University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II EXAMINATION 2011/2012

ACM 40540

Synoptic Meteorology II

External examiner: Professor Peter A Clark

Head of School: Dr Patrick Murphy

Lecturer: Professor Peter Lynch*

Time Allowed: 2 hours

Instructions for Candidates

Answer **all three (3)** questions.
Total: 80 marks.

Instructions for Invigilators

Colour versions of Figs 1 and 2
will be distributed at the examination.

Question 1 (25 marks)

(a) (*9 marks*) Write an account (approximately one page) of the use of weather radar in operational forecasting. Include a treatment of the following:

- The principles of determining target location.
- Scanning stragegies (PPI, RHI, etc.)
- Scanning modes (Clear-air mode, precipitation mode).
- Value of Doppler component.
- Ground clutter and other spurious echoes.

(a) (*7 marks*) How does the average returned power vary with the signal wavelength? What are the factors that determine the optimal operating wavelength?

(a) (*9 marks*) When the wavelength is fixed, the power is given by

$$P_r = \frac{R_c Z_e}{r^2}$$

where P_r is the average returned power, R_c is the radar constant, Z_e is the reflectivity (equivalent radar reflectivity factor) and r is the distance from radar to target. How does the reflectivity vary with the size of the scattering targets?

Question 2 (30 marks)

(a) (*9 marks*) Discuss the link between convergence/divergence and vertical velocity using the continuity equation (in isobaric coordinates).

(b) (*9 marks*) Describe Dines' simple two-level model of the atmosphere. What is the main kinematic controlling factor for development?

Using illustrations, indicate the typical pattern of convergence/divergence and vertical velocity in the troposphere for a developing min-latitude depression.

(c) (*12 marks*) The panel in Fig. 1 below shows an analysis valid at 0600 UTC on 2nd April, 2012. Fig. 2 shows a cross-section of the atmosphere at 60°N (south of Helsinki, north of Oslo, south of Shetland) also valid at 0600 UTC on 2nd April, 2012.

1. Relate the main areas of ascending and descending motion to the synoptic pattern along 60°N shown in Fig. 1.

2. Identify the approximate pressure level at which the vertical velocity is maximum or minimum. Does this correspond to large or small values of the (absolute value of) divergence?
3. Comment on the relationship between orography and vertical velocity, in view of the synoptic situation.

Question 3 (25 marks)

(a) (*7 marks*) Show, either analytically or geometrically, how two waves of equal amplitude and almost equal frequency combine to produce a signal with frequency comparable to the two input components and a low-frequency envelope.

(b) (*10 marks*) Given the dispersion relation for Rossby waves

$$c = \bar{u} - \frac{\beta}{k^2}$$

(where the notation is conventional), derive an expression for the group velocity. Explain the implications of the group velocity formula for the evolution of a wave packet of Rossby waves in middle latitudes.

(c) (*8 marks*) During November 2002, there was a succession of extreme weather events around the middle latitudes of the Northern hemisphere [as discussed in lectures]. Indicate on a Hovmöller diagram how the interrelationship between the events can be elucidated in terms of group velocity.

