

Exercises series 3
Due 18 May 2016

1. Atmospheric energy budget and heat transport

Consider, besides the top-of-atmosphere radiation budget, the surface energy budget, that consists of the net radiation flux and the turbulent fluxes of sensible and latent heat (the heat flux into soil and ocean is excluded here). The energy flux densities, ΔF , are provided¹ in units of $\text{J m}^{-2} \text{ day}^{-1}$.

The meridional energy flux is given in differential form as

$$\frac{dN}{d\phi} = 2\pi R_E \cos \phi \Delta F$$

with the Earth's radius R_E and the geographical latitude ϕ .

(a) Plot the total meridional energy flux by integrating the zonal-integral flux densities from the South pole to the North pole starting with $N(\phi=90^\circ\text{S}) = 0$!

(b) Plot the difference in meridional energy flux at the top and bottom of the atmosphere. What flux does this term indicate?

2. Freshwater flux

The total surface precipitation- and surface evaporation fluxes are provided from ERA Interim¹ in units of m day^{-1} . Plot geographical distribution of the freshwater flux!

3. Decomposition of the circulation

Consider the sensible heat $c_p T$, with the 2m temperature, T ; and 10m meridional wind, v , from the ECMWF re-analysis². Compute and plot as a function of latitude:

(a) the contributions to the zonal annual mean meridional heat flux ($v c_p T$) taking first the zonal, then the temporal average:

$$c_p \overline{[vT]} = c_p \overline{[v]} \overline{[T]} + c_p \overline{[v]'} \overline{[T]'} + c_p \overline{[v^*T^*]}$$

(b) the terms of the zonal annual mean meridional heat flux taking first the temporal, then the zonal average:

$$c_p \overline{[vT]} = c_p \overline{[v]} \overline{[T]} + c_p \overline{[v^*T^*]} + c_p \overline{[v'T']}$$

(c) the mean covariance term $c_p \overline{[v^*T^*]}$!

(d) List a table of the global temporal mean values of the different terms!

¹ File /home_local/quaas/data/ERA_fluxes.nc from the ERA Interim re-analysis (average over 14 years). The cdo command gridarea can be handy.

² files /home_local/quaas/data/T.nc and /home/quaas/data/V.nc