Tuning of convection in NorESM2 AMIP simulations

AMWG meeting, 19 February 2019, Boulder

Thomas Toniazzo, Dirk J.L. Olivie, Øyvind Seland, Alf Kirkevaag, and the INES consortium

Bjerknes Centre & met.no & UiO
Norway

I. Introduction
II. Tunings steps and biases
III. Systematic validation
IV. Non-linearities
V. Effect of cloud tunings
VI. Summary

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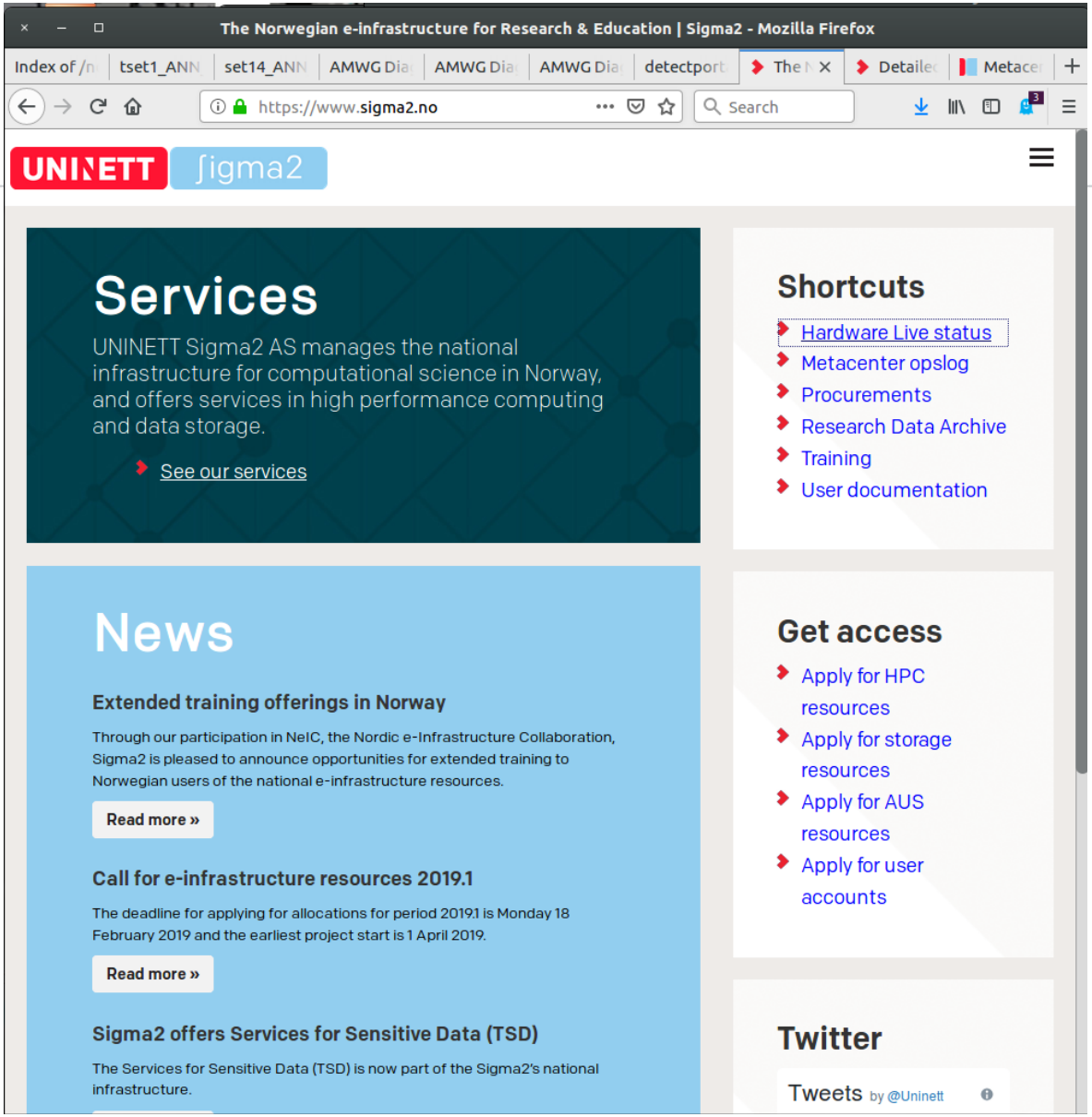
A word of apology: trouble with supercomputing/storage infrastructure



FEBRUARY 4, 2019

Scheduled downtime on the 12th of February

Update:

- **2019-02-19 14:10**: Disk rebuilds on NIRD have reached 40%. Current ETA for NIRD is Thursday morning.
  We are still waiting for the Fram parts to arrive to Tromsø.
- **2019-02-18 16:36**: Some disk pools must be rebuilt once again for NIRD, thus delaying the opening once more. We are terribly sorry for this. Will continue updating the log as soon as new information is available.
- **2019-02-18 10:10**:
  NIRD storage is stabilized now and the vendor will do a new attempt of taking the system back online during today. At this stage it is still uncertain when Fram can be put back into production.
- **2019-02-15 11:18**: We are still experiencing problems with the storage system on Fram. Disks begun to mass-fail once again after the system seemed to be stable during the night. We are depending on the vendor to resolve these issues and we are working closely with them.
  Based on the new instability we can not give an estimate for when the system will be ready for general use again. This is an unfortunate situation and we understand the impact on you, and thus we try all possible solutions to keep your data safe and bring up the system as soon as possible.The OpsLog will be updated with new information when the status of the situation changes.
- **2019-02-14 13:17**: Due to missing parts, and the size of the storage, disk recovery is progressing slowly ahead on approximately 50% reduced performance. Current ETA are:
  - Fram: 15.02.2019
  - NIRD: 19.02.2019
  - Service Plattform: 19.02.2019
- **2019-02-13 19:07**: Communication with the missing storage enclosures were re-established and disk pools are rebuilding at this time. Unfortunately we can not reopen machines until disk pools are stabilized. We will have a new round of checks and risk analysis tomorrow morning. Will keep you updated here.
- **2019-02-13 11:33**: Some of the parts arrived to the datacenter and we are working with the vendor on replacing and pathing the firmware on Fram. More details to follow as we know more.
- **2019-02-12 15:38**: NIRD Tromsø and Fram storages have each one disk enclosure which failed. We are waiting for replacement parts to arrive. After replacement we will have to rebuild disk pools before re-opening machines for production.Current estimate is tomorrow evening. Will keep you updated.
- **2019-02-12 12:36**: Firmware upgrade on NIRD is finished. We are proceeding to start back NIRD services. Will keep you posted.
- **2019-02-12 08:17**: Maintenance has started.
- **2019-02-11 13:20**: Due to the disk problems accellerating during the weekend, we have now changed the maintenance stop reservation so no new jobs will start until the maintenance is done. *Already running jobs will not be affected, but no new jobs will start.* This has been done to reduce the risk of data loss.

We need to have a scheduled downtime on a relatively short notice in order to upgrade the firmware on both Fram and NIRD (including NIRD Toolkit) storages.
This is a critical and mandatory update which will increase stability, performance and reliability of our systems.

The downtime is expected to last no more than a working day.

Fram jobs which can not finish by the 12th of February, are queued up and will not start until the maintenance is finished.

Thank you for your understanding!
Metacenter Operations

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I. Introduction

General philosophy

- Allow code changes that are motivated by physical considerations
- Do not ADD parametric dependencies to NCAR code
- Test changes against model performance, and accept them if overall impact is positive
- Identify and use (existing) free parameters to tune RESTOM
- Hope for the best, expect the worst

Summary of non-Oslo NorESM-specific options

1. COARE formulation of air-sea turbulent fluxes (NorESM1.2)
2. Local conservation of enthalpy (NorESM1.2)
3. Time-step averaging of SW radiation for albedo/chemistry (NorESM2)
4. Conservation of total angular momentum (NorESM2)
5. Convection (NorESM2)

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5. Convection (NorESM2)

5. Modifications to the ZM scheme

(in progress)

- **Standard ZM too sensitive to free entrainment parameter in CAPE function**
- **Generally too active**
- **Dilution process described inconsistently**

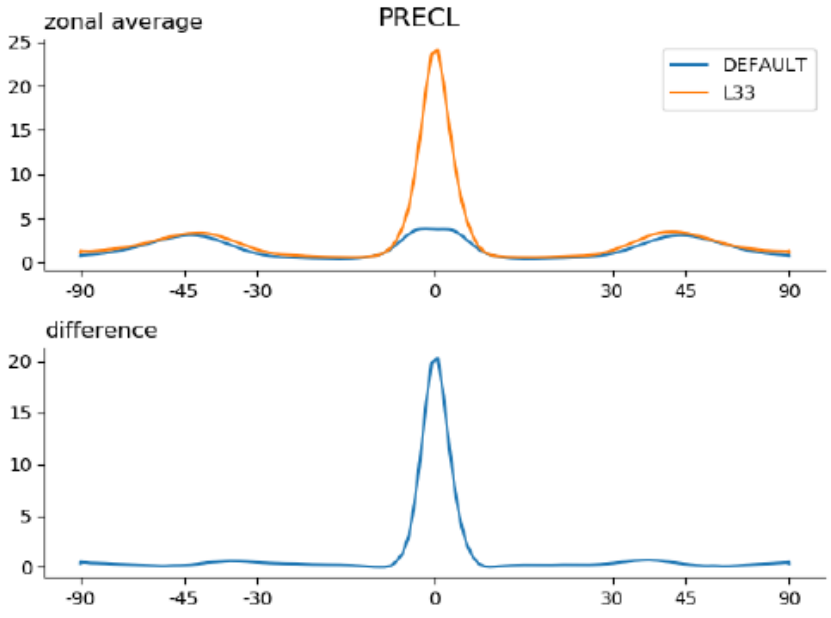
a) use moist enthalpy consistently throughout
b) add explicit **parametric dependence** in ZM plume-ensemble caculation
c) **iterate** test-parcel calculation with **diagnosed** ZM ensemble **entrainment**
d) **recompute CAPE** and respective ZM-tendency
e) Match sub-cloud layer with PBL

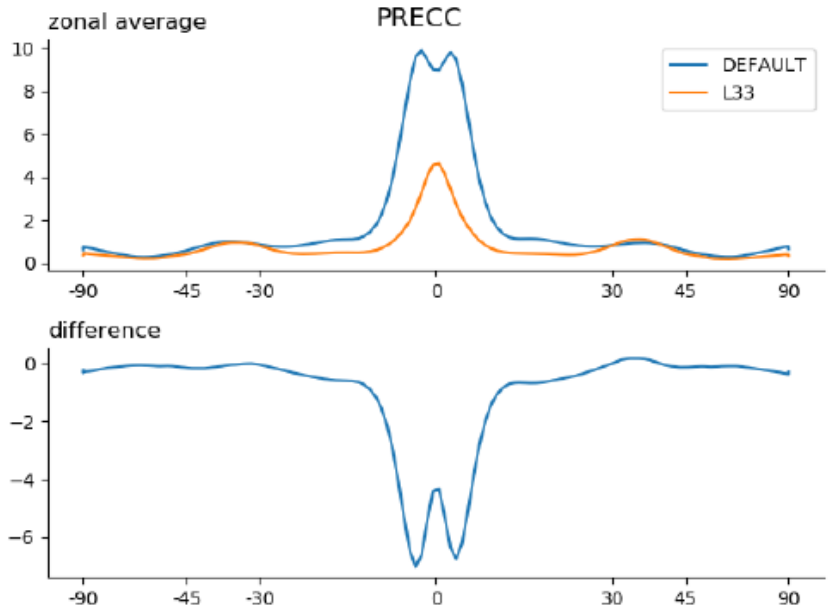
http://www.cesm.ucar.edu/working_groups/Atmosphere/development/cam6_dev_ZM/

