A different perspective on satellite data for model evaluation

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Introduction

Satellite observations provide the decades of global coverage necessary to monitor our climate and the processes which influence it. Most satellite data providers release "Level 3" products which average their data onto a regular grid, as this is easier for most users to manipulate. This is sensible for data that are spatio-temporally well correlated, such as the concentration of a well-mixed gas, but for many atmospheric variables the diversity of natural behaviour cannot be converyed by a simple mean.

This poster outlines an approach to data aggregation that better represents the nature of the original observations [1].

Equal means ≠ equal observations

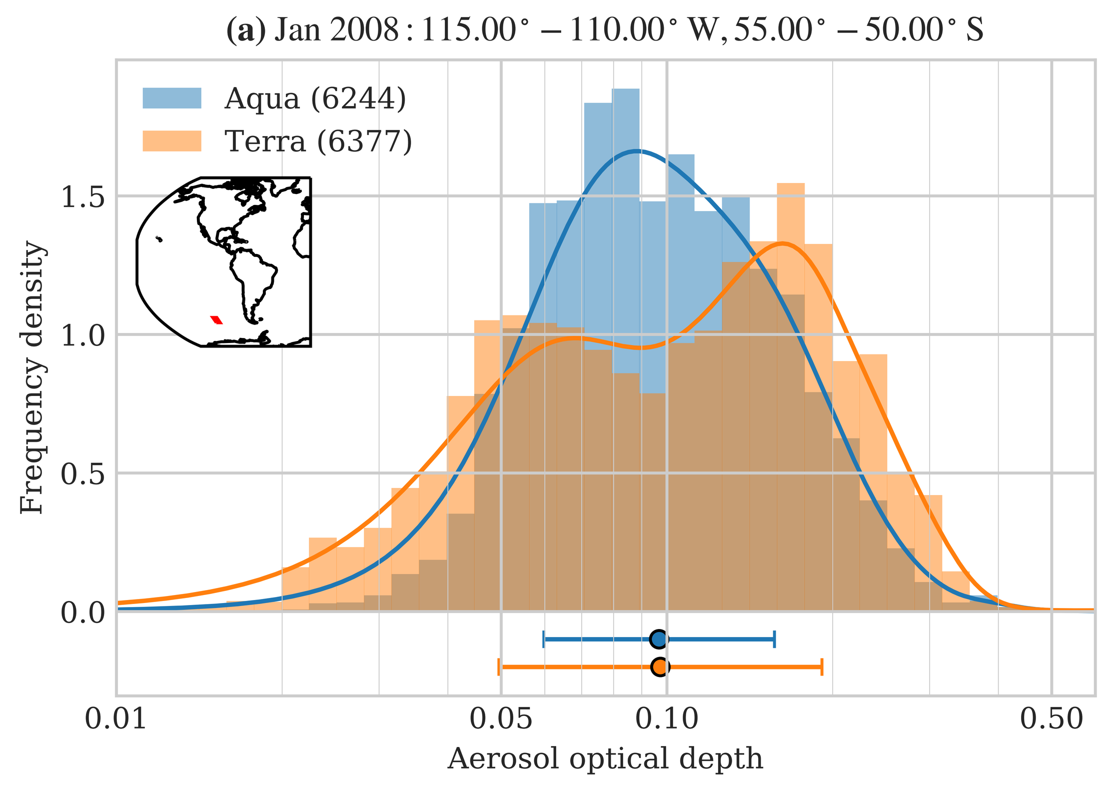
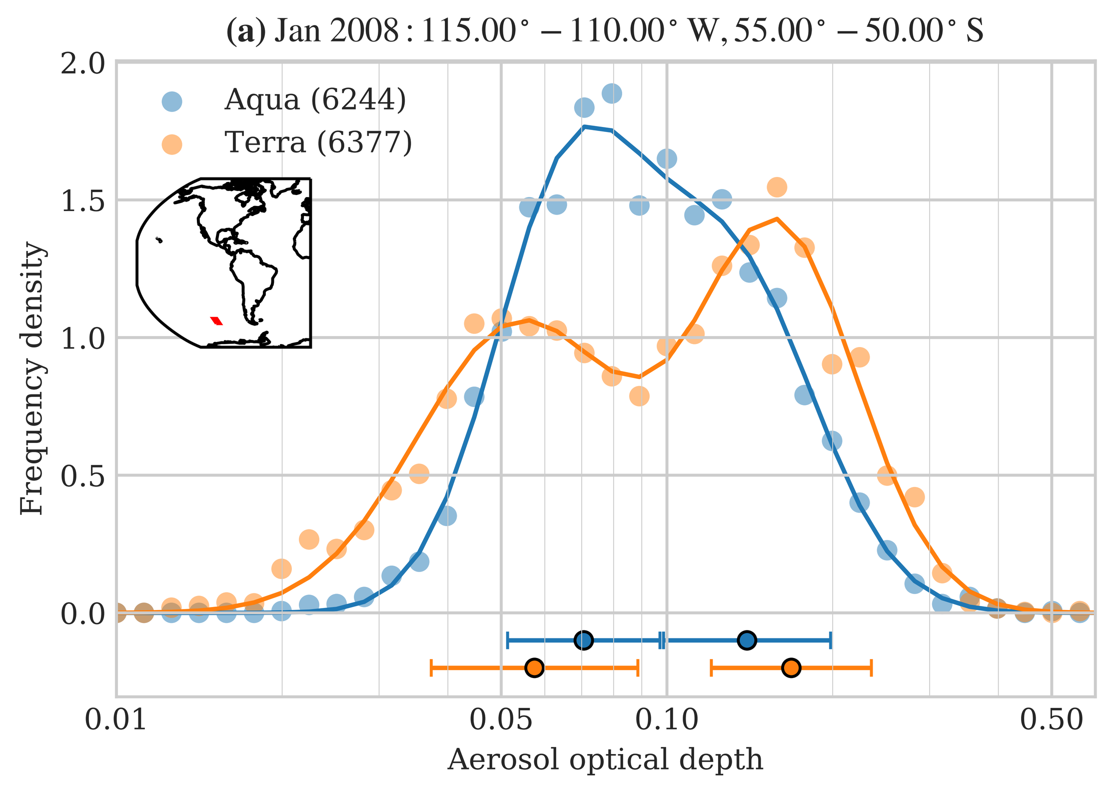


