B07 Impact of cirrus clouds on tropopause structure

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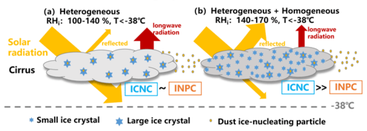
Motivation

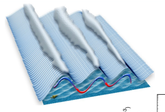
- Cirrus clouds influence the thermal and moisture structure of the UTLS; control stratospheric water vapor through freeze-drying in TTL
- Optical properties and life cycle of cirrus are strongly influenced by the small-scale dynamics
  (GWs, instabilities and turbulence)
- Poor representation of those interactions is a major source of uncertainties in GCMs

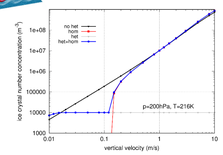


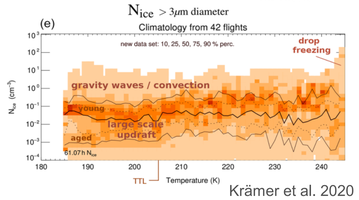
Y. He et al. 2022

Objectives

- **GW dynamics and ice clouds**: theory, validation and implementation of parameterisations in ICON
- **Heterogeneous and homogeneous nucleation competition**: theory and simulation (parcel vs. kinematic framework); dominant nucleation pathways in the UTLS
- **Ice clouds and instabilities**: development of minimal models as prototype parameterisations







Krämer et al. 2020

Collaborations within TPChange

B06 Joint WP, impact of GW dynamics and turbulence on ice clouds, water vapour transport and mixing

B01 Interpretation of measurement data, planning advise

B02 Evaluation of radiosonde data for determining environmental and initial conditions for model simulations

B08 Testing the parameterisation in semi-idealised and/or WCB cases

C01 Investigation of ice supersaturation in the UTLS, comparison of ERA5/IAGOS data and model simulations and theoretical derivations

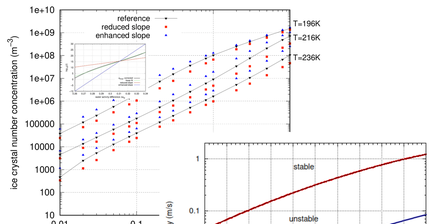
Z02 Radiosonde data evaluation; theoretically based interpretation of water vapour and ice cloud measurements; benchmark values for ice crystal number concentration

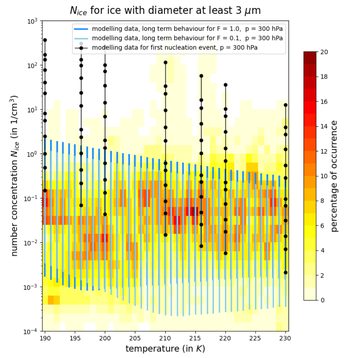
Z03 Complete ice cloud parameterisation in ICON coupled to MS-GWaM, provide novel simplified ice cloud parameterisations of instabilities and turbulence

Results from phase I

Hierarchy of reduced models describing the relevant ice microphysics processes

- Investigation of the nucleation rate formulation
  Spichtinger et al., ACP, 2023
- Study the underlying dynamical system properties and comparison with measurements
  Bergner and Spichtinger, 2025

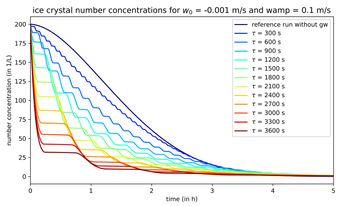


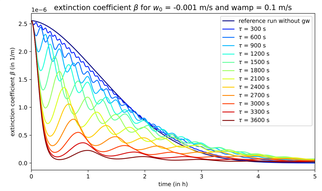


Framework for the investigation of GW-cirrus interactions

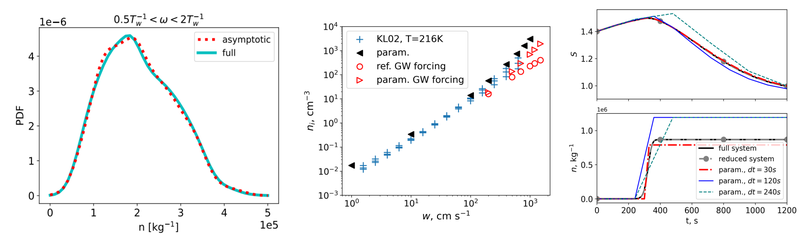
- Coupling of transient 3D GW parameterisation to two moment ice microphysics scheme; study cirrus dissipation due to GWs within parcel model

Dissipation of ice clouds driven by a slight downdraft (w = −0.001 m s^{-1}) and monochromatic GWs (no GW, and GW period from 300 s to 3600 s).





- Prototype parameterisations for homogeneous ice nucleation forced by GWs
  Dolaptchiev at al., JAS, 2023
  and extension to variable mean mass effects in the deposition
  Kosareva et al., GMD, 2025



Research plan phase II

Main goal: determine the impact of local dynamics due to GWs, instabilities and turbulence in the UTLS region on ice clouds; represent those processes in global models

WP 1: Theoretical investigations (PostDoc 2, all PIs, PhD from B06)

- Theory for competing nucleation pathways
- Investigation of nonlinear coupling of ice clouds and GWs
- Extension of asymptotic analysis
- Theory for ice clouds and instabilities

WP 2: Idealised simulations (PostDoc 1&2, all PIs, PhD from B06)

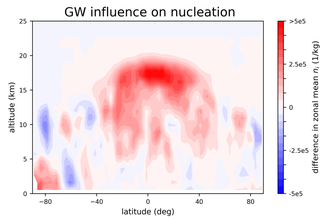
- Parcel simulations
- 2D kinematic framework and radiation calculations
- PinCFlow simulations

WP 3: Development of parameterisations and ICON simulations (PostDoc 1&2)

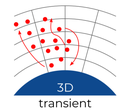
- Coupling of ice parameterisation with MS-GWaM/ICON
- Extension of parameterisation
- Subgrid scale cloud cover and GW fluctuations
- ICON simulations of dynamics - ice cloud interactions

Joint WP 4: GW transport/mixing impact on water vapour & ice (PhD from B06)

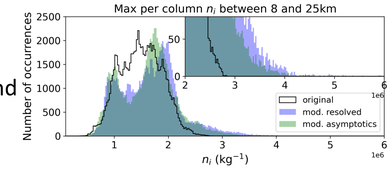
Current work and preliminary results

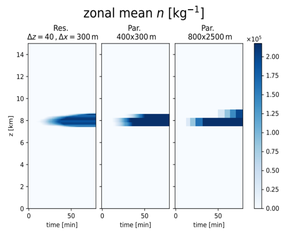


GW dynamics based on MS-GWaM parameterisation coupled to the ice microphysics scheme in ICON



Parameterisation validation against original scheme (Kärcher&Lohmann) and resolved ice physics





Idealised wave-resolving and wave-parameterised simulations coupled to ice physics