Reprinted with corrections August 2012.

p. x, 2nd column, 1st full paragraph should read:

In working to improve the text, constructive and insightful suggestions were provided by many colleagues, including Dave Schultz, John Nielsen-Gammon, Rod Gonski, Gail Hartfield, Jonathan Blaes, Jason Millbrandt, Sukanta Basu, Brian Colle, Anantha Aiyyer, Kevin Tyle, Frank Alsheimer, Kermit Keeter, Brian Etherton, Steven Decker, Greg Fishel, Andrew Odins, Chris Nunalee, Darin Figurskey, Patrick Market, Steven Businger, David Novak, Scott Rochette, Phil Schumacher, Walt Robinson, Greg Hakim, Neil Stuart, and others. In addition to much of the "PV inspiration" evident in this text, Professor John Nielsen-Gammon of Texas A&M University also provided a thorough and thought-provoking set of suggestions, comments, and corrections on the first printing of the text, many of which have been incorporated in the second printing. Sarah Jane Shangraw, Beth Dayton, Ken Heideman, and others at the AMS have been helpful, supportive, and flexible; they were understanding of my desire to make this text accessible to students via AMS discounts. I would also like to acknowledge Lesley Williams and Roger Wood at AMS, for their copy editing of the book. Support in the form of a sabbatical leave provided by North Carolina State University made this effort possible. Graduate student Whitney Rushing assisted with the graphics and copyright permissions.

CHAPTER 1

p. 4, 1st two lines should read:

k-hat unit vector maintains right angles with the horizontal unit vectors.

p. 13, Figure 1.5 has been replaced.

p. 24, 2nd column, 1st sentence should read:

Many of the wavelike perturbations seen in the geopotential height contours of Figs. 1.15 and 1.16 are examples of Rossby waves.

p. 28, 1st column, 1st paragraph, last sentence should read:

The boundary layer is not always turbulent; however, in situations characterized by strong winds or a warm lower surface, turbulence is typically present.

p. 30, 1st column, 1st paragraph, sentence before equation 1.59 should read:

The intuitive relations discussed above are consistent with the empirically defined *bulk aerodynamic* method of turbulence closure valid near the surface:

p. 31, Problem 7, 1st sentence should read:

The plot below shows a 120-h forecast of 500-mb height (blue contours) with SLP (red contours) superimposed, valid 0600 UTC 11 Sep 2007.

CHAPTER 2

p. 36, 2nd column, last sentence should read:

If we later wished to include frictional processes, then they can easily be included in the QG system; however, our goal is to simplify the system as much as possible while retaining the essential features of the midlatitude weather systems of interest; later, additional assumptions will be introduced, including *adiabatic* flow.

p. 39, 1st column, last paragraph, 1st sentence should read:
Assumption (1) is ranked as the most restrictive because of the presence of a significant ageostrophic component in certain situations, for example, in the presence of highly curved flow, such as in an intense upper trough or midlatitude cyclone.

p. 58, 2nd column, last paragraph, two lines up from equation 2.42 should read:
only of the *y* and *z* directions, and then we take the scalar product

p. 65, 2nd column, 1st full paragraph, 1st sentence should read:
If we carry this simple analogy over to a typical midlatitude cyclonic weather system, then it is clear that on average, air in regions of the system characterized by anomalous warmth (e.g., relative to a latitudinal average) is rising while anomalously cold air sinking (Fig. 2.26).

CHAPTER 3

p. 71, 1st column, section 3.3, 1st sentence before equation 3.10 should read:
Using the definition of omega, and evaluating horizontal derivatives on isentropic surfaces, we can write an equation for the vertical air motion in isentropic coordinates:

p. 71, 2nd column, 2nd full paragraph should read:
Diabatic processes also change potential temperature, and term C represents these heating and cooling effects. Diabatic processes such as radiation or the absorption or release of latent heat can cause isentropic surfaces to move vertically (Fig. 3.6). Put another way, a nonzero term C means that air parcels are moving from one isentropic surface to another.

p. 72, equation 3.12:
The vector cross product in the second expression should be a dot product.

p. 74, 1st column, last paragraph, 2nd sentence is replaced by:
While determining the storm-motion vector can be complex, closed centers or features on an isentropic surface can be tracked with time to establish the storm-motion vector. Here, a series of 12-hourly analyses was used to determine a system motion vector of 8.5 m/s toward the east-southeast.

CHAPTER 4

p. 88, equations 4.21, 4.22, and 4.24:
Q should be *P*

CHAPTER 5

p. 102, 1st column, 1st paragraph, 2nd sentence after equation 5.3 should read:
In nature, friction limits this growth rate; however, the value of convergence will also tend to increase with the intensity of a system which partially offsets the spindown.

p. 105, section 5.3.4., after last sentence include:
For a perfectly sinusoidal pattern, while the forcing is stronger with shorter wavelength, inverting the Laplacian to solve for omega can largely cancel this effect on the vertical motion itself.

p. 106, 2nd column, 2nd paragraph, 3rd sentence should read:
This feedback was recognized by Sutcliffe and collaborators and is consistent with the linear exponential growth mechanism of baroclinic instability (see chapter 7).

p. 110, 1st column, 1st full paragraph should read:
Conversely, at the lower boundary, warm advection to the east of the trough draws the cyclonic warm boundary anomaly in that direction, leading to a propagation speed that is faster than the mean flow in the lower levels. Because the mean westerly wind at the upper levels in a baroclinic flow is stronger than that near the surface, this counter-propagation effect is critical, because it allows the upper and lower disturbances to move at more similar speeds, which extends the duration of their mutual amplification and constructive cross advections. An additional effect is the change in phase speed in the upper and lower disturbance due to cross advection. Suppose that in Fig. 5.17 the movement of the upper wave was faster than the lower wave. Northerly cold potential temperature advection induced on the upper boundary by the lower wave will act to slow it, while the southerly warm advection on the lower boundary associated with the upper wave will increase its eastward movement. This process, referred to as “phase locking,” is also a function of the intervening static stability, along with the wavelength of the upper and lower features.

p. 115, 2nd column, 1st paragraph, last sentence should read:
The relative absence of rapid cyclogenesis over land is likely due to reduced diabatic contributions, generally greater static stability, and stronger friction.

