Chapter 6: Stratosphere-Troposphere Coupling

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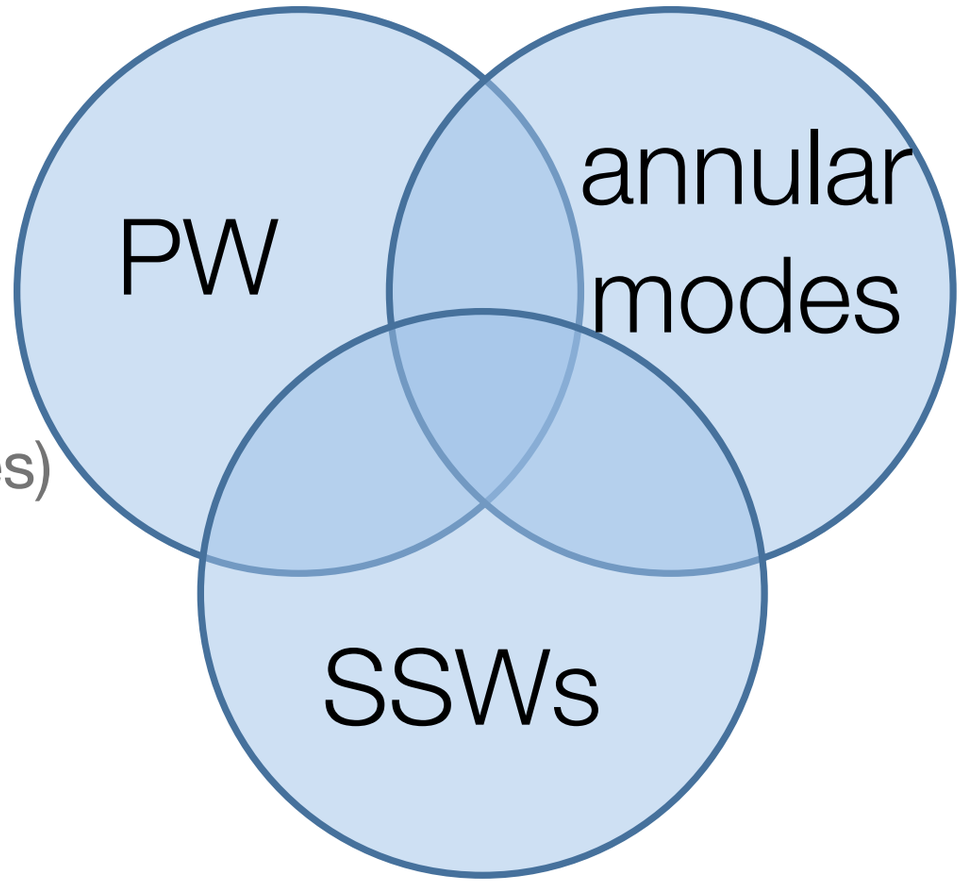
Key points for discussion

- What is the scope of this chapter?
    - Extratropical coupling on daily to intraseasonal time scales
    - ENSO + AMOC signals and connection to extratropics(?)
    - tropospheric impact of solar forcing, volcanoes, QBO (???)
- Who is our audience: The scientific approach to this intercomparison
- Diagnostics + observational data for validation (?)
- Guidelines for our analysis
    - Length of comparison period for validation
    - Analysis of earlier periods?
- Schedule + Logistics

Scope of “Stratosphere-Troposphere Coupling” Organization by direction/source

- Troposphere to Stratosphere (planetary wave forcing, E-P fluxes)
    - ocean signals (ENSO)
    - internal tropospheric variability
- Stratosphere to Troposphere
    - wave reflection/absorption
    - zonal mean coupling (annular modes)
    - ocean signals (AMOC)
- Stratospheric variability
    - sudden and final warmings
    - polar vortex oscillations / strong vortex events
    - QBO + forced natural variability (solar, volcanic)



Scope of “Stratosphere-Troposphere Coupling” Organization by time scales

- Short term Coupling: planetary wave propagation, absorption and reflection
- Intraseasonal Coupling: downward influence of sudden and final warmings
- Interannual Coupling: modification of the intraseasonal eddy-mean flow interactions by ENSO, QBO, solar, volcanoes, AMOC, climate trends ...

Scientific Approach:
Who is our audience?

- Reanalysis Centers
    - What are the metrics used by modeling groups to evaluate S-T coupling
    - Are these metrics adequately captured in reanalyses?
- Data Users (climate modeling, process oriented research, grad students!)
    - Establish benchmarks for common indices (descriptive)
        - standardize definitions (more to come)
        - provide indices and evaluation scripts
    - validate our analyses against observations, if possible (e.g. compare annular mode indices against station based measures, Marshall 2003)

Diagnostics

- synthesize current view of stratosphere-troposphere coupling (review like)
- show case new metrics (new research)
- will depend in part on participation - potential for a very broad assessment, given the current level of interest
- as lead authors, Yulia and I will coordinate analysis do our best to put them in a coherent storyline

