LAPCOD 2009

Program

LAGRANGIAN ANALYSIS AND PREDICTION OF COASTAL AND OCEAN DYNAMICS

LAPCOD 2009

7 - 11 september 2009

Agelonde - La Londe-les-Maures

LSEET · Office of Naval Research Global Science & Technology · Department of the Navy ONR Science & Technology · Région PACA · cnrs · Université du Sud Toulon-Var

Outline

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http://www.rsmas.miami.edu/LAPCOD/2009-La_Londe-les-Maures/

Meeting Announcement

Dear Colleague,

The LAPCOD 2009 meeting will take place in ***La Londe-les-Maures***, Cote d'Azur, France (near Toulon), during ***September 7-11, 2009*** (Monday-Friday).
The purpose of the LAPCOD meeting is to conduct a review of recent works on Lagrangian dynamics and transport. They include results from freely drifting instruments (strictly Lagrangian) as well as results from other types of measurements such as autonomous vehicles, remote sensing satellites and VHF radars. The focus is on new observations, theories and applications with the goal of accelerating future development in predictability and multi-disciplinary aspects, by bringing together different research communities and different types of 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, with12 minute discussion talks in the morning and poster sessions in the afternoon. Participants are encouraged to present both a short talk and a poster.

Monday:	Session A
Tuesday:	Session B & C
Wednesday:	A day of interactions via a group social activity.
Thursday:	Session C & D
Friday:	Session E

The 5 sessions are

A) Observational studies and instrumentation
B) Theory of dispersion, transport, and coherent structures
C) Dynamical system analysis and optimal deployment/sampling design
D) Lagrangian modeling, data assimilation, and error evaluation
E) Biological, meteorological and multidisciplinary applications

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,

Anne Molcard	*University of Toulon*
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
Edward H. Ryan	RSMAS, *University of Miami*, Miami, Florida, USA

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 (16 min + 4 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:	Session A	Observational studies and instrumentation.
Tue:	Session B & Session C	Theory of dispersion, transport, and coherent structures. Dynamical system analysis and optimal deployment/sampling design.
Wed:		A day of interactions via a group social activity.
Thu:	Session D	Lagrangian modeling, data assimilation, and error evaluation.
Fri:	Session E	Biological, meteorological and multidisciplinary applications.

Presentations

Computers with MS PowerPoint will be available for the presentations. You may bring your own laptop computer if you like, or you can bring your presentation on CD-ROM or USB 'flash drives'. Transparencies are also welcome.
We would like to avoid an early Monday morning rush. So, Only if you will be presenting Monday morning, you can arrange with Anne (molcard@univ-tln.fr) to transfer for presentation electronically (ie put it on an ftp site and email her the location).

Posters

We encourage people who give oral presentations to present also a poster in the afternoon of their morning talk. 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.
Posters should be limited to 180 cm x 100 cm (or less).
You will be able to, and we encourage you to, hang your poster in the morning of your talk.
Note: Thursday's and Friday's Poster Sessions will be concurrent on Thursday afternoon.

Favorite Trajectories

Thursday Afternoon
Please bring one or two "slides" highlighting your favorite (quasi-) Lagrangian trajectory (or cluster) from drifter, float, buoy, glider or animal-based measurements, numerical simulations, or theory.

Wifi

Uphill: wifi is available at the ***Astrolab*** where the meeting and the meals are.
Downhill: where are the rooms and the swimming pool, the only place where internet is available by wifi is in the lobby.

Monday, September 7th

Registration
8:30 am to 8:50 am

Welcome to the La Londe LAPCOD Meeting
8:50 am to 9:00 am
Opening remarks by **Anne Molcard**, *University of Toulon*.

Session A: Observational studies and instrumentation

Morning Session: A1
9:00 am to 10:40 am
Moderator: **Denny Kirwan**, *University of Delaware*

9:00 am	A101	What do global surface drifters tell us about cyclonic and anticyclonic submesoscale motion in the upper ocean? *A. Griffa, M. Veneziani, R. Lumpkin, Z. Garraffo*
9:20 am	A102	"SOS-Bocche di Bonifacio": management of environmental emergencies due to oil spills in the International Strait of the Bonifacio Mouth *Katrin Schroeder, Roberto Sorgente, Andrea Cucco, Alberto Ribotti, Mireno Borghini*
9:40 am	A103	Mediterranean subsurface circulation estimated from Argo data *Milena Menna, Pierre Marie Poulain*
10:00 am	A104	Near-Surface Circulation in the Marmara Sea *Riccardo Gerin, Pierre-Marie Poulain, Sukru Besiktepe, Pietro Zanasca*
10:20 am	A105	Surface circulation in the Liguro-Provençal basin as measured by Lagrangian drifters (2007-2009) *Pierre-Marie Poulain, Riccardo Gerin, Annalisa Griffa, Nadia Pinardi*

Short Break
10:40 am to 11:10 am
Short Break (30 minutes), refreshments will be served.

Morning Session: A2
11:10 am to 12:50 pm
Moderator: **Annalisa Griffa**, *University of Miami, Consiglio Nazionale Ricerche (CNR/ISMAR)*

11:10 am	A201	Lagrangian and Eulerian observations of the surface circulation in the Tyrrhenian Sea *Enrico Zambianchi, Eleonora Rinaldi, Bruno Buongiorno Nardelli, Rosalia Santoleri, Pierre-Marie Poulain*
11:30 am	A202	Lagrangian sampling of the northward route of the Atlantic Water and its spreading in the Nordic Seas *Inga Koszalka, Joseph Henry LaCasce, Cecilie Mauritzen, Heinrik Soiland*
11:50 am	A203	Relative dispersion in the Nordic Seas *Joe LaCasce, Inga Koszalka, Kjell Arild Orvik*
12:10 pm	A204	Relative dispersion observations in the coastal ocean and Lagrangian modeling with HF radar surface current data *Carter Ohlmann, Libe Washburn*
12:30 pm	A205	Structure and variability of the Norwegian Atlantic Current and associated eddy field from surface drifters *Maria Andersson, Inga Koszalka, Joe LaCasce, Cecilie Mauritzen, Kjell-Arild Orvik*

Announcements
12:50 pm to 1:00 pm

Lunch Break
1:00 pm to 2:00 pm
Lunch is being served at the Hotel.

Afternoon Session: A3
2:00 pm to 3:20 pm
Moderator: **Annalisa Griffa**, *University of Miami, Consiglio Nazionale Ricerche (CNR/ISMAR)*

2:00 pm	A301	Subducted Convection *Tom Rossby*
2:20 pm	A302	Intermediate circulation in the Norwegian Sea *Henrik Soiland, Tom Rossby, Mark Prater*
2:40 pm	A303	Surface circulation in the southern Gulf of Mexico *Paula Pérez-Brunius, Paula García-Carrillo*
3:00 pm	A304	Near Surface Circulation in the South China Sea During the Winter Monsoon *L.R. Centurioni, P.N. Niiler, Dong-Kyu Lee*

Short Break
3:20 pm to 3:50 pm
Short Break (30 minutes), refreshments will be served.

Poster Session
3:50 pm to 5:00 pm
Posters from **all** of today's talks plus the following.

3:50 pm	A401	Near-surface eddy dynamics in the Southern Ocean revealed by drifter observations *Marilisa Trani, Pierpaolo Falco, Enrico Zambianchi*

Tuesday, September 8th

Session B: Theory of dispersion, transport, and coherent structures

Morning Session: B1
9:00 am to 10:40 am
Moderator: **Anne Molcard**, *University of Toulon*

9:00 am	B101	Resolution and Scale Dependence of Relative Dispersion in a Hierarchy of Ocean Models *Andrew Poje, Angelique Haza, Tamay Ozgokmen*
9:20 am	B102	Quantifying the Reliability of Mixing Diagnostics in Local and Non-local turbulent flows *Shane Keating, Shafer Smith*
9:40 am	B103	Lagrangian dispersion of Argos surface drifters and model simulated trajectories *Kristofer Döös*
10:00 am	B104	Multifractal scaling of Lagrangian turbulent trajectories using arbitrary order spectral analysis *Yongxiang Huang, Francois G. Schmitt, Zhiming Lu, Yulu Liu*
10:20 am	B105	Comparison between VHF radar observations and data from drifter clusters in the Gulf of La Spezia (Mediterranean Sea) *A. Molcard, P.M. Poulain, P. Forget, A. Griffa, Y. Barbin , J. Gaggelli, J.C. De Maistre , M. Rixen*

Short Break
10:40 am to 11:10 am
Short Break (30 minutes), refreshments will be served.

Morning Session: B2
11:10 am to 12:50 pm
Moderator: **Andrew Poje**, *City University of New York*

11:10 am	B201	Transport properties in small scale coastal flows: VHF radar measurements and FSLE analysis in the Gulf of La Spezia *Angelique C. Haza, Tamay M. Ozgokmen, Annalisa Griffa, Anne Molcard, Pierre M. Poulain*

11:30 am	B202	THE EFFERVESCENT EDDY ENIGMA *A. D. Kirwan, Jr., H. S. Huntley, B. L. Lipphardt, Jr.*
11:50 am	B203	Reliability of a Lagrangian analysis from FSLEs *Ismael Hernandez-Carrasco, Emilio Hernandez-Garcia, Cristobal López, Antonio Turiel*
12:10 pm	B204	Zonal jets in rotating turbulence: organization and role as transport barriers *Stefania Espa, Antonio Cenedese, Michelangelo Mariani*
12:30 pm	B205	New tools for aperiodic time dependent flows: applications to the description of transport across the Kuroshio current. *Ana M Mancho, Carolina Mendoza*

Announcements
12:50 pm to 1:00 pm

Lunch Break
1:00 pm to 2:00 pm
Lunch is being served at the Hotel.

Session C: Dynamical system analysis and optimal deployment/sampling design

Afternoon Session: C1
2:00 pm to 3:20 pm
Moderator: **Andrew Poje**, *City University of New York*

2:00 pm	C101	Coherence of eddies in a rip channeled surfzone *Joseph Geiman, James T. Kirby, Ad J.H.M. Reniers, Jamie MacMahan, Jeff Brown, Jenna Brown, Tim P. Stanton*
2:20 pm	C102	Flow structures from Lagrangian tracers in a tidal driven flow (Ria de Vigo, Spain) *Florian Huhn, Vicente Perez-Munuzuri, Pedro Montero*
2:40 pm	C103	Constrained ensemble simulation for inverse Lagrangian prediction problem *Mike Chin, Arthur Mariano, Ashwanth Srinivasan*
3:00 pm	C104	On the use of Particle Filters for Lagrangian Prediction *Arthur J. Mariano, Mike Chin*

Short Break
3:20 pm to 3:50 pm
Short Break (30 minutes), refreshments will be served.

