Goals for today:

21 Oct., 2011

- Introduce concept of “thickness” – a surrogate for mean temperature of the lower half of the troposphere

- begin Part III, Distribution and Movement of Air

Ch. 8 “Atmospheric Circulation and Pressure Distributions”

- climatological paradigms for circulation on the global scale

- observed climatology of dominating surface pressure centres

Midterm exam next Friday. Value 20%. 30 multichoice questions. Covers to p236 of textbook (i.e. to end of today's lecture)

"Thickness"

- the interval in height between two constant pressure surfaces, usually expressed in [dam]

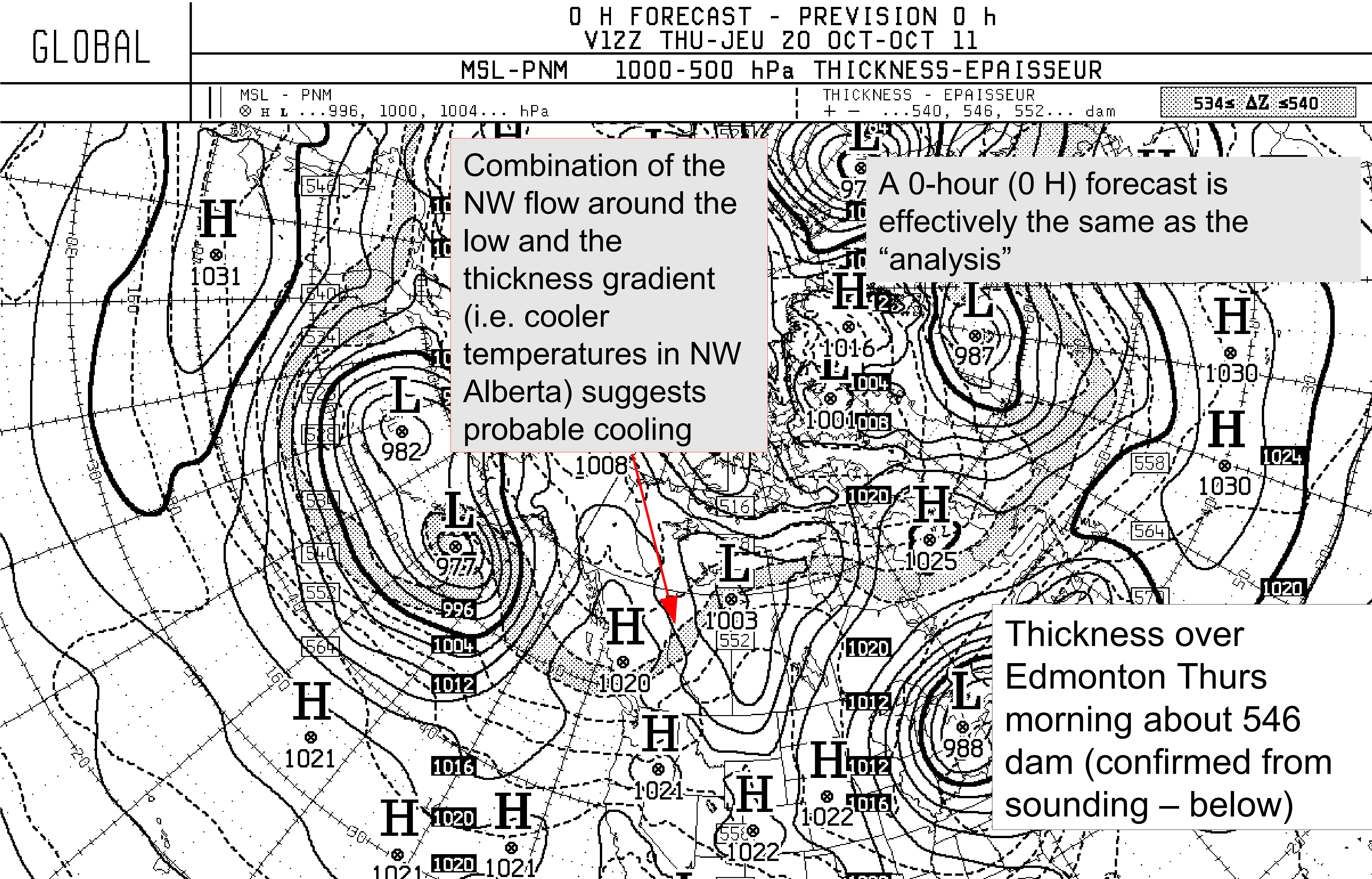
- thickness of any given layer is proportional to the height-averaged temperature of that layer

- the height interval between that height where p=1000 hPa and that height where p = 500 hPa is called the (1000 mb - 500 mb) thickness,

- an **increase** (**decrease**) in $\Delta Z_{500-1000}$ of **2 dam**

  corresponds to **warming** (**cooling**) by **1° C**

- contours of $\Delta Z_{500-1000}$ are plotted on several MSC charts

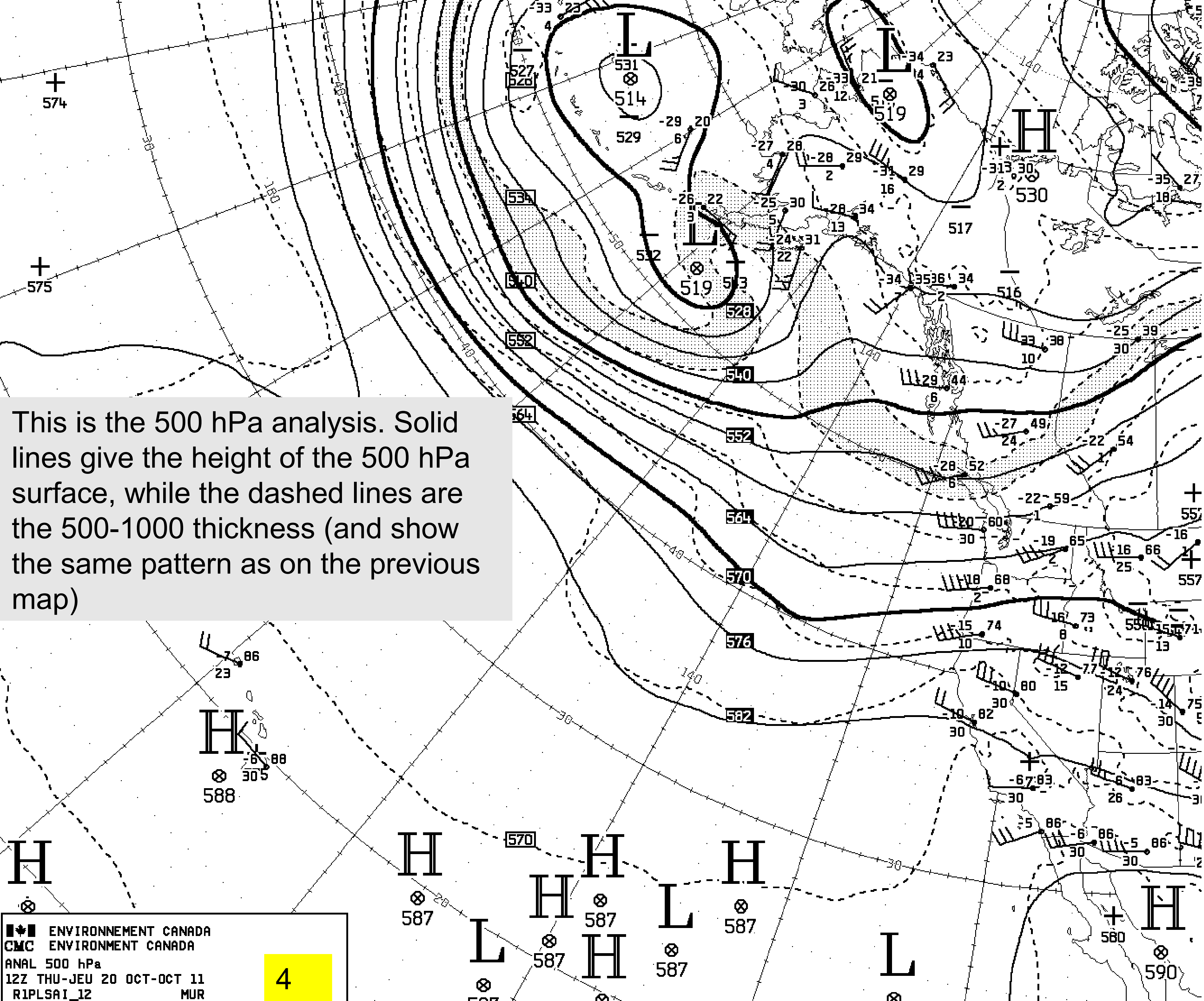


Combination of the NW flow around the low and the thickness gradient (i.e. cooler temperatures in NW Alberta) suggests probable cooling

