University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

**SEMESTER II EXAMINATION 2010/2011**

**ACM 40540**

**Synoptic Meteorology II**

Extern examiner: Prof Peter Clark

Head of School: Prof Mícheál Ó Searcóid

Examiner: Prof Peter Lynch*

**Time Allowed: 2 hours**

**Instructions for Candidates**

Answer **all (4)** questions.

Please avoid the use of red ink on the answer books.

**Instructions for Invigilators**

Non-programmable calculators may be used during this examination.

[Colour versions of the figures will be provided at the examination.]

# Question 1 (16 marks)

(a) (*8 marks*)

Review the four stages of extra-tropical frontal development according to the Shapiro-Keyser (SK) model. Illustrate each stage with a sketch or sketches.

(b) (*8 marks*)

Compare the SK model with the classical Norwegian model of a frontal depression, pointing out the similarities and differences between the two models.

Discuss the applicability of the two models to the storm *Xynthia*, which made landfall in France in February, 2010.

# Question 2 (24 marks)

Two air masses, of uniform temperature $T_1$ and $T_2$, are moving with constant velocity $V_1$ and $V_2$ respectively, parallel to the plane frontal surface separating them, with no along-front variations.

(a) (*8 marks*) Show, assuming geostrophic flow and making the Boussinesq approximation, that the angle of slope $\varepsilon$ of the frontal surface is given by

$$\tan\varepsilon = \frac{f\bar{T}}{g}\frac{V_1 - V_2}{T_1 - T_2}$$

where $\bar{T} = (T_1 + T_2)/2$. State any further approximations or assumptions that you make.

(b) (*8 marks*) Calculate the frontal slope assuming that the mean temperature is $\bar{T} = 280\,\mathrm{K}$, the Coriolis parameter $f = 10^{-4}\,\mathrm{s}^{-1}$, $g = 10\,\mathrm{m\,s}^{-2}$, the difference in windspeed across the front is $\Delta V = 12\,\mathrm{m\,s}^{-1}$ and the difference in temperature is $\Delta T = 4\,\mathrm{K}$.

(c) (*8 marks*) Sketch the pressure pattern associated with this flow configuration and describe how it is modified by superposition of a constant drift perpendicular to the front. How is this used in synoptic analysis.

# Question 3 (24 marks)

(a) (*12 marks*) The panel in Fig. 1 below shows a 36 hour forecast valid at 1800 UTC on 15th November, 2008. 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.

1. Describe the general synoptic situation over western Europe, as shown on the chart.
2. Identify the main areas of strong upper-level flow.
3. Indicate an area where the flow is barotropic, and an area where it is baroclinic.
4. Identify a region where there is cold advection in the lower troposphere.

(b) (*12 marks*) Fig. 2 shows a cross-section of the atmosphere at 40°N (through the heel of Italy, Sardinia and Madrid), also valid at 1800 UTC on 15th November, 2008. Vertical velocity, $\omega$ (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.

1. Relate the main areas of ascending and descending motion to the synoptic pattern along 40°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. Describe the overall patterns of divergence and vertical velocity in terms of the Dines two-layer model.
4. Does Dines conceptual model give a reasonably accurate representation of the actual synoptic configuration?

