Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Assimilating vertical profiles of dust observations with ensemble meteorological initial and boundary conditions

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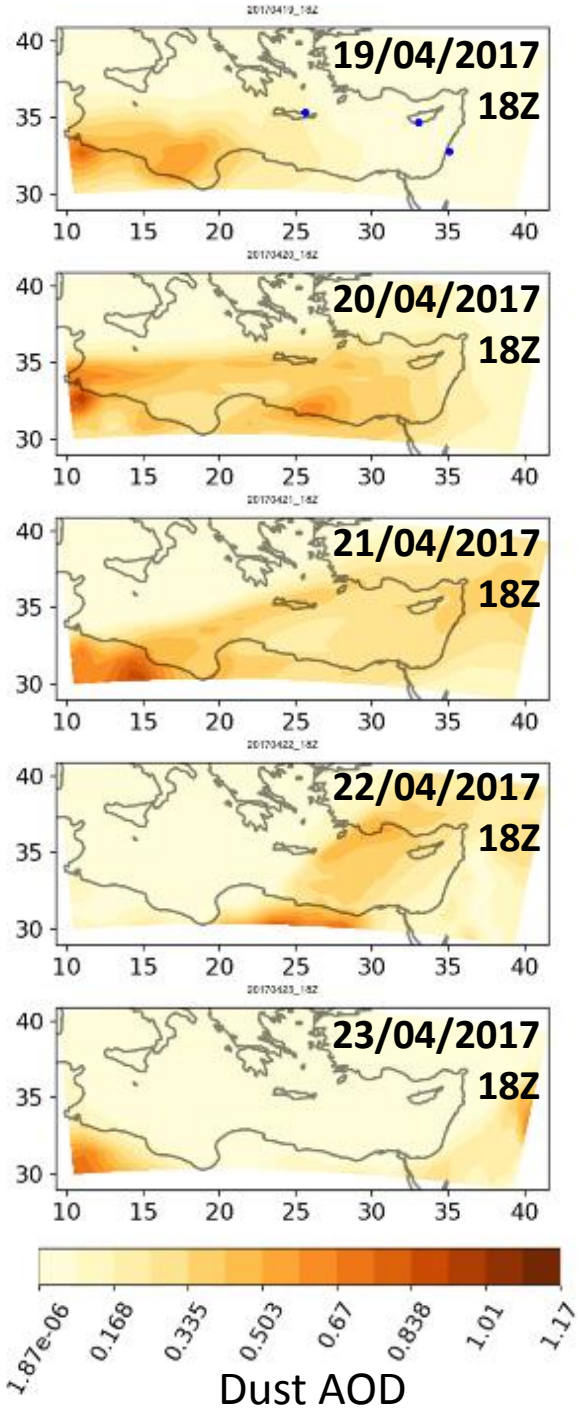
12/04/2019

EGU 2019

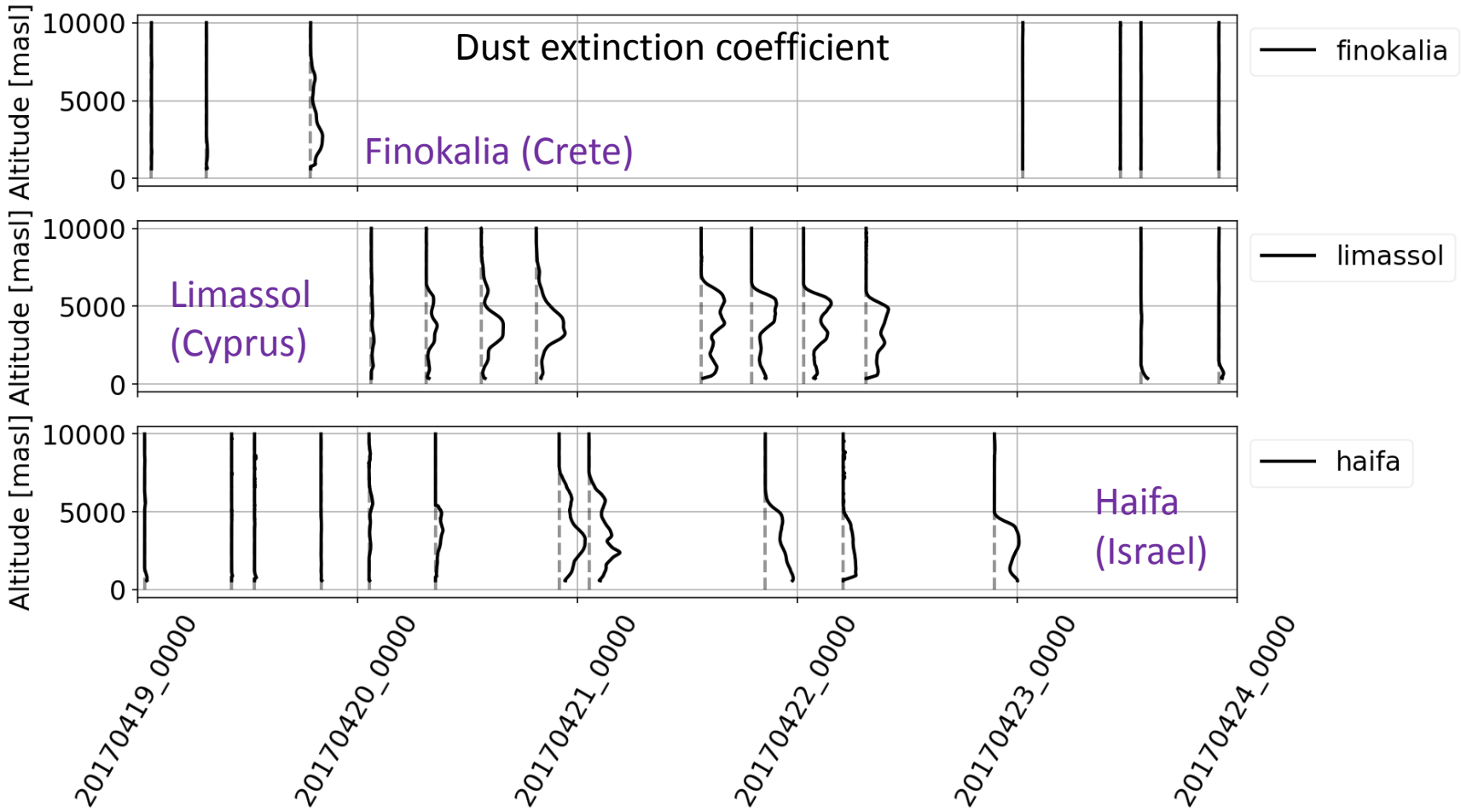
Case of study

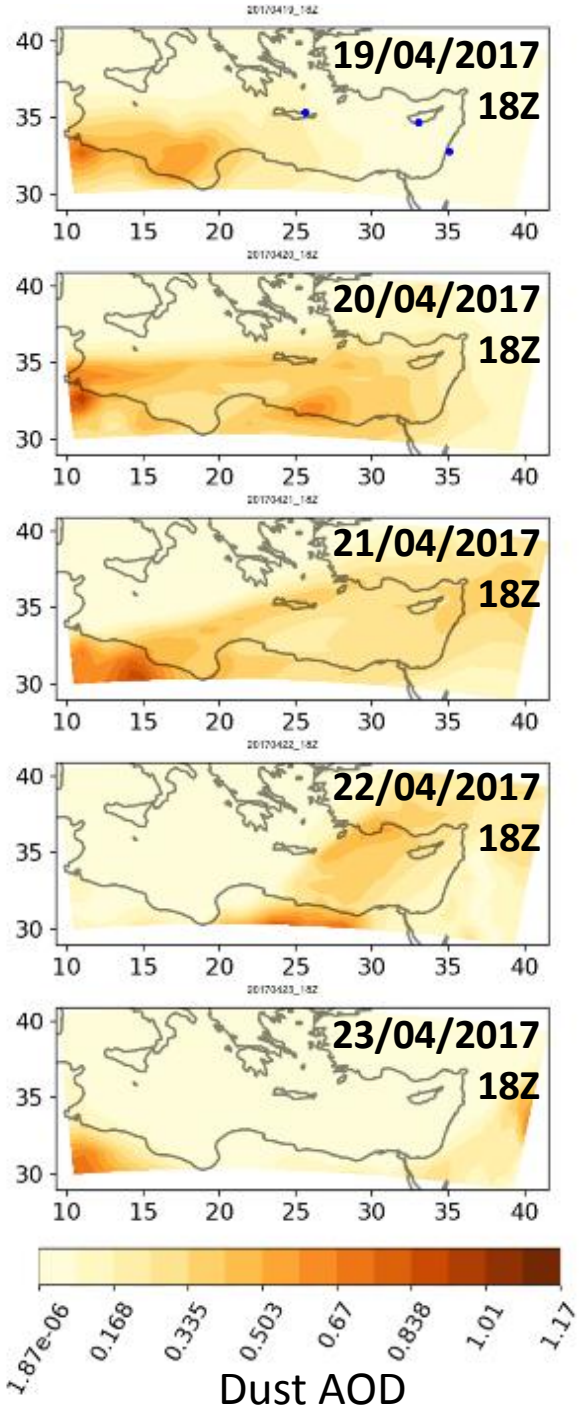
MODIS-Aqua 21/04/2017, NASA



Case of study

Event observed by 3 **lidar** sensors located **in Finokalia (Crete), Limassol (Cyprus) and Haifa (Israel)** part of the PollyNet (http://polly.tropos.de/) system. Data (with uncertainty estimation) processed by TROPOS.



