

GODAE



The Global Ocean Data Assimilation Experiment

# The GODAE Perspective

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*<http://www.bom.gov.au/GODAE/>*



# Where will I go?

- **The basis: a little history**
- **The concept: the architects and design**
- **Models and construction**
  - ❖ **Scientific and technical challenges**
- **Building the applications**
- **Testing and inspection: does it work?**
- **User scrutiny: is it useful?**

GODAE



GODAE Summer School

# Some History

# 150 years of “learning oceanography”

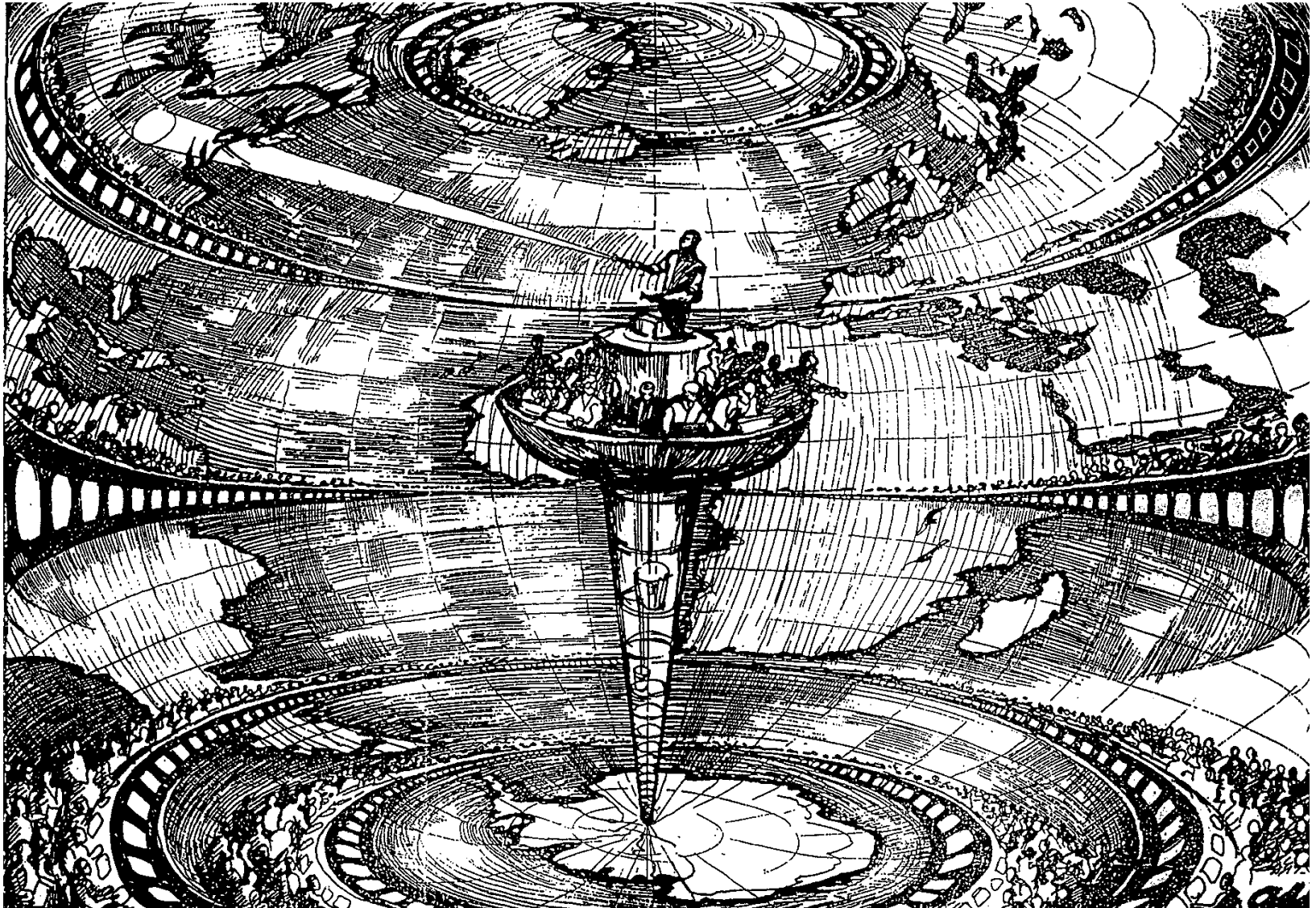
- 1800's - Challenger Exp, Franklin, Maury (“father” of Volunteer Obs)
- 1900's - Enhanced cooperation; fundamental knowledge
  - the ocean's rotate (Coriolis)
  - the winds blow (Ekman)
  - the west and east are different (Sverdrup)
  - the ocean obey  $F=ma$
- 1960's - marine forecasts; computer model
- 1970's - ocean satellites; global models; Expendable bathythermograph network starts; Southern Ocean buoys.
- 1980's - Operational Satellite for SST; Tropical Ocean Global Atmosphere Experiment; First successful El Nino forecast; operational ocean analyses
- 1990's - World Ocean Circulation Experiment; Topex/Poseidon; eddy-resolving models; Complex model El Nino forecasts; Climate change simulations; ...
- 2000+: Our decade: GODAE/operational oceanography, ..



# Persective 1

- **Our knowledge of ocean dynamics and, to a lesser extent, physics provides a sound basis for developing models and data assimilation**

# Meteorologists have been here too ...



# Plan for US participation in The Global Atmospheric Research Program

Charney et al. 1969

“It is estimated that the data requirements of computer models are met for only 20 per cent of the earth’s surface. Vast oceanic regions remain unobserved... the earth-orbiting satellite affords the opportunity of developing an economically feasible global observing capability.”



# The First GARP Global Experiment

- The goals of GARP were effectively:

- a) deterministic weather forecasting;
- b) understanding climate

**Ocean prediction**  
**Understand, predict**  
**climate**

- *FGGE Goals (circa 1978)*

- ❖ Development of more realistic models for extended range forecasting, general circulation studies, and climate.
- ❖ To assess the ultimate limit of predictability of weather systems.
- ❖ To develop more powerful methods for assimilation of meteorological observations and, in particular, for using non-synchronous data...
- ❖ To design an optimum composite meteorological observing system for routine numerical weather prediction...

**Ocean models**

**Ocean predictability**

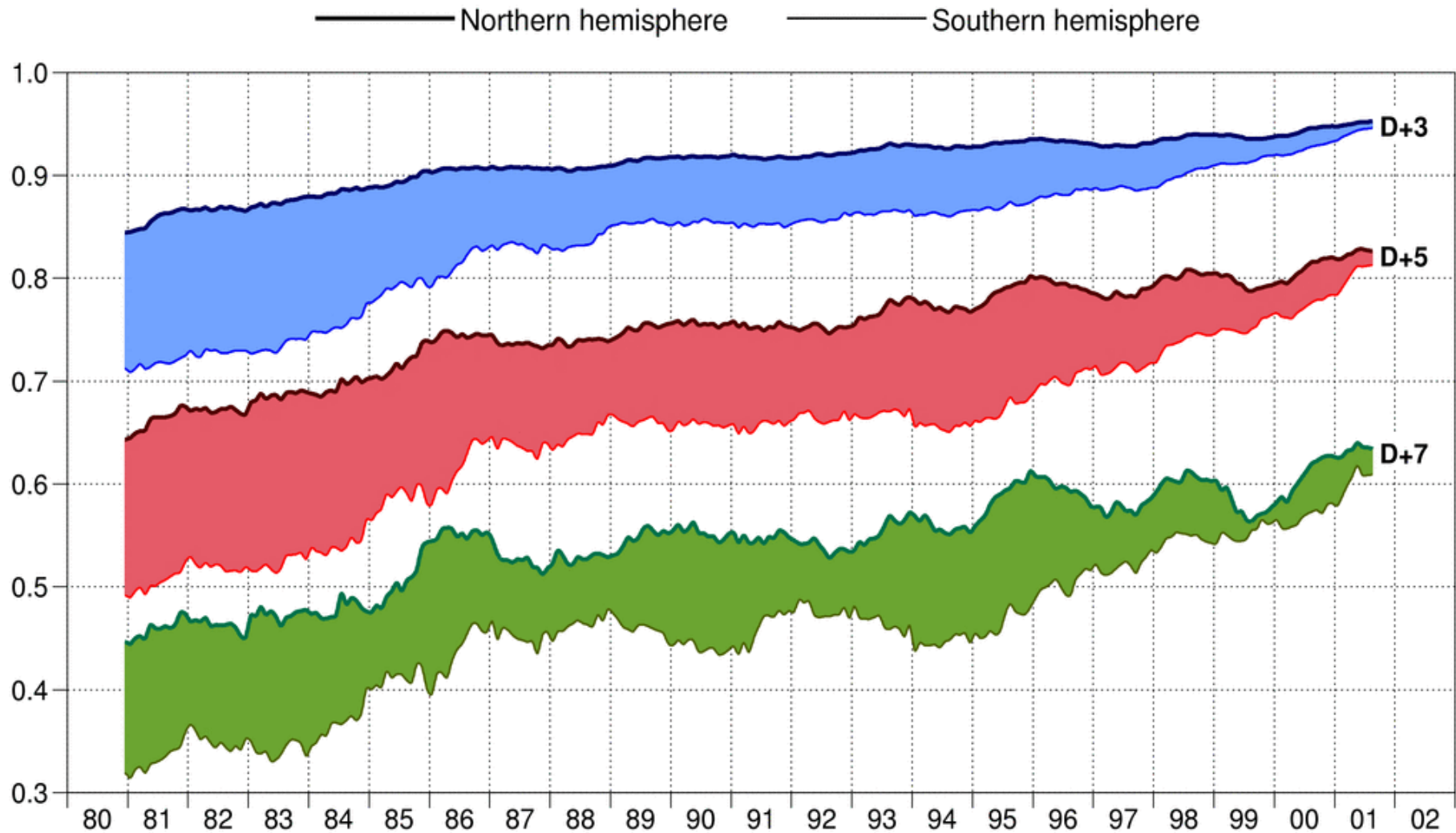
**Ocean assimilation**

**The observing**  
**system**



# Evolution of Forecast Skill for Northern and Southern Hemispheres

## Anomaly correlation of 500hPa height forecasts





## Perspective 2

- **We have a good model to follow in numerical weather prediction**
  - ❖ **But there are major differences in the operational model, and**
  - ❖ **We do not have a Global Ocean Research Program!**

**Question: Can the field of ocean assimilation and prediction progress without a coordinated ocean research program?**

GODAE



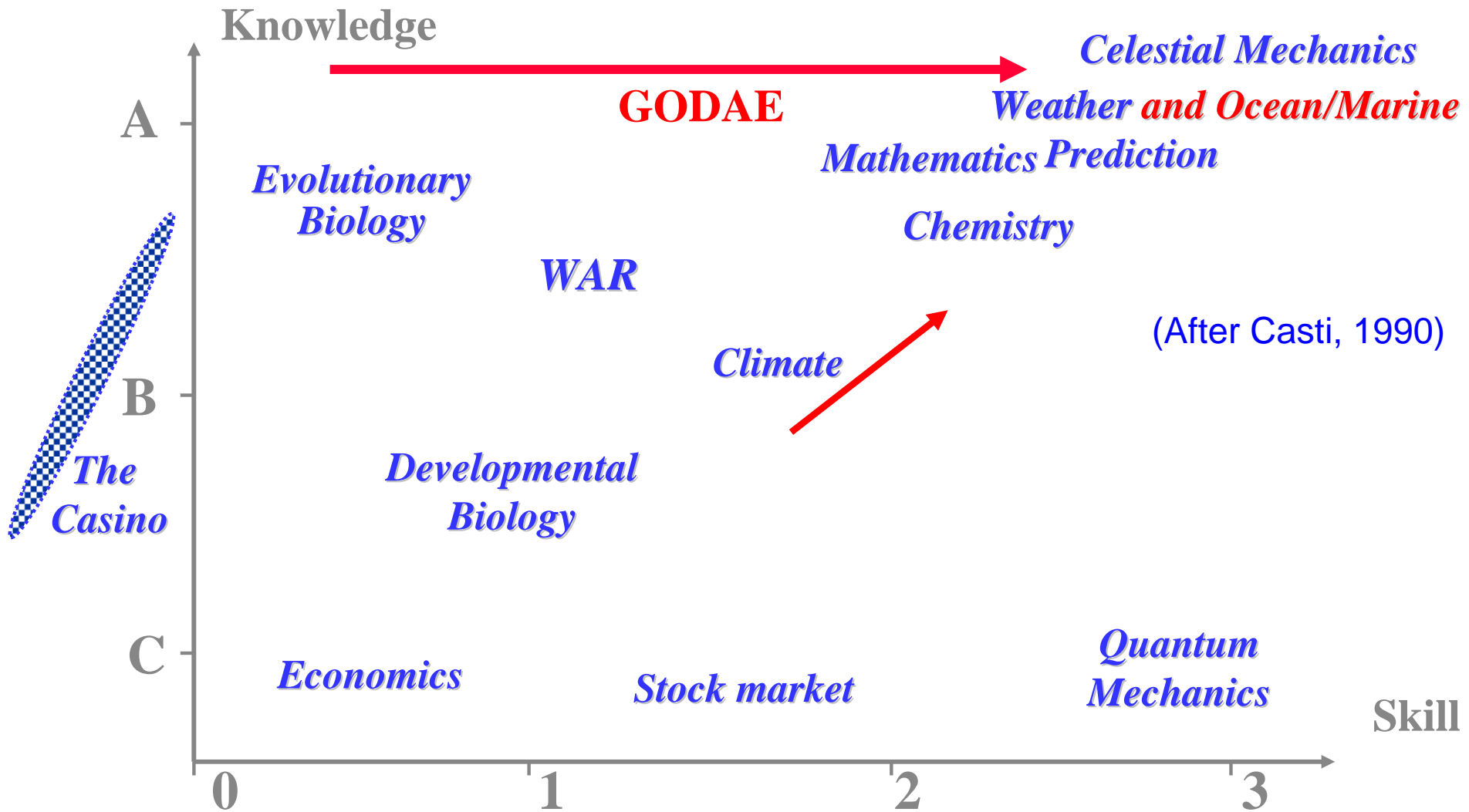
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# The Concept



