PhD Session 2022

Milan, September 04th 2022

organized by

ANIV-G

together with In-Vento2022 Conference

inVento

ANIV-G

ANIV-G is the group of young researchers within ANIV. Its goal is to promote cooperation in the Wind Engineering discipline, ease the exchange of ideas, support the spreading of knowledge, and favor contamination with other scientific communities. The group is open to students, PhDs, researchers, and practitioners who are interested in deepening their knowledge, sharing their experience and contributing to the development of Wind Engineering. Not limited to ANIV members and no membership fees required, ANIV-G is devoted to young researchers actively working in an Italian company or institution, or who has obtained a Ph.D. in an Italian university.

PHD SESSION 2022

During congresses it is usually very hard to convey to the public the complexity of the research performed during a Ph.D. Within the IN-VENTO2022 Conference, ANIV-G is thus organizing an informal session specially dedicated to the dissemination of the research performed by young members which are completing their last year or just obtained their Ph.D. The spirit of this session is to learn about each other's research projects and encouraging collaboration. The Ph.D. session is open also to other attendees of the In-Vento2022 Conference.

The 2022 edition foresees a 3-minute presentation from each participant to showcase his/her Ph.D. research. The audience will be then asked to vote for the best presentation based on clarity, quality of supporting material and respect for the time available. Finally, the top three qualified will be awarded the opportunity to present exhaustively their research with a longer presentation (approx. 30 minutes).

GENERAL PROGRAM

The ANIV-G events will be on September 04th. The general program is organized as follows:

10:30 – 12:00	ANIV-G Meeting
12:00 – 14:00	Light lunch
14:00 – 15:00	PhD Session: 3min presentations
15:00 – 16:30	PhD Session: top 3 qualified extended presentations

AFFILIATIONS OF SPEAKERS

UNIVERSITÀ DEGLI STUDI DI GENOVA

POLITECNICO MILANO 1863

National Technical University of Athens

LIÈGE université

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DETAILED PROGRAM

Hao-Yu Bin - *University of Genova*

Aerodynamic behavior of square cylinders under transient conditions typical of thunderstorm outflow

Federico Canepa - *University of Genova*

Towards a thorough experimental model of downburst winds

Alessandro Fontanella – *Politecnico di Milano*

Understanding the aerodynamic response of floating turbines with hybrid wind tunnel experiments

Mekdes Mengistu - *University of Genova*

The study of the dynamic response of a lighting pole during a downburst through full-scale wind and structural response monitoring

Paraskevi Modé - *National Technical University of Athens*

Deep Learning-based high wind speed prediction using weather historical data

Andrea Orlando - *University of Genova*

Full-scale monitoring of the wind-induced response of vertical slender structures

Giulia Pomaranzi – *Politecnico di Milano*

A new methodology for the assessment of the wind effects on Permeable Double Skin Façades

François Rigo – *University of Liege*

Parameter identification of generalized Vortex Induced Vibration model

Luca Roncallo – *University of Genova*

Evolutionary spectral model for thunderstorm outflows and application to the analysis of the dynamic response of structures

Federico Taruffi – *Politecnico di Milano*

Design and experimental testing of a large-scale wind turbine model installed on a floating structure

Domenico Toscano – *University of Naples Federico II*

Assessment of the impact of gaseous ship emissions in ports using physical and numerical models The case of Naples

Aandi Xhelaj – *University of Genova*

Downburst Wind Field Reconstruction by means of a 2D Analytical Model and Investigation of the Parameter's Variability through an Ensemble Approach

Josip Žužul – *University of Genova*

Characterization of thunderstorm downburst winds through CFD technique

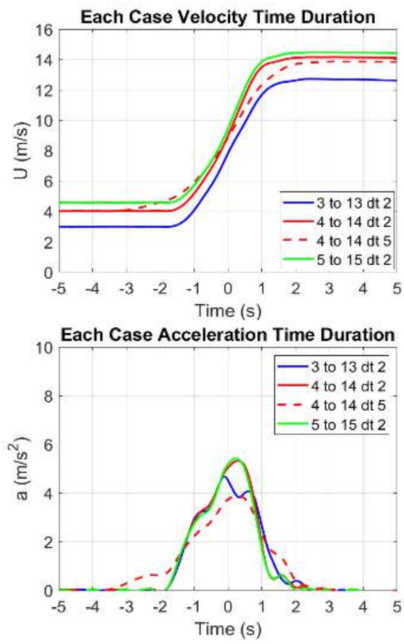
ABSTRACTS

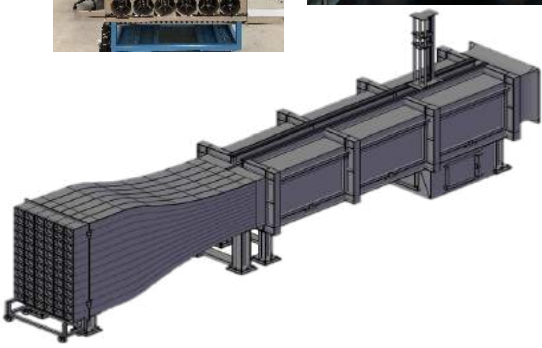
Hao-Yu Bin

University of Genova

Aerodynamic behavior of square cylinders under transient conditions typical of thunderstorm outflows