CHAPTER 6

p. 135, Figure 6.2b has been replaced.

p. 136, 2nd column, first paragraph starting first full sentence should read:
When air parcels are experiencing a change in horizontal temperature gradient, this holds important implications for thermal wind balance disruption, and as will be shown subsequently, for an ageostrophic response. While the terms on the right side of (6.2) contain information about the kinematic properties of the flow that impact the overall strength of a frontal zone, plotting frontogenesis often exhibits positive values—even for a weakening front. Often meteorological analysis software only accounts for the shearing and confluence term on the right side of (6.2). In this case, positive frontogenesis values at the location of the strongest potential temperature gradient can either indicate a strengthening front, or that the total frontogenesis including diabatic effects has not been calculated. As lower-tropospheric air parcels converge on a frontal zone, they will still experience an increasing gradient relative to that of the background synoptic setting.

p. 144, Figure 6.11 has been replaced.

p. 157, 1st column, 1st paragraph, 3rd sentence should read:
Studies of isentrope evolution in idealized barotropic flows (in which potential temperature is treated as a passive tracer) exhibit filamentation of the thermal field that strongly resembles the occlusion process, even when the warm and cold fronts are moving at the same speed.

CHAPTER 7

p. 176, 2nd column, 3rd sentence after equation 7.9 should read:

The ageostrophic streamfunction is related to the Q vector itself rather than the divergence of this vector field.

p. 179, 1st column, equation 7.113:
The denominator of the first expression for *s* is missing a "2".

p. 179, 2nd column, 1st sentence after equation 7.115 should read:
Recall from (7.95) that the growing or decaying portion of the solution depends entirely on the existence of a nonzero imaginary component of the phase speed; therefore, growing solutions can only exist if the discriminant in (7.115) is less than zero.

p. 179, 2nd column, last full paragraph should read:
In addition to the short-wave cutoff, it is also evident from Fig. 7.5 that there exists a wavenumber characterized by maximum growth, because, as the wavenumber becomes very small, *s*—tanh *s*—>0, leading to a reduction in growth rate at large wavelength.

p. 180, the first expression of equation 7.120 should be:
$B = 1$

p. 180, 2nd column, 1st paragraph, 1st sentence after equation 7.122 should read:
If we express the hyperbolic functions in (7.122) as exponentials using (7.124) it is evident that the Rossby depth H_R describes the *e*-folding vertical length scale for the disturbance.

p. 180, 2nd column, 1st full paragraph, 2nd sentence should read:
Starting with the perturbation geopotential field, we isolate the contribution from the top and bottom boundaries individually (Figs. 7.6a,c); these "edge waves" are presented in section 7.3.

p. 180, 2nd column, 3rd paragraph, last sentence should read:
Because there are no interior PV anomalies and friction is neglected, the solution presented here cannot produce isolated interior wind maxima.

p. 184, 2nd column, 2nd sentence after equation 7.129 should read:
The dispersion relation (7.129) reveals that the phase speed increases with wavelength, and with the basic-state shear, which is consistent with a faster motion from advection of the disturbance by the basic-state flow.

p. 185, 1st column, 1st sentence after equation 7.131 is deleted.

CHAPTER 8

p. 196, Figure 8.3b has been replaced.

p. 199, 1st column, last line should read:
section 8.2.2.

p. 216, Problem 4, the 2nd sentence is deleted.

CHAPTER 9

p. 223, 1st column, 1st full paragraph, 1st sentence should read:
As discussed in the previous paragraph, warm advection was taking place, but the accompanying ascent partially compensated this warming process through adiabatic expansion.

p. 233, Figure 9.13 has been replaced.

p. 237, 1st column, 1st paragraph, after last sentence include:
The height of the Great Lakes above sea level should also be taken into account in this calculation.

CHAPTER 10

p. 248, 2nd column, 4th line up from bottom:
"shown" should be "shone"

p. 256, Figure 10.6 has been replaced.

p. 277, 1st column, last paragraph, 1st two sentences should read:
For both polar-orbiting and geostationary satellites, an orbit is selected so as to allow force balance between the centrifugal and gravitational forces. Geostationary satellites, which are able to remain above a fixed point on the equator (rotating with Earth) in balanced orbit, must be located at a relatively high altitude of ~36,000 km to achieve this.

p. 283, 2nd column, sentence that starts before equation 10.21 should read:
Using this and the other notation introduced above, the analogous expression to (10.16) is written

p. 288, section 10.6.1.2, 2nd sentence should read:
Many model physical parameterizations are often designed using measurements over a relatively small range of conditions, but then are applied over a broad range of conditions when models are run in diverse circumstances.

