UNIVERSITÄT LEIPZIG

TROPOS

Leibniz Institute for Tropospheric Research

Investigating hemispheric differences in aerosol signatures in mixed-phase cloud processes with spectral polarimetric cloud radar observations

Teresa Vogl

Supervisors : *Heike Kalesse-Los, Patric Seifert*

and help from *Maximilian Maahn and Stefan Kneifel*

July 25, 2022

SPP-PROM Meeting

UNIVERSITÄT LEIPZIG

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...how aerosol influences riming/ aggregation using vertically-pointing cloud radar observations (PICNICC)

Teresa Vogl

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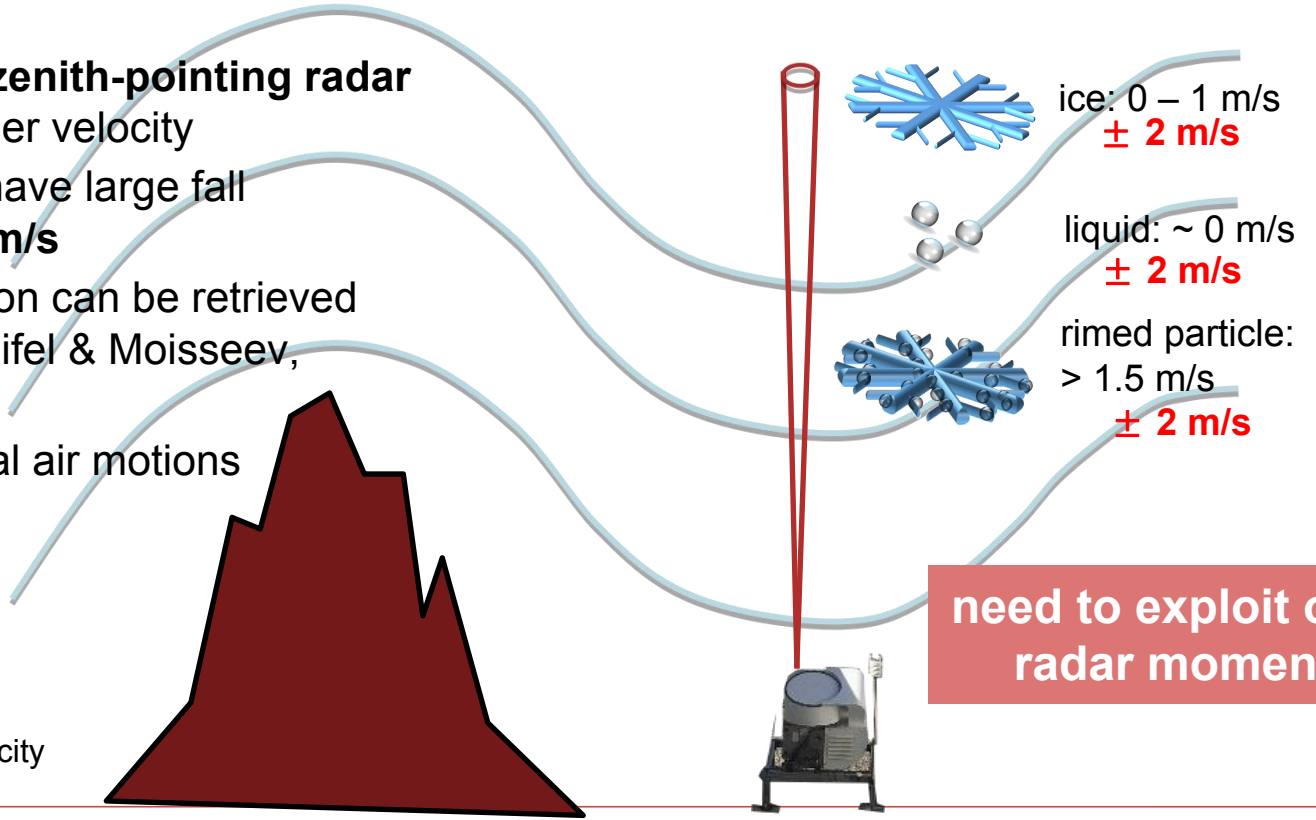
SPP-PROM Meeting

OUTLINE

- How to detect riming in orographic cloud systems (method 1)
- Exploiting peaks in cloud radar Doppler spectra (method 2)
- Outlook: answering our research question (application)

RIMING DETECTION USING GROUND-BASED RADAR

- **ground-based zenith-pointing radar** measures Doppler velocity
- rimed particles have large fall velocities **> 1.5 m/s**
- rime mass fraction can be retrieved using **MDV** (Kneifel & Moisseev, 2020)
- **Problem**: vertical air motions

