Report on the 2nd year

of the project No. 4200253259 (NASA OSTST grant NNX08AR49G)

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Project name: DYNAMICS OF ANISOTROPIC MEAN AND TIME-VARYING STRUCTURES OF OCEAN CIRCULATION

Project period: 10/01/2008-09/30/2012

This report period: 7/01/2009-06/30/2010

1. Project results

In year 2, the project was developing successfully and in accord with the initial plan. Significant progress was achieved in all subtasks. Data analysis moved to a new level, allowing in-depth investigation and global dynamical generalization. The model component of the project gained momentum and produced valuable datasets of the solution sensitivity to various conditions. Outreach and education activity were markedly enhanced.

1.1 Demographics of time-variant striations

Three-dimensional (longitude-latitude-time) spectra of 17 years of the AVISO gridded satellite sea level anomaly and output of the OFES (OGCM For the Earth Simulator) were studied to systemize characteristics of time-varying striated patterns, reported in previous studies in subtropical gyres. Remarkable agreement has been revealed between the data and the model.

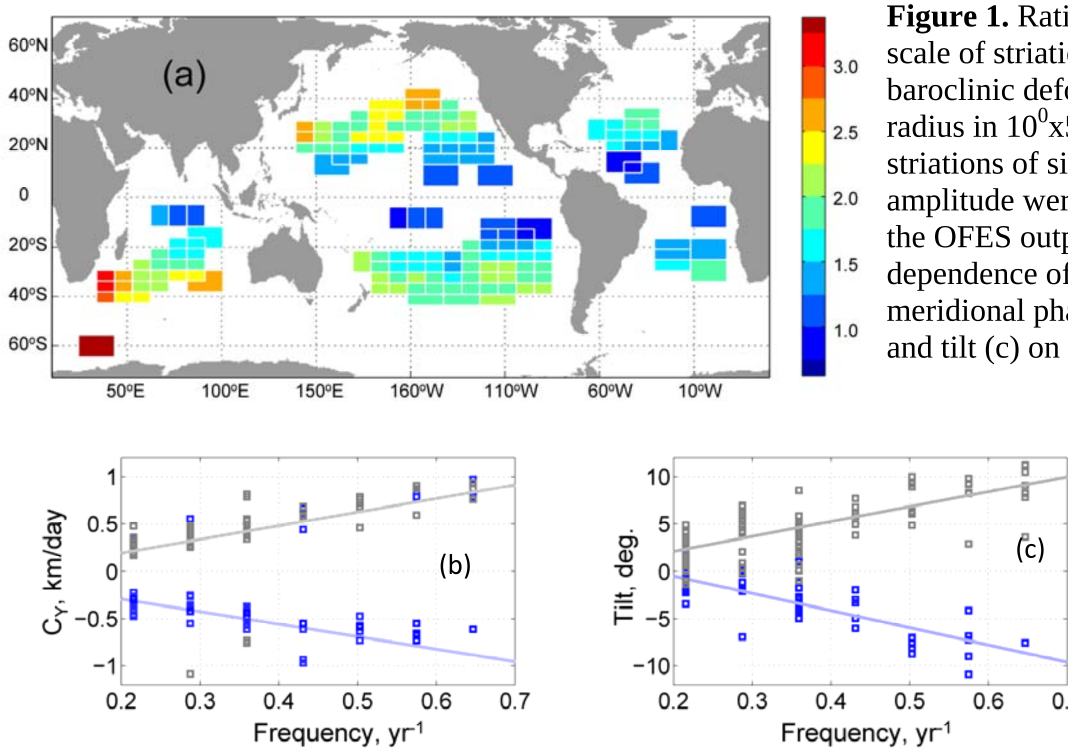

Figure 1. Ratio (a) of the scale of striations to the 1st baroclinic deformation radius in 10^0x5^0 bins, where striations of significat amplitude were identified in the OFES output. Also dependence of the meridional phase speed (b) and tilt (c) on frequency.

Striations are commonly tilted from the east-west orientation, with the dependence of the tilt and phase speed on frequency consistent with the dynamics of Rossby waves. Although alignment of eddies with the striations is remarkable, no correspondence between the scale of the striations and the Rhines scale is found.

1.2 Experiments with ROMS

The Regional Ocean Modeling System (ROMS) has been set up at Georgia Tech to study the sensitivity of stationary striations in the North Pacific, including their generation, to bathymetry, resolved scales, intensity and structure of wind forcing and background large-scale ocean flow. Preliminary runs, collected on the public project page www.oceanjets.org, indicate that with the broad variety of regimes simulated under different model conditions, generation of the striations starts from the eastern boundary of the model domain. Depending on the run, these initial perturbations are either anchored to features of coastline, bottom topography, etc. or they slowly change their latitude with time, if no anchor is offered. In all cases, model striations grow to the west as linear or nonlinear beta-plumes.

