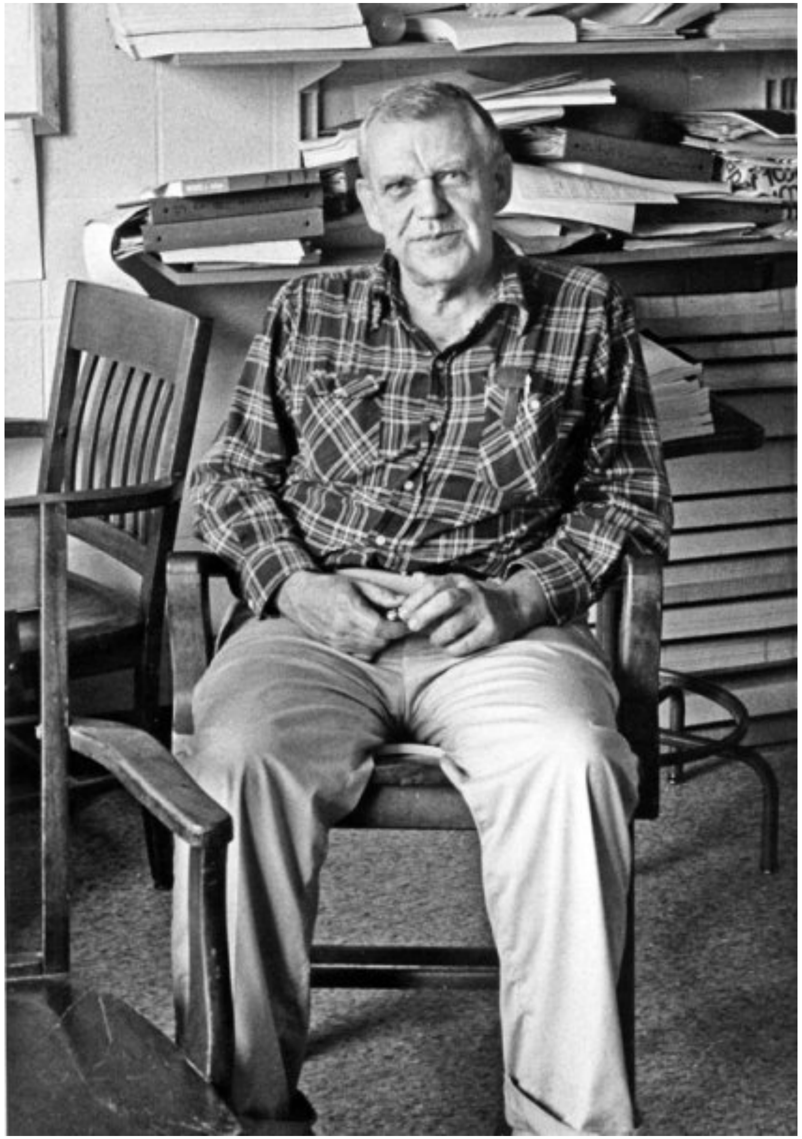
Vertical motion associated with mesoscale features plays a major role in the exchanges of properties between the surface and the ocean interior (Klein-Lapeyre 2008).

Mesoscale and Submesoscale impacts on physical variability and ecosystem variability.



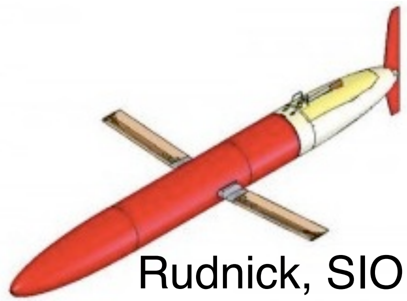
SeaWiFS chlorophyll image. Unites are mg m^{-3} . Mesoscale dynamics modulates biological responses.

Wisdom



"The chief source of ideas in oceanography comes, I think, from new observations."

Henry Stommel



Rudnick, SIO

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

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

Coastal Ocean Observ. 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.

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.

What is SOCIB?

SOCIB is an 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.

The SOCIB approach to sustained ocean observation…

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

→ RESPONDING TO 3 KEY DRIVERS

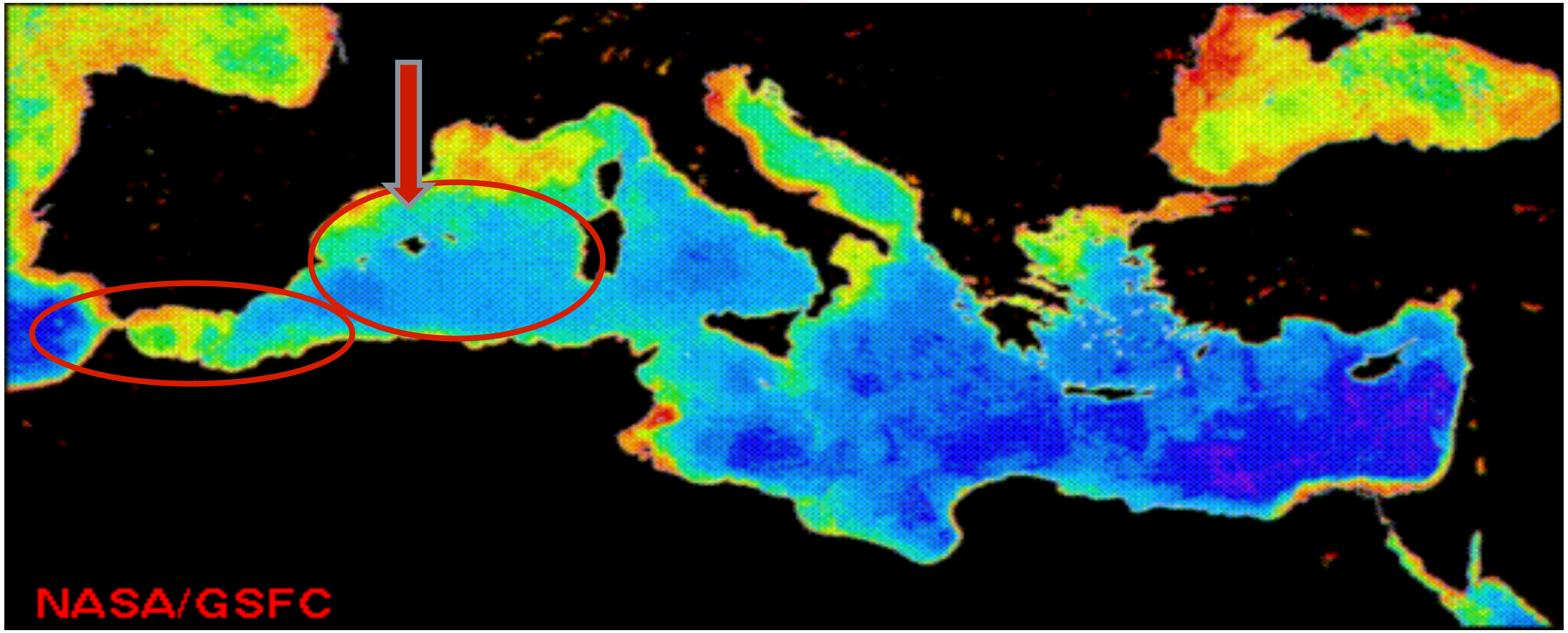
- Science Priorities
- Strategic Society Needs
- Technology Developments

→ BALEARIC ISLANDS, EXTENDING FROM THE NEARSHORE TO OPEN OCEAN

SOCIB activities

will be mostly (but not only) centred in the western Mediterranean, with focus in the Balearic Islands and adjacent sub-basins (specifically Algerian and Alborán/Gibraltar) and …

covering from the **nearshore** to the **open ocean**.



Why in the Mediterranean?

SOCIB will therefore take profit of:

- Strategic position of the Balearic Islands at the Atlantic/ Mediterranean Transition Area, one of the ‘**hot spots**’ in world’s oceans research and biodiversity

- Nature of this semi-enclosed sea, an ideal reduced scale ocean laboratory, where key ocean processes (**thermohaline circulation**, **deep convection**, shelf/slope exchanges, **mesoscale and submesoscale** dynamics, coastal interactions, etc.) can be studied at smaller scales than in other oceanic regions (Internal Rossby Radius of order 10 km).

Physical mechanisms are thus better monitored and understood in this ‘ocean basin’, contributing to the advancement of knowledge of physical interactions and biogeochemical coupling at nearshore, local, sub-basin and global scales.

<u>**Regional monitoring**</u>: word of caution... with extrapolations to global scale ... **“Real-time’ detection of secular changes in the oceanic overturning circulation by regional measurements is probably a mirage” (Wunsh,** Nature geoscience, 2008)

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

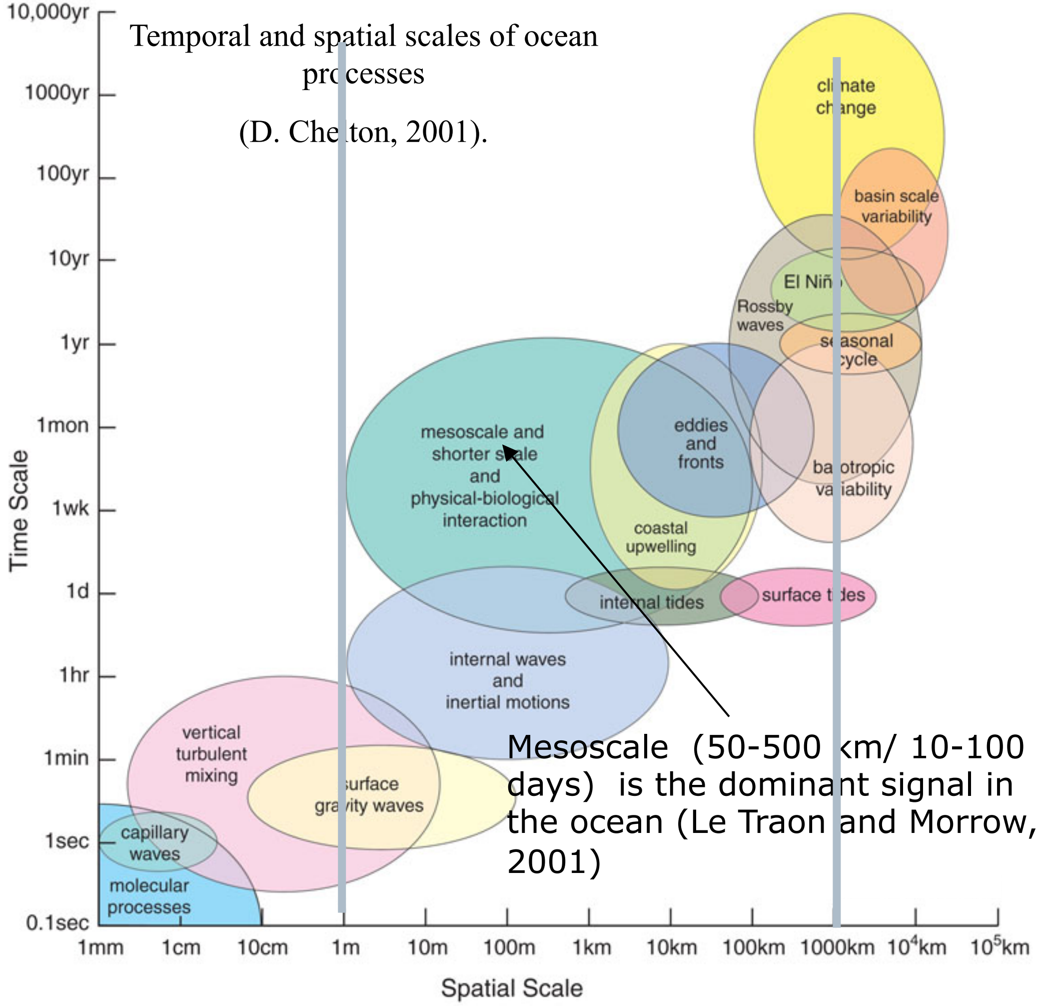
Theory and observations have shown that there is a maximum energy at the mesoscale (include fronts and eddies ~10-100km),

<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)

Temporal and spatial scales of ocean processes

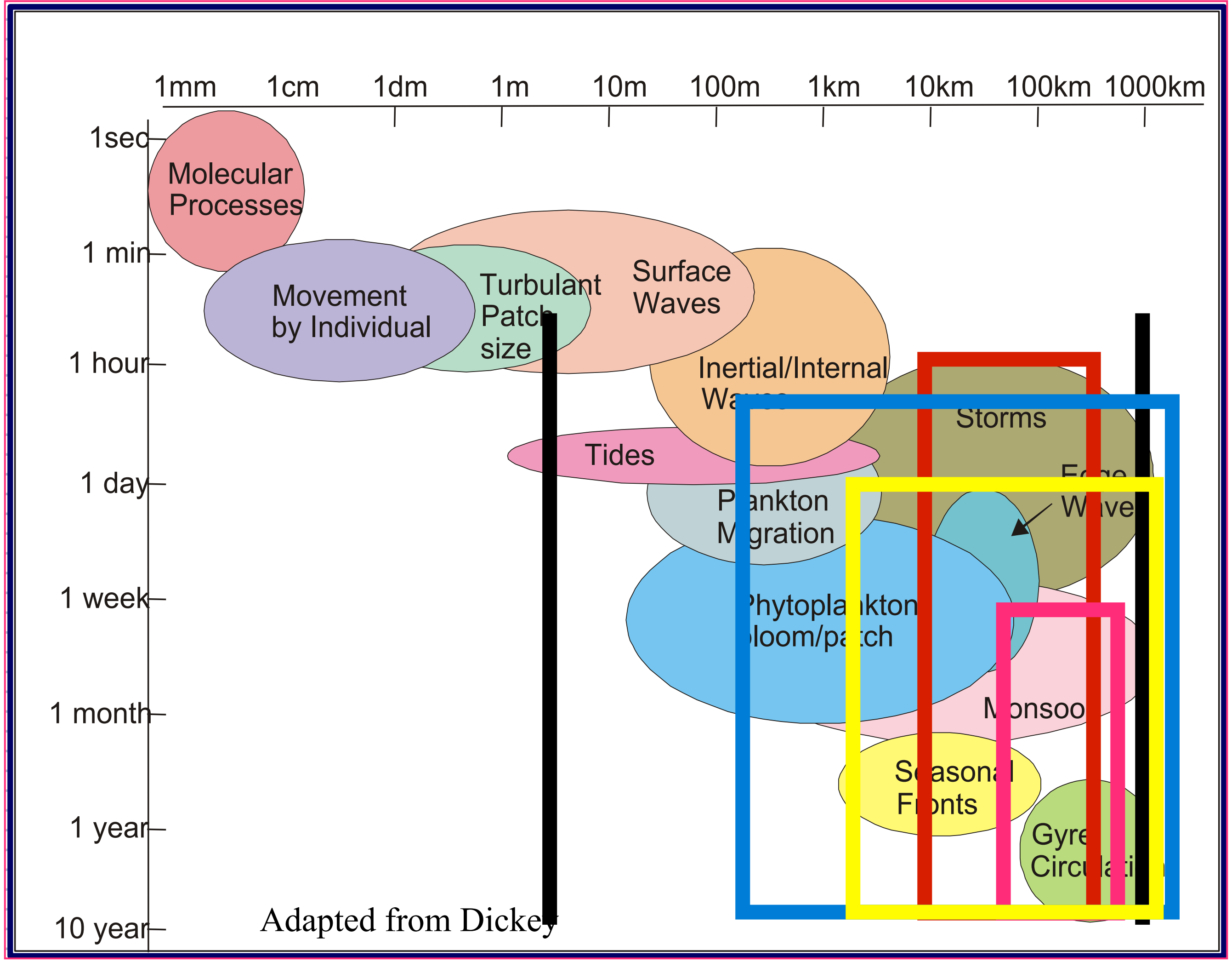
(D. Chelton, 2001).



