A Bayesian Approach to Upscaling Aircraft Particle Size Distribution Measurements to GCM Scale

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INTRODUCTION

This study addresses the issue of how to upscale ice particle size distributions measured with aircraft over scales of ~1 km to yield size distributions suitable for scales used in numerical models-cloud through climate scales.

OVERVIEW

Aircraft measurements of ice particle counts along a 79-km zigzag path were collected in a Costa Rican cloud formed in the upper-level outflow from convection during the TC4 experiment These are then used to explore the applicability of Bayesian statistics to the problems of upscaling and downscaling.

An article describing more details of this work is in press (JCAM).

APPROACH

For each observed count of particles of a specified size, the application of the Bayesian approach under the assumption of Poisson counting statistics leads to the distribution of mean values, *C*, for particles of a specified size. We use an aircraft path length of 10 m (Fig. 1).

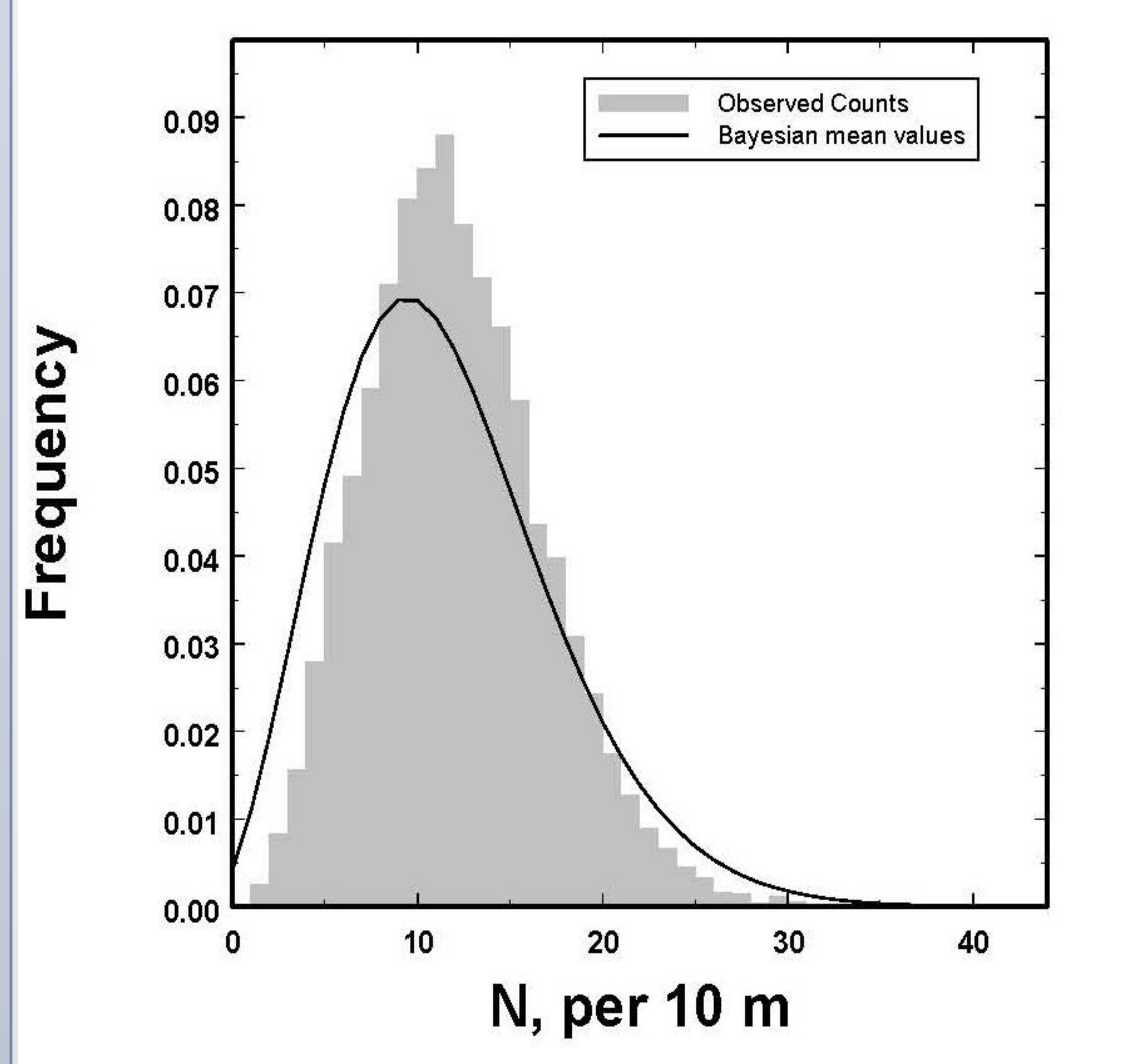


Figure 1: Plot of the observed histogram of 10 m counts of 200-300 micron sized ice Particles as well as the distribution of the mean Values derived from the Bayesian inversion of the observed counts.

Using the 10-m particle counts, the analyses using Bayesian statistics provide estimates of the probability distribution function of all possible mean values corresponding to these counts.