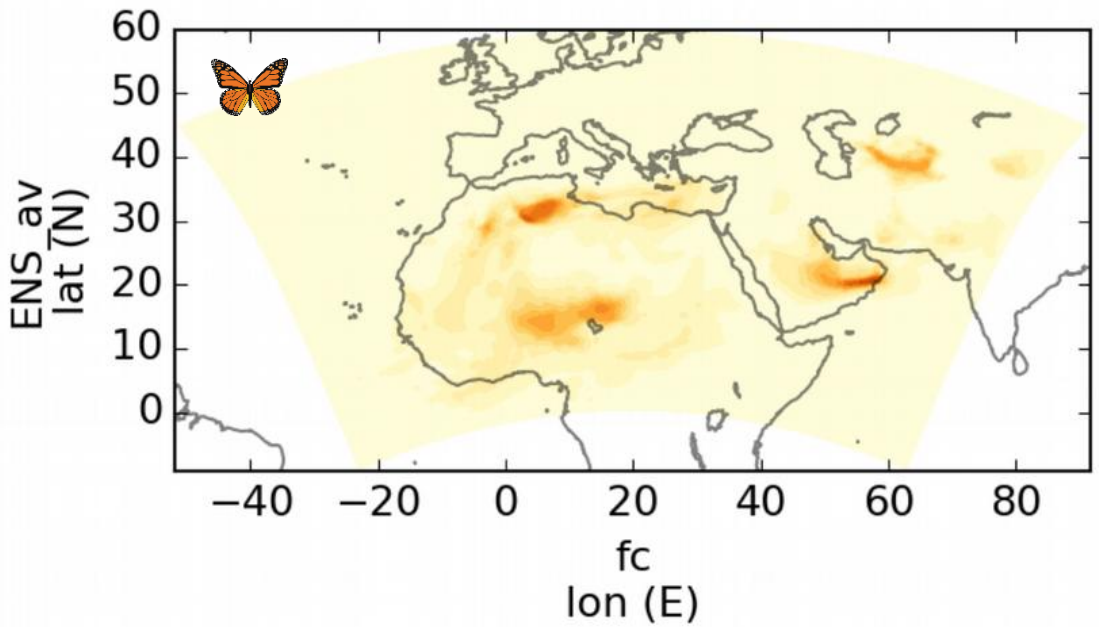


Model and Data Assimilation setup

Model:

NMMB - MONARCH multi-scale chemical weather prediction system model (Janjic et al., 2011, Perez et al., 2011)

- Aerosols: only dust configuration
- 0.66 degrees resolution, 40 vertical levels
- Dust emission schemes available



Mean ensemble forecast for April 20 18Z

Data assimilation:

Local Ensemble Transform Kalman Filter (LETKF, Hunt et al., 2007; Miyoshi and Yamane, 2007, Schutgens et al., 2010)

- 24 hours assimilation window
- Horizontal localization : 400 km
- Vertical localization : 1 model level
- Time localization : 4 hours
- Dust extinction coefficient observation operator

Ensemble generation:

- Perturbation in emission parameters
- Perturbation in emission strength
- Different dust emission schemes
- Different meteorological forcing for the regional model

Can we benefit from an ensemble with different meteorological inputs and emission schemes for aerosol vertical profiles data assimilation?

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Experiments description

4 experiments with different ensembles (**20** members):

Experiment	Meteorology boundary and initial conditions	Dust emission
1 meteo, 1 dust scheme	ERA Interim (Dee et al., 2011)	Ginoux et al., 2001
2 meteo, 1 dust scheme	ERA Interim FNL	Ginoux et al., 2001
1 meteo, **2 dust schemes**	ERA Interim	Ginoux et al., 2001 Perez et al., 2011
2 meteo, **2 dust schemes**	ERA Interim FNL	Ginoux et al., 2001 Perez et al., 2011

+ random perturbations in :

- source strength and dust size distribution
- dust scheme threshold friction velocity

(Di Tomaso et al., 2017)

Finokalia and Limassol assimilated
Haifa for verification

fr: "free" run (simulations without assimilation)
fc: "forecast" run (start from analysis of previous day)
an: analysis

FNL: NCEP Final Operational Global Analysis

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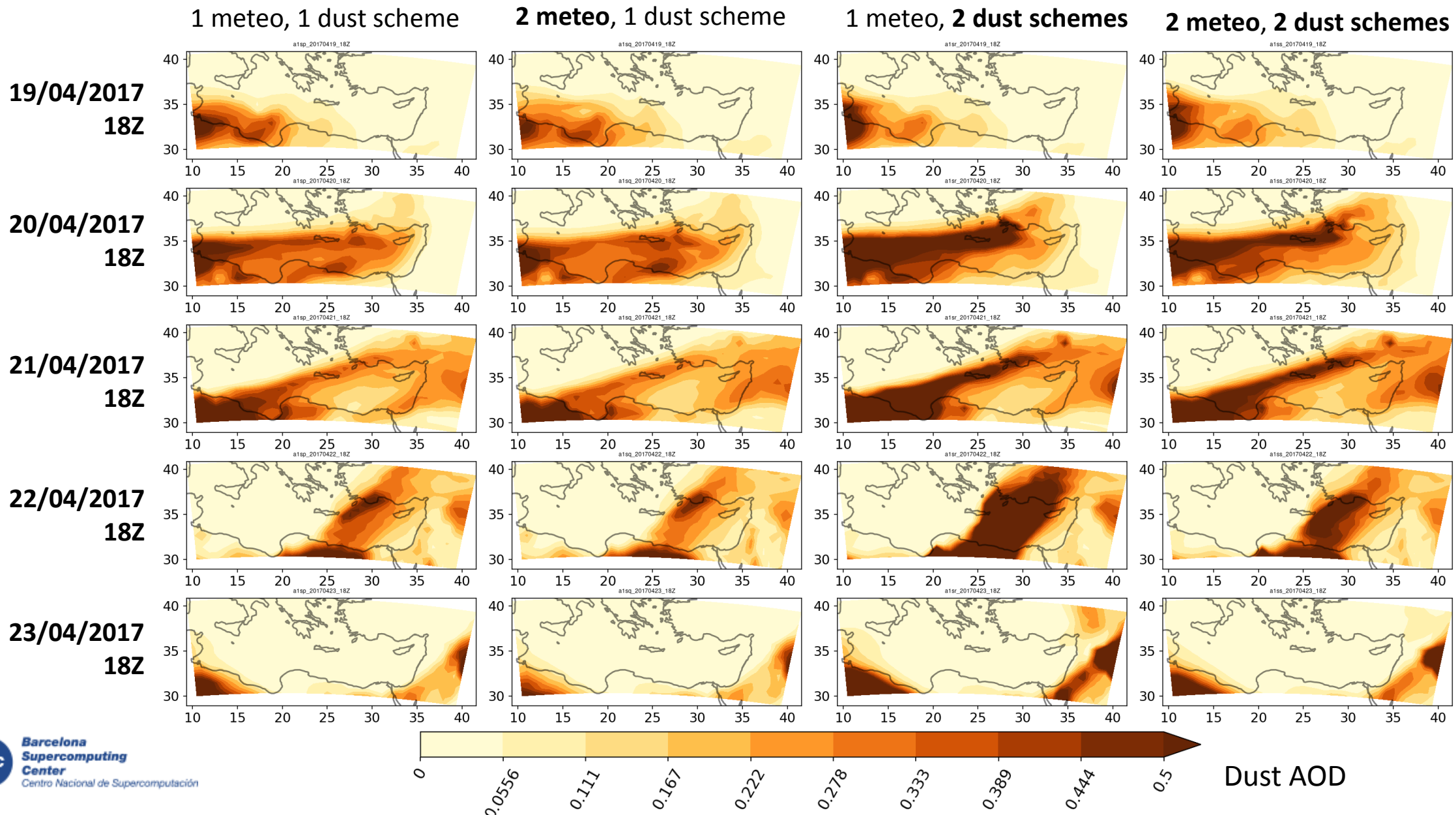
Dust Aerosol Optical Depth 532 nm Analyses