Mesoscale (50-500 km/ 10-100 days) is the dominant signal in the ocean (Le Traon and Morrow, 2001)

SOCIB scales

SOCIB scales and monitoring tools



Gliders

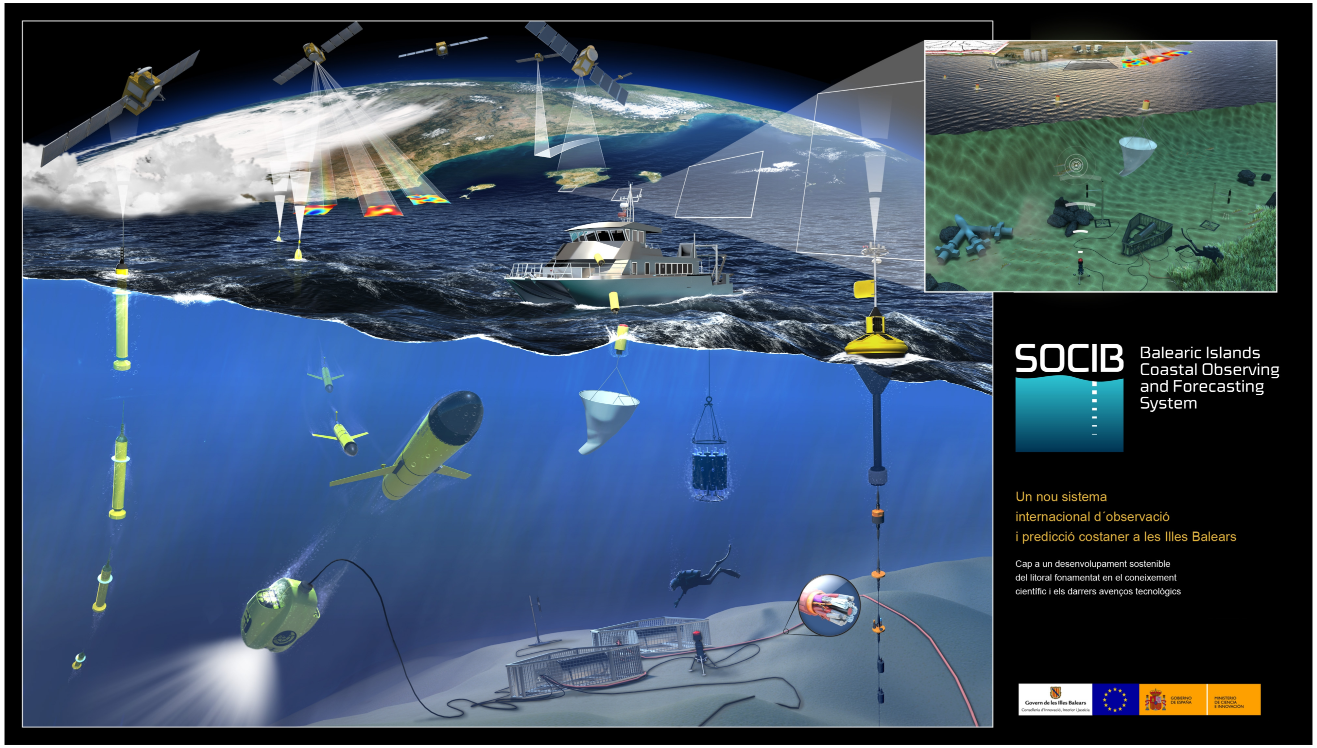
Fixed Platforms

HF radar

24 m R/V Catamaran

Satellite

SOCIB: the view….



PAPER

SOCIB: The Balearic Islands Coastal Ocean Observing and Forecasting System Responding to Science, Technology and Society Needs

AUTHORS

Joaquín Tintoré
SOCIB, Balearic Islands Coastal Observing and Forecasting System, Palma de Mallorca, Spain and IMEDEA (CSIC-UIB), Mediterranean Institute for Advanced Studies, Esporles, Spain

Guillermo Vizoso
Benjamín Casas

Aránzazu Lana
Evan Mason
Romain Escudier
Daniel Conti
Juan Manuel Sayol
Bàrbara Barceló
IMEDEA (CSIC-UIB)

Francisco Alemany
Patricia Reglero

Marine Technology Society Journal

January/February 2013 Volume 47 Number 1

SOCIB Balearic Islands Coastal Observing and Forecasting System

les Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

The real challenge 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/monthly/seasonal and inter-annual variability and by this
- Establish the decadal climate 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

Institut Mediterrani d'Estudis Avançats

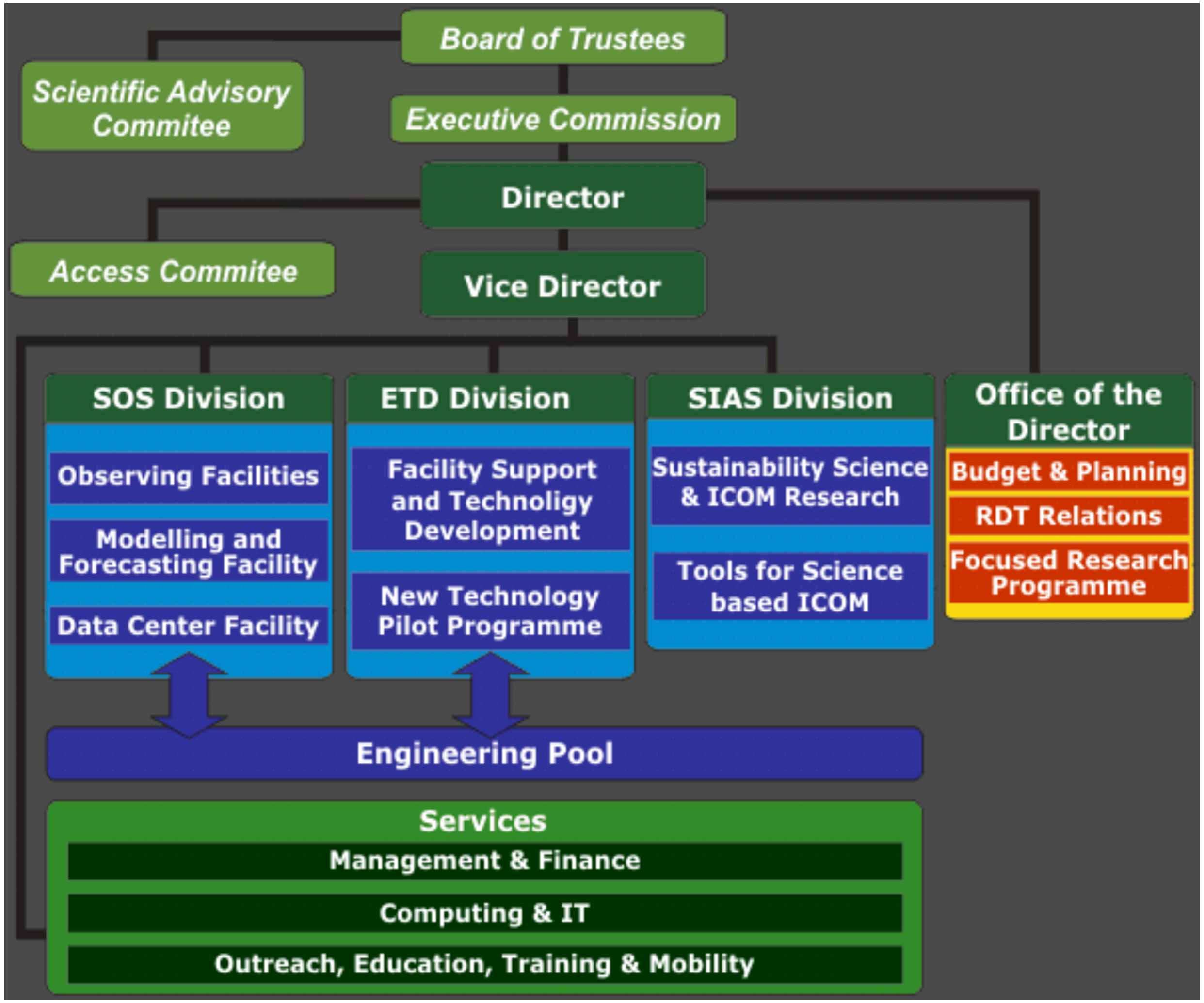
Universitat de les Illes Balears

Govern de les Illes Balears

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

SOCIB particularities: structure

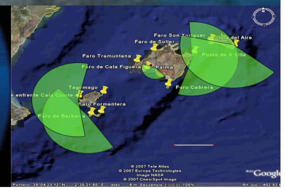


SOCIB: Systems Operations and Support Division

1. Observational Facilities (major elements)

- New Coastal Research Vessel (24 m LOA – 1.200 km coastline in the Islands)
- HR Radar
- Gliders
- Coastal stations and Satellite products
- Lagrangian Platforms
- Nearshore Beach monitoring



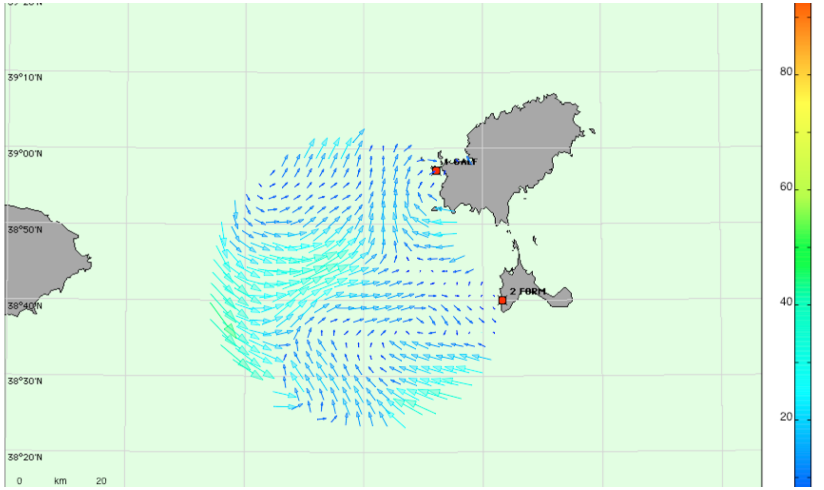
2. Forecasting sub-system

- Ocean currents (ROMS) and waves (SWAN) at different spatial scales, forced by Atmospheric model (WRF)
- Meteo-tsunamis pre-operational system

3. Data Centre

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

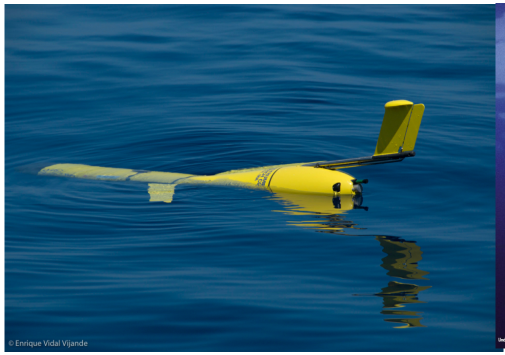
SOCIB new 2012 facilities

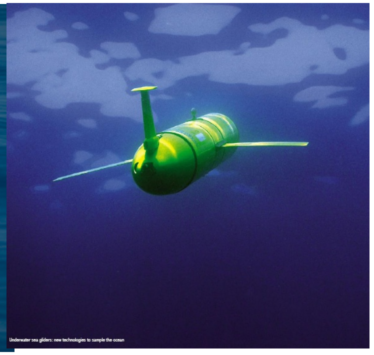


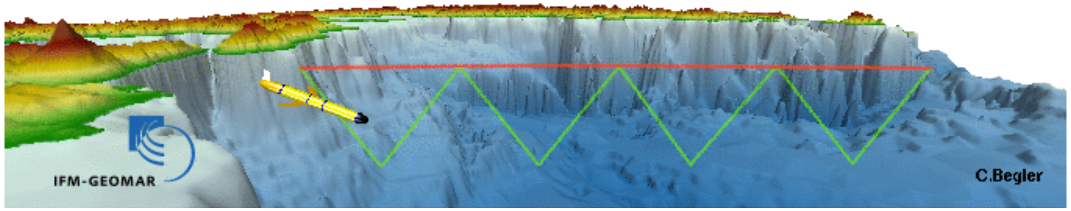
Glider Facility Activities

Glider data

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







Satellite data

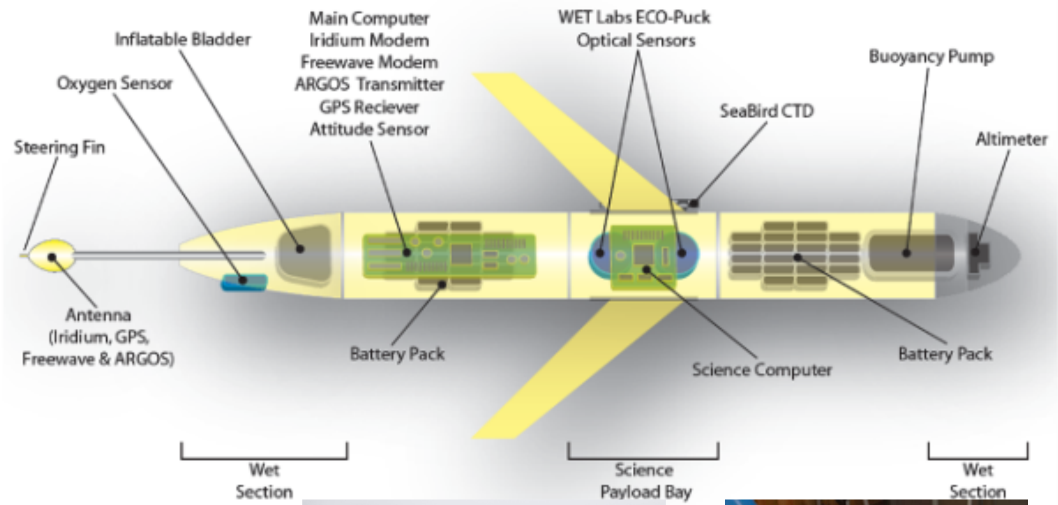
- Along track SLA (AVISO/CLS) + MDT (Rio et al.)
- Delayed time product
- Mediterranean product
-Horizontal resolution: 7 km

