ESA Climate Change Initiative
aerosol_cci

Option: Model Enabling Studies

Version 1.1

Document reference: Aerosol_cci_MES_v1.1.pdf

DOCUMENT STATUS SHEET

	FUNCTION	NAME	DATE	SIGNATURE
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EXECUTIVE SUMMARY

This report discusses the tools prepared to enable easy uptake of Aerosol_cci phase I retrieval products by climate and aerosol modellers. Requirements from the international AeroCom initiative are summarized and tools and guidance has been developed in response. Easy access and exemplary visualization tools are developed and provided on a common platform for the science community interested. Guidance and documentation is put in place on the web and on the AeroCom data server. Daily masks are provided, where satellite retrievals from Aerosol_cci phase I have observed aerosol optical depth, to guide modellers further. This is intended to output environmental variables on the fly during model execution and help interpretation of model-retrieval comparison.

Issue	Date	Modified Items / Reason for Change
1.0	21.11.2014	report issued
1.1	27.11.2014	Review by science leader, minor corrections

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1 INTRODUCTION

The Aerosol_cci project, part of ESA's Climate Change Initiative (CCI), has in it's first phase (2010-2013) conducted intensive work to improve and inter-compare several precursor algorithms for the retrieval of aerosol properties. At the end of this process the Climate Research Data Package (CRDP) was produced. The length of most data sets was one year (two or more years in only few cases) - with one exception at the end of phase I (Swansea AATSR time series produced in an optional work package).

This option reports on studies to enable the improved long-term utilization of the aerosol ECVs by the modelling community at the end of the Aerosol_cci project phase I. It provides guidance for the utilization of aerosol ECVs in models. It reports the development of an Aerosol_cci simulator&evaluation tool package for use with atmospheric transport models, which allows easy comparisons to quick diagnostics and uptake of the Aerosol_cci satellite aerosol ECVs products. It aims to foster more effective development of atmospheric global and regional models.

Aerosol transport models utilize different complexity of aerosol composition, size and mixing state and the comparison to more sophisticated remote sensing aerosol products would be very useful. However, only aerosol optical depth derived from Aerosol_cci phase I was of sufficient high quality and the tools developed here refer exemplary to usage of those products. This said, the conclusions provide a perspective of this study for more sophisticated usage, once more satellite products become available.

2 REQUIREMENTS FROM MODEL COMMUNITY

Discussions with the scientific user community, in particular international aerosol and climate modeling groups represented at the AeroCom workshop (see overview on presentations and topics of recent workshops here: aerocom.met.no) on synthesis work using model and satellite data have a long tradition in AeroCom. The recurrent problems and concerns of modelers may be summarized as follows:

Satellite products require to be traceable so that published work, using them, can refer to the data.

Satellite product data are often difficult to use with model data because of format, grid definition, spatial and temporal resolution and lengthy access procedures.

Monthly and daily data contain different information density and should be used either/or depending on scientific goals. If both are explored, they need to be consistent.

During model development quick looks and diagnostics are needed to guide further sensitivity tests on fairly short notice.

Tools to compare data should be based on open source software to facilitate international cooperation.

Tools and data provided by projects may be too complex and project specific, and are used barely as an inspiration source. Missing possibility to transform tools prevents adaptation to specific needs of science teams.

Different retrieval products should be compared on the same level.

3 METHODS AND IMPLEMENTATION

Considerable effort has been put into structuring the data and tools in such a way, that modellers can easily access them. The natural choice is a section on the AeroCom data server, a place which aerosol modellers are used to explore. An explanatory section has been also added to the AeroCom website section on benchmark data to publicise the data and the tools.

Table 1 summarizes the solutions and methods implemented for the requirements as formulated by the AeroCom modelling community.

Two scripts were developed to facilitate comparison of model data with satellite retrieval products. One script provides re-gridding of any model resolution to Aerosol_cci data grids and combination with the variables and data meant for comparison. A second script provides a simple visualisation routine based on python, which produces a quicklook set of images.

