Pixel-level uncertainties in aerosol remote sensing: Aerosat experiment progress report

Andrew Sayer, Antti Lipponen, Marta Luffarelli, Tero Mielonen, Falguni Patadia, Adam Povey, Marcin Witek

Goal and definitions

- How well do *current* techniques used to estimate pixel-level AOD uncertainties in satellite aerosol remote sensing represent the uncertainties in the data
  - Uncertainty/estimated error: the 1-sigma confidence envelope for a retrieval in which the truth is expected to lie
  - An expected magnitude; a width of a distribution
  - Retrieval error: the difference between retrieved (satellite) and truth (AERONET) AOD for an individual retrieval
  - An individual draw (realisation) from the distribution of uncertainties
- We are not evaluating how good the *retrievals* are, but how good the *estimated uncertainties* are

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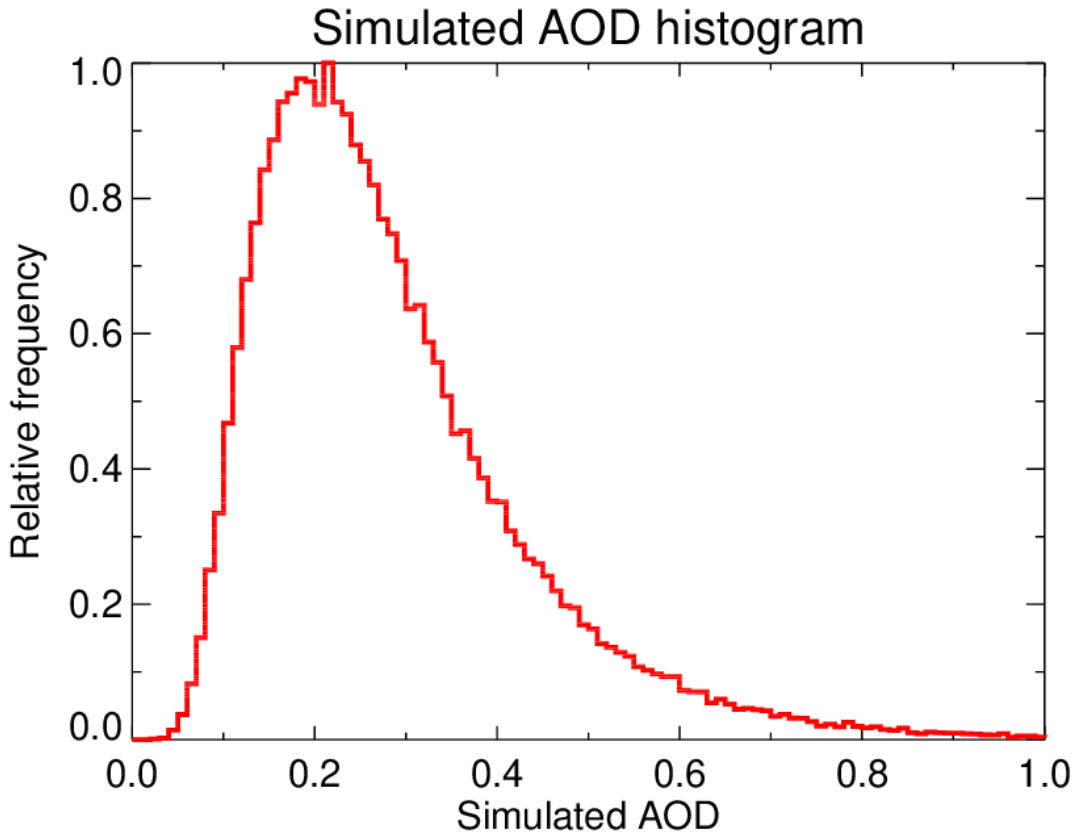

- If I have this AOD distribution, and an expected uncertainty of 0.05+15%,
  - What should the pdf of expected errors look like?
  - What should the pdf of absolute retrieval errors look like?

