Comparing cloud radar Doppler observations with 1D cloud microphysical model simulations using different autoconversion schemes

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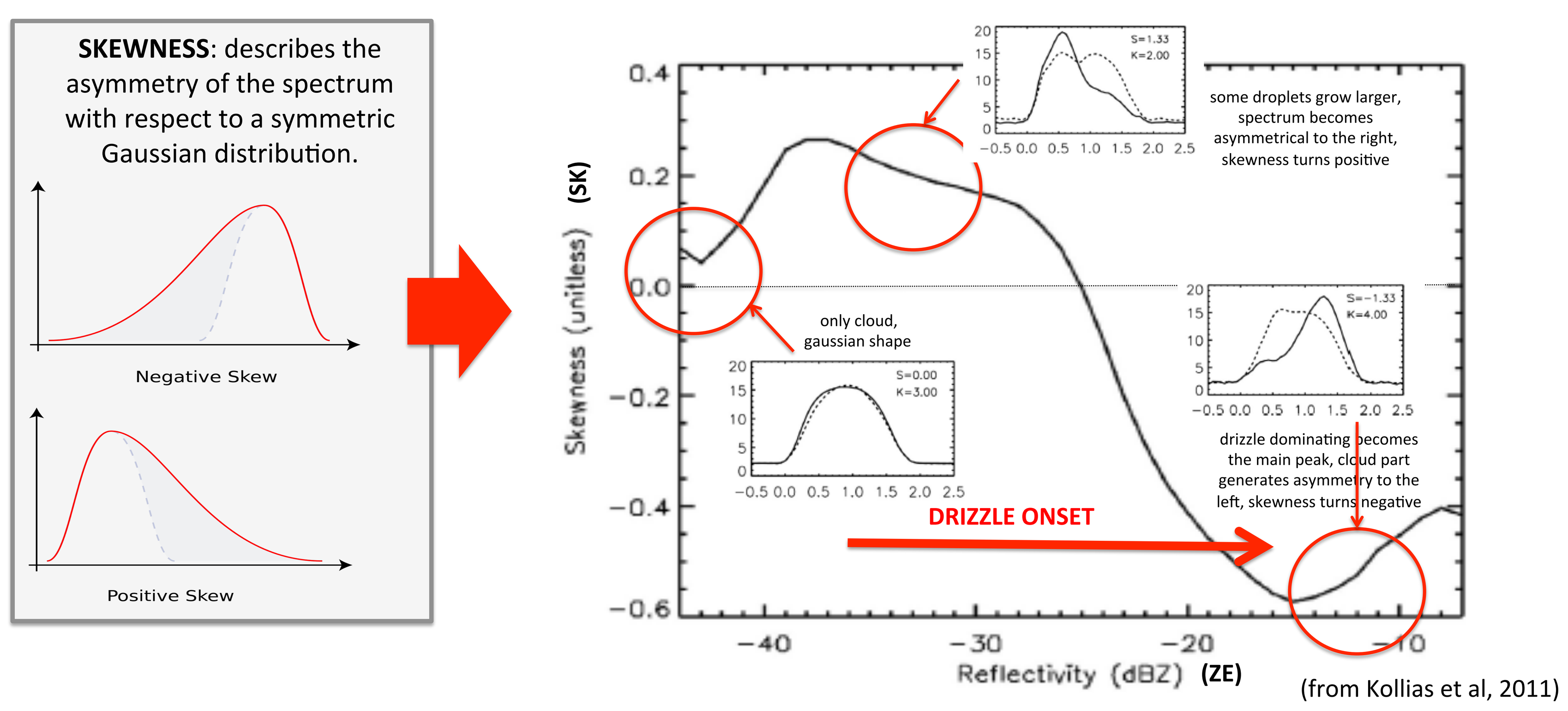
1. Motivation

- Autoconversion describes the mass transfer rate from cloud droplets to embryonic drizzle particles. It plays a key role in the atmospheric water cycle and for the short and long wave cloud radiative forcing in our climate system.
- Several parameterizations for autoconversion have been proposed for numerical models of varying scales. However, verification of the proposed schemes and their details (e.g., what is the typical size range of the embryo drizzle particles) remains not well understood, due to the lack of any direct observations.
- Higher moments of radar Doppler spectra obtained from vertically pointing cloud radars showed potential in the early detection of drizzle in clouds[(2)], which remains a challenging task for target classification schemes (e.g, Cloudnet[(1)]) which are mostly based on lower radar moments (Ze, v).