Table 1: Overview of modelling community requirements and the chosen implementation in Aerosol_cci *tool package.*

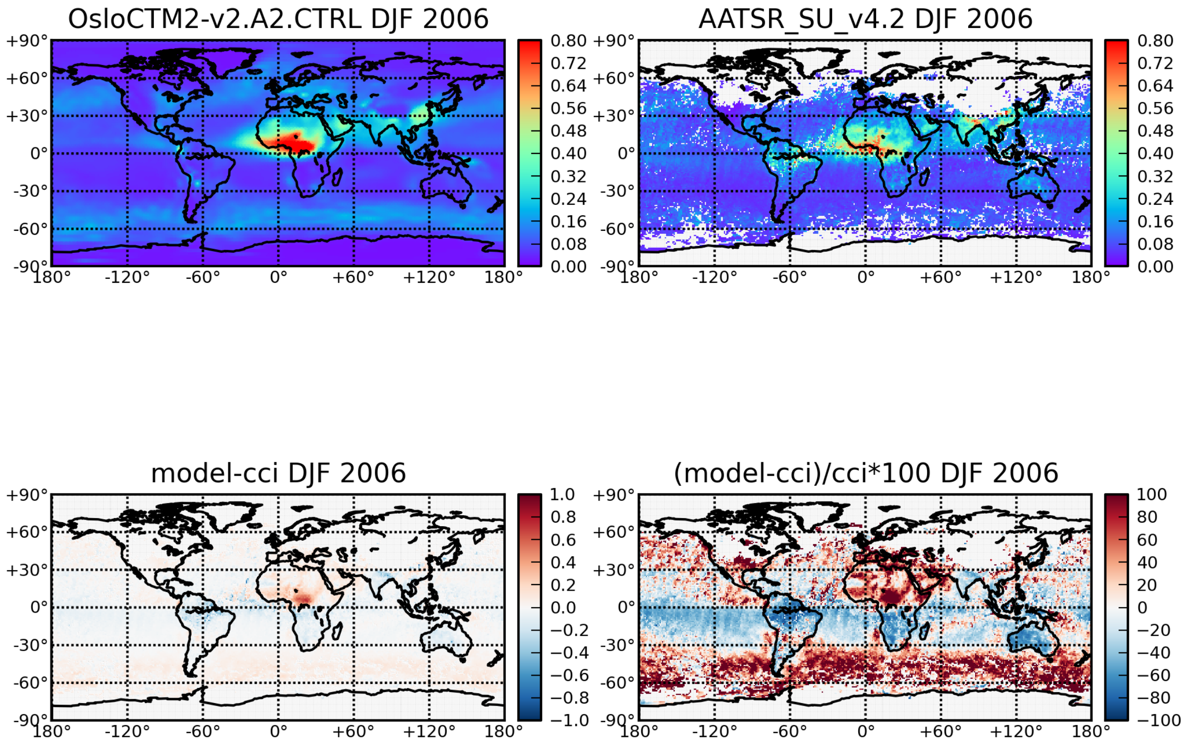
Requirement	Aerosol_cci ***simulator & evaluation package solution***
Traceable retrieval	Only data identified as Aerosol_cci products are included. Products are documented in scientific papers and via AeroCom web interface.
Easy format	netCDF files are prepared in aerocom standard format per year and per variable, with standard names, CF compliant.
Grid compatibility	A script using cdo is provided to re-grid any model data to Aerosol_cci resolution, 1x1 degree. Exemplary combination with Aerosol_ccidata is provided in the same script.
Temporal choice	Scripts and data are prepared for both monthly and daily data. Monthly data on AeroCom server are based on and consistent with daily data
Easy access	Data and tools are accessible on AeroCom users server, accessible to all AeroCom, EMEP, MACC and HTAP modelers
Quick looks	Exemplary visualization python script produces a set of quicklooks. Difference maps can be visualized very quickly on the fly.
Open software	Tools packaged and recommended are solely based on open software: netCDF, nco, bash, cdo, python, ncview
Tools adaptability	Scripts are exemplary, rather simple. They are provided with example output using data from AeroCom server.
Sampling consistency	Daily masks for each retrieval are provided to allow for output during model run of any variable, when observations are available for a given retrieval.
Retrieval choice	All Aerosol_cci products are foreseen, tested and can be used on

