Exploiting additional observables in the development of an advanced categorization scheme for detecting autoconversion from ground based observations.

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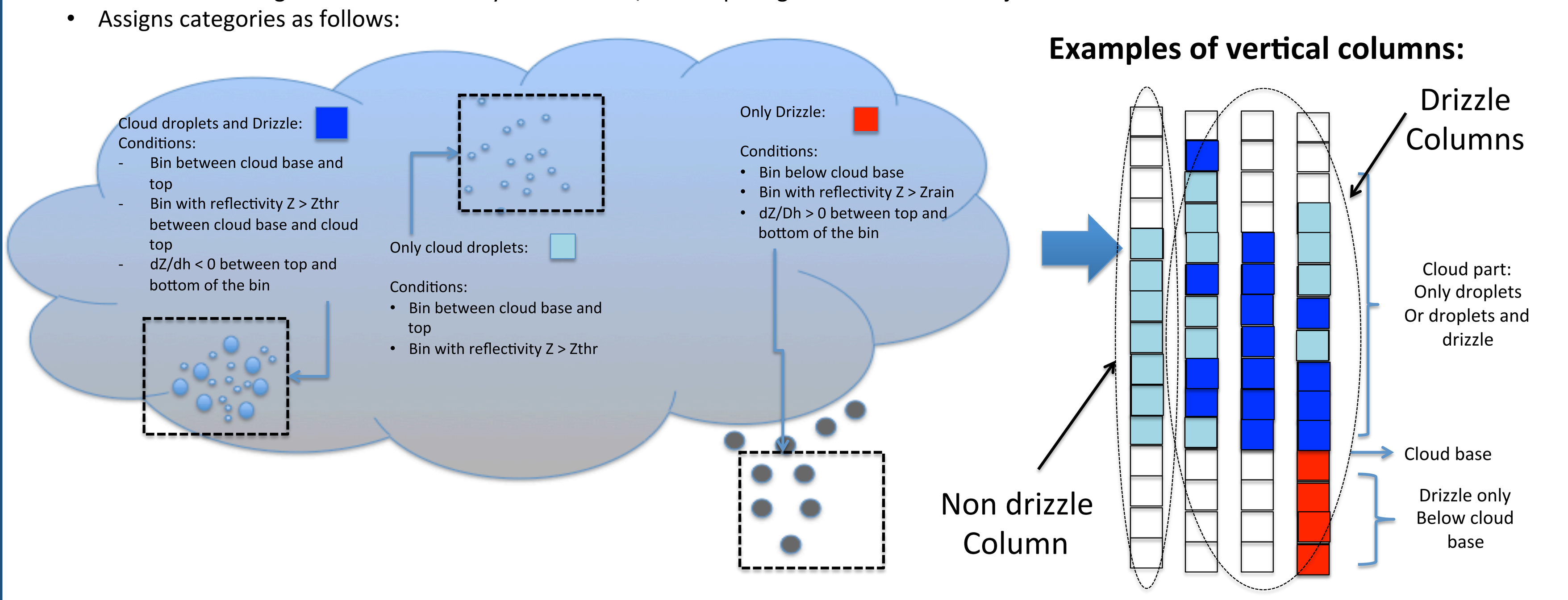
1. Overview

- In warm clouds the autoconversion process leads drizzle production and thus cloud decay. Currently, the conditions in which autoconversion occurs are still not clear and such processes cannot be identified with direct observations.
- In recent years, Cloudnet Classification(1) has been developed at the University of Reading: this is an operative tool which classifies the atmospheric vertical column using integrated ground based measurements from cloud radar, ceilometer and microwave radiometer. Such tool characterizes the moment of transition between cloud and drizzle drops.
- Since Cloudnet is not always able to identify the exact location of the drizzle onset into the cloud, here we give an evaluation of Cloudnet categorization and start the development of a new criteria exploting additional observables never used before.
- Such new criteria can be suitable for better retrievals of cloud parameters, which are impossible if a correct classification is missing.

