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http://www.rsmas.miami.edu/LAPCOD/2005-Lerici/
Meeting Announcement

Dear Colleague,

The LAPCOD 2005 meeting will take place in Lerici, Italy during June 13-17, 2005 (Monday-Friday).

The purpose of the LAPCOD meeting is to conduct a review of Lagrangian data, present new results on nonlinear aspects of Lagrangian dynamics, and to accelerate future development in predictability and multi-disciplinary aspects, by bringing together different research communities and different analysis. Workshop invitees will include experimentalists and theoreticians involved in data analysis and model development, as well as predictability experts (not necessarily all oceanographers), biologists, meteorologists and ecologists using Lagrangian instruments and approaches. Lagrangian predictability is of great importance for practical application in transport and environmental problems, and we expect that the workshop will facilitate its development through exchanges and collaborations.

We anticipate a total workshop attendance of 50-100 people. The workshop will be structured to encourage collaborations and exchanges of ideas, with 12 minute discussion talks in the morning and poster sessions in the afternoon. Participants are encouraged to present both a short talk and a poster.

Mon: Observations and biological applications.
Tue: Theory of dispersion / transport / mixing.
Wed: A day of interactions via a group social activity.
Thu: Lagrangian instruments and data analysis techniques.
Fri: Assimilation of Lagrangian data and predictability of trajectories.

We would also appreciate some talks/posters on a historical review of Lagrangian instruments, turbulent mixing, nonlinear analysis and what have we learned about the mean ocean state and its variability from measurements.

Feel free to send this announcement to colleagues.

Sincerely,

Annalisa Griffa, Consiglio Nazionale Ricerche (CNR/ISMAR), La Spezia, Italy
RSMAS, University of Miami, Miami, Florida, USA

Arthur Mariano, RSMAS, University of Miami, Miami, Florida, USA

Tamay Özgökmen, RSMAS, University of Miami, Miami, Florida, USA

Enrico Zambianchi, "Parthenope" University, Napoli, Italy
LAPCOD Meeting Agenda

This meeting is being structured to encourage collaborations between biological and physical oceanographers, numerical modelers, mathematicians and meteorologists who use Lagrangian measurements, both in-situ and simulated, to understand and model ocean and coastal dynamics. We ENCOURAGE you to present both a short talk (12 min + 3 min Q/A) in the morning session and a poster with details in the afternoon (This is not a strict requirement, you can do just one or the other).

Mon:  A Observations and biological applications.
Tue:  B Theory of dispersion / transport / mixing.
Wed:  A day of interactions via a group social activity.
Thu:  C Lagrangian instruments and data analysis techniques.
Fri:  D Assimilation of Lagrangian data and predictability of trajectories.

**Monday's** session will focus on estimates of first and second-order statistics of velocity, plankton, tracer and optical properties of the ocean and coastal regime from Lagrangian measurement. We encourage contributions that contain maps of mean circulation/transport, MKE, and EKE, Lagrangian spectra and covariance functions, variance ellipses, principal component analysis, diffusivity estimates, and estimates of Lagrangian time scales that can be used as benchmarks for modeling studies and for parameterizing turbulence.

**Tuesday's** session will focus on theoretical and numerical models of particle dispersion, turbulent mixing and transport. Contributions on nonlinear particle dynamics, chaotic advection, tracer dispersion, turbulence parameterizations, and particle trajectory models are encouraged.

**Thursday's** session will focus on the engineering aspect of Lagrangian data, analysis methods and present/future Lagrangian-based sensor technology. Contributions on error characteristic of Lagrangian measurements, calibration methods, new Lagrangian instruments, and comparisons with Eulerian measurements and with simulated Lagrangian trajectories are encouraged.

**Friday's** session will focus on assimilating Lagrangian data into both Eulerian models and Lagrangian particle models for nowcasts anf forecasts. Contributions on applied Lagrangian prediction (search and rescue operations and pollution dispersion), optimizing the Lagrangian information in float observations for assimilation into Eulerian models, and sampling design are encouraged.

**Posters**
We encourage people who give oral presentations to present also a poster. Posters can simply be made by hard copies of the presented material or they can serve to show details not given in your morning talk. The purpose of presenting a poster and having an afternoon poster session is to encourage individual communication stimulated by the morning presentation.
Monday, June 13th

Observations and biological applications

Moderator: Arthur Mariano, University of Miami

8:30 am  Registration

8:50 am  Welcome to the Lerici LAPCOD Meeting
Opening remarks by Annalisa Griffa, University of Miami, CNR/ISMAR

Morning Sessions

9:00 am  A101  Upper branch of the North Atlantic meridional overturning circulation, using observed and synthetic drifters
Elena Brambilla, Lynne D. Talley

9:15 am  A102  Permanent Meanders in the California Current System
L. R. Centurioni, J. C. Ohlmann, P. P. Niiler

9:30 am  A103  A Lagrangian study of pathways and mixing of Arctic and Atlantic water in the southern Norwegian Sea
Henrik Søiland, Kjell Arne Mork, Tom Rossby and Mark Prater

9:45 am  A104  Observations of non-linear internal waves in the South China Sea
Luca Centurioni, Peter Niiler

10:00 am  A105  Near-surface circulation in the central Mediterranean Sea as deduced from Lagrangian drifters in the 1990’s
Pierre-Marie Poulain and Enrico Zambianchi

10:15 am  A106  Aspects of the coastal dynamics off Southwest Iberian Peninsula
P. Relvas, E.D. Barton

10:30 am  A107  Near surface currents and wind observations in the open Ligurian Sea
P. Picco, M. Borghini, R. Bozzano, E. Schiano, S. Sparnocchia

10:45 am  Short Break  (30 minutes), Refreshments will be served.

11:15 am  A201  Lagrangian surface circulation in the Tyrrenian Sea
Enrico Zambianchi, Pierpaolo Falco, Milena Menna, Pierre-Marie Poulain

11:30 am  A202  Statistical analysis of high-resolution drifter data collected just beyond the surf-zone in the Santa Barbara Channel
J. C. Ohlmann

Riccardo Barbanti, Pierre-Marie Poulain, Sergey Motyzhev and Andrei Zatsepin

12:00 pm  A204  Non-Gaussian velocity probability density functions in the Mediterranean sea
J. Isern-Fontanet, E. García-Ladona, J. Font, A. García-Olivares

12:15 pm  A205  On the Lagrangian and Eulerian velocity PDFs in the North Atlantic
J. H. LaCasce

12:30 pm  A206  Potential Vorticity Dynamics
Thomas Rossby, Mark Prater, Henrik Søiland

12:45 pm  A207  Measurements of buoy and tracer dispersion in coastal areas
J.M. Redondo, M. Bezerra Diez and A. Carrillo
1:00 pm  Lunch Break  (60 minutes)

Afternoon Sessions
2:00 pm  A301  Individual-based models: formulation of development equations and computational aspects  
          Giuseppe Buffoni, Sara Pasquali
2:15 pm  A302  Lagrangian or not Lagrangian?  
          Jean-Olivier Irisson, Serge Planes, Michel de Lara
2:30 pm  A303  Lagrangian tracer studies of larval dispersal  
          G.L. Hitchcock, W.S. Arnold, R. Wanninkhof, M.E. Frischer, Y.P. Sheng
2:45 pm  A304  Lagrangian transport of benthic species in the Ligurian sea (Western Mediterranean)  
          Stefano Aliani, Annalisa Griffa, Carla Micheli, Anne Molcard, Andrea Peirano
3:00 pm  A305  Larval supply of meroplanktonic larvae in relation to behavioural strategies  
          Gunnar Brandt
3:15 pm  A306  Lagrangian modelling of phytoplankton coexistence  
          Daniela Cianelli, Luciana Sabia, Maurizio Ribera d’Acalà, Enrico Zambianchi
3:30 pm  A307  Ecological connectivity among coral reefs: Quantitative predictions of larval fish dispersal  
          Pierluigi Pantalone, Barry Ruddick, Bruce Hatcher, Jinyu Sheng
3:45 pm  A308  A dynamic filter to larval dispersal in a reef-building coral  
          L.M. Cherubin, I.B. Baums, and C. Paris

4:00 pm  Monday Poster Session  (2 hours)

Waiter, There is something floating in my drink!
Ice Breaker / Favorite Trajectories

5:00 pm  Ice Breaker at the Villa starts at 5:00 pm.
6:30 pm  Favorite Trajectories starts at 6:30 pm.
Tuesday, June 14th

Theory dispersion / transport / mixing

Moderator: Annalisa Griffa, CNR/ISMAR, University of Miami

Morning Sessions

9:00 am  B101  Impact of spatio-temporal variability of nutrient fluxes on primary productivity
Annalisa Bracco, Claudia Pasquero, Antonello Provenzale

9:15 am  B102  A Lagrangian Approach to the Role of Turbulence in Biological Physical Interactions
Louis Goodman, and Allan R. Robinson

9:30 am  B103  A Lagrangian model for the transport of sediments in coastal areas
Yannis N. Krestenitis, Katerina Kombiadou

9:45 am  B104  Observing Turbulence Regimes and Lagrangian Dispersal Properties in the Oceans
Volfango Rupolo

10:00 am  B105  Application of an idealized radial diffusion-advection model with eddy data
M. Auladell, J.L. Pelegrí, P. Sangrà, P. J. Vélez-Belchi and J.L. López-Jurado

10:15 am  B106  Multiple-scale analysis and renormalization for pre-asymptotic scalar transport
A. Vulpiani, A. Mazzino and S. Musacchio

10:30 am  B107  Lagrangian turbulence
G. Boffetta

10:45 am  Short Break  (30 minutes), Refreshments will be served.

11:15 am  B201  Mesoscale ocean turbulence and coherent structures as observed from Lagrangian data
M. Veneziani, A. Griffa, A. Reynolds, Z. Garraffo, E. Chassignet, and A. Mariano

11:30 am  B202  Coherent structures in coastal flows
Philippe Fraunie

11:45 am  B203  What's wrong with Gulf of Mexico rings?
A. D. Kirwan, Jr., L. Kantha, A. Poje, B. L. Lipphardt, M. Zweng

12:00 pm  B204  Rossby dynamics in the Mediterranean and associated Lagrangian transport properties
Enrico Zambianchi, Stefano Pierini

12:15 pm  B205  Relative dispersion in Lagrangian stochastic models
Leonid Piterbarg

12:30 pm  B206  Exploration of Lagrangian Stochastic Models in Simplified Shear Model Flows
Peter R. Kramer and Emilio Castronovo

12:45 pm  B207  On the formulation of Lagrangian stochastic models for geophysical turbulent flows
Alberto Maurizi, Francesco Tampieri

1:00 pm  Lunch Break  (60 minutes)

Afternoon Sessions

2:00 pm  B301  The Dynamical Systems Approach to Studying Transport in the Chesapeake Bay: An Application of
Synoptic Lagrangian Maps
Des Small, Lyon Lanerolle, Stephen Wiggins

2:15 pm  B302  Measures of mixing and transport
Christopher Jones, Thomas C. Redd, Sherry E. Scott and Igor Mezic
2:30 pm **B303** Insights into stirring and mixing in Monterey Bay from evolving circular blobs  
*B.L. Lipphardt, A.D. Kirwan, C.E. Grosch, J.D. Paduan*

2:45 pm **B304** Lobe dynamics and transport predictions across the North-East Balearic front  
*A. M. Mancho, E. Hernández-García, S. Wiggins, D. Small, V. Fernández*

3:00 pm **B305** The three-dimensional ocean circulation: Lagrangian diagnostics based on General Circulation Model results  
*Bruno Blanke, Sabrina Speich*

3:15 pm **B306** Tracking mesoscale exchange within a regional model of the Southern Africa Basin  
*Andrea M. Doglioli, Sabrina Speich, Bruno Blanke, Guillaume Lapeyre*

3:30 pm **B307** Inertial particle approximation to solutions of the Shallow Water Equations on the rotating spherical Earth  
*Nathan Paldor, Andrey Sigalov*

3:34 pm **Tuesday Poster Session** (2 hours), Refreshments will be served.  
**B401** Spin diagnostics and eddy census from Lagrangian data sets: preliminary results  
*M. Veneziani, A. Griffa, and R. Lumpkin*

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**Wednesday, June 15th**

**A day of interactions via a group social activity**

A trip to *Porto Venenere* and *Cinque Terre* by boat (public ferry). Those that wish to will be able to do part of the trip at Cinque Terre walking.
Thursday, June 16th

Lagrangian instruments and data analysis techniques

Moderator: Enrico Zambianchi, "Parthenope" University

Morning Sessions

9:00 am C101 Ocean Current Website
A.J. Mariano, E.H. Ryan, B. Bischof

9:15 am C102 Transport and mixing in the Mediterranean sea by Finite Size Lyapunov Exponents
Cristobal Lopez, Francesco d'Ovidio, Emilio Hernández-García and Vicente Fernández

9:30 am C103 open

9:45 am C104 Lagrangian observations of Antarctic sea ice: the International Programme for Antarctic Buoys
Enrico Zambianchi

10:00 am C105 Bottom-Following Lagrangian Floats
Mark Prater, Tom Rossby

10:15 am C106 Interpreting Box Models with Transition Matrices and POPS
Barry Ruddick, Pierluigi Pantalone, Keith Thompson

10:30 am C107 Meanders Downstream The Agulhas Retroflexion
Jose Ochoa, Peter Niiler

10:45 am Short Break (30 minutes), Refreshments will be served.

11:15 am C201 Dispersion 'probability' maps in the Mediterranean Sea
Claudia Pizzigalli, E. Lombardi, V. Rupolo

11:30 am C202 Oil dispersion in the ocean
J.M. Redondo, R. Castilla, J. Grau, and A. Platonov

11:45 am C203 Application of a random flight model in a search and rescue model systems
M. L. Spaulding, T. Isaji, A. Allen, P. Hall, and E. Howlett

12:00 pm C204 An operational ensemble trajectory model for search and rescue
Oyvind Breivik, Art Allen

12:15 pm C205 Surface Drift Prediction Using Linear and Non-linear Hyper-ensembles of Atmospheric, Ocean and Wave Operational Models in the Adriatic
Michel Rixen, Emanuel Ferreira-Coelho

12:30 pm C206 Surface Drift Uncertainty Analysis Using An High Resolution Tactical Ocean Modeling System
E.F. Coelho, M. Rixen

12:45 pm C207 FAST04 - Preliminary Results
Melissa Zweng, Denny Kirwan, Bruce Lipphardt, Dave Hammond, Robert Heitsenrether

1:00 pm Lunch Break (60 minutes)

Afternoon Sessions

2:00 pm C301 Preliminary Lagrangian Analysis of NCOM output for the Adriatic Sea for DART05 Project
Annalisa Griffa1,2, Angelique Haza1, Paul Martin3, Anne Molcard1,2, Tamay M. Ozgokmen1, Leonid I. Piterbarg1

2:15 pm C302 Simulation of Lagrangian trajectories from models with and without assimilation
Julio Sheinbaum, Julio Candela, Bernard Barnier, Michel Crepon
2:30 pm C303 Dynamical systems perspective of observing system design
   Kayo Ide, Christopher K.R.T. Jones, Hayder Salman

2:45 pm C304 The Inverse Lagrangian Prediction Problem
   A.J. Mariano, T. Ozgokmen, T.M. Chin, A Griffa, E.H. Ryan

3:00 pm C305 Directed Drifter Launch Strategies for Lagrangian Data Assimilation Using Hyperbolic Trajectories
   A. Molcard, A. Poje, T. Ozgokmen

3:15 pm C306 The surface circulation through the Sicily Strait deduced from NOOA images and hydrological data obtained during 2003
   Sana Ben Ismail, Cherif Sammari, and G.P. Gasparini

3:30 pm Thursday Poster Session (2 hours), Refreshments will be served
   C401 A semi-empirical Lagrangian model for search and rescue services in the Canary Islands archipelago
      L. Cardona, M.G. Villagarcía, J. Perez-Marrero, L. Maroto, J. Godoy, C. Barrera, E. Gonzalez-Roncero, M.J. Rueda, O. Llinás

   C402 A meteorological tides forecasting method: first results in the Eastern Ligurian harbours

8:00 pm Social Dinner
   We'll go in a restaurant in Lerici. More details are coming.
Friday, June 17th

Assimilation of Lagrangian data and predictability of trajectories

Moderator: Tamay Ö zgökmen, University of Miami

Morning Sessions

9:00 am D101 On the statistical approach to Lagrangian data assimilation
Leonid Piterbarg

9:15 am D102 Assimilation of float positions in general circulation and regional scale ocean models
A. Molcard, A. Griffa, T.M. Ozgökmen, L.I. Piterbarg, V. Taillandier, A. Mariano, T.M. Chin,

9:30 am D103 Variational assimilation of Lagrangian data in a Primitive Equations model
Maelle Nodet

9:45 am D104 Assimilation of Lagrangian Data Using Particle Filters
Keith Thompson, Kassiem Jacobs

10:00 am D105 Lagrangian data assimilation and overcoming the saddle effect
Christopher K.R.T. Jones, Kayo Ide, Liyan Liu, Amit Apte, Juan Restrepo

10:15 am D106 Reconstructing regional-scale velocity fields from lagrangian data
Vincent Taillandier

10:30 am D107 The impact of temperature and salinity data from profiling floats in the Mediterranean Forecasting System
F. Raicich, A. Griffa, A. Molcard, V. Rupolo

10:45 am Concluding remarks
Concluding remarks by Arthur Mariano, University of Miami

11:00 am Fridays Poster Session (60 minutes), Refreshments will be served.