Starting from the extensive previous research performed by the Wind Engineering research group of the University of Genoa (https://www.gs-windyn.it/) regarding thunderstorm outflows, this PhD Thesis investigates the topic of transient aerodynamics on bluff body through an experimental approach. This is mainly done concerning the two peculiar aspects of thunderstorm outflows, namely the transient wind velocity and the transient angle of attack. These features will be separately implemented in the wind tunnel to study discrepancies between the quasi-steady theory and the transient conditions. This research will take advantage of the traditional closed-circuit wind tunnel of the University of Genoa, as well as of the multiple fans wind tunnel (MFWT) at Tamkang University, which is perfect to simulate accelerating and decelerating flows. Moreover, a research period abroad is planned in the new multi-fan wind tunnel of the University at Buffalo. General aim of the PhD research is to combine developed theories with experiments, hoping to derive a general formulation based on the findings of the aerodynamics and aeroelastic effects. It is expected that the above results can be used as a reference for wind load design in engineering applications.

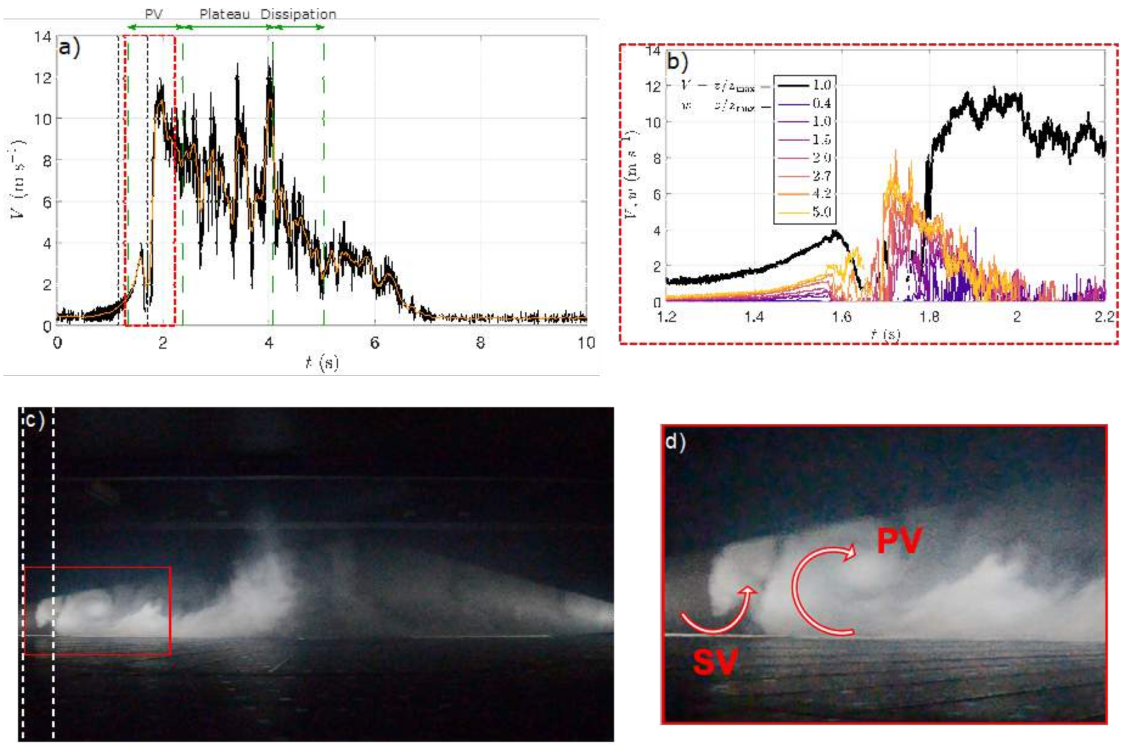




Federico Canepa
University of Genova

Towards a thorough experimental model of downburst winds

Downbursts develop from thunderstorm clouds as downdraft of cold air that spreads out radially upon impingement on the ground. A thorough experimental campaign on downburst winds was recently carried out at the WindEEE Dome, at Western University in Canada, a novel, three-dimensional (3D) and large-scale wind simulator. The research project aims to quantitively investigate the interplay between the main individual flow components that form the final downburst outflow reading at the recording station. The WindEEE Dome has the unique capability of reproducing the three components of the downburst system – (i) isolated downburst in the form of an impinging jet, (ii) background Atmospheric Boundary Layer (ABL) flow, (iii) thunderstorm cloud translation – independently and simultaneously at large geometric scales. This overcomes the shortcomings of the anemometric reading in nature where the final record loses evidence of the quantitative role played by each component. The analyses carried out returned understandings of the PV dynamics as developing from the different flow interactions, the dynamical behavior of the front between downburst and ABL winds as well as the effect of the parent cloud translation. The talk will shortly show the important role of WindEEE Dome towards the formation of a thorough experimental downburst model and implementation into the design codes.