RESULTS

The statistical method of copulas is used to produce an extensive ensemble of estimates of these mean values, which are then combined to derive the probability density function (pdf) of mean values at 1-km resolution (Fig. 2). These are found to compare quite well with the observed 1-km particle counts when spatial correlation is included.

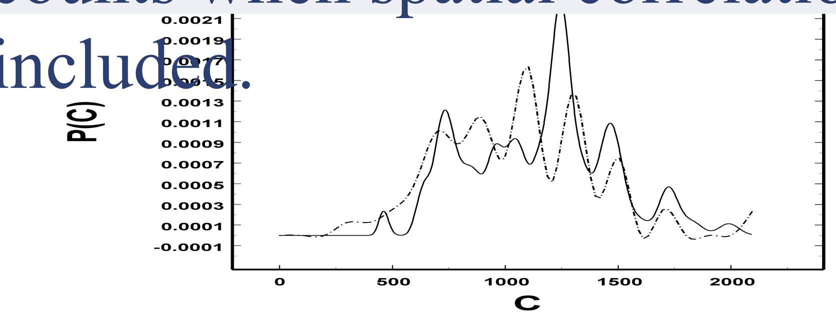
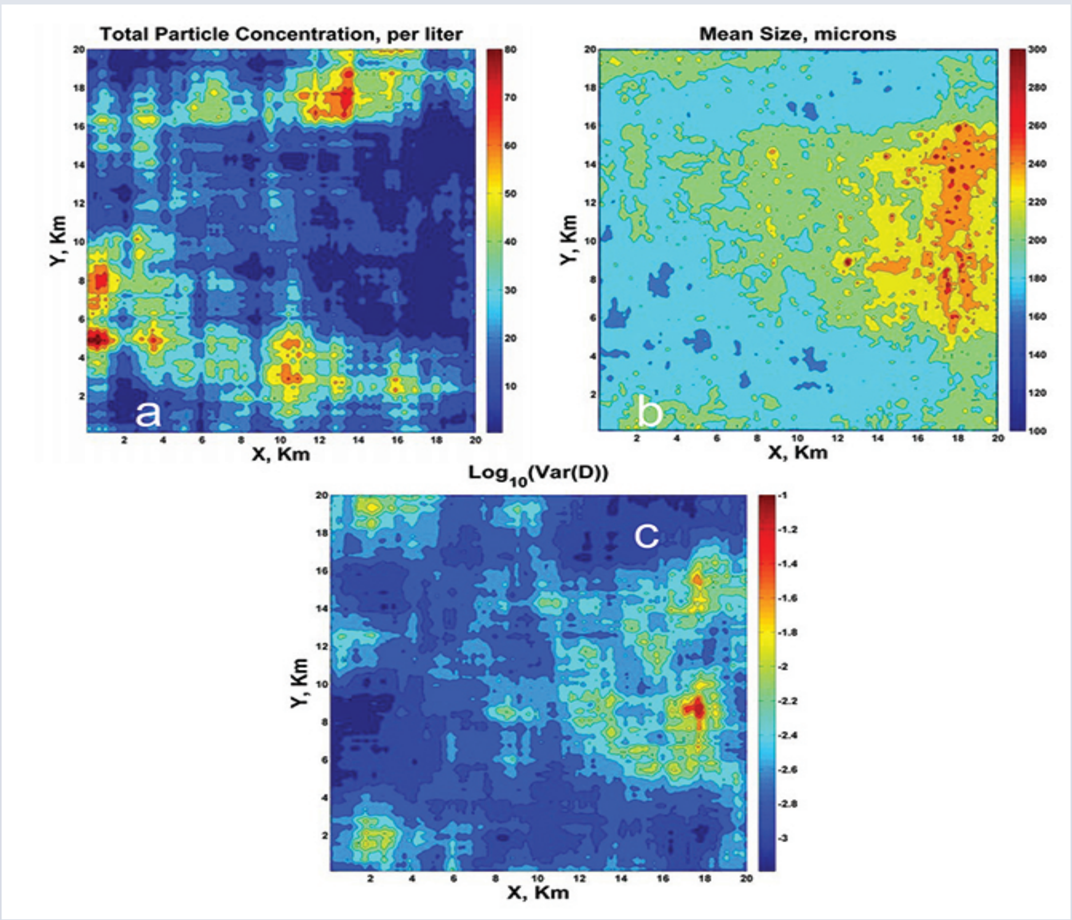


Figure 2: A comparison of the observed P(C) at 1 km resolution compared to that from upscaling from 10 m when exponential correlation is incorporated. They are never going to be identical because of the stochastic nature of the observations and upscaling.



CONCLUSIONS

The profiles of the observed and simulated mean counts along the flight path show similar features and have quite similar statistical characteristics. However, because the observed and the simulated counts are both the results of stochastic processes, there is no way to upscale exactly to the observed profile. Each simulation is a unique realization of the stochastic processes, as are the observations themselves. These different realizations over all the different sizes can then be used to upscale particle size distributions (PSD) over large areas (Fig. 3).

Figure 3: Contour plots of (a) the upscaled total particle concentration (b) mean particle size and (c) variance of particle size over the 20 km by 20 km grid.

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