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Global Atmospheric Circulation and its Response to Anthropogenic Forcing

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In short...

- Method

  The Atmospheric General Circulation in Thermodynamical Coordinates
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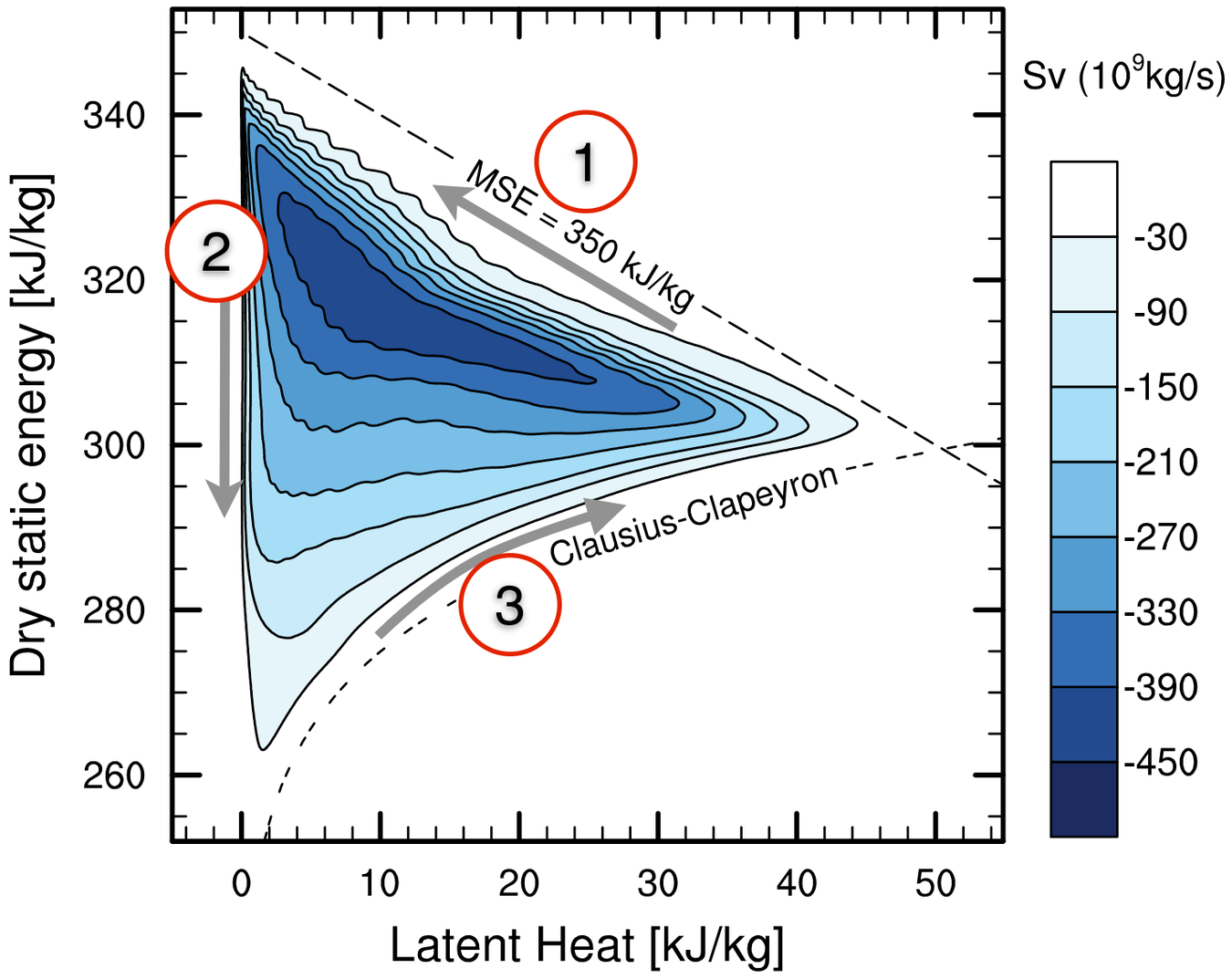
- Results

  A single thermodynamic cycle.
  Changes over the 19th, 20th and 21st centuries.

- Summary

  Thermodynamic representation that combines zonal and meridional overturning circulations.
  Future change in global atmospheric circulation.

