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Continuous Monitoring of the Lower Boundary Layer in the central State of São Paulo, Brazil, with a SODAR

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The increased demand worldwide for petroleum products derived from non-renewable resources and also its supply being susceptible to political problems, resulted in a drastically increased production of ethanol from sugar cane in several regions of Brazil, especially in the central and western parts of the State of São Paulo. However, this not only entailed agricultural problems through the change from large pastures with animal husbandry to the mono-culture of sugar cane, but also wide-ranging environmental problems, due to the practice of burning the sugar cane fields prior to manual harvesting, resulting in vast emissions of biomass-burning products, such as aerosols and various greenhouse gasses. With this in mind, the Brazilian state-owned Oil Producer and Refinery Owner, Petrobras, approved an Infrastructure Project in 2008, submitted by five research groups (Landulfo et al., 2010; SPIE Proceedings), through which a mobile Lidar and air quality monitoring laboratory were acquired.

One of these five partners is the Meteorological Research Institute (IPMet) of the São Paulo State University which has been monitoring the three-dimensional structure of severe thunderstorms, since 1992 and 1994, respectively, using two S-band Doppler radars in the central and western part of the State of São Paulo. However, in the absence of rain, especially during the dry winter months (April to September), the radars are well suited to monitor the plumes from large biomass fires ("queimadas"), which will facilitate the quantification of emissions from such fires. Within this infrastructure project, IPMet acquired a medium-sized Sodar for monitoring the vertical distribution of wind (u, v, w) within the lower Planetary Boundary Layer (PBL; up to 500–800 m above ground level (AGL), depending on the meteorological conditions). Average vertical profiles were recorded every 30 min. During specific campaigns, the Sodar was co-located with the mobile Lidar, which monitored aerosol layers within the PBL and the Sodar-derived wind profiles were used to identify the directions from which they came, subsequently identifying the biomass fires on the radar images.

A climatology of Sodar observations will be presented in this paper for the period of June 2009 to January 2011, with special emphasis on the stable nocturnal conditions, mostly during the relatively dry austral winter months (May – October), when strong Low-Level-Jets (LLJs) develop on top of the surface radiation inversion. These LLJs generally form shortly before midnight Local Time (LT) at altitudes ranging from 250–500 m AGL, with maximum speeds of 12–20 m/s. They usually last until 08:00–09:00 LT, when the inversion has been eroded by the solar radiation. The most common direction is from east-south-east. The progressive development of the inversion during the night can usually be identified from the backscatter signal of one or more of the 10 frequencies emitted by the Sodar. From May to August, LLJs could be identified on 30% of the days. Observations were made at three different locations in the central region of the State, viz. in Bauru, Rio Claro and Ourinhos.

The importance of these findings lies in the fact, that by Brazilian Law, cane fields may be burnt from 18:00 until the early hours of the morning, when emissions usually get trapped in the stable PBL, but a gradual phasing out of this practice has been prescribed and by 2021 all harvesting should be performed with cutting machines without pre-burning. The burning of sugar cane not only causes a huge problem with pollutants descending over urban settlements in the region, but also a great health risk to the population.