Use of tuning diagnostics to understand CAM's behavior

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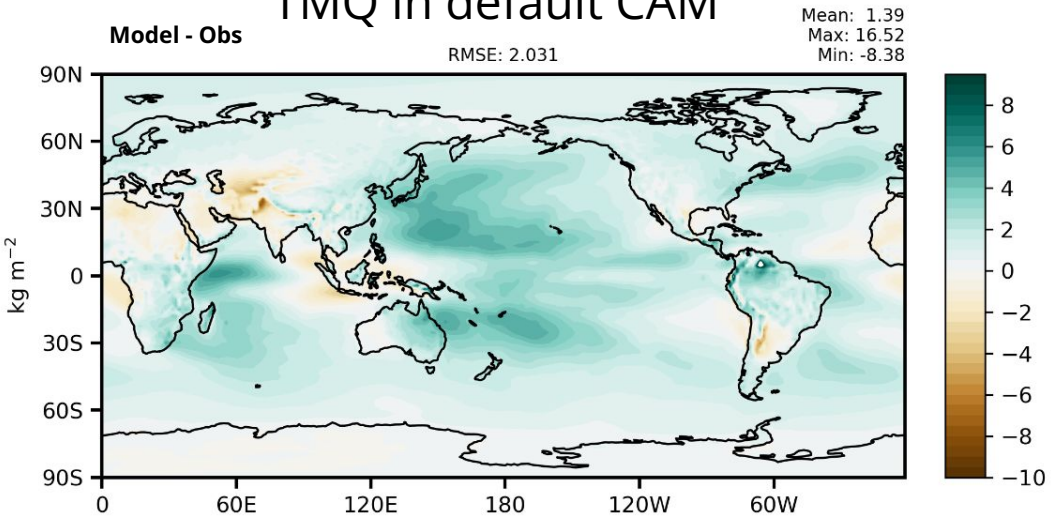
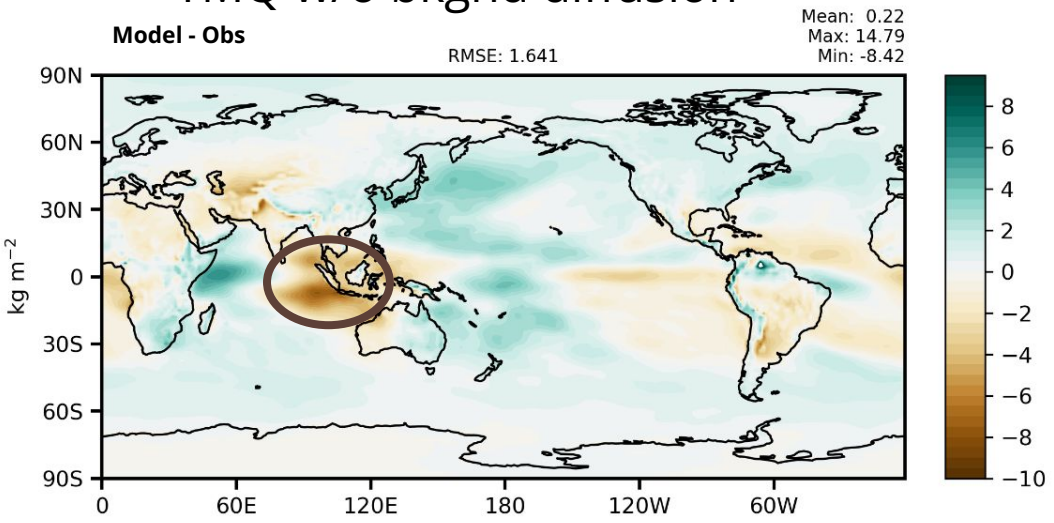
It all started innocently enough. We wanted to reduce precipitable water (TMQ), and so we shut off CLUBB's background diffusion:

