2008 ROMS/TOMS European Workshop

Maison Jean Kuntzmann
Grenoble, France
October 6 - 8, 2008

Organized by: B. Barnier, L. Debreu, J. L. Wilkin, and H. G. Arango

Getting to Grenoble

Flight Info:

You will want to fly into Lyon Saint-Exupéry airport (LYS). Grenoble is about 1 hour (approximately 60 miles/97 kilometers) by road from Lyon.

Bus Info links:

You can take a Satobus-Grenoble (http://www.satobus-grenoble.fr/index_en.html) bus from the Lyon Saint-Exupéry airport (LYS) to the Grenoble train station. The cost is 20 Euros one way and 30 Euros round trip. Once at the Grenoble train station you can take a taxi or walk to your hotel if it is close enough.

Train Info links:

The Grenoble train station can be reached from Paris by TGV (http://www.tgv.com/). It takes a little over 3 hours. Once at the Grenoble train station you can take a taxi or walk to your hotel if it is close enough.

Getting to the Workshop

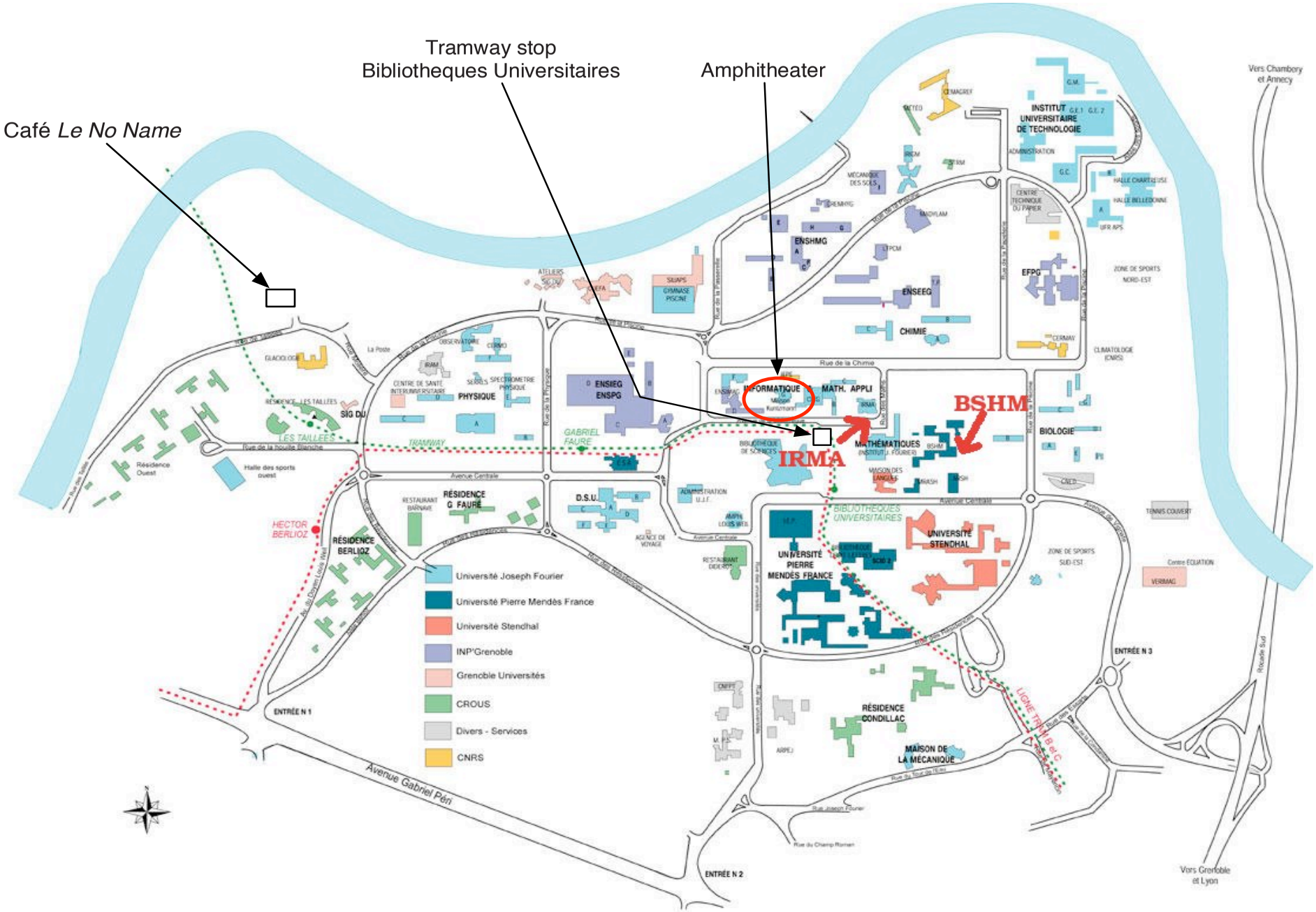
Tram:

The Jean Kuntzmann amphitheater is 100 meters away from the Bibliotheques Universitaires tramway stop (see map 1). Tickets are 1.40 Euros each or 10 trips for 11.20 Euros (http://www.semitag.com/). You must buy your ticket before you get on board. Tickets can be purchased at any tram station (automatic distributor) with cash (coins) or credit card. To get there, take the tramway line "B" (in green on map 2) towards Gières-Plaine des Sports. Get off the tram at the Bibliotheques Universitaires stop. The ride is approximately 22 minutes from the train station. Trains come aproximately every 4 minutes (http://www.sedeplacer-tag.fr/Lignes/HORAIRES_A.pdf). For reference, the train station is located at the Gares stop and Grenoble city center is located between the Victor-Hugo and Sainte-Claire Les Halles stops. The campus map (map 1) shows the meeting, tram stop and reception (Café NoName) locations.

Driving Info:

It is not recommended for you to drive to the workshop as there is no parking available.

Map 1: Campus Map with Amphitheater, Café Le No Name and Tramway Stop Labeled



Map 2: Grenoble Tramway Map

Map 3: Grenoble Hotels and Workshop Location

1. Hotel de l'europe
2. Ibis Grenoble Centre
3. Hotel d'Agleterre
4. Hotel des Alpes
5. France Touring Hotel
6. Hotel Terminus
7. Hotel de l'Institut
8. Hotel Suisse & Bordeaux
9. Hotel Bastille

W. Jean Kuntzmann Laboratory Amphitheater

T. Bibliotheques Universitaires Tramway Stop

Grenoble Tourist Information

Located in the Rhone-Alps region, Grenoble is a famous university town in southeastern France. Grenoble has several tourist attractions in the form of historic forts, castles, museums, theaters, cultural festivals, and nearby ski resorts. The old town of Grenoble still has the remains of the city wall, dating back to the III century altered with XVII century townhouses.

Grenoble is a lively, modern city that is attractively situated at the confluence of the river Drac and Isere. It is considered the cultural and economic capital of the French Alps and has established a reputation for being a centre of high-tech progress and commerce. A lot of its affluence is generated by a booming microelectronics and nuclear industry.

The Rhone-Alps' "pièce de résistance" is its famous cuisine. Five of France's 19 three-star chefs work their magic here, citing the quality of local produce, fish and game as the key to their success. Cooking is Provençal, characterized by garlic and olive oil with delicious sausages and smoked hams. The region produces delicious pastries and sweetmeats made from almond paste and flavored with aniseed, pistachio and orange - flower water.

Places to Visit:

1. **Musée Dauphinois:** This is a true regional museum of mankind, aimed at preserving, promoting and handing down the memories of the communities that lived in the old province of Dauphiné.

2. **Musée de Grenoble:** The Grenoble Art Gallery is one of France's most prestigious outside Paris. It is prized for its collections of ancient art as well as modern and contemporary art: paintings by Perugino, Veronese, Strozzi, Canaletto, Guardi, Rubens and Zurbaran are exhibited alongside a large collection of works by French artists including Philippe de Champaigne, Georges de la Tour, Claude Lorrain and Simon Vouet.

3. **Le Magasin - National Centre for Contemporary Art:** Founded in 1986 in Grenoble, le Magasin is one of the leading European contemporary art centres. Every year it puts on monographical or collective exhibitions, in close links with the artists.

4. **Muséum d'histoire naturelle:** This museum promotes the discovery, understanding and responsible use of the natural world. Enjoy and explore our world-class collections presented in exceptional exhibitions.

