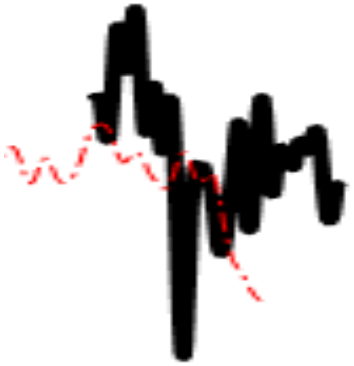


Using CMIP6 PI simulations to test significance of the AMOC trend seen by RAPID

(D Straub, C Dufour, R Kelson)
McGill

Does the observed (2004-2020, -0.14 Sv/yr) trend seen by RAPID stand out relative to natural variability?

Use CMIP6 simulations for an estimate of natural variability. Problems:

- the models underestimate variability
- the models largely disagree

Method

Chose 22 of the 50 PI simulations that give good ballpark estimates (+/- 10 Sv) of AMOC strength

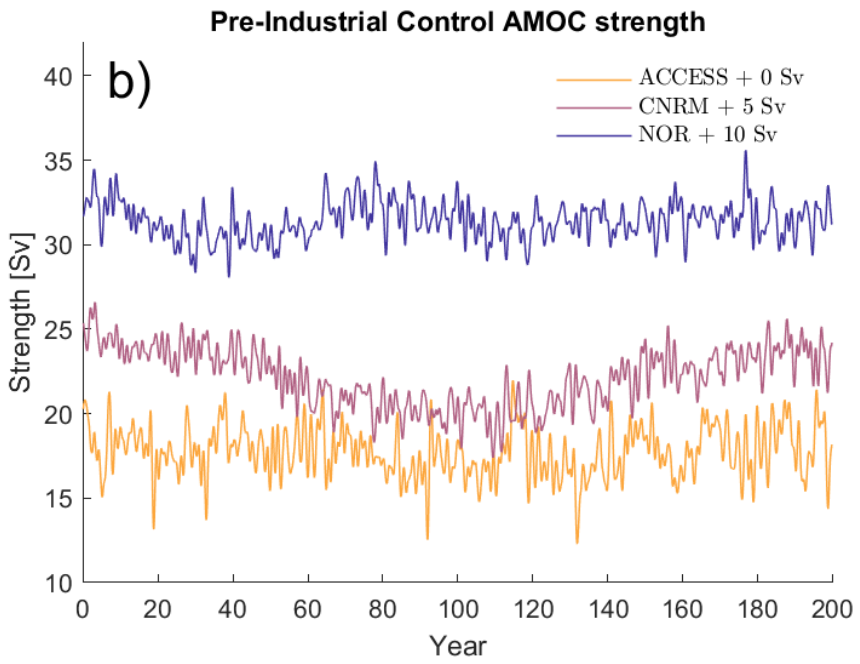
Construct PDFs of “Fake News Trends”

Check whether the RAPID trend is an outlier

Sample time series (PI simulations)

