Diagnostics of the troposphere-stratosphere interaction using the 3D Eliassen-Palm (Plumb) flux in different reanalyses

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1. The “Stratospheric bridge” concept
2. Methodology - using vertical component of E-P flux
3. Q: How capable different modern era reanalysis of replicating this mechanism?
4. Comparative assessment using ERA-Interim, MERRA, NCEP/NCAR1 and JRA-25
5. Conclusions

Concept

North Pacific SST anomalies **DECEMBER**

Planetary wave propagation **DECEMBER**

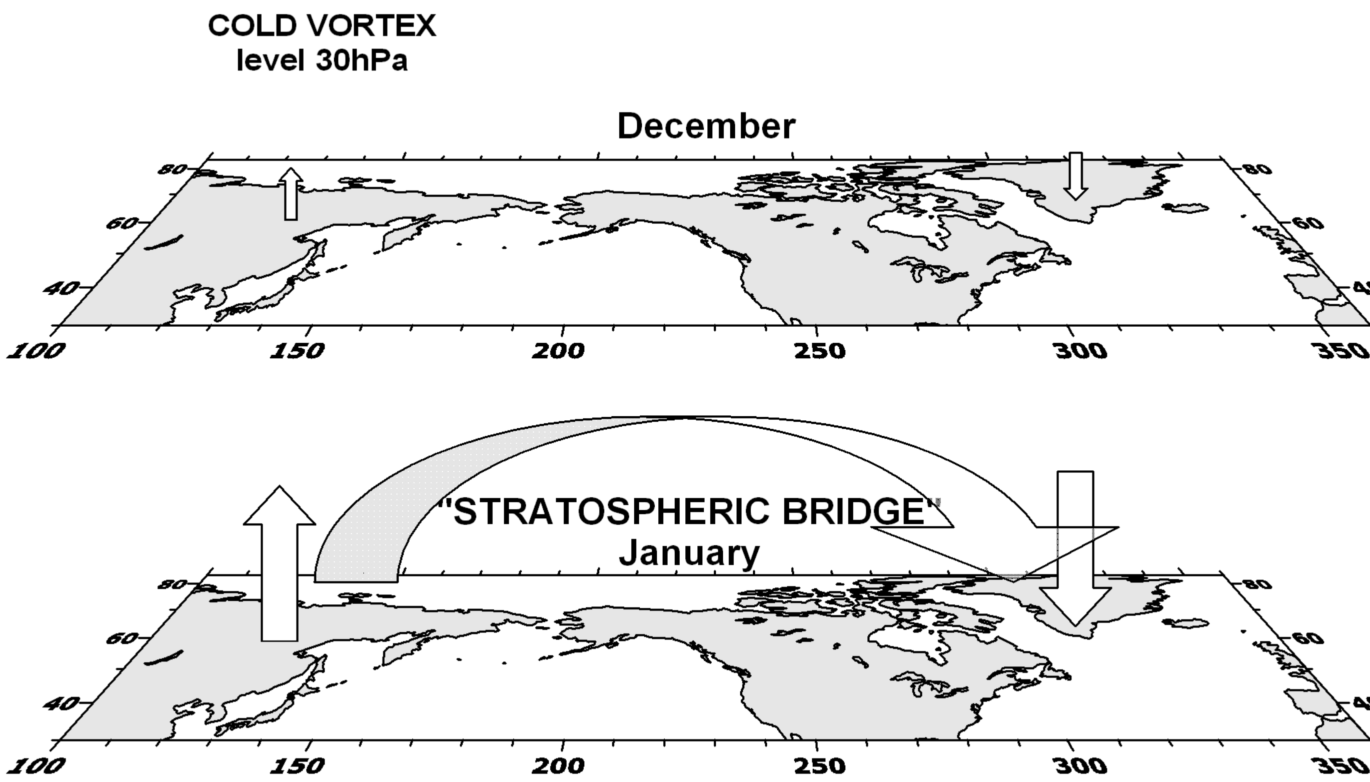
Stratospheric dynamics **JANUARY**, SSW

Downward propagation of the signal associated with EP-Flux **JANUARY**

Tropospheric synoptic processes

Scheme of the upward and downward wave propagation

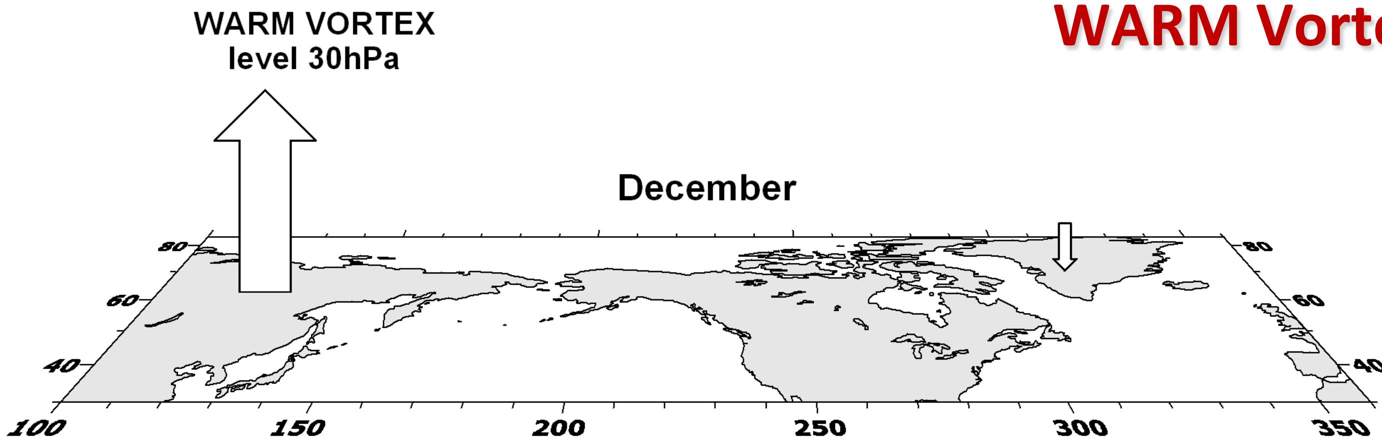
COLD Vortex



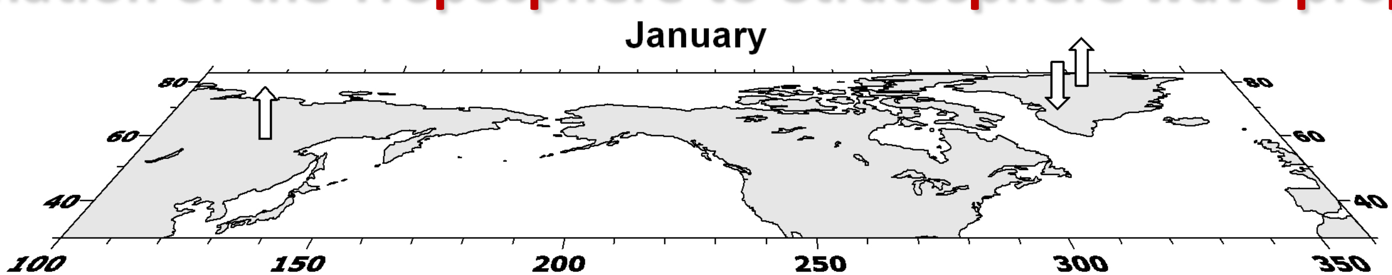
Zyulyaeva, Yu.A., Jadin, E.A., 2008. Analysis of three - dimensional Elliassen-Palm fluxes in the lower stratosphere, *Russian Meteorology and Hydrology, 2009, N 8, pp. 5-14*

Scheme of the upward and downward wave propagation

WARM Vortex



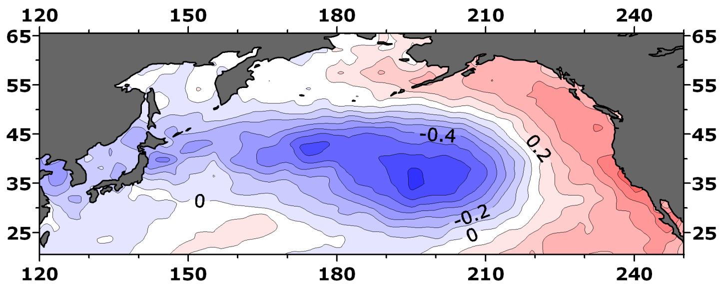
Termination of the Troposphere-to-Stratosphere wave propagation



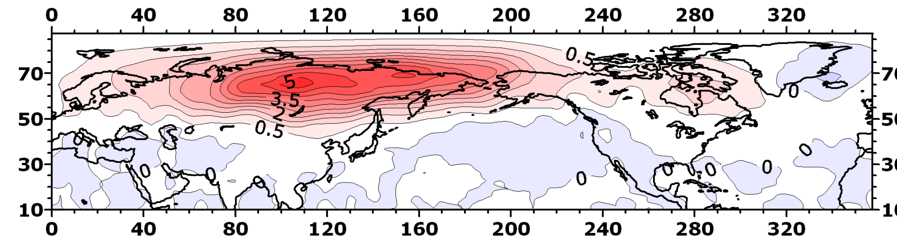
Zyulyaeva, Yu.A., Jadin, E.A., 2008. Analysis of three - dimensional Elliassen-Palm fluxes in the lower stratosphere, *Russian Meteorology and Hydrology, 2009, N 8, pp. 5-14*