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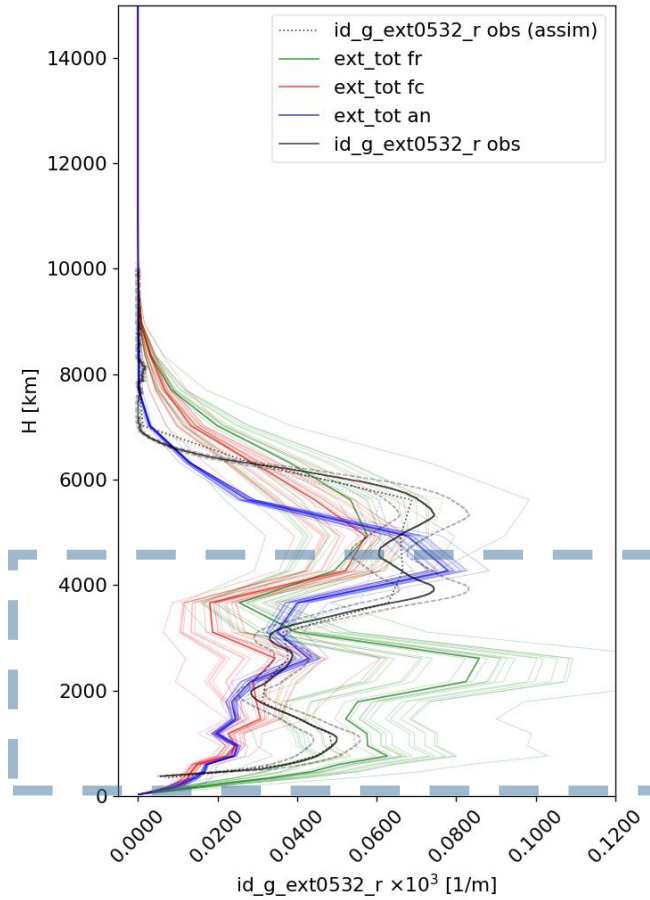
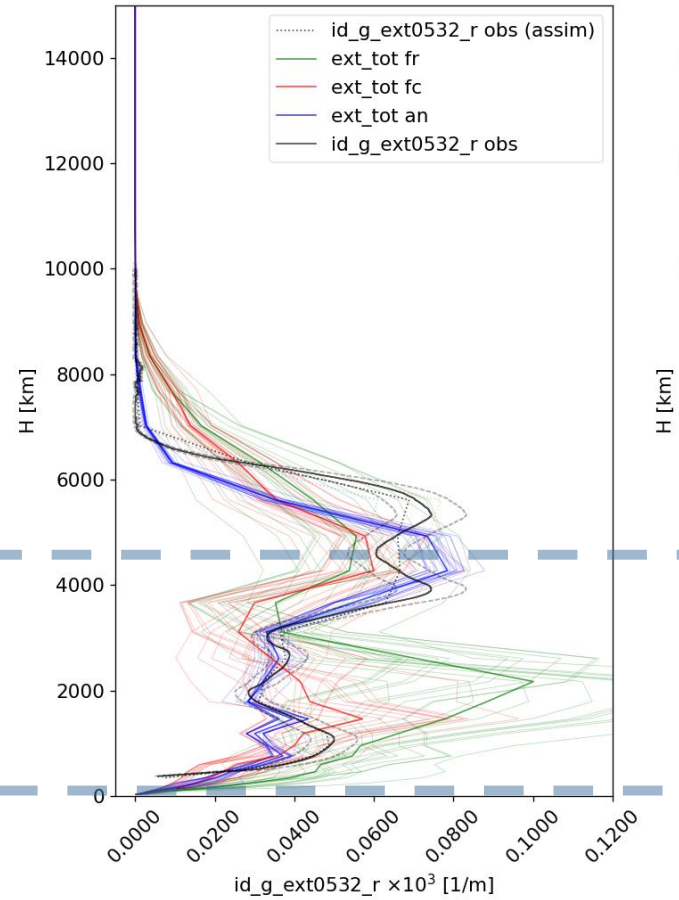
Profiles for the assimilated observations

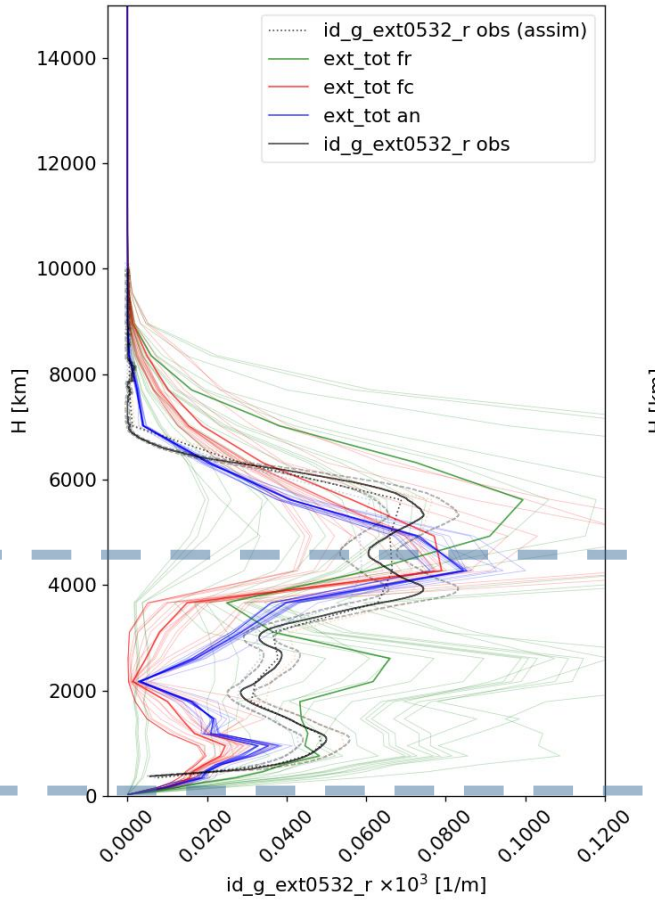
1 meteo, 1 dust scheme



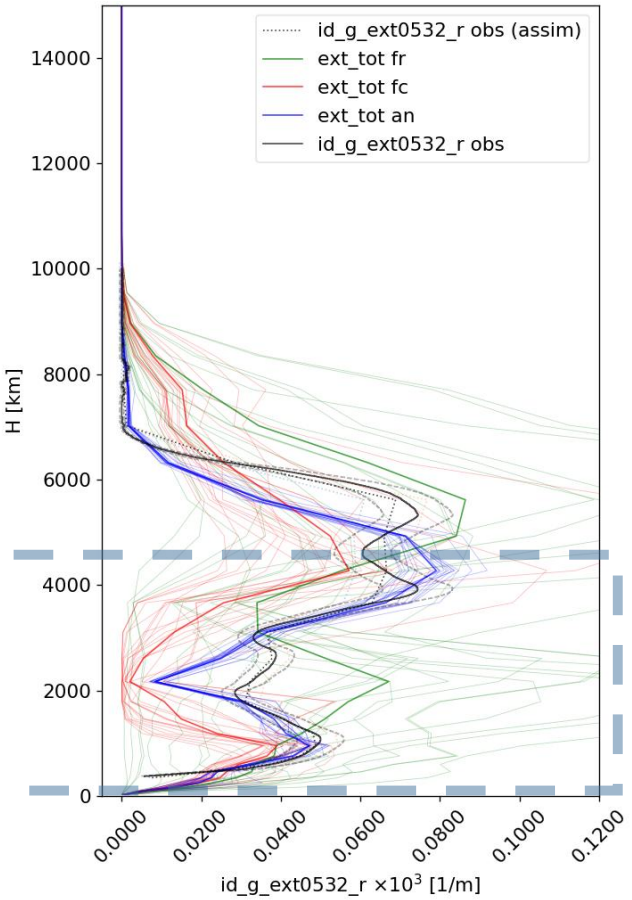
2 meteo, 1 dust scheme



1 meteo, **2 dust schemes**



2 meteo, 2 dust schemes



Extinction coefficient [km^{-1}]

Observation
No assimilation
Forecast run (1 day run from previous analysis)
Analysis

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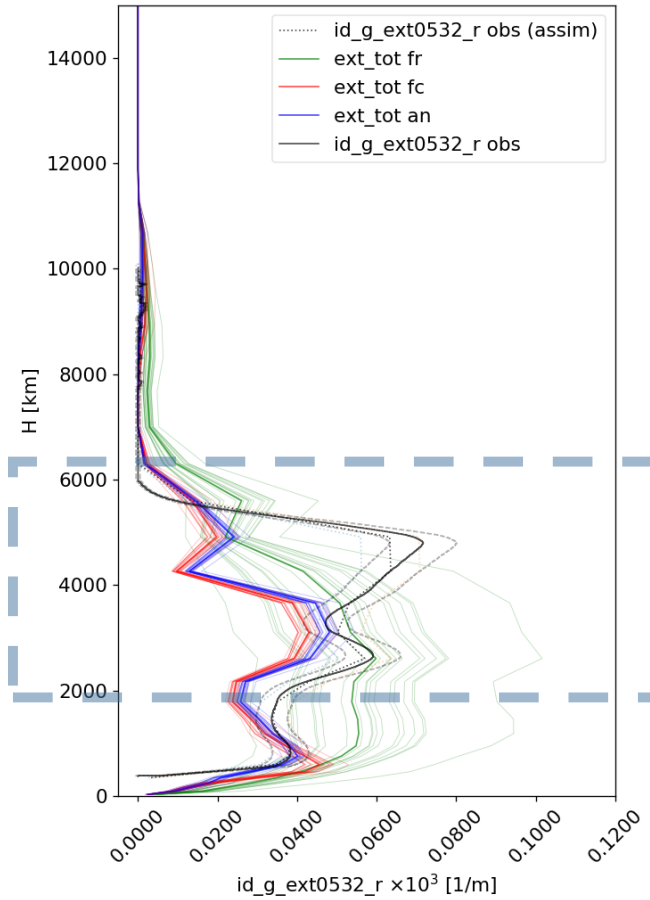
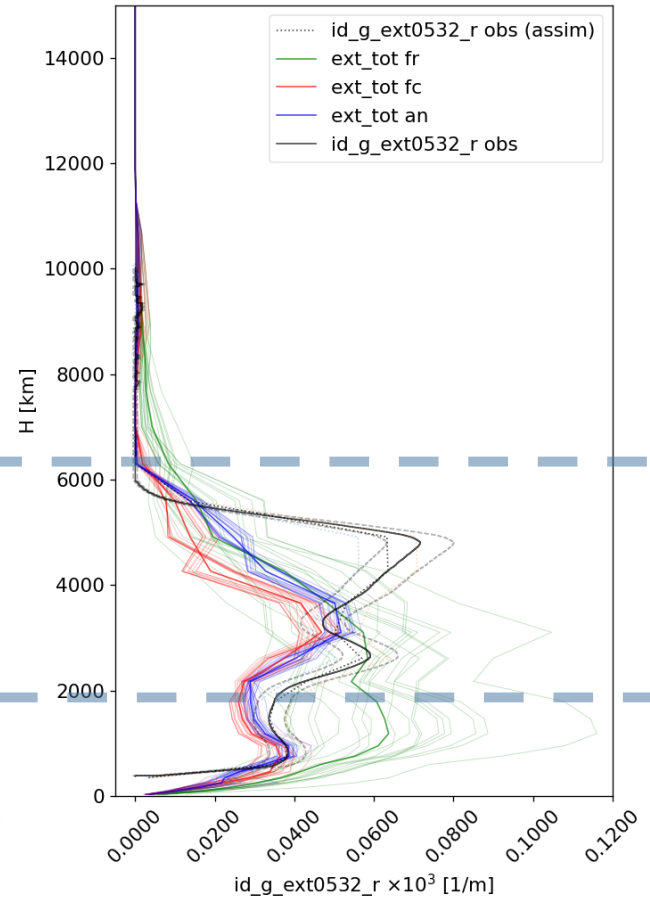
Limassol, 21/04/2017, 13UTC

