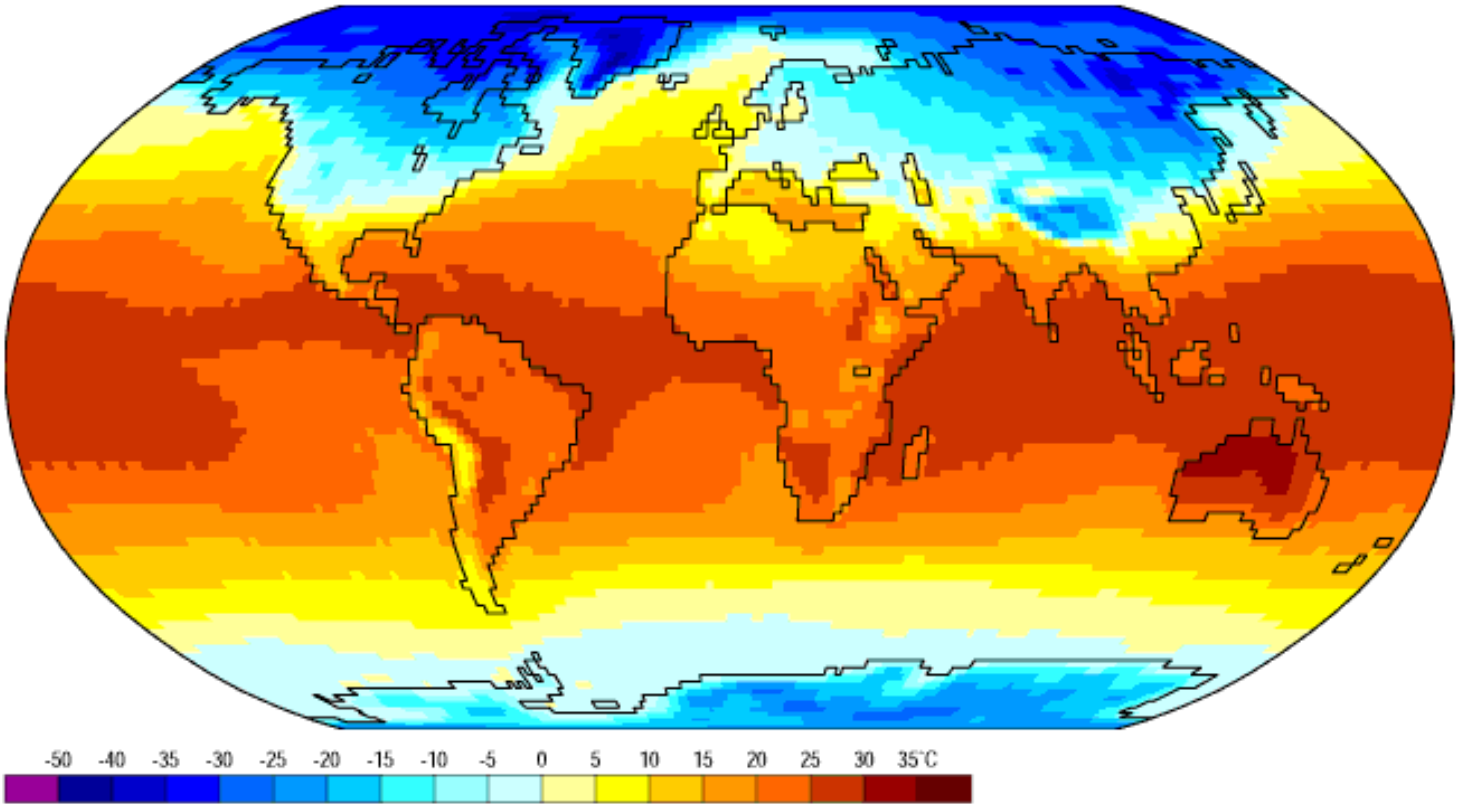
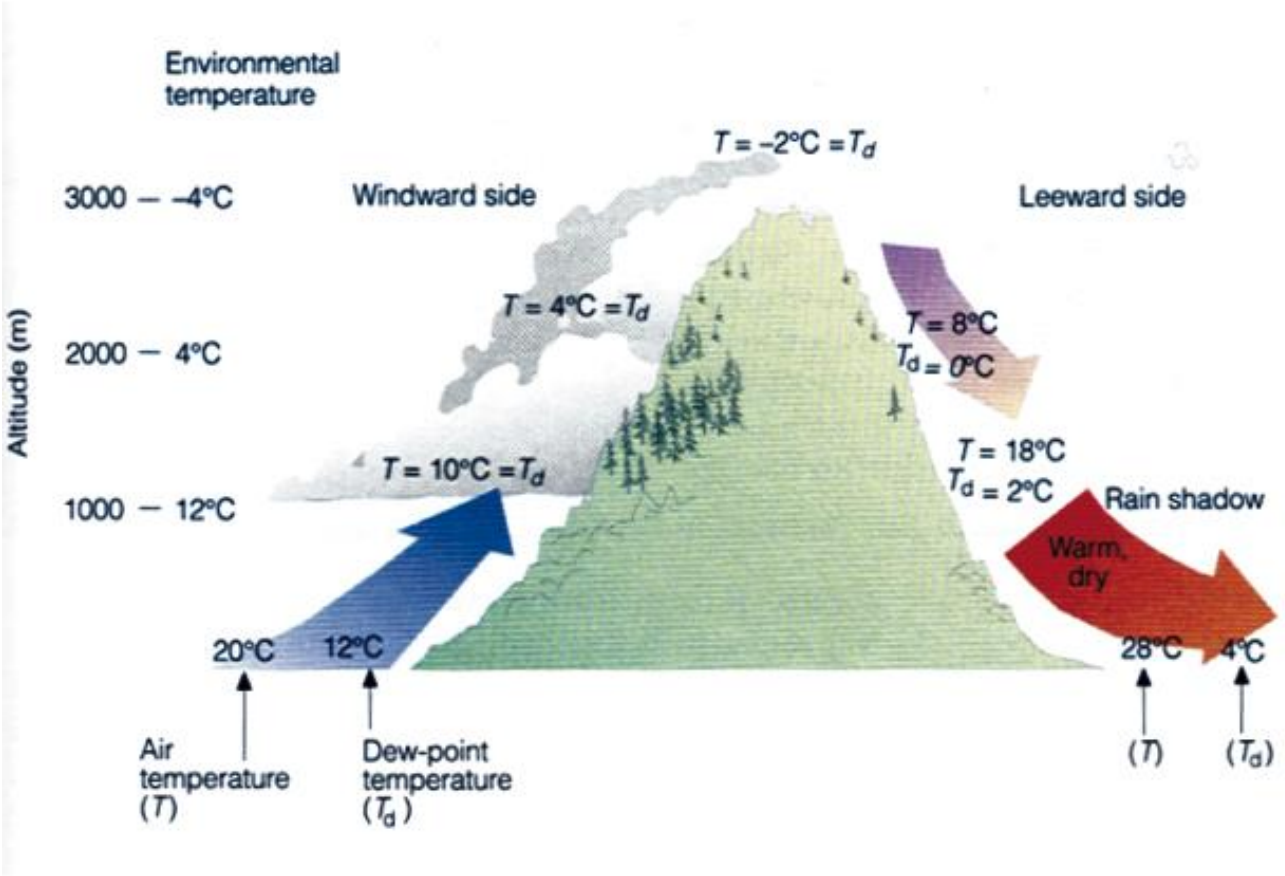
Air Temperature

Dec



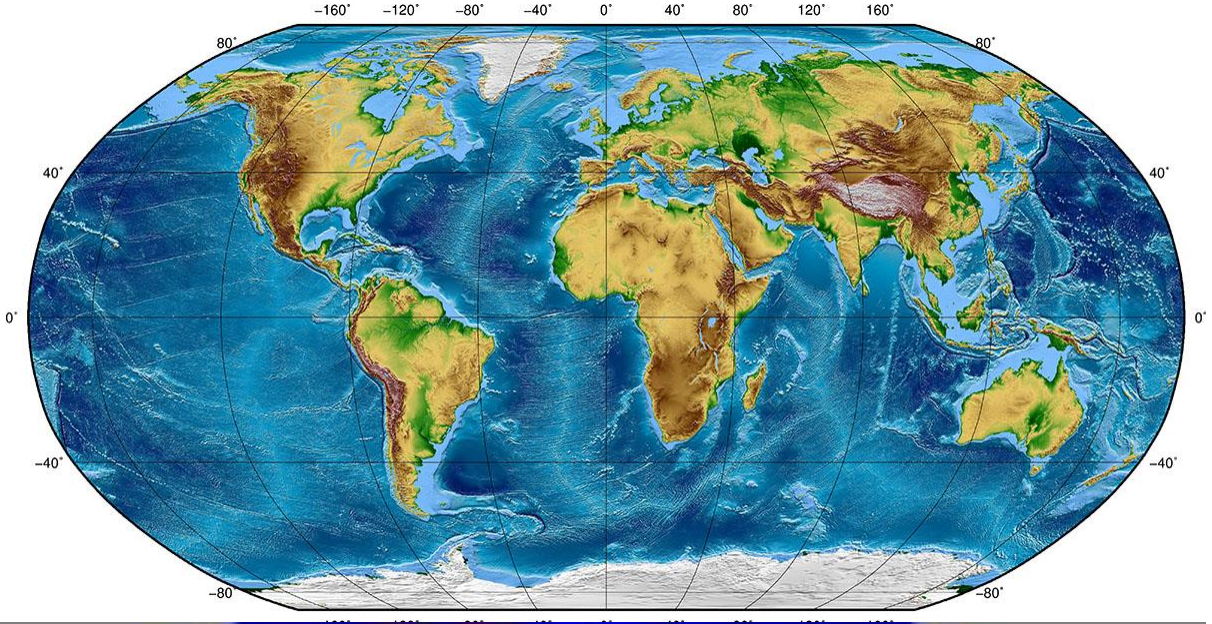
Data: NCEP/NCAR Reanalysis Project, 1959-1997 Climatologies
Animation: Department of Geography, University of Oregon, March 2000

Effects of Mountains on Local Climate

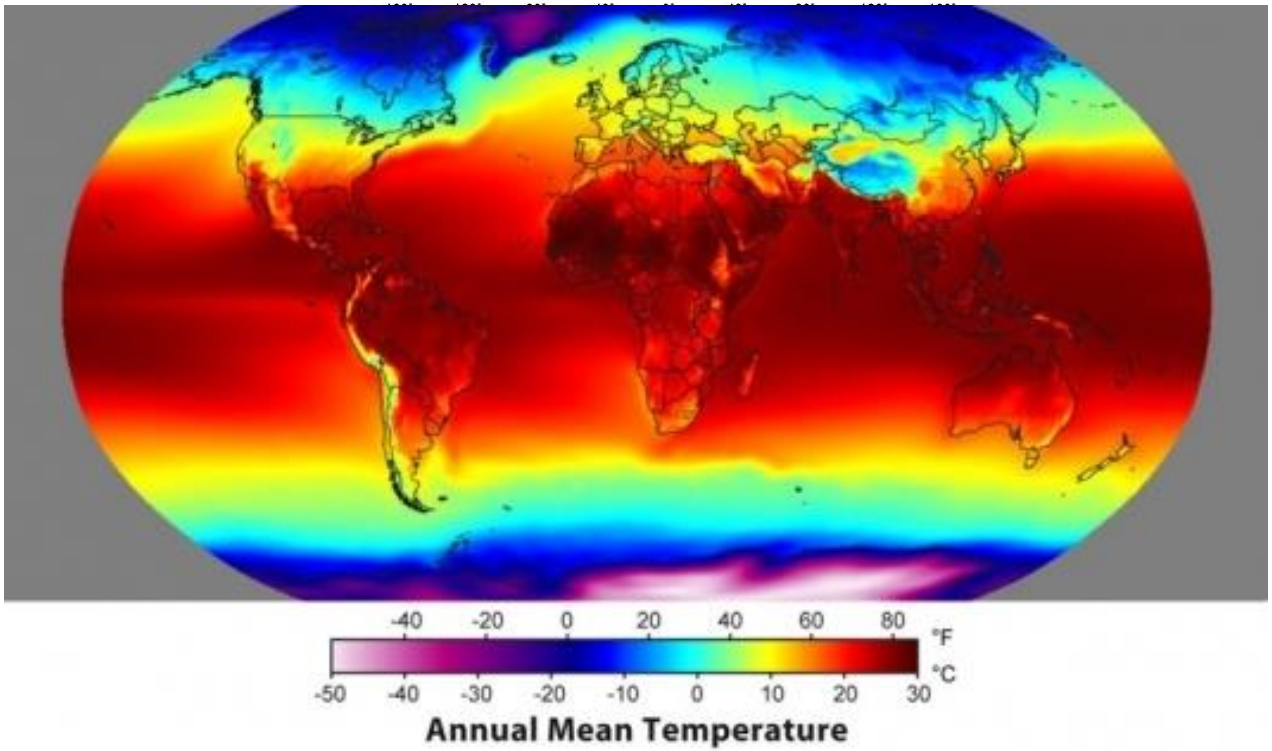


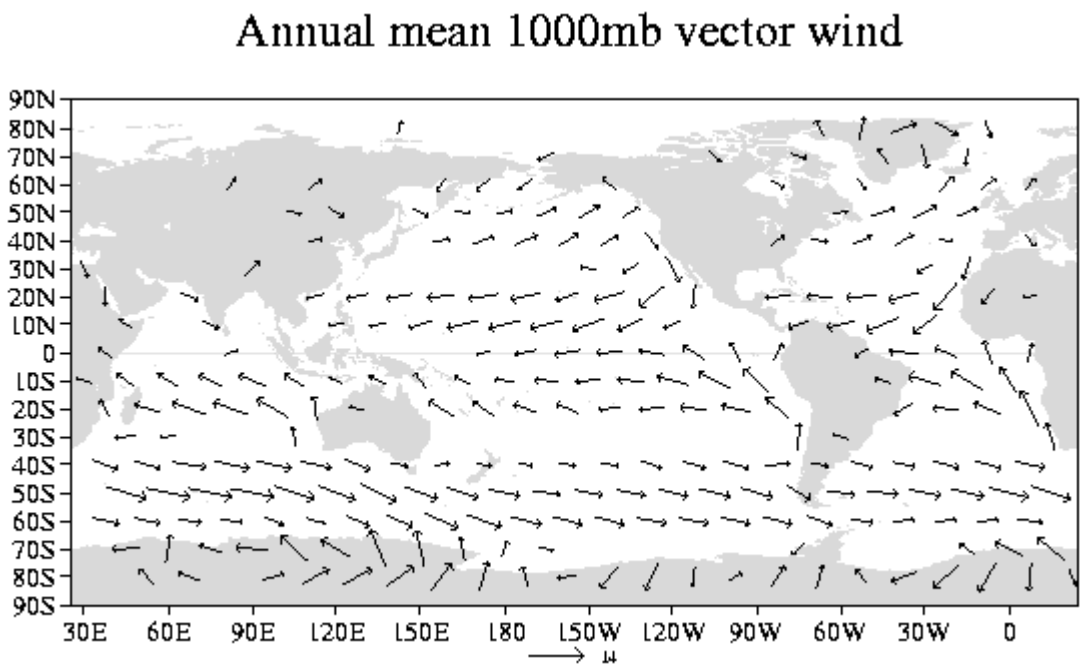
•Moist convection can explain the local climate effect of mountains, namely the tendency for large mountain ranges to have excess precipitation on the upwind side and a desert or rain shadow on the downwind side. The former is due to the lifting of the incoming air by the mountain. The latter is due to the warming of the rising air due to latent heat release.

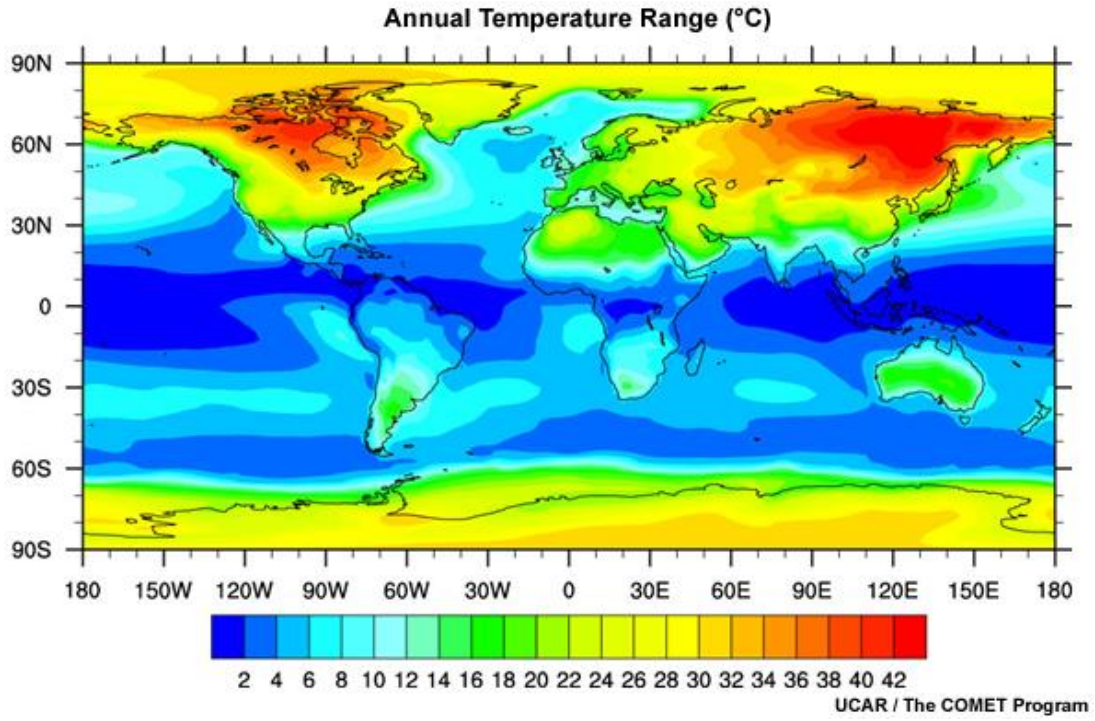
•Elevation effect on temperature- higher regions are colder



אזורים גבוהים
קרים יותר







הסעת החום גם חשובה
מאד- לים השפעה ממתנת

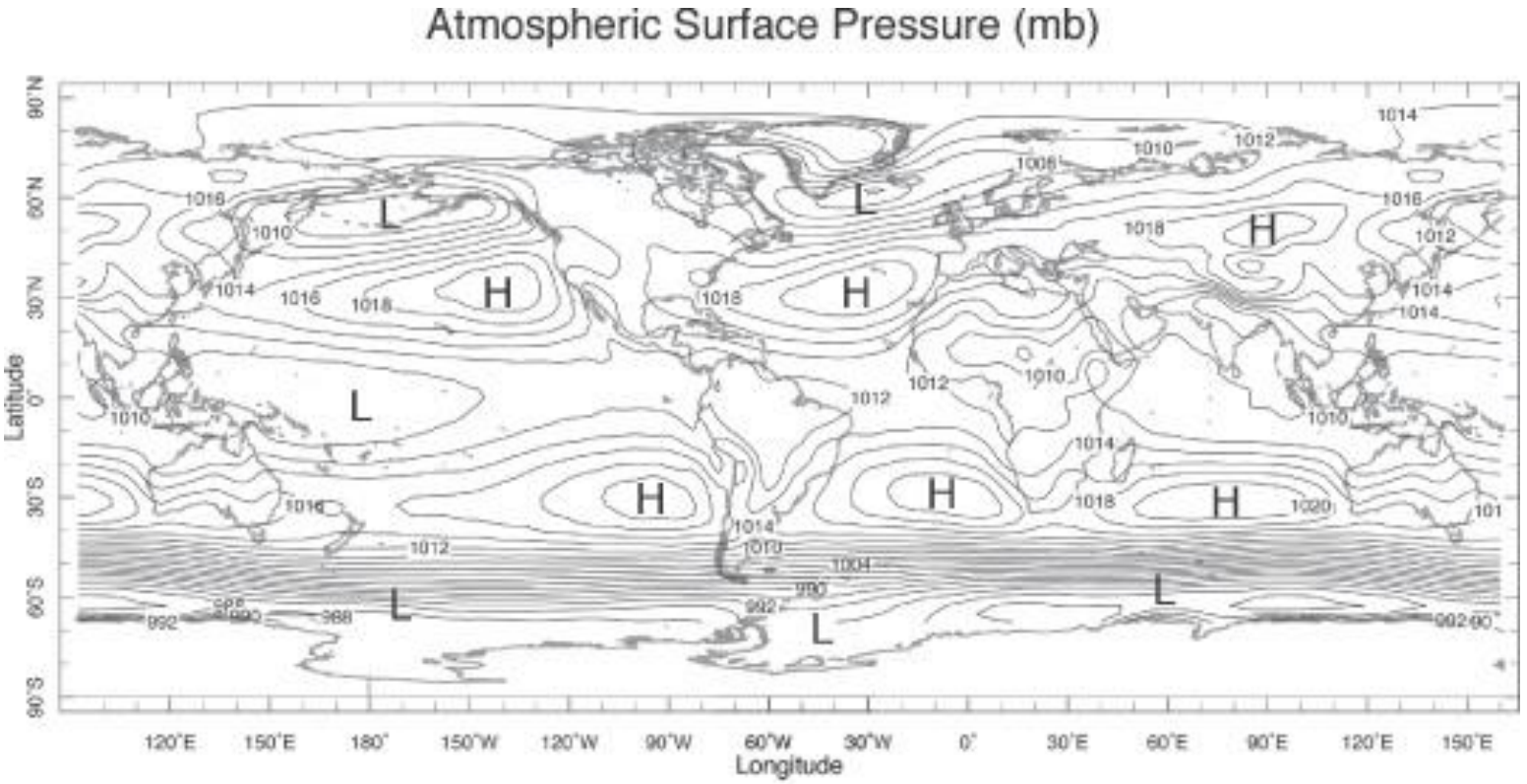
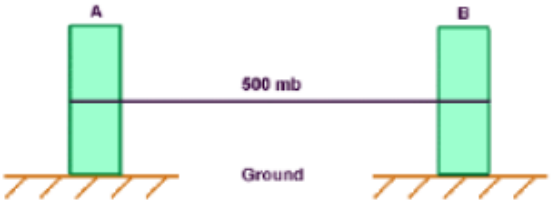
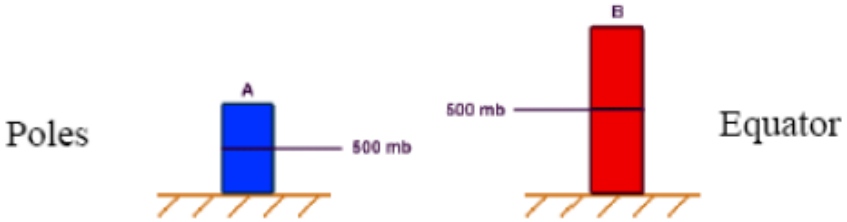
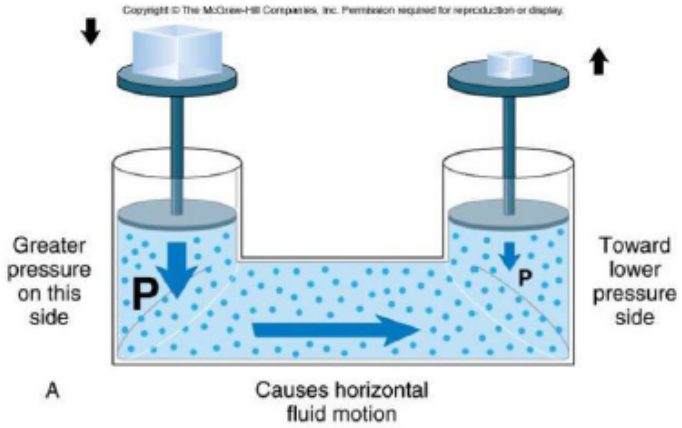


Figure 7.27: The annual-mean surface pressure field in mbar, with major centers of high and low pressure marked. The contour interval is 5 mbar.

