

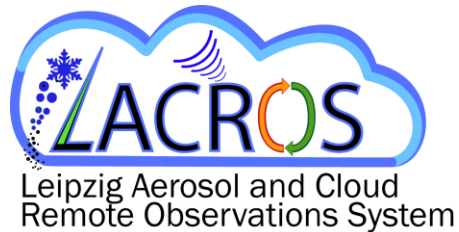
The PolarCAP project

Combined remote sensing and modelling of cloud microphysical perturbations in supercooled stratus clouds

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PROM All-hands Meeting – Kiel 2023



PolarCAP – Objective

Source: Kevin Ohneiser

By utilizing **cloud seeding**, it is possible to **disentangle** the contributions of **primary** and **secondary** ice formation to the glaciation process of supercooled stratiform clouds.



-10...0 °C

supercooled stratus

Seeding drone (ETH)

In-situ drone (ETH)

Holo-Balloon (ETH)

COSMO-SPECS

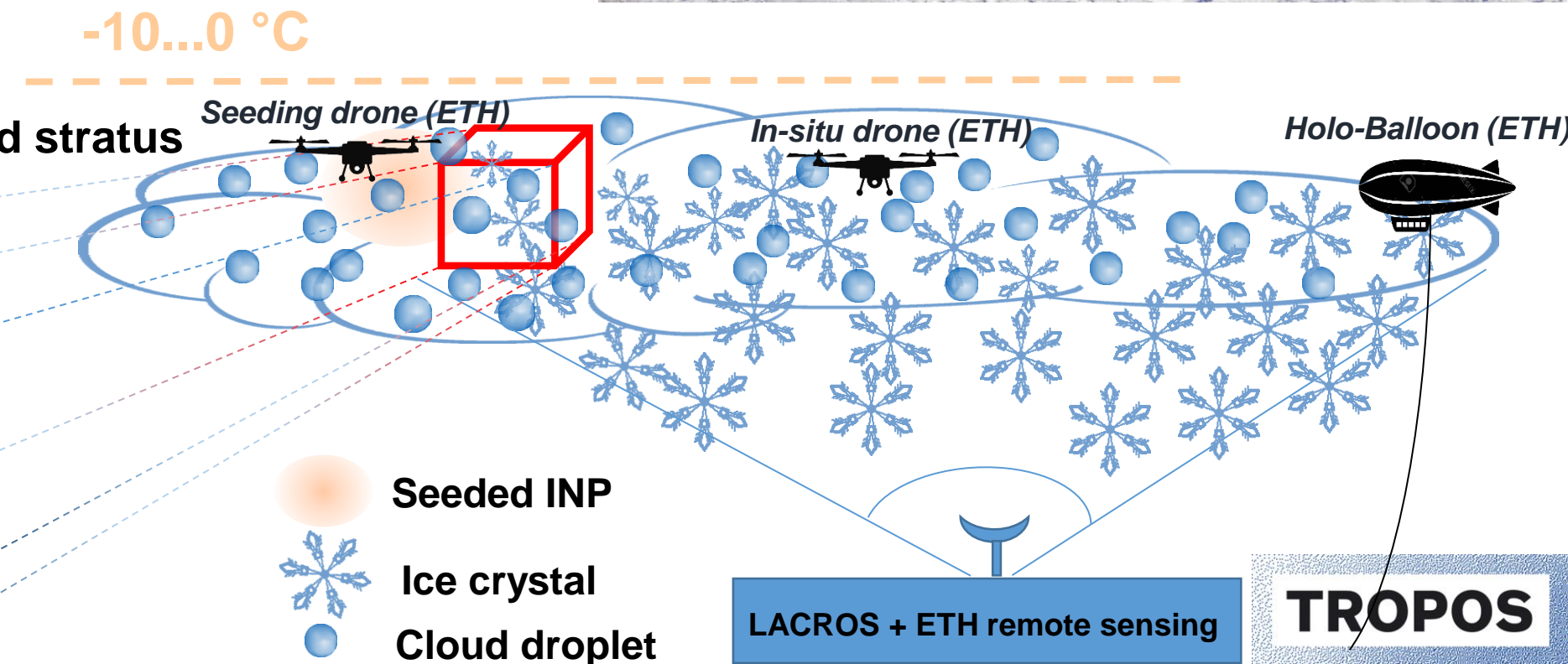
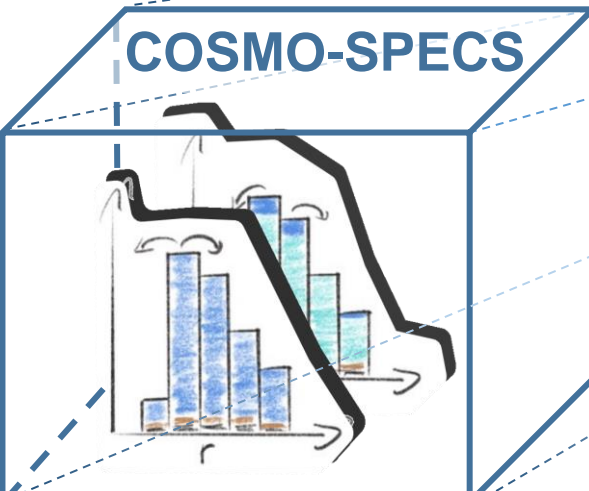
Seeded INP

