UNIVERSITÄT LEIPZIG

TROPOS

Leibniz Institute for Tropospheric Research

Polarimetry Influenced by CCN aNd INP in Cyprus and Chile (PICNICC)

An assessment of hemispheric polarimetric contrasts and its relation to differences in aerosol load

Leipzig, July 26, 2024

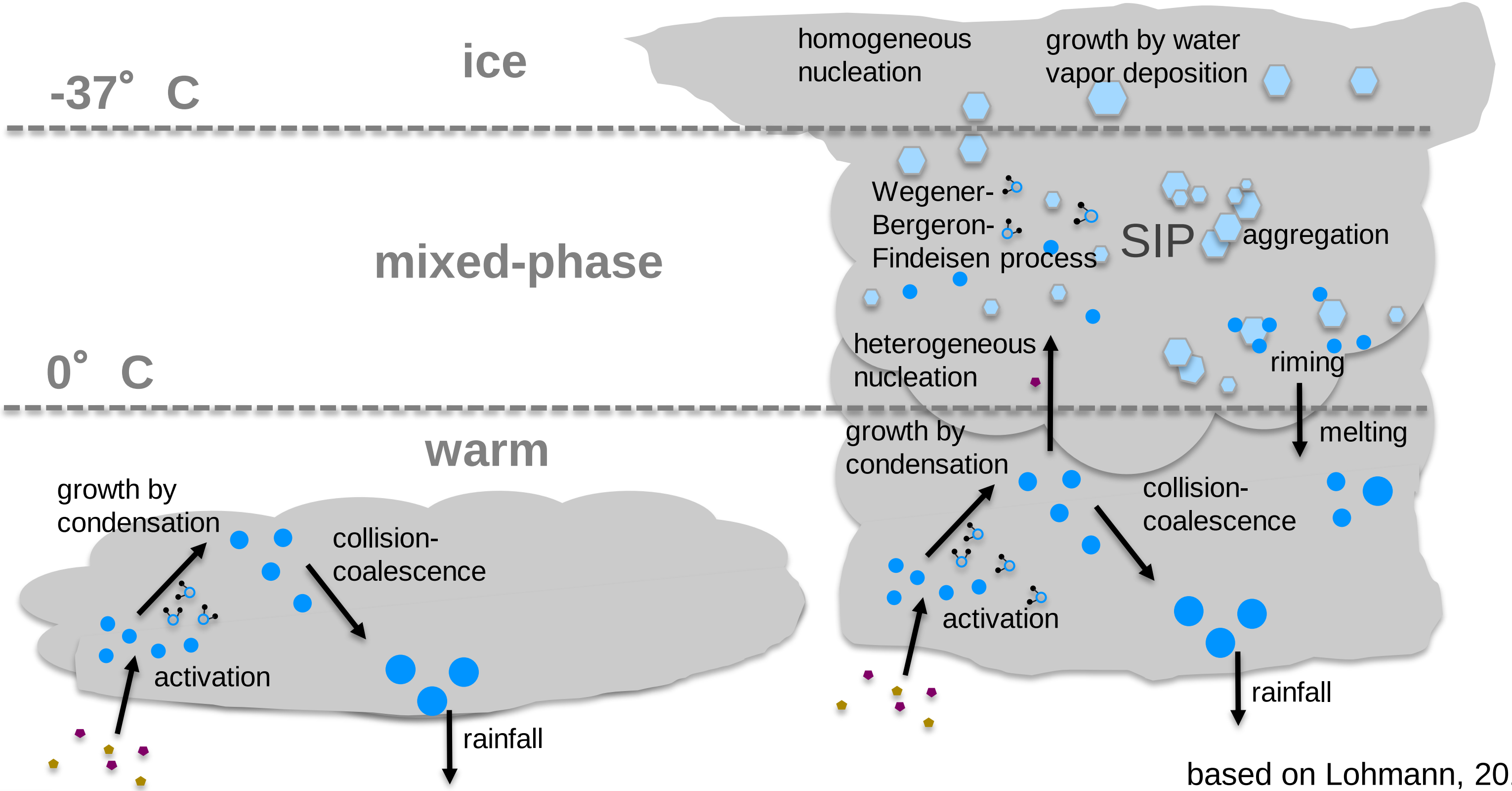
PIs: Heike Kalesse-Los, Patric Seifert, Johannes Quaas

PhD students: Teresa Vogl (Uni Leipzig), Audrey Teissiere (TROPOS)

OUTLINE

1. Introduction & Motivation
2. Status Report PhD 1 – Teresa Vogl (LIM)
    1. Part 1 : Developing a technique to retrieve riming in orographically influenced regions
    2. Part 2 : Techniques to exploit cloud radar Doppler spectra
    3. Conclusions & Outlook
3. Status Report PhD 2 – Audrey Teissiere (TROPOS)
    1. Part 1: VDPS technique
    2. Part 2: application of VDPS for riming and aggregation detection

