How does Sea Surface Temperature drive the **I**nter-**T**ropical **C**onvergence **Z**one in the Southern Indian Ocean?

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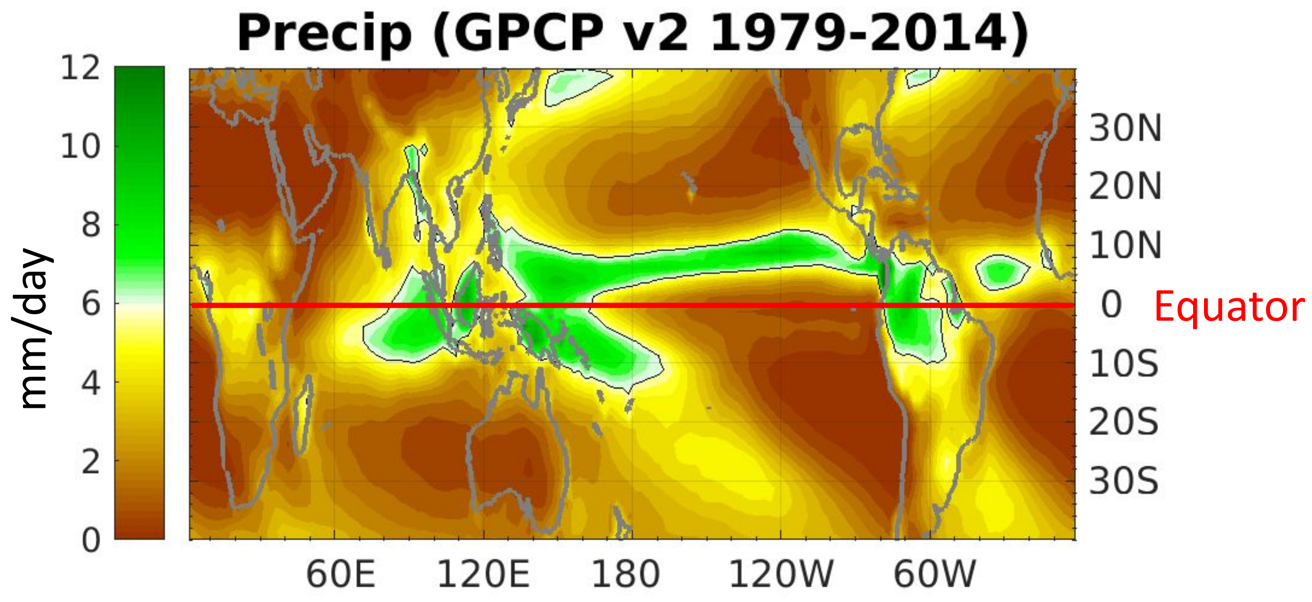
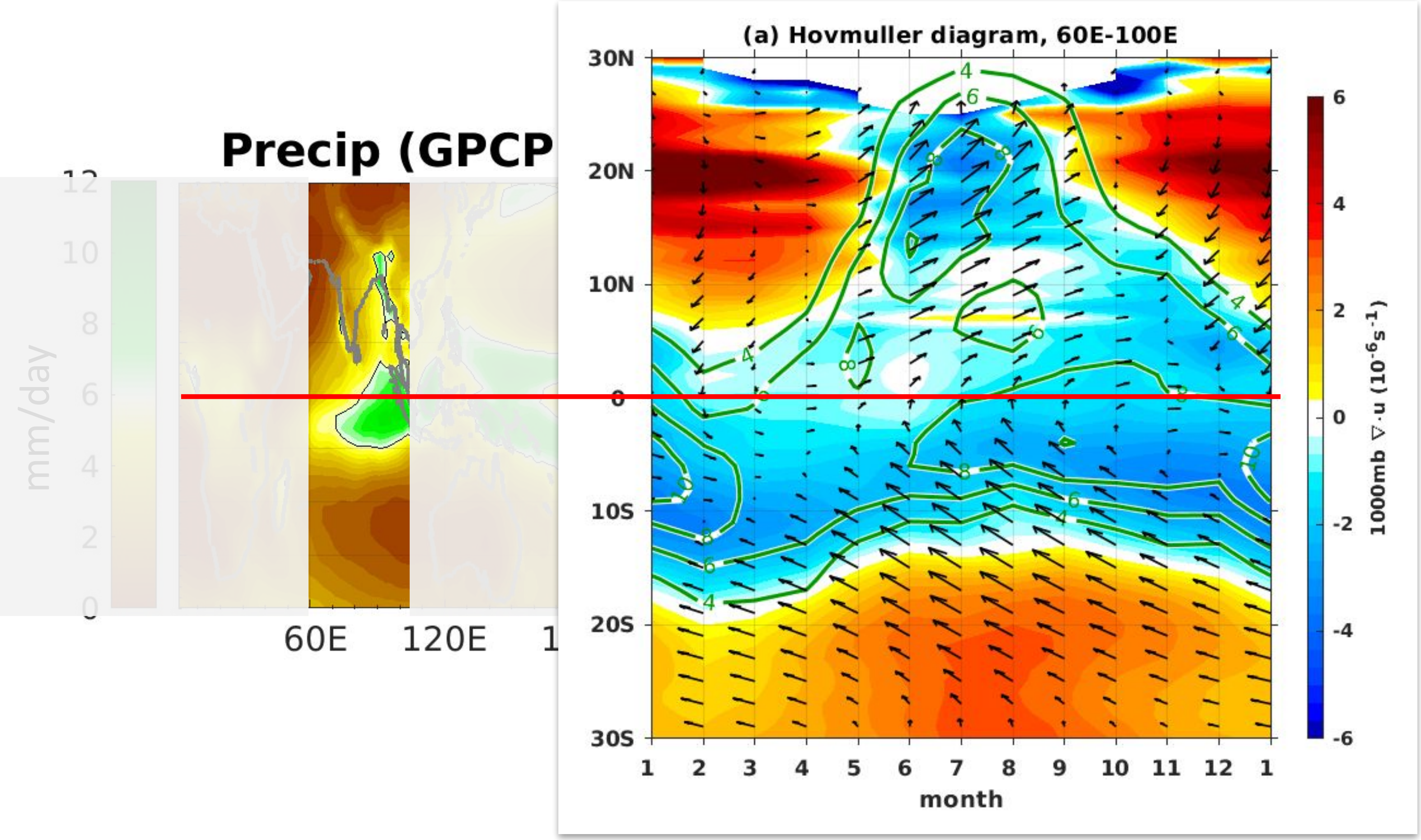


