Not all regional biases are created equal

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Sometimes we wish to prioritize the solution in a particular region of the globe and deprioritize it in other regions

E.g., we might prioritize the continental United States because we live there. Or we might prioritize the eastern equatorial Pacific because it affects the surface ocean temperatures there.

To prioritize a region in a global tuning calculation, we weight the region more strongly

This will, however, worsen the global RMSE, as compared to equal weighting for all regions. How great is this cost?

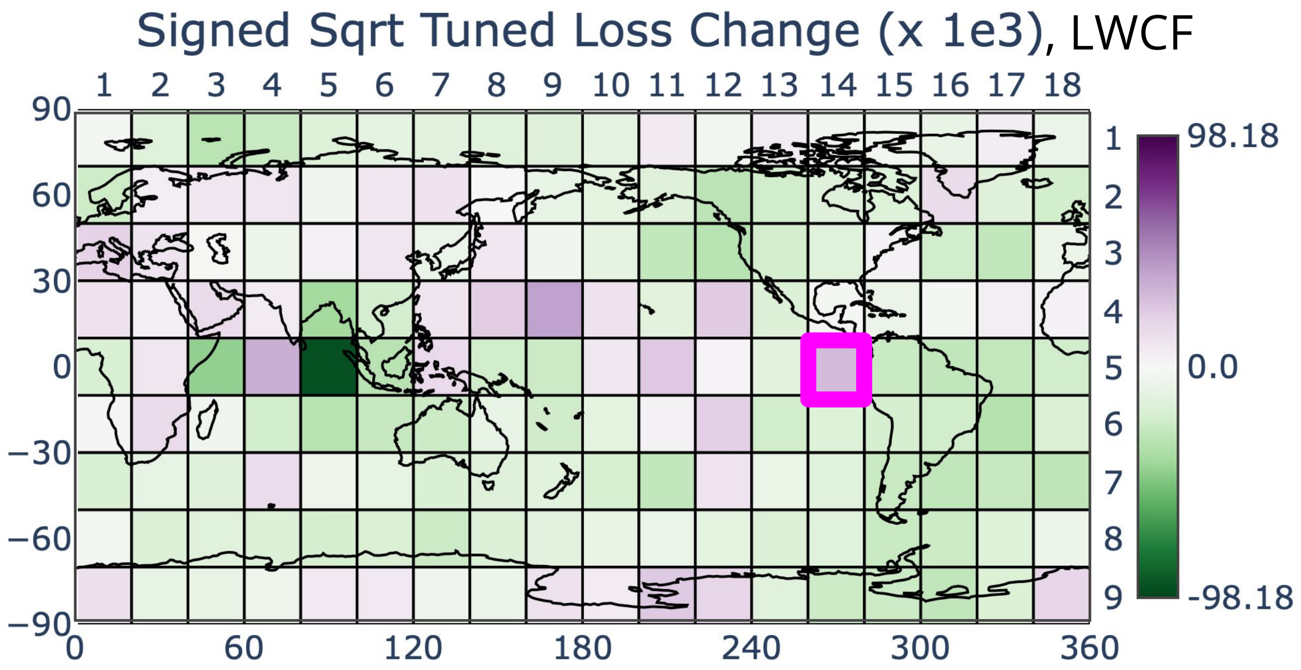
To explore the consequences of prioritized regional weighting, we will use a semi-automated tuner called "QuadTune"

QuadTune divides the globe into 20º x 20º regions. By default, QuadTune weights the regions by their areas (which we'll call "equal weighting"), but QuadTune also allows the user to boost a weight individually by a user-defined factor.

QuadTune uses a simple quadratic emulator of the parameter dependence.

QuadTune ignores interactions between parameters.

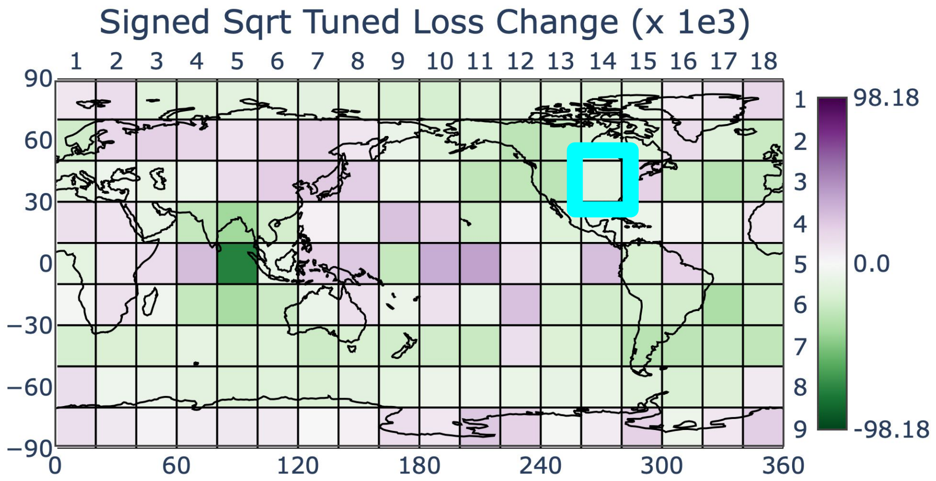
An equal-weight tuning degrades the LWCF in the eastern equatorial Pacificand elsewhere, but mostly leads to improvements (in QuadTune's estimate):



(Green indicates an improved fit relative to the default tuning; purple indicates a degraded fit.)

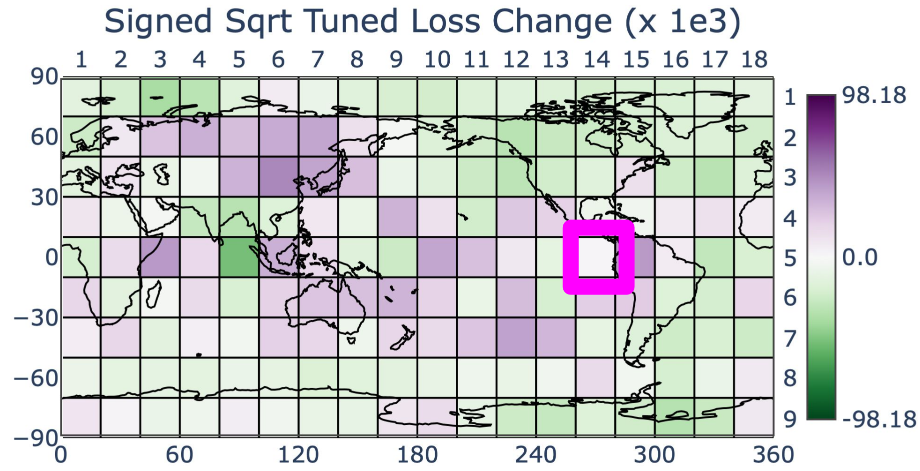
Prioritizing the continental United States has less damaging side effects than does prioritizing eastern equatorial Pacific. **Why is this??**

LWCF loss-function change when continental United States (CONUS) is upweighted:



The CONUS run still has plenty of green, i.e., areas of improvement.