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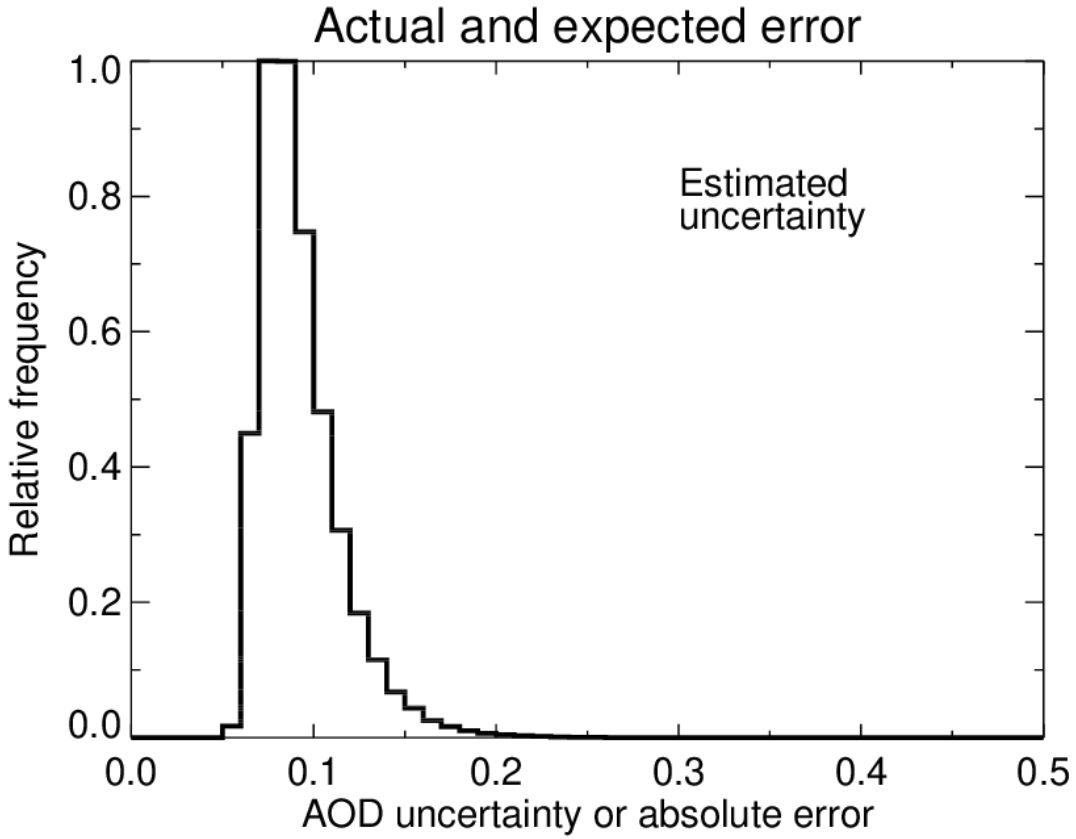

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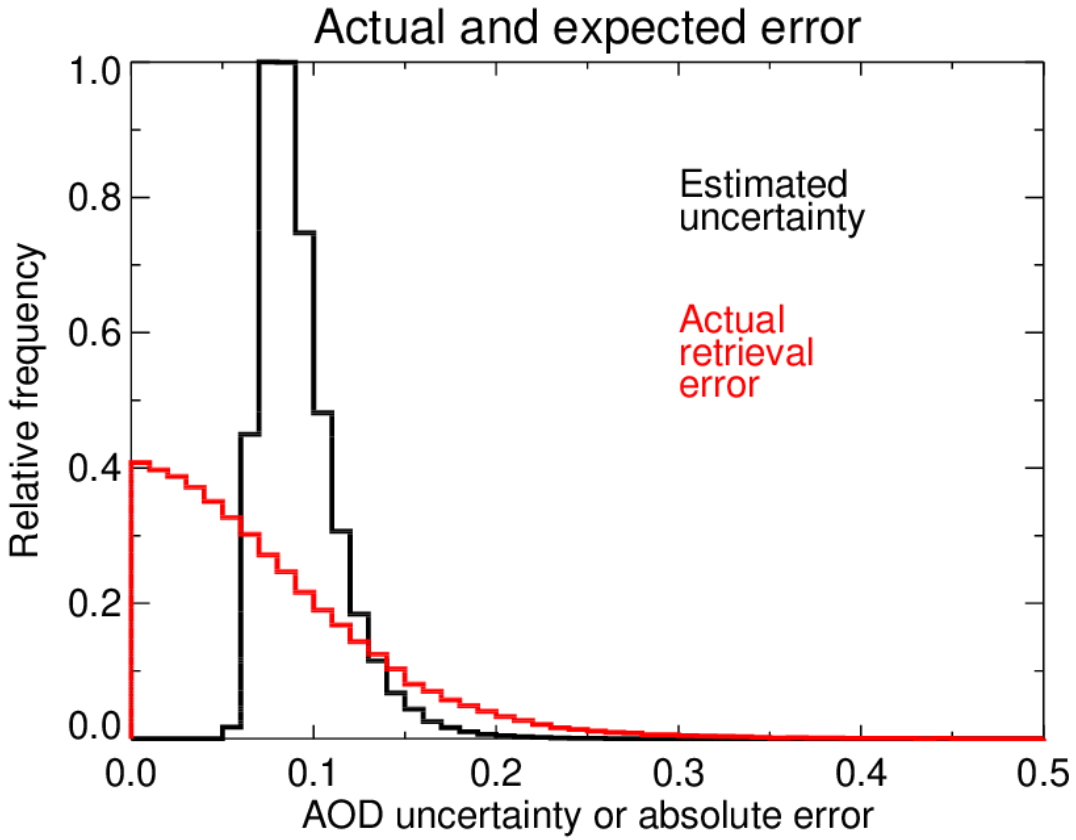

