



AMOC reconstruction for paleoclimate across multiple time scales



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KEY POINTS

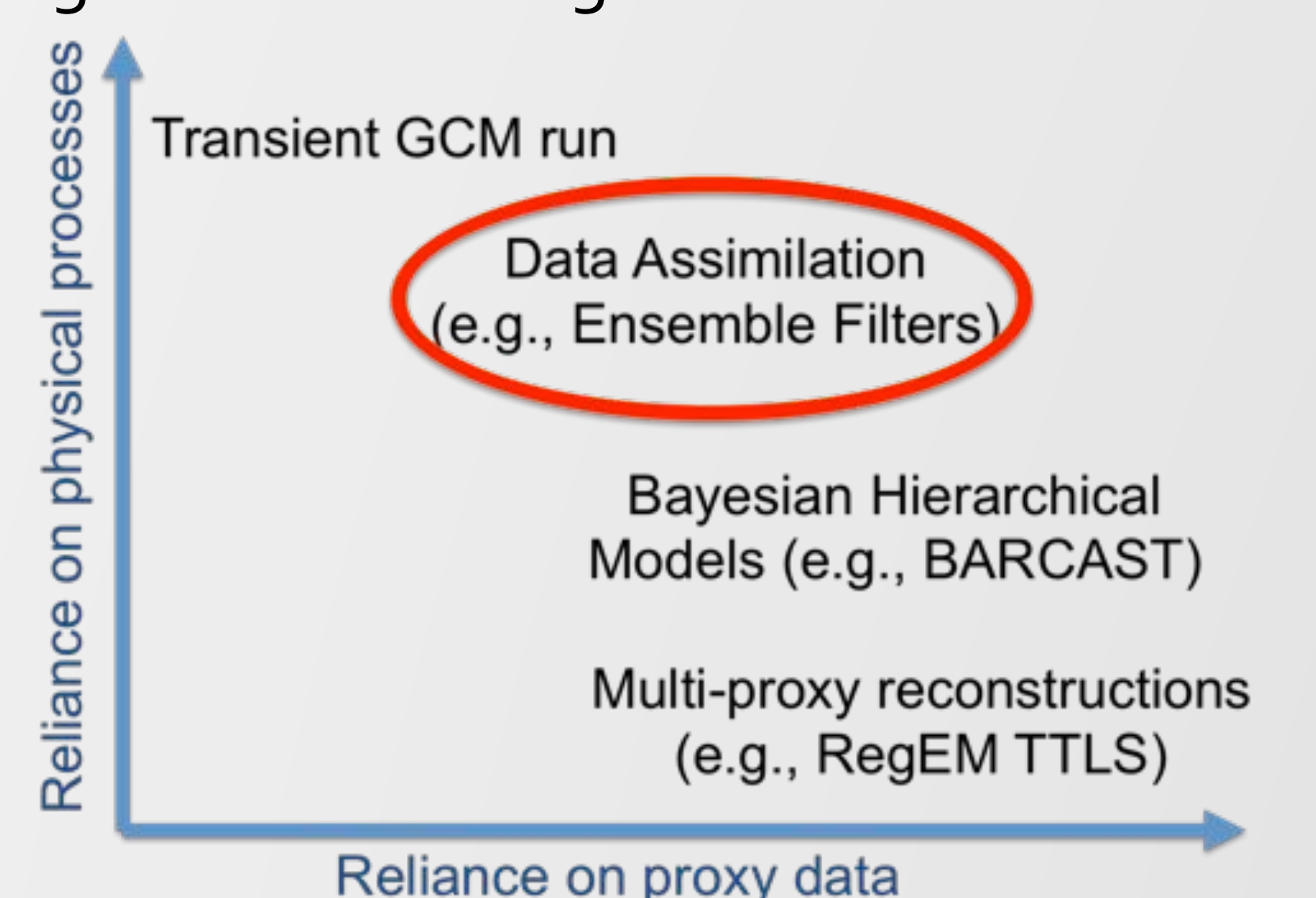
- Novel data assimilation technique operates across an arbitrary number of time scales
- Using both low and high frequency observations improves estimates of the AMOC
- Paleoclimate reconstructions of the AMOC may be possible using only surface atmospheric observations