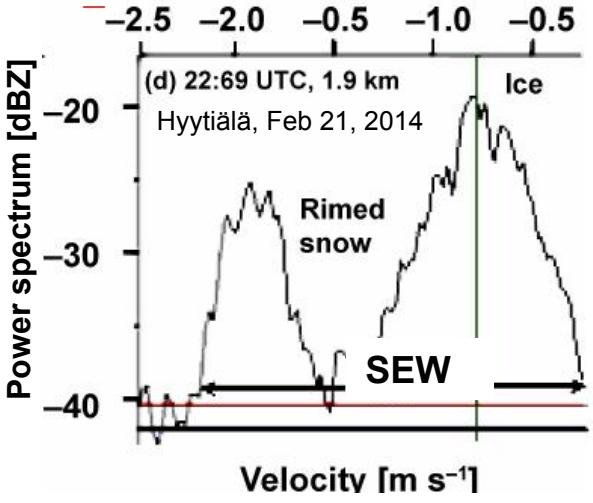


need to exploit other radar moments

MDV: Mean Doppler Velocity

FINGERPRINTS OF RIMING

- Increase in **MDV**
- Increase in **width**
- Nonzero **skewness**
- Increase in **reflectivity**

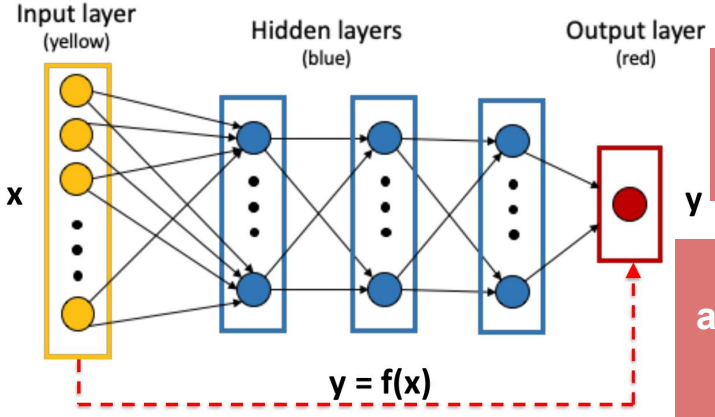


Kalesse et al., 2016

SEW: Spectrum Edge Width

- Fixed threshold techniques not always applicable
- **Machine learning** techniques well-suited for extracting relationships from large data sets
- Easy-to-use Python implementations

x = Doppler spectrum features



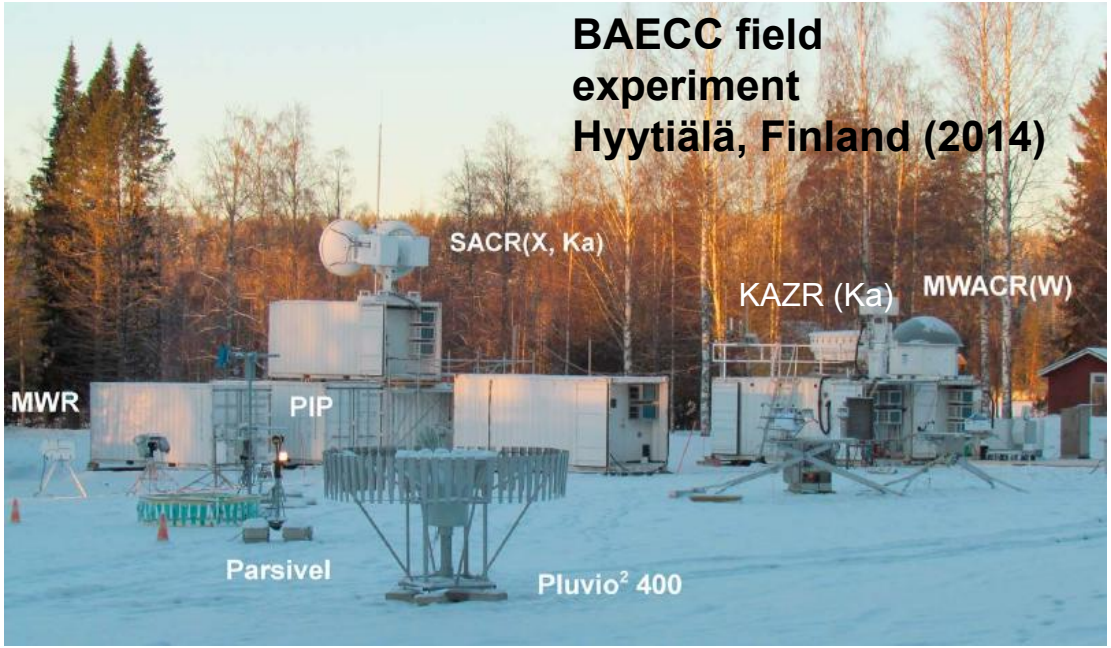
Artificial Neural Network (ANN)

Ebert Uphoff, 2020

y = rime mass fraction

ANN with and without MDV as input: comparable results → MDV not needed!