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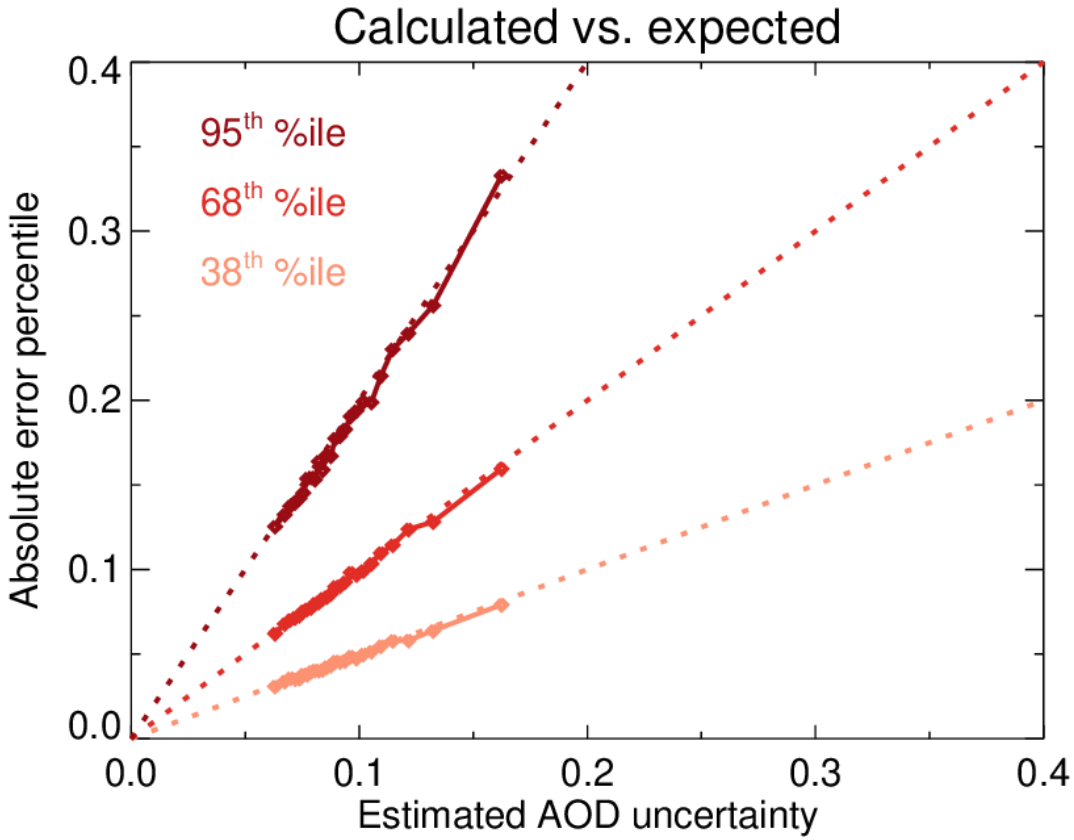

