A new criterion to improve operational drizzle detection with ground-based remote sensing

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1. Introduction

Liquid clouds have a strong impact on the Earth's energy balance and are thus important component of the climate system (Randall et al, 1984).

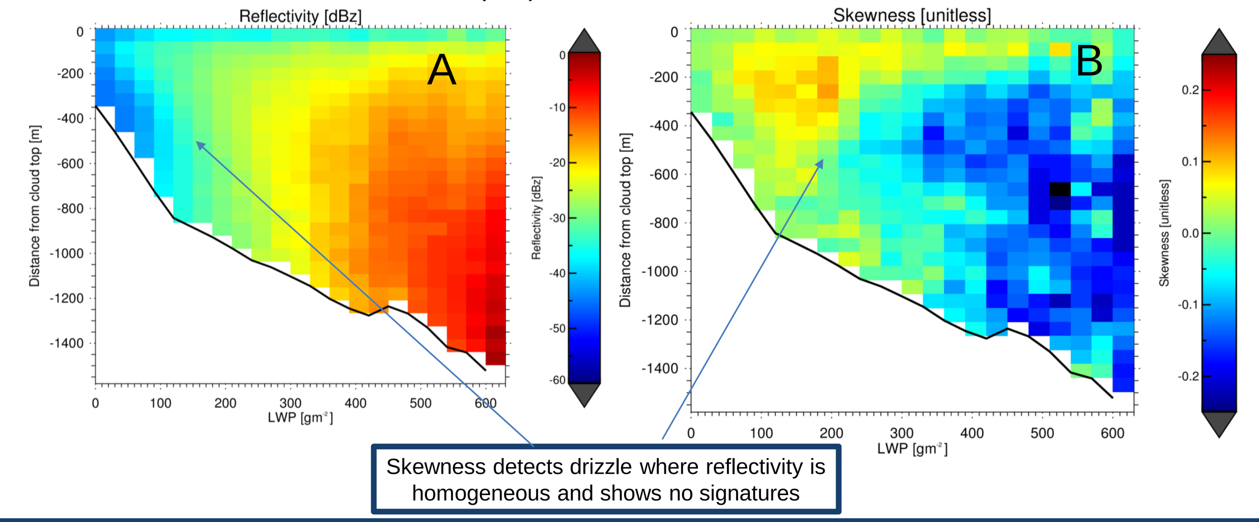
Drizzle is a fundamental element in the cloud life cycle because it can modify microphysical and radiative liquid cloud properties. Typically, drizzle is overestimated by general circulation models due to the great variability in the autoconversion parametrization (Sun et al. 2006).

Detection of drizzle from ground-based, compared to other platforms (satellite, in situ) is essential to properly evaluate climate models.

The skewness of the Doppler spectrum of cloud radars has potential for detecting drizzle and has not yet been used operationally for this purpose (Luke and Kollias, 2013)

2. Skewness potential for drizzle detection

Characterization of drizzle development using a dataset of 500h of continental liquid clouds collected at JOYCE-CF: a) Reflectivity mean values binned in terms of LWP and distance from cloud top. b) Same for skewness.



