



**National
Oceanography Centre**

NATURAL ENVIRONMENT RESEARCH COUNCIL



**National Centre for
Earth Observation**

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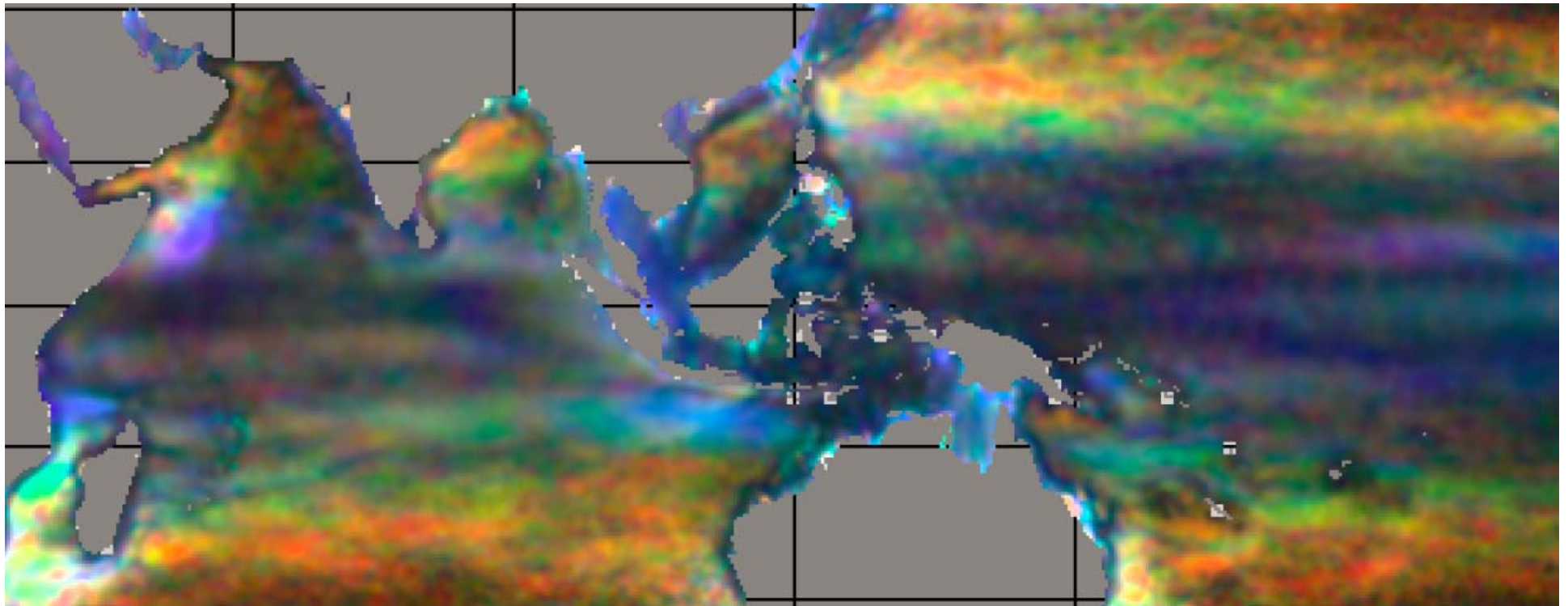
Colour of the sea level spectrum: When are observed trends statistically significant?

Chris W. Hughes and Simon D. P. Williams

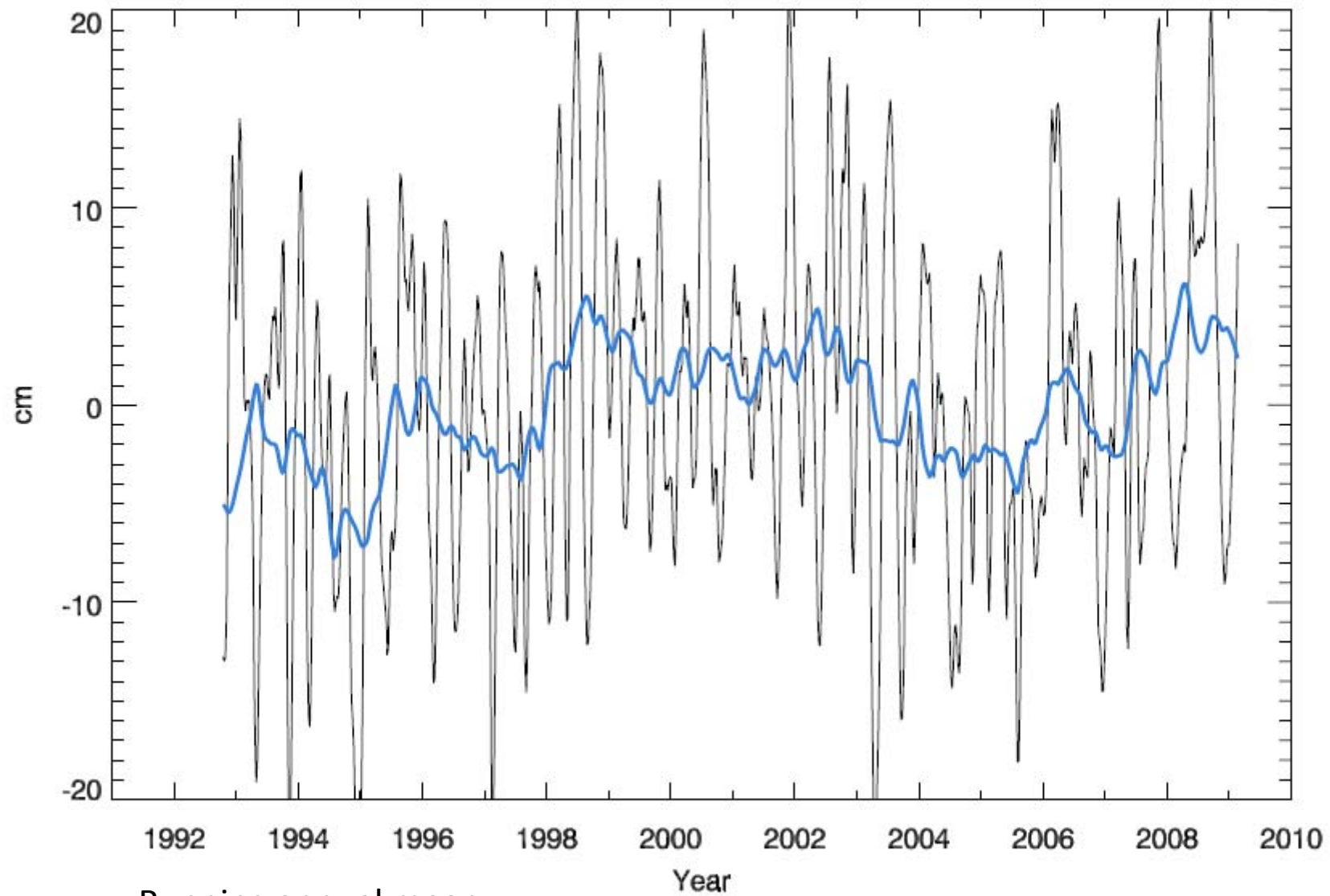
NOC (Liverpool)

