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Synoptic-Scale Behavior of the Extratropical Tropopause Inversion Layer

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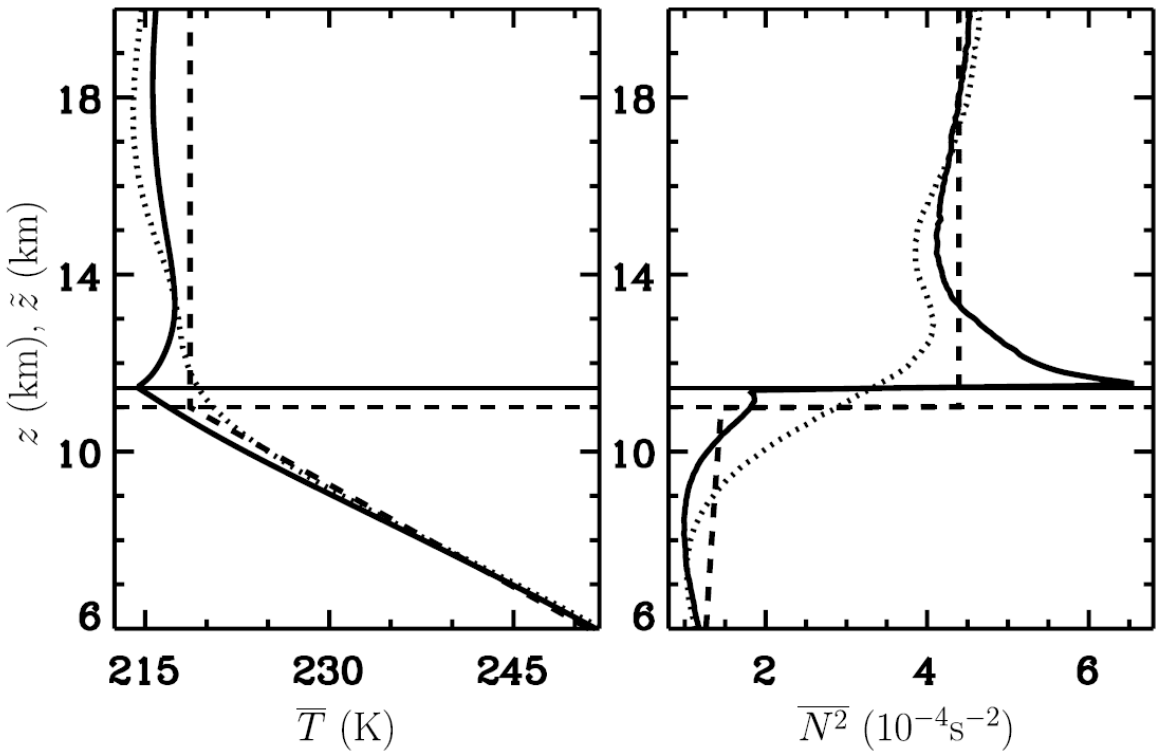
What is the TIL?

→ Narrow region of enhanced static stability

→ Right above the tropopause



[Birner 2006]

→ Has impacts on:
-Wave propagation / reflection
-Stratosphere-Troposphere exchange

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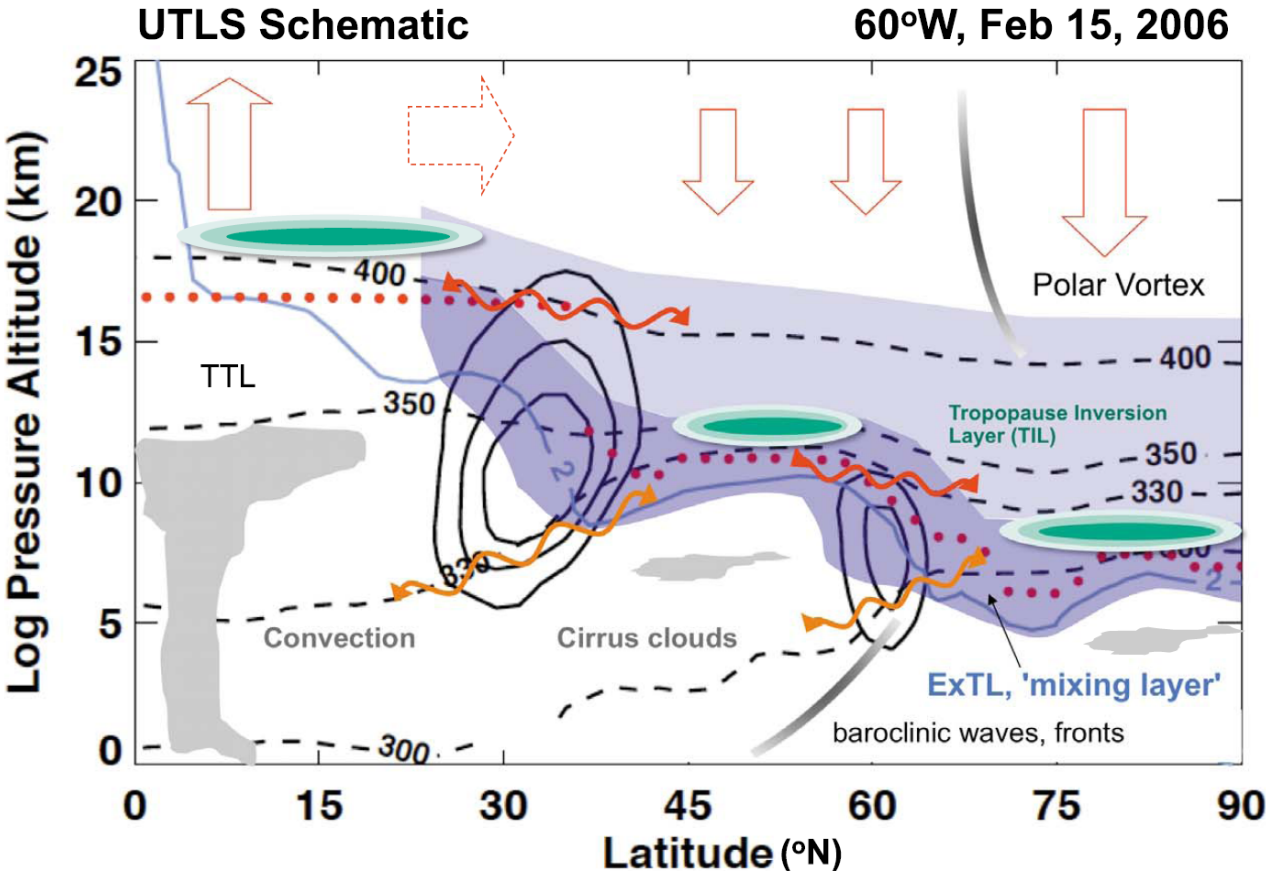

[Gettelman et al. 2011]

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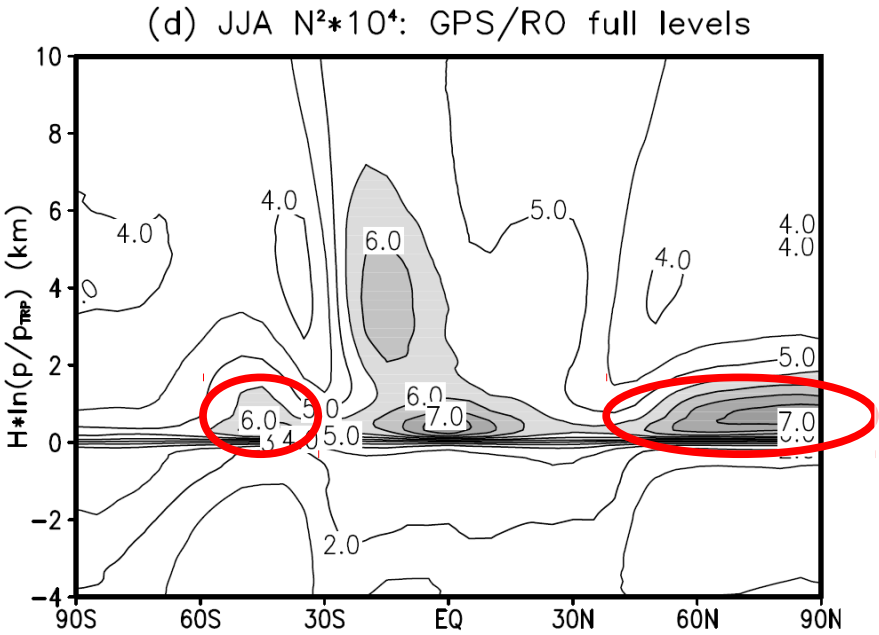
What do we know about the TIL?