PRECIPITATION FORMATION PROCESSES

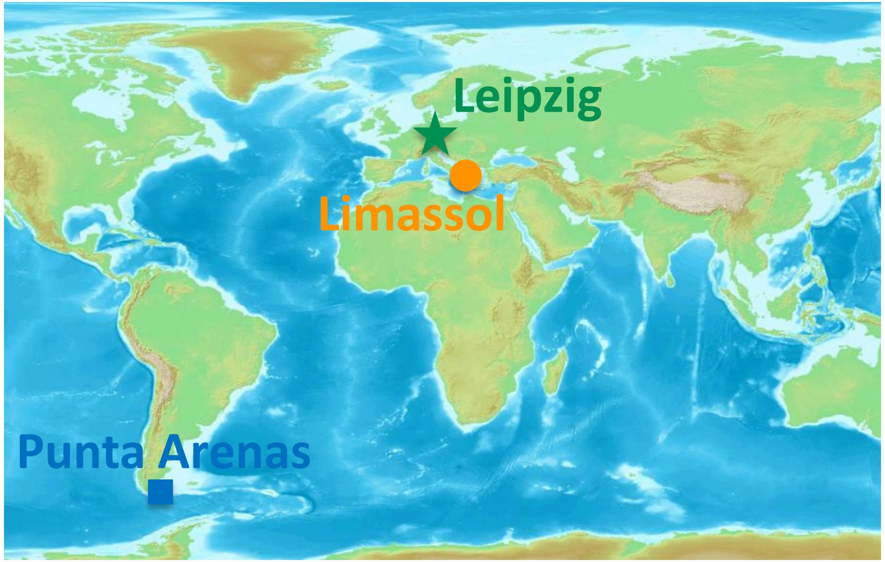


based on Lohmann, 2010

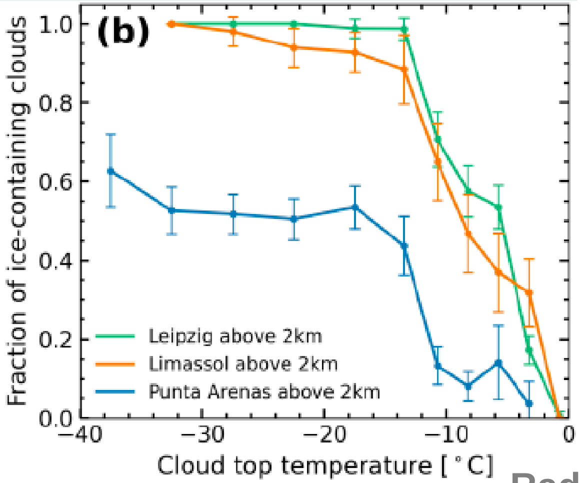
OBSERVED CONTRAST IN CLOUD PHASE

→ Central Europe vs. Southern Chile: stark contrast in ice formation efficiency in thin stratiform clouds likely due to INP availability (Radenz et al., 2021)

→ **contrasts in ice growth processes in thick cloud systems?**



Leipzig [h]	1	7	13	31	34	32	35	41	72	76	53
Limassol [h]	2	17	18	18	9	11	15	13	15	21	10
Punta [h]	14	36	54	46	46	23	29	23	8	9	2

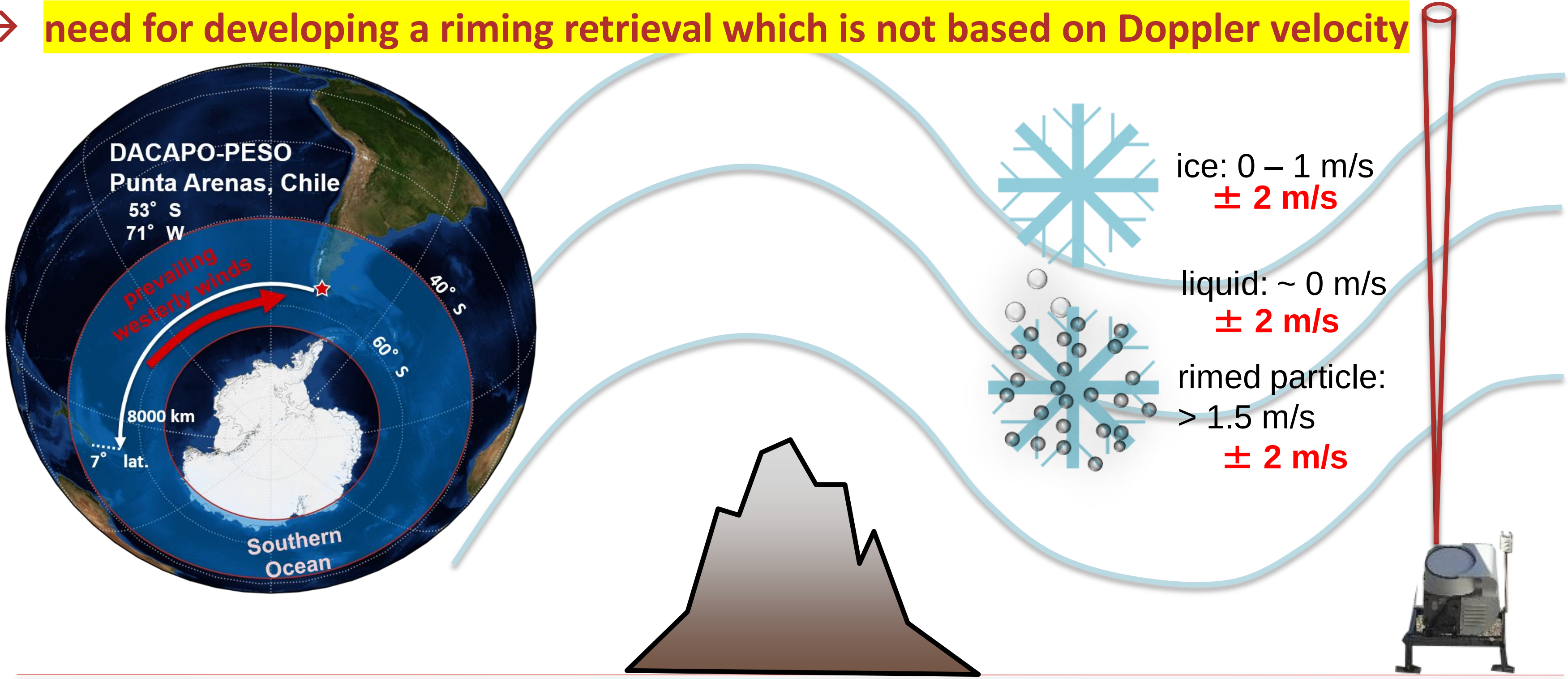


Radenz, 2021

PART 1: RIMING RETRIEVAL

→ Punta Arenas is stongly influenced by stationary and non-stationary gravity waves

