## SCOLARSHIP NO. 1

Task E of Project. CFD simulations

Thanks to several distributed sensors the wind monitoring network realized for previous European Projects provides a fine description of the local time structure of downbursts and, at LiDAR sites, also of their vertical profile. However, this is not enough to derive a detailed description of the space structure of a phenomenon that runs out in a few kilometers in the horizontal and in a few hundred meters in the vertical.

CFD simulations are fundamental tools to fill the gap represented by local and sparse field measurements. CFD has been applied for full-cloud, sub-cloud and impinging wall jet models. The full-cloud model offers a comprehensive representation of the phenomenon but fails in allowing a fine resolution close to the ground. Thus, wind engineering usually adopts the sub-cloud and impinging jet models making recourse to unsteady RANS and LES. URANS suffer from the inherent modelling of Reynolds stresses and their results in terms of turbulence are essentially ensemble-averaged; LES resolves the large scales while modelling the small ones but it is numerically very demanding at the spatial scale related to downbursts. The use of LES in sub-cloud models is far from being well-established.

The wind monitoring network realized for previous European Projects and the co-operation with the Eindhoven University of Technology (TU/e) and its well-known research group in CFD create unique conditions to carry out a frontier research that may contribute to remove many shortcomings and to produce clear indications on the best CFD tools that provide suitable estimates of the slowly-varying mean speed and turbulence field. It is planned that analyses will be carried out by sub-cloud and impinging wall jet models using RANS and LES. Special attention will be devoted to imposing realistic boundary conditions. Results will be processed by signal analyses. Field data and possibly wind tunnel tests will be used as reference data and as bases to build downburst models.

Co-tutoring Agreement and Joint Ph.D.

There is a longstanding collaboration between the University of Genoa (UNIGE) and the Urban Physics and Wind Engineering Research group (www.urbanphysics.net) at TU/e, a world leading authority in CFD. UNIGE and TU/e recently signed a co-operation agreement for the international co-tutoring of PhD students in the field of CFD simulations. It is planned that this Ph.D. position is co-tutored by UNIGE and TU/e and a joint double Ph.D. is awarded.

## SCOLARSHIP NO. 2

Task F of Project. Weather scenarios

There is a persisting large gap between research in atmospheric sciences, mainly focused on the genesis and life-cycle of thunderstorms, and in wind engineering, which analyses velocity measures aiming to develop thunderstorm models for actions on structures. The wind monitoring network realized for previous European Projects and the co-operation with Freie Universität Berlin (FUB), Germany and its research group in meteorology and severe storms are unique conditions to fill this gap and to share expertise between atmospheric sciences and wind engineering.

Starting from field data, extensive information will be gathered during thunderstorm events, e.g. those provided by Global Forecast System (GFS), Meteosat Second Generation (MSG) geostationary satellites, Radar Doppler, lightning and thunderstorm networks. In addition to the open data that can be downloaded from Internet, co-operation agreements will be made with specific institutions. The joint analysis of the whole of this information will be used to study and classify weather scenarios in which thunderstorms occur, pursuing the attempt to link weather conditions and wind speed records. Special attention will be given to the difference between dry and wet downbursts.

Results will be applied to calibrate some criteria developed to separate intense wind events, to develop research in downburst forecasting, and to formulate probabilistic models and simulation techniques that take into account the relationships between downbursts and their synoptic scenarios.

Task G of Project. Damage survey

Two previous European Projects arose from the frequent disasters (fatalities and injuries of people, collapse of cranes and other structures, stacked container overturning, accidents during the entry of ships in ports) and malfunction (paralysis of cities, closure of ports, suspension or deferral of activities) caused by windstorms in High Tyrrhenian Sea ports. The monitoring network generated by these projects is producing a huge amount of wind data that will be used to trace damage and losses due to major storms, separating the consequences of cyclones from those of thunderstorms. Analyses of the weather scenarios in which the most striking events occurred will be carried out.

Thanks to the involvement of FUB and of the European Severe Storm Laboratory (ESSL) similar studies will be made on sample areas of Italy and Europe to classify intense wind events and to quantify their effects depending on whether they are synoptic cyclones or mesoscale thunderstorms.

Co-tutoring Agreement and Joint Ph.D.

To establish a new fruitful collaboration between the University of Genoa (UNIGE) the Institut für Meteorologie of FUB (http://www.geo.fu-berlin.de/en/met/index.html), UNIGE and FUB plan to sign an agreement for international research co-operation aiming to fill the gap between wind engineering and atmospheric sciences. It is planned that this Ph.D. position is co-tutored by UNIGE and FUB and a joint double Ph.D. is awarded.

## SCOLARSHIP NO. 3

This scholarship is aimed at investigating one or two among the following topics.

Task K of Project. Thunderstorm simulation

While there is an extensive literature on the short-term (S-T, about 10-min) Monte Carlo (MC) simulation of stationary and non-stationary random fields, the literature on long-term (L-T) MC simulation of synthetic records (thousands of years) is vast for extra-tropical and tropical cyclones whereas very few preliminary papers exist on downbursts. This task of the project aims to create a pair of S-T and L-T simulators of thunderstorms nested the one inside the other.

The L-T simulator aims at generating synthetic series of downbursts consistent with the joint distribution of their parameters (frequency, position, downdraft diameter, direction, translational speed, intensity, ...). The S-T simulator may be based on the hybrid strategy introduced by the research group at the University of Genoa or on any other approach, provided its consistency with measurements.

Task M of Project. Dynamic response

There is an extensive literature on the dynamic response to thunderstorms. It includes the study of elementary systems based on time-domain solutions, evolutionary spectra, wavelet transforms and advanced methods, like methods that couple CFD and FEM to analyze real structures. All these methods suffer the drawback of exporting complex models to engineering practice, of solving equations numerically and, above all, the lack of measurements that support theory. This project pursues the development of 3 complementary methods – time-domain simulations and integrations of the equations of motion, response spectrum technique, and evolutionary spectral density - based on robust theoretical bases and on extensive field measurements. Each method aims at providing the wind-excited response and consistent equivalent static wind loadings.

Task N of Project. Wind loading

The wind loading on structures is usually evaluated through 5 steps: 1) cyclones and thunderstorms are separated; 2) the extreme distribution of each phenomenon is determined; 3) such distributions are joined in a mixed one; 4) design wind speed is obtained for any design return period; 5) lacking suitable methods for thunderstorms, wind loading is evaluated by classical method for cyclones. This is at odds with the awareness that the design wind speed is often due to thunderstorm outflows and they have different properties from cyclones.

A new 4-step approach will be set in this project. The first 2 steps are the same as the above ones. The following 2 steps apply, separately, to cyclones and thunderstorms; for each of these: 3) design wind speed is determined for any design return period; 4) wind loading is evaluated by distinct methods for cyclones and thunderstorms, so separating the classical unique wind loading into two distinct loading conditions. Accordingly, a novel set of partial and combination factors have to be investigated for thunderstorms.