Investigating sea surface temperature impacts on Philippine climate in CORDEX-SEA simulations

Angela Monina T. Magnaye[1*], Larry Ger B. Aragon[1**], Julie Mae B. Dado[1], Faye T. Cruz[1], Lyndon Mark P. Olaguera[1,2], Gemma T. Narisma[1,2], Fredolin Tangang[3,4], Liew Juneng[3], Thanh Ngo-Duc[5], Tan Phan-Van[6], Jerasorn Santisirisomboon[4], Patama Singhruck[7], Dodo Gunawan[8], Edvin Aldrian[9], and Ardhasena Sopaheluwakan[10]

1 Regional Climate Systems Laboratory, Manila Observatory, Philippines
2 Physics Department, School of Science and Engineering, Ateneo de Manila University, Philippines
3 Department of Earth Sciences and Environment, Universiti Kebangsaan Malaysia, Malaysia
4 Ramkhamhaeng University Center of Regional Climate Change and Renewable Energy (RU-CORE), Ramkhamhaeng University, Thailand
5 Department of Space and Applications, University of Science and Technology of Hanoi, Vietnam Academy of Science and Technology, Vietnam
6 Department of Meteorology and Climate Change, VNU University of Science, Vietnam
7 Department of Marine Science, Faculty of Science, Chulalongkorn University, Thailand
8 State College of Meteorology Climatology and Geophysics, Indonesia
9 Center for Climate and Atmosphere, National Agency for Research and Innovation (BRIN), Indonesia
10 Center for Research and Development, Agency for Meteorology, Climatology and Geophysics (BMKG), Indonesia
* Current affiliation: Graduate School of Life and Earth Sciences, University of Tsukuba, Japan (**email: s2230303@u.tsukuba.ac.jp**)
** Current affiliation: School of Geography, Earth and Atmospheric Sciences, The University of Melbourne, Victoria, Australia

Abstract: Models with well-represented SST surrounding the Philippines also have well-represented Philippine climate. Rainfall biases in the Philippines may be related to moisture transport and boundary layer stability. Underestimated (overestimated) SST with cold (warm) and dry (moist) biases with underestimated (overestimated) winds may contribute to less (more) simulated rainfall.

1 Introduction

- Sea surface temperature (**SST**) from global climate models (GCMs) generally have **cold biases** surrounding the Philippines, but some have warm biases (e.g. MPI-ESM-MR with cold (warm) biases over east (west) of the Philippines during December-February (DJF) (June-August (JJA))
- **GCMs best representing SSTs** (e.g. minimal bias) surrounding the Philippines have **well simulated Philippine climate** while GCMs with poorly represented SSTs have poorly simulated climate (Fig. 1)
- Downscaling with **RegCM** improved biases (~52% of model results) compared to GCMs (~44% of model results) (Fig. 1)

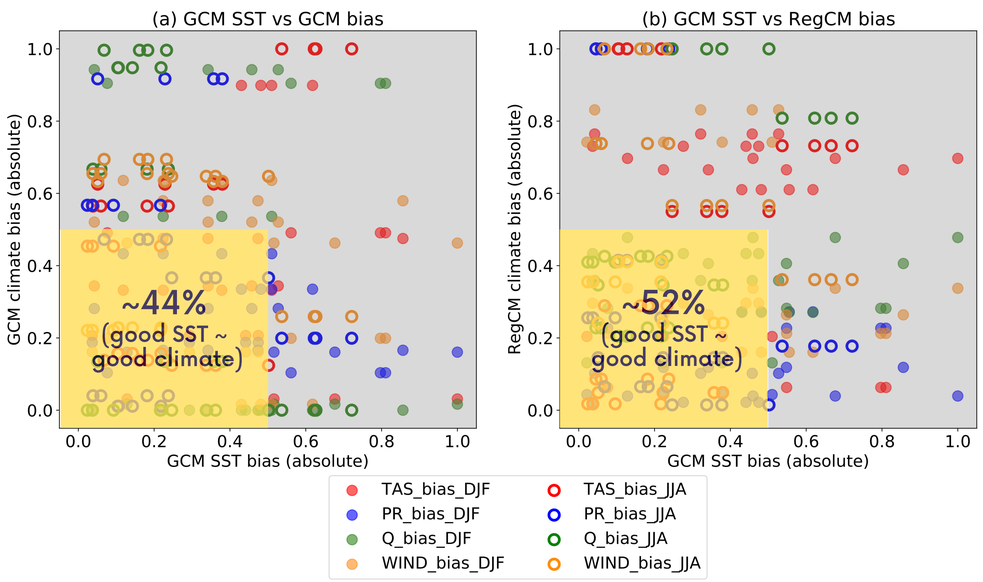


Fig. 1. Summary of GCM SST biases versus a) GCM and b) RegCM climate biases [1]

