Climate Dynamics
Summer Semester 2019

UNIVERSITÄT LEIPZIG

Homework 6
Due 5 June 2019

Problem 1 Wind climatology

(a) Using the files /home_local/quaas/data//home_local/quaas/data/ERA_U_dp50.nc and /home_local/quaas/data//home_local/quaas/data/ERA_V_dp50.nc, plot vector maps of the horizontal wind at 850 hPa and 200 hPa for climatological summer (JJA) and winter (DJF).

(b) Using the file /home_local/quaas/data/ERA_U_zonmean_mean.nc, plot the vertical–meridional distribution of the mean zonal wind for JJA and DJF.

Problem 2 Ekman spiral

(a) Find the general form of the solution to the Ekman-layer equations of motion, equations (2.149) and (2.150) in the lecture slides. Assume eddy viscosity friction proportional to $\partial^2/\partial z^2$, as given in the equations.

Note: assume that the solution takes the form $u_E(z) = V_0 \exp(\alpha z + \beta)$ *to turn the system of differential equations into arithmetic equations for* α *and* β*. The English word for this is "ansatz".*

(b) For a southerly wind with surface wind stress T, show that your solution recovers equations (2.151) and (2.152) in the lecture slides.

Problem 3 Ocean surface properties

The files /home_local/quaas/data/gecco_temp.nc, gecco_salt.nc, and gecco_zeta.nc contain temperature, salinity, and sea surface height data from the GECCO ocean synthesis (Köhl and Stammer, J. Climate, 2008).

(a) Plot the sea surface height, temperature, and salinity.

(b) Why is the North Atlantic so much saltier than the North Pacific?

Problem 4 Heat capacities

On short time scales, land surfaces and the mixed layer of the ocean act as heat buffers in the climate system. In this problem, we will compare their heat capacities.

(a) Assume the mixed layer of the ocean extends to a depth of 100 m. Using a specific heat for water of 4×10^3 kJ kg^{-1} K^{-1} and density 10^3 kg m^{-3}, find the heat capacity of the mixed layer.

(b) Assume that the seasonal cycle of air temperature penetrates the land surface to a depth of 1 m. Using a specific heat for rock of 800 J kg^{-1} K^{-1} and density 3×10^3 kg m^{-3}, find the heat capacity of the land surface.

Problem 5 Sea ice and Archimedes principle

(a) Consider an idealized rectangular ocean basin with horizontal side lengths w and sea level z. Floating at the surface of this ocean is a cubic iceberg of side length a. Show that the sea level does not change if the iceberg melts. *You may assume that the water density is constant throughout the ocean and that the water density change due to the melting of the iceberg is negligible.*

(b) Bonus: how does the situation change if the iceberg has a passenger in the form of an idealized cubic polar bear of density ρ_p and side length c? Assume that the polar bear floats after the ice has melted.

(c) Bonus 2: how does the situation change if a Viking ship of density ρ_v and side length d is frozen into the iceberg? Assume that the ship sinks after the ice has melted.