

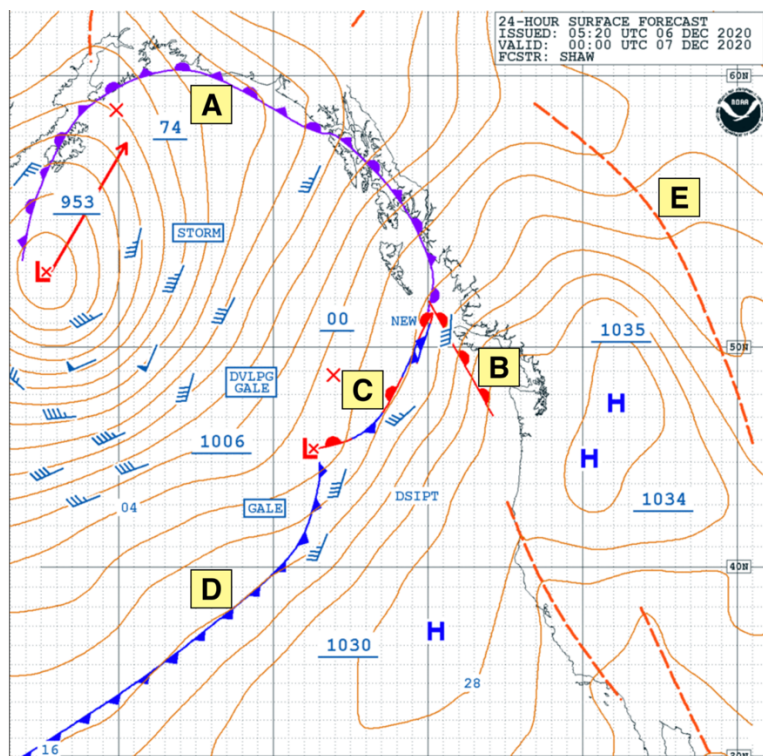
Due to COVID-19, two final exams were given: the normal final exam for most students (on 14 Dec 2020) and the make-up exam (on 16 Dec 2020) for students with exam & other conflicts.

=== the next 4 questions use the attached weather map =====
points = 2

- 1a. In the attached surface weather map in the Northern Hemisphere, a stationary front is at:
A, B, C, D, E
- 1b. In the attached surface weather map in the Northern Hemisphere, an occluded front is at:
A, B, C, D, E

points = 3

- 2a. In the attached surface weather map in the Northern Hemisphere, a trough axis (not associated with a front) is at:
A, B, C, D, E
- 2b. In the attached surface weather map in the Northern Hemisphere, a cold front is at:
A, B, C, D, E



points = 2

- 3a. In the attached surface weather map in the Northern Hemisphere, what type of clouds would you expect at the bottom left corner of the box indicating location B?
A) lenticular B) flammagenitus C) silvagenitus D) stratiform E) cumuliform
- 3b. In the attached surface weather map in the Northern Hemisphere, what type of clouds would you expect at the bottom right corner of the box indicating location D?
A) lenticular B) flammagenitus C) silvagenitus D) stratiform E) cumuliform

points = 4

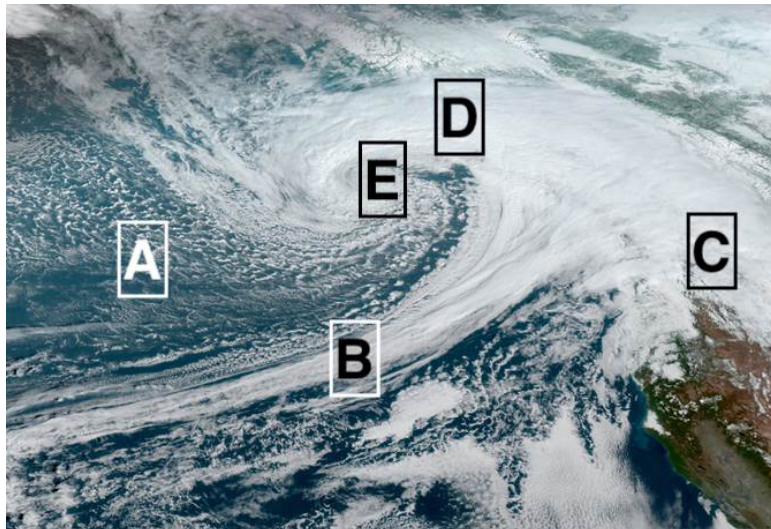
4a. In the attached surface weather map in the Northern Hemisphere, you would expect the fastest winds at:

- A, B, C, D, E

4b. In the attached surface weather map in the Northern Hemisphere, southeast winds are likely at which location?