3. Goal of this work

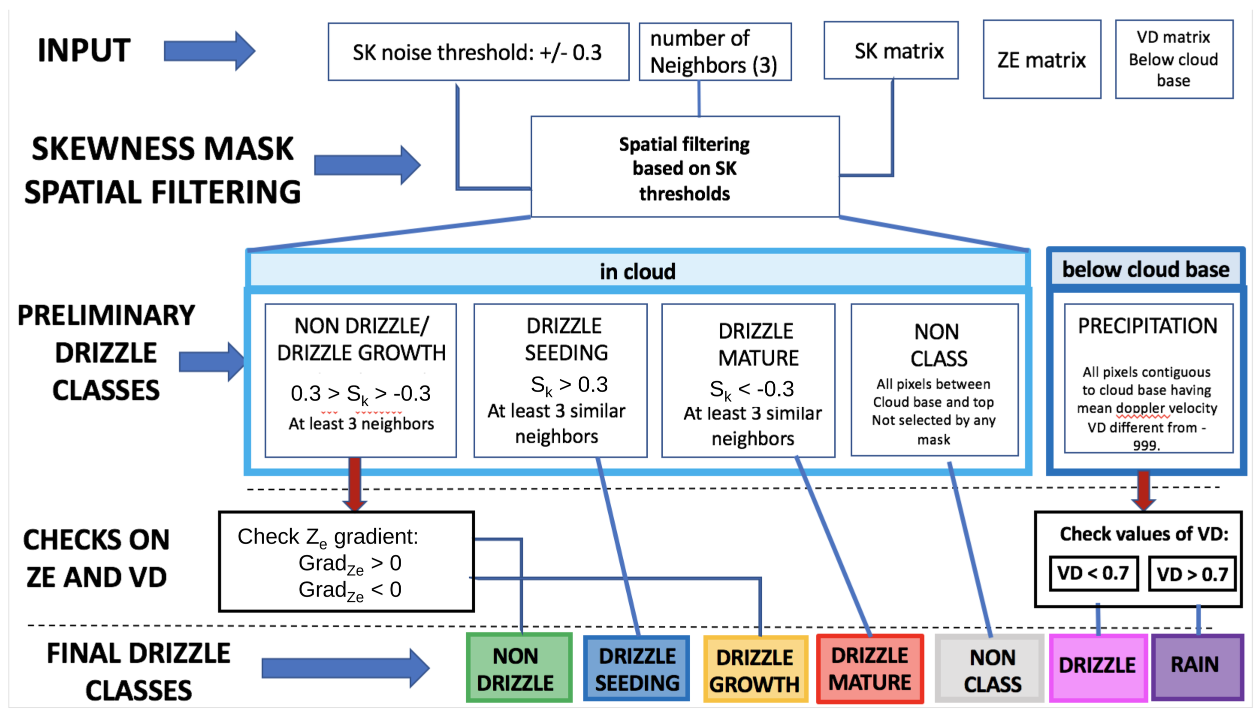
The goal of this work is to develop a new criterion for operational drizzle detection exploiting the skewness of the radar Doppler spectrum.

The criterion is designed to be an extension of the Cloudnet target classification and it can be provided as an optional product of the Cloudnet package (Illingworth et al, 2007).

The aim of the new criterion is to improve the Cloudnet target classification product and similar cloud phase retrievals (e.g. Shupe et al, 2004) in detecting early drizzle developments by means of the skewness.

4. Method

Flow chart of the algorithm for the CLAssification of the Drizzle Status (CLADS).



Example: skewness mask of the CLADS algorithm

Principle of the skewness mask for the *drizzle seeding* category: purple boxes indicate pixels that are fullfilling the skewness criterion, grey boxes are pixels that are discarded. Green boxes represent the final selection of pixels from the mask.

Skewness bins > 0.3

0.13	0.002	-0.28	0.524	0.34
0.56	-0.12	0.89	0.78	1.43
0.2	0.14	0.33	-0.1	0.04
-0.24	0.22	0.67	0.23	0.001
-0.78	0.75	-0.2	0.98	-0.21

↓

Skewness bins > 0.3 with at least 3 neighbours larger > 0.3

0.13	0.002	-0.28	0.524	0.34
0.56	-0.12	0.89	0.78	1.43
0.2	0.14	0.33	-0.1	0.04
-0.24	0.22	0.67	0.23	0.001
-0.78	0.75	-0.2	0.98	-0.21

