Goals for today:

24 Oct., 2011

- continue Ch 8: “Atmospheric Circulation and Pressure Distributions”

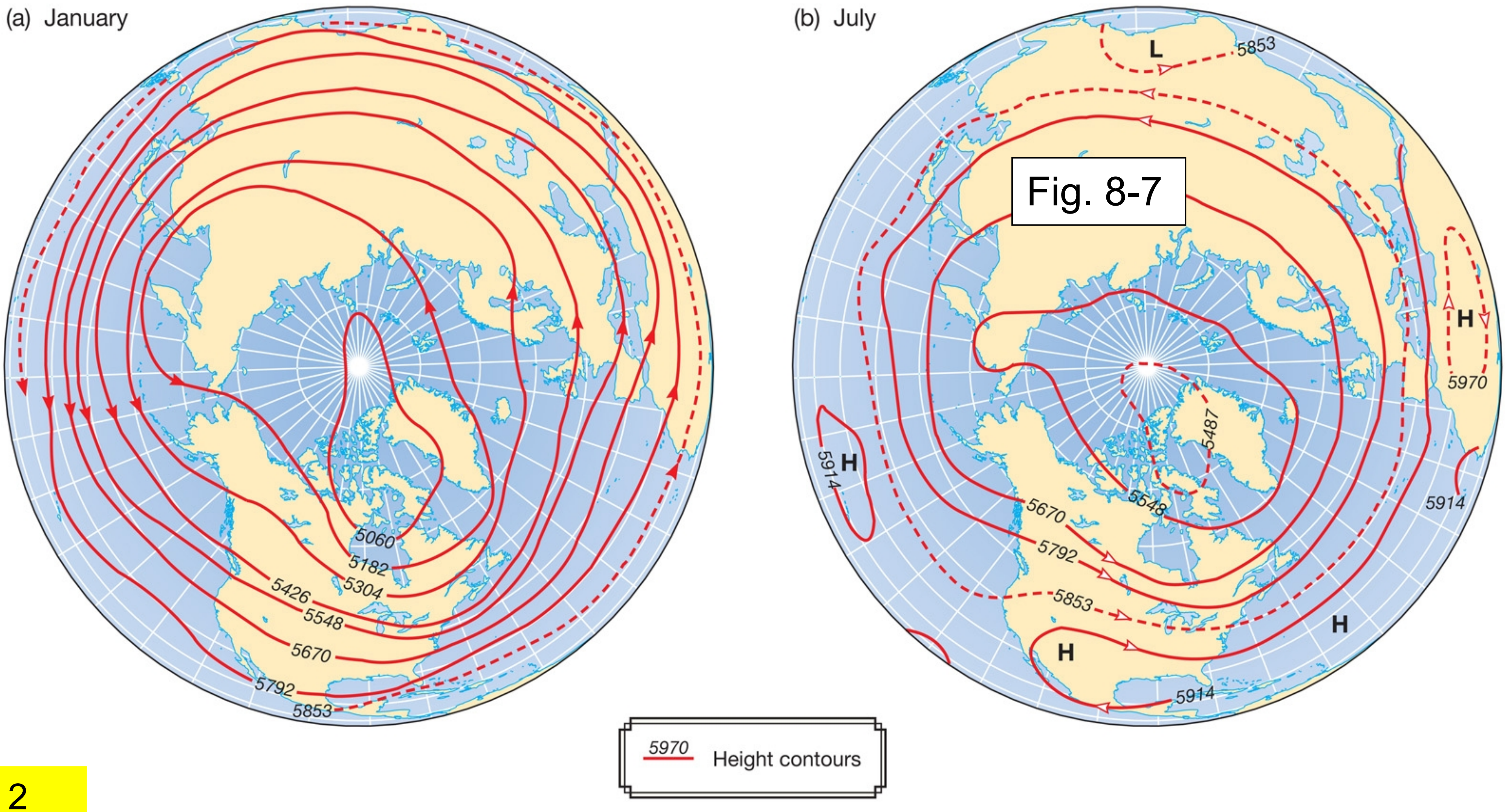
- Today: general circulation aloft; troughs, ridges, long (Rossby) waves

