International Cooperative for Aerosol Prediction

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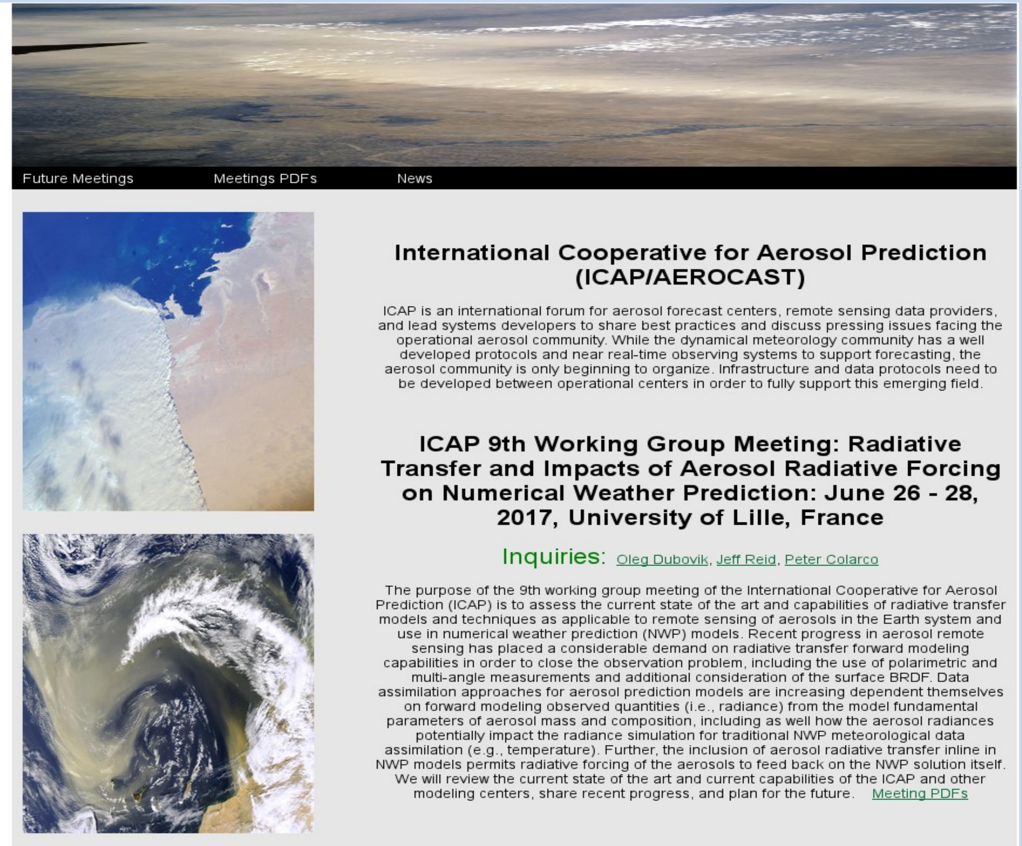
International Cooperative for Aerosol Prediction (ICAP)



http://icap.atmos.und.edu/

- ICAP is an unfunded, international forum for aerosol forecast centres, remote sensing data providers, and lead systems developers to coordinate efforts and share best practices.

- ICAP organizes yearly meetings to discuss pressing issues facing the operational aerosol community.

- It also coordinates the first global multi-model Ensemble for aerosol forecasts (described in Sessions et al 2015, ACP)

- ICAP centres depend on satellite and ground-based data for assimilation and verification of the forecast models.

ICAP meetings

Radiative Transfer and Impacts of Aerosol Radiative Forcing on Numerical Weather Prediction:
June 26 - 28, 2017, University of Lille, France

Lidar Data and its use in Model Verification and Data Assimilation: July 12-14, 2016, College Park, MD, USA

Assimilation: June 16-19, 2015, Barcelona, Spain

Validation: October 21-24, 2014 Boulder, CO

Recent Progress in Aerosol Observability for Global Modeling: November 5 – 8, 2013 Tsukuba, Japan

Aerosol Emission and Removal Processes: May 14 – 17, 2012, ESA/ESRIN, Frascati, Italy

Ensemble Forecasts and Data Assimilation: 11 - 13 May, 2011 Boulder, CO

Model Verification: 30 September-1 October, 2010 Oxford England (Joint with 9th AEROCOM Workshop)

