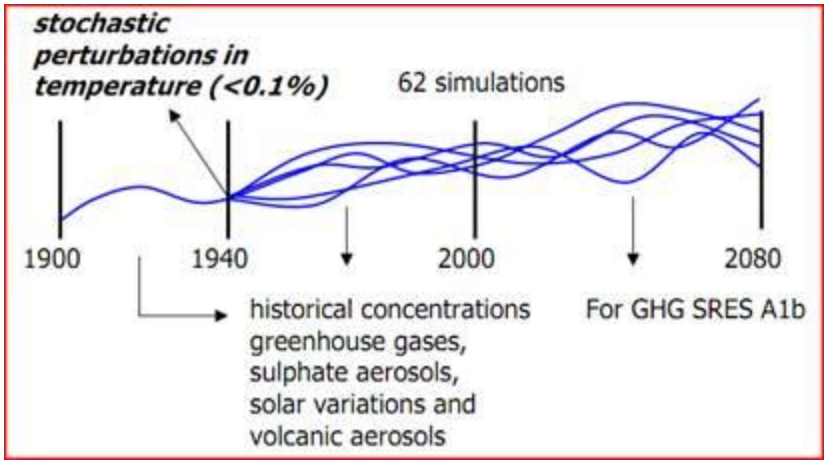
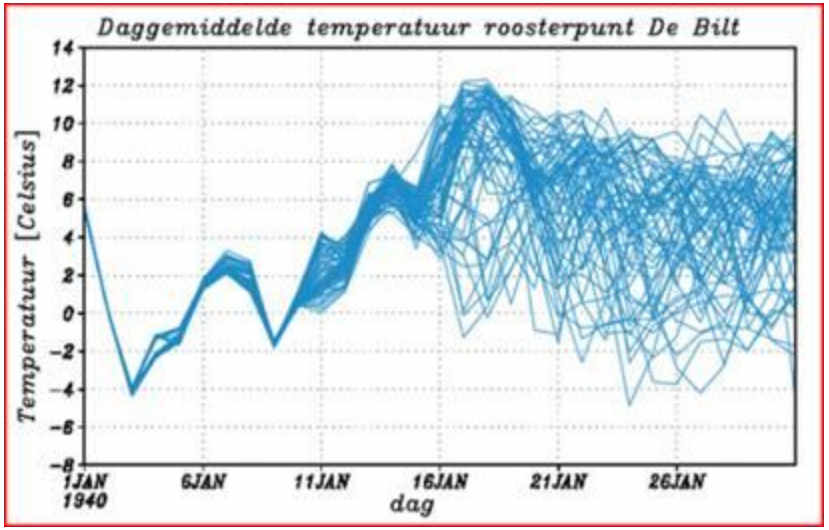
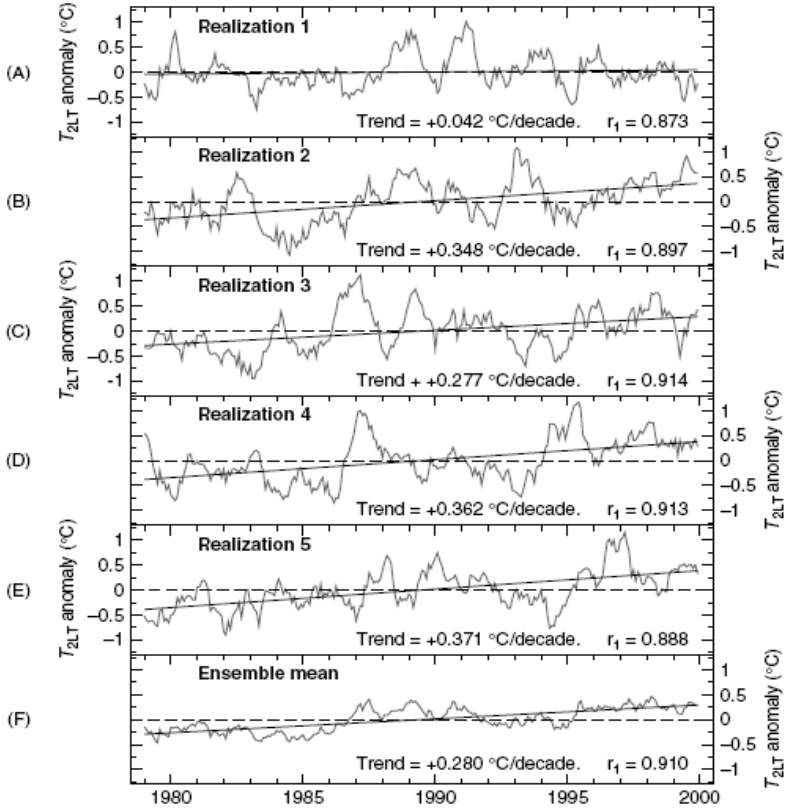
None of current climate models overcomes chaotic uncertainty

Dr. Singer argues that the number of realizations (simulations) by any climate model is too small to determine trends in a robust manner. We need larger ensembles.





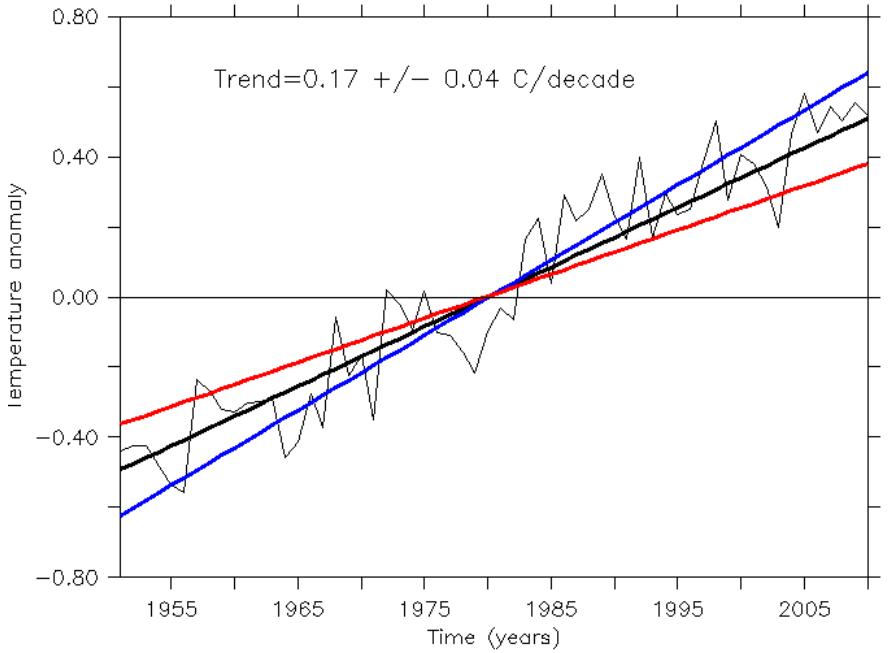
How many runs are needed to reproduce the signal?

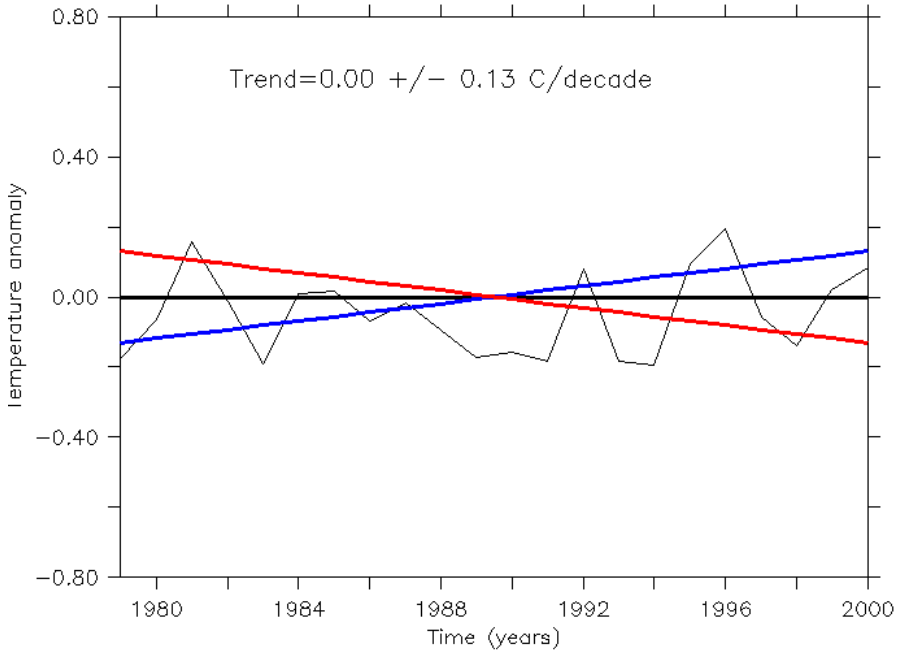


5 realizations and ensemble mean of noise, superimposed on a trend

- To detect signals with 99% confidence, signal/noise R > 3
- For an ensemble of size n, the noise decreases and R increases (with √n)
- The amount of runs needed depends on various factors:
  a larger trend means smaller n;
  larger noise means larger n;
  a longer run means smaller n

How many runs are needed to reproduce the signal, 20-40?



