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I have been an active member of the group of ONR SecNav/CNO Chairs in Oceanographic Sciences since being selected in 2008. The formal duration of the ONR Chairs grant was four years. For recent years, I have enjoyed no-cost extensions of this grant. I have continued to participate in Chairs meeting with the multiple Chiefs of Naval Research. These meetings are occasions for the Chairs to learn about ONR concerns and provide feedback on issues, such as opportunities and priorities for Arctic Ocean research. I will continue to participate at the pleasure of ONR.

The accomplishments of this grant include support of two graduate students, Kevin Taylor and Nathan Lauffenburger, whom I supervised. Both were awarded MS degrees by the UW School of Oceanography and are currently employed in ocean studies at APL-JHU and NOAA, respectively. These students participated in and used data from ONR DRI projects, including QPEU for Taylor and OKMC for Lauffenburger.

In addition to the PI's ONR Chair activities, the grant also supported the PI in various ONR research projects. These activities include PI participation in the field projects and data analyses for various Code 32 DRIs, including QPE (Gawarkiewicz et al. 2011, Lien et al. 2013) in E. China Sea, ITOP in typhoons in W. Pacific (D'Asaro et al. 2011 and 2013, Mrvaljevic, 2013) and OKMC off the Philippines and Taiwan.

Publications which benefited from partial support from this grant:

D'Asaro, E.A., T.B. Sanford, P. Niiler and E.J. Terrill (2007). Cold wake of Hurricane Frances,

Geophys. Res. Lett., 34, L15609, doi:10.1029/2007GL030160.

Lien, R.-C., and T. B. Sanford (2008). Observations of turbulence mixing and vorticity in a littoral surface boundary layer, *J. Phys. Oceanogr.*, 38(3), 648-669.

Lien, R.-C., and T. B. Sanford (2009). Vorticity and turbulence in a wake of bridge pier, *IEEE J. Ocean Engr.*, 34(3), 307-314.

MacKinnon, J.A, M. H. Alford, P. Bouruet-Aubertot, N. Bindoff , S. Gille, J.B. Girton, M. C. Gregg, R. Hallberg, E. Kunze, A.C. Naveira Garabato, H. Phillips, R. Pinkel, K. Polzin, T. B. Sanford, H. L. Simmons and K. G. Speer, (2009). Using global arrays to investigate internal-waves and mixing, *Proceedings of the "OceanObs'09: Sustained Ocean Observations and Information for Society" Conference*, Venice, Italy, 21-25 September 2009, Hall, J. and D.E. Harrison and D. Stammer, Editors.

Huang, P., T. B. Sanford and J. Imberger (2009). Heat and turbulence kinetic energy for surface layer cooling induced by the passage of Hurricane Frances (2004), *J. Geophys. Res.*, 114, C12023, doi:10.1029/2009JC005603.

You, Y., T. Sanford, T. and C.-T. Liu, (2010). Climate monitoring of the Indonesian Throughflow, *EOS Transac. Amer. Geophys. Un.*, 91, 13-15 (2010).

Sanford, T.B., K.A. Kelly and D.M. Farmer (2011). Sensing the ocean. *Phys. Today*, Feb. 24-28.

- D'Asaro, E., P. Black, L. Centurioni, P. Harr, S. Jayne, I-I Lin, C. Lee, J. Morzel, R. Mrvaljevic, P. P. Niiler, L. Rainville, T. B. Sanford, and T. Y. Tang (2011). Typhoon-ocean interaction in the Western North Pacific: Part 1, *Oceanography*, 24, 24-31.
- Gawarkiewicz, G. et al. (2011). Can we accurately predict circulation and internal waves northeast of Taiwan? Chasing Uncertainty in the Cold Dome. *Oceanography*, 24(4):110–121, <http://dx.doi.org/10.5670/oceanog.2011.99>
- Sanford, T.B, J.F. Price and J.B. Girton (2011). Upper ocean response to Hurricane Frances (2004) observed by profiling EM-APEX floats, *J. Phys. Oceanogr.*, 41, 1041-1056.
- Sanford, T.B. (2013). Spatial structure of thermocline and abyssal internal waves, *Deep-Sea Res. Part II*. 85, 195-209.
- Szuts, Z.B. and T. B. Sanford (2013). Observations of vertically-averaged velocity in the North Atlantic Current, *Deep-Sea Res. Part II*. 85, 210-219.
- Terker, S.R., T.B. Sanford, J.H. Dunlap and J.B. Girton (2013). EM-POGO: A simple, absolute velocity profiler, *Deep-Sea Res. Part II*. 85, 220-227.
- Mrvaljevic, R.A., P.G. Black, L.R. Centurioni, E.A. D'Asaro, S.R. Jayne, C. Lee, R-C Lien, J. Morzel, P.P. Niiler, L. Rainville, T.B. Sanford and T-Y Tang (2013). Evolution of the cold wake of Typhoon Fanapi. *Geophys. Res. Ltrs.* 49, 316-321.
- Lien, R-C, T.B. Sanford, S. Jan, M-H Chang and B-b Ma (2013). Internal tides on the East China Sea Continental Slope. *J. Mar. Res.*, 71, 151-185.
- D'Asaro, Eric, Peter G. Black, Luca R. Centurioni, Ya-Ting Chang, Shuyi Chen, Ralph C. Foster, Hans C. Graber, Patrick Harr, Verena Hormann, Ren-Chieh Lien, I.-I. Lin, Thomas B. Sanford, Tweng-Yung Tang, Chun-Chieh Wu (2014). Impact of Typhoons on the Ocean in the Pacific: ITOP, *Bull. Am. Met. Soc.* 95, (accepted)

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