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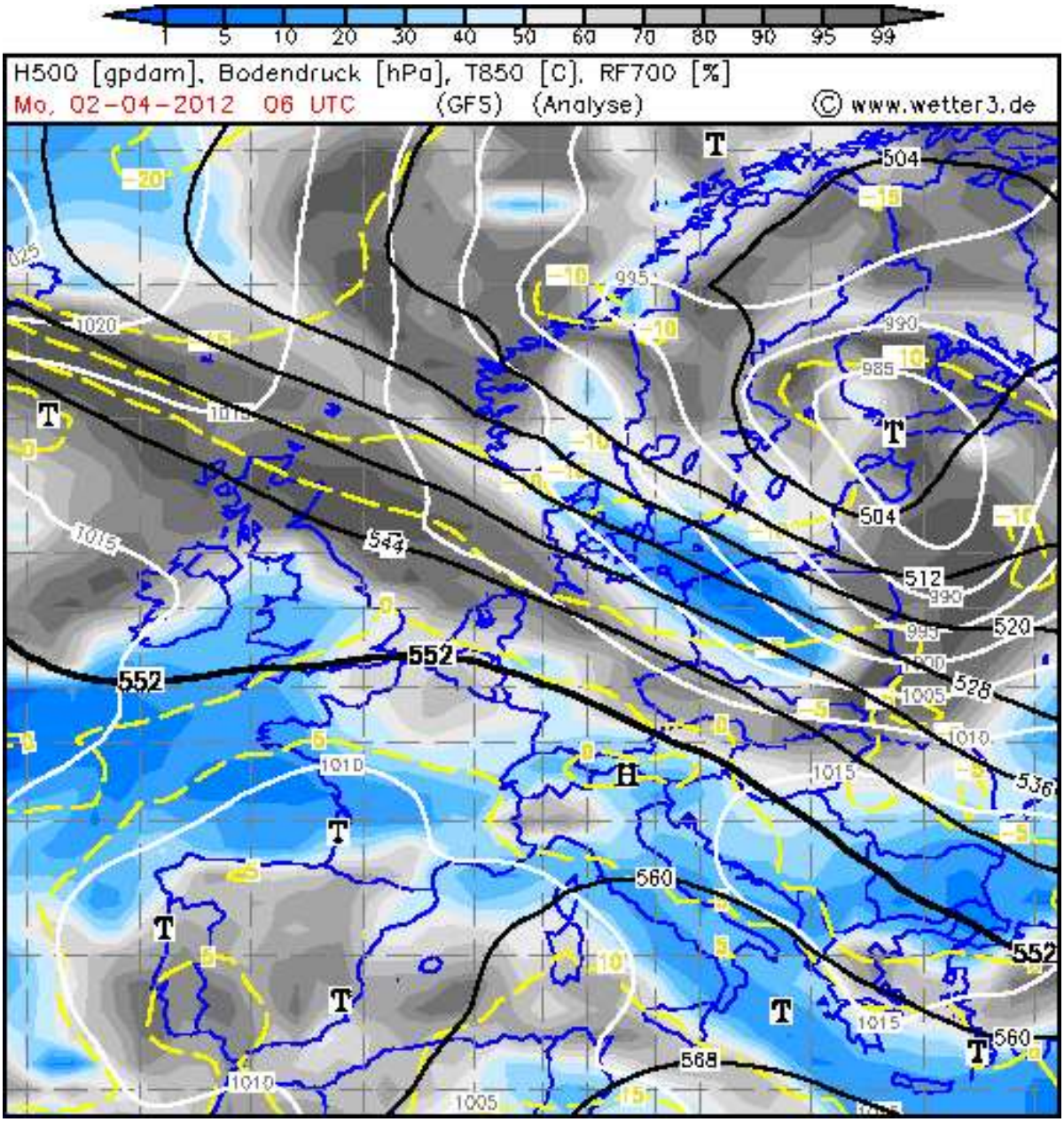

Figure 1: Analysis valid at 0600 UTC on 2nd April, 2012. Sea-level pressure (Bodendruck, white contours, hPa), 500 hPa height (H500, black contours, dam), 800 hPa temperature (T850, dashed yellow contours, degC), 700 hPa relative humidity (RF700, blue-black shading, %) and precipitation (Niederschlag, symbols) are shown.

