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The Effect of Sensor Resolution on the Number of Cloud-free Observations

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Air quality and surface emission inversions are likely to be focal points for future satellite missions on atmospheric composition. Most important for these applications is sensitivity to the atmospheric composition in the lowest few kilometers of the troposphere. Reduced sensitivity by cloud effects needs to be minimized. In this study we have quantified the increase in number of useful footprints, i.e. footprints with sufficient sensitivity to trace gases in the lowest part of the troposphere, as a function of sensor resolution (footprint area). High resolution (1 km$\times$ km) MODIS TERRA cloud mask observations are aggregated to lower resolutions. Statistics for different thresholds on cloudiness are applied. For each month in 2004 two days of MODIS data are analyzed. Globally the fraction of cloud-free observations drops from 26% at 100 km^2 resolution to only 3% at 10000 km^2 if not a single MODIS observation within a footprint is allowed to be cloudy. If up to 5% or 20% of a footprint is allowed to be cloudy, the fraction of cloud-free observations drops to 9% or 17%, respectively, at 10000 km^2 resolution. Under the assumption of a preserved sampling rate (that is, e.g., related to revisit time and swath) a doubling of sensor resolution would imply by definition a doubling of the absolute number of cloud-free observations over a certain area. Combined with the increase of useful footprints this allows e.g., a future mission with 10 km$\times$10 km footprint and similar swath to GOME-2 to statistically obtain as much cloud-free measurements over Europe in less than three days as GOME-2 would obtain in a full year.