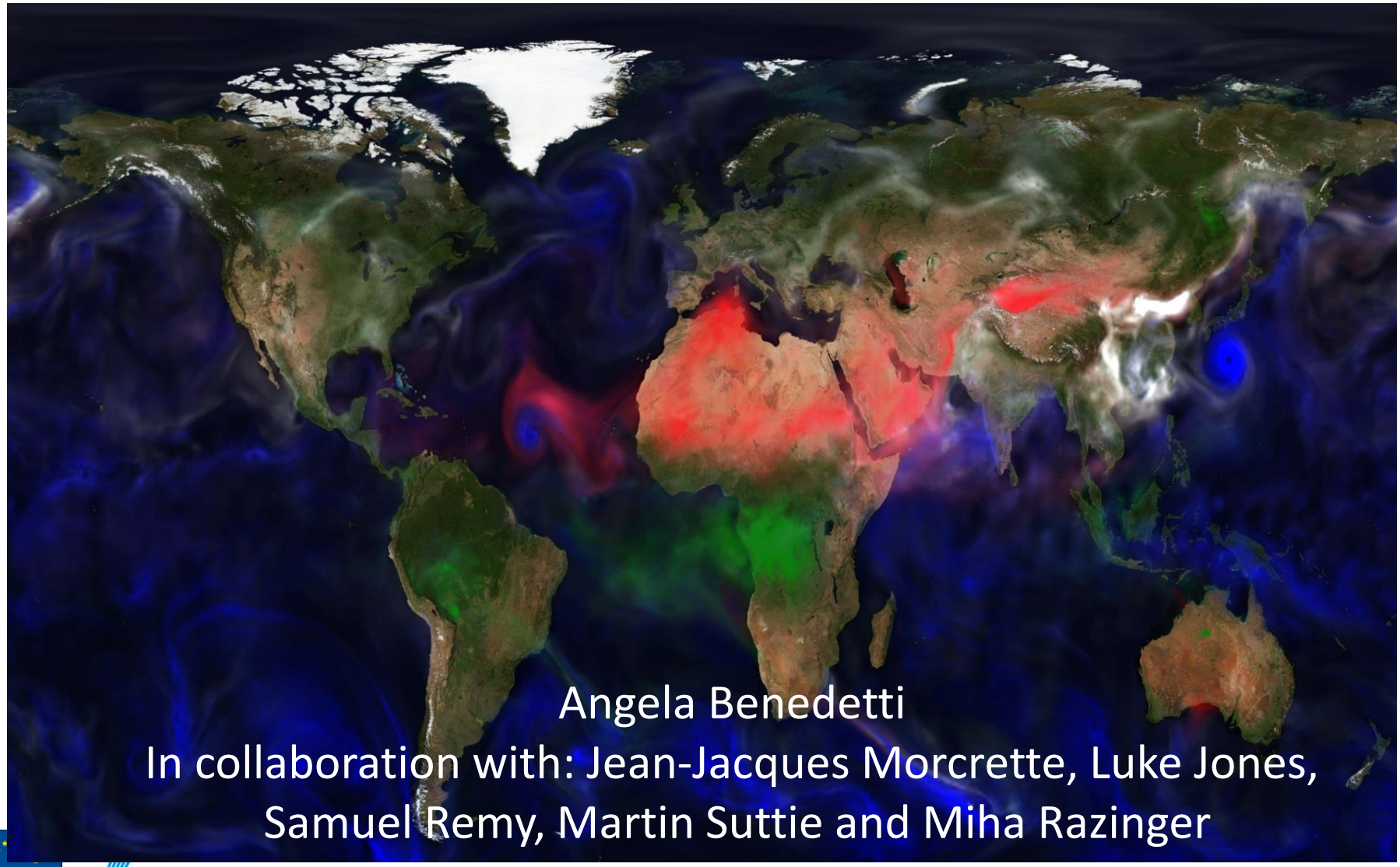
ECMWF/MACC-II AEROSOL UPDATES

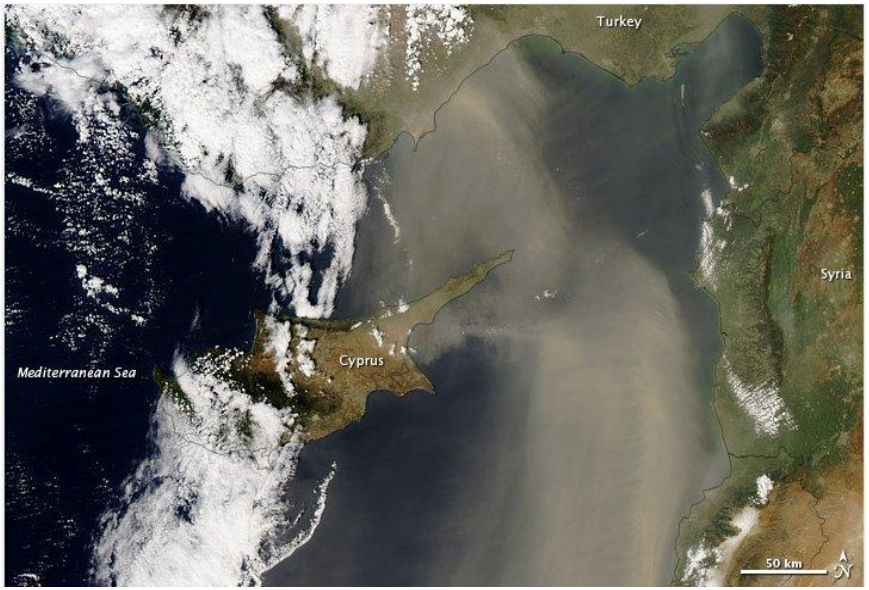


Angela Benedetti
In collaboration with: Jean-Jacques Morcrette, Luke Jones, Samuel Remy, Martin Suttie and Miha Razinger

Outline

- Forecast performance (desert dust and fire events)
- Model improvements and future upgrades
- Assimilation updates
- Future directions

Dust Storms over the Mediterranean in April 2013



Libyan dust storm hangs over Cyprus

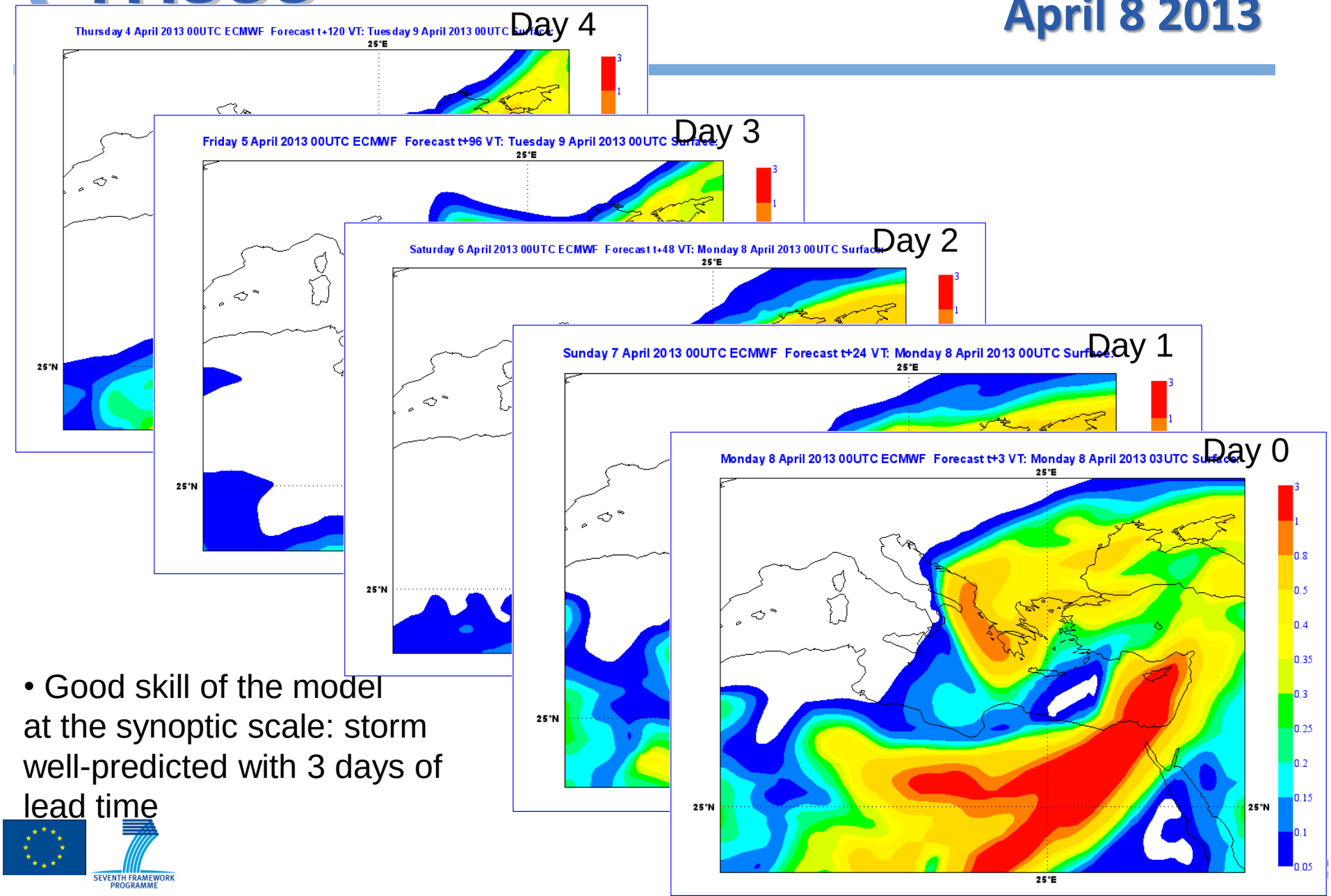
1 April 2013

April 1, 2013 4 Comments

A cloud of fine dust was left hanging over Cyprus today. The air was very still and temperatures unseasonably high as a fine yellow dust, that could have been mistaken for mist, lurked over land and sea.

