Meteorologisches Institut München

Bernhard Mayer

Ludwig-Maximilians-Universität (LMU)
Theresienstrasse 37, 80333 München, Germany

(also at Deutsches Zentrum für Luft- und Raumfahrt (DLR)
Oberpfaffenhofen, Germany)

January 14, 2022

Meteorologisches Institut München (MIM)

- **Experimental Meteorology** (Prof. Bernhard Mayer)
  Remote Sensing of Clouds and Aerosol; Radiative Transfer; Radiation-Cloud-Interaction
  Prof. Mark Wenig: Remote Sensing of Trace Gases
- **Theoretical Meteorology** (Prof. George Craig)
  Predictability; Data Assimilation; Cloud Parameterization
  Prof. Thomas Birner:
  Dynamics of the coupled troposphere / stratosphere system
- **Atmospheric Physics** (Prof. Markus Rapp)
  DLR, Institute for Atmospheric Physics

Teaching

- Bachelor "Physics plus Meteorology"
  (2/3 Physics, 1/3 Meteorology)
- Master Meteorology
- Minor Subject "Atmospheric Physics" for Master Physics

Theoretical Meteorology (Craig)

- Predictability of Weather
- Data Assimilation
- Stochastic cloud parameterizations

WAVES TO WEATHER

Waves to Weather

Speaker: George Craig

Phase 1: 2015-2019
Phase 2: 2019-2023
Phase 3: 2023-2027

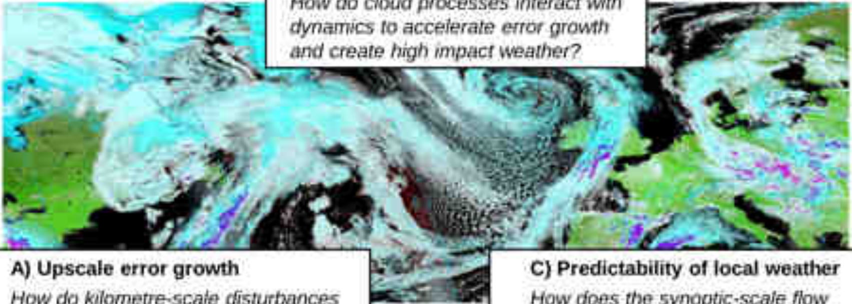
The Goal of W2W

The goal of Waves to Weather is to identify the **limits of predictability** of weather by explicit understanding of the **dynamical mechanisms** through which **errors** evolve and grow.

Scientific achievements

B) Cloud-scale Uncertainties

How do cloud processes interact with dynamics to accelerate error growth and create high impact weather?



A) Upscale error growth

How do kilometre-scale disturbances project coherently onto synoptic scales to create uncertainty?

C) Predictability of local weather

How does the synoptic-scale flow constrain the local weather events where impact occurs?

Experimental Meteorology (Mayer)

- Radiative Transfer model development
- Radiation-Cloud-Aerosol interaction
- Active and passive remote sensing of clouds and aerosol

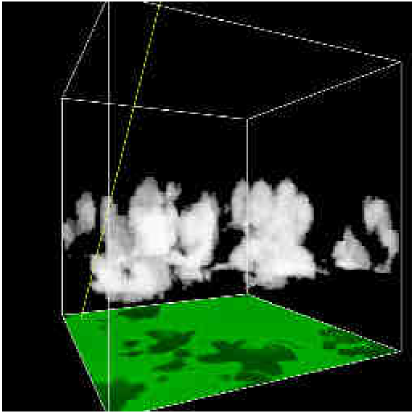
libRadtran

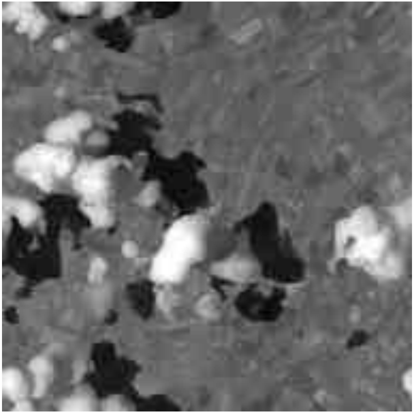
http://www.libradtran.org
1991 – 2022
Mayer and Kylling, 2005; Emde et al. (2016)