TRAINING DATA SET



Kneifel et al., 2015

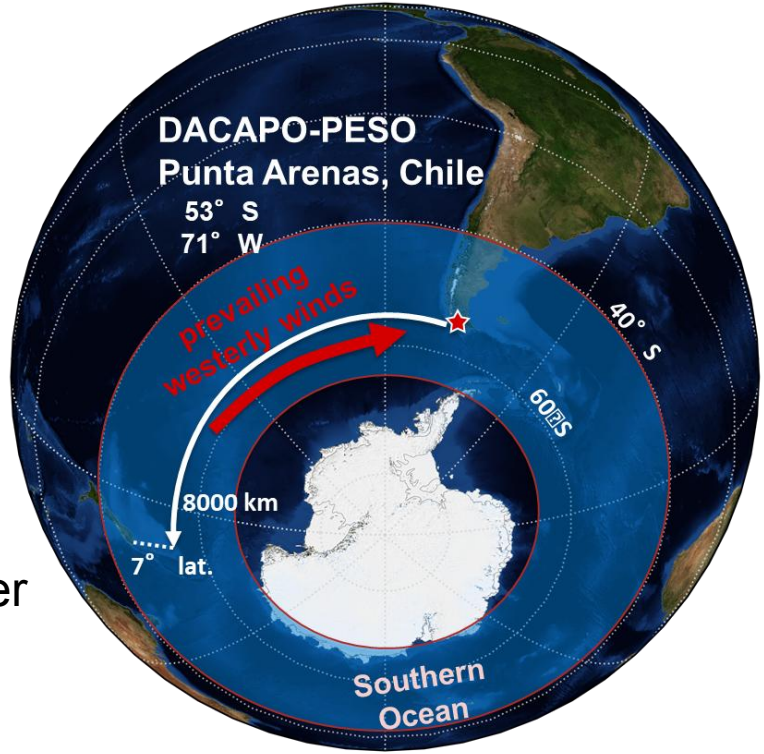
- For training, we need **pairs of input x and output y** → dataset with remote sensing and in-situ observations
- **Input x: KAZR & MWACR cloud radars** (35 & 94 GHz)
- **Output y: PIP** (Precipitation Imaging Package) → retrieving rime mass fraction $\mathbf{FR_{PIP}}$