- ❑ Northern ITCZs in the Pacific and Atlantic have been studied extensively
- ❑ **Southern ITCZ in the Indian Ocean has received little attention** (Zhang 2001; Keshtgar et al. 2020)

Year-round ITCZ in the Southern Indian Ocean

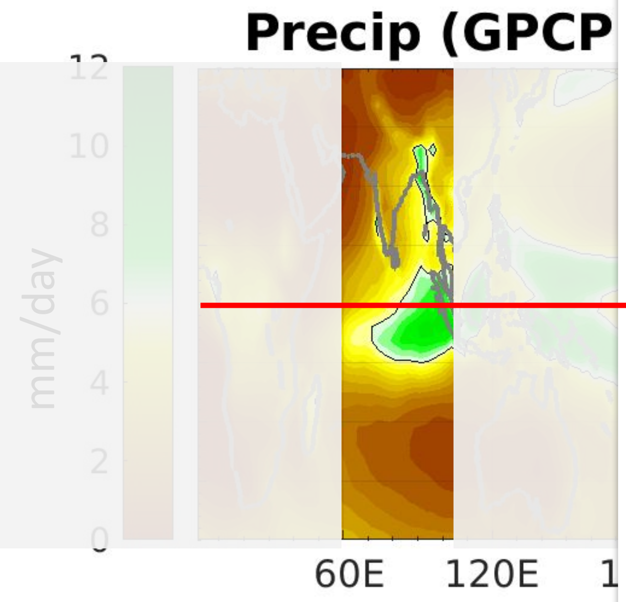
ERA5 1000mb winds and divergence



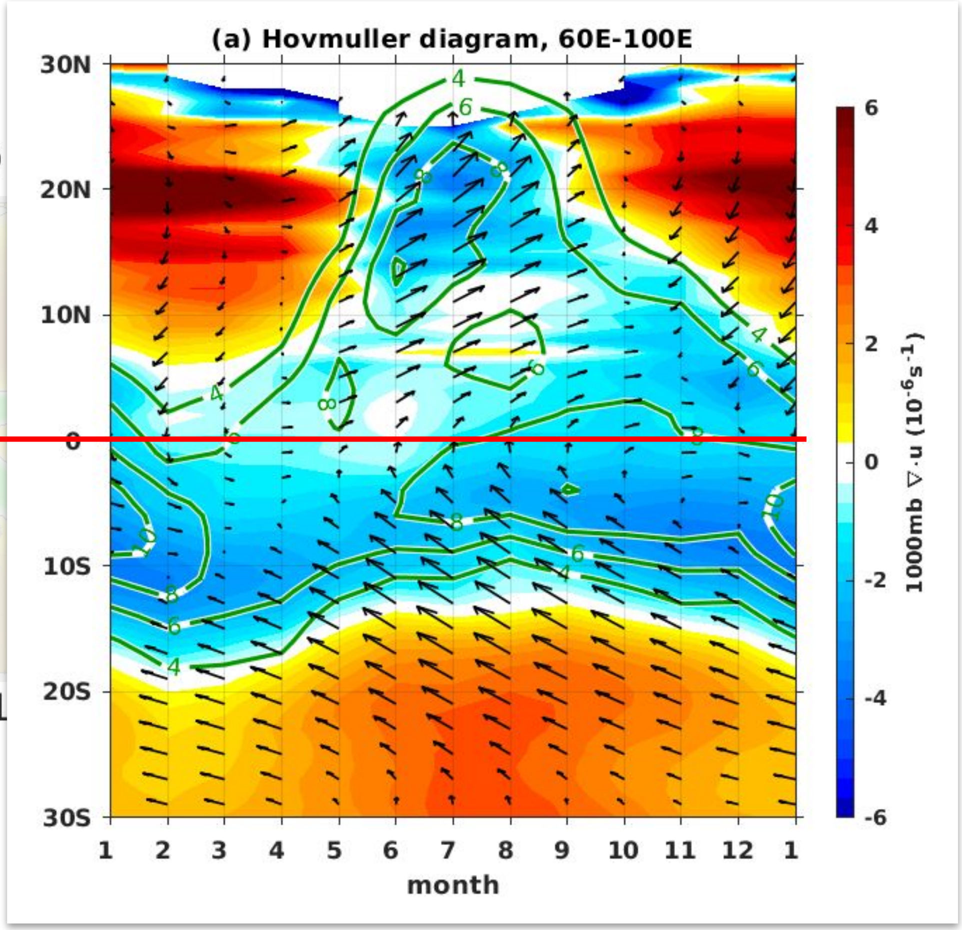
Green contours: precipitation (mm/day)

