The satellite observation of drizzle in Stratocumulus clouds

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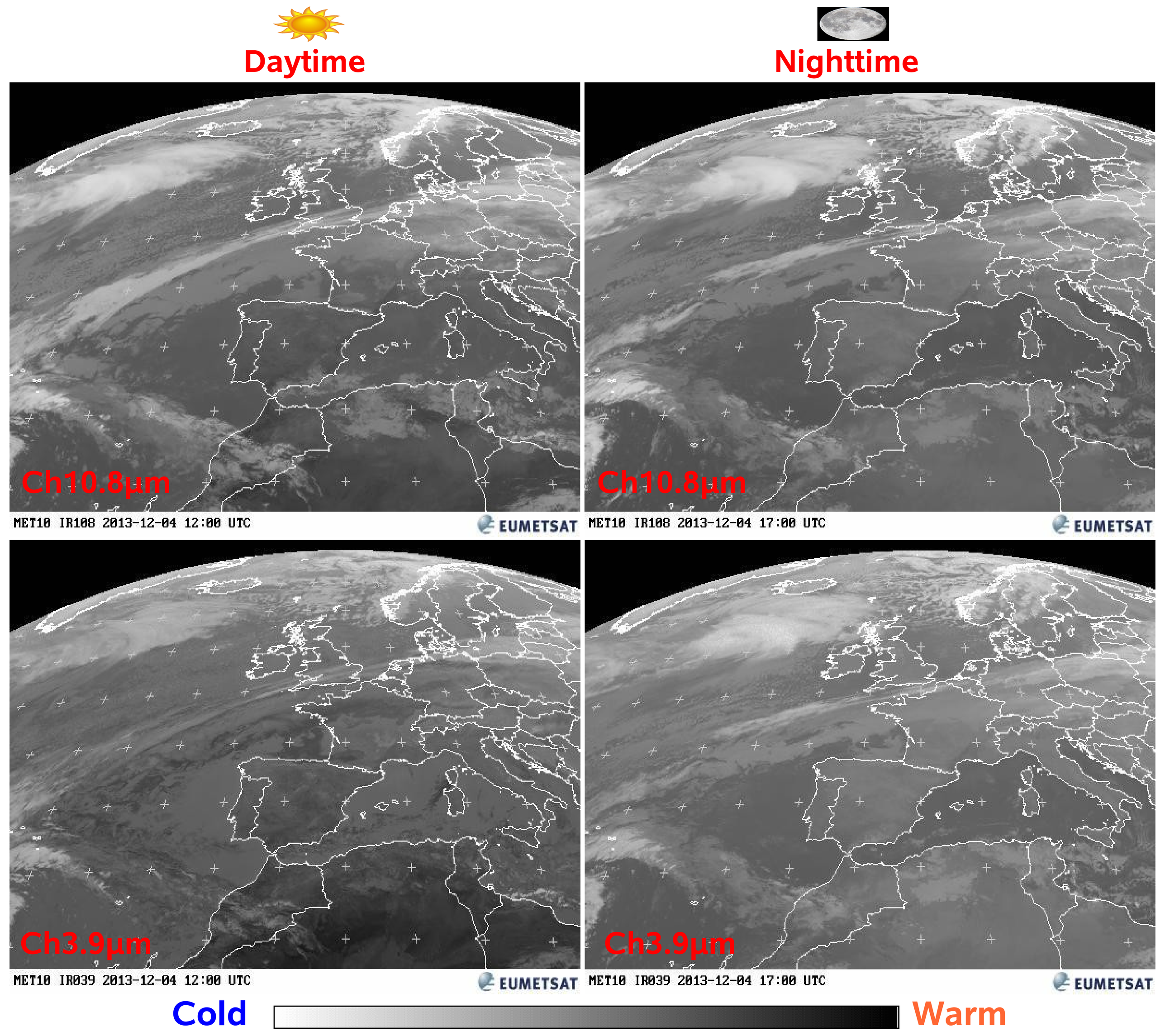
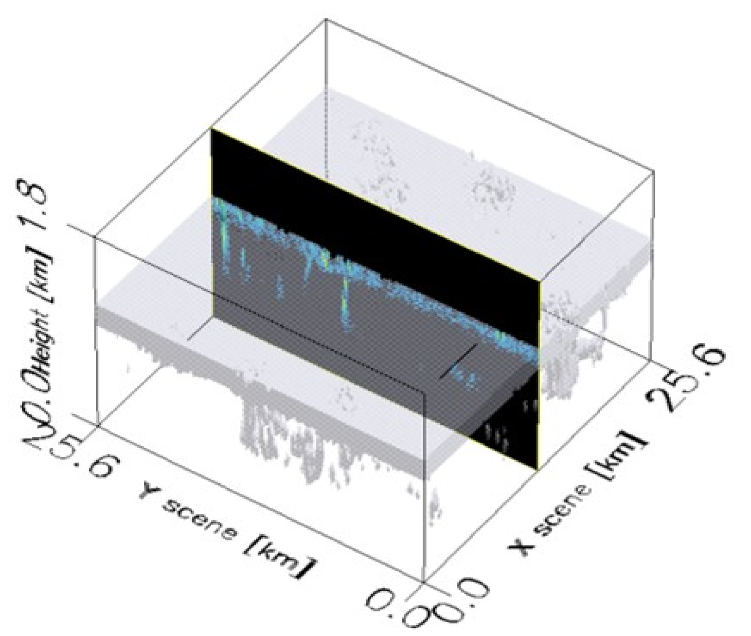
Ground perspective:

