The Skill of Cloud Fraction and Condensate Decorrelation Lengths to Reproduce Cloud Field Statistics According to a High Resolution MICROBASE Data Set

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The overlap problem

In order to optimize 1D radiative transfer calculations in multi-layer cloudy atmospheres it is important to know:

- *How cloud fraction (CF) overlaps*
- *How the condensate (WC) of cloudy regions overlaps*

Besides GCM models, knowledge of the above is needed to construct cloud fields for various instrument simulators.

What we address here

• Is generalized (a flexible combo of maximum and random) CF overlap

$$C_{true} = aC_{max} + (1-a)C_{ran} \qquad (1)$$

indeed better than classic max-ran overlap?

• Can generalized CF overlap be effectively modeled in terms of a decorrelation length L_0?

$$a = \exp\left(-\frac{\Delta z}{L_0}\right) \qquad (2)$$

• Likewise, can the *rank correlation* of condensate also be modeled as an inverse exponential?

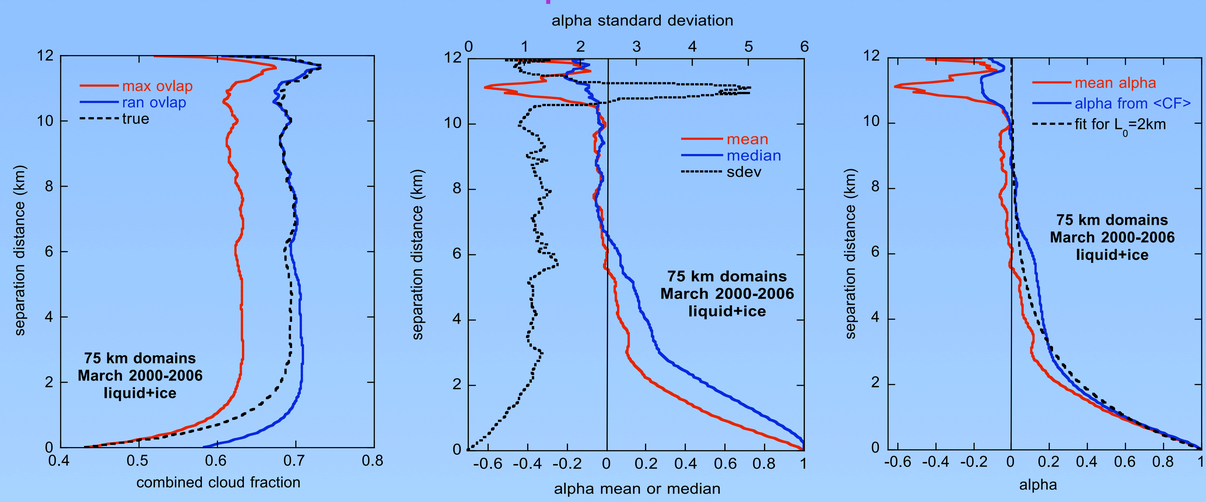
• Do the reconstructed cloud fields from decorrelation lengths have similar statistics as the original fields? *Yes, that's what the figures in the right indicate. Max-ran is also surprisingly good for CF.*

Dataset and methodology

We use the MICROBASE evaluation product of 2D cloud condensate for 2000-06 derived from MMCR, ceilometer, MPL, MWR and thermodynamic profiles (**thanks: Jensen and Dunn**). Vertical resolution is 45m (unprecedented for this type of study) and "horizontal" (temporal) resolution is 10 sec. The time-height series of each day was divided into 12 segments (we call these "75 km" domains) and liquid-ice condensates were combined.

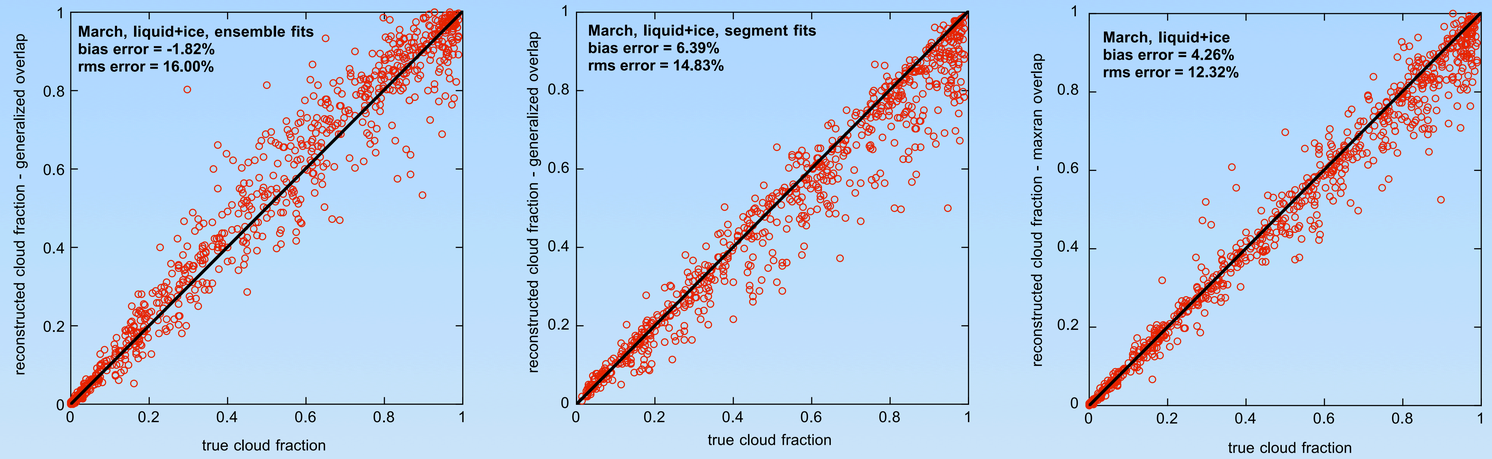
True, max, and ran CF were calculated for all cloudy layer pairs of a segment at all separation distances (multiples of 0.045 km) and eq. (1) was used to derive "alpha". The ensemble mean and all other statistics of alpha (median, sdev) were calculated from this (enormous) dataset for each month. L_0's can be fit to the alpha profile of each segment or to the ensemble mean (similar for rank correlations). These L_0's (from the ensemble mean or of each segment) can be used along with the profile of CF and average WC in a cloud generator to reconstruct cloud fields.