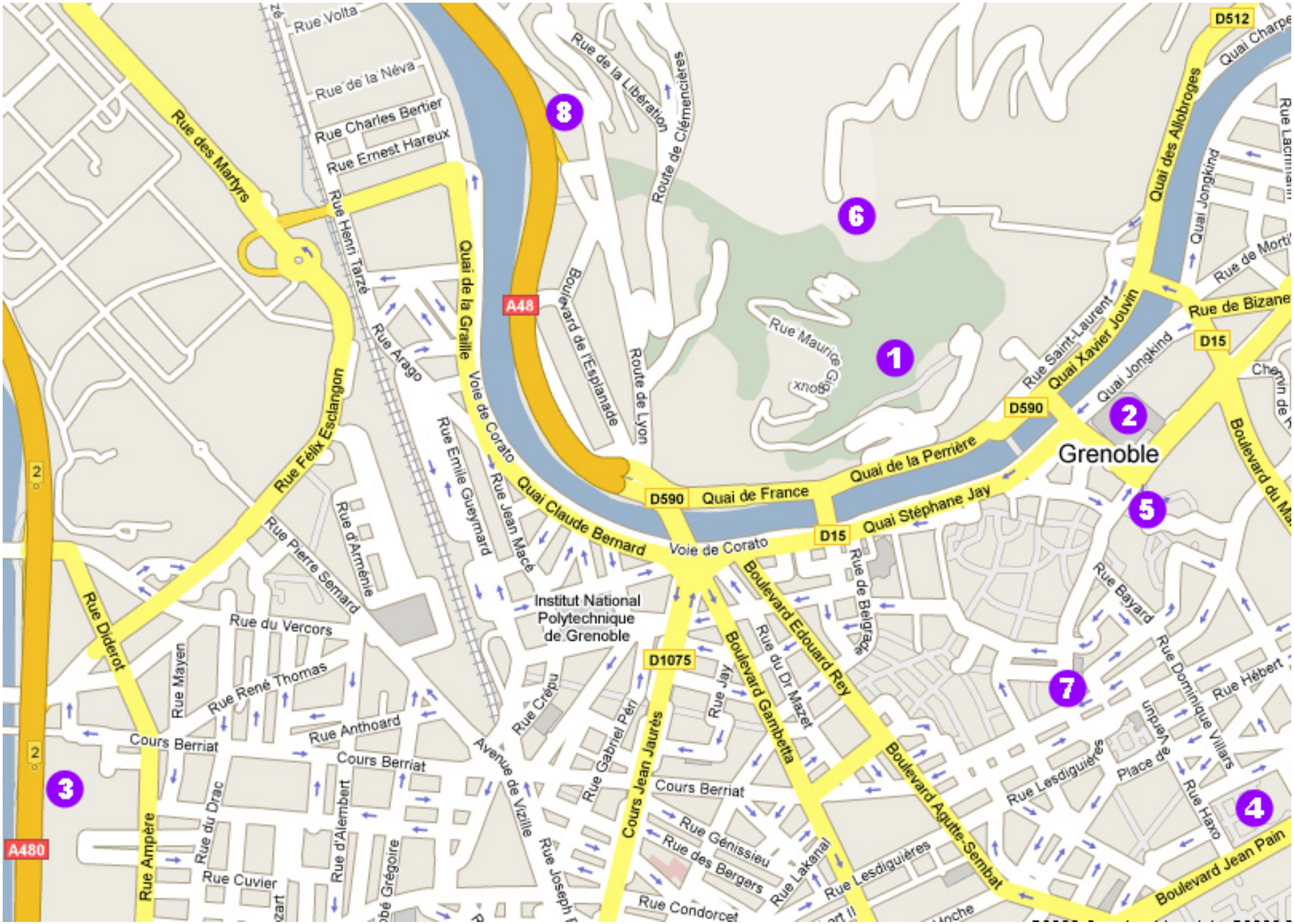
5. **Musée de l'Ancien Évêché:** Situated right in the heart of Grenoble's ancient city centre, the museum housed in the former bishop's palace traces the history of the Isère region and its people from Prehistoric times up to the present.

6. **Fort de la Bastille:** Situated high above the city, this old fortification was first constructed in the 16th Century. In the 19th Century, the structure was added to again, making it a formidable viewing point for defensive purposes. Today visitors enjoy the same views of the area, over the city and on a clear day one can see Mont Blanc.

7. **Horloge Solaire:** An amazing 17th century reflective sundial, Horloge Solaire is a must see tourist attraction in Grenoble. Known for its unmatched size and accuracy, the sundial shows accurate solar time, month, and zodiac sign.

8. **La Casamaures:** This mock oriental palace was built in 1855, 100 m from the fortifications on the northern side of Grenoble. It is one of the last examples of orientalist architecture involving the innovative use of moulded cement that was developed during the 19th century.

Map 4: Grenoble Tourist Attractions



Participants

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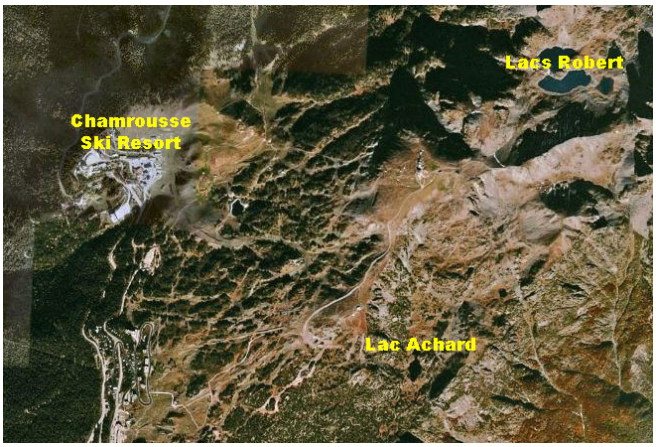
Hike: Sunday October 5, 2008

The hike is being organized by Jean-Marc Molines and others.