MOTIVATION

- Reconstruction techniques are needed that can incorporate proxies of varying time scales (annual, decadal, centennial)
- Different observables may have distinct covariability signatures across time scales that could be leveraged to improve reconstructions (e.g., covariance of daily temperatures vs. decadal temperatures with the AMOC)

DATA ASSIMILATION

- Climate reconstruction techniques may be roughly categorized according to the schematic:



Based on Fig. 1 of Hughes & Ammann, 2009

- Data assimilation (DA) optimally combines observations (proxies) with a model (e.g., a GCM)

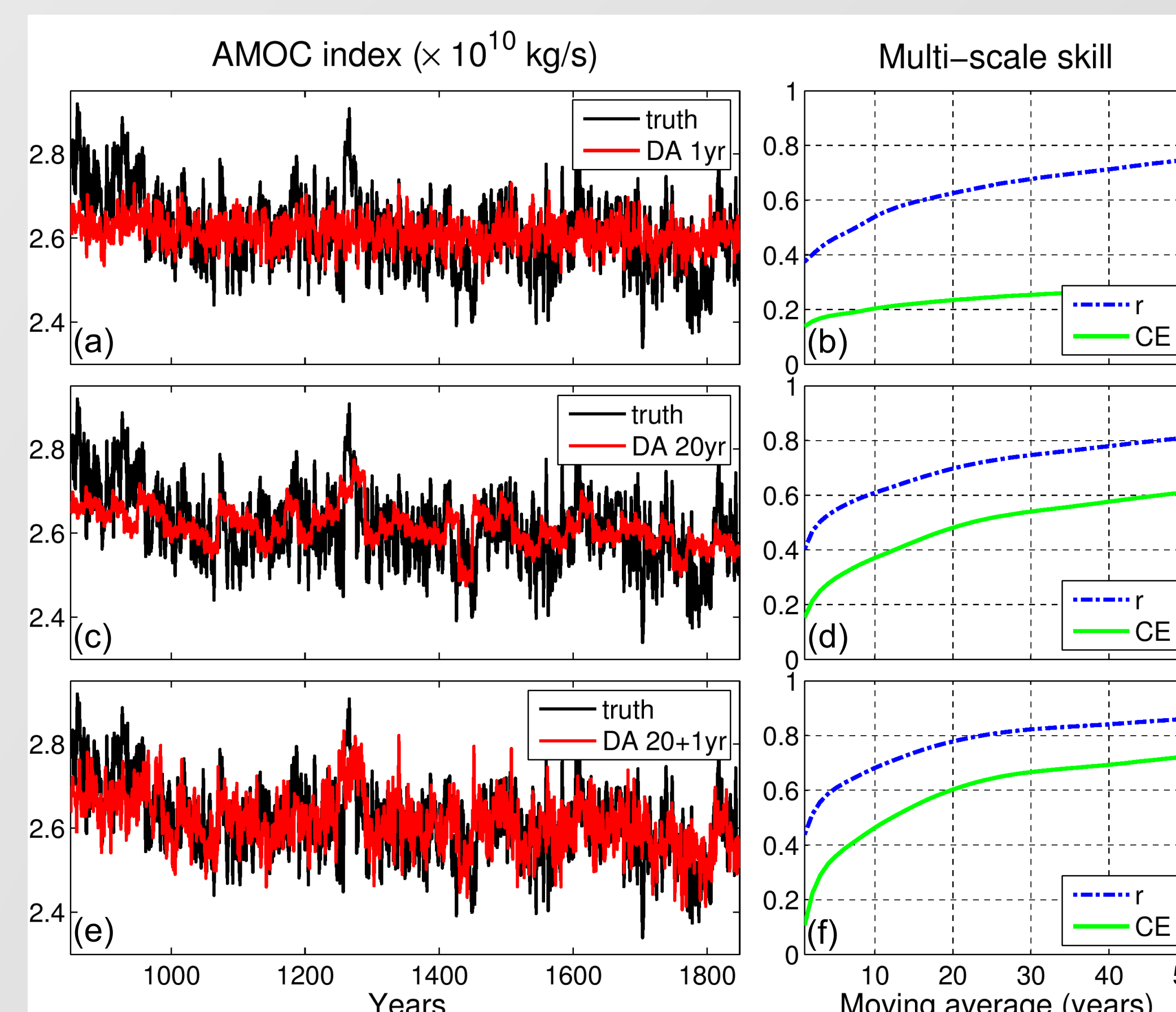
$$\mathbf{x}_a = \mathbf{x}_b + \mathbf{K}[\mathbf{y} - H(\mathbf{x}_b)]$$