Canepa et al. (2022)

Alessandro Fontanella

Politecnico di Milano

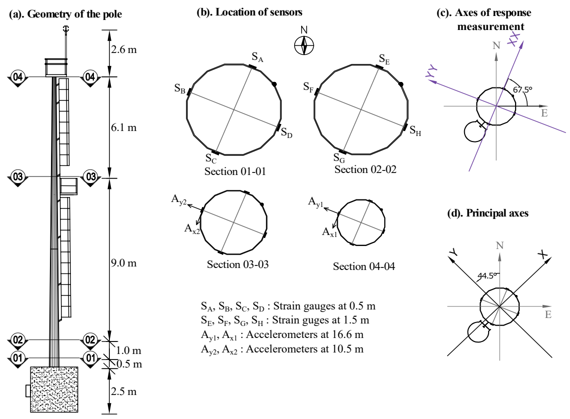
Understanding the aerodynamic response of floating turbines with hybrid wind tunnel experiments

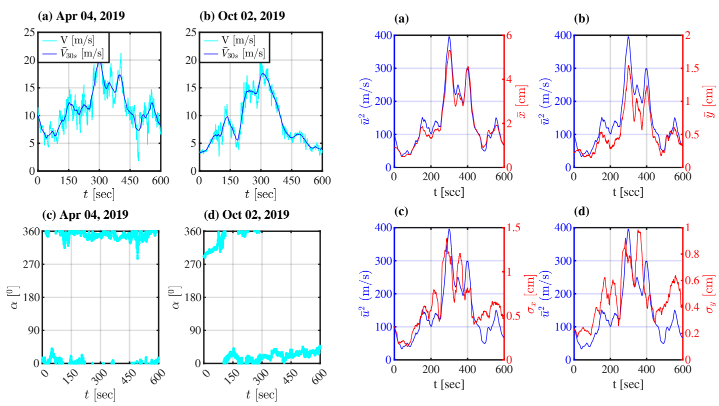
The aerodynamics of floating turbines is complicated by large motions permitted by the floating foundation and for this reason the interaction between turbine, atmospheric wind and wake is not yet fully understood. The goal of my research is to characterize the aerodynamic response of a large wind turbine as it experiences large rigid-body motions as would occur during normal operation. In the experiment, the turbine is reproduced with a high-fidelity scale model, featuring realistic control capabilities. The floating support platform, the hydrodynamic excitation, and the motion of the structure are simulated with a 6-degrees-of-freedom robotic platform. A variety of operating conditions is considered, ranging from imposed sinusoidal motion in different directions to normal sea states. The main outputs of the experiment are rotor forces and the wind speed in the turbine wake. Measurements collected in wind tunnel testing are utilized to shed light on the physics of the energy-conversion process for floating wind turbines, and to validate the accuracy of aerodynamic load predictions by offshore wind modeling tools.

Mekdes Mengistu
University of Genova

The study of the dynamic response of a lighting pole during a downburst through full-scale wind and structural response monitoring

Wind excited response of structures due to downbursts has been studied using wind tunnel simulations, computational fluid dynamics applications, and analytical procedures in the previous two decades. However, the studies have not been validated with full-scale wind and structural measurements. To fill this research gap, continuous wind and structural monitoring of three slender structures were implemented through the European research council-funded project, THUNDERR. This presentation focuses on one of the three monitored structures describing the monitoring system, the dynamic properties of the structure, and the registered data during two downburst events. The response of the structure during the two case studies of downburst events has been calculated using the time domain procedure and two selected analytical methods for validation with the response registered by the structural response monitoring system. The possibility of obtaining both the quasi-steady and resonant components of the response from strain gauge registrations and the structural simplicity of the selected structure was a major success in the study because it enabled validations of analytical methods of downburst wind load calculations.