TMQ in default CAM



TMQ w/o bkgnd diffusion

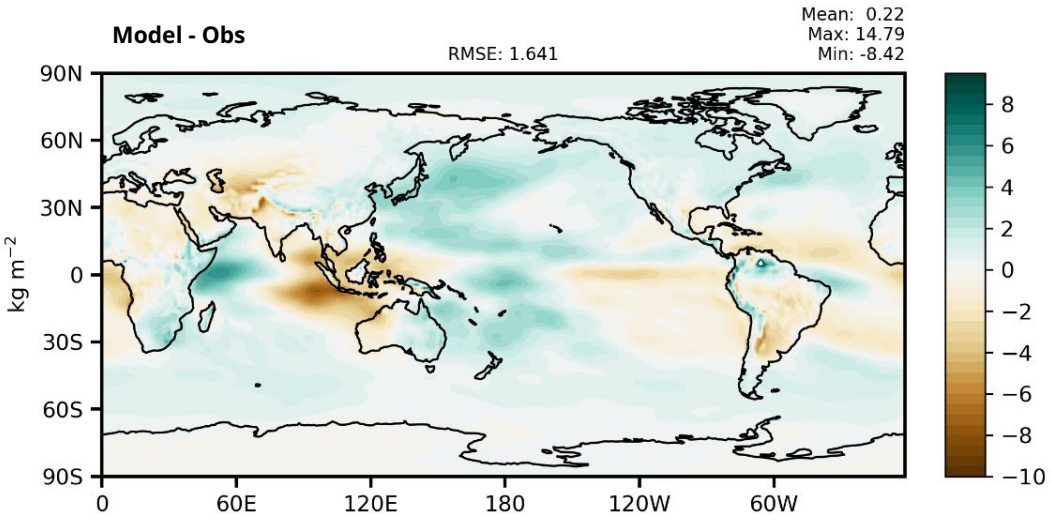


But without background diffusion, it's too dry in the warm pool and Indian Ocean.
—>

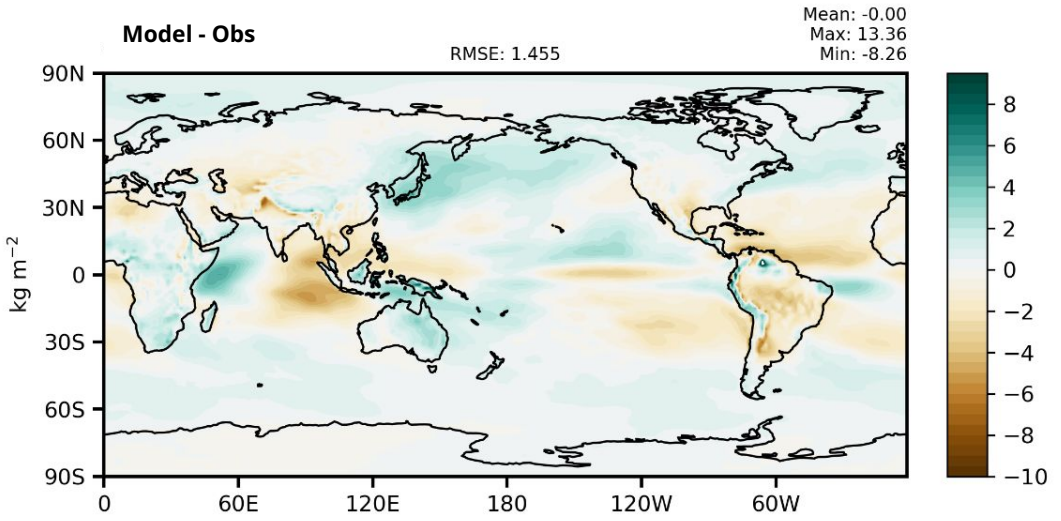
We retuned using a semi-automated tuner (``QuadTune"), and that helped a bit, but biases remain.

The Indian Ocean and Western Pacific are still too dry, and the Southeastern Pacific has become even drier.

TMQ w/o bkgnd diffusion, before tuning



TMQ w/o bkgnd diffusion, after tuning



Why doesn't tuning parameter values remove these model biases?

Parts of the model structure must be preventing further improvement.

Can we learn something about model structural errors by exploring the tuning trade-offs?

Outline of talk

- **What are the tuning trade-offs in cloud brightness (SWCF)?**
- What are the tuning trade-offs in surface precipitation (PRECT)?