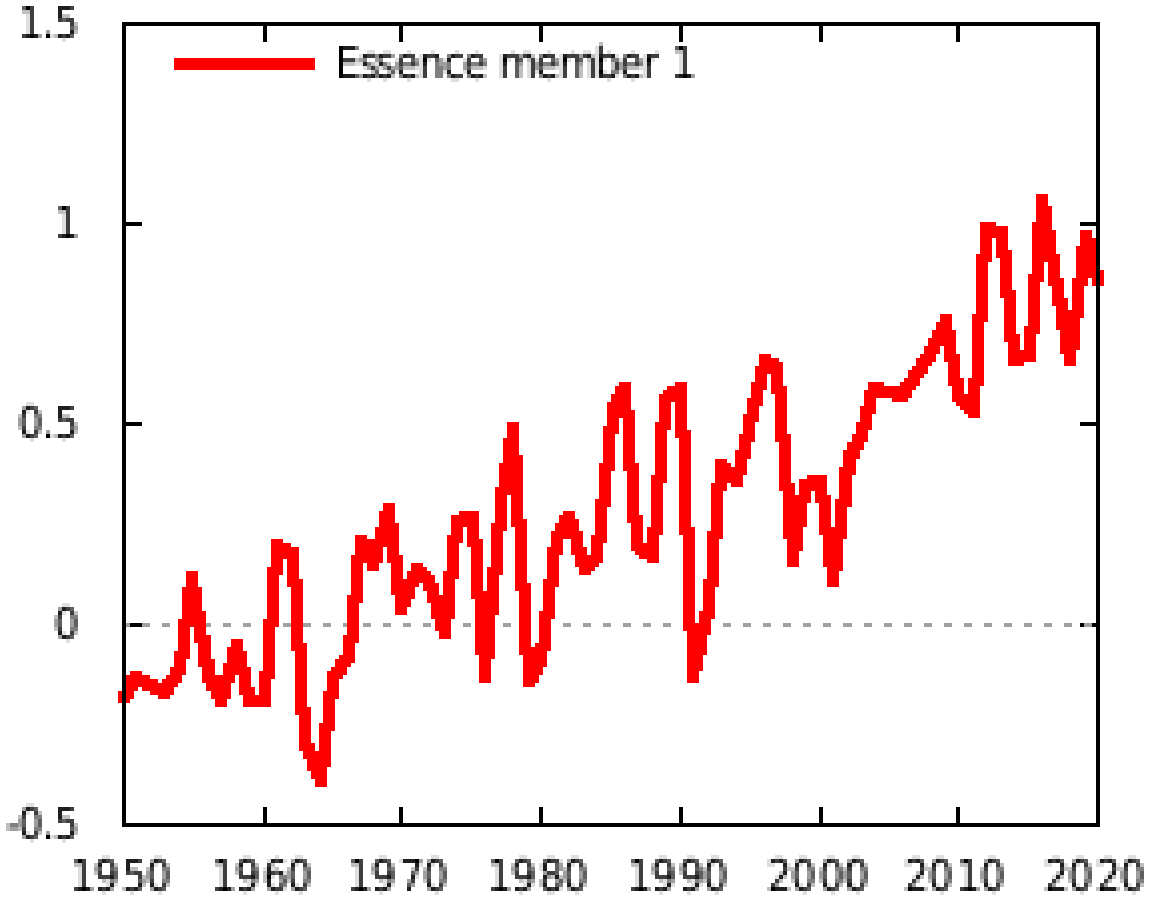


- When the trend is zero; n must be very large; 10-20 in Singer's example. But when the trend is large n can be smaller. Singer's example is not generic.

- To reproduce the observed 1980-2000 temperature rise n=5-6 is sufficient; to reproduce the 1880-2010 temperature rise n=1-2;
for 2000-2100 projections n=1

