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Recent trends in summer atmospheric circulation in the North Atlantic/European region: is there a role for anthropogenic aerosols?

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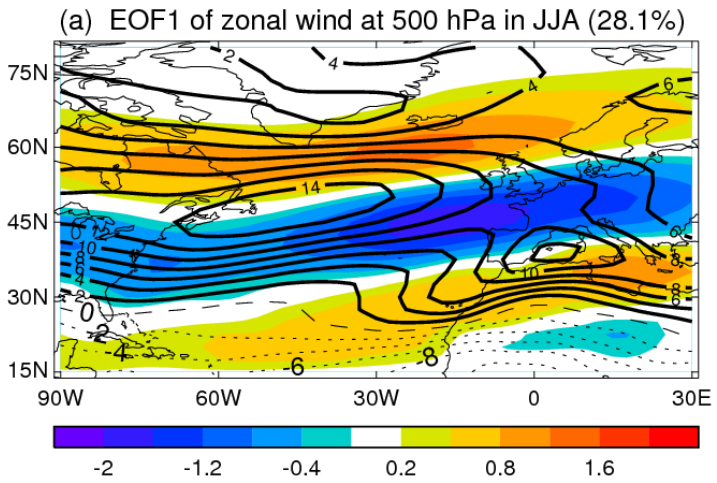
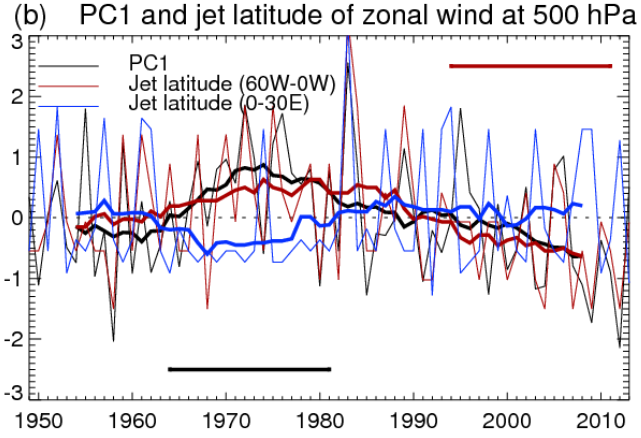
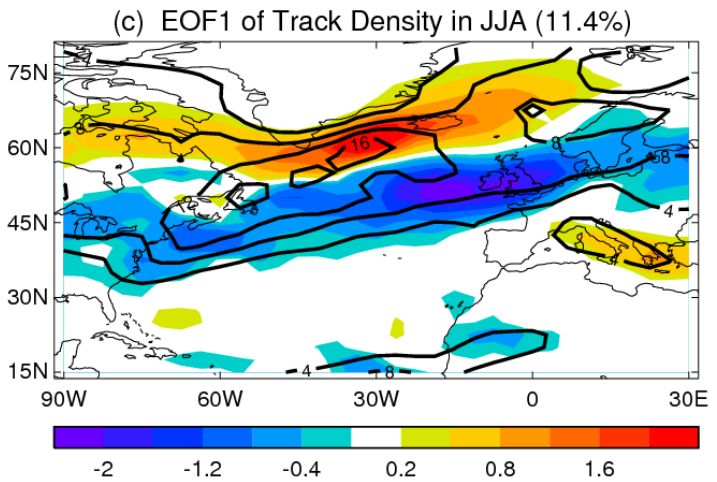
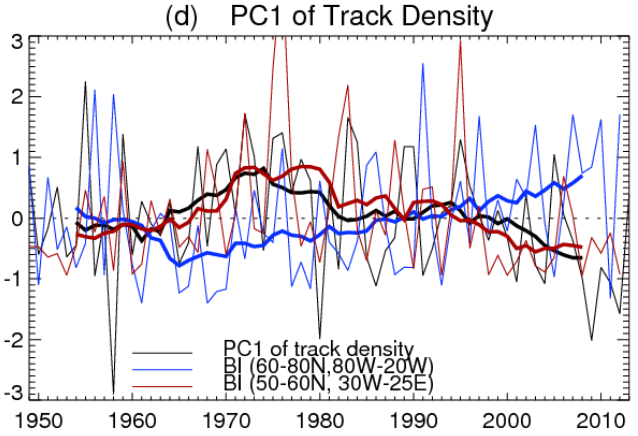
B. Dong & R. Sutton, J. Climate, 2021; DOI: 10.1175/JCLI-D-20-0665.1

Decadal variability in the latitude of the North Atlantic summertime jet









Since 1970:

- **southward displacement of North Atlantic jet**
- **northward displacement of Mediterranean jet**

- **More storms travelling into northern Europe favouring wet summers**
- **Increases in blocking frequency over Greenland and decreases over western Europe**

PC1s of zonal wind mode and storm track mode are highly correlated (0.90 or 0.96 on low frequencies).