Effect of temperature on pressure levels



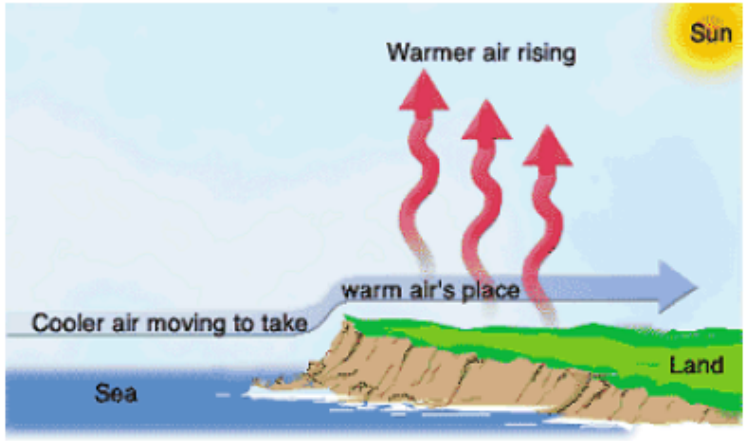


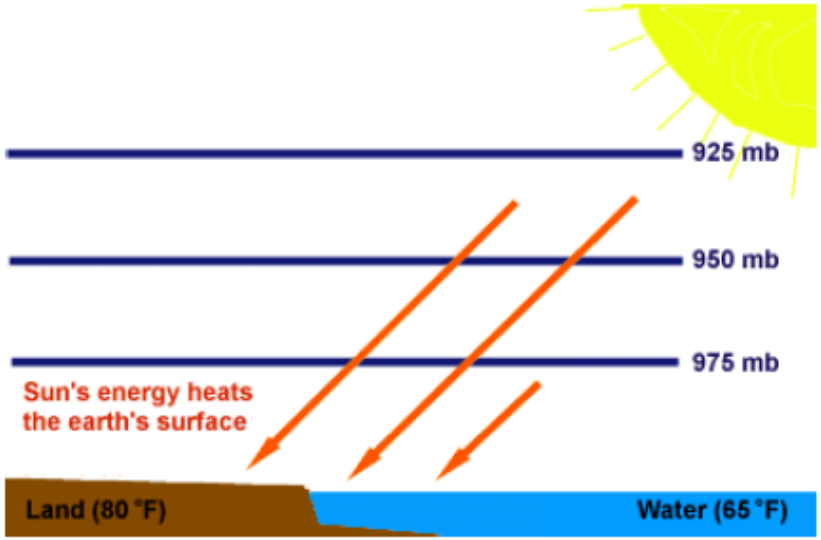


- Pressure gradients will cause air to move from high to low pressure

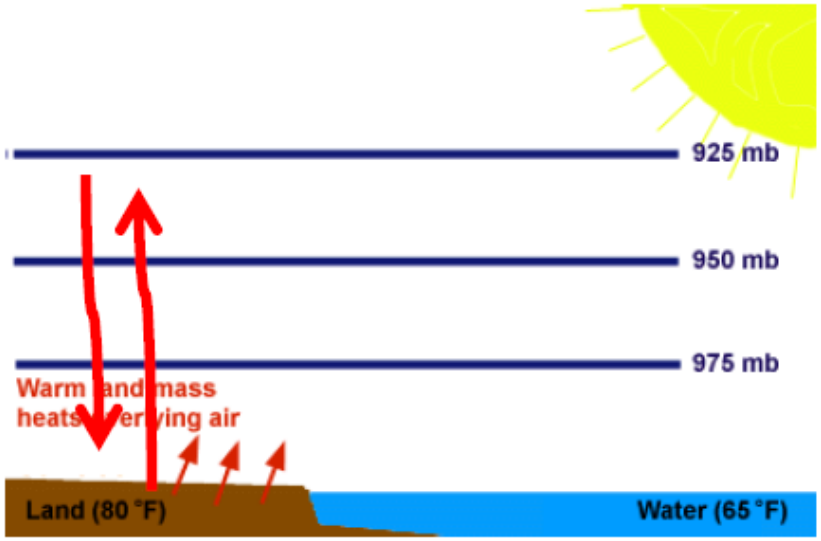
Sea Breeze

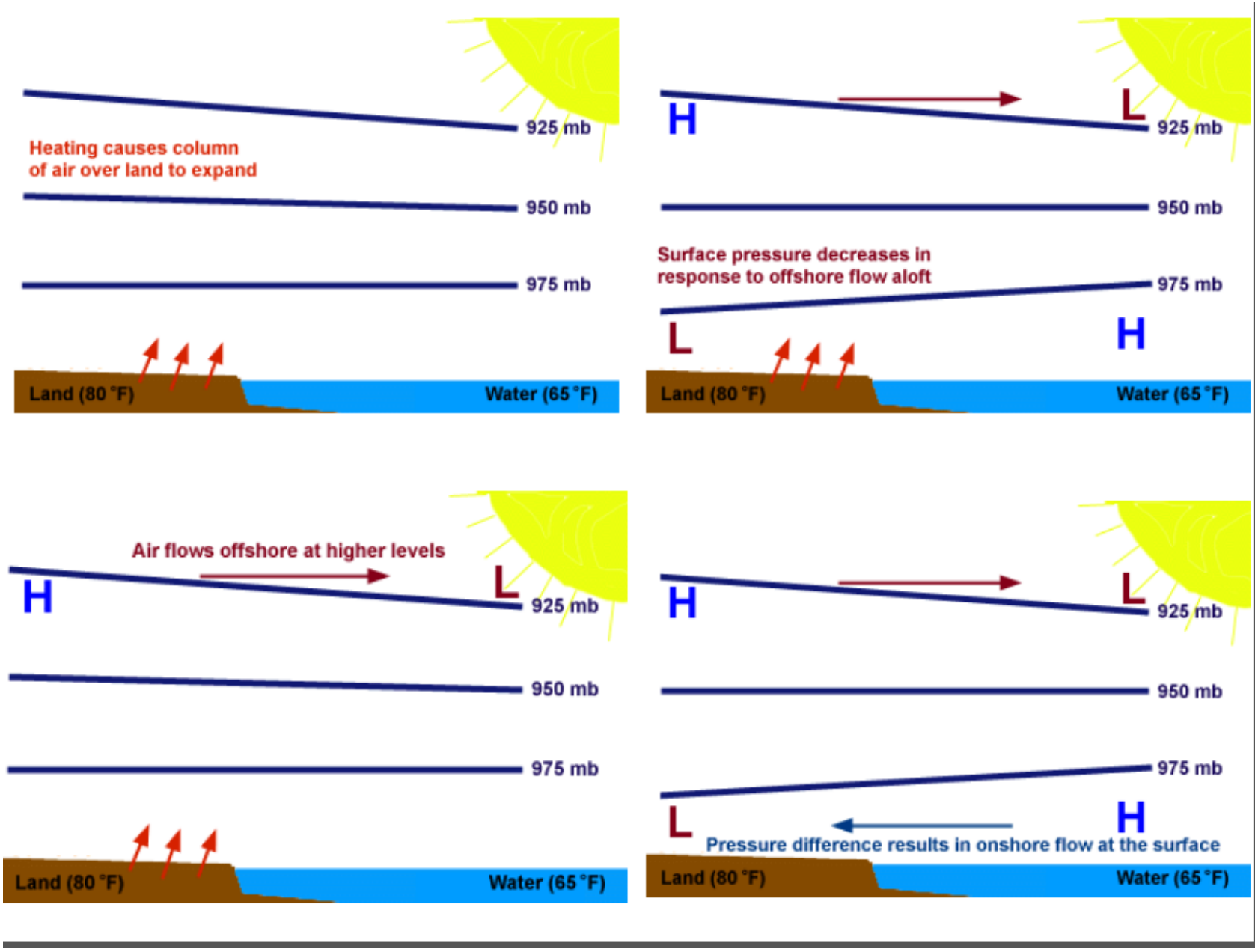
Daytime





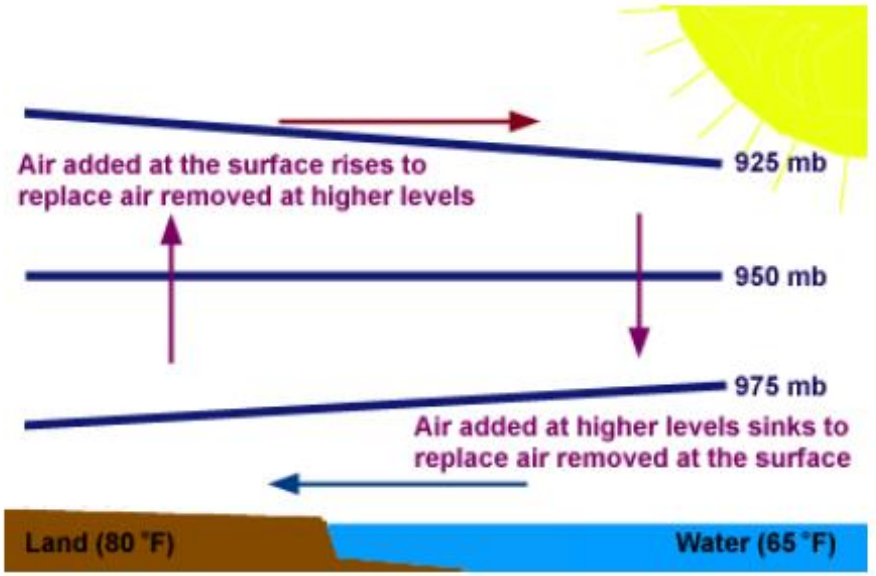
Air over land warms

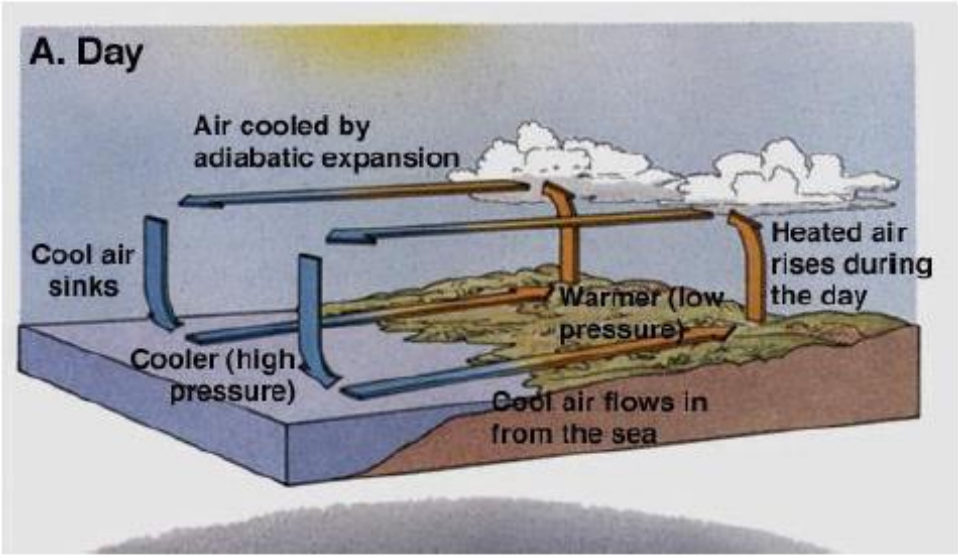


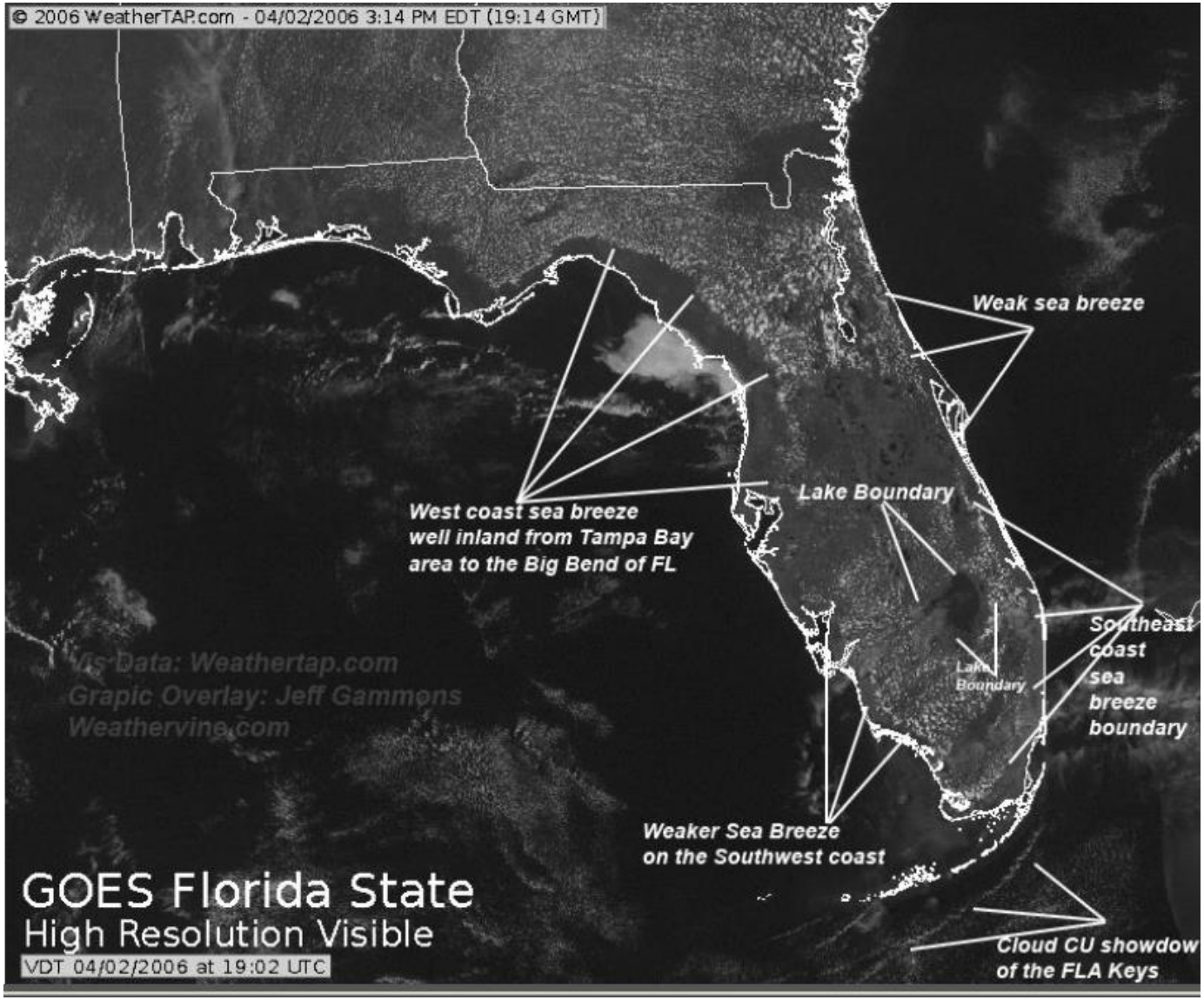

925 mb
Heating causes column
of air over land to expand
950 mb
975 mb
Land (80 °F)
Water (65 °F)
H
L
925 mb
950 mb
Surface pressure decreases in
response to offshore flow aloft
975 mb
L
H
Land (80 °F)
Water (65 °F)
Air flows offshore at higher levels
H
L
925 mb
950 mb
975 mb
Land (80 °F)
Water (65 °F)
H
L
925 mb
950 mb
975 mb
L
H
Pressure difference results in onshore flow at the surface
Land (80 °F)
Water (65 °F)

Sea Breeze

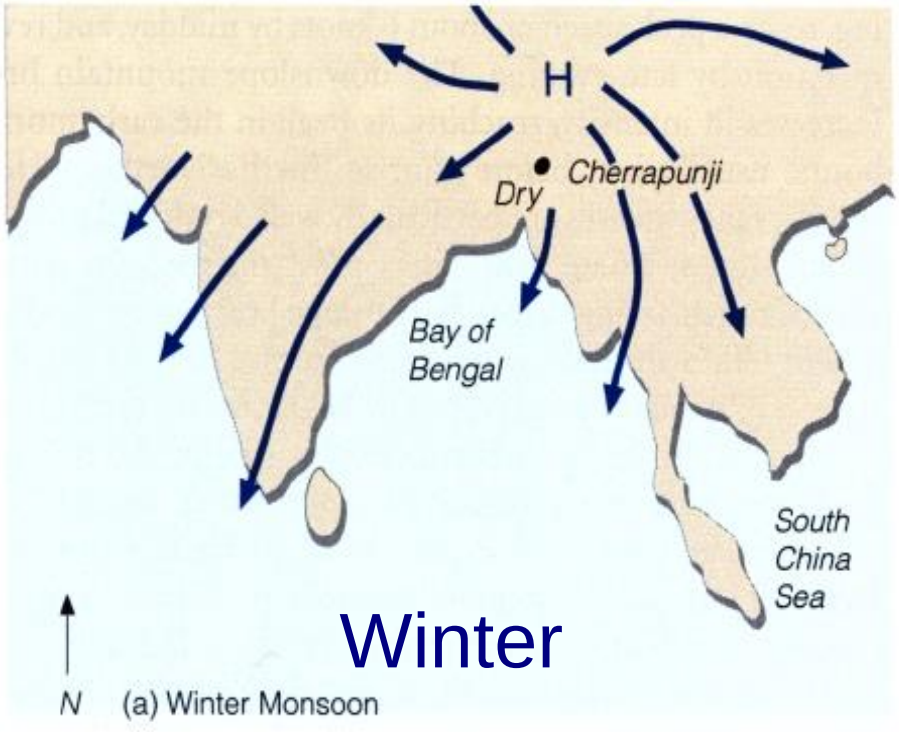
- Circulation perpendicular to shoreline
- Cool moist air from the sea rises over land
- Clouds over land



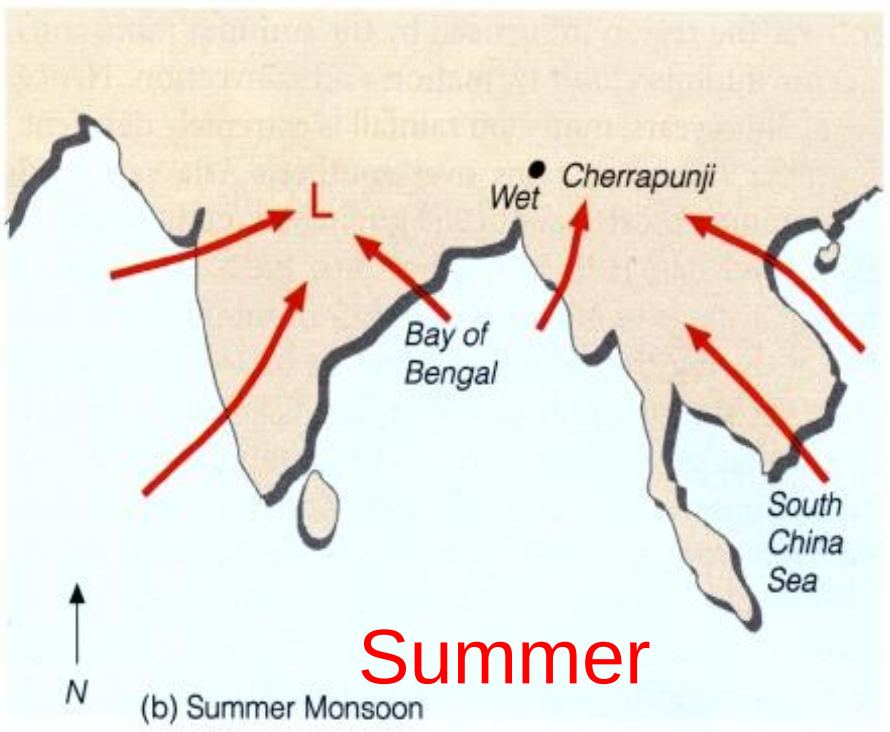



© 2006 WeatherTAP.com - 04/02/2006 3:14 PM EDT (19:14 GMT)
Weak sea breeze
West coast sea breeze
well inland from Tampa Bay
area to the Big Bend of FL
Lake Boundary
Vis Data: Weathertap.com
Grapic Overlay: Jeff Gammons
Weathervine.com
Lake
Boundary
Southeast
coast
sea
breeze
boundary
Weaker Sea Breeze
on the Southwest coast
GOES Florida State
High Resolution Visible
VDT 04/02/2006 at 19:02 UTC
Cloud CU showdow
of the FLA Keys

Monsoons – seasonal circulations



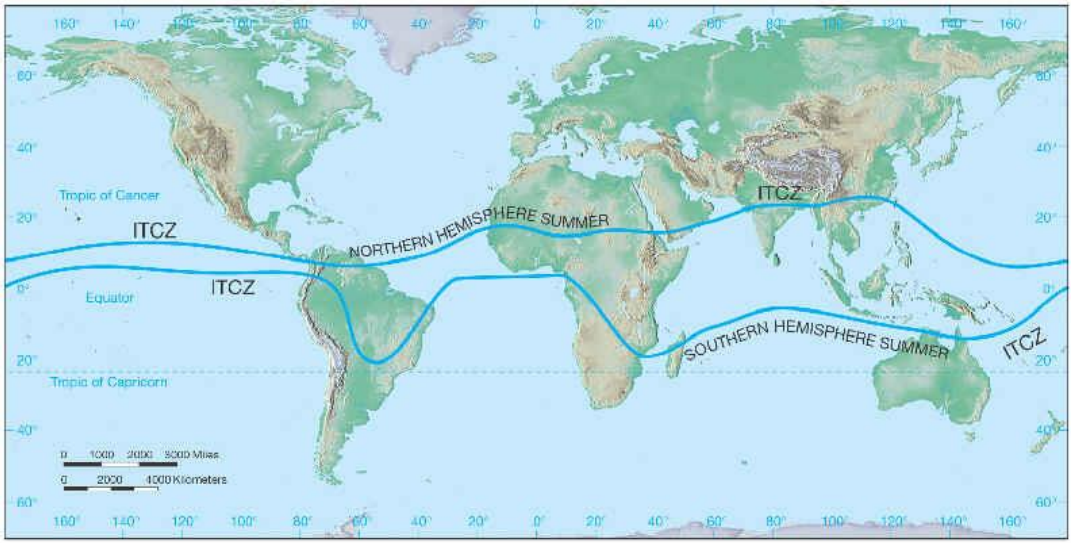
Winter



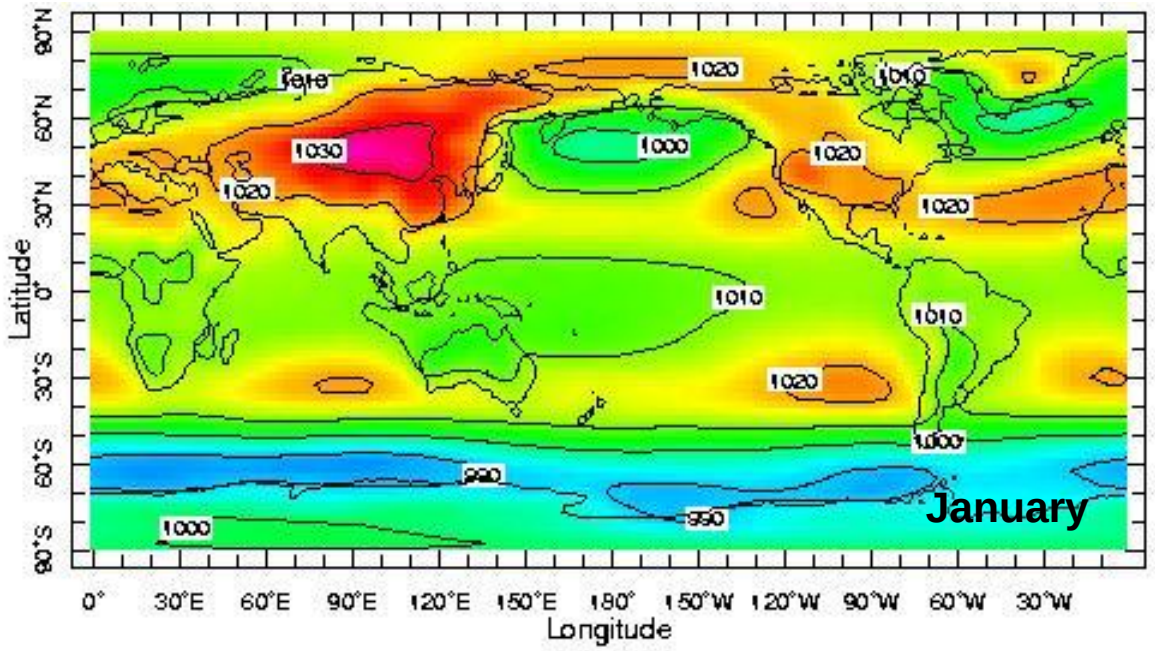
Summer

בחורף הים חם מהיבשה ובקיץ להפך.

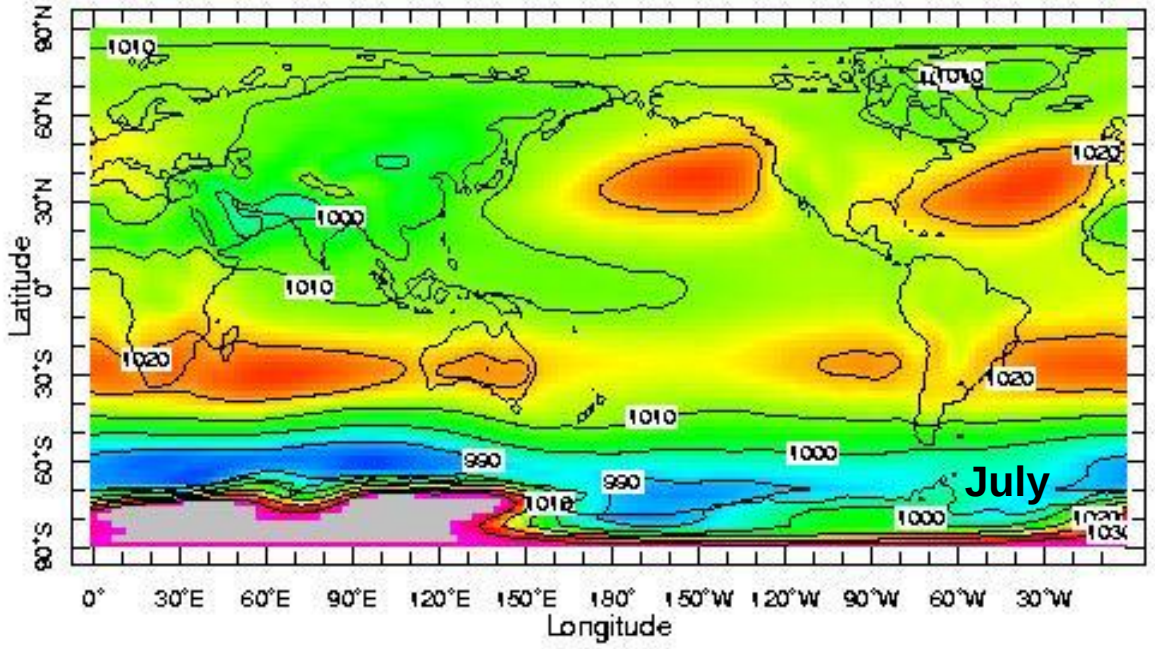
על יבשות שקרובות מספיק למשווה נוצרת סירקולציה אנכית של עליית אויר מעל היבשה החמה בקיץ- גשמי מונסון



שדה הלחץ בקרקע- שינוי עונתי המלווה את נדידת ה ITCZ צפון-דרום וגם היפוך הפרשי הטמפרטורה בין ים ויבשה.