- Flexible and comprehensive radiative transfer package
- line-by-line, narrow-band, and correlated-k
- Irradiance, actinic flux, radiance, heating rates
- Solvers: *cdisort*, *sdisort*, *twostream*, *MYSTIC*
- 182.057 lines C + 81.318 lines Fortran = 263.375 lines code
- Applications:
  - UV radiation, atmospheric transmission, radiation budget
  - Remote sensing of trace gases, water and ice clouds
  - Atmospheric heating rates
  - Solar energy
  - Atmospheric photochemistry
- Validated in several intercomparisons
- More than 800 peer-reviewed publications using libRadtran

Monte carlo code for the phYSically correct
Tracing of photons In Cloudy atmospheres

Mayer, 2009; Buras, Emde, Klinger, ...





MYSTIC: Exact radiative transfer simulations

Visualization of cloud-resolving model (UCLA LES) output with MYSTIC

MYSTIC: Fully spherical geometry

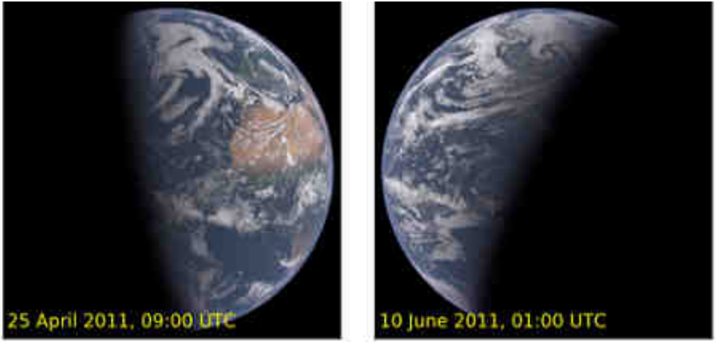
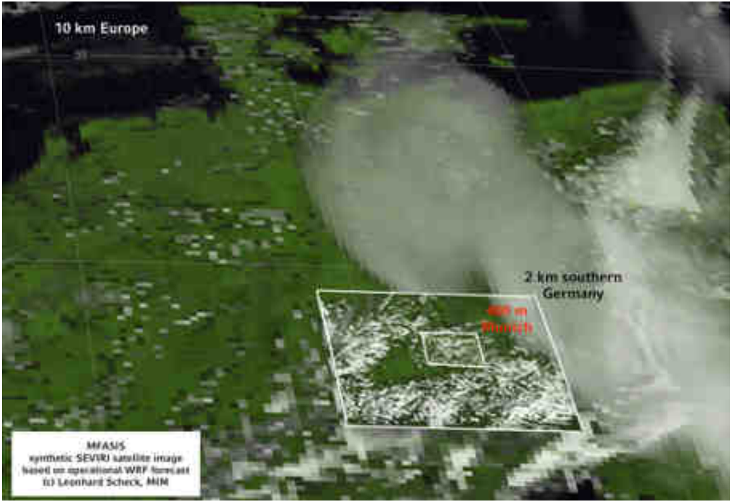


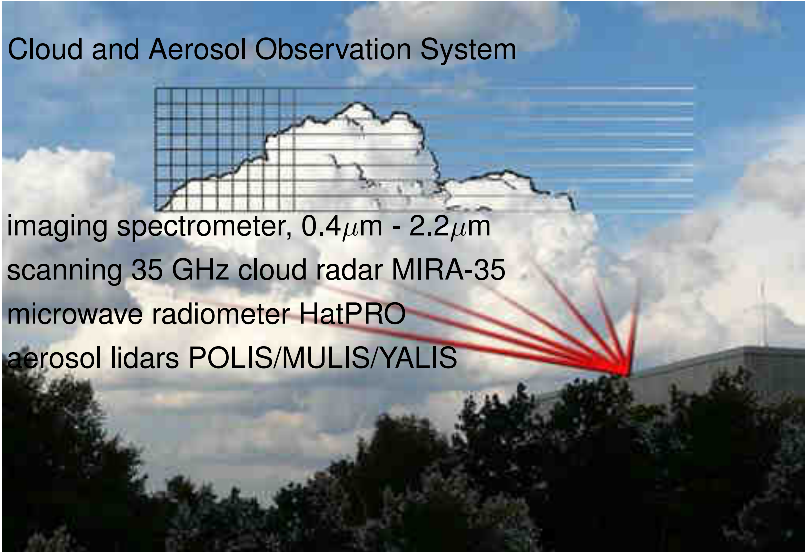
Fig. 10. Simulations of the Earth as seen by the moon. The figure shows a true color composite; red corresponds to 645 nm, green to 555 nm, and blue to 469 nm.