Diagnostics: Planetary wave coupling

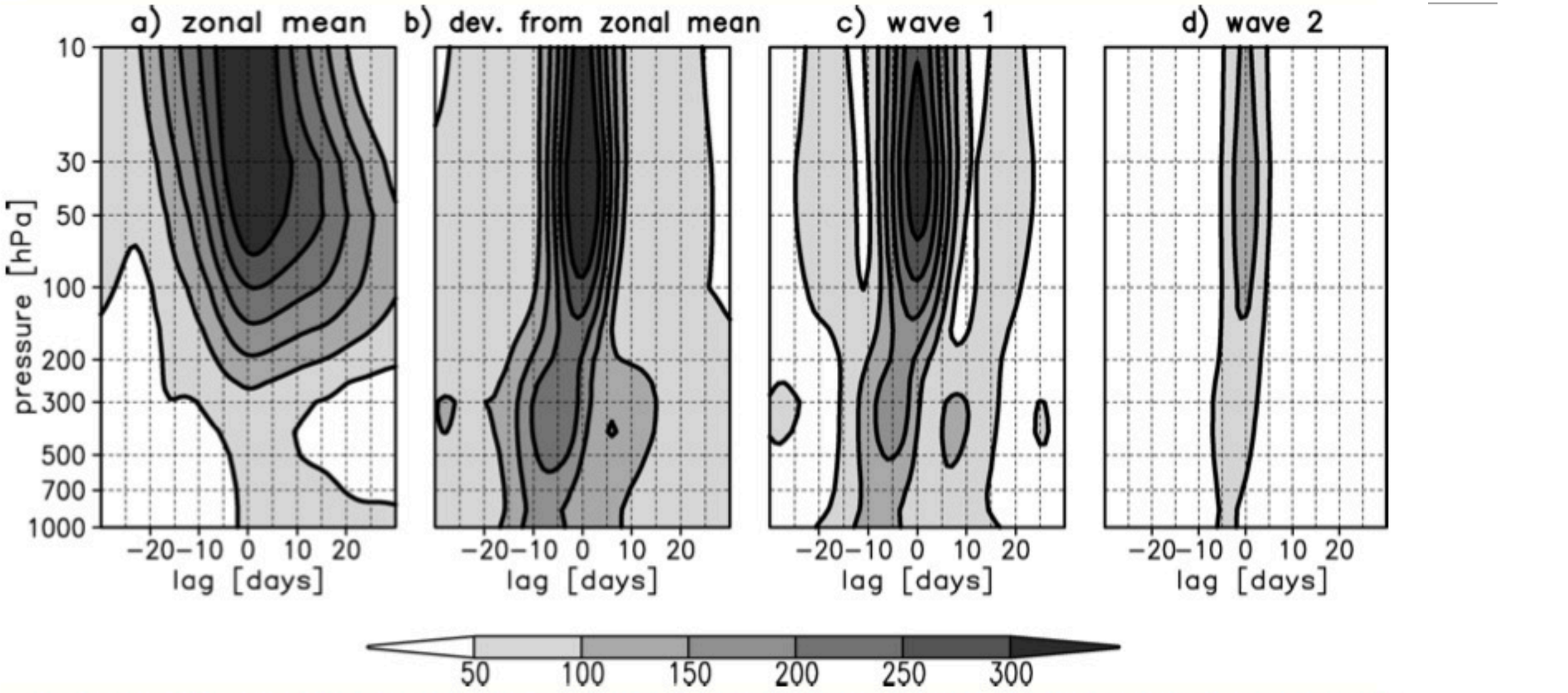
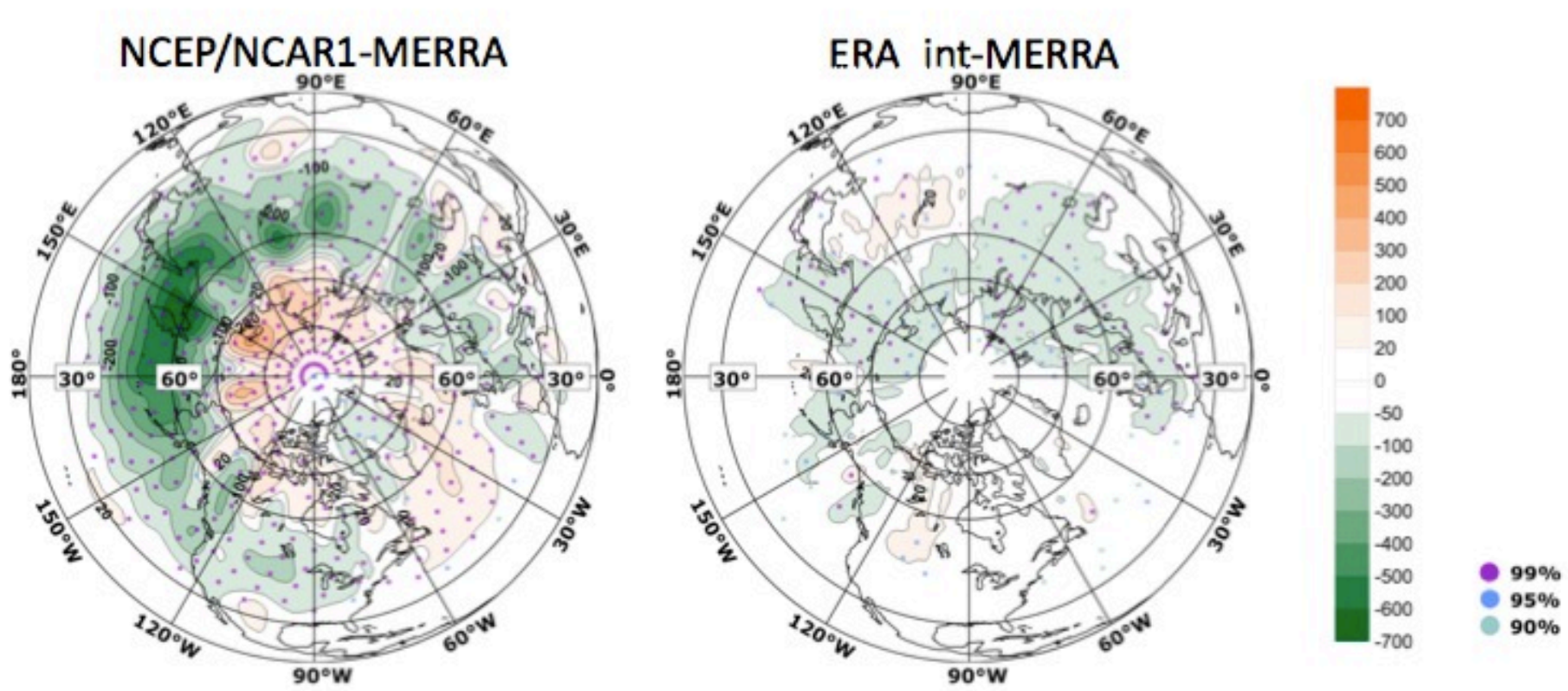


FIG. 1. The C [gpm^2] between geopotential height fields at 10 hPa and all pressure levels between 1000 and 10 hPa, for time lags ranging from −30 to 30 days. (a) Zonal mean, (b) deviations from zonal mean, (c) wave 1, and (d) wave 2. A positive time lag indicates that the stratospheric field is leading.

- Perlwitz and Harnik (2003) and subsequent papers: reflecting vs. absorption
- Shaw et al. 2013 wave index measures: comparison of wave 1 and 2 in troposphere and stratosphere