- A, B, C, D, E

==== end of weather map questions ====



points = 3

5a. At location E in the attached satellite image is a/an

- A) extratropical cyclone undergoing cyclolysis
- B) extratropical cyclone undergoing cyclogenesis
- C) tropical cyclone undergoing cyclolysis
- D) tropical cyclone undergoing cyclogenesis
- E) anticyclone

5b. At location E in the attached satellite image is a/an

- A) extratropical cyclone undergoing cyclolysis
- B) extratropical cyclone undergoing cyclogenesis
- C) tropical cyclone undergoing cyclolysis
- D) tropical cyclone undergoing cyclogenesis
- E) anticyclone

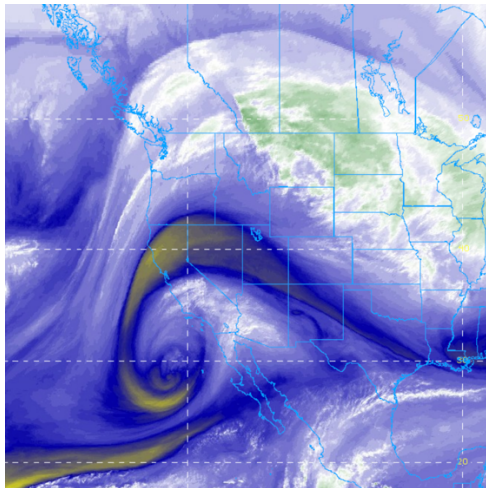
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points = 3

6a. The attached picture is likely a/an _____ image.

- A) radar reflectivity
- B) visible satellite

- C) water vapour satellite
- D) infrared satellite
- E) radar Doppler-velocity

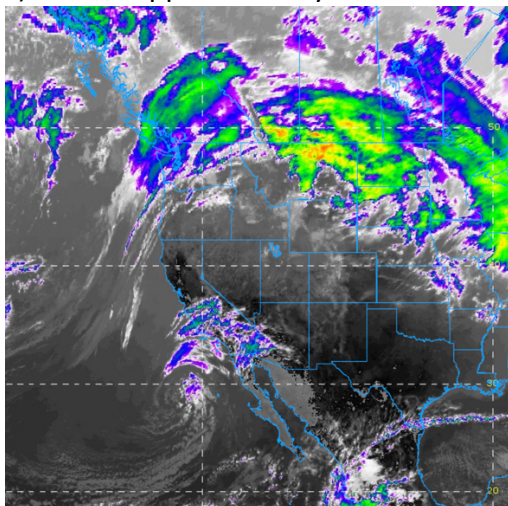


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points = 3

6b. The attached picture is likely a/an _____ image.

- A) radar reflectivity
- B) visible satellite
- C) water vapour satellite
- D) infrared satellite
- E) radar Doppler-velocity

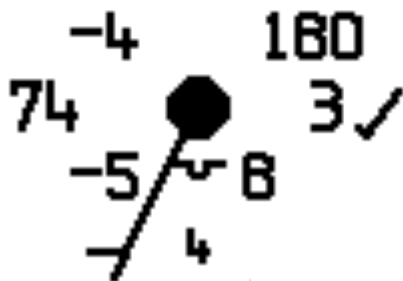


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points = 5

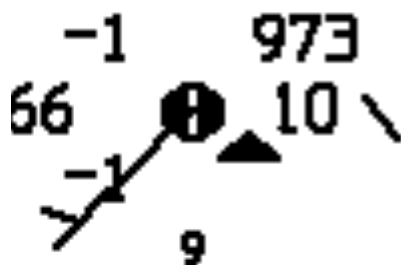
7a. In the attached image from a surface analysis weather map, what is the pressure in kPa?

- A) 74
- B) 180
- C) 918.0
- D) 118.0
- E) 101.80



7b. In the attached image from a surface analysis weather map, what is the pressure in kPa?