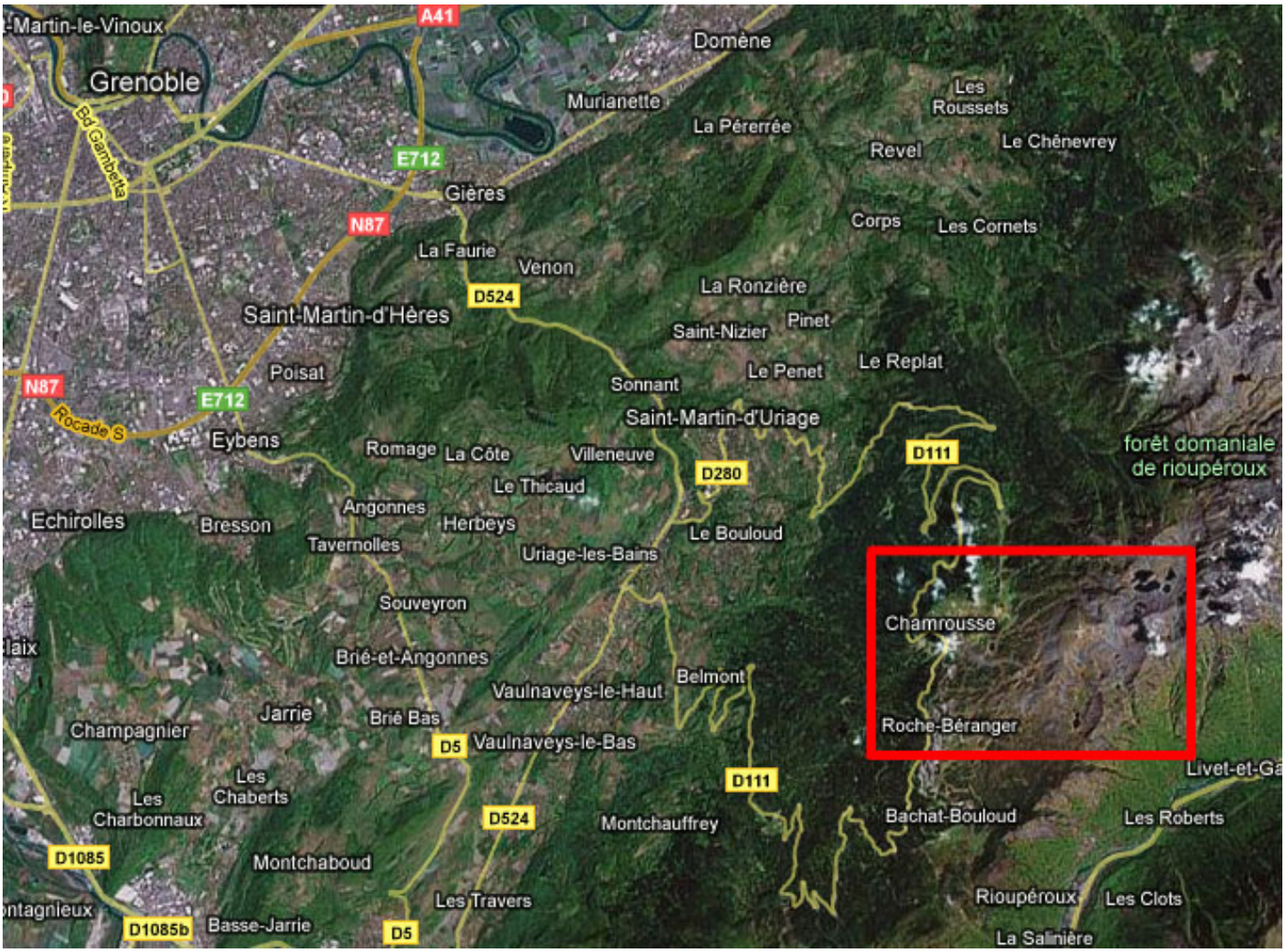


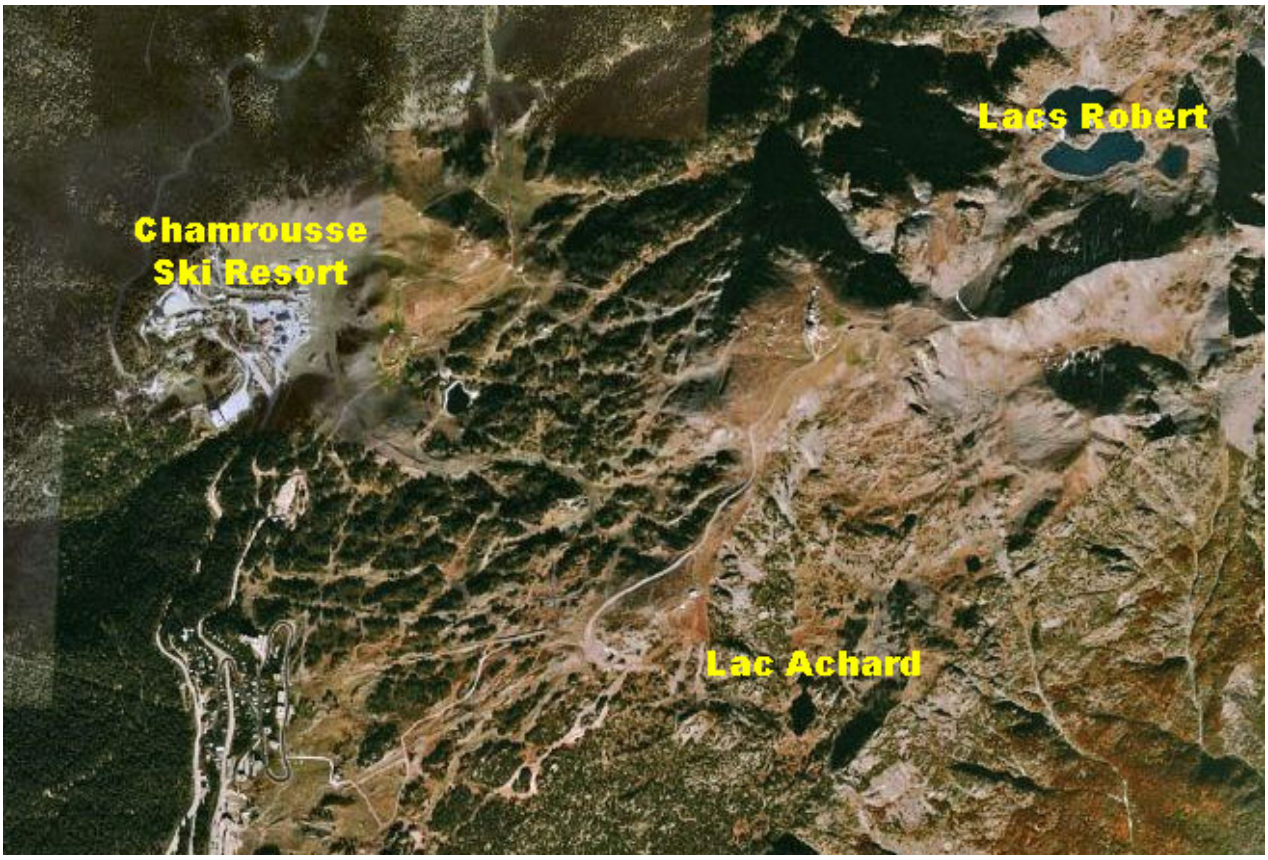
The plan is to go to Lac Achard and Lacs Robert. It is a gentle loop starting from the Chamrousse ski-resort about 35 km from downtown Grenoble. At the time of the hike, the ski resort is closed. The hike starts at an altitude of 1850 m, going up to Lac Achard at 1950 m in 1 hour 30 minutes, then the path get steeper for about 1 aditional hour, to arrive to the highest point of the hike (2200 m). Approximately 45 minutes later we will arrive at Lacs Robert (there are 3 lakes). The last part of the hike, is the return to the ski-resort, going down to 1650 m.

The whole hike should take 4 to 4:30 hours. Of course, we will stop for picnic and rest so the entire trip should take about 6 hours from starting point to return. Therefore, we will meet in downtown Grenoble (location to be determined soon) about 9 or 9:15 AM. The hike always follows a foot path, but there are some stones on the way and good walking shoes are necessary. Typically, at this time of the year, the temperature is cool (between 3°C and 12°C) with sun and no wind. We recommend the hikers bring some warm clothes.

Although there are buses that go to Chamrousse, our local hosts will drive their own cars because the start and end of the hike are not the same place. With few drivers, we can leave one car at the arrival point for shuttle people back to the starting point.

Of course, the final schedule will depend on the weather. In case of bad weather (but not too bad) we can still go to Lac Achard and come back the same way.


A41
Grenoble
Bd Gambetta
E712
N87
Rocade S
Domène
Murianette
Les Roussets
La Pérerrée
Revel
Le Chênevrey
Gières
Corps
Les Cornets
La Faurie
Venon
D524
La Ronzière
Saint-Martin-d'Hères
Saint-Nizier
Pinet
Poisat
Le Penet
Le Replat
Sonnant
Saint-Martin-d'Uriage
Eybens
Romage
La Côte
Villeneuve
D280
D111
forêt domaniale de rioupéroux
Le Thicaud
Angonnes
Herbeys
Echirolles
Bresson
Tavernolles
Le Bouloud
Uriage-les-Bains
Souveyron
Chamrousse
Brié-et-Angonnes
Belmont
Vaulnaveys-le-Haut
Jarrie
Brié Bas
Champagnier
D5
Vaulnaveys-le-Bas
Roche-Béranger
Les Chaberts
Les Charbonnaux
D524
Montchauffrey
Bachat-Bouloud
Les Roberts
D1085
Montchaboud
Les Travers
Rioupéroux
Les Clots
D1085b
Basse-Jarrie
La Salinière


Lacs Robert
Chamrousse Ski Resort
Lac Achard

PROGRAM

---------- Monday AM, October 6, 2008 ----------

08:00-08:55 Registration

08:55-09:00 Welcome and Logistics

Chairperson: Bernard Barnier

09:00-09:30 (30 min) Xavier Capet, IFREMER, France
Submesoscale frontal activity for dummies

09:30-10:00 (30 min) Jeroen Molemaker, IGPP-UCLA, USA
Sensitivity of Eastern boundary solutions to the nearshore wind structure

10:00-10:30 Break (30 min)

Chairperson: Hernan Arango

10:30-11:00 (30 min) John Wilkin, IMCS, Rutgers University, USA
Four-dimensional variational assimilation of satellite temperature and sea level data in the coastal ocean and adjacent deep sea

11:00-11:30 (30 min) Gregoire Broquet, UC Santa Cruz, USA
Application of the ROMS Incremental Strong 4D-Variational data assimilation in the California Current System

11:30-12:00 (30 min) Francois-Xavier Le Dimet, INRIA-UJF, France
Images and Prediction for Geophysical Fluids

12:00-14:00 Catered Lunch, Posters, and Discussion

---------- Monday PM, October 6, 2008 ----------

Chairperson: John Wilkin

14:00-14:30 (30 min) Laurent Debreu, INRIA, France
ROMS-AGRIF two-way nesting algorithms: latest developments

14:30-15:00 (30 min) John C. Warner, USGS, Woods Hole, MA, USA
Techniques for composed and refined grid implementations

15:00-15:30 (30 min) Pierrick Penven, LPO, France
Regional ocean modelling around Southern Africa with SAfE (Southern Africa Experiments)

15:30-16:00 Break (30 min)

Chairperson: Rich Signell

16:00-16:30 (30 min) Francois Colas, UC Los Angeles, USA
Circulation in Prince William Sound

16:30-17:00 (30 min) Rui Caldeira, CIMAR, U. do Porto, Portugal
Madeira Island wake studies

18:00 - Reception and Dinner at Café NoName

PROGRAM

---------- Tuesday AM, October 7, 2008 ----------

Chairperson: Laurent Debreu

09:00-09:30 (30 min) Hernan Arango, IMCS, Rutgers University, USA
ROMS Framework and Algorithms

09:30-10:00 (30 min) Rich Signell, USGS, Woods Hole, MA, USA
The Gulf of Maine Model Interoperability Experiment: a success story made possible by NetCDF, CF, NcML, NetCDF-Java, THREDDS, OPeNDAP

10:00-10:30 Break (30 min)

Chairperson: John Warner

10:30-11:00 (30 min) Patrick Marchesiello, IRD, New Caledonia
Lessons learnt from comparing global and regional models

11:00-11:30 (30 min) Bjørn Ådlandsvik, Inst. of Marine Res., Norway
Experience with ROMS for downscaling IPCC climate models

11:30-12:00 (30 min) Florian Lemarie, LJK / INRIA Grenoble, France
Global-in-time Schwarz method applied to Two-Way Ocean-Atmosphere coupling

12:00-14:00 Catered Lunch, Posters, and Discussion

---------- Tuesday PM, October 7, 2008 ----------

Chairperson: Pierrick Penven

14:00-14:30 (30 min) Jerome Fiechter, UC Santa Cruz, USA
Multi-nutrient limitation in the Coastal Gulf of Alaska: seasonal and interannual variability

14:30-15:00 (30 min) Julio Sheinbaum, CICESE, Mexico
A physical-biophysical model of the Meso-American Barrier Reef System

15:00-15:30 (30 min) Vincent Echevin, LOCEAN, France
Modelling of an upwelling filament off Peru

15:30-16:00 Break (30 min)

Chairperson: Patrick Marchesiello

16:00-16:30 (30 min) Zouhair Lachkar, ETH Zürich, Switzerland
Can eddies alter the response of productivity in EBCs to increases in upwelling favorable winds?