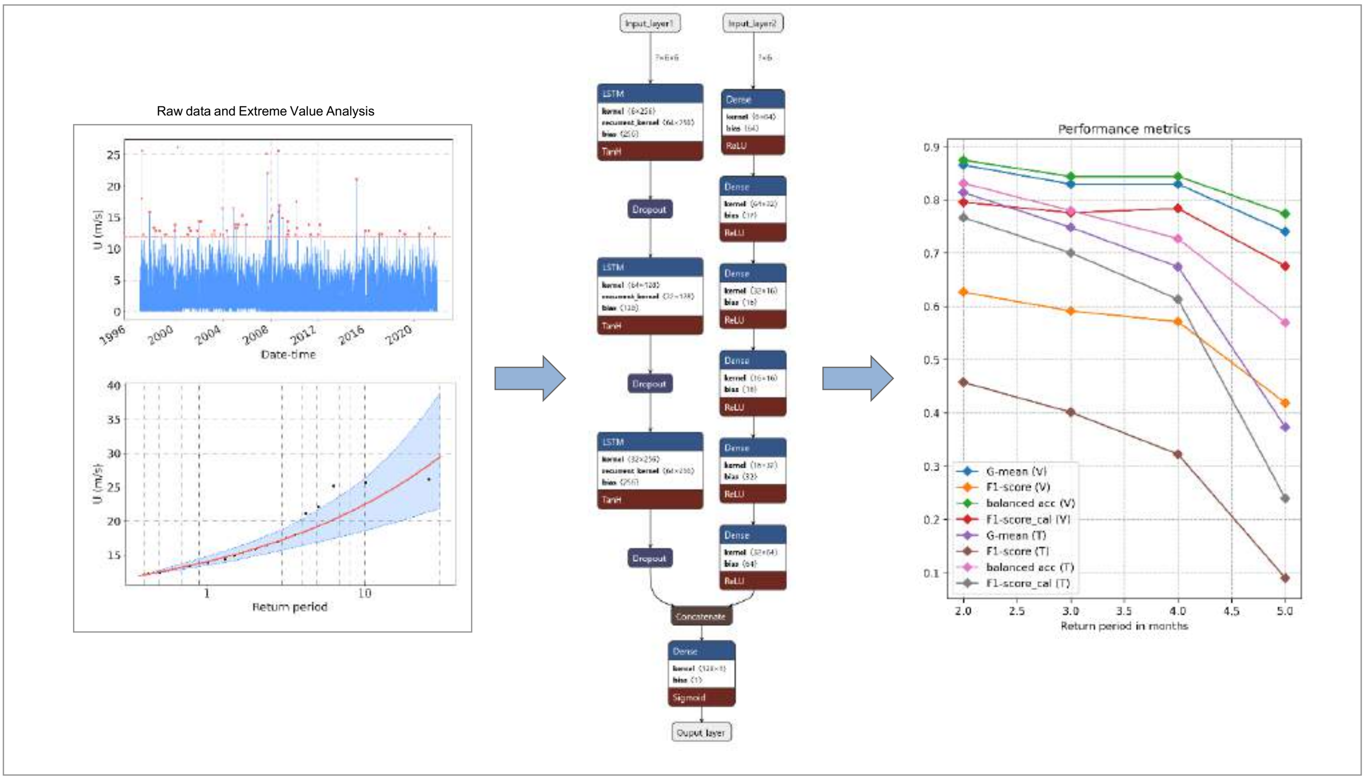
Paraskevi Modé

NTUA – National Technical University of Athens

Deep Learning-based high wind speed prediction using weather historical data

In the current work, the focus lays on the nowcast of maximum wind values in a specific location using historical weather data from the same location to produce accurate, in-time predictions. Little research has been conducted around this topic, while the real-time/monitoring wind engineering applications are numerous.

The model's topology used is a combination of an adaption of two common architectures. A simple Long Short-Term Memory (LSTM) sequential model is working in parallel with an adaption of an Autoencoder Artificial Neural Network (ANN) architecture. In that way, the new topology can benefit from both parallel architectures. A case study of openly available weather data taken from Florence's Peretola Airport is discussed to evaluate the performance of the model. The maximum wind speeds (starting from the upper limit of fresh breeze up to strong breeze) are denoted by classes that are defined in terms of a certain exceedance of return period (or exceedance frequency) based on a model of the extremes calibrated using the Peak Over Threshold (POT) method. The DL model was optimized using a trade-off between false alarms and missed alarms. The classification problem is highly imbalanced and the influence of the ratio of the maximum wind class in the performance is particularly discussed.