Profiles for the assimilated observations

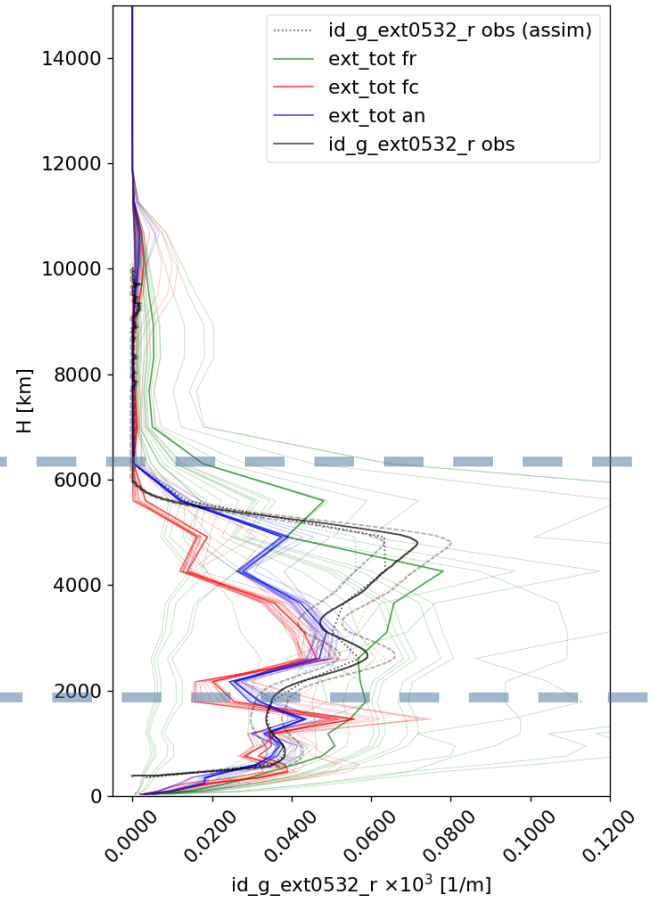
1 meteo, 1 dust scheme



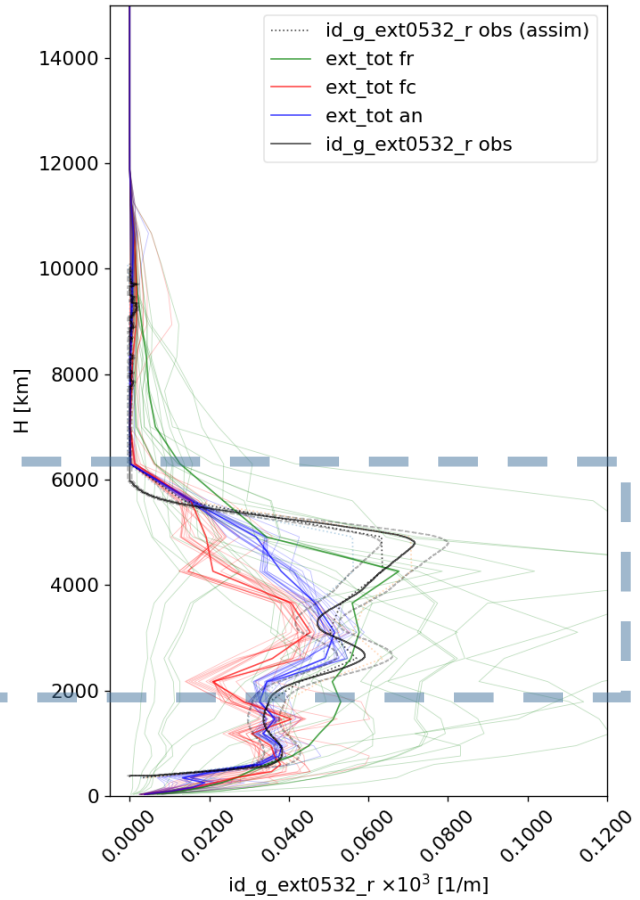
2 meteo, 1 dust scheme



1 meteo, **2 dust schemes**



2 meteo, 2 dust schemes



Extinction coefficient [km^{-1}]

Observation
No assimilation
Forecast run (1 day run from previous analysis)
Analysis

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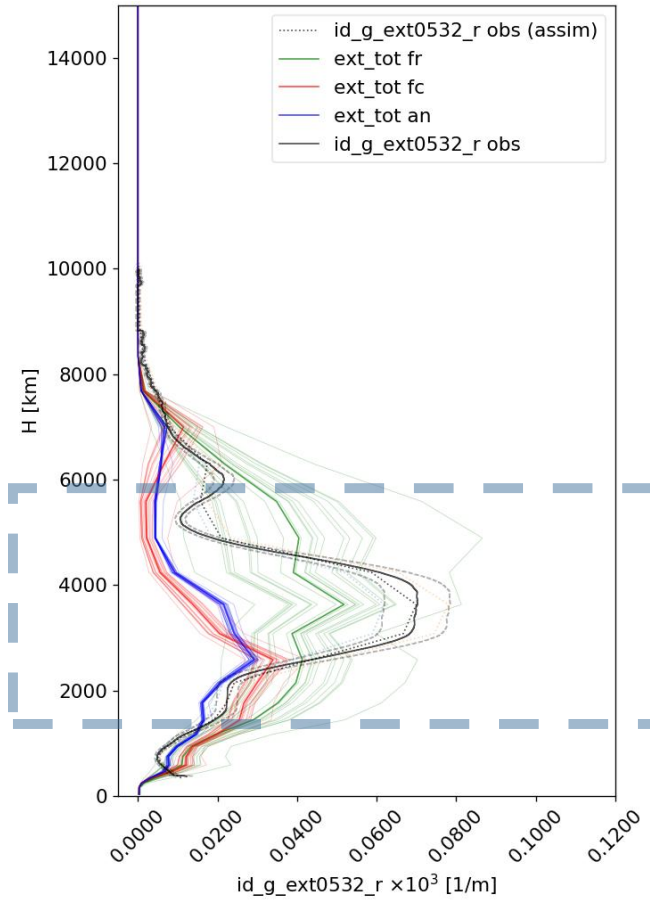
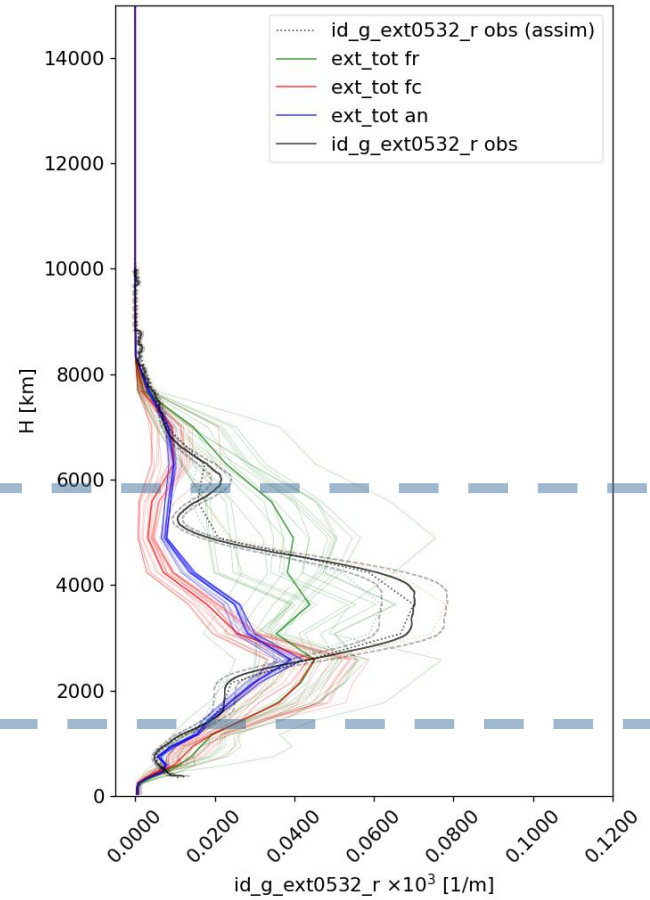
Limassol, 22/04/2017, 07UTC

