Identifying the leading patterns of variability in the extratropical circulation

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Motivation (i)

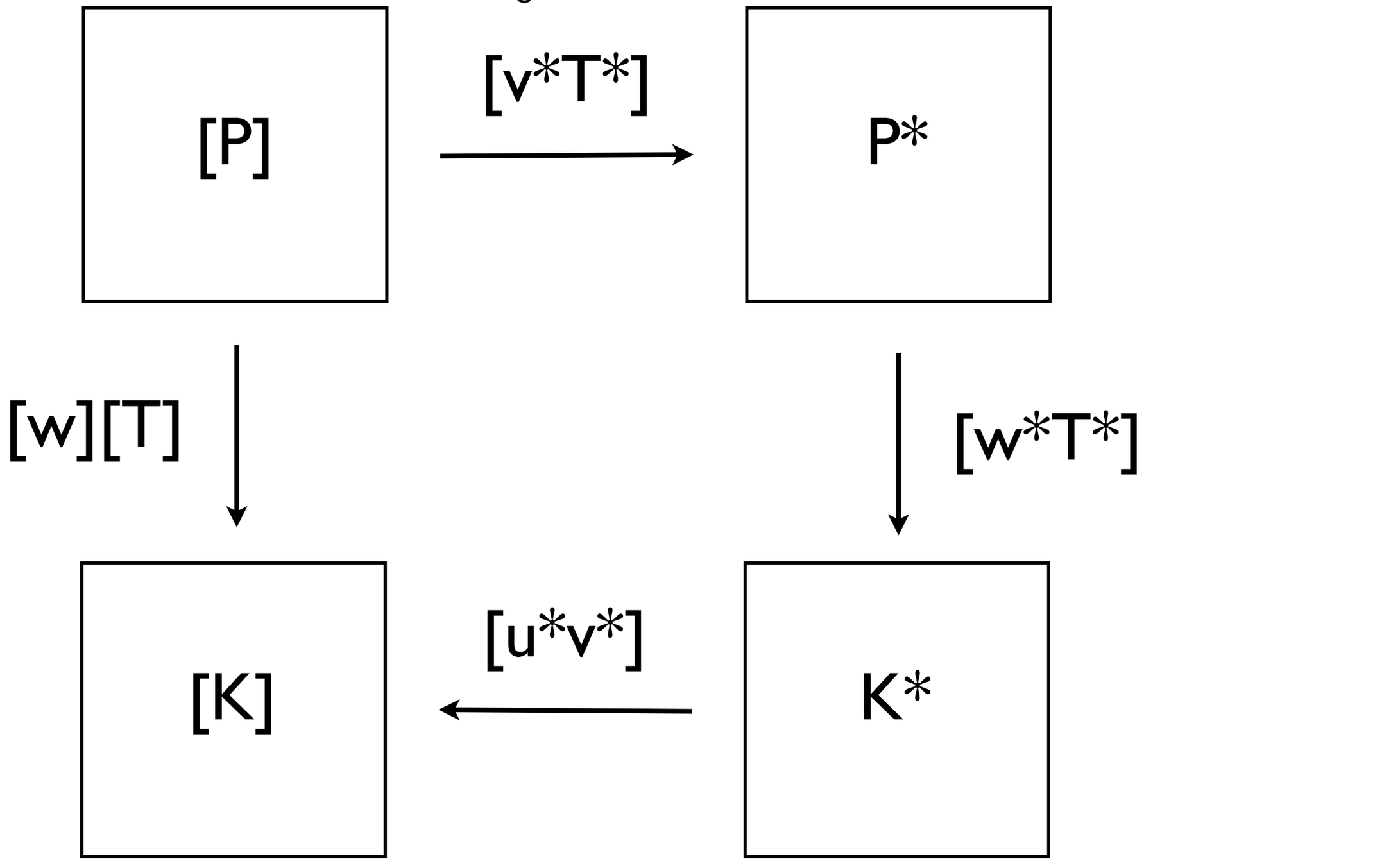
- Widely documented increases in eddy kinetic energy, poleward heat transport, and the latitude of the stormtracks in climate change simulations.

- Not clear if these varied changes reflect the same fundamental phenomenon.

Motivation (ii)

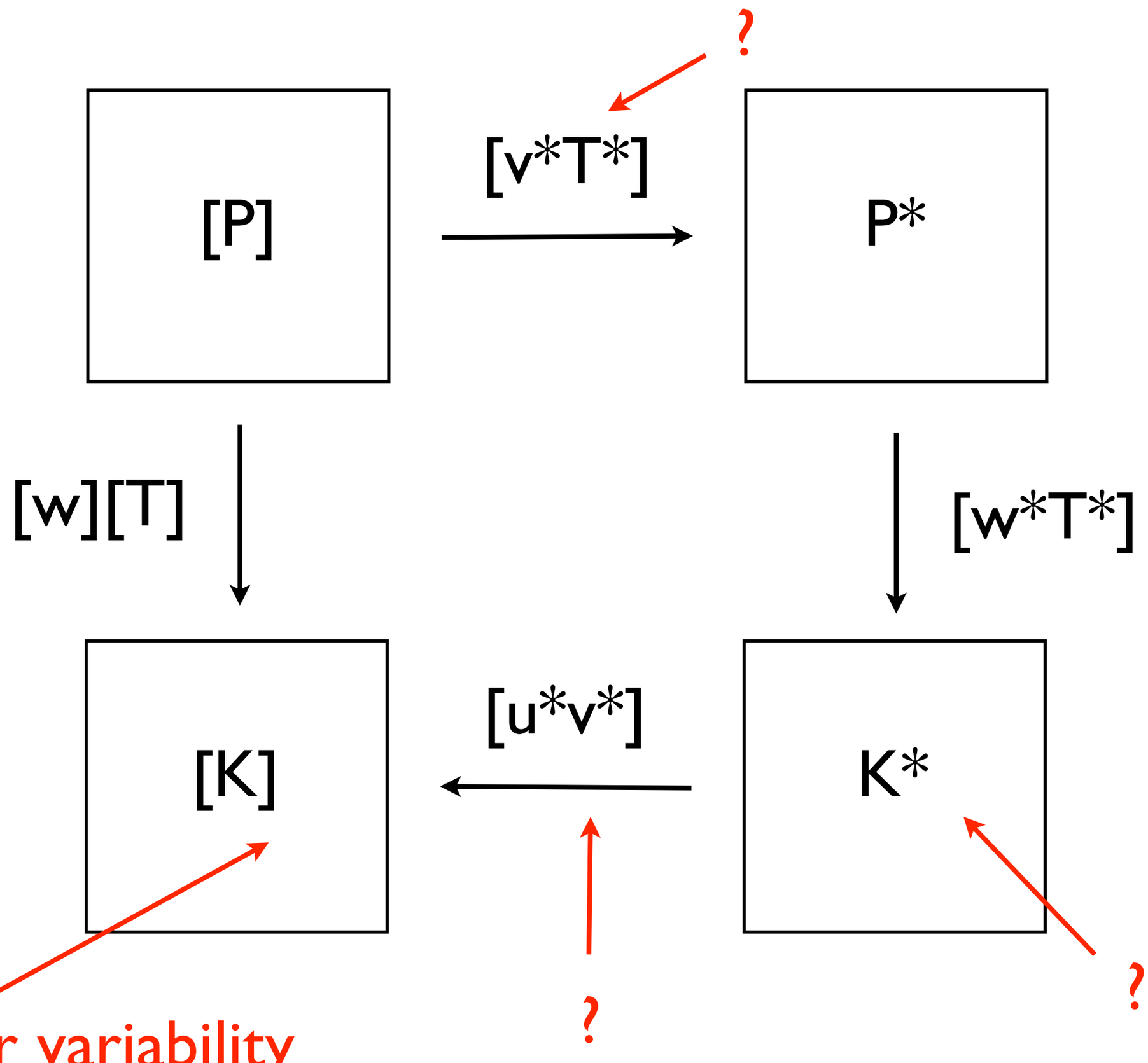
eg Vallis 2006

Gradients in zonal-mean diabatic heating



Available potential energy (P)
Kinetic energy (K)

Leading patterns of variability in the energy cycle



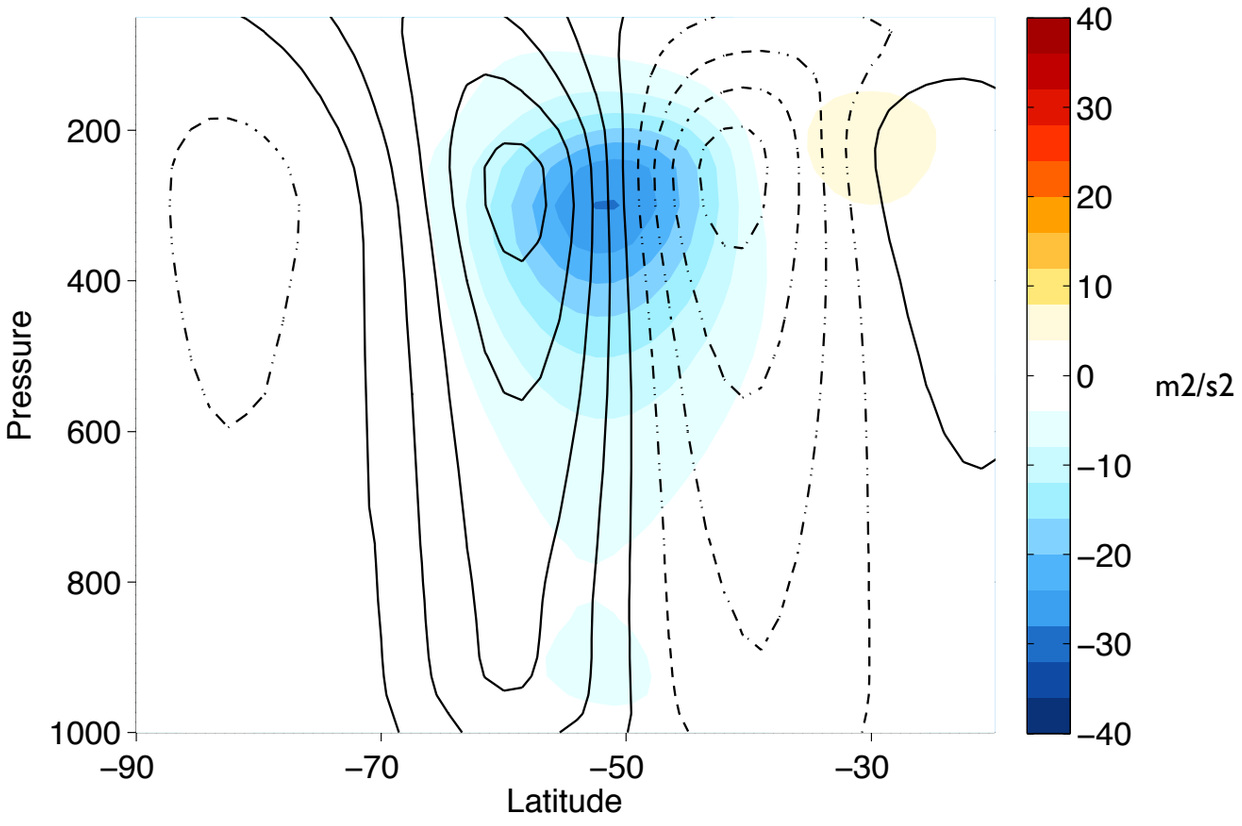
• Examine the leading PCs of zonal mean kinetic energy, eddy kinetic energy, and the conversions between eddy and mean potential and kinetic energy.