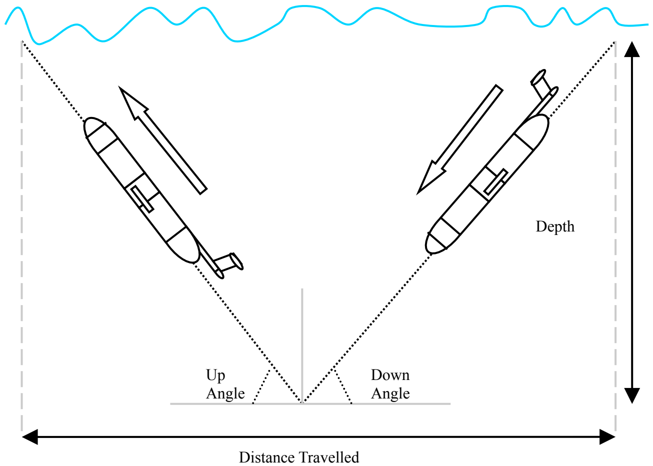
GLIDERS

- Started in 2005 at IMEDEA
- From 2011-Now at SOCIB Working Operationally

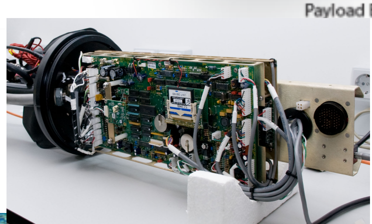
Glide

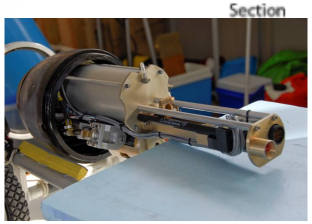
SLCOCUM GLIDERS

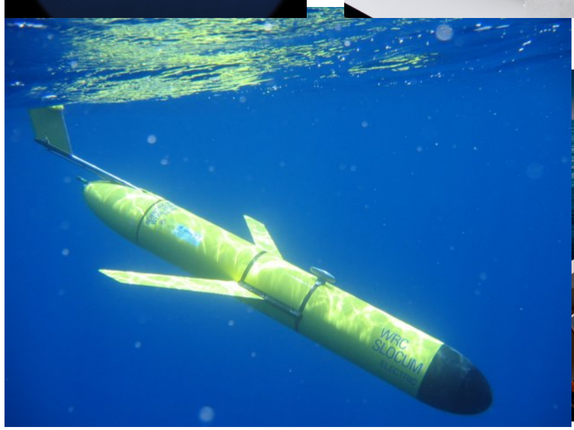




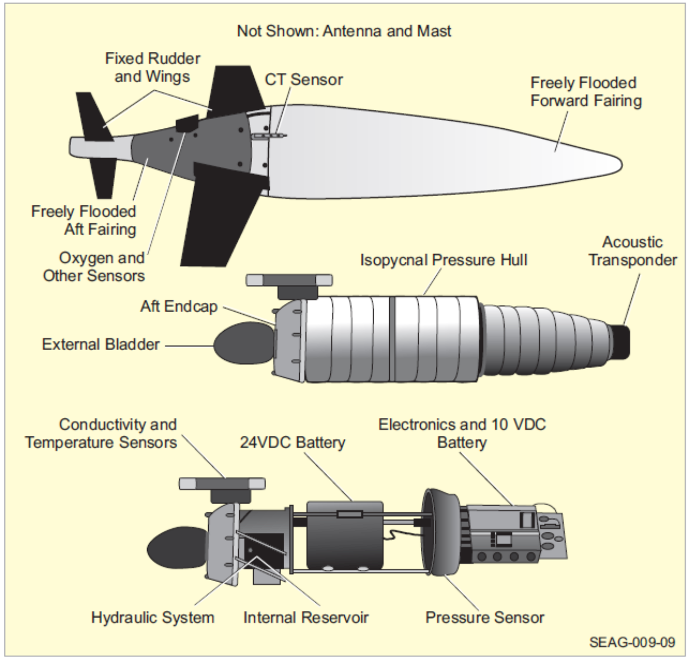
Weight in air:	52 Kg
Weight in water:	Neutrally buoyant
Hull Diameter:	21.3 cm / 8 3/8 Inch
Width including Wings	100.3 cm / 39 1/2 Inch
Vehicle Length:	1.5 meters
Depth Range:	4 - 1000 meters (Deep) / 4 – 200 meters (Coastal)
Speed, projected:	0.4 m/sec horizontal
Energy:	Alkaline Batteries
Endurance:	Dependent on measurement and communication, type. 30 days
Range:	1500 km
Navigation:	GPS, and internal dead reckoning, altimeter
Sensor Package:	Conductivity, Temperature, Depth, Fluorescence, turbidity and oxygen
Communications:	RF modem, Iridium satellite, ARGOS, Tele-sonar modem

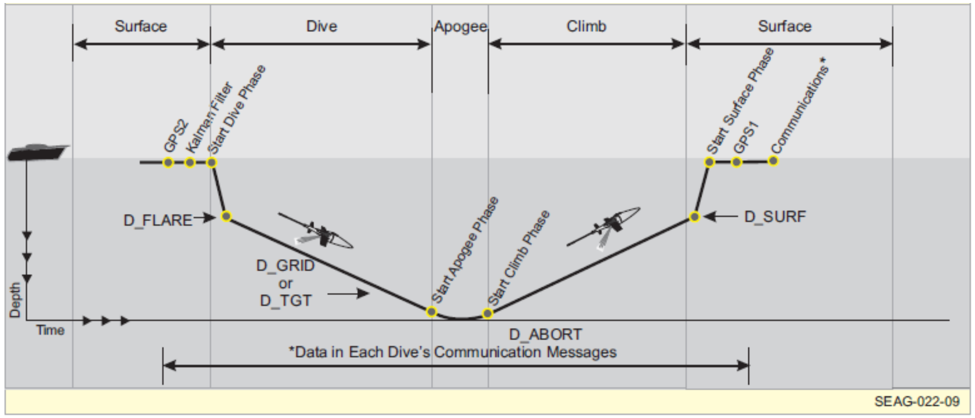


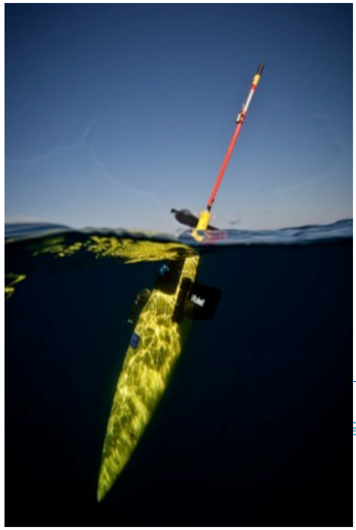




SEAGLIDERS







Weight in air: 52 Kg
Weight in water: Neutrally buoyant
Hull Diameter: max 30 cm
Hull material: Aluminium
Width including Wings 100 cm
Vehicle Length: 1.8 meters
Depth Range: 0 - 1000 meters
Speed, projected: 0.25 m/sec horizontal
Energy: Lithium Sulfuryl Chloride
primary batteries, 17 MJ.
Endurance: Dependent on navigation and sampling.

Typically 4 months.
Range: 3000 km
Navigation: GPS, internal dead reckoning, altimeter
Sensor Package: Conductivity, Temperature,
Depth, Clorophyll, CDOM, backscatter 650nm and

oxygen
Communications: Iridium satellite, ARGOS, Serial cable, Pinger for
recovery

New labs and facilities

Since 2011:

New glider laboratories

Glider test 1000 m pressure chamber

General specifications:

Manufacturer:
- KW Designed Solutions (UK)

Main Parts
- Pressure Chamber
- High Pressure Hand Pump (with 150mm analog gauge)
- Support Frame
- Purge Line Connection

Directive Compliance
- European Pressure Equipment Directive (PED) 97/23/EC
- European Machinery Directive (EMD) 2006/42/EC

Media
- All fluids but those Explosive, Flammable, Toxic and Oxidising

Operation Mode:
- Manual only

Technical specifications:

Materials
- Carbon Steel variety (European EN 10204:3.1b certified)
- Standard Rubber shore 70 (O-ring)

Working Pressure:
- 100 bar (1,450 psi)

Volume:
- 250 Liters (66 Gallons)

Dimensions
- 750x2460 mm (external)
- 400 x 2000 mm (internal)

Overall Weight:
- 1300 Kg (2866 Pounds)

Security Pressure Relief Valve cracking at
- 110 bar (CE marked)

SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

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]

L14607 RUIZ ET AL.: VERTICAL MOTION AND NEW TECHNOLOGIES L14607

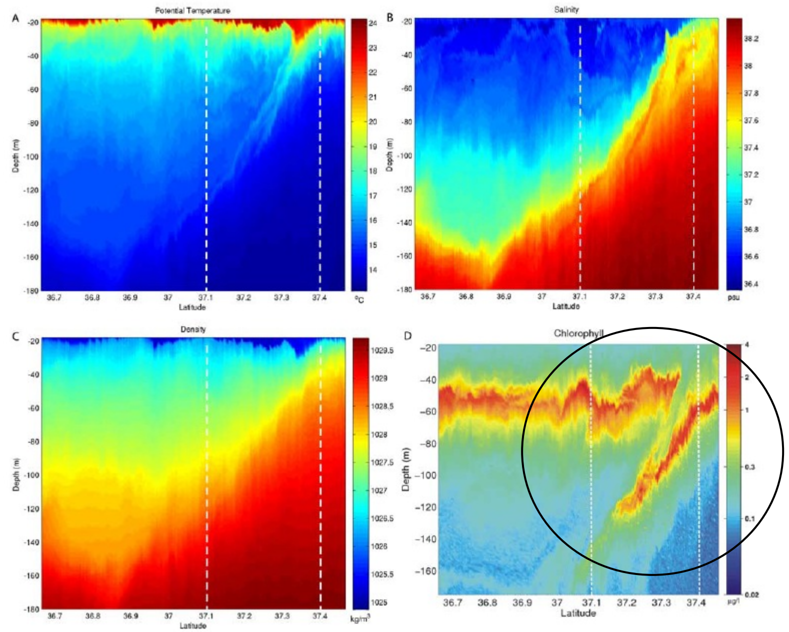


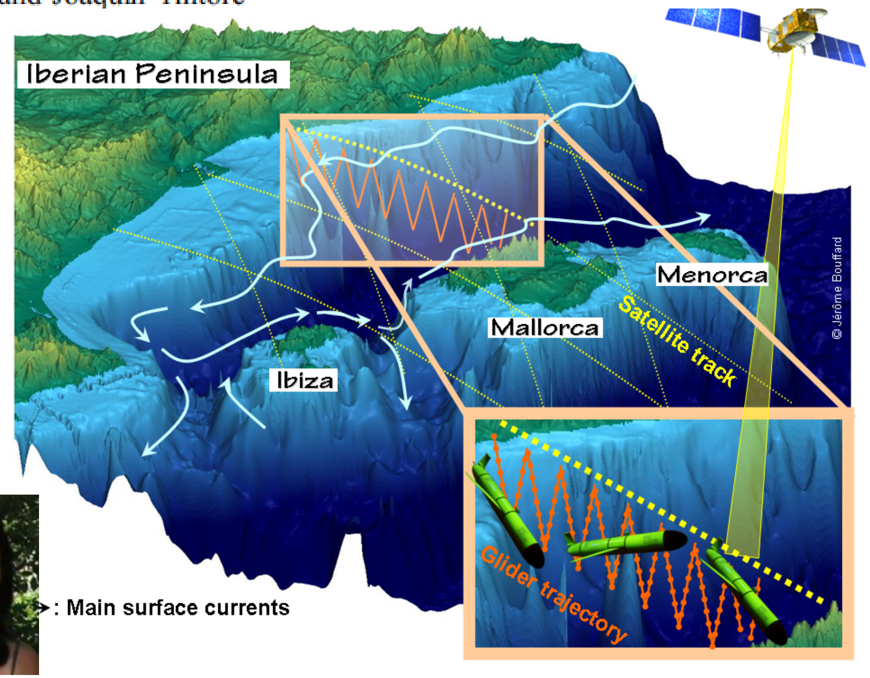
Figure 2. Vertical section of temperature (°C), salinity (PSU), density (kg/m^3) and chlorophyll (μg/l) from glider section 2 (dashed magenta in Figure 1). White dashed lines define sub-section in the northern part of the domain.

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

Govern de les Illes Balears

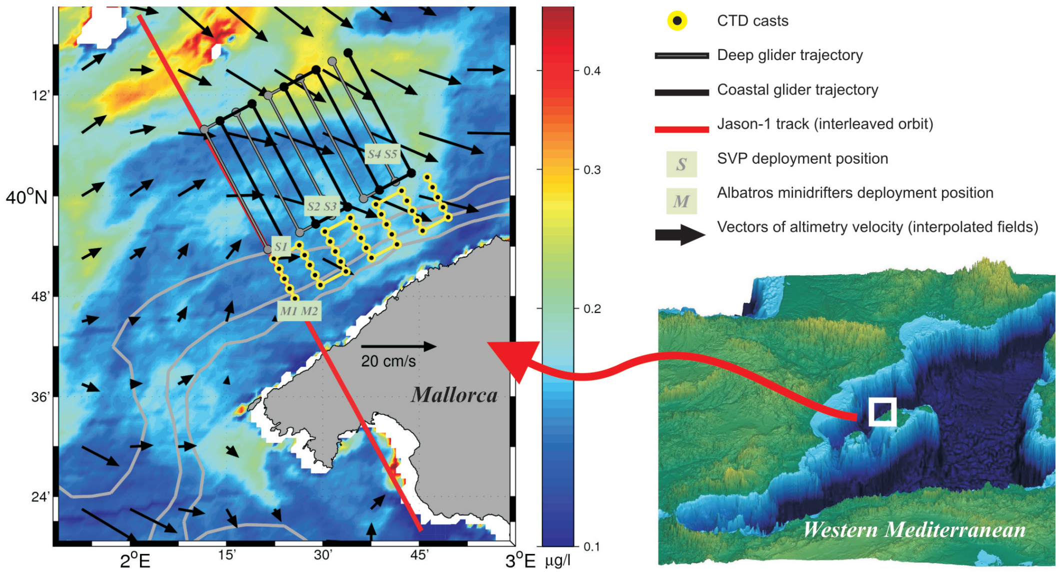
GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

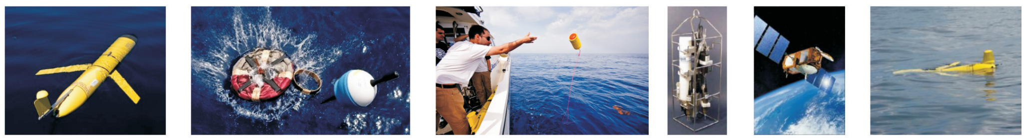
Gliders, Altimetry and Multi-Sensor approaches in the Balearic Sea: SINOCOP experiment

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, C10029, doi:10.1029/2009JC006087, 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]





Coastal Glider | SVP Drifter | Albatros Mini-drifter | CTD | Remote Sensing | Deep Glider

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

Gliders Facility: Science

Heat content, Mixed Layer Deepening, extreme events

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: Operational

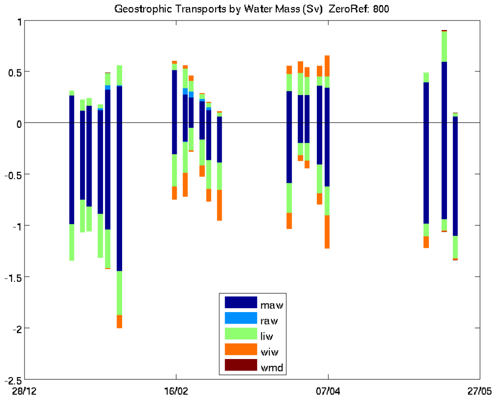
GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L20604, doi:10.1029/2012GL053717, 2012

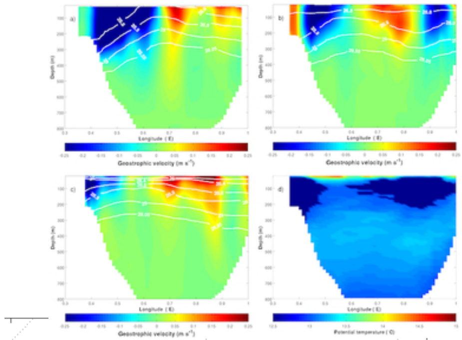
Autonomous underwater gliders monitoring variability at "choke points" in our ocean system: A case study in the Western Mediterranean Sea

