1. MOTIVATION: Research has suggested that regional changes in anthropogenic aerosols can influence the Pacific Decadal Oscillation (PDO), a major mode of climate variability, through modulation of the mechanisms through which anthropogenic aerosols can affect the Aleutian Low.

2. SUMMARY: We analyse changes to the Aleutian Low in boreal winter in an ensemble of climate models forced with idealised global and regional black carbon (BC) and sulphate aerosol perturbations. We show a robust weakening of the Aleutian Low forced by a global 10-fold increase in BC and prescribed SST experiments. We investigate the mechanisms through which BC emissions influence the Aleutian Low by forcing a linearised steady-state primitive equation model with diabatic heating anomalies. We find that direct aerosol heating over India and China generates Rossby wave trains that propagate north-east into the North Pacific. The response to a global 5-fold increase in sulphate aerosol and a regional 10-fold increase in sulphate aerosol over Asia shows poor consistency across models, with a mean response that does not project onto the Aleutian Low.

3. METHODOLOGY:
   i) Climate model data: 11 models from the Precipitation Driver and Response Model Intercomparison Project. The models ran with idealised global and regional step perturbations of sulphate and black carbon aerosol with 2 configurations – a fully coupled ocean-atmosphere (100 years) and a fixed ocean (run > 15 years). Each model specifies sulphate and black carbon as concentrations or emissions. Abbreviated experiment names: BCa10 = Global black carbon x 10, BCa10a = Black carbon x10 (Asia only), SulS5 = Global sulphate x 5, SulS10a = Sulphate x10 (Asia only), SulS10e = Sulphate x10 (Europe only). Some figures also show a double CO2 experiment for comparison (CO2x2).
   ii) Linear stationary wave model (LUMA): linearized steady-state primitive equation model. Diabatic heating anomalies associated with a) PDRMIP precipitation anomalies (BC & sulphate) and b) instantaneous heating due to absorbing BC aerosol derived from an offline radiative transfer model. We show a robust weakening of the Aleutian Low forced by a global 10-fold increase in BC in both coupled and prescribed SST experiments. We investigate the strength of the Aleutian Low through the excitation of anomalous Rossby wave trains showing instantaneous heating rates due to the BC aerosol.

4. ANALYSIS OF CLIMATE MODELS:
   - Key findings:
     - A robust weakening of the Aleutian Low due to 10-fold increase in global black carbon – similar response in fixed SST experiment indicates small role for ocean feedbacks.
     - Weaker but less robust weakening of Aleutian Low for regional black carbon increase in Asia.
     - Response to 5-fold increase in global sulphate aerosol and 10-fold increase in sulphate aerosol over Asia do not project strongly onto climatological Aleutian Low – fixed SST experiments indicate a larger role for ocean feedbacks.

5. CALCULATING DIABATIC HEATING ANOMALIES:
   - Key findings:
     - Diabatic heating over China and India are important for the North Pacific stationary wave response to BCx10 through generation of anomalous Rossby wave anomalies (not shown).
     - The direct radiative effect from the absorbing aerosol is a more important source of diabatic heating than the anomalous latent heat.
     - The model linear model does not reproduce pattern to SulS5 and BCa10a – responses are less consistent.

6. STATIONARY WAVE MODEL:
   - Key findings:
     - Diabatic heating over China and India are important for the North Pacific stationary wave response to BCa10 through generation of anomalous Rossby wave regions, and induce surface temperature anomalies in the North Pacific that resemble the PDO. In response to sulphate aerosol forcing, we do not see a consistent impact on the Aleutian Low across models, which contrasts with the studies by Smirn et al. (2016) and Oudar et al. (2018) who showed that the increase in aerosols over Asia during 1998-2012 tends to weaken the Aleutian Low in simulations with coupled climate models.

REFERENCES:

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