



Atmosphere Monitoring



Global aerosol modelling aspects: update and some results of the past year

CAMS43 contribution to CAMS

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Monitoring

Preamble

CAMS43 Phase 1
April 2016 – March 2019



UNIVERSITY OF LEEDS



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Norwegian
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Preamble

Atmosphere
Monitoring

CAMS43 Phase 1
April 2016 – March 2019

CAMS43 Phase 2
April 2019 – June 2021



OB Consulting





Recent updates of the Integrated Forecasting System presented in this talk :

- Summary of the recent upgrade to cycle 46R1
- Possible cycle 47R1 updates
 - New sea-salt scheme
 - New dust source function
 - Updated aerosol dry and wet deposition
- Volcanic simulations : towards a combined tropospheric-stratospheric aerosol-chemistry forecasting system
- Aerosol alert service
- Summary - conclusions

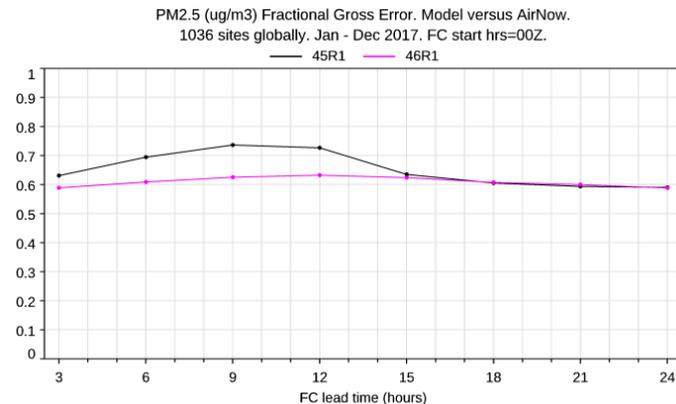
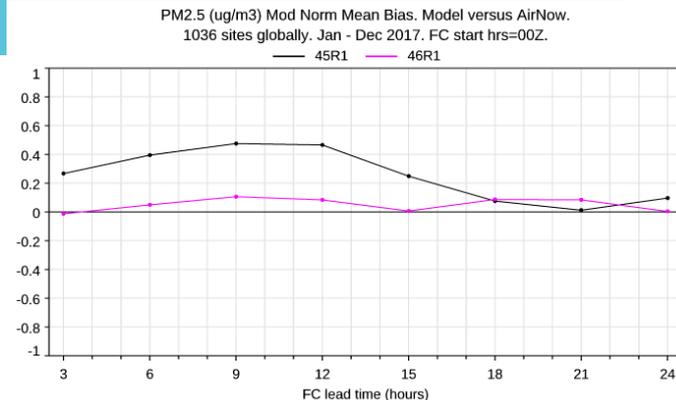


Cycle 46R1 upgrade

Cycle 46R1 is operational since 9th of July 2019. It is a major upgrade for aerosols:

- New dust scheme with MODIS-based dust source function
- New scavenging based on the TM5 scavenging routine
- Nitrate and ammonium
- Coupling with IFS-CB05 for sulphate aerosol production rates and nitrate/ammonium precursors
- Use of injection heights for biomass-burning emissions

The impact on AOD and PM scores is overall very positive



MNMB and FGE of forecast only (without assimilation) cycle 45R1 and 46R1 PM2.5 vs North American Airnow observations

