Stratospheric predictability and impact on the troposphere, Workshop
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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Eliassen-Palm-Fluxes and Stratospheric circulations – Teleconnections as forcing

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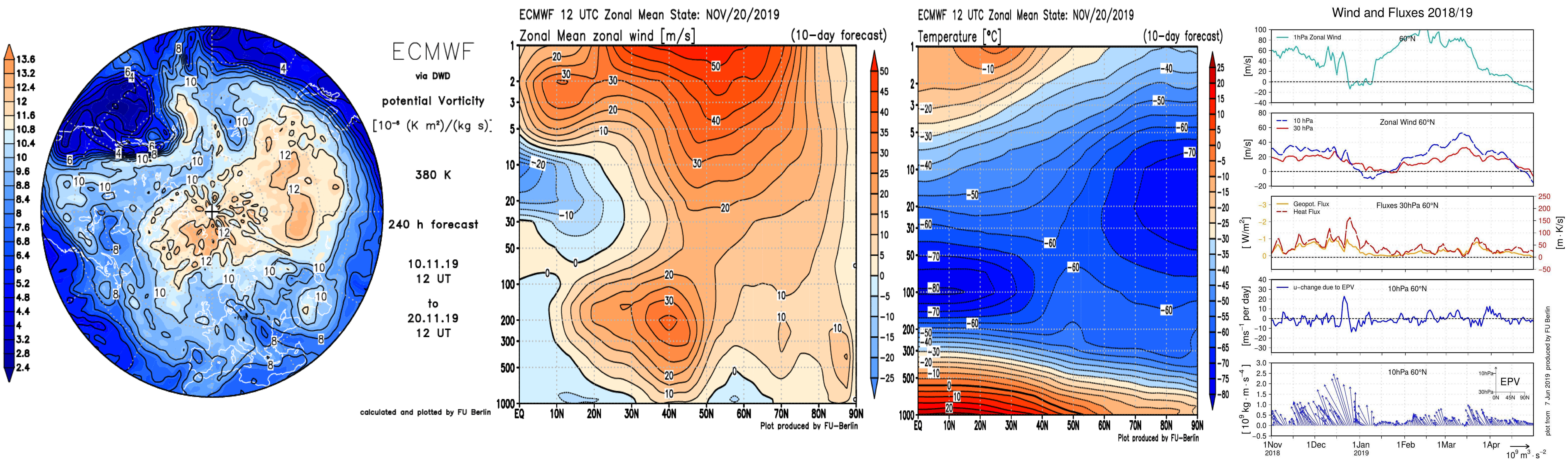

Fig. 1…4 ECMWF Forecast examples for PV distribution, zonal wind, temperature as well as fluxes with EPV

Transport of potential vorticity and Eliassen-Palm fluxes. Analysis and diagnostic of PV data from the stratosphere and upper troposphere. Applying the divergence of the Eliassen-Palm-Vector to mid- and long-term forecasts and together with seasonal variations of eddy fluxes of PV, heat and momentum in the stratosphere/ upper troposphere prognosis of sub-seasonal trends. All in context with SST-anomalies, ENSO, QBO, Brewer-Dobson-Circulation.

Eliassen-Palm-Flux (EPF) as diagnostic tool

Definition according to the American Meteorological Society (AMS): A vector quantity with nonzero components in the latitude–height plane, the direction and magnitude of which determine the relative importance of eddy heat flux and momentum flux. When the Eliassen–Palm flux (EPF) vector points upward, the meridional heat flux dominates; when the EPF vector points in the meridional direction, the meridional flux of zonal momentum dominates. The divergence of the Eliassen–Palm flux is more frequently used as a diagnostic tool, as it is proportional to the eddy potential vorticity flux. In the special case when the EPF divergence is zero, as for steady, frictionless, linear waves, thermal wind balance is maintained in an idealized zonally symmetric atmosphere through the induction of a mean meridional circulation, even though the waves produce significant eddy heat and momentum fluxes.

Formula for EPF: $\{F_\varphi, F_p\} = \{-a\cos\varphi\,\overline{u'v'},\ fa\cos\varphi\,\frac{\overline{v'\theta'}}{\theta_p}\}$

where a is the radius of the Earth, f the Coriolis parameter φ is latitude, θ the potential temperature and (u,v) the zonal and meridional wind. $\overline{u'v'}$ eddy momentum and $\overline{v'\theta'}$ eddy heat flux.

Reference:

Edmon, H. J., B. J. Hoskins, and M. E. McIntyre, 1980: Eliassen-Palm cross sections for the troposphere. *J. Atmos. Sci.*, 37:2600–2616

Transport of Potential Vorticity, related to ENSO

PV transport-EP fluxes are stronger in El Niño years compared to La Niña years, indicating stronger baroclinic activity. The changes in PV-transport seem to be mainly due to the changes in eddy heat fluxes. Due to the increase in the wind shear the Eddy growth rate is stronger during El Niño than during La Niña events. Consequently, the zonal winds are stronger in the El Niño event, although the location of the jet stream is almost the same in the contrasting years. In the case of summer, there is little difference in PV transport-EP fluxes between the hemispheres, although they are slightly higher in El Niño than in the La Niña-events (S. H. Franchito, V. Brahmananda Rao, J. P. R. Fernandez, and S. R. Chapa: Transport of potential vorticity and Eliassen-Palm fluxes for two contrasting years: 1995–1996 (La Niña) and 1997–1998 (El Niño). *Annales Geophysicae (2002) 20: 717–727).*

$$PV = -g\,(\zeta_\Theta + f)\frac{\partial\Theta}{\partial p}$$

f	Coriolis parameter
g	gravitational acceleration
p	pressure
PV	potential vorticity
Θ	potential temperature
ζ_Θ	relative isentropic vorticity

Complexity and interaction between other (stratospheric) circulations

Reanalyses reveal that the deep branch of the Brewer-Dobson-Circulation (BDC) is significantly enhanced in El Niño winters as more waves from the troposphere dissipate in the stratospheric polar vortex region. A secondary circulation cell is coupled to the temperature anomalies below the QBO easterly center at 50 hPa with tropical upwelling/cooling and midlatitude downwelling/warming, and similar secondary circulation cells also appear between 50–10 hPa and above 10 hPa to balance the temperature anomalies. The shallow branch of the BDC in the lower stratosphere is intensified during solar minima, and the downwelling warms the Arctic lower stratosphere (Jian Rao, Yue Yue Yu, Dong Guo, Chun Hua Shi, Dan Chen, Ding Zhu Hu: Evaluating the Brewer–Dobson circulation and its responses to ENSO, QBO, and the solar cycle in different reanalyses. *Earth and Planetary Physics, April 2019*)

Role of persistent positive SST-anomalies

Persistent positive anomalies of Sea Surface temperatures (SST), p.e. in the North Atlantic Region push through diabatic processes more anticyclogenesis over Sea (blocking) and generate vertical heat fluxes in the upper troposphere. This can lead to weakening of the Polarfront jetstream, especially in summer time. In winter time due to stronger vertical propagation of baroclinic waves into the lower stratosphere, this can support initiation of suddenly stratosphere warming events.

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