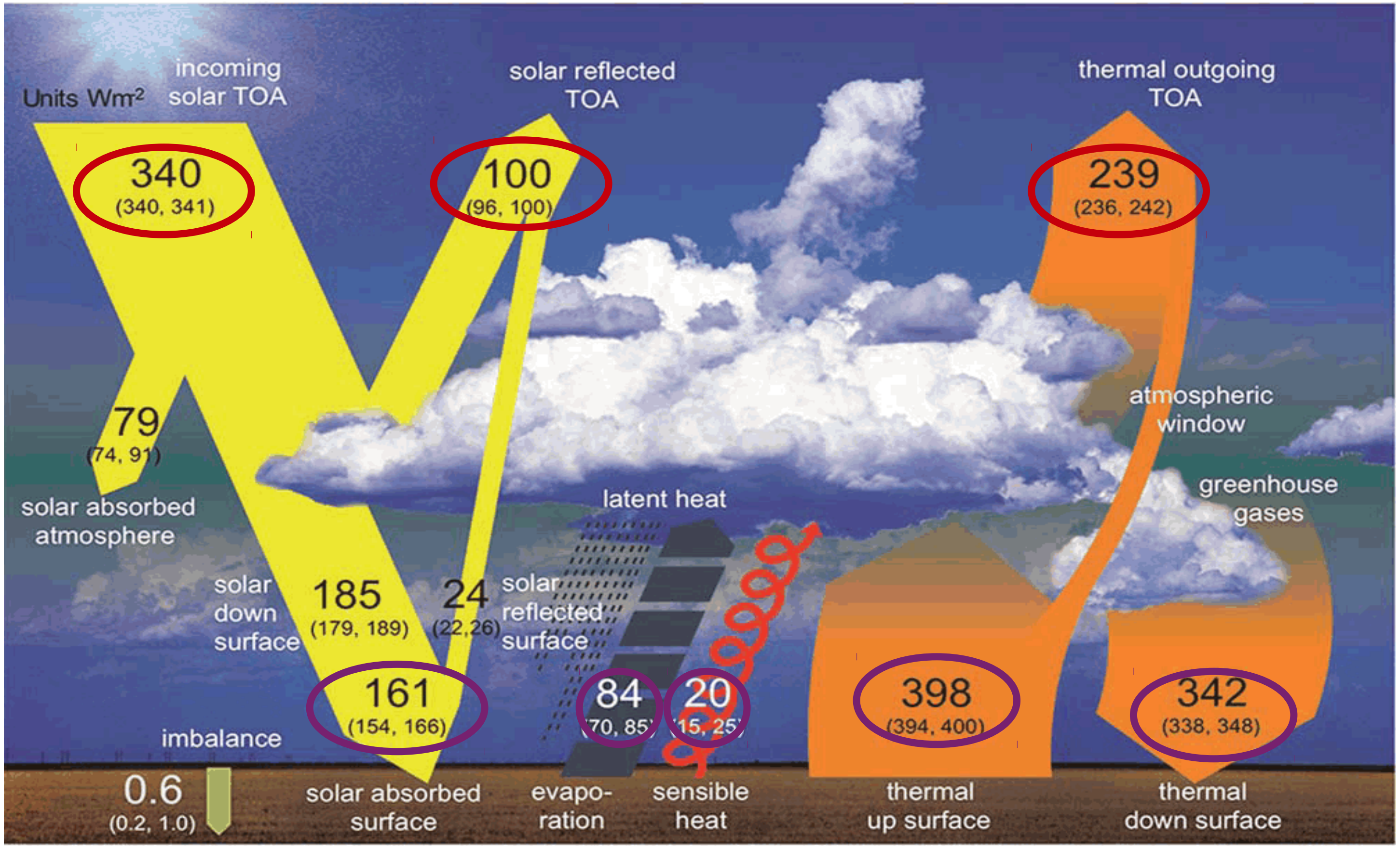
Valerio Lembo, Gabriele Messori, Rune Graversen, Valerio Lucarini

