Deep-Sea Research II 119 (2015) 1–2

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Editorial

Physical oceanography of fronts: An editorial

The present volume is the sixth special issue on ocean fronts in 14 years (Belkin, 2002, 2008, 2009; Belkin and Spall, 2002; Belkin et al., 2014). These years have seen tremendous progress in frontal oceanography. Technological innovation was a major driving force behind this progress, with new instruments – gliders, wave riders, Argo floats, undulated towed CTDs, data loggers on instrumented animals, etc. – becoming widely available. Remote sensing has seen a gradual improvement in spatial resolution, finally ushering in an era of high-resolution satellite oceanography. Space-born sensors such as MODIS, MERIS, and VIIRS made 1-km and even 300-m resolution (MERIS) imagery routine, which in turn allowed submesoscale processes to be studied in unprecedented detail. Algorithms for front detection in satellite imagery have come of age. Their proliferation called for comparative studies of such algorithms, which is more evidence of the maturity of this field.

Seven papers comprising this issue exemplify various aspects of modern frontal oceanography. Regionally, these papers represent four major oceans (Atlantic, Pacific, Indian, and Southern). Both North Atlantic (Miller et al., 2015) and South Atlantic (Pisoni et al., 2015) are represented. The China Seas are covered in three papers (Chang and Cornillon, 2015; Lee et al., 2015; Shi et al., 2015). The Eastern Tropical Pacific is the subject of Collins et al. (2015). The Southern Ocean fronts and frontal eddies are illuminated by Ansorge et al. (2015). Fronts of diverse physical nature are studied: water mass convergence fronts (Miller et al., 2015; Chang and Cornillon, 2015; Collins et al., 2015; Lee et al., 2015; Shi et al., 2015), tidal mixing fronts (Miller et al., 2015; Pisoni et al., 2015), fronts of the Antarctic Circumpolar Current (Ansorge et al., 2015), and coastal upwelling fronts (Lee et al., 2015).

Six out of seven papers rely largely or solely on satellite data – another evidence of critical advantages offered by remote sensing. Chang and Cornillon (2015) conducted a thorough comparison study of two front detection algorithms. They compared the histogram-based Cayula and Cornillon (1992, 1995) algorithm and the entropy-based Shimada et al. (2005) algorithm, the latter based on the Vazquez et al. (1999) entropic approach to edge detection in SST images. This study, inter alia, revived a discussion about definitions of fronts. Given the current proliferation of front-detection algorithms for satellite oceanography, more comparison studies of this kind are warranted.

Lee et al. (2015) used the Shimada et al. (2005) algorithm to study mesoscale fronts of the East China Sea from 1-km SST data. They confirmed SST fronts detected by Hickox et al. (2000) using the Cayula-Cornillon algorithm on 9-km data. Thanks to the 1-km resolution, Lee et al. (2015) described new features of previously known fronts and reported new fronts. In particular, they documented SST fronts associated with several sand ridges at the top of Jiangsu Shoal. Owing to the shallow depths over the Jiangsu Shoal, surface thermal manifestations of these sand ridges could be expected. Nonetheless, such surface manifestations of seafloor geomorphology in this region remained conjectural until finally documented by Lee et al. (2015).

Miller et al. (2015) used 300-m resolution MERIS data to describe numerous color fronts off Scotland. Their front detection and aggregation techniques revealed important structural details of these fronts hitherto unexplored, such as coastal fronts that were not detectable using coarser thermal data. These techniques also show their advantage as powerful visualization tools. Of particular importance is the combined use of (a) frontal frequency (probability) as a measure of front persistence and (b) cross-frontal gradient as a measure of frontal sharpness/intensity (Miller, 2009). The latter should not be confused with the total cross-frontal range, e.g. a temperature step across the front in question. This range (step) is often perceived as a measure of the front's strength. It remains to be seen which measure is more important to various species that demonstrate affinity to these fronts.

The huge Patagonian (Argentinean) Shelf features numerous fronts, whose ecological importance has been recognized (Acha et al., 2004; Belkin et al., 2009). Most of these fronts are tidal mixing fronts owing to the extremely high rate of tidal energy dissipation over this shelf. Pisoni et al. (2015) focused on two tidal mixing fronts and studied their temporal variability using 10 years of 1-km resolution SST data. This study is a rare example of a systematic approach to climatology of individual fronts based on satellite data with daily resolution. The study discusses the mechanisms leading to frontal displacements at seasonal to fortnightly frequency. Tidal mixing fronts are especially well suited for such studies since they are steered by topography. Scores of similar fronts elsewhere deserve the same kind of attention.