Analysis (Posterior) Weights Observations/Proxies

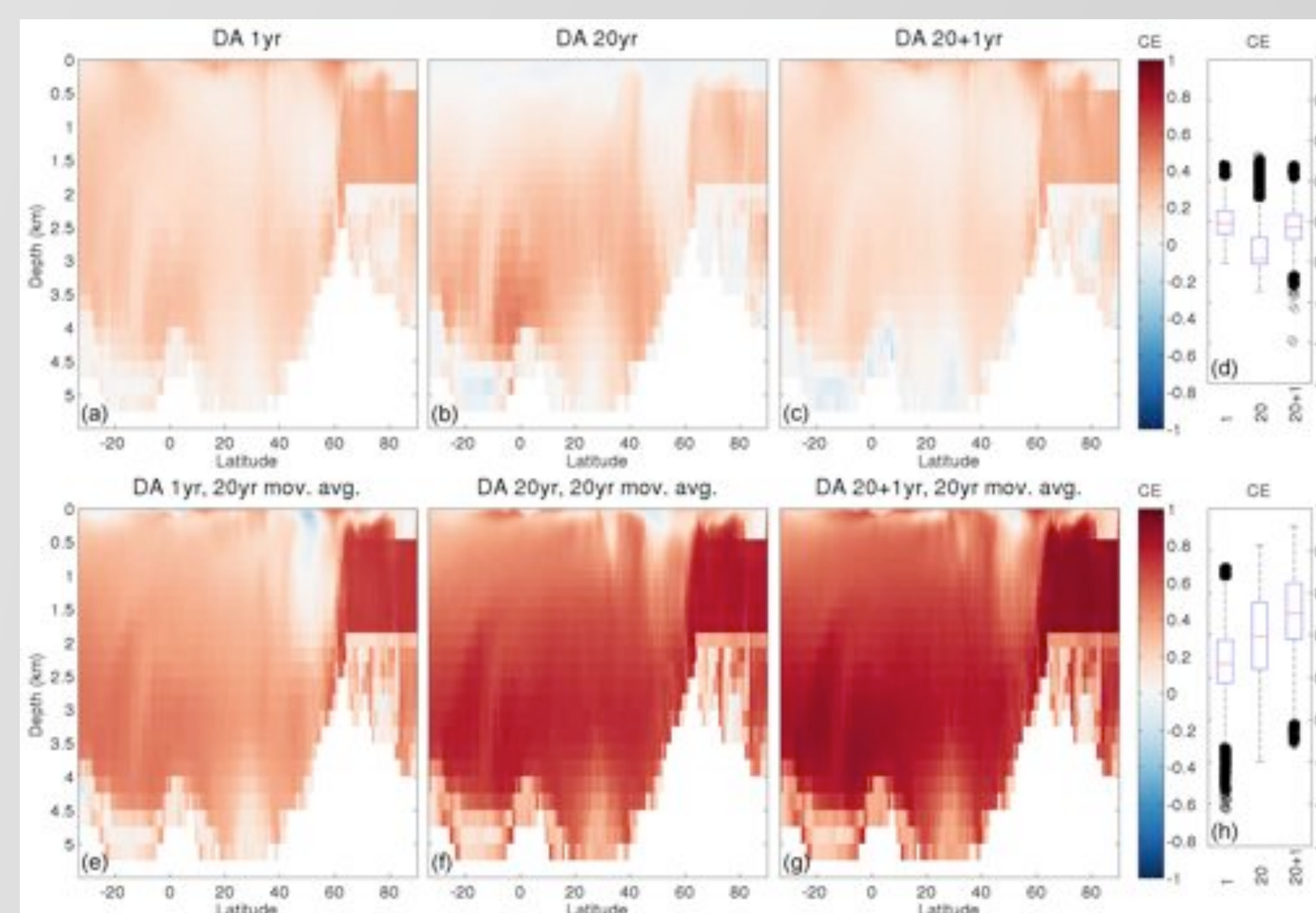
Background (Prior) Model Estimate of Observations/Proxies (proxy forward model)

