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Turbulent exchange over the city of Innsbruck

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Understanding turbulent exchange in complex terrain is necessary for weather forecasting and pollutant dispersion modelling, and is therefore of great importance to human health and well-being. Urban areas in mountainous terrain represent regions of high population density that are frequently exposed to adverse weather conditions (e.g. downslope windstorms, heavy snowfall) and poor air quality. Although the field of urban climate research has grown substantially over the last twenty years, there are very few observational studies focusing on turbulent exchange in cities in mountainous terrain. Thus, most of our knowledge, and therefore most of the physics underpinning mesoscale models, currently relies on theory that has been developed over simpler (i.e. flat and horizontally homogeneous) surfaces.

The city of Innsbruck is an ideal location for investigating urban areas in highly complex terrain. Measurements of the turbulent exchange of heat, water and carbon dioxide have been conducted at the Innsbruck Atmospheric Observatory (IAO) on the roof of the university building since 2014. Eddy covariance observations at two levels offer insight into the impact of local building effects on the measurements and variation of turbulence characteristics with height. Comparison with flux stations outside the city, established as part of the PIANO project (Penetration and Interruption of Alpine foehn), highlights the influence of urban characteristics on surface exchange processes. Meteorological conditions, air flow and turbulent exchange show substantial spatial variation, due to the city itself and its complex topographical setting. For example, limited vegetation within the city restricts the evaporation rate compared to the surrounding countryside; shading by the surrounding topography modifies the diurnal cycle of incoming shortwave radiation; and outflow from side valleys interacts with the main valley wind circulation, giving rise to complex flow patterns. Differences in the timing of foehn breakthrough and the duration of foehn events at each site lead to dramatic spatial and temporal variation in turbulent fluxes. The applicability of similarity scaling under various conditions is also assessed.

Initial results are presented here, which offer new insight into surface exchange processes in extremely complex environments.