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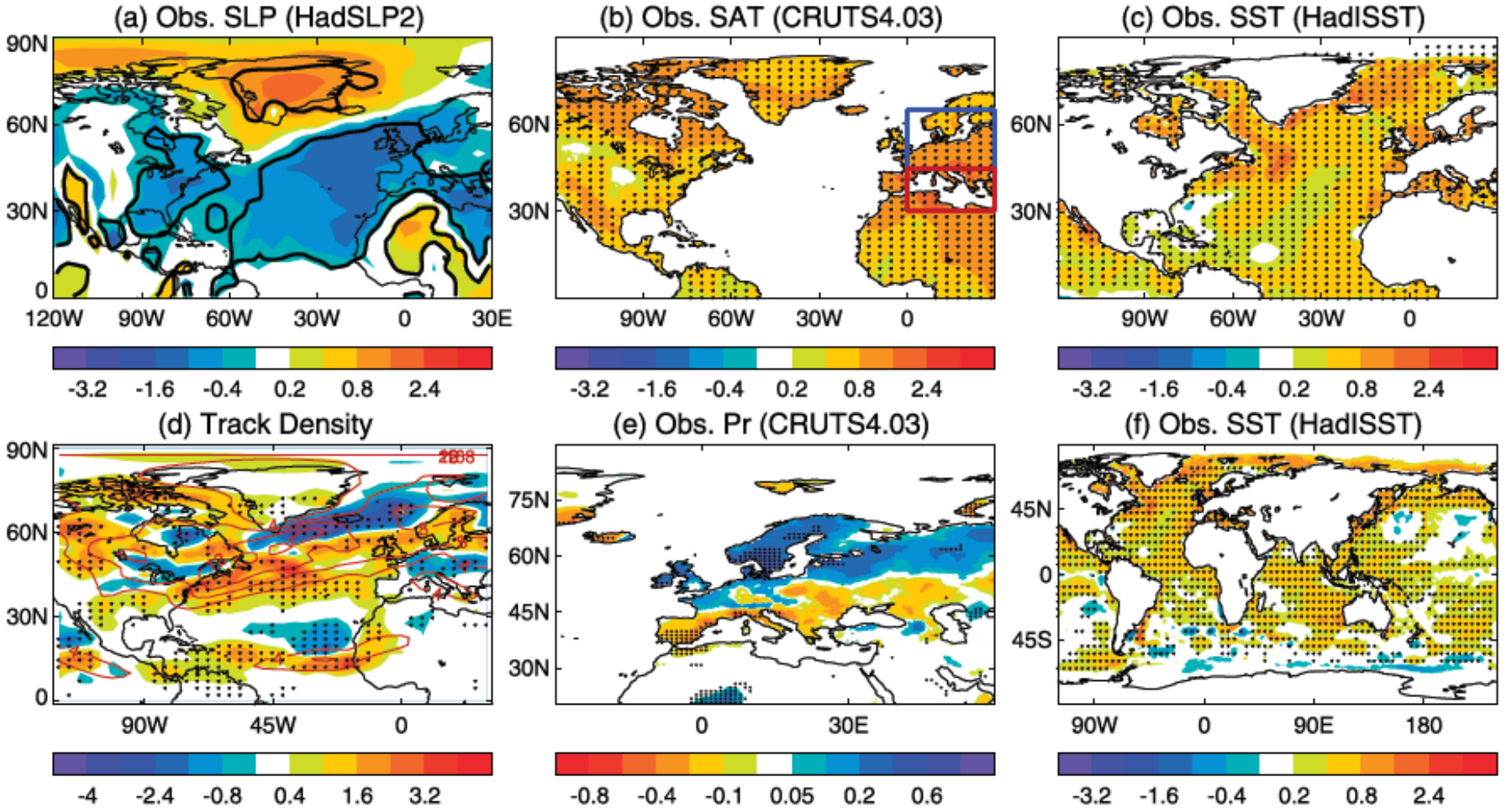
Observed changes (1994-2011)-(1964-81)

