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Sampling Errors of Climate Monitoring Constellations

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Satellites need to observe the earth with great accuracy to capture the decadal trend in climate. As part of an effort to design a constellation of low earth orbiting satellites to benchmark climate observations, we explore the impact of imperfect sampling of satellites to reproduce mean radiance on a variety of spatial and temporal scales. Our aim is to find those orbits which provide an accuracy of at least 0.1 K in brightness temperatures at different temporal and spatial resolutions and to look for alternate ways of calibrating existing and future satellites like NPOESS. ăThe 0.1K level of accuracy in brightness temperature is chosen to agree with the expected magnitude of decadal trends in temperature forced by changes in greenhouse gas concentration.

Results of sampling studies carried out at different frequencies representative of the lower, middle and upper troposphere will be presented. Model generated radiances rather than (poorly) observed radiances are used for this study. The brightness temperatures have been obtained by using MODTRAN to the archived GFDL coupled model simulations. These are then sub-sampled along the paths traversed by the satellite footprint for various potential orbits at different inclinations. Maps of retrieval accuracy for monthly mean, seasonal mean and annual mean radiance will be presented for single satellites and a constellation of satellites.

We show that in addition to random weather noise and diurnal sampling bias, the correlation between spatial, diurnal and seasonal sampling bias within grid squares can become important, depending on orbit height and inclination. In addition, we use high resolution geostationary satellite radiance data to define the role of temporal sampling frequency in producing accurate climate statistics.

Results for the annual mean indicate that: a single satellite in a precessing orbit can achieve sampling errors in 15 degree grid boxes less than 0.1 K for brightness temperatures in the spectral regions that mostly sample the upper troposphere and lower stratosphere; In the mid-troposphere channels and in the window channel, a single precessing orbiter requires zonal averaging to reliably attain errors of less than 0.1 K; Since the primary source of sampling bias arise due to inadequate sampling of the diurnal cycle and semidiurnal cycle, a constellation of satellites surely reduces the errors considerably and combinations with precessing polar orbits are normally better than their sun-synchronous counterparts.