-short term trends evident

-variance typically under-represented on observational time scales

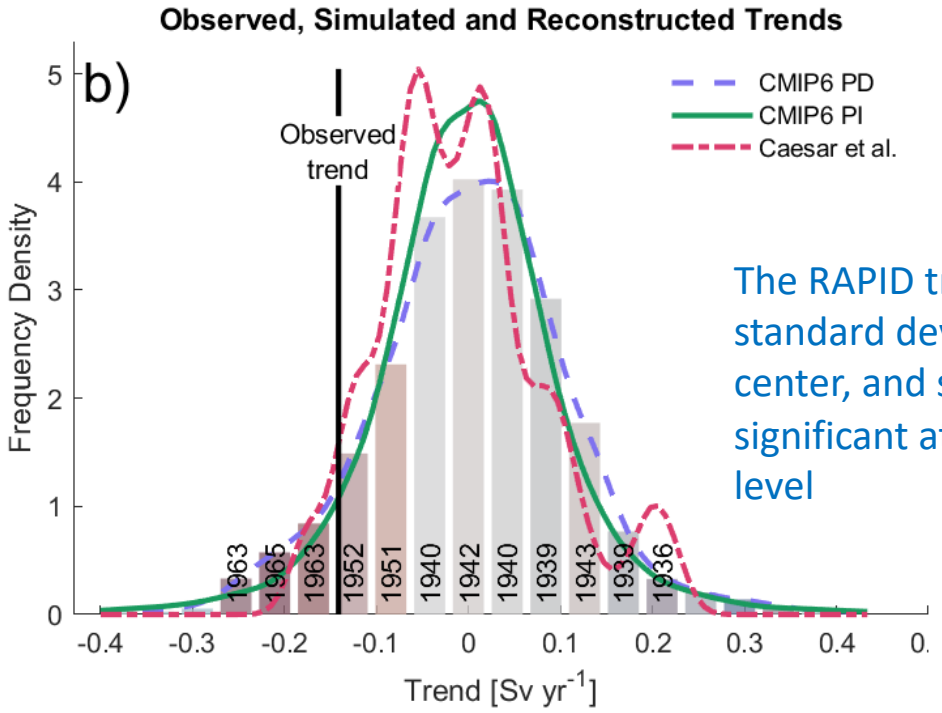


Orange: ACCESS-CM2

Maroon: CNRM-ESM2-1

Blue: NorESM2-MM

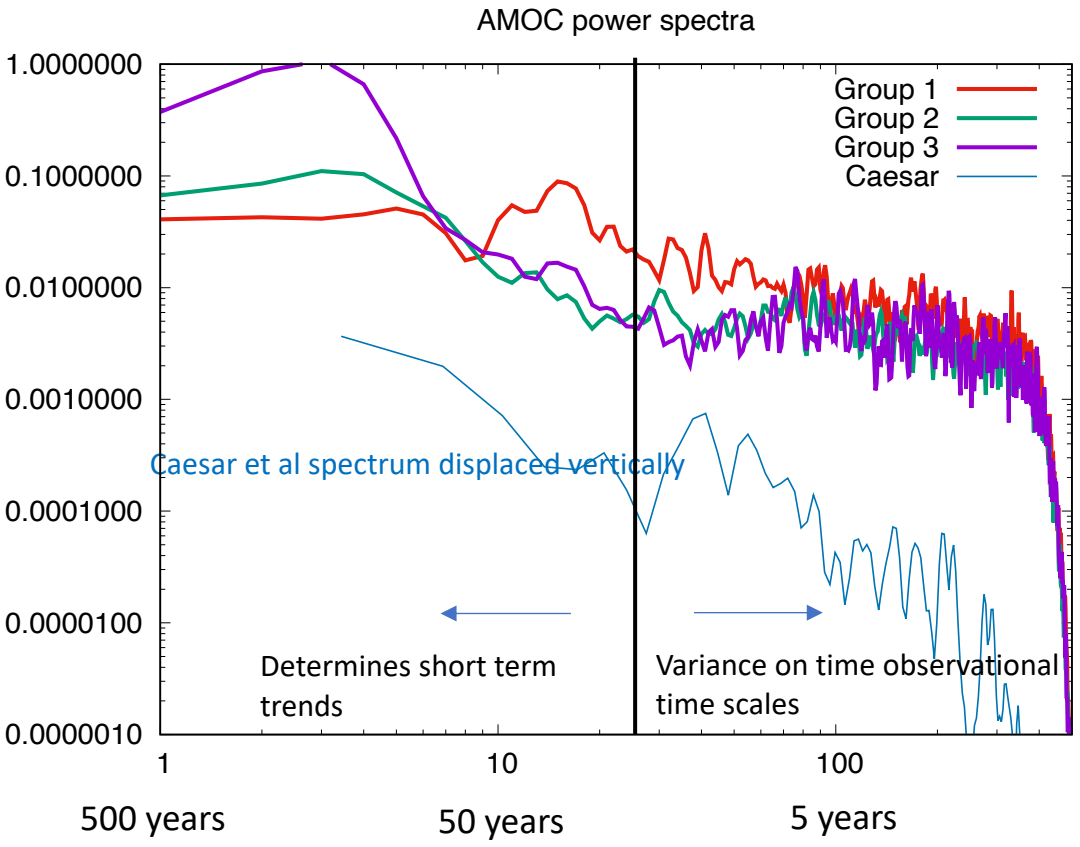
PDFs for PI, Historical and a reconstruction by Caesar et al. (2018)



