EarthCARE 2026 Science and Validation workshop

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Advances in dust optical modelling and EarthCARE dust data assimilation

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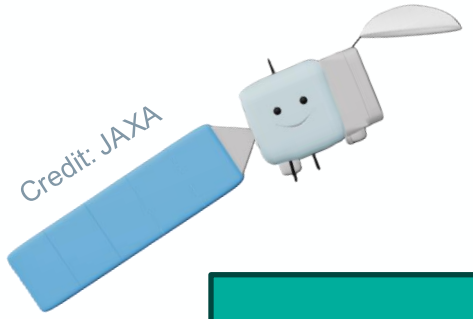
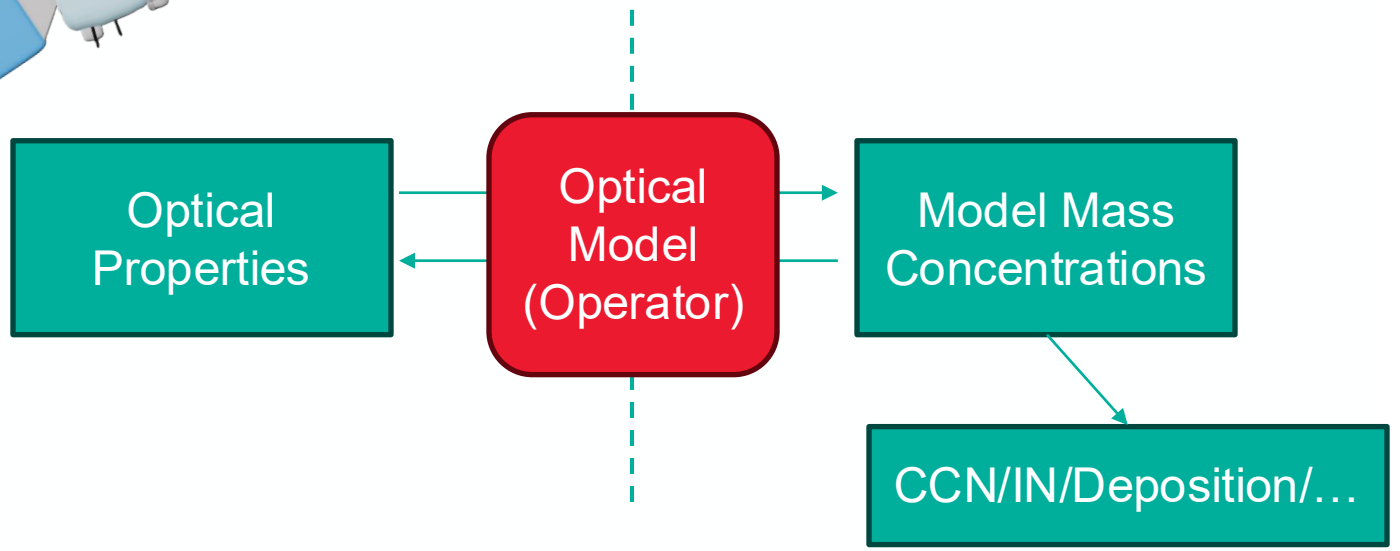
Optical models and data assimilation





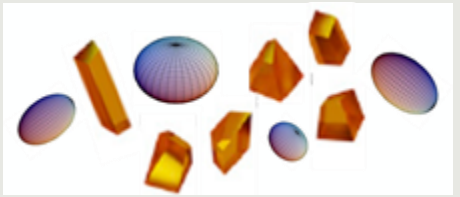
N	Model	Size [μm]	Emission [Tg yr^{-1}]	Load [Tg]	Deposition [Tg yr^{-1}]
1	CAM	0.1–10	4313	25.7	4359
2	GISS		1507	29.0	1488
3	GOCART	(bins)	3157	29.5	3178
4	SPRINTARS		3995	17.2	3984
5	MATCH		981	17.3	1070
6	MOZGN		2371	21.1	2368
7	UMI		1688	19.3	1691
8	ECMWF	0.03–20	514	6.8	750
9	LOA	(bins)	1276	13.7	1275
10	UIO_CTM	0.03–25 (bins)	1572	21.7	1571
11	LSCE		1158	20.3	1156
12	ECHAM5-HAM	modes	664	8.2	676
13	MIRAGE		2066	22.0	2048
14	TM5		1683	9.3	1682
15	AEROCOM_MEDIAN	–	1123	15.8	1257

AEROCOM Dust Intercomparison (N. Huneeus et al. 2011)

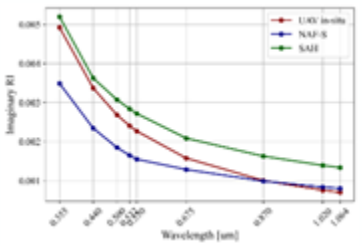
New dust properties to reproduce spectral lidar data