→ **convection becomes less frequent, less diffuse, more intense, and deeper**

5e. Modifications to the ZM scheme: sub-cloud layer

L33: Standard L32 grid with one extra level at ~8m.
2-year aquaplanet test with CAM6 by Brain M





http://www.cesm.ucar.edu/events/workshops/ws.2018/presentations/amwg/discussion.pdf

Split-ITCZ merges to single ITCZ.
Rain changes from dominated by convection to dominated by large-scale.
(Likely due to triggering of deep convection scheme)

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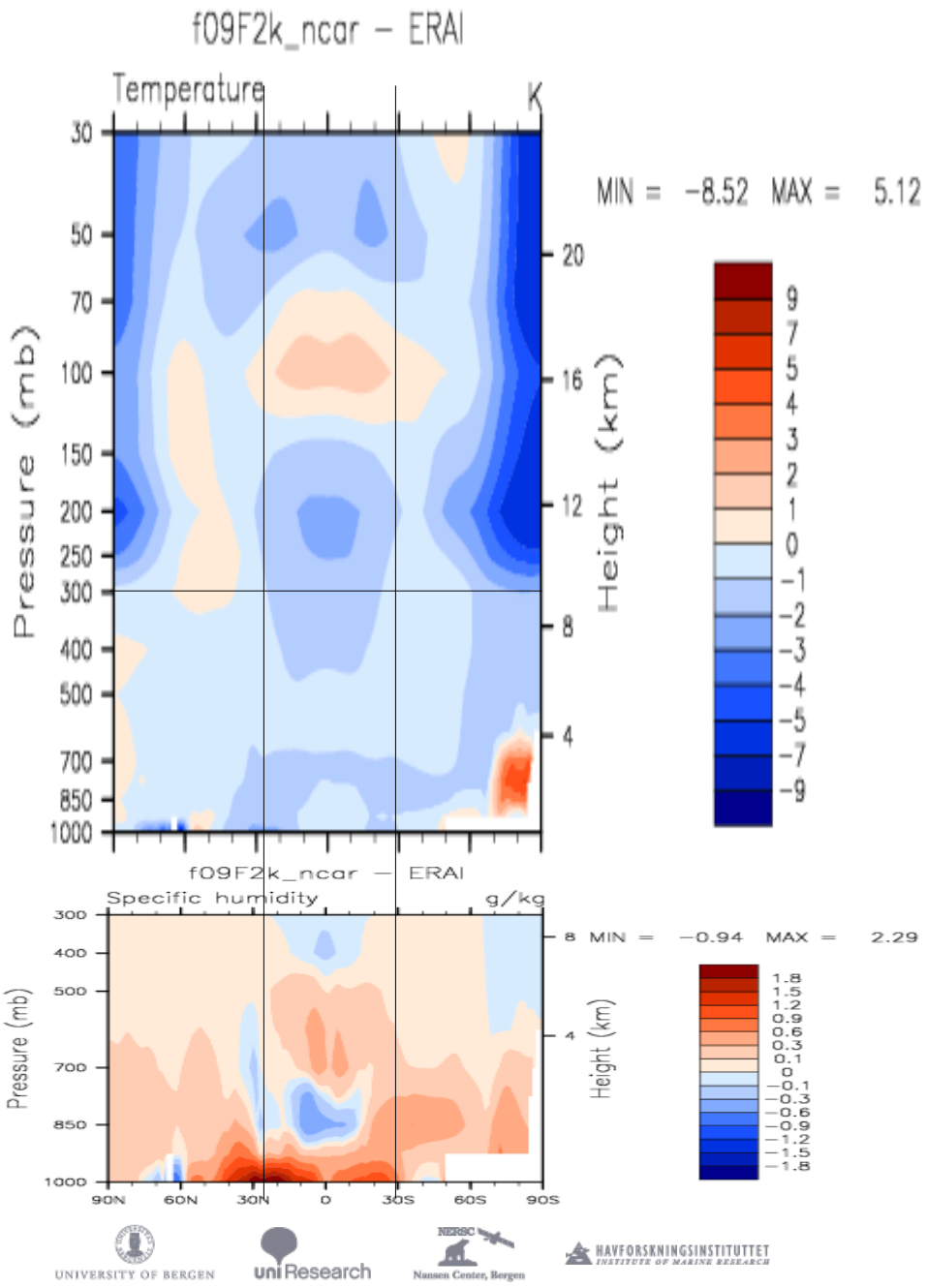

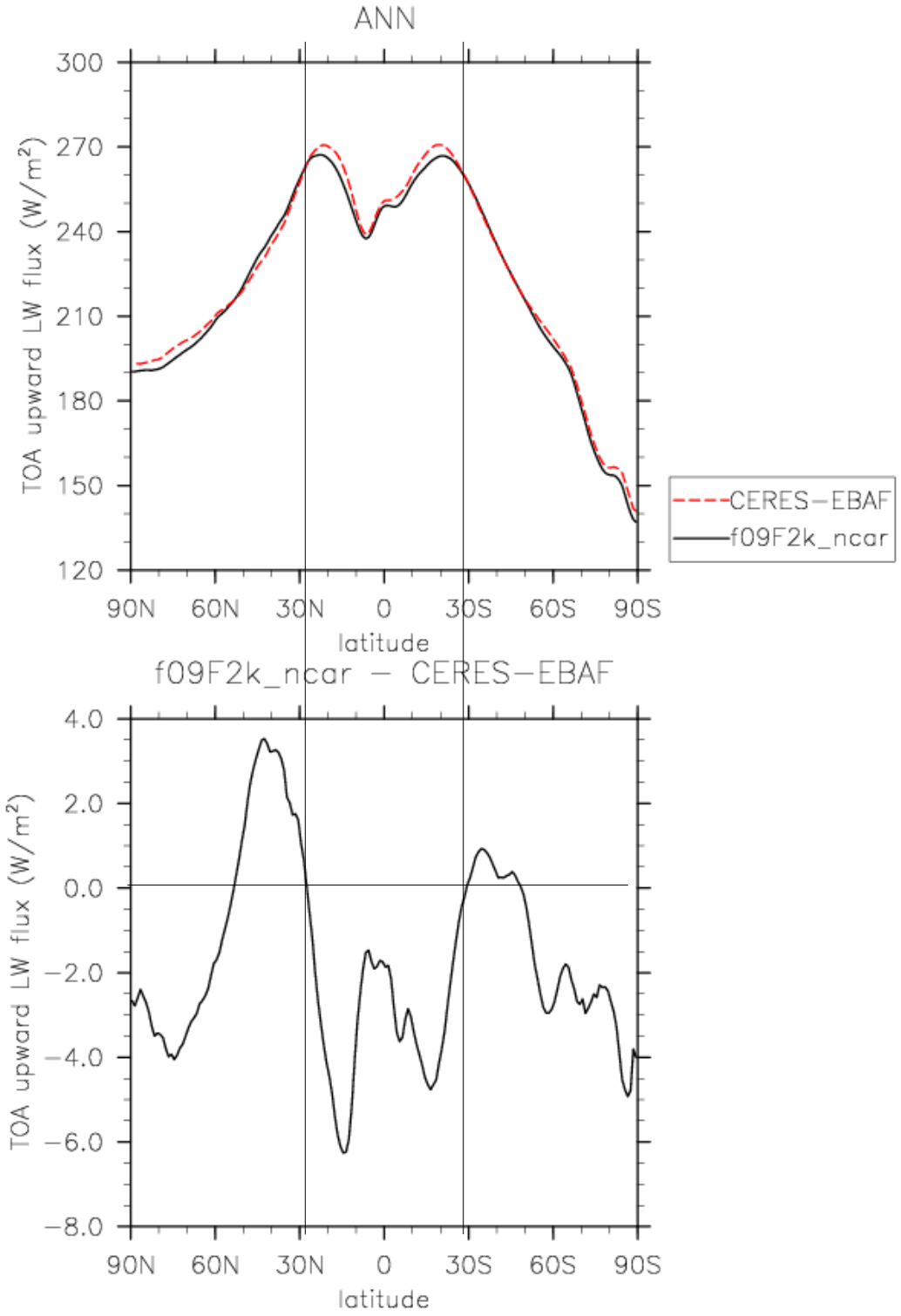

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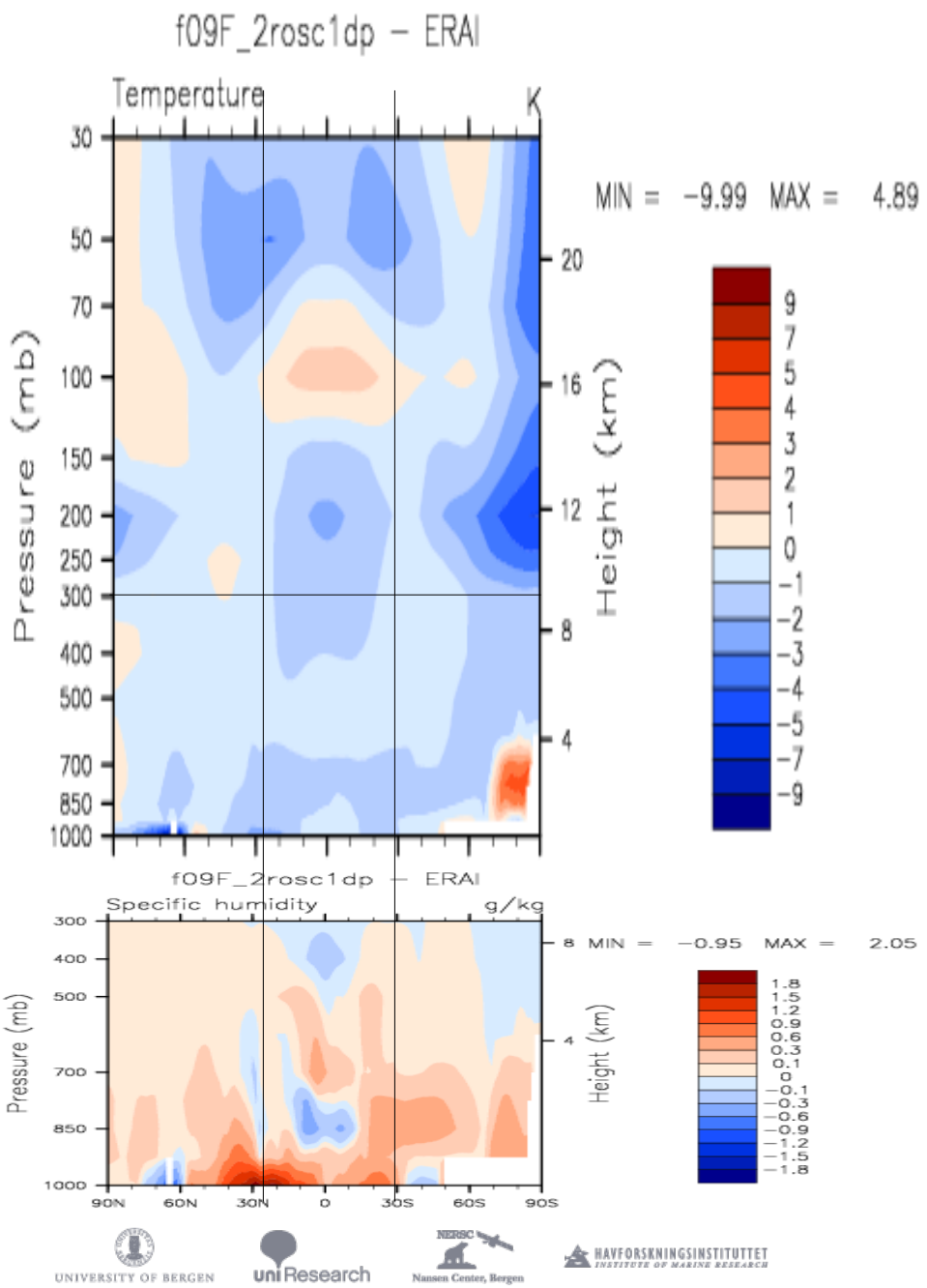