-Stratocumulus clouds span thousands of square kilometers over the Earth's surface. Due to drizzle presence at the cloud base and its dominant contribution to the radar backscatter, the cloud microphysical structure asserts itself as a blind spot for ground based profiling instruments.

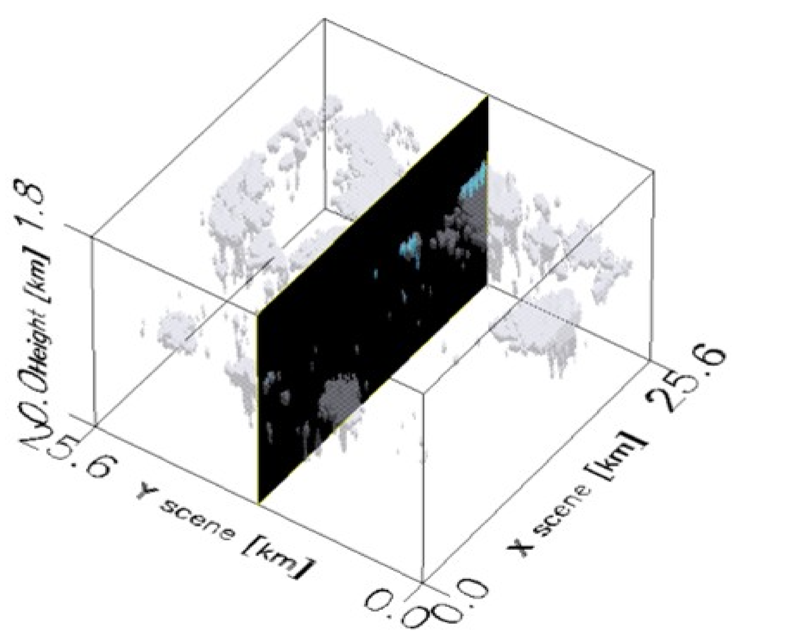
Satellite perspective:

-Imager on board Meteosat Second Generation provides day/night Brightness Temperatures. From retrievals point of view, using the infrared part of the spectra is practical (channels 3.9 and 10.8µm), due to their sensitivity to droplet size and cloud phase.





