# Dr. Bernat Font

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## Research interests

computational fluid dynamics; turbulence modelling; machine learning and data-driven models; numerical methods; high-performance computing.

## Experience

**Assistant Professor**, Ship hydromechanics, Technische Universiteit Delft, The Netherlands. 2024–

*Focus*: Data exploitation to improve current CFD methodologies, i.e. data-informed CFD. Current projects involve:

- ☐ Acceleration of scale-resolving simulations using generative methods
- ☐ Data-driven wall models for equilibrium and non-equilibrium boundary layers
- ☐ Active flow control using reinforcement learning
- ☐ Discovery of governing equations from raw data
- ☐ Pressure solver acceleration in unstructured grids

**Postdoctoral Researcher**, Large-scale Computational Fluid Dynamics Group, Barcelona Supercomputing Center, Spain. 2021–2023

*Topics*:

- ☐ NextSim EU project – Next generation of industrial aerodynamic simulation code
- ☐ Machine learning for CFD: wall models and active flow control
- ☐ Turbulence modelling in high-order scale-resolving simulations

**Postdoctoral Researcher**, Mathematical Institute, Oxford University, UK. 2020–2021

*Topic*: Transport of porous particles in fluid flow.

**Visiting PhD Researcher**, Institute of High-Performance Computing, A*STAR, Singapore. 2017–2020

## Education

**Ph.D.** Computational Fluid Dynamics, University of Southampton, UK. 2015–2020

*Thesis*: Modelling of Flow Past Long Cylindrical Structures. (eprint)

*Supervisors*: Prof. G.D. Weymouth, Prof. O.R. Tutty, Dr. V.-T. Nguyen.

*Visiting Researcher*: Research attachment funded by the ARAP mobility scheme, Institute of High-Performance Computing, A*STAR, Singapore.

**M.Sc.** Computational Fluid Dynamics, Cranfield University, UK. 2014–2015

*Thesis*: High-order Shock-capturing Schemes for Micro Shock Tubes. (eprint)

*Supervisor*: Dr. L. Könözsy.

*Double Degree with Ingeniería Superior in Aeronautical Engineering.*

**Ingeniería Superior** Aeronautical Engineering, Universitat Politècnica de Catalunya, Spain. 2012–2015

*Mentor*: Prof. C.-D. Pérez-Segarra.

*Equivalent to Master of Engineering.*

**Ingeniería Técnica** Aeronautical Engineering, Universitat Politècnica de Catalunya, Spain. 2009–2012
*Equivalent to Bachelor of Engineering.*

## Publications

### Peer-reviewed journal articles

3. Varela, P., Suárez, P., Alcántara-Ávila, F., Miró, A., Rabault, J., Font, B., García-Cuevas, L., Lehmkuhl, O., & Vinuesa, R. (2022). Deep reinforcement learning for flow control exploits different physics for increasing reynolds number regimes. *Actuators*, 11(12). (doi)
2. Font, B., Weymouth, G., Nguyen, V.-T., & Tutty, O. (2021). Deep learning of the spanwise-averaged Navier–Stokes equations. *Journal of Computational Physics*, 434, 110199. (doi, eprint)
1. Font, B., Weymouth, G., Nguyen, V.-T., & Tutty, O. (2019b). Span effect on the turbulence nature of flow past a circular cylinder. *Journal of Fluid Mechanics*, 878, 306–323. (doi, eprint)

### Peer-reviewed symposium proceedings

2. Radhakrishnan, S., Gyamfi, L., Miró, A., Font, B., Calafell, J., & Lehmkuhl, O. (2021). A data-driven wall-shear stress model for les using gradient boosted decision trees. In *ISC High Performance Computing Conference* (pp. 105–121): Springer International Publishing. (doi, eprint)
1. Font, B., Weymouth, G., Nguyen, V.-T., & Tutty, O. (2020). Turbulent wake predictions using deep convolutional neural networks. In *33rd Symposium on Naval Hydrodynamics*: Office of Naval Research, US. (eprint)

### Conference proceedings

2. Suárez, P., Alcántara-Ávila, F., Miró, A., Rabault, J., Font, B., Lehmkuhl, O., & Vinuesa, R. (2023a). Active flow control for three-dimensional cylinders through deep reinforcement learning. In *14th International ERCOFTAC Symposium on Engineering, Turbulence, Modelling and Measurements*. (eprint)
1. Font, B., Weymouth, G., & Tutty, O. (2017). Analysis of two-dimensional and three-dimensional wakes of long circular cylinders. In *OCEANS 2017 - Aberdeen*: IEEE. (doi, eprint)

