

Write all of your answers on the bubble sheet. Only the bubble sheet will be marked.

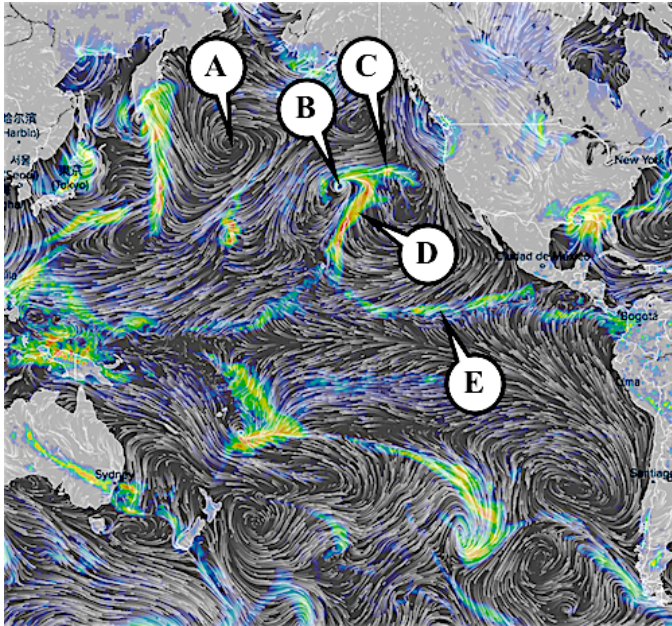


Fig. 1. Background image from VentuSky, showing surface winds (streaks) and precipitation (coloured areas).

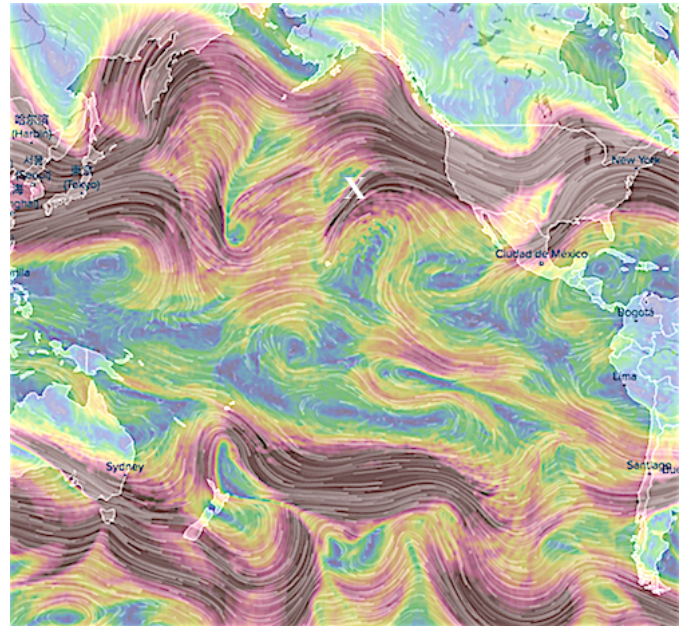


Fig. 2. Also from VentuSky, showing wind speeds (colours) and wind directions (streaks), all at the tropopause height.

- 1) (1 point) Use Fig. 1. A midlatitude **cyclone** is at: A B C D E (mark your answer on the bubble sheet)
- 2) (1 point) Use Fig. 1. A midlatitude **anticyclone** is at: A B C D E
- 3) (1 point) Use Fig. 1. The ITCZ is at: A B C D E
- 4) (1 point) Use Fig. 1. A cold front is at: A B C D E
- 5) (1 point) Use Fig. 1. A warm front is at: A B C D E
- 6) (3 points) Fig. 2 is for the same time and geographic location as Fig. 1. Based on these two figures, you expect that the midlatitude cyclone that you indicated in question (1) will likely:
  - A) weaken because it is under the left exit region of a jet streak
  - B) remain approximately constant intensity while it translates toward the northeast
  - C) remain approximately constant intensity while it translates toward the southeast
  - D) strengthen because it is east a trough in the polar jet stream
  - E) weaken because it is east of a trough in the African easterly jet.
- 7) (1 point) Cold fronts are always drawn at the \_\_\_\_\_ of the frontal zone.
  - A) warm side
  - B) cold side
  - C) middle
  - D) (not A, B, or C, because it varies depending on the weather)
- 8) (1 point) A cloud covers 100% of the sky. Its appearance is fairly uniform, and you can see a bright sun through the clouds, with a halo around the sun. The cloud is likely a/an:
  - A) nimbostratus
  - B) cumulonimbus
  - C) altostratus
  - D) cirrocumulus
  - E) cirrostratus
- 9) (4 points) Suppose there is warm air to the north and colder air to the south, in the Southern Hemisphere. The thermal wind is likely
  - A) from the west
  - B) from the east
  - C) from the north
  - D) from the south
  - E) roughly constant with increasing altitude