Ice crystal

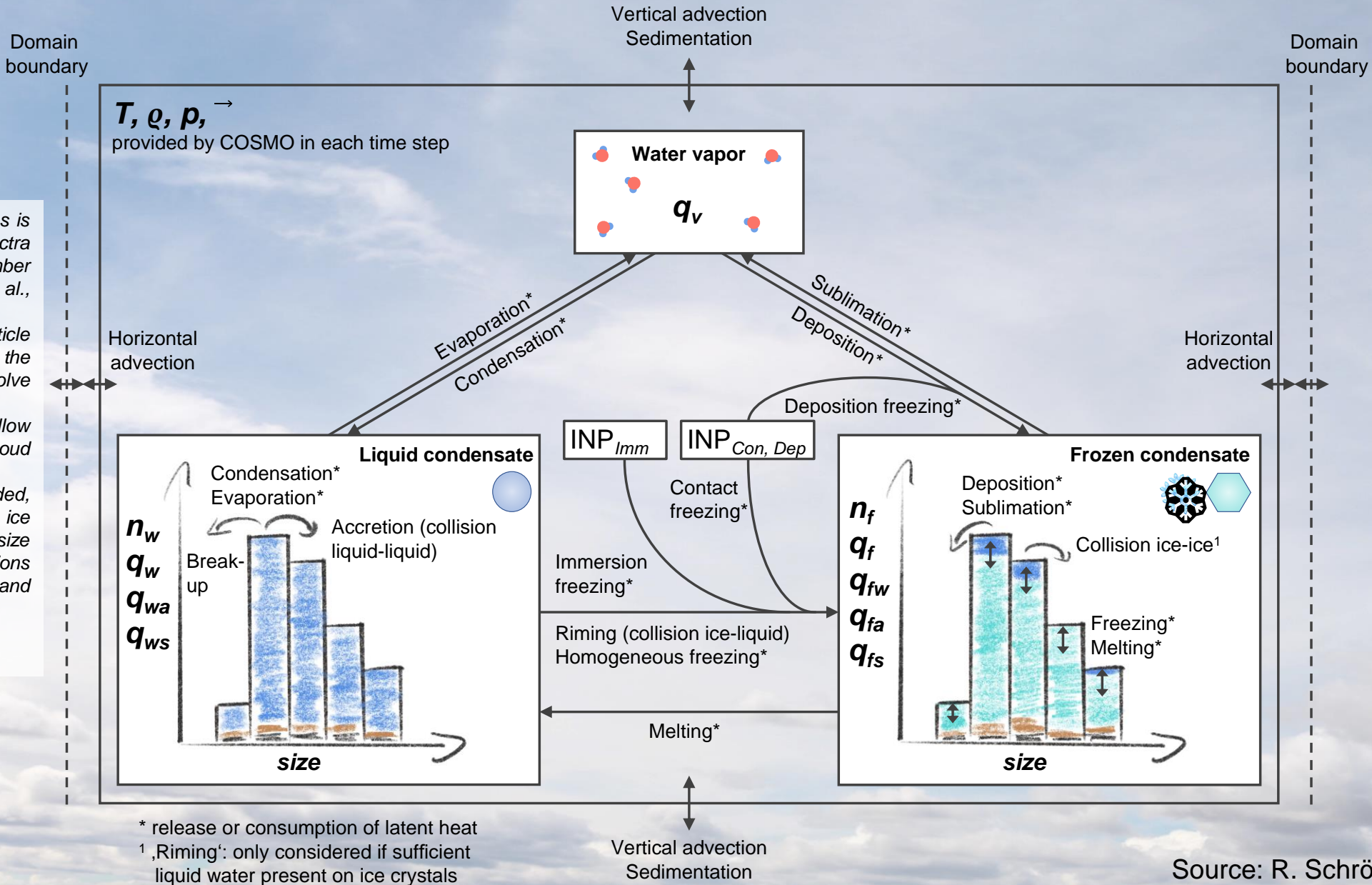
Cloud droplet

LACROS + ETH remote sensing

TROPOS



In spectral bin schemes the particle mass is discretized so that the hydrometeor spectra are divided into size bins for which number and mass are considered (e.g., Reisin et al., 1996; Khain et al., 2004). In those schemes initial aerosol particle spectra are explicitly included and the particle, drop, and ice particle spectra evolve freely. Thus, spectral microphysical schemes allow for detailed investigations of aerosol-cloud interactions. In particular, when the ice phase is included, explicit information about drop and ice particle sizes and the development of size spectra are given, allowing for conclusions about the correlations of ice formation and precipitation. [Diehl & Grützun, ACP 2018]



