

THE BEHAVIOUR OF SENSIBLE HEAT TURBULENT FLUX IN SYNOPTIC DISTURBANCE

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RESUMO: Este trabalho visa investigar o comportamento do fluxo turbulento de calor sensível no caso da passagem de um distúrbio sinótico na Região Metropolitana da Cidade de São Paulo. Os valores do fluxo turbulento foram calculados através do método de correlação dos vórtices, baseado nas medidas de turbulência realizadas pelo anemômetro sônico CSAT3 e com frequência de 10 Hz à 9 metros da superfície na plataforma micrometeorológica, localizada no topo do prédio do campus da Universidade de São Paulo durante 2010. Os resultados mostram uma forte correlação entre o fluxo turbulento de calor sensível e a radiação líquida indicando a nebulosidade como principal mecanismo responsável na redução causada pela passagem da frente fria na cidade de São Paulo.

ABSTRACT: This work aims to investigate the behavior of turbulent flux of sensible heat during the passage of synoptic disturbances in Metropolitan Area of São Paulo. Here turbulent fluxes are calculated by eddy covariance method based on measurements of turbulence carried out with a sonic anemometer CSAT3 and frequency of 10 Hz at 9 m above the surface of the micrometeorological platform located in the top of 4-store building in the University of São Paulo Campus during 2010. The results show a strong correlation between turbulent sensible heat fluxes and net radiation, indicating that cloud is the major mechanism controlling the reduction caused by the passage of cold fronts by the city of São Paulo.

1. INTRODUCTION

There are observational evidences that the metropolitan region of São Paulo City is capable to induce a Urban Heat Island (UHI) with maximum intensity varying from 2 °C to 6 °C and occurring during daytime (Ferreira et al, 2011). The seasonal variation of surface winds in the region of São Paulo is controlled by the position of South Atlantic anticyclone and the Continental Lower Pressure. The both systems combined induce winds during the summer N-NE and during the winter NE-E. This pattern is affected by synoptic systems such as a cold front and by the sea breeze circulation. In São Paulo City before the cold front wind is NW and after cold front is SE.

2. METHODOLOGY

In this work the vertical turbulent flux of sensible heat is estimated using eddy correlation (Hammerle et al., 2007). The turbulence measurements were carried out with a CSAT-3 sonic anemometer, Campbell Scientific Inc (Oncley et al., 1996) in the micrometeorological platform located at the top of the IAG four-store building in the University of São Paulo Campus, west of São Paulo City, during May of 2010, with 10 Hz frequency.

3. RESULTS

In the figure 1 are indicated the diurnal evolution of turbulent flux of sensible heat, net radiation, air temperature, air specific humidity, wind speed and wind direction observed during the year days 132, 133 and 134 (May, 2010). The turbulent flux of sensible heat was obtained from eddy covariance method considering interval of 30 minutes.

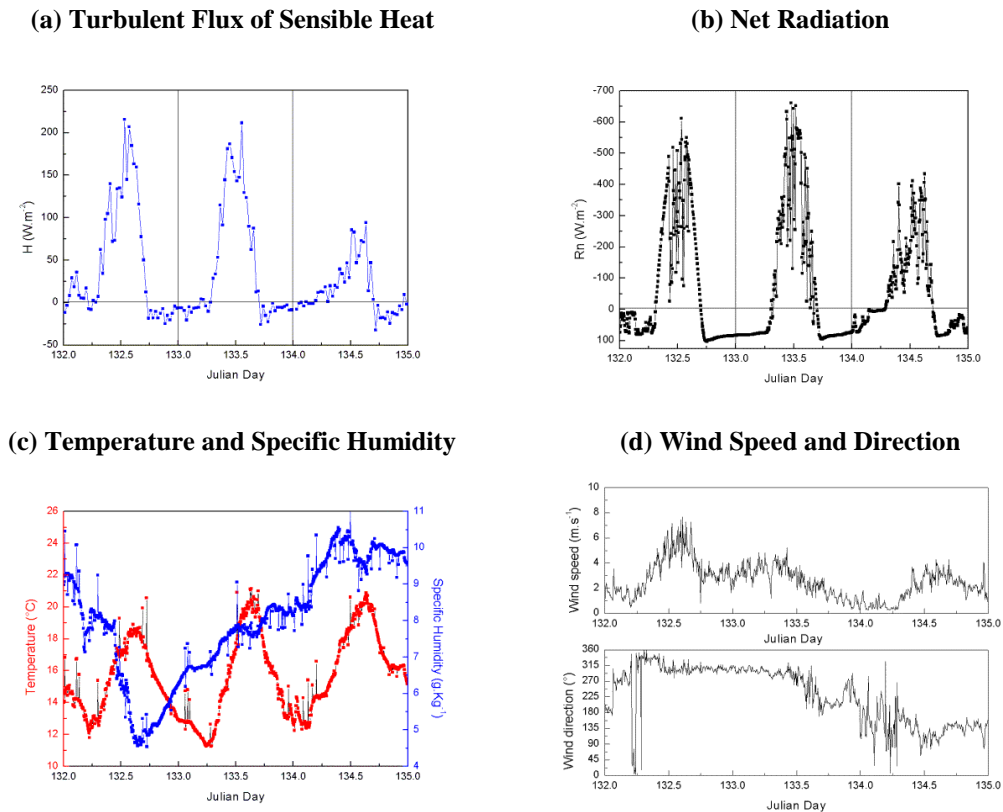


Figure 1. Turbulent flux of sensible heat, net radiation, temperature, specific humidity and wind during julian days 132, 133 and 134 in São Paulo city.

