

Preface

This book is about turbulence in incompressible fluids.

We have asked people in the street what the word “turbulence” means for them. One woman replied: “Turbulence makes me think of the sea, because it makes one feel what is invisible, what cannot be predicted.” More generally, people answered giving only one word, such as disorder, aircraft, clouds, weather forecast, power, and chemistry. Therefore, turbulence is something that anyone has experienced in one way or another. Mathematicians will answer that turbulence is about fluids, mixing, chaos, and connected scales. It may be a source of inspiration for painters or poets. One may attempt to control it for technological progress. It is however a source of concern because of its impact on environment and human life, the most critical environmental challenge being climate change.

Although understanding turbulence is of primary importance, there is no mathematical definition of it, and many physical mechanisms governing turbulent motions remain unknown. One could say that there is a chance for mankind to understand quantum physics someday, but not turbulence. Nevertheless, it is possible to simulate by means of computers some features of turbulent motions: weather forecasts are rather accurate over 5 days, the mean Gulf Stream path can be calculated, numerical flow simulations around an aircraft wing are in good agreement with experimental data, etc. All these numerical simulations are performed by means of “turbulence models.”

Turbulence models aim to simulate statistical means of turbulent flows or some of their scales. It is however estimated that an accurate computation of all scales of such flows will be possible only by the end of the twenty-first century, if the improvement of the computational resources continues at the same rate.

We do not pretend to give a definition of what turbulence is. Our goal is to provide a comprehensive and innovative presentation of turbulence models, at the crossroads of modeling and mathematical and numerical analysis, including all these aspects in one single book, in complementarity with the other reference manuals in the field.

This book is the synthesis of almost 20 years of thoughts and works about turbulence models, through the meeting of a mathematician with a numerical analyst, leading to a long-term collaboration and friendship. This resulted in

several joint research works, which gave us the opportunity to check that the complementarity of these specialities can be quite fruitful. Finally, it led us to the project of jointly writing a book from a comprehensive point of view on one of the most challenging scientific problems, as is the understanding of turbulence: we deliver here what we are able to understand from turbulence.

In mathematics, authors are always listed in alphabetical order, which is the case of this book.

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