Poster Session
3:50 pm to 5:00 pm
Posters from **all** of today's talks plus the following.

3:50 pm	C401	Dispersion patches prediction with NCOM model corrected with Lagrangian statistical characteristics. Sensitivity study *Julien Marmain, David Magnen, Anne Molcard, Angélique Haza*
3:50 pm	C402	Particle dispersion in stochastic flows with linear shear *Leonid Piterbarg*
3:50 pm	C403	Numerical Lagrangian study of typical pathways for water masses in the North Western Mediterranean *H. Berger, A. Petrenko, A. Doglioli*

Social Dinner
7:00 pm to 11:00 pm
"La Ferme des Janets" Restaurant
The social dinner (included in your package) is planned for *Tuesday 8 September* at "La Ferme des Janets" restaurant near to **Bormes-les-Mimosas**. A bus will pick up attendees at **Agelonde** around 7 pm and bring them back around 11 pm. Dinner for accompanying person is for 50 euros and has to be payed directly to the restaurant. This includes appetizer, starter, main course, cheese course, dessert and coffee. (All drinks are included).

Thursday, September 9th

Session D: Lagrangian modeling, data assimilation, and error evaluation

Morning Session: D1
9:00 am to 10:40 pm
Moderator: **Enrico Zambianchi**, "*Parthenope" University, Napoli, Italy*

9:00 am	D101	Implementation of a new simple method to estimate surface velocities from satellite data and numerical models. *Enrico Zambianchi, Alessandro Mercatini, Annalisa Griffa, Leonid Piterbarg, Marcello Magaldi*
9:20 am	D102	Improving Lagrangian Predictability by Blending Drifter Observations with Model Velocities *Helga S. Huntley, B. L. Lipphardt, Jr., A.D. Kirwan, Jr.*
9:40 am	D103	Assimilation of Lagrangian Data in a Variational framework *Claire Chauvin , Francois-Xavier Le-Dimet , Maelle Nodet , Innocent Souopgui , Olivier Titaud , Arthur Vidard*
10:00am	D104	Lagrangian data assimilation: accomplishments and challenges for surface drifter applications *A. Griffa, V. Taillandier, T. Ozgokmen, A. Molcard, Y. Chang*
10:20am	D105	Integration of ARGO trajectories in the Mediterranean Forecasting System and impact on the regional analysis of the Western Mediterranean circulation *V. Taillandier, S. Dobricic, P. Testor, N. Pinardi, A. Griffa, L. Mortier, G.P. Gasparini*

Short Break
10:40 am to 11:10 am
Short Break (30 minutes), refreshments will be served.

Morning Session: D2
11:10 am to 12:50 pm
Moderator: **Enrico Zambianchi**, "*Parthenope" University, Napoli, Italy*

11:10 am	D201	Large eddy simulations of mixed layer instabilities and sampling strategies *Tamay M. Ozgokmen*
11:30 am	D202	Surface current trajectories in the Southern California Bight: Model results and observations *Carter Ohlmann, Satoshi Mitarai*
11:50 am	D203	Characterization of Lagrangian variability on forecasting time scales using Eulerian velocity field of a forecasting high resolution model of the Tyrrhenian Sea. *Volfango Rupolo, Claudia Pizzigalli, V. Artale, R. Iacono, E. Napolitano, Gianmaria Sannino*
12:10 pm	D204	Ensemble analysis of predicted trajectory uncertainty in an operational Navy model of the western Pacific Ocean *B. L. Lipphardt, Jr., H. S. Huntley, A. D. Kirwan, Jr., P. Hogan*
12:30 pm	D205	Ocean Eddy Tracking using Lagrangian Data Assimilation *Kayo Ide, Guillaume Vernieres, Chris Jones*

Announcements
12:50 pm to 1:00 pm

Lunch Break
1:00 pm to 2:00 pm
Lunch is being served at the Hotel.

Afternoon Session: D3
2:00 pm to 3:00 pm
Moderator: **Arthur Mariano**, *University of Miami*

2:00 pm	D301	Dealing with Nonlinearity in Lagrangian Data Assimilation *Christopher Jones*
2:20 am	D302	Exploring the impact of ocean currents on sea turtles *Graeme Hays, Sabrina Fossette*

2:40 am	D303	Using genetic and global Lagrangian drifter data to investigate the dispersal of small juvenile green turtles in the Atlantic *Patricia L.M. Lee*

Favorite Trajectories
3:00 pm to 3:30 pm
Moderator: **Arthur Mariano**, *University of Miami*
Please bring one or two "slides" highlighting your favorite (quasi-) Lagrangian trajectory (or cluster) from drifter, float, buoy, glider or animal-based measurements, numerical simulations, or theory.

Short Break
3:30 pm to 4:00 pm
Short Break (30 minutes), refreshments will be served.

Poster Session
4:00 pm to 5:00 pm
Posters from **all** of today's talks plus the following.
Note: Friday's Poster Session will be concurrent with Thursday's Poster Session.

4:00 pm	D401	Estimating Lagrangian trajectories from tracer observations and model output *Leonid Piterbarg*
4:00 pm	D402	Front Propagation and Superdiffusion in Active Media *Vicente Perez-Munuzuri, Alexandra von Kameke, Guillermo Fernández-García*

Friday, September 10th

Session E: Biological, meteorological and multidisciplinary applications

Morning Sessions
9:00 am to 10:40 pm
Moderator: **Tamay Özgökmen**, *University of Miami*

9:00 am	E101	Frigatebirds follow Lagrangian Coherent Structures *E. Hernandez-Garcia, E. Tew Kai, V. Rossi, C. Lopez, J. Sudre, V. Garçon, H. Weimerskirch, F. Marsac*
9:20 am	E102	Extending the Use and Interpretation of Ocean Satellite Data Using Lagrangian Modeling *Bror Jonsson, Joe Salisbury, Amala Mahadevan*
9:40 am	E103	LATEX (LAgrangian Transport EXperiment): strategy and preliminary results. *A. Petrenko, A. Doglioli, Z. Hu, F. Diaz, R. Campbell, I. Dekeyser, and LATEX group.*
10:00 am	E104	Field Work for assessment of the leeway of drifting objects *Christophe Maisondieu, O. Breivik, A.A. Allen, J-C. Roth, M. Pavec*
10:20 am	E105	Numerical modelling of wave-current interactions in the Sea of Marmara during a wind storm event (Feb 2009) *Jacopo Chiggiato*

Short Break
10:40 am to 11:10 am
Short Break (30 minutes), refreshments will be served.

Morning Session: E2
11:10 am to 12:50 pm
Moderator: **Anne Molcard**, *University of Toulon*

11:10 am	E201	FOAM the new degradation model coupled with the advection-lagrangian dispersion model: the impact evaluation of the fish farm waste *Patrizia De Gaetano, Andrea M. Doglioli, Paolo Vassallo, Marcello G. Magaldi*
11:30 am	E202	Lagrangian models for the dynamics of a multistage population: effects of different development models *Giuseppe Buffoni, Sara Pasquali*
11:50 am	E203	The role of time and length scales of mesoscale eddies on phytoplankton production *Vicente Perez-Munuzuri, Florian Huhn*
12:10 pm	E204	Comparison between modeled and observed surface drifter trajectories and calculation of FTLE fields to explain a spatial separation between two genetic clades of copepods *Simon St-Onge Drouin, Jean-François Dumais, Gesche Winkler*
12:30 pm	E205	Overwinter transport of the zooplankton Calanus finmarchicus in the Norwegian Sea *Henrik Soiland, Geir Huse*

Closing remarks
12:50 pm to 1:00 pm
Closing remarks by **Anne Molcard**, *University of Toulon*

Lunch Break
1:00 pm to 2:00 pm
Lunch is being served at the Hotel.

Poster Session
The time has been shifted to Thursday's Poster Session.
Posters from **all** of today's talks plus the following.
Note: Friday's Poster Session will be concurrent with Thursday's Poster Session.

Session A Abstracts
Observational studies and instrumentation

A101

What do global surface drifters tell us about cyclonic and anticyclonic submesoscale motion in the upper ocean?

A. Griffa, M. Veneziani, R. Lumpkin, Z. Garraffo
RSMAS/CNR
(Abstract received 08/11/2009 for session A)

A recent global census of surface loopers (drifter trajectories with a definite sense of rotation) has revealed some unexpected features of the distribution of structures at scales of the submesoscale (R<15 km; Griffa, Lumpkin, and Veneziani 2008). Three main regimes have emerged: a) a preva-lently cyclonic zonal band at 1020 latitude; b) a prevalently anticyclonic zonal band at 3040; and c) regions devoid of submesoscale presence corresponding to areas of formation of great rings. The dynamical mechanisms behind this distribution are not completely understood yet, one of the reasons being that small loopers can be the signature of different dynamics, such as submesoscale eddies and subinertial Ekman response, and also possivle biases can occurr in the drifter loopers distribution. An investigation is presently underway addressing these questions.

A102

"SOS-Bocche di Bonifacio": management of environmental emergencies due to oil spills in the International Strait of the Bonifacio Mouth

Katrin Schroeder, Roberto Sorgente, Andrea Cucco, Alberto Ribotti, Mireno Borghini
CNR - Institute for Marine Science
(Abstract received 08/11/2009 for session A)

An innovative numerical system is realized for the management of environmental emergencies due to oil spills in the International Strait of the Bonifacio Mouths through the integrated use of nested high resolution forecasting numerical models at different spatial scales, mesoscale high resolution meteorological mesoscale forecasting numerical models, oil-spill modules for the simulation of transport and dispersion of an oil-spill, meteorological observations from remote station and Lagrangian measurements of the surface current field.

A103

Mediterranean subsurface circulation estimated from Argo data

Milena Menna, Pierre Marie Poulain
OGS
(Abstract received 08/12/2009 for session A)

Data from 38 profiling floats, deployed as a part of the International Argo program since October 2003, are used to describe the subsurface Mediterranean currents for the period 2003-2009. These floats were programmed to execute 5-day cycles, to drift at a neutral parking depth of 350 m and measure temperature and salinity profiles from either 700 or 2000 m up to the surface. At the end of each cycle the Argo floats remain at the sea surface for about 6 hours, enough time to be localised and transmit the data to the Argos satellite system.