- A) 66 B) 973 C) 197.3 D) 99.73 E) 109.73



=====

points = 3

8a. Which statement is TRUE?

- A) The Hadley cells transport heat from the equator to the poles.
- B) The trade winds are found at low latitudes.
- C) In mid-latitudes, cyclones and anticyclones generally move toward the west.
- D) The ITCZ marks the level of free convection.
- E) Over continents in summer are generally monsoon high-pressure systems at the bottom of the atmosphere.

8b. Which statement is TRUE?

- A) The Hadley cells transport heat from the equator to the poles.
- B) The trade winds are found at mid latitudes.
- C) In mid-latitudes, cyclones and anticyclones generally move toward the east.
- D) The ITCZ marks the level of free convection.
- E) Over continents in summer are generally monsoon high-pressure systems at the bottom of the atmosphere.

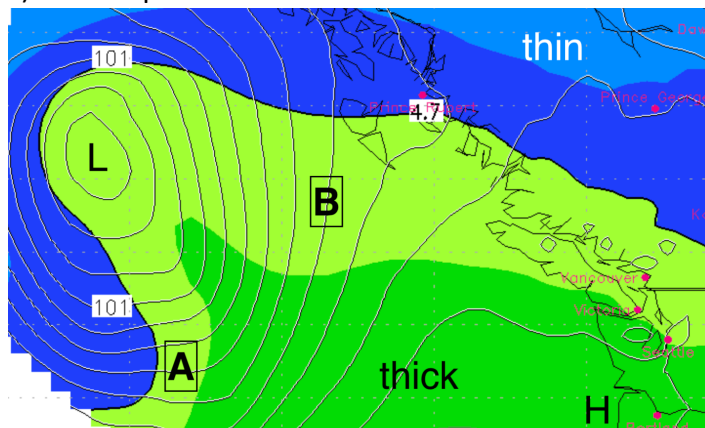
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points = 5

9a. The attached N. Hemisphere weather map shows 100 to 50 kPa thickness (colour shading) and sea-level Pressure (thin black lines). Which statement is TRUE for location A ?

- A) Geostrophic winds are from the west and thermal winds are from the north.
- B) Geostrophic winds are from the west and thermal winds are from the south.

- C) Geostrophic winds are from the east and thermal winds are from the north.
 D) Geostrophic winds are from the east and thermal winds are from the south.
 E) Geostrophic winds are from the south and thermal winds are from the west.



- 9b. The attached N. Hemisphere weather map shows 100 to 50 kPa thickness (colour shading) and sea-level Pressure (thin black lines). Which statement is TRUE for location B ?
- A) Geostrophic winds are from the west and thermal winds are from the north.
 B) Geostrophic winds are from the west and thermal winds are from the south.
 C) Geostrophic winds are from the east and thermal winds are from the north.
 D) Geostrophic winds are from the east and thermal winds are from the south.
 E) Geostrophic winds are from the south and thermal winds are from the west.

=====

points = 5

10a. Which statement is FALSE?

- A) The thermal wind describes the variation of geostrophic wind with height due to a horizontal temperature gradient.
 B) The hypsometric equation explains why the warm core in hurricanes helps to drive outflow winds at the top of the storm.
 C) The waves in African easterly jet can trigger tropical cyclones east of trough axes.
 D) The waves in the polar jet can trigger extratropical cyclones east of trough axes.
 E) Westward tilt of low pressure with increasing altitude in midlatitudes helps to drive cyclolysis.

10b. Which statement is FALSE?

- A) The thermal winds describes the variation of geostrophic wind with height due to a vertical temperature gradient.
 B) The hypsometric equation explains why the warm core in hurricanes helps to drive outflow winds at the top of the storm.
 C) The waves in African easterly jet can trigger tropical cyclones east of trough axes.
 D) The waves in the polar jet can trigger extratropical cyclones east of trough axes.
 E) Westward tilt of low pressure with increasing altitude in midlatitudes helps to drive cyclogenesis.

