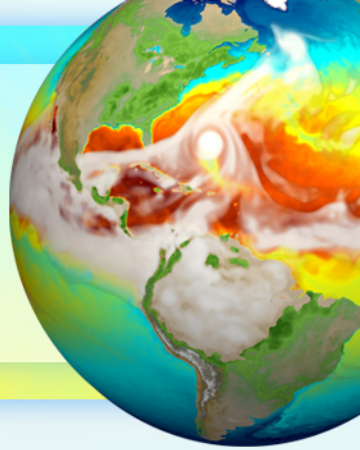

Assessment of E3SM Atmospheric Simulations Over the Southern Polar Region-- Status of v2

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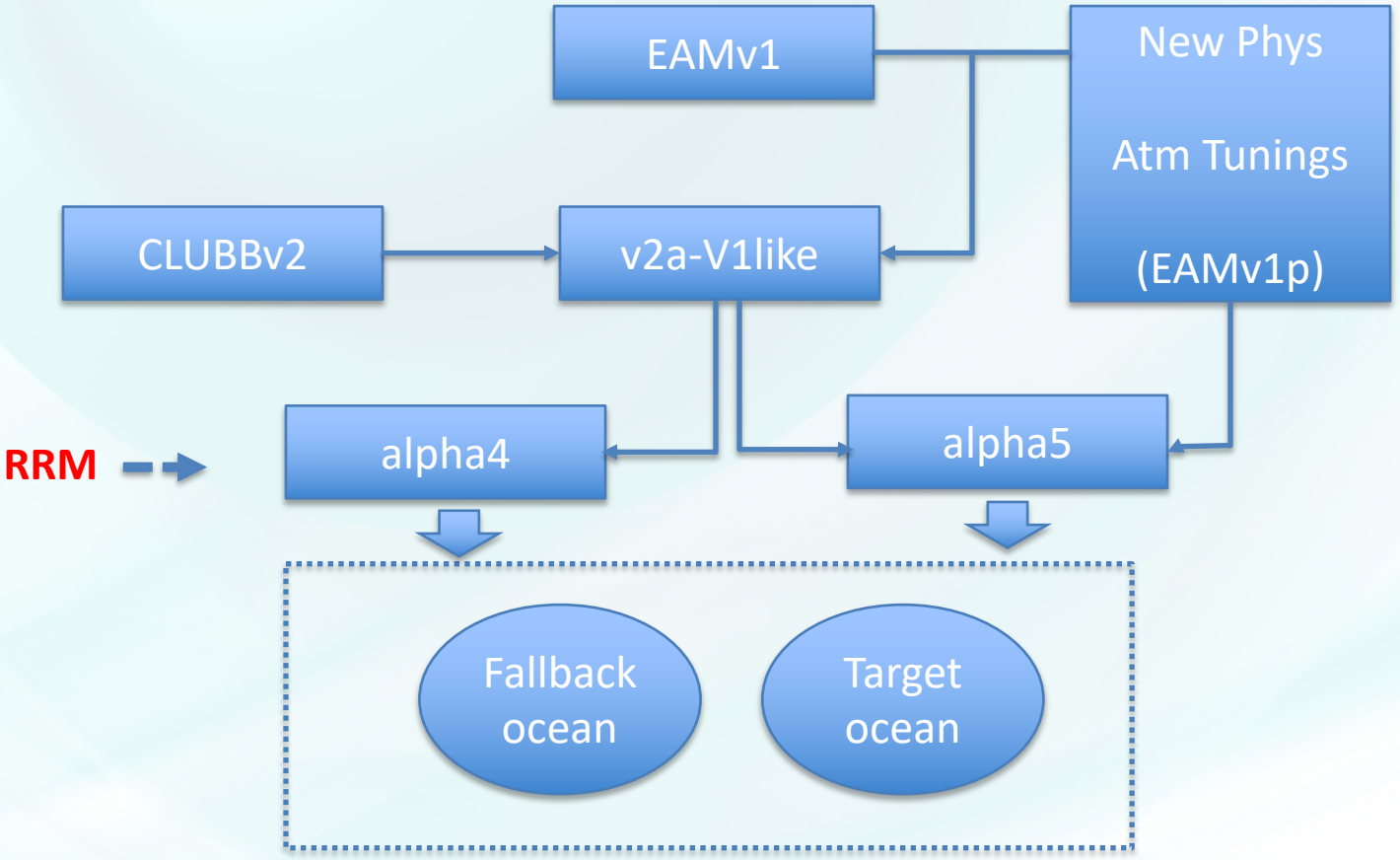
[4]Sandia National Laboratories, Albuquerque, NM 87123

Acknowledgement: Chris Golaz, Xue Zheng, E3SM water cycle group

Outline

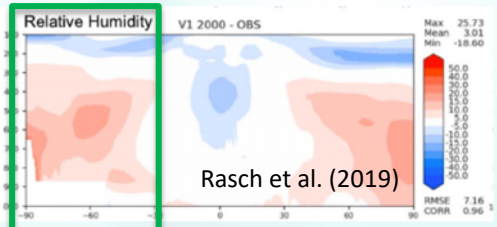
- Current status from water cycle v2 finalization
  - Evolving v2 alpha climatology with reference to v1
- Status of Antarctica RRM and simulations
  - RRM vs. low- and high-res. simulations
  - RRM response to atmospheric tuning
- Summary and further work

- **Current status from water cycle v2 finalization**
  - **Evolving v2 alpha climatology with reference to v1**

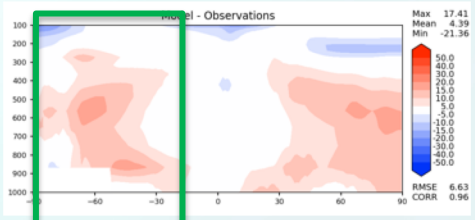


Annual mean bias in relative humidity (RH)