The Argos positions are used to determine the float surface and subsurface displacements. The estimation of surface displacement involves the determination of the exact surfacing and diving times and the extrapolation in time of the Argos positions using a simple model based on linear displacement and inertial motion. The determination of subsurface displacement involves the use of the average vertical speed of the float and an approximation of current shear in the upper water column to evaluate the times and positions of the start and end of the subsurface drift. From these, the subsurface velocities at the 350 m parking depth, are estimated and finally used to compute pseudo-Eulerian circulation statistics. In the best sampled regions, the statistics show typical circulation pathways related to the motion of the Levantine Intermediate Water. Subsurface typical speeds can reach 15-20 cm/s and partial control of the currents by the continental shelf slope is evident.

A104

Near-Surface Circulation in the Marmara Sea

Riccardo Gerin, Pierre-Marie Poulain, Sukru Besiktepe, Pietro Zanasca
OGS
(Abstract received 08/12/2009 for session A)

As part of the Turkish Straits System (TSS) experiment, the surface circulation of the Marmara Sea was studied using low-cost CODE Lagrangian drifters over about a year (from September 2008 to May 2009). In addition to the standard positioning and data telemetry (SST, battery) provided by the Argos Data Collection and Location System (DCLS), the drifters were equipped with GPS receivers to have a more frequent and a better determination of their positions. About 30 surface drifters were deployed in two seasonal episodes at key locations close to the Bosphorus and in the middle of the Marmara Sea (to maximize the geographical coverage), mainly in small (1 nm) clusters of three drifters. The combined raw Argos and GPS positions were edited for outliers and spikes using statistical and manual techniques and were interpolated at regular 2-hours intervals. Surface velocity were calculated by central finite differencing the interpolated positions. The Pseudo-Eulerian statistics (mean flow, variance ellipses, MKE and EKE) were calculated using a spatial averaging scale of 0.05° x 0.05° overlapping bins. The lifetime of the drifters in the Marmara Sea is very low due to the recovery by seafarers and stranding. The maximum time after deployment at sea

is only about one month. The map of the mean surface flow shows two eddy located in the northern part which extend for about 30 km and reach the middle of the Sea (the western feature is anticyclonic and the eastern one is cyclonic). South of these large features, a flow of about 20 cm/s joins the Bosphorus to the Dadarnelles and another cyclonic eddy is evident in the southeastern area of the Marmara Sea.

A105

Surface circulation in the Liguro-Provençal basin as measured by Lagrangian drifters (2007-2009)

Pierre-Marie Poulain, Riccardo Gerin, Annalisa Griffa, Nadia Pinardi
OGS
(Abstract received 08/13/2009 for session A)

The surface circulation in the Liguro-Proven√ßal basin is studied using the data of Lagrangian CODE drifters deployed as part of Marine Rapid Environmental Assessment (MREA) exercises. The drifters were deployed in small-scale clusters in the open Ligurian Sea. Counting some drifters that stranded and were subsequently redeployed, the dataset used consists of 35 trajectories spanning the period 14 May 2007 to 23 January 2009.

All drifters were tracked by, and transmitted data to, the satellite-based Argos system. They were also equipped with GPS receivers to increase the accuracy and frequency of their positions. The drifter positions were edited, interpolated and low-pass filtered to remove tidal/inertial currents.

First the surface circulation is described qualitatively. Complex circulation patterns prevail in the Ligurian Sea, before the drifters eventually joined the Northern Current and moved rapidly to the southwest from the Gulf of Genoa to the Gulf of Lion. There, some units were advected offshore towards the south, before heading to the east and approaching the Corsican coast, and re-entering the Ligurian to close a basin-wide cyclonic circulation. Only a few drifters continued moving towards the southwest in the Gulf of Lion and approached the Catalan Sea. The drifter trajectories were compared to the absolute dynamic topography derived from satellite altimeters and a remarkable match was found. Discrepancies only occur when strong Mistral winds blow and wind-driven currents and slippage become important.

Second, pseudo-Eulerian velocity statistics are calculated in the coastal region extending between the Gulf of Genoa and the Gulf of Lion, where the data are more abundant. Fast currents (mean ~60 cm/s) are evident on the shelf break in the Northern Current, especially off Imperia (Italy). In this area, low-pass filtered individual speeds can reach 90 cm/s. In contrast, a stagnation area near Fréjus (France) is characterized by little mean flow, low velocity fluctuations, and high probability of drifter stranding.

A201

Lagrangian and Eulerian observations of the surface circulation in the Tyrrhenian Sea

Enrico Zambianchi, Eleonora Rinaldi, Bruno Buongiorno Nardelli, Rosalia Santoleri, Pierre-Marie Poulain
Parthenope University, Napoli, Italy
(Abstract received 08/14/2009 for session A)

The circulation of the Tyrrhenian Sea is described first by a set of 53 surface drifters deployed in the area between December 2001 and February 2004. The Lagrangian data reveal a complex pattern of the circulation, especially in the southern portion of the Tyrrhenian, which is poorly known, dominated by semi-permanent recirculations and transient features which sometimes make it difficult to identify a consistent mean flow, while the northern sub-basin is characterized by a pair composed by a cyclonic and anticyclonic circulations known in the literature as North Tyrrhenian Cyclone and North Tyrrhenian Anticyclone.

In order to supplement the drifter data with a more continuous in time sampling source, and to characterize the seasonal, inter-annual, as well as higher frequency variability of the surface circulation, the Lagrangian analysis is associated to a study of simultaneous satellite remotely-sensed altimeter. The investigation is based on the computation of the pseudo-Eulerian statistics from drifter data and on the comparison of these to the statistics obtained from the same binning and space-time averaging of altimeter data. This approach shows the representativeness of a joint analysis of altimeter and drifter data and yields useful indications about proper preliminary preprocessing and resampling procedures, so as to make the comparison statistically sound.

A202

Lagrangian sampling of the northward route of the Atlantic Water and its spreading in the Nordic Seas

Inga Koszalka, Joseph Henry LaCasce, Cecilie Mauritzen, Heinrik Soiland
University of Oslo, Institute for Geosciences
(Abstract received 08/17/2009 for session A)

Lagrangian techniques provide an unique insight into structure of the oceanic circulation and its variability. In this study we focus on the route of the Norwegian Atlantic Current (NwAC) towards the Arctic as well as spreading of the Atlantic Water in the Nordic Seas with help of surface drifters and subsurface RAFOS floats. Surface drifters dataset consists of 118 drifters drogued at 15m depth and deployed along the path of the Norwegian Atlantic Current during 6 fields campaigns (June 2007 - October 2008) within the POLEWARD project. These data were integrated with historical drifters released in the

Nordic Seas region in 1990-2008 and available through the Global Drifter Program database (http://www.aoml.noaa.gov/phod/dac/gdp.html). RAFOS float data embraces 45 instruments deployed in the southern Norwegian Sea in July-October 2004: 23 floating at 200m depth and 22 floating at 800m depth (SÃ¸iland et. al. 2008, Rossby et. al. 2009).

The goal of the study is to describe the circulation within NwAC, Lofoten and Norwegian basins from the Lagrangian viewpoint, and better understand the fates of fluid parcels transported from the southern part of the Nordic Seas northward towards the Arctic. For this purpose, the drifter and float data are analyzed with respect to the following aspects: (1) Lagrangian pathways of fluid parcels from drifters and floats deployed in the Nordic Seas (2) Exchange of the surface drifters from the NwAC into Norwegian Coastal Current, the Norwegian and Lofoten basins (3) Characterisation of the velocity signal in the Lagrangian instruments floating at different depths with focus on topographic steering quantified by means of the sensitivity of oceanic float dispersion to f/H (potential vorticity) contours (LaCasce, 2000).

We compare information provided by instruments floating at different depths and assess the value of such comparative study.

A203

Relative dispersion in the Nordic Seas

Joe LaCasce, Inga Koszalka, Kjell Arild Orvik
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(Abstract received 08/14/2009 for session A)

We examine the relative dispersion of surface drifters deployed in the POLEWARD experiment in the Nordic Seas during 2007-2008. The drifters were launched in pairs and triplets, yielding 67 pairs with an initial separation of 2 km or less. There were 26 additional pairs from drifters which subsequently came near one another. As these produced statistically identical dispersion to the original pairs, we used them as well, yielding 93 pairs.

The relative dispersion exhibits three phases. The first occurs during the first two days, at spatial scales less than 10 km. The dispersion increases approximately exponentially during this period, with an e-folding time of roughly half a day. During the second phase, from 2 to roughly 10 days and scales of 10 to roughly 100 km, the dispersion exhibits the Richardson scaling. At the largest spatial and temporal scales, the dispersion increases linearly in time and the pair velocities are uncorrelated, consistent with diffusive spreading.

We use a stochastic model with a representative mean flow to test the effect of the mean shear on dispersion. The model produces dispersion comparable to the observed during the second and third phases but fails to capture other statistics, such as the PDFs of the displacements. These statistics are instead suggestive of an inverse energy cascade, from the deformation scale up to 100 km.

A204

Relative dispersion observations in the coastal ocean and Lagrangian modeling with HF radar surface current data

Carter Ohlmann, Libe Washburn
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(Abstract received 08/14/2009 for session A)

Eddy diffusivity values and related parameters, not well observed in coastal regions, are obtained from in situ surface drifter observations and presented along with a discussion of their utility in Lagrangian stochastic models. Lagrangian trajectory information in the coastal ocean is important for problems in larval transport, contaminant movement, search-and-rescue, and in oceanographic research where “advective” terms in the Navier-Stokes equations are non-negligible. Eulerian high frequency (HF) radar data can provide the basis for easily determining large numbers of observationally based trajectories. However, Monte Carlo simulations of trajectories from HF radar require knowledge of unresolved eddy, or sub grid scale, information corresponding to the gridded, time-averaged mean currents.

Triplets of GPS tracked surface drifters, drogued at 1 meter depth, were repetitively deployed in the Santa Barbara Channel with initial horizontal spacing of ~ 10 meters. Drifter sets were deployed on 24 occurrences during the July 2004 through June 2005 period and left to sample their position every 10 minutes for 1 to 2 days. The drifter triplets demonstrate that eddy diffusivity values for spatial scales from 10’s to 100’s of meters range from 10^-2 to 10^1 m^2 sec^-1. These values follow closely with Richardson’s four-thirds power law scaling and Okubo’s historical empirical fits. The drifter data are used to evaluate Lagrangian stochastic model results using mean currents from HF radar. Both the mean (center of mass) and relative dispersion of modeled trajectories are evaluated.

