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Tropical Circulation Variance Response to Climate Change

Competing Influences of Energy Budget Variability and Gross Moist Stability

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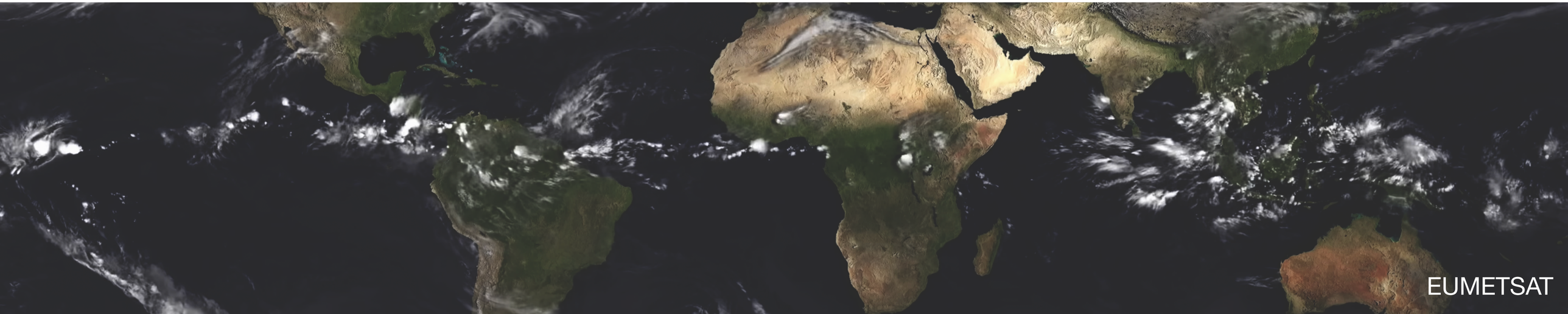
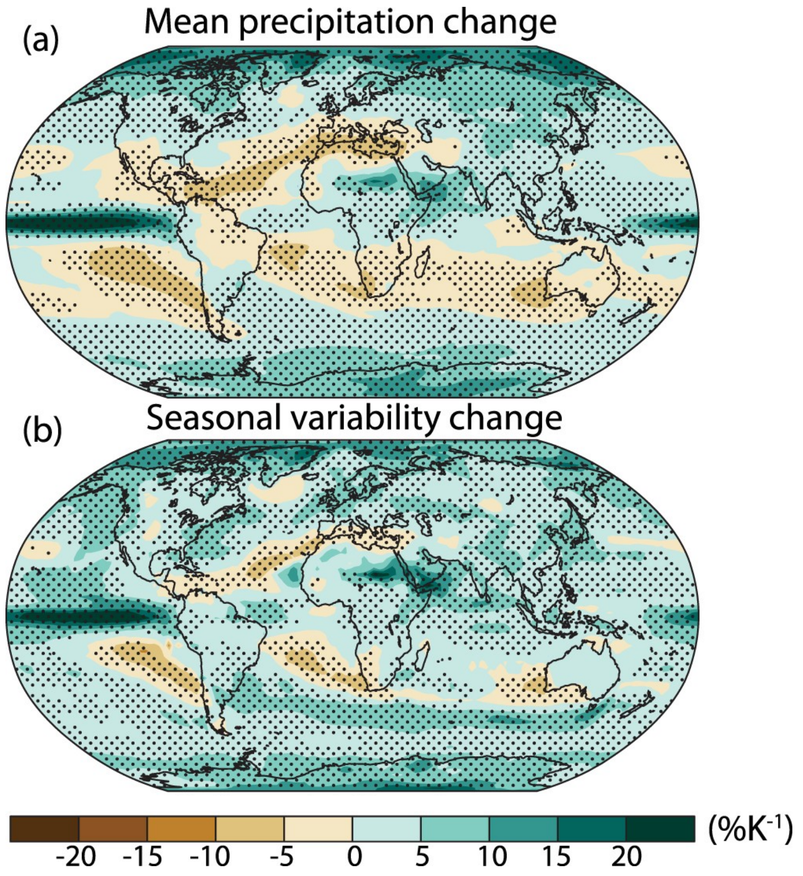


