Characteristics of cumulus population and properties over Southeast Atlantic

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Motivation

- Tropical marine boundary layer clouds have a large effect on Earth's energy budget and are known to be the regime where climate models disagree substantially in the magnitude of cloud feedback
- Representation of cumulus processes and interactions with radiation is challenging because of their high heterogeneity and their small size and cover
- The Ascension Island region is ideal for studying cloud-aerosol-radiation interactions, due to its rich sources of biomass burning aerosols, and its complex cloud regimes from stratocumulus transition to cumulus.

Observed cumulus population

- 1578 cloud scenes are reconstructed from 13-minute cross-wind RHI scans from Ka-scanning cloud radar (Ka-SACR) between July and September 2017
- Cumulus type inferred from cloud duration (< 20min) based on vertically-pointing radar (KAZR) data. They occurred about 35-45% of total sky with a possibility of precipitation of 10%
- Classify cloud using a reflectivity threshold of –50 dBZ

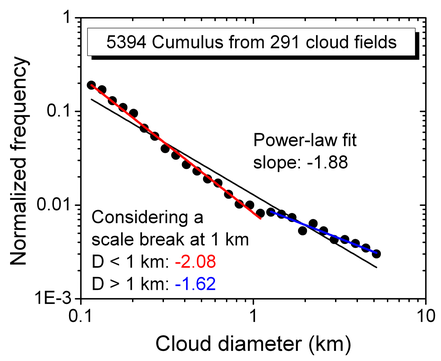

Fig. 1. Cloud diameter distribution using ARM Ka-SACR at Ascension Island

Cumulus statistics:
Mean diameter: 331 m
Mean Thickness: 158 m

- Cloud diameter is derived from volume assuming a cylinder shape
- Observed cloud fields show a power-law distribution (slope = -1.88) of cloud size diameter (Fig. 1), with a scale break close to 1 km. Cloud volume distribution also follows a power-law distribution.

Cluster information

- When cumulus are organized in cluster they tend to favour precipitation
- Borrow the concept of Simple Convective Aggregation Index (SCAI), which considers both distance between clouds and number of clouds (N) in the fields. Larger index meaning more clouds, bigger distance or less clustered. SCAI range from 0 to 2.5 with a mean at 0.6

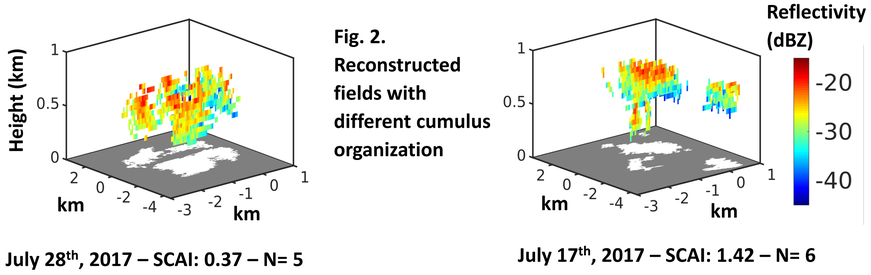

Fig. 2. Reconstructed fields with different cumulus organization

July 28th, 2017 – SCAI: 0.37 – N= 5

July 17th, 2017 – SCAI: 1.42 – N= 6

Microphysical properties

- Retrievals based on ENCORE3D technique (Fielding et al, 2014) :
  -Combine scanning cloud radar and zenith radiances and include 3D radiative transfer as a forward model
- Sampling effect (as zenith looking) and 3D vs. 1D simulations

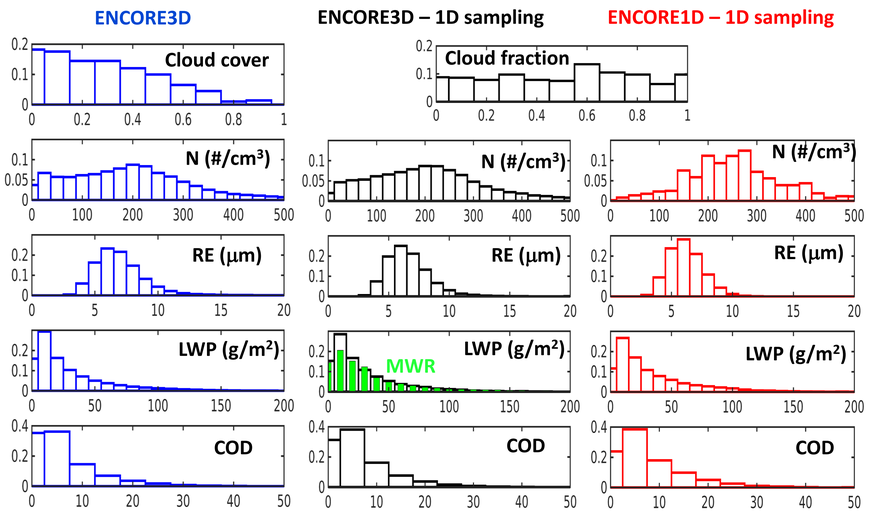

Fig. 3. Retrieved microphysical properties from 291 cumulus fields

Summary

- 291 cumulus scenes retrieved from scanning cloud radar observations were analyzed.
- The cloud population of these 3D reconstructed fields follows a power-law relationship, with a scale-break at 1km, as found in 2D satellite images, but with opposite pattern.
- Cumulus sizes are generally small with small liquid water path (75% got less than 35 g/m2). Droplet effective radii (mean value ~7 μm) are also slightly smaller than those from RICO and Nauru.
- Preliminary study shows that our 3D retrieval can close radiation to ~10%, while retrieval from 1D-view leads to ~66% errors, compared to MFRSR.
- Fig. 3 shows that 1D sampling along one axis has a limited impact on retrieved quantities but 1D cloud fraction is overestimating cloud cover
- From a statistical perspective, the traditional approach of using 1D with plane-parallel assumption leads to differences in the retrieved properties between 8% (for effective radius) to 22 % (for number concentration) due to not considering 3D effects of clouds
- Those clouds have small COD and LWP, as also seen by MWR

Preliminary radiation closure

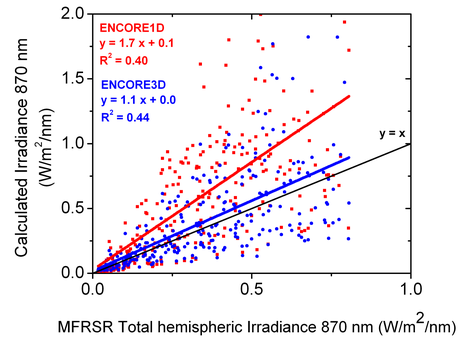

Fig. 4. Comparison of field-averaged irradiance with hemispheric irradiance at 870nm from MFRSR

Irradiance statistics:
Average (W/m2/nm) (std)
MFRSR: 0.35 (0.22)
ENCORE3D: 0.38 (0.35)
ENCORE1D: 0.58 (0.53)

- As 3D retrievals use a better representation of the cloud field, the agreement with hemispheric MFRSR measurements is better than 1D