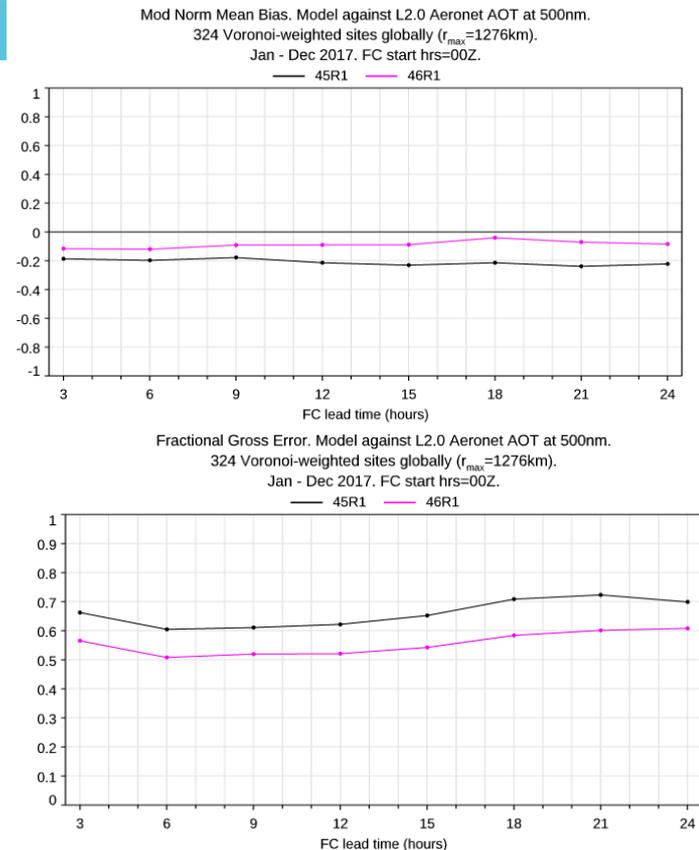


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MNMB and FGE of forecast only (without assimilation) cycle 45R1 and 46R1 AOD at 500nm vs global AERONET observations



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Cycle 47R1 potential updates

Candidates for operational cycle 47R1 are already being tested. The following aerosol developments are tested:

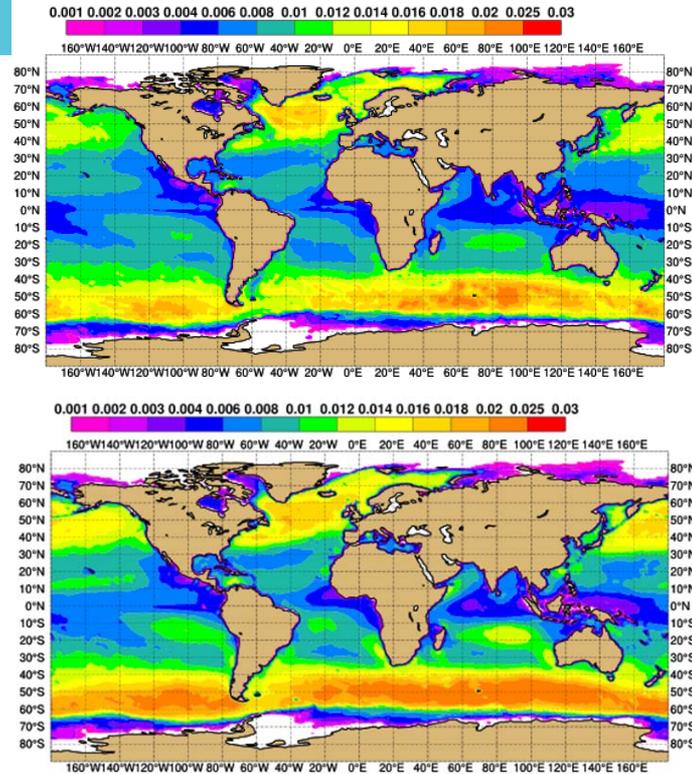
- New sea-salt aerosol emission/sedimentation scheme
- New aerosol dry and wet deposition schemes
- Adjusted Dust Source Function (DSF) for dust emissions



Cycle 47R1 potential updates

New sea-salt aerosol (SSA) emission/sedimentation scheme:

- Based on Albert et al. (ACP, 2016).
- Whitecap fraction estimated as a fit between WindSAT observations and wind speed and Sea-surface temperature (SST).
- SSA emissions are then derived from whitecap fraction using the Monahan et al. (1986) parameterization.
- Estimated whitecap fraction can be compared with WindSAT observations
- Sedimentation velocity horizontally and vertically varying with particle size and density



