Coupled models capture regional summertime circulation trends in the Northern Hemisphere

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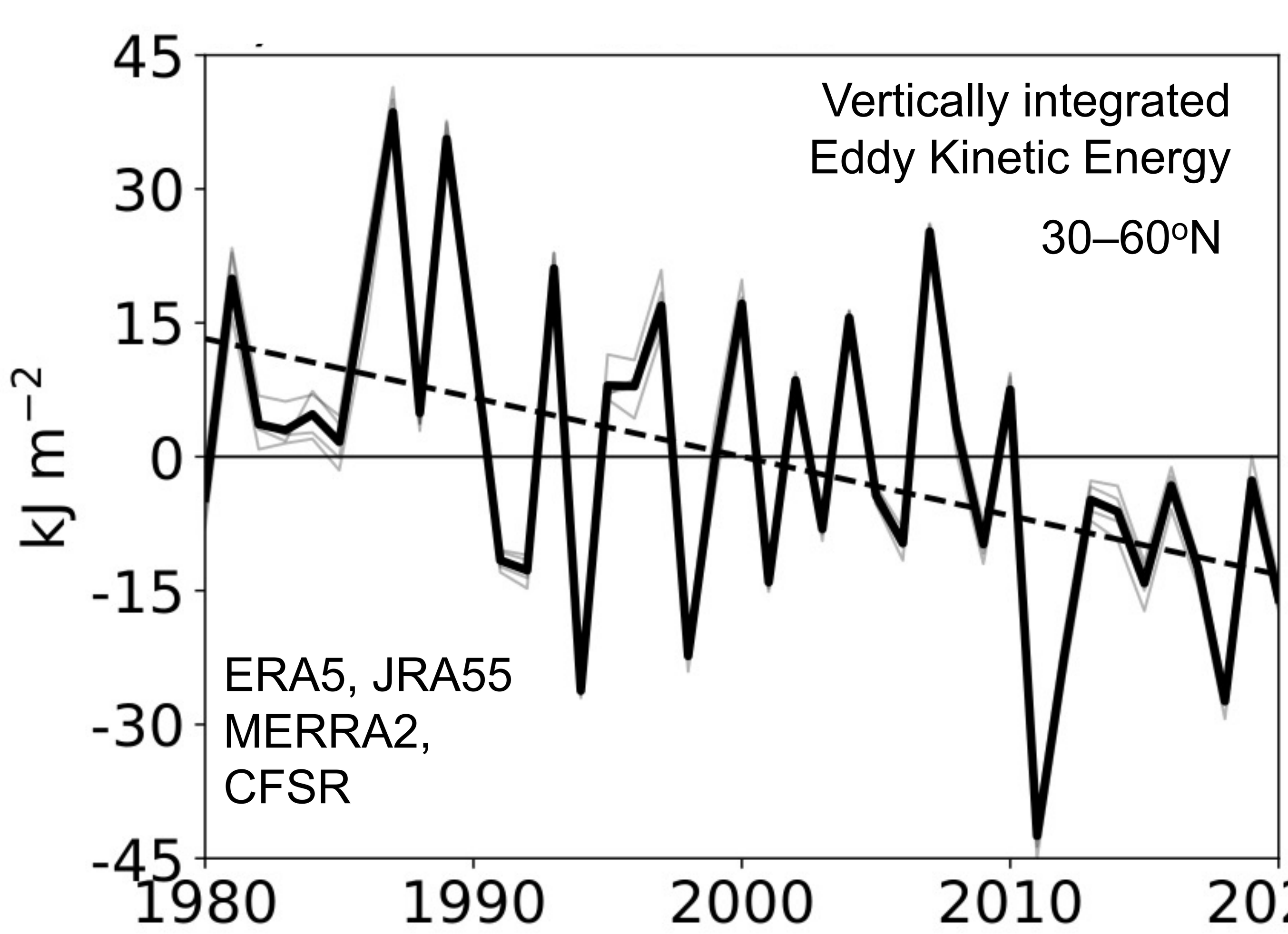
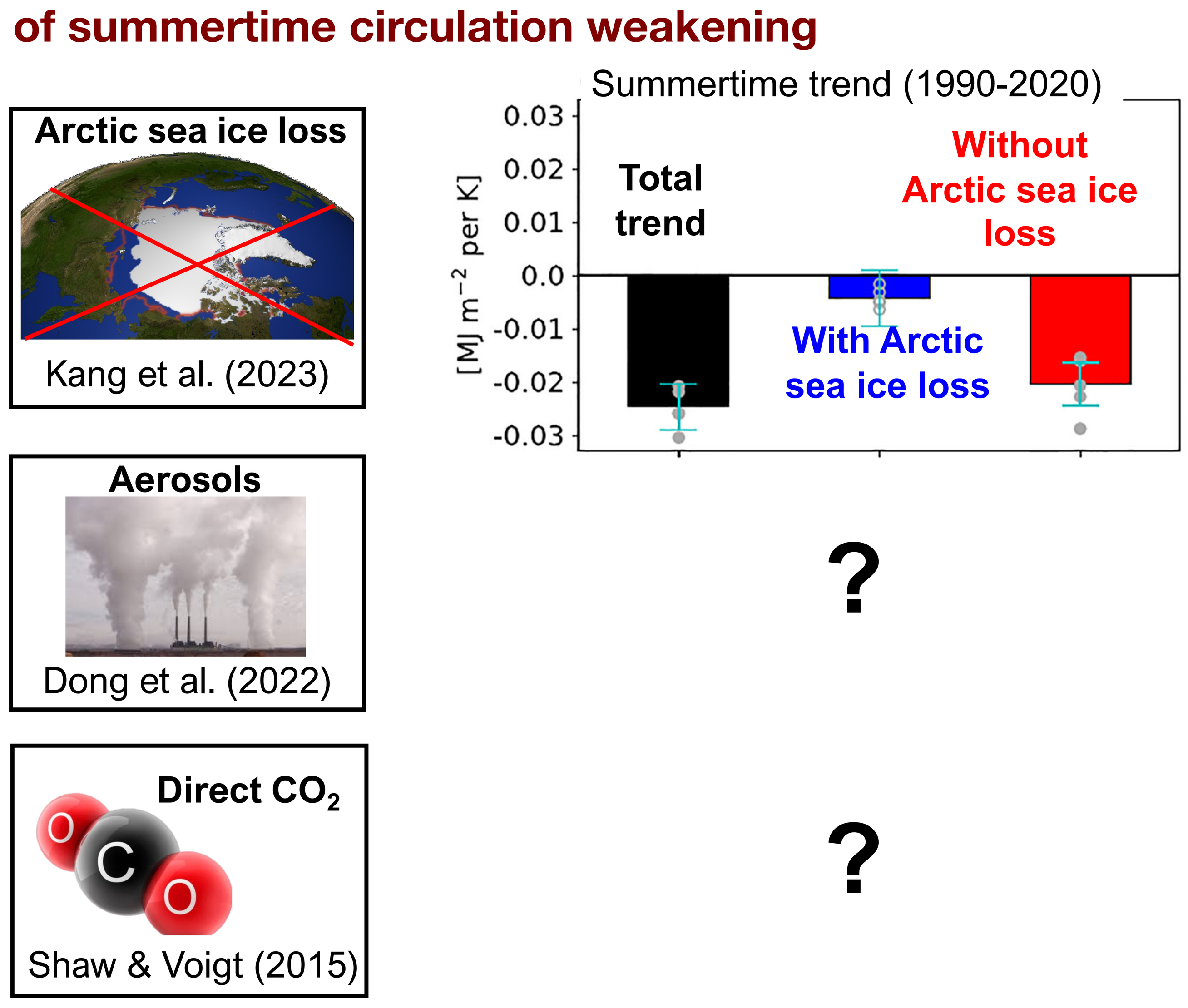
Abstract

Reanalysis data show the regional summertime circulation in the Northern Hemisphere midlatitudes has weakened significantly in the satellite era. CMIP6 models capture the regional weakening trend, which recent work showed is not significantly affected by changes in the Arctic. Here we use simulations from the Detection and Attribution Model Intercomparison Project (DAMIP) to show aerosols and greenhouse gases both contribute to weakening the summertime circulation. Anthropogenic aerosol forcing dominates the weakening in the East Asian jet and Pacific sector. The mechanism underlying the anthropogenic aerosol response is the weakening of the equator-to-pole surface shortwave radiation gradient (decreasing AOD in Europe, increasing AOD in Asia). Greenhouse gas forcing leads to zonally symmetric trends that dominate the weakening trend in the Atlantic. Our results show aerosols are a dominant factor in regional circulation trends during the Northern Hemisphere summertime in the satellite era.