Figure 1: Above: The distribution of aerosol optical depth (AOD) observed in a 5° cell off the S.American coast in Jan 2008 by the Moderate-resolution Imaging Spectromaters (MODIS) on Aqua (blue) and Terra (orange) [2, 3]. **The mean and standard deviation of each dataset, shown below the axes, are consistent despite clear differences in the distributions.** Lines show a kernel density estimate. *Below:* Lines show a fitting of a bimodal log-normal distribution to those distributions (circles). The mean and width of each fitted mode is shown below the axes. **The modes are in agreement, with both platforms observing a bimodal distribution.** Note that the modes refer to different sources, such as maritime and land, rather than different aerosol sizes.



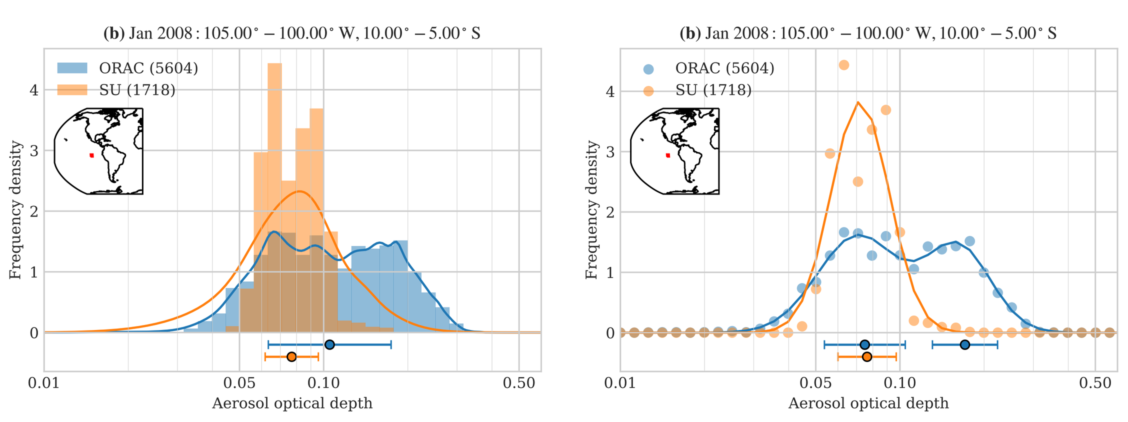


Figure 2: As Fig. 1, but for a different cell and for AOD retrieved from the Advanced Along-Track Scanning Radiometer (AATSR, [4]) by two algorithms: the Optimal Retrieval of Aerosol and Cloud (ORAC, [5]) and Swansea University (SU, [6]). Both algorithms observed a mode around 0.075. The discrepancy in their means can be explained by SU filtering higher AOD observations from its data, as these are more likely to be contaminated by cloud.