None of current climate models overcomes chaotic uncertainty?

KNMI has run (with Utrecht University) a 17-member ensemble of an IPCC climate model to overcome chaotic uncertainty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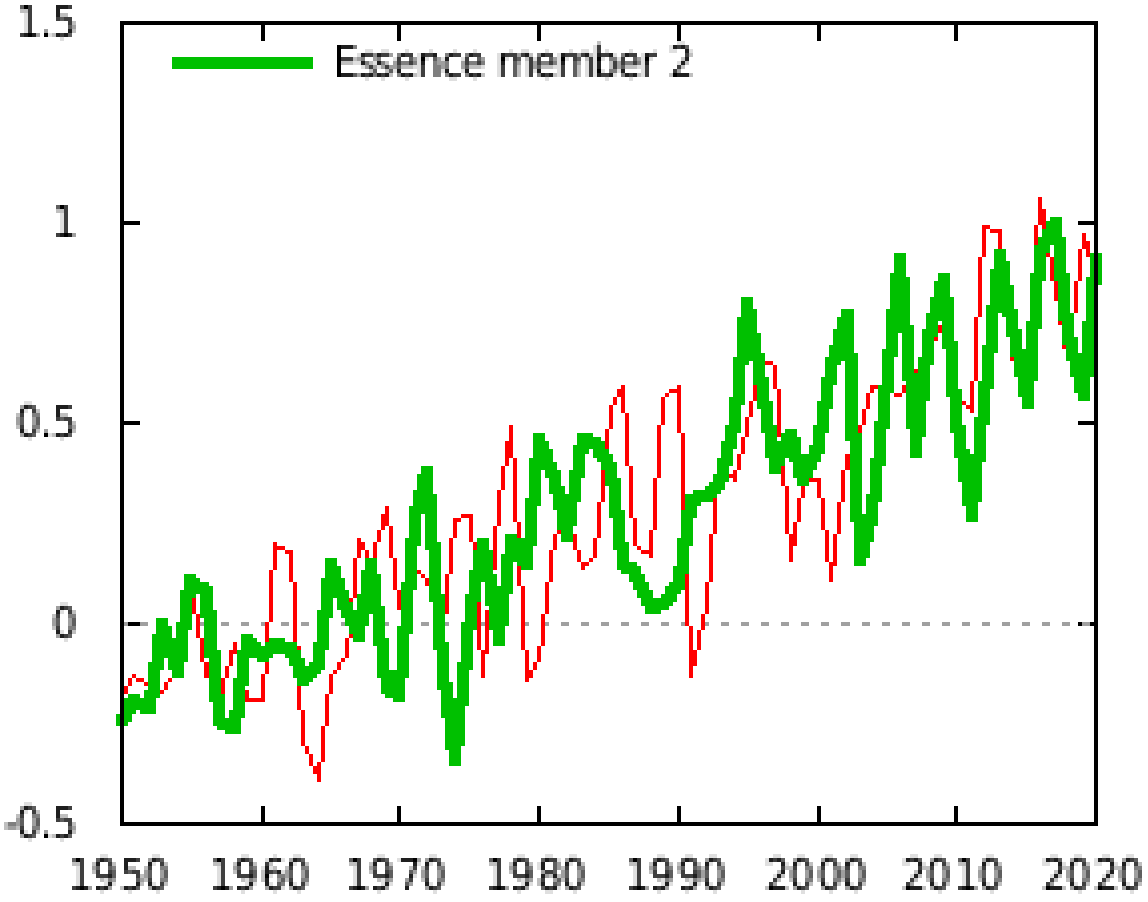
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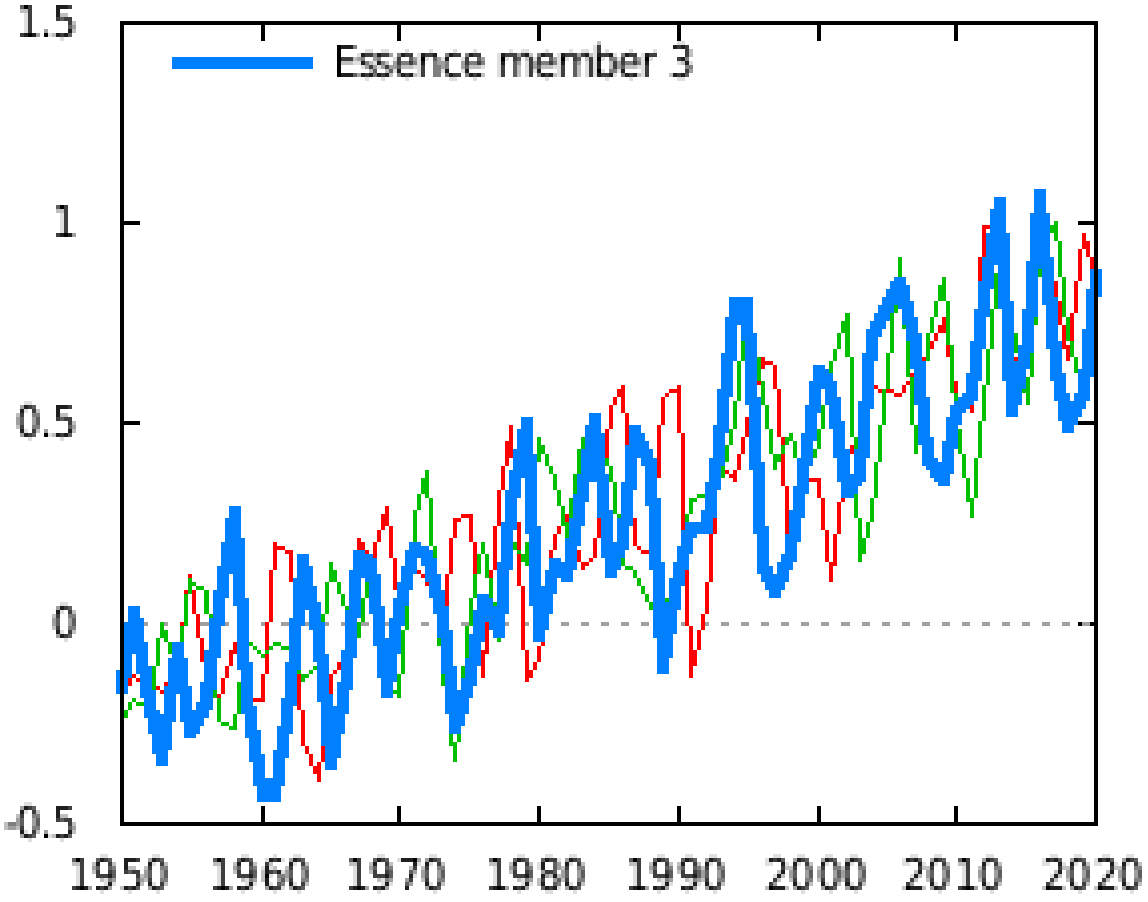
