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Precipitation changes with midlatitude strength and frequency and the resulting climate feedbacks in observations and models

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Changes in midlatitude storm properties, such as strength and frequency, have been occurring in the last 50 years and are predicted to intensify as climate continues to change. The UKMO climate model, for example, simulates decreases in storm frequency and increases in storm strength with climate warming. At the same time, observational analyses show significant changes in the distribution of cloud, radiation, and precipitation properties with midlatitude storm strength and frequency. This points to the potential for midlatitude radiation and hydrologic feedbacks with climate warming. The observational analysis results provide a useful testing ground for model skill in simulating midlatitude cloud, radiation, and precipitation changes with atmospheric dynamics. If successful, models can be used to understand and evaluate feedback processes resulting from such changes.

In the present study, satellite and reanalysis data and IPCC model output are used to 1) identify midlatitude storm centers and tracks and define their area of influence, 2) extract precipitation properties in the storm centers' area of influence, and 3) examine relationships between precipitation properties and storm dynamics in observations and models. All models estimate correctly the increase in precipitation due to increasing storm strength but overestimate the decrease in precipitation due to decreasing storm frequency. This is because all models produce very little midlatitude precipitation outside storm events. When the UKMO-predicted storm changes in storm strength and frequency are applied together, models produce a negative feedback as the decrease in storm frequency dominates. Observations on the other hand point to a positive precipitation feedback dominated by the increase in storm strength. This points to the need for improved midlatitude precipitation simulation in climate models.