WAVE DECOMPOSITION OF MERIDIONAL ENERGY TRANSPORTS IN NORTHERN HEMISPHERE MIDLATITUDES

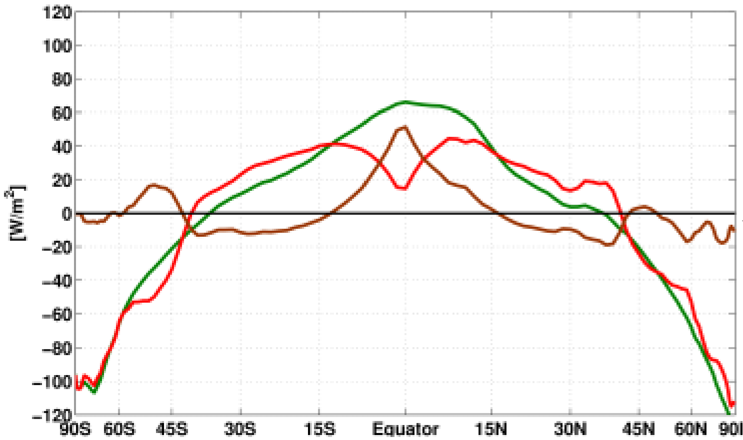
Somewhere, 06.05.2020

The radiative and heat budget

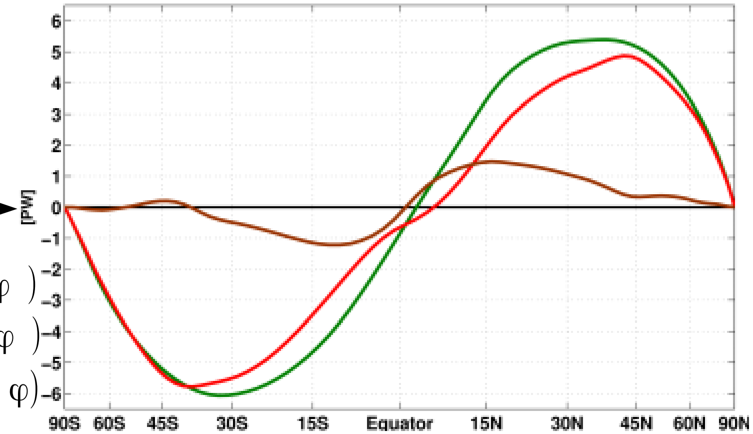


(Wild et al., 2013)

Differential heating... and meridional heat transports



$$\overline{B_t(\varphi)}=\nabla\cdot F_t(\varphi)$$
$$\overline{B_a(\varphi)}=\nabla\cdot F_a(\varphi)$$
$$\overline{B_s(\varphi)}=\nabla\cdot F_o(\varphi)$$