MULTIPLE TIME SCALES

- Reconstructions using “off-line” ensemble DA with annual climate model states from CCSM₄ as the prior ensemble
- Assimilate 1 year and 20 year 2m surface temperature pseudoproxies created from CCSM₄
 - Locations characteristic of annual and low resolution proxy availability
 - Using SNR = 1, where SNR = std(signal)/std(noise)

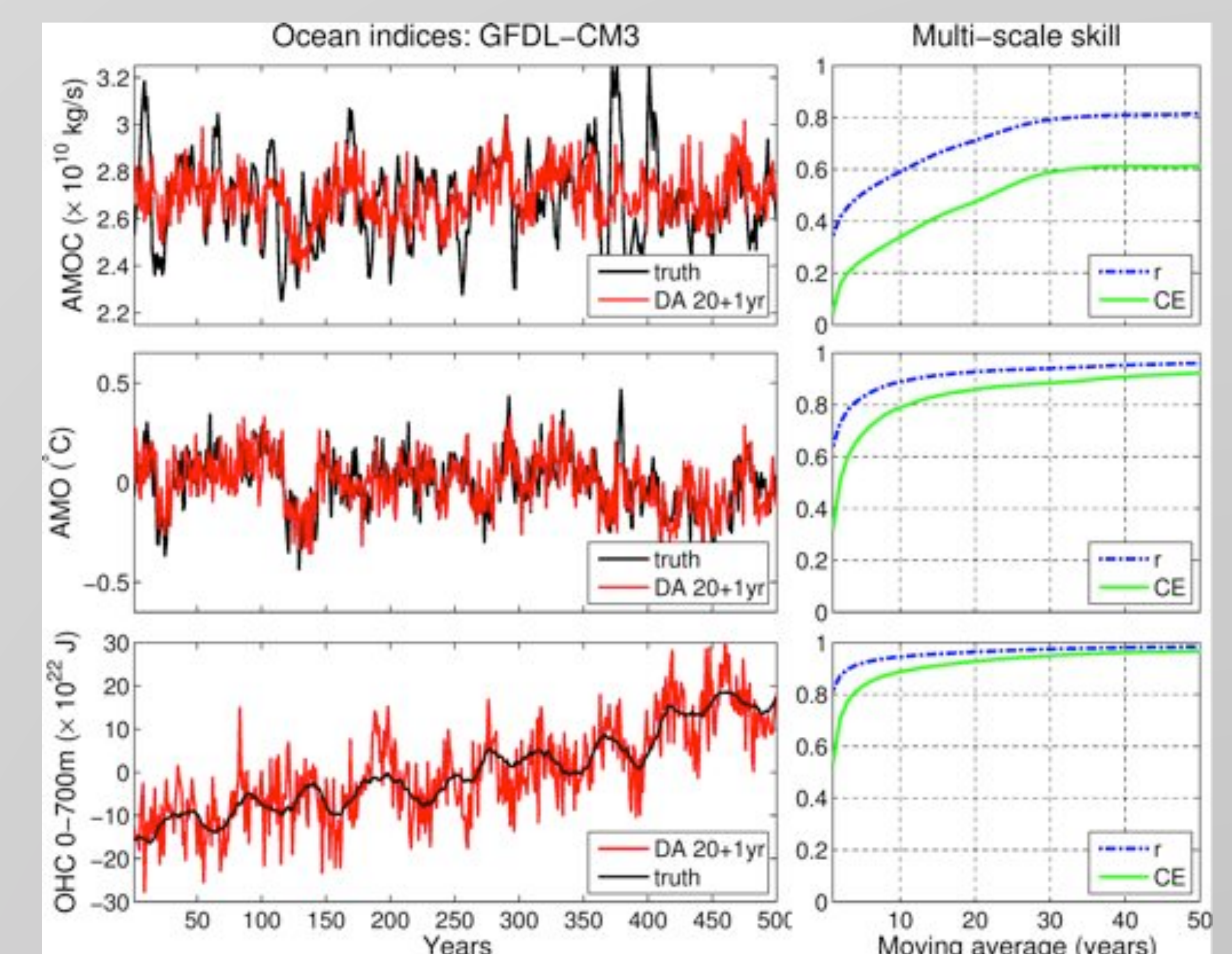
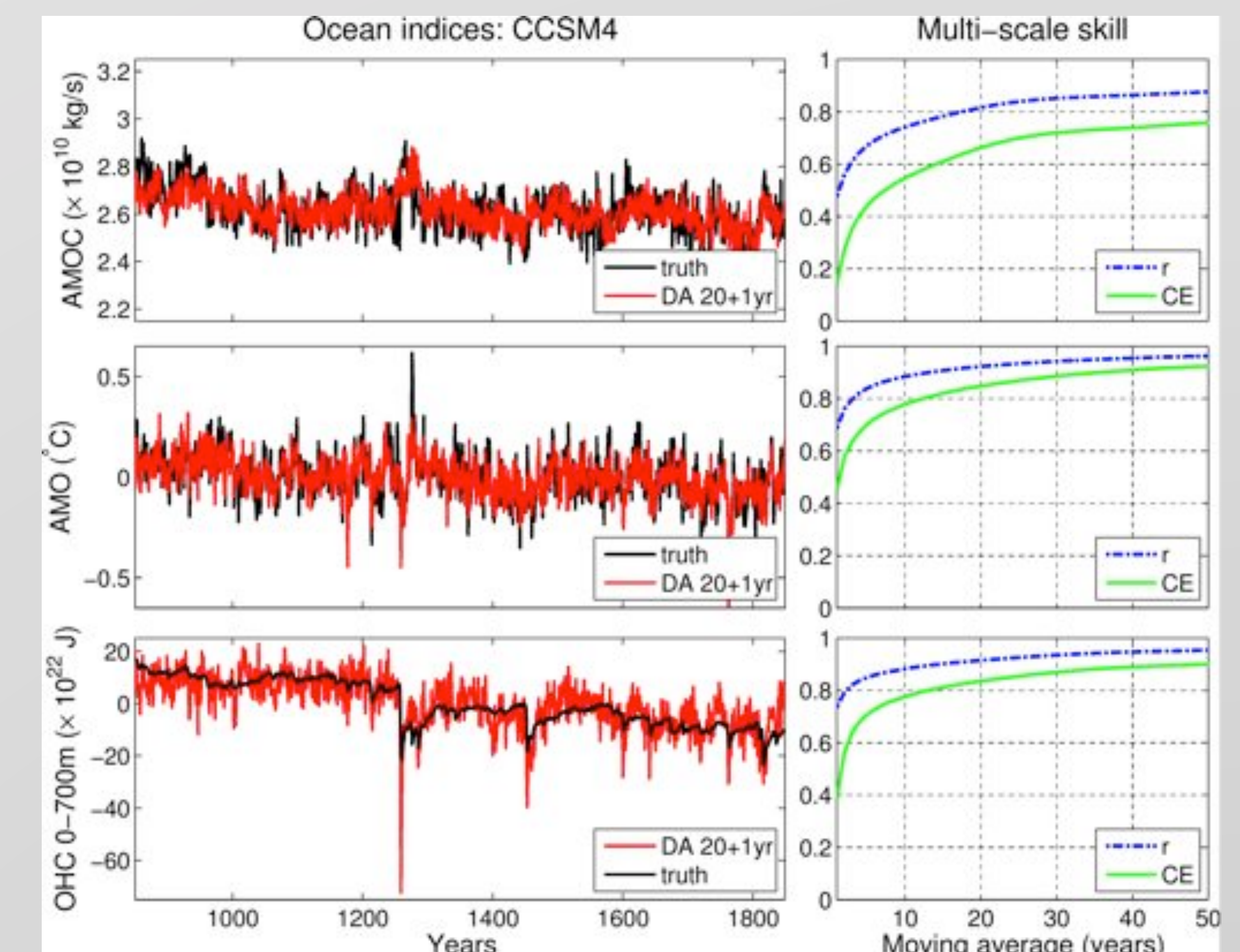


- Spatial skill for the entire AMOC variable at annual resolution and at a 20 year moving average. Box plots show the distribution of values in each spatial map.



MODELS AND VARIABLES

- Repeat previous reconstructions with *two* models (CCSM₄ and GFDL-CM₃) and multiple variables: AMOC, Atlantic multidecadal oscillation (AMO), global ocean heat content (OHC)



FUTURE DIRECTIONS

- Incorporate all known uncertainties
 - Choice of model, proxy noise characteristics, proxy dating uncertainty, proxy system modeling
- Perform real proxy reconstructions over the past 2,000 years

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