5th International Workshop on Modeling the Ocean

IWMO 2013

17-20 June

Bergen, Norway

Agenda and Abstracts

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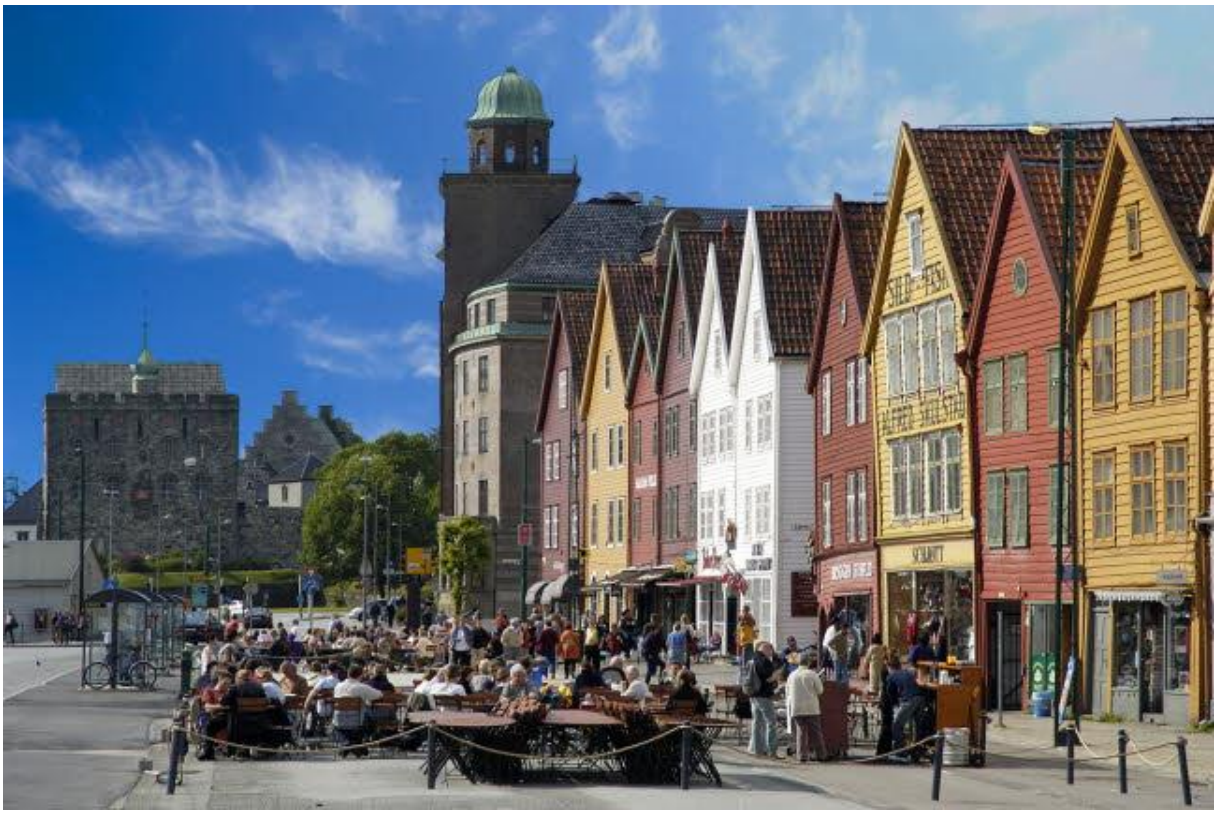

5th International Workshop on Modeling the Ocean

Keynote Speaker:

George L. Mellor (Princeton University)

International Science Committee

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Agenda of the 5th International Workshop on Modeling the Ocean

Sunday 16. June

18:00-20:00 Early registration

Monday 17. June

07.30-08.30 Registration

08.30-09.00 Opening remarks

09.00-09.30 Keynote Lecture: George Mellor, Surface Boundary Layers and Gravity Waves

09.30-10.10 Coffee break

Session 1: Surface waves, the parameterisation of wind stress and their effect on ocean circulation

Session Chairs: Richard Greatbatch and Alastair Jenkins

10.10-10.25 ***Igor Esau****, Simulations of turbulent air-sea interaction with a coupled atmosphere- ocean turbulence-resolving model PALM*

10.30-10.45 Hidenori Aiki and ***Richard J. Greatbatch****, A new expression for the form stress term in the vertically Lagrangian mean framework for the effect of surface waves on the upper ocean circulation: implications for the surface stress implemented in models*

10.50-11.05 ***Hidenori Aiki****, R.J. Greatbatch, H. Tamura, M. Yoshioka, K. Tsukobi, Mo- mentum fluxes to ocean circulation as given by the dissipation rate of surface gravity waves under tropical cyclone conditions*

11.10-11.25 ***Alastair D. Jenkins****, Angus Graham, Helge Avlesen, Alok K. Gupta1, Torge Lorenz, IdarBarstad, yvind Thiem, Ilker Fer and Mostafa Bakhoday Paskyabi, Responding to the challenges involved in coupling pre-existing numerical models for the atmosphere, ocean waves and ocean hydrodynamics, for shelf sea and coastal/fjord applications*

11.30-11.45 ***Kai H. Christensen****, Wave/mean flow-interactions in ocean models with time varying vertical coordinates*

Session 2: Circulation and Dynamics in Shelf Seas

Session Chairs: Jianping Gan and Bjørn Ådlandsvik

11.50-12.05 ***Danya Xu*** *and Paola Malanotte-Rizzoli, OYSA, Numerical Modeling the Seasonal Variation of the Upper Layers of the South China Sea (SCS) circulation and the Indonesian Throughflow (ITF)*

12.10-13.30 Lunch Break

13.30-13.45 ***Shuwen Zhang****, Lingling Xie, Yijun Hou, Tropical storm-forced near-inertial energy dissipation in the continental shelf region of Hainan Island*

13.50-14.05 ***Juan-Manuel Sayol****, Alejandro Orfila, Gonzalo Simarro, Daniel Conti, Alvaro Galan and Lionel Renault, OYSA, Western Mediterranean Sea surface characterization. A Lagrangian perspective*

14.10-14.25 ***Sourav Sil****, Yasumasa Miyazawa, Sergey M. Varlamov, Toru Miyama, Takuji Waseda, and Xinyu Guo, OYSA, Topography-tide-current interaction on the South of the Japan*

14.30-14.45 ***F. A. Velazquez-Munoz****, Numerical study of coastal circulation by offshore wind-stress jet in the Gulf of Tehuantepec, Mexico*

14.50-15.05 ***Valerie Garnier****, Pierre GARREAU and Delphine Fernandez-Bruyere, Impact of the high resolution modelling onto the dynamics of the North Western Mediterranean Sea*

15.10-15.30 Coffee break

15.30-15.45 T.S.Anandh, Saswati Deb and ***Arun Chakraborty****, OYSA, Mechanisms of Eddy Formation along Western Boundary of the Bay of Bengal*

15.50-16.05 ***Bjørn Ådlandsvik****, Jon Albretsen, Anne D. Sandvik and Lars Asplin, An ocean model system for the Norwegian Coast*

16.10-16.25 ***Clare Coughlan****, Adolf Stips, Johan van der Molen, Interannual variability in temperature and salinity across the northwest European Shelf*

16.30-16.45 ***Jianping Gan****, Cross-isobath geostrophic transport in the shelf sea*

16.50-17.05 Varjola Nelko and **Vivien P. Chua**, Modeling circulation in the South China Sea with an unstructured-grid SUNTANS model

19.00 Reception at the Institute of Marine Research

Tuesday 18. June

Session 3: Numerical techniques, data assimilation and forecast systems

Session Chair: Jinyu Sheng

08.30-08.45 ***Nguyen Tan Duoc****, OYSA, A development of POM model to simulate Tsunami propagation in South China Sea*

08.50-09.05 ***Shouxian Zhu****, Wenjing Zhang, Yancheng Wu and Lin Zhou, The improvement of POM by Eulerian-Lagrangian method with Hybrid N-order Lagrangian interpolation*

09.10-09.25 ***Sergey M. Varlamov****, Yasumasa Miyazawa, Xinyu Guo and Toru Miyama,Validation of Updated Level 2.5 Mellor-Yamada Ocean Mixing Model in Operations of JCOPE-T Regional Ocean Modeling System*

09.30-09.45 Wang Qiang, ***Weidong Zhou****, Dongxiao Wang, Several New Time Integration Schemes for Implementation in POM*

09.50-10.05 ***Tarumay Ghoshal****, Arun Chakraborty, OYSA, Development of High Resolution Synoptic Surface parameters for short-term ocean state forecasting of the Bay of Bengal using ROMS*

10.10-10.30 Coffee break

10.30-10.45 ***Laurent Bertino****, Franois Counillon, Pavel Sakov, Sylvain Bouillon, Tim Williams, Modeling and data assimilation developments of the TOPAZ system in support of operational oceanography in the Arctic*

10.50-11.05 ***Annette Samuelsen****, Cecilie Hansen, Laurent Bertino, Environmental forecasting with the TOPAZ forecasting system*

11.10-11.25 ***Xunqiang Yin****, Fangli Qiao and Wei Zhao, New developments on parallel computation of Princeton Ocean Model based on MPI*

11.30-11.45 Jorge Urrego-Blanco and ***Jinyu Sheng****, Assessment of one-way and two-way nesting techniques in a coupled ocean-ice circulation model for the eastern Canadian Shelf*

11.50-13.10 Lunch Break

Session 4: Analysis methods for oceanic observations, satellite data, and model simulations

Session Chair: Tal Ezer

13.10-13.25 ***Karina Hjelmervik*** *and Karl Thomas Hjelmervik, Estimating time calibrated 3D climatology for ocean model validation*

13.30-13.45 ***Tal Ezer****, Using EMD/HHT Analysis to Connect Coastal Sea Level Rise with Ocean Dynamics and Climate Change*

13.50-14.05 ***Nataliya Stashchuk****, Vasiliy Vlasenko, Mark Inall, Dye release experiment: in-situ measurements and modelling*

14.10-14.25 ***Stefan Kraatz****, A hydrodynamic model of the Black Sea- Azov Sea using adaptive vertical coordinates*

14.30-14.45 Michela De Dominicis, ***Silvia Falchetti****, Francesco Trotta, Nadia Pinardi, A Relocatable Ocean Model for simulating drifter trajectories*

14.50-15.10 Coffee break

15.10-15.25 ***Lars Petter Røed****, Nils Melsom Kristensen, Pål Erik Isachsen, Øyvind Sætra, The triply nested Norwegian numerical ocean weather prediction system: Problems and possible solutions*

15.30-15.45 ***Jon Bergh****, Timothy Williams, Francois Coullion, A sea ice forecast system in the Barents and Kara Seas including a newly developed marginal ice zone model*

*15.50-16.05 Qiang Wang,****Weidong Zhou****, Theoretic analysis of splitting errors in split time stepping of ocean modeling*

Session 5: Modelling and Prediction of Marine Extreme Events

Session Chair: Jinyu Sheng

16.10-16.25 ***Tsimplis M.N****., R. Torres, Xiangbo Feng, Changes of the sea level extremes at marginal seas*

16.30-16.45 ***Feng Xiangbo****, M. N. Tsimplis, M. Yelland and G. Quartly, Significant and maximum wave heights in the Northeastern Atlantic and their relationships to the NAO*

Evening Free

Wednesday 19. June

Session 5 cont.: Modelling and Prediction of Marine Extreme Events

Session Chair: Jinyu Sheng

08.30-08.45 ***Liping Yin****, Fangli Qiao, Quanan Zheng, OYSA, A dynamic exceptional cold water event around Penghu on February 2008 and 2011*

08.50-09.05 ***Kuo-Tung Chang****, Shu-Huei Li, Three-Dimensional Evolutions of Tsunami on a Sloping Beach*

09.10-09.25 ***Heng Zhang****, Jinyu Sheng, Estimation of Extreme Sea Levels over the Continential Shelf off Eastern North America*

09.30-09.45 ***Lian Xie****, Bin Liu, Huiqing Liu, and Xiaoping Zhang, High Impact Storm Surges Affecting US Southeast Coast*

09.50-10.10 Coffee break

Session 6: Ocean circulation and its scale interactions with various other phenomena

Session Chairs: Yasumasa Miyazawa and Leo Oey

10.10 - 10.25 Alan Cuthbertson, ***Peter Davies****, Vasiliy Vlasenko and Nataliya Stashchuk, Modelling Studies of Topographically-Constrained Deep Water Overflows within the Faroese Channels*

10.30-10.45 ***Björn C. Backeberg****, Francois Counillon and Johnny A. Johannessen, Sensitivity experiments in the Agulhas Current using a hybrid framework*

10.50-11.05 ***Y.-L. Eda Chang*** *and L.-Y. Oey, Instability and finite-amplitude evolution of STCC eddies, from model and satellite data*

11.10-11.25 ***Toru Miyama****, Yasumasa Miyazawa and Humio Mitsudera, Short-term variations of the Kuroshio downstream of Cape Shionomisaki*

11.30-11.45 ***Bert Viikma****e and Tomas Torsvik, OYSA, Analysis of the lifetime of eddy structures*

11.50-12.05 ***Jonathan Tinker****, Jason Lowe, Anne Pardaens, Jason Holt, Sarah Wakelin, Rosa Barciela, Climate Projections for the NW European Shelf Seas with a quantification of uncertainty*

12.10-13.30 Lunch Break

13.30-13.45 ***H. R Langehaug****, P. B. Rhines, T. Eldevik, K. Lohmann, J. Mignot, OYSA, Water mass transformation and the North Atlantic Current in three multi- century climate model simulations*

13.50-14.05 ***Ying Bao****, Fangli Qiao, Zhenya Song, The global carbon cycle simulation of FIO-ESM v1.0*

Session 7: Oceanic internal waves: Theoretical modelling and observational evidence

Session Chair: Vasyl Vlasenko

14.10-14.25 ***Vasiliy Vlasenko****, Nataliya Stashchuk, Mark Inall, Matthew Palmer, Modelling of baroclinic tides over an isolated underwater bank*

14.30-14.45 ***Yasumasa Miyazawa****, Xinyu Guo, Kaoru Ichikawa, Toru Miyama, Sergey M. Varlamov, Takuji Waseda, Sourav Sil, Internal tide variability south of Japan: modeling and observation*

14.50-15.05 ***Tsubasa Kodaira*** *and Takuji Waseda, OYSA, Numerical analysis of oceanic internal solitary wave generation around an island in stratified shear flow*

15.10-15.25 Coffee break

Session 8: Coastal and Estuarine Dynamics

Session Chairs: Xiao Hua Wang and Jarle Berntsen

15.30-15.45 ***Xiao Hua Wang****, The effects of tidal flat reclamation on tidal dynamics and sediment transport in the muddy coasts*

15.50-16.05 ***Saswati Deb*** *and Arun Chakraborty, OYSA, Effect of Sediment Transport on the Productivity of Hooghly Estuary using High Resolution Biogeochemical Model*

16.10-16.25 ***Jing Lu****, F.L. Qiao, X.H. Wang, Y. Teng, K. T. Jung and Y.G. Liu, OYSA, Modeling the Yellow River sediment flux, deposition patterns and their monthly variability*

16.30-16.45 ***Giorgia Verri****, Stefania Ciliberti, Paolo Oddo and Nadia Pinardi, The sensitivity of coastal circulation to river discharge in the central Mediterranean Sea*