**Top: mean 2014 whitecap fraction retrieved by
WindSAT (provided by NRL)**

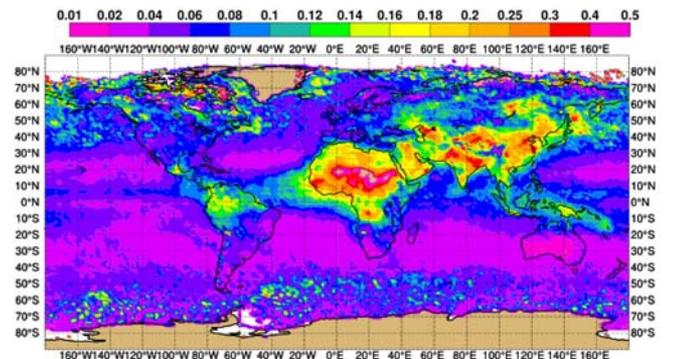
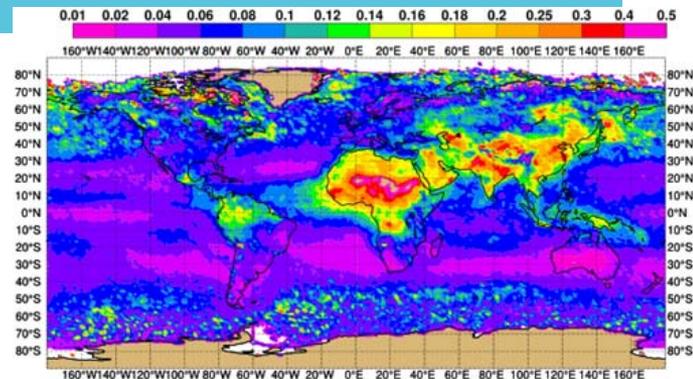
**Bottom: mean simulated 2017 whitecap
fraction**



Cycle 47R1 potential updates

New sea-salt aerosol (SSA) emission/sedimentation scheme:

- Positive impact on simulated AOD vs MODIS



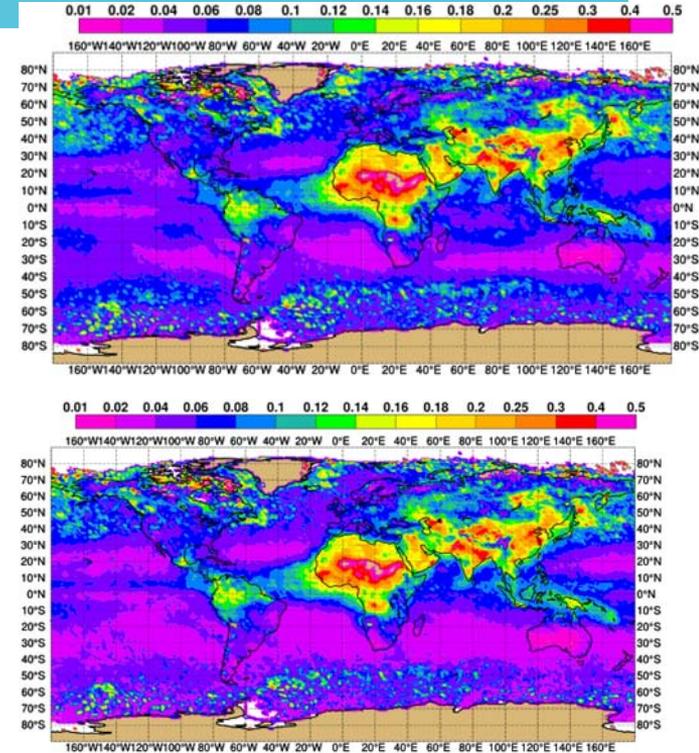
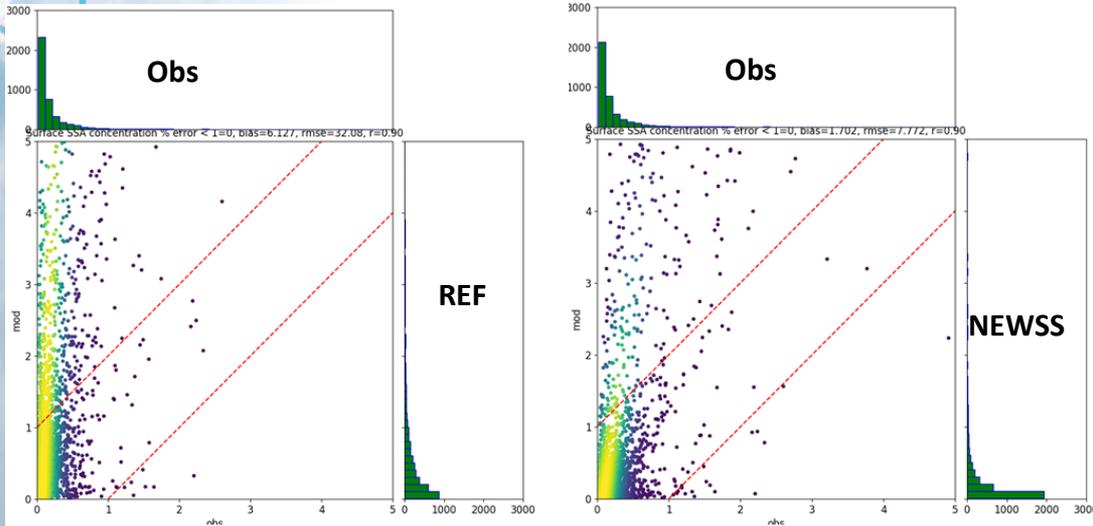
2017 average of RMSE of daily AOD@550nm vs MODIS/Aqua retrieval. FC only cycle 46R1 with current operational SSA scheme (top), with new SSA scheme (bottom).