A 0-hour (0 H) forecast is effectively the same as the “analysis”

Thickness over Edmonton Thurs morning about 546 dam (confirmed from sounding – below)

The stippled band is the thickness range 534 – 540 dam. It is considered that *if* there were to be precipitation in that region, it could be a freezing rain. As the thickness calculation depends *only* on temperature, this band cannot and does not designate a region of probable freezing rain.

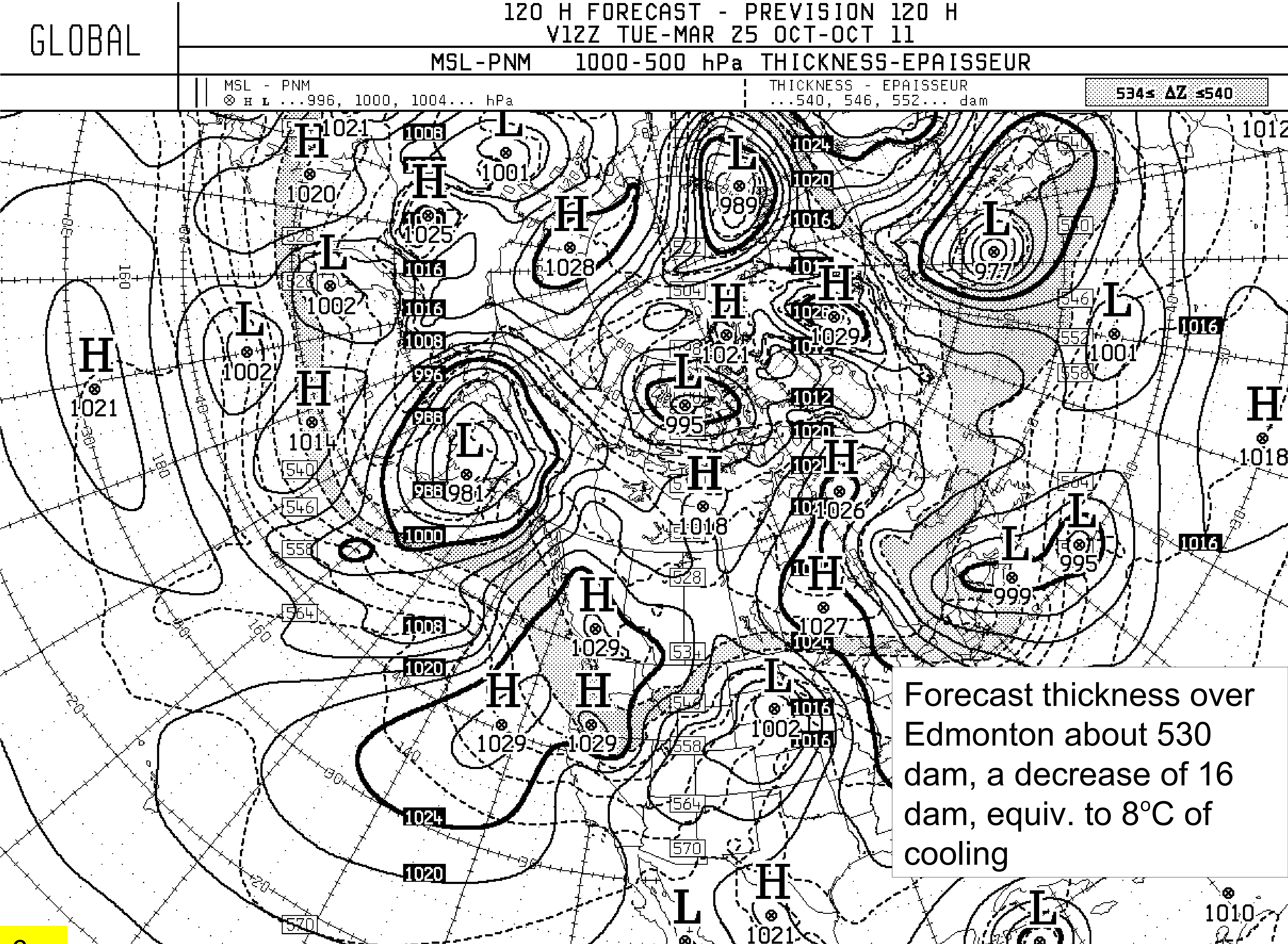


This is the 500 hPa analysis. Solid lines give the height of the 500 hPa surface, while the dashed lines are the 500-1000 thickness (and show the same pattern as on the previous map)

71119 WSE Edmonton Stony Plain Observations at 12Z 20 Oct 2011

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	74									
925.0	727									
921.0	766	7.2	2.3	71	4.93	280	7	287.0	301.2	287.9
904.4	914	6.4	0.7	67	4.47	315	21	287.7	300.7	288.5
871.2	1219	4.8	-2.6	59	3.63	325	24	289.1	299.8	289.7
860.0	1324	4.2	-3.8	56	3.37	328	28	289.6	299.6	290.1
850.0	1419	4.8	-7.2	41	2.63	330	32	291.2	299.1	291.6
848.0	1438	4.8	-9.2	36	2.26	330	32	291.4	298.3	291.8
839.1	1524	4.2	-9.8	35	2.18	330	33	291.6	298.3	292.0
830.0	1613	3.6	-10.4	35	2.10	329	28	291.9	298.4	292.2
822.0	1691	3.0	-4.0	60	3.47	327	24	292.1	302.5	292.7
808.1	1829	1.8	-3.2	69	3.75					
799.0	1920	1.0	-2.7	76	3.94					
785.0	2062	0.4	-2.0	84	4.23					
777.9	2134	0.0	-2.2	85	4.19	310	23	293.5	306.0	294.2
748.7	2438	-1.7	-3.2	89	4.04	290	22	294.8	307.0	295.6
720.5	2743	-3.4	-4.2	94	3.89	270	20	296.2	308.0	296.9
700.0	2973	-4.7	-5.0	98	3.78	275	21	297.2	308.8	297.9
693.4	3048	-5.1	-5.4	98	3.71	270	32	297.6	308.9	298.2
688.0	3109	-5.5	-5.7	98	3.65	266	30	297.8	309.0	298.5
666.8	3353	-6.9	-7.2	98	3.35	250	22	298.9	309.3	299.5
641.2	3658	-8.7	-9.1	97	3.01	265	18	300.3	309.6	300.8
627.0	3832	-9.7	-10.2	96	2.82	265	22	301.0	309.9	301.6
607.0	4082	-11.3	-11.4	99	2.65	265	28	302.0	310.4	302.5
592.4	4267	-12.6	-13.4	94	2.31	265	33	302.6	310.0	303.0
569.2	4572	-14.8	-16.6	86	1.84	275	31	303.5	309.5	303.8
568.0	4588	-14.9	-16.8	85	1.82	273	31	303.6	309.5	303.9
546.4	4877	-16.9	-18.5	87	1.63	245	28	304.5	309.9	304.8
500.0	5540	-21.5	-22.5	92	1.26	230	29	306.8	311.0	307.0

$$\Delta Z_{500-1000} = 5540 - 74 = 547 \text{ dam}$$



Forecast thickness over Edmonton about 530 dam, a decrease of 16 dam, equiv. to 8°C of cooling