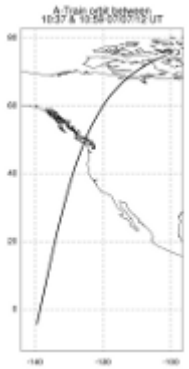
Dust plumes blew over the Mediterranean Sea in early April 2013. Thick plumes hovered off the coasts of Libya and Egypt on April 7 and spanned the sea's eastern shoreline the following day, reaching as far north as Turkey. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite captured these natural-color images on April 1 and April 8 .

MACC-II/ECMWF forecasts for April 8 2013

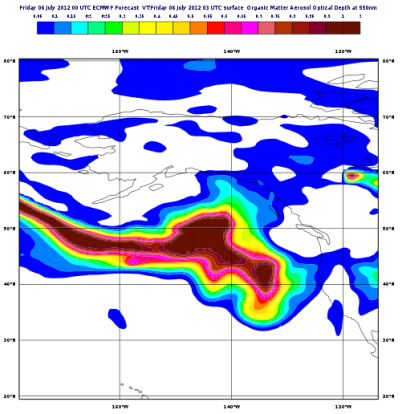


- Good skill of the model at the synoptic scale: storm well-predicted with 3 days of lead time

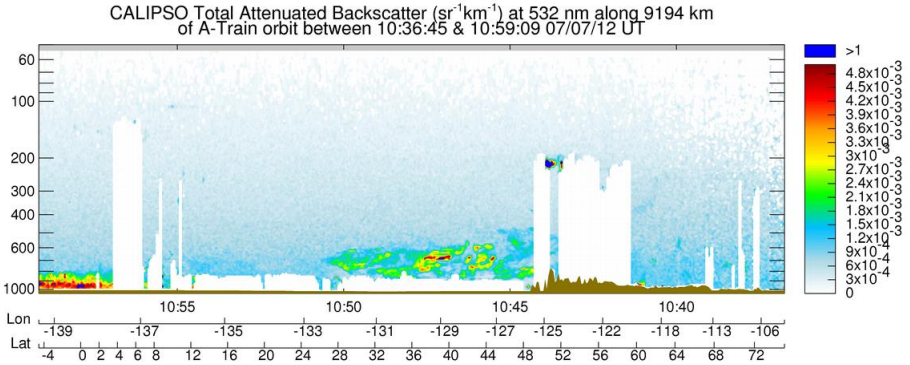
Siberian Smoke in Seattle July 2012

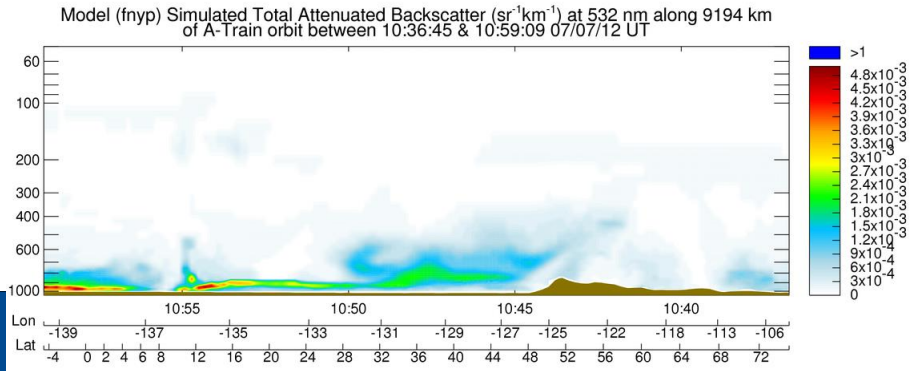


Smoke plume approaching Seattle



Verification with CALIPSO data





9:09 AM
Mon July 9, 2012

E-mail
Print
0 Comments
Share
Tweet
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Asian fires clouding Seattle's sunny skies

By KPLU News Staff and Bellamy Pailthorp

Credit Cliff Mass / KPLU

Enlarge image

A MODIS satellite image that shows the smoke yesterday very clearly.

Updated Jul 9, 2012 · 3:11 pm

Wildfires in Asia to blame for hazy sunsets

By **Tim Haeck**
97.3 KIRO FM Reporter

Comments (2) | Print | E-mail | +1 0 | Tweet 1

Haze at sunrise at Mount Pilchuck. (Photo courtesy Josh Thayer-Facebook)

You might have noticed a haze in the skies of Western Washington, particularly at sunset the last several days.

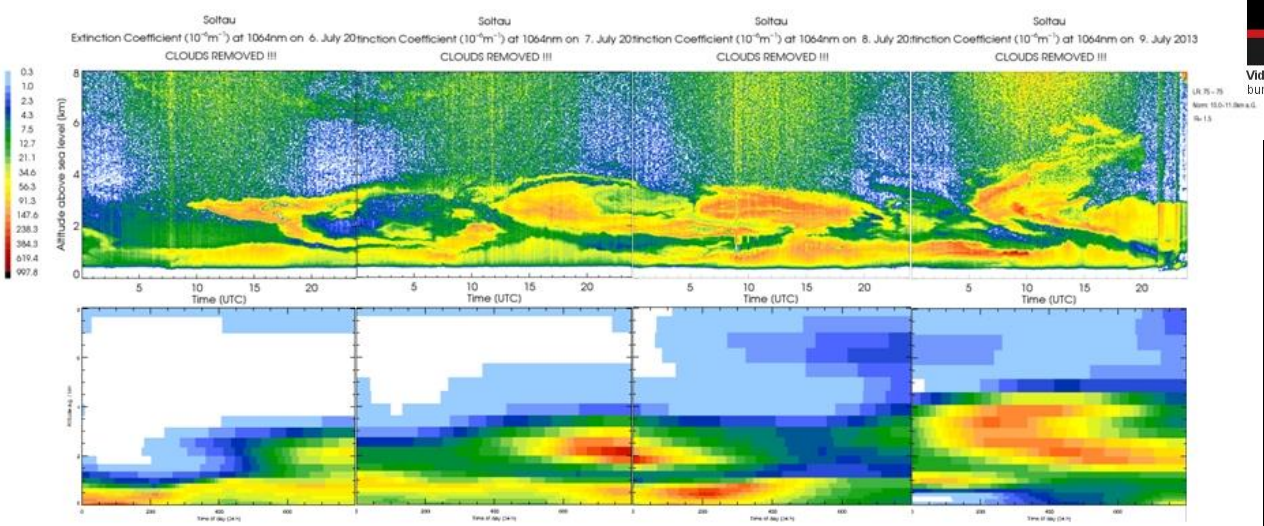
At first, Cliff Mass, University of Washington Professor of Atmospheric Sciences, thought it was smoke from massive wildfires in Colorado circulating in the upper atmosphere and into our area.

"And then finally, when I did a little investigation, it became clear it was from Asia. It was from major fires over Asia and that smoke went all the way across the Pacific into us," said Mass.

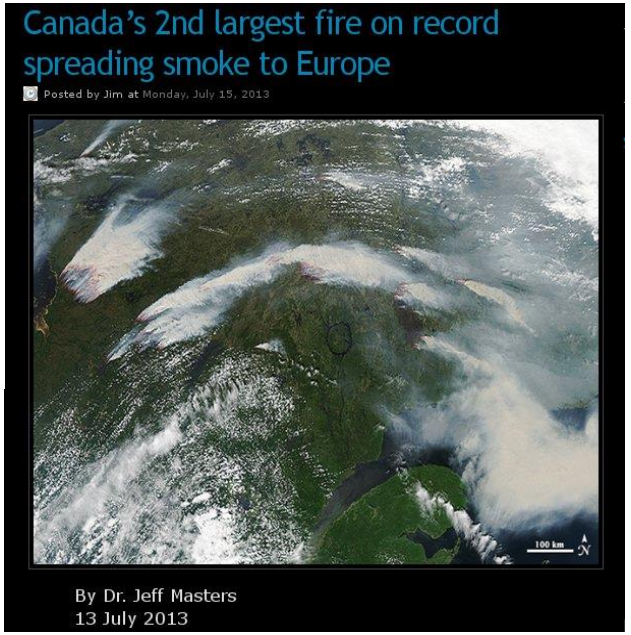
Canadian Smoke in Europe July 2013

Comparison of Canadian forest fire plume seen by Ceilometers over Soltau, North Germany
6 – 9 July 2013

MACC-2D plot is QUALITATIVE and linear scale in contrast to ceiloplot!!!
Shall just show the reproduction of the plume structure



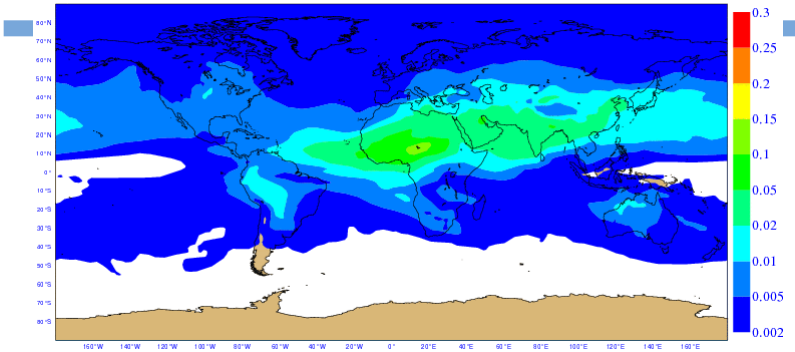
Video 1. Maxime Duperré, traveling in a truck near Nemiscau, Quebec, took this video of one of the massive fires burning in Quebec this July.