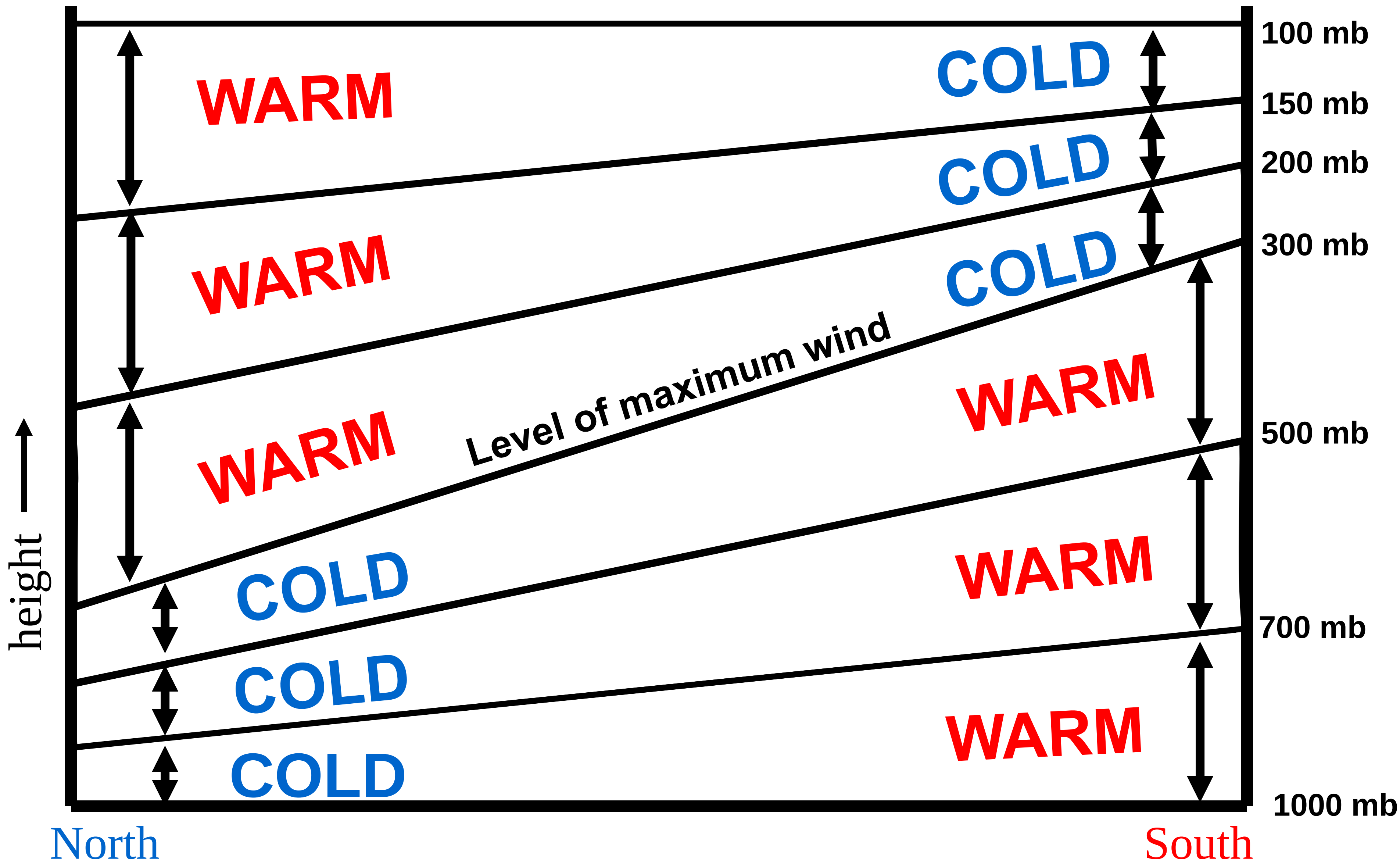
p. 300, 1st column, point 2 has been deleted.

CHAPTER 12

p. 327, attribution of quote should read:
W. J. Saucier, "Principles of Meteorological Analysis" (1989)

p. 329, 2nd column, section 12.1, 2nd paragraph, 1st sentence should read:
It is beyond the scope of this text to cover manual analysis in great depth. Saucier (1989) includes much more comprehensive information.

p. 335, additional reference:
Saucier, W. J., 1989: *Principles of Meteorological Analysis*. 2nd ed. Dover, 438 pp.



100 mb
150 mb
200 mb
300 mb
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700 mb
1000 mb
WARM
WARM
WARM
COLD
COLD
COLD
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COLD
COLD
WARM
WARM
WARM
Level of maximum wind
height
North
South