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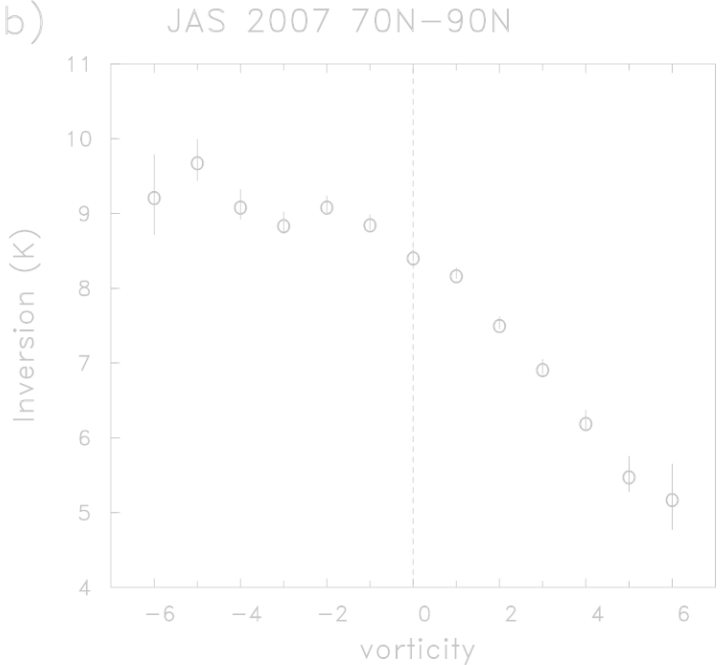

[Randel and Wu 2010]

→ Strongest in polar summer

→ Enhanced under anticyclonic conditions

Formation/maintenance mechanisms:
-Dynamical
-Radiative

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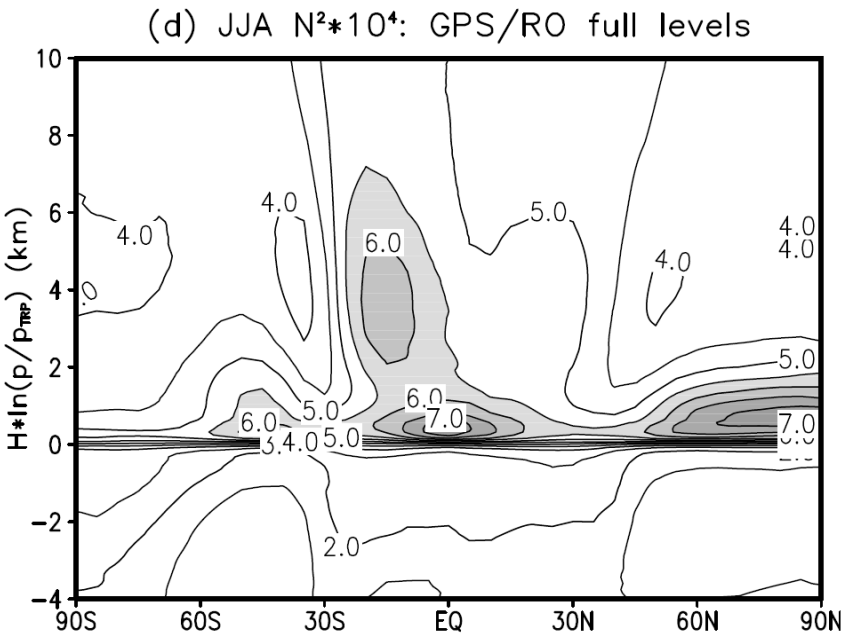

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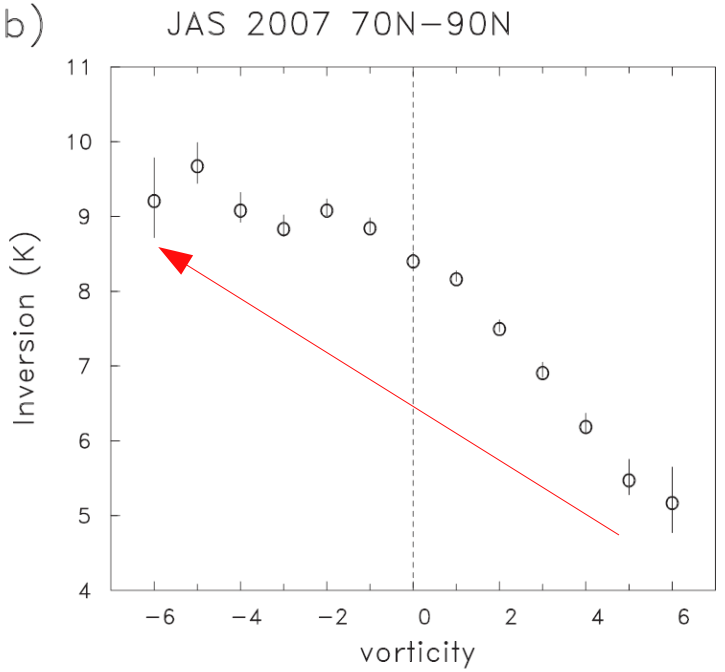

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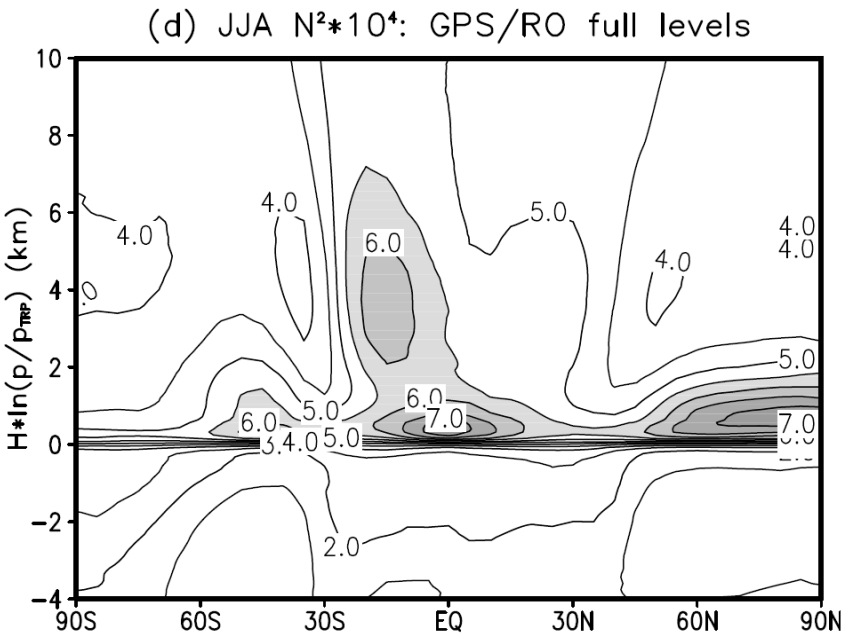

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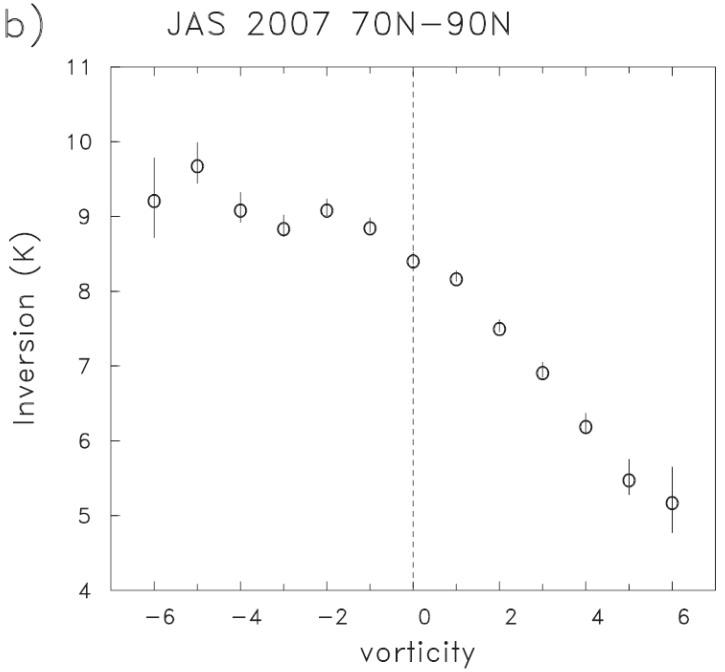

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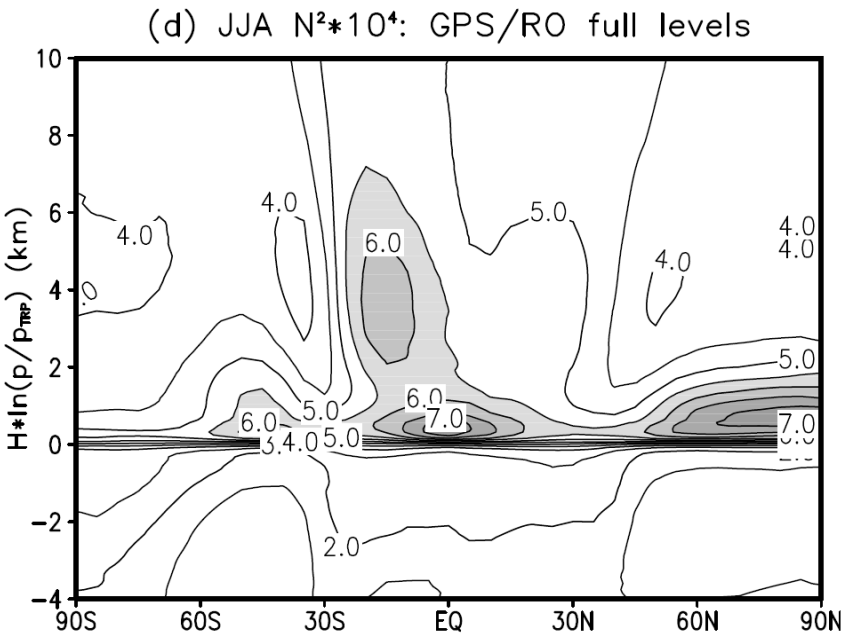

