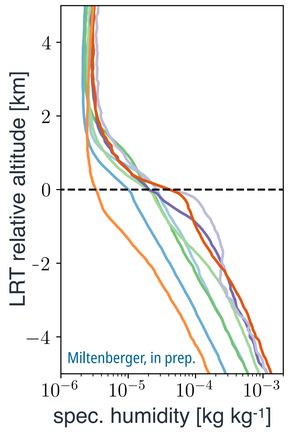
B08 Lagrangian analysis of the multicomponent structure of the extratropical UTLS

Ziyan Guo, Cornelis Schwenk and Annette Miltenberger (JGU)

Motivation

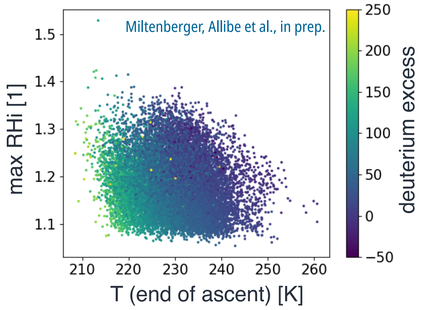


Gradients in trace constituents in the UTLS are large, but also strongly variable and important for radiative flux divergence as well as mixing processes. The gradients are strongly impacted by

- vertical transport from lower troposphere
- differential horizontal transport and
- diabatic processes in the UTLS.

Quantifying the contributions is key to understanding the current structure of the UTLS as well as future changes.

Transport and moist processes affect constituents differently. Therefore consideration of the UTLS multi-component composition may provide indications of key processes shaping the distribution of trace constituents in the UTLS.

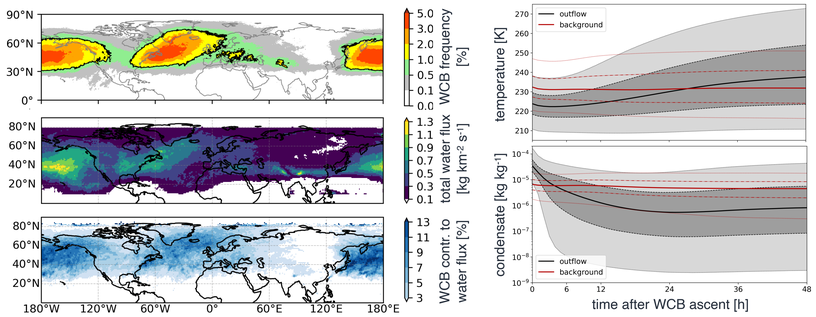


Collaborations within TPChange

A05	lab data on SOA partitioning, boxmodel formulation
B01	Lagrangian diagnostics for TPex II planning / analysis
B06 / B07	testing impact of new parameterisations in our cases
B09	interaction of moisture variability & large-scale flow regime
C03	comparison of approaches to quantify humidity variability
C01 / C04	IAGOS observations of humidity, cirrus & CO_2
C08	different convection representation, tracer transport
A02 / A04 B02	Lagrangian & TPex/BISTUM/CIRCUS data
B03 C06	online-trajectories / Lagrangian diagnostics
Z01 / Z02	use of observational data, provide Lagrangian & high-resolution ICON data for TPex II, archetypical cases
Z03	development of SOA box-model, ICON-MESSy, Lagrangian diagnostics, isotope boxmodel

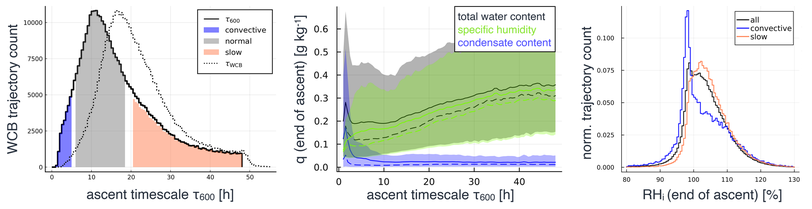
Results from phase I

Climatological relevance of WCB related moisture transport



Guo and Miltenberger, J. Clim., 2025

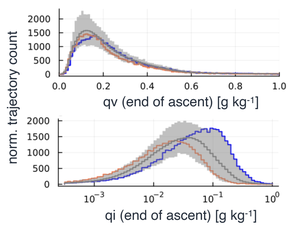
Physical processes controlling WCB moisture transport



Schwenk and Miltenberger, ACP, 2024

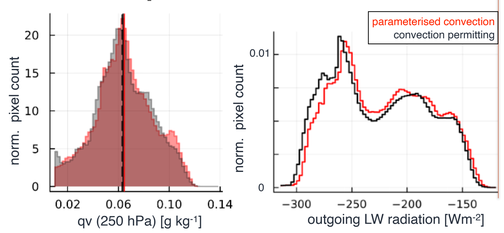
Uncertainties in modelling WCB moisture transport

Microphysics sensitivity



Schwenk et al., ACP, 2025

Convection parameterisation



Schwenk and Miltenberger, in prep.

Other results & contributions to TPchange

- observational evidence for WCB impact on UTLS humidity and cloud (analysis of radiosonde, IAGOS and satellite (MSG) data)
- novel aged WCB diagnostic for flight planning & analysis (TPex) e.g. Breuninger et al., ACP, 2025; Joppe et al., ACP, 2025
- diabatic PV tendencies for cirrus impact Emig et al., ACP, 2025

Research plan phase II

Main goal:
Identify the fingerprints of (diabatic & transport) processes shaping exTL structure by analysing the UTLS multicomponent composition

Objectives

- O1 Quantify WCB impact on extra-tropical UTLS aerosol and trace gas distribution (WP1, WP2)
- O2 Identify controls on synoptic-scale variability of extra-tropical UTLS humidity structure (WP3, WP4)
- O3 Identify the signature of different synoptic-scale processes in multicomponent UTLS composition (aerosol, trace gases & water isotopes) (WP5)

Strategy

- use of high-resolution and climatological Lagrangian analysis framework developed in phase 1
- extension of modelling capibilites to include aerosol, secondary aerosol precursors and water isotopes (boxmodels, ICON-MeSSY)
- tighter integration of observational (radiosonde, satellite, TPexI/II, NAWDIC) and laboratory (A05/A07(E)) data

Work plan

WP 1: Transport of aerosols by WCBs (PhD 1)
ICON-MESSy simulations of observed cases (e.g. TPex I)

WP 2: Transport of trace gases by WCBs (PhD 1)
offline boxmodel for SOA transport, comparison with MESSy

WP 3: Analysis of UTLS moisture variability, cross-tropopause moisture gradient and Lagrangian history (PhD2)
climatological analysis of radiosonde and ERA5 data

WP 4: Detailed analysis of physical processes controlling UTLS structure with high-resolution simulations (PhD2)
high-resolution ICON simulations of archetypical cases selected in WP3

WP 5: Multicomponent signature for typical modes of variability in UTLS moisture (PhD1/PhD2)
offline SOA, isotope simulations for archetypical cases selected in WP3, synthesis on archetypical multi-component UTLS structure