Hydrothermal stream function

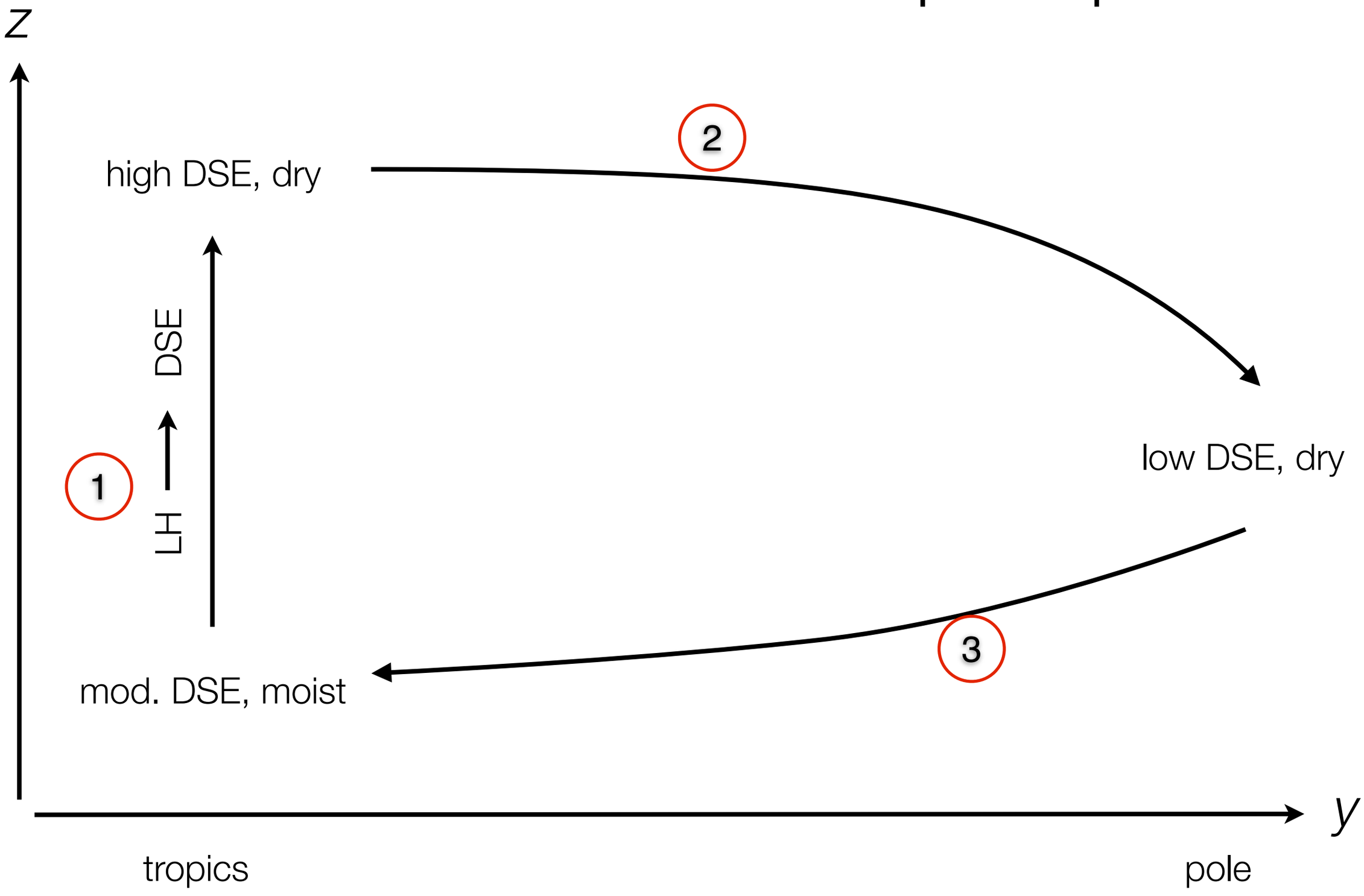


- ERA-Interim 1979-2009.
  Global u,v,T,q,z,p.
  428 Sv anti-clockwise circulation.

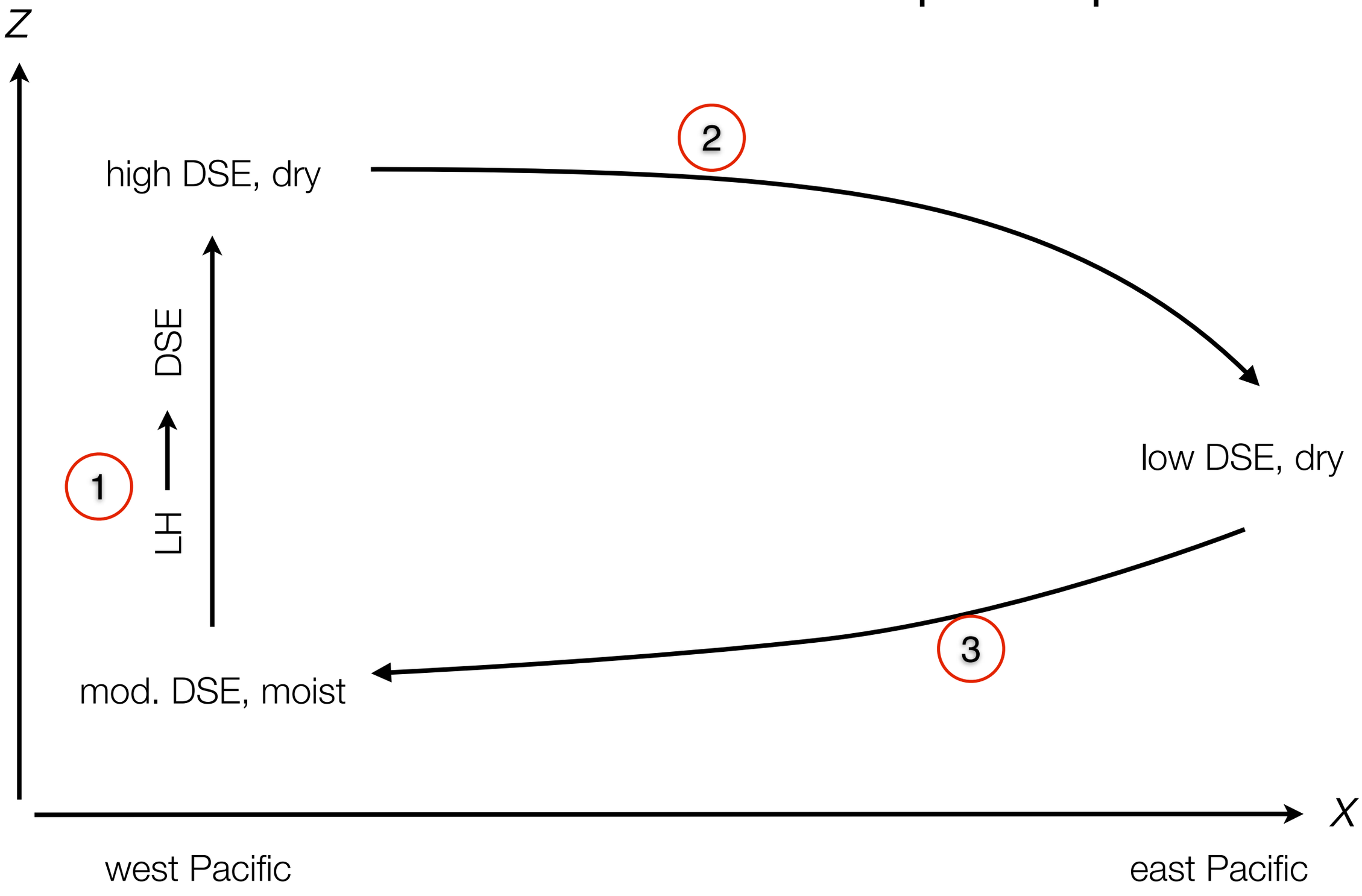
- 1. Moist convection following moist adiabats.
  2. Radiative cooling at latent heat ≈ 0.
  3. Moistening & heating following Clausius-Clapeyron

- Thermodynamic projection of the atmospheric circulation that lets us diagnose it in one picture!