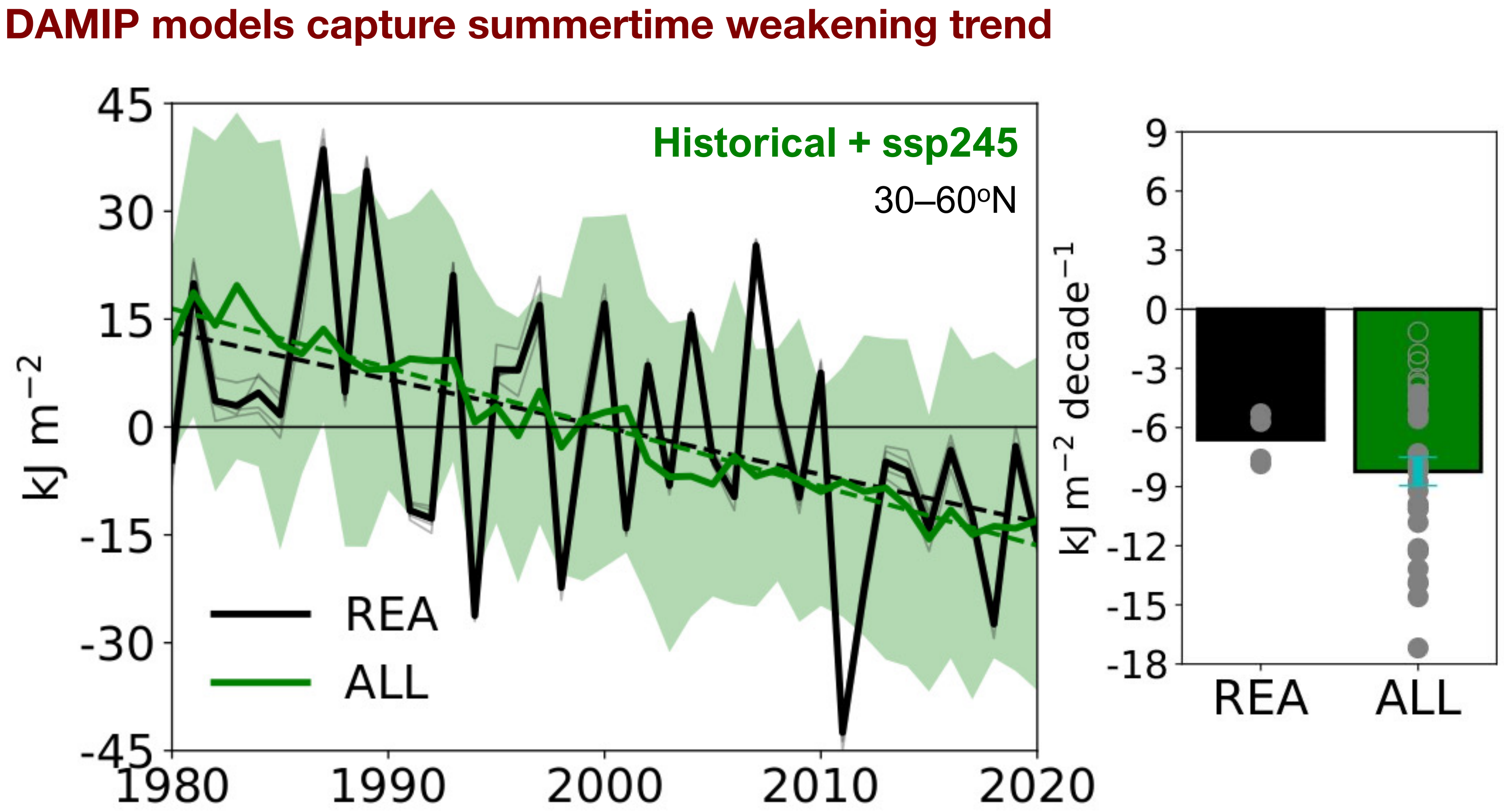
Significant weakening of Northern Hemisphere summertime circulation



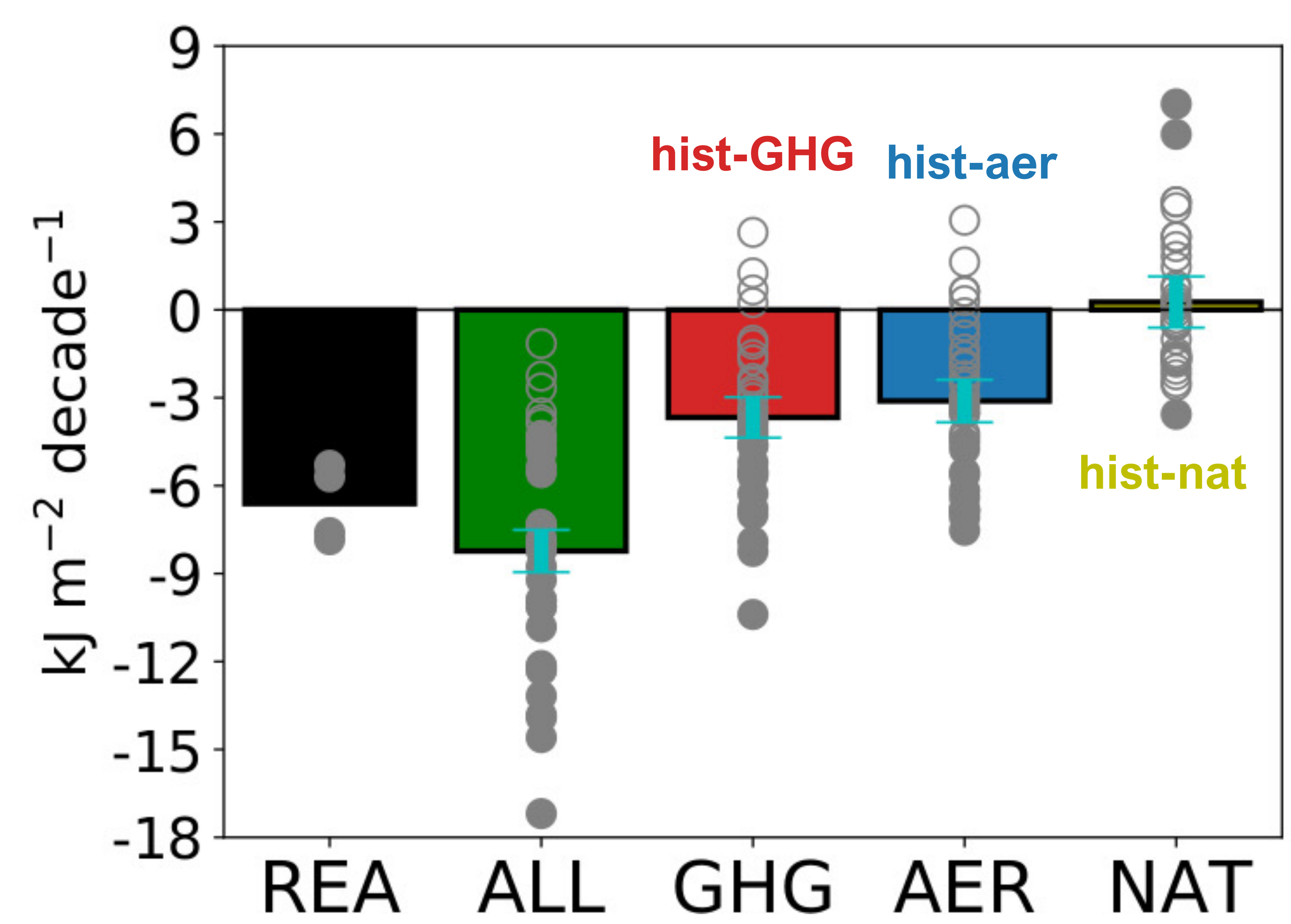
Potential drivers of summertime circulation weakening



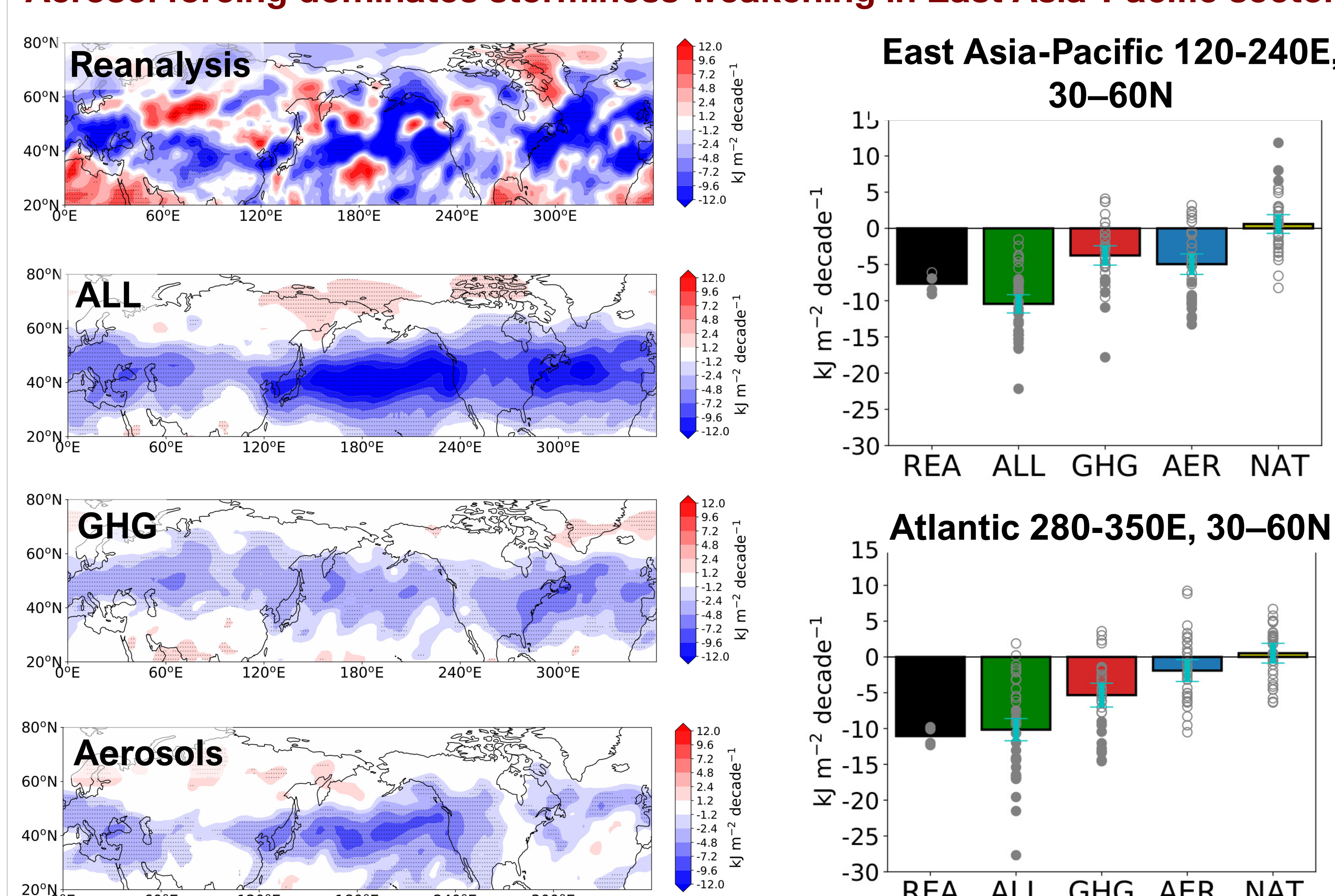
DAMIP models capture summertime weakening trend