• Argue that patterns of variability in the extratropical circulation can be viewed in the context of two *largely independent* classes of structures:

1) those that convert eddy to mean kinetic energy.
2) those convert mean to eddy potential energy.

Regressions on SAM (PC1 ZKE)

[u*v*] (shading) and U (contours)

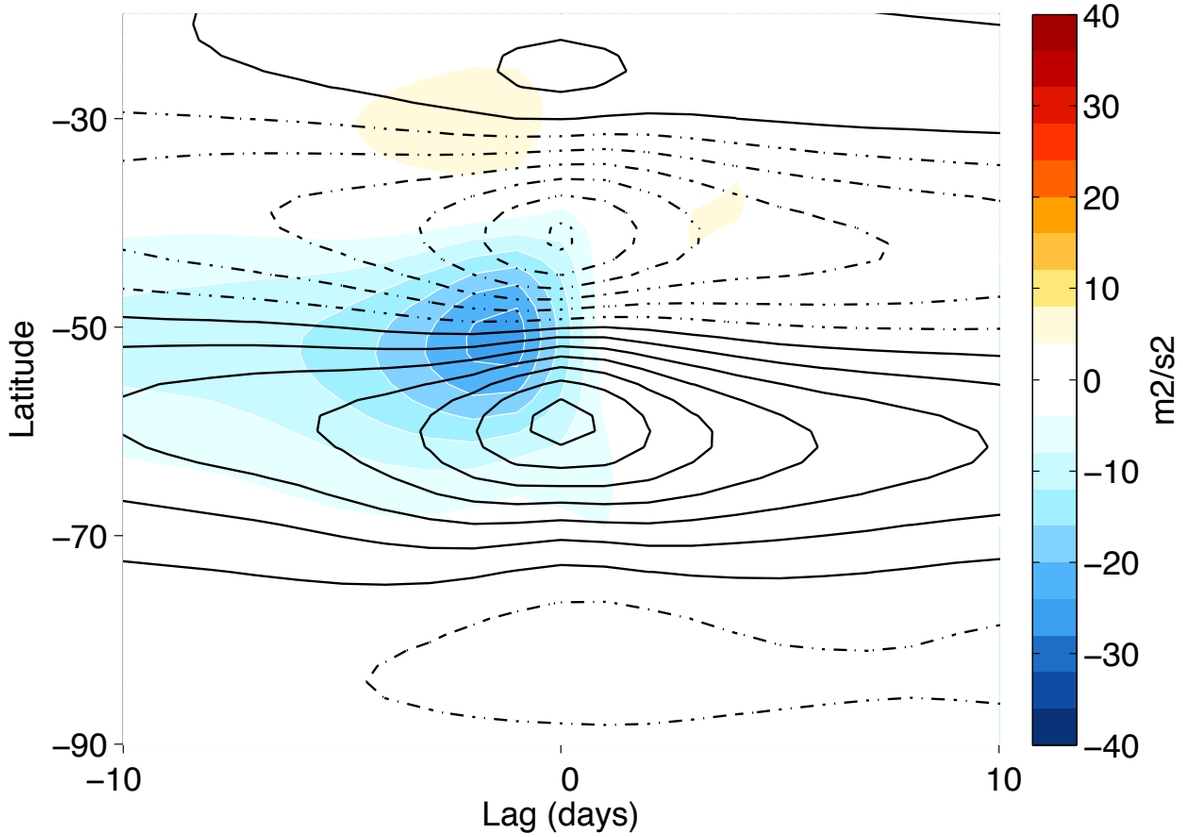


Results based on 6 hrly data from ERA Interim 1979-2010.

(As shown in dozens of papers. Early papers include those by Karoly, Kidson, Trenberth, Hartmann).

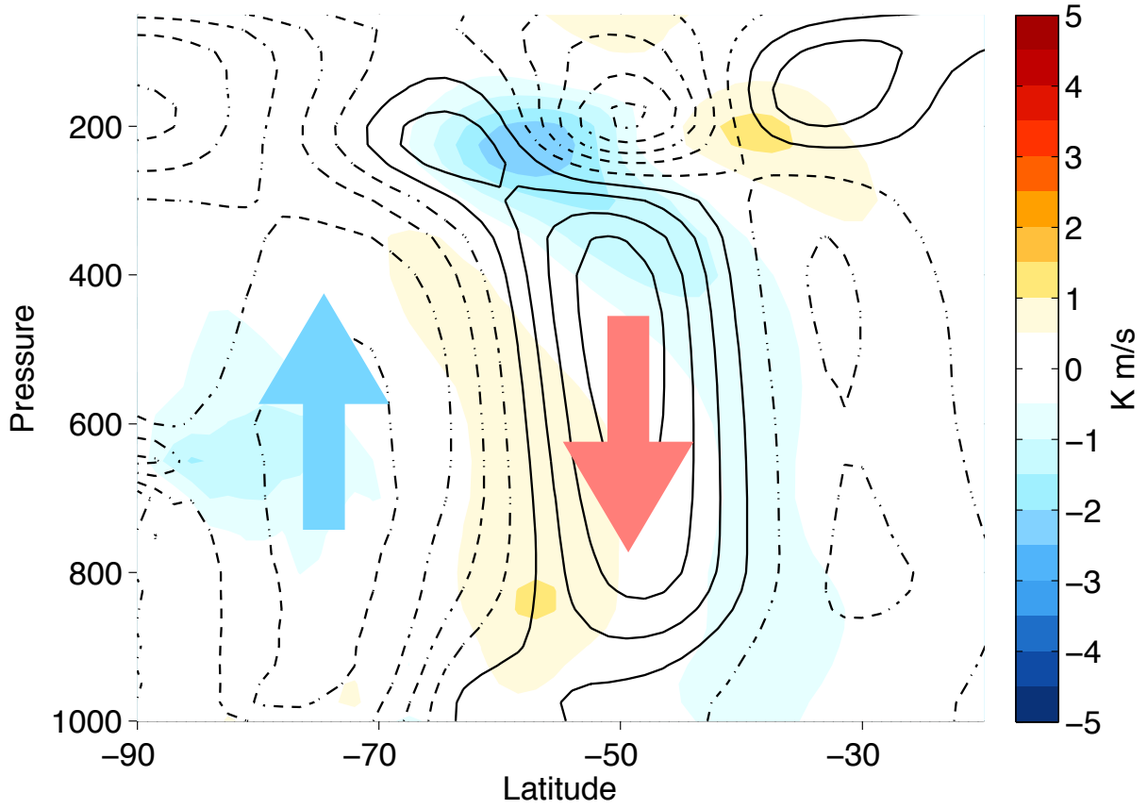
Regressions on SAM (PC1 ZKE)

[u*v*] (shading) and U (contours) at 250 hPa

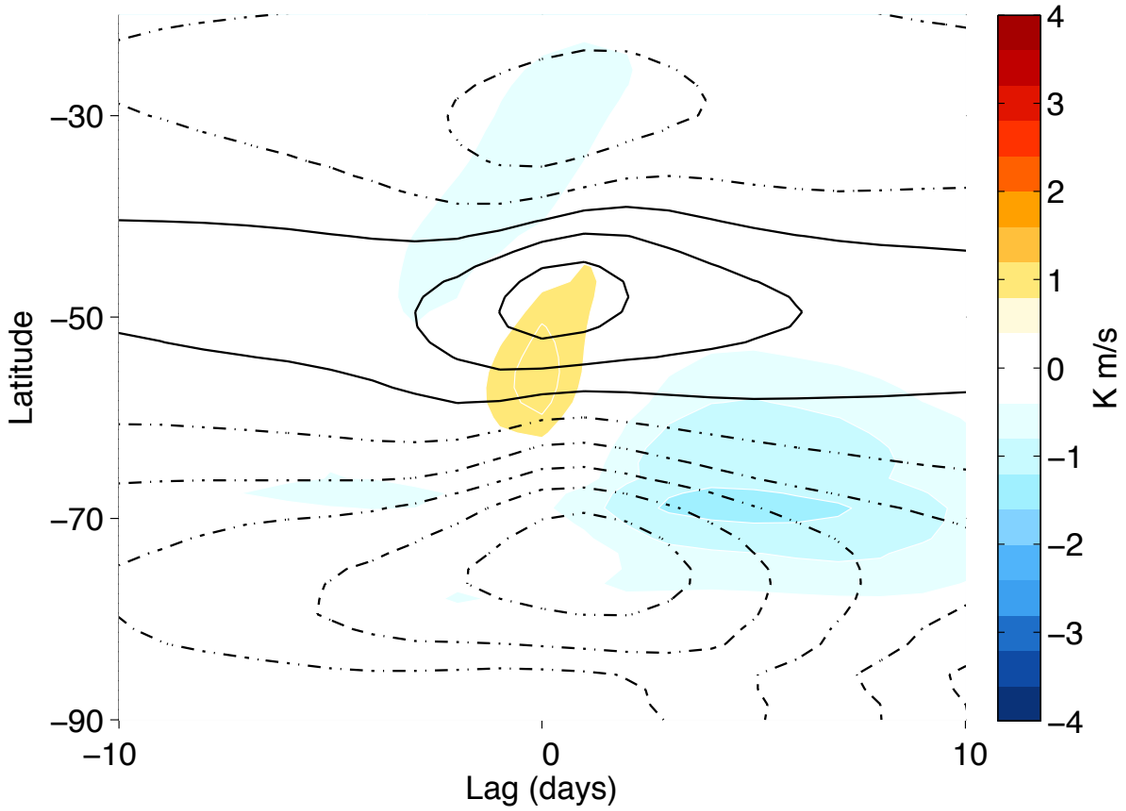


(eg Hartmann and Lo 1998; Lorenz and Hartmann 2001)