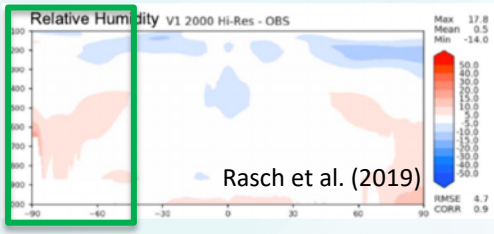
V1 low-resolution



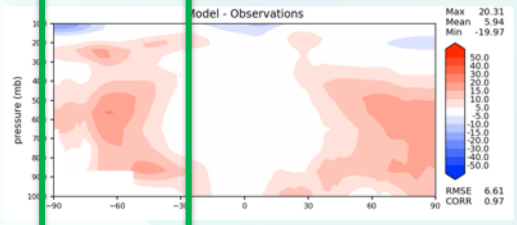
V1 low-resolution coupled



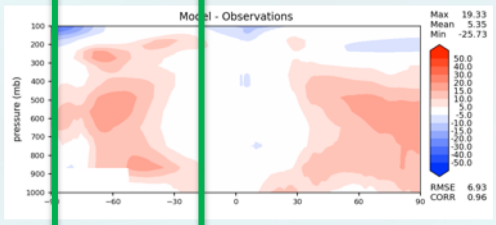
V1 high-resolution



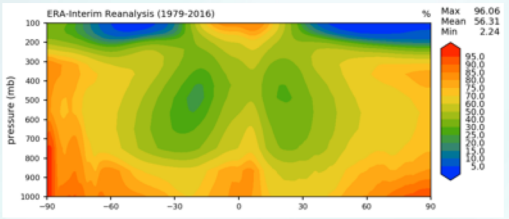
V2 alpha4 low-resolution



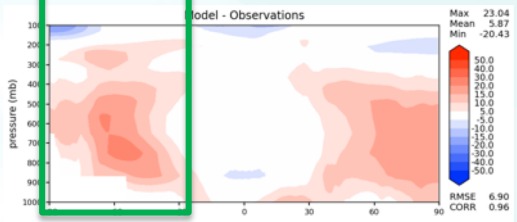
V2 alpha4 low-resolution coupled



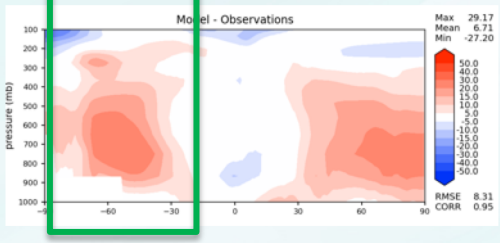
Observations



V2 alpha5 low-resolution



V2 alpha5 low-resolution coupled

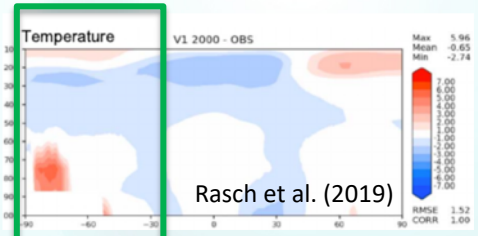


Alpha4: v1like with clubbv2
Alpha5: a latest tunning

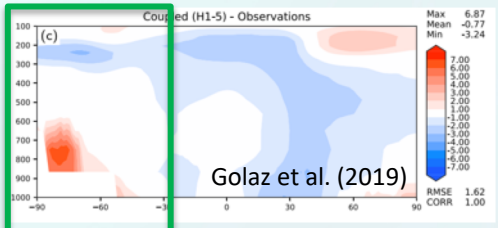
- Biases are sensitive to atmosphere-ocean coupling, resolution and parameterization changes
- Evolving E3SMv2 alpha versions still produce similar climatology to E3SM v1 over SH polar region
- Benefits of high-resolution + tuning, at least in some aspects, justifying exploitation of RRM

Annual mean bias in temperature (T)

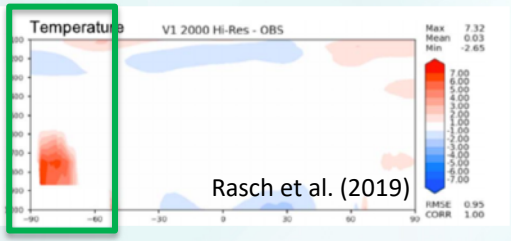
V1 low-resolution



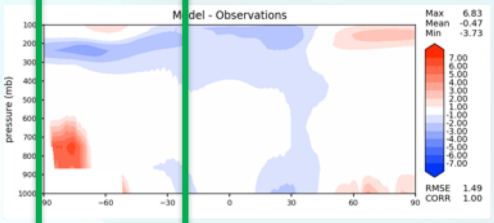
V1 low-resolution coupled



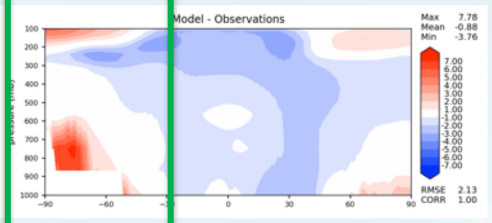
V1 high-resolution



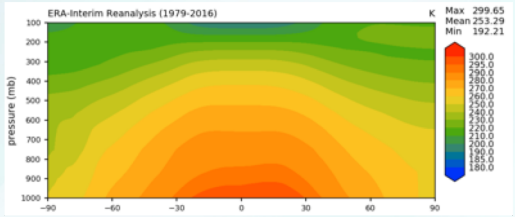
V2 alpha4 low-resolution



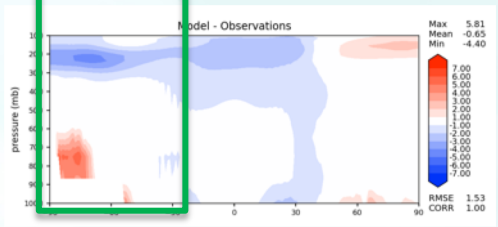
V2 alpha4 low-resolution coupled



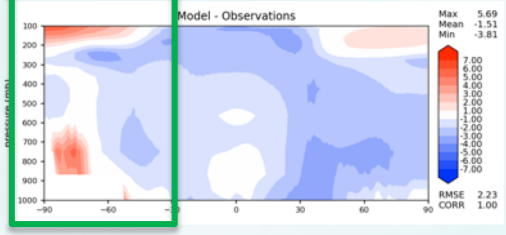
Observations



V2 alpha5 low-resolution



V2 alpha5 low-resolution coupled

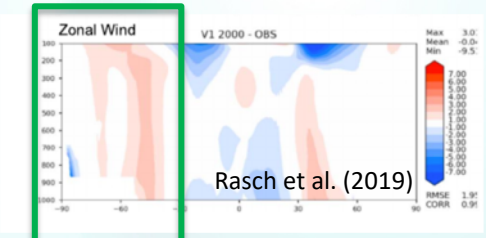


Alpha4: v1like with clubb v2
Alpha5: a latest tunning

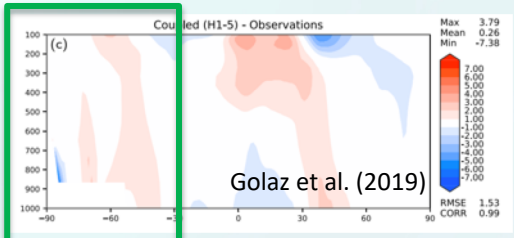
- Biases in lower-tropospheric temperature over southern polar region, appear insensitive to horizontal resolution in E3SMv1, suggesting that those deficiencies are likely driven by inadequacies in physical parameterizations

Annual mean bias in zonal wind (U)