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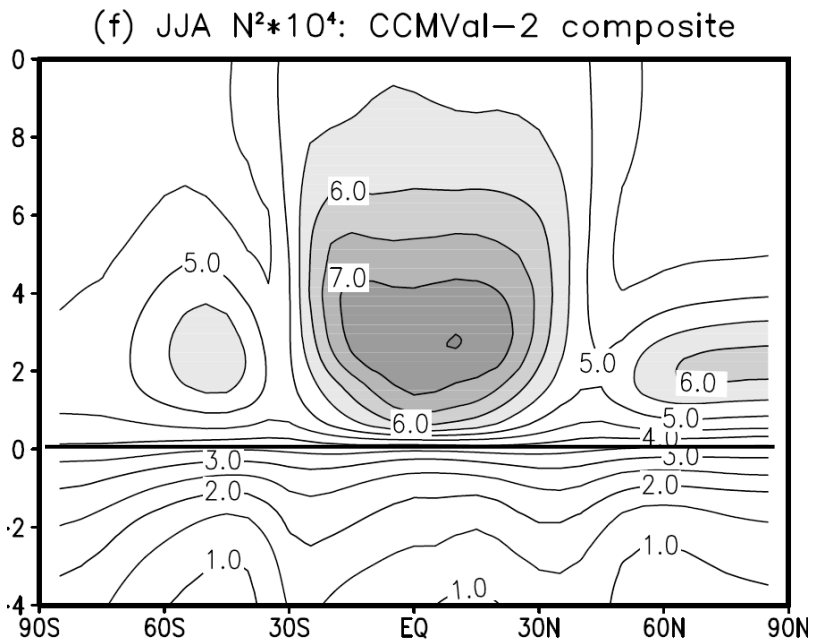
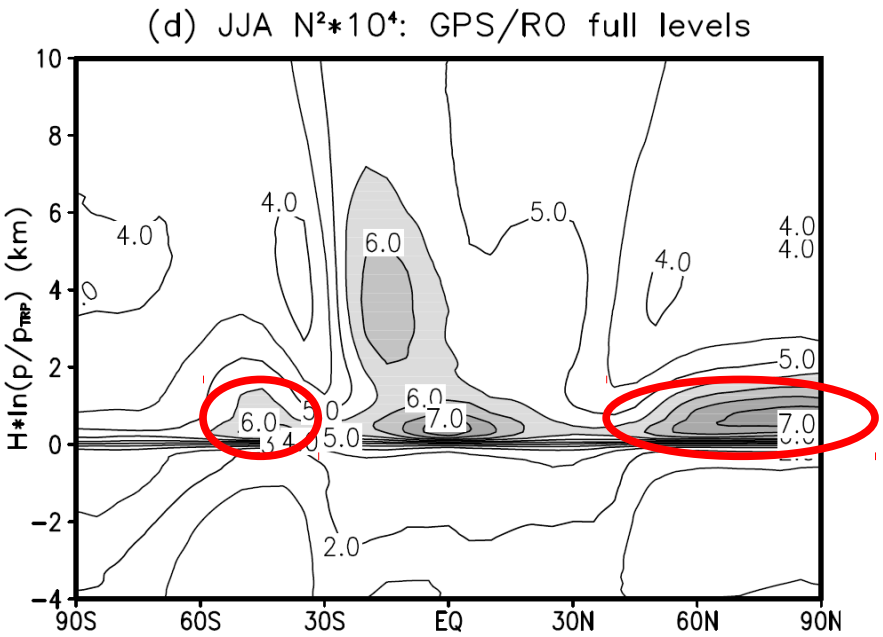


[Gettelman et al. 2010]

→ Importance of vertical resolution

Goals



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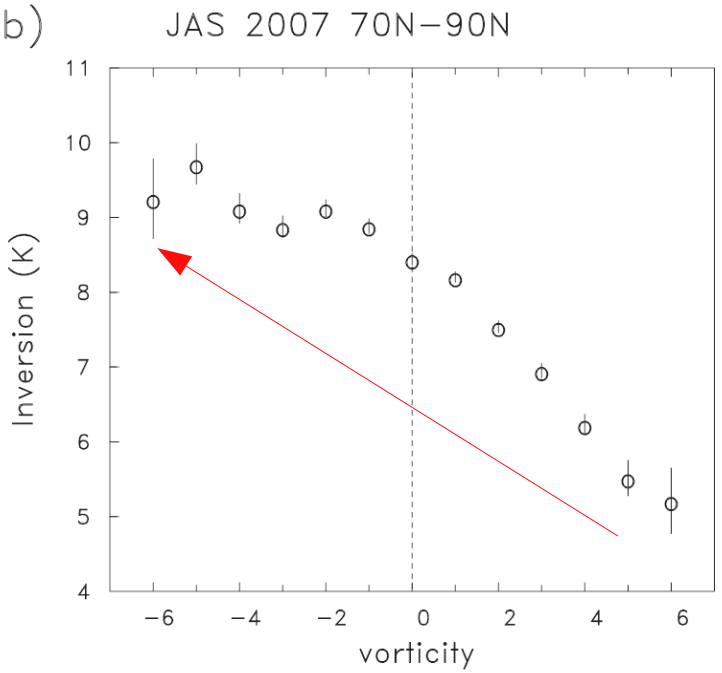


[Randel and Wu 2010]

→ Daily snapshots: how does real-time TIL look like?

→ Split relative vorticity into curl and shear: what is the contribution of each term?

Data

→ COSMIC satellite mission

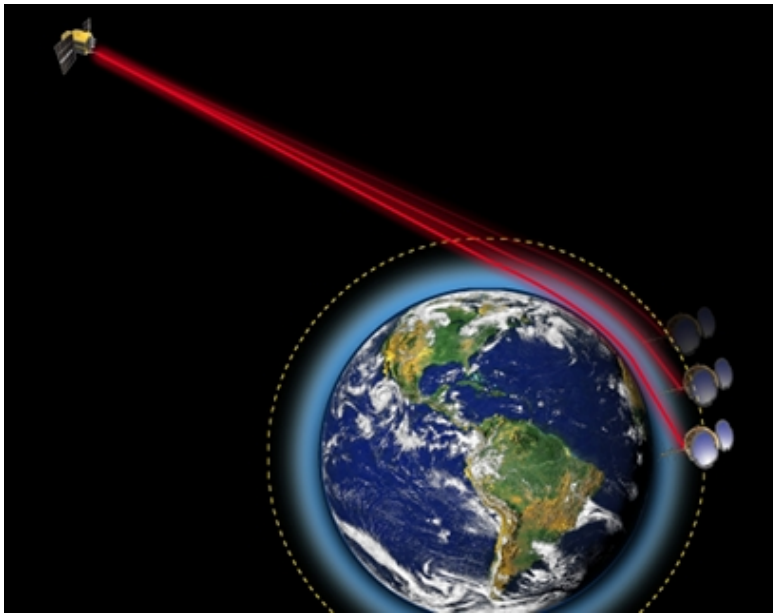
[Anthes et al. 2008]

-GPS-RO temperature profiles (wetPrf)
~2000 profiles/day, **GLOBALLY**
-100m vertical resolution

→ ERA-Interim reanalysis

[Dee et al. 2011]

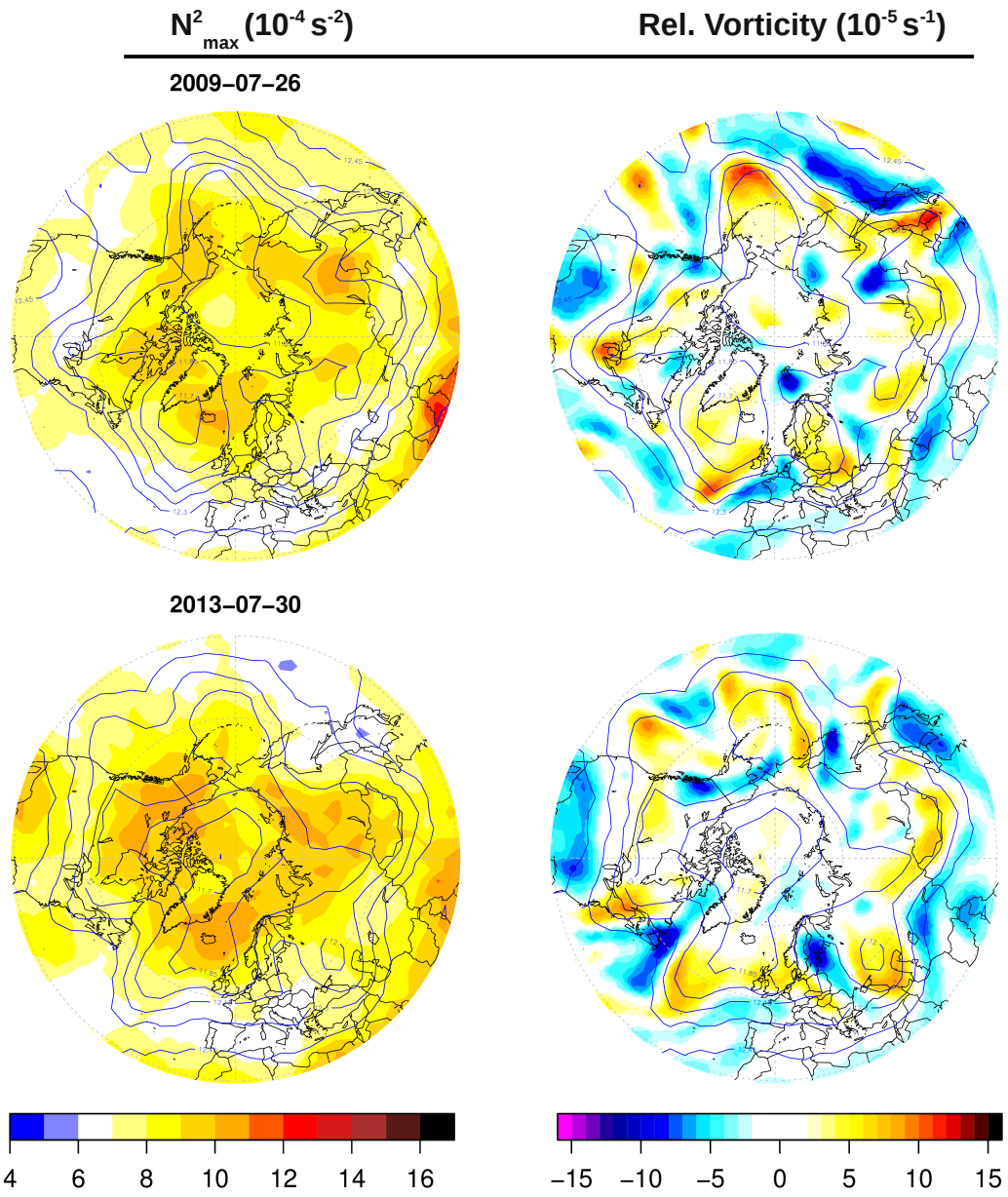
-2.5x2.5deg lon-lat grid
-200hPa level
-Winds and geopotential height



