Stratosphere-Troposphere Dynamical Coupling and Tropospheric Predictability

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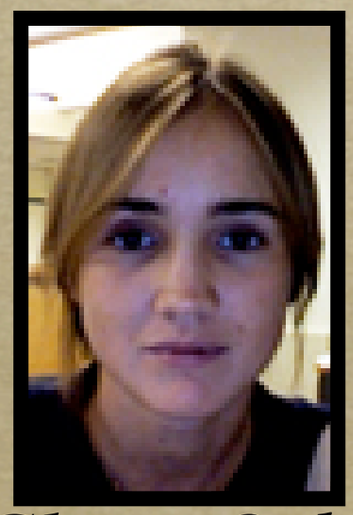
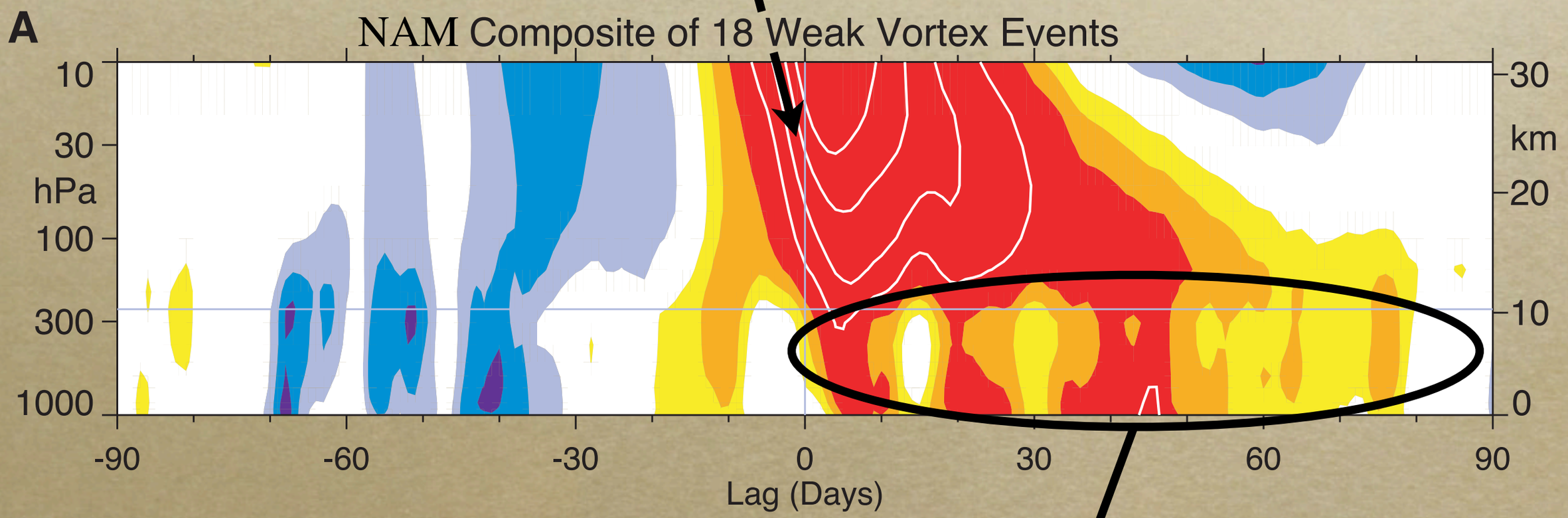
Lorenzo M. Polvani



Clara Orbe

Tropospheric Response to SSWs

Stratospheric Sudden Warming

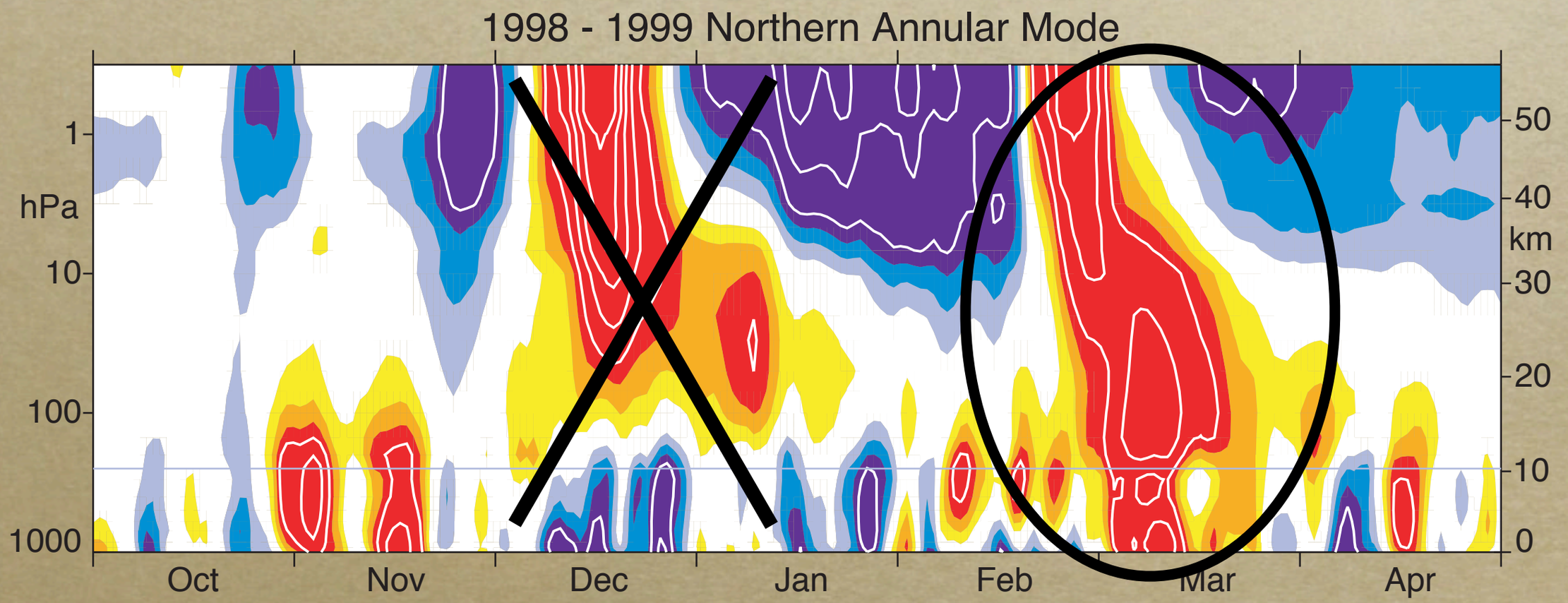


delayed, *persistent* shift of jet stream equatorward

[Baldwin and Dunkerton, 2001]

Tropospheric Response to SSWs

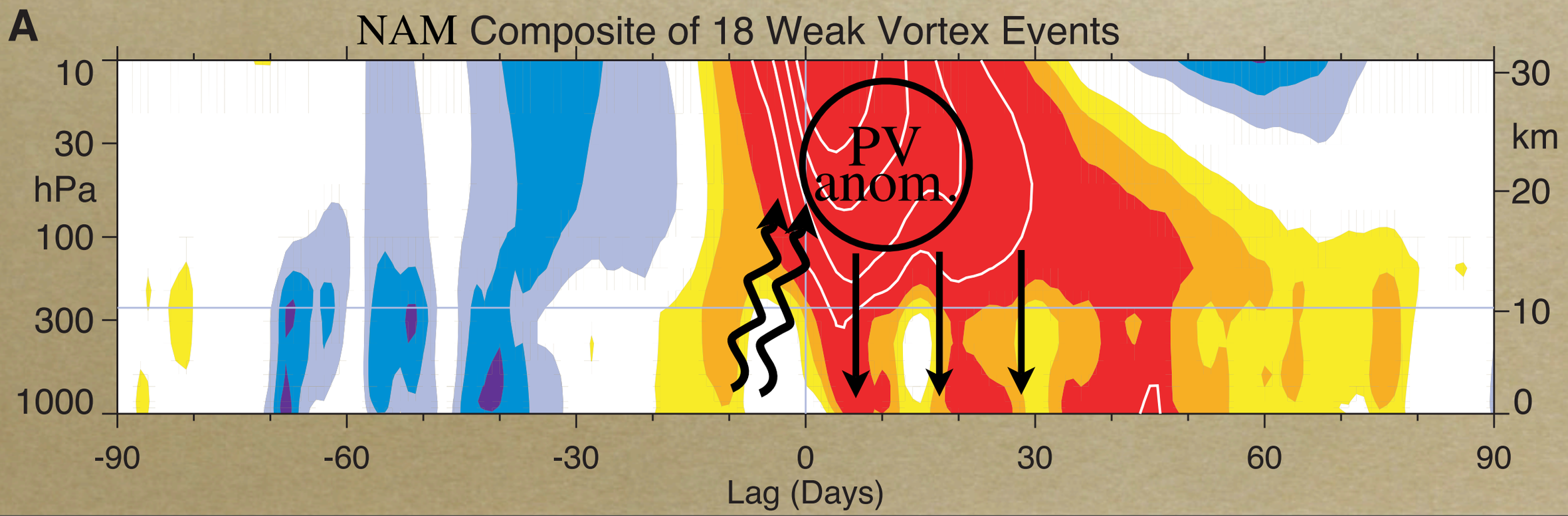
- response not “deterministic”
- mechanism not clear



[Baldwin and Dunkerton, 2001]

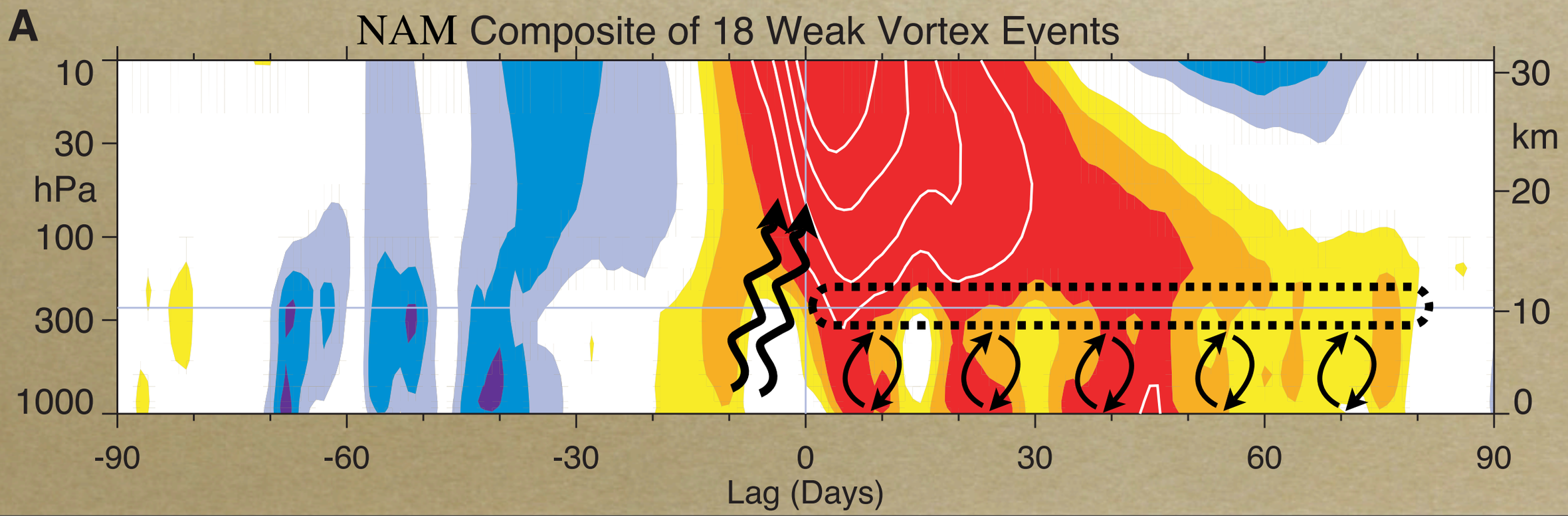
Mechanisms

1. downward control [e.g. *Hartley, Villarin, Black & Davis 1998*; *Thompson, Furtado & Shepherd 2006*]



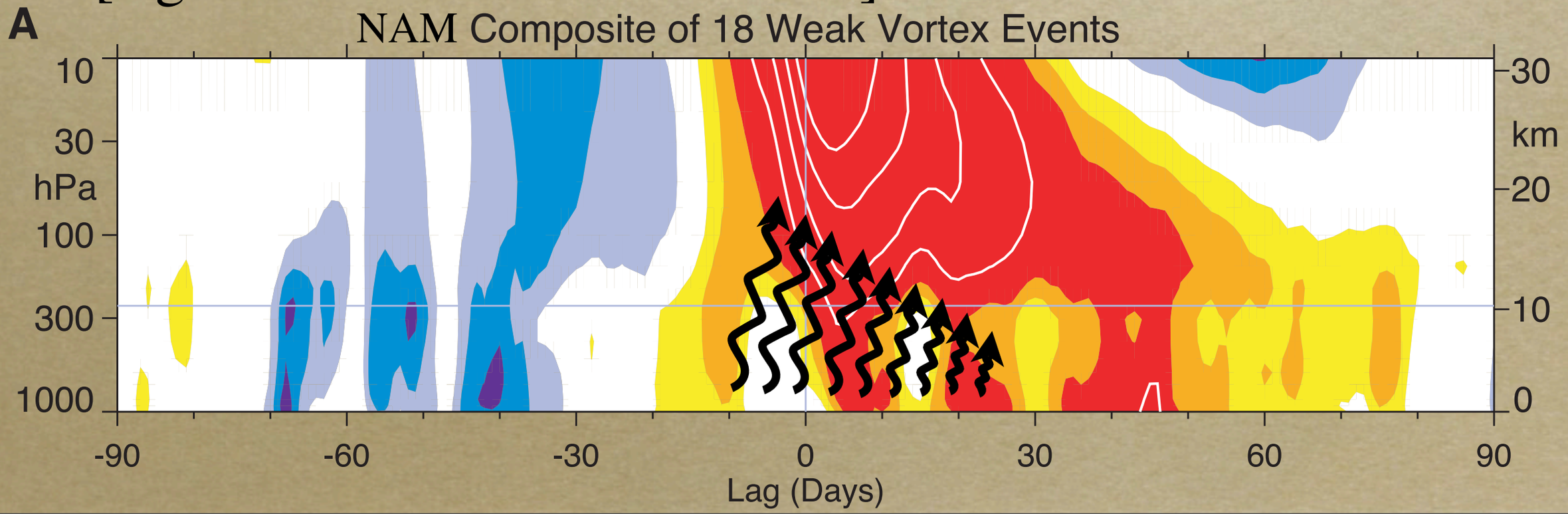
Mechanisms

1. downward control [e.g. *Hartley, Villarin, Black & Davis 1998*; *Thompson, Furtado & Shepherd 2006*]
2. stratospheric signal mediated by tropospheric eddies [e.g. *Kushner and Polvani 2004*; *Song and Robinson 2004; Chen and Held 2007*]



