Descriptive questions

1. Explain the difference between meteorology and climate.
2. Illustrate how surface weather observations are carried out and distributed in meteorology.
3. Describe the main and more used types of maps (weather charts) existing in meteorology (surface and upper levels).
4. Describe the typical radiosounding chart, comment the information provided, and draw two examples of diagrams containing an inversion layer, with and without radiation fog.
5. Describe the typical radiosounding chart, comment the information provided, and draw an example of diagram typical of freezing rain.
6. Describe the typical radiosounding chart, comment the information provided, and descrive how to get from the diagram the information about relative humidity at a given level.
7. Describe the typical radiosounding chart, comment the information provided, and draw an example of diagram characterized by fair-weather cumulus clouds.
8. Describe the typical radiosounding chart, comment the information provided, and draw an example of diagram characterized by cumulonimbus thunderstorm clouds.
9. List and describe the most important equations regulating the radiation, and discuss the radiative balance of Earth system.
10. Describe a thermal inversion at the soil surface, and correlate it with the radiative budget during nighttime, also mentioning the wind effect.
11. Explain the main characteristics of the Mean Meridional Circulation in the atmosphere at large scale (the cells).
12. Introduce the Rossby waves and their link with the mean meridional circulation.
13. Mention and discuss the main forms of condensation/freezing at the ground and in the surface atmospheric boundary layer.
14. Describe all types of tropospheric clouds: physical characteristics, precipitation chances and associated phenomena.
15. Why homogeneous nucleation is unable to create water droplets in a cloud? Which other ingredient is needed?
16. Discuss the formation of cloud droplets by diffusion and condensation, mentioning also their initial formation by nucleation, in warm clouds.
17. Discuss the growth of cloud droplets into raindrops by collision and coalescence, in warm clouds.
18. Discuss the growth of cloud ice crystals into snow crystals according with the mechanism of Bergeron-Findeisen in cold clouds.
19. Explicit in detail the typical characteristics of weather fronts.
20. Fronts and slope: describe how Margules equation is able to predict the slope of a front.
21. Fronts and air masses: describe in detail their definitions and characteristics.
22. Describe the conceptual models of extratropical cyclone formation, growth and decay.
23. Describe the connections between tropospheric and stratospheric circulation.
24. Describe the NAO, its phases and their consequences on weather in Atlantic region.

25. Describe the ENSO, its phases and their consequences on weather and climate.
26. Briefly describe weather radar principles: operating, the simplified radar equation, main observables, source of uncertainties and errors.
27. Discuss the echo radar and the way to estimate the precipitation by radar.
28. Convective cells: describe and comment the classification of thunderstorms
29. Numerical modeling: comments the main differences between global and local NWP models
30. Describe the principles of operating of satellites.
31. Limit and advantage of geostationary and LEO satellites.
32. Spectral and multispectral images of satellites.
33. The breezes: formation and characteristics.
34. Main synoptic and mesoscale characteristics of alpine foehn.
35. ~~Tropical cyclones: genesis and characteristics.~~
36. ~~TLC or Medicanes: genesis, characteristics, and differences with tropical cyclones.~~

Formal questions

1. List and comment the governing equations of the free atmosphere.
2. Derive the vertical component of vorticity equation in its complete form.
3. Scale analysis of the vertical component of vorticity equation (below reported):

$$\rho \frac{d}{dt}\left(\frac{\zeta + f}{\rho}\right) = -\frac{\partial v}{\partial z}\frac{\partial w}{\partial x} + \frac{\partial u}{\partial z}\frac{\partial w}{\partial y} + (\zeta + f)\frac{\partial w}{\partial z} - \nabla_H \alpha \times \nabla_H p$$

4. Illustrate the effect of potential vorticity conservation in the case of an adiabatic flow over a mountain range.
5. Derive the quasi geostrophic vorticity equation starting from the primitive equations below reported, by explicating (and commenting) all passages and assumptions:

$$\frac{d\vec{v}}{dt} + f\vec{k}\times\vec{v} = -\nabla\Phi \qquad \nabla\circ\vec{v} + \frac{\partial\omega}{\partial p} = 0 \qquad \frac{\partial\Phi}{\partial p} = -\alpha = -\frac{RT}{p} \qquad \left(\frac{\partial}{\partial t} + \vec{v}\bullet\nabla\right)T - S_p\omega = \frac{J}{c_p}$$