Negative summer NAO



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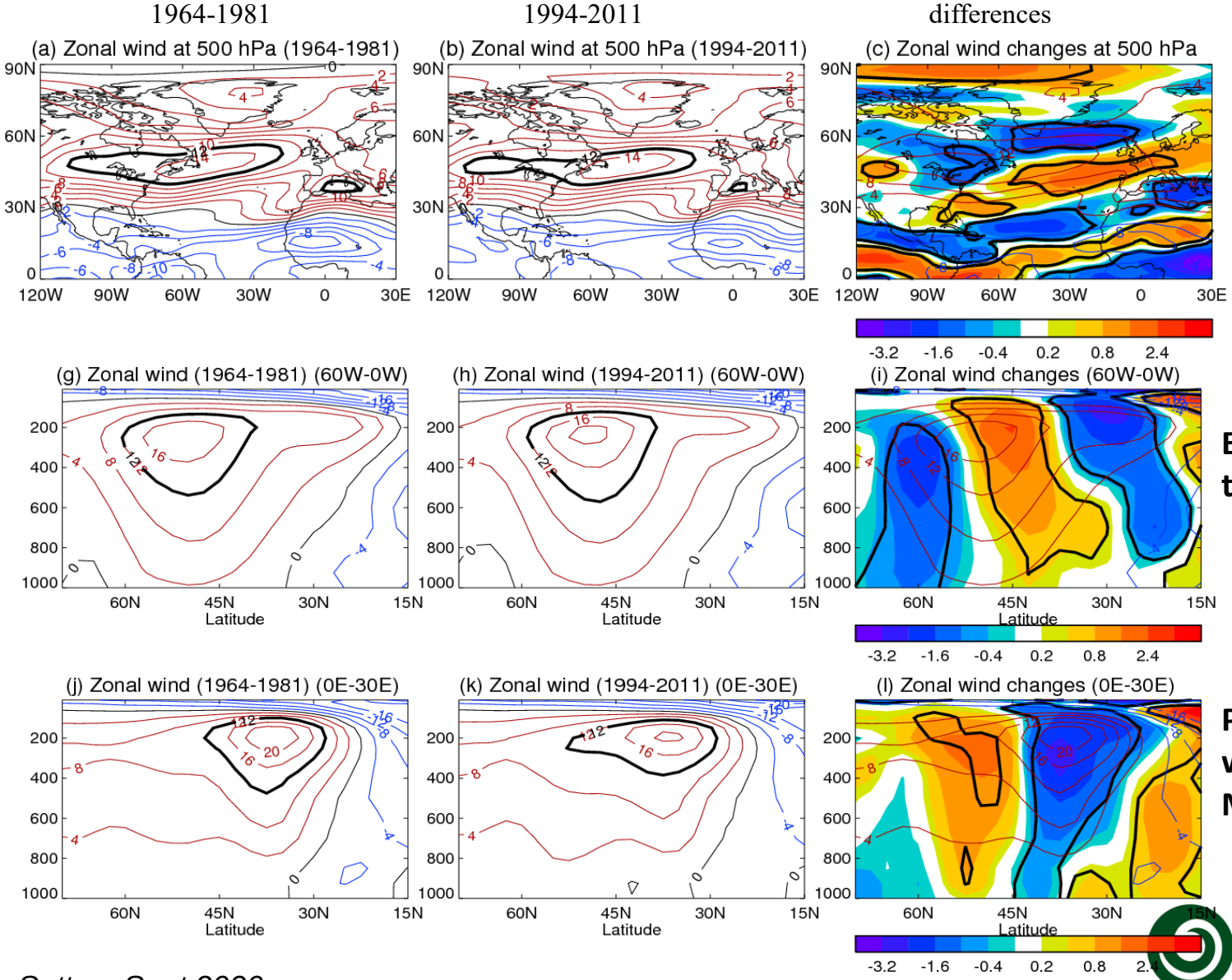
Observed changes (1994-2011)-(1964-81)



