The length scale of poleward moisture transport

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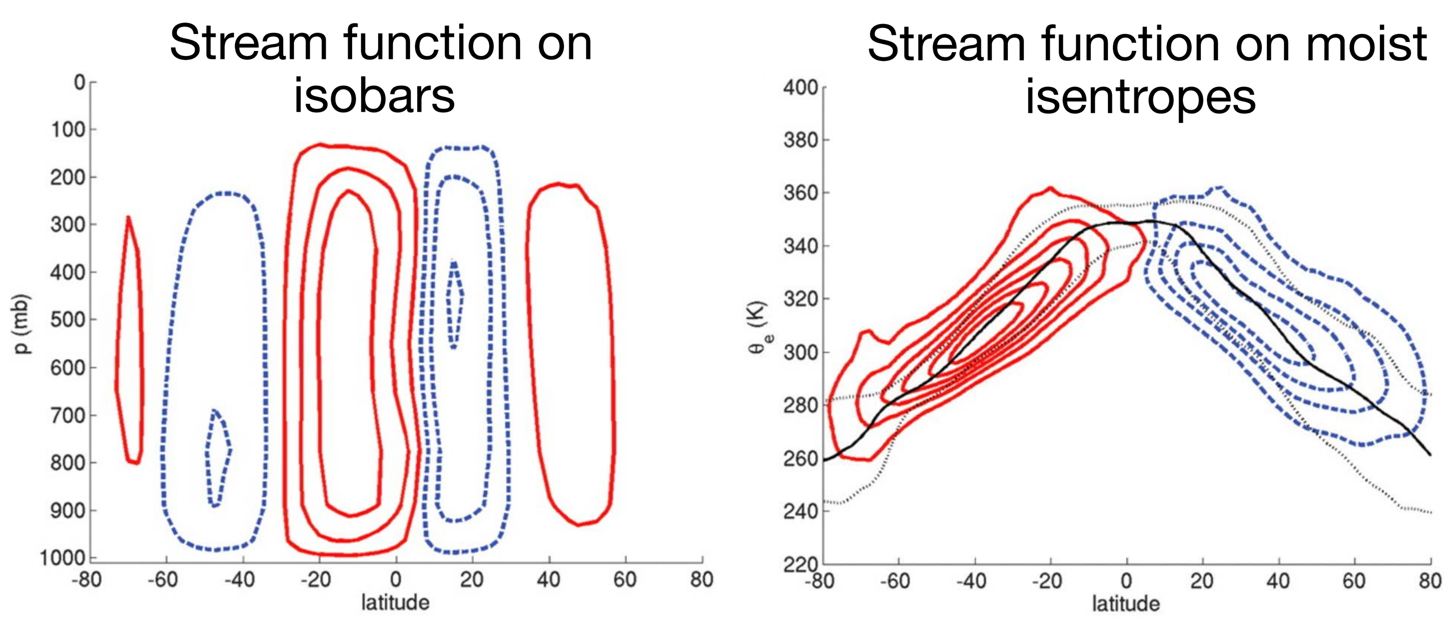
Moist entropy: an idealized framework for poleward moisture transport