"Earthshine", Emde et al, Astronomy & Astrophysics, 2017

Fast radiative transfer for data assimilation



WRF forecast for Munich,
simulated satellite observations (MFASIS, Scheck et al, 2016; 2017)



Cloud and Aerosol Observation System

- imaging spectrometer, 0.4μm - 2.2μm
- scanning 35 GHz cloud radar MIRA-35
- microwave radiometer HatPRO
- aerosol lidars POLIS/MULIS/YALIS

LMU is ACTRIS cloud and aerosol remote sensing faciliy

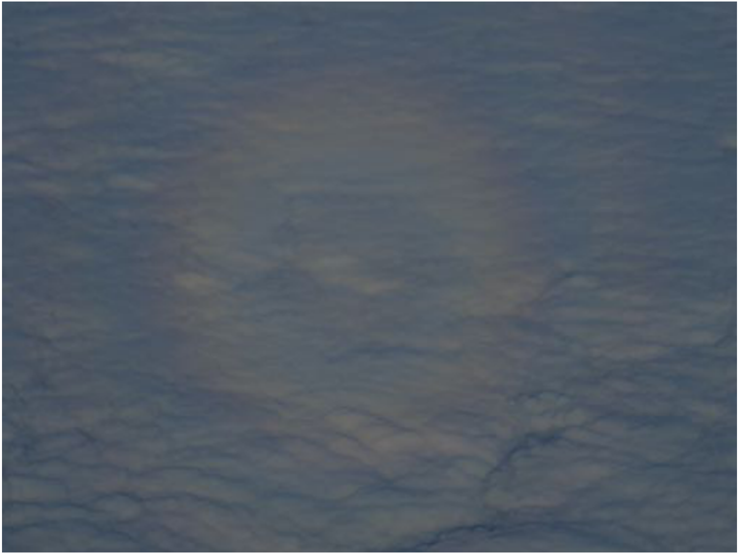
Airborne Observations with HALO

Backscatter glory ..., Mount Taranaki, NZ

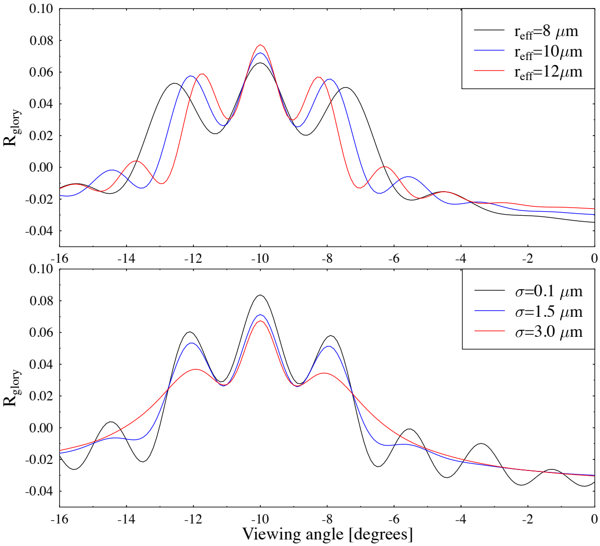
... und cloudbow, Wai-O-Tapu, NZ

Backscatter glory, North Atlantic, 27.12.2012

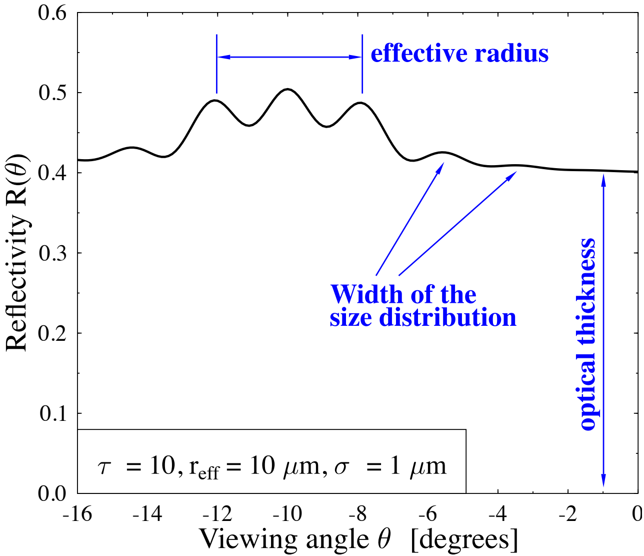
Backscatter glory, North Atlantic, 27.12.2012