Source: R. Schrödner

COSMO Model Domain – Eriswil

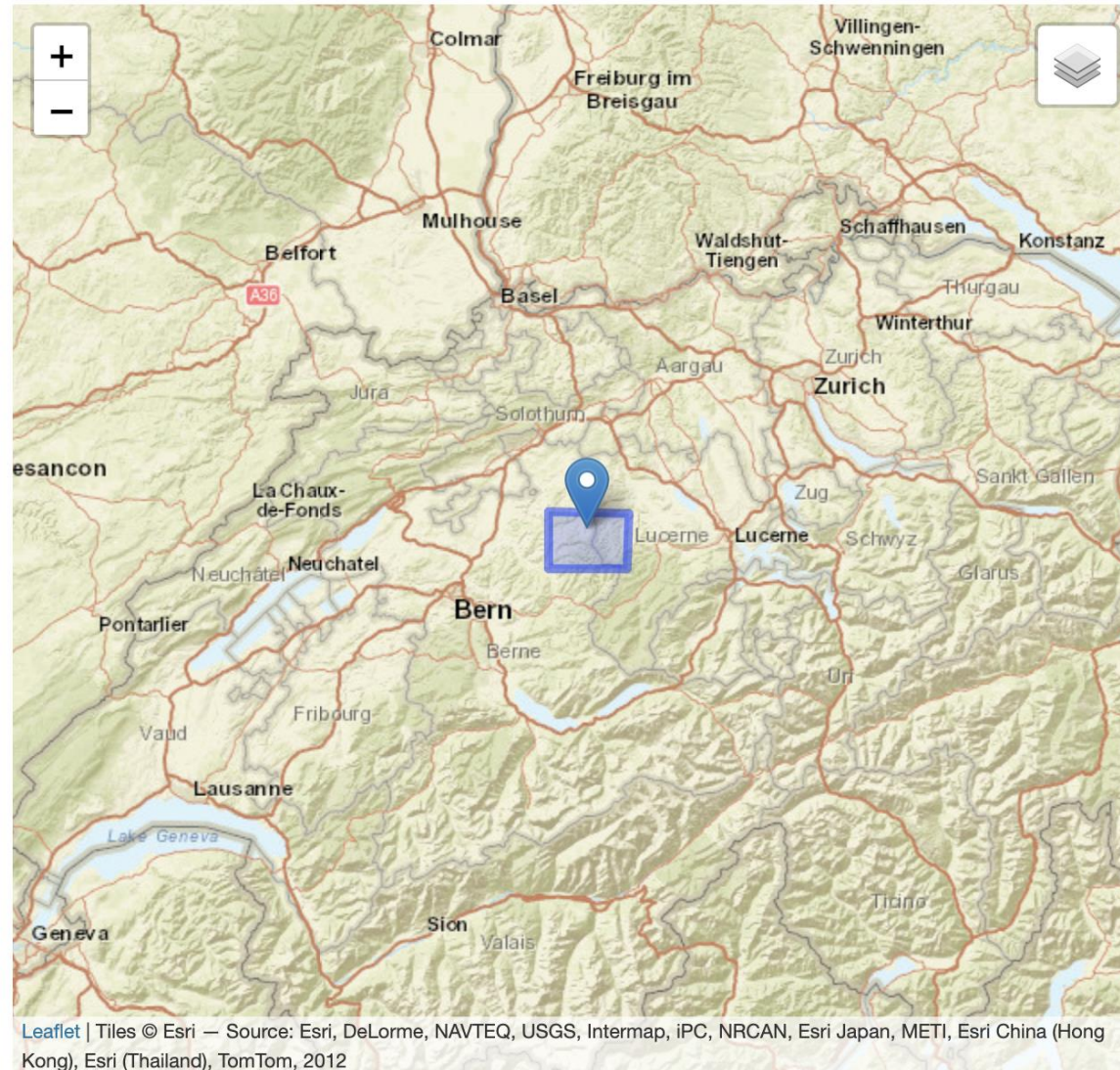
Version: EXTPAR-5.2.1

README

Click on a box for info

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origin lat	<input type="text" value="47.0799"/>
ie_tot	<input type="text" value="42"/>
je_tot	<input type="text" value="32"/>
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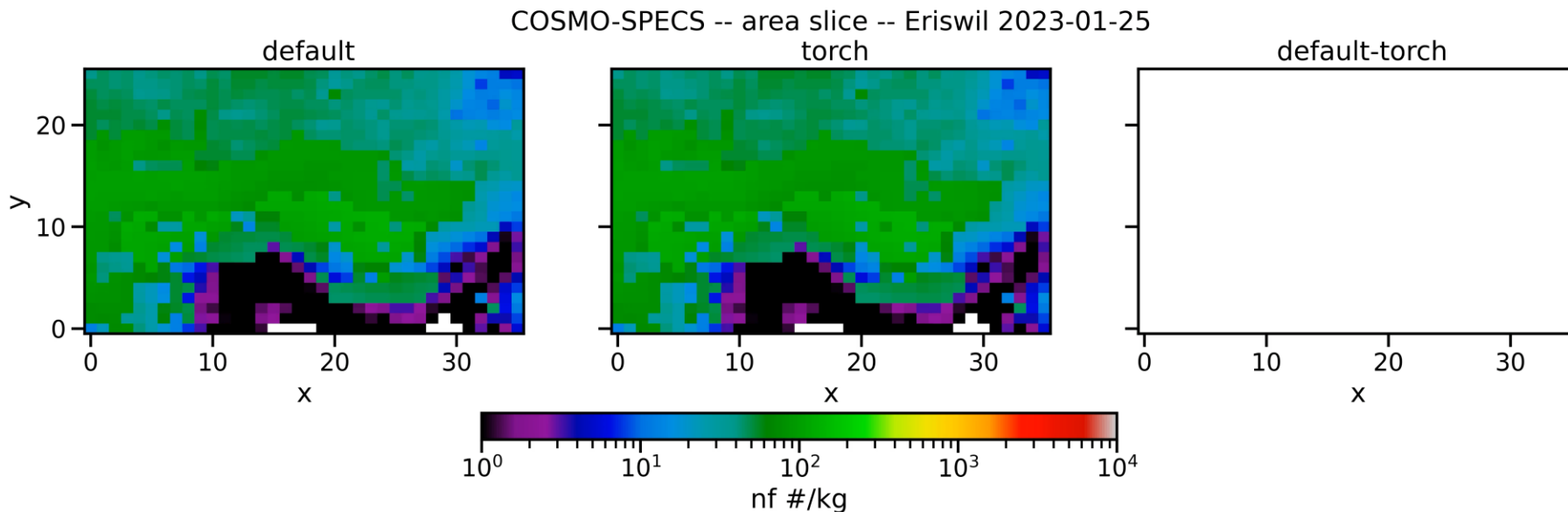
dim: $x = 42, y = 32, z = 50$