- If we aggregate the data as a function of estimated uncertainty, then
  - 1 standard deviation (68%) should match within the expected error
  - 2 standard deviations (95%) should match within twice the expected error
  - 0.5 standard deviation (38%) should match within half the expected error

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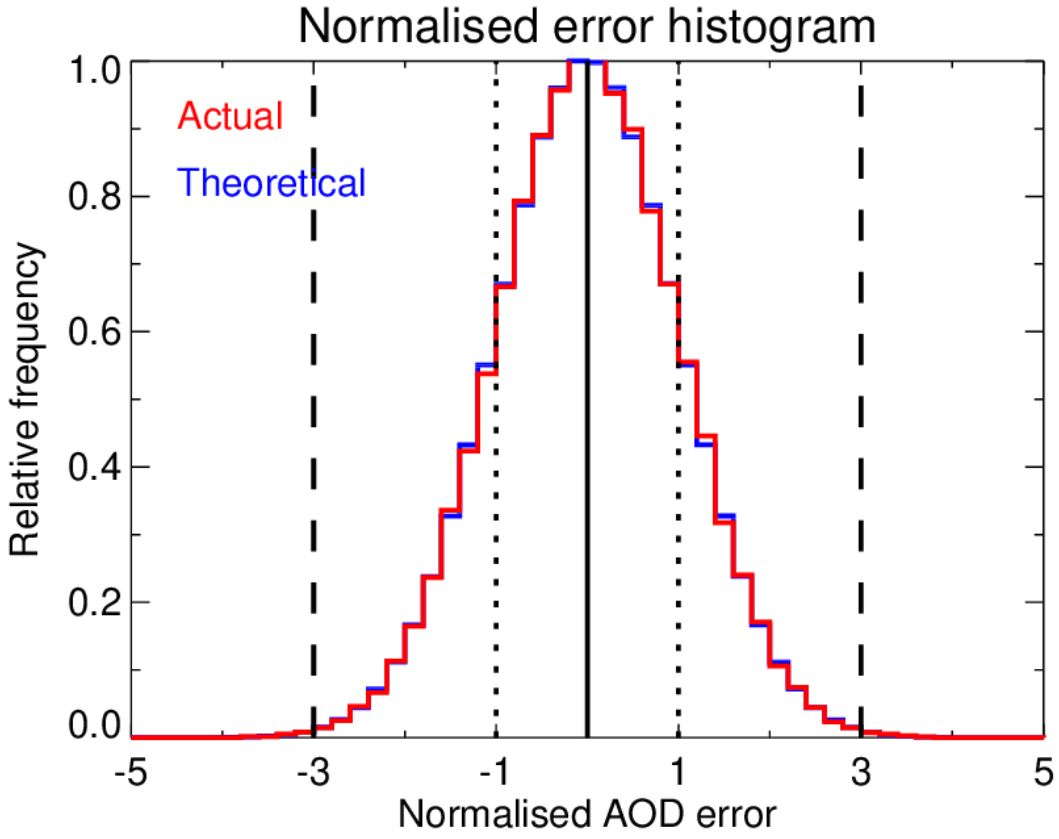
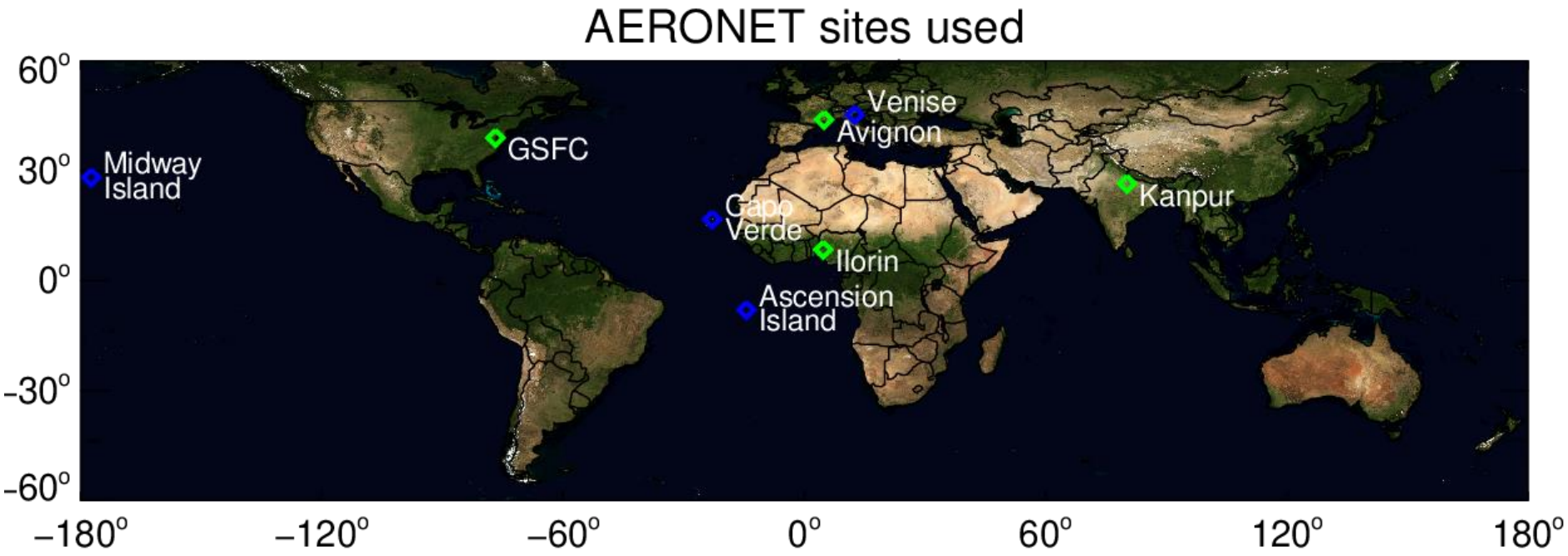


