Sensitivity of Jet Stream to Model Horizontal Resolution

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Dependence of jet stream on resolution

In 3 AGCMs under identical SST, jet location shifts poleward and jet strength weakens with increasing resolution.
A PV staircase paradigm

- A simple fact: Jet $\iff$ PV staircase/sharp PV gradient

Dritschel and McIntyre (2008)
A PV mixing perspective for jet shift

Rad-conv equilibrium
Hadley circulation
Eddy mixing
Enhanced & expanded mixing

Inspired by Held and Phillips (1990)
See Lu et al (2014 JC)
Wave activity $A(\Phi_e)$

Area operator: 
$$\mathcal{A}(X) = \frac{1}{2\pi \cos \varphi_e} \left( \iint_{q>Q, \varphi \leq \varphi_e(Q)} X \, dS - \iint_{q<Q, \varphi > \varphi_e(Q)} X \, dS' \right)$$

Finite-Amplitude Wave Activity: 
$$A \equiv \mathcal{A}(q)$$

$\Phi_e$ (Equivalent Latitude)
Area-Coordinate Transformation

\[ \frac{\partial q}{\partial t} + \vec{v}_\psi \cdot \nabla q = -\nabla \cdot (\vec{v}_\chi q) + k\nabla^2 q \]

Area-coordinate transformation

\[ \frac{\partial A}{\partial t} + \overline{v}_\psi q' = -A \left( -\nabla \cdot (\vec{v}_\chi q) \right) - K_{eff} \frac{\partial Q}{\partial y} \]
Wave activity budget

\[ \overline{v' \psi q'} = -\mathcal{A} \left( -\nabla \cdot (\overline{\mathbf{v}' \chi q}) \right) - K_{\text{eff}} \frac{\partial Q}{\partial y} \]

- Wave source and PV flux are stronger for T340
- But the jet strength is weaker
- Mixing at jet core is stronger for higher resolution; the AM has to be distributed over a wider range.
Take home message/image

low resolution
high resolution

Wave Source