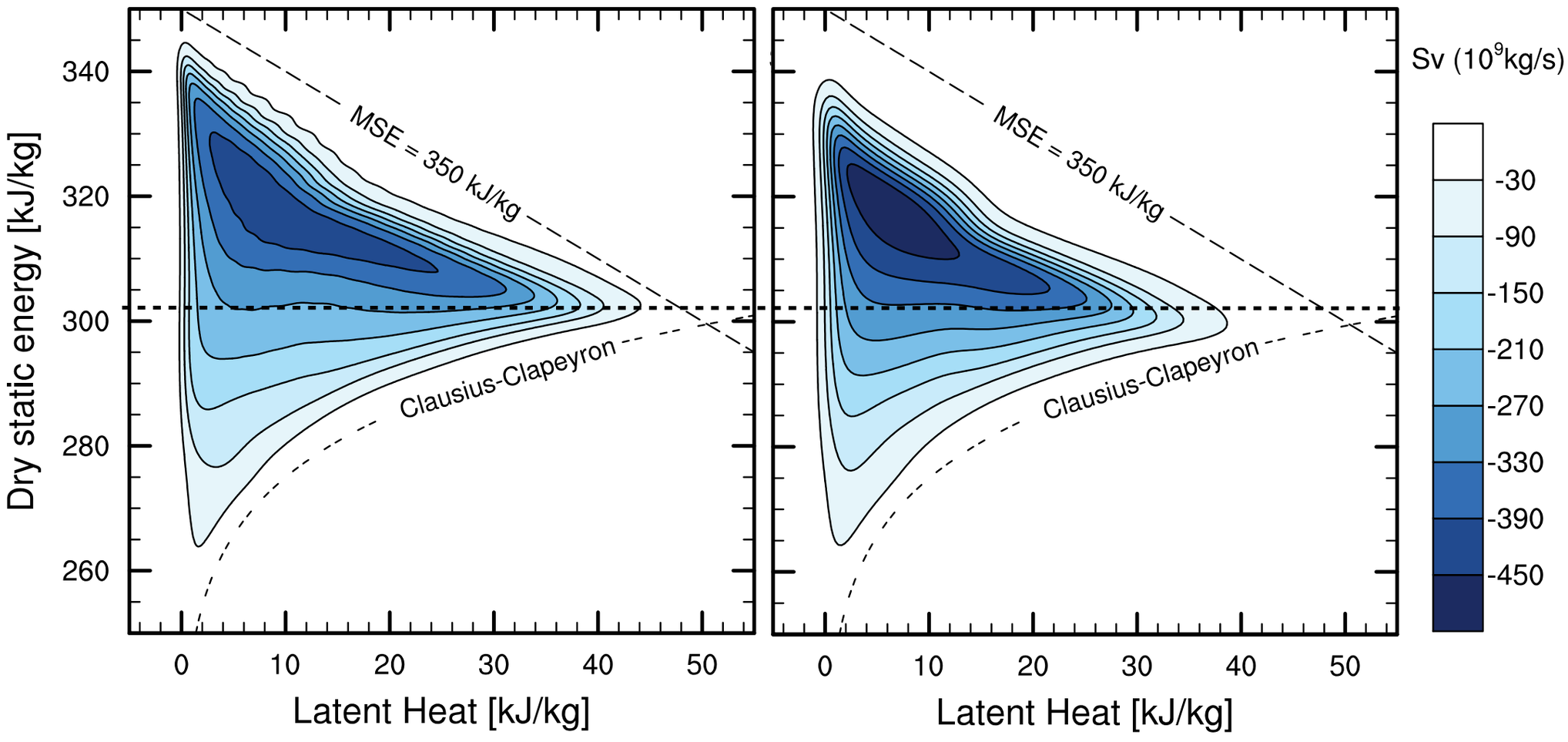
Conceptual picture



Conceptual picture

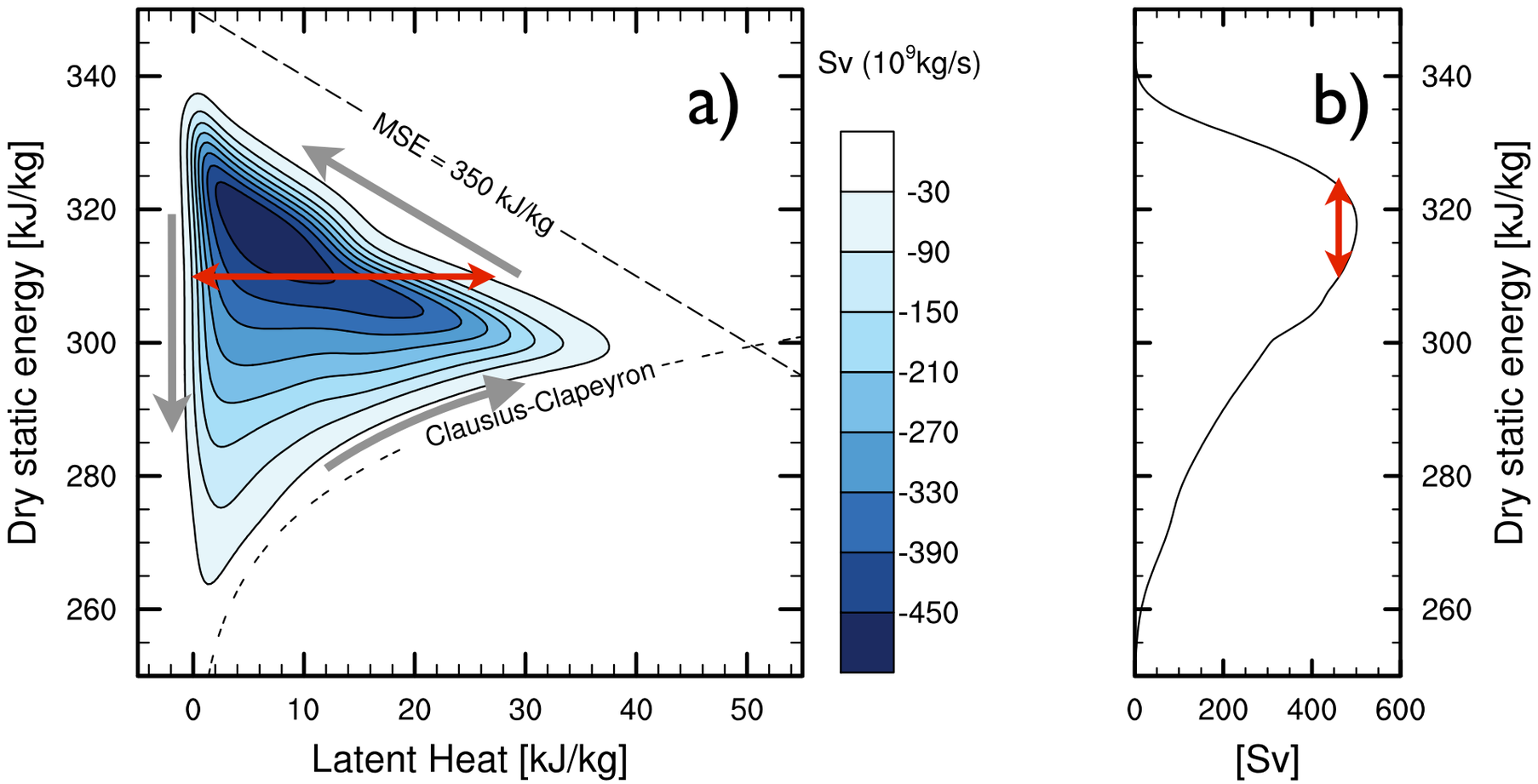


ERA-Interim / EC-Earth hist. run



- EC-Earth: Narrower and stronger. More moist convection of colder/drier air.