1. Drizzling stage Sc during ASTEX, early phase of depleting



2. Evolved Sc, via phase of Pocket of Open Cells (POCs), into scattered fractions

Large Eddy Simulation output → ECSIM synthetic observations

Liquid Water Content → [Fixed number concentration] → Droplet Effective Radius

[Assumed γ-distribution] → Drop Size Distribution → 3D cloud scene model

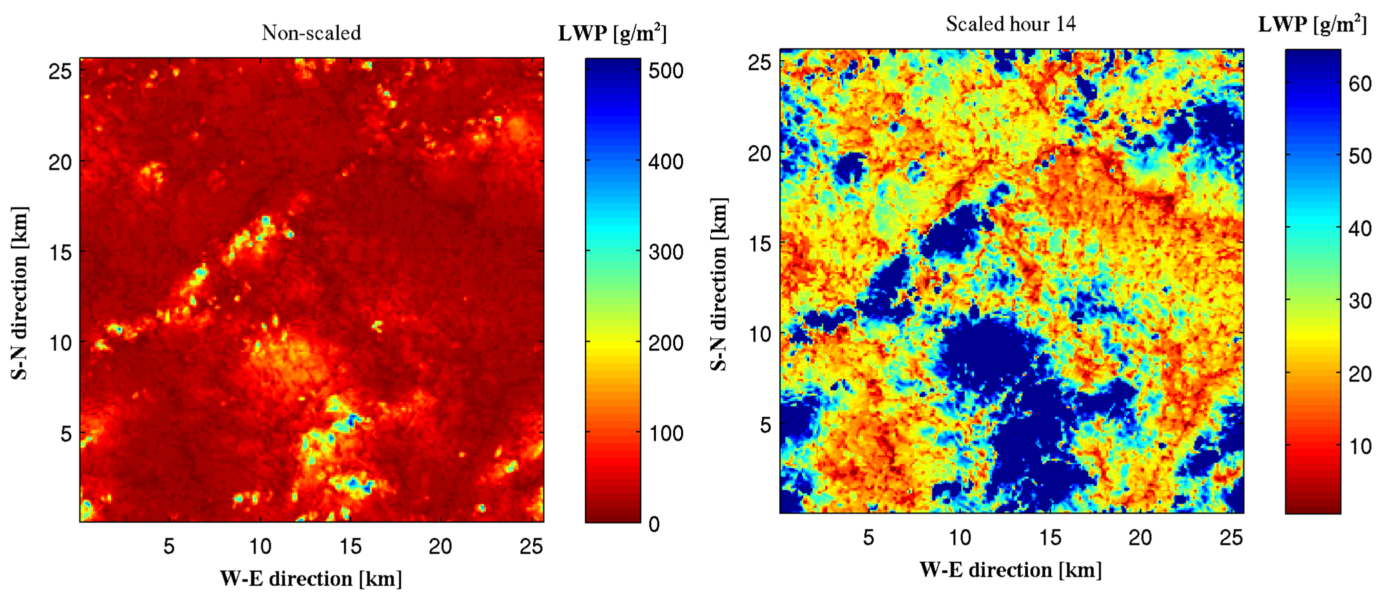


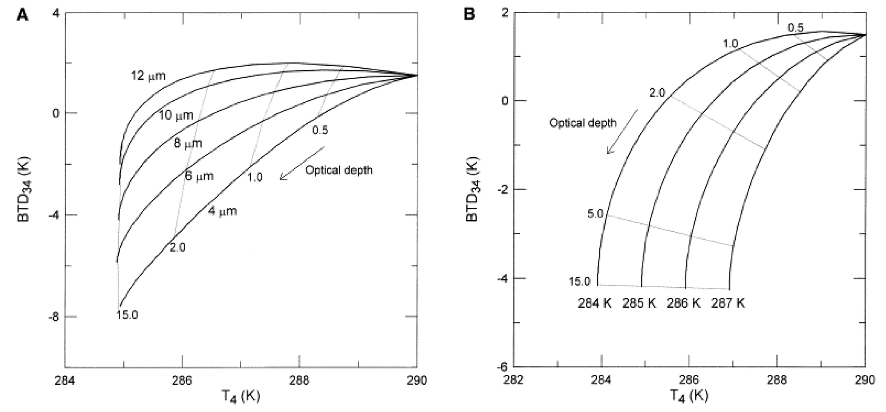
Figure above: Extracted Liquid Water Path (LWP) variability during a non-intensive precipitation process (hour14 of the ASTEX simulation)

