Centre for Southern Hemisphere Oceans Research

Understanding Present and Future Dynamics of ENSO, IOD, and their interactions with the Southern Ocean

23 July 2020
Team members

Dr Wenju Cai  
Dr Guojian Wang  
Dr Agus Santoso  
Dr Benjamin Ng

Dave Bi  
+ 1 postdoc to be recruited

Collaborators: Lixin Wu, Mike McPhaden, Toshio Yamagata, Mat Collins, and many others
Objectives:

1. to understand **how ENSO and IOD events are generated**, in particular, how they attain extreme amplitude, how they interact with each other and with the Southern Hemisphere oceans.

2. examine the **causes for decadal modulation of ENSO and IOD characteristics**, and the potential role of Southern Hemisphere oceans.

3. project **changes in ENSO and the IOD under greenhouse warming**, as well as their **interactions and teleconnection**, and assess uncertainty in the projected change.

4. improve **understanding of model deficiencies** in simulating processes of extreme ENSO and IOD events, and the ramifications on their future projections.
Project highlights in 2020
Climate impacts of the El Niño–Southern Oscillation on South America

Wenju Cai1,2,21,2, Michael J. McPhaden4, Alice M. Grim4, Regina R. Rodrigues5, Andréa S. Taschetto4, René D. Carreaud1,6, Boris Dewitte9,10,11,12, Germán Poveda1,8, Yoo-Geun Ham14, Agus Santos12,6, Benjamin Ng1, Weston Anderson15, Guojian Wang1,2, Tao Geng1,2, Hyun-Su Jo3, José A. Marengo16, Lincoln M. Alves17, Marisol Osmár18,19, Shujun Li1,2, Lixin Wu4, Christina Karamperidou20, Ken Takahashi21, and Carolina Vera16,19

Abstract | The climate of South America (SA) has long held an intimate connection with El Niño, historically describing anomalously warm sea-surface temperatures off the coastline of Peru. Indeed, throughout SA, precipitation and temperature exhibit a substantial, yet regionally diverse, relationship with the El Niño–Southern Oscillation (ENSO). For example, El Niño is typically accompanied by drought in the Amazon and north-eastern SA, but flooding in the...
A large community project on ENSO research spearheaded by CSHOR
21 Chapters, 98 Authors

ENSO Science Symposium, CSHOR, Hobart, January 2019
Book Meeting February, CSHOR, Hobart, February 2019
13

ENSO Response to Greenhouse Forcing

Wenju Cai\textsuperscript{1,2}, Agus Santoso\textsuperscript{2,3}, Guojian Wang\textsuperscript{1,2}, Lixin Wu\textsuperscript{1}, Mat Collins\textsuperscript{4}, Matthieu Lengaigne\textsuperscript{5}, Scott Power\textsuperscript{6} and Axel Timmermann\textsuperscript{7,8}

ABSTRACT

How ENSO responds to an increasing concentration of greenhouse gases in the atmosphere has remained an elusive issue for decades. Climate models produce widely diverging results based on the traditional sea surface temperature (SST) metrics of ENSO. Some models show stronger ENSO, some weaker, some show no clear change. Steering away from these static measures, but more carefully examining the underlying processes and the associ-

Figure 13.1 Schematic of tropical Pacific mean-state changes due to greenhouse forcing. Red arrows and red

Figure 13.4 Eastern Pacific El Niño events defined by SST anomalies, and their projected changes under future


https://doi.org/10.1175/JCLI-D-19-0376.1.
Indian Ocean Dipole in CMIP5 and CMIP6: Characteristics, biases, and links to ENSO

Sebastian McKenna1,*, Agus Santoso1,2,*, Alexander Sen Gupta1, Andréa S. Taschetto1, Wenju Cai2,3

(Scientific Reports, 10, 11500, doi: 10.1038/s41598-020-68268-9)

Slightly stronger IOD and ENSO amplitude going from CMIP5 to CMIP6

Worse (underestimated) IOD skewness in CMIP6

Nino3 skewness is still underestimated in CMIP6
Indian Ocean Dipole in CMIP5 and CMIP6: Characteristics, biases, and links to ENSO

Sebastian McKenna¹,*, Agus Santoso¹-²,*, Alexander Sen Gupta¹, Andréa S. Taschetto¹, Wenju Cai²,³

(Scientific Reports, 10, 11500, doi: 10.1038/s41598-020-68268-9)

Change in the relationship between IOD amplitude with SST climatology across models

CMIP5

Stronger IOD corresponds with colder eastern Indian Ocean and eastern Pacific Ocean

CMIP6

Stronger IOD corresponds with warmer western Pacific Ocean
Indian Ocean warming modulates global atmospheric circulation trends

Shreya Dhame¹ · Andréa S. Taschetto¹ · Agus Santoso¹,² · Katrin J. Meissner¹

¹ Climate Change Research Centre and ARC Centre of Excellence for Climate Extremes, University of New South Wales, Sydney, Australia
² Centre for Southern Hemisphere Oceans Research (CSHOR), CSIRO Oceans and Atmosphere, Hobart 7004, Australia