Aerosol Observability: 27-29 April, 2010 Monterey CA

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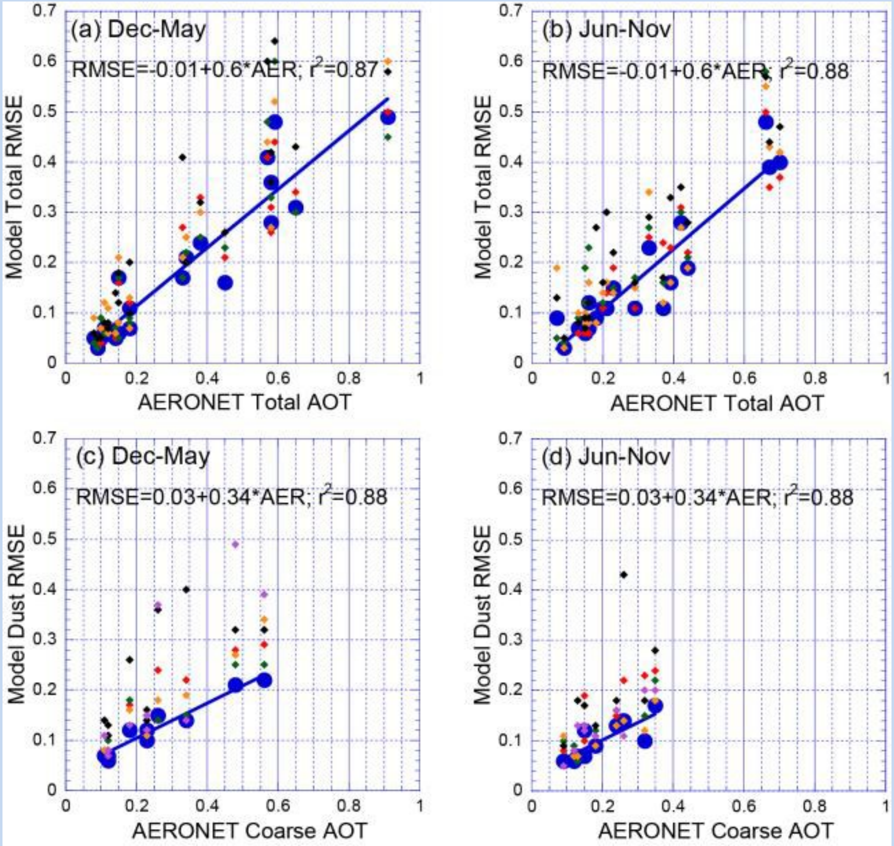
ICAP MME

- Participating members are: BSC, Copernicus/ECMWF, US Navy/FNMOC, NASA/GMAO, JMA, NCEP, UKMO, and MeteoFrance (FMI to join soon)
- Aerosol Optical Thickness consensus of deterministic models from 8 centers out to 5 days
- New parameters in future, including surface concentrations
- It helps to identify problem areas for aerosol modeling.
- Ensemble is the top performer (Sessions et al 2015)
- Provides reliable forecast guidance and serves as a research/reference dataset (e.g. TIGGE NWP)
- Public website with ensemble aerosol charts: https://www.nrlmry.navy.mil/aerosol/
- Maintained by NRL, Monterey (credits: Peng Xian)

ICAP Multi-Model Ensemble products

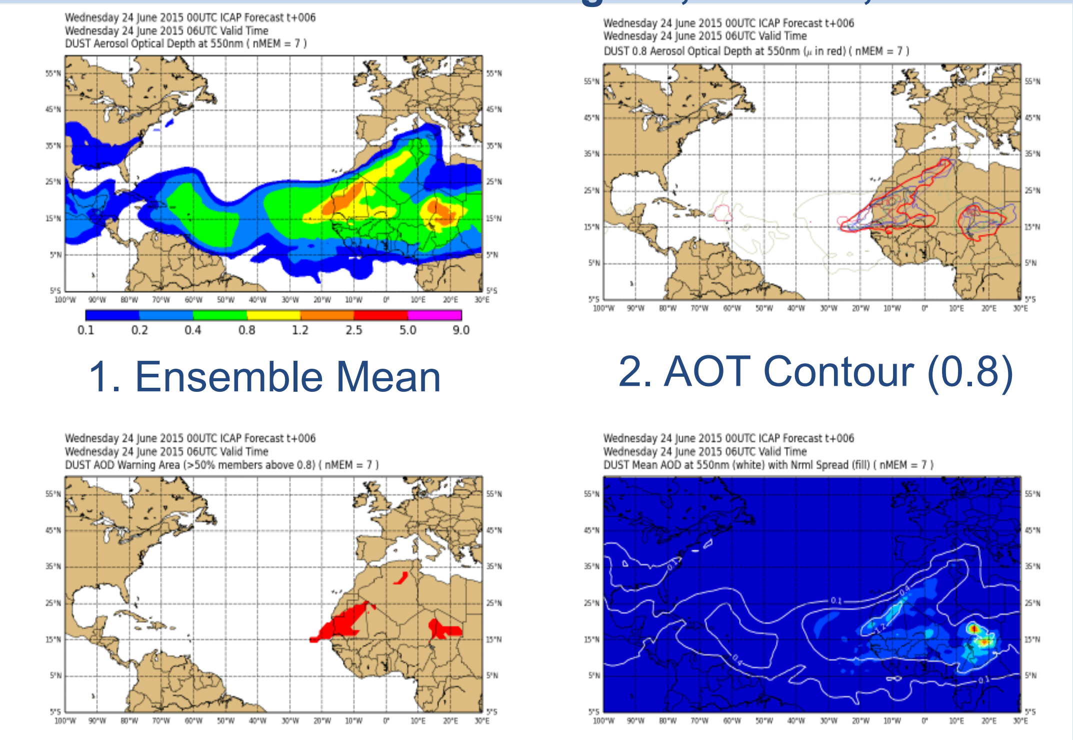
Plots are publicly available at:
https://www.nrlmry.navy.mil/aerosol/

- First MME for global aerosol prediction
- Probabilistic products with independence among ensemble members
- Ensemble mean is the top performer (large blue dots)