www.cosmic.ucar.edu

Analysis period: 2007-2013

TIL Strength Summer Examples

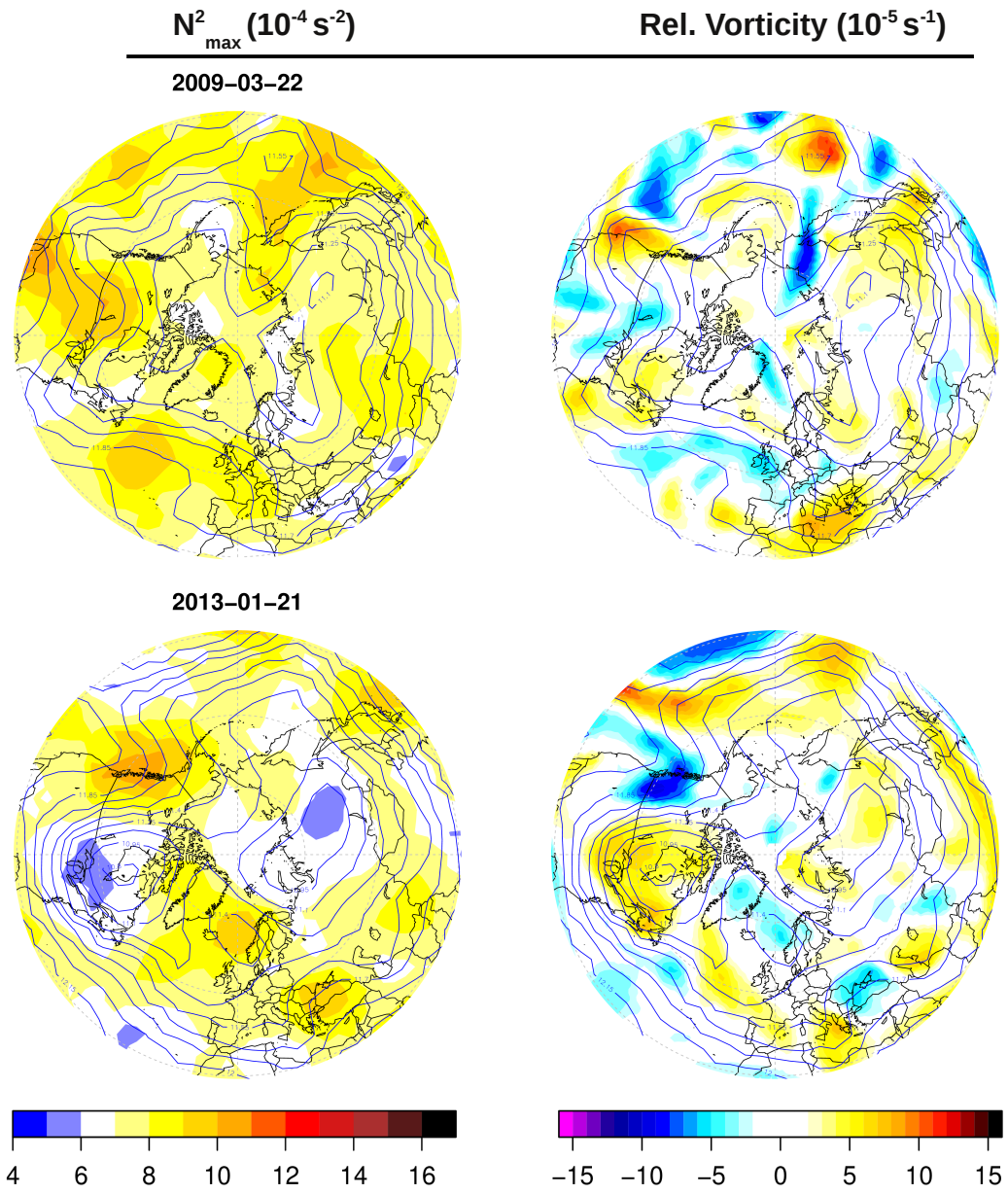


→ TIL stronger towards the pole

→ Zonal structures

→ Values around 8-10

Weak Winter Examples



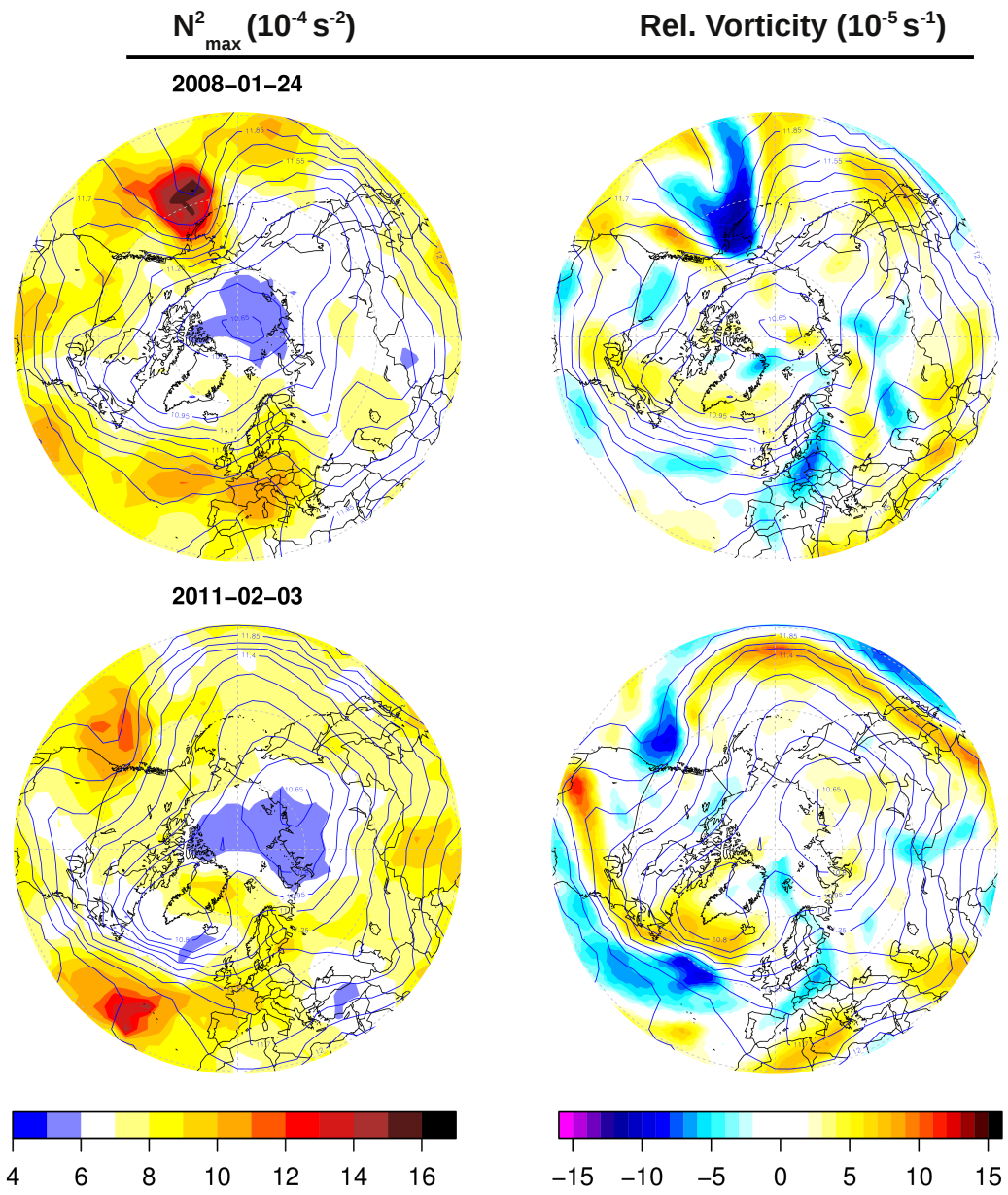
→ TIL stronger at mid-latitudes

→ Trough/Ridge contrast

→ Ridges: values around 8-10

→ Troughs: values around 5-7

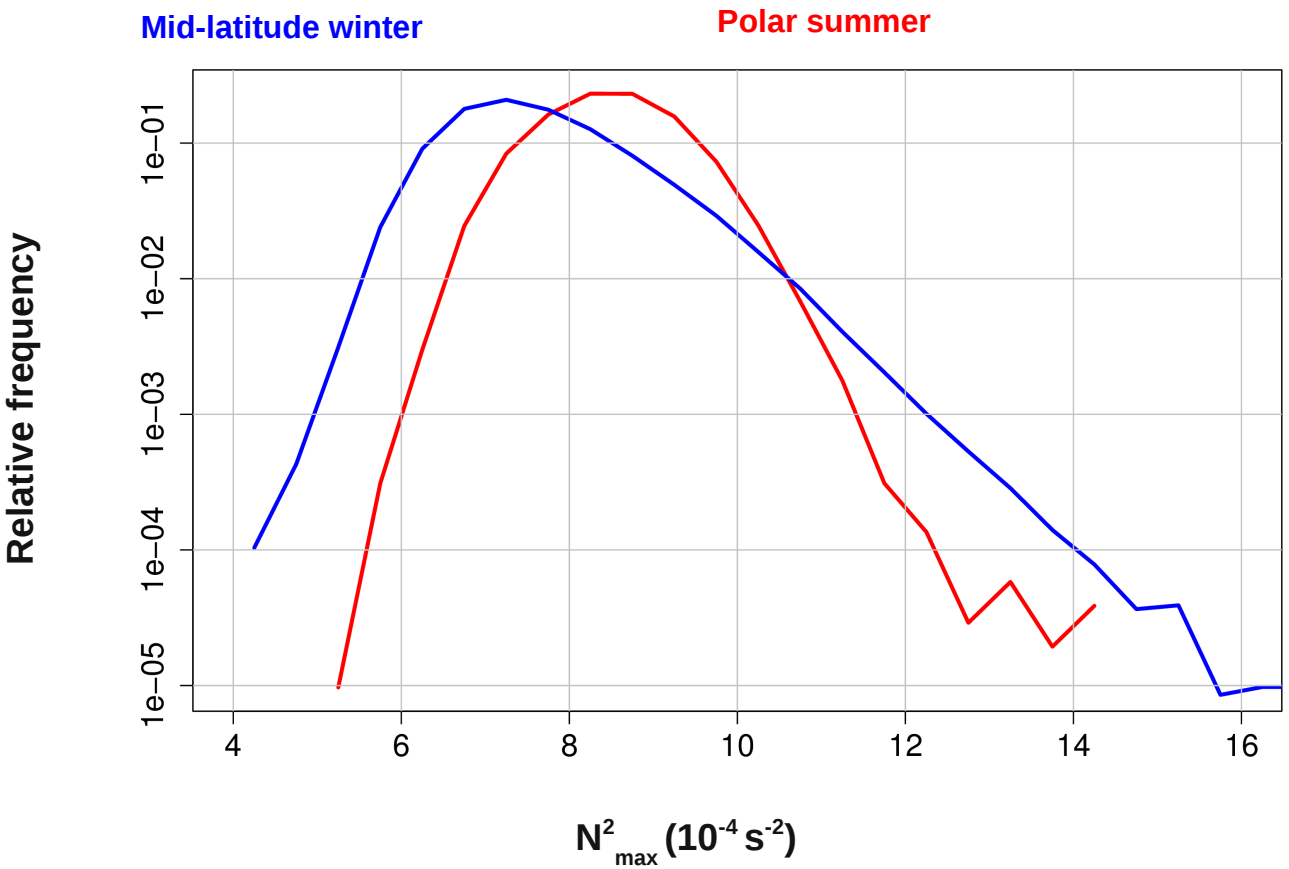
Strong Winter Examples