Jan

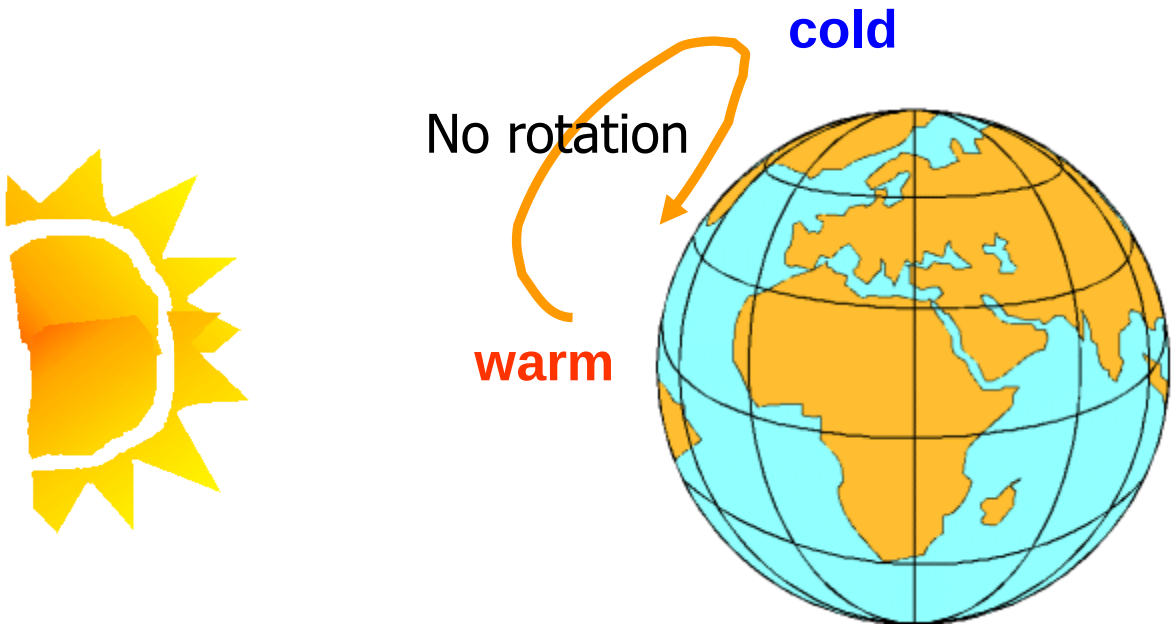


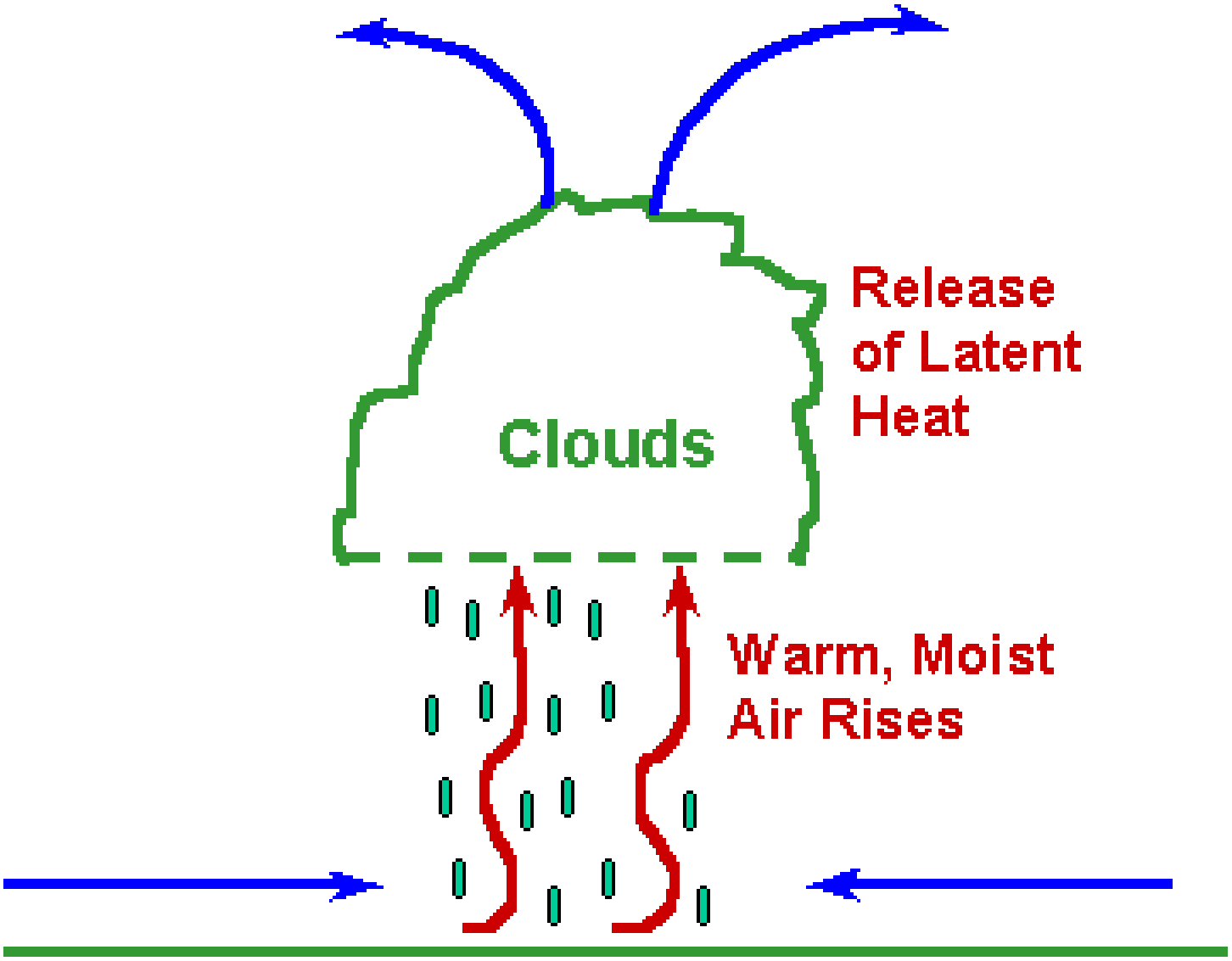
Jul

Differential heating forces an overturning circulation

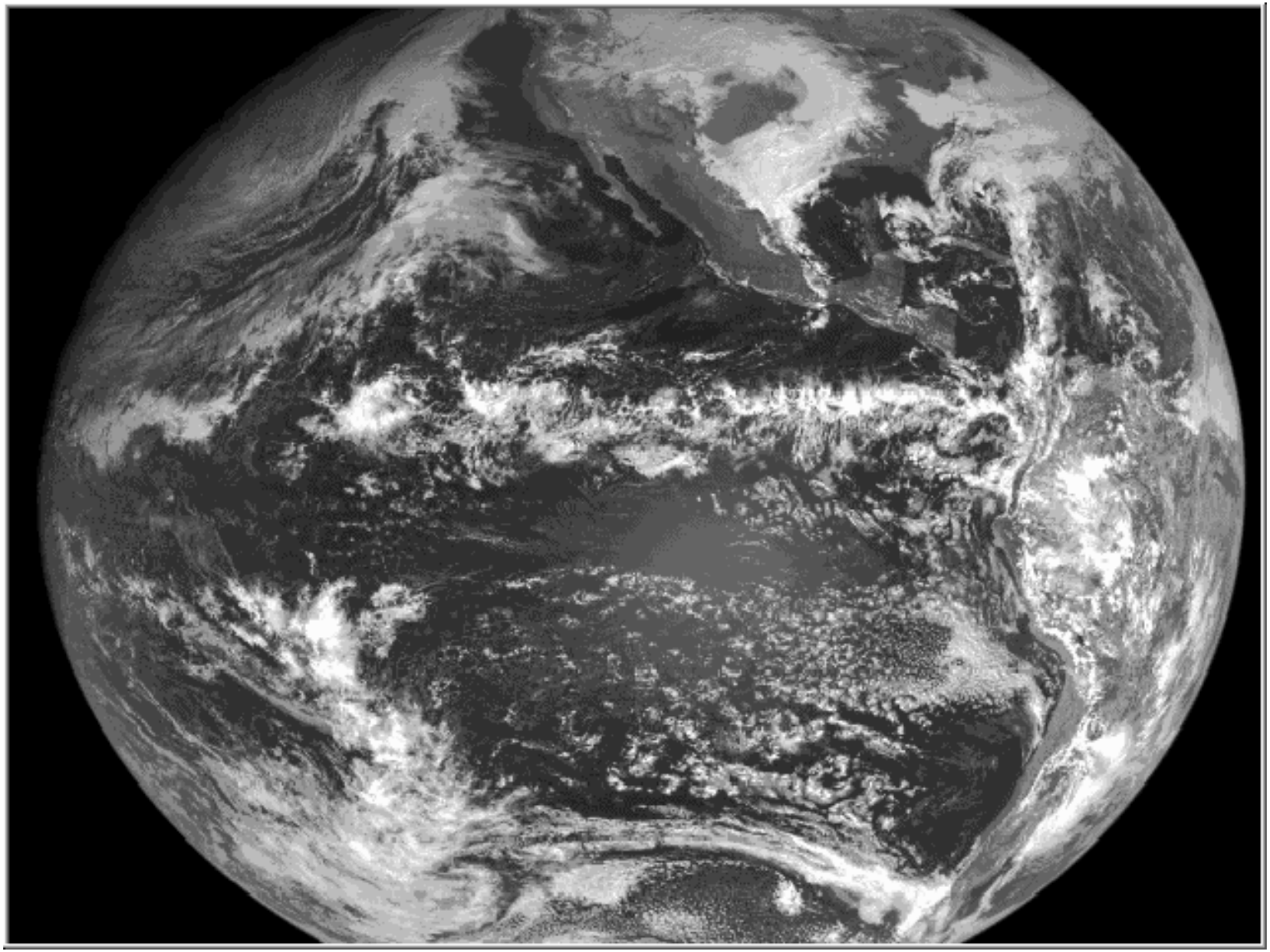
1) pressure gradient at upper level forces upper level outflow, and then lower level inflow, due to surface pressure gradients, and continuity

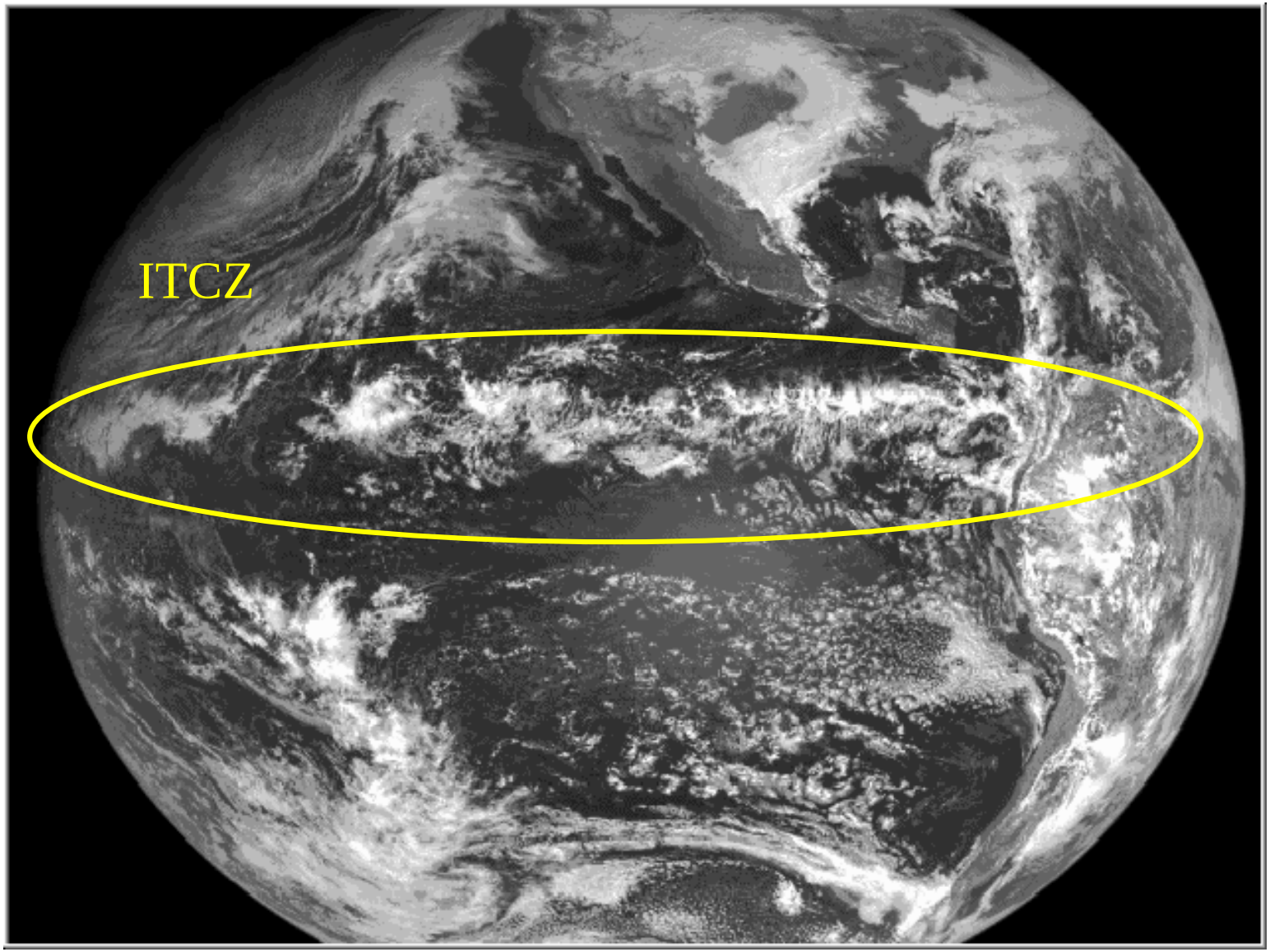
2) Radiation forces convectively unstable conditions at maximum heating locations- strong updrafts, which hit the tropopause above which the air is statically stable → air diverges polewards



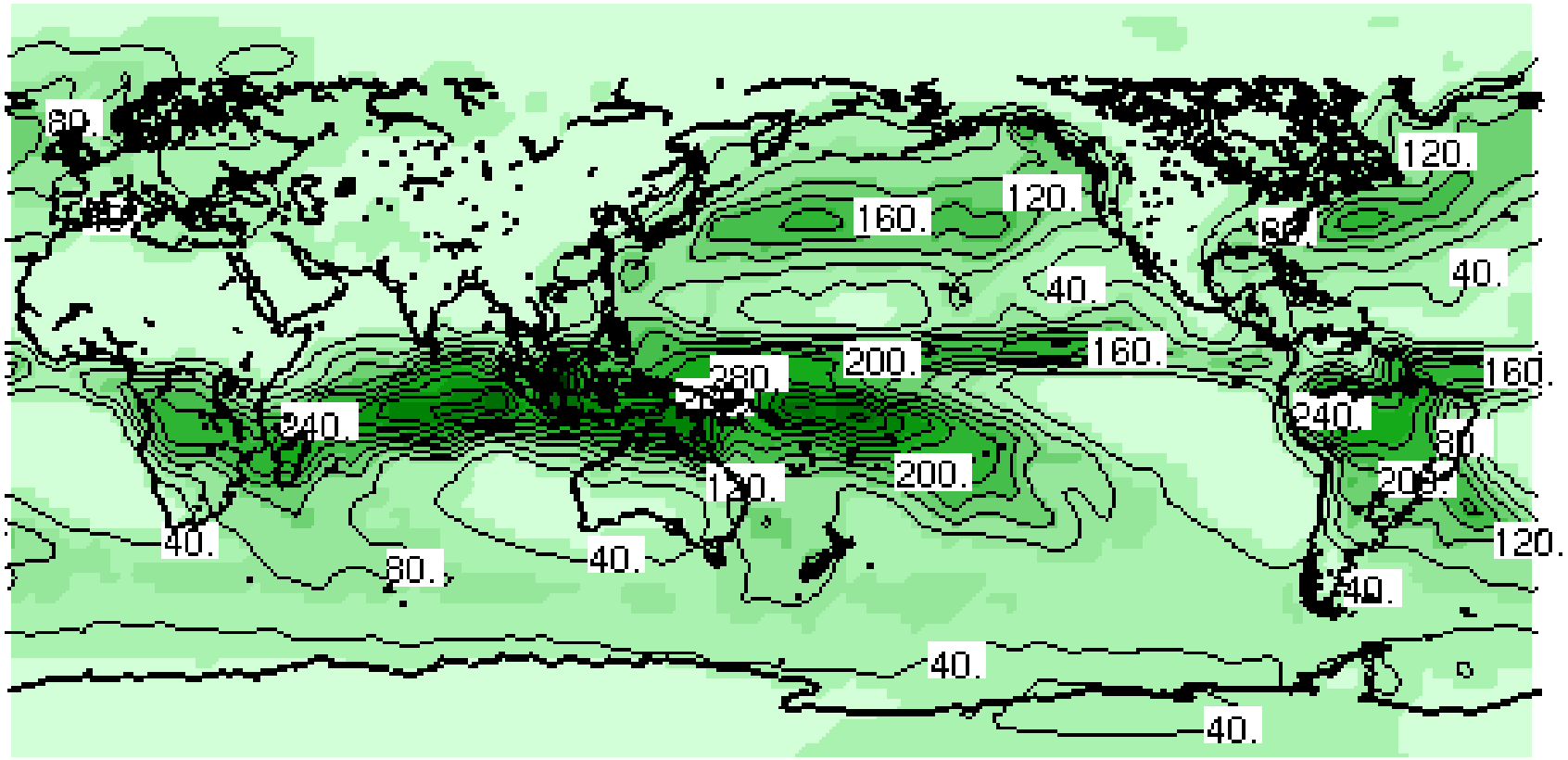


Intertropical Convergence Zone -- ITCZ



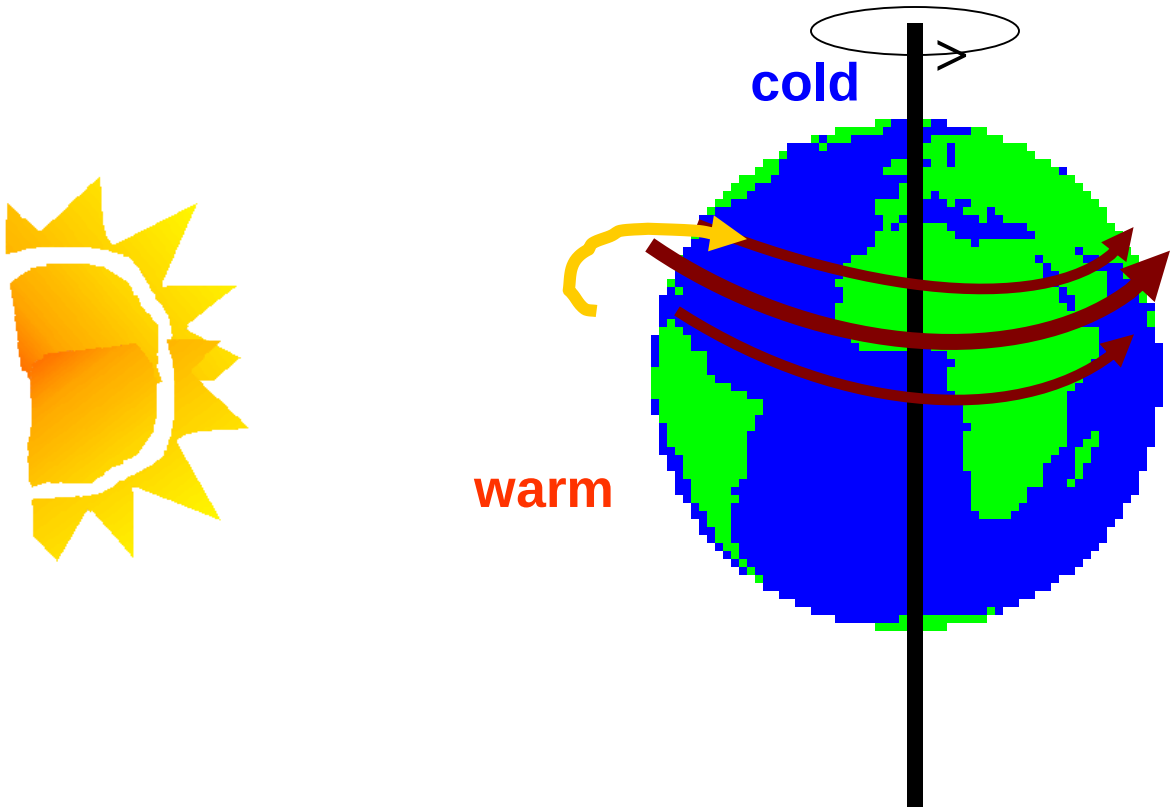

ITCZ

Monthly Rainfall Rates
Maximum along ITCZ



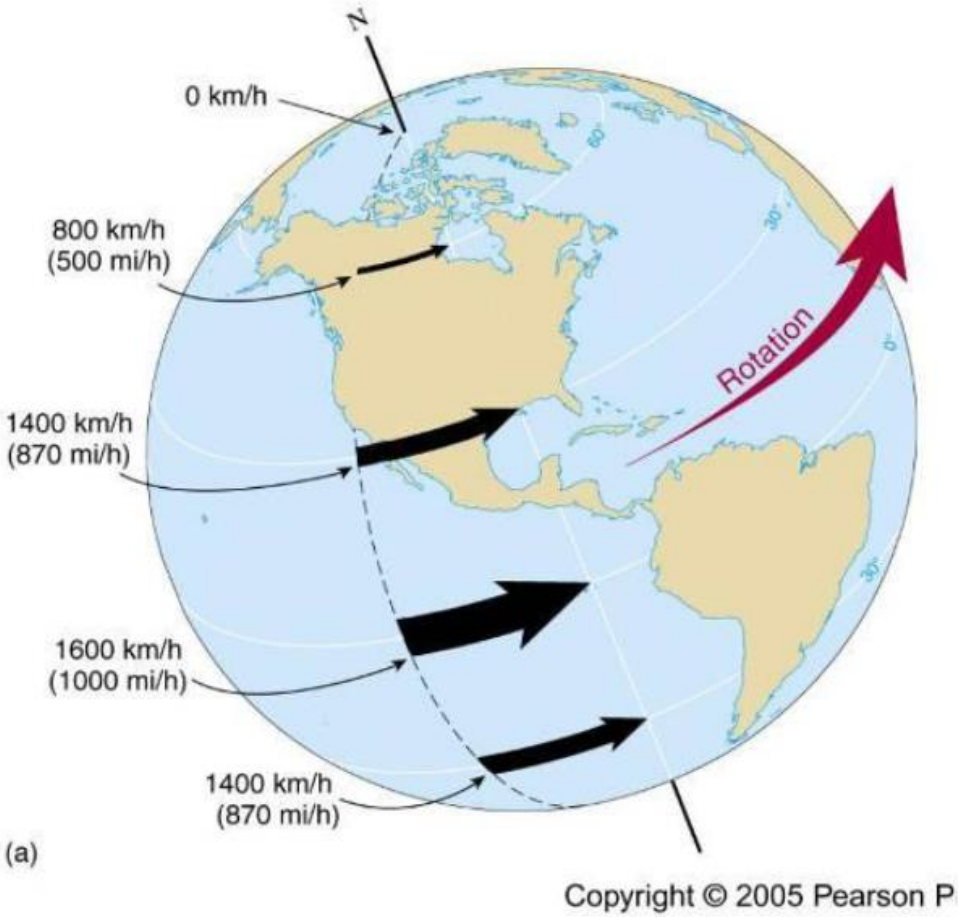
Jan

But with rotation, the Coriolis force induces a zonal jet stream. Geostrophic balance



At surface return branch, Coriolis deflects to the west. Since friction slows the flow, it becomes easterly- trade winds

Effect of Earth rotation on air motion



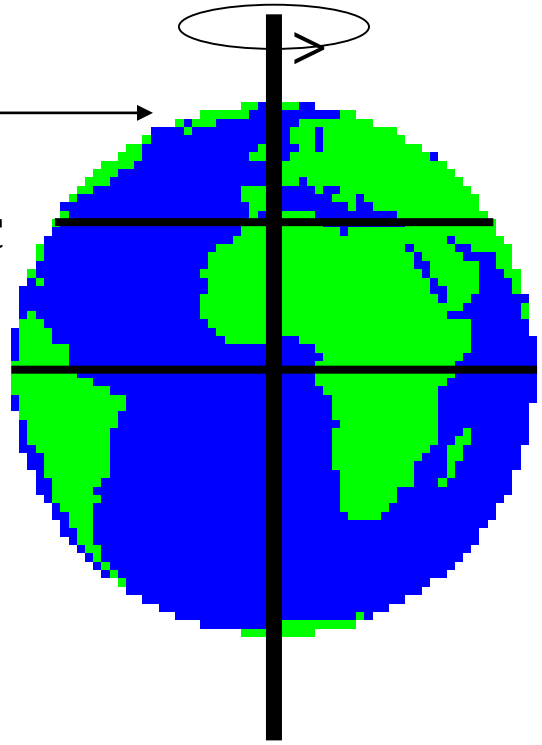
Earth's Rotation period= 24 hours=86400sec

Speed of point on surface: V= diameter/time = $2\pi r/24h = \Omega a \cos\varphi$

North Pole a ~ 0km, V=0m/sec

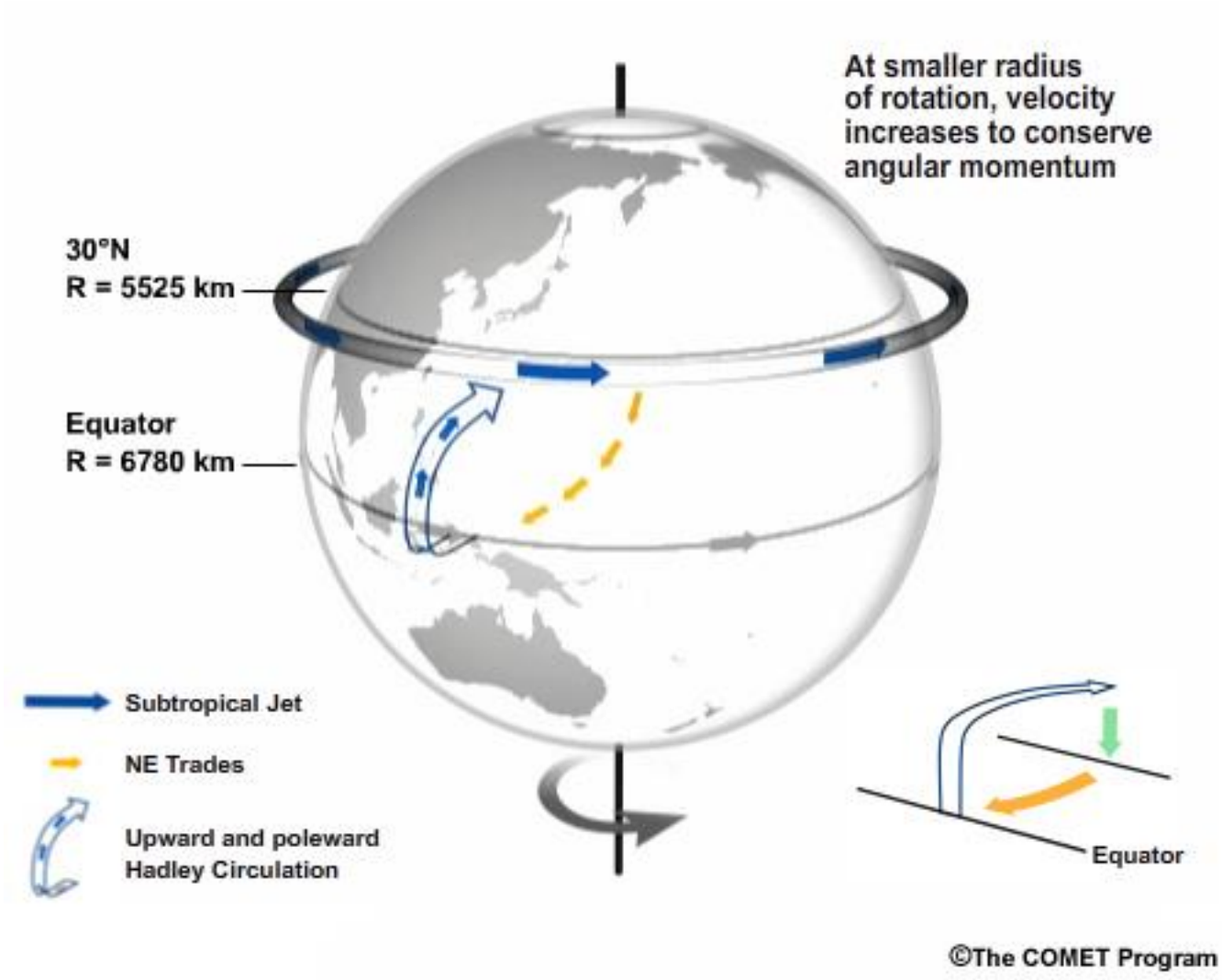
Tel Aviv a~34,000 km, V~1417km/h~400m/sec