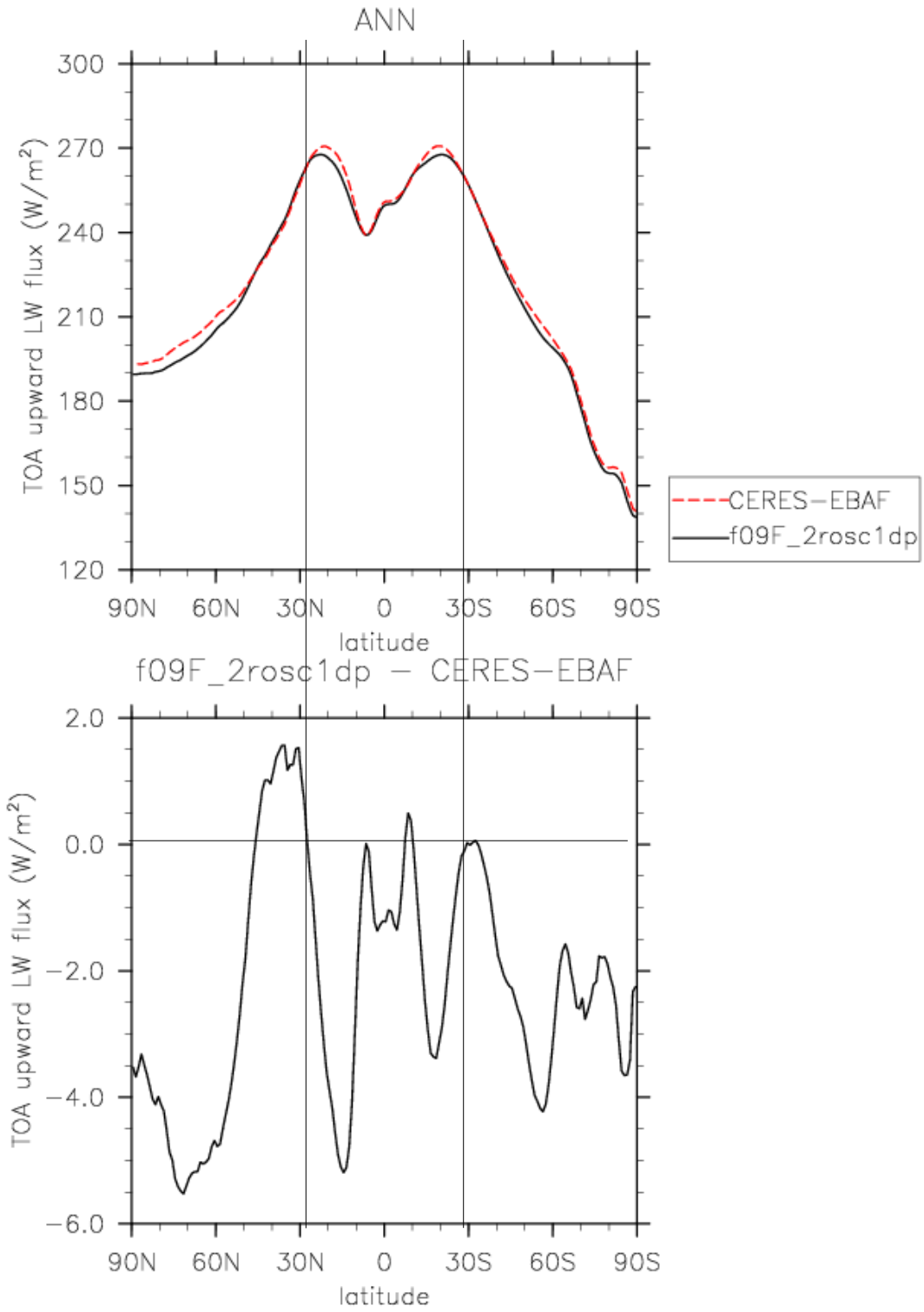

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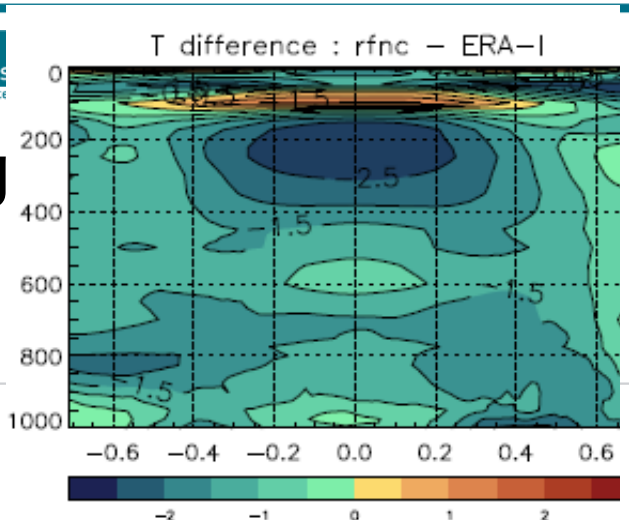
II. Tuning steps and biases

Model parameters and changes to convection used in tuning

• TOA balance (cloud SW forcing):	CLUBB gamma
• TOA SW-LW partition:	MG2 dcs
• Stratospheric wind and polar vortex:	GW tau_0_bc
• PBL stability (continental rainfall):	ZM land/sea parameters
• Tropospheric MSE (convective heating):	ZM iterative entrainment
• Tropospheric MSE (convective drying):	ZM CIN
• TOA balance (cloud LW forcing):	ZM c0
• Temperature and humidty profile (CMF):	ZM sub-cloud layer

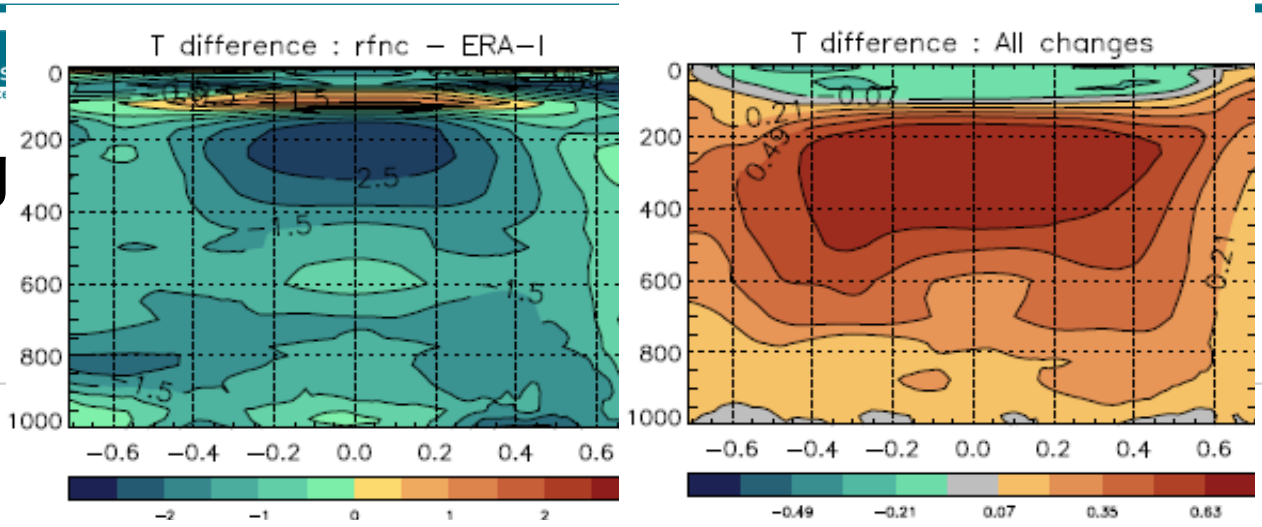
Choices:
- tau_0_bc = .true. always
- Tune state using ZM
- Tune TOA using gamma and dcs