Relations between EPz-Flux and SST anomalies

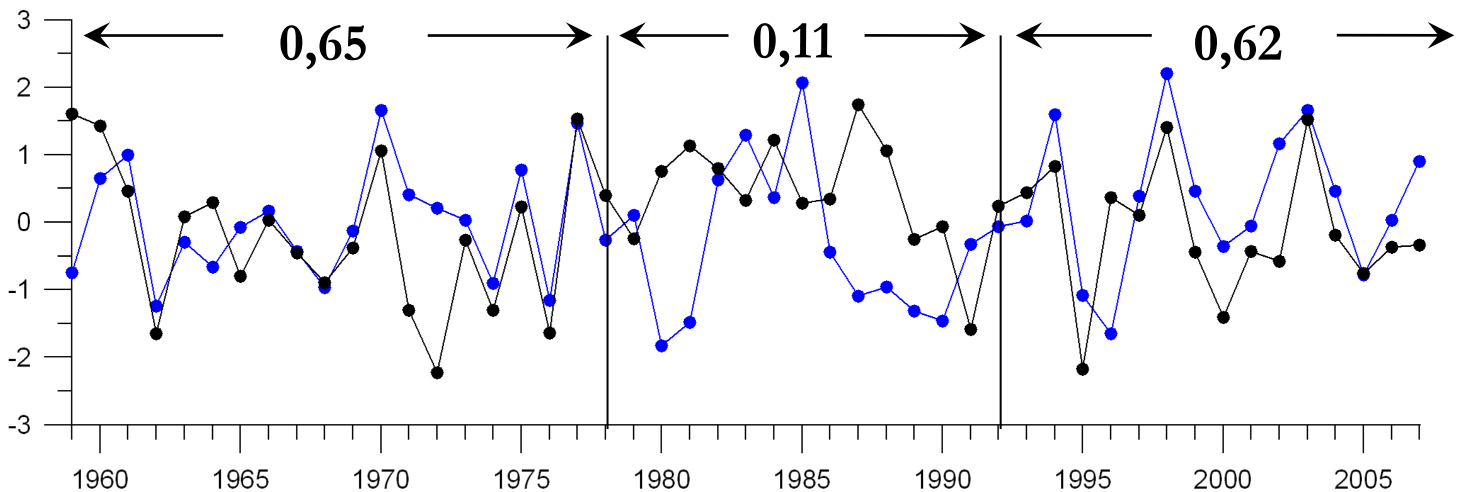
December - December



1st EOF for SST



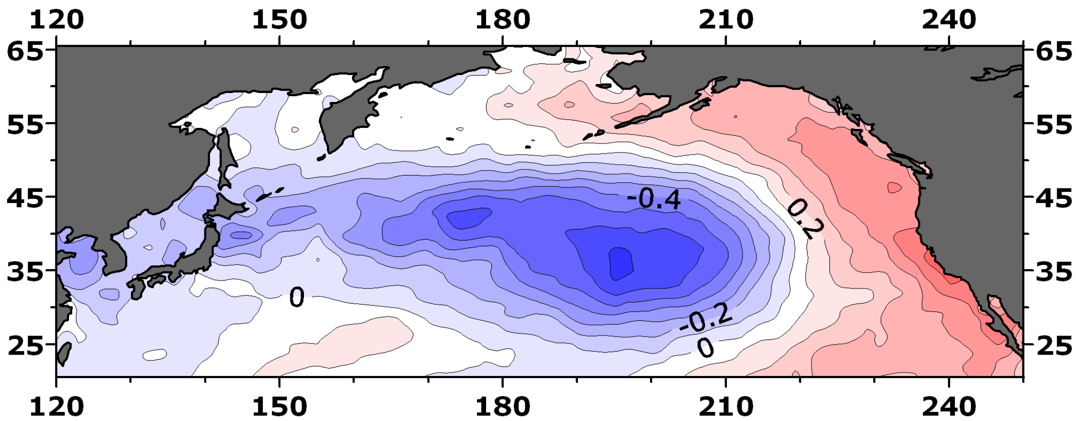
1st EOF for F_z



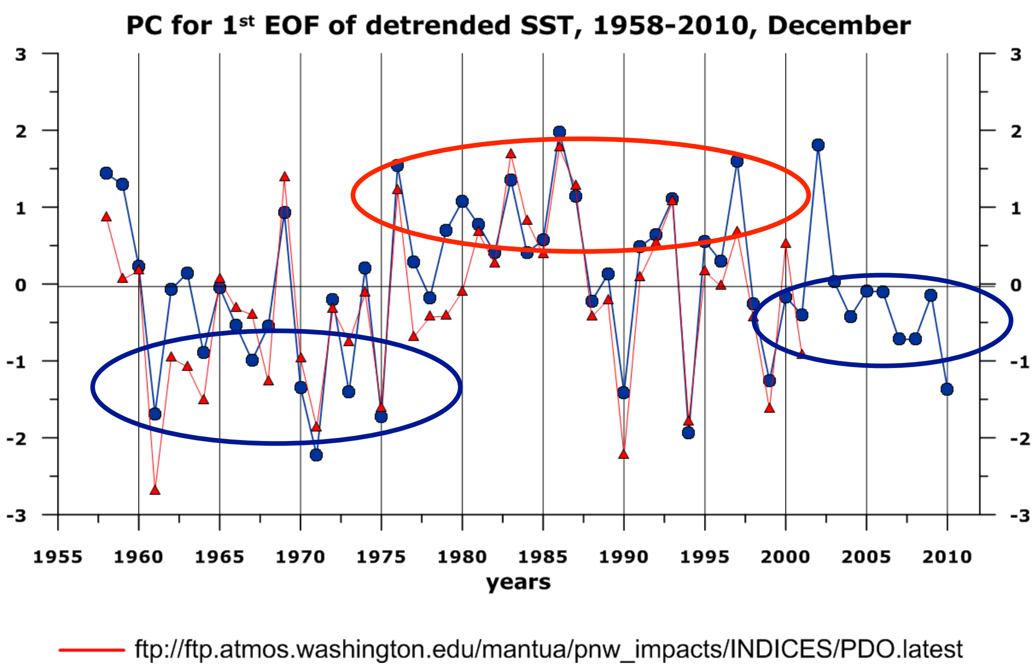
PCs for the 1st EOF of SST and F_z

Evgeny A. Jadin, Ke Wei, Yulia A. Zyulyaeva, Wen Chen, Lin Wang, Stratospheric wave activity and the Pacific Decadal Oscillation, *Journal of Atmospheric and Solar-Terrestrial Physics 72 (2010) 1163–1170*

The Pacific Decadal Oscillation



1st EOF for SST



PCs for the 1st EOF of SST

Methodology

$$\frac{\partial \bar{u}}{\partial t} - f\bar{v}^* = \nabla \bullet \vec{F}$$

As proposed by **Eliassen and Palm** (1961)[1]

$$\vec{F} = \begin{pmatrix} -\overline{u'v'} \\ \frac{2\Omega \sin\varphi}{S} \times \left[\overline{v'T'}\right] \end{pmatrix}$$

If zonal averages are taken

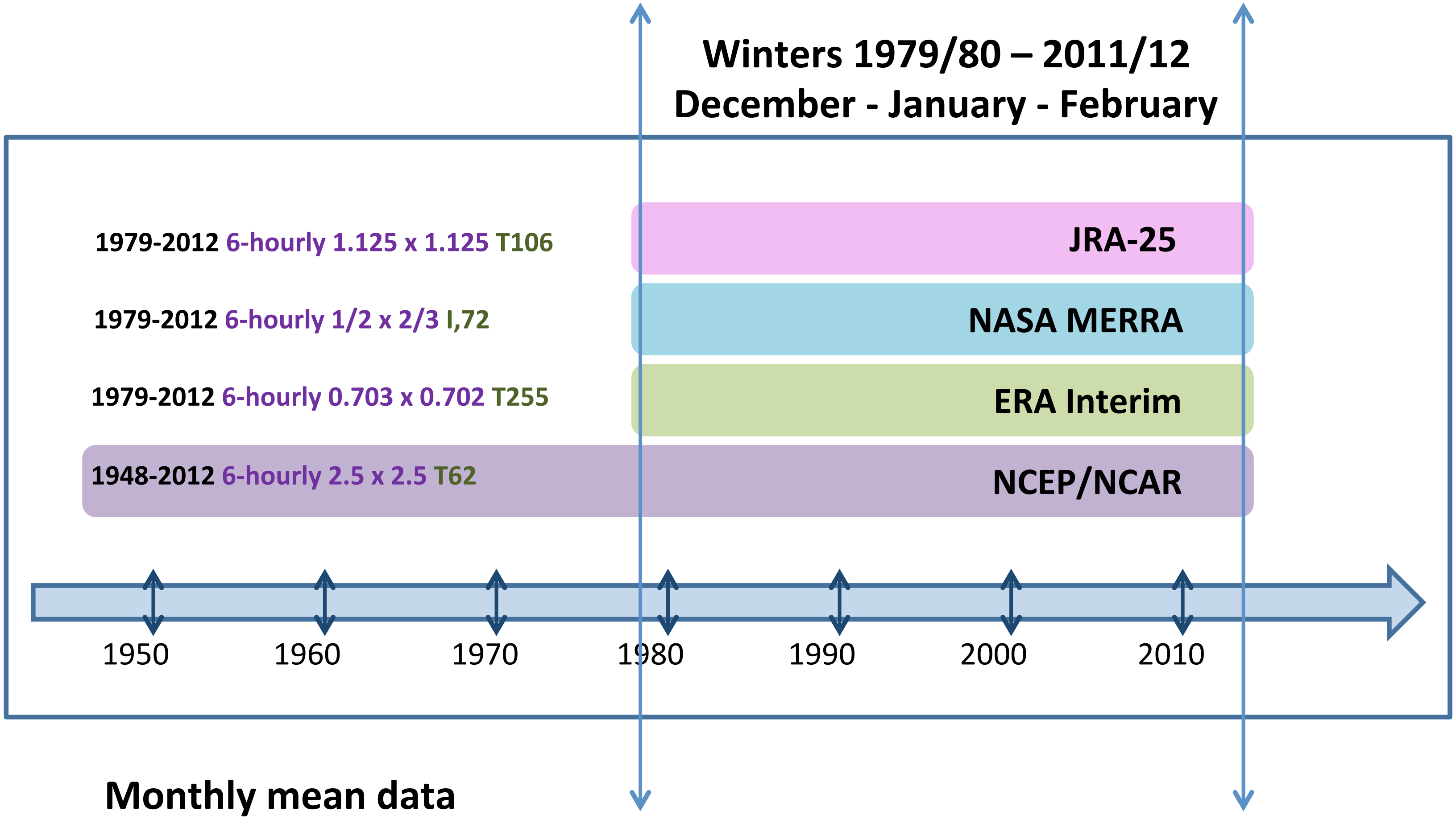
$\vec{F}_s$ reduces to the $\vec{F}$

As proposed by **Plumb** (1985)[2]

$$\vec{F}_s = \frac{p}{p_0}\cos\varphi \times \begin{pmatrix} v'^2 - \frac{1}{2\Omega a \sin 2\varphi}\frac{\partial(v'\phi')}{\partial\lambda} \\ -u'v' + \frac{1}{2\Omega a \sin 2\varphi}\frac{\partial(u'\phi')}{\partial\lambda} \\ \frac{2\Omega \sin\varphi}{S} \times \left[v'T' - \frac{1}{2\Omega a \sin 2\varphi}\frac{\partial(T'\phi')}{\partial\lambda}\right] \end{pmatrix}$$

1) Eliassen, A. and E. Palm,1961: On the transfer of energy in stationary mountain waves. *Geofys. Publ., No. 3, 1-23*
2) Plumb, R.A., 1985: On the three-dimensional propagation of stationary waves. *J. Atmos. Sci., 42, 217-229*