- Next class: disturbances (perturbations of the circulation) on various scales

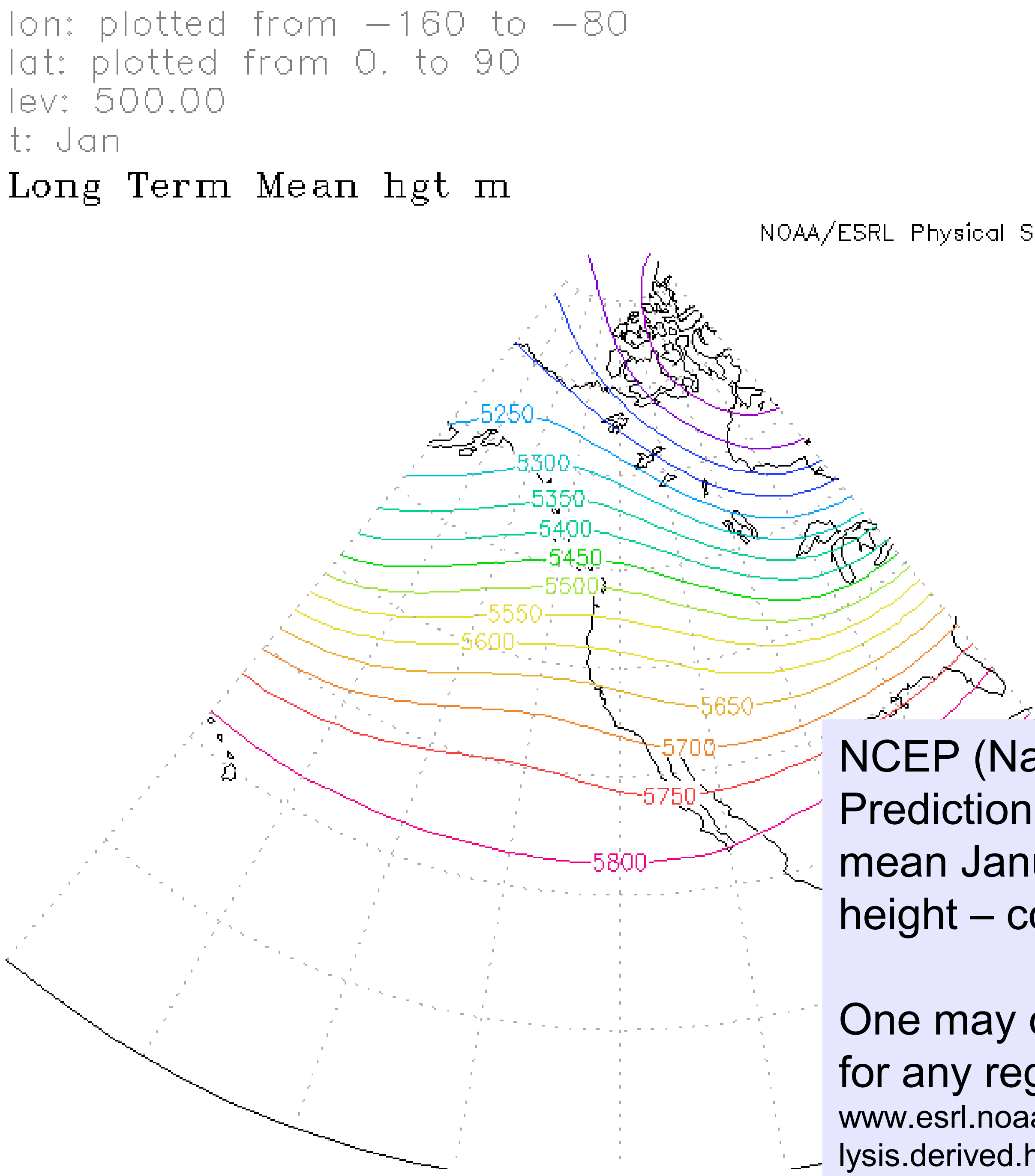
Midterm exam Friday. Value 20%. 30 multichoice questions. Covers to p236 of textbook (i.e. to end of last Friday's lecture)

Climatological mid-tropospheric winds (at 500 hPa)

- heights largest where air is warmest – i.e. slope down from eqtr to pole
- lowest heights *h* and strongest gradient $\Delta h/\Delta x$ (thus, strongest winds) in winter
- zonal component generally dominant at mid-latitude