Equator a ~ 40,000 km, V~1667km/h~460m/sec



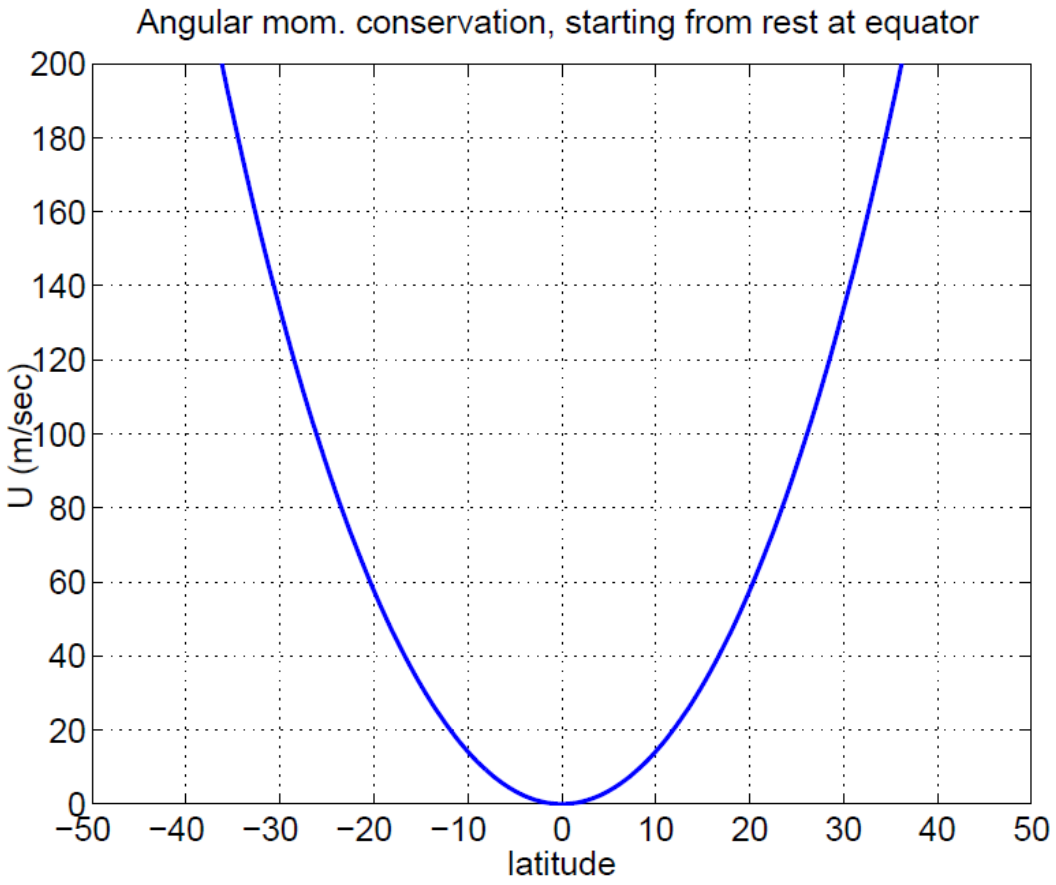
Angular momentum conservation:

$$M = (\Omega a \cos\varphi + u) a \cos\varphi \quad \rightarrow \quad u = \frac{\Omega a \sin^2\varphi}{\cos\varphi}$$



Angular momentum conservation:

$$M = (\Omega a \cos\varphi + u) a \cos\varphi \quad \rightarrow \quad u = \frac{\Omega a \sin^2\varphi}{\cos\varphi}$$



לא רואים כאלו מהירויות- מדוע?

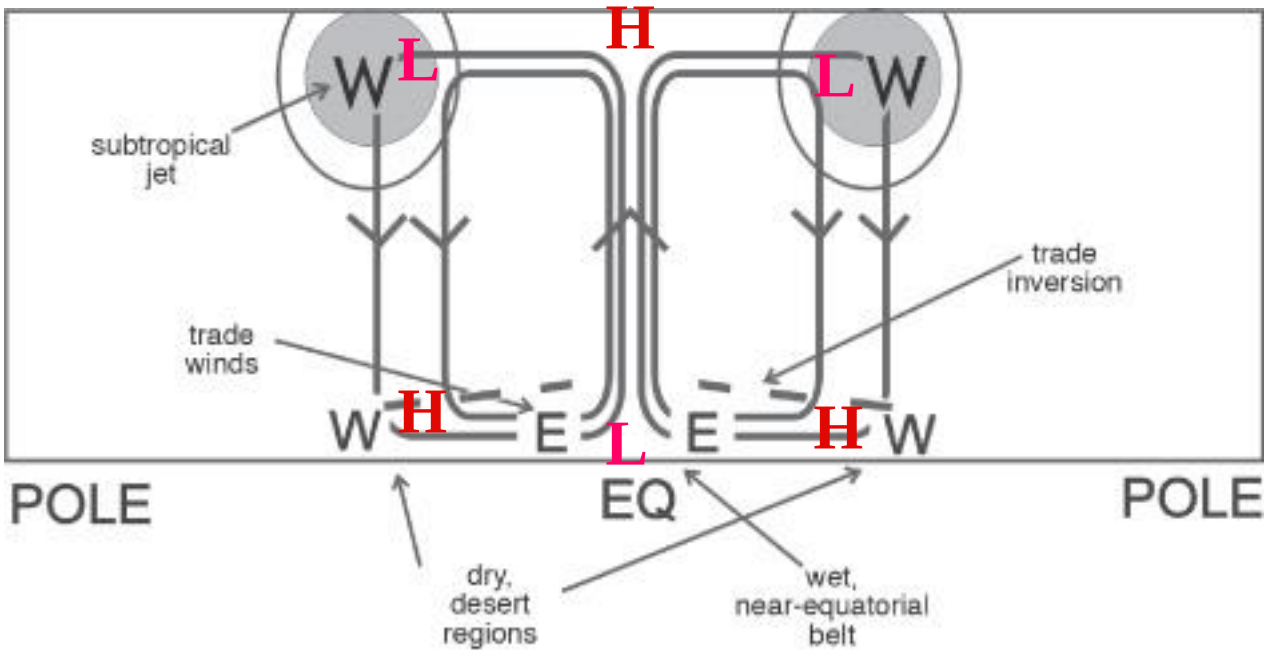


Figure 8.5: A schematic diagram of the Hadley circulation and its associated zonal flows and surface circulation.

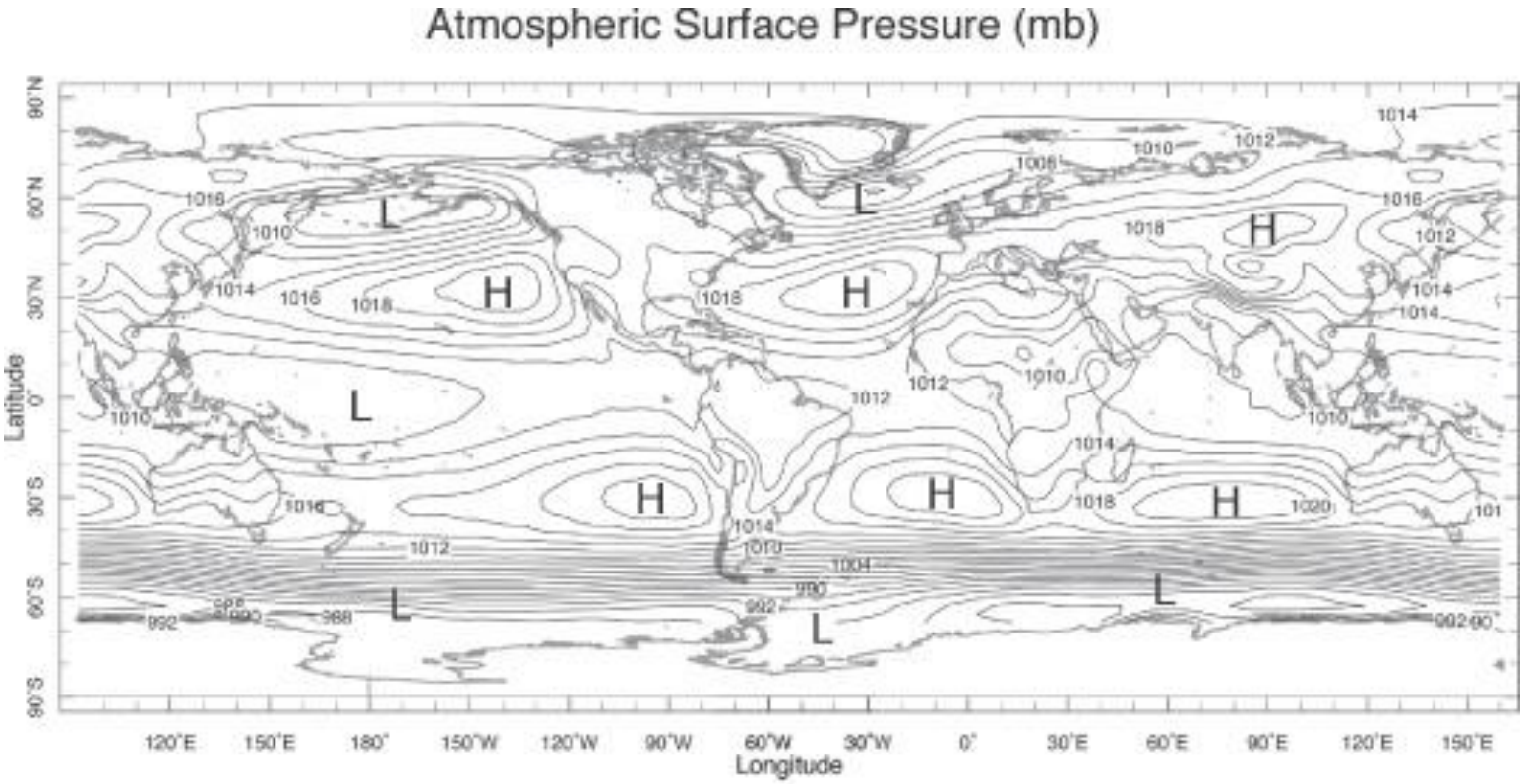
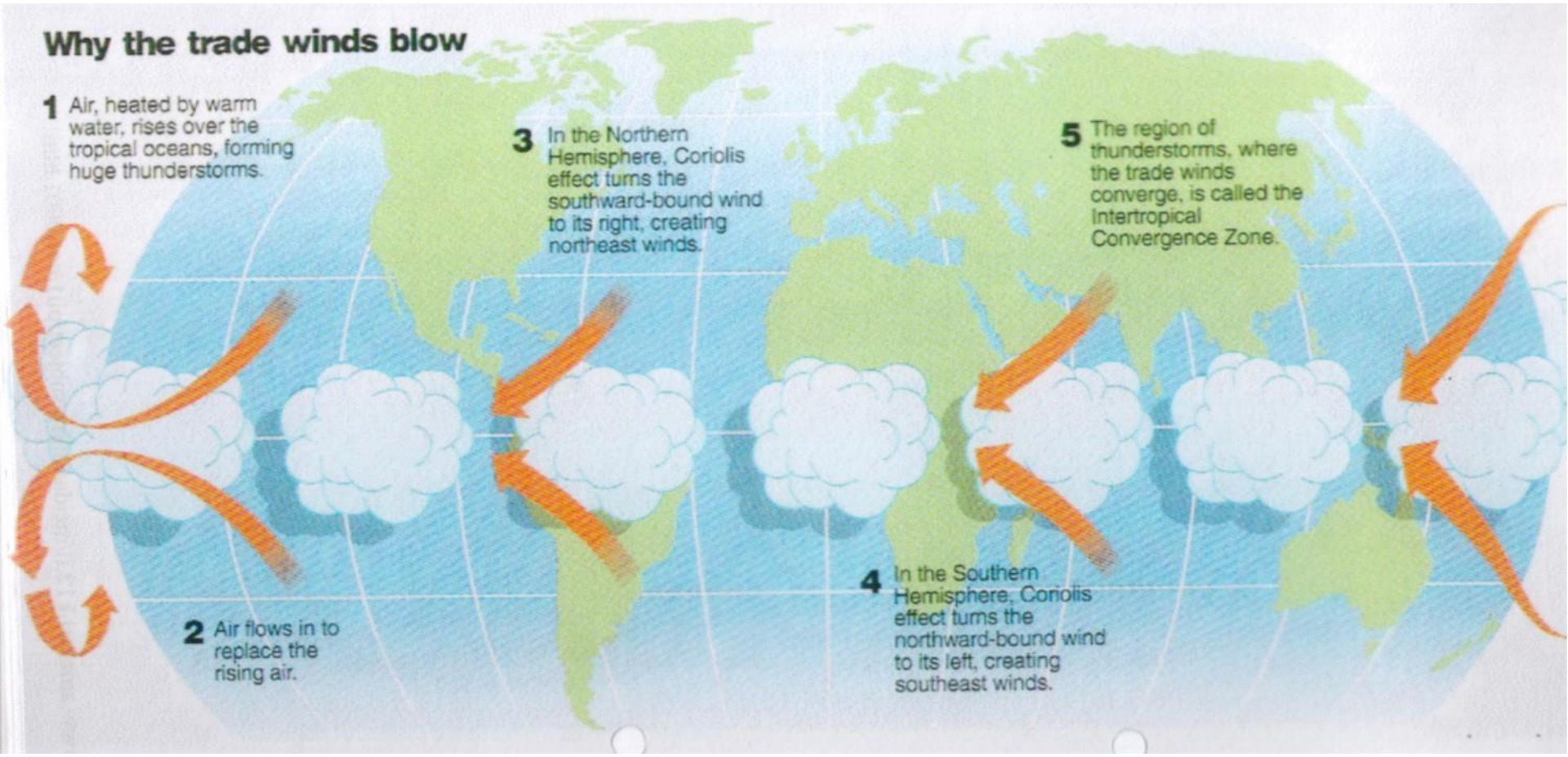


Figure 7.27: The annual-mean surface pressure field in mbar, with major centers of high and low pressure marked. The contour interval is 5 mbar.

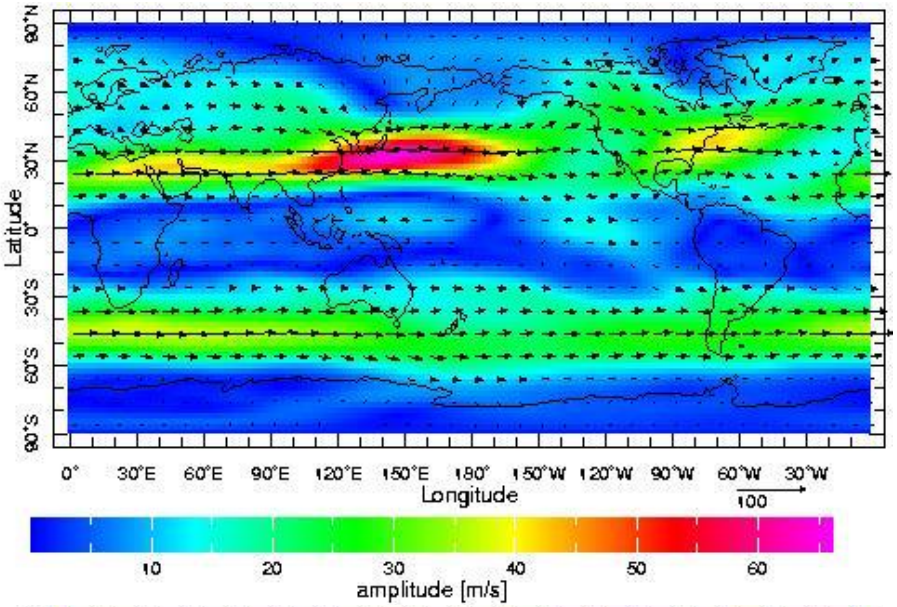


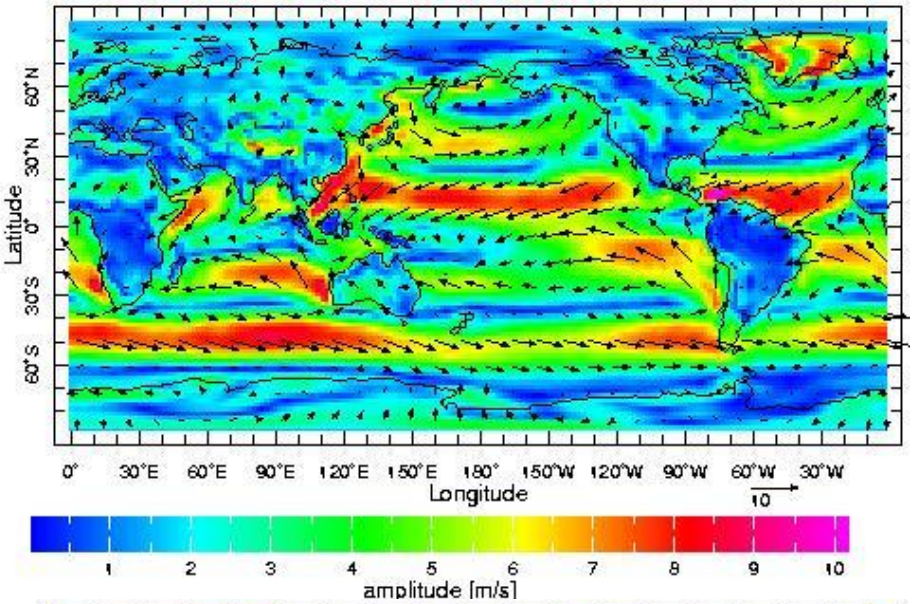
ITCZ=Inter Tropical Convergence Zone

300mb

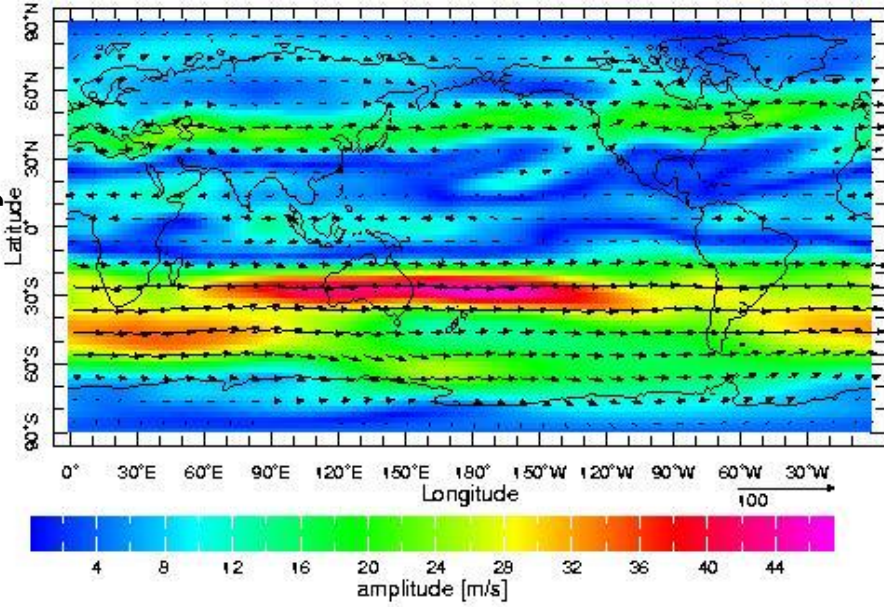
surface

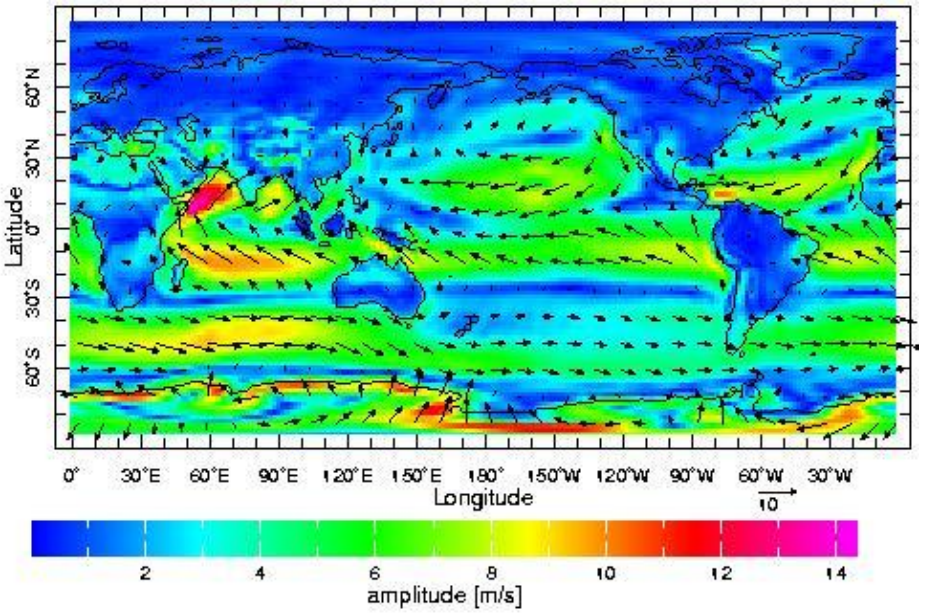
January



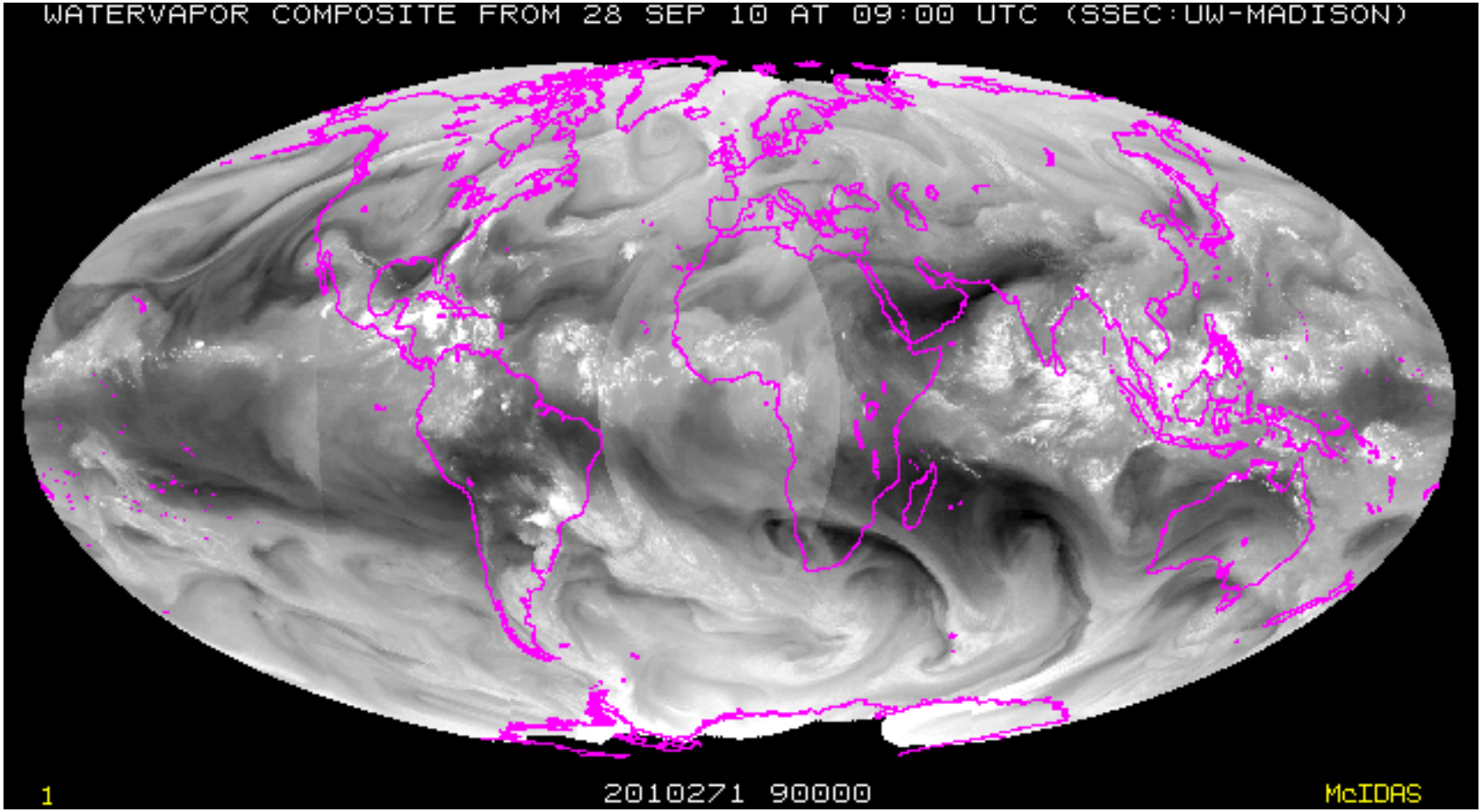


July





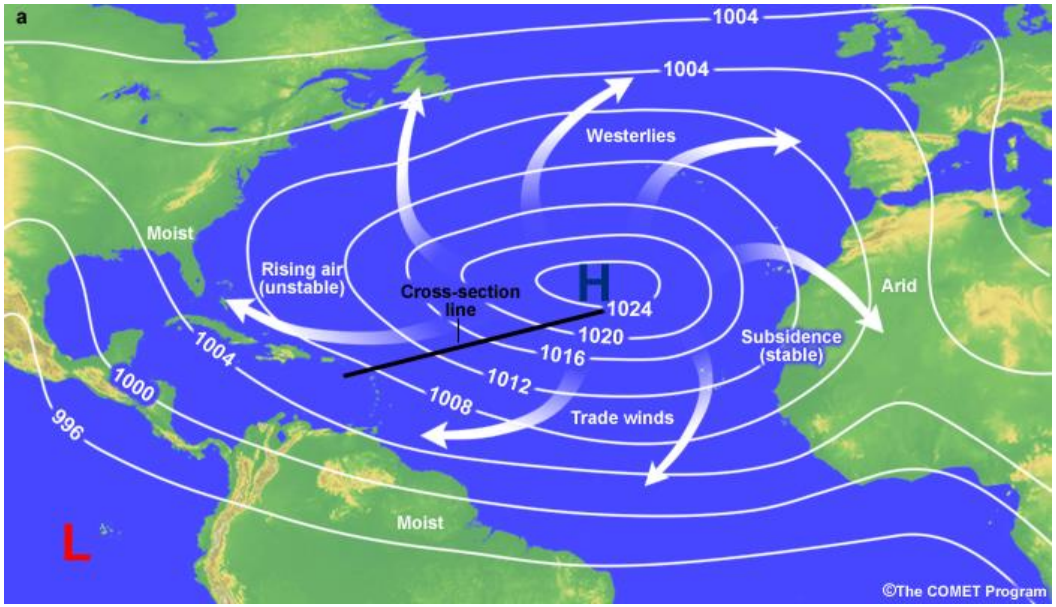
תמונת לווין יומית של אדי מים. רואים שהטרופים הלחים והחגורות הסובטרופיות יבשות