Mie-Theory, libRadtran

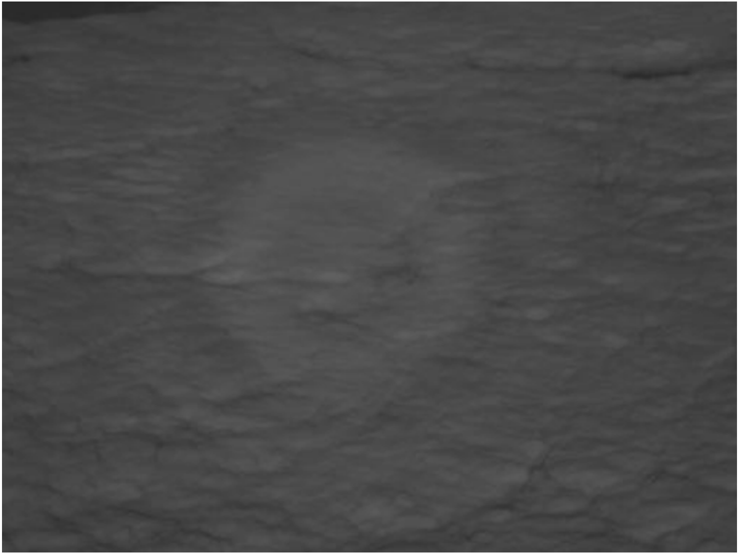


Information content of the glory

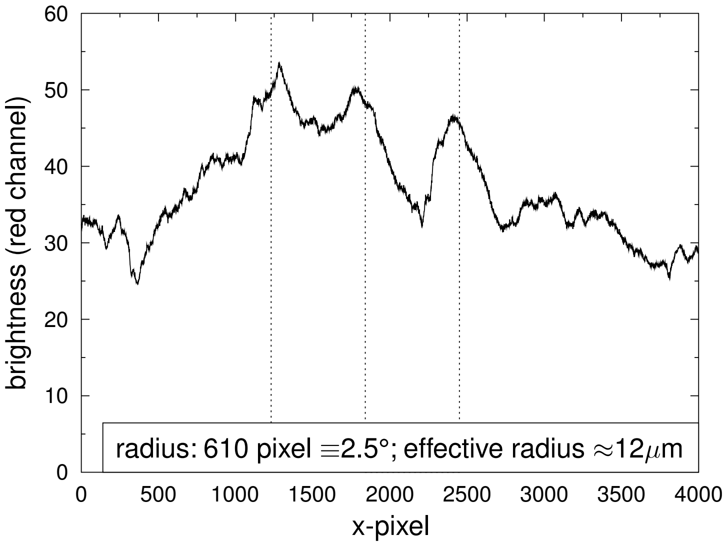


The image

The image: Red channel



Cross section through the glory, 100 Pixel averaged “vertically”



Atmos. Chem. Phys., 4, 1255–1263, 2004
www.atmos-chem-phys.org/acp/4/1255/
SRef-ID: 1680-7324/acp/2004-4-1255

Atmospheric Chemistry and Physics

Remote sensing of water cloud droplet size distributions using the backscatter glory: a case study

B. Mayer[1], M. Schröder[2], R. Preusker[2], and L. Schüller[3]

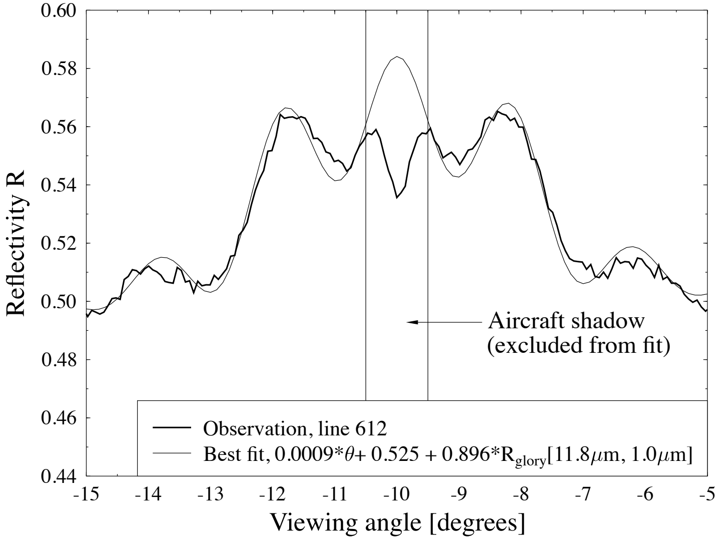
[1]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, 82234 Wessling, Germany
[2]Institut für Weltraumwissenschaften, Freie Universität Berlin, Carl-Heinrich-Becker Weg 6–10, 12165 Berlin, Germany
[3]ESA, European Space & Technology Centre (ESTEC), Keplerlaan 1, Postbus 299, 2200 AG Noordwijk, The Netherlands