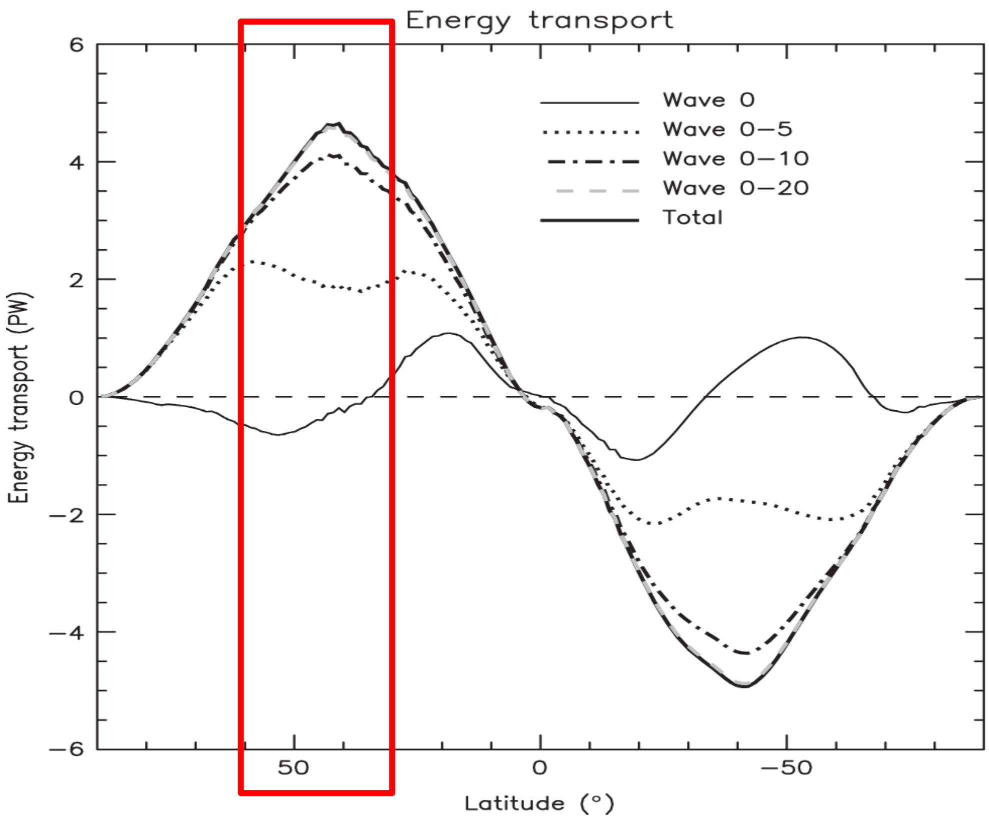


(Lembo et al., 2017)

	Tot. (NH)	Tot. (SH)	Atm. (NH)	Atm. (SH)	Oc. (NH)	Oc. (SH)
Intensity (PW)	5.9 +/-0.3	5.9+/-0.5	5.1+/-0.5	4.9+/-0.2	1.7+/-0.3	1.2+/-0.5
Location (φ)	35	-35	41	-41	15	-11

(Fasullo and Trenberth, 2008)

Decomposition of the atmospheric heat transport



(Graversen et al., 2016)

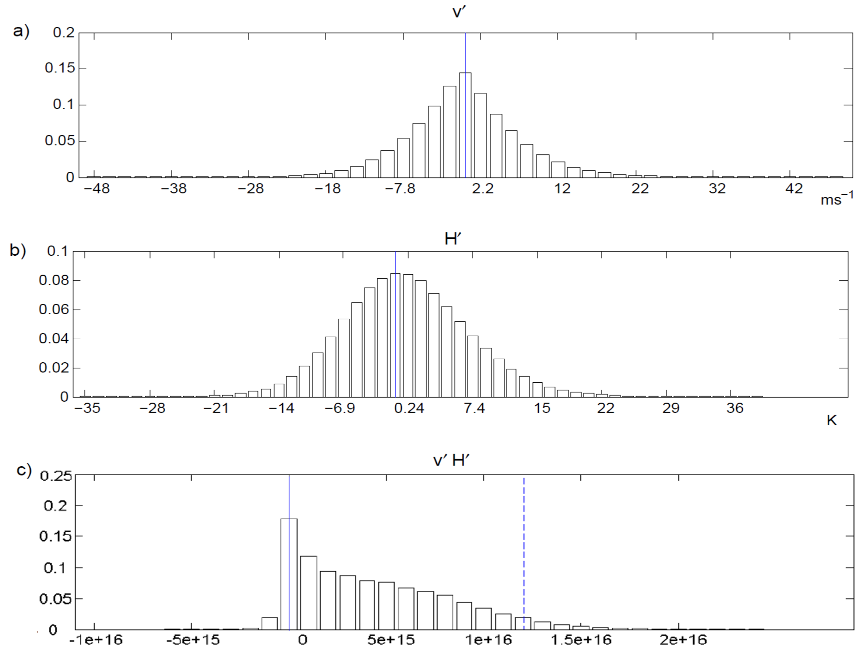
In the NH mid-latitudes (30-60) the first 10 wavenumbers contribute to nearly all the transport:

- Wave 0 (zonal mean): slightly negative

- Waves 1-5 (planetary waves): contributes nearly half of the transport;

- Waves 6-10 (synoptic waves): set the peak of the transport;