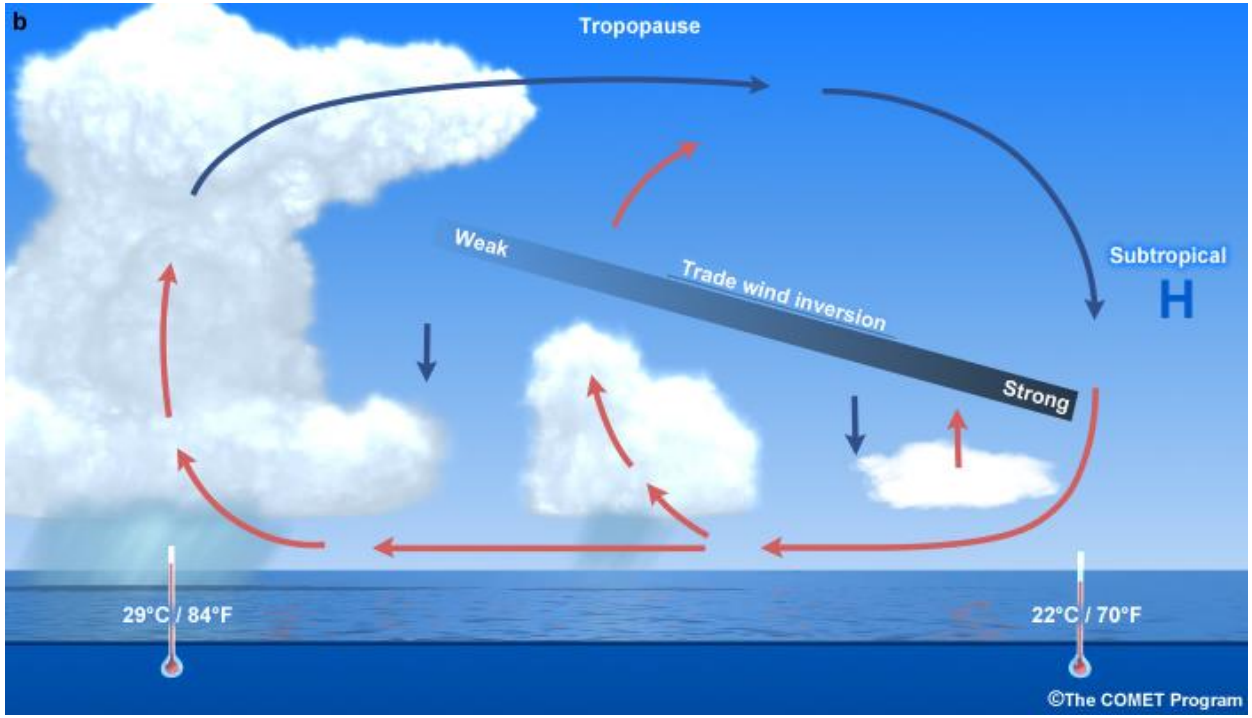


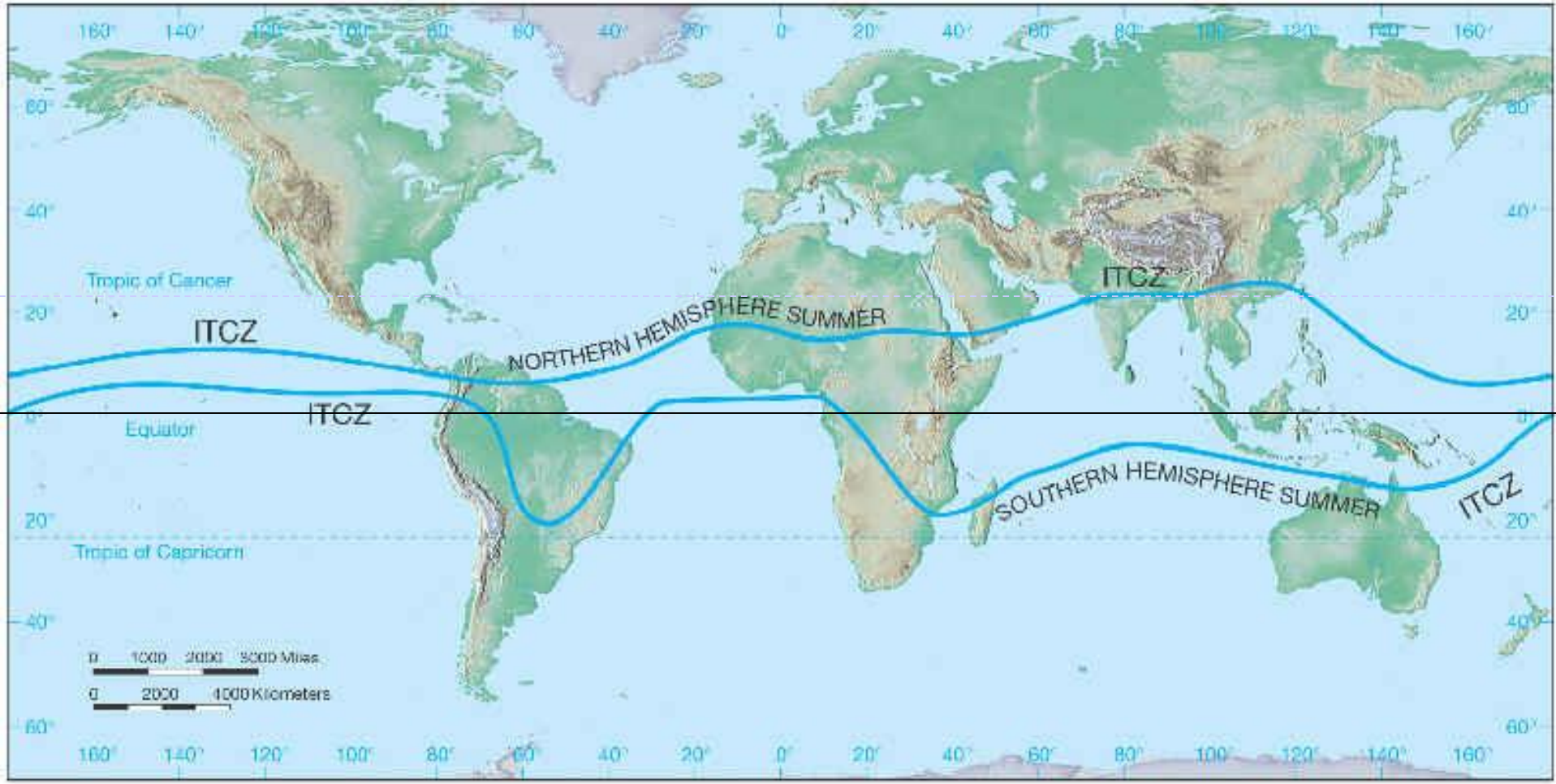
Trade wind boundary layer and trade wind inversion.

Dry warm air on top of cold moist air which becomes unstable- shallow boundary layer clouds

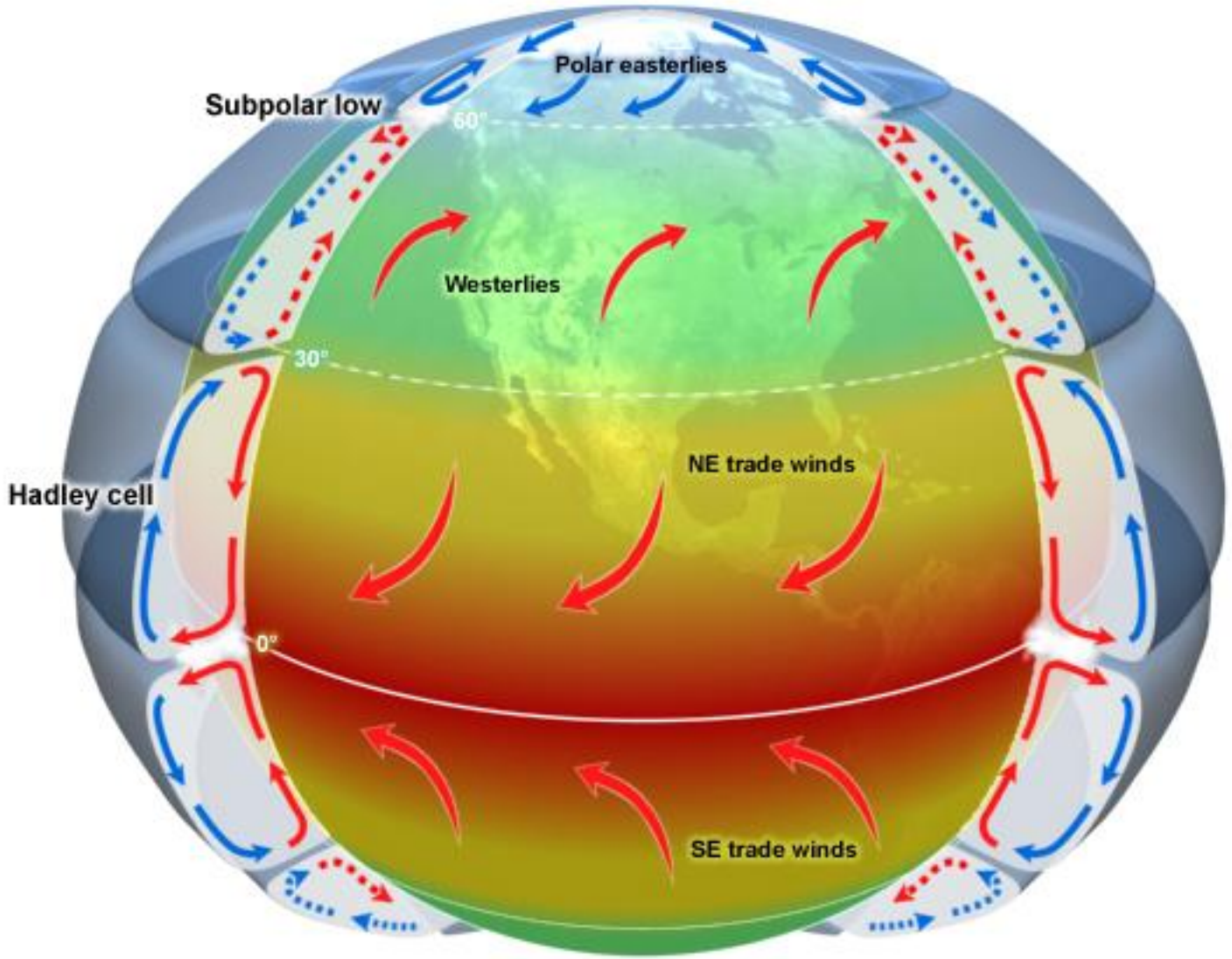
Note- north eastward flow in midlatitudes



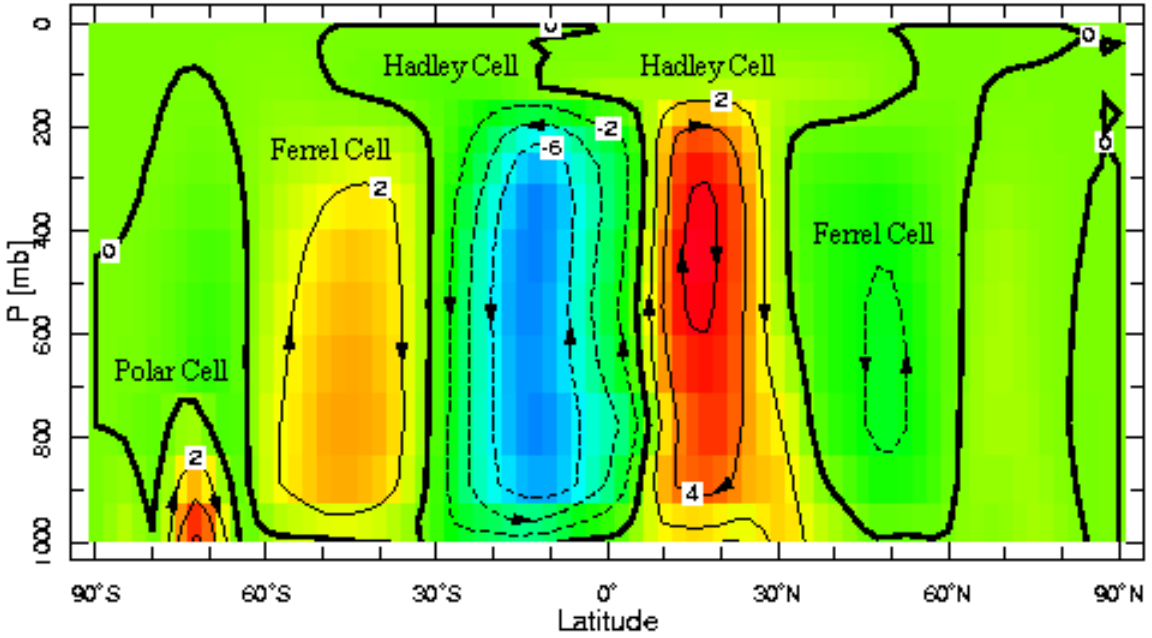



Tropic of Cancer
ITCZ
NORTHERN HEMISPHERE SUMMER
ITCZ
ITCZ
Equator
SOUTHERN HEMISPHERE SUMMER
ITCZ
Tropic of Capricorn
0 1000 2000 3000 Miles
0 2000 4000 Kilometers

בקווי הרוחב הממוזגים - תאי פרל



The Zonally Averaged vertical-meridional Circulation



The annually-averaged atmospheric circulation in the latitude pressure plane (the meridional plan). The arrows depict the direction of air movement in the meridional plane. The contour interval is 2x10 10 Kg/sec - this is the amount of mass that is circulating between every two contours. The total amount of mass circulating around each "cell" is given by the largest value in that cell. Data based on the NCEP-NCAR reanalysis project 1958-1998.

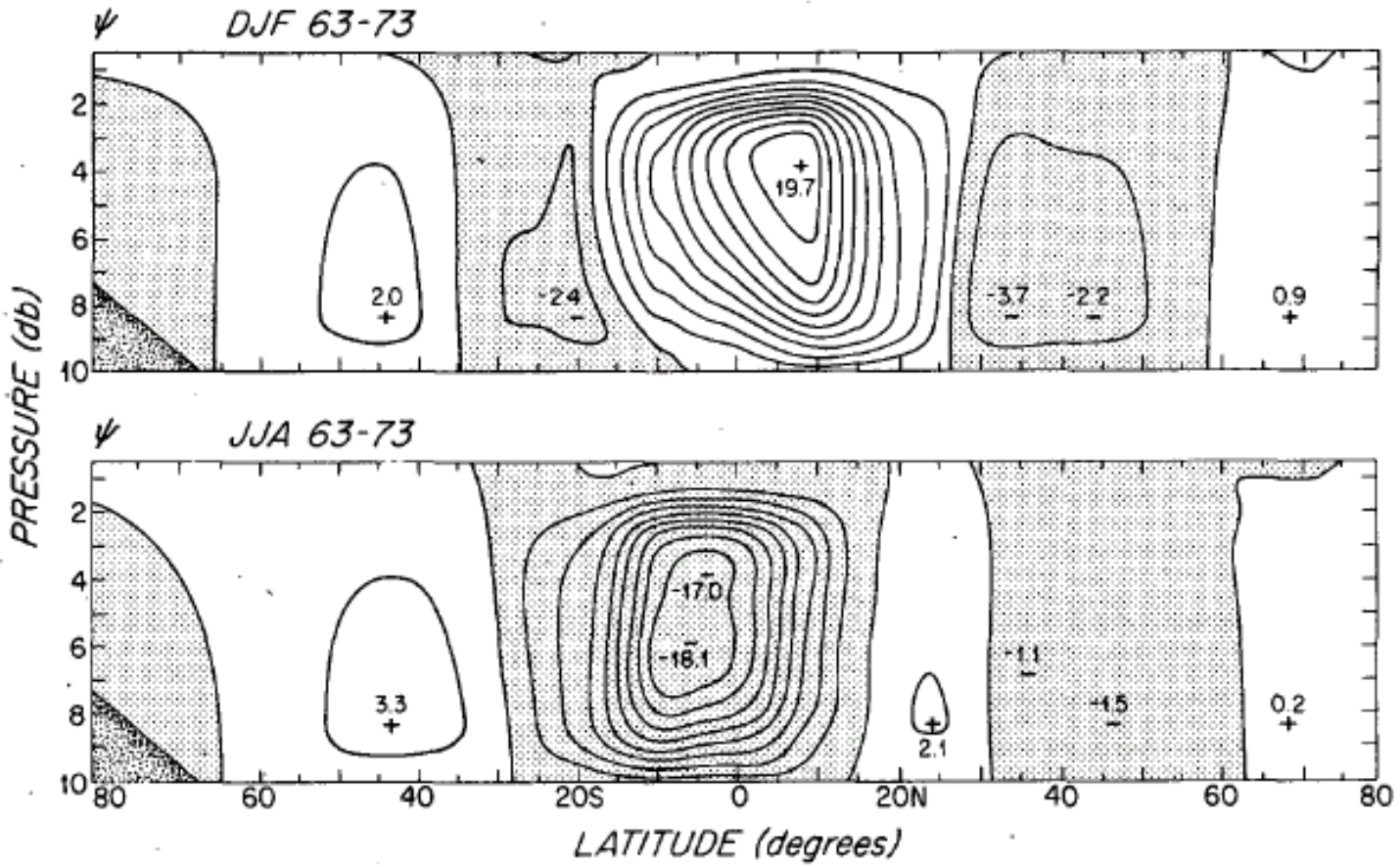
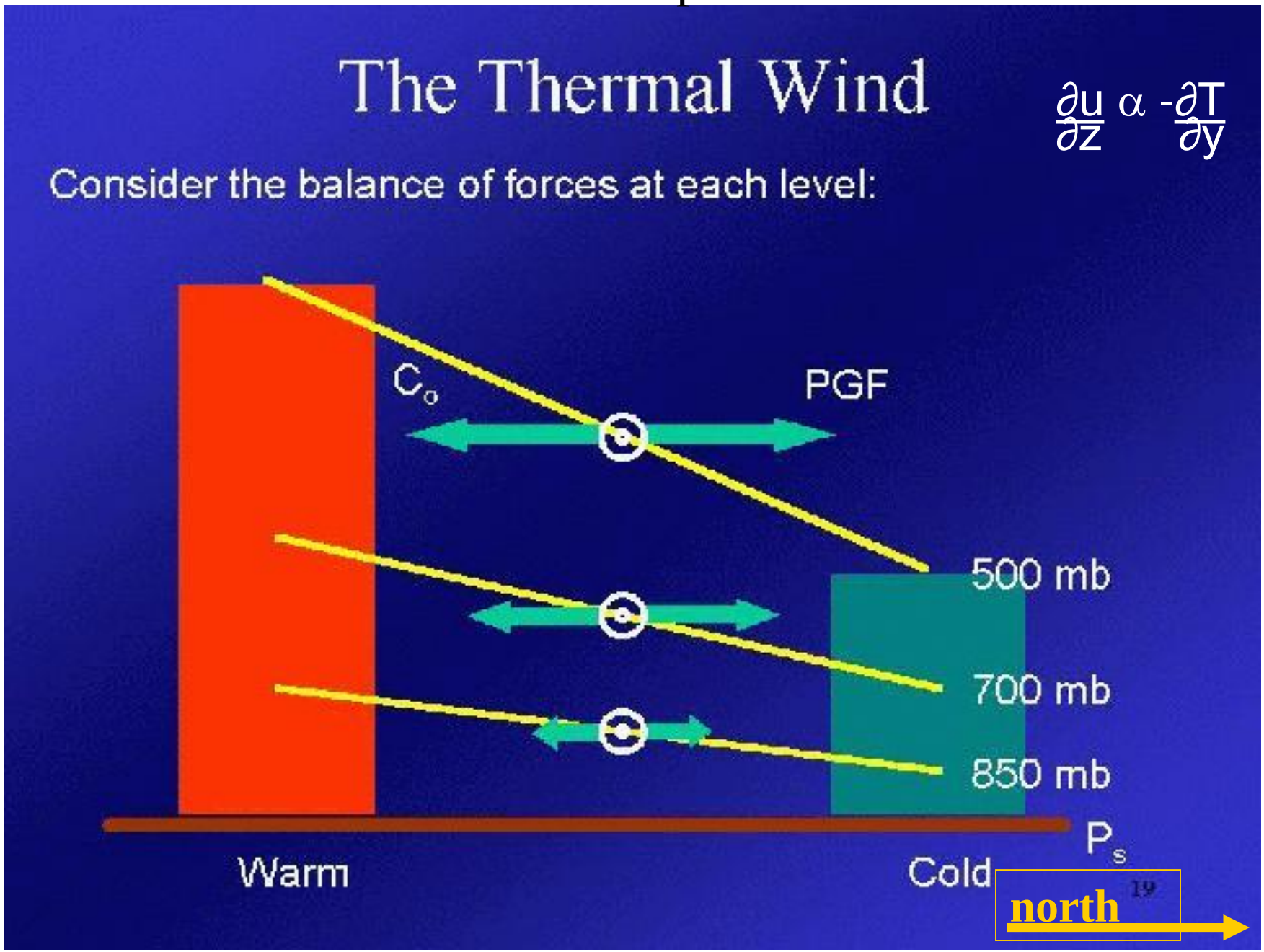
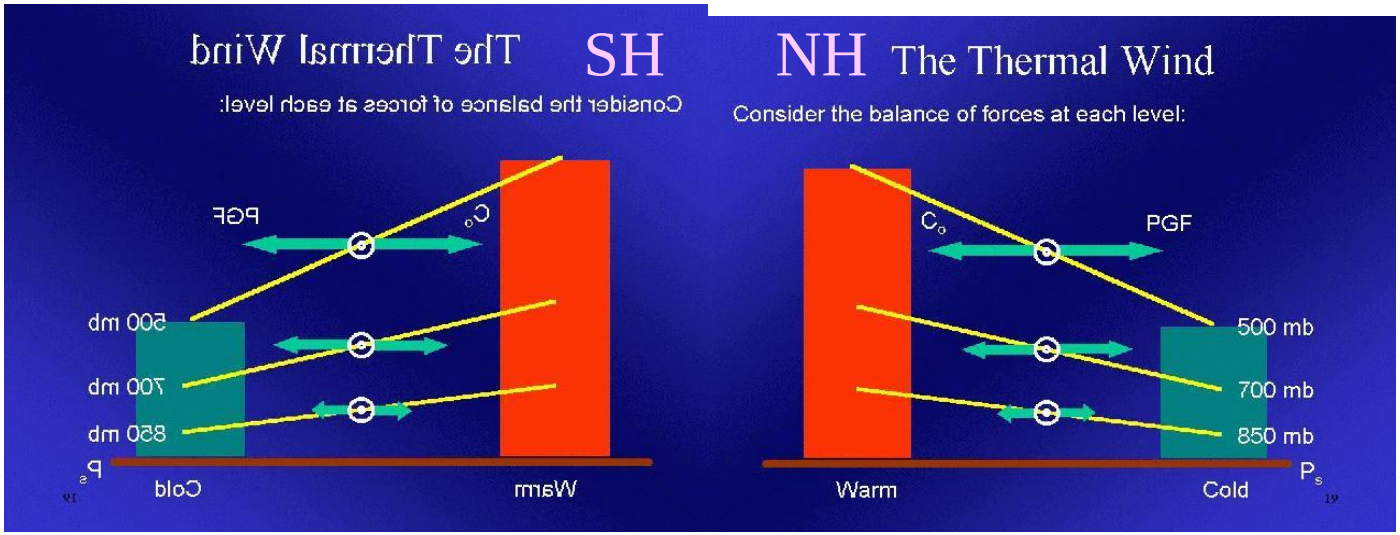


FIG. 2. Time average meridional-height cross sections of the streamfunction for the mean meridional circulation. Units, 10^{13} g s^{-1}; contour intervals, 0.2×10^{13} g s^{-1}. December–February 1963–1973 (upper panel) and June–August 1963–1973 (lower panel). (From Oort 1983.)