Figure 1.5

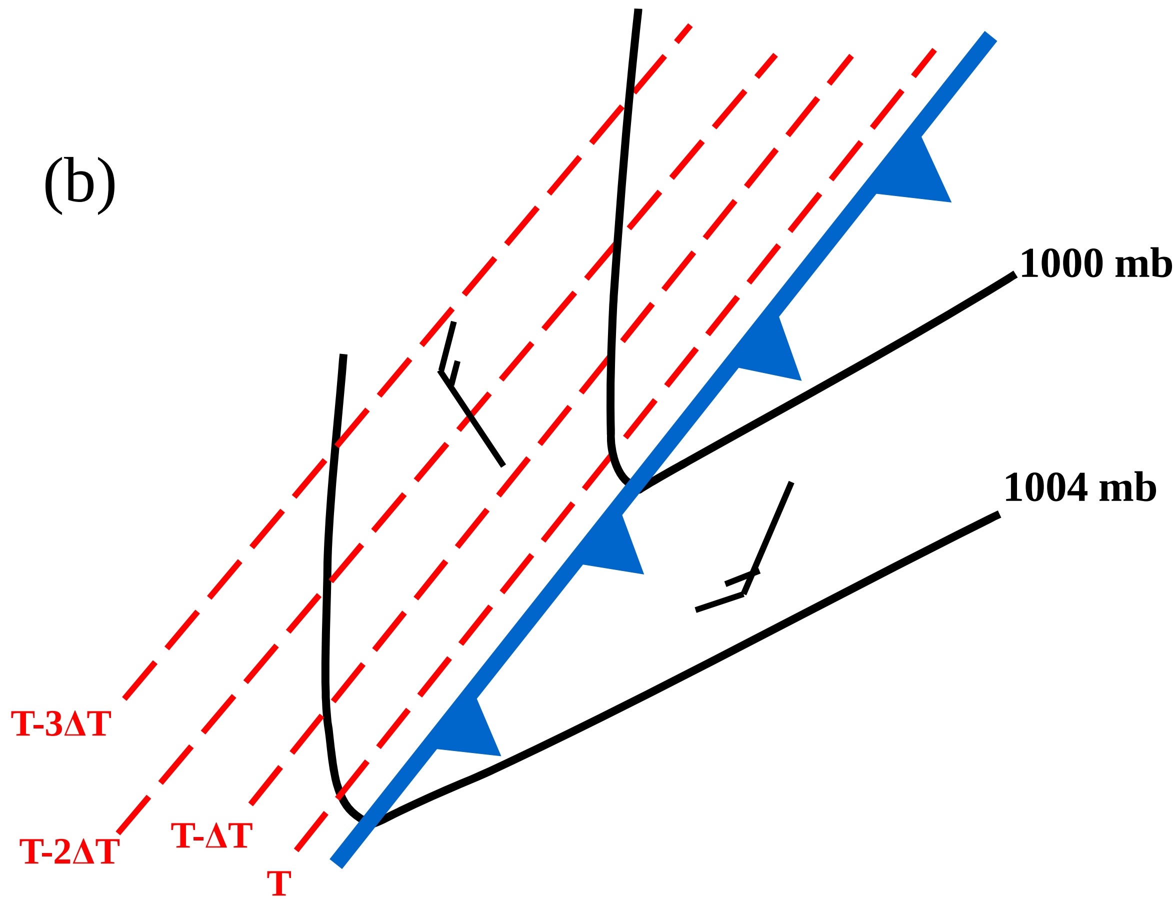


Figure 6.2b

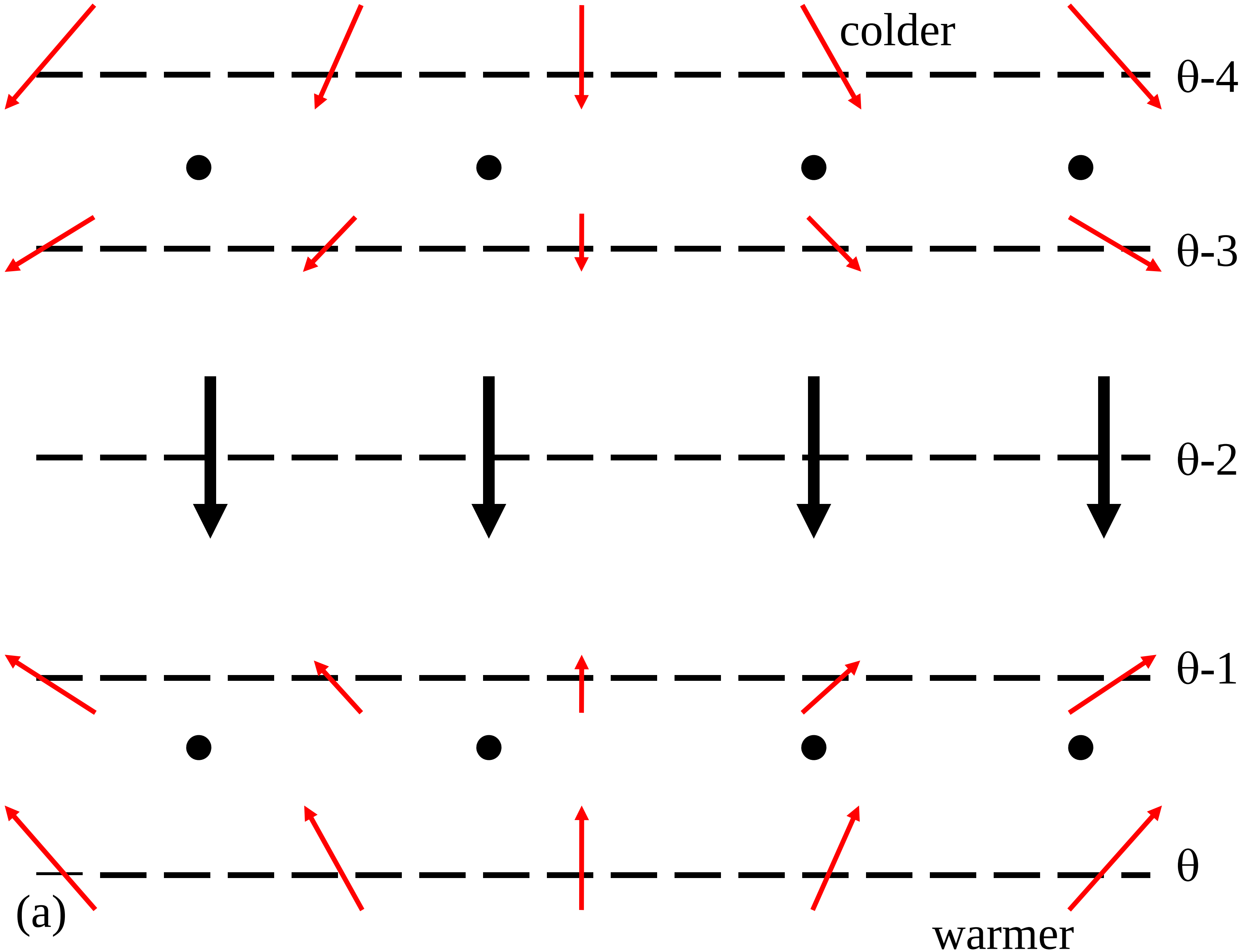