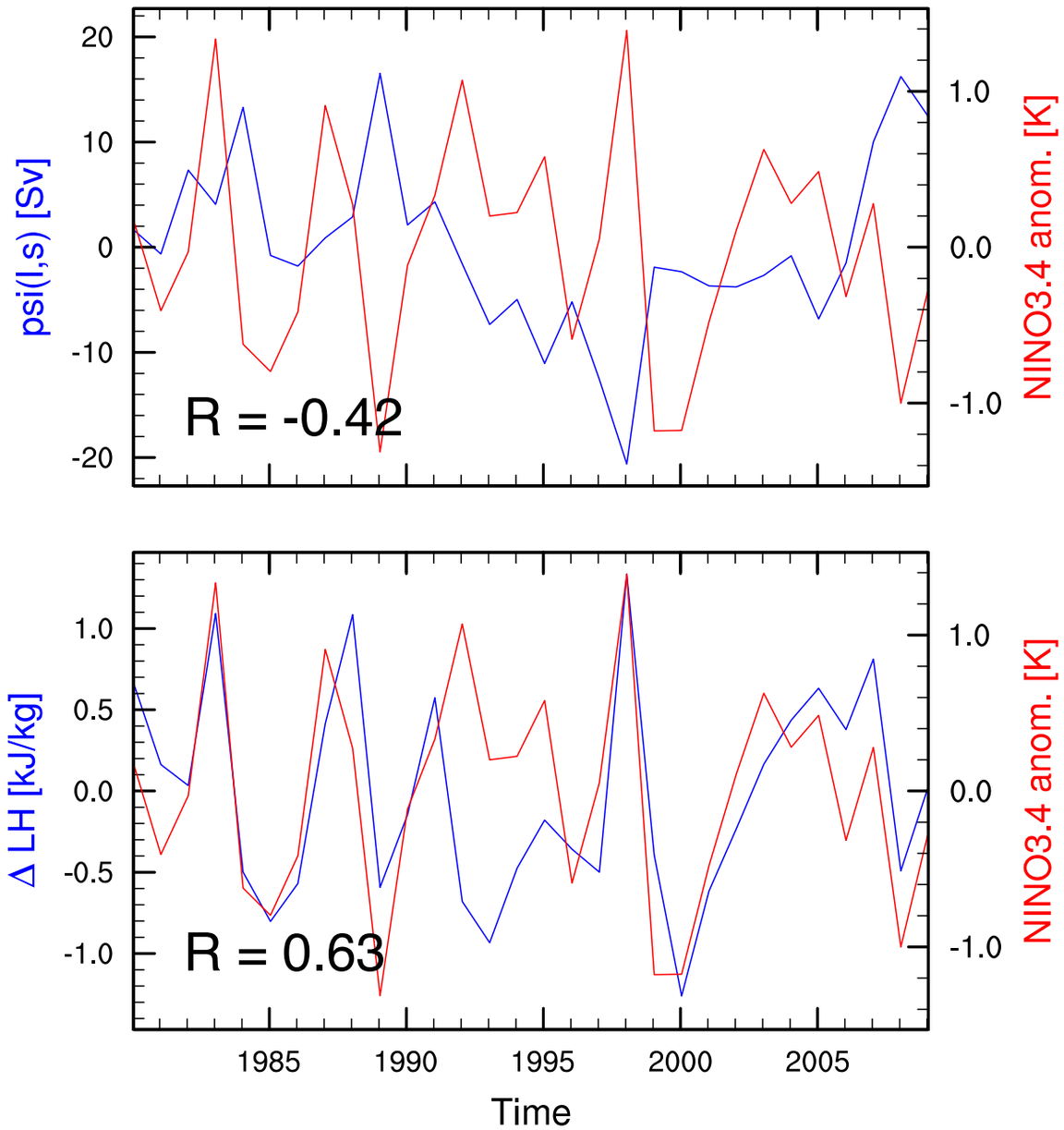
Strength & width



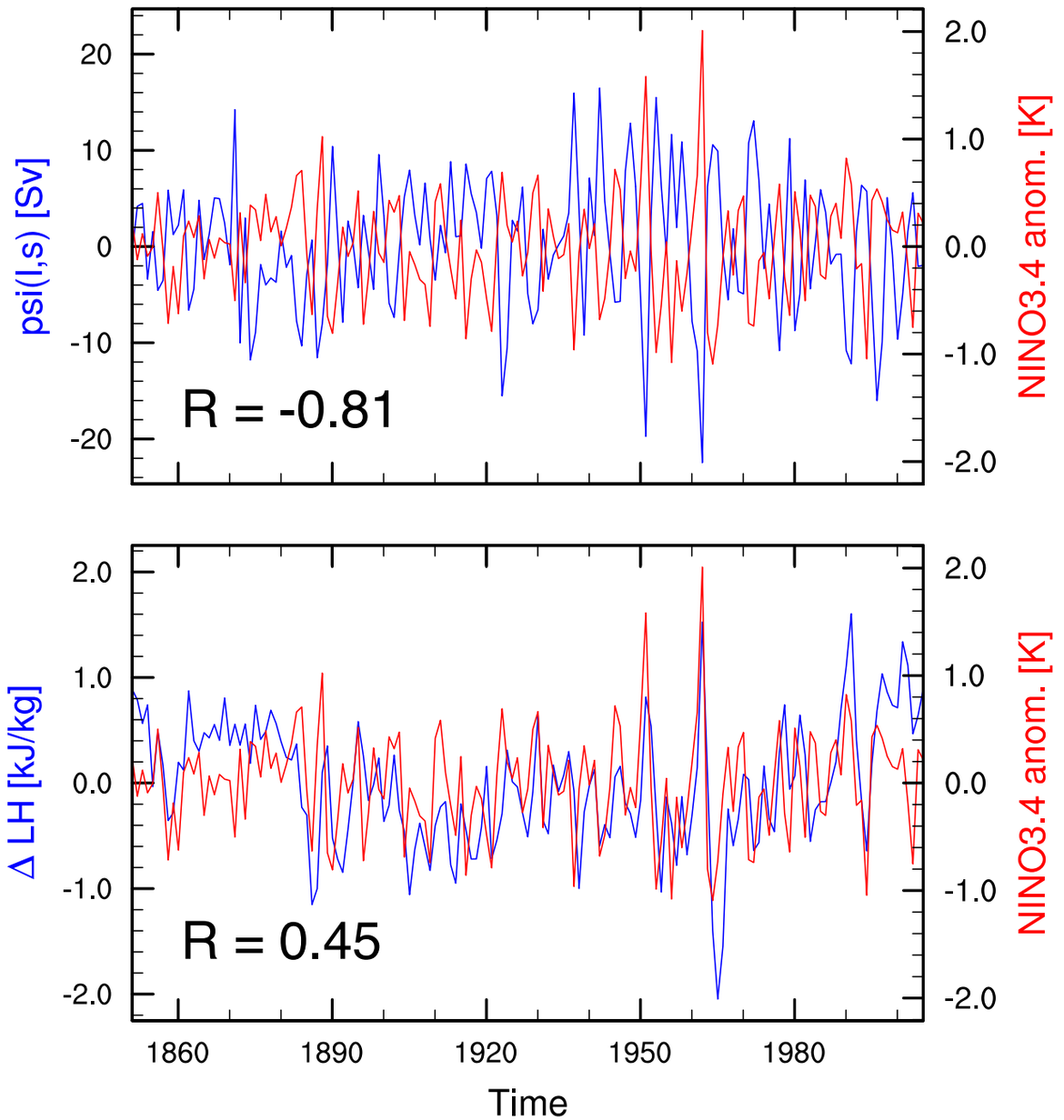
- Average max(psi)-min(psi) between DSE 310 and 325 kJ/kg. ”Strength”

- Span in LH at DSE 310 kJ/kg. ”Width”