Mechanisms

1. downward control [e.g. *Hartley, Villarin, Black & Davis 1998*; *Thompson, Furtado & Shepherd 2006*]
2. stratospheric signal mediated by tropospheric eddies [e.g. *Kushner and Polvani 2004*; *Song and Robinson 2004; Chen and Held 2007*]
3. local wave-mean flow interaction (not driven by stratosphere) [e.g. *Plumb and Semeniuk 2003*]



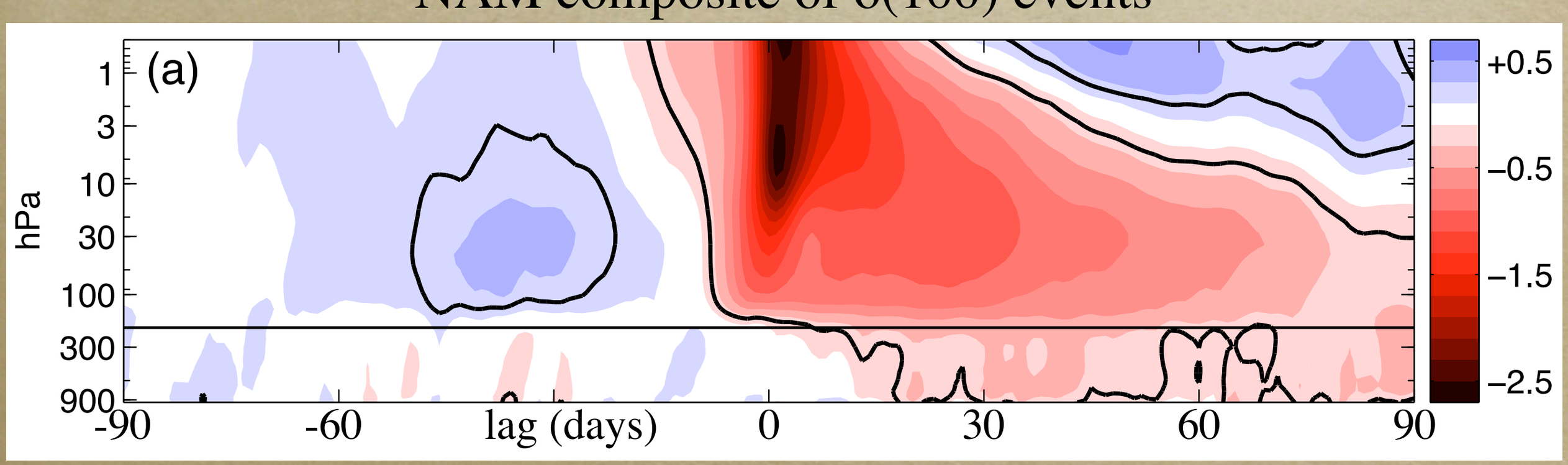
Establish the role of the stratosphere in tropospheric response to SSWs

- Prior studies: perturb/modify the stratosphere above, observe the response below [e.g. *Boville 1984; Norton 2003; Charlton, O'Neil, Lahoz & Massacand 2004*]
- Here we perturb troposphere below to "erase" tropospheric memory following an SSW. *Is the tropospheric response destroyed, or does the signal come from above?*

Idealized Model Framework

- full GCM dynamics, simplified forcing
- captures SSWs, tropospheric response

NAM composite of o(100) events



[Polvani and Kushner, 2002; Gerber and Polvani, 2008]

Idealized Model Framework

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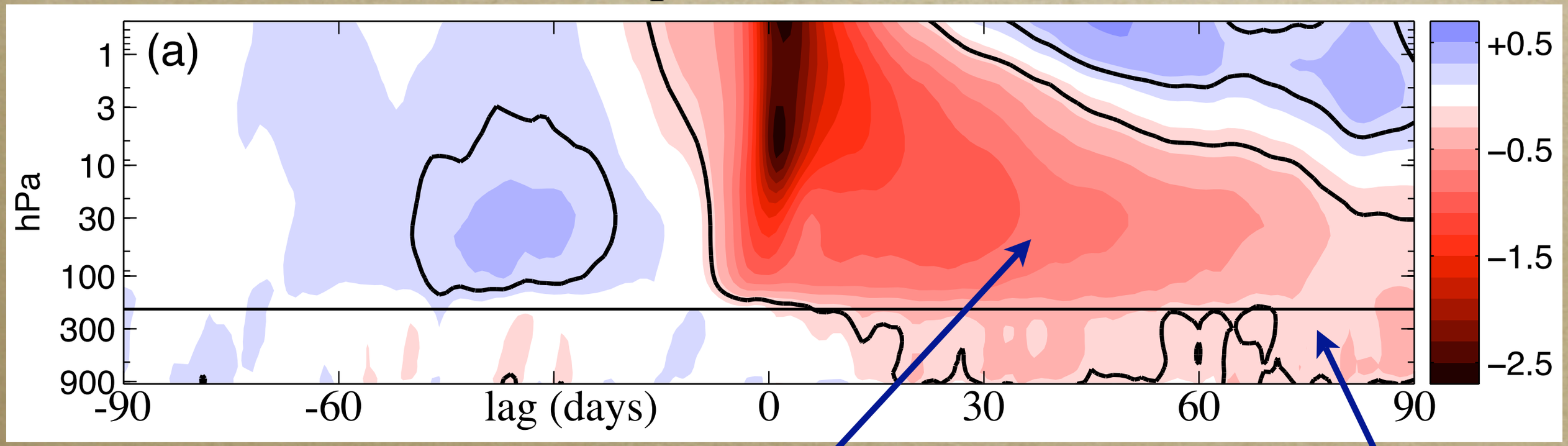
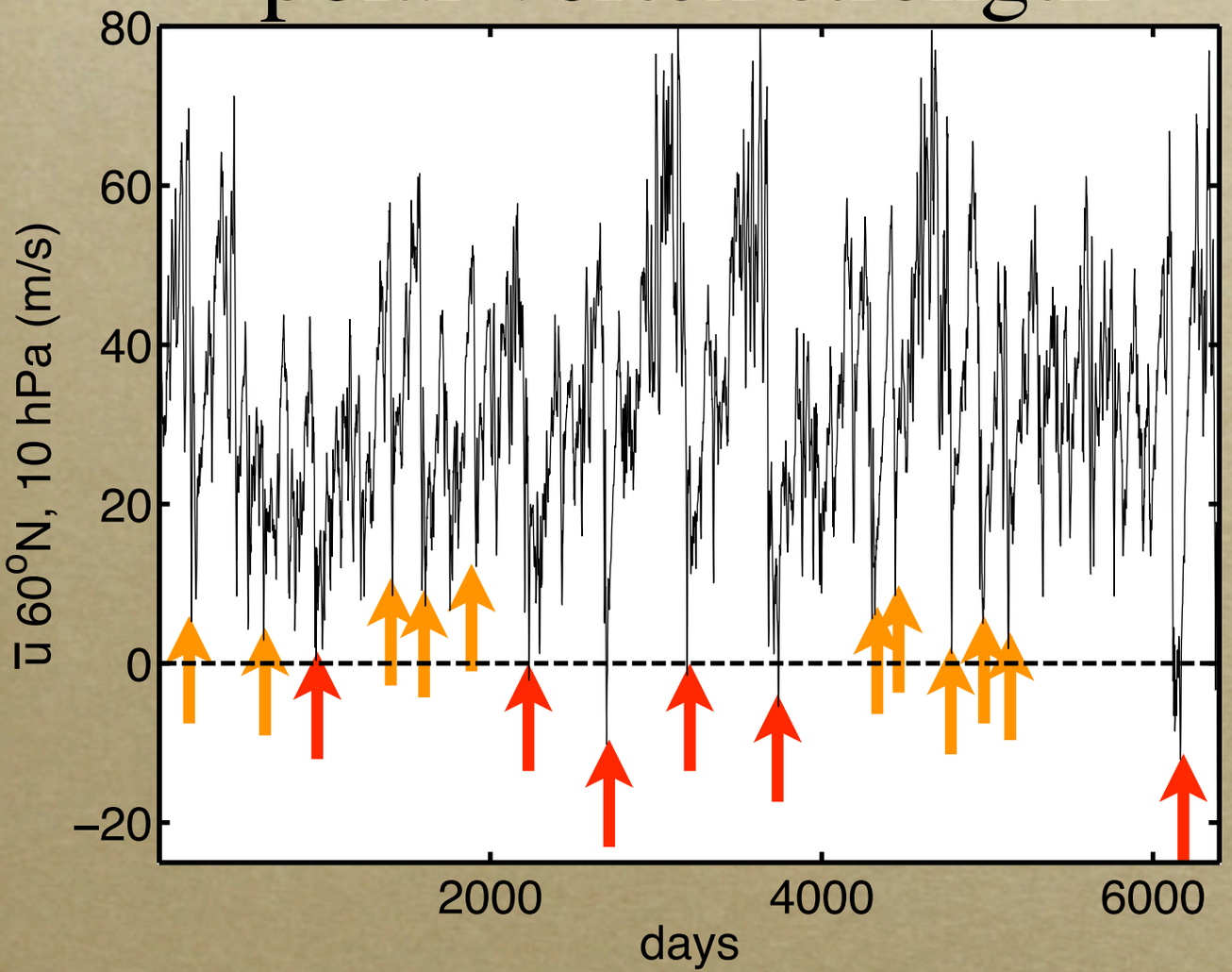


[Polvani and Kushner, 2002; Gerber and Polvani, 2008]