- ❑ Peak in Dec-Feb (DJF)
- ❑ Weaken in Mar-May
- ❑ Grow in Jun-Nov
- ❑ Coexist with South Asia monsoon in Jun-Aug (JJA)

Year-round ITCZ in the Southern Indian Ocean



ERA5 1000mb winds and divergence



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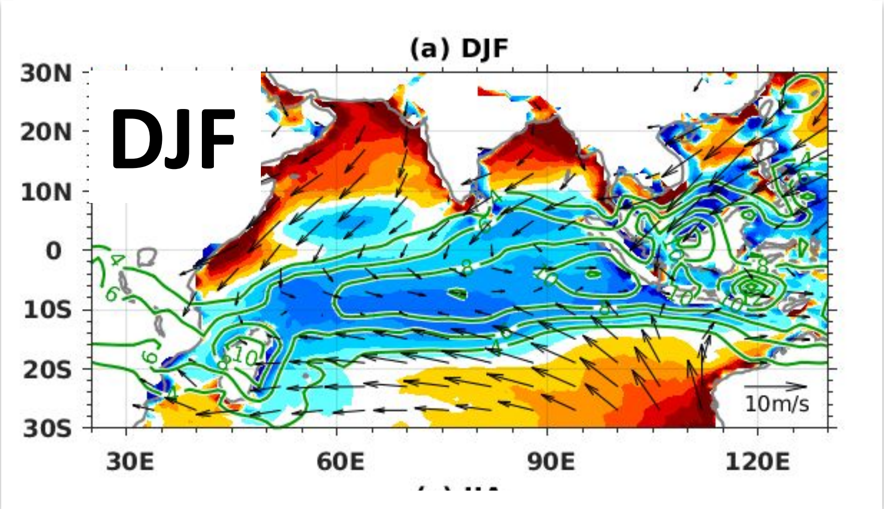

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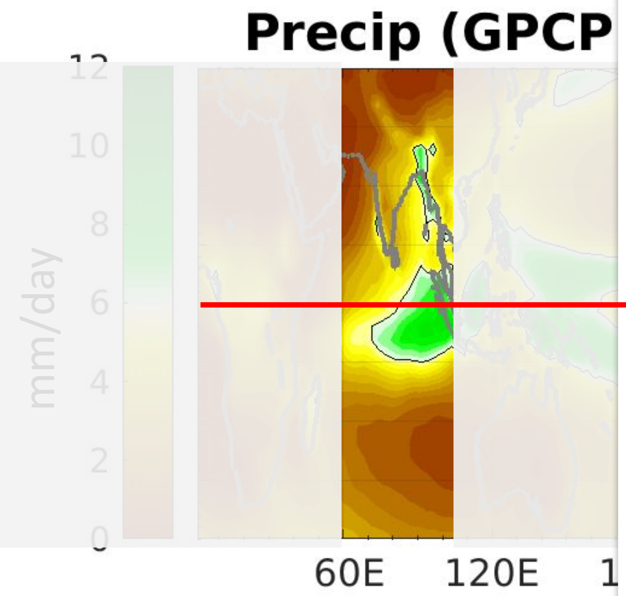

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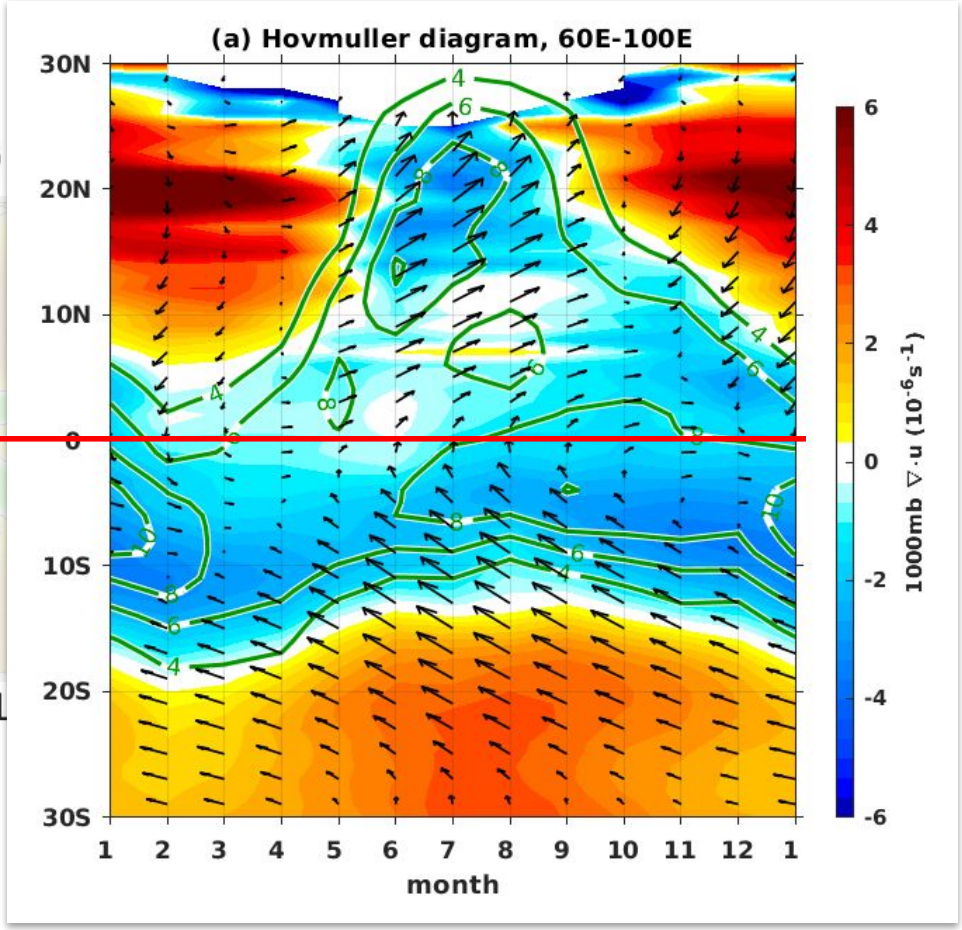

