The influence of the Gulf Stream on Wintertime European Blocking and North Atlantic Jet

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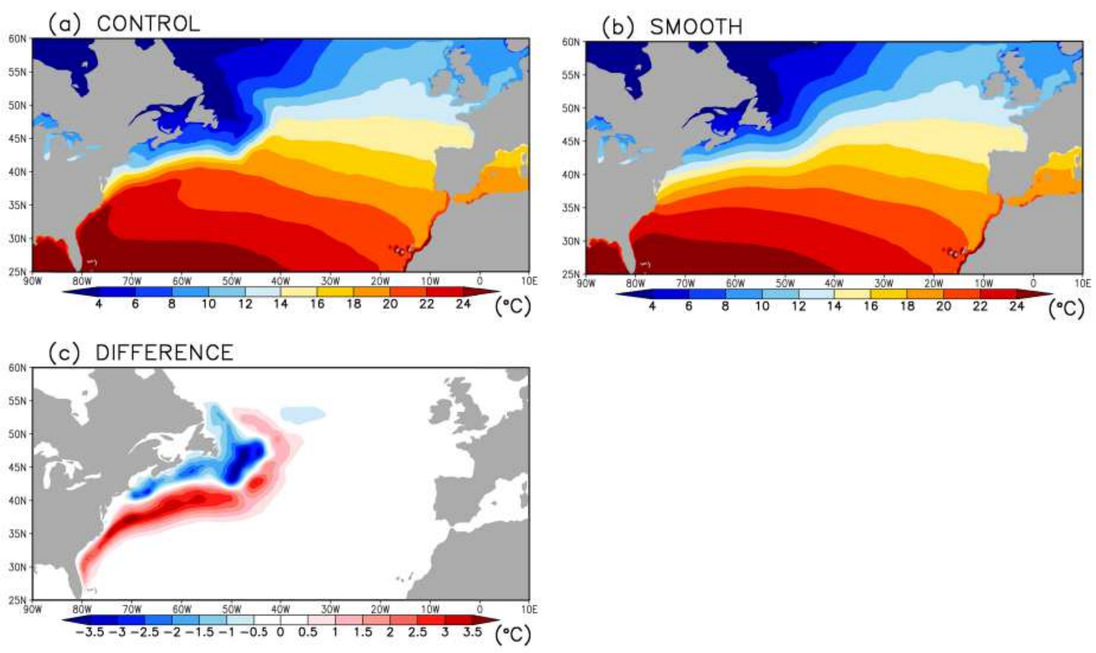
1. SUMMARY

Influences of mid-latitude ocean to the atmosphere, especially associated with oceanic fronts, such as the Gulf Stream and the Kuroshio, have been studied for mainly on time-mean fields as well as interannual, synoptic (several days) and diurnal timescales. However, possible ocean-to-atmosphere influence on a timescale from week to about twenty days were not studied. We report that the presence of the Gulf Stream influence two phenomena on this timescale, i.e., North Atlantic eddy driven jet and the European blocking and associated cold spells, by conducting a pair of AGCM experiments using observed and smoothed SSTs. The results suggest that for a correct simulation of these phenomena a high-resolution atmospheric model and SSTs are necessary.

2. Model Experiments & Data

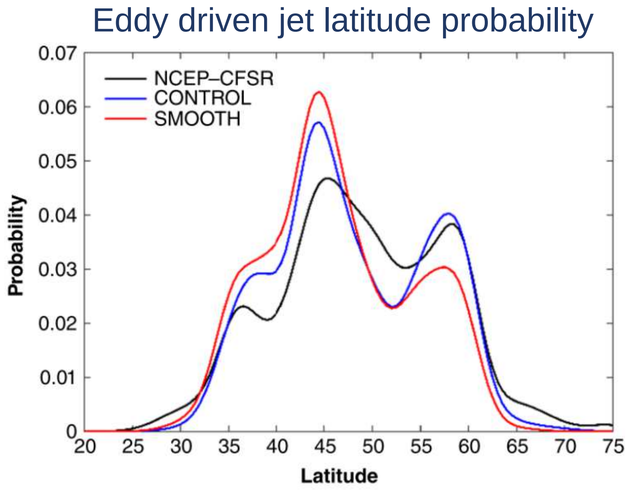
We conducted two experiments using an AGCM (AGCM for Earth Simulator, AFES, Ver. 3) with 0.5-degree resolution for 21 years (from September 1982 to August 2001). In one experiment (CONTROL), SST boundary condition is given by observed SST (OI SST v. 2), while in the other Stream region. experiment (SMOOTH), SSTs are smoothed over the Gulf Stream region.



In order to compare the model results, we analyzed NCEP-CFSR reanalysis data, which is 38 km grid resolution for 31 years (1979 to 2009).