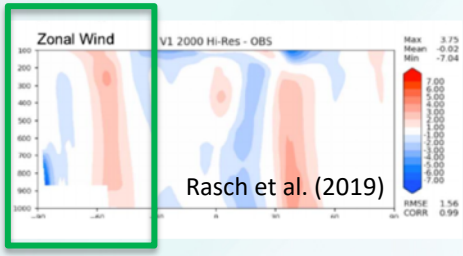
V1 low-resolution



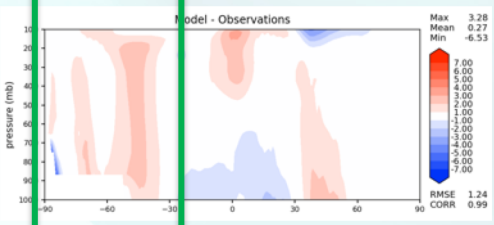
V1 low-resolution coupled



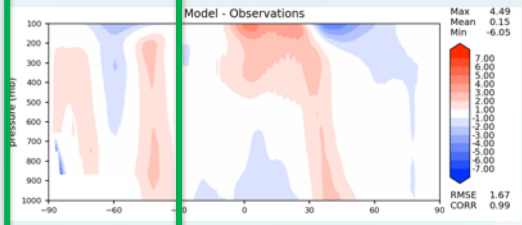
V1 high-resolution



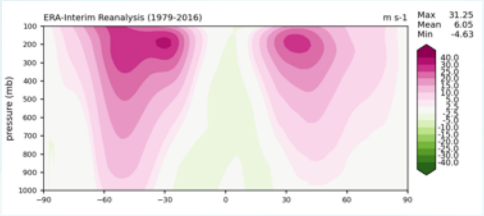
V2 alpha4 low-resolution



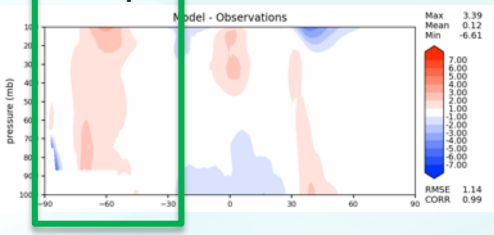
V2 alpha4 low-resolution coupled



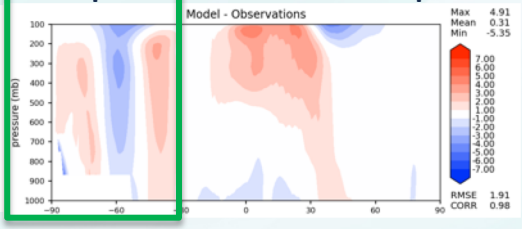
Observations



V2 alpha5 low-resolution



V2 alpha5 low-resolution coupled

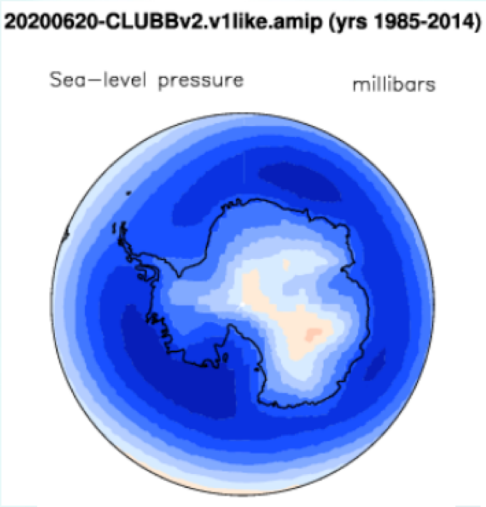


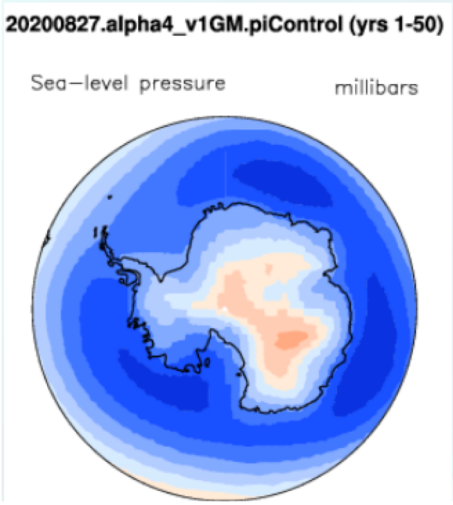
Alpha4: v1like with clubbv2
Alpha5: a latest tunning

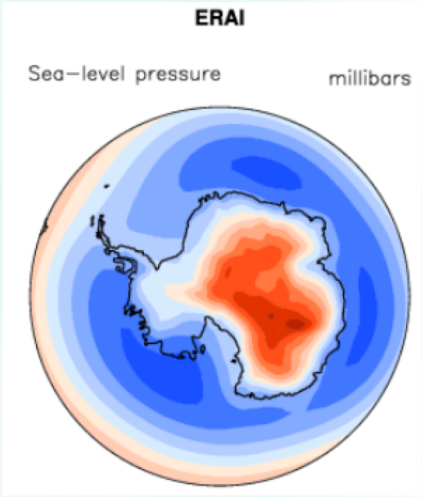
- Equatorward shift of the westerlies jet seen in both EAMv1 and v2 simulations
- Bias are sensitive to atmosphere-ocean coupling and atmospheric tuning
- Warm bias over the Antarctica could be a contributor to biases in westerlies
- A challenge in v2 WC finalization: F-Case tuning may not translate to B-case

ANN Sea Level Pressure

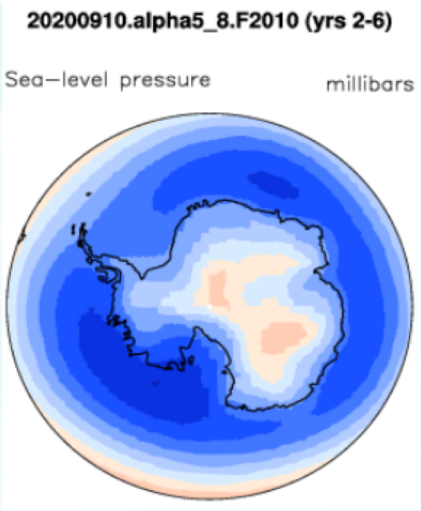
alpha4

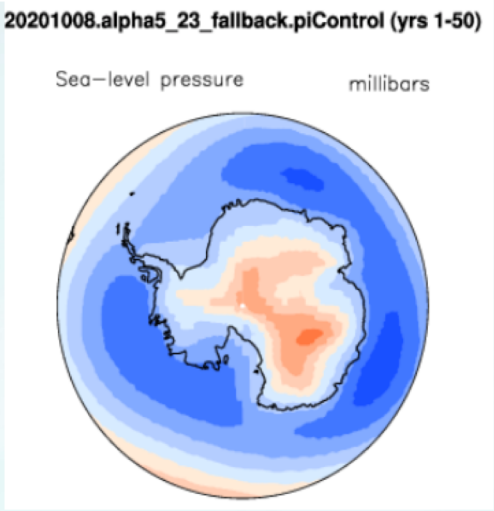


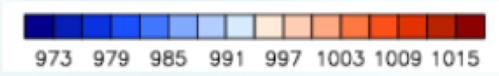




alpha5



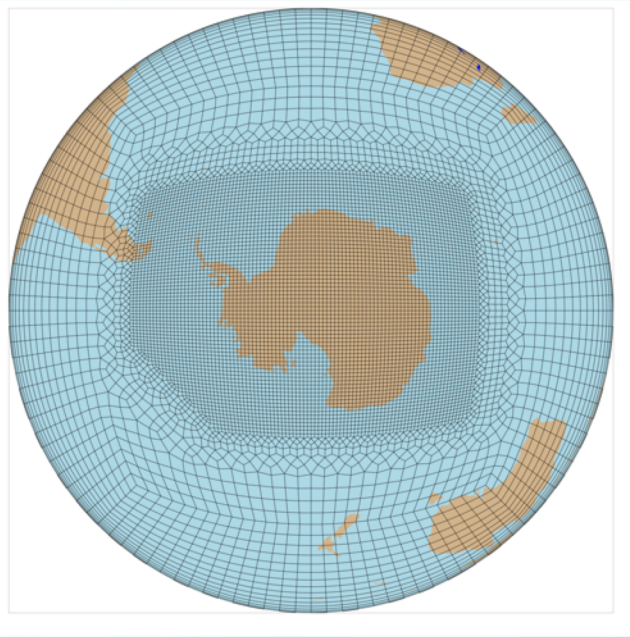




Atm-only **Coupled**

large responses expected from atmos tuning and/or coupling

- **Status of Antarctica RRM and simulations**
  - **RRM vs. low and high-res. simulations**
  - **RRM response to atmospheric tuning**



