Dynamics II, Summer semester 2025 | Exercise 7
Lecturer: Prof. Dr. G. Lohmann, Dr. M. Ionita | 26.5.2025
Tutors: Alessandro Gagliardi, Georg Hüttner | Due date: 2.6.2025

1. **Rossby, gravity, and Kelvin waves** *(10 points, 3,3,4)*

   Start with the shallow water equations

$$\frac{\partial u}{\partial t} - fv = -g\frac{\partial \eta}{\partial x} \quad (1)$$

$$\frac{\partial v}{\partial t} + fu = -g\frac{\partial \eta}{\partial y} \quad (2)$$

$$\frac{\partial \eta}{\partial t} + H\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = 0 \quad (3)$$

   with H=const. as mean depth and η as surface anomaly.

   a) With the elimination of the fast gravity waves in equation (3)

$$\frac{\partial \eta}{\partial t} = 0$$

   derive the dispersion relation for divergence-free Rossby waves! Ansatz: Introduce a streamfunction for u,v: $\Psi \sim \exp(ikx + ily - i\omega t)$

   b) With the assumption of $f = f_0 = 0$ derive the dispersion relation for gravity waves! The restoring force is related to gravity.
   Ansatz: Start with the equation (3) and derive the solution.

   c) Kelvin waves:
   Derive the dispersion relation for Kelvin waves?
   Why are Kelvin waves trapped along the equator and the coasts? Make a sketch!

2. **Questions about advection** *(4 points, 2,2)*

   a) The temperature at a point 50 km north of a station is 3°C cooler than at the station. If the wind is blowing from the northeast at 20m/s and the air is being heated by radiation at a rate of 1°C/h, what is the local temperature change at the station?

   b) The following data were received from 50 km to the east, north, west and south of a station, respectively: 90 degrees, 10m/s; 120 degrees, 4m/s; 90 degrees, 8m/s; 60 degrees, 4m/s. Given are the angle and absolute value of the wind speed. Calculate the approximate horizontal divergence at the station.

<u>Notes on submission form of the exercises:</u> *Working in study groups is encouraged, but each student is responsible for his/her own solution. The answers to the questions can be send until the due date (12:00 pm) to Alessandro Gagliardi (Alessandro.Gagliardi@awi.de), Georg Huettner (Georg.Huettner@awi.de).*