Tropical Climate Variability and Teleconnections:
past, present and future

Stockholm University

Variability of the Atmospheric General Circulation and the Connection to ENSO

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In short...

- Method

  The Atmospheric General Circulation in Thermodynamic Coordinates
  J. Kjellsson, K. Döös, F. Laliberté, J. Zika

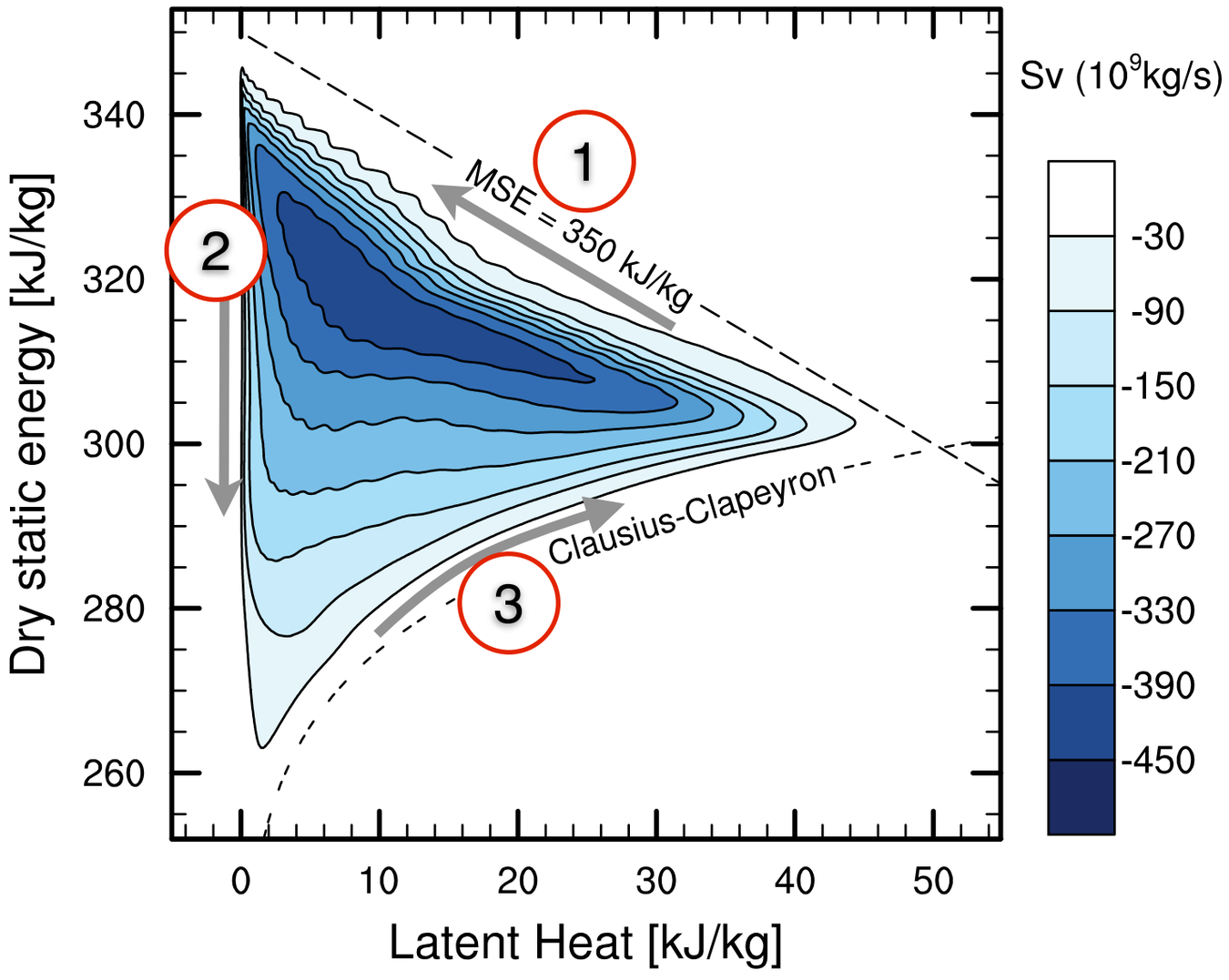
- Results

  A single thermodynamic circulation.
  Variability on annual & inter-annual time scales.

- Summary

  Thermodynamic representation that combines zonal and meridional overturning circulations.
  Connected to ENSO.