Fitting permits more nuanced global comparisons

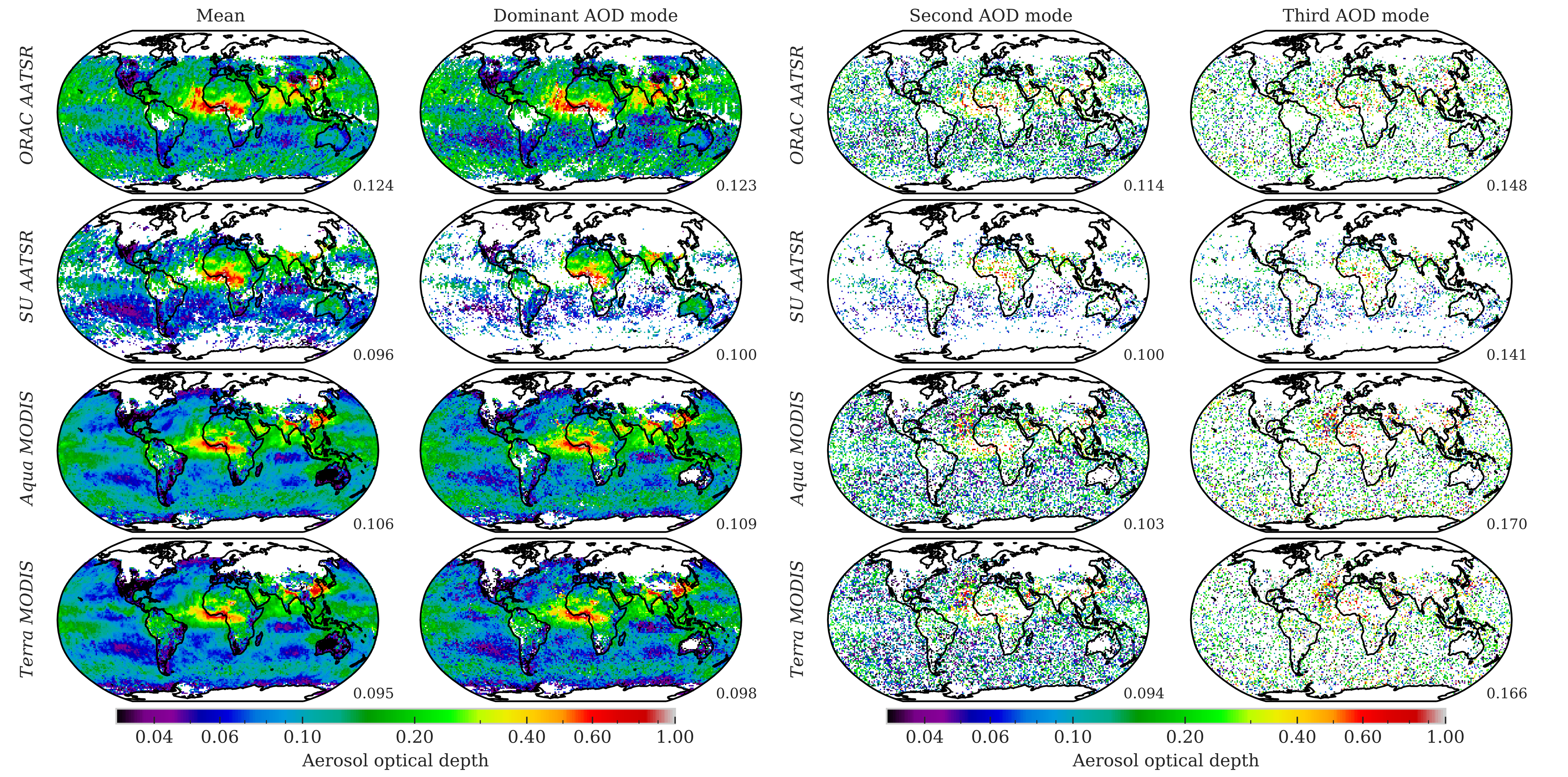


Figure 3: AOD in Jan 2008 on a 1° lat-lon grid from ORAC, SU, Aqua and Terra (*rows top to bottom*). Arithmetic mean is compared to the fitted multimodal distribution, plotting the median value of each mode in order of decreasing frequency (*columns left to right*). White indicates no fit. **The fitted fields are more consistent between the different datasets.** For example, the minima south of India converge to 0.04 across the datasets after fitting, while the means vary between 0.03 and 0.07.

45% of pixels fit **two modes, reconciling the discrepancies between ORAC and MODIS** west of California and around western Africa. Only a third of pixels required a third mode, concentrated in dusty and polluted regions.