16:30-17:00 (30 min) Jihene Abdennadher, IPEIT, Tunisia
Internal Tide Energetics in the Sicilian Strait

17:00-17:30 (30 min) Alexander Yankovsky, U. South Carolina, USA
Modeling of large-scale edge waves generated by the hurricane landfall

PROGRAM

---------- Wenesday AM, October 8, 2008 ----------

Chairperson: Sandro Carniel

09:00-09:30 (30 min) Jose Alves, FCUL - U. of Lisbon, Portugal
Variability of temperature and currents during an upwelling event off the Western Iberian Coast

09:30-10:00 (30 min) Nobuhito Mori, Kyoto University, Japan
Thermal predictions in enclosed shallow water areas using ROMS: Osaka Bay, Japan

10:00-10:30 Break (30 min)

Chairperson: Julio Sheinbaum

10:30-11:00 (30 min) Manel Grifoll, LIM / UPC, Spain
Circulation Forecast in Spanish harbours using ROMS

11:00-11:30 (30 min) Mathieu Dutour Sikiric, IRB, Croatia
Bathymetry smoothing in ROMS: A new approach

11:30-12:00 (30 min) David Robertson, IMCS, Rutgers U., USA
Website and Documentation Satatus

12:00-14:00 Catered Lunch, Posters, and Discussion

---------- Wenesday PM, October 8, 2008 ----------

14:00-17:00 Open Discussion
Training Talks

Posters

1. Albert, Aurélie, LOCEAN, France
Impact of Coastal Kelvin waves on the nearshore productivity in the Humboldt Current System

2. Burls, Natalie, U. of Cape Town, South Africa
The Role of Ocean Processes with Coupled Variability in the Tropical Atlantic

3. Castelao, Renato, IMCS, Rutgers University, USA
The effects of tides on the wind-driven inner shelf cross-shelf circulation

4. Grima, Nicolas, LPO - CNRS, France
Ariane: A Lagrangian diagnostic tool

5. Halo, Issufo, U. of Cape Town, Mozambique
The influence of Madagascar Ridge on the circulation in the Agulhas Current System

6. Kantha, Lakshmi, U. of Colorado, Boulder, USA
Some loose ends in second moment closure approach to modeling oceanic mixing

7. Montes, Ivonne, U. de Concepción, Chile
Interannual Variability of subsurface connections in the Southeastern Tropical Pacific during 1999 - 2004

8. Peliz, Alvaro, University of Lisbon, Portugal
Tore seamount study

9. Renault, Lionel, LEGOS, France
Modelling of the air-sea interaction off central Chile: sensitivity to the resolution

10. Russo, Aniello, U. Politecnica delle Marche, Italy
Simulation and Operational Forecast of Hydrodynamics, Biogeochemical Fluxes and Hypoxia in the Adriatic Sea

11. Solé, Jordi IMCS, USA & IMEDEA, Spain
Study of potential effects of climate change on the ecosystems of temperate Seas: the Alboran Sea case

12. Troupin, Charles, University of Liège, Belgium
Vorticity balance in the Northwestern African Upwelling

Talk Abstracts

Internal Tide Energetics in the Sicilian Strait

Jihene Abdennadher
Institut Préparatoire aux études d'ingénieurs de Tunis, Tunisia

A non-linear hydrostatic model (ROMS) is used to study the generation and propagation of internal tides in the Strait of Sicily. Realistic topography and stratification from existing observational data were used. The numerical simulations has shown that there are three distinct sites of strong M2 internal tide generation: the western sill of the Adventure Bank, northwest of Sicily, and north of Pantelleria island. The conversion from the M2 surface to internal tide energy integrated over the whole model domain amounts to 47.5 MW, 75% of which are found to be generated over the three prominent topographic features mentioned above. The depth-integrated baroclinic energy flux of the M2 internal tide shows two directions of propagation (north and southwest) at the western sill, the most energetic site. About 42.3 % of the M2 baroclinic energy produced in the modelled region is dissipated near the generation sites.

The K1 internal tide is generated mainly at the Adventure Bank's edge and near the Pantelleria island. The conversion of energy from surface to K1 internal tide in the strait of Sicily is approximately 30 MW. This energy is completely dissipated at the strait. This is because the K1 frequency is sub-inertial at this latitude and cannot propagate. Analysis of the internal flux reveals that the K1 internal tide is topographically trapped which is consistent with Artale et al. (1989).

Experience with ROMS for downscaling IPCC climate models

Bjørn Ådlandsvik, Paul Budgell and Vidar Lien
Institute of Marine Research, Bergen, Norway

Global climate models as used in the IPCC 4AR have low resolution in the ocean. Important physical processes in coastal regions, such as upwelling and tidal mixing, are unresolved or not implemented. To resolve these processes higher resolution and improved physics are needed to study regional ocean climate and its impact on the ecology.

The Regional Ocean Model System (ROMS) has been used at IMR to downscale results from global coupled atmosphere-ocean climate models. This has been done on a regional scale for the North Sea, and a basin scale for the North Atlantic and the Arctic. Results from these simulations will be presented. These results show that downscaling provides added value to IPCC model results.

Variability of temperature and currents during an upwelling event off the Western Iberian Coast

Jose Alves and **Pedro Miranda**
CGUL Centro de Geofísica Universidade de Lisboa, Portugal

Nuno Serra
University of Hamburg Center for Marine and Atmospheric Research, Germany

The effect of surface atmospheric variables, in particular surface winds, on the sea surface temperature and currents off the western Iberian coast are studied with results obtained from the ROMS model. An analysis of sea surface temperature and currents off the western Iberian coast during year 2000 is made at a location close to the coast.

A more detailed analysis was conducted for July and August of 2000 which showed two upwelling episodes which lasted for 8 to 10 days. These were accompanied by a maximum decrease of 5°C in sea surface temperature and an increase in offshore surface currents to values above 0.4 m s-1. The sea surface temperatures results were validated against remote sensing data from the NOAA/AVHRR. A good agreement between the model results and the observations were found.

ROMS Framework and Algorithms

Hernan G. Arango
IMCS, Rutgers University, USA

The typical annual overview of ROMS framework and algorithms will be presented. ROMS is still evolving and substantial structural changes have been made to allow multiple levels of nesting (composite, mosaic and refinement grids), multiple model coupling, and parallel I/O. We continue improving the 4DVar data assimilation algorithms to accelerate convergence. A new algorithm was coded to quantify the impact that each observation has on the 4DVar data assimilation system. This driver can help us to determine the type of measurements that need to be made, where to observe, and when.

Application of the ROMS Incremental Strong 4D-Variational data assimilation in the California Current System

Gregoire Broquet, **Christopher A. Edwards**, **Andrew M. Moore**, and **Milena Veneziani**
University of California, Santa Cruz, USA

Brian S. Powell
University of Hawaii, USA

James D. Doyle
Naval Research Laboratory, USA

Hernan G. Arango and **Javier Zavala-Garay**
IMCS, Rutgers University, USA

The Incremental Strong constraint 4D Variational (IS4DVAR) algorithm of ROMS is used to study the impact of data assimilation on a realistic, high resolution model of the California Current System. The model is forced with regional COAMPS atmospheric data and with ECCO data at the open boundaries. Climatological fields and both satellite-derived surface and *in situ* observations are assimilated to significantly improve many characteristics of the circulation dynamics. The parameterization of the background error statistics are shown to be particularly critical to providing a compatible and consistent use of these different observations. Additionally, the use of ROMS-IS4DVAR to adjust surface forcing provides sensible corrections to the wind stress and heat flux improving the results even further.