Profiles for the assimilated observations

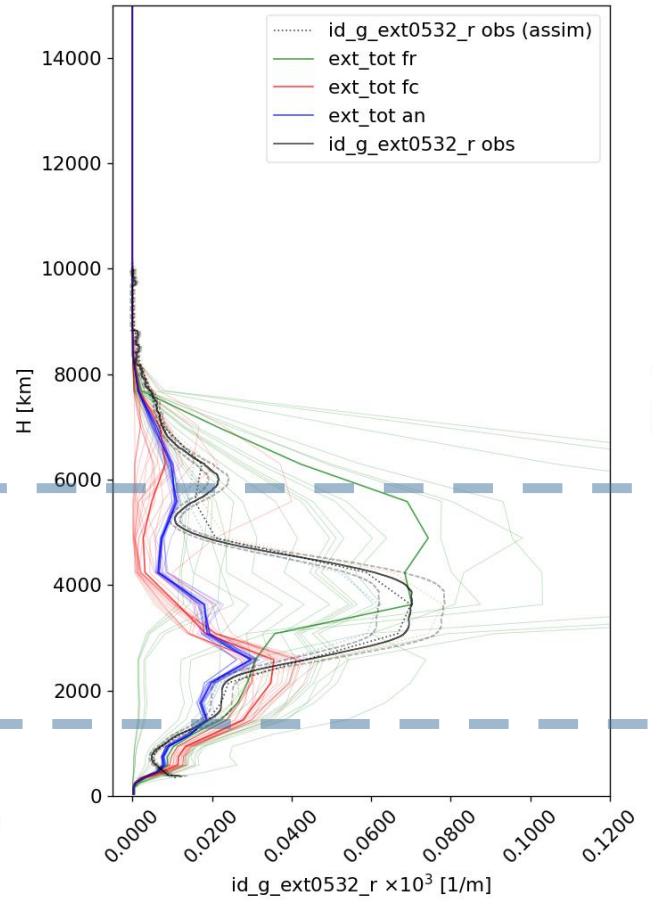
1 meteo, 1 dust scheme



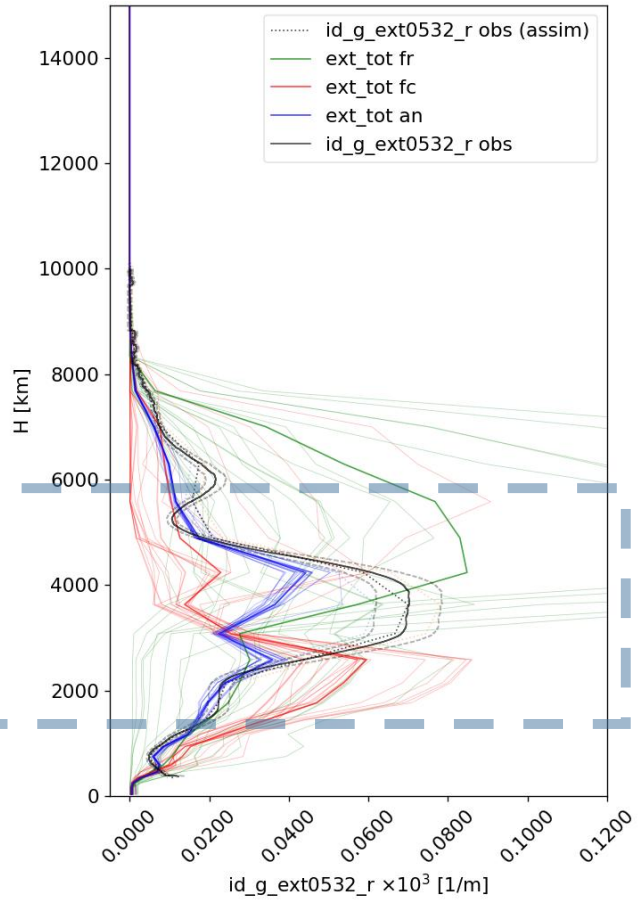
2 meteo, 1 dust scheme



1 meteo, **2 dust schemes**



2 meteo, 2 dust schemes



Extinction coefficient [km^{-1}]

Observation
No assimilation
Forecast run (1 day run from previous analysis)
Analysis

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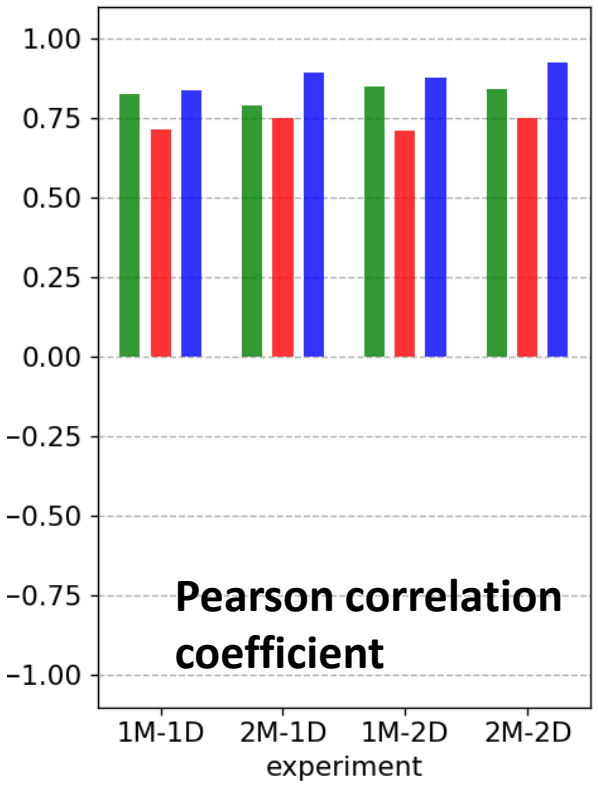
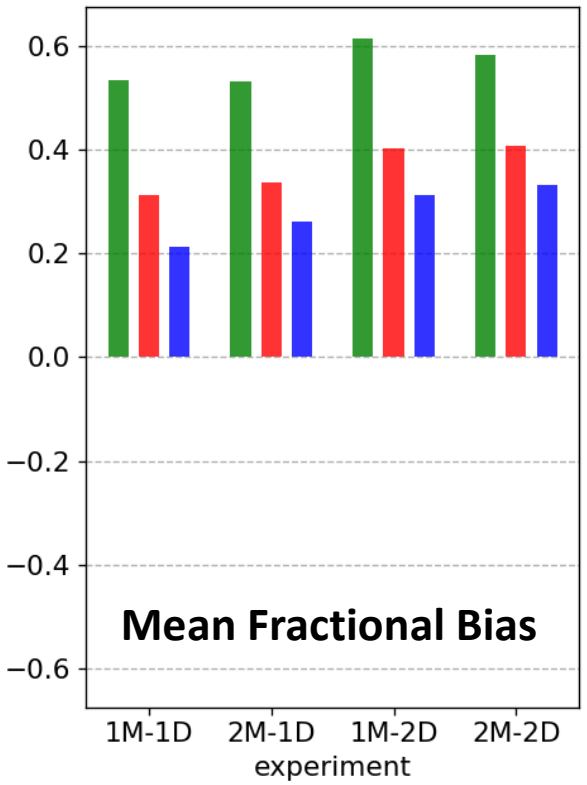
Limassol, 20/04/2017, 13UTC

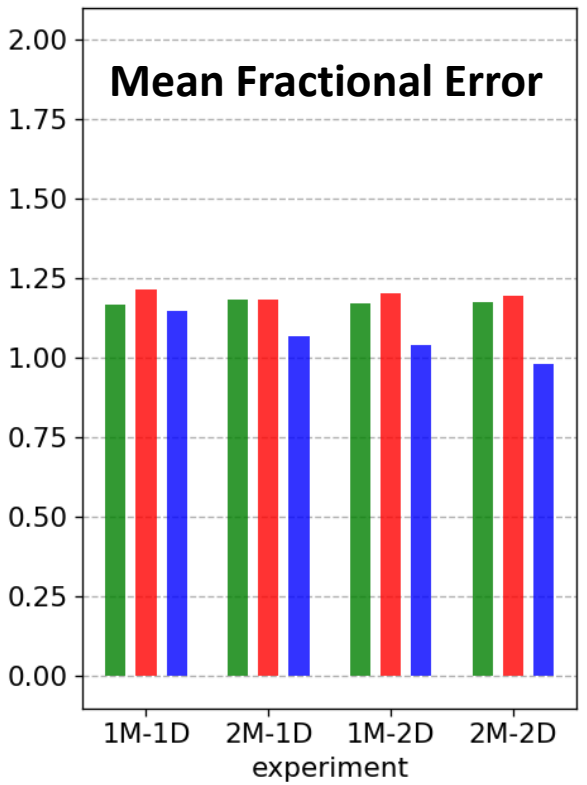
Profiles for the assimilated observations