16.50-17.05 ***Olivier Gourgue,*** *Anouk de Brauwere, Eric Deleersnijder and Marc Elskens, A first attempt to predict trace metal concentrations in the Scheldt Estuary with a two dimensional depth-averaged sediment model*

19.00 Dinner/reception at The University of Bergen

Thursday 20. June

Session 8 continued: Coastal and Estuarine Dynamics

Session Chairs: Xiao Hua Wang and Jarle Berntsen

08.30-08.45 ***Karina Hjelmervik****, Birgit Kjoss Lynge and Bjørn Gjevik, Modelling of tides and storm surges in Tjeldsund channel*

08.50-09.05 ***Shiliang Shan****, Jinyu Sheng, and Blair J.W. Greenan, OYSA, Physical Processes Affecting Circulation and Hydrography in the Sable Gully of Nova Scotia*

09.10-09.25 ***Li-Feng Lu****, Keiko Takahashi, A numerical study on the SST variation in Tokyo Bay*

09.30-09.50 Coffee break

Session 9: Coupled bio-physical ocean models

Session Chairs: Huijie Xue and Corinna Schrum

09.50-10.05 Yuan Wang, ***Huijie Xue****, Fei Chai, A model study of the Copper River plume and its effect on the northern Gulf of Alaska*

10.10-10.25 ***Ute Daewel****, Corinna Schrum, Multi-decadal simulation of Atlantic cod (Gadus morhua) early life stages in the North Sea: on the potential of spatially-explicit IBMs to be used in ecosystem based management*

*10.30-10.45 Pengfei Lin, **Fei Chai**, Huijie Xue, Peng Xiu, Modulation of Decadal Oscillation on Marine Ecosystems in the Kuroshio Extension*

*10.50-11.05 **Rune Rosland**, Marco Castellani, Øyvind Fiksen, A mass-balanced pelagic ecosystem model with size-structured behaviourally adaptive zooplankton and fish*

*11.10-11.25 **Dhanya Pushpadas**, Corinna Schrum, Ute Daewel, Assessing climate change impacts on North Sea and Baltic Sea ecosystems through ensemble simulations forced byIPCC AR and IPCC AR5 models under different scenarios*

*11.30-11.45 **Corinna Schrum**, Johannes Bieser, Ute Daewel, Evgeniy Yakushev, Modelling the fate and transport of pollutants in the marine environment - A Case study application of the ECOSMO model system for mercury*

11.50-13.00 Lunch break

13.00-14.00 Discussion-IWMO 2014

Poster session

*1. Jarle Berntsen, Elin Darelius and **Helge Avlesen**, Mixing in lock release gravity currents down canyons*

*2. **Valentin Vallaeys**, Jonathan Lambrechts, Emmanuel Hanert and Eric Deleersnijder, A finite-element, multi-scale model of the Congo River, Estuary and ROFI*

*3. **Lulu Qiao**, Yongzhi Wang, Fei Gao, Numerical study on sedimentary dynamic processes of the Yellow Sea Warm Current*

*4. **Mostafa Bakhoday Paskyabi,** Interaction between Acoustic Field and Surface Gravity Waves in the Presence of a Large Offshore Wind Farm*

*5. **Ricardo de Camargo**, Hindcasting 20th century in the South Atlantic for storm surges identification and analysis*

*6.. Yvonne Gusdal, **Vidar S. Lien,** Frode B. Vikebø and Arne Melsom, A 50-year model hindcast of the Nordic, Barents and Kara seas: physical basis for biological applications*

*7. **Jennifer Veitch** and Pierrick Penven, The role of the Agulhas on the Benguela Current System: an experimental modelling approach*

*8. **Øyvind Thiem**, Numerical simulation of aqauculture organic waste dispersion from a fjord located fish farm*

*9. **Chuncheng Guo**, Vasiliy Vlasenko, The effect of rotation on shoaling of large amplitude internal solitary waves in the northern South China Sea*

*10. **Changshui Xia**, Fangli Qiao, Yongzeng Yang and Yeli Yuan, Simulation of the Yellow Sea Warm Current using a wave-tide-circulation coupled model*

*11. **Wenjing Zhang**, Shouxian Zhu and Xunqiang Li, The impact of tide induced residual current on the low-salinity water lens in the northeast out of the Changjiang river mouth*

*12. **Feng XU**, Yu ZHANG, Su-wen ZHANG, Ke-xin HUANG, Ling-yue Zeng, Analysis and Research on Characteristic of Sea-Land Breeze over Donghai Island of Zhanjiang,China*

*13. **CHEN Shengli**, HU Jianyu, Jeff A. POLTON, ZHENG Quanan, SUN Zhenyu, Some observed features of near-inertial motions on the shelf of northern South China Sea*

*14. **H. Namaoui**, Analysis methods for oceanic observations, satellite data, and model simulations*

15. ***L.-Y Oey****, Y.-L. Chang, Y.-C. Lin, M.-C. Chang, S. Varlamov and Y. Miyazawa, Currents in Taiwan Strait under winter-spring relaxing northeasterly wind conditions*

16. ***Chris Chambers****, Gary Brassington, Ian Simmonds, and Kevin Walsh, Upper Ocean Heat Influence on Australian East Coast Cyclone Thunderstorms*

17. ***Lars Petter Røed****, Arne Melsom, Laurent Bertino, Magne Simonsen, Francois Counillon, Bruce Hackett, How good are the products generated by the MyOcean Arctic Monitoring and Forecasting System?*

18. ***Jessica Benthuysen****, The Leeuwin Current: the roles of topographic trapping, mixing, and advection in a buoyancy driven eastern boundary current*

Keynote Lecture

Surface Boundary Layers and Gravity Waves

George Mellor

Princeton University, Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ 08544

Contact: glmellor@princeton.edu

Abstract

The paper focuses on the methodology and the consequences of including surface and subsurface, wave-induced, pressure-slope momentum transfer into the oceanic water column, a transfer process which competes with now-conventional turbulence transfer based on mixing coefficients. Focus is enabled by stipulating horizontal homogeneity as is customary when introducing a new surface boundary layer model or significantly new physics to an existing model. An introduction to pressure-slope momentum transfer is first provided by a phase-resolved, vertically dependent analytical model which is followed by a discussion of the consequences of phase-averaging; an appendix is an important adjunct to the discussion. Finally, a wave-circulation coupled model which includes pressure-slope and turbulence momentum transfer is presented and numerically executed.

Session 1:

Surface waves, the parameterisation of wind stress and their effect on ocean circulation

Simulations of turbulent air-sea interaction with a coupled atmosphere-ocean turbulence-resolving model PALM

Igor Esau

GC Rieber Climate Institute, Nansen environmental and Remote Sensing Centre, Thormohlensgt. 47, 5006, Bergen, Norway. E-mail: igore@nersc.no

The Parallelized Atmospheric Large-eddy simulation Model (PALM) was modified to simulate turbulent interactions in a coupled atmospheric and upper ocean mixed layers. A set of numerical experiments with PALM in the coupled mode was conducted to study co-organization of the free convection in the atmosphere and the ocean – a regime frequently observed in the wintertime in North Atlantic and Nordic Sea regions. The experiments demonstrate an important role of the latent (in the atmosphere) – salt (in the ocean) turbulent flux in dynamical coupling of these two fluid media on turbulent scales.

A new expression for the form stress term in the vertically Lagrangian mean framework for the effect of surface waves on the upper ocean circulation: implications for the surface stress implemented in models

Hidenori Aiki[1] and Richard J. Greatbatch[2]

1 JAMSTEC, Japan

2: GEOMAR, Kiel, Germany. Email: rgreatbatch@geomar.de

There is an ongoing discussion in the community concerning the wave-averaged momentum equations in the hybrid vertically Lagrangian and horizontally Eulerian (VL) framework and, in particular, the form stress term (representing the residual effect of pressure perturbations). The present study shows that the traditional pressure-based form stress term can be transformed into a set of terms that do not contain any pressure quantities but do contain the time derivative of a wave-induced velocity. This wave-induced velocity is referred to as the pseudomomentum in the VL framework, as it is analogous to the generalized pseudomomentum in Andrews and McIntyre. This enables the second expression for the wave-averaged momentum equations in the VL framework (this time for the development of the total transport velocity minus the VL pseudomomentum) to be derived together with the vortex force. The velocity-based expression of the form stress term
also contains the residual effect of the turbulent viscosity, which is useful for understanding the dissipation of wave energy leading to transfer of momentum from waves to circulation. It is found that the concept of the virtual wave stress of Longuet-Higgins is applicable to quite general situations: it does not matter whether there is wind forcing or not, the waves can have slow variations, and the viscosity coefficient can vary in the vertical. These results provide a basis for revisiting the surface boundary condition used in numerical circulation models.

Momentum fluxes to ocean circulation as given by the dissipation rate of surface gravity waves under tropical cyclone conditions

H. Aiki[1], R. J. Greatbatch[2], H. Tamura[1], M. Yoshioka[3], K. Tsuboki[4]

1 Japan Agency for Marine-Earth Science and Technology, Japan

2 GEOMAR, Germany

3 Tohoku University, Japan

4 Nagoya University, Japan

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Traditional bulk formula for wind stress on ocean circulation models is based on only 10m wind speed, and is directed downwind. However, under high wave conditions, the drag coefficient for wind stress might be better parameterized using quantities associated with surface gravity waves, such as significant wave height, wave age, and the direction of waves. Previous studies suggest that the net momentum flux from air (i.e. wind) to water (i.e. ocean circulation and surface waves) is given by the sum of the skin stress and the wave stress associated with the generation of surface waves, while the net momentum flux to ocean circulation is given by the sum of the skin stress and the dissipation-induced stress associated with the breaking of surface waves. We have developed a coupled atmosphere ocean surface-wave model based on CReSS (Cloud Resolving Storm Simulator), NHOES (NonHydrostatic Ocean model for ES), and the surface-wave model of Donelan et al. (2012). This model adopts the dissipation (rather than roughness) approach for estimating the momentum flux to ocean circulation. A byproduct of this approach is the availability of the dissipation rate of surface wave energy which is then used as the source term of the TKE equation for the oceanic mixed layer. We have investigated the impact of these effects on the hindcast simulation of tropical cyclones.

Responding to the challenges involved in coupling pre-existing numerical models for the atmosphere, ocean waves and ocean hydrodynamics, for shelf sea an*d coastal/fjord applications*

Alastair D. Jenkins[1], Angus Graham[1] , Helge Avlesen[1] , Alok K. Gupta[1] , Torge Lorenz[1], Idar Barstad[1], Øyvind Thiem[1], Ilker Fer[2] and Mostafa Bakhoday Paskyabi[2]*

[1] *Uni Computing, Thormøhlensgate 55, N-5008 Bergen, Norway. E-mail: alastair.jenkins@uni.no*

[2] *Geophysical Institute, University of Bergen, Allégaten 70, N-5007 Bergen, Norway.*

Accurate simulation of the near-surface boundary layers of the atmosphere and ocean required for applications such as: the estimation of wind speed and turbulence for wind generators; the prediction of local meteorology, surface wave fields, ocean and fjord currents; the transport and dispersion of atmospheric and ocean pollutants, nutrients, and small organisms; the efficient and safe operation of fish farms; and so on. Simulations should be improved by allowing dynamic coupling between individual models of the lower atmosphere, the surface wave field, and ocean and fjord hydrodynamics. Many existing numerical models are available - for example, WRF and HIRLAM for the atmosphere, WAM and SWAN for the wave field, ROMS and BOM for the marine circulation. In order to couple the models adequately we need to consider the physical process coupling (how to exchange energy, momentum, heat and mass; turbulent energy generation near the interface and in the boundary layers; accuracy of boundary layer parameterisation), the numerical aspects (accuracy, stability, interpolation error, nesting), and computational efficiency (load balancing, interpolation between different model grids, parallel processing). A number of different coupling techniques are available (e.g., models as compiled-in subroutines, models as individual processes, application of coupling libraries such as MCEL, MCT, and ESMF). We present results from coupled simulations of the atmosphere and wave field over the north-west European shelf, and of waves and ocean hydrodynamics in Norwegian inshore locations, and show how the physical and numerical accuracy and computational efficiency of the results depends on choices of coupling physics, coupling scheme parameterisation, and model parallelisation.

Wave/mean flow-interactions in ocean models with time varying vertical coordinates

Kai H. Christensen, Norwegian Meteorological Institute, Research and Development Division, Section for Ocean and Ice, Oslo, Norway

Second order accurate, three-dimensional equations for the mean flow in a fluid, which include surface wave/mean flow-interactions, are derived using a new method for transforming the vertical coordinate. The transformation is based on previous works by e.g. Andrews and McIntyre (1978), Longuet-Higgins (1986), and Brostr??m et al. (JPO, 2006). Both the inviscid mean drift in the waves (the Stokes drift) and the associated change in mean vertical position of a material surface (the divergence effect) are key components of the transformed equations. More specifically, the vertical coordinate now contains a temporally and spatially varying component that can be obtained from e.g. numerical wave prediction models. As posed the equations are suited for numerical ocean models that already use a temporally varying vertical coordinate such as e.g. ROMS (the Regional Ocean Model System). Some comments are given on the importance of using a consistent set of equations valid for both the waves and the mean flow.

Session 2:

Circulation and Dynamics in Shelf Seas

Numerical Modeling the Seasonal Variation of the Upper Layers of the South China Sea (SCS) circulation and the Indonesian Throughflow (ITF)

Danya Xu [,1] and Paola Malanotte-Rizzoli[2]*

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[2] Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge MA 02139 USA

The wind-driven circulation and thermal structure of the South China Sea (SCS), Indonesian Seas (IS) and Indonesian Throughflow (ITF) are simulated using the Finite Volume Coastal Ocean Model (FVCOM) in a regional domain covering the Maritime Continent. We choose the two decades 1960-69 in the pre-warming phase and 1990-99 in the full warming phase to simulate the two decadal climatological regimes in the regional domain. The circulation of the SCS is primarily driven by the monsoon system and reflects its seasonality reversing from Winter to Summer, with a net cyclonic tendency in Winter and anticyclonic in Summer. The wind system over the ITF is more complex. The surface layer also reflects the monsoon seasonality, with a very important interaction between the South China Sea Throughflow (SCSTF) and the ITF. The southward ITF in fact can be completely blocked by the SCSTF at the Makassar Strait in the upper 50 m during winter. In summer the ITF reinforces the reversed SCSTF entering the SCS through the Karimata Strait. Below the surface layer however the ITF is consistently southward, indicating that its dominant driving force is the sea level difference between the Pacific and Indian oceans and the resulting boundary pressure gradients. The inter-ocean volume transports through the main straits, Luzon (inflow), Karimata and Mindoro (outflow) for the SCS; the ITF inflow straits (Makassar and Lifamatola) and outflow ones (Lombok, Ombai and Timor) are evaluated from the model simulation. The model estimates of the total SCSTF and ITF inflow/outflow are also in good agreement with the recent in situ observations, especially for the 90s.The comparison of the wind-driven circulations of the 60s and 90s show weaker currents in the 90s in the SCS, reflecting the weaker monsoon of the second decade. The ITF currents and transports are instead stronger in the 90s, evidence of the greater importance in the 90s of the sea level difference between the Pacific and Indian oceans. Both wind curls and circulation patterns are overall very similar in the two decades. These similarities indicate that the difference in the circulation is a manifestation of interdecadal variability around a stable climatology. For the thermal structure of the basin, the SODA reanalysis dataset clearly shows that the yearly average temperature patterns of the 90s at different depths in the SCS are overall warmer than in the 60s. In the model simulation the warming trend is reproduced at the surface and also at 15 m depth. Two shallow sites are chosen in the southern SCS to analyze the temperature

profile variations throughout the year in the two decades. The model simulated profiles at these two sites agree rather well with the analogous SODA profiles.