Picture by Susan Woodworth

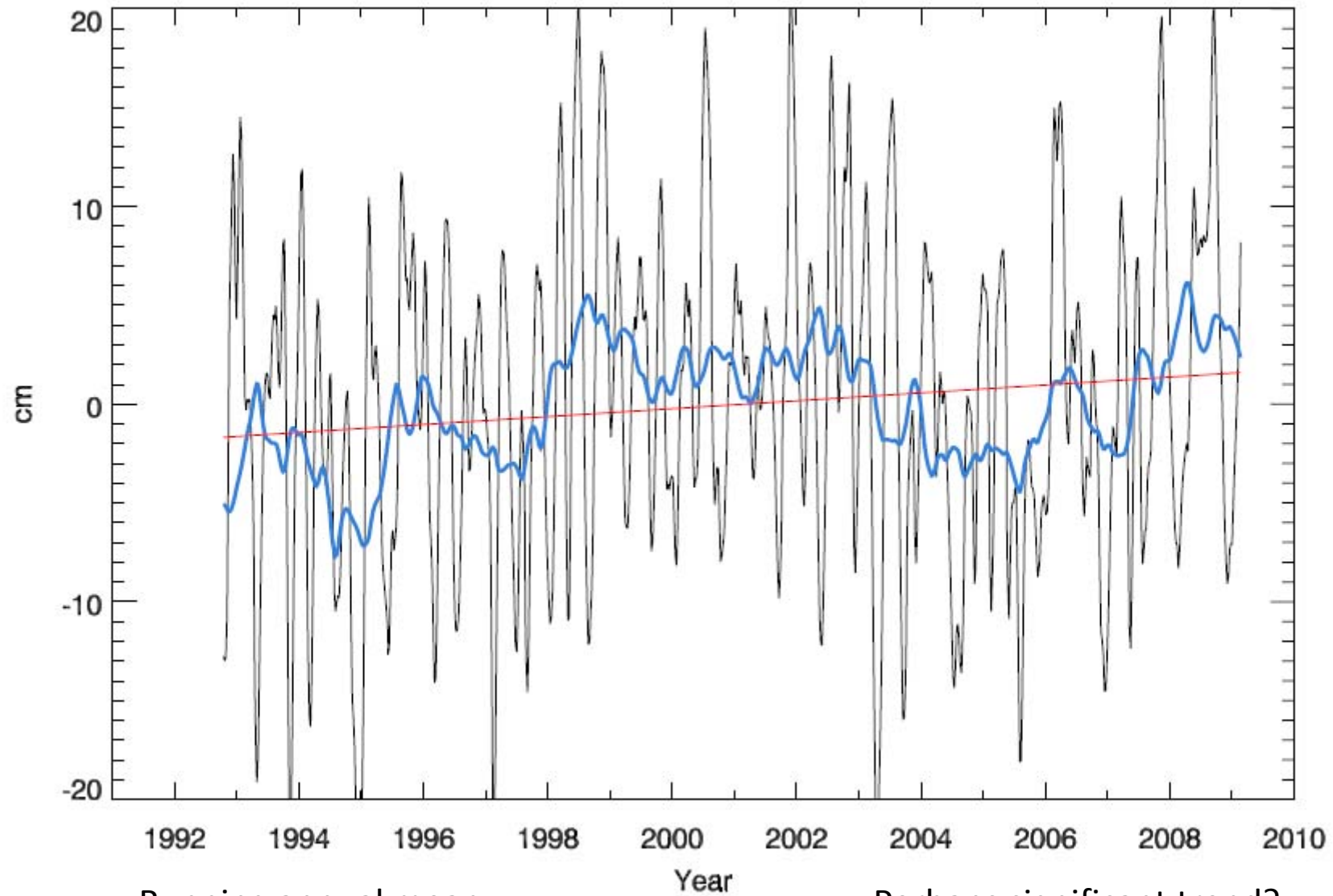
The sea level rainbow



Sea level time series from a point in the Pacific



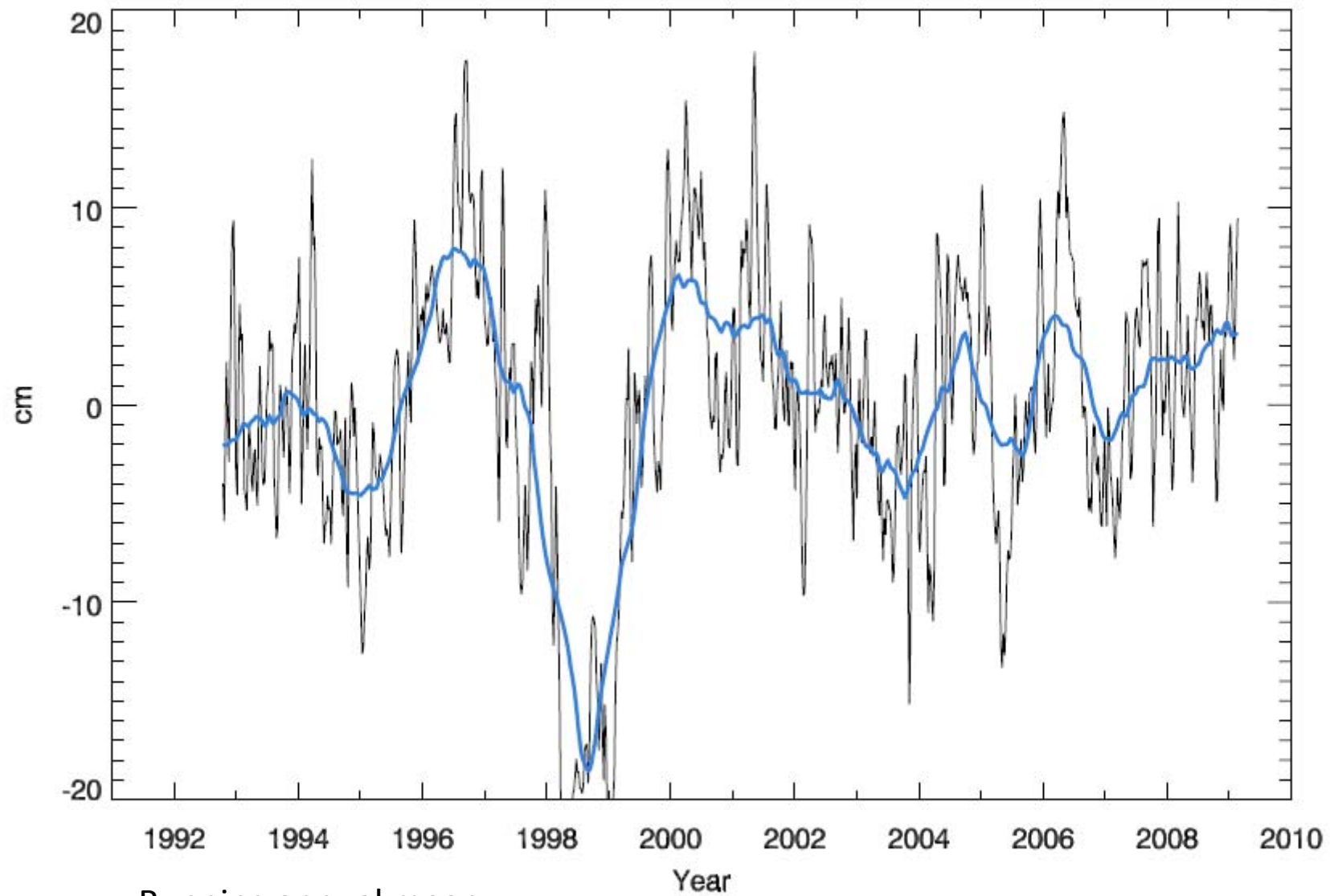
Sea level time series from a point in the Pacific



Running annual mean

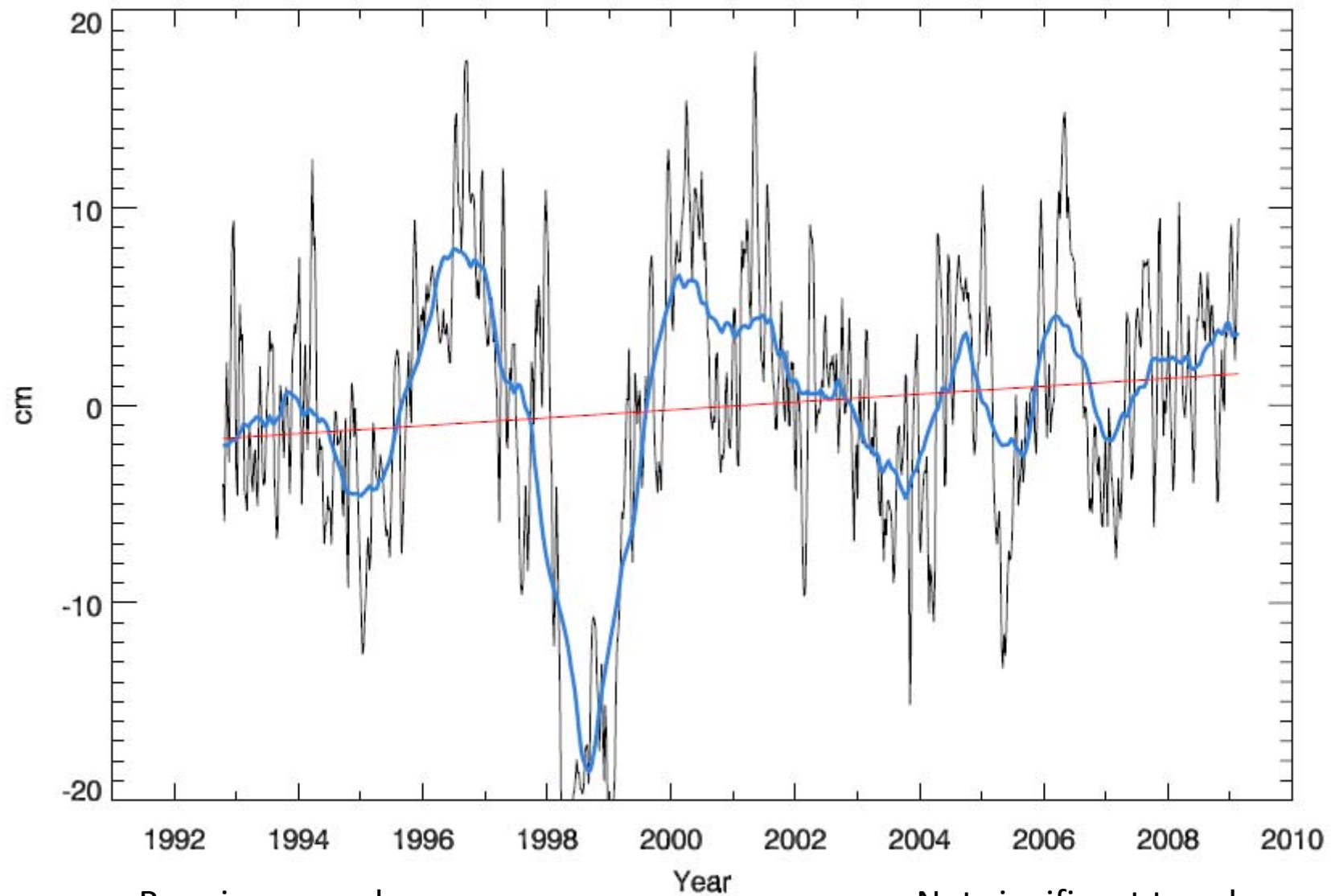
Perhaps significant trend?

Sea level time series from a point in the Pacific



Running annual mean

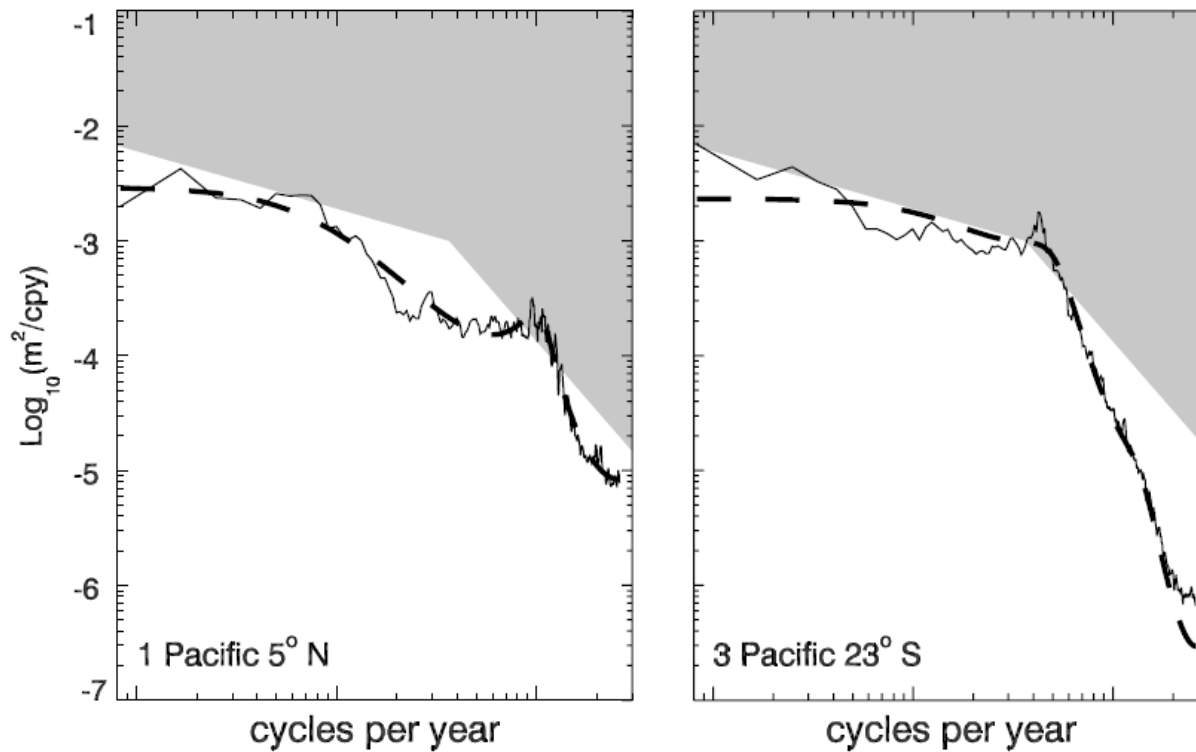
Sea level time series from a point in the Pacific