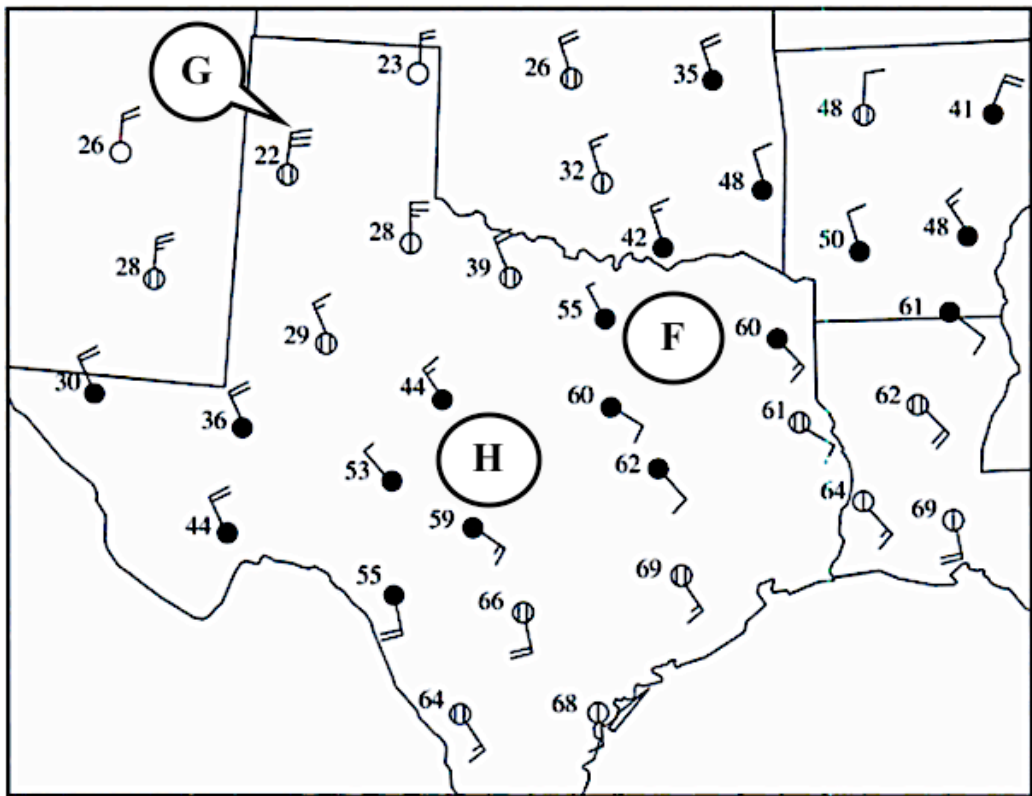
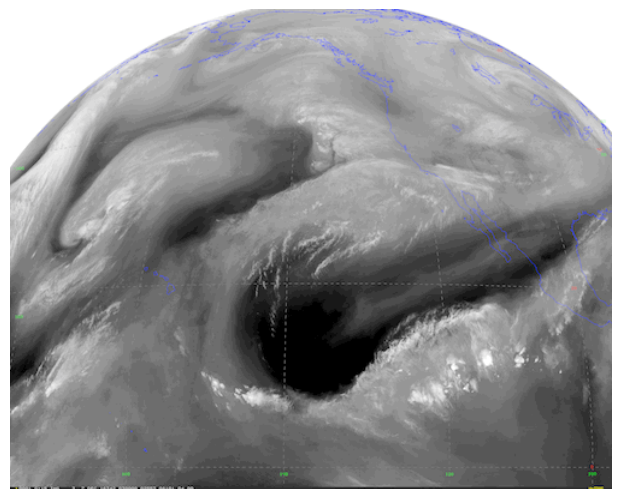


Fig. 3. Surface temperatures ( $^{\circ}\text{F}$ ), winds (knots) and cloud coverage. Texas, in N. America. (modification from World of Weather).