Tropical storm-forced near-inertial energy dissipation in the continental shelf region of Hainan Island

Shuwen Zhang[1], Lingling Xie[1], Yijun Hou [2]

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The near-inertial wave is thought to be an important component for upper ocean dynamics processes, possibly playing a significant role in mass, heat and energy transport across the thermocline. In this study, the wind-induced near-inertial energy dissipation in thermocline is investigated by using the data of a moored observing system in the continental shelf region off Hainan Island at $19.35°N, 111.2°E$ and remote sensing wind data in July and August 2005 during the tropic storm Washi. Over the course of 5 days of mooring observations, extremely strong mixing was observed during the passage of storm Washi, with a turbulent energy dissipation rate ε of $10^{-6} W kg^{-1}$ in thermocline. High values of ε within thermocline indicate the near-inertial energy dissipation is significantly enhanced. Of the remarkable finding is that most of wind-generated near-inertial energy is dissipated in thermocline and the energy loss of near-inertial waves is mainly determined by the large-scale near-inertial waves. This is in contrast to the previous hypothesis of "Kolmogorov cascade" theory in turbulence that the energy dissipation is dominated by small-scale motions.

Keywords: continental shelf region off Hainan Island, tropic storm Washi, near-inertial energy dissipation

Western Mediterranean Sea surface characterization. A Lagrangian perspective.

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Seasonal spatio-temporal variability of the surface dynamics in the Western Mediterranean Sea is assessed by means of a Lagrangian descriptor: the Finite Size Lyapunov Exponents (FSLE). FSLE are computed backwards in time from the daily re-analysed model surface velocity fields provided by the WMOP/ROMS operational model. Variability of FSLE during 2009-2011 is decomposed using a Single Value Decomposition analysis (SVD) with special attention to the connectivity between two critical sub-basins: the Alboran Sea and the North-Western Mediterranean Sea. The statistically significant modes are physically interpreted and discussed.

Results in the Alboran Sea show that the first FSLE mode is related to the inflow of Atlantic Waters (AWs) that modulate the two Alboran gyres and the Algerian boundary current. The second mode describes the weakening of the Eastern Alboran Gyre during spring and as a consequence the deflection of AWs towards the Ibiza Channel.

In the North-Western Mediterranean Sea, the first mode accounts for seasonality. More intense and permanent winds blowing perpendicular to the North-Catalan coast result in intense mixing in the northern part of the Balearic Islands as well as in the south of the Gulf of Lions. The second FSLE mode reflects the variablity of the coastal shelf currents into the Liguro-Provenzal basin. In addition, the third FSLE mode connects the deflection of AWs towards the Channel of Ibiza emphasizing the importance of the physical mechanism driving the weakening of the second Alboran gyre for the advection of AWs through the North-Western Mediterranean areas.

The present work shows the convenience of using dynamical systems approaches to study the complex ocean spatio-temporal patterns.

Topography-tide-current interaction on the South of the Japan

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A high resolution (1 km) tidal ocean model has been implemented on the south of Japan to study the tide-topography-current interaction. The simulations have been conducted with the lateral boundary conditions, temperature and salinity fields derived from the coarse resolution (10 km) operational model (JCOPE2). Model is forced by surface fluxes estimated using six-hourly NCEP-GFS atmospheric forcing fields and it is integrated for the period of over one year. The simulated results have been validated with the available observations. The power spectrum of the ocean current shows that interaction of ocean current with the islands topography produces ocean current variations with shorter time scale of 1-5 days compared with the frontal variability of the Kuroshio that have been reported as 20-30 days time scale. The experiments with tide show that the tidal forcing enhances the current magnitude in the islands region significantly and it produces semi-diurnal and diurnal variability in the ocean conditions which has been reasonably good as compared with the observations. But the dominant variability among those two varies with the presence of Kuroshio near or away from the islands region.

Numerical study of coastal circulation by offshore wind-stress jet in the Gulf of Tehuantepec, Mexico.

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We used a numerical, tridimensional, hydrostatic ocean model to investigate the winter coastal dynamics due to strong wind events in Tropical Eastern Pacific and the effect by the shoreline shape and coastal shelf. The initial condition was set at rest with horizontal uniform distribution of temperature and salinity profiles varying only in vertical. The model was forcing by wind stress in two manners: in whole domain wind stress and delimited wind stress. As we focus in the Gulf of Tehuantepec, we make a mask to remove the wind stress outside the region of strong wind events, knowledge as Tehuanos.

Numerical results using wind stress in entire domain, shows the typical response with westward coastal current entering to Gulf head from the east and turning to flow toward off-shore and the emergence of anticyclone mesoscale eddie that stretched cold water that upwelling under wind jet by presence of coastal boundary. In a similar experiment using flat bottom, we observe an important difference in ocean response. The sea surface temperature drops under offshore wind jet and coastal current in eastern side have a strong influence by the eastern wide continental shelf.

The simulations with delimited wind were used to study the ocean response by isolated offshore wind jet events of different time duration. In these cases, is possible to observe a coastal-trapped wave that was originated in the Gulf of Tehuantepec during wind events and travel to the east. For 2 – 6 days wind events, the anticyclone and cyclone eddies are generated on the sides of the wind, having a significant wave generation for time events near of local inertial period.

Downscaling from Oceanic Global Circulation Model towards Regional and Coastal Model using spectral nudging techniques.

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In the context of operational oceanography, the coherence between coastal and global numerical solution is a key point especially from the users's point of view. In this study, the performance of spectral nudging, a low computed coast technique, was assessed using a regional hydrodynamic model (MARS3D) forced by a coarser global one (MFS/MOON). This technique prevents large and unrealistic departures between the global circulation model (GCM) driving fields and the regional model fields at the GCM spatial scales. To this end, the model's temperature and salinity are spectrally nudged towards global numerical solution using nudging terms in the tracer equations. In order to estimate the optimal nudging coefficient, several simulations-test over the Mediterranean sea were conducted. The SST and salinity fields obtained from nudged models are then compared with those estimated by free (no-nudged) model and confronted to satellite SST observations and in situ data. Results show that the spectral nudging is able to constrain error growth in large-scale circulation in upper level during simulation, without significant damping of the meso-scales eddy fields.

Mechanisms of Eddy Formation along Western Boundary of the Bay of Bengal.

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Eddies play a key role in understanding the oceanic surface movements, circulations and productivity. Studying these physical phenomenon can help to determine the nutrient rich upwelled zones for improving fisheries, determining safe sea routes and strategic military hiding grounds along the ocean surface. In this paper, eddies along the western boundary of the Bay of Bengal are analyzed for studying their mechanisms of genesis and growth.

Most of these eddies are semi-permanent in nature occurring around the monsoon season of India. In order to study these eddies, climatology data for ocean currents, temperature and salinity derived from the high resolution (10 km X 10 km) three-dimensional hydrodynamic model simulation using ROMS (Sil and Chakroborty, 2011) is analyzed with wind stress curl and bathymetry datasets. Eddy found along 82˚E longitude is almost permanent throughout the year with its vertical extent more than 1000 meters. The main reason for the genesis of this eddy is the strong monsoonal wind forcing and wind stress curl over this region. Along 12˚N to 20˚N latitudes, wind stress is not very high, yet some eddies have wind stress signatures over them. This region has high values of Rossby radius of Deformation which depicts upwelling due to the bathymetry effect in turn giving rise to these eddies. There are few eddies with no significant signatures of either wind stress or bottom effect. There may be other remote effects and instabilities influencing these eddies. Further investigation is required to determine their genesis and growth.

An ocean model system for the Norwegian Coast

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A model system, NorKyst-800, with 800 meter resolution has been developed for the whole Norwegian Coast. This is a national cooperation between Institute of Marine Research (IMR), Meteorological Institute (met.no) and the Norwegian Institute for Water Research (NIVA). The ROMS-based model kernel and the surrounding software environment are described. Examples are provided on validation and applications of NorKyst-800. Ongoing work on an information system for delivering results from NorKyst-800 and nested higher resolution fjord models towards coastal management is presented.

Interannual variability in temperature and salinity across the northwest European Shelf

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The northwest European Shelf is a broad temperate shelf, forming the eastern margin of the northern north Atlantic and adjacent to the most populous and industrialized countries of Europe. It includes several shelf sea regions where the dynamics are controlled by the seasonal heating cycle, atmospheric fluxes, tides river inputs and exchanges with the open ocean. The regional hydrodynamic model simulation was carried out using GETM (www.getm.eu) on a 3 nautical mile grid with 25 layers to examine the trends and variability in temperature and salinity of the northwest European shelf seas. The model was forced with atmospheric and oceanographic boundary forcing from the European Centre for Medium-Range Weather Forecasts (ECMWF) and a mixture of observed and synthetic riverine discharges (Cefas). Tidal forcing is applied across the domain using a relaxation scheme. Tides provide the dominant hydrodynamic forcing across the shelf, so it is particularly important to model them accurately. Sensitivity testing highlighted the importance of boundary forcing and bathymetry in reproducing tidal currents and elevations. Model skill is assessed against satellite sea surface temperature measurements and data obtained from the International Council for the Exploration of the Seas (ICES) database. The model reproduces the observed seasonal and longer-term cycles in temperature, but estimates of salinity are less accurate and year to year variability tends to dominate the salinity variability. We discuss the model performance and sources of errors, and examine the trends and variability in temperature and salinity across the northwest European Shelf for the period 1960-2010.

Cross-isobath geostrophic transport in the shelf sea

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Governed by the first-order dynamics, the currents in water column flow predominantly along the isobaths, or f/H, where f is Coriolis parameter and H is the water depth. In the shallower shelf sea, while the frictional transport in the boundary layers has been well recognized as one of the major sources for the cross-isobath (shelf) transport, the contribution from the cross-isobath geostrophic transport (CGT) induced by the interaction between shelf circulation and variable shelf topography remains dynamically unclear. Based on field measurement and numerical modeling, we present dynamic evidence and interpretation for the intensified CGT over the highly variable topography in the China Shelf Sea. Dynamic forcing elements such as topography, remote forcing, stratification and nonlinearity to CGT will be illustrated based on the analyses of combined momentum-vorticity balances.

Modeling circulation in the South China Sea with an unstructured-grid SUNTANS model

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The South China Sea is a large marginal sea surrounded by land masses and island chains, and characterized by complex bathymetry and irregular coastlines. The circulation in South China Sea is subjected to seasonal and inter-annual variations of tidal and meteorological conditions. The complexity of our problem together with the limited amount of available data in the region presents a challenging research topic. An unstructured-grid SUNTANS model (Fringer et al., 2006; Chua and Fringer, 2011) is employed to perform depth-averaged simulations of the circulation in South China Sea. The open boundaries for our domain, located at the Taiwan Strait, the Luzon Strait, the north of Sulu Sea, the north of Karimata Strait and the south of Andaman Sea, are tidally forced with 8 main tidal constituents obtained with the OSU tidal prediction software (Egbert and Erofeeva, 2002). The depth-averaged model is calibrated and validated by comparing model predictions of the surface elevations and currents with observations. The sensitivity of model resolution on the simulation results is tested with a series of grids with varying horizontal grid resolution. Skill assessment of the model is performed using statistical measures that include the Pearson correlation coefficient (r), the mean absolute error (MAE) and the root-mean-squared error (RMSE). The model-predicted surface elevations and currents compare favorably with observations at locations throughout the South China Sea. The results suggest that the quality of the model prediction appears to be dependent on the horizontal grid resolution, initial fields and forcing along the open boundaries. Other important issues to be addressed in the future include the transport of salinity and temperature, the effects of wind stress on the sea surface, and the interactions between vertical mixing and stratification.

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Session 3:

Numerical techniques, data assimilation and forecast systems

A development of POM model to simulate Tsunami propagation in South China Sea

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An open source general 3D numerical ocean model POM (Princeton Ocean Model) was developed to simulate tsunami propagation. The interaction between tsunami and tide has considered in the model. This model has validated with water level collected at water stations along Vietnam coast in case simulating tidal elevation. Tsunami properties (wave height, wave travel time) calculated by this model were also compared with results calculated by Imamura F1 model – a tsunami model has been using widely on the world. The results show that the effect of tide on tsunami is significant. The different of total water levels between the cases tsunami reaches the coast on spring tide and ebb tide periods are considerable, especially in big tidal amplitude regions. Improvement of accuracy in forecasting tsunami wave height plays an important role, it affects not only many human lives near the coast but also local emergency evacuation plans. This model was applied to predict tsunami wave height cause by earthquake in South China Sea and gave noticeable results. This is the first time a 3D numerical model is used to simulate tsunami propagation in South China Sea considering tide – tsunami interaction.

The improvement of POM by Eulerian-Lagrangian method with Hybrid N-order Lagrangian interpolation

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The Eulerian-Lagrangian method (ELM) has been adopted by many ocean models as the solution of the advection equation, but the numerical error caused by the interpolation restricts its accuracy. In the present study, a hybrid N-order Lagrangian interpolation ELM is put forward in which the N-order Lagrangian interpolation is adopted at first, then the lower-order Lagrangian interpolation is applied in the point where the result of interpolation is unusually bigger or lesser. The new method is used in POM. The steps-shape salinity advection calculations are analyzed and explained in theory, then some conclusions are given. Firstly, high-order(N=3~8) Lagrangian interpolation ELM can reduce the average error of salinity calculation, but its numerical oscillation error is still evident. Secondly, hybrid N-order Lagrangian interpolation ELM can smooth the numerical oscillation, as well as reduce average error further. The new method is also contrasted with MAPDATA of POM, it is better in the case of little ().

Validation of Updated Level 2.5 Mellor-Yamada Ocean Mixing Model in Operations of JCOPE-T Regional Ocean Modeling System

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Recent success of large eddy simulation (LES) experiments made it possible to re-estimate relations and empirical constants introduced for description of vertical turbulent mixing in atmospheric and oceanic models. Based on the approach of Mellor and Yamada (1982, MY), Nakanishi and Nino (2004, 2009, NN) realized level 3 and re-evaluated level 2.5 vertical mixing models (VMM). Modifications to the level 2.5 model include updated presentation for the vertical "stability" functions S_H and S_M which become a functions of two macro-flow parameters instead of single one in original MY model version. Numerical constants in these relations were re-evaluated based on the LES experiments for the atmospheric (NN) and oceanic (Furuichi et al, 2012) planetary boundary layers. Also NN model version uses diagnostic expression for estimation of the vertical turbulent mixing length scale instead of prognostic equation in the MY model.

We implemented NN level 2.5 mixing scheme in JCOPE-T real-time regional ocean modeling system (based on the POM code) and compared simulation results with observations on the JAMSTEC JKEO buoy observations site and simulation using original MY mixing scheme. Compared to observed vertical temperature distribution in upper ocean 15m layer, NN version of VMM better reproduces formation of surface mixed layer in warm seasons when original MY scheme tends to supports stable stratification near the sea surface. As result NN scheme decreases overestimation of ocean SST in warm seasons. Same time enhanced mixing with NN version of VMM in case of strong winds in some cases seems overestimating the cooling of sea surface in warm seasons do not confirmed by available daily SST analyses (JMA MGD daily SST analysis, NCEP RTG HR daily SST analysis and NOAA OI daily SST analysis). Further validation of different mixing schemes is going.

