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Reducing errors in satellite-simulated views of clouds with an improved parameterization of unresolved scales

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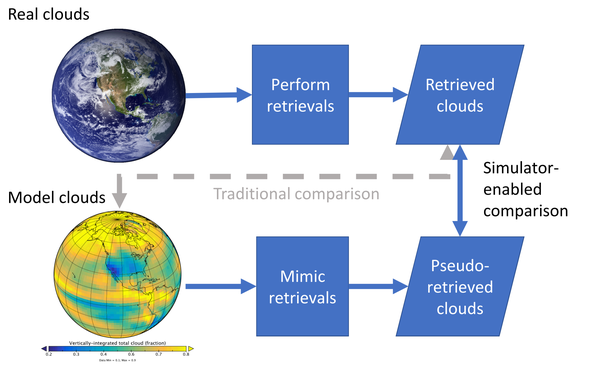
Key points

- Simulated cloud-property retrievals are sensitive to assumptions about cloud overlap and condensate variability
- Errors in simulated retrievals arise when using the popular maximum-random overlap and homogeneous condensate assumptions
- Errors in simulated retrievals are reduced using a more realistic treatment of cloud overlap and variability

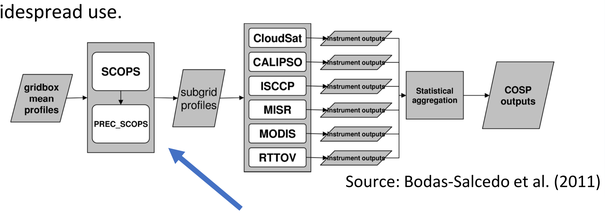
Background: satellite simulators

Satellite simulators enable more reliable comparisons between models and satellite retrievals by accounting for limitations in specific retrievals.



The satellite simulator package COSP

A suite of simulators have been collected into the CFMIP Observation Simulator Package (COSP; Bodas-Salcedo et al. 2011), enabling straightforward implementation into models and widespread use.



Source: Bodas-Salcedo et al. (2011)

Simulated retrievals from COSP depend on a subcolumn generator to infer unresolved cloud structure from large-scale model gridbox means; we show here that the simulators are sensitive to the assumptions used in this crucial step.

A better subcolumn generator for COSP

- Subcolumn generators are a way of accounting for overlap (and variability) below the gridbox scale
- Input profiles of gridbox-mean cloud occurrence fraction and condensate amount and produce stochastic subcolumns of pseudo-resolved cloud condensate
- Implement scheme described by Räisänen et al (2004)

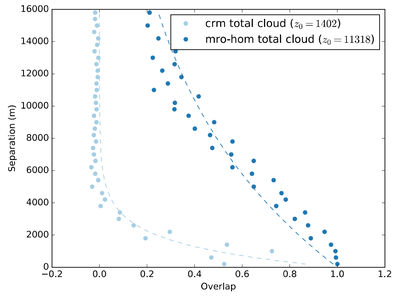
Overlap

- Generalized overlap: linear combination of maximum and random

$$C_{true} = \alpha\, C_{max} + (1 - \alpha) C_{rand}$$

- Weighting is a decaying exponential function of separation

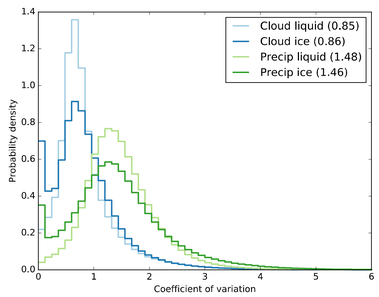
$$\alpha = \exp(-\Delta z / z_0)$$



Condensate variabiility

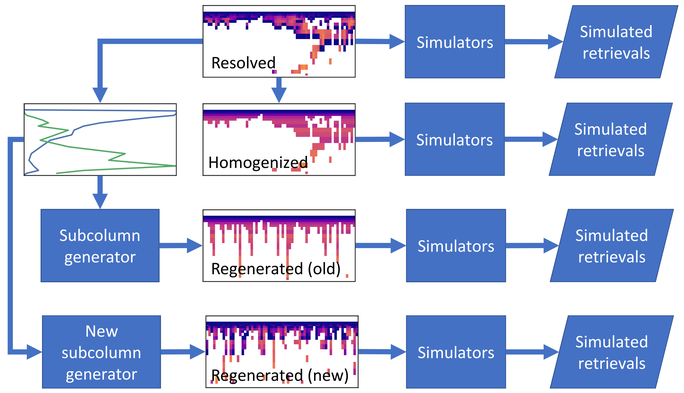
- Subcolumn condensate follows gamma distribution with assumed mean (provided) and variance (parameterized)
- Variance parameterized assuming constant coefficient of variation

