Acta Oceanol. Sin., 2019, Vol. 38, No. 1, P. 1–3
https://doi.org/10.1007/s13131-019-1365-y
http://www.hyxb.org.cn
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Cover Story

China published ocean forecasting system for the 21st-Century Maritime Silk Road on December 10, 2018

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Received 9 December 2018; accepted 11 December 2018

1 The unique ocean forecasting system (OFS) based on FIO-COM

The OFS is based on the surface wave-tide-circulation coupled ocean model developed by the First Institute of Oceanography (FIO-COM), Ministry of Natural Resources, China. The half-century challenge that ocean circulation models must address is that the forecasting/simulated sea surface temperature overheats while the sub-surface temperature is too cold, especially during the summer. Qiao et al. (2004, 2010, 2016) found that the non-breaking surface wave can generate turbulence through wave-turbulence interaction, and they developed the wave-induced mixing theory, which has been confirmed by observations, laboratory experiments and model numerical simulations. As validated by ocean circulation models from various research groups, including Geophysical Fluid Dynamics Laboratory (GFDL) in the US (Fan and Griffies, 2014), Uppsala University of Sweden (Wu et al., 2015), Laboratoire d'Etudes en Géophysique et Océanographie Spatiale (LEGOS) in France (Malek and Babanin, 2014), Budapest University of Technology and Economics in Hungary (Péter and Krámer, 2016) and the Ocean University of China (Lin et al., 2006), the non-breaking surface wave-induced vertical mixing (Bv) can always dramatically improve the simulation capacity of various ocean circulation models. The First Institute of Oceanography (FIO) research group found that tidal-induced mixing plays a key role in the formation of coastal upwelling, in the bottom mixed layer and in areas with sea mounts (Lü et al., 2006, 2008). With the above breakthroughs, the first surface wave-tide-circulation coupled model of FIO-COM was developed in 2013. It was adopted to produce a reanalysis dataset for the period of January 2014 to April 2016, and it has been used for the operational OFS since May 2016. A highly efficient parallel scheme was designed to use the full capacity of Taihu Light with 10 649 600 CPU cores (Qiao et al., 2016), which earned a finalist nomination for the international Association for Computing Machinery (ACM) Gordon Bell Prize.

2 International cooperation project for OFS on the IOC/WESTPAC platform

The IOC Sub-Commission for the Western Pacific (WESTPAC) held its 7th International Scientific Symposium in Sabah, Malaysia on May 21–25, 2008, and the lead author was invited to give a keynote speech on "From ocean mixing to climate change". Somkiat Khokiattiwong from Phuket Marine Biological Center (PMBC), Thailand, also the chair of the WESTPAC-Southeast Asian Global Ocean Observing System (WESTPAC/SEAGOOS), and Fredolin Tangang from Universiti Kebangsaan Malaysia (UKM), Malaysia had a lively discussion with the lead author over the lack of OFS in Southeast Asia. Then, Tangang, Somkiat and the lead author jointly proposed the OFS project for the Southeast Asian Waters, which was evaluated and approved by the WESTPAC at its 8th Intergovernmental Session in Bali, Indonesia on May 10–13, 2010. During Phase I of the OFS project in 2010–2012, the first operational OFS for the southern region of the South China Sea was launched by Wendy Watson-Wright, Executive Secretary of the IOC and Assistant Director General of United Nations Educational, Scientific and Cultural Organization (UNESCO), during the 9th Intergovernmental Session of the WESTPAC on May 9–12, 2012 in Busan, Republic of Korea. The demonstration forecasts had been broadcast since then through the website http://221.0.186.5/IOC_WESTPAC/OFS. In addition, the Malaysian Meteorological Department (MMD) has published OFS products since March 2018 through the website http://ideas.met.gov.my/marine.html. During Phase II of the OFS project in 2013–2015, the model domain was extended to cover the whole Southeast Asian area, the Northwest

Foundation item: The National Natural Science Foundation of China under contract No. 41821004; the NSFC-Shandong Joint Fund for Marine Science Research Centers under contract No. U1606405; the International Cooperation Project of Indo-Pacific Ocean Environment Variation and Air-Sea Interaction under contract No. GASI-IPOVAI-05; the IOC/WESTPAC OFS Project.
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Pacific, the South China Sea and the Northeastern Indian Ocean. The OFS went into operation at Phuket Marine Biological Center (PMBC), Thailand in July 2015, and operational forecasting results have been published at http://110.49.56.166/thailand/results.jsp. Based on this OFS, the search and rescue model was developed and was successfully applied to two boat accidents in Phuket on July 5, 2018. The accuracy of the forecasts was confirmed by the follow-up rescue, which drew a great deal of attention from many countries. The OFS results were also used to predict the outcome of the *Sanchi* oil spill on January 6, 2018 (Yin et al., 2018), and the prediction results were reported by *Nature* on January 24, 2018 (Carswell, 2018). Phase III of the OFS project started in 2016. OFS became a long-term project, and its performance has been evaluated (Wang et al., 2016). The forecast system has been extended to cover the global ocean as FIO-COM, which has a resolution of 0.1°×0.1° and uses the data assimilation scheme of the ensemble adjustment Kalman filter (EAKF) (Yin et al., 2011).

3 OFS for the 21st-Century Maritime Silk Road

Motivated by the call for accurate ocean forecasting results from member states, WESTPAC invited FIO to publish OFS products on its official website. The OFS provides 5-day forecasting products and downloadable archived data for surface wave height, wave period, sea level, three-dimensional ocean current, sea temperature and salinity (Fig. 1). This crucial forecasted information could serve the needs of a variety of human activities related to the prevention and reduction of marine hazards, fishery management, the protection of marine environment, and the conservation of marine ecosystems. All products are for non-commercial use only and must bear the citation “FIO-COM products”. The forecasting products can be easily accessed through the website http://221.215.61.118:2018/#/ and the mobile “Global Ocean On Desk” (GOOD) app.

