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A Residual Kriging method for the reconstruction of 3D high-resolution meteorological fields from airborne and surface observations

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Manned light aircrafts and remotely piloted aircrafts represent very valuable and flexible measurement platforms for atmospheric research, as they are able to provide high temporal and spatial resolution observations of the atmosphere above the ground surface. In the present study the application of a geostatistical interpolation technique called Residual Kriging (RK) is proposed for the mapping of airborne measurements of scalar quantities over regularly spaced 3D grids. In RK the dominant (vertical) trend component underlying the original data is first extracted to filter out local anomalies, then the residual field is separately interpolated and finally added back to the trend; the determination of the interpolation weights relies on the estimate of the characteristic covariance function of the residuals, through the computation and modelling of their semivariogram function. RK implementation also allows for the inference of the characteristic spatial scales of variability of the target field and its isotropization, and for an estimate of the interpolation error. The adopted test-bed database consists in a series of flights of an instrumented motorglider exploring the atmosphere of two valleys near the city of Trento (in the southeastern Italian Alps), performed on fair-weather summer days. RK method is used to reconstruct fully 3D high-resolution fields of potential temperature and mixing ratio for specific vertical slices of the valley atmosphere, integrating also ground-based measurements from the nearest surface weather stations. From RK-interpolated meteorological fields, fine-scale features of the atmospheric boundary layer developing over the complex valley topography in connection with the occurrence of thermally-driven slope and valley winds, are detected. The performance of RK mapping is also tested against two other commonly adopted interpolation methods, i.e. the Inverse Distance Weighting and the Delaunay triangulation methods, comparing the results of a cross-validation procedure.