



Aerosol and chemical weather forecasts

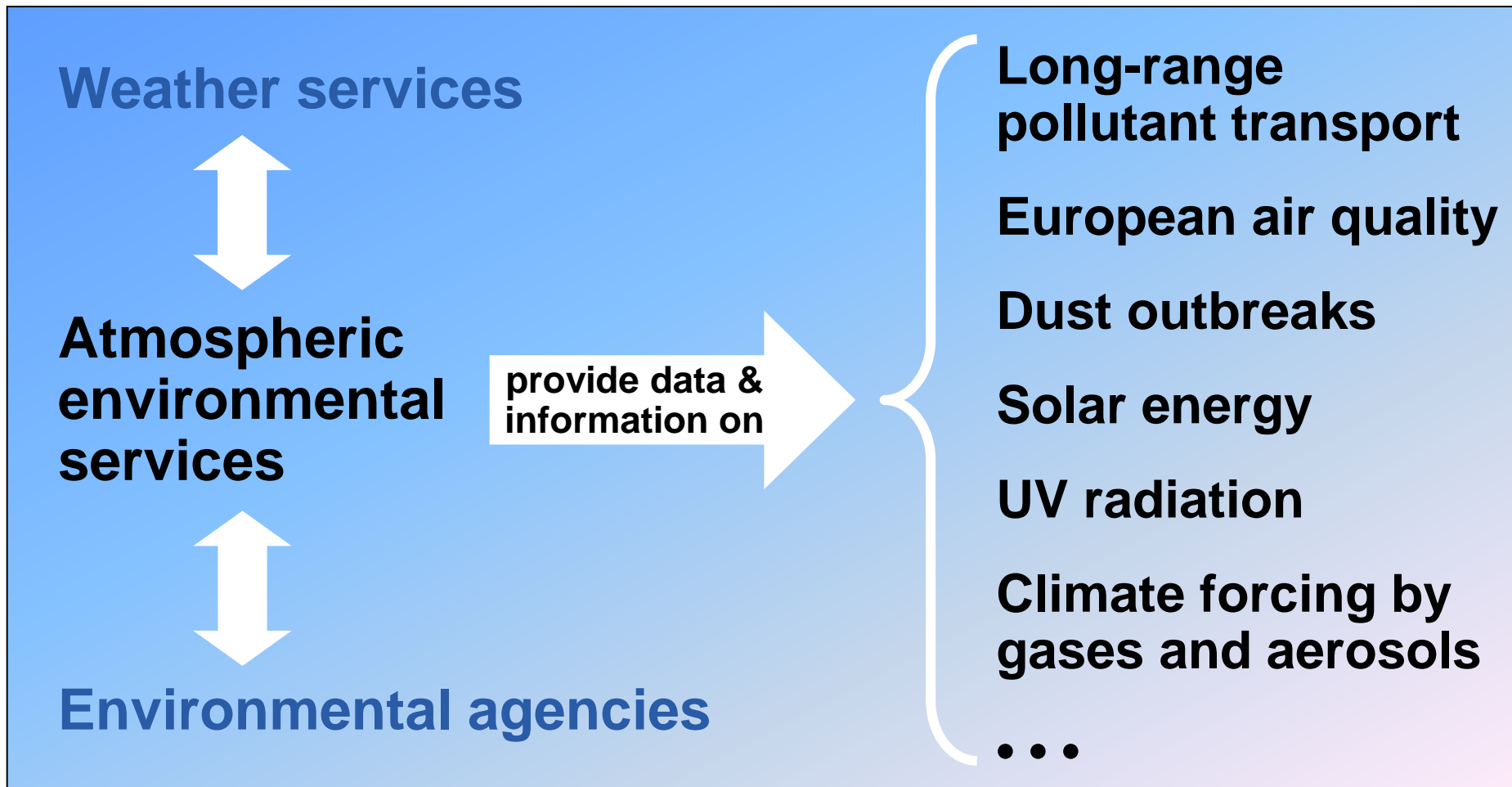
Angela Benedetti

Presenting on behalf of the MACC-II team at ECMWF:

Anna Augusti Panareda, Angela Benedetti, Marijana Crepulja, Richard Engelen, Johannes Flemming, Antje Inness, Luke Jones, Johannes W. Kaiser, Sebastien Massart, Jean-Jacques Morcrette, Vincent-Henri Peuch, Miha Razinger, Martin Suttie and Xiaobo Yang



Services related to the chemical and particulate content of the atmosphere

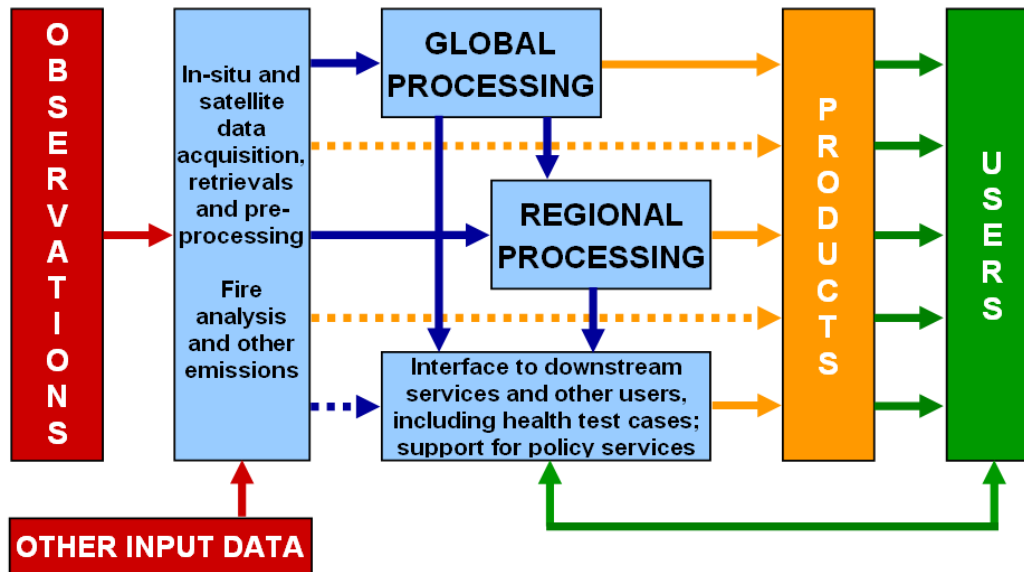


MACC-II

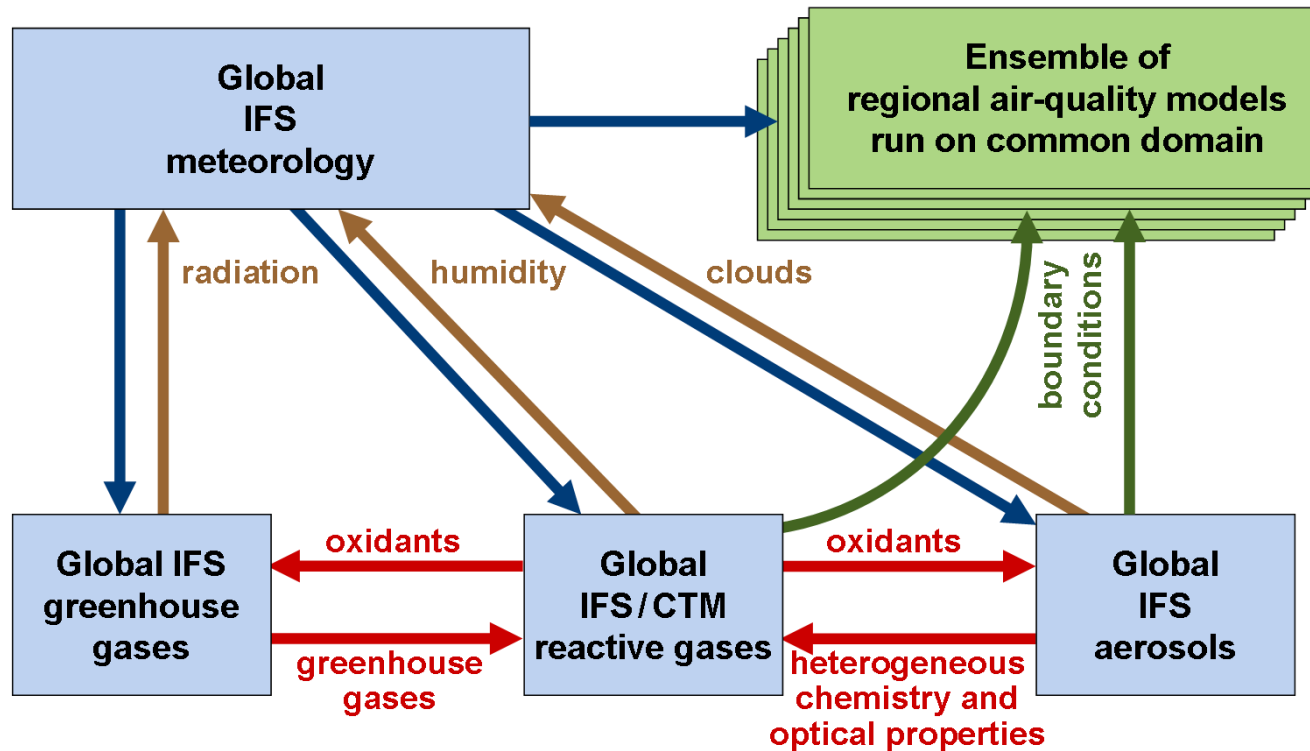
Monitoring Atmospheric Composition and Climate- Interim Implementation