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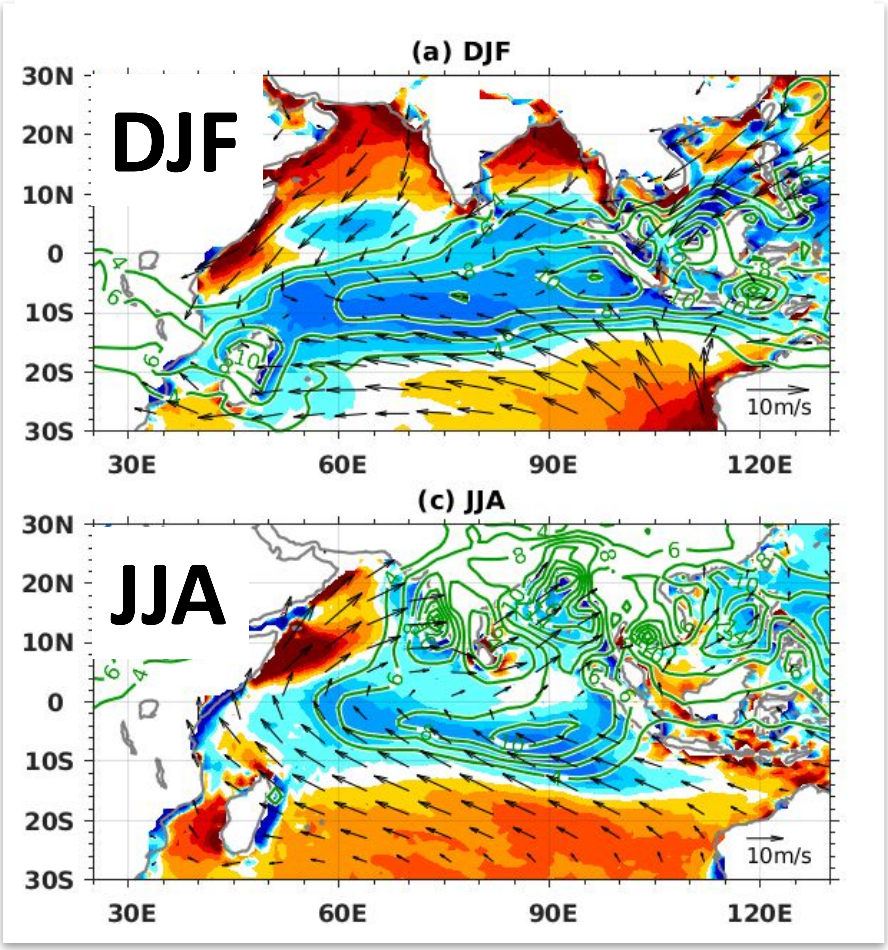
ERA5 1000mb winds and divergence

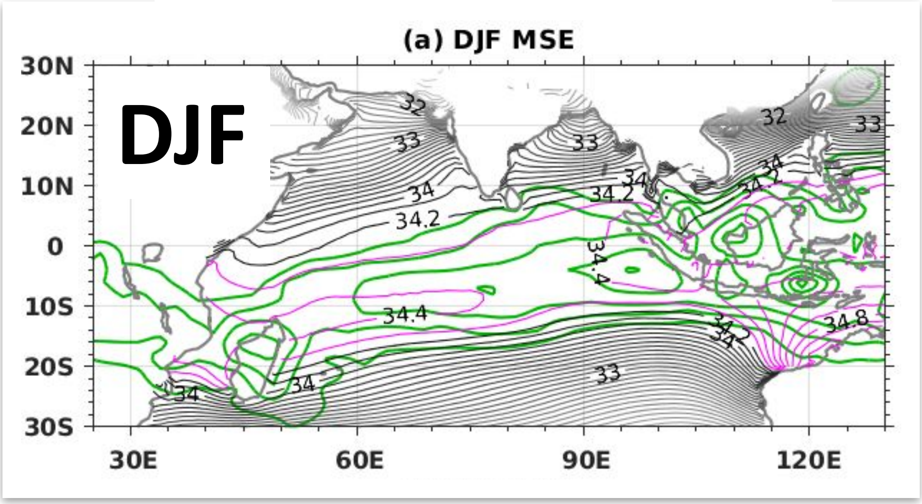


Observational interpretation

- **Convective quasi-equilibrium (CQE) theory**: ITCZ should occur over regions of **maximum surface moisture static energy (MSE)**

Observational interpretation

ERA5 1000mb MSE (10^4 J kg^{-1})