# Inspiration 1 (circa 1997):

... Put oceanography on the map





# INTRODUCING GODAE

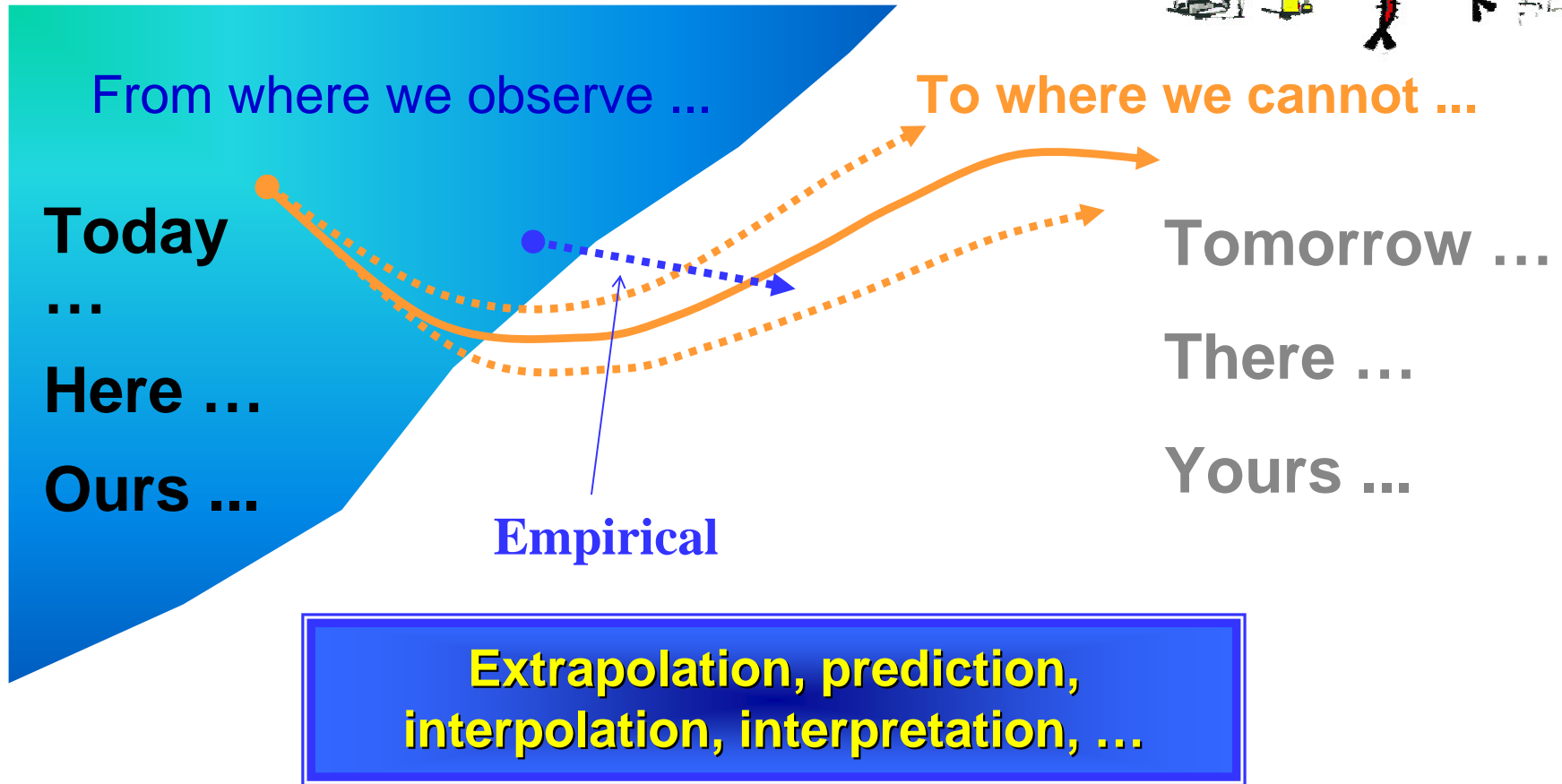
- ***The concept of a Global Ocean Data Assimilation Experiment (GODAE)***
  - ❖ A belief that the community was ready, and able, to do operational marine/ocean and climate prediction;
  - ❖ A belief that attracting the long-term resources necessary for an adequate long-term operational system depended upon a clear demonstration of the feasibility and value of such a system;
- ***FGGE/Numerical Weather Prediction as a model***
  - ❖ ***The relationship with Numerical Weather Prediction***
    - ***Our “big brother”***
- ***An experiment in which:***
  - ❖ ***a comprehensive, integrated observing system (GOOS) would be established and maintained for several years, with the data assimilated into state-of-the art models of the global ocean circulation in near real-time.***



# Why a Global Ocean Data Assimilation Experiment ?

- **Opportunity**
  - ❖ development and maturity of remote sensing and in-situ observing systems, making global real-time observation feasible
  - ❖ steady advances in scientific knowledge (e.g. TOGA, WOCE) and our ability to model the global ocean and assimilate data
  
- **Oceanic FGGE**
  - ❖ user demand for (global) ocean products for a variety of applications including scientific research
  - ❖ the future sustained, well supported ocean observing system requires a convincing demonstration of its utility
  
- **Timing**
  - ❖ 2003-2005: the demonstration of feasibility, practicality and utility
  - ❖ 2006-2007: post-operational assessment and consolidation

# A scientific perspective ...





# GODAE: the approach

**Objective:** To provide a practical demonstration of real-time **operational** global oceanography

- ❖ Regular comprehensive description of the ocean circulation at high temporal and spatial resolution
- ❖ Consistent with a suite of remote and in-situ measurements and appropriate dynamical and physical constraints

**Includes the main operational and research institutions from Australia, Japan, the United States, the United Kingdom, France, Norway, Europe**

**Main demonstration phase : 2003 to 2005 - Consolidation phase 2006 - 2007**

**Climate and seasonal forecasting, marine safety, fisheries, the offshore industry, Navy applications and management of shelf/coastal areas are among the expected beneficiaries of GODAE**

**The integrated description of the ocean that GODAE will provide will also be highly beneficial to the research community**





# Scientific and Technical Core

- **Sound scientific basis.**
  - ❖ **A strategy based on scientific best practice (GODAE 2000).**
- **Concept of a GODAE “Common”.**
  - **Assimilation products;**
  - **Data products;**
  - **Infrastructure;**
  - **The knowledge base accumulated through joint development, intercomparison experiments and other GODAE collaborations.**



## Perspective 3

- **The time was right (in the late 1990's) to move oceanography from a purely scientific endeavor to one where routine and regular observation gathering and prediction (operations, applications) would co-exist with ocean science**



# Perspectives 4

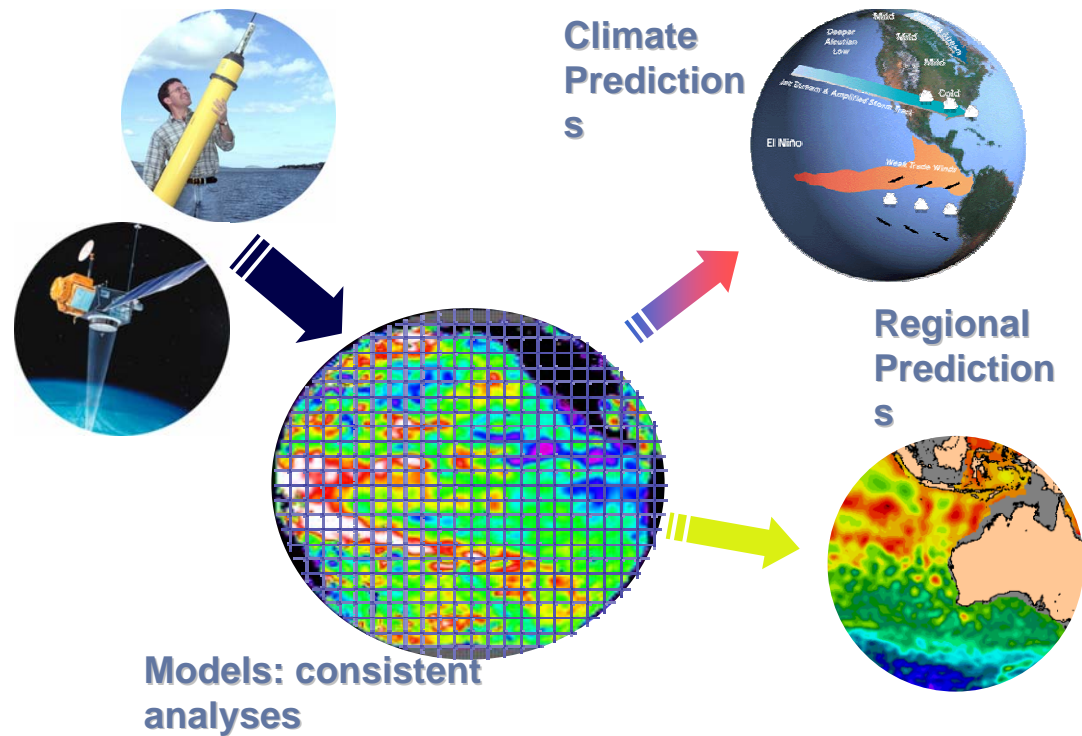
- **Believed we would have the need observation (but ...)**
- **Believed we had the scientific knowledge and models for assimilation**
- **Believed there was a user community ready and willing to exploit**



# Perspectives 5

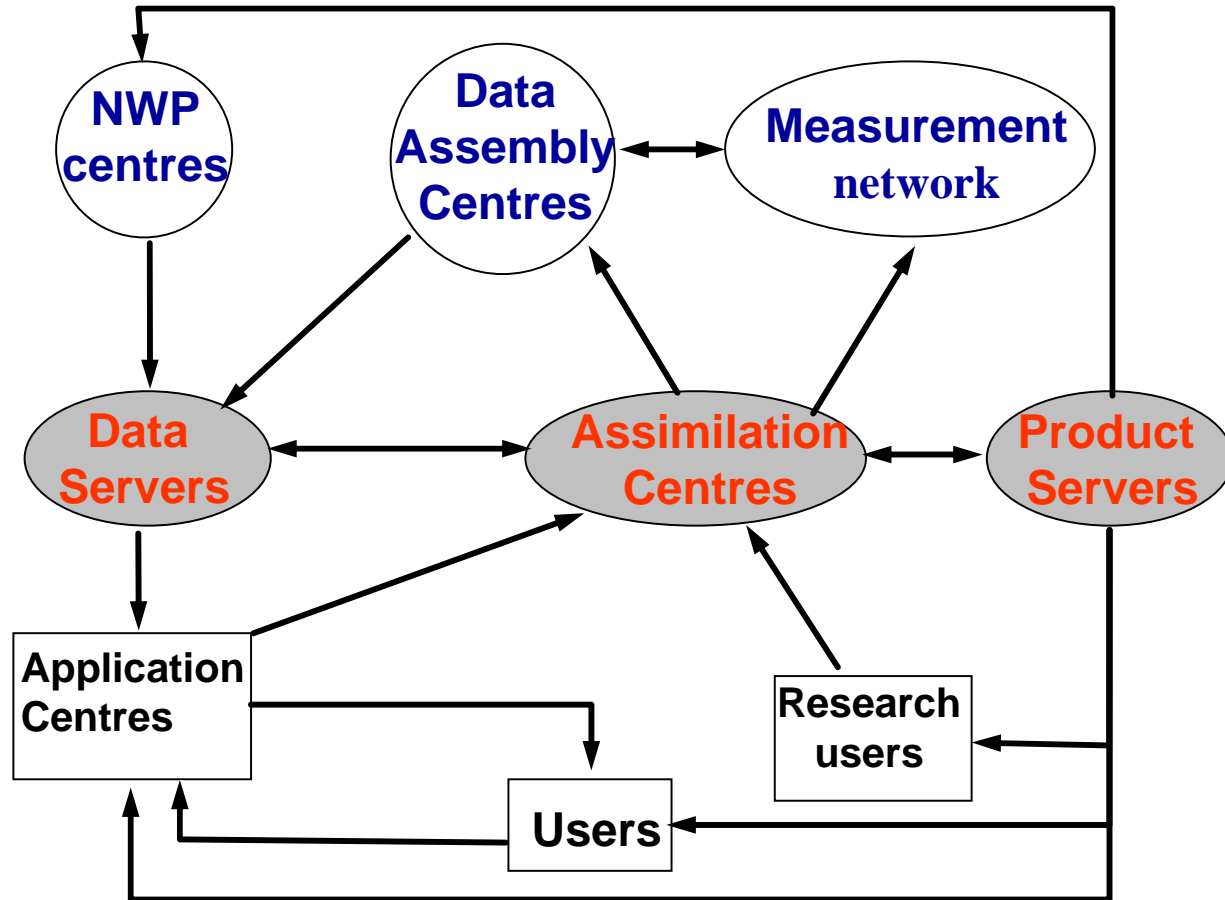
- **The GODAE Common concept is essential for GODAE, and must also be transported into the “operational” environment.**

# Building the Systems

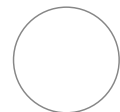




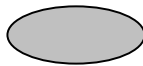
# Building these components



Legend:



Sources of input



GODAE common



Users of GODAE outputs



Flows of information



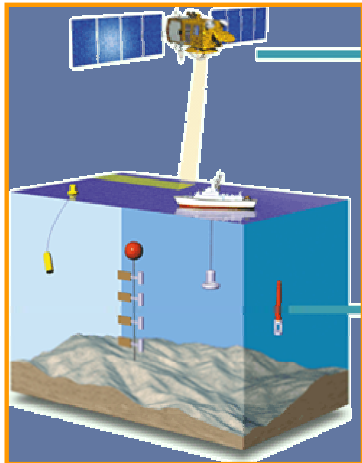
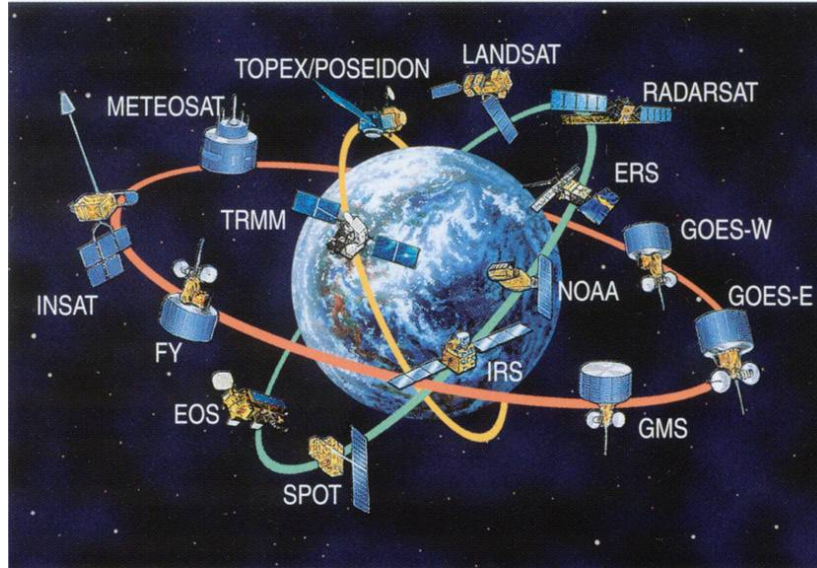
# Building the observational basis

See Robinson, Send, Pouliquen, Large, Rabier

- You can observe, but not understand.
- You cannot understand if you do not observe
  - ❖ Observations are needed to build and sustain the prediction systems
  - ❖ "We " will not truly benefit unless understanding is translated into the modelling context (parameterisations)

**Question: Can you do a prediction without observations? What does it represent?**

# The observing system





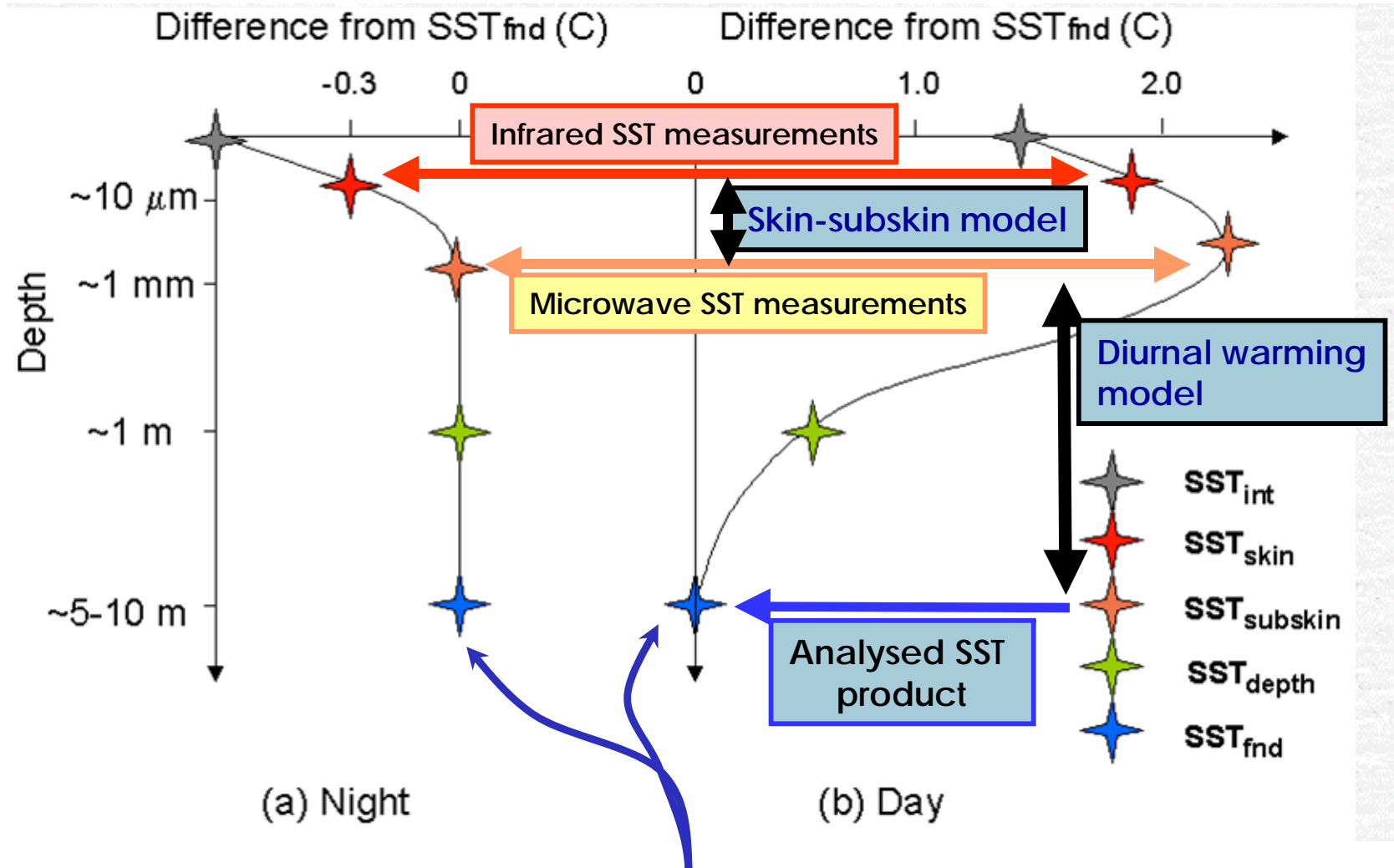


# High-resolution SST analysis



Gone from this ...