- 36-partner Collaborative Project, funded by European Union FP7
- Started in November 2011 with expected completion in July 2014
- Prototype for the operational GMES Atmospheric Service (follow-on of MACC project)
- Providing air quality regional forecasts and global atmospheric composition forecasts and reanalysis in support of Europe's air quality policies and health aspects



Global/regional system



- The global system is based on the **ECMWF** Integrated Forecasting System (IFS), coupled to a global chemical transport model (CTM: **MOZART**, TM5 or MOCAGE)
- Regional ensemble comprises seven Chemical Transport Models run on a common European domain

<http://www.gmes-atmosphere.eu>

Reanalysis of Atmospheric
Composition (2003-2010)



Monitoring atmospheric composition & climate

macc Monitoring atmospheric composition & climate

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LATEST MACC forecasts help to interpret Seattle haze

Services

- Air Quality & Atmospheric Composition
- Climate Forcing
- Ozone Layer & Ultra-Violet Radiation
- Solar Radiation
- Emissions & Surface Fluxes

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Today's Forecasts

- Reactive Gases
- Aerosols
- European Air Quality
- UV Index
- Ozone Layer

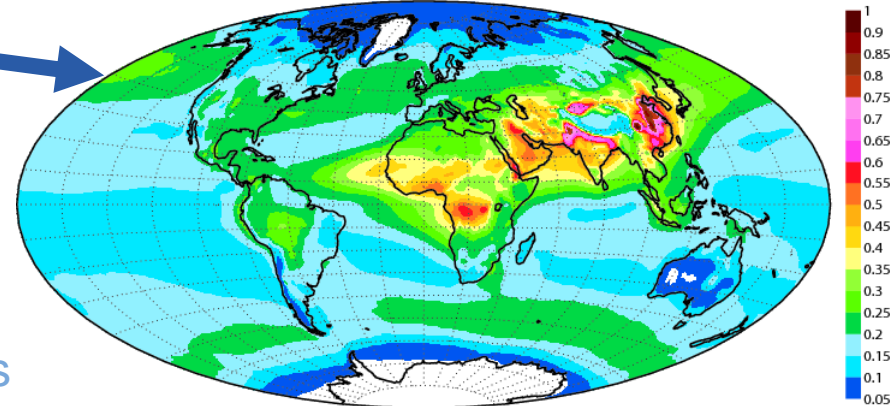
Latest Analyses

- Fire Monitoring
- European Air Quality
- Reactive Gases
- Aerosols

In Focus: MACC-II forecasts help to interpret Seattle haze

July 2012 The MACC-II forecasts of the smoke plume from large wildfires in Russia have been instrumental in understanding the origin of the smoke/haze impact on the American north-west. The area around Seattle has suffered from significant hazy skies over the last week, making people wonder if this was smoke coming from the large fires in Colorado or from some other region.

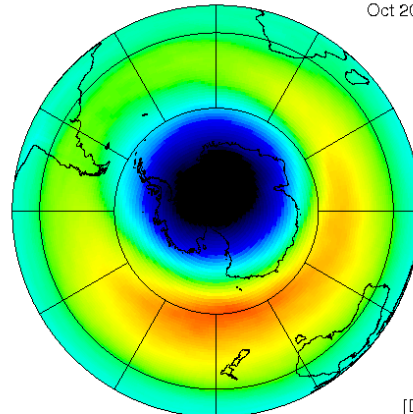
Aerosol Optical Depth



Ozone records

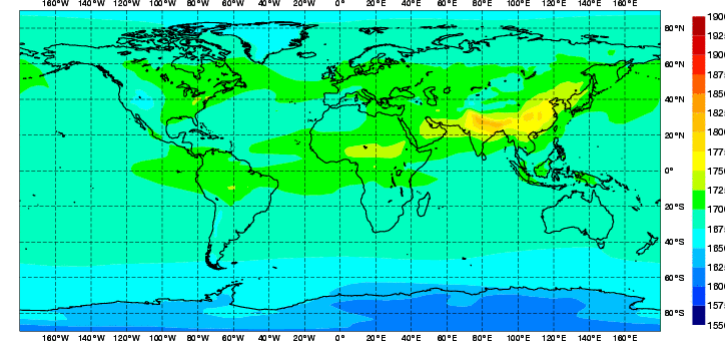
(30 years)

Multi Sensor Reanalysis Monthly mean total ozone Oct 2008



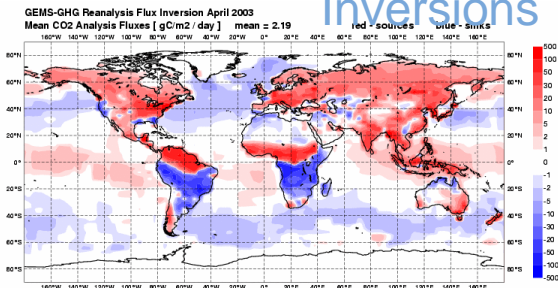
ECMWF/GEMS Reanalysis Global Monthly Mean August 2004
Mean Column CH₄ Mixing Ratio [ppb]

Methane



Potential users of MACC-II are invited to complete the questionnaire at this link

CO₂ Flux
Inversions



<http://www.gmes-atmosphere.eu>



Monitoring atmospheric composition & climate

macc Monitoring atmospheric composition & climate

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LATEST MACC forecasts help to interpret Seattle haze

Air Quality and Atmospheric Composition **Climate Forcing** **Ozone Layer & UV** **Solar Radiation** **Emissions and Surface Fluxes**

Services

- Air Quality & Atmospheric Composition
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In Focus: MACC-II forecasts help to interpret Seattle haze

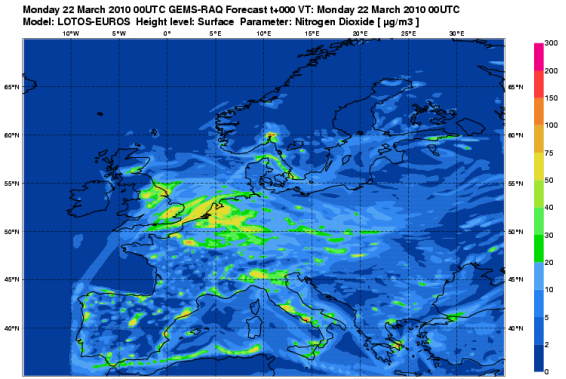
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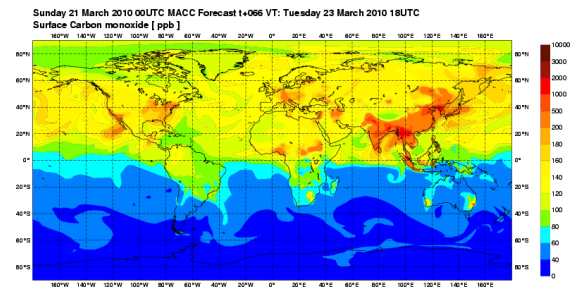
Air quality