Flowchart of the predictive methodology

Andrea Orlando
University of Genoa

Full-scale monitoring of the wind-induced responseof vertical slender structures

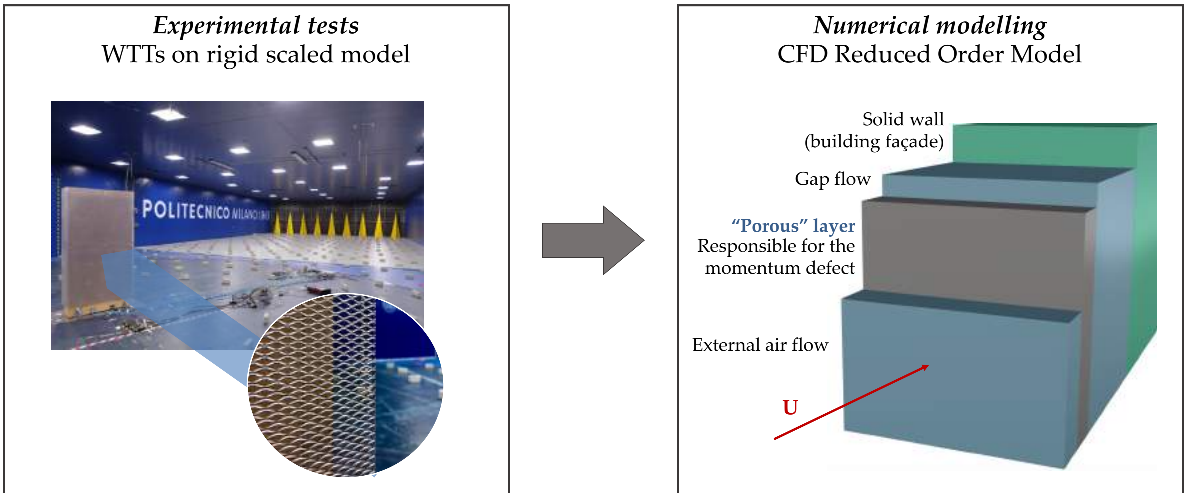
The behavior of slender structures subject to wind action is well established in the scientific literature. However, the practical application of current methods involves uncertainties that can strongly affect the final calculation. Indeed, the implementation of these models in the design stage requires the knowledge of several parameters characterizing the structure, whose evaluation is very delicate and awkward. Full-scale measurements are therefore a fundamental tool for many reasons: from one hand, they supply direct information on structural response that can be used as input in the calculation models; from the other, they represent a benchmark against which loading and response models can be compared and calibrated.

Starting from these premises, the present study develops a comprehensive structural-monitoring procedure tailored for the full-scale investigation of the wind-induced response of vertical slender structures. The defined procedure finds application in the monitoring campaign of two real structures: a small wind turbine and a lighting tower, equipped with accelerometers and strain gauges. Outcomes of the monitoring activity are used to assess the capability of simplified calculation models from literature of predicting the actual wind-induced response of vertical slender structures, and to evaluate the propagation of uncertainties due to the parameters involved in the calculation.

Giulia Pomaranzi
Politecnico di Milano

A new methodology for the assessment of the wind effects on Permeable Double Skin Façades

Nowadays the energy efficiency represents a key issue in the building façade design. This has led to the development of cladding system that may help to reduce the energy demand of the structure, such as the Permeable Double Skin Façade (PDSF). As far as wind loading assessment is concerned, the multi-scale nature of the problem, dictated by the large geometrical scale separation between the porous façade openings and the overall building size, poses several challenges that have been still very little investigated so far.
Experimental tests based on wind tunnel tests allows putting light on the potentialities coming from the adoption of a PDSF, mainly represented by a reduction of design pressure for the inner façade if compared to the single façade case. On the other hand, some intrinsic limitations of a purely experimental approach, essentially due to the representation of the porous façade in the scaled model, have been highlighted. To overcome them, a reduced-order model able to fully represent the aerodynamic behaviour of the PDSF is implemented in the CFD framework through the porous media approach, allowing it to describe the complex aerodynamics of the outer façade, with no geometrical modelling in the computational domain.



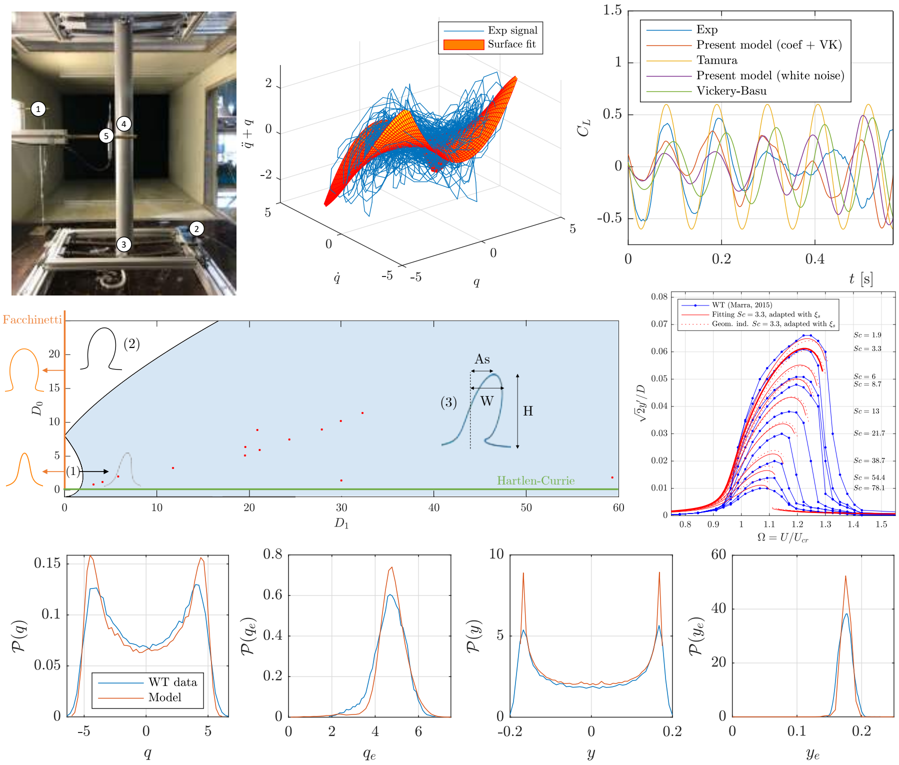
The new methodology for the PDSF – wind interaction problem: experimental and numerical methods.

