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Snow Crystal Observations at Dome C, Antarctica

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INTRODUCTION

Snow deposition is a factor of primary importance in calculating the surface mass balance of the Antarctic ice sheet. Knowledge of ice crystals is also important for surface remote sensing: crystals interact with both solar and infrared radiation, thereby affecting the planetary energy budget. The shape and size of crystals affects the post-depositional loss and diffusion of chemical-isotope species in snow. During the Antarctic winter of 1992, 9 types of ice crystals were identified at the South Pole. These fall into three main categories: diamond dust, blowing snow and snow grains (Walden, 2003). In February 2001, over 900,000 digital images of ice crystals were recorded at the South Pole using two ground-based cloud particle imagers (CPI's) (Lawson et al., in press). Systematic observations of snow deposition were carried out using conventional methods (manually) near Concordia Station at Dome C (eastern Antarctic plateau) over a 6-month period (April-September 2005).

METHODS

A raised wooden support 50 x 50 cm in size was installed approximately 600 m from the base to collect falling and blowing snow. A millimetric crystal grid in black plastic material was fixed to the wooden tablet. Observations on the amount of deposition and the shape and size of snow crystals were made daily with a pocket lens (8x power) and, when possible, pictures were taken with a digital camera (Fig. 1). Snow crystals typologies

Fig. 1 - Observation of snow crystals during the Antarctic winter.

Tab. 1 - Distribution of snow deposition at Dome C.

	April	May	June	July	August	September
Tot. deposition (mm of snow)	24.5	22.0	41.8	40.8	24.6	20.0
N° of dep. > 5 mm	0	0	1	0	0	0
N° of dep. 2-5 mm	4	0	9	8	4	3
N° of dep. <2 mm	25	29	14	22	25	25
Average density (kg/m^3)				90.95	112.79	72.88

were identified according to the Magono and Lee classification system (Magono & Lee, 1966). Photographic books were used to classify crystals (Bentley et al., 1962; Seligman, 1980, La Chapelle, 1969; Libbrecht & Ramussen, 2003). When possible, the snow depositions were collected in a test-tube and melted in laboratory in order to calculate the snow water equivalent and therefore the snow density.

SNOW DEPOSITION AND CRYSTAL TIPOLOGIES

Observation of snow deposition at Dome C revealed that snow was deposited in small but continuous quantities. Snow deposition was observed in 85% of the days, but the deposit was generally less than 2 mm thick. In only one case (June) was the thickness of the deposit greater than 5 mm (Tab. 1) .

As for the quality of depositions, they can be grouped into the following categories: precipitation crystals, diamond dust, blowing snow, air hoar and surface hoar. The main characteristics of these crystals and their classification according to the system proposed by Mogono and Lee are shown in table 2 and figure 2. The density of fallen snow ranges from 20 kg/m^3 (precipitation crystals) to 160 kg/m^3 (blowing snow), with an average of about 90 kg/m^3.

Precipitation crystals

Precipitation crystals are ice crystals precipitated from clouds. They are usually a combination of bullets and hollow columns, and are usually much larger that either diamond dust or blowing snow particles due to the relatively large source of water vapour. Crystals are generated in high cirrus clouds and in midlevel strata.

Diamond dust

Diamond dust particles are small, simple crystals (solid plate and solid column with a few inclusions of air) formed when atmospheric temperatures are below -40°C and growth is slow because of low excess water vapour density. In some

Tab. 2 - Snow deposition typologies (shapes classified according to Magono and Lee) and maximum dimensions of crystals in mm.

Crystal typologies	Prevailing shapes	Max. dimensions (mm)
Precipitation crystals	C2a + C1f	0.5-0.7
Diamond dust	C1e + C1g + N1e	0.2-0.5
Blowing snow	N/A (rounded grains)	0.1-0.2
Air hoar	N1a + C1f	0.5-2.0
Surface hoar	C1b + C1d + P1a	0.5-2.0

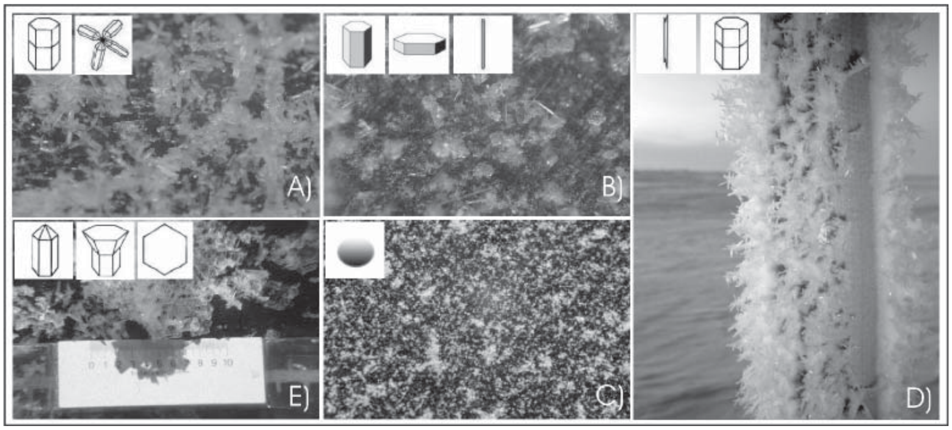

Fig. 2 - Snow deposition typologies [A) Precipitation crystals, B) Diamond dust, C) Blowing snow, D) Air hoar, E) Surface hoar].

cases we observed extremely long crystals called “Shimizu Crystals” typically associated with the atmospheric halo phenomena.

Blowing snow

These snow grains are created when the surface wind is strong enough to lift the ice grain off the surface. The threshold wind speed is about 5-7 m/s. Drifting snow produces snow surface erosion features called “sastrugi”.

Air hoar

These are wind-orientated or free-growing crystals produced by sublimation of air water vapour. In the case of free-growing air hoar the subliming crystal form is more fascicular, like bundles of needles or very fine, hollow columns.

Surface hoar

These crystals sublime on the snow surface and grow in the direction whence the water vapour which forms them comes. The crystals are generally hollow (cup and hollow bullet) or hexagonal plate but the grow direction produces a flattened shape. Surface hoar crystals form under calm, clear skies.

Concerning the frequency of the various crystal’s typologies, the observations carried out during a 6-month period (April-September 2005) confirmed the remarkable contribution of the subliming crystal forms (air hoar) compared to the precipitation crystal forms which were observed in case of medium and high stratified cloudiness, and compared to diamond dust which rarely have been observed.

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