Marine aerosol distribution over the pristine Southern Indian

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Introduction

Context

Ocean cover about 70 % of the Earth surface and thus sea-air interactions play a key role in the atmospheric system. In particular, oceans are a reservoir of sea spray aerosols, i.e. sea salt aerosols and primary organic matter. These are thus the most widely distributed natural aerosols (around 4100 Tg/year for total flux sea spray). These natural aerosols are of fundamental importance for climate and interrelated topics: direct and indirect radiative forcing, cloud formation and lifetime, chemical cycles and health. Marine environments are also be influenced by continental emissions and contain other kinds of both natural and anthropogenic aerosols.

The focus is put on the vast region of the Southern Indian Ocean, identified as possibly pristine (e.g. Hamilton et al., 2014). In pristine regions, where land and human activities have little impact, sea salt are dominant. Such regions are interesting for at least two reasons:

1. they can be considered good indicators of the meteorological conditions during pre-industrial epochs, which is crucial reference point to distinguish between respective contribution of natural versus anthropogenic emissions to the changing climate
2. Aerosol contributions are relatively low and so changes in the aerosol concentration can give rise to unexpected results

Objectives

• Characterize aerosol distribution and properties over the pristine southern Indian on a 8-year period
• Use this description to investigate radiative effect of aerosol and aerosol-cloud interactions

Material

Satellite observations:
- POLDER (2006-2013): Aerosol Optical Thickness et 865 nm
- CALIOP (2006-2013): Aerosol extinction profile at 532 nm

Results

Horizontal distributions

January
July

Vertical distributions

January
July

Conclusions & outlook

The aerosol distribution and properties have been investigated on a 8-year period through different approaches. The role of the large scale atmospheric circulation the aerosol distribution have been highlighted. At the center of the area, an anticyclonic circulation is established, presenting the lowest aerosol concentration (no terrestrial aerosol transport, weak sea salt emission from the surface). Northward and southward, there is two (relatively) high marine aerosol concentration areas, due to high near surface wind speed. Here, the importance of the seasonal cycle is evinced through the ITCZ (Inter-Tropical Convergence Zone) north-south displacement, which modulate the high sea salt emission area position and intensity. These sea salt aerosols appear to be restrained to the lowest atmospheric layers, mostly under 2 km.

Terrestrial aerosols are present over the area, mainly during dry periods of the year, as dust emissions from Australia, transported over the northeastern part of the area by trade winds, and organic matter emissions from the Rhin of Africa (pollen and products of combustion), transported over the southwestern part of the area by the circumpolar winds. The MACC reanalysis indicates that these terrestrial aerosols are mainly contained in atmospheric layers above the boundary layer (between 2 and 4 km), while this is not obvious in the CALIOP observations.

Then, the description of the aerosol distribution and properties is used to assess the impact of aerosols on climate. The study find that the aerosols cool the top of the atmosphere by -2.14 Wm-2. The cloud-aerosol interactions are also investigated. The susceptibility of cloud properties to AOD appears clearly, and an evolution is shown according to atmospheric thermodynamics conditions.

References

Sea salt emission flux (ng m-2 s-1)
Sea salt mixing ratio (10-6 kg kg-1)
Dust mixing ratio (10-6 kg kg-1)
AOD marine

Figure 1: Polder marine AOD 1998-2013 (a), sea salt mixing ratio (10-6 kg kg-1) on the right (b) and dust mixing ratio (10-6 kg kg-1) on the right (c) from the MACC reanalysis, and clip aerosol extinction (d).

Figure 2: January (left) and July (right) monthly averaged horizontal patterns of wind surface speed and direction from ERA Interim reanalysis, where the intertropical convergence zone (ITCZ) is schematically represented as a brown band (a), sea salt emission flux from the sea surface according to the Ovadnevaite et al. (2018) parametrization (b), sea salt (c) and dust and organic marine (d) aerosol optical depth (AOD) from the MACC reanalysis, and Polder AOD (e).

Figure 3: January (left) and July (right) monthly averaged vertical cross sections (pressure/haloe vs latitude) of vertical velocity, in blue for ascending, red for descending) and aerosol (black aerosol) atmospheric circulation (a), sea salt (b) and dust (c) mixing ratio from the MACC reanalysis, and clip aerosol extinction (d).

Figure 4: Direct radiative effect of the aerosol at the top of the atmosphere statement based on MACC reanalysis AOD by type of aerosol (a) and susceptibility of a cloud parameter (here the ERA Interim low cloud cover to the marine aerosol concentration) represented by the sea salt and sulfate AOD from MACC according to an environmental parameter, here relative humidity (b).

Figure 5: Aerosol implication on climate

AOD Polder
Sea salt MACC
AOD dust and organic marine
Sea salt Polder

Figure 6: Aerosol implication on climate