François Rigo

University of Liège

Parameter identification of generalized Vortex Induced Vibration model

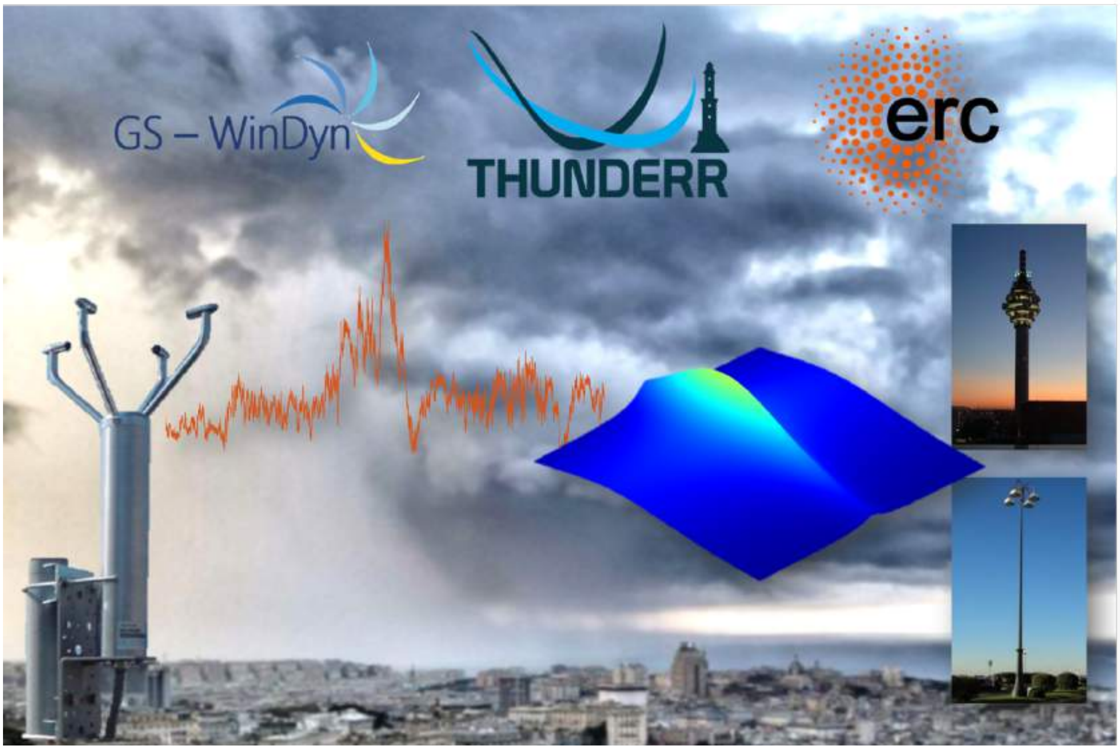
This work proposes a generalized model for Vortex-Induced Vibration (VIV) of a cylinder. It is the step following the proposed generalized vortex shedding model (Rigo, 2022) for a static cylinder, based on a non-linear fluid equation combining all third order terms with coefficients identified from experimental lift force data. The stochasticity observed in lift force measurement is reproduced using an exogenous noise, whose parameters are adjusted in a second step. The present study extends the parameter identification of the vortex shedding model with a direct identification of all parameters based on the lift force statistics. The methodology is then extended to identify parameters of the VIV model (fluid and structure coupled equations), using statistics of both degrees of freedom. A multiple timescale analysis of the dimensionless version of the wake-oscillator model shows that the response is governed by two dimensionless groups, highlighting the importance of the forcing terms in the two governing equations, in addition to the exogeneous noise from wake turbulence. Applying this methodology to wind tunnel measurements (lift force and structural displacement) gives promising results. The model is sufficiently versatile to estimate the maximum amplitude and lock-in range. The identified parameters can then be used in a prediction phase.



Luca Roncallo
University of Genova

Evolutionary spectral model for thunderstorm outflows and application to the analysis of the dynamic response of structures

Thunderstorms are destructive phenomena at the mesoscale with extension of few kilometres and short duration, potentially dangerous for mid-low structures. The nonstationary nature of the wind field generated by thunderstorm outflows makes most of the theory and models developed for extra- tropical cyclones unsuitable and their small extension make them difficult to be detected by one single anemometer. These circumstances prevent the collection of precious data over which research can be carried out and the development of robust models for the structural design shared by the scientific community. Therefore, a unified and reliable analytical model for the assessment of the wind loading and maximum dynamic response of structures to thunderstorms, coherent with the techniques commonly adopted in wind engineering, is not yet available. In this framework, my Ph.D. thesis introduces an evolutionary power spectral density model of the wind velocity related to thunderstorm outflows, consistent with full-scale records, and studies its application to calculate the alongwind dynamic response of structures and its maximum from an operative perspective, generalizing the Davenport gust factor technique to thunderstorm outflows and providing a closed-form solution suitable for rapid engineering calculations.