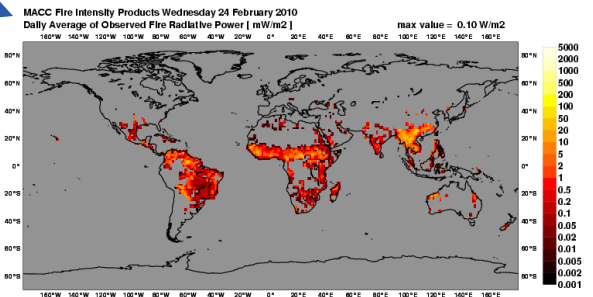
Europe



Global Pollution



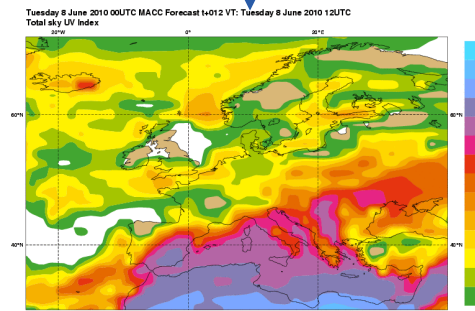
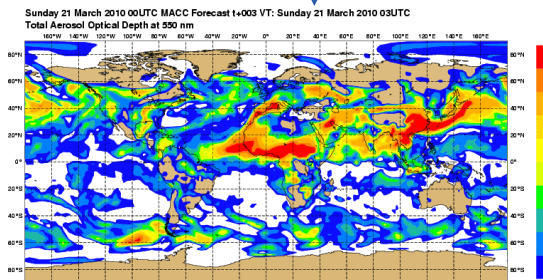
Biomass burning



Aerosol



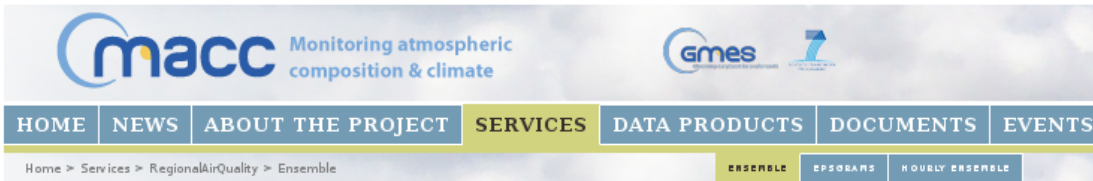
UV index



MACC NRT Service Provision

Ensemble of European Air-Quality forecasts

Monitoring atmospheric composition & climate



macc Monitoring atmospheric composition & climate

HOME NEWS ABOUT THE PROJECT SERVICES DATA PRODUCTS DOCUMENTS EVENTS

Home > Services > RegionalAirQuality > Ensemble

ENSEMBLE EPSGRAMS HOURLY ENSEMBLE

Forecast base time ALL 20120614

Thu 14 Jun 2012 00UTC

Day 0 Day 1 Day 2

Model

- ALL
- Ensemble
- CHIMERE
- EMEP
- EURAD
- MATCH
- MOCAGE
- LOTOS-EUROS
- SILAM

Parameter

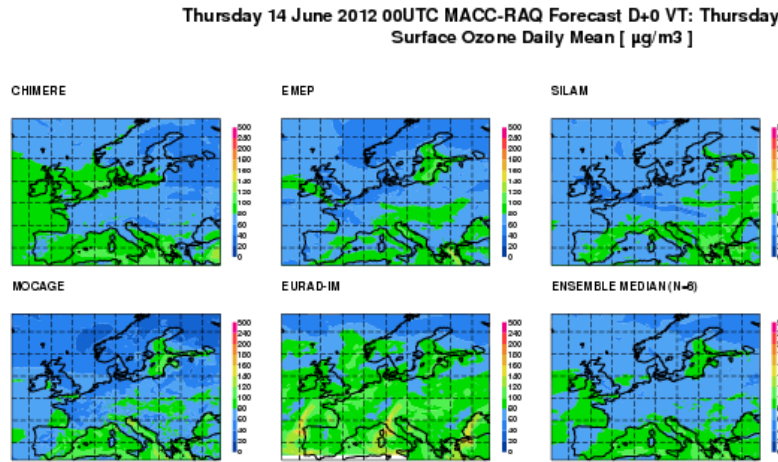
- Ozone
- Nitrogen Dioxide
- Sulfur Dioxide
- Carbon monoxide
- PM 10 aerosol
- PM 2.5 aerosol

Field

- Daily Mean
- Daily Maximum

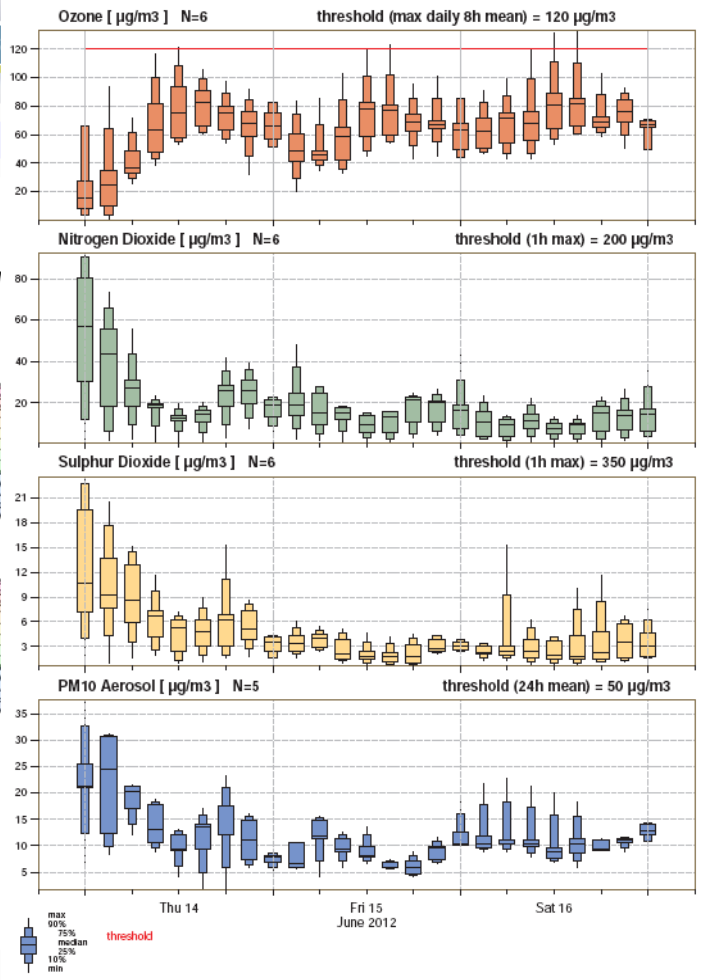
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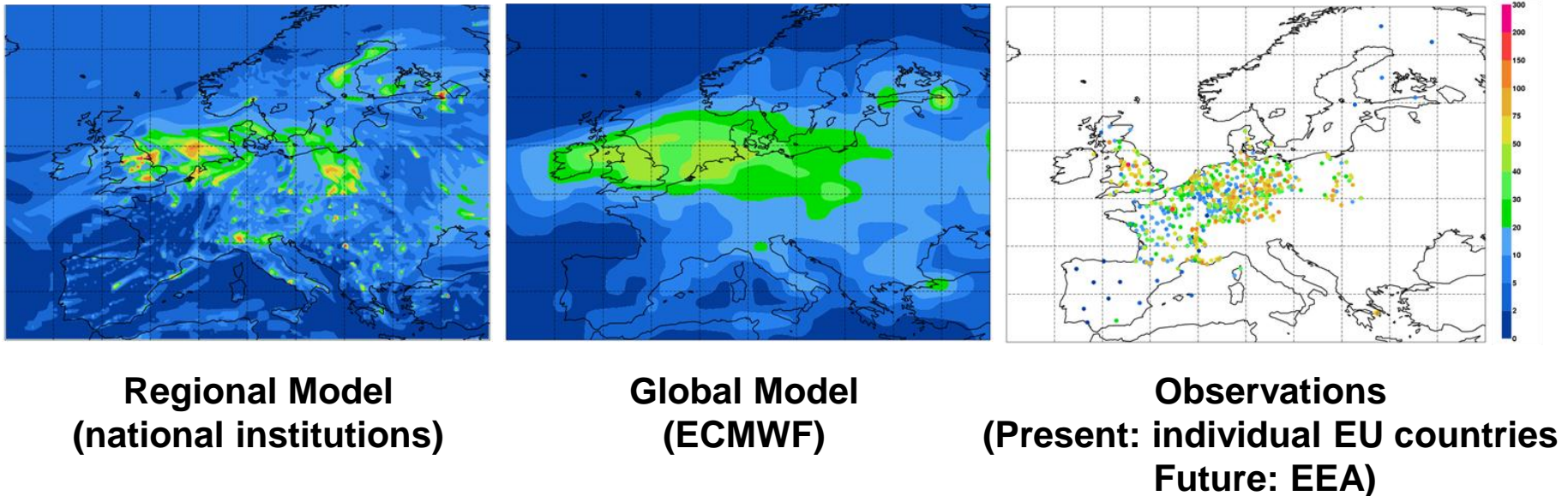
MACC RAQ EPSGRAM
 London(51.5°N, 0.13°W)
 Forecast Thursday 14 June 2012 00 UTC

London



- World-class air quality services for the European region, verified routinely
- Probabilistic “c-meteograms” for the main European cities from the multi-model ensemble

2-day nitrogen dioxide forecasts for 25 February 2010 from the MOCAGE regional model (left) and the coarser-resolution global model (middle) validated with observations (right).