Long Term Field Campaign @ Punta-Arenas, Chile

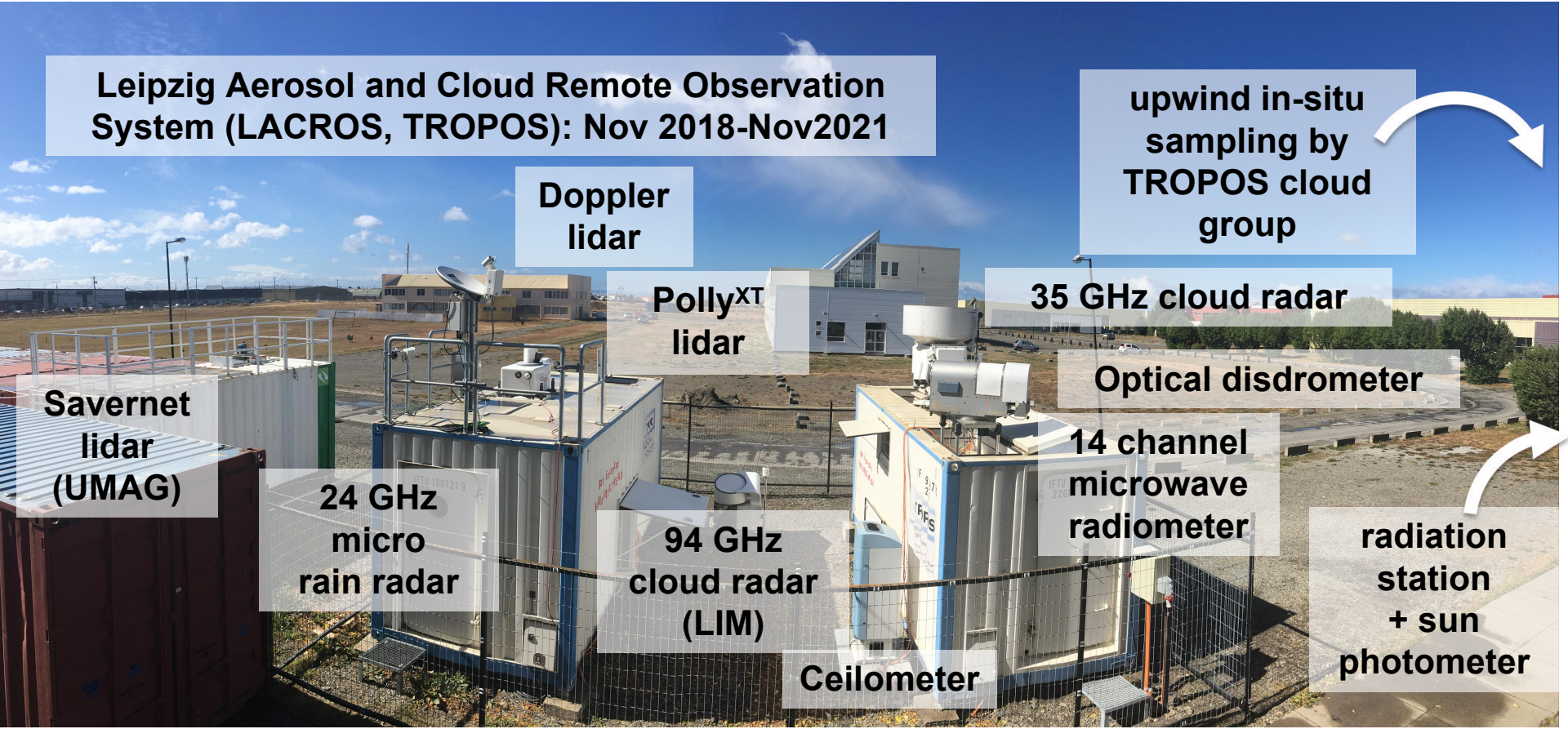
DACAPO PESO

Dynamics, **A**erosol, **C**loud and **P**recipitation **O**bservations in the **P**ristine **E**nvironment of the **S**outhern **O**cean

- lack of observational data
- low INP concentrations
- high cloud fraction
- large amounts of supercooled liquid water

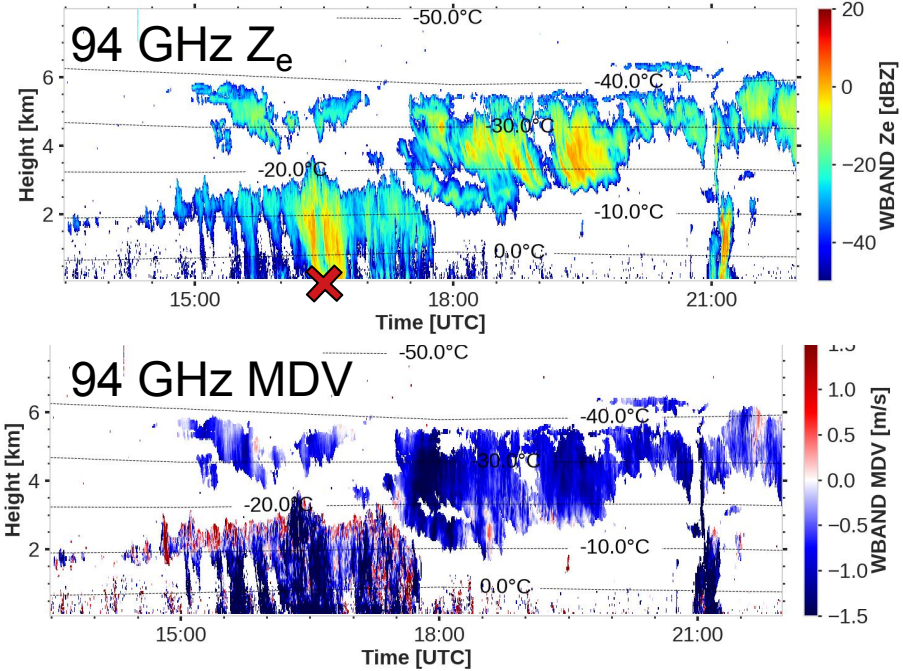


[M. Radenz]


Leipzig Aerosol and Cloud Remote Observation System (LACROS, TROPOS): Nov 2018-Nov2021
Doppler lidar
upwind in-situ sampling by TROPOS cloud group
Polly^XT lidar
35 GHz cloud radar
Optical disdrometer
Savernet lidar (UMAG)
14 channel microwave radiometer
24 GHz micro rain radar
94 GHz cloud radar (LIM)
radiation station + sun photometer
Ceilometer