Climatological mid-tropospheric winds

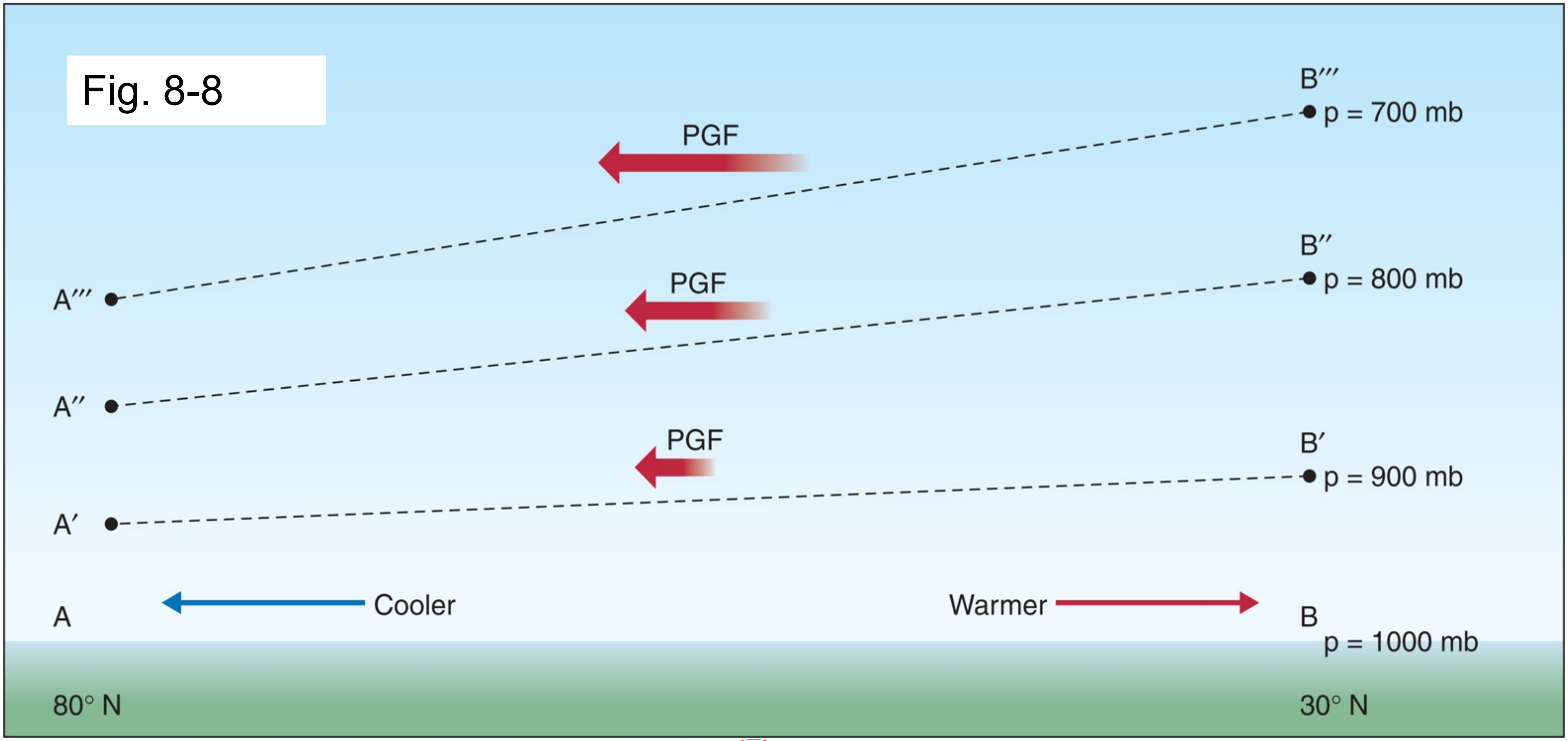


NCEP (Nat'l Center Environ. Prediction) Re-analysis – long term mean January pattern of 500 hPa height – comparable with Fig. 8-7(a)

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

Winds are stronger aloft due to (a) decreased friction (b) typically stronger pressure gradient

(A greater slope of the isobaric surface implies a stronger pressure gradient force)