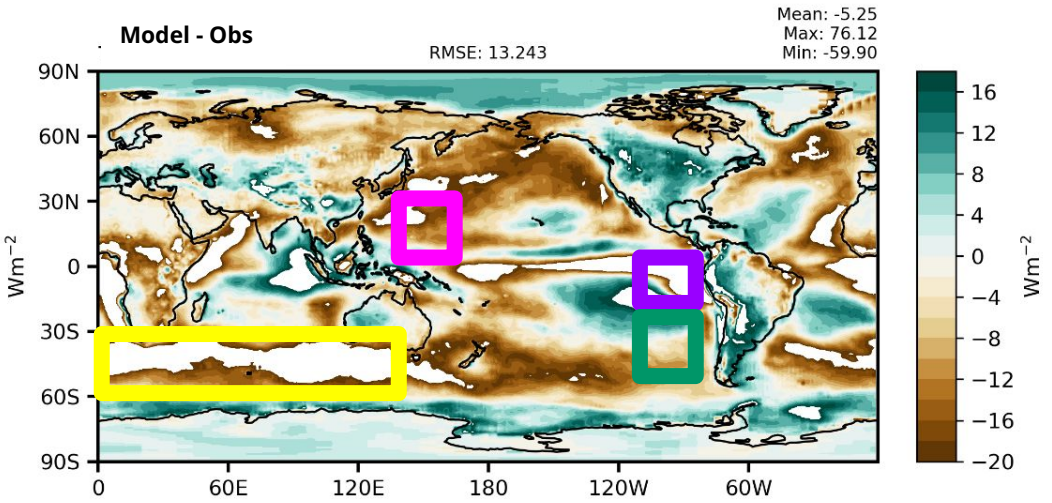
After tuning, SWCF improves (dims) in the SH storm track and off the coast of Japan, but Peru stratocumulus (Sc) is left too dim.

Tuning mitigates the excessive brightness of the Southern Hemisphere Storm Track, the region off the coast of Japan, and a bit in the Eastern Pacific ITCZ.

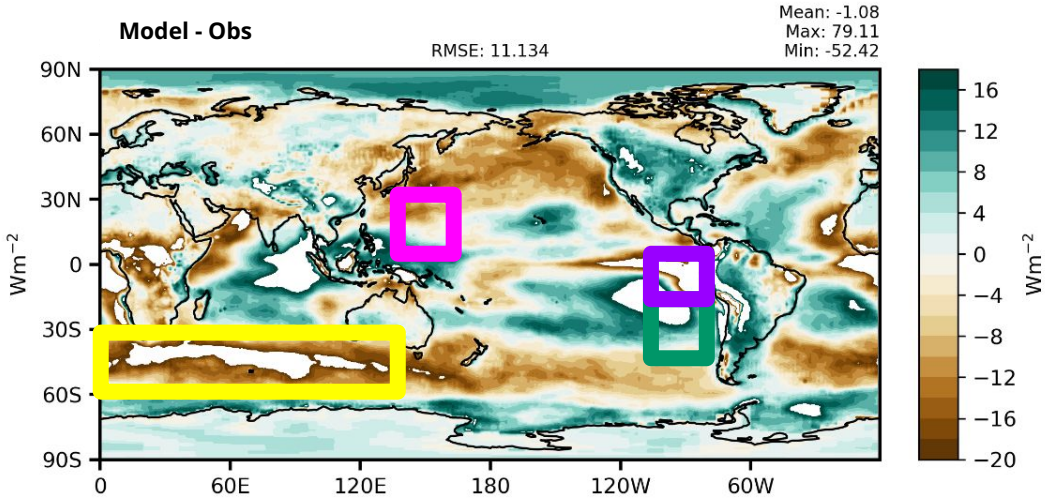
However, in the process, Peru Sc goes from too bright to too dim.

Is QuadTune sacrificing Peru Sc to improve one of these other regions?