A205

Structure and variability of the Norwegian Atlantic Current and associated eddy field from surface drifters

Maria Andersson, Inga Koszalka, Joe LaCasce, Cecilie Mauritzen, Kjell-Arild Orvik
University of Bergen, Norway
(Abstract received 08/13/2009 for session A)

The Norwegian Atlantic current (NwAC) transports warm and saline Atlantic water northward toward the Arctic Ocean, being an important part of the global thermohaline

circulation and affecting the distribution of the ice cover in the Arctic. Therefore it is crucial to monitor spatio-temporal variability of the current and the associated heat transport as it passes through the Nordic Seas towards the Arctic. In this study we use information extracted from Lagrangian instruments to build a more complete picture of the surface circulation in the Nordic Seas with NwAC as its key component. In the POLEWARD project, SVP drifters have been deployed to track fluid parcels in the NwAC as it traverses the Nordic Seas. In the period June 2007 to October 2008, 118 ARGOS-tracked drifters, drogued at 15 meters depth, were deployed in the NwAC. We combine this data with historical data from SVP drifters in the same region available through Global Drifter Program database. By augmenting the historical data set, the POLEWARD deployments allow a Lagrangian study of the seasonal variability of the circulation, which was insofar limited because of the paucity of the Lagrangian data set in the area. The interpolated, quality controlled and low-pass filtered position data have been used to construct maps of the mean velocity field, the eddy kinetic energy and the principal axes of variance for both summer and winter seasons. Also estimations of Lagrangian time and space scales have been performed. The drifters reveal strong, localized current systems along the Norwegian coast, the continental margins and their extensions to the Barents Sea and Spitsbergen. The eddy kinetic energy reveals stronger variability in the Lofoten Basin area, particularly in the wintertime. The variance axes show significant variations, both spatially and seasonally.

A301

Subducted Convection

Tom Rossby
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(Abstract received 08/14/2009 for session A)

A recently concluded study of the Nordic Seas hydrography from an isopycnal perspective reported that the waters in the Lofoten Basin exhibited significantly greater spiciness than the inflowing Atlantic waters from the south of the same density. It was shown that the increase in spiciness stemmed from downward mixing of overlying saltier water in wintertime. Clearly open ocean convection plays a major role in providing the mixing, especially where isopycnal surfaces outcrop in winter. But other mechanisms exist by which water can be mixed downward. These include the subduction of surface eddies that form at the Northwest Corner. Similar processes have been documented in the Sea of Japan.

In the Lofoten Basin large anti-cyclonic eddies form where the Norwegian Atlantic Current passes the steep escarpment off the Lofoten Islands. These drift towards the center of the basin where they build up a huge reservoir of heat. In winter this pool loses a significant fraction of the previous summer's build-up, a loss that leads to increased spiciness on the oncropping surfaces. Inspection of individual CTD profiles reveals what look like subducted eddies reminiscent of the lenses that originate at the Northwest Corner. In this talk I will suggest the possibility that these features result from the cooling of Lofoten eddies without their destruction, unlike what happens to eddies that form due to intense heat loss at the surface. The somewhat more general question might be whether preexisting anticyclonic eddies at the surface can serve as nuclei for coherent subsurface eddies. Next year a 2-year field program will take place in the Lofoten Basin to study the circulation and the hydrographic changes that take place over the summer-winter heating-cooling cycle. Each year 25 isopycnal RAFOS floats will be deployed to map the circulation and probe diapycnal processes if and when float experiences an outcropping process. The question is how best to deploy these and what measurement strategies will best recognize and distinguish between these diverse processes.

A302

Intermediate circulation in the Norwegian Sea

Henrik Soiland, Tom Rossby, Mark Prater
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(Abstract received 08/14/2009 for session A)

To study the movement of Arctic Intermediate Waters (AIW) around the Norwegian Sea we deployed 26 isobaric RAFOS floats across the northern slope of the Iceland-Faroe Ridge. In recent times these waters have increasingly been replacing the Greenland Sea waters that in the past were the major contributor to the dense water overflow into the North Atlantic. The topographic control of the movement of these 800m deep floats was extraordinary. Floats deployed in waters shallower than 1500m without fail drifted into the North Atlantic whereas floats deployed in water deeper than 1500m turned north following isobaths anticlockwise around the Norwegian Sea. Topographic control of their movement meant that their fate was sealed long before they reached their branch point at the entry into the Shetland Channel. Flow at intermediate depth in the central Norwegian Basin is weakly to the North East with low EKE levels. The AIW flow north along the Norwegian continental margin takes place in a narrow band around the 2500m isobath and, significantly, is a fast track for moving AIW from the Norwegian Sea into the Lofoten Basin.

A303

Surface circulation in the southern Gulf of Mexico

Paula Pérez-Brunius, Paula García-Carrillo
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(Abstract received 08/13/2009 for session A)

We present preliminary results from a surface drifter program that started in September 2007 as part of a large

modeling and observational effort funded by the mexican oil industry to study the physical oceanography of the deep waters of the southern Gulf of Mexico (Bay of Campeche). Pseudo-Eulerian statistics show the presence of a mean cyclonic gyre, with a western boundary current particularly strong in the Fall-Winter, supporting the hypothesis of a wind-driven gyre as suggested in the literature from the few oceanographic data previously available for the region. The cyclonic gyre appears to be topographically confined to the western Bay of Campeche, delimited by a broadening of the isobaths that fan out towards the East. Although the Bay of Campeche is a relatively quiet area compared to the northern Gulf of Mexico (the latter being dominated by energetic Loop Current Eddies which rarely penetrate into the Bay), strong northward flowing jets were occasionally observed within the central Bay of Campeche. Most of these occurrences seem to result from the interaction of the cyclonic gyre with small anticyclones locally generated in the southeastern boundary.

A304

Near Surface Circulation in the South China Sea During the Winter Monsoon

L.R. Centurioni, P.N. Niiler, Dong-Kyu Lee
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(Abstract received 08/25/2009 for session A)

Original velocity measurements at 15 m depth gathered by the authors from Surface Velocity Program drifters are used to calculate the circulation in the South China Sea during the Winter Monsoon. The Ekman currents are computed with a new method and subtracted from drifter,Äôs velocity to calculate the residual circulation, which is approximately in geostrophic balance. The geostrophic flow is cyclonic and extends into the southern Luzon Strait. The Ekman flow is nearly zonal and comparable to the zonal geostrophic flow in the northern basin. Strong jets occur south of Hainan, off Vietnam and, to the south, off peninsular Malaysia. The Vietnam jet is concentrated inshore of the 200 m isobath, with mean speeds in excess of 1 ms-1. The onshore Ekman transport and pumping velocity computed from the wind stress curl offers a qualitative explanation of the existence and behavior of such jets.

A401

Near-surface eddy dynamics in the Southern Ocean revealed by drifter observations

Marilisa Trani, Pierpaolo Falco, Enrico Zambianchi
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(Abstract received 08/14/2009 for session A)

Observations obtained from drifters represent a very useful dataset to analyse eddy components of the velocity field because they may describe turbulence at different scales while providing a synoptic coverage of the investigated area. In the Southern Ocean the eddy field plays a central role in the dynamical and thermodynamical balance of the circulation.

Estimates of the eddy heat and momentum fluxes are carried out in this work using data from WOCE-SVP drifters along their pathways approximately south of 40¬∞S from 1995 to 2007. Variance ellipses, EKE, momentum and heat fluxes have been calculated using the pseudoeulerian method. Results show patterns in good agreement with those present in literature, although there are some quantitative differences. A rearrangement of the data has been carried out using isolines of constant absolute dynamic height as bin limits. This has been done in order to have bins which separate areas with similar dynamical characteristics.

Maxima of the eddy momentum flux are observed near the major topographic features where the mean field there is consistently deviated to the north (south) with a positive (negative) value of the flux. Sea Suface temperature variability is higher at lower latitudes, in particular in the Agulhas retroflection and off the east coast of south America at the Brazil-Malvinas confluence where water masses with strongly contrasting characteristics meet each other. Distributions of vertically integrated eddy heat transports are also presented and discussed.

Session B Abstracts
Theory of dispersion, transport, and coherent structures

B101
Resolution and Scale Dependence of Relative Dispersion in a Hierarchy of Ocean Models
Andrew Poje, Angelique Haza, Tamay Ozgokmen
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(Abstract received 08/14/2009 for session B)

We examine a hierarchy of ocean models, ranging from simple 2D turbulence simulations to North Atlantic HYCOM output, to determine the effect of Eulerian spatial model resolution on the two particle statistics of synthetic drifter trajectories. In each case, particle dispersion at large time and space scales is found to be controlled by hyperbolic structures produced by identifiable meso-scale features of the flow. In all cases, time-distance graphs given in terms of computed Finite Size Lyapunov Exponents show an in- crease in the extent of exponential scaling with increasing spatial smoothing of the velocity field and scaling of the limiting exponent with resolved hyperbolicity.

B102
Quantifying the Reliability of Mixing Diagnostics in Local and Non-local turbulent flows
Shane Keating, Shafer Smith
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(Abstract received 08/18/2009 for session B)

Several recent studies make use of satellite altimetry data to infer mixing diagnostics in the global upper ocean. The reliability of these diagnostics is unclear, however: in particular, the effect of unresolved scales on turbulent transport is difficult to quantify. We examine a range of mixing diagnostics in simulations of quasigeostrophic and surface quasigeostrophic turbulence and directly probe their dependence on sampling resolution. In this way, we aim to quantify the reliability of mixing diagnostics in turbulent flows exhibiting local and non-local spectral dynamics.

B103
Lagrangian dispersion of Argos surface drifters and model simulated trajectories
Kristofer Döös
Stockholm University
(Abstract received 06/24/2009 for session B)

The Lagrangian dispersion from model trajectories and Argos surface drifters are computed. The model trajectories are based on the TRACMASS trajectory code and driven by the ocean general circulation model NEMO. Pairs of Argos drifters are selected and the corresponding average dispersion has been calculated.

Different model resolutions are used in order to evaluate to what extent the model resolution affects the Lagrangian dispersion. The model trajectory solutions always include implicit large scale diffusion due to along-trajectory changes of temperature and salinity/humidity and by the models parameterisation of turbulent mixing in the momentum equations. These trajectories do not, however, explicitly include sub-grid scale turbulence since they are passively advected by the simulated currents on the model grid. There are however two ways to incorporate sub-grid scale turbulence in TRACMASS, which are here tested to investigate the possibility of tuning the dispersion rate of the model trajectories to that of the Argos surface drifters. One consists of adding a random horizontal turbulent velocity (u',v') to the horizontal velocity (U,V) from the GCM. The other adds a random displacement to the trajectory position in order to incorporate a sub-grid parameterisation of the non resolved scales. Both methods enable an increase of the dispersion rate that can be adjusted by changing the diffusion coefficients of the trajectory sub-grid parameterisations.