To answer the next 3 questions, first draw isotherms in Fig. 3 every  $5^{\circ}\text{F}$ . Namely: 25, 30, ... , 60,  $65^{\circ}\text{F}$ .

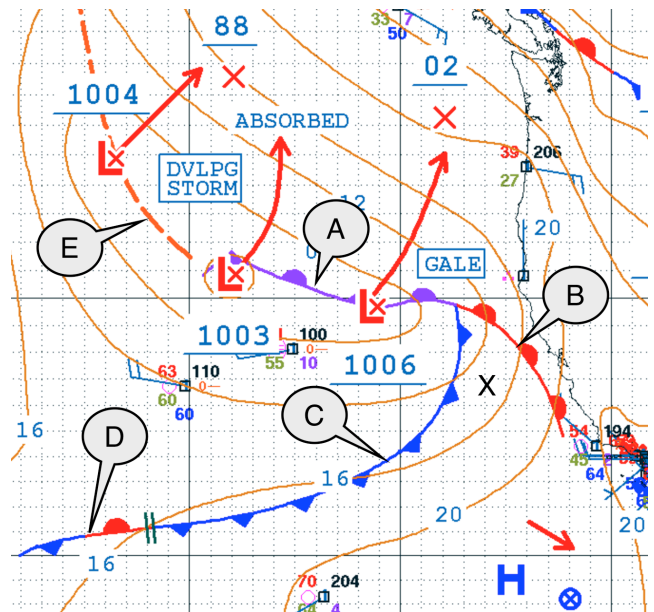
- 10) (3 points) the weather feature at location F is:
  - A) low B) high C) cold front D) warm front E) stationary front
- 11) (3 points) the weather feature at location H is:
  - A) low B) high C) cold front D) warm front E) stationary front
- 12) (3 points) The wind at location G is:
  - A) north wind at 30 knots B) south wind at 30 knots
  - C) north wind at 15 knots D) south wind at 15 knots E) west wind at 30 knots
- 13) (2 points) The figure at right is a/an:
  - A) radar reflectivity image B) Doppler radar image
  - C) visible satellite image D) IR satellite image
  - E) water vapour satellite image
- 14) (2 points) What drives the general circulation?
  - A) gravity B) the ocean currents C) Coriolis force
  - D) differential heating E) boundary-layer winds
- 15) (1 point) The main general-circulation feature at mid-latitudes is/are the:
  - A) Hadley cell B) ITCZ
  - C) trade winds D) katabatic winds E) jet stream
- 16) (2 points) High surface pressure often forms under cold air because
  - A) colder air is denser than warmer air B) of the formation of a thermal circulation
  - C) winds cannot be geostrophic there D) of the extra weight due to water vapour condensing
  - E) surface winds converge toward the high



- 17) (2 points) Barotropic instability causes the jet stream to oscillate north and south due to  
 A) the conservation of relative vorticity B) the increase of the Coriolis parameter toward the poles  
 C) heat released over the warm Gulf-stream ocean current D) the change of the sun angle with latitude E) Planck's law
- 18) (5 points) Given: latitude = 60°N. Rossby wavelength = 10,000 km. Background wind speed from the west is  $U_0 = 40$  m/s. Calculate the phase speed of the Rossby wave relative to the earth's surface.  
 A)  $2.9 \times 10^{-5}$  m/s B) 11 m/s C) 16.1 m/s D) 29 m/s E) 39.99 m/s
- Given: Air near sea level has  $T = 10^\circ\text{C}$  and  $T_d = 8^\circ\text{C}$  at  $P = 100$  kPa. The wind blows this air over a mountain range 3000 m high (assume the ambient pressure at mountain top is 70 kPa). Assume that all liquid water that forms in this air will fall out on the windward side of the mountain. The air then descends the lee side of the mountain to an interior plateau where the ambient pressure is 95 kPa. Use this info to answer the following 3 questions. (Hint, use a thermo diagram).
- 19) (3 points) How many grams of liquid water falls out per kilogram of air? A) 0 B) 2.7 C) 4.0 D) 6.7 E) 12
- 20) (3 points) The final air temperature at the plateau is \_\_\_ °C. A) -9 B) -7 C) 10 D) 15 E) 20
- 21) (3 points) The final relative humidity of the air at the plateau is \_\_ %. A) 23 B) 36 C) 51 D) 83 E) 96
- 22) (2 points) The “pineapple express” is a local name for an atmospheric river, also known as a pre-frontal jet. Atmospheric rivers ahead of cold fronts can advect abundant moisture toward British Columbia, causing heavy rains. The main mechanism creating this jet is: A) the Hadley cell B) a thermal circulation C) a monsoon circulation D) the thermal wind E) the left exit region of the jet