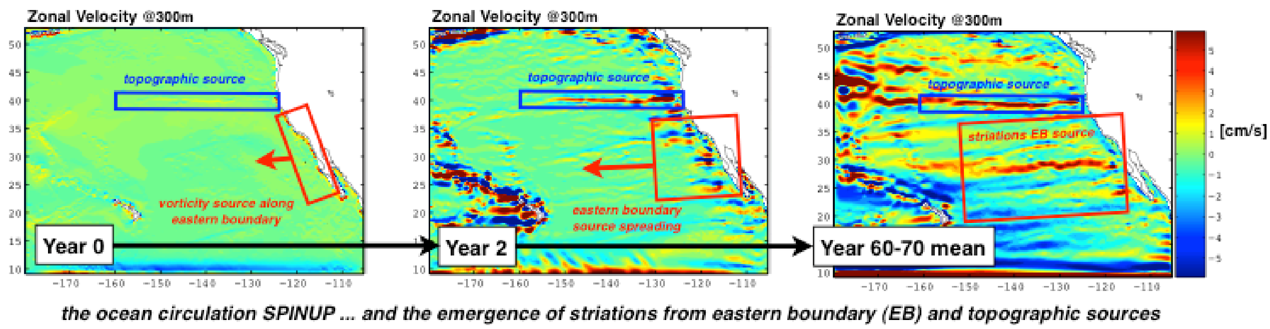

Figure 2: Example of the emergence of striations in the ROMS ocean model.

1.3 Atmospheric signature of oceanic striations

Spatial structure of the signal of the oceanic striations, detected in atmospheric satellite data, is being studied, using CFES (Coupled model For the Earth Simulator). The investigation revealed three-dimensional air circulation cells penetrating into troposphere, induced by the air-sea interaction modulated by SST anomalies associated with the striations.

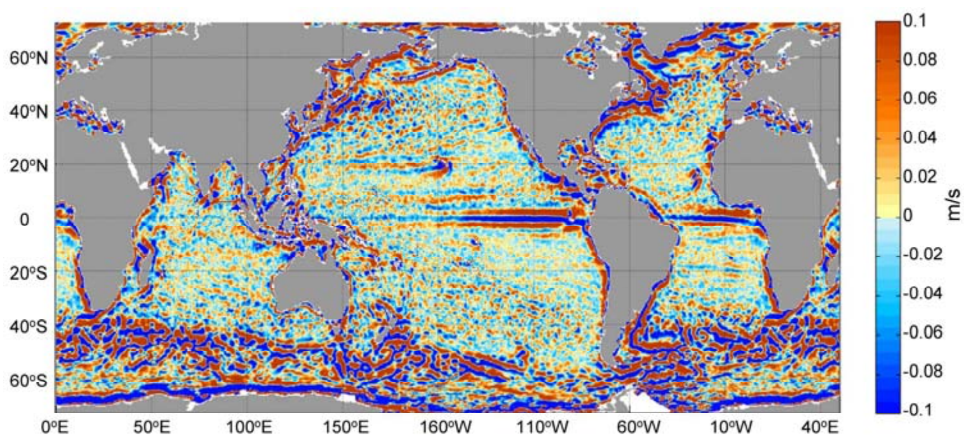

Figure 3. High-pass filtered in space time-mean wind speed measured by the QuikSCAT scatterometer.

1.4 Surface currents and marine debris

The technique, used earlier to compute the mean dynamic topography, has been generalized to diagnose near-real time surface currents, consistent with trajectories of drifters. Daily maps of globally gridded velocity (SCUD), based on AVISO altimetry and QuikSCAT winds, have been made public at http://apdrc.soest.hawaii.edu/projects/SCUD/ and applied to the problem of the debris, aggregating in large amounts in some parts of the ocean and on the shore. Field trip to Kamilo beach on Big Island of Hawaii, famous for its highest debris accumulation rate, provided the first-hand experience and resulted in new multiple collaborations.

2. Plan for the 3rd year of the project (07/01/2009-06/30/2010)

2.1 Stationary Rossby waves in the ocean

Technique will be developed to detect and catalog globally ocean features that demonstrates properties of stationary Rossby waves. These features include but are not limited to stationary striations. General property of stationary wave-like features is that their crests and troughs are oriented across the larger-scale flow. Suspected examples of the stationary waves are the North Equatorial Currents and the web of secondary fronts in the Kuroshio Extension. The census of the features, accompanied by the suggested forcing mechanism, will be useful for tune-up and validation of numerical models.

2.2 Atmospheric signature of oceanic striations

Study of the spatial structure of the signal of the oceanic striations, detected in atmospheric satellite data, will be continued, using CFES (Coupled model For the Earth Simulator) and atmospheric satellite data. Impact of the striations on anisotropy of atmospheric fluxes will be assessed.

2.3 Nonlinear beta-plumes

Dynamical details of the non-linear beta-plume will be studied with ROMS and OFES in implication to the striations and eddies observed in the eastern subtropical gyres. Power of ROMS will used to isolate most important physical processes and factors.

2.4 Organized ocean turbulence

The nature of the correspondence between oceanic eddies and striations will be investigated. Processes of the eddy self-organization will be evaluated, using satellite data and model outputs, versus the processes anchoring formation of new eddies to the underlying striations.