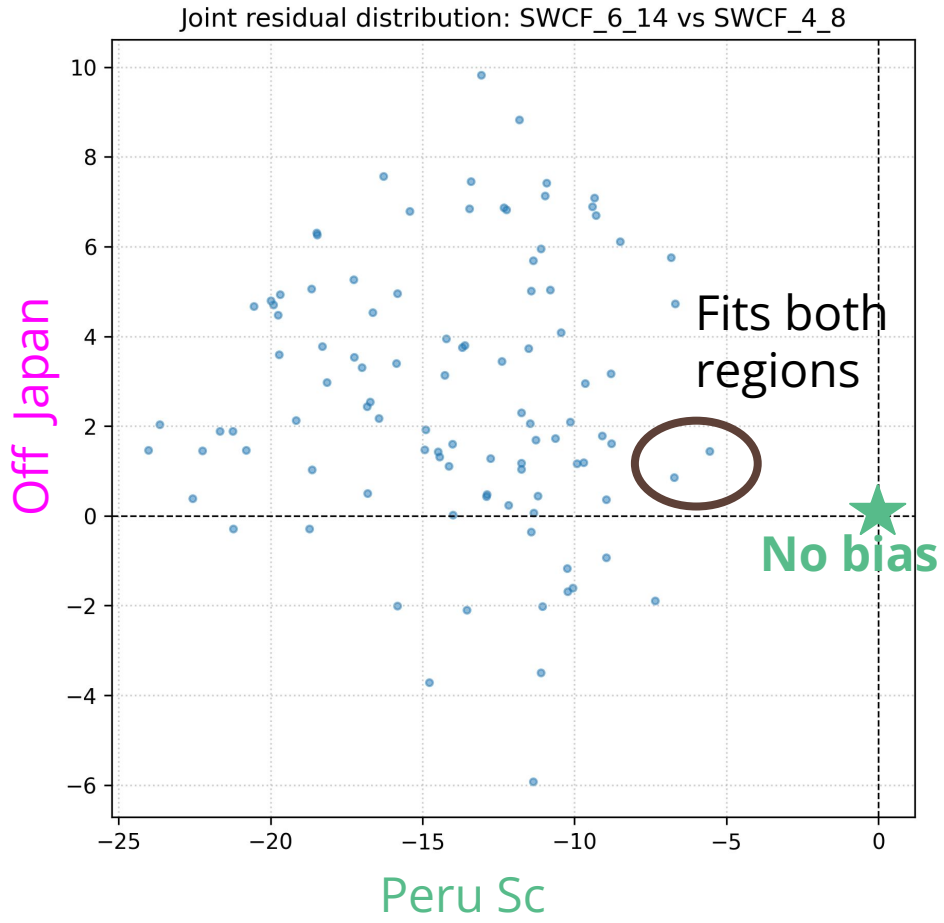
SWCF w/o bkgnd diffusion, before tuning



SWCF w/o bkgnd diffusion, after tuning

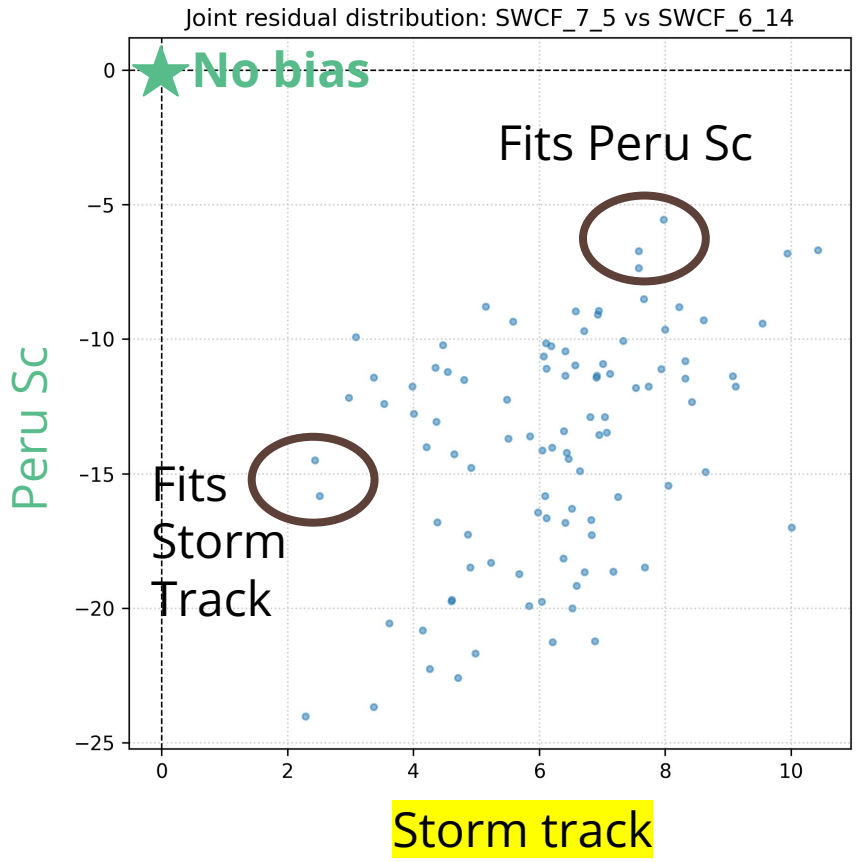


When we tune SWCF alone, there is no trade-off between Peru Sc and the off-Japan region