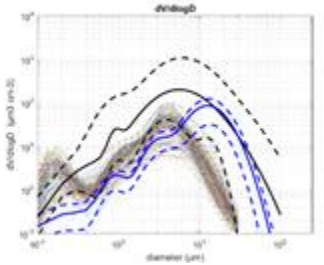
Random non-realistic shape ensembles

Spheroids & Irregular hexahedral mixtures



Dust climatology



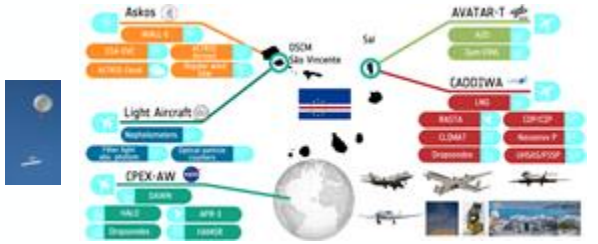


Simulated lidar related properties (S_p, d_p)

ASKOS lidar observations (S_p, d_p)

Gialitaki et. al., in preperation

CERTAINTY
CLOUD–AEROSOL INTERACTIONS & THEIR IMPACTS IN THE EARTH SYSTEM



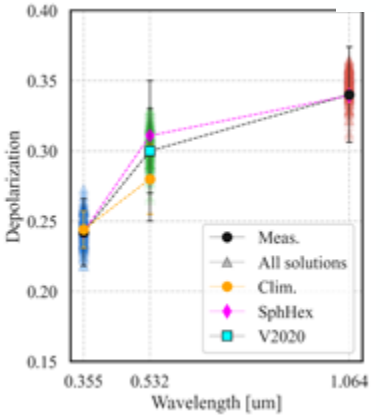
ASKOS

(See also Marinou et al., 2023)

Source: ESA

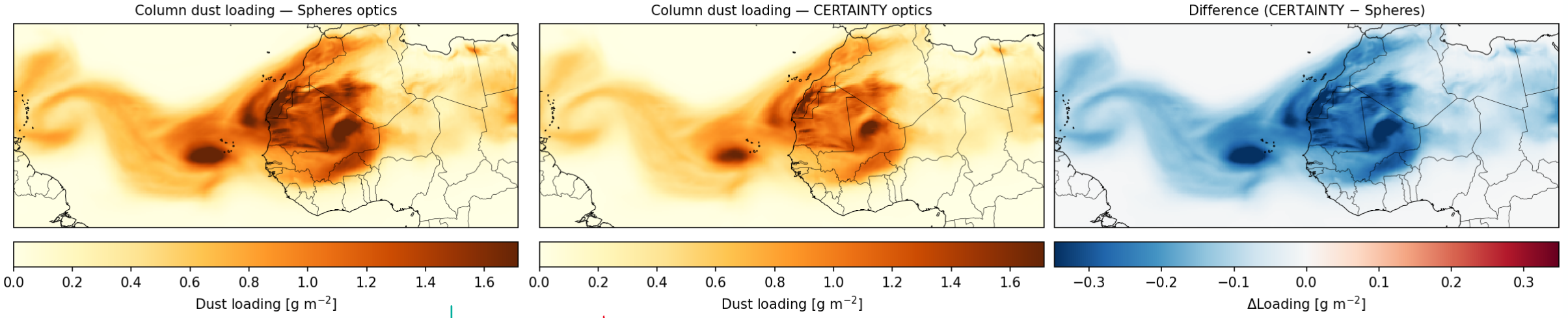
Location: Cabo Verde
Period: Sep. 2021, Jun., Sep. 2022
Dataset: https://evdc.esa.int/publications/