=====

points = 2

11a. The variation of Coriolis force with latitude helps explain Rossby waves due to its role in the

- A) conservation of relative vorticity
- B) the restoring force of gravity
- C) the length of a pendulum day
- D) conservation of heat
- E) conservation of potential vorticity

11b. The variation of Coriolis force with latitude helps explain Rossby waves due to its role in the

- A) conservation of potential vorticity
- B) the restoring force of gravity
- C) the length of a pendulum day
- D) conservation of heat
- E) conservation of relative vorticity

=====

points = 7

12a. Jet streaks and Rossby waves have some characteristics in common? Which answer does NOT give a common characteristic?

- A) They both can cause cyclogenesis.
- B) They are both at the top of the troposphere.
- C) They are both associated with the polar jet stream.
- D) They both can cause divergence in the upper atmosphere.
- E) They both are strengthened by boundary-layer drag.

12b. Jet streaks and Rossby waves have some characteristics in common? Which answer does NOT give a common characteristic?

- A) They both can cause cyclogenesis
- B) They both are strengthened by boundary-layer drag.
- C) They are both associated with the polar jet stream.
- D) They both can cause divergence in the upper atmosphere.
- E) They are both at the top of the troposphere.

=====

points = 5

13a. Lee cyclogenesis

- A) is caused by change in depth of tropospheric air as it flows over mountain ridges.
- B) results in tropical cyclones forming east of the Rocky mountains in N. America.
- C) is caused by mountain waves as statically stable air flows over mountain ridges.
- D) results in extratropical cyclones forming west of the Rocky mountains in N. America.
- E) is strongest under the right exit region of jet streaks.

13b. Alberta clippers

- A) result in tropical cyclones forming east of the Rocky mountains in N. America.
- B) are caused by mountain waves as statically stable air flows over mountain ridges.
- C) result in extratropical cyclones forming west of the Rocky mountains in N. America.
- D) are caused by change in depth of tropospheric air as it flows over mountain ridges.
- E) are strongest under the right exit region of jet streaks.

=====

points = 3

14a. Which statement is FALSE?

- A) Fronts usually pivot around Lows.
- B) Cold fronts are drawn on the cold side of frontal zones.
- C) Warm fronts are drawn on the warm side of fronts zones.
- D) Surface pressure is at a relative minimum when a front moves across your location.
- E) Stormy weather is often associated with fronts.

14b. Which statement is FALSE?

- a) Fronts usually pivot around Lows.
- B) Cold fronts are where cold air is advancing
- C) Warm fronts are where warm air is advancing.
- D) Surface pressure is at a relative minimum when a front moves across your location.
- E) Stormy weather is often associated with fronts.

=====

points = 2

15a. The name "typhoon" is associated with tropical cyclones over which ocean?

- A) Eastern North Pacific
- B) North Atlantic
- C) Western North Pacific
- D) Western South Pacific
- E) Indian Ocean

15b. The name "hurricane" is associated with tropical cyclones over which ocean?

- A) Eastern North Pacific
- B) Arctic Ocean
- C) Western North Pacific
- D) Western South Pacific
- E) Eastern Indian Ocean

=====

points = 3

16a. If there is a 11 kPa pressure difference between the sea-level pressures at the eye of the storm and well outside of the eye, then the intensity Category on the Saffir-Simpson Wind scale would be Category _____, according to the info in our textbook.

A) Cat. 1 B) Cat. 2 C) Cat. 3 D) Cat. 4 E) Cat. 5

16b. If there is a 15 kPa pressure difference between the sea-level pressures at the eye of the storm and well outside of the eye, then the intensity Category on the Saffir-Simpson Wind scale would be:

A) Cat. 1 B) Cat. 2 C) Cat. 3 D) Cat. 4 E) Cat. 5

=====

points = 3

17a. Which statement is TRUE?

- A) Hurricanes are strongest over the equator where waters are warmest.
- B) Hurricanes get their energy from heat stored in the ocean.
- C) Hurricanes are "cold-core" cyclones.
- D) Hurricane depth is roughly 10 times the depth of tropical thunderstorms.
- E) Stronger environmental wind shear supports stronger hurricanes.

17b. Which statement is TRUE:

- A) Hurricanes are strongest over the equator where waters are warmest.
- B) Hurricanes are "cold-core" cyclones.
- C) Hurricane depth is roughly 10 times the depth of tropical thunderstorms.
- D) Stronger environmental wind shear supports stronger hurricanes.
- E) Hurricanes weaken and die when they move over cold water.