Equatorward shift in the Atlantic jet

Poleward shift and weakening of the Mediterranean jet

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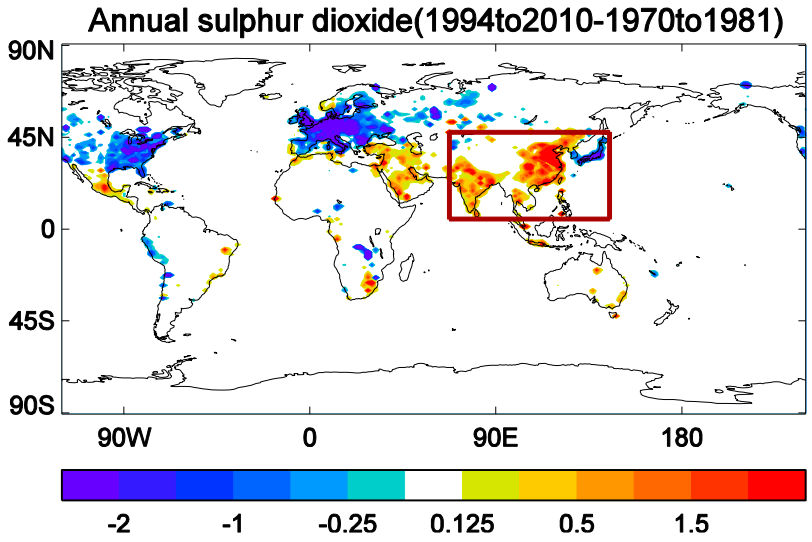
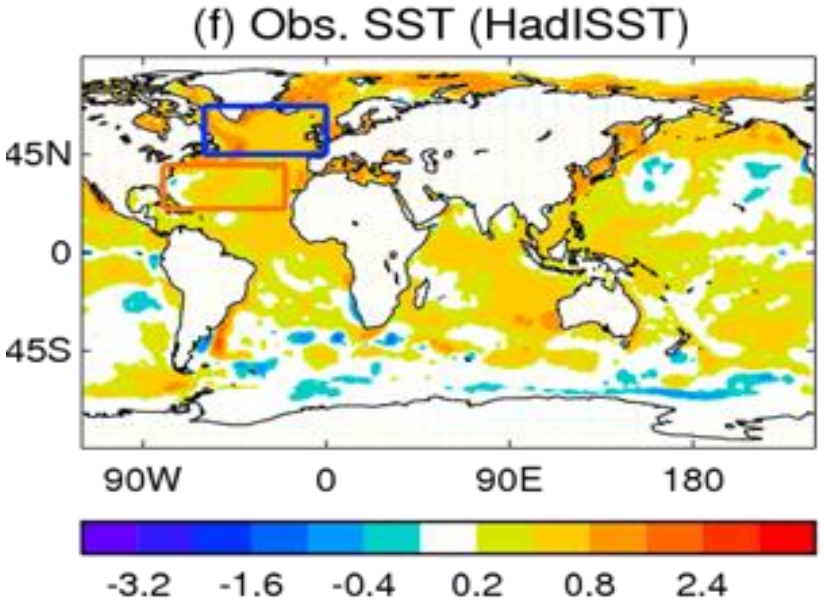
Forcing changes between 1994-2011 and 1964-1981

GHG changes: 10% increase in CO_2, 8% increase in CH_4 and 5% increase in N_2O



Decreased emissions over Europe and North America and increased emissions over East and South Asia



Large warming of subpolar gyre in North Atlantic, weakened meridional SST gradient

- To understand the relative importance of these forcing factors (SST/SIE, GHGs, AA) we carried out time-slice numerical experiments using an atmospheric GCM
- HadGEM3-A GA6 at N96 (135km) with 86 vertical levels.
- We do not address the anthropogenic contribution to the SST/SIE changes, but consider these changes as an independent forcing factor.
- Hence the response to AA and GHG forcings considers only the fast atmosphere-land response rather than the coupled response