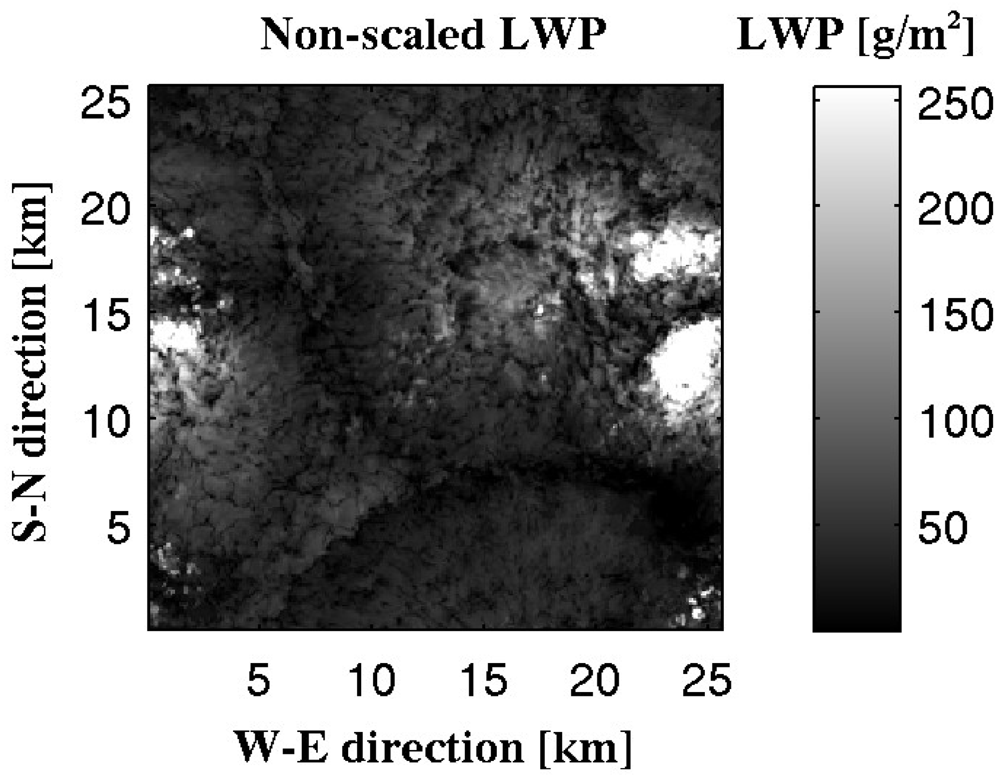
Cloud scenes utilization:

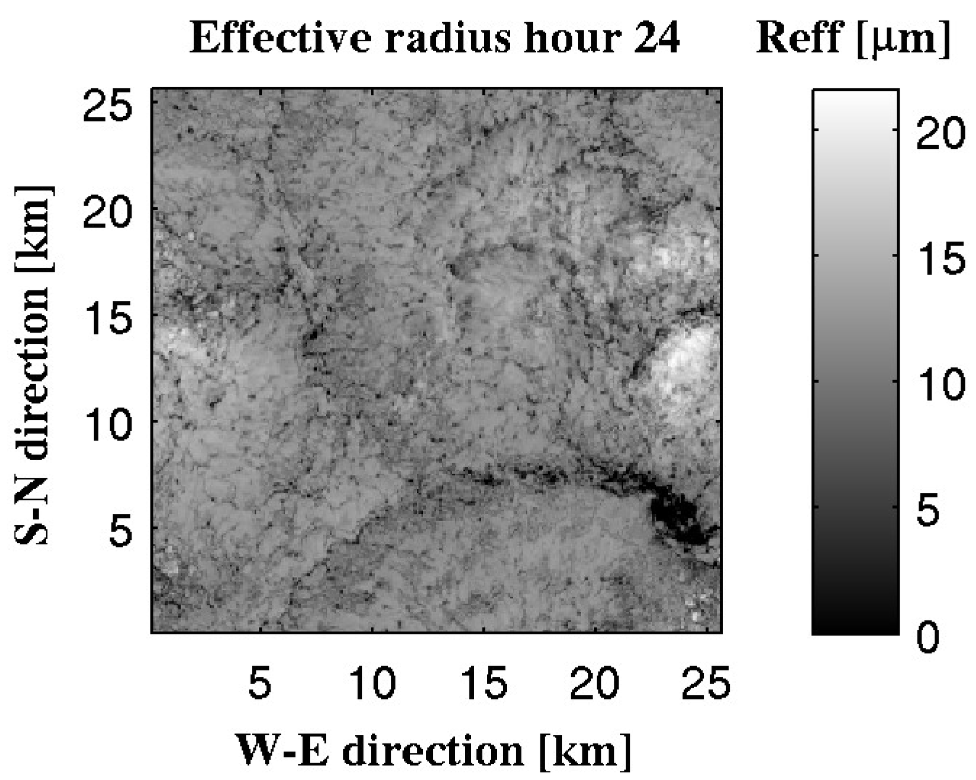
- **Quantity extraction**: *effective radius, liquid water content, liquid water path, optical depth, droplet number concentration.*
- **Simulated retrievals** using 3D Monte Carlo or Independent Column of Approximation long wave Radiative Transfer Model: ***Radiance*** (Wm⁻²sr⁻¹cm⁻¹) and ***Brightness Temperature*** (K)