Shi et al. (2015) studied fronts of the Northern South China Sea (South China Shelf). This area is of particular interest thanks to the diversity of fronts, owing in turn to the seasonally-reversing circulation driven by monsoons. The year-round Pearl River discharge, alternating coastal and shelf-break currents in summer/winter, summer upwelling and winter downwelling off the China coast, tidal mixing and sporadic intrusions of the Kuroshio Current and its eddies, all these processes complicate the oceanography of this region. Shi et al. (2015) used satellite data and models to study the interaction between ocean fronts and atmosphere, particularly the fronts' impact on winds, which inter alia was a subject of an in-depth review by Small et al. (2008), published in a previous special issue on fronts.

http://dx.doi.org/10.1016/j.dsr2.2015.08.004

Ansorge et al. (2015) present new evidence of vigorous frontal eddy generation in the South-West Indian Ocean due to the Antarctic Circumpolar Current's interaction with the South-West Indian Ridge (SWIR). They combined tracking a single eddy for 10 months (and studying this eddy in a Lagrangian reference frame) with algorithm-based multiple eddy tracking (as opposed to previously used manual search) in satellite altimetry data (using the Chelton et al. (2011) algorithm). The latter resulted in detection of 78 eddies in the SWIR region from 1992 through 2012 including 28 eddies (25 anticyclonic and 3 cyclonic) propagating southward. The importance of the southward transport of heat and salt by these eddies is obvious, as well as their potential impact on sea ice cover. These frontal eddies undoubtedly play a role in cross-frontal transfer of species, especially passive swimmers. This fascinating field is awaiting its researchers.

Unlike the above remote-sensing studies based largely on satellite data, Collins et al. (2015) relied on in situ data alone and demonstrated how much information and insight could be obtained from just two oceanographic sections. They focused on a persistent but poorly studied front near the entrance to the Gulf of California, which was identified during a global survey of SST fronts (Belkin, 2005; Belkin et al., 2009). This front could be categorized as a classical water mass convergence front, a boundary between high-salinity water formed in the Gulf of California and low-salinity water of the Tropical Pacific. Notwithstanding the relative simplicity of the formation mechanism of this feature, its structure, dynamics, and kinematics are quite complicated as emphasized by Collins et al. (2015).

This volume would not be possible without selfless dedication of numerous reviewers. We gratefully acknowledge all of them. Each manuscript was reviewed by four-to-five reviewers, who enforced rigorous standards, resulting in a 50% rejection rate, multiple revisions, and a protracted peer-review process. Our most sincere thanks go to all authors who worked diligently with the reviewers and guest editors to make this volume happen. Special thanks are reserved for the Editor-in-Chief John Milliman for his patience, encouragement, and careful final editing of all manuscripts. The entire submission/peer-review/publication process was ably and cheerfully handled by Ann Barajas and Carolyn Abram, Journal Managers. We cannot thank them enough.

References

Acha, E.M., Mianzan, H.W., Guerrero, R.A., Favero, M., Bava, J., 2004. Marine fronts at the continental shelves of austral South America: physical and ecological processes. J. Mar. Syst. 44 (1–2), 83–105. http://dx.doi.org/10.1016/j.jmarsys.2003.09.005.

Ansorge, I.J., Jackson, J.M., Reid, K., Durgadoo, J.V., Swart, S., Eberenz, S., 2015. Evidence of a southward eddy corridor in the South-West Indian Ocean. Deep-Sea Res. Part II 119, 69–76. http://dx.doi.org/10.1016/j.dsr2.2014.05.012.

Belkin, I.M., 2002. New challenge: ocean fronts. J. Mar. Syst. 37 (1–3), 1–2. http://dx.doi.org/10.1016/S0924-7963(02)00191-4.

Belkin, I.M., Spall, M., 2002. New old frontier: ocean fronts. Dyn. Atmos. Oceans 36 (1–3), 1–2. http://dx.doi.org/10.1016/S0377-0265(02)00021-0.

Belkin, I.M., 2005. Oceanic Fronts in Large Marine Ecosystems. Final Report to the United Nations Environmental Program (UNEP), 51 pp. (64 color maps).

Belkin, I.M., 2008. Dynamics of oceanic fronts and their interaction with atmosphere and abyssal circulation. Dyn. Atmos. Oceans 45 (3–4), 69–70. http://dx.doi.org/10.1016/j.dynatmoce.2008.06.001.

Belkin, I.M., 2009. Observational studies of oceanic fronts. J. Mar. Syst. 78 (3), 117–118. http://dx.doi.org/10.1016/j.jmarsys.2008.10.016.

Belkin, I.M., Cornillon, P.C., Sherman, K., 2009. Fronts in large marine ecosystems. Prog. Oceanogr. 81 (1–4), 223–236. http://dx.doi.org/10.1016/j.pocean.2009.04.015.