Sessions et al. 2015

African Dust reaching DC, June 23, 2015



1. Ensemble Mean

2. AOT Contour (0.8)

3. Dust Warning Product

4. Normalized Ensemble Standard Deviation

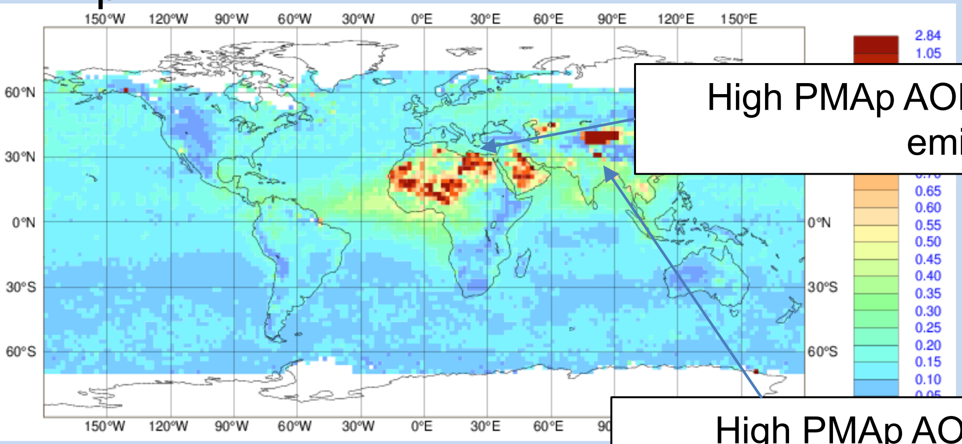
Credits: Peng Xian (NRL)

Challenges with multi-sensor satellite AOD data: an example from the assimilation of PMAP in the CAMS model

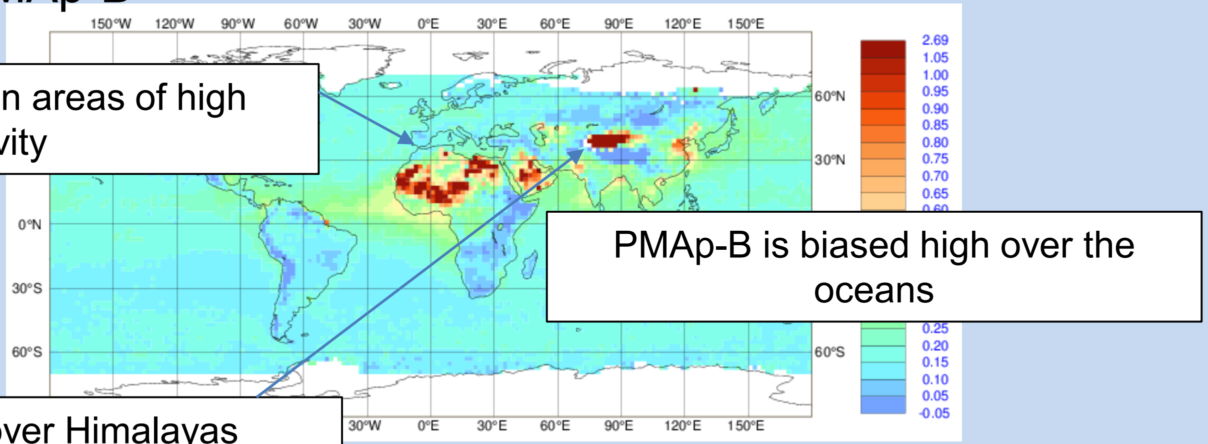
PMAp = Polar Multi-sensor Aerosol product (provided by EUMETSAT)
CAMS = Copernicus Atmosphere Monitoring Service

Mean AOD (1/02/2015-31/05/2015)