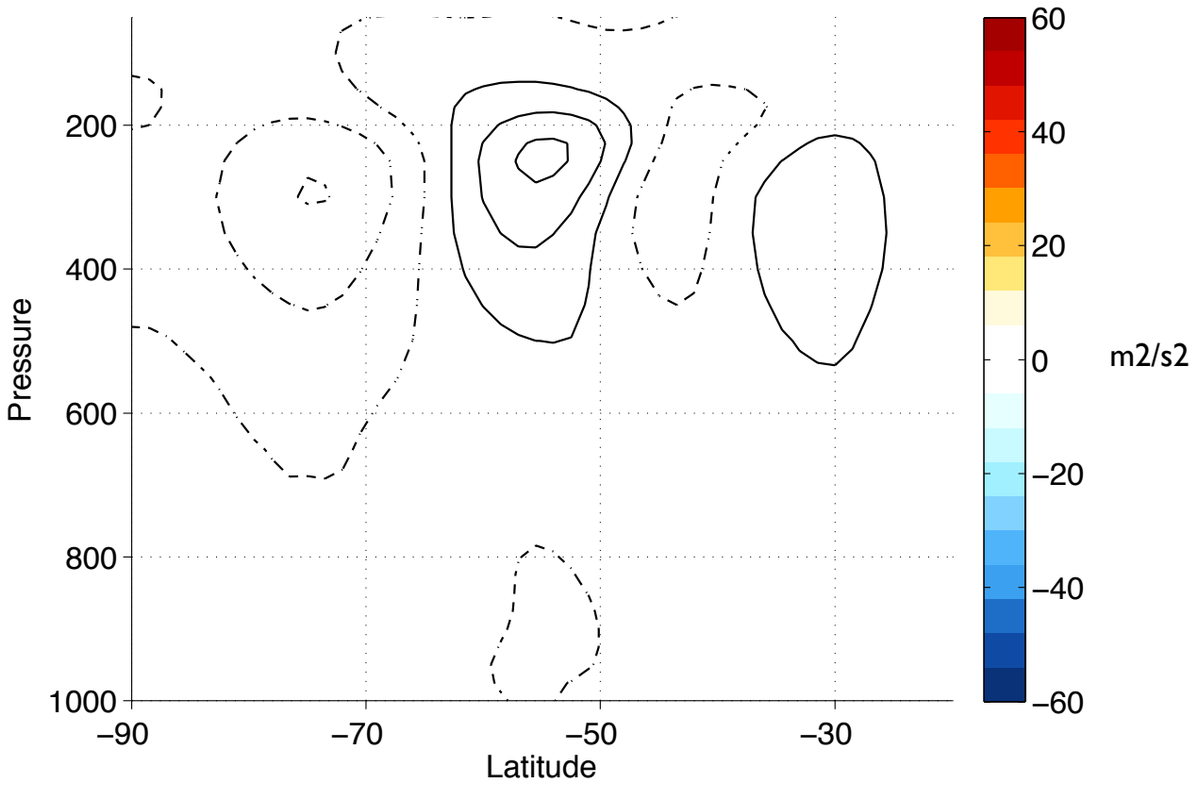
[v*T*] (shading) and T (contours)



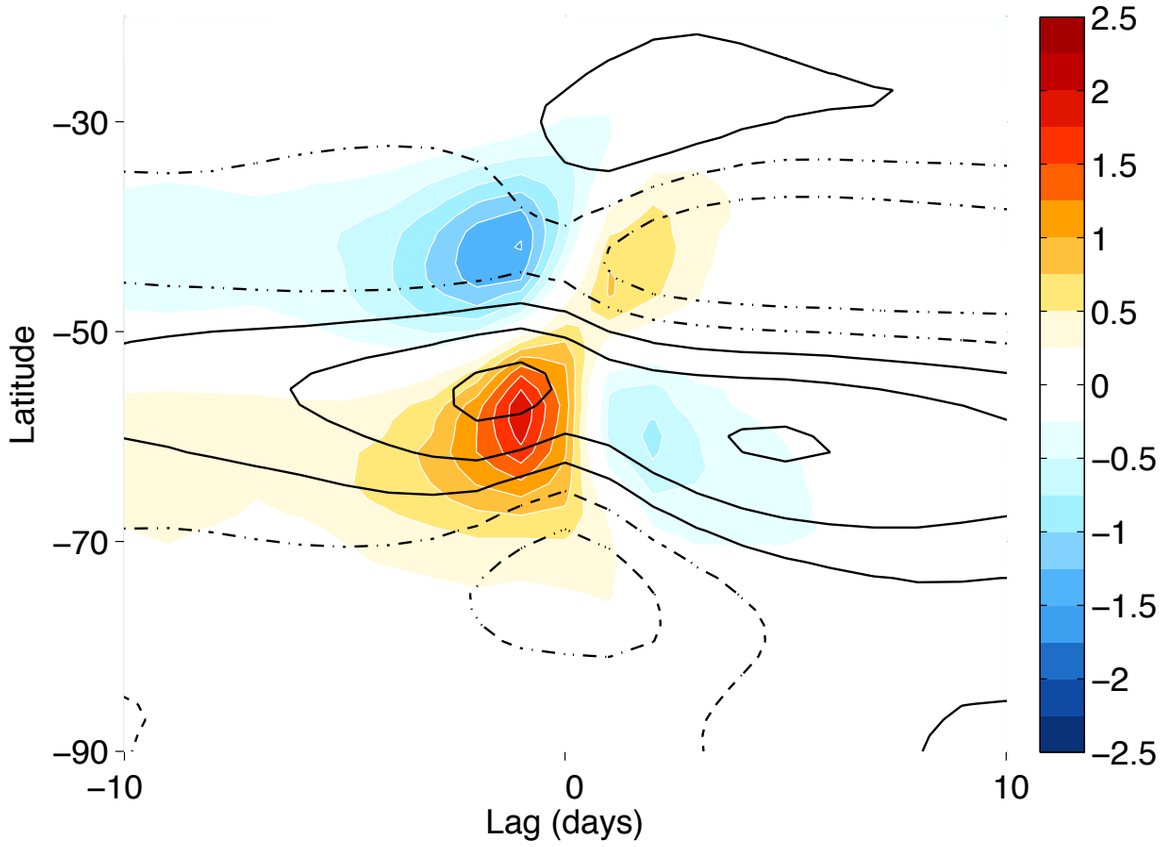
[v*T*] (shading) and T (contours) at 850 hPa



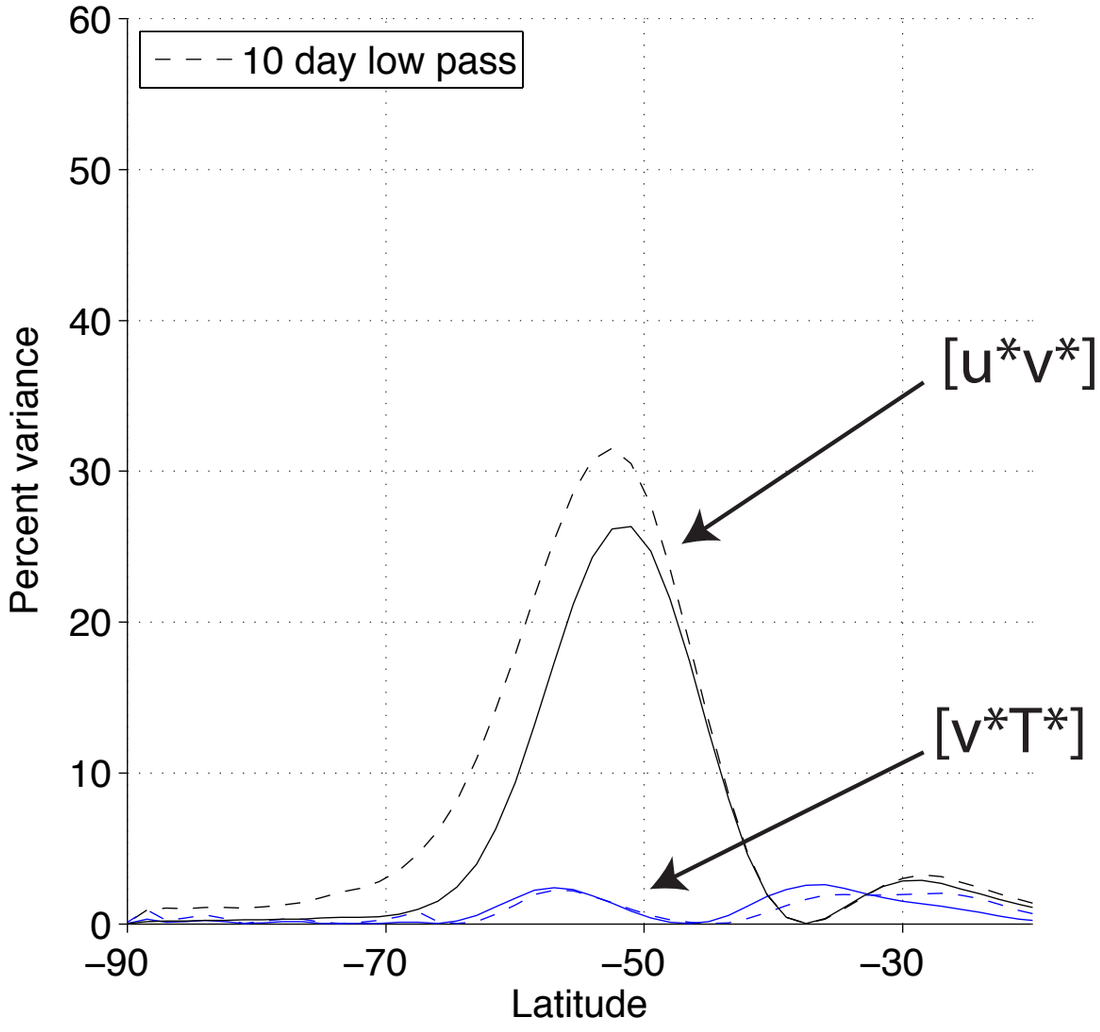
Eddy kinetic energy (EKE)



Eddy kinetic energy and [v*PV*]



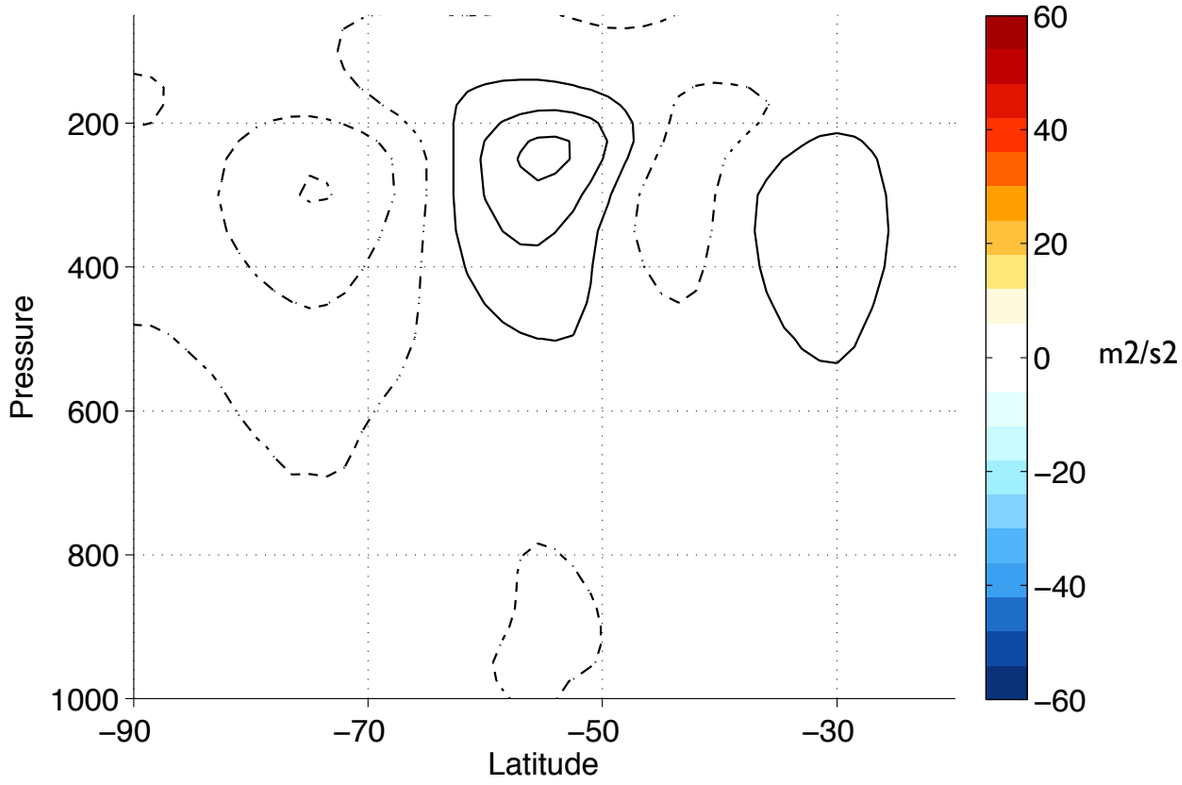
a) Variances explained by the SAM (PC1 ZKE)