Hydrothermal stream function

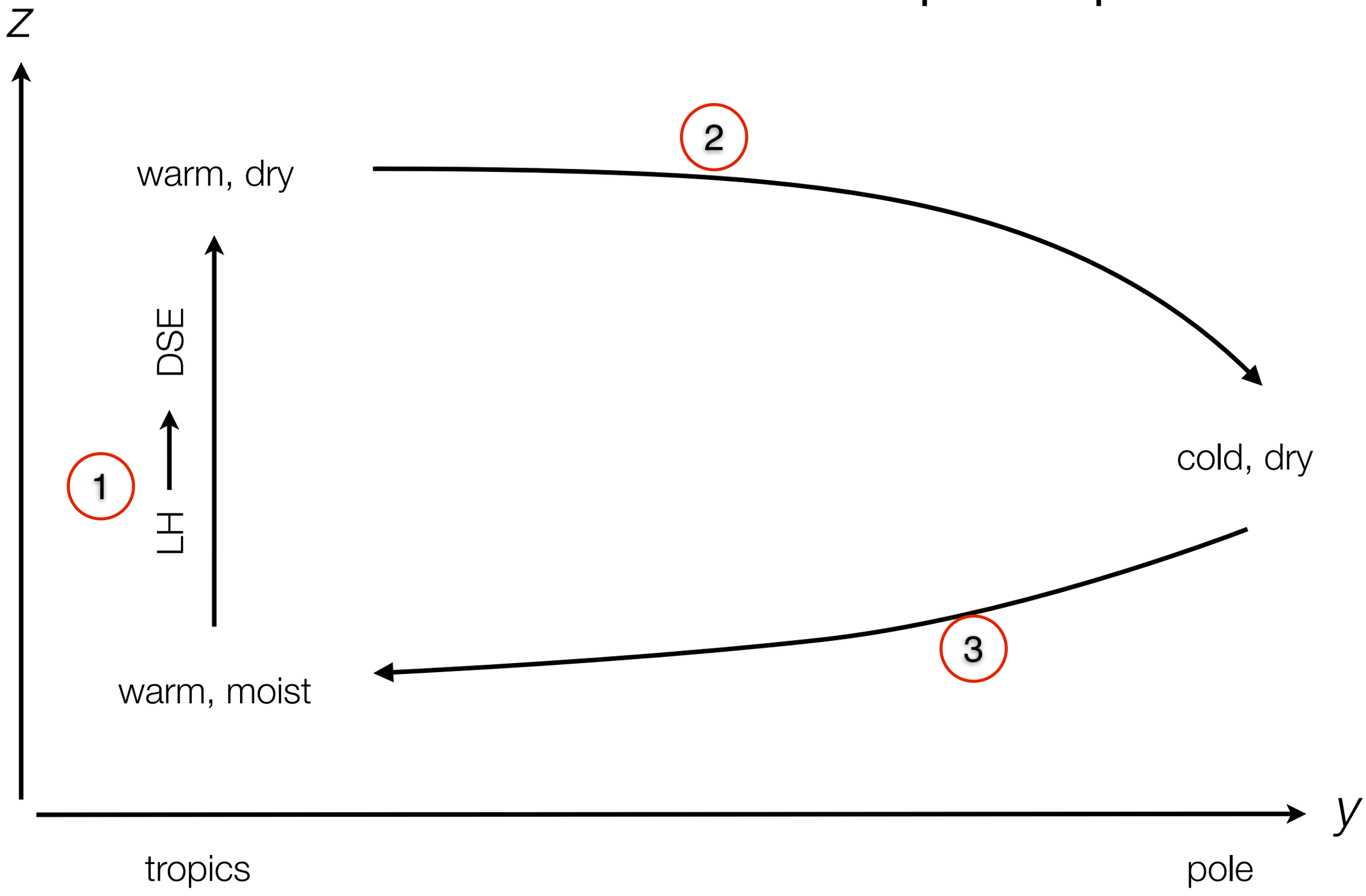


- ERA-Interim 1979-2009.
  Global u,v,T, q,z,p.
  428 Sv anti-clockwise circulation.

- 1. Moist convection following moist adiabats.
  2. Radiative cooling at latent heat ≈ 0.
  3. Moistening & heating following Clausius-Clapeyron

- Hydrothermal circulation lets us diagnose the general circulation in one picture!