Tuning steps: T



Bias in untuned NorESM F2k

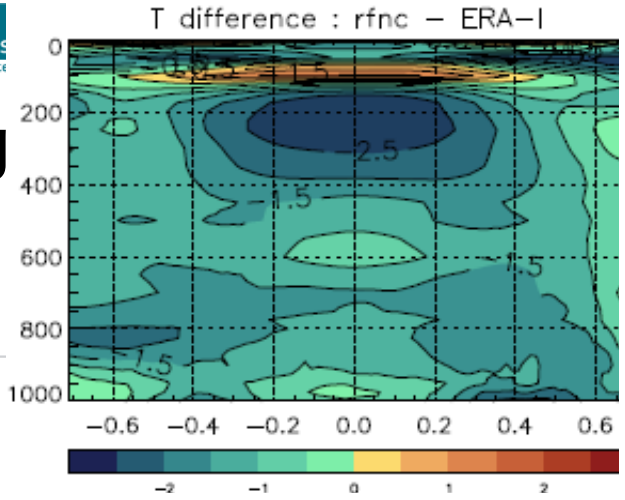
Tuning steps: T

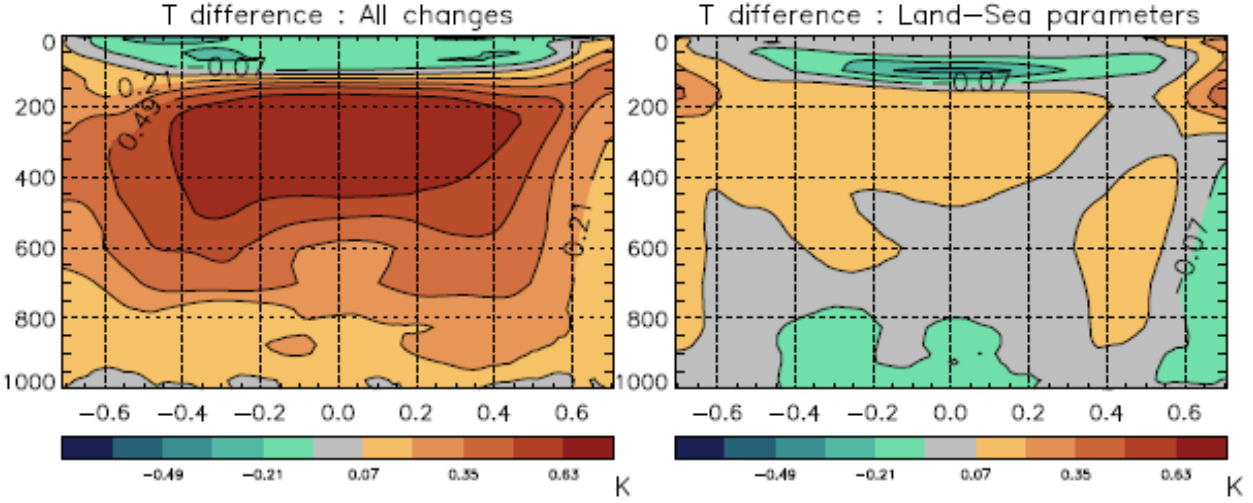


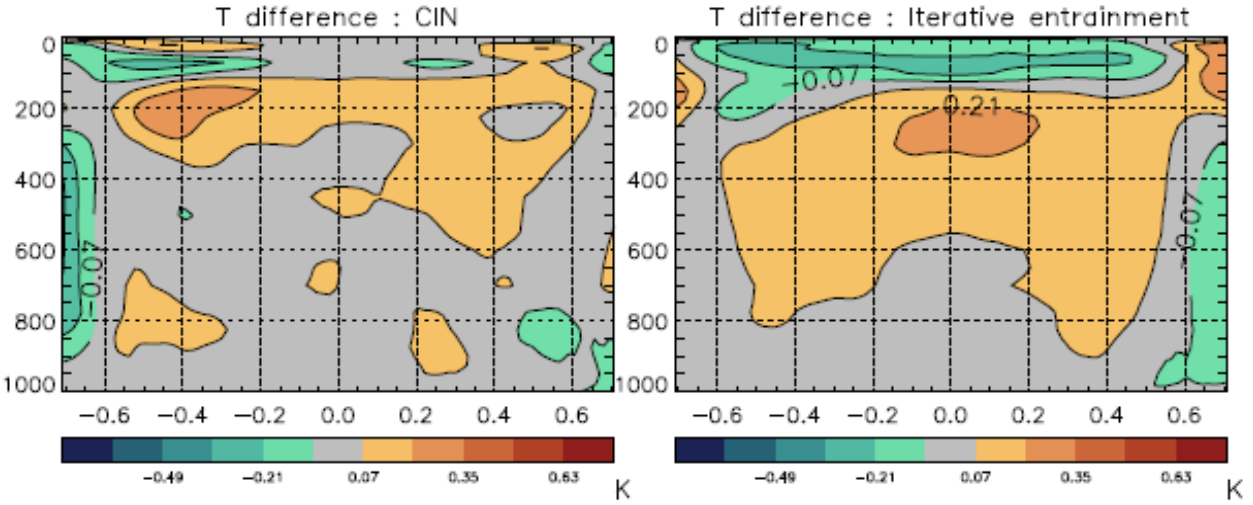
Bias in untuned NorESM F2k

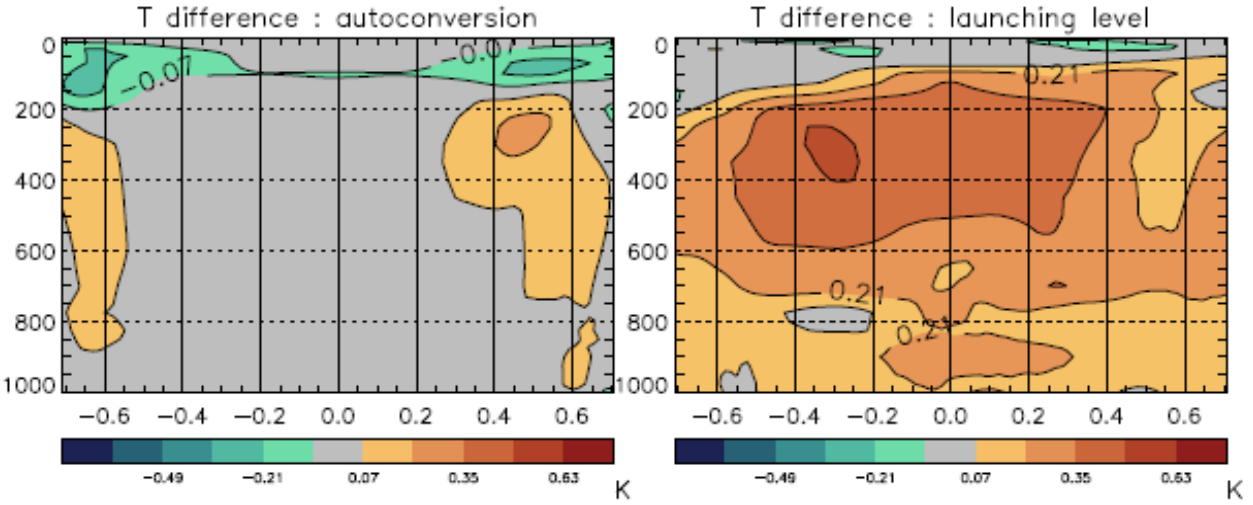
Change due to tunings

Tuning steps: T

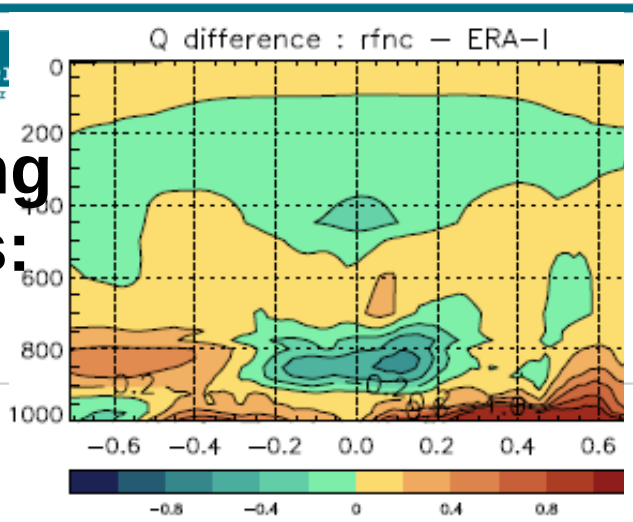








Tuning steps: Q



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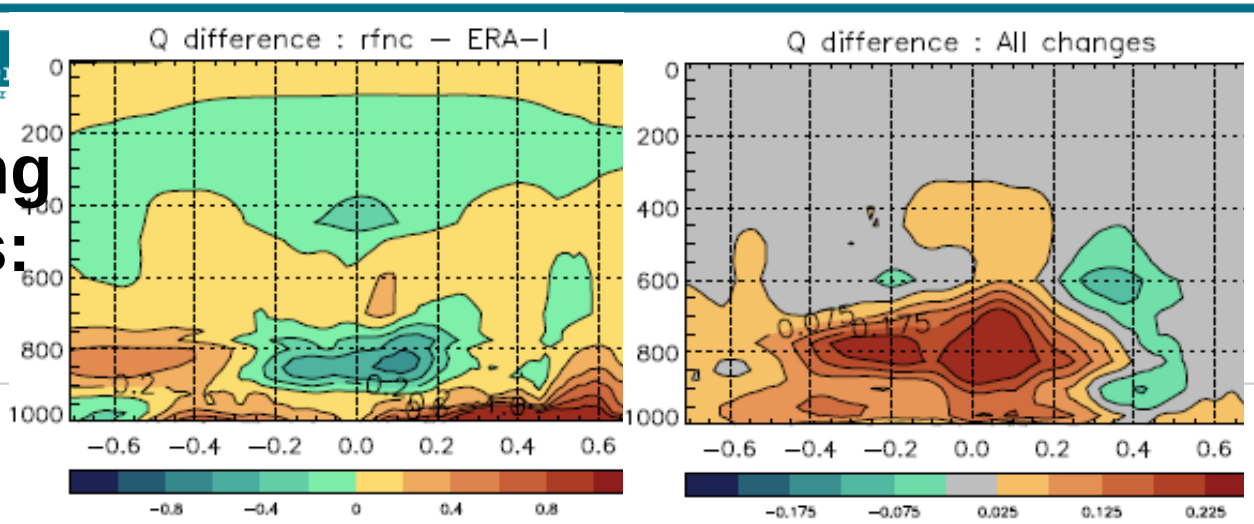

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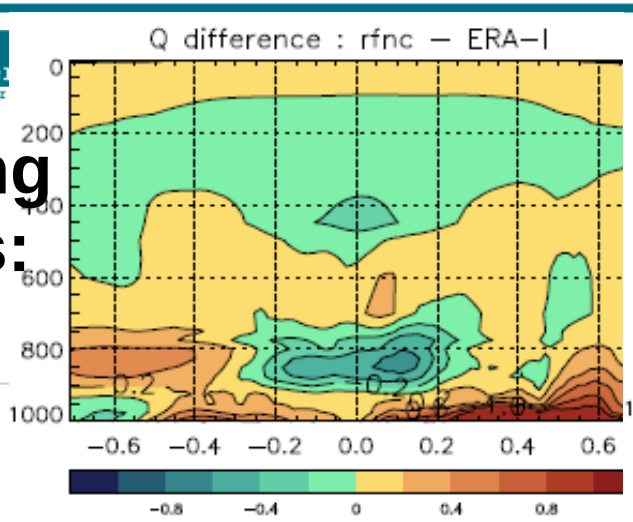
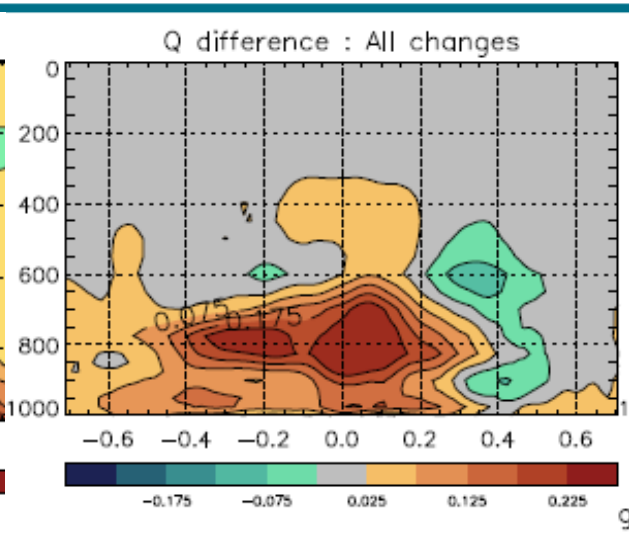
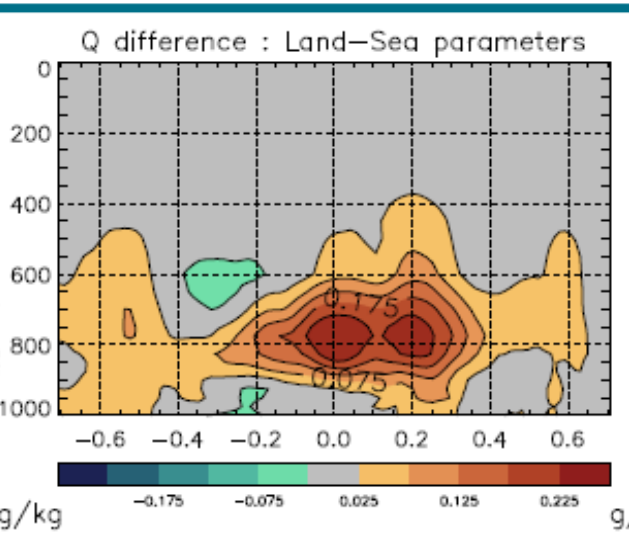
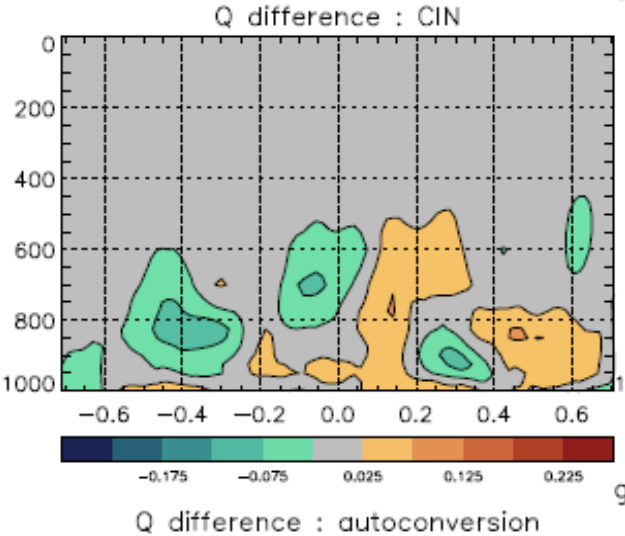
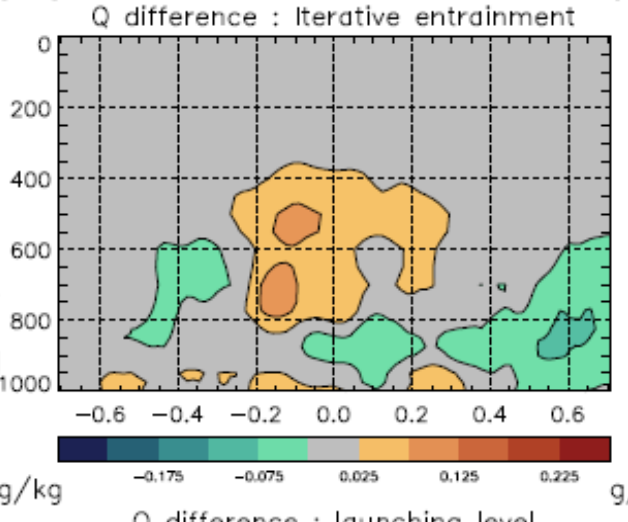
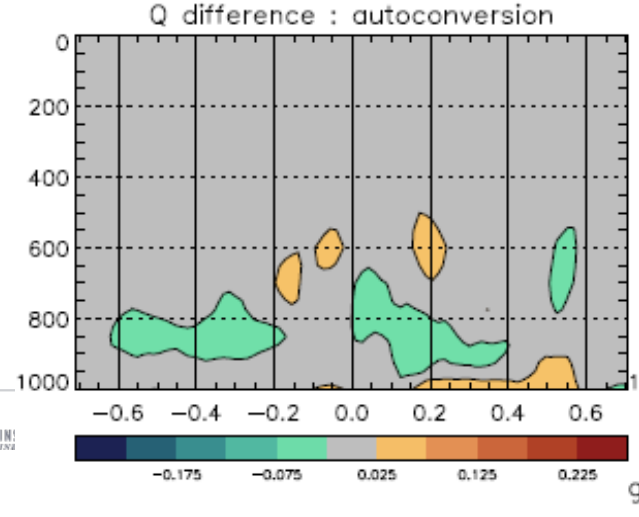