Madeira Island wake studies

Rui Caldeira
CIMAR , Universidade do Porto, Portugal

Euclides Luís
CEMAT-IST, Portugal

A. Santos
MARETEC, IST, Portugal

J.Videman
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The Madeira Archipelago, located in the NE Atlantic, has been the focus of idealized and quasi-realistic studies using ROMS. The results show a strong asymmetry between cyclonic and anticyclonic leeward-eddies for different Re, Ro and Bu regimes. A quasi-realistic representation of the Madeira Archipelago replaces the idealized cylinder used by Dong et al (2007). Island asymmetry and the presence of nearby (smaller) islands play an important role in the wake formation. Quasi-realistic ROMS solutions compare well with satellite and in situ regional observations. (http://wakes.uma.pt/)

Submesoscale frontal activity for dummies

Xavier Capet
Laboratoire de Physique des Oceans, IFremer, France

Nowadays, it is possible to run regional ocean model applications with a horizontal grid resolution of 2km or less. At these resolutions, there is plenty of evidence that the near-surface flow is usually energized and exhibits increased frontal activity at around 5km scales (*i.e.*, within the submesoscale range). On the other hand, submesoscale frontal activity manifests itself in various ways and can be difficult to quantify (*e.g.*, using spectral methods).

An overview of the main characteristics of the submesoscale frontal activity will be presented using ROMS numerical solutions for a wide range of oceanic regimes (subtropical eastern boundary, wide mid-latitude shelf and Antarctic circumpolar circulation). The analysis includes underlying processes and physical features, dependency on the parameter range and environmental conditions and integrated effects on the larger scale.

Circulation in Prince William Sound

Francois Colas and **James C. McWilliams**
University of California, Los Angeles, USA

Xavier Capet
Laboratoire de Physique des Oceans, IFremer, France

A three nested-grid configuration has been designed to investigate the circulation in Prince William Sound (PWS). The embedded domains encompass the Gulf of Alaska, the central coast of Alaska and PWS. Quasi-equilibrium solutions of the Gulf of Alaska are obtained in which the importance of freshwater forcing is shown. The PWS circulation is controlled by a complex interplay between tides, freshwater run-off and local atmospheric forcing. A set of sensitivity experiments have been conducted to untangle the roles of these factors. Additionally, the circulation is affected by the complex nature of the exchange between the inner sound and the adjacent outer shelf.

ROMS-AGRIF two-way nesting algorithms: latest developments

Laurent Debreu
INRIA and Laboratoire Jean Kuntzmann, France

Local mesh refinement (nesting) capabilities have now been added to a number of numerical ocean models. In its crudest form, a high resolution grid is embedded in and interacts with a coarser resolution grid which usually covers the area of interest. The aim of this presentation is to review existing two-way grid embedding algorithms. First, the basic algorithms and their applications to ocean modelling are described. Then, several important issues will be addressed including: barotropic coupling, conservation properties, design of interpolation/restriction operators, and noise control techniques. Finally, results of some numerical experiments with the latest version of the ROMS-AGRIF model are presented.

Bathymetry smoothing in ROMS: A new approach

Mathieu Dutour Sikiric, **Ivica Janekovic** and **Milivoj Kuzmic**
Institut Rudjer Boskovic, Croatia

Terrain-following (sigma) coordinates are often the system of choice for both large scale basins and regional coastal applications. This coordinate system exhibits an intrinsic error in the discretization of the horizontal pressure gradient (HPG) term in areas with tall and steep bathymetry.

We present a new linear-programming (LP) procedure to minimize HPG errors. This new procedure has been applied to an Adriatic Sea test case using the Rutgers implementation of ROMS. Its level of success in alleviating the HPG error is judged by comparing against two implementations of the Shapiro filter, the Mellor-Ezer-Oey (1994) algorithm, and the recently proposed scheme of Martinho and Batteen (2006). The comparisons reveal that even an improved Shapiro filter creates very large modifications to the bathymetry and should be avoided. The Martinho-Batteen procedure's performance is comparable to that of LP, when the slope factor (r-factor) is larger than about 0.2, and inferior to it at smaller values. The difference between the studied solutions are more pronounced for coarser grids.

Modelling of an upwelling filament off Peru

Vincent Echevin, **Aurelie Albert** and **Alexis Chaigneau**
LOCEAN, France

The *Filamentos* cruise took place in February 2008 off the northern coast of Peru to study the dynamical and biogeochemical processes occurring in a coastal upwelling filament. In this work we present preliminary modelling results using the ROMS/PISCES model in a realistic context, forced by boundary conditions from the data-assimilating MERCATOR 1/4° OGCM. Several wind products are used to study their impact on the surface primary productivity and subsurface patterns.

Multi-nutrient limitation in the Coastal Gulf of Alaska: seasonal and inter-annual variability

Jerome Fiechter and **Andrew M. Moore**
University of California, Santa Cruz, USA

Hernan G. Arango
IMCS, Rutgers University, USA

Nutrient limitation and regional ecosystem dynamics in the northwestern Coastal Gulf of Alaska (CGOA) on monthly to inter-annual timescales is investigated by coupling a lower trophic ecosystem model to a three-dimensional coastal ocean circulation model. By including explicit growth limitation by light, nitrate, ammonium, silicate, and iron, the ecosystem model provides an ideal framework to investigate the combined role of macro- and micro-nutrients in shaping phytoplankton community structure. Based on comparisons with available in situ and remotely-sensed observations from 1998 to 2002, the model reproduces the dominant modes of variability associated with the northwestern CGOA ecosystem dynamics. Empirical orthogonal functions (EOFs) for nutrient limitation indicate alongshelf variations in diatom growth regime, with the northeast subregion limited mainly by nitrate, and the southwest subregion limited by both nitrate and silicate. At the shelfbreak, iron limitation regulates diatom growth. Changes in dissolved iron availability in that region will likely shift the cross-shelf phytoplankton community structure between the diatom-dominated shelf population and nanophytoplankton-dominated basin population. Furthermore, the EOFs suggest that regions where nitrate, silicate, and iron most severely limit phytoplankton growth vary in time. This implies that not only the frequency but also the timing of cross-shelf transport events will affect the seasonal and inter-annual CGOA ecosystem variability.

Circulation Forecast in Spanish harbours using ROMS

Manel Grifoll and **Luis Ferrer**
Azti-Tecnalia Marine Research Division, Spain

Marc Mestres, **Gabriel Jordà** and **Manuel Espino**
Universitat Politècnica de Catalunya, Spain

Marcos García Sotillo
Puertos del Estado, Spain

In this presentation we discuss the operational implementation of ROMS in several Spanish harbours (*e.g.* Barcelona, Bilbao and Tarragona). Specific features concerning harbour domains, such as complex geometries or dynamical assumptions (*i.e.* hydrostatic hypothesis) are discussed. A set of sensitivity tests have been carried out to determine the factors that will have the greatest influence on modelling harbour dynamics and the quality of the hydrodynamical forecasts. Taking these results into consideration, further experiments are performed to assess the memory of the harbour system and the relevance of the initial T/S conditions. The final goal is to provide a tool for harbour managers to control water contamination and develop plans to minimize the environmental risk of pollution in harbours.

Can eddies alter the response of productivity in EBCs to increases in upwelling favorable winds?

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Environmental Physics, Institute of Biogeochemistry and Pollutant Dynamics, ETH Zurich, Zurich, Switzerland

Hartmut Frenzel
IGPP, University of California, Los Angeles, Los Angeles, CA

Eastern Boundary Current (EBC) systems are well known for their high biological productivity and for playing an important role in the marine carbon cycle. Several previous studies have reported that changes in upwelling-favorable, alongshore winds are likely triggered by anthropogenic greenhouse forcing in some major EBC regions. The potential biological response to such a wind perturbation may, however, substantially vary from one EBC to another depending on the local environmental and physical conditions, including the intensity of mesoscale activity. Here we investigate the role of eddies in controlling the biological response in EBCs to changes in upwelling-favorable winds. The present study is based on a series of regional model simulations of the California Current System (CalCS) and the Canary Current System (CanCS) using ROMS at various horizontal resolutions. The physical circulation model is coupled with a nitrogen based NPZD model that includes a representation of the marine carbon cycle. We explore how wind stress changes affect the mesoscale eddy activity and their biological response in both EBCs by comparing model simulations forced with different alongshore winds with and without inclusion of the eddy impact.

Images and Prediction for Geophysical Fluids

Francois-Xavier Le Dimet, **Arthur Vidard**, **Oliver Titaud**, and **Innocent Souopgui**
INRIA-UJF, France

Predicting the evolution of the ocean requires gathering all the available information (models, data, statistics) in order to retrieve an initial condition. This task is carried out through a process of data assimilation. It is worthwhile to point out that the number of degrees of freedom of the model is much larger than the number of observations leading to an ill-posed problem. In recent years, many satellites have been launched and provide a lot of information in the form of images.

How to incorporate images into numerical models? Two basic approaches are proposed:

1. Extract some patterns (vortex, fronts, *etc.*) from a sequence of images. Tracking these patterns/features allows you to estimate horizontal velocity which can be assimilated into the model as regular data.
2. Project the patterns to model state variables using the appropriate basis functions. Then, create associated observation operators to assimilate into the model.