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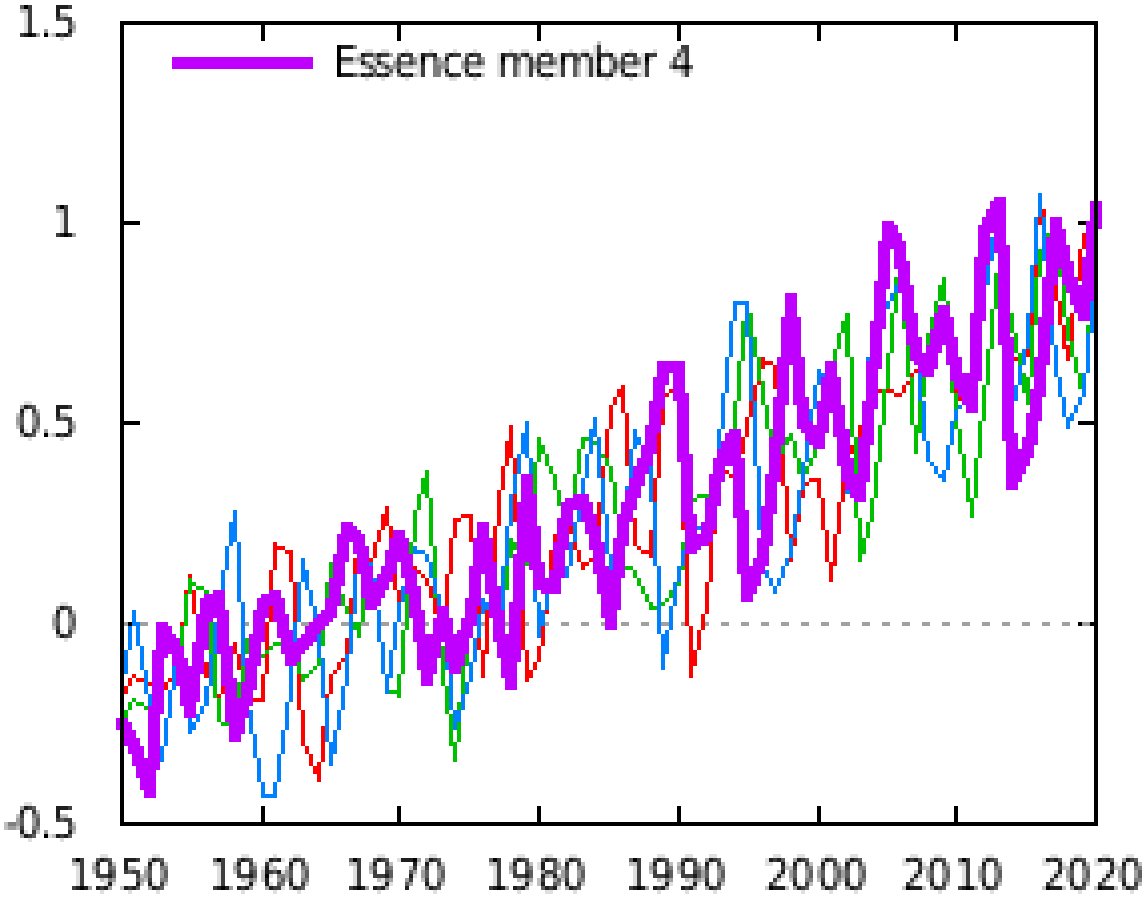
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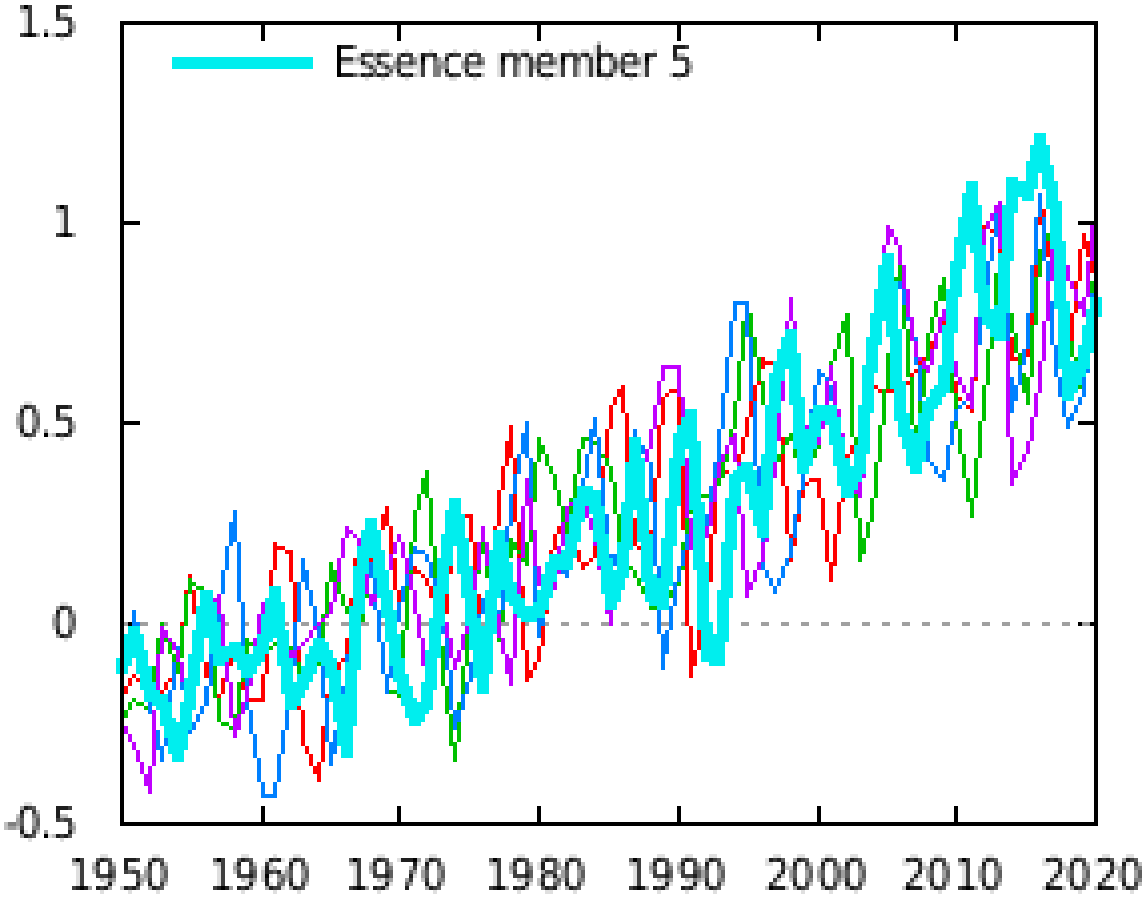
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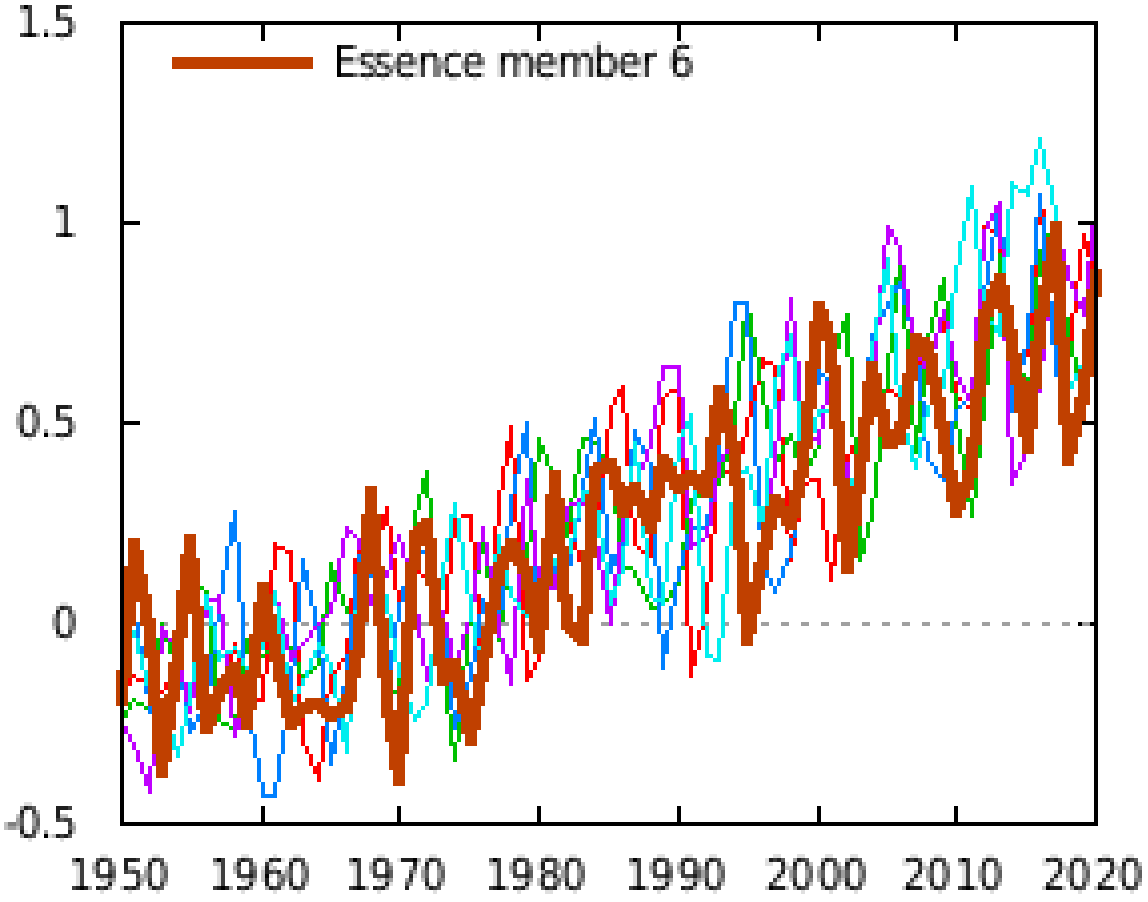
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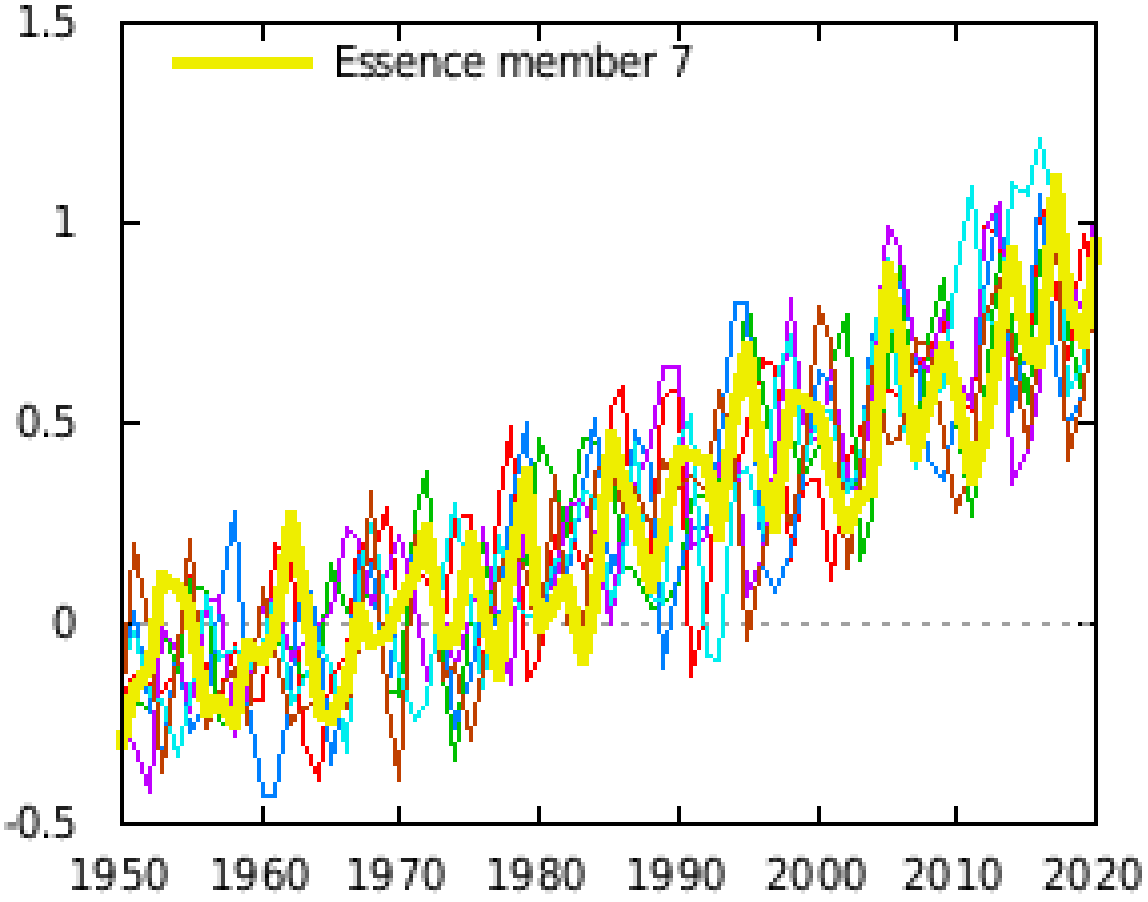