Cycle 47R1 potential updates

New sea-salt aerosol (SSA) emission/sedimentation scheme:

- Positive impact on simulated AOD vs MODIS
- Also on SSA surface concentration



2017 average of RMSE of daily AOD@550nm vs MODIS/Aqua retrieval. FC only cycle 46R1 with current operational SSA scheme (top), with new SSA scheme (bottom).

2017 weekly observed SSA surface concentration in $\mu\text{g}/\text{m}^3$ observed by the CASTNET network over US (horizontal) and simulated by FC only cycle 46R1 with current operational SSA scheme (left), with new SSA scheme (right).



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Cycle 47R1 potential updates

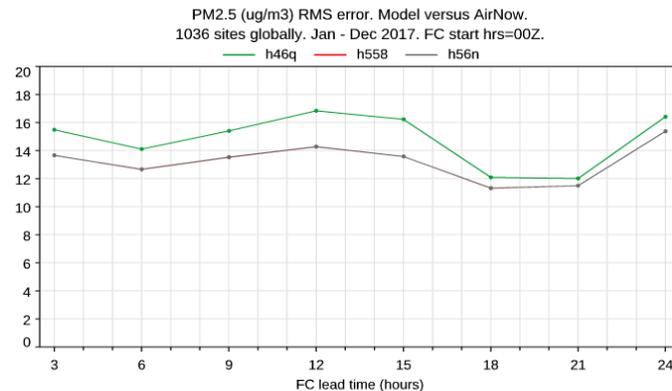
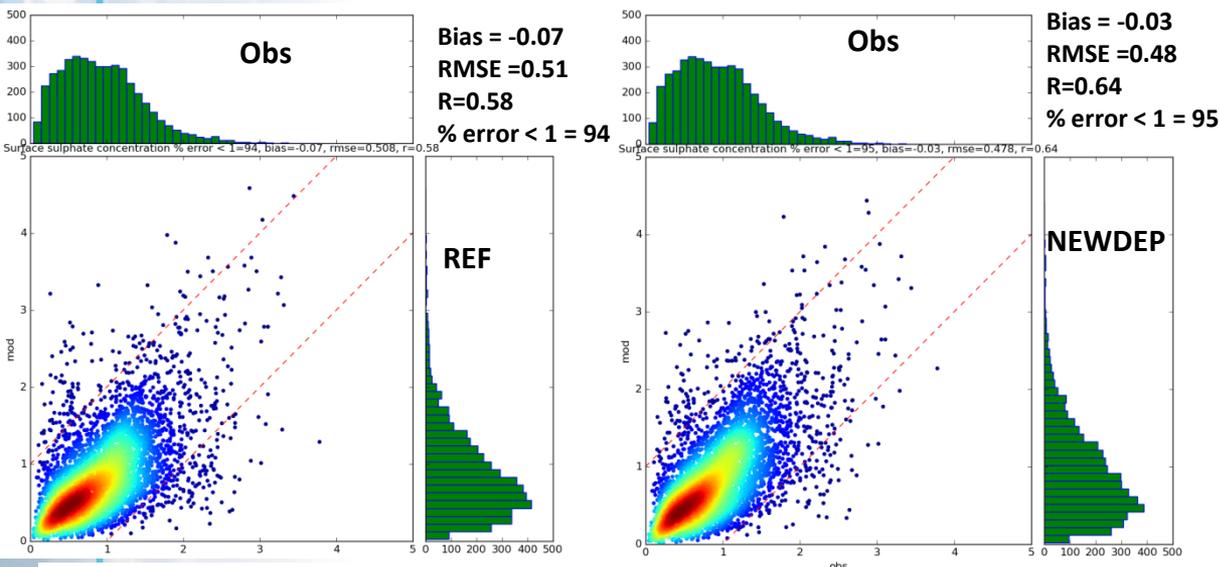
New aerosol deposition:

- Dry deposition from Zhang and He (2014)
- Wet deposition adapted from Luo et al. (2019), implemented in GEOS-CHEM v12



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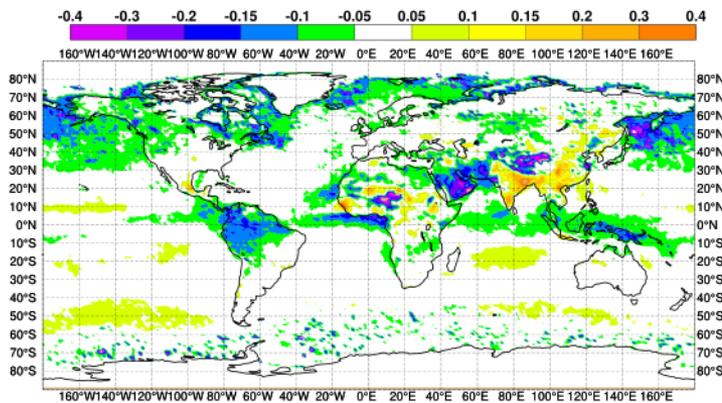
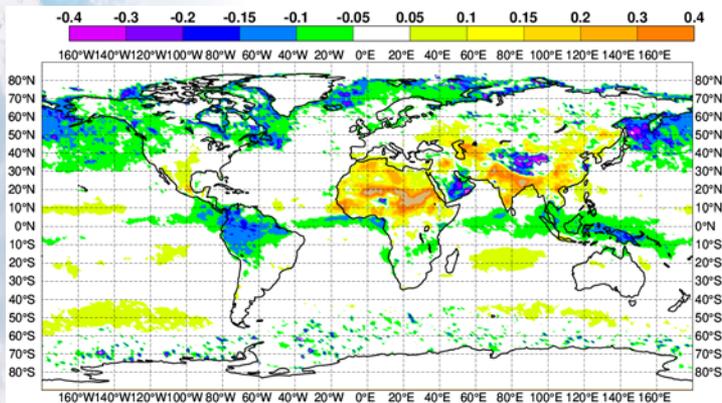
2017 RMSE of PM2.5 vs Airnow observations (mainly US), vs 46R1 reference (green) and with new deposition (gray).

2017 weekly sulfate surface concentration in $\mu\text{g}/\text{m}^3$ observed by the CASTNET network over US (horizontal) and simulated by FC only cycle reference (left), with new deposition (right).



