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/yr 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 epoch, 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.

Area of investigation → Southern Indian

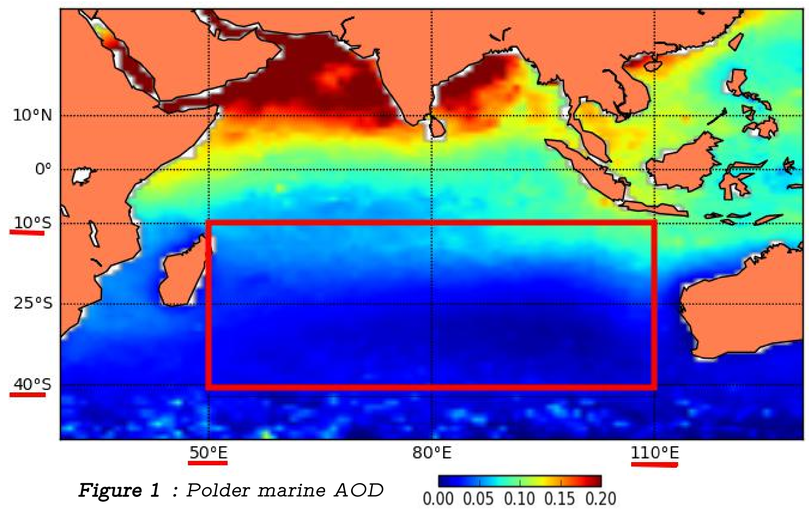


***Figure 1** : Polder marine AOD*

- **Marine** → aerosols are mainly cloud condensation nuclei, i.e. highly reactive with humidity
- **Natural** → study of natural behavior, highlight anthropic influence
- **Pure** (low aerosol concentration) → allow study of cloud development phase transition
- Rather stable atmospheric circulation → easier to study

Material

Satellite observations:

- Polder 3 (2005-2013): Aerosol Optical Thickness et 865 nm
- Caliop (2006-2013): Aerosol extinction profiles at 532 nm

Reanalysis from the ECMWF:

- ERA-Interim (Atmospheric thermodynamics: U, V, W…)
- Wave Model (Sea surface properties)
- MACC (Atmospheric composition)