Figure 6.11a

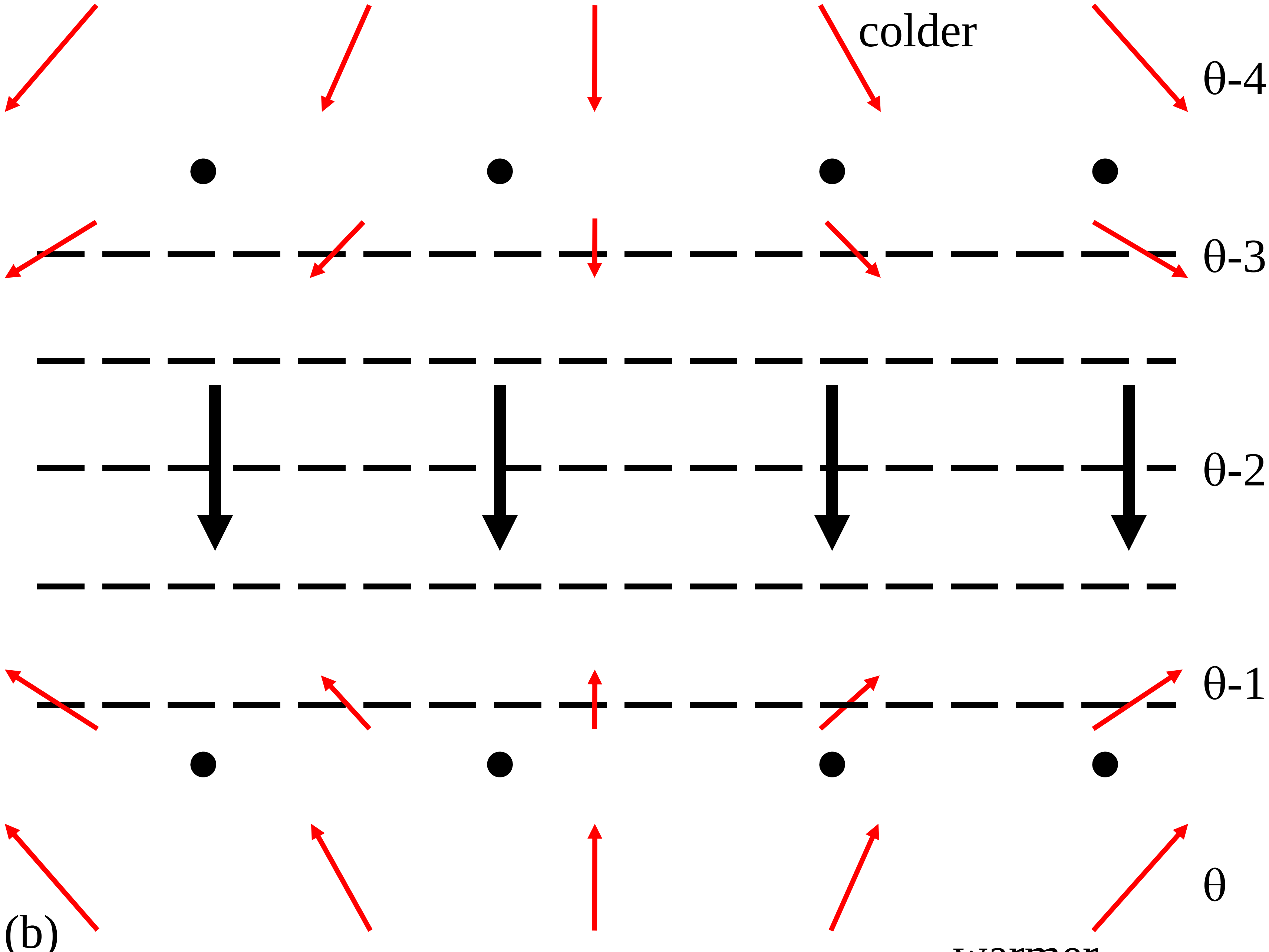
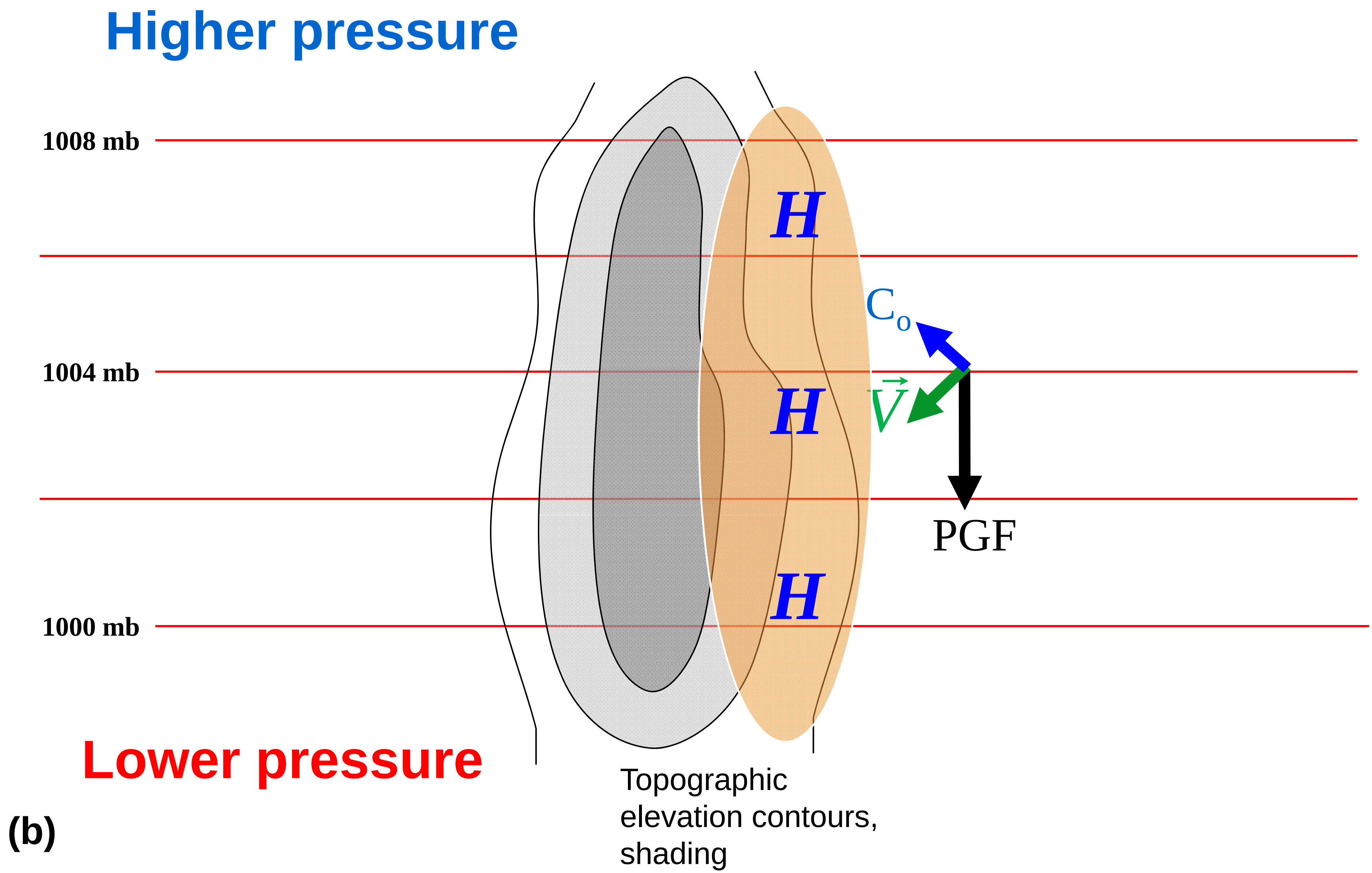