2.5 Near-real time surface velocities

SCUD product will be extended to the real time by adjusting the technique, developed for QuikSCAT, to the ASCAT scatterometer data.

3. Peer-reviewed publications relevant to the project

Maximenko, N., and O. Melnichenko, 2010: Mesoscale activity observed by satellite altimetry in the subtropical North Pacific: striations versus eddies, *J. Geophys. Res.*, in preparation.

Maximenko, N., J. Hafner, and P. Niiler, 2010: Pathways of marine debris derived trajectroies of Lagrangian drifters, Marine Pollution Bulletin, under review.

Law, K. L.,, S. Morét-Ferguson, N. A. Maximenko, G. Proskurowski, E. E. Peacock, J. Hafner, and C. M. Reddy, 2010: Well-defined plastic accumulation in North Atlantic gyre shows no increase in 22 years, Science, under review.

Dohan, K., ..., N. Maximenko, et al, 2010: Measuring the global ocean surface circulation with satellite and in situ observations, *Proc. of OceanObs'09,* in press.

Shum, C. K., ... N. Maximenko, et al, 2010: Geodetic observations of ocean surface topography, ocean currents, ocean mass, and ocean volume change, *Proc. of OceanObs'09,* in press.

Scott, R., ..., N. Maximenko, et al, 2010: Integrating satellite altimetry and key observations: what we've learned, and what's possible with new technologies, *Proc. of OceanObs'09,* in press.

Lamas, L., A. Peliz, I. Ambar, A. Barbosa Aguiar, N. Maximenko, A.Teles-Machado, 2010: Evidence of time-mean cyclonic cell southwest of Iberian Peninsula: The Mediterranean Outflow-driven beta-plume? *Geophys. Res. Lett.*, 37, L12606, doi:10.1029/2010GL043339

Melnichenko, O. V., N. A. Maximenko, N. Schneider, H. Sasaki, 2010: Quasi-stationary striations in basin-scale oceanic circulation: Vorticity balance from observations and eddy-resolving model. *Ocean Dynamics*, 60 (3), 653-666.

Sasaki,Y., N. Schneider, N. Maximenko, and K. Lebedev, 2010: Observational evidence for propagation of decadal spiciness anomalies in the North Pacific. *Geophys. Res. Lett.*, 37, L07708, doi:10.1029/2010GL042716.

Maximenko, N., P. Niiler, M.-H. Rio, O. Melnichenko, L. Centurioni, D. Chambers, V. Zlotnicki, and B. Galperin, 2009: Mean dynamic topography of the ocean derived from satellite and drifting buoy data using three different techniques. *J. Atmos. Oceanic Tech.*, 26 (9), 1910-1919.

4. Other publications

Maximenko, N., and J. Hafner, 2010: SCUD: Surface currents from diagnostic model, *IPRC Tech. Note #5,* 17p.

N. Maximenko, O. Melnichenko, P. Niiler, N. Schneider, E. Di Lorenzo, J. Hafner, and H. Sasaki , 2010: Striations: newly found oceanic features, *Proc. of the 2009 International Conference* "Fluxes and Structures in Fluid", in press.

4. Presentations at scientific meetings

Maximenko, N. A., O. Melnichenko, P. P. Niiler, N. Schneider, J. Hafner, and E. Di Lorenzo, **(invited)** Ocean striations and role of satellite altimetry in their detection, Ocean Sciences Meeting, Portland, February 22-26, 2010

Melnichenko O., N. Maximenko, and H. Sasaki, Demographics of time-variant striations over the global ocean, 2010 Ocean Sciences Meeting, 22-26 February, 2010, Portland, Oregon.

Hafner, J., N. A. Maximenko, and P. Niiler, Convergence Zones at the Ocean Surface with Implication for Marine Debris Distribution, 2010 Ocean Sciences Meeting, 22-26 February, 2010, Portland, Oregon.

Maximenko, N., and J. Hafner, Pathways of Marine Debris Derived from Trajectories of Drifters, Press Conference, Ocean Sciences 2010, February 23, 2010

Melnichenko O., N. Maximenko, and H. Sasaki, Time-variant zonal jet-like structures (striations) in the ocean circulation, 2010 EGU General Assembly, 3-7 May, 2010, Vienna, Austria.

Hafner, J., N. Maximenko, and P. Niiler, Ocean Surface Circulation with Implication for Marine Debris Distribution, 2010 EGU General Assembly, 3-7 May, 2010, Vienna, Austria.

Hafner, J., and N. Maximenko, SCUD: Surface Currents from Diagnostic Model, PACON 2010, 1-5 June, 2010, Hilo, Hawaii
Maximenko, N., and J. Hafner, Dynamics of near-surface currents with implication to pathways of marine debris, PACON 2010, 1-5 June, 2010, Hilo, Hawaii
Melnichenko O., N. Maximenko, and H. Sasaki, Alternating quasi-zonal jets in the eastern North Pacific, PACON 2010, 1-5 June, 2010, Hilo, Hawaii