Use the weather map at right to answer the following questions. Note: the thin orange/brown lines are isobars.

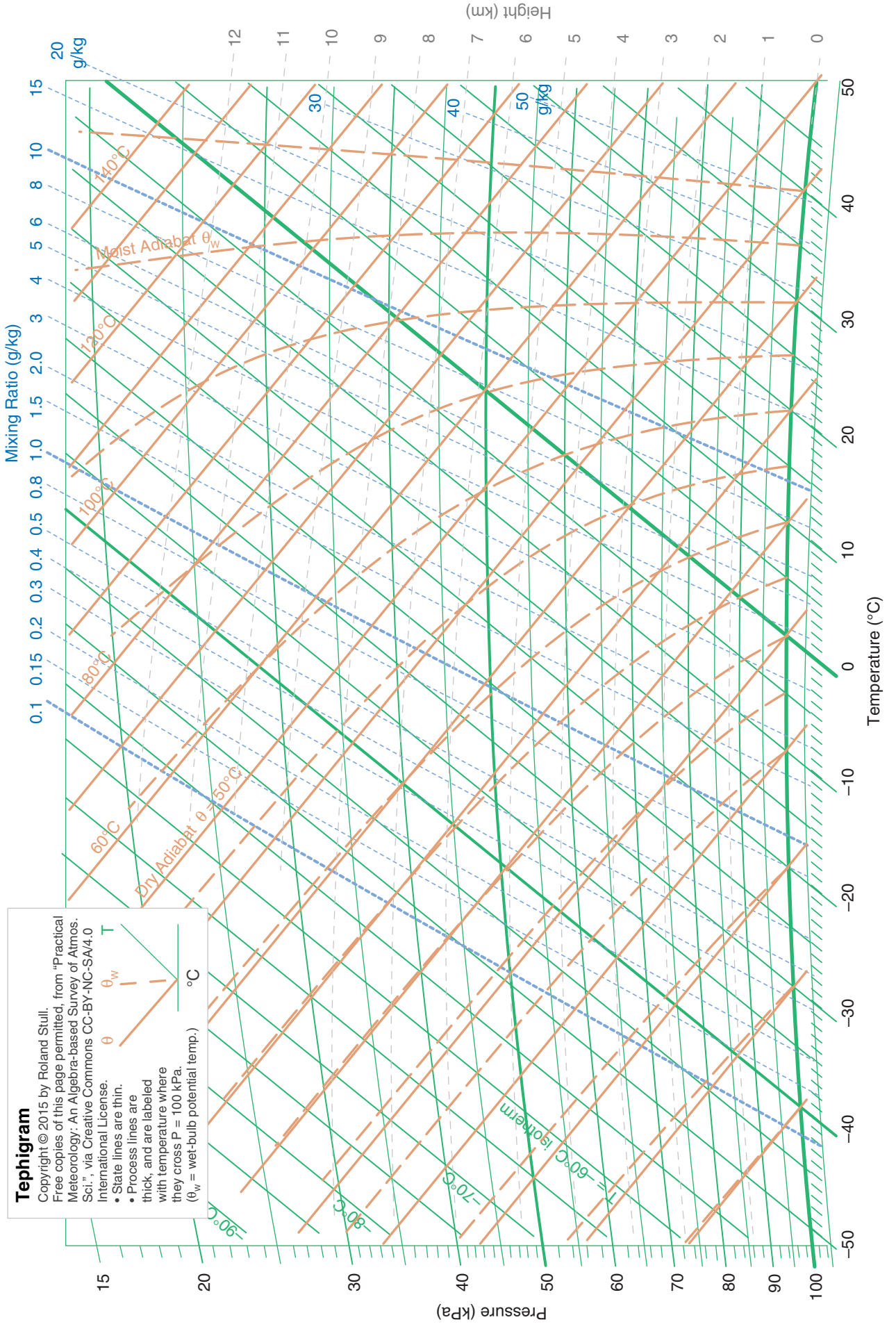
- 23) (1 point) A warm front is at location: A B C D E
- 24) (1 point) A cold front is at location: A B C D E
- 25) (1 point) An occluded front is at location: A B C D E
- 26) (1 point) A trough axis is at location: A B C D E
- 27) (1 point) A stationary front is at location: A B C D E
- 28) (2 points) Suppose you were in a boat at location “X” on the map (between the B and C labels). The wind direction is likely: A) northeast B) north C) southwest D) southeast E) (calm)
- 29) (3 points) At the “X”, the current weather and forecast is likely: A) thunderstorms with clearing later B) stratus clouds with drizzle later C) warm and humid with thunderstorms later D) cold and clear with stratus clouds later E) warm and humid with nimbostratus clouds later