AeroCom server

4 EXEMPLARY OUTPUT OF TOOL PACKAGE

The tools were applied to compare typical model data sets from the AeroCom database (exemplary OsloCTM2) to selected Aerosol_cci retrievals. The figures below show the aerosol optical depth from model and satellite retrieval, the bias and the relative bias for the given time interval. All comparisons are based on daily data, removing the areas from the model data where no observations are available.

Figure 1: Exemplary comparison of an AeroCom model (year 2006) with an Aerosol_cci retrieval of aerosol optical depth at 500 nm (2006). Bias and relative bias are plotted for the winter season (DJF).



5 USER GUIDE FOR UTILIZATION OF THE TOOL PACKAGE

Data and tools can be found on the AeroCom user server. How to get access is explained on the AeroCom wiki server: https://wiki.met.no/aerocom/user-server .

Data and storage are provided on the server in the directory /metno/aerocom/users/aerocom1/CCI-AEROSOL-products/

For each retrieval, corresponding mask files are available for daily and monthly resolution, where grids with available observation are marked with 1. The files are stored in the sub-directory masks.

Exemplary plots can be found in the sub-directory:
/metno/aerocom/work/aerocom1/CCI_AEROSOL_products/cci-aerosol-tool-plots.

The use of the re-gridding and recombination script ***compute_diff_to_cci.job*** requires to

- Install nco (http://nco.sourceforge.net) for combination of variables
- Install cdo (https://code.zmaw.de/projects/cdo) for re-gridding
- Copy Global360x180.griddes file to specify cci target grid
- Adapt model file name and model file directory path in script
- Adapt year of model data in script
- Adapt Aerosol_cci retrieval name, to which model data shall be compared
- Ensure that satellite data ar in place on the AeroCom server, or copy of satellite data and correction of path to satellite data
- Find results in sub-directory /metno/aerocom/work/aerocom1/CCI_AEROSOL_products/cci-aerosol-tools-outputfiles

The use of the the quicklook plotting script ***makeplot.py*** requires to

- Install python (https://www.python.org)
- Prior execution of ***compute_diff_to_cci.job*** script to prepare input for plotting
- Adapt model name in script

Excerpts from the two scripts are documented below for illustration.

Script excerpt ***compute_diff_to_cci.job:***

```
#!/bin/bash
## Aerosol-cci regridding and recombination script
## Model enabling tool suite
## http://www.esa-aerosol-cci.org
## Norwegian Meteorological Institute, Michael Schulz, Jan Griesfeller
## November 2014
## requires nco, cdo and cci retrieval data &Global360x180.griddes grid description file
## see for more detail http://aerocom.met.no/databenchmarks.html

set -ex

var=od550aer
year=2006
model=OsloCTM2-v2.A2.CTRL
modeldir=../../${model}/renamed
cciretrieval=AATSR_SU_v4.2

file=${modeldir}/aerocom.${model}.daily.${var}.${year}.nc
filem=${modeldir}/aerocom.${model}.monthly.${var}.${year}.nc

#interpolation to CCI grid using distance weighted averaging
GriddescriptionFile=Global360x180.griddes

#daily
file_regriddedd=${file}.regridded.daily.nc

if [ ! -f ${file_regriddedd} ] ; then
REMAP_EXTRAPOLATE='off' cdo remapdis,${GriddescriptionFile} ${file} ${file_regriddedd}
ncatted -a _FillValue,${var},o,f,-999. ${file_regriddedd}
fi

filecci="../${cciretrieval}/renamed/aerocom.${cciretrieval}.daily.od550aer.2008.nc"
filecomp=${var}.${model}-comparison-to-${cciretrieval}.daily.nc
ncks -O -3 -v ${var} $filecci $filecomp
ncrename -v ${var},${var}cci $filecomp
ncks -A -3 -v od550_aer_mask 2008.WORLD.1x1deg.OD550_AER.daily.${cciretrieval}.nc $filecomp
ncks -A -3 -v ${var} $file_regriddedd $filecomp
ncap2 -O -s "${var}diff=(${var}-${var}cci)" $filecomp $filecomp
ncap2 -O -s "${var}diffpercent=(${var}-${var}cci)/${var}cci" $filecomp $filecomp
ncwa -O -a lon,time -y avg -v ${var}diff $filecomp $filecomp.latitudinal.nc
ncwa -O -a lat,time -y avg -v ${var}diff $filecomp $filecomp.longitudinal.nc
ncwa -O -a time     -y avg -v ${var}diff $filecomp $filecomp.field.nc
```