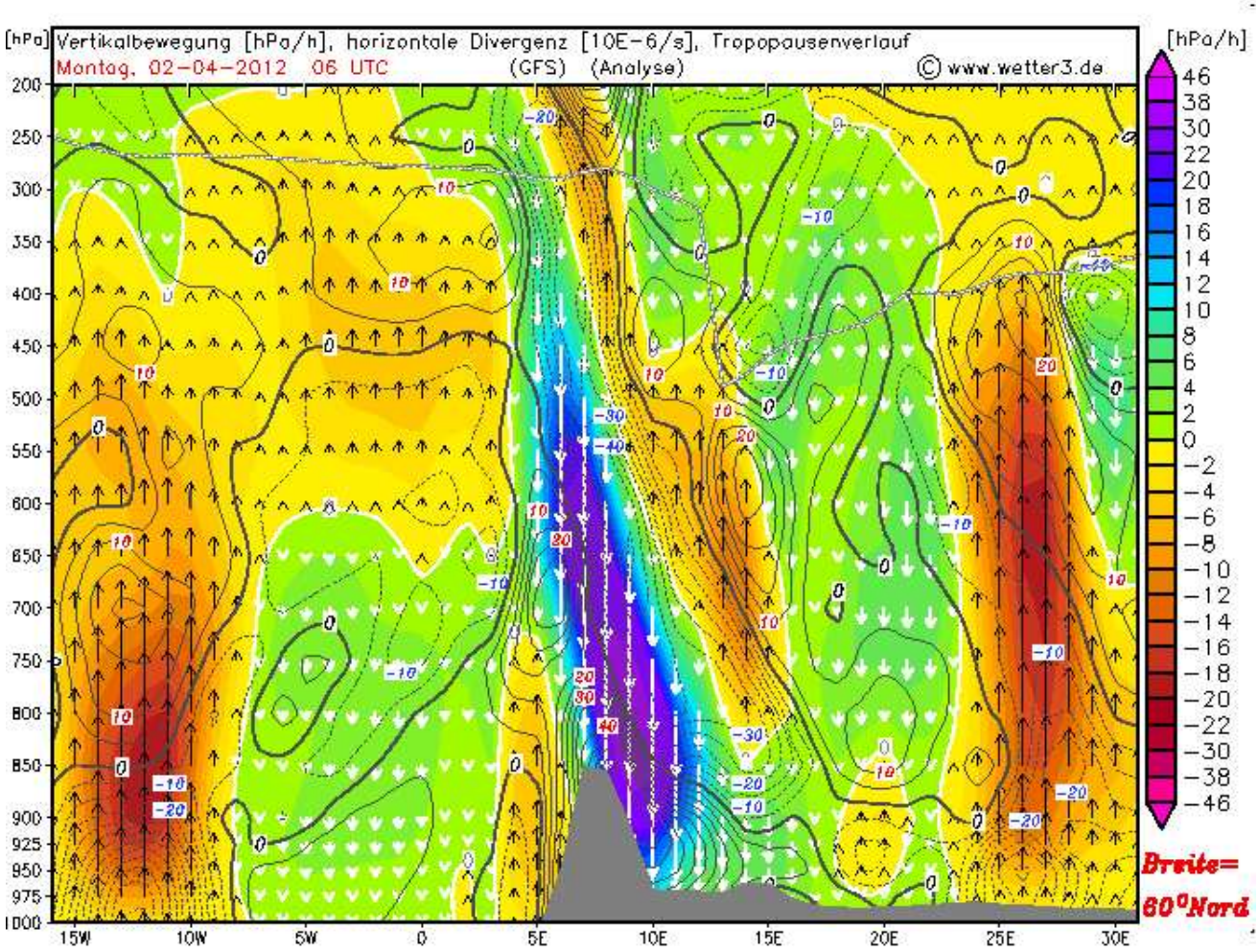

Figure 2: Cross-section of the atmosphere at 60°N valid at 0600 UTC on 2nd April, 2012. Vertical velocity, ω (Vertikalbewegung, vertical arrows and colour shading, hPa/h), horizontal divergence (horizontale Divergenz, black contours, $10^{-6}s^{-1}$) and tropopause height (Tropopausenverlauf, black/white line) are shown.