

Environmental Measurement : the help of hydraulic simulation

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The large water flume of Météo-France is a channel built in 1982 ; it was originally designed to provide realistic simulations of atmospheric boundary layer flows. Since the beginning of the project, the study of stably stratified flows was already planned, that is why it includes a unique three-layer flow design, each one stabilized in velocity as well as in density (Figure 1). Density gradient is obtained by adjusting a mix of clear water and brines of sodium chloride (NaCl). The large dimensions of this facility (30m*3m*1,60m) allow to perform similarities with a high Reynolds number, using water instead of air like it would be in a classical wind tunnel. Thus, a fully turbulent flow can be obtained, even in parts of the model where the stream gets slower.

Constant improvements in the infrastructure and associated measurement devices, made it evolve to a facility for research in geophysical fluids including atmospheric and oceanic flows. A very significant fact is its adaptation to the « towing tank » mode, which allows to produce stably stratified gradients, within or without a mixing layer to reproduce a typical temperature inversion. In this case, fluid is still and the model is moved through the channel, supported by a trolley pulled by a motion controlled system. Sensors and data acquisition systems are also embedded.

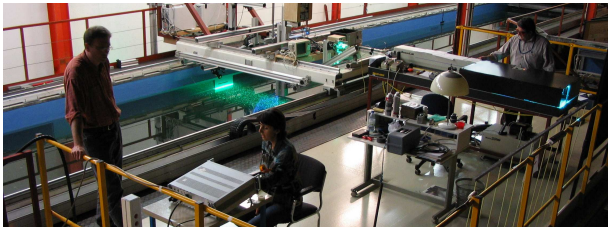


Figure 2 – The channel with its measurement trolley

Wake of a GSM mast

Similarity between criteria for environment of antennas for cell phone networks and for meteorological measurement sites, sometimes lead mobile phone operators to choose sites near meteorological observation sites. Mast heights up to 45m are very frequent, and there are often questions about their influence on the wind measurements, on a 10m-height mast. A model of such typical GSM mast has been built, and its wake visualised in a vertical plan, parallel to the flow ; visualisations have also been made in horizontal plans at various heights, including one corresponding to 10m at the actual size Velocity measurements in the flow have been made by the mean of Laser Doppler Velocimetry (LDV) at that height, onto lines perpendicular to the flow, at various distances downstream the mast. It could be shown a wake, thin and intense, drastically different from the one classically expected when the mast is modelled by a full-cylindrical shape

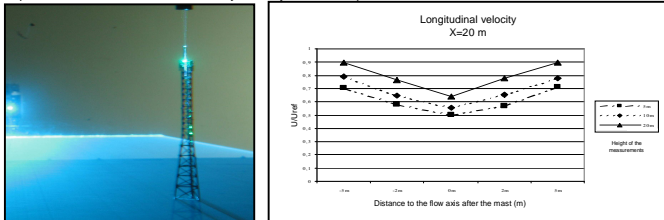


Figure 5 – Laser tomography of the vertical wake of a 45m « cell-phone » mast (left), and horizontal profile of longitudinal and normalised velocities on a line perpendicular to the flow at heights of 5m, 10m et 20m (right).

Exposure of meteorological sensors on board the oceanographic vessel « L'Atalante » (AMMA experiment)

French laboratory CETP has developed a platform to perform flux measurements during the AMMA experiment. This platform, put on the front mast of the « Atalante » bears in particular two classical anemometers (Young) and a sonic one, which measurements have to be corrected from the modifications of the field of wind, mainly due to the ship itself and to the mast and platform. Laser Doppler Velocimetry measurements (LDV) made twice in our flume, first before AMMA then, after it because of unexpected wind conditions met during the experiment, permitted to qualify differences between wind conditions where the sensors were, and at a reference point at the same height as the platform but 60m upstream from the previous one. Various wind azimuths, as well as various roll and pitch attitudes have been simulated. Some visualisations were also made, to describe the flow at the front of the « Atalante », into parallel plans containing the sensors.