We spoke earlier of the vast and continuous range of scales of motion in the atmosphere… “The largest-scale patterns, called the general circulation, can be considered the background against which unusual events occur” (p 227). Paradigms for the general circulation:

Hadley’s (1735) Single-cell Model

• ocean-covered planet

• sub-solar point perpetually over equator – so equatorial heating produces lift, and symmetric poleward motion aloft, with sink at poles

• return equator-ward motion at surface

• reasoned earth’s rotation must deflect the wind to right (left) in north (south) hemisphere – “zonal” wind component resulting from deflection of “meridional”

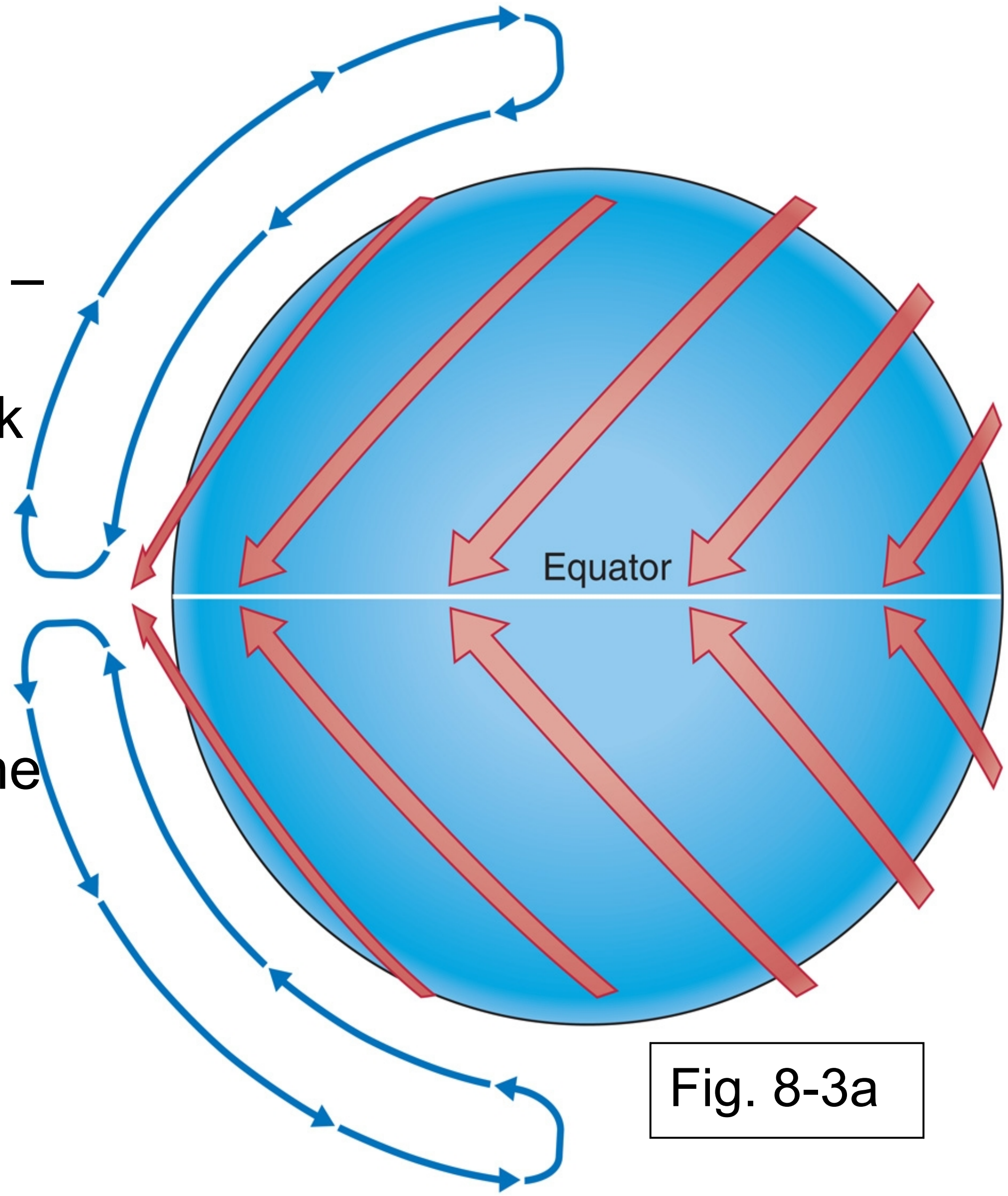


Fig. 8-3a

Single-cell Model** is

• consistent with the observed (and important) surface equatorial “trade winds”, “the most persistent on earth”

• but polar surface easterlies emerge only as a long term average, not as a prevailing feature

Air aloft “diverges” out of the air column, air at surface “converges” into column; low pressure at the surface