Pauluis et al. 2008: red contours indicate southward transport

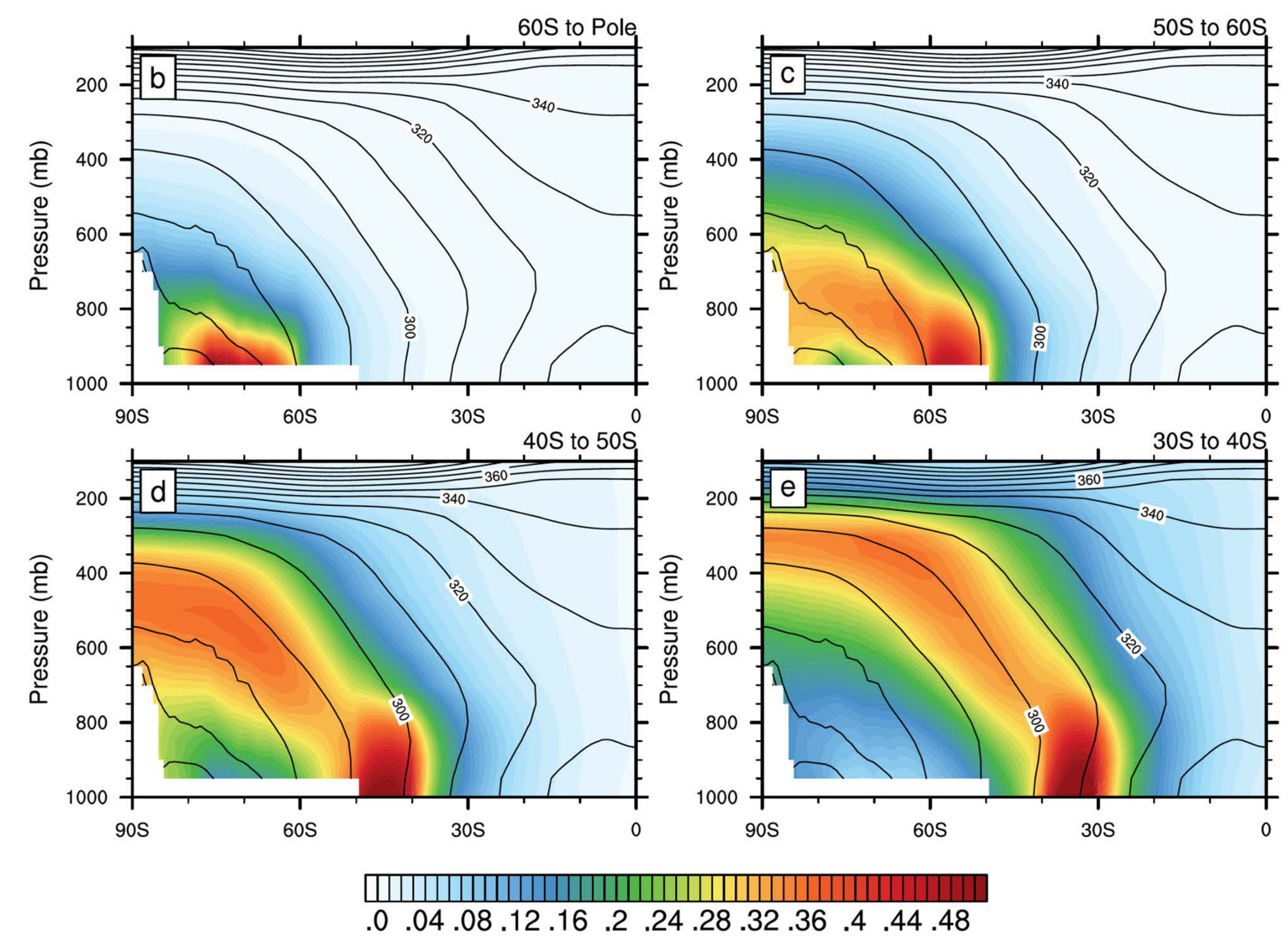
Defined on surfaces of constant moist entropy (moist isentropes), the general circulation collapses to a single hemispheric cell in which mass moves poleward from the tropics.

Equivalent potential temperature is a typical measure of moist entropy and depends on 3 key variables:

$$\theta_e \approx \left(T + \frac{L_v}{c_{pd}} r\right)\left(\frac{p_0}{p}\right)^{R_d/c_{pd}}$$