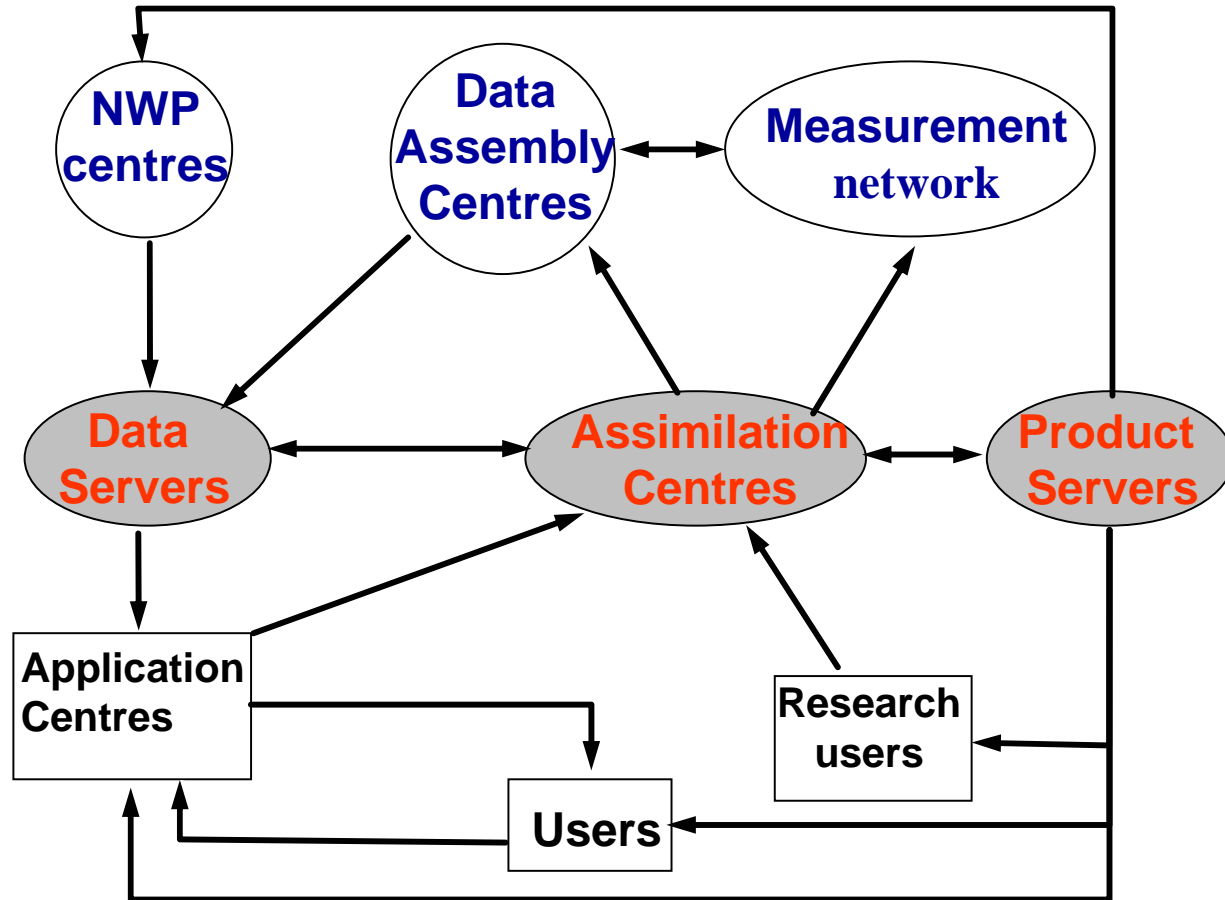
# High-resolution SST analysis



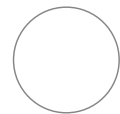
Presently estimate this



# The Observational Perspective



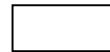
Legend:



Sources of input



GODAE common



Users of GODAE outputs



Flows of information



## Perspectives 6

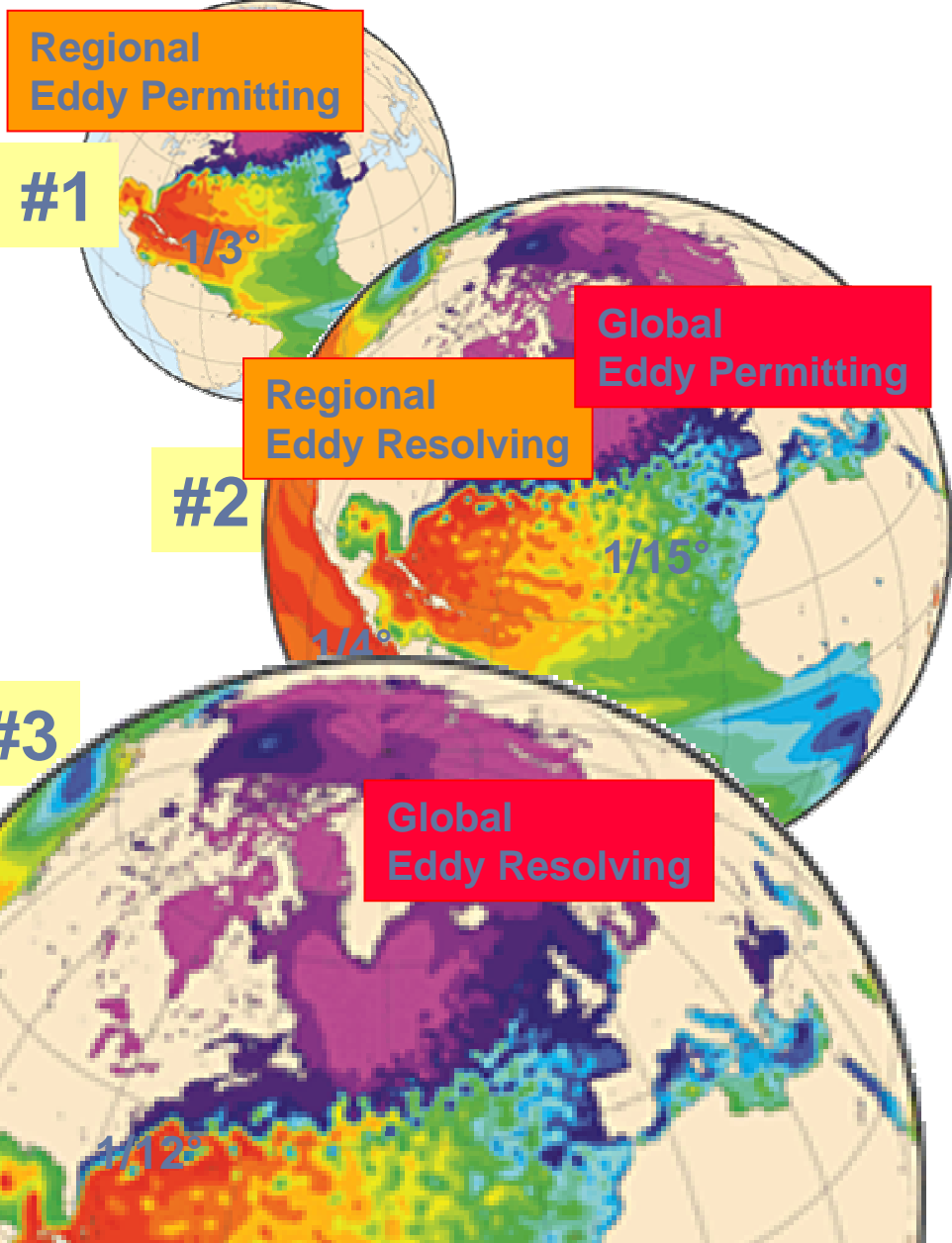
- With Argo, we are filling the (*in situ*) void identified with the concept of GODAE
- With the GODAE High-Resolution SST Project, we are satisfying our need, and that of others, for a better scientific product, at higher temporal and spatial resolution
- Many challenges remain ...
- **What are the appropriate experiments to demonstrate effect (or lack of)?**



# Building the modelling systems

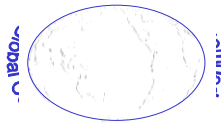
[See many other presentations]

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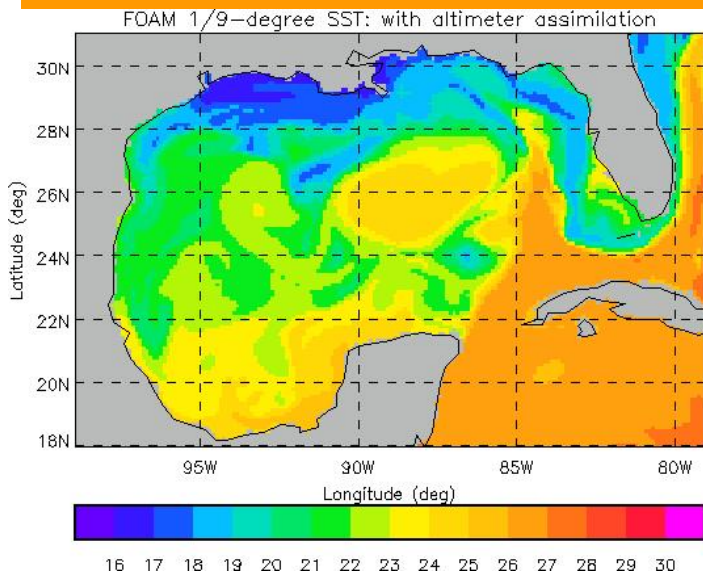
**Build an hierarchy of modelling systems**

From Pierre Bahurel and MERCATOR



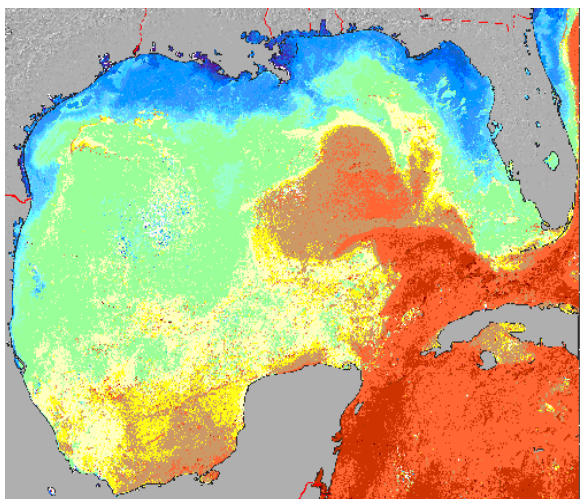
# Mesoscale monitoring and operational applications

Real-Time products, for basin scale (mesoscale) monitoring and downscaling to coastal. Requires real time high resolution and accurate observation (altimeter, ..).



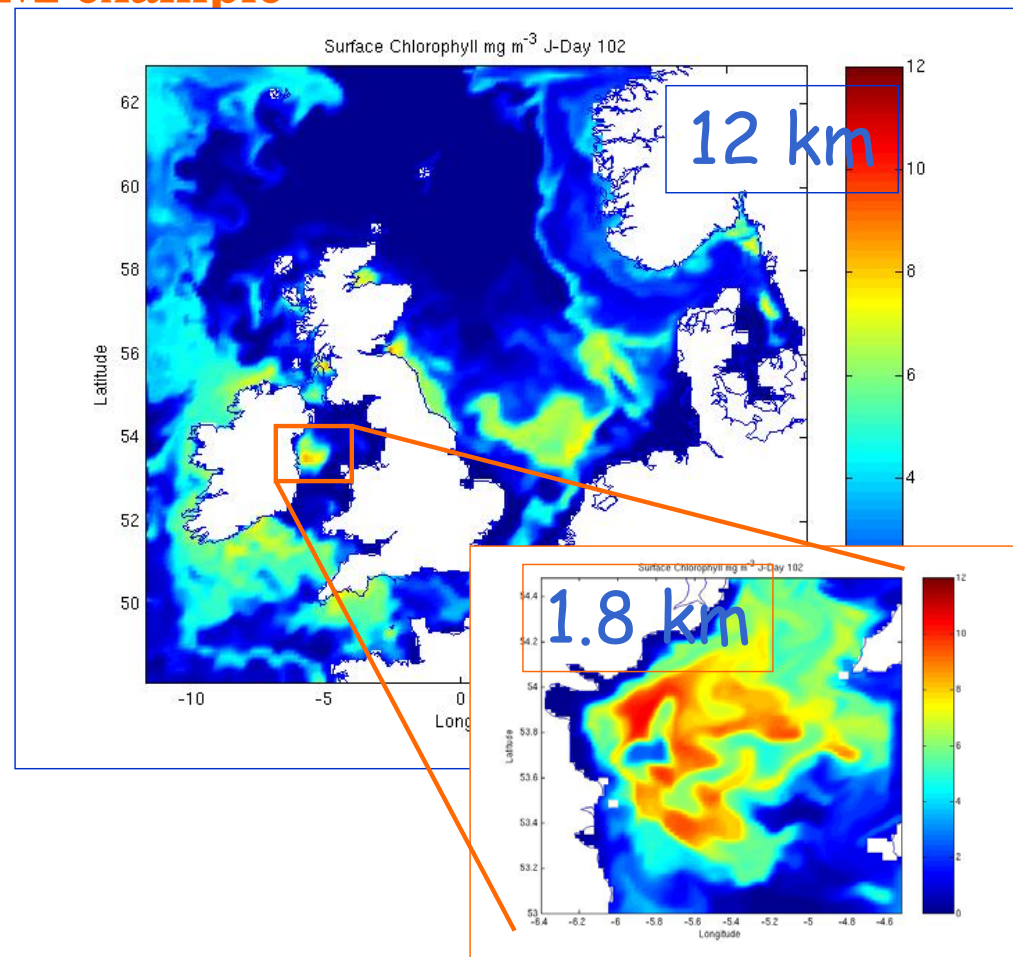
**1/9° FOAM with altimeter assimilation**