12:00 pm Optimal Deployment of Drifting Acoustic Sensors I
Discussion on "Optimal Deployment of Drifting Acoustic Sensors (ODDAS)"

1:00 pm Lunch Break (60 minutes)

2:00 pm Optimal Deployment of Drifting Acoustic Sensors II
Discussion on "Optimal Deployment of Drifting Acoustic Sensors (ODDAS)"
Section A Abstracts

A101
Upper branch of the North Atlantic meridional overturning circulation, using observed and synthetic drifters
Elena Brambilla, Lynne D. Talley
Scripps Institution of Oceanography
ebrambilla@ucsd.edu
(Abstract received 04/18/2005 for session A)

A transport of 15-20 Sv from the Gulf Stream should flow to the subpolar gyre as the warm water source for the dense water formation. The surface flow at 15 m, based on Lagrangian drifters, identifies the Gulf Stream system and the North Western Corner of the North Atlantic Current, but it does not provide an accurate description of the water mass exchange between the two gyres. Most of the drifters are trapped in the subtropical gyre and only one reaches the subpolar gyre. Considering the goal of analyzing the apparent lack of connection between subtropical and subpolar gyre showed by drifter observations, we initially verify the adequacy of the dataset used. Secondly, we used synthetic drifters advected through the observed mean velocity field to investigate the influence of the Ekman velocity on the drifter trajectories. The results from this simple numerical experiment show that removing the Ekman component increases the number of the drifter trajectories that flow into the subpolar gyre, but not by enough to represent the 15-20 Sv that should flow from low to high latitudes in the North Atlantic. Since neither Ekman or sampling issues can explain the low number of Lagrangian drifters entering the subpolar gyre, other processes must be involved. They could include: depth of the core of the northward flow, shear between surface and subsurface flow, obduction or subduction events.

A102
Permanent Meanders in the California Current System
L. R. Centurioni, J. C. Ohlmann, P. P. Niiler
Scripps Institution of Oceanography
cohlmann@ucsd.edu
(Abstract received 04/29/2005 for session A)

SVP drifter data from 1992-2004, AVISO sea level anomalies and NCEP reanalysis winds, are used to assemble a time mean distribution of 15 m velocity in the California Current System (CCS) seaward of 50 km from the coast. Ekman currents are subtracted from the drifter measurements and the resulting geostrophic velocities from drifers and AVISO are used to form an unbiased mean geostrophic circulation. The CCS flows southward with four permanent meanders that can have seaward extensions more than 3000 km offshore. The observed time mean circulation and its associated eddy energy are compared to those produced by various high resolution OGCS solutions (HYCOM, NLOM, POP, and ROMS). Simulations in closest agreement with observations come from ROMS, which produces four meanders and eddy energy within 50% of observed values. The time mean ageostropic velocity in ROMS is strongest within the cyclonic part of the meanders and appears similar to the ageostrophic velocity produced by non-linear interaction of Ekman currents with the near surface vorticity field. Because ROMS shows the near surface velocity within 50km of the coast is neither in Ekman nor in geostrophic balance, Lagrangian observations on the continental shelf of the CCS are necessary.

A103
A Lagrangian study of pathways and mixing of Arctic and Atlantic water in the southern Norwegian Sea
Henrik Søiland, Kjell Arne Mork, Tom Rossby and Mark Prater
Institute of Marine Research
henrik@imr.no
(Abstract received 04/29/2005 for session A)

The circulation in and the inflow to the southern Norwegian Sea are studied with acoustically tracked subsurface drifters (RAFOS floats). The main objectives in the project are to investigate the inflow and diffusive modification of the transport of warm saline water across the Iceland-Faroe ridge north into the Norwegian Sea and the spreading of the Arctic Intermediate Water (AIW) and its interaction with the warm Atlantic waters in the Norwegian Sea. 26 RAFOS floats were deployed in September 2004 north of the Faroes at 800m depth in the Arctic Intermediate Water (AIW) and from November 2004 to through June 2005, 54 RAFOS floats are being deployed in a sequential manner in the Atlantic Water (AW) at 200m depth in the Iceland Faroe Front off Iceland and the Faroes. Most of the RAFOS floats are due up in April 2006, but the few floats that have surfaced show interesting features of the circulation. The deep circulation (1500m) is simultaneously monitored by a small number of
ARGO floats in the Norwegian Sea. 3 ARGO floats were deployed in summer of 2003 and 6 in summer of 2004. They show that the mean flow speed is about 3 cms\(^{-1}\) in the southern Norwegian Sea, whereas in the Lofoten Basin the mean flow speed is about 6 cms\(^{-1}\). A strong topographic steering is clearly evident in some of the ARGO float trajectories. Also the RAFOS floats at intermediate depth follow the topography closely whereas the shallow RAFOS floats cross the isobaths. The project is a cooperative effort between scientists at the Bjerknes Centre for Climate Research in Bergen, Norway, and scientists at University of Rhode Island, USA.

**A104**

**Observations of non-linear internal waves in the South China Sea**

*Luca Centurioni, Peter Niiler*

*Scripps Institution of Oceanography*

lcenurioni@ucsd.edu

(Abstract received 05/09/2005 for session A)

Large amplitude depression-like internal solitary waves with vertical amplitudes in excess of 80 m and over 100 km long are known to occur in the northern part of the South China Sea. They are thought to originate in the Luzon Strait and propagate westward. The processes by which the waves are generated are still unclear.

In the attempt to measure the isopycnal displacement and the three-dimensional absolute velocity field associated with these waves, we designed and built four drifting thermistor chains equipped with Acoustic Doppler Current Profilers and GPS receivers. An array of four instruments was deployed at 119.5E, 20.5N on May 2, 2005 and was recovered after 2.5 days. On May 7 we re-deployed two drifting chains at the same location together with 29 SVP drifters equipped with GPS receiver. The two chains were recovered after 5 days in order to sample the spring tide of May 8. Some preliminary results are presented.

All the devices moved to the south-west and the surface trajectories show the signature of tides and internal waves. The internal tide signal dominated by the diurnal component and the associated solitons with amplitudes larger than 100 m are also visible in the temperature data. Concurrent CTD casts show that the waves signature extends from the surface to at least 1000 m depth.

**A105**

**Near-surface circulation in the central Mediterranean Sea as deduced from Lagrangian drifters in the 1990’s**

*Pierre-Marie Poulain and Enrico Zambianchi*

*Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Trieste, Italy*

poulain@ogs.trieste.it

(Abstract received 04/22/2005 for session A)

The near-surface circulation in the central Mediterranean, including the Straits of Sicily, the southern Tyrrenian and western Ionian Seas, is studied using the data of more than 150 satellite-tracks drifters for the period spanning 1990-1999. Pseudo-Eulerian maps of mean flow, eddy variability and energy levels are produced using all the data, the data sorted by seasons and the data divided in major wind categories, to study the circulation variability at meso to seasonal scales, and in terms of the local wind forcing. The quasi-Lagrangian nature of the drifters is also exploited to estimate Lagrangian statistics, such as the auto-covariance, the diffusivity and the integral time and space scales. In general, the new results revealed by the drifter data confirm the general characteristics of the surface circulation as detected in previous Eulerian investigations. However, they provide new broad quantitative description of the central Mediterranean surface circulation and they shed light on the dynamics of the Straits at large, including the Tunisian shelf and the area south of Malta, which shows unexpected characteristics of the surface velocity field, sometimes stagnant or even directed the opposite way with respect to the currents flowing further to the north. In addition, the drifter dataset allows to underline the seasonal character of the surface circulation in the area, and to assess the importance of the wind forcing. It was found that when winds blow from the northwestern sectors (like the Mistral) the surface eastward transport in the Straits of Sicily is enhanced. In contrast, for opposing wind conditions (blowing from the southeastern sectors), the transport through the Straits is significantly reduced.

**A106**

**Aspects of the coastal dynamics off Southwest Iberian Peninsula**

*P. Relvas, E.D. Barton*

*CIMA - Universidade do Algarve*

prelvas@ualg.pt

(Abstract received 04/29/2005 for session A)

The coastal transition zone off Southwest Iberian Peninsula exhibits an upwelling season from March
to September, with the associated upper-layer cold equatorward current jet, and poleward circulation during winter, that remains as an undercurrent during the upwelling season. The Cape São Vicente represents the edge point of the discontinuity imposed by the entrance of the Mediterranean. There, the upwelling jet is no longer bonded by a coast. Historical data and "in situ" observations shows that it lagrangian path follows eastward along the southern shelf break, or if energetic enough, crosses the isobaths resulting in the southward development of a filament. A warm countercurrent over the inner shelf, progressing from the Golf of Cadiz, often turns northward around Cape Sao Vicente. This feature is associated with periods of decay of upwelling favourable winds. Data reveal the existence of a negative alongshore pressure gradient, stronger during the upwelling season, forcing the poleward coastal circulation. The coastal dynamics depends on the relative magnitudes of the wind stress and the pressure gradient alongshore. A survey carried out during the upwelling season under relaxed winds, just after a live upwelling event, show evidence of this two contrasting regimes.

A107
Near surface currents and wind observations in the open Ligurian Sea.
P. Picco, M. Borghini, R. Bozzano, E. Schiano, S. Sparnocchia
ENEA marine Environment Research Centre, La Spezia (Italy)
paola.picco@santateresa.enea.it
(Abstract received 04/29/2005 for session A)

In order to investigate the vertical structure of the upper layer currents and their variability, a mooring equipped with an ADCP (Acoustic Doppler Current Profiler) RD&I Sentinel 300 Khz and SBE temperature and salinity sensors was deployed in the open Ligurian Sea (43° 47.77' N; 9°02.85 E) at 1000 m depth near the meteo-oceanographic buoy ODAS ITALIA1, from September 2003 to May 2004. The ADCP sampled the upper 50 m of water column with 8 m vertical resolution and 1h time interval, while meteorological data were collected each hour from the buoy. Although the mean current is mainly directed northwest, the data reveals an interesting mesoscale variability. The vertical structure is characterized by highly correlated currents having the same pattern, with intensity decreasing with the depth. Rotary spectral analysis evidences the inertial frequency peak, which dominates from September to December, and mesoscale components on both positive and negative spectra. The meteorological measurements from the buoy ODAS ITALIA1 allow to investigate the relationships between the wind at the surface and the variability of the currents in the upper layers. Even representing single-point eulerian measurements, such kind of observations can be also useful for a better interpretation of data from lagrangian drifters, as they provide an insight of open sea circulation short-term variability and information on the relation between currents at surface and in the layers below.

A201
Lagrangian surface circulation in the Tyrrhenian Sea
Enrico Zambianchi, Pierpaolo Falco, Milena Menna, Pierre-Marie Poulain
Università Parthenope, Napoli
enrico.zambianchi@uniparthenope.it
(Abstract received 04/30/2005 for session A)

The circulation in the Tyrrhenian Sea is still poorly understood. In particular, the southern sector of the basin is thought to be characterized by a basinwide cyclonic circulation, whereas the northern one by a seasonally modulated gyre induced by the wind, channelled through the Straits of Bonifacio which separate the two main islands bounding the basin on the west side, Sardinia and Corsica. Communication between the two subbasins would be ensured by the presence of two coastal currents, a northward one along the eastern boundary and a less well defined southward one along the western boundary. Starting in late 2001, some 50 CODE drifters have been released in the southern sector of the Tyrrhenian. Regular deployments have been carried out on the routes from Napoli to Palermo and from Napoli to Cagliari from research vessels and from ferries made available by the Italian shipping company Tirrenia. The very preliminary results of this experiment were presented at LAPCOD2 in 2002; in this update we show how the basin can be roughly divided into two subareas, characterized by different circulation features and regimes. The southern half of the Tyrrhenian Sea is dominated by a very high variability of the current field: the strong eddy activity makes it even difficult to identify a mean surface field. Most of the instruments deployed along the Napoli-Palermo route get trapped in the southeastern portion of the Tyrrhenian: this might lead to reconsider previous estimates of the residence time of surface waters in the basin. On the contrary, a northeastward current along the coast is visible north of the Gulf of Naples, and drifters caught in this stream rapidly reach the Corsica Channel and exit into the Ligurian Sea.
A202
Statistical analysis of high-resolution drifter data collected just beyond the surf-zone in the Santa Barbara Channel
J. C. Ohlmann
University of California, Santa Barbara
cohlmann@ucsd.edu
(Abstract received 04/29/2005 for session A)
New drifter technology utilizing GPS and terrestrial cellular communications allows inexpensive collection of high-resolution trajectories in the nearshore region to address questions related to small-scale advection and dispersion. A total of 21 deployments of a fleet of up to 15 GPS-cellular drifters over the inner shelf of the Santa Barbara Channel during 2003 yielded near 300 tracks comprised of position measurements, accurate to ~5 m, recorded every 10 minutes. Tracks are mostly a few hours in length. The combined resolution in time and space, along with drifter density, make for a unique data set enabling examination of the flow field on extremely small scales. The drifters generally move up coast and on-shore, in opposition to the prevailing wind direction, suggesting that pressure or Coriolis forces play a significant role in the local momentum balance despite the very nearshore region. Velocity variance is the same order as mean values indicating the importance of high frequency fluctuations in both time and space. Eddy kinetic computed on a typical HF radar scale (hourly in a 2 by 2 km box) reaches nearly 30 cm² s⁻². Lagrangian time and space scales are near 40 min and 100 m, respectively. Mean square pair separations grow exponentially in time from the smallest resolved scale (~10 m) to ~100 m with an e-folding time of near 60 min. Along-shore dispersion is slightly greater than cross-shore growth. The underlying dynamics are presently being investigated.

A203
Riccardo Barbanti, Pierre-Marie Poulain, Sergey Motyzhev and Andrei Zatsepin
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Trieste, Italy
rbarbanti@ogs.trieste.it
(Abstract received 04/20/2005 for session A)
The near-surface circulation in the Black Sea is studied using the data of 55 satellite-tracked drifters in the period 1999-2003. The drifter trajectories confirm the prevalence of the Rim Current trapped along the periphery of the basin where sub-inertial speeds can reach 1 m/s. Meanders and loops in the tracks prove the existence of mostly anticyclonic features inshore of the Rim Current. They also reveal the presence of cyclonic and anticyclonic currents in most areas of the Black Sea. Pseudo-Eulerian statistics (mean currents and velocity variances) show a strong and highly fluctuating signature of the Rim Current, and the enhanced variability associated with the Batumi and Sevastopol eddies. The Rim Current tends to form a stronger single loop trapped on the continental slope in winter/spring, whereas in summer/fall the mean circulation is more meandering and recirculation cells appear in the central areas. In the Batumi eddy region, the currents change from mainly anticyclonic in summer/fall to cyclonic in winter/spring. Mean residence times were calculated in the 50-km bins, with values ranging from 2 to 8 days. Single-particle Lagrangian statistics (velocity variance, diffusivity and Lagrangian integral time scales) were also estimated. They appear generally larger in the zonal direction.