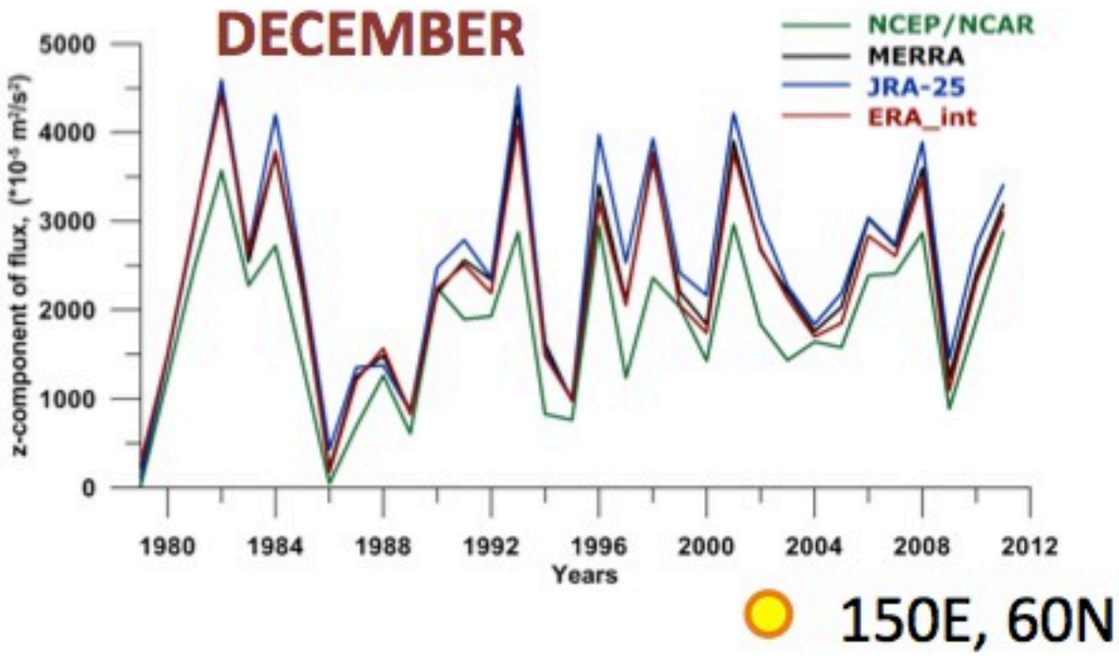
Diagnostics:
Wave Flux Analysis

Comparison of the climatology of the Plumb Flux for DECEMBER

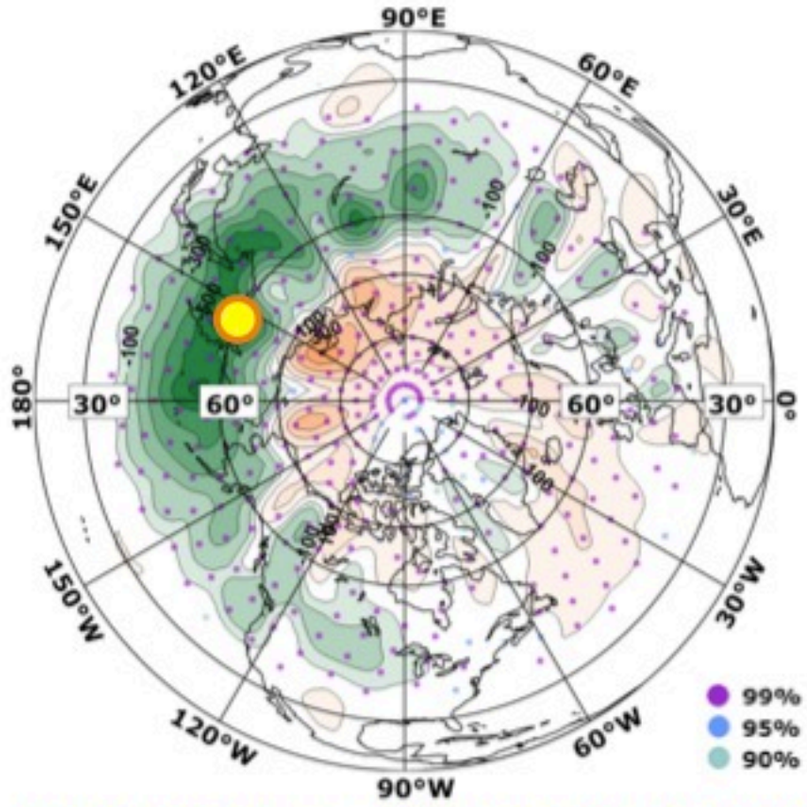


No significant differences in x and y components

Time series for z-component of the Plumb Flux



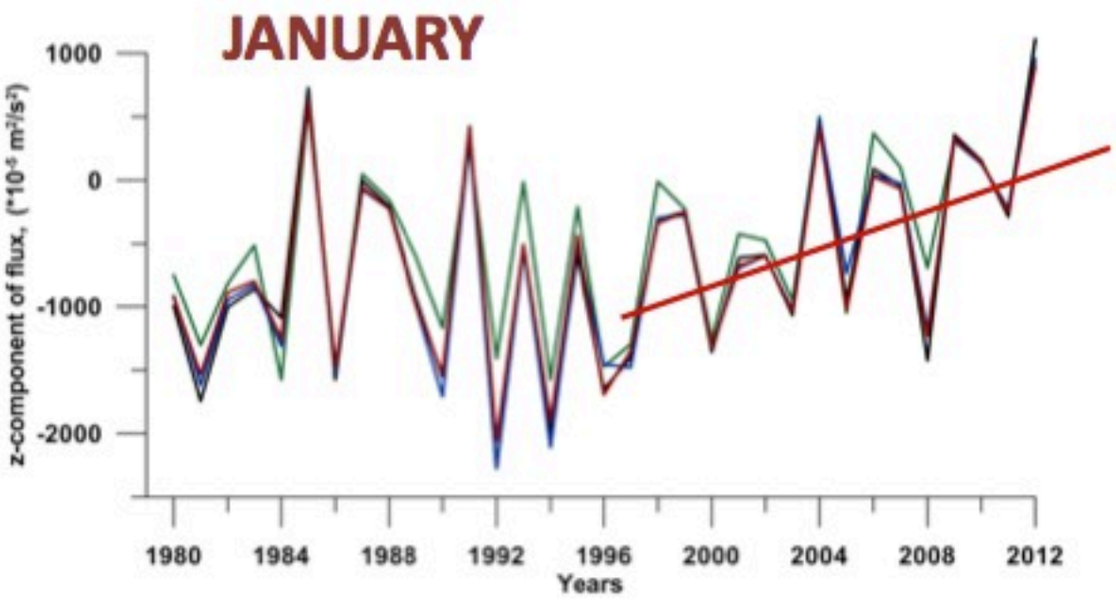
150E, 60N



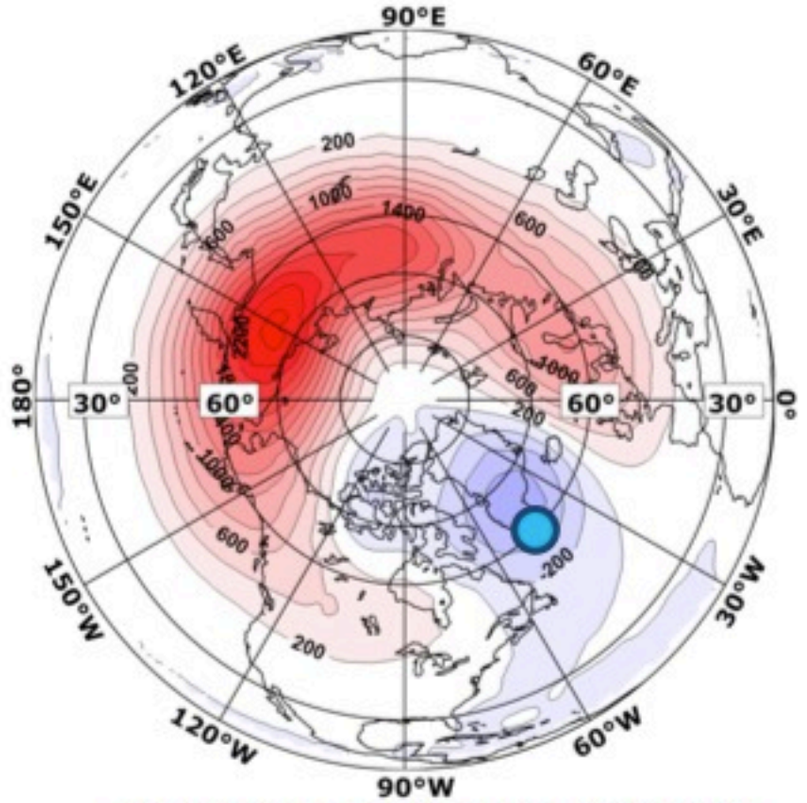
Differences for z-component for DECEMBER
NCEP/NCAR – ERA Interim

