CCCma Canadian Centre for Climate Modelling and Analysis

Parameterization of Sea Salt Optical Properties and Physics of the Associated Radiative Forcing

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1. Introduction

In the last several decades the interest in sea salt aerosol has grown, partly because it is essential for explanation a large portion of the difference in clear sky top of the atmosphere irradiance between the observation (CERES) and modeling study over ocean.

Global averaged, sea salt dominates the radiative transfer in the marine atmosphere compared to all other aerosols.

Sea salt is important for understanding both past and future climate changes. to the end of this century, IPCC scenarios are predicting an additional -0.8 W/m2 direct sea salt solar forcing as increasing of sea salt burden (Penner et al. 2001).

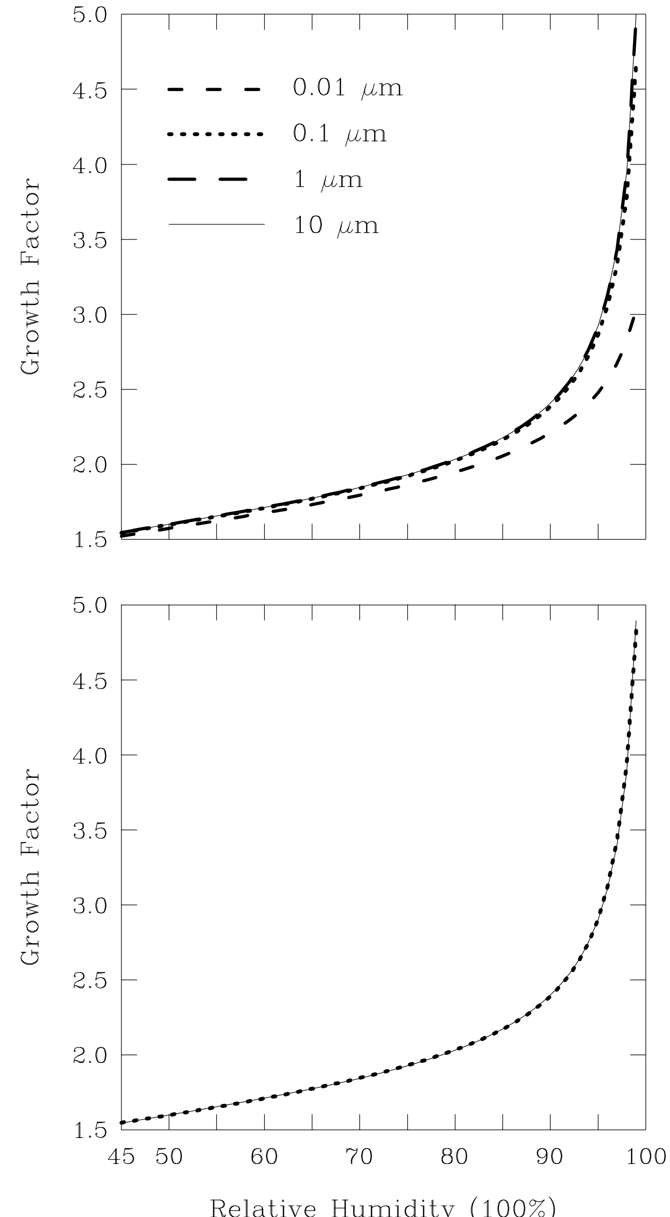
Therefore it is important to a correct parameterization to evaluate the sea salt optical properties accurately.

2. Sea salt growth and size distribution

Sea salt is generated at ocean surface by various mechanisms including bubble bursting and the generation of spume droplets

From observations, all sea salt particles (diminish) in size as relative humidity increase (decrease) (Tang et al 1997)

The growth factors is function for both of the relative humidity and dry particle size. However for dry size larger than 0.1 the dependent on dry size is very weak, except for relative humidity close to 1



CCCma aerosol model did good job in simulating salt size distribution. It is single mode for sea salt only!

μ

μ

μ

1. Parameterization of sea salt optical properties

Now CCCma aerosol model can simulate the sea salt size distribution properly by PLA method (Salzen 2005), not just using two dry size modes. This is the main motivation for generating a new parameterization which can deal with sea salt aerosol distribution with any values of effective radius.

There are two approach for generating the parameterization of optical property for sea salt

Based on wet size distribution

$$\psi = \sum_i a_i \psi_i (r_e, RH)$$

Based on dry size distribution, first using parameterization associating the wet size to dry size for different relative humidity

$$\psi = \sum_i a_i \tilde{\psi}_i (r_{eD}, RH)$$

1.5 um 3.0 um

Parameterization based on the wet size distribution,

5 previous calculated results For effective radius 0.73, 175, 2.75, 4 and 6.13 um

The results for other effective radius are obtained through Lagrangian interpolation

Parameterization based on the dry size distribution,

8 previous calculated results For effective radius 0.35, 0.5, 0.73, 1.2, 1.75, 2.75, 4 and 6.13 um

The results for other effective radius are obtained through Lagrangian interpolation

4. Physics associated with sea salt radiative forcing

Using single column model with standard atmospheric profile to calculate the sea salt forcing based on the new parameterization. It is much easier to understand the important factors determining the sea salt forcing by using single 1-D column model.

Using GCM to evaluate the sea salt global forcing

Almost linear in solar and infrared forcing corresponding to the sea salt loading. Since the optical depth of sea salt is far less than the gaseous optical depth, perturbation theory can well explain the linear results.

Solar forcing at surface to variation of surface albedo

Sea salt over high albedo (like sea ice)
Could have dramatic impact on the forcing.
Diminishing rapidly as surface albedo close 1

Net solar flux at surface approach to zero

Solar forcing to variation of solar zenith angle

For solar zenith angle less than 30 degree the sea salt solar forcing becomes positive, opposite to common accepted concept that aerosol solar forcing is always negative.

This can be used to predict a lower forcing in tropic region where the chance for small solar zenith angle is larger than extra-tropics

For small solar zenith angle the strong forward scattering peak causes photons to have a high probability to penetrate through the sea-salt layer as they would do in absence of the sea salt.

JJA

1.34 W/m2

DJF

1.54 W/m2

5. Conclusions

- Previous assumption for dry sea salt distribution with two dry effective radii is incorrect

- It is better to parameterize the sea salt optical properties based on wet size distribution. The new proposed parameterization works very well for continuous size distribution with any values of effective radius.

- Both the sea salt solar and infrared forcing were shown to respond linearly to the sea salt loading

- It is interesting to note the sea salt can generate a positive solar forcing when solar zenith angle is less than 30 degree and also it can generate negative infrared forcing when there is a temperature inversion.