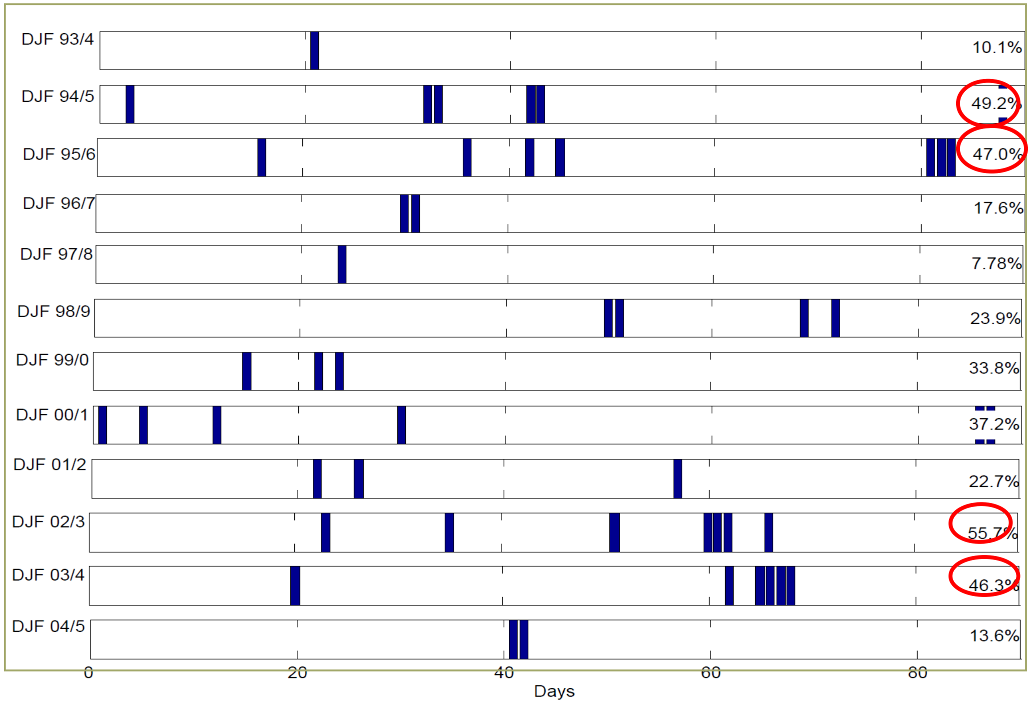
NH mid-latitudinal heat transports and eddies



(Messori and Czaja, 2013; Messori and Czaja, 2015)

- PDF of NH DJF meridional heat transports related to transient eddies are strongly asymmetric, with a preference for northward transports;

Occurrence of top 5% percentile values at specific gridpoint



(Messori and Czaja, 2013)

A few sporadic events can make up to 56% of the total poleward transport related to eddies in a season!

Key questions

- Which wavenumbers are most relevant for the overall transport?

- What are the statistical properties of meridional heat transports across scales?

  - How do northward and southward extremes vary as a function of wavenumber?

  - Are statistical properties to some extent invariant?

- What is the seasonal variability of such transports and related properties?

Data

- ERA-Interim Reanalyses (1979-2012):
  - T255 horizontal resolution (approx. 0.5°);
  - 60 hybrid levels;
  - 6-hr time resolution;
  - Barotropic correction for mass-flux inconsistencies due to data assimilation;

Methods

- The computation of atmospheric energy results from the combination of a dry static, moist and kinetic component:

$$E = c_p T + gz + Lq + \frac{1}{2}\mathbf{v}^2$$

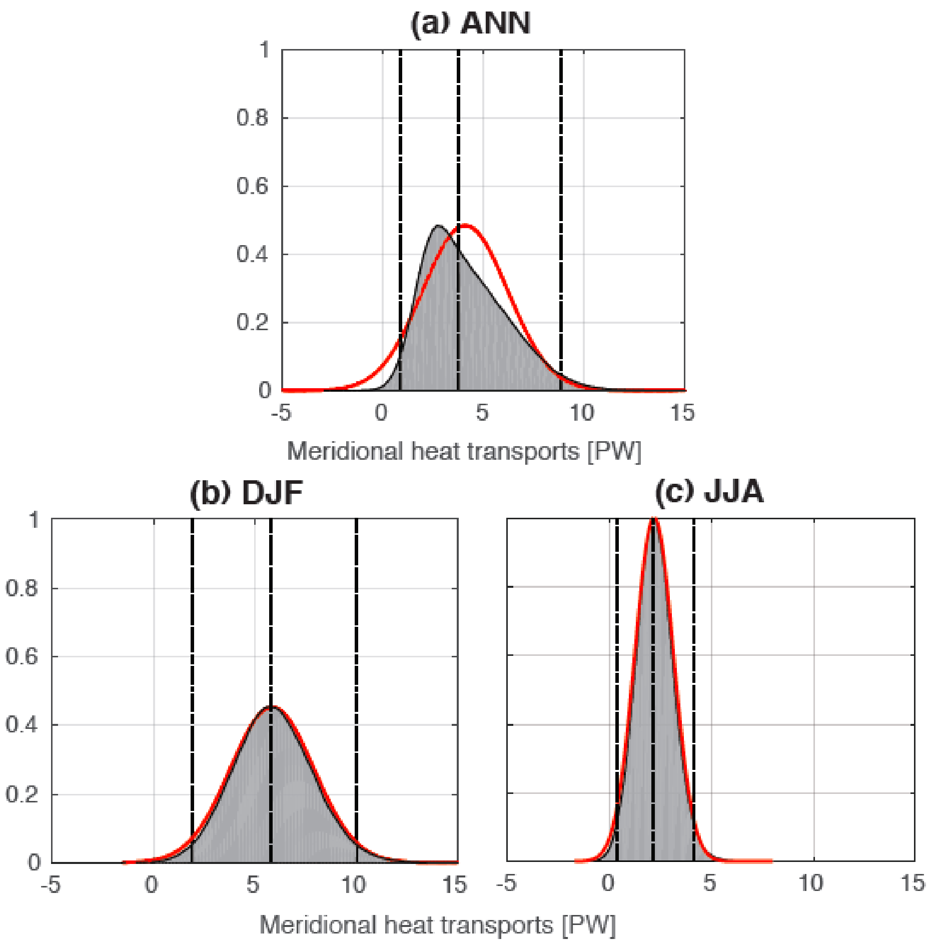
- The zonal integrated total meridional energy transport is thus:

$$vE(\phi) = \oint \int_0^{p_s} vE \frac{dp}{g} dx$$

- The Fourier coefficients (a_n, b_n) are separately computed for meridional velocity and energy at every level, thus the energy transport for wavenumber n is retrieved as:

$$vE_n(\phi) = d \sum_n \left\{ \int_0^{p_s} \frac{1}{2} (a_n^v a_n^E + b_n^v b_n^E) \frac{dp}{g} \right\}$$