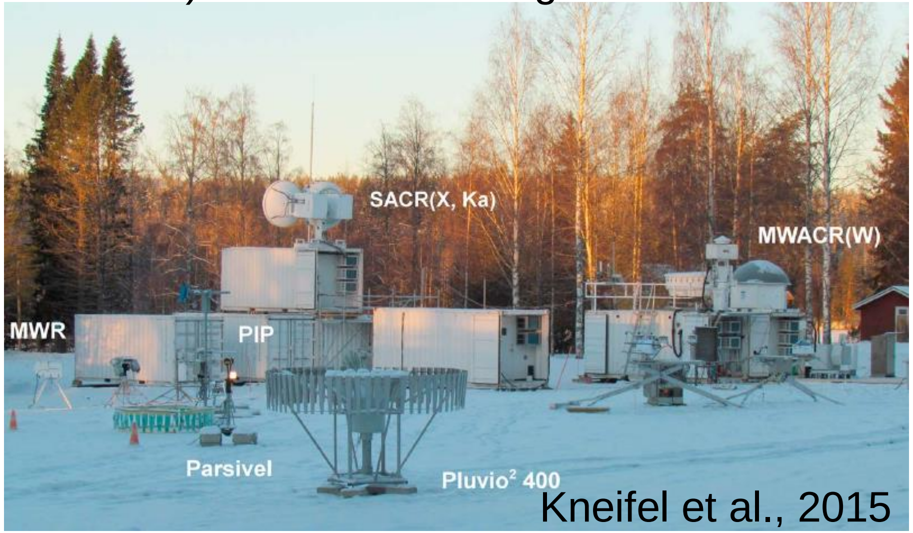
→ **need for developing a riming retrieval which is not based on Doppler velocity**



PART 1: RIMING RETRIEVAL

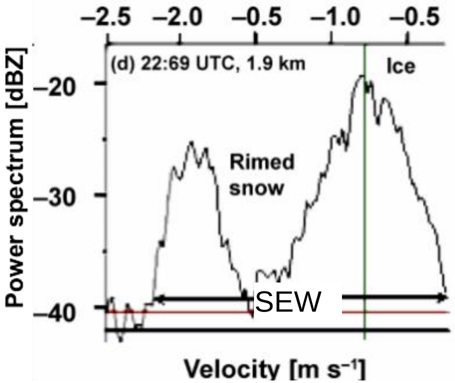
→ Developed using data from Hyytiälä, Finland, with co-located in situ and cloud radar observations

- PIP: rime fraction (**FR**) at surface
- Doppler spectra (W and Ka band) at cloud base height



Kneifel et al., 2015

“spectrum edge width”



Kalesse et al., 2016

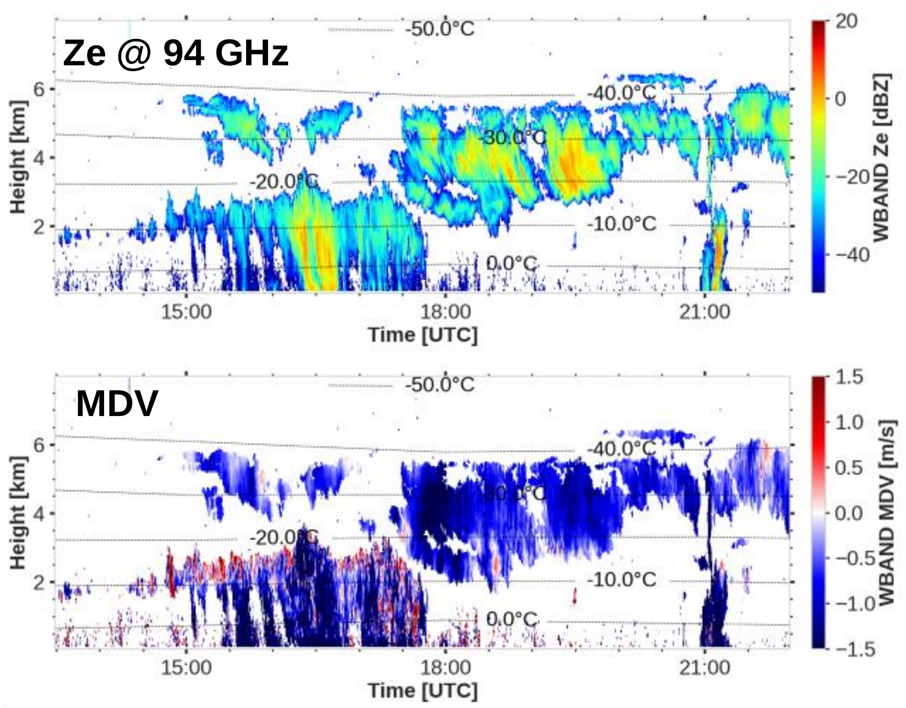
- reflectivity Ze
- skewness
- (mean Doppler velocity)

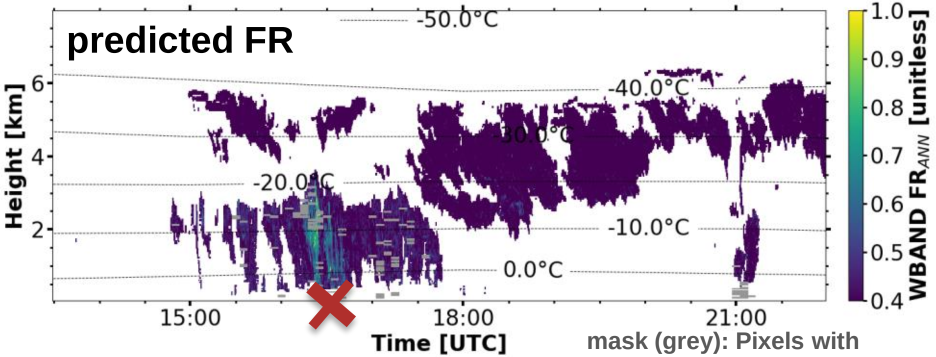
Training data set: **pairs of input x (radar variables) and output y (rime fraction from PIP)**

→ **Training artificial neural networks to predict FR from radar variables**

PART 1: RIMING RETRIEVAL

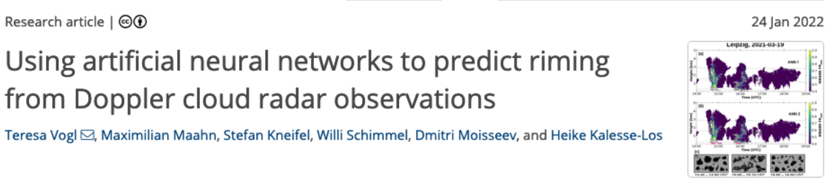
→ Example: 21 February 2019, Punta Arenas





graupel observed at site

mask (grey): Pixels with EDR > $10^{-3} m^2 s^{-3}$ strong broadening due to turbulence = increased SEW not necessarily related to riming


Research article | 24 Jan 2022

Using artificial neural networks to predict riming from Doppler cloud radar observations