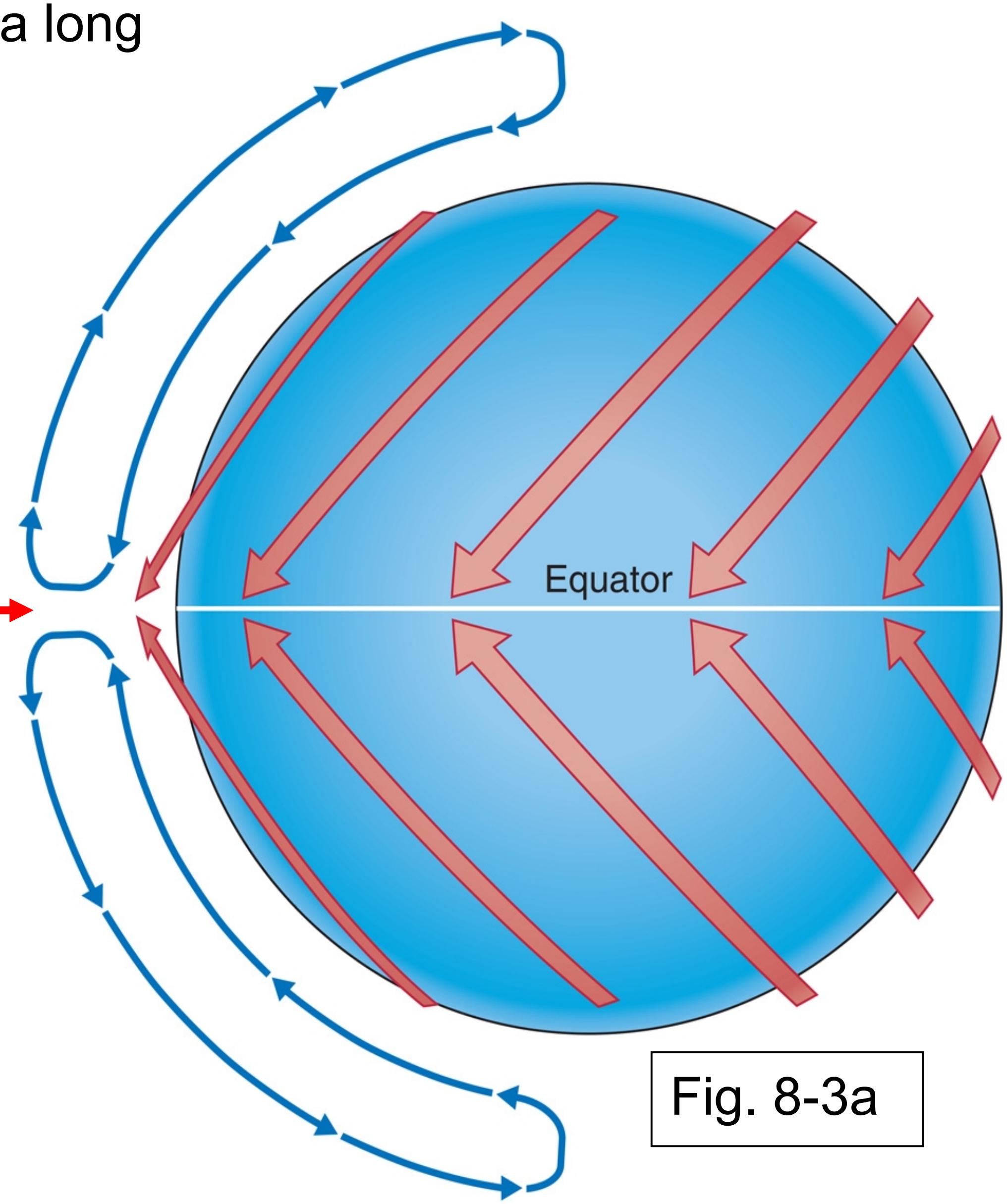


Fig. 8-3a

** Hadley is honoured by a “Hadley Centre for Climate Prediction & Research” in UK

Ferrel's (1865) Three-cell Model

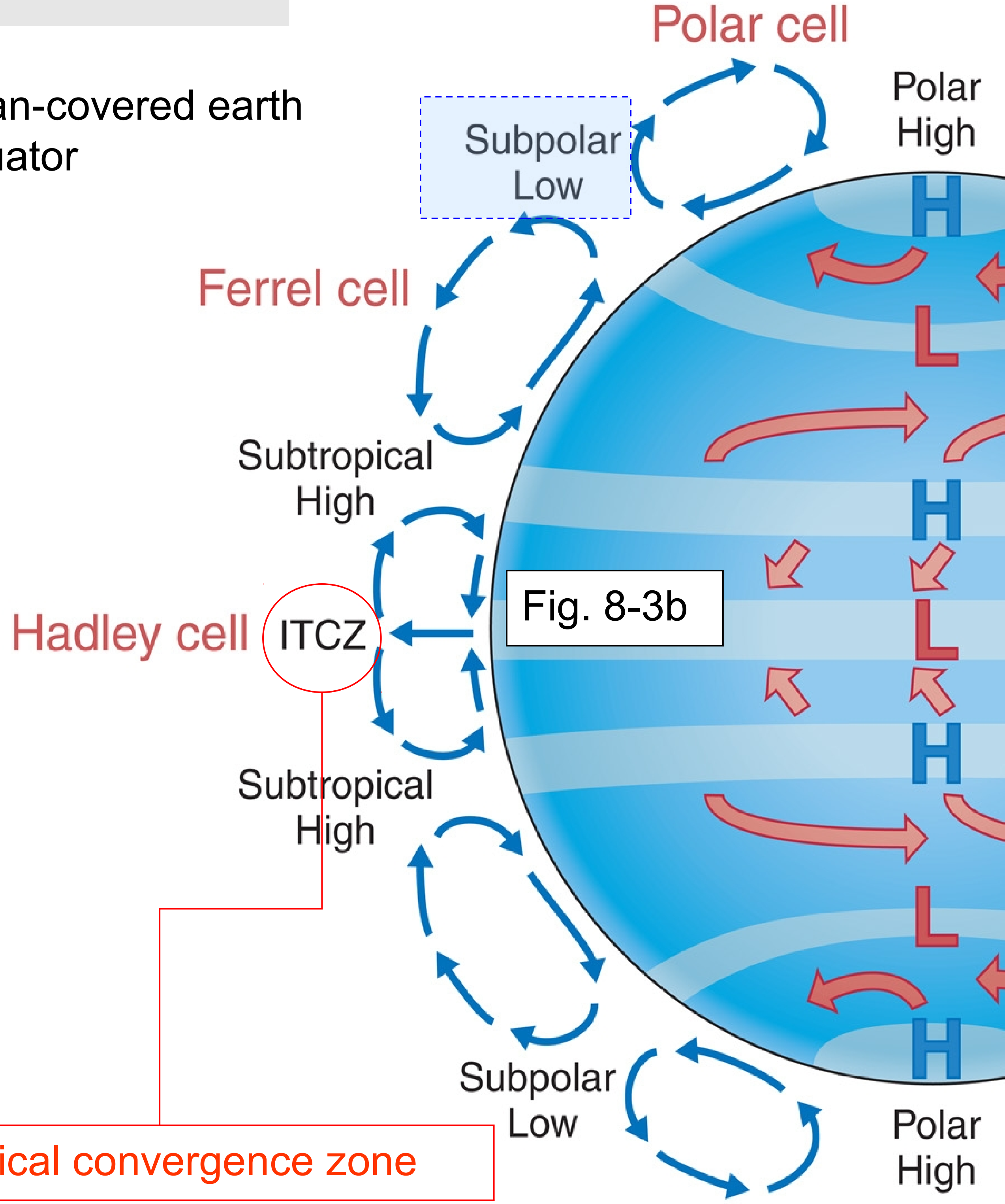
System still conceived as an ocean-covered earth with the subsolar point on the equator

- the low lat. "Hadley cell" thermally driven by powerful ITCZ convection

- the mid lat. Ferrel cell is "indirect" (forced by the other two)

- the high lat. Polar cell is thermally driven by sink at the poles, *but*, we do not get vigorous overturning (stable stratific'n)

- "Three-cell model is so general that only fragments of it actually appear in the real world"