Northern Hemisphere



Zonal mean wind and temperature are in thermal wind balance: $fU_z \alpha - T_y$



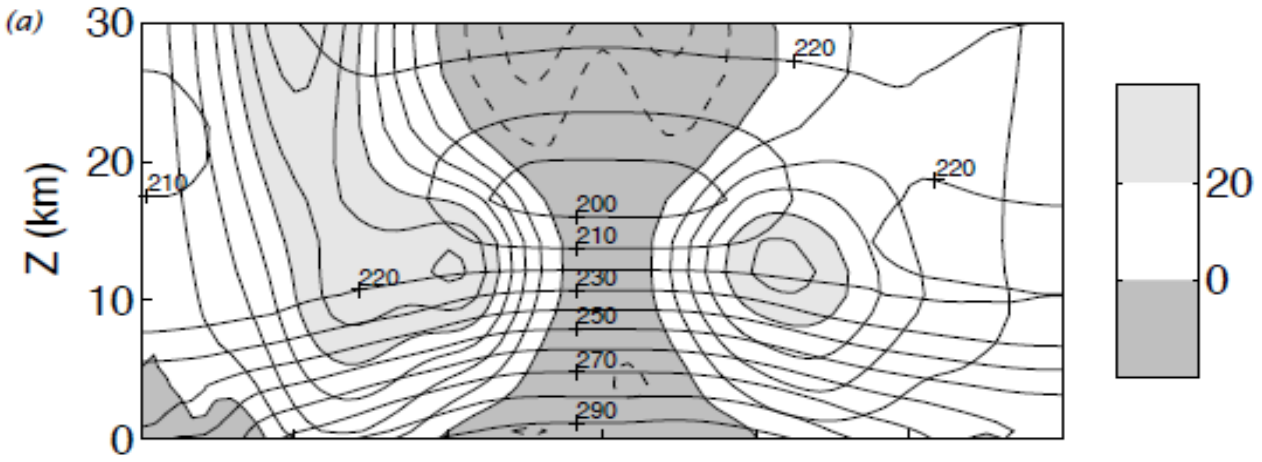
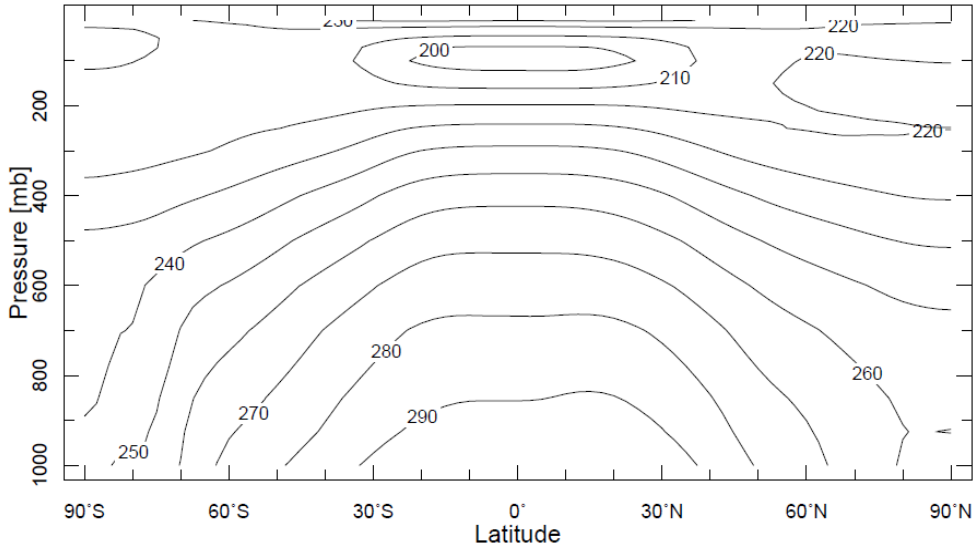
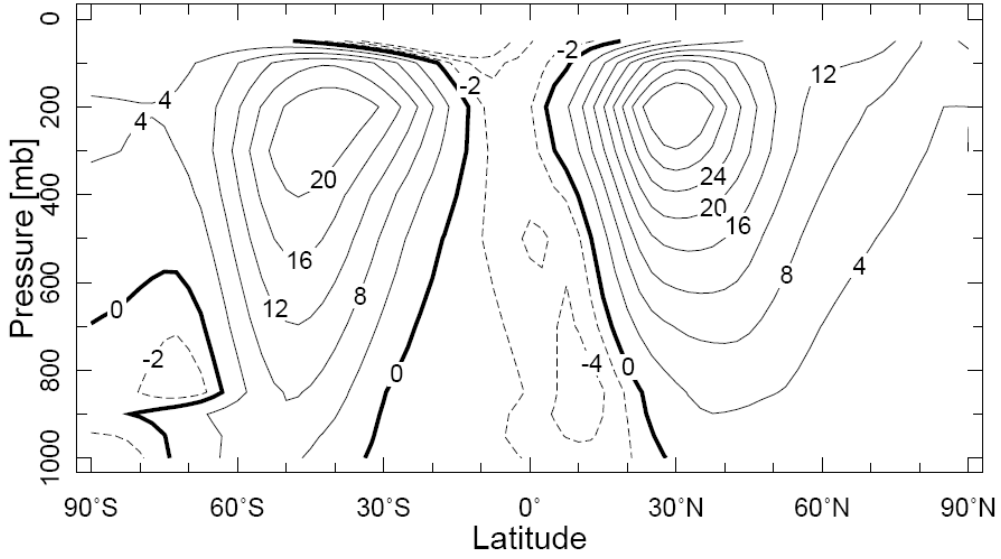


Fig. 11.2 (a) Annual mean, zonally averaged zonal wind (heavy contours and shading) and the zonally averaged temperature (lighter contours). (b)


Pressure [mb]
200
400
600
800
1000
200
210
220
220
220
240
250
270
280
290
260
90°S
60°S
30°S
0°
30°N
60°N
90°N
Latitude


Pressure [mb]
0
200
400
600
800
1000
4
4
-2
-2
20
16
12
8
0
0
-2
-4
0
24
20
16
12
8
4
90°S
60°S
30°S
0°
30°N
60°N
90°N
Latitude

אי יציבות ברוקלינית

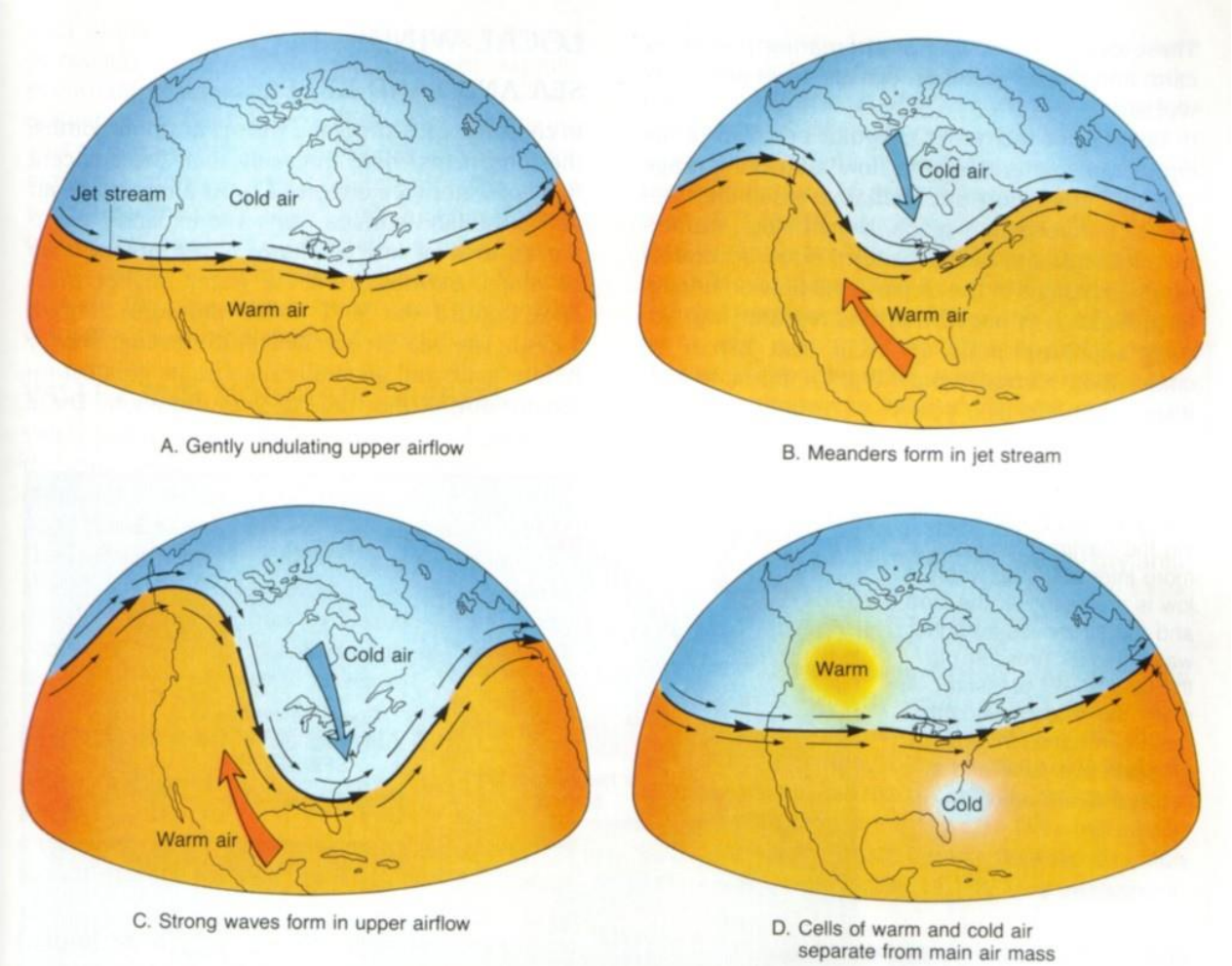


FIGURE 14.13
Cyclic changes that occur in the upper-level airflow of the westerlies. The flow, which has the jet stream as its axis, starts out nearly straight, then develops meanders, which are eventually cut off. (After J. Namias, NOAA)

הסופות מערבבות חום בכוון צפון-דרום ולמעלה-למטה. שני אלו מורידים מרכז המסה של האטמוספירה ומקטינים את האנרגיה הפוטנציאלית של הזרימה. זה מקור לאנרגיה קינטית של הסופות- רוחות חזקות

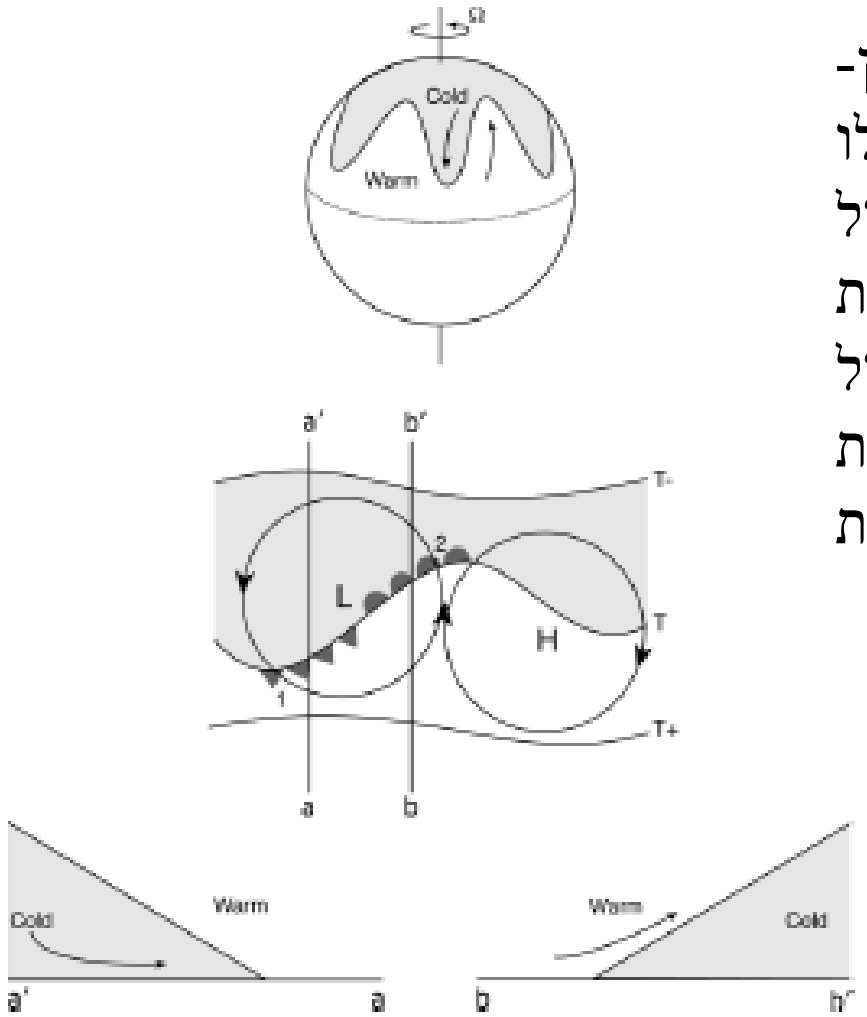
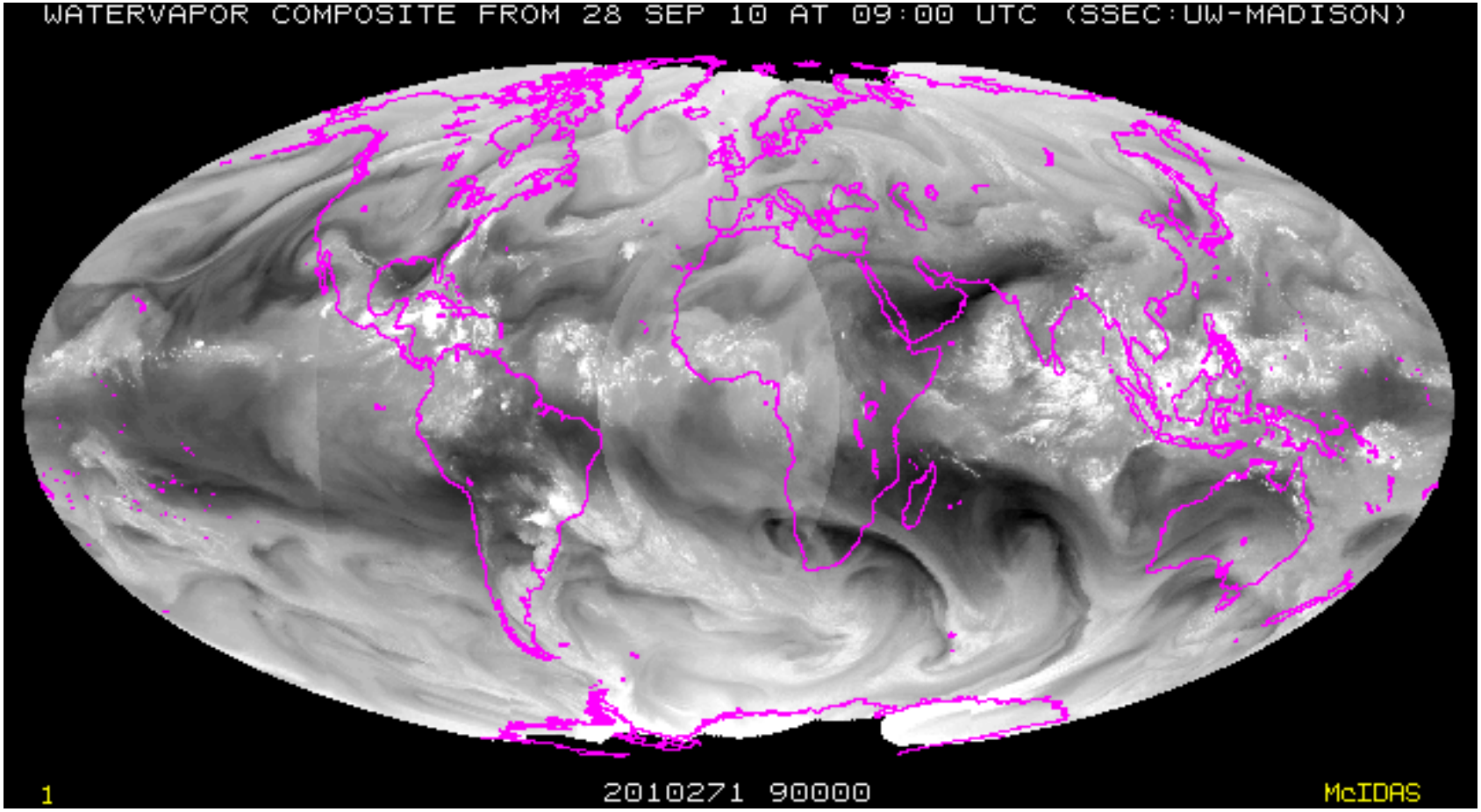


FIGURE 8.8. Top: In middle latitudes eddies transport warm air poleward and upward and cold air equatorward and downward. Thus the eddies tend to "stir" the atmosphere laterally, reducing the equator-to-pole temperature contrast. Middle: To the west of the "L," cold air is carried in to the tropics. To the east, warm air is carried toward the pole. The resulting cold fronts (marked by triangles) and warm fronts (marked by semicircles) are indicated. Bottom: Sections through the cold front, $a' \longrightarrow a$, and the warm front, $b \longrightarrow b'$, respectively.

קווי הרוחב הממוזגים: מאפיין בולט- גלים / מערבלים



Midlatitude weather systems
messy but geostrophic

Daily 300 mb height (m) and winds (m/s) 1 Apr 1997

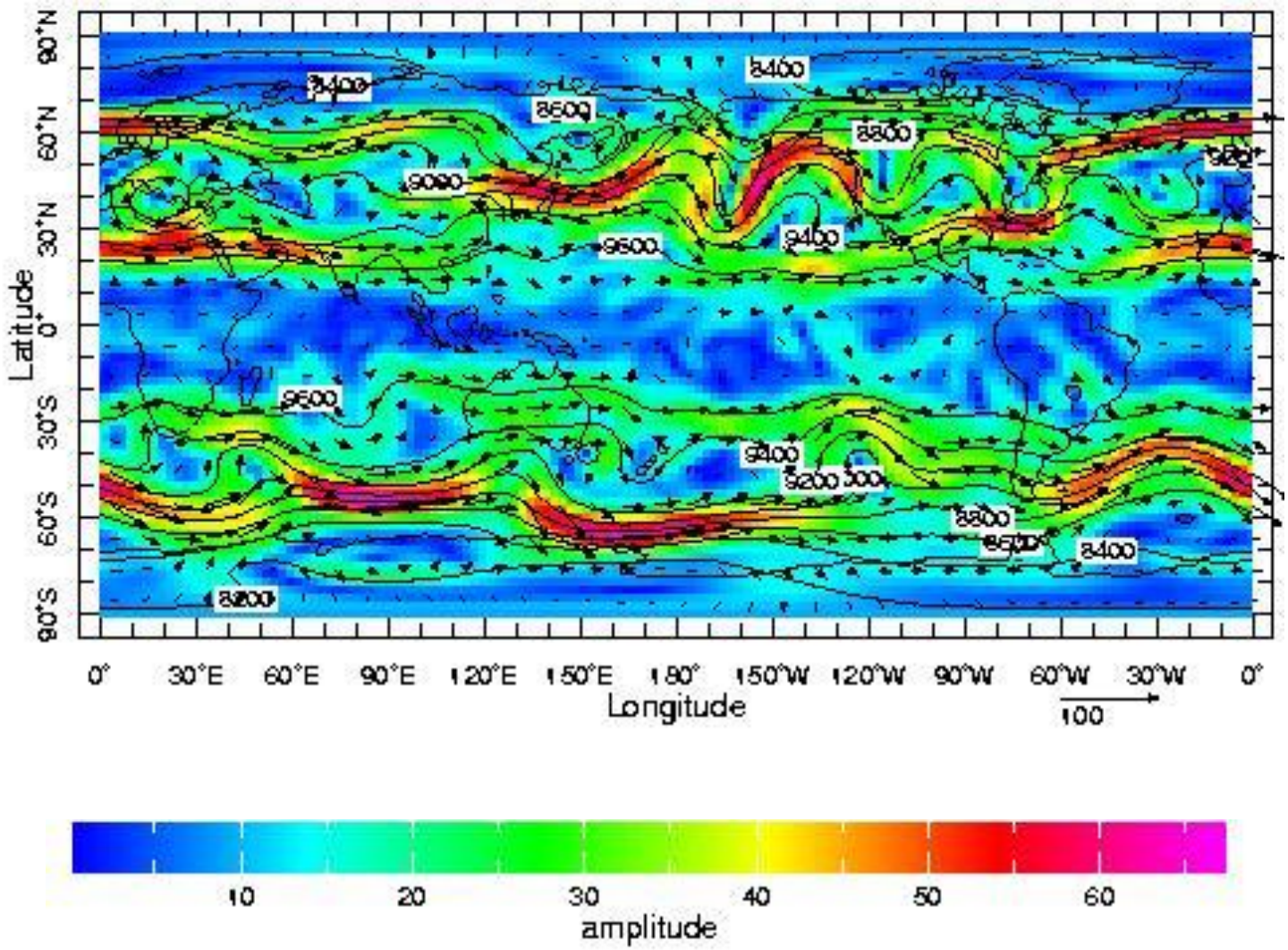
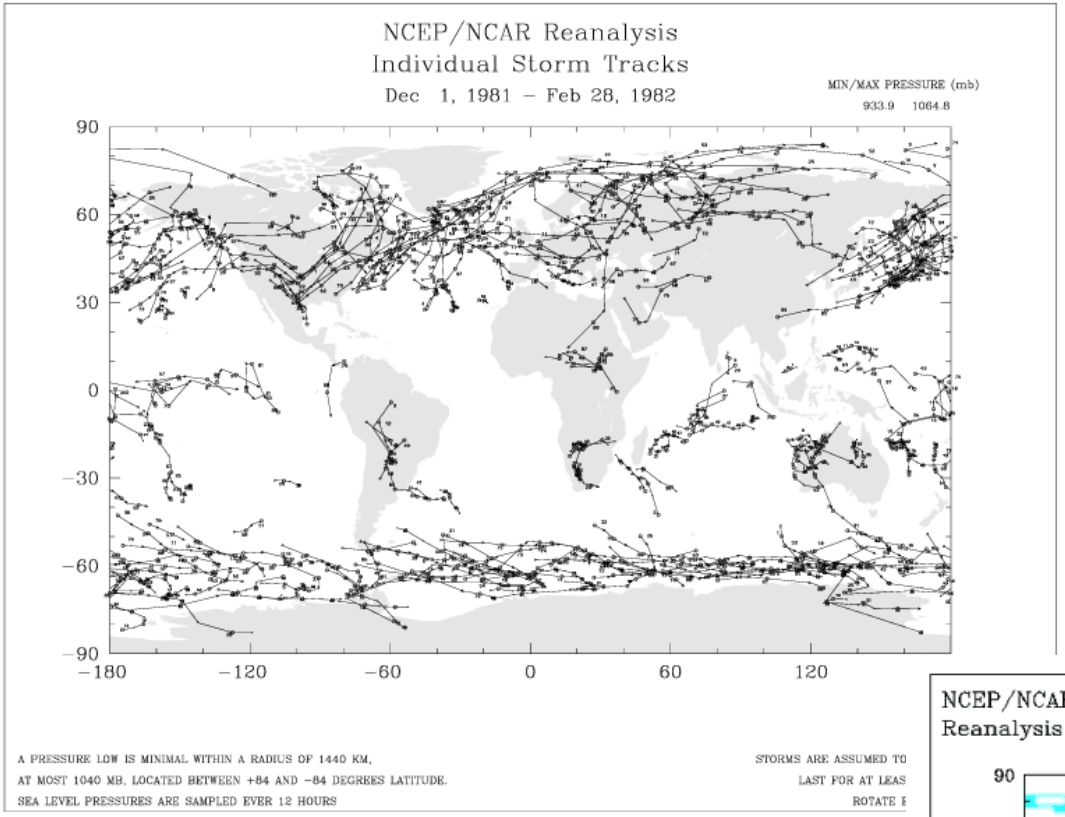
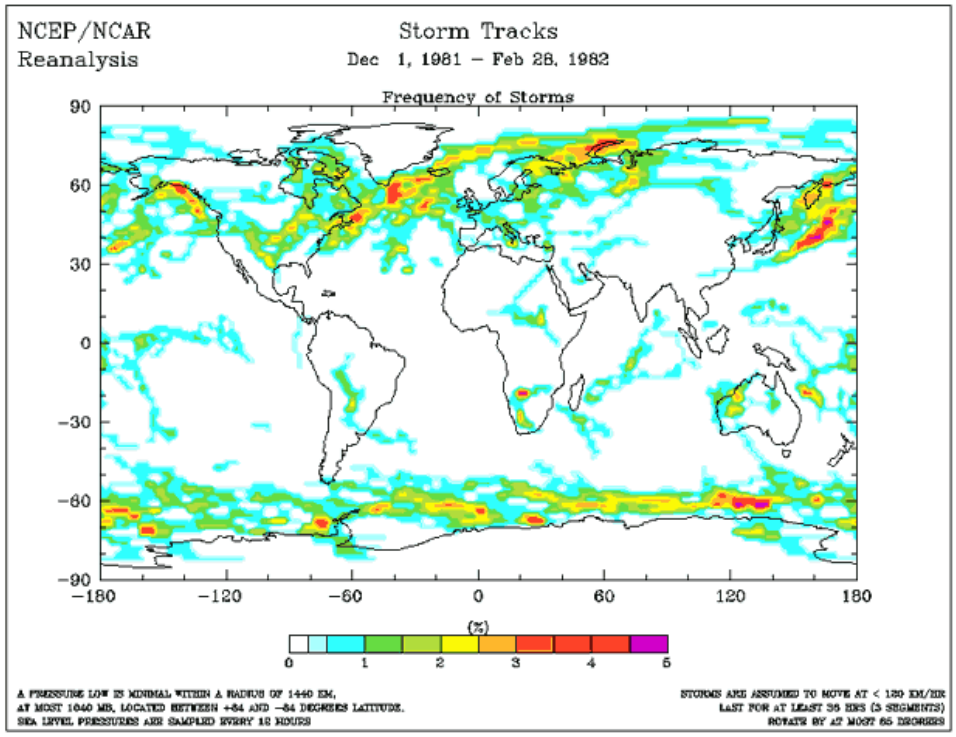
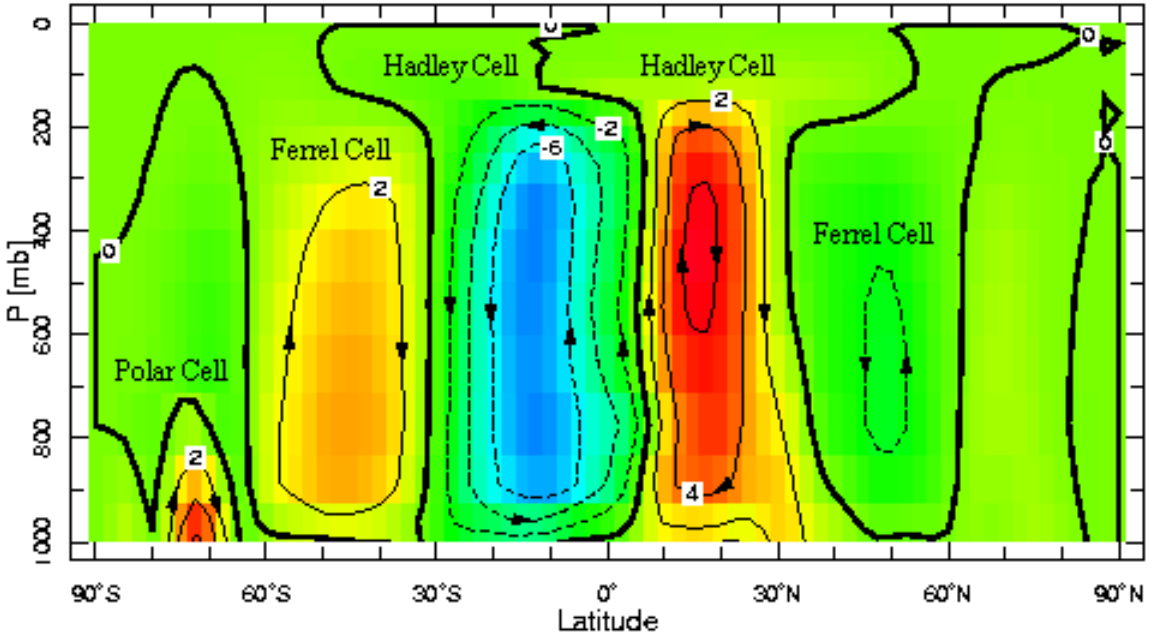


Figure 00.1: A view of Earth from space over the North Pole. The Arctic ice cap can be seen in the center. The white swirls are clouds associated with atmospheric weather patterns. Courtesy of NASA/JPL.