→ Ridges: values above 12

→ Present in ~25% of days

TIL Strength Relative Frequency



→ Mean state: polar summer strongest

→ At synoptic scale: mid-latitude winter ridges have TIL as strong or stronger!

The Roles of Curl and Shear Relative Vorticity

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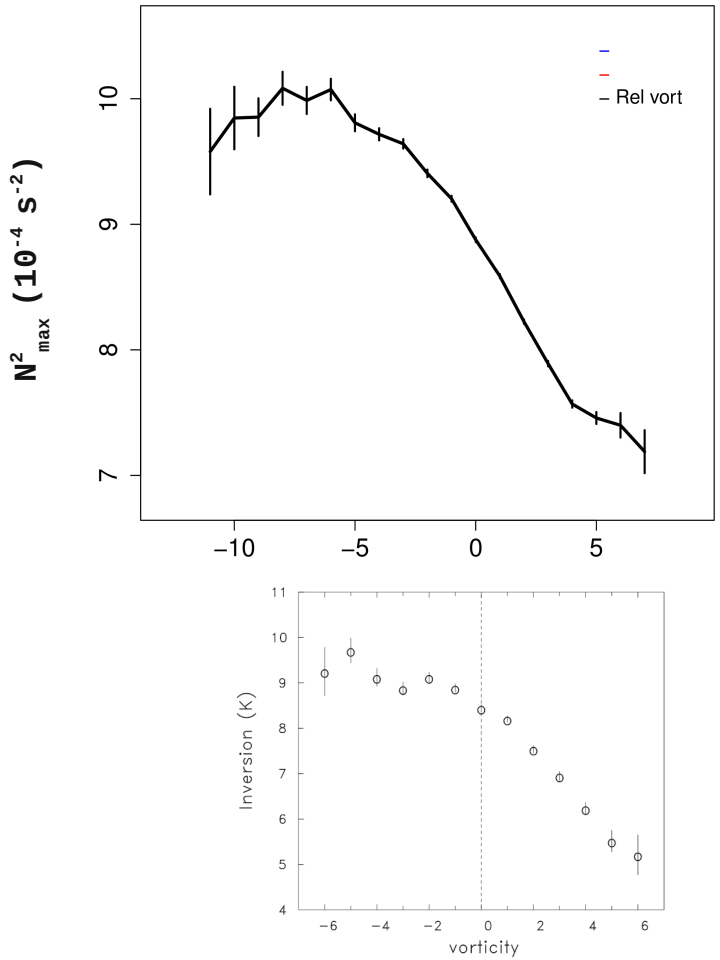
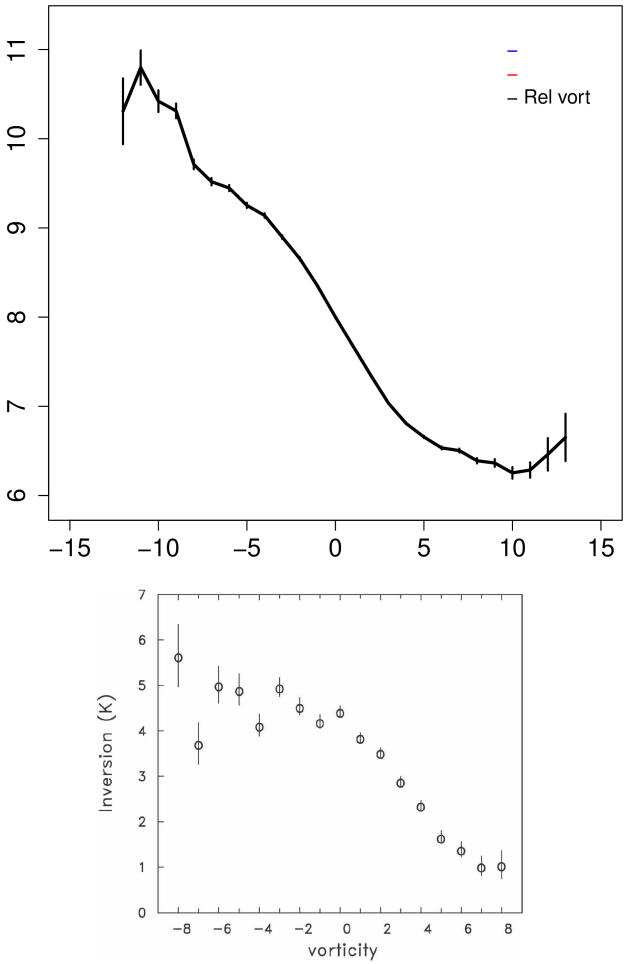
Polar summer



[Randel and Wu 2010]