Results

Horizontal distributions

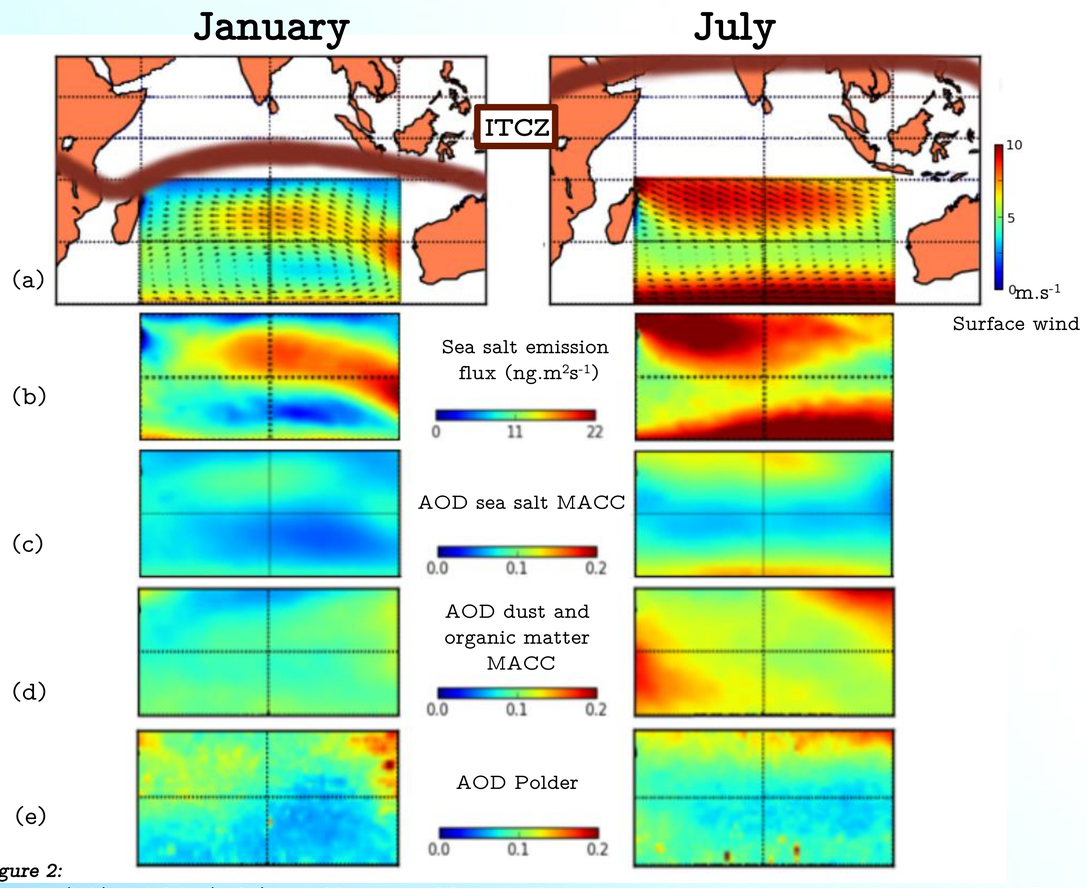


Figure 2:
January (left) and July (right) monthly averaged horizontal patterns of wind surface speed and direction from ERA Interim reanalysis, where the intertropical convergence zone (ITCZ) is schematically represented as a brown band (a), sea salt emission flux from the sea surface according to the Ovadnevaite et al (20??) parametrization (b), sea salt (c) and dust and organic matter (d) aerosol optical depth (AOD) from the MACC reanalysis, and Polder AOD (e).