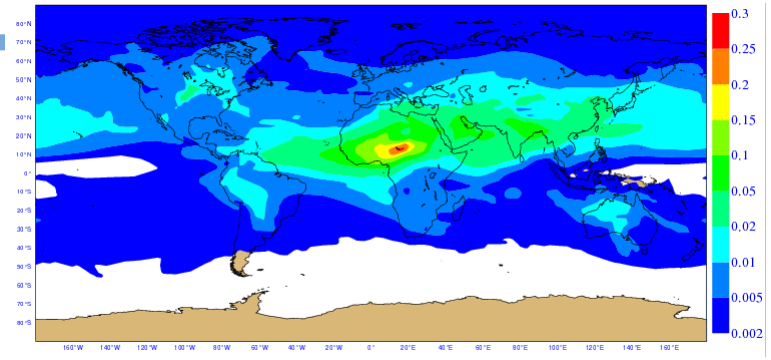
Verification of MACC aerosol forecast with ceilometer data shows good performance for most plume occurrences (plots courtesy of Harald Flentje, DWD)

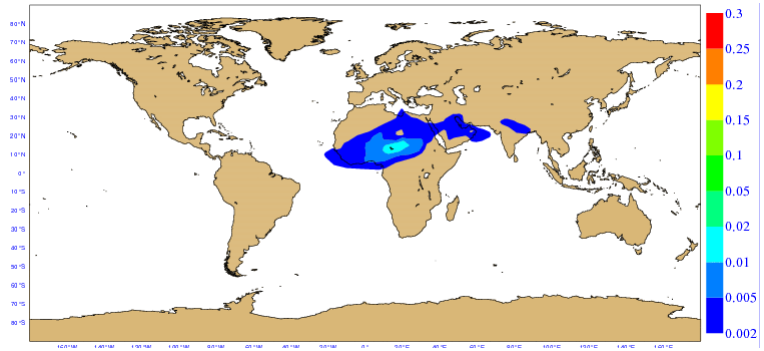
Improvements in dust modelling

Credits: Jean-Jacques Morcrette

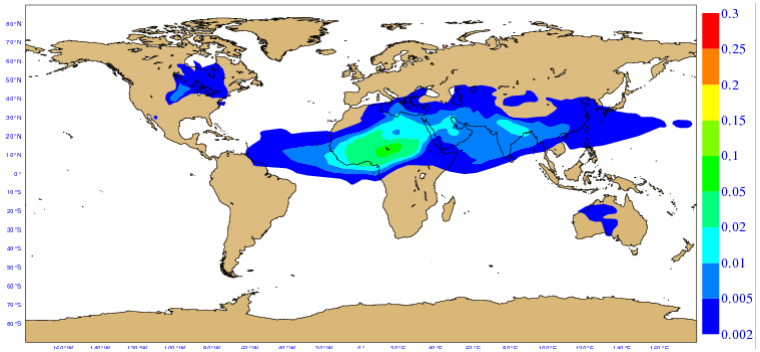


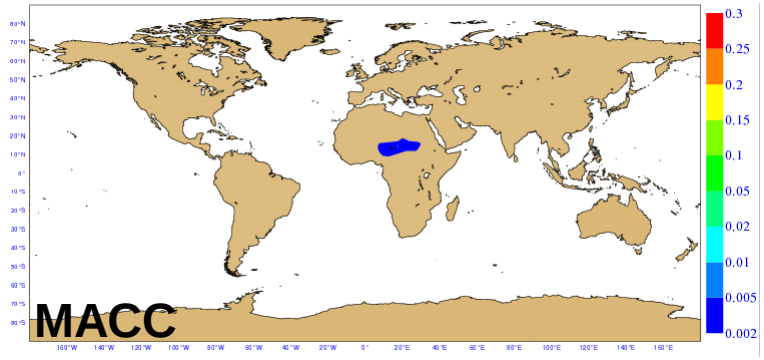
Dust particles 0.03-0.55 microns



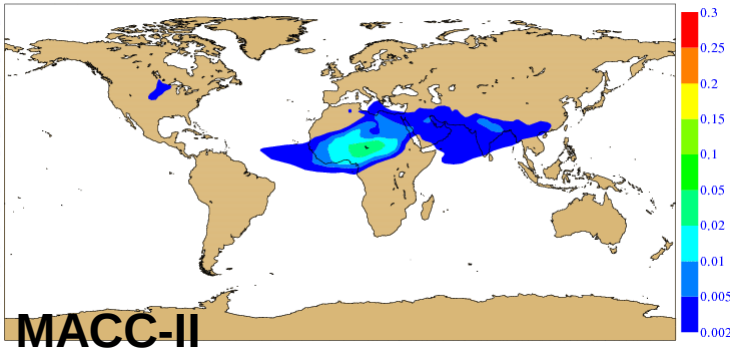


Dust particles 0.55-0.9 microns





Dust particles 0.9-20 microns



MACC

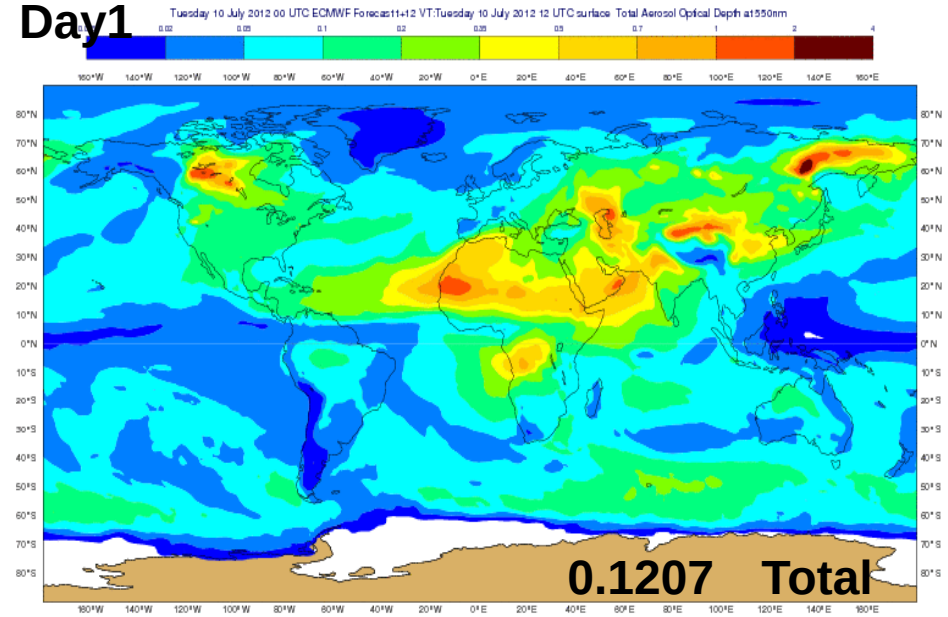
MACC-II

Original formulation: too many fine dust particles!

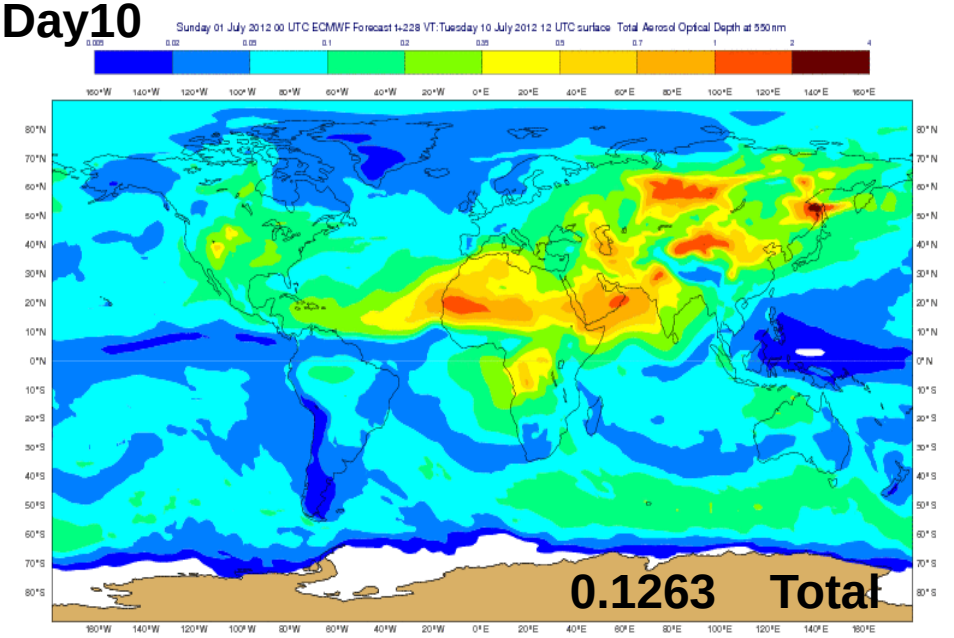
Current formulation: more realistic dust distribution

