Synoptic Meteorology MAPH 40410

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Syllabus

This module will comprise 24 lecture sessions and 24 tutorials and practical laboratory sessions. Current weather situations will be studied in the practical sessions. Texts used:

- *Applied Atmospheric Dynamics.* Amanda H Lynch and John J Cassano. Wiley (2006).
- *Mid-Latitude Atmospheric Dynamics: A First Course.* Jonathan E. Martin. Wiley (2006).

Additional references:

- *Weather Analysis and Forecasting.* Patrick Santurette and Christo G. Georgiev. Elsevier Academic Press (2005).
- *Mid-Latitude Weather Systems.* Toby N. Carlson. Routledge (1992).
- *Synoptic Meteorology.* Manfred Kurz. DWD (1998).

1 Practical Synoptic Meteorology

The tutorials and laboratory sessions deal with practical weather analysis and forecasting. Current weather are analysed using a range of observational and NWP inputs. Case studies are being developed in collaboration with Met Éireann.

1.1 Observations

Basic observational methods. Observational standards. Surface synoptic stations. Radiosonde ascents. Weather radar. Satellite Data.

1.2 Codes

Encoding and transmission of observations. The global telecommunications system (GTS). WMO codes and standards. SYNOP code. METARs and TAFs.

1.3 Chart analysis

Graphical representation of observations. The station model. Subjective analysis of surface and upper air charts. Interpretation of analysed charts.

1.4 Weather case studies

Detailed analysis of case studies, developed in conjunction with Met Éireann staff. Also, cases from MetEd/COMET and SatRep websites.

1.5 Current weather data

The XCHARTS system. Observations from Met Éireann. HiRLAM products, radar and satellite data from Met Éireann. HiRLAM forecasts from `http://fminwp.fmi.fi`. Deterministic and probabilistic guidance from ECMWF, UKMO, NCEP.

1.6 Practical forecasting

Analysis of newsprint and TV forecasts. Preparation of short and medium-range forecasts. Presentation techniques for forecasters. Intensive one-week practical forecasting course (in second semester break).

2 Synoptic Meteorology Lectures

2.1 Introduction: Anatomy of a Mid-latitude Depression

Structure of the the atmosphere. Air masses and fronts. The structure of a typical extra-tropical cyclone.

2.2 Review of Mathematical Methods

Scalar and vector fields. Coordinate systems on the earth. Gradient, divergence and curl. Deformation flows. Line and surface integrals. Eulerian and Lagrangian frames of reference. Advection.

2.3 Overview of Basic Equations

Equation of state. Hydrostatic equation. Continuity equation. Height and pressure coordinates. Forces in inertial and rotating reference frames. The Navier-Stokes equation.

2.4 Scale analysis and steady motions

Dimensional homogeneity. Non-dimensional parameters. Scale analysis. The geostrophic approximation. Natural coordinate system. Balanced flows: geostrophic; inertial; cyclostrophic; gradient. The Boussinesq approximation. The thermal wind. Departures from balance.

2.5 Circulation and Vorticity

Circulation. Vorticity. An introduction to the vorticity equation. Relationship between vorticity and divergence. Conservation of potential vorticity. The quasi-geostrophic system.

2.6 Simple wave motions

Properties of waves. Perturbation analysis. Gravity waves and Rossby waves. Application to analysis of atmospheric flows. Group velocity and its significance for development.

2.7 Extra-tropical weather systems: basic structure

Airmasses: classification, origin, transformation. The structure of the polar front. Qualitative description of baroclinic instability. Observed structure of an extra-tropical depression. Theories of cyclogenesis and synoptic development.

2.8 Midlatitude synoptic-scale systems: detailed analysis

Clouds and precipitation associated with midlatitude systems. Jet streams and jet streaks. Heat, moisture and momentum transport by midlatitude eddies. The angular momentum budget. The energy cycle. Cyclogenesis: the QG perspective. Frontogenesis and frontolysis. Case studies.

2.9 Potential vorticity and mid-latitude systems

Isentropic potential vorticity and its inversion. Characteristics of a positive PV anomaly. Cyclogenesis from the PV perspective. The influence of diabatic heating. Case studies.

2.10 Additional Topics

A selection of additional topics will be included in the lectures, depending on available time.

- The atmospheric boundary layer. Turbulence in the ABL.
- Mesoscale convective systems.
- Polar lows.
- Extreme weather events.
- Tropical cyclones. Hurricanes.
- Flow over mountains. Mountain weather.