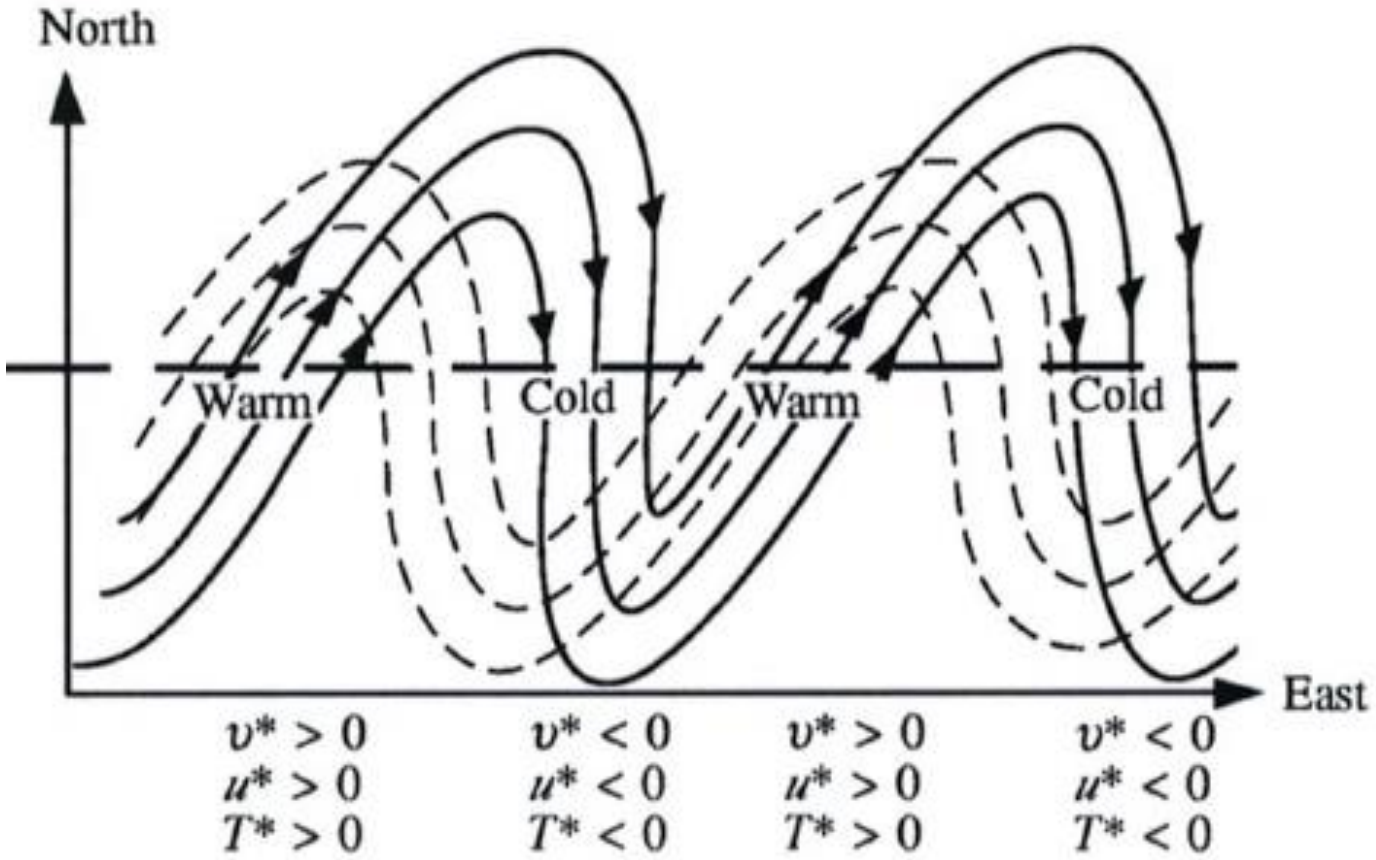

NCEP/NCAR Reanalysis
Individual Storm Tracks
Dec 1, 1981 – Feb 28, 1982
MIN/MAX PRESSURE (mb)
933.9 1064.8
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
A PRESSURE LOW IS MINIMAL WITHIN A RADIUS OF 1440 KM,
AT MOST 1040 MB, LOCATED BETWEEN +84 AND −84 DEGREES LATITUDE.
SEA LEVEL PRESSURES ARE SAMPLED EVER 12 HOURS
STORMS ARE ASSUMED TO
LAST FOR AT LEAS
ROTATE


NCEP/NCAR
Reanalysis
Storm Tracks
Dec 1, 1981 – Feb 28, 1982
Frequency of Storms
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
(%)
0
1
2
3
4
5
A PRESSURE LOW IS MINIMAL WITHIN A RADIUS OF 1440 KM,
AT MOST 1040 MB, LOCATED BETWEEN +84 AND −84 DEGREES LATITUDE.
SEA LEVEL PRESSURES ARE SAMPLED EVERY 12 HOURS
STORMS ARE ASSUMED TO MOVE AT < 120 KM/HR
LAST FOR AT LEAST 36 HRS (3 SEGMENTS)
ROTATE BY AT MOST 65 DEGREES

The Zonally Averaged vertical-meridional Circulation



The annually-averaged atmospheric circulation in the latitude pressure plane (the meridional plan). The arrows depict the direction of air movement in the meridional plane. The contour interval is 2x10 10 Kg/sec - this is the amount of mass that is circulating between every two contours. The total amount of mass circulating around each "cell" is given by the largest value in that cell. Data based on the NCEP-NCAR reanalysis project 1958-1998.


North
Warm
Cold
Warm
Cold
East
$v^* > 0$
$u^* > 0$
$T^* > 0$
$v^* < 0$
$u^* < 0$
$T^* < 0$
$v^* > 0$
$u^* > 0$
$T^* > 0$
$v^* < 0$
$u^* < 0$
$T^* < 0$

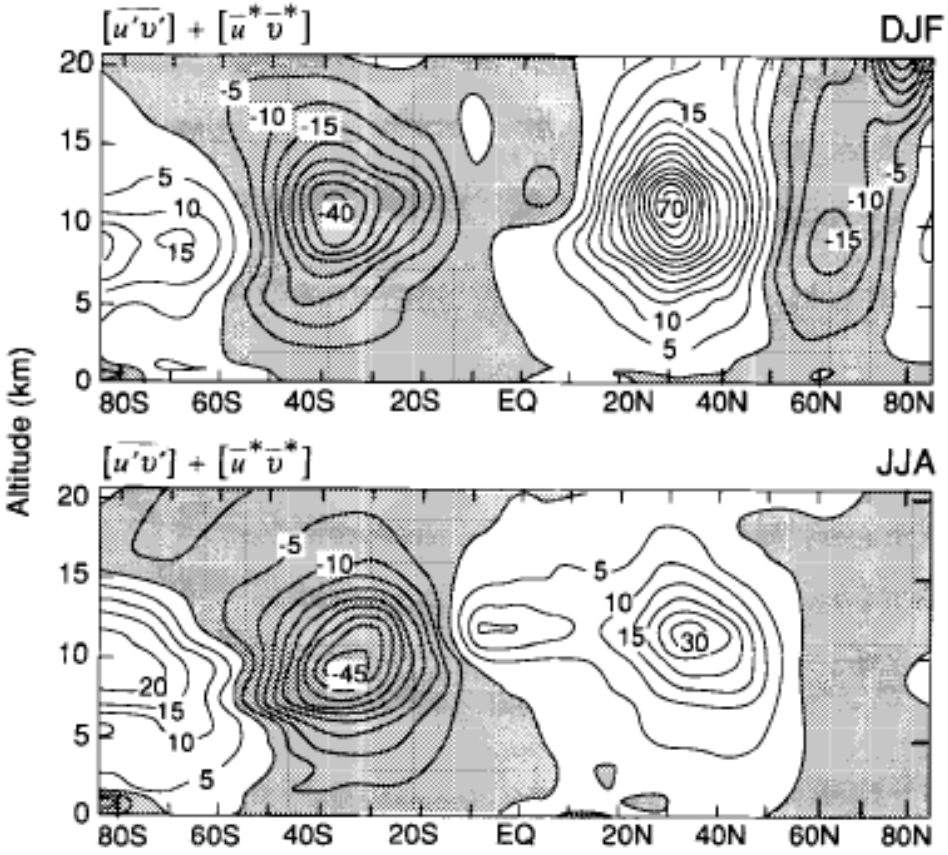


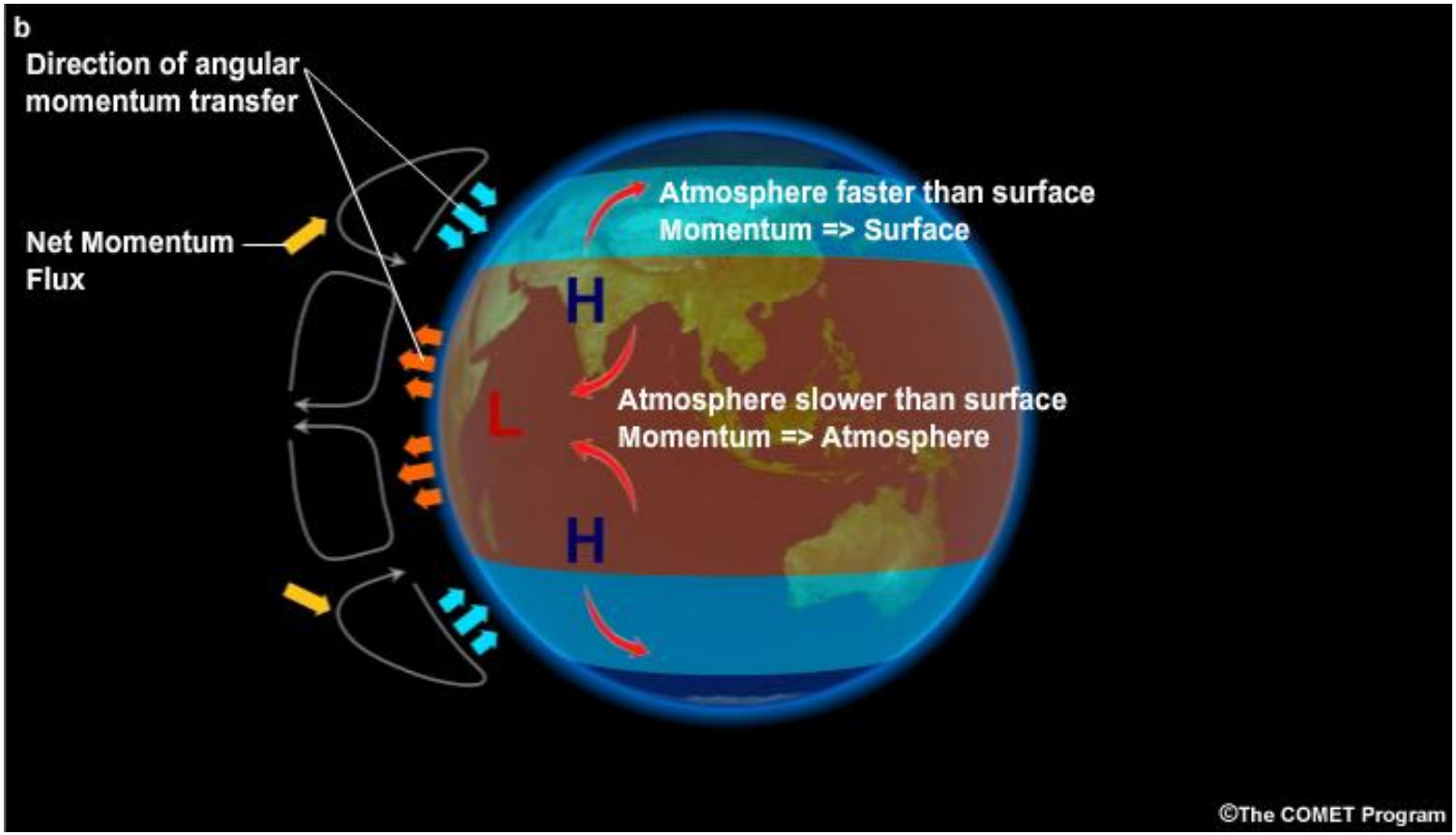
Fig. 6.15 Zonal cross sections of the northward flux of zonal velocity by eddies. Contour interval is 5 $m^2 s^{-2}$. [Data from Oort (1983).]

מאזן תנע זויתי: ראינו שיש שטף צפונה בתא הדלי.

יש גם שטף צפונה בסופות הברוקליניות

←רוחות מערביות בקרקע בקווי הרוחב הממוזגים. מתחייב גם משימור תנע גלובלי.

מאזן עם חיכוך בקרקע מוביל לרכיב צפונה של הרוח ← תא פרל



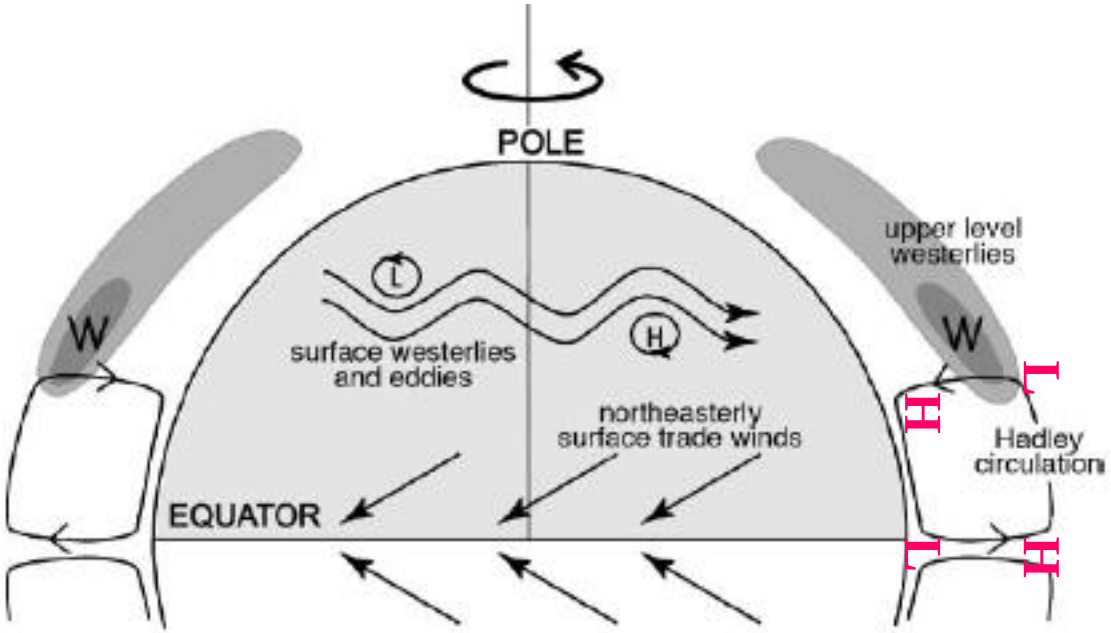


FIGURE 8.2. Schematic of the observed atmospheric general circulation for annual-averaged conditions. The upper level westerlies are shaded to reveal the core of the subtropical jet stream on the poleward flank of the Hadley circulation. The surface westerlies and surface trade winds are also marked, as are the highs and lows of middle latitudes. Only the northern hemisphere is shown. The vertical scale is greatly exaggerated.

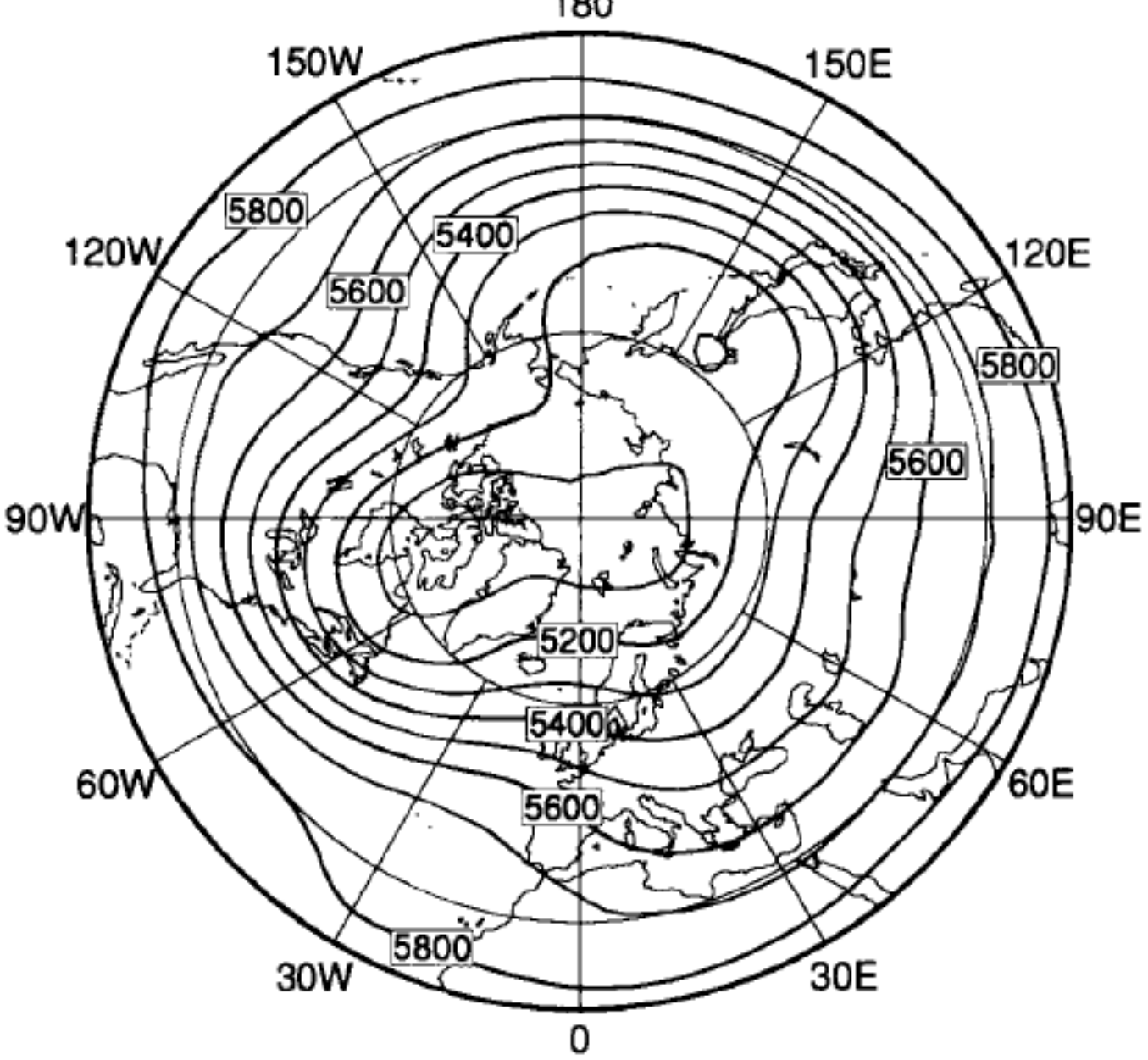
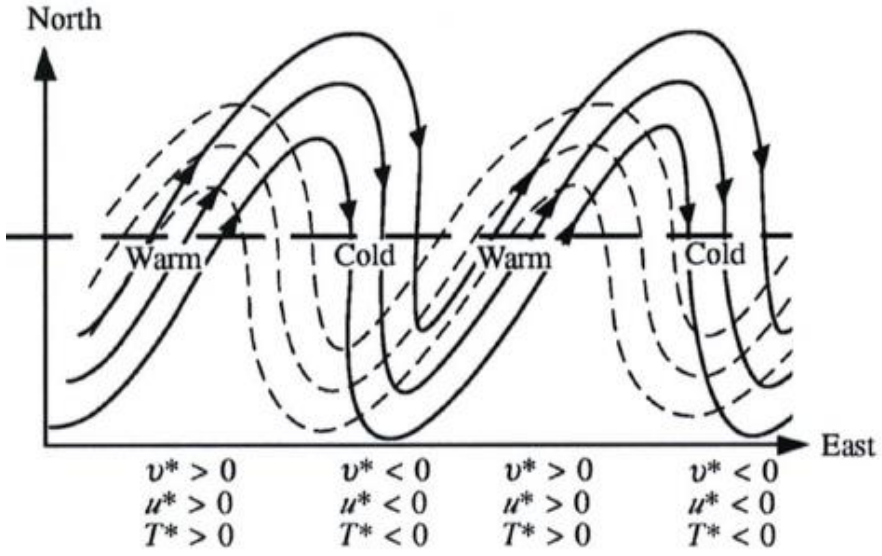


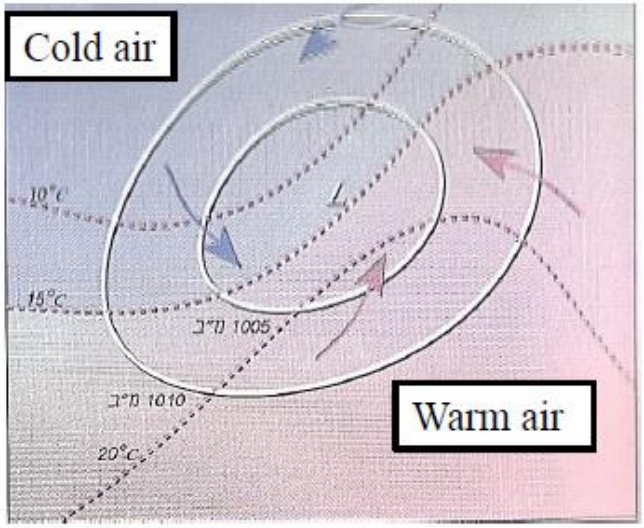
Fig. 6.7 Average height of the 500-mb pressure surface during January in the Northern Hemisphere. Contour interval is 100 m.

The total northward heat flux

$$[\overline{vT}] = [\bar{v}][\bar{T}] + [\bar{v}^*\bar{T}^*] + [\overline{v'T'}]$$

total | mean meridional circulation | stationary eddies | transient eddies





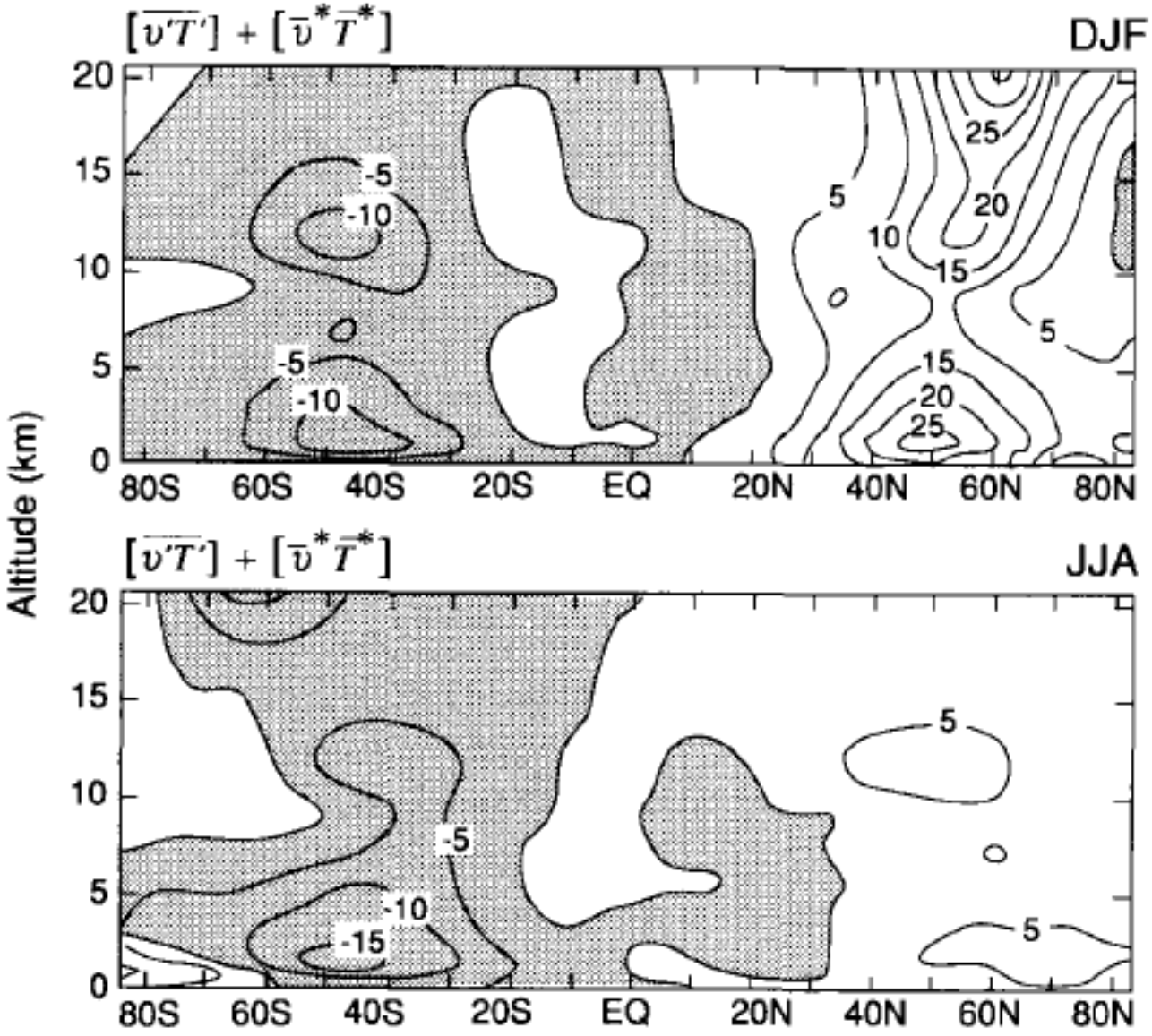


Fig. 6.8 Meridional cross section of the zonally averaged northward flux of temperature by eddies. Note that in the Southern Hemisphere the poleward fluxes are negative as a result of our arbitrarily defining north as the positive direction. Contour interval is 5 K m s^{-1}. [Data from Oort (1983).]