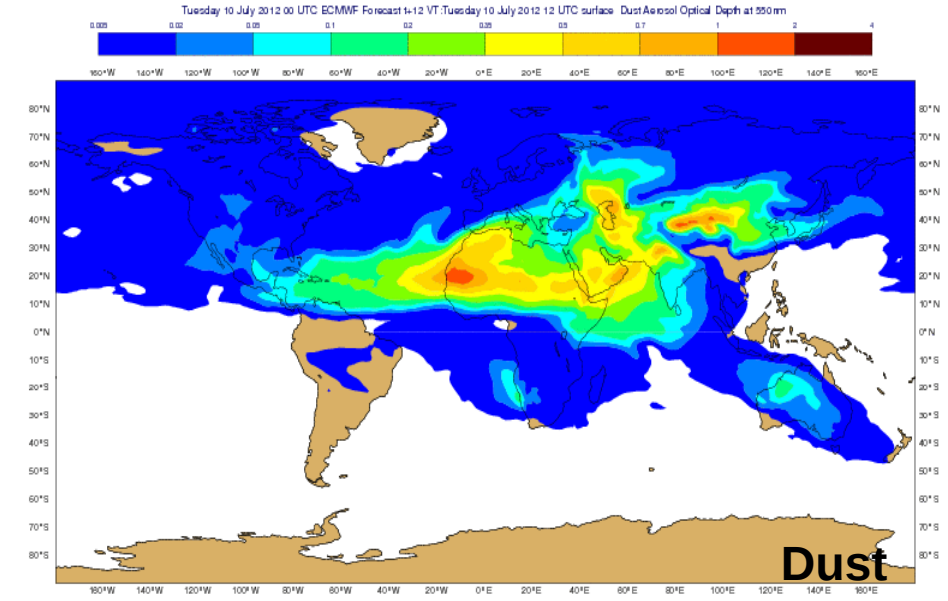
Current NRT aerosol model

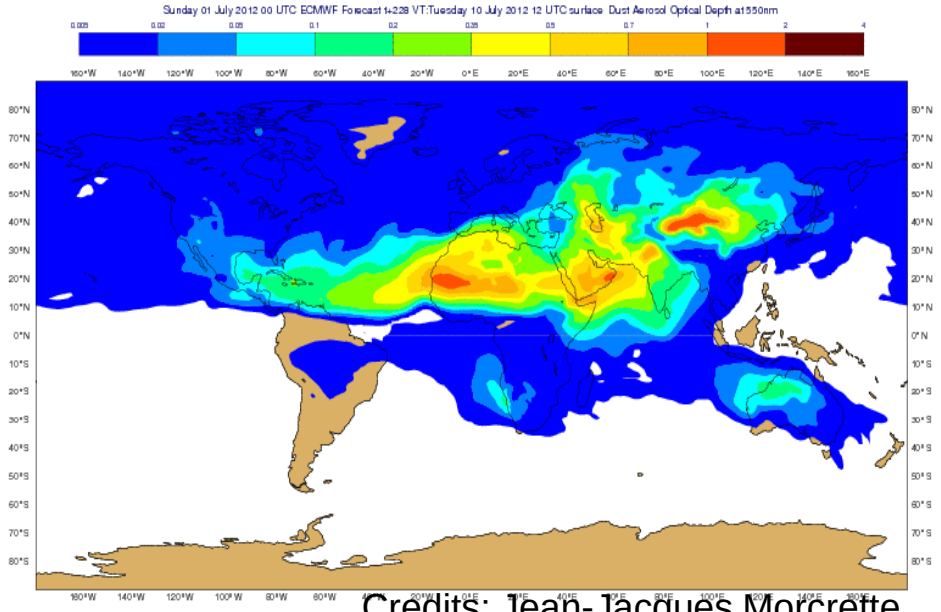
Day1



Day10



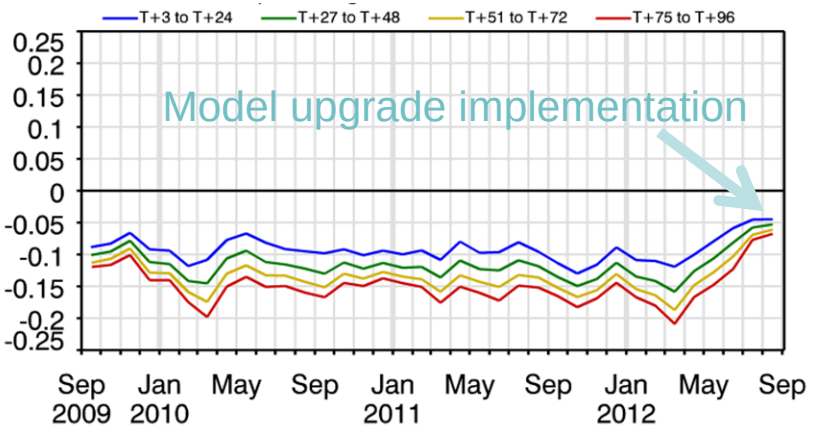




Credits: Jean-Jacques Morcrette

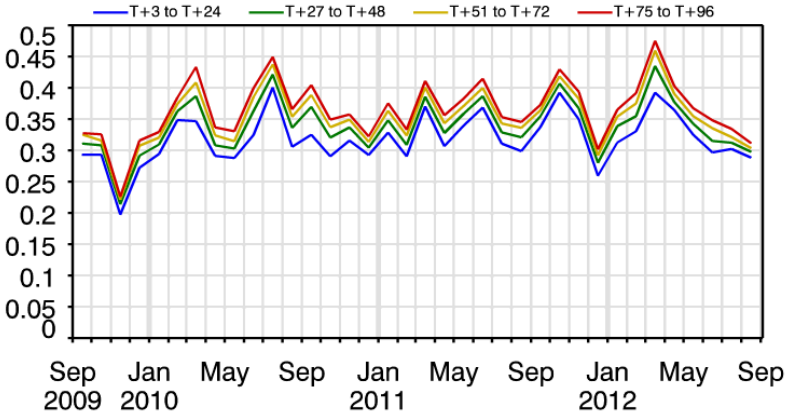
AERONET verification showing model improvements

Aerosol Optical Depth BIAS

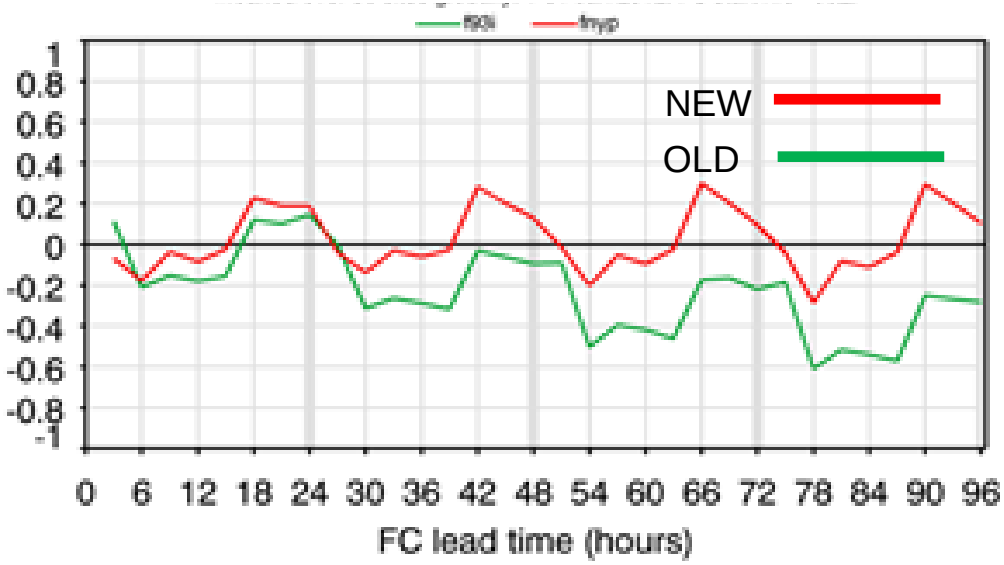


Day 1
Day 2
Day 3
Day 4

Aerosol Optical Depth RMS

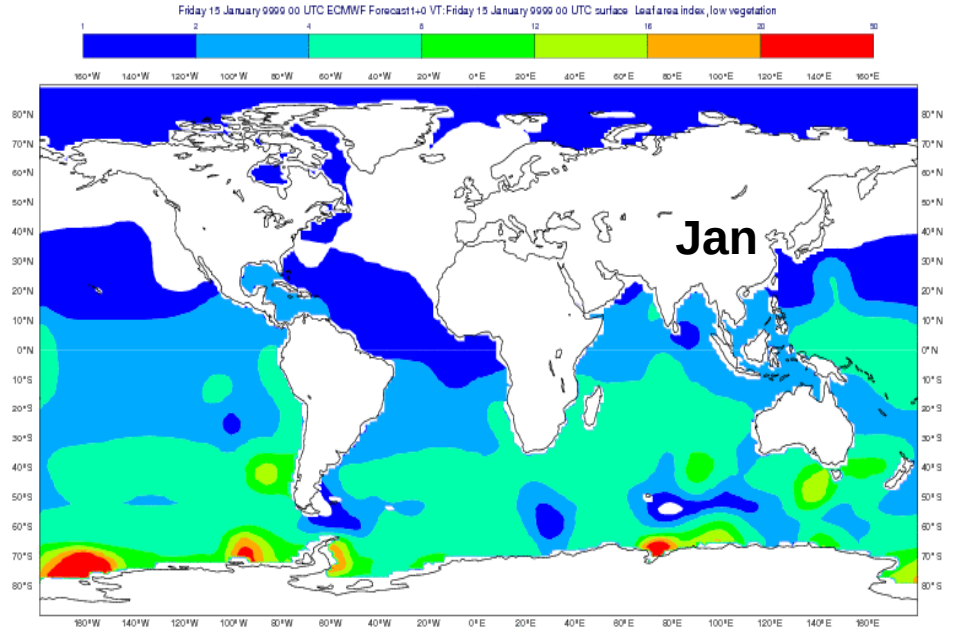


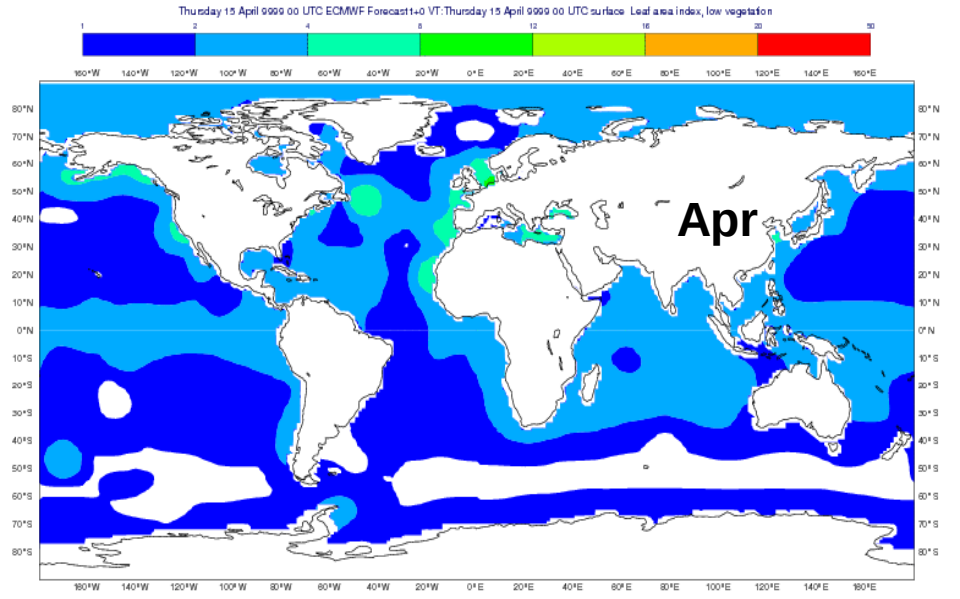
Aerosol Optical Depth NORMALIZED MEAN BIAS

