Effect of tropical instability waves on the eastern tropical Pacific basin: damping of TIWs in a high-resolution ocean circulation model.

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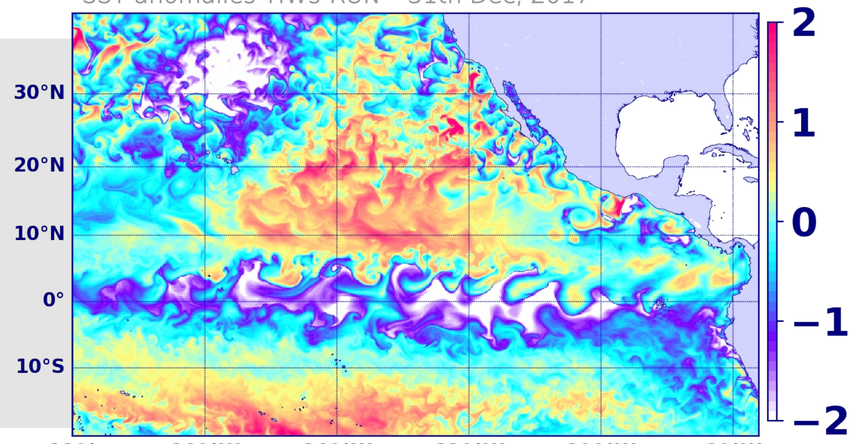
1 Tropical Instability Waves (TIWs)

Discovered in 1977 in the Pacific by R. Legeckis[1], TIWs are **westward propagating oceanic features** initiated by meridional temperature gradient and current shear.
TIWs are **seasonally and interannually modulated**, being stronger in spring and during La Niña events. In return, TIWs **advect heat meridionnally**, warming up the cold tongue and cooling down off-equatorial waters. This redistribution of heat **impacts the eastern tropical pacific mean state**, as well as **ENSO**[2]. TIWs are likely to participate to the El Niño/La Niña asymmetry (i.e. stronger El Niños than La Niñas)[3]

SST anomalies TIWs-RUN – 31th Dec, 2017



2 Aim of our study

An **eddy-rich is deemed to be required to simulate TIWs** and to our knowledge, their effect has only been isolated by comparing coarse resolution models (e.g., 1°) to eddy-rich models. Therefore the **role of TIWs in modulating the oceanic mean state and climatic signals is still an open question**. In this study, to better answer to this question, an **eddy-rich model has been configurated** over the Eastern Pacific Ocean. Two simulations are carried out: a control run (TIWS-RUN) where **TIWs are free to develop**, and an additional run (NOTIWS-RUN) where **TIWs are selectively damped**.

3 Modeling framework

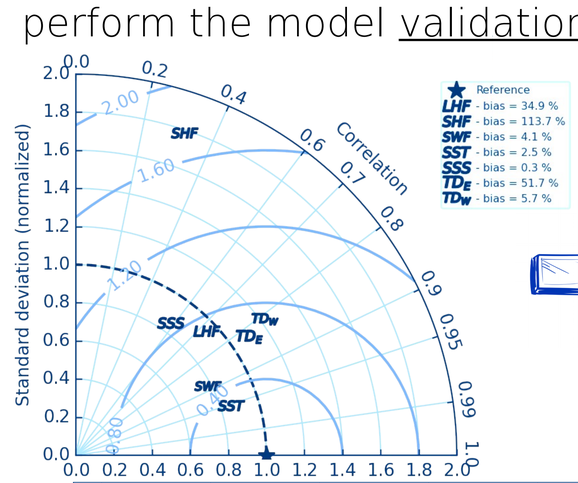
Tropical Eastern Pacific | 40-yrs (1980-2019) | ocean model CROCO 1/12°
atmo. forcing CFSR & CFSv2 | Open boundaries and initial conditions SODA 3.4.2 | 7-yrs spinup

- 2 simulations -

• TIWS-RUN •

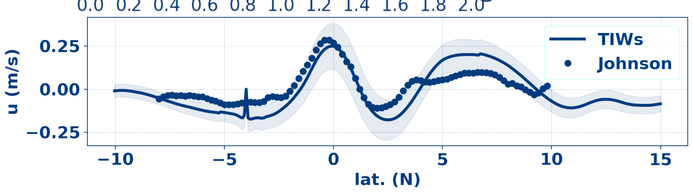
TIWs are free to develop
This is the control simulation in which we perform the model validation

Taylor diagram Obs: SODA3.4.2, TROPFLUX, QUICKSCAT, Johnson currents Averages over the equatorial band (2S-2N), and distinction West/East for thermocline depth (20°C)



Biases in tracers and vertical structure (weak upwelling) most likely due to the forcing set[5] and resulting in flux biases.
Very good zonal circulation

Vertically averaged zonal current bw 0-400m at 155°W – 40-yrs avg. Obs: Johnson et al. 2002



VS

• NOTIWS-RUN •

TIWs are damped
using an online nudging of meridional currents toward monthly climatology estimated from TIWs-RUN

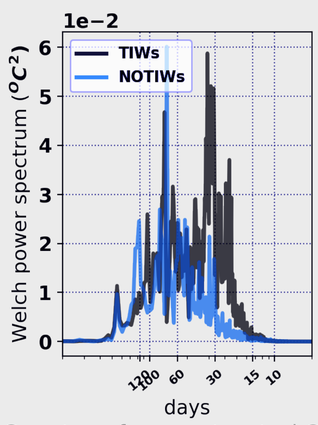
Nudging applyed to TIWs active region only (Max. in the first 100m depth, at 1°N; decreases below & poleward)

