Institute for Meteorology and Climate Research

Thermosphere and Ionosphere Extension of the MESSy Earth-System Model

A. Vlasov[1], A. Baumgärtner[2], S. Versick[1], T.Reddmann[1]

[1]Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology; [2]Aerospace Engeneering Sciences, Universtiy of Colorado.

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.

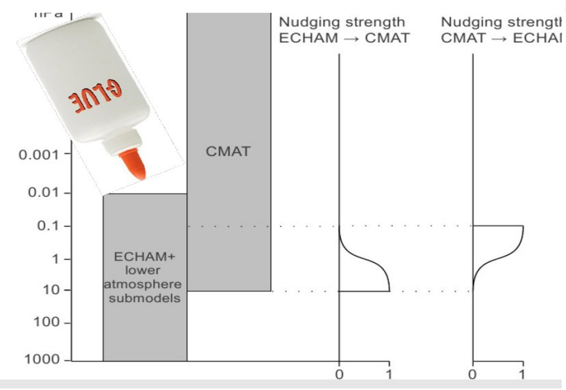
A concept for such an innovative whole atmosphere model has been laid by the former PI A. Baumgärtner and implemented in the EMAC/CMAT2 extension (A. Baumgärtner, 2012). During the last year, the model was further tested at the Blizzard system and several additional adaption to the local configuration 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

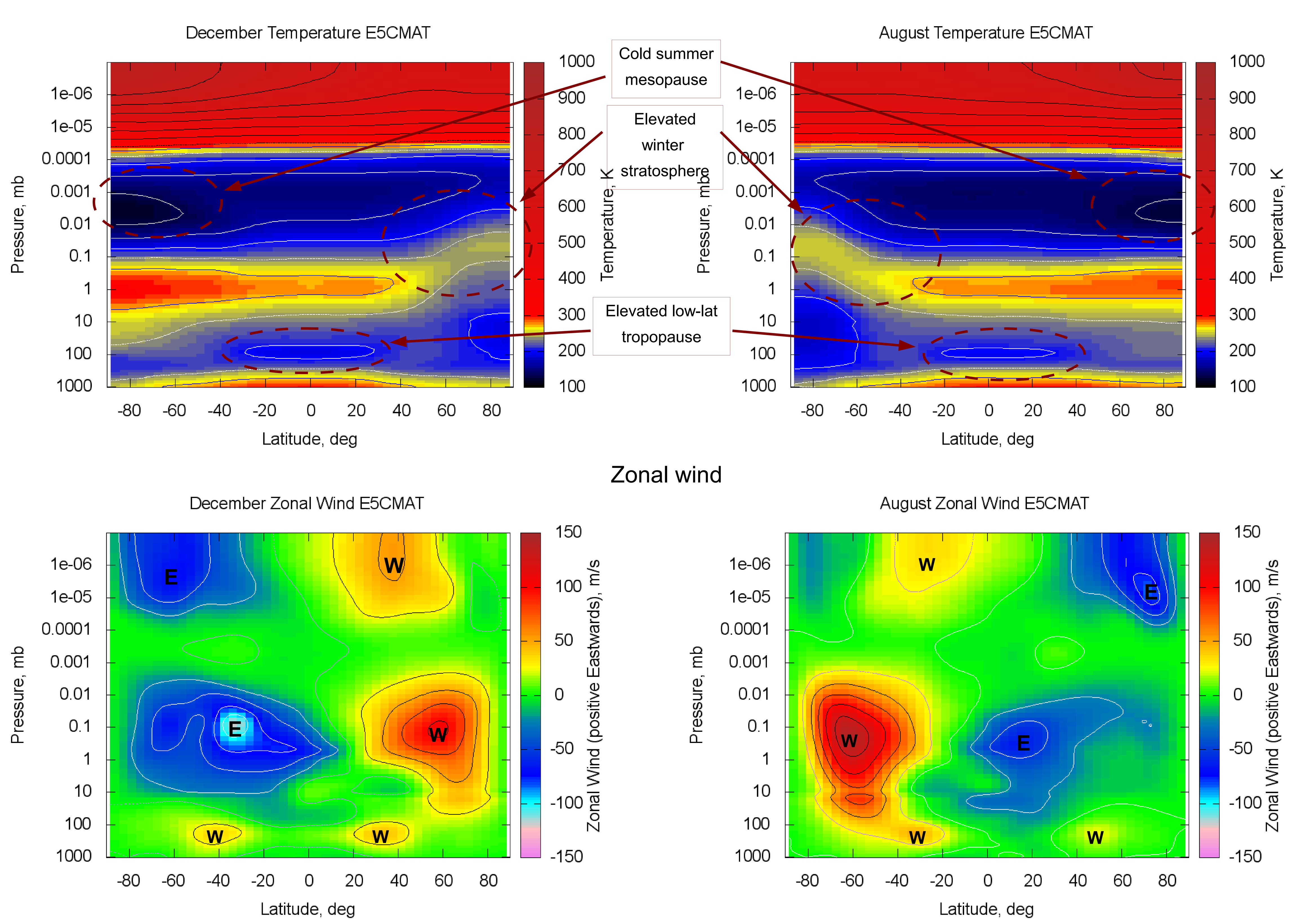
CMAT2 (thermosphere/ionosphere, mesosphere)
- Modular model system describing the coupled middle atmosphere, thermosphere and ionosphere
- Includes radiative cooling from O3, NO, O, LTE and non-LTE CO2; heating, disassociation and photoionisation due to X-ray and EUV