Application to Punta Arenas DACAPO-PESO data

Punta Arenas, 2019-02-21

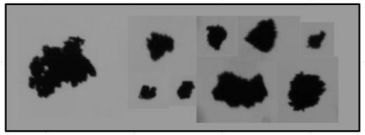


Vogl et al., 2022

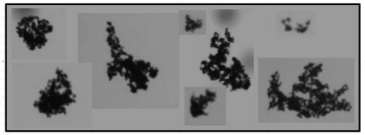
EDR: Eddy Dissipation Rate

Application to Leipzig data

VISSS: Video-In Situ Snowflake Sensor

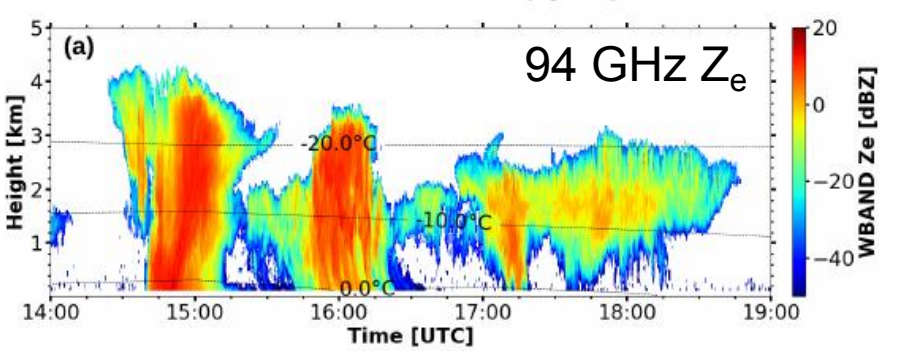


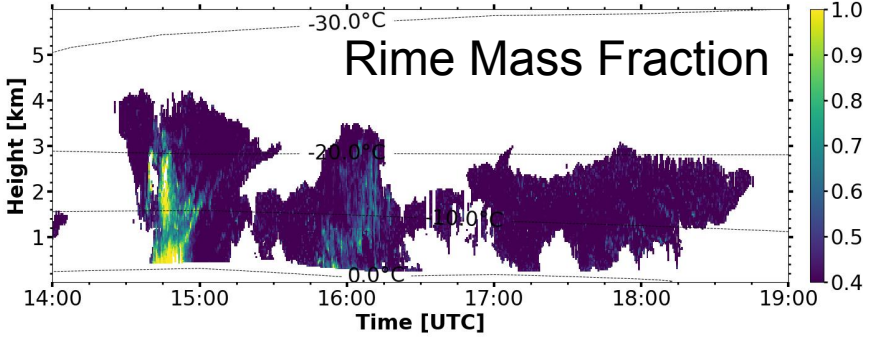
14:40 – 14:50 UTC

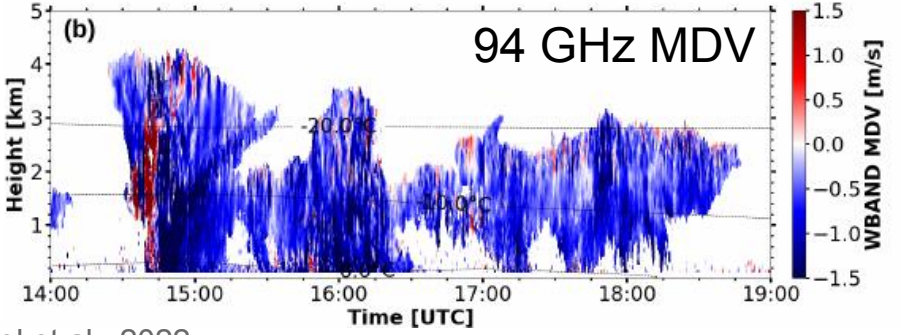


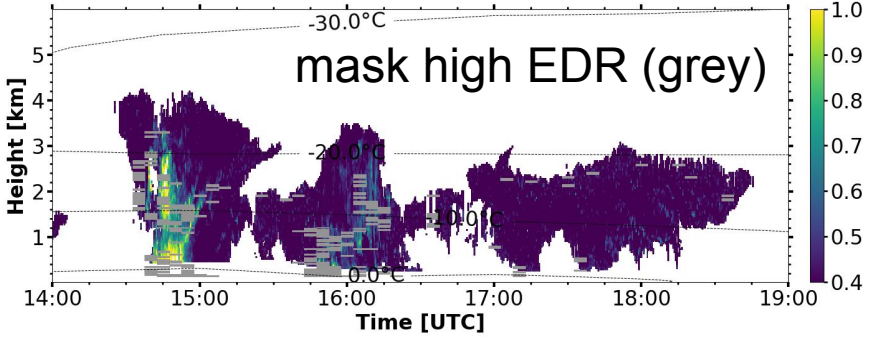
15:00 – 15:10 UTC