Conceptual picture



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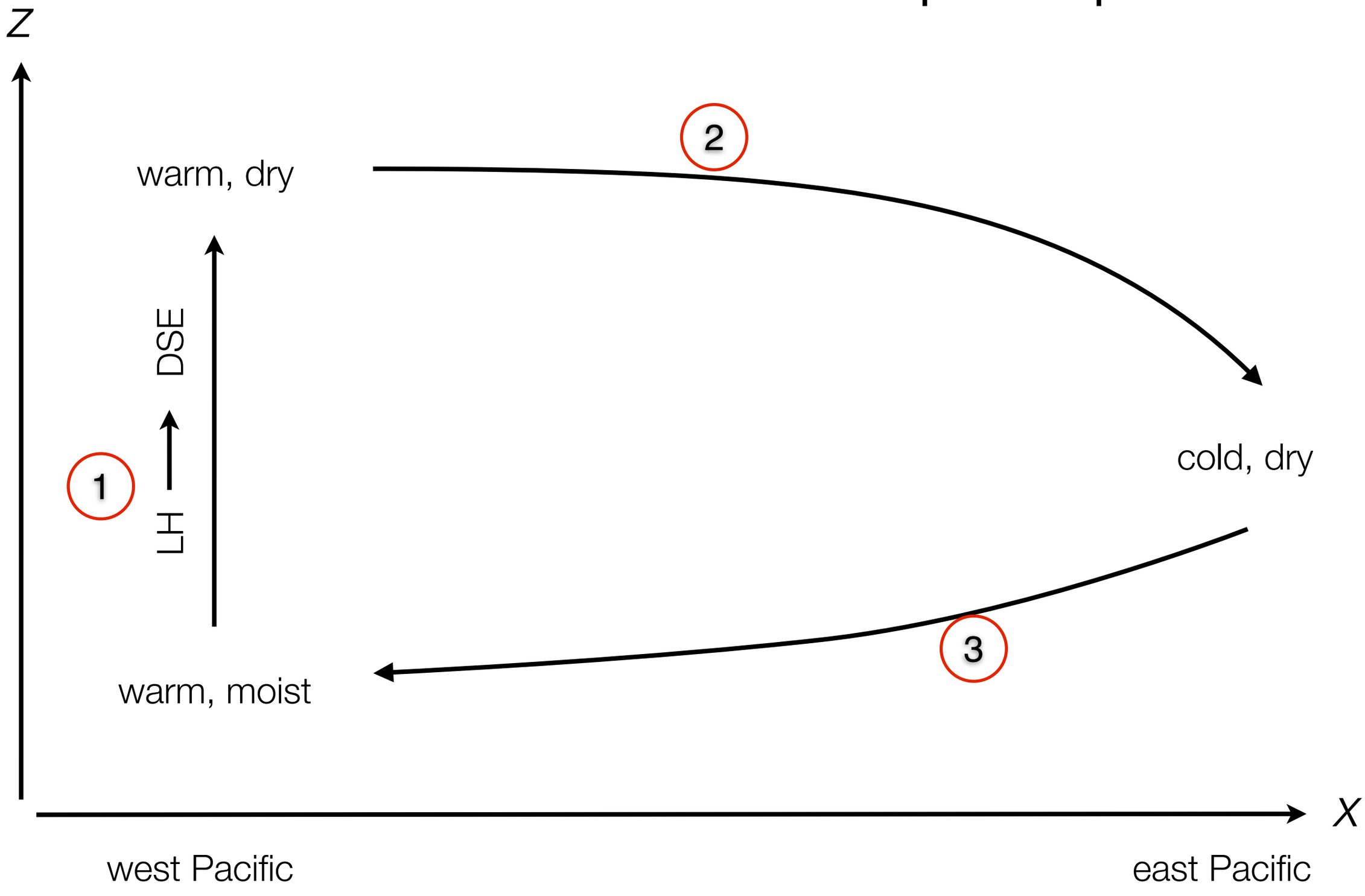
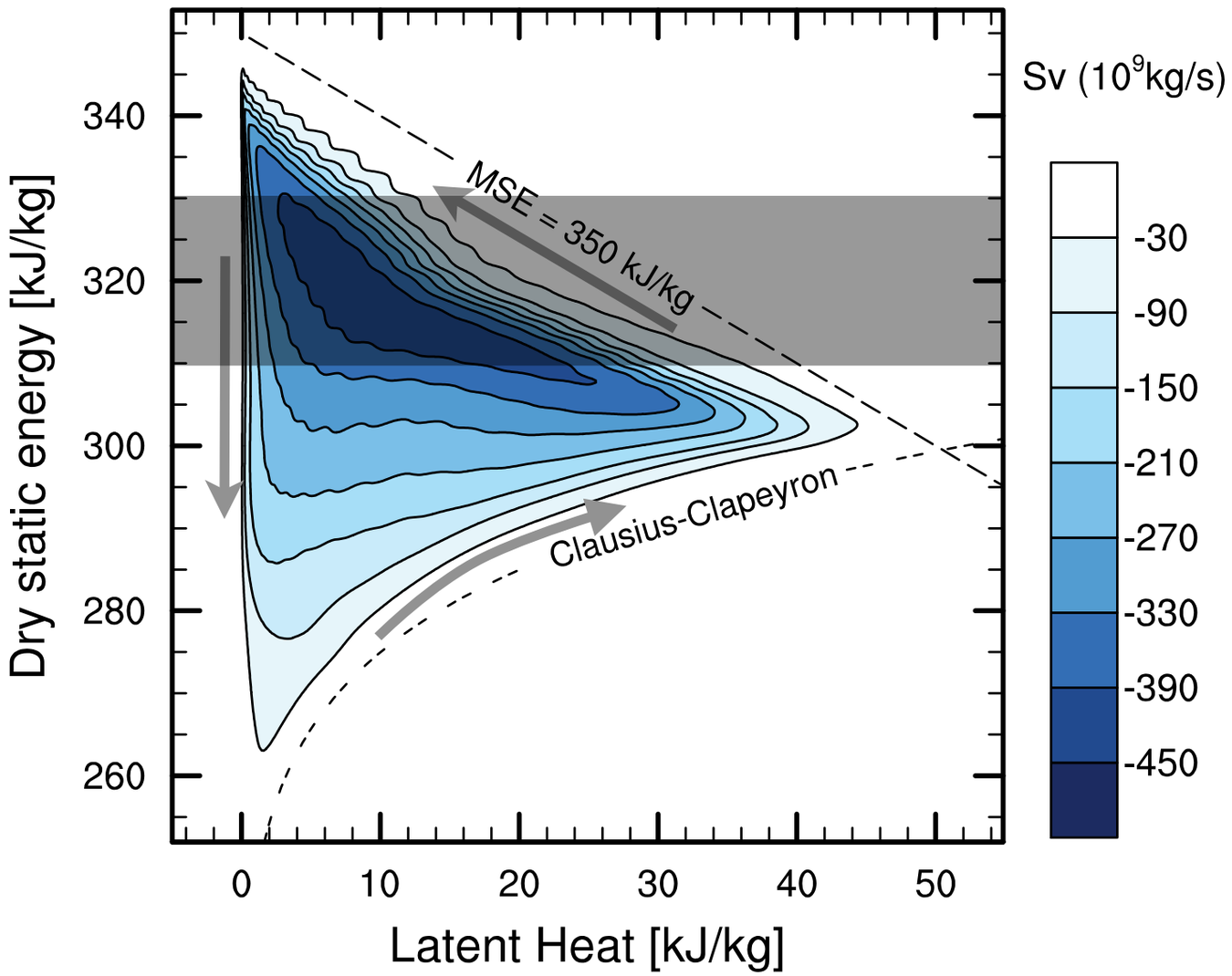
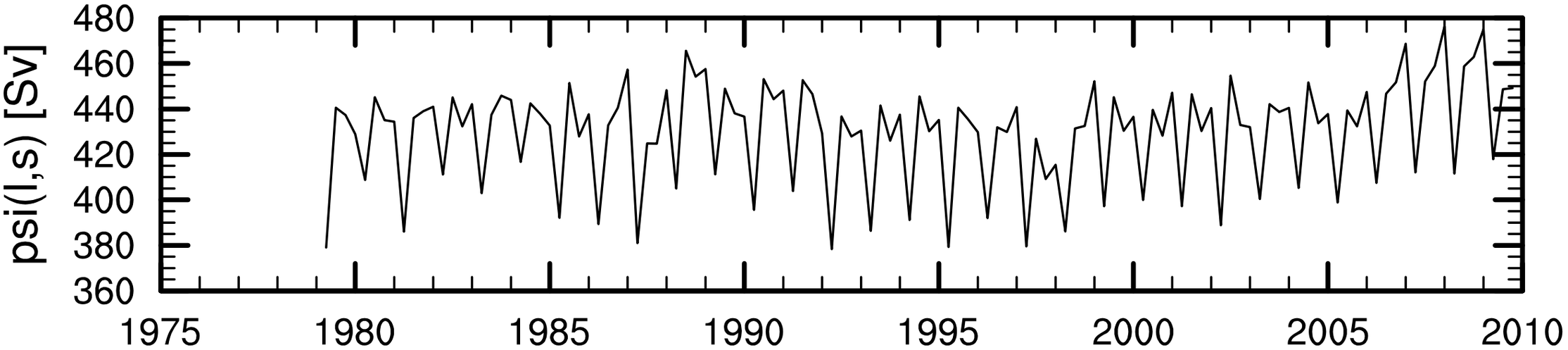


Maximum transport



- Average max(psi)-min(psi) between DSE 310 and 330 kJ/kg.

Variability of the hydrothermal circulation



- Calculate the hydrothermal stream function for every season (black) and year (blue).

- Two highest amplitudes 1989 and 2008 (La Nina years) and amplitude 1998 (El Nino year).

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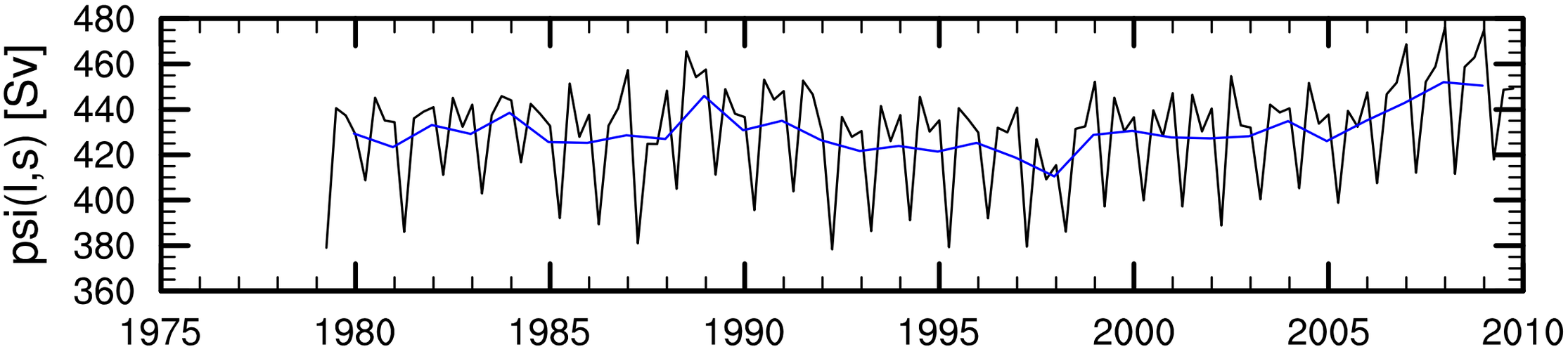