Grid	np4 elements phys. columns	pg2 physics columns
antarcticax4v1	12209/109883	48836
ne30	5400/48602	21600
ne120	86400/777602	345600

RRM cost: ~2.5x ne30pg2 when using same phys dtime

Simulations for RRM Assessment

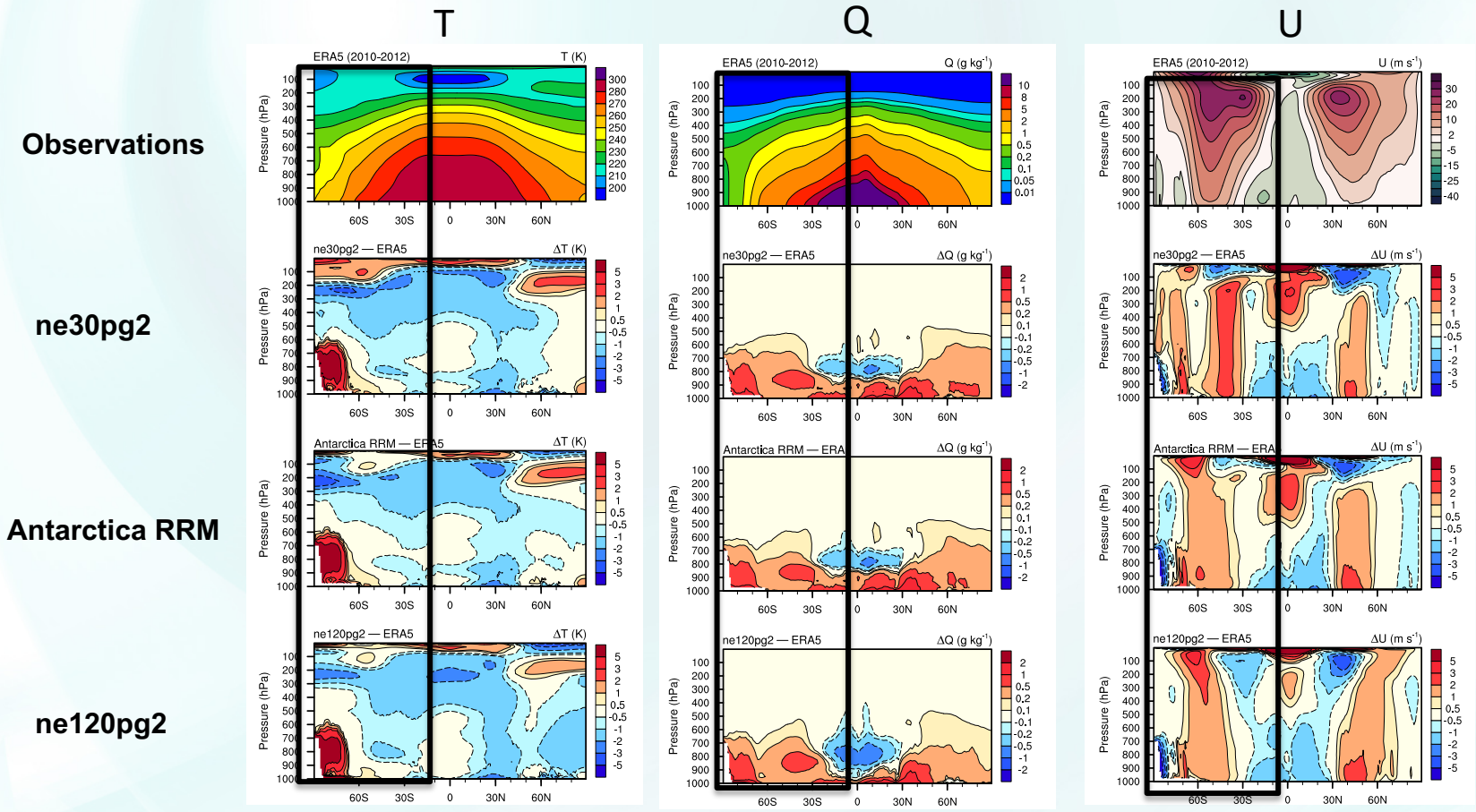
(mirror the configurations for a recent high-res simulations for Q4 MCS metric report to BER)

Exps	Grids	Configuration
ne30pg2	ne30pg2_r05_oECv3	v1 like atmosphere with CLUBBv2
ne120pg2	ne120pg2_r0125_oRRS18to6v3	v1 like atmosphere with CLUBBv2
Antarctica RRM	antarcticax4v1pg2_r0125_antarcticax4v1pg2	v1 like atmosphere with CLUBBv2
RRM_alpha5_8	antarcticax4v1pg2_r0125_antarcticax4v1pg2	Alpha5 version of V2 atmosphere

- **Simulation length**: 2010-2012 (3yr)
- **Compset**: F2010SC5-CMIP6
- **Dycore**: theta-l and SL transport, CAM_TARGET=theta-l
- **SST/Sea ice**: OISSTv2 weekly
- **No further tuning when resolution is changed.**

- **Reanalysis products:**
  - **ERA5 reanalysis (https://cds.climate.copernicus.eu/#!/search?text=ERA5&type=dataset)**

Annual mean bias in Temperature (T), Humidity (Q) and zonal wind (U)



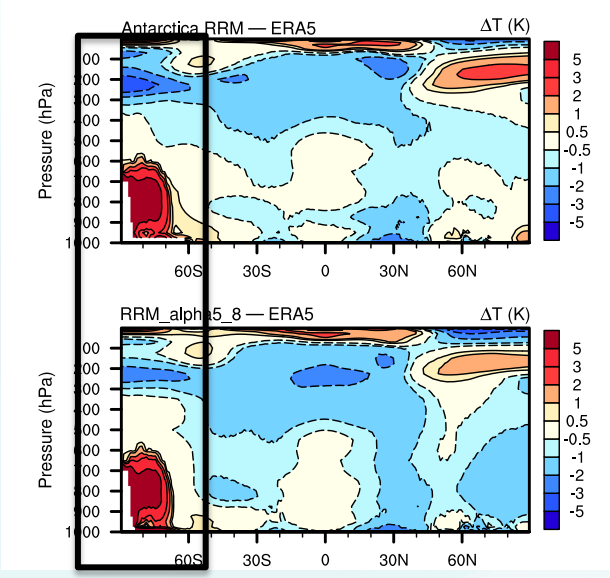
- Bias in temperature and zonal wind are sensitive to resolution changes
- RRM “reproduces” most of the features in high-resolution simulations