The RAPID trend is 1.7 standard deviations from center, and so is not significant at the 95% level

Years in PD bin boxes are means for (middle) years of windows giving a given trend (more negative trends occur later in the PD simulations)

Frequency spectra, trend PDFs, and variability



Vertical line is 16-year period
(i.e., length of RAPID time series)

Models underestimate variability (not enough energy in periods shorter than 16 years)

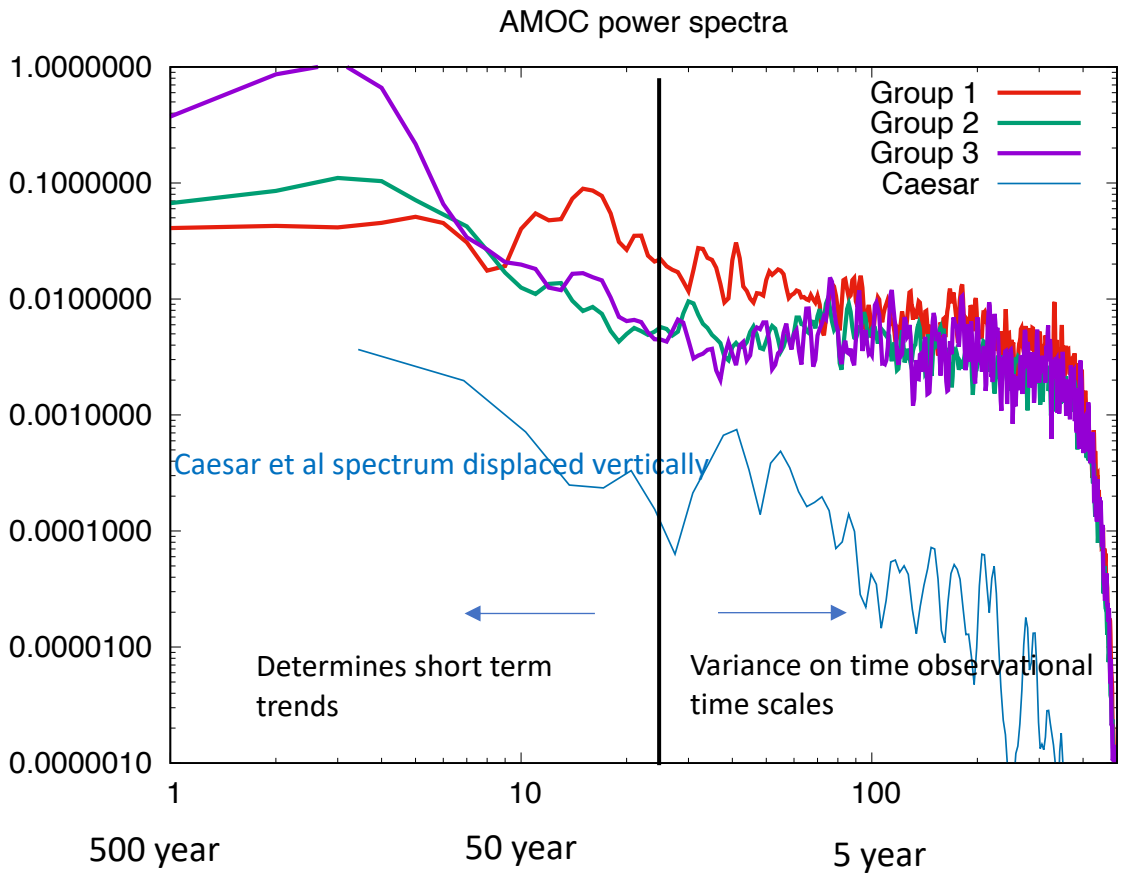
Disagreement between models at low frequencies