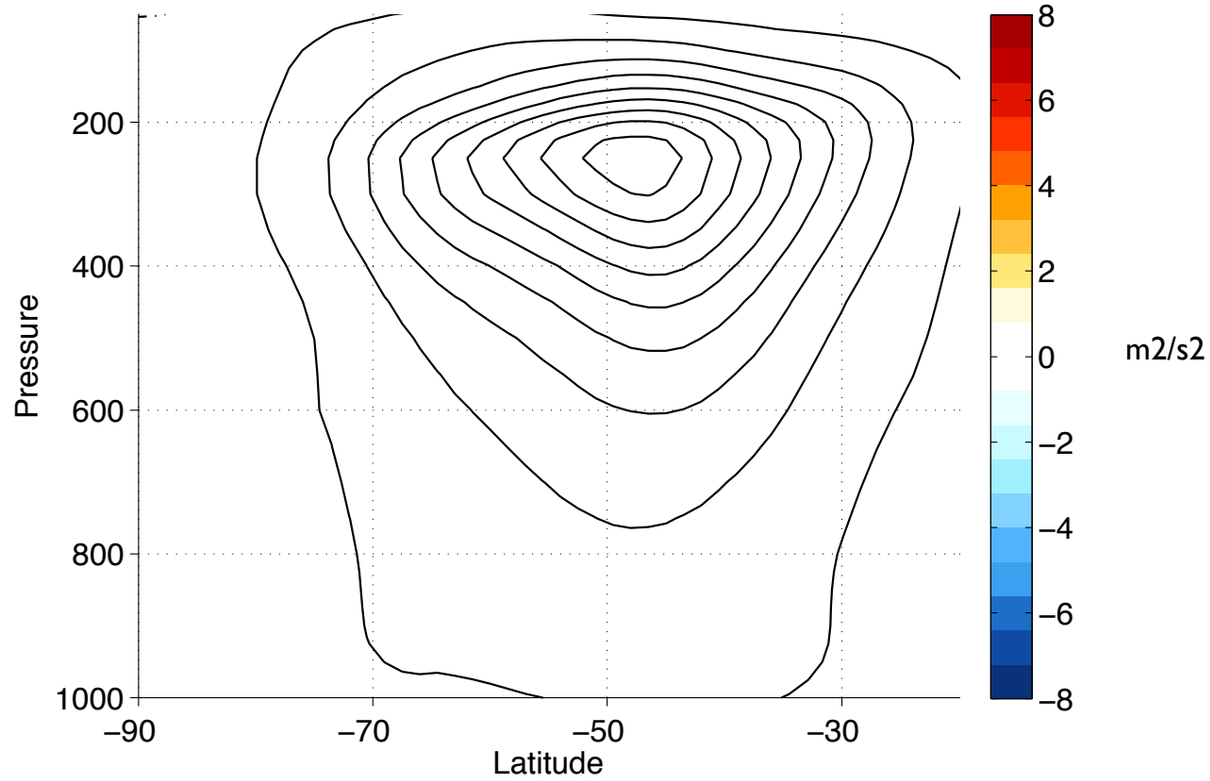


Regressions on SAM (PC1 ZKE)

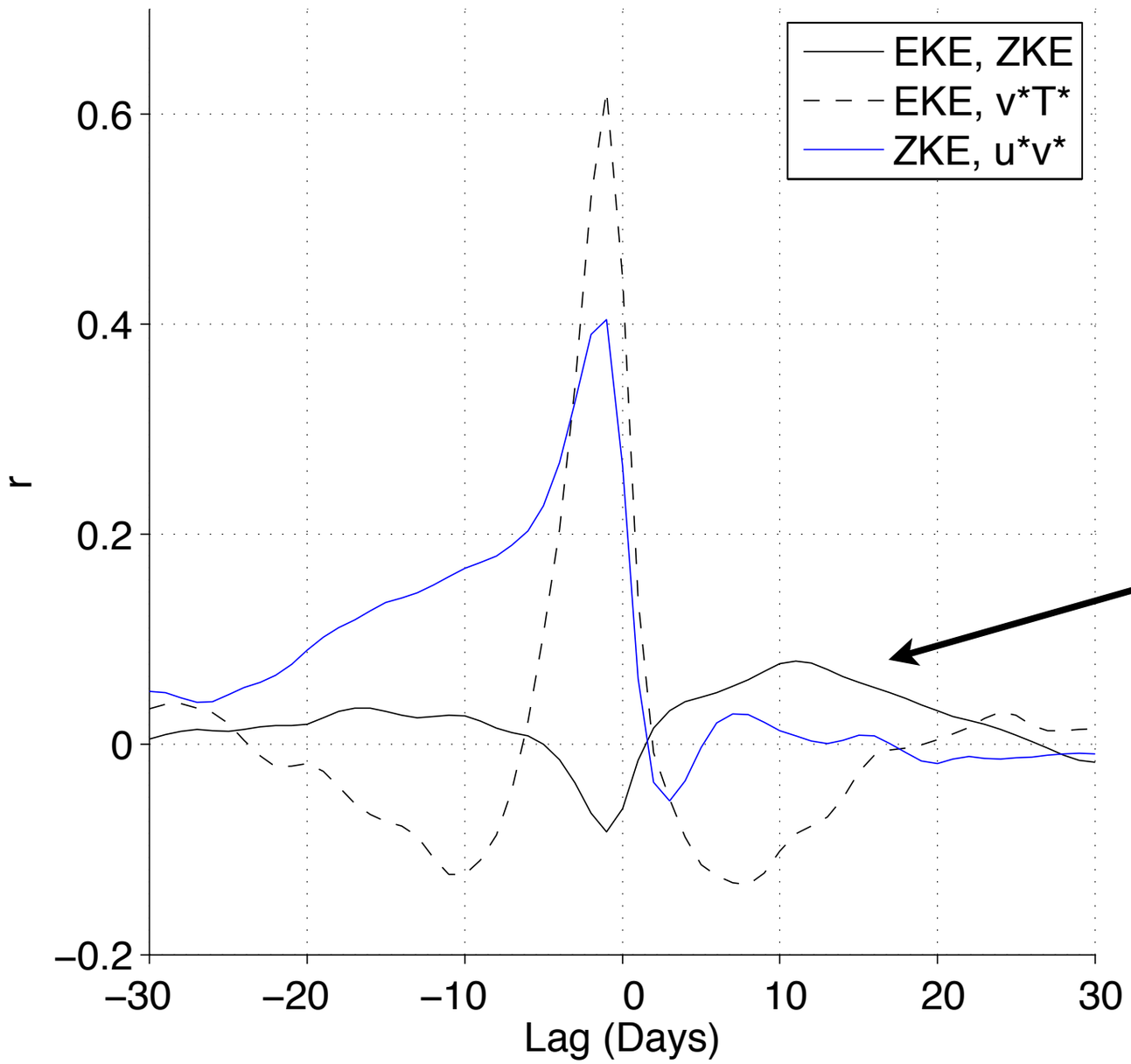
Regressions on PC1 EKE

Eddy kinetic energy (EKE)