ENSO

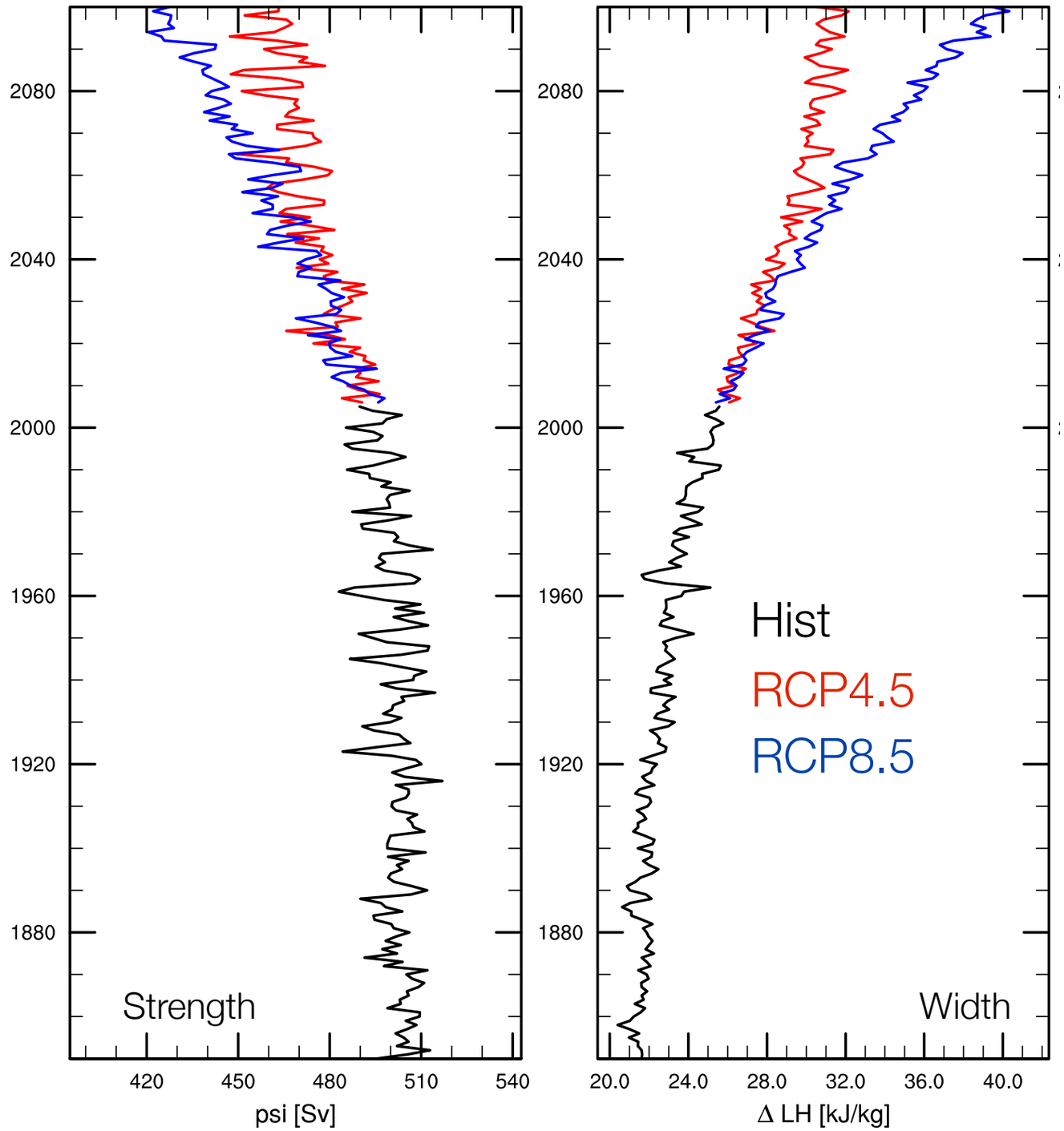


ERA-Interim

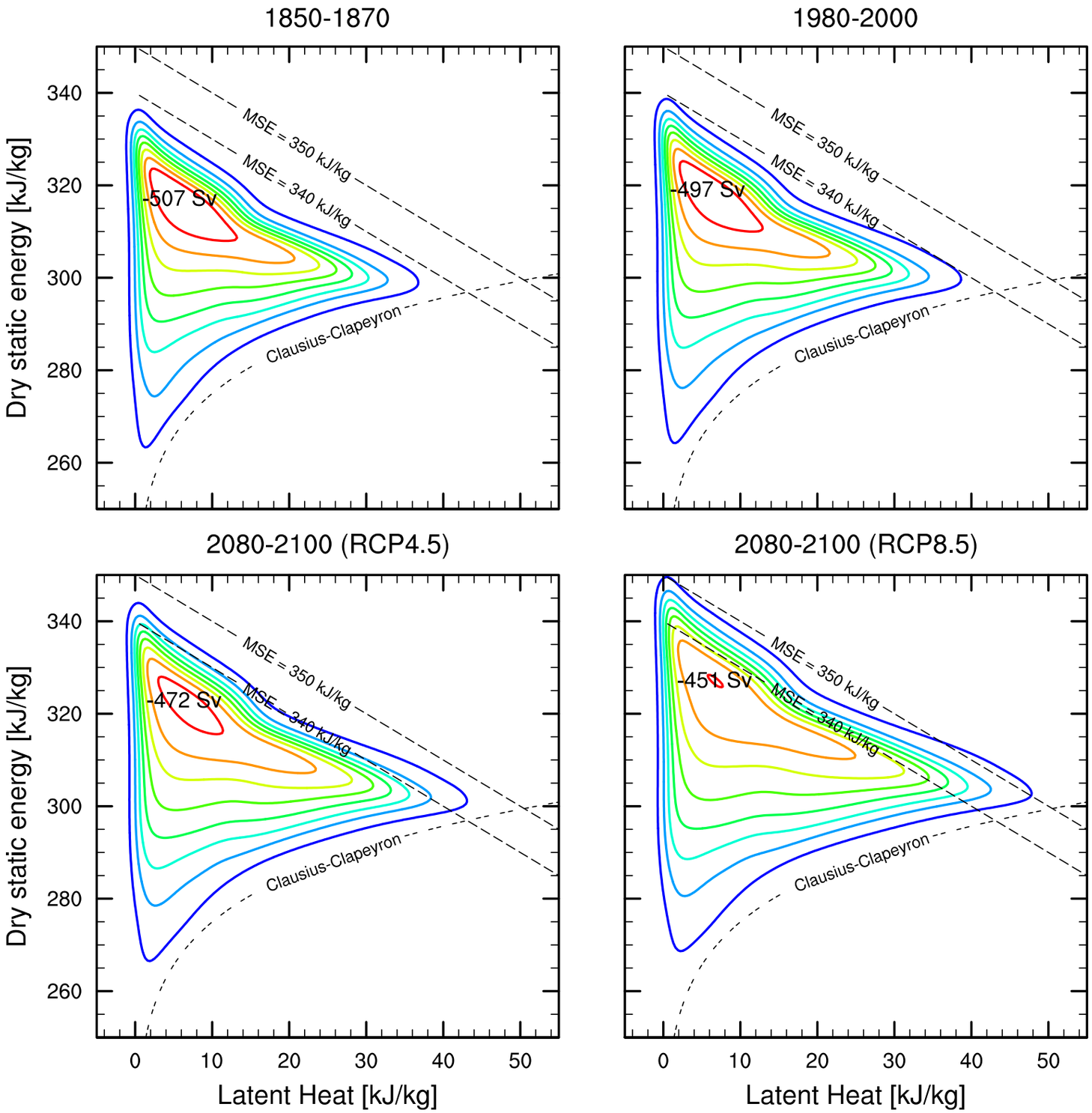


EC-Earth

19th, 20th and 21st centuries



19th, 20th and 21st centuries



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- The hydrothermal stream function combines the Hadley and Walker cells and midlatitude eddies into a single thermodynamic cycle.

