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The effect of scale on the applicability of Taylor's hypothesis

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Taylor's frozen flow hypothesis is a central assumption in most fluid mechanics experiments with stationary sensors, and many statistical theories of turbulence where links between the Lagrangian and Eulerian nature of turbulence are made. In this work we seek to quantify the effectiveness of Taylor's hypothesis at the field scale using water vapor as a passive tracer. A horizontal Raman Lidar is used to capture the humidity field in space and time above a small lake in Switzerland. High resolution wind speed and direction measurements are conducted simultaneously allowing for a direct test of Taylor's hypothesis. Through a wavelet decomposition of the data we show that scale has a strong influence on the applicability of Taylor's hypothesis. This effect is explained through the use of dimensional analysis and turbulent structure functions, which ultimately leads to the definition of a nondimensional parameter describing the 'persistency' of the turbulence.