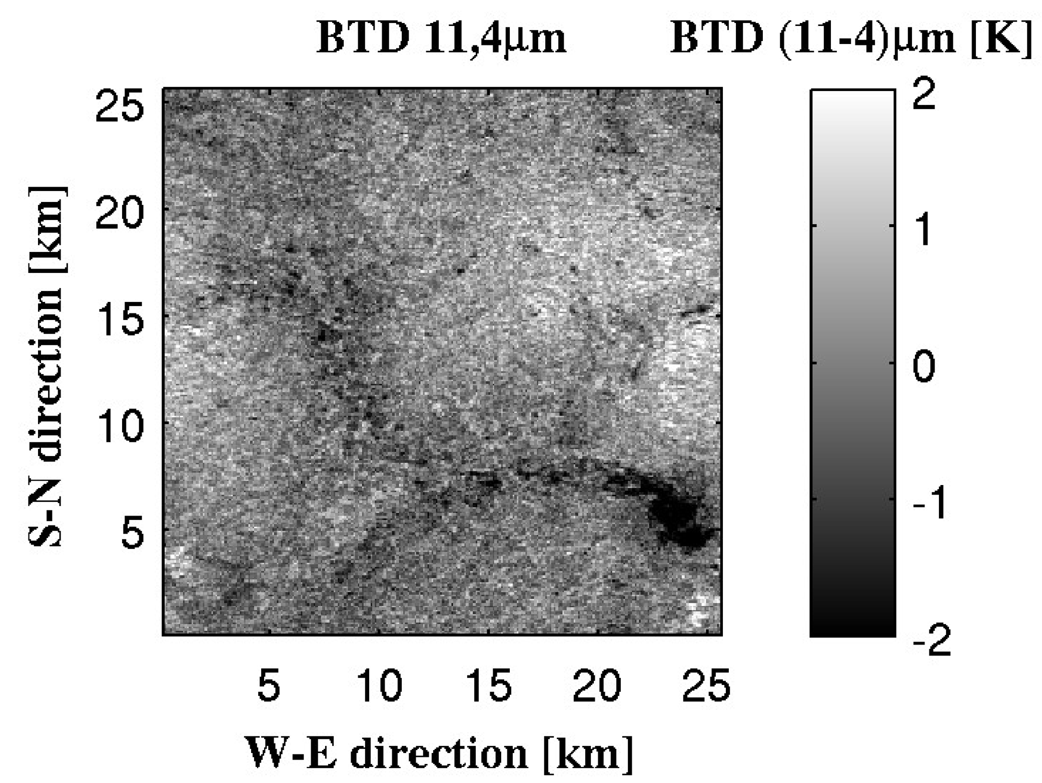
Pockets of Open Cells (POCs) - Location where drizzle forced change of structure in Stratocumulus cloud can be found[1]. Compared to surrounding cloud field, POCs are flagged as areas with significant precipitation.