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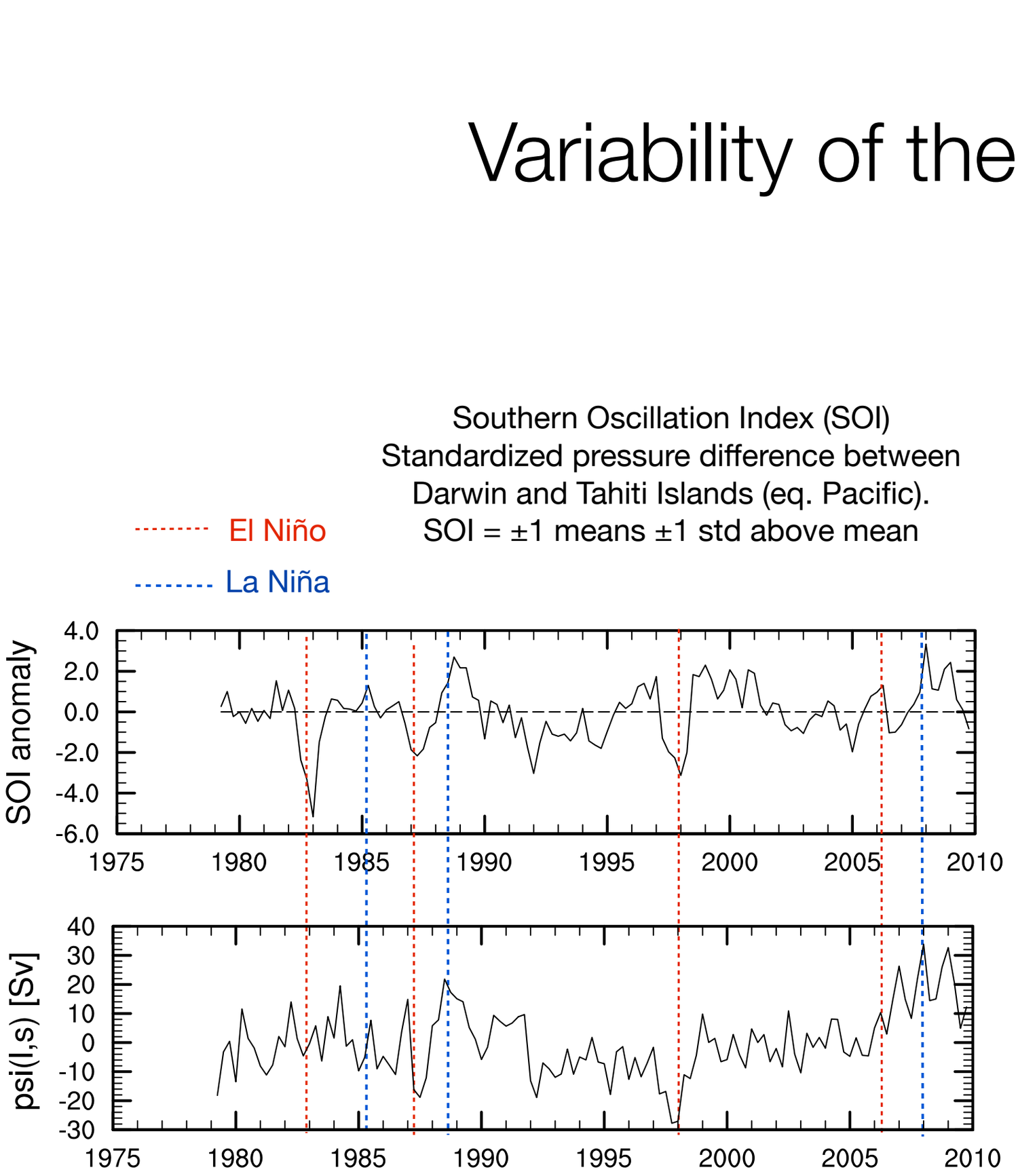
Variability of the hydrothermal circulation

Southern Oscillation Index (SOI)
Standardized pressure difference between Darwin and Tahiti Islands (eq. Pacific).
SOI = ±1 means ±1 std above mean



- Subtract climatologies for each season. Gives seasonal anomalies.

- ENSO indicated by SOI. Linear fit so that: amp. = k * SOI + m

- SOI explains 16% of the seasonal anomalies. 30% for annual data. 99% significance.

SOI from observations. Provided by NOAA Climate Prediction Center.