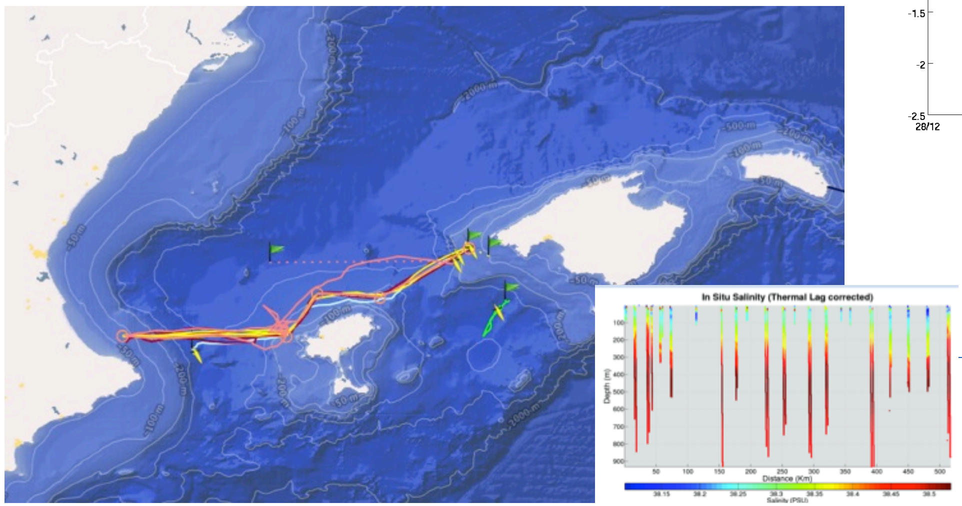
Emma E. Heslop,[1] Simón Ruiz,[1] John Allen,[2,3] José Luís López-Jurado,[4] Lionel Renault,[5] and Joaquín Tintoré[1,5]

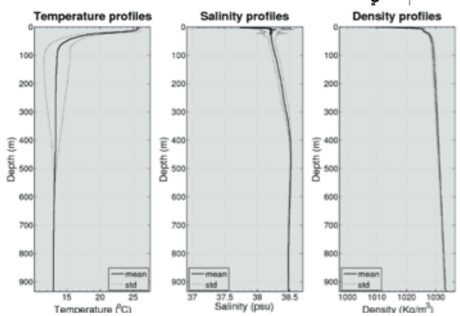
- **After 32 glider missions (started in 2006), + 17.000 profiles (30 Euros/profile)**
- **Since January 2011; routine operations**

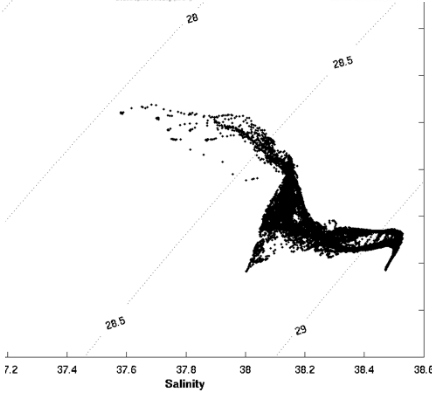
Major transport changes











SOCIB Glider Facility (Summary)

Gliders (a fleet of …) ?:

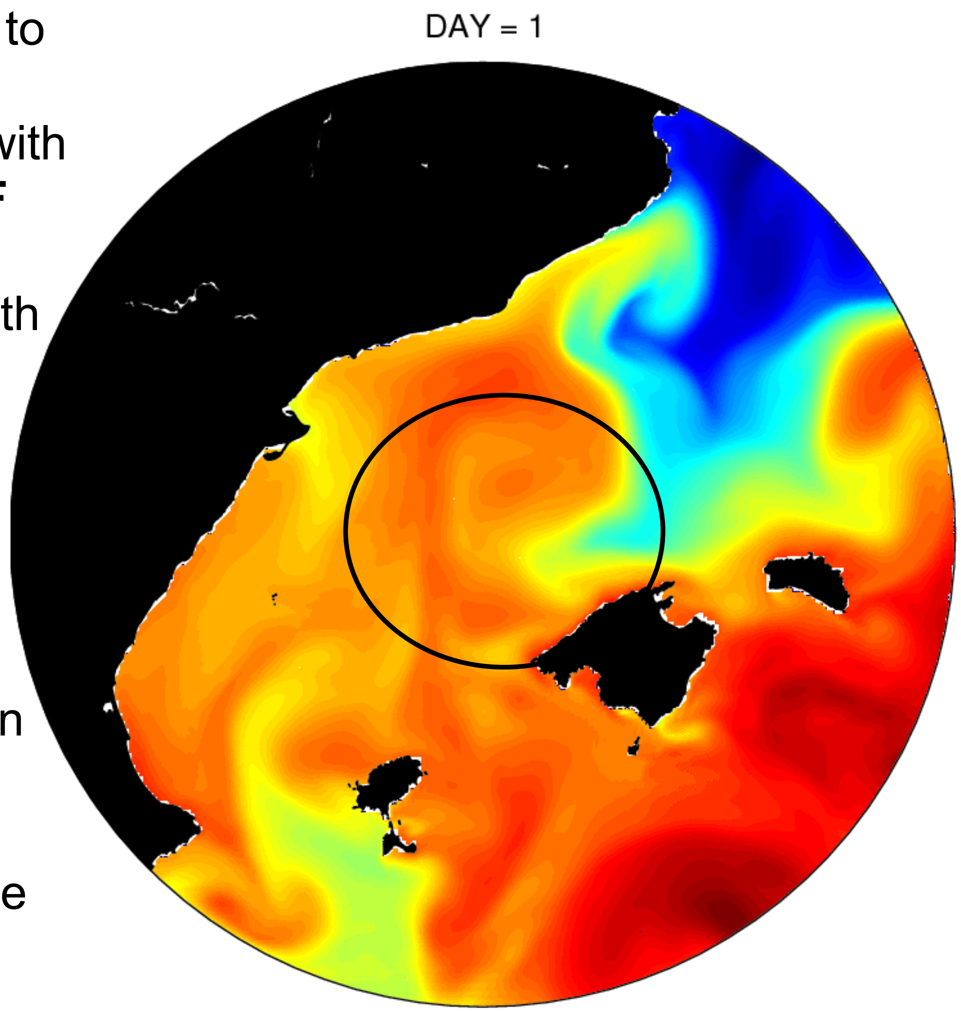
- They allow long term, sustained, multidisciplinary monitoring of the coastal ocean for example at key control sections.

- 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

<u>Operational Modeling:</u> **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

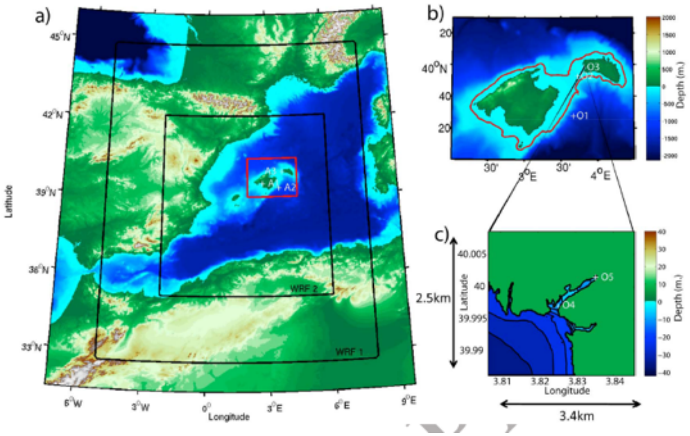
Modelling Facility; Meteotsunamis forecasting

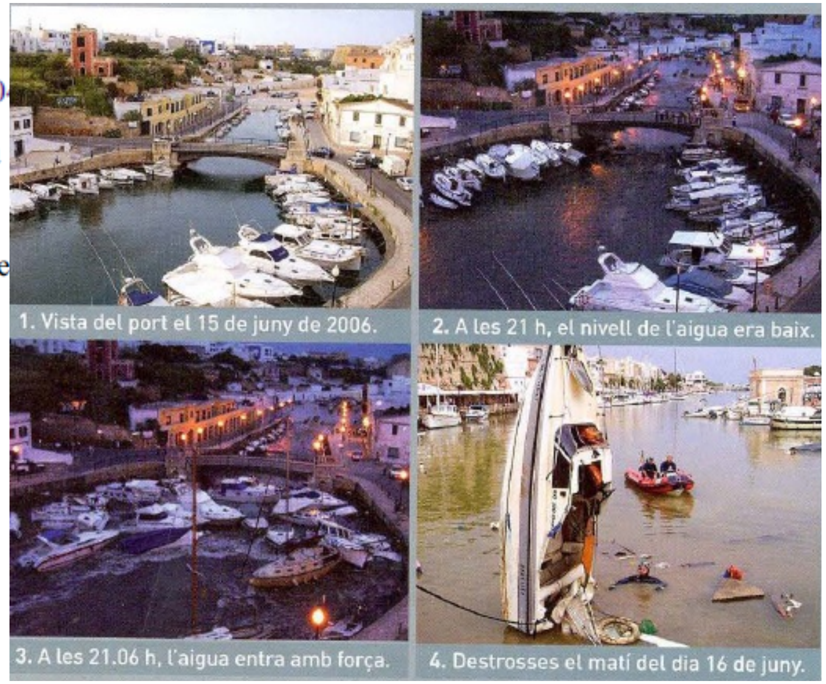
GEOPHYSICAL RESEARCH LETTERS, VOL. 38, LXXXXX, doi:10.1029/2011GL0

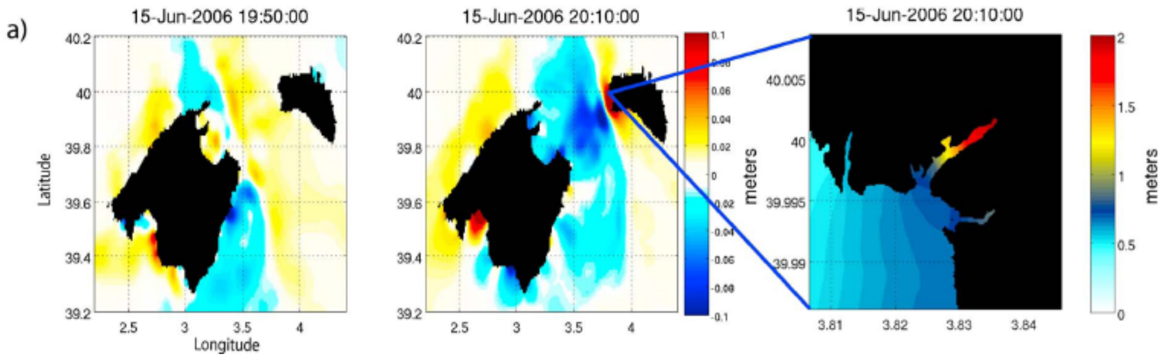
1 **Toward the predictability of meteotsunamis in the Balearic Sea**
2 **using regional nested atmosphere and ocean models**

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.







SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Govern de les Illes 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

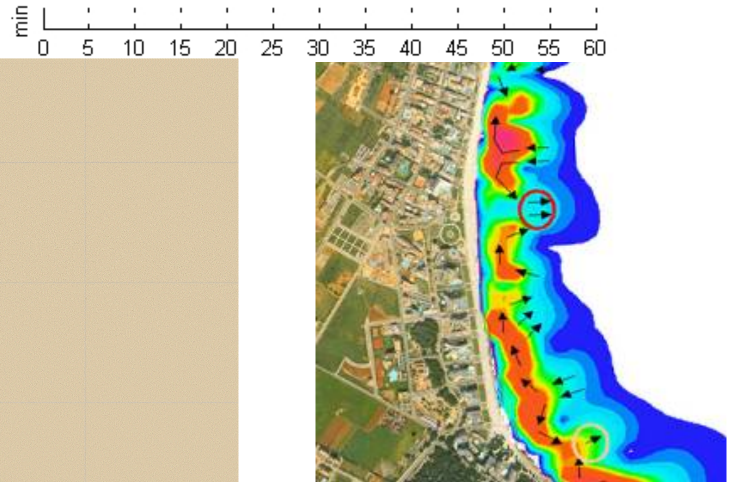
‡Environmental Hydraulic Institute
IH Cantabria
Universidad de Cantabria
39005 Santander, Spain

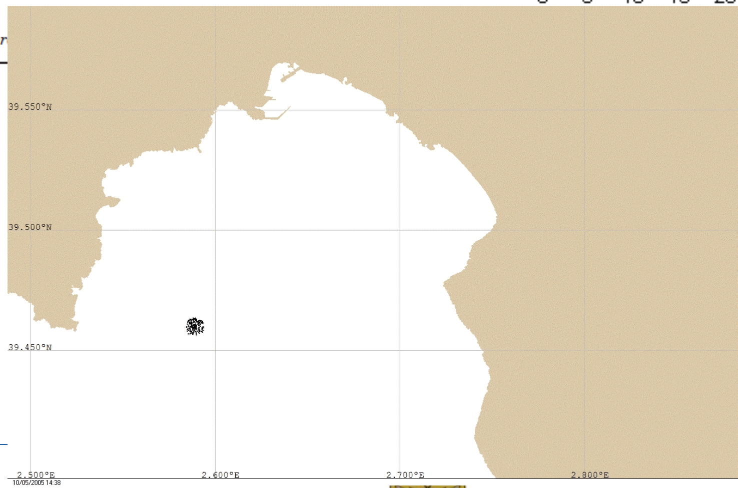
ABSTRACT

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

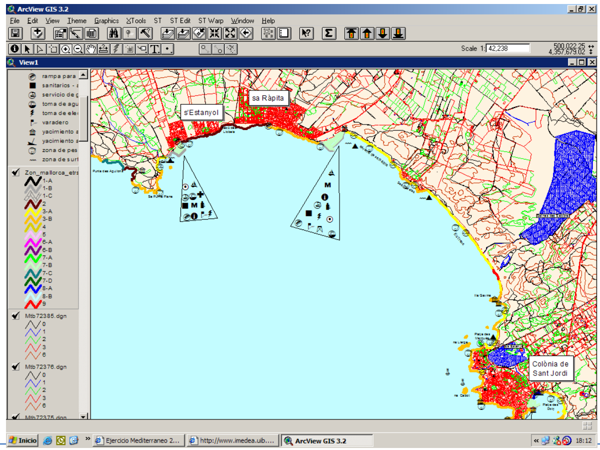
Govern de les Illes Balears

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.