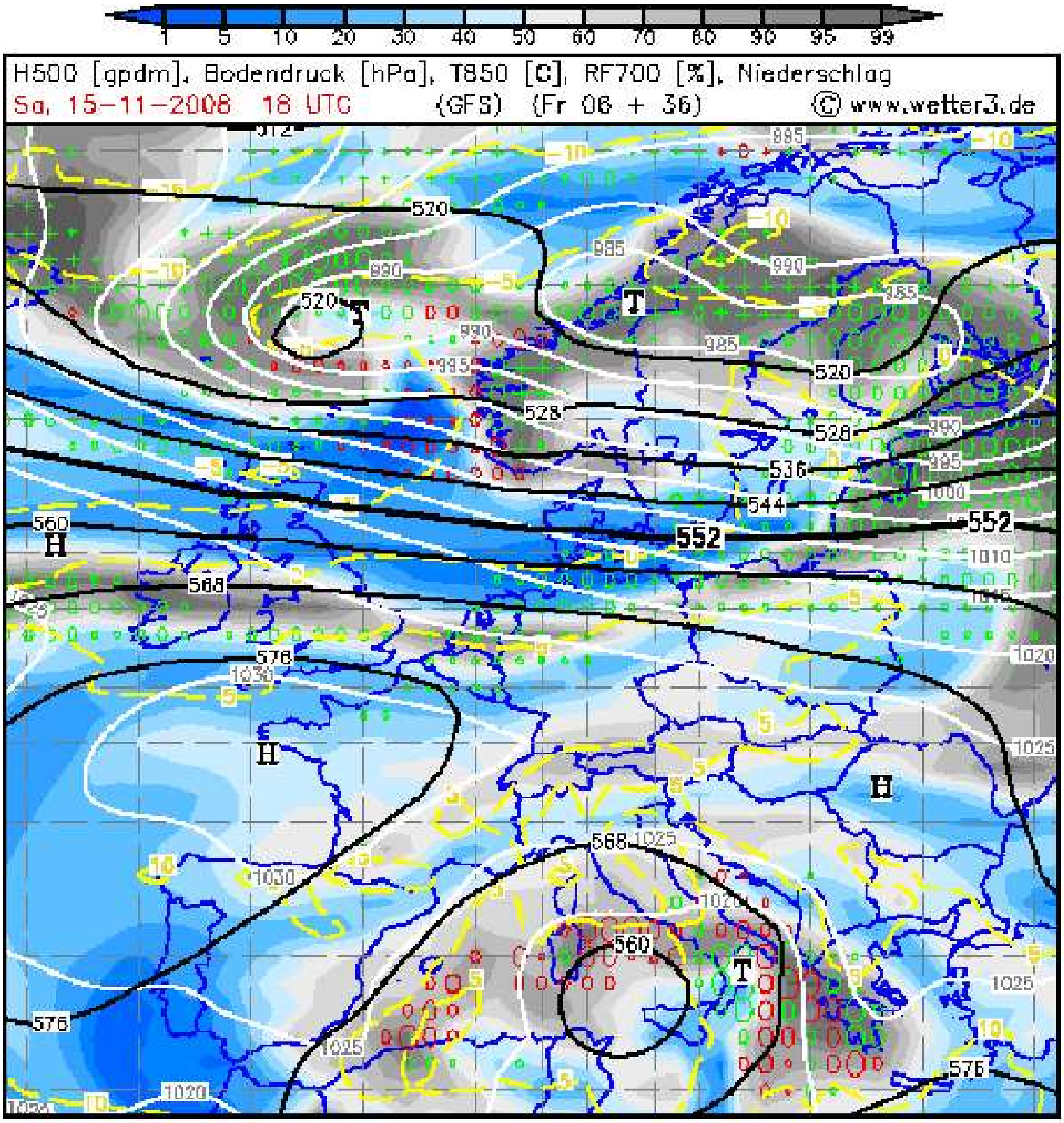


**Figure 1.** GFS 36 hour forecast valid at 1800 UTC on 15th December, 2008. Sea-level pressure (Bodendruck, white contours, hPa), 500 hPa height (H500, black contours, dam), 800 hPa temperature (T850, dashed yellow contours, °C), 700 hPa relative humidity (RF700, blue-black shading, %) and precipitation (Niederschlag, symbols).