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

- Widening and weakening with ENSO and in future. Increase in DSE and LH but decrease in moist convection.

- Notable differences between EC-Earth and ERA-Interim. Dependence on surface temperature.

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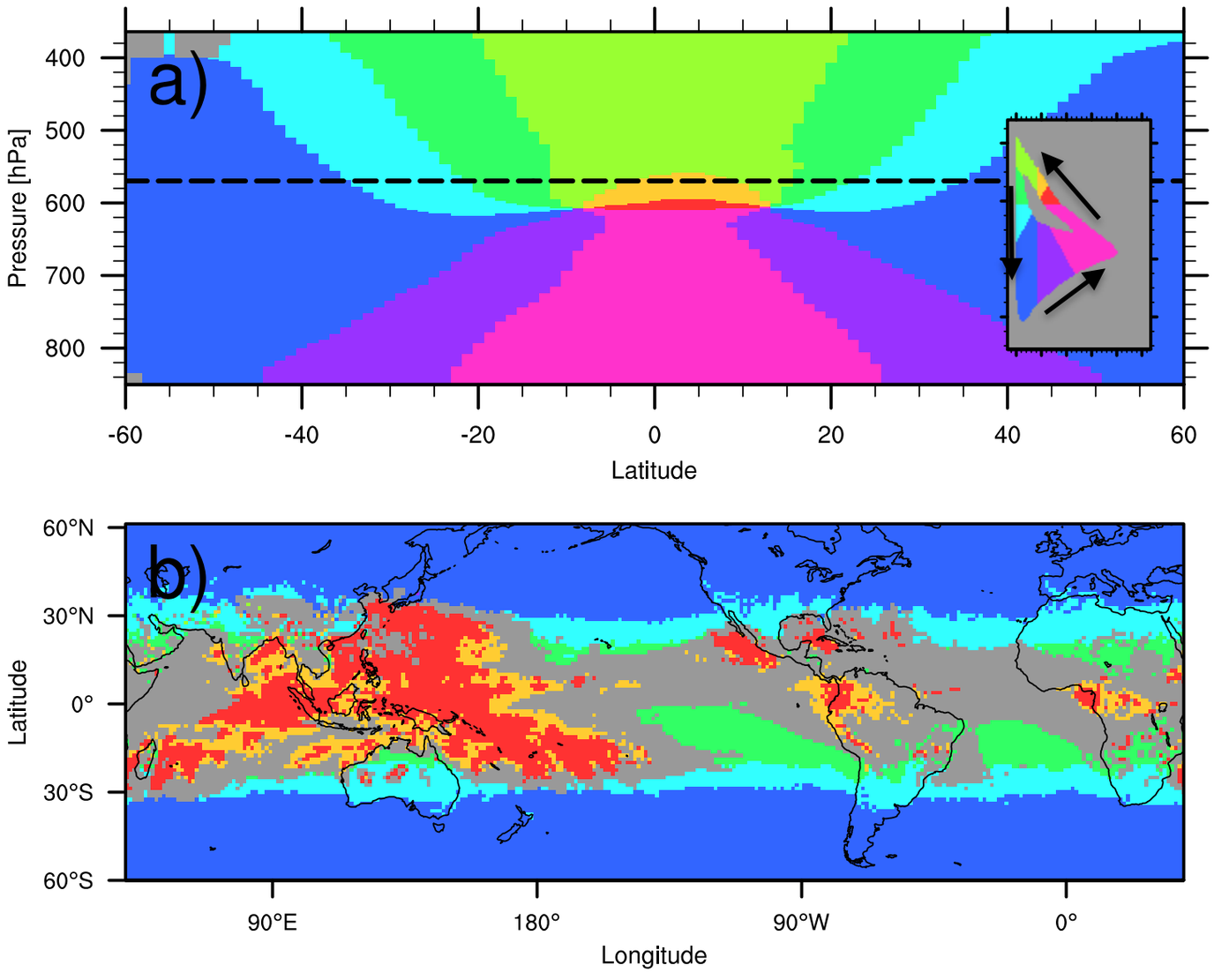
In spatial coordinates

