Helmholtz Climate Initiative

Regional Climate Change

Topic 5: Chemistry-climate interactions on global to regional scales

Towards the simulation of the Middle Atmosphere-Lower Thermosphere with EMAC-CMAT

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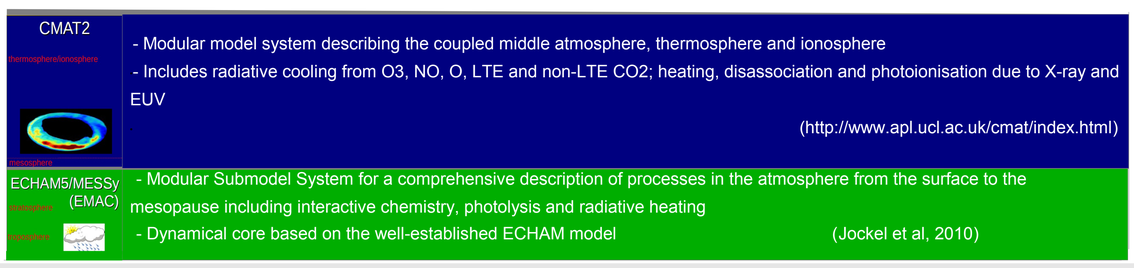
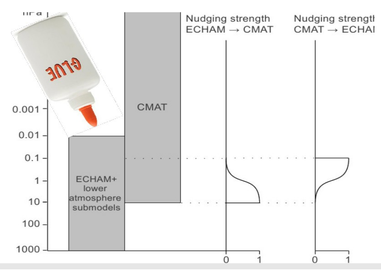
Introduction

The variability of the lower and middle atmosphere is mostly influenced by processes originating at the surface, while the variability of the upper atmosphere is controlled by solar variability. Traditionally different numerical models have been used to study these regimes, although they are neither distinct regions nor completely independent. Waves from the lower atmosphere can have large effects in the upper atmosphere, and solar variability can have significant effects at least down to the middle stratosphere. The aim of the project is to bridge the gap between meteorology and space science because such atmospheric coupling can only be captured and understood in models describing all involved regions consistently.

A concept for such an innovative whole atmosphere model has been laid by the former PI A. Baumgärtner and implemented in the EMAC/CMAT2 extension (A. Baumgärtner, 2012). During the last year, the model was further tested at the Blizzard system and several additional adaption to the local configuration had to be implemented. A first evaluation of the model in a climatological mode showed encouraging results (see progress report) but still the model integration has to be extended especially for chemical tracers spanning the thermosphere to stratosphere region. Scientific focus will be on ozone depleting NOy species that are produced by particle precipitation and their interactions with polar chemistry and dynamics, as well as the transfer of the solar signal through vertical coupling by atmospheric waves.

The concept





Motivation:

Surface effect of space weather?

- Only few CCM simulations so far
- No global effect
- Impact on regional climate?
- Statistical analyses of ERA-40 data shows correlation with AP-index (Seppälä et al. 2009)
- Similar results with CCMs (Baumgärtner et al. 2011)