- The pdf of normalised error (actual error divided by estimated uncertainty) should be Gassian with mean 0, variance 1

How are we testing this?



- Looking at 8 AERONET sites (4 land, 4 water)
- Two ‘straightforward’ and two ‘complicated’ from each
- Take the nearest retrieval to site
- Strict matchup and homogeneity criteria on AERONET

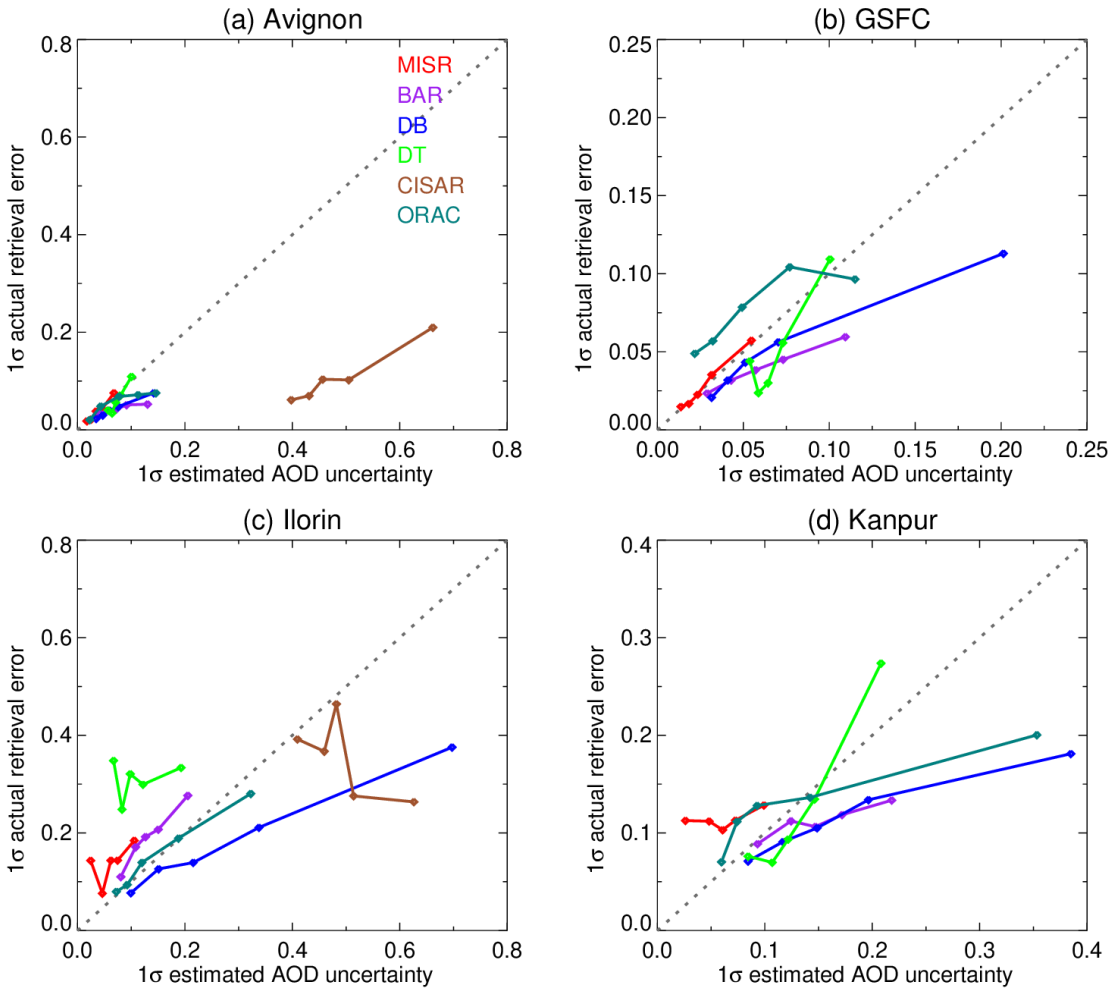
Who is participating?