(Here, each scatterpoint corresponds to a different, good set of parameter values.)

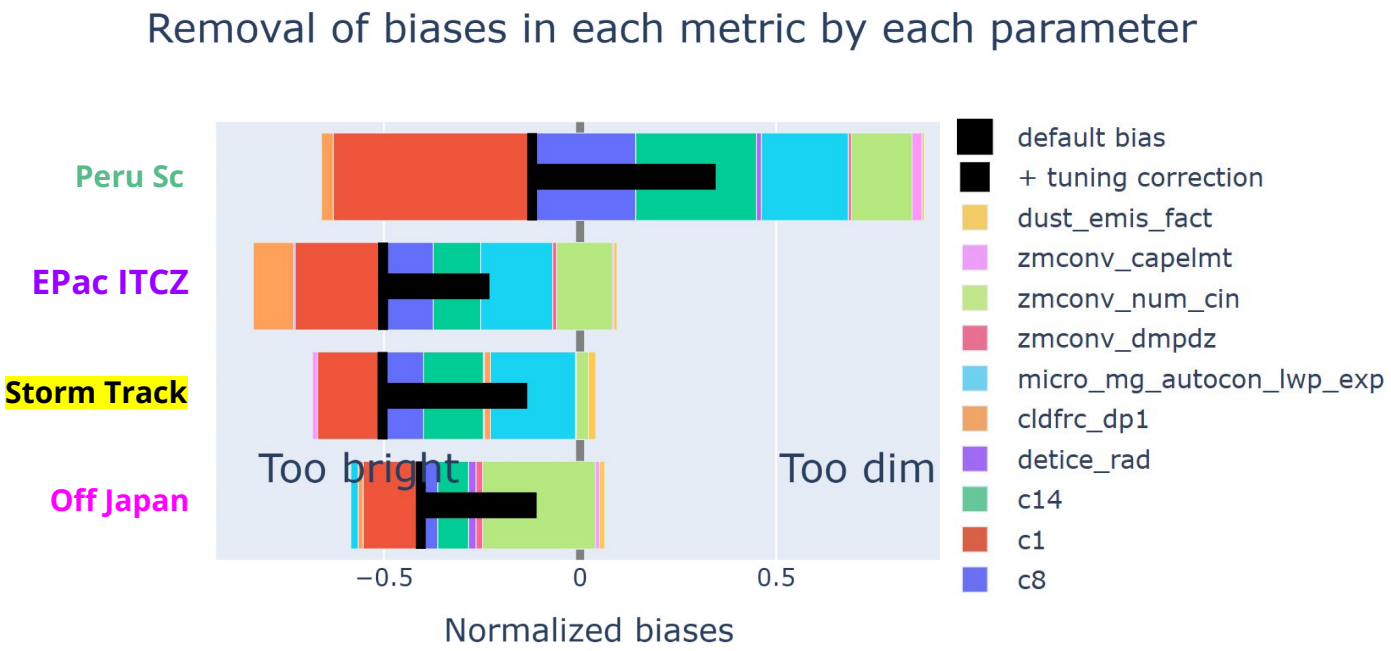
However, when we tune SWCF alone, there is a trade-off between Peru Sc and Storm Track.