Leipzig, 2021-03-19









Vogl et al., 2022

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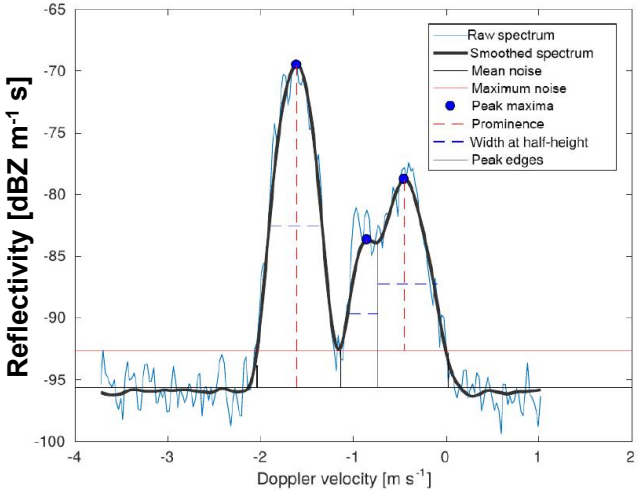
PEAKO & peakTree: radar Doppler spectra peak finding and structuring

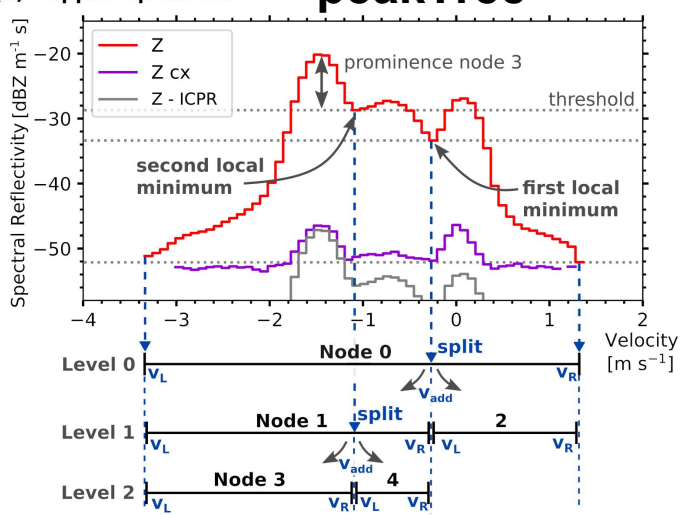
- Supervised peak detection using **PEAKO** (Kalesse et al., 2019) parameters: width, prominence, span for smoothing
- Representing sub-peaks in a binary tree structure using **peakTree** (Radenz et al., 2019)

