Dust and Black Carbon size distributions in snow and links to snow physics.

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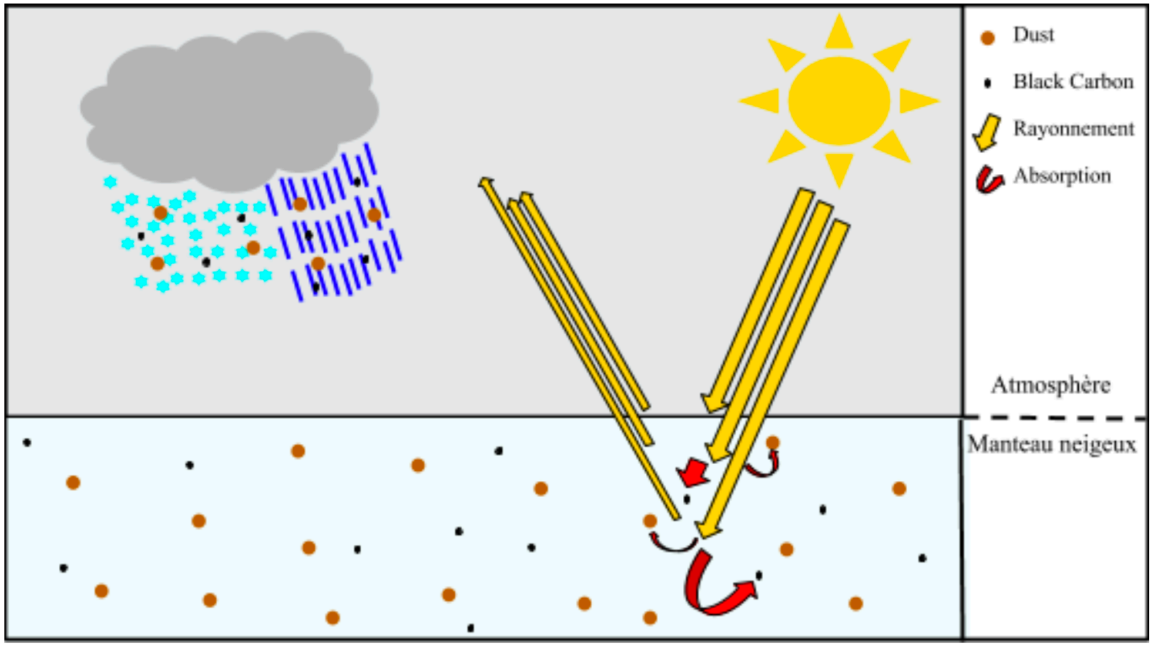
Light Absorbing Particles influence snow physics



- By their presence, light absorbing particles change the snow albedo
- by changing the heat distribution in the snowpack, light absorbing particles induce snow metamorphism feedbacks
- This is most sensitive in the spring when particles accumulate at the surface

Snow physics influences particles physics and chemistry

JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 5553–5569, doi:10.1002/jgrd.50235, 2013

Observed vertical redistribution of black carbon and other insoluble light-absorbing particles in melting snow

Sarah J. Doherty,[1] Thomas C. Grenfell,[2] Sanja Forsström,[3] Dean L. Hegg,[2] Richard E. Brandt,[2,4] and Stephen G. Warren[2]

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Motion of dust particles in dry snow under temperature gradient metamorphism

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frontiers in Earth Science

ORIGINAL RESEARCH
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Microscale Rearrangement of Ammonium Induced by Snow Metamorphism