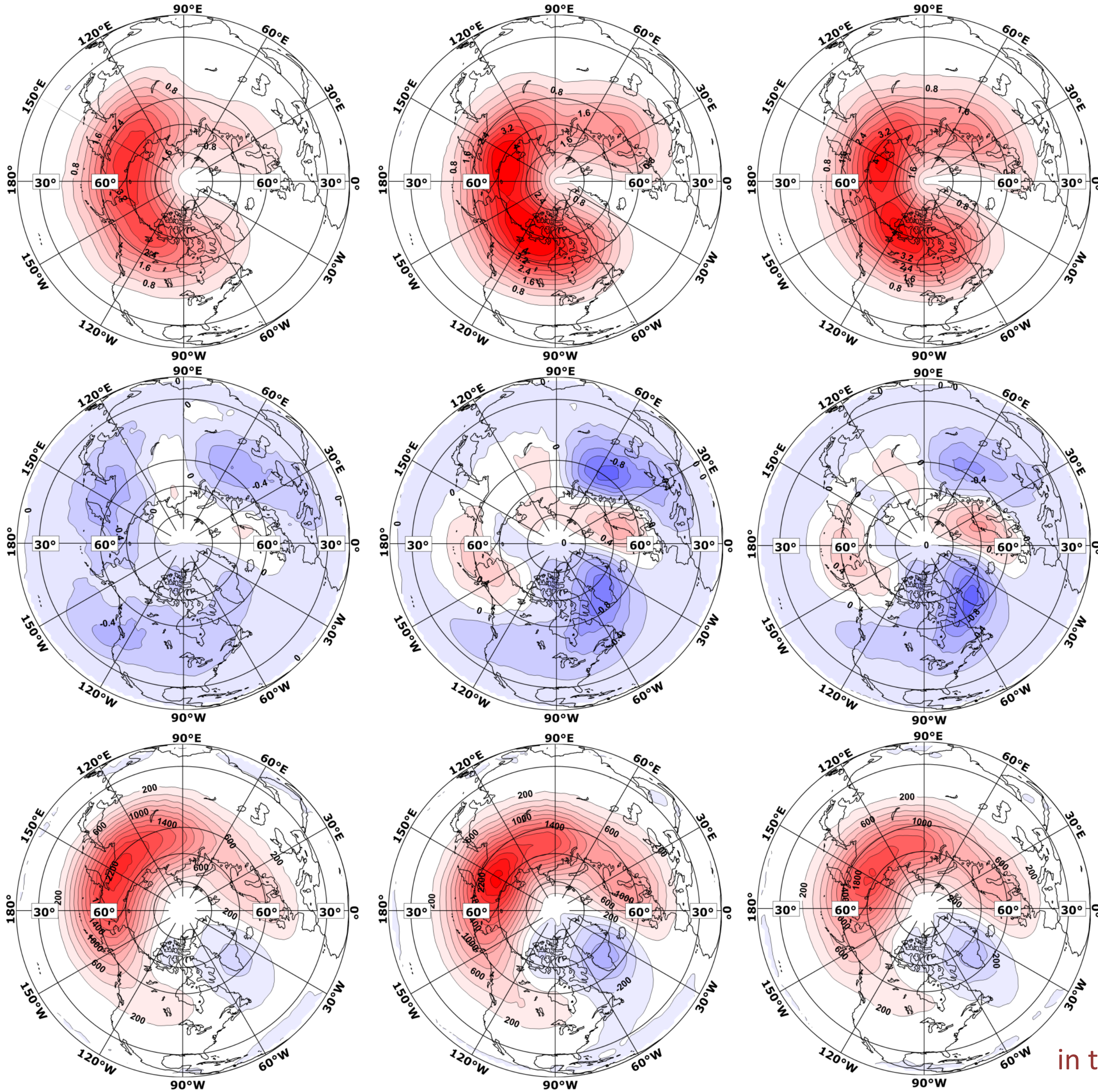
DATA



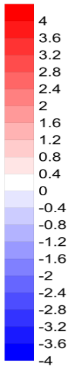
Monthly mean data

Climatology ERA_int

December, 1979-2011 | January, 1980-2012 | February, 1980-2012

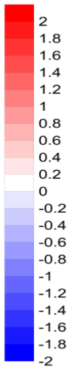


Fx



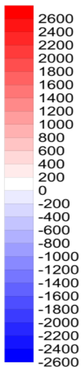
Positive x-component
eastward propogation

Fy



Negative y-component
equatorward propagation

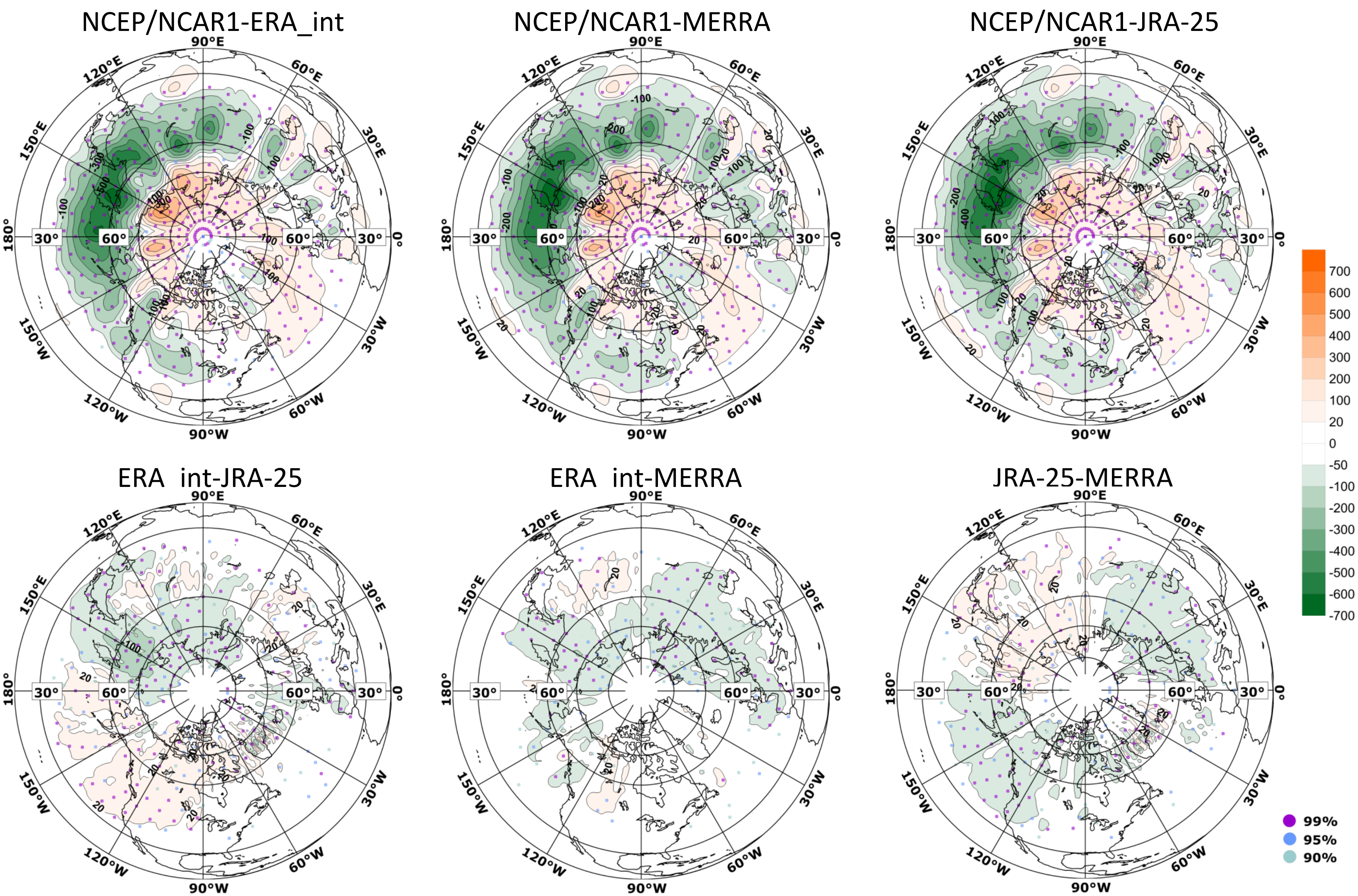
Fz



Positive z-component
upward propagation

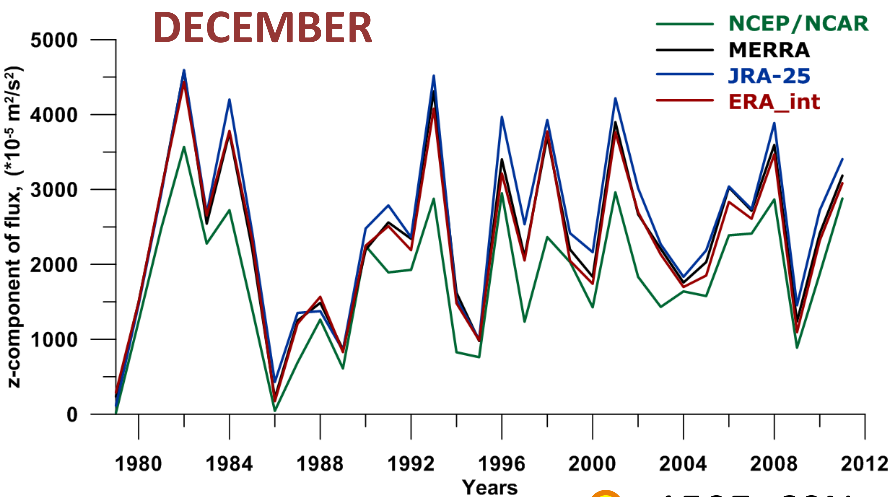
Imporatant!
Negative values
in the Northern Atlantic region