Script excerpt ***makeplot.py:***

```
from netCDF4 import Dataset
import pylab as pl
from mpl_toolkits.basemap import Basemap
import numpy as np
import matplotlib.pyplot as plt
from pylab import savefig
data = Dataset('od550aer.comparison-to-AATSR_SU_v4.2.monthly.nc', 'r')

ModelYear='2006'
ModelName='OsloCTM2-v2.A2.CTRL'
CCIName='AATSR_SU_v4.2'
#read the variables
lons=data.variables['lon'][:]
lats=data.variables['lat'][:]
od550aerdiffyear=data.variables['od550aerdiff'][:,:,:]
od550aerdiffpercentyear=data.variables['od550aerdiffpercent'][:,:,:]
od550aeryear=data.variables['od550aer'][:,:,:]
od550aercciyear=data.variables['od550aercci'][:,:,:]

data.close()

#calculate the seasonal mean
SeasonString='DJF'
OutFileName=ModelName+'.comparison-to-'+CCIName+'.'+SeasonString+'.png'
MeanMonths=[11,0,1]
od550aerdiff=np.mean(od550aerdiffyear[MeanMonths,:,:],axis=0)
od550aerdiffpercent=np.mean(od550aerdiffpercentyear[MeanMonths,:,:],axis=0)
od550aer=np.mean(od550aeryear[MeanMonths,:,:],axis=0)
od550aercci=np.mean(od550aercciyear[MeanMonths,:,:],axis=0)

#plot model start
plt.subplot(2, 2,1)
m = Basemap(projection='cyl',llcrnrlat=-90,urcrnrlat=90,\
            llcrnrlon=-180,urcrnrlon=180,resolution='c')

#convert array from netCDF4 to numpy
lon, lat = np.meshgrid(lons, lats)
#plot the data
xi, yi = m(lon, lat)#
palette = plt.cm.rainbow
palette.set_bad ('w',0.0)
cs = m.pcolormesh(xi,yi,np.squeeze(od550aer),cmap=palette,vmin=0.0,vmax=0.8)

m.drawcoastlines()
m.drawparallels(np.arange(-90.,91.,30.),labels=[1,0,0,0],labelstyle='+/-',yoffset=0.03,fontsize=7)
m.drawmeridians(np.arange(-180.,180.,60.),labels=[0,0,0,1],labelstyle='+/-',xoffset=0.03,fontsize=7)
m.drawmapboundary(fill_color='black')
cb = m.colorbar(cs,location='right',pad=0.08) # draw colorbar
cb.ax.tick_params(labelsize=7)
plt.title(ModelName+" "+SeasonString+' '+ModelYear,fontsize=11)
#plot model end
```

CONCLUSIONS AND OUTLOOK

This report presents the tools prepared to enable easy uptake of Aerosol_cci phase I retrieval products by climate and aerosol modellers. Requirements from the international AeroCom initiative have been taken up and implemented in a tool package. Easy access and exemplary visualization are achieved via the AeroCom user server common platform for the interested science community.