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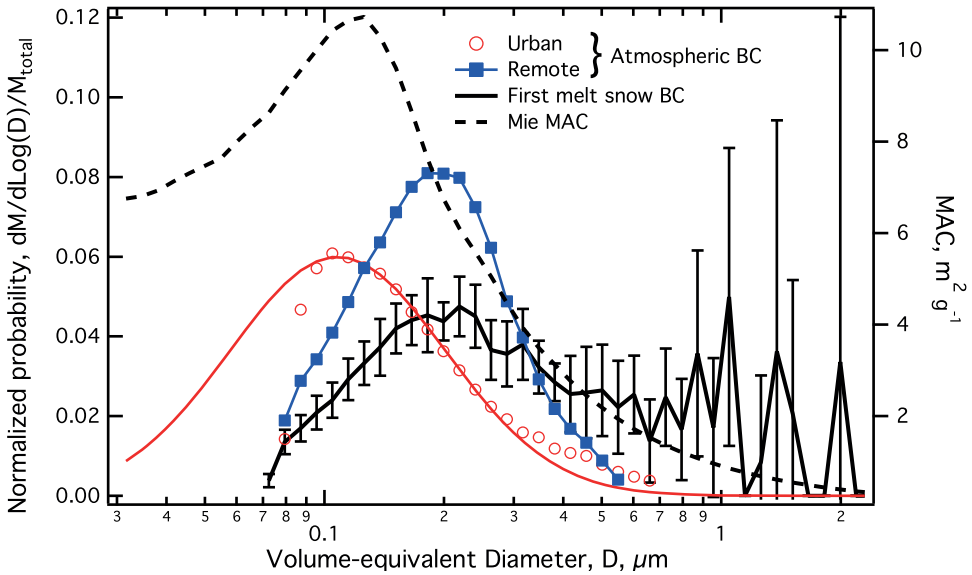
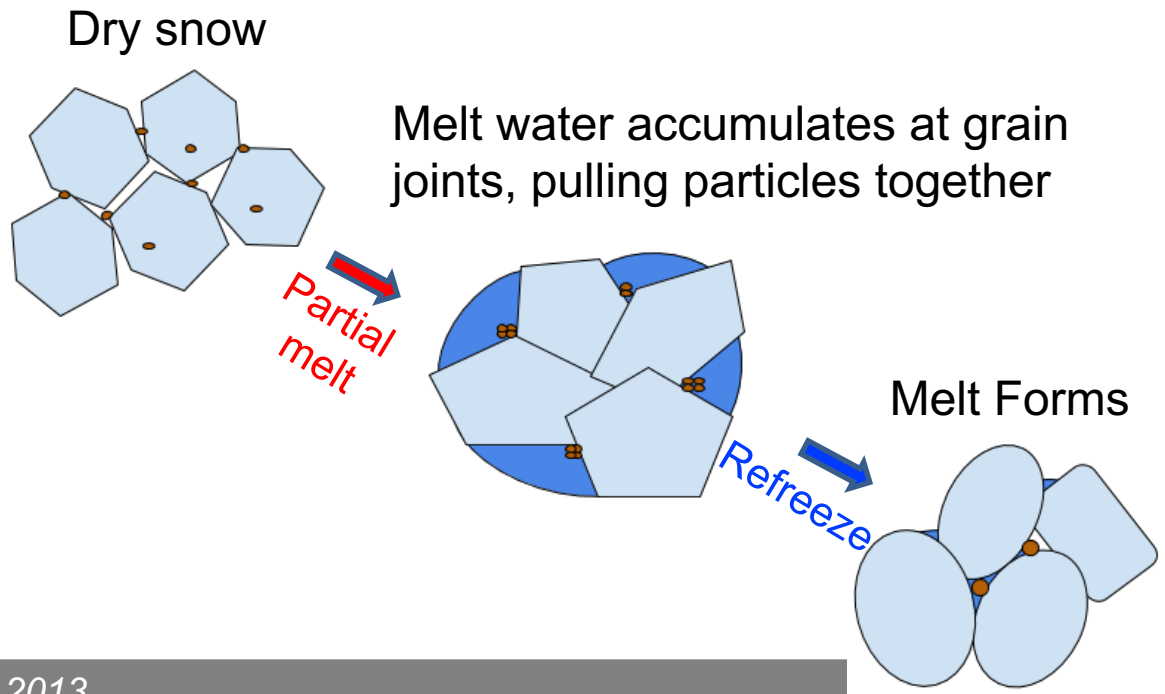
Particles size distributions in snow and working hypothesis