c) Correlations between leading PCs

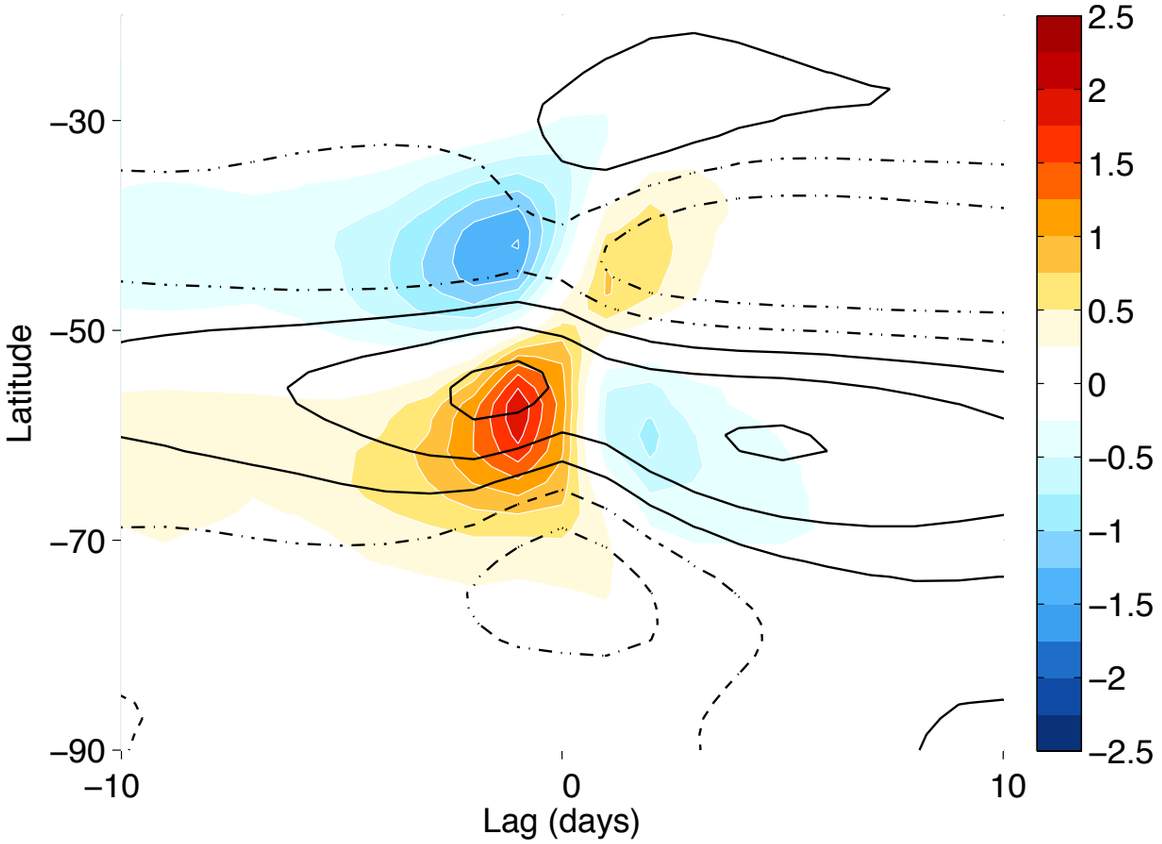


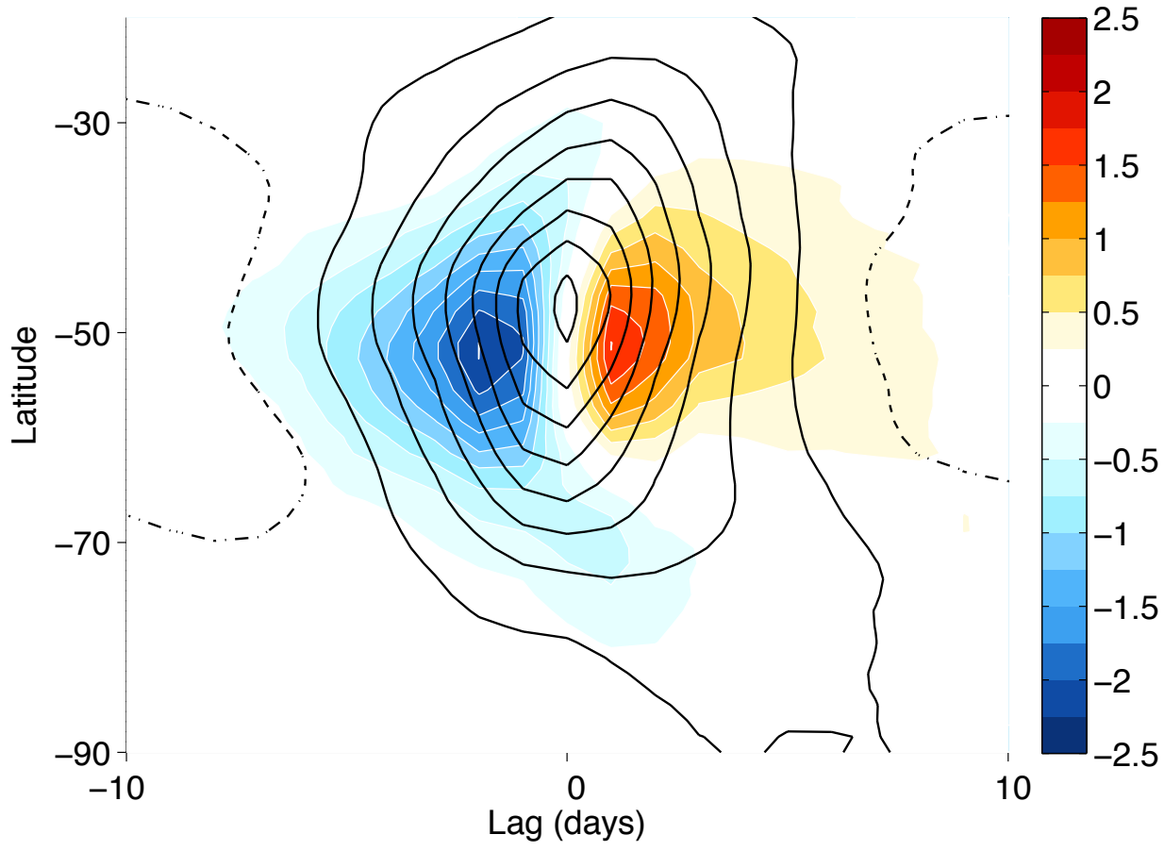
~0 between SAM and PC1 EKE

Regressions on SAM (PC1 ZKE)

Regressions on PC1 EKE

Eddy kinetic energy and [v*PV*]

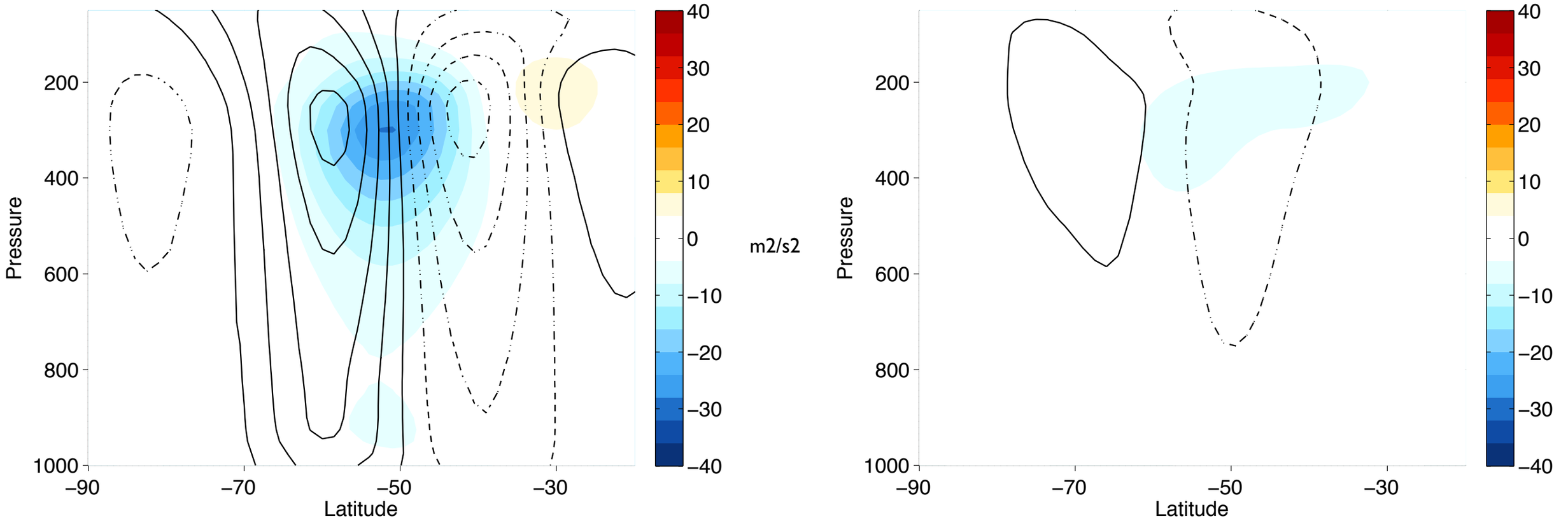




Regressions on SAM (PC1 ZKE)

Regressions on PC1 EKE

[u*v*] (shading) and U (contours)



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Regressions on PC1 EKE

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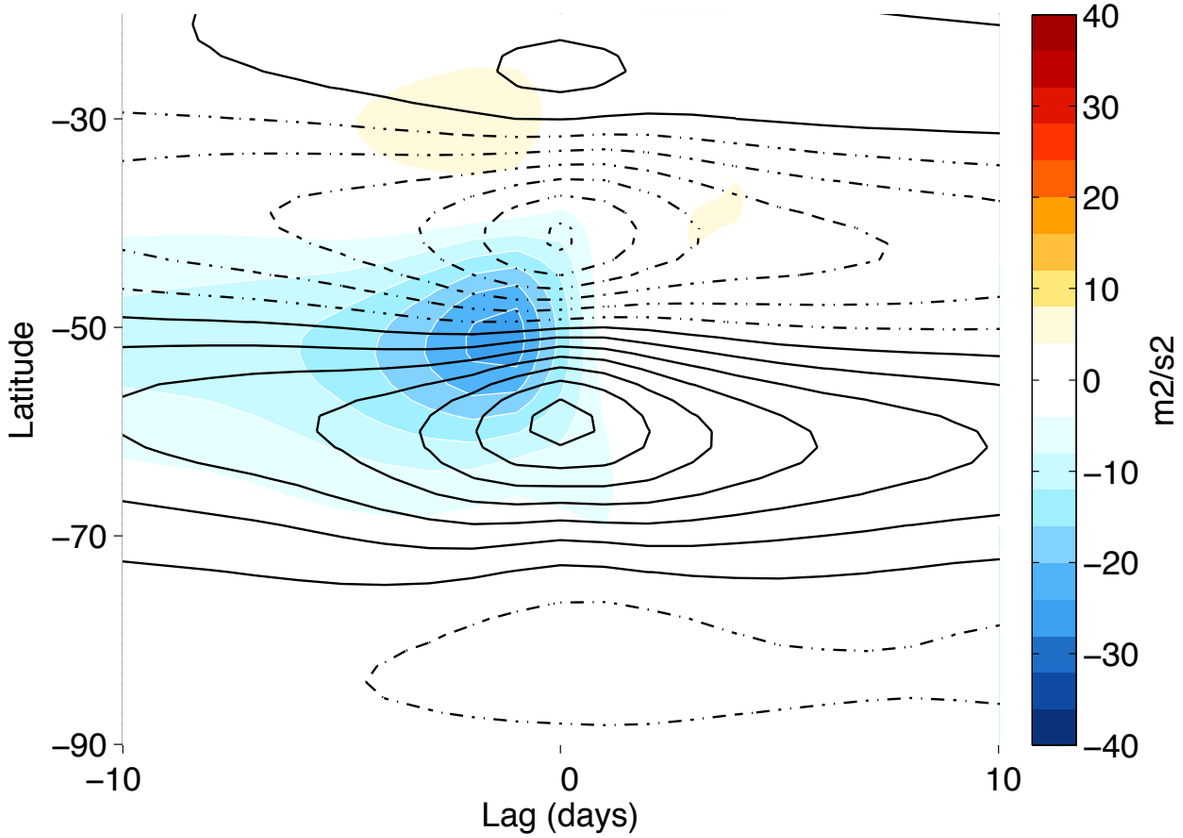