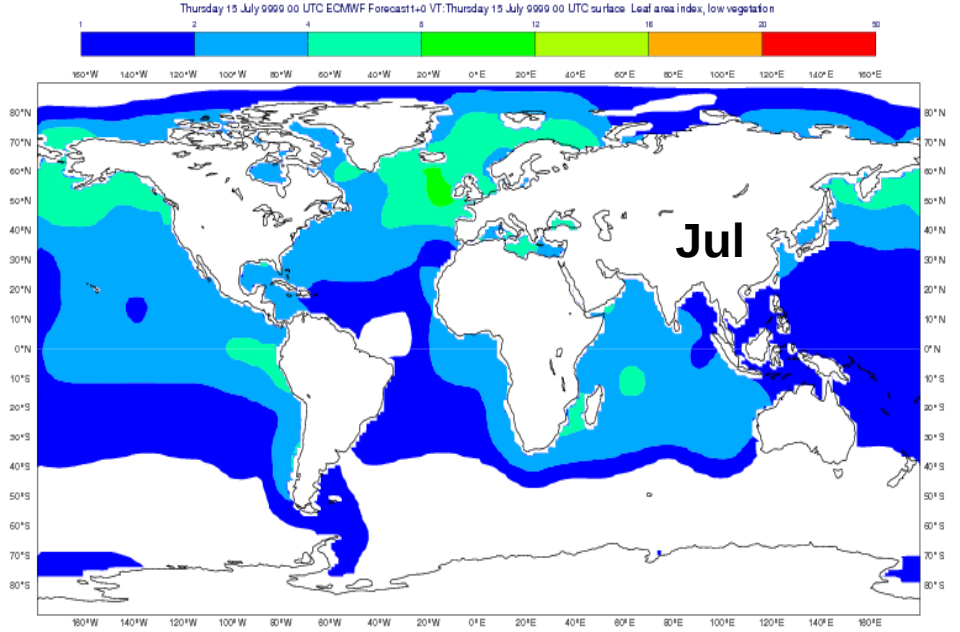


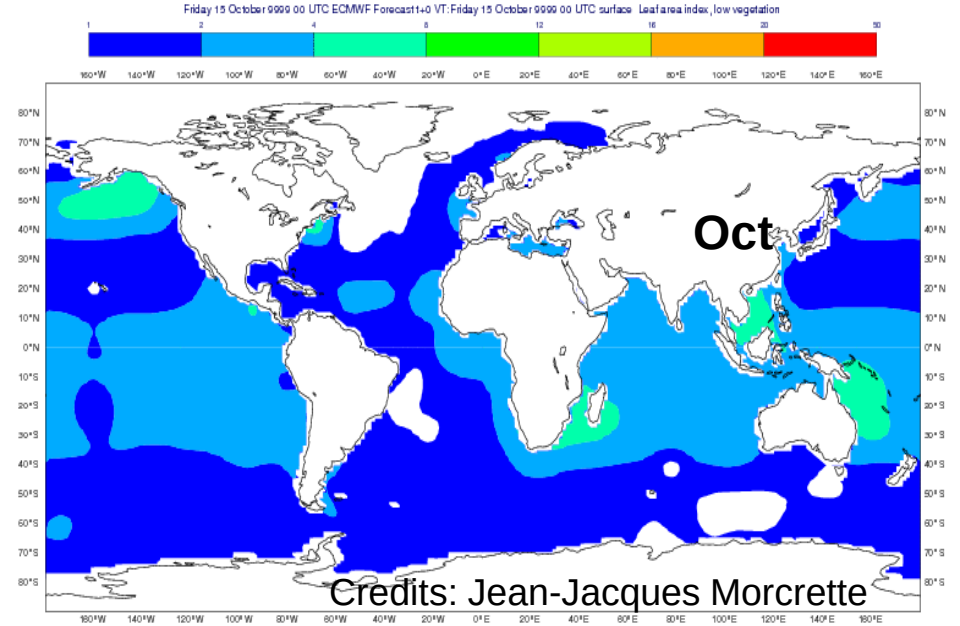
Credits: Luke Jones and Jean-Jacques Morcrette

Emission of oceanic DMS







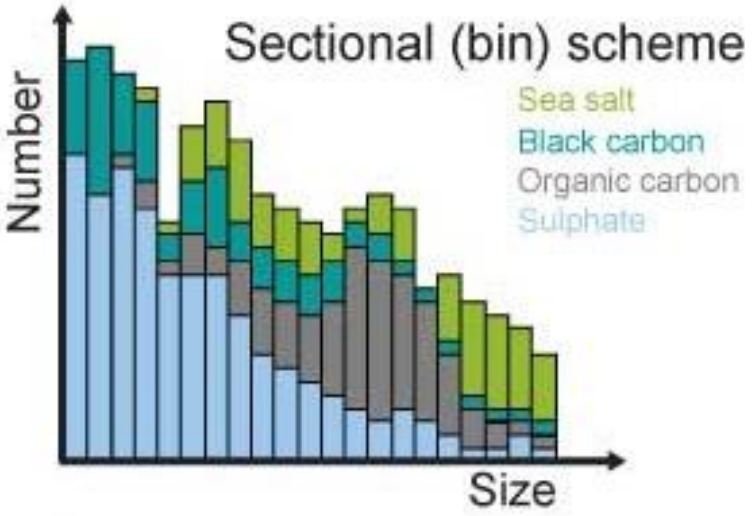


Credits: Jean-Jacques Morcrette

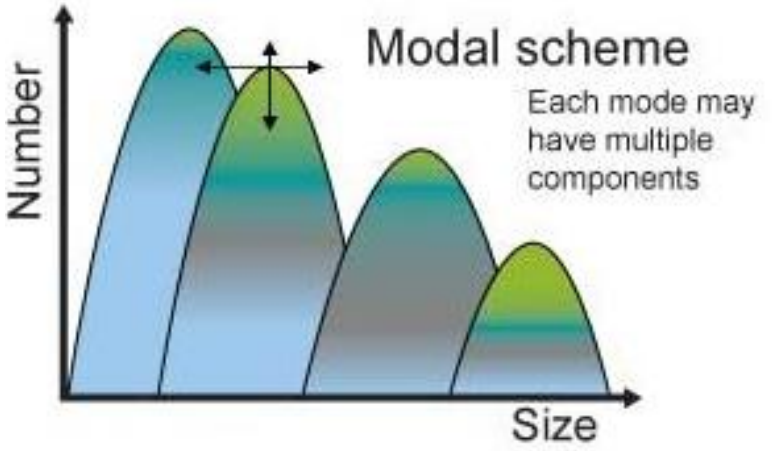
Towards a more complex aerosol model

GLOMAP
Global Model of Aerosol Processes

- GLObal Model of Aerosol Processes
- Developed in TOMCAT CTM
- Processes: nucleation, condensation, coagulation, scavenging and deposition, chemistry



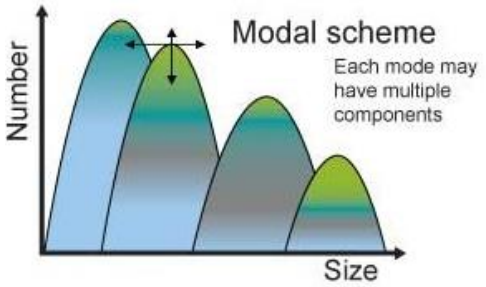
- Mann et al., 2010, GMD
- 4 soluble modes, 3 insoluble modes
- SU, SS, EC, OC, DU



Credits: Matt Woodhouse (now at BoM) and Graham Mann (University of Leeds)

Current modal configuration
7 modes, 5 components

Sulphate, sea salt, black carbon, organic carbon, dust



Insoluble Aitken
N_5
BC OC

insoluble
N_6
DU

insoluble
N_7
DU

Soluble nucl
N_1
SO4 OC

soluble Aitken
N_2
SO4 OC BC

soluble accum
N_3
SO4 OC BC Cl DU

soluble coarse
N_4
SO4 OC BC Cl DU

Tracks number concentration for each mode, and mass concentration for each component in each mode