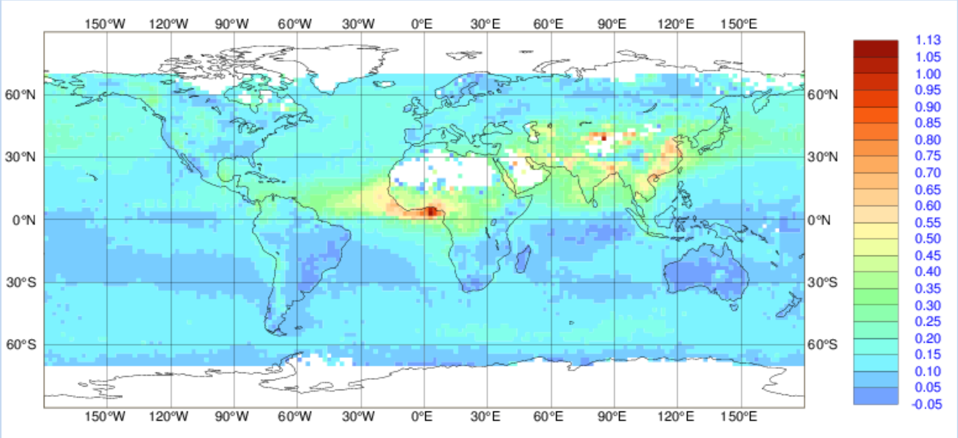
PMAp-A



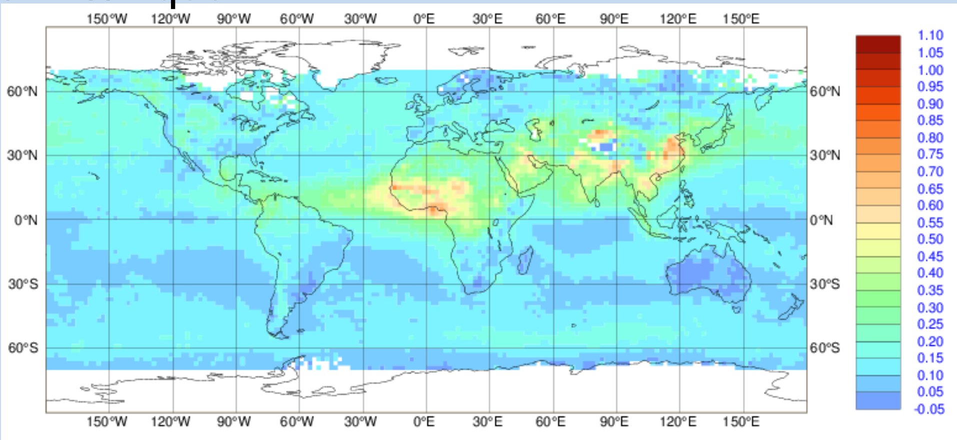
PMAp-B



MODIS/Terra



MODIS/Aqua



Results shown for PMAp V2.1 test data (1/2/2015-31/5/2015)