Running annual mean

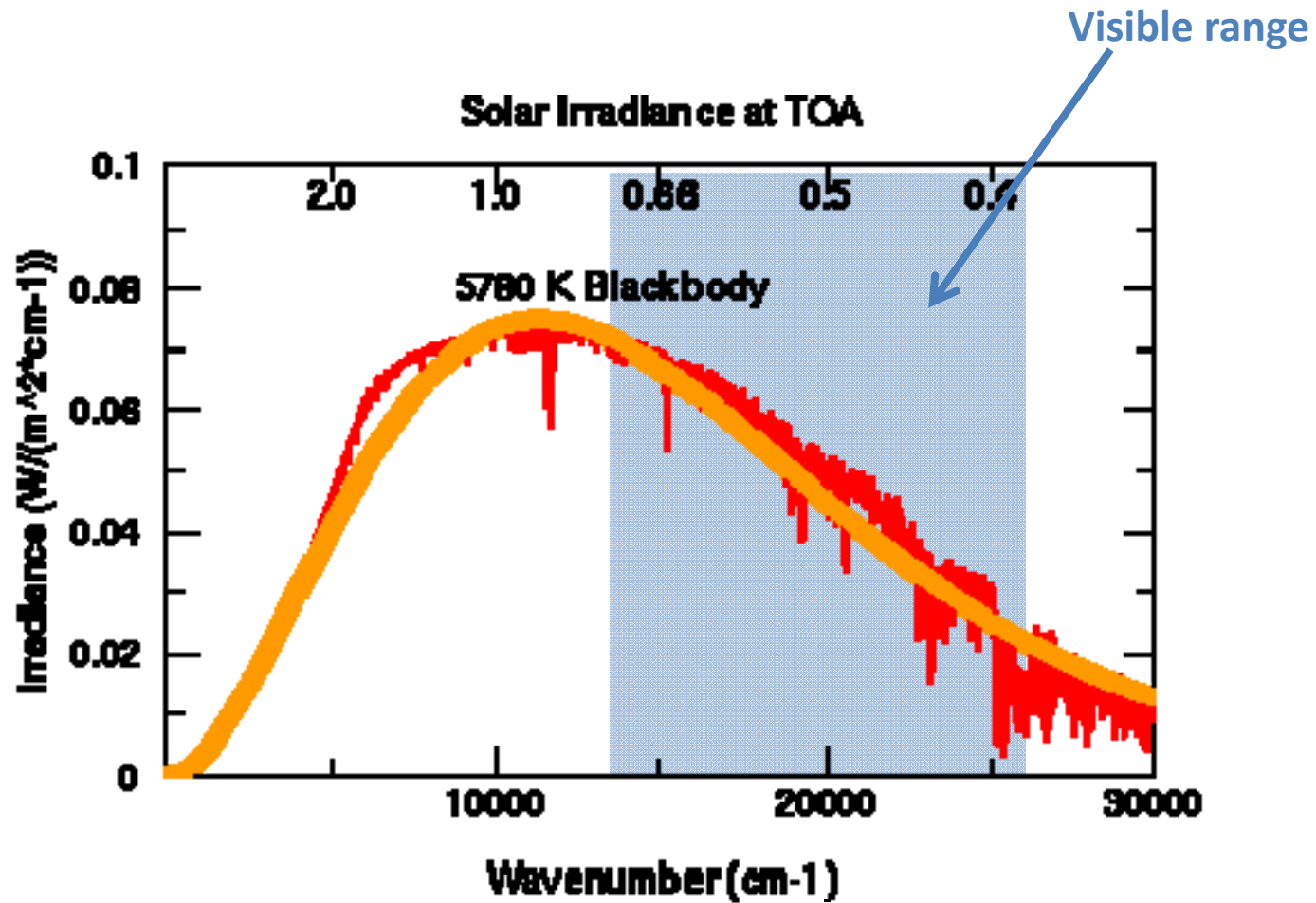
Not significant trend

Same standard deviation, same trend, just different shapes of spectra

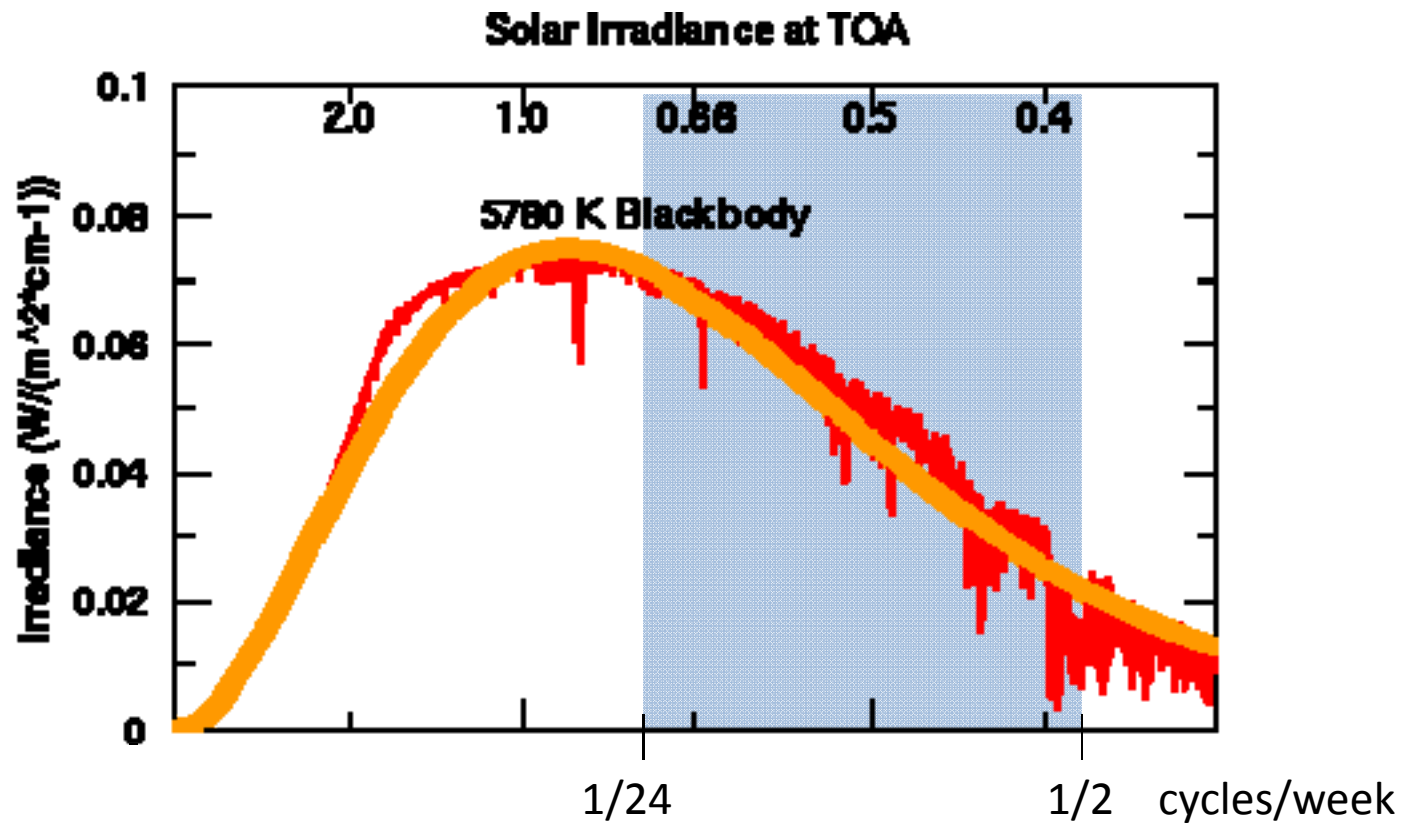


How much variation is there in the shape of the spectrum?
Need a way to show this without plotting a spectrum for each
grid point.