2. Skewness for drizzle onset detection



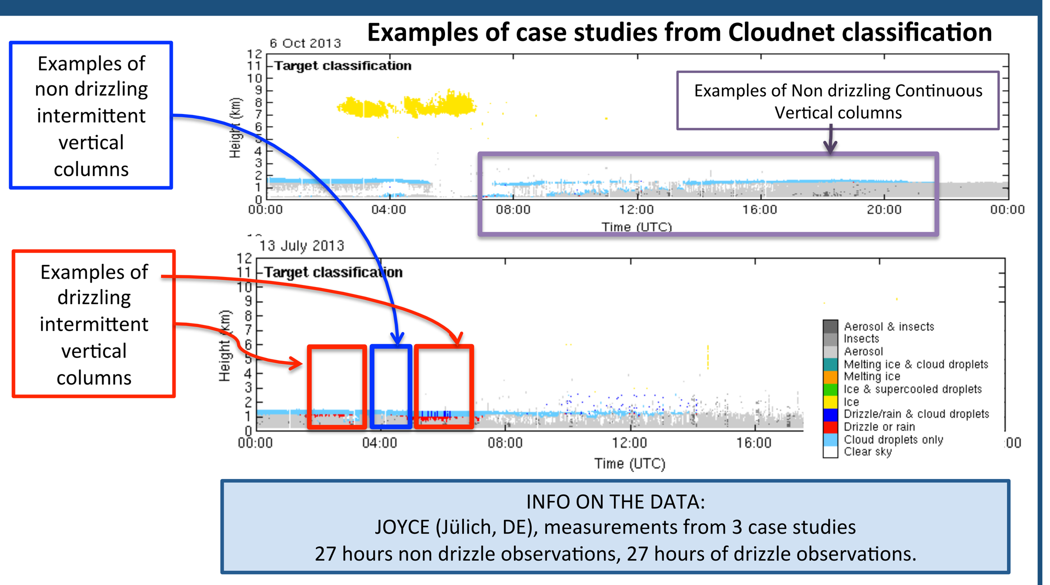
(from Kollias et al, 2011)

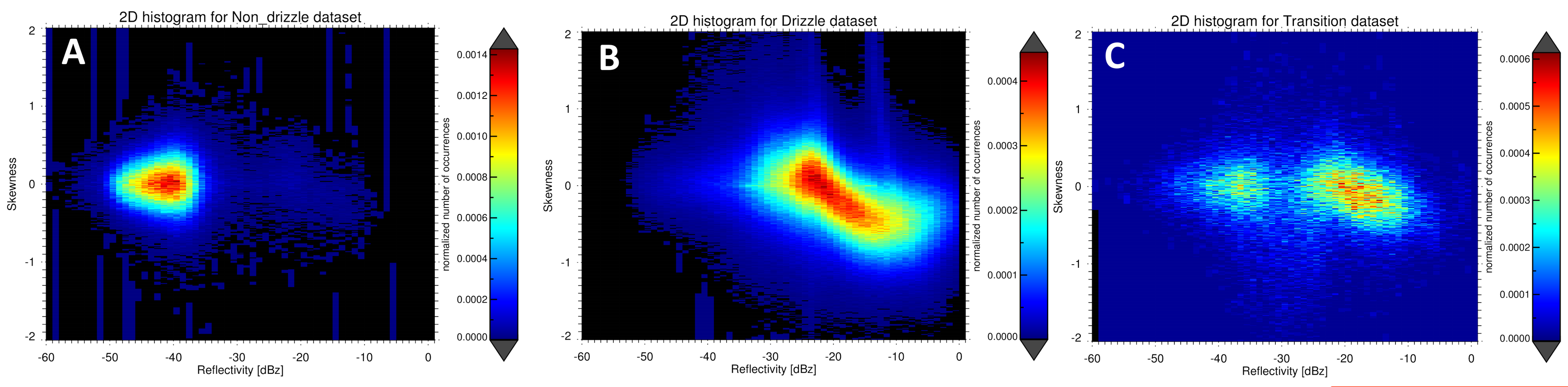
3. Observations of drizzling and non drizzling clouds