$$\sigma_q' = \sigma_q / \mu_q$$

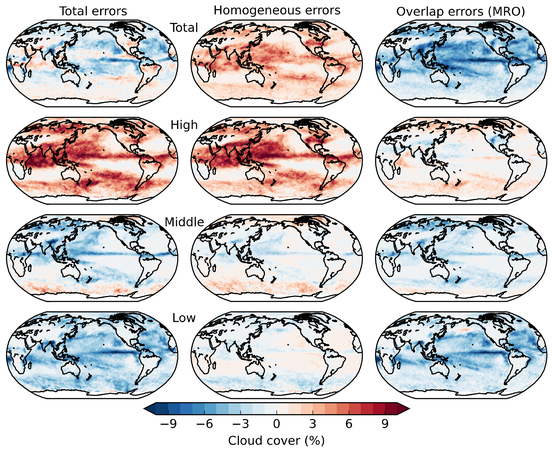


Analysis approach

- Examine sensitivity of COSP outputs to subcolumn assumptions using “resolved” (4 km horizontal resolution) condensate fields produced by the Multi-Scale Modeling Framework (MMF; Randall et al. 2003), in which the subcolumn generator is not needed
- Create a series of modified condensate fields from the MMF fields that mimic the assumptions used in COSP (and GCMs), using subcolumn generator to “regenerate” resolved fields from calculated gridbox means
- Modified condensate fields created in such a way that we can isolate effects of cloud overlap and condensate variability

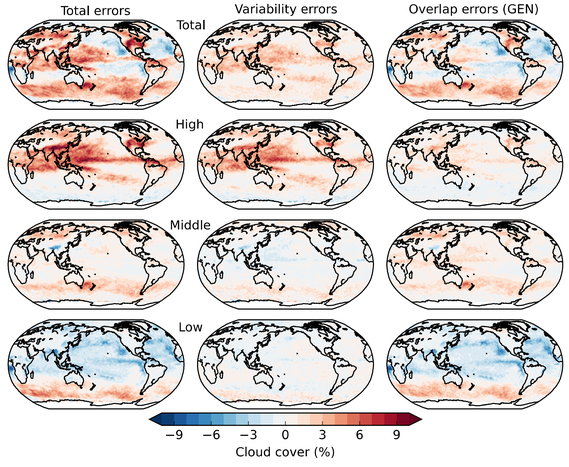


Errors in MISR-simulated cloud area: old generator



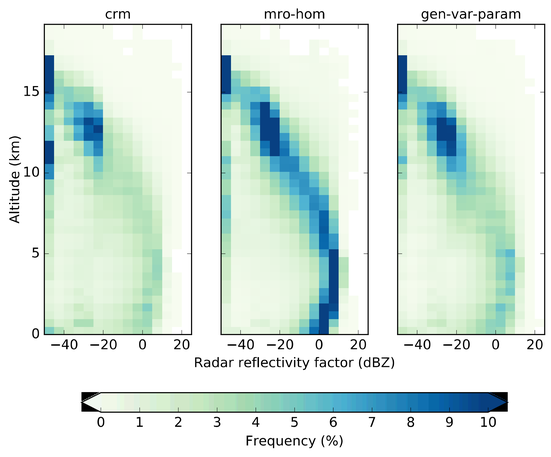
- Large regional errors due to both homogeneous and maximum-random overlap assumptions
- Errors are compensatory in sign

Errors in MISR-simulated cloud area: new generator



- Errors due to variability are substantially reduced
- Errors due to overlap are reduced
- Sign of overlap errors change; less compensation of errors

CloudSat-simulated radar reflectivity factor histograms



- Old subcolumn generator overestimates frequency of occurrence along characteristic curve
- Errors substantially reduced with new treatment of variability

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