There is no single parameter set that matches both regions.

There is a tuning trade-off because Peru Sc has similar parameter dependencies as Storm Track (and EPac ITCZ). But the off-Japan region is different.

Off-Japan is independently tunable because it depends more on zmconv_num_cin.



Peru Sc and Storm Track are not independently tunable. Upon tuning, Peru Sc becomes too dim because the Storm Track is too bright to begin with. So Peru Sc is sacrificed (i.e., traded off).

Outline of talk

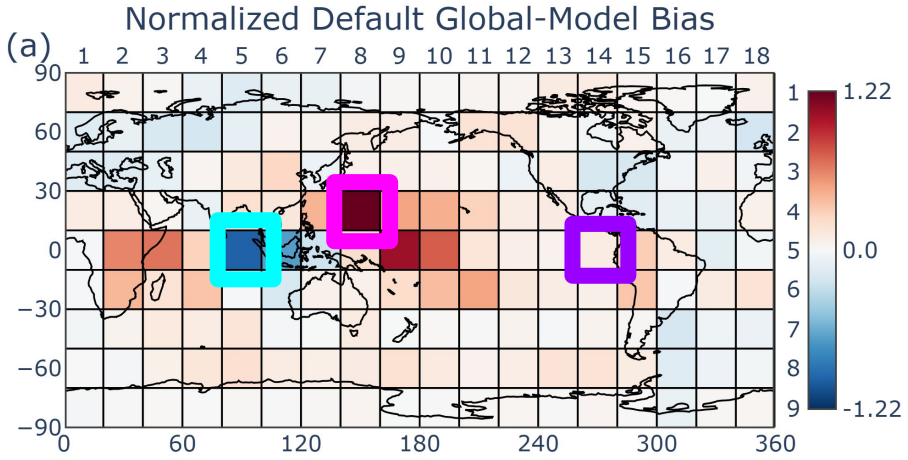
- What are the tuning trade-offs in cloud brightness (SWCF)?
- **What are the tuning trade-offs in surface precipitation (PRECT)?**

After tuning, sfc precip (PRECT) improves off the coast of Japan, and a little over the Indian Ocean, but not over the EPac ITCZ

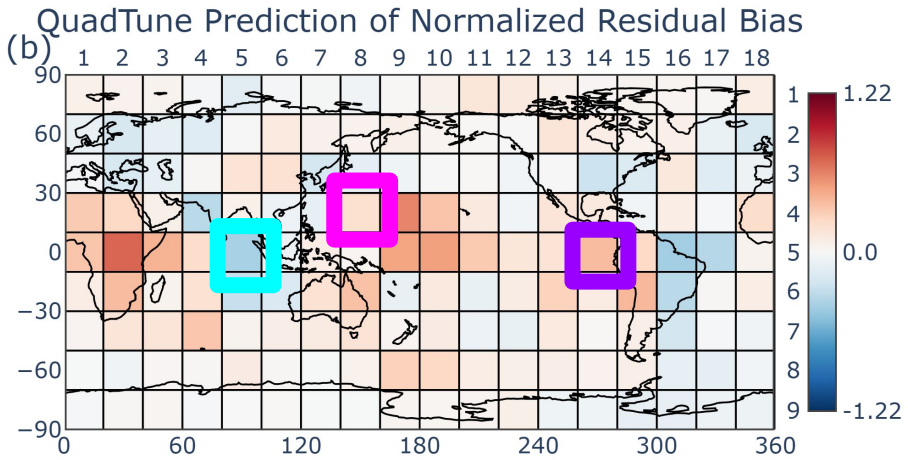
The trade-off between Indian Ocean and EPac ITCZ is similar to the trade-off between Storm Track and Peru Sc.

However, the fact that a excessively dry (Indian Ocean) and excessive rainy (off-Japan) region are simultaneously tunable is quite different than our experience with Peru Sc!