Several New Time Integration Schemes for Implementation in POM

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Instead of the standard leapfrog (SLF) scheme, an alternative leapfrog (ALF) scheme is introduced to solve barotropic surface gravity wave equations and is implemented to solve the barotropic equations in the Princeton Ocean Model (POM). A proper method of split-time stepping is applied to the POM for the equations between the external and internal modes to reduce the time splitting errors.

The ALF scheme was initially developed for linear form of surface gravity wave equations, and is modified in this study to solve the nonlinear equations in the POM. The numerical experiments of one-dimensional (1D) wave equations show that the energy can be conserved during long-time integration with ALF.

The explicit numerical scheme for the Coriolis term needs to be adjusted for the implementation of ALF in the 2D POM. A new scheme of Euler forward scheme with weighted average (EF-WA) is therefore developed to solve the problem. Theoretical study shows that this new scheme has no damping effect and second order accuracy, which is confirmed by numerical experiments.

The numerical experiments of the 2D POM confirm that all the numerical advantages of ALF remain, such as the time step of ALF is twice as large as the SLF scheme, and Asselin filter is no longer necessary. Therefore, the ALF is better than the SLF for the POM, not only for numerical stability but also for the physical conservative property.

The time-splitting method used in the 3D POM is studied. It is found that there exists mismatched stepping between external and internal modes, which causes the splitting error for the equations between external and internal modes. To deal with the splitting error, a proper time-splitting method is proposed for the POM. We show that there is no mismatched stepping with this new time-splitting stepping method. The numerical experiments confirm that its splitting error is largely reduced by two or three orders when the proper time-splitting method is implemented in the POM.

Keywords: Alternative leapfrog scheme; Euler forward scheme with weighted average, Princeton Ocean Model (POM); Time-splitting error

Development of High Resolution Synoptic Surface parameters for short-term ocean state forecasting of the Bay of Bengal using ROMS

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The thermodynamic complexity of Bay of Bengal basin is well known and has been attributed to seasonal circulation with different current patterns, heavy monsoon, enormous river discharge and the seasonally upwelling-downwelling planetary wave's propagation. This complexity needs to be studied in daily scale so that small features in the circulation pattern or short scale variability can be well understood. This becomes important when we want to identify the pre and post event changes in the ocean state due to remote influence like ENSO or severe tropical cyclones those are common in this region. To achieve this efficient high resolution model ROMS has been set up and climatology run has been conducted. However, in order to obtain the good quality model hindcast and forecast the initial condition has to be very much realistic. For this reason the satellite daily pass sea surface temperature data of TMI and AVHRR sensor has been assimilated with the inclusion of in-situ scatter data for the period 1998-2008. The high resolution daily data are of 9 km resolution and daily, monthly climatology fields have been computed. In the second step this monthly climatology is again assimilated with ROMS initial run climatology which is forced with prevailing wind patterns and radiations. This has been done to make the data more near to the true ocean state. Similarly the AVISO mean absolute dynamic topography data are assimilated with ROMS sea surface height so that the thermal expansion of sea water column can also be taken into account along with high resolution model data. The Barnes objective analysis has been adopted as the basic procedure. In each step the data have been quality controlled with standard deviation and root mean square error analysis with respect to in-situ and other available satellite data so that error will be minimized. The seasonal features like cooler SST tongue formation, summer and winter time surface temperature patterns have become more prominent in this new daily and monthly climatology. These data will be used as initial condition for model forecast.

Modeling and data assimilation developments of the TOPAZ system in support of operational oceanography in the Arctic

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We will present the TOPAZ4 modeling and data assimilation system, based on the Nansen Center's version of the HYCOM model (at horizontal resolution of about 12 km) and an Ensemble Kalman Filter (EnKF), integrating a dynamical ensemble of 100 members. The multivariate properties of the EnKF allow the TOPAZ system to assimilate several ocean and sea ice data types simultaneously, both in real-time forecasts applications (exploited at met.no) and in reanalysis mode. The TOPAZ system is the core Arctic component of the MyOcean system (http://www.myocean.eu).

We will analyze the results from a 20-years TOPAZ reanalysis, showing the good stability of the EnKF used in realistic settings and its ability to provide physically consistent error estimates for most variables assimilated. The reanalysis also pointed to limitations of the sea ice model in terms of sea ice drift and motivates the further developments of new sea ice rheology models for the Marginal Ice Zone and the ice pack.

Environmental forecasting with the TOPAZ forecasting system

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The TOPAZ forecasting system is run on a weekly basis in the North Atlantic and Arctic. TOPAZ currently produces 10-day forecasts of temperature, salinity, currents, phytoplankton biomass, chlorophyll and nutrients. Surface temperature, sea surface anomalies as well as ARGO-profiles are assimilated in the model. The bio-physical part of the modeling system has been running operationally since early 2011. The forecast for the growth season of 2012 showed room for improvement both in terms of timing and magnitude of the bloom. A retuning of the model has been performed on the basis of past data and new parameters were implemented late in the fall of 2012 and we expect to see improvements in the quality for the 2013 spring bloom forecast.

Here we will present the forecasting system and the methods implemented for validation of the system. We also compare the quality of the 2012 and 2013 simulations in view of the model updates performed during the past year, and give some outlook on the future development and possible applications of the forecasting system.

New developments on parallel computation of Princeton Ocean Model based on MPI

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To save the numerical computation time, designing the parallel scheme based on Massage Passing Interface (MPI) becomes more and more important in ocean numerical modeling. In general, the parallel scheme contains 3 main parts: the partition of the model domain, the massage passing and the parallel input/output. The domain partition is the base of the last two parts and will determine the performance of the whole parallel model. In previous studies, the regular partition methods through which the model domain is being divided by small rectangles are commonly used. Once there are many land points in the model domain, these methods will cause the number of the computation points are quite different in different rectangles. As the result, the performance of the parallel model becomes lower. In this study, an irregular partition method is developed in the parallel design of POM using the quasi-rectangles in horizontal. In this method, the number of computation points for each processor becomes absolutely balanced and the maximum of their difference is only 1 points. But the model variables will be hard to be described by the original model grid system because that the model domain have been partitioned by an irregular region. In order to solve this problem, the model variables related to horizontal space in POM are being re-designed in sequential style. In this way, those arrays in 2/3 dimensions becomes 1/2 dimensional arrays. The new parallel version of POM has been tested using the example case of SEAMOUNT and the coastal ocean model of North-west Pacific Ocean. The results of these experiments are all indicated the high performance of this model in parallel computing.

Assessment of one-way and two-way nesting techniques in a coupled ocean-ice circulation model for the eastern Canadian Shelf

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A coupled ocean-ice model based on NEMO was developed for the eastern Canadian Shelf which consists of the Gulf of St. Lawrence, the Scotian Shelf and the Gulf of Maine. The coupled model has two components: a coarse-resolution (1/4)° parent model (PM) and a fine-resolution (1/12)° child model (CM). The algorithm know as Adaptive Grid Refinement in FORTRAN (AGRIF) is used to exchange information between the PM and the CM. This study presents an assessment of one-way and two-way nesting techniques between the PM and the CM. The model results in five different numerical experiments demonstrate that the two-way nesting has advantages over the one-way nesting. The use of two-way nesting improves significantly the large-scale circulation in the PM and leads to a more realistic representation of the shelf break jet over the Scotian Shelf in the CM. Our study also demonstrates that feedback from the CM to the PM guarantees the dynamically consistent circulation between the PM and CM over the whole CM domain.

Session 4:

Analysis methods for oceanic observations, satellite data, and model simulations

Estimating time-calibrated 3D climatology for ocean model validation

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Observations are needed in order to validate ocean models. SAR pictures provide maps showing the horizontal distribution of the sea surface temperature. Sufficient amount of simultaneously measured vertical profiles are more difficult to achieve. Here we propose a new method to create time-calibrated 3D climatology estimates intended for ocean model validation. Empirical orthogonal functions and clustering are employed to group historical oceanographic profiles in clusters where each cluster contains profiles with similar depth-dependent behaviour. By knowing the sea surface temperature from for example SAR pictures, promising estimates for the vertical profiles are generated. The calibrated 3D climatological estimate may then be used to validate global 3D ocean model.

Using EMD/HHT Analysis to Connect Coastal Sea Level Rise with Ocean Dynamics and Climate Change

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The coastal sea level in the Chesapeake Bay and in the Mid-Atlantic region of the US East coast has been rising 2-3 times faster than the global sea level rise (SLR), resulting in a significant increase in the frequency and extent of flooding in places like Norfolk, VA. Recent independent studies using different analysis methods (Boon et al., Ezer et al., Sallenger et al., all published in 2012) show evidence that SLR is accelerating in this so-called "hot spot" region. To show that this acceleration is caused by climate-related changes in ocean dynamics, Ezer et al. (2013) used an analysis methods that can separate seasonal, interannual and decadal oscillations from long-term trends. Empirical Mode Decomposition/Hilbert-Huang Transformation (EMD/HHT) method was introduced for the first time for SLR studies by Ezer and Corlett (2012a,b). Unlike the traditional least square fitting methods used in the past for extracting SLR trends, the EMD/HHT method is non-parametric, so the trend can take any shape and is separated from decadal oscillations. Bootstrap simulations provide statistical significance intervals for the trend.

The EMD/HHT method was applied to tide gauge data, altimeter data and Gulf Stream transport data, showing clear evidence that the recent acceleration of SLR in the Mid-Atlantic region is the result of a slowdown of the Atlantic Meridional Overturning Circulation (AMOC) and weakening of the Gulf Stream (GS). The new data analysis confirms the results of numerical ocean models that predict a significant dynamic height rise along the US East coast due to warming of the Atlantic Ocean.

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Dye release experiment: in-situ measurements and modelling

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The main goal of this study was to reproduce numerically the dye release experiment conducted near Jones Bank in the Celtic Sea. One of the objectives of the experiment was the investigation of the role played by tidal and inertial motions in horizontal dispersion within the thermocline. Rhodamine WT was chosen as a tracer due to its ability to be visible during several days after release.

To model the dye release experiment that was in the Celtic Sea the Massachusetts Institute of Technology general circulation model was used. Rhodamine was set into the model as a passive tracer with zero initial fields except of only one point where its concentration was set to 1. Special block was added to the code to find the location of the tracer.

It was found that a residual jet stream generated by tides at the NE edge of the bank is able to transport the dye patch away from the bank during only two tidal cycles. The observations that were conducted with Scanfish showed eastward position of Rhodamine from the bank. The relatively weak (0.05 m s^{-1}) additional current that was found from the ADCP data was initiated in the model. Due to such a modification of water circulation around the bank, the trajectories of the dye patch and the Lagrangian drifter which was released during the field experiment were ideally reproduced by the model.

A hydrodynamic model of the Black Sea- Azov Sea using adaptive vertical coordinates

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A new three-dimensional hydrodynamic model of the Black Sea has been set up using the adaptive vertical coordinate method implemented in the General Estuarine Transport Model (GETM). Spherical coordinates are used with a resolution of ~2x2' and 40 vertical layers. The vertical coordinates are adapted to be sensitive to stratification to resolve the Cold Intermediate Layer (CIL) of the Black Sea proper. The model is forced with meteorological data from the European Centre for Medium-Range Weather Forecasts (ECMWF) with a temporal resolution of 6 h and with river data from the *Global Runoff Data Centre (*GRDC). Climatology data of the Black Sea is taken from the MEDATLAS, the Azov Sea climatology is derived from the Climatic Atlas of the Sea of Azov provided by the NOAA. Several multi-annual simulations were done for optimizing the model parameters and performing a sensitivity analysis. For model validation the monthly-averaged Sea-Surface-Temperature (SST) of the model is compared with satellite SST datasets.

A Relocatable Ocean Model for simulating drifter trajectories

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The goal of this work is to understand the improvements in simulating the ocean state deriving from a nesting relocatable model approach.
Relocatable models can be rapidly implemented in any region of the word, proving accurate forecasts in a very short time, as required in environmental emergency management such as oil spills and contaminant spreading.

The oil spill model MEDSLIK-II, together with a relocatable model based on the Harvard Ocean Prediction System (HOPS) are today available allowing a possible support to oil spill emergencies in the entire Mediterranean basin. MEDSLIK-II has been used in the field to forecast the possible spill of the 2500 tons of oil from the Costa Concordia. Every day, until the unloading operations had run out, a bulletin with the forecast scenario for the next 72 hours has been released to the competent authorities.

To assess the accuracy of the oil spill simulations and of the ocean current predictions, drifters trajectories were released in the area of the accident. MEDSLIK-II has been used to simulate the drifters trajectories using the current fields coming from different operational oceanographic models and from the relocatable model. It will be shown that the trajectories prediction improves by using the relocatable model and a sensitivity study on model parameters will be presented.

The triply nested Norwegian numerical ocean weather prediction system: Problems and possible solutions

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Recently a triply nested numerical ocean weather system was implemented at the Norwegian Meteorological Institute. It is based on the public domain ocean model ROMS. The innermost model (NorKyst-800) employs an 800 m regular grid and covers the entire Norwegian Coastal Shelf waters. The middle model (Nordic 4) employs a 4 km grid and covers the Nordic Seas, while the outermost model (Arctic 20) employs a 20 km grid and covers the entire Arctic Ocean and the northern North Atlantic down to about 50ºN. At the southern open boundary of the Arctic 20 model we use the global ocean forecasts made by the UK Met Office derived by the model FOAM. The development of NorKyst-800 is a national collaborative effort by and between the Norwegian Meteorological Institute (met.no), the Institute of Marine Research, Bergen (IMR) and the Norwegian Institute for Water Research (NIVA). Problems associated with the nesting (artificial rim currents) and water level will be discussed along with some possible solutions.

A sea ice forecast system in the Barents and Kara Seas including a newly developed marginal ice zone model

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Offshore activities in the Barents and Kara Seas have increased during the last years leading to much higher demands on forecast capabilities related to offshore operations at platforms, shipping, rescue operations, and oil-spill recovery. The Barents and Kara Seas are at the doorstep to the Arctic Ocean and characterised by large variability in the weather conditions, as well as strong seasonal and inter annual variability in the sea-ice cover. The present forecast system distinguishes between the sea-ice rheology in the consolidated ice pack and in the marginal ice zone. An elastic-viscous-plastic (EVP) formulation is used in the pack ice while a rheology based on statistics of random collisions between solid ice floes is used in the marginal ice zone. The present forecast system propagates surface waves into the ice and may break large pieces of sea ice into smaller floes. The waves at the boundary of the ice edge are taken from forecasts given by a surface wave model. A floe sizes based criterion then determines the transition from pack ice rheology to marginal ice zone rheology. A nested configuration of HYCOM was set up for the area, where the TOPAZ operational forecasting system provide boundary conditions to a high resolution model (5 km) covering the Barents and the Kara Sea. The daily forecast is available in real time at *topaz.nersc.no/Knut/IceForecast/Barents*, together with validations against remote observation of sea-ice concentrations. Work is ongoing to validate the model performance and forecast products.

Theoretic analysis of splitting errors in split time stepping of ocean modeling

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Two-level model is introduced to study the splitting errors in split stepping method in ocean modeling. The shear or non-shear flow is considered to study the splitting error occur in advection terms. Coriolis force is also considered to investigate the splitting errors occur in Coriolis term. The splitting errors are given by theoretical study of numerical analysis. Study shows there exists splitting errors in commonly used split time stepping method. The splitting errors are caused by improper way of inconsistence between barotropic and baroclinic time step levels, of which baroclinic equation are integrated from n-1 to n+1 while barotropic one are from n to n+1. The theoretical study also shows that splitting errors grow largely when baroclinic time step increment is larger.