Differences for z-component for DECEMBER

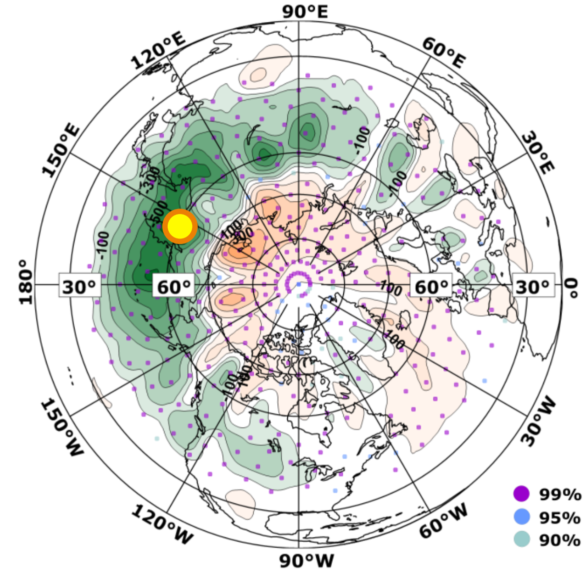


No significant differences in x and y components

Time series for z-component of the Flux



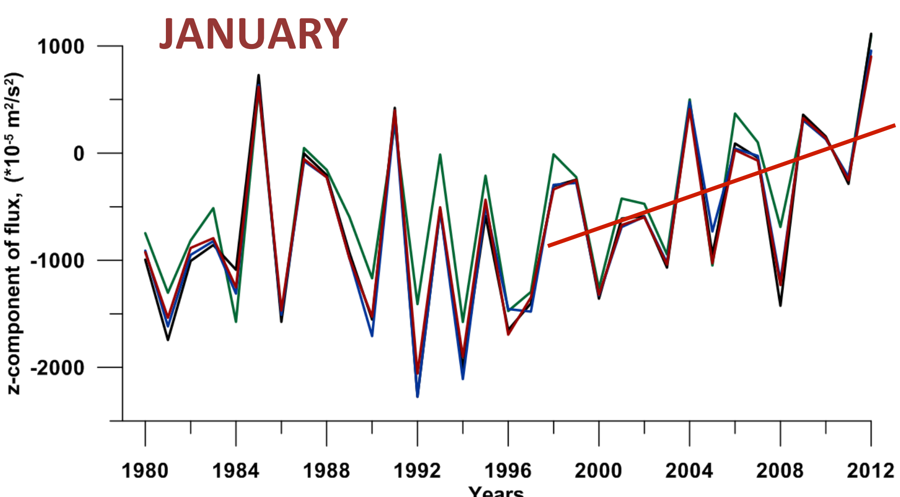
150E, 60N



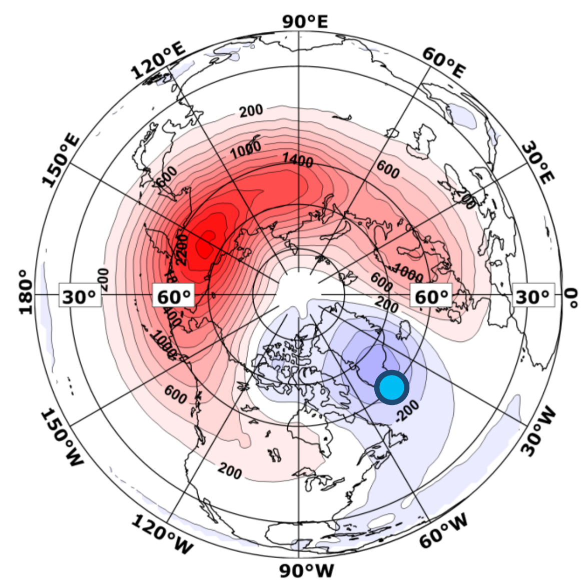
Key region for **Upward Flux**

The bigest differences

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



45W, 60N

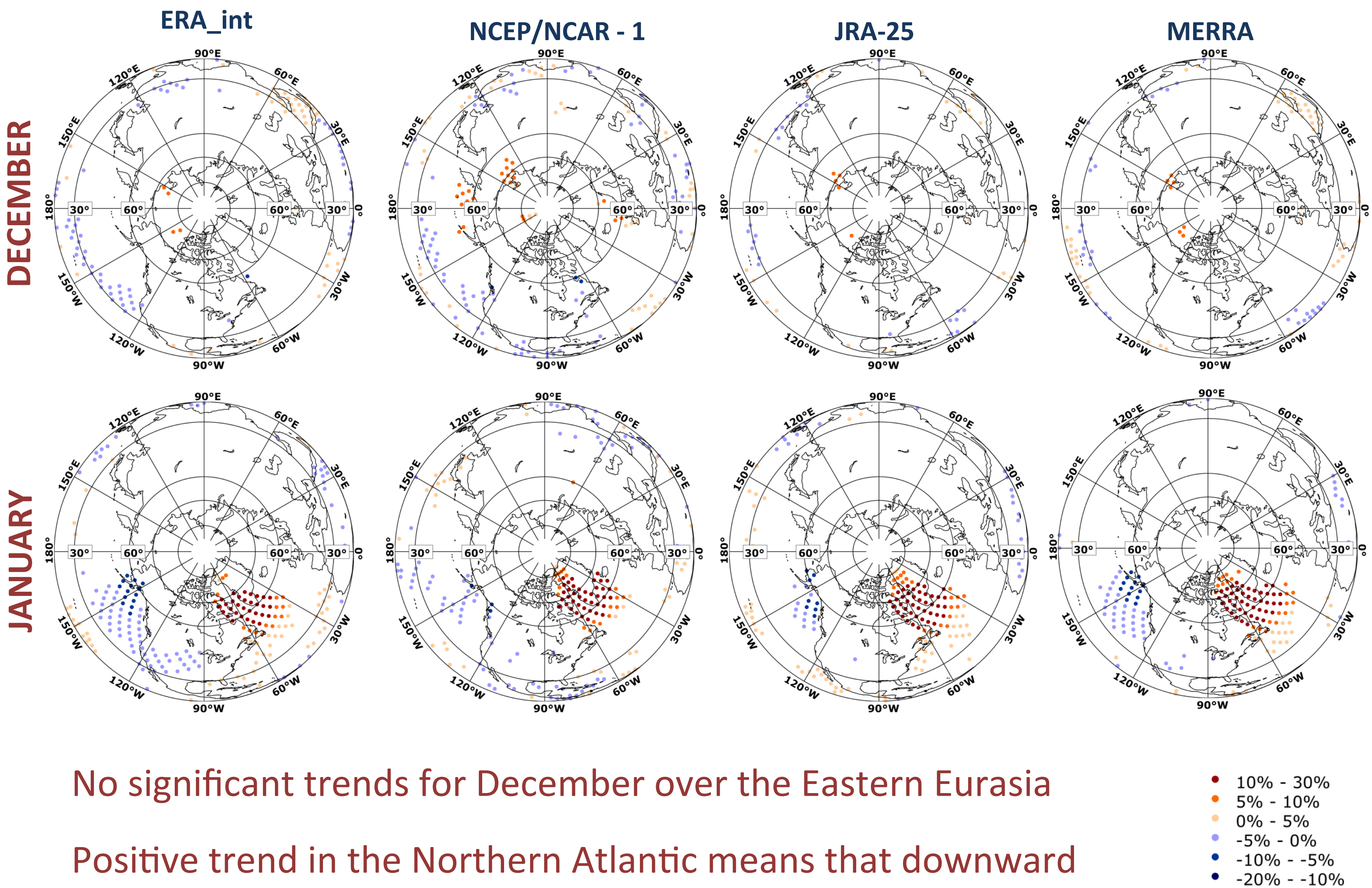


Key region for **Downward Flux**

33-year mean of the Fz, JANUARY
ERA Interim

Linear Trends of the z-component

% of the average values for 10 years

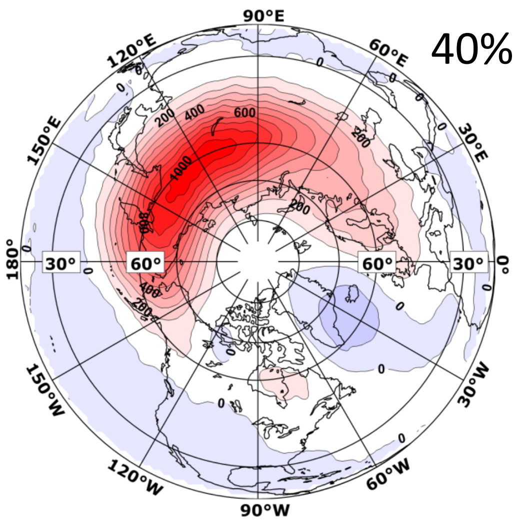


No significant trends for December over the Eastern Eurasia

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

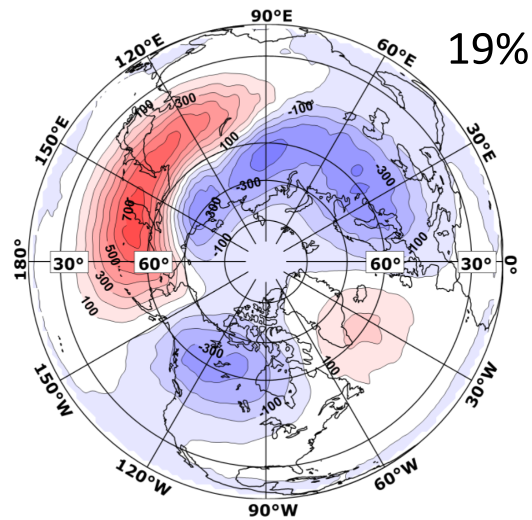
EOF for ERA Interim

Intensification



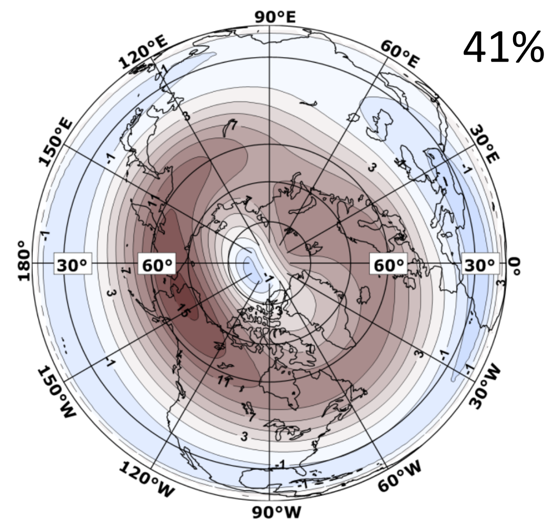
1 EOF of the Fz 30hPa, December

Displacement

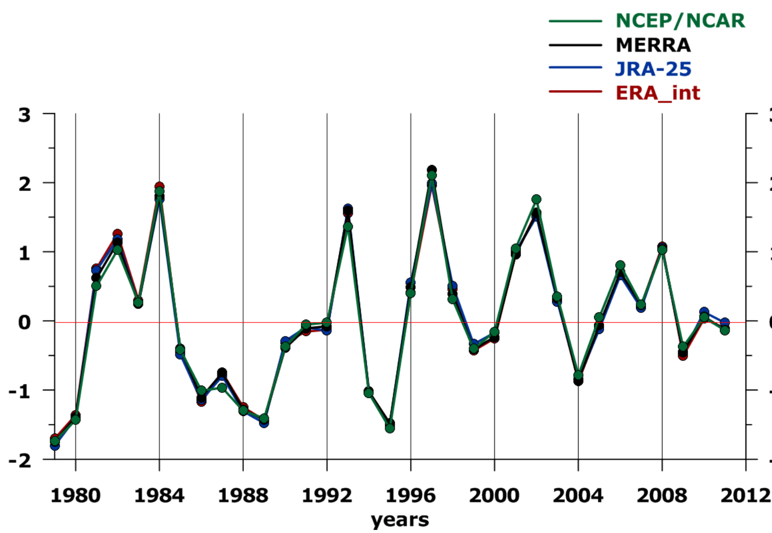


2 EOF of the Fz, December

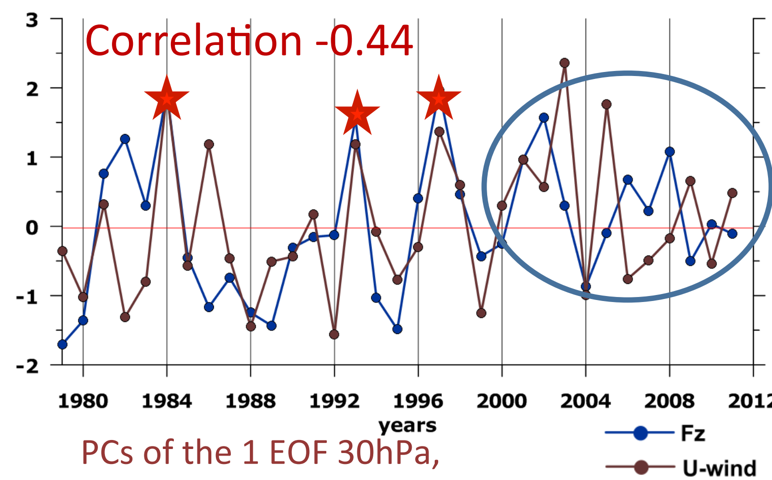
Polar night Jet pattern



1 EOF of the U-wind, January



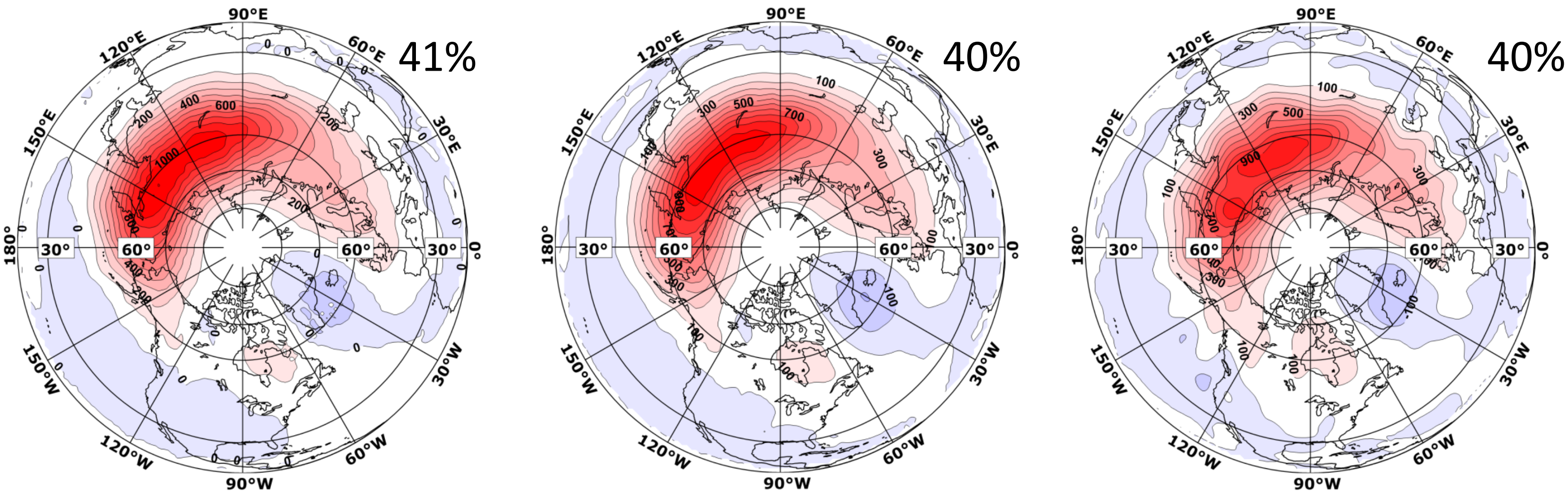
PC of the 1 EOF of the Fz 30hPa, December



