Atmospheric Deposition of Trace Metals to the South Indian and Atlantic Oceans

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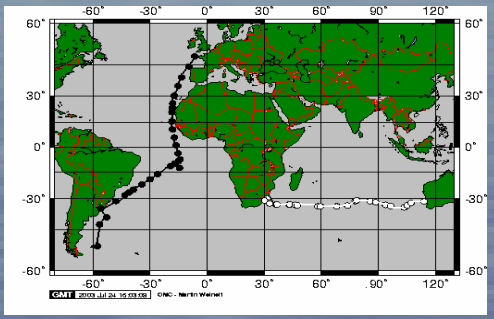
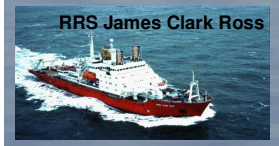
Introduction

The atmosphere is recognised as an important source of trace metals to the oceans (Duce et al. 1991). However, there are few measurements of trace metal concentrations in remote marine regions, particularly in the Southern hemisphere. Aerosol samples were collected during cruises in the Indian and Atlantic Oceans and their metal content investigated. These are the first trace metal concentration data reported for aerosols over the South Indian Ocean.

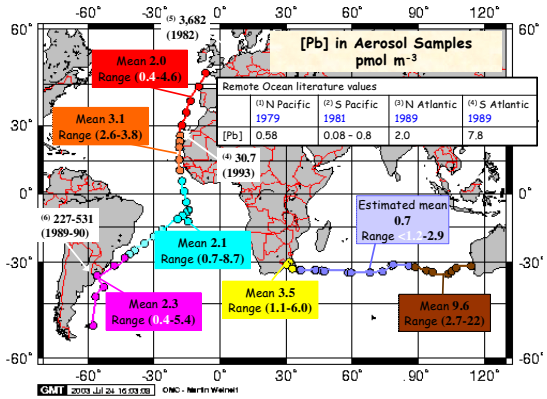




Methods

Aerosol samples were collected during cruises in the Indian and Atlantic Oceans. High volume aerosol samplers were employed to collect aerosol particles on the surfaces of acid washed Whatman 41 filter papers. A 0.1 M Nitric Acid extraction solution was used followed by analysis for a suite of trace metals using Graphite Furnace Atomic Absorbance Spectroscopy. This enabled the readily soluble metals in the aerosols to be quantified.

Lead Concentrations Measured in Aerosols in this Study (*coloured boxes*) and Literature Values (*white boxes*).



The lead data are presented here and similar trends were seen in other metals studies (Cu, Ni, Zn and Cd).

- Most samples in this study had air mass back trajectories suggesting they had a predominantly marine origin.
- Low lead concentrations were observed even fairly close to industrial regions such as Western Europe and South America.
- Similar concentrations were observed in the Northern and Southern hemispheres.
- In terms of metal concentrations in remote ocean regions, generally:

Pacific Ocean < Indian Ocean < Atlantic Ocean

Calculated Dry Deposition Fluxes of Trace Metals to Oceans Compared to Literature Data and River Fluxes

Units 10^9g year^{-1}

This Study	Pb	Cu	Cd	Ni	Zn
North Atlantic	8.3	14.1	0.16	2.6	24.4
South Atlantic	6.7	9.7	0.12	1.3	27.2
South Indian	3.7	27.3	0.07	0.7	16.1

Duce et al. [7]					
North Atlantic	9.6	6.6	0.2	3.2	29
South Atlantic	1.1	0.8	0.03	0.4	3.3
South Indian	0.3	0.2	0.01	0.1	0.9

Dissolved River Inputs [8]					
North Atlantic	0.5	36	3.7	44	21
South Atlantic	0.2	20	1.4	16	13

- The fluxes to the North Atlantic in this study are of a similar magnitude to those calculated by Duce et al[7] and Spokes et al. [9].
- The values are higher than those of Duce et al. for the South Atlantic and South Indian Oceans. This may reflect an increase in industrialisation in the Southern hemisphere in recent years.
- **The input of trace metals to the North and South Atlantic are of a similar magnitude.**
- Atmospheric flux of lead more important than river fluxes. For other metals, river fluxes are a similar magnitude or larger than atmospheric but;
- The atmosphere likely to deliver several times the dry deposition flux through wet deposition processes.
- Rivers only deliver material in continental regions, **the atmosphere is the most important source in remote ocean areas.**

Summary

- Even close to industrial centres such as Montevideo and Buenos Aries, low trace metal concentrations were observed reflecting the importance of sample history when assessing aerosol data.
- Calculation of Enrichment factors (using Al and Na as reference elements) showed that trace metals were enriched above both crustal and oceanic sources in aerosols collected close to land and in remote ocean regions 1000s of km from emission sources. This confirms that continental emissions of trace metals can impact even very remote parts of the ocean.
- Aerosols over the remote Pacific Ocean appear to have the lowest trace metal content, followed by the remote Indian Ocean with higher concentrations found in the remote Atlantic Ocean.
- This work confirms the atmosphere as an important source of metals even in remote oceanic regions.
- Atmospheric deposition of trace metals to oceans in the Northern and Southern hemisphere are now of a similar magnitude possibly resulting from the increase in industrialisation in many countries in the southern hemisphere.

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