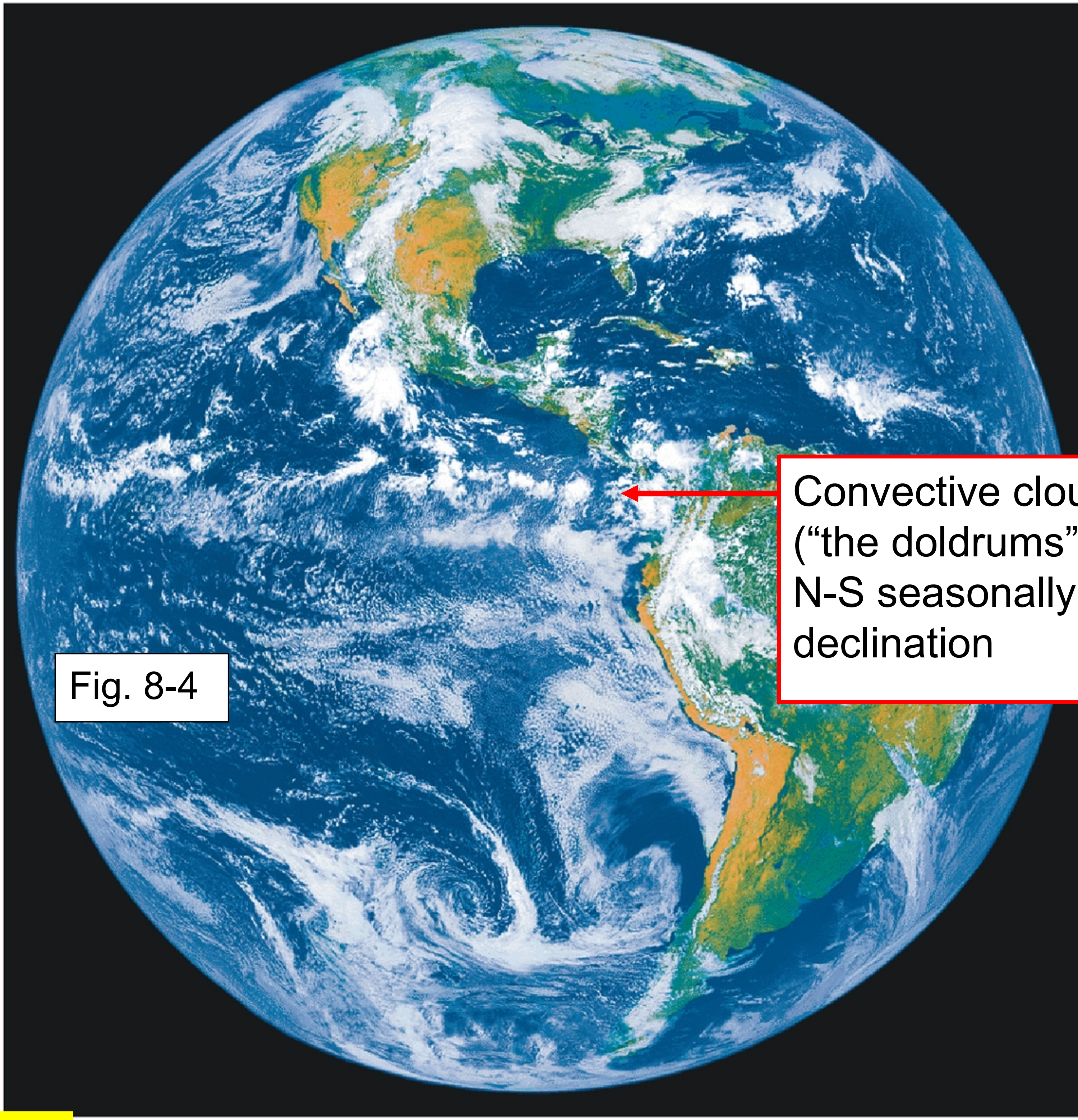
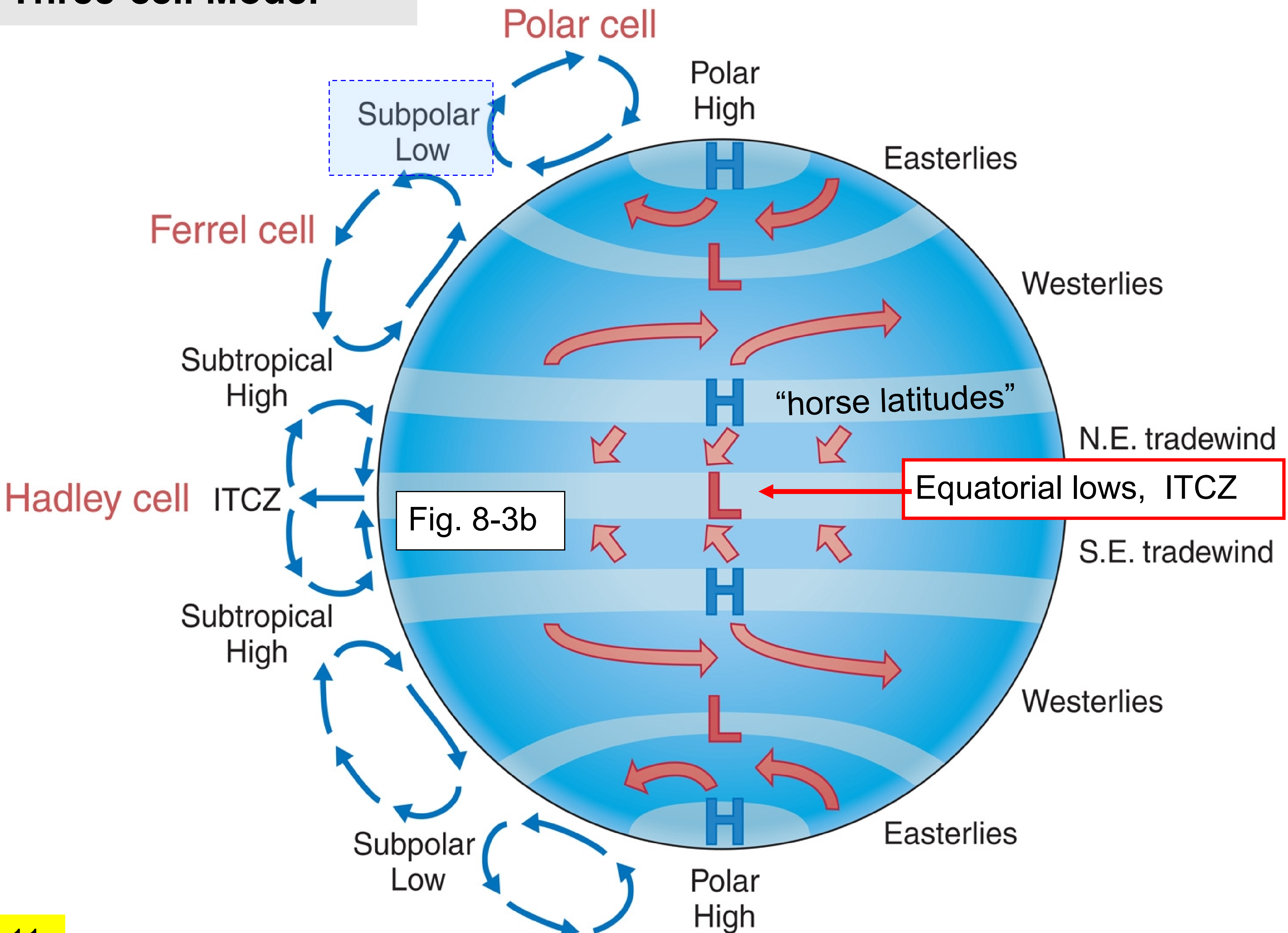

Convective cloud in the ITCZ (“the doldrums”). The ITCZ migrates N-S seasonally with changing solar declination

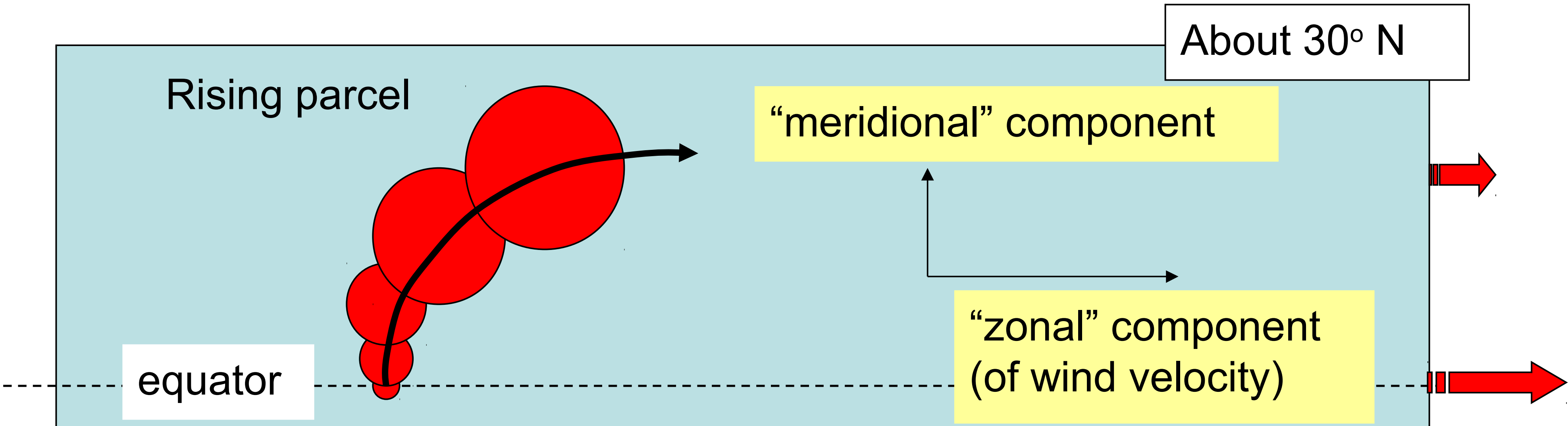
Fig. 8-4

Three-cell Model



Three-cell model – winds aloft in the Hadley cell

Air rising at equator feeds into poleward upper streams, which are deflected by the Coriolis force (to right in N. hemisphere) to produce a zonal component of motion… result: westerly upper currents in both hemispheres



Arrows denote rate of movement of the ground surface towards the east… angular mtm of a stationary parcel is largest at the equator

Alternative view (Sec. 8-1): each parcel with fixed mass *m* tends to conserve its “angular momentum” *m v r* . Constancy of *m v r* demands an increase of the <u>zonal</u> component (*v*) of the parcel's velocity as it moves north, where the circumference of a latitude line about the earth ($2 \pi r$) is shorter. (Friction intervenes so conservation not quite perfect.)