Federico Taruffi

Politecnico di Milano

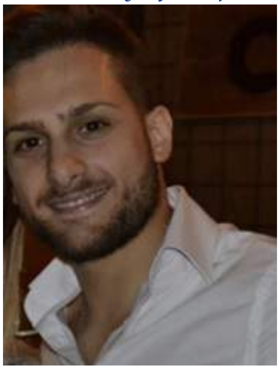
Design and experimental testing of a large-scale wind turbine model installed on a floating structure

Floating Offshore Wind Turbines (FOWTs) are recognized both by academia and industry as the key technology to exploit the high-quality wind resource available far from coastal areas. Installing a FOWT on a multi-purpose platform (MPP) instead of a traditional floater can bring further advantages. Considering the MPPs low TRL and high complexity, model testing is of fundamental importance: large scale models deployed in a natural outdoor environment are a valid complement in understanding the real features of the system and in validating numerical codes.

In this scenario, The Blue Growth Farm project aims at developing an offshore farm that combines aquaculture with wave energy converters and a wind turbine. The development of the MPP concept is going to be supported by experimental data collected on a 1:15 model deployed at the Natural Ocean Engineering Laboratory (NOEL) in Reggio Calabria (Italy). The present work focuses on the design, testing and validation of a large-scale wind turbine model, based on the DTU 10MW reference wind turbine, installed on the scaled MPP. The first step in the experimental testing is the validation of the model itself to assess that the physical model is well respecting the properties requested in the design phase.

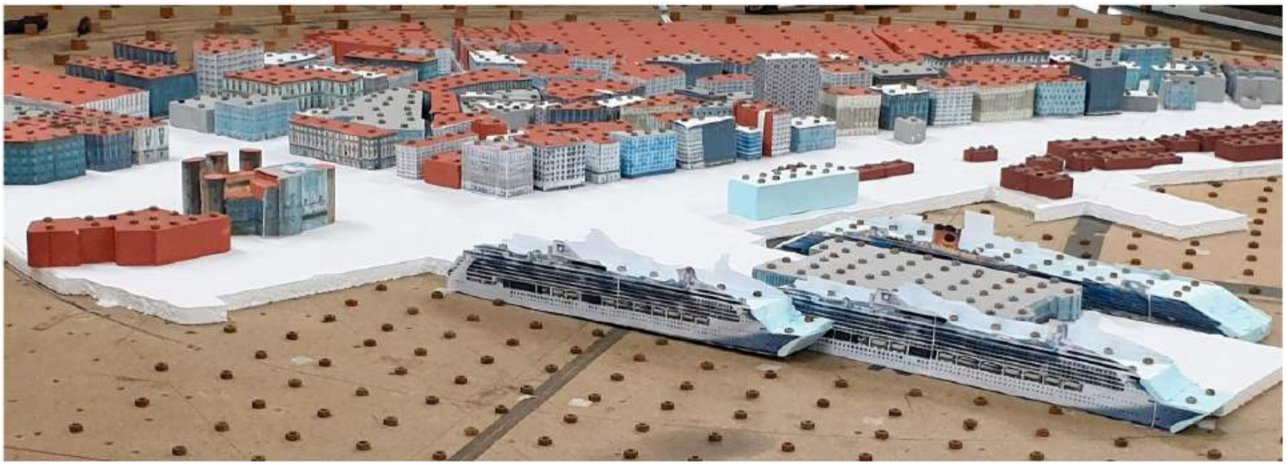
The large-scale wind turbine model installed on the multi-purpose platform and deployed in front of NOEL laboratory (Reggio Calabria, Italy) for the experimental campaign of "The Blue Growth Farm" EU H2020 project.

Domenico Toscano
University of Naples Federico II



Assessment of the impact of gaseous ship emissions in ports using physical and numerical models The case of Naples

My Ph.D. research focuses on the assess of the impact of ship emissions in the port of Naples in 2018. The first issue analysed is the validation and the optimization of CALPUFF model when used to simulate the dispersion of the ship emissions in a port. With this aim wind tunnel tests and CFD simulations were used to model the dispersion of atmospheric emissions of cruise ships at hoteling in the port of Naples. A part of the Naples urban area large about 1.2 km2 was reproduced at a scale of 1:500 for the wind tunnel experiments. The emission scenario with three cruise ships emitting at the same time and wind blowing from the south-east with a speed at funnel height of 3 m/s in neutral stability conditions of the atmospheric boundary layer was studied. Two different values of the ratio funnel gas velocity/wind speed were considered. The dispersion of ship emissions in the same area was also studied by CFD simulations using steady-state solutions of the RANS equations with a k-ω SST turbulence model. Once verified and optimized the accuracy of CALPUFFF simulations, the complete emission inventory developed for the port of Naples was used as input to CALPUFF together with meteorological data in order to assess the impact of ship emissions.