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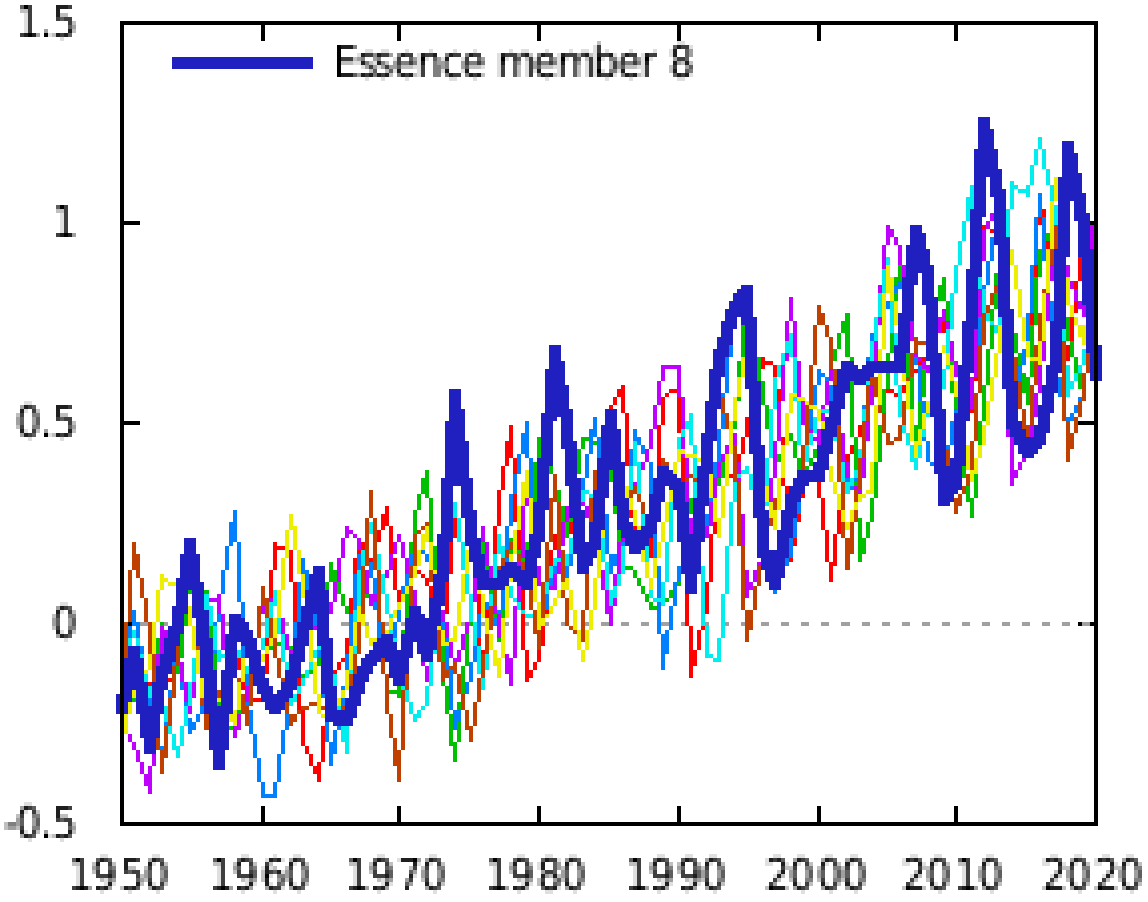
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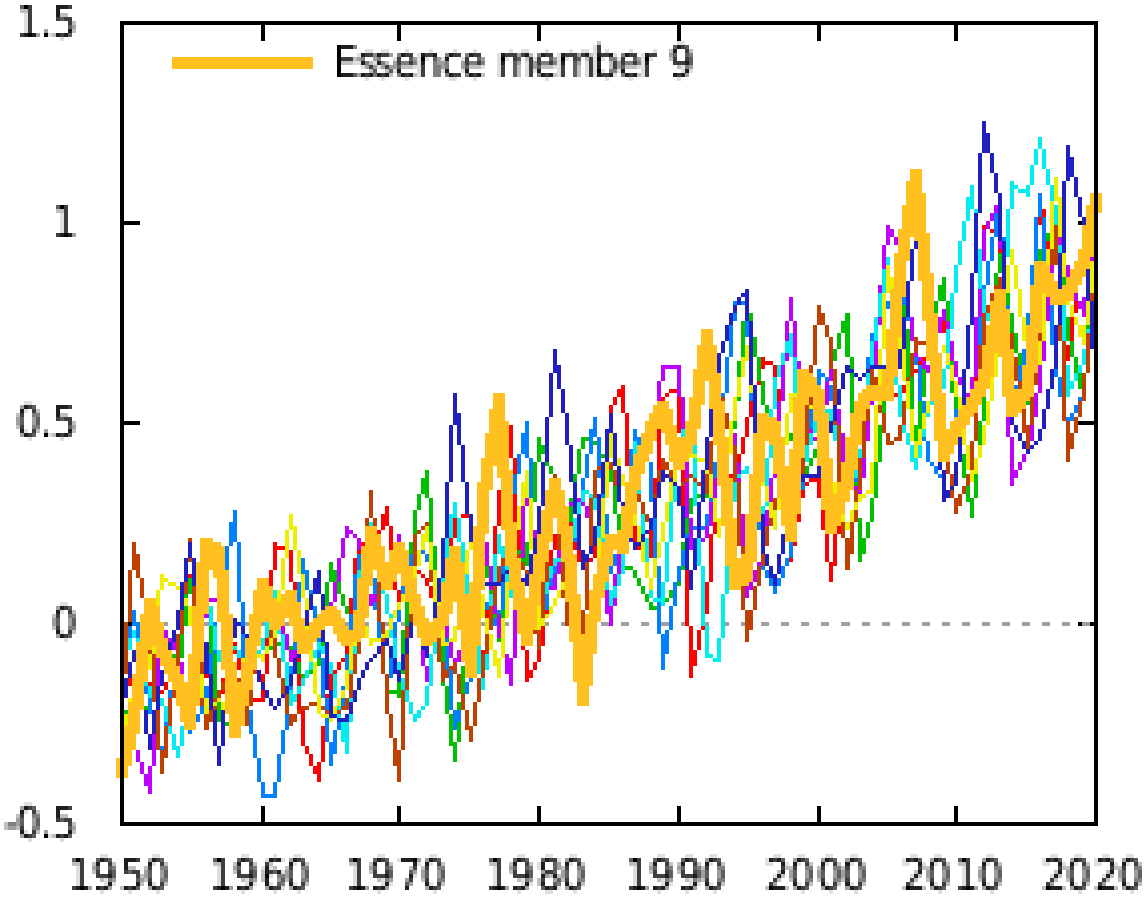
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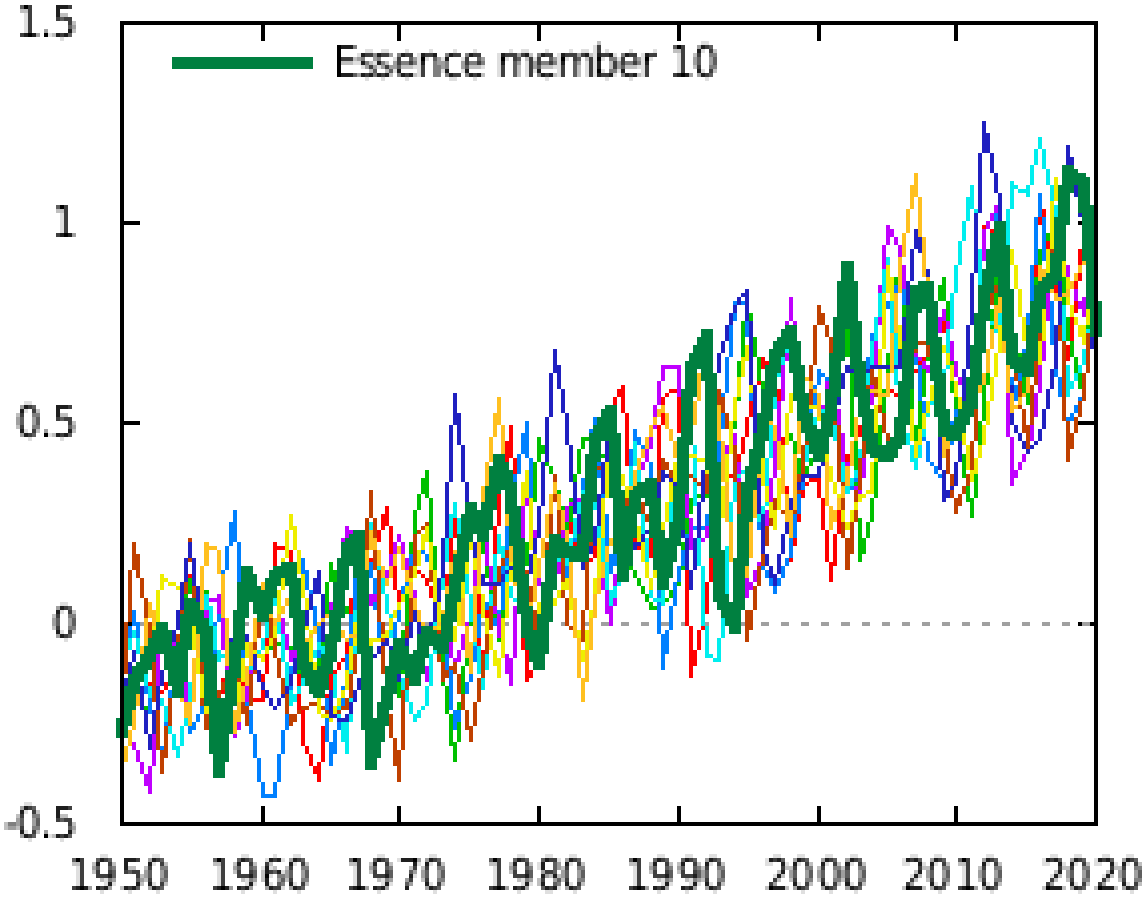
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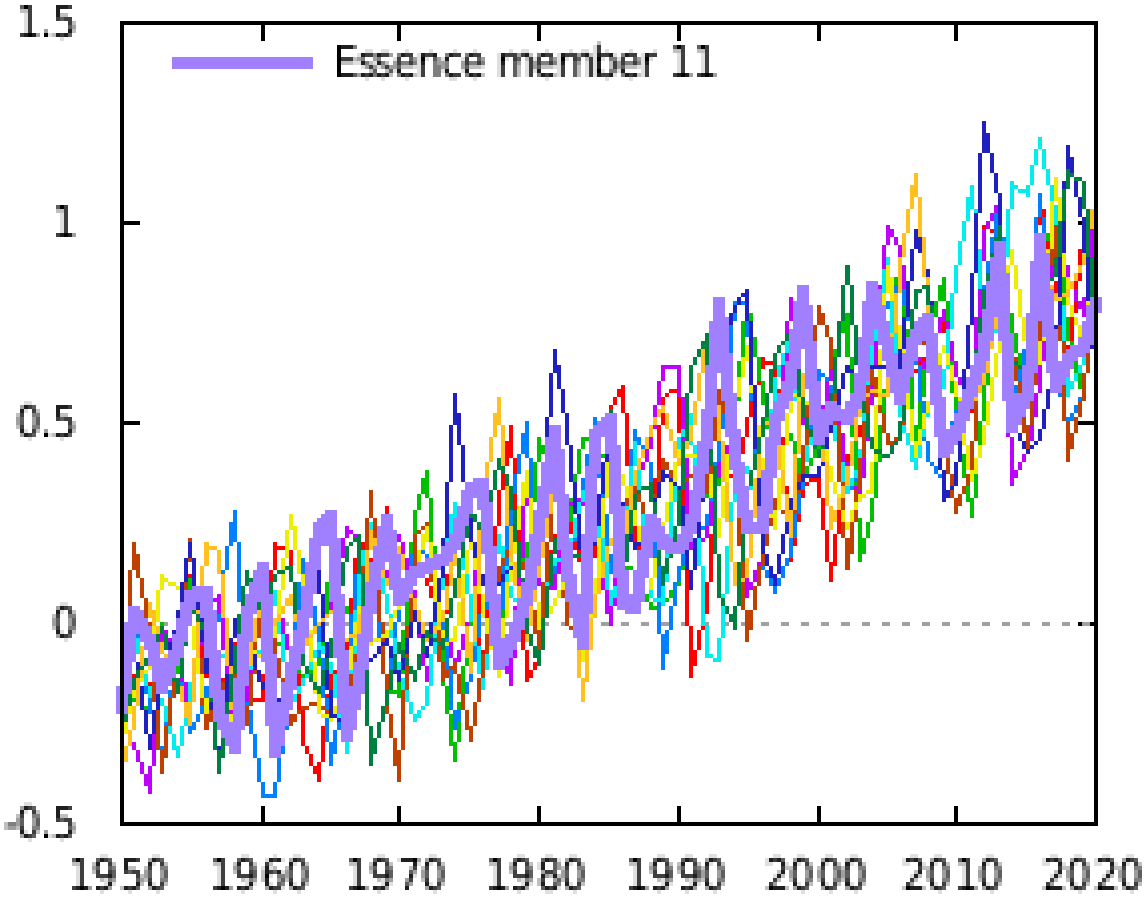