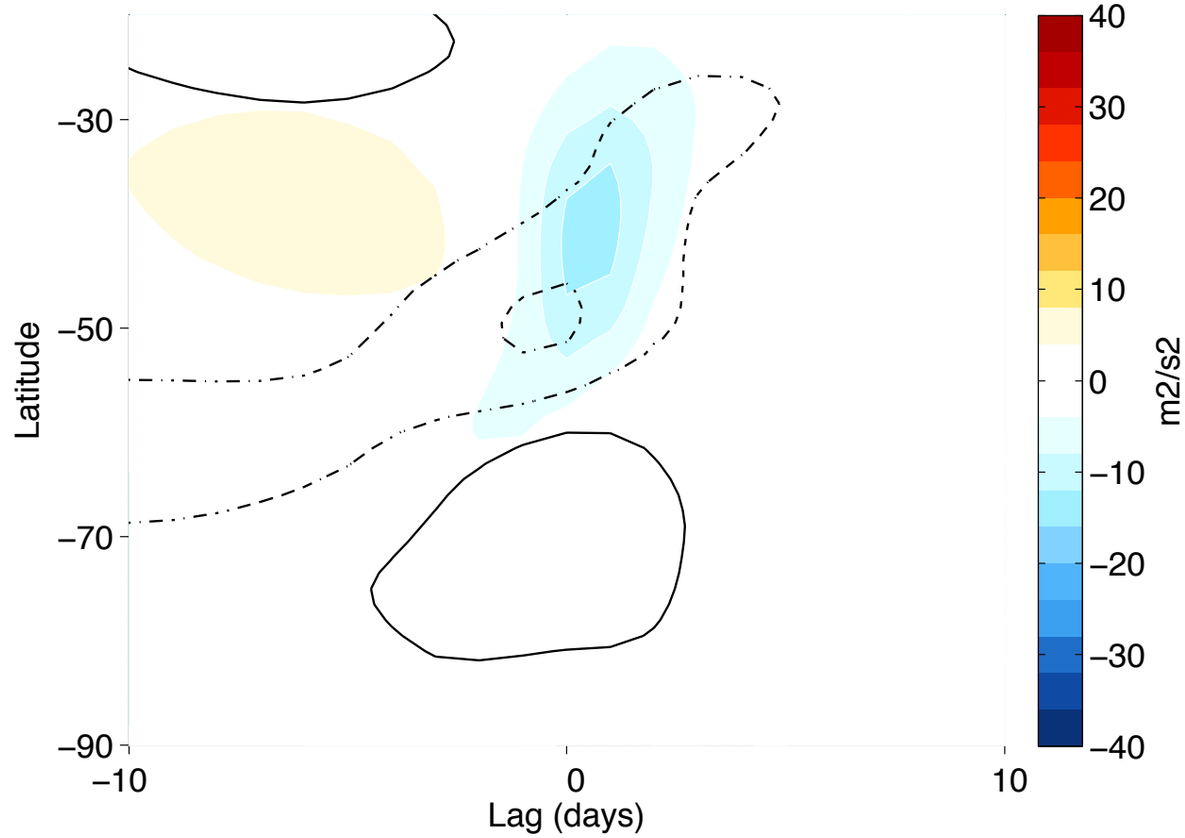

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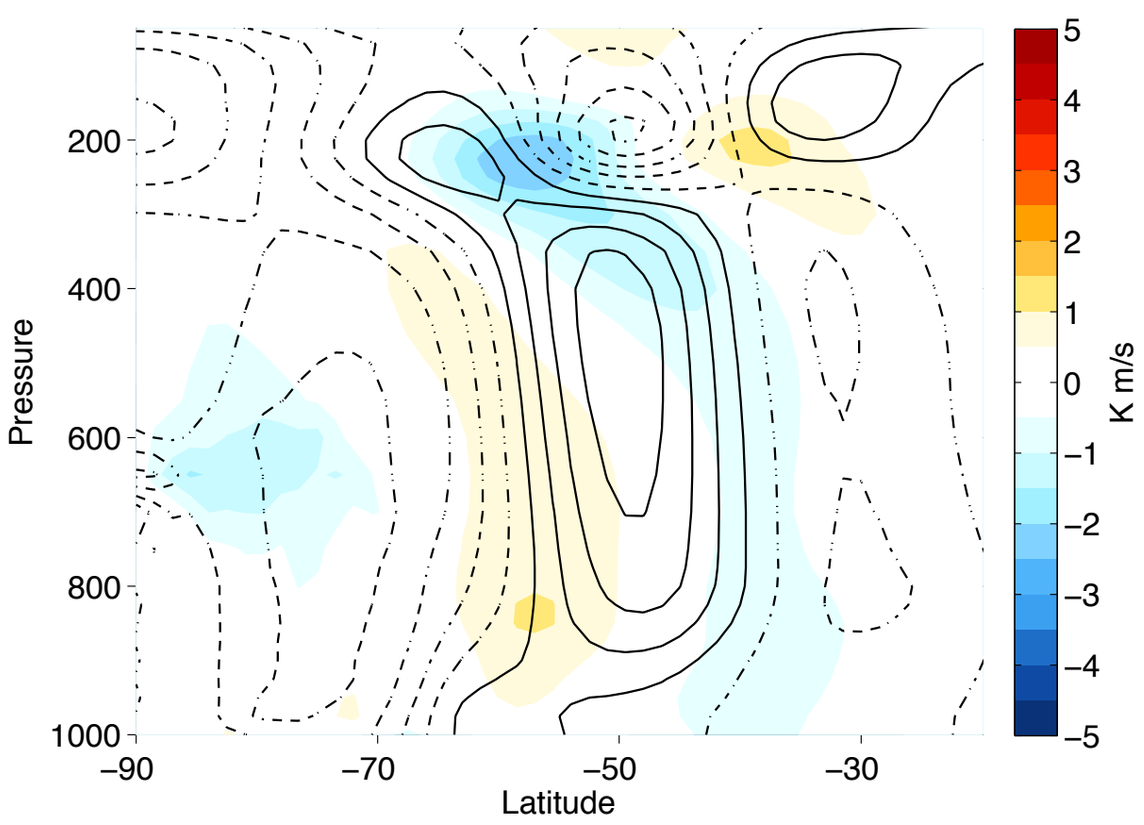
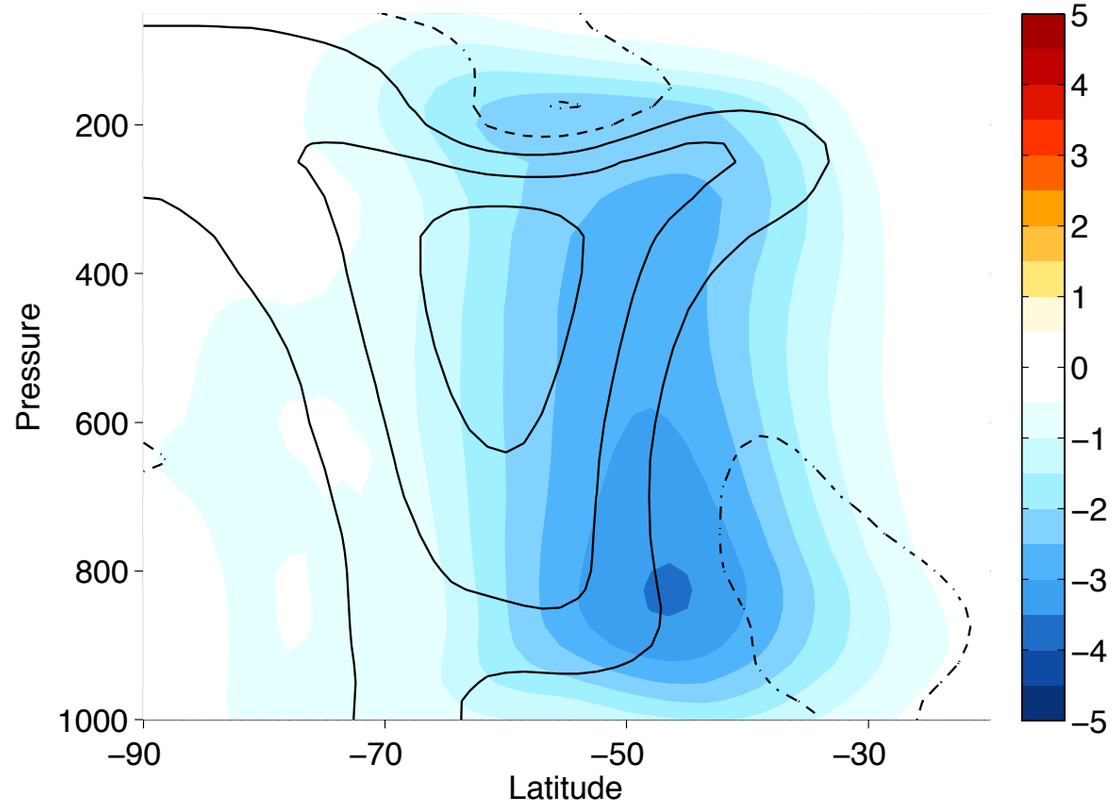
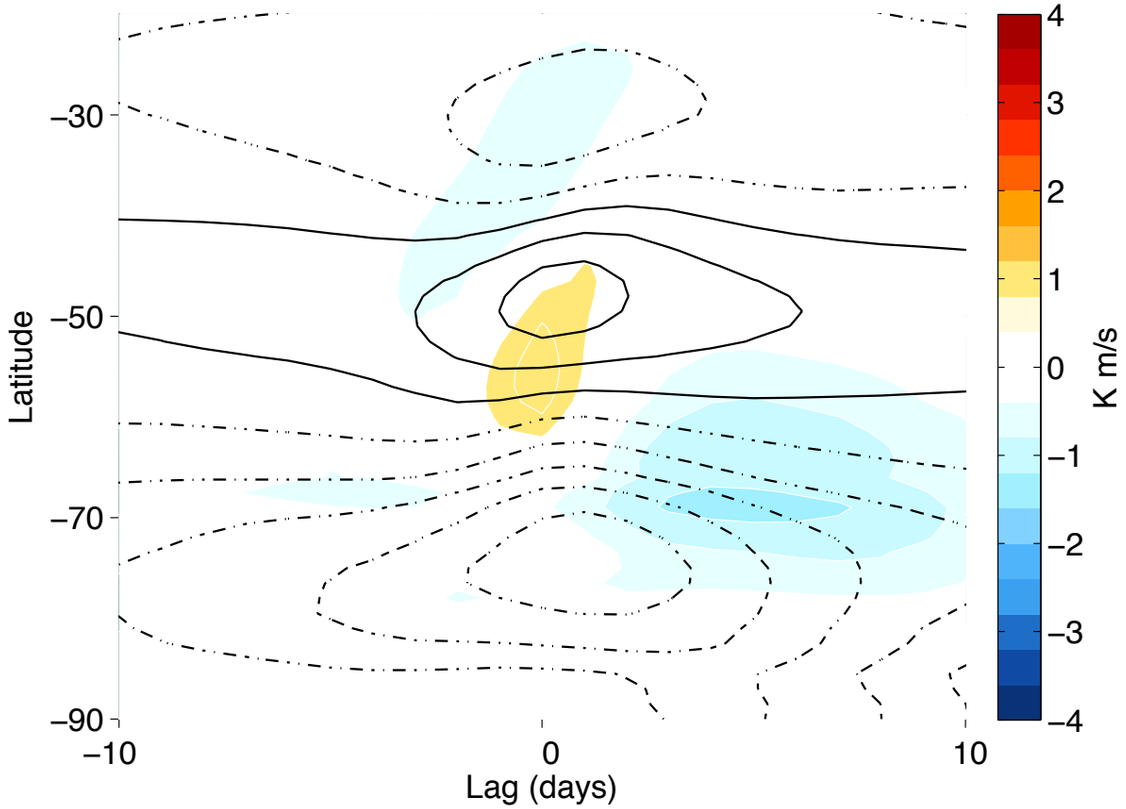