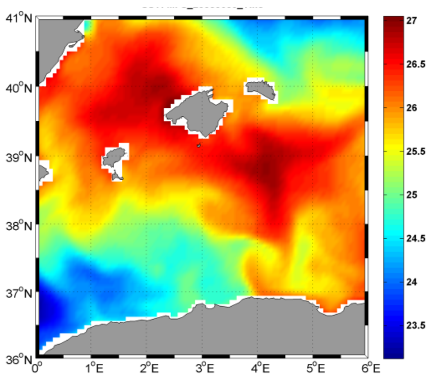
ESI (Environmental Sensitivity Index)

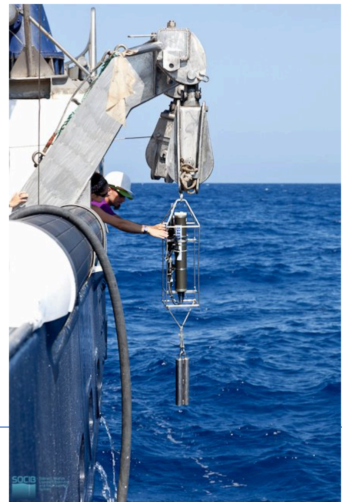


Bluefin Tuna Target Project: scientific problem solving for sustainable fisheries: at SOCIB since 2011

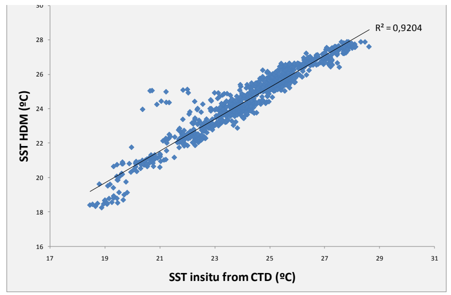
Initial Activities and First Results:

- 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



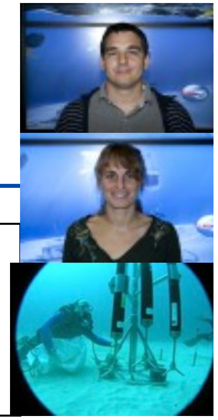
SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

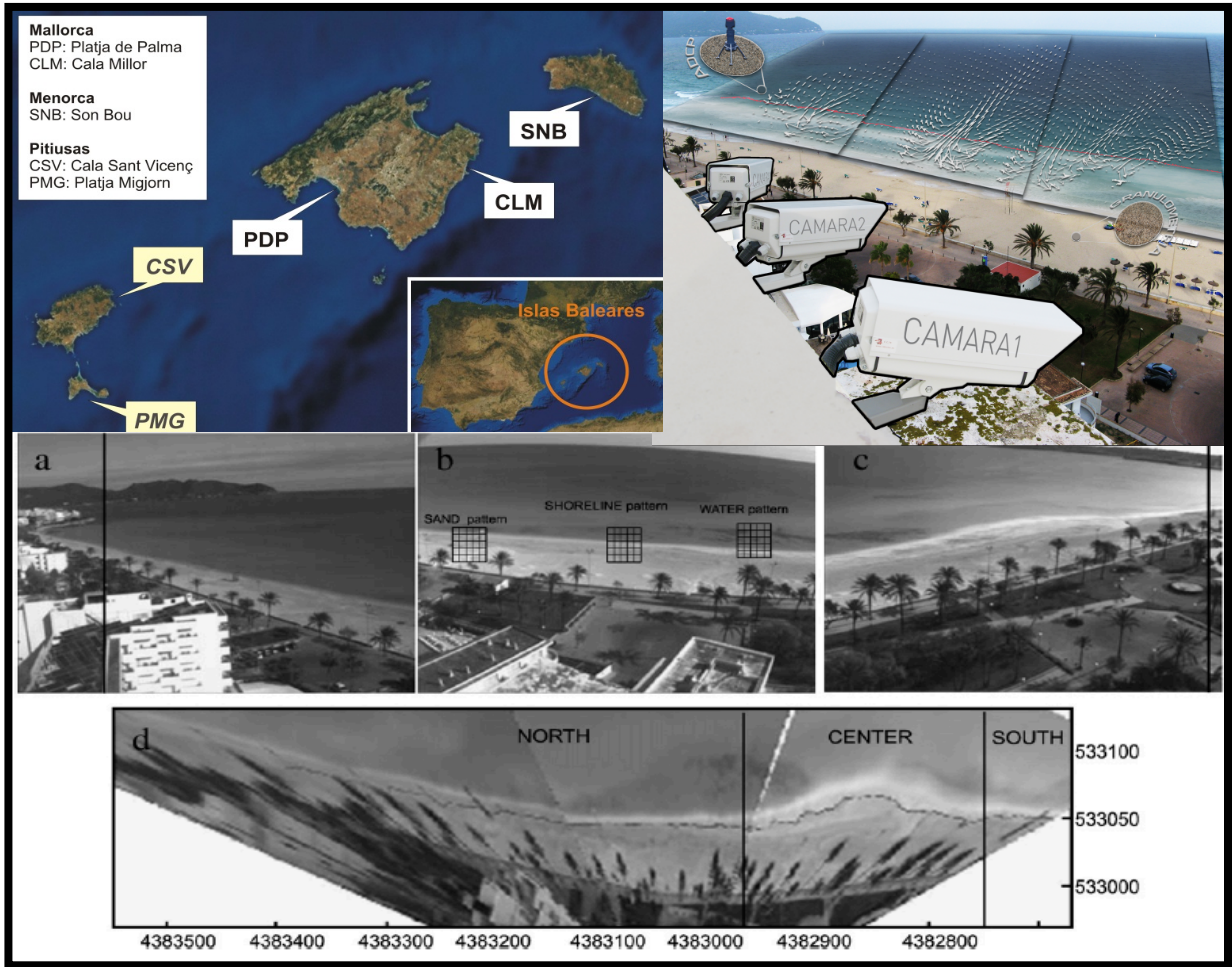
de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

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

EARTH SURFACE PROCESSES AND LANDFORMS
Earth Surf. Process. Landforms 35, 1712–1719 (2010)
Copyright © 2010 John Wiley & Sons, Ltd.
Published online 4 June 2010 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/esp.2025

An open source, low cost video-based coastal monitoring system

M. A. Nieto,[1] B. Garau,[1] S. Balle,[1] G. Simarro,[2] G. A. Zarruk,[3] A. Ortiz,[4] J. Tintoré,[1] A. Álvarez-Ellacuría,[1] L. Gómez-Pujol[1]* and A. Orfila[1]
[1] IMEDEA (CSIC-UIB), Mediterranean Institute for Advanced Studies, Esporles (Illes Balear), Spain
[2] Department of Hydraulic Engineering, Universidad de Castilla La Mancha, Ciudad Real, Spain
[3] Institute for Energy Technology, Kjeller, Norway
[4] Department of Mathematics and Computer Science, Universitat de les Illes Balears, Palma (Illes Balears), Spain

Received 27 October 2009; Revised 16 February 2010; Accepted 22 February 2010

*Correspondence to: L. Gómez-Pujol, IMEDEA (CSIC-UIB), Mediterranean Institute for Advanced Studies, 21 Miquel Marquès, 07190 Esporles (Illes Balear), Spain. E-mail: lgomez-pujol@uib.cat

ESPL
Earth Surface Processes and Landforms

ABSTRACT: A low cost, automated, remote monitoring video system built on standard commercial off-the-shelf (COTS) components and implemented with open source software is presented. The system has been implemented in a coastal area to perform image acquisition and processing, generating statistical products and transferring the information from the field to a central node where post-processing and data visualization are made available to the general public. The open structure of the software allows the user to implement new routines and modules appropriate to fit specific needs as well as to adapt the system to study other dynamical processes where continuous observation is required. The software and image data base can be obtained as freeware. Copyright © 2010 John Wiley & Sons, Ltd.

KEYWORDS: video monitoring; remote sensing; coastal zone

Introduction

Several experiments and coastal monitoring facilities have been developed and carried out in the last decade. The most complex approaches are field-based and use coastal oceanographic equipment. These have a broad capacity to produce spatial and temporal measurements of physical and environmental variables being the only way to measure processes responsible for sediment transport. Unfortunately, these facilities require a large time and money investment and have relatively long installation and set-up times before producing useful data-sets. Classical examples of this kind of installations are the Field Research Facility operated since 1980 by the US Army Coastal Engineering Research Centre at Duck (Larson and Kraus, 1994; Miller and Dean, 2007), the US Geological Survey station at the Columbia River Littoral Cell in the Pacific coast (Ruggiero and Voigt, 2000) or the JARKUS data set in the Dutch coast (Wijnberg and Terwindt, 1995). Other recent development that must be considered are the Gold Coast shoreline and wave record obtained by the Northern Gold Coasts Beach Protection Strategy in southeast Australia (Boak *et al.*, 2000) or the POL Liverpool Bay Coastal Observatory (Proctor *et al.*, 2004).

Another alternative to measuring coastal processes is based on remote sensors. In this way, information is acquired automatically, continuously and periodically from high resolution digital images. This alternative to traditional field studies that utilizes a significantly lower amount of human, economic, and computational resources, allows better continuity and frequency in data acquisition. Among optical remote sensors, fixed digital video cameras have proven to be an attractive alternative for coastal monitoring because it provides the possibility to study a range of spatial and temporal scales, from specific cross-shore profiles to several kilometres of coast, with sampling intervals depending on the required measurement. Therefore, a broad number of coastal forms and nearshore processes can be monitored using remote techniques. For instance, researchers have used video images to extract beach and nearshore bathymetry (Stockdon and Holman, 2000; Aaminkhof *et al.*, 2003), the nearshore hydrodynamics (Chickadel *et al.*, 2003), as well as to unravel the formation and displacement of sand bars (Lippman and Holman, 1989; Ojeda, 2008; Ruessink *et al.*, 2000) or the beachface morphodynamics (Almar *et al.*, 2008; Ortega-Sánchez *et al.*, 2007). The capabilities and functionality of video-based costal monitoring systems are evolving rapidly; more so with the CoastView project (Davidson *et al.*, 2007) that highlighted and standardized the possibilities and future trends of these systems for coastal zone or navigational channels management (Medina *et al.*, 2007; Turner and Anderson, 2007; Koningsveld *et al.*, 2007).

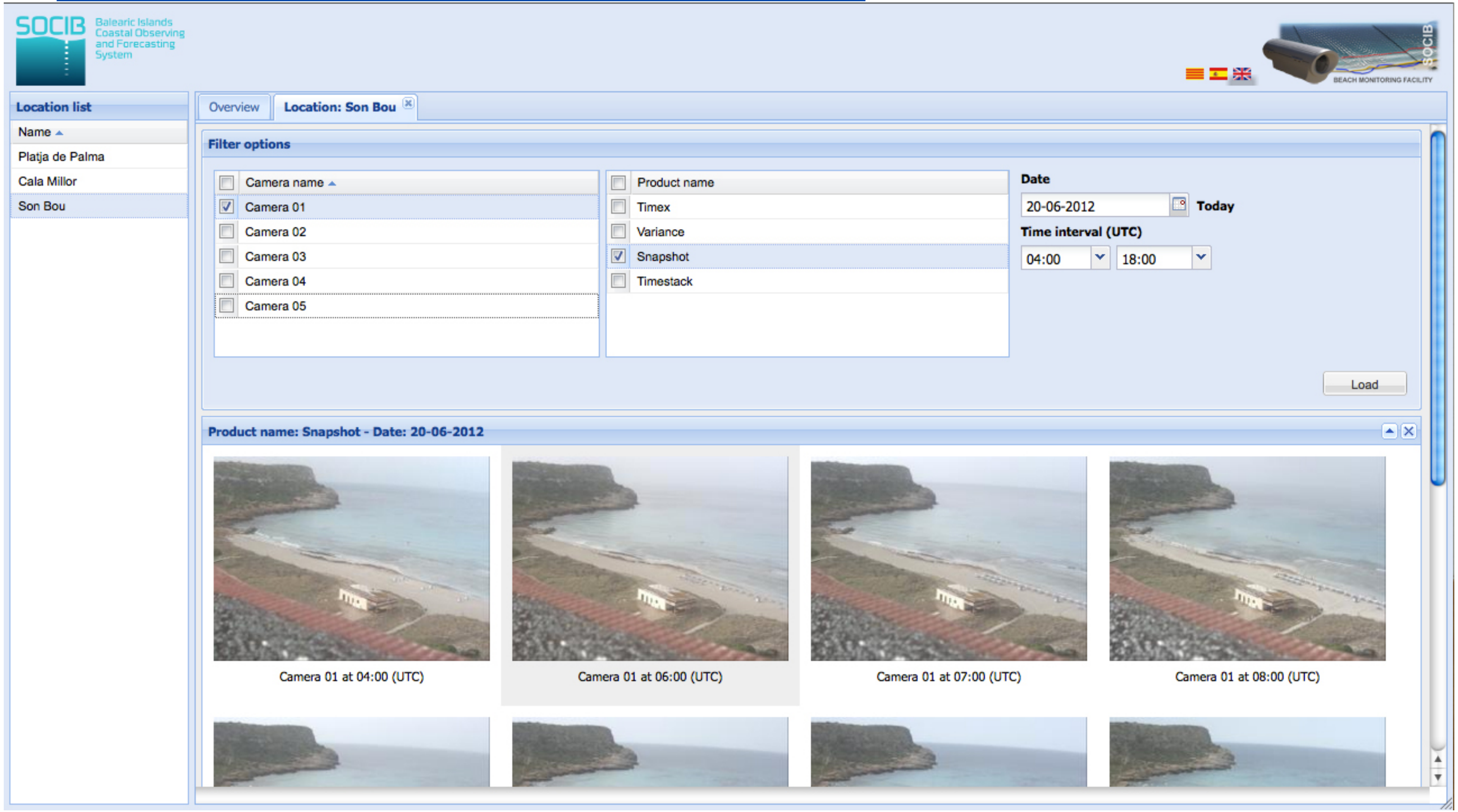
Since the commercialization of ARGUS – a video-based coastal monitoring system developed by the Coastal Imaging Laboratory at Oregon Sate University (Holman and Stanley, 2007) – and because many potential applications to unravel nearshore issues based on video monitoring systems have

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

- Real time monitoring consists on the automated collection of coastal videomonitoring images, weather data and waves data.
- The SOCIB Beach Monitoring Facility is using **SIRENA, the open source, low cost video-based videomonitoring system developed at IMEDEA (CSIC-UIB)**. It captures 1500 images of the coast at 4Hz during the first 10 minutes of each hour resulting in a set of different types of images: snapshot, timex, variance and timestack.
- SOCIB videomonitoring real time data is a web based system and images are hourly available from each one of the monitoring sites.

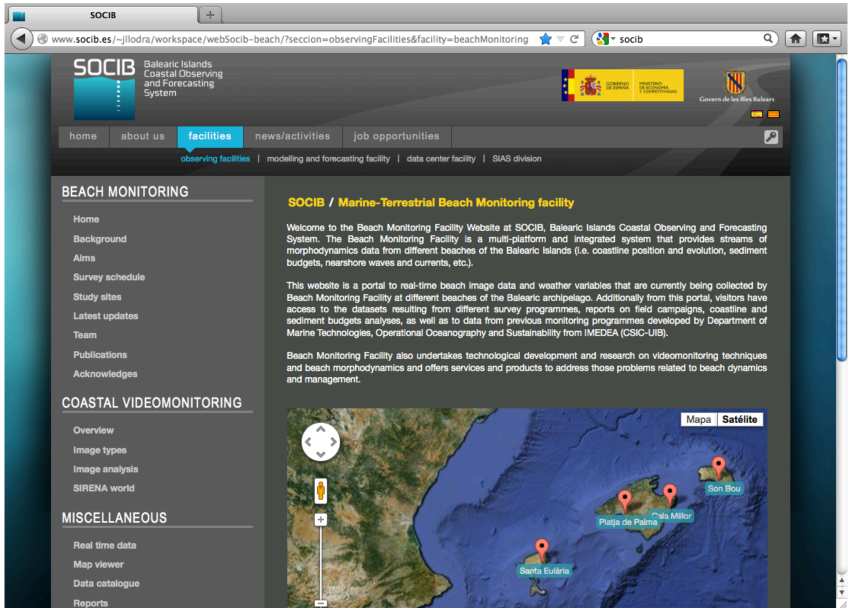
Snapshot **Timex** **Variance**

Time stack



○ Every hour the web site is updated with the latest snap-shot, timex and variance images. These can be viewed to provide and immediate qualitative assessment. A zoom and calendar tool enables more detailed examination and image comparison.

