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Validation of a statistc algorithm applied to LES model - Part 1: First and second order statistcs

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Abstract

The main objective of this work is to develop a statistical algorithm to process the data generated by the Large-Eddy-Simulation model (LES) in real time. The simulations analyzed here were based on a convective, neutral and stable periods. Mainly the temperature and velocity components were analyzed. The new statistical algorithm generates all the first and second order statistic moments for "u,v,w,θ,q", and the components of TKE equation budget. All these parameters were developed to the resolved and sub-grid scales and indicate agreement with the expected profiles.

Resumo

O objetivo principal deste trabalho é desenvolver um algoritmo estatístico com o intuito de processar as saídas do modelo Large-Eddy-Simulation (LES) em tempo real. As simulações analisadas foram para os períodos convectivo, neutro e estável. Principalmente a temperatura a umidade específica e as componentes da velocidade serão analisadas. O novo algoritmo gera todos os momentos estatísticos de primeira e segunda ordem para "u,v,w,θ,q", e as componentes da equação do balanço de energia cinética turbulenta. Todos os parâmetros foram desenvolvidos para a escala resolvida e subgrade. Os perfis verticais para todas as variáveis foram reproduzidos com sucesso validando assim o algoritmo para estas configurações.

Introduction

Numerical modeling has been one of the most useful tools to understand the PBL behavior, Saiki, et.al. (2000). Large-Eddy Simulation models (LES) are the most advanced technique available to simulate turbulence. The LES code used in this work was proposed by Moeng

(1984) and improved by Sullivan, et.al. (1994), mainly in the 2-steps subgrid scheme. Understanding this kind of model, it is possible to simulate several conditions of the planetary boundary layer (PBL) over stable, neutral or convective situations. see Moeng, (1994) for a convective PBL, Saiki et.al. (2000) and Kosovic et.al. (2000) for neutral and stable cases.

The main objective of this work (part I) is to use the LES model to characterize the PBL first and second-order statistic moments in a convective, neutral and stable conditions, over a horizontally homogeneous domain. To accomplish that, a real time statistic algorithm was developed and implement inside the code to eliminate the post-processing. The part II of this work will discuss the TKE budget over the stable, neutral and convective cases.

Methodology

The computations presented here were performed on a 5x5x2Km domain for convective case and 1x1x1Km for the neutral and stable ones. All simulations use 96^3 grid points evenly spaced. More details about the simulations can be found in Moeng, et.al. (1994), for the convective case and in Saiki et.al. (2000) for the neutral and stable situations.

In the convective case, 2.5 hours of PBL was simulated. In the second one, a 3 hours neutral and 11 hours stable PBL were simulated sequentially. The computer processing time is respectively about 4.5 hours, 13 hours and 60 hours. All the numerical simulations were run using a DELL-R900 Intel 2-quad (8 cores total) 12 Gb RAM and 1.2 Tb HD.

The new algorithm implemented in the LES model consists in a real time TKE budget, momentum, humidity and temperature calculations. The horizontal fluxes and the characteristic scale time evolutions were implemented. All the improvements were developed to the sub grid scale too. It is important to say that the computation time did not grow with the new improvements in the code.

In this work an especial overview will be given to the temperature and velocity profiles and second-order statistics.

Results

The Figure 1 shows the mean temperature and velocity vertical profiles. The Figure 2 shows the second-order velocity, u and v components, and temperature vertical profiles, only for convective and stable cases.

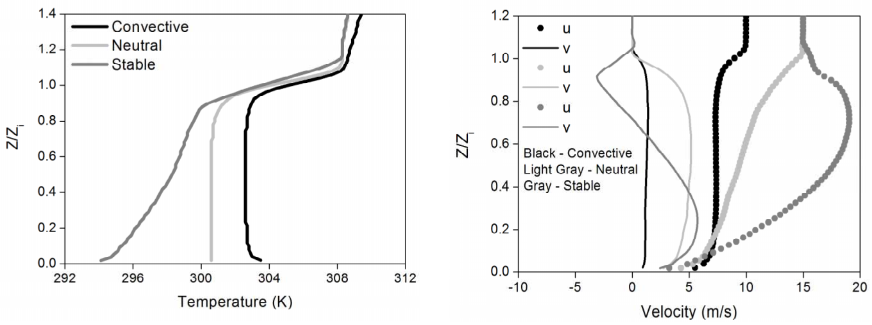

Figure 1. (a) Mean temperature vertical profile, convective (red), neutral (blue) and stable (black) simulations and (b) mean velocity vertical profile, convective, neutral and stable simulations. These results are displayed to the last simulation's time-step.

The temperature and velocity profiles presented in the figure 1 show agreement with the previous papers. The low level jet can be visualized in the figure 1b during the stable period. In the neutral situation the mixed layer can be visualized. The temperature inversion either can be observed. In the PBL top a strong <u'θ'> and <v'θ'> intensification can be observed in the convective case. This intensification cannot be observed in the stable profiles. The subgrid results are not significative in the horizontal statistics.

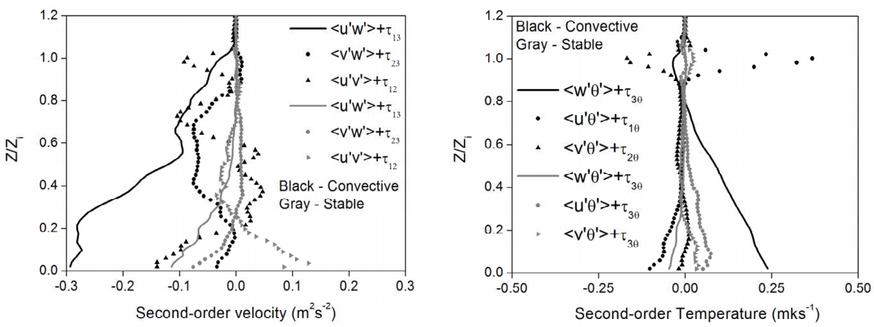

Figure 2. (a) Second-order velocity vertical profile, convective (red) and stable (black) cases and (b) second-order temperature profile, convective and stable cases. These results are displayed to the last simulation's time-step.

Conclusion

These results indicate that the statistic algorithm performs satisfactorily in all the PBL situations presented in this work. The results were compared with the original papers with agreement. The subgrid implementations show concordance with these articles ensuring the algorithm.

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