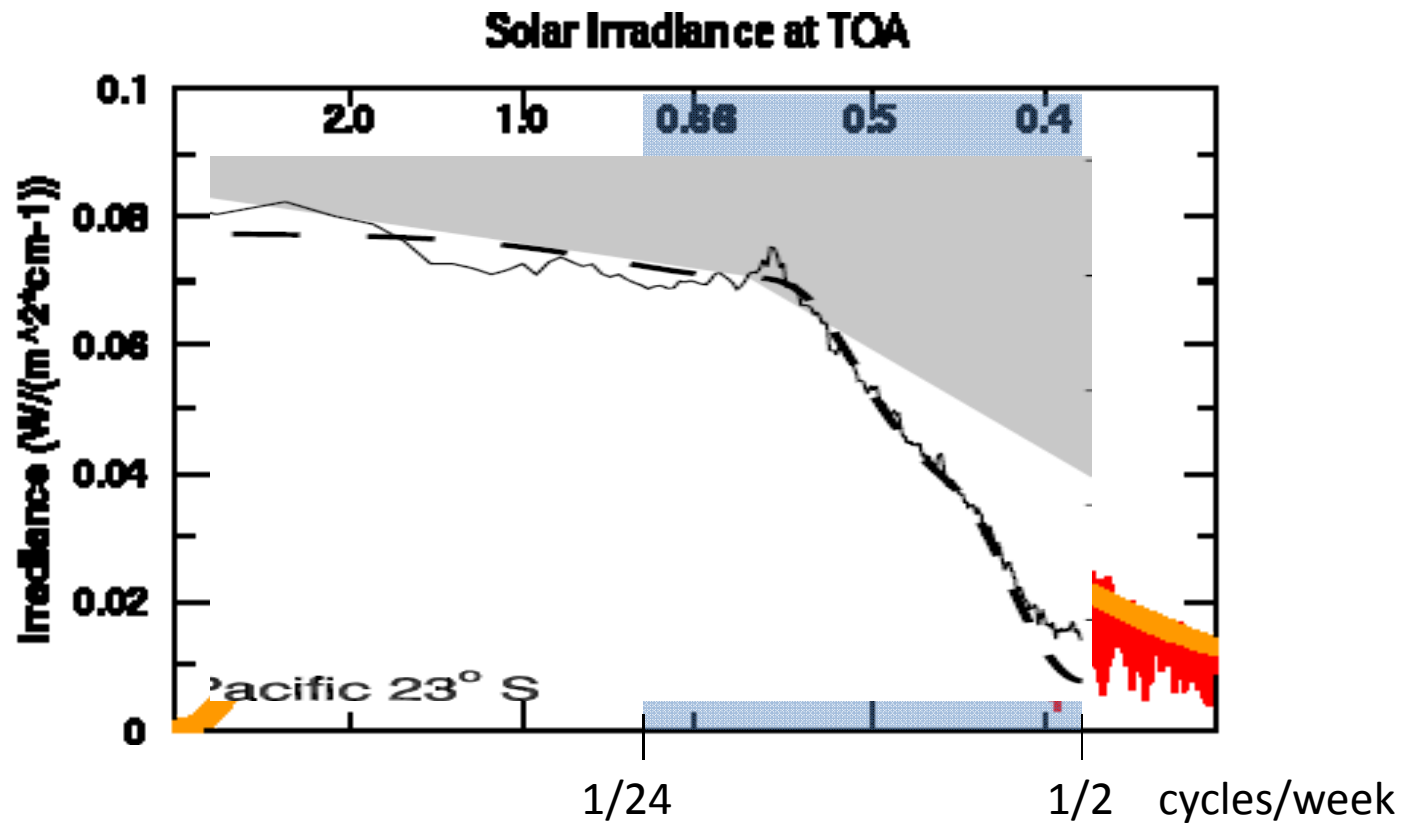
The solar spectrum



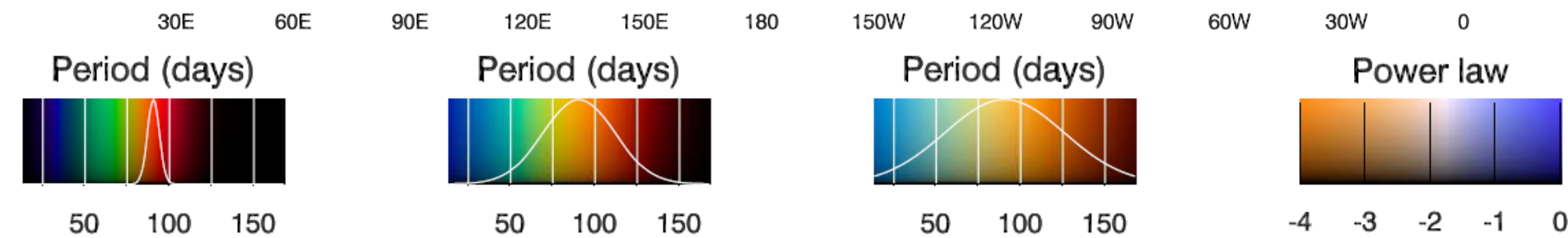
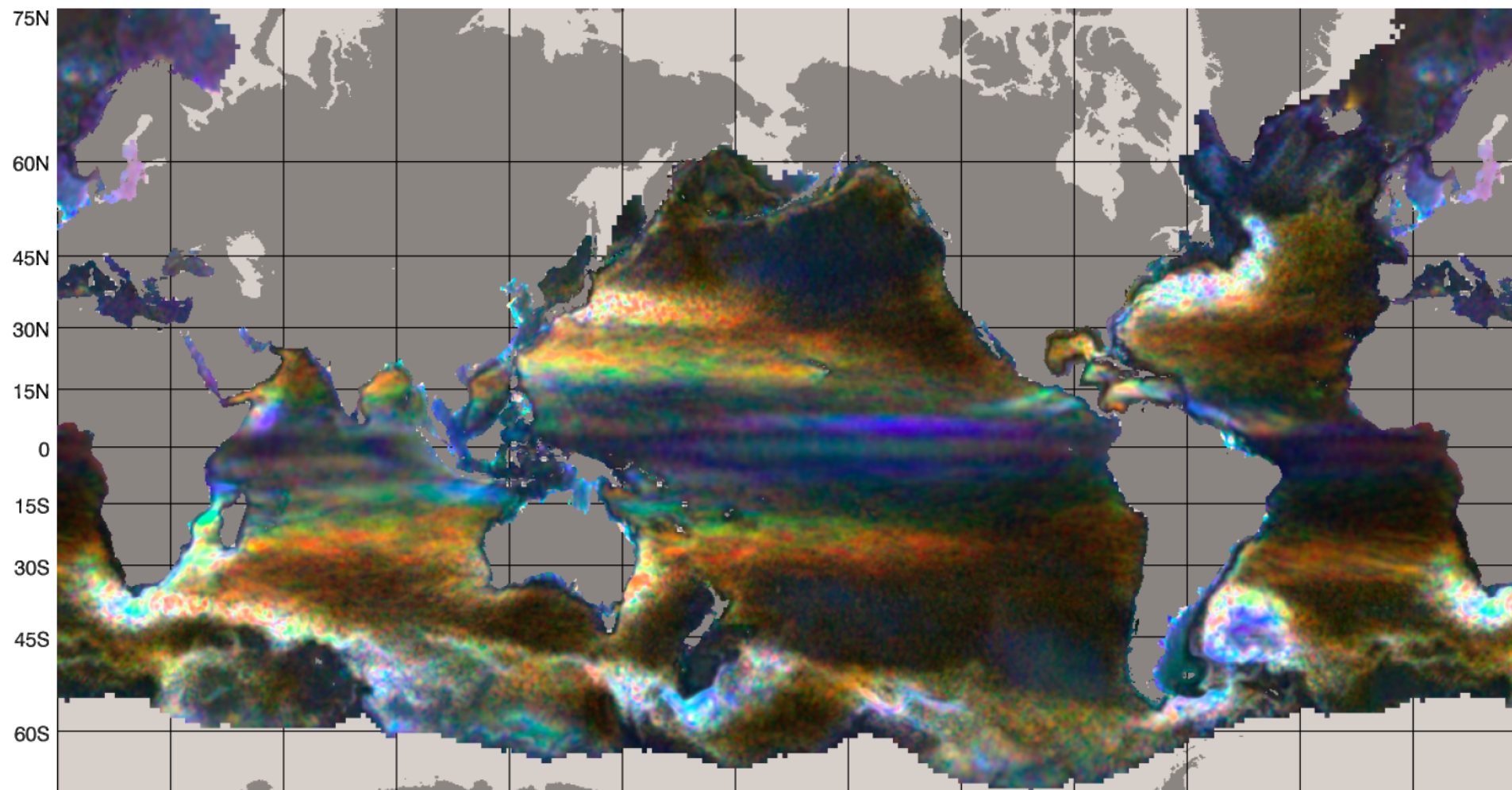
Courtesy, Bob Cahalan, NASA Goddard