A204
Non-Gaussian velocity probability density functions in the Mediterranean sea
J. Isern-Fontanet, E. García-Ladona, J. Font, A. García-Olivares
Institut de Ciències del Mar (CSIC)
jisern@icm.csic.es
(Abstract received 04/27/2005 for session A)
Velocity Probability Density Functions (PDF) are a key information to study complex flows and of great importance to model particle dispersion. PDF computed in the Mediterranean sea from both, surface Lagrangian data and geostrophic velocities derived from Sea Level Anomalies exhibit non-Gaussian shapes, in agreement with the observations done in other ocean regions. Relatively recent studies on 2D turbulence have shown that non-Gaussian PDF may be associated to the presence of coherent vortices. To investigate this, a flow partition criterion based on the Okubo-Weiss parameter (W) has been used to separate the contribution of coherent vortices and the background field. Then, the velocity PDF have been recomputed showing that only a 20% of the vortices identified in the data set are the main responsible of this non-Gaussianity. This vortices, defined as intense vortices in previous works, are those vortices with amplitudes of about $a \geq 2\sigma_W$ and radius of the order of 40 km.
A205
On the Lagrangian and Eulerian velocity PDFs in the North Atlantic
J. H. LaCasce
Norwegian Meteorological Institute
jlacasce@met.no
(Abstract received 05/02/2005 for session A)

We calculate velocity probability density functions (PDFs) using data from subsurface current meters in the western North Atlantic. The PDFs are weakly, but significantly, non-Gaussian. They deviate from normality due to an excess of energetic events, and there are evidently more such events in the main thermocline than in the deep ocean. We also compare the PDFs to those obtained from subsurface floats in the same region. The PDFs are statistically indistinguishable so long as the float data is averaged in appropriately-sized bins. Taking too small bins yields overly Gaussian float PDFs and too large bins yields too non-Gaussian PDFs. With this caveat, the Lagrangian and Eulerian PDFs agree, consistent with expectations from theory and previous numerical simulations.

A206
Potential Vorticity Dynamics
Thomas Rossby, Mark Prater, Henrik Søiland
University of Rhode Island
trossby@gso.uri.edu
(Abstract received 05/09/2005 for session A)

It is just over 50 years ago that John Swallow wrote his first paper on the neutrally buoyant float. Since then floats have been used to explore and address an ever-widening range of phenomena, from simple descriptive questions about flow patterns to inferences about the underlying dynamics. In this talk we first give a brief review of how different flow patterns can be clarified and understood in terms of conservation of potential vorticity (PV): planetary wave motion, flows in fronts and flows in relation to topography. But PV is not always conserved: there exist locations where it must be modified, and presumably does so through locally enhanced dissipation. For example, the flow of buoyancy-driven water from the northeast Atlantic into the Norwegian Sea between Iceland and the Faroes almost certainly demands a substantial change in PV to clear the sharply shoaling ridge that separates the two basins. Knowing that Lagrangian methods can be quite effective at interpreting flow dynamics, we outline some conceptual field programs that might help us to better understand processes that can set and modify PV in the ocean interior.

A207
Measurements of buoy and tracer dispersion in coastal areas
J.M. Redondo, M. Bezerra Diez and A. Carrillo
Dept. Fisica Aplicada, Univ. Politecnica de Catalunya
redondo@fa.upc.edu
(Abstract received 05/09/2005 for session A)

The eddy diffusivities in the ocean exhibit a large variation and show a marked anisotropy, not only horizontal values are much larger than vertical ones but there is a strong dependence on the spatial extent of the tracer dye or pollutant and at larger scales the topology of the basic flow is very important. In the case of oil spills, solutes or buoy tracers, these are strongly influenced by the buoyancy and horizontal diffusion depends on ambient factors such as wave activity, wind and currents. Measurements have been made near the coast for a variety of weather conditions and these values have been compared with cruise measurements and with estimates from satellite observations. There is a strong dependence of horizontal eddy diffusivities with the Wave Reynolds number as well as with the wind stress measured as the friction velocity from wind profiles measured at the coastline. Some of these results have been published in Bezerra et al. (1998). Both effects are important and give several decades of variation of eddy diffusivities measured near the coastline (between 0.0001 and 2 m²s⁻¹). Longshore currents are also important near the coast. Experiments of dye diffusion such as those performed filming the evolution of slicks allow to characterise the ranges of Kₓ and Kᵧ as a function of the distance to the coast and other environmental factors (Wave height and frequency, wind stress and mean current). A good estimate of the eddy diffusivity comes from a scaling that includes the thickness of the surf zone as well as the depth and the wave period. Measurements in the Mediterranean are almost two orders of magnitude smaller than in the Pacific coast. On a larger scale, and further away from the coast the relevant eddy diffusivities are much larger, because large eddies, that often scale on the Rossby deformation radius, Rd=N/h f, disperse further oil or tracer slicks in the sea surface. Here N is the local Brunt-Vaisalla frequency, f is the Coriolis parameter and h is the relevant depth. A laboratory model of coastal mixing in rotating-stratified flows is useful to realize the wide parameter space exhibited by real flows. A series of field experimental measurements of the Lagrangian characteristics of the surface currents in and near the Barcelona harbour as well as in other
sites (Ebro delta, Recife, Toulon) have been performed during several years in order to include a wide range of different wind and wave conditions. The seasonal influence on the water recirculation and the influence of tidal seiches is apparent when the formation of a local thermocline also forces strong vertical shear. The identification of stagnation points and the role of the friction by the wind have to be taken into account in certain typical conditions. Image analysis of both buoys and tracers help to identify the recirculating areas and to estimate the flushing time in terms of different forcings outside the harbour area. There are regions with parabolic or even smaller time dependence of the relative dispersion while for other conditions Richardson's law or hiperdispersion applies.

A301

Individual-based models: formulation of development equations and computational aspects

Giuseppe Buffoni, Sara Pasquali
ENEA - Santa Teresa
giuseppe.buffoni@santateresa.enea.it
(Abstract received 03/08/2005 for session A)

The individual-based models (IBMs) track all the individuals in a population. In this Lagrangian modelling approach, the dynamics of the overall population is obtained by performing numerical simulations of the life histories of the individuals. The status of an individual (the individual state variable) is individuated by a physiological age which can be defined in terms of biometric descriptors (such as a characteristic length, a weight) or by the percentage of development. The model equations describe the time evolution of the status of an individual, i.e. its life history, which is assumed completely determined by the main biological processes. We assume that the individuals belong to a stage-structured population, where the stages are defined by sharp biological events and address our analyses only to the main biological processes of development (growth), reproduction, and mortality. The individual state variable, i.e. the physiological age of an individual, considered as a stochastic process, is defined as the percentage of development in a stage. The development of an individual is regarded as an accumulation of small increments of physiological age over time. These increments are given by the contributions of a deterministic term, due to the stage-specific mean development rate, and of a stochastic term, due to the variability of development time among the individuals. When regression effects are not allowable in the development process, the stochastic term must assume only non negative values. Different formulations of the development equations of an individual are illustrated. They are based on various distributions (normal, gamma, beta) of the stochastic term. A comparison of the development schemes is performed, by means of theoretical analysis and numerical experiments. Some computational aspects regarding the choice of time step, probability distribution and averaging procedures of the realizations of the overall population dynamics are illustrated.

A302

Lagrangian or not Lagrangian?

Jean-Olivier Irisson, Serge Planes, Michel de Lara
University of Perpignan
irisson@normalesup.org
(Abstract received 04/28/2005 for session A)

Tracking passive or active biological particules does not have the same requirements. Lagragian tracking is an efficient way of representing the complex movement of passive particules (planctonic organisms for example) advected in a changing current regime. When dealing with active organisms, such as fishes larvae, the problem is made even more complex by the behaviour of the animal. Indeed this very behaviour can be sufficiently important on a spatial scale to entrain the particule away from the passive trajectory. We elaborated a model of the pelagic phase of coral reef fishes which accounts for the behaviour of the larvae. The current advection scheme is outrageously simple but the first results obtained seem promising. In this talk I will present this model with special focus on the differences with a Lagrangian model of the same kind of process in order to underline the advantages and the drawbacks of each method.

A303

Lagrangian tracer studies of larval dispersal

G.L. Hitchcock, W.S. Arnold, R. Wanninkhof, M.E. Frischer, Y.P. Sheng
University of Miami
g.hitchcock@miami.edu
(Abstract received 05/12/2005 for session A)

Larval dispersal is a common feature in the life cycle of many benthic marine invertebrates. We have examined the dispersal characteristics of intentionally-released cohorts of recently-hatched larvae of the hard clam Mercenaria mercenaria in two coastal lagoons of the Indian River, Florida, USA.
Both modeled and Lagrangian data (observations from dye and gas tracers and surface drifters) were used to track introduced larval cohorts from release to periods when the larvae were competent to settle. When modeled dispersal was compared to observed larval distribution in one of the lagoons, the fate of larvae predicted by a tracer model and by the distribution of sulfur hexafluoride (SF6) did not agree with that predicted by trajectories of subsurface drifters and by a particle trajectory model. Thus, Lagrangian data suggest that model predictions of larval dispersal must be interpreted with care. Additionally, components of larval dispersal observed in the field that were not adequately replicated in the model were the spread (diffusion) of larvae as they were advected through the lagoon and larval behavior. These aspects of dispersal have important consequences for spatial patterns of recruitment, and illustrate the utility of Lagrangian observations in studies of larval dispersal. Future Lagrangian experiments with modified drifters and fluorescent particles are planned to further resolve larval dispersal.

A304
Lagrangian transport of benthic species in the Ligurian sea (Western Mediterranean)
Stefano Aliani, Annalisa Griffa, Carla Micheli, Anne Molcard, Andrea Peirano
Istituto Scienze Marine Sezione di La Spezia CNR
amolcard@rsmas.miami.edu
(Abstract received 05/11/2005 for session A)

The records of alien species in the Ligurian sea recently increased. Some were directly transported by humans, and others were transported by currents. In this work we aim i) to use a simplified mathematical model to describe the possible time scale that a passive larva requires to travel from the Corsica Channel to the Ligurian sea; ii) to assess whether rafting of organisms on floating objects may affect dispersal processes; iii) to show evidences of long distance dispersal which may supply the local populations. A Lagrangian model has been applied to study dispersion of passive tracers by simulating a high number of particles/larvae. Results of such simulations show that after 30 days only 3% of the larvae can reach the Ligurian coast from the Corsica Channel. Floating debris were estimated from visual sightings during oceanographic cruises in the Ligurian Sea and areas of high concentration were used to assess the potential of floating objects as ways of extending dispersion of settled larvae. After 30 days 11% of larvae reached one of the highest concentration area and after settling on debris the possibility to reach the Ligurian coast increased to 33%. For some species, extension of geographic range can be related to transport of mature individuals on floating objects more efficiently than the active or passive dispersal of reproductive units. The links between offshore presence and coastal settling are under discussion but some clues of connection are from the Mediterranean seagrass Posidonia oceanica. The plant reproduces by floating seeds that are usually found stranded on the beaches. Samples of seeds were collected on the Tuscan and Ligurian beaches to show the possibility of genetic supply despite long distances. A small part of the seeds found stranded in Monterosso (East Liguria) was from offshore. The model suggests that possible sources are from the south.

A305
Larval supply of meroplanktonic larvae in relation to behavioural strategies
Gunnar Brandt
ICBM, University of Oldenburg
brandt@icbm.de
(Abstract received 05/01/2005 for session A)

A three-dimensional Individual-Based Model (IBM) including the Lagrangian solution for the advection-diffusion equation and formulations for temperature-dependent development and vertical movement is used to simulate the fate of larvae of the Blue Mussel (Mytilus edulis) in the German Bight (North Sea). Simulations were carried out for different spawning dates during spring of the years 2000 to 2004. Passive drifting results in an export of more than 70% of all individuals to unsuitable offshore areas due to high turbulence and a counterclockwise tidal residual flow. The spawning date within the year and, thus, the development time has only very limited influence on larval supply to potential settlement areas. Diurnal vertical migration (upward at night, downward at daytime) is often proposed for various planktonic species to enhance retention in vertical sheared flows. In contrast, vertical swimming that is induced by salinity changes (upward at increasing, downward at decreasing values of salinity) leads to significantly higher values for return and retention exceeding 75% for a maximum swimming velocity of 6mm/s. The success of this behavioural strategy is based on the ubiquitous coastal salinity gradient with higher values offshore and the resulting oscillations of salinity values in phase with the tides. Despite the coarse
resolution of the hydrodynamic model used in this study the results robustly explain retention in tidal areas and thus propose a potential mechanism for mobile planktonic species to effectively influence patterns of dispersal.

**A306**

**Lagrangian modelling of phytoplankton coexistence**

Daniela Cianelli, Luciana Sabia, Maurizio Ribera d’Alcalà, Enrico Zambianchi
Università Parthenope, Napoli
daniela.cianelli@uniparthenope.it

(Abstract received 04/30/2005 for session A)

In the aquatic ecosystem processes controlling the phytoplankton growth are non linear; physical, chemical and biological factors, including resource availability, fluctuate both in time and space. The main resources for which phytoplankton species compete are not homogeneously distributed in the water column because of the spatial and temporal variability of turbulent mixing and the concurrent biological response. A dynamical description of light and nutrient supply is a prerequisite for the understanding of competition between phytoplankton species. On this basis, we have devised an Individual Based Model to investigate coexistence of two phytoplankton species in realistic turbulent conditions. We consider turbulent mixing as an additional factor determining the outcome of phytoplankton species competition. The model combines the availability of light and nutrients in the water column with the distribution of the different species determined by a realistic turbulent flow field. The two investigated phytoplankton species are characterized by different photophysiological behaviours and interact only through shading and turbulent mixing rate; the latter is simulated introducing measured values of vertical eddy diffusivity. Using the Lagrangian approach, the dynamics of the two phytoplankton populations is analyzed in terms of the unique temporal and spatial history of individual organisms and of the effect of realistic resource fluctuations upon them. Results suggest that turbulent conditions may induce different photosynthetic responses and adaptive strategies and have a major impact on the species composition during a phytoplankton bloom.

**A307**

**Ecological connectivity among coral reefs: Quantitative predictions of larval fish dispersal**

Pierluigi Pantalone, Barry Ruddick, Bruce Hatcher, Jinyu Sheng
Dalhousie University
pierluigi_pantalone@hotmail.com

(Abstract received 04/30/2005 for session A)

In this study we apply (1st order) Markov Chains theory to investigate the source-sink relationship between discrete areas of the MesoAmerican Barrier Reef System (MBRS; NW Caribbean Sea) in terms of bioparticles exchange. A 2-D numerical model with horizontal resolution of 1/18 degree and a time-step of 6 hours is used to perform Lagrangian tracking of an ensemble of passive (drifters) and active (larvae) particles over 60 days. The model is forced by monthly mean (near-surface) wind driven circulation with current velocities vertically integrated over the top 10 meters. Sub-grid scale dispersion effects are introduced by a random walk technique to simulate unresolved circulation features such as tidal currents or small scale eddies. Reflective boundary conditions are applied in the model to prevent beaching of the particles; the accuracy of the particle tracking is increased by bivariate linear interpolation (time-space) and 4th order Runge Kutta scheme. The biological parameters introduced in the model define the sensory and swimming abilities of an average (late-stage) coral reef fish larva with a planktonic larval duration (PLD) of 30 days. Ecological connectivity (units: # larvae/unit area*unit time)) is estimated both for the passive and active case scenarios through the computation of time-dependent transition probability matrices (P(k) and PB(k)) derived from the particles trajectories in the MBRS. Time-independent transition probability matrices (P(k)) are also computed for the passive runs using a constrained nonlinear optimization that provides the best fit to P(k). Analysis of the results for specific reef areas in the MBRS are illustrated both for the passive and active case scenarios in order to highlight the importance of biological behaviors on larval fish dispersal patterns. The predictive capability of (P^(k)) in quantifying the above properties for each reef area is also shown through comparison with the estimates of retention and exchange based on the trajectories of the tracked particles each time-step (P_(k)).