Motivation

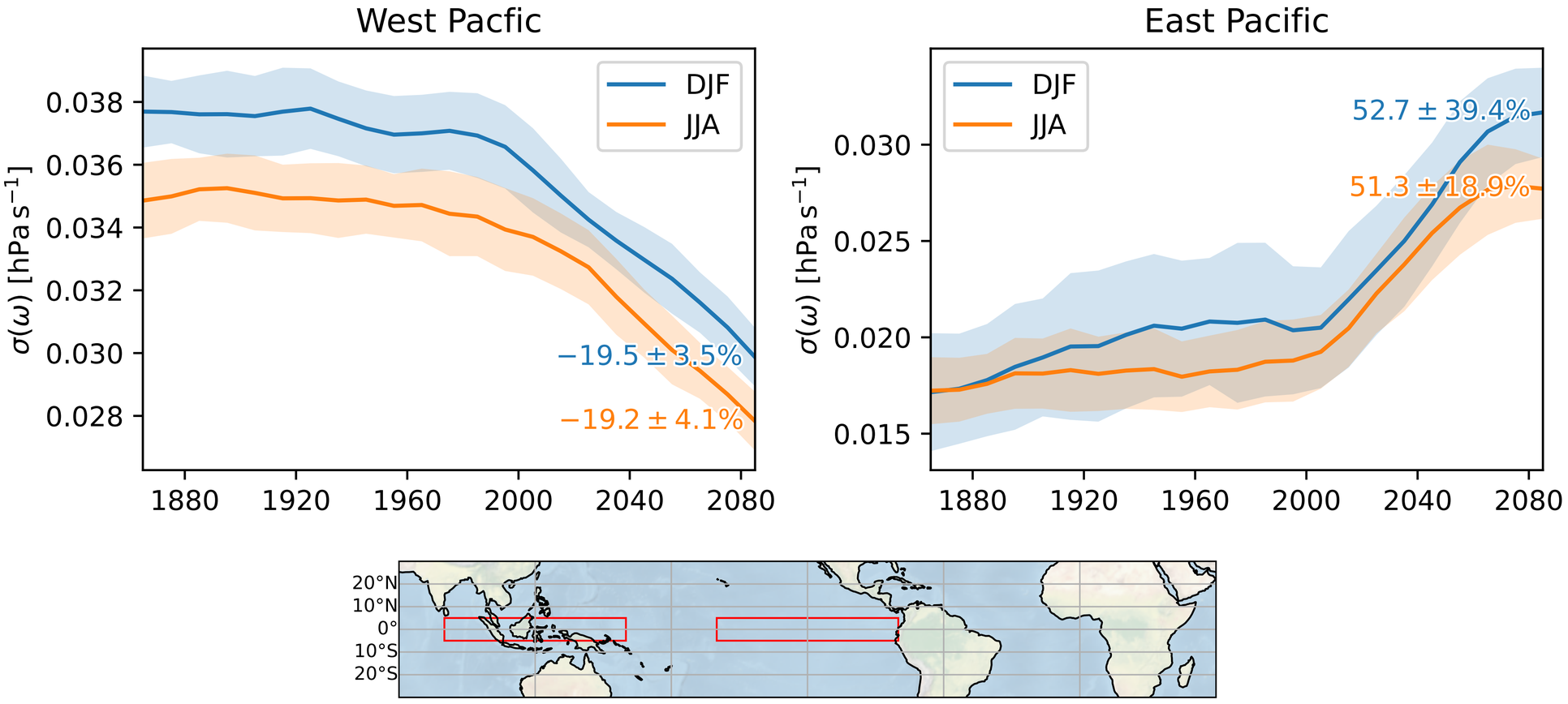
- Atmospheric circulation has strong impacts on mean precipitation
- Precipitation variability also responds strongly to climate change
- Mean circulation response well understood; variance response not

$$P \sim \omega \frac{\mathrm{d}q}{\mathrm{d}p}$$



Pendergrass et al. 2017

Vertical velocity variance changes significantly in response to climate change in CESM2-LE