B104
Multifractal scaling of Lagrangian turbulent trajectories using arbitrary order spectral analysis
Yongxiang Huang, Francois G. Schmitt, Zhiming Lu, Yulu Liu
UMR LOG-Station marine de Wimereux, France and Shanghai University, China
(Abstract received 07/15/2009 for session B)

Hilbert-Huang Transform (or Empirical Mode Decomposition), is a new data analysis technique which was developed 10 years ago by Norden Huang (1998) in order to decompose time series into different scales. We have recently generalized this approach (Huang et al, Europhysics Letters, 2008, 2009) in order to be able to extract multifractal scaling exponents from Eulerian turbulence time series. In the present paper we adapt this methodology to the Lagrangian case.

We first theoretically describe how to adapt the previsou methodology to 3D Lagrangian paths, and then show how this can be used to extract multifractal Lagrangian scaling exponents in the framework of turbulent diffusion in homogeneous isotropic turbulence (Kolmogorov-Landau-Novikov's framework). We also consider the same methodology for Lagrangian passive scalar measurements.

We then perform data analyses in this framework. For this, we consider two different data bases: experimental measurements of Lagrangian diffusion in a homogeneous turbulent situation (using polystyrene particles), performed by Ott and Mann (2000) and several oceanic Lagrangian databases. We show how the new methodology using arbitrary order Hilbert-Huang spectral analysis is able to better extract scaling exponents, on a wider range of scales, compared to the more classical structure functions analysis.

B105

Comparison between VHF radar observations and data from drifter clusters in the Gulf of La Spezia (Mediterranean Sea)

A. Molcard, P.M. Poulain, P. Forget, A. Griffa, Y. Barbin , J. Gaggelli, J.C. De Maistre , M. Rixen
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(Abstract received 08/24/2009 for session A)

Results from a WERA radar system in very high frequency (VHF) mode in a small coastal area (range of 7 km, resolution of 250 m) are compared with surface drifter data. The measurements are performed in the Gulf of La Spezia, a highly populated area characterized by a complex use of the territory, where monitoring of surface currents can play an important role in correct management. The drifters have been launched in clusters of 3-6 units, aimed at investigating the significant time and space variability of the flow. Radial velocities, single trajectories and spreading patterns from radar and drifter data are compared. The results confirm that radar data are well suited for the study of coastal flows in limited areas with complex patterns of velocity and transport.

B201

Transport properties in small scale coastal flows: VHF radar measurements and FSLE analysis in the Gulf of La Spezia

Angelique C. Haza, Tamay M. Ozgokmen, Annalisa Griffa, Anne Molcard, Pierre M. Poulain
RSMAS, University of Miami
(Abstract received 08/14/2009 for session C)

FSLE maps are computed from VHF radar velocities in a 10 km by 10 km coastal area with a resolution of 250 meters. The evolution of the VHD radar-derived FSLEs is compared to an independent data set consisting of two drifter clusters launched during the same period. Results show that the drifters tend to follow the edges of FSLE ridges or extrema, leading to the following conclusions: First, the local FSLE appears to be an effective tool in mapping the natural transport barriers of the flow, and its evolution in time can document the potential fate of surface passive tracers for each region delimited by the ridges of FSLE extrema, even in the case of rapidly-varying complex coastal flows. Second, the computations of the FSLE maps at each time iteration eliminates the propagation and accumulation of errors from radar velocity measurements into particle advection. As such, comparison of FSLE maps to observed drifter trajectories appears to provide insight to study transport characteristics in coastal flows.

B202

THE EFFERVESCENT EDDY ENIGMA

A. D. Kirwan, Jr., H. S. Huntley, B. L. Lipphardt, Jr.
University of Delaware
(Abstract received 08/05/2009 for session B)

The MODE/POLYMODE experiments conclusively established that the ocean has an energetic mesoscale, which is a major contributor to the northward transport of heat and the mixing of salinity and other conserved properties. The early process models for the mesoscale emphasized long-lived isolated vortices. Flierl (Ann. Rev. Fluid Mech., 1987) and Olsen (Ann. Rev. Earth Planet. Sci, 1991), present comprehensive reviews of these models. The ultimate examples of long-lived vortices are modons (Larichev and Reznik, Rep. USSR Acad. Sci., 1976). Modons are exact solutions to the nonlinear Euler equations with both wave-like and vortex-like properties. All isolated vortex models share a common characteristic: a substantial amount of core fluid trapped by bounding surfaces of potential vorticity. Climatologically forced general circulation models also are consistent with the notion of long-lived mesoscale vortices containing a core of trapped fluid. See for example Kantha et al (in Circ in Gulf of Mexico: Observations and Models, AGU Press 2005). In contrast, we have studied mesoscale eddies in a variety of data assimilating models and have found that all exhibit considerable exchange between the eddy cores and the ambient fluid outside the eddies. A detailed blob calculation for one ring, Fourchon, from the Gulf of Mexico illustrates the leaky property. This calculation illustrates the fundamental dilemma: does data assimilation corrupt mesoscale processes, or does it delineate new physics?

B203

Reliability of a Lagrangian analysis from FSLEs

Ismael Hernandez-Carrasco, Emilio Hernandez-Garcia, Cristobal López, Antonio Turiel
IFISC (CSIC-UIB)
(Abstract received 08/12/2009 for session B)

We have analyzed surface velocity data of the Mediterranean Sea as obtained from a primitive equation circulation model (Diecast model). We have computed the Finite Size Lyapunov Exponents (FSLEs) from this data set, which provide a measure of oceanic horizontal stirring, as well as reveal with their extreme values the

barriers of transport.

A particular property of the FSLE is that it is able to study spatial structures at scales under the resolution of the velocity data used in this computation. In this way, we can obtain information of submesoscales and mesoscales structures (1-100km). We investigate here how reliable are the results of a Lagrangian diagnosis at a similar and at a finer resolution than that of the velocity data. We address this work by the analysis of two properties:
- Multifractal character of the spatial distribution of the FSLE, in order to study its scale invariance properties.
- Relative error of the FSLE for three cases: a) by introducing a random perturbation in the velocity data, b) by decreasing the resolution of the velocity field, and finally, c) by adding white noise in the computation of the particle's trajectories.

B204

Zonal jets in rotating turbulence: organization and role as transport barriers

Stefania Espa, Antonio Cenedese, Michelangelo Mariani
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(Abstract received 08/04/2009 for session B)

The organization of a sequence of alternating intense and elongated eastward-westward bands i.e. zonal jets in the atmosphere of Giant Planets and in the Earth,Äôs oceans have been widely investigated (Galperin et al. (2004); Maximenko et al. (2007)). Nevertheless jets formation and their role as material barriers remain still unclear. Jets are generated in a quasi 2D turbulent flow due to the effects of the latitudinal variation of the Coriolis parameter which modify the inverse cascade process channeling energy towards zonal modes (Rhines (1975)) but may also originate from baroclinic instability process via the non-linear interaction between the eddies and the mean flow (Kaspi & Flierl (2007)). In this work we are concerned with the first mechanism, in particular the dynamical properties of quasi-2D turbulence under the influence of strong rotation will be experimentally reproduced and analyzed. The role of eastward and westward jets as meridional transport barriers is then discussed both in terms of potential vorticity gradient distribution and of Finite Size Lyapunov Exponents (Boffetta et al. (2001)).

B205

New tools for aperiodic time dependent flows: applications to the description of transport across the Kuroshio current.

Ana M Mancho, Carolina Mendoza
ICMAT, CSIC
(Abstract received 08/03/2009 for session B)

In recent years there has been a lot of progress in the application of dynamical systems concepts to the description of transport in oceanic flows. In these flows the classical dynamical system theory does not apply as typically they are aperiodic and finite-time defined. Definitions of Lyapunov exponents and invariant manifolds have been adapted for describing finite time flows. Recently a new definition of distinguished trajectory has been proposed in Madrid & Mancho (Chaos, 2009). Distinguished trajectories are special trajectories that act as organizing centres of the geometrical template of aperiodic time-dependent flows, like fixed points and periodic orbits do in time independent or periodic flows. The computation of distinguished trajectories as reported in Madrid & Mancho (Chaos, 2009) uses a function M of which we show contains a lot of Lagrangian information. In this presentation I will discuss how the visualization of this function M, allows the identification of relevant Lagrangian features at a glance. In particular we study an application to real altimetry data taken from satellite in the area of the Kuroshio current. We combine this information with the computation of distinguished trajectories and invariant manifolds and we report an accurate description of transport routes in this region.

Session C Abstracts
Dynamical system analysis and optimal deployment/sampling design

C101
Coherence of eddies in a rip channeled surfzone
Joseph Geiman, James T. Kirby, Ad J.H.M. Reniers, Jamie MacMahan, Jeff Brown, Jenna Brown, Tim P. Stanton
University of Delaware
(Abstract received 08/14/2009 for session B)

Breaking waves on a rip-channeled beach often generate mean two-dimensional vortical structures that contribute to most of the mixing of fluid inside the surfzone. The RCEX experiment (Monterey, CA in 2007) investigated the rip current circulation over a bathymetry consisting of persistent shoals and rip channels using GPS aided drifters. The experiment revealed instances where a well developed rip current circulation pattern suprisingly did not lead to frequent transport of drifters beyond the outer edge of the surfzone. This trend of drifter retention is echoed in recent numerical simulations of the RCEX field experiment using the wave and current resolving model Funwave. Model output reveals dipolar rip structures that oscillate at a time period much longer than the incident wave period, leading to episodic ejections of simulated drifters. Coherence of these rip current eddies is assessed by calculating finite-time invariant manifolds using FTLE fields as well as methods used by Miller et al. (1997). Eddy coherence is also assessed by mapping the retention time of fluid particles inside the surfzone.

C102
Flow structures from Lagrangian tracers in a tidal driven flow (Ria de Vigo, Spain)
Florian Huhn, Vicente Perez-Munuzuri, Pedro Montero
Universidad de Santiago de Compostela
(Abstract received 08/11/2009 for session C)

We analyze the 2-dimensional surface velocity field from a 3-dimensional flow model for an estuarine (Ria de Vigo, Galicia, Spain). Fields of the Finite-time Lyapunov Exponent (FTLE) are calculated from passive advected tracers in the time-dependent flow to detect Lagrangian Coherent Structures (LCS). These structures seperate the flow and act as transport barriers. They reveal zones of retention and allow for an exact localization of the tidal inflow from the shelf. First comparisons of the LCSs to drifter trajectories show good agreement, as long as the drifters are hardly influenced by the local winds in the estuarine. Measured surface velocity fields from HF radar will be used to verify the results from the model and the drifters. Knowledge about the flow structures in the Ria de Vigo are useful to follow contaminations from the large harbour and intense ship traffic. Furthermore, the region has one of the most productive mussel industries of the world due to the seasonal upwelling of cold nutrient rich water. The transport of nutrients or eggs and larvae of fish and shellfish, but also the presence of harmful algae blooms are directly connected to the present flow structures.

