Cloud Edge Properties over Ocean and Land Observed by ARM Shortwave Spectrometer

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Key Points:

- Cloud edge properties are observed by ARM's shortwave spectrometer, SASZe (1Hz over a small field-of-view);
- The spectrally invariant method is used to analyze the observations of the warm boundary layer cloud over land (SGP) and ocean (MAGIC);
- While cloud optical depth decreases towards cloud edge for both cases, the decrease of droplet size is much more pronounced over land than over ocean.

Entrainment and mixing - important cloud processes

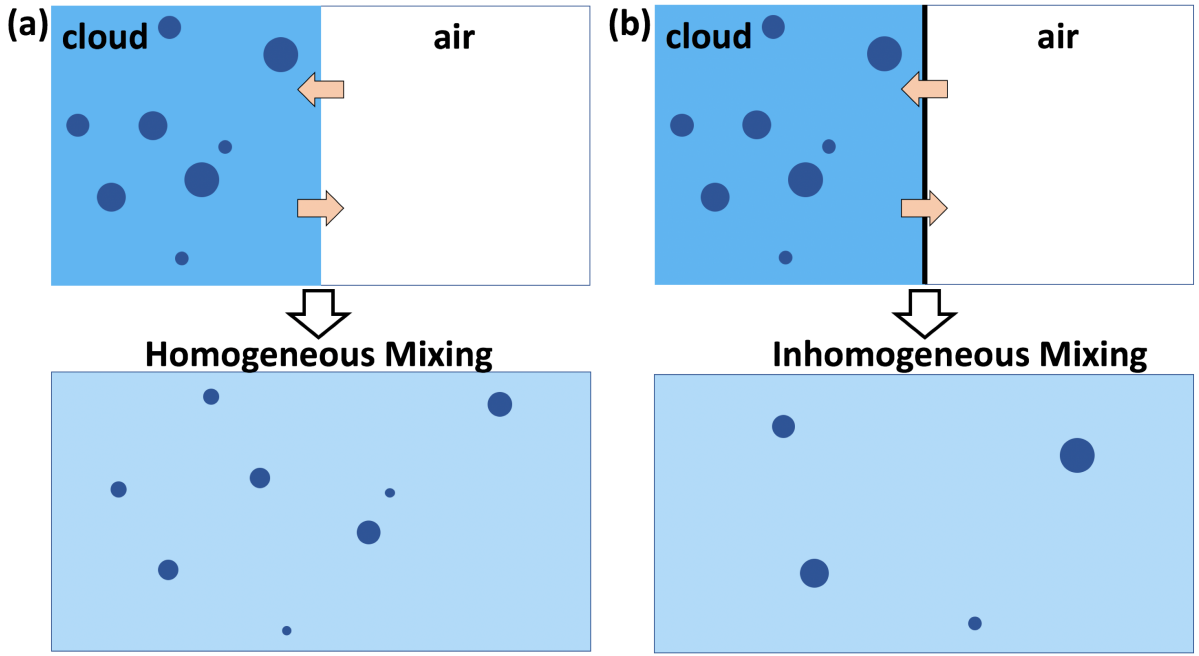
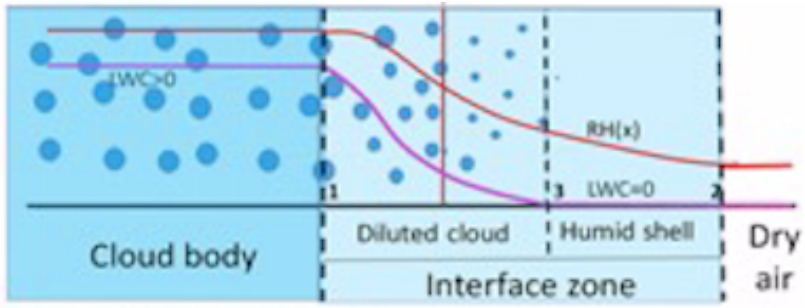


Illustration of limiting scenarios of cloud mixing (Baker et al., 1980):

a) the homogeneous mixing (a drier air penetration into the cloud before cloud drops begin to evaporate): the size of all droplets reduced but not the number concentration;

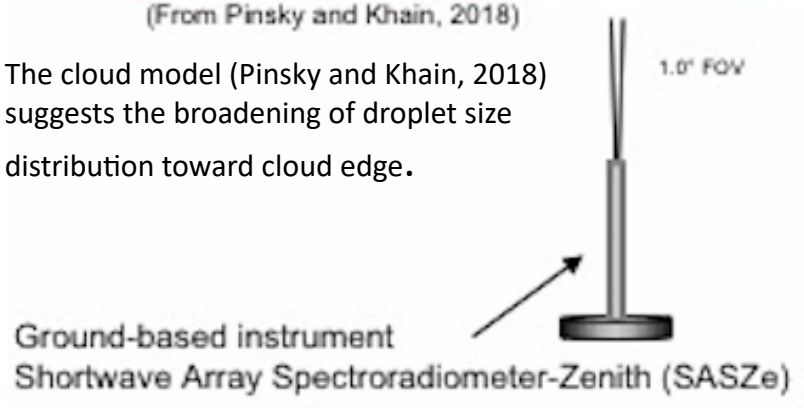
b) the inhomogeneous mixing (evaporation begins before dry air penetrates the cloud) the droplet number concentration reduced but does not change the droplet size spectrum.

These mixing processes lead to completely different droplet size distribution at cloud edges.