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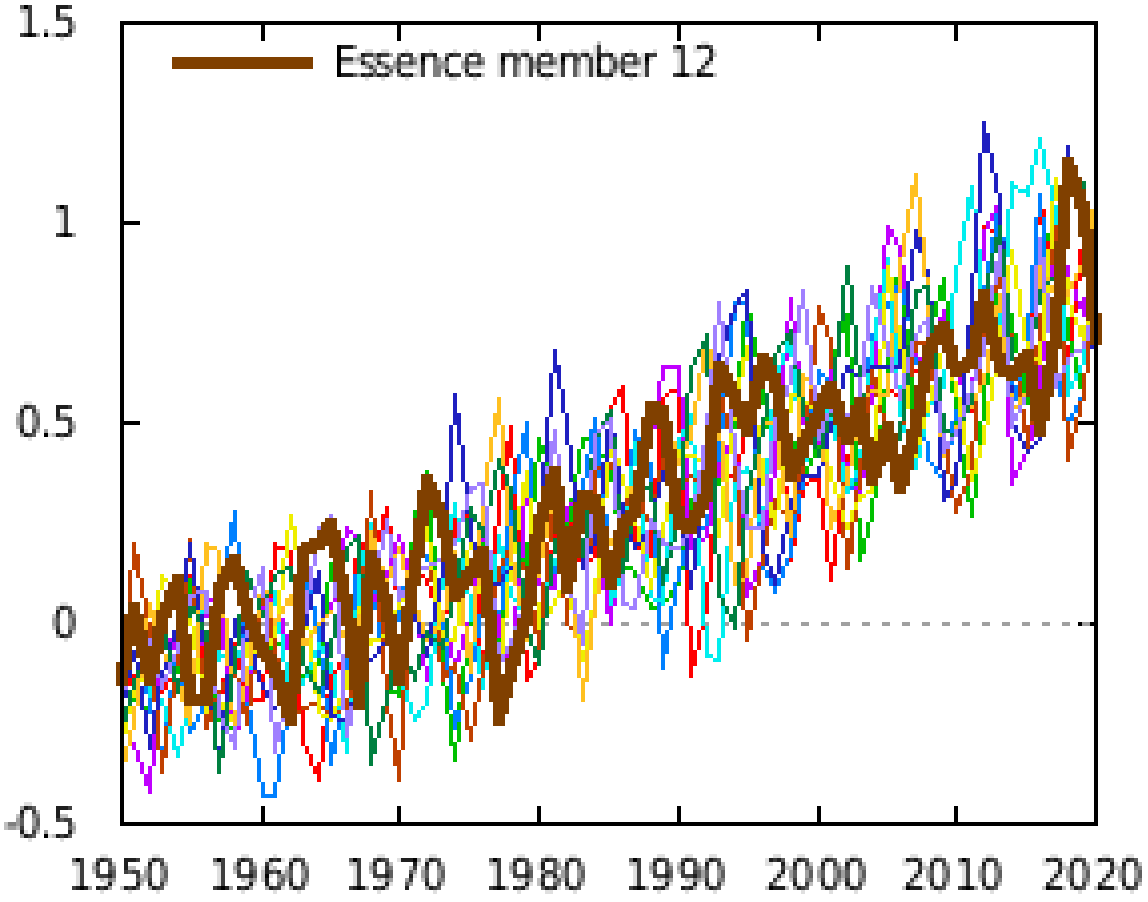
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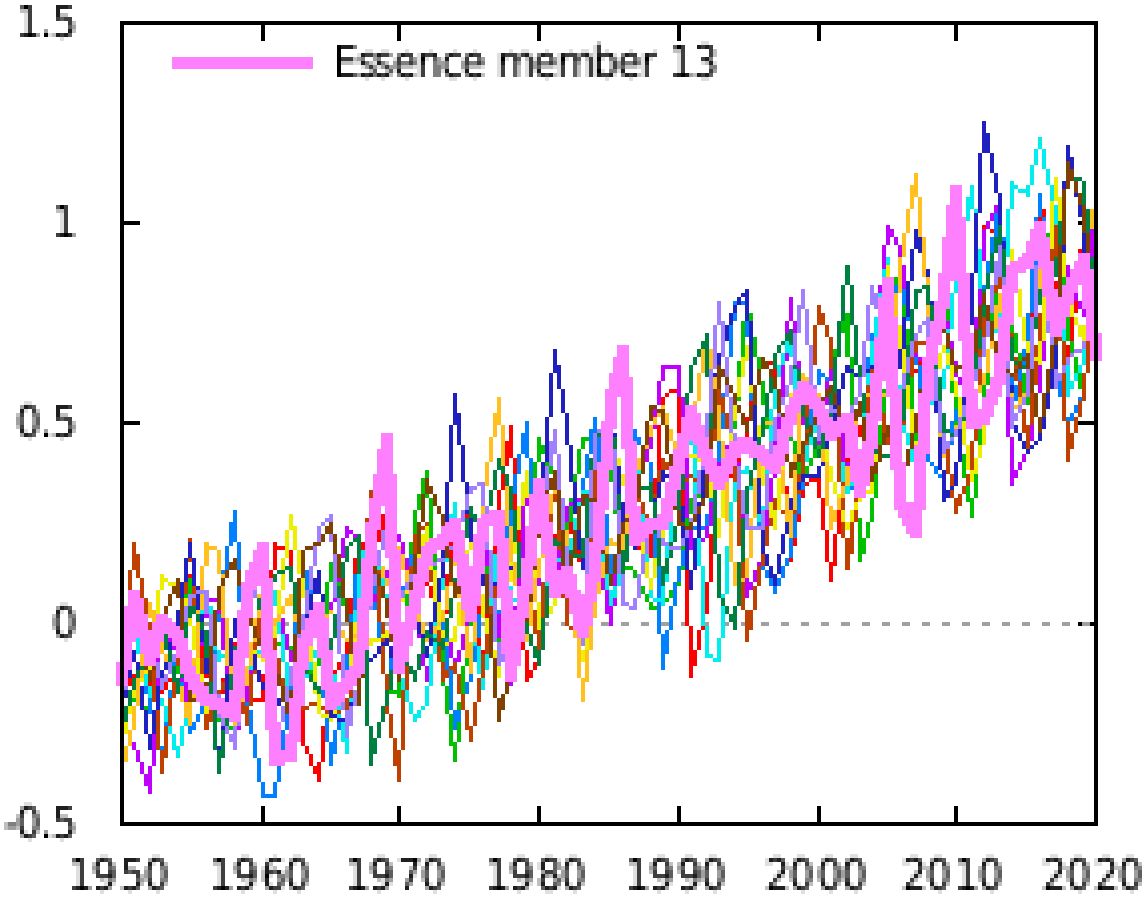
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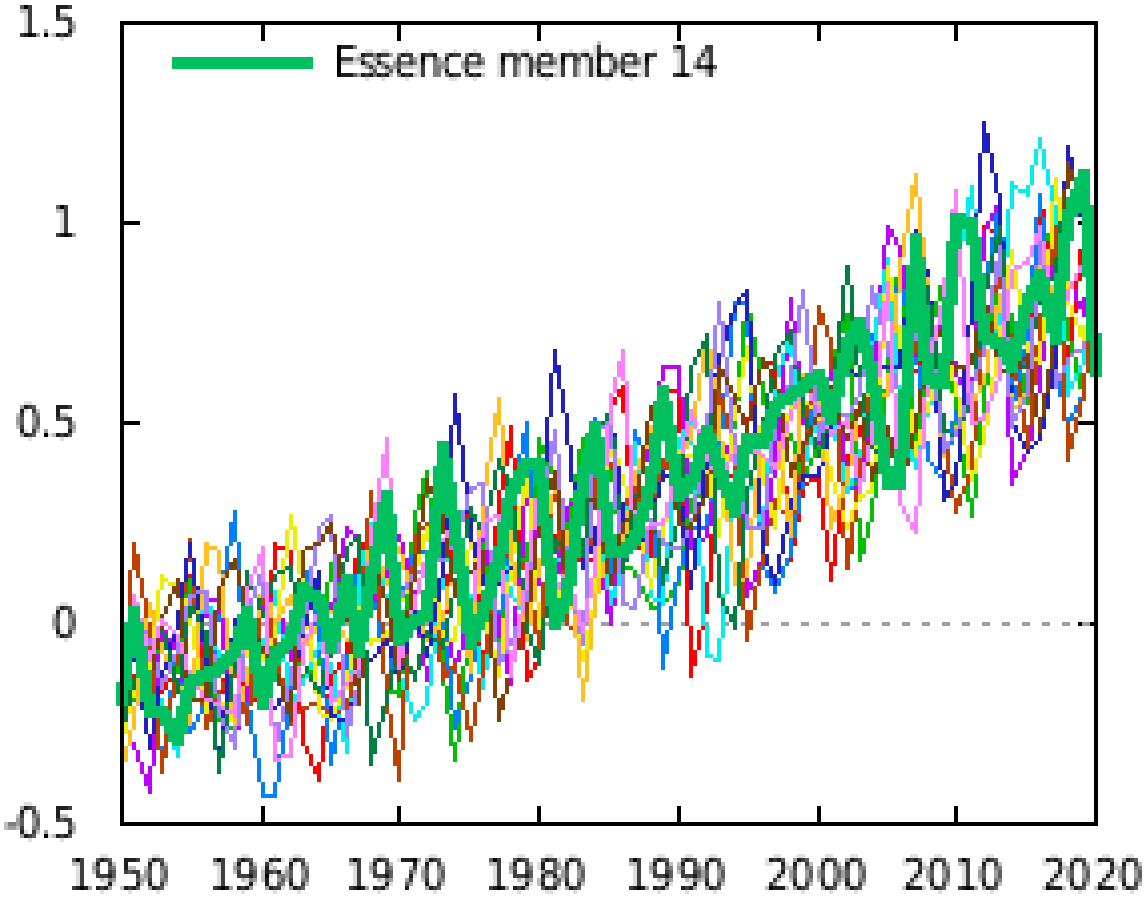
