High-resolution regional dust analysis based on ensemble data assimilation techniques within the NMMB-MONARCH model

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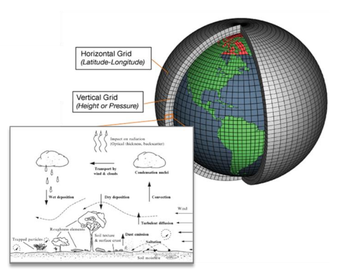
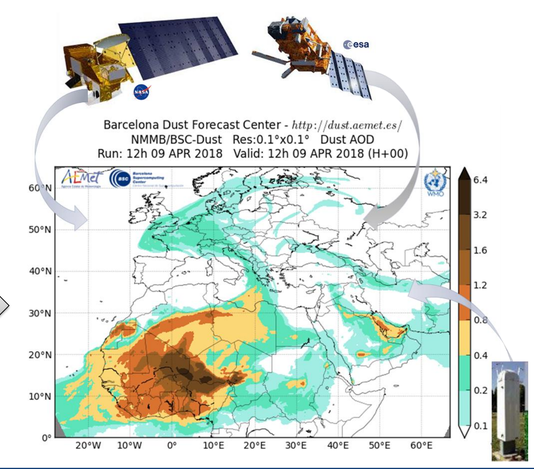
Background

Mineral dust is one of the main components of the atmospheric aerosol loading and plays an important role in the earth's energy balance. The presence of dust in the atmosphere and its deposition on land, ocean and ice surfaces has a relevant impact on economical activities, on the ecosystem, on health, as well as on weather and climate

Model simulations and observations are combined to obtain the 'best' estimate of current dust atmospheric conditions (dust analysis):

- useful to initialise models
- and improve predictions
- used to produce reanalysis



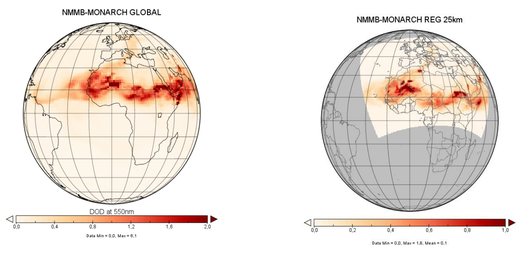


NMMB-MONARCH model

(Pérez et al., 2011; Haustein et al., 2012; Jorba et al., 2012; Spada et al., 2013; Badia and Jorba, 2016: Di Tomaso et al., 2017)

The atmospheric composition **NMMB-MONARCH** system is build on the meteorological driver **NMMB**:

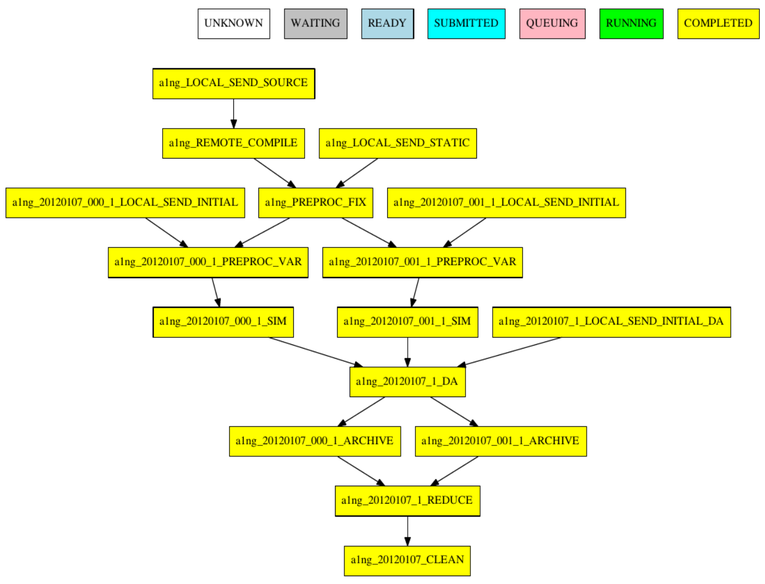
- Multiscale: global to regional scales allowed (nesting capabilities)
- Nonhydrostatic dynamical core: single digit km resolution allowed
- Fully on-line coupling: weather-chemistry feedback processes allowed
- Enhancement with a data assimilation system