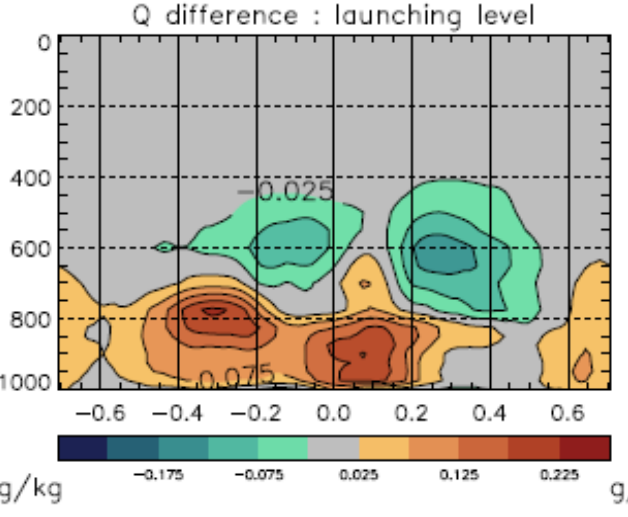




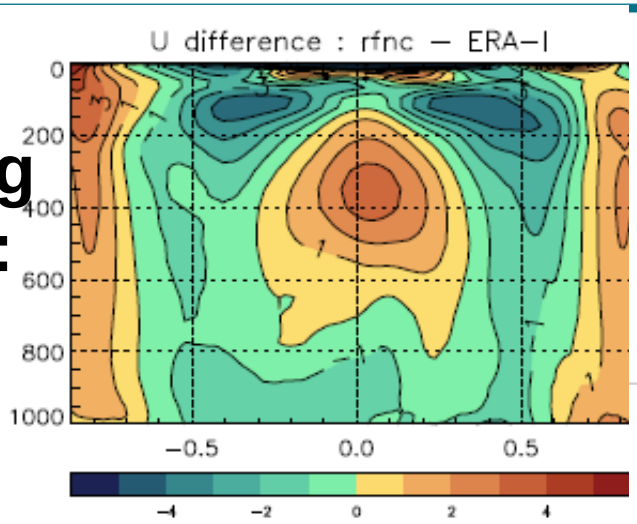








Tuning steps: U



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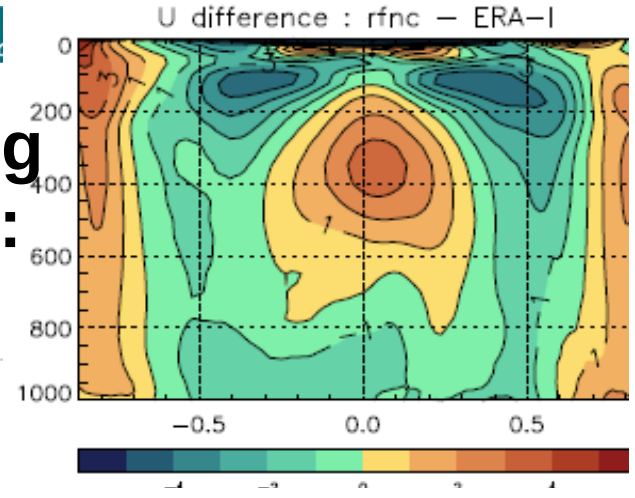
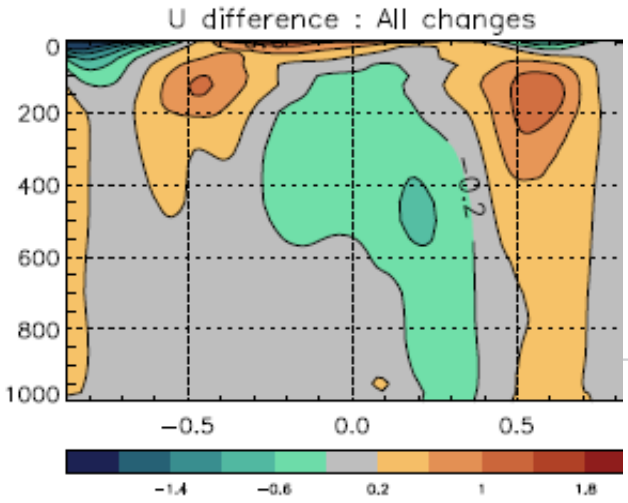
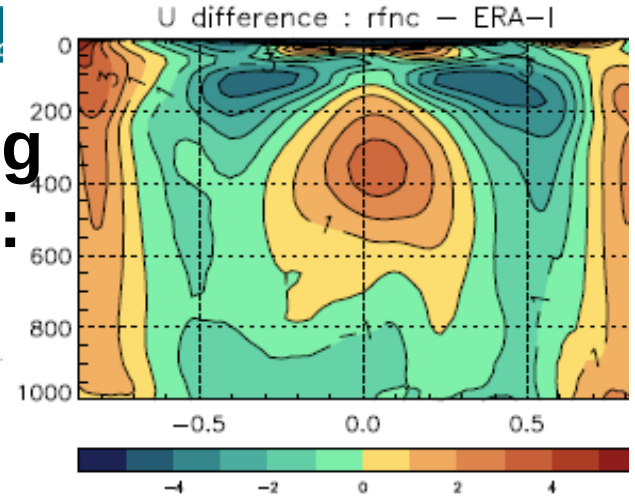
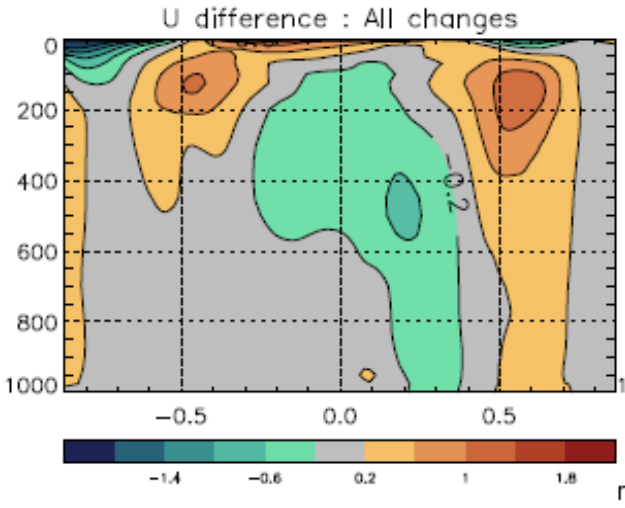
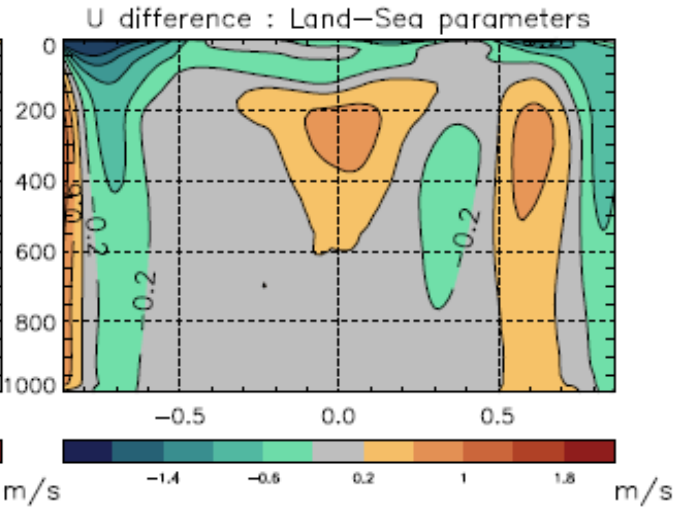