We will present some applications to experimental data in the lab (Coriolis Platform) and to images of a model of the Black Sea.

Global-in-time Schwarz method applied to Two-Way Ocean-Atmosphere coupling

Florian Lemarie
LJK / INRIA Grenoble, France

We propose an iterative process based on Schwarz-like methods to couple ocean and atmosphere models. This method has the advantage of ensuring good consistency of the coupled solution across the air-sea interface. Common coupling algorithmic approaches are only consistent asymptotically as the time step goes to zero. Until now, it was assumed that this lack of consistency does not significantly affect the physical properties of the solution. The relevancy of our approach is assessed in the context of coupling WRF and ROMS in a realistic configuration to simulate the genesis and the propagation of the tropical cyclone Erica.

Lessons learnt from comparing global and regional models

Patrick Marchesiello
IRD, New Caledonia

In the last 10 years, regional and global models have evolved significantly. Regional models have extended their boundaries beyond the continental slope, while global models have increased resolution to handle the turbulent scales. In the process, numerical methods and parameterizations have converged. Because of this and the open boundary conditions issue, some may be tempted to question the relevancy of the regional approach as computational costs keep decreasing. In this presentation we will show with some examples that the regional approach, particularly with new-generation models, is still very relevant and may lead us to produce regional solutions of unprecedented quality. However, we will also discuss some of the drawbacks of our system and see how it may evolve in the future..

Thermal predictions in enclosed shallow water areas using ROMS: Osaka Bay, Japan

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Disaster Prevention Research Institute,
Kyoto University, Japan

The stratification of upper layer coastal waters can be regarded as an unused energy source for heat pump systems in the summer. This study examines the feasibility of using cold water masses below the thermocline to power heat pump systems. Thermal stratification modeling depends on the vertical turbulence parameterization. Several turbulence schemes exist to parameterize vertical mixing in ocean models. These schemes have been verified in deep open ocean but not in shallow coastal regions. The characteristics of water exchange are investigated by the field observations and numerical simulations. The field observations were conducted in the bay throughout the summer season.

Sensitivity of Eastern boundary solutions to the nearshore wind structure

Jeroen Molemaker and **Francois Colas**
University of California, Los Angeles, USA

Xavier Capet
Laboratoire de Physique des Oceans, IFremer, France

It is well known that in upwelling regions, the structure of the very nearshore wind profile has a strong influence on the amplitude and shape of the upwelling cell, associated currents, and sea surface temperature. When forcing regional models, we often rely on satellite data, such as QuikSCAT, or larger scale atmospheric models. In both cases, wind changes within the nearest few tens of kilometers are unresolved. This may to lead to a cold SST bias. Recently, it has been suggested that the coupling between surface wind stress and SST gradient, as suggested by Chelton, can be used to recover some of these inshore wind gradients. We present a method to recover the inshore structure of the surface wind forcing and discuss the sensitivity of ROMS solutions to this nearshore wind structure.

Regional ocean modelling around Southern Africa with SAfE (Southern Africa Experiments)

Pierrick Penven
Laboratoire de Physique des Oceans (UMR6523: CNRS, Ifremer,IRD, UBO), France

J. Veitch, **N.Chang**, **Mathieu Rouault** and **Frank Shillington**
Department of Oceanography, University of Cape Town, South Africa

Pohl
Centre de Recherches de Climatologie, Université de Bourgogne, France

The SAfE (Southern Africa Experiments) model configuration was designed to resolve the dynamics of the Agulhas Current from its sources around Madagascar to the Southern Atlantic where the Agulhas Rings dissipate. The grid extends from 2.5°W to 54.75°E and from 46.75°S to 4.8°S at 1/4° horizontal resolution. Several grid refinements are created using ROMS-AGRIF nesting capabilities to resolve the complex dynamics around Southern Africa.

One refinement, located along the west coast of Southern Africa, is used to compare the equilibrium dynamics of the Northern and Southern Benguela. The focus is to study the upwelling systems, signal cycles, and eddy dynamics. The impact of the Agulhas Current on the upwelling system is also addressed.

Another refinement, centered on the Agulhas Bank, is used to quantify the effects of the Agulhas Current on the Cool Ridge. The

Cool Ridge is a tongue of colder water that is rich in nutriments and propagates along the southern coast of Africa.

On the larger scale, a recent increase in the Agulhas Current in response to an augmentation in wind stress curl in the South Indian Ocean is detected by our inter-annual regional simulation. This causes an intensification of the fluxes of salt and heat into the Atlantic Ocean. This, in turn, causes a transfer of energy from the ocean to the atmosphere. These changes could have far reaching consequences which could impact the climate and ecosystem.

Website and Documentation Status

David Robertson and **Hernan G. Arango**
IMCS, Rutgers University, USA

Kate Hedstrom
ARSC, University of Alaska Fairbanks, USA

We will discuss the current status and capabilities of the ROMS websites. Much work has been done on the documentation in WikiROMS (http://www.myroms.org/wiki). The underlying software of WikiROMS was updated allowing us to add the capability to use the WikiTex extension. This facilitates the use of real TeX syntax for any mathematical equation without needing html syntax. That is, you can paste from any TeX document.The resulting equations are of much higher quality with transparent background. This has facilitated the addition of much of the missing technical information about ROMS.

The forum (http://www.myroms.org/forum) was upgraded to the latest release. The new version allows better search, private messaging for administrators, and attaching files to forum posts.

A physical-biophysical model of the Meso-American Barrier Reef System

Lorena Guerrero, **Julio Sheinbaum**
Departamento de Oceanografia Fisica, CICESE, Ensenada, Mexico

Andrew M. Moore
Ocean Sciences Department, University of California, Santa Cruz, USA

A high resolution ROMS model coupled to an ecosystem (NPZD) model has been developed for the Meso-American Barrier Reef System. It is used to study the role of eddies and the Yucatan western boundary current dynamics in sustaining the reef ecosystem. Current meter data in the open ocean and reef lagoons suggest that there is a strong coupling between these systems. Several model runs have been carried out using open boundary conditions from climatology, the IAS-ROMS operational system, and output from the SODA system. Preliminary results comparing model output to available physical and biophysical observations are discussed.

The Gulf of Maine Model Interoperability Experiment: a success story made possible by NetCDF, CF, NcML, NetCDF-Java, THREDDS, OPeNDAP

Rich Signell
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The Gulf of Maine Ocean Data Partnership Modeling Committee has been developing a Model Interoperability Experiment in the Gulf of Maine built around the CF standard. The goal was to allow scientists using Matlab to issue a single identical command to retrieve geospatially located data, regardless of what type of model they are accessing. Our starting point was output from four ocean circulation models (ROMS, POM, ECOM, FVCOM), a meteorological model (WRF) and an ocean-wave model (WaveWatch 3) with six different grid conventions produced at six different institutions around the Gulf of Maine. All groups produced NetCDF files, used Matlab for visualization and analysis, and had a standard HTTP 1.1 web server. However, only one group used CF-conventions and as a result each group had their own set of analysis and visualization routines to perform nearly identical tasks.

The goal is to achieve interoperability with a minimum of effort on the part of the data providers and data users. To provide data for the interoperability experiment, participants need only place their existing NetCDF files on their own web sites. A layer of XML (NcML) is used to achieve CF standardization without altering the existing NetCDF files, and to provide virtual aggregation of data. This functionality is made possible by the NetCDF-Java library, which understands NcML and has the ability to access a byte range of a remote file on a web site. The final component of the distributed system is the THREDDS Data Server, which uses NcML and NetCDF-Java behind the scenes, but allows for central cataloging of the datasets and access via the OpenDAP service. For uniformly spaced grids, the datasets are available via THREDDS using the OGC Web Coverage Service (WCS).

The CF-standard data is accessed with the CF Toolkit for Matlab, a toolbox we are actively developing using NetCDF-Java. The advantage of these tools is that they work on any system without compiling, and they work for any structured grid model that can be described by the CF standard, eliminating the need for custom toolkits for individual models. We need to work to develop CF conventions that specify staggered grids, masked regions, velocity components and unstructured grid data so that toolboxes like this one can address an even broader range of user needs.

Techniques for composed and refined grid implementations

John C. Warner
U.S Geological Survey, Woods Hole Science Center, Woods Hole, MA, USA

Hernan G. Arango
IMCS, Rutgers University, USA

The capabilities of structured grid models to resolve flow dynamics can be limited due to the rectilinear connectivity of the grid. The rectilinear grid may have difficulties to resolve fine spatial scales in regions of strongly varying connections or along coastal features. Methods to allow increased flexibility include grid curvature, land/sea masking, and grid stretching. However these techniques can be inadequate to provide increased resolution for many numerical investigations.