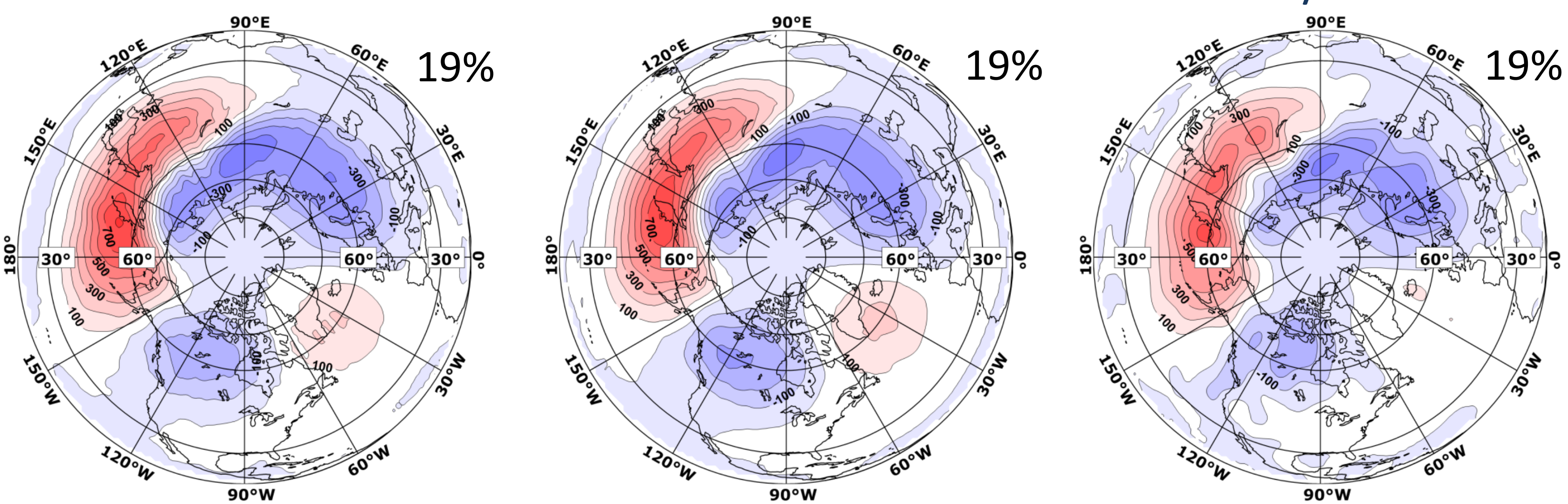
PCs of the 1 EOF 30hPa,
Fz – December, U-wind - January

EOFs

1 EOF of the Fz 30hPa, December



JRA-25 | **MERRA** | **NCEP/NCAR - 1**



2 EOF of the Fz, December

Conclusions

✓ **Qualitatively** all four reanalysis adequately replicate the stratospheric bridge connecting the North Pacific and the North Atlantic.

✓ **Quantitatively** there are significant differences in absolute values of the vertical component of E-P flux across different reanalysis.

I.e. NCEP/NCAR-1 underestimates the vertical component of E-P flux compared to the other reanalyses that can be associated with the computation of the coefficient of the static stability in this reanlysis.

✓ **Linear trends** in the vertical component of E-P flux are in a high agreement across different products.

✓ **EOF analysis** confirms a close consistency of E-P flux in different products

In Progress

1. Extend the comparison to NCEP-CFSR, NCEP-DOE and potentially to the ASR (Arctic System reanalysis)

2. Work with daily (and finer resolution data) → timing of the events

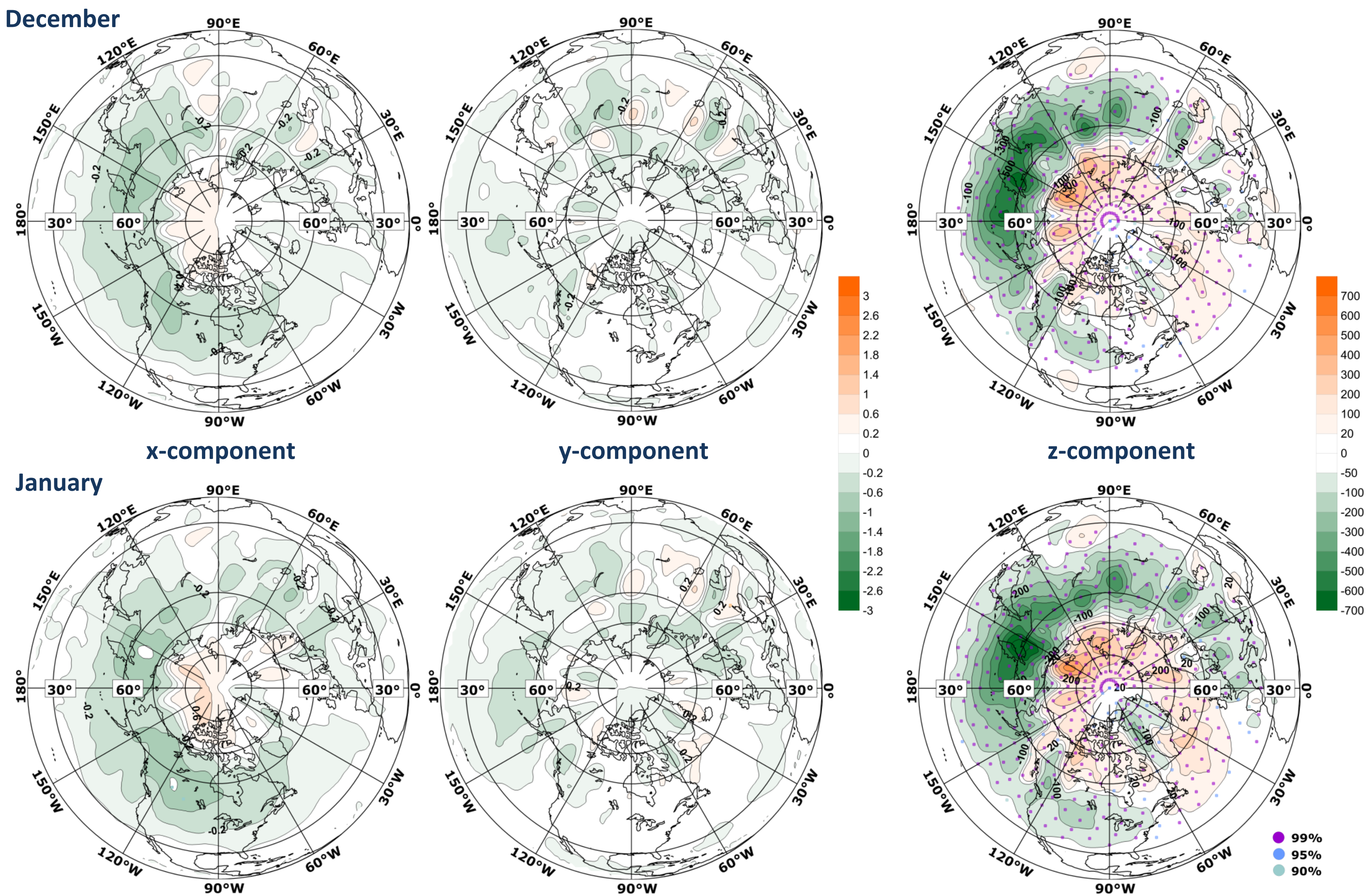
3. Case studies (e.g. 2009, 2010 winters)