Figure 6.11b


Higher pressure
1008 mb
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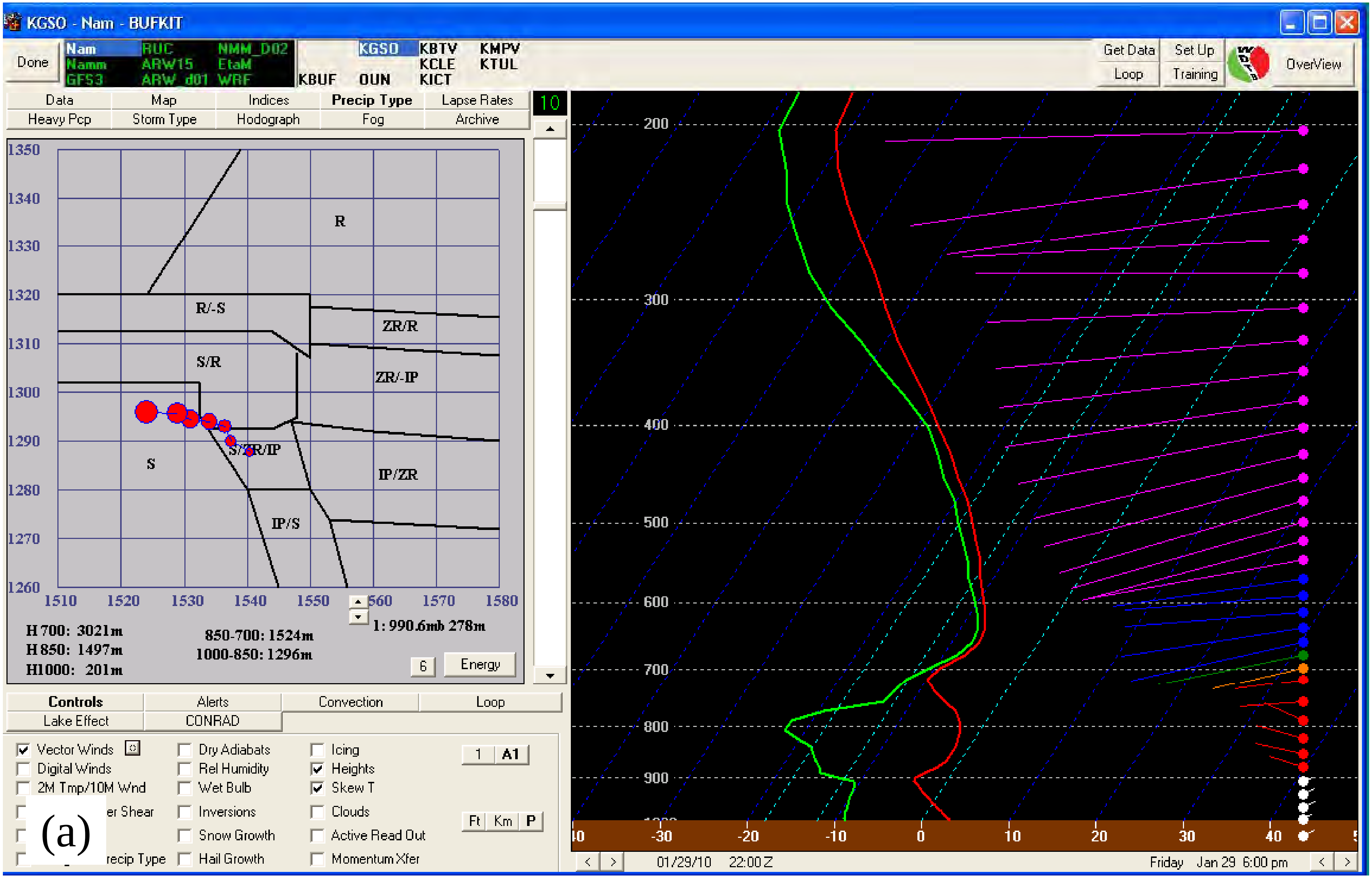
shading
(b)