PEAKO



Kalesse et al., 2019

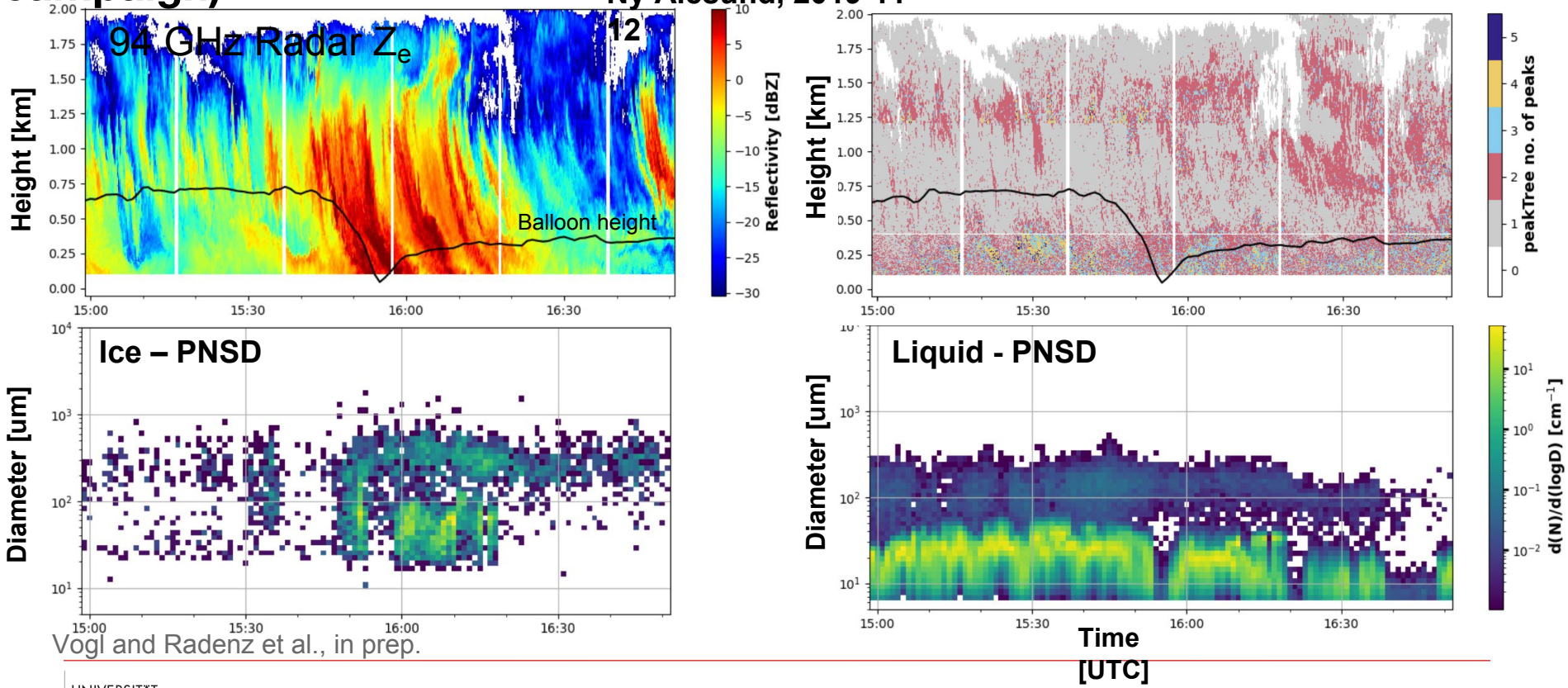
peakTree



Radenz et al., 2019

Merging of PEAKO & peakTree in progress

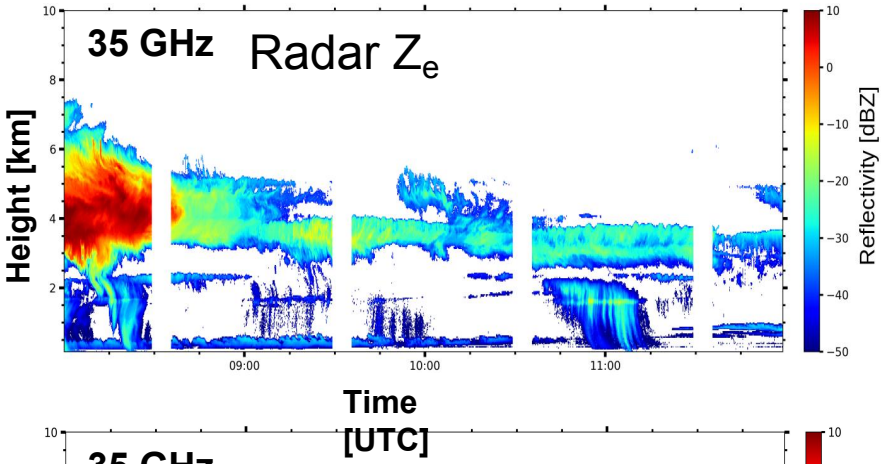
Validation with in-situ data: collaboration with Uni Cologne-NyA Remsens & ETH Zurich – tethered balloon-borne in-situ obs (NASCENT campaign)



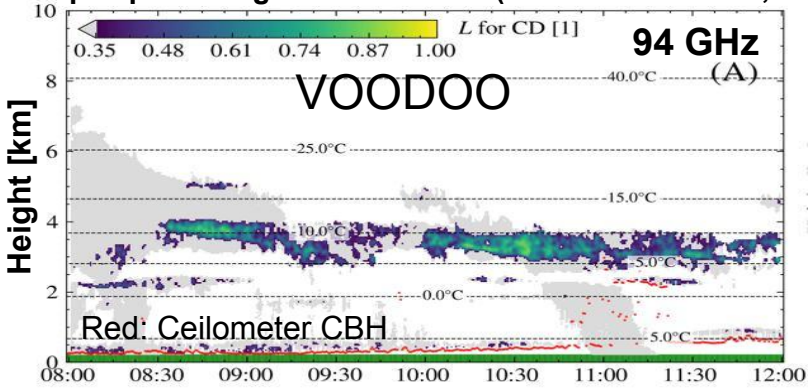
Vogl and Radenz et al., in prep.

