VALIDATION OF A STATISTIC ALGORITHM APPLIED TO LES MODEL - PART II: TKE VERTICAL PROFILE AND TKE BUDGET

Eduardo Wilde Bárbaro[1*], Amauri Pereira de Oliveira[2], Jacyra Soares.
[1,2,3] Institute of Astronomy, Geophysics and Atmospheric Sciences – University of São Paulo

ABSTRACT

The major objective of this study is to evaluate the turbulent kinetic energy (TKE) data generated by the Large-Eddy-Simulation model (LES) improved with a statistic algorithm developed to process in real time the LES outputs. The simulations analyzed here were based on a convective and stable periods. Mainly the TKE vertical profile and TKE budget were analyzed. All these parameters were developed to the resolved and sub-grid scale. The results indicate agreement with the expected profiles, mainly in the convective case.

RESUMO

O objetivo principal deste trabalho é avaliar os dados de energia cinética turbulenta (ECT) gerados pelo modelo Large-Eddy-Simulation (LES) com um algoritmo estatístico desenvolvido para processar em tempo real as saídas do modelo. As simulações analisadas foram para o período convectivo e estável. Principalmente a o perfil vertical de ECT e o balanço de ECT serão analisados. Todos os parâmetros foram desenvolvidos para a escala resolvida e subgrade. Os resultados indicam concordância com os perfis esperados, principalmente para o caso convectivo.

[1] BSc.Met (Sponsored by FAPESP # 2008/07532-0), Rua do Matão, 1226
Tel:(55-11)3091-4702, eduardo.barbaro@usp.br

INTRODUCTION

Turbulent kinetic energy (TKE) budgets are very important to understand the planetary boundary layer (PBL) physical process. Depending on the PBL's flow, e.g. stable, neutral or convective, the TKE budget behavior indicates the main process that is acting in the PBL. Following Lin, (2000) and Dwyer, (1997), despite the TKE budget has been exhaustively studied experimentally and numerically, many problems still remain in the TKE determination and inconsistencies has been founded by several authors, mainly in the transport and dissipation terms. Based on these facts, this work pretends to estimate the TKE budget using the Large-Eddy Simulation model (LES).

The main objective of this work is using LES to characterize the PBL's TKE budget and TKE vertical profile in convective and stable conditions, over a horizontally homogeneous domain.

METHODOLOGY

The computations presented here are equal to the part I of this paper. Equally, more details can be founded in Moeng, et.al. (1994), (convective case) and in Saiki et.al. (2000), (stable one). 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 were implement-ted and all the improvements were developed to the sub grid scale. In this work an especial overview will be given to the TKE budget and TKE vertical profile in a stable and convective PBL.

RESULTS

The figure 1 shows the TKE vertical profile for convective and stable conditions. The figure 2 shows the TKE budget profile for the same conditions. In figure I resolved and subgrid scales are presented separately.

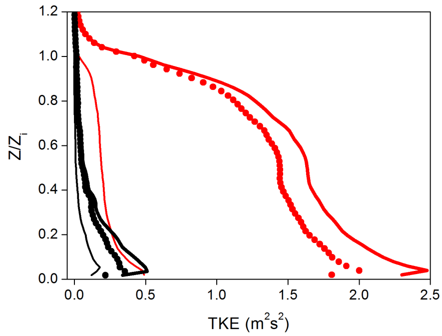

Figure 1: TKE vertical profile for convective (red) and stable (black) PBLs. Solid curves are for the total field; spheres are for the resolved scale and fine curves for the subgrid. These results are displayed to the last simulation's time-step.

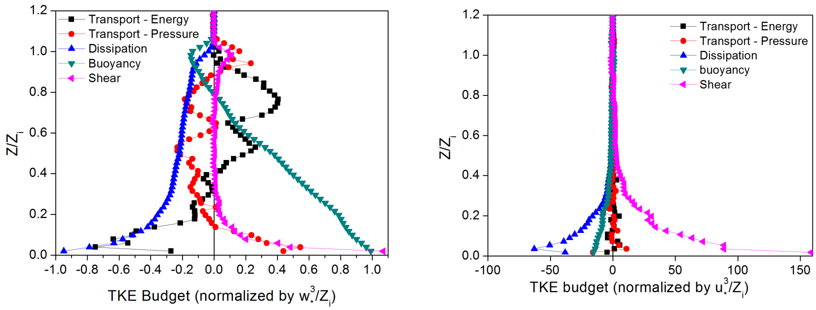

Figure 2: TKE budget. a) Convective PBL and (b) stable PBL. These results are displayed to the last simulation's time-step.

The figure I present the expected results for a TKE vertical evolution in both cases. For the stable case, a significant reduce in the TKE profile can be observed. The subgrid either presents a good agreement with the previous results, e.g. Moeng et.al. (1994).

Higher geostrophic winds and deeper stratification significantly increases the shear production, mainly in the lower PBL. The TKE budget seems to be very sensible to the surface heat flux decreasing, (stratification process). The buoyancy profile indicates agreement with the expected results, i.e. large and positive in the convective PBL and negative and less intense in the stable one. The transport term, split in energy and pressure parts, presents conformity with others authors in both cases, e.g. Moeng, et.al. (1994), Saiki, et.al. (2000) and Lin C-L, (2000). The total transport is negative in the lower PBL, (except in the first grid point, see Moeng, et.al. 1994 and Lin, 2000) and positive in the top. In the stable PBL it seems to be negligible, mainly the energy part. The pressure term presents positive values in the lower and upper PBL and the energy part presents the opposite profile. The dissipation term shows agreement with expected results mainly in the convective case. For the stable case the dissipation seems to be slightly underestimated.

CONCLUSION

The statistic algorithm performs adequately for the TKE budget, mainly in the convective case. In the stable one, the dissipation term needs to be investigated. The transport term (energy and pressure parts) and buoyancy indicate agreement with the previous papers. The shear term agrees in the convective case and slightly overestimates in the stable case.

BIBLIOGRAPHY

MOENG, C-H., SULLIVAN, P.P. A Comparison of shear- and buoyancy-driven Planetary Boundary Layers Flows, *Journal of Atmospheric Sciences* **51-7** 999-1022, 1994.

DWYER, J.D., PATTON, E.G., SHAW, R.H. Turbulent Kinetic Energy Budgets from a Large-Eddy Simulation of Airflow above and within a Forest Canopy, *Boundary-Layer Meteorology* **84** 23-43, 1997.

SAIKI, E.M., MOENG, C-H., SULLIVAN, P.P. Large-Eddy Simulation of the Stably Stratified Planetary Boundary Layer. *Boundary-Layer Meteorology* **95** 1-30, 2000.

LIN, C-L. Local Pressure-transport Structure in a Convective Atmospheric Boundary Layer. *Physics of Fluids* **12(5)** 1112-1128, 2000.