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Understanding coupled model errors in the tropical Pacific using initialised hindcasts and a lead time analysis

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Seasonal and decadal hindcasts of the last decades can provide a powerful test to understand the development of biases in IPCC-class CGCMs. The classical analysis of ENSO in IPCC- type integrations (either basic statistics or more advanced evaluation of feedbacks) usually concentrates on long (at least multi-decadal) stabilized time series statistics needed to compute robust signals. Yet, this strategy cannot fully explain how the model's errors were generated in the first place. Since seasonal and decadal forecasts are initialized closed to the observations, and their errors grow with time integration, they offer an ideal framework to obtain the time scale of errors, to study the sequence of biases apparition and to find their origin.

Such a lead time analysis was applied to the IPSL-CM5A-LR coupled model. The SST in the tropical Pacific exhibits four main bias structures, shared by many CMIP coupled models: a warm bias in the south-east Pacific, a cold bias at the equator, two stripes of warm bias on both sides of the equator and a spurious spring upwelling.

The analysis strategy developed builds on a hierarchy of experiments designed to address specific questions: hindcasts to inform on biases time scales, partially restored experiments to locate the region of origin of the bias development, ocean-only experiments forced by blended model and/or observational fields to provide information on the variable/field ultimately responsible for the bias development.

Initial results show that the warm south-east tropical Pacific bias is caused by a lack of upwelling due to too weak coastal meridional winds. The cold equatorial bias is the result of the slow equatorward advection of subtropical heat content errors, in contrast to its attribution to fast equator-only zonal wind/SST interactions generally found in the literature. The two stripes of warm SST errors straddling the equator are caused by a combination of latent and solar heat fluxes errors. Finally, the spurious spring upwelling involves a coupled mechanism triggered by the south-east Pacific warm bias.