Ensemble Forecasting

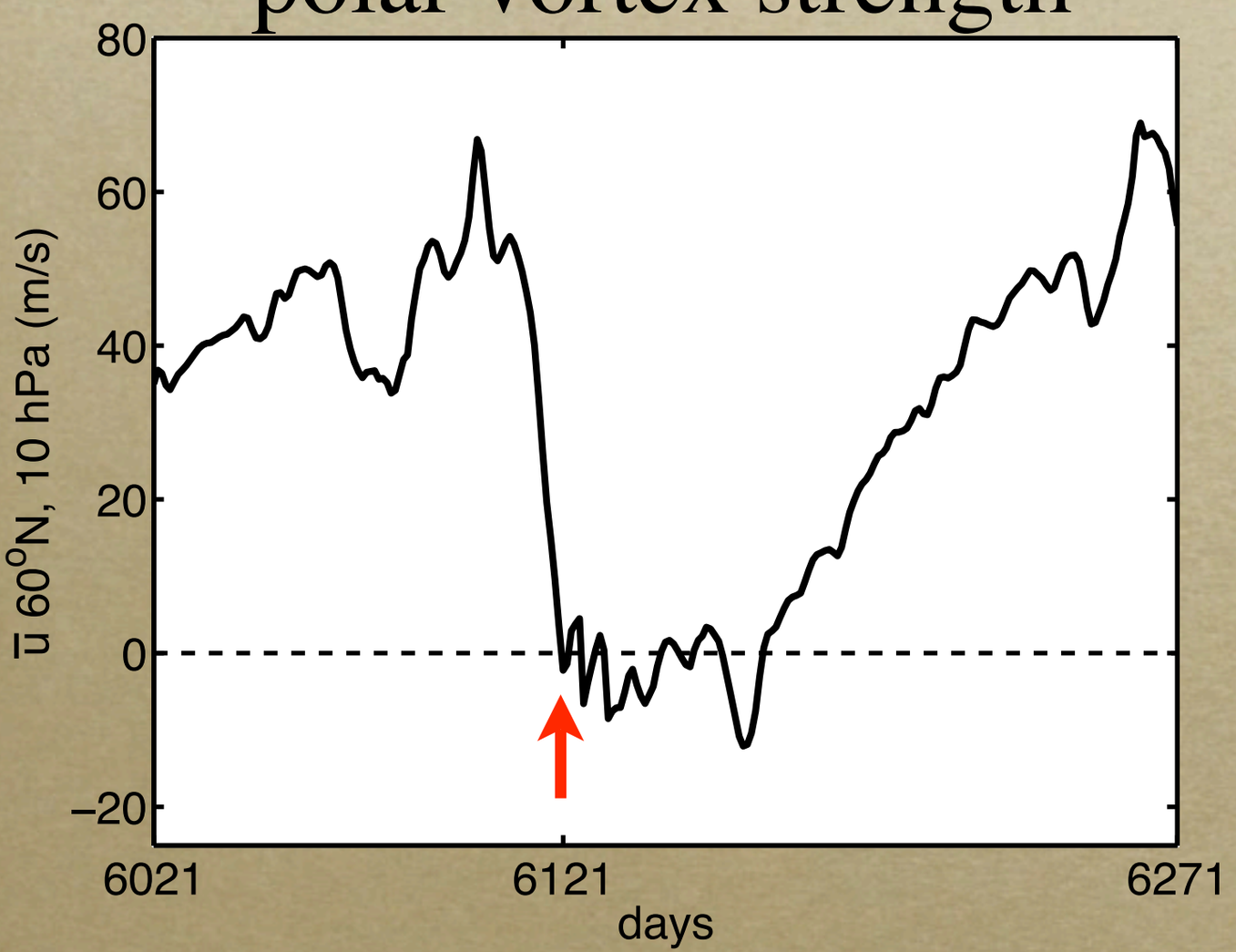
- long control integration

polar vortex strength



major + minor warming events

Ensemble Forecasting

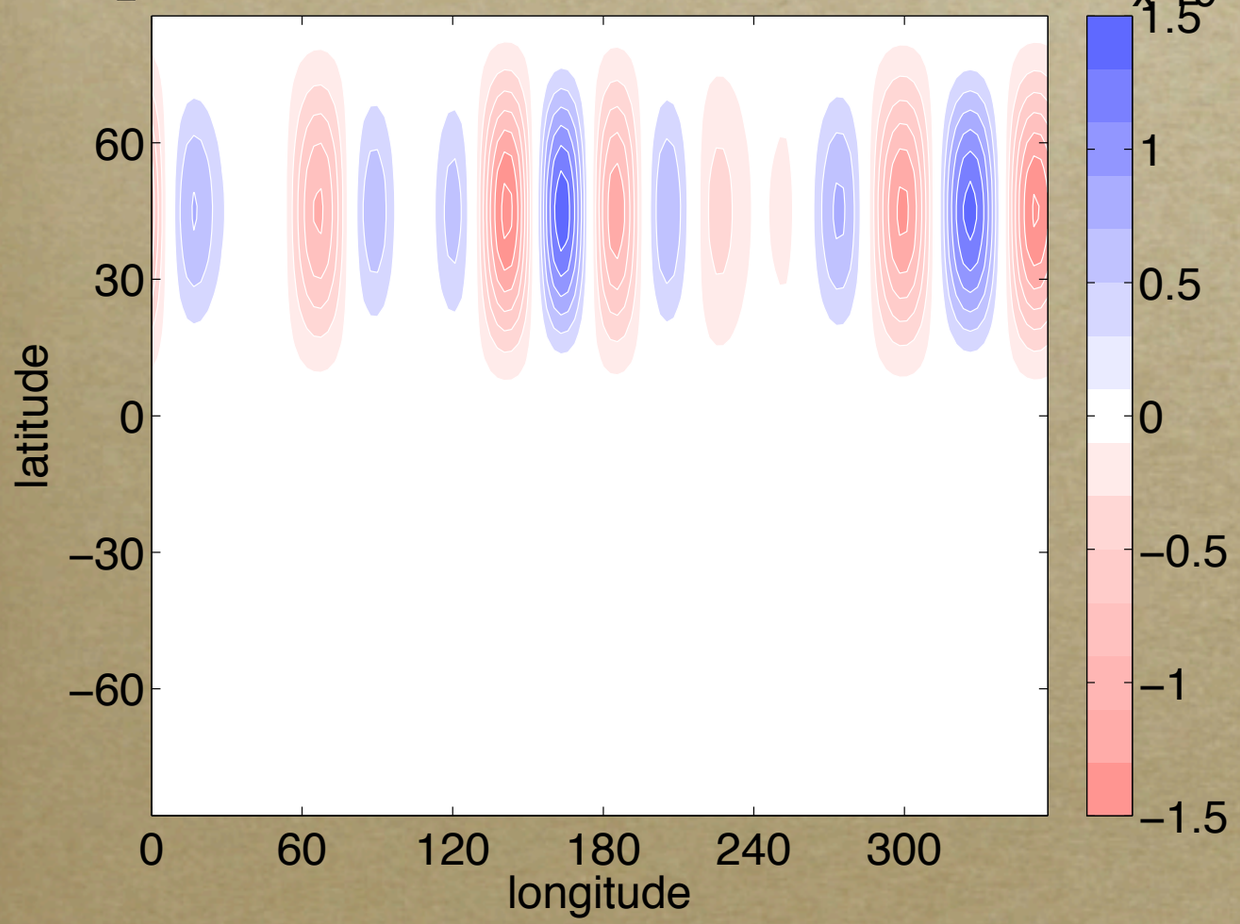


- long control integration
- determine warming events dates

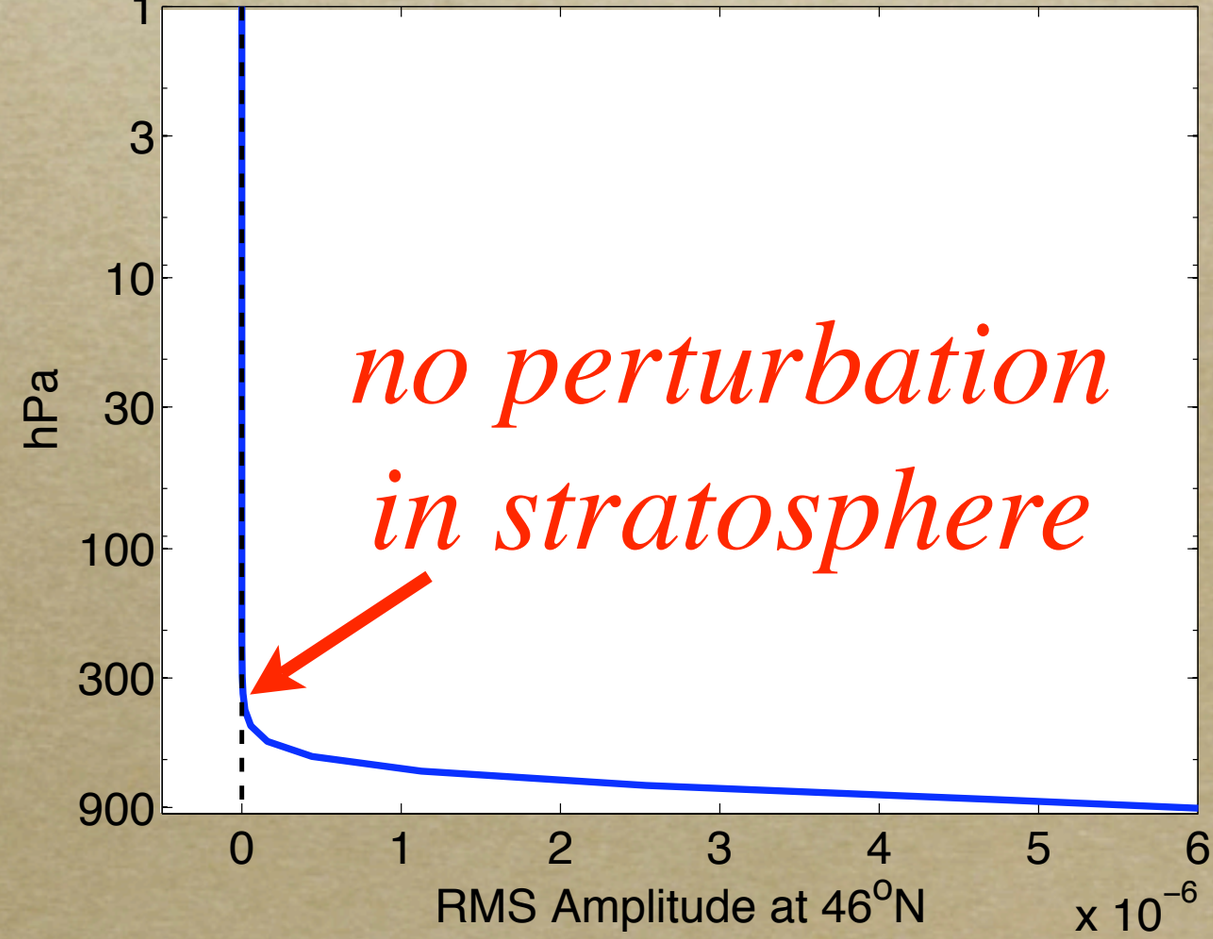
Perturb Troposphere

- vorticity field perturbations
- confined to lower troposphere

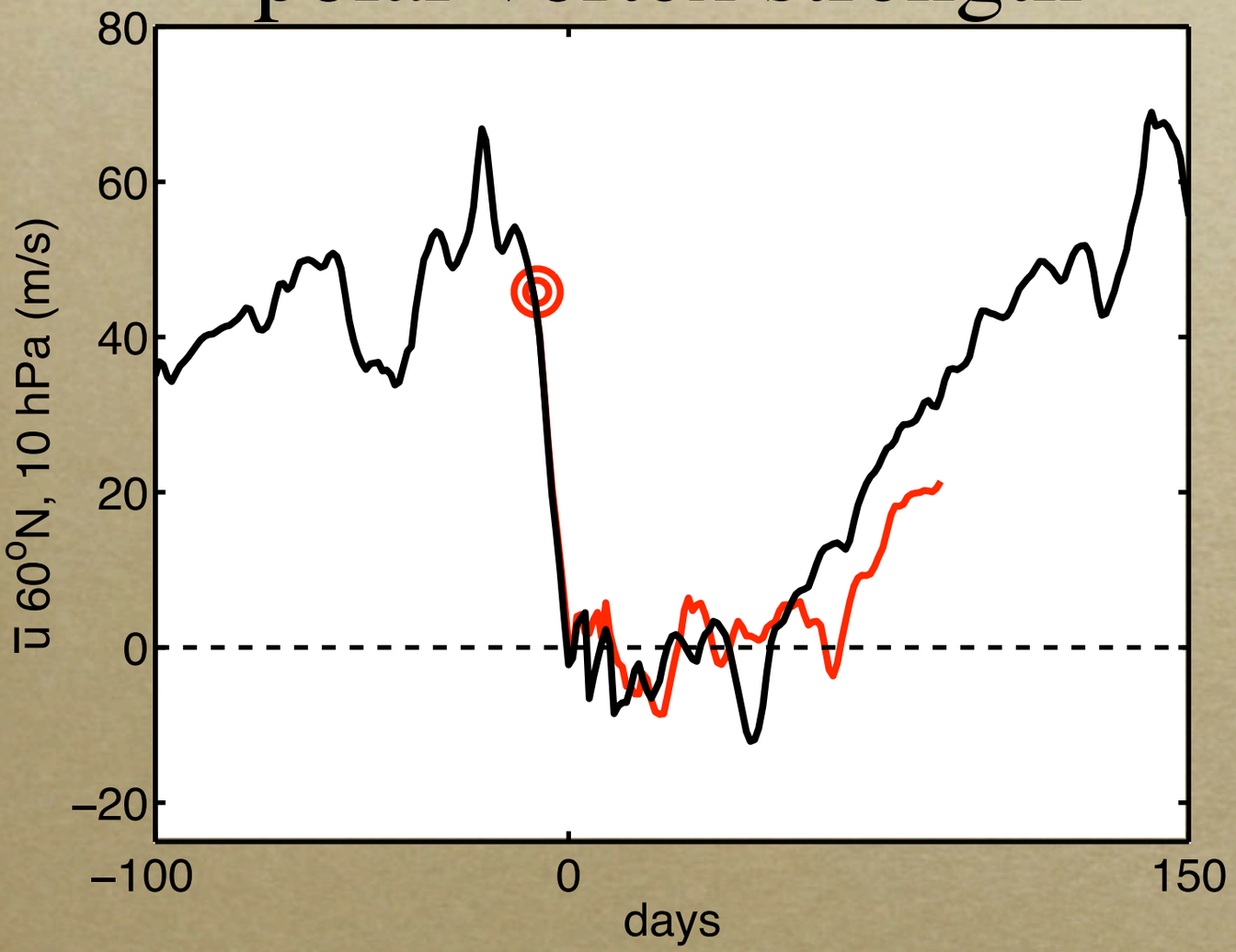
perturbation horizontal structure



perturbation vertical structure



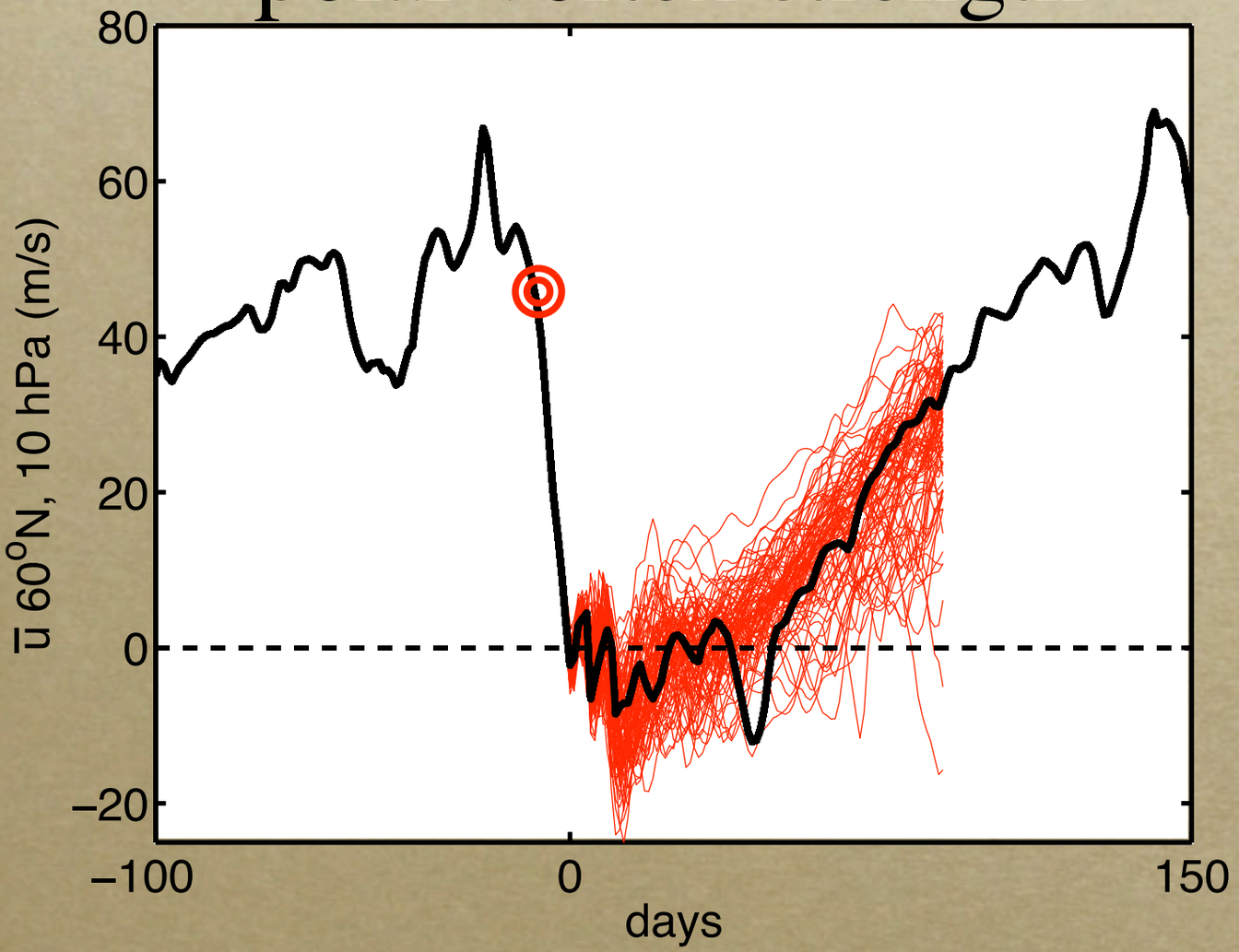
Ensemble Forecasting



- long control integration
- determine warming events dates
- launch perturbation integrations