2. How Cloudnet works

Cloudnet identifies the transition between cloud and drizzle droplets using three categories: "Cloud droplets only|", "Cloud droplets and drizzle", "Drizzle only". Such categories are assigned on the basis of the observations from cloud radar, ceilometer and microwave radiometer in the following way:

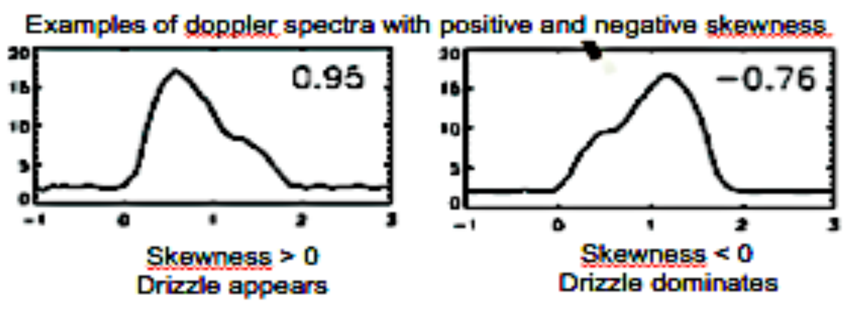
The algorithm
- Gets cloud base and cloud top from ceilometer backscattering coefficient and cloud radar reflectivity (Z), respectively
- Uses the vertical gradient of reflectivity in the bin dZ/dh comparing Z values between adjacent bins
- Assigns categories as follows:

