10.2 VALIDATION OF THE NOCTURNAL BOUNDARY LAYER TECHNIQUE

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1. INTRODUCTION

In our effort to create protocols and regulations targeted at minimizing the rate of increase of global warming, we must keep in mind the uncertainties that surround our best estimates of greenhouse gas (GHG) emissions. While most micrometeorological measurement techniques are only suitable for windy conditions, the nocturnal boundary layer (NBL) budget technique, first introduced by Denmead *et al.* (1996), can be used to measure trace gas flux during calm clear nights as the nighttime stability enables gas emitted at the ground to accumulate.

2. MATERIALS AND METHODS

Using the NBL technique, a trace gas flux can be generated by integrating the measured concentration difference between pairs of profiles from the surface to the top of the NBL. On nights of measurement, balloon ascents of 20-25 minutes duration were completed approximately once every hour. Wind speed and direction, potential temperature, humidity and air pressure profiles were measured in "real-time" by a tethersonde (AIR Model TS-5A-SP) attached to the balloon tether line. A light-weight CO_2/H_2O infrared gas analyzer (CIRAS-SC, PP Systems) was deployed every second profile storing carbon dioxide instantaneous concentrations every 10 seconds. A minisodar system (SFAS, Scintec Inc) was operated on site for a period of two weeks during each summer field campaign (June 24 to July 8, 2002 and July 22 to August 5, 2003) and continuously measured the three wind components between 10 m to 200 m every 2 to 5 minutes in 5-m vertical increments. Basic meteorological variables were continuously recorded above the crop surface using standard instrumentation installed on a small tower and recorded by a data logger.

During the two summer field campaigns (2002 in Ottawa, Ontario, Canada (45°23' N, 75°43' W), and 2003 in Côteau-du-Lac, Québec (45°19' N, 74°10' W)), used to investigate this technique, 24 nights of data were collected for a three week period in 2002 and a 116-day period spanning May through September in 2003. Of these, six nights were calm enough for the technique to be used for the entire nighttime period from sunset to sunrise. Our goal was to examine the NBL profiles in concert with the mini-SODAR to better evaluate the NBL technique itself. In doing so, new knowledge on the nighttime circulation of trace gases would be explored.

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3. RESULTS

On June 28-29 2002, a low level jet (LLJ), a region of maximum wind speed, was found to have a notable effect on gas accumulation. As previously observed with the tracer SO_2 (Beyrich, 1997; Corsemeir, 2002), accumulation of CO_2 can be seen underneath the LLJ, but in this case, a comparison of profiles strongly suggested that the presence of a 'constant' LLJ acted as a stronger barrier to the gas accumulation than the temperature inversion alone. Figure 1, even if not showing a true LLJ, shows the effect of a wind maximum on gas accumulation.

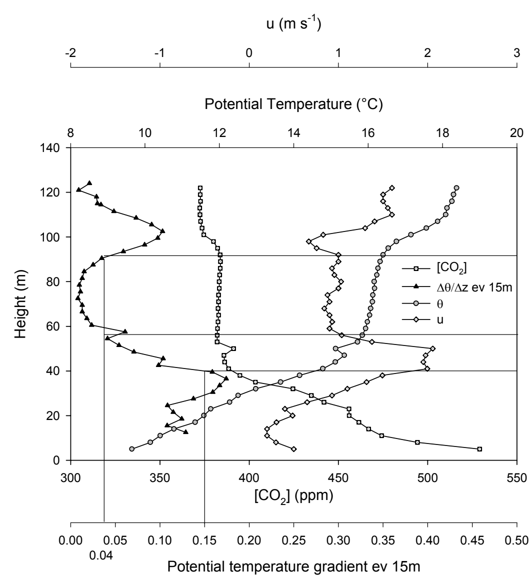

Figure 1: A greater accumulation of CO_2 can be seen under the wind maximum. Accumulation is also shown to be greater under regions of higher static stability.

The potential temperature, although not acting as a strong cap like the low level jet, still controls the vertical gas distribution. Figure 1 also demonstrates the close relationship between the potential temperature gradient and the gas concentration gradient.

From different nights, the influence of specific source areas was observed to influence the resulting trace gas flux. For example, the CO_2 concentration throughout the profile was found to increase dramatically in a two hour period following a change in wind direction. The flux calculated using the NBL technique that includes two different profiles spanning a time interval including such a shift in wind direction may therefore not be trustworthy.

Strong atmospheric events can interfere with trace gas measurement. Such events are presented as a breakdown in the nocturnal boundary layer evolution. The build up in trace gas concentration as well as the temperature evolution are disrupted.

4. DISCUSSION

Trace gases can accumulate quite differently from night to night and a good classification of nights is essential to permit reliable measurements using the NBL technique.

On nights where a LLJ was present, a net gas accumulation was observed and the ease of definition of the NBL top resulted in low uncertainty associated with the calculated flux. CO_2 was observed to accumulate more under regions of stronger static stability. This will also reduce uncertainties in the calculated flux.

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