Parameterization MACv2-SP for aerosol optical properties

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Frascati, 7 October 2015
14th International AeroCom Workshop, Session on AerChemMIP
Why MACv2-SP?

Parameterization of aerosol optical properties

- **Constrained** by observations
- Computationally **efficient**
- Flexible application
- Easy to implement
Why MACv2-SP?

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Observational constraint

Anthropogenic fine-mode AOD of MACv2

anthropogenic fine-mode AOD

0.001 0.1 0.2 0.3 0.4 0.5
Observational constraint

Anthropogenic fine-mode AOD of MACv2

Industrial pollution
Observational constraint

Anthropogenic fine-mode AOD of MACv2

Industrial pollution
Biomass burning

Anthropogenic fine-mode AOD

0.001 0.1 0.2 0.3 0.4 0.5
Why MACv2-SP?

Parameterization of aerosol optical properties

Constrained by observations

Computationally efficient

Flexible application

Easy to implement
Efficent and flexible design

Aerosol properties
\( f(x, y, z, t) \)

- **Horizontal**
  - Rotated Gaussian function
  - AOD
  - Longitude

- **Vertical**
  - Beta function
  - AOD
  - \( z \)

- **Time**
  - Cosine function
  - AOD
  - Month

MACv2-SP
Fortran 90/95 module

ESM
Offline Driver

RTM
Construction of plume

Gaussian #1

AOD (Courtesy: Karsten Peters)
Construction of plume

Gaussian #1

Gaussian #2

AOD (Courtesy: Karsten Peters)
Construction of plume

Gaussian #1

Gaussian #1 + #2

Gaussian #2

AOD (Courtesy: Karsten Peters)
Construction of plume

Gaussian #1

Gaussian #2

Gaussian #1 + #2

Gaussian #1 + #2 + beta

AOD

longitude

AOD

longitude

AOD

longitude

AOD

longitude

AOD

z

AOD (Courtesy: Karsten Peters)
Construction of seasonal cycle

Seasonal cycle from MACv2 and MACv2-SP (fit)

- MACv2, ‘Angola’
- MACv2, S America
- fit, ‘Angola’
- fit, S America

AOD

Month

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Courtesy: Karsten Peters

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Parameterization of aerosol optical properties

Constrained by observations

Computationally efficient

Flexible application

Easy to implement
Pre-industrial to 2100

Global 10 year-running mean of anthropogenic AOD
Pre-industrial to 2100
Development of anthropogenic AOD over years and longitude
Why MACv2-SP?

Parameterization of aerosol optical properties

- Constrained by observations
- Computationally efficient
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What input does MACv2-SP need?

- Height of orography
- Vertical discretization
- Longitude
- Latitude
- Month
- Year
- Wavelength

MACv2-SP
What does MACv2-SP provide?

Calculates for each month, location and wavelength:

- **AOD(z)**
  - Aerosol optical depth

- **SSA(z)**
  - Single scattering albedo

- **ASY(z)**
  - Asymmetry parameter
1. **Conserve** globally averaged anthropogenic AOD

2. **Balance** deviations in anthropogenic AOD over sources and oceans
1. Global mean AOD

Development of anthropogenic AOD over years and longitude

Annual cycle

Zonal mean

Anthropogenic fine-mode AOD

MACv2
MACv2-SP

NH
Global
SH
2. Balance sources and oceans

Mean anthropogenic AOD at 550nm for 2005

Annual

MACv2 0.025

MACv2-SP minus MACv2

0.021
What is MACv2-SP’s gain?

- **Constrained by observations**
- **Optical properties from MACv2**
- **Computationally efficient**
- **Mathematical construction of 9 plumes**
- **Easy to implement**
- **Input: position, vertical info, time, wavelength**

**Industrial pollution**

**Biomass burning**
What is MACv2-SP’s gain?

- **Constrained** by observations
- **Optical properties** from MACv2
- **Computationally efficient**
  - Mathematical construction of 9 plumes
- **Easy to implement**
  - Input: position, vertical info, time, wavelength
- **Flexible applications**
  - Different models and resolutions
  - Historical simulations and climate change projections

**Industrial pollution**
**Biomass burning**

**Anthropogenic fine-mode AOD**

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Outlook

• Use MACv2-SP in PSrad-O and MPI-ESM
  Implementation into RTMs and ESMs (RFMIP)
  (Time variable and background climatology)

• Validation with other data
  Anthropogenic AOD from historical simulations of aerosol-climate models

• Incorporate Twomey effect
  Approximation from MACv2

Interested in using or contributing to MACv2-SP?
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MORE VALIDATION

MACv2-SP
1. Global mean AOD

January
MACv2-SP
MACv2

February

March

April

May

June

Anthropogenic fine-mode AOD
Latitude

Anthropogenic fine-mode AOD
Latitude

Anthropogenic fine-mode AOD
Latitude

Anthropogenic fine-mode AOD
Latitude

Anthropogenic fine-mode AOD
Latitude

Anthropogenic fine-mode AOD
Latitude

1. Global mean AOD

July

August

September

MACv2-SP

MACv2

Anthropogenic fine-mode AOD

Latitude

2. Balance sources and oceans

Mean anthropogenic AOD at 550nm for 2005

MACv2-SP minus MACv2

March

MACv2

0.023

MACv2-SP

0.020

difference in anthropogenic fine-mode AOD

-0.2 -0.1 -0.02 0 0.02 0.1 0.2
2. Balance sources and oceans

Mean anthropogenic AOD at 550nm for 2005

June
2. Balance sources and oceans

Mean anthropogenic AOD at 550nm for 2005

September

MACv2
0.030

MACv2-SP
0.026

difference in anthropogenic fine-mode AOD

-0.2  -0.1  -0.02  0   0.02  0.1  0.2
2. Balance sources and oceans

Mean anthropogenic AOD at 550nm for 2005

December

[Map showing anthropogenic AOD distribution globally, with MACv2 and MACv2-SP data highlighted.]

MACv2
0.022

MACv2-SP
0.018

[Color scale indicating difference in anthropogenic fine-mode AOD.

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Evaluation of AAOD

March

June

\[ AAOD = AOD \times (1 - SSA) \]
Evaluation of AAOD

September

December

MACv2

MACv2-SP

AAOD = AOD x (1 - SSA)
Evaluation of Asymmetry

Shown is AOD x SSA x ASY
Evaluation of Asymmetry

Shown is AOD x SSA x ASY