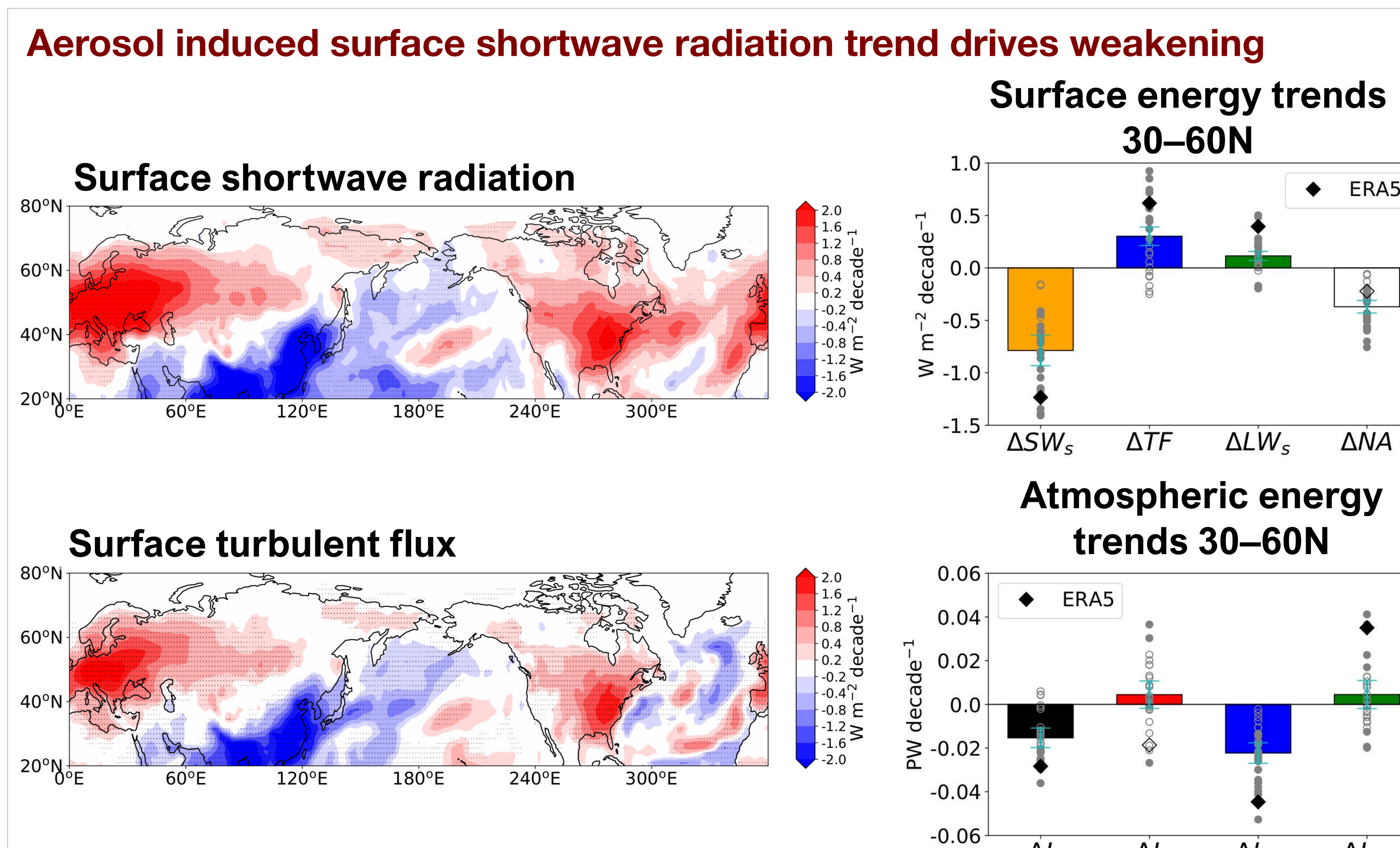
DAMIP models show GHG and aerosol forcing drive weakening trend



Aerosol forcing dominates storminess weakening in East Asia-Pacific sector



Aerosol induced surface shortwave radiation trend drives weakening



Conclusions

DAMIP simulations capture the weakening trend of the zonal-mean circulation seen in reanalysis data. According to DAMIP simulations the weakening is driven in equal parts by greenhouse gas and aerosol forcing. The weakening driven by aerosol forcing is largest in the East Asia-Pacific sector consistent with a dipole trend of surface shortwave radiation and turbulent flux. The atmospheric energy trends suggest weakening of energy input in the low latitudes and strengthening in high latitudes leads to weaker energy transport and thus weaker storminess. The results show historical aerosol forcing has induced significant regional climate impacts.