Three-cell model

This poleward moving upper current cools, and around 20-30° latitude (ie. in the "horse latitudes") it sinks, with consequent adiabatic warming mitigating against cloud at that latitude – here the subtropical highs occur (fair weather, light winds), and broadly coincide with continental deserts

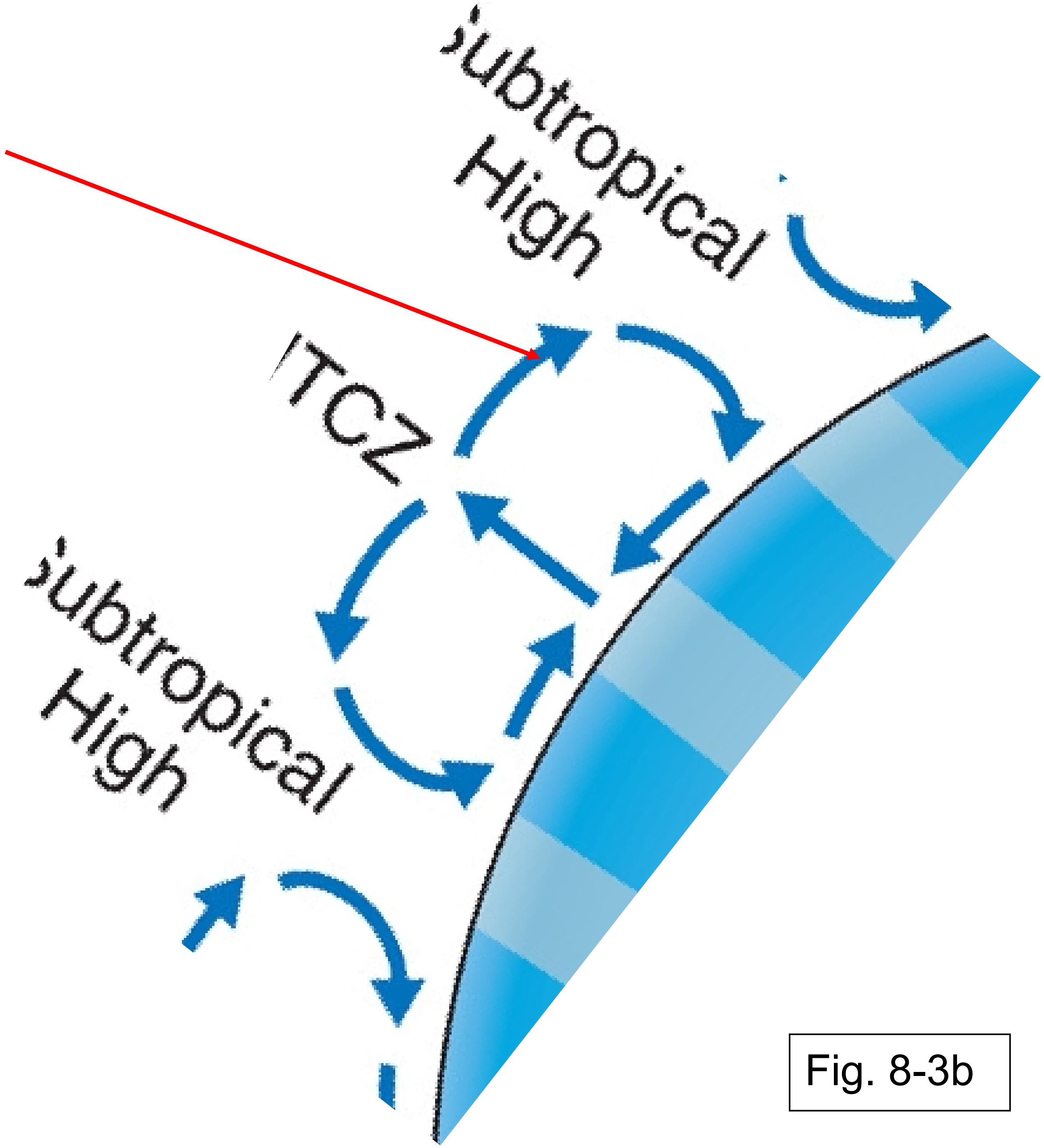


Fig. 8-3b

Three-cell model

Surface convergence and ascent, in the zone of the polar lows (mid-latitudes)