Ensemble Forecasting

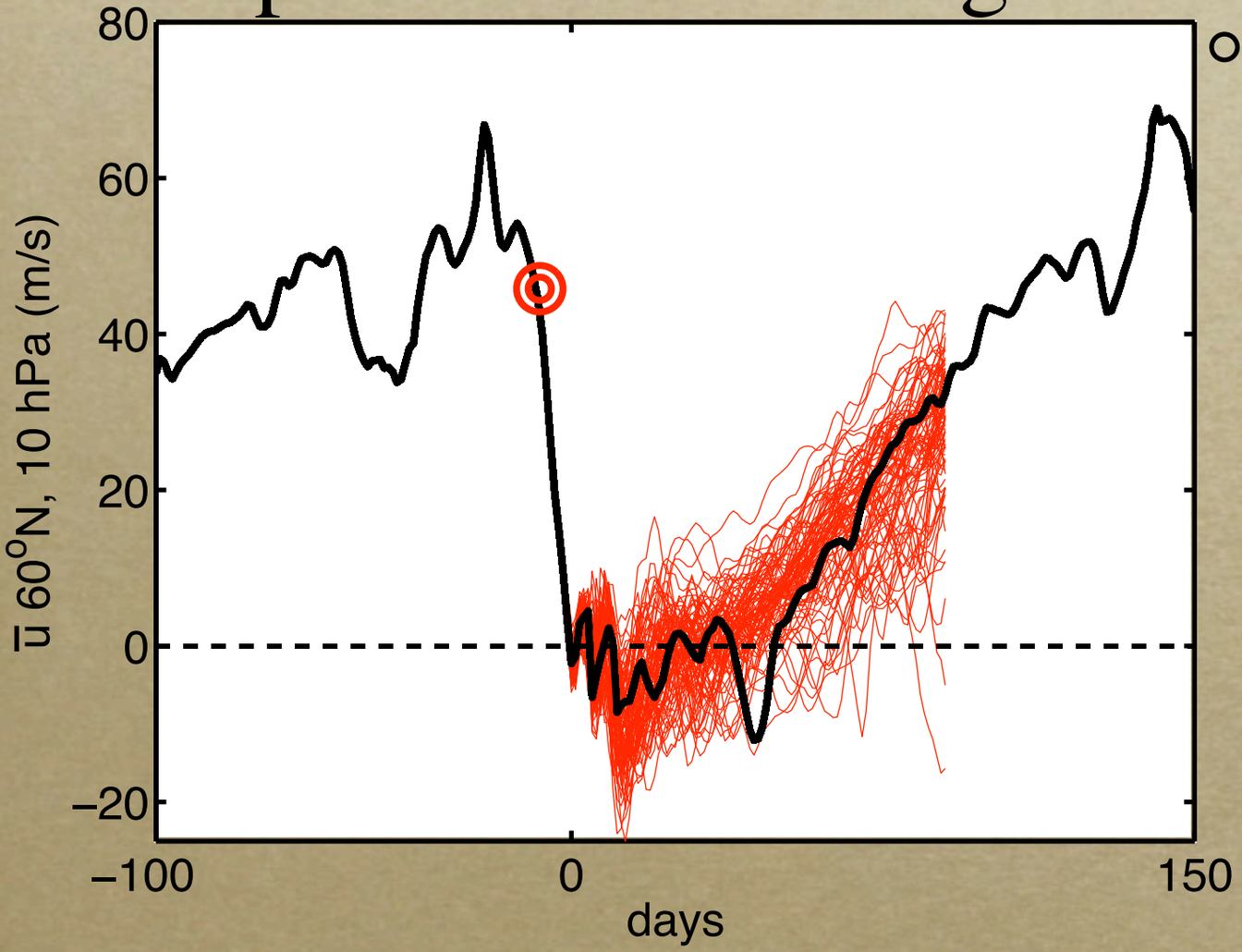
polar vortex strength



- long control integration
- determine warming events dates
- launch perturbation integrations
- couple multiple realizations of the troposphere to *one stratospheric event*

Stratospheric Predictability

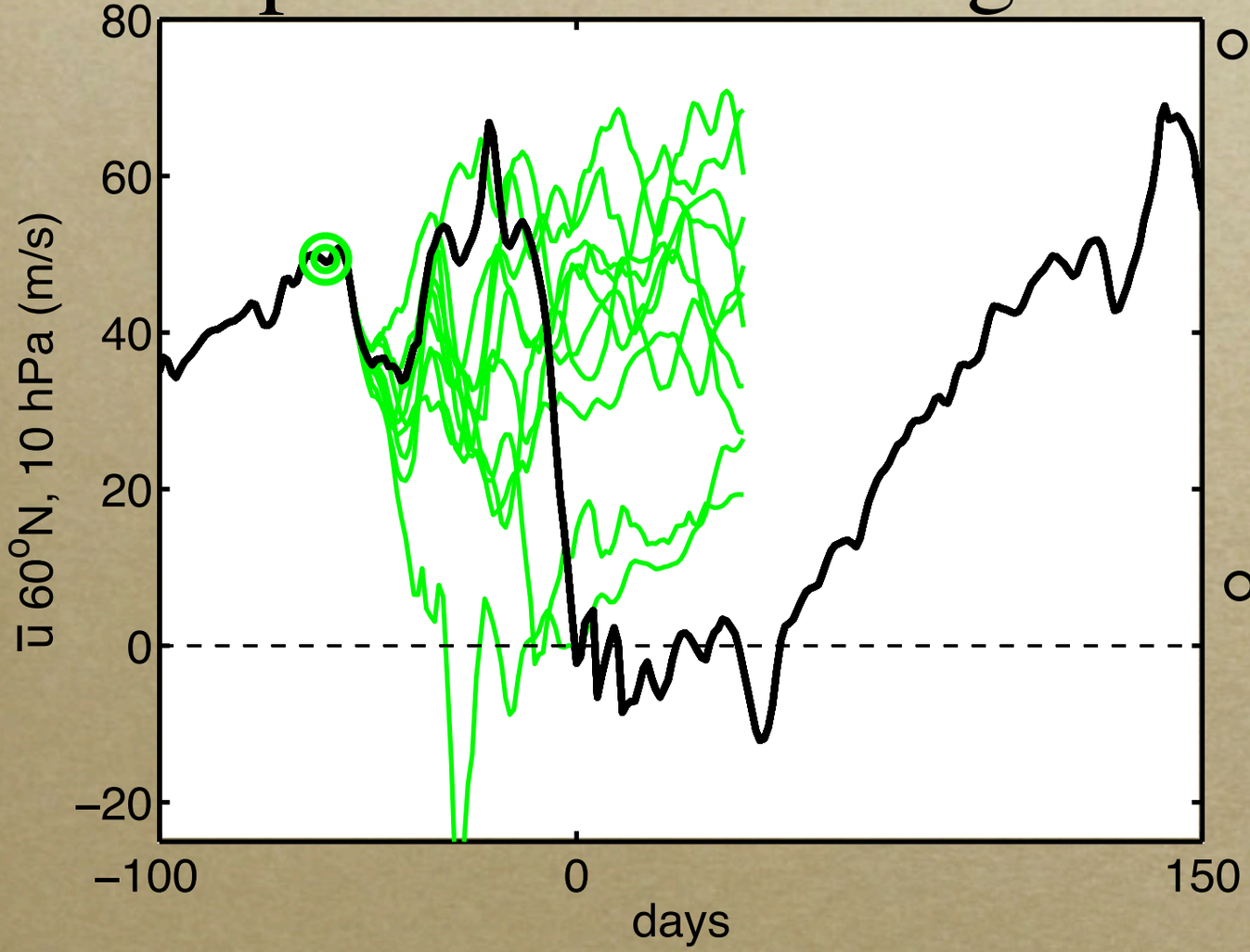
polar vortex strength



- stratospheric circulation more "predictable" after an SSW event: *slow recovery*

Stratospheric Predictability

polar vortex strength

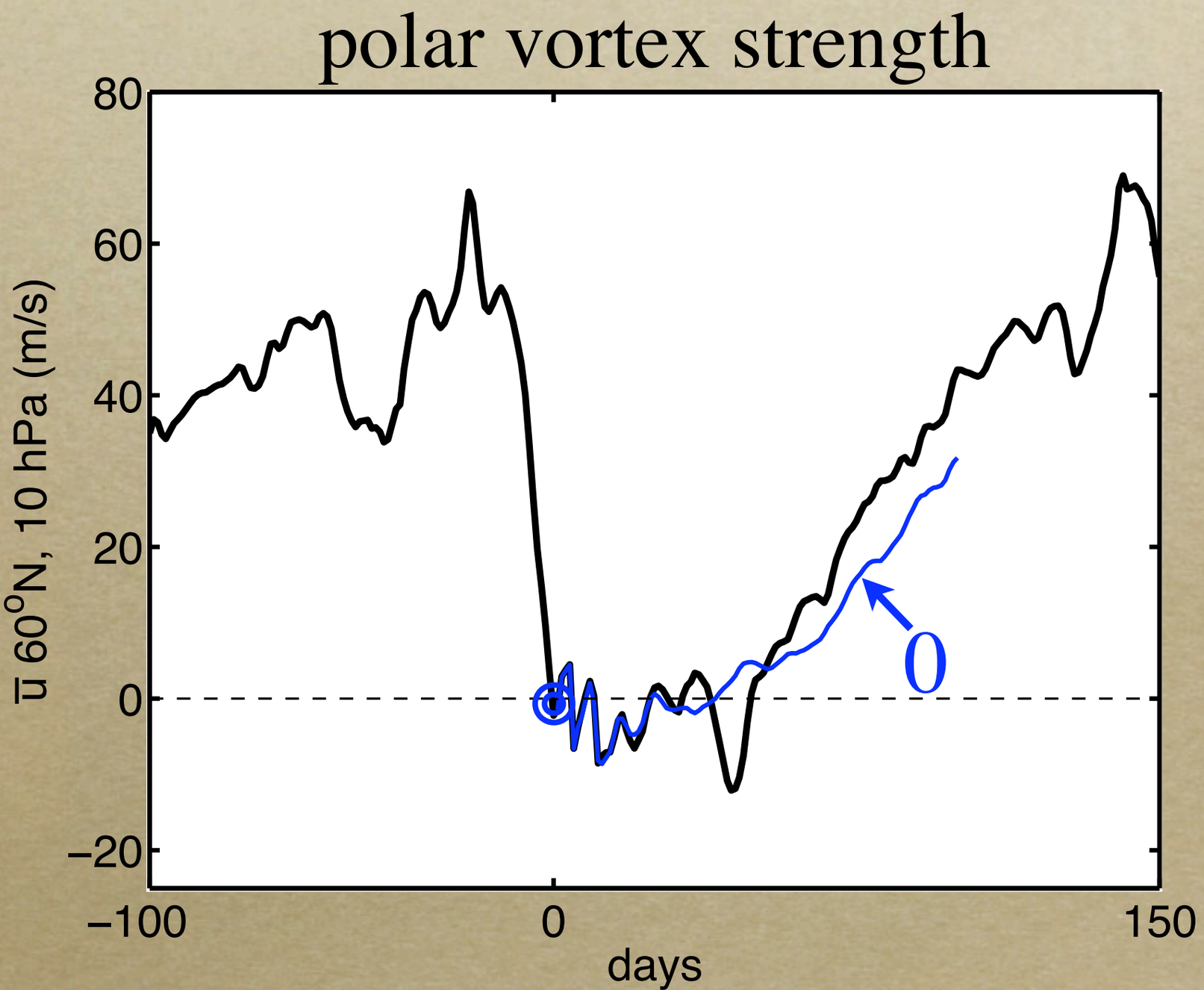


- stratospheric circulation more "predictable" after an SSW event: *slow recovery*
- more limited predictability at other times