4. Impact of the downward E-P flux in the Atlantic on the blocking activity

Thank you

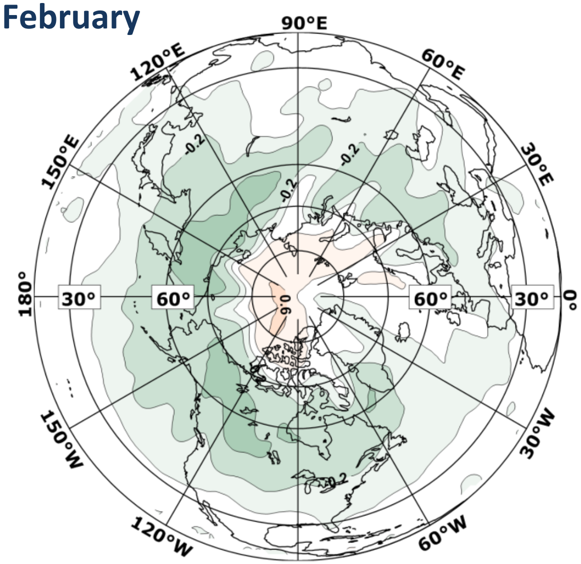
Differences NCEP1 – ERA_int

No significant differences in x and y components

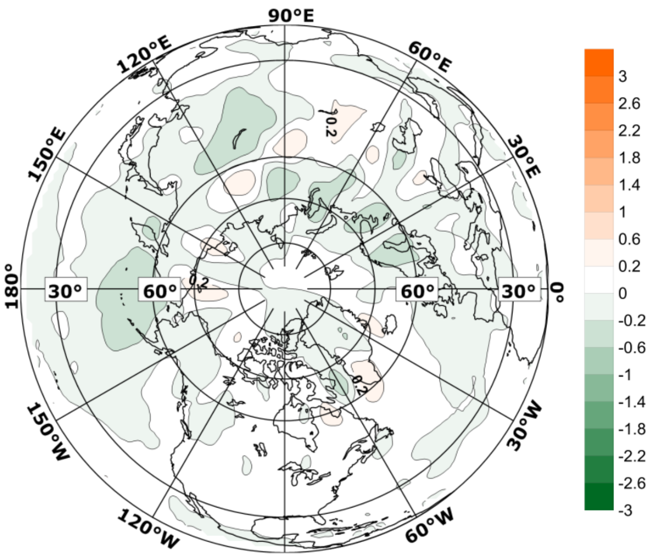


Differences NCEP1 – ERA_int

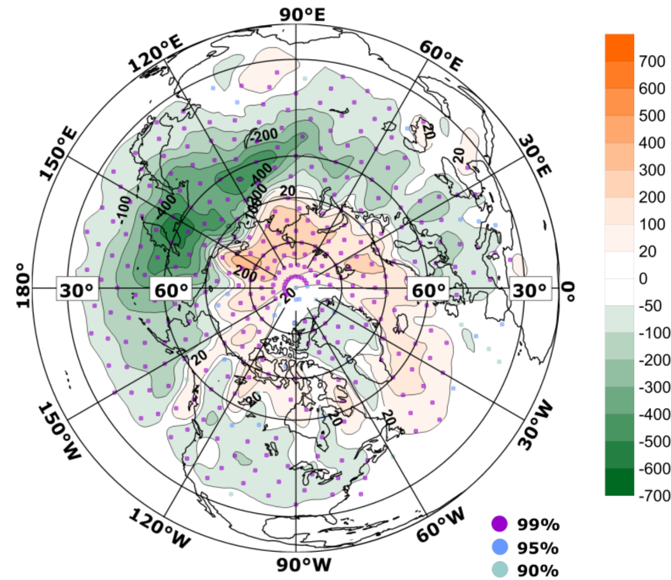
February



x-component

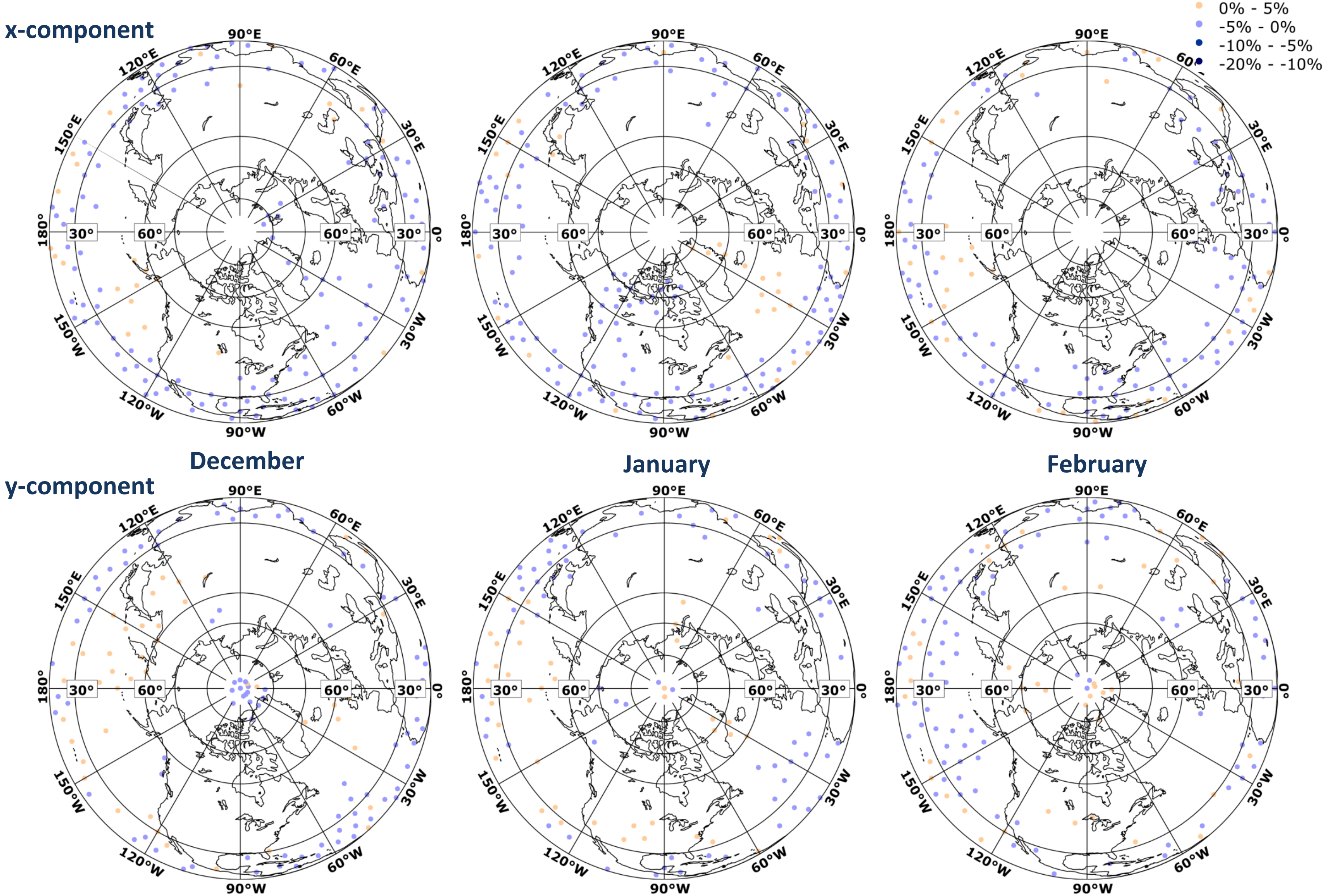


y-component



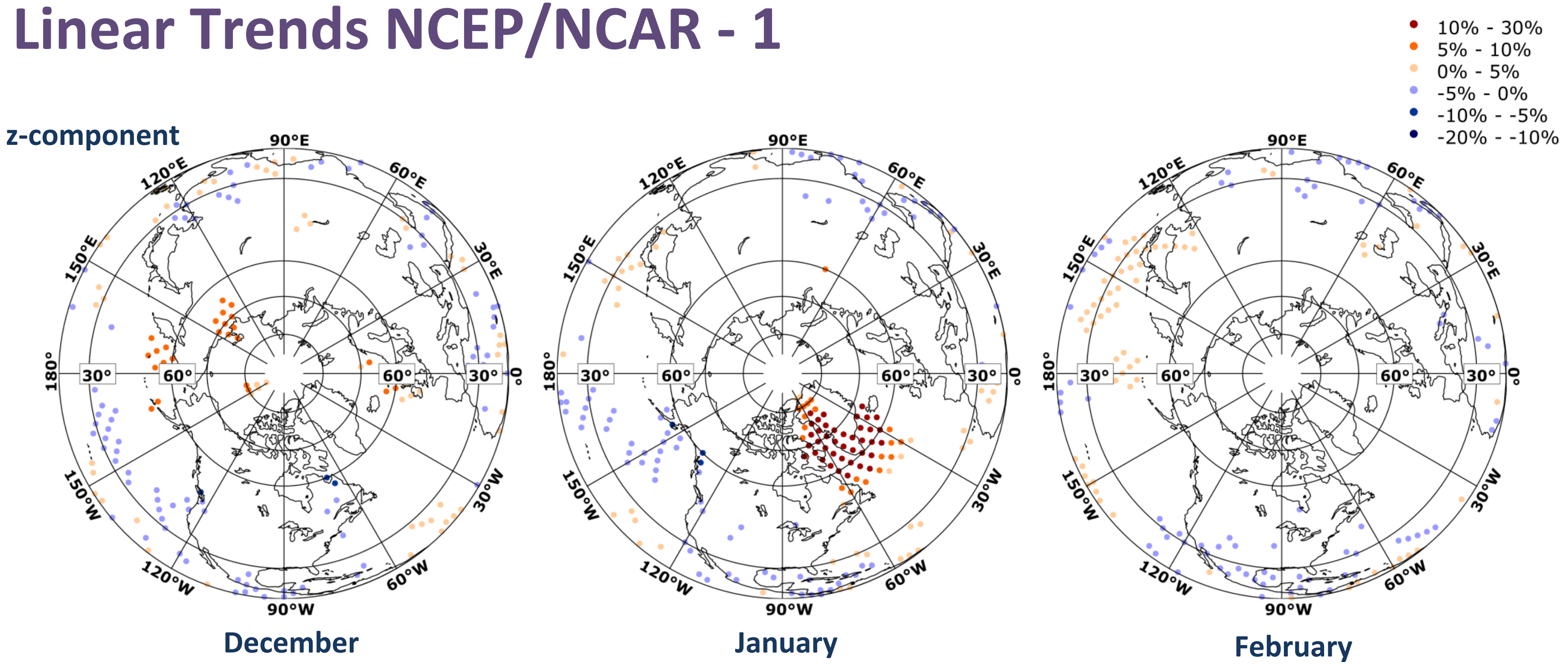
z-component

Linear Trends NCEP/NCAR - 1



No significant trends in the key-role regions in x and y components!