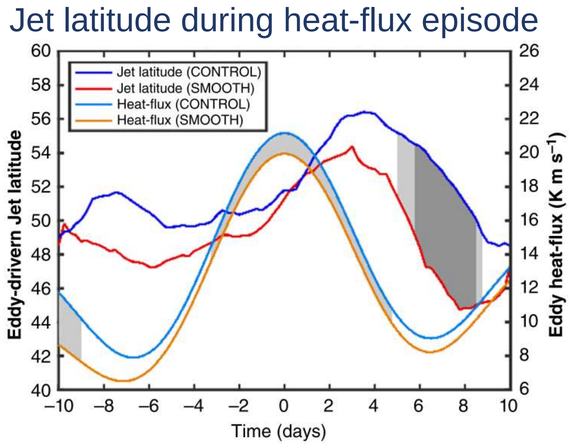
3. North Atlantic Jet

Eddy driven jet latitude probability



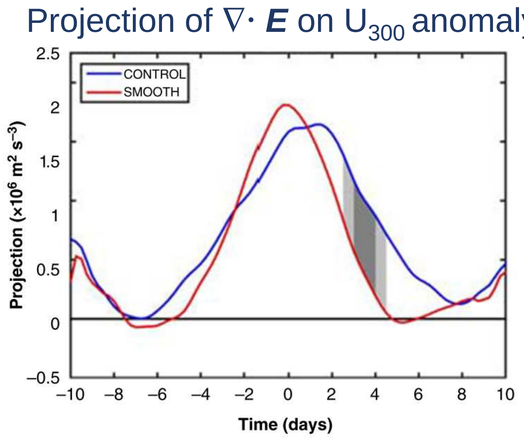
Three local maxima of jet latitude frequency are prominent in NCEP-CFSR, and are better captured in CONTROL especially for the northern peak.

Jet latitude during heat-flux episode



Eddy heat flux event leads northward excursion of jet.

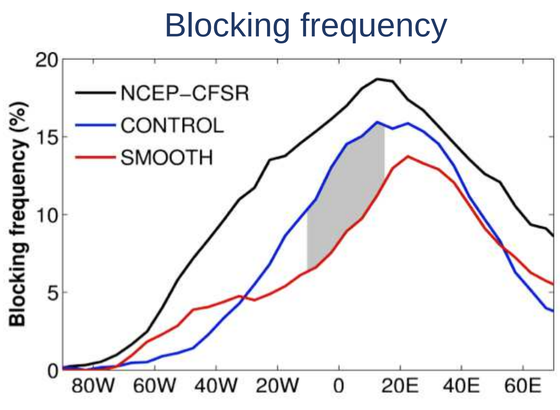
Projection of $\nabla \cdot \boldsymbol{E}$ on U_{300} anomaly



Stronger eddy feedback maintains more poleward eddy driven jet.