Stratospheric Predictability

black: control integration

colors: ensemble mean response



Stratospheric Predictability

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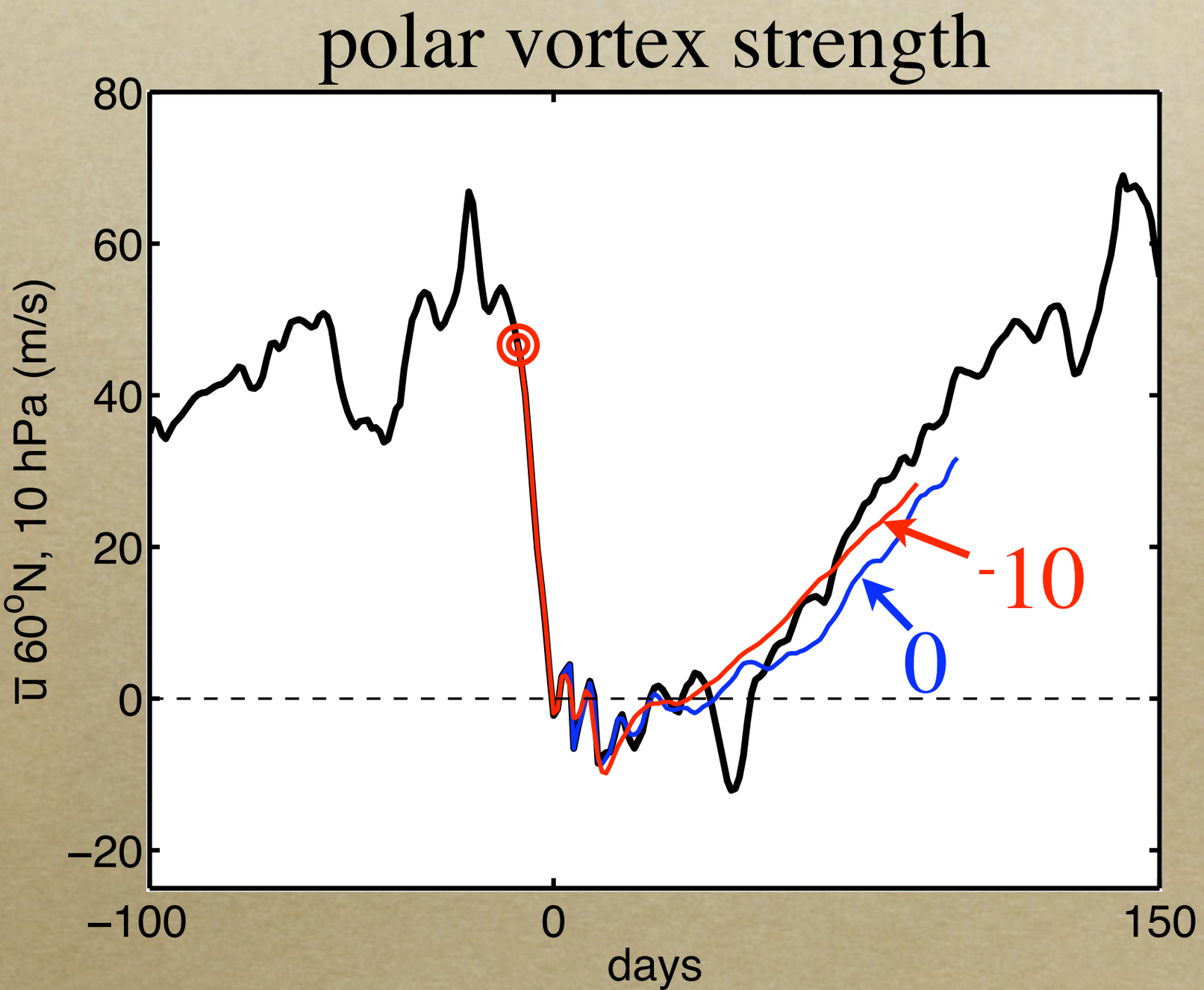

Stratospheric Predictability

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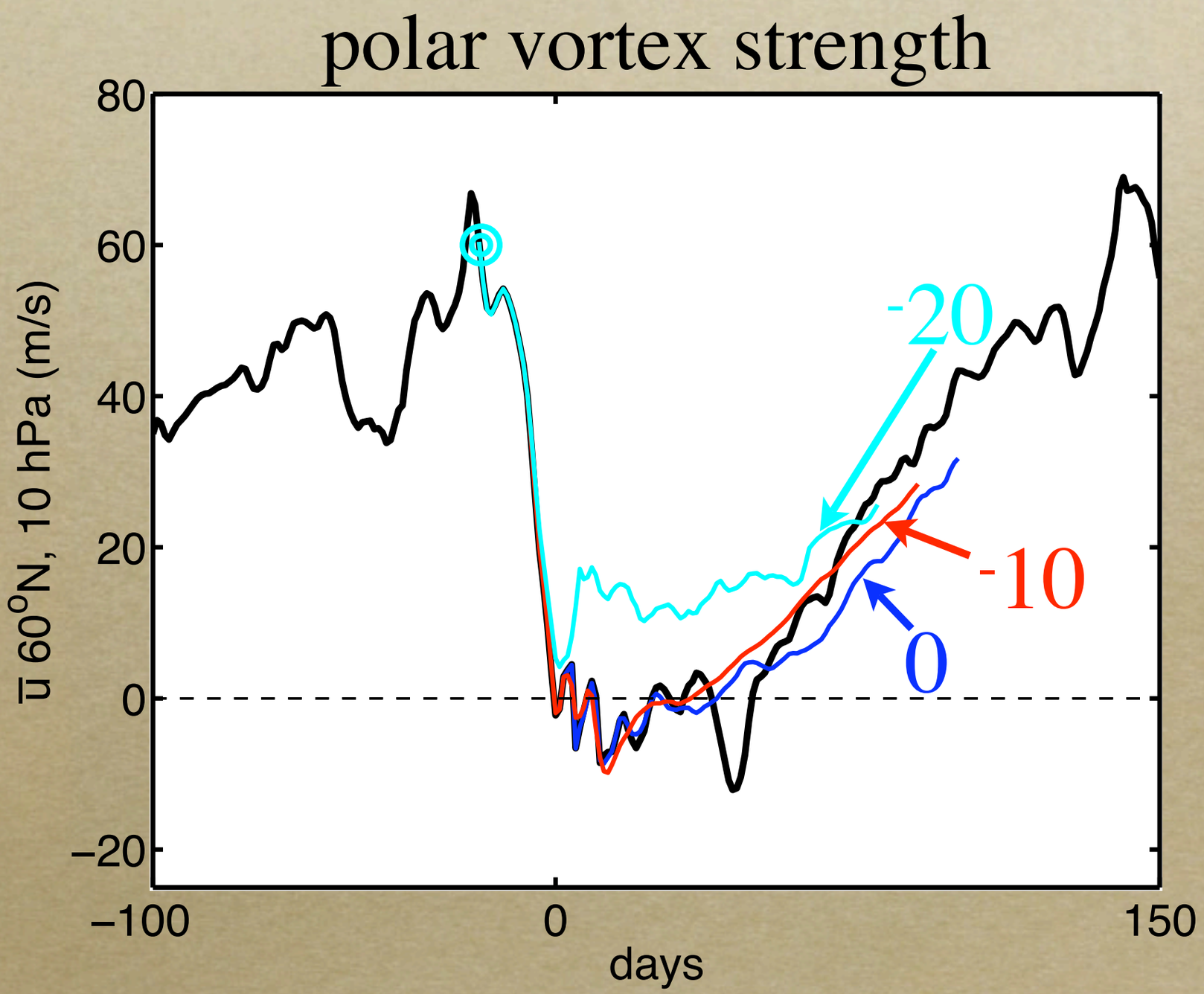

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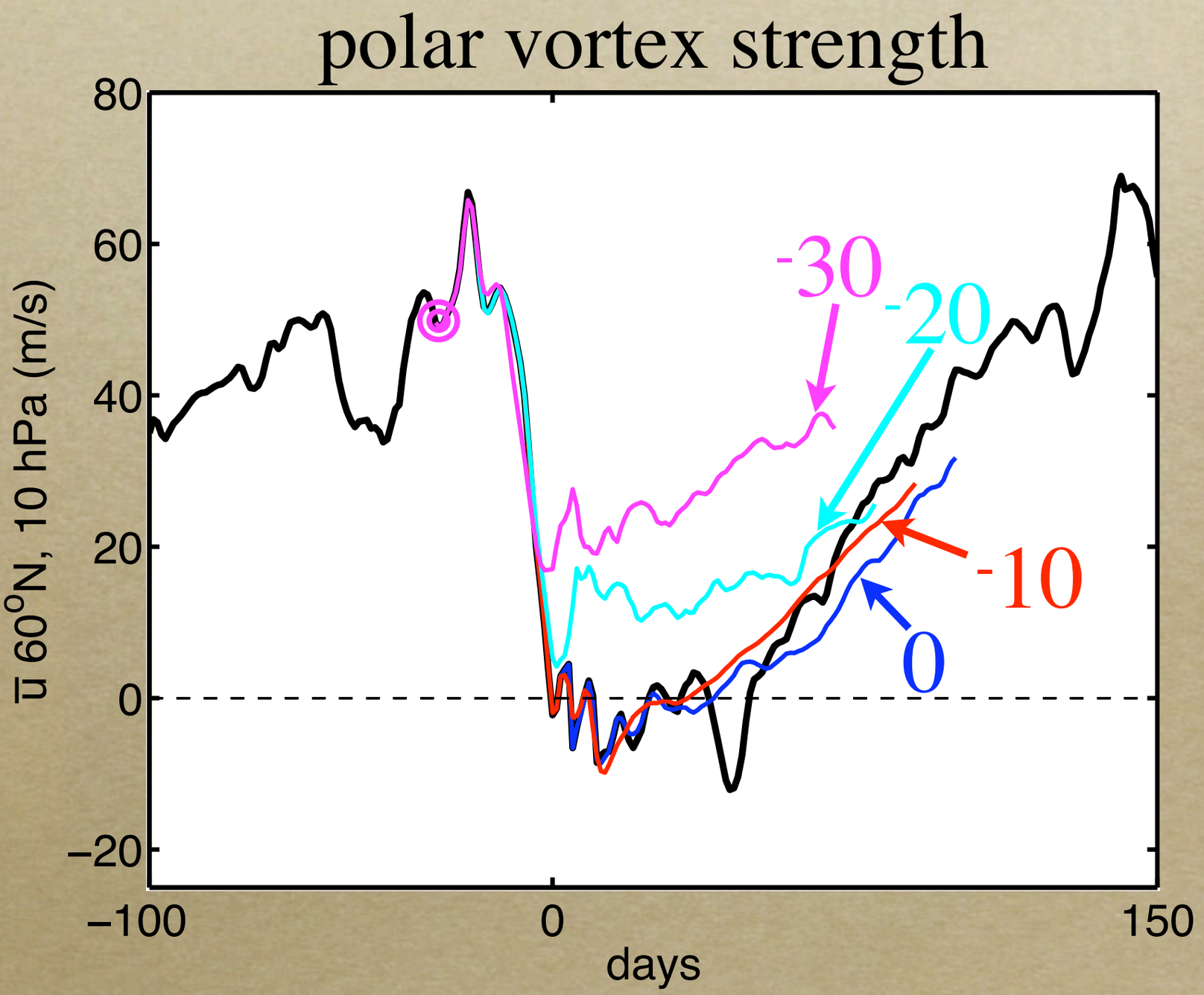

