12B.4 Drifting and blowing snow field studies in the Canadian North

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For a significant part of the year snow covers the ground, or ice, in the Canadian North and offshore areas of the Arctic Ocean. Strong winds are also common and the combination leads to drifting and blowing snow conditions. These in turn can redistribute and sublimate snow cover as well as cause significant and hazardous reductions in visibility. Modelling studies using the Prairie Blowing Snow Model and the Piektuk model have addressed sublimation issues but both are critically dependent on assumptions about ice particle concentrations and size distributions in the air just above the surface. In order to obtain data on these and related issues we have developed particle counters and imaging systems to address these issues and mounted field measurement campaigns in the Canadian Arctic and sub-Arctic. From January through April 2004 we deployed particle counters and other meteorological instrumentation on the ice of Franklin Bay in the Beaufort Sea to obtain data on particle number densities at several heights above snow covered first-year ice, visibility and wind and snow conditions. Snow bags were also used. Similar studies were conducted on land at Churchill, Manitoba in winters 2005/6 and 2006/7, including measurements of size distributions. Measurements were also made near the airport at Iqaluit, Nunavut as part of the IPY-related Storm Studies in the Arctic program in winter 07/08. Results indicate threshold velocities, show variations of particle number density and size distribution with wind speed and with height above ground. Relationships with visibility and particle concentration and size. Instrument development issues will also be addressed.

Particle Counter Results from the CASES study over first year,Arctic ice about 12 km from shore in Franklin Bay are shown in Figure 1. This shows typical reductions in particle count with height and a good correlation between particle counts and visibility. The threshold 10-m wind speed in this case is around 6 ms^{-1}.

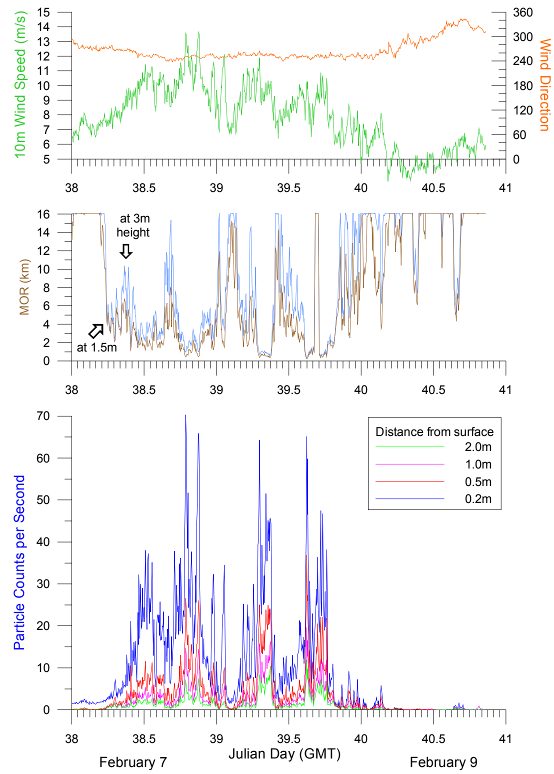

Figure 1 Data from a blowing snow event over Arctic Ocean ice during CASES. Feb 7-9, 2004. Note MOR is Meteorological Optical Range from a Sentry visibility sensor. Maximum range is 16 km.

For the 2007/8 Storm Studies in the Arctic (STAR) field program we used essentially the same particle counters with slight modifications to the electronics. These were installed on a 10-m post and offset 2m post in the Environment Canada instrument compound at Iqaluit (Nunavut) airport. Similar results were obtained throughout the winter season together with wind, pressure, humidity and temperature data from the mesonet depicted in Figure 2

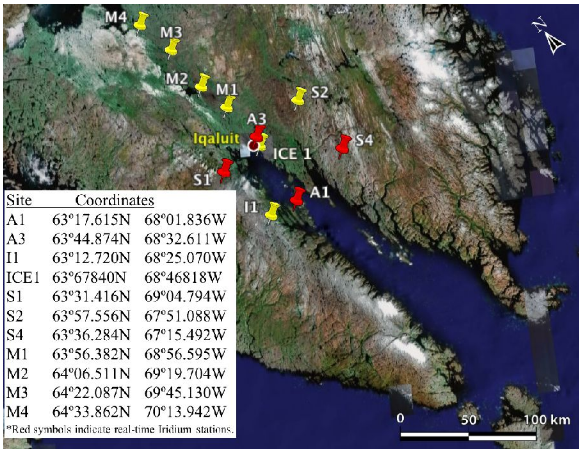

Figure 2: Nework of surface weather stations operated during STAR 07/08 on Southern Baffin Island

Data from the airport were available via internet in real time and four other stations were interrogated daily via satellite phone. Typical data are shown in Figure 3. The airport is station A3.