Green contours: precipitation (mm/day)

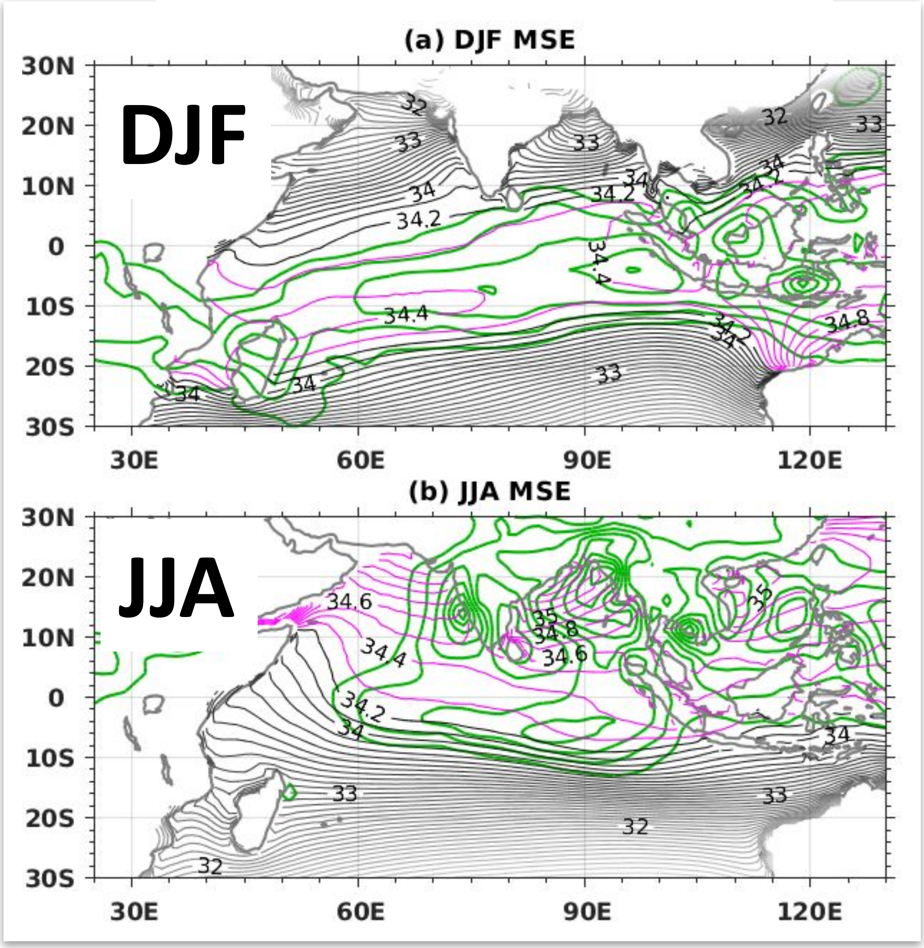
- ❑ **Convective quasi-equilibrium (CQE) theory**: ITCZ should occur over regions of **maximum surface moisture static energy (MSE)**

- ❑ DJF: Consistent with CQE theory

Observational interpretation

- **Convective quasi-equilibrium (CQE) theory**: ITCZ should occur over regions of **maximum surface moisture static energy (MSE)**
- DJF: Consistent with CQE theory
- JJA: Inconsistent with CQE theory

ERA5 1000mb MSE (10^4 J kg^{-1})



Green contours: precipitation (mm/day)

Modeling interpretation

- Goal: to quantify the contribution of **two types of atmospheric processes** to the Indian Ocean ITCZ, **given observed SST forcing**
  - Planetary boundary layer (PBL) processes (Lindzen-Nigam)
  - Free-atmosphere diabatic heating (Gill)