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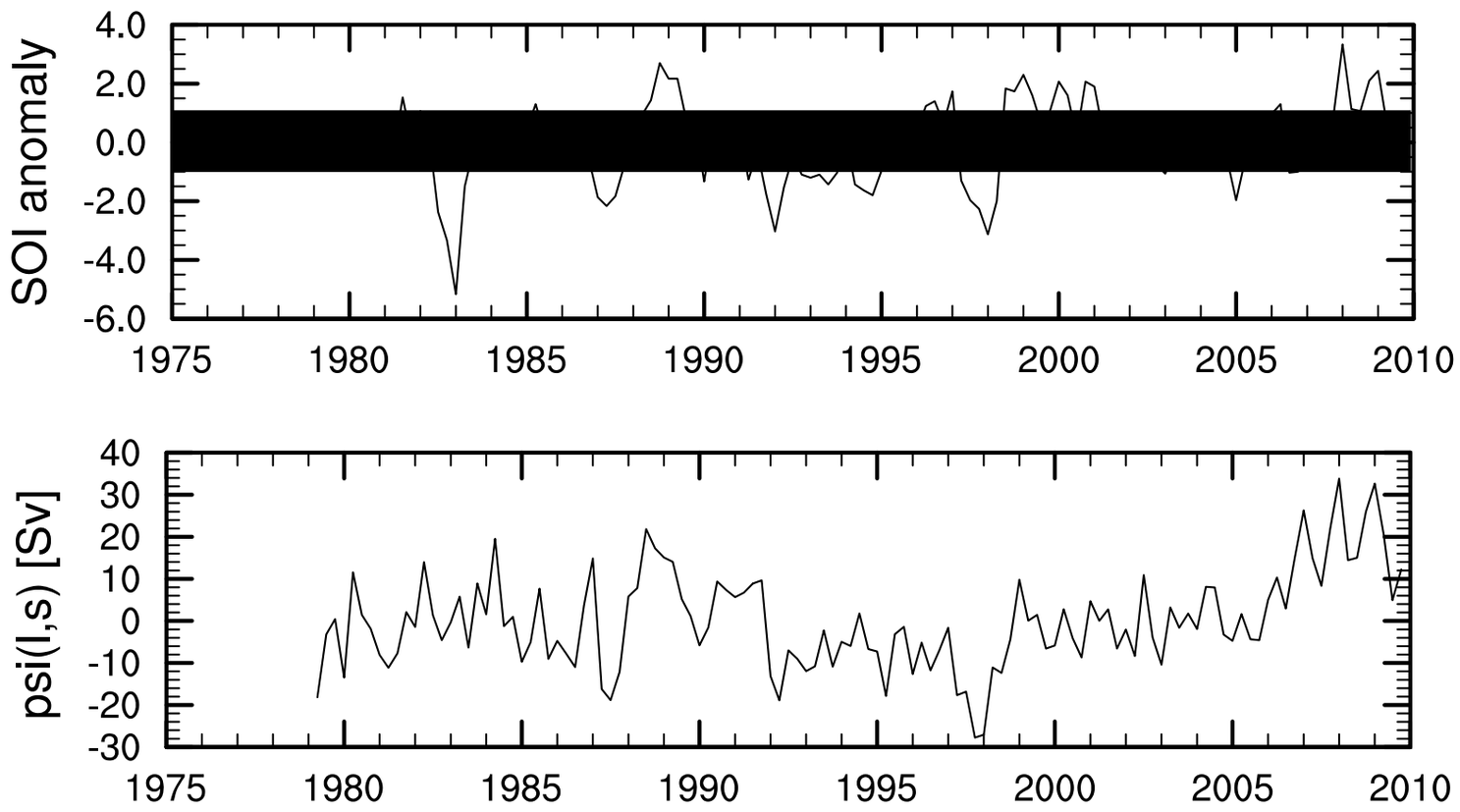

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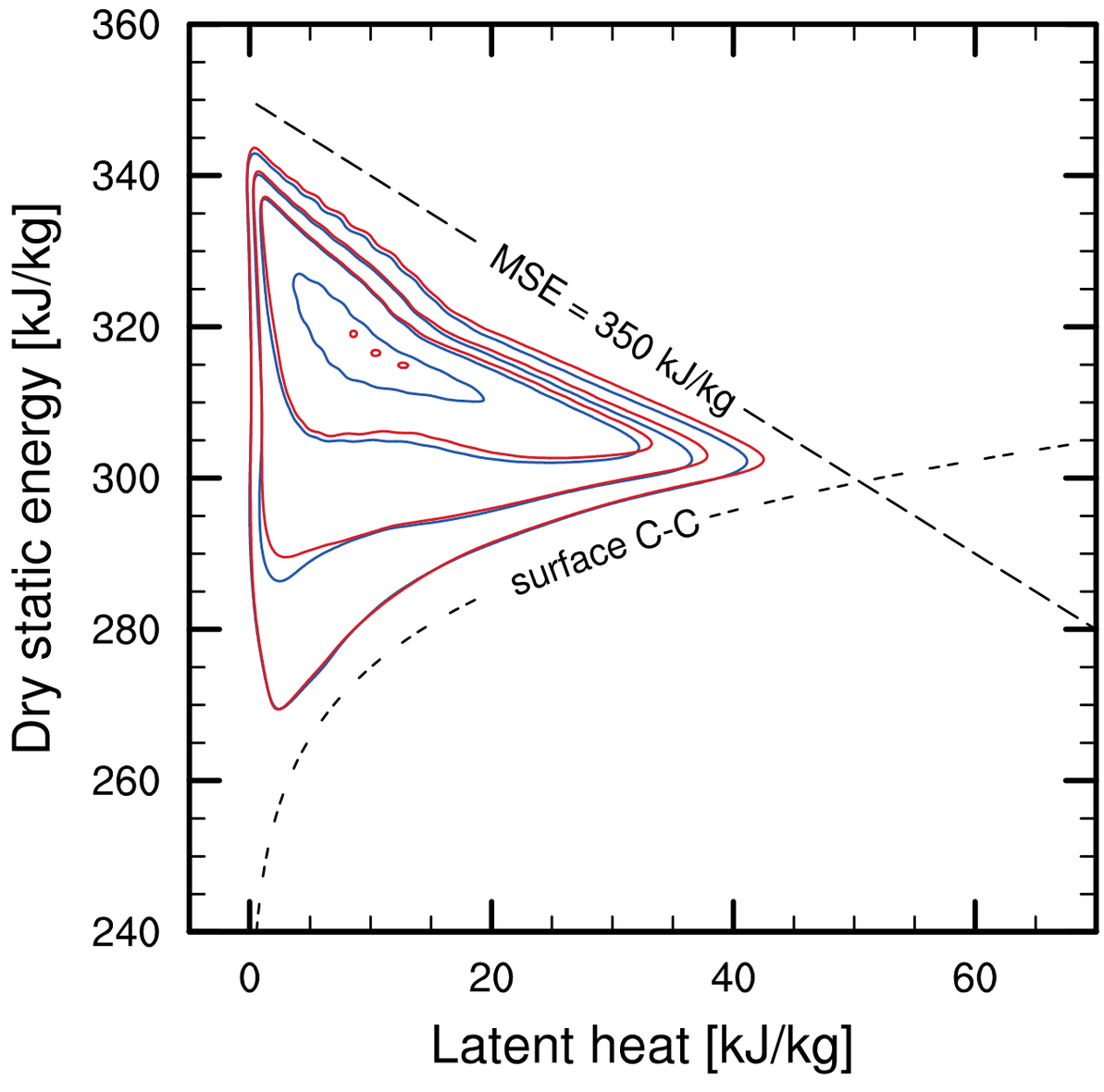
ENSO composites



- 5 consecutive months (Trenberth, BAMS 1997)
- SOI < -1 (El Niño) Weaker and wider
- SOI > 1 (La Niña) Stronger and narrower
- Stream lines shift towards a higher/lower moist adiabat (~1-2 kJ/kg).

- The hydrothermal circulation combines the Hadley and Walker cells and midlatitude eddies into a single circulation.

