The role of ice cores in understanding the dust cycle

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Dustspec Workshop Lamont
Overview

→ Short introduction

→ What have we learned in the past decade?
  (1) more ice cores
  (2) longer records
  (3) higher resolution
  (4) more understanding of the processes
Ice cores

- „clean“ archive, low dust concentration
- sink for dust (despite dust input to the ocean via melting ice)
- pure aeolian input
- high latitude archive
- Antarctic ice cores proximity to the Southern Ocean → iron supply in HNLC
- annual to orbital timescales (>800000 a) covered

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All ice core dust is transported via long range atmospheric transport

→ Reflects source conditions and conditions during transport
Vostok 1999

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Petit et al. 1999
Antarctica

Record extended to 800 ka

Dust and temperature are strongly coupled

Glacial-Interglacial dust flux ratio ~ 25
Dust - temperature coupling is stronger during Glacial stages

\[ \rightarrow \text{easier input of dust to the Antarctic continent} \]

Sources during the Glacial: Southern South America Pantagonian Pampa and the puna Altiplano (e.g. Delmonte et al. 2007)

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No uniform behaviour of the particle size over Antarctica:
→ different regional influences at different locations
→ transport in high altitude and via subsidence
Dust size does not follow strictly the dust concentration (especially during warmer climate)
What have we learned in the past decade?

(1) more ice cores:
   EPICA DML, EPICA Dome C, Dome Fuji, Talos Dome, WAIS-devide

(2) longer records:
   EPICA Dome (>800 ka), Dome Fuji (720 ka)

(3) higher resolution:
   continuous dust record in 55 cm (Lambert et al.)
   0.5 cm resolution (to be published)

(4) more understanding of the processes
   - stronger coupling during warm phases to the sources
   - high altitude transport vs. low altitude transport
Greenland dust sources:

- East asian deserts (Bory et al. 2003, Biscaye et al. 1997)

Dust and temperature are strongly coupled

- Glacial-Interglacial dust concentration ratio ~ 100
- Stadial-Interstadial dust concentration ratio ~ 8

Ruth et al. 2007

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Larger particles during colder climate:

→ intensified transport
→ dryer sources
→ reduced washout
→ change in transport routes

Simple conceptual model: Only a factor of 2-4 can be explained by transport intensification

Ruth et al. 2003

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Greenland - High resolution studies

Ruth et al. 2007
Greenland - High resolution studies

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Steffensen et al. 2008
Younger Dryas → Holocene

- Precipitation moisture source: Switch within 1-3 years
- Greenland air temperature: Gradual change over 30 years

slightly preceded by decreasing Greenland dust deposition → reflecting the wetting of Asian deserts
Greenland air temperature: Gradual change over centuries

precipitation moisture source:
→ Switch within 1-3 years

Following by a slow increase in Greenland dust deposition → drying of land surfaces and vegetation reduction
Summary

- Dust records are extended
  100 ka BP in Greenland
  800 ka BP in Antarctica

- Dust provenance
  East asian deserts for Greenland
  Patagonian Pampa and the Puna Altiplano for Antarctica during Glacials, additional (not common) source during Interglacials

- 100 fold (25-fold) increase in dust can be explained by
  intensification of transport (2-4 / factor of 2-3)
  intensification of sources / change of source areas
  reorganisation of the atmospheric circulation

→ Total amplitude in Glacial-Interglacial dust amplitude not fully understood
Thank you for your attention
Antarctica – Provenance studies with Rare Earth Elements

Source constant until 15 ka B.P.
common for EDML and EDC
Southern South America (e.g. Delmonte et al. 2004)