A proper way of split time stepping is therefore introduced, of which both baroclinic and barotropic equations are integrated from n-1 to n+1. Numerical analysis shows there are no splitting errors in this method. Numerical experiments is implemented to investigate the splitting errors. A practically useful splitting error are introduced. Numerical experiment shows this proper way of split stepping has the splitting errors under the machine round off error.

(Key words: two-level model, split time stepping, splitting errors, shear flow, advection term, Coriolis term)

Session 5:

Modelling and Prediction of Marine Extreme Events

Changes of the sea level extremes at marginal seas

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Sea level in the Mediterranean Sea, the Caribbean Seas and the Chinese coasts are examined. Tide gauge records from these areas have been analysed and changes in the occurrence of the extreme sea levels and extremes storm surges have been identified. The changes in extremes are linked with changes in mean sea level in each basin. The relationship of extremes and mean sea level with large scale atmospheric features is also examined. For the Mediterranean the consistency of storm surge models with observed extremes is also discussed.

Significant and maximum wave heights in the Northeastern Atlantic and their relationships to the NAO

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10 years of in-situ measurements of significant wave height (Hs) and maximum wave height (Hmax) from the ocean weather ship Polarfront in the Norwegian Sea is analyzed. Hs and Hmax are both correlated with the North Atlantic Oscillation (NAO) index during the winter period. The correlation with the NAO index is highest for the more frequently encountered wave heights. The persistence of Hs and Hmax in winter is also examined. The persistence of wave fields with Hs and Hmax around the median values is correlated with the NAO index. In contrast, the extreme wave heights, i.e. the largest 2% of waves, and wave fields that persist for more than 2.5 days are not correlated with the NAO index. The wave field variability associated with the NAO index is reconstructed using a 500-year NAO index record. The NAO index does not change significantly in 21st century projections from CMIP5 climate models under scenario RCP85. Thus no changes in the wave field due to changes in the NAO index are expected. But future changes in the extreme wave heights at this location cannot be ruled out.

A dynamic exceptional cold water event around Penghu on February 2008 and 2011

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The exceptional cold water event which happened in spring in 2008 and 2011 has bring about tremendous losses to Taiwan's fisheries, especially the disaster in middle February in 2008. To recognize and to predict the 'fishery disaster' is important. In this paper, we studied the formation mechanism with a coastal trapped long waves theory. On the impact of the LaNiña event, the northeast wind in the western pacific is strong and continuous; and it can produce resonance when the wind frequency and the coastal trapped waves frequency come closer. The cold water in the Yellow sea will be transported to the Taiwan Strait with a speed of the coastal trapped waves speed, which is about 10 m/s. In addition, the coastal trapped waves will enhance the Zhejiang-Fujian coastal current which can also bring the cold water to the Taiwan Strait.

Three-Dimensional Evolutions of Tsunami on a Sloping Beach

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This study simulates the 3-D evolutional processes of tsunami from offshore towards coastal region. We adopt COMCOT, a well-known tsunami model, to run the simulation. Tsunami generation is based on the theory from Mansinha & Smylie (1971). The model domain consists of a constant depth offshore and a plane sloping beach with different slopes 1/25, 1/50 and 1/100, respectively. The results reveal the milder the slope, the higher the run-up. Trough leading wave generate higher run-up than crest leading wave. Water surface elevation near shoreline for trough leading wave and crest leading wave are almost symmetrical. As the normal incident tsunami reaches shoreline, part of the energy may propagate along the shore in the form of edge waves.

Estimation of Extreme Sea Levels over the Continential Shelf off Eastern North America

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This study estimates the spatial distribution of the return level of extreme storm surges and total sea levels over the continential shelf off eastern North America (CSENA) based on results produced by a two-dimensional (2D) circulation model for the period 1979-2011. The 2D circulation model is driven by tidal and atmospheric forcing. The tidal forcing includes the specification of tides at the model open boundaries and the tide generating potential at each model grid. The atmospheric forcing is the combination of the NCEP reanalysis fields and a bogus vortex to better represent atmospheric forcing associated with a tropical storm or hurricane. The model results are validated against sea level records from 90 tide gauge stations along the east coast of North America. An extremal analysis is used to estimate the 50 and 100-year return level of extreme storm surges and total sea levels over the CSENA. Our results demonstrate that the most potential regions to be threatened by severe storm surges are the northern coast of the Gulf of Mexico, coastal water from Long Island Sound to Pamlico Sound, southern part of Hudson Bay, the western Gulf of St. Lawrence and regions between eastern Canadian coast and Greenland. The simulated tides and storm surges are also used to estimate the return periods of extreme total sea levels based on the Monte Carlo method. The extreme total sea levels particularly large over the regions of the Hudson Strait and western part of the Hudson Bay, the St. Lawrence Estuary, Gulf of Maine and coastal waters from Long Island Sound to Trident Pier in Florida.

High Impact Storm Surges Affecting US Southeast Coast

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The total losses from Hurricane Sandy (2012) exceeded $60 billion. A large portion of the loss occurred when storm surge flooded the streets, tunnels and subway lines in New York City on October 29, 2012. Although the storm track of Sandy was well predicted in advance of its landfall, the severity of its storm surge surpassed even the "worst case" scenario expected to be induced from such a weak storm. Sandy was only one of many recent cases in which the severity of their storm surges caught many decision makers and coastal residents off guard. So, what are the key factors and mechanism which led to the formation of extreme storm surges and inundation? In this presentation, we will present findings from a statistical and numerical modeling study of historical storm surge cases which affected the US Southeast Coastal region from Florida to North Carolina, group them into three main categories (weak, average and severe storm surge cases) and identify the main factors and physical mechanisms responsible for the creation of severe, high impact storm surge events in the study area.

Session 6:

Ocean circulation and its scale interactions with various other phenomena

Modelling Studies of Topographically-Constrained Deep Water Overflows within the Faroese Channels

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Results are presented from combined physical and numerical model simulations of topographically-constrained deep-water overflows within the Faroese Channels. A detailed topographic model of the Wyville-Thomson Basin/Ridge and Faroe Bank Channel region was constructed and mounted within a rotating tank, allowing a series of parametric experiments to be conducted to investigate deep-water overflow pathways and circulations within this region. High-resolution density profiling measurements were combined with dye tracing to determine the range of parametric outflow conditions under which spillage over the Wyville-Thomson Ridge was initiated. Resulting circulation patterns within the region were also observed through particle drogue tracking, revealing the presence of persistent deep-water eddy structures within the Wyville-Thomson Basin and in converging, upsloping approach channel to the Faroe Bank Channel threshold sill. Experimental results were compared directly with full-scale 3D numerical model simulations of the region, using the MIT general circulation model (MITgcm). Overall, the deep-water overflow pathways and circulations within the region under consideration were shown to demonstrate good qualitative agreement between physical and numerical models, with many of the observed persistent eddy structures also evident within the full-scale topographic simulations using MITgcm. In both cases, these appear to have prominent role in the promotion of spillage across the Wyville-Thomson Ridge.

Sensitivity experiments in the Agulhas Current using a hybrid framework

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The Agulhas Current is one of the strongest western boundary currents in the world's ocean. South of Africa, the Agulhas Current retroflects and most of the flow returns to the South Indian Ocean. Periodically, large anti-clockwise rotating pools of warm and saline water, called Agulhas rings, are shed from the retroflection, drifting westwards into the South Atlantic Ocean. This process, known as the Agulhas leakage, is thought to be a source of saline water important for maintaining the Atlantic Ocean meridional overturning circulation. However, in the absence of continuous in-situ observations, the understanding of the complex and non-linear ocean dynamics, including the eddy shedding, in the Agulhas retroflection region remains limited. Hence, the parameterization of these processes in ocean models is inadequate and validation of the simulated magnitude of the Indo-Atlantic inter-ocean exchange of volume, heat and salt remains a significant challenge. Nevertheless, model deficiencies can be examined through numerical sensitivity experiments. For the Agulhas Current, and in particular the Agulhas retroflection, simulations using a Hybrid Coordinate Ocean Model, reveal significant sensitivity to the numerical choices. In particular higher order numerics and the vertical stratification, which is determined by the choice of the vertical grid discretization in the hybrid framework, significantly change the model solutions

Instability and finite-amplitude evolution of STCC eddies, from model and satellite data

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The North Pacific Subtropical Counter Current (STCC) east of Taiwan (18~25N) is a weak zonal current comprising of a weak eastward flow near the surface (with speeds of less than 0.1 m/s, and a thickness of approximately 50~100m) and westward flow (the North Equatorial Current) beneath. Previous studies [e.g. Qiu 1999, JPO] have shown that the STCC is baroclinically unstable consisting of the mixed Phillips-Charney instability modes because its meridional QGPV-gradient changes sign twice, once very near the surface (upper 50m) and another one at the deeper level (z~-200m; Tulloch et al. 2011, JPO). Therefore, despite its weak mean speeds, nonlinear STCC eddies with diameters ~ 300 km or larger and rotational speeds exceeding the eddy propagation speeds develop [Samelson, 1997, JPO; Chelton et al. 2012, Prog Oceanogr]. These eddies can have profound influences on the circulation of the Western Pacific marginal seas including the Kuroshio transport east of Taiwan [Chang and Oey, 2011, GRL]. In this work, the authors present numerical experiments to describe and explain the instability and eddy-generation processes of the STCC, extending previous works in the literature to finite-amplitude eddies.

Short-term variations of the Kuroshio downstream of Cape Shionomisaki

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Short-term (from 10 to 70 day) variations of the Kuroshio downstream of Cape Shionomisaki in the JCOPE2 data, which is an ocean assimilation product of 1/36º horizontal resolution based on the Princeton Ocean Model, was analyzed. With a wavelet analysis, characteristics of short-term variations in time-frequency domain were systematically obtained. Variation of 10-30 day band has a nearshore peak and its amplitude shows correlation to the Kuroshio velocity. It is suggested that the variation in this frequency band has a relation with sudden Kuroshio acceleration at Cape Shionomisaki (Miyama et al, 2013) when the Kuroshio takes a near-shore path. On the other hand, variation of 40-70 day band has an offshore peak. Its amplitude seems enhanced by interaction to the Izu ridge when the Kuroshio takes an off-shore path. Variations of the both frequency bands in the JCOPE2 data of 1/12º horizontal resolution are much weaker than those of 1/36º resolution.

Analysis of the lifetime of eddy structures

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Turbulent surface current motion is characterized by a complex field of eddies or vortices interspaced by meanders, fronts and filaments. Eddies are generally more energetic than the surrounding currents, and play an important part in transport of heat, mass and momentum, as well as biological and chemical agents, from their area of generation to areas where they disintegrate. The detection of eddies from field measurements have been carried out in several research programs over the last 40 years.

When analyzing instantaneous flow fields, e.g. satellite images, there are two main groups of methods available for eddy detection. Detection methods based on physical quantities depend on local variations in some quantity, such as pressure or vorticity. Relatively strong gradients are required to be reasonably sure that the anomaly represents a persistent structure, so these methods tend to detect the strong, dominant vortex field. Another method depends on the geometric properties of streamlines, in which case the curvature of the streamline is indicative of vortex structures. An eddy structure is detected if a streamline undergoes a rotation of $\pm 2\pi$ and the end point after rotation is close to the starting point. In the present paper, we use a hybrid method, based on both, a physical and a geometrical detection to examine the existence of eddies in simulated velocity fields. The aim of this study is to analyse the lifetime of these eddy structures.

Climate Projections for the NW European Shelf Seas with a quantification of uncertainty

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We present climate projection for the NW European Shelf Seas. A perturbed parameter ensemble of transient climate simulations by a variant of the IPCC AR4 model HadCM3 is dynamically downscaled with the shelf seas model POLCOMS. The ensemble approach allows quantification of some of the sources of uncertainty, and so provides an estimate of the range of changes. We present projected changes of temperature, salinity, stratification and circulations out to 2100. We find the ensemble mean (and uncertainty) of temperatures increases in a linear manner from the present day. Salinity evolves in a more complex manner with a generally freshening across the domain, however towards the end of the simulation, some ensemble members show a greater freshening, driven by oceanic forcings. This study extends the projections provided as part of the United Kingdom Climate Projections 2009 (UKCP09), so will provide evidence for policy decisions and inform a wide range of impact and adaptation studies. For example, future temperature changes will affect plankton and fish distribution, and so these projections may aid decisions on aquaculture, fisheries, Marine Protected Areas (MPA) and achieving and maintaining Good Environmental Status (GES, a requirement of the EU's Marine Strategy Framework Directive).

As the simulations are run under the SRES A1B emissions scenario and only a single model is used, the emission and model structural uncertainty is not addressed by this study.

Water mass transformation and the North Atlantic Current in three multi-century climate model simulations

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The warm and saline Subtropical Water carried by the North Atlantic Current undergoes substantial transformation on its way to higher latitudes, predominantly from oceanic heat loss to the atmosphere. The geographical distribution of the surface forced water mass transformation is assessed in multicentury climate simulations from three different climate models (BCM, IPSLCM4, and MPI-M ESM), with a particular focus on the eastern subpolar North Atlantic Ocean. A diagnosis, originally introduced by Walin (1982), estimates the surface water mass transformation from buoyancy forcing. While the depth structure of the Atlantic Meridional Overturning Circulation (AMOC) is similar in all models, their climatological heat and freshwater fluxes are very different. Consistently, the models differ in their mean pathways of the North Atlantic Current, location of upper ocean low salinity waters, as well as in sea ice cover. In the two models with an excessive sea ice extent in the Labrador Sea, most of the water mass transformation in the subpolar region occurs in the eastern part (east of 35ºW). The variability of the eastern water mass transformation on decadal time scales is related to the variable warm northward flow into the subpolar region, the upper branch of AMOC, where a strengthened flow leads an intensified transformation. This relationship seems to disappear with a weak connection between the Subtropical and Subpolar gyres.

The global carbon cycle simulation of FIO-ESM v1.0

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The earth system model FIO-ESM v1.0 includes the MASNUM ocean surface wave model besides the atmosphere, ocean, land and ice components. FIO-ESM v1.0 is fully coupled with the global carbon cycle processes and driven with the anthropogenic CO_2 emissions. The historical simulation and 21st prediction of the global carbon cycle are following the CMIP5 (Climate Model Inter-comparison Project phase 5) long-term experiments design. The model is validated with the historical observations such as the surface air temperature, sea surface temperature, dissolved inorganic carbon, alkality including the atmosphere, ocean, land surface and biogeochemical process of ocean and terrestrial ecosystem. The long-term change of the air-sea and air-land CO2 fluxes is further analyzed.

Session 7:

Oceanic internal waves: Theoretical modelling and observational evidence

Modelling of baroclinic tides over an isolated underwater bank

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Interaction of stratified tidal flow with Jones Bank (shelf of the Celtic Sea) was investigated numerically using the Massachusetts Institute of Technology general circulation model and observational data collected in 25-th cruise of the R/V "James Cook" in July 2008. Two regimes of wave generation observed in-situ were investigated, one with only tidal forcing activated in the model, and another with an extra tidal current added to the system. It was found that the tidal currents alone provided subcritical conditions for the generation of the first-mode internal waves, and supercritical once for the second-mode. As a result, the first-mode waves with amplitudes up to 10 m freely radiated from the bank gradually transforming into an attenuating dissipative baroclinic bores. Due to the supercritical conditions, the second-mode waves were arrested at the lee side of the bank for three hours where they grew in amplitude (up to 35 m) and after their release propagated from the bank as a series of second-mode internal solitary waves.