**Surface temperatures 14-19 March 1998**



**AVHRR data processed by JHU APL**

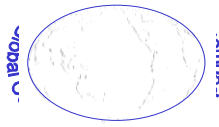
## FOAM example



**Coupling 12 km FOAM Atlantic model, to 1.8 km POLCOMM ecosystem model (EC Mersea Strand 1 result)**

*Courtesy of M. Bell and I. Allen*

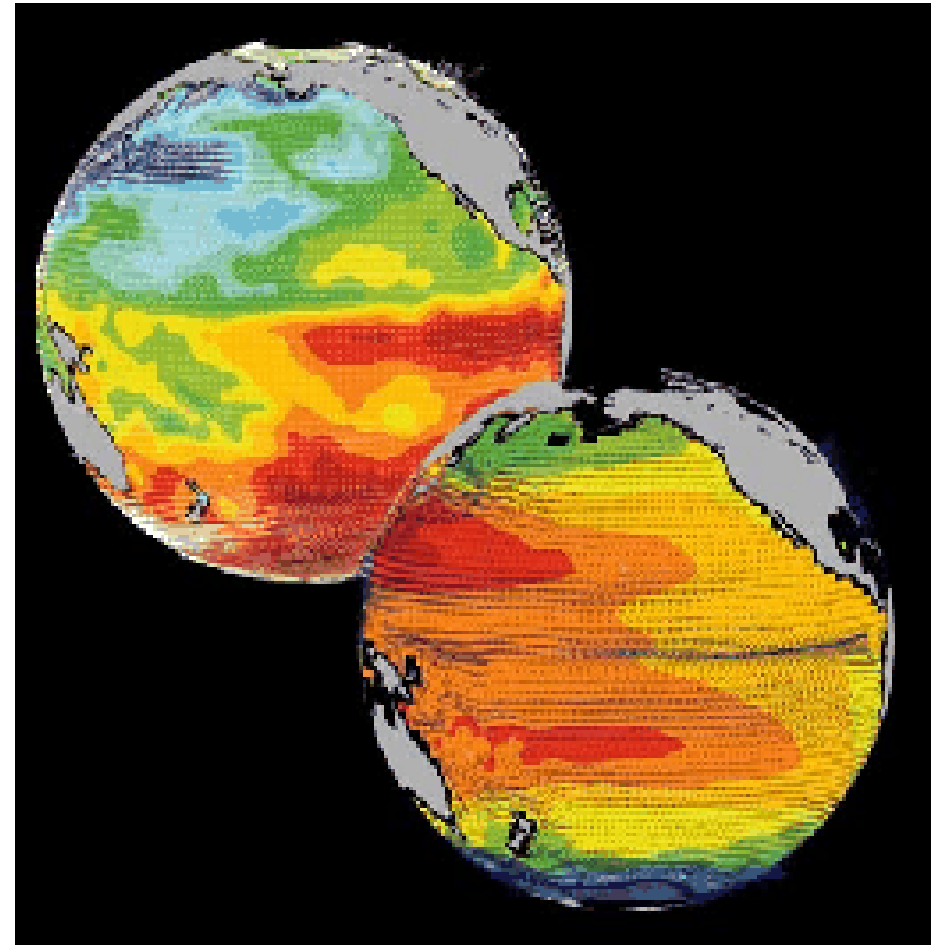
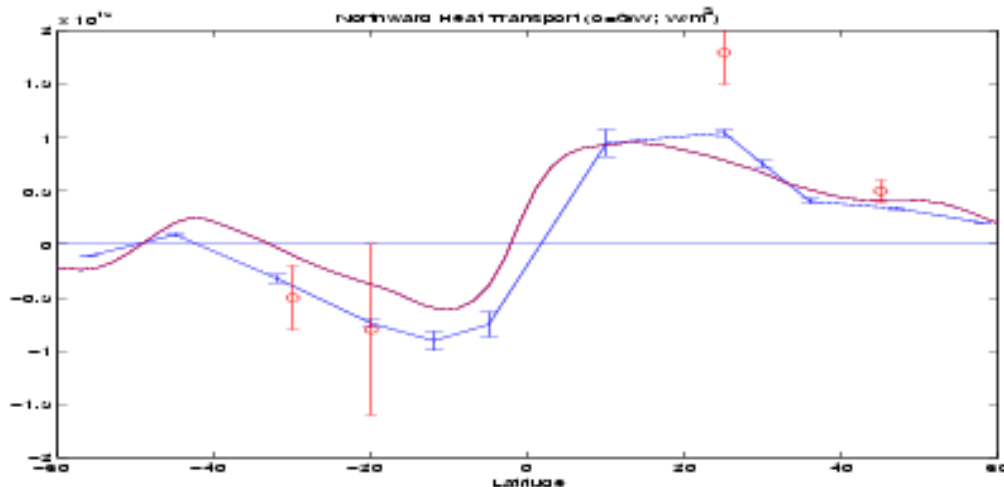
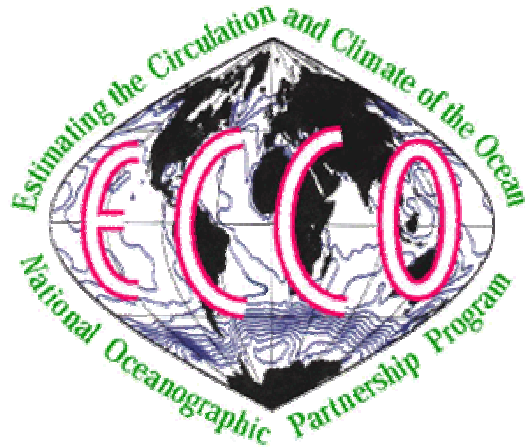




# Ocean climate monitoring and research applications

High emphasis on quality and coherence (self-consistent estimates of  $u$ ,  $T$ ,  $S$ ) over the full ocean depth (and global ocean)

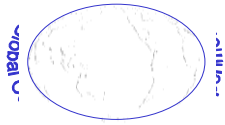
## ECCO example



Northward Heat Flux from assimilated ECCO fields

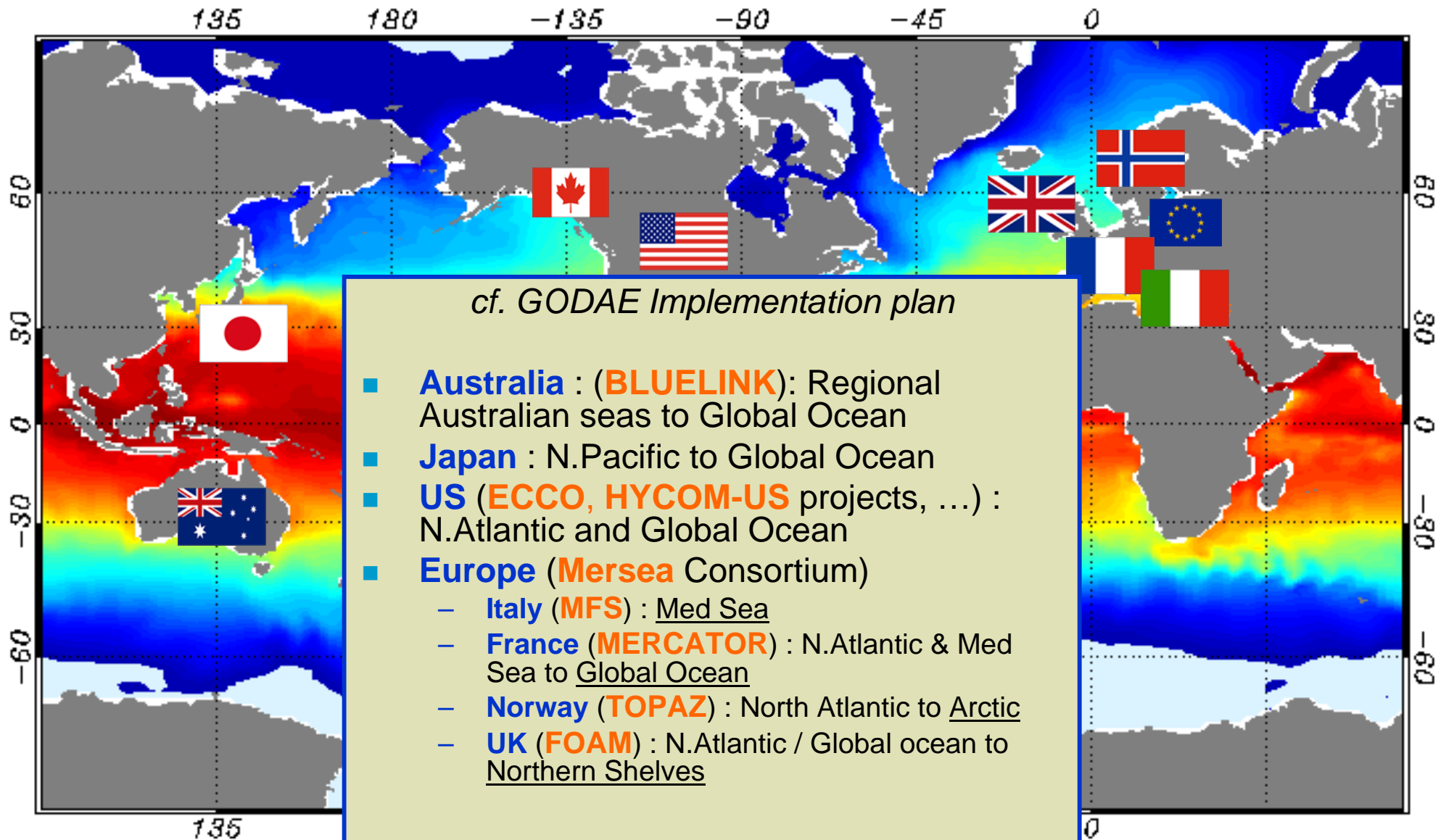
*Courtesy of D. Stammer*





# GODAE Modelling/Assimilation Centers

initialised temperature : T on 16-06-2004 near 0 m





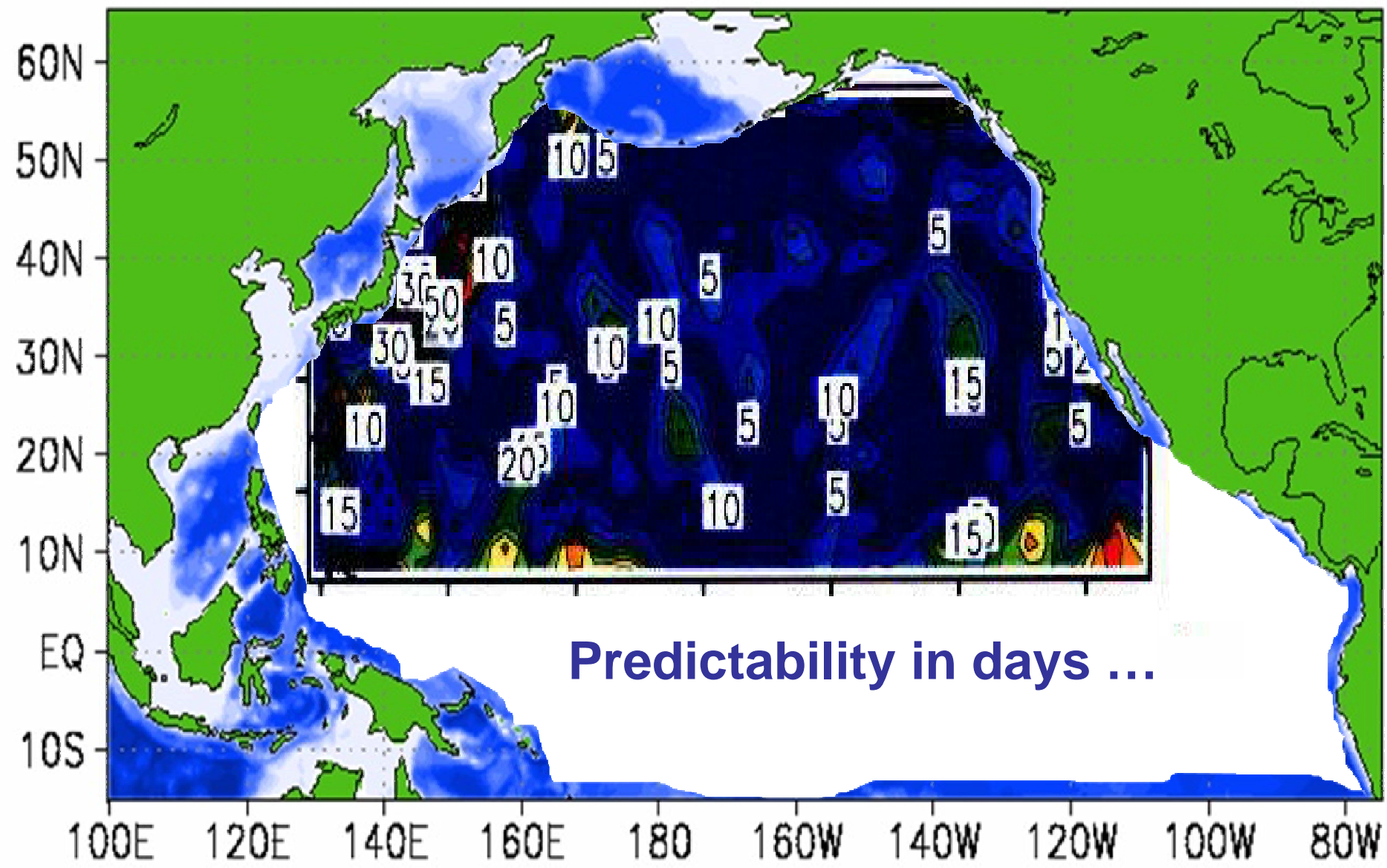


# Perspectives 7: Modelling

- **Global high resolution ocean models remains central target**
  - ❖ **Regional prototypes for learning, then for applications**
  - ❖ **Sector-specific prototypes (e.g., global climate)**
- **Many model and assimilation challenges, but prospects are good**



# We know little about the levels of predictability in the ocean itself ...





## Perspective 8:

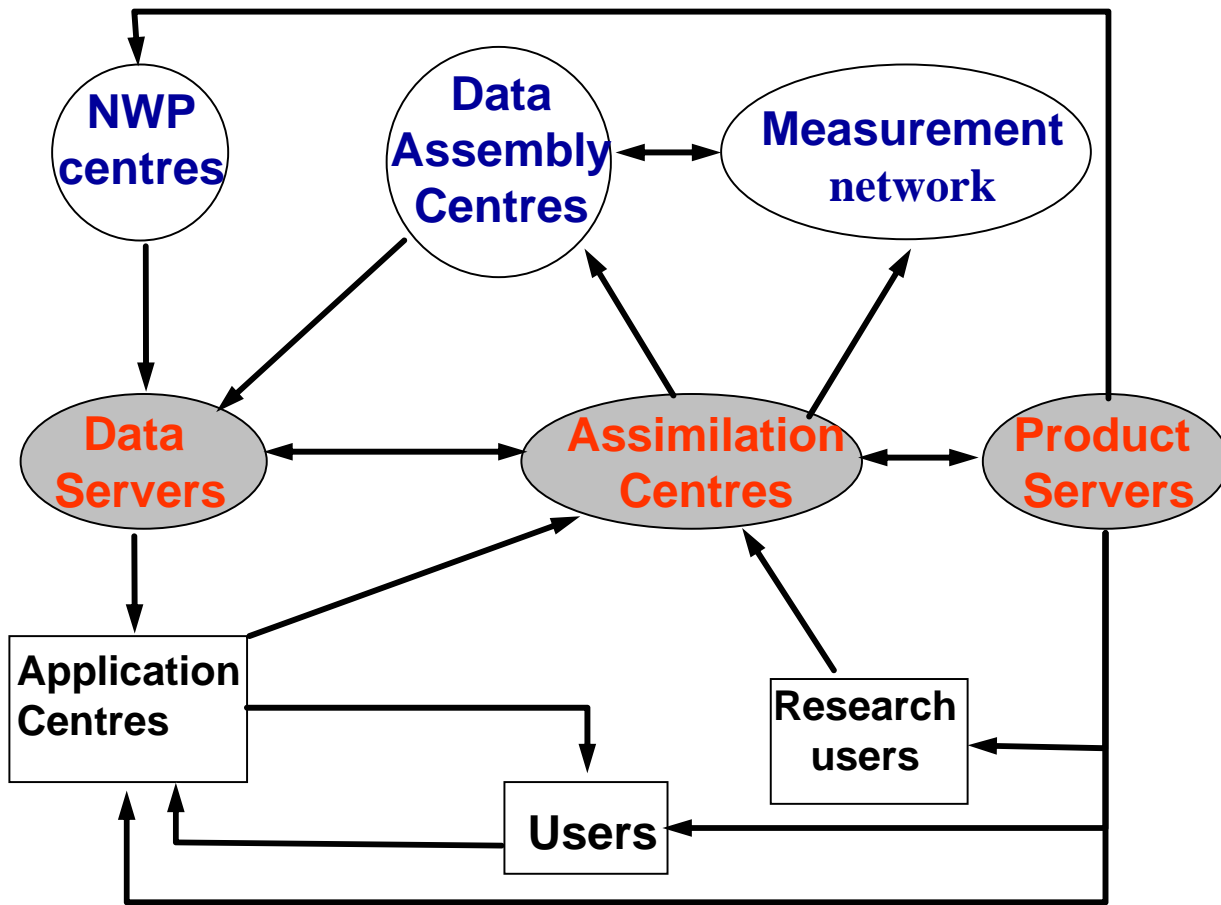
- The oceans are predictable ...

but when and where, and for how long?

