

Preface

This book series is a collection of the main contributions from the first five workshops held by Ercoftac Special Interest Group on Synthetic Turbulence Models (SIG42), a summary of each workshop can be found in Ercoftac Bulletin [1, 12–15]. It is intended as an illustration of the sig's activities and of the latest developments in the field.

Synthetic turbulence can be traced back to [14], in which diffusion was simulated on a one dimensional grid with a random velocity field. Kraichnan [13] continued with a random flow field in three dimensions, and constructed incompressible fields as an isotropically random sum of unsteady Fourier waves with distributed frequencies.

Most of the applications really started with what was to be called Kinematic Simulation (KS) [8]. Kinematic simulation are perhaps the best known of the synthetic turbulence models. They are based on a simplified incompressible velocity field which kinematically simulates the Eulerian velocity field and is generated as a sum of random incompressible Fourier modes with a given wavenumber-energy spectrum.

More generally by synthetic turbulence models we mean Lagrangian models for turbulent diffusion which simulate Lagrangian statistics based on an underlying (synthesized) Eulerian field. These models were not intended as a simulation of the Eulerian field per se, but only of the Lagrangian statistics that would arise from the underlying Eulerian field. Synthetic turbulence has been used as an approach to understand the general mechanisms of turbulent diffusion, but also to make quantitative predictions of relative dispersion and higher order statistical moments.

Predictions of Eulerian statistics, however, are not outside the remit of KS. For instance, it is possible to incorporate linear dynamics, or 'Rapid Distortion Theory' operators in each KS realization. In addition to the effects of waves and related phase-mixing, in connection with anisotropic Lagrangian diffusion, unstable cases with mean shear flows can also be investigated, with approach to, e.g., the baroclinic instability [16]. Eulerian structures can naturally emerge as well in KS realizations, by prescribing anisotropic spectra, as illustrated in rotating and MHD turbulence. A recent breakthrough was made with inhomogeneous turbulence, with appearance of realistic streaklike elongated structures in a synthetic 3D channel flow [3].

While remaining as simple a model as possible, synthetic turbulence models are expected to capture the essence rather than the details of the bigger picture. Synthesized turbulent flows contain less information than the real flow, but by keeping only what we choose, we can better see what matters for what.

Further to their interest for fundamental understanding, synthetic turbulence models have now moved from simple to more complex flows, some are discussed in contributions herein, KS for stratified and rotating flows [2], turbulent flow in channel [3] and even quantum turbulence [10]. They are also now moving to more practical grounds as subgrid models [6, 8] or bench mark models for comparisons [9]. Because synthetic models give access to two-time two-point, Eulerian or Lagrangian, statistics, they are also relevant for the prediction of the far-field radiated noise in aeroacoustics, using for example an acoustic analogy [4, 5].

Further to Synthetic turbulence the workshop had contributions that advanced our general knowledge of turbulence and dispersion some have been included in the present book series.

Nine contributions have been selected for this book:

The first one, by D. Kivotides, presents the impact of KS on quantum turbulence theory.

The second, by H.W. Zheng *et al.*, and the third, by T. Michelitsch *et al.* explicitly address the fractal concept, which is often implicit in KS when prescribing spectra. This aspect is illustrated by DES for a pipe flow with a fractal orifice in the former paper, and by the generation of a vibration spectrum of a self-similar chain in the latter.

The fourth paper, by F. Nicolleau and A. Abou El-Azm Aly, investigates the KS capability to predict the Richardson regime.

The fifth contribution, by C. Cambon *et al.*, gives a survey of incorporating linear dynamics and strong anisotropy in KS, with application to rotating, stratified and MHD turbulence, and to aeroacoustics.

The sixth one, by S.C. Kassinos and E. Akylas, reports a specific way to incorporate RDT in a synthetic model: The ‘Particle Representation Model’. In addition, an interacting viscoelastic IPRM model is developed for nonlinear dynamics.

The next two papers are not directly linked to KS, but their content was presented and discussed within SIG42’s workshops. The seventh contribution, by H.W. Zheng *et al.*, is ‘Oscillation-free adaptive simulation of compressible two-fluid flows with different types of equations of state.’ The eighth contribution, by F. Ghangir and A.F. Nowakowski, is on ‘Computing the evolution of interfaces using multi-component flow equations.’

Finally, the ninth and last paper, by C.A. Klettner *et al.* on ‘The effect of turbulence on the spreading of infectious airborne droplets in hospitals’ presents a practical application of KS.

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