Credits: Melanie Ades

Assimilation test of global PMAp AOD

MODIS only   MODIS + PMAp

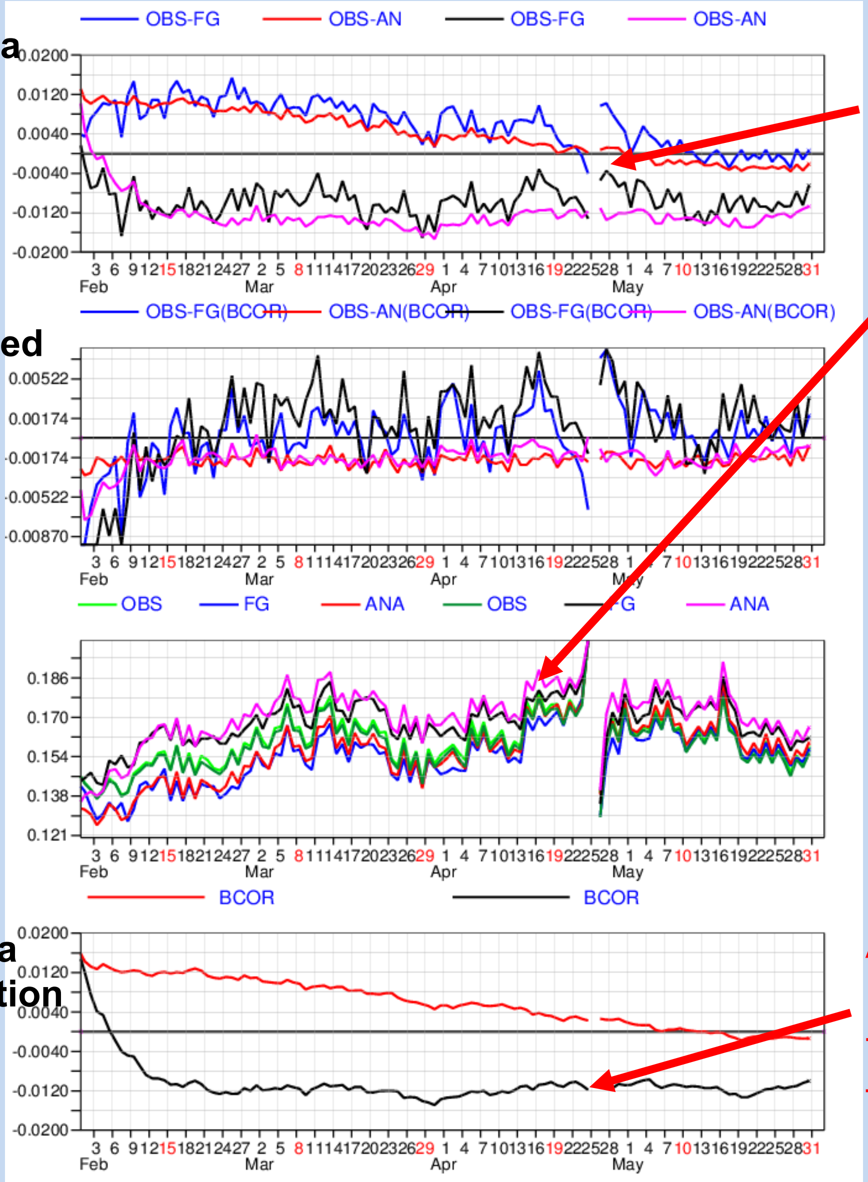
MODIS only + **BIAS CORRECTED** PMAp

MODIS/Aqua departures

Bias corrected Departures

AOD values

MODIS/Aqua Bias correction

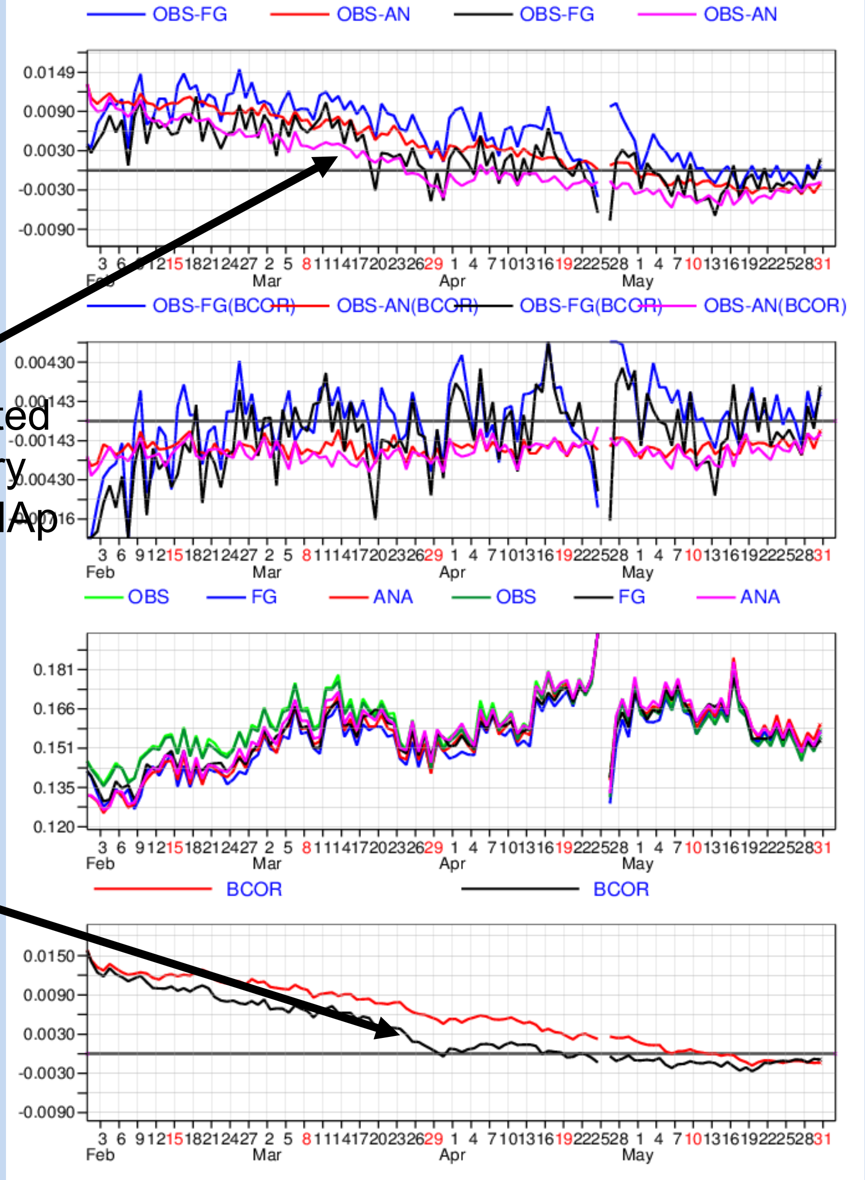


If PMAp is not bias corrected then the CAMS model is higher than the MODIS observations when PMAP is assimilated

A much larger and negative bias correction is applied to the MODIS data to account for this mismatch

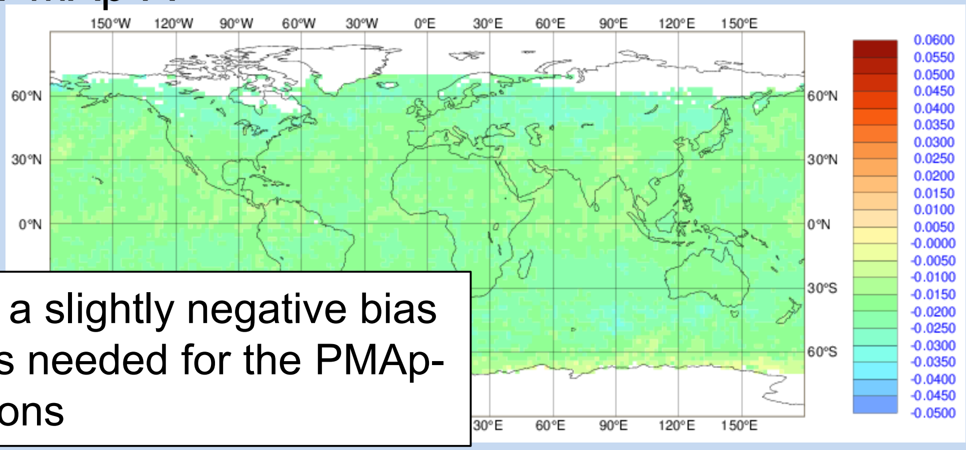
When PMAp is bias corrected then the departures are very similar with and without PMAp