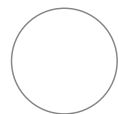
- What are the dependencies? Data?  
F=ma? Models? Assimilation? Other?



# Added Assimilation Centre Perspective



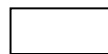
Legend:



Sources of input



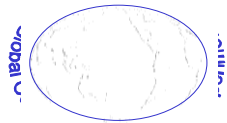
GODAE common



Users of GODAE outputs



Flows of information



# Data and Product Servers (thanks to P. Bahurel)

MFS

Live Access to Data - Microsoft Internet Explorer

Fichier Edition Affichage Favoris Outils ?

Précédente Recherche Favoris Média

Adresse [http://las.mersea.eu.org/las/servlets/constrain\\_compare?var=188](http://las.mersea.eu.org/las/servlets/constrain_compare?var=188)

**MERSEA** Live Access Server

single data set compare two

1: Datasets > MEDITERRANEAN SEA > MERCATOR > Merc  
1: Variable(s): Sea water potential temperature (deg C)  
2: Datasets > MEDITERRANEAN SEA > MFS > MFS SY2 bes  
2: Variable(s): Sea water potential temperature (deg C)

Select your desired view (geometry of output) and out (lon-lat-depth-time) and any :

Select view: xy (lat/lon) slice

Select output: Comparison plot (GIF)

Select region: Full Region

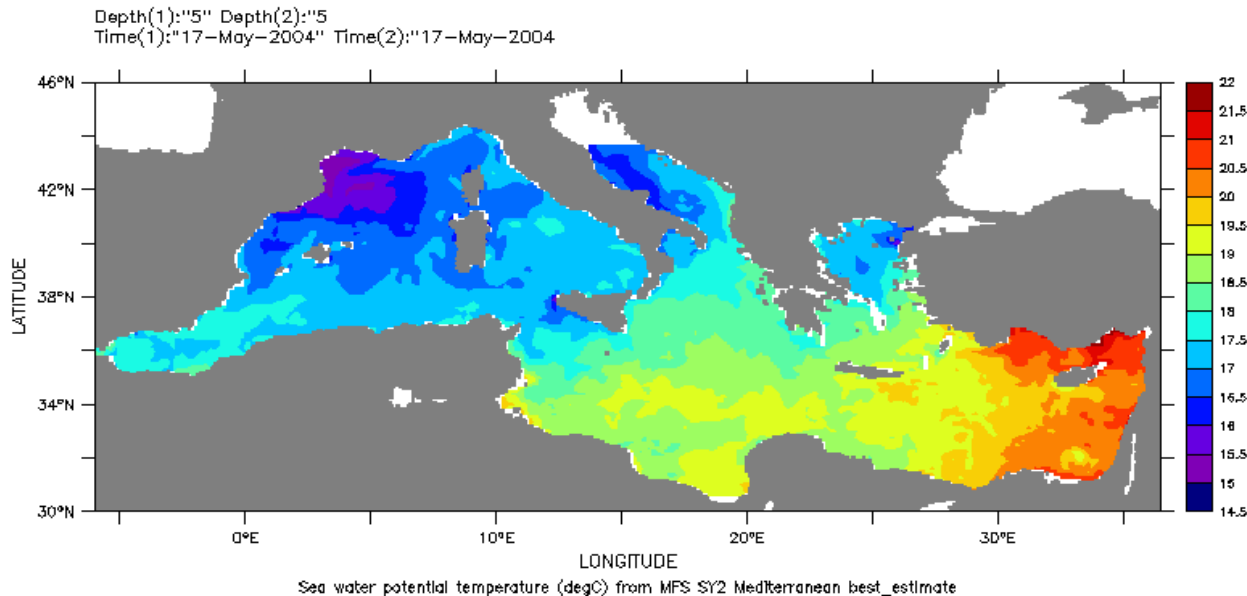
Select time for first variable: 17-May-2004

Select depth for first variable: 5

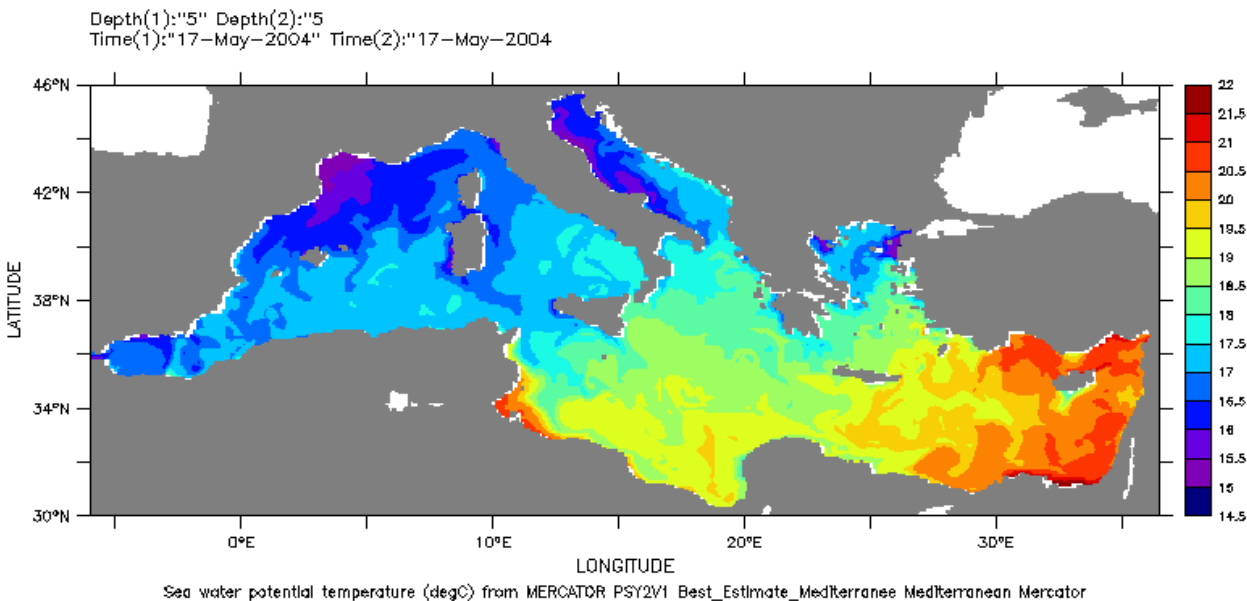
Select time for second variable: 17-May-2004

Select depth for second variable: 5

Get output for selected variable

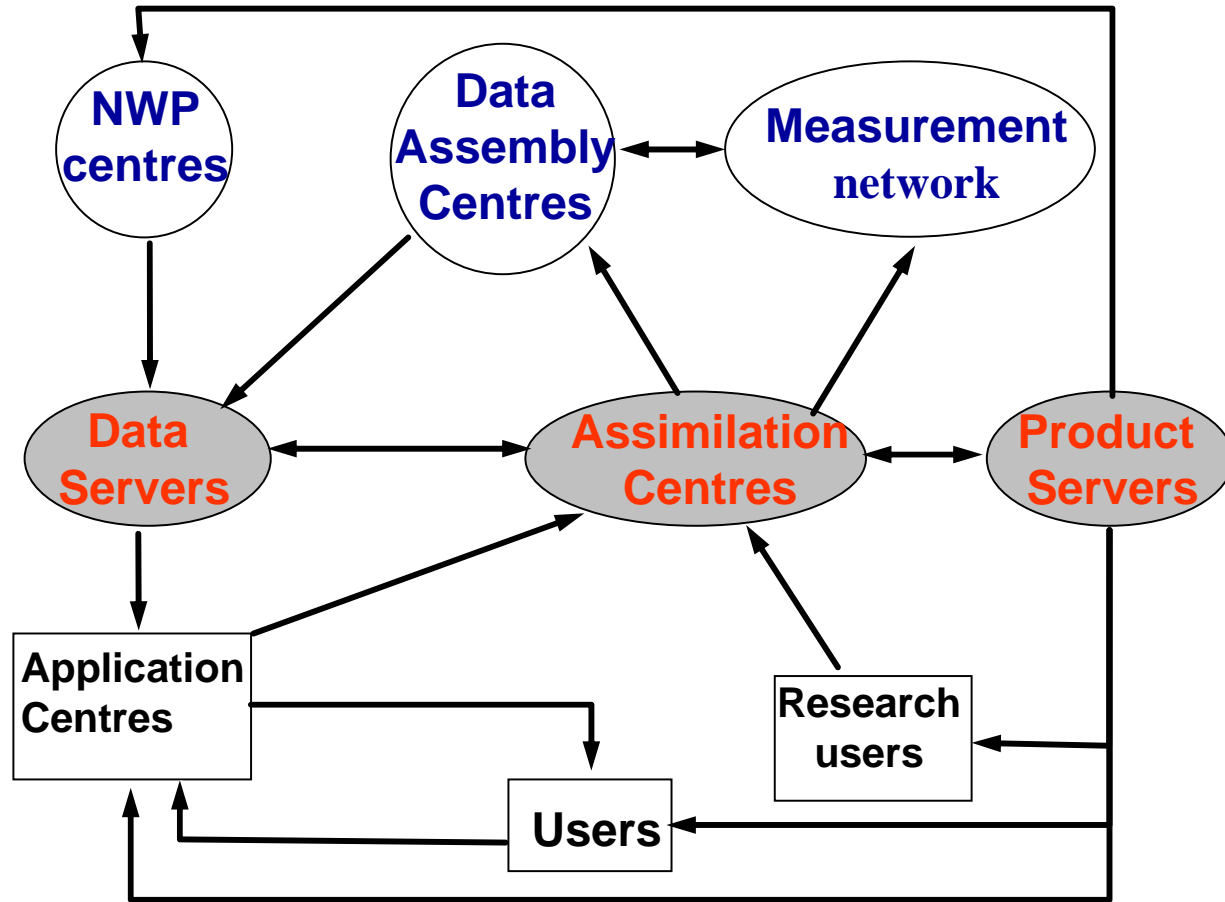


MERCATOR

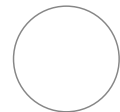




# Adding Server Perspective



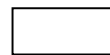
Legend:



Sources of input



GODAE common



Users of GODAE outputs



Flows of information



# Perspectives 9

- **The real impact of GODAE will come through its ability to bring its complex information to applications and users.**



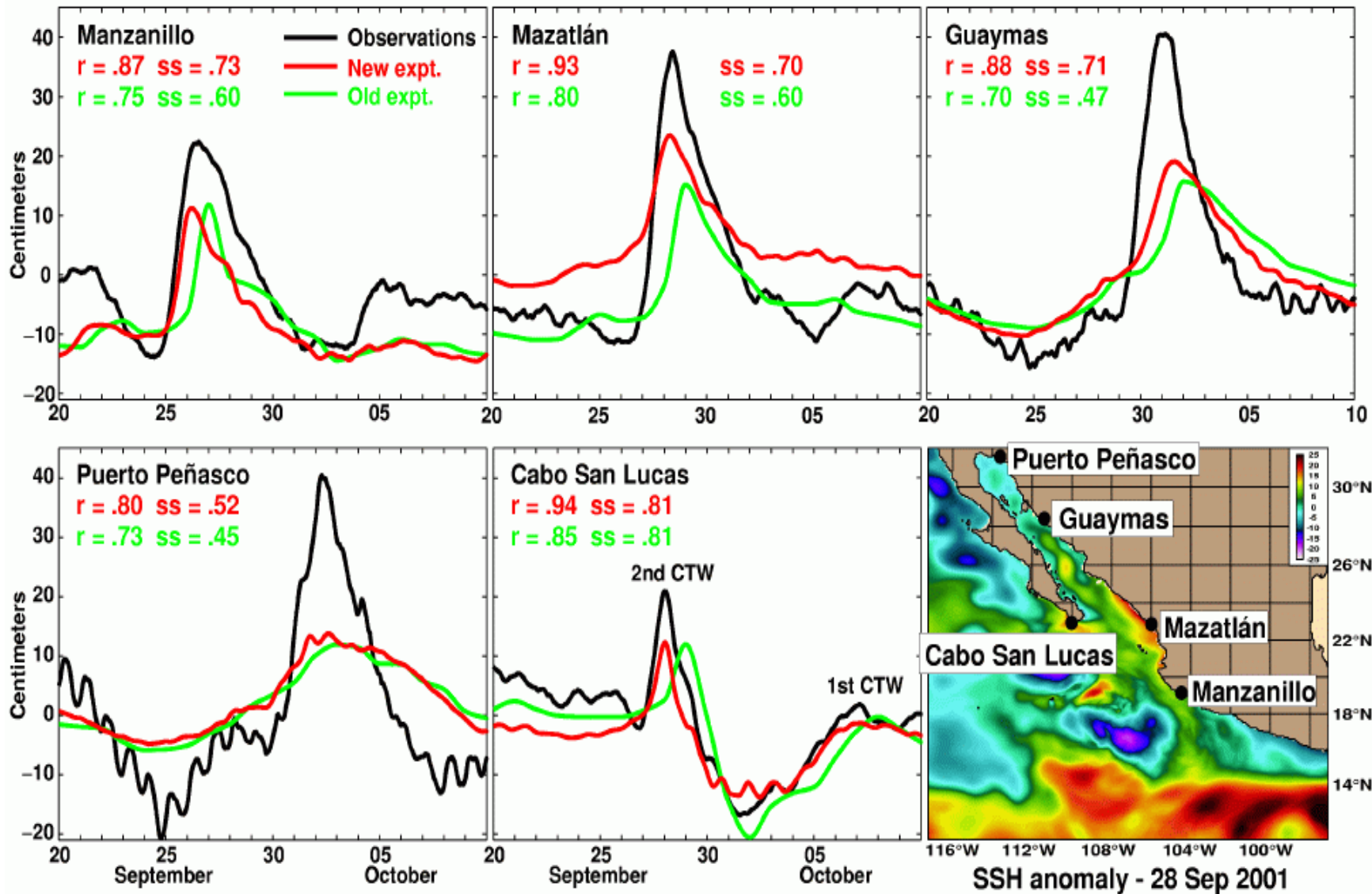
# Applications

- Reanalysis (marine environment, climate)
- Short-range ocean prediction
- Seasonal-to-interannual prediction
- Medium to long-term climate
- Coastal prediction and marine ecosystems
- Research
- **What is the role of research in operational oceanography, and vice versa?**