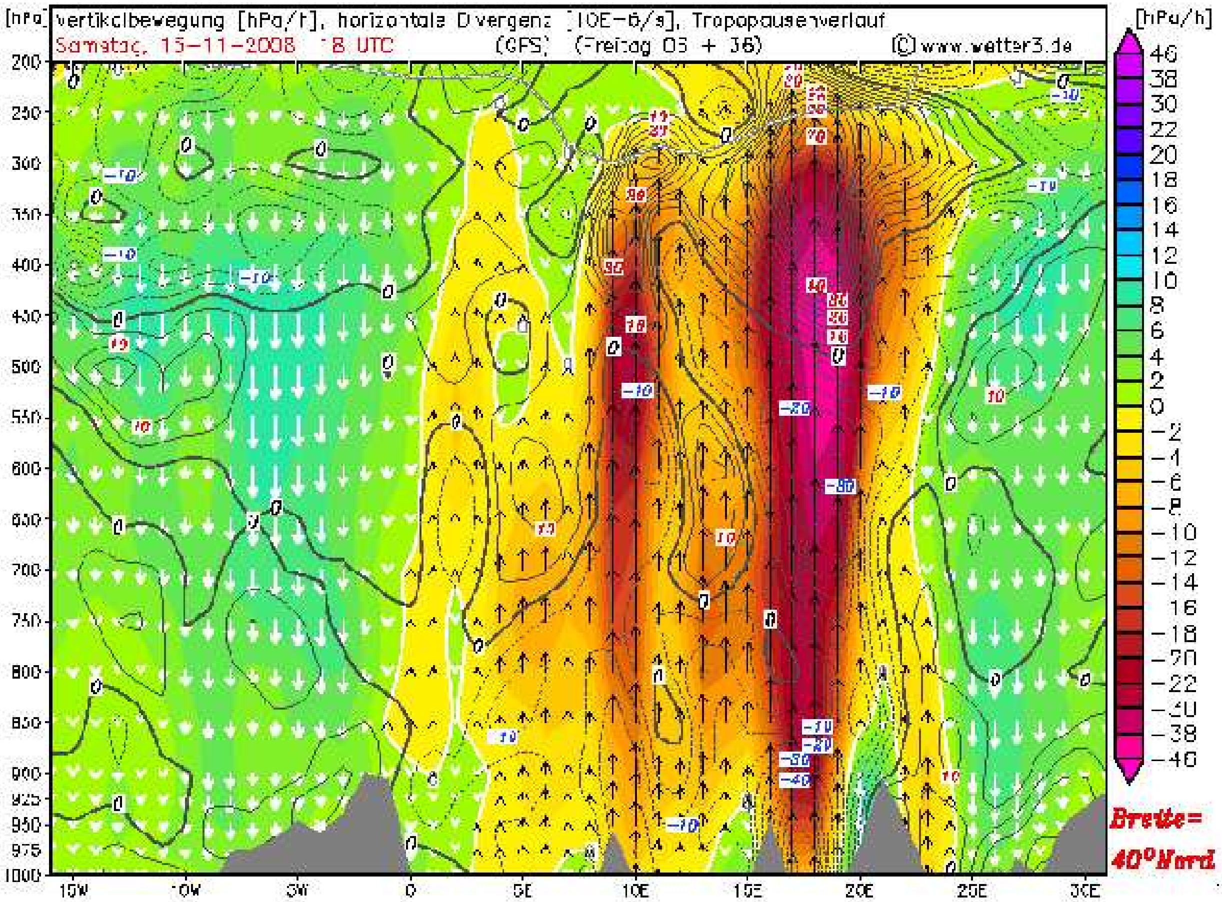


**Figure 2.** Cross-section of the atmosphere at 40 degrees North (through the heel of Italy, Sardinia and Madrid), valid at 1800 UTC on 15th December, 2008. Vertical velocity, ω (Vertikalbewegung, vertical arrows and colour shading, hPa/h), horizontal divergence (horizontale Divergenz, black contours, 10E-6/s) and tropopause height (Tropopausenverlauf, black/white line).

## Question 4 (16 marks)

(a) (*6 marks*) Briefly describe the phenomenon of "sensitive dependence on initial conditions". Comment on its implications for short-range and for medium-range weather forecasting. Which weather elements are more predictable and which are less predictable at medium range?

(b) (*10 marks*) Consider the EPS-gram in Fig. 3. *Using only the evidence in this diagram*, describe the probable weather conditions in Dublin for

(i) St. Patrick's Day, 17th March 2011.

(ii) Friday, 18th March 2011.

Give a brief weather outlook for the weekend (19th and 20th March 2011). What is your confidence in the prediction for the weekend, based on the ensemble forecasts?