2 Rainfall biases present in simulations with well-represented SST

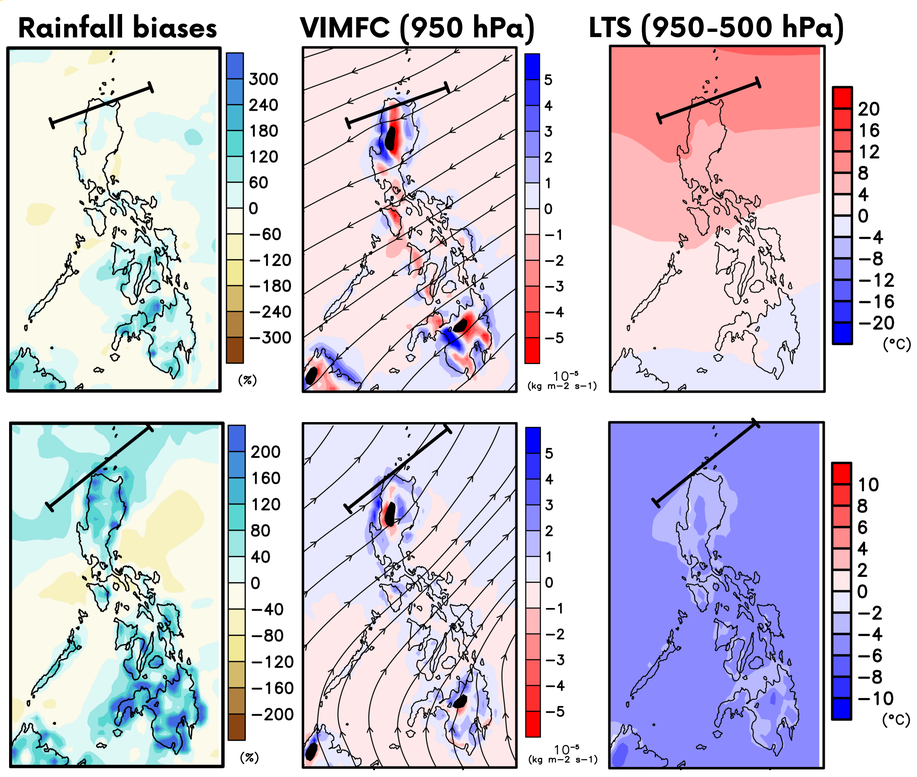


Fig. 2 Rainfall biases of RegCM(MPI-ESM-MR), vertically integrated moisture flux convergence (VIMFC) from 1000 to 925 hPa, and lower tropospheric stability (LTS) from 950 to 500 hPa during DJF and JJA [2]

- Example of **well-simulated climate with well-represented SST** using **MPI-ESM-MR downscaled with RegCM**, analyzed from 1998-2005 during DJF and JJA seasons (Fig. 2)
- **Moisture transport** from sea to land shows **topographic effect** with increase in moisture on coastal areas and windward side (DJF, JJA)
- **Overestimated rainfall** may be related to more **unstable atmospheric conditions** (south Philippines during DJF, all areas during JJA) and vice versa (northern Philippines during DJF)

Acknowledgments:
- Asia Pacific Network for Global Change Research (ARCP2013-17NMYTangang, ARCP2014-07CMY-Tangang, ARCP2015-04CMY-Tangang)
- Department of Science and Technology – Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD) project number 2018-03675
- AMT Magnaye is supported by JST-SPRING Grant Number JPMJSP2124.