Key region for
Upward Flux

The biggest
differences



45W, 60N



33-year mean of the Fz, JANUARY
ERA Interim

Key region for
Downward Flux

Linear Trends of the z-component

% of the average values for 10 years

DECEMBER

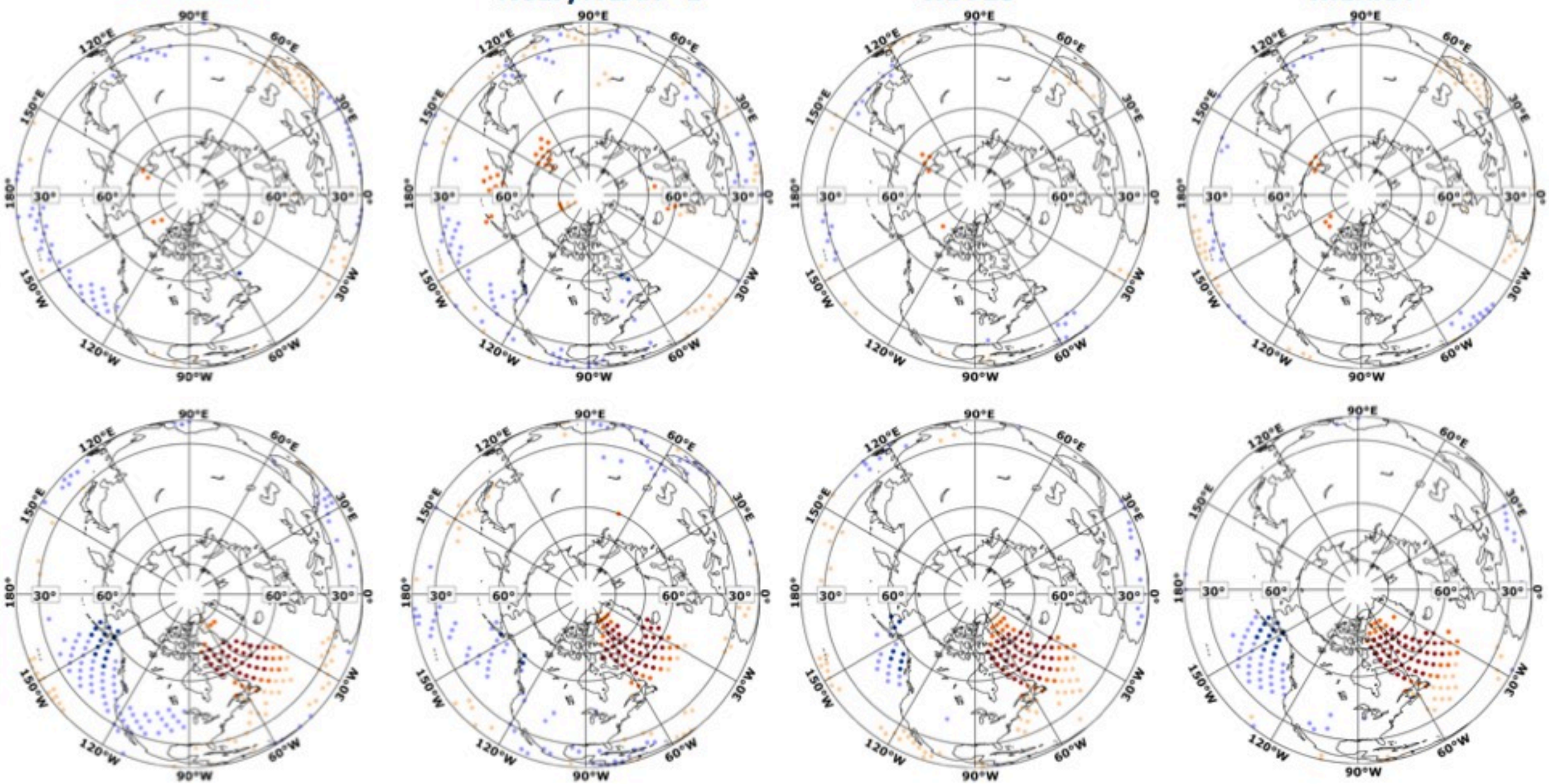
JANUARY

ERA_int

NCEP/NCAR - 1

JRA-25