Detailed evaluation of satellites and models against sun photometers

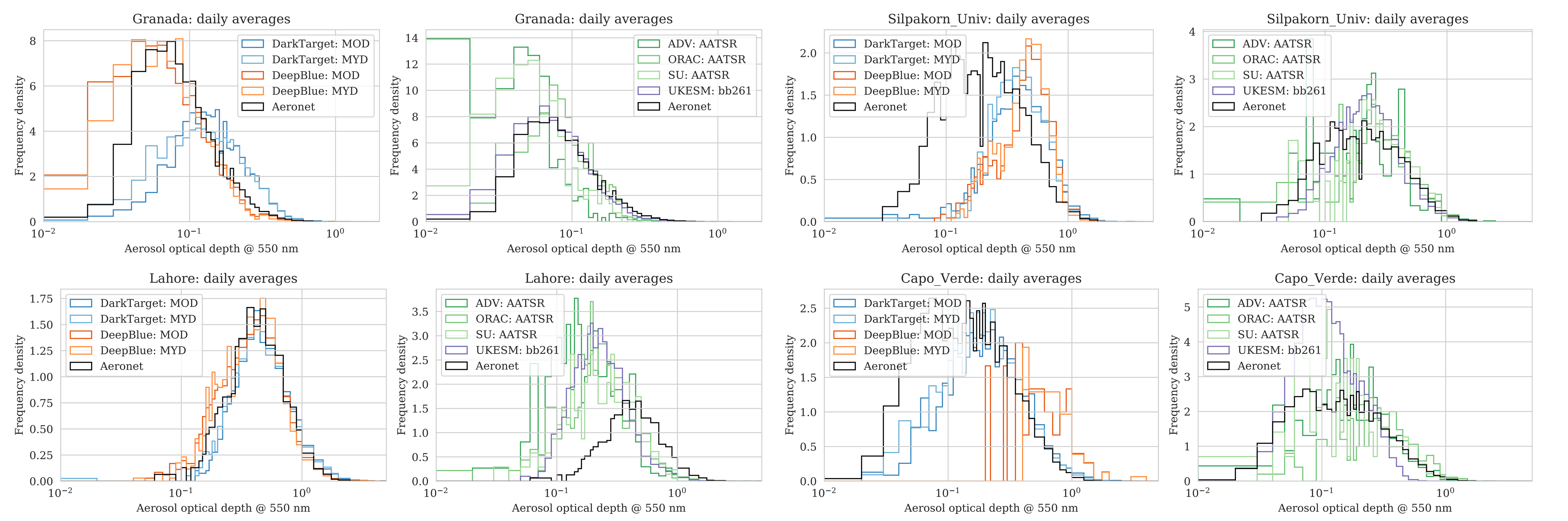


Figure 4: Distribution of daily geometric mean AOD observed over four AERONET [7] sun photometer installations: Granada, Spain; Silkaporn University, Thailand; Capo Verde; and Lahore, Pakistan (*clockwise from top left*). Observations from AERONET (black) are compared to the MODIS Dark Target (blue) and Deep Blue (orange) products, three AATSR retrievals (green), and the UK Earth System Model (purple). **Monomodal environments (left) are well fit by a log-normal distribution.** More complicated environments (right) are better fit by a generalised gamma distribution, but appear to be bimodal. **No one method performs universally well.**