- Amplitude of 428 Sv. Moist convection, radiative damping and warming and moistening of near-surface air.

- El Niño: wide and weak.
  La Niña: narrow and strong.

- ENSO explains
  ~16% of the seasonal variability,
  ~30% of the inter-annual variability of the general circulation.

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The End

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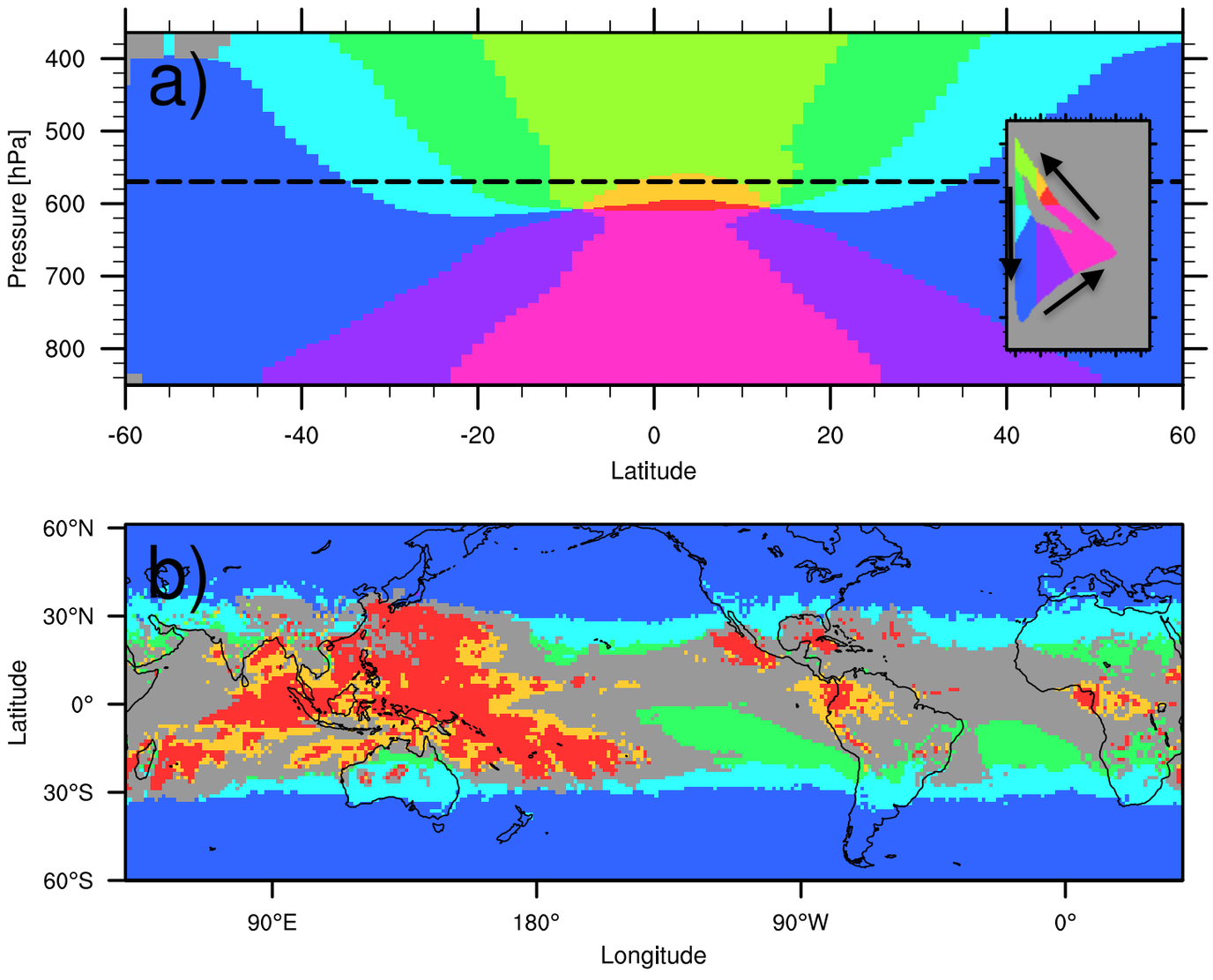
In spatial coordinates