An additional background current that was recorded near the bank in the middle of June, 2008 radically changed the conditions of wave generation. Strong EW current arrested the first mode perturbations at the lee side of the bank for two hours where they grew in amplitude to almost 40 m and disintegrated into packets of first-mode internal solitary waves after their release. For the second-mode perturbations the flow was substantially supercritical more than a quarter of tidal period so that these waves were just washed away from the generation site without any visible amplification.

Internal tide variability south of Japan: modeling and observation

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Recent development of ocean modeling allows concurrent simulation of the ocean circulation and tide. Investigation of possible occurrence of their interactions is of importance for deeper understanding of the oceanic phenomena. Internal tide is one of key processes that are responsible for the interactions between the ocean circulation and tide. The Izu-Ogasawara Ridge south of Japan is considered as an active generation site of internal tide. We try to detect M2 internal tide signals there from products of the operational tide-resolving ocean circulation model (JCOPE-T) and satellite altimeters (Topex/Poseidon, Jason-1, 2). The amplitude of simulated M2 internal tide harmonics agrees with the observed one, while the simulated phase structure is not much similar to the observation. The model result indicates standing wave features associated with remote propagation of the M2 internal tide south of Japan. We discuss possible modulation of the M2 internal tide variability due to mesoscale eddies and its implications on the vertical mixing processes.

Numerical analysis of oceanic internal solitary wave generation around an island in stratified shear flow.

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A four-day ADCP and CTD measurements was conducted from Aug., 30, 2010 around Miyake Island in the south of mainland Japan. Fortunately, ALOS/PALSAR sea surface image was captured around Miyake Island on Aug., 30, 2010. The acquired SAR image shows a shock-wave-like pattern in the upstream of the island. This pattern is supposed to be created by internal solitary wave whose phase speed is close to the background ocean current velocity.

To investigate a generation mechanism of the internal solitary wave around the island, we conducted non-hydrostatic numerical simulation by MITgcm with a simplified geometrical setting. It was found that vertical velocity shear was important to produce internal solitary wave upstream the island. The generated internal wave shape was compared with an analytical solution known as a KdV solitary wave. Since the generated internal wave in numerical simulation is three-dimensional, we chose a vertical section passing through the center of topography to compare it with a two-dimensional KdV solution. They are in good agreement for small amplitude internal solitary wave, but discrepancy increases as the amplitude becomes larger. This is plausible because the KdV solution is theoretically valid only for finite but small amplitude wave. However, threedimensionality and background shear flow effect should be considered for conducting a more accurate comparison.

Session 8:

Coastal and Estuarine Dynamics

The effects of tidal flat reclamation on tidal dynamics and sediment transport in the muddy coasts

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In recent decades, the reclamation on tidal flat carried out by the authorities along the muddy coasts has reached new heights as a consequence of significant economic expansion in the coastal areas. We are concerned that the tidal flat reclamation may have not only local but also far-field effects on tidal dynamics and sediment transport. I will present several case studies of the tidal and sediment dynamics in the muddy coastal and estuarine environment such as Darwin Harbour, Australia and the Yellow and East China Seas where numerical studies show that reclamation can result in rise of tidal amplitude, change in tidal asymmetry and onshore sediment transport. The former may enhance the coastal hazards such as storm surge, whereas the latter will result in severe siltation. Therefore, care must be taken when contemplating artificial alterations to tidal flats and coastlines.

Effect of Sediment Transport on the Productivity of Hooghly Estuary using High Resolution Biogeochemical Model

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First attempt has been made towards the setup of three dimensional high resolution (0.5km X 0.5km) biogeochemical model coupled with sediment model to estimate the productivity in the Hooghly Estuary (significant part of Ganga - Brahmaputra deltaic zone) to gain insights into the key physical and chemical processes that control the productivity in the estuary using Regional Ocean Modeling System (ROMS). In-situ observational data for physical, chemical and biological parameters are collected from nine stations conducted by Calcutta University during 2003 – 2010 and Kolkata Port Trust are assimilated using multiscale objective analysis (OA) and successive over relaxation (SOR) method and incorporated into the model as satellite data is sparse in this economic and biologically diverse zone.

In the present study, the model output revealed that phytoplankton (above 1.25mg/m^3) response is high towards the south-western mouth of the estuary during flood flow and erratic salinity (vary 12-25 psu). The model is forced by tides in the southern boundary with a maximum tidal height of 5.97m during September and inclusion of river discharge (3000m^3/s) in the northern boundary well explains the deposition of suspended sediment concentration by cohesive transport mechanism with a value of 8g/m^3 at the bottom near Nayachar Island (area of low productivity). Numerical experiments and sensitivity analysis show that variation in salinity levels, nutrients and grazing are the controlling factors. Sediment stabilization process by micro-organisms is studied in the south of the estuary. Model output yielded good conformity with the available (Indian Meteorological Department) IMD dataset and Ocean Color Monitor (OCM-2).

Modeling the Yellow River sediment flux, deposition patterns and their monthly variability

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A sediment numerical model (Wang, 2002; Wang and Pinardi, 2002) was embedded into a wave-tide-circulation coupled model to quantitatively estimate the suspended sediment fluxes (SSF) and distribution in different seas of the Yellow River derived sediment considering the wave-induced vertical mixing (Bv). The model is validated by comparing model predicted sediment deposition rate with those from the observation.

Simulated results show that SSF of the Yellow River at four major sections (Bohai Strait, 37ºN section, Korea/Tsushima Strait and 32ºN section) are highest during September and October except for the 32ºN section where the flux is negligibly small (less than 0.1 kg/s). We demonstrated that the SSF across the Bohai Strait is about 30% of the Yellow River discharge, 15.8% across 37ºN section. The Yellow River suspended sediment passes the Korea/Tsushima Strait through the northwest part of the strait, and its SSF is nearly 10% of that across 37ºN section into the South Yellow Sea. Our study shows that about 70% of the total discharged Yellow River sediments are deposited in the Bohai Sea while 14.7% in Yellow Sea. There are two deposition branches in the Yellow Sea. The main one is located off the eastern tip of the Shandong Peninsula and extends to southwest off the coastline, which is consistent with the observed 'Ω' shape deposition pattern. This simulated tongue shape deposition pattern is isolated from the north by the strong resuspension off the Shandong Peninsula tip. The other branch extends to the middle of the South Yellow Sea which is strengthened by the resuspension from the deposited sediment elsewhere. This two deposition branch is separated by the wintertime Yellow Sea Warm Current in the bottom layer. In no tide is not considered, there is hardly any sediment deposited on the Yellow Sea floor, while in the Bohai Sea most of the sediment is transported southward and northwestward around the river mouth instead of eastward as in the Control Run, indicating the tides play a key role in forming the deposition pattern.

Key Words: sediment dynamics; deposition; resuspension; vertical mixing; Yellow River

The sensitivity of coastal circulation to river discharge in the central Mediterranean Sea

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Freshwater inflow strongly affects the shelf area adjacent to estuary (Region of Fresh Water Influence - ROFI), but it is often also one of the major circulation forcing of the large scale thermohaline circulation.

The aim of this study is to understand and to assess the effects of river discharge on the circulation and dynamics of the Central Mediterranean Sea.

In order to achieve our goal a three dimensional, finite difference model based on the Nucleus for European Modeling of the Ocean (NEMO) code has been implemented in the central Mediterranean covering both the Adriatic and the Ionian Seas.

The model horizontal resolution is 1/45° (about 2.2km) and 121 unevenly spaced vertical z-levels with partial steps have been used to discretize the vertical direction. The air-sea momentum and buoyancy fluxes are computed by mean of bulk formulae using atmospheric data from European Centre of Medium Range Weather Forecast (ECMWF) and model predicted Sea Surface Temperature. About river runoff contribution**,** the model considers the estimate (via hydrological modeling and available observations) of the runoff of the major rivers that flow on the Adriatic and Ionian Seas available from several datasets. All monthly climatologies have been corrected according to Killworth (Killworth, P.D., 1996) and linearly interpolated to produce daily data. Only for the Po river, runoff daily observed date have been used.

In this study the model response to different river parameterizations is investigated. The first implementation of the model includes the river effect as component of the surface water balance (Evaporation minus Precipitation minus Runoff/area).

The inclusion of rivers input as lateral open boundaries condition (considering both momentum and mass fluxes) is under development.

The issue is to investigate how the coastal circulation is affected and driven by the river input taking in consideration also the wind stress (upwelling or downwelling favourable wind stress), topography, interaction with the deeper basin flow and other external forcings covering a wide range of time and space scales.

A further step of the study will consist of the implementation of a *meteo-hydrological* forecasting chain (the mesoscale meteorological model Weather Research and Forecasting, WRF, plus the Hydrology Prediction Model, HYPROM) in some catchments. These case studies could allow a better evaluation of the influence of the whole hydrological cycle on the coastal circulation.

A first attempt to predict trace metal concentrations in the Scheldt Estuary with a two-dimensional depth-averaged sediment model

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We use the 2D depth-averaged component of the finite element SLIM to predict trace metal concentrations in the Scheldt Estuary. This model proved to be an efficient tool to describe accurately the hydrodynamics and the transport of dissolved and particulate matter in the Scheldt. As a finite element model, it takes advantage of unstructured grids to get a finer resolution of the coastlines and to increase the resolution where and when it is needed. As a 2D model, its computational cost is rather small, even with rather high temporal resolution, making it particularly efficient to undertake long term studies.

In the Scheldt, trace metals are mainly originating from industrial activities. Even though their release has drastically decreased now, the bottom sediments are still highly contaminated, with the risk of reinfecting water during strong resuspension events. The toxicity of trace metals is generally thought to be low as long as they remain attached to suspended particles. But it is not the case anymore once they are dissolved in the water.

It has been observed that the total metal concentration can be relatively well predicted in the Scheldt by empirical functions of environmental variables such as salinity and turbidity. The total metal concentration can therefore be predicted without having to explicitly represent it as a variable of the model. Moreover, similar empirical regressions are also available to predict the metal partition coefficient KD, which is the ratio between particulate and dissolved metal concentrations. The dissolved-particulate speciation can therefore also be reconstructed a posteriori with this method. Although it does not allow to understand the observations, this empirical approach is relatively fast and easy to implement.

A second approach consists in computing explicitly the total metal concentration and deducing the concentration of each phase from the partition coefficient KD. This method allows for a better understanding of the metal transport. However, unlike the empirical approach, this method requires accurate informations about the sources of pollution. Moreover, it has the drawback to consider an instantaneous equilibrium between the two phases.

Both approaches are considered in this talk.

Modelling of tides and storm surges in Tjeldsund channel

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Accurate predictions of currents may lead to improved safety and prove valuable during clean-up operations after oil-disasters, search, and surveillance operations during ship accidents. The Tjeldsund channel is an important sailing lane in northern Norway. The complex bottom topography and coastline in the channel require a very fine spatial grid resolution. A high resolution, fully nonlinear, depth integrated tidal and storm surge model with horizontal grid resolution of 50 meters has been implemented for the Tjeldsund channel. The modelled tidal current fields reveal important features of the flow in the channel with tidal jets and topographically trapped or slowly propagating eddies associated with over-harmonic tidal oscillations. Two storm surge events have been studied by driving the model by the observed sea level difference between the two ends of the channel system. At certain instants storm surges are found to interact strongly with the tide, producing complex flow patterns which to some extent are verified by observations.

Physical Processes Affecting Circulation and Hydrography in the Sable Gully of Nova Scotia

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The Sable Gully is the largest submarine canyon along the shelfbreak off the east coast of North America. The circulation and hydrography in the Gully have significant temporal and spatial variability. This study presents a numerical study of the three-dimensional circulation and hydrography in the Gully using a multi-nested model. The model is forced by tides, wind stress and surface heat/freshwater fluxes. Model results are in fair agreement with the current and hydrographic observations made in the Gully in 2006 and 2007. A process study is conducted to examine the main physical processes affecting the circulation and hydrography, including tide-topography interaction, wind forcing, and the shelf-scale circulation over the eastern Canadian Shelf. The model results demonstrate significant tide-topography interaction inside the Gully. The circulation and hydrography above the canyon rim are also influenced significantly by wind, particularly during storm events, while the subsurface flow over the shelf slope is affected by the shelf-scale circulation.

Keywords: Sable Gully, shelf slope, submarine canyon, hydrodynamic model, process study

A numerical study on the SST variation in Tokyo Bay

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Tokyo city is one of the largest metropolitan areas in the world and undergoing a temperature rise year on year due to the heat island effect. While Tokyo Bay, which is located to the southeast of Tokyo, has been reported to have a potential cooling effect on the Tokyo urban area due to the lower sea surface temperature (SST). To better understand the variation of SST in Tokyo Bay and its underlying mechanism, a numerical study is conducted using the MSSG (Multi-Scale Simulators for the Geoenvironment) model. The model is driven by the wind and surface heat flux obtained from MSM data (Meso Scale Model issued by Japan Meteorological Agency) and the modeling results are compared with the observation. Preliminary results show that the model has captured the main features of SST variation in Tokyo Bay, including an abrupt increase in SST during Kuroshio intrusion period and a sharp decrease in SST during typhoon event.

Session 9:

Coupled bio-physical ocean models

A model study of the Copper River plume and its effect on the northern Gulf of Alaska

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The Regional Ocean Modeling System coupled with the Carbon, Silicate, Nitrogen Ecosystem model has been configured to study the effects of the Copper River runoff on the coastal current and nutrient dynamics in the northern Gulf of Alaska (GoA). This coupled model runs in three nested domains from the Gulf of Alaska to the northern shelf then to Prince Williams Sound. The coupled model is driven with the predicted atmospheric forcing from the NCEP's North American Master Grid model and observed river discharges. In addition to the distributed sources of freshwater from numerous glaciers along the coast, point sources of freshwater and nutrients from the Copper River are considered. A conservative tracer is also added in the model to delineate the river plume and its response to wind-driven and mesoscale processes on the northern Alaskan shelf. The plume enhances both the along shore and cross-shelf nutrient transport. By comparing the model runs without with, and doubling the river discharge, potential implications of glacier recession on nutrient and plankton dynamics in the northern Gulf of Alaska are discussed.

Multi-decadal simulation of Atlantic cod (*Gadus morhua*) early life stages in the North Sea: on the potential of spatially-explicit IBMs to be used in ecosystem based management

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Previous studies on processes related to multi-decadal changes in the recruitment of Atlantic cod in the North Sea indicate a close correlation to temperature changes as well as changes in the zooplankton compartment. But, environmental variability might impact the vital rates of cod early life stages in many direct or indirect ways and observed correlations might not indicate a causal link. To disentangle direct and indirect effects on larval fish survival we used an Individual Based Model for North Sea Atlantic cod coupled to the 3d ecosystem model ECOSMO that provides physical forcing and prey fields. The model was integrated over a 60-year time period (1949-2008) and the results were analysed using common statistical methods such as correlation analysis and Empirical Orthogonal Functions. The simulated long-term dynamics in annual potential larval survival (PLS) exhibited pronounced year to year variability on the one hand and, on the other hand, a significant decrease after 1989. Ten environmental parameters, including water temperature, current velocities, biological components, and turbulence, were analysed with respect to their relevance for PLS whereof 6 were found to be significantly correlated to PLS. Nonetheless, only water temperature (T) and the u-component of the velocity field (U) showed the same significant shift after 1989. Furthermore, the EOF analysis revealed that further offshore spawned larvae were impacted by T and U, while those spawned along the coast were correlation to the zooplankton dynamics. Finally, we assessed the linkage between the simulated larval survival and North Sea Atlantic cod recruitment and identified a change in the correlation after 1989, indicating a general change in process interactions relevant for recruitment.