19 mass
7 number

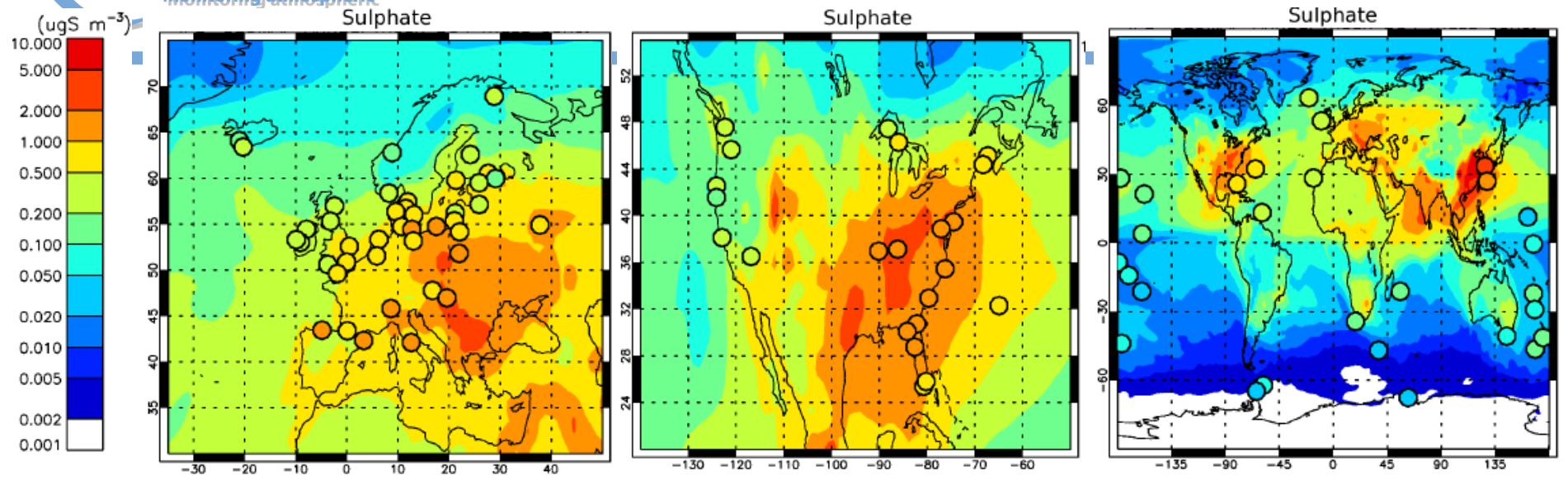
Transported tracers=26

Current aerosol model vs. GLOMAP-mode

	IFS-MACC-II	GLOMAP-mode
Transported aerosol tracers	Mass of aerosol types in size bins.	Size modes have number concentrations and component masses
Size distribution	Fixed Size constant for each of the transported types.	Variable Size determined by aerosol microphysics
Mixture assumed	Types externally mixed	Types internally mixed in each mode.
Chemistry	Only simple SO2-> SO4	Gas- and aqueous-phase oxidation
Gaseous tracers	1 (SO2)	5 (DMS, SO2, H2SO4, MONOTER, SEC_ORG)
Aerosol tracers	11 (11 mass, 0 number)	26 (19 mass, 7 number)

IFS-GLOMAP is currently ~2x expensive as IFS-MACC-II
(the latter being 85% more expensive than no-aerosol IFS)

MASS VERIFICATION FOR IFS-GLOMAP



EMEP

Dataset	b	r
EMEP	0.05	0.66
IMPROVE	0.09	0.98
University of Miami	-0.34	0.97

- Close to source, comparisons very good.
- Lacking DMS, remote SO4 therefore low

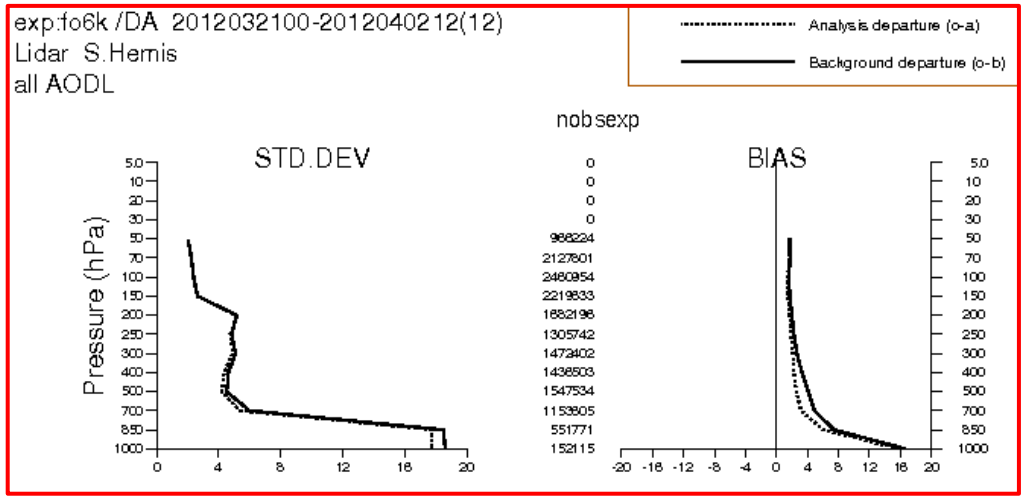
Burden comparisons:

	IFS-GLOMAP	IFS-GEMS	AeroCom	GLOMAP-mode
Sulphate (TgS)	0.68	0.20	0.66	0.52

Credits: Matt Woodhouse

Status of the assimilation of lidar data

Last year, old model version

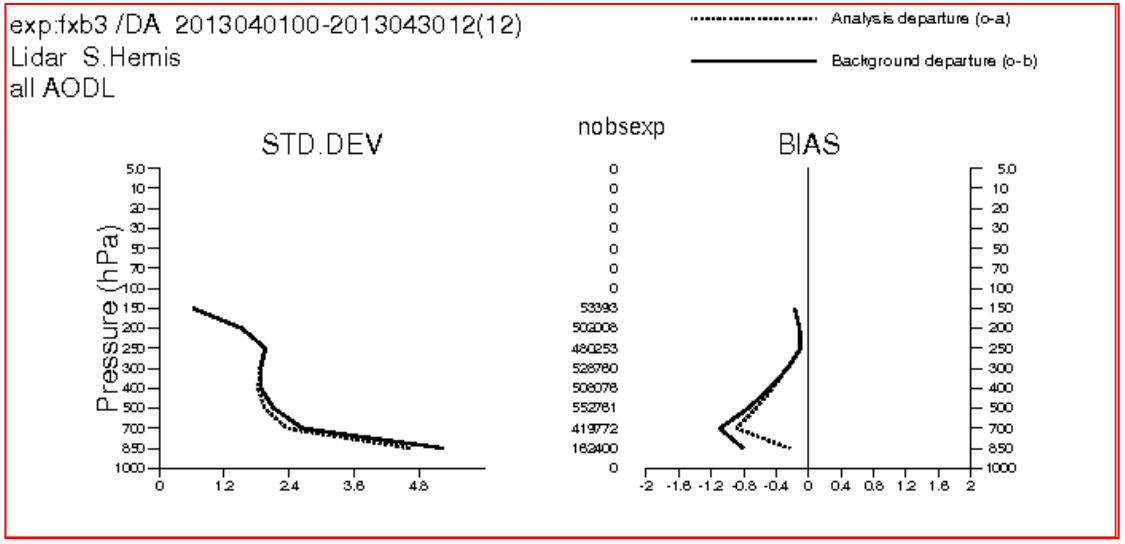


- Bug fix for molecular backscatter
- Model changes
- Non-spherical particles optical properties
- Data averaging/filtering
- More stringent quality control checks
- Redefinition of errors, including simple representativeness
- Variational Bias Correction level-by-level

This year, current model version

Lidar backscatter x 1e7 (sr m)-1

- Reduced max values of bias and standard deviation
- Gaussian distribution
- Different bias structure, possibly due to model improvements



Data: all operational data plus MODIS AOD and CALIOP Level 1.5 backscatter

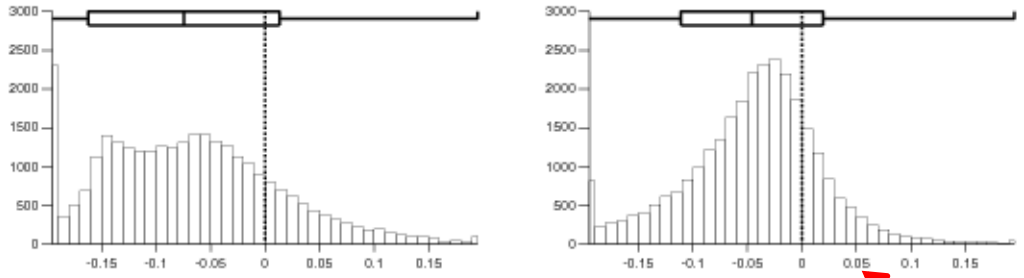
Impact of lidar on AOD fit to MODIS observations

fo6k /DA 2012032100-2012040212(12)
Aqua MODIS NASA (Aerosol Optical Depth) S.Hemis
used AOD AQUA MODIS Aerosol

Old model version

Background departure (o-b)
nb= 28942 rms= 0.115
mean= -0.745E-01 std= 0.876E-01
min= -0.662 max= 0.830

Analysis departure (o-a)
nb= 28942 rms= 0.796E-01
mean= -0.458E-01 std= 0.651E-01
min= -0.470 max= 0.413

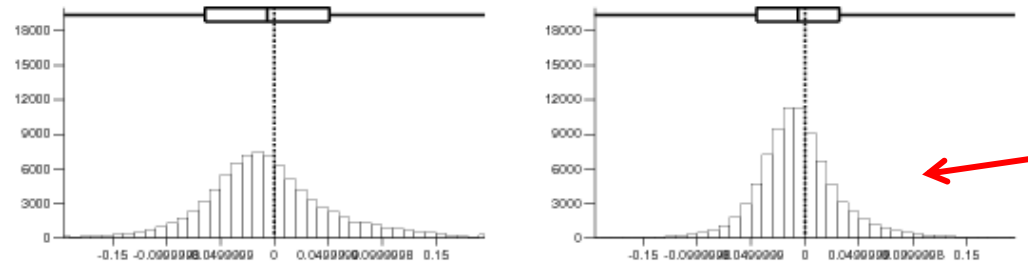


fxb3 /DA 2013032200-2013040212(12)
AOD S.Hemis
used AOD AQUA MODIS Aerosol

New model version

Background departure (o-b)
nb= 83447 rms= 0.582E-01
mean= -0.662E-02 std= 0.578E-01
min= -0.297 max= 0.329

Analysis departure (o-a)
nb= 83447 rms= 0.389E-01
mean= -0.652E-02 std= 0.383E-01
min= -0.245 max= 0.325

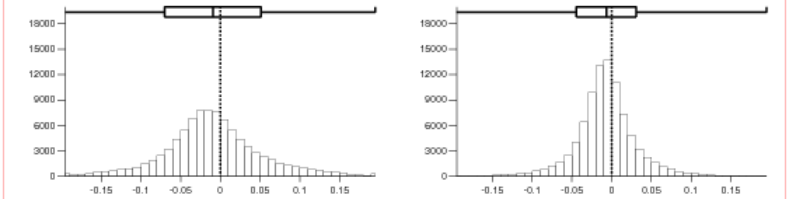


MODIS only (current NRT):
Nice Gaussian departures and low bias both in first guess and analysis.