3 Atmospheric conditions

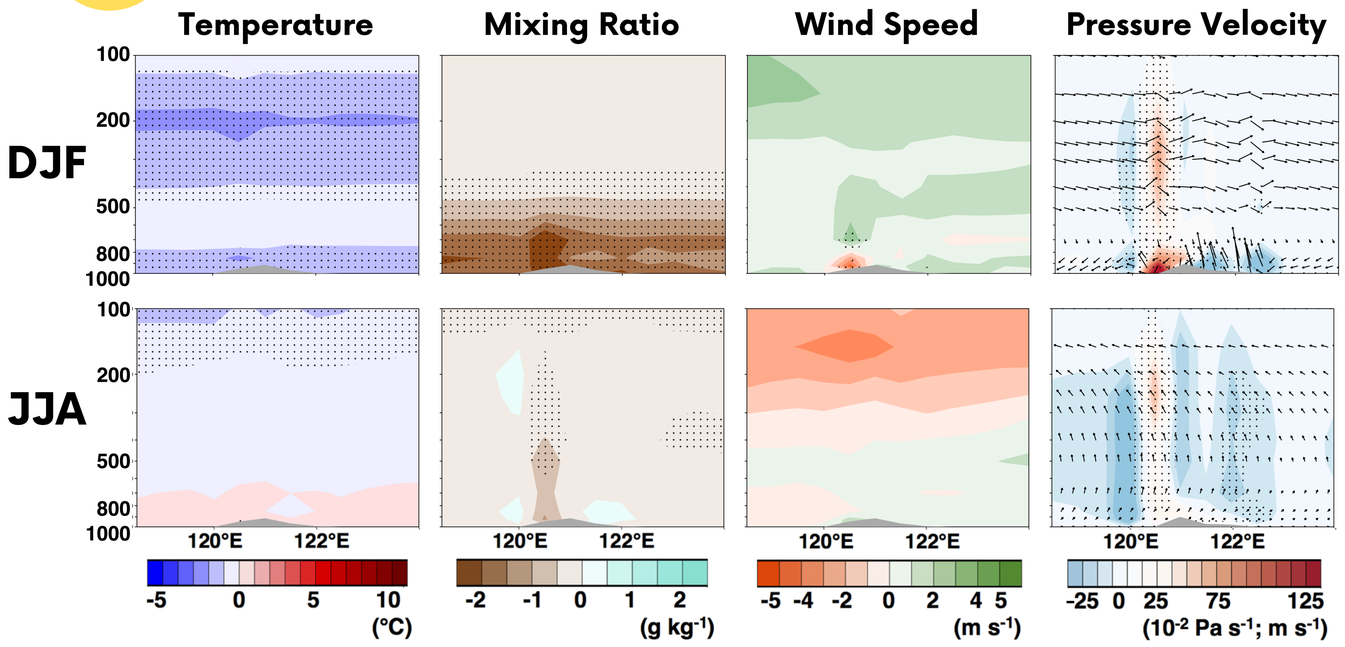
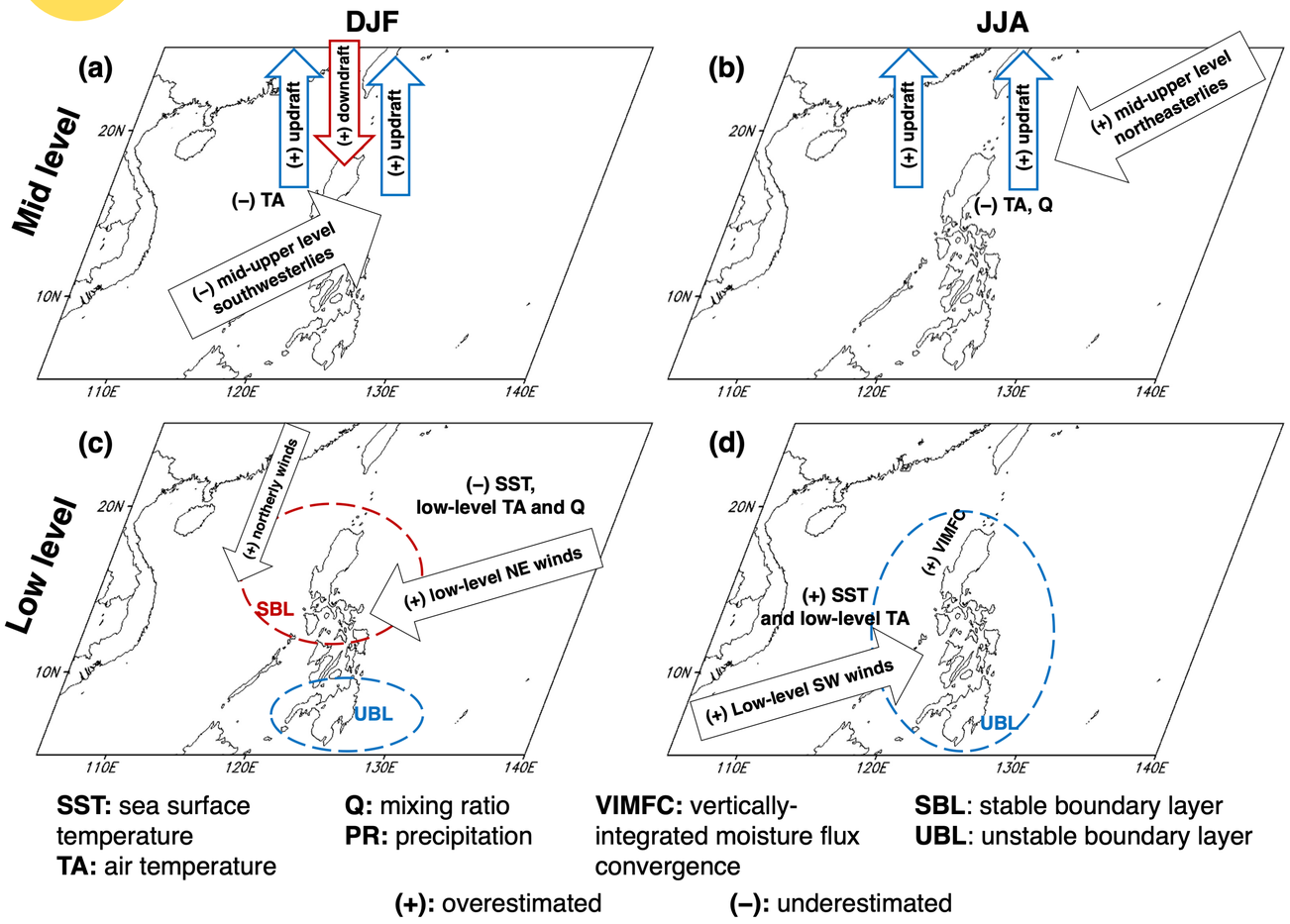