C103
Constrained ensemble simulation for inverse Lagrangian prediction problem
Mike Chin, Arthur Mariano, Ashwanth Srinivasan
RSMAS / U.Miami
(Abstract received 08/14/2009 for session C)

Stochastic dynamic models are often used in drifter track simulations due partly to uncertainty in subgrid scale circulation velocity. The random flight model is an example of such. The nature of Lagrangian trajectory forecast using such models is that an ensemble of trajectories with a common release location would diverge in time. Numerically, divergence of trajectories is not convenient for inverse Lagrangian prediction problems such as drifter array deployment and source estimation problems, in which a common (or very small number of) release location(s) is sought given the knowledge of the final distributions of drifter locations/concentrations. In this talk, we explore application of the particle filter to constrain the drifter trajectories to "contract" while the Lagrangian simulations progress backward in time. The initial goal of the experiment is to improve localization of the source (or deployment site) of the drifters.

C104
On the use of Particle Filters for Lagrangian Prediction
Arthur J. Mariano, Mike Chin
RSMAS, U. of Miami
(Abstract received 08/14/2009 for session C)

Particle Filter is a class of Sequential Monte Carlo methods that estimate the Probability Density Function (PDF) of the state variables of your system using data, prior PDF estimates, Bayes theorem, a Markov assumption, and quasi-random (re-)sampling. Particle Filters have very low developmental cost, but the efficiency of algorithm is problem dependent. At the heart of most of the algorithms is how to sample and resample the PDF (or a parameterization of it) so that peaks in multi-modal PDFs are resolved and PDF estimates are not too diffuse. Standard statistical, sampling-based particle filtering methods have not worked as well as expected for some geophysical prediction problems. A number of researchers have recently reported very good results for

predicting Lagrangian trajectories using particle filtering methods. These recent results suggest that a more dynamical-based (re-)sampling and weighting strategy may be needed for geophysical prediction problems. A number of suggested sampling approaches will be presented for Lagrangian prediction problems.

C401

Dispersion patches prediction with NCOM model corrected with Lagrangian statistical characteristics. Sensitivity study

Julien Marmain, David Magnen, Anne Molcard, Angélique Haza
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(Abstract received 08/24/2009 for session B)

The IMC (Inserting Missing Component) method (Haza et al., 2007), based on the insertion of an eulerian velocity correction term computed from drifters statistical characteristics, is applied to the DART (Dynamic of the Adriatic in Real Time) march 2006 data, during which 13 surface floats were deployed in the Adriatic. The ratios between synthetic and real Lagrangian decorrelation time scale (TL) and variance (œÉ2) are the essential parameters, both estimated from the autocovariance functions by different methods. The sensitivity to the statistical parameters computation is described, showing the importance of the chosen method in terms of mean and autocovariance computation. The IMC method is applied for the correction of dispersion patches in quasi real-time for short time advection.

C402

Particle dispersion in stochastic flows with linear shear

Leonid Piterbarg
University of Southern California
(Abstract received 06/13/2009 for session B)

Absolute and relative dispersion are investigated for two types of stochastic flows with a linear drift, the Brownian flow, which implies delta-correlated velocity fluctuations, and the first order Markov flow with memory characterized by finite correlation time. It is shown that anisotropy of absolute dispersion is completely determined by anisotropy of the drift while its magnitude depends on both, drift and velocity fluctuation statistics. In contrast, anisotropy of the relative dispersion is strongly affected by the fluctuation statistics and the crucial parameter is the normal correlation length.

C403

Numerical Lagrangian study of typical pathways for water masses in the North Western Mediterranean

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Centre d'Océanologie de Marseille
(Abstract received 07/17/2009 for session C)

The numerical Lagrangian diagnostic tool Ariane is used to determine the main pathways in the North Western Mediterranean (NWM) and their associated transports. Quantitative and qualitative simulations are made for this region with Eulerian outputs from the ocean regional circulation model Symphonie for years 2001 to 2003.
A clear correlation is shown between the mean position of the Northern Current and the bathymetry.
The transport for the pathway linking Corsican waters and the Balearic channel is evaluated around 0.25 Sv.
A strong recirculation in the Ligurian sea appears in our diagnostics. We named it the Ligurian Recirculation.
The preliminary focus on it shows that water masses involved are centered around 500-meter depth.
Future analysis on tracers (temperature and salinity) could allow us to link these results with specific water masses.

Session D Abstracts
Lagrangian modeling, data assimilation, and error evaluation

D101

Implementation of a new simple method to estimate surface velocities from satellite data and numerical models.

Enrico Zambianchi, Alessandro Mercatini, Annalisa Griffa, Leonid Piterbarg, Marcello Magaldi
Parthenope University, Napoli, Italy
(Abstract received 08/14/2009 for session D)

A simple method of fusing tracer observations and model outputs for computing surface velocities is implemented and tested in the framework of the twin experiment approach. Synthetic data from realistic velocity outputs produced by the operational Mediterranean Forecasting System are used. The method allows to estimate a velocity field using two consecutive tracer snapshots. The focus is on testing realistic time intervals between snapshots and partial tracer observations. The considered configuration consists of a tracer patch released and advected by the current, and is motivated by the practical problem of estimating velocities and concentrations using satellite data in case of pollutant releases such as oil spills. An extensive set of experiments has been carried out, and the method performance has been quantified in terms of improvements in accuracy with respect to the model. The improvement ranges from values of approximately 80-90% for concentration and 50-60% for velocity in the case of almost perfect data, to values of 30-40% for realistic time intervals of the order of days and reduced tracer information, and values of 15-20% when only the boundary of the patch is observed. The results are found to be robust to flow variability and patch parameters.

D102

Improving Lagrangian Predictability by Blending Drifter Observations with Model Velocities

Helga S. Huntley, B. L. Lipphardt, Jr., A.D. Kirwan, Jr.
University of Delaware
(Abstract received 08/12/2009 for session D)

Even today's state-of-the-art ocean models struggle with meeting desired Lagrangian predictability targets. We investigate the potential for decreasing Lagrangian prediction errors by applying a constrained normal mode analysis (NMA), blending drifter observations with model velocity fields. The energy spectrum of an unconstrained NMA and its variability are discussed, as well as the effects of parameter choices. The constrained NMA technique is initially presented in a perfect model simulation, where the ‚Äútrue‚Äù velocity field is known and the result can be directly assessed in both Lagrangian and Eulerian metrics. Finally, we will show results from a recent experiment in the East Asia Sea, where real observations were assimilated into operational ocean model hindcasts.

D103

Assimilation of Lagrangian Data in a Variational framework

Claire Chauvin, Francois-Xavier Le-Dimet , Maelle Nodet , Innocent Souopgui , Olivier Titaud , Arthur Vidard
INRIA
(Abstract received 08/11/2009 for session D)

We present a review of our work on Lagrangian Data Assimilation in a Variational Framework.

The Variational Data Assimilation aims at finding an optimal trajectory, solution of a given model, that is consistant with past observations of the modelled system. The observations we are interested in assimilating are of Lagrangian type: float positions (whose dynamics contain local physical information) and images. Satellite observations of atmosphere and ocean contain a huge quantity of visual information (such as eddies, fronts) that is underused by numerical forecasting systems.

The construction of the observation operator is done thanks to passive tracers, whose dynamics are interpreted as an image. The turbulent structure of this image is then compared to the observed image, both of them being represented in a set of curvlets. After a short presentation of the several steps of our method, and more especially the Image Assimilation techniques, we will present the first results on twins experiments.

D104

Lagrangian data assimilation: accomplishments and challenges for surface drifter applications

A. Griffa, V. Taillandier, T. Özgökmen, A. Molcard, Y. Chang
RSMAS/CNR
(Abstract received 08/13/2009 for session D)

Assimilation of Lagrangian data in OGCMs is emerging as a natural avenue to improve ocean state forecast with many potential practical applications such as environmental pollutant transport, biological and defense-related problems. Methods have been developed to assimilate Lagrangian data, and they have been applied to subsurface ARGO float with very positive results. Present investigations are focused on applications for surface drifters. They are especially challenging because they sample the surface velocity, characterized by high variability, small scale of motion and a mix of geostrophic and ageostrophic dynamics. Reults from velocity

reconstruction using drifter data in coastal and open ocean flows are shown and transition to full assimilation is discussed.

D105

Integration of ARGO trajectories in the Mediterranean Forecasting System and impact on the regional analysis of the Western Mediterranean circulation

V. Taillandier, S. Dobricic, P. Testor, N. Pinardi, A. Griffa, L. Mortier, G.P. Gasparini
Laboratoire d'Océanographie de Villefranche
(Abstract received 07/27/2009 for session D)

The impact of ARGO float trajectory assimilation on the quality of ocean analyses is studied by means of an operational oceanographic model implemented in the Mediterranean Sea and a 3D-var assimilation scheme. For the first time, both ARGO trajectories and vertical profiles of temperature and salinity (TS) together with satellite altimeter data of sea level anomaly (SLA) are assimilated to produce analyses for short term forecasts. The study period covers three months during winter 2005 when four ARGO trajectories were present in the northwestern Mediterranean Sea. The scheme is first assessed computing the misfits between observations and model forecast and analysis. The misfit statistics appear improved for float trajectories, while they are not degraded for the other assimilated variables (TS profiles and SLA). This indicates that the trajectory integration is consistent with the other components of the assimilation system, and provides new information on horizontal pressure gradients. Comparisons between analyses obtained with and without trajectory assimilation suggest that trajectory assimilation can impact on the description of boundary currents and their instabilities, as well as mesoscale activity at regional scales. Changes are depicted by intermediate water mass redistributions, mesoscale eddy relocations and net transport modulations. These impacts are detailed and assessed considering historical and simultaneous in-situ datasets. The results motivate the integration of ARGO trajectories in the operational Mediterranean Forecasting System.

D201

Large eddy simulations of mixed layer instabilities and sampling strategies

Tamay M. Özgökmen
RSMAS, University of Miami
(Abstract received 08/13/2009 for session D)

The ocean's surface mixed layer is notoriously complex due to high spatial and temporal gradients of density and velocity fields. The surface mixed layer also exhibits sub-mesoscale instabilities which are challenging to observe due to their small scale and fast temporal evolution. Nevertheless, the small and sub-mesoscales represent the range of scale of naval operations and thus anomalous currents and perturbations in the acoustic and optical environment that can affect a variety of naval operations. Understanding the motion in this range of scales is therefore critical to help improve the predictive capability of the existing ocean models.