fo9i /DA 2012032100-2012040212(12)
Aqua MODIS NASA (Aerosol Optical Depth) S.Hemis
used AOD AQUA Aerosol

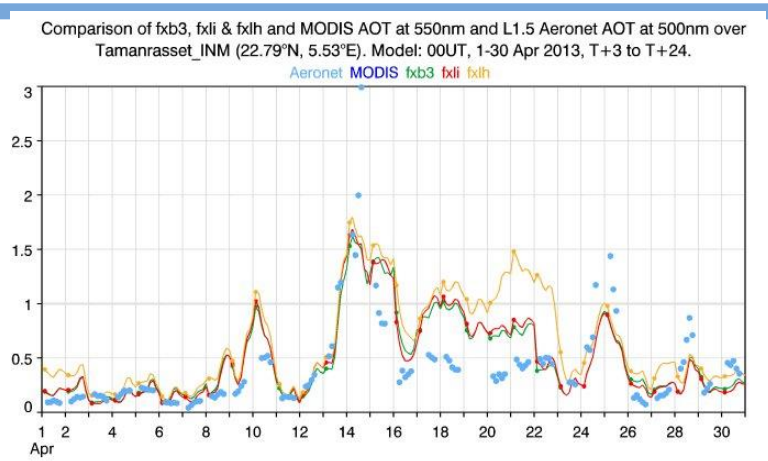
Background departure (o-b)
nb= 89058 rms= 0.615E-01
mean= -0.946E-02 std= 0.608E-01
min= -0.369 max= 0.375

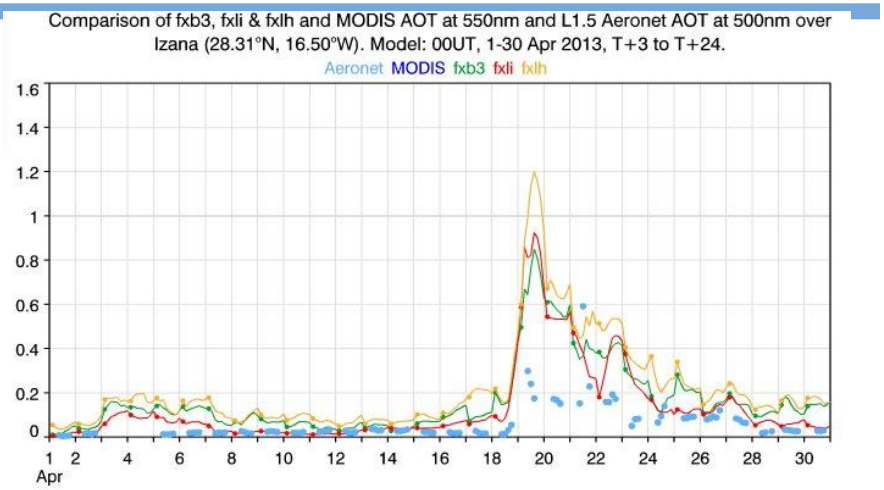
Analysis departure (o-a)
nb= 89058 rms= 0.382E-01
mean= -0.676E-02 std= 0.376E-01
min= -0.298 max= 0.294

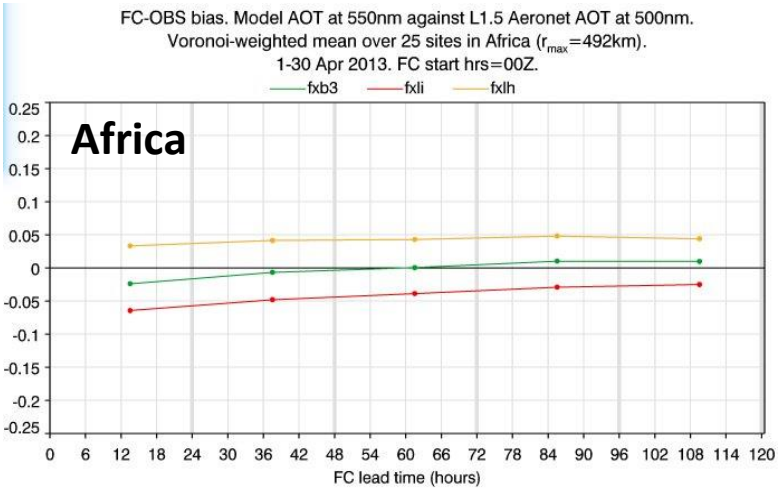


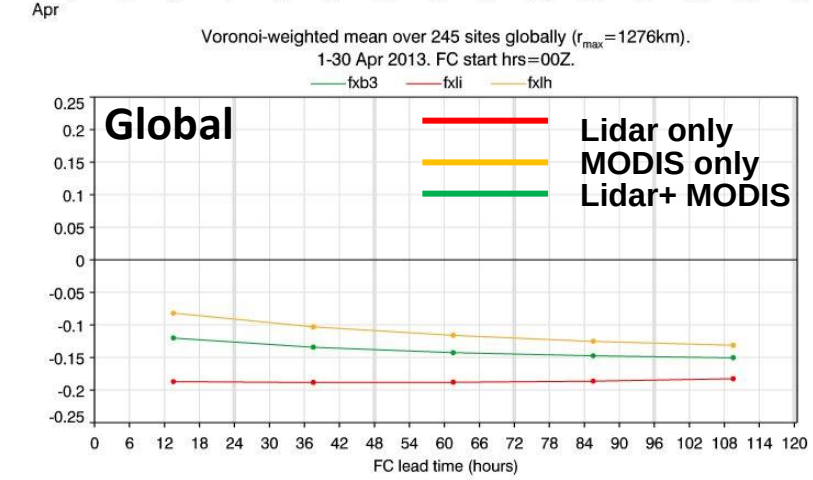
MODIS and CALIOP:
Non-Gaussian first-guess departures in old model version!
Gaussian departures in new model version.

Preliminary verification of lidar experiments



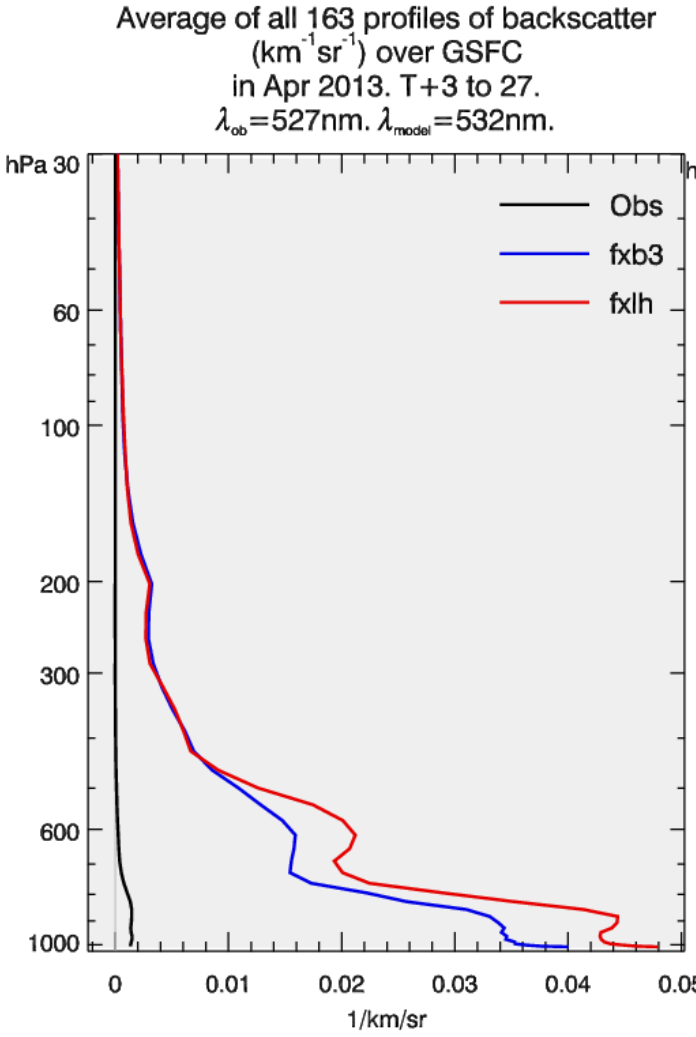


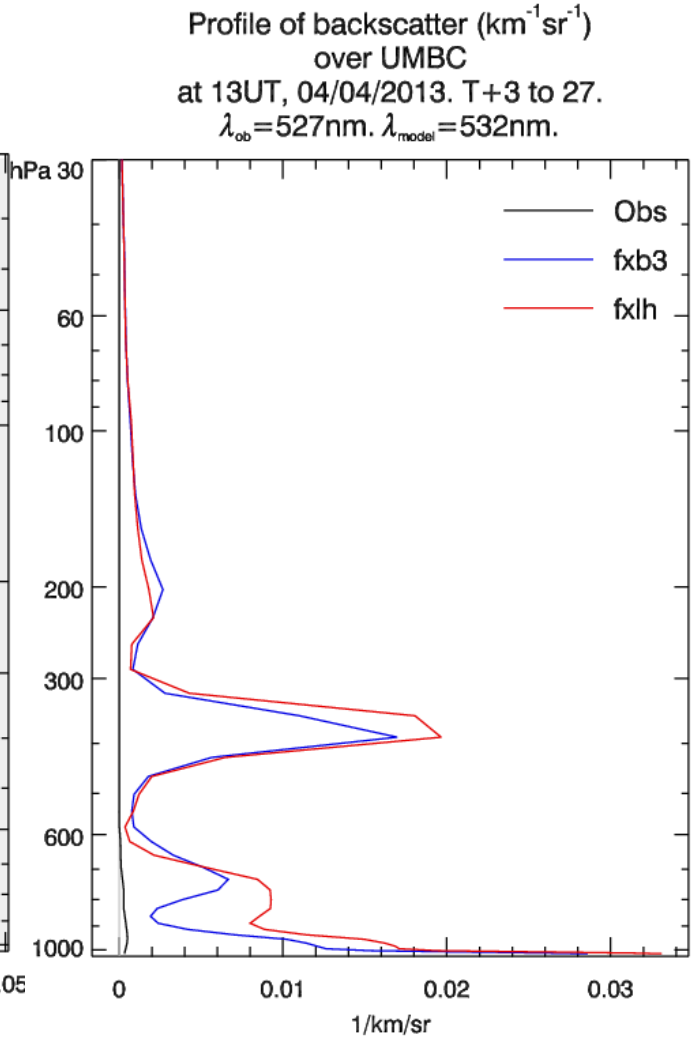




Needs verification of vertical structure! This is work in progress in collaboration with Luke Jones and Jean-Jacques Morcrette + NASA (MPLNET team: Judd Welton and Simone Lolli) and Harald Flentje at DWD + MACC-II VAL partners (European ceilometer data)