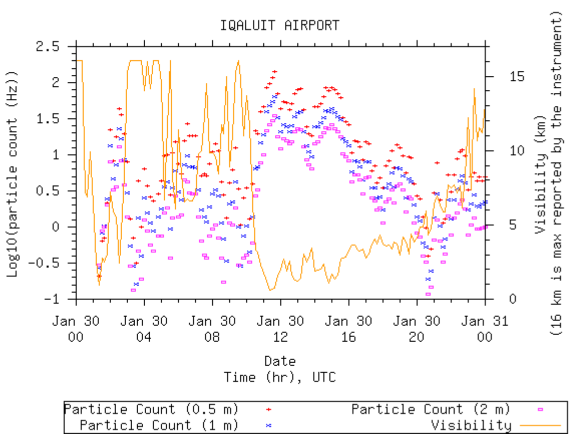

Figure 3 Particle counter and visibility data from station A3 on Jan 30, 2008. Wind speeds were in excess of 15 m/s from 1200-1600 UTC and temperatures rose to about -15C.

The particle counters (Figure 4) are based on partial interruptions of an infra-red light beam in a circular cylindrical sample volume of diameter 150μm and length 20 mm. a particle count of 100 s^{-1} corresponds to 3.3 particles per cc if the wind speed (at the height of the counter) is 10 ms^{-1}. Threshold detection size for particles is of order 25 μm diameter but is wind speed dependent with our present counters. Further research on this aspect of their performance is planned.

Threshold wind speeds for low-level drifting snow are somewhat dependent on the amount of fresh, cold snow available as well as temperature and snow density but are usually in the range 5-8 ms^{-1}.

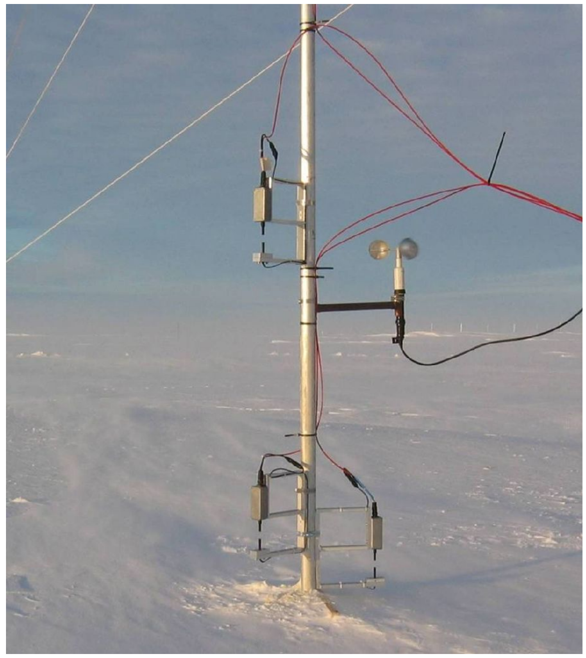

Figure 4. Particle counters deployed during CASES 03/04.

Using data from the CASES study we established good correlations between particle number density (from the counters) and visibility (as reported by a forward scattering Sentry sensor). Using assumptions about scattering efficiencies and cross sections of the particles, and their size distribution we get the straight line fits as in Figure 5.

Figure 6 from the same study relates particle number density to 10m wind speed.

One of the issues we try to address is the particle size distribution. Figure 7 depicts a camera system developed by Mark Gordon and Figure 8 shows some near-surface size distribution data obtained with it. These are consistent with the visibility data in Figure 5.

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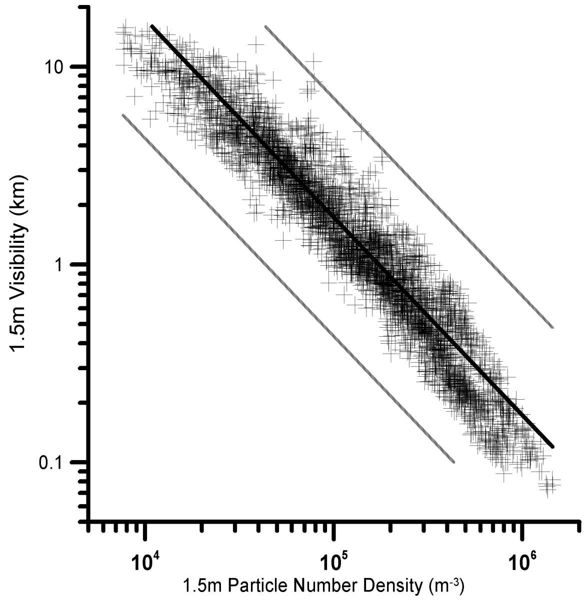