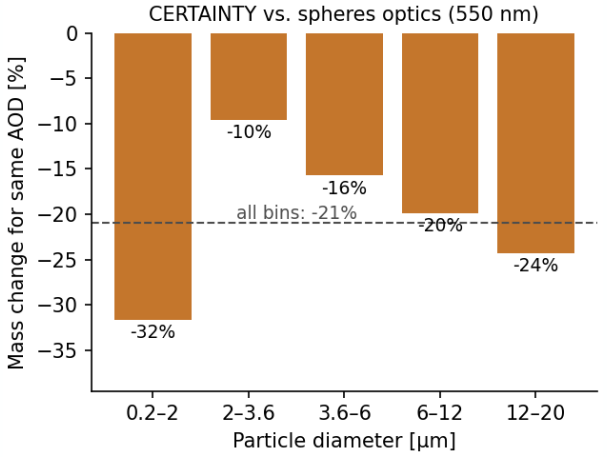
Results

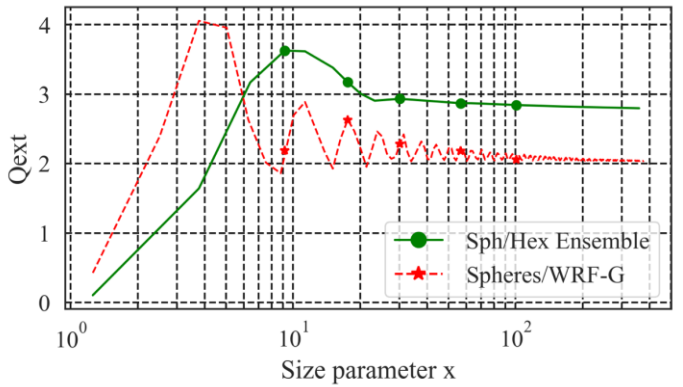


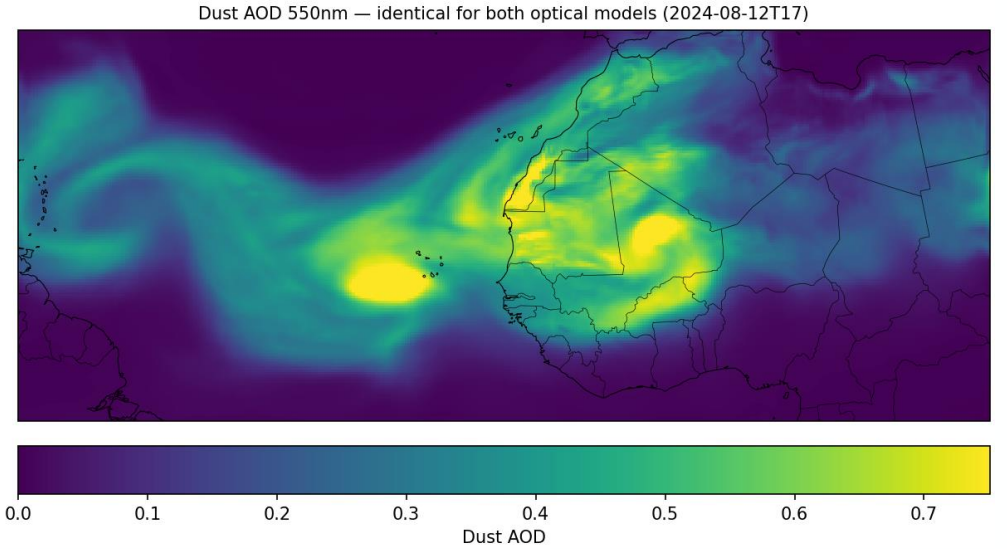
Successfully reproduces 3+3+3 lidar observations