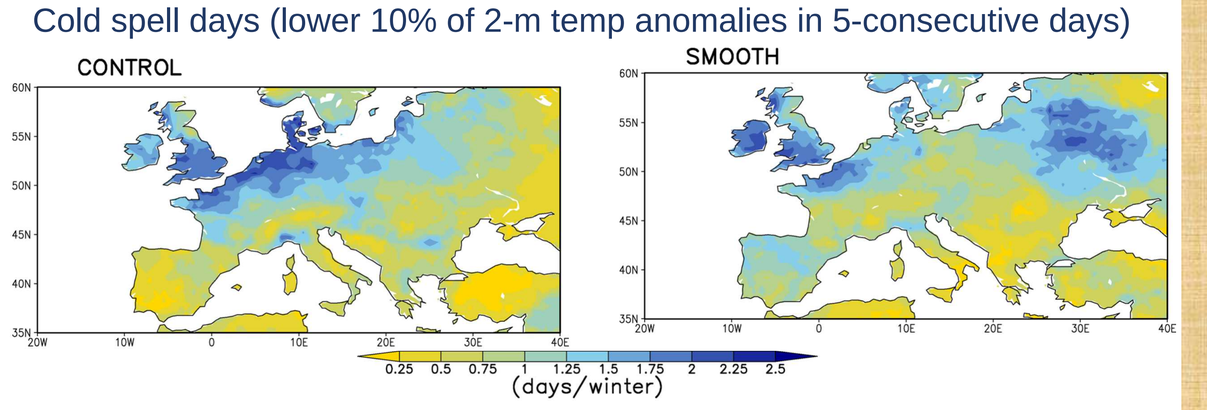
4. European Blocking

Blocking frequency



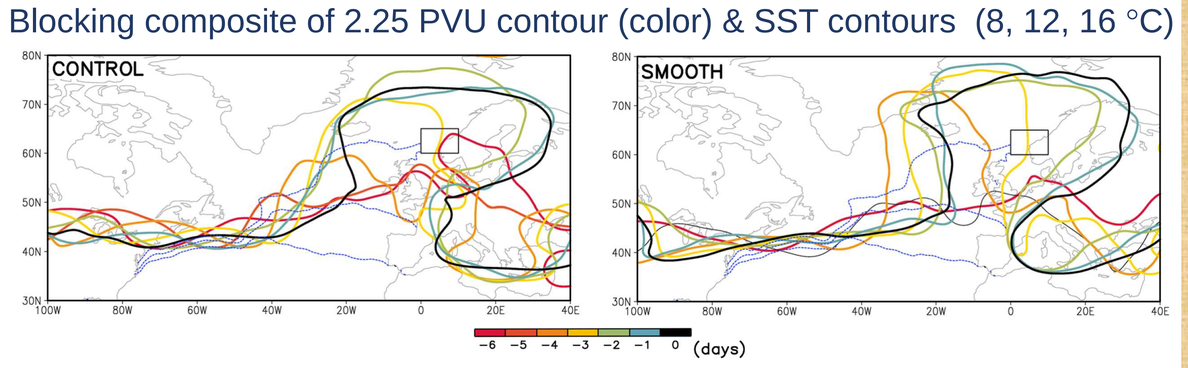
Sharp SST front (CONTROL) causes more frequent blocking than smoothed SST (SMOOTH). Smoothed SST results in eastward shift of the blocking frequency peak.

Cold spell days (lower 10% of 2-m temp anomalies in 5-consecutive days)



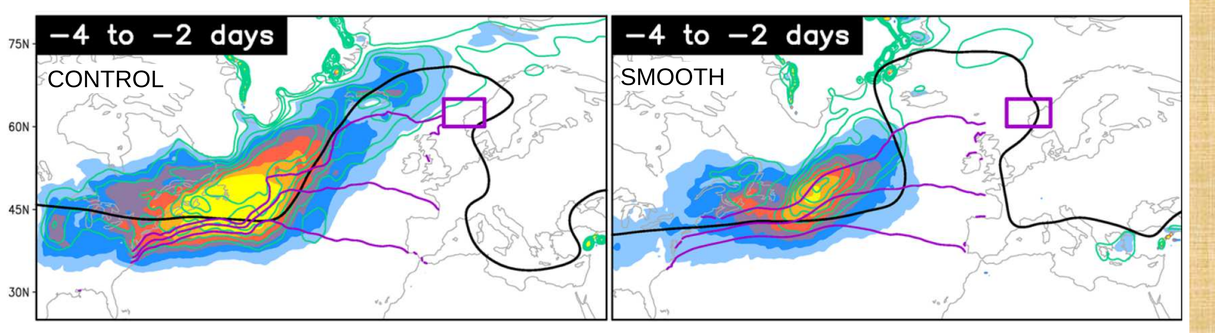
Distribution of cold spell days are substantial difference between CONTROL & SMOOTH, and CONTROL is similar to NCE-CFSR (not shown).

Blocking composite of 2.25 PVU contour (color) & SST contours (8, 12, 16 °C)



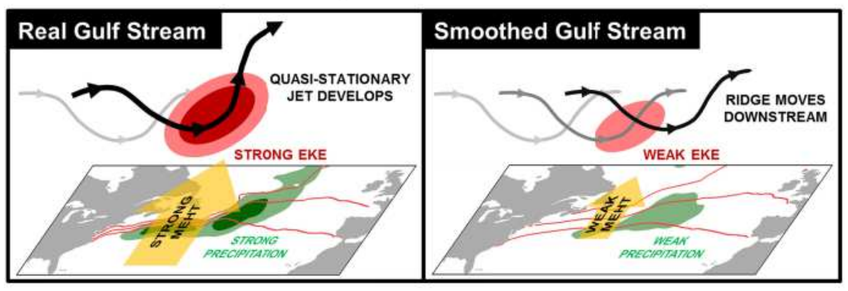
Quasi-stationary developments of western flank of the blocking ridge in NCEP-CFSR and in CONTROL, but not in SMOOTH.

Blocking composite of meridional heat transport at 850 hPa



Meridional heat transport in CONTROL is stronger than that in SMOOTH.

Summary of European blocking differences between two experiments



References

O'Reilly, Minobe, Kuwano-Yoshida, 2016: The influence of the Gulf Stream on wintertime European Blocking, Climate Dynamics, DOI 10.1007/s00382-015-2919-0.

O'Reilly, Minobe, Kuwano-Yoshida, Woollings, 2017: The Gulf Stream influence on wintertime North Atlantic jet variability, Q. J. R. Meteorol. Soc., DOI:10.1002/qj.2907