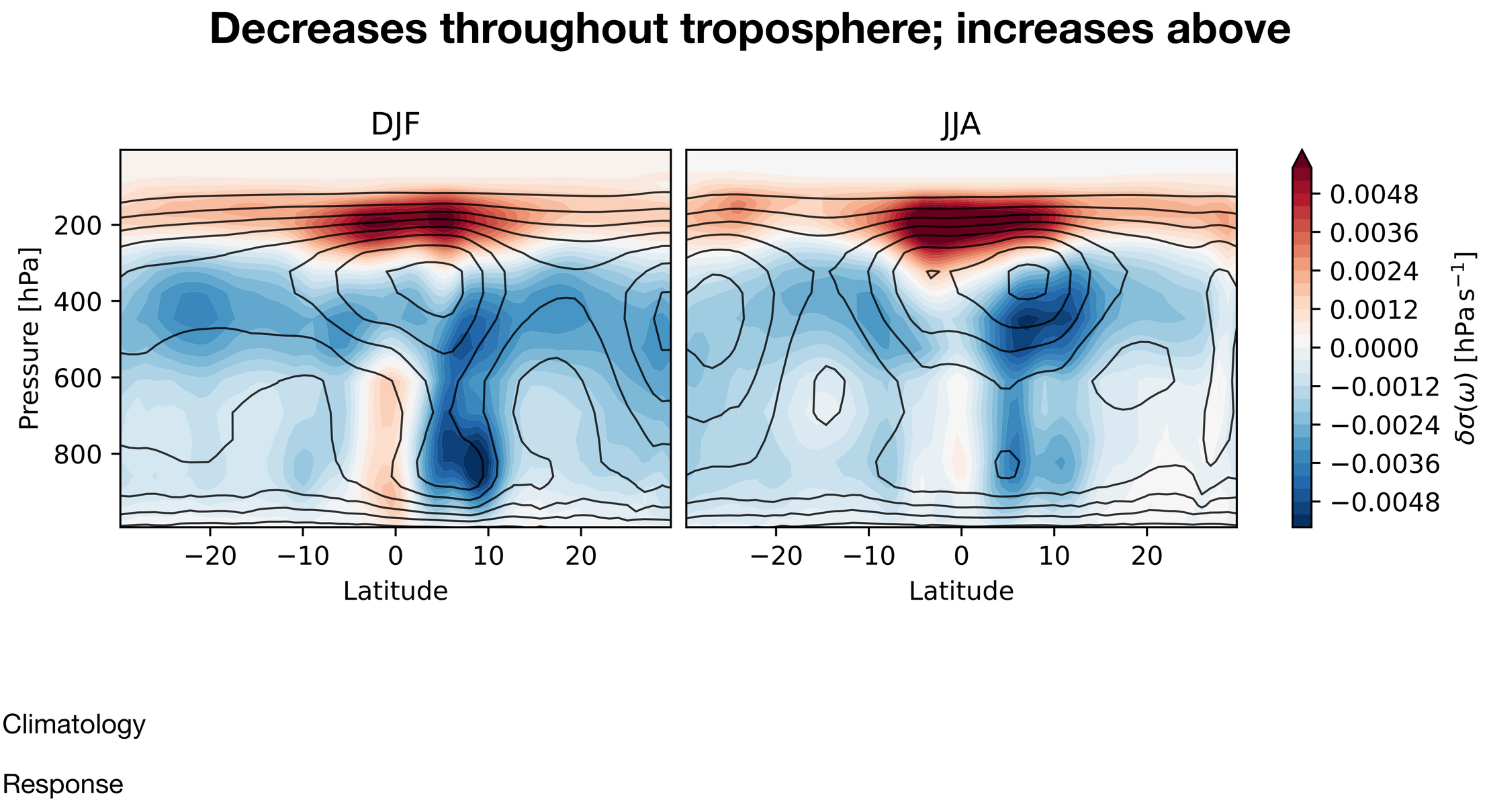
Questions:

1. How is vertical velocity variance changing?
2. What are the mechanisms?

Methods

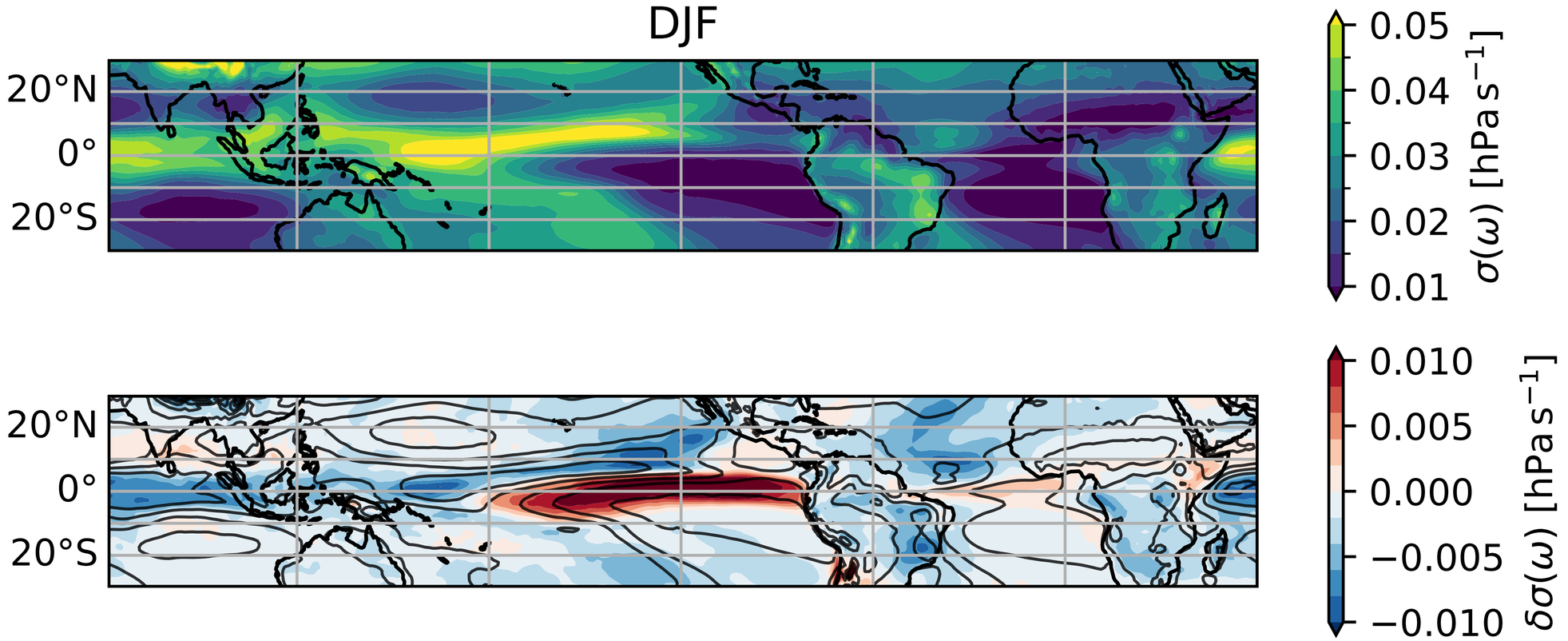
- CESM2-LE, 50 members with SMBB
- 1970-1999 (historical) vs 2070-2099 (SSP3.70)
- Monthly data

How is vertical velocity variance changing?