(http://www.apl.ucl.ac.uk/cmat/index.html)

ECHAM5/MESSy (EMAC) (stratosphere, troposphere)
- Modular Submodel System for a comprehensive description of processes in the atmosphere from the surface to the mesopause including interactive chemistry, photolysis and radiative heating
- Dynamical core based on the well-established ECHAM model (Jockel et al, 2010)



Zonal means



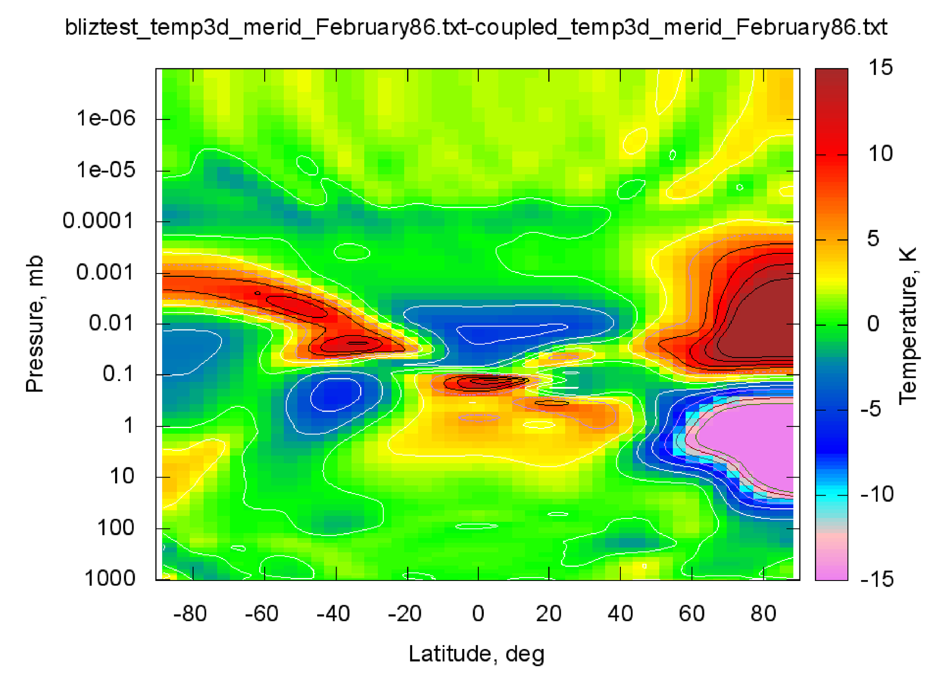
Objectives

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.