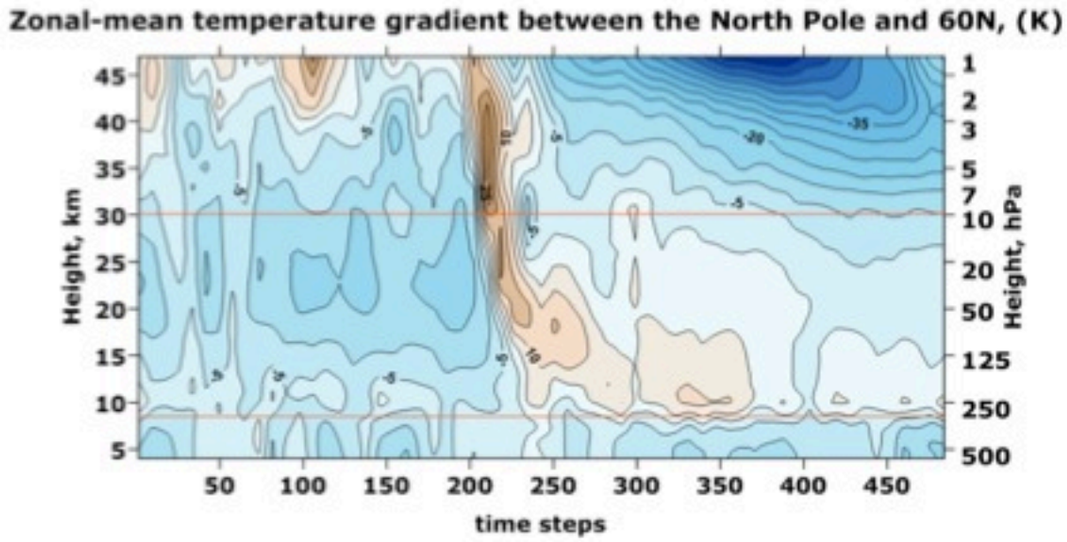
MERRA

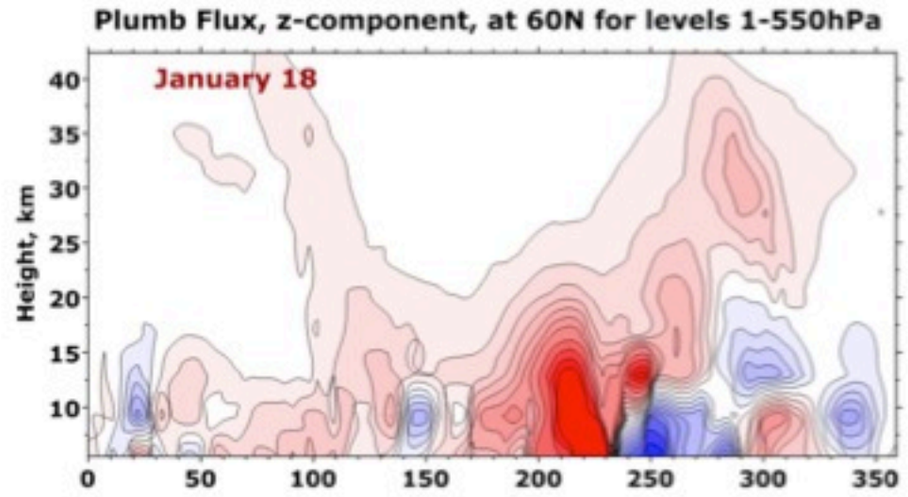


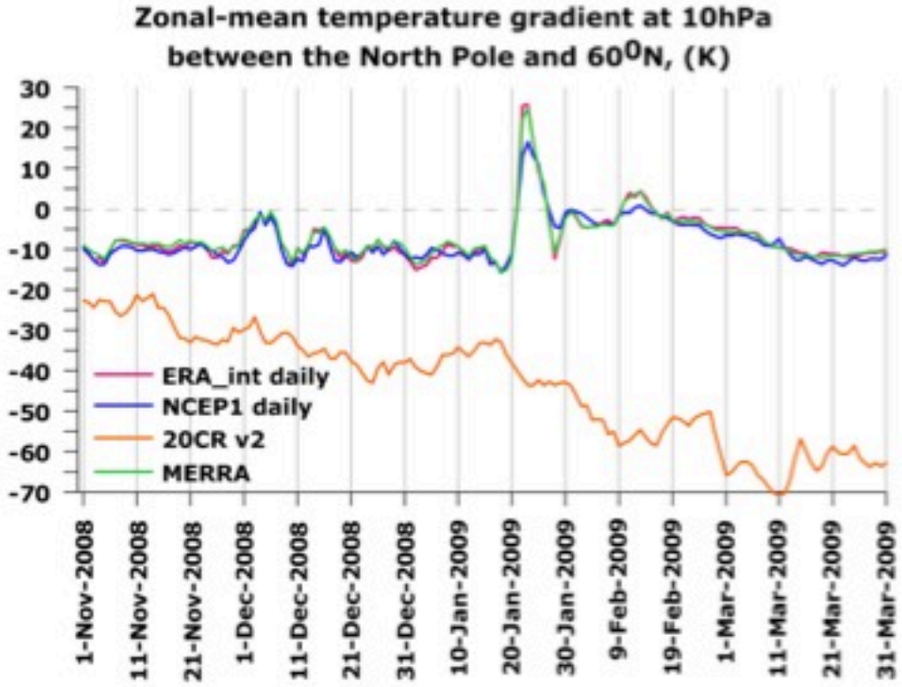
No significant trends for December over the Eastern Eurasia

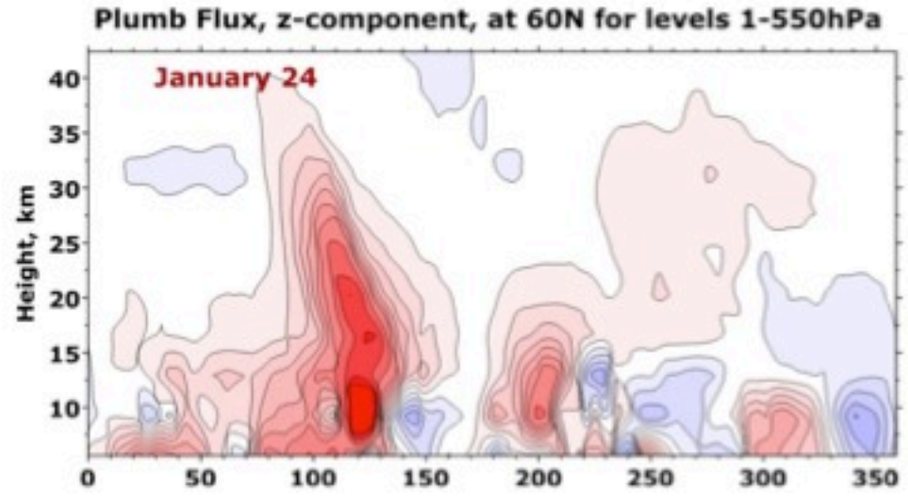
Positive trend in the Northern Atlantic means that downward propagation is getting weaker!