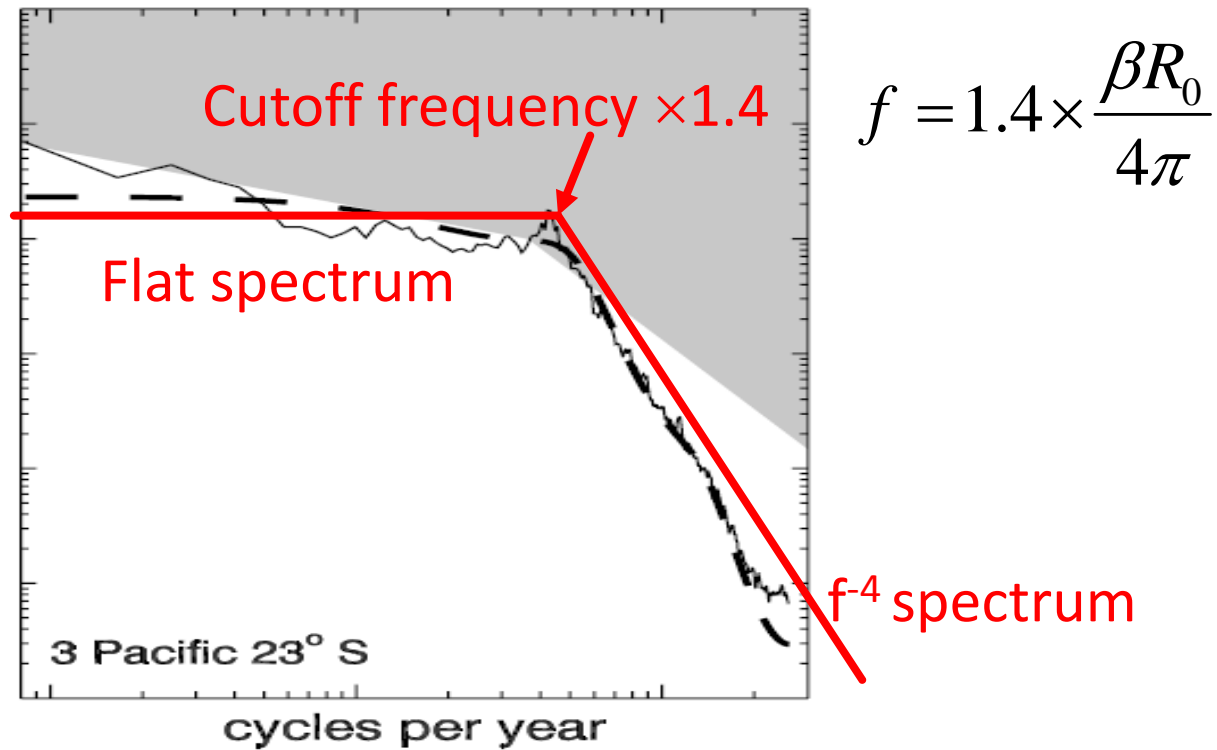
Courtesy, Bob Cahalan, NASA Goddard



Courtesy, Bob Cahalan, NASA Goddard

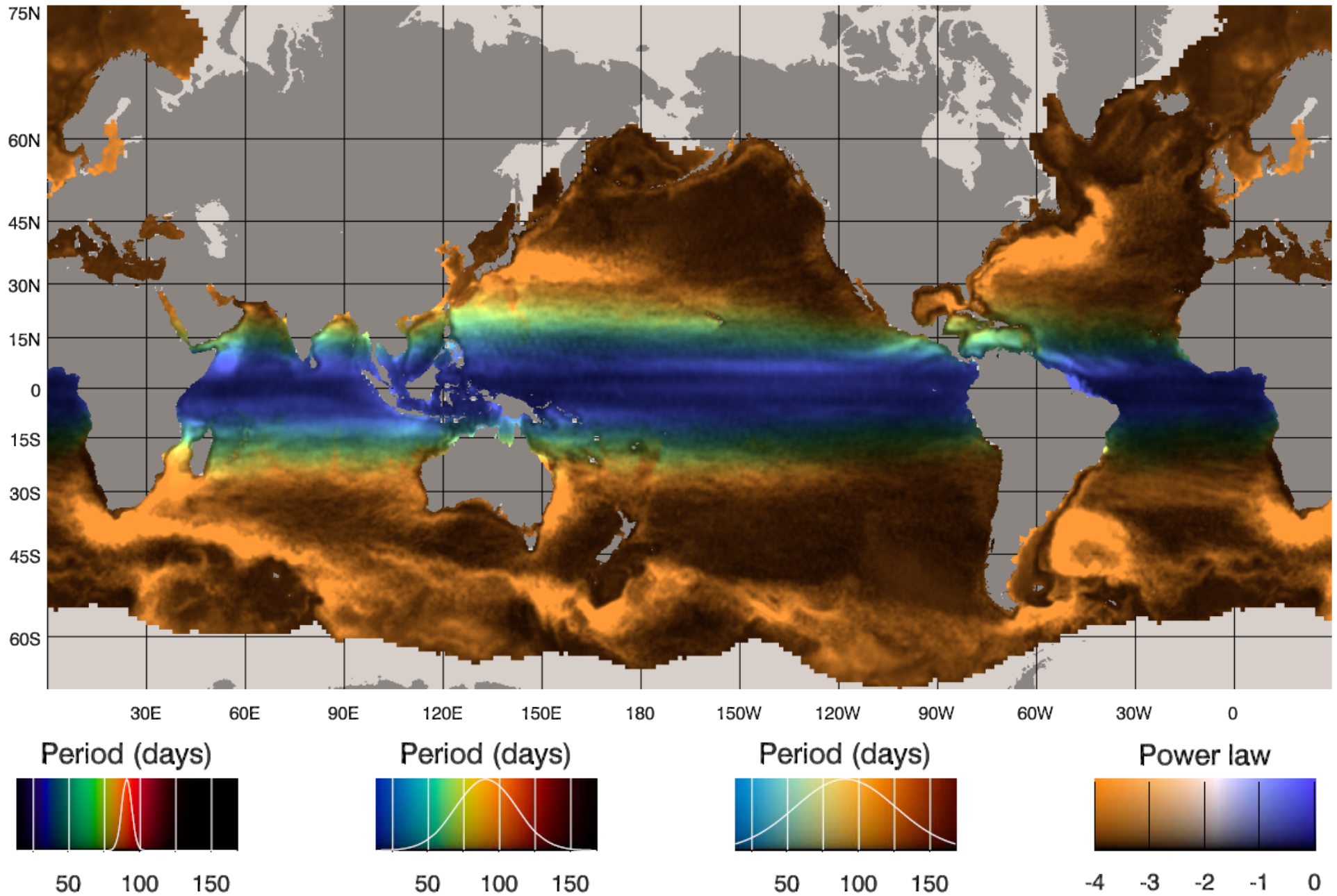


Rossby wave cut-off model spectrum

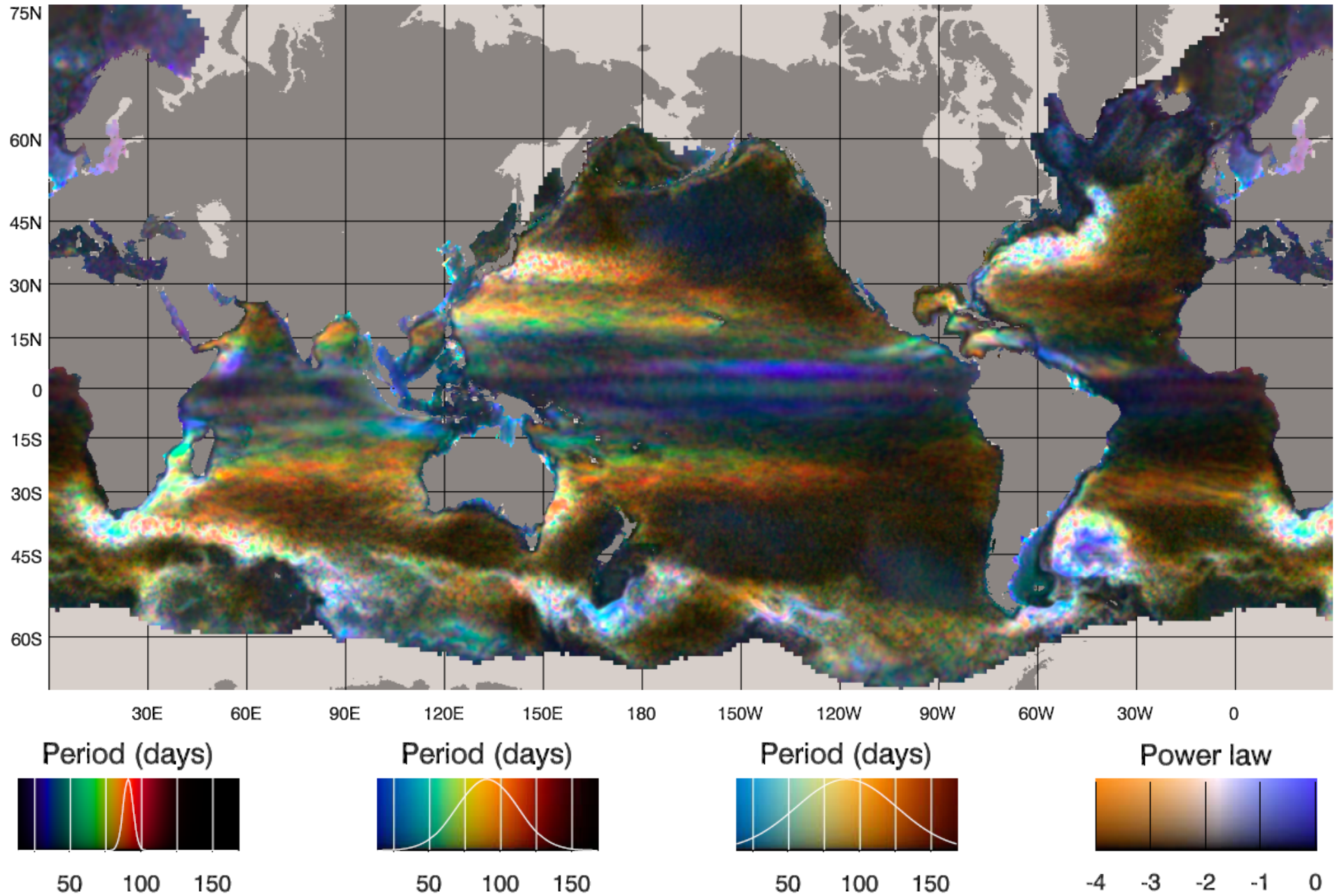


Cutoff frequency calculated at each grid point based on mapped first-baroclinic rossby radii taken from Chelton et al. (1998). We find the best fit when multiplying by about 1.4.

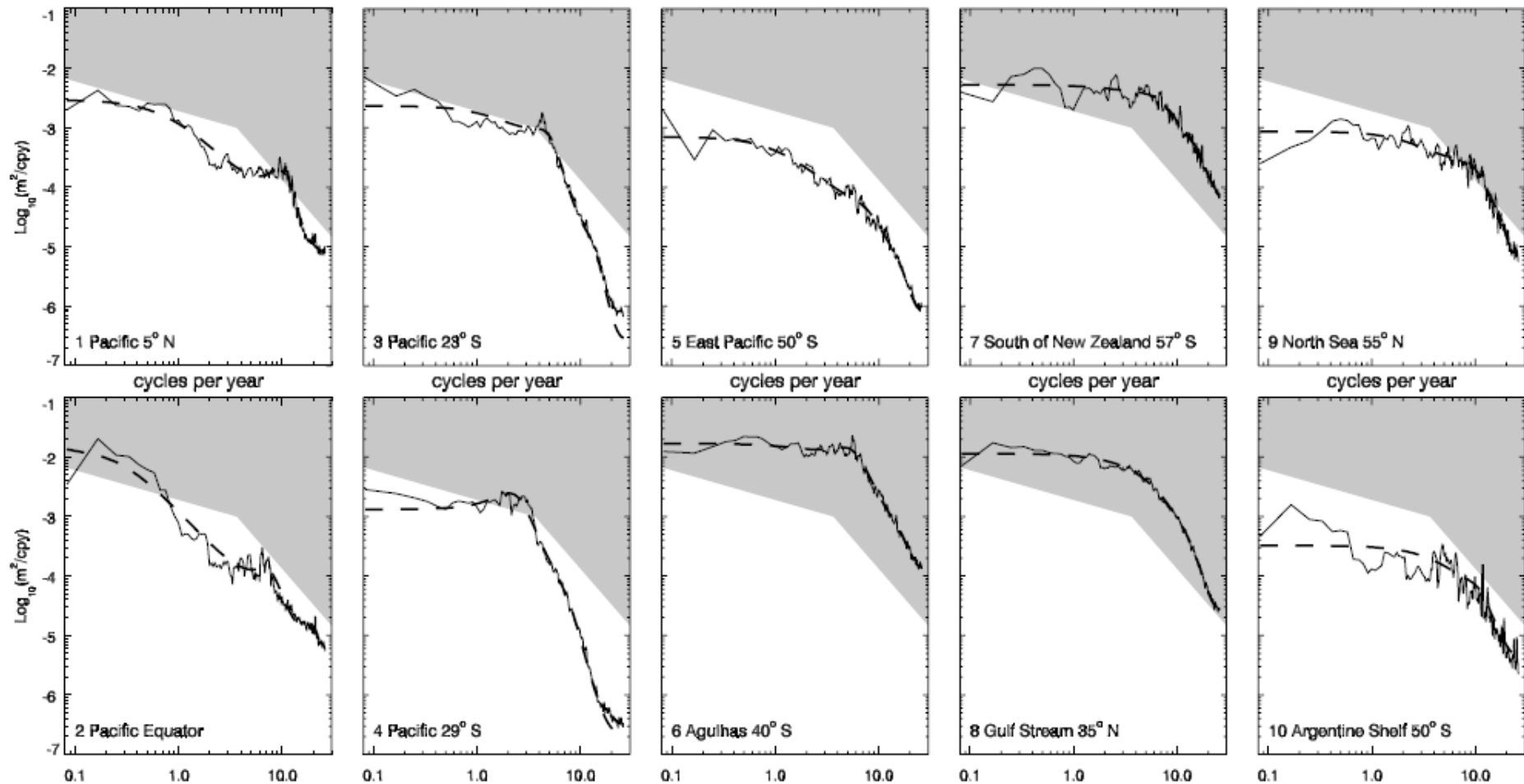
The spectrum using the Rossby wave model