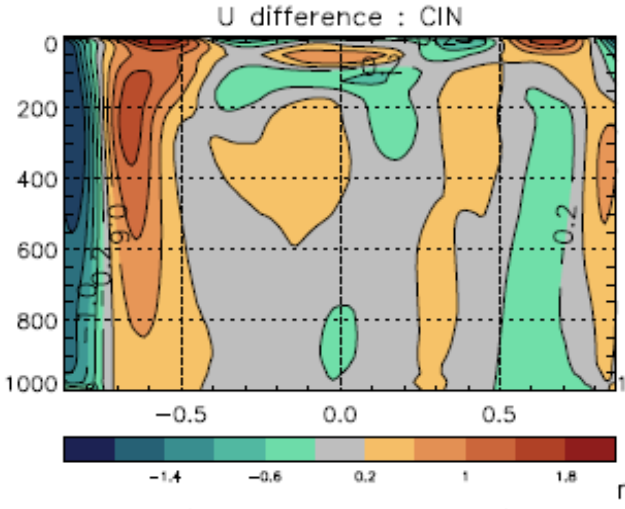


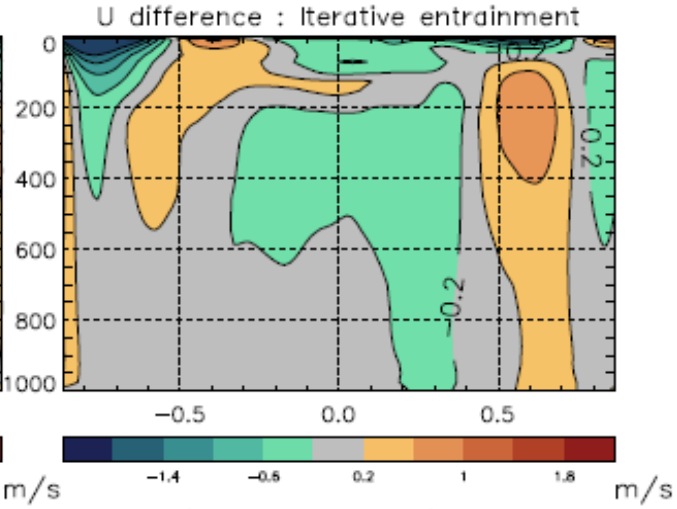
Tuning steps: U

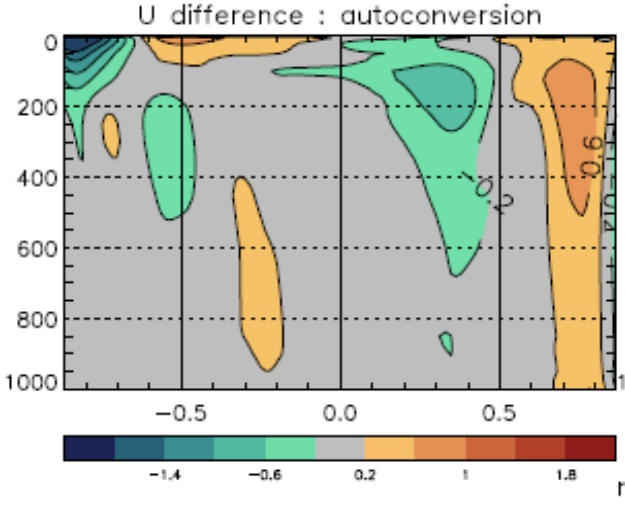


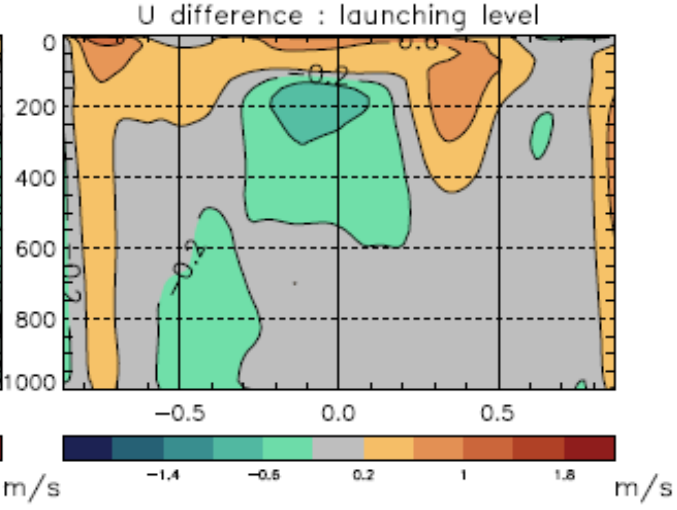












III. Systematic validation

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All tuned experiments: validation of biases and RMSE

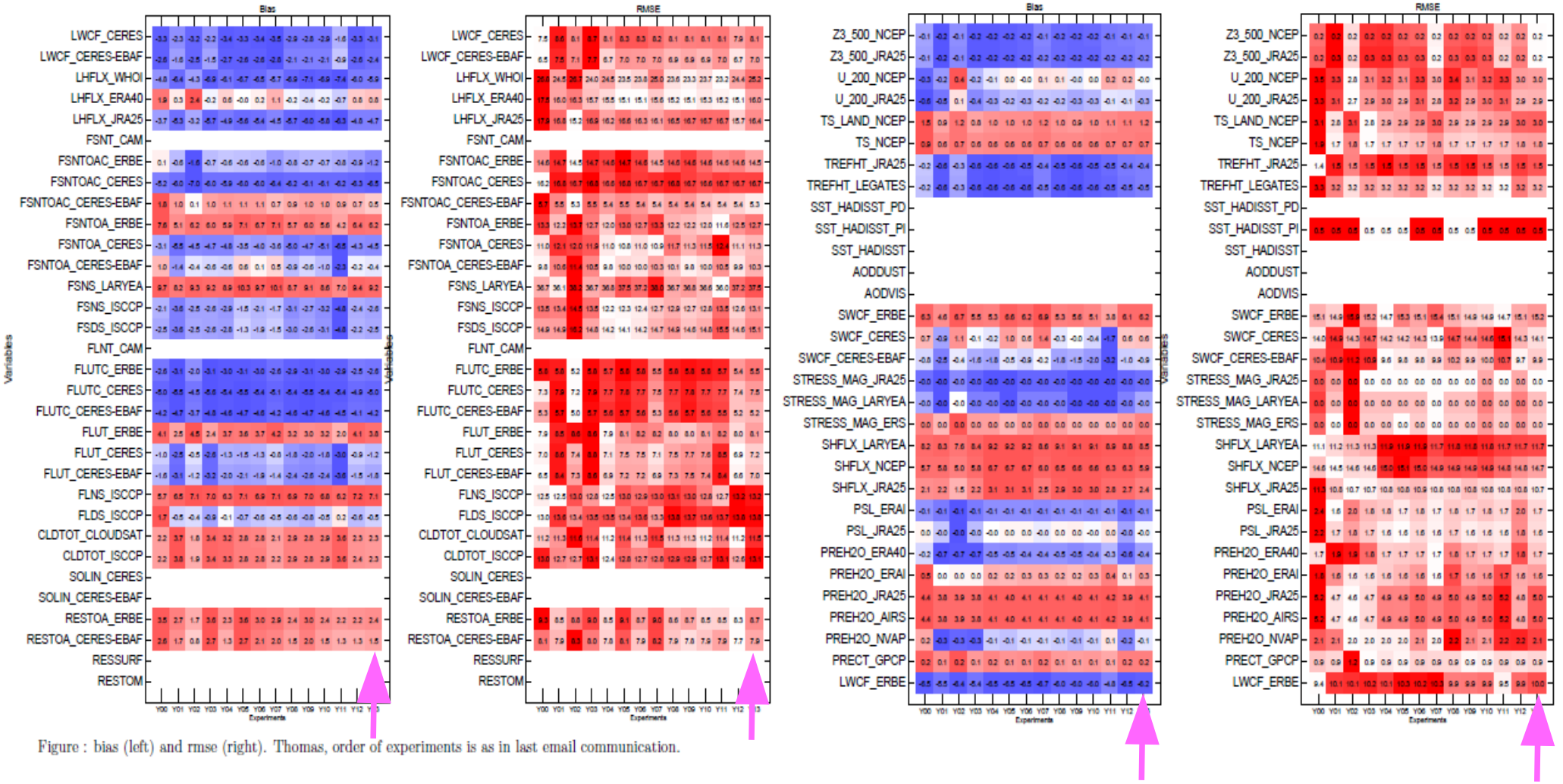

Figure : bias (left) and rmse (right). Thomas, order of experiments is as in last email communication.

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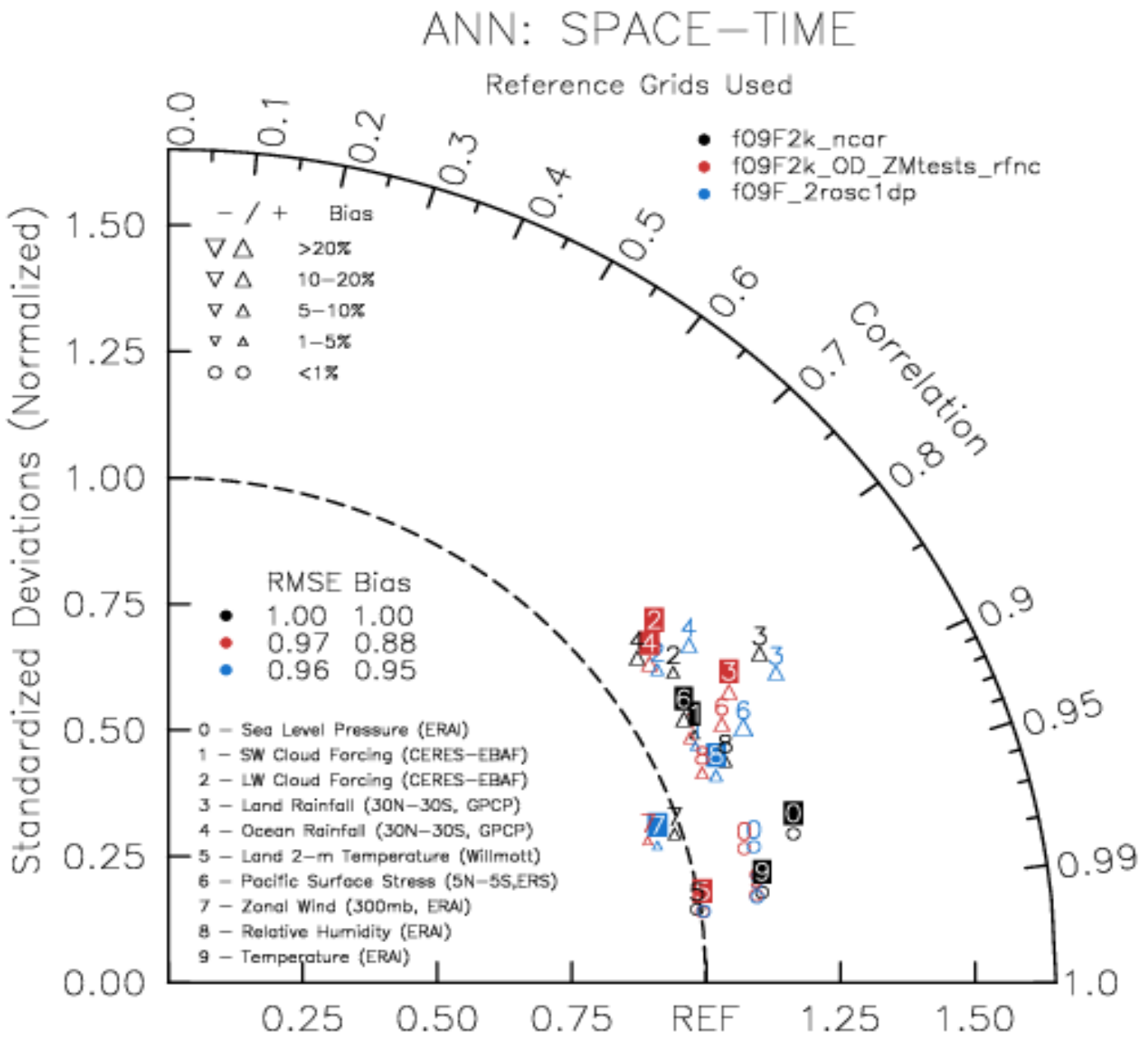