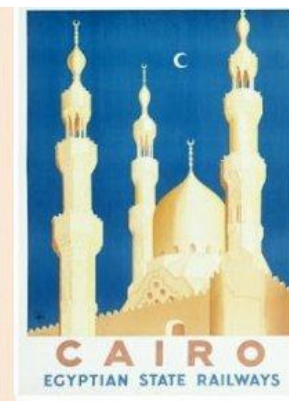
- MACC provides forecasts of European air quality from an ensemble of regional models.
- All forecasts are being validated with observations from the various European Union member states.
- The **Boundary Conditions** for reactive gases and aerosols are provided from the coupled global model run at ECMWF

EXTREME EVENTS

Dust Storm on April 18 2012



Dust over the Nile delta from satellite imagery. Image courtesy of Chelys.

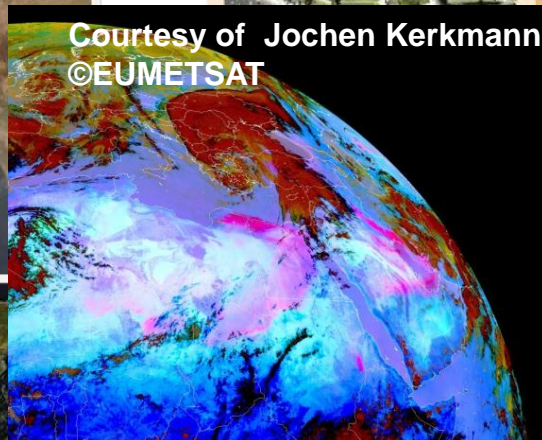


Wednesday, April 18, 2012

#Sandstorm in #Cairo

We are having the worst sandstorm in Cairo today. It is the **Khamsin** in its official time after Easter. The storm started at 8:30 AM this morning. Suddenly we got this yellow color in the air.

Here is Tahrir square from short awhile ago .



Courtesy of Jochen Kerkmann
©EUMETSAT



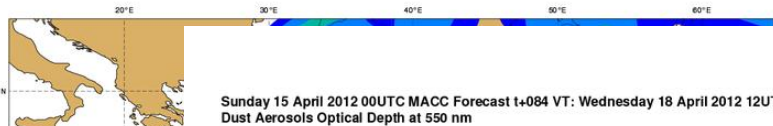
Khamisin in Tahrir square "Kolena Khaled Said"



Palestinian men cross a main road as a sand storm envelops the town of Rafah along the border with Egypt in southern Gaza Strip, on April 18, 2012. (SAID KHATIB/AFP/Getty Images)

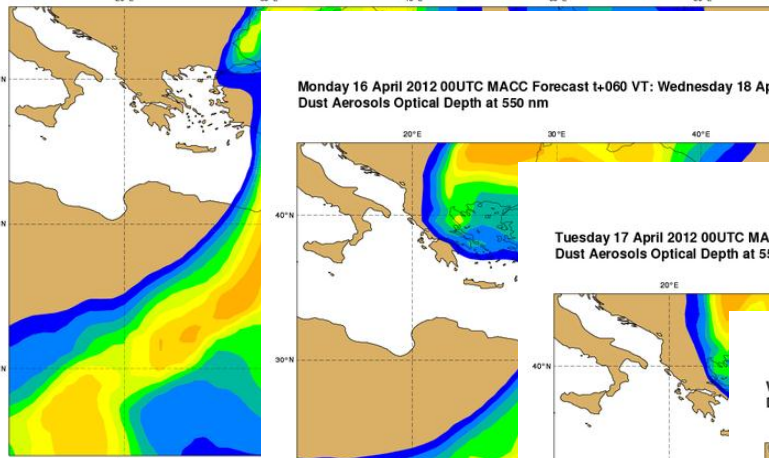
Saturday 14 April 2012 00UTC MACC Forecast t+108 VT: Wednesday 18 April 2012 12UTC
Dust Aerosols Optical Depth at 550 nm

Day 4



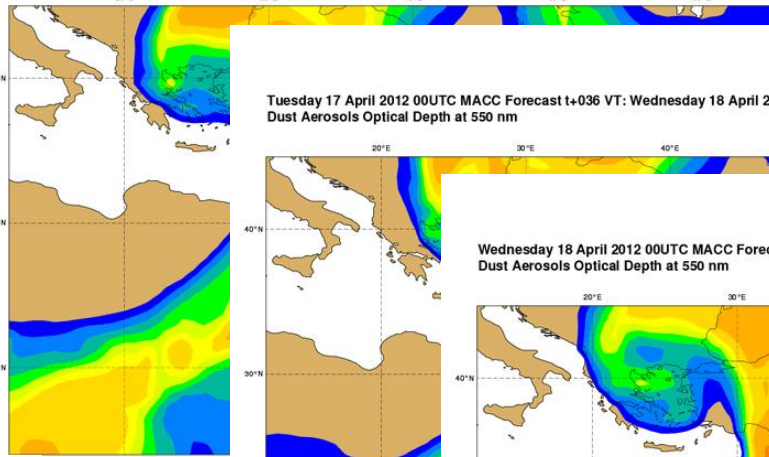
Sunday 15 April 2012 00UTC MACC Forecast t+084 VT: Wednesday 18 April 2012 12UTC
Dust Aerosols Optical Depth at 550 nm

Day 3



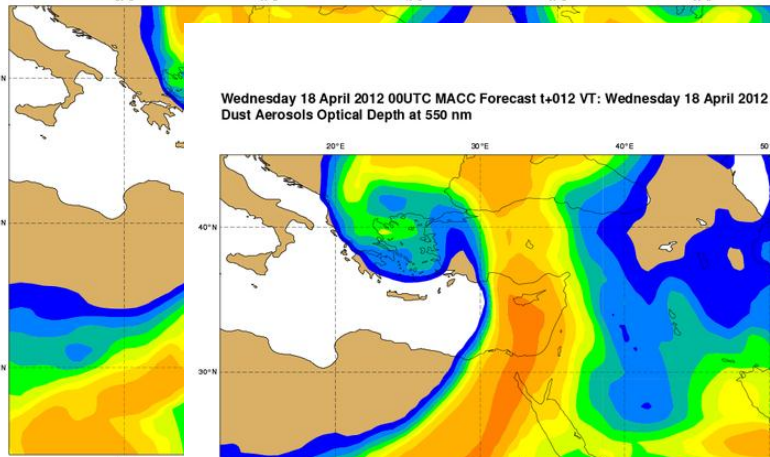
Monday 16 April 2012 00UTC MACC Forecast t+060 VT: Wednesday 18 April 2012 12UTC
Dust Aerosols Optical Depth at 550 nm

Day 2



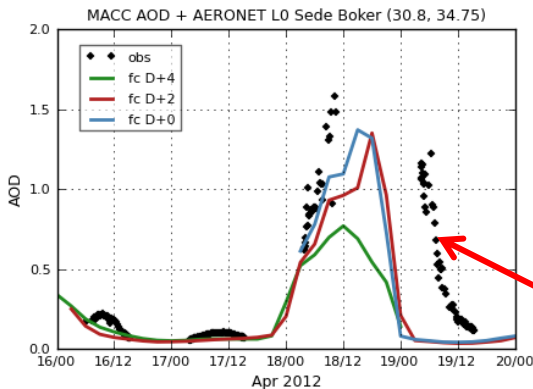
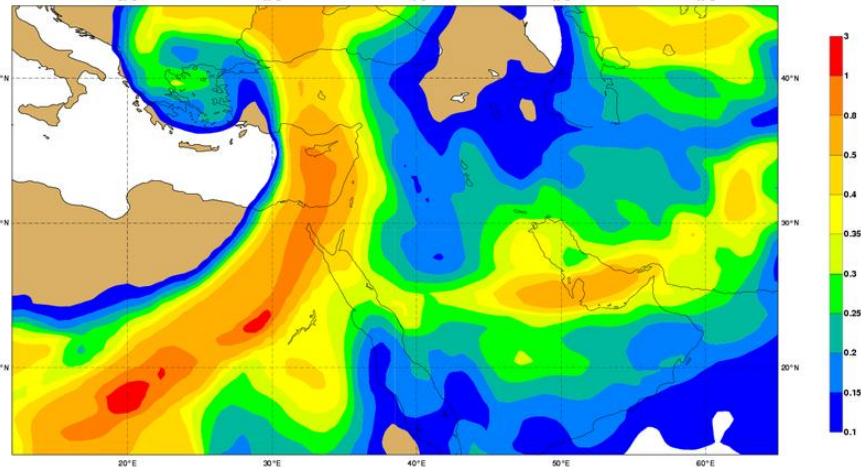
Tuesday 17 April 2012 00UTC MACC Forecast t+036 VT: Wednesday 18 April 2012 12UTC
Dust Aerosols Optical Depth at 550 nm