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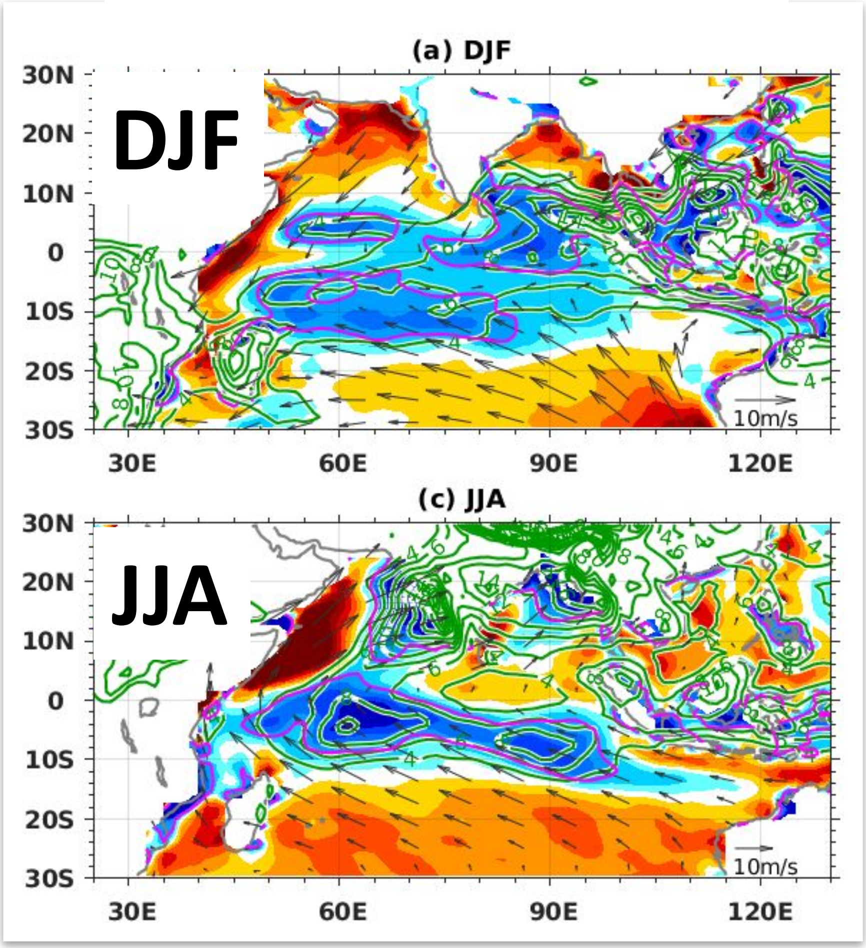
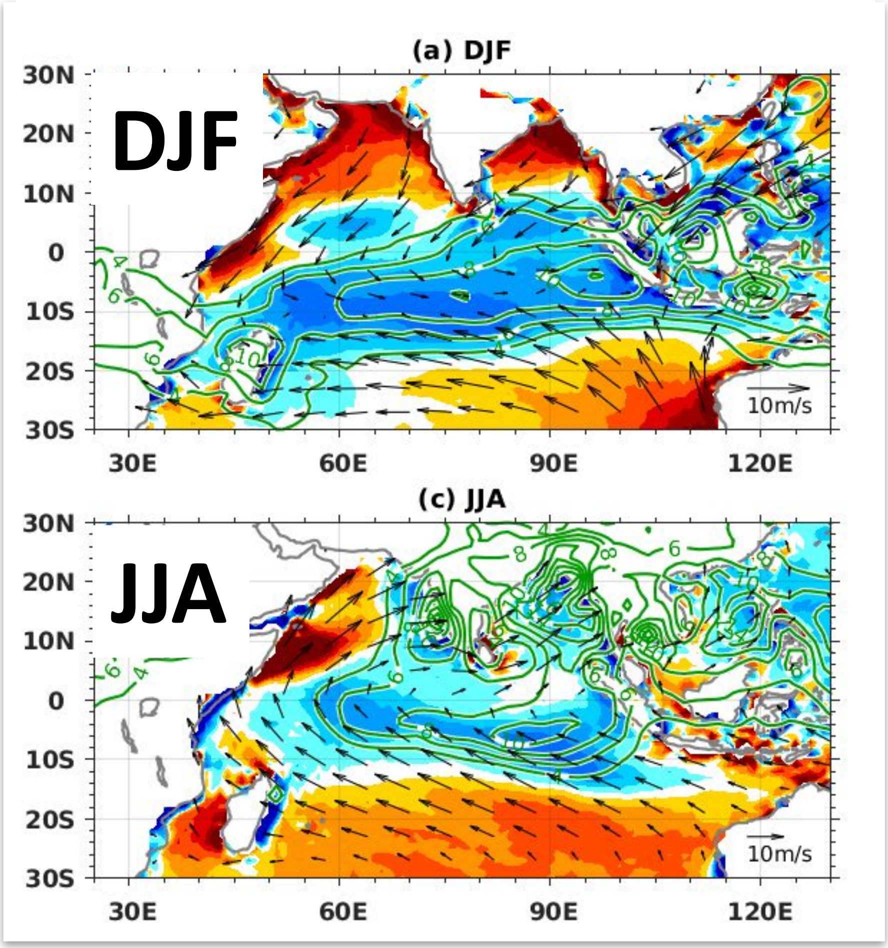
- A Linear dynamical model: Lindzen-Nigam vs Gill
- A state of the art AGCM
  - NCAR **Community Atmosphere Model v6.3 (CAM6)**, ~1° horizontal resolution
  - Driven by climatological monthly SST from HadISST (v2)

Control experiment (CNTL): overall realistic (with biases)

CAM6 winds and divergence



ERA5 1000mb winds and divergence

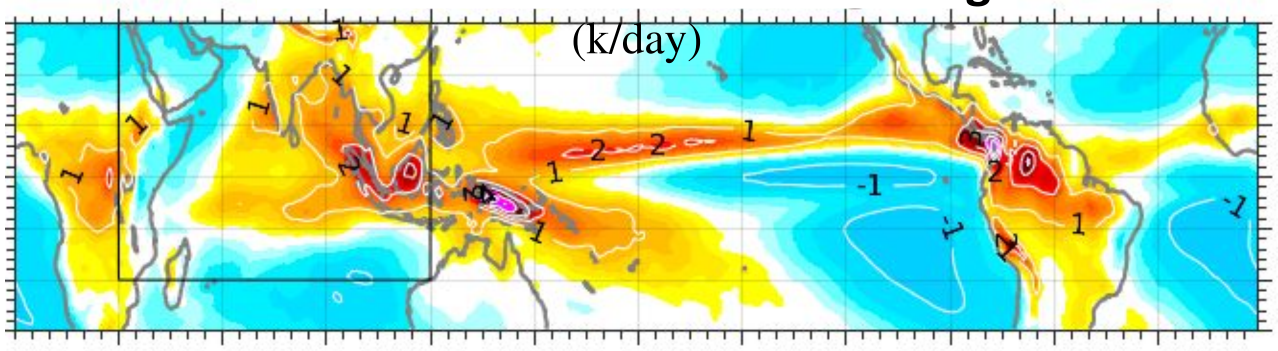


Green contours: precipitation (mm/day)