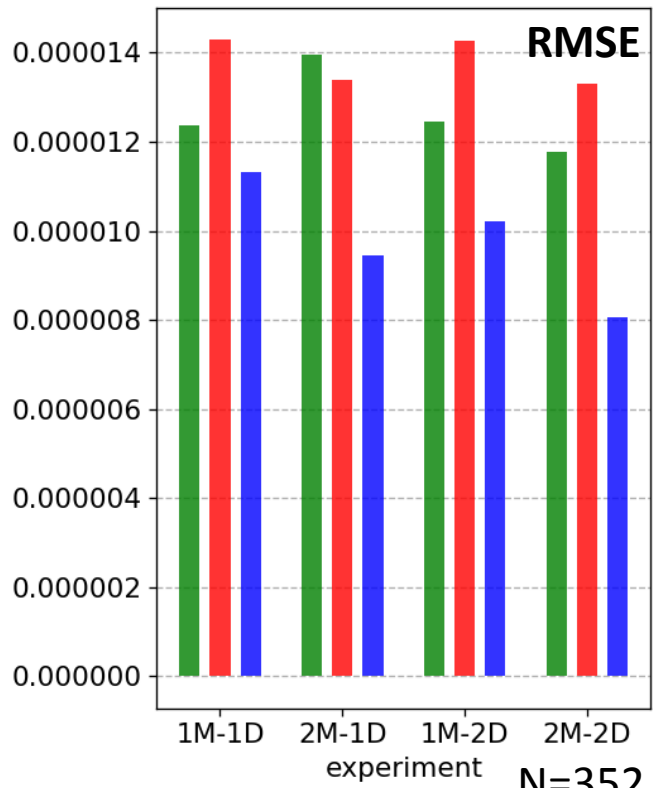
1 meteo, 1 dust scheme
***2 meteo**, 1 dust scheme*
1 meteo, ***2 dust schemes***
2 meteo, 2 dust schemes

No assimilation
Forecast run (1 day run from previous analysis)
Analysis





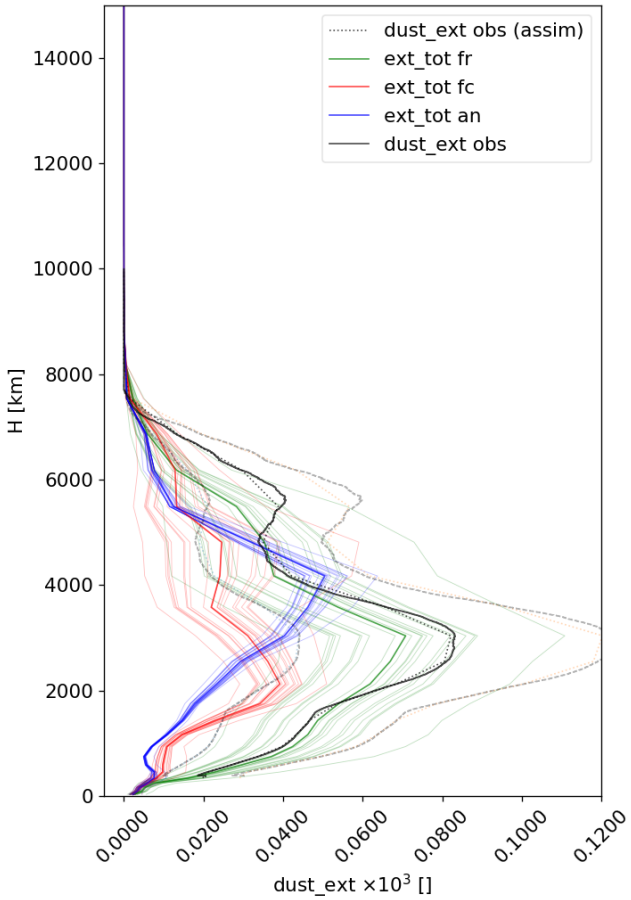




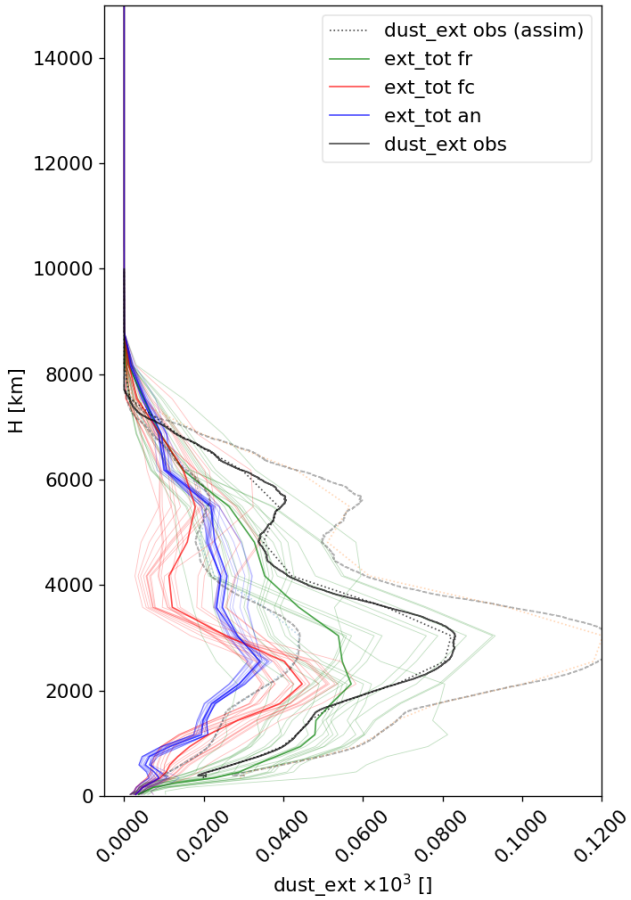
N=352

Profiles over Haifa (not assimilated)

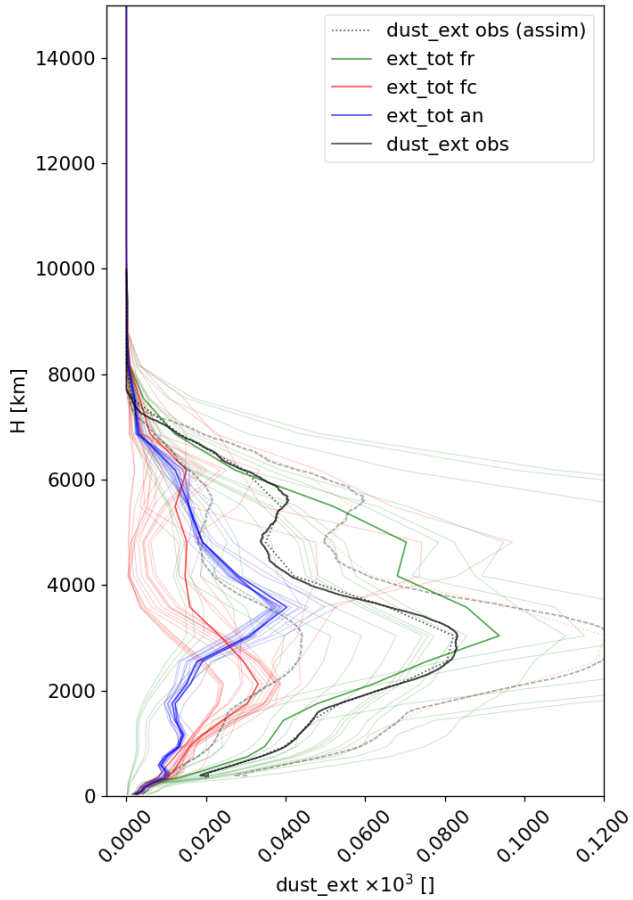
1 meteo, 1 dust scheme



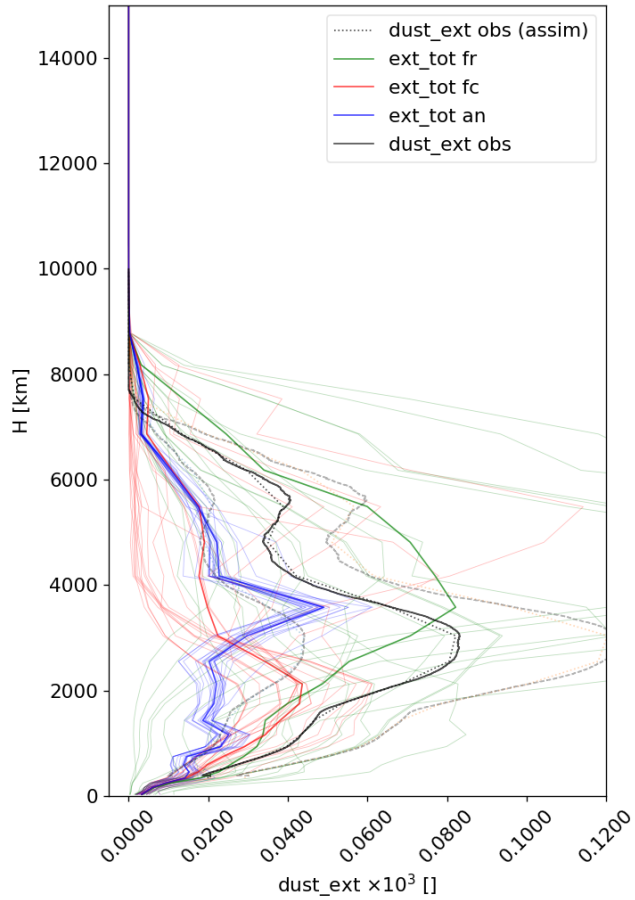
2 meteo, 1 dust scheme



1 meteo, **2 dust schemes**



2 meteo, 2 dust schemes



Extinction coefficient [km^{-1}]

Observation
No assimilation
Forecast run (1 day run from previous analysis)
Analysis