6. Comment on the meaning of each term of the quasi geostrophic vorticity equation:

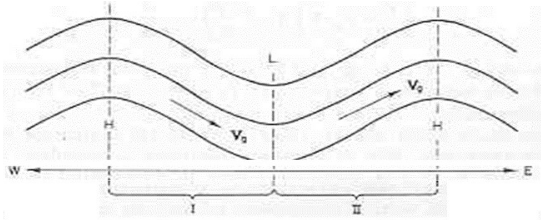
$$\frac{\partial\zeta_g}{\partial t} + \overrightarrow{v_g}\cdot\nabla(\zeta_g + f) = f_0\frac{\partial\omega}{\partial p}$$

7. Derive the geopotential tendency equation starting from the quasi geostrophic system, giving a schematic desctiption of each component:

$$\frac{\partial\chi}{\partial p} = -\overrightarrow{v_g}\cdot\nabla\left(\frac{\partial\Phi}{\partial p}\right) - \sigma\omega \qquad \nabla^2\chi = -f_0\overrightarrow{v_g}\cdot\nabla\left(\frac{1}{f_0}\nabla^2\Phi + f\right) + f_0^2\frac{\partial\omega}{\partial p}$$

8. Comment on the geopotential tendency equation, by explaining in detail the meaning of each term (as we did in class) and showing the behaviors in the zone I and II:

$$\left[\nabla^2 + \frac{\partial}{\partial p}\left(\frac{f_0^2}{\sigma}\frac{\partial}{\partial p}\right)\right]\chi = -f_0\vec{v}_g \cdot \nabla\left(\frac{1}{f_0}\nabla^2\Phi + f\right) - \frac{\partial}{\partial p}\left[-\frac{f_0^2}{\sigma}\vec{v}_g \cdot \nabla\left(-\frac{\partial \Phi}{\partial p}\right)\right]$$

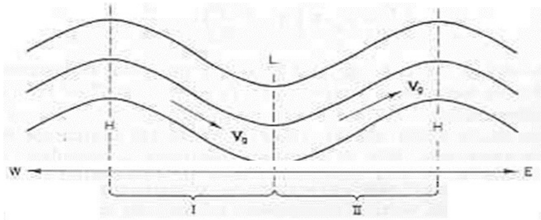


9. Derive the omega equation from the two following equations:

$$\frac{\partial \chi}{\partial p} = -\vec{v}_g \cdot \nabla\left(\frac{\partial \Phi}{\partial p}\right) - \sigma\omega \qquad \nabla^2\chi = -f_0\vec{v}_g \cdot \nabla\left(\frac{1}{f_0}\nabla^2\Phi + f\right) + f_0^2\frac{\partial \omega}{\partial p}$$

10. Comment on the omega equation, by explaining in detail the meaning of each term (as we did in class) and showing the behaviors in the zone I and II:

$$\left(\nabla^2 + \frac{f_0^2}{\sigma}\frac{\partial^2}{\partial p^2}\right)\omega = \frac{f_0}{\sigma}\frac{\partial}{\partial p}\left[\vec{v}_g \cdot \nabla\left(\frac{1}{f_0}\nabla^2\Phi + f\right)\right] + \frac{1}{\sigma}\nabla^2\left[\vec{v}_g \cdot \nabla\left(-\frac{\partial \Phi}{\partial p}\right)\right]$$



11. Explain the idealized model of baroclinic disturbance.

Meteorological analysis

1. Make a comprehensive analysis of the meteorological situations by using the attached material (maps, satellite images and radiosounding), with a special eye on Italian and Piedmontese territory.

Modality of exam

One descriptive question, one formal question (both randomly selected), and the meteorological analysys on a given case study.

Time for answers: max 3 hours.

Material allowed: nothing, excepting pen and white paper.

Only for 2020, due to Coronavirus emergency: exam will be oral and individual. Questions will be selected randomly as explained above. For questions which need formulae or figures, candidate can write or draw on a paper and then show us the result with video.