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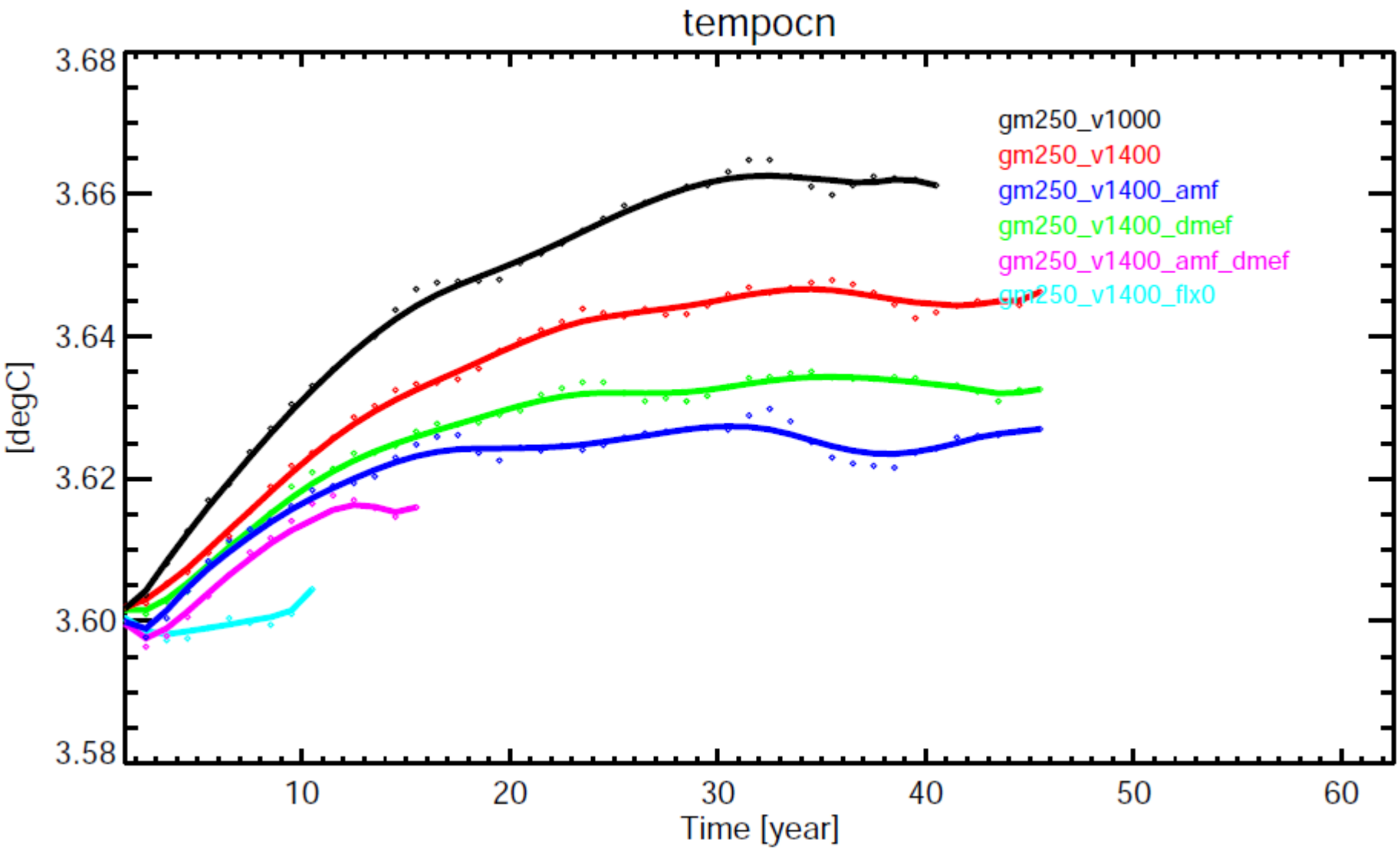
IV. Non-linearities

- **Untuned Oslo changes reduce RESTOM**
- **Untuned non-Oslo changes reduce RESTOM**
- **Combined changes have nearly no effect on RESTOM!**



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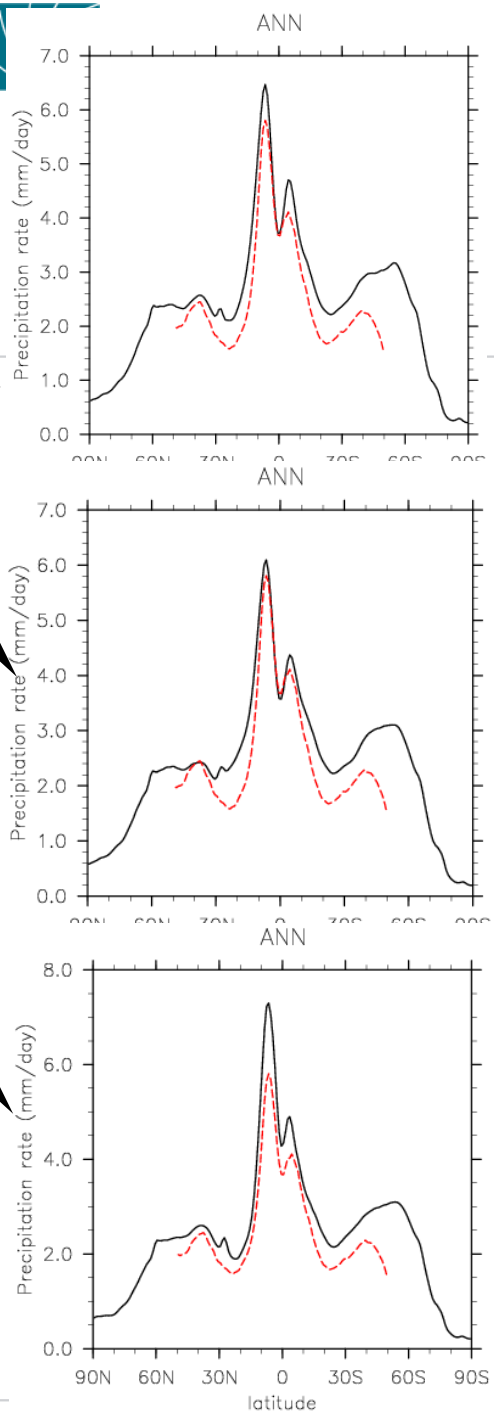
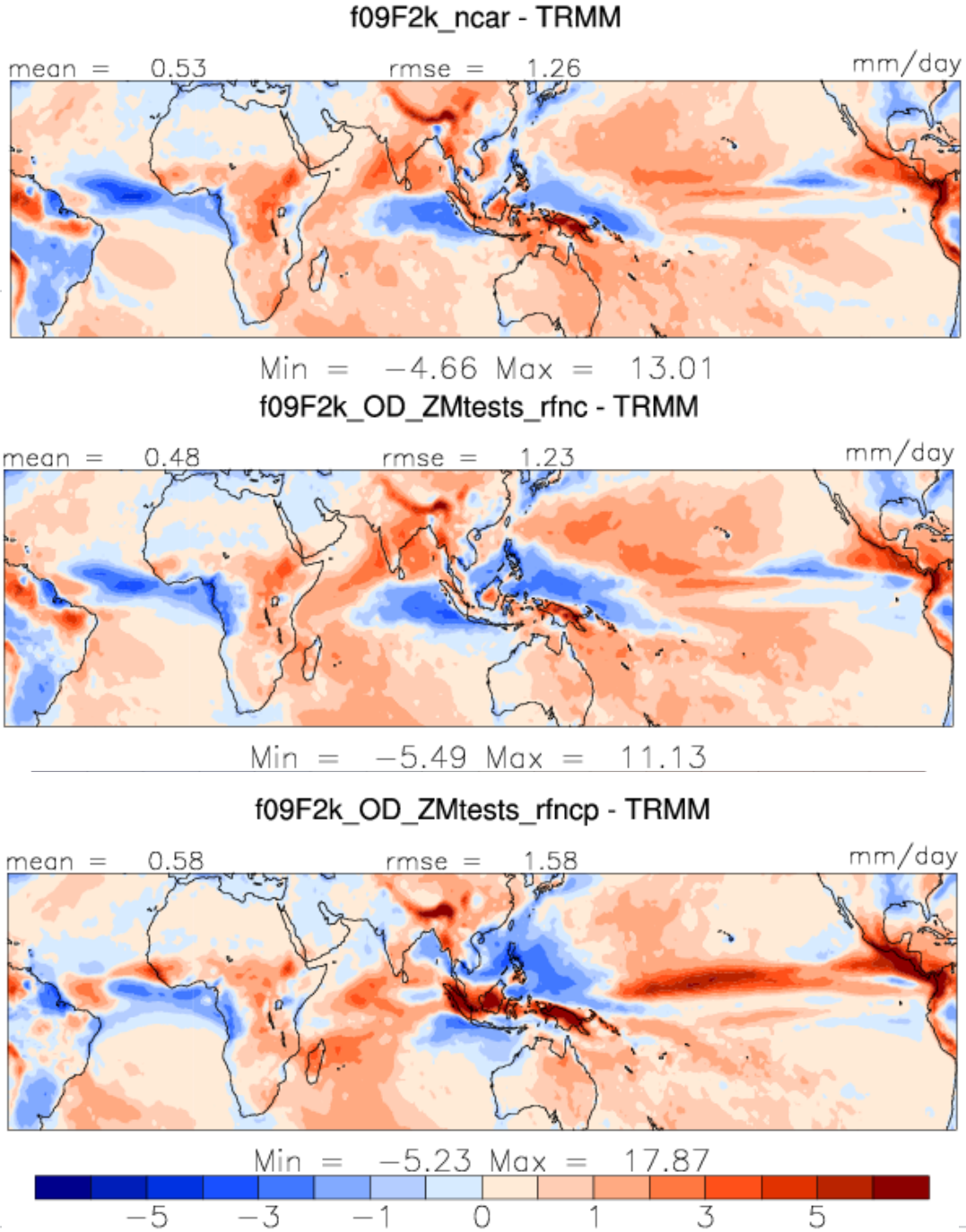
Precipitation

annual mean

- Oslo
- Non-Oslo
- gamma

- Sub-cloud layer





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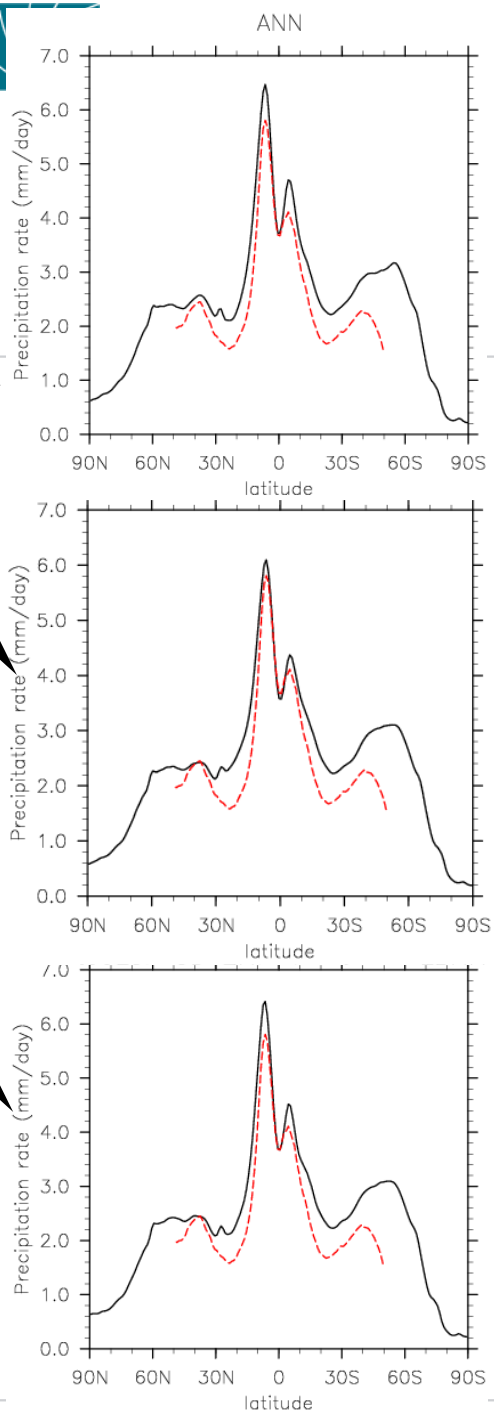
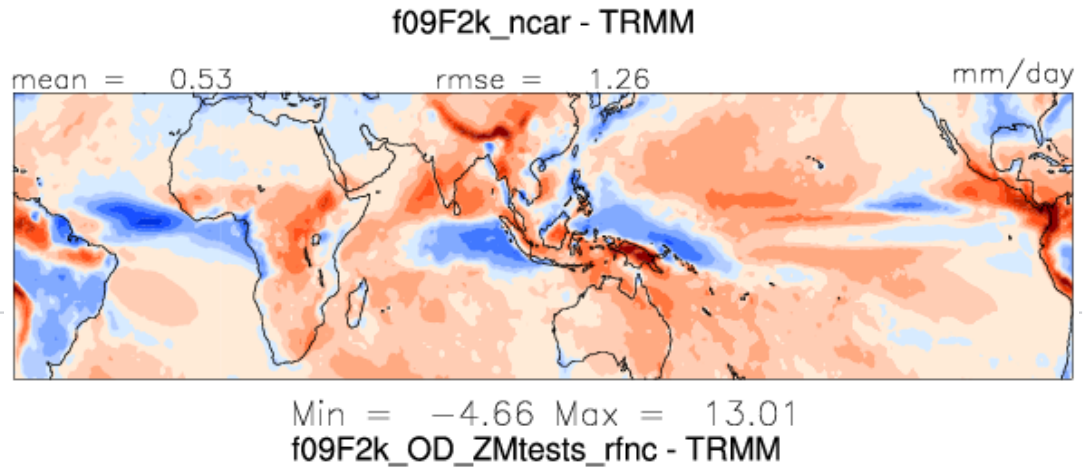
Precipitation