Example of 14 July 2011 at 18h

Workflow manager autosubmit

(Manubens-Gil et al., 2016)

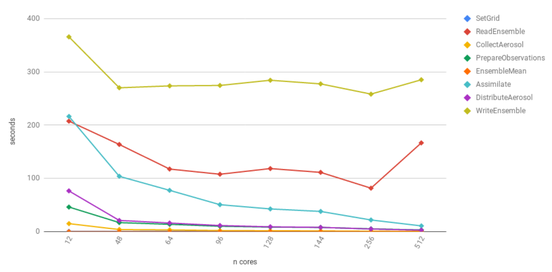


Workflow manager developed at BSC manages all the tasks associated to a model experiment submitting jobs in HPC systems and post-processing results in local machine.

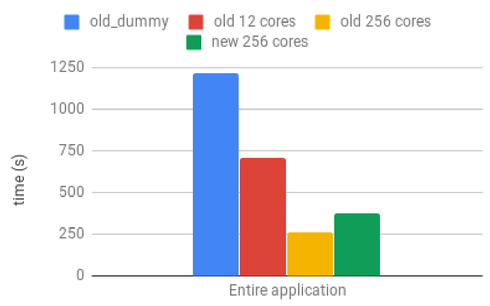
Figure shows the job workflow to produce one day of ensemble data assimilation (DA) simulation with the **NMMB-MONARCH** model coupled to a DA scheme.

NOTE: For clarity of the figure, only two ensemble members are used. Jobs can be submitted using a horizontal and vertical job wrapper strategy.

Scalability tests and performance improvement



Scalability of the DA application for the execution of the main subroutines



Comparison in execution time (in seconds) between the new improved version of the DA code run using 256 cores ("new 256 cores") and previous versions using either 12 cores ("old_dummy" and "old 12 cores") or 256 cores ("old 256 cores").

Model configuration

An ensemble of model simulations is generated for data assimilation purposes following Di Tomaso et al. (2017). Each ensemble member is run with a perturbation of model parameters which are deemed to be particularly uncertain in the dust emission scheme.

- In the present contribution is tested the impact of the model result assimilation different observational datasets based on an ensemble of 12 members.

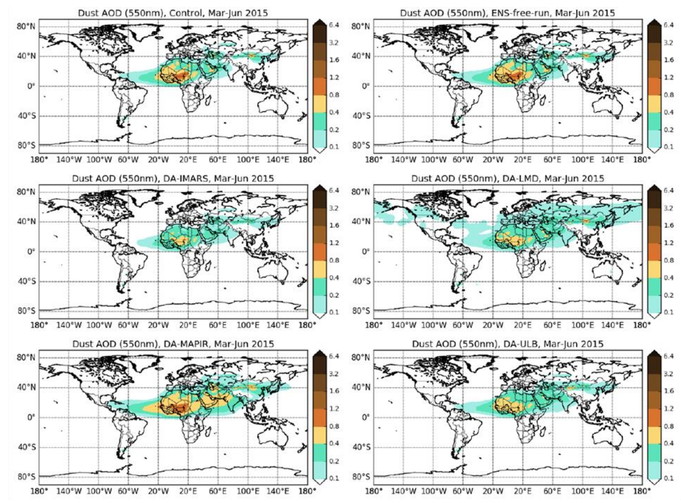
Experiments

ESA Aerosol CCI – IASI Dust (Global runs at 1º x 1º)

- Observations available day time and night time, over ocean and over land (desert)
- 10 µm: detection of dust aerosol coarse mode pixel level uncertainty
- suited for long-term evolution

Results using 4 different dust IASI retrievals

Dust optical depth (AOD) averaged for March to June 2015 for the Control (with no DA; top left), ENS-free-run (top right), DA-IMARS (centre left), DA-LMD (centre right), DA-MAPIR (bottom left), DA-ULB (bottom right) experiment.