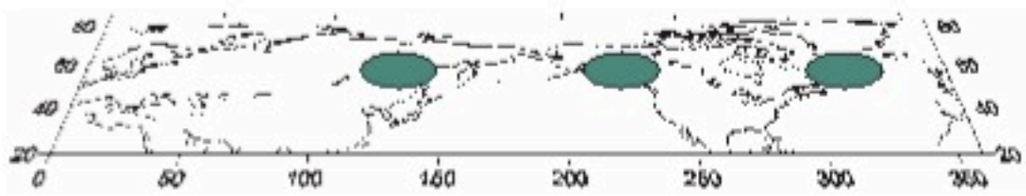
2009 case study









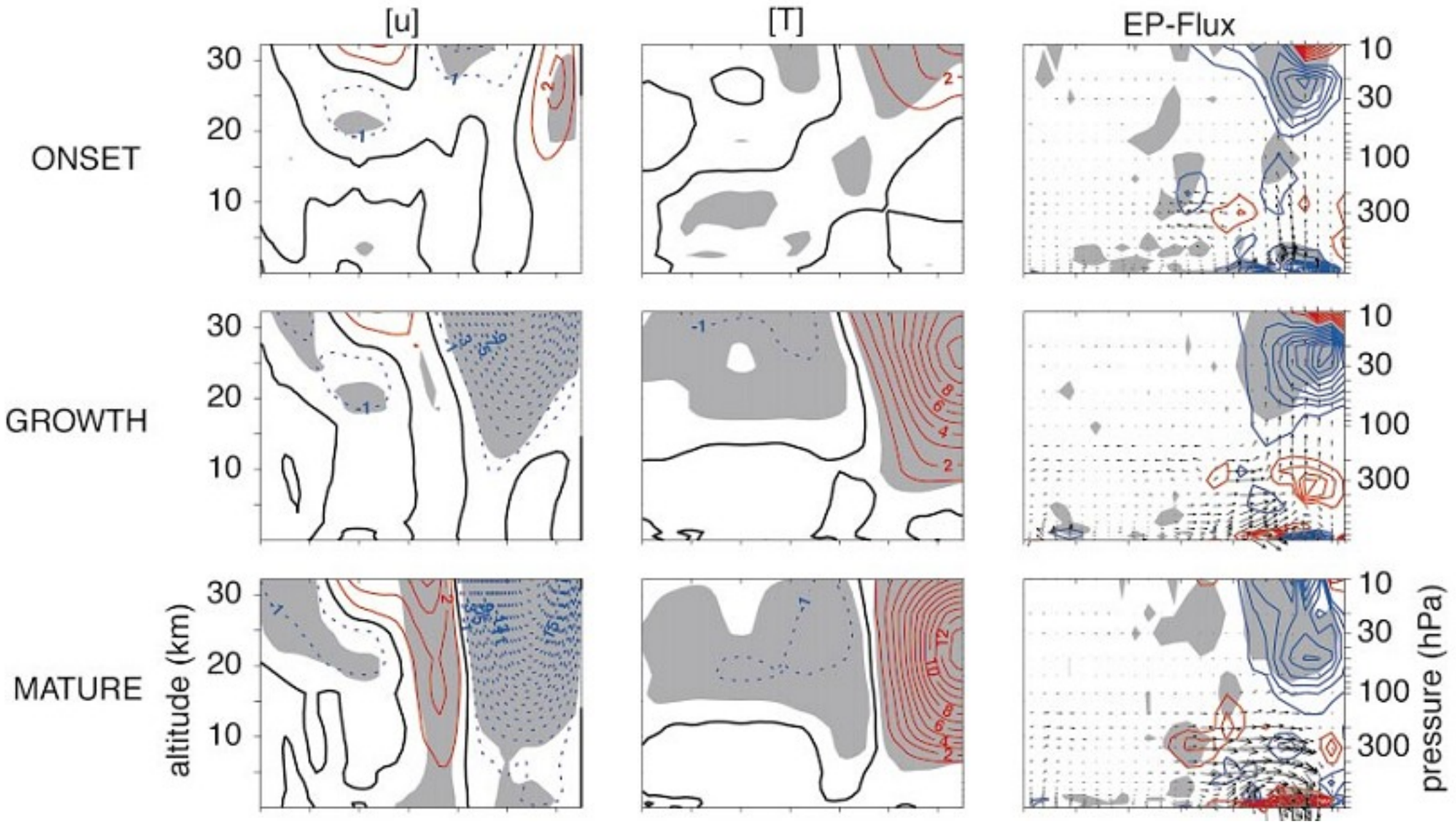


ERA_int, MERRA, NCEP 1 show good coincedence of representing this process. But 20CR don't reproduce it at all.

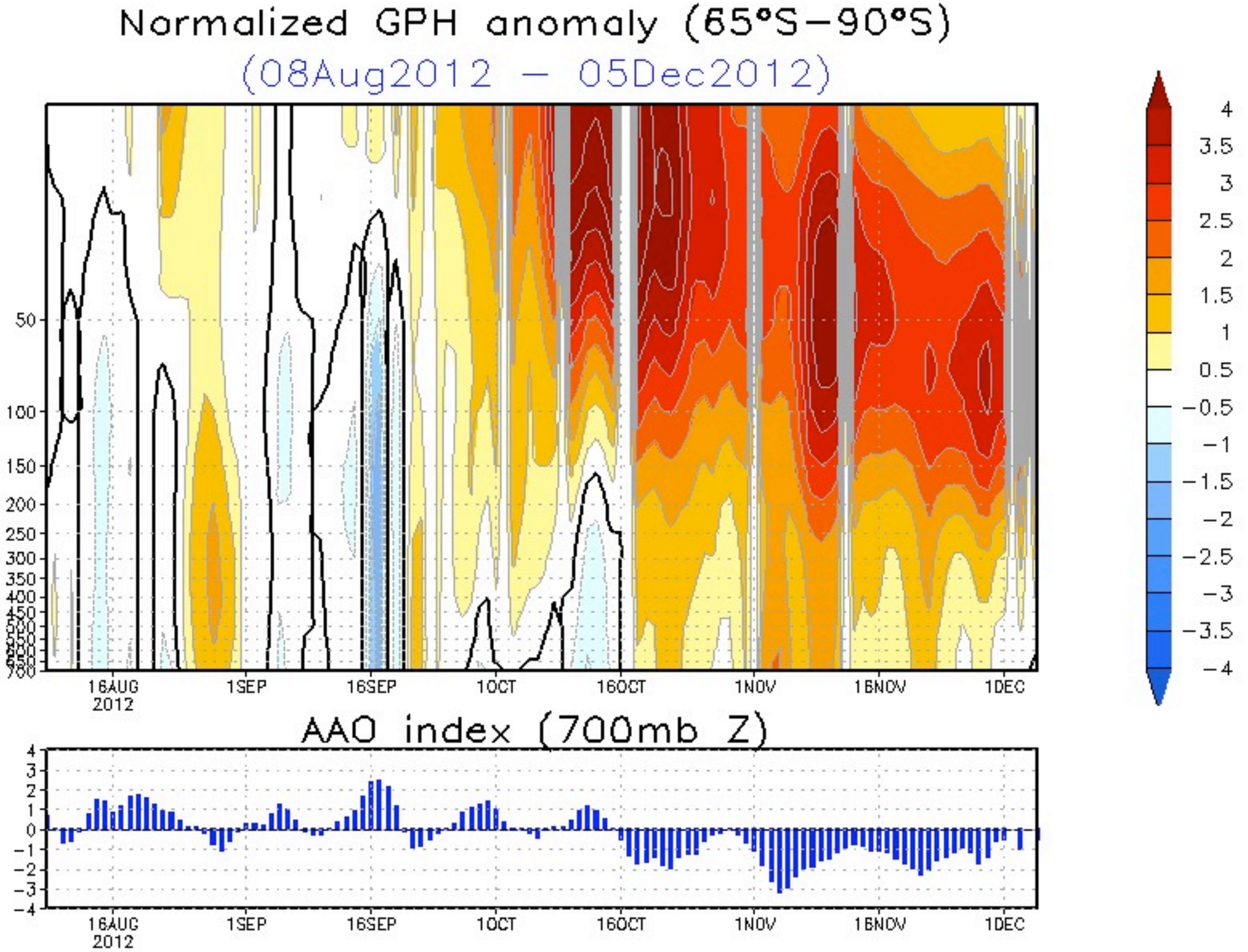
Diagnostics:
Sudden and Final Warmings, Polar Vortex Oscillations

- Definition of sudden and final warmings: WMO threshold vs. newer ideas
    - threshold on winds vs. temperature
    - displacement vs. split events
- Evaluation of events across data sets (update of Charlton and Polvani 2007)
    - separation between wave 1 and wave 2 warmings
    - quantify both intensity and persistent (polar vortex oscillations)
- Annular Mode Diagnostics (definitions, benchmark calculations)
- Connection between SSW/final warmings and tropospheric blocking
- Beyond the annular modes: tropopause height diagnostics (intraseasonal variability of the tropopause and how it couples to troposphere)