-21% dust mass needed for same optical depth with the new model





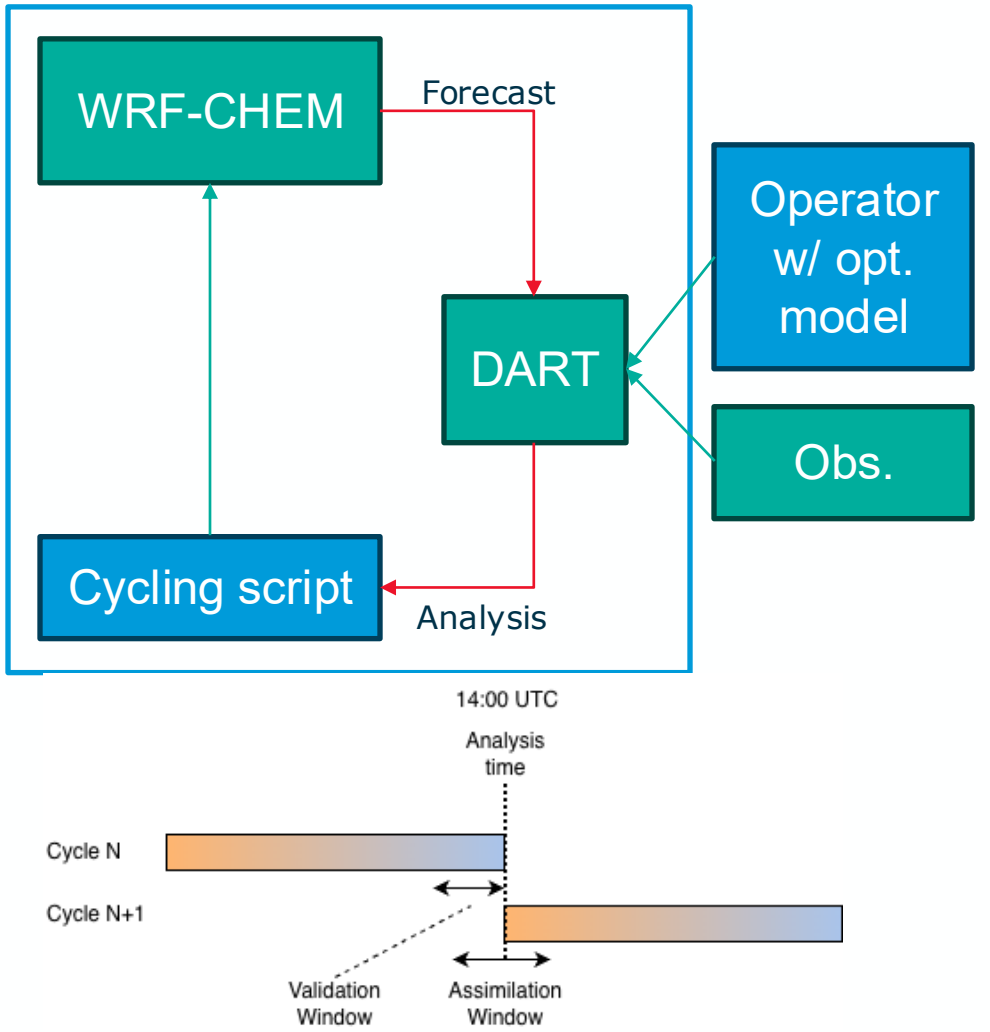




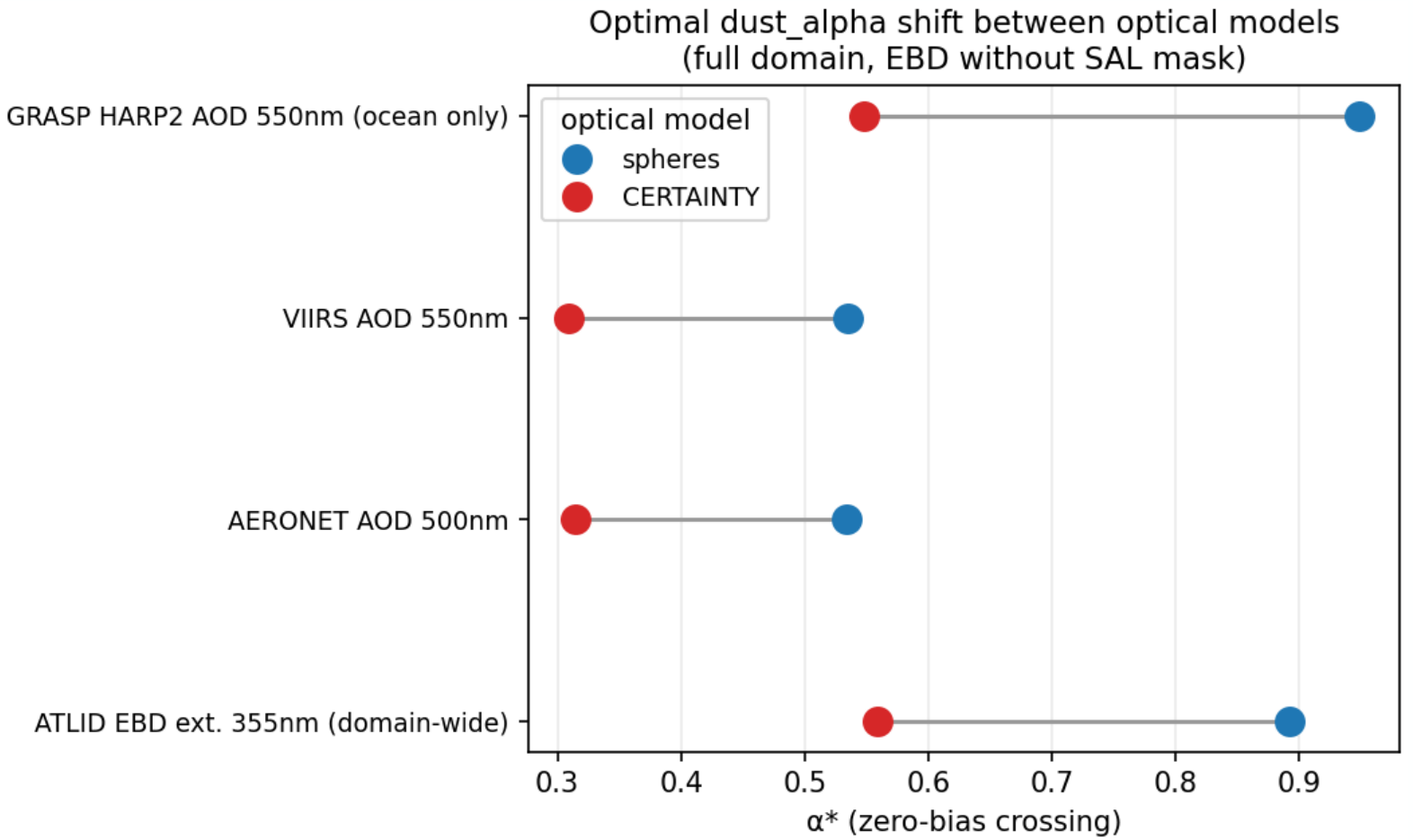
Testing in an assimilation system

- **WRF-CHEM v4.7.1**
  - Morrison two-moment microphysics
  - Dust-aware IN/CCN
  - GOCART Aerosols (Desert dust and sea salt only)
  - 27km horizontal resolution
- **NCAR DART**
  - Ensemble Adjustment Kalman Filter (EAKF)
  - 30 member ensembles, initialised by the IFS Ensemble forecasts
  - Dust field initialised by the CAMS Global Atm. Composition forecasts
  - Spatial emission perturbations
- **Observations**
  - EarthCARE ATLID EBD, Baseline BA
  - Verification: VIIRS Deep Blue AOD, AERONET, GRASP HARP2 AOD retrieval