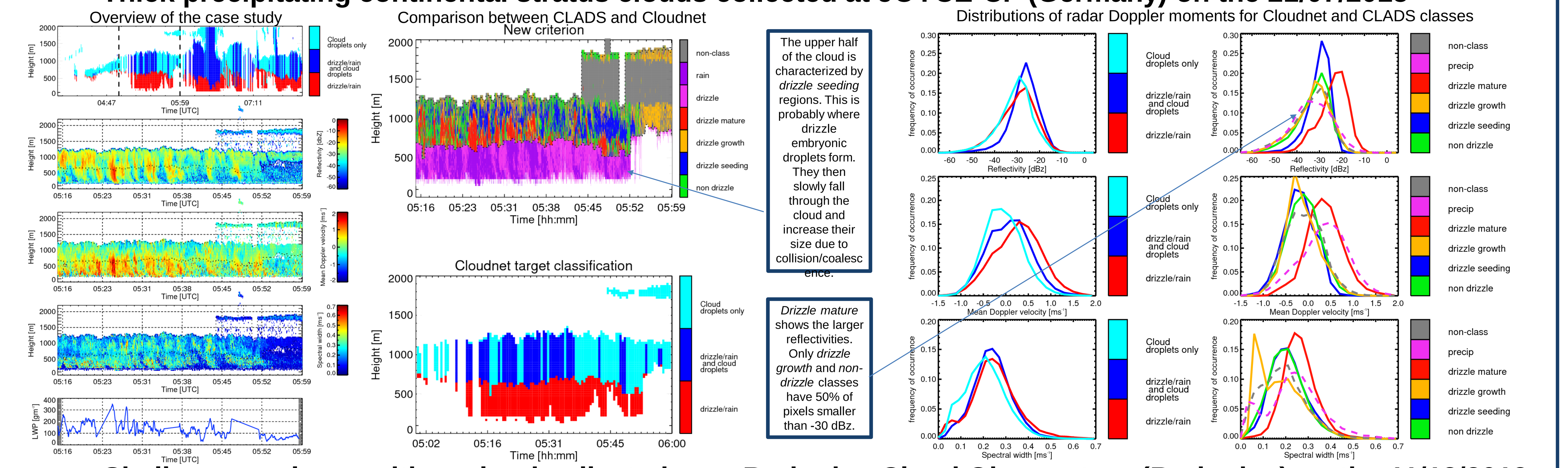
↓

Pixels selected by the mask

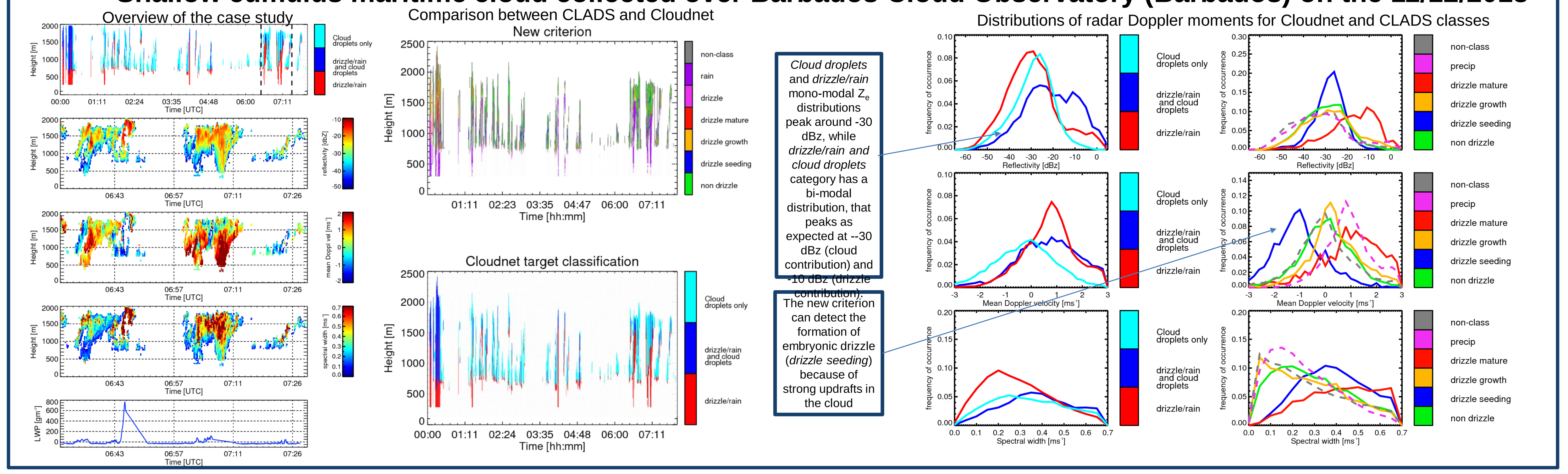
0.13	0.002	-0.28	0.524	0.34
0.56	-0.12	0.89	0.78	1.43
0.2	0.14	0.33	-0.1	0.04
-0.24	0.22	0.67	0.23	0.001
-0.78	0.75	-0.2	0.98	-0.21

5. Results: case studies

Thick precipitating continental stratus clouds collected at JOYCE-CF (Germany) on the 21/07/2015