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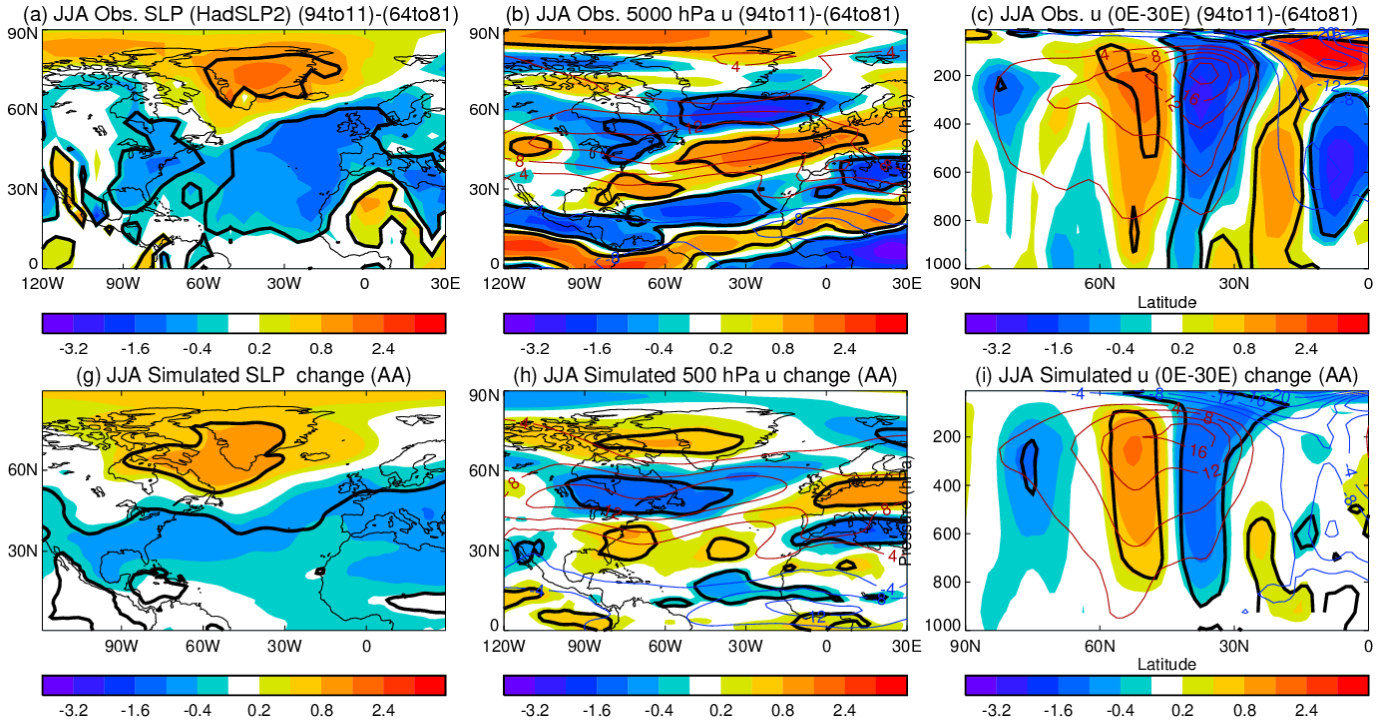
Simulated response to changes in AA forcing only

Mediterranean jet

SLP | 500 hPa zonal wind | Zonal wind at 0E-30E

Obs:

AA



- Weakening and northward shift of the Mediterranean jet well simulated
- Model simulates a weakening of the Atlantic jet rather than the observed southward shift.