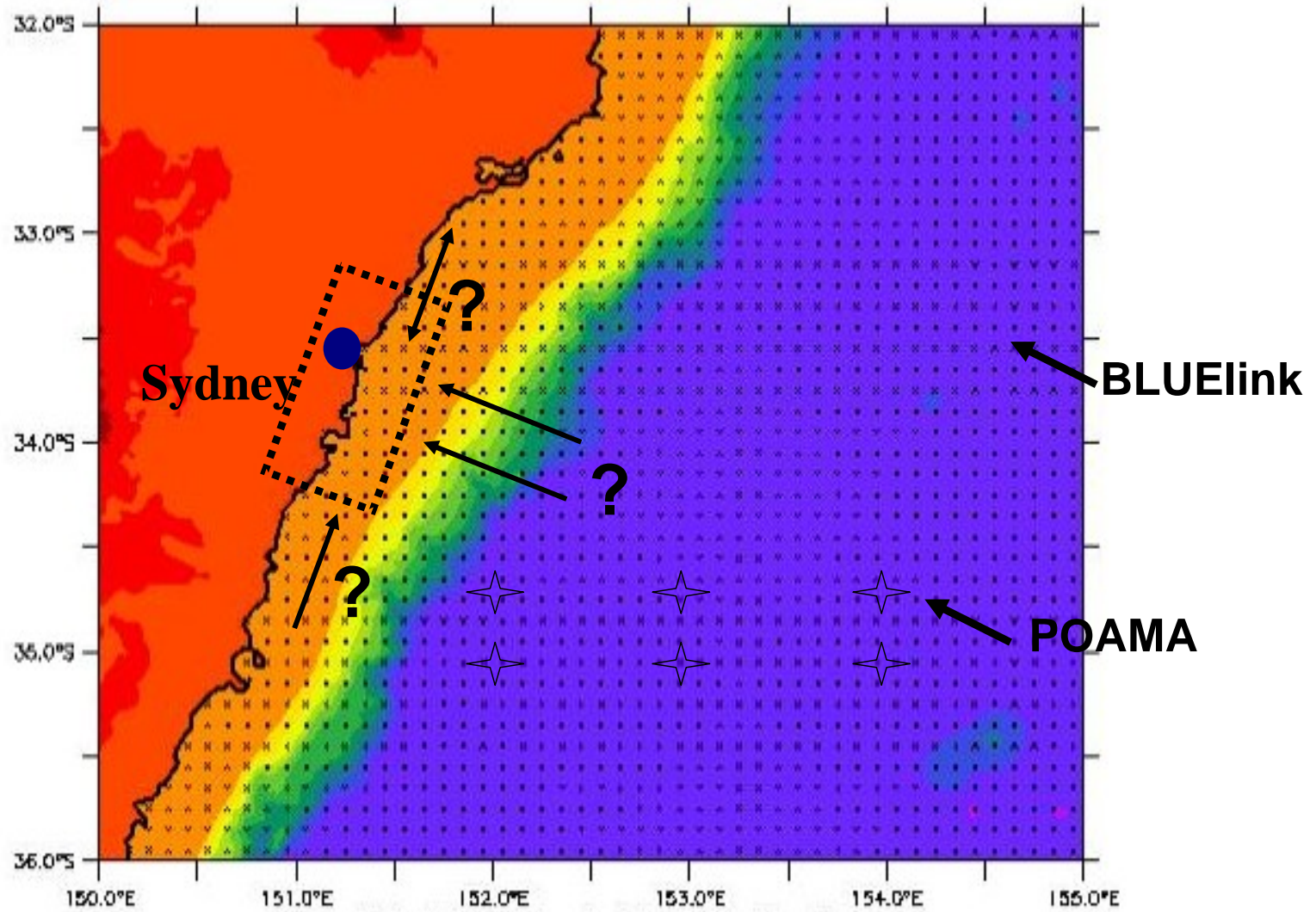


# Taking the models "down-scale"

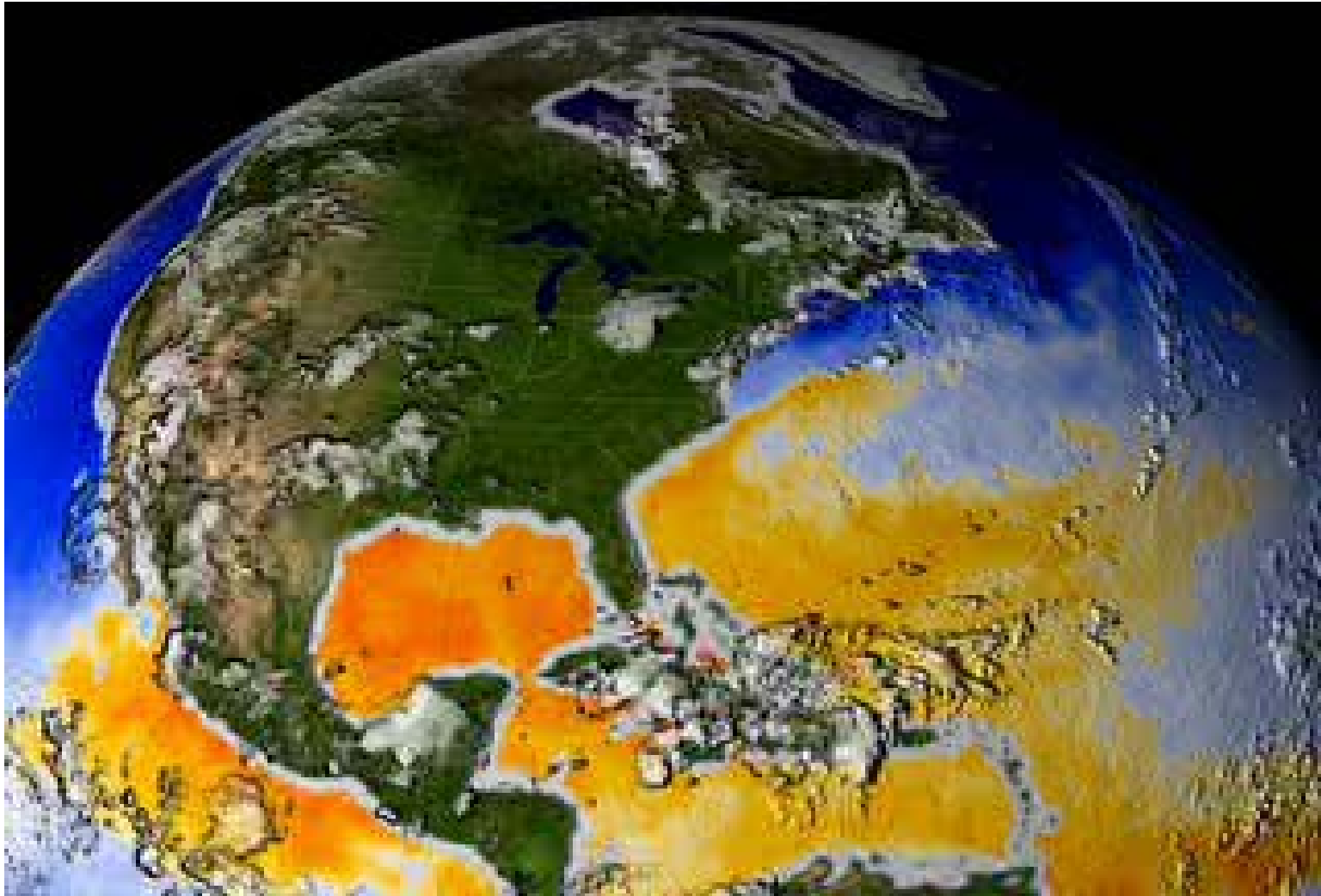


Courtesy H. Hurlburt

# How dependent are regional ocean or coupled systems on the outer BCs (from climate or ocean models)?



# Fabian and Isabel (Aug 03)





# Many scientific questions ...

- **Will accurate surface current predictions and simulations prove as elusive as atmospheric fluxes and winds?**
- **To what extent can we “predict” subsurface currents?**
- **Will we always be slave to the errors of (un-named) others?** [Wait for Bill Large presentation]
- **How well can we “predict” boundary conditions?**

**How much does it matter when we get it right?**



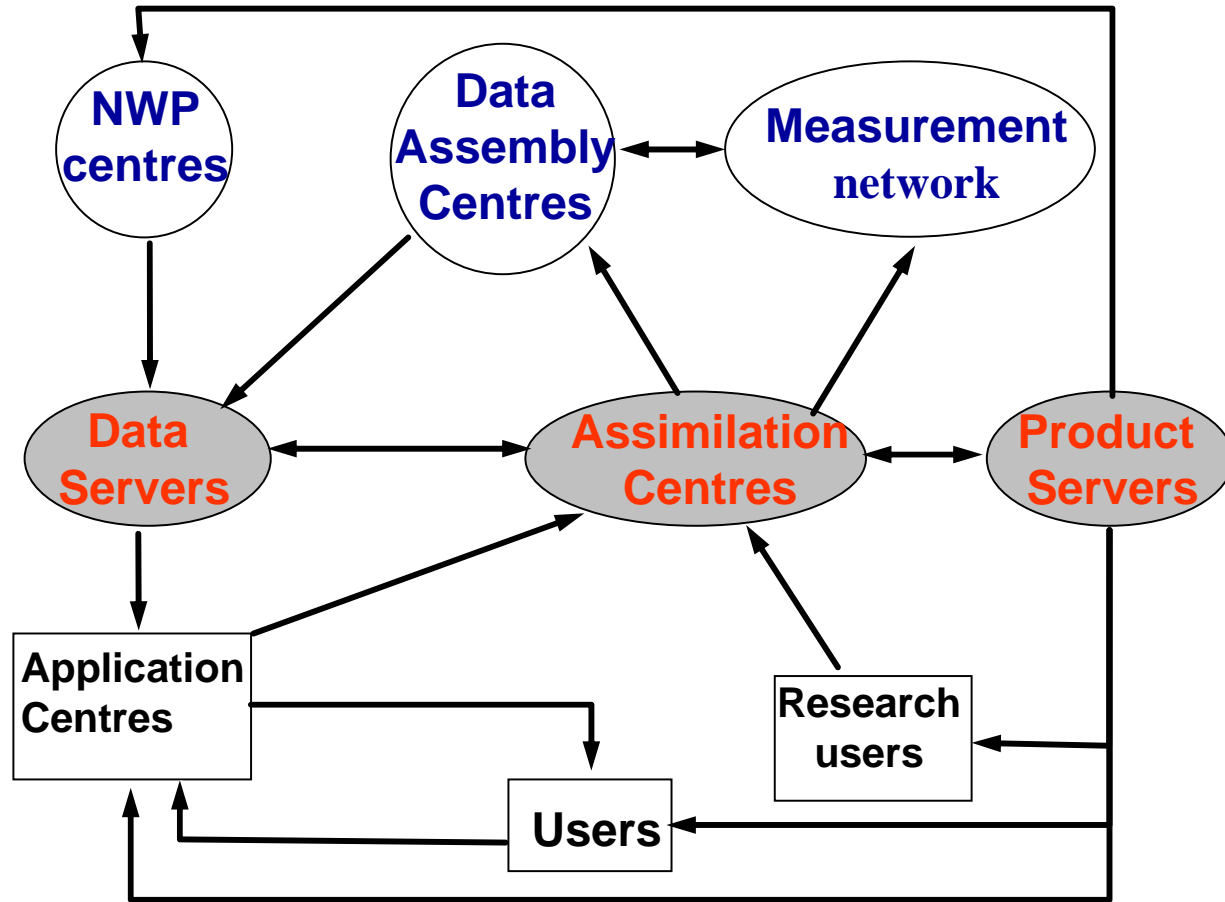
# A balanced approach ...

## Questions to ponder

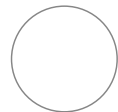
- **What is the rationale for global high-resolution modelling systems? E.g., why should Australia care about the Atlantic?**
- **What does “operational” mean for models and data assimilation?**



# Adding the Application Perspective



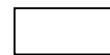
Legend:



Sources of input



GODAE common



Users of GODAE outputs



Flows of information



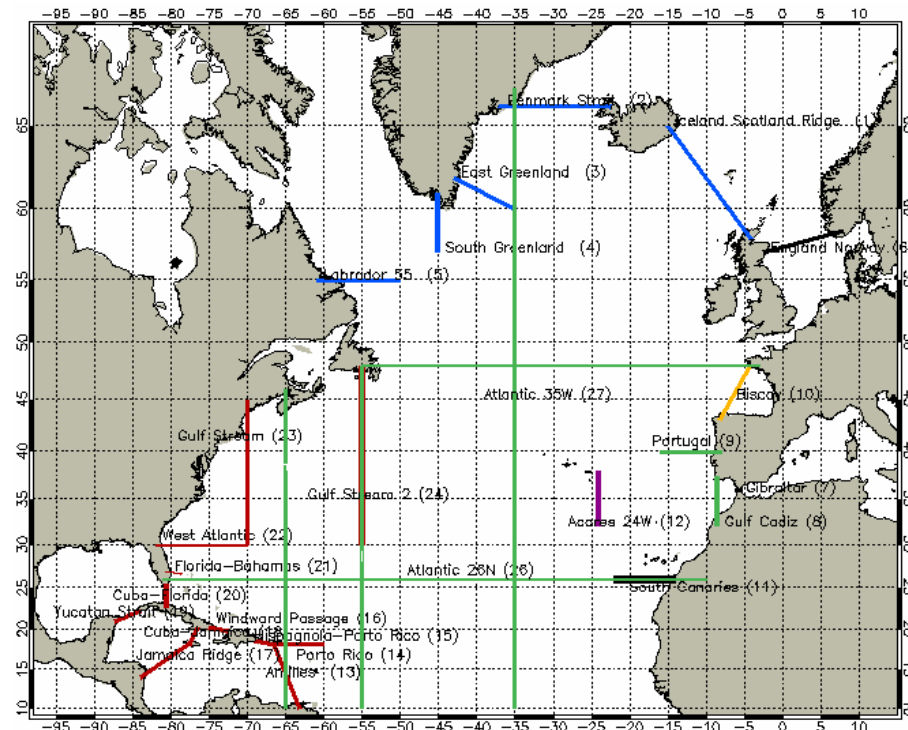
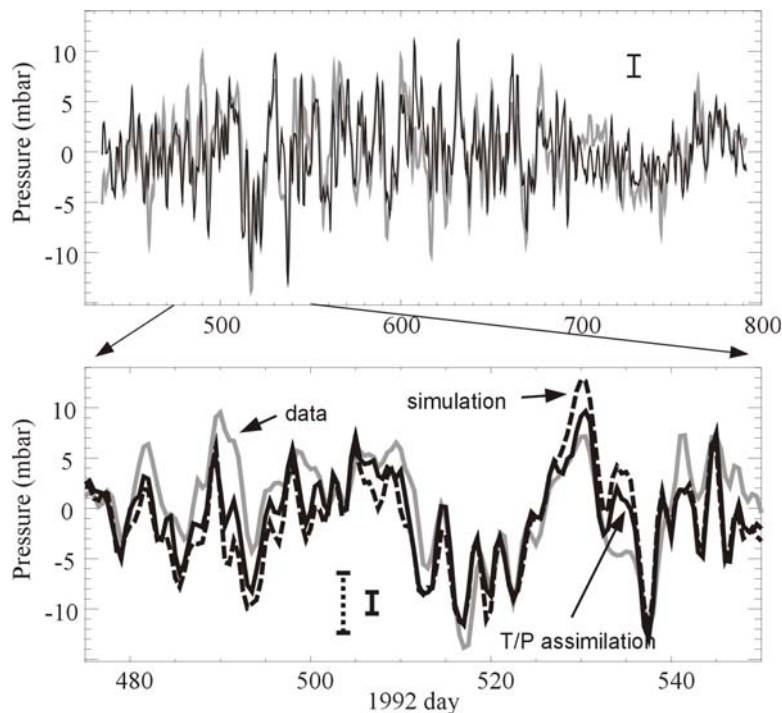
# “Internal” Assessment

- **As scientists we need to set standards for data and products that are testable and defensible**



# Evaluation – « metrics »

- Definition of common metrics (model and assimilation)
- Agree on common formats/grids and fields to be compare
- Use of Live Access Server to facilitate the intercomparison,
- EC “MERSEA Strand 1” pilot project with prototype systems (North Atlantic and Med Sea)





# Systematic InterComparisons

(From Mersea Strand 1 – Le Provost, Crosnier, Blanc, Bahurel, ...)



