EXPLOITATION OF HOMOGENEOUS ISOTROPIC TURBULENCE MODELS FOR OPTIMIZATION OF TURBULENCE REMOTE SENSING

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Abstract Homogeneous isotropic turbulence (HIT) models are compared, with respect to optimization of turbulence remote sensing. HIT models have different applications such as load calculation for wind turbines (Mann, 1998) or droplet track modelling (Pinsky and Khain, 2006). Details of vortices seem of less relevance for modelling 'realistic measurements', where the single purpose is to retrieve the eddy dissipation rate (EDR). Without the need for modelling the vortices, a faster and simpler approach might be favorable. The cascade turbulence model (CTM) is suggested. The CTM solution is scale invariant and a fast solution for one-dimensional HIT modelling. In this presentation modelled radar measruments for scanning mode (rotating antenna) are compared for different HIT models. The consequences for turbulence remote sensing optimization are discussed.

INTRODUCTION

Aviation has an increasing interest in monitoring the local wind and turbulence fields to enhance aviation safety and to increase the airport capacity. For this purpose the measurements of turbulence intensity, wake vortex detection and wake vortex monitoring are important. [1] The turbulence intensity is quantified by the eddy dissipation rate (EDR), and it is statistically represented by the turbulent energy spectrum of the velocities, known as the Kolmogorov -5/3 power law:

$$E(\kappa) = \quad C\epsilon^{2/3}\kappa^{-5/3}, \qquad (1)$$

where $\kappa = 2\pi/l$ is the wavenumber, with κ in the inertial range, l being the length scale, C is the universal Kolmogorov constant and ϵ is the eddy dissipation rate. Eq. 1 is used to obtain a formula that gives EDR as a function of the wind velocity variance or the wind velocity power spectrum. Alternatively, the second order structure function can be applied to wind velocities to obtain the EDR. At this time no generally accepted algorithm for EDR retrievals from experimental data exists. An EDR retrieval algorithm intended for turbulence warning and forecasting must be able to resolve (1) high-intensity values to avoid turbulence encounters and (2) low-intensity values that enhances the wake vortex lifetime. Comparisons of EDR retrievals by different instruments are made in several studies [6, 3, 5]. An essential problem with all these measurements is that there is no reference to true EDR. In this work EDR retrievals are comparatively studied by turbulence model experiments to understand the nature of their differences and to optimize turbulence remote sensing. This issue was investigated with the cascade turbulence model (CTM) [8, 7]. An overview of HIT models is given in Tab. 1. The general property is that the velocities satisfy to the Kolmogorv spectrum but the implementations differ. A different implementation can have a different correlation length for u in the transverse (e.g. y-) direction. Simulated measurements can be seen in Fig. 1. In this work the optimization of the radar turbulence intensity retrievals are studied using multiple homogeneous isotropic turbulence models.

Reference	Application	Features
Mann98 [4]	Load calculations on wind turbines and bridges	3D
CTM14 [8]	EDR retrievals	1D, scale symmetric
Pinsky06 [9]	Droplet tracks	2D
Careta93 [2]	-	2D

Table 1. Selection of homogeneous isotropic turbulence models.

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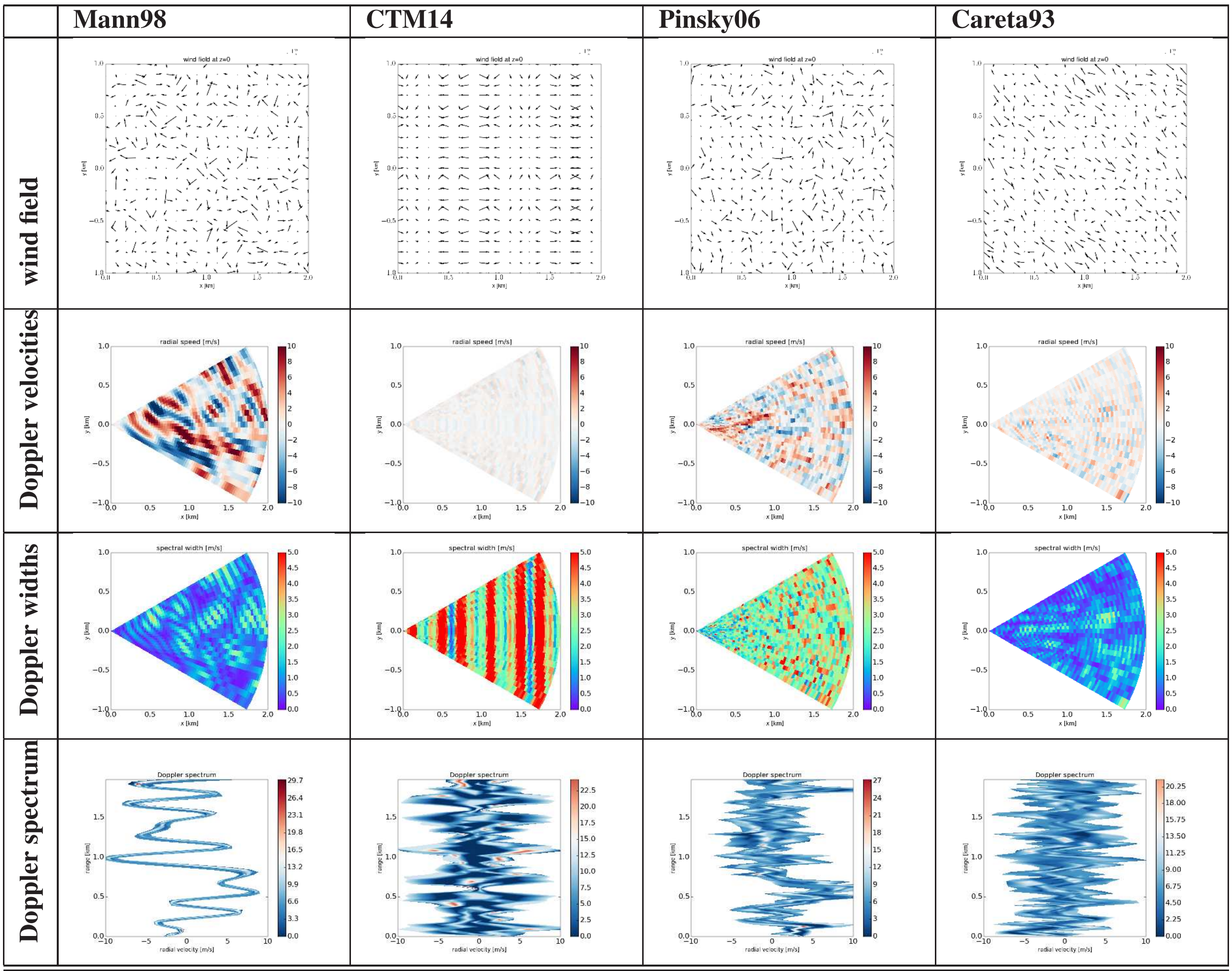

Figure 1. Overview of homogeneous isotropic turbulence models and simulated measurements. From top to down is plotted: the wind fields, the Doppler spectral mean velocties, the Doppler spectral width and the Doppler spectrum. From left to right the different models are used. The measurements have been simulated using Zephyros, which is a tool under development for simulation and retrieval of air dynamics (wind and turbulence). The range resolution of the radar is 30 m, and the full widht halve maximum (FWHM) is 2 degrees. Note: The figures are not reprentative for the final abstract version. Because of some remaining bugs, these figures have to be updated.