A web based products dissemination (www.socib.org)



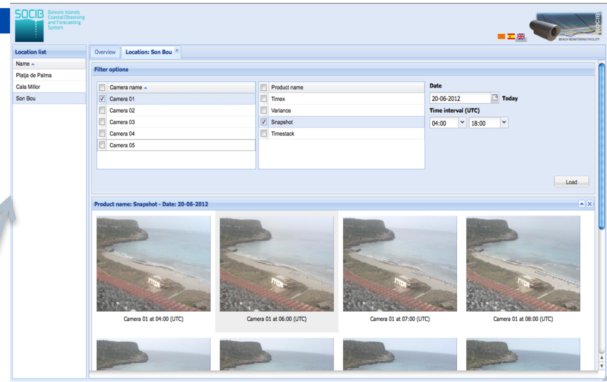
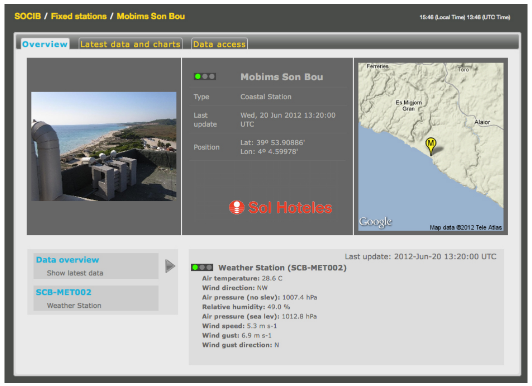
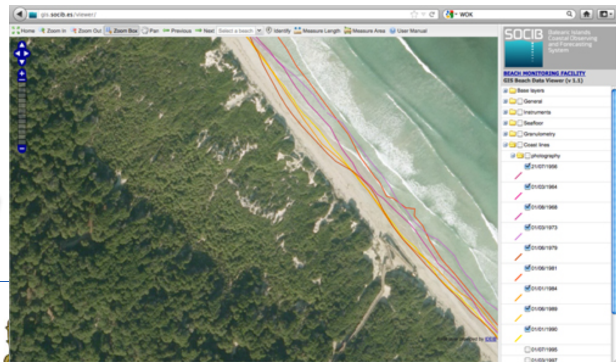


image application



Weather & wave application



GIS beach maps and data application

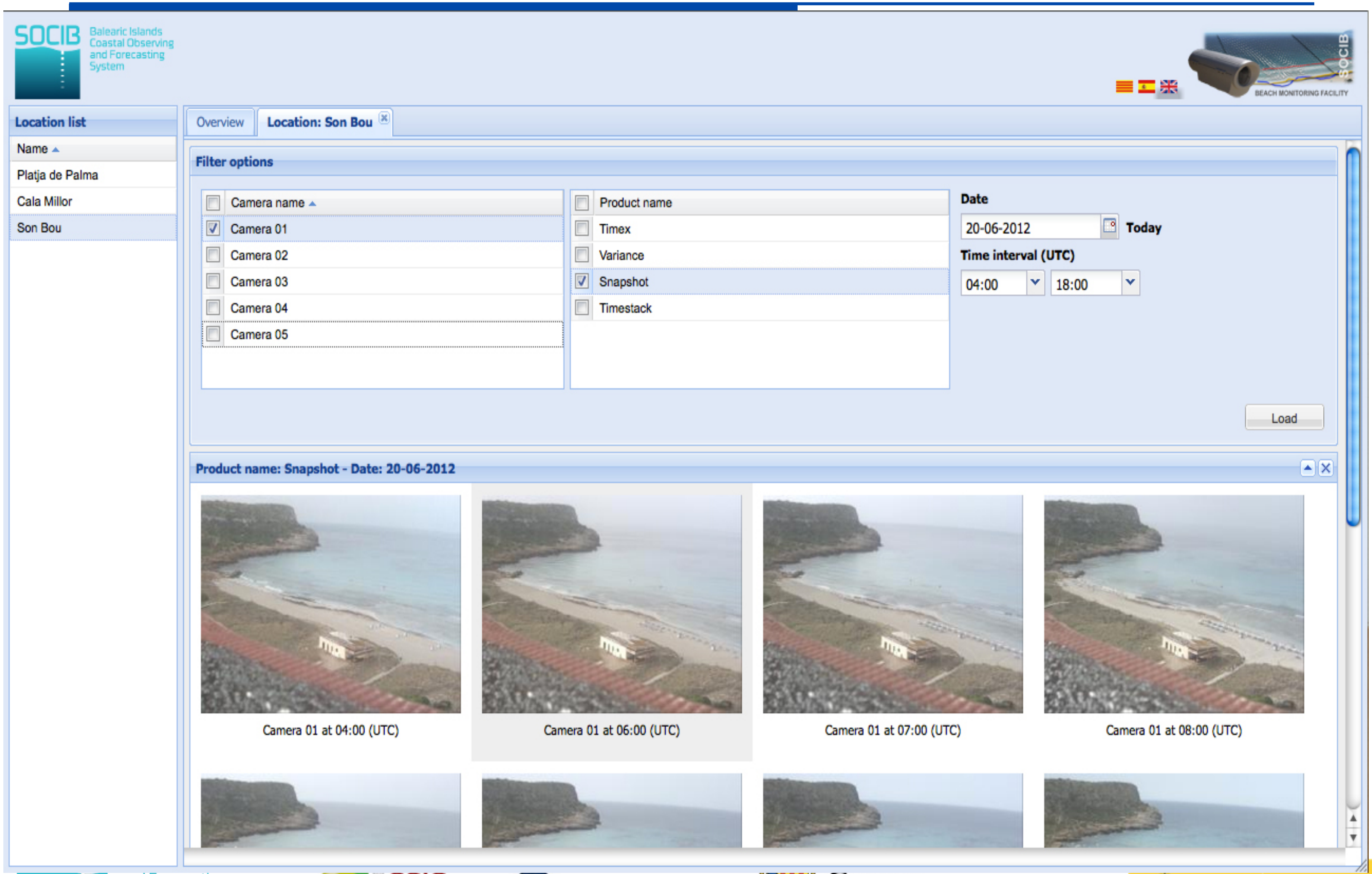
SOCIB Balearic Islands Coastal Observing and Forecasting System

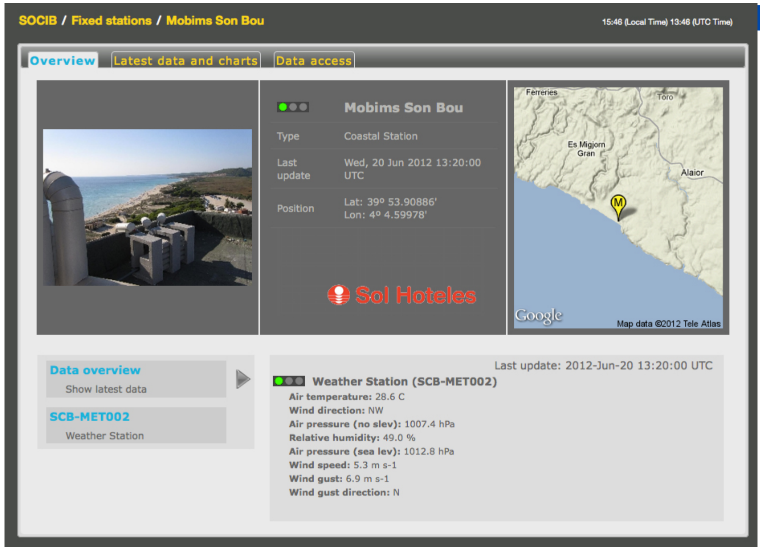
CSIC

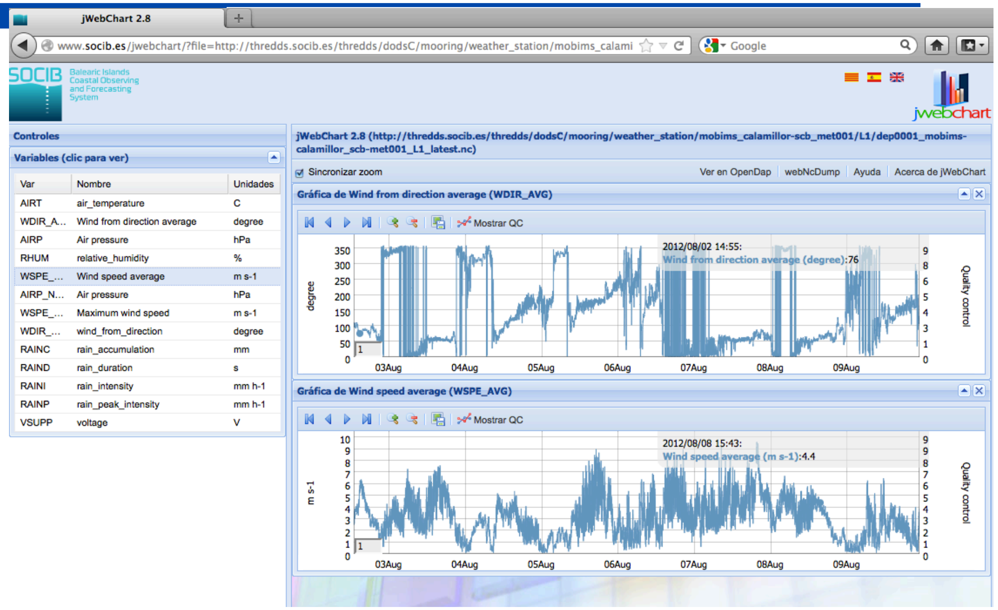
de les Illes Balears

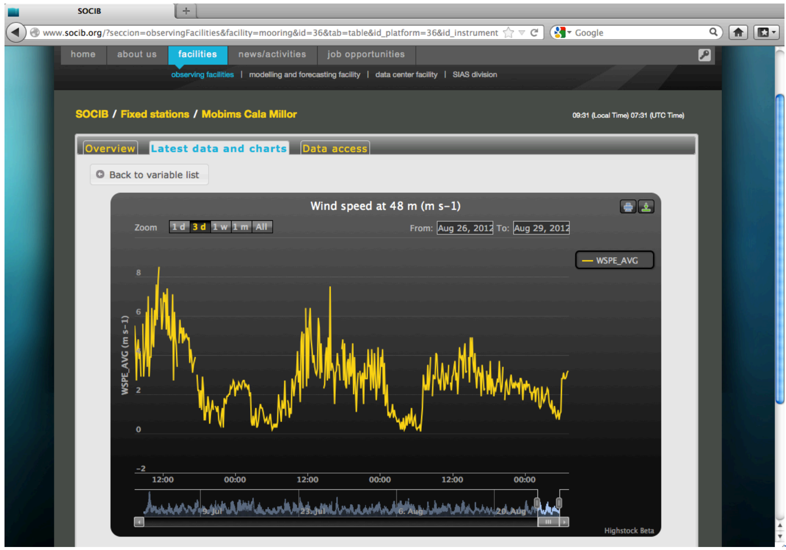
GOBIERNO DE ESPAÑA

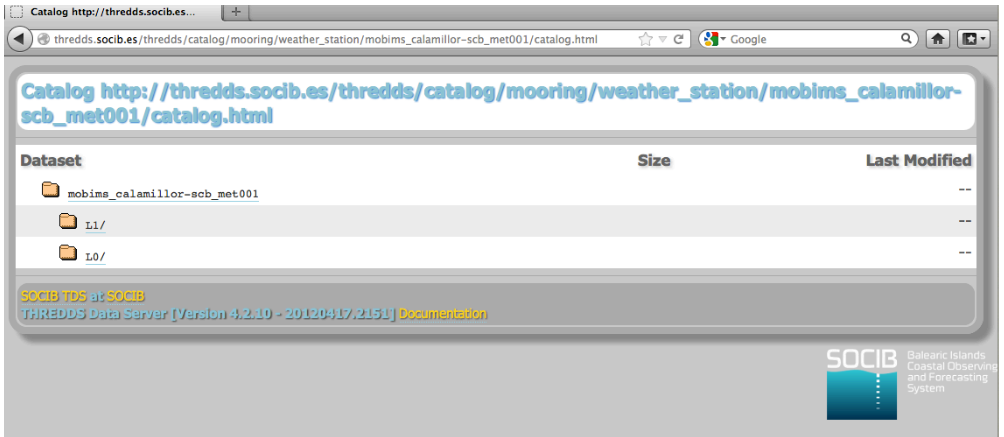
MINISTERIO DE CIENCIA E INNOVACIÓN


SOCIB Balearic Islands Coastal Observing and Forecasting System
BEACH MONITORING FACILITY
Location list
Name
Platja de Palma
Cala Millor
Son Bou
Overview
Location: Son Bou
Filter options
Camera name
Camera 01
Camera 02
Camera 03
Camera 04
Camera 05
Product name
Timex
Variance
Snapshot
Timestack
Date
20-06-2012
Today
Time interval (UTC)
04:00
18:00
Load
Product name: Snapshot - Date: 20-06-2012
Camera 01 at 04:00 (UTC)
Camera 01 at 06:00 (UTC)
Camera 01 at 07:00 (UTC)
Camera 01 at 08:00 (UTC)









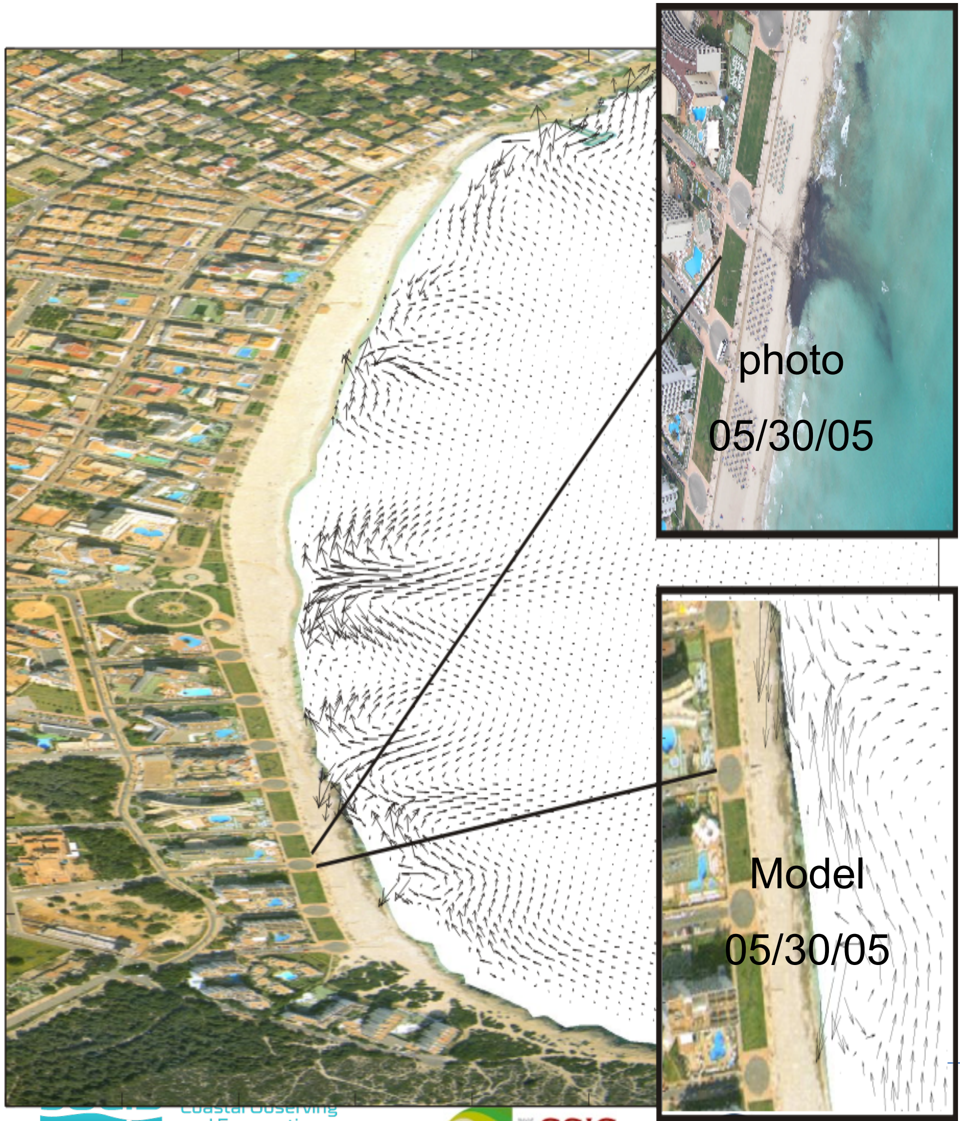
SOCIB Balearic Islands Coastal Observing and Forecasting System