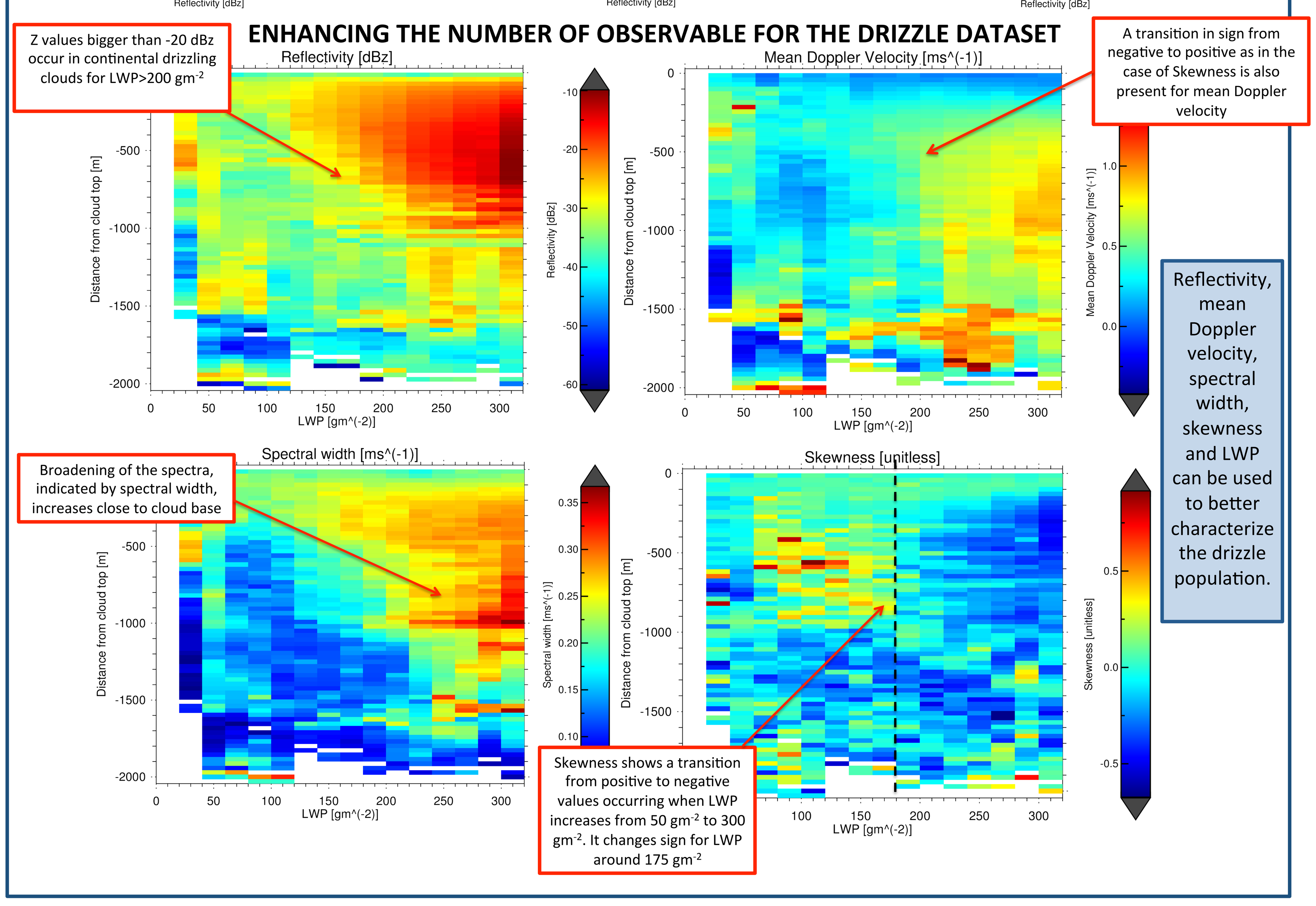
The current operational tool to discriminate drizzle and non drizzle vertical columns from ground based observations at the JOYCE site (Jülich, DE) is the Cloudnet classification.