Haifa, 20/04/2017, 22UTC

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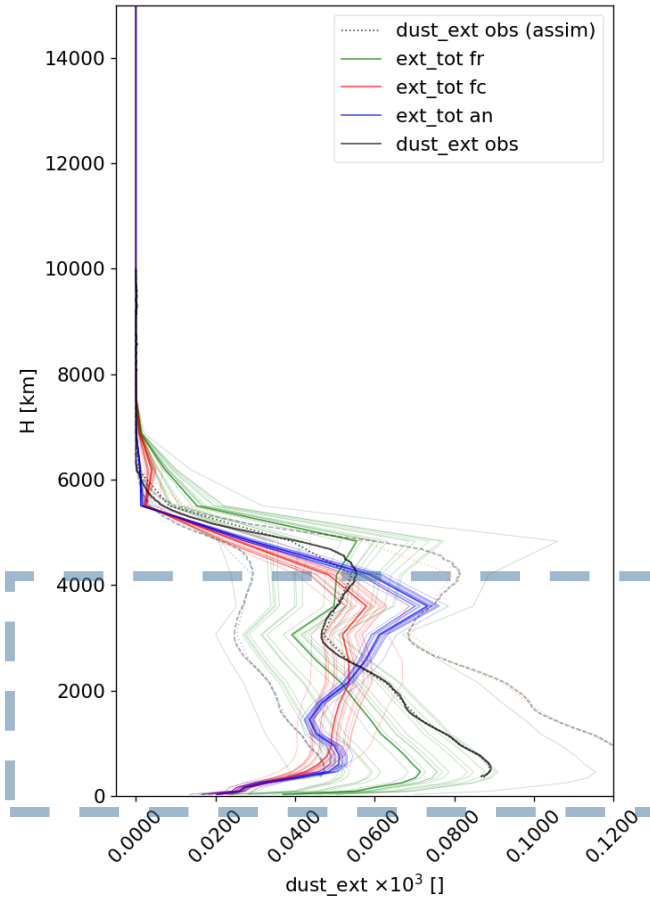
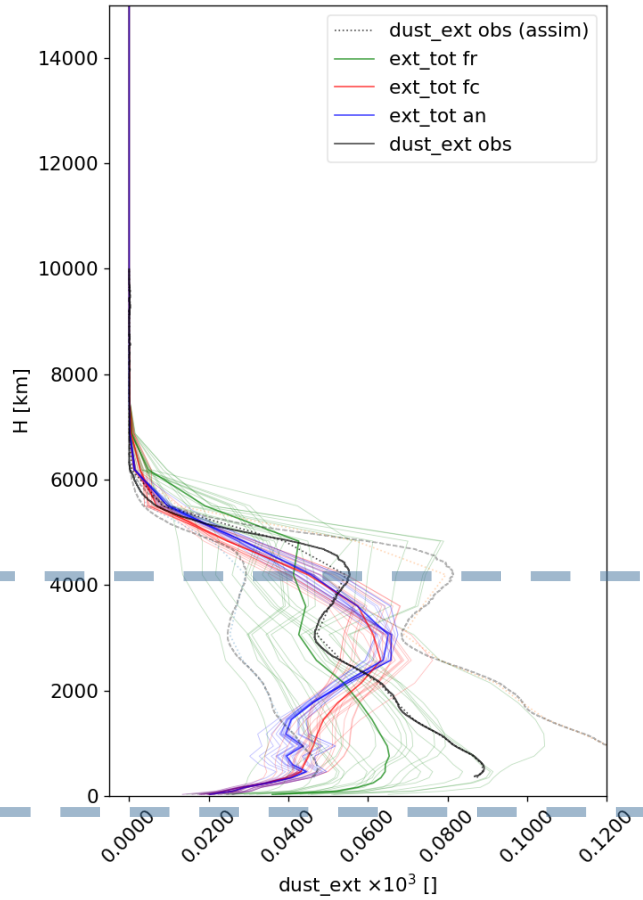
Profiles over Haifa (not assimilated)

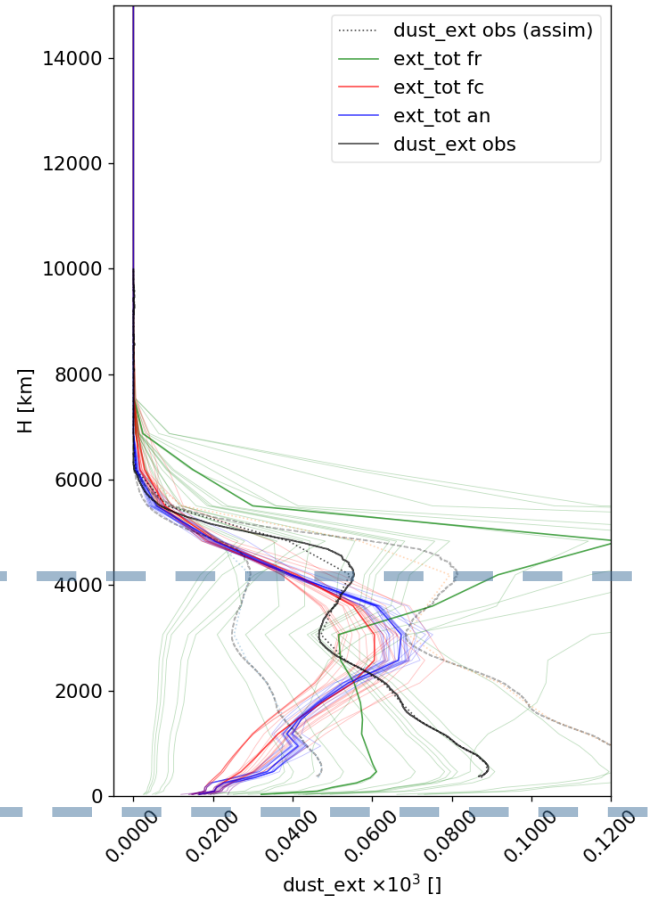
1 meteo, 1 dust scheme



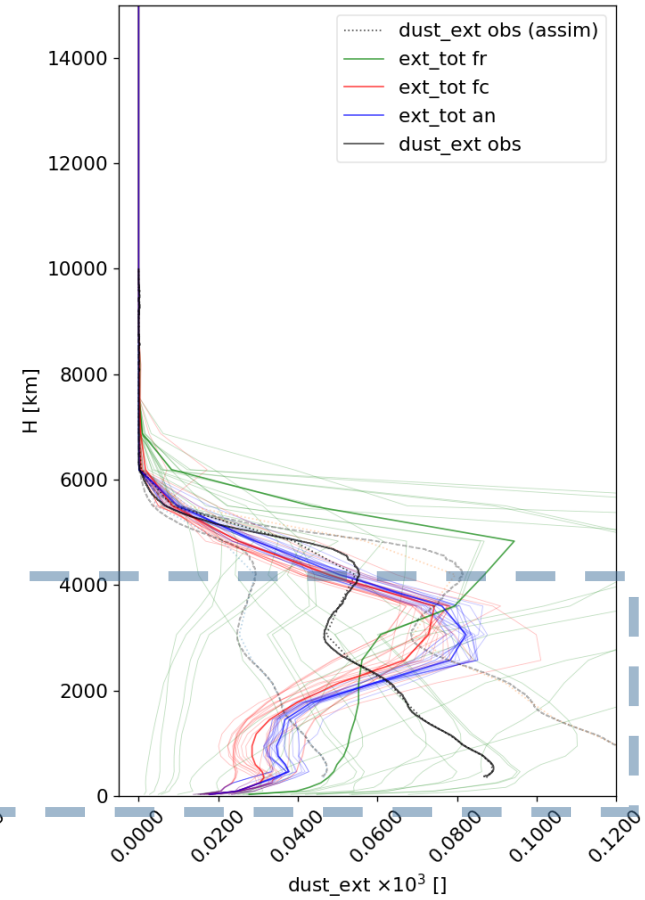
2 meteo, 1 dust scheme



1 meteo, **2 dust schemes**



2 meteo, 2 dust schemes



Extinction coefficient [km^{-1}]

Observation
No assimilation
Forecast run (1 day run from previous analysis)
Analysis

Haifa, 21/04/2017, 20:30UTC

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Profiles over Haifa (not assimilated)