Mid-latitude winter



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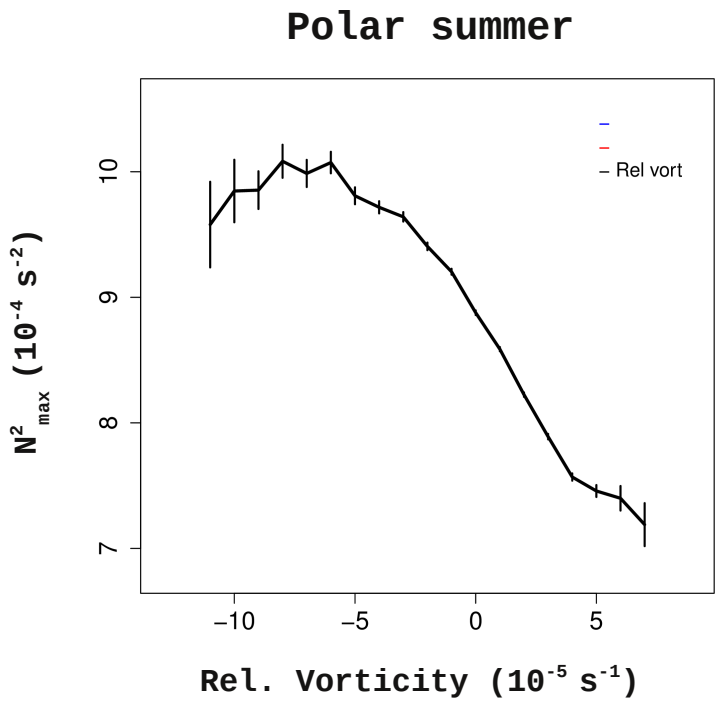
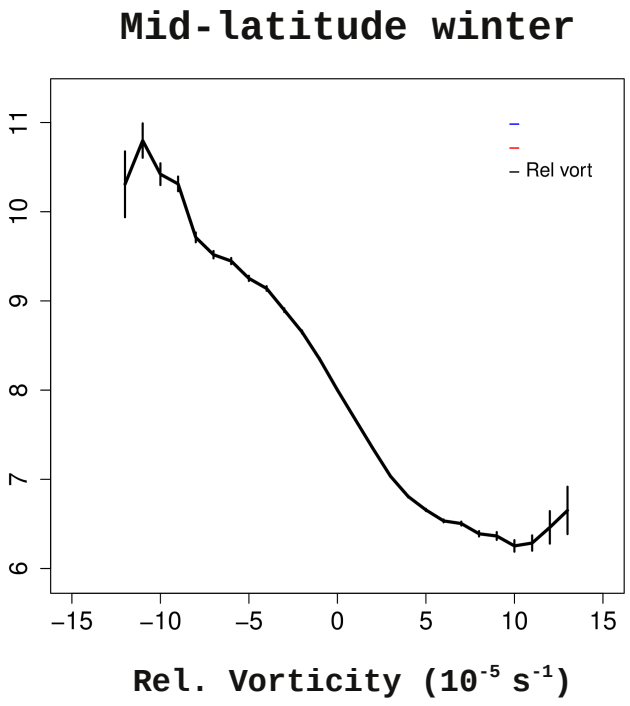
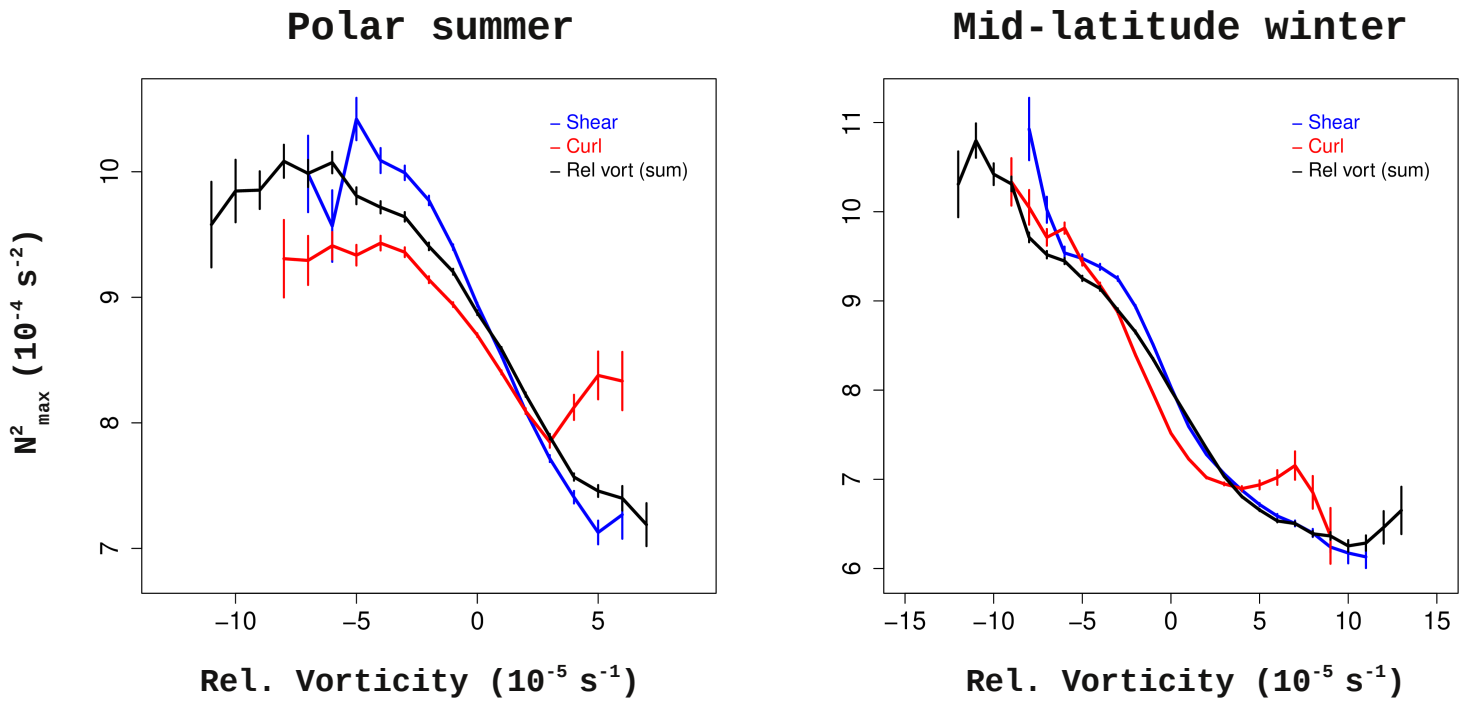
The Roles of Curl and Shear Relative Vorticity





The Roles of Curl and Shear Relative Vorticity

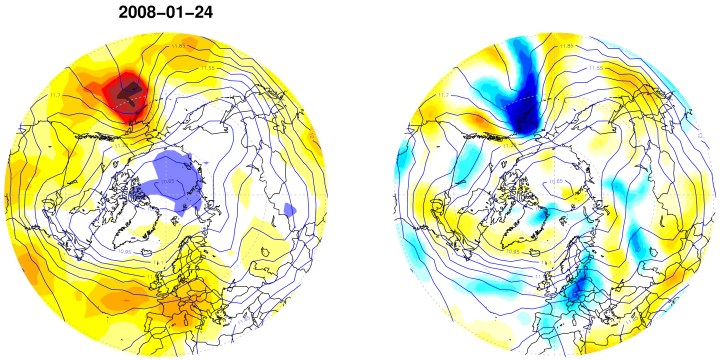


→ Strong cyclonic curl: TIL stronger than expected

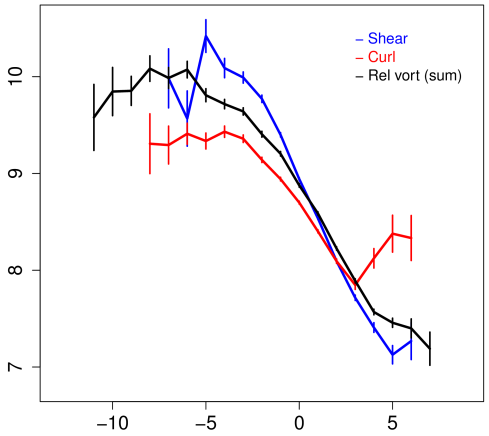
→ Anticyclonic shear: gives strongest TIL

Concluding Remarks

- TIL at synoptic scale



- Relative vorticity split into curl and shear



Concluding Remarks

- TIL at synoptic scale

-TIL in mid-latitude winter ridges is as strong or stronger than in polar summer

- Relative vorticity split into curl and shear

-Cyclonic curl enhances TIL where weaker is expected
-Anticyclonic shear dominates to give strongest TIL

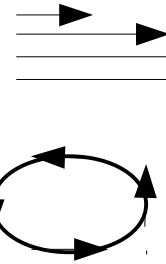
Appendix

Appendix: Shear and Curl calculations

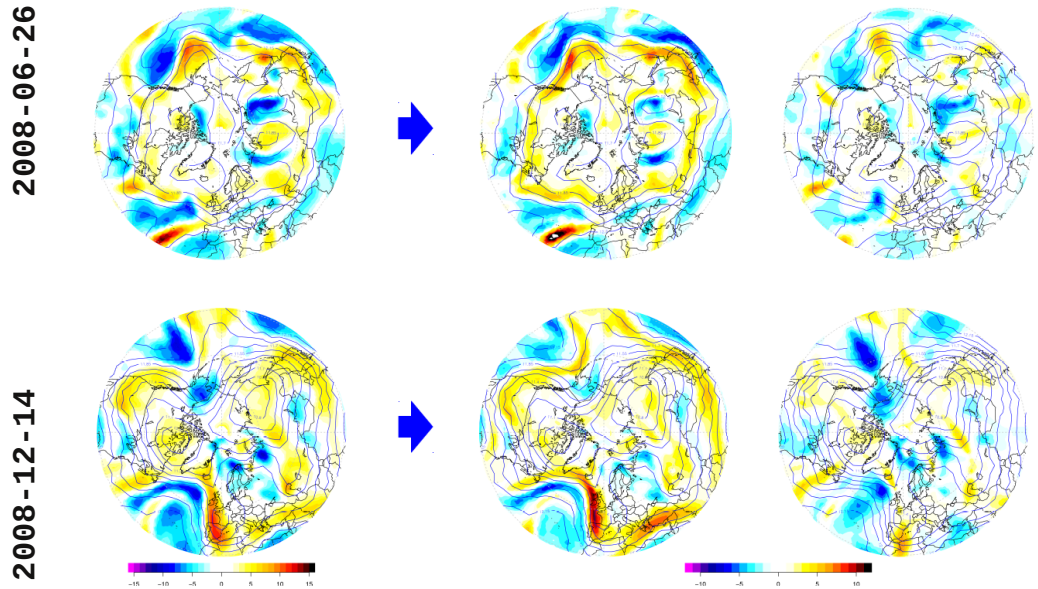
→ Formulation by Bell and Keyser 1993

$$-\frac{\partial V}{\partial n} = -\frac{1}{V^2}\left[u^2 u_y - v^2 v_x - uv(u_x - v_y)\right]$$

$$V\frac{\partial \alpha}{\partial s} = \frac{1}{V^2}\left[u^2 v_x - v^2 u_y - uv(u_x - v_y)\right].$$

