P4.21 REAL-TIME PROFILES OF ORGANIC TRACE GASES IN THE ARCTIC BOUNDARY LAYER OBTAINED DURING THE ARCTIC OCEAN EXPEDITION (AOE-2001)

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1. INTRODUCTION

PTR-MS (Proton-Transfer-Reaction Mass Spectrometry) is a chemical ionization mass spectrometry technique that allows for on-line measurements of organic trace gases in air at pptv levels. A rugged and field portable PTR-MS instrument developed at the University of Innsbruck was successfully deployed during the Arctic Ocean Expedition (AOE-2001).

In a new experimental approach, the CIRES Tethered Lifting System (TLS) (Balsley et al., 1998) was used to raise a Teflon tube connected to the sample gas inlet of the PTR-MS apparatus. Both systems were operated from an ice camp set up on a moderately-sized ice floe during a three-week drift near the North Pole. Selected organic trace gases (including acetonitrile, acetone and dimethyl sulfide) were measured between the surface and roughly 200 m.

2. THE PROTON TRANSFER REACTION MASS SPECTROMETER

PTR-MS is a chemical ionization mass spectrometry technique that uses proton transfer reactions with H_3O^+ ions for on-line measurements of volatile organic compounds (VOCs) in air. A detailed description of the PTR-MS instrument (see Fig. 1) is given by Lindinger (1998). A hollow cathode discharge acts as an ion source producing H_3O^+ ions from pure water vapor. These ions are injected into a flow drift tube, which is continuously flushed with ambient air. Most VOCs have proton affinities higher than the one of water and in these cases a collision with the H_3O^+ ions will result in a proton transfer reaction. H_3O^+ ions and protonated VOC ions are mass analyzed and detected with a quadrupole mass spectrometer. The portable instrument (weight: ~100 kg) has been successfully employed in several field campaigns throughout the world during the past few years: LBA-CLAIRE 1998 (Crutzen et al., 2000; Pöschl et al., 2001); INDOEX 1999 (Sprung et al., 2002), (Wisthaler et al., 2002), SOS 1999 (Wisthaler et al., 2000); and TEXAQS 2000.

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During the Arctic Ocean Expedition (AOE-2001), in a new experimental approach, a kite and an aerodynamic balloon were employed as lifting platforms for a 200 m long PFA Teflon tube (OD: 6.35 mm, ID: 4.826 mm, weight: app. 6 kg) connected to the kite/balloon tether at one end and the sample gas inlet of the PTR-MS apparatus at the other. The tube was pumped by a diaphragm pump with a flow-rate of 6.7 slpm limiting the residence time of the air in the inlet to about 20 s.

Fig. 1. The PTR-MS instrument was housed in a heated ice hut in a position close to the base station and winch of the TLS.

3. THE TETHERED LIFTING SYSTEM (TLS)

The complementary platforms of the TLS allowed the raised inlet system to be tested under wind conditions ranging from calm to moderate. The net lift of 10 kg available from the 21 m^3 aerodynamically-shaped balloon allowed the 6 kg Teflon inlet tube and the Basic Meteorological Payload (BMP) to be easily raised to nearly 200 m above the surface. Under stronger wind conditions, the parafoil kites allowed the inlet to be raised, although maximum altitude was typically limited to under 180 m, as the increased wind drag on the inlet tube created greater curvature of the 200 m tube.

The inlet was typically raised through a major portion of the boundary layer and on one occasion, completely through it. Boundary layer height was determined for each flight using meteorological data from the BMP. In

addition, backscatter returns from a monostatic sodar operated by NOAA's Environmental Technology Laboratory (ETL) operated close to the kite and balloon launch site were used to determine boundary layer height and kite or balloon altitude in real-time.

4. PRELIMINARY RESULTS FROM AOE-2001

Although one of the primary compounds of interest to the AOE-2001 campaign was dimethyl sulfide (DMS), lack of significant local production or transport during the raised inlet test period kept DMS levels below the detection limit of the PTR-MS (40 pptV for a 20 s integration time). To demonstrate the utility of the system, however, boundary layer profiles of acetone were measured and are shown below (see Fig. 2).

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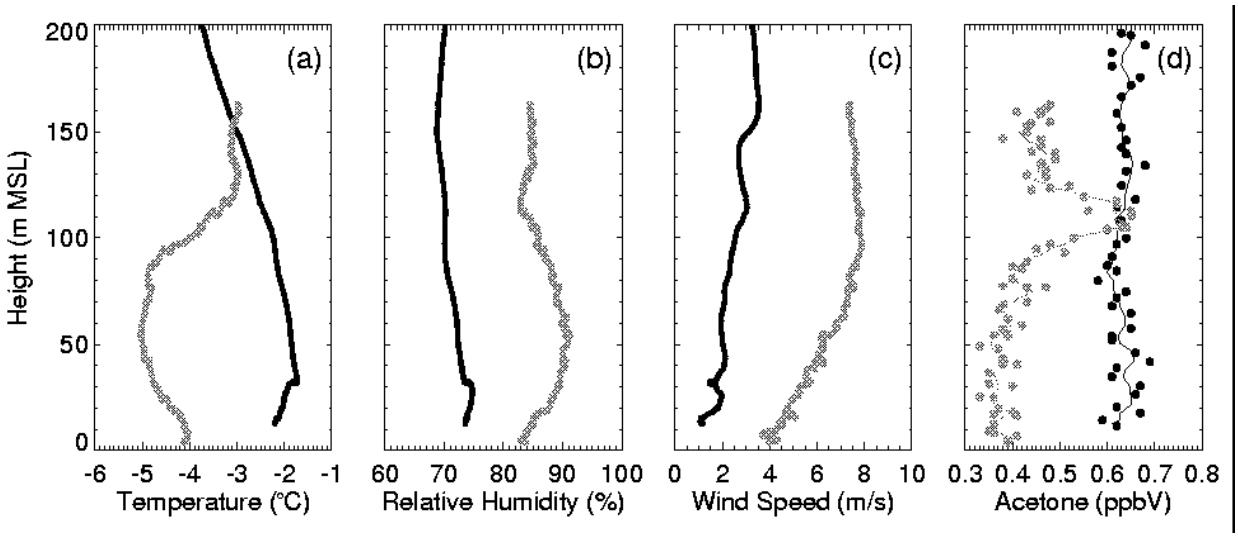

Fig. 2. Comparative profiles of temperature (a), relative humidity (b), wind speed (c), and acetone concentration (d) for TLS raised PTR-MS inlet flights made on consecutive days from the AOE-2001 ice camp. The black points represent values observed during a profile between 15:21-15.36 UTC on August 14, 2001. The gray points show the profile obtained between 16:37-17:02 UTC on August 15, 2001, with enhanced acetone at 110 m corresponding to a weak temperature inversion. The solid lines represent 1 minute smoothing of the acetone data.