Modulation of Decadal Oscillation on Marine Ecosystems in the Kuroshio Extension

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In the study, the responses of chlorophyll to decadal oscillations of Kuroshio Extension (KE) between two dynamical states are investigated using satellite observations data. Associated with the KE stable and unstable states, the chlorophyll also undergoes two different contrast patterns: low chlorophyll (-12% relative to multi-year mean) corresponding to strengthened KE jet (high SLA and low eddy kinetic energy, i.e., EKE) and high chlorophyll (11%) corresponding to weakened KE jet (low SLA and high EKE) south of 35N. An obvious dipole exists between southern and northern sides of 35N for both chlorophyll and SLA. Another dipole exists for both chlorophyll and EKE in the east-west direction bounded by 153E. Modulated by decadal oscillation of KE, the spring bloom of chlorophyll also takes on decadal oscillation. The spring bloom was suppressed (enhanced) relative to the magnitude of climatological spring bloom south of 35N during the KE stable (unstable) periods. They can even change 35% in 2006 and 2009. The decadal variation of chlorophyll in the KE may be modulated by nutrient supply induced by the local eddy divergence (convergence) and not modulated by the local Ekman pumping induced by the local wind stress curl. These eddies are caused by the westward propagation of wind-induced Rossby waves in the central and east North Pacific Ocean, which modulated by North Pacific Gyre Oscillation.

A mass-balanced pelagic ecosystem model with size-structured behaviourally adaptive zooplankton and fish

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Traditional marine ecosystem models often reduce the biological parts into a few state variables, representing major functional groups, with state dynamics prescribed by fixed rates of mass transfer. Such rigid model structures often cannot capture emerging changes in community structure and function in response to physical and biological drivers, nor can they describe how these changes may feedback on the system dynamics. Here we present an existing mass-balanced marine ecosystem model which has been extended to include a wide range of zooplankton species and size-classes growing from small to large, maturing at different sizes, and with size-dependent physiology and behavior. The zooplankton consumes phytoplankton and smaller zooplankton and responds adaptively to the instant rates of growth and mortality by migrating towards the more profitable depths. A dynamic pool of fish with a fixed mortality rate, mechanistic fish foraging and an adaptive spatial behavior is a closure term of the system. Model simulations demonstrate that inclusion of behavior and flexibility in the biological structures moderates the ecosystem dynamics and responses to physical and biological drivers, and how structural changes in the biological communities generate feedback on the system dynamics. Fish generally have strong size-structuring effects on the zooplankton, but little influence on phytoplankton because the total zooplankton biomass remains relatively stable over the fish cycles. The model reveals persistent spatial and cascading behavioral interactions and is a step towards a mechanistic and adaptive representation of the upper trophic levels in ecosystem models.

Assessing climate change impacts on North Sea and Baltic Sea ecosystems through ensemble simulations forced by IPCC AR4 and IPCC AR5 models under different scenarios

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Dynamic downscaling of global climate research has so far largely been restricted to the regional atmosphere and to the land ecosystems and downscaling of marine climate change impacts is a relatively newly emerging research area. We here present an ensemble of marine climate change projections for the North Sea and Baltic Sea using the 3D coupled biophysical model ECOSMO forced with six different Global Climate Models (GCMs) and different scenarios from the 4th and 5th IPCC assessments. The multi-model multi-scenario ensemble simulations allow identifying the uncertainty of regional climate projection for this region. When applying the same scenario, different GCM forcing caused a relatively wide range in projected future changes for both physical and biological parameters. Despite the uncertainties, sea surface temperature change was positive in both regions and for all projections, while the amplitude of the change varied among models and scenarios. Projected changes in primary production of the North Sea were mostly negative and accompanied with a large uncertainty. In contrast, the projected primary production of the Baltic Sea increased for all considered scenarios and models. Our results indicate that regional climate projections are accompanied by a large degree of uncertainty for physical and biological parameters.We elucidate uncertainties in regional future projections due to internal variability of climate models, scenario chosen, and downscaling method. The results emphasis the need to use multi-model ensemble studies for robust climate change impact assessment.

Modelling the fate and transport of pollutants in the marine environment- A Case study application of the ECOSMO model system for mercury

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The world ocean constitutes a large pool for a variety of pollutants which reach the regional marine environment through different pathways. They are either directly released by offshore marine activities and ship traffic or reach the regional ocean via loads from land surface, groundwater and river flows, by wet deposition from the atmosphere and air-sea gas exchange, by release from the sediments and with ocean currents from other marine sites. Once pollutants reach the marine realm, their fate, transport, and toxic risk is controlled by physical, chemical, and biogeochemical processes which influence the burial, transport, partitioning, speciation, and bio-accumulation of pollutants. These processes are critical to partitioning and bioavailability, and have to be resolved to provide reliable risk assessments for contamination of the marine environment.

Marine ecosystems are extremely complex and variable in space and time and chemical observations and experiments are complex and costly. Complementary understanding can be gained by numerical models and model experiments, which are able to resolve and integrate key processes and their temporal and spatial variations. Here we present a coupled physical-chemical-biological model for the North and Baltic Sea. The model is part of the ECOSMO (ECOSystem Model) model environment, a marine ecosystem model which incorporates modelling tools for early life stages of fish. The model can be used for a variety of pollutants with different properties, which influence their behaviour in the marine enviroronment. Moreover, the model is coupled to an atmospheric chemistry transport model, the Community Multiscale Air Quality (CMAQ) model.

One key pollutant of major concern is mercury. Mercury gained attention in the recent past because of increasing emissions and alarming high concentrations in marine seafood. Exemplary for mercury, we will discuss the significance of the biogeochemical cycle and its interplay with marine transport processes and air sea exchange for the fate and transport of mercury in the marine realm. Moreover we will identify hotspot areas in the North and Baltic Sea system, where feeding can pose a potential risk for seafood contamination.

Poster session

Mixing in lock release gravity currents down canyons

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Overflows and gravity currents are important components of the global circulation. The focus in the present paper is on mixing and mixing efficiencies in such flows. The mixing may be affected by the earth's rotation. In a rotating system, Ekman transport creates a transverse or secondary circulation and the transverse flows may transport lighter fluid parcels underneath the heavier core of the dense plumes. This will create instabilities and enhanced mixing. On the other hand, the speed of the down-flowing water will decrease in a geostrophically balanced flow. This will reduce the vertical shear and thereby the mixing.

These effects are studied in two sets of high resolution numerical experiments with a nonhydrostatic model. First it is shown that the model reproduces the main features of a laboratory scale gravity current in a canyon. Furthermore, a sequence of lock release experiments is performed to investigate the sensitivity of the mixing efficiency to rotation and other relevant parameters. In the present experiments, the mixing efficiency increases substantially as the initial volume, V, of the released water mass is reduced. It is suggested that the mixing efficiency scales as V**(-1/3).

A finite-element, multi-scale model of the Congo River, Estuary and ROFI

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Understanding coastal and estuarine flows is a great challenge due to the huge amount of physical phenomena involved. In particular, coastal currents are strongly impacted by the water discharged by large rivers. We present a numerical model of the lower section of the Congo River and the neighbouring coastal ocean. This work is carried out in the framework of the Second-generation Louvain-la-neuve Ice-ocean Model (SLIM[1]) project that aims to create a numerical ocean model using the (discontinuous Galerkin) finite element method to solve the governing equations on an adaptive unstructured mesh.

The first part of the work involves modelling the Congo land-sea continuum with a simplified 2D depth-averaged model. Since the stratification seems to play a significant role in the physics due to the large river runoff and the presence of a deep canyon that directly connects the river with the deep sea by cutting through the continental shelf, the second part of the work is the development of a robust 3D baroclinic numerical model.

The poster will be about the construction of such a model (numerical and physical aspects) and a preliminary simulation of a hypothetical pollution inflow will be shown.

1 www.climate.be/slim

Numerical study on sedimentary dynamic processes of the Yellow Sea Warm Current

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The sedimentary process of the Yellow Sea Warm Current (YSWC) in the Yellow Sea (YS), China, was reported as cyclonic deposition, however, lack of hydrodynamic explanation. Furthermore, the effect of YSWC on the sediment transport in the YS need further study.

Based on the filed data and numerical experiments, the problems mentioned above were studied.

Most of the suspended particle matters (SPM) carried by the YSWC were larger than mid silt, which may be related to the plankton. The concentration of SPM in the YSWC area in the 35°N transect is 1.0 to 1.4mg/L, and the median particle diameter is 18 to 26um. The halocline at the depth of 60m was formed. Stratified water in the halocline can prevent SPM from being transported from bottom to upper layer. According to the numerical simulation, a frontal deposition induced by the barotropic composition of YSWC and YS coastal currents contributed to the formation of the muddy area in the middle southern YS. However, the baroclinic composition and winter storm events can result in seabed erosion. Fine suspended sediment flux at the 35°N transect transported by the YSWC was 10^7 t/s. The transports of SPM from Yangtze River and muddy area to the southwest of Jeju Island were independent of the YSWC.

Interaction between Acoustic Field and Surface Gravity Waves in the Presence of a Large Offshore Wind Farm

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Offshore wind farms on the coastal waters comprise hundreds of wind turbines that affect the noise disturbances patterns in the adjacent coastal regions. Understanding impacts of these man-made structures is a necessary step to optimize their designing under this constraint to reduce public discomfort and environmental damages. Field measurements and numerical studies are strong tools that provide such insights for planning to control environmental wind farm exerted noise levels.

Large wind farms exert significant disturbances on both wind speed in the vicinity of sea surface and upper ocean acoustic field. The corresponding noise levels are associated to several physical and meteorological factors such as the decaying mechanism away from boundaries, the wave climate changes in development site, meteorological changes, and water salinity and temperature. In this study, a two-dimensional ocean surface model is coupled with an acoustic wave propagation model. Here the goal is first to investigate the interaction between the near-surface sound propagation and sea surface roughness length variability, and secondly to simulate upper ocean acoustic field response to the presence of large wind farm. To model changes of transmission loss due to farm effect and surface gravity waves, a harmonic acoustic source with different frequencies is considered for generating cylindrical symmetric sound wave. A stable finite difference technique is employed to implement both the acoustic field and wave field. A series of model experiments are conducted to simulate the underwater sound propagation and examine the sensitivity of the simulations to model parameters. The results show that the high frequency acoustic field is influenced by wind farm and sea surface state.

Hindcasting 20th century in the South Atlantic for storm surges identification and analysis

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Many aspects of interest arose from the availability of continuous hindcast simulations, from studies of physical processes to analysis of long time series for extreme events determination. The western portion of the South Atlantic Ocean is often affected by cyclogenesis processes that generate extreme events with strong impacts for the South and Southeastern Brazilian Shelf and Coast. This coastal area is densely populated and has a strong potential for oil and gas exploitation, which makes it highly vulnerable in environmental and economic aspects. The Princeton Ocean Model (POM) and the Regional Ocean Modeling System (ROMS) are being used in this numerical effort, based on different climatological dataset for temperature and salinity (WOA09, CARS, SODA) and also on some different atmospheric forcing (NCEP/NCAR-Reanalysis, NOAA/CFS-Reanalysis, Era-Interim). Preliminary results comparing known features of South Atlantic - such as SEC bifurcation, Brazil Current characteristics and Brazil-Malvinas Confluence behavior - showed some interesting differences between the experiments. On the other hand, both models suggested similar results in terms of storm surges, but not always in correspondence to the available sea level information.

A 50-year model hindcast of the Nordic, Barents and Kara seas: physical basis for biological applications

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A 50-year long model hindcast archive covering the Nordic, Barents and Kara seas at 4 km horizontal resolution is evaluated. The hindcast is obtained with the ocean model ROMS (Regional Ocean Modeling System) using 32 sigma-layers in the vertical and high-resolution NORA10 atmospheric forcing. The model hindcast is evaluated against available hydrographic measurements in several densely sampled sections along the Atlantic Water advection path towards the Arctic, as well as direct current measurements. Furthermore, "Great salinity anomalies" (GSAs) are identified and investigated with respect to origin and propagation speed. The results indicate that the model represents well the decadal variability in Atlantic Water hydrography, including GSAs, and reveal internal differences among the different GSAs. Also, the model's representation of variability in salinity in the Norwegian Coastal Current is unrealistic, most likely due to a crude treatment of run off from land, while the temperature variability is well represented both at annual and inter-annual time scales. Based on the evaluation, the model's suitability as a physical background for biological modeling applications is discussed.

The role of the Agulhas on the Benguela Current System: an experimental modelling approach

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The Benguela Current system is unique among the worlds four major eastern boundary upwelling systems in that it is in direct contact with the western boundary current of the South West Indian Ocean - the intense Agulhas Current. The Benguela Current can be thought of as the passage for Agulhas rings and eddies as they advect into the Atlantic Ocean after being shed at the Agulhas retroflection. As such, the southern Benguela system is a region of intense mesoscale turbulence. An experimental modelling approach, using the Regional Ocean Modelling System (ROMS), is used to assess the role of the Agulhas in both the large-scale hydrographic features as well as in the nearshore upwelling regime of the Benguela Current system. An idealized model experiment is designed such that the Agulhas Current is diverted eastward before reaching the tip of Africa, thereby removing most of its influence on the Benguela Current system. Comparisons of a ROMS reference run and the idealized experiment provide an assessment of the importance of the Agulhas Current in driving salient features of the southern Benguela such as the Good Hope Jet, the upwelling front, cross-shelf volume fluxes, the generation of instabilities at the shelf-edge and the transport of the Benguela Current itself. It also allows for a quantification eddy flux contributions of the Agulhas Current in the southern Benguela region.

This model experiment explicitly shows that the Agulhas contributes about 10Sv to the transport of the Benguela Current and that the large-scale, depth-integrated, circulation patterns deviate from the Sverdrup relation largely due to Agulhas influx. The meandering nature of the mean Benguela Current is shown to be driven by eddy fluxes associated with the Agulhas Current. The model suggests that the Agulhas contributes 46% to the annual mean heat flux into the Atlantic across 35°S, from 5-20°E, with a stronger seasonal signal evident in the reference simulation (with a peak in austral spring) than in the idealized experiment. Comparisons of EKE for the reference and no Agulhas simulations, suggest that the Agulhas results in up to 80 % of the mesoscale variability south of 30°S. It also allows for a quantification of locally-driven mesoscale tubulence as opposed to turbulence connected to Agulhas influx. The Agulhas Current is also shown to have a significant role in the transport of fish eggs and larvae to the St. Helena Bay nursery area. Aside from contributing to a broader and more perennial Good Hope Jet, the Agulhas influx in the southern Benguela is instrumental in driving the shoreward branch of the jet into St Helena Bay as it bifurcates downstream of Cape Columbine. Large filaments are observed off Lüderitz for both the

reference simulation and for the idealized experiment, thus suggesting that Agulhas rings are not necessarily connected to their extreme offshore extents. This experimental modelling investigation confirms that salient dynamic features of the southern Benguela, some of which are key drivers of ecosystem functioning, are closely related to Agulhas influx.

Numerical simulation of aquaculture organic waste dispersion from a fjord located fish farm

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The dispersion of biological waste from a fjord located fish farm is studied with use of a three-dimensional terrain following ocean model coupled to a random-walk particle tracking model. Two methods are used for tracking the particles, the Euler forward and the Heuns method, together with linear and bilinear interpolation of the velocities.