Torch Flare Implementation via Namelist

- no dilution by cell volume -> filled whole cell
- no accumulation, INP concentration is kept constant for burning time

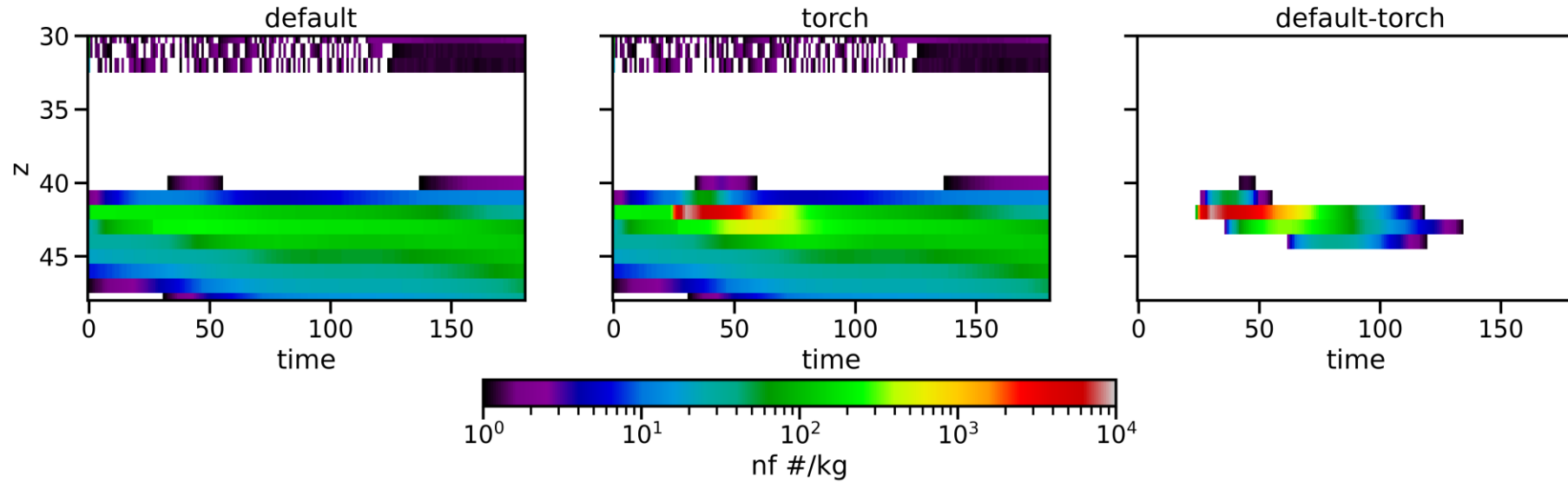
```
&FLARE_SBM  
lflare                =.true.  
flare_starttime       = 120.  
flare_endtime         = 330.  
flare_btime           = 30.  
flare_restart_intervall = 900.  
flare_high            =-43  
flare_emission         = 8d8  
flare_effect_temp     = 268
```



Torch Flare Test Case

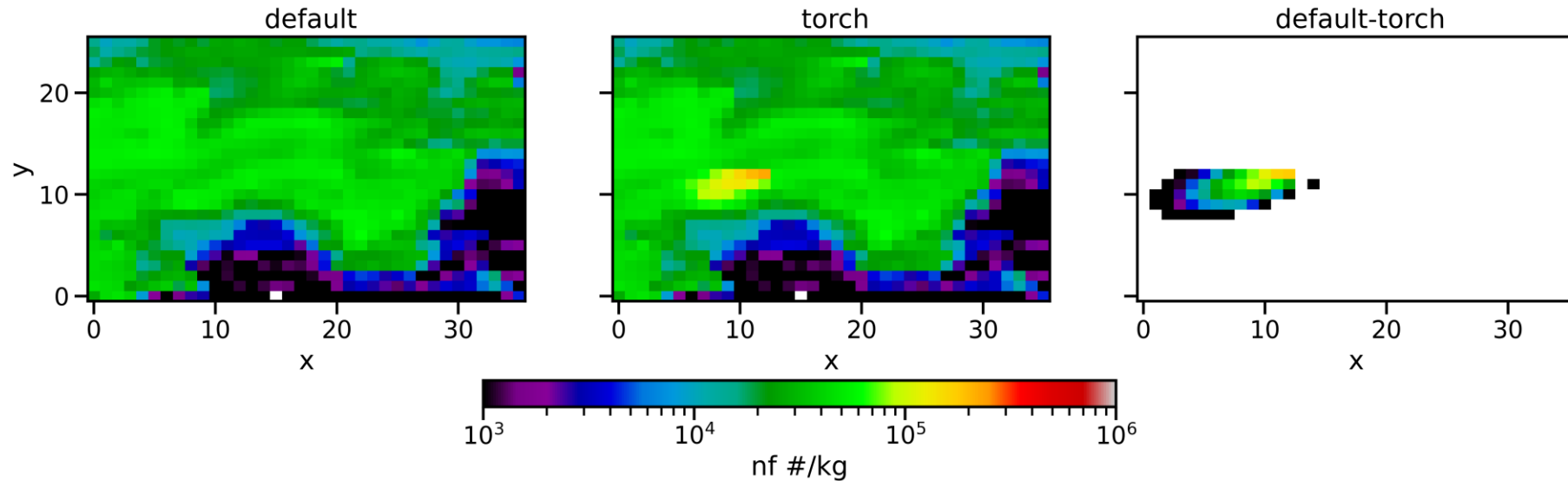
COSMO-SPECS -- vertical slice -- Eriswil 2023-01-25