Cycling Assimilation System



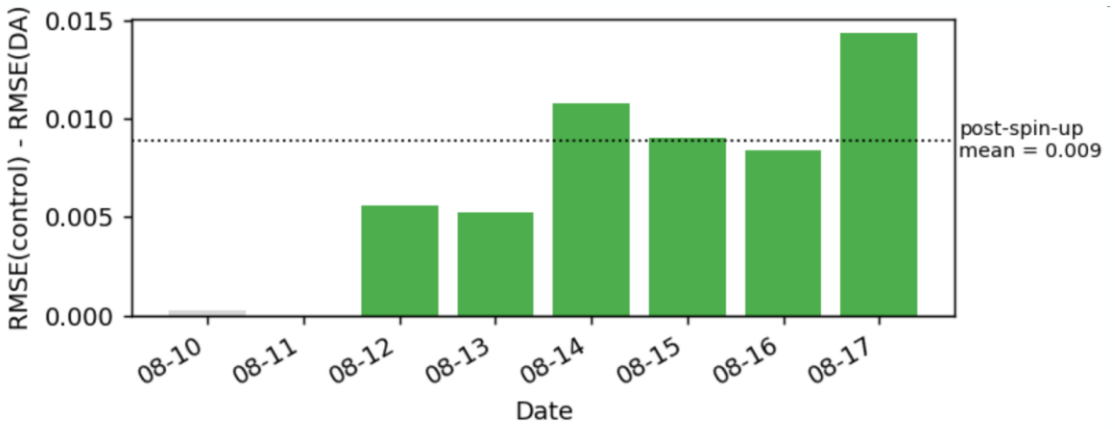
What is the right prior? Depends on your optical model



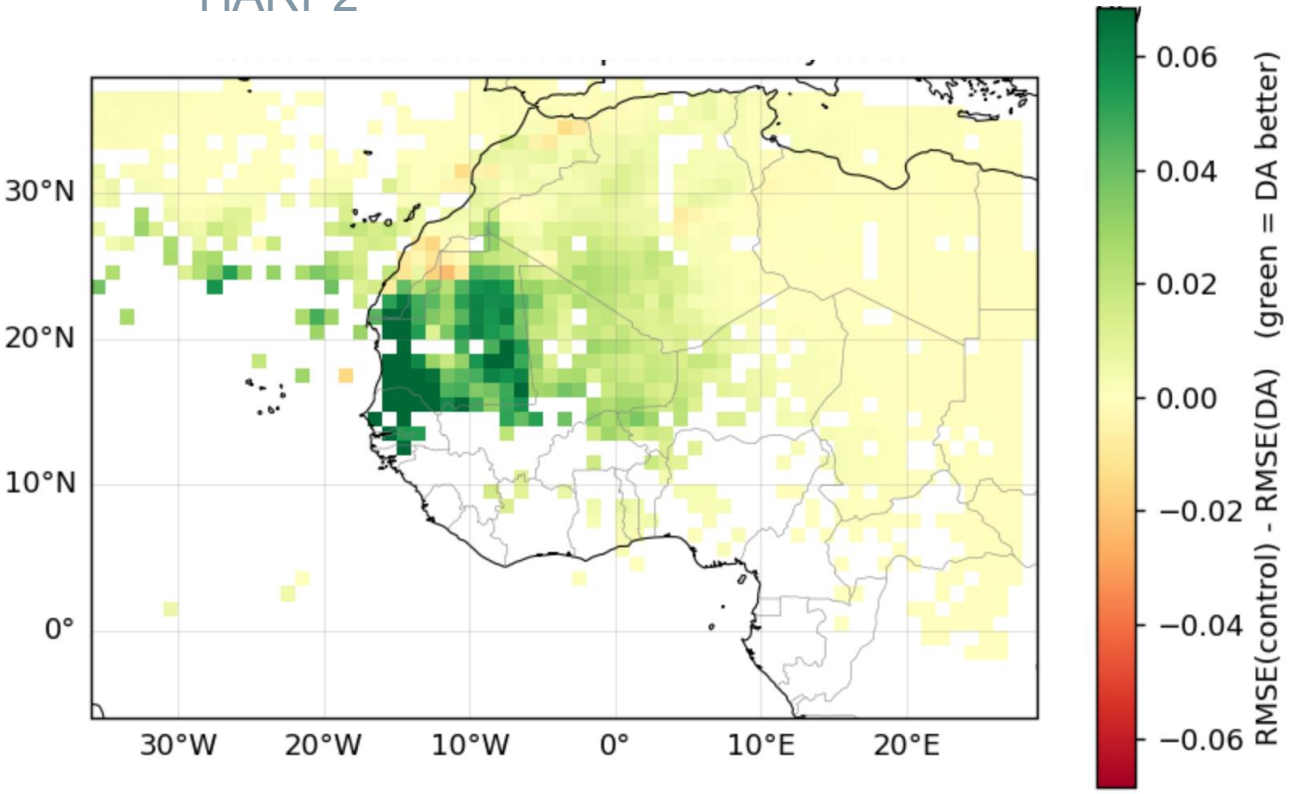
Changing the optical model means you must also reduce your emissions by ~42%

Different emissions for different regimes (PACE HARP2 DA)

Assimilating a GRASP-retrieved Coarse-mode AOD from PACE HARP2 reduces the next day's forecast RMSE agaisnt HARP2