The MODIS bias correction is now actually reduced when using the PMAp data

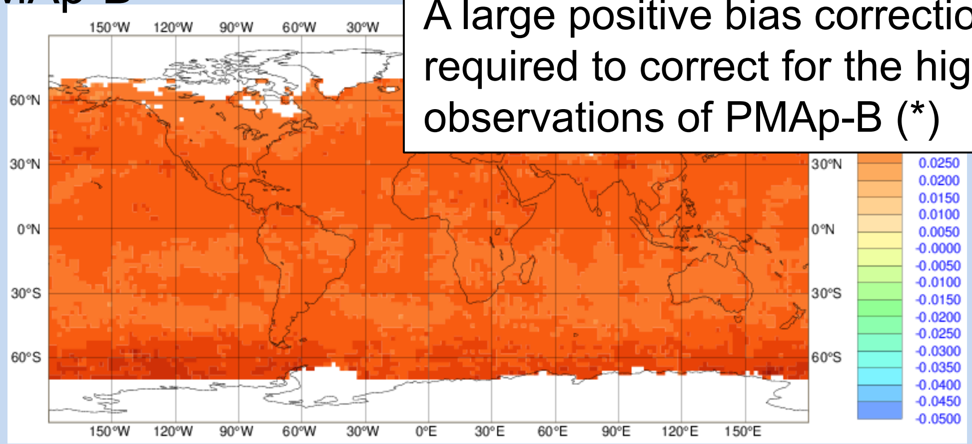


Bias correction fields from CAMS run

PMAp-A



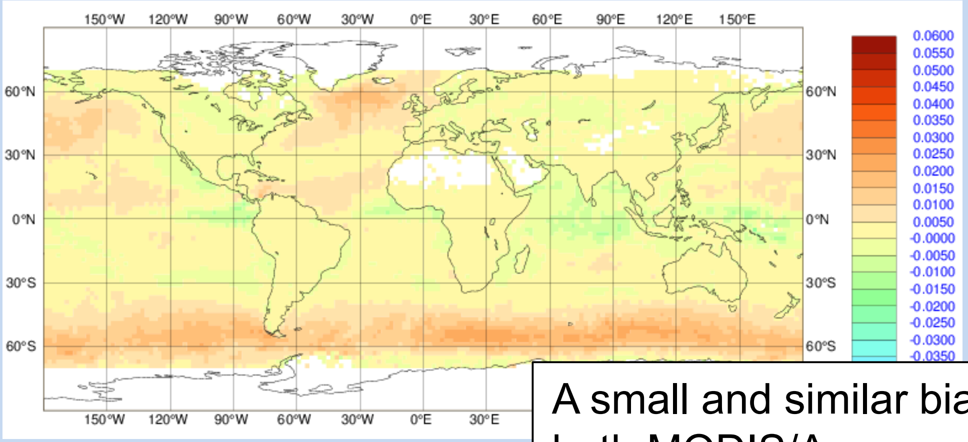
PMAp-B



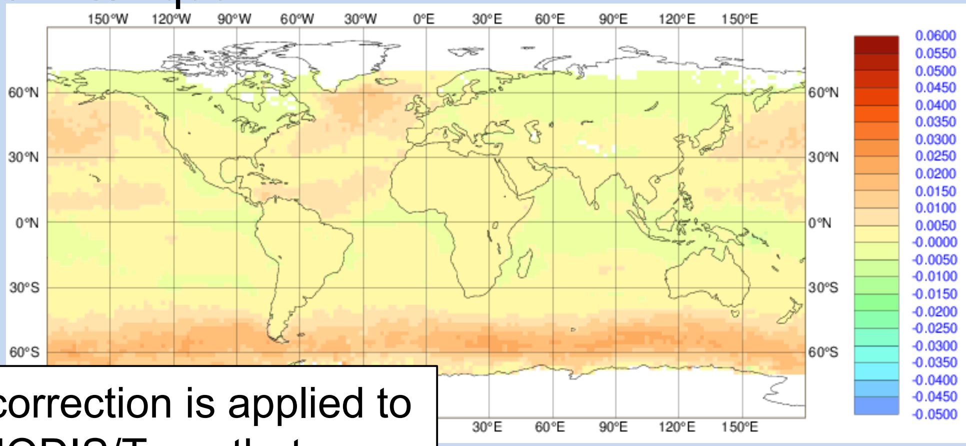
A large positive bias correction is required to correct for the high observations of PMAp-B (*)

In contrast, a slightly negative bias correction is needed for the PMAp-A observations

MODIS/Terra



MODIS/Aqua

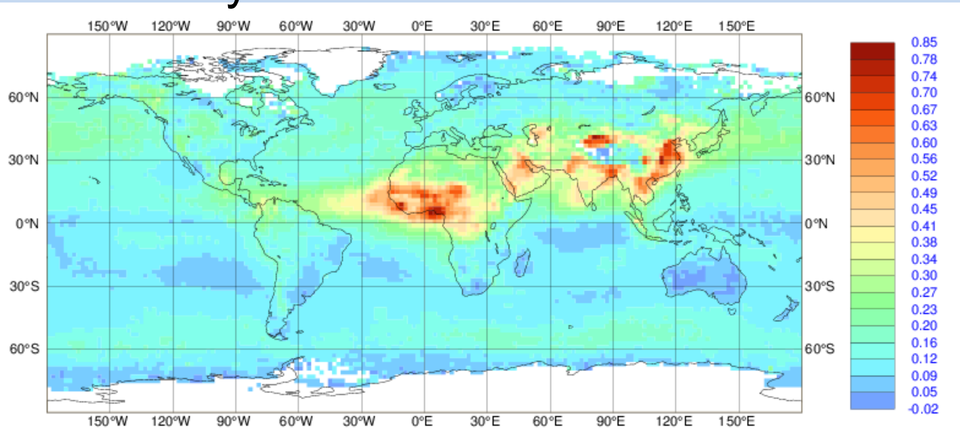


A small and similar bias correction is applied to both MODIS/Aqua and MODIS/Terra that accounts for the known difficulties with collection 5 data over the Southern ocean

