High-resolution regional modeling of eastern Pacific climate

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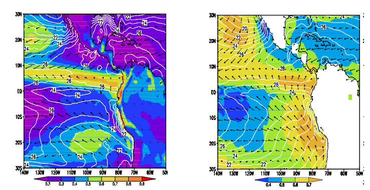
Introduction. The Eastern Pacific is home to El Nino, and its climate is characterized by strong asymmetry in both the north-south and east-west directions. Global coupled climate models suffer large biases in this climatically important region, notably in their failure to maintain the intertropical convergence zone (ITCZ) north of the equator and to simulate a realistic annual cycle in equatorial sea surface temperature (SST), both features important for El Nino. IPRC, in collaboration with FRCGC, have developed a coupled regional ocean-atmosphere model (ROAM) for the eastern Pacific that have been integrated for several years on Japan's Earth Simulator. This poster highlights the control simulation in comparison with observations.

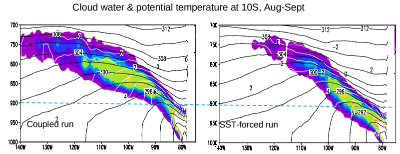
Rationales for regional modeling

- Eastern Pacific processes are key to establishing basin-wide climatic asymmetry and equatorial annual cycle, including geometry of South America and air-sea interaction that involves the ITCZ, upwelling and stratus cloud.
- High resolution is needed to represent mesoscale features such as narrow mountain ranges, ITCZ and the equatorial front.

iROAM cloudiness (radiatively defined) | COADS annual-mean climatology



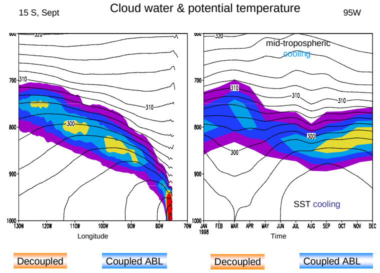
Cloud water & potential temperature at 10S, Aug-Sept



Warm SST biases in the coupled run lift the cloud base east of 100W

Cloud regime transition in space and time

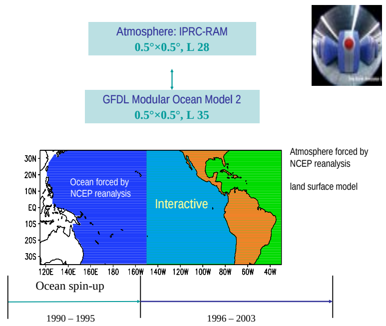
15 S, Sept | Cloud water & potential temperature | 95W

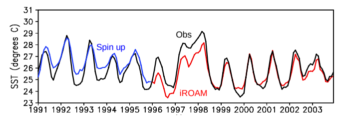


Coupled ABL: over cold water, cloud layer forms in the mixed layer

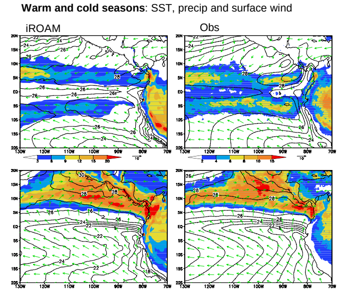
Decoupled ABL: over warm water, cloud base is separated from mixed layer by a stable layer ← moisture transport by shallow cumulus convection.

IPRC Regional Ocean-Atmosphere Model (iROAM) on ES





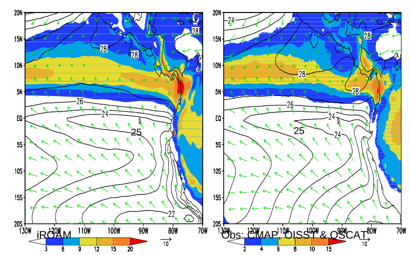
Warm and cold seasons: SST, precip and surface wind



March
- Double ITCZ
- Orographic effect on the northern ITCZ

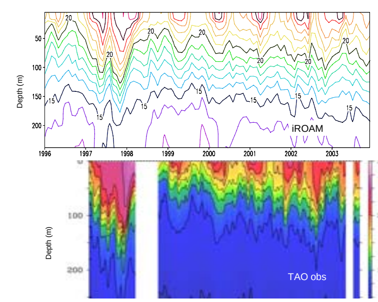
September
- Cold tongue

Annual-mean climatology: SST, precipitation and surface wind



The iROAM successfully captures the climatic asymmetry about the equator (the northward-displaced ITCZ), and the equatorial cold tongue. It also realistically simulates the seasonal migration of the ITCZ and the annual cycle on the equator.

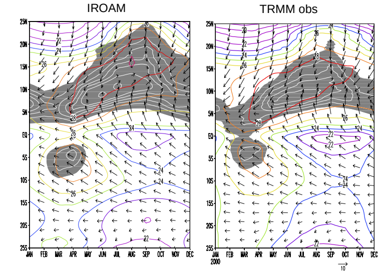
Temperature at 110W, EQ



Little annual variations in thermocline depth in contrast to El Nino

Seasonal Cycle

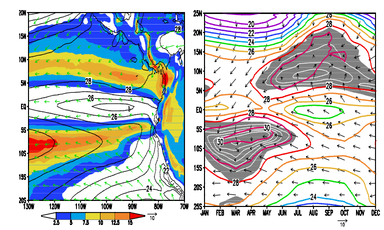
SST (contours), surface wind vectors & precip (gray shade)



ITCZ's meridional migration (125-95W), with a double ITCZ for a brief period of Mar-Apr)

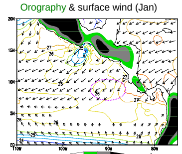
Importance of internal feedback:

The model produces a double ITCZ when cloud-radiative effect is suppressed in the Southern Hemisphere despite realistic lateral forcing



Left: Annual-mean SST, precipitation and surface wind velocity. Right: Time-latitude section averaged in 120-100°W.

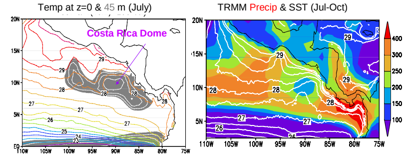
Orography & surface wind (Jan)



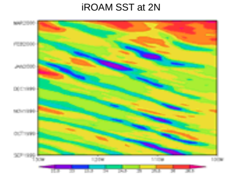
Gap winds and ocean dome

Papagayo wind jet → Thermocline dome → Cool spot in summer

Temp at z=0 & 45 m (July) | TRMM Precip & SST (Jul-Oct)



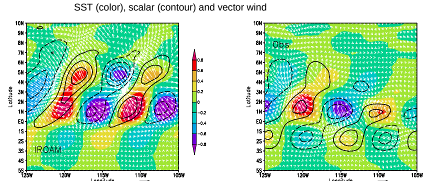
iROAM SST at 2N



Tropical Instability Waves

Instability of equatorial currents → Meanders of equatorial front → Wind & cloud response

SST (color), scalar (contour) and vector wind



Summary

The iROAM simulates reasonably well key features of east Pacific climate, including the northward-displaced ITCZ, cold tongue, their seasonal variations, stratus cloud deck and cloud regime transition in the South Pacific, mesoscale features included by narrow mountains and ocean dynamics. The model will be used to study physical processes responsible for biases of global model simulations.

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References

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Wang, Y., H. Xu, and S.-P. Xie, 2004: Regional model simulations of marine boundary layer clouds over the Southeast Pacific off South America. Part II: Sensitivity experiments. *Mon. Wea. Rev.*, **132**, 2650–2668.

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