SELECTIVE REMOVAL OF DUST PARTICLES AND ITS DEPENDENCE ON MINERALOGY

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ASTAR 2004

- Arctic Study of Tropospheric Aerosols, Clouds and Radiation
- Assess ‘Aerosol direct and indirect effect’ on the Arctic radiative balance
- Focus on the transitional period

Mid-Spring Arctic haze (ASTAR2000) March, April

Late-Spring Background (ASTAR2004) May, June
ASTAR 2004

- Arctic Study of Tropospheric Aerosols, Clouds and Radiation

Flight track of POLAR 4 (Dornier228, AWI)
Longyearbyen [79N, 15E]
31 May 2004
Aerosol (NIPR) payload on POLAR4
*National Institute of Polar Research, Tokyo

**Aerosol Impactor**

- Jet diameter: 2 mm
- Flow: 22 L/min
- (50% cutoff = 0.18 - 0.2 µm)
- Substrate: C (and Ca) coated collodion film
- Sampling time: 5 min / sample
  (20-25 samples / flight)
TEM / SEM-EDX analysis

Transmission Electron Microscope
JEOL JEM-2010

Scanning Electron Microscope
HITACHI S-3000N

Energy Dispersive X-ray Spectrometer
HORIBA EMAX-500

Dust coated in sulfate
Sulfate + Silicate

X-ray counts

X-ray Emission (keV)
Abundance of aged mineral dust vs. Altitude

1. Silicate (Total 673)

Silicate dust > Sea Salt in the free troposphere (2-7km)

Many dust contained S

Silicate dust having sulfate coating increased with decreasing altitude!
particles surviving such transport must have had good chance of getting aged
Increased low cloud (0-2km) activity

Remarkable seasonal change in the Arctic cloudiness which may have impact on the collected particles.

Stratiform cloud layer covering large area
Increased low cloud (0-2km) activity

Relative humidity along the air-mass trajectory

Air-mass arriving at lower altitudes likely experienced higher RH

Stratiform cloud layer covering large area
Abundance of aged mineral dust vs. Altitude

1. Silicate (Total 673)

Silicate dust having sulfate coating increased with decreasing altitude

Air-mass arriving at lower altitudes likely experienced higher RH

- increased uptake of SO$_2$
- in-cloud processing

Matsuki et al. (2005a)
Spherical mineral dust

Such Ca-rich spherical particles were spotted during all flights. - what are they?

Calcite $[\text{CaCO}_3]$ may react with $[\text{HNO}_3(g)]$ to form extremely hygroscopic $[\text{Ca(NO}_3)_2]$.

POSTER by Matsuki et al.
“AGING OF MINERAL DUST: COMPARATIVE STUDIES OVER DESERT AND DOWNWIND REGIONS IN EAST ASIA BASED ON BALLOON AND AIRCRAFT MEASUREMENTS”

Laskin et al. (2005)
Krueger et al. (2003, 2004)
Okada et al. (2005)
Matsuki et al. (2005a, 2005b)
1. Silicate (Total 673)

2. Carbonate? (Total 314)

- Spherical + S detect
- Irreg. + S detect
- Irreg. + S coat

Relatie abundance of Carbonate(?) relative to Silicate particles

1. Sulfate + Silicate

- Ca rich sphere

Silicate dust having sulfate coating increased with decreasing altitude!

- Ca rich spherical particles (likely modified carbonates) decreased with decreasing altitude!!
Abundance of aged mineral dust vs. Altitude

If Ca-rich spheres were indeed aged carbonates...
(i.e. Ca(NO$_3$)$_2$)

All Carbonate particles have the potential

large size & extreme hygroscopicity = efficient CCN

which would have been removed selectively from the atmosphere leaving behind less soluble silicate fraction

⇒ this may explain the absence of Ca-rich spheres in the lowest 2km.
Conclusions

Though found in small numbers, mineral dust outnumbered sea salts in the Arctic free troposphere in late spring. Sea salts were abundant in < 2km (marine boundary layer).

Most of the irregular particles identified as silicate dust, many of which contained S (35-75%) and some had sulfate coatings (<25%).

Fraction of Sulfate coated dust increased with decreasing altitude. Most likely due to the enhanced reactivity under higher relative humidity condition encountered in the lower troposphere (stratiform cloud), or in-cloud processing.

Almost no irregular carbonate particles were found. Instead, spherical particles resembling carbonate composition (Ca enriched) were found in every flight (especially > 2km). They were suggested to be the modified carbonates formed upon reaction with HNO$_3$, which would have been selectively removed from the atmosphere due to the extreme hygroscopicity of Ca(NO$_3$)$_2$.

Current result highlights the distinct roles played by silicate and carbonate fractions of the mineral dust in the actual troposphere.
On going and future works:

- What are the characteristics of dust acting as CCN?
- Does aging (e.g. sulfate coating) affect CCN activity?
- How efficient is in-cloud processing?

we need to directly compare:
cloud residual
vs.
interstitial particles

African Monsoon Multidisciplinary Analysis
http://amma-international.org/about/index

EAC, European Aerosol Conference, 9-14 September 2007, Salzburg, Austria
“Mixing states and hygroscopicity of aerosol particles in West Africa:
Based on AMMA aircraft campaign in summer 2006”
by Matsuki et al.
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Hara et al., (2003) JGR

Early spring (Arctic Haze)

Late spring (background)