Here we describe methodology to increase the capabilities of structured grid models to allow increased grid flexibility and grid resolution. We describe a method of composed grids that allow an unlimited number of grids to be seamlessly connected. The formulation allows increased grid flexibility that can be used to resolve strongly varying geometric configurations. Additionally, we describe a method for grid refinement that maintains the dynamics of the numerical algorithms and allows two-way feedback between a region of increased resolution and the coarser parent grid. Examples of both methods are shown for idealized test cases and for realistic applications.

Four-dimensional variational assimilation of satellite temperature and sea level data in the coastal ocean and adjacent deep sea

John Wilkin, **Javier Zavala-Garay**, **Julia Levin** and **W. Gordon Zhang**
IMCS, Rutgers University, USA

Incremental, Strong constraint, 4-Dimensional Variational (IS4DVAR) data assimilation with ROMS is used to initialize operational, coastal, mesoscale resolution, forecast models of continental shelf and associated boundary current regimes. In particular, we show assimilation results from the East Australia Current and the Mid-Atlantic Bight Slope Sea. In both areas the assimilation of adjacent, deep ocean data influence the coastal dynamics through remote forcing. We assimilate observations of daily satellite sea surface temperature, multi-satellite altimeter sea level anomalies, and subsurface temperature and salinity data from Volunteer Observing Ship transects and/or autonomous underwater vehicles. At the open boundary, both models use data from operational basin-scale circulation models. The atmospheric forcing is from operational weather forecast models. Control variables of the data assimilation are the initial conditions of a sequence of 3- to 7-day assimilation windows. The nonlinear model trajectory through each interval is deemed as the best-estimate analysis for initializing the subsequent forecast. We evaluate model skill from a large set of multi-day forecasts, from different initial mesoscale states. Forecast skill is enhanced and uncertainty reduced when empirical statistical subsurface pseudo-observations and/or so-called balance constraints are used to augment surface satellite data.

Modeling of large-scale edge waves generated by hurricane landfall

Alexander Yankovsky
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Direct observations of the storm surge induced by Hurricane Wilma's landfall on the West Coast of Florida on October 24, 2005 revealed the formation of a wave pulse propagating alongshore as Wilma moved inland and the surge was no longer sustained by wind forcing. The height of the wave pulse exceeded 1.5 m in detided sea level data. However, its magnitude was obscured in direct surge measurements because it propagated during low tide. The duration of this wave pulse was ~6 hrs and the propagation speed was of O(10) m s-1. The wave pulse was followed by a train of much weaker oscillations during the next 24 hrs. The observed wave is identified as an edge wave of large spatial and temporal scales.

A set of numerical experiments using ROMS has been conducted to study the generation of edge waves with large spatial and temporal scales by a fast-moving cyclonic storm system. The model of the coastal ocean was set in a 2-D idealized configuration with the continental shelf and slope topography similar to the West Florida shelf. A moving cyclonic storm system in the gradient wind balance was prescribed analytically. In order to identify a long wave response in the model, a linear boundary problem was solved yielding dispersion characteristics and across-shelf structure of the edge wave modes. A fast-moving storm system crossing the shelf at a right angle produces a nearly symmetrical response of two edge wave trains propagating both downstream (in the direction of Kelvin wave) and upstream along the coast. A zero mode edge wave is generated in the model whose structure coincided almost precisely with the theoretical wave solution for the same phase speed. As the translation speed becomes lower, the Eulerian time scale of the storm becomes longer and the waves are more affected by the Earth's rotation. In that case the wave energy propagates predominantly downstream. When the storm trajectory deviates from the normal approach, the edge wave response is not symmetric; most of the energy propagates in the direction of the alongshore component of the storm translation velocity. Edge waves are potentially more dangerous for the coastal inundation because they travel faster and have a stronger horizontal divergence (stronger sea level disturbance) than the subinertial coastal trapped waves which are traditionally associated with the hurricane's landfall.

Poster Abstracts

Impact of Coastal Kelvin waves on the nearshore productivity in the Humboldt Current System

Aurélie Albert, **Vincent Echevin** and **Marina Lévy**
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Olivier Aumont
LPO, UBO, Brest, France

The Humboldt Current system is the most productive upwelling area in the world ocean. Due to its proximity to the tropics, it is highly sensitive to the intense intra-seasonal to inter-annual fluctuations originating from the Equatorial Pacific, which propagate poleward along the Peruvian coasts in the form of coastal Kelvin waves. These waves act to displace water up or down the thermocline and the nutricline, generating a modification of the nutrient input into the euphotic zone and modifying the nearshore mesoscale activity. The impact of this process on the primary productivity of the upwelling system, the structure of the ecosystem, and the offshore and downward export of organic mater is evaluated for the different characteristics of the waves during 2000/2006. To do so, we use SeaWiFS sea color data, DUACS altimetry, and numerical simulations from a regional coupled physical/biological model forced by WOA2005 and by geochemical climatology. The effects of the coastal waves on the biological activity is contrasted with regards to the seasonality of the upwelling system.

The Role of Ocean Processes with Coupled Variability in the Tropical Atlantic

Natalie Burls
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The zonal mode of variability in the tropical Atlantic is often referred to as the Atlantic Niño mode because it resembles the Pacific El Niño Southern Oscillation (ENSO). Several differences between the nature of the zonal mode in the Atlantic and its counterpart in the Pacific have prompted the question: Is the role of the ocean in the zonal mode in fact similar to its role in ENSO? Although both modes of variability display a decrease (increase) in the trades associated with positive (negative) SST anomalies in the east, the oceanic processes behind these modes of variability may be quite different.

Local coupled ocean-atmosphere feedbacks in the Atlantic are weaker than they are in the Pacific and so tropical climate variability within the Atlantic is more susceptible to external influences. This remote forcing, together with the existence of another dominant mode of coupled variability, the meridional mode, means that the situation in the Tropical Atlantic is in many ways more complex. As a result of this complexity and relatively fewer studies than in the Pacific, understanding of the zonal mode is limited.

To facilitate an investigation into the role of the ocean within this inter-annual coupled mode, ROMS is used to simulate conditions in the Tropical Atlantic between 1958-2004. Preliminary results from this simulation and an investigation into the energetics of equatorial Atlantic oceanic variability will be presented. This work forms part of the first author's PhD research.

The effects of tides on the wind-driven inner shelf cross-shelf circulation

Renato Castelao, **Robert Chant**, **Scott Glenn** and **Oscar Schofield**
IMCS, Rutgers University, USA

Cross-shelf currents play an important role in the transport of heat, salt, nutrients, detritus, phytoplankton, sediments, pollutants and larvae on most continental shelves. They are also an important component of the upwelling circulation that typically brings cold, nutrient-rich subsurface waters to the surface, fueling phytoplankton growth and influencing the water column density structure. Despite having great importance, the mechanisms that control the cross-shelf circulation on the inner shelf have only recently become an area of active research. It is clear from previous studies that stratification plays a crucial role in controlling the strength and spatial structure of the wind-driven circulation, with decreased stratification leading to a reduction in the cross-shelf transport. In this study, we use a numerical model forced by winds and tides of different amplitudes (representative of the US east coast) to explore the effect of tides on the wind-driven inner shelf cross-shelf circulation. It is shown that tidal currents, by increasing mixing and altering the stratification in the regions close to the coast, can significantly affect the efficiency of the wind to drive cross-shelf currents. This leads to variations in the width of the region where divergence in the surface wind-driven transport occurs. This effectively changes the cross-shelf location where upwelling and downwelling occurs impacting the exchange of water at the inner-shelf and the ecological processes that depend on it.

Ariane: A Lagrangian diagnostic tool

Nicolas Grima and **Bruno Blanke**
Laboratoire de Physique des Océans (LPO/CNRS), France

Ariane is an offline computational tool that computes 3D streamlines from output velocity fields of any OGCM, such as ROMS, OPA-NEMO, and Symphonie.

Water mass and/or current transports are calculated from the numerical displacement of water particles. In its so called *qualitative mode*, Ariane calculates and outputs the trajectories of a few particles. In its *quantitative mode*, Ariane estimates volume transport based on the statistics of thousands of particles. The algorithm is fast and accurate. Each trajectory segment respects the local continuity equation. The method allows backward integration of trajectories. The Ariane tool, which is freely available to the whole scientific community, is designed to be user friendly, portable and efficient.

The influence of Madagascar Ridge on the circulation in the Agulhas Current System

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The Agulhas Current system is characterized by an enhanced mesoscale variability of the flow. The bathymetry in this region is characterized by several shallow ocean ridges: The Davie Ridge, the Madagascar Ridge, the Mozambique Ridge, and the Southwest Indian Ocean Ridge.