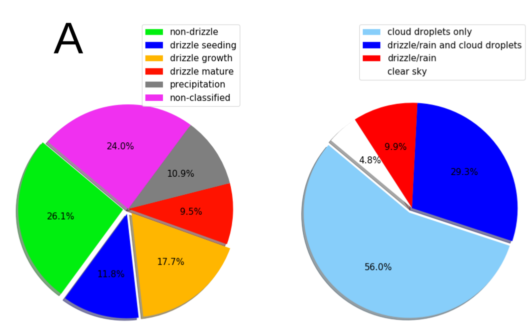


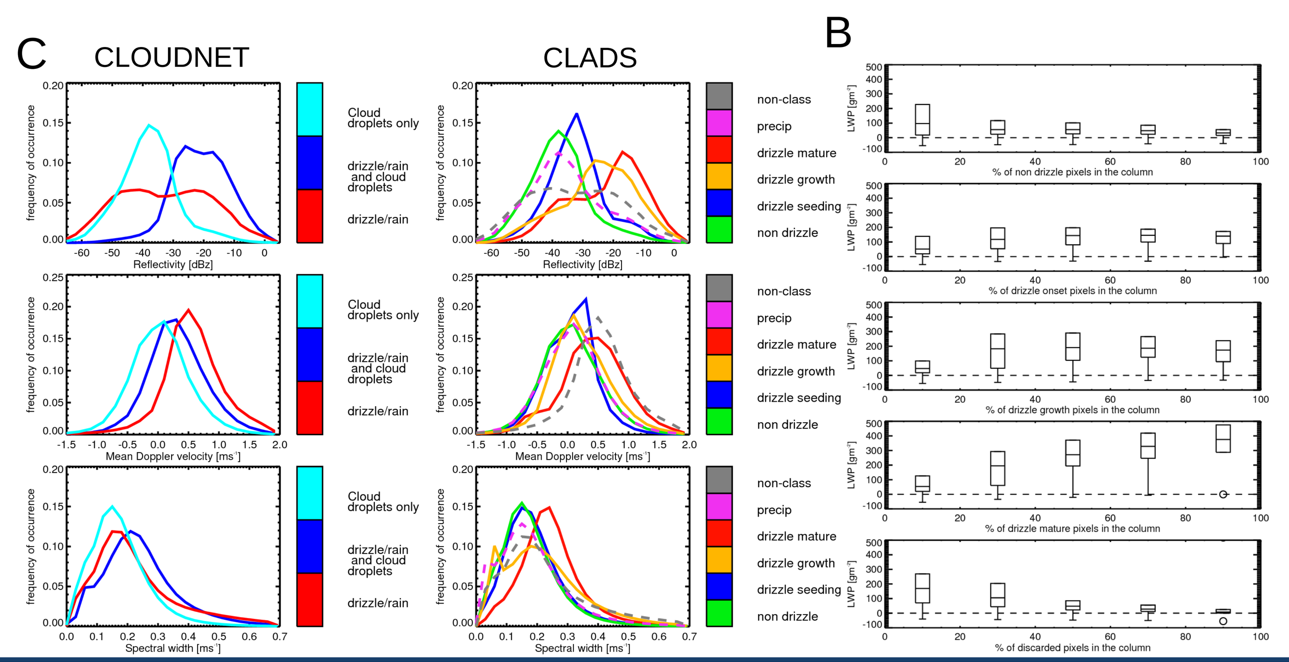
Shallow cumulus maritime cloud collected over Barbados Cloud Observatory (Barbados) on the 11/12/2013



6. Results: statistics from JOYCE-CF

A. Statistics of the 378 h of dataset for the 1 to 1 matching of Cloudnet/CLADS datasets. The total number of pixels used is 13378154.
B. LWP percentiles for the dataset calculated from fixed percentages of *non-drizzle, drizzle seeding, drizzle growth, drizzle mature* and *discarded pixels* between cloud base and cloud top.
C. Distributions of reflectivity (top), mean Doppler velocity (center), and Doppler spectrum width (bottom) obtained for the Cloudnet target classification (left) and CLADS (right).





7. Conclusions and future work

- CLADS is able to detect drizzle formation at an earlier stage compared to the common Cloudnet target classification as shown with multiple case studies as well as with a statistical ensemble of classified cloudy pixels.
- CLADS is able to provide a geospatial collocation in time/height of the different drizzle areas. Each stage of drizzle development can be characterized in terms of LWP and highlights distinct features in terms of reflectivity, mean Doppler velocity and Doppler spectrum width.
- Turbulence can dampen the skewness signal; this may result in an increased amount of *non-classified* bins. The high resolution of the radar observations is key to exploit the full potential of the skewness observations and minimize the impact of turbulence (Acquistapace et al, 2017)
- Future work may focus on developing new techniques to properly separate *non-drizzle* areas from *drizzle-growth* areas.
- CLADS is currently being implemented as an additional Cloudnet product.

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