Global warming causes extreme precipitation to increase faster in winter than in summer over the Northern Hemisphere.

On the seasonality of northern hemisphere precipitation extremes.

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INTRODUCTION

- Future changes in extreme precipitation are considered one of the most impactful consequences of climate change, with potential effects ranging from increased flood risk to crop failures.
- Climate models have predicted a distinct seasonality to changes in extreme precipitation, however it is currently unclear whether this seasonality also exists in the observational record.
- Specifically, climate models predict that over Northern Hemispheric land there will be a strong, positive increase in winter vs weaker increases in summer. [See *Figure 1.*] However the mechanism underlying these changes is still very poorly understood.
- These uncertainties make it difficult for the scientific community to provide clear policy suggestions to governments regarding adaption strategies, so it is imperative that they are addressed.

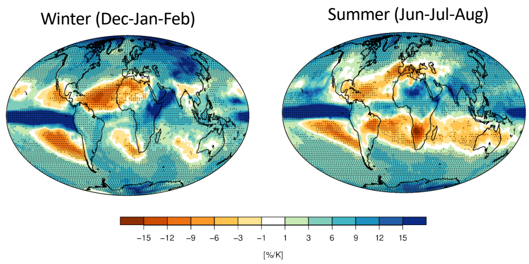

Figure 1: Climate model projections for changes in extreme precipitation under global warming. Note the decreased response over Northern Hemisphere (NH) land during summer.

METHODS

1. Analyse observed trends from the Hadley Centre's global climate extremes dataset (HadEX2) to test whether observations corroborate the model outputs. *[Figure 2]*
2. Conduct an analysis of the inter-model difference across the state-of-the-art CMIP5 climate model to investigate possible physical mechanisms. *[Figure 3, Figure 4]*
   1. **Hypothesis**: seasonal changes in relative humidity inhibit convection during summer (JJA) and thus reduce precipitation extremes in that season relative to in winter.

RESULTS

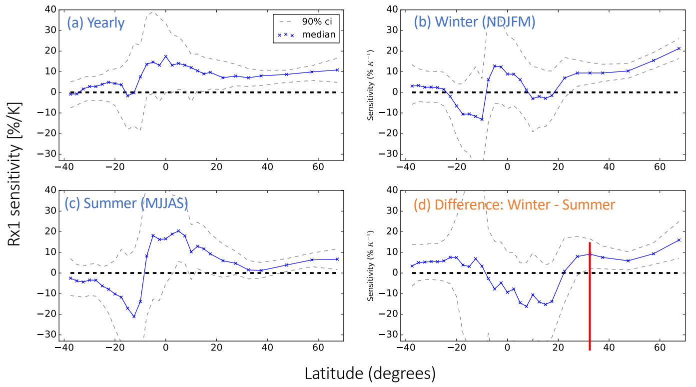

Figure 2: Latitudinal analysis of land-based precipitation observations from 1901-2010. Panels (a)-(c): The yearly, winter and summer response of extreme precipitation to observed warming, with 90% confidence interval at each latitude. Panel (d): Analysis of the difference between Winter and Summer response.

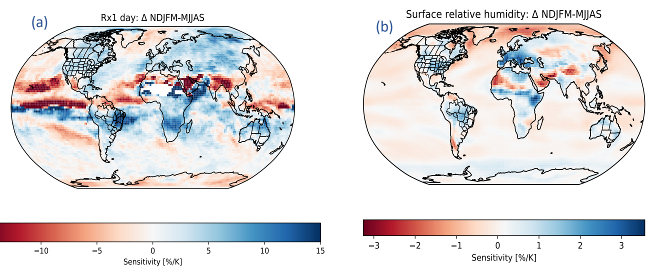

Figure 3: Visual comparison of the projected seasonal differences (ie. winter changes – summer changes) for; (a) extreme precipitation and (b) near-surface relative humidity (RH). In agreement with our initial hypothesis, the pattern of changes in RH qualitatively matches that of extreme precipitation over land. These correlations are further investigated in *Figure 4.*

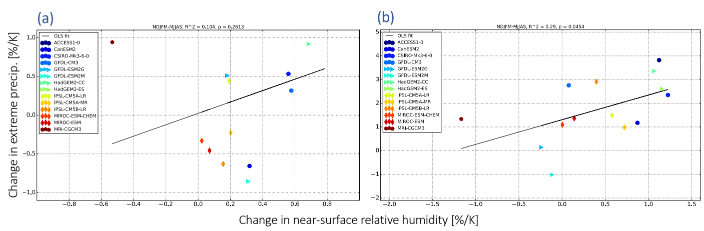

Figure 4: Regression of changes in extreme precipitation against changes in near-surface relative humidity in 15 of the CMIP5 models. Each point represents a separate climate model. Panel (a) considers changes over all land. Panel (b) considers land changes only within a 30N-70N latitude band as suggested by the analysis in *Figure 2.*

CONCLUSIONS

- We have demonstrated that NH precipitation extremes do have a distinct seasonal cycle, as predicted by the climate models.
- Additionally, changes in near-surface relative humidity are a plausible explanation for the predicted seasonal changes in extreme precipitation.

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