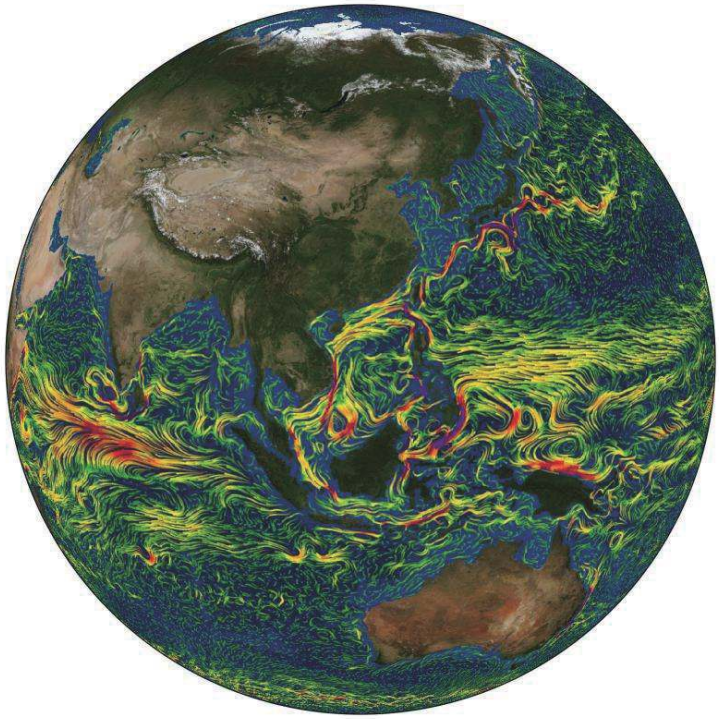

Fig. 1. A snapshot of sea surface current for the OFS for the 21st-Century Maritime Silk Road.

References

Carswell C. 2018. Unique oil spill in East China Sea frustrates scientists. Nature News, 554: 17–18, doi: 10.1038/d41586-018-00976-9

Fan Yalin, Griffies S M. 2014. Impacts of parameterized Langmuir turbulence and nonbreaking wave mixing in global climate simulations. Journal of Climate, 27: 4752–4775, doi: 10.1175/JCLI-D-13-00583.1

Lin Xiaopei, Xie Shangping, Chen Xinping, et al. 2006. A well-mixed warm water column in the central Bohai Sea in summer: Effects of tidal and surface wave mixing. Journal of Geophysical Research: Oceans, 111: C11017, doi: 10.1029/2006JC003504

Lü Xingang, Qiao Fangli, Wang Guansuo, et al. 2008. Upwelling off the west coast of Hainan Island in summer: Its detection and mechanisms. Geophysical Research Letters, 35: L02604, doi: 10.1029/2007GL032440

Lü Xingang, Qiao Fangli, Xia Changshui, et al. 2006. Upwelling off Yangtze River estuary in summer. Journal of Geophysical Research: Oceans, 111: C11S08, doi: 10.1029/2005JC003250

Malek G, Babanin A V. 2014. Ocean mixing by wave orbital motion. Acta Physica Slovaca, 64(1): 1–56

Péter T, Krámer T. 2016. Modeling the effect of waves on the diurnal temperature stratification of a shallow lake. Periodica Polytechnica Civil Engineering, 61(2): 165–175, doi: 10.3311/PPci.8883

Qiao Fangli, Yuan Yeli, Deng Jia, et al. 2016. Wave-turbulence interaction-induced vertical mixing and its effects in ocean and climate models.

Philosophical Transactions of the Royal Society of London Series A–Mathematical Physical and Engineering Sciences, A 374: 20150201, doi: 10.1098/rsta.2015.0201

Qiao Fangli, Yuan Yeli, Ezer T, et al. 2010. A three-dimensional surface wave-ocean circulation coupled model and its initial testing. Ocean Dynamics, 60(5): 1339–1355, doi: 10.1007/s10236-010-0326-y

Qiao Fangli, Yuan Yeli, Yang Yongzeng, et al. 2004. Wave-induced mixing in the upper ocean: Distribution and application in a global ocean circulation model. Geophysical Research Letters, 31: L11303, doi: 10.1029/2004GL019824

Qiao Fangli, Zhao Wei, Yin Xunqiang, et al. 2016. A highly effective global surface wave numerical simulation with ultra-high resolution. In: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC'16), Vol 5. Piscataway, NJ, USA: IEEE Press, 46–56, doi: 10.1109/SC.2016.4

Wang Guansuo, Zhao Chang, Xu Jianglin, et al. 2016. Verification of an operational ocean-wave coupled forecasting system for the China Seas. Acta Oceanologica Sinica, 35(2): 19–28, doi: 10.1007/s13131-016-0810-4

Wu Lichuan, Rutgersson A, Sahlée E. 2015. Upper-ocean mixing due to surface gravity waves. Journal of Geophysical Research: Oceans, 120: 8210–8228, doi: 10.1002/2015JC011329

Yin Xunqiang, Qiao Fangli, Shu Qi. 2011. Using ensemble adjustment Kalman filter to assimilate Argo profiles in a global OGCM. Ocean Dynamics, 61: 1017–1031, doi: 10.1007/s10236-011-0419-2

Yin Liping, Zhang Min, Zhang Yuanling, et al. 2018. The long-term prediction of the oil-contaminated water from the Sanchi collision in the East China Sea. Acta Oceanologica Sinica, 37(3): 69–72, doi: 10.1007/s13131-018-1193-5