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points = 11

18a. A Rossby wave of wavelength 1000 km at latitude 60°N would propagate at a barotropic intrinsic phase speed of _____ km/day.

- A) -4
- B) -25
- C) -100
- D) -250
- E) -400

18b. A Rossby wave of wavelength 4000 km at latitude 60°N would propagate at a barotropic intrinsic phase speed of roughly _____ km/day.

- A) -4
- B) -25
- C) -100
- D) -250
- E) -400

=====

points = 8

19a. For a rainfall rate of 90 mm/day from an extratropical cyclone, the central sea-level pressure of the Low would change at a rate of _____ kPa / day.

- A) -9.8 B) -7.4 C) -0.41 D) -0.31 E) -0.21

19b. For a rainfall rate of 120 mm/day from an extratropical cyclone, the central sea-level pressure of the Low would change at a rate of _____ kPa / day.

- A) -9.8 B) -7.4 C) -0.41 D) -0.31 E) -0.21

=====
points = 3

20a. The circulations in the earth's atmosphere can be thought of as analogous to

- A) population cycles associated with prey-predator relationships.
- B) the exponential spread of pandemics around the globe.
- C) the application of Occam's razor to the scientific method applied for a rotating earth.
- D) Bernoulli's principle as a compressible atmosphere responds to gravitational accelerations.
- E) LeChatelier's principle as the atmosphere responds to differential heating.

20b. The circulations in the earth's atmosphere can be thought of as analogous to

- A) population cycles associated with prey-predator relationships.
- B) the exponential spread of pandemics around the globe.
- C) the application of Occam's razor to the scientific method applied for a rotating earth.
- D) LeChatelier's principle as the atmosphere responds to differential heating.
- E) Bernoulli's principle as a compressible atmosphere responds to gravitational accelerations.

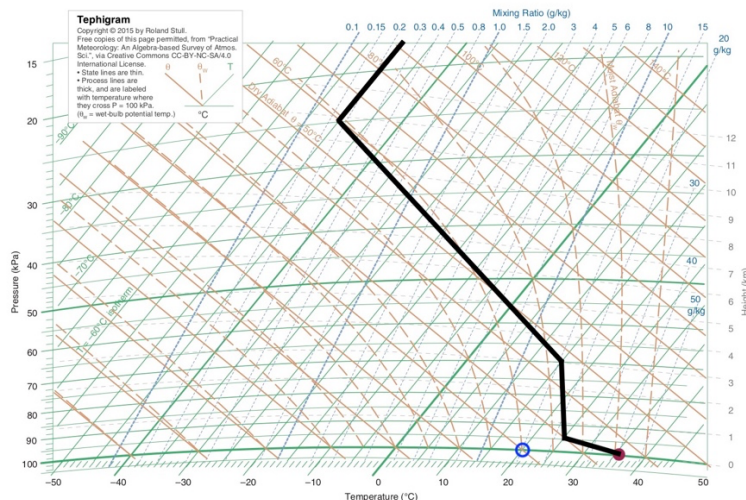
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points = 3

21a. For the sounding in the attached thermo diagram, what is the static stability (parcel method) for the environmental air between 25 and 20 kPa? Assume dry air.

- A) unstable B) neutral C) stable D) (not enough info to answer)