Teresa Vogl, Maximilian Maahn, Stefan Kneifel, Willi Schimmel, Dmitri Moisseev, and Heike Kalesse-Los

https://amt.copernicus.org/articles/15/365/2022/

PART 2: EXPLOITING CLOUD RADAR DOPPLER SPECTRA

→ Further development of algorithms used for detecting and organizing peaks in cloud radar Doppler spectra

→ **PEAKO** (Kalesse et al., 2019): machine learning tool **for obtaining optimized peak detection parameters**

→ **peakTree** (Radenz et al., 2019): tool for organizing the peaks into binary trees, retrieving **moments of sub-peaks** & assigning hydrometeor types

10 Apr 2024

PEAKO and peakTree: Tools for detecting and interpreting peaks in cloud radar Doppler spectra – capabilities and limitations

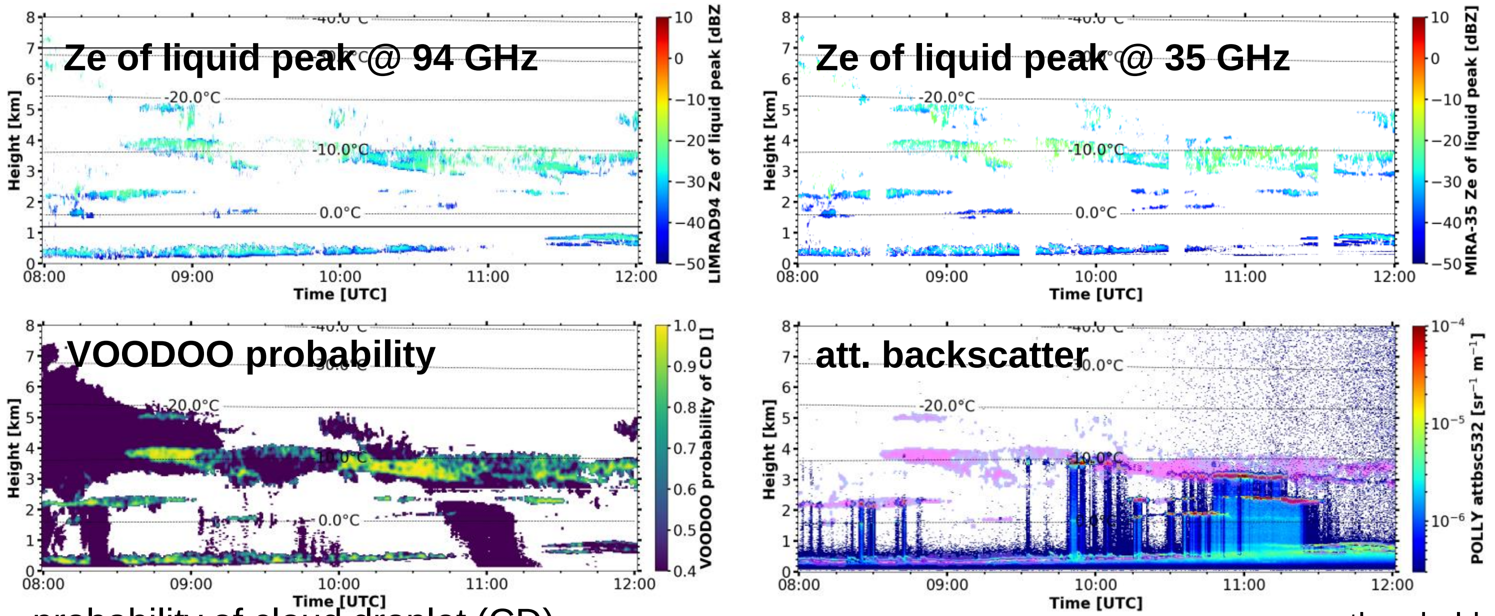
Teresa Vogl, Martin Radenz, Fabiola Ramelli, Rosa Gierens, and Heike Kalesse-Los

https://egusphere.copernicus.org/preprints/2024/egusphere-2024-837/#discussion

→ Algorithms are compatible
→ Translated to Python
→ work with RPG radar spectra
→ Available on GitHub

PART 2: EXPLOITING CLOUD RADAR DOPPLER SPECTRA

→ case study from DACAPO-PESO campaign: 13 March 2019



probability of cloud droplet (CD) containing → liquid water layers
Schimmel et al., 2022

+ VOODOO

thresholds for liquid peak:
Z < 20 dBZ
|MDV| < 0.3 m/s

FINALIZED & ONGOING WORK

Finished work:

- ☑ Development of a **riming retrieval** that works for W-Band and Ka-Band radars even in orographic and moderately turbulent conditions
- ☑ further development of the **PEAKO-peakTree toolkit**
- ☑ application of both methods to the **entire datasets from Leipzig & Punta Arenas**

Ongoing work:

- ○ statistical comparison of the two datasets

→ **more SLW = more riming?**
→ **riming vs. temperature dependence (Kneifel & Moisseev 2020)**
→ **effect of riming on rainfall rate and PSD**

Investigation of the susceptibility of mixed-phase cloud processes to aerosol perturbations with scanning SLDR-mode cloud radar

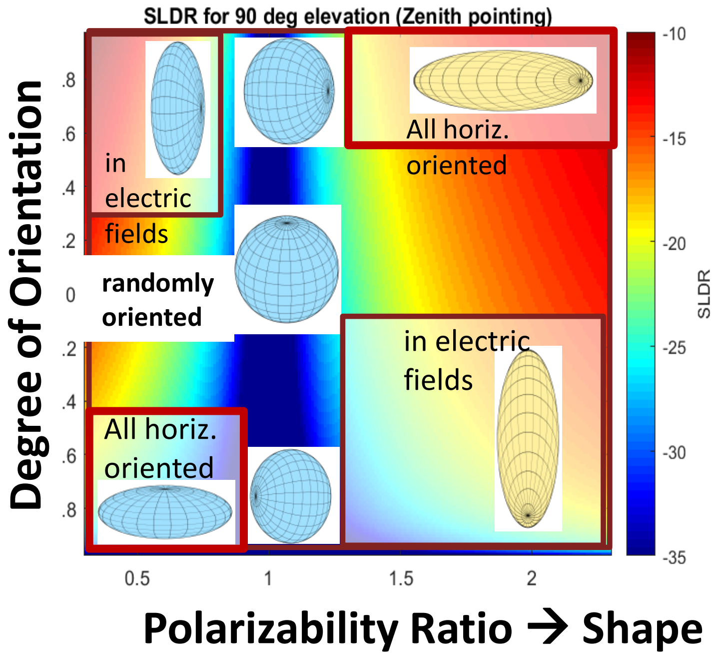
PhD student (2) : ***Audrey Teisseire***