Updated Dust Source Function (DSF):

- Derived from climatological frequency of occurrence of MODIS dust optical depth (DOD) above a given threshold
- Solves the problem of too high dust burden over Sahara with 46R1

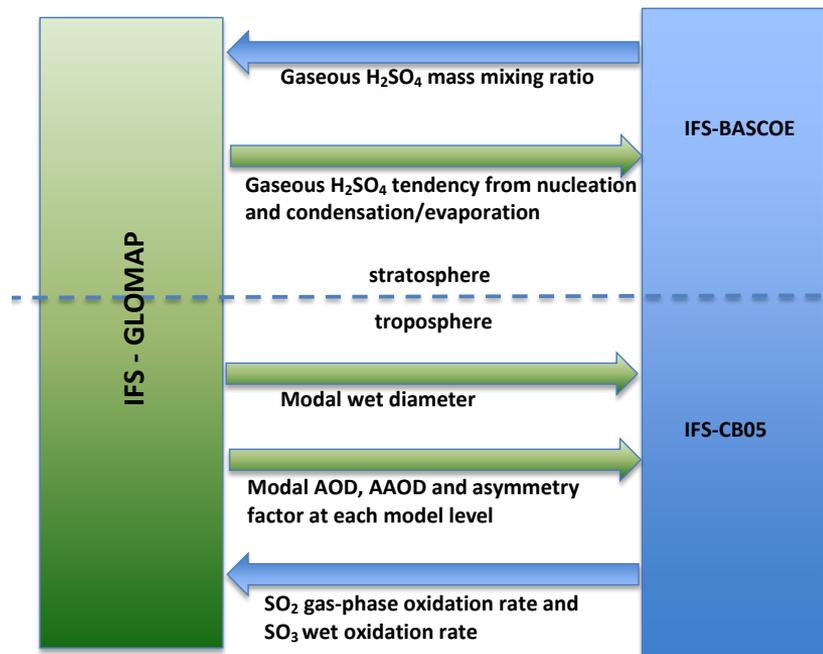


March-April-May 2017 mean bias of daily AOD@550nm vs MODIS/Aqua retrieval. FC only cycle 46R1 with current operational DSF (left), with new DSF (right).



Volcanic simulation: coupling of IFS-CB05-BASCOE with IFS-GLOMAP

- Stratospheric sulphur cycle has been implemented in IFS-CB05-BASCOE
- Stratospheric coupling of IFS-CB05-BASCOE with IFS-GLOMAP
 - Sulphuric acid from IFS-BASCOE
 - Sulphuric acid tendencies from nucleation and condensation from IFS-GLOMAP
- Tropospheric coupling of IFS-CB05 with IFS-GLOMAP
 - SO_x oxidation rate from IFS-CB05
 - Aerosol wet diameter from IFS-GLOMAP to compute Surface Area Density (SAD) for heterogeneous chemical reactions
 - Aerosol optical properties to compute photolysis rates



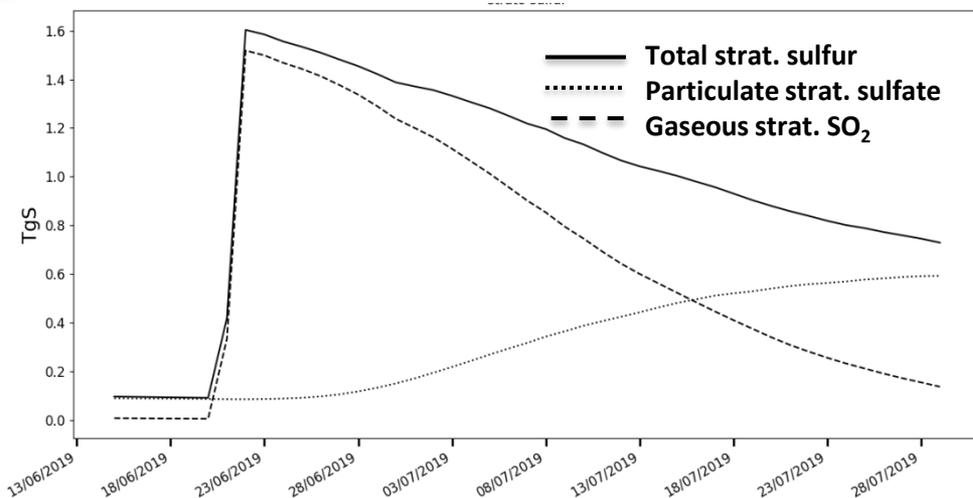


Volcanic simulation: coupling of IFS-CB05-BASCOE with IFS-GLOMAP

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This new IFS-CB05-BASCOE-GLOMAP (ICBG) system has been tested on various volcanic events:

- Pinatubo (June 1991, ~14Tg SO₂ release)
- Calbuco (April 2015, ~0.4 Tg SO₂ release)
- Raikoke (June 2019, ~1.5 Tg SO₂ release)

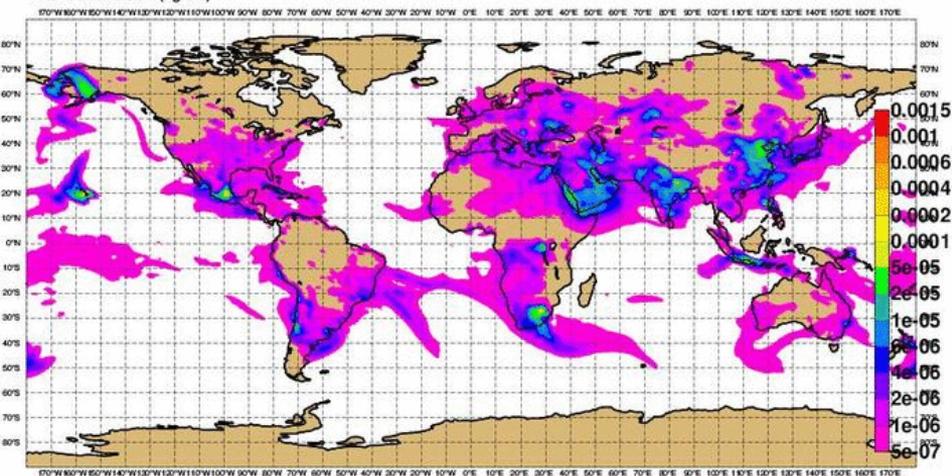


Time evolution of simulated global stratospheric total, particulate and gaseous sulfur during the Raikoke eruption (using a 3Tg release of SO₂ on 21/22 June 2019)