Sensitivity of annual mean bias to parameterization changes

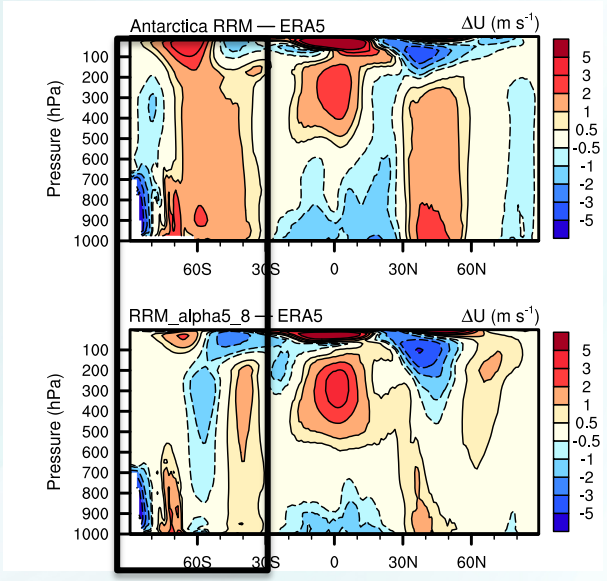
RRM + v1 like atmosphere

RRM + v2 alpha5 atmosphere

T



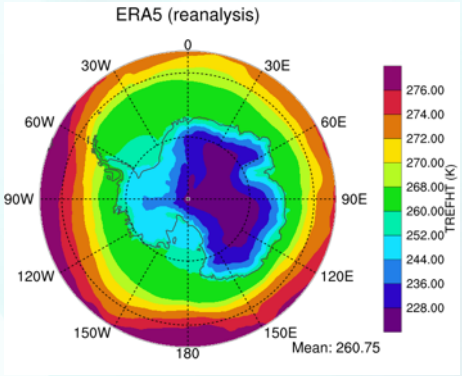
U

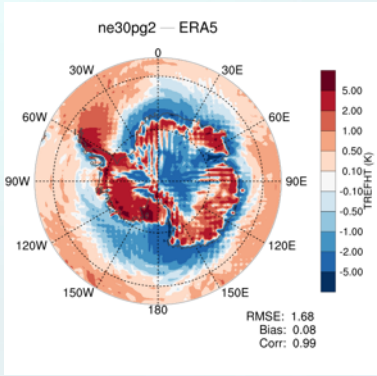


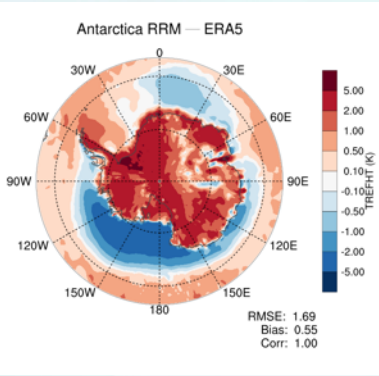
- The tuning changes in v2 alpha5 reduce the biases in the westerly jet stream

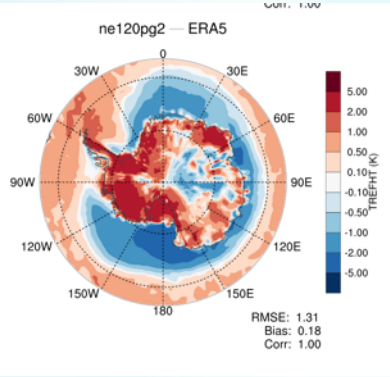
Annual mean bias over southern polar region