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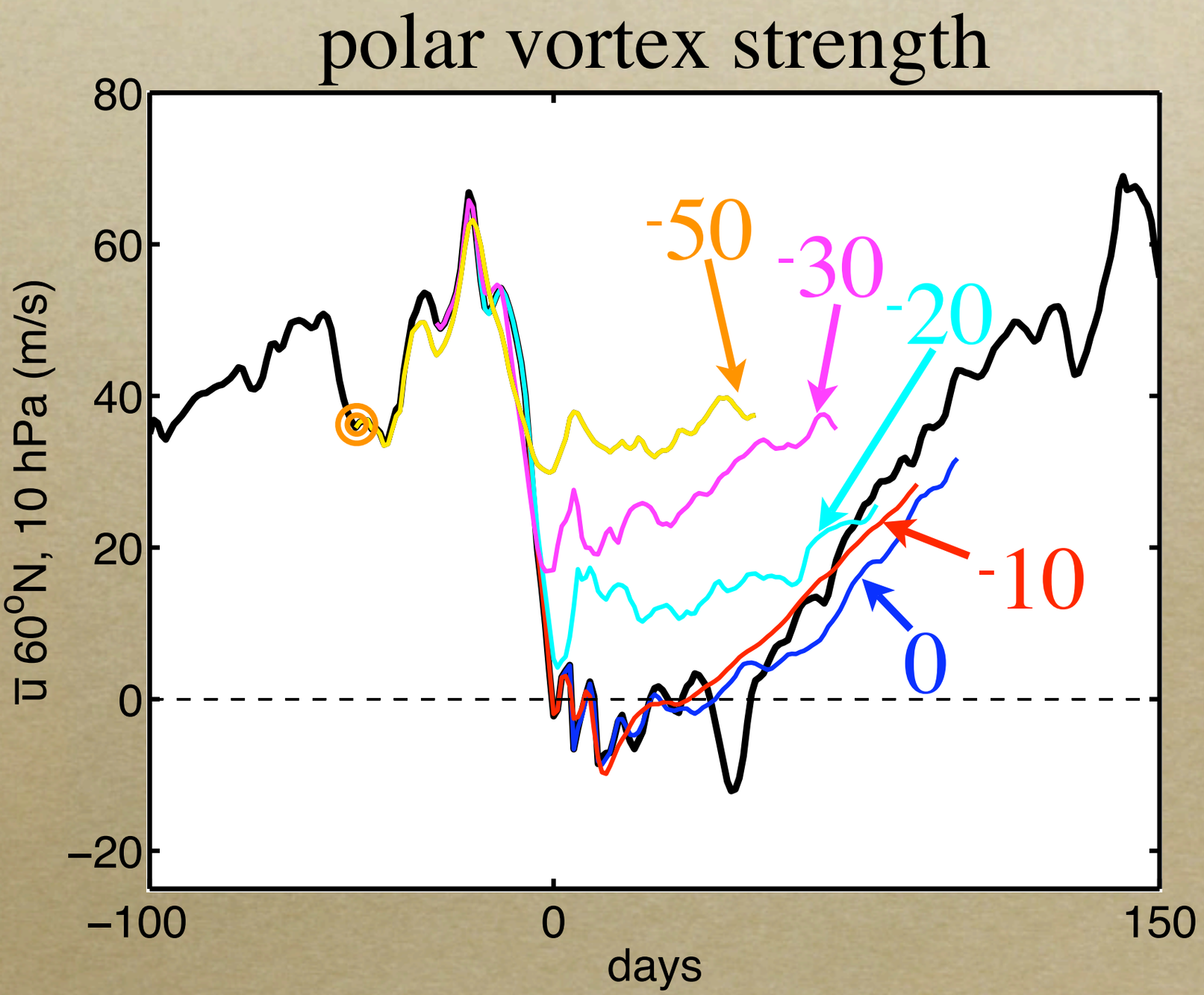

Stratospheric Predictability

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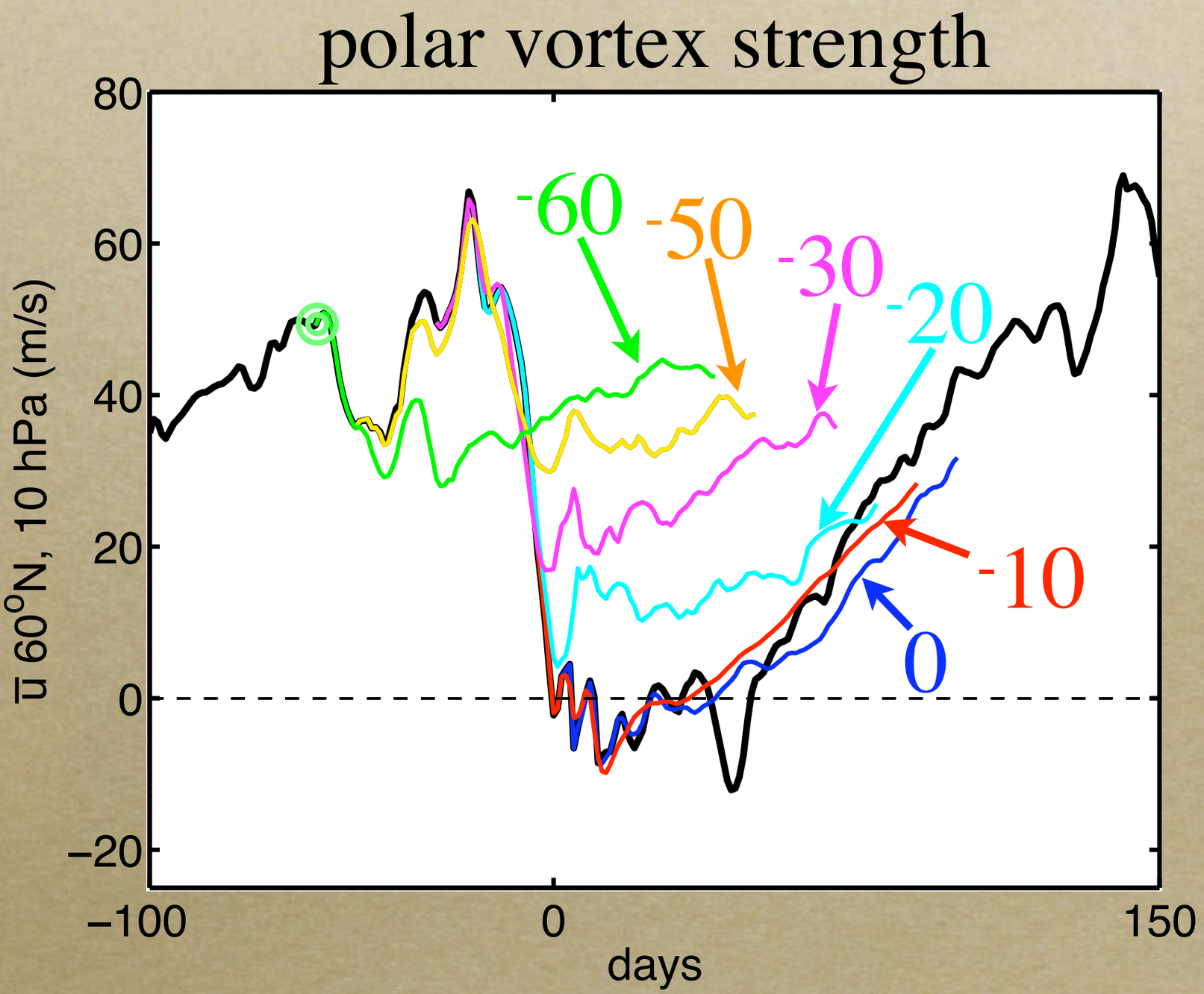
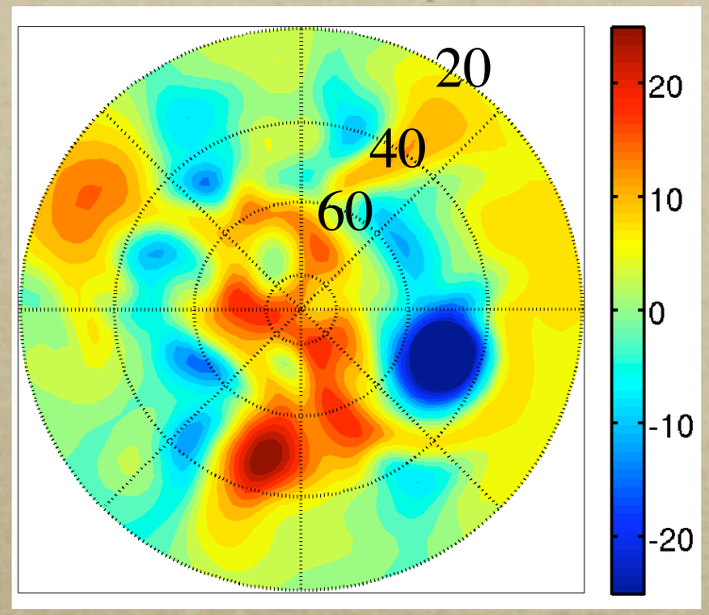
SSW lost for leads >20 days

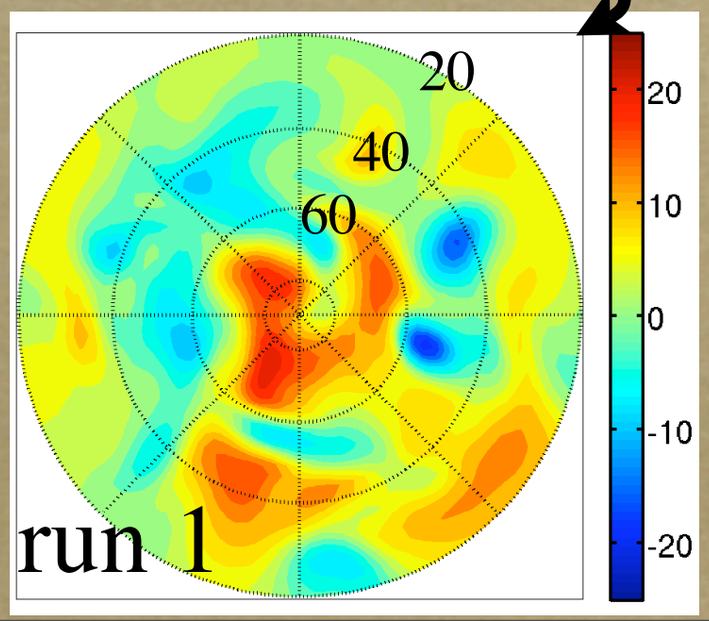


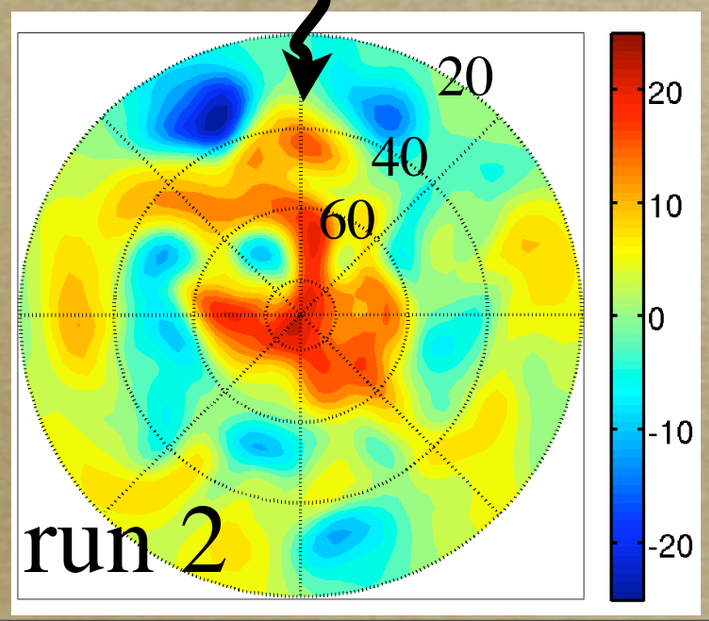
Tropospheric Predictability

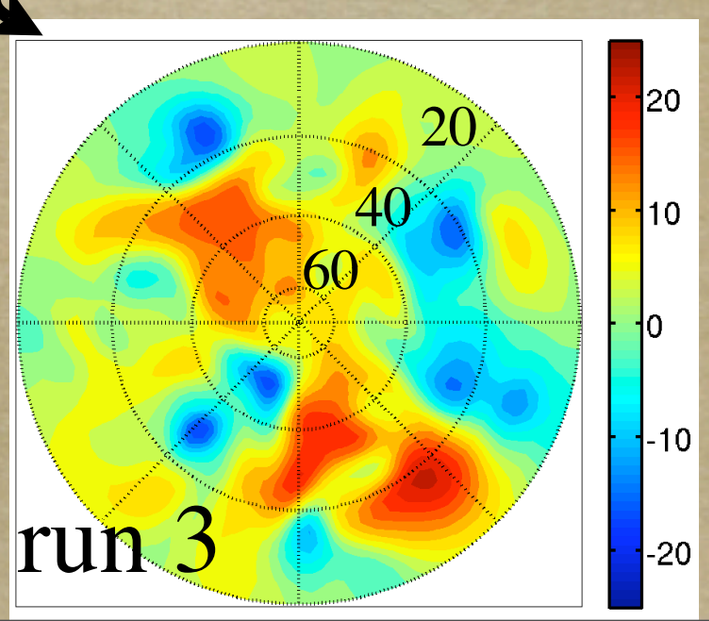
SLP′, day 0 (hPa)



SLP′, day 50 (hPa)