Underlying distribution

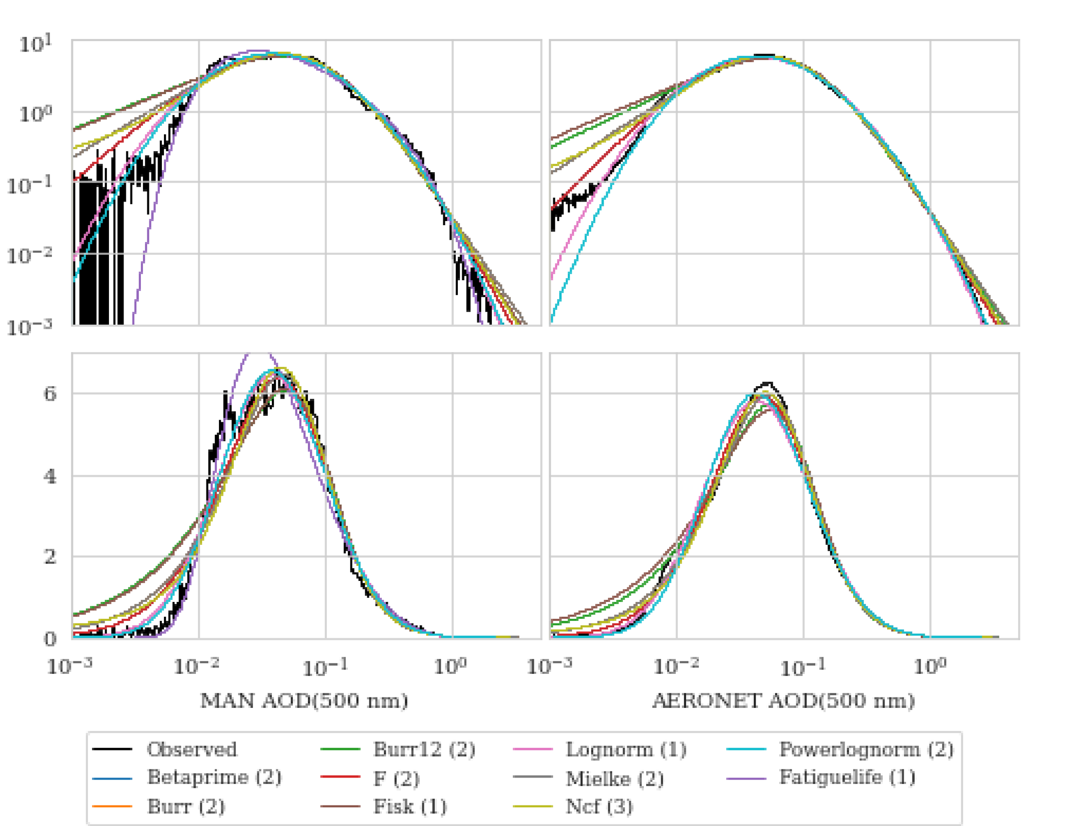


Figure 5: The observed (black) and fitted (colours) PDFs of AOD at 500 nm observed over all Maritime Aerosol Network cruises (left) or Aerosol Robotic Network sites (right). Technically, no distribution passes a Kolmorgorov-Smirnov test due to the shape of the wings but log-normal distributions perform best.

Take-away messages

- The mean of AOD over a month is a poor representation of the underlying observations.
  - Daily means are better because conditions tend to evolve slower than that.
- AOD is log-normally distributed but is frequently multimodal.
  - Use geometric, not arithmetic, means.
  - A power log-normal distribution can be useful if a single mode is needed to represent a complicated environment.
- Describing the distribution of AOD observed allows a more nuanced comparison of datasets and models.
  - Highlights differences in sampling and filtering methods.

References

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