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# OBSERVATIONAL STUDIES OF THE PLANETARY BOUNDARY LAYER AT SUBTROPICAL REGIONS OF BRAZIL

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A 12m micrometeorological tower has been used to measure fluctuation of vertical velocity, temperature and water vapor density at three levels, 3, 5, and 9.40m, and horizontal $u$ and $v$ components at 11.5m with a sample rate 1-10 Hz. Simultaneously, measurements of net radiation 2m above the surface and heat flux in the soil are also carried out. The area around the measurement site is flat and occupied by a corn field during the summer and short grass during the winter. The measurement site is located at 22.5° S, 120 km westward from the Atlantic Ocean, approximately 600 m above the mean sea-level, in the State of São Paulo, Brazil. The vertical evolution of the local Planetary Boundary Layer (PBL) was also followed by a tethered ballon system. Four campaigns were carried out, three during summer condition (March 1991, 92 and 93) and one during winter conditions (July, 1992). The main objective of these campaigns was to describe the PBL in typical areas of the Subtropical regions in order to investigate its impact in the local dispersion conditions of pollutants. During the summer (rainy season), the PBL is strongly dependent from the cloud activity, that inhibits its vertical evolution to 1300 m. In the absence of cloud activity the vertical extent of the PBL was observed to reach 2000 m above the surface. During the nightime, the PBL height was characterized by stable conditions its height was around 300 m coincident with low level jet maximum wind speed in both seasons.

## INTRODUCTION

The Planetary Boundary Layer is the region of the atmosphere adjacent to the surface where the time and spatial evaluation of its dynamic and thermodynamic structure are the result of the interactions between the atmosphere and the surface. In general, most pollutants are released within the PBL, therefore to understand and predict the behavior of most pollutants it is necessary to have a quantitative description of the physical process that controls the PBL evolution.

In the last two years a group of Micrometeorological Studies formed by researchers from the Department of Atmospheric Science (IAG/USP) and Department of Physics (UFSM) has carried out turbulence measurements with a 12m tower during four campaigns of two weeks in the Centro Experimental Aramar, State of São Paulo. Simultaneously, the COPESP carried out vertical profiles of temperature, humidity, wind speed and direction with a tethered balloon and radiosonde systems.

This note will sumarize a few observational results of four field missions carried out by this group in the State of São Paulo, as well as describe the future field observations that will be carried out in the thermoelectric power plant, Candiota, in the State of Rio Grande do Sul.

## SITE AND INSTRUMENTATION

The measurements reported here were taken at the nuclear installation named Centro Experimental Aramar, located at the countryside of State of São Paulo (23°25' S, 47°35'W), approximately 120 km from the Atlantic Ocean coastline and 500m above the mean sea level. The area site is flat, with a high elevation mountain at SW (Araçoiaba Sierra) with peak of 300 m. The area is crossed by the Ipanema river in the North-South direction, and by the Sorocaba river in the West-East direction; these rivers are small, and are located at the bottom of a 50 m deep valley.

Four field campaigns were carried out during the last two years, during the summer, in March 1991, 1992 and 1993, and during the winter, in July 1993. The first campaign measured turbulence at the surface, using a 6m tower with a sonic anemometer, fine wire thermometer and krypton hydrometer (set of turbulence sensors made by CAMPBELL) at 5m above the surface. In the other three campaigns three turbulence sensors were measuring turbulence at 3.5 and 9.4m above the surface in a 12m tower. These sensors allowed the measurements of fluctuation of vertical velocity, air temperature and water vapor density with sampling frequency that varied from 1 to 10 Hz. Net radiation and soil heat flux measurements were carried out during these four campaigns (Oliveira, 1992). Vertical profiles of air temperature, moisture and horizontal wind were obtained during these four field campaigns each two hours, using a tethered balloon system. In March 1991 and July 1992 the surface was covered by short grass 15 cm high. In March 1992 and 1993 the surface was covered by a corn field 1.5 and 0.5 m tall respectively.

## PBL OBSERVED CHARACTERISTICS

The vertical extent of the PBL is a function of turbulence intensity and the static stability of the free atmosphere (Tennekes, 1973). The turbulence is maintained by the production (thermal and mechanical) and the destruction (thermal and viscosity) of turbulent kinetic energy, which in turn are related to radiative heating (and cooling) of the surface. The sensible heat and latent heat fluxes are strong indication of how the surface uses the energy from radiation to heat and change the moisture content of the PBL.

The sensible and latent heat fluxes were evaluated using the covariance method applied to the turbulence measurements in the tower. Net radiation and the soil heat fluxes were measured directly at 2 m above and 1 cm below the surface respectively. During the summer campaigns the sensible heat fluxes are smaller than the latent heat fluxes. During the summer, the sensible heat fluxes are larger than the latent. Comparatively, there is less available energy for these processes.

The height of the PBL was estimated during the daytime as the vertical extent of the mixing layer and nighttime as the top of the surface inversion layer. In the summer of 1991, for an undisturbed period, the height of the PBL varied from 300m during the stable regime to more than 1000 m during the convective regime. The data analysis for the other periods of observations indicates a similar pattern, with a stronger and shallower surface inversion layer during the winter of 1992 and a higher PBL during the summer of 1993 (drier than normal).

With respect to the horizontal winds, the intensity of thermal induced mixing was sufficient to produce a homogeneous PBL during the daytime. At night, low level jets of maximum speed as large as 5-10 m/s were frequently observed over the site.

## CONCLUSION

Some results of four observation campaigns at a nuclear installation in the subtropical region of Brazil where turbulence intensity in the surface layer and profiles of wind, temperature and moisture of the PBL were measured simultaneously, are presented.

The results indicate a daytime mixed layer during the summer and the winter and nighttime surface inversion layer and residual mixed layer. The winds are well mixed during the day time and a low level jet was observed during the nighttime.

These observations will be used to evaluate the dispersion conditions at the particular site through numerical and analytical models.

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