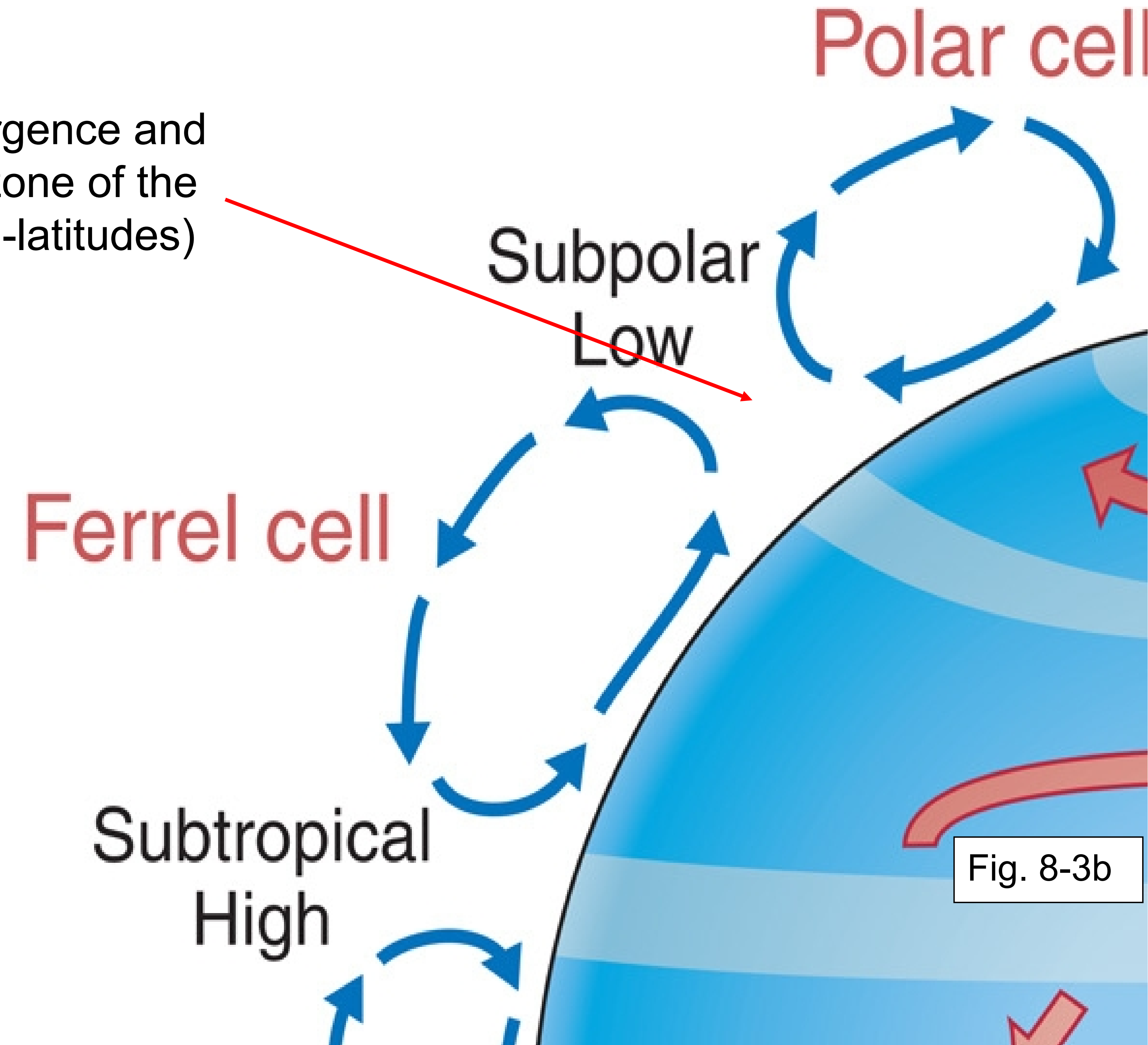


Fig. 8-3b

Three-cell model

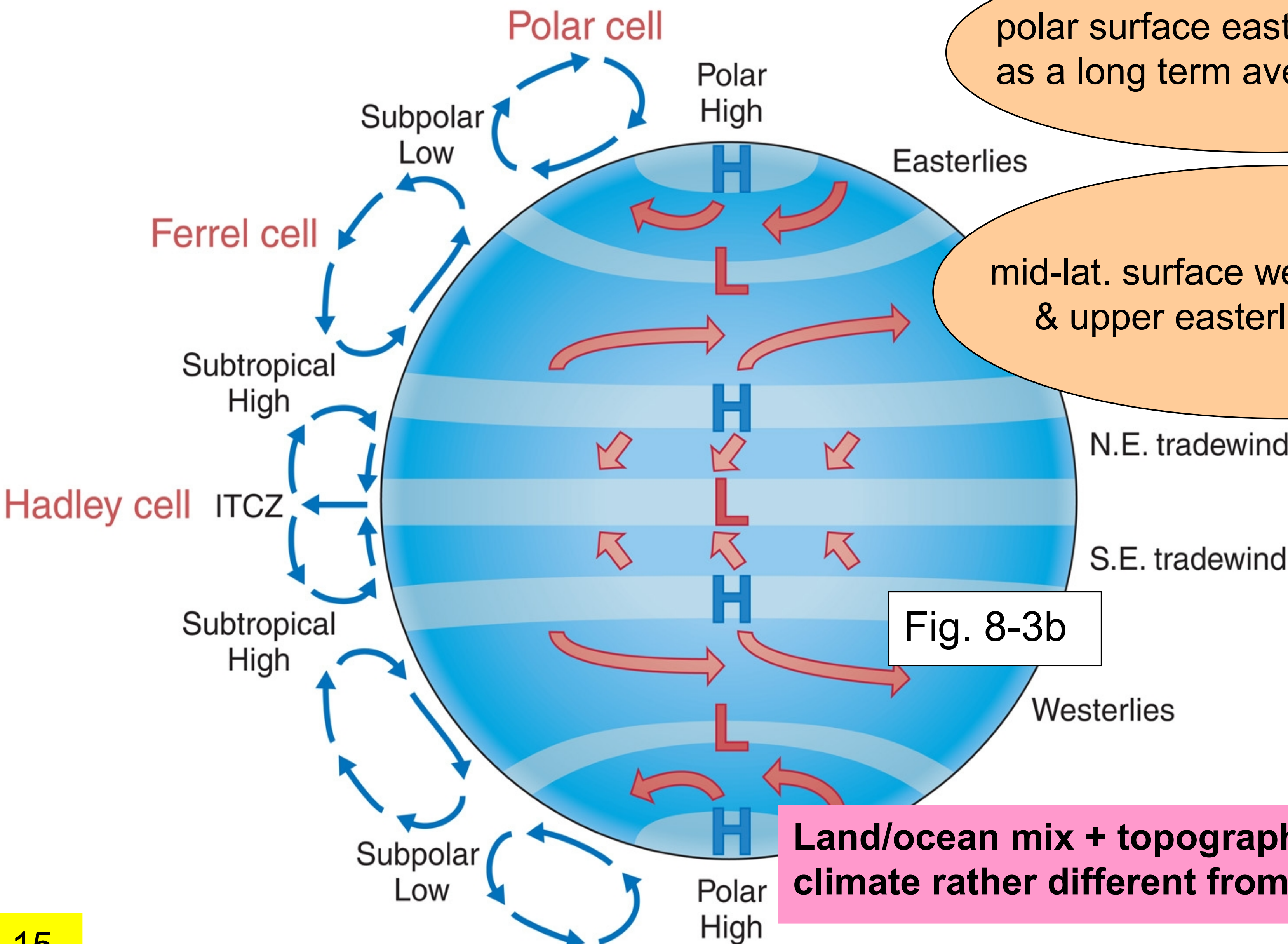


Fig. 8-3b

polar surface easterlies do emerge as a long term average

mid-lat. surface westerlies (realistic) & upper easterlies (unrealistic)

