From Large Eddy Simulations to Experimental field work, Wind Energy and the Atmospheric Boundary Layer in a Nutshell.

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Over the last decade, an increasing concern regarding the extensive usage of fossil fuels and its related emission of greenhouse gasses has encouraged society on developing newer and cleaner energy harvesting technologies such as wind or solar power. For wind energy to be a profitable source of energy, large extensions of wind turbines (so called wind farms) must be built, where massive extraction of energy from the atmospheric boundary layer flow takes place at an advantageous rate. Large Eddy Simulations (LES) has become an incredibly useful tool when studying such complex systems, either to improve energy harvesting from the wind or when trying to better understand the bi-directional relationship between wind turbines and the atmospheric boundary layer (ABL). Some recent studies (Baidya-Roy et al. 2004, Baidya-Roy et al. 2010, Baidya-Roy et al. 2011, Calaf et al. 2010, Calaf et al. 2011, Porté-Agel 2011) have shown that large wind farms change the scalar and momentum fluxes close to the surface. Understanding how the momentum fluxes are modified will help us design better and more efficient wind farms. And computing the net effect on scalar fluxes will allow us to better asses the effect of wind farms into the land-atmosphere evapo-transpiration processes, so important on irrigated farmlands.

Large eddy simulations exist since 1963, when Smagorinsky presented his seminal paper in the Monthly Weather Review journal. Since then, much research has been developed in order to get reliable ABL numerical simulations, specially focusing on how to improve the so important Subgrid-Stress model. Unfortunately, the surface boundary conditions have been left almost unchanged, becoming at present one of the main sources of error (Hultmark et al. 2013- under review). Further experimental work is needed in order to develop new surface boundary conditions especially in complex terrain such as mountain slopes or surface roughness changes. This being a fundamental issue also for wind energy forecasting.

In this presentation, a recent field experiment carried over lake Leman (in Switzerland in winter 2012) by means of Wind LiDar technology will be presented. A spectral analysis on the flow field close to the surface is carried out, and compared to a realistic LES simulation. Results will be presented in the context of wind energy and its interaction with the atmospheric boundary layer, especially when placed in complex terrain.