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Preface to the Special Issue of Numerical Ocean Modeling and Prediction

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The International Workshop for Numerical Ocean Modeling and Prediction was held at the National Taiwan University in Taipei, Taiwan, 23 - 25 April 2008. The workshop was organized by Yu-Heng Tseng (National Taiwan University), Christopher N. K. Mooers (University of Miami), and Malcolm J. Bowman (State University of New York at Stony Brook). There were more than sixty participants representing Taiwan, Canada, Germany, Japan, South Korea, Vietnam, USA and the People's Republic of China.

As the world's population grows and the use of fossil fuels continues to increase, the Earth is experiencing significant changes to its climate and environment. This includes the melting of glaciers and the Greenland ice sheet, a thinning of the north polar ice cap (which if lost, will change the Earth's albedo), and breaking up of the Antarctic ice shelves. In response, the sea level is beginning to rise, which, in the future, will threaten and disrupt coastal communities worldwide. The world's oceans stabilize the Earth's climate and play key roles in modulating and regulating climate change. Oceanographers, meteorologists, hydrologists, geodesists, geologists, fish biologists, ecologists, climate and social scientists are being called upon with increasing urgency to make more accurate predictions about these changes and their influence on human society and marine ecosystems.

As well as vast networks of *in situ* and remote sensing observations, high resolution, accurate and verifiable numerical ocean models are essential tools for the understanding and prediction of long-term changes in ocean circulation and mixing, marine ecosystems and fisheries, weather and climate, with El Niño, Asian monsoons, and decadal variability being three very important examples. Modeling the oceanic circulation and structure with fidelity is also critical to applications such as shipping and naval operations, harmful algal bloom abatement, ecosystem-based fisheries management, search-and-rescue, coastal inundation, oil spills and, contaminant transport and pollutant dispersal.

The workshop brought together a group of seventy-three international researchers to discuss modern ocean modeling and prediction technologies using advanced numerical models, spanning spatial scales ranging from regional coastal seas to the global ocean. The workshop focused on five major themes:

- Advances in numerical ocean modeling techniques;
- Simulations of ocean tides;
- Simulations of air-sea (atmosphere-ocean) interactions;
- Applications of ocean models;
- Skill assessments of nowcast and forecast ocean models.

A representative cross-section of manuscripts based on presentations at the workshop has been accepted for publication in this Special Issue. Techniques for numerical ocean modeling continue to advance rapidly. For example, accurate coupling of the upper ocean, snow/sea ice cover, and the lower atmosphere (Sun and Chern 2010) is linked to process-oriented field experiments. For downscaling from a basin-scale model to a continental shelf model and then to an estuarine model, multiply-nested grid models (Sheng and Yang 2010) improve predictions. New numerical integration methods provide more accurate and more stable semi-Lagrangian computational schemes (Chu and Fan 2010).

Simulations of ocean tides involve a better understanding of detailed bottom topography, deterministic forcing, and nonlinear dynamics. Though seemingly simpler than general circulation modeling, tidal simulations remain challenging due to shallow water effects (Chiou et al. 2010) and a mix of forced and free responses or, alternatively, a mix of standing and progressive wave responses (Hu et al. 2010).

Realistic simulations of air-sea (atmosphere-ocean) interactions involve correctly representing accurate bottom topography, particularly in regions of steep and highly irregular bottom topography, the effects of density stratification and the Earth's rotation, uncertainties of oceanic and atmospheric turbulent boundary layer exchanges, and stochastic, partially predictable atmospheric forcing. Atmospheric and/or oceanic responses to strong storms created via upper water column mixing and transport, especially during tropical and extra-tropical cyclones, are of great importance and interest. These responses range from coastal storm surges (You 2010) and powerful surface currents, to intense ocean-atmosphere heat and moisture exchanges (Tseng et al. 2010).

Outputs of ocean circulation and mixing models are often used to drive a variety of application models, as illustrated by three examples. The distributions of sea surface temperature from an ocean circulation model can improve estimates of seasonal precipitation patterns by an atmospheric model

(Yamamoto and Hirose 2010). The complex, evolving flow field from an ocean model can drive a Lagrangian tracking algorithm for predicting the transport and dispersal of oil spills (Korotenko et al. 2010). Flow and mass fields coupled with mixing parameters of an ocean model can drive a biogeochemical model to estimate the impact of variations in coastal ocean nutrient loading on marine ecosystems (Staneva et al. 2010). Importantly, ocean models may be applied to better understand dynamic ocean processes by conducting sensitivity studies (Kueh et al. 2010).

Skill assessments of nowcast and forecast ocean models are key diagnostic tools for establishing and improving the credibility of ocean predictions, and, thus, their utility for societal applications and scientific research. As may be anticipated, skill assessment methodologies vary with the nature of the dynamical processes being investigated, availability of accurate observations, and intended applications. Here, examples are presented for operational surface wave forecasts (Lee et al. 2010), operational forecasts of basin-scale ocean circulation (Mehra and Rivin 2010), and quasi-operational nowcasts/forecasts for a semi-enclosed sea and a strait (Mooers 2010).

Thanks to recent advances in computer power (e.g., parallel architecture and low power-consumption CPUs), expanding networks of more sophisticated ocean observing systems, and better understanding of fundamental ocean processes, numerical ocean circulation models have advanced significantly in the past few decades. Consequently, the development of integrated and sustained ocean observing, modeling, and analysis systems has become an important adjunct to modern numerical ocean modeling.

More information on the workshop and its participants can be found at http://efdl.as.ntu.edu.tw/workshop/iwnop.

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