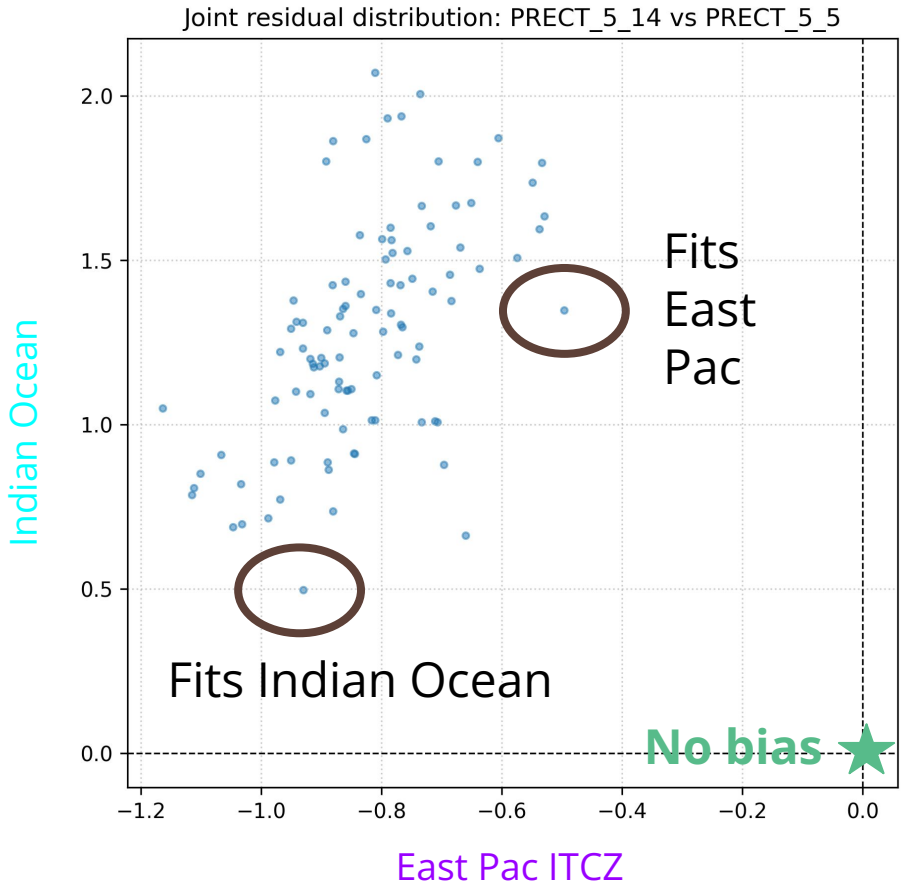
PRECT w/o bkgnd diffusion, before tuning