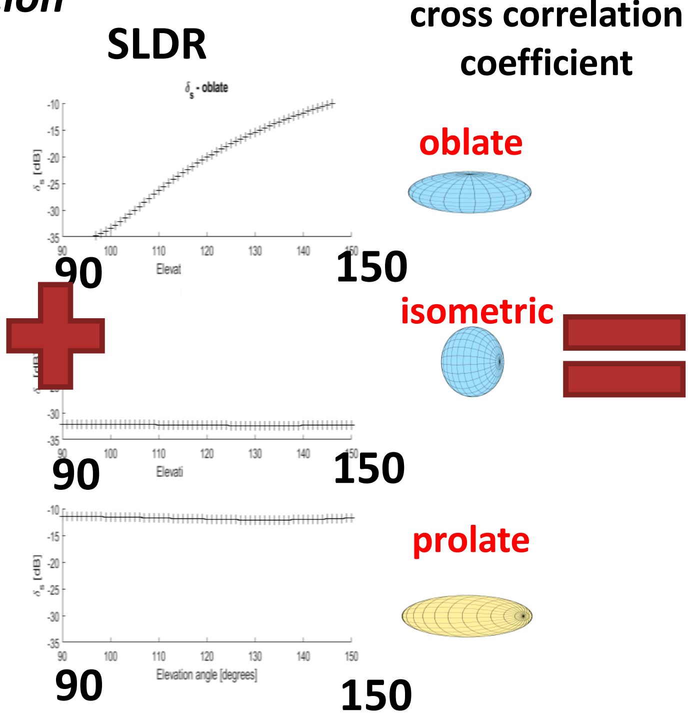
Supervisors : *Patric Seifert, Heike Kalesse-Los*

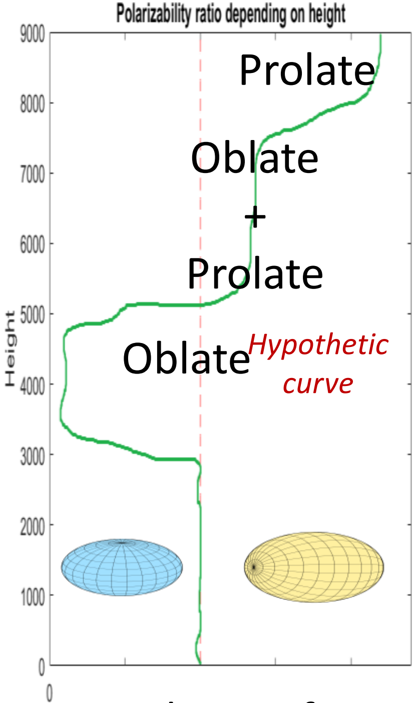
VDPS method : estimation the Vertical Distribution of Particle Shape

Combination of spheroidal scattering model and scanning SLDR cloud radar observations

→ Retrieval of shape and orientation







Shape of particles

Myagkov et al., 2016a, AMT; Tesseire et al., 2024, AMT

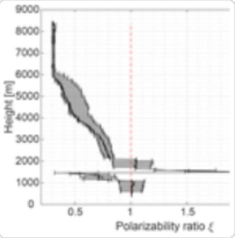
Teisseire et al., 2024, https://doi.org/10.5194/amt-17-999-2024

https://doi.org/10.5194/amt-17-999-2024

Article | Assets | Peer review | Metrics | Related articles

Research article | 12 Feb 2024

Determination of the vertical distribution of in-cloud particle shape using SLDR-mode 35 GHz scanning cloud radar



Audrey Teisseire, Patric Seifert, Alexander Myagkov, Johannes Bühl, and Martin Radenz

Abstract

In this study we present an approach that uses the polarimetric variable SLDR (slanted linear depolarization ratio) from a scanning polarimetric cloud radar MIRA-35 in the SLDR configuration, to derive the vertical distribution of particle shape (VDPS) between the top and base of mixed-phase cloud systems. The polarimetric parameter SLDR was selected for this study due to its strong sensitivity to shape and low sensitivity to the wobbling effect of particles at different antenna elevation angles. For the VDPS method, elevation scans from 90 to 30° elevation angle were deployed to estimate the vertical profile of the particle shape by means of the polarizability ratio, which is a measure of the density-weighted axis ratio. Results were obtained by retrieving the best fit between observed SLDR from 90 to 30° elevation angle and respective values simulated with a spheroidal scattering

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- Full-text XML
- BibTeX
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Short summary
The vertical distribution of particle shape (VDPS) method, introduced in this study, aids in...
- Read more

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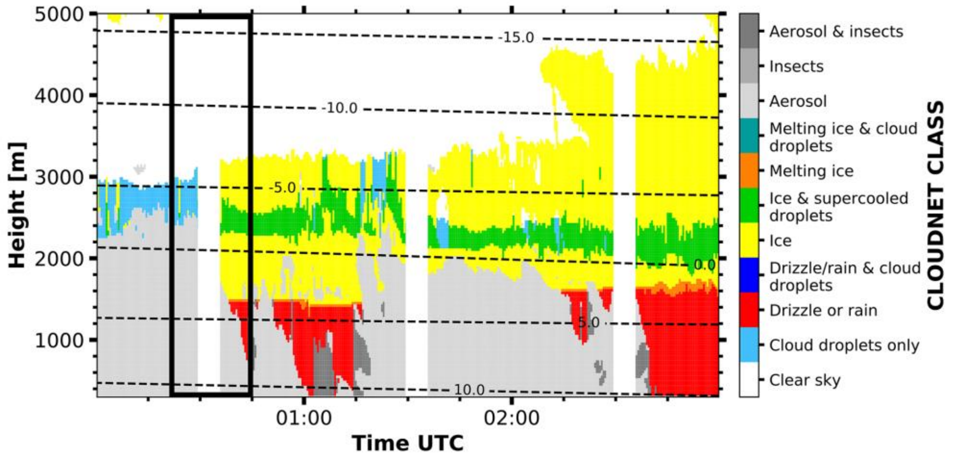
Special issue
Fusion of radar polarimetry and numerical atmospheric modelling...