AGCM experiments with uniform SST trend vs observed trend

- Indian Ocean warming across the entire basin drives strengthening of the Pacific Walker Circulation, Atlantic drying, and trends in extratropical modes of variability
- The spatially varying warming trend is important for changes in rainfall over the basin and Hadley circulation.
The Pacific Decadal Oscillation less predictable under greenhouse warming

Shujun Li\textsuperscript{1,2}, Lixin Wu\textsuperscript{1\ast}, Yun Yang\textsuperscript{3}, Tao Geng\textsuperscript{1,2}, Wenju Cai\textsuperscript{1,2\ast}, Bolan Gan\textsuperscript{1}, Zhaohui Chen\textsuperscript{1}, Zhao Jing\textsuperscript{1}, Guojian Wang\textsuperscript{1,2} and Xiaohui Ma\textsuperscript{1}

Reduced PDO predictability with increasing greenhouse forcing due to increased stratification leading to faster oceanic Rossby wave propagation which sets the timescale of PDO.
Media and Outreach Activities in 2020

- Wenju Cai interviewed by ABC, National Geographic and Science News on Indian Ocean Dipole and global warming.

- Agus Santoso in live TV interview with Channel News Asia (2 January 2020), providing his perspectives on the Australian bushfires and flooding in Jakarta.

- Wenju Cai and Agus Santoso in a CarbonBrief online article looking at the possible causes of the recent locust swarms.
Conferences

• **AMOS 2020, Fremantle**: CSHOR session chaired by Agus Santoso, Guojian Wang, Benjamin Ng, and Ming Feng. AMOS plenary talk by Wenju Cai: “Positive Indian Ocean Dipole and El Nino under greenhouse warming”. Other presentations: “Pan-tropical climate interactions” (Wenju Cai); “Stabilised frequency of extreme positive Indian Ocean Dipole under 1.5 °C warming” (Guojian Wang); “Linkage between Indian Ocean Dipole Asymmetry and Southeastern Indian Ocean Upwelling” and “Intermodel relationships between Southern Ocean surface temperature and global climate” (Agus Santoso); “Internal climate variability and impacts of greenhouse warming on the El Niño-Southern Oscillation” (Benjamin Ng).

• Agus Santoso presented 2 talks at **100th American Meteorological Society Annual Meeting 2020** in Boston, and received the AMS Editor’s award. His service as *J. Climate* associate editor has been renewed for another term.

• Wenju Cai and Guojian Wang attended the **Ocean Sciences 2020**. Wenju Cai presented “Increased variability of eastern Pacific El Nino under greenhouse warming”.


AOGS 2020, South Korea – Cancelled (COVID-19)

AS7. Indo-Pacific Climate Variability and Its Teleconnection to Southern Hemisphere

Conveners: Agus Santoso, Xuebin Zhang, Xiaopei Lin, Guojian Wang

39 presentations (8 invited)

Postponed to next NH summer

3rd Summer School on Theory, Mechanisms and Hierarchical Modeling of Climate Dynamics: Tropical Oceans, ENSO and their Teleconnections

3 - 14 August 2020
Trieste, Italy

Speakers:

S. BORDONI, University of Trento
M. CANE, Columbia University
A. CAPOTOND, University of Colorado and NOAA/ESRL
R. CHATTERJEE, Indian Institute of Tropical Meteorology
A. CHERCHI, INGV
E. GLYVARDI, LOCEAN/IPSIL
F-E. JIN, University of Hawaii
I.-S. KANG, SIO
B. KIRTMAN, University of Miami
M. L’HÉREUX, NOAA
M. LENGAIGNE, Institut de recherche pour the developpement (IRD)
M. MCPHADEN, Pacific Marine Environmental Laboratory
F. MOLTENI, ECMWF
A. MOURA, INPE
A. SANTOSO, CSIRO
E. SARACHIK, University of Washington
C. WANG, Chinese Academy of Sciences
A. WITZENBERG, Geophysical Fluid Dynamics Laboratory
S.-F. XIE, Scripps Institution of Oceanography, UCSD

AMOS 2021 (Melbourne)

Postponed to next NH summer
El Niño Southern Oscillation in a Changing Climate

Conveners: Agus Santoso, Mike McPhaden, Antonietta Capotondi, Andrew Wittenberg

Keynote speakers: Wenju Cai, Kim Cobb

In collaboration with the CLIVAR Pacific Region Panel

Section: Ocean Sciences | Co-organized: Global Environmental Change
2020-2021 Outlook

• Postdoc recruitment

• Further investigating observed changes in ENSO and IOD and their future projections

• Investigating 2019 positive IOD and impact of Indian Ocean long-term warming

• Investigating tropical variability interactions with Southern Hemisphere Oceans

• Examining impact of tropical variability in Southern Ocean heat uptake
A unique feature of the 2019 extreme positive Indian Ocean Dipole event

Guojian Wang, Wenju Cai, Kai Yang, Agus Santoso and Toshio Yamagata

Heat budget terms off Sumatra-Java (EEIO)

Large anomalous negative air-sea heat flux in 2019
Increasing wind speed

Increasing evaporation

• Mean-state changes reminiscent to model projections that support increasing occurrences of extreme positive IOD.

• We will investigate whether the processes associated with 2019 pIOD are projected to be more rigorous under greenhouse forcing.

Wang et al. (2020)