Temperature, Moisture, Altitude

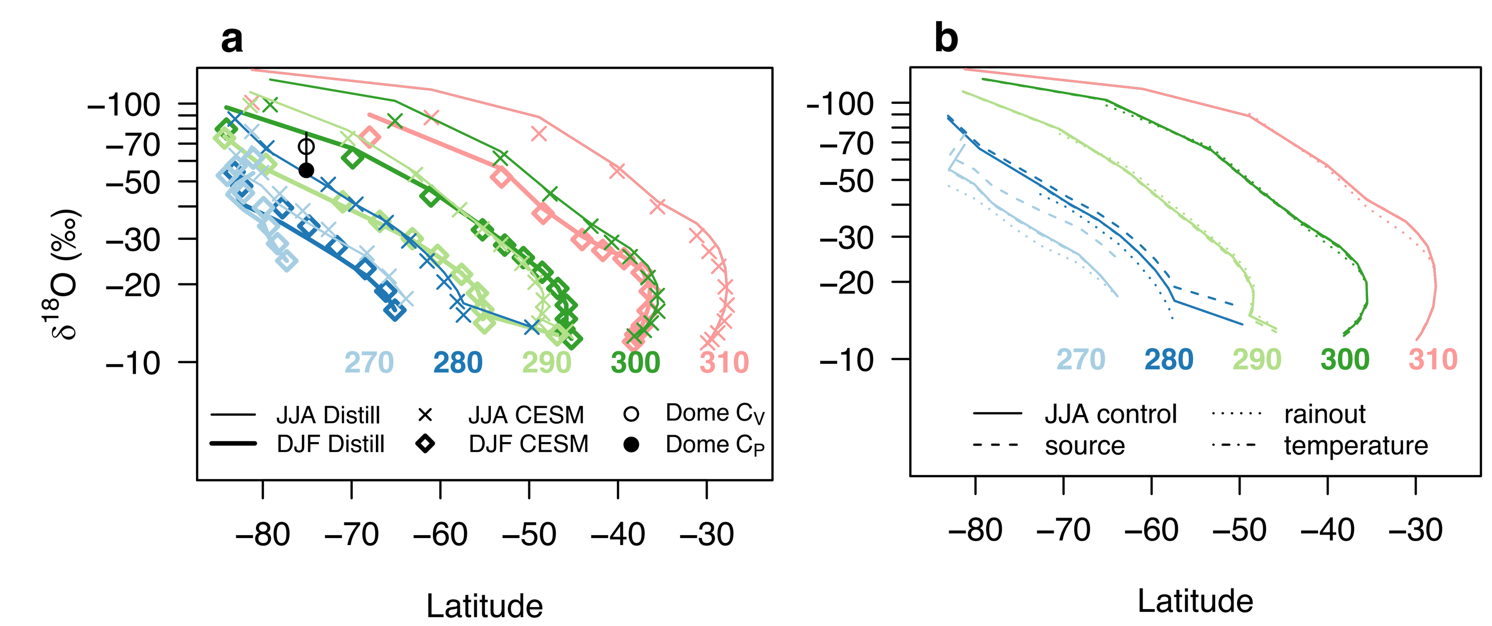
Water tags (CESM) show ocean evaporation largely following moist isentropic surfaces



Water vapor concentration normalized by total moisture evaporated from each zonal band

Each moist isentrope (contours) defines a moisture transport pathway with a length that depends on the surface geometry.

Surface length describes total rainout and predicts isotopic changes seasonally



Water vapor isotope ratios (×,◇) in CESM, averaged along moist isentropic surfaces (colors, units K), match predictions from simple Rayleigh distillation (lines), as expected if poleward moisture transport is moist isentropic and mixing negligible (a).

Individually, air temperature, moisture content (i.e. rainout), and the isotopic composition of the moisture source cannot predict seasonal isotopic changes (b). Shifts in moist isentropic surface geometry, indicating changes in total effective rainout, can (a).

Implications for detecting changes in the global circulation with isotopes

If **moisture flux divergence = evaporation (*E*) – precipitation (*P*)**, the isotope ratio of atmospheric moisture (R_x) in zone *x* is given by

$$R_x = I_x + \exp(-\lambda\, dx) \times R_{x-1}$$

I_x describes isotopic imbalance between local *E* and *P*

R_{x-1} is the isotope ratio of the zone upstream

λ is (E-P)/*F*, the inverse of the **moisture length scale**, and *F* is the moisture flux

If both *E-P* and atmospheric moisture scale with Clausius-Clayperon (e.g. temperature),

$$\Delta\lambda/\lambda = -\Delta v/v$$

or λ will change proportionally with the meridional wind.

If local isotopic variations are small, the ratio of isotope ratios from neighboring regions will track this change.

Because the geometry (and length) of moist isentropic surfaces depends on temperature, the moist isentropic framework (verified isotopically) provides a simple way to describe and predict changes in moisture source regions and transport pathways.

Read more at
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