LWCF loss-function change when eastern equatorial Pacific (East Eq Pac) is upweighted:



The East Eq Pac run has more purple, i.e., more areas of degradation.

Let's start back at the beginning. An equally weighted tuning will tend to target the largest biases.

We'll present tuning runs based on the following configuration:

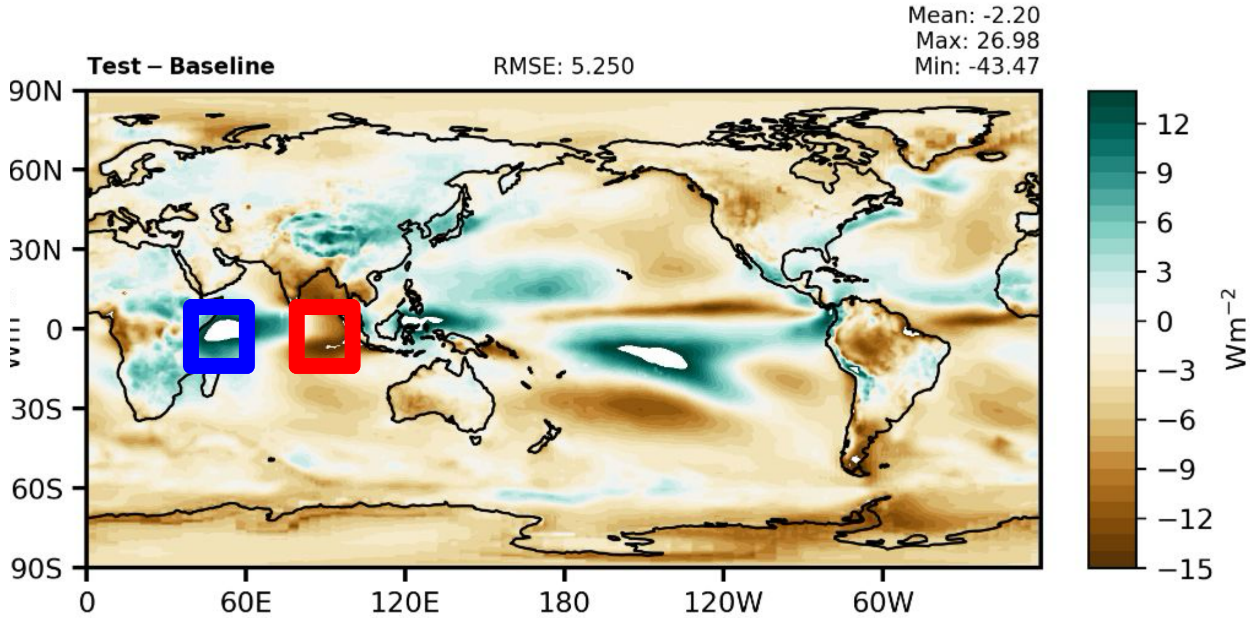
- We use a recent tag of proto-CESM3, namely, alpha07g.
- To sample the parameter space, we do 13-year coupled ocean-atmosphere simulations (i.e., B-case runs).
- When we tune, we attempt to match observations of both LWCF and SWCF.
- Our tuning parameters include those from microphysics, Zhang-McFarlane deep convection, and CLUBB turbulence.

In the recent alpha07g version of proto-CESM3, two of the largest regional biases occur in the Indian Ocean and Somalia

Over the eastern Indian Ocean, there is insufficient convection.

Over Somalia, there is too much convection.

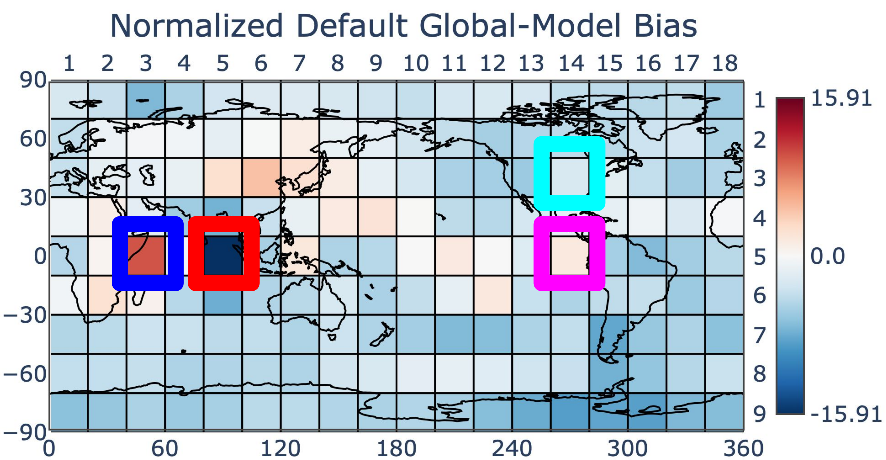
Bias in LWCF:

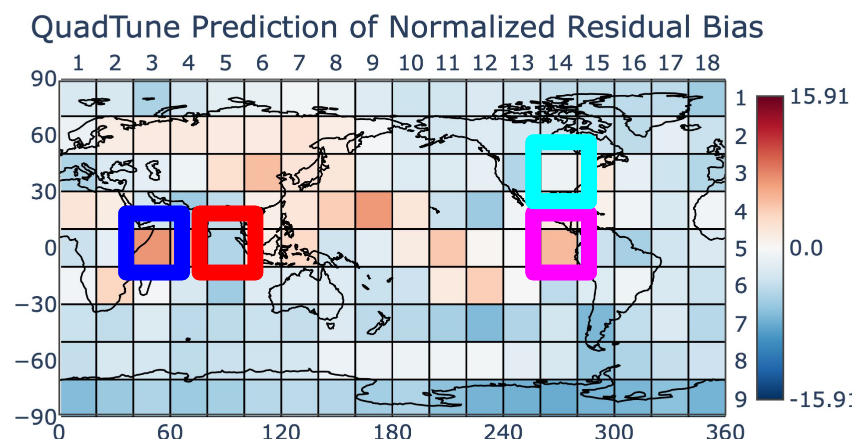


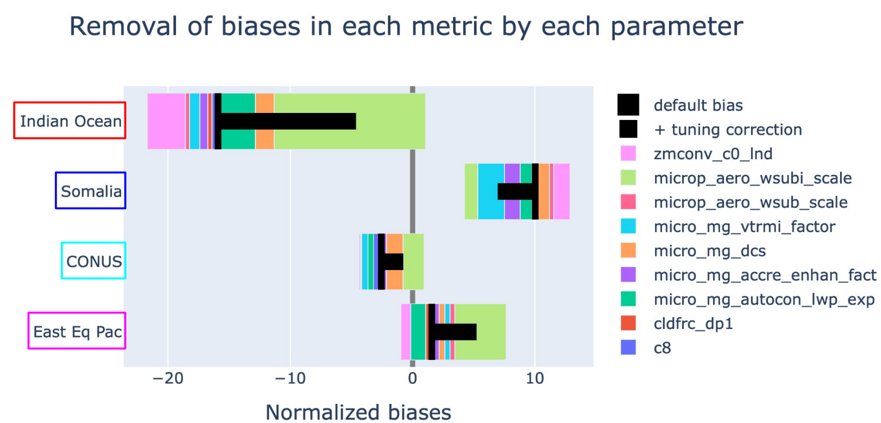
The largest biases (Indian Ocean and Somalia) can be mitigated by equal-weight tuning

QuadTune's estimate of residual biases in LWCF after tuning:

Default-run biases in LWCF:







Red regions are where LWCF is too strong, blue regions are where LWCF is too weak.

How are the biases over the Indian Ocean and Somalia diminished? In our tuning run, the most important parameters are wsubi and vtrmi

wsubi (a.k.a. microp_aero_wsubi_scale) is a scale factor on subgrid vertical velocity. An increase in wsubi boosts the number of ice crystals. It can be thought of as a “source” of ice processes.

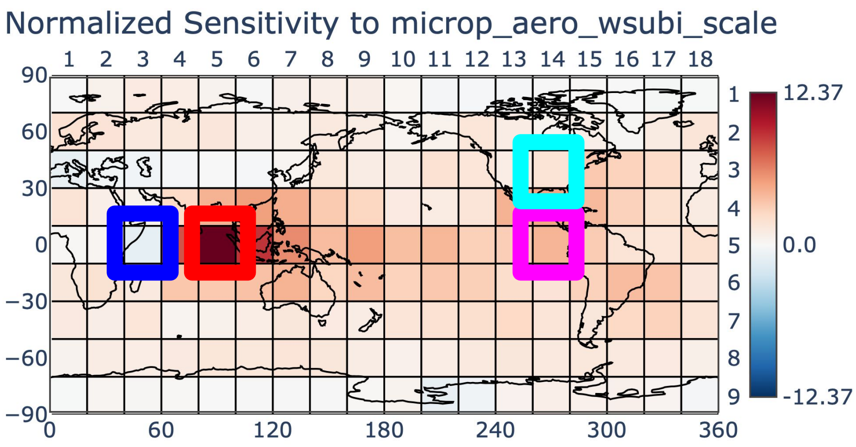
An increase in vtrmi (a.k.a. micro_mg_vtrmi_factor) boosts the fall speed of cloud ice. It can be thought of as a “sink” of ice processes.

Boosting both wsubi and vtrmi increases convection in the Indian Ocean and diminishes it in Somalia and the Warm Pool

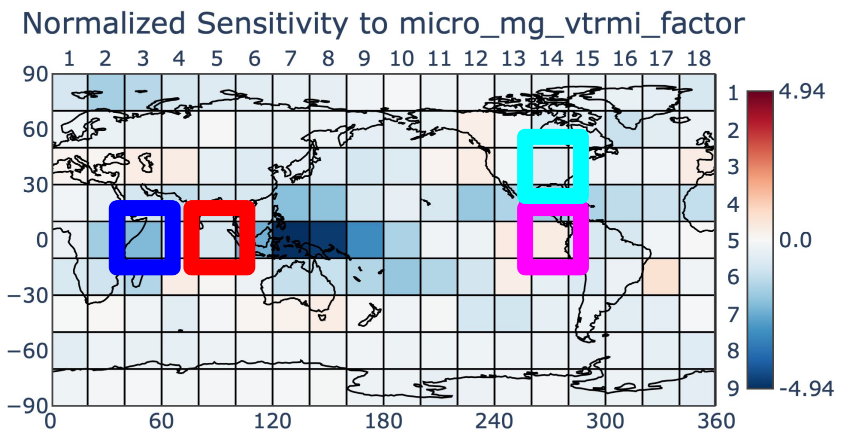
Boosting both parameters increases both a “source” and “sink” of ice processes, leaving the overall magnitude similar. But the spatial pattern shifts.

Boosting both parameters worsens the bias in East Eq Pac but not so much in CONUS.

LWCF is boosted in the Indian Ocean by wsubi:

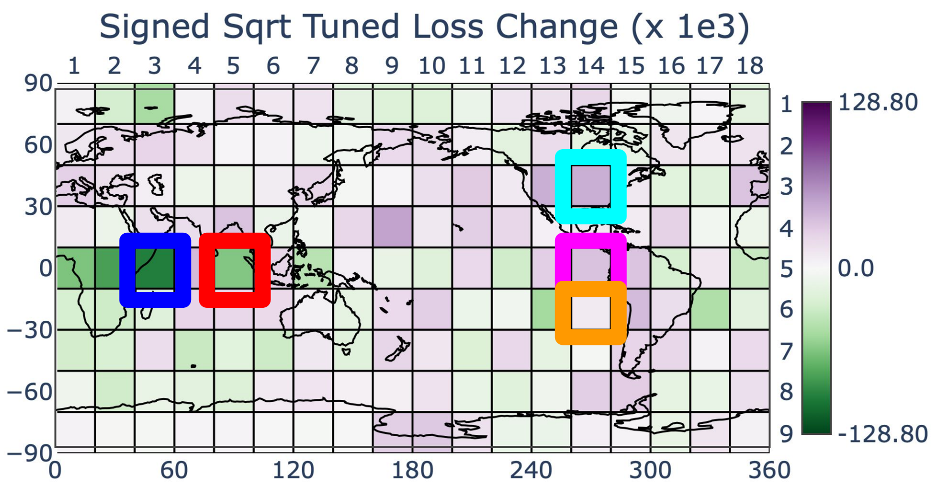


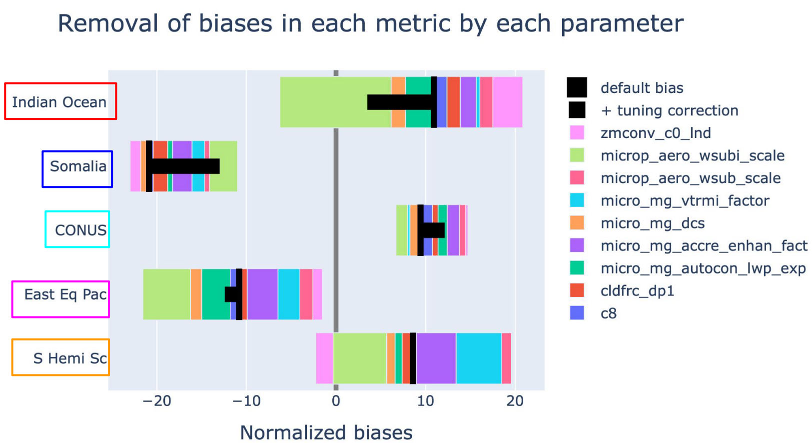
LWCF is diminished in the Warm Pool by vtrmi:



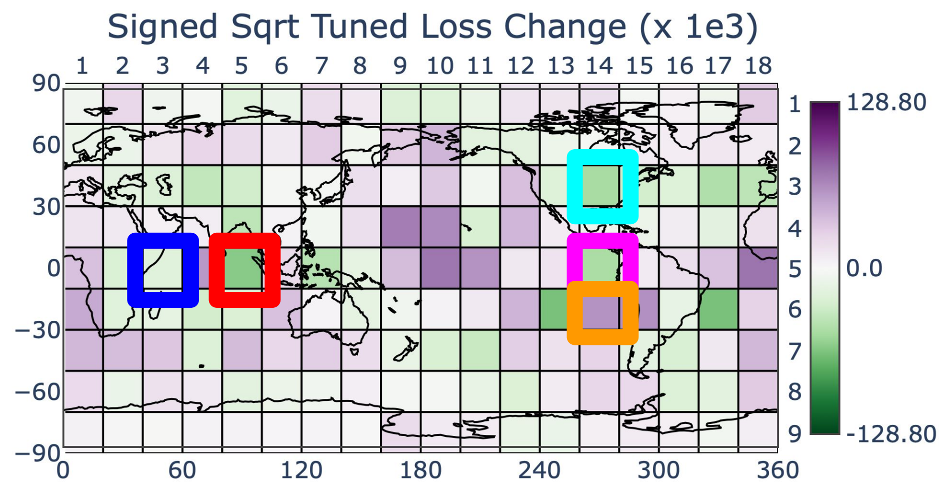
When CONUS is upweighted by a factor of 10, then the SWCF of other regions degrades

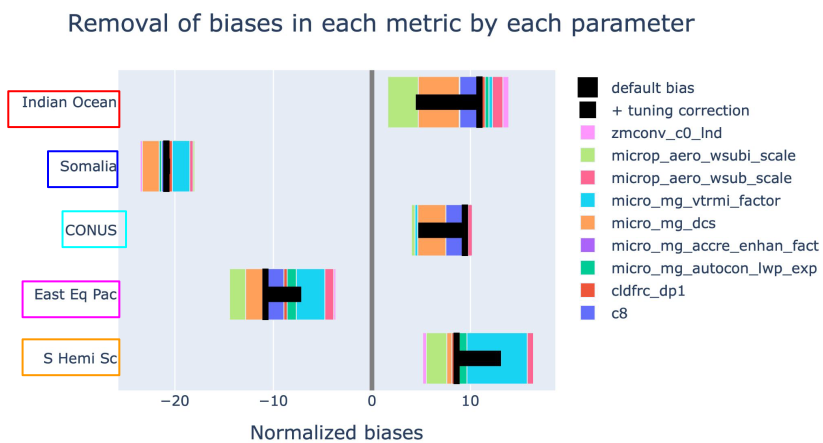
All regions equally weighted:





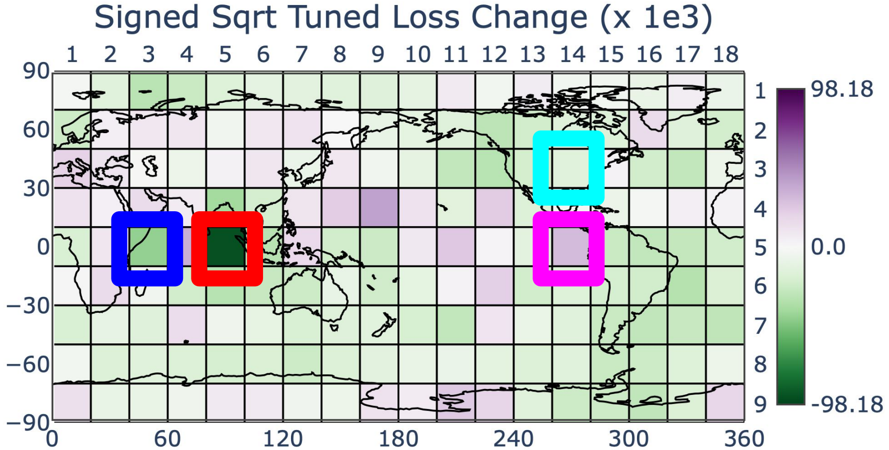
CONUS upweighted:

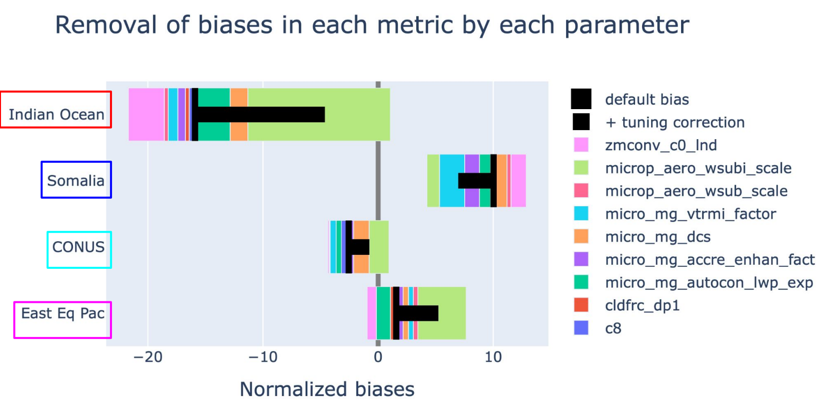




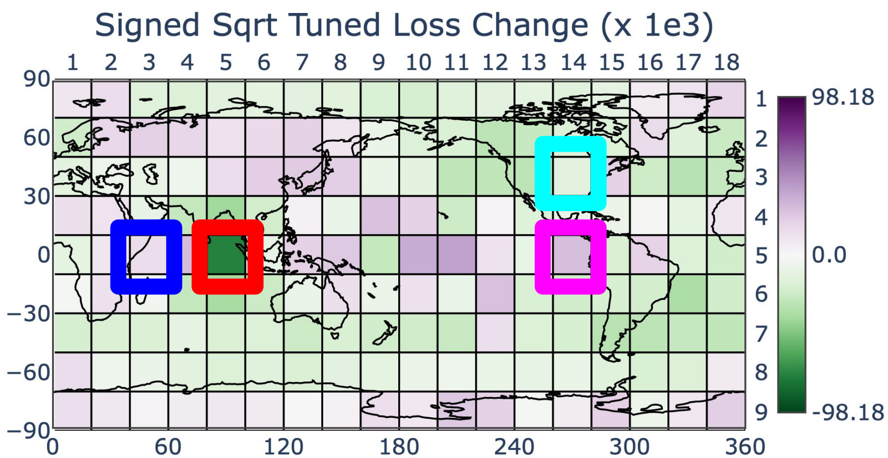
But there are only relatively minor degradations in LWCF