In this preliminary study, large eddy simulations of an idealized mixed-layer problem are conducted using a spectral element model. Characteristics of the different phases of the evolution of a mixed-layer front, as well as the sensitivity of the solution to model parameters are described. The fields are then sampled using tracers and Lagrangian particles, and relative dispersion statistics are discussed.

D202

Surface current trajectories in the Southern California Bight: Model results and observations

Carter Ohlmann, Satoshi Mitarai
University of California, Santa Barbara
(Abstract received 08/14/2009 for session D)

Many applied problems in coastal oceanography are inherently Lagrangian, requiring trajectories to determine the ,"fate and transport" of passive tracers. Probability distributions of water parcel location as a function of initial position and advection time are the primary quantities of interest. In the turbulent ocean, numerical model derived trajectories must be relied upon for the extreme number of realizations needed to calculate probability density functions (pdfs). The model-derived trajectories must be shown to be suitably representative.

A model-data comparison between Lagrangian pdfs from ROMS simulations and historical drifter observations is presented. The two dimensional Kolmagorov-Smirnov (K-S) statistical model for comparing sampled data with a known pdf is the basis of the comparison. Data are from surface current trajectories collected primarily in the Santa Barbara Channel from 1996 through 1999 with one-meter CODE style drifters. Modeled pdfs come from trajectories (at one meter depth) computed with one-kilometer resolution ROMS simulations for the Southern California Bight for the same time period. Deployments within 10 kilometers of the coast throughout the Santa Barbara Channel with one to four day advection times are evaluated. In general, in situ data lie within the area given by model pdfs and K-S statistics rarely disprove the null hypothesis (H0: data are from the model pdf) for the relatively small data samples available. Both the underlying assumptions and power of the K-S test are discussed. The Lagrangian based comparison elucidates an improved understanding of model performance and ocean circulation beyond that offered with a Eulerian comparison.

D203

Characterization of Lagrangian variability on forecasting time scales using Eulerian velocity field of a forecasting high resolution model of the Tyrrhenian Sea.

Volfango Rupolo, Claudia Pizzigalli, V. Artale, R. Iacono, E. Napolitano, Gianmaria Sannino
ENEA
(Abstract received 08/14/2009 for session D)

Forecast operational oceanographic models are by now available in several regional seas. In the Mediterranean the MFS (http://www.bo.ingv.it/mfstep) project is active from almost ten years using a hierarchy of nested models with increasing resolution. Simply computing trajectories from Eulerian velocity field is easy. The forecasting of a trajectory of a drifting object or pollutant is of paramount importance but is a really challenging task due to the intrinsic chaotic behavior of the oceanic velocity fields and to the wind-wave interactions. Neglecting these last two factors, we addressed in the last years the problem of introducing the concept of Lagrangian indeterminacy in the in an operative context.

In the past the archive of Eulerian velocity fields from the global MFS was used to provide a statistics of dispersion properties in the Mediterranean basin integrating particles systematically using 2D "hindcast" velocity fields. Results were grouped in a user friendly web site (http://clima.casaccia.enea.it/riskmap) for a direct visualization of dispersion characteristics. When possible, real Lagrangian data and statistical properties of dispersion were compared in order to quantify errors on the reproduction of the natural variability of Lagrangian dispersion by the model.

We are now using forecasting Eulerian velocity field from an high resolution model of the Tyrrhenian Sea (1/48° x 1/48°) actually running at ENEA (http://clima.casaccia.enea.it/tirreno) in order to characterize (numerical) dispersion properties in the basin.

In this presentation we will focus on this second point. In particular, after a validation of the model, several techniques commonly used to characterize 2D turbulence are used and compared integrating about 67000 particles uniformly released at surface. We use both relatively long time series of Eulerian velocity fields and 7 days velocity field, i.e. the time window of the forecasting. The aim is to test the possibility of providing operative products highlighting the variability of Lagrangian dispersion in a given sub basin.

D204

Ensemble analysis of predicted trajectory uncertainty in an operational Navy model of the western Pacific Ocean

B. L. Lipphardt, Jr., H. S. Huntley, A. D. Kirwan, Jr., P. Hogan
University of Delaware
(Abstract received 08/19/2009 for session A)

Trajectory predictions from a twenty-four member ensemble set of Navy ocean forecasts for the western Pacific are compared to determine the variability of Lagrangian uncertainty in a regional ocean model with energetic features including the Kuroshio and mesoscale eddies. The spread of evolving trajectory ensembles with a common set of initial conditions is used to quantify the model,Äôs Lagrangian uncertainty. Variations in the spatial distribution of this uncertainty are compared with variability in the velocity field. Thirty drifters launched as part of a Navy acoustics exercise in October 2007 are also used to assess the variability of trajectory prediction errors among the ensemble set.

D205

Ocean Eddy Tracking using Lagrangian Data Assimilation

Kayo Ide, Guillaume Vernieres, Chris Jones
University of Maryland
(Abstract received 08/15/2009 for session D)

The Lagrangian data assimilation (LaDA) is a method for the assimilation of Lagrangian observations directly into the model. By augmenting the model state vector with the coordinates of the Lagrangian instruments and computing their trajectories based on the model velocity, the LaDA removes the need for any commonly used approximations to transform the Lagrangian observations into the Eulerian velocity observations. We demonstrate effectiveness of LaDA in a realistic setting for ocean-eddy tracking in Gulf of Mexico. We evaluate three types of observations for ocean eddy tracking: the measurement of velocities at fixed station, the horizontal position of surface drifters, and the three dimensional position of isopycnal floats. We examine how and to what extent the LaDA propagates the information vertically to estimate the three-dimensional ocean structure. We show that as little as one judiciously placed drifter or isopycnal float is needed to recover an eddy being shed by the loop current.

D301

Dealing with Nonlinearity in Lagrangian Data Assimilation

Christopher Jones
University of Warwick and University of North Carolina
(Abstract received 08/16/2009 for session D)

I will compare Kalman filter methods with statistical particle filtering methods in Lagrangian data assimilation. Even EnKF has problems handling certain nonlinear issues that arise from trajectories that sample from regions of high nonlinearity. Particle filter methods offer a way

forward but also challenges in scaling up to large-dimensional problems.

D302

Exploring the impact of ocean currents on sea turtles

Graeme Hays, Sabrina Fossette
Swansea University
(Abstract received 08/14/2009 for session E)

We are exploring how currents impact the movements of sea turtles throughout their lives. Hatchlings are small (a few grams) and so passive drift may explain a large component of their movement. However, hatchlings shown directional swimming with respect to the Earth's magnetic field which may help them maintain their position within ocean gyres. Adults are large (sometimes several 100 kg) and powerful swimmers. It is not fully known how, or if, adult turtles are able to correct for current drift during their oceanic movements. While we have assembled a huge data-set of adult movements by Argos tracking we are only just starting to explore the role of currents in shaping these movements.

D303

Using genetic and global Lagrangian drifter data to investigate the dispersal of small juvenile green turtles in the Atlantic

Patricia L.M. Lee
Swansea University
(Abstract received 08/14/2009 for session E)

Green turtle hatchlings disperse away from their natal location to spend an early pelagic stage in the ocean. This is quickly followed by a neritic stage, where small juveniles settle in coastal areas. Here, we compared the DNA data of small juveniles sampled in foraging groups, with those of samples collected from nesting populations from around the Atlantic. This showed that small juvenile foraging groups are highly mixed compared with nesting populations, implying that drift has a strong role in dispersing the turtles at a trans-Atlantic scale after hatching. Global Lagrangian Drifter Data was then employed to better understand the dispersal patterns revealed by the genetic analysis.

D401

Estimating Lagrangian trajectories from tracer observations and model output

Leonid Piterbarg
University of Southern California
(Abstract received 06/13/2009 for session D)

A stable method of low computational cost is suggested for estimating Lagrangian trajectories by combining observations of a continuously distributed conservative tracer and a circulation model output (background velocity field). A theoretical error analysis for a homogeneous flow is provided while for a more sophisticated synthetic flow the error is evaluated numerically. The reduction in error comparatively to the background varies in the range 1%-34% depending on the flow structure. Finally, the method is applied for estimating the absolute and relative dispersion in a gyre perturbed by periodic or stochastic fluctuations.

D402

Front Propagation and Superdiffusion in Active Media

Vicente Perez-Munuzuri, Alexandra von Kameke, Guillermo Fernández-García
Universidad de Santiago de Compostela
(Abstract received 08/11/2009 for session E)

We study the effect of superdiffusion on front propagation in active media, in order to enlighten the principles of plankton spreading in the turbulent ocean.
A chaotic velocity field generated by Faraday instabilities was used. Passive particles in this type of flow were shown to undergo Levy flights such that the mean square displacement $R^2(t) \sim t^v$ with $v \neq 1$, ($v = 1$ indicates Gaussian process). Thus the system exhibits superdiffusion. The formation of a reactive front propagating through the reactor was observed owed to the domination of advection coupling over diffusion coupling. We analyzed the front dynamics with respect to velocity and spreading behaviour and found evidence for non-gaussian diffusion.

Session E Abstracts
Biological, meteorological and multidisciplinary applications

E101

Frigatebirds follow Lagrangian Coherent Structures

E. Hernandez-Garcia; E. Tew Kai; V. Rossi; C. Lopez, J. Sudre, V. Garçon, H. Weimerskirch.; F. Marsac
IFISC (CSIC-UIB)
(Abstract received 08/13/2009 for session E)

We have analyzed meso- and submesoscale Lagrangian structures in the surface of the Mozambique Channel, as revealed by Finite-Size Lyapunov exponents (FSLEs), over a 2-month observation period, and compared them with ARGOS-tracked flying trajectories of a marine predator, the Great Frigatebird. We find that frigatebirds track precisely FSLE ridges, which reveal Lagrangian Coherent Structures. They do so while foraging, but also while performing long displacements between foraging and nest sites. The birds might use visual and/or olfactory cues and/or atmospheric current changes over the structures to move along these biological corridors. Comprehension of this behaviour would be important not only to seabirds¬¥ ecology but for the understanding of the full Channel ecosystem.
Tew Kai at al., PNAS 106, 8245-8250 (2009)

E102

Extending the Use and Interpretation of Ocean Satellite Data Using Lagrangian Modeling

Bror Jonsson, Joe Salisbury, Amala Mahadevan
Princeton University
(Abstract received 07/28/2009 for session E)

We propose a new methodology for synthesizing satellite or in situ observations with ocean circulation velocity fields from an operational model. This is done by attaching values taken from the satellite observations to virtual particles seeded in the domain of a circulation model and advecting them in a Lagrangian fashion. It is then possible to track the fate and change in composition of individual water parcels between two satellite images, and hence estimate the change in satellite-derived properties along the trajectories of water parcels. The power of the method lies in deciphering the change in sea surface properties from satellite data in the Lagrangian (advective) frame. We use this to estimate rates of biological processes. Further, we generate a dynamically correct time-interpolation of satellite fields by considering the temporal change in water properties as occurring along trajectories of moving water parcels, rather than in a static medium. We use the methodology to interpret and interpolate MODIS satellite √ûelds in the Gulf of Maine, which has notoriously intermittent satellite coverage. The dynamic interpretation is made possible for this region by the availability of time-specific velocity fields from an operational coastal circulation model.