Data set	Contact	Type
MODIS Deep Blue Terra/Aqua	Andy Sayer	Empirical prognostic expression
MODIS Dark Target Terra/Aqua	Falguni Patadia	Diagnostic global envelope
MODIS Bayesian Aerosol Retrieval Terra/Aqua	Antti Lipponen, Tero Mielonen	Optimal estimation
ORAC ATSR2/AATSR	Adam Povey	Optimal estimation
MISR	Marcin Witek	Weighted spread of potential solutions
SEVIRI CISAR	Marta Luffarelli	Optimal estimation

- Not all data sets can provide all sites
- Other groups are welcome to join

What did we find so far?

- The uncertainty estimates are generally proportionate to the retrieval errors (i.e. they have skill)
- The magnitudes are not perfect
- Data volume is a challenge for narrow-swath instruments
- Can't necessarily distinguish 'straightforward' from 'complicated' sites
- Similarities between sites can point to potential issues in individual approaches
- Differences between Optimal Estimation approaches highlights the difficulty of quantifying some terms



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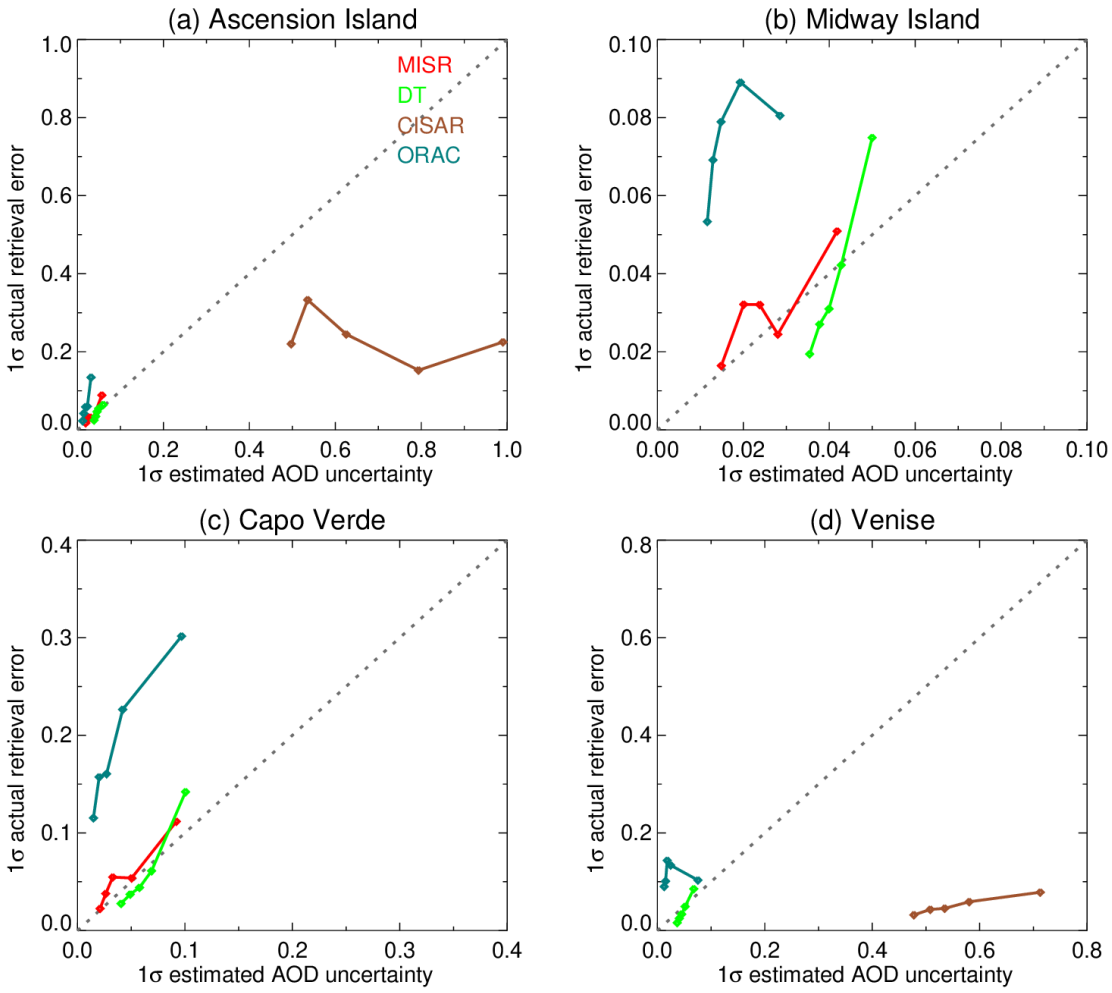

