Forecast cooling of the Atlantic sub-polar gyre and associated impacts

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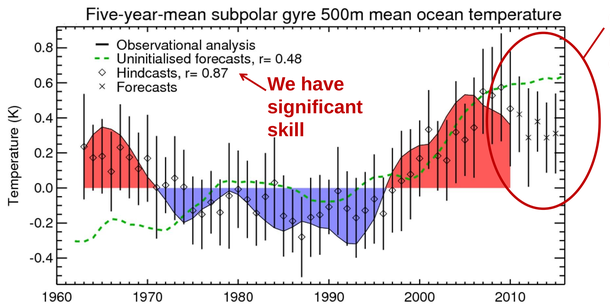
Research Questions

Changes to the temperature of the sub-polar gyre (SPG) have previously been shown to have important wide ranging impacts on climate, including European, American and African temperature and precipitation[1,2,3,4]. Can three versions of the Met Office Decadal Prediction System (DePreSys) be combined to provide a skilful forecast of the sub-polar gyre and the associated impacts? If so, what are the mechanisms that give rise to this predictability? What are the impacts for the five summers (June-July-August, JJA) of 2012 - 2017?

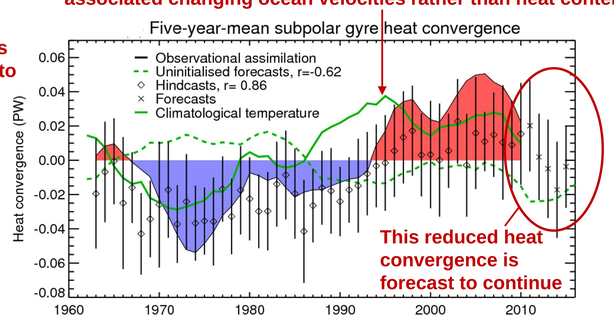
Conclusions

- DePreSys shows skill at predicting changes in SPG temperature and the variations in the AMOC that cause them over a 52 year hindcast period.
- The recent cooling trend in the SPG is predicted to continue over the next five years due to decreased SPG heat convergence.
- Forecast is for a “less warm” SPG, i.e. a reduced probability of the types of weather previously shown to be associated with a warm SPG.
- Counting Atlantic tropical storms in the models for June to November indicate a reduction in numbers, as expected with SPG cooling[1,2,3,4], probably related to higher pressure in the tropical North Atlantic.
- Weaker signals in the forecast suggest, compared to recent years:
  - Reduced summer rainfall in western Sahel and increased rainfall in NE Brazil - consistent with the lit. on SPG cooling.
  - A warmer Mediterranean in the summer - inconsistent with the lit. on SPG cooling.

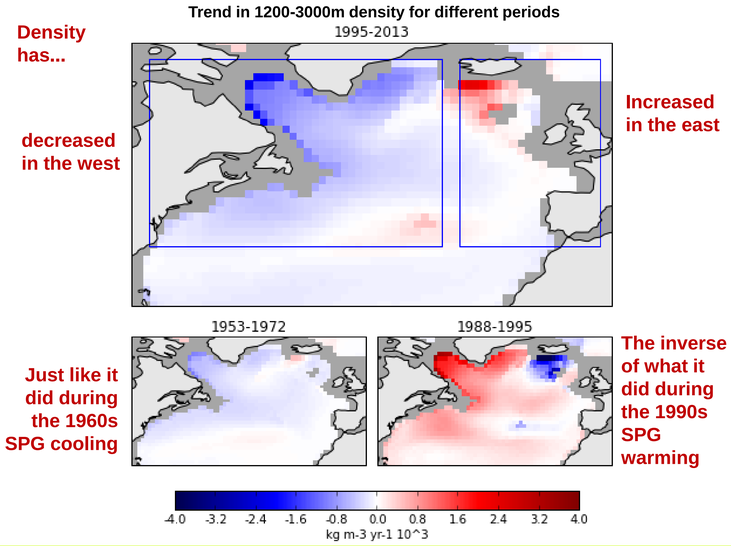
We combined three different versions of the decadal prediction system to increase the ensemble size. We studied the predictability of five year means of the grand ensemble.