DODS Directory – Netscape

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop http://www.sincem.unibo.it:80 Search Print

Mail Home Radio Netscape Search Bookmarks

## DODS Directory for: THREDDS/DODS Aggregation/Catalog Server

- Test DODS Aggregation Server Catalog Top-level
  - Bathymetry: [DDS DAS Information Data Request Form](#)
  - Mediterranean Climatological Data: [DDS DAS Information Data Request Form](#)
  - Profile Best Estimate Data: [DDS DAS Information Data Request Form](#)
  - Profile sixth forecast day Data: [DDS DAS Information Data Request Form](#)
  - MFS Best Estimate: [DDS DAS Information Data Request Form](#)
  - MFS sixth forecast day: [DDS DAS Information Data Request Form](#)
  - Best Estimate XBT Section 1: [DDS DAS Information Data Request Form](#)
  - Best Estimate XBT Section 2: [DDS DAS Information Data Request Form](#)
  - Best Estimate XBT Section 3: [DDS DAS Information Data Request Form](#)
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Microsoft Internet Explorer

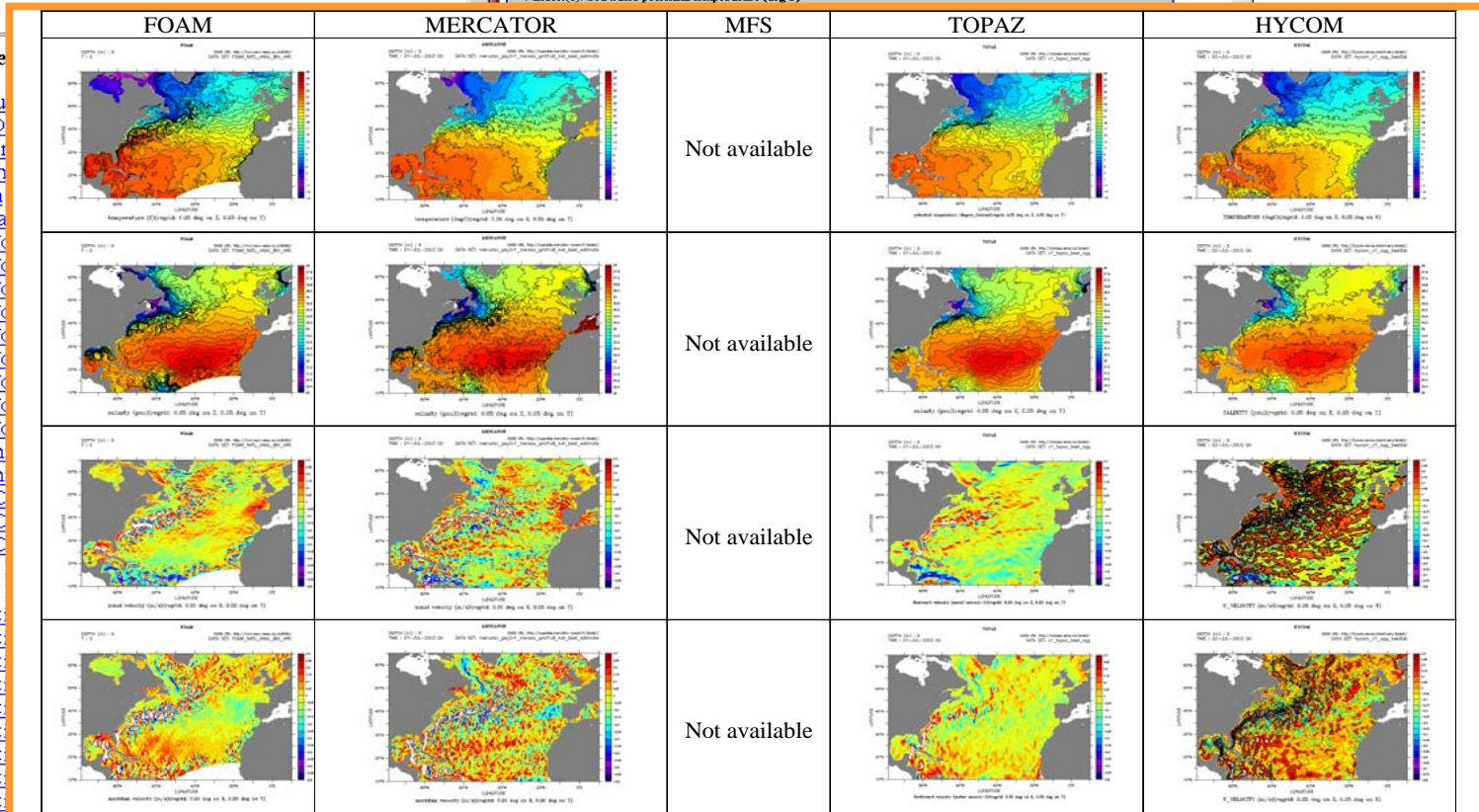
ba.eu.org/las/services/constrain?var=755

Live Access Server

Search dataset/variable:  Go

Datasets > MEDITERRANEAN > MFS > MFS.SYZ.best.estimate.time.series

Variable(s): Sea water potential temperature (degC)



The North Atlantic Case

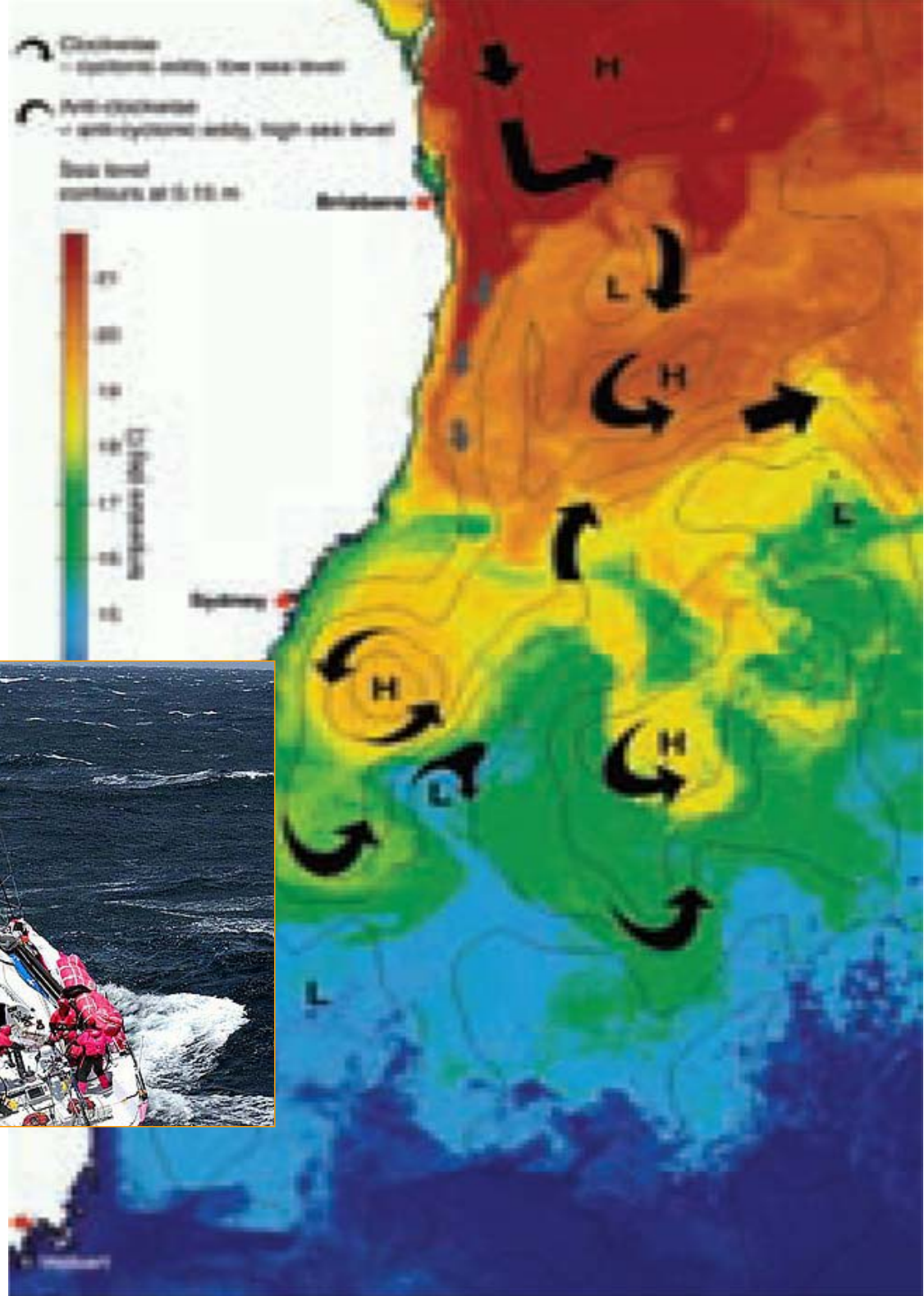


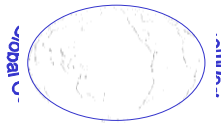
# Perspectives 10

- **Implementing a rigorous system of internal tests and intercomparisons in order to evaluate systems and to set standards.**
- **We need to foster the development of international infrastructure, and national infrastructure, to support and monitor the performance of these systems.**



Can this be captured in a model? In a prediction?

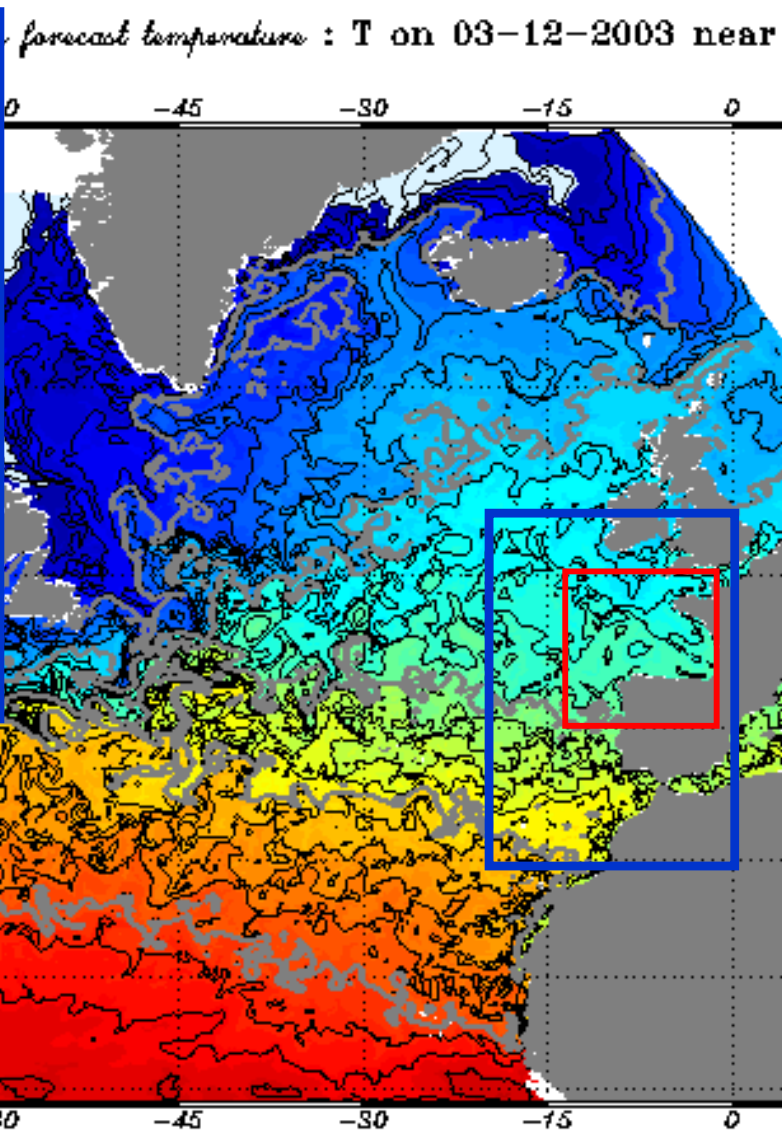
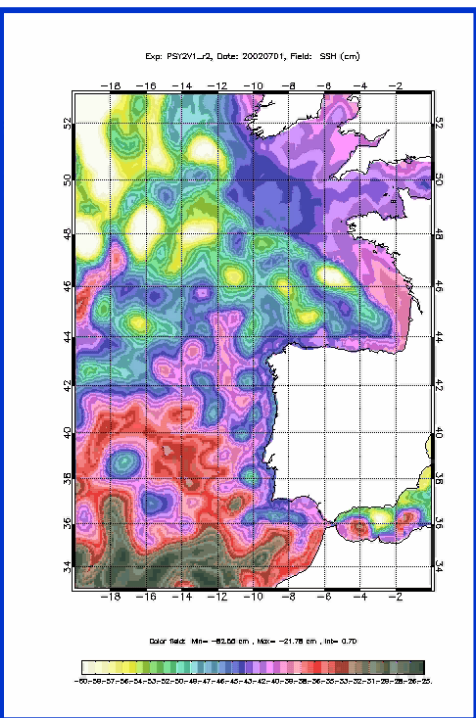