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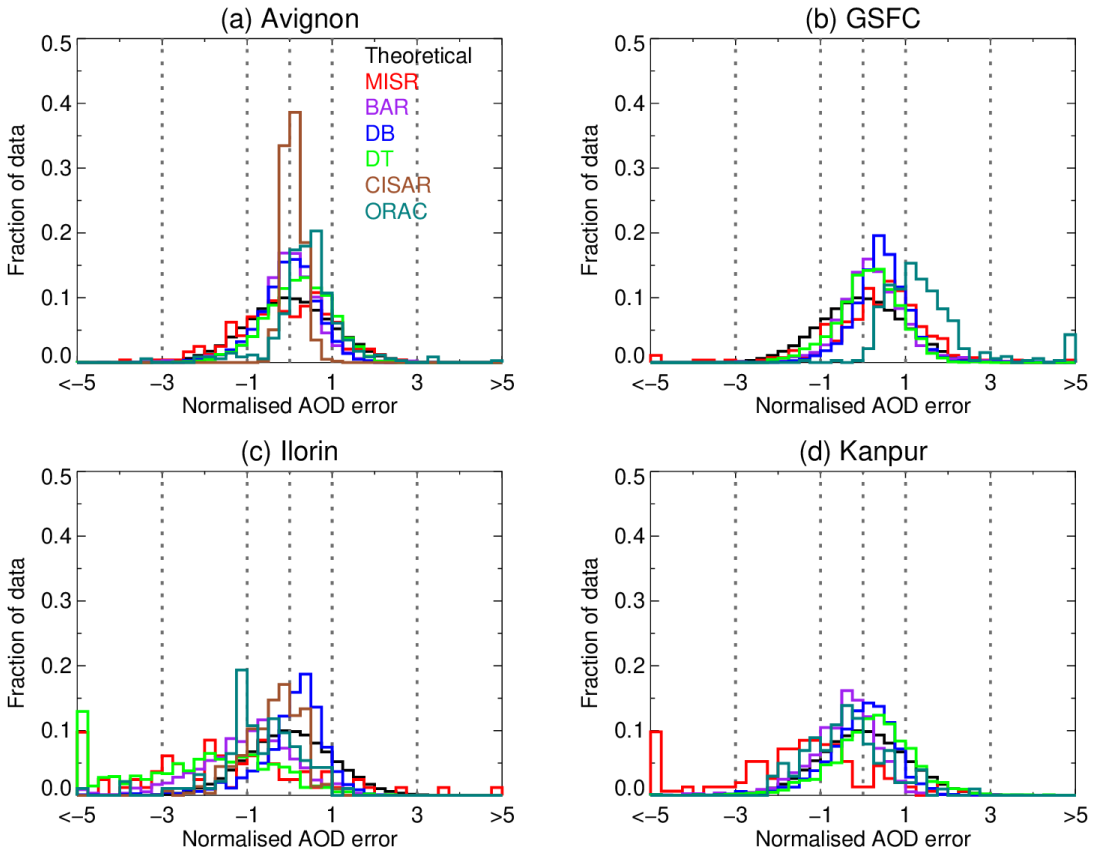