### Conference abstracts

12. Cabral, M., Font, B., & Weymouth, G. (2023). The effect of physical constraints on the loss function landscapes of deep learning. In *76th APS Division of Fluid Dynamics Meeting Abstracts, Washington DC (US)*. (url)
11. Alcántara-Ávila, F., Font, B., Rabault, J., & Lehmkuhl, R. V. O. (2023a). Deep reinforcement learning for active separation control in a turbulent boundary layer. In *76th APS Division of Fluid Dynamics Meeting Abstracts, Washington DC (US)*. (url)
10. Weymouth, G. & Font, B. (2023a). Waterlily: A fast differentiable CPU/GPU flow simulator in Julia. In *76th APS Division of Fluid Dynamics Meeting Abstracts, Washington DC (US)*. (url)
9. Weymouth, G. & Font, B. (2023b). Waterlily.jl: A differentiable fluid simulator in Julia with fast heterogeneous execution. In *ParCFD 2023, Cuenca (Ecuador)*. (eprint)
8. Font, B., Miró, A., & Lehmkuhl, O. (2023). On the entropy-viscosity method for flux reconstruction. In *2nd Spanish Fluid Mechanics Conference, Barcelona (Spain)*
7. Alcántara-Ávila, F., Sanchis, M., Gasparino, L., Muela, J., Font, B., Rabault, J., Lehmkuhl, O., & Vinuesa, R. (2023b). Separation control in adverse-pressure-gradient turbulent boundary layers. In *European Turbulence Conference 18th, Valencia (Spain)*
6. Suárez, P., Alcántara-Ávila, F., Miró, A., Rabault, J., Font, B., Lehmkuhl, O., & Vinuesa, R. (2023b). Active flow control on three-dimensional cylinders through deep reinforcement learning. In *First International Conference Math 2 Product, Taormina (Italy)*
5. Font, B., Naddei, F., & Lehmkuhl, O. (2022a). Progress in high-order large-eddy simulation of aeronautical flows using the integral-length scale approximation turbulence model. In *3rd High-Fidelity Industrial LES/DNS Symposium, Brussels (Belgium)*
4. Font, B., Naddei, F., & Lehmkuhl, O. (2022b). Turbulence models assessment using finite-volume and high-order methods for aeronautical applications. In *ECCOMAS Congress 2022, Oslo (Norway)*
3. Font, B., Weymouth, G., Nguyen, V.-T., & Tutty, O. (2019a). Deep learning the spanwise-averaged wake of a circular cylinder. In *72nd APS Division of Fluid Dynamics Meeting Abstracts, Seattle (US)* (pp. L17–005). (url)

2. Font, B., Weymouth, G., Nguyen, V.-T., & Tutty, O. (2019c). Turbulence dynamics transition of flow past a circular cylinder and the prediction of vortex-induced forces. In *17th European Turbulence Conference, Torino (Italy)*. (eprint)
1. Font, B., Weymouth, G., & Tutty, O. (2016). A two-dimensional model for three-dimensional symmetric flows. In *UK Fluids Conference, London (UK)*. (eprint)

### Invited Talks

9. (2023). Julia for HPC course, High Performance Computing Center Stuttgart (HLRS), Germany
8. (2021a). PPPL Computer Science Department's Machine Learning seminar, Princeton University, US
7. (2021b). Engineering Mind Podcast. (url)
6. (2021c). Applied Mathematics in Aerospace Engineering seminar, Universidad Politecnica de Madrid, Spain
5. (2021d). Applied Math Colloquium, University North Carolina, US
4. (2021e). Ocean Engineering, University Rhode Island, US
3. (2020a). Fluid Dynamics Group at the Institute of High Performance Computing (A*STAR), Singapore
2. (2020b). Fluid Structure Interactions Group Seminar series, University of Southampton, UK
1. (2017). Fluid Structure Interactions Group Seminar series, University of Southampton, UK

### Student supervision

Mentored and supervised students at different stages of their educational program such as Undergraduate students, MSc students, and most recently a PhD student. As a mentor, the goal is to motivate students to pursue an interesting scientific topic while providing guidance throughout the process of learning and achieving. The supervision involves regular meetings to assess their progress, and answering technical questions when needed.

#### PhD students

☐ Physics-based machine learning of marine hydrodynamics, TU Delft 2023–

#### MSc projects

☐ Machine learning wall model for bluff bodies forces calculation, University of Southampton 2019–2019

☐ Accurate flow interpolation using optimal transport theory, University of Southampton 2018

#### Undergraduate projects

☐ Discovering new scaling laws in turbulent boundary layers via multi-expression programming, Universitat Politècnica de Catalunya (url) 2021

☐ Discovering new expressions for the vortex trajectories and velocity profiles of synthetic jets, Universitat Politècnica de Catalunya (url) 2021

### Teaching

Served as demonstrator and marker of multiple modules during my PhD. Tasks involved preparing and delivering the laboratory sessions which included a theory part and an experimental part. Additionally, served as lecturer of the BSC summer school on AI and HPC delivering a lecture on AI for CFD.

Lecturer at the PUMPS+AI Summer School, Barcelona Supercomputing Center 2022

☐ Machine learning for computational fluid dynamics (url)

Demonstrator, University of Southampton 2015–2017

☐ Aerodynamics: Nozzle lab

☐ Propulsion: Ramjet, turbojet and rocket engine labs

☐ Aerothermodynamics: Marking of lab reports

### Software skills

**Programming languages**: Fortran (including MPI), Julia, Python (including PyTorch, Keras, and Tensorflow), C, Java, Matlab.

**Tools**: Git, LaTeX, Inkscape, Paraview.

**Selection of popular repositories**:

- ☐ `WaterLily.jl` (co-developer): Fast CFD Julia solver based in the finite-volume and immersed boundary methods with backend-agnostic execution (CPU and GPU).
- ☐ `SANSpy`: Spanwise-averaged Navier–Stokes modelling through convolutional neural networks.
- ☐ `f2py-sockets`: Data transfer from Fortran to Python and viceversa using sockets.
- ☐ `Flower1D`: Flux reconstruction fluid flow solver for 1D PDEs written in Julia.
- ☐ `nuatsbot`: Technical analysis trading bot.

### Open science statement

I advocate for open science. Most of my papers have an e-print version that can be downloaded for free either on arXiv or my website. The codes I write are also open-source, and you can find them in my Github repository.

### References

Gabriel D. Weymouth, Professor of Ship Hydromechanics.
TU Delft, Netherlands.
Relation: PhD supervisor.
g.d.weymouth@tudelft.nl

Oriol Lehmkuhl, Leading Researcher of the Large-scale CFD group.
Barcelona Supercomputing Center, Spain.
Relation: Current research group principal investigator.
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