Time-Height slice



COSMO-SPECS -- area slice -- Eriswil 2023-01-25

Horizontal slice



Closure with forward simulator PAMTRA

Passive and **A**ctive Microwave radiative **TR**ansfer tool for simulating radiometer and radar measurements of the cloudy atmosphere [Mech et al. 2020 GMD]

Input:

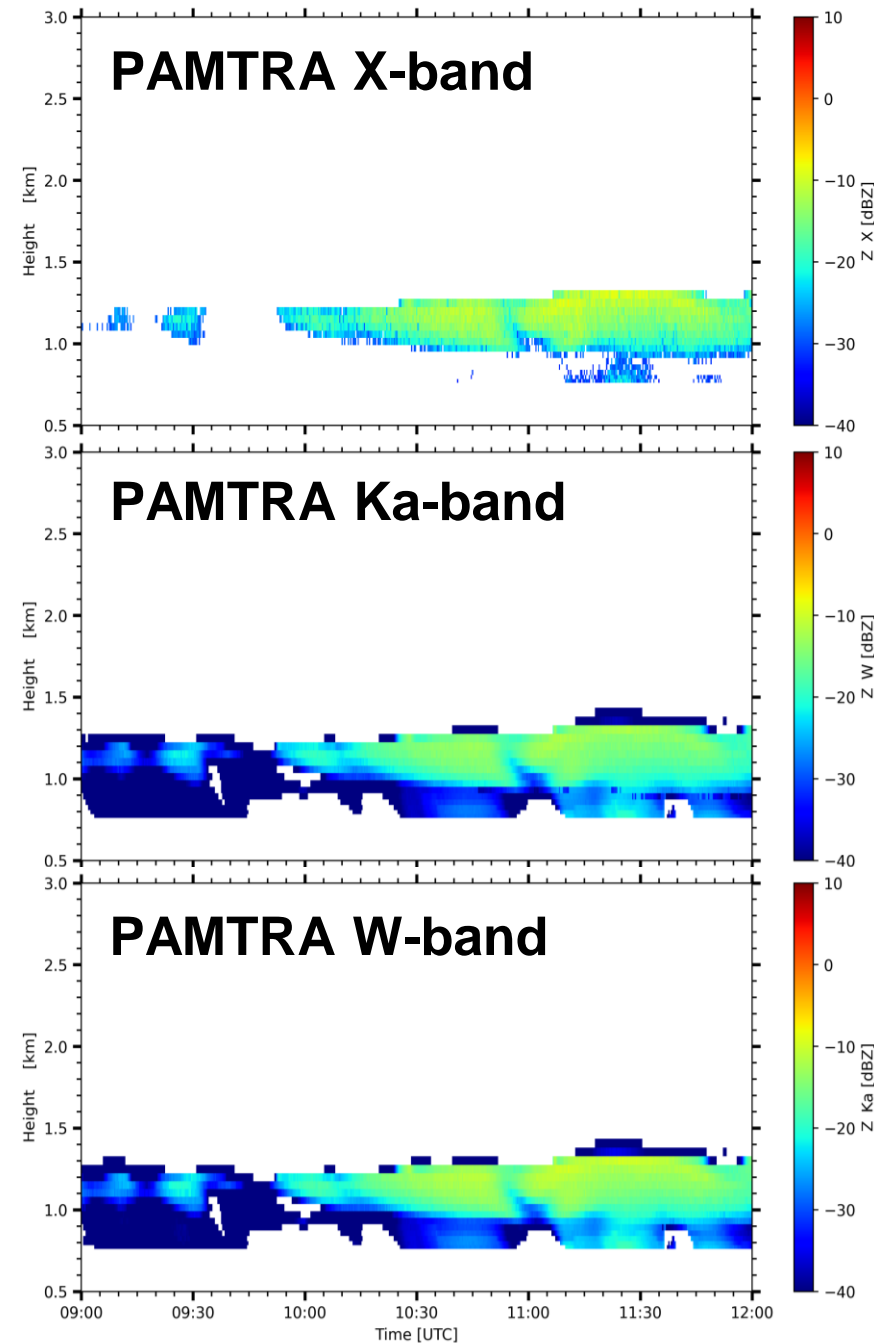
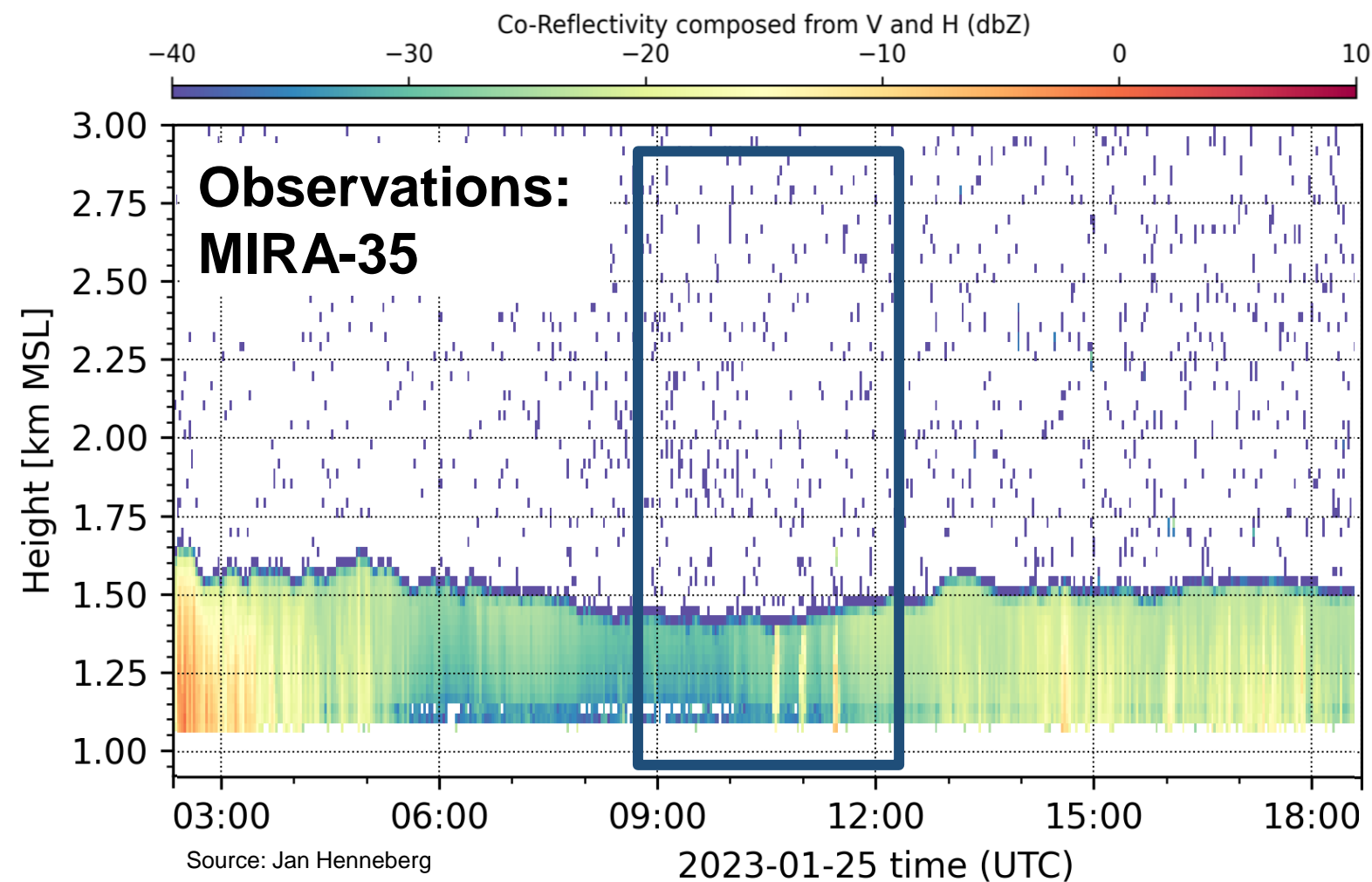
- the **atmospheric state**: P, T, U, V, W, RH, cloud water/ice content, mixing-ratio and number concentration: **rain, snow, graupel, hail, droplets, crystals**
- the assumption on **absorption, scattering, and surface emissivity,**
- instrument specifications

Output:

- polarized radiances or brightness temperature for the passive part and **LWP, IWP**
- **radar Doppler spectra** and derived moments (**Z_e , mdv, width, ...**)

Preliminary: ICON-LEM-PAMTRA

(reference run, i.e. no-torch)



ToDo's 2023

ICON-LEM ref. sim.



ICON-LEM-PAMTRA



COSMO-SPECS ref. sim.