PBL vs free-atmosphere contributions

- Sensitivity experiment (SENS): keep PBL untouched, remove free-atmosphere diabatic heating horizontal gradients
  - Over the Indian Ocean, homogenize all diabatic heating above 800hPa
  - Outside the Indian Ocean, nudge wind and moisture fields back to their CNTL mean state

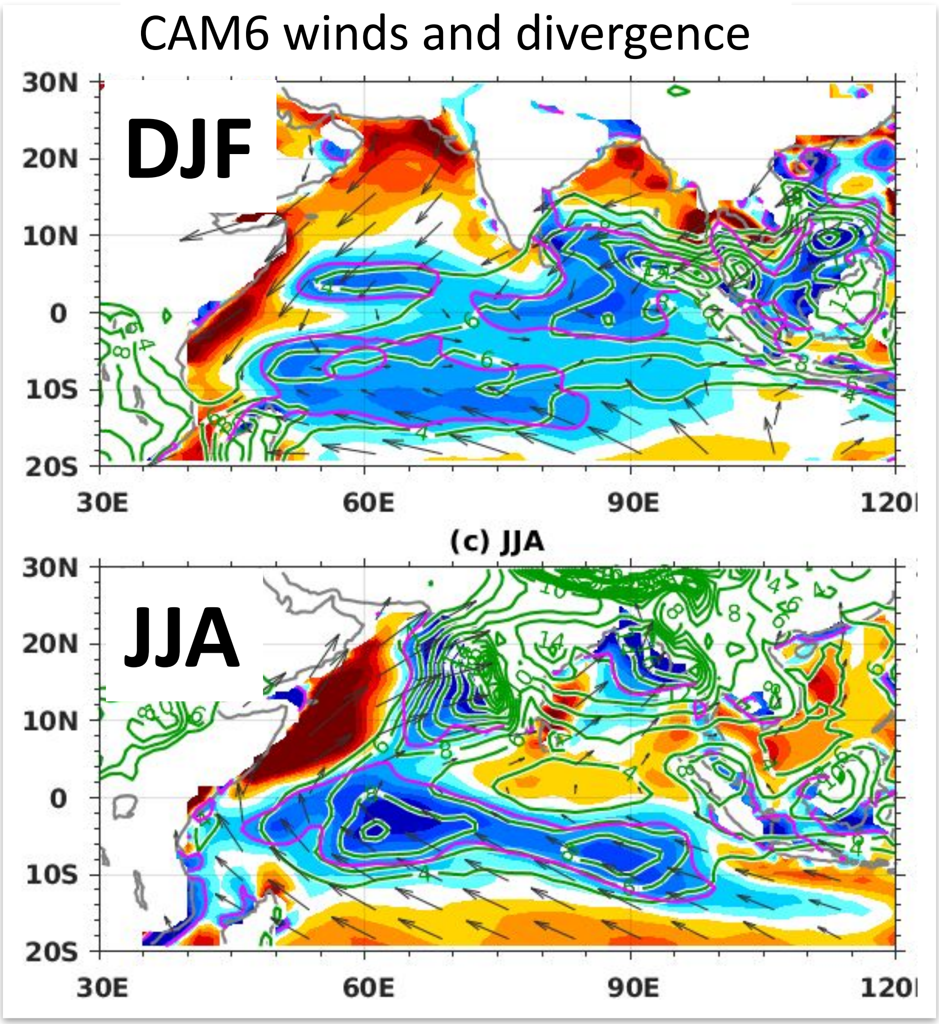
CAM6 0-850mb diabatic heating



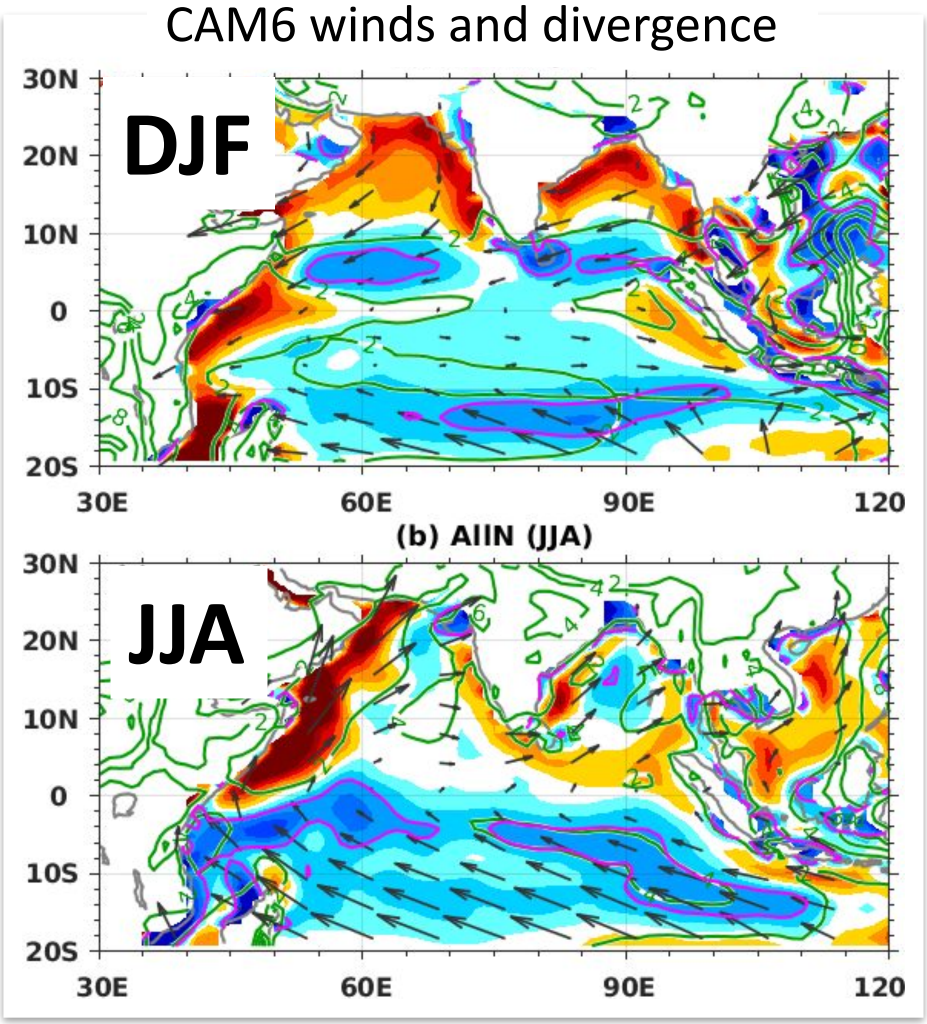
- SENS: Planetary Boundary Layer contributions
- CNTL- SENS : free-atmosphere diabatic heating