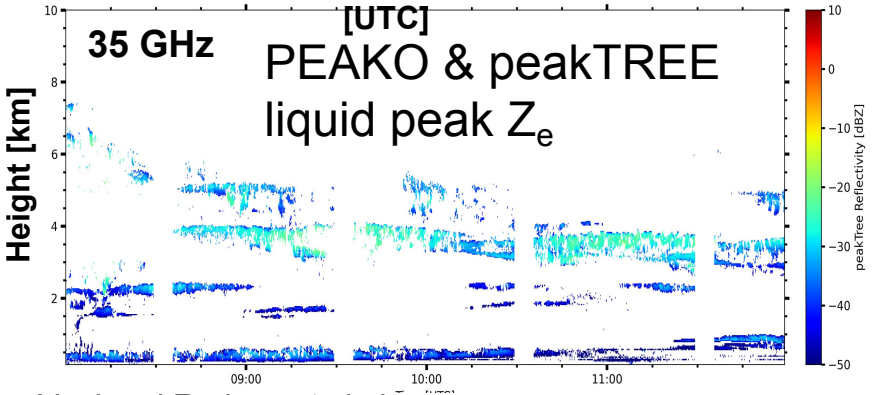
PNSD: Particle Number Size Distribution

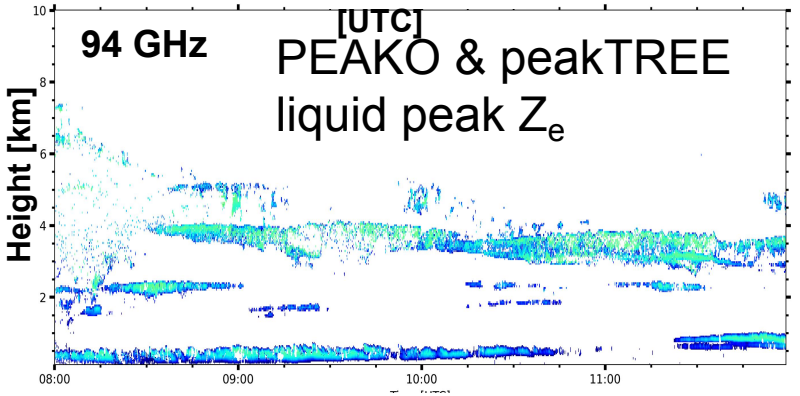
Punta Arenas example (March 13, 2019): liquid peak detection and validation



Liquid predicting neural network (W. Schimmel et al., 2022)







Vogl and Radenz et al., in prep.

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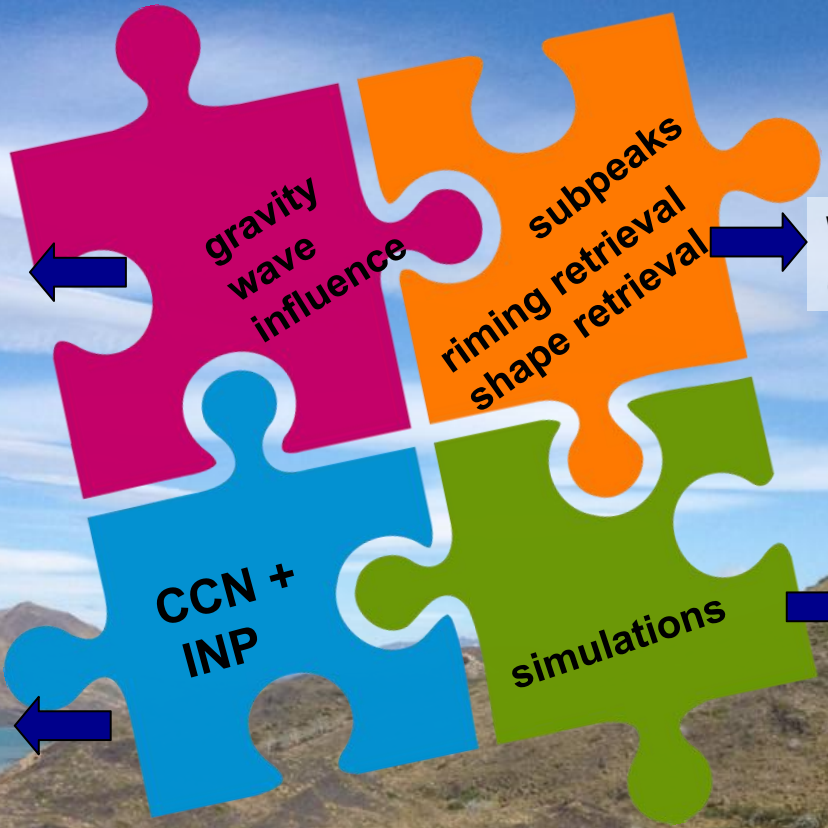
Bringing everything together…

How does aerosol influence riming?

- **Riming**: ANN-based cloud radar retrieval, vertical profiles of particle shape from cloud radar RHI scans (Audrey Teissiere)
- Information on **CCN / INP**: Can be derived from lidar profiles
- (Mamouri & Ansmann, 2016; Gong et al., 2022)
- Representativity / **attribution**: NWP model runs (ICON or COSMO-SPECS)

Bringing everything together…possible collaborations of LIM and TROPOS

Martin Radenz
(TROPOS)



Willi Schimmel
(LIM)

TROPOS
lidar group

TROPOS modeling group
SPOCC project ?

Thank you!

…Teresa is currently on PICNICC break (on parental leave)
→ PhD project will be extended until Fall 2023

BACKUP SLIDES

TRAINING DATA SET