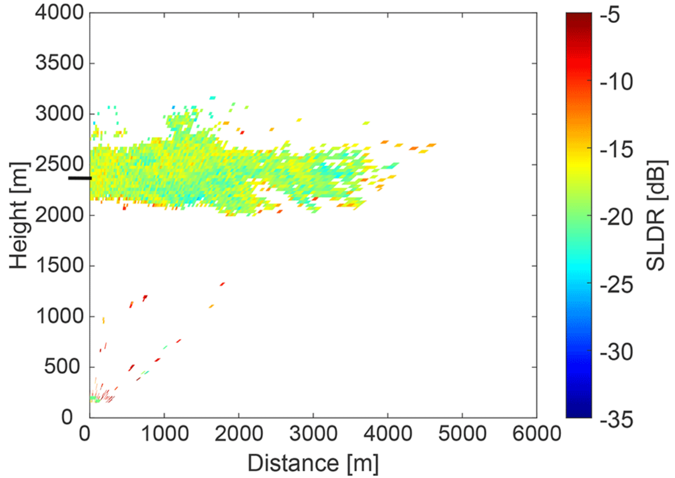
Teisseire et al., 2024, https://doi.org/10.5194/amt-17-999-2024

- Prolate-crystal case study: Punta Arenas, 4 January 2019

Cloudnet overview

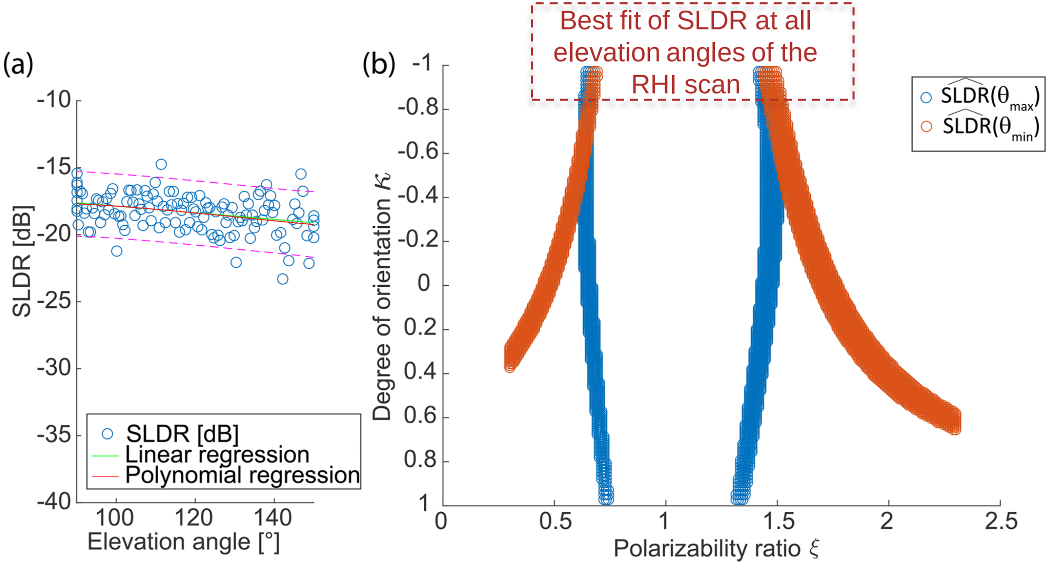


Mira-35 RHI scan of SLDR, 4 Jan 2017, 00:31 UTC



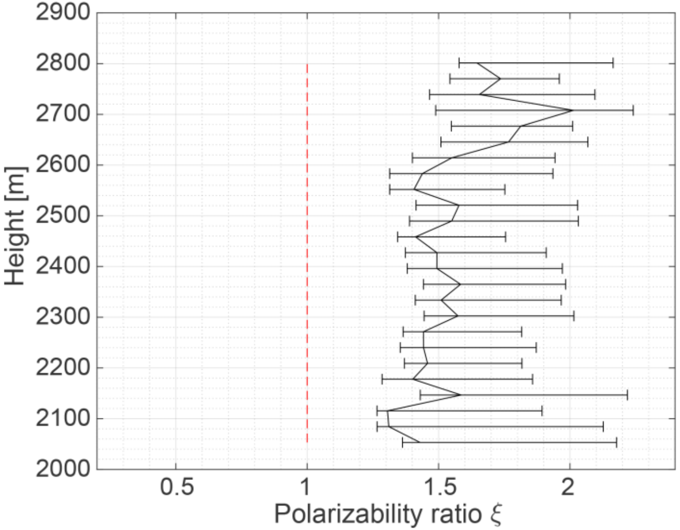
Teisseire et al., 2024, https://doi.org/10.5194/amt-17-999-2024

- Prolate-crystal case study: Punta Arenas, 4 January 2019
  - Application of VDPS method at 2458-2490 m height



Fit between observed SLDR and simulated SLDR at Θ_{min} (150°) and Θ_{max} (90°) agree best for polarizability ratio of 1.5 and degree of orientation of -1
→ horiz. aligned prolate crystals

- Polarizability ratio after application of VDPS to entire cloud layer → prolate shapes



Polarizability ratio: quantifyable observable that can potentially also be derived from model simulations (Wells et al., 2024, JAMES)

Teisseire et al., 2024b, submitted to ACP, VDPS for riming and aggregation discrimination

- Application VPDS, dual-wavelength and spectral techniques to distinguish between riming and aggregation
- **Applicable to cloud regions with orographic wave activities**
- 4 case studies presented (2 x riming, 2 x aggregation)

EGUSPHERE-2024-2019 | Research article

Received: 01 Jul 2024

Attribution of riming and aggregation processes by application of the vertical distribution of particle shape (VDPS) and spectral retrieval techniques to cloud radar observations

Audrey Teisseire, Anne-Claire Billault-Roux, Teresa Vogl, and Patric Seifert

Status: Initial editor decision (EGUsphere) | **Iteration**: Initial submission | **Journal relation**: ACP