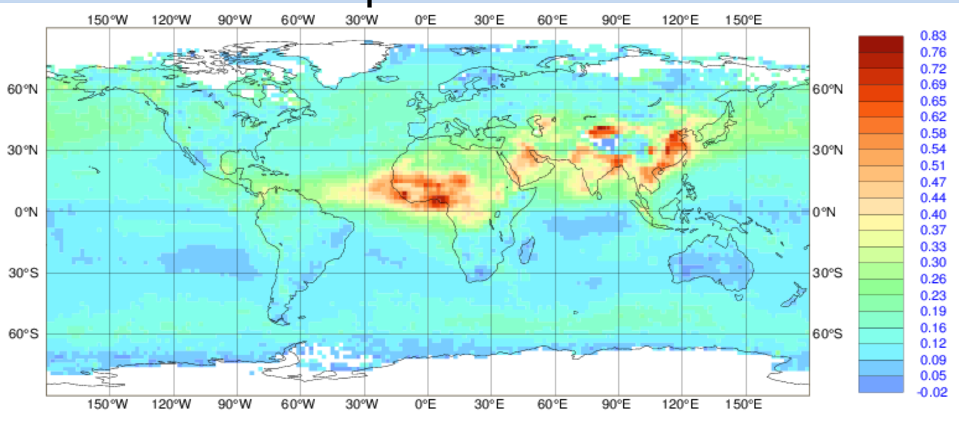
(*) EUMETSAT is aware that there is a difference between the two instruments due to differences in their degradation level. This will be addressed with a new version of PMAp in Q1 2018.

What happens if we only use PMAp?