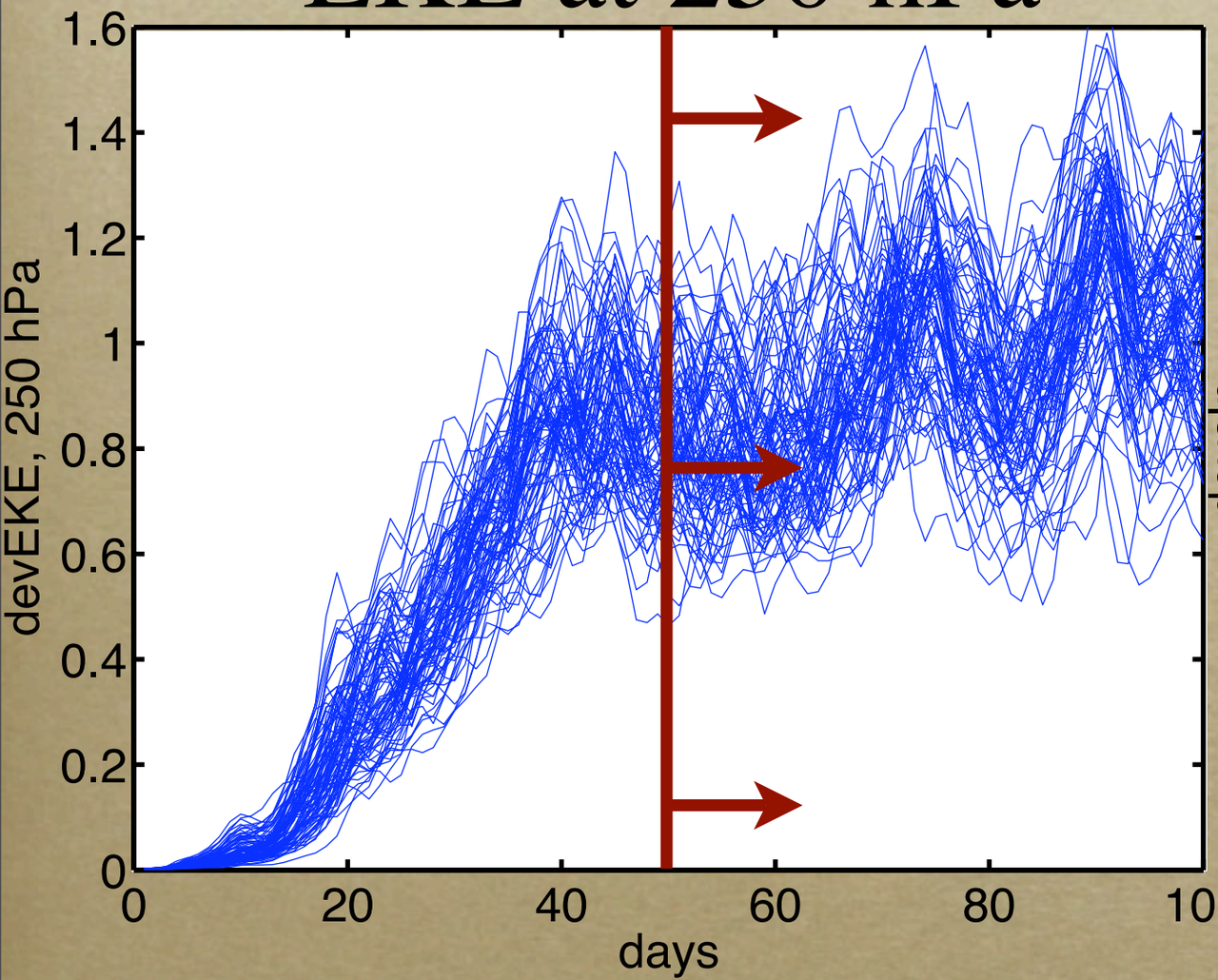




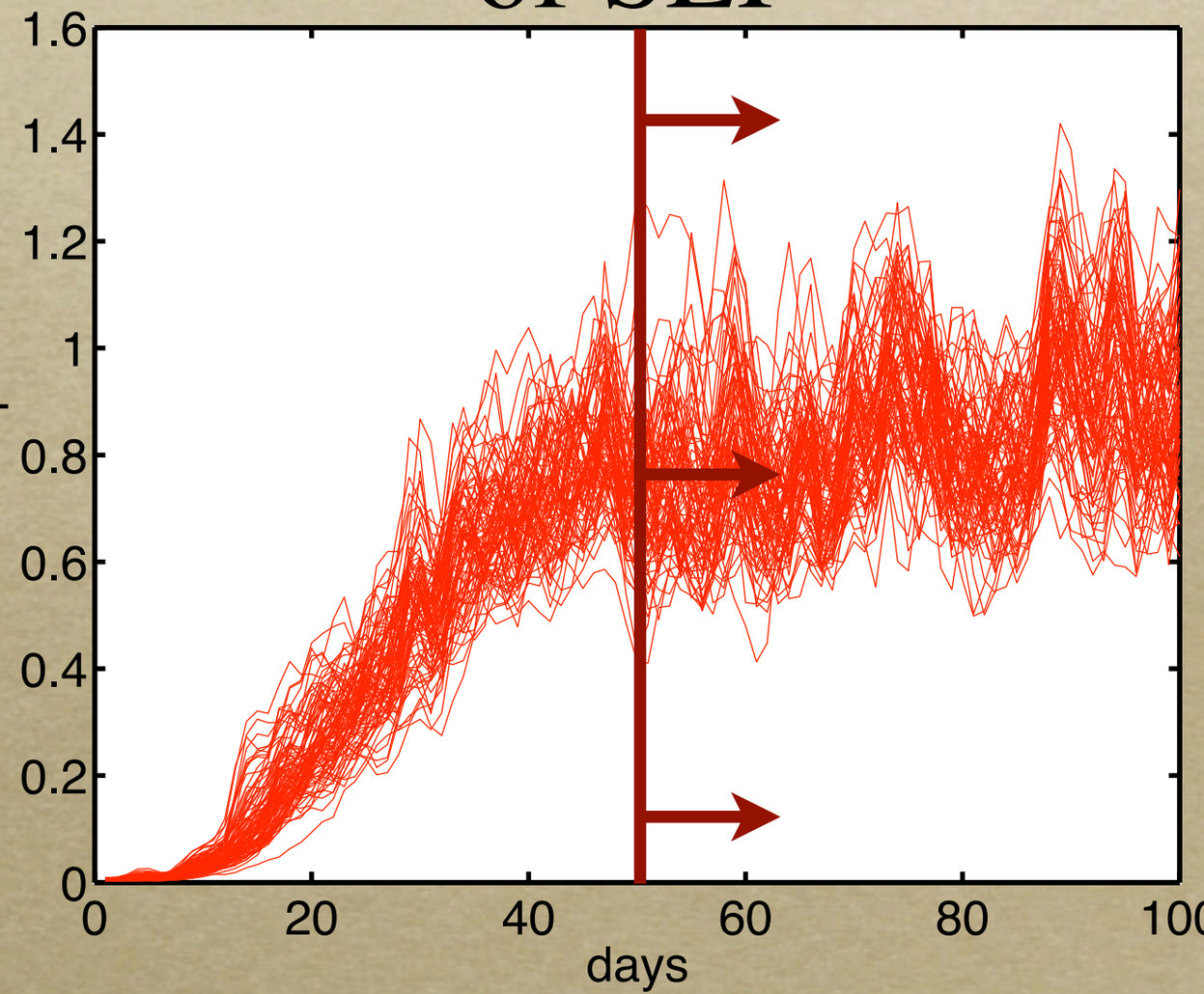


Scrambling the Troposphere

ensemble spread of EKE at 250 hPa



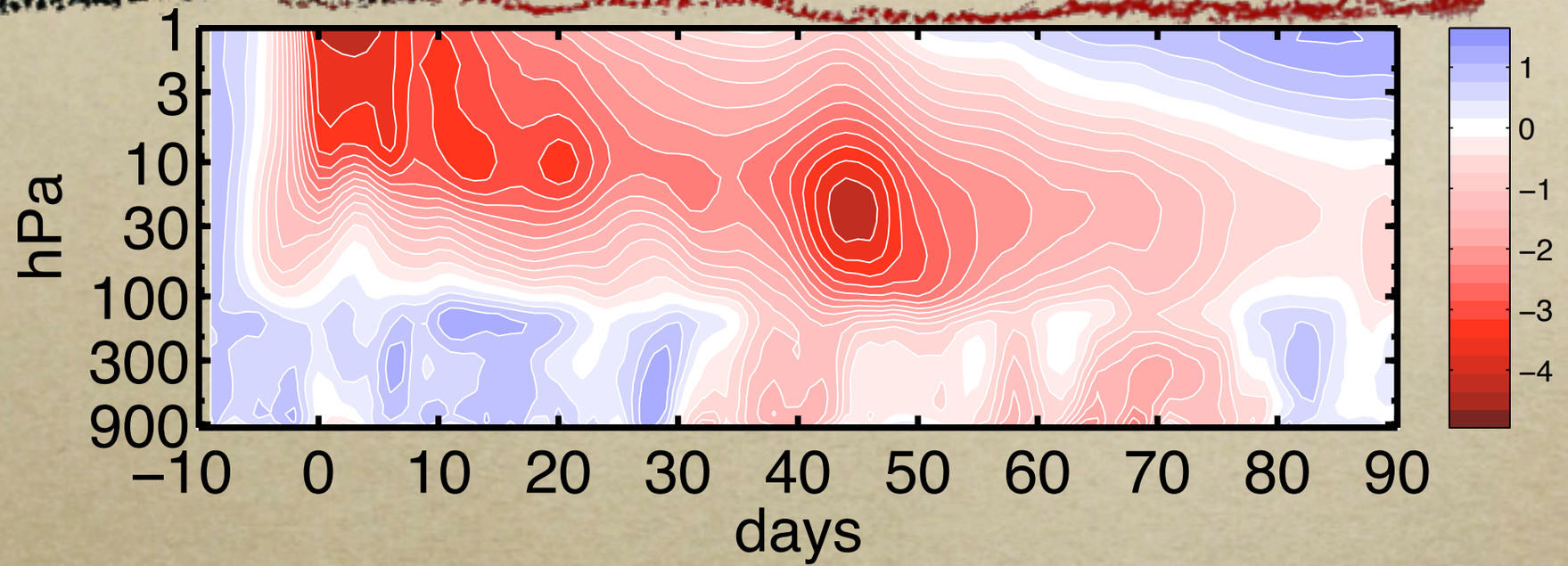
ensemble spread of SLP



ensemble members completely randomized

Tropospheric Response to SSW

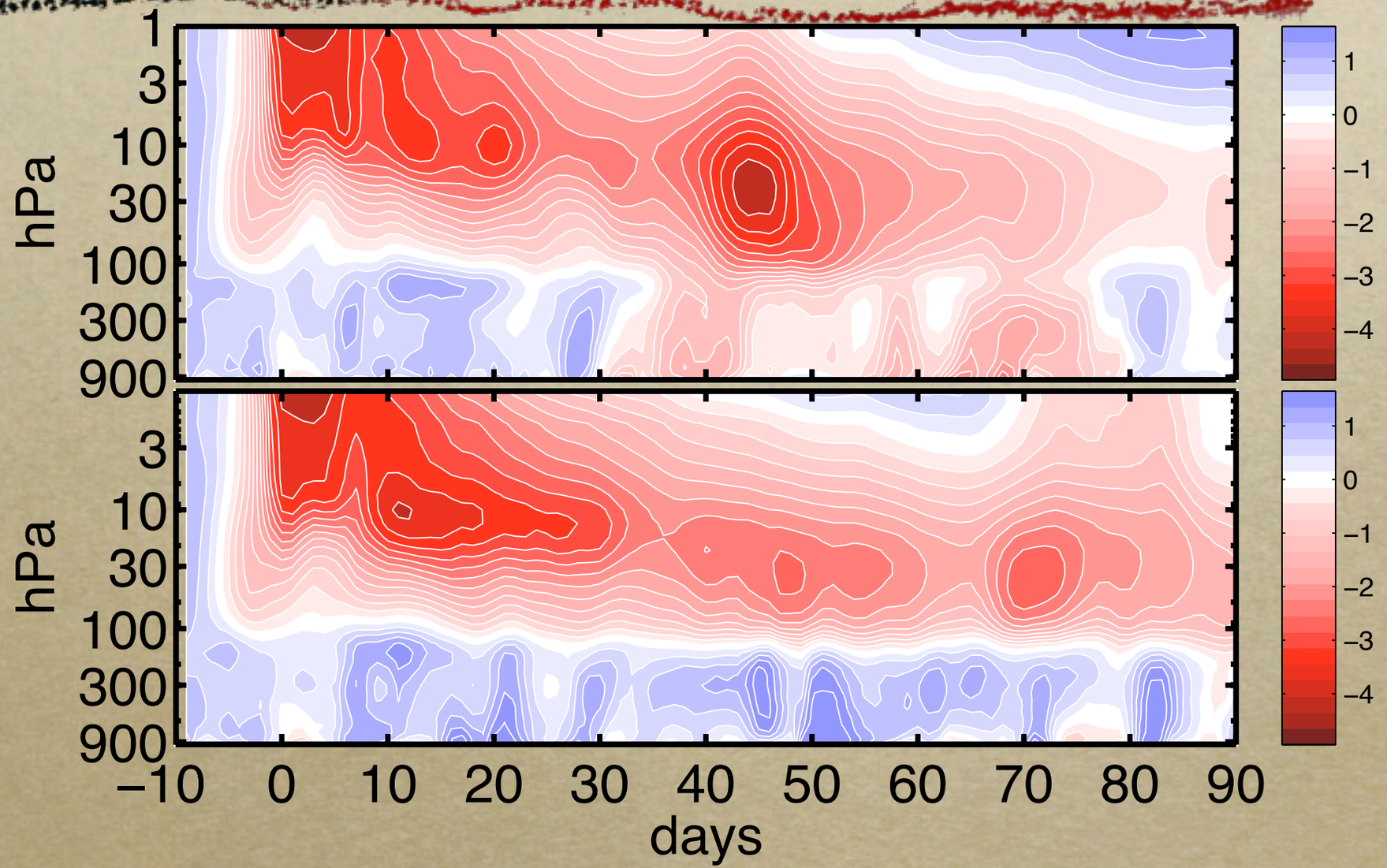
NAM index, control integration



Tropospheric Response to SSW

NAM index, control integration

ensemble member, *no* response

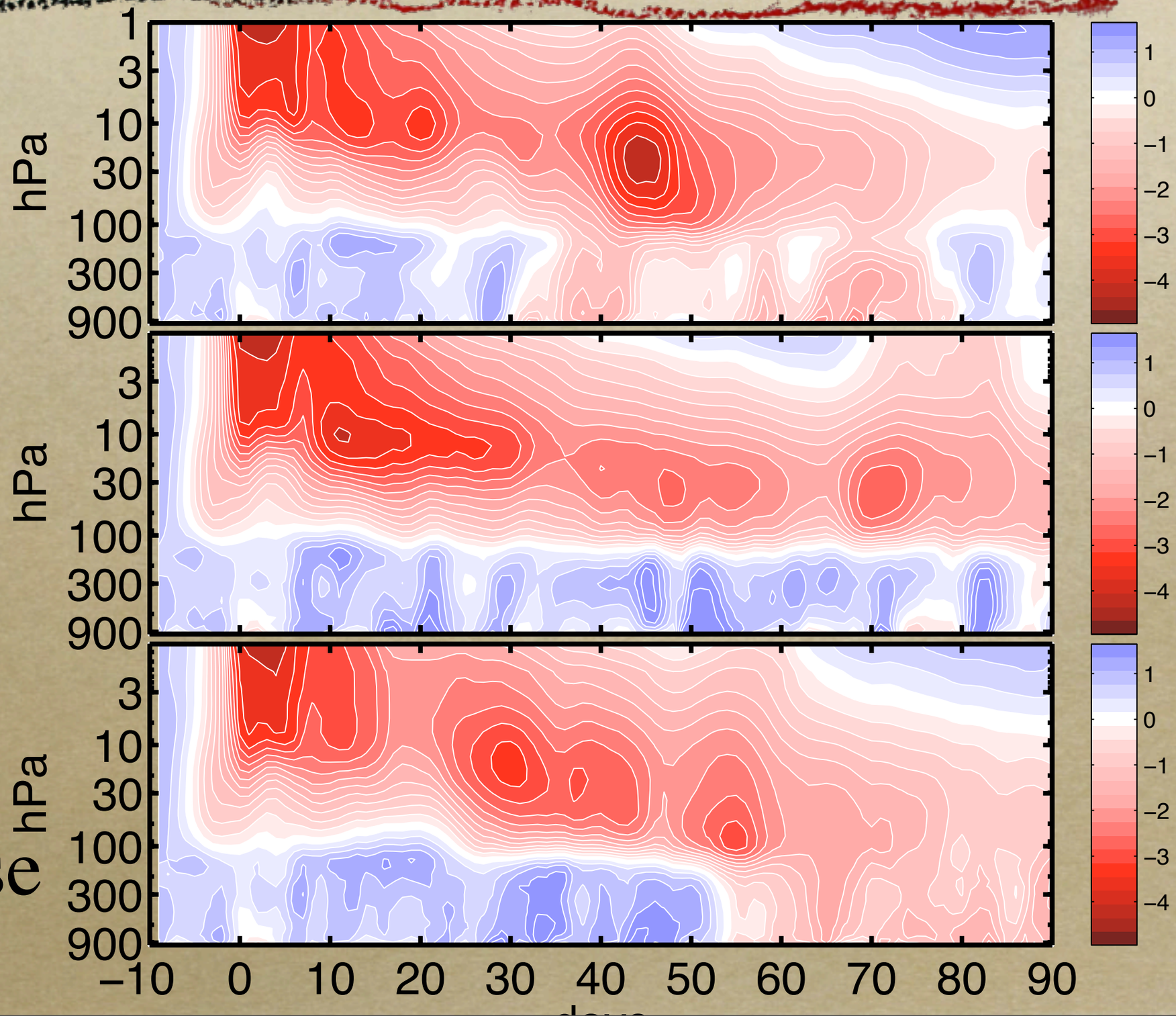


Tropospheric Response to SSW

NAM index, control integration

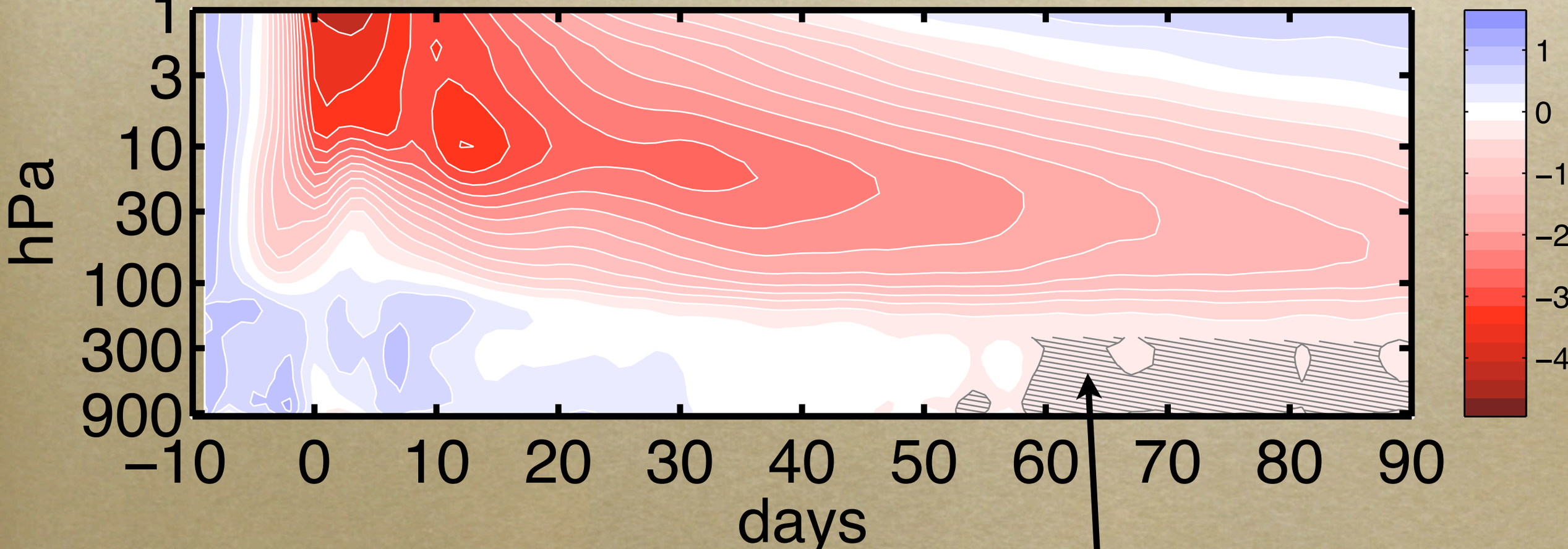
ensemble member, *no* response

ensemble member, *strong* response