EGUSPHERE-2024-2019
- Contact
- Initial submission
- Manuscript information
- Funding & payment
- Production information

Contact

First contact: Audrey Teisseire

Second contact: Patric Seifert

Corresponding author: Audrey Teisseire

Initial submission

05 Jul 2024
Editor found

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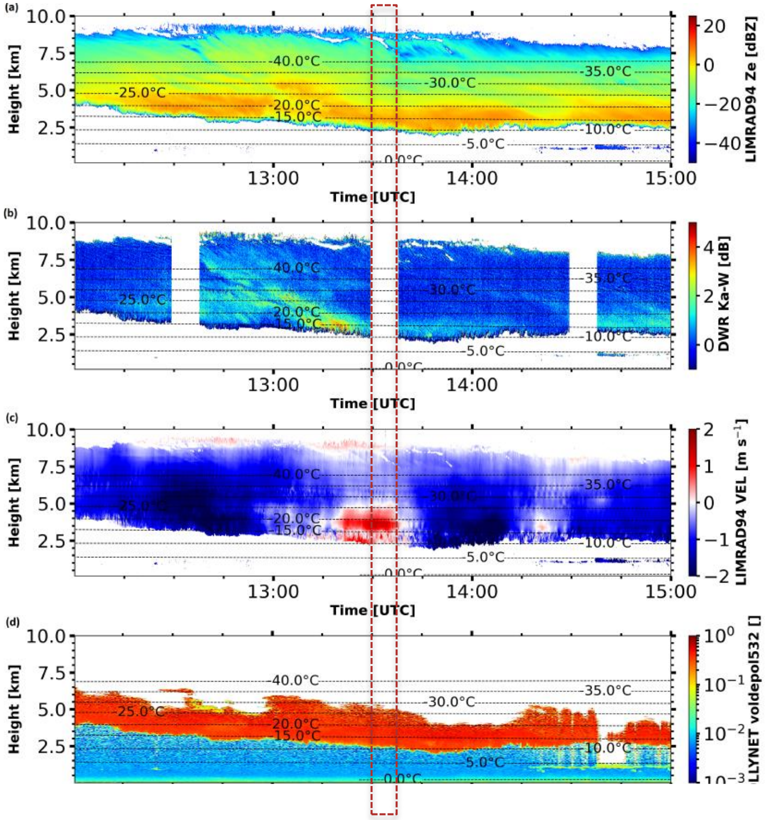
Teisseire et al., 2024b, submitted to ACP, VDPS for riming and aggregation discrimination

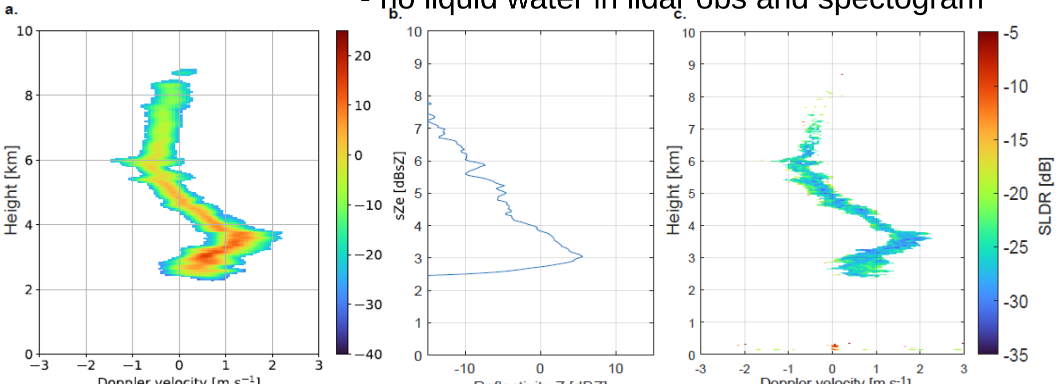
- Aggregation case study: Punta Arenas, 13 August 2019

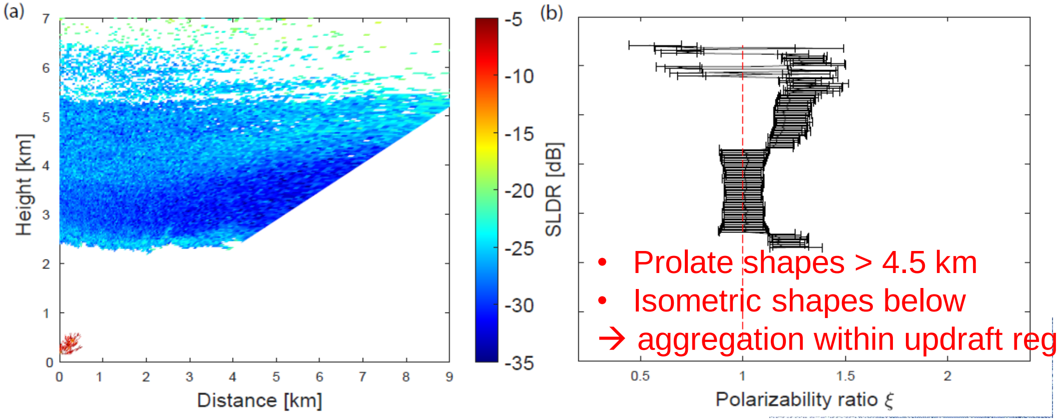


Case study period

Spectrogram 13:29 UTC:
(LIMRAD-94)

- Steady increase of reflectivity
- No remarkable SLDR features
- no liquid water in lidar obs and spectogram





- Prolate shapes > 4.5 km
- Isometric shapes below

→ aggregation within updraft region

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FINALIZED & ONGOING WORK

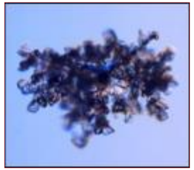
Finished work:

☑ Big progress in retrieval development for particle shape classification & process identification (riming vs. aggregation)