Day 1



Wednesday 18 April 2012 00UTC MACC Forecast t+012 VT: Wednesday 18 April 2012 12UTC
Dust Aerosols Optical Depth at 550 nm

Day 0

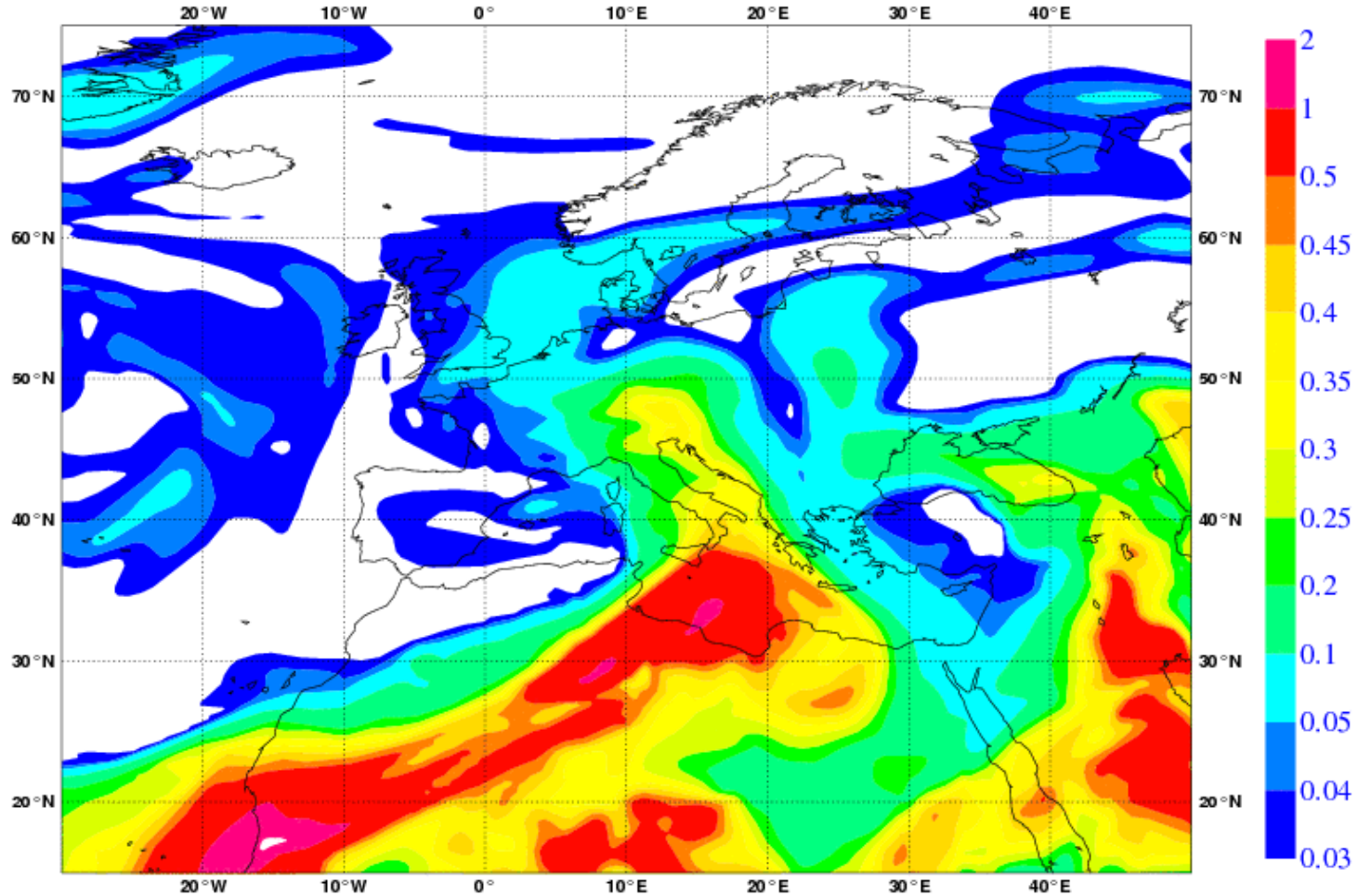


• Secondary peak possibly due to mesoscale features not predicted as well

• Good skill of the model at the synoptic scale: storm predicted with 4 days of lead time!

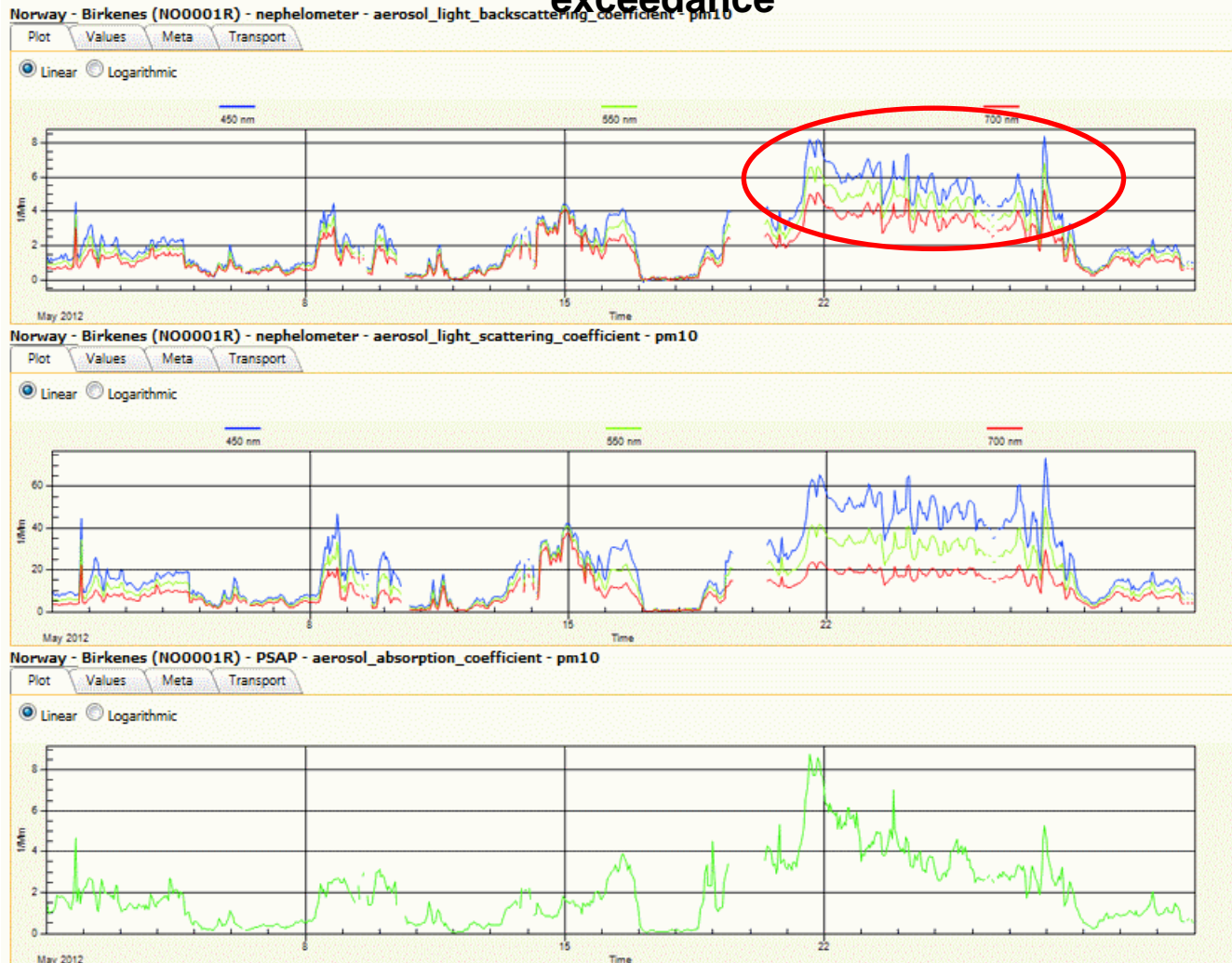
Dust in Norway (May 21)