Cloudnet discriminates drizzle/non drizzle populations mainly on the basis of reflectivity thresholds.

1. it is a reliable classification for persistent situations of drizzle/nondrizzle conditions (in the ZE-SK plane they occupy distinct well separated areas, see plot A and B)
2. The ZE-SK plane of the intermittent cases reveals problems in unambiguously differentiating between drizzle and non drizzle pixels (see plot C).







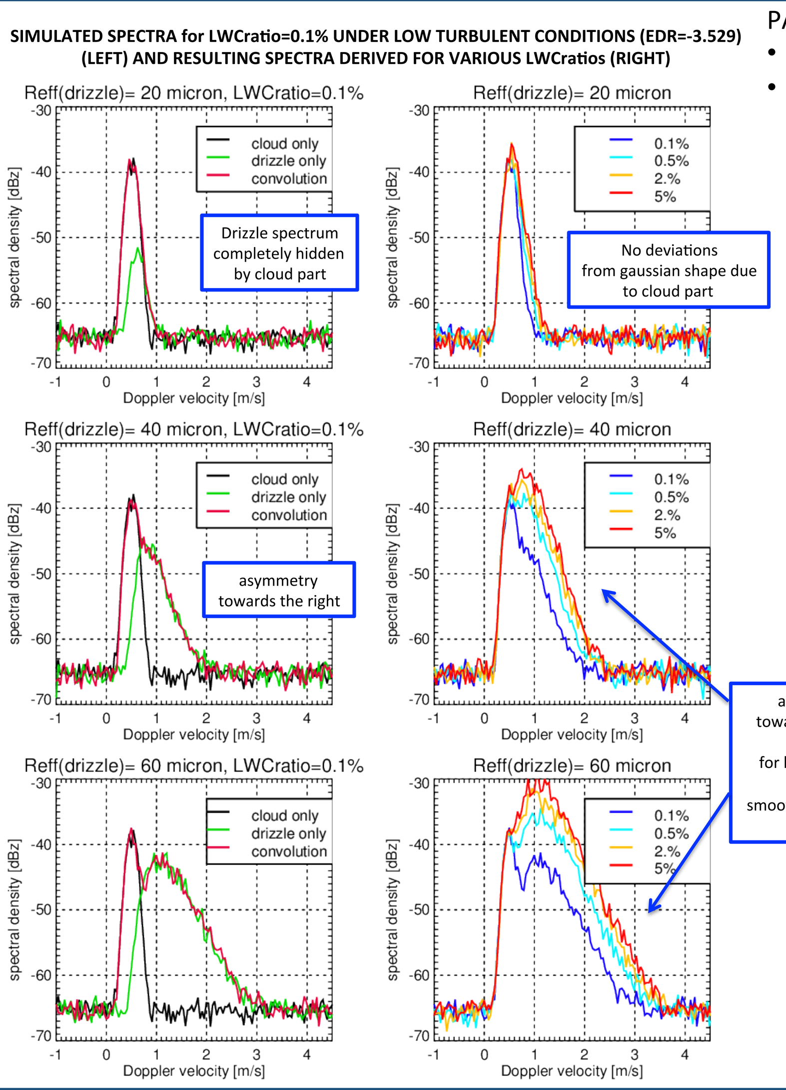
4. Understanding microphysics behind skewness signal

We use the forward radar simulator developed within the passive and active microwave radiative transfer (PAMTRA) model to simulate the observations and quantify drizzle and cloud water contents generating the fingerprints observed in the data.