The main water source is the South Equatorial Current. Upon reaching the east coast of Madagascar, the South Equatorial Current bifurcates into the North Madagascar Current and the East Madagascar Current. The shear created on the North Madagascar Current by the northern tip of Madagascar generates eddies. These eddies propagate southward through the Mozambique Channel and flow with the Agulhas Current into the South Atlantic. The East Madagascar Current separates from the continental shelf south of Madagascar. Parts of the flow propagate near the Agulhas Current in the form of dipolar vortices. How these eddies form and whether the remaining flow of the East Madagascar Current retroflects or not is still debatable. Nevertheless, studies suggest that the Madagascar Ridge plays a crucial role in this matter. We expect that this topographic feature has a strong influence not only on the local circulation but also on the overall circulation in the South-West Indian Ocean. To test this, we have designed 2 experiments using a 10 years climatologic ROMS simulation at 1/6 degree resolution. The first simulation was used as a reference. In the second simulation, we have removed the upper 4000 m of the Madagascar Ridge. Removing the Madagascar Ridge affects the variability of the flow by shifting its position and intensity from the east to the west side of the ridge. This also increases the mean SSH downstream of the flow. The ridge seems to control the intensity of the Agulhas Current farther downstream. These results are in agreement with previous studies which reported that the Madagascar Ridge strongly affects the overall circulation on the Agulhas Current system.

Some loose ends in second moment closure approach to modeling oceanic mixing

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Sandro Carniel
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The second moment closure (SMC) approach to modeling turbulent mixing in the ocean is well-established. In fact, SMC models are part of ROMS. However, there are many loose ends that still remain: (i) glaring deficiencies in the handling of convection through local parameterization, (ii) absence of Stokes production of TKE, (iii) absence of double-diffusive mixing, and (iv) tidal mixing in the deep ocean which is crucial to the proper simulation of the water mass structure in the interior. This poster will touch upon some of these issues and present recent advances that hold the potential of being included in ROMS. The main concentration will be on Stokes production.

Inter-annual Variability of subsurface connections in the Southeastern Tropical Pacific during 1999 - 2004

Ivonne Montes
Universidad de Concepción, Chile

A remarkable feature of the Humboldt Current system (HCS) is its remote connection with the Equatorial Current System (ECS). Evidence has shown that, under climatological atmospheric and oceanic conditions, the eastward subsurface currents of ECS feed the Peru-Chile Undercurrent (PCUC). This constitutes the main source of coastally upwelled waters off Peru. Based on this hypothesis and considering that the region is strongly affected by inter-annual variability (e.g. ENSO events), we configure ROMS to investigate the ECS-HCS subsurface interactions during the warm (El Niño) and cold (La Niña) phases of ENSO. Our domain covers the Peruvian and equatorial domains. The solution is obtained with

inter-annual forcing (atmospheric and open boundaries) between 1999 and 2004. Preliminary results, mainly based on offline Lagrangian diagnostics, will be presented.

Tore seamount study

Alvaro Peliz
University of Lisbon, Portugal

Tore is a very deep seamount system (ridge) located west of the Iberian Peninsula with a crater in the middle, possibly the result of a meteorite impact. This submerged crater isolates a 1200 m water column from adjacent water masses. The aim of this study is to investigate whether the deeper part of the crater is ventilated. The seamount's dynamics are analyzed and results of some preliminary simulations are described. A significant flow rectification is observed. The role of different factors, such as baroclinic tides mixing on the Tore slopes and in the enclosed abyss (crater) are discussed. The relevance of numerical options for this application and how they affect the abyssal circulation and mixing processes are also discussed.

Modelling of the air-sea interaction off central Chile: sensitivity to the resolution

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Coastal upwelling regions are of special interest as they are places of intense biological activity, mesoscale, and submesoscale circulations. They play a key role in the exchange of water properties between the open and coastal oceans. Our interest is on the upwelling region off central Chile (26°S-36°S), which is under the influence of persistent low-level along-shore southerly winds. Satellite data, marine reports, and coastal *in situ* observations off central Chile indicate that those along-shore winds intensify at intra-seasonal timescales leading to so-called Costal Jet events. Off central Chile, the southerly jet events occur year-round but are more frequent during the summer upwelling season. The jet is characterized by an elongated maximum of surface wind speed (10 ms-1) with its axis at about 150 km off the coast and a cross-shore scale of about 500 km. It is associated with a significant oceanic mesoscale variability that contributes to cross shore exchanges of heat, salt and biogeochemical material between open and coastal oceans.

Using the high-resolution ocean (ROMS) and atmosphere (WRF) regional models, one year of atmosphere and ocean variability was simulated to investigate the sensitivity of upwelling to the spatial resolution of the atmospheric forcing. The sensitivity of surface winds and air-sea heat fluxes to the horizontal resolution of the atmospheric model is evaluated. Near the coast, increased resolution improves the realism of the cross-shore variability of the wind stress. The simulated atmospheric fields at various resolutions (40km, 10km) are then used as surface boundary conditions for the regional high-resolution ocean model. The results indicate a high sensitivity of the oceanic turbulent flow to the characteristics of the atmospheric forcing. They suggest that air-sea coupling at the mesoscale level is a significant contributor to the upwelling variability in this region. The well defined Coastal Jet event of October 2000 is also examined in more detail by focusing on its impact on the mixed-layer dynamics. We found that there is a significant sensitivity to heat-budget based on the resolution.

Simulation and Operational Forecast of Hydrodynamics, Biogeochemical Fluxes and Hypoxia in the Adriatic Sea

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The Adriatic Sea is a continental basin of the Mediterranean Sea. The northwestern region is particularly shallow and influenced by large river runoff. Po is the main river with an average runoff of about 1500 m3 s-1. This region of the Adriatic basin has been affected by eutrophication, mucilage, and bottom water anoxia. All of which have negative impacts on the environment, tourism and fisheries of the area.

ROMS has been used in the Adriatic Sea since the 2002-03 Adriatic Circulation Experiment. An operational hydrodynamic version, AdriaROMS, is running at Hydro-Meteorological service of ARPA Emilia-Romagna (ARPA-SIM, Bologna, Italy).

Because of the relevant environmental concerns about the northern Adriatic basin, a new ROMS implementation (with a biogeochemical flux module active) has been developed.

The biogeochemical model (Fennel et al, 2006) is a simplified representation of nitrogen cycling processes in the water column. It also includes organic matter remineralization at the water-sediment interface that explicitly accounts for sediment denitrification. This model is based on a single limiting nutrient (nitrogen) and incorporates only one class of phytoplankton and one zooplankton class. It also includes equations for C-related components and for dissolved oxygen.

As in AdriaROMS, the air-sea fluxes are interactively computed using LAMI (Limited Area Model Italy) atmospheric model forcing (provided by ARPA-SIM) with ROMS sea surface temperature. The model initialized from field data collected during September

2002. The effects of river runoff and tidal forcing have been included and validated with *in situ* and remotely sensed data.

A multi-year simulation spanning the period from September 2002 to December 2006 provided a sufficiently clear picture of the general biogeochemical characteristics of the Adriatic Sea. Additionally, it shed some light on the role of the physical factors influencing nutrient levels, phytoplankton mass, and oxygen distributions in the northern sub-basin.

Currently, ROMS is providing operational 72-hour forecasts. These forecasts can be used by environmental officials to track the evolution of hypoxic events in the Rimini area (Italy) and develop mitigation plans. This research activity is supported by the EC through the LIFE program.

Study of potential effects of climate change on the ecosystems of temperate Seas: the Alboran Sea case

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We study the inter-annual variability of the circulation in the Alborán Sea. We use ROMS forced by a 40-year reanalysis and MFS boundary conditions to identify global change trends. These trends are characterized by the duration and intensity of the main oceanic features, gyres and fronts, that usually form in this area. We study adjustment processes between Modified Atlantic Water (MAW, S < 36) and denser Mediterranean Water (MW, S>37) in the Alboran gyres and Almeria-Oran front. The interaction of these two major water masses is particularly important in the Eastern Alboran area, where the Almeria-Oran front is a major dynamical boundary. The impact of the physical variability on the ecosystem is studied by coupling ROMS to an NPZD model.

Vorticity balance in the Northwestern African Upwelling

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Upwelling filaments are typical features in Eastern Boundary Current Systems and have been the object of numerous *in situ* (e.g. Ramp et al., 1991, Barton et al., 2004), and numerical studies (e.g. Haidvogel et al., 1991; Johnson and Stevens, 2000).

However, the physical processes that drive filaments are still not well understood. Recent studies (Pelegrí et al., 2005) suggest that filaments the result of a combination of three phenomena:

1. Baroclinic instability of the coastal upwelling jet.
2. Interaction of the flow with coastline and topography shape.
3. Coastal convergence due to wind stress.

Our goal is to develop a simple theory based on potential vorticity conservation. We assume that filament generation is related to the injection of positive, relative vorticity in the vicinity of Cape Ghir. As the flow gains positive vorticity, it becomes unable to continue southward and detaches from the coast.

Since several processes (wind curl, bottom friction, variable topography, *etc.*) may be responsible for positive vorticity generation, we performed several experiments with ROMS to assess the role of each process.

Results show great correlation between temperature and relative vorticity. The filaments are characterized by intense positive vorticity and they are surrounded by a region of anticyclonic vorticity to the north. Preliminary results suggest that wind-stress resolution is important to the filament generation while topography is less important.