2m temperature

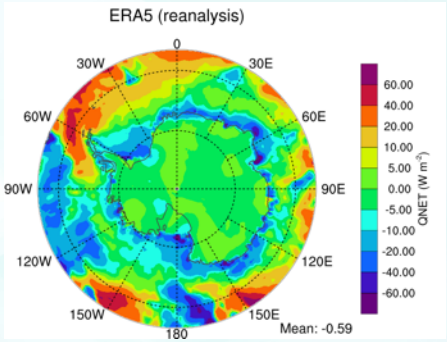


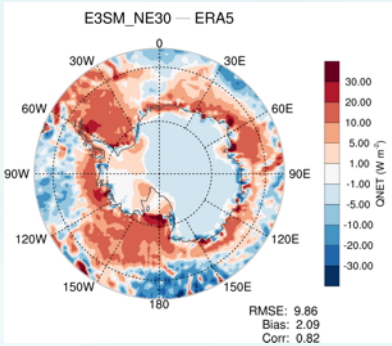


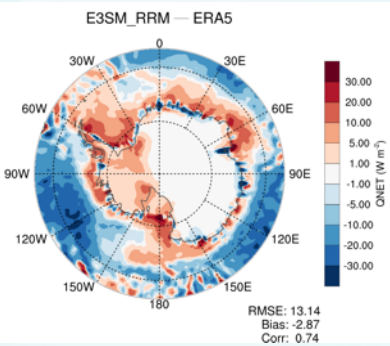


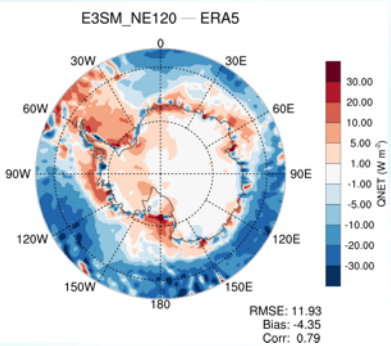


Surface net fluxes



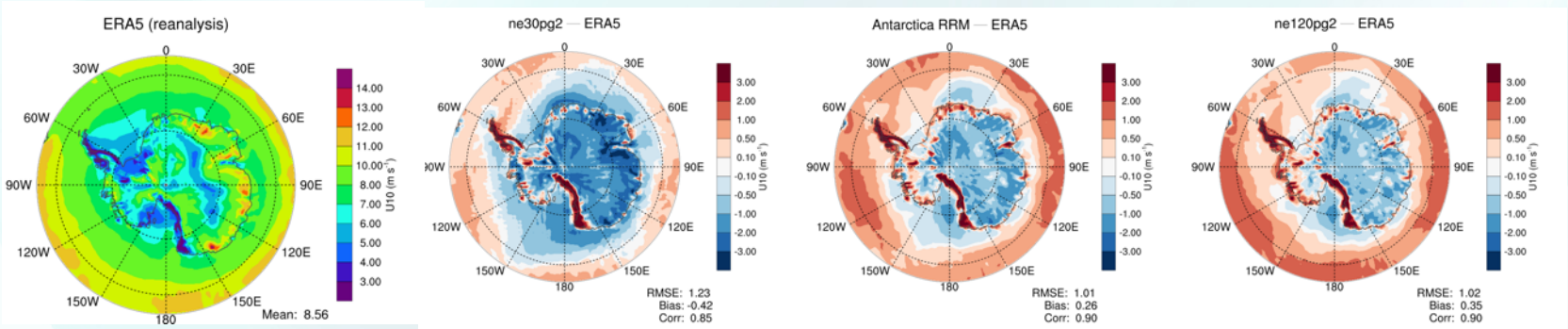




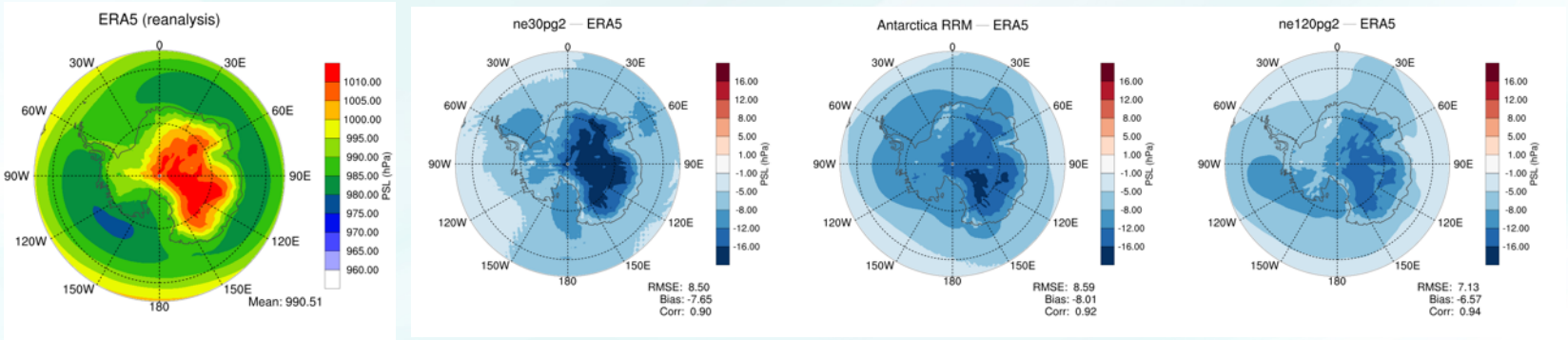


Annual mean bias over southern polar region (continue)

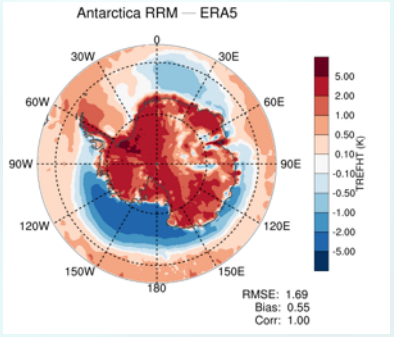
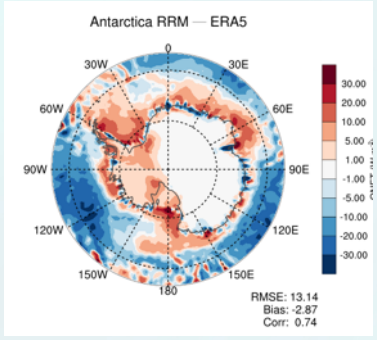
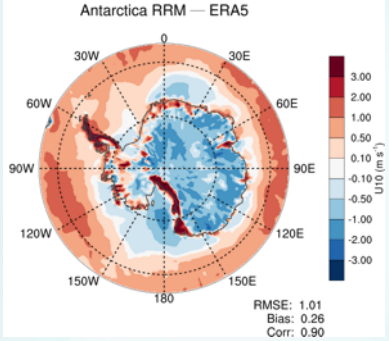
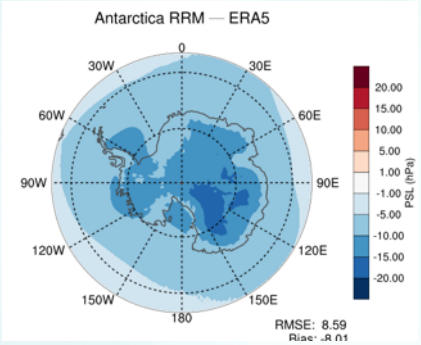
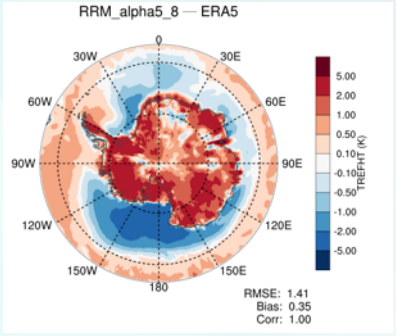
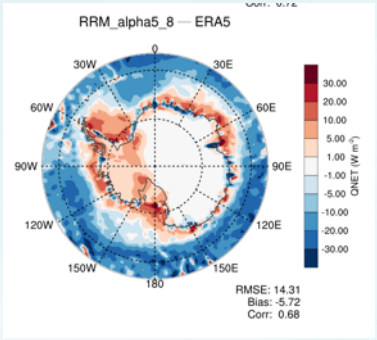
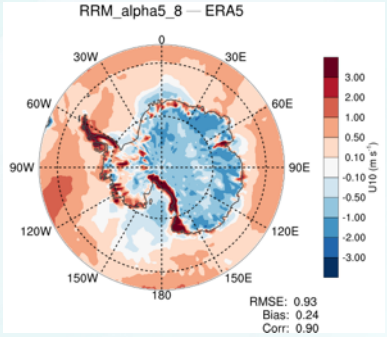
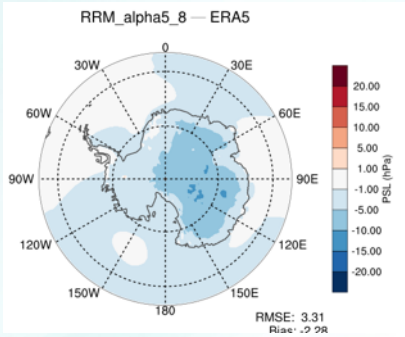
10 m wind



Mean sea level pressure



Sensitivity of annual mean bias to parameterization changes

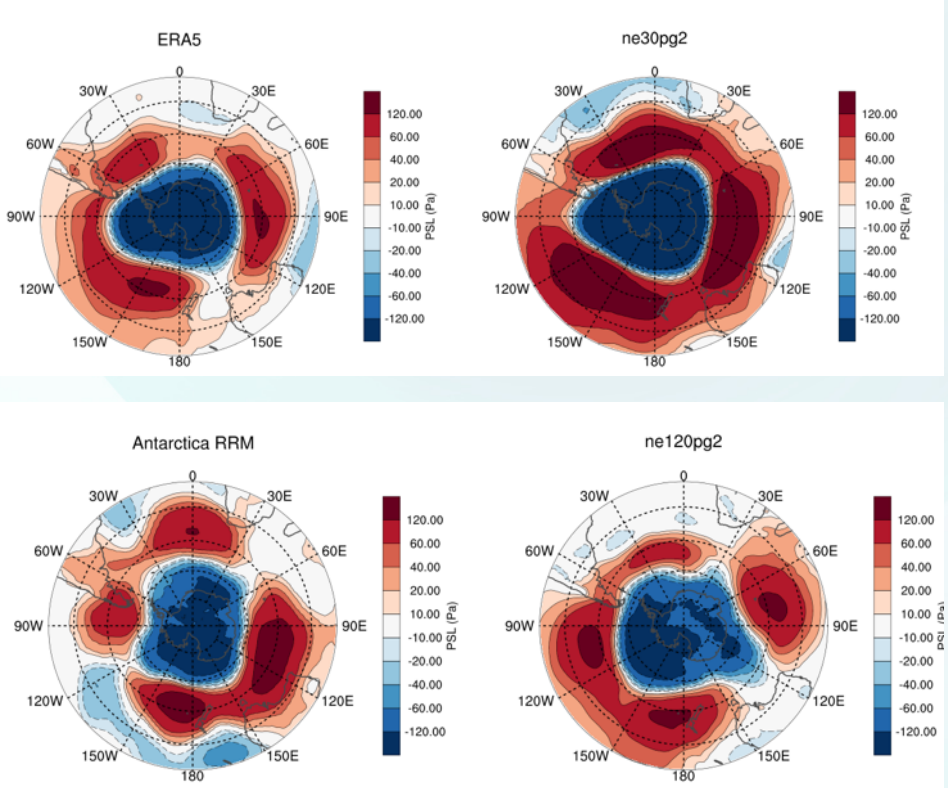
	2m temperature	Surface net fluxes	10 m wind	Mean sea level pressure
RRM + v1 like atmosphere				
RRM + v2 alpha5 atmosphere				