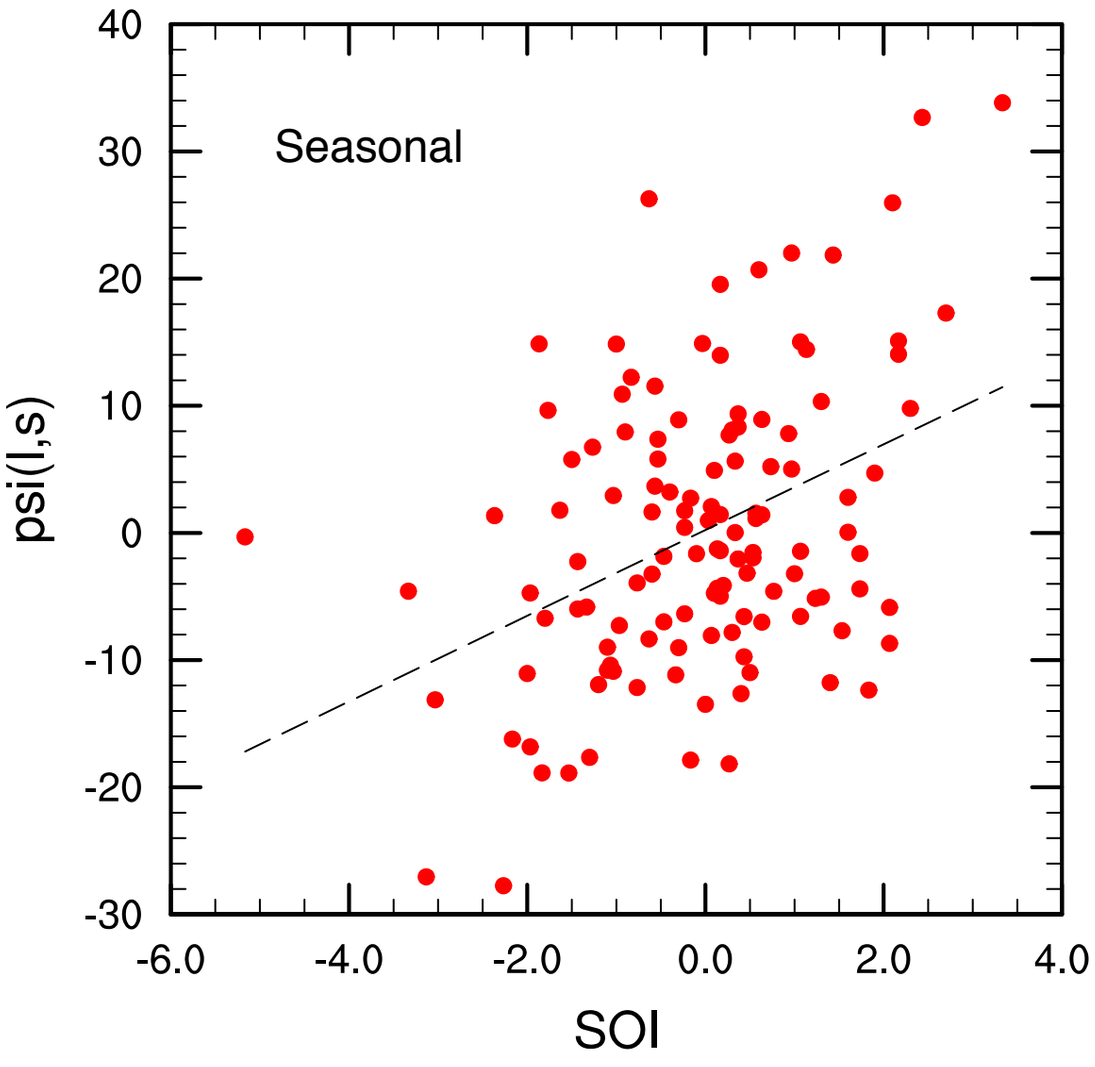


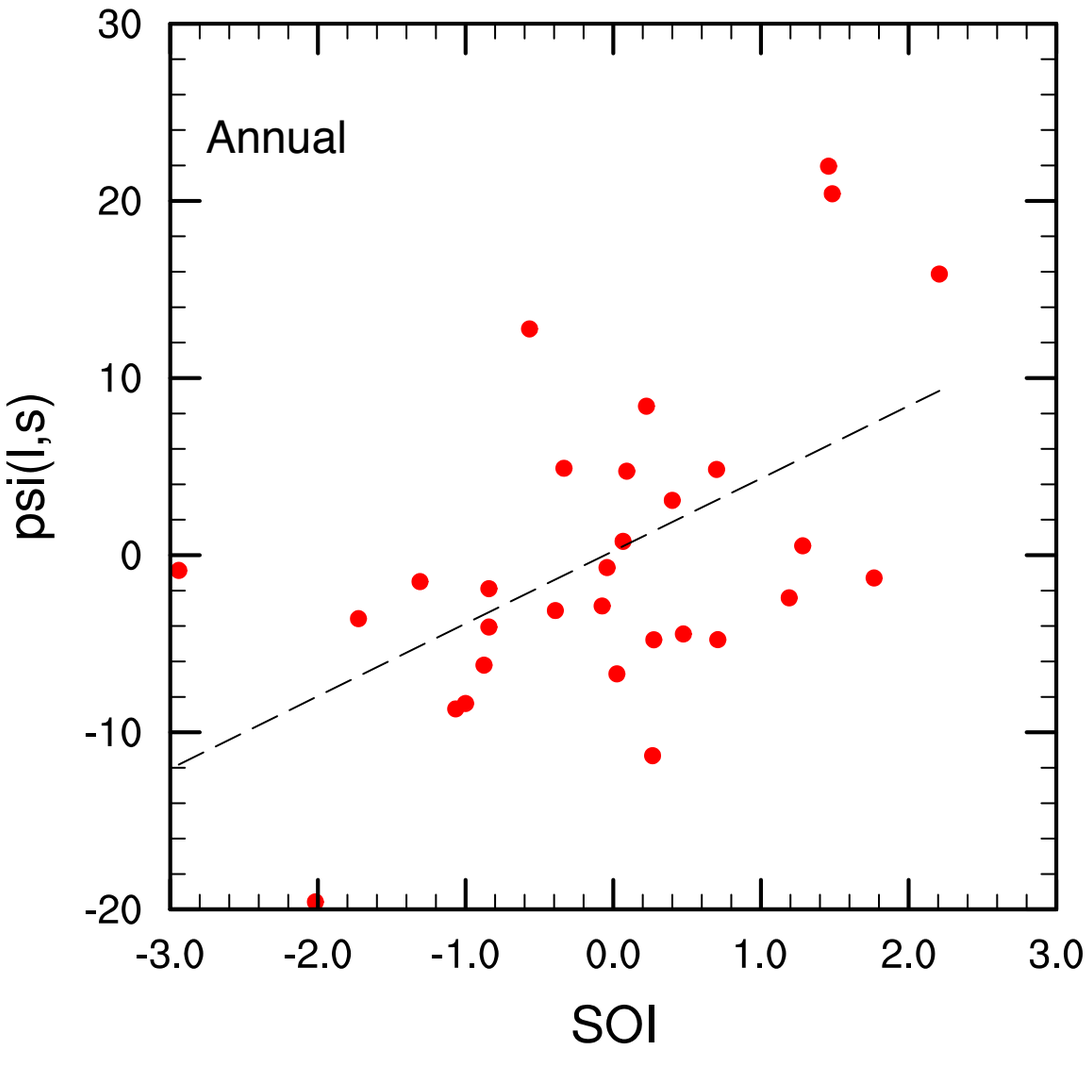
- Projecting the 100-400 Sv stream function on time-averaged LH and DSE.

- Meridional overturning similar to isentropic mean. Large zonal asymmetries - Walker circulation.

- Thus, the hydrothermal circulation combines the mass fluxes in both zonal and meridional overturning circulations.