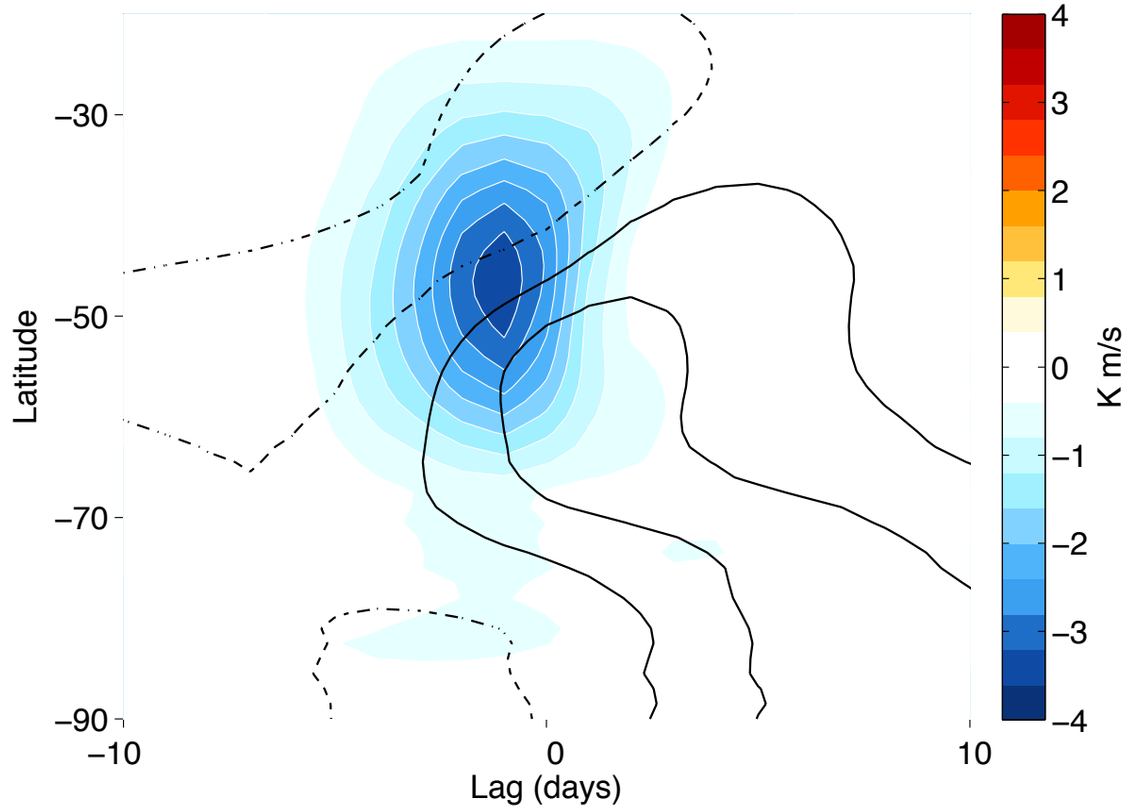


Regressions on SAM (PC1 ZKE)

Regressions on PC1 EKE

[v*T*] (shading) and T (contours) at 850 hPa





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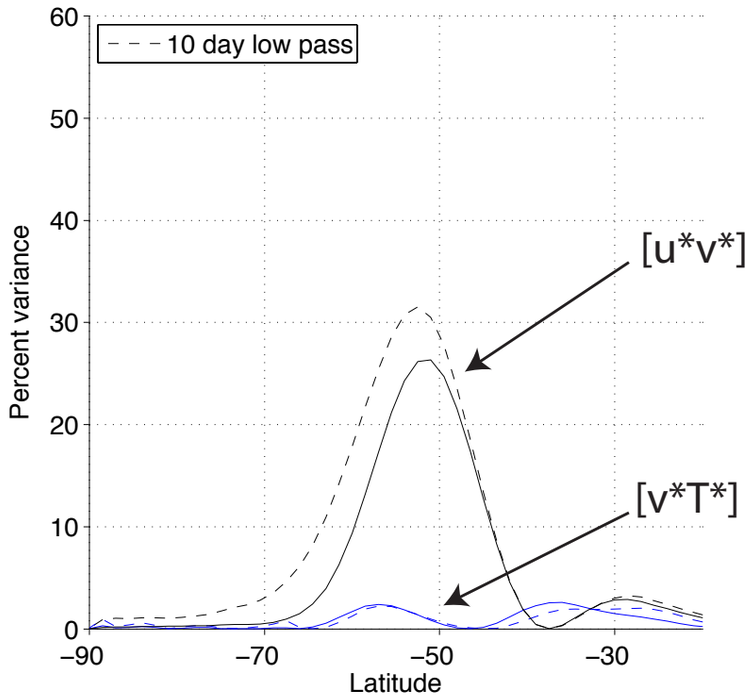
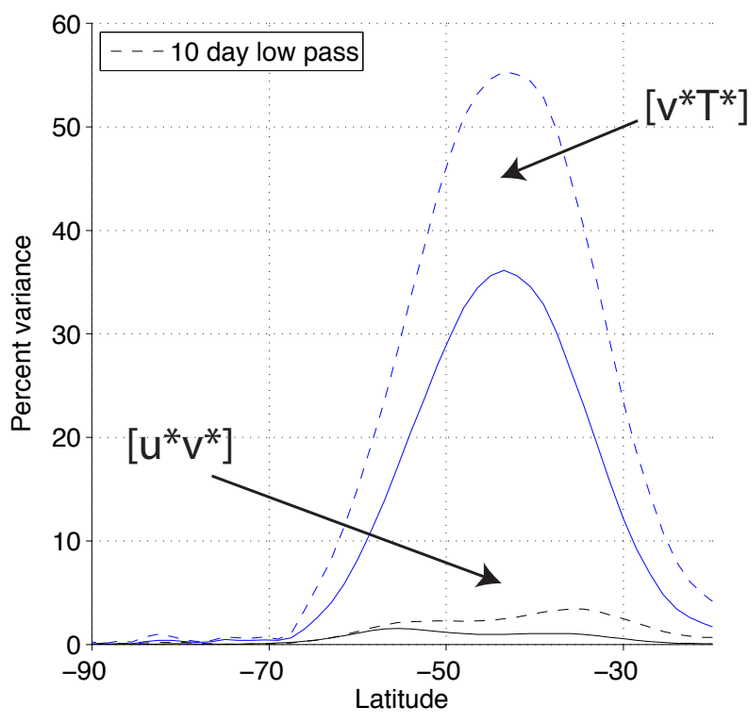
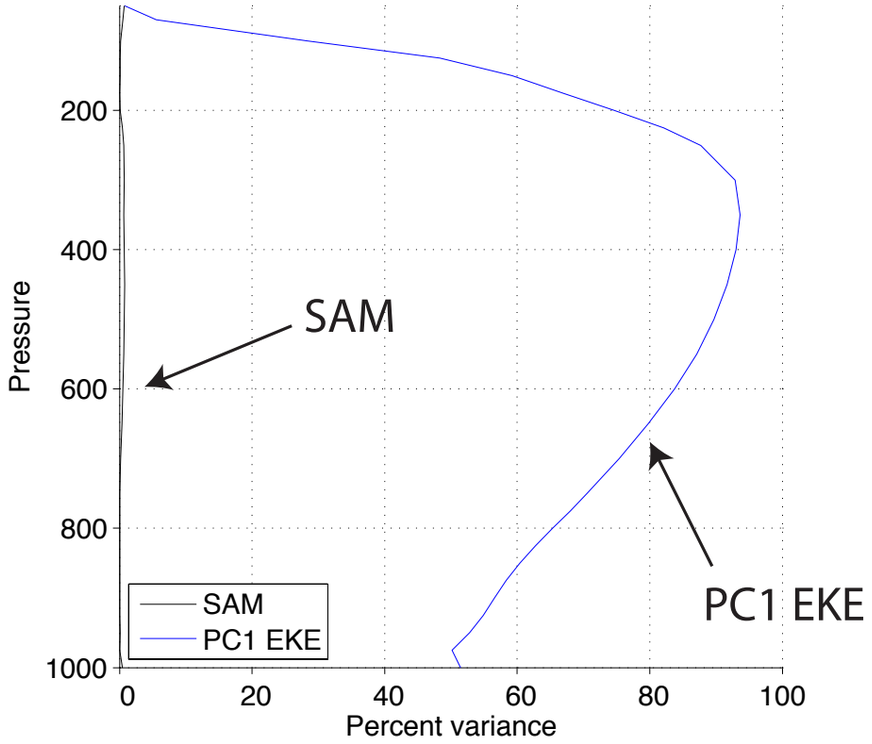


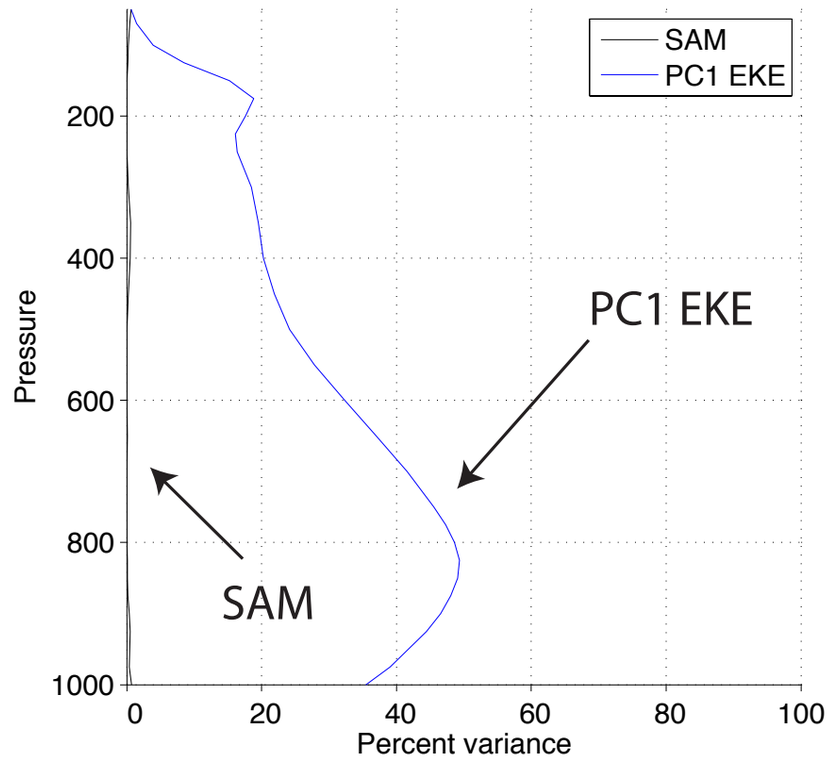
b) Variances explained by PC1 EKE



c) Variances explained in SH EKE



d) Variances explained in SH [v*T*]