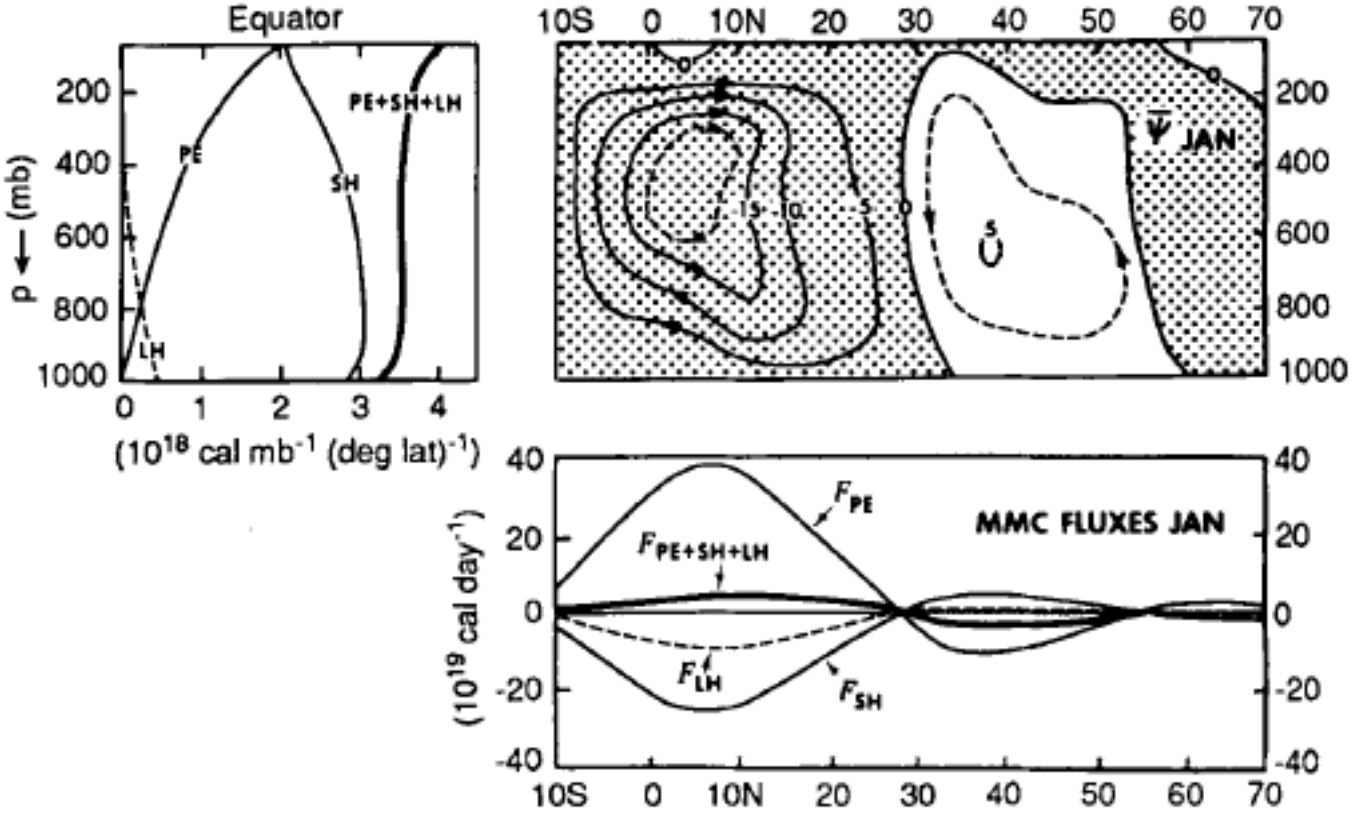


Fig. 6.10 Diagrams explaining the transport of energy by the mean meridional circulation using the month of January. The vertical distribution of potential energy (PE), sensible heat (SH), latent heat (LH), and total moist static energy (PE + SH + LH) near the equator (upper left). The mean meridional mass streamfunction for January contoured in pressure–latitude cross section (upper right). The northward fluxes of various energy types by the mean meridional circulation (lower right). [From Oort (1971). Reprinted with permission from the American Meteorological Society.]

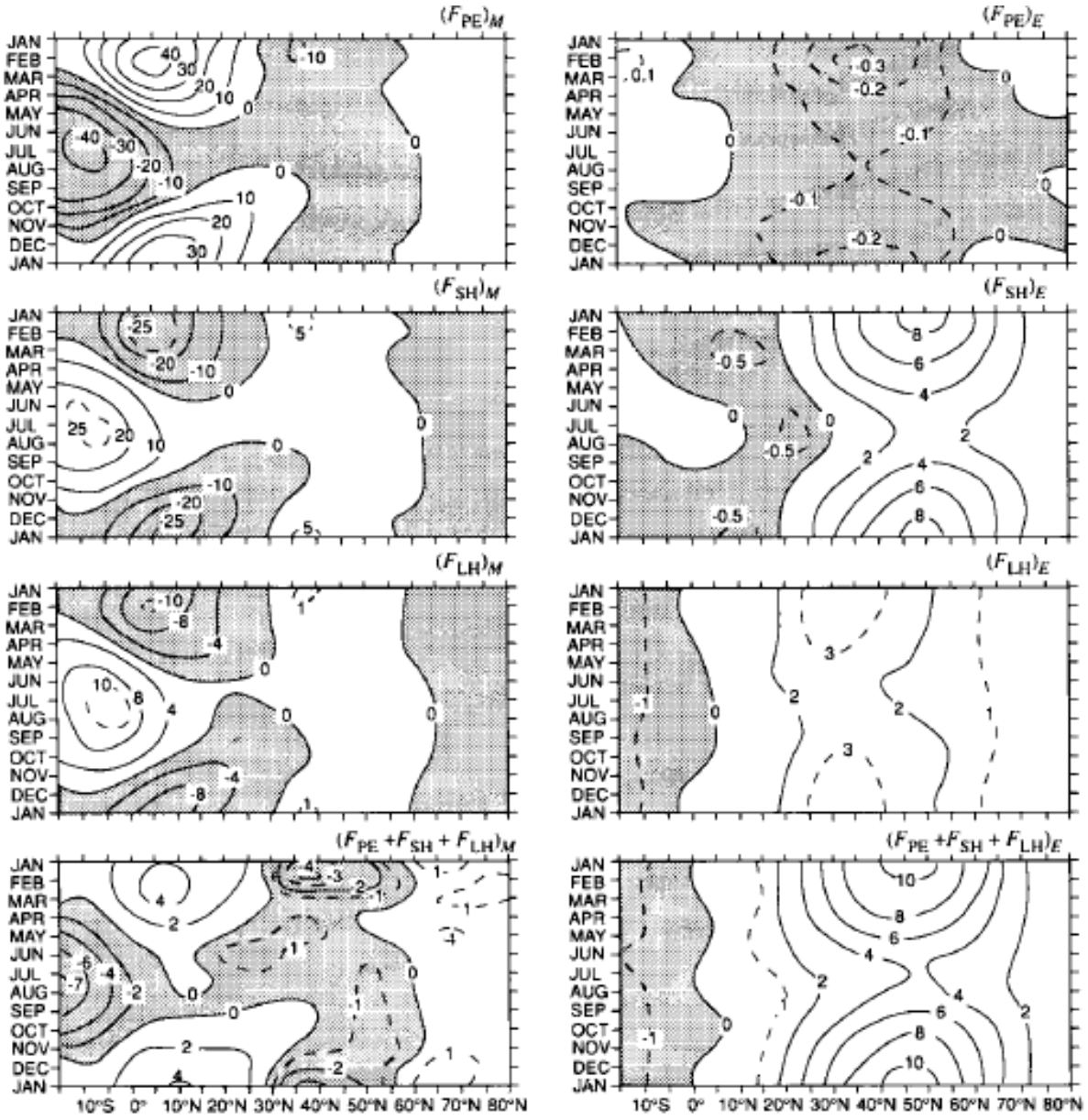


Fig. 6.9 Northward fluxes of potential energy (F_{PE}), sensible heat (F_{SH}), latent heat (F_{LH}), and total energy by the atmosphere as functions of latitude and season. Panels on the left show fluxes by the mean meridional circulation and those on the right by eddy circulations. Units are 10^{19} calories per day and southward fluxes are shaded. [From Oort (1971). Reprinted with permission from the American Meteorological Society.]

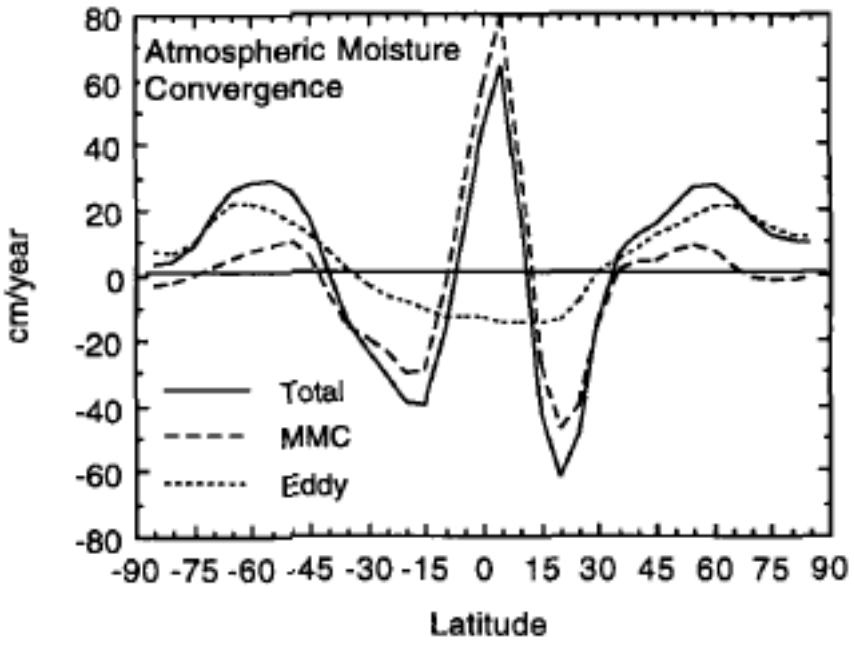


Fig. 6.12 Convergence of the meridional flux of water vapor in the atmosphere in cm year^{-1}. [Data from Peixóto and Oort (1984). Reprinted with permission from the American Physical Society.]

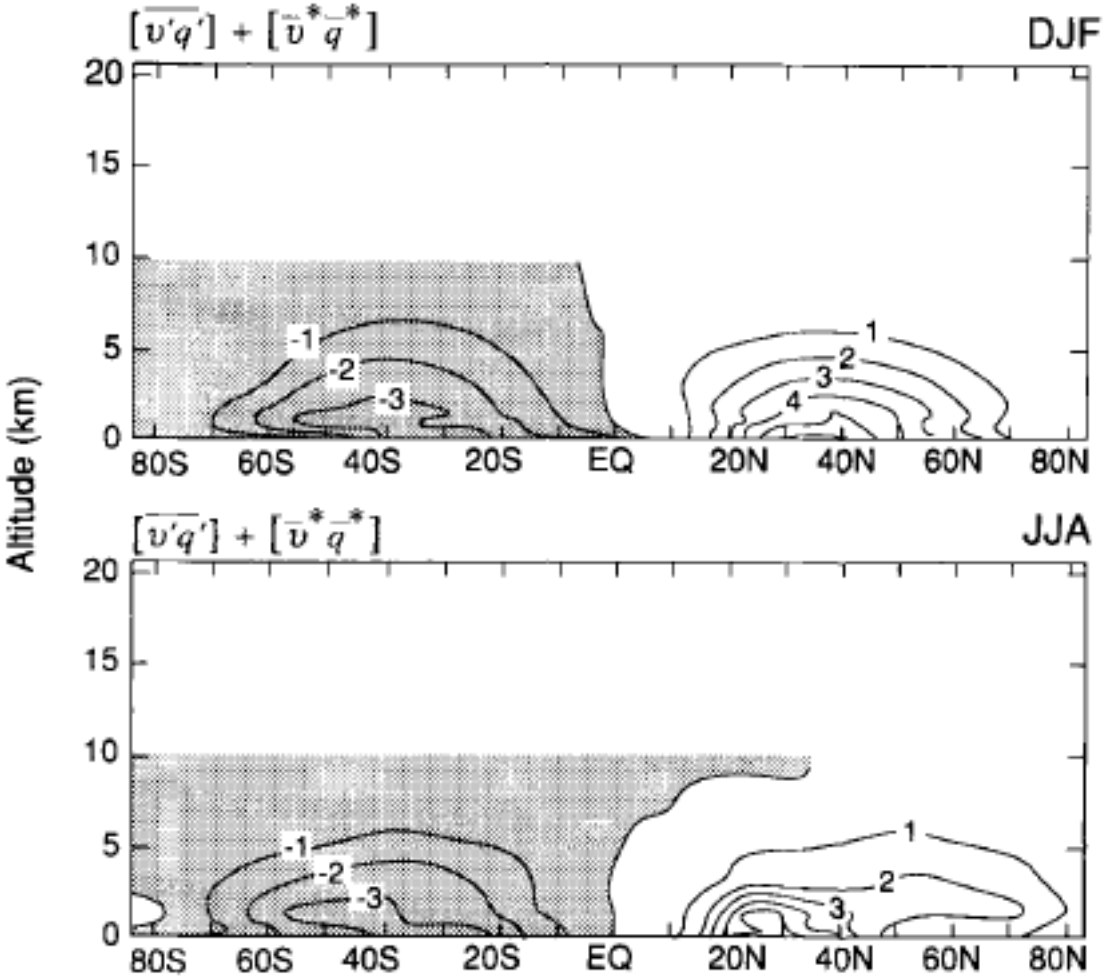


Fig. 6.13 Zonal cross section of the zonally averaged northward flux of specific humidity by eddies. Contour interval is 1 m s^{-1} g kg^{-1}. [Data from Oort (1983).]

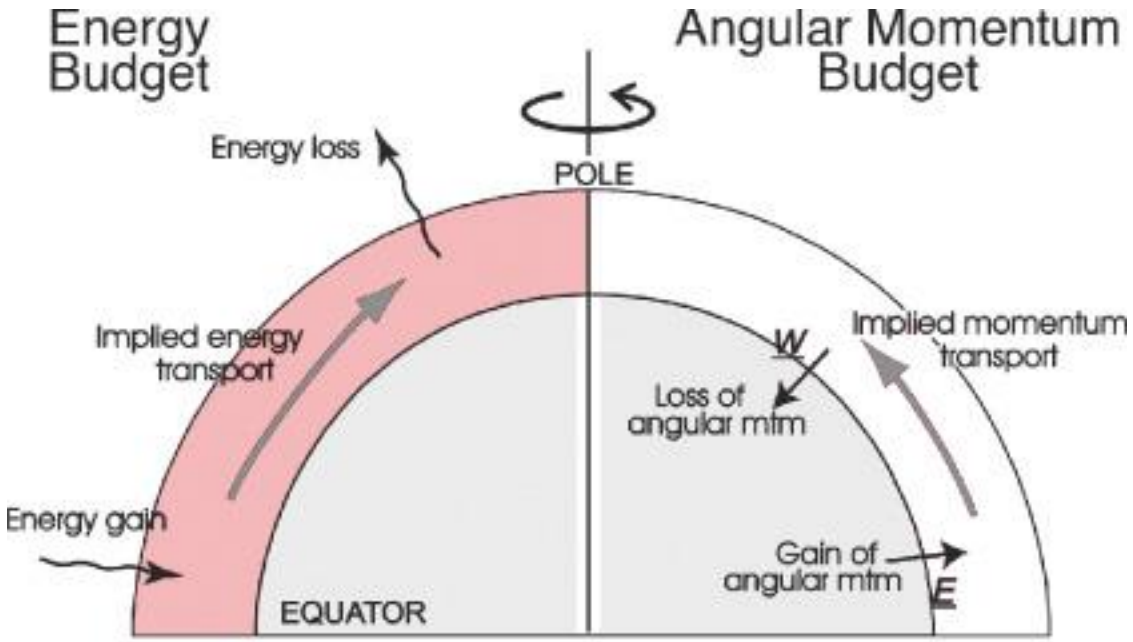
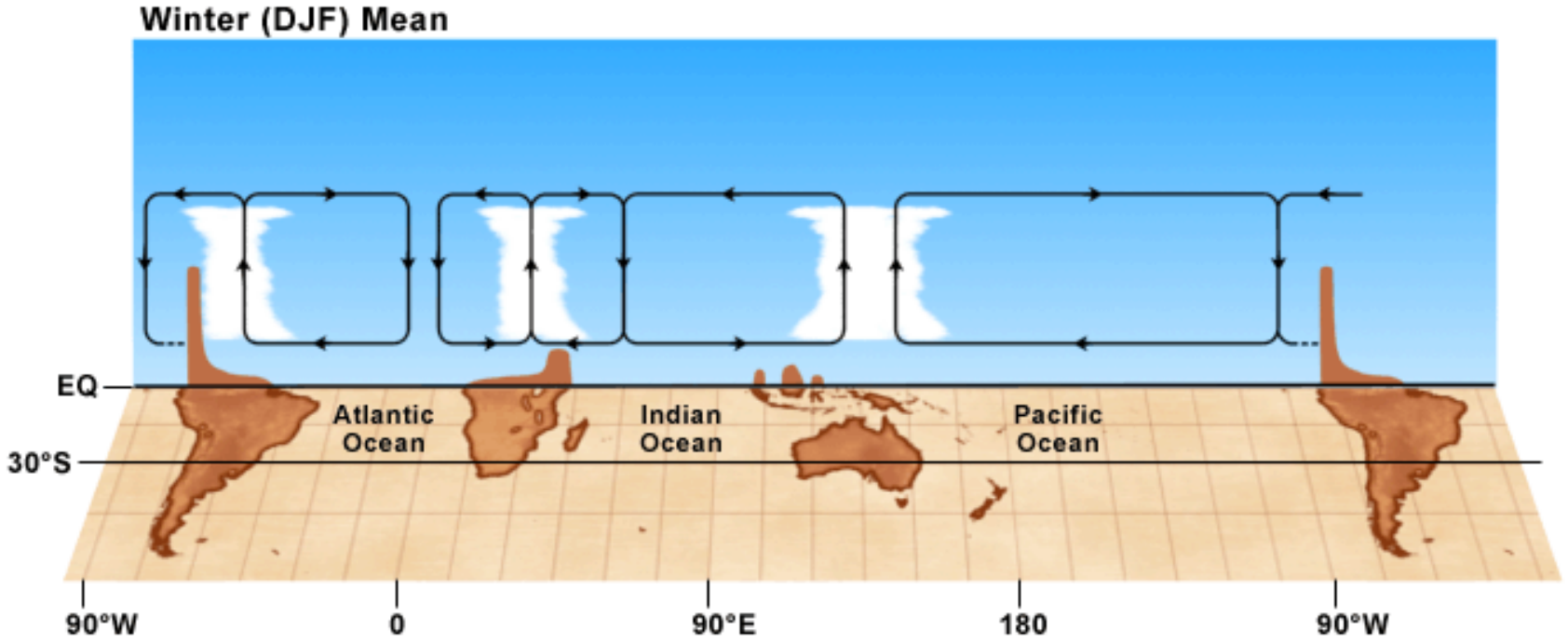
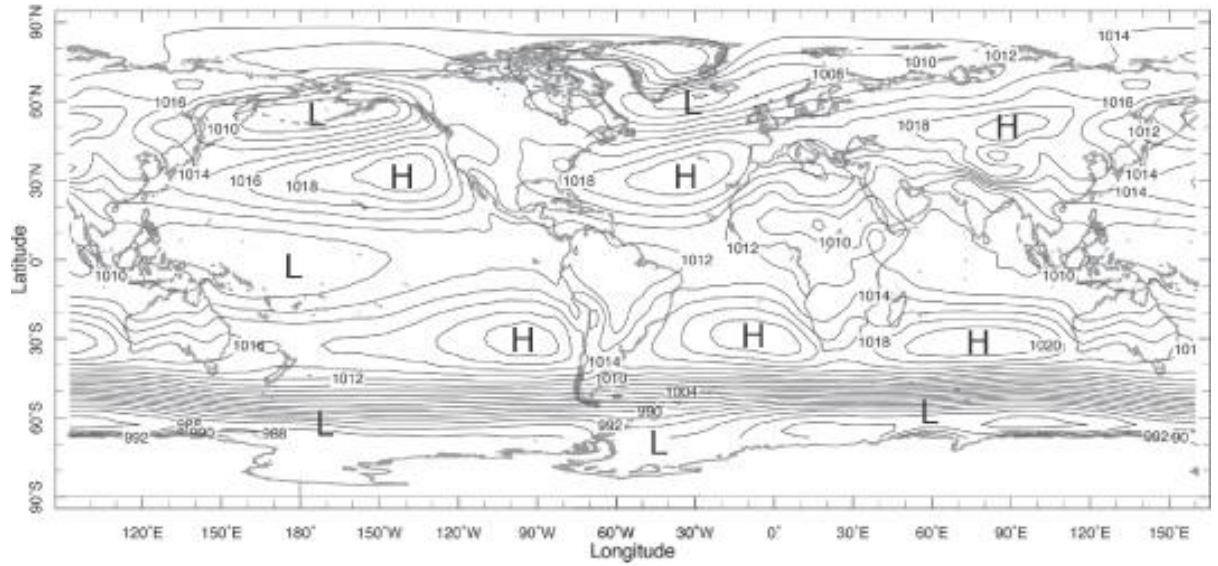


Figure 8.1: Latitudinal transport of (left) energy and (right) angular momentum (mtm) implied by the observed state of the atmosphere. In the energy budget there is a net radiative gain in the tropics and a net loss at high latitudes; to balance the energy budget at each latitude, a poleward energy flux is implied. In the angular momentum budget the atmosphere gains angular momentum in low latitudes (where the surface winds are easterly) and loses it in middle latitudes (where the surface winds are westerly). A poleward atmospheric flux of angular momentum is thus implied.

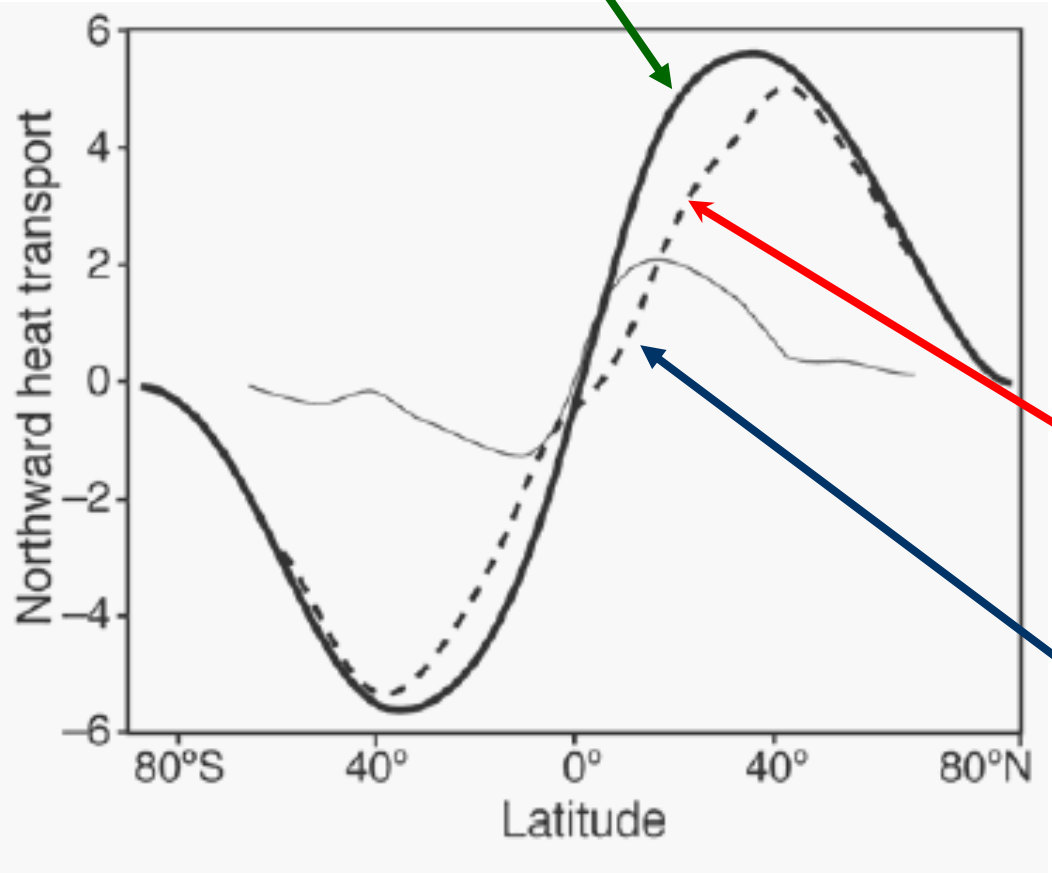
Global Walker Circulation



Atmospheric Surface Pressure (mb)



Total heat transport



Atmospheric heat transport

Ocean heat transport