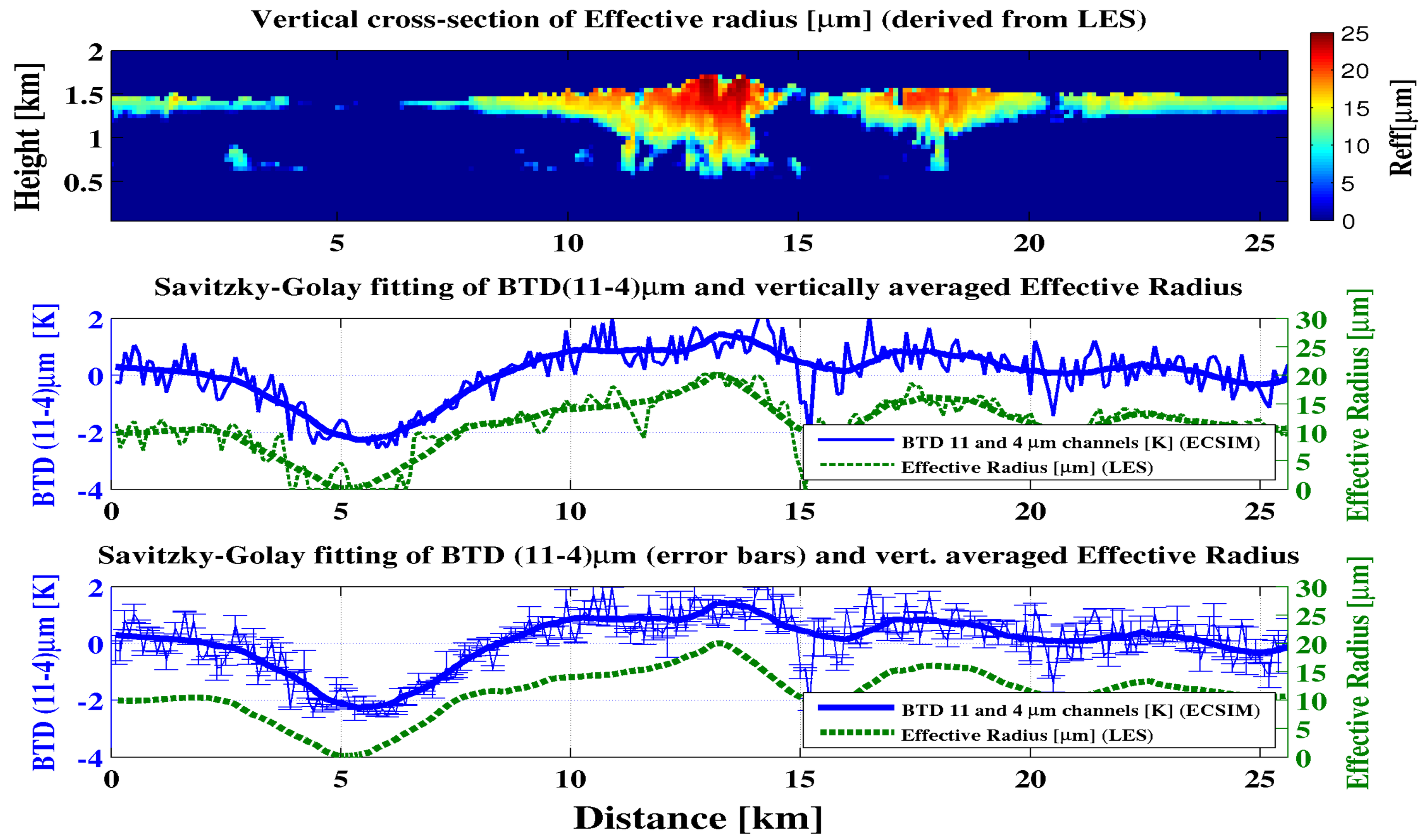
ΔT_b - a proxy for the droplet size (*see Figure below*)[2], which is an indicator of the size of the droplets at the top of the cloud (location of POCs), related to precipitation triggering mechanism.