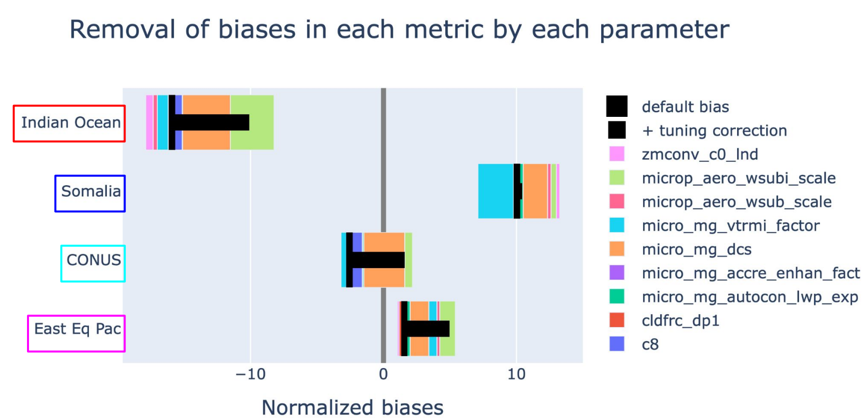
All regions equally weighted:





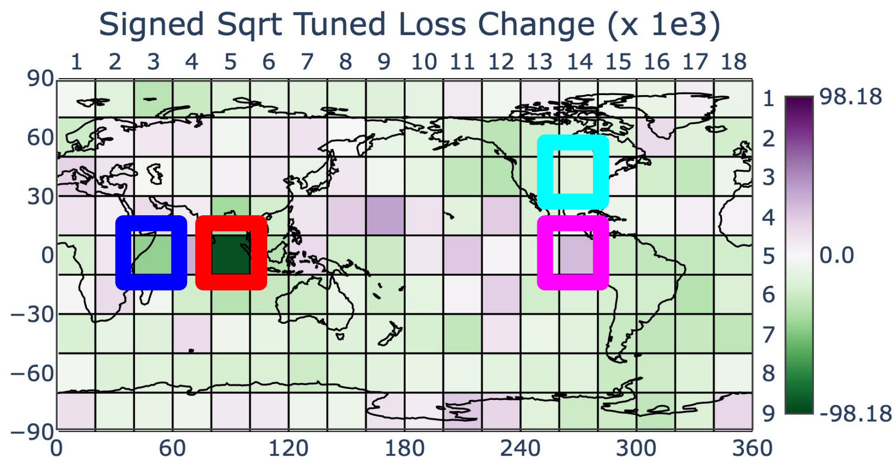
CONUS upweighted:

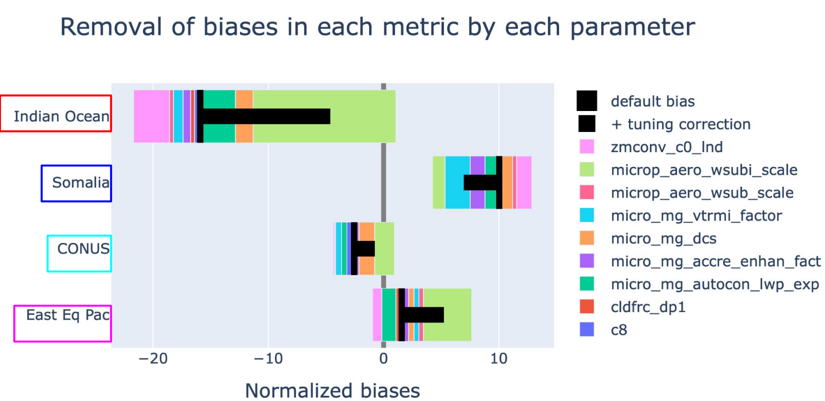




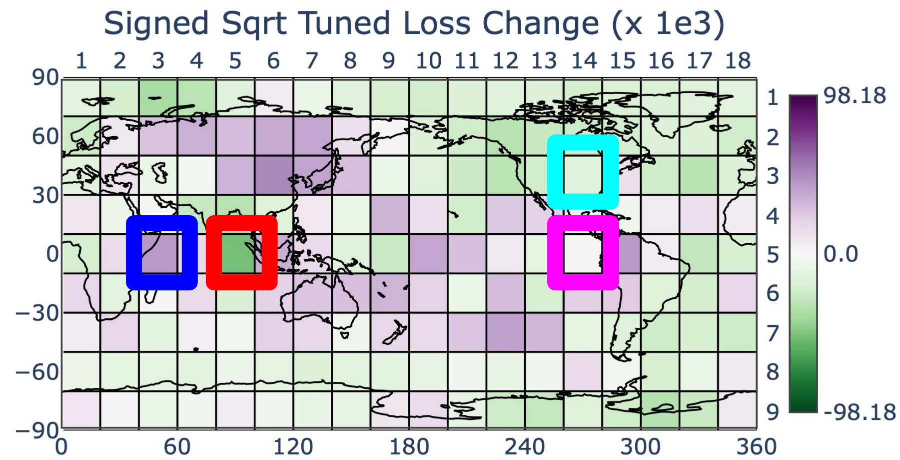
When eastern equatorial Pacific is upweighted by 10x, then the side effects on LWCF are more severe, in part because wsubi and vtrmi are dialed back

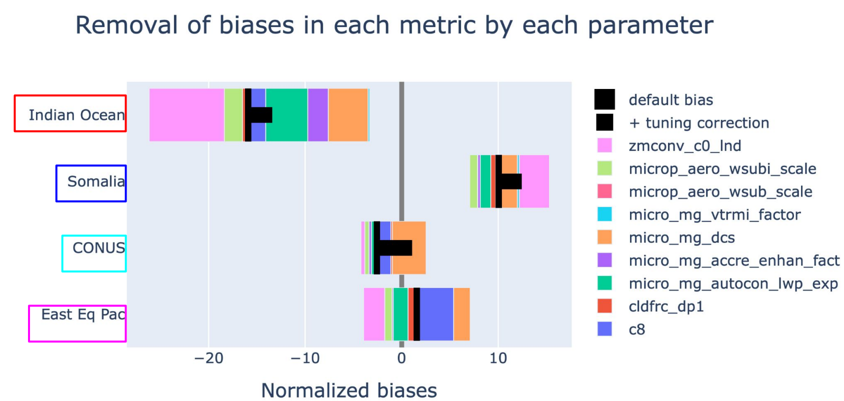
All regions equally weighted:





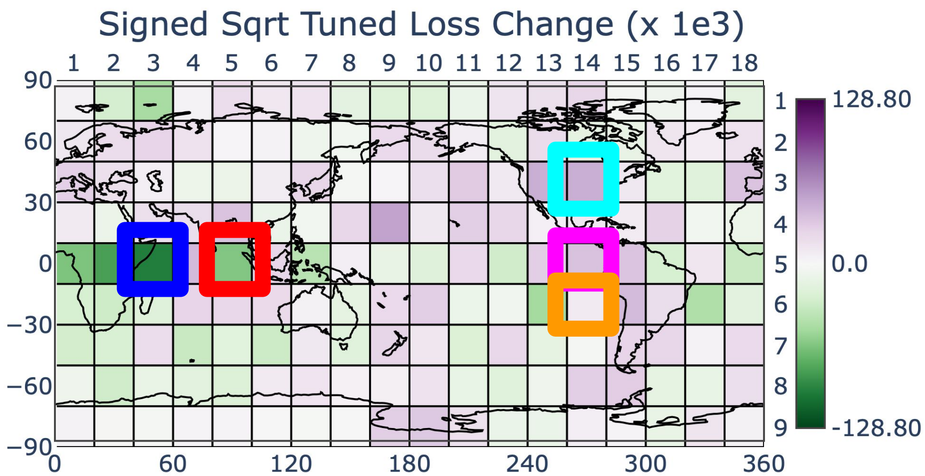
East Eq Pac upweighted:

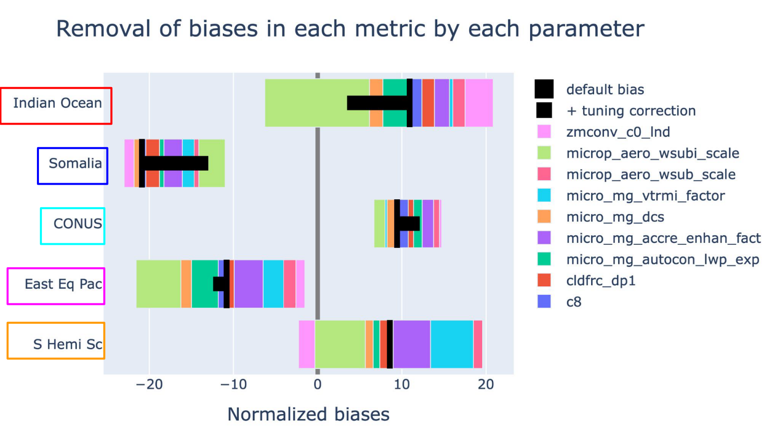




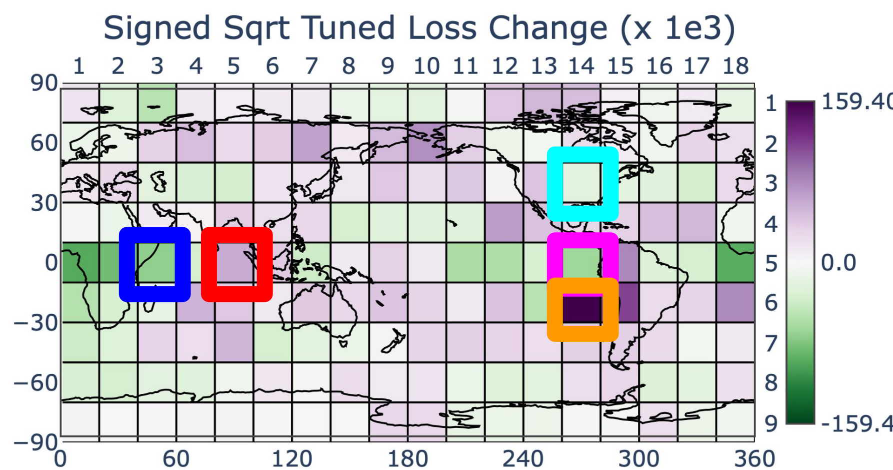
The side effects are also severe on SWCF because c8 needs to be reduced

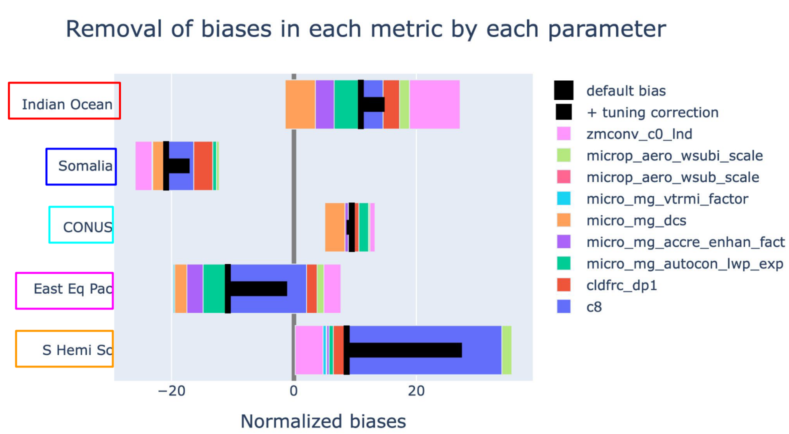
All regions equally weighted:





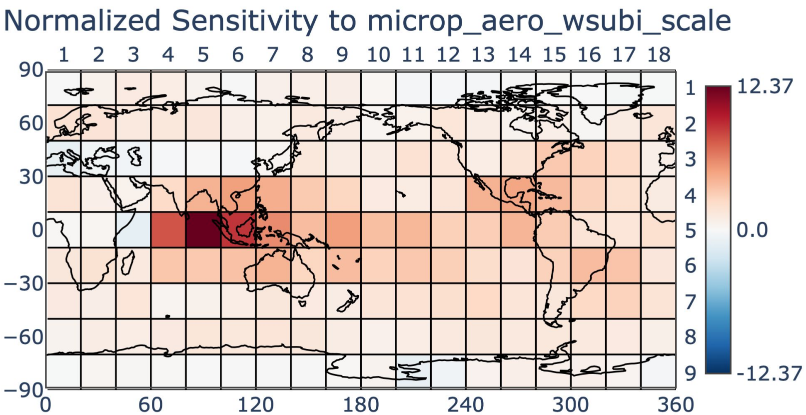
East Eq Pac upweighted:

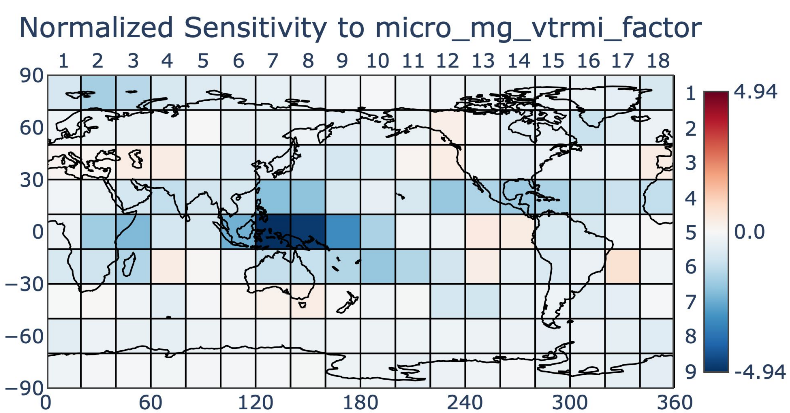




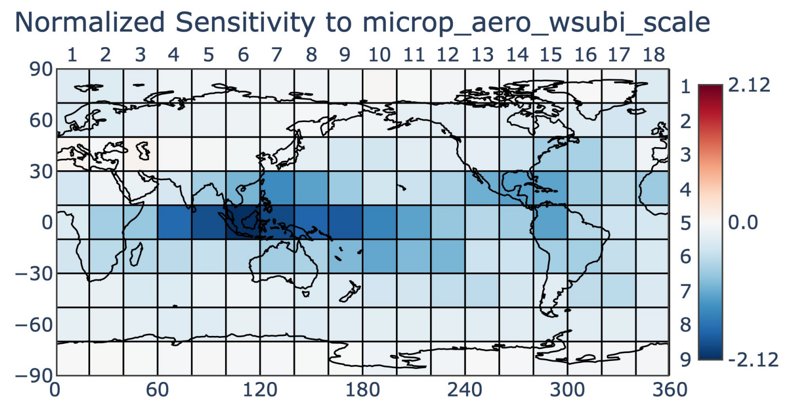
Upweighting the eastern equatorial Pacific causes bigger side effects because doing so forces us to reverse the benefits of wsubi and vtrmi

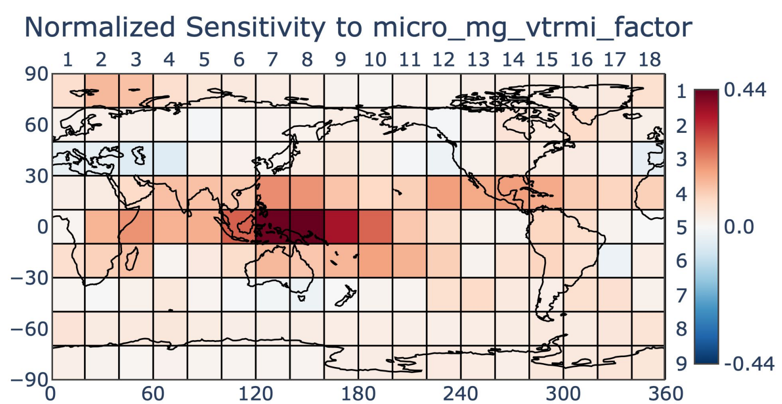
Effect on LWCF from equal weighting:





Effect on LWCF from upweighting East Eq Pac:

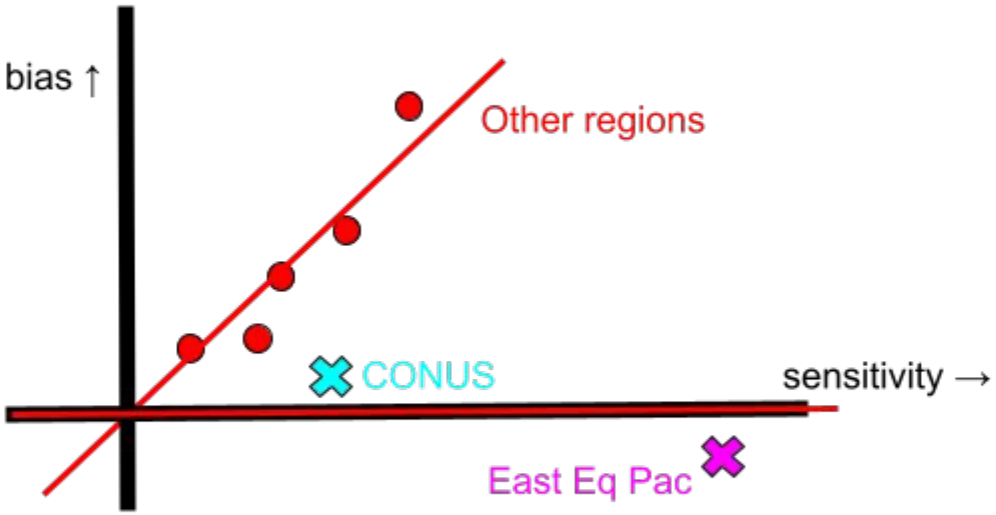




Additionally, the East Eq Pac point appears to have more “leverage” (i.e. sensitivity to parameters) than the CONUS point

The extra leverage of East Eq Pac means that the tuner has greater incentive to fit that point. But that pulls the fit away from observations in the other regions.

The tuner has a harder time fitting CONUS, but it also doesn’t get pulled away so much from the other points.



We can’t win! Either the prioritized region is improved and other regions are worsened, or nothing happens at all.

Conclusions:

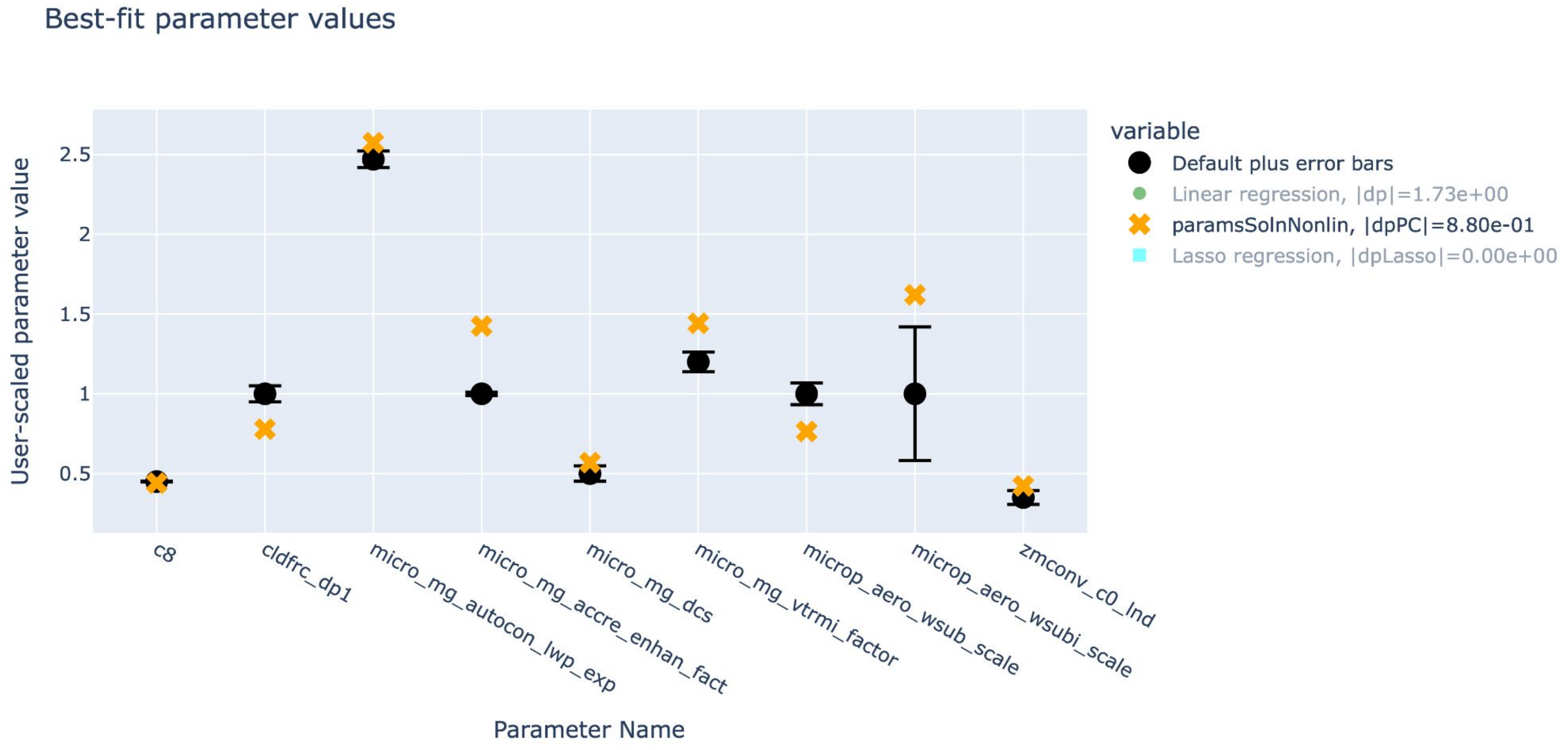
1) An equal-weight tuning will prioritize the largest biases. (Here, the Indian Ocean and Somalia.)

2) If our tuning prioritizes a smaller regional bias (e.g., CONUS or East Eq Pac), the overall accuracy across the globe will degrade.

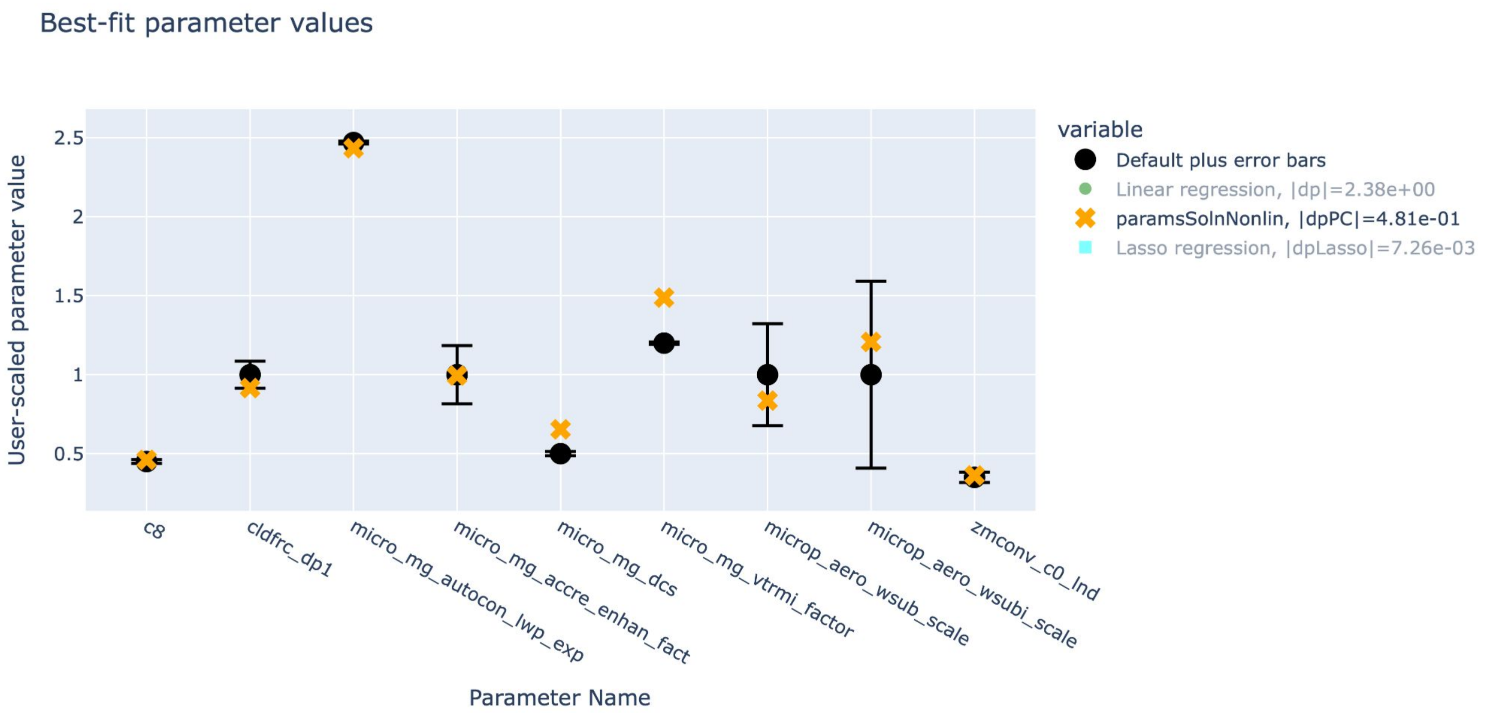
3) The degree of degradation depends on the degree of consistency between the prioritized bias and the largest biases. It also depends on the leverage of the prioritized point.

Extra slides

Parameter values for default weighting



Parameter values when CONUS is upweighted



Parameter values when East Eq Pac is upweighted