IMARS

MAPIR

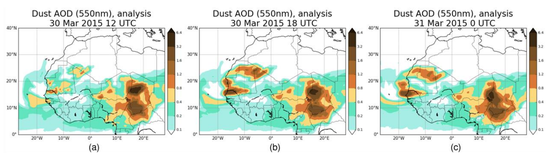
LMD

ULB

ACTRIS-2: Lidar observations (Regional runs at 10km x 10 km)

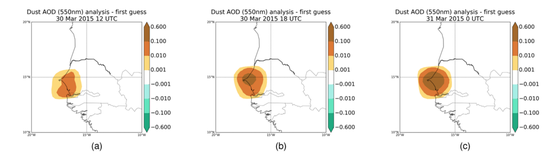
Results assimilating dust profiles near Dakar

Dust analysis



Dust AOD analysis at 550 nm at three time steps of the assimilation window produced by the assimilation of a lidar extinction profile at the M'Bour site, near Dakar, in Senegal.

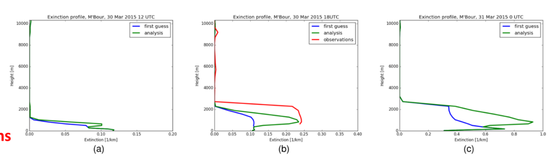
Analysis increments (~1.3° radius of influence)



Analysis increments (analysis – first guess; top) and extinction profiles at 532 nm (bottom) for the model first guess (blue), the analysis (green), and, when available, for the assimilated observations (red) at the M'Bour site at three time steps of the assimilation window.

Correction of an underestimation in total column extinction in the model

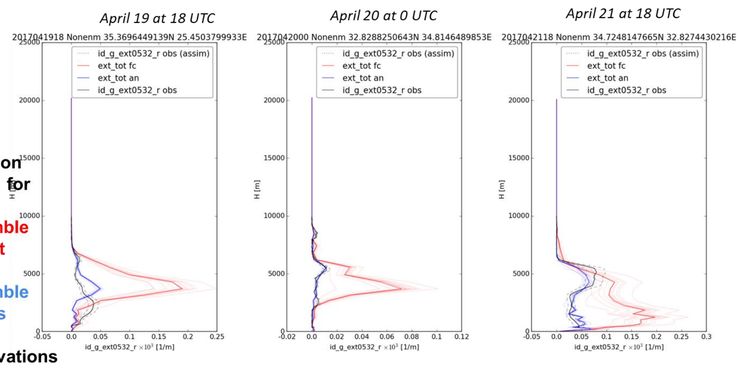
Exinction profiles for
- ensemble forecast
- ensemble analysis
-observations



Results assimilating dust profiles at sites in the East Mediterranean

Finokalia *April 19 at 18 UTC*
Haifa *April 20 at 0 UTC*
Limassol *April 21 at 18 UTC*

Extinction profiles for
- ensemble forecast
- ensemble analysis
- observations



Extinction vertical profiles for the ensemble forecast (red), the ensemble analysis (blue) and the observations (black) at Finokalia on April 19 at 18 UTC (left), at Haifa on April 20 at 0 UTC (centre) and at Limassol on April 21 at 18 UTC (right)

Acknowlegments

The results of this contribution were producet within the eDust PRACE project (reference number 2016153617).The authors also acknowledge calibration efforts from AERONET-Europe TNA supported by the PHOTONS and RIMA networks and partially financed by the European Community Research Infrastructure Action under ACTRIS grant no. 262254. We also acknowledge the AXA Research Fund for funding aerosol research at the Barcelona Supercomputing Center through the AXA Chair on Sand and Dust Storms. The authors would like to acknowledge the COST programme through its funding of the COST Action CA16202 and the ACTRIS-2 under grant agreement no. 654109 from the European Union's Horizon 2020 Research and Innovation Programme.

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