C08(N) Convection and its moisture transport into the UTLS in Lagrangian and Eulerian frameworks

Holger Tost (JGU), Patrick Jöckel (DLR)

Motivation

- Atmospheric deep convection is complicated and difficult to analyse and simulate due to a multitude of involved processes and scales.
- Parameterised convection is a large source of uncertainty for the representation of transport and H_2O abundance in the UTLS, leading to substantial differences of simulation results in climate model intercomparisons.
- Parameterised convection will be required for CCMs in future due to the computational costs of atmospheric chemistry, which cannot be applied at very high resolution on the global scale, at least not for simulations spanning several decades.
- Besides moisture redistribution, also different trace species (aerosols, aerosol precursors, chemical compounds of different lifetimes) are vertically redistributed.
- The representation of transport (updraft strength, downdrafts, mixing with the environment) affects substantially the UTLS composition.

Collaborations within TPChange

A03 Bridging scales for convection representations; comparing local
C06 to global scale convective transport with resolved and parameterised convection; assessing the role of downdrafts and subsidence for aerosol tracer transport.

B08 Comparison of different Lagrangian trajectory tools in ICON with respect to convection.

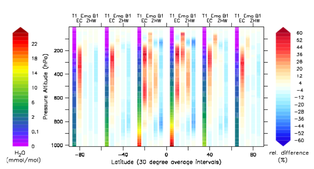
C07 Joint and cooperative developments and usage of the new model system ICON/MESSy.

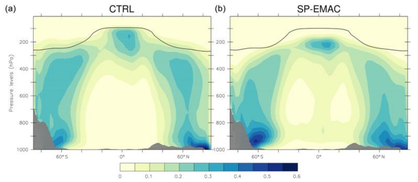
Z01 Provide composition data for comparison with convectively
Z02 dominated campaigns; data exchange.

Z03 Enable further convection representations in ICON/MESSy.

Preliminary work

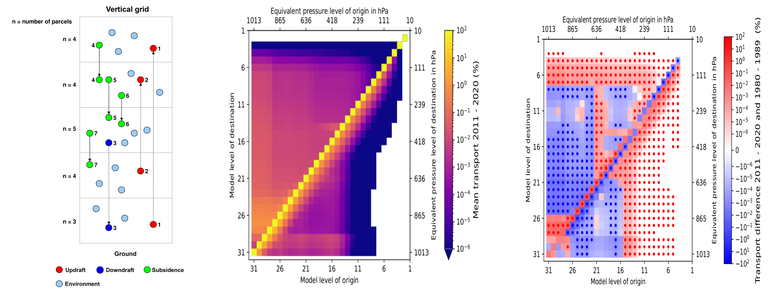
- In Z03 and work beyond the CRC substantial steps towards a chemistry-enabled ICON version (ICON/MESSy) have been undertaken. This includes the preparation of the multiple available convection parameterisations of EMAC.
- For EMAC a convective superparameterisation has been embedded.





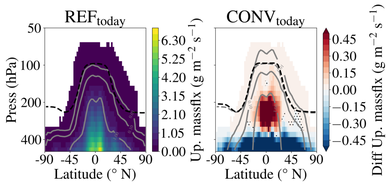
Tost et al, 2010; Rybka et al., 2021

- The Lagrangian framework LAMETTA (a Lagrangian transport scheme developed for ICON/MESSy) contains a Lagrangian representation of convection.
- In A03 / C07 / Z03 an Eulerian convective exchange matrix for diagnosing convective transport activity has been developed and evaluated.

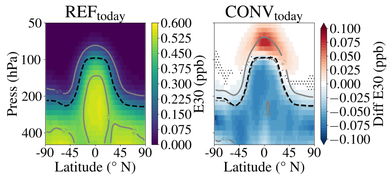


Brinkop & Jöckel, 2019, Jeske & Tost, 2025

- In phase I of C07 the UTLS composition simulated by EMAC with differing convection parameterisation has been analysed.



- Substantial differences between convective updraft massfluxes of the Tiedtke and the Emanuel convection scheme in the UTLS.
- Resulting tracer differences of an E30 tracer in the UTLS are obvious in the EMAC simulations.



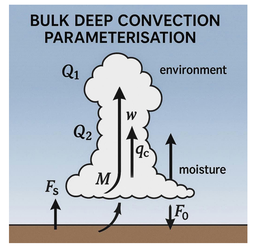
C07

Research plan phase II

Main goal: Quantification of the effects of different convection representations for the chemical composition of the UTLS (including water vapour) on the global scale.

- The project targets atmospheric deep convection and its various representations in chemistry climate models, such as ICON/MESSy. Consequently, a more comprehensive modelling system with different representations of convection will be developed (WP1). In three subsequent WPs the influence of the convection schemes will be addressed, analysing both, water vapour and trace species.

WP 2:

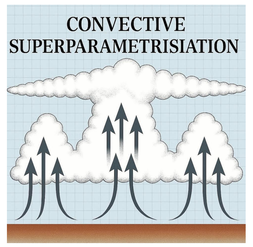


Analyse the impact of different Eulerian convection schemes and their effects on transport including moisture.

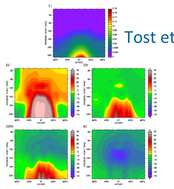
WP 3:

Analyse the impact of Lagrangian convective transport of chemical constituents on the composition of the UTLS.

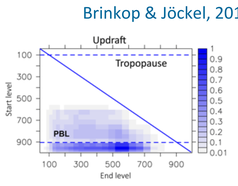
WP 4:



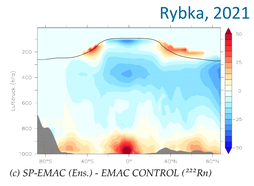
Analyse the effects of superparameterised Eulerian convection on moisture and constituent transport into the UTLS.



Tost et al., 2006



Brinkop & Jöckel, 2019



Rybka, 2021

(c) SP-EMAC (Ens.) - EMAC CONTROL (^{222}Rn)

- WP 5: Synthesising, the climatological effects of the individual convection representations (via the subsequent radiative impact) of the simulations will be inter-compared and brought into context of observations during aircraft campaigns, such as the CAFE campaigns, CONTANGO-Fire, TPEX I & II and other campaigns outside the CRC (e.g., DC3, SEAC4RS). Furthermore, implications (e.g., downward transport and mixing), diabatic processes in the upper troposphere and diagnostics for dynamical developments will be analysed in cooperation with other projects of the CRC.