Observing Systems Research Studies: Climate Phenomena and Impacts

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Table of Contents

1. Project Summary 1
2. Scientific and Observing System Accomplishments 2
3. Outreach and Education 3
4. Publications and Reports 4
   4.1. Publications by Principal Investigators 4
   4.2. Other Relevant Publications 5

1. Project Summary

The Observing System Research Studies group performs data and modeling studies to identify climatically significant ocean-atmosphere interaction patterns and indices that usefully characterize their amplitudes and their linkages to US and global weather anomalies, with the goals of improving our awareness and understanding of present climate conditions, the effectiveness of the global observing system for climate and helping society understand, forecast and project seasonal and longer term weather and climate anomalies. We provide guidance about the specific activities required of the global climate observing system to meet its goals as well as work to help understand developing user needs. Often this involves estimating the uncertainty in our present ability to make statements of scientific and societal relevance with the historical ocean and climate data sets.

We also work within the NOAA, US, international and intergovernmental ocean and climate organizations, with particular focus on the Global Climate Observing System program, the Joint Commission on Oceanography and Marine Meteorology and the CLIVAR program, to develop and advance agreed international plans for the climate observing system, standards for making the observations and for sharing data among all interested parties, and for internationally coordinated activities to exploit the data collected, for the good of all nations.

This project does not collect any observations, but does make ocean and climate information available via the State of the Ocean website at NOAA's Pacific Marine Environmental Laboratory, and collaboration with the Observing System Monitoring Center project led by Steve Hankin.

2. Scientific and Observing System Accomplishments

Group work has now lead to the publication of a manuscript that describes how outgoing longwave radiation (OLR) information over the tropical Pacific can be used to sort through the El Nino events identified by the commonly used SSTA definitions to separate those that are most likely to have a strong influence on U.S. weather from those that are not. Since, the tell-tale OLR behavior typically occurs before winter, considering this OLR behavior allows more skillful seasonal forecasts to be issued in the identified years than previously thought possible (Chiodi and Harrison, 2013a).

Progress has been made on work that extends the El Nino-impacts analysis of Chiodi and Harrison (2013) to global precipitation and also identifies a new OLR-based index for La Nina. Results show that, not just in the U.S., but globally as well, most of the useful seasonal weather associations are due to the subset of commonly identified El Nino and La Nina years that are distinguished by OLR behavior (Chiodi and Harrison, 2013c). Another interesting result is that the winter seasonal weather anomalies associated with La Nina are less statistically significant than those with El Nino, even for the OLR-based subset.

Group work has revealed novel asymmetries between the effects that El Nino and La Nina events have on the global carbon cycle. Our results confirm that both La Nina and El Nino can greatly affect the net change in atmospheric CO_2 seen in any given year, but reveal that the El Nino effects involve about twice as much concentration change and persist longer into the calendar year than the La Nina effects. Thus, efforts to better understand other sources of atmospheric CO_2 variability must properly account for those driven by La Nina and El Nino. A manuscript documenting these results, and thereby correcting some mistakes made in a previously published analysis of the historical La Nina and El Nino effects on atmospheric CO_2 change (that of Qian et al, 2008) has been accepted in Tellus B (Chiodi and Harrison, 2013b). This work makes available improved benchmarks for the ongoing development and evaluation of the carbon system behavior of Earth System Models.

We have continued to contribute to outreach about climate variability and trends to the global oceanic fishery management community. Group work has previously emphasized, with examples, the extent to which interannual to decadal variability will, in most places, dominate long term trends for the next couple of decades (Harrison and Carson, 2012). We have also now shown that because the El Nino-Southern Oscillation (ENSO) greatly affects several Pacific fisheries and the magnitude of ENSO variability is so strong that it will likely dominate environmental conditions in the tropical Pacific in the next few decades, compared to the 'climate change' projections from most coupled earth system models, fishery management decisions will have to be made in a context of very substantial uncertainty about upcoming environmental conditions (Harrison and Chiodi, 2013). Although this work is presented within the framework of tropical Pacific fisheries management implications, the fundamental result is much more widely applicable in climate science. In particular, it suggests strongly that efforts to identify changes in recent multi-decadal trends, as is a goal of the IPCC ARs, is very likely to be frustrated by low frequency natural variability.

Progress has been made on work that sorts through various classes of sub-seasonal tropical Pacific wind variability, and, through examination of their co-occurrence statistics, relationship with the observed warming of the equatorial Pacific, and effects on numerical ocean models, determines which are and are not important to improving our understanding of the processes that initiate El Nino events, and their predictability (Harrison et al. 2013). As we found our work with the Darwin SLP record, multi-decadal variability in tropical Pacific wind variability has consequences for the characteristics of El Nino events; the westerly wind events that are now familiar had different characteristics, on average, after the 97-98 El Nino and now are more likely to force Dateline events than Conventional events.