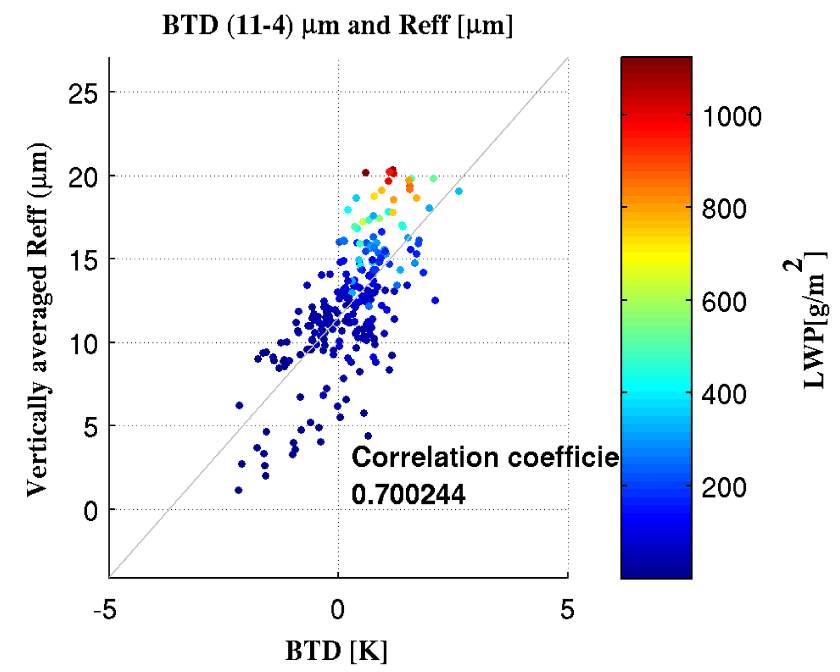












Qualitative and quantitative analysis of BTD correlation to the droplet size at the top of the cloud

- Running mean smoothing of raw BTD signals shows a qualitative match to the droplet size when compared to average droplet size along the vertical profile.
- Range of BTD errors provides restrictions to categorization of its intensity to the droplet size parameter (as in [3])
- Sensitivity of BTD to the **adiabatic profile of effective radius** to be studied → proxy → **flag for drizzle at cloud base.**

We aim to categorize the particular evolution stages of the cloud from the moment of onset until depletion, due to evaporation or precipitation. For the fine scale microphysical processes and dynamical analysis of a drizzling Stratocumulus, synthetic remote sensing observations were used. In this study, a **large eddy simulation** cloud scene is simulated based on the ASTEX (The Atlantic Stratocumulus Transition Experiment) campaign, on domain size 25.6x25.6*km*, and ingested into the ***EarthCARE Simulator (ECSIM) Radiative Transfer Model***.

Meteosat Second Generation Imager data

- Data available in **Pixel Counts** (*binary pixel value*)
- Conversion necessary to obtain infrared **radiance** (*physical value*)
- Radiance conversion to **Brightness Temperature**

Radiance = CAL_offset + CAL_slope * Count

$$T_b = \left[C_2\nu_c/\log\left(\frac{C_1\nu_c^3}{R}+1\right) - B\right]/A$$

C_1 = 1.19104 10⁻⁵ mW m⁻² sr⁻¹(cm⁻¹)⁻⁴

C_2 = 1.43877 K(cm⁻¹)⁻¹

ν_c = central wavenumber of the channel

A, B coefficients

References

[1] VanZanten, Margreet C., and Bjorn Stevens. "Observations of the structure of heavily precipitating marine stratocumulus." Journal of the atmospheric sciences 62, no. 12 (2005): 4327-4342.

[2] Pérez, Juan C., Félix Herrera, Fernando Rosa, Albano Gonzalez, Melanie A. Wetzel, Randolph D. Borys, and Douglas H. Lowenthal. "Retrieval of Marine Stratus Cloud Droplet Size from NOAA–AVHRR Nighttime Imagery." Remote sensing of environment 73, no. 1 (2000): 31-45.

[3] Lensky, Itamar M., Daniel Rosenfeld, 2003: Satellite-based insights into precipitation formation processes in continental and maritime convective clouds at nighttime. J. Appl. Meteor., 42, 1227–1233.

Acknowledgments

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