According to Figure 1a, the turbulent fluxes show a progressive decreasing in the diurnal amplitude varying from approximately 200 Wm^{-2} in the first 2 days to 100 Wm^{-2} . The reducing in the sensible heat is followed by a reduction in the net radiation (Fig. 1b). The minimum air temperature occurred in morning of year day 133 (Fig. 1c). While the specific humidity increases progressively, starting from the middle of the afternoon of year day 132 (Fig. 1c). The wind at the surface changes from NW to SE and the wind speed decreases progressively as the wind shifts its direction (Fig. 1d). This pattern of change is typical of a cold front penetration the City of São Paulo. Indeed, the synoptic chart indicated the presence of cold front SE of São Paulo (Fig. 2).

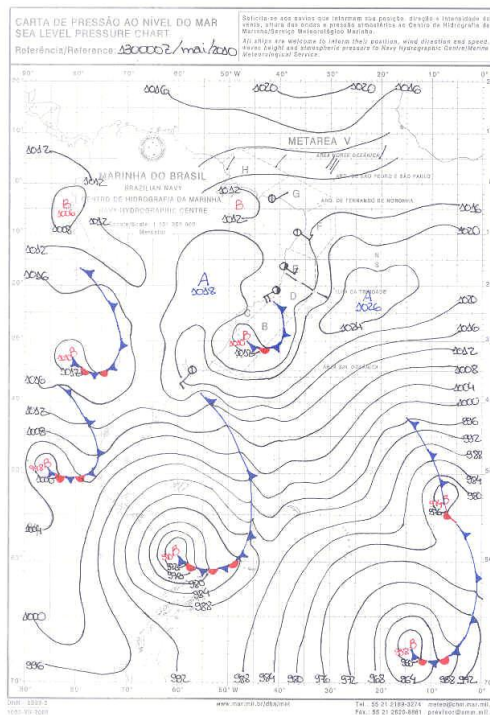
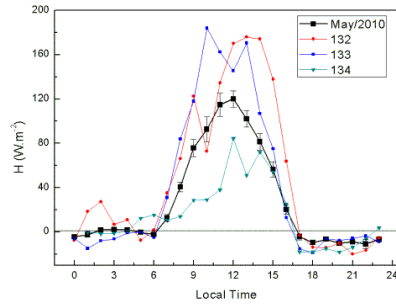


Figure 2. Synoptic chart at 00Z in yearday 133.

Considering the monthly average hourly values of turbulent fluxes and net radiation observed in São Paulo as reference, the diurnal evolution of these parameters during the period of synoptic disturbance are indicated in the figure 3. Clearly, the diurnal evolution of sensible heat (Fig. 3a) is strongly correlated with the net radiation (Fig. 3b). After the cold front passage cloud activity reduces considerable the net radiation and the sensible heat fluxes seems to follow it, so that the amplitude of diurnal cycle is smaller than the monthly averaged one in both cases.

(a) Turbulent Flux of Sensible Heat



(b) Net Radiation

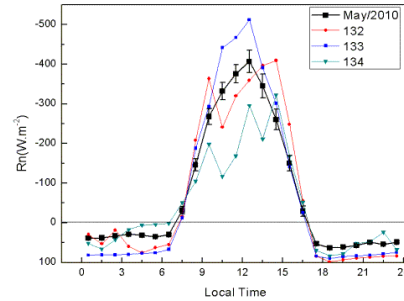


Figure 3. Turbulent flux of sensible heat and net radiation with month average during year day 132, 133 and 134. Observed in the City of São Paulo in 2010.

In order to investigate the relation between the sensible heat flux and net radiation it was carried out a dispersion diagram of hourly values observed in São Paulo City during three consecutive months, from April to June, 2010 (Fig. 4). In this figure, becomes clear that there is a strong correlation between net radiation and sensible heat flux with a correlation coefficient (r^2) of 0.72.

The impact of the cold front passage in the case of São Paulo

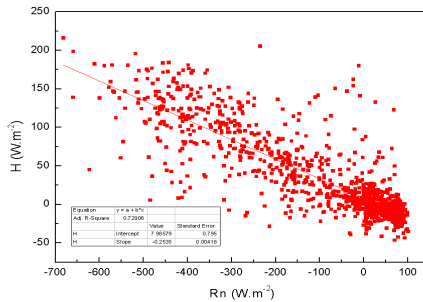


Figure 4. Correlation of H and Rn in 2010.

city seems to be associated to the reduction in the net radiation due to cloud effects. The changes caused by the cold front over other parameters such as air temperature, specific humidity and wind speed did not seem to be strong enough to cause any detectable effect on the turbulent fluxes in São Paulo City.

4. CONCLUSION

The effect of a synoptic disturbance on the diurnal evolution of turbulent sensible heat flux at the surface in São Paulo City was investigated. It was found a strong correlation between the turbulent flux of sensible heat and net radiation with $r^2 = 0.72$. A more detail analysis on the effect of other meteorological parameters will be investigated.

5. ACKNOWLEDGEMENTS

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