Example month: March



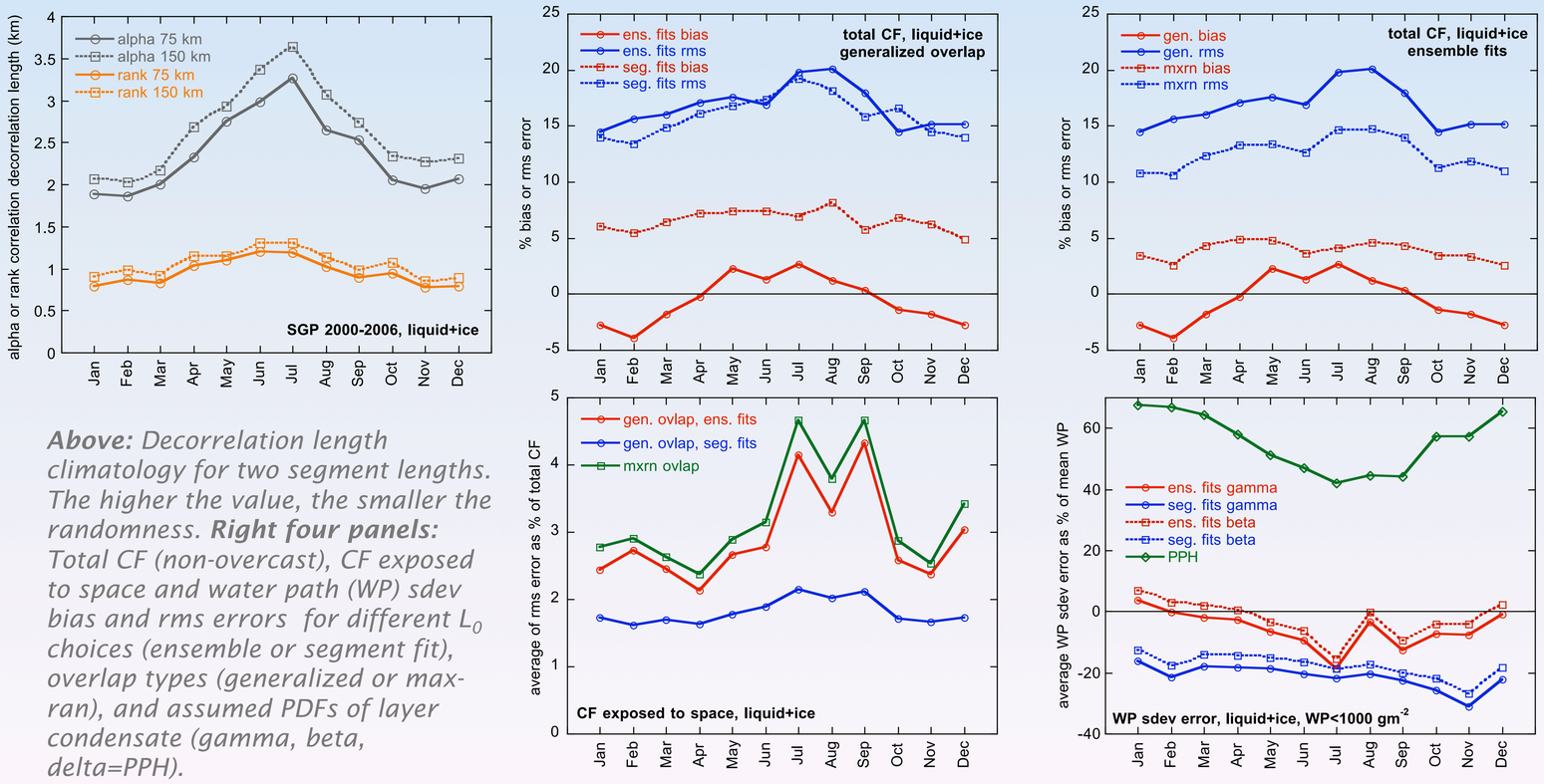
Left: *Ensemble mean profiles of combined CF for two overlap assumptions vs. truth.* ***Middle:*** *Ensemble mean, median and sdev profiles of alpha.* ***Right:*** *ensemble mean profile of alpha and alpha from ensemble mean CF profiles; an inverse exponential with L_0=2 km fits quite well both profiles. When alpha is 1 overlap is maximum, when 0, random, and when negative, minimum.*

Reconstructing the March 2000-2006 total cloud fraction



Total reconstructed (via cloud generator) CF vs. true CF (non-overcast segments only). ***Left:*** *L_0 from fit to ensemble March mean of alpha.* ***Middle:*** *L_0 fits to individual segments.* ***Right****: max-ran overlap (performs quite well with smallest rms error!)*

2000-2006 SGP decorrelation length climatology



Above: *Decorrelation length climatology for two segment lengths. The higher the value, the smaller the randomness.* ***Right four panels:*** *Total CF (non-overcast), CF exposed to space and water path (WP) sdev bias and rms errors for different L_0 choices (ensemble or segment fit), overlap types (generalized or max-ran), and assumed PDFs of layer condensate (gamma, beta, delta=PPH).*