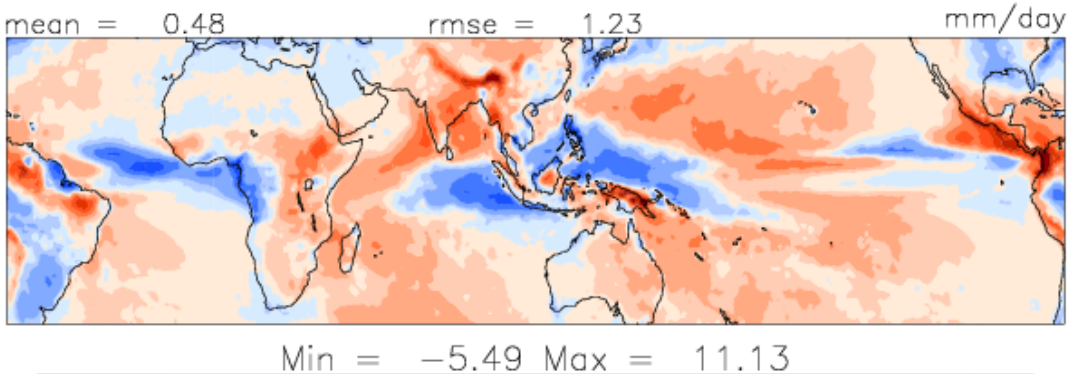
annual mean

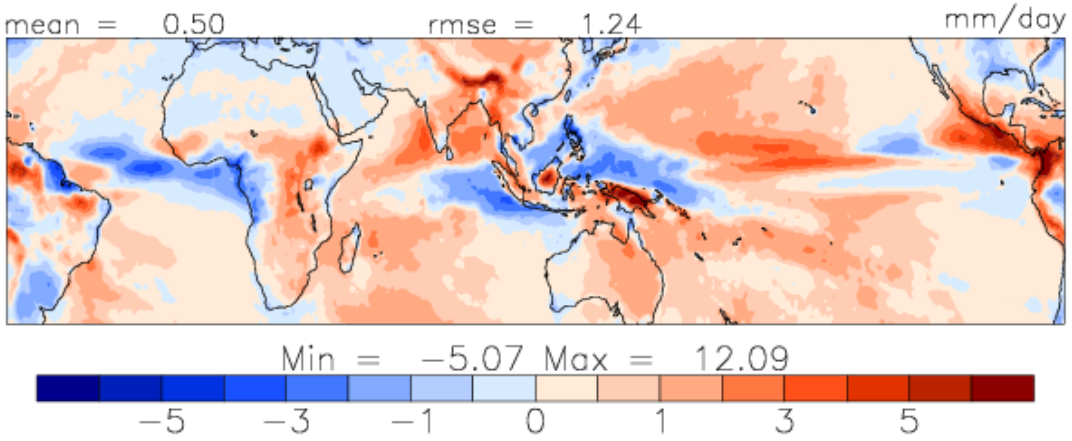
- Oslo
- Non-Oslo
- gamma

- sub-cloud layer
- variable entrainment
- reduced c0
- CIN







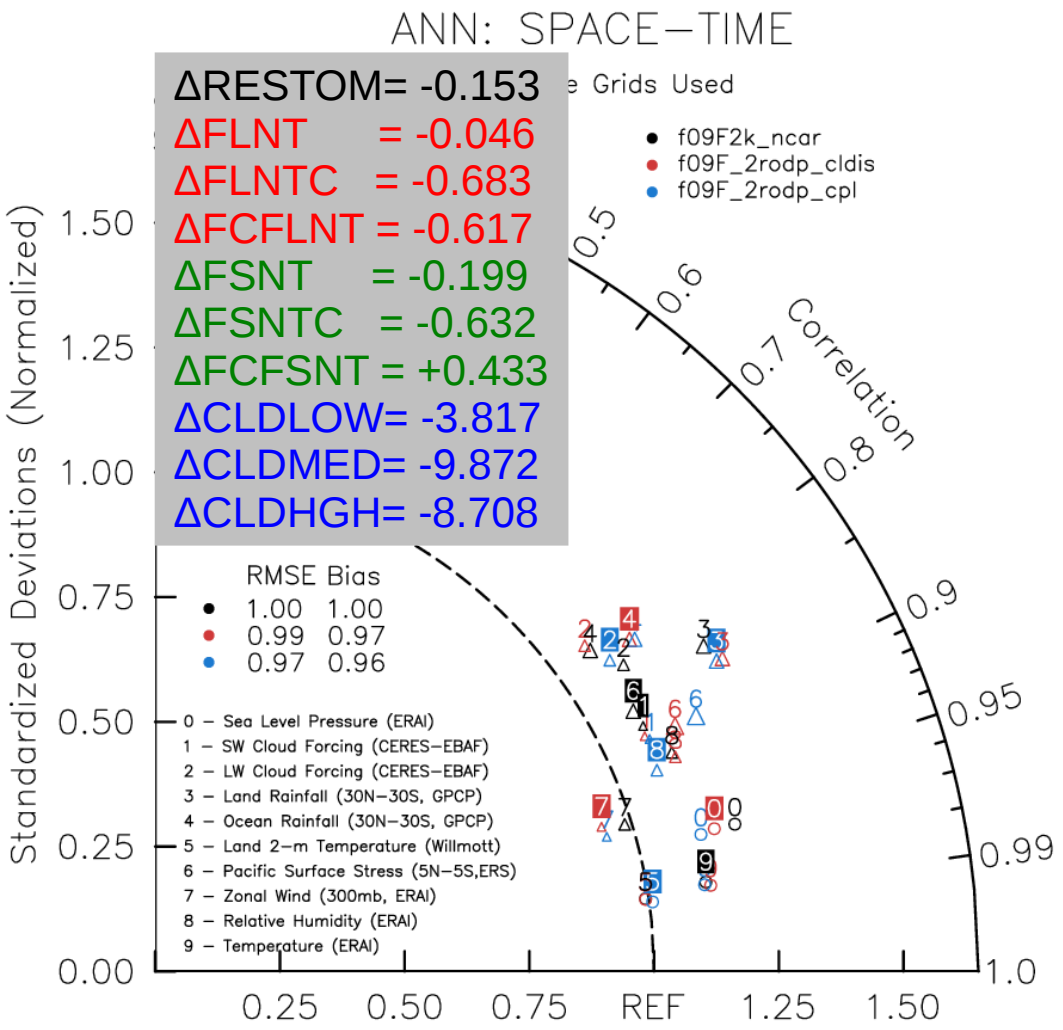


V. Effect of cloud tunings

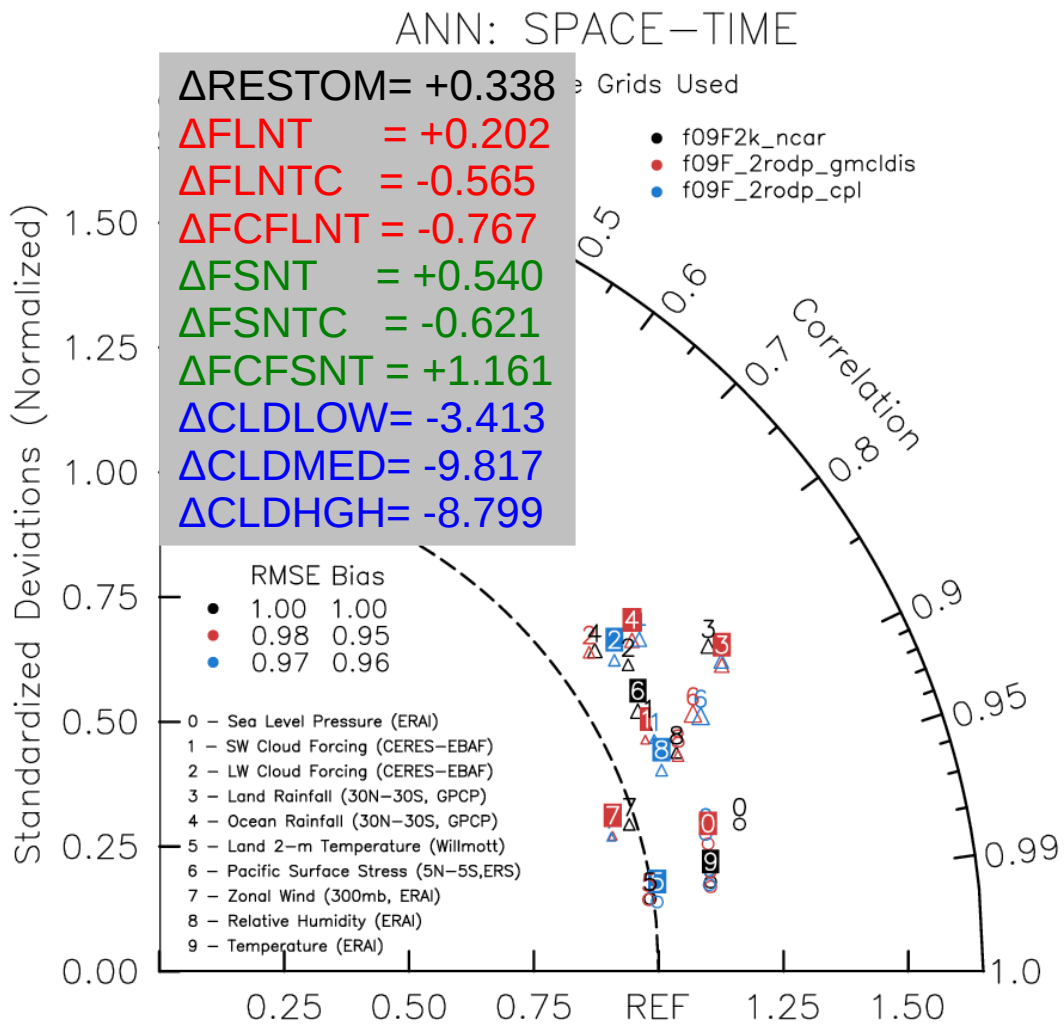
f09 NF2000climo results

Ice cloud parametrisation (Øyvind's talk)

Effect of iceopt=4 tunings (γ=0.283)



Effect of iceopt=4 tunings (γ=0.288)



Summary

- Non-Oslo changes reduce generally improve the simulations, e.g. winds robustly improve (wrt NCAR) in all experiments
- However the RESTOM remains high, mainly due to the cool tropical troposphere
- Tuning TOA with gamma alone makes the mean state worse by cooling model further
- Attempts to warm the tropical troposphere via changes to the convection scheme are largely successful
- A mass-flux source layer tied to PBL thickness is particularly helpful
- Additional tuning of ZM parameters allows to mitigate model biases
- To reduce RESTOM we still need to use a lower value of gamma than NCAR
- Tuned F2k simulations with NorESM look reasonably good compared with CESM
- NorESM2 **coupled** simulations however are plagued by a small, persistent positive RESTOM and additional tunings are required (Øyvind's talk)