The PDFs of the total transports throughout the seasons

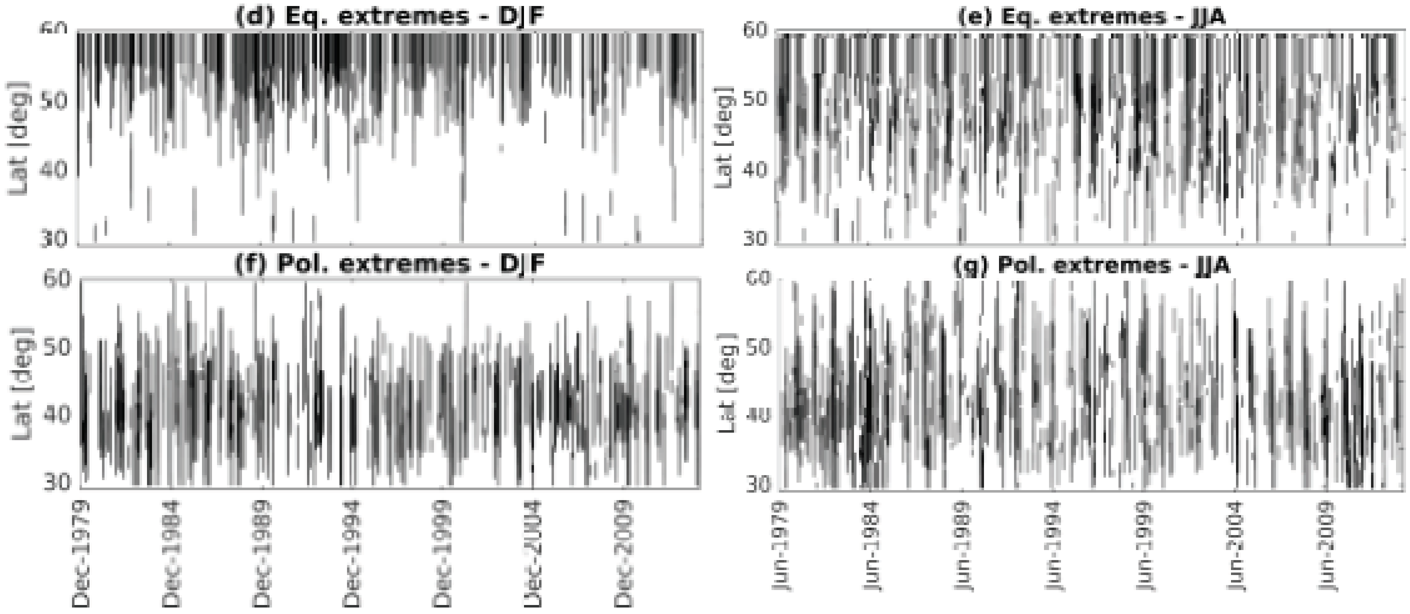


The PDF of the annual transports is strongly non-gaussian;

This is mainly attributed to the DJF-JJA different range of transports;

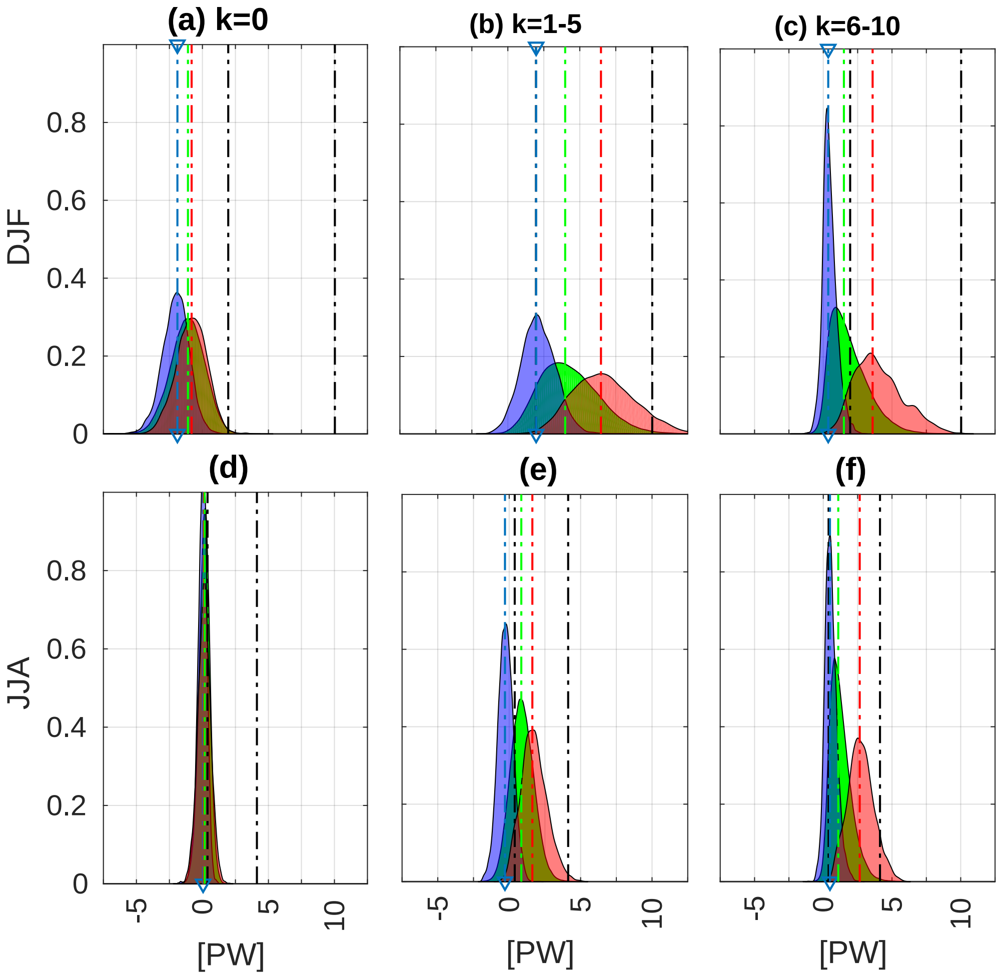
Not quite interesting, though...