COSMO-SPECS -- INP tracer development



parental
leave



parental leave
substitution: Jens Stoll



parental leave
substitution: Jens Stoll



Jan / 2023

Mai / 2023

Aug / 2023

Dec / 2024



Start

INP tracer
simulation

2-day Workshop
@Zürich

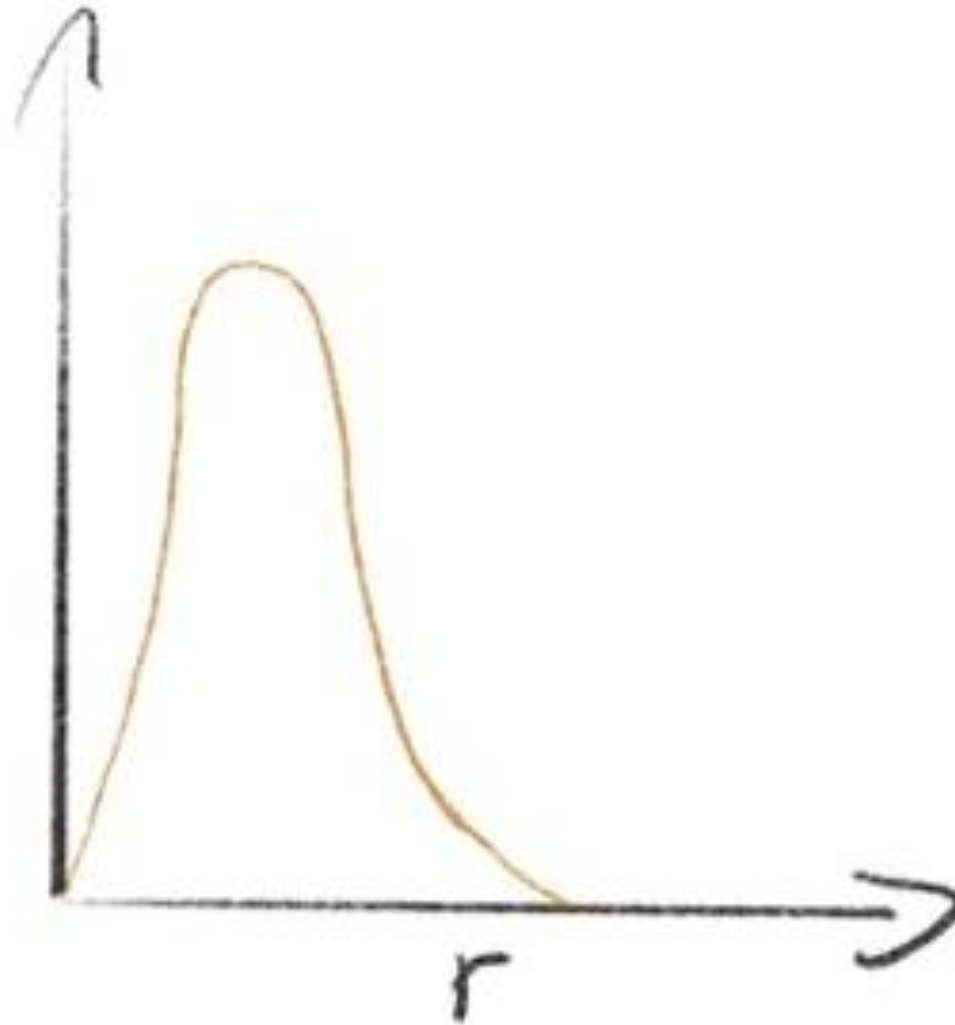
TROPOS

WP	Task	Year 1	Year 2	Year 3
		2023 – 2024	2024 – 2025	2025 – 2026
1	Remote Sensing			
T1.1	Field campaigns			
T1.2	Establish and evaluate scan strategy during seeding			
T1.3	Characterization of cloud and aerosol conditions			
2	Modelling of aerosol-induced perturbations			
T2.1	Nested COSMO-SPECS setup for supercooled stratus			
T2.2	Revise coupling to cloud Doppler radar forward operator			
T2.3	Implementation of an additional INP tracer			
T2.4	Execution of numerical cloud seeding experiments			
3	Synergy: PolarCAP ↔ CLOUDLAB			
T3.1	Statistical assessment of different cloud-top-temperature and turbulence regimes			
T3.2	Quantifying the role of contact and immersion freezing			
T3.3	Quantifying the role of secondary ice formation			

Figure 4: Gantt chart. Orange: PostDoc1 (observations); Green: PostDoc2 (modelling); Blue: Cooperation of PostDoc1, PostDoc2 & CLOUDLAB partners.