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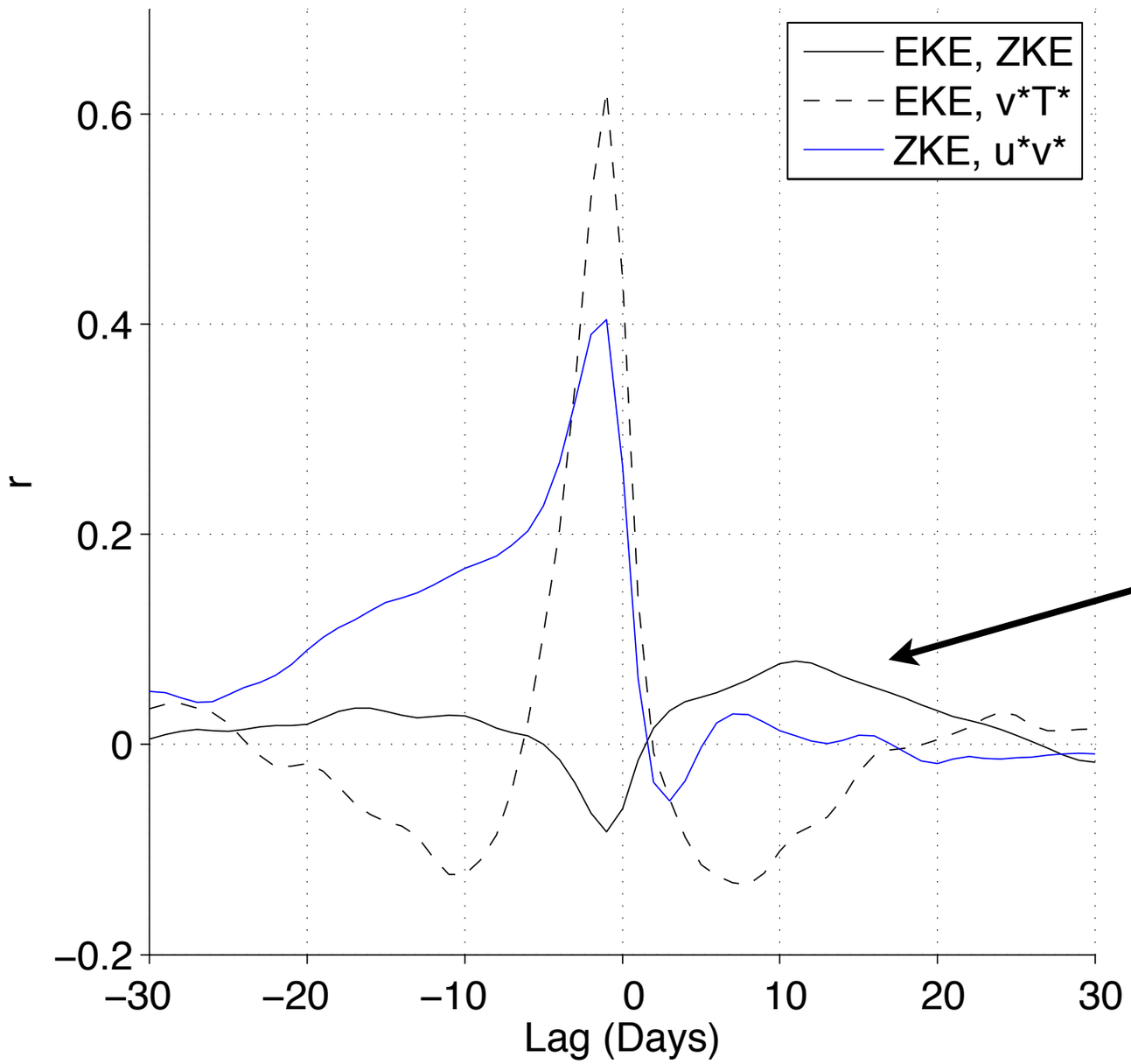
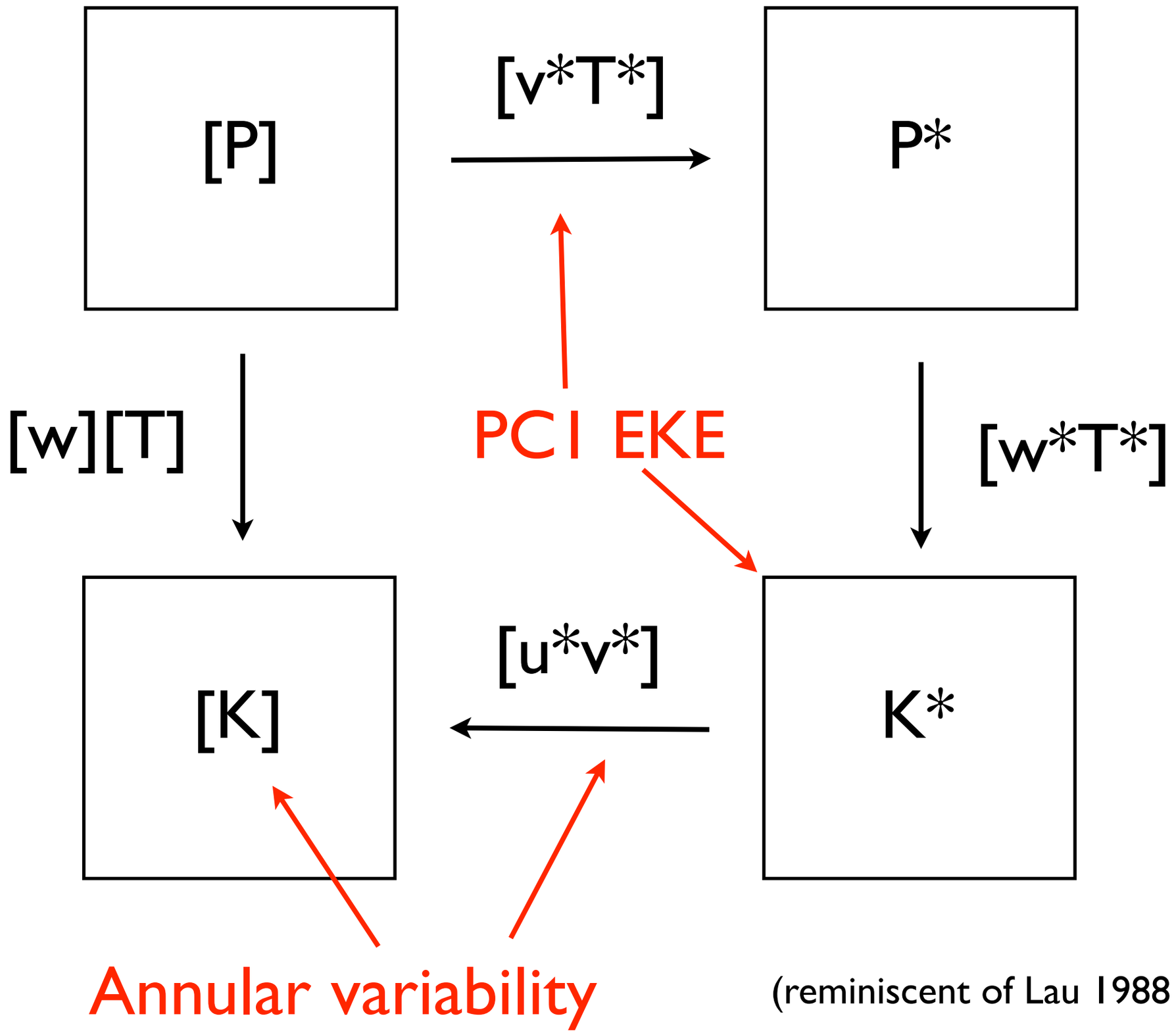


~0 between SAM and PC1 EKE

Leading patterns of variability in the energy cycle



(reminiscent of Lau 1988

The zonal-mean SH circulation is dominated by two largely independent structures:

1) one that converts eddy to mean kinetic energy and dominates the zonal mean kinetic energy field (the SAM).

2) one that converts mean to eddy potential energy and dominates the eddy kinetic energy field (PC1 EKE).

So what?

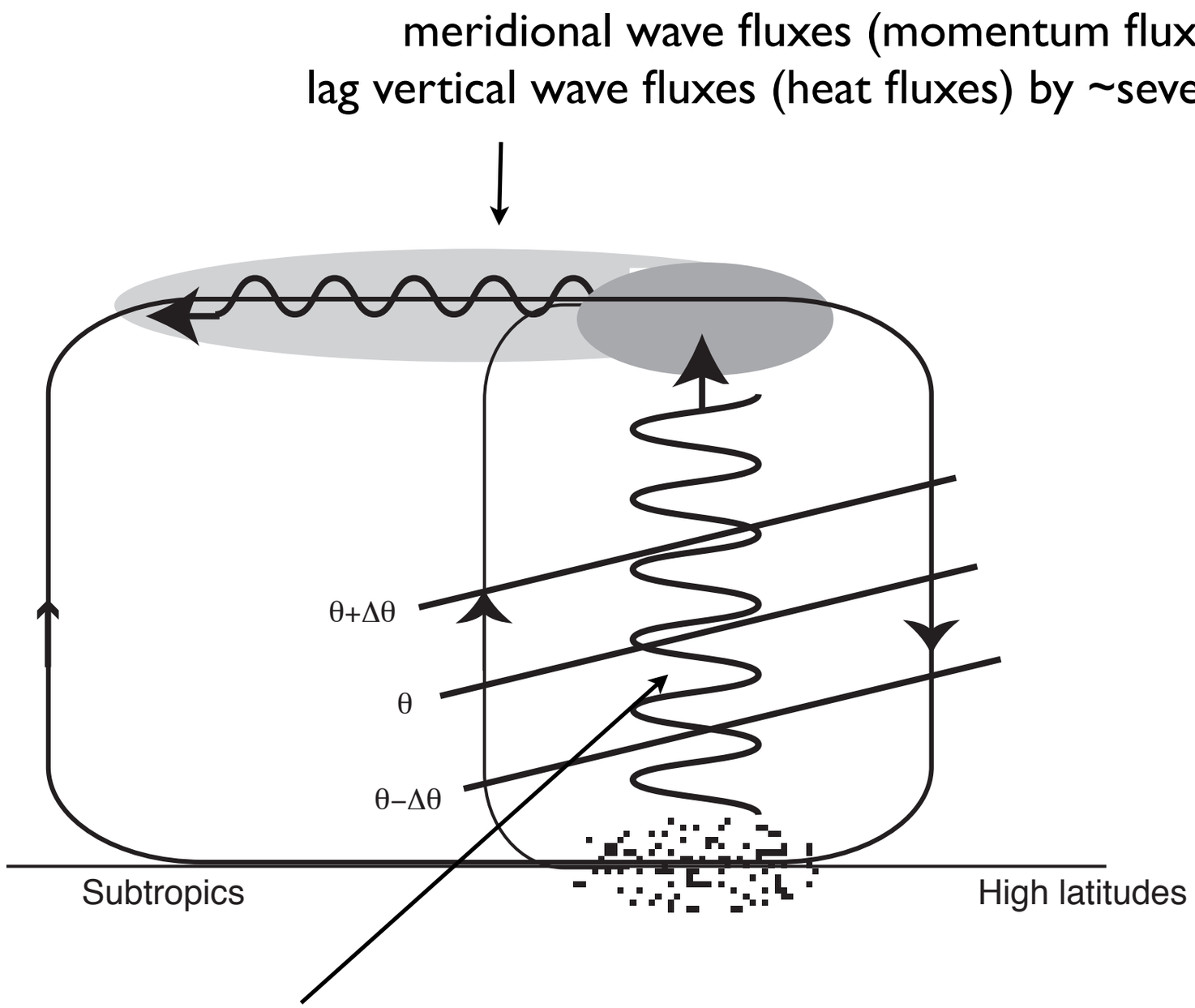
Next steps:

- Identify climate "impacts" of PC1 of EKE.

Presumably related to the variance (rather than mean) of surface weather.

- Identify signatures of PC1 of EKE in climate change simulations. Presumably accounts for much of the predicted increases in EKE and v*T*. (The SAM accounts for the increases in ZKE and u*v*).

- Assess linkages to other patterns of variability (eg, Lau 1988). Examine NH stormtracks.



Heat and momentum fluxes are both key components of the lifecycle of baroclinic waves (eg, Simmons and Hoskins 1978). But they are not strongly correlated.