Figure 8.3b



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KGSO KBTV KMPV
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KBUF OUN KICT
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Training
OverView
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Indices
Precip Type
Lapse Rates
Heavy Pcp
Storm Type
Hodograph
Fog
Archive
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ZR/R
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S/ZR/IP
S
IP/ZR
IP/S
H 700: 3021m
H 850: 1497m
H1000: 201m
850-700: 1524m
1000-850: 1296m
1: 990.6mb 278m
Energy
Controls
Alerts
Convection
Loop
Lake Effect
CONRAD
Vector Winds
Digital Winds
2M Tmp/10M Wnd
Dry Adiabats
Rel Humidity
Wet Bulb
Inversions
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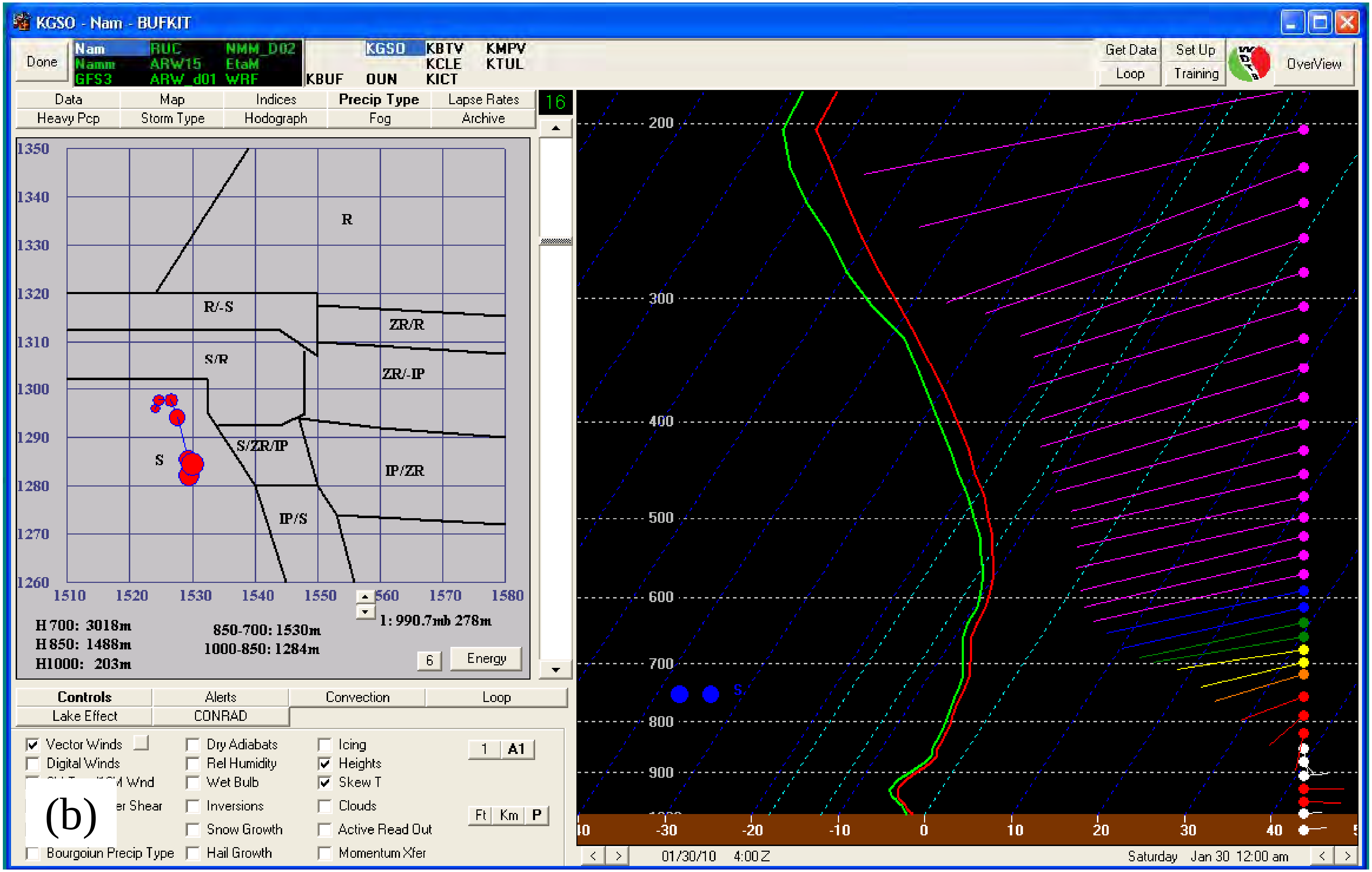
Figure 9.13a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KBUF OUN KICT
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Heavy Pcp Storm Type Hodograph Fog Archive
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H1000: 203m
850-700: 1530m
1000-850: 1284m
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Energy
Controls Alerts Convection Loop
Lake Effect CONRAD
Vector Winds
Digital Winds
Bourgoiun Precip Type
Dry Adiabats
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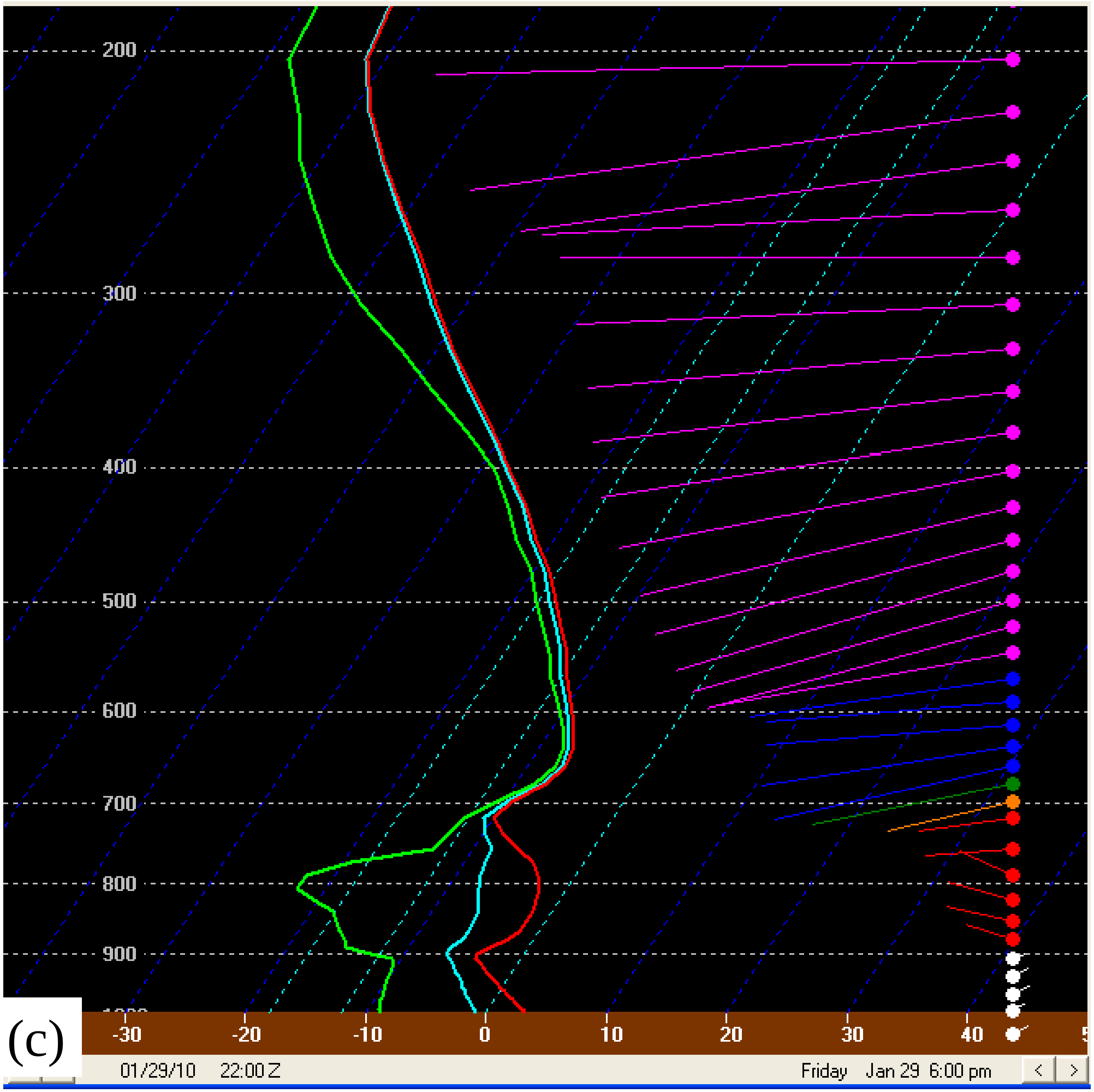
Figure 9.13b