It is the low frequencies that determine trend PDFs

Groups based on how quickly trend PDFs narrow with increasing segment length used to infer the trends

- Group 1 narrows quickly
- Group 3 narrows slowly

Observed variability, short-term trend variability, and frequency spectra



Assume AMOC strength a(t) has a Fourier representation

$$a(t) = \sum_{1}^{N} A_n \sin(\omega_n(t - t_0) + \phi_n)$$

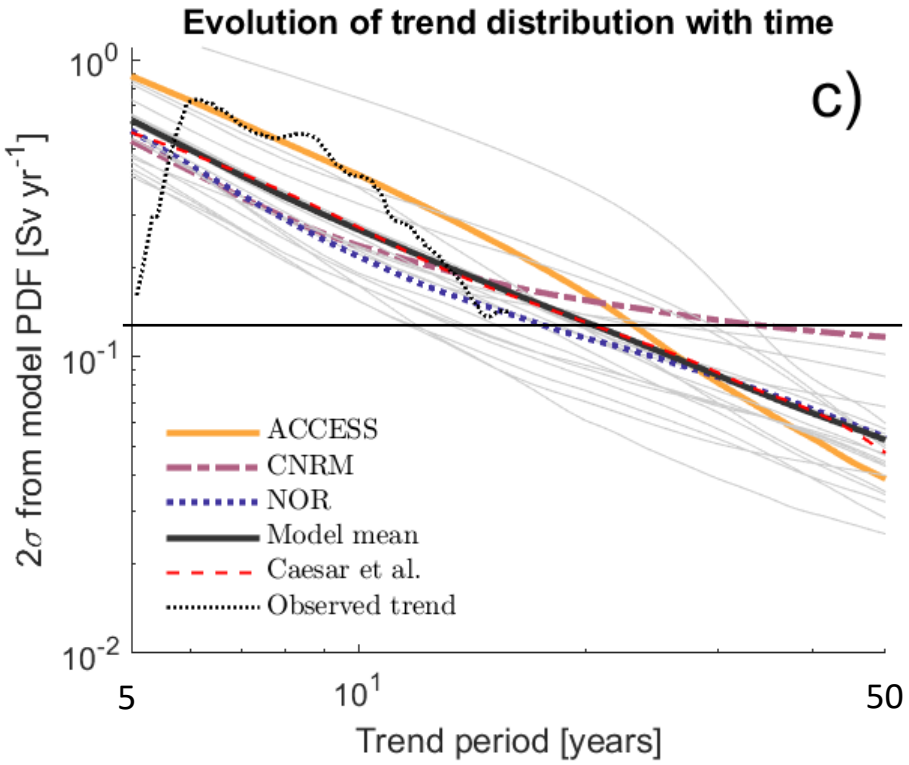
$$\frac{da}{dt} = \sum_{1}^{N} \omega_n A_n \cos(\omega_n(t - t_0) + \phi_n),$$

Short term trends correspond (roughly) to truncated versions of the da/dt series

Approximate trend PDFs can be constructed by averaging the truncated for different choices of the random phase angles