Coarse Mode AOD



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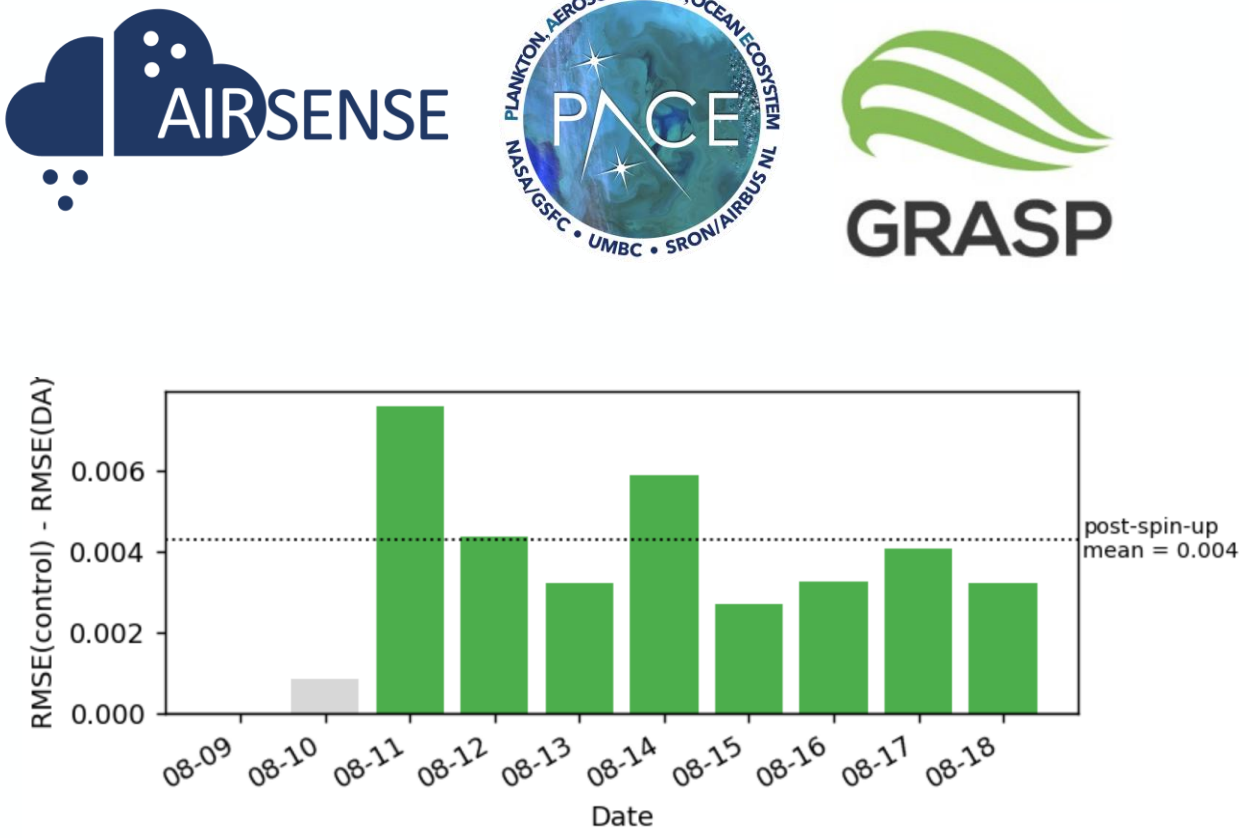
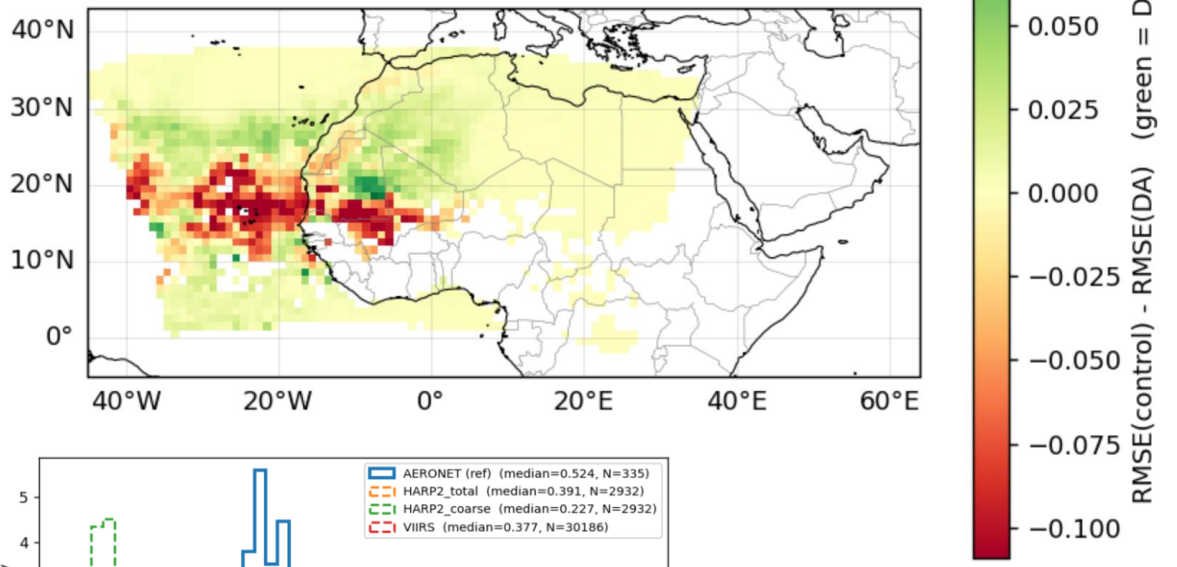
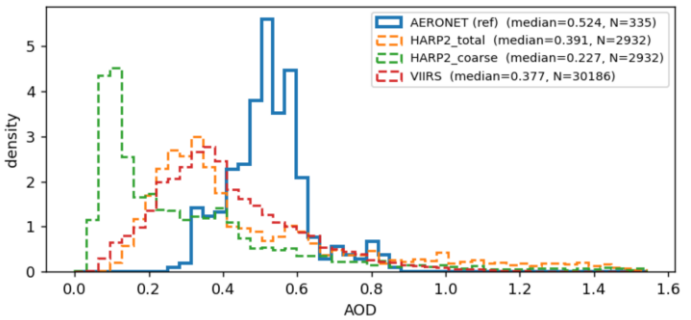