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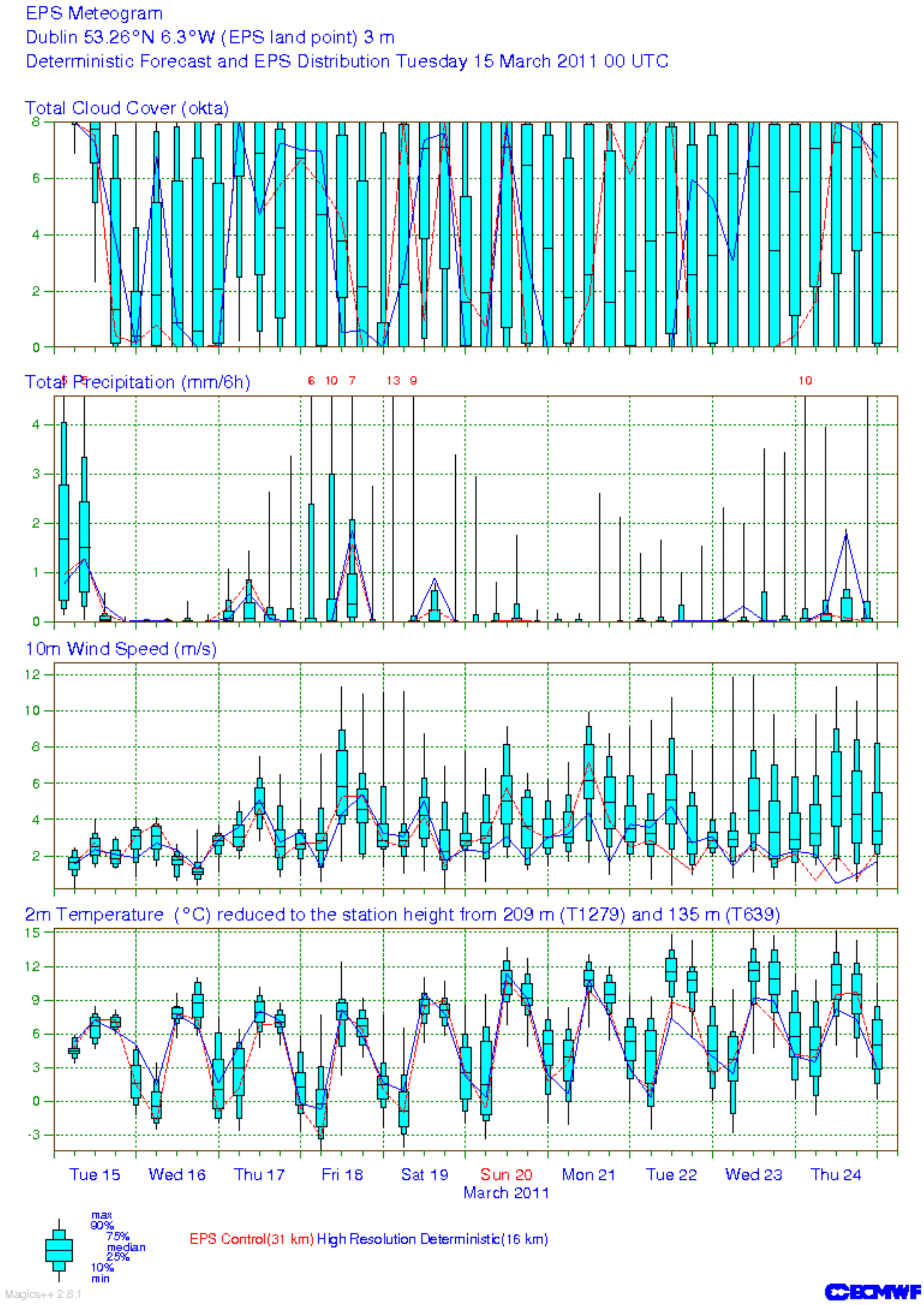


Figure 3: EPSgram for Dublin, 15–24 March, 2011