Photographic Methods for Antarctic Snow Crystal Evaluation

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With Many Collaborators
How is snowfall partitioned before accumulating?

Size distributions needed for: precipitation rate
mass transport of blowing snow cloud / precip characteristics
Model Snowfall (AMPS)
Ice crystal formation in the atmosphere

**Supersaturation Relative to Ice %**

- Temperature °C
- Plates
- Hollow columns
- Sector plates
- Dendrites

**Saturation**
- Plates
- Thick plates
- Solid very thick plates
- Cups
- Solid columns

![Graph showing ice crystal formation](image)
Automated shipboard precipitation measurement

Photoelectric particle counter (disdrometer) measures beam interruptions by snow crystals larger than 200 µm. Mounted high above waterline to avoid blowing snow, but subject to high winds, icing, ship orientation effects.
model precip & shipboard measurements

- ECMWF
- GPCP
- NCEP2
- JRA-25
- Particle Count

R. Cullather
Particle sizes of precipitating snow crystals are assumed to follow a gamma distribution.

Total number of counted particles (from disdrometer) during a snowfall event is partitioned into the portion of the size distribution observed by the sensor ($d > 200 \, \mu m$).

Mass flux calculated from full size distribution (includes small crystals).

What does the snow look like? (size, habit, etc.)

Bright circles are lighting, grid lines are 200 \( \mu m \) apart.
Snow collection strategy

- Captured falling snow on chilled gridded glass slides for immediate photographic documentation
- Minimum 10 slides per snowfall to gain adequate sample for mean size determination
- Mean size and typical crystal habit evaluated for each snowfall event
- Rime amount estimated from observations, average for snowfall event determined.
Case Study, Feb 3-6 2009

17351 & 19472 flakes from 2 sensors
Mean long-dimension of snowflakes was ~2 mm
Net mass flux using conservative $m = aD^\alpha$ (low-mass dendrites) = 10 - 20 cm w.eq. before rime considered

MERRA: 13.9 cm w.eq.
CFS: 8.75 cm w.eq.
ECMWF: 3.84 cm w.eq.
JRA-25: 4.92 cm w.eq.
NCEP: 4.14 cm w.eq.
Is there continued crystal growth and rime formation below the atmospheric levels with good moisture data? Upper-troposphere well observed by GPS surface energy balance modeling suggests 1-10 mm/day could easily evaporate from leads and re-precipitate.

Pinto & Curry 1995 model study found sim order of magnitude for lead-induced clouds In southern ocean sea ice pack, this may be a significant source of snow mass flux
Surface snow on sea ice after the storm
Snow accumulation processes role in Antarctic sea ice mass balance

Precip (ERA-I) Precip - Drift

US-NSF project ANT-1142075 & Leonard and Maksym, 2011
Winter Sea Ice Cruises

“WeSI(e)S” 2013

“SIMBA” 2007

“SIPEX-2” 2012 (SIPEX 2007)
Winters 2012 & 2013
- 3 snow / AWS stations, shipboard snowfall measurements
- (repeat) Terrestrial Laser Scanning of surface
- multiple shorter ice stations, deploying IMBs / AWSs
3D Snow Crystal Replicates in Formvar Resin
Formvar replicate, E. Antarctic sea ice October 2013

Approx 2mm diameter
Findings, so far

- Falling snow in West Antarctica (summer, open sea ice pack) was aggregated, rimed
- Falling snow in East Antarctica (spring, close-pack sea ice) mostly single-crystal, un-rimed
- Snow on the “ground” had little relationship to precipitating snow habit or size (more similar in East than West Antarctic project)
- Blowing snow was amorphous, very fine grained relative to coincident precipitation

- Why are these so poorly related?