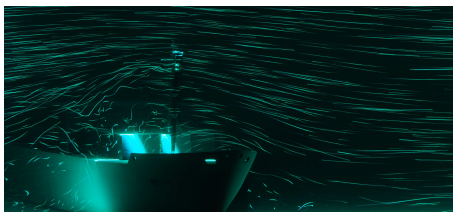


Figure 6 – Laser tomography of the current by port (ie left) 67,5°

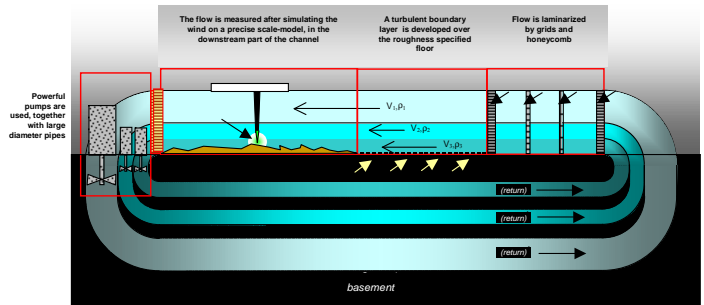


Figure 1 – Simplified plan of the channel in its flume configuration

Windfarm potential in Tahiti

One of the most recent applied studies concerned the island of Tahiti, about local electric power production : a descriptive study of the wind potential has been made to know more about the type of flow on precise zones, where wind farms were projected. A model at the scale of 1/20 000th was put in the channel, with various angular positions in the flow, to reproduce the effect of wind for some directions of the trade winds. Visualisation techniques using a laser sheet, and LDV wind measurements (on horizontal and vertical profiles) were used in this expertise.

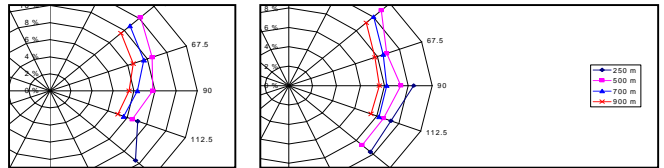


Figure 3 – Intensity of turbulence by direction and by altitude in Tautira (left) and on the sea (right)

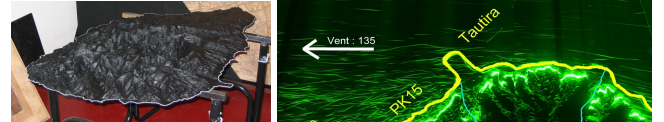


Figure 4 – The Tahiti model (left) and an example of wake in the horizontal plan (right)

Development of neutral boundary layers over a rough surface

PhD thesis of Séverine Tomas (under direction of Olivier Eiff and Valéry Masson)

During a thesis made in CNRM, simulations in the flume of the development of neutral and rough boundary layers were performed, in order to initialize and validate numerical simulations of boundary layer simulations by 1D version of the MESO-NH model (collaboration with CNRM/GMME/TURBAU team). Developments and transitions of boundary layers were not always properly reproduced by this model. These inaccuracies are attributed to the parametrization in the mixing length, as well to the anisotropy of turbulence which is not taken into account. In the flume experiments, average and turbulent quantities of the neutral boundary layers, developed after a roughness change, were measured by Particle Image Velocimetry (PIV). Fluxes and speed RMS were measured in a vertical plan and permitted to evaluate the terms of dynamic production, as well as the longitudinal and vertical gradients of the average and turbulent quantities (fluxes, RMS and 3rd order moments). PIV measurements also allowed to quantify integral spatial scales and, thus, to estimate the mixing and dissipation lengths. One of the main interests of this experimental study was to propose a parametrization of the mixing length, adapted to the neutral case.

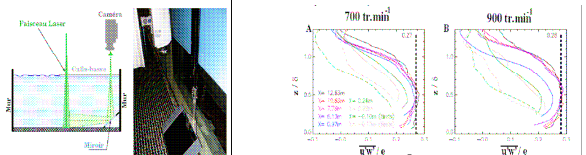


Figure 7 – (left) : experimental installation with fast camera, mirrors and lego® bricks for roughness ; (right) profiles of the ratios and of the average values of the turbulent fluxes, in the layer external to balance (black dashed line) at 700 et 900 rpm (i.e. tr.mn-1)

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