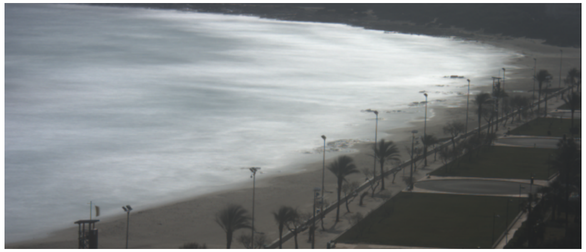
CSIC

Govern de les Illes Balears

GOBIERNO DE ESPAÑA | MINISTERIO DE CIENCIA E INNOVACIÓN

TOOLS FOR RIP CURRENTS IDENTIFICATION TO CONTRIBUTE TO BEACH SAFETY

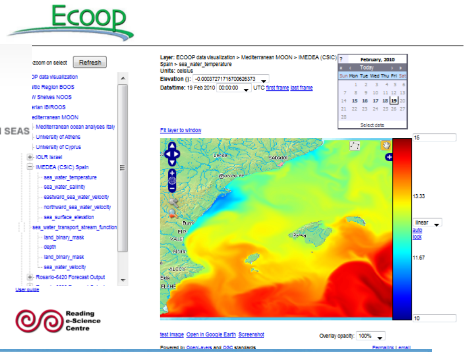


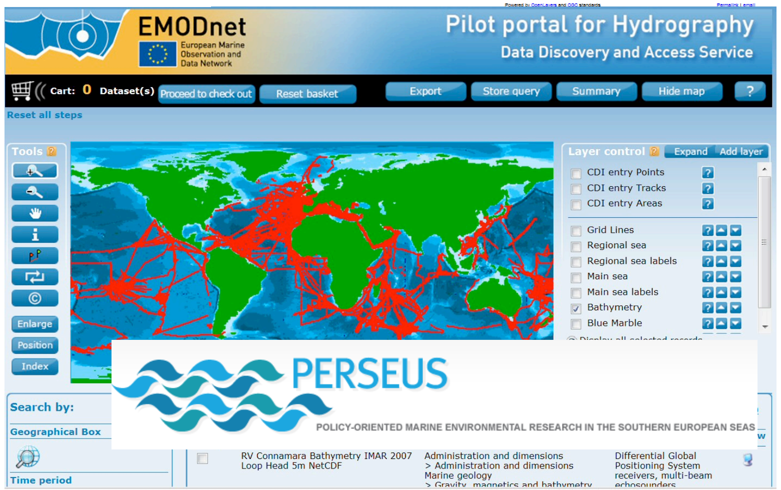


and Forecasting System
CSIC
Govern de les Illes Balears
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

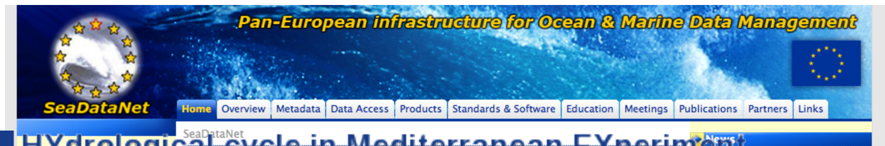
Data Centre Facility

The European framework





The international framework



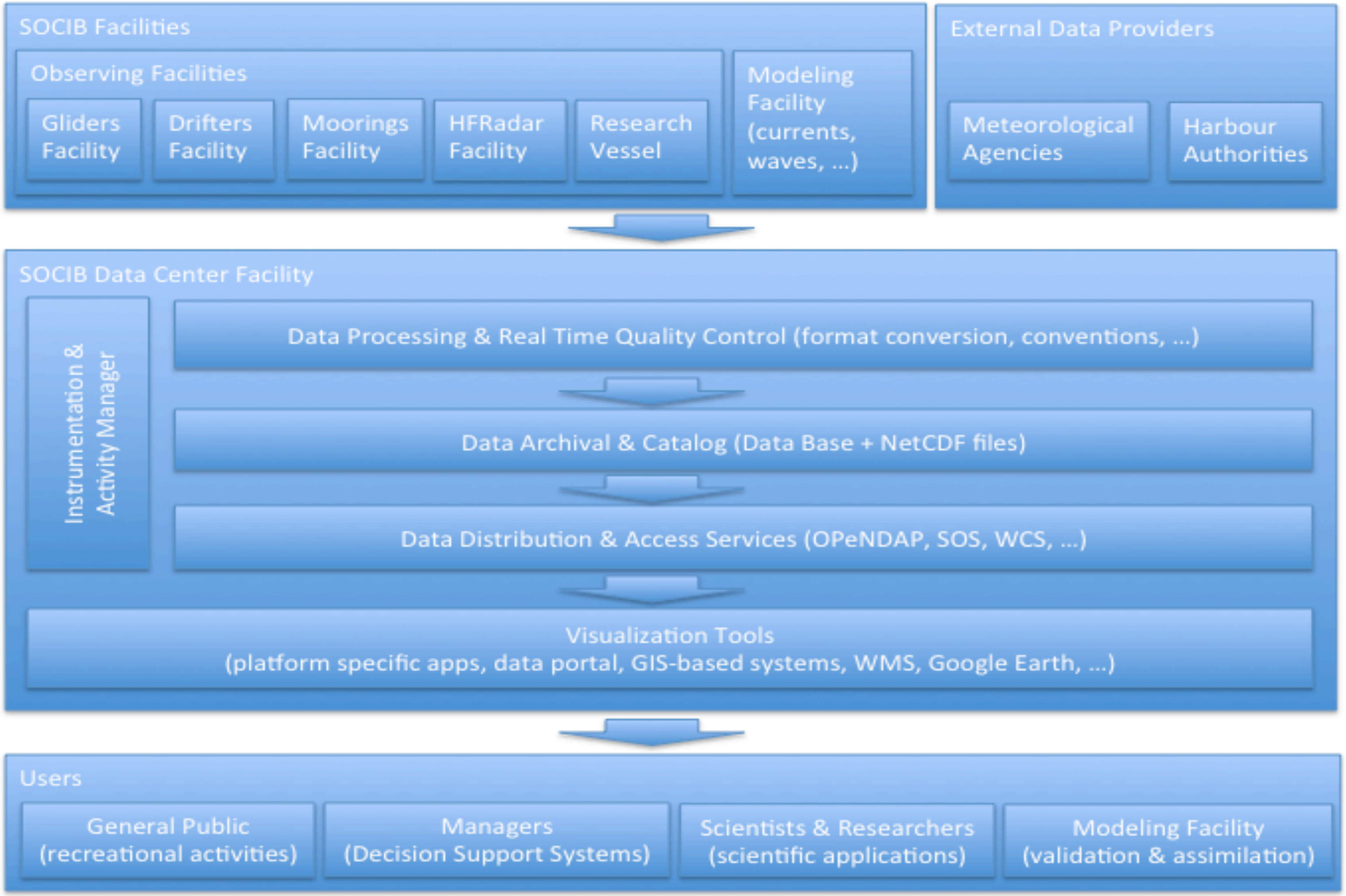
HYdrological cycle in Mediterranean EXperiment

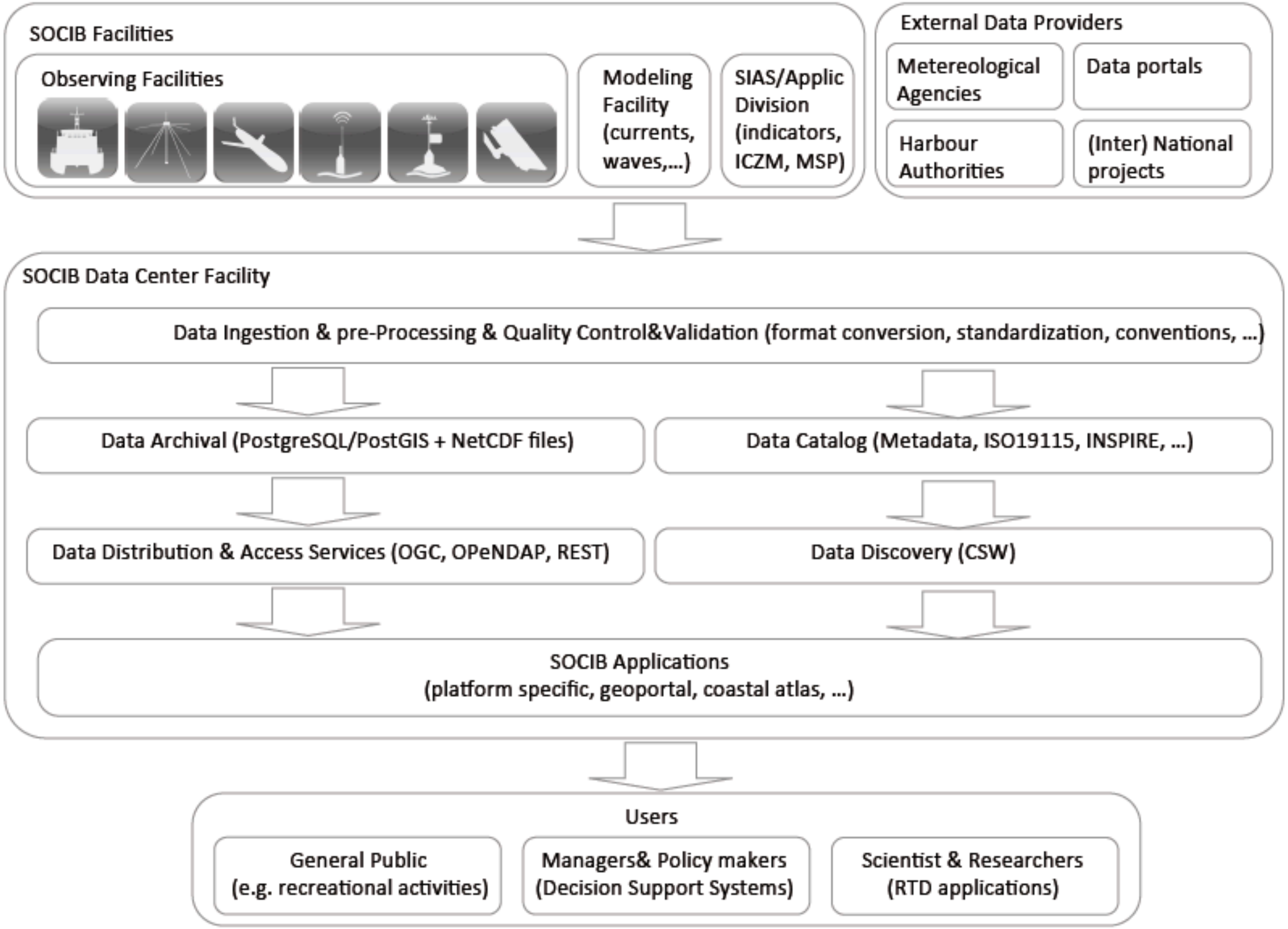
Data Center: Science and Technology

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

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)


SOCIB Facilities
Observing Facilities
Modeling Facility (currents, waves,...)
SIAS/Applic Division (indicators, ICZM, MSP)
External Data Providers
Metereological Agencies
Data portals
Harbour Authorities
(Inter) National projects
SOCIB Data Center Facility
Data Ingestion & pre-Processing & Quality Control&Validation (format conversion, standardization, conventions, ...)
Data Archival (PostgreSQL/PostGIS + NetCDF files)
Data Catalog (Metadata, ISO19115, INSPIRE, ...)
Data Distribution & Access Services (OGC, OPeNDAP, REST)
Data Discovery (CSW)
SOCIB Applications
(platform specific, geoportal, coastal atlas, ...)
Users
General Public
(e.g. recreational activities)
Managers& Policy makers
(Decision Support Systems)
Scientist & Researchers
(RTD applications)

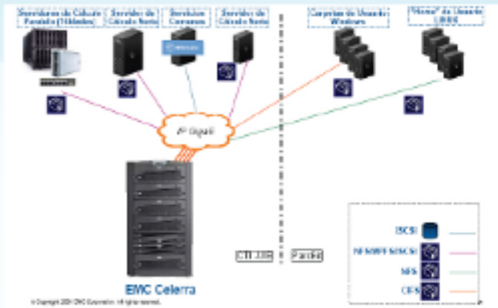
Data Centre: Technologies

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.

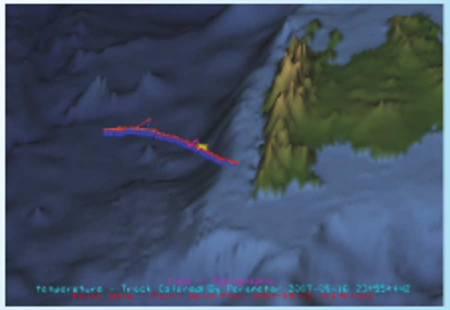
4. Catalog

THREDDS to organize data and Metadata to automatic harvesting.

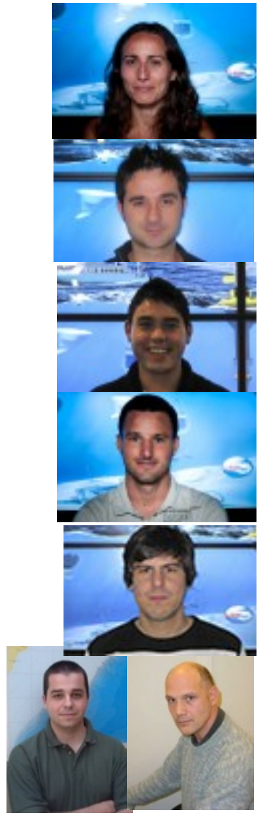
5. Discovery

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

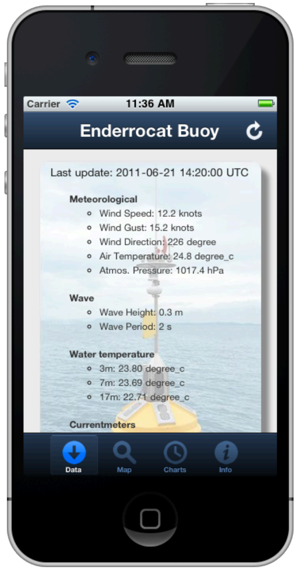
6.Analisis and Visualization



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

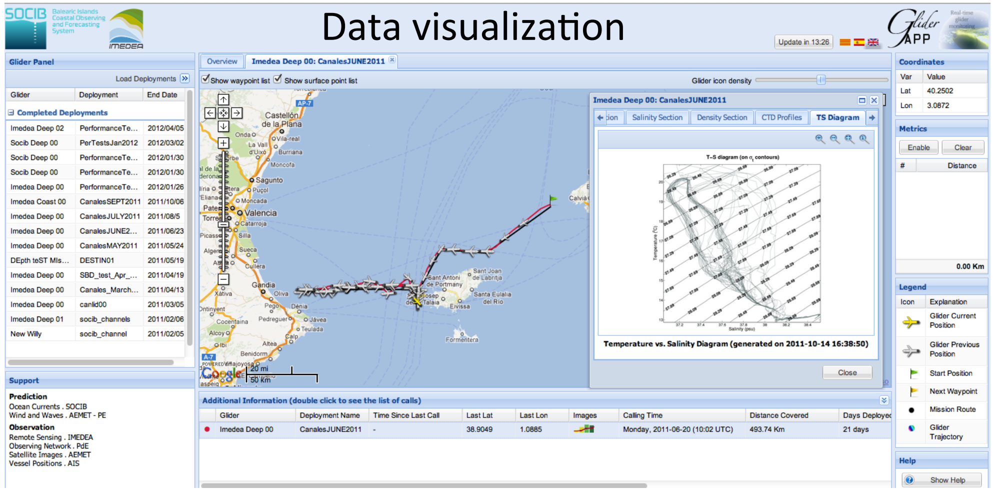


Data Centre (Technologies; example of Apps)