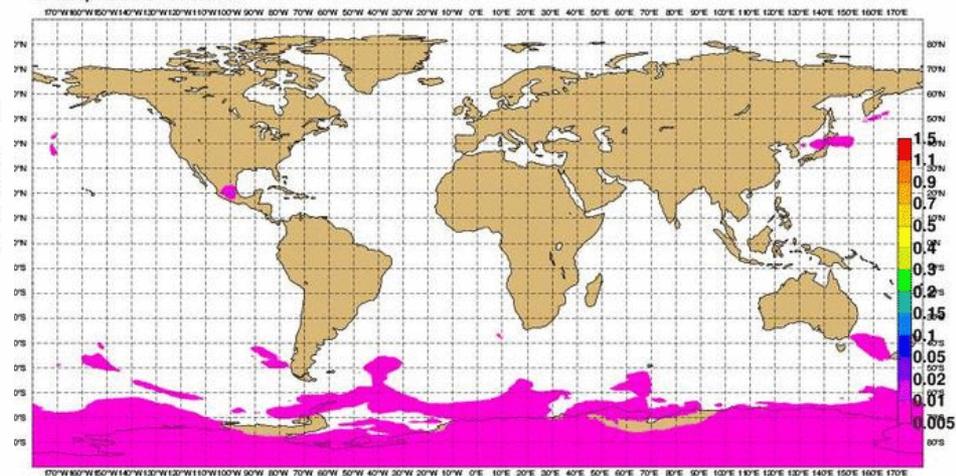


Simulation of the Raikoke eruption on 21/22 June 2019

2019062100 MACC Forecast t+003
Total column SO₂ (kg/m²)



2019062100 MACC Forecast t+003
Stratospheric AOD at 550 nm

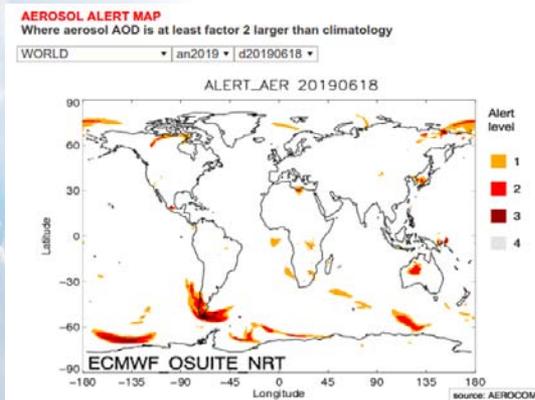




Aerosol alert service upgrade

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The aerosol alert service is maintained, developed, evaluated and routinely run by MetNorway in the framework of CAMS43

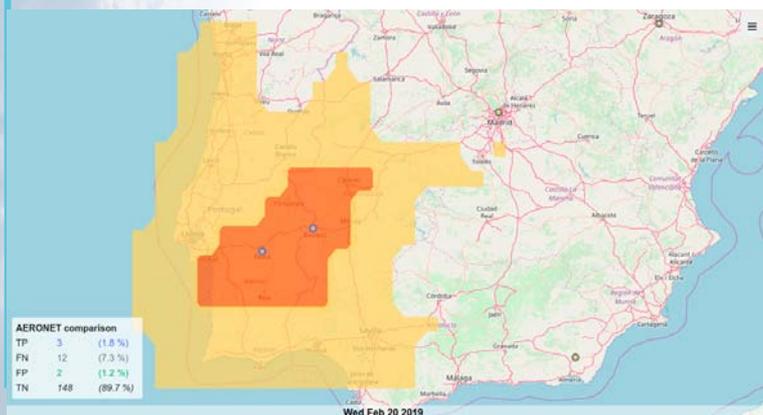
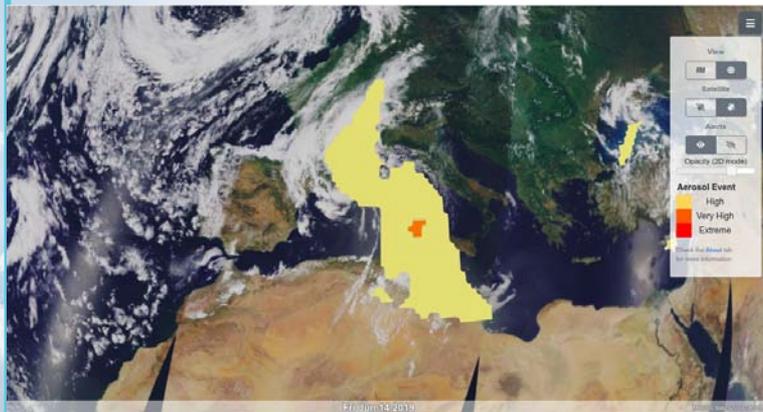


Alerts computed using **MACC** climatology

- Precomputed pictures in predefined regions

Alerts computed using **CAMS** climatology

- Dynamic maps (zoomable)
- Alerts represented as filled polygons (same color code)



Map Customization

- Add **MODIS True Color** as background layer
- Switch **2D/3D**
- **Species specific** alerts (in development)

Exploration of past events

- **Online evaluation** against alerts computed with AERONET observation

TP	True Positive	OBS: + MOD: +
FN	False Negative	OBS: + MOD: -
FP	False Positive	OBS: - MOD: +
TN	True Negative	OBS: - MOD: -



Summary - conclusions

- The new developments presented here led to a significant improvement of the skill of both IFS-AER and IFS-GLOMAP AOD (vs AERONET and MODIS) and PM
- Diversification of the evaluation of the simulations:
 - PM : Airnow, Airbase)
 - AOD: AERONET, MODIS
 - surface concentration: sulfate, nitrate, ammonium, sea-salt aerosol against CASTNET and EBAS
- More evaluation of ICBG and IFS-GLOMAP (size distribution) is incoming