☑ **Aerosol effect will likely not be included**

BACKUP SLIDES

RETRIEVAL OF RIME MASS FRACTION FR



$$\mathrm{FR} = 1 - \frac{\mathrm{IWC}_{us}}{\mathrm{IWC}}$$

$$= 1 - \frac{\int m_{us}(D_{max}) \cdot N(D_{max}) \mathrm{d}D_{max}}{\int m(D_{max}) \cdot N(D_{max}) \mathrm{d}D_{max}}$$

retrieved **measured by PIP**

Kneifel & Moisseev, 2020

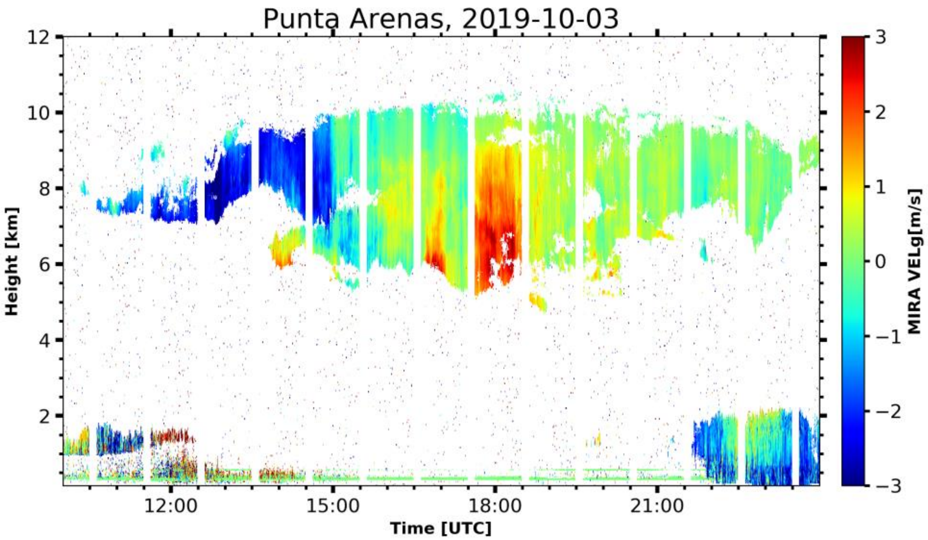
…us = unrimed snow
IWC = ice water content
D_{max} = maximum diameter

Assuming that the observed particles with the lowest 5% density values are unrimed, Moisseev et al 2017 have derived this relation:

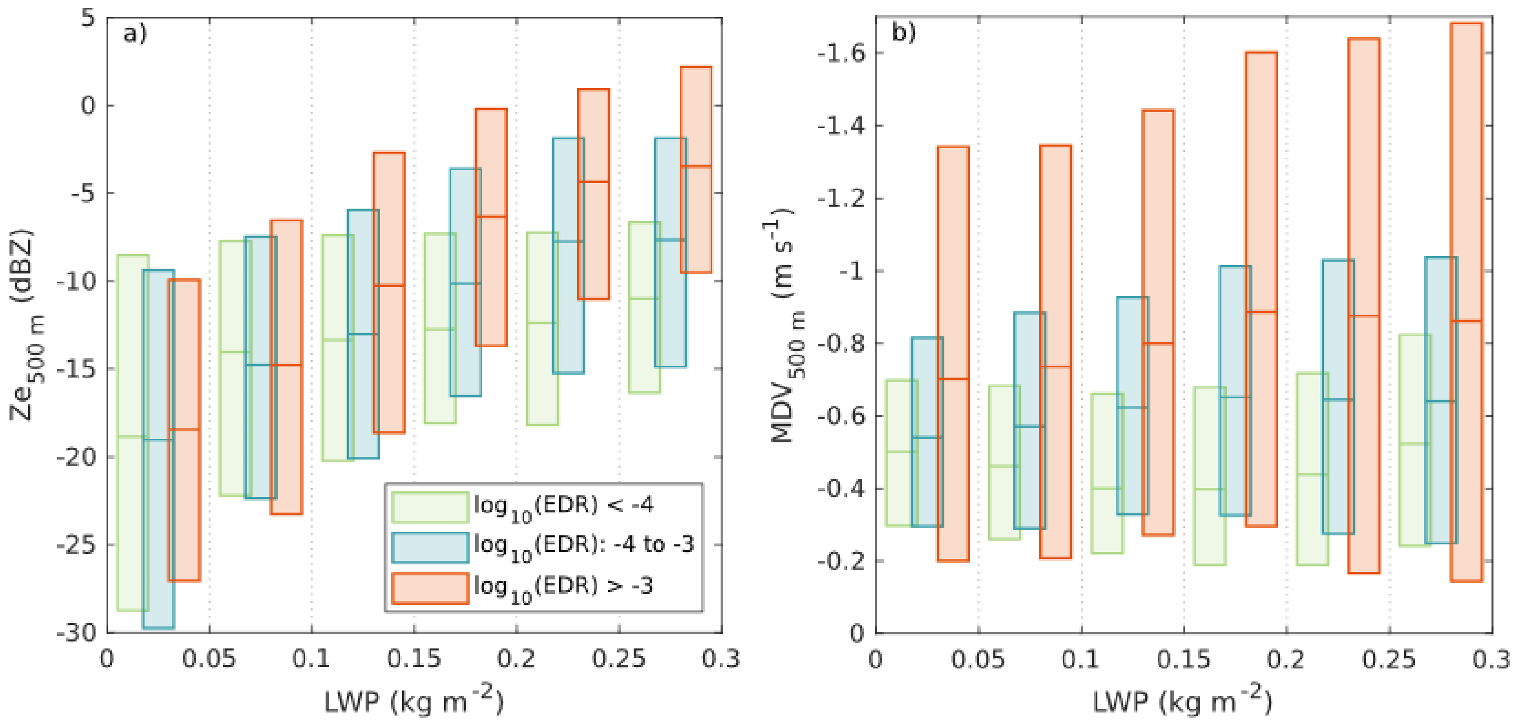
$$m_{us} = 0.0053 D_{\mathrm{max}}^{2.05}$$

Moisseev et al., 2017

WAVE CLOUD EXAMPLE PUNTA ARENAS



CHELLINI AND KNEIFEL, 2024, FIGURE 3



LACROS at Punta Arenas, Chile

LACROS: Leipzig Aerosol and Cloud Remote Observation System

DACAPO PESO

Dynamics, Aerosol, Cloud and Precipitation Observations in the Pristine Environment of the Southern Ocean