Atmos tuning can further improve the RRM simulations over the SH polar region

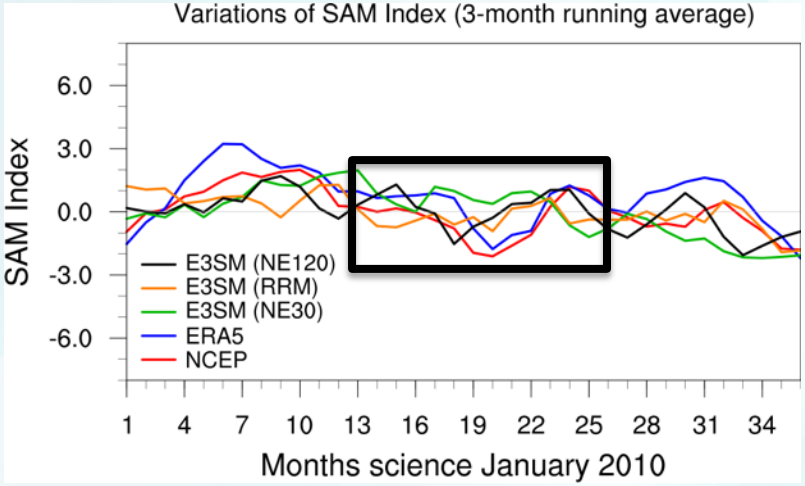
(Note this particular tuning is from WC group for ne30pg2)

Large-scale atmospheric circulation and variability

Regression of mean sea level pressure on the SAM index (20S – 90S)