Detectability Threshold vs observation length

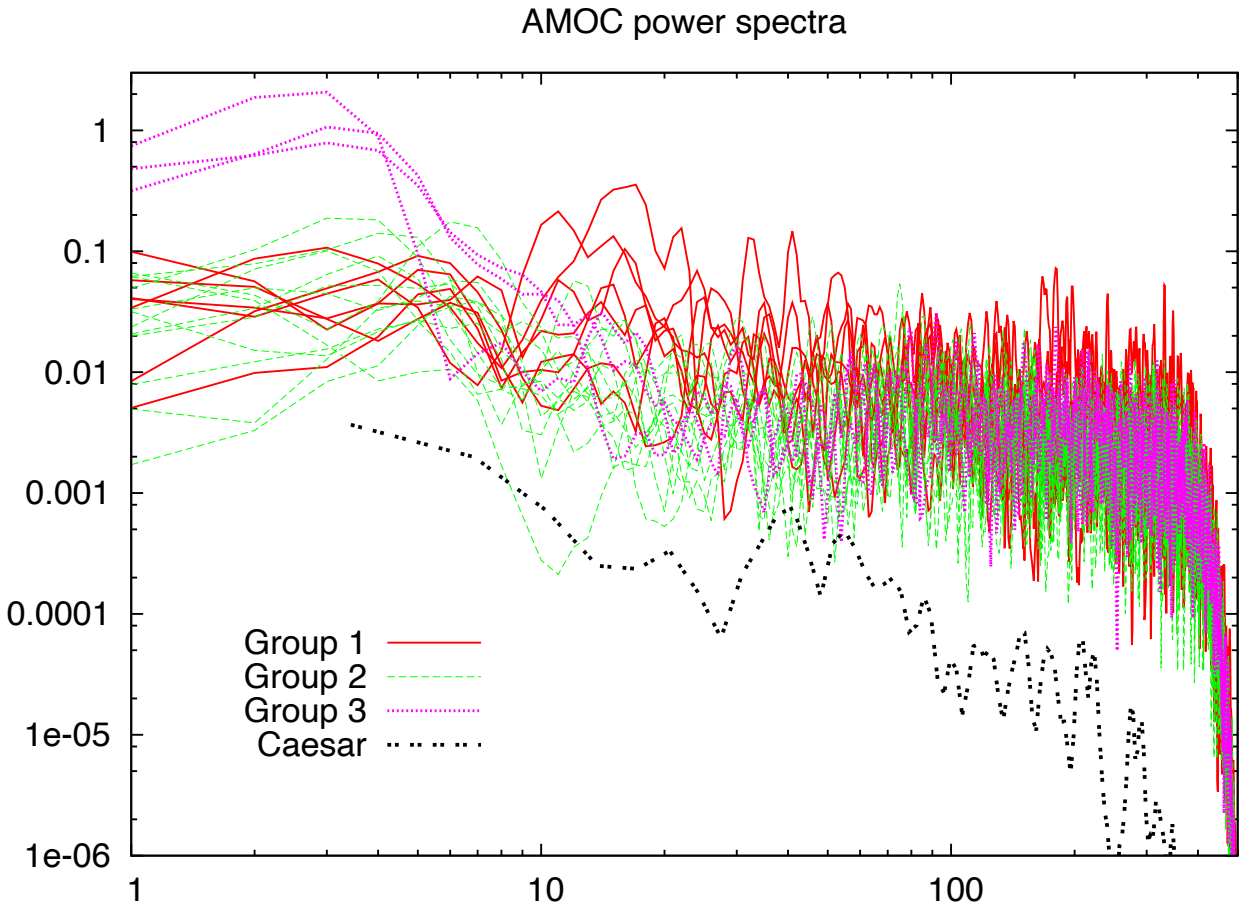
(calculated using PI time series; using spectra gives similar results)



Group 1 (e.g., ACCESS), detectability threshold drops off quickly with increased window length

Group 3 (e.g., CNRM) threshold does not drop off much for increased window length

Group 2: in between



Group 1

ACCESS-CM2
ACCESS-ESM1-5
FGOALS-g3
INM-CM4-8
MPI-ESM1-2-LR
MPI-ESM-1-2-HAM
NorCPM1

Group 2

CanESM5
CESM2
CESM2-WACCM-FV2
CESM2-FV2
CESM2-WACCM
EC-Earth3-Veg-LR
INM-CM5-0
MIROC6
MPI-ESM1-2-HR
NorESM2-LM
NorESM2-MM
SAM0-UNICON

Group 3

CNRM-CM6-1
CNRM-ESM2-1
EC-Earth3-Veg