**A308**

**A dynamic filter to larval dispersal in a reef-building coral**

L.M. Cherubin, I.B. Baums, and C. Paris
University of Miami
lcherubin@rsmas.miami.edu
The movements of larvae between marine populations are difficult to follow directly and have been the subject of much controversy, especially in the Caribbean. The debate centers on the degree to which populations are demographically open, such that depleted populations can be replenished by recruitment from distant healthy populations, or demographically closed and thus in need of local management. Given the depressed state of many tropical reef populations, understanding of these movements now bears critically on the number, placement, and size of marine reserves. Genetic analyses have shown that populations of the Caribbean reef-building coral, Acropora palmata, have experienced little or no recent genetic exchange between the western and eastern Caribbean. Puerto Rico was identified as an area of mixing between the two subregions. Here, we aim to verify the plausibility of a present day oceanographic barrier in the vicinity of Mona Passage using two larval migration numerical models, based on both life history characteristics and physical forcing. The models differed in spatial scales with one simulating Caribbean-wide dispersal and the other focused on dispersal in the Mona Passage. Our results from the larger scale dispersal experiment confirmed that there was no significant larval exchange between the eastern and western Caribbean, driven by the large scale flow. The smaller scale numerical model indicated that virtual larvae released from localities on both sides of the Mona Passage did not readily traverse the passage during the August spawning season, while those released from Mona Is. were retained in the lee within topographically steered eddies. These eddies formed partly as a result of the steep topography of Mona Island and acted as a defacto barrier to dispersal of the largely passive coral larvae. The comparison of genetic and coupled physical-behavioral models of larval movements is a powerful tool to address dispersal over several time scales.
Section B Abstracts

B101
Impact of spatio-temporal variability of nutrient fluxes on primary productivity
Annalisa Bracco, Claudia Pasquero, Antonello Provenzale
The Abdus Salam ICTP
annalisa@ictp.it
(Abstract received 04/21/2005 for session B)

Oceanic carbon uptake depends on the primary productivity of the marine ecosystem. Here we study the dependence of primary productivity in the ocean on the spatial and temporal variability of the nutrient flux and the functional form used to parameterize it. We show that primary productivity is significantly affected by the form of the nutrient flux. For restoring nutrient flux, used to parameterize nutrient input by upwelling, primary productivity strongly depends on the size and/or temporal duration of upwelling events. We also show that High-Nutrient Low-Chlorophyll (HNLC) regions can easily appear when the nutrient input is in the fixed-flux form, without necessarily implying the lack of some micronutrient. We suggest a way to obtain upper and lower bounds to primary productivity in coarse-resolution models.

B102
A Lagrangian Approach to the Role of Turbulence in Biological Physical Interactions
Louis Goodman, and Allan R. Robinson
School for Marine Science and Technology
University of Massachusetts Dartmouth
lgoodman@umassd.edu
(Abstract received 04/11/2005 for session B)

An extension is made of the Robinson NPZ model (Proc. R. Soc., Lond., A, 1999, 455, 1813-1828) of the role of advective upwelling of nutrients and seed plankton into the euphotic zone to include the effect of turbulence. The formalism is based on the usage of the probability density function associated with the Fokker-Plank equations. First and second order moment expressions for both the biological N, P, Z and physical variables are derived. Equivalence of the probability density function with that of the direct solution of the inhomogeneous Fokker-Plank equation for the case of turbulence embedded in an arbitrary advective velocity field is established. Application is made to two simple models - open ocean and coastal upwelling of nutrient and seed plankton into a turbulent euphotic zone. Both the case of a uniform deep reservoir of nutrients and that of a deep nutricline are considered. Inclusion of turbulence in the Robinson advection model of open ocean upwelling model in a linear strain rate field results in a broadening of the phytoplankton vertical profile maximum. The degree of this broadening is shown to be related to a turbulent Reynolds number criteria.

B103
A Lagrangian model for the transport of sediments in coastal areas
Yannis N. Krestenitis, Katerina Kombiadou
Aristotle University
ynkrest@civil.auth.gr
(Abstract received 05/17/2005 for session B)

A 3-D transport model for ‘ideal’ particles passively advected and dispersed by the currents is developed which is based on the Lagrange - Monte Carlo Method. A large number of particles, each representing a particular amount of mass are presented to the flow domain through various sources (rivers, seabed, and atmosphere). Their transport and fate is traced with time. The horizontal advection of the particle is controlled by the local fluid velocity and the vertical advection is controlled by the local fluid velocity and the particle settling velocity. The turbulent diffusion is simulated by the random Brownian motion of the particles due to the turbulence. Thus the motion of each particle is analyzed into a deterministic part, which expresses convection and a stochastic part that accounts for diffusive processes. Once the cohesive sediment particles are introduced to the coastal environment they undergo various processes that affect their properties and their movement. More specifically, they flocculate or deflocculate and gradually change density, thus altering their representative diameter and settling velocity. Seawater stratification influences the vertical movement of the particles by either intercepting or enhancing settling rates. Near-bed processes are included in the simulation, with the possibility of the particles to settle onto the bed, consolidate or resuspend at a later time, and the introduction of eroded material from the sea bottom, according to the shear stress conditions. The mathematical model is realized for the case of the Thermaikos Gulf. The four rivers, Axios, Loudias, Aliakmon and Pinios that discharge along the west coasts of the gulf, supply the coastal basin with a
A large amount of fine-grained sediments. The necessary hydrodynamic data, are obtained from the Northern Aegean shelf model, a 3-D hydrodynamic model based on the Princeton Ocean Model (POM). The shelf model obtains the boundary conditions (asynchronously nested) from the Aegean-Levantine area model.

**B104**

**Observing Turbulence Regimes and Lagrangian Dispersal Properties in the Oceans**

*Volfango Rupolo*

**ENEA**

rupolo@casaccia.enea.it

(Abstract received 04/20/2005 for session B)

In this talk we will show that the ratio \( y = \frac{Ta}{Tv} \) between the acceleration and velocity time scale, directly estimated from the lagrangian trajectory, is an useful index to rationalize the analysis of real Lagrangian trajectories and to avoid a mixture of different regimes, when averaging quantities. We analyzed sub-surface floats data in the Atlantic basin and surface drifters data in the world oceans obtained through the WOCE archive (2002) and we observed that trajectories having respectively a small value of \( y \), and a complex conjugates pair of time scales, belong to two extreme classes, characterized by different shapes, correlation and dispersal properties. In particular, the Lagrangian correlation length varies according to the energy very differently, indicating that this index is an useful tool to discriminate between the two limiting cases in which the spatial structure is strong or weak. On the other hand, the spectral and correlation properties of trajectories belonging to the same class in different datasets are similar. These observations allow us to estimate the role of the diverse regimes in the particles dispersion, both in time and in the geographical space. The dimensionless form of the structure function shows that coherent structures, when present, prevail in the Lagrangian dispersion only for time smaller than 4-5 \( T_L \), where \( T_L \) is the Lagrangian correlation time. The same analysis, performed in the dimensional space, has lead to the characterization of the role of the coherent structures in the dispersion in the sub-surface in the Atlantic basin. - WOCE Data Products Committee. 2002. WOCE Global Data: Subsurface Floats and Surface Velocity Data, Version 3.0, WOCE International Project Office, Report 180/02, Southampton, UK

**B105**

**Application of an idealized radial diffusion-advection model with eddy data.**

*M. Auladell, J.L. Pelegrí, P. Sangrà, P. J. Vélez-Belchi and J.L. López-Jurado*

**Institut de Ciencies del Mar (CSIC)**

maricel@icm.csic.es

(Abstract received 03/09/2005 for session B)

We present some buoy data from two quite different eddy types. The first type are deep eddies topographically-generated by the Canary Islands, and the second one are shallow frontal eddies found south of the Balearic Islands. For the Canary Islands we have examined a total of four buoys, all dragged at 100 m depth. Three buoys tracked one anticyclonic eddy in 1998 during 100 days while drifting 500 km with the mean southwestward Canary Current. The other buoy has been launched recently tracking a cyclonic eddy in the same area. We illustrate the track of the center of both eddies and examine the characteristics of the orbital motions. During their life-time the eddies interact strongly with other cyclonic and anticyclonic eddies, which modifies their mean trajectories as well as their orbital characteristics. For the Balearic Islands we analyze the trajectory of one buoy in 2003, dragged at 10 m. We examine the buoys' data to describe the evolution of the eddies and discuss their similarities and difference. Finally, we use an idealized model, with two active layers, to predict the relative motion of the buoys. The model assumes an axisymmetric eddy, each layer initially having constant angular velocity that evolves subject to radial advection and diffusion. The radial velocity of the surface layer is made proportional to the relative vorticity and for the lower layer it is obtained from continuity. The radial diffusion coefficient is obtained taking into consideration that the vortex must always remain inertially stable. From the angular velocity field we calculate the temporal evolution of both interfaces by assuming a gradient balance for each layer.

**B106**

**Multiple-scale analysis and renormalization for pre-asymptotic scalar transport**

*A. Vulpiani, A. Mazzino and S. Musacchio*

**Università di Roma La Sapienza**

angelo.vulpiani@roma1.infn.it

(Abstract received 02/15/2005 for session B)

Pre-asymptotic transport of a scalar quantity passively advected by a velocity field formed by a large-scale component superimposed to a small-scale fluctuation is investigated both analytically and by
means of numerical simulations. Exploiting the multiple-scale expansion one arrives at a Fokker-Planck equation which describes the pre-asymptotic scalar dynamics. Such equation is associated to a Langevin equation involving a multiplicative noise and an effective (compressible) drift. For the general case, no explicit expression for both the effective drift and the effective diffusivity (actually a tensorial field) can be obtained. We discuss an approximation under which an explicit expression for the diffusivity (and thus for the drift) can be obtained. Its expression permits to highlight the important fact that the diffusivity explicitly depends on the large-scale advecting velocity. Finally, the robustness of the aforementioned approximation is checked numerically by means of direct numerical simulations.

B107
Lagrangian turbulence
G. Boffetta
University of Torino, Italy
boffetta@to.infn.it
(Abstract received 01/12/2005 for session B)

Lagrangian acceleration in turbulence is one of the most intermittent phenomenon in nature. At the typical Reynolds number of laboratory experiments, the instantaneous acceleration can easily attain values 80 times the root mean square value. In this talk I will review the problem of turbulent Lagrangian statistics on the basis of a set of high resolution direct numerical simulations. High resolution Lagrangian statistics is obtained in a range of time spanning more than three decades, from less than a tenth of the Kolmogorov timescale up to one large-eddy turnover time. Acceleration intermittency is found to originate from the trapping of Lagrangian tracers in strong vortices at the Kolmogorov scale.

B201
Mesoscale ocean turbulence and coherent structures as observed from Lagrangian data
M. Veneziani, A. Griffa, A. Reynolds, Z. Garraffo, E. Chassignet, and A. Mariano
RSMAS/University of Miami
eveneziani@rsmas.miami.edu
(Abstract received 04/26/2005 for session B)

Lagrangian data provide direct information on ocean currents in terms of velocity and water particle dispersion. Extensive data sets of historical Lagrangian data are available today for most of the world oceans, both at the surface and in the ocean interior. Their statistical analyses have significantly contributed to improve our knowledge of the ocean circulation. In particular, Lagrangian data provide direct information about transport processes, allowing to identify the mesoscale eddy component. An important conceptual question is whether the eddy transport can be considered approximately diffusive, as assumed in climate modeling and parameterizations, or whether it presents significant deviations due to the presence of coherent structures such as vortices and waves.

B202
Coherent structures in coastal flows
Philippe Fraunie
LSEET Universite Sud Toulon Var
fraunie@lseet.univ-tln.fr
(Abstract received 02/25/2005 for session B)

Field and numerical modeling experiments in Rhone and Ebro regions of freshwater influence are analysed concerning suspended matter dispersion. Non linear interaction between up/downwellings, density and shelf background circulation involve secondary vortices the size of the internal Rossby radius - a few kilometers - responsible for vertical mixing and retention. High order numerical schemes and turbulence models are shown necessary to reproduce such complex flows including density fronts. Optimal control techniques are used for turbulent Schmidt number optimization for Richardson numbers larger than one. Available satellite data are used to confirm occurrence of such small scale structures.

B203
What's wrong with Gulf of Mexico rings?
A. D. Kirwan, Jr., L. Kantha, A. Poje, B. L. Lipphardt, M. Zweng
University of Delaware
adk@udel.edu
The conceptual model of the circulation in the GoM is based on anticyclonic rings shed from the Loop Current migrating westward as isolated vortices and spinning down in the western Gulf. This model is validated by non-data assimilating models. Data assimilating models agree with this picture in the eastern Gulf, but diverge dramatically at 93W. We have examined 11 rings with a data assimilating model and have been unable to find any that could be identified west of 93W where they dissolve abruptly. Three cases have been examined in detail. We found that the rings are torn apart by manifolds associated with baroclinic hyperbolic trajectories.

B204

Rossby dynamics in the Mediterranean and associated Lagrangian transport properties
Enrico Zambianchi, Stefano Pierini
Università Parthenope, Napoli
enrico.zambianchi@uniparthenope.it
(Abstract received 04/30/2005 for session B)

Rossby dynamics is one of the main aspects of oceanic variability. The importance of Rossby waves is first discussed in the context of large scale ocean circulation, looking at their role in shaping the wind-driven response as revealed by altimeter data. We then focus on the Mediterranean Sea, and suggest the possibility of the presence of barotropic planetary Rossby waves in its western subbasin, and of topographic Rossby normal modes in the Straits of Sicily. We present an analytical model for Rossby normal modes in a circular domain and investigate the Lagrangian transport properties associated with them. The adimensional study is shown to be compatible with the previously discussed Mediterranean examples. As a result of chaotic advection, the first normal mode is seen to produce a strong mixing in the direction of phase propagation while the second mode produces a stronger dispersion in the normal direction. A quantitative analysis of chaotic advection is carried out by computing in several relevant cases the particle pair correlation function and the Finite Size Lyapunov Exponent. The comparison of the derived estimates of effective diffusivity with diffusivities drawn from Lagrangian data relative to the same areas shows that chaotic advection may contribute significantly to tracer dispersion in basins characterized by the presence of Rossby normal modes.

Relative dispersion in Lagrangian stochastic models
Leonid Piterbarg
University of Southern California
piter@math.usc.edu
(Abstract received 04/14/2005 for session B)

A principal question for any multi particle LSM is whether it can reproduce observed regimes of the relative dispersion such as Richardson t-cubed and Batchelor exponential. We answer this question for two types of LSM, the Brownian flow (Kraichnan model) and a flow with memory (first order Markov model). For the Brownian flow exact scalings and their applicability limits are obtained. For the 'random flight' model both, local and non-local dynamics, are investigated. In the first case an exact exponential asymptotic is obtained for the relative dispersion. In turn, two regimes are considered in the case of non-smooth forcing: weak and strong turbulence. For weak turbulence the obtained asymptotic of relative dispersion is similar to that of the Brownian flow. As for strong turbulence, an upper bound is obtained for the scaling of relative dispersion.