How is vertical velocity variance changing?

Decreases in most of the tropics; increases in the equatorial eastern Pacific



Climatology

Response

What are the mechanisms?

Neelin and Held 1987
Neelin and Zeng 2000
Wills et al. 2017

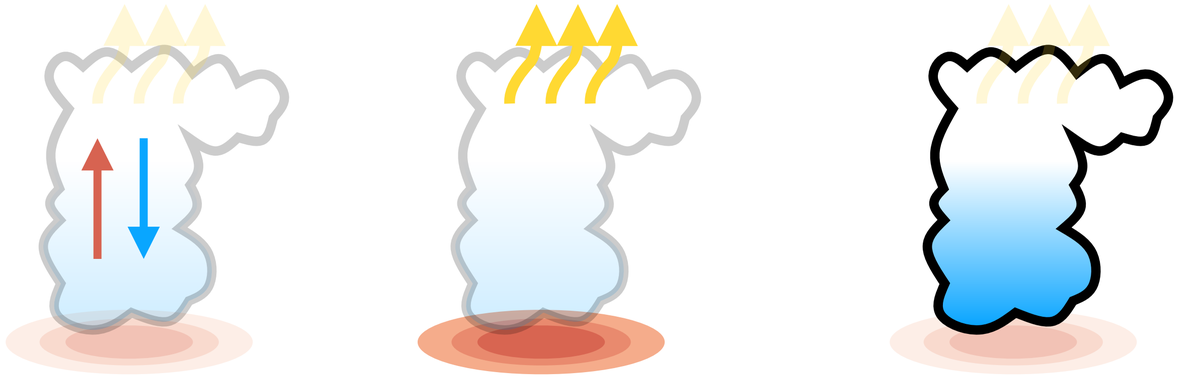
Gross moist stability

$$\mathrm{GMS} = \frac{\text{Energy export}}{\text{Unit convective flux}}$$

Net energy input

$$\mathrm{NEI} = \mathrm{SW} + \mathrm{LW} + \mathrm{LH} + \mathrm{SH}$$

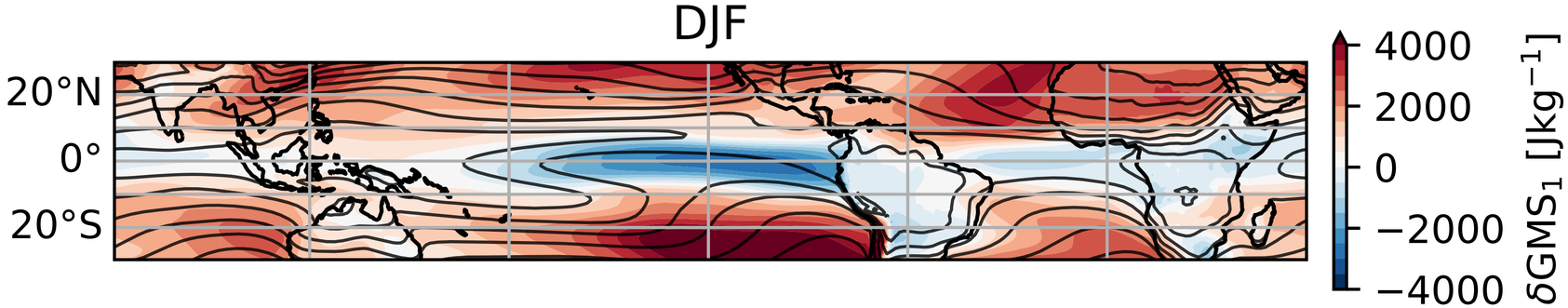
What are the mechanisms?