E103

LATEX (LAgrangian Transport EXperiment): strategy and preliminary results.

A. Petrenko, A. Doglioli, Z. Hu, F. Diaz, R. Campbell, I. Dekeyser, and LATEX group.
LOPB, COM, Marseille
(Abstract received 07/17/2009 for session E)

The Lagrangian Transport Experiment (LATEX) aims to study the influence of coupled physical and biochemical dynamics at (sub) mesoscales on matter and heat transfers between the coastal zone and the open ocean. Mesoscale and sub-mesoscale hydrodynamic features, occuring at the interface between the continental slope and the coastal margin, are key to the understanding of transfers between the coastal zone and the open ocean. However, these processes are still not fully understood. At these scales, the influence of physical processes on biogeochemistry is clearly shown in numerical studies. Confirmations by experiments are difficult, and hence rare, because experimental strategies generally differ greatly whether they are oriented towards a physical study or a biogeochemical one. The LATEX strategy is based on combining Lagrangian in situ measurements (Lagrangian buoys and SF6 tracer) with numerical modelling, satellite data, gliders and Eulerian measurements. The study area is the western part of the Gulf of Lion, where coastal anticyclonic eddies are suspected to interact with the Northern Current flowing along the slope. The project sampling strategy will be presented as well as preliminary results on numerical modeling and in situ measurements.

E104

Field Work for assessment of the leeway of drifting objects

Christophe Maisondieu, O. Breivik, A.A. Allen, J-C. Roth, M. Pavec
IFREMER
(Abstract received 07/10/2009 for session E)

Operational drift forecast models developed for prediction of the trajectory of objects lost at sea are now mostly based on stochastic approaches for the definition of search areas from computation of probable trajectories. Such models take into account environmental forcing components, mainly surface or near-surface currents and wind, as well as simplified drift speed computation models based on objects hydrodynamic and aerodynamic properties. Drifting properties of objects can be described by mean and standard error of their leeway coefficients. Assessment of these coefficients is based on a direct method which requires measurements acquired during field tests. We discuss here procedures for conducting

such field tests and present results from campaigns for evaluation of leeway coefficients of various objects. Finally we present results of a drift forecast model for the case of a twenty-foot shipping container and discuss sensitivity of the forecast to quality of environmental data, by comparing results obtained using model data with results obtained with HF radar data. We also discuss the need to provide more sophisticated Lagrangian uncertainty estimates, models and parameters into operational Search and Rescue trajectory models.

E105

Numerical modelling of wave-current interactions in the Sea of Marmara during a wind storm event (Feb 2009)

Jacopo Chiggiato
NURC - Nato Undersea Research Centre
(Abstract received 08/13/2009 for session E)

The talk describes a NURC modeling effort for the TSS08-TSS09 trials in the Marmara Sea (small and deep basin interconnecting the Mediterranean Sea and the Black Sea). The two way coupled ROMS/SWAN model is used to simulate wave-current interactions during a wind storm event in February 2009. Several realistic model experiments have been carried out providing a sensitivity analysis of physics and parameterizations associated to wave-current interaction implemented in ROMS/SWAN. These implementations in particular are the Mellor (2003) equation for the inclusion of radiation stress and stokes drift in the momentum balance equation, the impact of wave age dependency in the momentum stress parameterization and the inclusion of wave breaking as TKE injection as surface boundary condition of the Generic Length Scale turbulence model. Model performance is eventually assessed using skill scores based on lagrangian drifters as well as other available observations.

E201

FOAM the new degradation model coupled with the advection-lagrangian dispersion model: the impact evaluation of the fish farm waste

Patrizia De Gaetano, Andrea M. Doglioli, Paolo Vassallo, Marcello G. Magaldi
DIFI, Dipartimento di Fisica, Universit\`a di Genova, Genoa, Italy
(Abstract received 08/13/2009 for session E)

A new numerical benthic degradative module FOAM (Finite Organic Accumulation Module) has been developed in order to improve the prediction of the potential impact of marine fish farms. FOAM has been coupled with the model POM-LAMP3D, an advection and lagrangian dispersion model able to compute the 3D particle concentration in the sea. Real historic current-meter data are employed to force the hydrodynamic and dispersion simulations and recent measurements of settling velocity values specifically targeting Mediterranean fish species are considered.

FOAM uses the output of the other functional units of the modeling framework to calculate the organic load on the seabed, considering the natural capability of the seafloor in absorbing part of this organic load. Different remineralization rates reflect the sediment stress levels and are used to compute the organic carbon concentration remaining on the seabed. Two sampling campaigns have been performed in a typical Mediterranean fish farm in the warm and cold season in 2006 in order to measure the benthic response to the organic load and the mineralization rates in the Mediterranean conditions. Organic degradation for both uneaten feed and faeces is evaluated by changing release modality (continuous and periodical) and by varying the settling velocities. The results show that the feed, especially released in periodical mode, produces the greatest impacts and in the Mediterranean conditions, the benthic response to the organic enrichment of the bottom depends on water temperature. The introduced modeling framework successfully improves capability predictions, therefore it can represent an important tool in decision making processes, for planning and monitoring purposes.

E202

Lagrangian models for the dynamics of a multistage population: effects of different development models

Giuseppe Buffoni, Sara Pasquali
CNR-IMATI
(Abstract received 08/04/2009 for session E)

It is assumed that the development process equations of an individual are stochastic equations, describing the time evolution of the status of an individual, in terms of a physiological age. General properties of development models of an individual, together with the basic steps identifying the life history of an individual, are briefly illustrated. Then, we address the formulation of development models, when "regression" effects (defined as negative development) on the status of an individual are forbidden; this is the case when the physiological age is defined in terms of an abstract non-decreasing indicator measuring maturity or the percentage of development. Three different discrete stochastic models of the development process are presented, and their responses compared. Their behaviours are analyzed by varying the stochasticity level, which takes into account the degree of intraspecific variability. A multi-stage system, representing a copepod population, is used to illustrate the different dynamics outcomes, depending on the dvelopment model applied, by means of numerical simulations. Some idealized situations will be considered, trying to separate the effects of the main processes influencing the life history of an individual. First, the stochastic development process from egg to juvenile and adult stages, neglecting the mortality events, and the

consequent stage distributions of the individuals, is illustrated. Then, the effects of the stochastic mortality process on stage distribution is shown. Finally, the total population growth is estimated.

E203

The role of time and length scales of mesoscale eddies on phytoplankton production

Vicente Perez-Munuzuri, Florian Huhn
MeteoGalicia, Universidad de Santiago de Compostela
(Abstract received 08/11/2009 for session E)

Hydronamic forcing was found to play a crucial role in the development of spatial plankton structures. The role of time and length scales of the flow on plankton production is investigated. To that end, we used a coupled model consisting of a three component ecological NPZ model and a fluid model able to mimic the mesoscale structures observed in the ocean. Two hydrodynamical models were used: a Gaussian flow, where the length and time scales can be easily controlled, and a real velocity field derived from altimetry data in the North Atlantic ocean. Optimal time and length scales were obtained for the Gaussian flow model and this result was confirmed by the real altimetry flow. Results are discussed in terms of the time scale of the NPZ model, the front roughness and the Finite-Time Lyapunov Exponent analysis.

E204

Comparison between modeled and observed surface drifter trajectories and calculation of FTLE fields to explain a spatial separation between two genetic clades of copepods

Simon St-Onge Drouin, Jean-Fran√ßois Dumais, Gesche Winkler
ISMER/UQAR
(Abstract received 08/06/2009 for session E)

The Upper St-Lawrence estuary, about 180km long and up to 30km wide, is characterized by strong tidal currents (~2 m/s). A three-dimensional numerical model of this estuary is used to compare modeled and observed drifter paths. This fully prognostic model has a 30 seconds time step with a lateral resolution of 400m and 35 levels in the vertical. The modeled and observed paths are found to be in good agreement. Finite-time Lyapunov exponents are then computed from modeled drifter trajectories. These results are used to show the importance of hydrodynamics in maintaining the separation between two genetic clades of the calanoid copepod species complex Eurytemora affinis.

E205

Overwinter transport of the zooplankton Calanus finmarchicus in the Norwegian Sea

Henrik Soiland, Geir Huse
Institute of Marine Research
(Abstract received 08/14/2009 for session E)

The Norwegian Sea is one of the core areas of the zooplankton Calanus finmarchicus, and harbours high abundances in the upper waters during summer. The C. finmarchicus is vital to many of the planktivorous fish species which feed in the Norwegian Sea during summer. C. finmarchicus spends the period from late summer until January-February resting in diapauses, mainly at depths between 500-1500 m. We use drift trajectories from 26 RAFOS floats to describe and discuss overwinter transportation of C. finmarchicus in the Norwegian Sea. The RAFOS floats were deployed in the fall of 2004 and surfaced in March 2006, thus spending two winters in the Norwegian Sea. The RAFOS floats drifted at 800m and we use the winter trajectories to mimic the winter drift of the C. finmarchicus. These data allowed us to investigate in more detail specific questions about the overwintering transport of C. finmarchicus.

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Meeting Attendees

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Maria Andersson Geophysical Institute

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Henrick Berger	Centre d'Océanologie de Marseille
Sukru Besiktepe	Principal Scientists
Giuseppe Buffoni	ENEA

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Luca Centurioni	Scripps Institution of Oceanography
Claire Chauvin	LJK - INRIA
Jacopo Chiggiato	NURC - NATO Undersea Research Centre
Toshio Chin	RSMAS / U.Miami

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Andrea Doglioli	Centre d'Océanologie de Marseille
Kristofer Döös	Dep. of Meteorology, Stockholm University

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Anders Engqvist	Royal Institute of Technology
Stefania Espa	DITS-Sapienza Università di Roma

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Philippe FRAUNIE	LSEET CNRS

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Joseph Geiman	University of Delaware
Riccardo Gerin	OGS
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Ismael Hernández	IFISC (CSIC-UIB)
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Marilisa Trani	University of Siena

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