Diagnostics:
SSW Life cycle analysis



Diagnostics:
Dripping paint analysis (for both hemispheres)

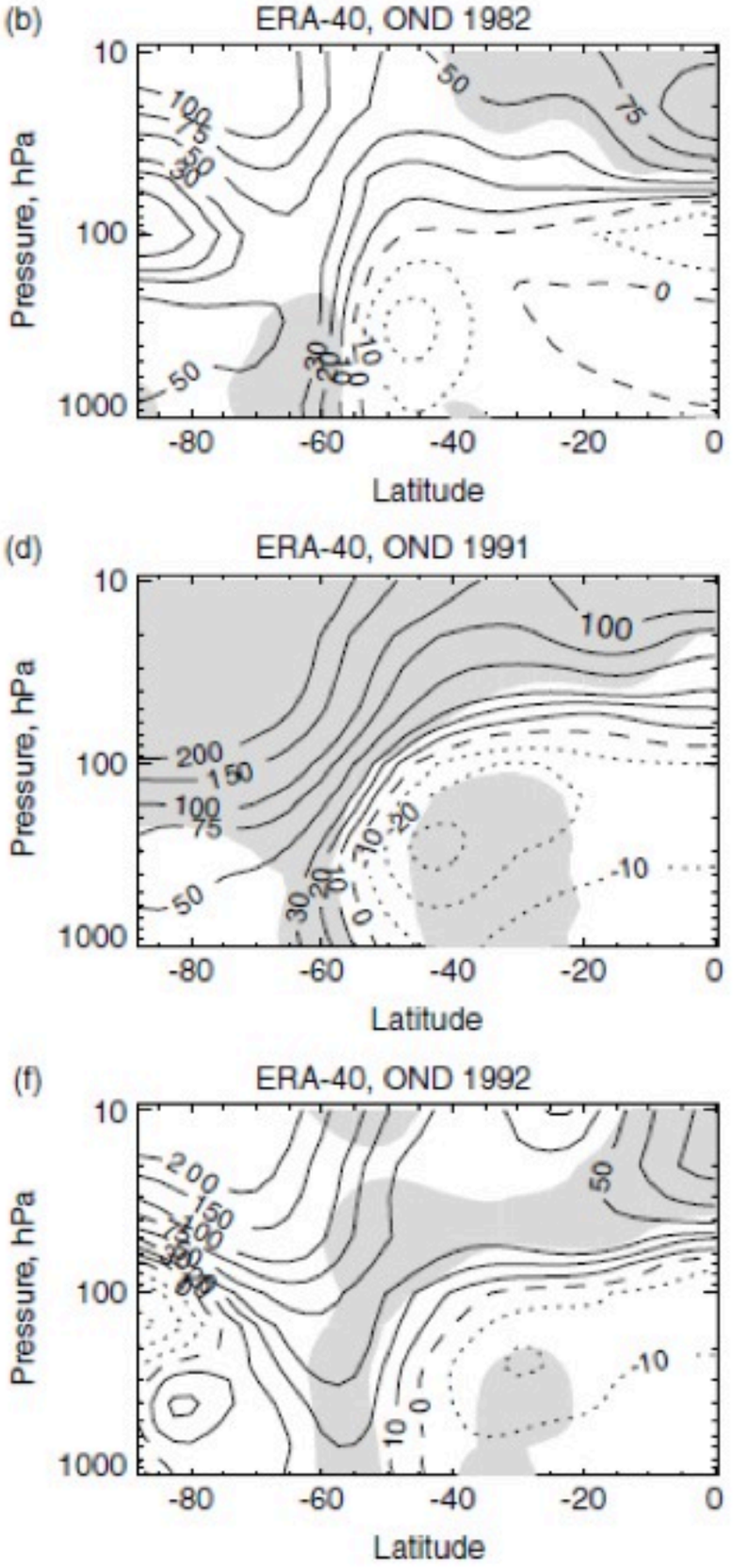


Diagnostics: Low frequency modulation of Intraseasonal Coupling

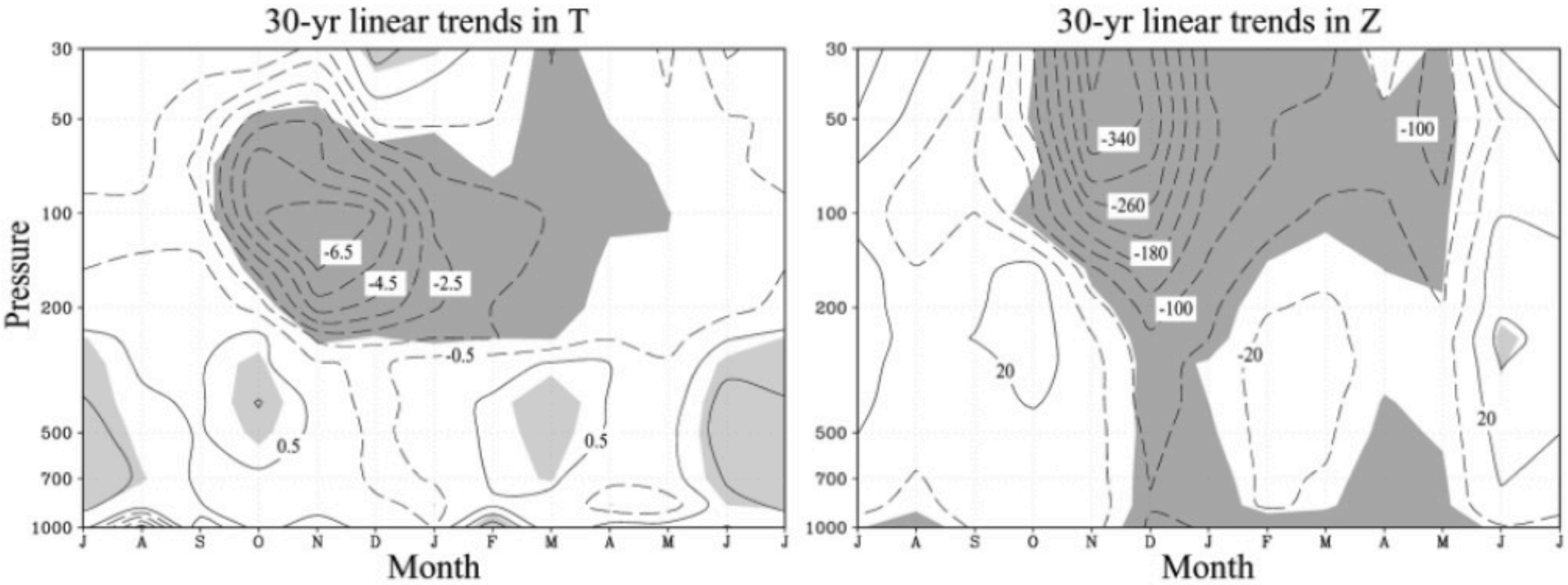
- ENSO impact on stratospheric variability (SSWs) and connection to surface weather
- Holtan-Tan effect (or will this be in the QBO chapter?)
- volcanic influence
- solar(?)
- influence of stratospheric trends (e.g. ozone) on troposphere

Response to volcanic eruptions

Reanalyses are often used to assess responses of the circulation to volcanic eruptions. Discrepancies in the response across reanalyses should be verified. The figure on the right is from our paper on SH responses (Karpechko et al. 2010, QJRMS). It shows Z in the OND seasons after El Chichon and Pinatubo. NH is of course even more important. See e.g. Charlton-Perez et al. 2013.