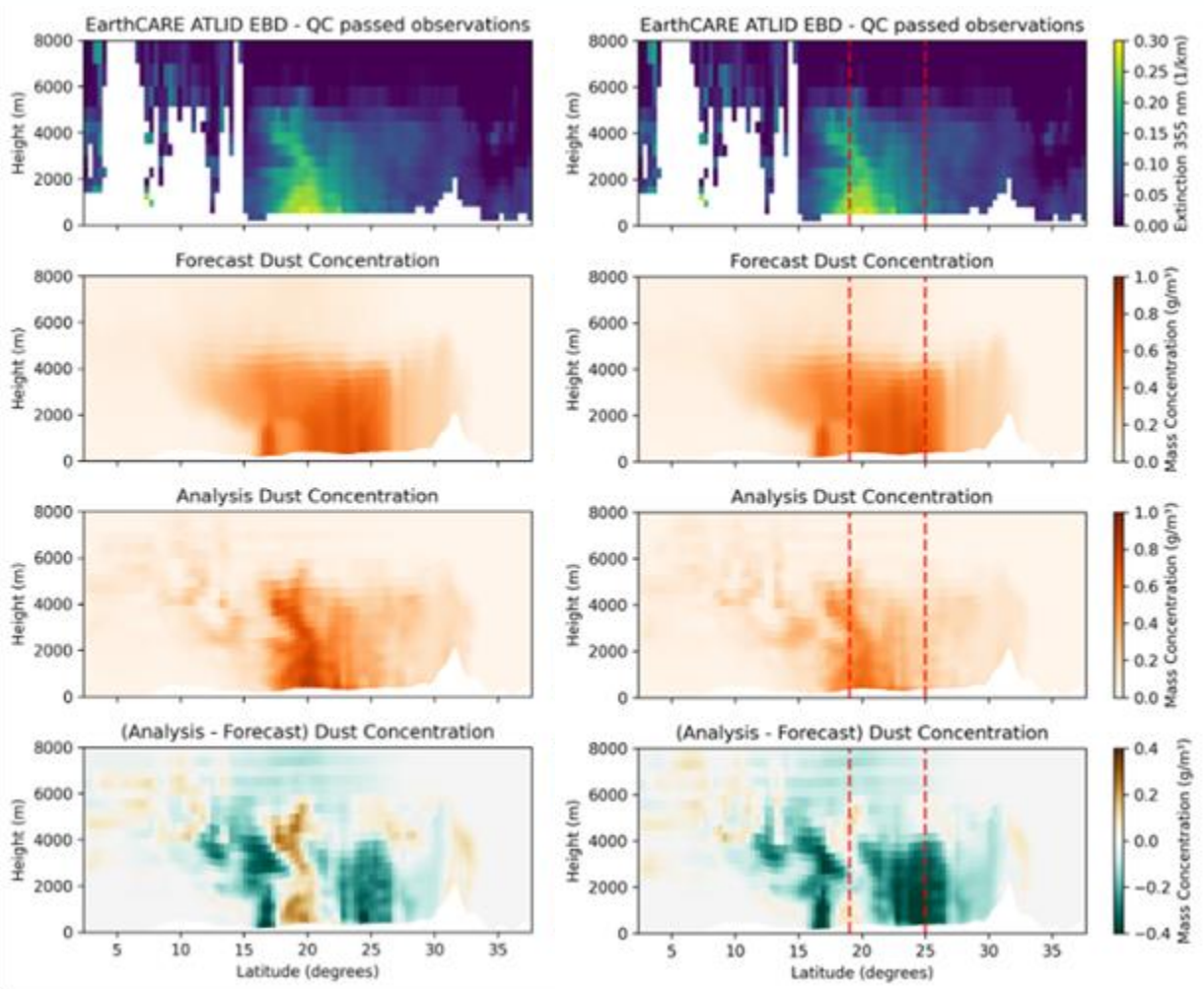
Total AOD

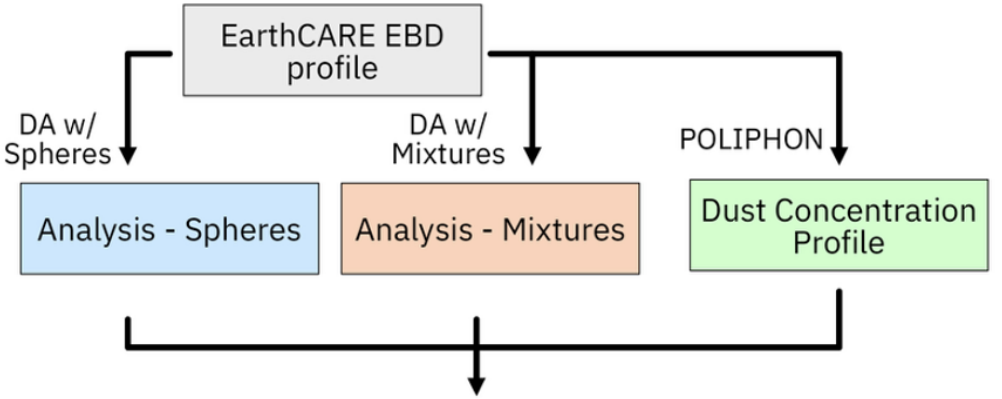
But comparing the next day's forecast with VIIRS Deep Blue AOD shows improvement in some areas and degredation in others