Vertical distributions

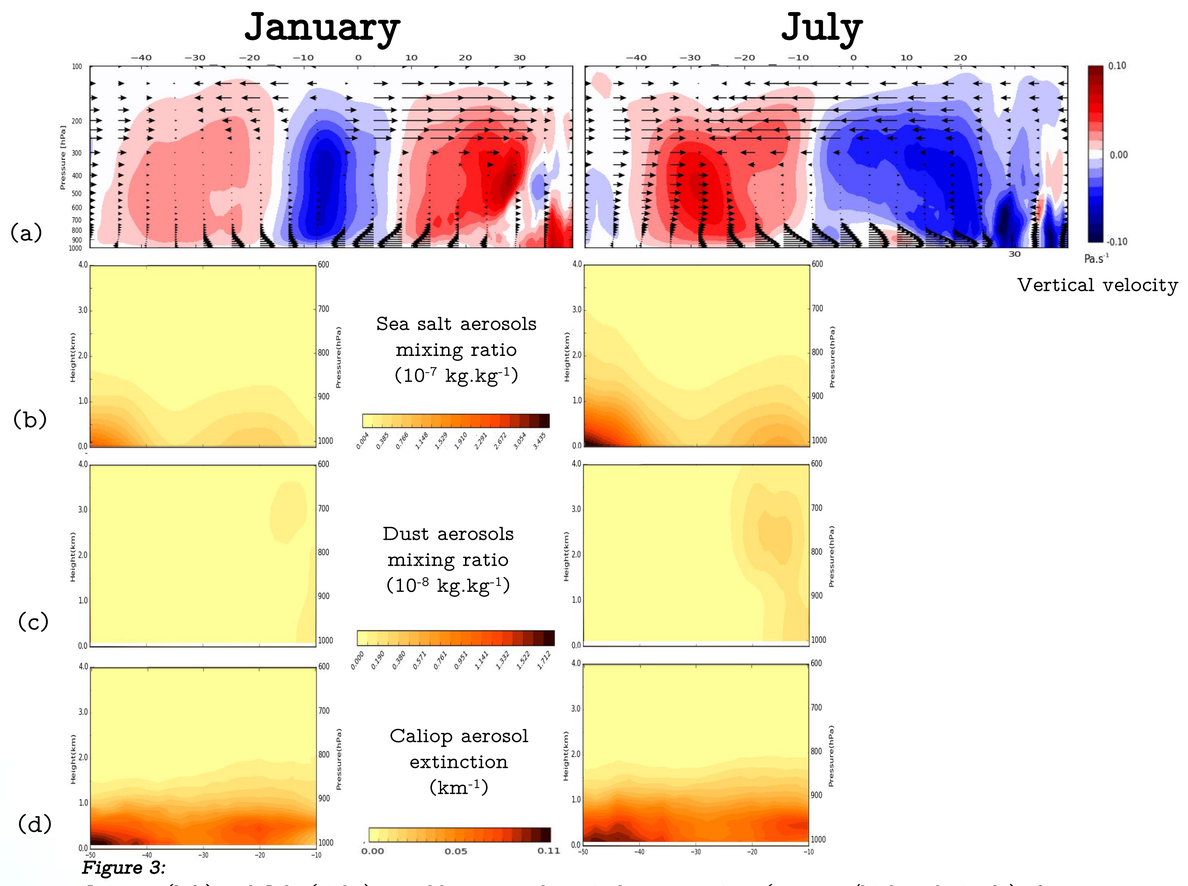


Figure 3:
January (left) and July (right) monthly averaged vertical cross sections (pressure/high vs latitude) of vertical (vertical velocity, in blue for ascending, red for descending) and meridian (black arrows) atmospheric circulation (a), sea salt (b) and dust (c) mixing ratio from the MACC reanalysis,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

Aerosol implication on climate

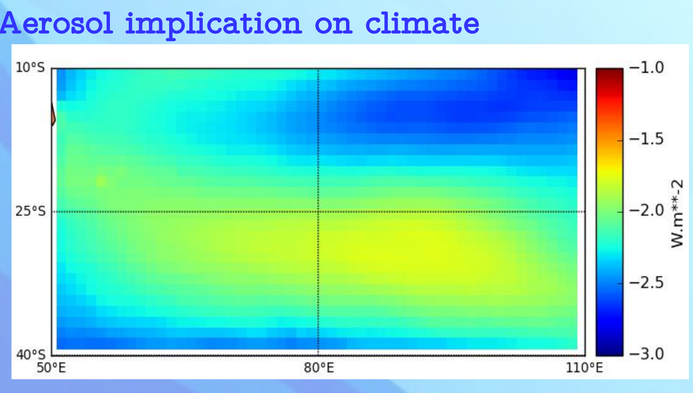
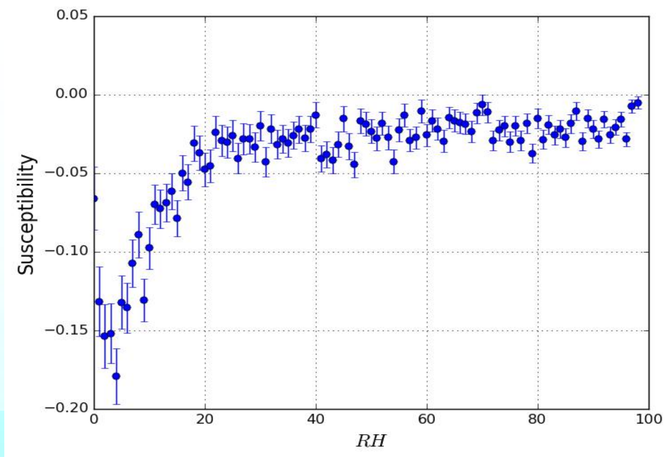


Figure 4:
Direct radiative effect of the aerosol at the top of the atmosphere assessment based on MACC reanalysis AOD by type of aerosol (a). Susceptibility of a cloud parameter (here the ERA Interim low cloud cover) to the marine aerosol concentration (represented by the sea salt and sulfate AOD from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



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 obvious through the ITCZ (Inter-Topical 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 south 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 W.m^{-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.

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