B206

Exploration of Lagrangian Stochastic Models in Simplified Shear Model Flows
Peter R. Kramer and Emilio Castronovo
Rensselaer Polytechnic Institute
kramep@rpi.edu
(Abstract received 02/08/2005 for session B)

Lagrangian Stochastic Models (LSMs) are being actively developed as computationally tractable schemes to predict and analyze oceanic transport of immersed substances, without full resolution of the oceanic turbulence. In order to better understand the capacity of LSMs to model certain transport features, such as subdiffusion and superdiffusion, we analyze them (including randomized versions) in the context of relatively simple anisotropic shear flow models including a mean flow, low-frequency variability, and a turbulent component. The simplified geometry of our mathematical model flows permits us to study in particular how the modeling of anomalous diffusion through LSMs affects transport predictions through the interaction between the resolved (low-frequency) and unresolved (high-frequency) scales of the flow.

B207
On the formulation of Lagrangian stochastic models for geophysical turbulent flows
Alberto Maurizi, Francesco Tampieri
ISAC-CNR
a.maurizi@isac.cnr.it
(Abstract received 03/25/2005 for session B)

In this work the formulation of Lagrangian stochastic models in geophysical non-homogeneous flows is discussed, focusing on the role of the mean shear. Simplified model formulations that do not satisfy the basic "well mixedness" requirement are also considered, and the differences between the correct and simplified formulations are evaluated for simplified flows.

B301
The Dynamical Systems Approach to Studying Transport in the Chesapeake Bay: An Application of Synoptic Lagrangian Maps
Des Small, Lyon Lanerolle, Stephen Wiggins
University of Bristol, CSDL/OCS/NOS/NOAA
des.small@bristol.ac.uk
(Abstract received 04/30/2005 for session B)

The Residence time parameter in a bay or estuary can provide critical information about its water quality and usefulness to humans. Synoptic Lagrangian Maps (SLM) are a new tool arising from dynamical systems theory for understanding transport phenomena. They can be used in conjunction with hydrodynamic model outputs (currents) with sufficient spatio-temporal resolution where, effectively, an unlimited number of trajectories can be generated. They provide a way of compressing this large amount of trajectory data in a way that shows the spatio-temporal structure of transport from a global point of view. In the present research, residence times and SLMs have been calculated using hydrodynamic model outputs provided by Rutgers University's Regional Ocean Modeling System (ROMS) and the Chesapeake Bay application includes tidal, river and surface forcing. A comparison of these two diagnostics is made. The usefulness of other dynamical systems diagnostics, such as Lyapunov exponents and invariant manifolds, is also considered.

B302
Measures of mixing and transport
Christopher Jones, Thomas C. Redd, Sherry E. Scott and Igor Mezic

University of North Carolina at Chapel Hill
ckrjf@unc.edu
(Abstract received 05/09/2005 for session B)

A fundamental problem arises in comparing fluid flows, for instance different model approximations, in terms of their mixing characteristics. A multi-scale approach is proposed here for assessing the extent of mixing in a model flow. The approach uses wavelets as a means to capturing mixing and ergodicity at different scales. It is exposed in the context of some simple examples of maps. Building on work of Kuznetsov et al. (Physica D, 2004), a measurement of transport is also discussed in terms of manifold comparison.

B303
Insights into stirring and mixing in Monterey Bay from evolving circular blobs
B.L. Lipphardt, A.D. Kirwan, C.E. Grosch, J.D. Paduan
University of Delaware
brucel@udel.edu
(Abstract received 05/16/2005 for session B)

Archives of objectively mapped Monterey Bay surface currents from HF radar are used to evolve simulated particles. Blobs of particles that are initially circular allow the evolving local horizontal divergence and circulation to be studied using line integrals around the blob boundary. Changes in the blob area and perimeter mark transitions from stirring to mixing, and, ultimately, to diffusion. Example blobs in Monterey Bay during summer demonstrate surprisingly long (twenty days or more) residence times in the bay, and the rich structure that develops during transition events over these long time periods.

B304
Lobe dynamics and transport predictions across the North-East Balearic front.
Inst. Matematicas y Fisica Fundamental. CSIC
a.m.mancho@imaff.cfmac.csic.es
(Abstract received 04/22/2005 for session B)

Dynamical systems theory develops mathematical concepts that are applied to quantify transport processes in oceans. Hyperbolic fluid particle trajectories and their stable and unstable manifolds are the basic building blocks of the dynamical systems approach which describes Lagrangian transport. In a recent article [1] these tools are used to
describe the turnstile mechanism in a quasigeostrophic double gyre model. In this work we extend those ideas to identify the same mechanism in a realistic turbulent flow that represents the dynamics of the surface layers of the Mediterranean Sea. A 3D primitive equation ocean model [2,3] provides us with daily surface velocity fields. Visual inspection of the resulting flow in the Mediterranean basin and of their instantaneous stagnation points, both elliptic and hyperbolic, reveals a meandering but persistent Eulerian current that flows eastwards above the Northern slope of the Balearic islands, bends slightly to the South after leaving Minorca island, and then crosses eastwards the Western Mediterranean. Its location seems to coincide with observed density fronts separating waters of Atlantic origin to the South and older Mediterranean waters to the North. Our purpose is to quantify transport across this current, which would greatly contribute to the mixing among the two water masses. Once a Lagrangian barrier is defined, the intersections between stable and unstable manifolds define lobes that evolve and transport fluid masses from the South to the North and from the North to the South. We compute lobe areas and with them we quantify North-South transport in that area of the Western Mediterranean.


B305
The three-dimensional ocean circulation: Lagrangian diagnostics based on General Circulation Model results
Bruno Blanke, Sabrina Speich
Laboratoire de Physique des Océans
blanke@univ-brest.fr
(Abstract received 05/03/2005 for session B)

We point here a general question that arises in Physical Oceanography: where do water masses come from and where are they going? Pathways and mechanisms for oceanic heat and fresh water transports are critical issues in the understanding of the present climate and its stability. Indeed, the ocean circulation transfers heat and fresh water between different climate regimes and between different ocean basins. On regional scales, e.g., eastern boundary current systems, water mass transfers are also worth studying to understand the complexity of the connections achieved between the coastal and open oceans. Transports and pathways are often inferred by merging distinct (mostly Eulerian) sources of data and matching available pieces of knowledge on a basin or global scale. Yet, the most natural approach to estimate flows’ origins and pathways is to follow the movement of water masses and their transformation. In this talk we will show quantitative and qualitative information about the ocean dynamics calculated by the Lagrangian analysis of high performance ocean models. The accent will be put on large-scale diagnostics aiming at characterizing the various branches of the thermohaline circulation as well as on connections established on a regional scale. Our Lagrangian diagnostics rest on the injection of fictitious particles in the time varying, three-dimensional velocity field of a general circulation model. Trajectories are computed with an appropriate scheme that fully respects the local non-divergence of the flow. Quantitative results are obtained by increasing considerably the number of particles. As a current may be entirely determined from the particles that compose it, with well-defined characteristics (position, velocity, and other scalars), the transport of a given water mass can be computed from its own particles and their associated infinitesimal transport.

B306
Tracking mesoscale exchange within a regional model of the Southern Africa Basin
Andrea M. Doglioli, Sabrina Speich, Bruno Blanke, Guillaume Lapeyre
Laboratoire de Physique des Océans, UMR CNRS/IFREMER/UBO, Université de Bretagne Occidentale, Brest
Andrea.Doglioli@univ-brest.fr
(Abstract received 03/10/2005 for session B)

Eulerian and Lagrangian observations, satellite data and numerical model have already shown the complexity of the regime of turbulent interocean exchange between the Indian and the Atlantic, upstream and within the Cape Basin. Rings and eddies pinch off from the Agulhas retroflection, before they penetrate into the Atlantic. They interact with the Agulhas Current and its retroflection, as well as with neighboring mesoscale structures. They are thought to impact the dynamics and variability of the South Benguela upwelling region, which represents one of the richest ecosystems and a major fishing area in the world. Satellite measurements allow rough transport estimates achieved by the eddy field, but gaps in knowledge of the full 3D identity of these structures are handicaps that prevent more accurate diagnostics. On the other hand, the Lagrangian
analysis of eddies simulated by regional ocean models offers promising bases for the development of more robust estimates of the propagation and conservation of eddy properties. Our numerical simulations were run with the ROMS model (for the regional RIBA configuration developed by P. Penven and S. Speich with a 1/10° horizontal resolution). They represent fairly well the crucial properties of the Southern Africa Basin eddy field. We use a technique based on wavelet decomposition to identify coherent eddy structures and to follow water mass properties along their tracks. Then we disseminate Lagrangian numerical particles (ARIANE tool, B. Blanke) in selected cyclones and anticyclones to diagnose their water mass origin and to evaluate the associated mass transfer. The results are here discussed mostly in terms of temperature and salinity temporal evolution, and are compared, where possible, with observations.

B307
Inertial particle approximation to solutions of the Shallow Water Equations on the rotating spherical Earth
Nathan Paldor, Andrey Sigalov
Hebrew University of Jerusalem
nathan.paldor@huji.ac.il
(Abstract received 05/03/2005 for session B)

The work estimates qualitative and quantitative relationships between solutions of two classical problems associated with the horizontal dynamics on the surface of the rotating spherical Earth. The first problem, where explicit expressions exist, is the mechanical problem of particle motion subject only to the gravitation force (called Inertial particle motion) and the second problem is the fluid dynamical problem, described by the Shallow Water Equations (SWE), where the relevant results can only be obtained by numerical integration of the nonlinear partial differential equations. Trajectories of fluid parcels advected by a time-dependent velocity field subject to the SWE on the sphere are computed numerically and compared to inertial particle trajectories. In addition the density (i.e. free surface height) of an ensemble of non-interacting particles is estimated within the classical mechanics framework and compared to computed height of the SWE. The zero gravity (i.e. g=0) case is considered a test case for the reliability of our numerical method for solving the SWE and we find that trajectories of fluid parcels generated by the SWE coincide with trajectories of inertial particles in this, g=0, limit. For g>0 agreement between corresponding solutions is guaranteed by continuity only for small gravity and for short times. Nevertheless, comparison between solutions of two systems shows very good qualitative as well as quantitative agreement for times of several inertial periods in the following elementary low-energy cases: inertial particle oscillations in mid-latitudes (corresponding to inertial waves in fluid dynamics) and divergent motion near the equator. Moreover, for realistic values of the reduced gravity and height (gH of 1 to 100 (m/s)^2) and for time interval of 1--2 days the periods of the trajectories of fluid parcels coincide with those of inertial particles. Our numerical calculations also show that the beta-effect on inertial waves is very similar to its effect on particle motion: in both cases it causes a westward drift of fluid parcels or particles, respectively.

B401
Spin diagnostics and eddy census from Lagrangian data sets: preliminary results
M. Veneziani, A. Griffa, and R. Lumpkin
University of Miami
cveneziani@rsmas.miami.edu
(Abstract received 05/10/2005 for session C)

The presence of mesoscale coherent vortices and eddies in the ocean is thought to alter the transport characteristics of passive tracers, especially in highly energetic regions and in proximity of strong western boundary currents. An important step towards the assessment of the contribution of mesoscale vortices over extensive oceanic regions can be achieved by studying the eddies' overall distribution at the surface as well as in the subsurface and deep ocean. A new methodology is suggested here to identify coherent vortices through a spin parameter estimated from Lagrangian data sets. Lagrangian data coverage has dramatically improved during the last two decades over most of the world oceans, thus providing a very good sampling of large oceanic regions. The spin parameter can be easily estimated from the Lagrangian trajectories, and it represents a good proxy for the relative vorticity of the coherent vortex in which the particles are embedded. We present preliminary results of spin statistics obtained from the historical Lagrangian data sets of the surface and subsurface floats in the North Atlantic Ocean.
Section C Abstracts

C101
Ocean Current Website
A.J. Mariano, E.H. Ryan, B. Bischof
U. of Miami
amariano@rsmas.miami.edu
(Abstract received 01/10/2005 for session A)

An educational web-based ocean current reference site is being constructed. Each major ocean current has a listing of important links, text and data plots. The text provides a detailed summary of observed velocities, transport, salinity, temperature, water mass characteristics, and seasonal variability for each current. Data plots include average and seasonal surface current fields derived from ship-drift, sea surface temperature maps, near-surface drifter trajectories, topographic maps, geography, video clips, circulation schematics, and output from numerical simulations by the HYCOM Consortium for Data-Assimilative Ocean Modeling. Examples for the Atlantic Ocean will be presented. A glossary of oceanographic terms, a tutorial on ocean circulation, a primer on ocean current observations, and a description of oceanography as a career are also on the site.

C102
Transport and mixing in the Mediterranean sea by Finite Size Lyapunov Exponents
Cristóbal López, Francesco d’Ovidio, Emilio Hernández-García and Vicente Fernández
Instituto Mediterráneo de Estudios Avanzados (IMEDEA)
clopez@imedea.uib.es
(Abstract received 04/08/2005 for session C)

In chlorophyll and temperature patterns taken from satellite pictures one can easily recognise convoluted filaments typical of passive tracers in advection systems. By identifying the surface of the sea with a phase space, one can formally use the velocity field as the definition of a two dimensional, time dependent dynamical system. Then, it is possible to show that the filaments observed are related to unstable manifolds of hyperbolic points. The problem of understanding the observed patterns is thus reconducted to the problem of localizing manifolds in a dynamical system and is of great importance for the marine dynamics, since such manifolds mainly control the transport and mixing properties. Such approach is specially appealing in the last decade, since now models and satellite measurements provide the velocity field with a good spatio-temporal resolution. In this talk I will discuss a technique, the Finite Size Lyapunov Exponents (FSLEs), that allows to locate manifolds of hyperbolic points from a velocity field. I will first discuss the technique on ideal systems, like the von Karman model, and then apply it to both simulation and satellite data of the Mediterranean surface velocity field. I will show that the FSLEs not only predict thermal and chlorophyll patterns, but can also be used to quantify mixing and seasonal oscillations.

C103
Open

C104
Lagrangian observations of Antarctic sea ice: the International Programme for Antarctic Buoys
Enrico Zambianchi
WCRP/SCAR - IPAB Chairman
enrico.zambianchi@uniparthenope.it
(Abstract received 04/30/2005 for session C)

We take the opportunity to acquaint the LAPCOD community with the Lagrangian description of a (relatively) unusual fluid environment: the ice-covered sea, and in particular the Antarctic sea-ice zone (ASIZ), which we define as the region of the Southern Ocean and Antarctic marginal seas south of 55 S or within the maximum seasonal sea ice extent. The International Programme for Antarctic Buoys (IPAB), a programme of the World Climate Research Project (WCRP) co-sponsored by the Scientific Committee on Antarctic Research (SCAR) has been active for over 10 years, with the objective of establishing and maintaining a network of drifting buoys in the ASIZ. We review how IPAB platforms have contributed in the past to shed light on many aspects of the dynamics and thermodynamics of the ASIZ: tagging and revisiting ice formation sites; studying the large scale ice drift mechanisms and climatology; providing estimates of annual sea ice transport from and of freshwater balance in marginal basins; assessing the thermodynamic importance of open water regions, and in particular the role of leads in energy balance and ice formation. We also review the application of buoy data in the validation of models and of satellite product. We finally outline an initiative to implement and coordinate the collaborative deployment of a dense network of
instrumented drifting buoys, put forward by IPAB for the International Polar Year (2007-2008) on the basis of the past experience, which shows that the role of autonomous platforms may not be easily substituted - - but rather very efficiently complemented -- by in situ measurement campaigns, necessarily limited in time, or by remotely sensed data, characterized by coarser temporal resolution.