Our group has also begun work on a project that promises to improve our understanding of the processes that initiate La Nina events by examining the types of sub-seasonal wind variability that occur over the equatorial Pacific as the system transitions from its neutral to cool-anomaly (La Nina) state, as well as their effects on the upper layers of the tropical Pacific Ocean. Preliminary work has identified substantial surges in the easterly winds over the western and central tropical Pacific that occur during this transition that are followed by near-surface cooling in the equatorial Pacific Ocean waveguide. Composites of the wind stress anomalies associated with these easterly surges have also been shown to drive equatorial Pacific waveguide cooling, with amplitudes of a few tenths of a degrees C per event, when applied to realistic numerical models of the tropical Pacific. Although the easterly surges are seen in each of the wind data sets we have looked at, comparison of the available in situ wind measurements (from the Tropical Atmosphere Ocean, or "TAO" buoy array) with the wind data available from the current suite of numerical weather model reanalysis products has revealed some discrepancies that highlight the need for making sustained and accurate wind and upper ocean current measurements in this region.

The PI has continued to work nationally and internationally on the development of an initial suite of ocean subsurface climate indices that can be linked to familiar patterns of weather anomalies over land via the 'recurring patterns of climate variability'. The I-CLIVAR program has set up a task team to try to take development further in the next two years, working with the GSOP, GODAE/OceanView, and WGOceanModel Development.

The PI has continued to be active in the Global Climate Observing System and JCOMM and their efforts to advance sustained global scale observing in support of climate science, climate services and climate forecasting.

The PI has continued to chair the OAR/CPO Climate Observing System Council.

3. Outreach and Education

Group outreach efforts have included efforts, via publication of results and presentations at various national and international scientific conferences and workshops (such as are listed below) to inform various scientific communities about the relevant aspects of group research results.

Our group also partners with Steve Hankin's group to provide the State of the Ocean Climate website (http://stateoftheocean.osmc.noaa.gov), which gives an at-a-glance view of the amplitudes of ocean climate indices, along with estimates of their uncertainty, that can be linked to major patterns of climate variability.

The PI and/or co-P.I. have made the following presentations at national and international scientific conferences;

D.E Harrison, A.M. Chiodi and G.A. Vecchi, *Subseasonal Atmospheric Variability and El Niño waveguide warming; observed effects of the MJO and Westerly Wind Events*, The 2012 Fall AGU Meeting, 3-7 December 2012.

A.M. Chiodi and D.E. Harrison, *OLR-based El Niño and La Niña indices for impacts on global seasonal precipitation anomaly*. The 2012 Fall AGU Meeting, 3-7 December, 2012.
Chiodi, A.M. and D.E. Harrison, *El Niño and La Niña indices for impacts on global seasonal weather anomalies*, U.S. CLIVAR ENSO diversity workshop, Boulder CO, February 6-8, 2013

Harrison, D. E. and A.M. Chiodi, *Pre- and Post-1997/1998 Westerly Wind Events and Equatorial Pacific Cold Tongue Warming*, U.S. CLIVAR ENSO diversity workshop, Boulder CO, February 6-8, 2013.

Chiodi, A.M. and D.E. Harrison, *An OLR perspective on La Nina and El Nino precipitation impacts over North America*, U.S. CLIVAR ENSO diversity workshop, Boulder CO, February 6-8, 2013.

The work on using OLR information to improve seasonal forecasting skill has been well received by various conference attendees including some working for the Bureau of Reclamation and involved in South Florida Water Management. Following its publication in *J. Climate*, this work was highlighted in a NOAA press release and appeared in a front-page article in the "The Daily", the University of Washington's newspaper.

4. Publications and Reports

4.1. Publications by Principal Investigators

Published

Chiodi, A. M., and D.E. Harrison, 2013: El Niño impacts on seasonal U.S. atmospheric circulation, temperature and precipitation anomalies: The OLR-event perspective. *J. Climate*, **26**(3), doi: 10.1175/JCLI-D-12-00097.1, 822–837.

Harrison, D.E., and M. Carson, 2012: Recent sea level and upper ocean temperature variability and trends; Cook Islands regional results and perspective. *Climatic Change*, doi: 10.1007/s10584-012-0580-8.