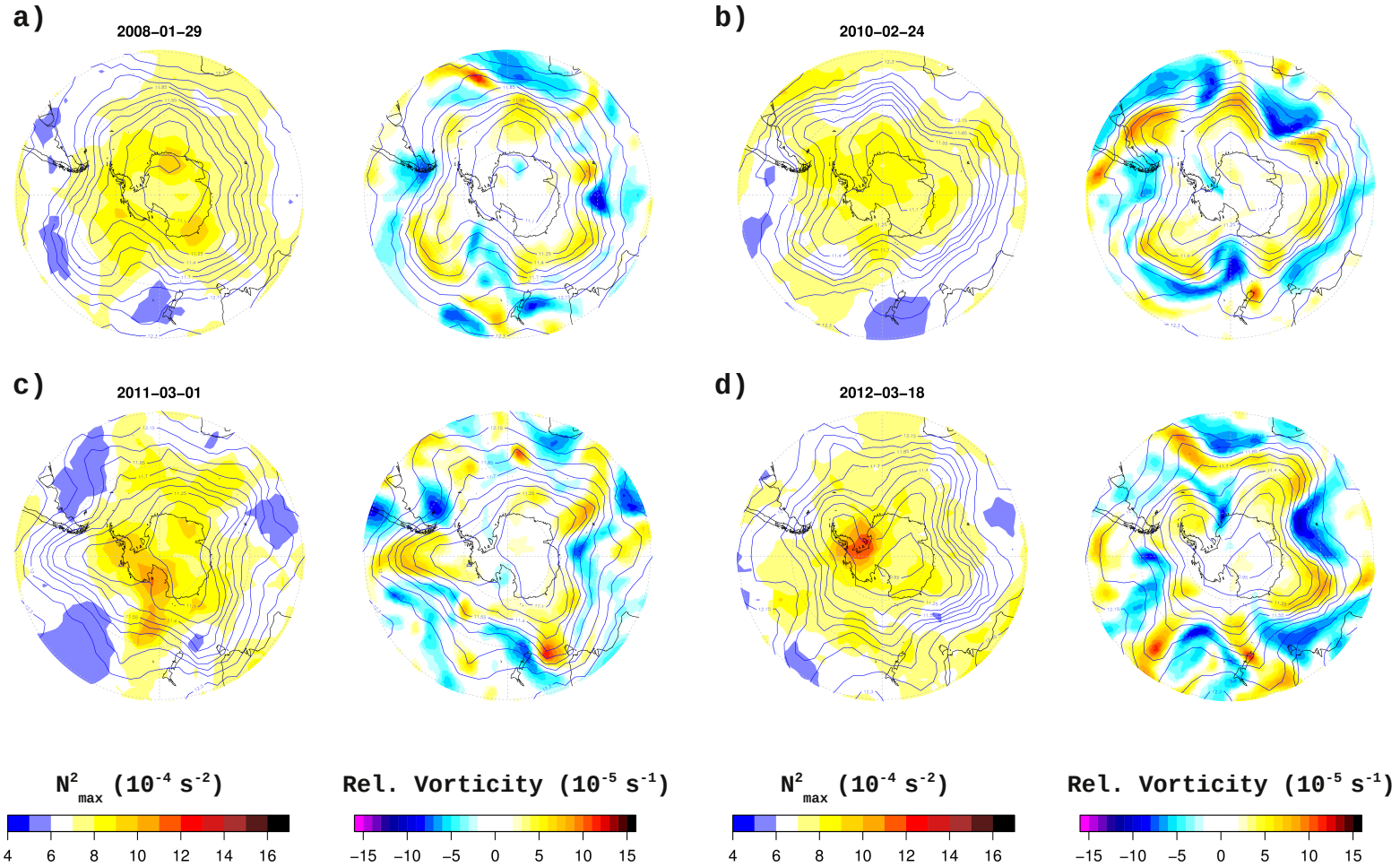


Sum= $v_x - u_y$



Appendix: Southern Hemisphere

→ Summer examples



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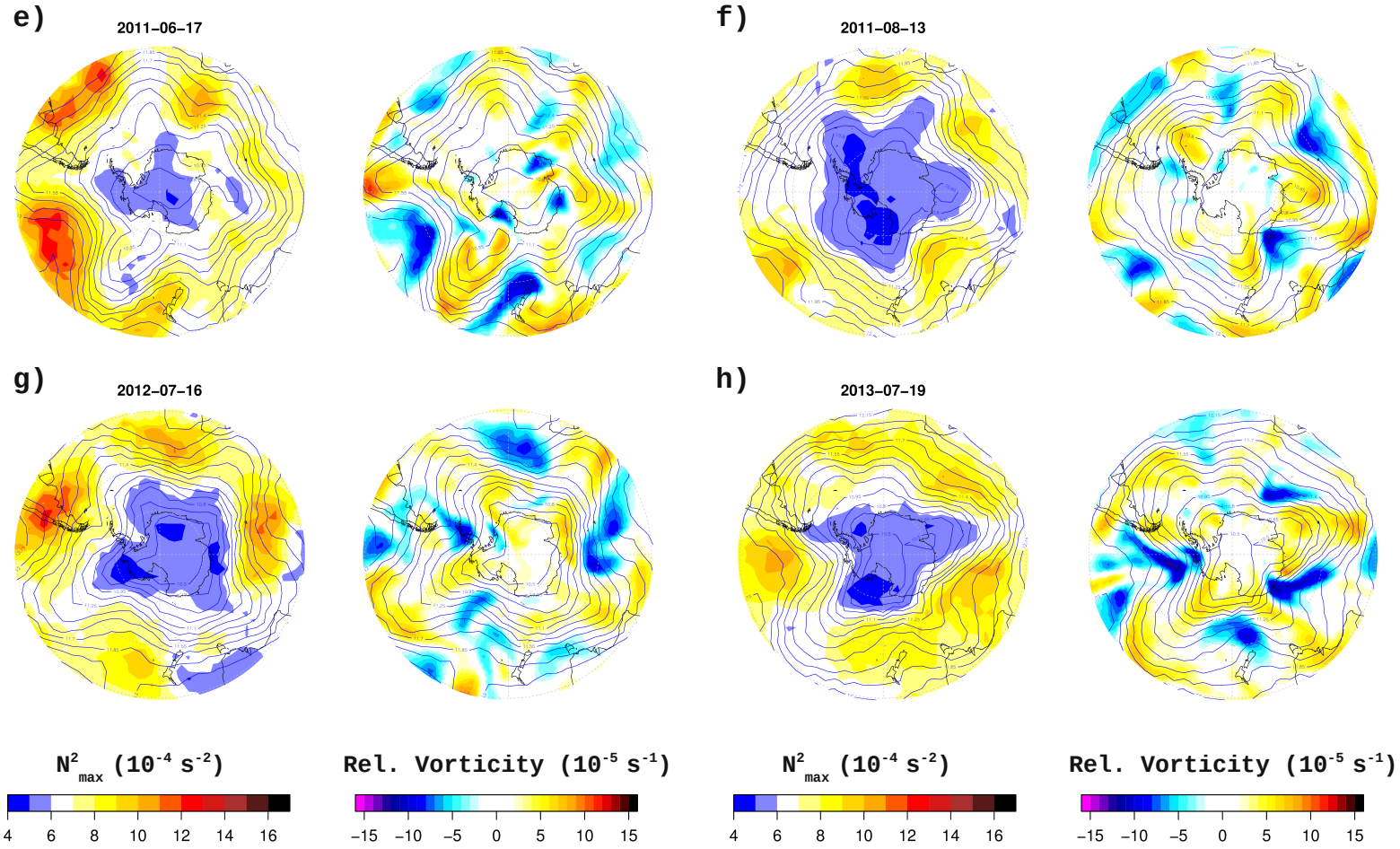
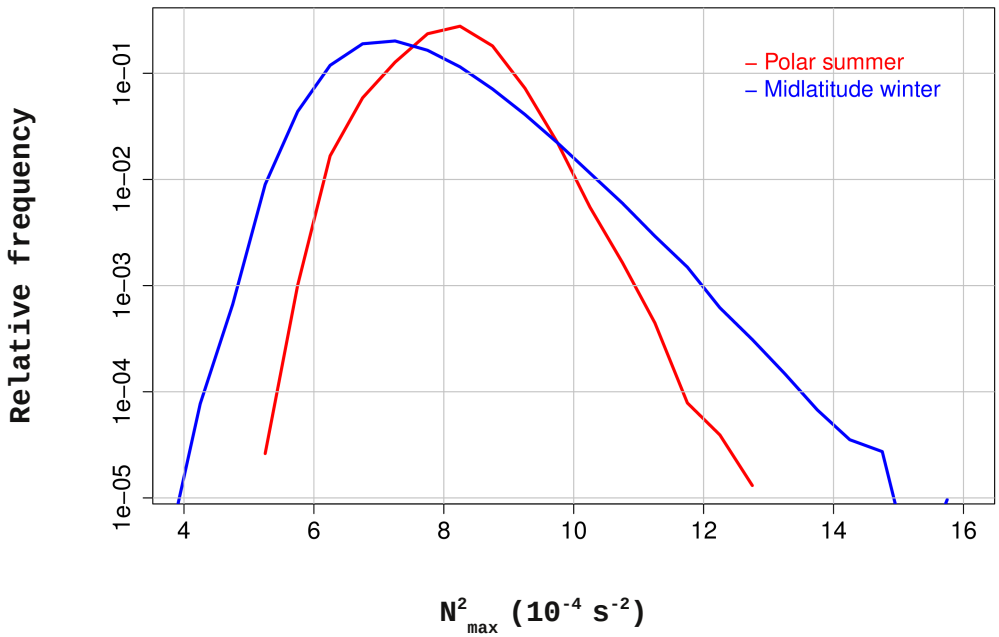
→ Winter examples