Received: 4 March 2004 – Published in Atmos. Chem. Phys. Discuss.: 4 May 2004
Revised: 22 July 2004 – Accepted: 30 July 2004 – Published: 10 August 2004

Abstract. Cloud single scattering properties are mainly determined by the effective radius of the droplet size distribution. There are only few exceptions where the shape of the size distribution affects the optical properties, in particular the rainbow and the glory directions of the scattering phase function. Using observations by the Compact Airborne Spectrographic Imager (CASI) in 180° backscatter geometry, we found that high angular resolution aircraft observations of the

tering albedo, and scattering phase function) for spherical water droplets are readily calculated with Mie theory, providing the size parameter $x=2\pi r/\lambda$ and the complex refractive index of water as input (r is the droplet radius and λ the wavelength). For a single droplet with given size, the scattering phase function exhibits considerable structure and resonances, characteristic for the particular size parameter. When averaged over a size distribution of an ensemble of

Example from Mayer et al. [2004]

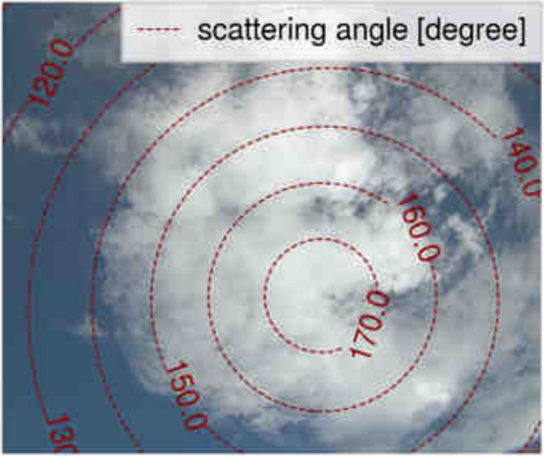


January/February 2020 EUREC^{4}A


NARVAL

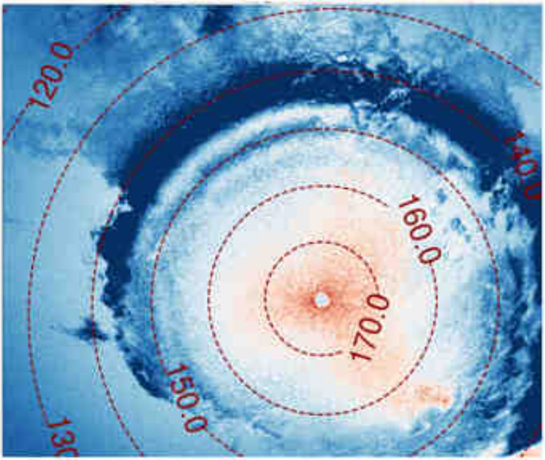

SES

EUREC^{4}A campaign, 02.02.2020



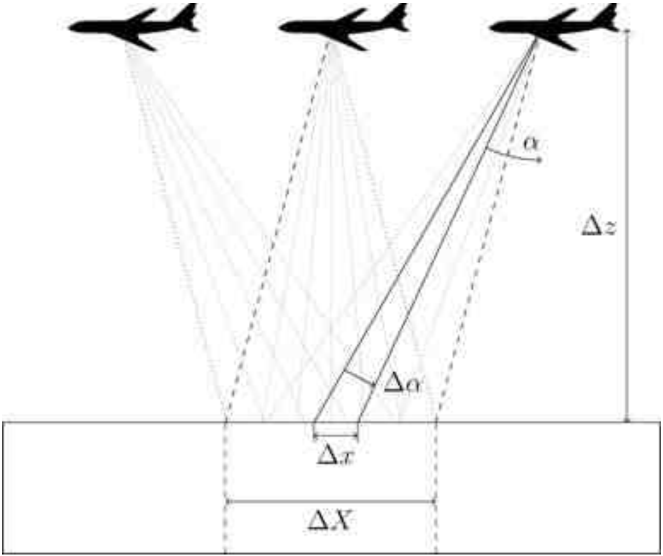
Veronika Pörtge

EUREC^{4}A campaign, 02.02.2020



Veronika Pörtge, Anna Weber

EUREC^{4}A campaign, 02.02.2020

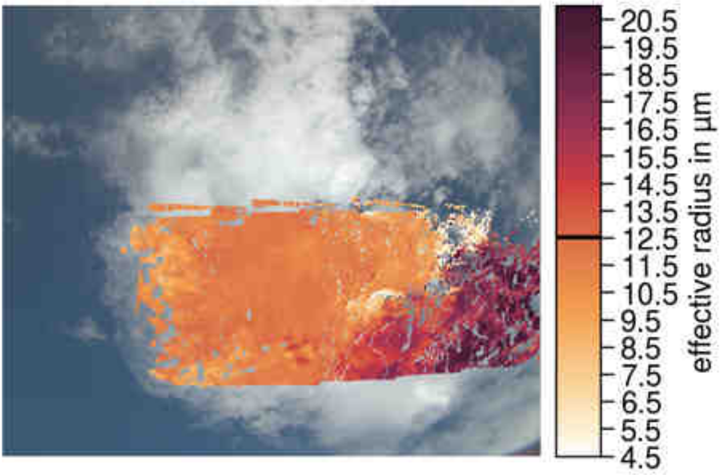


Tobi Kölling

EUREC^{4}A campaign, 02.02.2020

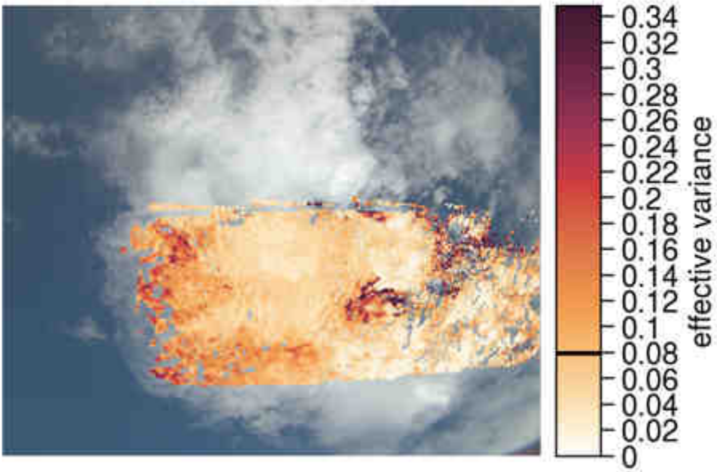
Veronika Pörtge

EUREC^{4}A campaign, 02.02.2020



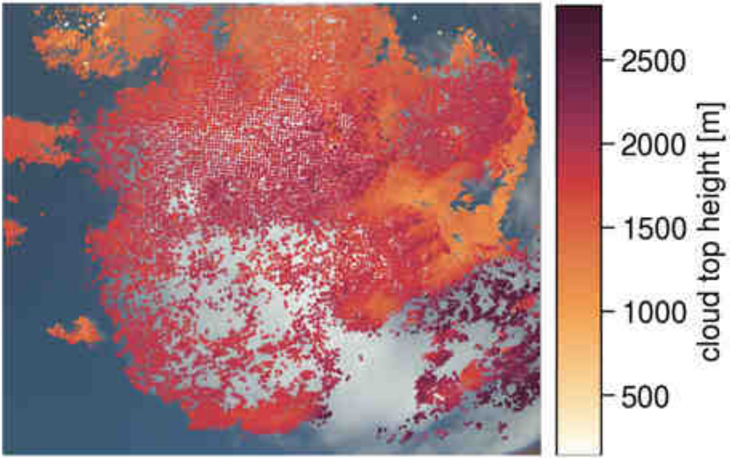
Veronika Pörtge

EUREC^{4}A campaign, 02.02.2020



Veronika Pörtge

EUREC^{4}A campaign, 02.02.2020



Tobi Kölling, Lea Volkmer, Veronika Pörtge,