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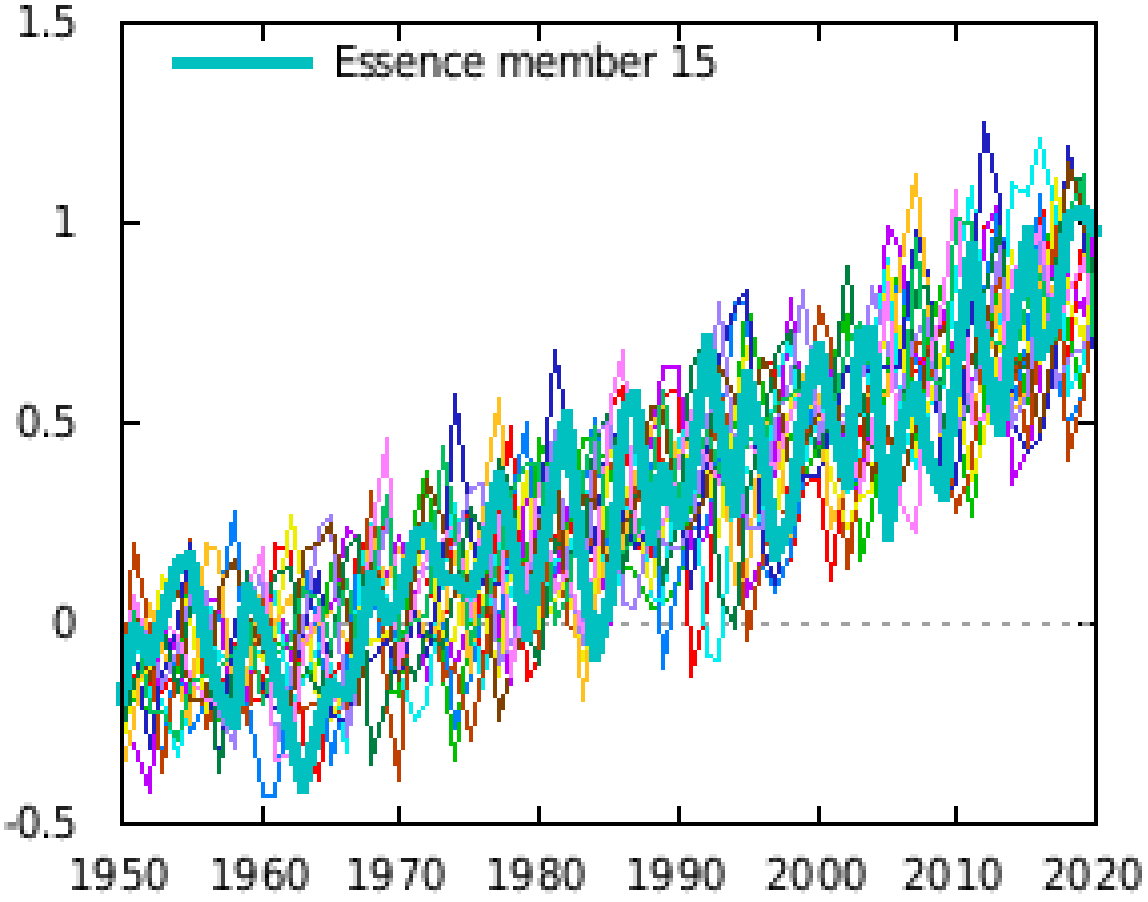
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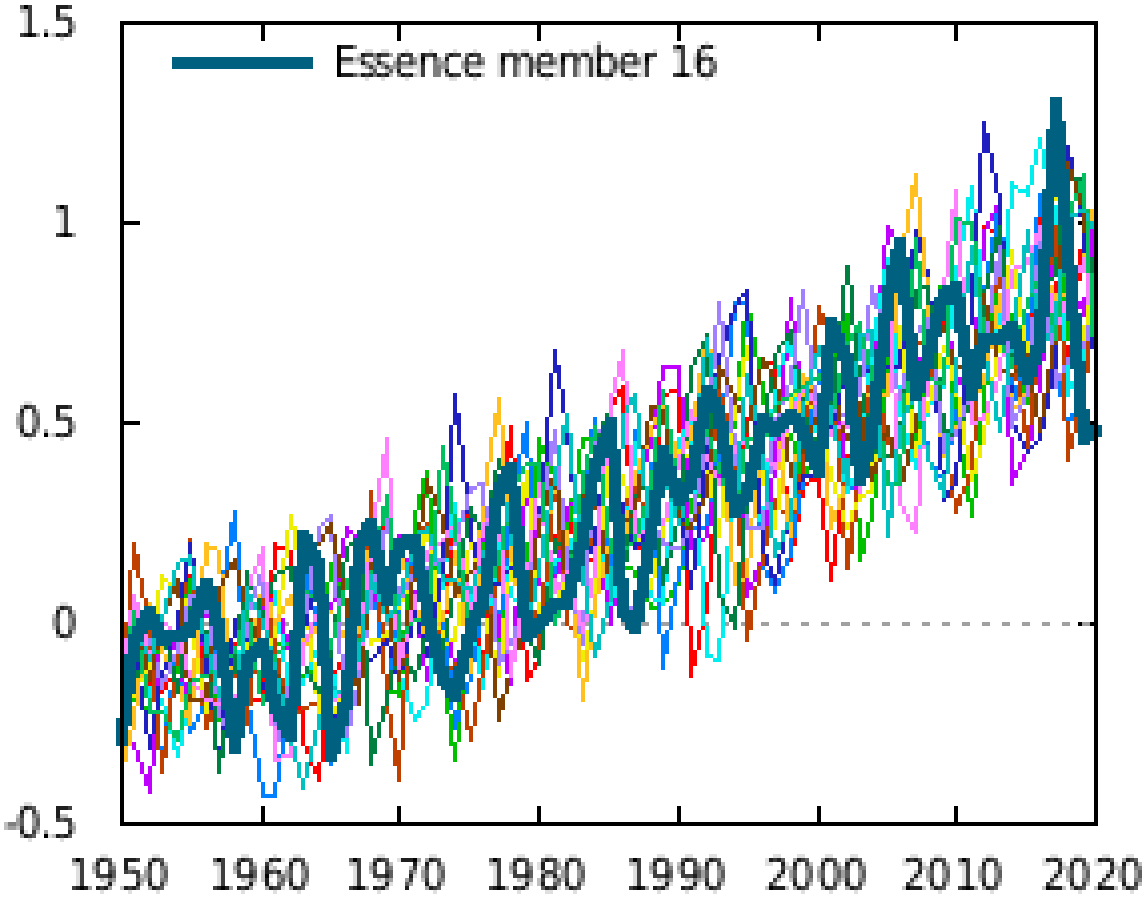
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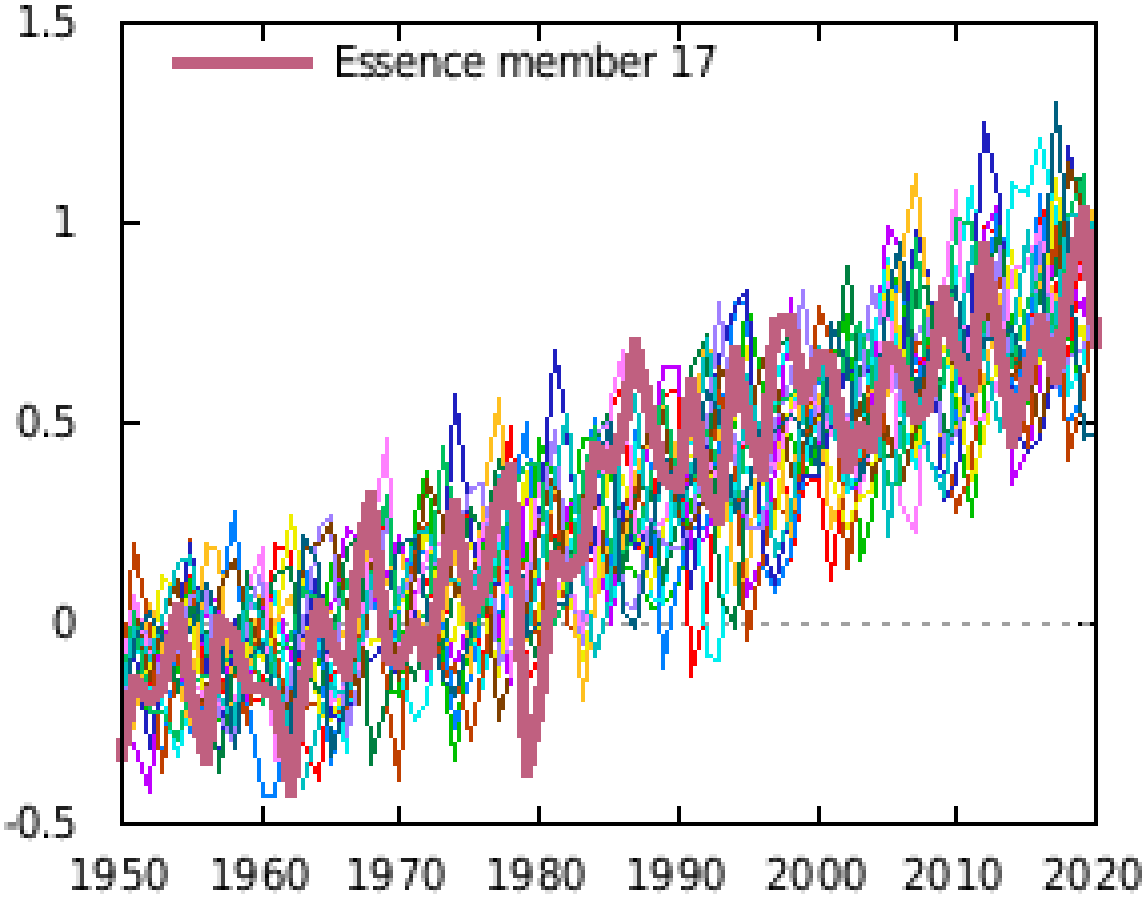
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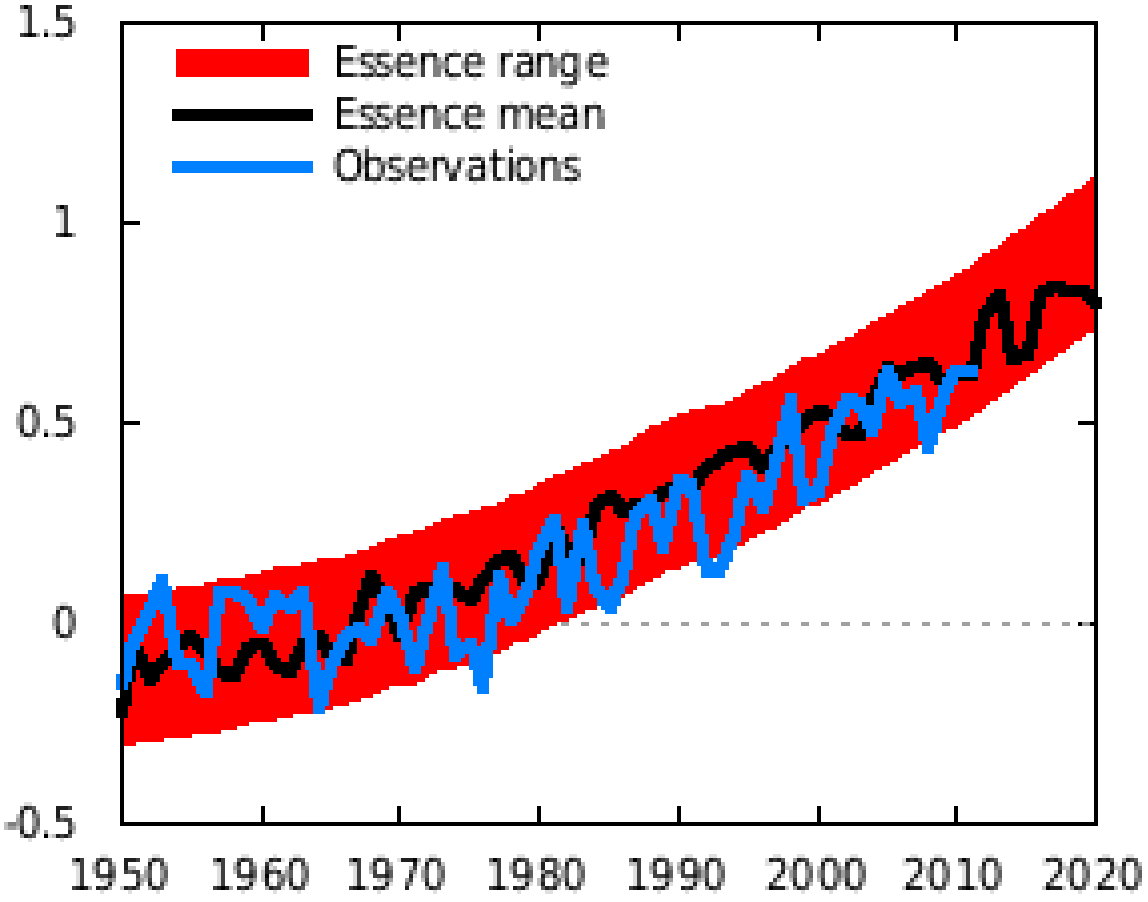
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Conclusions

- The proposition that none of current climate models overcome chaotic uncertainty is wrong

- The amount of runs needed to detect trends and validate the model with observations depends on the strength of the forcing and the noise, and the length of the run, but it is generally enough in IPCC evaluations