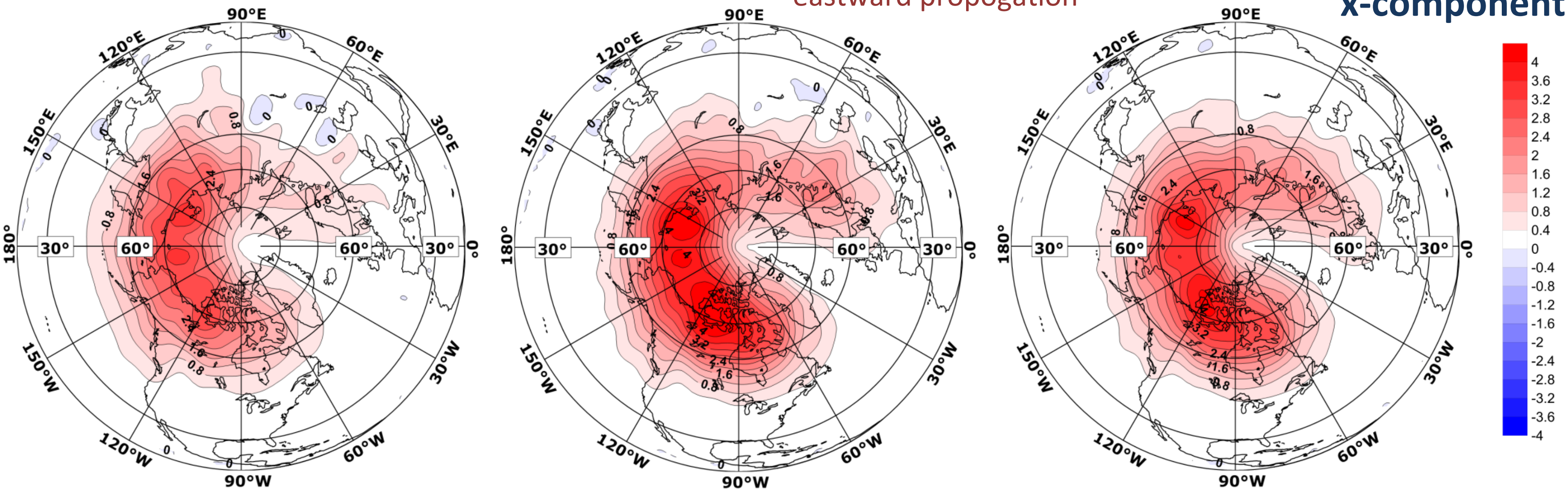
Linear Trends NCEP/NCAR - 1



Climatology NCEP/NCAR - 1

Positive x-component means eastward propogation

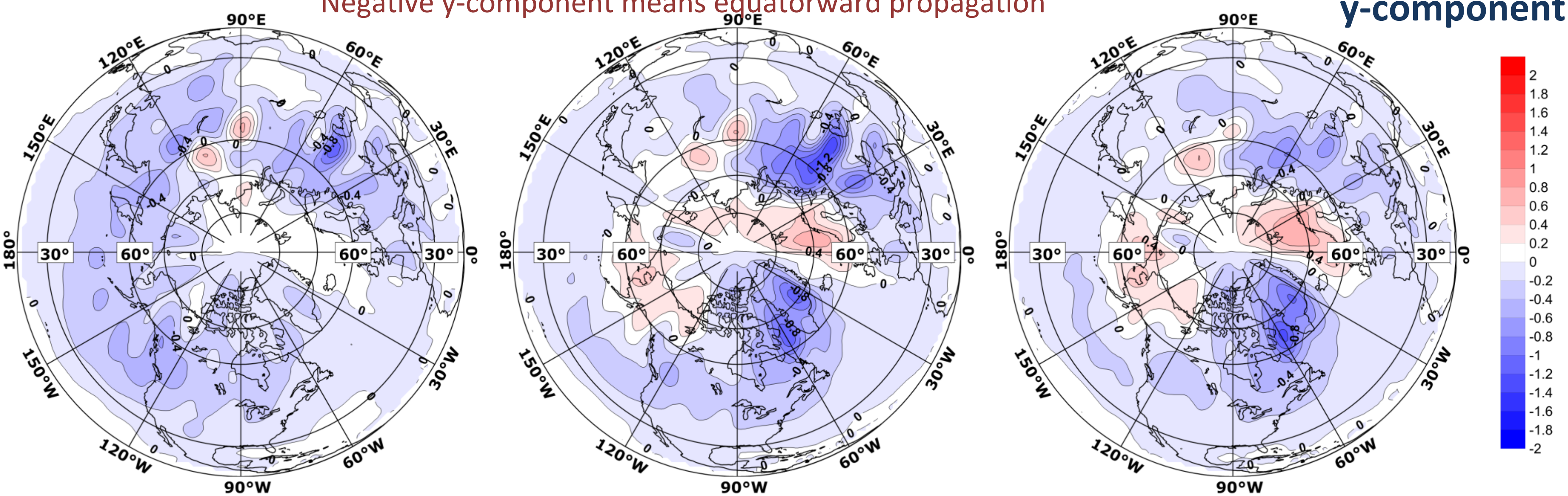
x-component



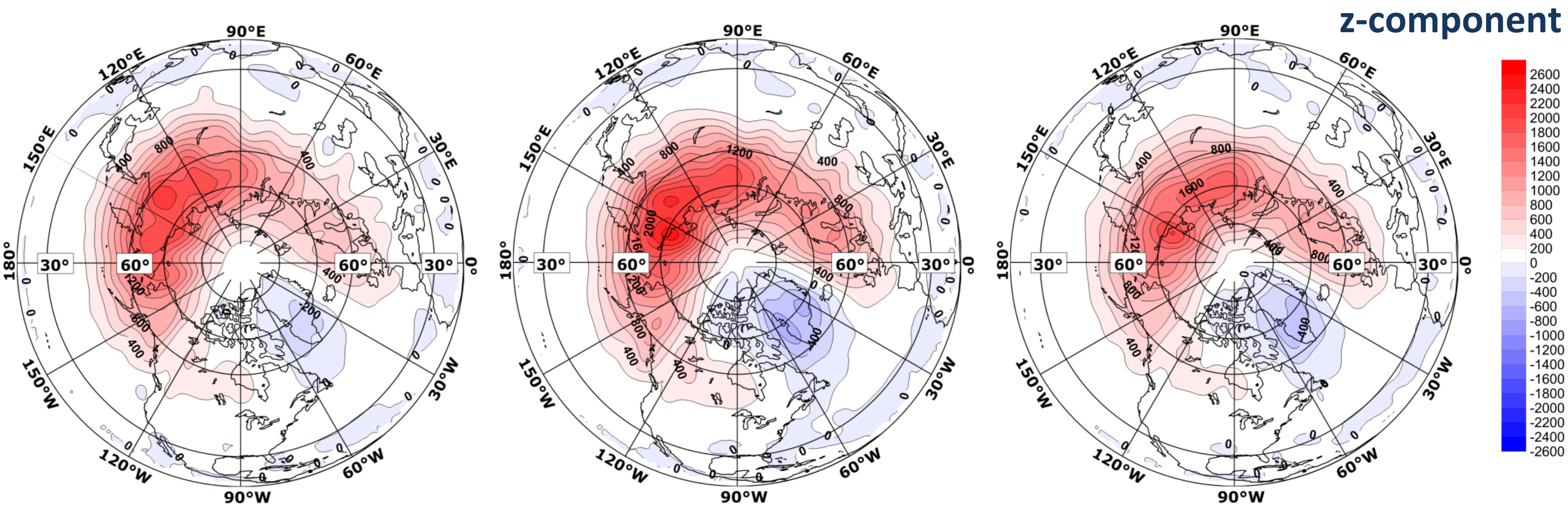
December, 1979-2011 **January, 1980-2012** **February, 1980-2012**

Negative y-component means equatorward propagation

y-component



Climatology NCEP/NCAR - 1



December, 1979-2011

January, 1980-2012

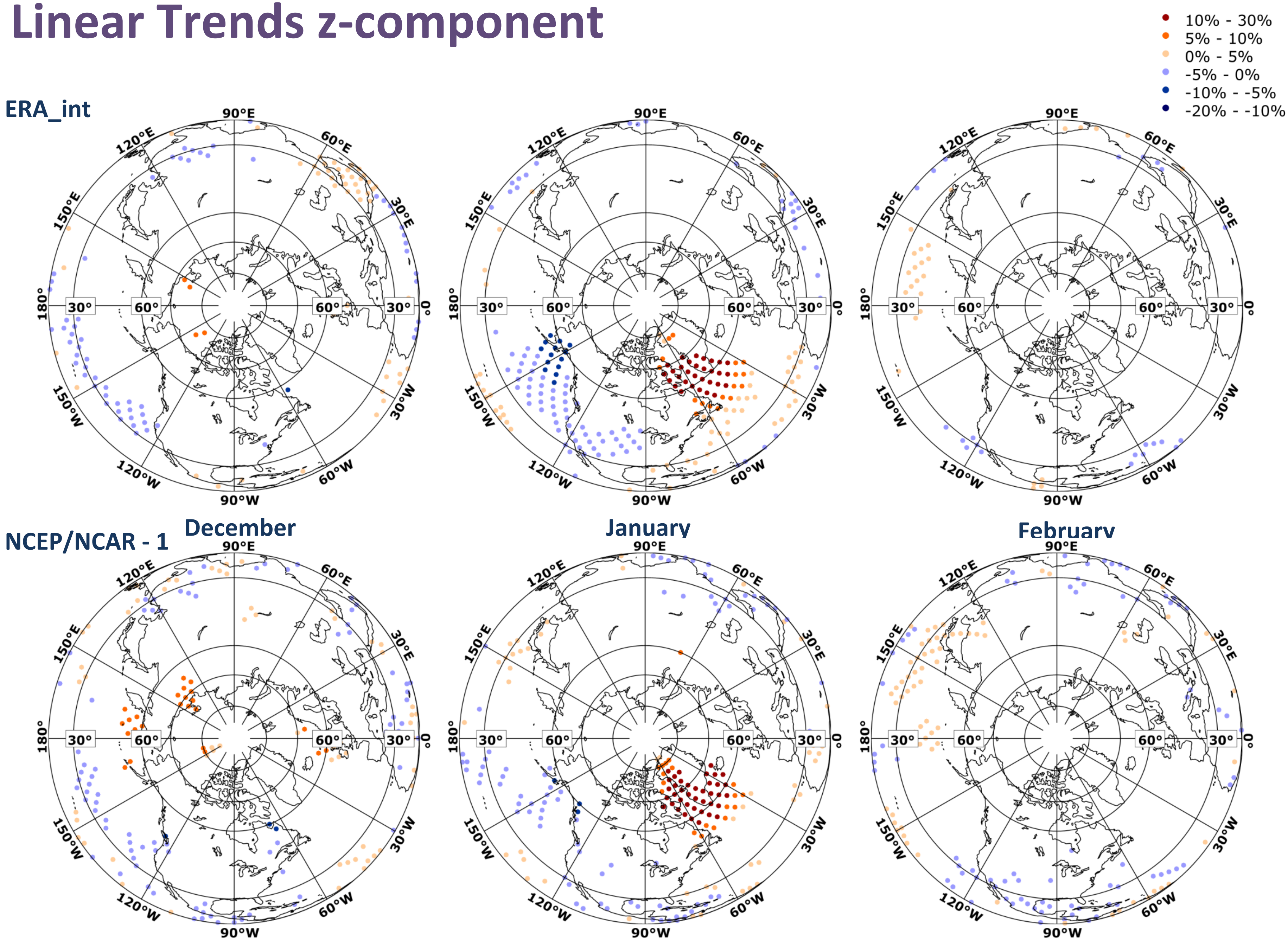
February, 1980-2012

Positive z-component means upward propagation

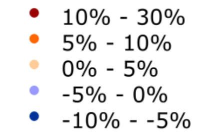
Imporatant!

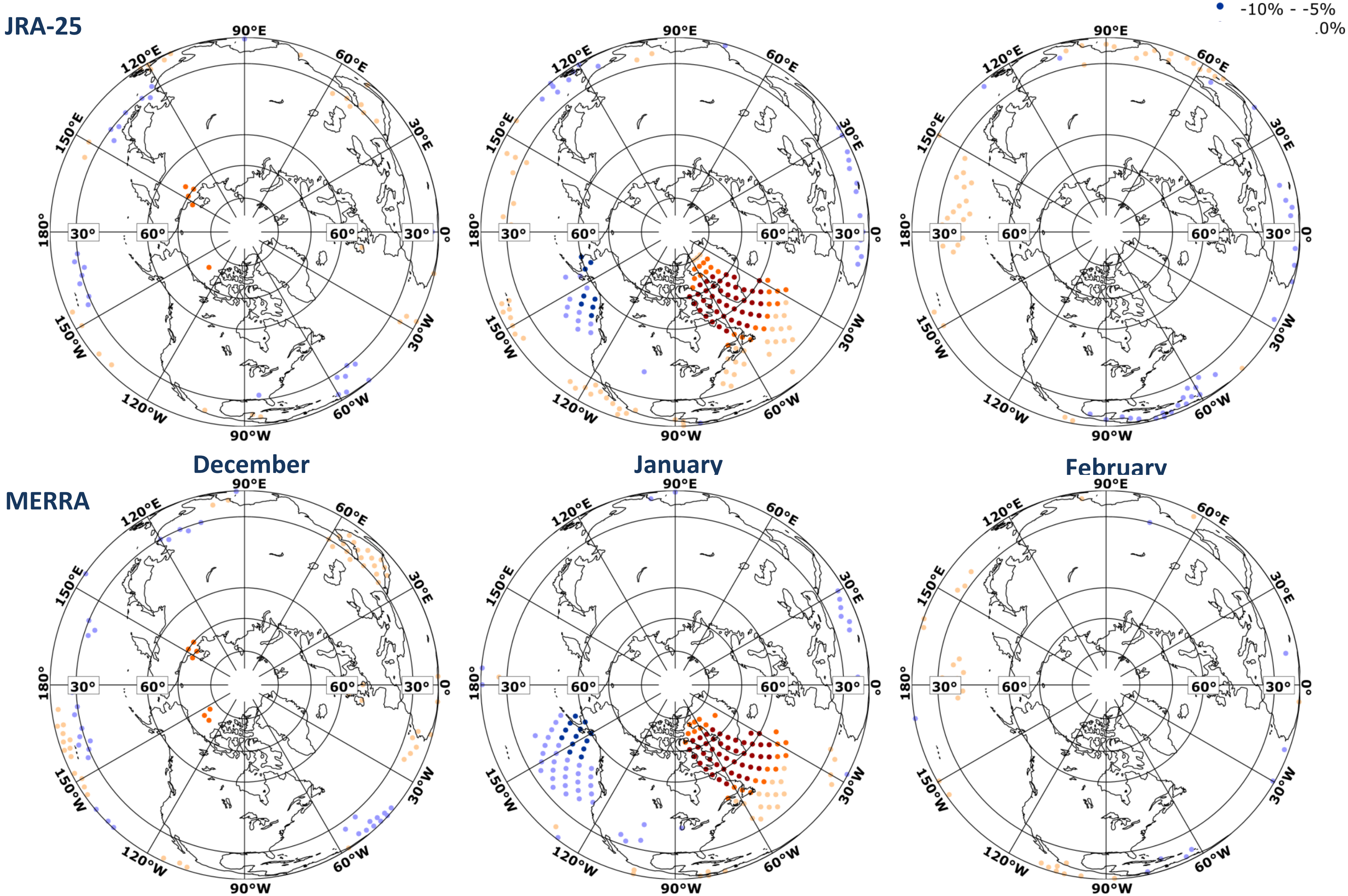
Negative values in the Northern Atlantic region

