Dynamics of regional climate change

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- SST patterns & rainfall change
- Changes in modes: IOD & IO capacitor
Ocean warming is not uniform; precip change is even more variable in space.

<table>
<thead>
<tr>
<th>50-yr change</th>
<th>Air Temp</th>
<th>Precip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global mean</td>
<td>1.16</td>
<td>1.48</td>
</tr>
<tr>
<td>Spatial $\sigma$</td>
<td>0.46</td>
<td>7.17</td>
</tr>
</tbody>
</table>
Hypothesis 1: The wet gets wetter (e.g., Held & Soden 2006, JC) (Precipitation increases in equatorial rain bands; decreases in subtropics; and increases in high-latitudes due to increase in moisture transport)
The **wet-get-wetter pattern** is realized in atmospheric response to a uniform SST warming in so-called Cess runs.

But what about in coupled simulations with $\delta$SST patterns?
Hypothesis 2: **Warmer get wetter** (Xie et al. 2010, JC)

Convective Instability: \( I_M = (c_p T + Lq)_{sfc} - (c_p T + Lq)_{300 \text{ hPa}} \)

- Flat warming in upper troposphere \( \Leftarrow \) equatorial waves
- \( I_M \) follows closely SST patterns

![300 hPa Temp](image1)

![\( I_M/c_p \)](image2)
IOD-like change

Interannual SST variance remains constant (Zheng et al. 2010 JC)
Thermocline feedback strengthens but wind feedback weakens $\rightarrow$ IOD variance remains constant but skewness weakens.

**Graphical Representation:**

- **Graph a:**
  - Label: Zonal wind feedback
  - Data plot indicating variations over time.

- **Graph b:**
  - Label: σ(T')
  - Data plot showing standard deviation over time.

- **Graph c:**
  - Label: Skewness
  - Data plot showing skewness over time.

**Axes:**
- **Time (yr):**
  - X-axis from 1950 to 2300

**Legend:**
- **EEIO SST**

**Data Trends:**
- Thermocline feedback shows a consistent increase.
- Zonal wind feedback shows a decreasing trend.
- Skewness shows variability with a general decrease.

**Analysis:**
- The model indicates a shift in the balance of feedback mechanisms, favoring thermocline feedback over zonal wind feedback, which results in a more predictable IOD variance and a weakening skewness pattern.
Indian Ocean Capacitor

SST warming persists through JJA(1), and exerts climatic influences after El Nino has dissipated.

How does IO warming force NW Pacific anticyclone?

IO warming $\rightarrow$ Warm Kelvin wave into the WP
$\rightarrow$ Northeasterly winds to the north under friction
$\rightarrow$ Divergence over NW Pacific $\leftrightarrow$ Suppressed convection

North Indian Ocean SST (5-15N) regression upon NDJ Nino3.4 SST


SST & surface wind regressions upon NDJ Nino3.4
Enhanced variability in NW Pacific monsoon is due to intensified TIO SST variability.

Decadal Shift
Has the TIO capacitor intensified?


21-yr running correlation of NIO SST and wind (on ship track) with NDJ Niño 3.4 SST.

Guam & Philippine rainfall correlations.
Interdecadal modulation of El Niño amplitude during the past millennium

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Summary

• Patterns of SST warming determine tropical rainfall change → Warmer get wetter.

• IOD-like warming pattern; IOD’s interannual variance remains unchanged but skewness weakens.

• Indian Ocean capacitor may intensify in the ENSO decay summer under global warming → increased predictability.

• IO capacitor was stronger around 1900 and after 1970s.

• It remains to be seen if the recent intensification of IO capacitor is part of natural variability or due to global warming.
Over the past 30 years, the convective threshold has risen in parallel with the tropical mean SST.

Consistent with the moist adiabatic lapse rate (MALR) adjustment of the tropical troposphere.
A 21-year running correlation with ENSO of JJA(1) tropospheric temperature at Singapore.