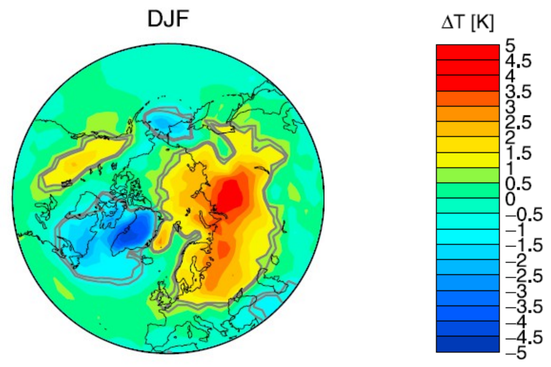
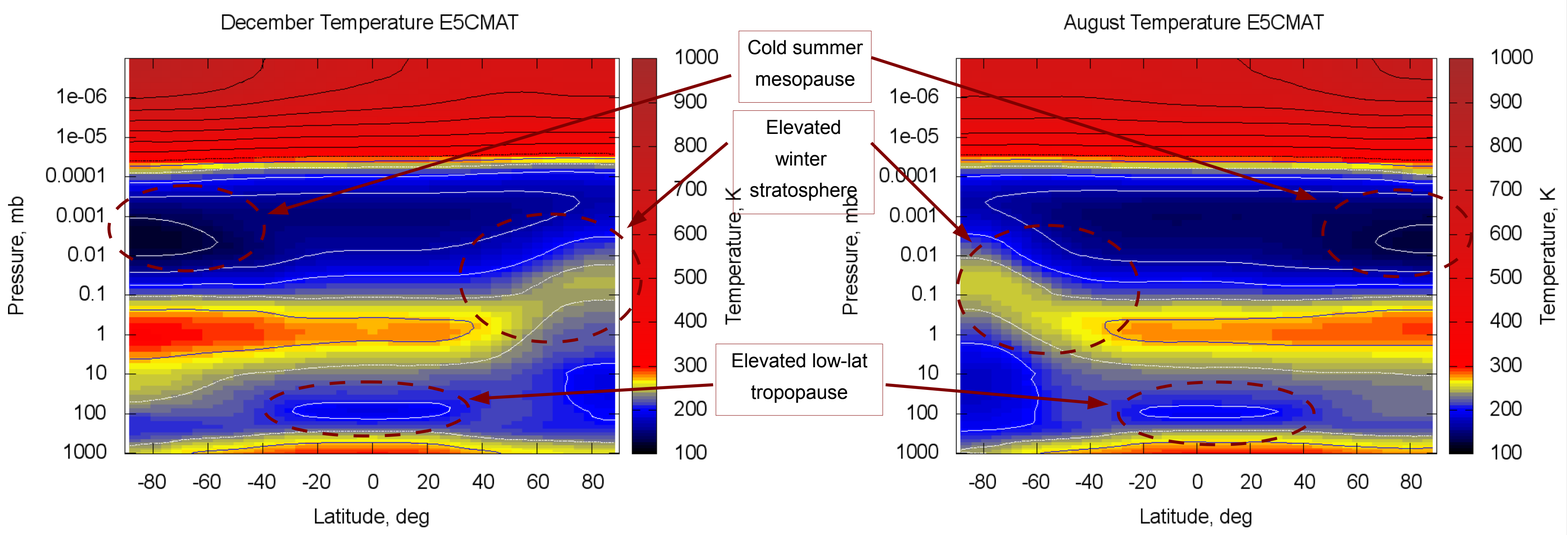


Figure 3. Northern hemisphere seasonal differences in SAT (DT = High Ap Low Ap) for Case N1with SSW years excluded for the seasons denoted.
(Adapted from Seppälä et al 2009)