C105

**Bottom-Following Lagrangian Floats**

*Mark Prater, Tom Rossby*

*Graduate School of Oceanography, University of Rhode Island*

mprater@gso.uri.edu

(Abstract received 04/29/2005 for session C)

The majority of the Lagrangian floats used today are designed to follow the flow along two different surfaces: either those of constant pressure (isobaric), or else of constant potential density (isopycnal). However, many oceanographic processes result in flows that follow neither isobaric nor isopycnal (nor even neutral) surfaces. For example, density currents off continental shelves or over inter-basin sills hug the bottom and descend hundreds to thousands of meters, and thus dramatically deviate from an initial isobaric surface. In addition, mixing in the overflow can change the density of the current as lighter ambient waters are entrained and thus can cause the plume to deviate from the initial isopycnal surface. A simple "bottom-following", or constant altitude, RAFOS float was developed to better follow the plume from the Faroe Bank Channel Overflow, and examine the plume from a Lagrangian viewpoint. These floats were deployed at, or downstream, of the sill and were tracked through the Iceland Basin. The resulting trajectories agreed well with Killworth's idealized plume descent model, and showed evidence of deep mesoscale motions. However, the simplistic technique used to maintain the float's altitude above the bottom had obvious problems, and a new method is proposed. This new type of float will be valuable in studies of overflows and casades, as well as in shallow seas where it is difficult to follow conventional isobaric or isopycnal surfaces.

C106

**Interpreting Box Models with Transition Matrices and POPS**

*Barry Ruddick, Pierluigi Pantalone, Keith Thompson*

*Department of Oceanography, Dalhousie University*

barry.ruddick@dal.ca

(Abstract received 04/30/2005 for session A)

Pantalone et al (this conference) describe the use of first order Markov Chain theory to estimate the "Transition Matrix" ecological connectivity - the probability of larvae spawned at one location arriving at specific other locations in a specified time window, as required for recruitment. This matrix succinctly summarizes complex flow paths and biological behaviours in terms of transfer and retention probabilities, but can be too complicated to easily understand. We discuss the use of Peripheral Oscillation patterns (POPS, Hasselman, 1988, J Geophys Res 93D : 11015o11021) to interpret the inherent time scales and associated modal patterns of the Transition Matrix. We illustrate the technique with a simple advective box model and its transition matrix. We find three types of modes: 1. A uniformly-mixed steady state. 2. A "checkerboard" pattern that decays rapidly by mixing within boxes at each time step. 3. Complex conjugate pairs that form complementary modes, giving propagating patterns analogous to the sin and cosine parts of a travelling wave. These modes have a decay time and a period that can be interpreted in terms of advection and mixing. Any initial state can be represented as the sum of the above modes, which decay to leave the steady mode. Thus the time evolution of the system can be understood in terms of the modes and their time scales. The technique should be useful in a variety of applications using box models, to identify the dominant time scales and associated mechanics. The effect of larval settlement onto a reef is investigated by allowing a "sticky" reef to cover part of one box. This breaks the (spatial) symmetry of the transition matrix and modifies the modal shapes and time scales. The steady state has an enhanced concentration of larvae in the box containing the reef. The complex conjugate modes no longer form orthogonal pairs, causing their patterns to form more of a standing than propagating pattern.

C107

**Meanders Downstream The Agulhas Retroflexion**

*Jose Ochoa, Peter Niiler*

*Department of Physical Oceanography/CICESE*

jochoa@cicese.mx

(Abstract received 05/01/2005 for session D)

The surface mean flow, derived from lagrangian trajectories of the Global Drifter Program, shows meanders downstream all separation points of Western Boundary Currents. The most pronounced case is the Agulhas Current (Pazan and Niller, 2004). We do an analysis of the five first meanders, which
have wavelength of about 700 km and their amplitude decrease from 170 km in the first one to 50 km in the following. The region of the meanders shows, relative to further south and north, an increase in mean speed (i.e. it is a jet) and variability. This system has been the subject of many studies (see Lutjeharms et. al., 2004). Here we argue that the large meanders in the mean flow follow a simple vorticity balance where the beta effect, or meridional excursion, and curvature of the displacements balance out. This balance has been the core in explaining the trajectories of vertical coherent jets, particularly in the absence of bottom effects (Warren 1963, Niiler an Robinson, 1966, ..). However, in this case solely applying for the 2D, and surface, flow requires non-divergent conditions (as applied by Reid, 1972, for the Loop Current). We argue that such requisite is a known characteristic of frontal jets (Niiler and Reynolds, 1984) and the only remaining plausible terms to balance on the axis of the jet are: the one due to curvature and the beta effect. Calculations along pathlines show remarkable agreement with this balance, although the non-divergence is not captured in the mean flow estimate.

C201

Dispersion 'probability' maps in the Mediterranean Sea.

Claudia Pizzigalli, E. Lombardi, V. Rupolo
ENEA
claudia.pizzigalli@casaccia.enea.it
(Abstract received 04/28/2005 for session D)

A web site for an easy visualization of surface dispersion properties in the Mediterranean is being constructed. The aim is to obtain a friendly user instrument to be used to have a first information on the statistics of dispersion starting from a generic point in the Mediterranean Sea. Maps of statistical properties of the dispersion are constructed considering 200 28-days long lagrangian simulations in which particles are integrated off-line using the eulerian velocity fields of the MFS (Mediterranean Forecasting System) GCM from September 1999 to July 2004. This OGCM is forced with ECWMF and satellite SST daily data and it 'assimilates' XBT-VOS and altimetry data. In each lagrangian integration about 350 000 particles are uniformly released at surface and then integrated (and constrained to remain at surface) for 28 days. The statistics of the dispersion properties is computed in all the Mediterranean Sea surface considering 'clusters' of particles released in a non-overlapping grid of 3/8° x 3/8° boxes.

We present here some examples of seasonal dispersion probability's maps. A possible next step could be the construction in region of particular interest (e.g. ship tracks) of dispersion probability maps as a function of wind regimes.

C202

Oil dispersion in the ocean

J.M. Redondo, R. Castilla, J. Grau and A. Platonov
Dept. Fisica Aplicada, Univ. Politecnica de Catalunya
redondo@fa.upc.edu
(Abstract received 05/09/2005 for session B)

In recent years the marine pollution has been highlighted thanks to the advances in detection techniques. There is also more public awareness to both the large nautical catastrophes (e.g. oil tankers Amoco Cadiz, Exxon Valdez and recently Erika and Prestige) and the habitual smaller oil spills from the ships. The range of marine pollution events, should even the very smaller oily spills of a few square meters caused by small boats. The middle size oil spills often originate due to coastal sources and from small accidents or habitual cleaning of ballast water in ships. The great oil spills are caused by crude/oil tankers’ catastrophic accidents of varied consequences. From the analysis of SAR observations and new satellite based sensors new methods of oil spill detection in the Ocean, coupled with self-similar statistical techniques allows to determine with precision the range of event and its topological structure. We analyzed more than 700 SAR images obtained during 1996-1998 and compared the small pollution events with the historical databases of great marine accidents during 1966-2004 in European coastal waters. The interactions between the self-similar ocean turbulent, where the Rossby deformation Radius plays an important role and the oil spills is used to model numerically the dispersion. Traditionally in environmental studies of diffusion, oil patches have been numerically predicted and computed with homogeneopus forcing and random free paths, which gives Brownian behavior. These stochastics methods have the objection that don't take into account the toplogy of flow profile. On the other hand, there are many ways to simulate a fluid flow, but when this is turbulent, these simulations become complicated, expensive and inaccurate. Our aim is to present the theoretical and experimental bases needed to simulate accurately the behavior of oil spills (or tracer particles) in a turbulent flow, in a simple and efficient way that may be updated in an emergency with the latest output from dedicated environmental Atmosphere (wind) and ocean currents.
and wave nested models. This is accomplished with a kinematic simulation model and in the presentation we validate the results with detected oil spills. We use a 2D Kinematic Simulation (KS) model, suggested by Kraichnan (1966, 1970) and developed by Fung et al. (1990). In this model, velocity field is generated, maintaining the Energy and enstrophy cascades through a Fourier series of random modes. The typical scales and the energy and enstrophy spectral power laws of the turbulence are inputs of the model. As we do not solve the flow in a discrete grid, but use a random predictive expression, we can simulate the flow (with updated wind, wave and current data) at a wide range of scales. The filamentation and multifractal characteristics of both model and observations are compared and discussed.

C203
Application of a random flight model in a search and rescue model systems
M. L. Spaulding, T. Isaji, A. Allen, P. Hall, and E. Howlett
University of Rhode Island
spaulding@oce.uri.edu
(Abstract received 04/12/2005 for session D)

Random walk, Lagrangian (particle) trajectory models are typically used to predict the transport of objects drifting at sea in most search and rescue planning systems. The movement of an object is approximated as the vector sum of the current field plus an empirically based down and cross (leeway) drift in response to wind forcing, based on the classification of the drifting object. The principal goal of the trajectory model is to predict the location and size of the search area as a function of time, starting from one to several days in the past to about the same number of days in the future. The center of the search area is determined by the advective properties of the surface current and wind fields and the object's mean drift characteristics, while the size of the area is normally dependent on the evolution of the ocean turbulence fields, the shear in the mean current, and the uncertainty in the empirically based leeway estimator. The turbulence and current shear are characterized by the horizontal dispersion coefficients. Spaulding et al (2005) have recently extended SARMAP, a widely used, state of the art search and rescue model which uses a random walk approach, to include an option to perform the trajectory simulation using a random flight technique. The motivation for using a random flight model is the possibility to improve the accuracy of the predictions and to optimize the size of the predicted search area. Random walk and flight options also being included in the next generation of search and rescue model, SAROPS, being developed for the US Coast Guard for use in US coastal waters and the Great Lakes. To evaluate random walk and flight techniques statistically independent, advective simulations were performed using SARMAP to predict the daylong trajectories at successive (non-overlapping) locations along the paths of the seven US Coast Guard, Self Locating Datum Marker Buoys (SLDMB) Argos tracked drifters (Davis like), deployed for 35 days in three separate clusters in the Mid Atlantic Bight. High frequency coastal radar (CODAR) measurements were collected during the same time period for the study area and used as input to the simulations. Model predicted (advection only) and observed locations at the end of one day (typical search and rescue model prediction time scale) showed an averaged difference comparable to the distance the drifter traveled in one day. Differences were significantly higher in areas where the CODAR data return rates were lower. Estimates of the random walk dispersion coefficients, necessary as input to the search and rescue model to ensure that the predicted and observed locations of the drifters were within the model predicted search area, were made and gave values ranging from 20 to 500 m²/sec, with a median value of 90 m²/sec. This range of dispersion coefficient is comparable to independent estimates based on drifter cluster analysis and radar velocity variances and errors. A random flight model was used, with velocity variance based estimates of the dispersion coefficient and autocorrelation times, to simulate the trajectories of the drifters. The random flight model offered no improvement in predictive perform over the corresponding random walk model due to the substantial uncertainty in estimates of the dispersion coefficient and the short (4 to 7 hr) velocity autocorrelation time scale.

C204
An operational ensemble trajectory model for search and rescue
Oyvind Breivik, Art Allen
Norwegian Meteorological Institute
oyvind.breivik@met.no
(Abstract received 04/29/2005 for session D)

An ensemble trajectory model for search and rescue in the open ocean is presented. Empirical formulae relate the leeway of a number of typical search objects to the windfield of a numerical weather prediction model. The empirical leeway coefficients were compiled by the US Coast Guard. An operational ocean model provides surface current
fields. An ensemble of O(500) particles allows uncertainties in geophysical fields and leeway properties to be accounted for through a simple Monte Carlo technique. The operational setup is confined to the Norwegian Sea and the North Sea by the ocean model coverage.

**C205**

**Surface Drift Prediction Using Linear and Non-linear Hyper-ensembles of Atmospheric, Ocean and Wave Operational Models in the Adriatic**

Michel Rixen, Emanuel Ferreira-Coelho
NURC NATO
rixen@nurc.nato.int

(Abstract received 04/08/2005 for session D)

The Adriatic is an ideal natural laboratory and test bed to conduct oceanographic research, with a high concentration of observational and modeling operational efforts and expertise. The forecast of surface velocities, which usually results from a complex combination of ocean, atmospheric and wave forcing, has always been very challenging in the basin. However, our current monitoring and operational predictive capabilities do not allow yet inferring accurate surface drift velocities despite high-resolution modeling and extensive surface drifter data sets in the basin. It appears that an entirely different approach is warranted for a definitive significant improvement in surface drift forecast skills. Multimodel superensemble forecasts, which exploit the power of an optimal local combination of individual models usually show superior forecasting skills when compared to individual models because they allow for local correction and/or bias removal. Here we apply linear and non-linear statistical methods to generate hyper-ensembles, which are optimal combinations of models of different kinds, namely atmospheric, ocean and wave operational models, to investigate the Adriatic Sea Dynamics. Optimization methods are based on a training/forecast cycle and include simple least-square methods, neural networks and genetic algorithms. The performance and the limitations of the hyper-ensembles and standard surface drift methods are illustrated and discussed.

**C206**

**Surface Drift Uncertainty Analysis Using An High Resolution Tactical Ocean Modeling System**

E.F. Coelho, M. Rixen
NATO Undersea Research Centre
coelho@nurc.nato.int

(Abstract received 04/07/2005 for session D)

The NATO Tactical Ocean Modeling System (NTOMS) was designed to measure and improve reliability of local forecasting. It proposes a hierarchical methodology that starts from the available operational information, builds a reliability flag based on statistical analysis and environmental model ensemble and introduces high resolution sampling and stochastic-feature modelling as a solution to improve the reliability and resolution of local end-products. The NTOMS superensembles, using simplified stochastic modeling applied to surface drift estimation, have shown efficiency and reliability could significantly increase, when compared to standard operational support. However, there were still observed persistent forecast mismatches when in the presence of strong near-inertial dynamics. Data collected during two sea trials in the Eastern Ligurian Sea, and off western Portugal was used to assess near-inertial bands dynamics and to discuss the ability of the existent operational systems to accurately capture these dynamics. Once the NTOMS strategy is fine-tuned, it is expected to produce locally more accurate oceanographic field estimation, providing the additional field functions required to solve the NTOMS ensembles mismatches, and to improve the impact of local high resolution data assimilation in the overall operational models domains.
Preliminary Lagrangian Analysis of NCOM output for the Adriatic Sea for DART05 Project
Annalisa Griffa, Angelique Haza, Paul Martin, Anne Molcard, Tamay M. Özgökmen, Leonid I. Piterbarg
RSMAS/MPO, University of Miami, Florida, USA
tozgokmen@rsmas.miami.edu
(Abstract received 05/??/2005 for session D)

Preliminary results relevant to the DART05 project in the Adriatic Sea will be presented, based on particle releases in 1-km resolution NCOM simulations.

C302
Simulation of Lagrangian trajectories from models with and without assimilation
Julio Sheinbaum, Julio Candela, Bernard Barnier, Michel Crepon
Physical Oceanography, CICESE, Ensenada, Mexico, LEGI-CNRS, Grenoble, LODYC, Paris, France
julios@cicese.mx
(Abstract received 04/29/2005 for session A)

The statistics of lagrangian trajectories in the Caribbean Sea obtained by integrating the surface currents of two numerical models are compared. The models used are two different configurations of the OPA French model: One is the CLIPPER ATL6 configuration forced with observed satellite winds (ERS), with no data assimilation. The other is the MERCATOR operational model that assimilates satellite derived sea surface height anomalies. The lagrangian statistics derived from simulated trajectories in the two models differs significantly and also when compared with that from available observed trajectories in the region. The unrealistically large number of eddies in the model without assimilation may explain these differences. Several tracer release experiments are carried out with the two models to compute the probability of finding particles in different regions of the domain; this information is particularly valuable to understand biological connectivity in the Mesoamerican Barrier-Reef System.

C303
Dynamical systems perspective of observing system design
Kayo Ide, Christopher K.R.T. Jones, Hayder Salman
University of California, Los Angeles
kayo@atmos.ucla.edu
(Abstract received 05/01/2005 for session D)

We present the Lagrangian data assimilation (LaDA) method due to Ide and collaborators (Ide et al 2002, Kuznetsov et al 2003). We invoke an ensemble Kalman filter in order to estimate and forecast the (ocean) state using the shallow-water model (Salman et al, 2005). Based on the augmented state representation, the LaDA eliminates the need for any conventionally used approximation in assimilating the Lagrangian information. This augmentation also allows us to use dynamical systems theory for the design of a comprehensive observing system. We show how deploying drifters in the flow near the (Lagrangian) saddle point enhances the information content of the (Eulerian) flow dynamics extracted from the Lagrangian data using LaDA.