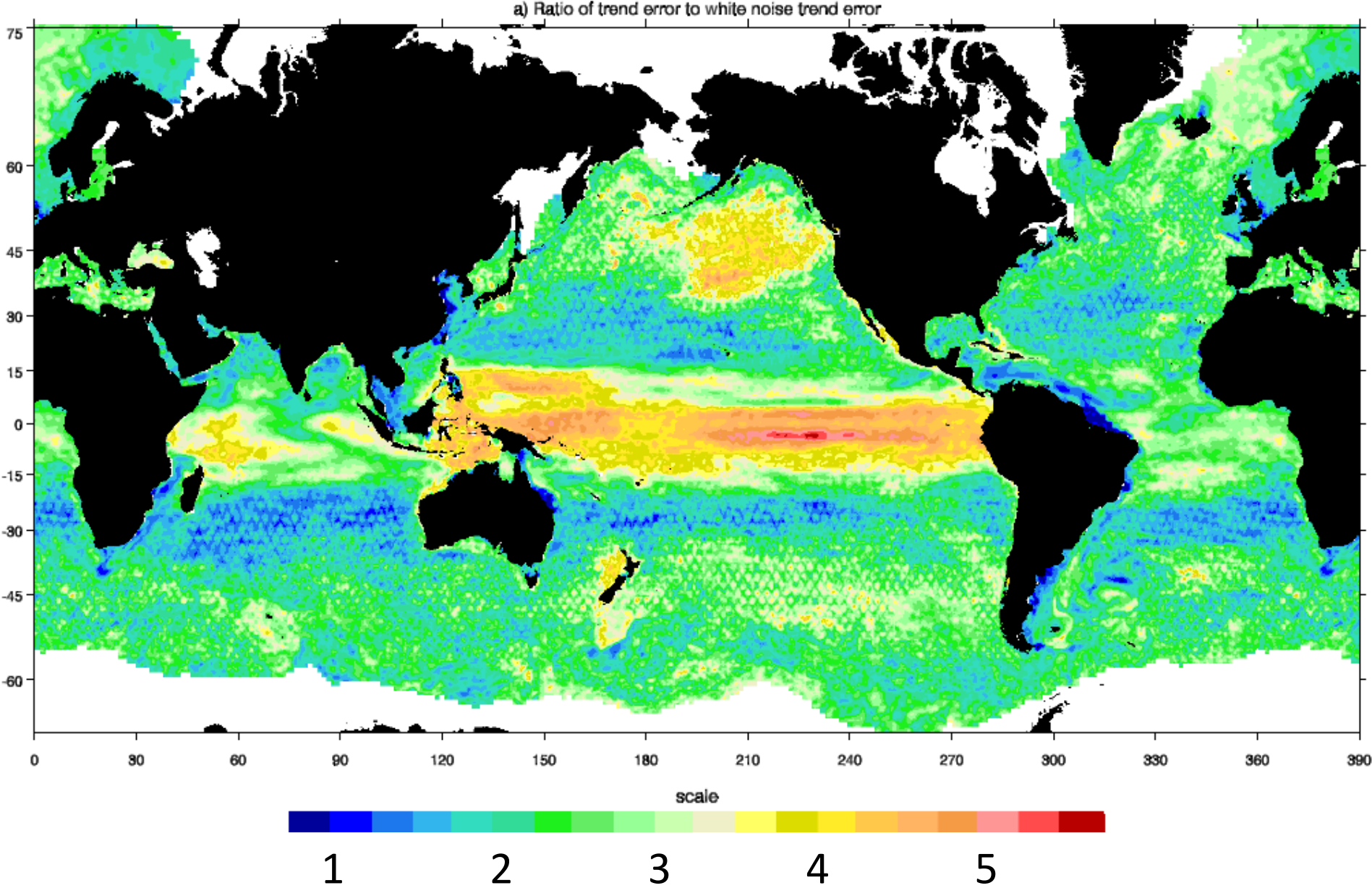
The observed spectrum



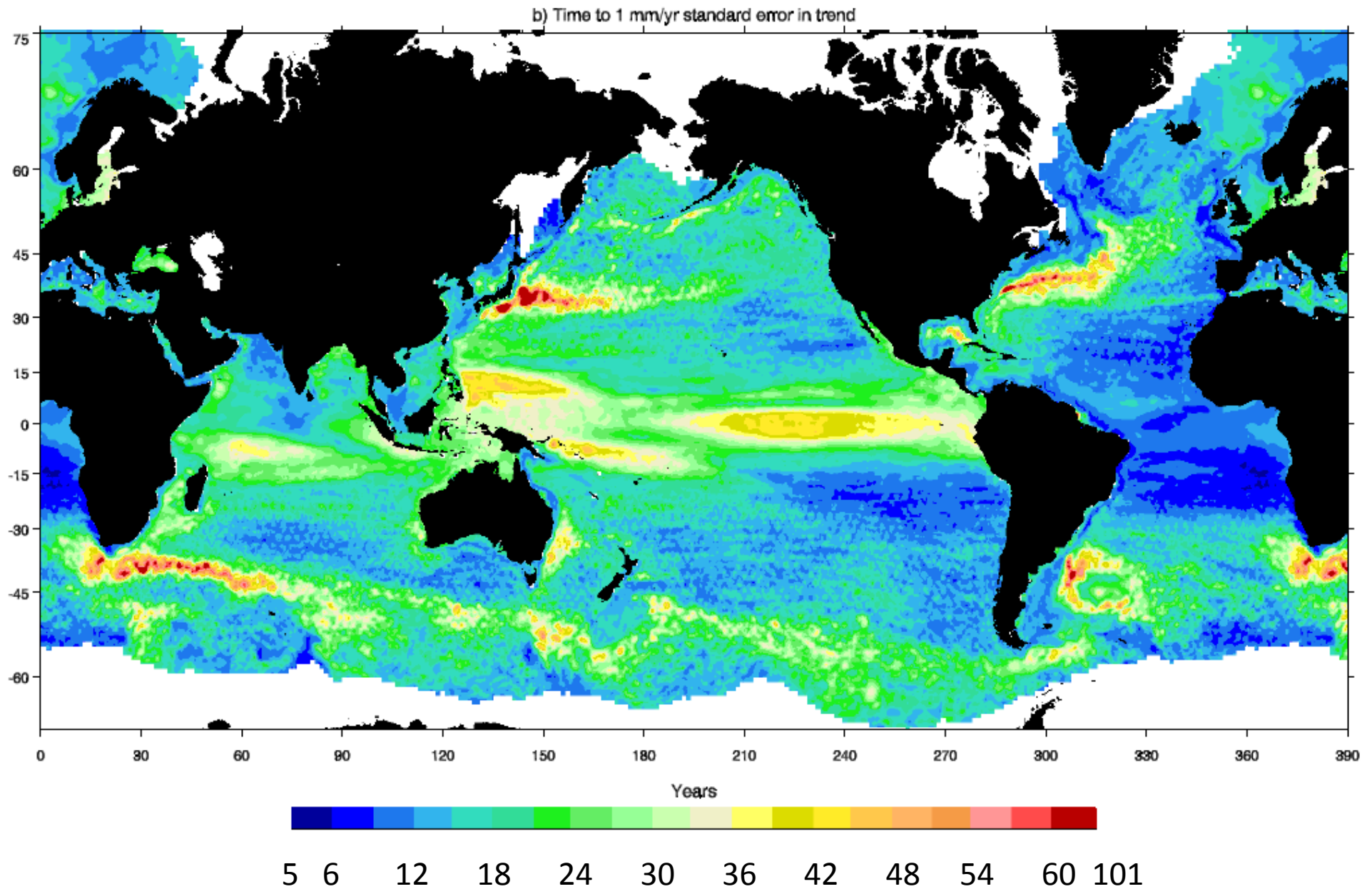
Shapes of spectra are actually much more varied than this: we find they can generally be modelled with a 5th order autoregressive model – AR(5) – shown here as the dashed curve.