Correlating ENSO and hydrothermal circulation





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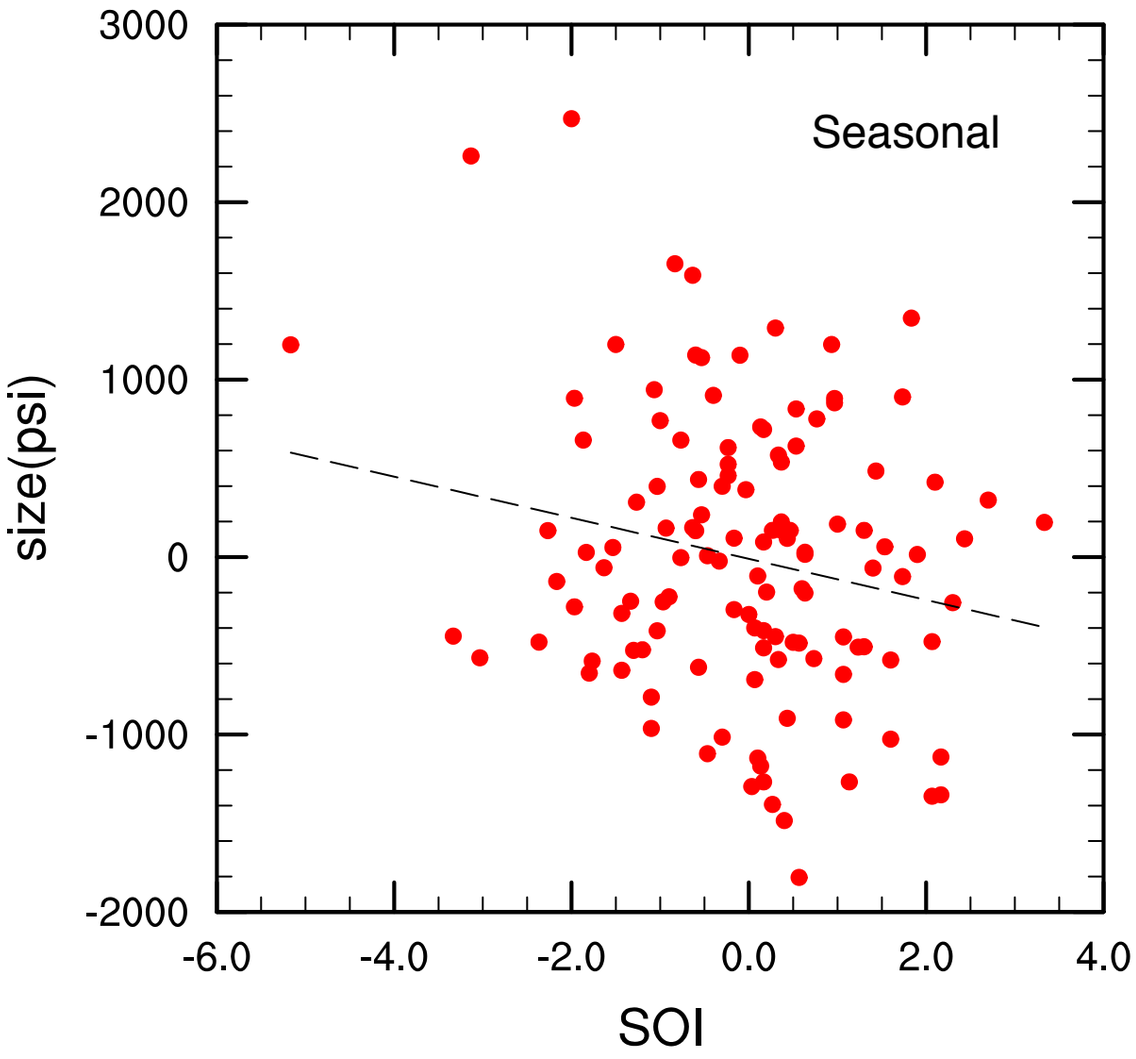

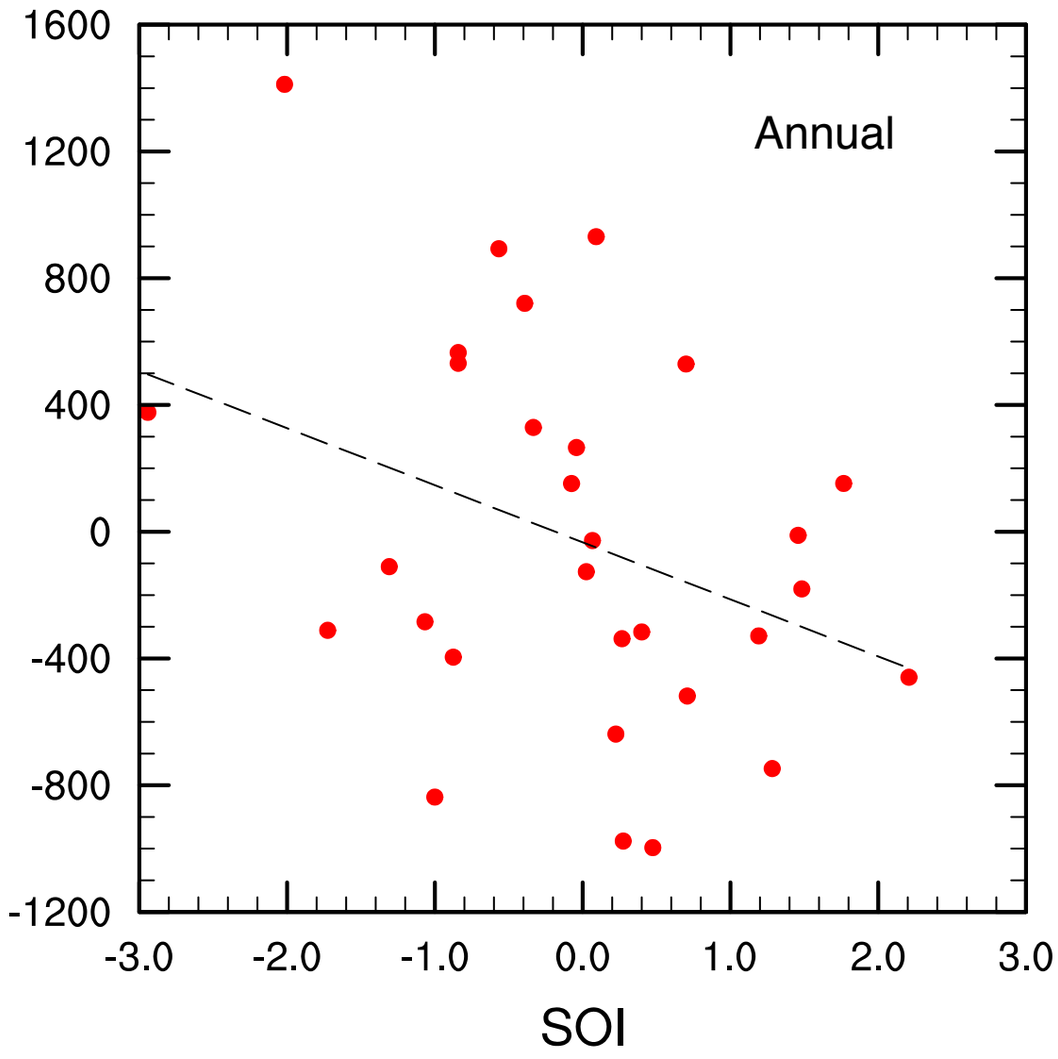

Meridional overturning

- Indications that the meridional overturning strengthens (weakens) in positive (negative) ENSO phases.