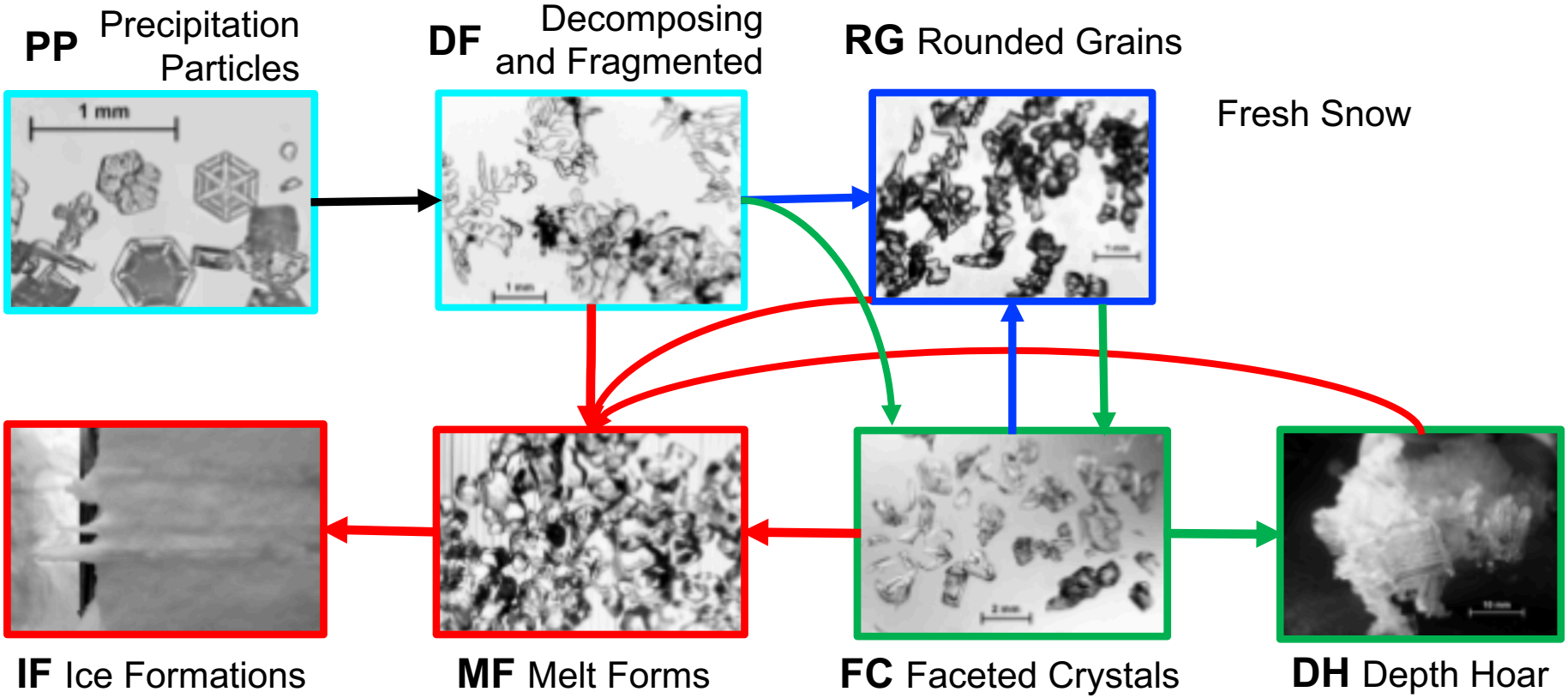
Black Carbon in snow has wider size distribution than in the atmosphere
(e.g. Schwarz et al, 2013)

Hypothesis:

- Partial melt and refreeze induces in snow BC coagulation
- Might also influence Dust
- Measuring normalized size distributions is important