PBL processes (given SST) **dictates the ITCZ location**

CNTL



SENS

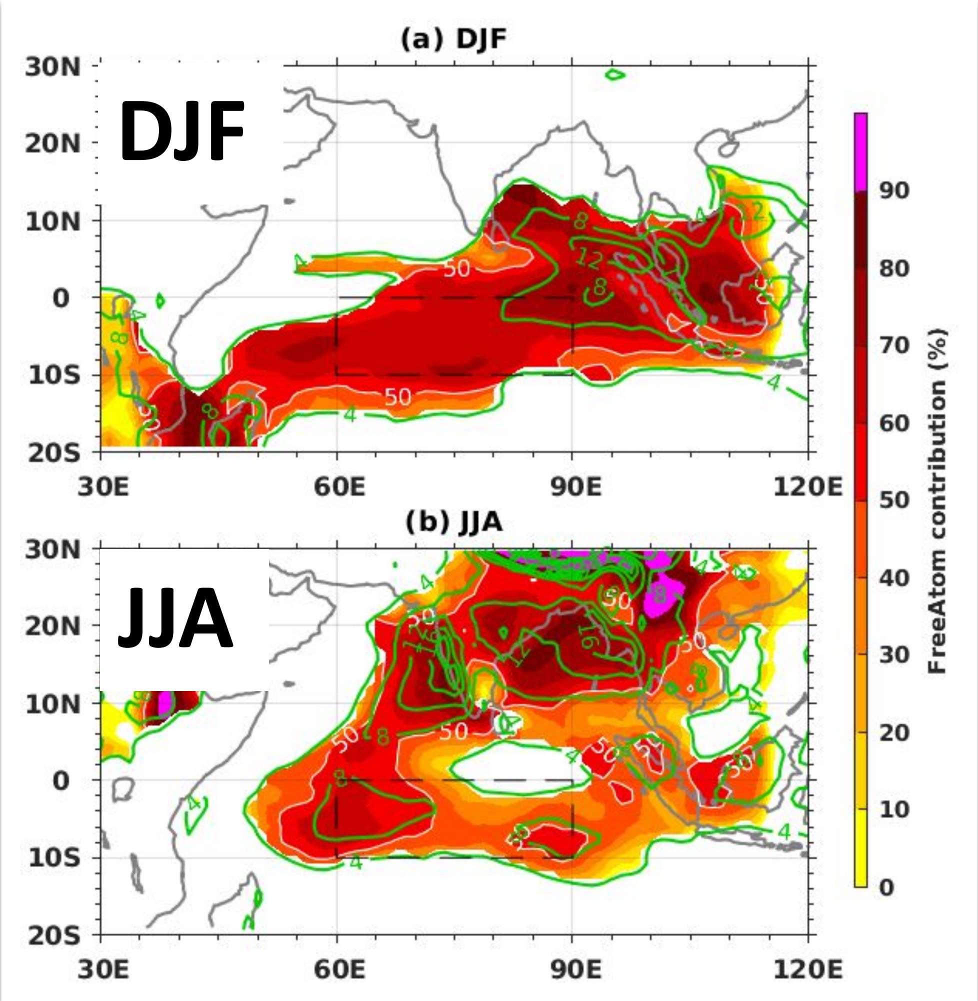


Green contours: precipitation (mm/day)

Free-atmosphere **dominates the ITCZ amplitude**

- $$\frac{CNTL - SENS}{CNTL} \times 100\%$$

❑ The stronger the mean precipitation, the larger the free atmosphere contribution



Green contours: CNTL precipitation (>4mm/day)
White contours: 50% isoline

Takeaways

- In CAM6, SST drives the Southern Indian Ocean ITCZ directly via PBL processes and indirectly via free-atmosphere processes

- PBL processes dictate the ITCZ location, while free-atmosphere processes dominate the ITCZ amplitude

Zhang et al. 2022: How does sea surface temperature drive the Intertropical Convergence Zone in the southern Indian Ocean? *J. Climate,* **35**, 5415–5432.

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Homogenize entire tropics