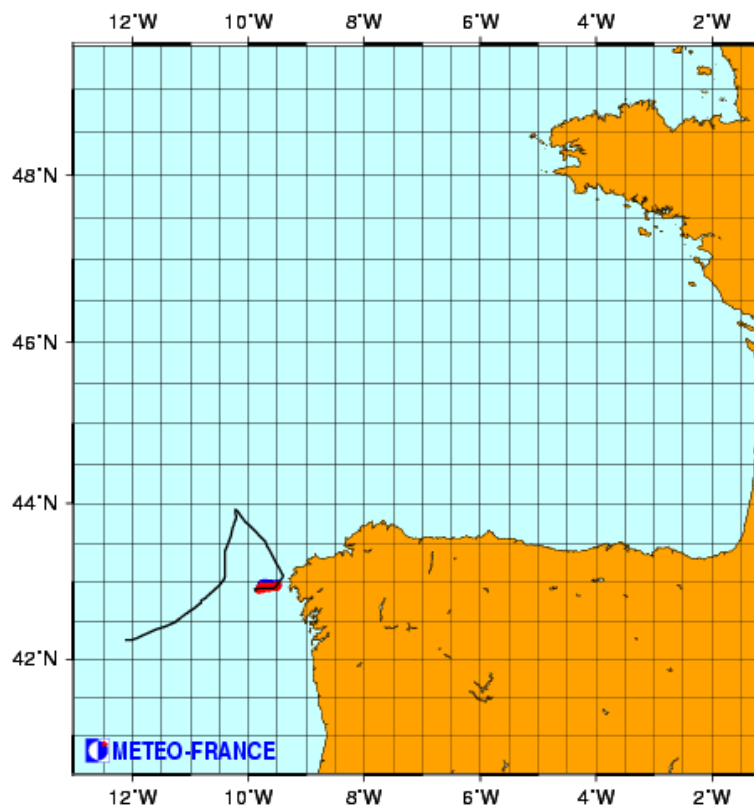
From P Bahurel

# The Prestige Case, Impact of « GODAE » systems

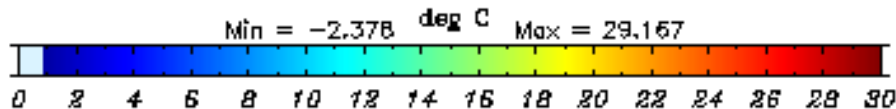
## 4D Ocean Inputs



MOTHY/ARPEGE\_ANA : Analyse pour le 14/11/2002



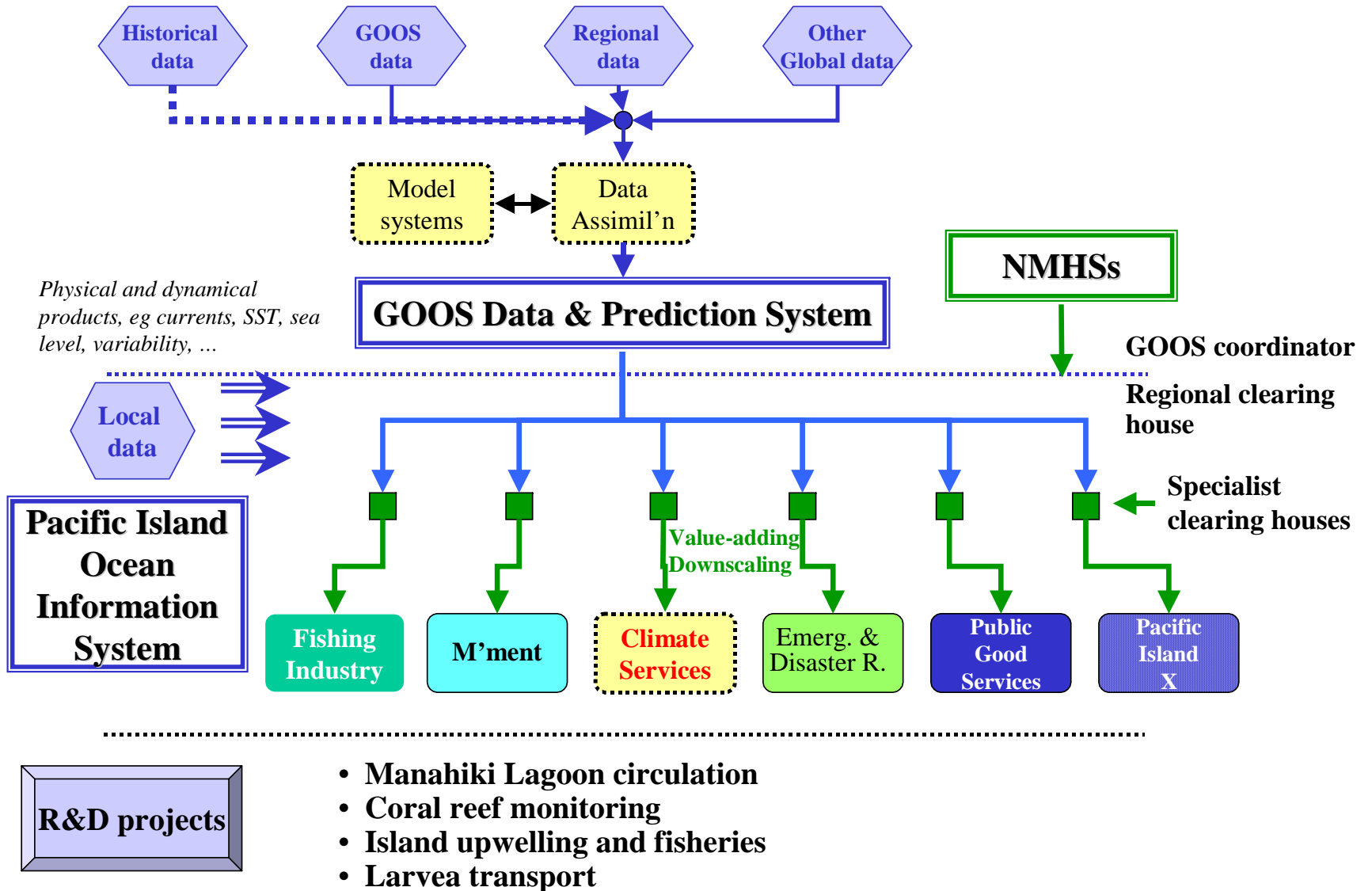
Météo-France Oil Drift Forecast  
(courtesy of P.Daniel)



10-20% ice cover  
jul day 19684



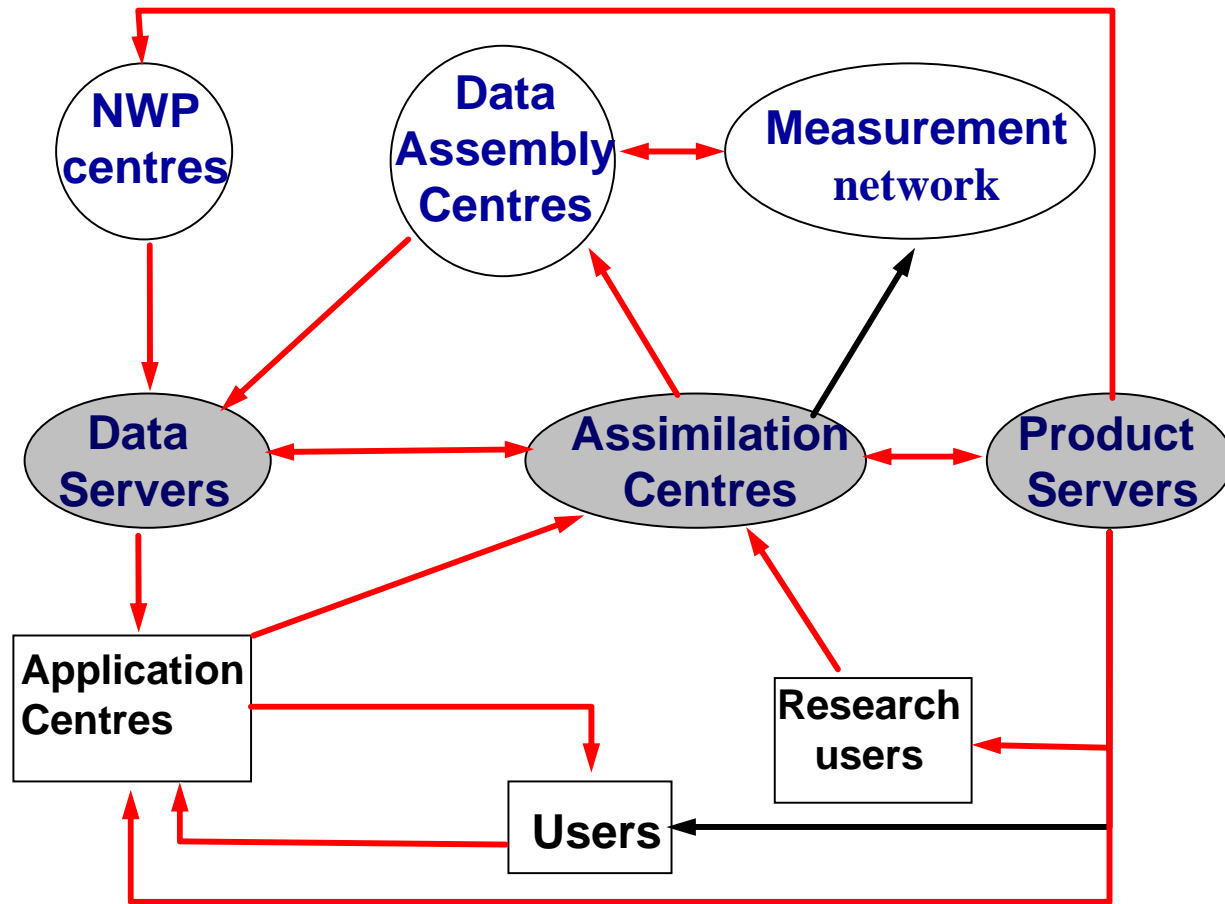
# Schematic of possible Pacific Initiative



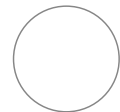




# Monitoring and testing the flow of information



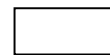
Legend:



Sources of input



GODAE common



Users of GODAE outputs



Flows of information



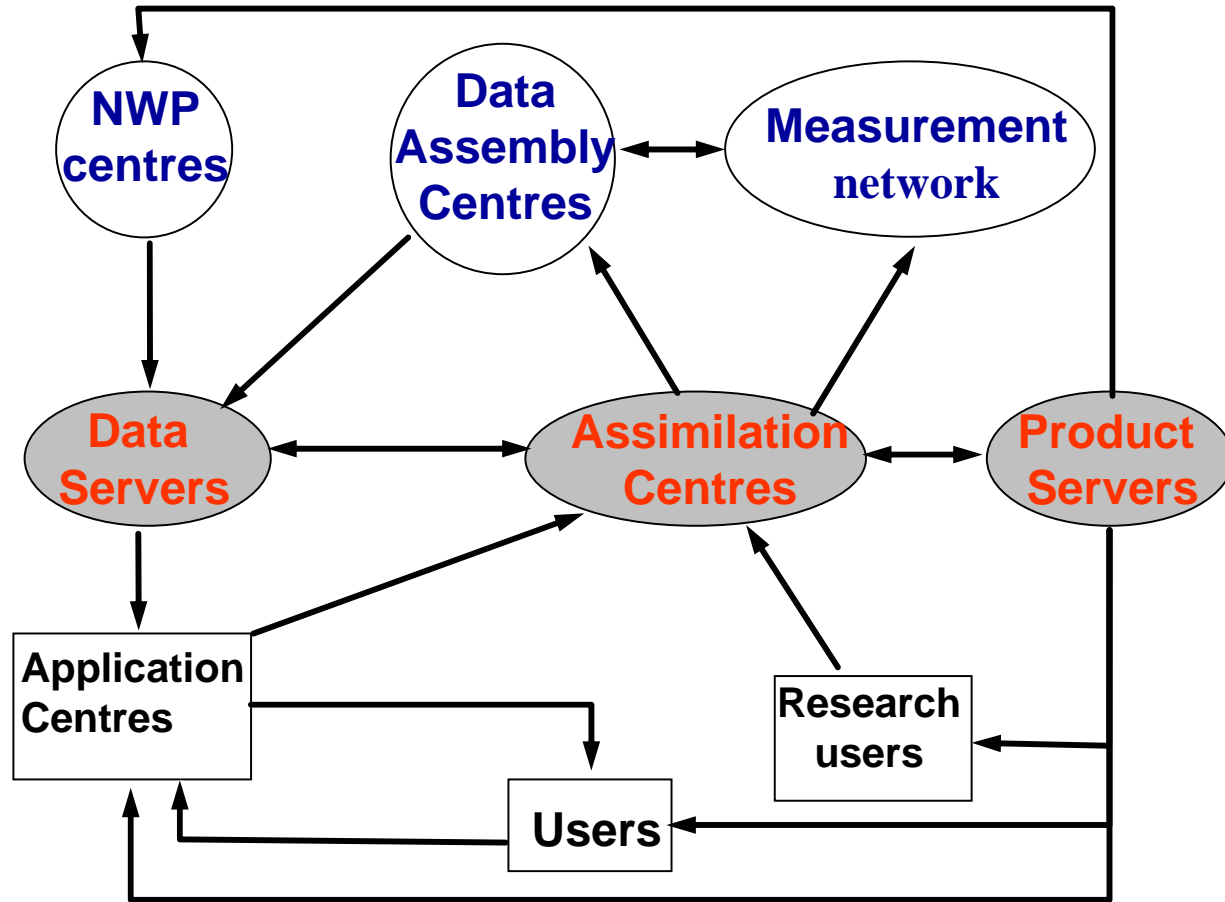
# Perspectives 11

- **Determining the utility of products for different users and sectors of the ocean community is the major challenge at this time.**

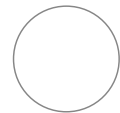
**What are the top 10 in terms of use of products?  
How do you measure it? Number? \$\$s? Societal impact?  
How do we make sure we communicate with our users,  
and that they communicate well with us?  
What business model should we use?  
Have we done our scio-economic homework?**



# Adding the Application Perspective



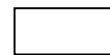
Legend:



Sources of input



GODAE common



Users of GODAE outputs



Flows of information



# GODAE Phases

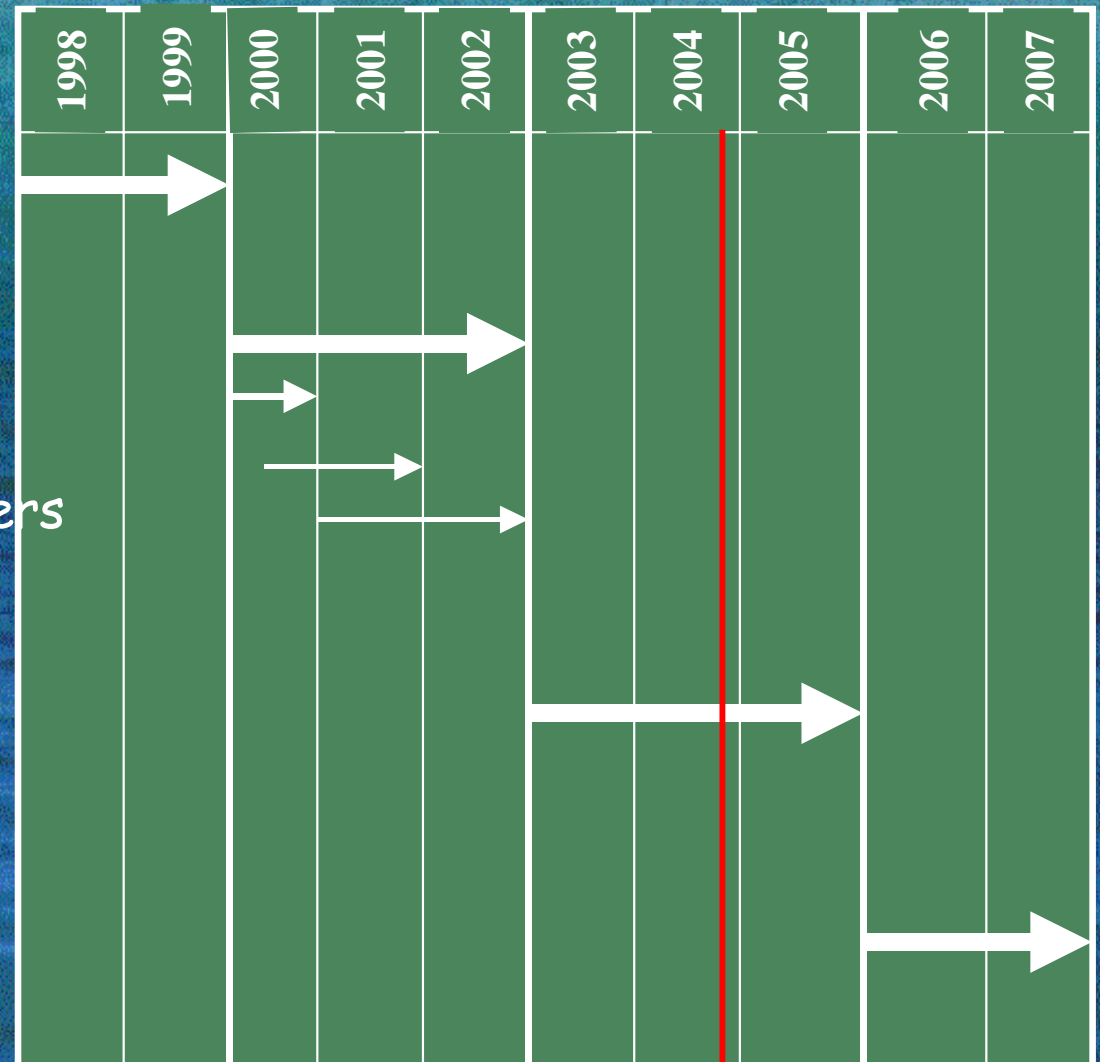
Concept

Development

Identify Application Centers  
Establish metrics  
Exercise real-time in situ servers

Operational Demonstration

Consolidation and transition



Things are unpredictable ...  
The challenges are immense ..



... but it is also good fun ...