Meridional current — monthly,climatology

$$\frac{dv}{dt} = f(v) + G(x,y,z)\frac{v_0(t) - v(t)}{\tau}$$

All other processes — Nudging time-scale, 5 days

4 Does it work ?

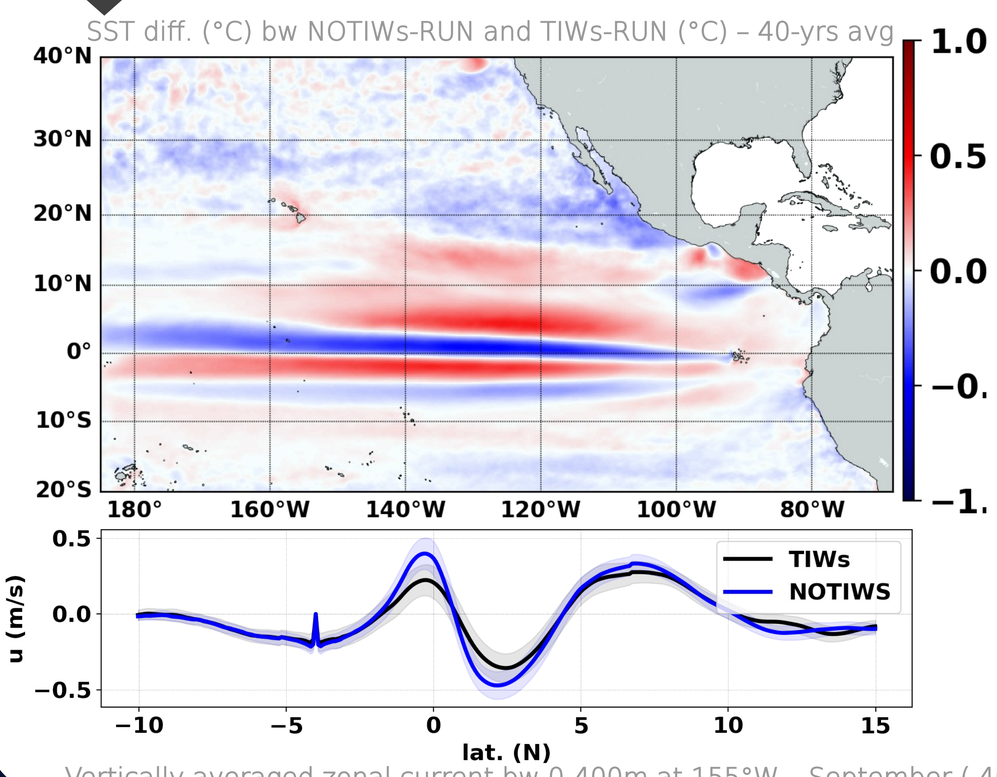


Spectra of reconstructed SSTa at 2°N,130°W from 3 first CEOF modes

TIWs are **removed** (30-days peak) while other components are almost not impacted

5 First Insights

SST diff. (°C) bw NOTIWs-RUN and TIWs-RUN (°C) – 40-yrs avg



Vertically averaged zonal current bw 0-400m at 155°W – September (40-yrs avg)

The **stronger temperature gradient** reveals the importance of TIWs in meridionnal advection of heat.

The **strenghtening of zonal circulation** is consistent with a TIWs generation by barotropic instability (current shear)

6 Perspectives

TIWs are successfully removed from the simulation, whithout altering the model physics. Next, a **heat budget** comparison will be performed to study the rectified effect of TIWs on the heat distribution in the tropical pacific ocean. The **link between ENSO and TIWs** will also be diagnosed, as these waves are thought to be partly responsible for the El Niño/La Niña asymmetry. Using this methodology, we aim at developping an **accurate TIWs parameterization** for global Earth models which have a too coarse spatial resolution to resolve these waves.

References: *1 - Legeckis, R. « Long Waves in the Eastern Equatorial Pacific Ocean: A View from a Geostationary Satellite ». Science 197, nº 4309 (16 septembre 1977): 1179-81. https://doi.org/10.1126/science.197.4309.1179. 2 - Willett, Cynthia S., Robert R. Leben, et Miguel F. Lavín. « Eddies and Tropical Instability Waves in the Eastern Tropical Pacific: A Review ». Progress in Oceanography 69, nº 2-4 (mai 2006): 218-38. https://doi.org/10.1016/j.pocean.2006.03.010. 3 - An, Soon-Il. « Interannual Variations of the Tropical Ocean Instability Wave and ENSO ». Journal of Climate 21, nº 15 (1 août 2008): 3680-86. https://doi.org/10.1175/2008JCLI1701.1. 4 - Graham, Tim. « The Importance of Eddy Permitting Model Resolution for Simulation of the Heat Budget of Tropical Instability Waves ». Ocean Modelling 79 (juillet 2014): 21-32. https://doi.org/10.1016/j.ocemod.2014.04.005. 5 - Dolinar, Erica K., Xiquan Dong, and Baike Xi. 'Evaluation and Intercomparison of Clouds, Precipitation, and Radiation Budgets in Recent Reanalyses Using Satellite-Surface Observations'. Climate Dynamics 46, no. 7–8 (April 2016): 2123–44. https://doi.org/10.1007/s00382-015-2693-z.* *Pictures*: *Andrew Doane (waves), Marcel Dornis(arrow) and iconcheese (check) from Noun Project*