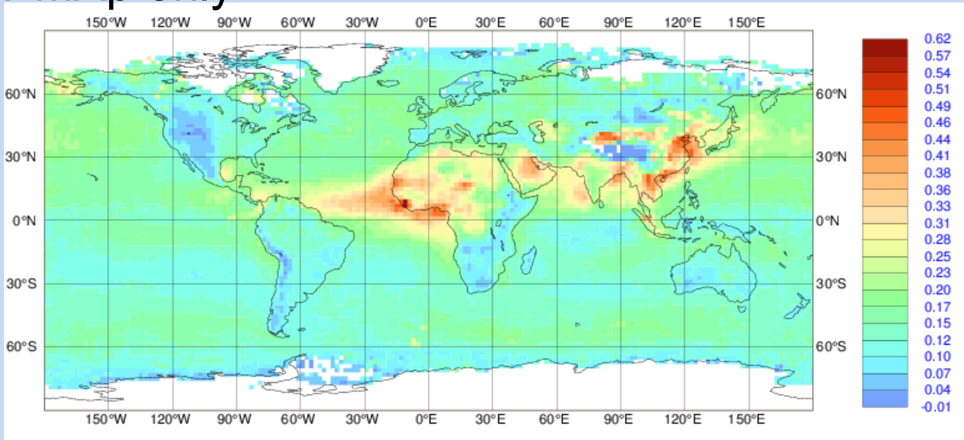
MODIS only



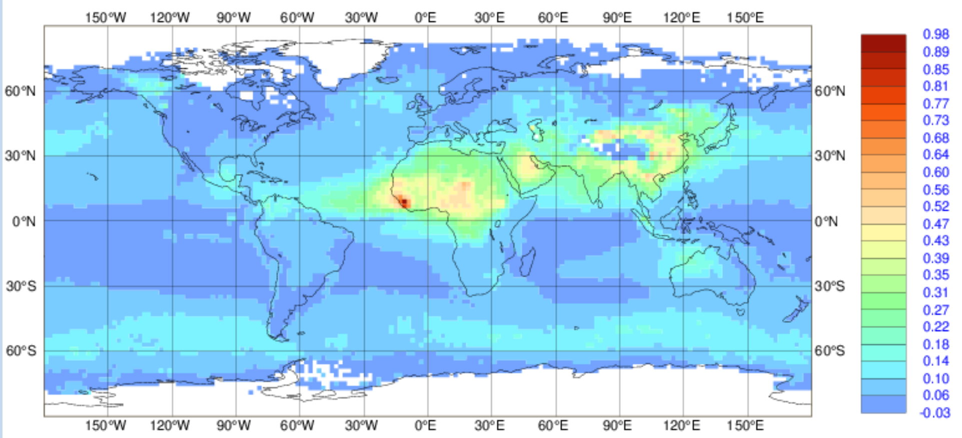
MODIS and PMAp



PMAp only



No AOD

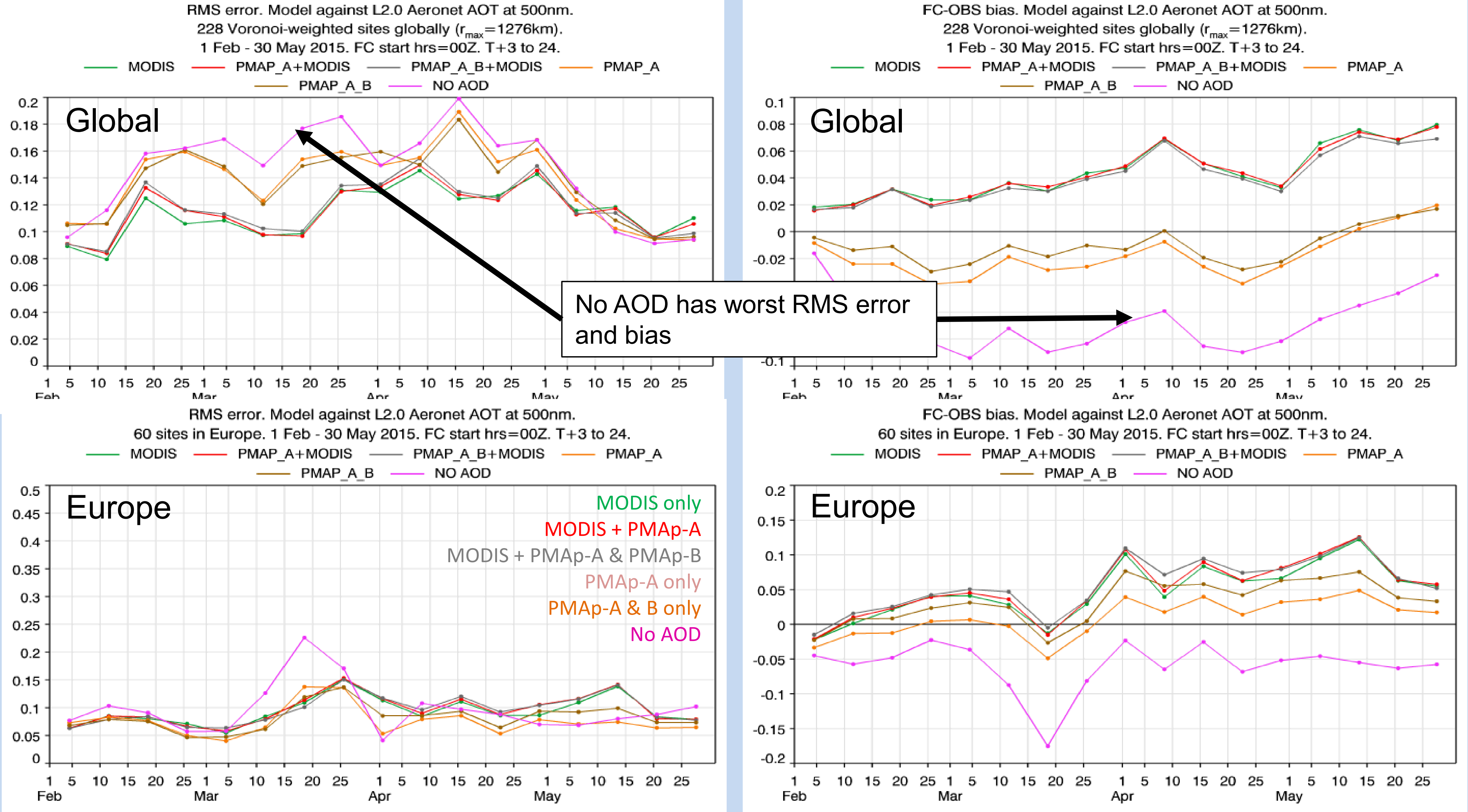


- Very similar mean model state for MODIS only and MODIS + PMAp
- Effect of higher PMAp-B observations apparent for PMAp only
- PMAp only better than no AOD observations

Verification – PMAp only

RMS error

FC-OBS bias



What ICAP models need

- For data assimilation we need a de-biased products with a residual point wise error estimate. That is, we need an error model for bias and root mean square deviation. Large errors are ok, as long as we know they are big.
- Feel free to pack in as much metadata as is reasonable (cloud fraction, snow, aggregated radiance or reflectances). It helps us develop our own error models and select the right data to use.
- Categorical aerosol models such as "dust, polluted dust, etc." can be difficult to implement in data assimilation. Index of refraction of a complex mixture is not easily relatable. More generally, unless we can clearly define an observation operator, an observable cannot be effectively assimilated. Great uncertainties in observation operators --> specification of large observation errors --> less impact.
- Data needs to be easy to get and parse. Be consistent with a few major upgrades being preferable to lots of incremental changes.
- Consider the niche market and keep the global constellation in mind. Every product does not need to do everything.

Components of Level 2 Error Model (requires lots of data to pull out)

- **Can be as simple as RMSE as a function of AOD**
  - AOD can be from AERONET (diagnostic) or own AOD (prognostic).
  - But, RMSE is symmetric nor does it address massive outliers which are often the problem
- **Terms include:**
  - Differential Signal to Noise: Lower boundary minus total, including view angle/optical path length.
  - Lower Boundary Condition:
    - Ocean: Wind/glint/whitecap, class 2 waters, sea ice
    - Land: Surface reflectance model, snow, view angle/BRDF/hotspot
  - Cloud mask
  - Microphysical: Fine coarse/partition, $P(\theta)/g$, ω_o, AOD
- **Biases are often folded into "random" error models. If they are known, why not correct for them?**
- **Radiance Calibration: Individual wavelengths propagate non-linear through retrievals and are not easy to incorporate.**
- **Verification of errors is also needed**

Considerations
Simple AERONET comparisons are a good start. But…

- We can't use bulk regressions, or compliance stats. We want point wise RMSE
- One way or another, it is best if we can de-bias the data
- Everything we do to the data has a consequence.
- Sole AERONET verification games errors in favor of the satellite product through sampling in many forms (cloud screening, support availability).
- Tuning to AERONET does not get at error covariance.
- And AERONET has its own errors, particularly in association with perceived coarse mode.
- AOT is simple, tractable and generally has an obs error much less than the model. Spectral Deconvolution Algorithms give us a good fine/coarse partition too. AAOT or ω_o not so, and the error bars are large on all fronts. So how do we want error information delivered?

Summary

- ICAP is a good forum to make progress on common goals related to aerosol observations. All centres involved in aerosol forecasting care about satellite data for assimilation, model development and evaluation.

- Assimilation so far has heavily relied on satellite-retrieved AOD with MODIS being the number one product.

- Incorporation of other products is happening but there are challenges related to relative biases between the various products (including lidar backscatter – a talk on its own)

- AOD is still needed – bias corrected and error characterized

- Other observations are needed: lidar backscatter, absorption AOD, mass concentrations (difficult from satellite)

- Multi-sensors aerosol climatologies are needed (also by the NWP community)

THANK YOU!