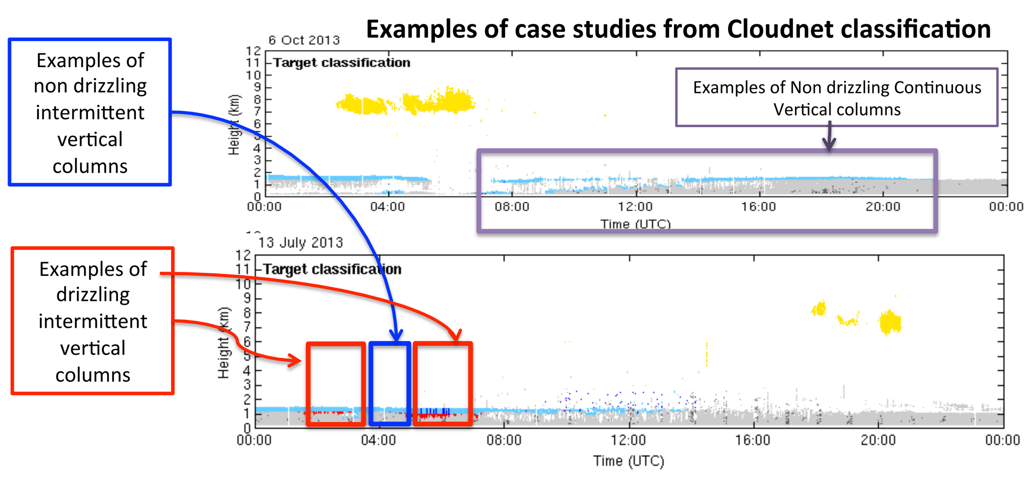


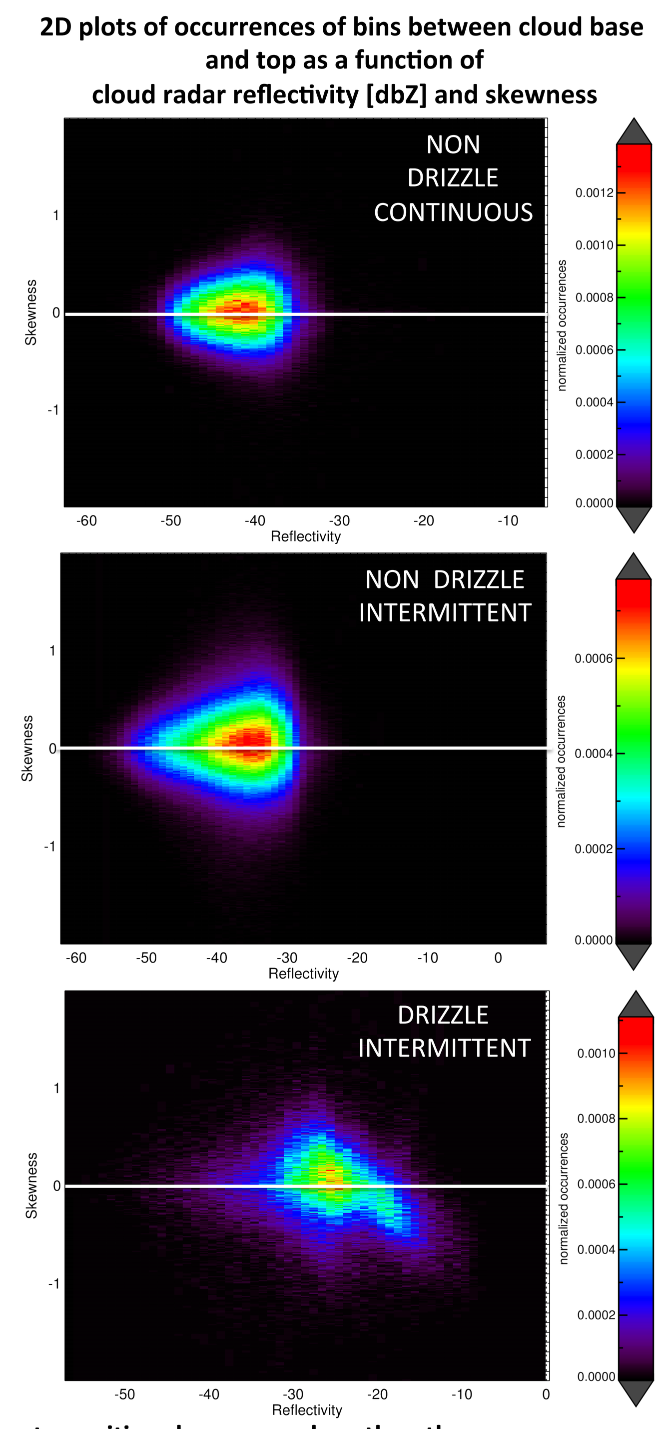
3. Cloudnet evaluation

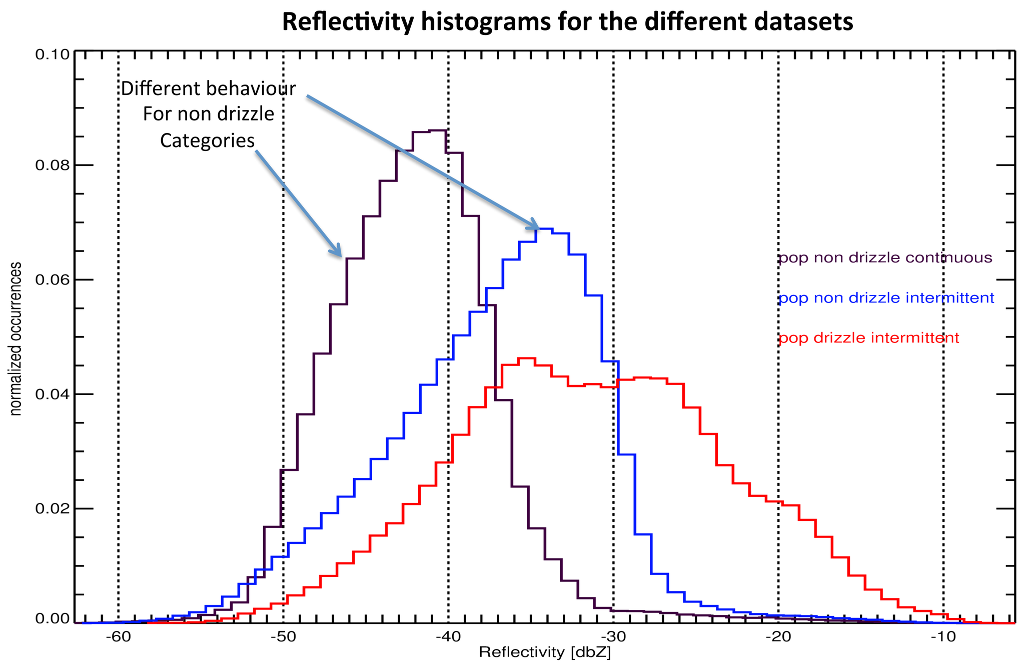
To evaluate Cloudnet's ability in detecting drizzle onset into clouds, we defined:

- An ensemble of non drizzling continuous in time vertical columns: these are taken in case studies in which Cloudnet only shows non drizzle columns made of "only cloud droplets" radar bins.
- An ensemble of non drizzling intermittent and drizzling intermittent in time vertical columns: these are taken from case studies in which Cloudnet identifies at some point during the day the presence of drizzle columns among the non drizzle ones.
- To evaluate Cloudnet skills in separating cloud droplets from drizzle, we used the skewness of the cloud radar Doppler spectra(2), since such parameter increases the probability of detecting drizzle at a much earlier stage.





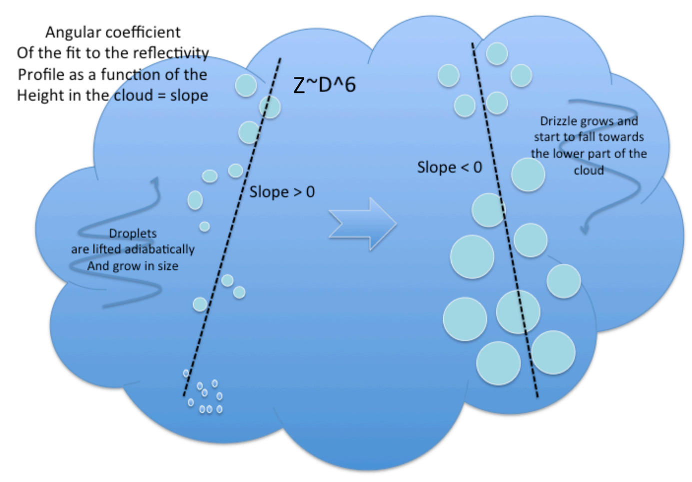


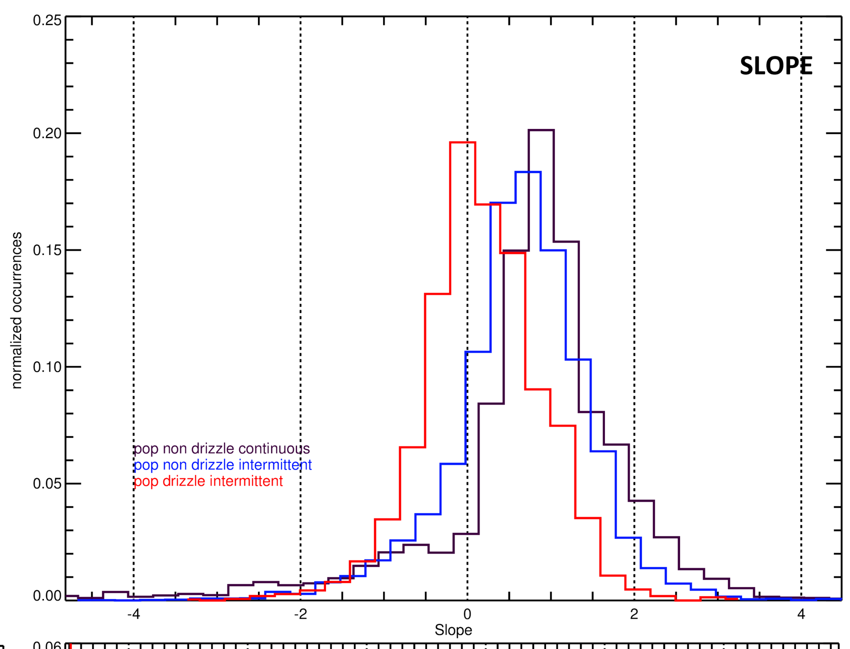


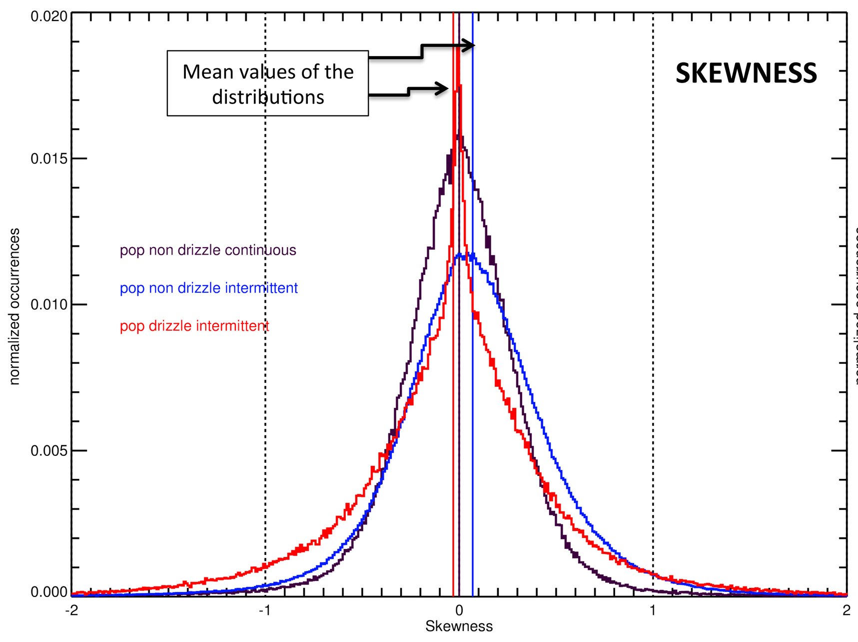
The non drizzle intermittent population shows higher Z values and stronger tendency to positive skewness values than the non drizzle continuous population. This can be due to a misclassification of drizzle droplets into the cloud droplet category.

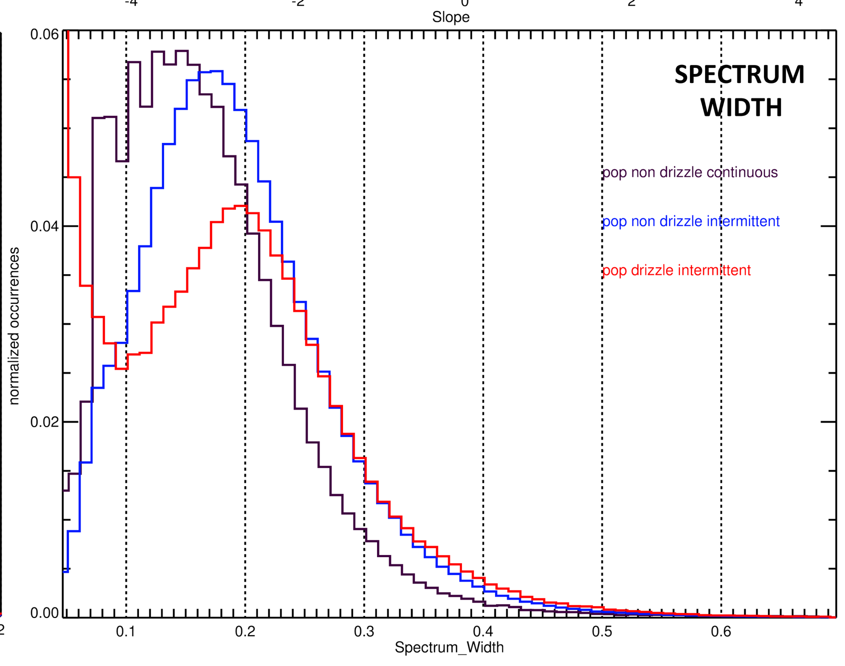
4. Additional observables for a new criteria