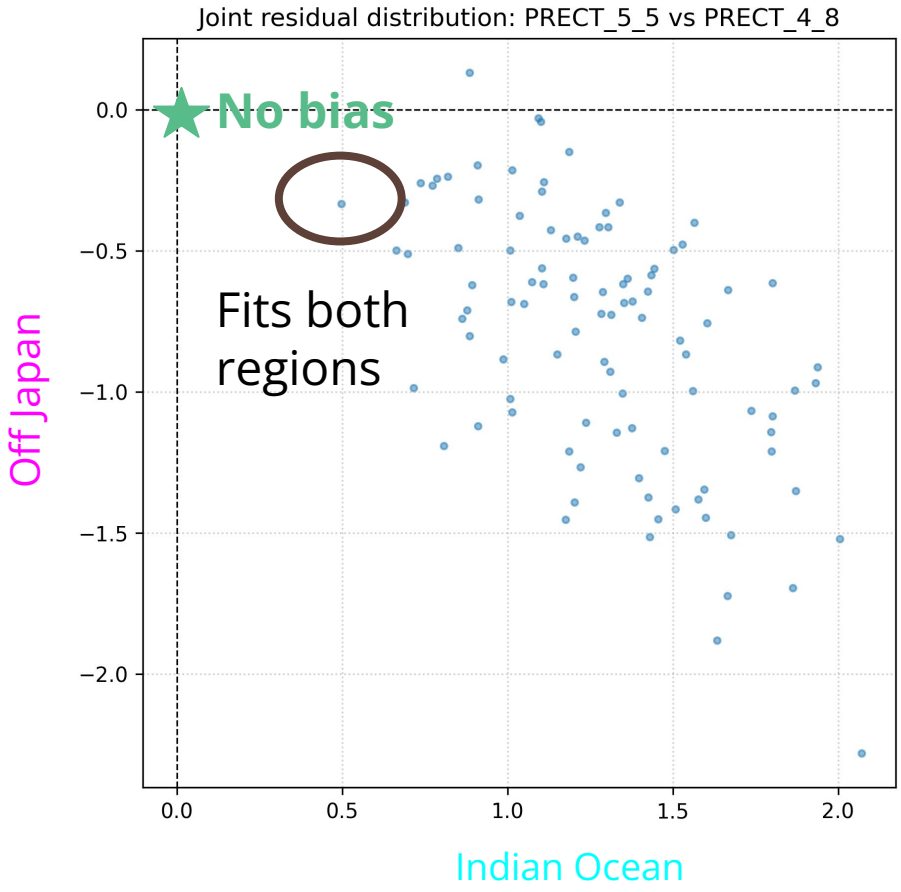


PRECT w/o bkgnd diffusion, after tuning



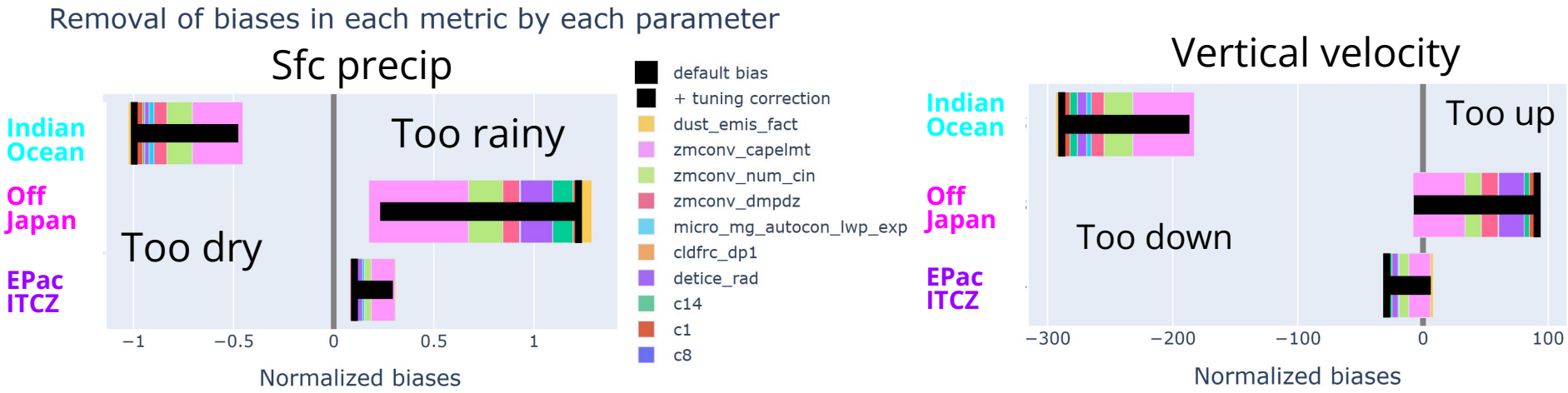
When we tune PRECT alone, the Indian Ocean region is compatible with the off-Japan region but not with the East Pacific ITCZ:





The tuning of convection is complicated by changes in circulation

Sfc precip and vertical velocity are correlated:



Hence sfc precip and vertical velocity not independently tunable.

The circulation changes help us tune off Japan, but hamper the tuning in the Eastern Pacific ITCZ.

Conclusions:

1) QuadTune is able to dim the storm tracks, but in so doing, the Peru Sc are dimmed too much. This is because the parameter dependencies in these regions are similar. We need to find a parameter that is specific to storm tracks.

2) Vertical velocity is correlated with sfc precip (but not as much with cloud brightness). This complicates tuning.

3) Circulation changes help us simultaneously tune sfc precip in the Indian Ocean and off-Japan regions (lucky us!).

4) But circulation changes don't help us simultaneously tune the Indian Ocean and the East Pacific ITCZ. There must be a model structural error.