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Spatial representativeness of ground-based solar radiation measurements

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The validation of gridded surface solar radiation (SSR) data, i.e. satellite-derived or climate model calculated, relies on the comparison with ground-based in-situ measurements. Detached from any modeling or temporal averaging biases, the question remains how representative a point measurement is for a larger-scale grid cell. In the present study, we make extensive use of high-resolution (0.03°) SSR data from the Satellite Application Facility on climate monitoring (CM SAF) to study in detail: 1) the spatial variability in SSR over Europe, 2) the sub-grid variability within an example grid of 1° resolution, 3) the representativeness of 143 surface sites (BSRN and GEBA) for their corresponding 1° grid cells, and 4) the point-centered and grid-independent surface sites' representativeness for larger-grid cells up to 3°. These analyses are done on a climatological annual mean basis over the period 2001-2005. Annually, the spatial variability as given in the CM SAF data set is largest in regions of sudden changes in weather conditions and topography, e.g., in Northern Spain, the Alpine region, the Carpathians, and Adriatic coast. The 1° sub-grid variability (mean absolute deviation from grid cell mean, relative to grid cell mean, RMAD) is on average 1.64 % (2.43 Wm-2) over European land, with maximum RMAD of up to 10% in Northern Spain. The surface sites' (GEBA and BSRN) representativeness for larger-grid cells is highly dependent on region and grid size. The difference between the CM SAF value at the GEBA site's location and the grid cell mean (calculated from CM SAF data) can vary from almost 0% to more than 10% for a 1° grid cell, and up to 15% for a 3° grid cell. On average, this spatial sampling error is below 5% even for grid cells of 3° resolution. We show that the latitudinal shift of a point relative to the larger-grid cell center may account for a spatial sampling error of up to +-1.81 Wm-2 (for a maximum distance of +-0.5° within 1° grid cell) based on the mean meridional trend in clear-sky SSR of -3.63 Wm-2degree-1. Theoretically, the difference between a point value and the corresponding larger-grid cell mean could be used to obtain a correction factor. We briefly discuss the possibility of error correction based on a combination of the latitude effect and the point-centered representativeness for a surrounding 1° grid cell, instead of using the grid-specific spatial sampling error. The approximate correction approach halves the mean absolute error of 2% (mean of 134 GEBA sites) down to 1%.