The modellers should find it very easy to use the tools, if the open software is available and installed on the user side. Alternatively the user can use the AeroCom -users server. Other visualization tools can make easy use of the intermediate comparison files produced by our re-gridding and recombination script. Ncview, Panoply and any netCDF tool should have no problem visualizing the comparison.

Daily masks are provided, where satellite retrievals from Aerosol_cci phase I have observed aerosol optical depth to guide modellers to do further research. With the masks more consistent comparisons can be made between model and satellite data. These masks are not only available for each retrieval, but also across ATSR retrievals to allow for comparison across retrieval algorithms. The masks are especially intended to output environmental variables on the fly during model execution and help interpretation of model-retrieval comparison. They can be used during model run (after appropriate re-gridding) and may simplify also assimilation procedures. With the mask one can imagine that the meteorological environment (high, low humidity) used to calculate aerosol optical depth in the model can be better characterised and investigated. Incorporation of more complex satellite retrieval products may be facilitated if model data are consistently sampled at the time of model run (retrieval error estimate, cloudy super-pixels). Using daily masks is a more simple and still sufficient way to sample model output consistently with satellite observations, rather than computing and sampling the model at satellite overpass times.

6 REFERENCES

Applicable Documents

1 Statement of Work "ESA Climate Change Initiative Stage 1, Scientific User Consultation and Detailed Specification", ref EOP-SEP/SOW/0031-09/SP. Issue 1.4, revision 1, dated 9 November, 2009, together with its Annex C "Aerosols" (altogether the SoW).

Reference Documents

[RD1] Aerosol_cci User Requirements Document, v1.5, 03.08.2012

[RD2] Aerosol_cci Product Validation and Intercomparison Report, v1.3, 22.02.2014

[RD3] Aerosol_cci Product User Guide, v1.3, 14.03.2014

[RD4] de Leeuw, G., T. Holzer-Popp, S. Bevan, W. Davies, J. Descloitres, R.G. Grainger, J. Griesfeller, A. Heckel, S. Kinne, L. Klüser, P. Kolmonen, P. Litvinov, D. Martynenko, P.J.R. North, B. Ovigneur, N. Pascal, C. Poulsen, D. Ramon, M. Schulz, R.Siddans, L. Sogacheva, D. Tanré, G.E. Thomas, T.H. Virtanen, W. von Hoyningen Huene, M.Vountas, S. Pinnock (2013). Evaluation of seven European aerosol optical depth retrieval algorithms for climate analysis, Remote Sensing of Environment (2013), http://dx.doi.org/10.1016/j.rse.2013.04.023

[RD5] Holzer-Popp, T., de Leeuw, G., Martynenko, D., Klüser, L., Bevan, S., Davies, W., Ducos, F., Deuzé, J. L., Graigner, R. G., Heckel, A., von Hoyningen-Hüne, W., Kolmonen, P., Litvinov, P., North, P., Poulsen, C. A., Ramon, D., Siddans, R., Sogacheva, L., Tanre, D., Thomas, G. E., Vountas, M., Descloitres, J., Griesfeller, J., Kinne, S., Schulz, M., and Pinnock, S., Aerosol retrieval experiments in the ESA Aerosol_cci project, Atmos. Meas. Tech., 6, 1919 - 1957, doi:10.5194/amt-6-1919-2013, 2013

Acronyms

AATSR	Advanced Along Track Scanning Radiometer
AEROCOM	Aerosol Model Comparison
AERONET	Aerosol Robotic Network (NASA)
AOD	Aerosol Optical Depth
CCI	Climate Change Initiative
ECV	Essential Climate Variable
MACC	Monitoring Atmospheric Composition and Climate (EU project)
netCDF	Network Common Data Format
SU	Swansea University
URD	User requirements document

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