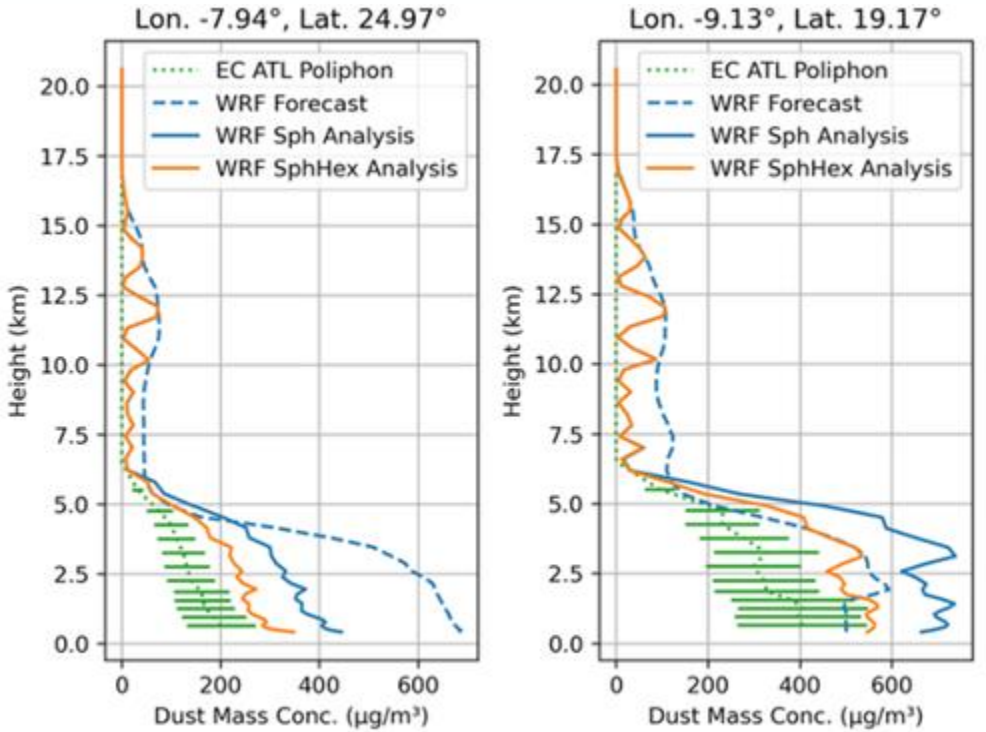
Overpass assimilation example

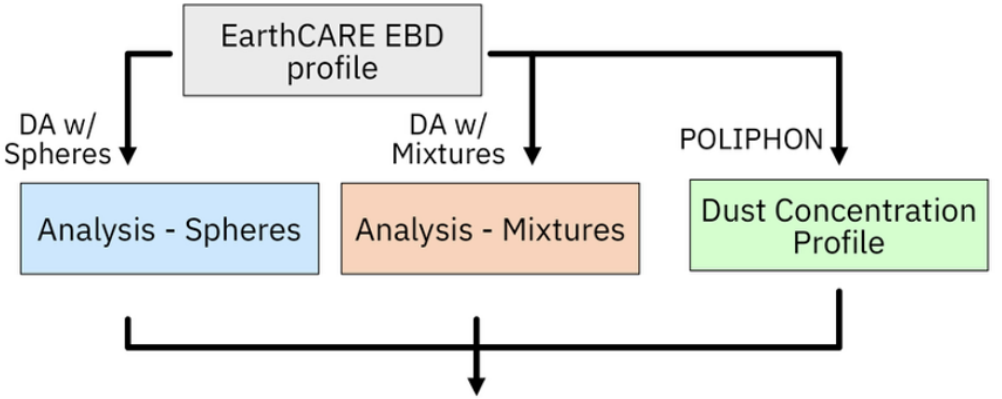




Assimilating the EarthCARE Extinction profile seems to bring the mass concentrations closer to what the POLIPHON method estimates.

Overpass assimilation example





Assimilating the EarthCARE Extinction profile seems to bring the mass concentrations closer to what the POLIPHON method estimates.

Next steps

- New dust mass means new aerosol direct/indirect effects
    - Radiative closures (BBR) and IN concentrations as indirect valdation
- Quantify the 3D improvement of lidar assimilation on the dust field
- Deal with different bias regimes over the ocean (transport) and the desert (emissions)
- Extend the operators to assimilate EarthCARE Lidar Depolarization and lidar ratio within DISC

Thank you!

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