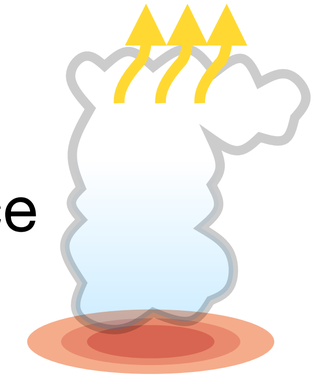
$$\delta_{\%}\sigma(\omega) \approx \delta_{\%}\sigma(\mathrm{NEI}) - \delta_{\%}\mathrm{GMS}$$

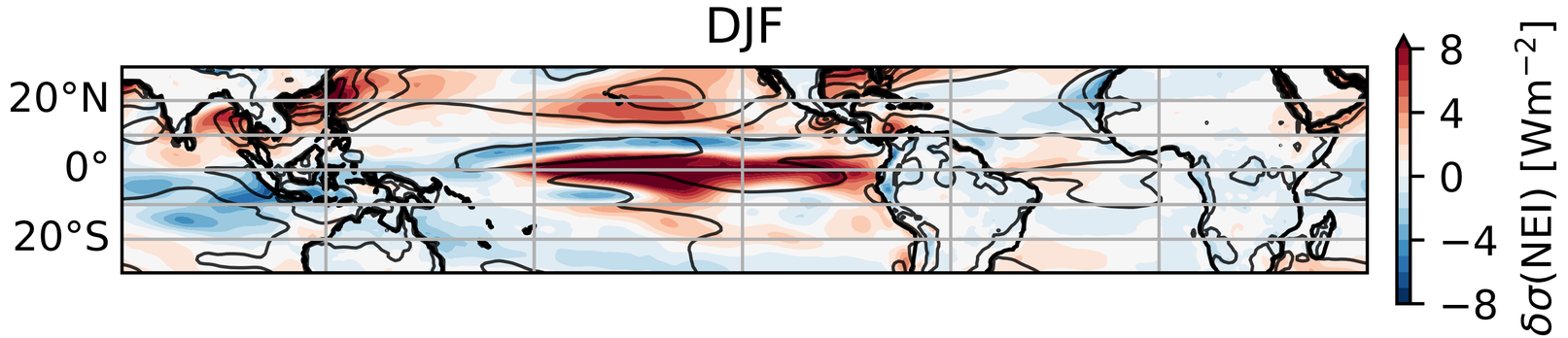
$\delta_{\%}X$ fractional response of X

GMS



NEI variance

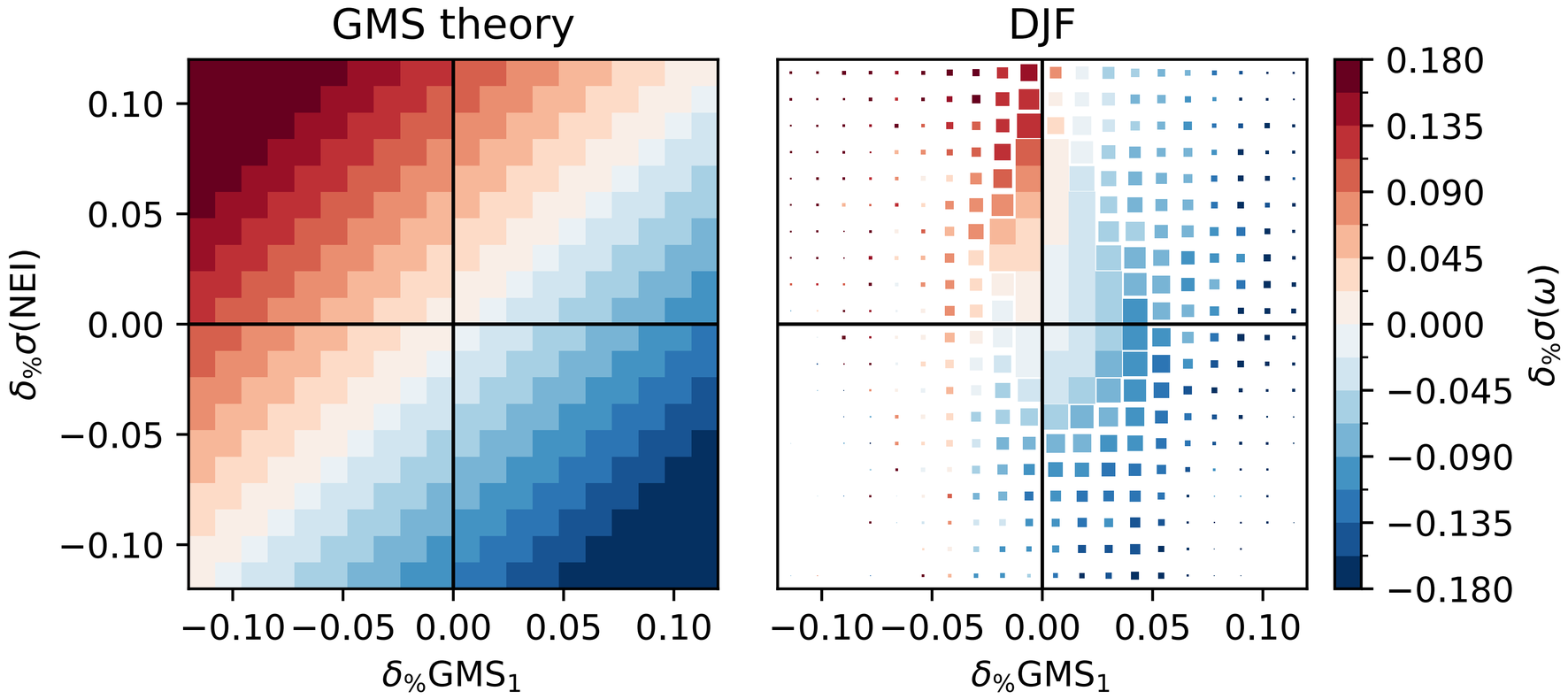




Climatology

Response

GMS and NEI variance both contribute to circulation variability changes



$$\delta_{\%}\sigma(\omega) \approx \delta_{\%}\sigma(\mathrm{NEI}) - \delta_{\%}\mathrm{GMS}$$