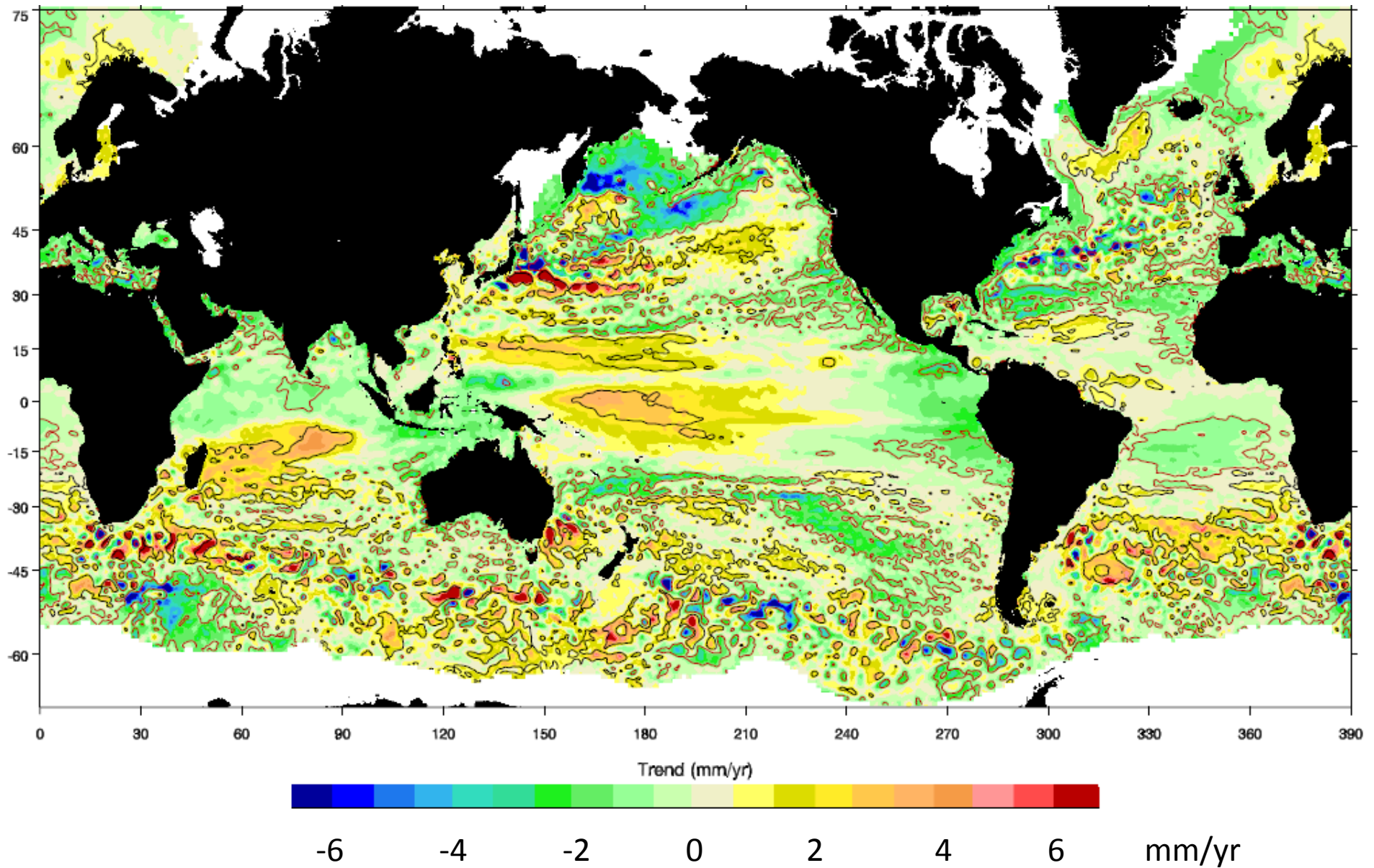
Given a spectral model at each point, we can calculate trend errors:



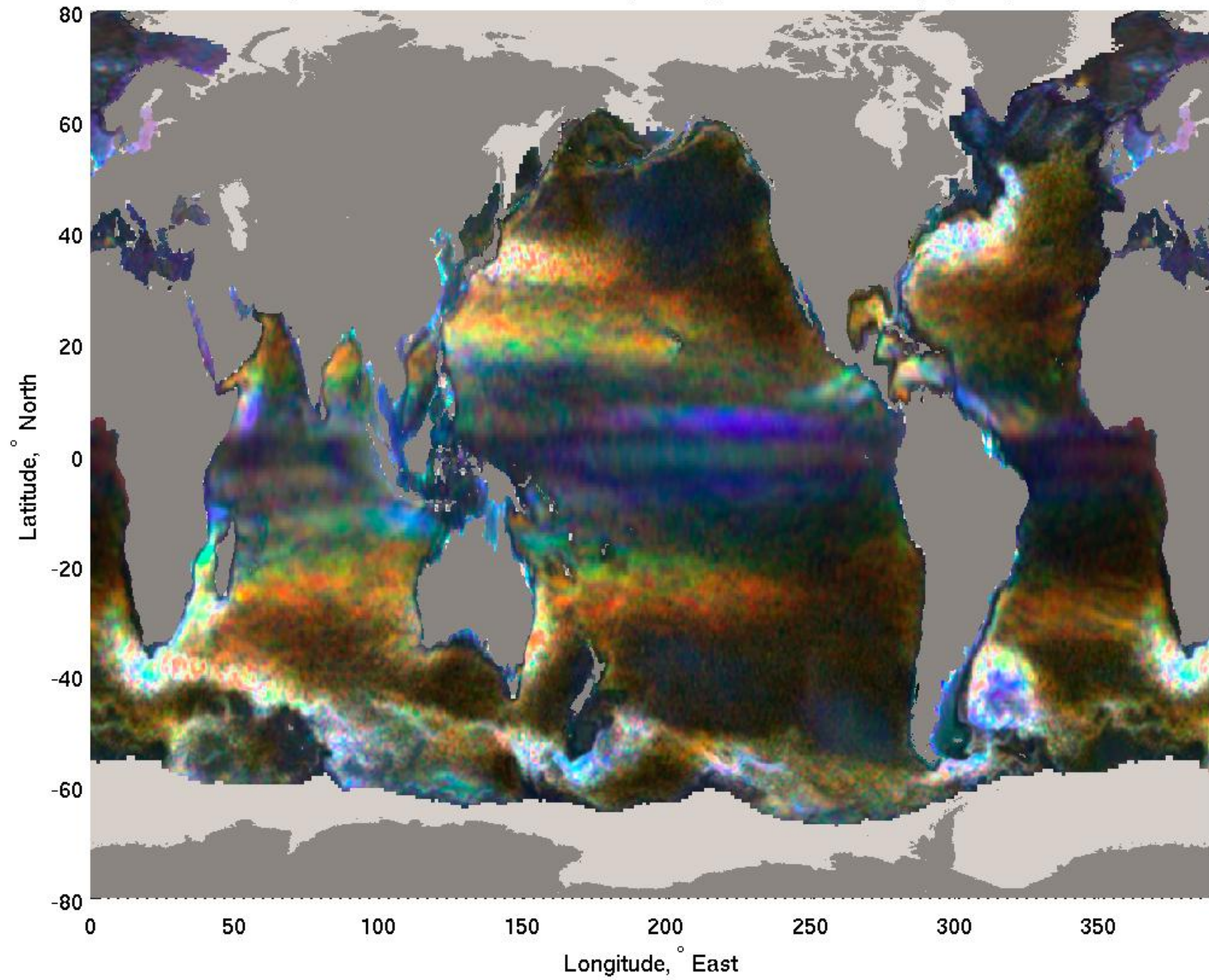
Number of years needed for 1 mm/yr to be the statistical error



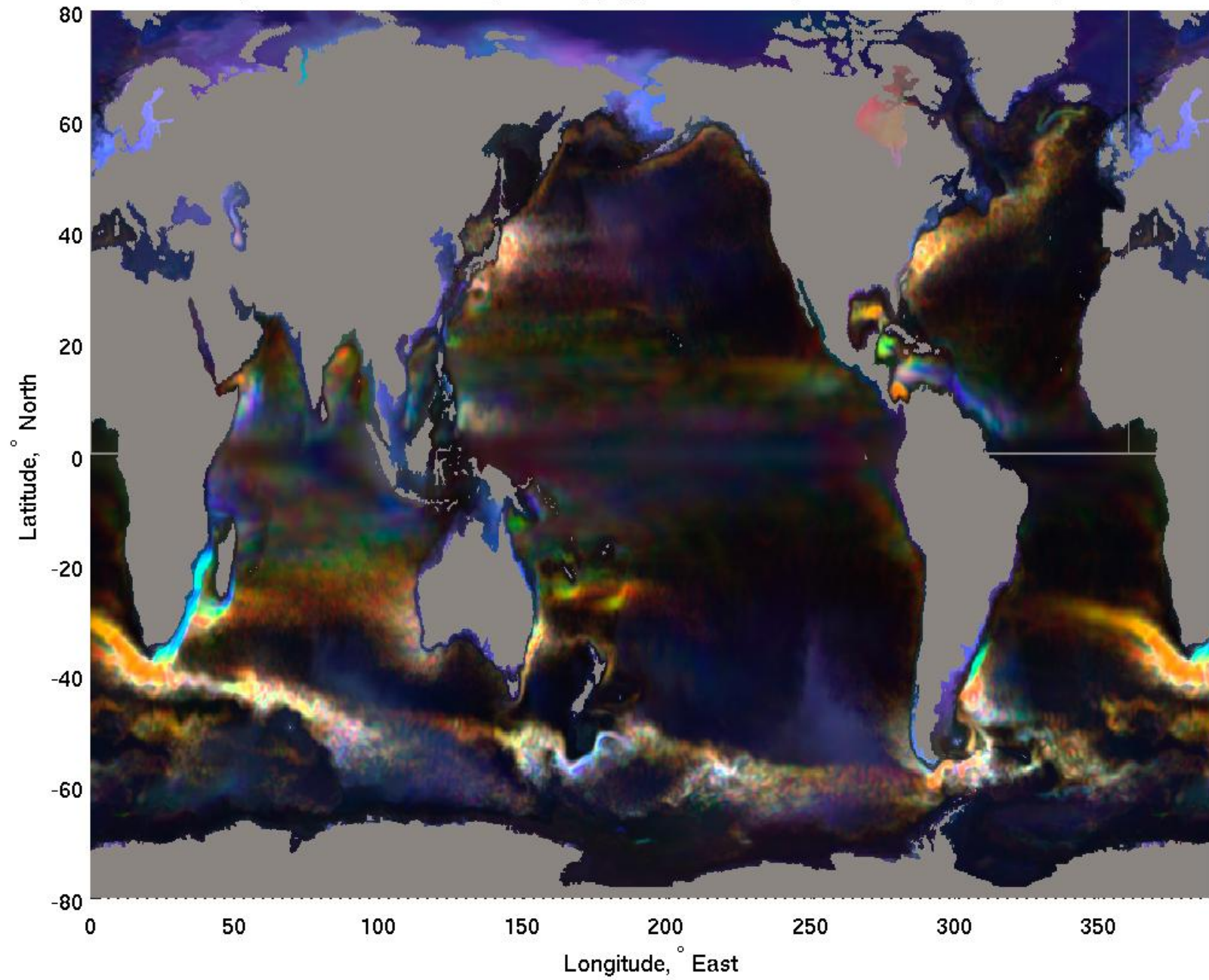
April 1995 – April 2007 trend minus a global average of 3.2 mm/yr.
Contours indicate 2σ significance