Using snow type as indicator of past metamorphism

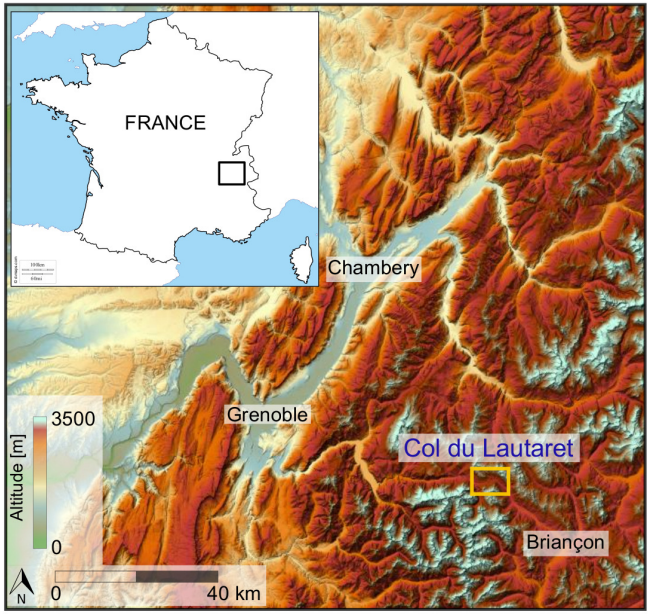


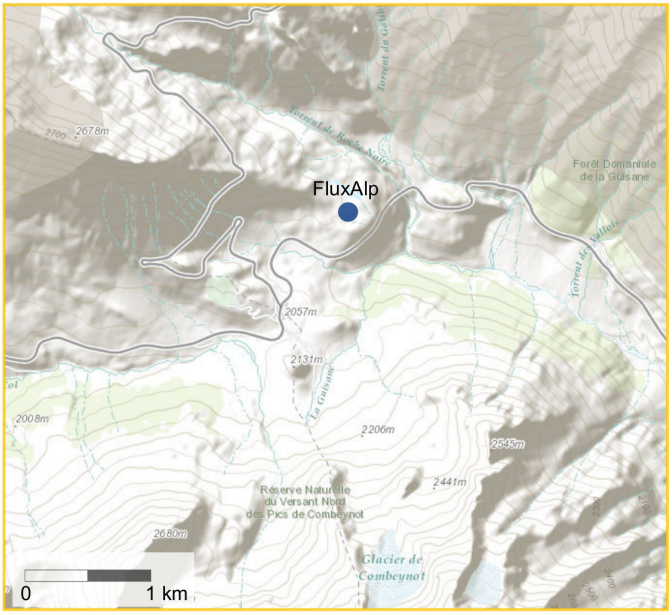
- MF and IF are indicators of partial melt and refreeze

- Compare normalized size distributions between these populations : melt- and refreeze induced coagulation should lead to increases in particles sizes

See Voisin et al, JGR 2012 for another application of this idea, to organic carbon

Sampling site and data





- Col du Lautaret, 2 winters: 2016-17 and 2017-18
- Snow pits every ~2 weeks ;
  - Detailed stratigraphy with snow type identification
  - 5 cm resolution sampling for particles analysis
- Black Carbon: SP2 measurements 60 – 600nm ;
- Dust: coulter counter, 0.6 – 30 µm…

Size Distributions and detection ratio

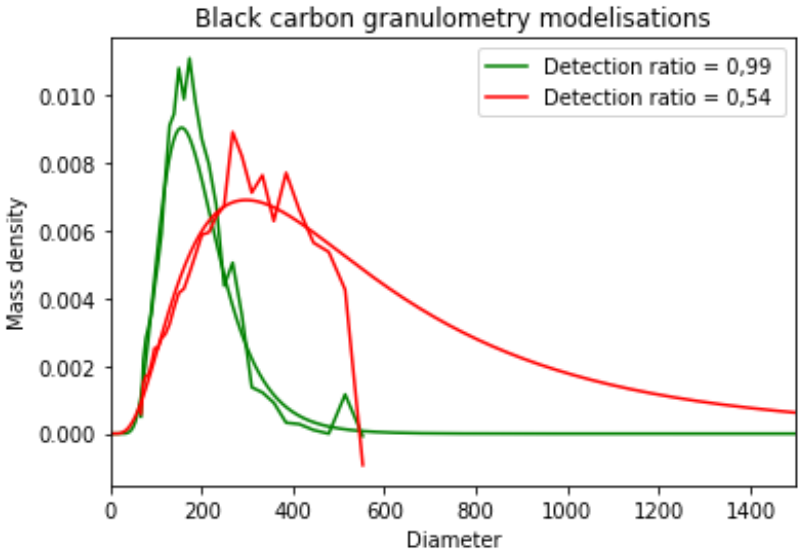
- Particles size distributions often modeled with log-normal laws:

$$\frac{M}{\Delta D} \simeq \frac{dM(D)}{dD} = m(D) = \frac{M_0}{\sqrt{2\pi}\, ln\, \sigma_g\, D} exp\left[-\frac{1}{2}\left(\frac{ln\,(D/\,D_n)}{ln\,\sigma_g} \right)^2 \right]$$

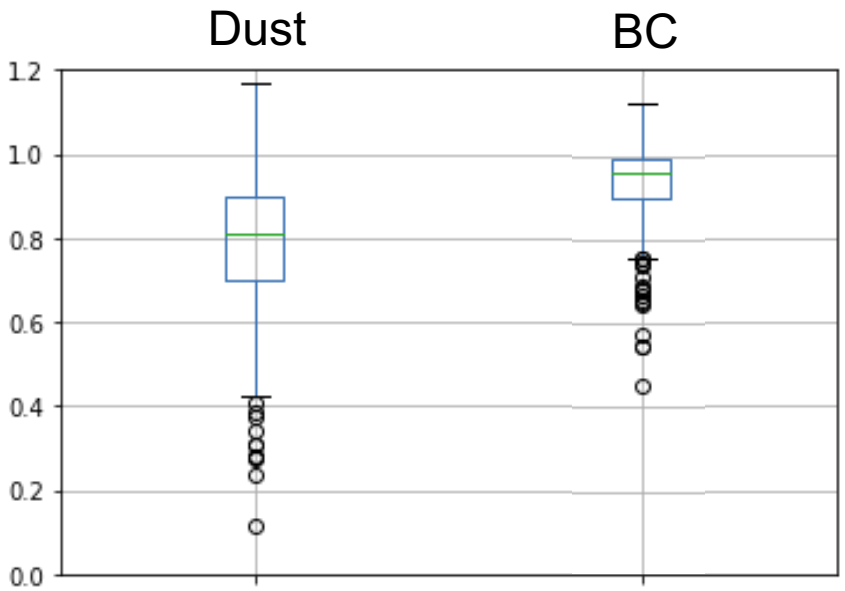
  - D_n: median diameter for distribution
  - σ_g: geometric standard deviation of the distribution
  - M_0 : total mass in the distribution

- Because of instrumental limitations the measured distributions are truncated

- we calculate for each sample a detection ratio defined as the ratio of the total measured particle mass to M0, the total mass obtained by fitting a log-normal law through the experimental distribution