C304
The Inverse Lagrangian Prediction Problem
RSMAS, U. of Miami
amariano@rsmas.miami.edu
(Abstract received 05/04/2005 for session D)

An inverse Lagrangian prediction problem is posed as follows: What is the initial location and deployment time so that the object will be found at a given location later in time? The "final" location/time of the object, such as a ship or drifting instrumented buoy, its drift characteristics, and noisy observation/simulation of the currents and winds are assumed to be known. Also, a multiple-object version of this problem would be: Can we design an optimal deployment strategy for a cluster of objects so that the objects end up in a specific configuration at some later time? A unique and/or numerically stable solution for such inversion problems is difficult to obtain computationally, given
imperfection in the current and wind data, the chaotic nature of the forward prediction problem, convergent and divergent flows, deployment constraints, and bimodal, down-wind drag coefficients. An "ensemble" of solutions describing a set of possible deployment locations/times for each final location might be the best one can achieve.

A brute-force optimization technique that minimizes the mean-square distances between predicted final locations from a Monte-Carlo based simulation of trajectories and the desired final location is formulated and applied with good results to a practical problem in the Gulf of Mexico. Our optimization technique is applied to the array configuration problem, the central theme of ONR's Optimal Deployment of Drifting Acoustic Sensors (ODDAS) initiative.

C305
Directed Drifter Launch Strategies for Lagrangian Data Assimilation Using Hyperbolic Trajectories
A. Molcard, A. Poje, T. Özgökmen
ISAC-CNR, City University of NY, RSMAS UM
amolcard@rsmas.miami.edu
(Abstract received 04/25/2005 for session B)

The dependence of the fidelity of a Lagrangian data assimilation scheme on the initial launch locations of the observed drifters is studied in the context of a reduced gravity, primitive equation model of mid-latitude circulations. A directed launch strategy, based on tracking the Lagrangian manifolds emanating from strongly hyperbolic regions in the flow field, is developed. In a series of twin assimilation experiments, the convergence of the data assimilating scheme is shown to be consistently and significantly improved by such directed launches compared to randomly selected initial drifter positions. By directing initial drifter positions along the out-flowing branch of identifiable Lagrangian boundaries the relative dispersion of the drifters, the overall data-coverage and the sampling of high kinetic energy features in the flow are optimized. In general, the performance of the assimilation procedure is shown to depend strongly on the independence of the observed drifter trajectories and the temporal persistence of the corrections provided by the data.

C306
The surface circulation through the Sicily Strait deduced from NOOA images and hydrological data obtained during 2003
Sana Ben Ismail, Cherif Sammari, and G.P. Gasparini
INST
sana.benismail@instm.rnrt.t
(Abstract received 05/25/2005 for session C)

[no abstract submitted]

C401
A semi-empirical Lagrangian model for search and rescue services in the Canary Islands archipelago
L. Cardona, M.G. Villagarcia, J. Perez-Marrero, L. Maroto, J. Godoy, C. Barrera, E. Gonzalez-Roncero, M.J. Rueda, O. Llinás
Instituto Canario de Ciencias Marinas
laura@iccm.rcanaria.es
(Abstract received 05/09/2005 for session D)

A system of operational oceanography is being implemented, based in the combination of observation and analyses of oceanographic data with numerical simulation, in order to try predicting the drifting objects trajectories. It is intended to cover marine emergency situations in the Canarian archipelago waters, such as search and rescue operations and pollutants dispersal. The study of the trajectories of about 75 NOAA drifters deployed monthly at the ESTOC time series station located in the North Atlantic (29º10'N, 15º30'W) since 1998 till nowadays, has provided a good knowledge of the surface current system in the area, depicting some seasonal tendencies. In order to provide emergency teams with a probable trajectory of the drifting object, a semi-empirical model based in Alves et al. (2002) is being develop for the Canary Islands waters. Drifters trajectories and Quikscat (wind) data in the area are being used to develop the model at a preliminary stage; geostrophic data will be added as a second step. Further, some practical exercises are being carried out with the local Search and Rescue team to feed the model. A new drifter with bi-directional communication via Inmarsat has been deployed and collected several times to compare the trajectories with the model outputs.

C402
A meteorological tides forecasting method: first results in the Eastern Ligurian harbours
INGV - Stazione di Geofisica Marina
faggioni@ingv.it
Sea level oscillations are the superposition of many contributions, among which the main are astronomic tides (astro-tides) and meteorological low-frequency components (meteo-tides). Particularly in the Ligurian Sea the meteo-tides, being most ample than the astronomic fluctuations, role the water exchange in harbours and the tide oscillations of coastal water masses (with particular reference to low-frequency sea level fluctuations). Moreover, this phenomenon has a primary role about environmental aspects, e.g. pollutants dispersion and water oxygenation balance. Meteorological tide is the geodetic adjustment of free sea surface to the variations of atmosphere weight burdening on it. The newtonian forecasting method of the meteorological tides is based on the measure of the time elapsing between the barometric sea level unbalance and its meteorological tide compensation. The meteorological tide component is independent on the Earth-Moon-Sun gravitational relationships, moreover the parameters related to the shifted water mass are too many to describe the phenomenon analytically. Then, meteorological tide can't be foreseen by the measurement of atmospheric pressure; on the contrary, meteo-tides can be foreseen by a statistic method starting from gravimetric measurements. In fact, a gravimeter can detect the time when the geodetic unbalance starts and a tide-gauge can detect the time when newtonian compensation happens by the arrival of tide wave. The difference between these two time-instants is the meteorological tide delay. An opportune statistic of this delay can provide an experimental law typical for each harbour to forecast the meteo-tide compensation wave delay and to plan human activities in the harbour waters. This work describes the methodological procedure adopted and the first experimental evidences of the phenomenon in Genoa and La Spezia harbours.
Section D Abstracts

D101
On the statistical approach to Lagrangian data assimilation
Leonid Piterbarg
University of Southern California
piter@math.usc.edu
(Abstract received 04/14/2005 for session D)

The Lagrangian data assimilation problem is treated as a statistical problem of optimal estimating a random velocity field given noisy observations of particles released in the flow. One of the most serious obstacles on this way is the non-linear relation between Eulerian and Lagrangian velocities. We, first, discuss how to overcome this difficulty. Then, a new justification is presented for the simplest optimal interpolation procedure which already was used in our twin experiments with OGCM's. Finally, we investigate the dependence of the assimilation skill on the observation time in the framework of Markov LSM's.

D102
Assimilation of float positions in general circulation and regional scale ocean models
A. Molcard, A. Griffa, T.M. Özgökmen, L.I. Piterbarg, V. Taillandier, A. Mariano, T.M. Chin.
RSMAS UM, CNR
amolcard@rsmas.miami.edu
(Abstract received 04/25/2005 for session D)

Because of the increase in the realism of ocean models and in the coverage of Lagrangian data sets in most of the world's oceans, assimilation of Lagrangian data emerges as a natural avenue to improve ocean state forecast. In this study, we provide an overview of recent work performed by the authors (Molcard et al., 2003; Ozgokmen et al. 2003; Molcard et al., 2005; Taillandier et al., 2005), where a Lagrangian data assimilation method for particle position is developed, implemented in a hierarchy of models, and tested using the twin-experiment approach. The first and main step consists of using the Lagrangian data to correct the Eulerian model velocity in the same layer where the data are collected. This is done by minimizing the distance between observed positions and positions of synthetic floats simulated by the model. The corrections obtained in a single layer are then projected to other layers using statistical correlations and the mass variables are corrected using a dynamical balancing technique based on geostrophy and mass conservation. An extensive set of twin experiments have been performed using an idealized double-gyre configuration. The results indicate that the assimilation is effective provided that the data sampling period Dt is smaller than the Lagrangian time scale TL. The performance of the Lagrangian assimilation technique is also compared to that of conventional methods of assimilating drifters as moving current meters, and assimilation of Eulerian data, such as fixed-point velocities. Overall, the results are very favorable for the assimilation of Lagrangian observations to improve the Eulerian velocity field in ocean models. Applications to realistic regional flows in the Mediterranean Sea have also been performed, further improving the method using an adjoint formulation to extend the Eulerian velocity corrections and to implement the mass correction.

D103
Variational assimilation of Lagrangian data in a Primitive Equations model
Maelle Nodet
Laboratoire J.A. Dieudonne, Universite de Nice, CNRS
nodet@unice.fr
(Abstract received 04/26/2005 for session D)

We investigate variational assimilation of Lagrangian data. We begin our study by doing twin experiments using an idealized configuration of the North-Atlantic Ocean and simulated positions of drifting floats. We are using the four dimensional variational technique and the adjoint method: we aim at minimizing a cost function which represents the root mean square error between observed positions of drifting floats and positions generated by the model. This cost function is minimized with respect to the control vector, which is the initial velocity field of the ocean. Observed variables, namely the positions of the floats, are expressed as a function of the control vector thanks to a non linear observation operator. The minimization of the cost function requires the tangent linear observation operator and its adjoint, whose implementation is quite difficult because of the non linear aspect of the operator. This method has been implemented in the OPA Primitive Equations model in the incremental 4D-Var approach. It has the ability to reconstruct the main patterns of the oceanic circulation. Moreover it is very robust with respect to increase of time-sampling period of observations. We
have run many twin experiments in order to analyze the sensitivity of our method to the number of floats, the time-sampling period and the vertical drift level. We compare also the performance of the Lagrangian method to that of the classical Eulerian one.

**D104**

**Assimilation of Lagrangian Data Using Particle Filters**  
*Keith Thompson, Kassiem Jacobs*  
*Dalhousie University, Canada*  
*keith.thompson@dal.ca*  
(Abstract received 04/29/2005 for session D)

A straightforward scheme for assimilating Lagrangian data is described and illustrated using the idealized dynamical model of Kuznetsov, Ide and Jones (2003). This model includes a drifter that is passively advected by the flow fields of two self-advecting point vortices. The theory underlying the assimilation method is fully Bayesian and the method is implemented using a Particle Filter (PF). It is shown that the PF can accommodate the highly non-Gaussian probability density function of drifter position and can provide reliable estimates of vortex position from intermittently observed drifter positions over a wide range of parameter values. The number of ensemble members required by the PF is discussed and some simple schemes for reducing this number below O(100) are described and shown to work in this simple dynamical system. The prospect of using PF in realistic, fully nonlinear ocean model to assimilate Argo data is discussed.


**D105**

**Lagrangian data assimilation and overcoming the saddle effect**  
*Christopher K.R.T. Jones, Kayo Ide, Liyan Liu, Amit Apte, Juan Restrepo*  
*University of North Carolina at Chapel Hill*  
*ckrtj@email.unc.edu*  
(Abstract received 05/01/2005 for session D)

We present and discuss issues essential to the assimilation of Lagrangian data in general. By removing the necessity for a commonly used approximation, in terms of velocity, in assimilating Lagrangian data, a recently developed Lagrangian data assimilation (LaDA) method has been shown to offer a variety of advantages (Ide et al 2002, Kuznetsov et al 2003, Salman et al, 2005). Success of LaDA depends on properly estimating the error correlation between the ocean model variables and drifter positions within the augmented state space. We examine the information propagation process for the error variance and correlations using variants of the Kalman filter, e.g., Extended Kalman filter (EKF), Ensemble Kalman filter (EnKF), Sequential Evolutive Extended Kalman (SEEK). The estimation process may, however, fail when the Lagrangian instrument passes near to a (Lagrangian) saddle point of the ocean flow. This leads to a sudden divergence of the filter, termed the "saddle effect" (see LAPCOD, 2002). We present a series of strategies to attack this problem using tracer control, ensemble filter, and a path integral method. On the basis of these approaches, we develop an efficient and robust LaDA method that overcomes the saddle effect. Finally, an application of LaDA for estimation of the sub-surface flow using surface drifter observations will be presented.


**D106**

**Reconstructing regional-scale velocity fields from lagrangian data**  
*Vincent Taillandier*  
*CNR-ISMAR*  
*vincent@sp.ismar.cnr.it*  
(Abstract received 04/29/2005 for session D)

The accuracy for reconstructing regional circulations from float trajectories is tested on a model generated time-dependent velocity field. In the present approach, the eulerian field solution of the equation governing the float advection is found by minimizing the distance between predicted float positions and the observed trajectories. The sensitivity of reconstruction is assessed considering different space-time distributions of lagrangian data. Applications to the Mediterranean circulation analysis are discussed for medARGO profilers deployed at the basin scale and surface drifters deployed at the regional and coastal scales.
The impact of temperature and salinity data from profiling floats in the Mediterranean Forecasting System.
F. Raicich, A. Griffa, A. Molcard, V. Rupolo CNR, Istituto di Scienze Marine, viale Romolo Gessi 2, 34123 Trieste, Italy
fabio.raicich@ts.ismar.cnr.it
(Abstract received 04/18/2005 for session D)