Summary

- Vertical velocity variance decreases in most of the tropical troposphere, except in the East Pacific
- Both NEI variance and GMS changes are needed to explain the response

See the preprint for more information

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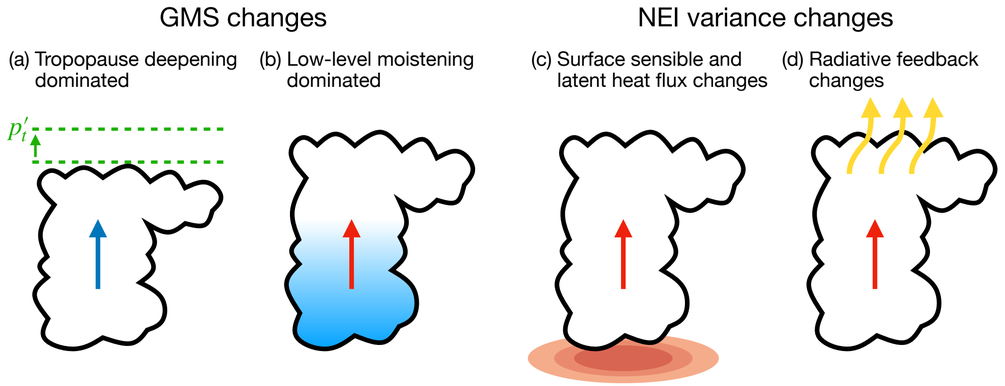
DOI: https://doi.org/10.22541/essoar.176990601.11274984/v1

Preview of all mechanisms



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