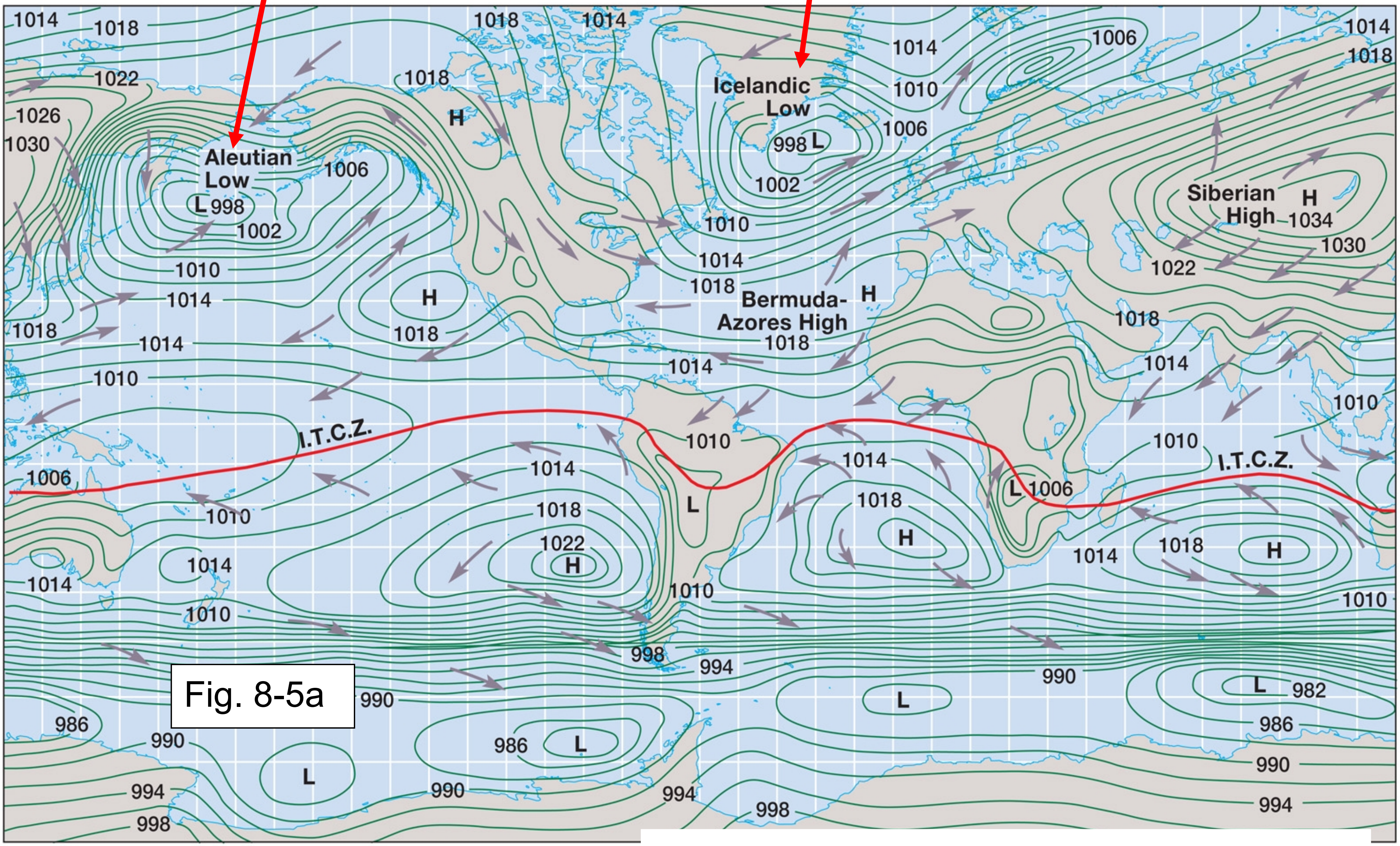
realistic

Land/ocean mix + topography make true climate rather different from 3-cell model

What's observed: semipermanent surface pressure cells & winds

Gone in summer

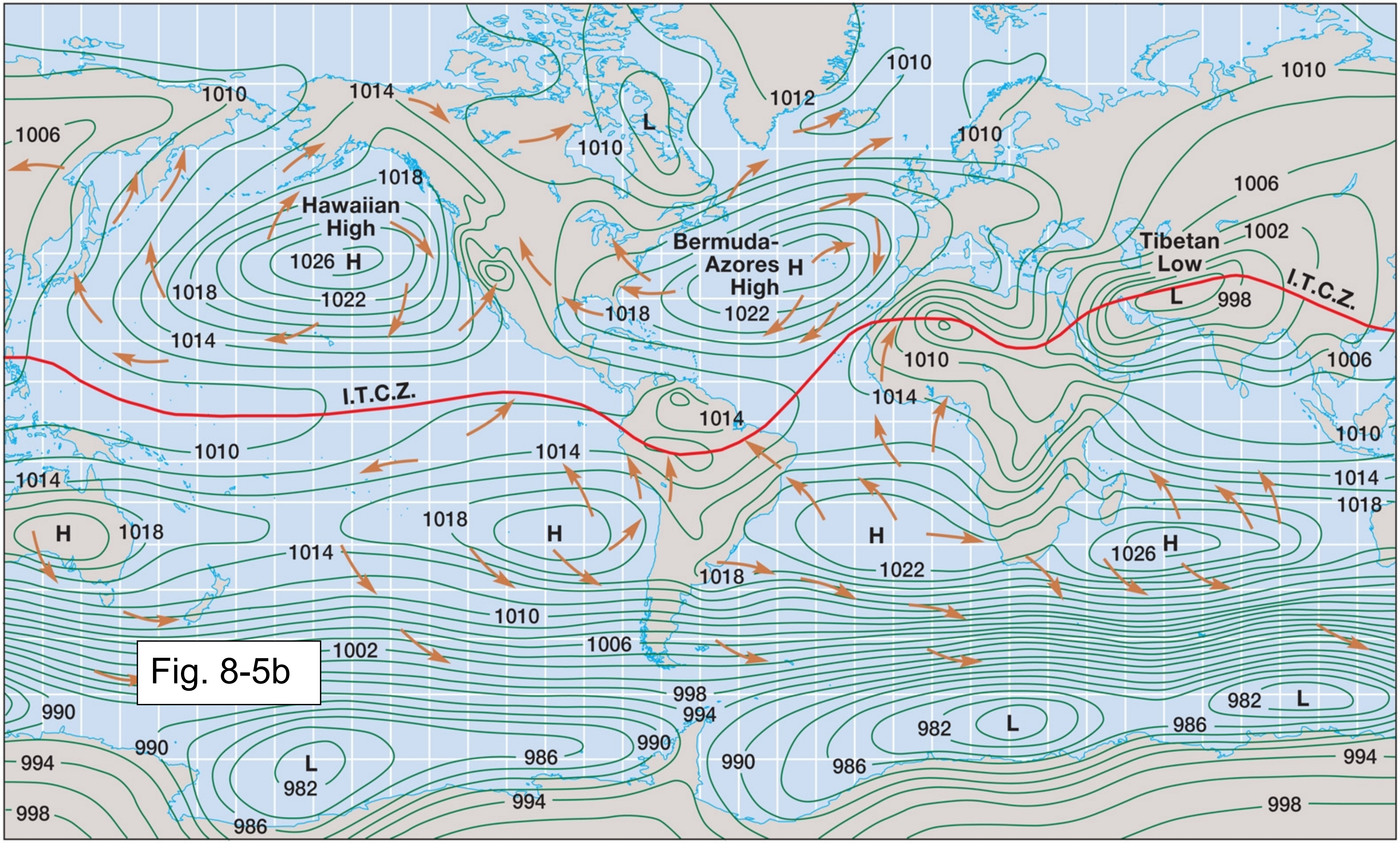
Migrates W and weakens in summer



(a) January

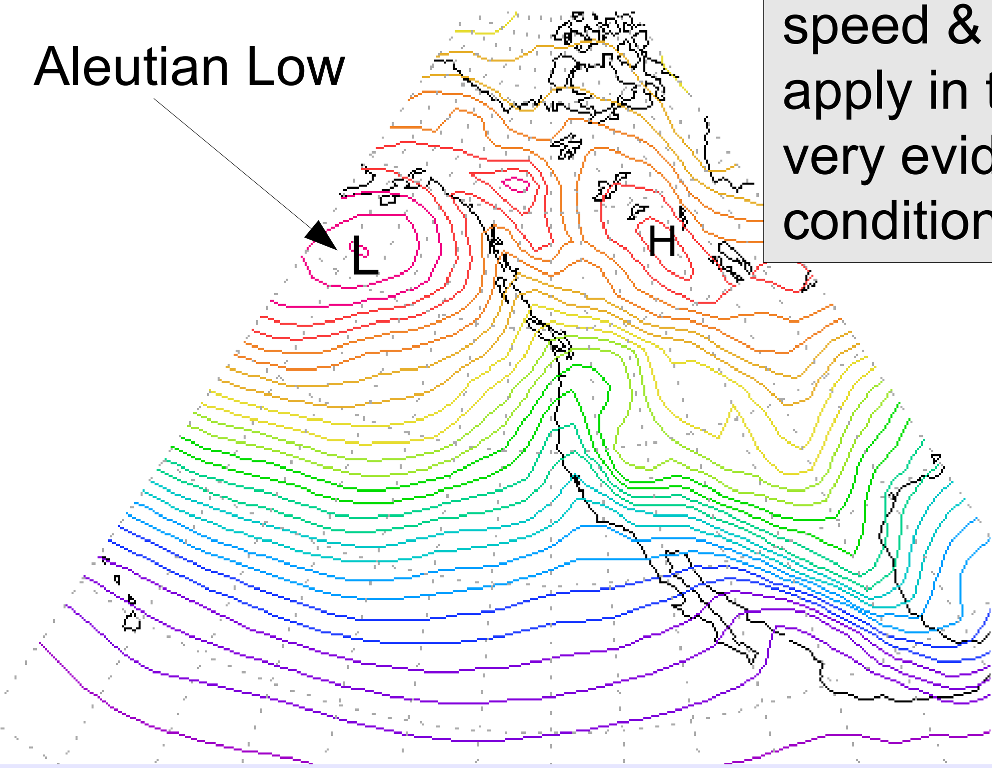
• note strong influence of continents!

(Sea-level isobars averaged over 30 Januaries)


Hawaiian High
1026 H
Bermuda-Azores High H
Tibetan Low
L
998
I.T.C.Z.
I.T.C.Z.
1010
1006
1014
1018
1022
1012
1002
H
1026 H
L
982
986
990
994
998
Fig. 8-5b

(b) July

The rules we've learned relating sfc wind speed & direction to the pressure field apply in the *short term* and need not be very evident in relation to long term mean conditions



NCEP (Nat'l Center Environ. Prediction) Re-analysis – long term mean January pattern of sea-level pressure – comparable with Fig. 8-5(a)

One may construct charts of this type for any region/time of year at:
www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.derived.html