Monday 21 May 2012 00UTC ECMWF Forecast t+3 VT: Monday 21 May 2012 03UTC Surface:



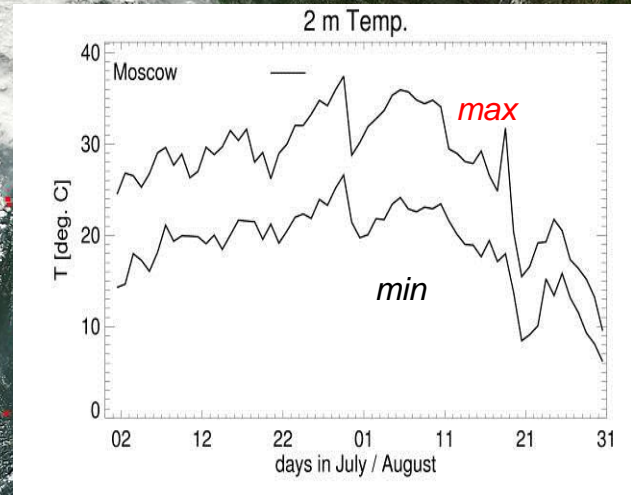
Dust in Norway (May 21)

Seen also in in-situ data at Birkenes, Norway - might be important information for Air Quality exceedance



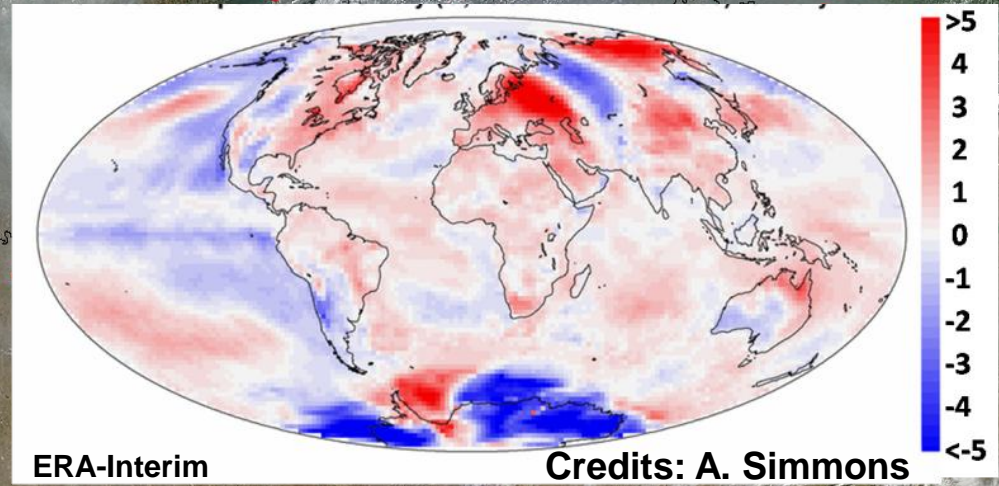
Heat Wave and Fires Russia 2010

Credits: V. Huijnen - KNMI



Moscow

2m temperature anomaly (K) for July 2010



MODIS image 4 August

Heat Wave and Fires Russia 2010

BBC News - Fog from peat fires blankets Moscow amid heat wave - Mozilla Firefox

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http://www.bbc.co.uk/news/world-europe-10762921

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Africa Asia-Pacific Europe Latin America Middle East South Asia US & Canada

26 July 2010 Last updated at 13:12

Fog from peat fires blankets Moscow amid heat wave

An acrid fog from forest and peat fires has blanketed Moscow, as the Russian capital sweaters in a record heat wave.

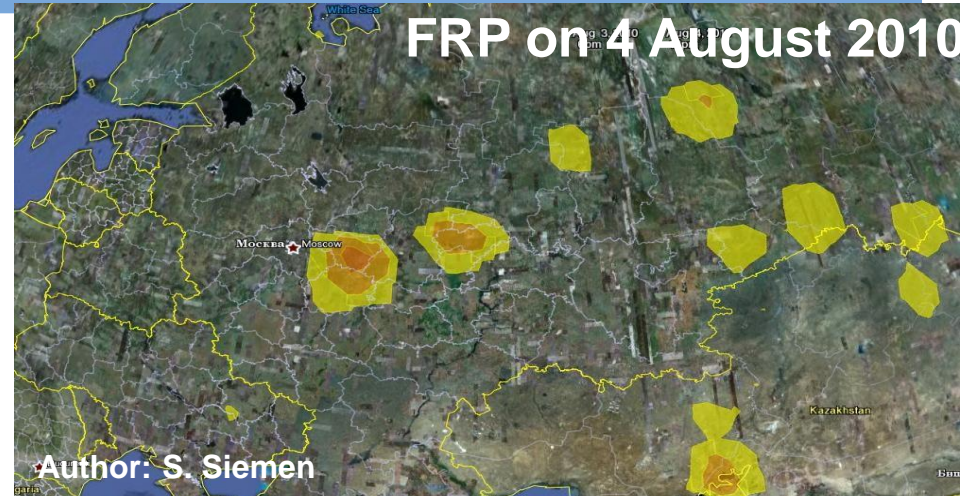
Firefighters were trying to douse 60 fires covering 59 hectares (145 acres) in the countryside outside Moscow on Monday, the emergencies ministry said.

People with bronchial problems were advised to stay indoors as the level of toxic particles in the air rose five to eight times above the norm.



The Kremlin was barely visible as a pungent fog closed in on baking Moscow

Author: S. Siemen



2010072603

Aerosol optical depth due to black carbon and organic matter

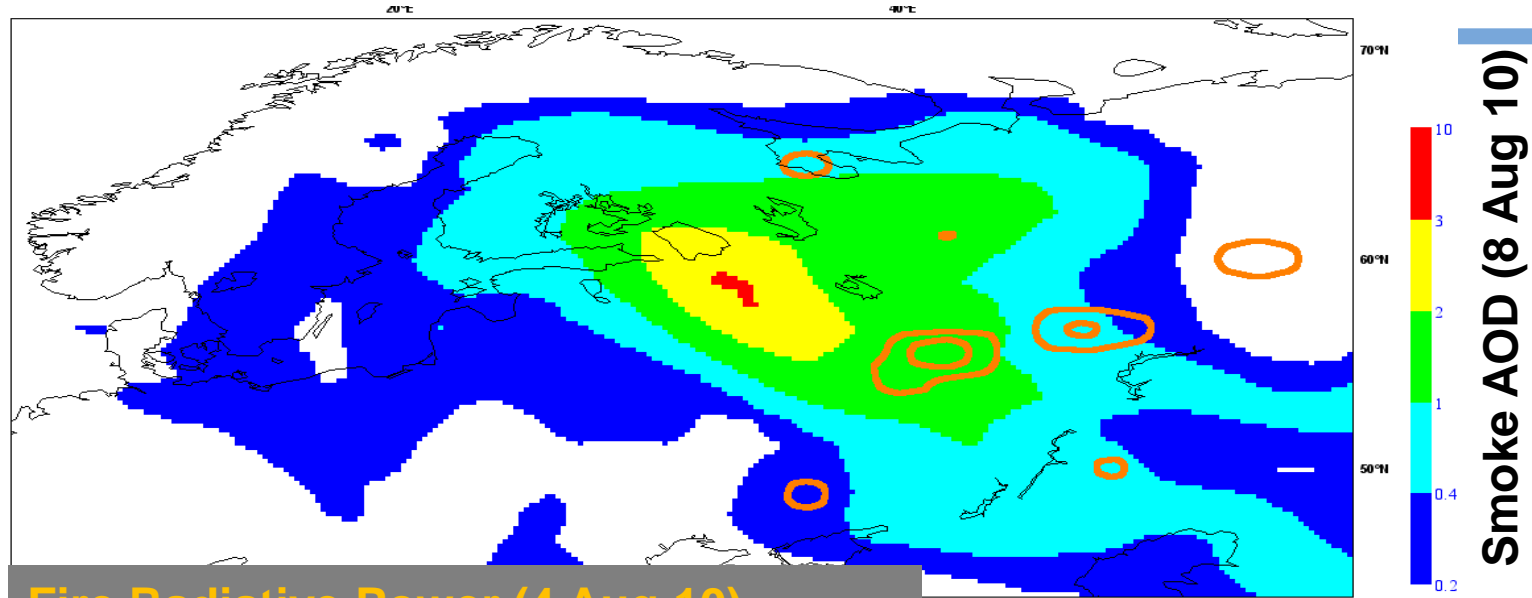


The daily jump in the modeled smoke distribution is due to the assimilation of satellite information on the fires

