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Spectral Interaction of the LES subgrid-stress and coherent structures

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Over the last ten to fifteen years the existence of coherent structures in turbulent flows has been subject of many debates. Is turbulence as chaotic as it is thought to be, or does it exist some sort of order and hierarchy?
Winter 2012 offered us the occasion to further investigate into this subject given that natural evaporation over lake Geneva acted as a direct PIV tracer of the wind flow. Given the unusual low temperatures over central and northern Europe, and the fact that lake Geneva's water was still warm after an intense summer, large amounts of evaporation took place over lake Geneva. These phenomena coupled with the strong predominating winds on that specific region, made the emanating fog a natural tracer of the turbulent flow. Coherent streaks of water vapor were observed with digital photography and captured together with the flow field by means of Wind LiDar measurements. Proper Orthogonal Decomposition (POD) technique has been used to treat the data. Results show a correlation between the water vapor modes and the turbulent flow field modes, a sign that turbulence might not be as random as we thought. Further, the turbulent spectra has been recomposed with the projection of POD modes back into the original signal, allowing to better understand the influence of these coherent structures into the turbulent energy cascade.
The size and distribution of the measured structures overlaps with the spectral region modeled by means of the Large Eddy Simulations subgrid-stress (SGS). In the present study, the role and relevance of these coherent structures into the subgrid-stress will be presented.