In press

Chiodi, A. M. and D. E. Harrison, 2013: Comment on Qian et al. 2008; La Nina and El Nino composites of atmospheric CO_2 change. *Tellus B*

Submitted/In revision

Chiodi, A.M., and D.E. Harrison 2013: OLR-based El Niño and La Niña indices for impacts on global seasonal precipitation anomaly. *J. Climate*

Chiodi, A.M., D.E. Harrison, and G.A. Vecchi, 2013: Subseasonal atmospheric variability and El Niño waveguide warming; observed effects of the Madden-Julian Oscillation and Westerly Wind Events. *J. Climate*

D.E. Harrison and A.M. Chiodi, 2013: Multi-decadal variability and trends in the El Nino-Southern Oscillation and tropical Pacific fisheries implications, *Deep Sea Research II.*

Bond, N.A., A.M. Chiodi, N.K. Larkin, and J. Barbour, 2013: Summertime rainfall events in eastern Oregon and Washington.

4.2. Other Relevant Publications

This section includes a partial list of peer-reviewed papers that have appeared in print within the last year, been authored by scientists outside of our group, and cited recent (since 2005) work by the project P.I, or co-P.I.

Chand, S. S., J. L. McBride, K. J. Tory, et al., 2013: Impact of Different ENSO Regimes on Southwest Pacific Tropical Cyclones. *J. Climate*, **26**, 600-608.

Chung, P.-H. and T. Li, 2013: Interdecadal relationship between the mean state and El Nino types. *J. Climate*, **26**, 361-379.

DeWitte, B., J. Vazquez-Cuervo, K. Goubanova, et al., 2012: Change in El Nino flavours over 1958-2008: Implications for the long-term trend of the upwelling off Peru. *Deep-Sea Res. II*, **77-80,** 143-156.

Du Y.-G., J.-J. Song, and J.-P. Tang, 2013: Impacts of different kinds of ENSO on landfalling tropical cyclones in China. *J. Trop. Meteorol.*, **19**, 39-48.

Feng, J. and J. Li, 2013: Contrasting impacts of two types of ENSO on the boreal spring Hadley circulation. *J. Climate*, **26**, 4773-4789.

Garfinkel, C. I, M.M. Hurwitz, L. D. Oman, et al., 2013: Contrasting effects of central pacific and eastern pacific El Nino on stratospheric water vapor. *Geophys. Res. Lett.*, **40**, 4155-4120.

Gouretski, V., J. Kennedy, T. Boyer, et al. 2012: Consistent near-surface ocean warming since 1900 in two largely independent observing networks. *Geophys. Res. Lett.*, **39**, L19606, doi: 10.1029/2012/GL052975

Gu, G. and R.F. Adler, 2013: Interdecadal variability/long-term changes in global precipitation patterns during the past three decades: global warming and/or pacific decadal variability? *Climate Dynamics*, **40**, doi:10.1007/s00382-012-1443-8.

Guschina, D. and B. DeWitte, 2012: Intraseasonal tropical atmospheric variability associated with the two flavors of El Nino. *Mon. Wea. Rev.*, **140**, 3669-3681.

Ham, Y.-G., J.-S. Kug, J.-Y. Park, et al., 2013: Sea surface temperature in the north tropical Atlantic as a trigger for El Nino/Southern Oscillation events. *Nature Geosci.*, **6**, 112-116.

Hereid, K.A., T.M. Quinn and Y. M. Okumura, 2013: Assessing spatial variability in El nino-Southern Oscillation event detection skill using coral geochemistry. *Paleoceanography*, **28**, doi: 10.1029/2012PA002352.

Hsin, Y.C. and B. Qiu, 2012: The impact of Eastern Pacific versus Central-Pacific El Ninos on the North Equatorial countercurrent in the Pacific Ocean. *J. Geophys. Res. – Oceans*, **117**, C11017, doi: 10.1029/2013JC008362.

Johnson, N. C., 2013: How many ENSO flavors can we distinguish? *J. Climate*, **26**, 4816-4827.

Karori, M. A., J. Li, and F.-F. Jin, 2013: The asymmetric influence of the two types of El Nino and La Nina on summer rainfall over Southeast China. *J. Climate*, **26**, 4567-4582.

L'Heureux, M. L., D. C. Collins, and Z.-Z.Hu, 2013: Linear trends in sea surface temperature of the tropical Pacific Ocean and implications for the El Nino-Southern Oscillation. *Climate Dynamics*, **40,** 1223-1236.

Lee, T., D.E. Waliser, J.-L. F. Li, et al., 2013: Evaluation of CMIP3 and CMIP5 Wind Stress Climatology using satellite measurements and atmospheric reanalysis products. *J. Climate*, **16**, 5810-5826.

McGregor, S., N. Ramesh, P. Spence, et al. 2013: Meridional movement of wind anomalies during ENSO events and their role in event termination. *Geophys. Res. Lett.*, **40**, 749-754.
Ohba, M., 2013: Important factors for long-term change in ENSO transitivity. *Int. J. Climatology*, **33**, 1495-1509.