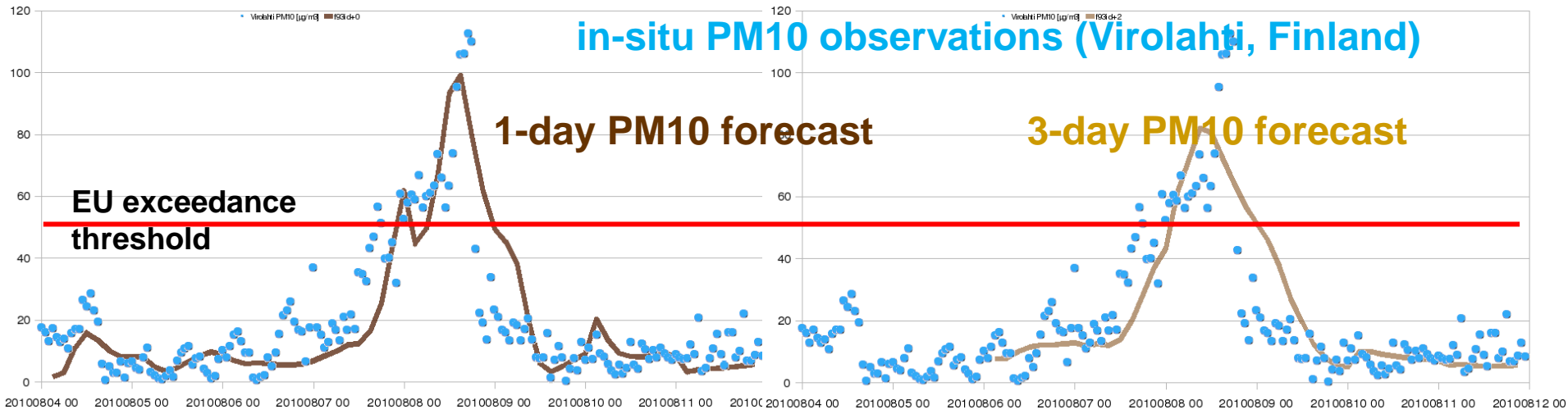


Source: wikipedia

Russian Smoke in Finland



Fire Radiative Power (4 Aug 10)
 (contour lines at 50 and 500 mW m⁻² fire radiative power).



Volcanic ash prediction activities

- A new prognostic variable has been added to represent volcanic aerosols, and the code reorganised to allow volcanoes to be “switched on or off”, with namelist or file definition of the emitted mass and boundaries of the plume.
- SO₂ tracer simulation also performed
- April 2010 Icelandic eruption investigated (and a few others ...)

Volcanic plume (aerosols) off the coast of Iceland, 14 April 2010

Wednesday 14 April 2010 00UTC ECMWF Forecast t+6 VT; Wednesday 14 April 2010 06UTC Model Level 52 Aerosol type 2 source/gain accumulated
tkgp: Stohl et al's emission, 10-day FC from MACC analysis On 20100414 00UTC



This activity is not intended to replace the services provided by the local Volcanic Ash Advisory Centres, but only to supply additional information

Chilean Puyehue eruption June 2011 – SO₂ Plume Forecast

BBC NEWS ASIA-PACIFIC

21 June 2011 Last updated at 14:12

Chile volcano ash causes renewed air chaos in Australia



Passengers at Sydney Airport frustrated by ash cloud delays

Australia's two major airports are facing up to 48 hours of disruption as the ash cloud from a Chilean volcano drifts across the south of the country.

Qantas and Virgin have cancelled all flights into and out of Sydney and Melbourne. Adelaide airport has been shut and Canberra flights also hit.

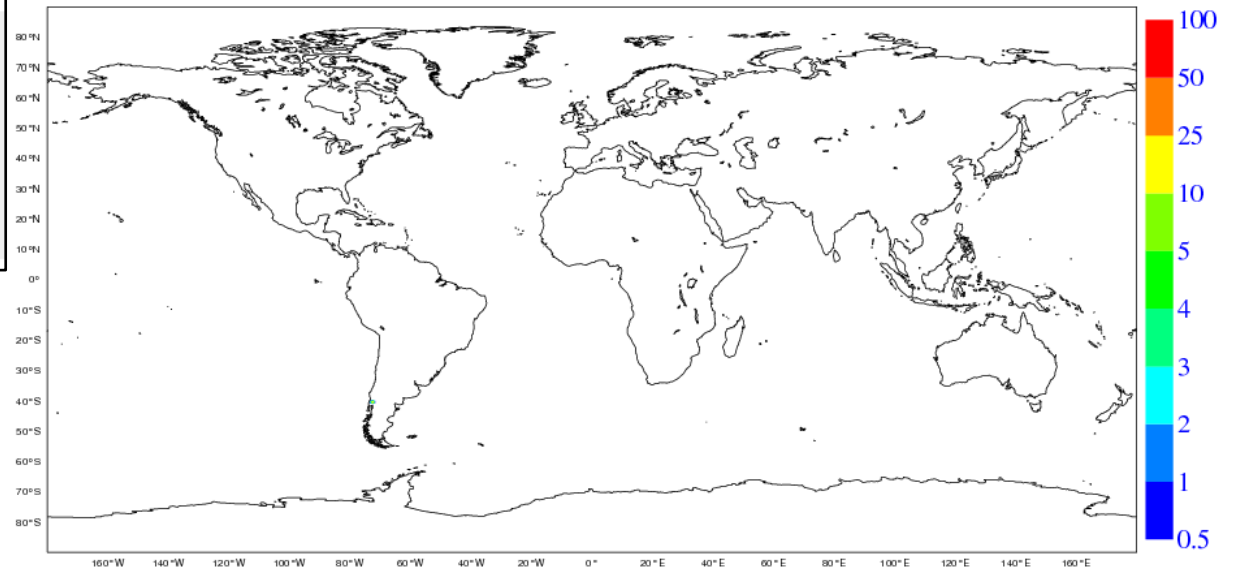
Last week, tens of thousands of people were stranded as airlines grounded flights, and now the ash has returned.

Related Stories

- Unwelcome return for Chilean ash
- Qantas cancels flights over ash
- Chile volcano wreaks fresh havoc



Plume Forecast for 4 June 2011 00 UTC Injection level 5-9 km



Forecast Product Users

User	Purpose	Means of access
MACC-II regional models	Boundary conditions for aerosol and reactive gases	MARS & ECFS
Other regional AQ models	Boundary conditions for aerosol and reactive gases	MARS & ECFS
Solar power companies	Aerosols	FTP
WMO Sand and Dust Storm service	Dust aerosol forecast	MARS
Scientific field campaigns	Specific forecasts for flight planning	Web site, MARS, ECFS, & FTP

All atmospheric composition products are freely available to users from public and private institutions/companies worldwide

Recent new developments in the global system at ECMWF

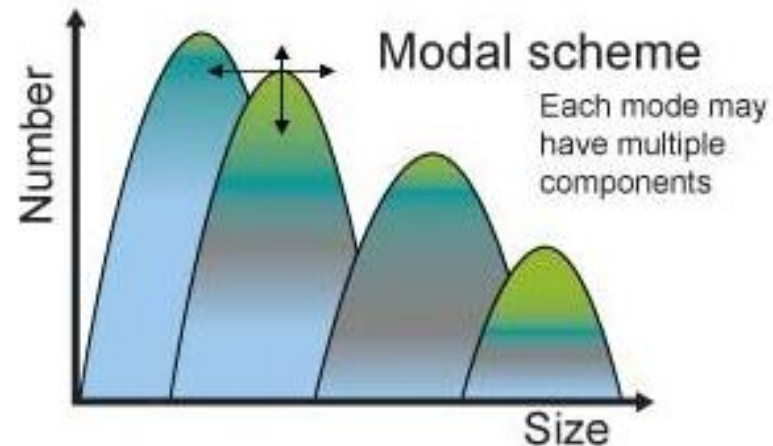
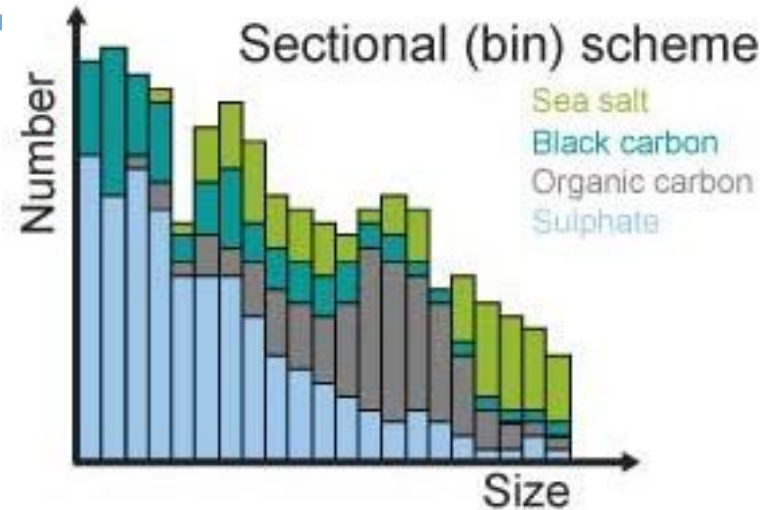
- Integration of chemistry modules (TM5) in IFS to replace coupled system IFS-CTM
- Integration of new aerosol model (GLOMAP)
- Assimilation of fine and total AOD from MODIS
- NRT global fire emissions from FRP (2003-present)
- MACC NRT forecast suite to be run by operations department
- Developments on assimilation and forecast of volcanic SO₂ and aerosols (NRT)