Size Distributions and detection ratios



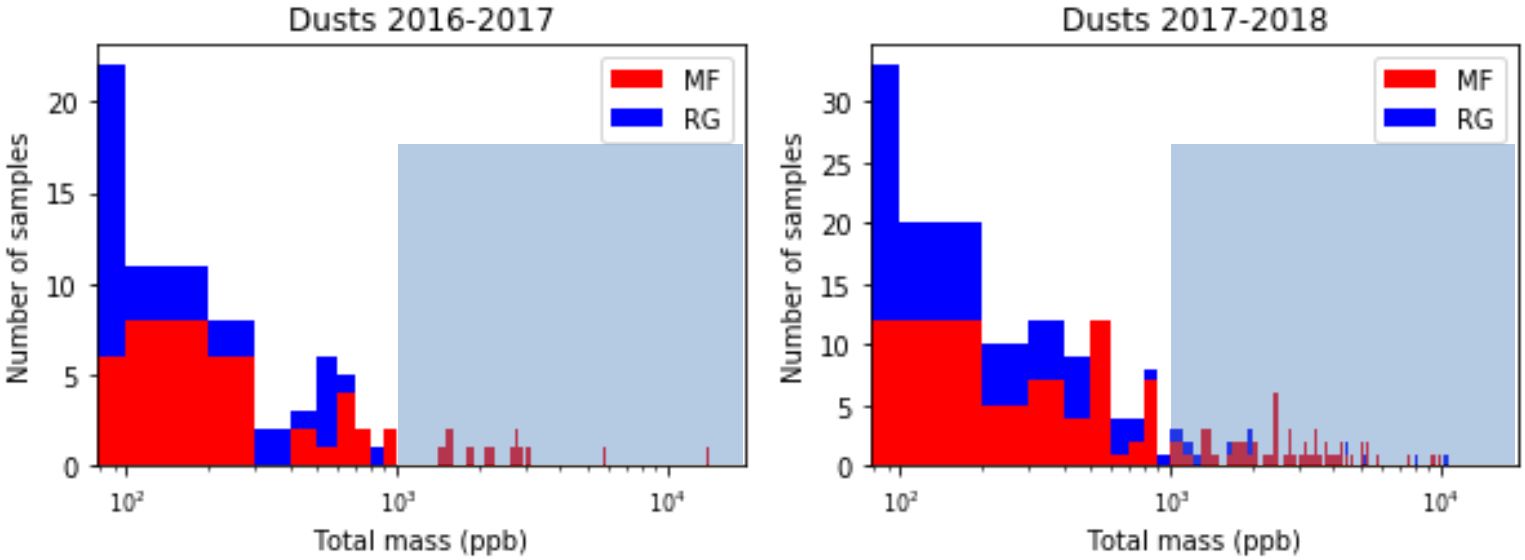
- Dust concentrations can be largely underestimated in the measurements
- Not so much for BC, yet…
- Very sensitive

Sample types summary

	Dusts 2016-17	Dusts 2017-18	Black Carbon
Total number	124	350	405
unclassified	0	24	10
Classified	**124 (100%)**	**326 (100%)**	**395 (100%)**
Fresh Snow	7 (6%)	12 (4%)	17 (4%)
Rounded Grains	34 (27%)	147 (45%)	170 (43%)
Gradient influenced samples	4 (3%)	11 (3%)	10 (3%)
Melted samples	79 (64%)	156 (48%)	198 (50%)

Statistical analysis is done only on Rounded Grains and Melt influenced snow samples