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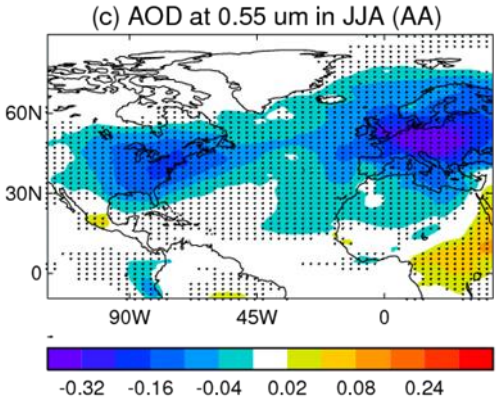
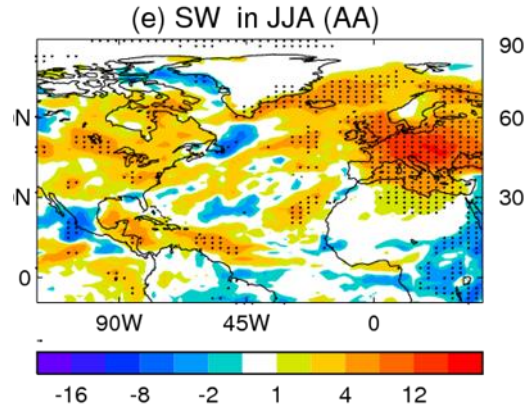
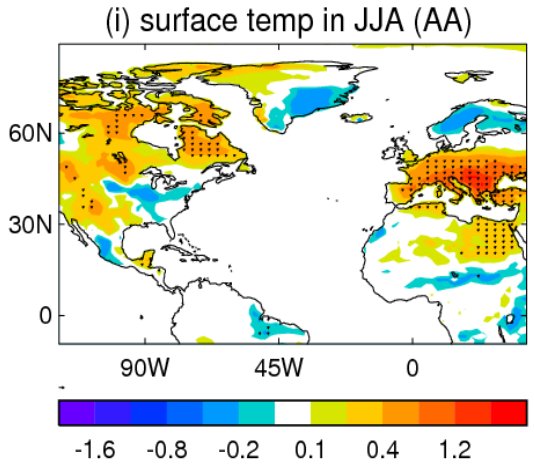
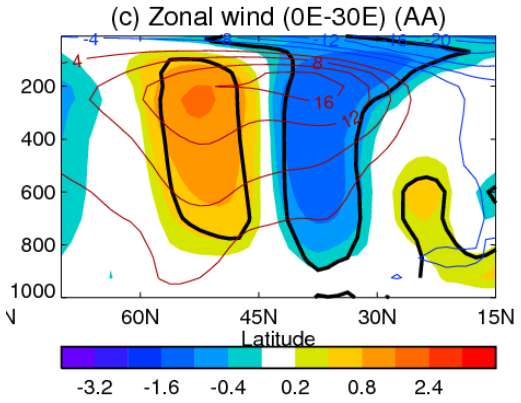
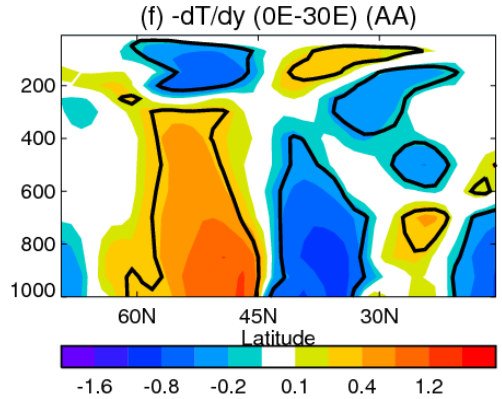
Mechanism of Mediterranean jet response to AA changes

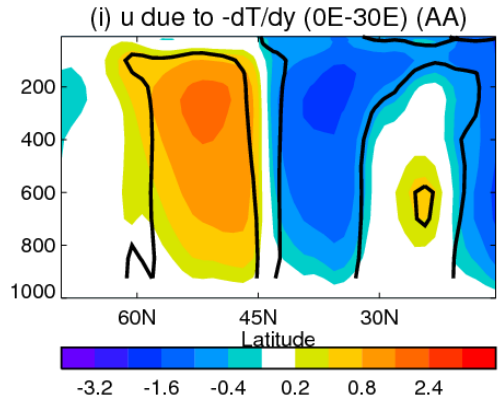




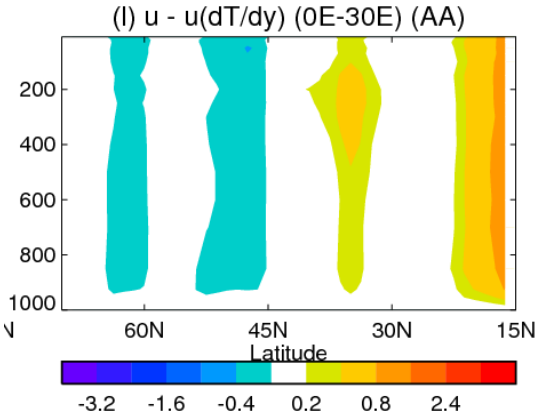








Zonal wind response predominantly related to change in meridional temperature gradient through thermal wind balance