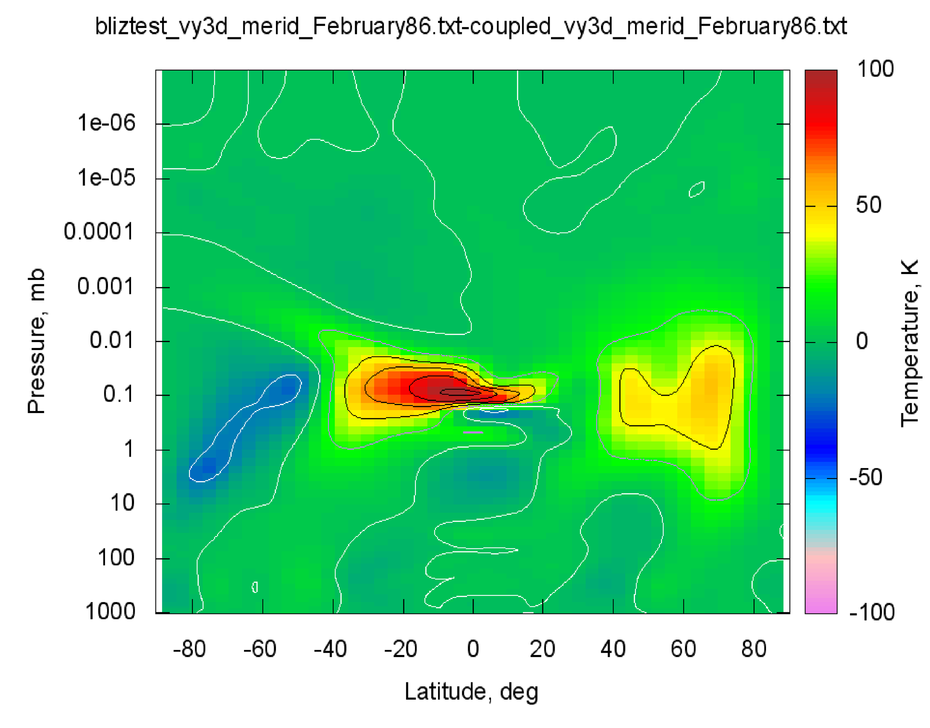
Architectures

- 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.

Run-to-run differences

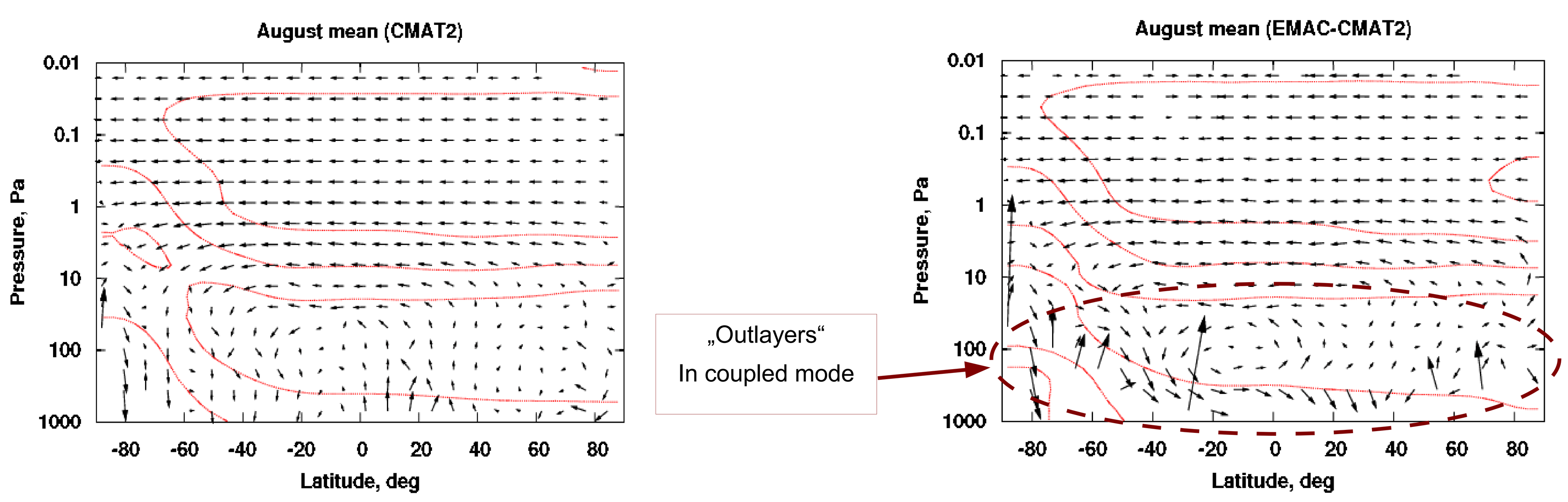


Difference in zonal mean teperature of Febuary between identical experiments on Blizzard and HC3-cluster.



Difference in zonal mean wind of Febuary between identical experiments on Blizzard and HC3-cluster.

Coupling problemes (vertical velocity/divergence)



Zonally averaged meridional and vertical winds (not to scale) with zonal mean temperature isoterms (red lines), uncoupled run.

Zonally averaged meridional and vertical winds (not to scale) with zonal mean temperature isoterms (red lines), coupled run.

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. Transition region between 2 models still requires additional attention.
5. The differences in results on different architectures have to be investigated.

References

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2. http://www.apl.ucl.ac.uk/cmat/index.html
3. Jöckel, P., Kerkweg, A., Pozzer, A., Sander, R., Tost, H., Riede, H., Baumgaertner, A., Gromov, S., and Kern, B., Development cycle 2 of the Modular Earth Submodel System (MESSy2), Geosci. Model Dev., 3, 717-752, 2010