Fig. 3. Vertical profile (from transect in Fig. 2) of differences between simulations RegCM(MPI-ESM-MR) and RegCM(ERA-Interim) of temperature, mixing ratio, wind speed, and pressure velocity during DJF and JJA [2]

- **DJF**: near-surface **cold and dry biases** with **underestimated** horizontal **wind speed** and **downdrafts** at leeward side of mountain may contribute to **underestimated rainfall**; overestimated rainfall may be due to updrafts near the coast and windward side
- **JJA**: **updrafts** reaching up to 200 hPa with weak downdraft possibly due to southwest monsoon reaching until the eastern side may contribute to **overestimated rainfall** over whole transect (see Fig. 2)

4 Proposed mechanism and summary



SST: sea surface temperature
TA: air temperature
Q: mixing ratio
PR: precipitation
VIMFC: vertically-integrated moisture flux convergence
(+): overestimated
(–): underestimated
SBL: stable boundary layer
UBL: unstable boundary layer

Fig. 4. Schematic diagram of proposed mechanisms for simulated conditions from RegCM(MPI-ESM-MR) from 1998-2005 [2]

- **For the case of RegCM(MPI-ESM-MR):** well-represented SST with well-simulated climate [1,2]
- During **DJF**, **underestimated SST**, low-level TA and Q combined with overestimated low level NE winds and SBL possibly contributed to **underestimated rainfall** in northern Philippines
- During JJA, **overestimated SST** and low-level TA with overestimated SW winds, combined with UBL may have resulted to **overestimated rainfall**
- Regardless of season, **overestimated updrafts** reach until mid level which may be due to MIT-Emanuel convection scheme used in the GCM-driven simulations

This work is dedicated to our dearly beloved Prof. Gemma Narisma.

References:
[1] AMT Magnaye et al. (2021). Int J Climatol. https://doi.org/10.1002/joc.7440
[2] AMT Magnaye et al. (2023). Clim Dyn. https://doi.org/10.1007/s00382-023-06826-3