1 meteo, 1 dust scheme

***2 meteo**, 1 dust scheme*

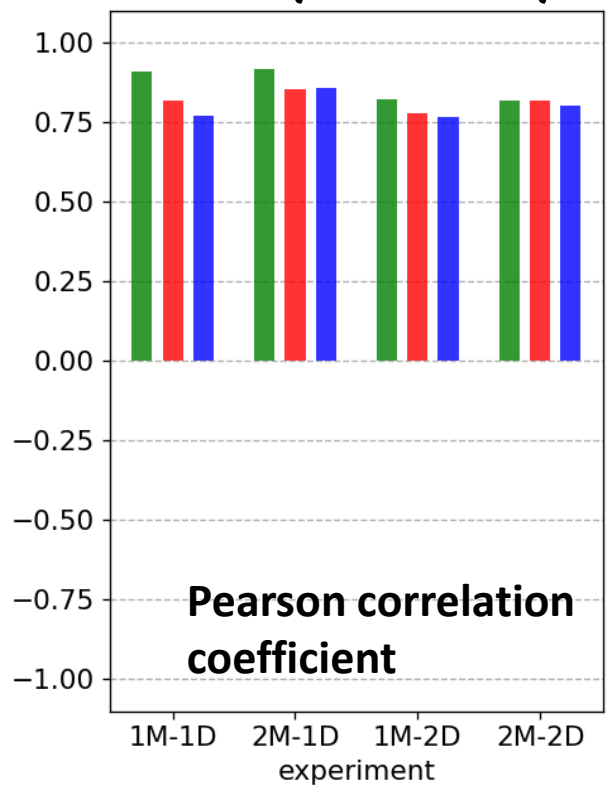
*1 meteo, **2 dust schemes***

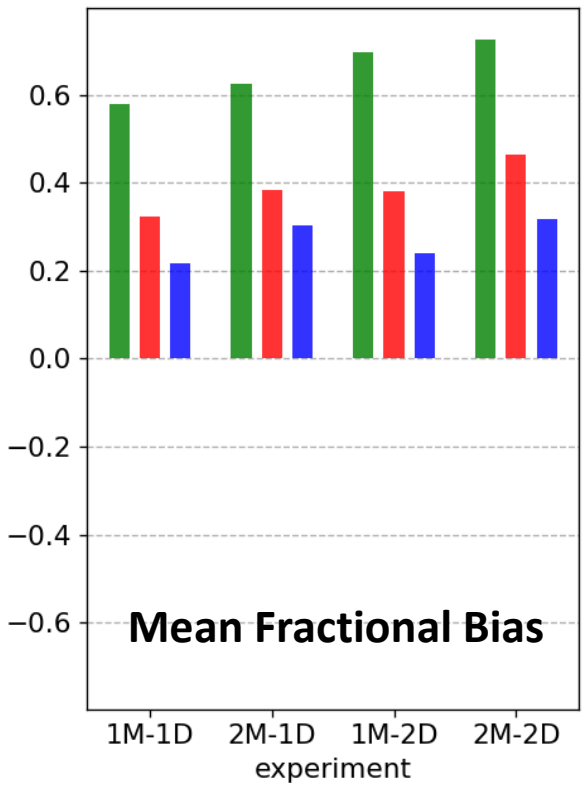
2 meteo, 2 dust schemes

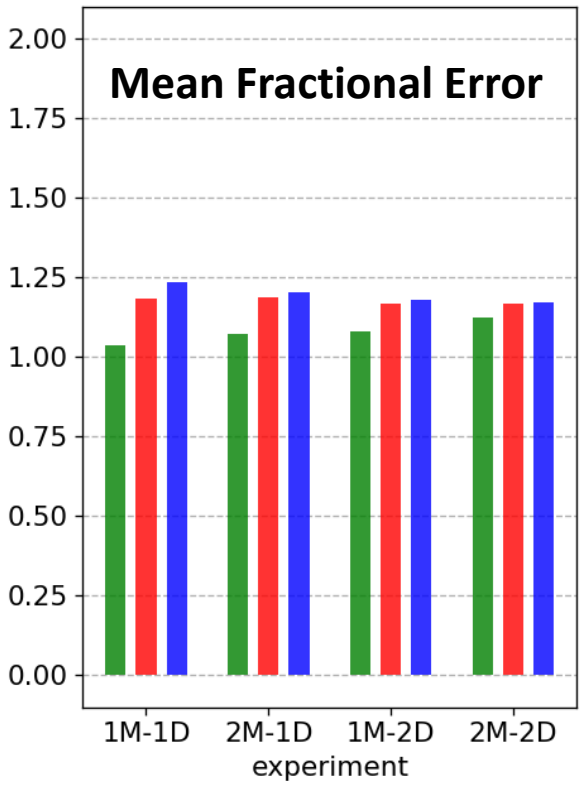
No assimilation

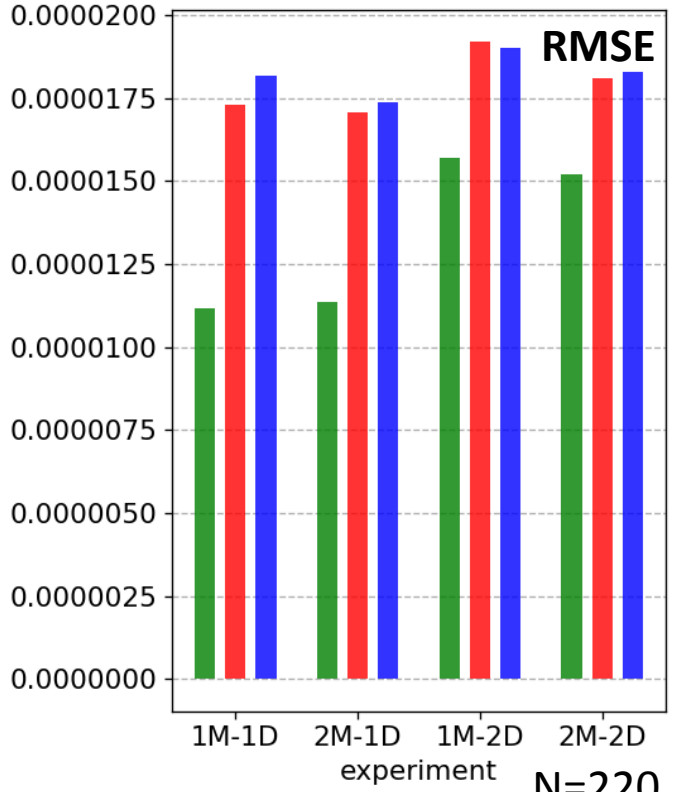
Forecast run (1 day run from previous analysis)

Analysis









N=220

Summary

- Multi-model and multi-emission schemes increase variability in the ensemble profile shape
  - Better description of profile prior uncertainties
- Multi-model and multi-emission schemes increase variability in spatio-temporal dust emissions
  - Better description of dust plume location and transport uncertainties
- Evaluation against a 3rd LIDAR not convincing
  - More work needed
    - Quality of ensemble
    - Observational errors and ensemble inflation (avoid overfitting)
    - More observations to assimilate and evaluate
- Forecast runs performs worse than non-assimilation case: to be investigated

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EXCELENCIA SEVERO OCHOA

Thank you

ACTRiS

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Ensemble-Based Data Assimilation at BSC

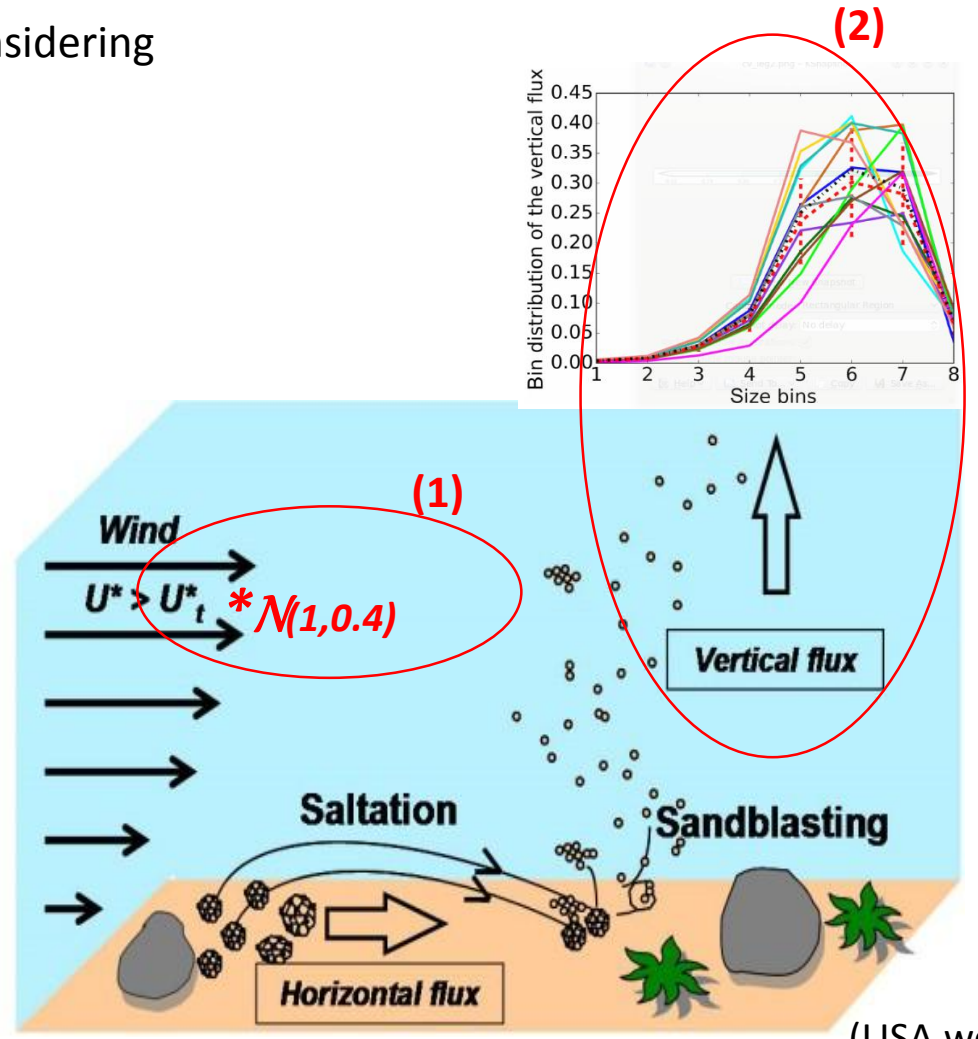
The ensemble forecast has been designed considering model uncertainties with respect to:

- **surface winds,**
- **soil humidity,**
- **vertical flux distribution at sources,**

by perturbing:

(1) the threshold friction velocity which is soil moisture-dependent, and determines the velocity above which the soil particles begin to move in horizontal saltation flux;

(2) the vertical flux of dust in each of the eight dust transport bins imposing some physical constraint (correlated multiplicative noise across the bins; unimodal distribution)**.**



(LISA website)

Uncalibrated attenuated backscatter (Limassol)