- 32) (2 points) Lee cyclogenesis can be explained by:  
A) the baroclinicity across mountain ranges B) banner clouds C) relative vorticity conservation  
D) absolute vorticity conservation E) potential vorticity conservation
- 33) (5 points) Very cold Arctic air of depth 1 km is capped by a temperature inversion of strength  $\Delta\theta_v = 20^\circ\text{C}$ . What is the max wind speed (m/s) you would expect when this air flows through a short gap in a mountain range? (Hint, assume  $|g|/T_v = 0.0333 \text{ m s}^{-2} \text{ K}^{-1}$ ). A) 0.82 B) 3.12 C) 25.8 D) 98.8 E) 666
- 34) (2 points) Hurricanes don't form or cross the equator because  
A) They would be called tropical cyclones if they did. B) The ocean surface waters are too cold.  
C) The ocean surface waters are too warm. D) Coriolis force is too large E) Coriolis force is too small
- 35) (3 points) For the African easterly jet, clusters of thunderstorms (precursors to hurricanes) can form  
A) in regions of divergence east of troughs B) in regions of convergence east of troughs  
C) in regions of divergence east of ridges D) in regions of convergence east of ridges  
E) and then advect toward the east by the trade winds.
- 36) (2 points) In the eye of hurricanes is low pressure near the sea surface, and relatively high pressure at the top of the storm. Which statement is FALSE?  
A) The warm core helps create this pressure distribution.  
B) High pressure at storm top is important for driving outflow winds (the exhaust system of the hurricane).  
C) Pressure decreases more slowly with height outside the storm compared to inside the core.  
D) The pressure gradient at sea level drives strong winds that create breaking waves and sea spray.  
E) In the eye of the hurricane the horizontal winds are often calm or light.
- 37) (5 points) A 30 m/s wind is blowing across a mountain range that is 1 km high (relative to the surrounding plains) and is 5 km wide. The air is statically stable with  $\Delta T/\Delta z = -8^\circ\text{C}/\text{km}$ . Assume  $|g|/T_v = 0.0333 \text{ m s}^{-2} \text{ K}^{-1}$ . What is the wavelength (km) of the resulting mountain wave?  
A) 3.14 B) 5.0 C) 14.6 D) 24.3 E) 3,142.
- 38) (2 points) Given the same scenario as the previous problem. If the static stability were to become more stable, then the wavelength of the waves would: A) decrease B) not change very much C) increase
- 39) (5 points) Suppose a "dry line" at sea level has the same temperature of  $30^\circ\text{C}$  on both sides of the line, but the relative humidity on the west side is 10% and on the east side is 90%. What is the virtual temperature difference ( $^\circ\text{C}$ ) across the dry line? A) 0 B) 4.1 C) 24.0 D) 30.0 E) 4,135.
- 40) (2 points) If the dry line from the previous exercise were to advance toward the east, it would behave like a/an \_\_\_\_\_ front. A) cold B) warm C) stationary D) occluded E) elevated (upper-troposphere)

-- end of exam --



**Tephigram**  
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 • State lines are thin.  
 • Process lines are thick, and are labeled with temperature where they cross  $P = 100$  kPa. ( $\theta_w =$  wet-bulb potential temp.)  
 • °C