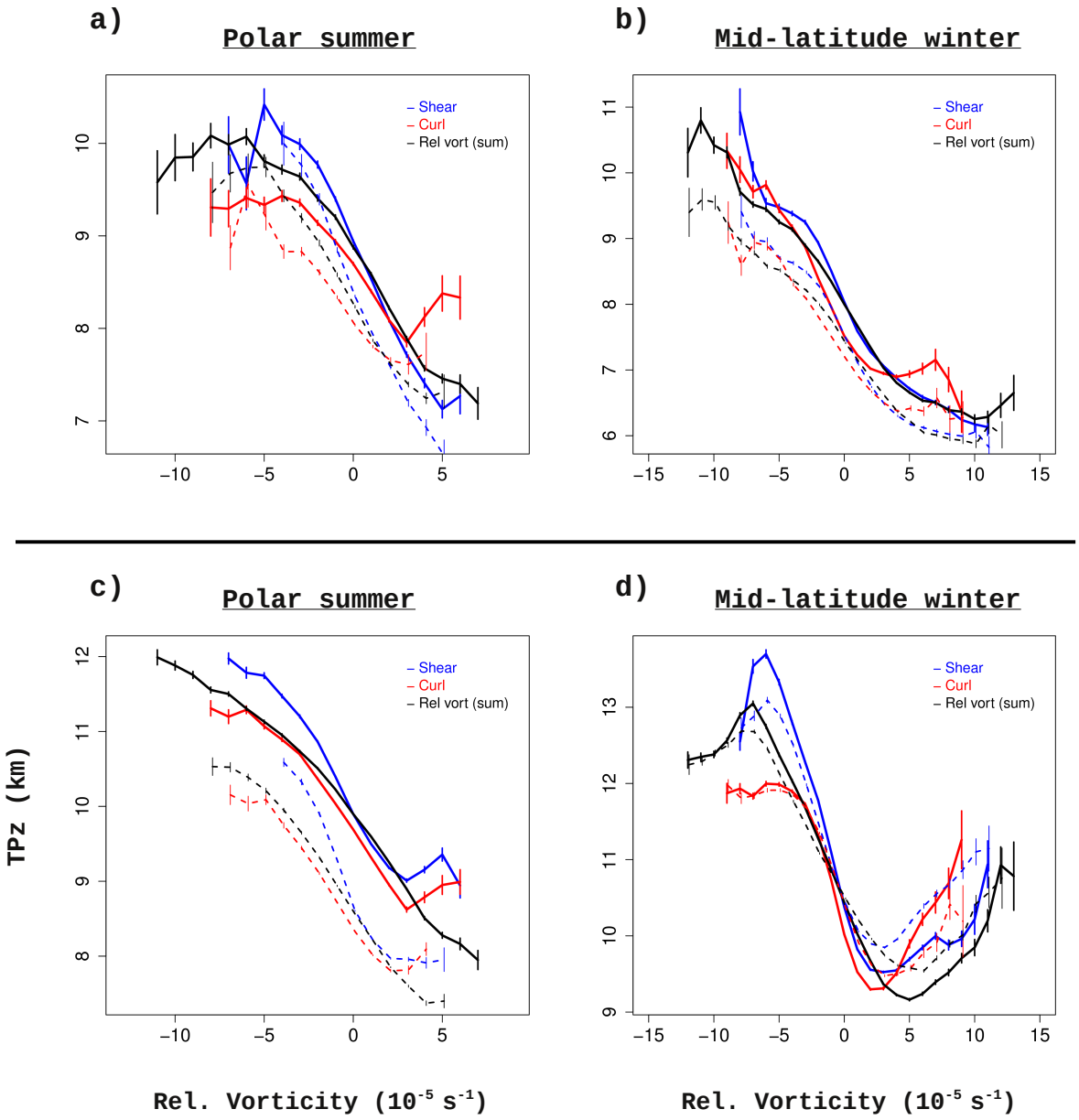


Appendix: Southern Hemisphere

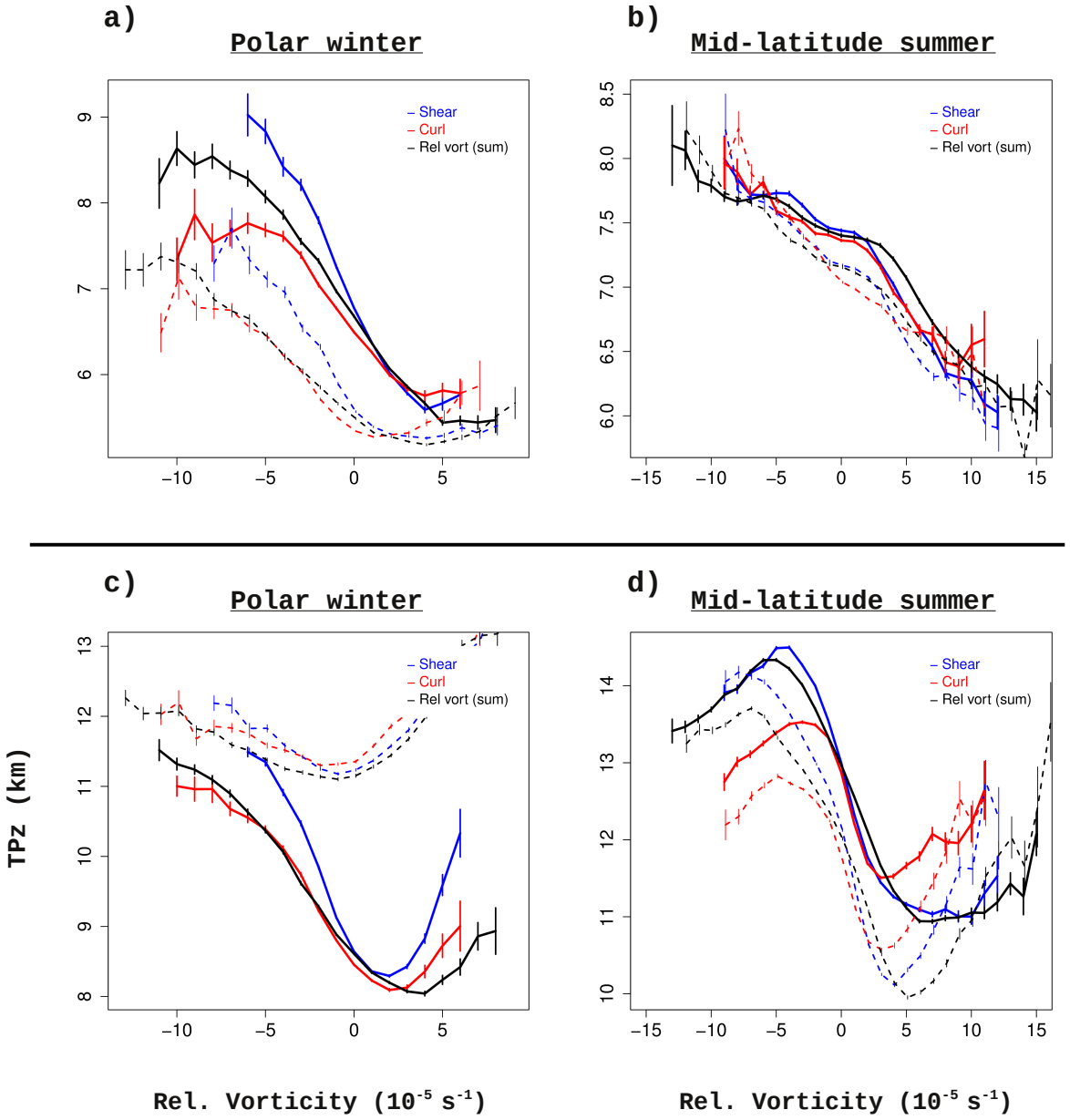
→ TIL strength relative frequencies



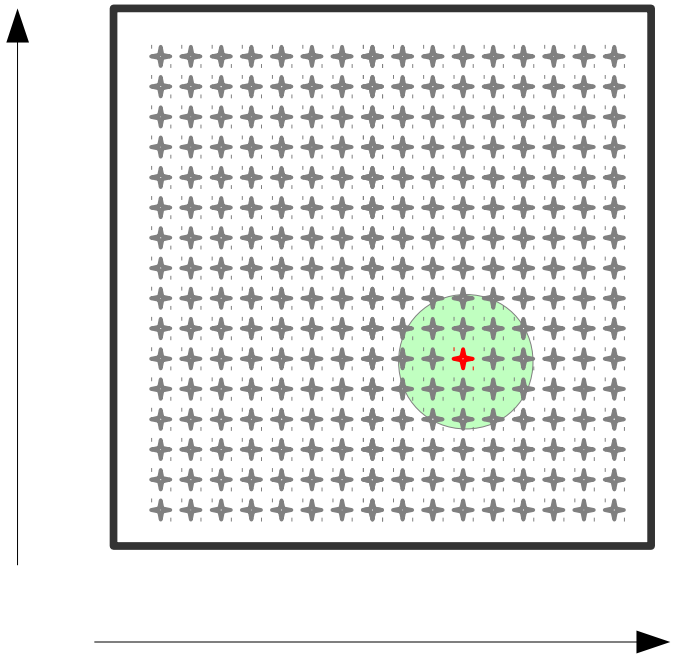
Appendix: Shear / Curl results extended



Appendix: Shear / Curl results extended (II)



Appendix: Mapping and Gridding



41x41 grid

30-90N

1000km radius, simple averaging of all profiles' N^2_{max}

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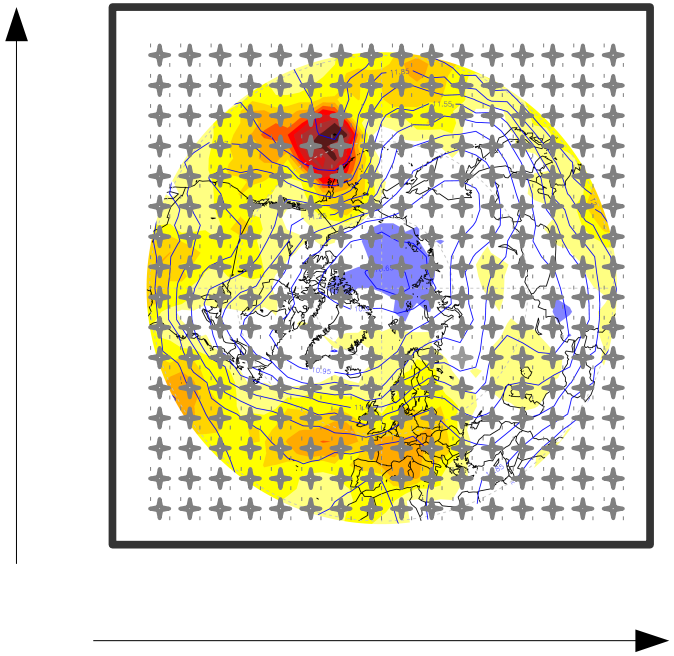

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