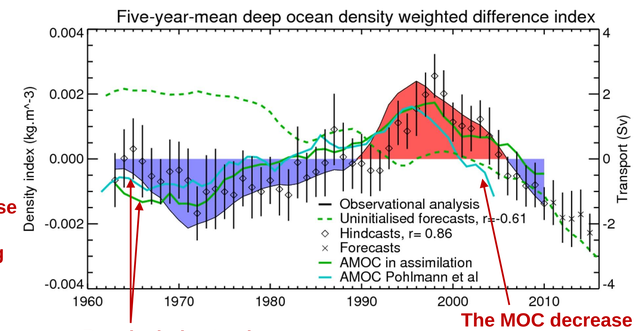


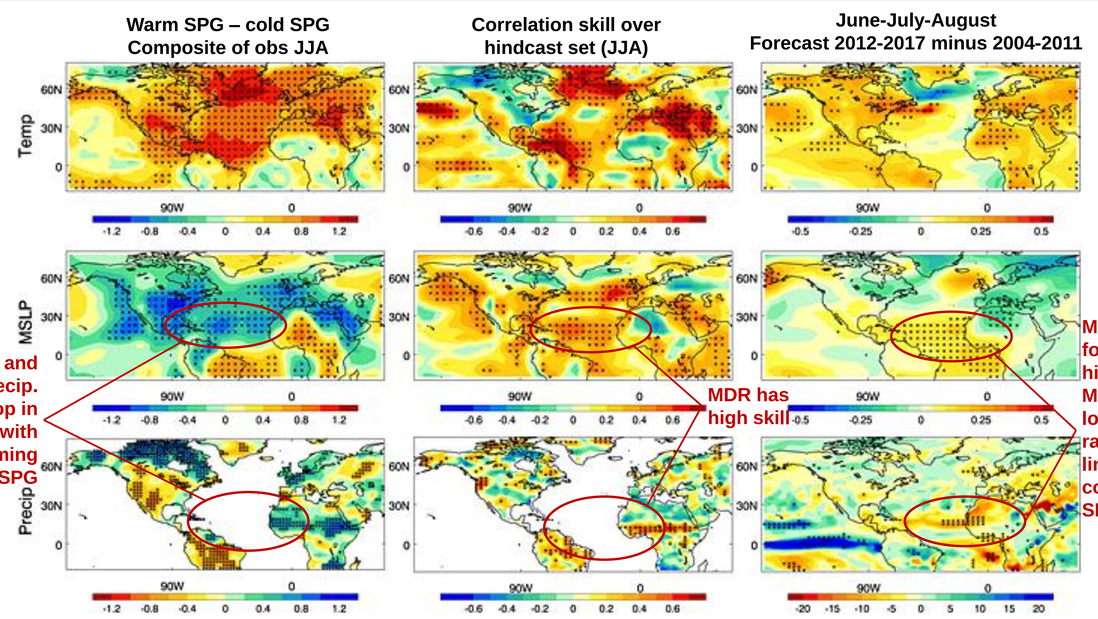
Using constant climatalogical temperature but varying velocities captures heat convergence i.e. SPG cooling seems to be associated changing ocean velocities rather than heat content



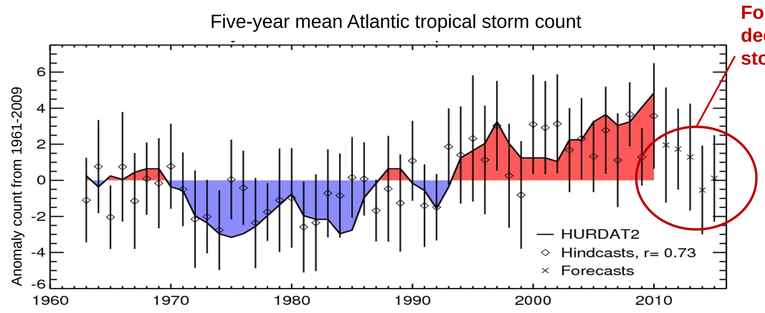
Previous studies[6,7] show SPG ocean velocities are largely driven by 1200-3000m west-east density gradient. Density is also better observed than velocity, so we can use it to infer changes to the AMOC. We constructed an index of the difference in density (west minus east) between the mean density in two regions (blue boxes).







The observed composites indicate that a cooling SPG can lead to conditions that are less conducive to forming tropical cyclones in the Main Development Region (MDR) of the North Atlantic. The grand ensemble predicts similar conditions for the tropical cyclone seasons of 2012-2017. The grand ensemble also predicts a decrease in tropical storm count.



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References

1: Goldenberg, S. B., C. W. Landsea, A. M. Mestas-Nunez, and W. M. Gray (2001), The recent increase in Atlantic hurricane activity: Causes and implications, Science, 293, 474–479.
2: Smith, D. M., R. Eade, N. J. Dunstone, D. Fereday, J. M. Murphy, H. Pohlmann, and A. A. Scaife (2010), Skilful climate model predictions of multi-year North Atlantic hurricane frequency, Nat. Geosci., 3, 846–849, doi:10.1038/ngeo1004.
3: Smith, D. M., A. A. Scaife, and B. P. Kirtman (2012), What is the current state of scientific knowledge with regard to seasonal and decadal forecasting?, Environ. Res. Lett., 7, 015602, doi:10.1088/1748-9326/7/1/015602.
4: Dunstone, N. J., D. M. Smith, and R. Eade (2011), Multiyear predictability of the tropical Atlantic atmosphere driven by high latitude North Atlantic Ocean, Geophys. Rev. Lett., 28, L14701, doi:10.1029/2011GL047949.
6: Hodson, D. L. R., and R. T. Sutton (2012), The impact of resolution on the adjustment and decadal variability of the Atlantic meridional overturning circulation in a coupled climate model, Clim. Dyn., 39(12), 3057–3073.
7: Roberts, C. D., F. K. Garry, and L. C. Jackson (2013), A multi-model study of sea surface temperature and sub-surface density fingerprints of the Atlantic meridional overturning circulation, J. Clim., 26, 9155–9174, doi:10.1175/JCLI-D-12-00762.1.
8: Pohlmann, H., D. M. Smith, M. A. Balmaseda, N. S. Keenlyside, S. Masina, D. Matei, W. A. Müller, and P. Rogel (2013), Predictability of the mid-latitude Atlantic meridional overturning circulation in a multi-model system, Clim. Dyn., 41, 775–785, doi:10.1007/s00382-013-1663-6.

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