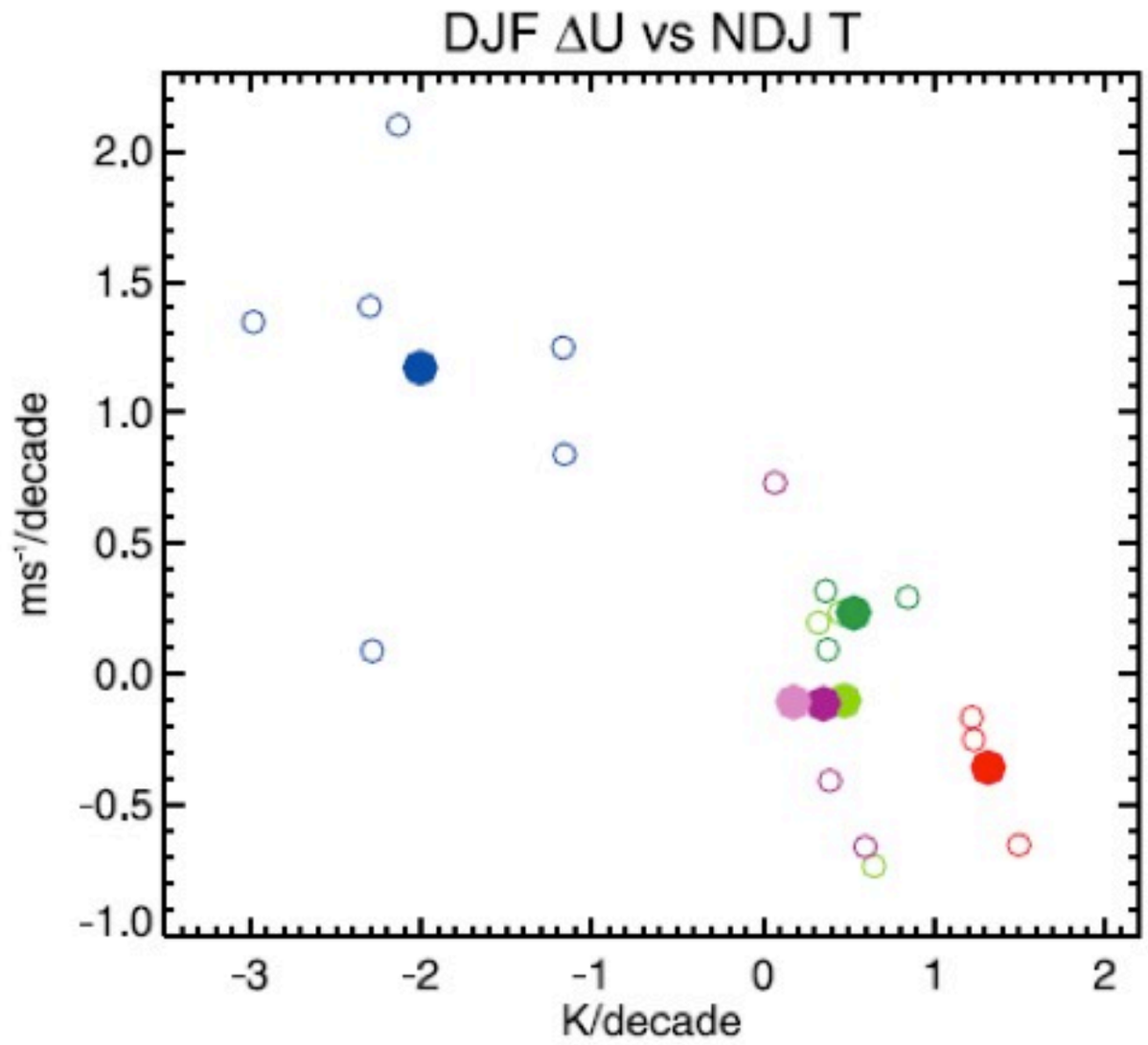
Downward propagation of trends



Thompson and Solomon 2002

This type of trend plots can be useful for our chapter. For reanalyses the period can be restricted to satellite era.

Summer jet changes vs spring cooling



Karpechko et al. 2010, JGR

Scatterplot of changes in summer tropospheric jet (500hPa) against spring stratospheric cooling (100hPa). Figure shows model results for ozone depletion and recovery simulations. How these type of diagnostics resolved in reanalyses?

Guidelines for analysis

- Period for direct intercomparison
    - ideally should be 1979-2012
    - can we extend ERA-40?!? 1979-2002 is very short
- Uncertainty due to finite time record will likely dwarf differences between reanalyses - but we must establish this carefully
- ssessing differences between pre- and post-satellite eras: Is intraseasonal coupling fairly uniform across the record?

Logistics - connections to other chapters

- consistent colors for each reanalysis (solid for modern, dashed for periods extending back to c. 1950, dot-dashed for 20th century?)
- common grid (which?) and interpolation (linear?) for *final* comparisons
- intermediate calculations on native grids (can be important for derivatives)
- getting the data: Masatomo has set up one page with all the links - *THANKS*!

Logistics - within the chapter

- organizing and coordinating work
    - co-authors propose what they would like to do (crowd sourcing!)
    - lead authors will organize an overall outline, seek volunteers to fill in holes
        - make standard indices available on working website, to ease comparisons: may be particularly useful for those working on interannual influences (coordinate with QBO chapter ...)
- By late June (AMS Middle Atmosphere Meeting) consolidate a first order outline of the project
- will see updates from co-authors on a 6 (?) month time scale
- informal side meetings (i.e. over lunch) at conferences/workshops

Chapter 6: Stratosphere-Troposphere Coupling Tentative state of the chapter

- Our scope
    - Extratropical coupling on daily to intraseasonal time scales
    - Modulation of this coupling on interannual time scales: ENSO, AMOC, solar forcing, volcanoes, QBO (???), trends
- Audience and approach
    - for reanalysis centers: key metrics and comparison of reanalyses
    - for data users: suggested definitions, benchmarks, and assessment of agreement/disagreement between various reanalyses (what can we trust? where must one be cautious?)
- Diagnostics: wave coupling (PW indices, E-P fluxes), zonal mean flow metrics (annular modes, PV/tropopause), and low frequency variations thereof
- Guidelines for our analysis
    - validate over common period (1979-2012, we hope)
    - compare pre- and post-satellite periods (as available)
- Schedule + Logistics: start soon, operating on 6 month time scale, set up working website to share standardize indices and analysis scripts