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Scales of variability of black carbon plumes

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Black carbon (BC) is the major anthropogenic aerosol absorber of solar radiation, characterized by its strong absorption across a broad spectrum of visible wavelengths. Uncertainties in model simulations of BC are largely due to its high degree of spatial and temporal variability; therefore, quantifying its scales of variability is critical to determining a model's ability to accurately represent BC in the atmosphere. The purpose of this study is to quantify the scales of variability of BC plumes and to determine how these scales relate to current GCM resolutions. To analyse the plumes, we use BC measurements from the HIAPER Pole-to-Pole Observations (HIPPO) aircraft campaign, which flew multiple missions from pole-to-pole over the Pacific Ocean. During the first three missions of the HIPPO campaign, over 400 vertical profiles of BC mass measurements, extending from hundreds of metres to 14 km, were obtained using a Single Particle Soot Photometer (SP2). In this campaign, we identify a total of 102 BC plumes. We objectively analyse the plume scales using autocorrelation analysis and a plume-centric compositing technique. We found that the plumes account for a significant amount of total BC in the atmosphere and represent a large degree of the overall variability of BC. In order to make a meaningful estimation of a model's ability to resolve these plume structures, we define an approximate 'effective model resolution', which takes into account the flight track geometry of the HIPPO campaign and the vertical resolution of a typical GCM. We present results decribing the scales of variability of the identified plumes and compare these scales to the 'effective model resolution'. Implications of the findings and directions for future research are discussed.