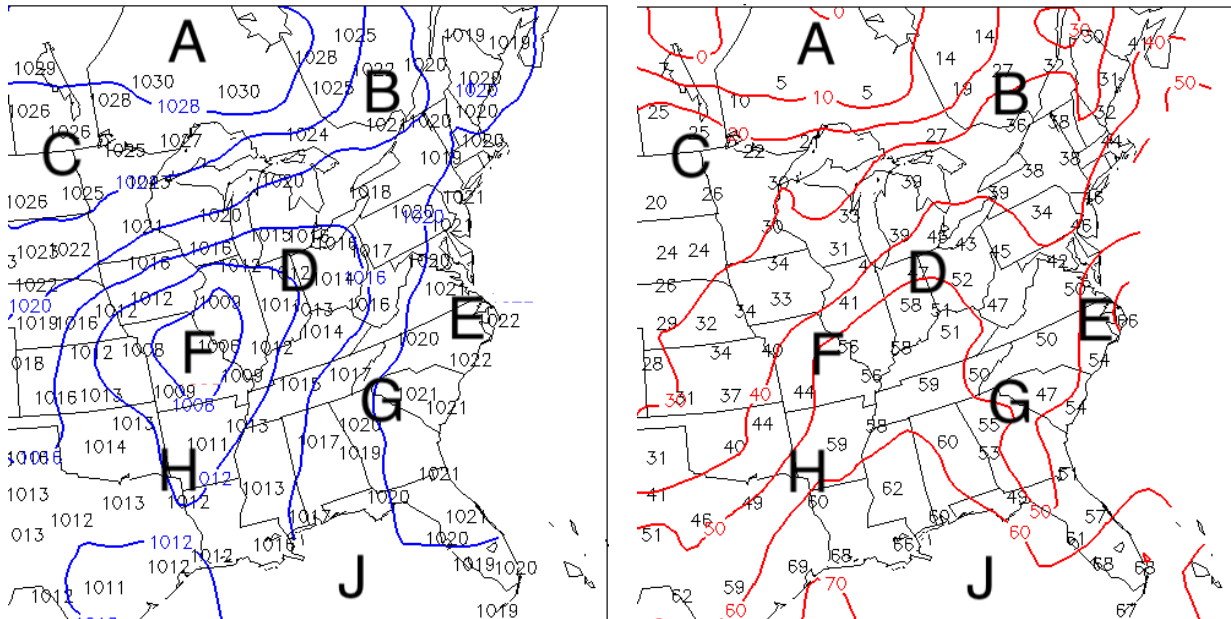
21b. For the sounding in the attached thermo diagram, what is the static stability (parcel method) for the environmental air between 80 and 75 kPa? Assume dry air.

- A) stable B) neutral C) unstable D) (not enough info to answer)



=====

The attached 2 weather maps are for the same date and time. The left one shows sea-level pressures (hPa) and isobars. The right one shows temperatures (deg F) and isotherms. Use these maps to answer the following question.



points = 2

22a. An extratropical cyclone is likely centered at which location? A B C D E F G H J

22b. An anticyclone is likely centered at which location? A B C D E F G H J

points = 3

23a. A warm front is likely at which location? A B C D E F G H J

23b. A cold front is likely at which location? A B C D E F G H J

points = 5

24a. A cP airmass is likely at which location? A B C D E F G H J

24b. An mT airmass is likely at which location? A B C D E F G H J

=====

points = 5

25a. Suppose there is an atmospheric river oriented along a line connecting Hawaii and the central coast of British Columbia. Why would this atmospheric river cause heavy precipitation over the Coast Mountains of BC (the mountain range closest to the Pacific coastline)?

A) It would NOT cause heavy precipitation over the Coast Mountains, because the cold ocean current adjacent to the BC coast prevents the atmospheric river from strengthening.

B) Coriolis force forces the air to turn upward, to cross the isobaric surfaces at a slight angle toward the lower pressure higher in the atmosphere.

- C) Pressure at mountain tops is lower than in the valleys, causing air to circulate counterclockwise around the mountain tops creating mesocyclones with heavy precipitation.
- D) Geostrophic adjustment limits the spread air behind the cold front and causes a post-frontal jet of cold rainy air that is called the atmospheric river.
- E) Maritime air that is forced to rise over the mountains will expand and cool, causing water vapour to condense to make clouds and rain.

25b. Suppose there is an atmospheric river oriented along a line connecting Hawaii and the central coast of British Columbia. Why would this atmospheric river cause heavy precipitation over the Coast Mountains of BC (the mountain range closest to the Pacific coastline)?

- A) It would NOT cause heavy precipitation over the Coast Mountains, because the cold ocean current adjacent to the BC coast prevents the atmospheric river from strengthening.
- B) Coriolis force forces the air to turn upward, to cross the isobaric surfaces at a slight angle toward the lower pressure higher in the atmosphere.
- C) Maritime air that is forced to rise over the mountains will expand and cool, causing water vapour to condense to make clouds and rain.
- D) Pressure at mountain tops is lower than in the valleys, causing air to circulate counterclockwise around the mountain tops creating mesocyclones with heavy precipitation.
- E) Geostrophic adjustment limits the spread air behind the cold front and causes a post-frontal jet of cold rainy air that is called the atmospheric river.

== end of exam ==