Linear Trends z-component

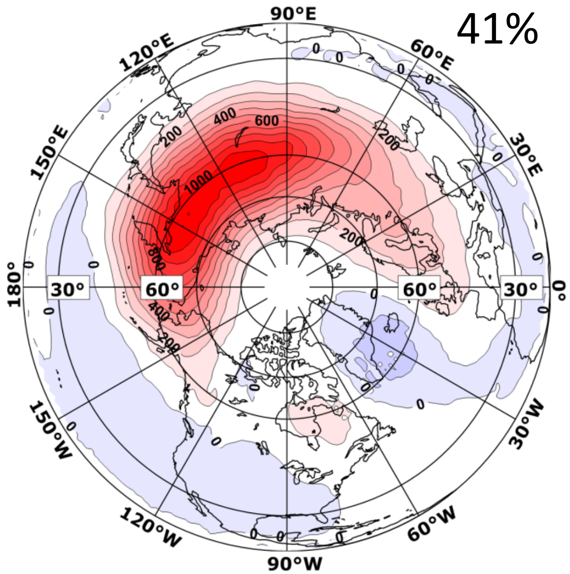


Linear Trends z-component

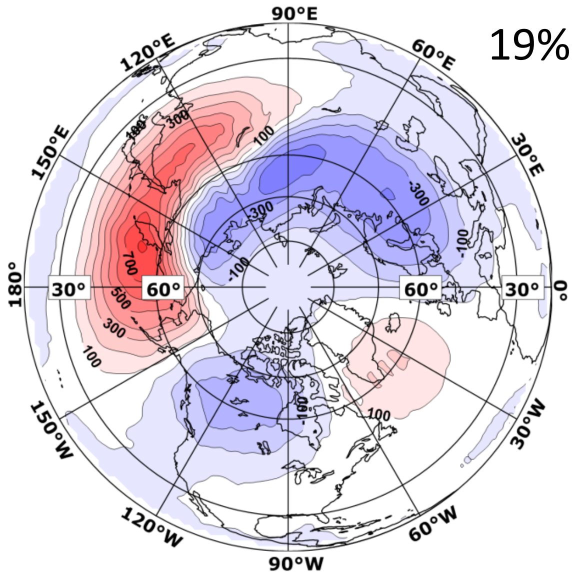




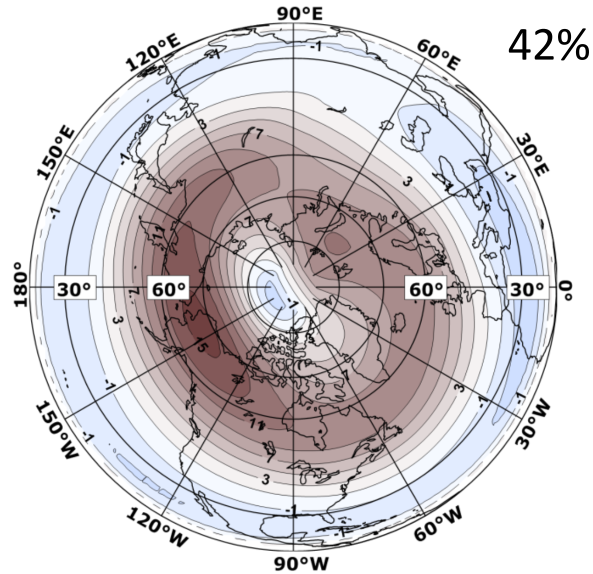
EOF JRA-25



1 EOF of the Fz 30hPa, December

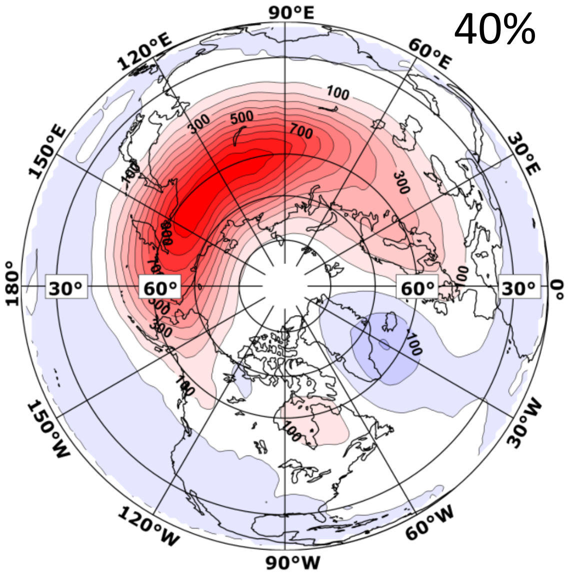


2 EOF of the Fz, December

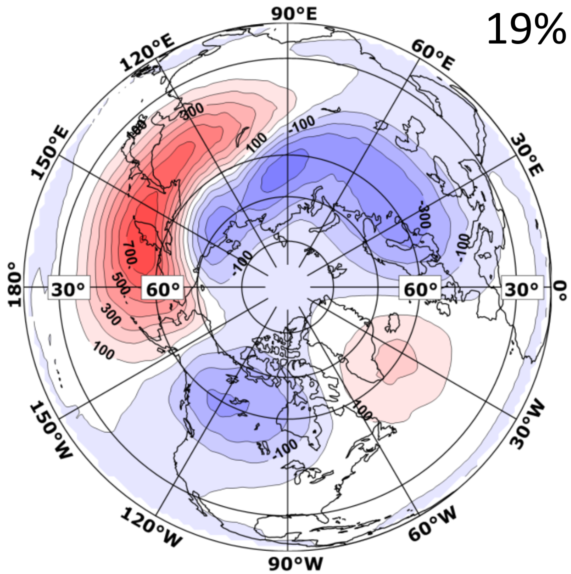


1 EOF of the U-wind, January

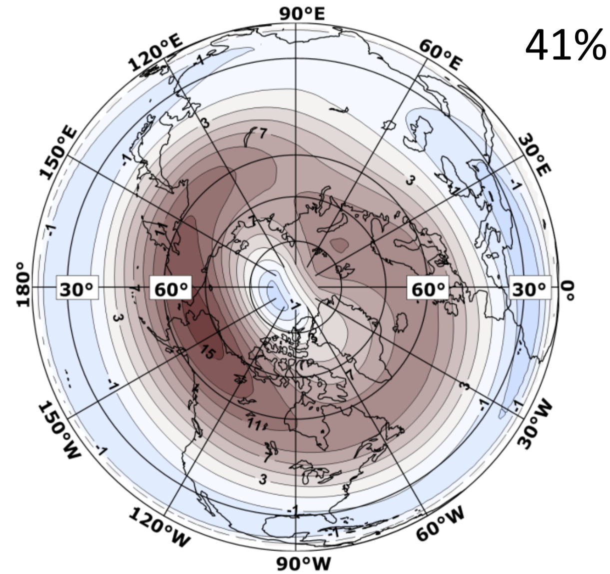
EOF MERRA



1 EOF of the Fz 30hPa, December

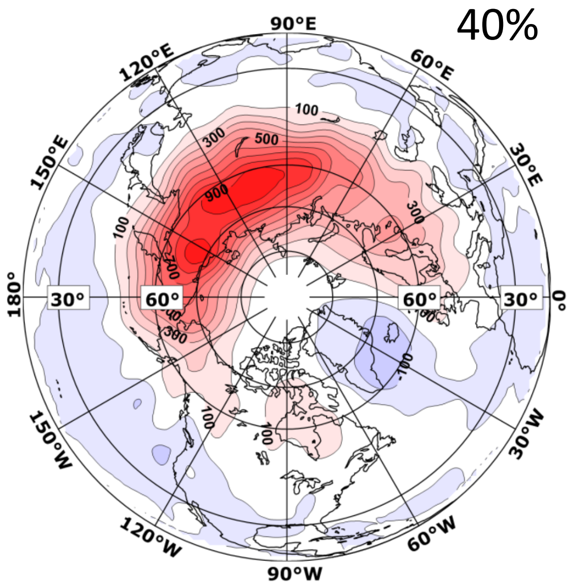


2 EOF of the Fz, December

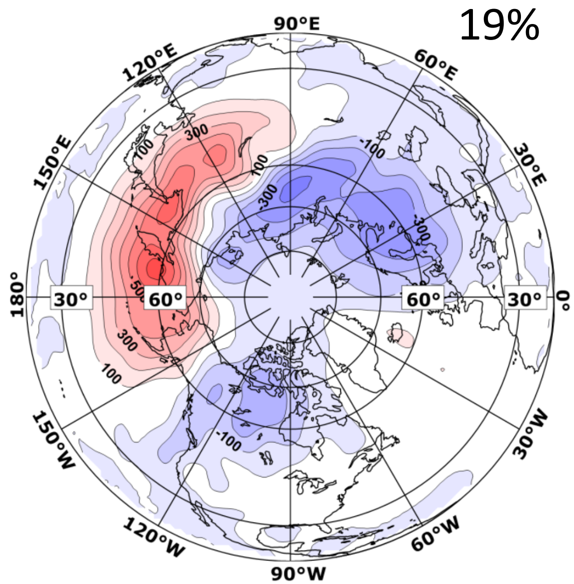


1 EOF of the U-wind, January

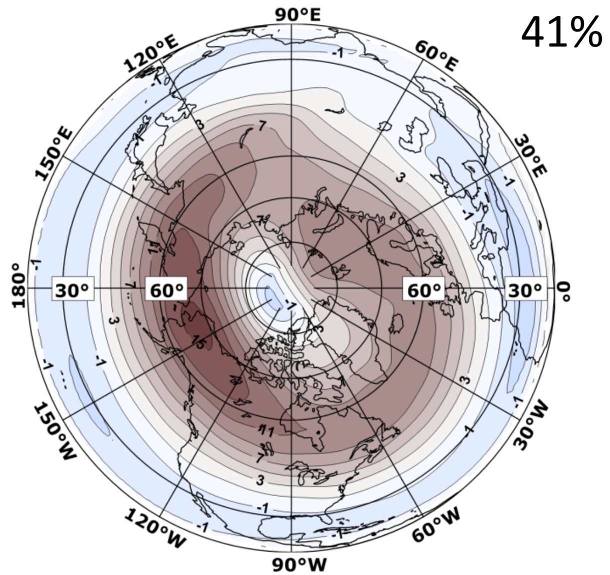
EOF NCEP/NCAR - 1



1 EOF of the Fz 30hPa, December



2 EOF of the Fz, December



1 EOF of the U-wind, January