We provided 2 different inputs to the radar forward simulator:

1. theoretical cloud and drizzle lognormal distributions.
2. output of a 1D spectrally binned model using different parametrizations for autoconversion, accretion, and various number concentrations

5. Cloud and drizzle drop size distributions



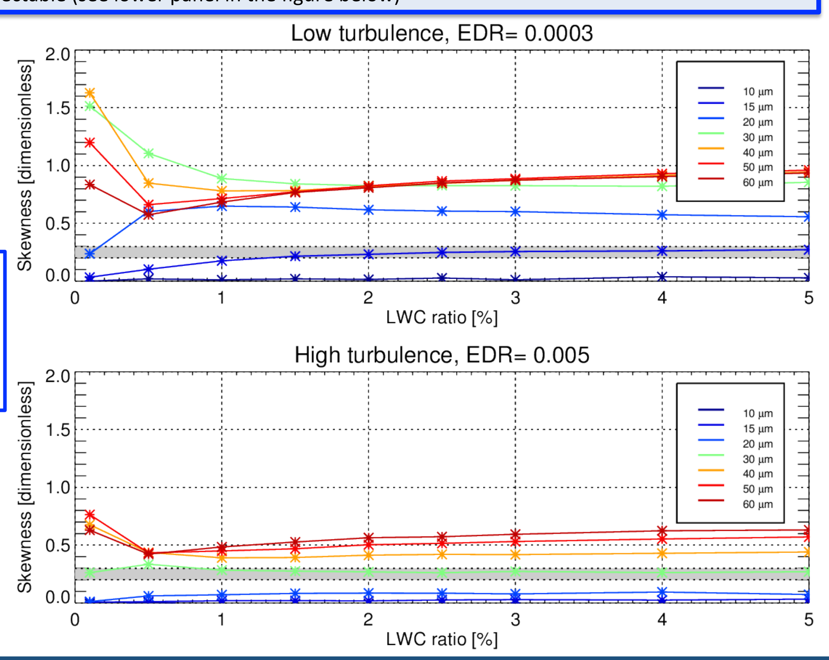
PARAMETERS OF THE DISTRIBUTIONS:

- for cloud lognormal distribution: Reff=5.4 µm, sigma=0.35 N=300 cm^{-3}
- for drizzle lognormal distribution: sigma=0.35, Ref=[10,20,30,40,50,60] µm, fixing LWCratio=[0.1%,0.5%, 1%,1.5%, 2%, 2.5%, 3%, 4%, 5%] and adjusting N consequently.

SKEWNESS OF THE CONVOLUTED SPECTRA vs LWCratio:

Two main features are evident:

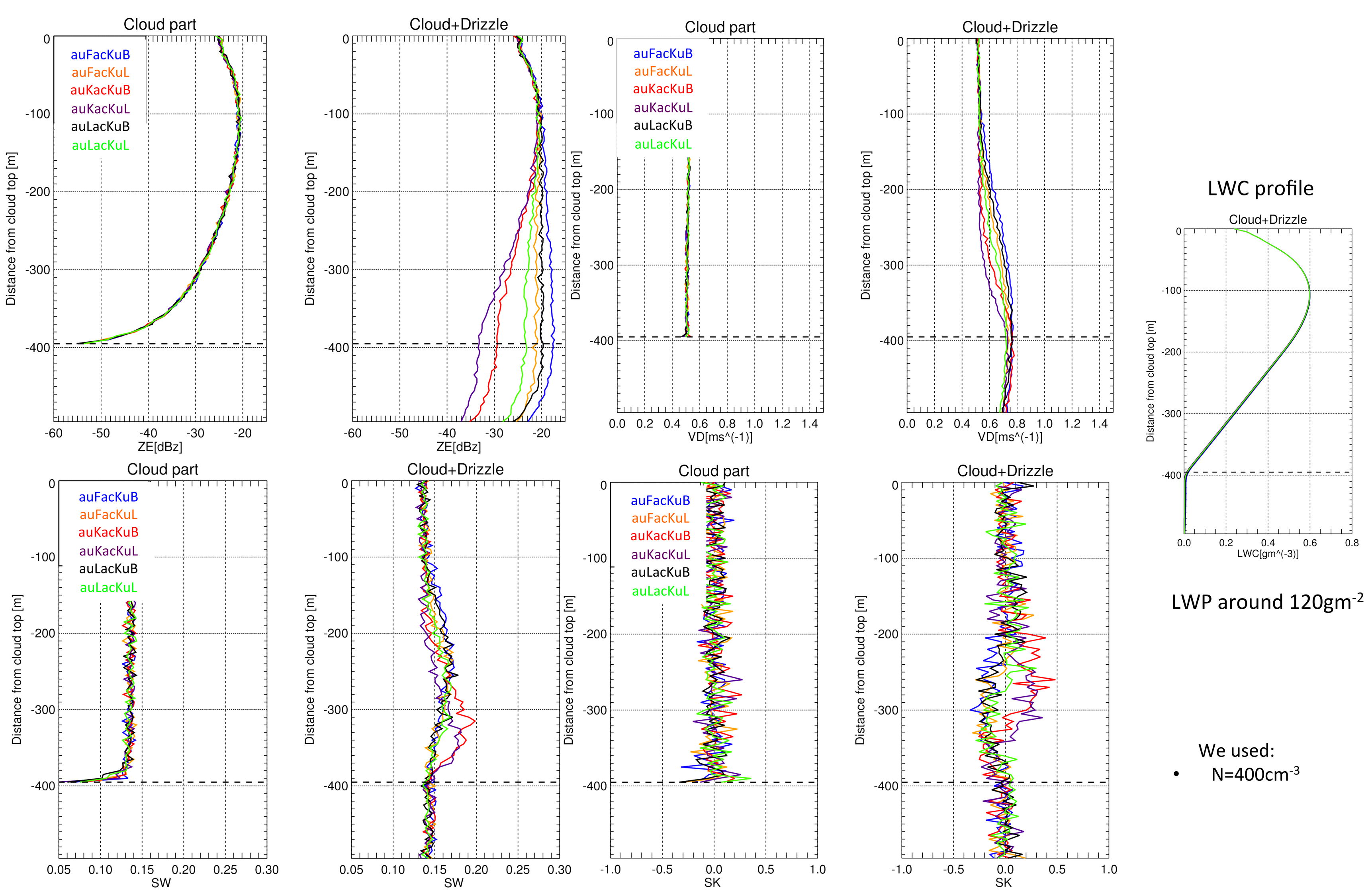
- if Reff(drizzle) is large enough to introduce an asymmetry to the right of the spectrum peak, skewness grows to high values for low LWCratios.
- if Reff(drizzle) is too small, drizzle is concealed by the cloud part and it results in being only slightly positive
- Reff(drizzle) > 20 µm can induce significant skewness fingerprints above the instrumental noise (see upper panel in the figure below)
- high turbulence strongly dampens the signal: in this case only Reff(drizzle) of 40 µm is detectable (see lower panel in the figure below)



6. Ongoing: confronting drizzle parametrizations with obs

MAIN MODEL CHARACTERISTICS

Autoconversion schemes	*Accretion schemes:*	*Terminal velocity calculations*
K: Khairoutdinov and Kogan 2000 F: Franklin 2008 (assumed eddy dissipation rate:150 cm^2/s^3) L: Liu et al. 2007	K: Kerkweg et al. 2003, from tables W: Wood 2009	B: Beard 1976 L: Lhermitte 1988



- the choice of the parametrizations strongly impacts the resulting moments, especially for skewness and spectral width.
- Comparing with observations having LWP of 120 gm^{-2}, the Khairoutdinov and Kogan 2000 autoconversion scheme seems to better reproduce the observed features in the vertical profile of reflectivity, mean Doppler velocity and skewness.

References:

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(2) Separating cloud and drizzle radar moments during precipitation onset using doppler spectra. Edward P. Luke and Pavlos Kollias, 2013. *J. Atmos. Oceanic Technol.*, **30**, 1656–1671.

ICTP 2016 – CFMIP/WCRP/ICTP Conference on Cloud Processes, Circulation and Climate Sensitivity, Trieste, July, 4-7, 2016