Belkin, I.M., Hunt Jr., G.L., Hazen, E.L., Zamon, J.E., Schick, R.S., Prieto, R., Brodziak, J., Teo, S.L.H., Thorne, L., Bailey, H., Itoh, S., Munk, P., Musyl, M.K., Willis, J.K., Zhang, W., 2014. Fronts, fish, and predators. Deep-Sea Res. Part II 107, 1–2. http://dx.doi.org/10.1016/j.dsr2.2014.07.009.

Cayula, J.-F., Cornillon, P., 1992. Edge detection algorithm for SST images. J. Atmos. Ocean. Technol. 9 (1), 67–80. http://dx.doi.org/10.1175/1520-0426(1992)009<0067:EDAFSI>2.0.CO;2.

Cayula, J.-F., Cornillon, P., 1995. Multi-image edge detection for SST images. J. Atmos. Ocean. Technol. 12 (4), 821–829. http://dx.doi.org/10.1175/1520-0426(1995)012<0821:MIEDFS>2.0.CO;2.

Chang, Y., Cornillon, P., 2015. A comparison of satellite-derived sea surface temperature fronts using two edge detection algorithms. Deep-Sea Res. Part II 119, 40–47. http://dx.doi.org/10.1016/j.dsr2.2013.12.001.

Chelton, D.B., Schlax, M.G., Samelson, R.M., 2011. Global observations of nonlinear mesoscale eddies. Prog. Oceanogr. 91 (2), 167–216. http://dx.doi.org/10.1016/j.pocean.2011.01.002.

Collins, C.A., Castro, R., Mascarenhas, A., 2015. Properties of upper ocean fronts associated with water mass boundaries at the entrance to the Gulf of California, November 2004. Deep-Sea Res. Part II 119, 48–60. http://dx.doi.org/10.1016/j.dsr2.2014.06.002.

Hickox, R., Belkin, I., Cornillon, P., Shan, Z., 2000. Climatology and seasonal variability of ocean fronts in the East China, Yellow and Bohai seas from satellite SST data. Geophys. Res. Lett. 27 (18), 2945–2948. http://dx.doi.org/10.1029/1999GL011223.

Lee, M.A., Chang, Y., Shimada, T., 2015. Seasonal evolution of fine-scale sea surface temperature fronts in the East China Sea. Deep-Sea Res. Part II 119, 20–29. http://dx.doi.org/10.1016/j.dsr2.2014.03.021.

Miller, P.I., 2009. Composite front maps for improved visibility of dynamic sea-surface features on cloudy SeaWiFS and AVHRR data. J. Mar. Syst. 78 (3), 327–336. http://dx.doi.org/10.1016/j.jmarsys.2008.11.019.

Miller, P.I., Xu, W., Carruthers, M., 2015. Seasonal shelf-sea front mapping using satellite ocean colour and temperature to support development of a marine protected area network. Deep-Sea Res. Part II 119, 3–19. http://dx.doi.org/10.1016/j.dsr2.2014.05.013.

Pisoni, J.P., Rivas, A.L., Piola, A.R., 2015. On the variability of tidal fronts on a macrotidal continental shelf, Northern Patagonia, Argentina. Deep-Sea Res. Part II 119, 61–68. http://dx.doi.org/10.1016/j.dsr2.2014.01.019.

Shi, R., Guo, X., Wang, D.X., Zeng, L.L., Chen, J., 2015. Seasonal variability in coastal fronts and its influence on sea surface wind in the Northern South China Sea. Deep-Sea Res. Part II 119, 30–39. http://dx.doi.org/10.1016/j.dsr2.2013.12.018.

Shimada, T., Sakaida, F., Kawamura, H., Okumura, T., 2005. Application of an edge detection method to satellite images for distinguishing sea surface temperature fronts near the Japanese coast. Remote Sens. Environ. 98 (1), 21–34. http://dx.doi.org/10.1016/j.rse.2005.05.018.

Small, R.J., de Szoeke, S.P., Xie, S.-P., O'Neill, L., Seo, H., Song, Q., Cornillon, P., Spall, M., Minobe, S., 2008. Air–sea interaction over ocean fronts and eddies. Dyn. Atmos. Oceans 45 (3-4), 274–319. http://dx.doi.org/10.1016/j.dynatmoce.2008.01.001.

Vazquez, D.P., Atae-Allah, C., Luque-Escamilla, P.L., 1999. Entropic approach to edge detection for SST images. J. Atmos. Ocean. Technol. 16 (7), 970–979. http://dx.doi.org/10.1175/1520-0426(1999)016<0970:EATEDF>2.0.CO;2.

Igor M. Belkin *
Graduate School of Oceanography, University of Rhode Island, 215 South Ferry Road, Narragansett, RI 02882, USA
E-mail address: igormbelkin@gmail.com

Robert W. Helber
Naval Research Laboratory, Stennis Space Center, 1009 Balch Blvd., MS 39529, USA
E-mail address: robert.helber@nrlssc.navy.mil

Available online 10 August 2015

* Corresponding author.