The extremes of the total transports



- "Poleward" extremes (5% top percentile of northward transports) lie in the middle of the mid-latitudinal channels in both seasons;
- "Equatorward" extremes (5% bottom percentile of northward transports) lie at the northernmost edge of the mid-latitudinal channel in winter, less clear in summer;

PDFs of the extreme transports, spectral-wise



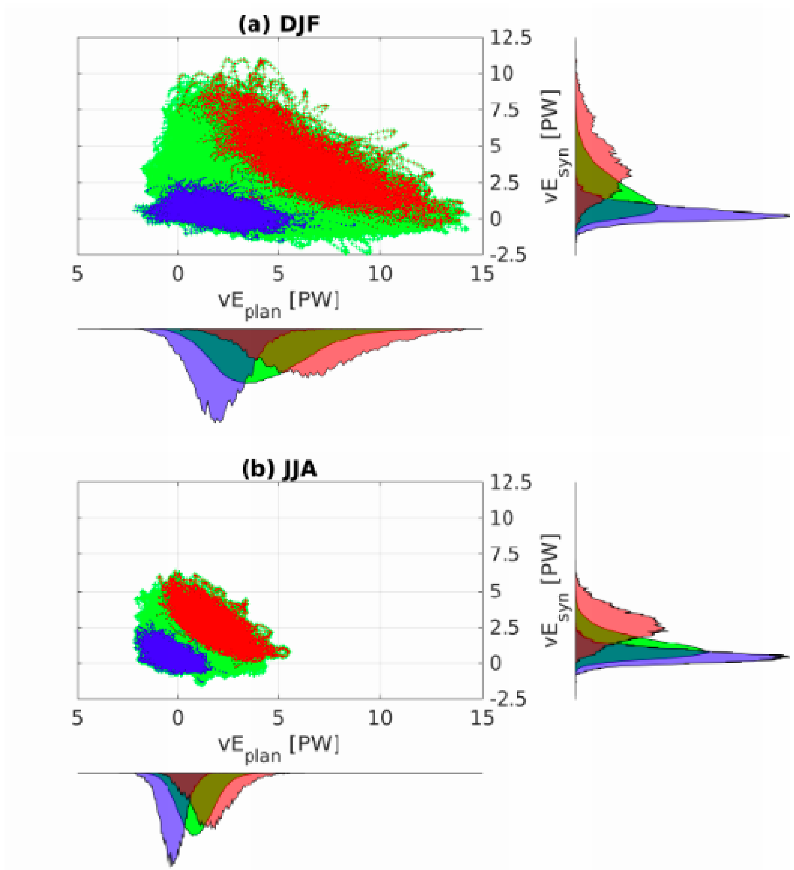
- The instantaneous zonal mean transport (k=0) has a marginal relevance;

- Planetary-scale transports account for most of the overall transport in DJF;

- Synoptic-scale transports have similar magnitude as the planetary-scale in JJA;

- Poleward extremes have much more skewness than the equatorward extremes;