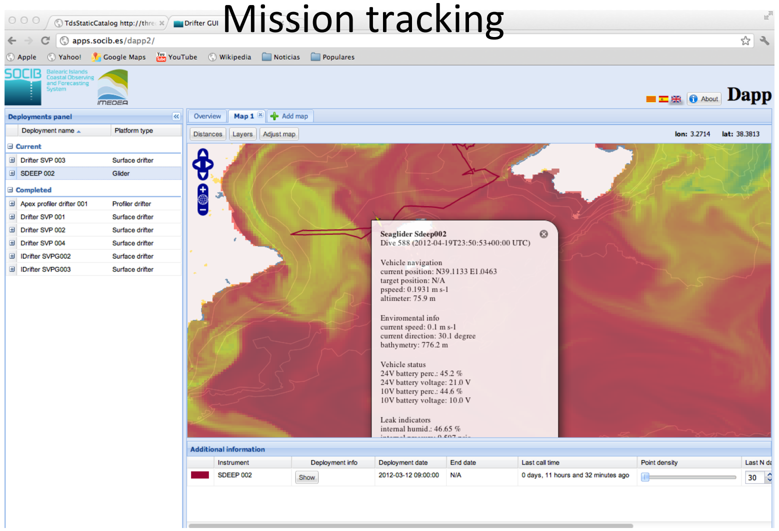


Some products tools (examples)

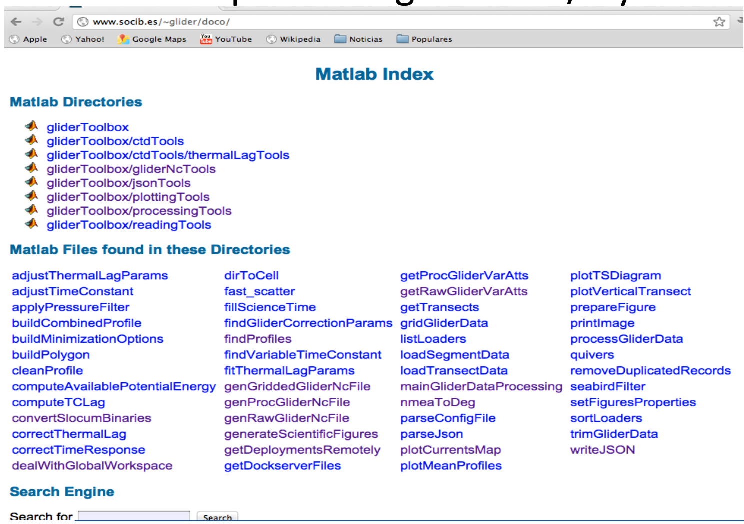
Data visualization



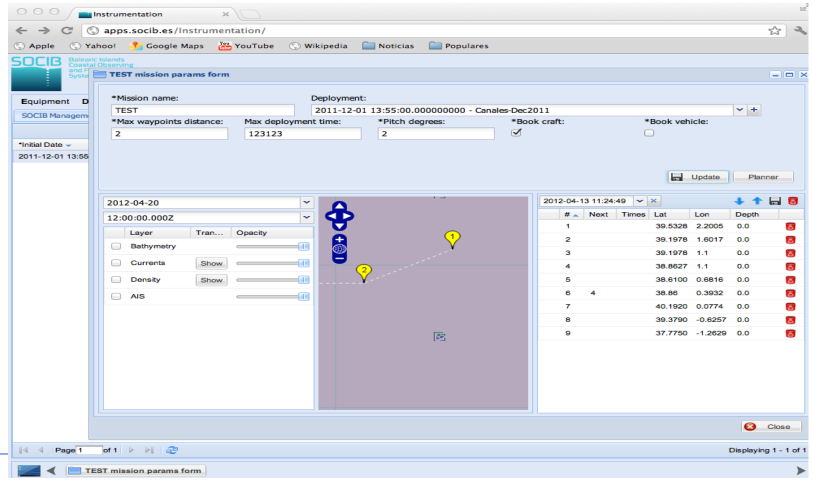
Mission tracking



Data processing: matlab / Python scripts



Platform management: mission planning

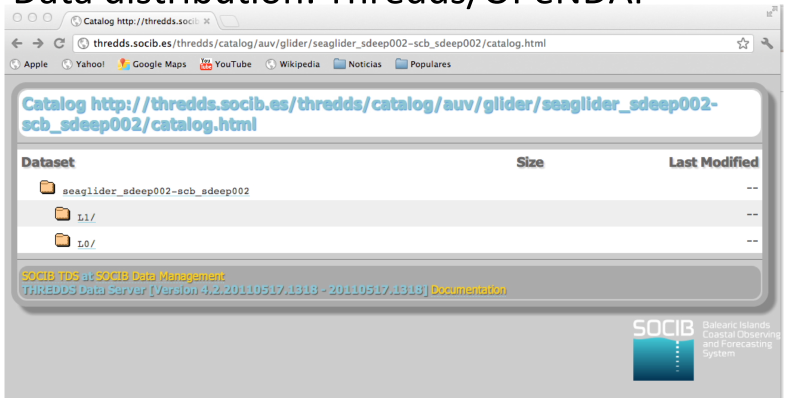


Balearic Islands Coastal Observing and Forecasting System

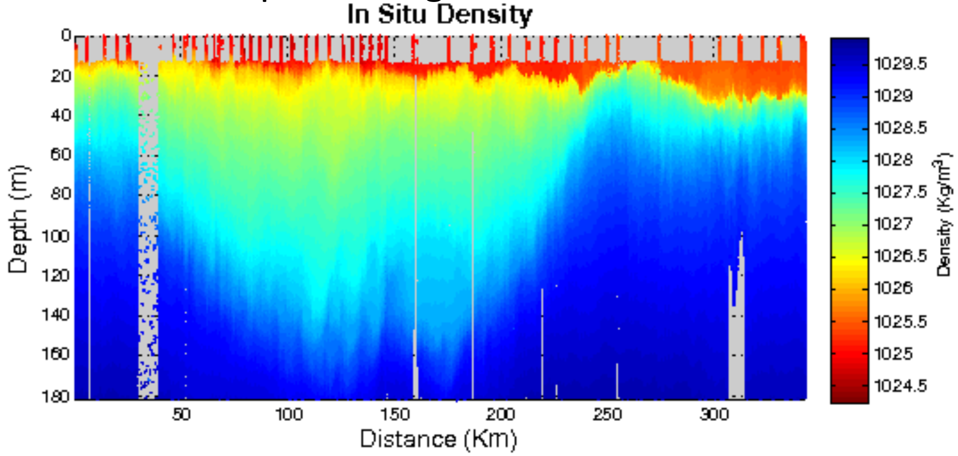
Govern de les Illes Balears

Some products tools (examples)

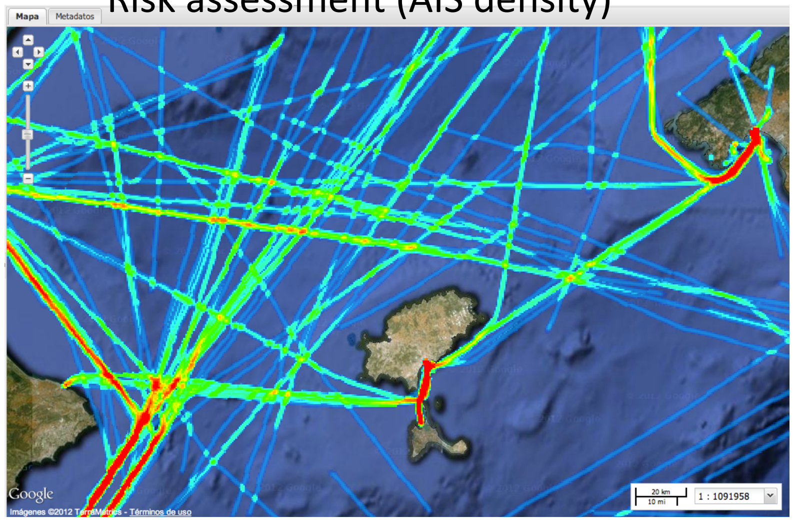
Data distribution: Thredds/OPeNDAP



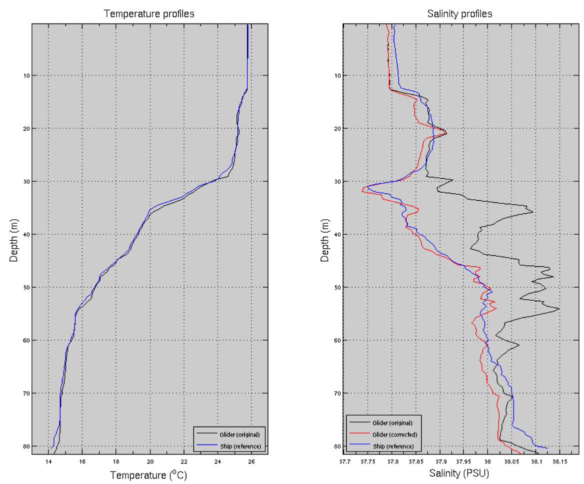
Postprocessing: visualization tools



Risk assessment (AIS density)



Postprocessing: thermal lag corrections



SOCIB Balearic Islands Coastal Observing and Forecasting System

CSIC

Govern de les Illes Balears

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

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

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)

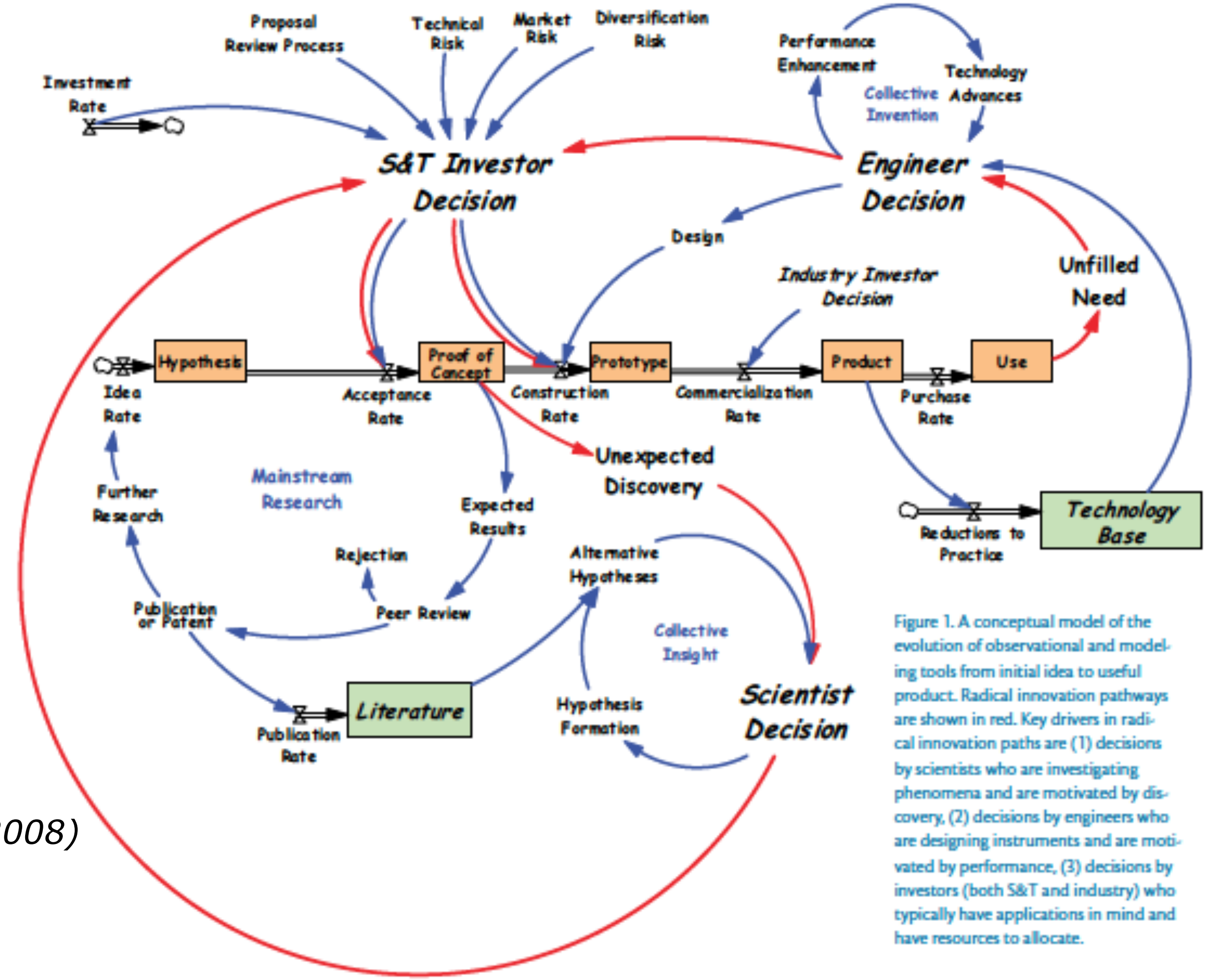


Figure 1. A conceptual model of the evolution of observational and modeling tools from initial idea to useful product. Radical innovation pathways are shown in red. Key drivers in radical innovation paths are (1) decisions by scientists who are investigating phenomena and are motivated by discovery, (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 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.

SUMMARY (the SOCIB perspective, 1)

From the Observing systems… consider the new capabilities/possibilities from the new technologies and new <u>Multi-platform Observing Systems</u>

e.g., HF Radar, drifters, gliders, coastal 'efficient' R/V, moorings, satellite, etc… all in real time… - SOCIB just an ex. (similarities with NANOOS, IMOS, COSYNA, etc.)

- Therefore, from the Observing Systems side, there are new real time capabilities to characterize coastal ocean state and coastal ocean variability and open ocean exchanges. In particular at the meso and submesoscale and at key control choke points. *(e.g., Heslop et al, GRL; 2012).*
- This is obviously a new situation that needs to be considered for model validation, development of new tools for data assimilation, …

SUMMARY (the SOCIB perspective, 2)

1. The challenge for next decade: 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 …

2. The Strategy:

- Select key control sections in coastal ocean, from coast to open slope, for routine monitoring 'choke or control points' to characterise coastal and ocean variability
- Evaluate the relevance of meso and submesoscale activity, shelf/slope exchanges on coastal ocean state & ocean variability and impacts open ocean

SUMMARY (the SOCIB perspective, 3)

From the Modelling side, new capabilities of Observing Systems Simulation Experiments;

1. The Challenges for next decade:

- To examine how well the different sampling platforms contribute to (a) characterize coastal ocean state and (b) its variability.

- To establish its interactions and impacts on global ocean

- To understand factors that control accuracy of the reconstruction of the oceanic state.

2. The Strategy:

- Observation system simulation experiments (OSSE), to sub-sample oceanic fields in these experiments to quantify errors in reconstructions of the oceanic state, and to study factors that control these errors.

In Summary: that’s exactly what SOCIB and other Observatories, or Marine Res. Infrastructures bring….

- State of the art research capacity, scientific excellence
- Technology development and development of management tools for public and private sectors
- Capacity to respond to society needs

The key:…”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”. *(Curtin and Belcher, TOS, 2008)*

Question: Is the science/scientific system structure adequate for this change ?

Thank you!!!