The impact of temperature (T) and salinity (S) from profiling floats (MedARGO) in the Mediterranean Forecasting System (MFS) is assessed by means of numerical twin experiments. These consist of a control run, in which ‘true’ T and S data are extracted from a Mediterranean General Circulation Model (MOM-1, 1/8°x1/8°, 31 vertical levels), a free run, with different initial conditions relative to the control run, and an assimilation run. The assimilation T and S data is performed by means of SOFA bivariate optimal interpolation scheme. The convergence of the assimilation run towards the control run is assessed by means of standard deviations of differences between the two runs. The convergence of the free run towards the control run, assessed in the same way, is used for reference, since it shows the ability of the model to converge towards the control run without data assimilation. The data impact is quantified by the error reduction achieved in the assimilation run relative to the free run. Both idealized, although realistic, and real MedARGO float distributions are studied. Twin experiments are performed in summer and winter circulation conditions. In the idealized case 47 floats are released along Volunteer Observing Ship (VOS) tracks and advected by the velocity field computed by 1/8° OPA model, according to the real operative scheme. The maximum error reduction is about 20-30%, depending on season, geographic area and depth. The most effective float trajectories sample dynamically active regions, such as the frontal areas in the western Mediterranean and the northwestern Ionian Sea. The MedARGO data impact is compared with that of T and S observations collected along VOS tracks. Real data distributions are also studied, using the profile positions during the MFS operational activity. In this case the sampling does not provide enough data to achieve notable error reductions when only MedARGO data are assimilated, but the data impact is improved when MedARGO and VOS data are associated.
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<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stefano Aliani</td>
<td>CNR - ISMAR SP</td>
<td><a href="mailto:stefano.aliani@ismar.cnr.it">stefano.aliani@ismar.cnr.it</a></td>
</tr>
<tr>
<td>Arthur Allen</td>
<td>USCG - Office of Search and Rescue</td>
<td><a href="mailto:aallen@rdc.uscg.mil">aallen@rdc.uscg.mil</a></td>
</tr>
<tr>
<td>Carlos Alonso-Hernandez</td>
<td>Centro de Estudios Ambientales de Cienfuegos</td>
<td><a href="mailto:carlos.alonso@santateresa.enea.it">carlos.alonso@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Isabel Arozarena</td>
<td>Università degli studi di Pisa Scienze della Terra</td>
<td><a href="mailto:iarozarena@dst.unipi.it">iarozarena@dst.unipi.it</a></td>
</tr>
<tr>
<td>Vincenzo Arrichiello</td>
<td>Consultant</td>
<td><a href="mailto:mail@vincenzoarrichiello.com">mail@vincenzoarrichiello.com</a></td>
</tr>
<tr>
<td>Maricel Auladell</td>
<td>Institut de Ciencias del Mar (CSIC)</td>
<td><a href="mailto:maricel@icm.csic.es">maricel@icm.csic.es</a></td>
</tr>
<tr>
<td>Riccardo Barbanti</td>
<td>OGS</td>
<td><a href="mailto:rbarbanti@ogs.trieste.it">rbarbanti@ogs.trieste.it</a></td>
</tr>
<tr>
<td>Mattia Barsanti</td>
<td>ENEA - CRAM S.Teresa</td>
<td><a href="mailto:mattia.barsanti@santateresa.enea.it">mattia.barsanti@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Sana Ben Ismail</td>
<td>INSTM</td>
<td><a href="mailto:sana.benismail@instm.rnrt.tn">sana.benismail@instm.rnrt.tn</a></td>
</tr>
<tr>
<td>Bruno Blanke</td>
<td>Laboratoire de Physique des Océans</td>
<td><a href="mailto:blanke@univ-brest.fr">blanke@univ-brest.fr</a></td>
</tr>
<tr>
<td>Guido Boffetta</td>
<td>University of Torino</td>
<td><a href="mailto:boffetta@to.infn.it">boffetta@to.infn.it</a></td>
</tr>
<tr>
<td>Annalisa Bracco</td>
<td>The Abdus Salam ICTP</td>
<td><a href="mailto:annalisa@ictp.it">annalisa@ictp.it</a></td>
</tr>
<tr>
<td>Elena Brambilla</td>
<td>Scripps Institution of Oceanography</td>
<td><a href="mailto:ebrambilla@ucsd.edu">ebrambilla@ucsd.edu</a></td>
</tr>
<tr>
<td>Gunnar Brandt</td>
<td>ICBM, University of Oldenburg</td>
<td><a href="mailto:brandt@icbm.de">brandt@icbm.de</a></td>
</tr>
<tr>
<td>Øyvind Breivik</td>
<td>Norwegian Meteorological Institute</td>
<td><a href="mailto:oyvind.breivik@met.no">oyvind.breivik@met.no</a></td>
</tr>
<tr>
<td>Giuseppe Buffoni</td>
<td>ENEA</td>
<td><a href="mailto:giuseppe.buffoni@santateresa.enea.it">giuseppe.buffoni@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Julio Candela</td>
<td>CICESE</td>
<td><a href="mailto:jcandela@cicese.mx">jcandela@cicese.mx</a></td>
</tr>
<tr>
<td>Laura Cardona</td>
<td>Instituto Canario de Ciencias Marinas (ICCM)</td>
<td><a href="mailto:laura@iccm.rcanaria.es">laura@iccm.rcanaria.es</a></td>
</tr>
<tr>
<td>Sandro Carmiel</td>
<td>CNR - ISMAR</td>
<td><a href="mailto:sandro.carmiel@ismar.cnr.it">sandro.carmiel@ismar.cnr.it</a></td>
</tr>
<tr>
<td>Luca Centurioni</td>
<td>Scripps Institution of Oceanography</td>
<td><a href="mailto:lcenturioni@ucsd.edu">lcenturioni@ucsd.edu</a></td>
</tr>
<tr>
<td>Laurent Cherubin</td>
<td>University of Miami</td>
<td><a href="mailto:lcherubin@rsmas.miami.edu">lcherubin@rsmas.miami.edu</a></td>
</tr>
<tr>
<td>Toshio Chin</td>
<td>University of Miami</td>
<td><a href="mailto:mike.chin@jpl.nasa.gov">mike.chin@jpl.nasa.gov</a></td>
</tr>
<tr>
<td>Daniela Cianelli</td>
<td>Université Parthenope</td>
<td><a href="mailto:daniele.cianelli@uniparthenope.it">daniele.cianelli@uniparthenope.it</a></td>
</tr>
<tr>
<td>Andrea Cucco</td>
<td>IAMC - CNR, Oristano Section</td>
<td><a href="mailto:andrea.cucco@iamc.cnr.it">andrea.cucco@iamc.cnr.it</a></td>
</tr>
<tr>
<td>Ivana Delbono</td>
<td>ENEA - Marine Environment Research Centre</td>
<td><a href="mailto:ivana.delbono@santateresa.enea.it">ivana.delbono@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Andrea Doglioli</td>
<td>Université de Bretagne Occidentante</td>
<td><a href="mailto:Andrea.Doglioli@univ-brest.fr">Andrea.Doglioli@univ-brest.fr</a></td>
</tr>
<tr>
<td>Osvaldo Faggioni</td>
<td>INGV - Stazione di GeoFisica Marina</td>
<td><a href="mailto:faggioni@ingv.it">faggioni@ingv.it</a></td>
</tr>
<tr>
<td>Pierpaolo Falco</td>
<td>Università Politecnica delle Marche</td>
<td><a href="mailto:p.falco@ismar.cnr.it">p.falco@ismar.cnr.it</a></td>
</tr>
<tr>
<td>Emanuel Ferreira-Coelho</td>
<td>NATO Undersea Research Centre</td>
<td><a href="mailto:coelho@nurc.nato.int">coelho@nurc.nato.int</a></td>
</tr>
<tr>
<td>Manuel Fiaideiro</td>
<td>ONR</td>
<td><a href="mailto:fiaideim@onr.navy.mil">fiaideim@onr.navy.mil</a></td>
</tr>
<tr>
<td>Philippe Fraunie</td>
<td>LSEET Universite Toulon Var</td>
<td><a href="mailto:fraunie@lseet.univ-tln.fr">fraunie@lseet.univ-tln.fr</a></td>
</tr>
<tr>
<td>Gian Pietro Gasparini</td>
<td>CNR - ISMAR</td>
<td><a href="mailto:gasparini@sp.ismar.cnr.it">gasparini@sp.ismar.cnr.it</a></td>
</tr>
<tr>
<td>Louis Goodman</td>
<td>University of Massachusetts</td>
<td><a href="mailto:lgoodman@umassd.edu">lgoodman@umassd.edu</a></td>
</tr>
<tr>
<td>Annalisa Griffa</td>
<td>ISMAR/CNR - RSMAS/UM</td>
<td><a href="mailto:agriffa@rsmas.miami.edu">agriffa@rsmas.miami.edu</a></td>
</tr>
<tr>
<td>Gary Hitchcock</td>
<td>University of Miami</td>
<td><a href="mailto:g.hitchcock@miami.edu">g.hitchcock@miami.edu</a></td>
</tr>
<tr>
<td>Kayo Ide</td>
<td>UCLA</td>
<td><a href="mailto:kayo@atmos.ucla.edu">kayo@atmos.ucla.edu</a></td>
</tr>
<tr>
<td>Jean-Olivier Irisson</td>
<td>University of Perpignan</td>
<td><a href="mailto:irisson@normalesup.org">irisson@normalesup.org</a></td>
</tr>
<tr>
<td>Jordi Isern-Fontanet</td>
<td>Institut de Ciències del Mar (CSIC)</td>
<td><a href="mailto:jisern@icm.csic.es">jisern@icm.csic.es</a></td>
</tr>
<tr>
<td>Christopher Jones</td>
<td>Univ North Carolina at Chapel Hill</td>
<td><a href="mailto:ckrtj@email.unc.edu">ckrtj@email.unc.edu</a></td>
</tr>
<tr>
<td>Name</td>
<td>Affiliation</td>
<td>Email</td>
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<td>------------------------------</td>
</tr>
<tr>
<td>Ali Keyhani</td>
<td>Shahrood University of Technology</td>
<td><a href="mailto:a_keyhani@hotmail.com">a_keyhani@hotmail.com</a></td>
</tr>
<tr>
<td>Denny Kirwan</td>
<td>University of Delaware</td>
<td><a href="mailto:adk@udel.edu">adk@udel.edu</a></td>
</tr>
<tr>
<td>Peter Kramer</td>
<td>Rensselaer Polytechnic Institute</td>
<td><a href="mailto:kramep@rpi.edu">kramep@rpi.edu</a></td>
</tr>
<tr>
<td>Yannis Krestenitis</td>
<td>Aristotle University</td>
<td><a href="mailto:ynkrest@civil.auth.gr">ynkrest@civil.auth.gr</a></td>
</tr>
<tr>
<td>Balasaheb Kulkarni</td>
<td>The Institute of Science</td>
<td><a href="mailto:balasahebk@yahoo.com">balasahebk@yahoo.com</a></td>
</tr>
<tr>
<td>Joe LaCasce</td>
<td>Norwegian Meteorological Institute</td>
<td><a href="mailto:jlacasce@met.no">jlacasce@met.no</a></td>
</tr>
<tr>
<td>Bruce Lipphardt</td>
<td>University of Delaware</td>
<td><a href="mailto:bruce@udel.edu">bruce@udel.edu</a></td>
</tr>
<tr>
<td>Cristóbal López</td>
<td>Instituto Mediterrâneo de Estudios Avanzados</td>
<td><a href="mailto:clopez@imedea.uib.es">clopez@imedea.uib.es</a></td>
</tr>
<tr>
<td>Ana Maria Mancho</td>
<td>CSIC</td>
<td><a href="mailto:a.m.mancho@imaff.cfmac.csic.es">a.m.mancho@imaff.cfmac.csic.es</a></td>
</tr>
<tr>
<td>Arthur J. Mariano</td>
<td>University of Miami</td>
<td><a href="mailto:amariano@rsmas.miami.edu">amariano@rsmas.miami.edu</a></td>
</tr>
<tr>
<td>Alberto Maurizi</td>
<td>ISAC - CNR</td>
<td><a href="mailto:a.maurizi@isac.cnr.it">a.maurizi@isac.cnr.it</a></td>
</tr>
<tr>
<td>Anne Molcard</td>
<td>ISAC-TO-CNR/LSEET-Univ. Toulon</td>
<td><a href="mailto:Anne.Molcard@icg.to.infn.it">Anne.Molcard@icg.to.infn.it</a></td>
</tr>
<tr>
<td>Maelle Nodet</td>
<td>Universite de Nice</td>
<td><a href="mailto:nodet@unice.fr">nodet@unice.fr</a></td>
</tr>
<tr>
<td>Jose Ochoa</td>
<td>CICESE</td>
<td><a href="mailto:jchooa@cicese.mx">jchooa@cicese.mx</a></td>
</tr>
<tr>
<td>Carter Ohlmann</td>
<td>University of California, Santa Barbara</td>
<td><a href="mailto:carter@cicese.ucsb.edu">carter@cicese.ucsb.edu</a></td>
</tr>
<tr>
<td>Olakunle Francis</td>
<td>Emmaus Christian School</td>
<td><a href="mailto:olakunlefrancis@yahoo.com">olakunlefrancis@yahoo.com</a></td>
</tr>
<tr>
<td>Omidiora</td>
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</tr>
<tr>
<td>Tamay Ö zgökmen</td>
<td>University of Miami</td>
<td><a href="mailto:tozgokmen@rsmas.miami.edu">tozgokmen@rsmas.miami.edu</a></td>
</tr>
<tr>
<td>Jeffrey Paduan</td>
<td>Naval Postgraduate School</td>
<td><a href="mailto:paduan@nps.edu">paduan@nps.edu</a></td>
</tr>
<tr>
<td>Nathan Paldor</td>
<td>Hebrew University of Jerusalem</td>
<td><a href="mailto:nathan.paldor@huji.ac.il">nathan.paldor@huji.ac.il</a></td>
</tr>
<tr>
<td>Federica G. Pannacciulli</td>
<td>ENEA - Marine Environment Research Centre</td>
<td><a href="mailto:pannacciulli@santateresa.enea.it">pannacciulli@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Pierluigi Pantalone</td>
<td>Dalhousie University</td>
<td><a href="mailto:pierluigi_pantalone@hotmail.com">pierluigi_pantalone@hotmail.com</a></td>
</tr>
<tr>
<td>Alejandro Pares-Sierra</td>
<td>CICESE</td>
<td><a href="mailto:apan@icis.mi.cnr.it">apan@icis.mi.cnr.it</a></td>
</tr>
<tr>
<td>Sara Pasquali</td>
<td>CNR - IMATI</td>
<td><a href="mailto:sara@mi.imati.cnr.it">sara@mi.imati.cnr.it</a></td>
</tr>
<tr>
<td>Giovanna Lucia</td>
<td>INGV - Stazione di Geofisica Marina</td>
<td><a href="mailto:gpiangiamore@yahoo.it">gpiangiamore@yahoo.it</a></td>
</tr>
<tr>
<td>Piangiamore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paola Picco</td>
<td>ENEA - Marine Environment Research Centre</td>
<td><a href="mailto:paola.picco@santateresa.enea.it">paola.picco@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Leonid Piterberg</td>
<td>University of Southern California</td>
<td><a href="mailto:piter@math.usc.edu">piter@math.usc.edu</a></td>
</tr>
<tr>
<td>Claudia Pizzigalli</td>
<td>ENEA</td>
<td><a href="mailto:claudia.pizzigalli@casaccia.enea.it">claudia.pizzigalli@casaccia.enea.it</a></td>
</tr>
<tr>
<td>Andrew Poje</td>
<td>CUNY - College of Staten Island</td>
<td><a href="mailto:poje@math.csi.cuny.edu">poje@math.csi.cuny.edu</a></td>
</tr>
<tr>
<td>Pierre-Marie Poulain</td>
<td>OGS</td>
<td><a href="mailto:ppoulain@ogs.trieste.it">ppoulain@ogs.trieste.it</a></td>
</tr>
<tr>
<td>Mark Prater</td>
<td>University of Rhode Island</td>
<td><a href="mailto:mprater@gso.uri.edu">mprater@gso.uri.edu</a></td>
</tr>
<tr>
<td>Fabio Raicich</td>
<td>CNR - Istituto di Scienze Marine</td>
<td><a href="mailto:fabio.raicich@ts.ismar.cnr.it">fabio.raicich@ts.ismar.cnr.it</a></td>
</tr>
<tr>
<td>Peter Ranelli</td>
<td>NATO Undersea Research Centre</td>
<td><a href="mailto:ranelli@nurc.nato.int">ranelli@nurc.nato.int</a></td>
</tr>
<tr>
<td>Jose M. Redondo</td>
<td>Univ. Politecnica de Catalunya</td>
<td><a href="mailto:redondo@fa.upc.edu">redondo@fa.upc.edu</a></td>
</tr>
<tr>
<td>Paulo Relvas</td>
<td>CIMA - Universidade do Algarve</td>
<td><a href="mailto:prelvas@ualg.pt">prelvas@ualg.pt</a></td>
</tr>
<tr>
<td>Michel Rixen</td>
<td>NATO Undersea Research Centre</td>
<td><a href="mailto:rixen@nurc.nato.int">rixen@nurc.nato.int</a></td>
</tr>
<tr>
<td>Salvador Romo-Fragos</td>
<td>University of Miami</td>
<td><a href="mailto:sromof@bellsouth.net">sromof@bellsouth.net</a></td>
</tr>
<tr>
<td>Thomas Rossby</td>
<td>University of Rhode Island</td>
<td><a href="mailto:trossby@gso.uri.edu">trossby@gso.uri.edu</a></td>
</tr>
<tr>
<td>Barry Ruddick</td>
<td>Dalhousie University</td>
<td><a href="mailto:barry.ruddick@dal.ca">barry.ruddick@dal.ca</a></td>
</tr>
<tr>
<td>Volfango Rupolo</td>
<td>ENEA</td>
<td><a href="mailto:rupolo@casaccia.enea.it">rupolo@casaccia.enea.it</a></td>
</tr>
<tr>
<td>Edward Ryan</td>
<td>University of Miami</td>
<td><a href="mailto:eryan@rsmas.miami.edu">eryan@rsmas.miami.edu</a></td>
</tr>
<tr>
<td>Katrin Schröder</td>
<td>ENEA - CRAM</td>
<td><a href="mailto:katrin.schroder@santateresa.enea.it">katrin.schroder@santateresa.enea.it</a></td>
</tr>
<tr>
<td>Julio Scheinbaum</td>
<td>CICESE</td>
<td><a href="mailto:julios@cicese.mx">julios@cicese.mx</a></td>
</tr>
</tbody>
</table>