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Friday Jan 29 6:00 pm

Figure 9.13c

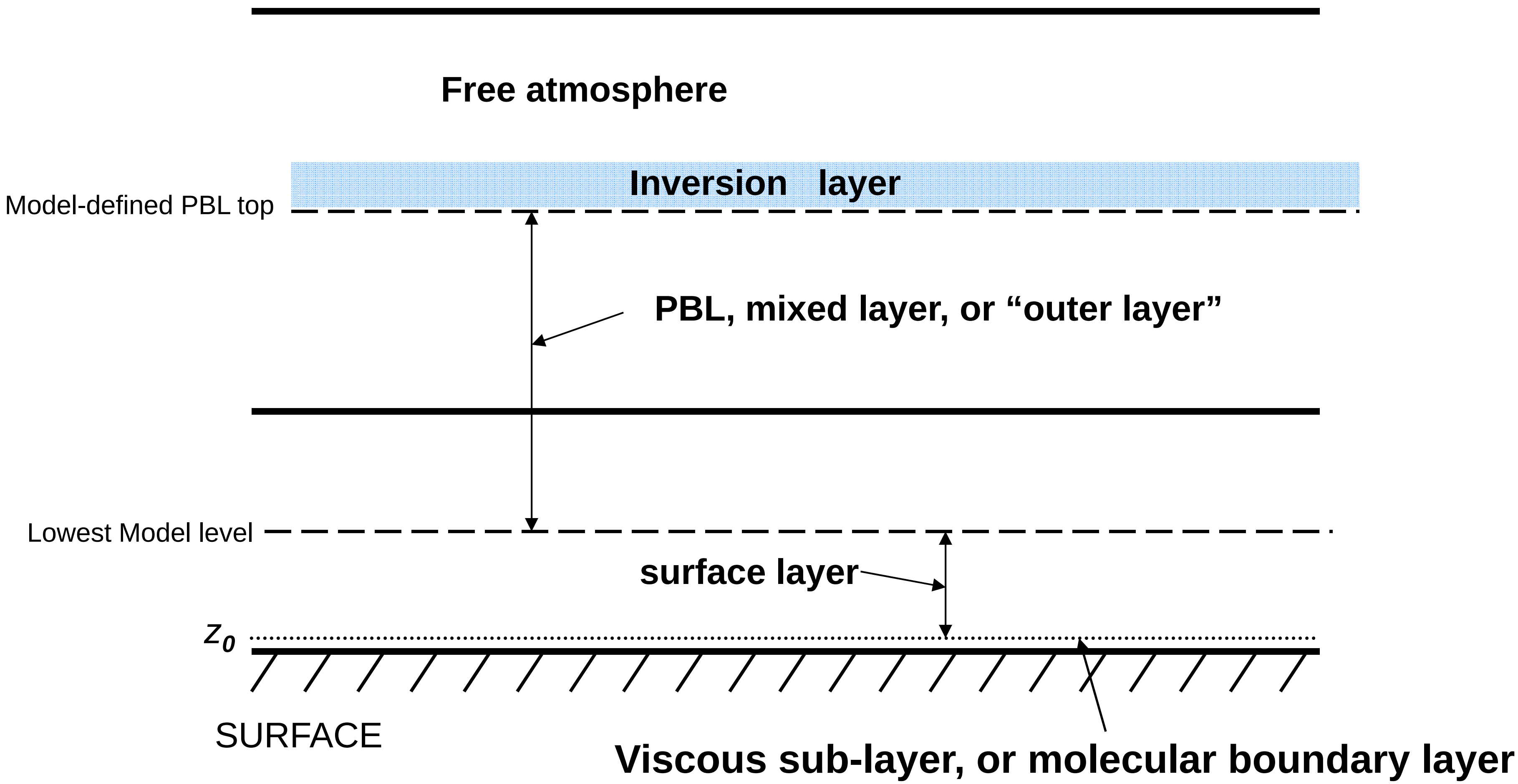
Free atmosphere
Inversion layer
Model-defined PBL top
PBL, mixed layer, or “outer layer”
Lowest Model level
surface layer
z_0
SURFACE
Viscous sub-layer, or molecular boundary layer

Figure 10.6