Towards a more complex aerosol model

Matt Woodhouse & Graham Mann (U Leeds)



- **GLO**bal **M**odel of **A**erosol **P**rocesses
- 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



	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 SO ₂ -> SO ₄	Gas- and aqueous-phase oxidation
Gaseous tracers	1 (SO ₂)	5 (DMS, SO ₂ , H ₂ SO ₄ , MONOTER, SEC_ORG)
Aerosol tracers	11 (11 mass, 0 number)	26 (19 mass, 7 number)

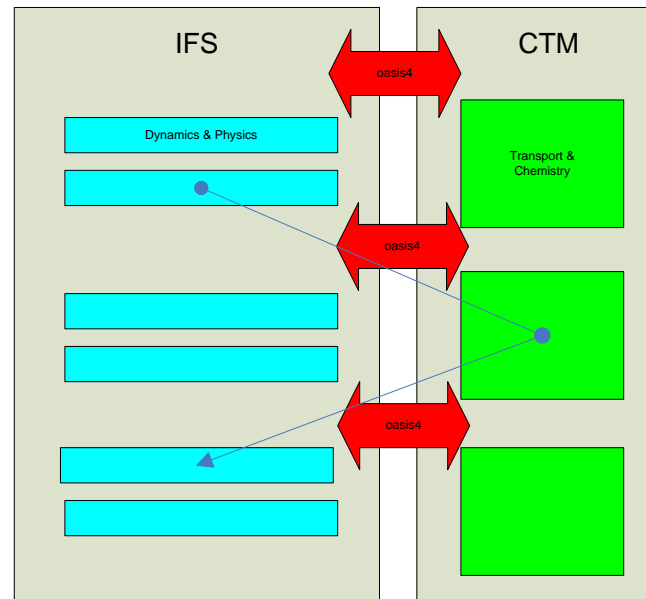
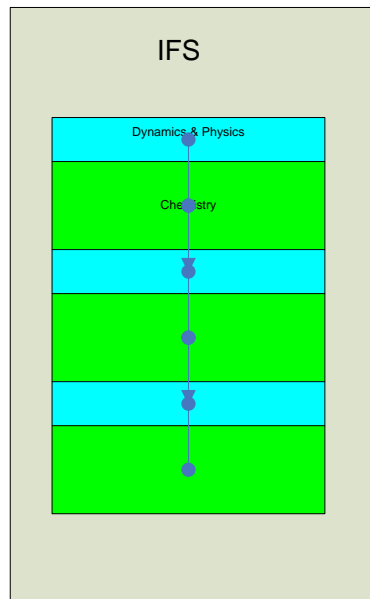
IFS-GLOMAP is currently ~2x expensive as IFS-MACC-II (the latter being 85% more expensive than no-aerosol IFS)

Development of C-IFS - online chemistry in IFS

Chemistry and Aerosol in IFS

Coupled System IFS – CTM

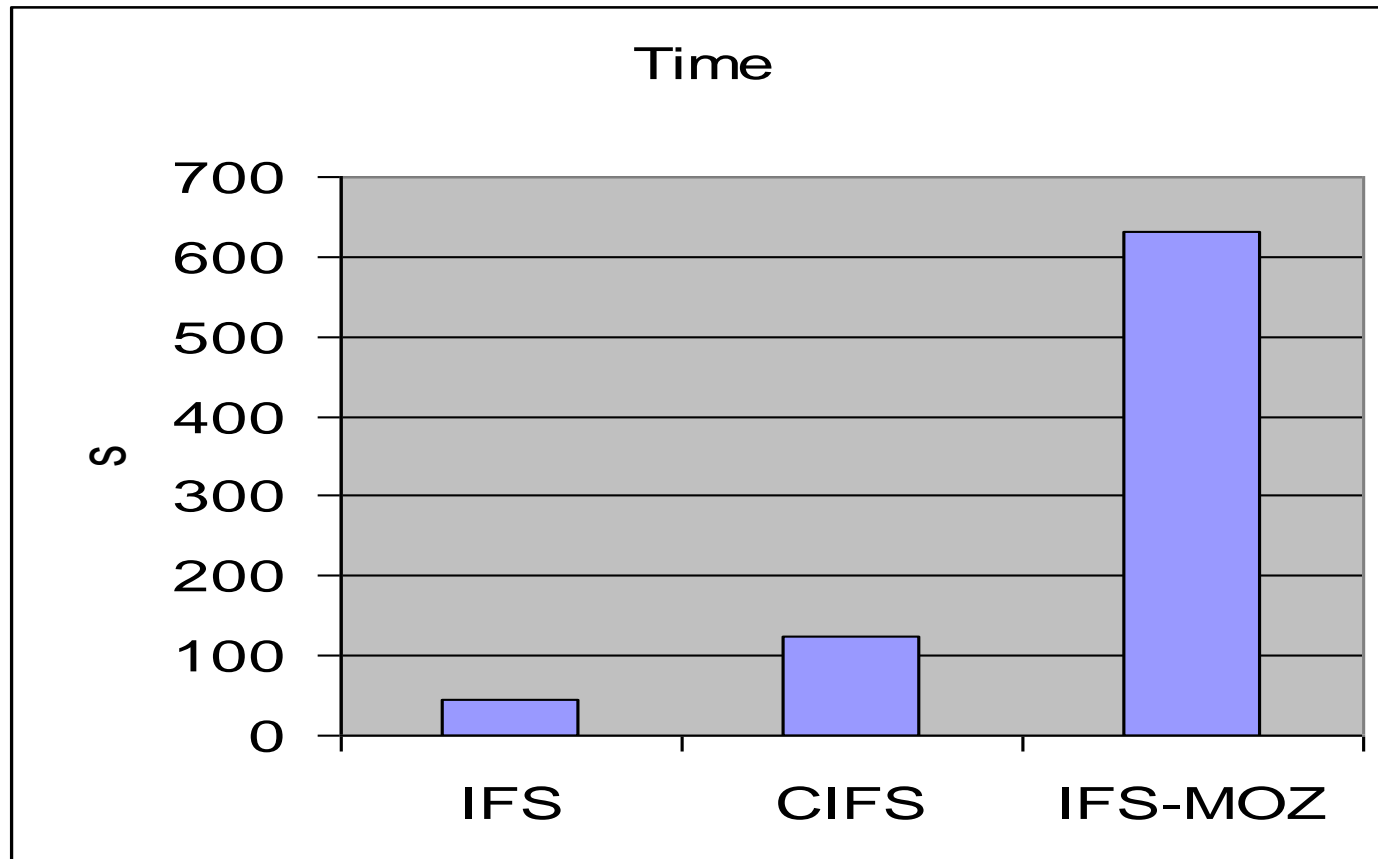
Aerosol
GHG
C-IFS



● Feedback Flow →

Integrated System
Feedback: fast
Flexibility: low

Coupled System
Feedback: slow
Flexibility: high



C-IFS is far more efficient than coupled system IFS-CTM

- MACC provides quasi-operational daily forecasts and re-analysis of atmospheric composition on global and regional scale
- Data are used as boundary conditions for European air quality models
- Developments in modelling and assimilation are ongoing and always included in the latest IFS cycle
- Assimilation of aerosol and SO₂ of Volcanic eruptions has become a research focus
- NRT fire emissions improve forecast skill on global scale for specific events (Russian Fires)
- OD to run MACC forecast and assimilation suite