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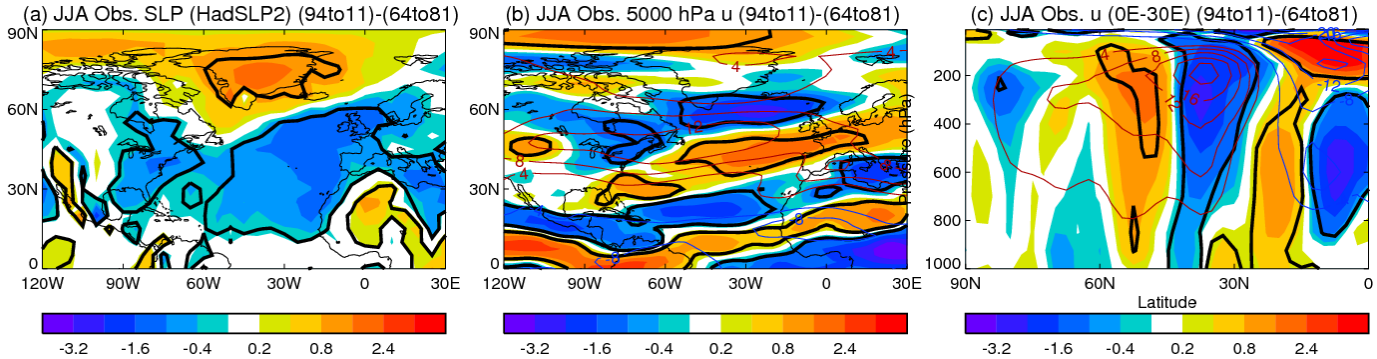
Simulated response to changes in GHG forcing only

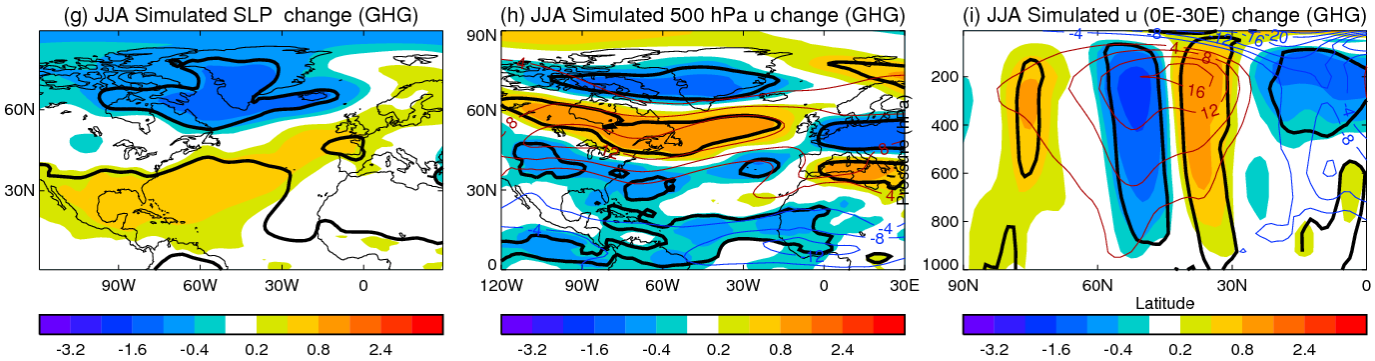
Mediterranean jet

SLP | 500 hPa zonal wind | Zonal wind at 0E-30E

Obs:



GHG



- Strengthening and southward shift of Mediterranean jet is opposite to that observed
- Strengthening of the Atlantic jet

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Conclusions

- **Observations show significant decadal changes in North Atlantic summer circulation since 1970s:**
  - **Southward displacement of the Atlantic jet**
  - **Northward displacement & weakening of the Mediterranean jet**
  - **More storms traveling across the UK into northern Europe and fewer over the Mediterranean, leading to *wet summers* in northern Europe and *dry summers* in southern Europe.**
- **Time slice AGCM experiments indicate that changes in the Mediterranean jet were very likely strongly driven by AA emission changes (with an additional influence of Atlantic SST changes, not shown here).**
- **The experiments suggest that the Atlantic jet may have been influenced by GHG, AA and SST changes, but the model does not simulate the observed southward displacement, possibly because of biases in the mean jet position which is located too far north.**
- For more details see: B. Dong & R. Sutton, J. Climate, 2021; DOI: 10.1175/JCLI-D-20-0665.1