The particles are continuously released, randomly in the horizontal, at 5 m depth in the vertical, over a M2 period. The particles have gotten individual settling velocities drawn from a normal distribution based on laboratory experiments of falling velocities for organic waste. Effects of disintegration, particle shape and resuspension is not taken into account. Further, the dispersion of produced water, modelled as a passive concentration (no biological effect included), is continuously released in the upper 10 m at the same location and tracked over a 10 day period.

The results show that in the area of the fjord where the the particles and the concentration are released vortexes are developing and some of these may be stable throughout the simulation. The existence of such vortexes are anticipated, but usually studies are using a grid resolution that is to coarse to resolve these features. The concentration is dispersed as filaments and plumes which may be important for transferring diseases from farmed fishes to the wild fishes and may also be used for identifying the infection- and the reinfection pressure of fish farms.

The different methods used for tracking particles affect the propagation, but when stranding or settling of organic waste is of interest, the different methods quantitatively identify the same areas in this study.

The effect of rotation on shoaling of large amplitude internal solitary waves in the northern South China Sea

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Propagation of large amplitude internal solitary waves (ISWs) in the northern South China Sea (SCS) was simulated using the fully nonlinear, nonhydrostatic Massachusetts Institute of Technology general circulation model (MITgcm). Special attention was paid to the effects of rotation and shoaling three-dimensional topography. Three-dimensional (3D) evolution of wavefronts and vertical wave profiles were first scrutinized, and the issue of influence of rotation was put forward. Second, by setting up a series of high-resolution two-dimensional (2D) experiments with constant depth, it was found that for the conditions of the northern SCS, an initial ISW goes through a decay and reemergence process. However, in contrast with previous studies, the frontal waves constantly attenuate by repeatedly shedding inertia-gravity waves backwards. Third, with variable topography implemented in the 2D runs, it was shown that as distinct from the non-rotational case, under the combined effect of rotation and shoaling topography, an initial ISW can lead to the generation of two wave packets of different nature upon reaching the shelf break: the first packet with multiple ISWs is due to the fission of the initial ISW, whereas the second packet is a solibore that contains a number of short waves that resemble ISWs. The secondary solibore does not turn up when rotation is switched off, and it is much more remarkable in the northern portion of the SCS slope-shelf area where the shelf break is steep and shallow.

Simulation of the Yellow Sea Warm Current using a wave-tide-circulation coupled model

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The wintertime circulation of the Yellow Sea is studied using a prognostic wave-tide-circulation coupled Model based on Princeton Ocean Model (POM) and a surface wave model. The simulated tidal harmonic constants and temperature structure agree the observation well. The main feature of the Yellow Sea circulation in wintertime is the Yellow Sea Warm Current. The center path of the Yellow Sea Warm current is on the west part of the Yellow Sea trough. Numerical experiments are carried out to examine the forming mechanism of the Yellow Sea Warm Current.

The impact of tide induced residual current on the low-salinity water lens in the northeast out of the Changjiang river mouth

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The low-salinity water lenses (LSWLes) in the expansion area of the Changjiang diluted water exist in partial time of some years. It is necessary to analyze the dynamical mechanism of the actual LSWL Wind, runoff, Taiwan Warm Current and tide mixing have been discussed in the study of LSWL's dynamical mechanism. In this paper, some numerical simulations are made for dynamical analysis of LSWL in Aug 1983. The results show that tide induced residual current is helpful to the formation of LSWL in the northeast out of the Changjiang river mouth.

Analysis and Research on Characteristic of Sea-Land Breeze over Donghai Island of Zhanjiang,China

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In this paper, the characteristics of average wind and sea-land breeze circulation during 2011 are analyzed by using the data of wind profiler (CFL-08) which is located in Donghai Island of Zhanjiang and can uninterruptedly probe meteorological elements of vertical air flow, atmospheric refractive structure constant Cn2 and atmospheric wind field from 150 m – 8.0 km in vertical height direction.

The results show that: the prevailing wind direction at 150m high is northeasterly in winter and easterly in summer. The average wind speed is 2.5 m/s in summer. In winter, the monthly average speed of sea-land wind has few change around 1 m/s at 1:00(CST)-15:00(CST). However it became fluctuated at 15:00-20:00(CST) with the maximum speed of 2.1 m/s appeared at 16:00(CST). Obviously, the average sea-land wind speed in summer is greater than it in winter. The period of sea breeze duration in winter is from 8:00 to 20:00(CST), lasting for 12 h, and land breeze duration is from 0:00 to 7:00(CST), lasting for 7h, sea breeze period is longer than land breeze. In summer, the average duration time of sea-land breeze (11.5h) is longer than land breeze (6.5h). The vertical height of land breeze is about 1.2 km high during the sea-land breeze day, which has little difference with sea breeze. The speed of sea breeze and land breeze has the same changing trend with high, which is increased firstly and then decreased. The sea-land breeze's characteristic of time and space distribution is of quasi-bimodal type.

Some observed features of near-inertial motions on the shelf of northern South China Sea

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Some localized features of near-inertial motions on the northern shelf of the South China Sea are observed, by a mooring deployed in summer 2009 during two typhoon passages. The typhoon Linfa passed by the mooring to its right hand side and produced a significant injection for inertial energy, while the typhoon Nangka passing by to its left killed the previous inertial energy. The near-inertial current reaches as much as 30 cm/s, and exhibits a two-layer and 180 phase-out pattern separated at the middle depth. Spectra analysis shows two remarkable peaks at both sub-inertial and super-inertial frequencies. The sub-inertial part can be interpreted as the shift by background vorticity, while it remains unknown for the super-inertial. The vertical energy flux of near-inertial motions is not only downward, but also upward. The energy seems to be reflected several times in three layers, with 17m and 40m working as reflection boundaries. Between 25m and 30m, the wave vector of near-inertial waves tilts, probably due to an increased buoyancy frequency.

Additional Notes: I am still learning to solve the problem by modelling, but have not got valuable things from running. Hope to learn more on modelling from this workshop.

Estimation of troposphereic parameter from IGS station

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The global navigation satellite System (GNSS) occupies nowadays a very important place in several areas, including the GPS, in addition to its function of geodetic positioning also allows the estimation of the water vapor. Indeed, it is possible to convert the propagation delay of the electromagnetic wave integrated content of water vapor.

The goal of this work is to estimate different troposphere parameter and quantication the integrated water vapor from each GPS station.

Various tests were carried out on different IGS stations, and an analysis of different parameters was compared. These results are preliminary and require other work.

Currents in Taiwan Strait under winter-spring relaxing northeasterly wind conditions

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In late March 2012, debris from a shipwreck off the southeastern coast of China were found on the other side of the Taiwan Strait along the northwestern shore of Taiwan. The ship broke in bad weather under a strong northeasterly monsoon some 2 weeks earlier; fortunately the crews were rescued as the wind subsequently relaxed. Simulated tracer and particles from a wind-driven ocean model track well the end and begin locations of the debris, suggesting that the surface currents may be analyzed using a model forced by the fluctuating wind and a slower-varying sea-level gradient originating from the open ocean outside the strait. An analytical formula is derived and it yields upper- and lower-bound wind stress criteria for conditions that lead to cross-strait flows under a relaxing northeasterly monsoon wind in the Taiwan Strait. For northeasterly wind stresses stronger (weaker) than the upper (lower) bound ⍰ 0.12 (0.068) N m^{-2}, surface currents in the strait are predominantly southwestward (northeastward). Analyses of the numerical model further show that, in addition to the slowly-varying component, the along-strait sea-level gradient contains also a wind-induced fluctuating part which contributes to forcing a cross-strait N-shape flow pattern when the wind relaxes.

Upper Ocean Heat Influence on Australian East Coast Cyclone Thunderstorms

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Global Position and Tracking System (GPATS) lightning data and Weather Research and Forecast model (WRF) simulations are used to investigate the distribution of thunderstorms during the life cycle of four east-coast cyclones. The locations of lightning strikes are overlayed on maps of sea surface temperature (SST) and sea level height anomalies to look for potential relationships between thunderstorms and upper ocean heat content. A complex picture emerges of a correspondence between the distribution of upper-ocean temperature gradients and that of lightning strikes. Past research on the effect of SST gradients on surface winds has shown that convergence occurs when air flows from a warm to cold sea surface. In an unstable environment, such as that associated with a cold core upper-level low, this convergence may help to trigger atmospheric deep convection and thunderstorms. The lightning distributions will be discussed in relation to this hypothesis. Results will be presented from high-resolution WRF simulations currently being conducted to establish what atmospheric changes are occurring that contribute to the observed distributions of thunderstorms.

How good are the products generated by the MyOcean Arctic Monitoring and Forecasting System?

Lars Petter Røed, Arne Melsom, Laurent Bertino, Magne Simonsen, Francois Counillon, Bruce Hackett*

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The Arctic Monitoring and Forecasting Center (ARC MFC) produces daily a 10 day forecasts of ocean physical variables as well as a limited number of biogeochemical variables. The forecasts are based on the TOPAZ system. The ARC MFC is a collaborative effort between the Nansen Environmental and Remote Sensing Center (NERSC), the Norwegian Meteorological Institute (met.no), and the Institute of Marine Research (IMR) within the EU project MyOcean. As part of the project an automatic validation system is developed consisting of time series of biases and root mean square errors for a number of parameters. Results from this validation system along with some recent forecasts will be discussed.

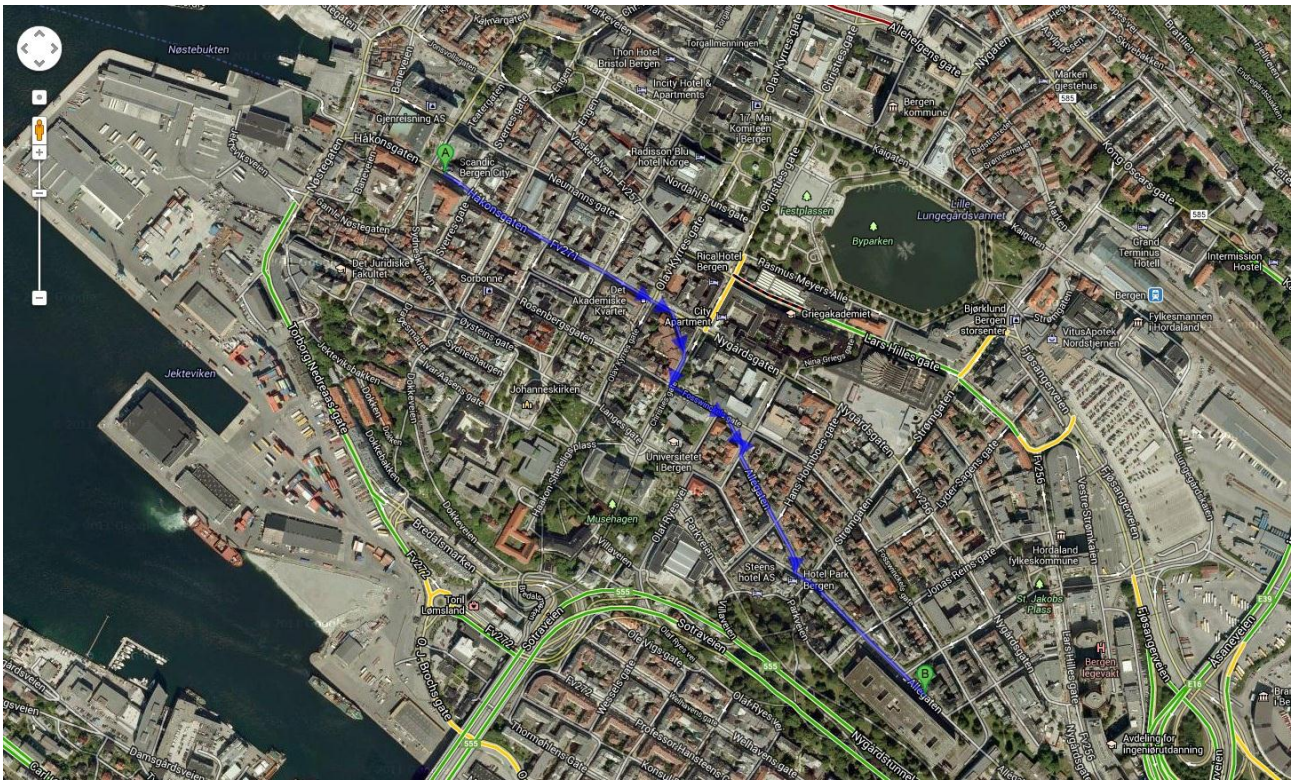
The Leeuwin Current: the roles of topographic trapping, mixing, and advection in a buoyancy driven eastern boundary current

Jessica Benthuysen

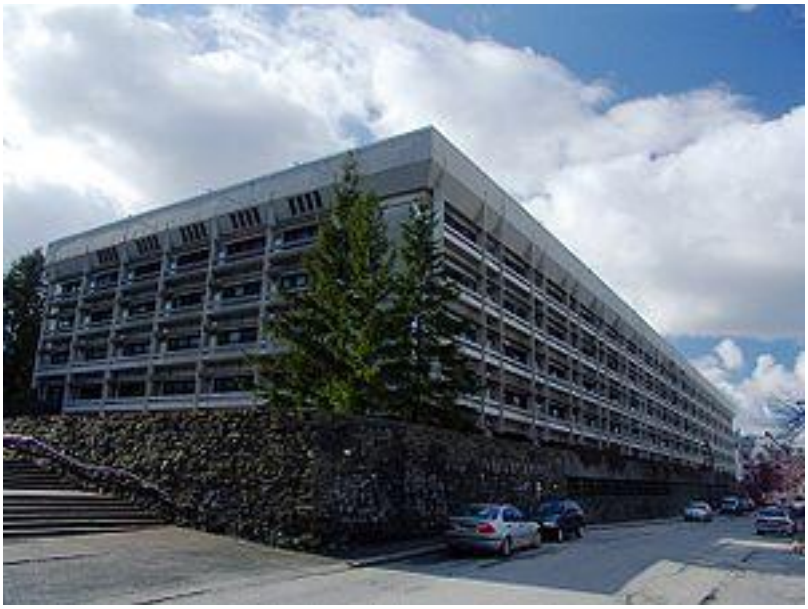
Benthuysen, Furue, McCreary, Bindoff, Phillips*

The Leeuwin Current is a poleward eastern boundary current that is shelfbreak intensified. For a buoyancy driven basin, numerical experiments are used to investigate how shelf-slope topography, mixing, and advection contribute to an eastern boundary current's speed, transport, and spatial structure. The buoyancy forcing is composed of a meridional density gradient distributed over an upper layer depth. This density structure supports a near-surface eastward flow that converges over topography. The position where the upper layer intersects the slope sets the offshore width of the current by topographic trapping of Rossby waves. Vertical diffusion thickens the upper layer, strengthening the poleward current. Horizontal viscosity modifies the current width over which the zonal flow converges and hence controls the jet speed. Poleward density advection forms a cross-shelf density front, intensifying the poleward flow near the surface. Offshore density advection by frictionally driven, near-bottom flows can contribute to the jet's frontal position near the shelf break.

Meeting Place



Venue: The Faculty of Mathematics and Natural Sciences, The University of Bergen



Address: Allégaten 41, Bergen

To walk from Scandic Hotel Bergen City (A) to The Faculty of Mathematics and Natural Sciences (B) takes about 15-20 minutes on foot