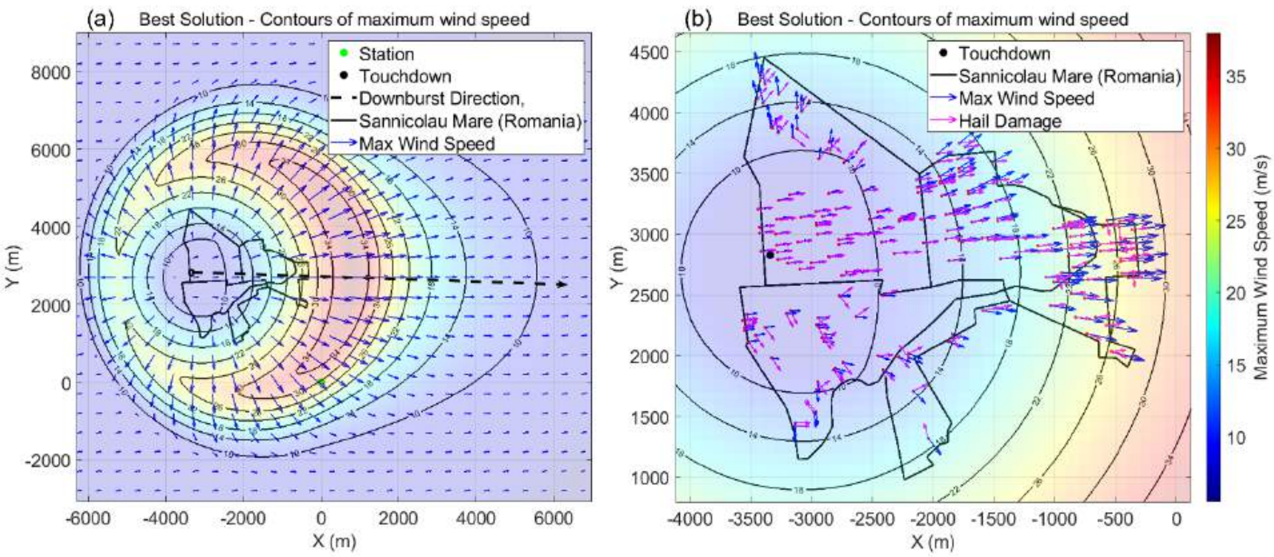
The reduced-scale physical model of the port of Naples realized in the wind tunnel

Andi Xhelaj

University of Genova

Downburst Wind Field Reconstruction by means of a 2D Analytical Model and Investigation of the Parameter's Variability through an Ensemble Approach

A "downburst" is defined as a diverging wind system that occurs when a strong downdraft induces an outflow of damaging winds on or near the ground. Severe wind damage in many parts of the world are often due to thunderstorm outflows and their knowledge is therefore relevant for structural safety. An analytical model that simulates the horizontal mean wind velocity originated from a travelling downburst is proposed. The horizontal wind velocity is expressed as the vector summation of three independent components: the stationary radial velocity, the downdraft translating velocity, and the boundary layer background wind field where the downburst is immersed. Two metaheuristic optimization algorithms are used to reconstruct the space-time evolution of downburst events starting from recorded anemometric data of wind speed and direction. The proposed model coupled with the metaheuristic Teaching Learning Based Optimization algorithm was validated against a strong downburst event that took place in Sânnicolau Mare (Romania) during the summer of 2021. Investigation of downburst parameter variability is assessed by means of a Principal Component Analysis and Cluster Analysis. Results of parameter variability confirms that the best overall solution for downburst reconstruction is the one that minimizes the objective function defined by the optimization procedure.



(a) Example of simulated damage footprint for the Sânnicolau Mare Downburst (2021).
(b) Comparison between hail damage and maximum simulated wind speed during the passage of the downburst event.

Josip Žužul

University of Genova

Characterization of thunderstorm downburst winds through CFD technique

The characteristic wind field of a certain region is mostly governed by the climatology of its larger-scale area. In the case of mid-latitude regions, the climatology is determined by the extra-tropical cyclones at the larger synoptic scale. Atmospheric boundary layer (ABL) winds based on synoptic-scale flow structures are hence considered the foundation for codes and standards used to assess the wind loading to design structures and to prevent wind-related damage. In addition to the ABL winds, the mid-latitude regions are also prone to winds of a non-synoptic origin at the mesoscale level, with thunderstorm outflows or downbursts being the representative of such non-synoptic wind action. Since they are determined by a set of features (ring vortices) that make them fundamentally different from the ABL winds, downbursts can produce the corresponding wind action that is often fatal to low-rise and mid-rise structures. This work therefore aims to address the behavior and especially the physical characteristics of severe downburst-producing winds with the particular emphasis on their underlying flow features through the usage of Computational Fluid Dynamics (CFD) technique. In that perspective, two common downburst scenarios were analyzed: (i) an isolated downburst, and (ii) a downburst immersed in an ABL wind.