Figure 5 Relation between visibility and particle number density. Dark line corresponds to results for a particle size distribution with average (area weighted) radius of 50 μm. Lines above and below are for radii of 25 and 100 μm

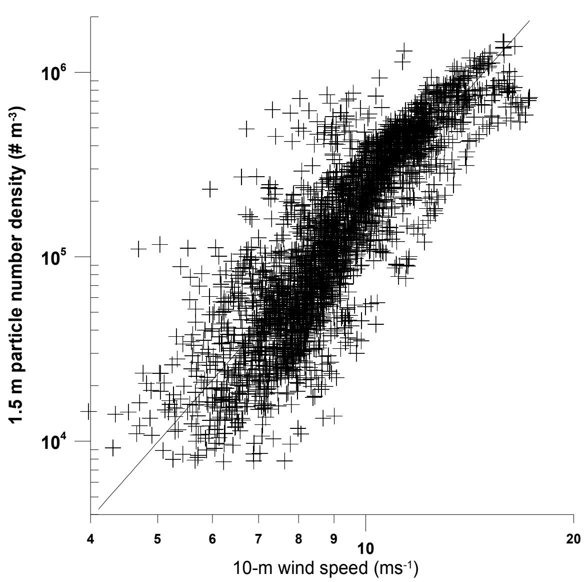

Figure 6 Particle number density, at 1.5m as a function of wind speed. Selected CASES data. Note that these particle number density are per cubic meter.

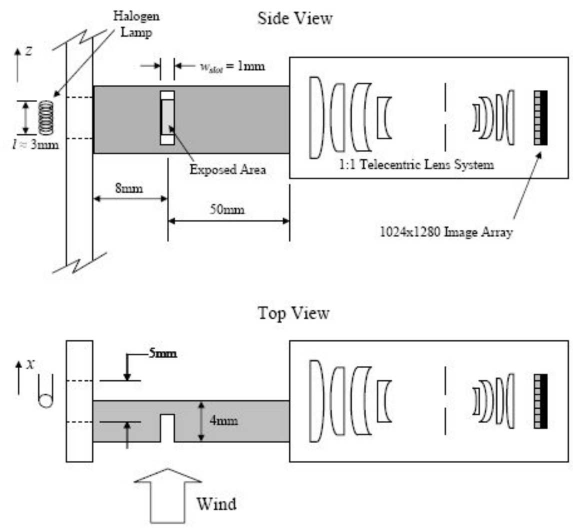

Figure 7 A schematic of the lamp, slot, lens, and image sensor array confguration (not to scale).

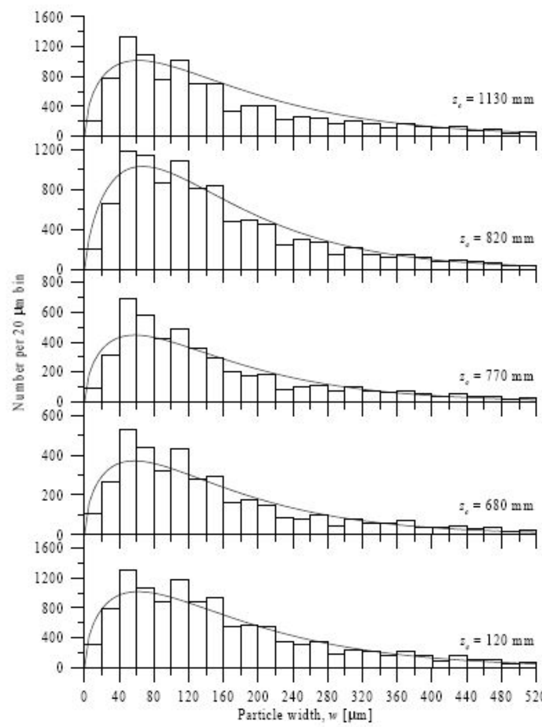

Figure 8 Histogram of particle widths collected at Churchill, at heights of z = 120, 680, 770, 820, and 1130 mm (see Table 1 for details). Least-squares fits to Equation 4 are also shown).