Fakultät f. Mathematik, **Universität Wien**
Forschungsplattform MMM „Mathematics-Magnetism-Materials“

Public PhD defense of Daniel BÄUMER, MSc

Asymptotic PDE models of intermediate complexity for large-scale dynamics of a moist atmosphere

Time: Tuesday, 24. June 2025, 15h00 – 17h…

Place: MMM-WPI Seminar room, 8th floor, Oskar MorgensternPlatz 1, 1090

1a) 15h00 – 15h45 – 16h00 c.t. : **Presentation by Daniel Bäumer + Questions of jury & public**

1b) 16h10 – 16h15 : **closed session of jury**

2) 16h15 : **« deliberation » + « le pot qui suit »** (beer/champagne & tapas/cakes)

PhD jury :

Andreas **Cap** (U. Wien) - president
Peter **Spichtinger** (U. Mainz) - referee
Edriss **Titi** (U. Cambridge) – referee
Rupert **Klein** (FU Berlin) – PhD co-advisor / member
Norbert J. **Mauser** (U. Wien) – PhD director / member

Everyone present with a PhD in mathematics/meteorology/physics allowed to ask a public question.

Norbert J Mauser
(director of thesis
Head MMM,
Director WPI)

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

Short Biography: ***Daniel Bäumer*** (born 1987) is an Austrian mathematician. After high school in Salzburg he studied mathematics, initially at the University of Salzburg. After his BSc at U. Salzburg, he pursued a career in classical singing, returning to academia in 2019 in Vienna and obtaining his MSc in mathematics at U. Wien in 2021. His master thesis on *Asymptotic models for near-equatorial atmospheric motions* was supervised by N.J. Mauser and co-supervised by Sabine Doppler (Hittmeir); the two then accepted him as their PhD student, funded in the subproject of the SFB F65 of S. Doppler.

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