universität wien

FAKULTÄT FÜR MATHEMATIK
Dekan Univ.-Prof. Dr. Radu Ioan Boţ

Einladung zur öffentlichen Defensio

Daniel BÄUMER

Thema der Dissertation

Asymptotic PDE models of intermediate complexity for largescale dynamics of a moist atmosphere

Abstract:

In the atmospheric and oceanic sciences, there is a long and rich tradition of utilizing reduced mathematical models in the form of time-dependent partial differential equations, systematically derived from the governing Euler or Navier-Stokes equations by formal asymptotic methods, to further our theoretical understanding of the earth's weather and climate. This thesis makes a contribution to the field "mathematics for meteorology" by unifying two recent developments in the mathematical modeling of geophysical flows: the extension of the classical quasi-geostrophic (QG)-Ekman theory for synoptic-scale atmospheric flows in the middle latitudes by a diabatic layer (DL) of intermediate height due to Klein et al. and the precipitating quasi-geostrophic (PQG) model family of Smith & Stechmann. Two PQG model variants with bulk microphysics closures are derived, one of which turns out to be suited to connect to a moist, precipitating DL. This leads to the first triple-deck boundary layer theory for atmospheric flow with moist process closures, the new PQG-DL-Ekman theory. In a simplified axisymmetric version of this model, explicit solutions in the precipitating DL are found. These solutions permit numerical simulations by well-established methods for the coupled system that illustrate the complex interactions across the various layers. In particular, the simulations show how disturbances initially confined to the DL propagate across the whole troposphere. Furthermore, a first mathematically rigorous investigation of the dry DL equations, which belong to the class of geostrophically and hydrostatically balanced models, is presented.

The PhD thesis contains 4 publications:

1) D. Bäumer, R. Klein and N.J. Mauser (2025) *A general framework for the asymptotic analysis of moist atmospheric flows*, accepted in Asymptotic Analysis

2) D. Bäumer, S. Hittmeir and R. Klein (2023) *Scaling approaches to quasigeostrophic theory for moist, precipitating air*, Journal of the Atmospheric Sciences, Vol. 80, 1771 1786.
3) D. Bäumer and R. Klein (2025) *PQG DL Ekman: a triple deck boundary layer theory for large scale flow with moist process closures*, submitted
4) D. Bäumer (2025): *The diabatic layer equations: well posedness of a new boundary layer theory for quasigeostrophic flow*, manuscript

Prüfungssenat

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Zeit und Ort

Dienstag, 24. Juni 2025, 14:15 Uhr

Seminarraum 08.135, 8. Stock, Oskar-Morgenstern-Platz 1