- Aside from CISAR (uncertainties too big), algorithms have more outlying large errors than expected
- In part due to systematic biases in low-AOD, notional low-uncertainty conditions
- But at some sites, uncertainties are just systematically too small

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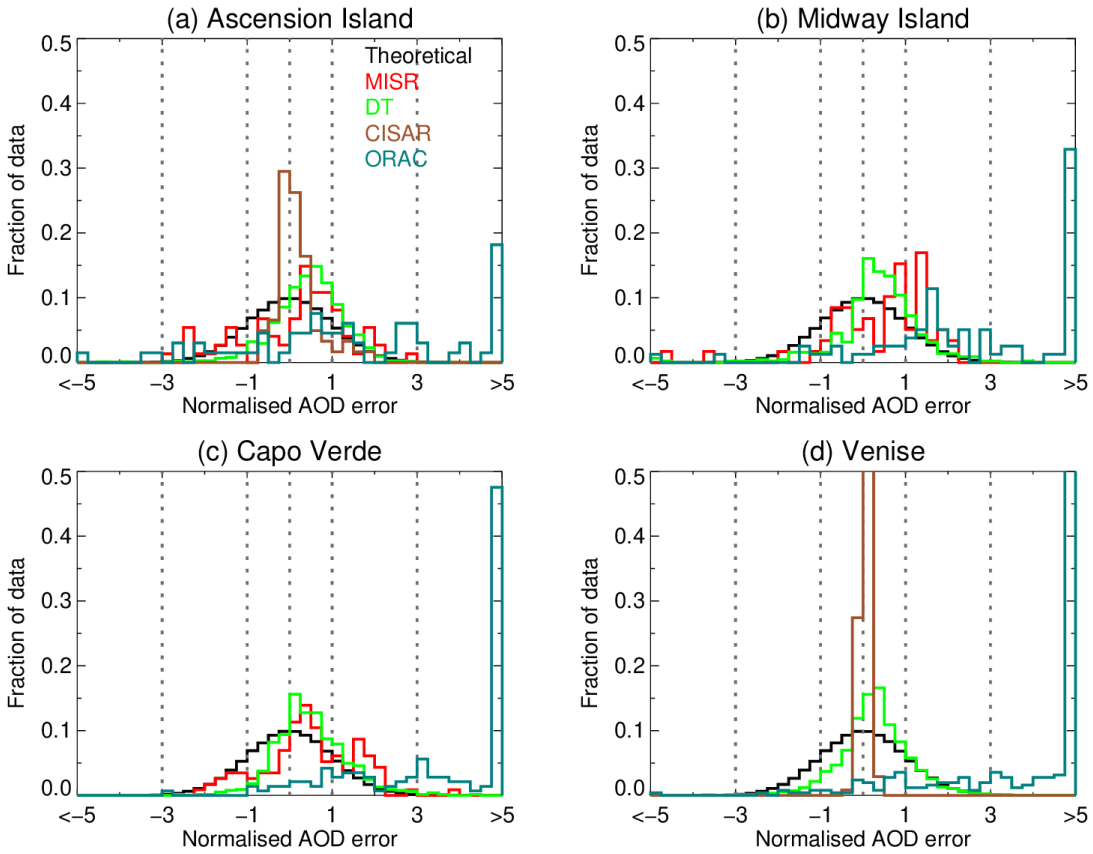

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Questions and potential next steps

- Given site-to-site differences in performance, can we overcome some of the data volume issues in some data sets?
- Can we assess/refine the assumptions going into the techniques?
  - Repeat retrievals adding noise to known measurements, and compare dispersion with uncertainty
  - Repeat retrievals with multiple optical models, and compare dispersion with uncertainty
- Even if magnitudes aren't perfect, can uncertainty estimates be used to identify and screen the extreme outliers?
- Any other thoughts?