Influence of Dust deposition events

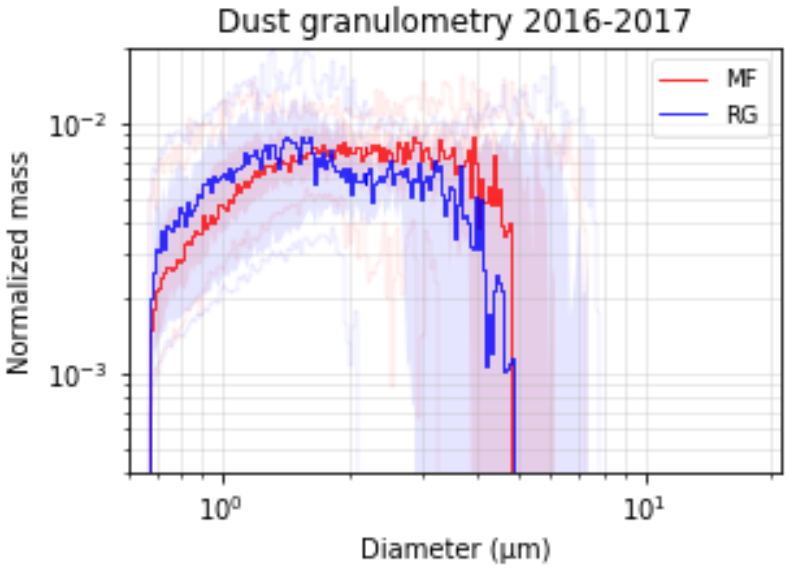


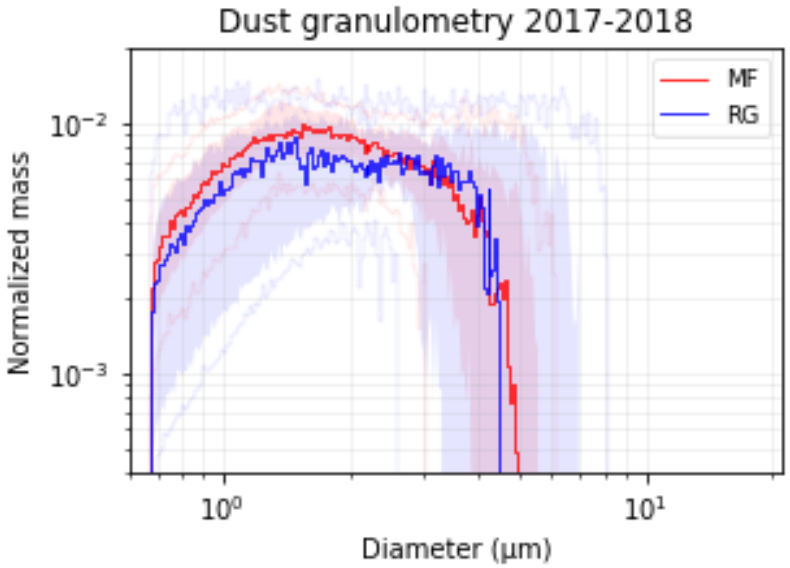
Dust deposition events induce partial melting, which makes them more represented in the Meleted Forms (MF) population compared to the Rounded Grains (RG) population.

We excluded these samples (C > 1000 ppb) from further analysis

Dust granulometry for non dust events

Normalized size distributions are calculated for each sample.
Curves = median ; shaded areas = inter quartile ; dashed lines = deciles

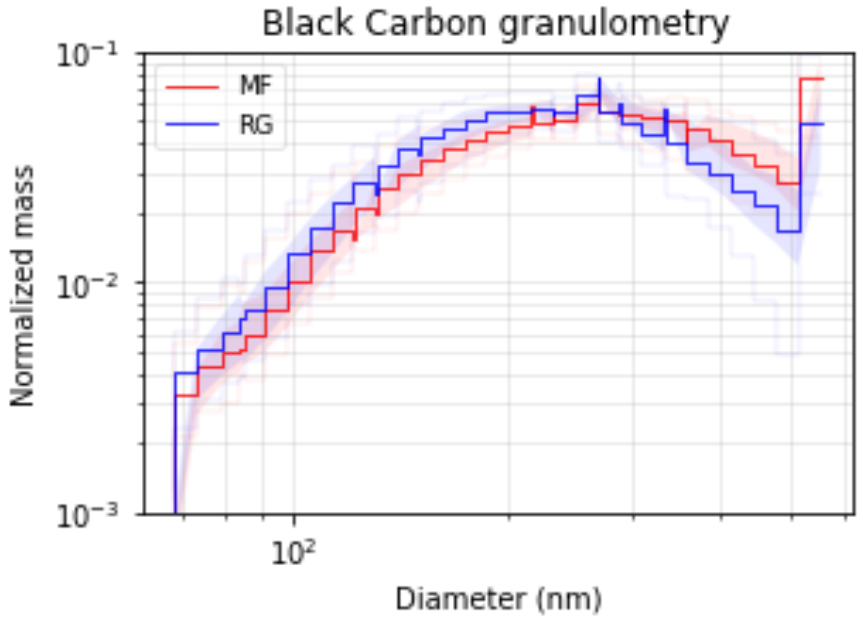




- Some difference between snow types
- Inconsistent from year to year
- Variability in size distributions larger than the observed differences

BC granulometry

Normalized size distributions are calculated for each sample.
Curves = median ; shaded areas = inter quartile ; dashed lines = deciles



- Some difference between snow types, larger than the variability
- Consistent from year to year (so both years are mixed together here)

Conclusions and perspectives

- Size distribution analysis for dust and BC indicates that particle counters tend to underestimate total concentrations of particles.

- Detection ratios can be as low as 20% for dust

- Snow type and detailed stratigraphy was used to investigate the impact of partial melt-freeze on particles size distributions

- Impact on dust is smaller than natural variability (dust event to dust event, year to year, …)

- BC size distributions seem to be shifted to larger sizes in melt forms, which we interpret as the sign of melt and refreeze induced coagulation