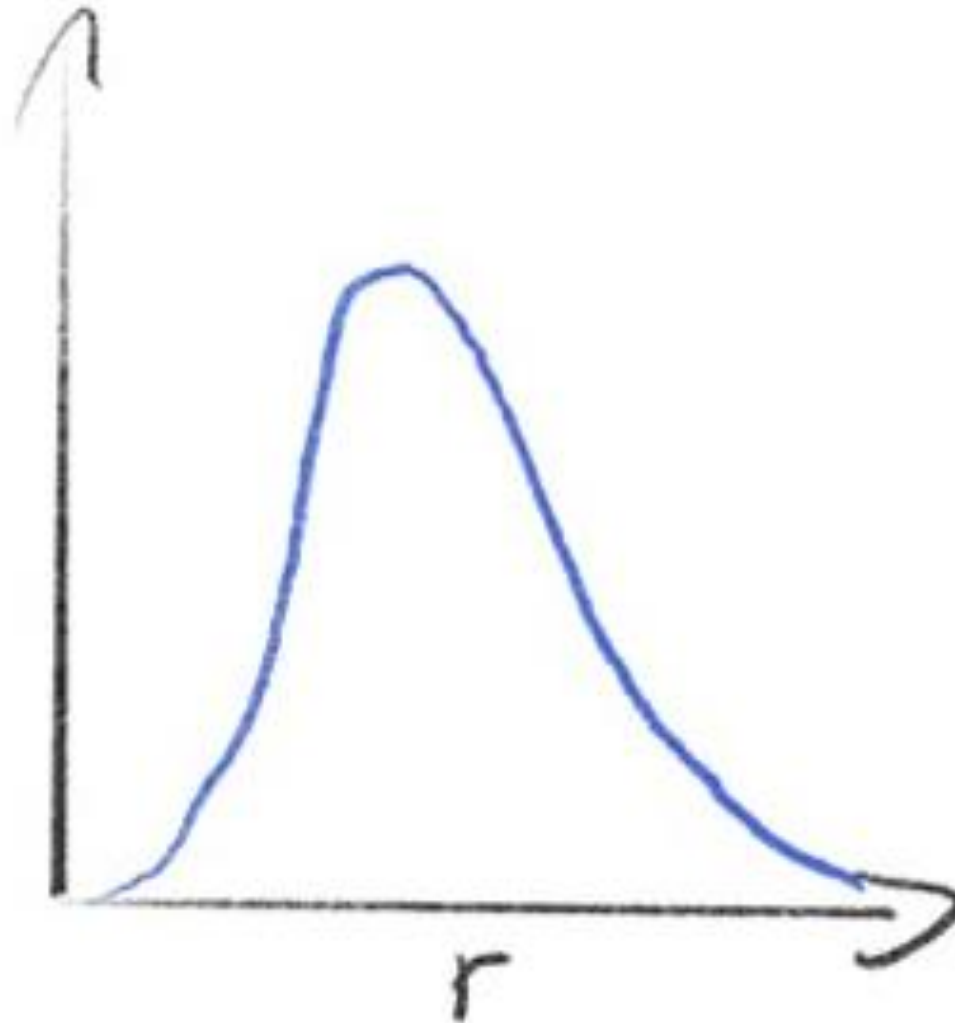
Initialization of the hydrometeors

Initial (assumed) aerosol distribution



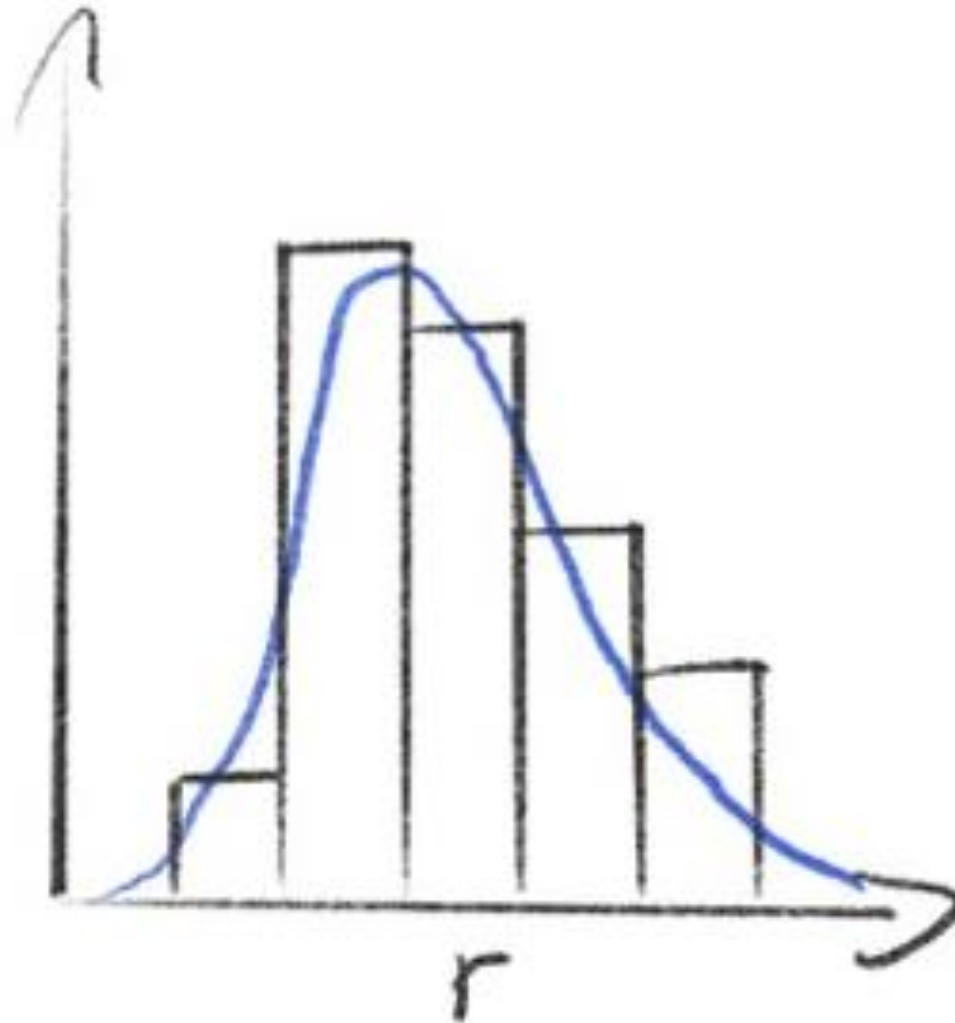
Initialization of the hydrometeors

Add water until equilibrium with water vapor in the surrounding



Initialization of the hydrometeors

Discretize into given SPECS bins (66 at present ~1 nm – 4 mm)



Initialization of the hydrometeors

Add already existing COSMO cloud and ice water