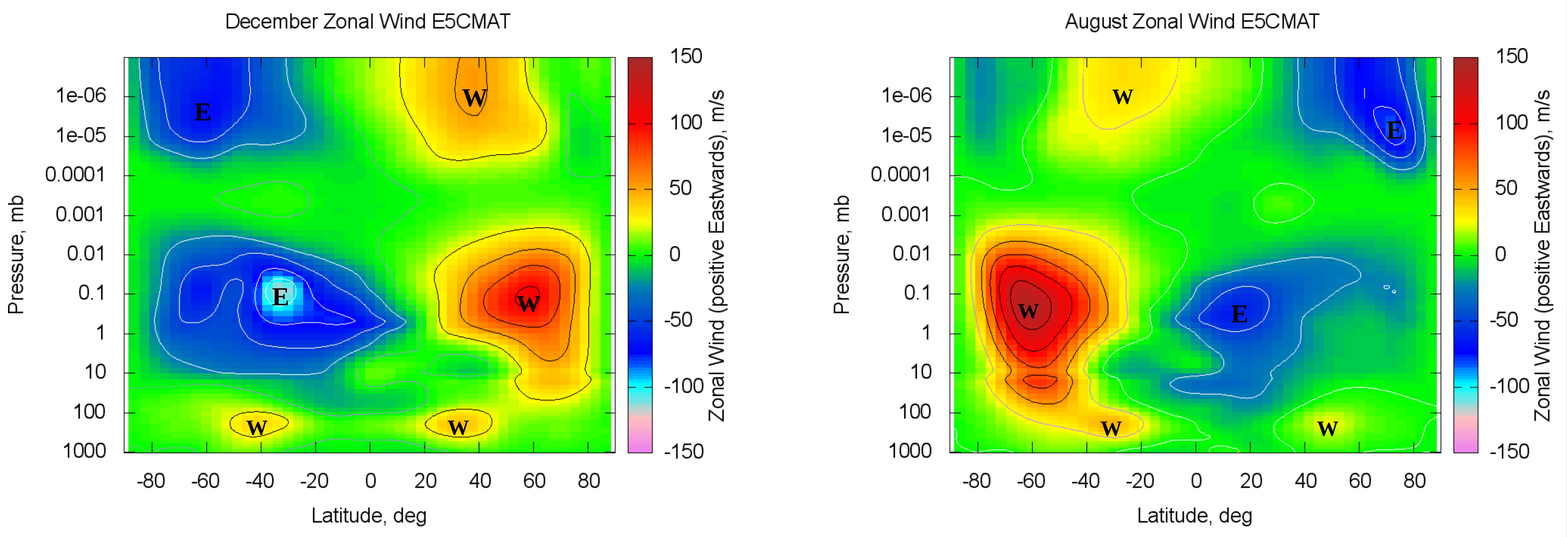
Zonal means

Temperature

Steady low solar activity (F10.7=80, Kp=2+)



Zonal wind



Objectives

1. Study NOx intrusions using EMAC-CMAT (validation).
2. Study the impact of Gravity Wave induced turbulence on the transport of NOx in comparison with other transport phenomena (molecular diffusion and bulk transport).
3. Consider different existing GW-parameterisation schemes: Lindzen, Matsuno, Yigit-Medvedev-Klassen, Stochastic approach.
4. Consider other tracers.

Architectures

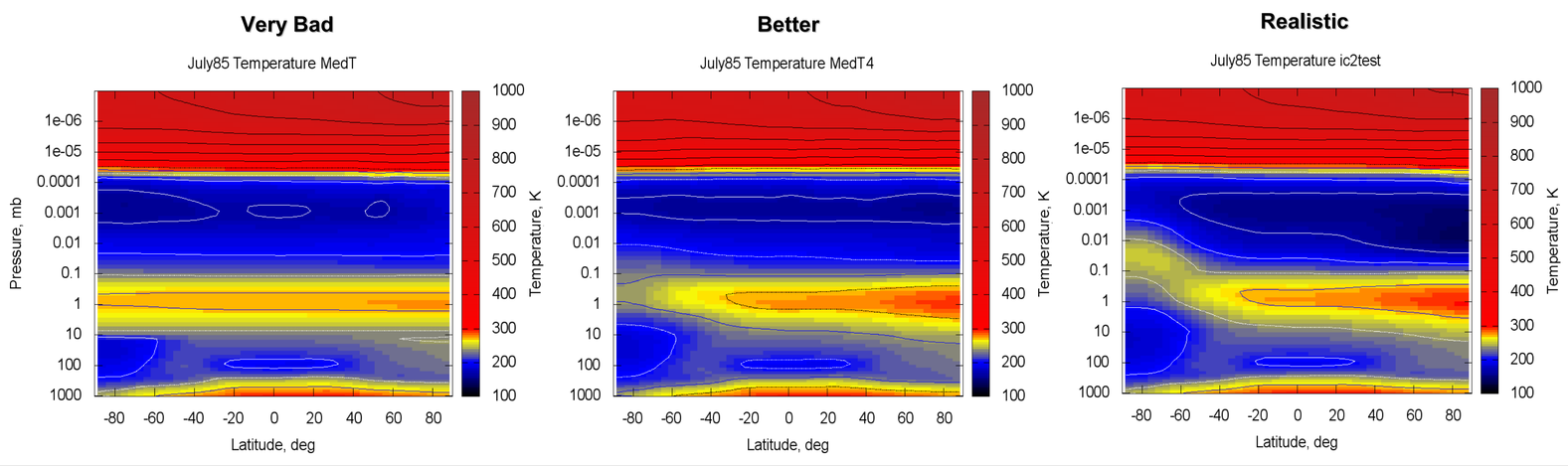
- Linux 64 on Intel i7, 4 cores, g95, openmpi; Running!
- HC3-cluster: Linux 64 on HP Intel Xeon cluster, 2864 cores, ifort 11, openmpi; Running!
- blizzard: AIX on IBM Power 6, 264 X 32 cores, IBM XLF, IBM-mpi; Runs from the restart files.

Conclusions

1. The coupled model is stable.
2. The model is capable of reproducing seasonal variations of the Middle Atmosphere's thermal structure.
3. The zonal mean winds are reasonably reproduced.
4. The simulated regime of the Middle Atmosphere is very sensitive to the Gravity Wave Parameterization.
5. The transition region between the two models requires additional attention.

The Role of Gravity Wave Parameterization

Proper tuning provides realistic seasonal pattern in the middle atmosphere



References

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