Slope: angular coefficient of the linear fit of the reflectivity as a function of height.
Which is the idea?



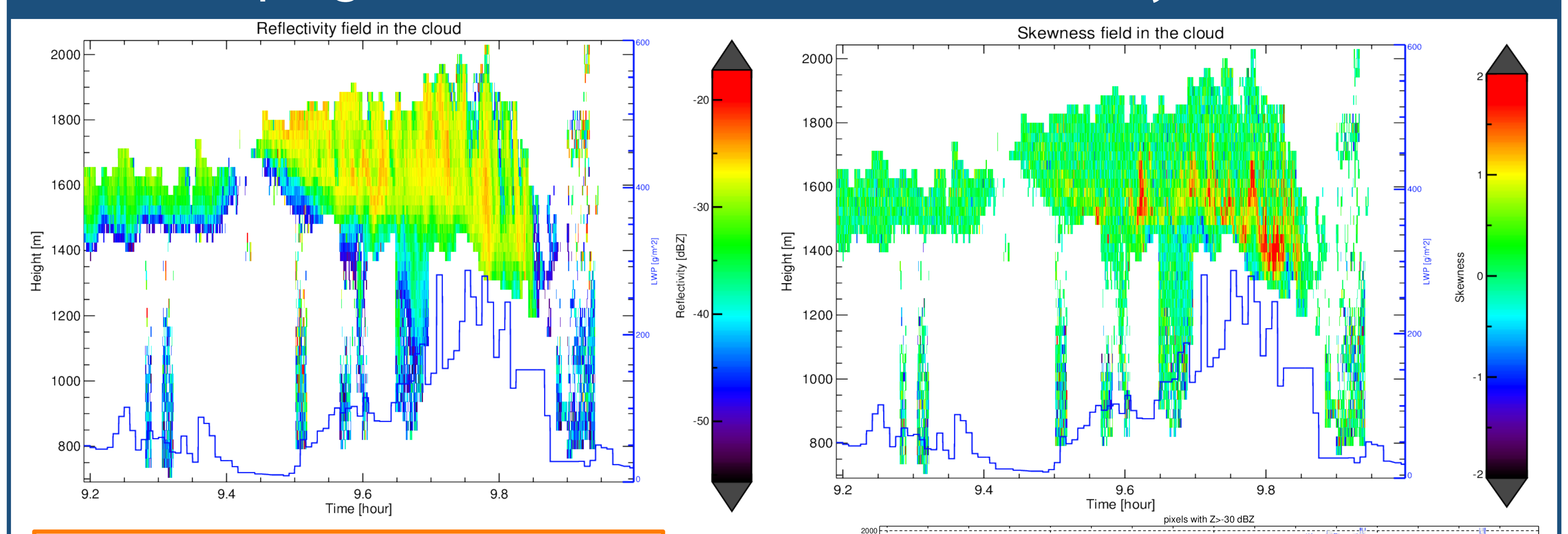




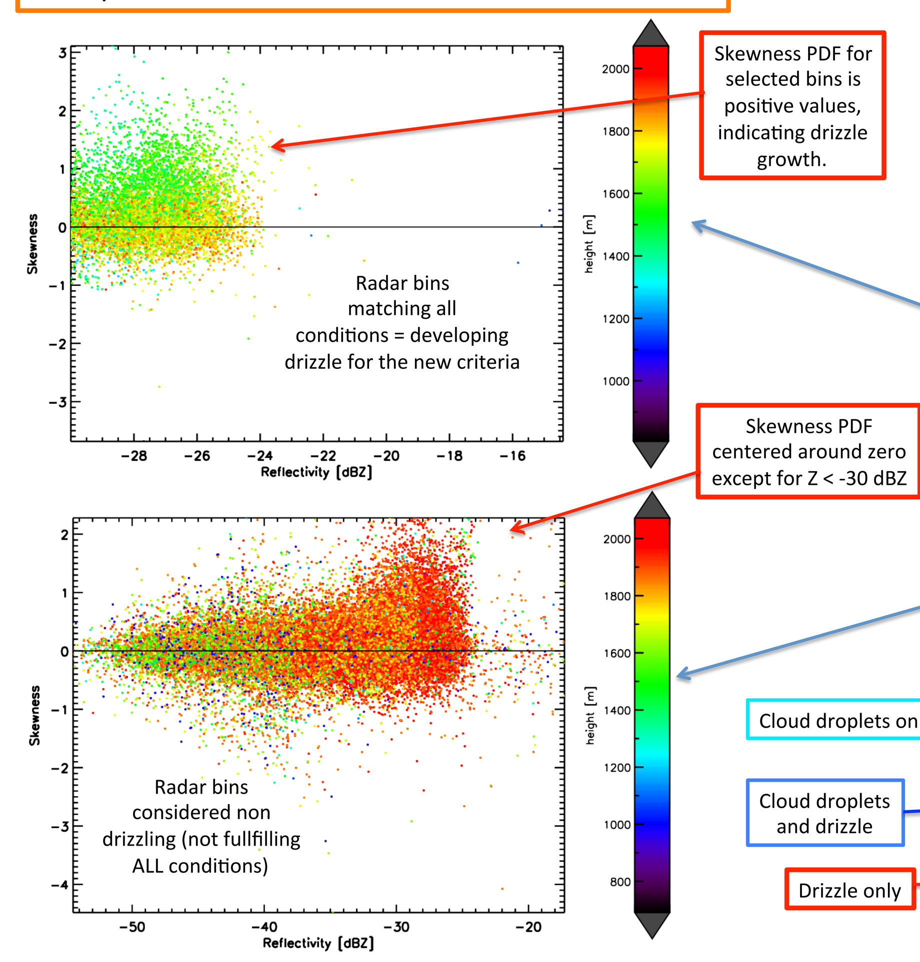


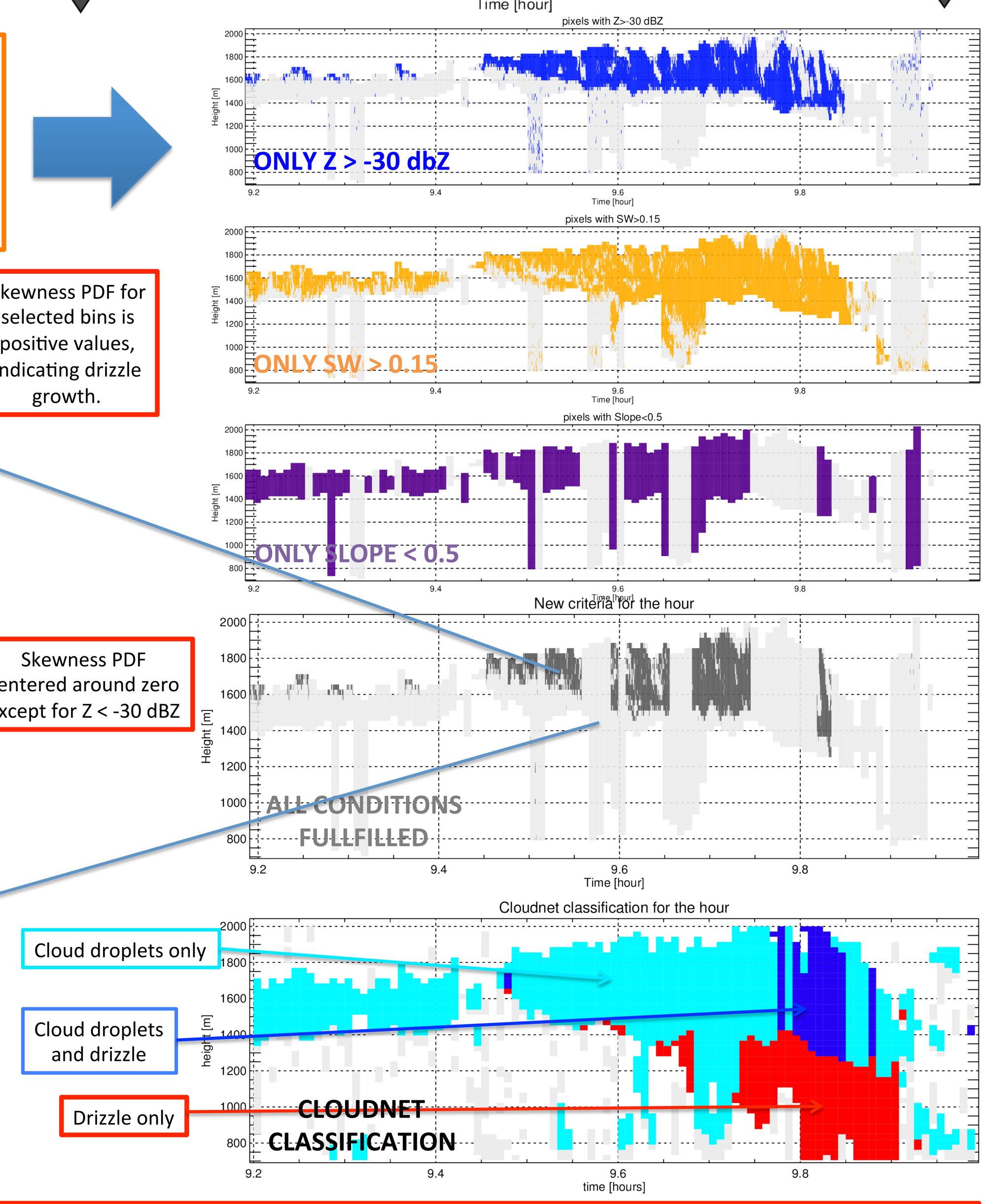
DATASET	N hours	Number of radar bins	LWP (mean) [g/m^2]	STD(LWP) [g/m^2]	Mean geom. thickness [m]	Mean of the skewness	Skewness of skewness	Mean Slope	STD(Slope)
Non drizzle continuous	40	325159	20.4411	18.4324	222.8	-0.0002	-0.1152	1.273	0.731
Non drizzle intermittent	80	1730487	53.7481	92.9726	350.1	0.0698	-0.1806	1.005	0.620
Drizzle intermittent	80	261016	69.0428	194.580	862.9	-0.0308	0.0476	0.671	0.535

5. Developing a new criteria: one hour case study



Set of NEW conditions to be fulfilled for a cloud to develop drizzle.
For radar bins between cloud base and top and cloud top:
- Reflectivity > -30 dbZ
- Spectrum width > 0.15
- Slope < 0.5





CONCLUSIONS: The conditions established are able to select radar bins with mainly positive skewness values corresponding to drizzle developing, which for such cloud occur close to cloud base. The criteria appears a little too restrictive and can be improved with the inclusion of conditions on the skewness parameter.

FUTURE STEPS:
- Add to the new criteria conditions on skewness in the pixel and conditions on the neightbouring pixels in time height.
- Establish a probability of developing drizzle for every bin on the basis of the conditions fulfilled
- Simulate skewness observations using a model to better interpret the observations.

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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.

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