Omondi, P., J. L. Awange, L. A. Ogallo, et al.: 2013: The influence of low frequency sea surface temperature modes on delineated decadal rainfall zones in Eastern Africa region. *Ad. Water. Resources*, **54**, 161-180.

Park, T.-W., Y. Deng, and M. Cai, 2012: Feedback attribution of the El Nino-Southern Oscillation-related atmospheric and surface temperature anomalies. J. Geophys. Res.-Atmos., **117**, D23101 DOI: 10.1029/2012JD018468.

Pauline, M., F. Lott, L. Guez, et al., 2013: Tropical variability and stratospheric waves in the IPSLCM5 model. *Climate Dynamics*, **40**, 2331-2344.

Ren, H.-L. and F.-F. Jin, 2013: Recharge oscillator mechanisms in two types of ENSO. *J. Climate*, **26**, 6506-6523.

Sohn, B. J., S.-W. Yeh, J. Schmetz, et al., 2013: Observational evidences of Walker circulation change over the last 30 years contrasting with GCM results. *Climate Dynamics*, **40**, 1721-1732.

Susskind, J., M. Gyulla, L. Iredell, et al., 2012: Interannual variability of outgoing longwave radiation as observed by AIRS and CERES. *J. Geophys. Res.*, **117**, doi:10.1029/2012JD017997.

Tedeschi, R. G., I. F. A. Cavalcanti, and A. M. Grimm, 2013: Influences of two types of ENSO on South American precipitation. *Int. J. Climatology*, **6**, 1382-1400.

Trenary, L. L. and W. Han, 2013: Local and remote forcing of decadal sea level and thermocline depth variability in the South Indian Ocean. *J. Geophys. Res.-Oceans*, **118**, 381-398.

Wang, C., Li, C., Mu, M., et al., 2013: Seasonal modulations of different impacts of two types of ENSO events on tropical cyclone activity in the western North Pacific. Climate Dynamics, 40, 2887-2902.

Wang, C., and X. Wang, 2013: Classifying El Nino Modoki I and II by different impacts on rainfall in Southern China and typhoon tracks. *J. Climate*, **26**, 1322-1338.

Wu, C.-R. and L.-C. Wang, 2013: Contrasting the evolution between two types of El Nino in a data assimilation model. *Ocean Dynamics*, **63**, 577-587.

Xiang, B., Wang, B., and T. Li, 2013: A new paradigm for the predominance of standing Central Pacific Warming after the late 1990s. *Climate Dymanics*, **41**, 327-340.

Xue, Y., M. Chen, A. Kumar et al., 2013: Prediction skill and bias of tropical Pacific sea surface temperatures in the NCEP climate forecast system Version 2. *J. Climate*, **26**, 5358-5378.

Yadav, R. K., D. A. Ramu,, and A. P. Dimri, 2013: On the relationship between ENSO patterns and winter precipitation over North and Central India. Global and Planetary Change, **107**, 50-58.

Yu Y., J. He, W. Zheng,, et al., 2013: Annual cycle and interannual variability in the tropical pacific as simulated by three versions of FGOALS. *Adv. Atmos. Sci.*, **30**, 621-637.

Yu, J.-Y. and S. T. Kim, 2013: Identifying the types of major El Nino events since 1870. *Int. J. Climatology*, **33**, 2105-2112.

Yu, J.-Y., and Y. Zou, 2013: The enhanced drying effect of Central-Pacific El Nino on US winter. *Env. Res. Lett.*, **8**, doi: 10.1088/1748-9326/8/1/014019.

Yuan, Y. and S. Yang, 2012: Impacts of different types of El Nino on the East Asian climate: focus on ENSO cycles. *J. Climate*, **25**, 7702-7722.

Yuan, Y., S. Yang, and Z. Zhang, 2012: Different evolutions of the Philippine Sea anticyclone between the Eastern and Central Pacific El Nino: Posiible effects of Indian Ocean SST. *J. Climate*, **25**, 7867-7883.

Yumul, G. P., Jr., C.B. Dimalanta, N. T Servando et al., 2013: Abnormal weather events in 2009, increased precipitation and disastrous impacts in the Philippines. *Climatic Change*, **118**, 715-727.

Zhang, W., Graf, H. -F., Leung, Y., et al., 2012: Different El Nino types and tropical cyclone landfall in East Asia. *J. Climate*, **25**, 6510-6523.

Zhuang, W., M. Feng, Y. Du, et al., 2013: Low-frequency sea level variability in the southern Indian Ocean and its impacts on the oceanic meridional transports. *J. Geophys. Res.-Oceans*, **118**, 1302-1315.