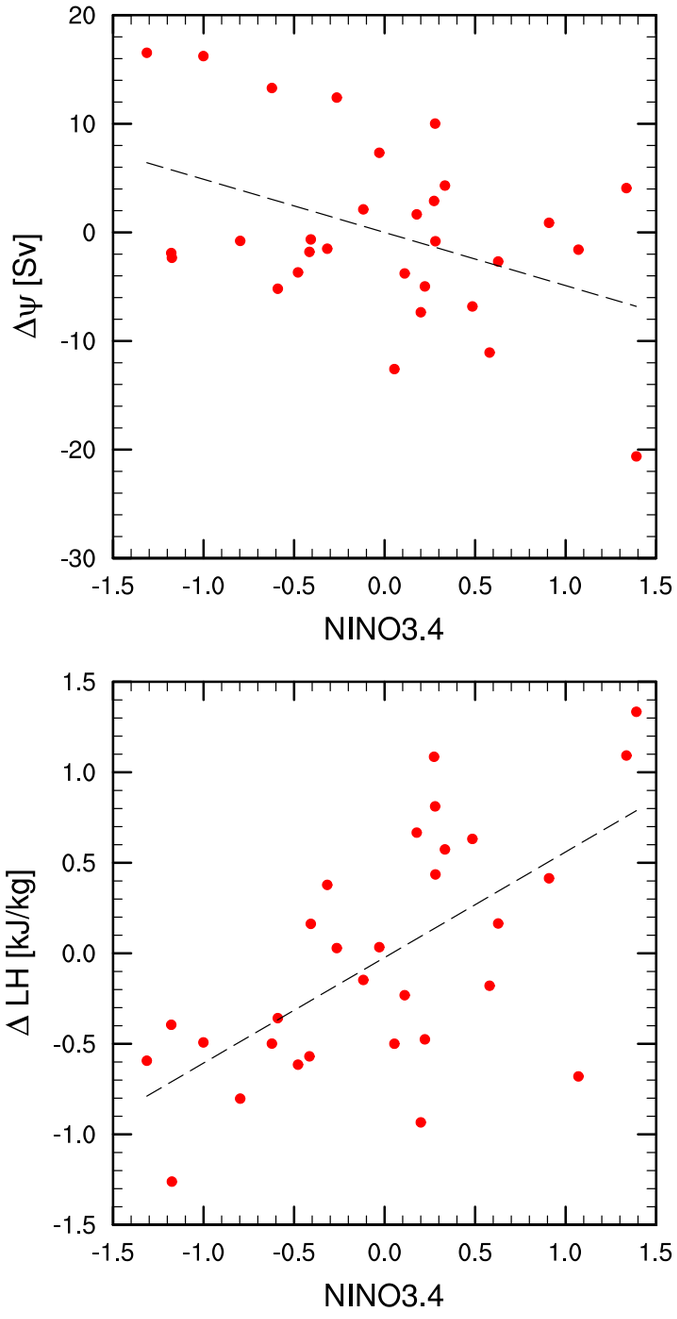


- Projecting the 100-400 Sv stream function on time-averaged LH and DSE.

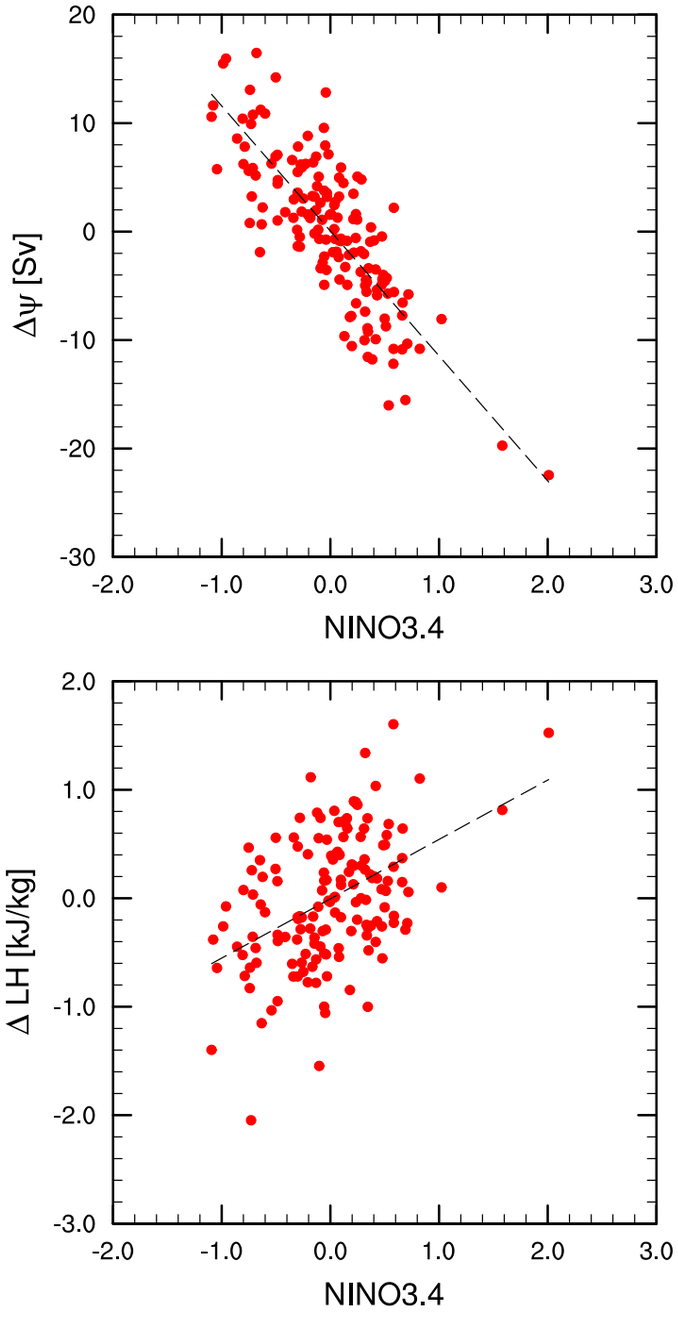
- Meridional overturning similar to isentropic mean. Large zonal asymmetries - Walker circulation.

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

ENSO



ERA-Interim (30yr)



EC-Earth (155yr)