Relating planetary and synoptic-scale extremes



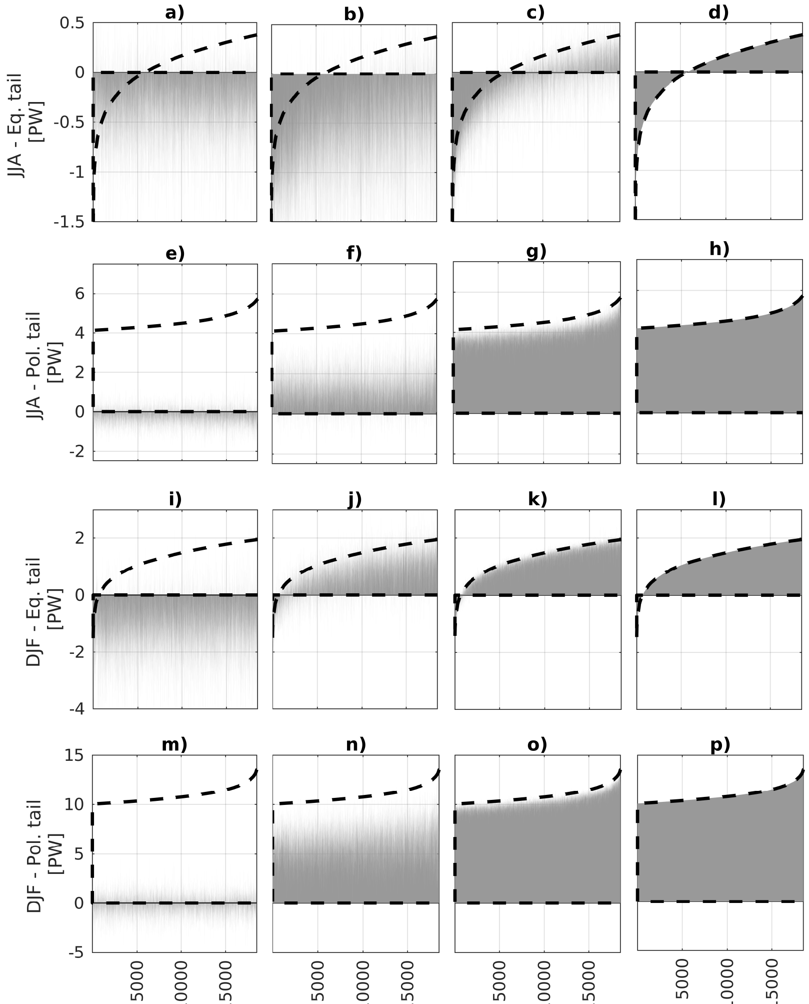
- Poleward planetary-scale and synoptic-scale transports show some degree of anti-correlation;

- This is also suggested for JJA equatorward extremes;

- Planetary-scale transports carry a lot of heat equatorward (counter-gradient) in JJA!

TRR181

Sorting the extremes from larger to smaller...



- a,e,i,m) k=0;
  b,f,j,n) k=0-5;
  c,g,k,o) k=0,10;
  d,h,l,p) k=0,21;

- Planetary and synoptic-scale eddies cooperate for the overall transport extremes in almost every case;

- In JJA equatorward extremes planetary transports contrast the overall transport, "cooperating" with the zonal mean transport;

- The relative importance of planetary transports has much more seasonality;

Summary and Conclusions

- Competition exists in all seasons between regular and extreme meridional transports performed by zonal mean, synoptic and planetary waves.
- The seasonality is particularly pronounced in planetary transports than in synoptic transports, as the reduced baroclinicity narrows the range of scales where baroclinic conversion can take place.
- A constructive interference exists in both seasons between planetary and synoptic transports, for what concerns poleward extremes;
- As for the equatorward extremes, the mean meridional circulation is overwhelmingly equatorward in winter, and is contrasted mainly by planetary transports. In summer the synoptic eddies contrast both zonal mean and planetary equatorward transports;

- What are the physical mechanisms leading the planetary and synoptic eddies to cooperate or contrast each other?

Thank you very much for the attention!

Reference

Lembo V, Messori G, Graversen R, Lucarini V (2019) Spectral Decomposition and Extremes of Atmospheric Meridional Energy Transport in the Northern Hemisphere Midlatitudes. Geophys Res Lett

Mail: valerio.lembo@uni-hamburg.de