(From Pinsky and Khain, 2018)

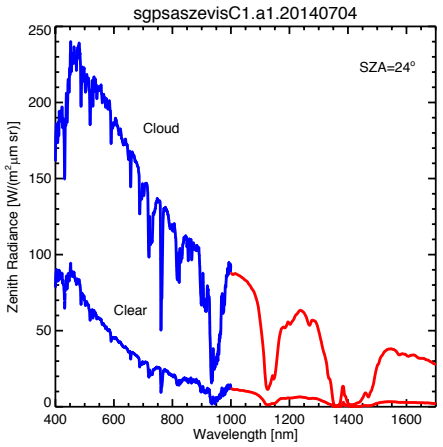
The cloud model (Pinsky and Khain, 2018) suggests the broadening of droplet size distribution toward cloud edge.



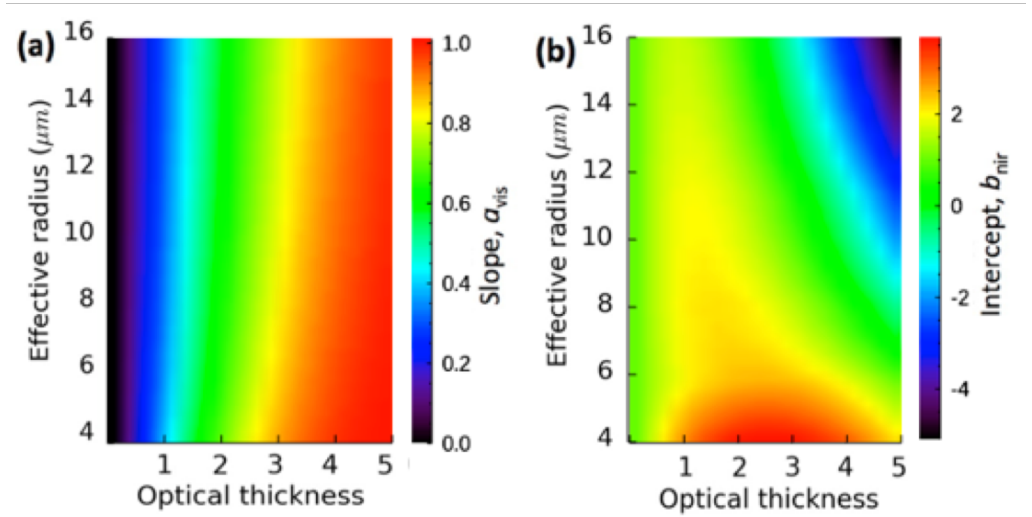
Ground-based observations from Shortwave Array Spectroradiometer-Zenith (SASZe) are very good for studying cloud edge properties. **We found that optical depth decreases towards cloud edge in all cases but the inhomogeneous mixing is much more pronounced over ocean than over land.**

SASZe: 300 – 2200 nm, 1 Hz, FOV=1^{o} (~ 17 m for 1 km cloud base.

Spectrally-invariant method for SASZe observations and future plans



SASZe zenith radiance

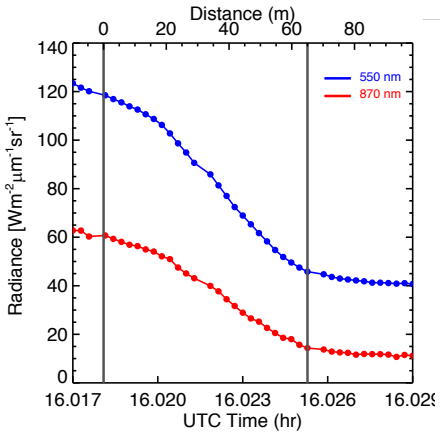


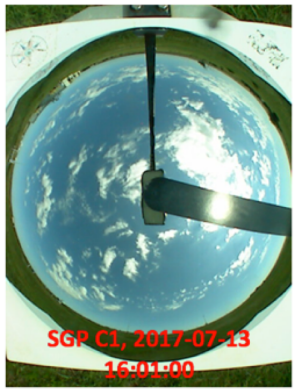
Spectrally-invariant method:

$$I(t,\lambda)/I(t_{clear},\lambda) = a(t)\, I(t_{cloudy},\lambda)/I(t_{clear},\lambda) + b(t), \quad t_{cloudy} \le t \le t_{clear}$$

visible slope, $a(t)$, depends on cloud optical depth and NIR intercept, $b(t)$, is a function of effective radius.

22 cloud edge cases from SGP C1 site and the MAGIC field campaign have been analyzed

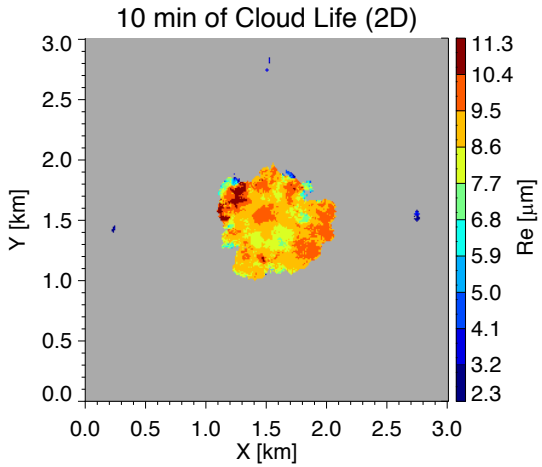




SGP;
16 UTC on July 13, 2017

Future work & collaboration:

- study the causes of aerosol particle changes in the vicinity of clouds;
- improve model representation of aerosol-cloud interactions near clouds with collaboration of cloud modelers (Khain and Pinsky) at the Hebrew Univ. of Jerusalem.



An example of cloud model results