EMS Annual Meeting Abstracts
Vol. 13, EMS2016-680, 2016
16th EMS / 11th ECAC


# A parametrization of the vertical overlap of clouds based on wind-shear

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Previous studies using ground-based and satellite observations show that the total cloud cover of cloudy layers separated by clear sky is close to, but can statistically exceed that given by the random overlap assumption,suggesting a tendency towards minimum overlap. In addition, vertically continuous clouds which are maximally overlapped in adjacent layers, decorrelate as the separation distance increases, with the resulting decorrelation length-scale found to be sensitive to the horizontal scale of the cloud scenes used to conduct the analysis. No satisfactory explanation has been given for the minimal overlap and scene-scale sensitivity of the cloud statistics. Using simple heuristic arguments, it is suggested that both these phenomena can be expected due to the statistical truncation that results from the omission of overcast cloudy layers from the analysis, which occurs more frequently as the scene length falls progressively below the typical cloud system scale.

We first validate this claim using a easily interpreted system of repeating cyclic clouds sampled at various length scales, which reproduces both of the above phenomena. This analysis is then repeated with realistic fractal clouds from a cloud generator, which demonstrates that the degree of minimal overlap diagnosed in previous studies for is continuous clouds would result from sampling randomly overlapped clouds at spatial scales that are 30% to 80% of the cloud system scale. Based on this, a simple filter is suggested for cloudy scenes which removes the diagnosis of minimal overlap for discontinuous clouds, and results in a scene-length invariant calculation of the cloud overlap decorrelation for continuous clouds. Using CloudSat-CALIPSO data for 6 months, a scale-invariant decorrelation length scale of 3.7km is found.

Using this filter we analyse a special application. By processing more than eight million cloud scenes from CloudSat observation in conjunction with co-located ECMWF analysis data we identify an empirical relationship between cloud overlap and wind-shear that can be applied to global models with confidence. The analysis confirms that clouds separated by clear sky gaps are randomly overlapped while continuous cloud layers decorrelate from maximum towards random overlap as the separation distance increases. There is a clear and systematic impact of wind-shear on the decorrelation length-scale, with cloud decorrelating over smaller distances as wind shear increases, as expected.

A simple empirical linear-fit parametrisation is suggested that is straightforward to add to existing radiation schemes.