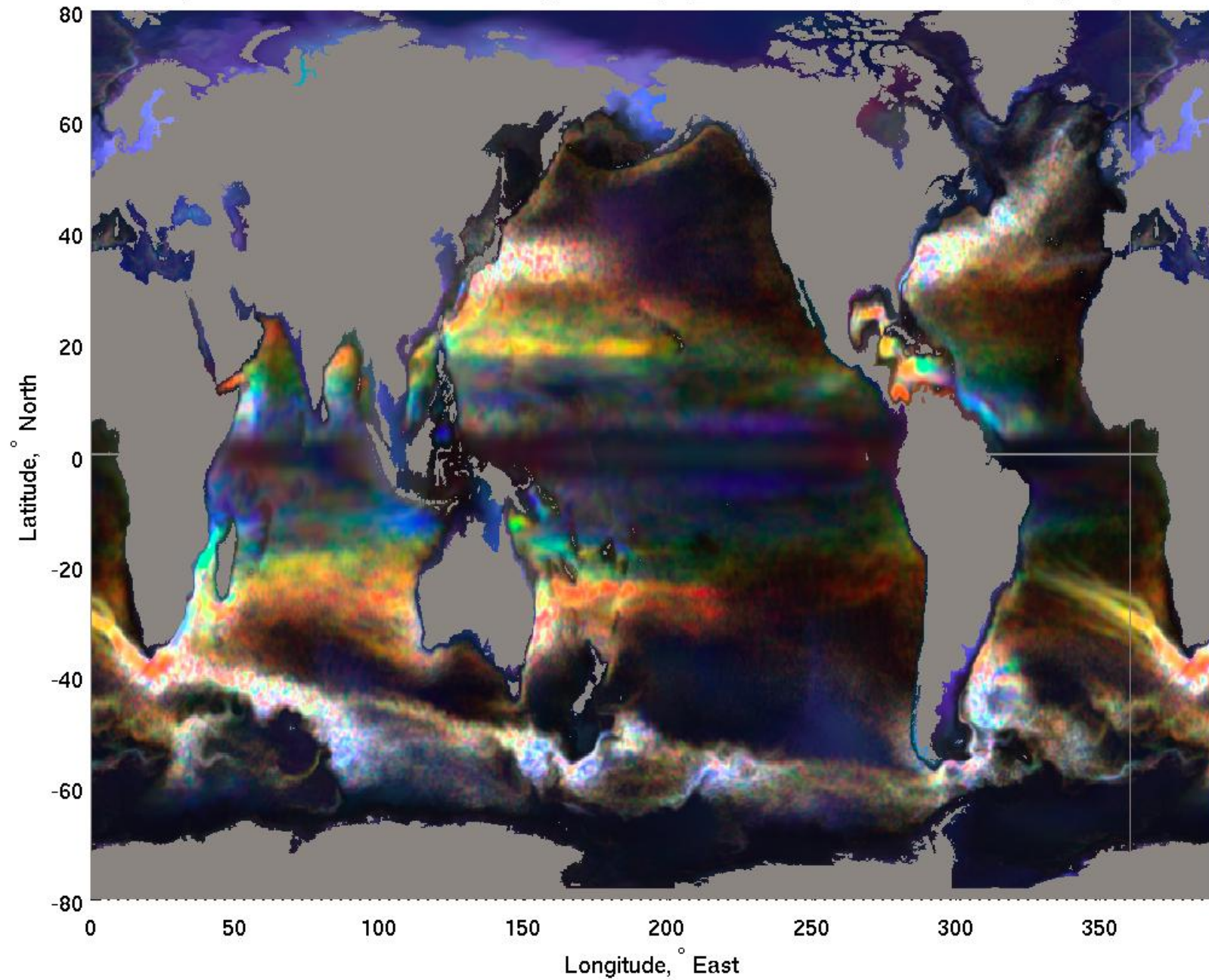
Observed spectrum



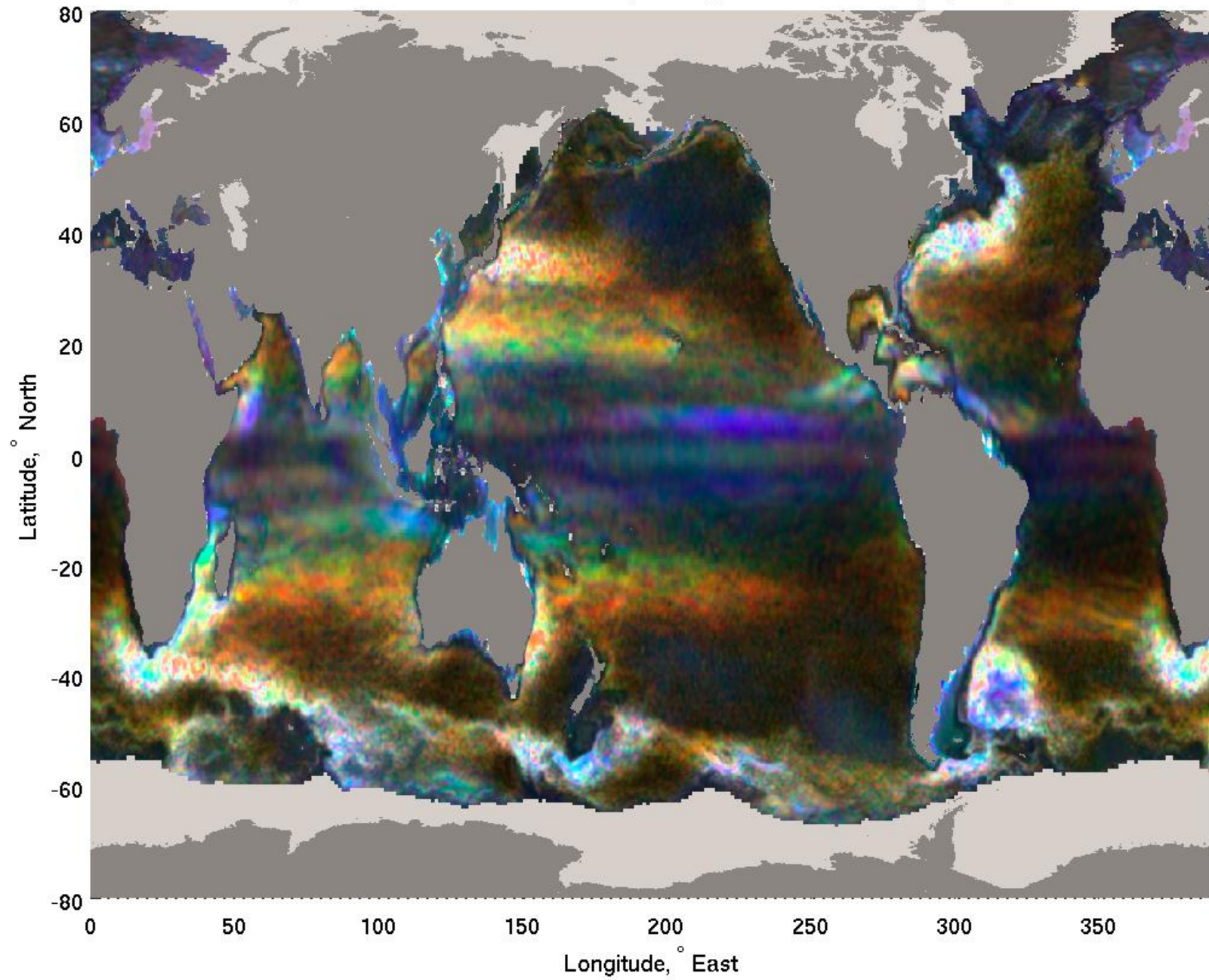
OCCAM model spectrum, $\frac{1}{4}$ degree resolution



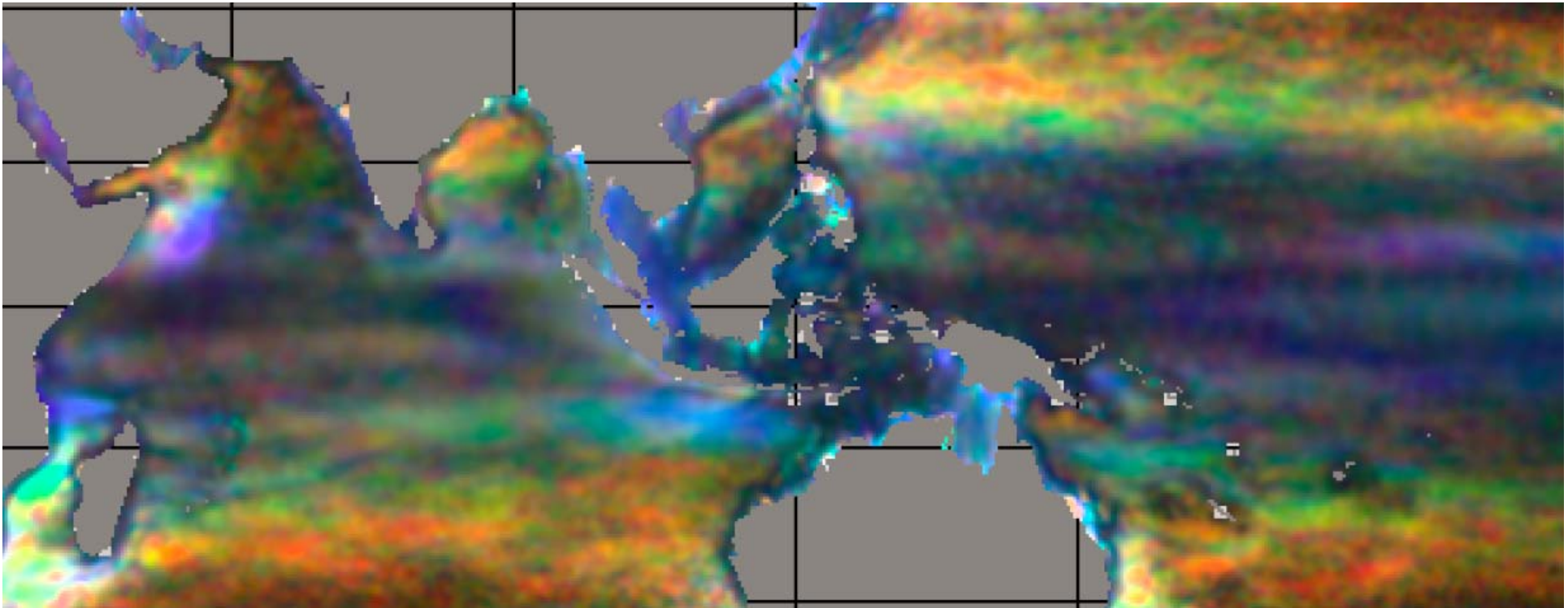
OCCAM model spectrum, 1/12 degree resolution



Observed spectrum



Conclusion



- The spectrum of sea level variability is far from uniform in shape, and changes can be over short distances.
- Differences in the shape tell us about the dynamics of the ocean, including the relevance of Rossby wave dynamics.
- Differences in shape must be accounted for to determine whether sea level trends are statistically significant.

Order of AR model recommended by BIC

