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TKE Budget in The Convective Martian PBL

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Abstract

Values for the different terms involved in the equation of the evolution of the Turbulent Kinetic Energy (TKE) will be derived in the Convective Planetary Boundary Layer of Mars. This will be done at the most convective hours (close to noon) both for the Surface Layer and for the Mixed Layer.

Data-inputs employed to perform this study belong to the Vikings and Pathfinder landing sites. Specifically, Sols 27, 28, and 35 for the Viking Lander 1, and Sols 20 and 25 for the Viking Lander 2 have been chosen, whereas for the Pathfinder site it has only been selected Sol 25. Hourly in situ temperature and hourly in situ horizontal wind speed have been used, as well as simulated ground temperature (obtained by a self-modification of [1]). These all correspond to typical low mid latitudes northern summer time conditions, and thus the results of this work are representative of such conditions.

1. Introduction

The equation that governs the evolution of the TKE

$$e = \frac{1}{2}(\sigma_u^2 + \sigma_v^2 + \sigma_w^2) \tag{1}$$

with the assumption of horizontal homogeneity and no subsidence, is written in the Reynold's average form as (see [2]):

$$\frac{\partial \overline{e}}{\partial t} = \frac{g}{\overline{\theta}_v}(\overline{w'\theta_v'}) - \overline{u'w'}\frac{\partial \overline{U}}{\partial z} - \\ -\frac{\partial \overline{w'e}}{\partial z} - \frac{1}{\overline{\rho}}\frac{\partial(\overline{w'p'})}{\partial z} - \epsilon \tag{2}$$

where the right-side terms correspond to buoyancy, shear, turbulent transport of TKE, pressure fluctuations, and dissipation, respectively.

As we have performed our calculations for northern summertime Sols, no baroclinic disturbances were present. In addition, Vikings and Pathfinder landing sites were moderately flat. Thus, the atmospheric horizontal homogeneity and the absence of subsidence needed to apply Eq. (2) is expected to be met.

2. TKE Budget for the Convective Surface Layer

Focusing on the Surface Layer at the strongest convective hours, and assuming the mean wind in the direction of the X-axis, we obtain that Eq. (2) transforms into:

$$\frac{\partial(\overline{\sigma_u^2} + \overline{\sigma_w^2})}{\partial t} = -\frac{g}{\overline{T_g}}u_* T_* + \frac{u_*^3\phi_m(z/L)}{kz} - \\ -\frac{\partial \overline{w'e}}{\partial z} - \frac{1}{\overline{\rho}}\frac{\partial(\overline{w'p'})}{\partial z} - \epsilon \tag{3}$$

where it has been taken into account the definition of the surface stress $u_* = -\overline{u'w'}$, that the kinematic heat flux at surface can be rewritten as $\overline{w'\theta_v'}_s = -u_* T_*$, and that $\frac{kz}{u_*}\frac{\partial U}{\partial z} = \phi_m(z/L)$ based on [3].

3. TKE Budget for the Convective Mixed Layer

For the Mixed Layer at the strongest convective hours, assuming the TKE nearly constant with height, that $\langle\overline{w'\theta_v'}\rangle \sim 0.2\langle\sigma_w\rangle\langle\sigma_\theta\rangle$ (see [4]), neglecting the shear of the horizontal mean wind $\partial\overline{U}/\partial z \simeq 0$, and that the mean wind is aligned to the X-axis, we find that Eq. (2) transforms into:

$$\frac{\partial(\langle\sigma_u^2\rangle + \langle\sigma_w^2\rangle)}{\partial t} = \frac{g}{\overline{\theta}}0.2\langle\sigma_w\rangle\langle\sigma_\theta\rangle - \\ -\langle\frac{\partial \overline{w'e}}{\partial z}\rangle - \langle\frac{1}{\overline{\rho}}\frac{\partial(\overline{w'p'})}{\partial z}\rangle - \langle\epsilon\rangle \tag{4}$$

where the signs $\langle\rangle$ denote average over the bulk of the Mixed Layer.

4. Objective

Many of the terms involved in Eqs. (3) and (4) have already been obtained in our previous works [5] and [6]. Our objective will be to determine values for each of the terms participating in Eqs. (3) and (4), and thus to elucidate the importance of each of them creating and destroying turbulence, both in the Martian Surface Layer and Mixed Layer at the most convective hours.

References

[1] Savijärvi, H., Määttänen, A., Kauhanen, J., and Harri, A.: New data and new model simulations, Quarterly Journal of the Royal Meteorological Society, Vol. 130, pp. 669-683, 2004.

[2] Stull, R.: An Introduction to Boundary Layer Meteorology, Springer, 1988.

[3] Monin, A. S., Obukhov, A. M.: Basic Laws of Turbulent Mixing in the Atmosphere Near the Ground, Trudy geofiz. inst., Vol. 24, pp. 163-187, 1954.

[4] Tennekes, H.: Free Convection in the Turbulent Ekman Layer of the Atmosphere. Journal of the Atmospheric Sciences, Vol 27, pp. 1027–1034, 1970.

[5] Martínez, G., Valero, F., Vázquez, L.: Characterization of the Martian Surface Layer. Journal of Atmospheric Sciences, Vol 66, pp. 187–198, 2009.

[6] Martínez, G., Valero, F., Vázquez, L.: Characterization of the Martian Surface Layer. Journal of Atmospheric Sciences, Vol 66, pp. 2044-2058, 2009.