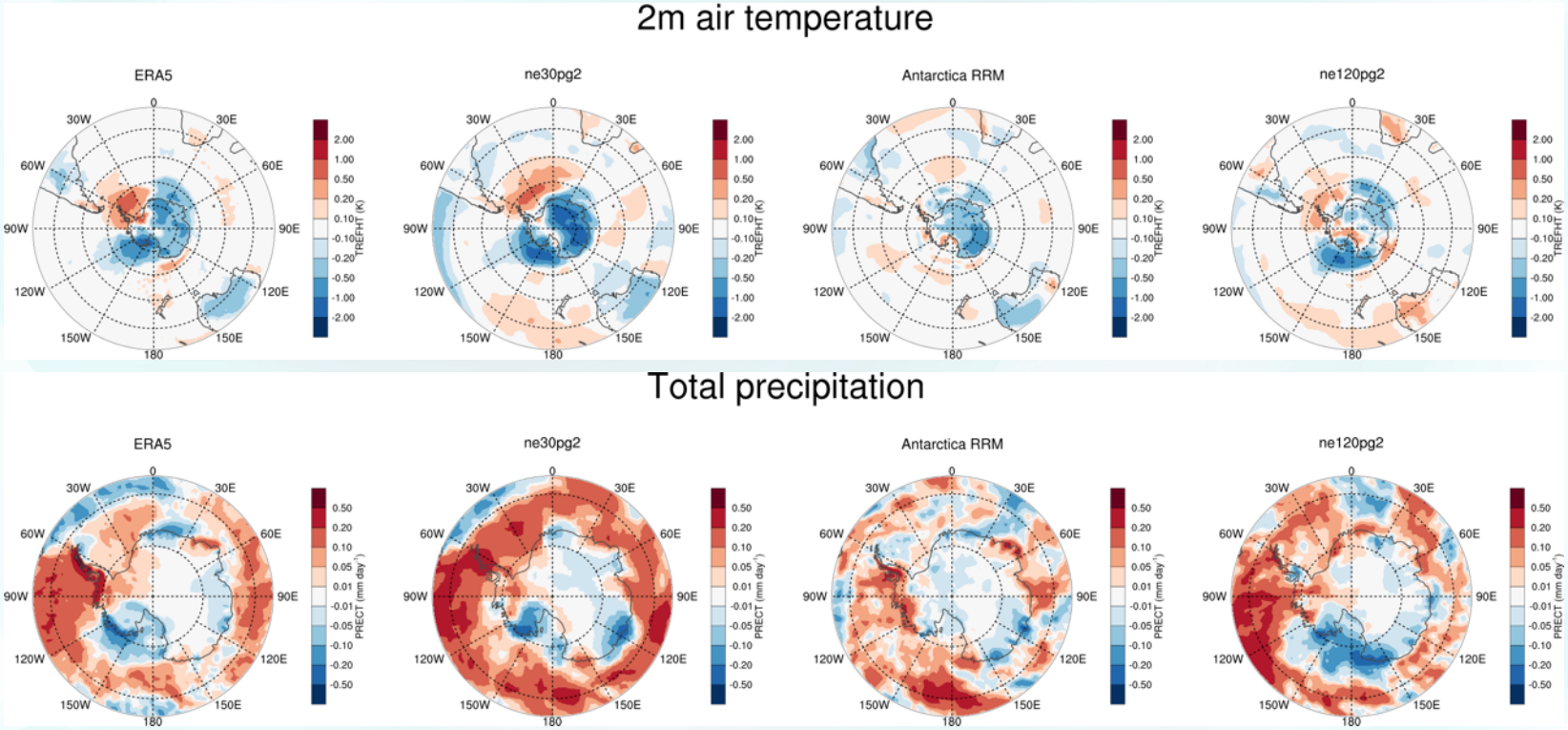


$$SAM = P^*_{40°S} - P^*_{65°S}$$



Surface air temperature and total precipitation responses

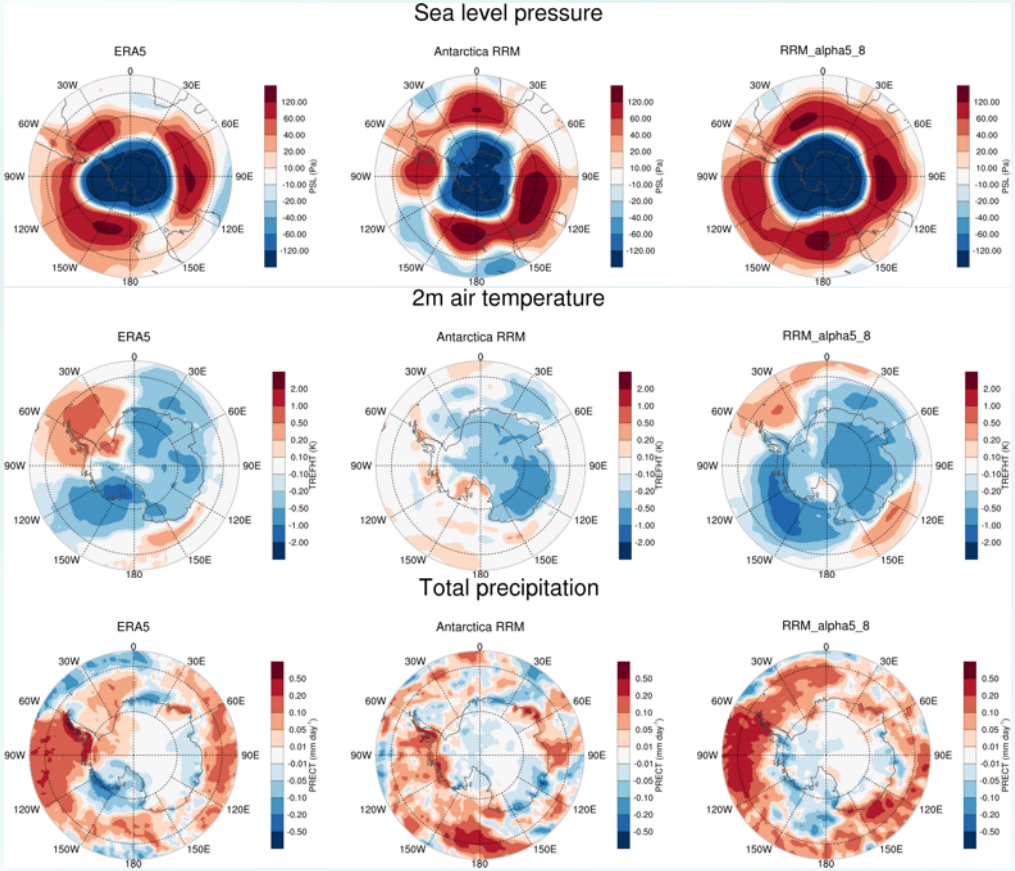
Regression of 2m air temperature and total precipitation on the SAM index (55S -- 90S)



- Better representation of SAM mode leads to better relationship between SAM and near-surface air temperature and total precipitation

Sensitivity to parameterization changes (atm tuning)

ERA5 | **RRM + v2 alpha4 atmosphere** | **RRM + v2 alpha5 atmosphere**



(Regression of anomaly fields to SAM index)

Summary

- E3SMv2 alpha versions mostly produce similar climatology to E3SMv1 over southern polar region.
- Model biases over SH polar region appear sensitive to resolution and parameterization changes (atmos tuning)
  - High resolution help to aalleviaate the equatorward shifting of westerly jet
  - Atmos tuning and coupling in E3SM v2 alpha versions can lead to large responses in surface winds, SLP, westerly jets, modes of variability (e.g., SAM)
- RRM generally reproduces the results of high-resolution simulation.

Further work

- Continue to monitor the climatology over SH polar region from WC v2 finalization.
- Incorporate new tunings for RRM simulations; more detailed analysis and evaluation of long-term RRM simulations.
- Coupling atmos RRM with ocean/ice, including with SORRM.

Thank you!

Tracking the evolution of v2 alpha5

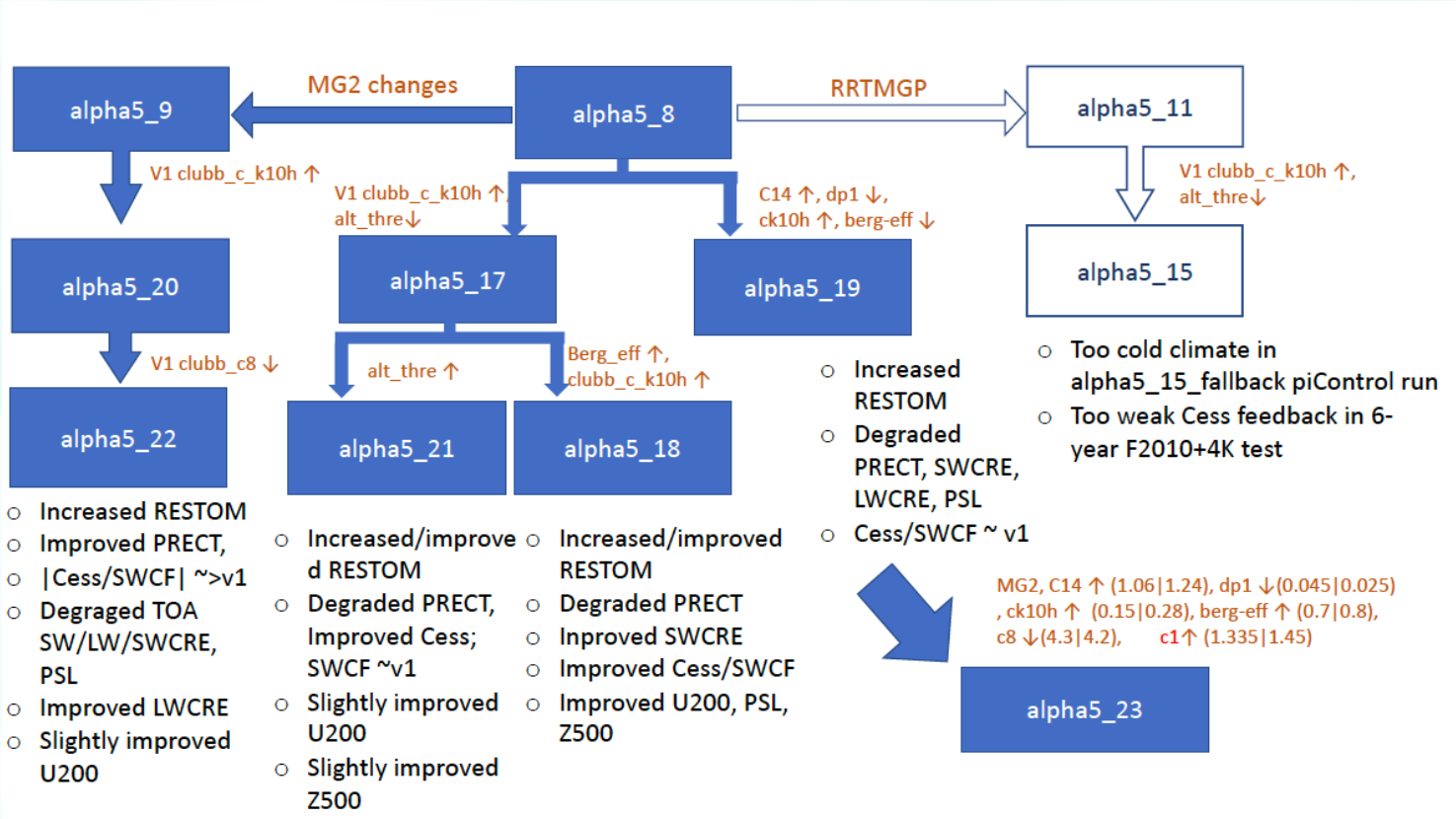


Figure 1. flow chart for the evolution of alpha5 development. Courtesy of Xue Zheng