Robust Tropospheric Response

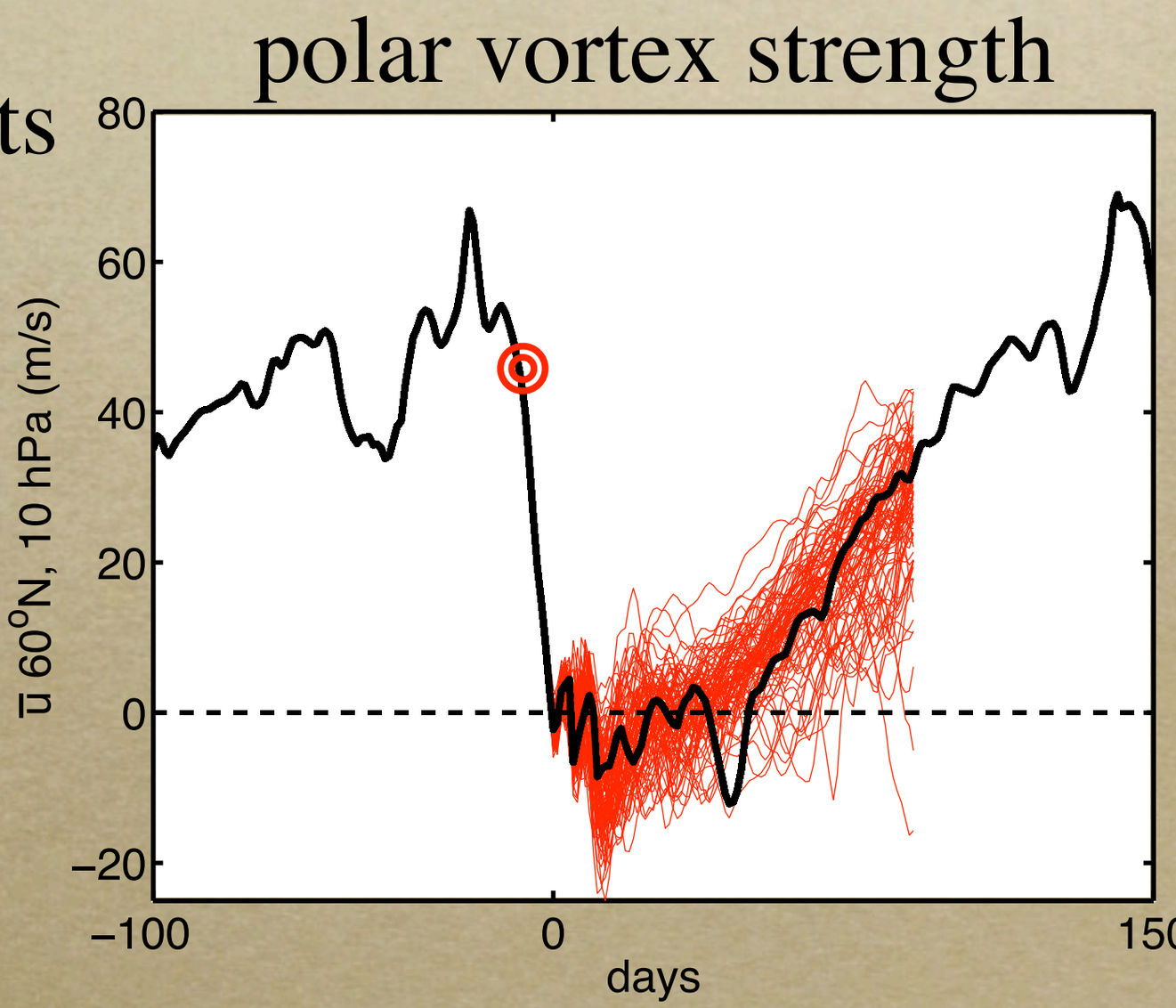
NAM index composite, 90 ensemble members



statistically significant response (>95%) in the troposphere

Summary and Conclusions

- ensemble forecasting framework for SSW events



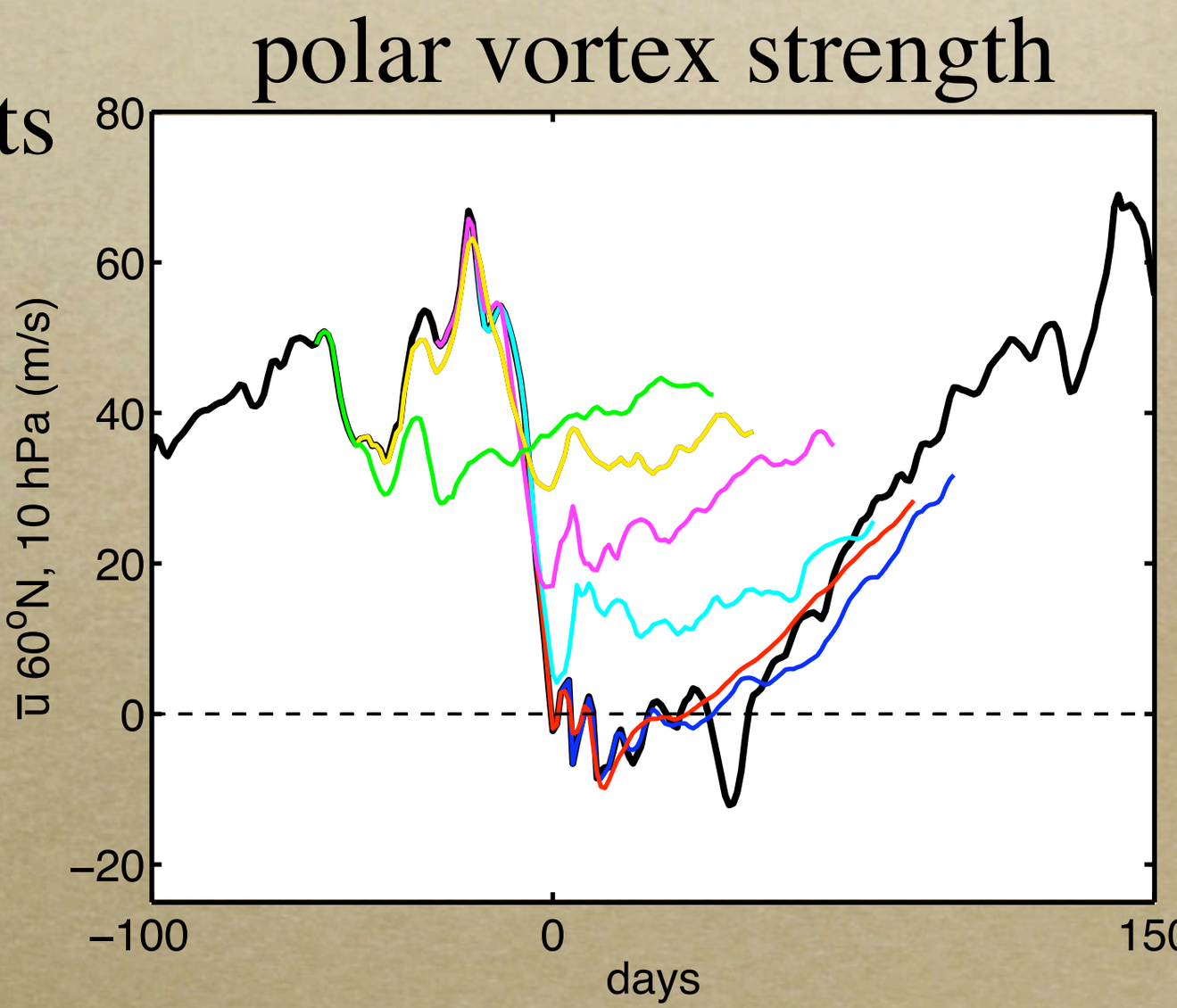
Summary and Conclusions

- ensemble forecasting framework for SSW events

- analyze stratospheric predictability

How predictable are SSWs?

enhanced predictability after an SSW event



Summary and Conclusions

perturbations erase tropospheric memory

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equatorward shift in tropospheric jet *driven by stratosphere*