Impact of CALIPSO data on vertical profile





- Indication that CALIPSO data have definitely an impact on the shape of the profile

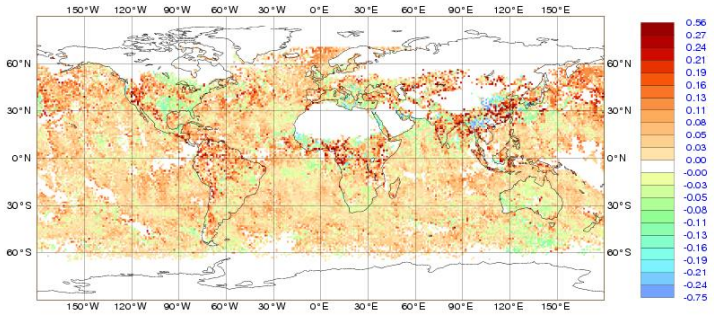
- Need to verify with comparable ground-based lidar observations of Attenuated backscatter to asses whether the impact is positive

Lidar and MODIS

MODIS only

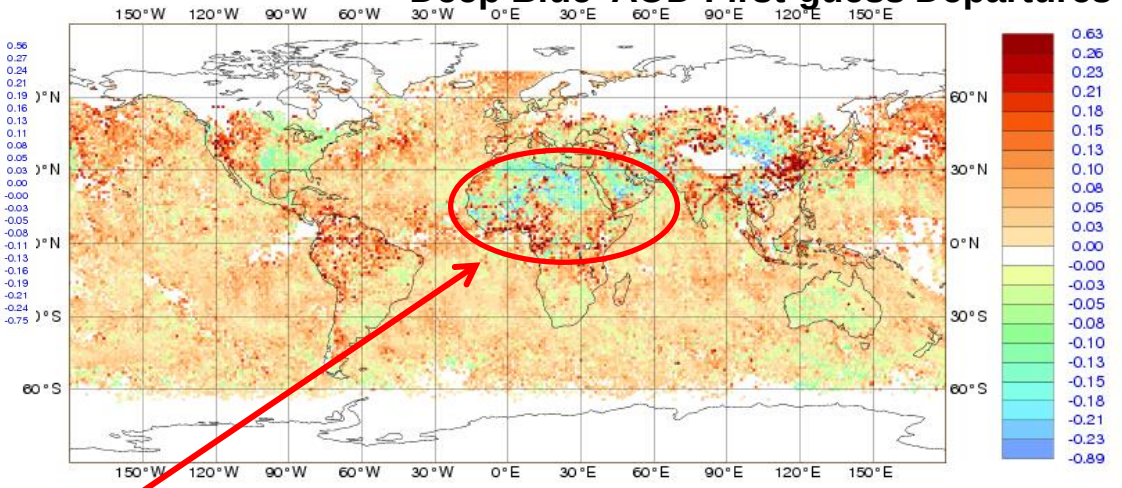
MODIS Deep Blue Monitoring/Assimilation

Promising results – monitoring of Deep Blue can start soon

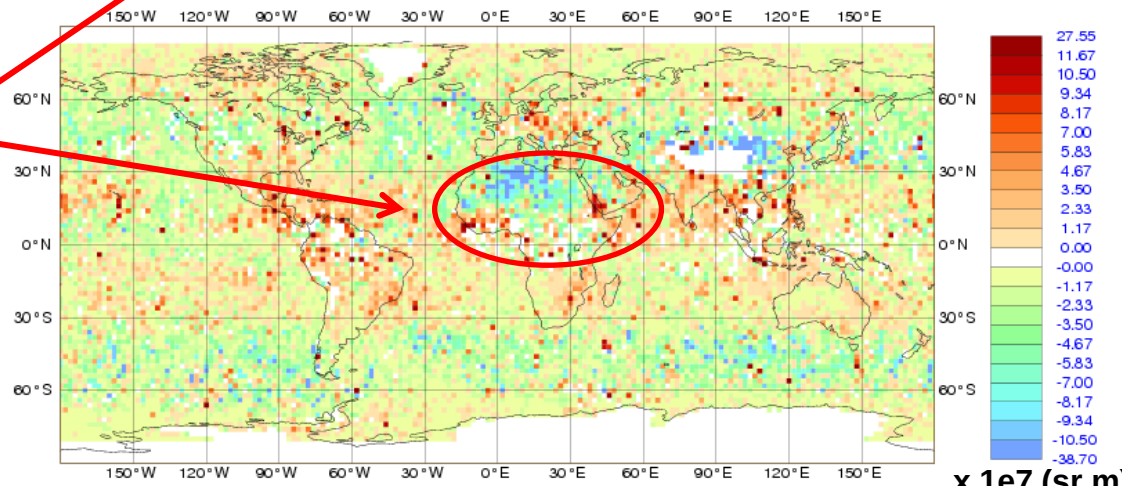


Standard MODIS AOD First-guess (OBS-FG) Departures

Deep Blue AOD First-guess Departures



Deep Blue and CALIOP Departures are consistent, especially over desert dust source areas where model overestimates observations

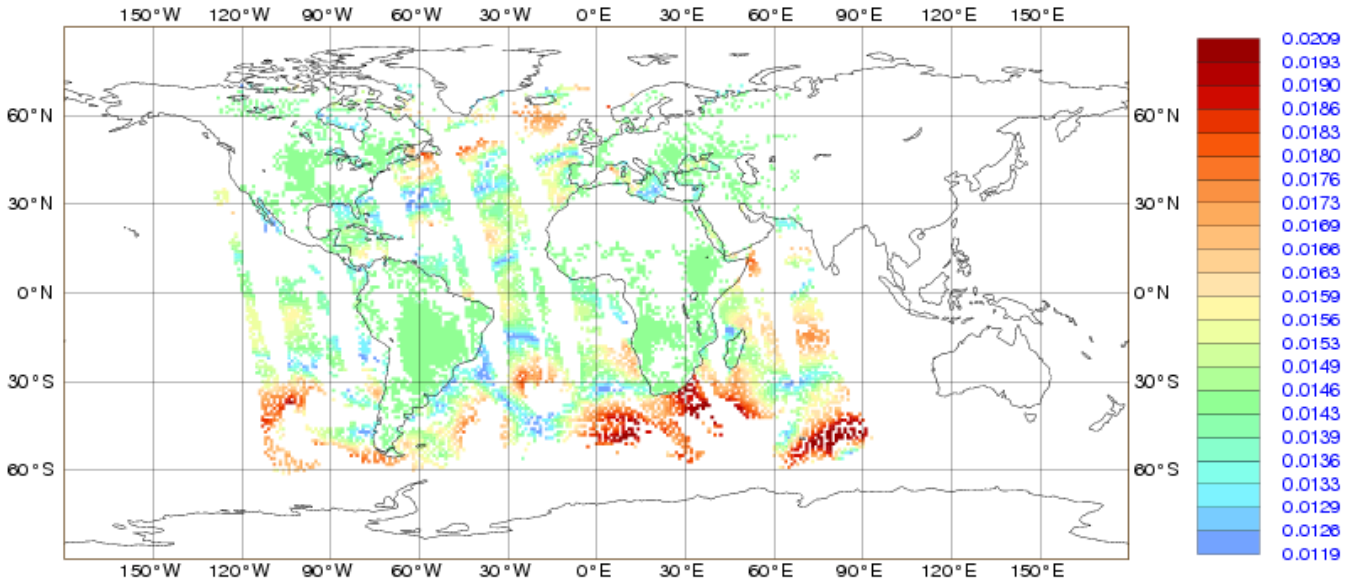


Lidar backscatter First-guess Departures for the layer 800-850hPa

x 1e7 (sr m)-1

Updated BIAS correction

STATISTICS FOR AEROSOL FROM FROM AQUA/389
MEAN BIAS CORRECTION (USED)
DATA PERIOD = 2012-09-01 09 - 2012-09-01 21
EXP = FU3V, LEVEL = 0.00 - 1013.25 HPA
Min: 0.012 Max: 0.021 Mean: 0.015
GRID: 1.00x 1.00



Variational bias correction for MODIS AOD is now a function of surface wind speed over ocean and total cloud cover

Ultra-recent developments

- Inclusion of volcanic species (ash, volcanic SO2 and volcanic SO4)

- Assimilation of multi-channel MODIS AOD in collaboration with Prof Shuhua Chen, University of California, Davis (visiting ECMWF for 6 months)

- Revamping of the dual control variable assimilation (fine and coarse mode) – still not working properly, possibly due to the background error covariance matrix developed for older model version

- New B-matrix under testing

- Monitoring of MODIS Deep Blue data to be started soon

Future Directions

- Continue preparation of CALIOP lidar data assimilation
- Start one-year reanalysis with ESA AEROSOL_CCI data
- Look at other aerosol data-sets as they become available (VIIRS)
- Start integrating new aerosol model (GLOMAP) in assimilation
- Investigate next steps to move towards radiance assimilation

ありがとうございます

Thank you for your attention!