Geostrophic wind speed $$V = \frac{g}{f} \frac{\Delta h}{\Delta n}$$

slope of isobaric surface

Polar front jet stream – located near tropopause

- *P* falls more slowly with increasing height in warmer air
- wherever horiz temperature gradient strong (fronts), strong height gradient
- strong height gradient implies strong wind (Geostrophic law)
- strongest in winter (stronger *T*-gradient)
- as a weather feature, the jet is irregular – it meanders & branches

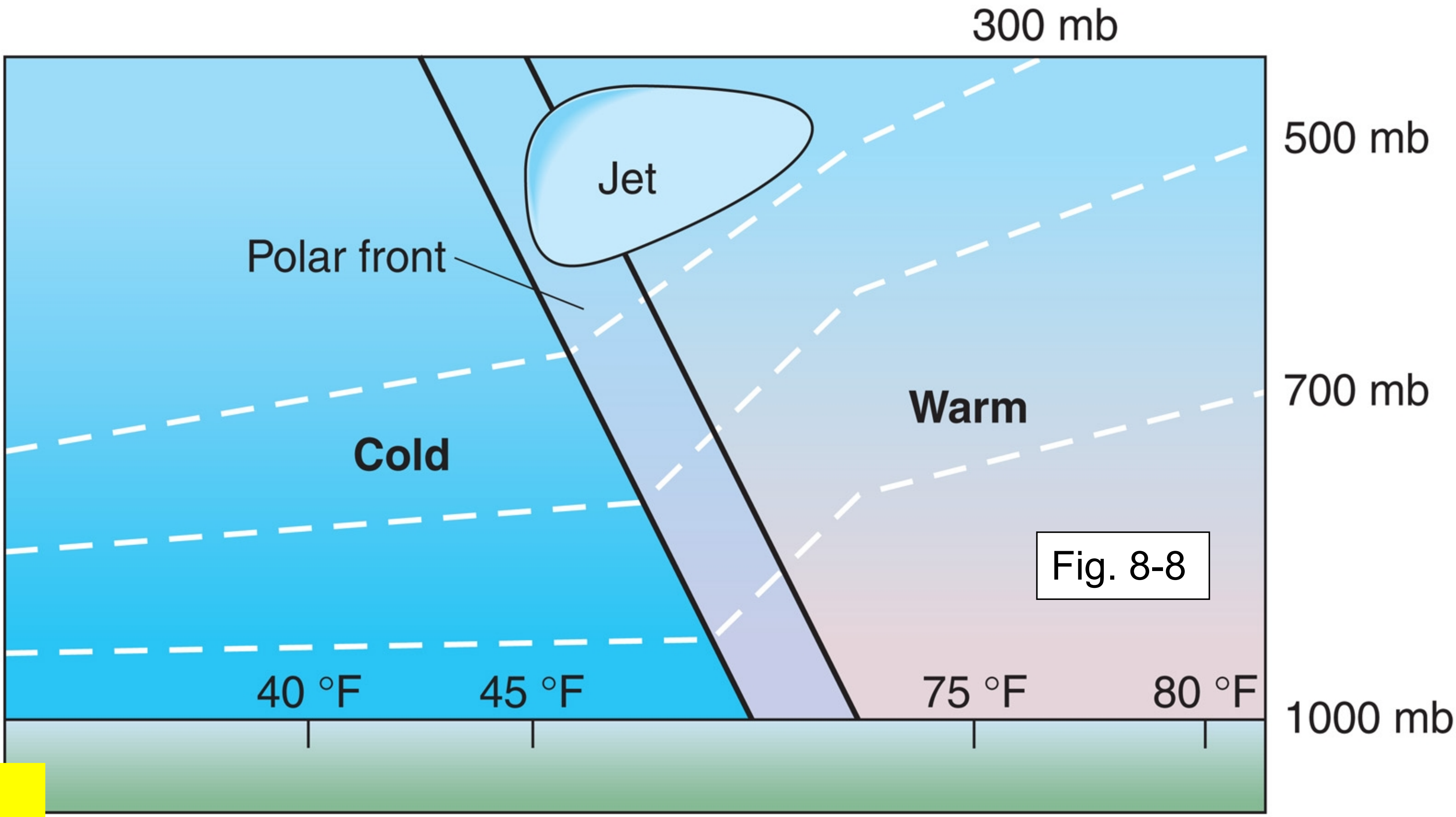
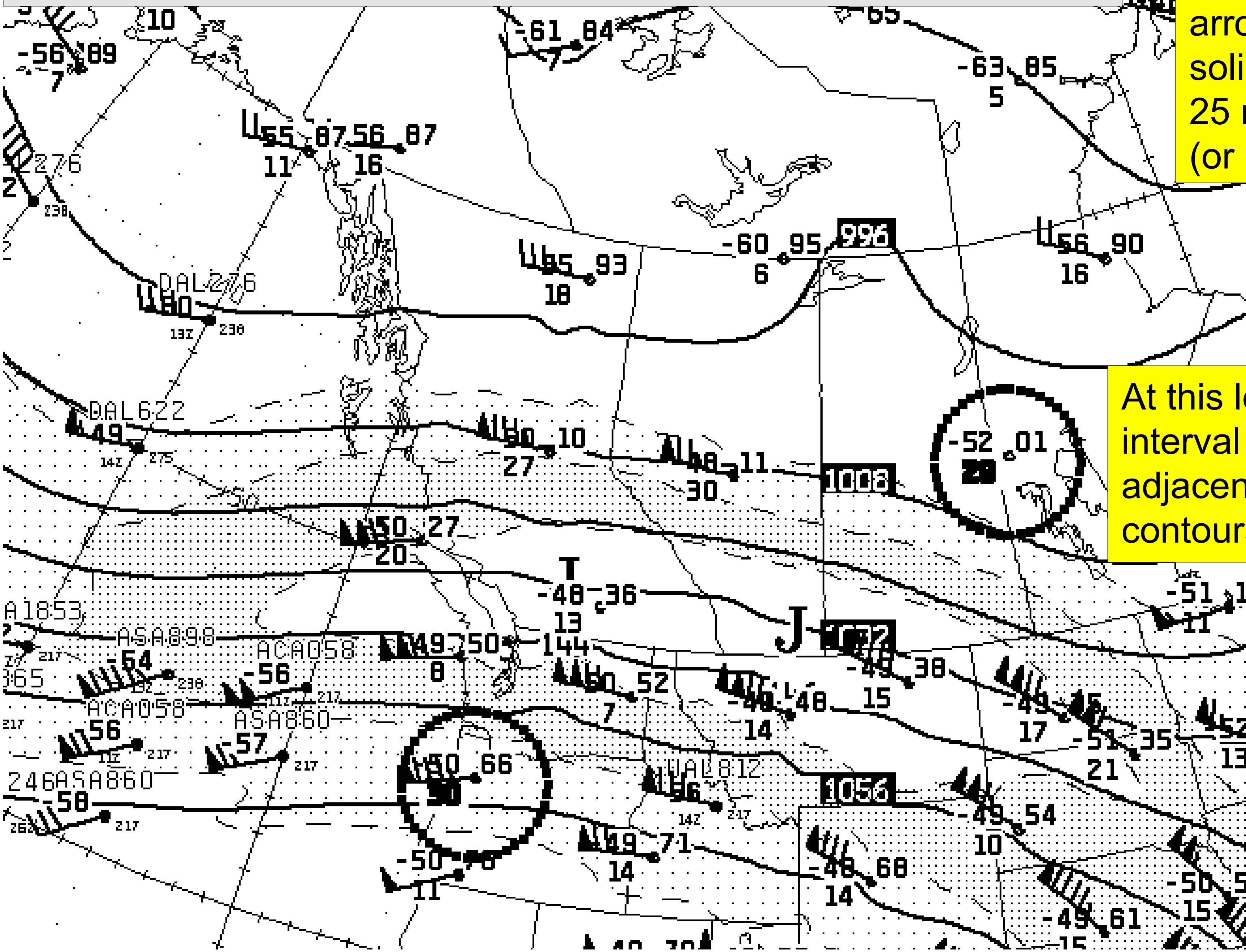


Fig. 8-8

CMC 250 hPa analysis 12Z Sun 23 Oct. 2011. Note the jet (J)

On the wind arrow each solid triangle is 25 m/s (or 50 knots)



At this level the interval between adjacent height contours is 12 dam

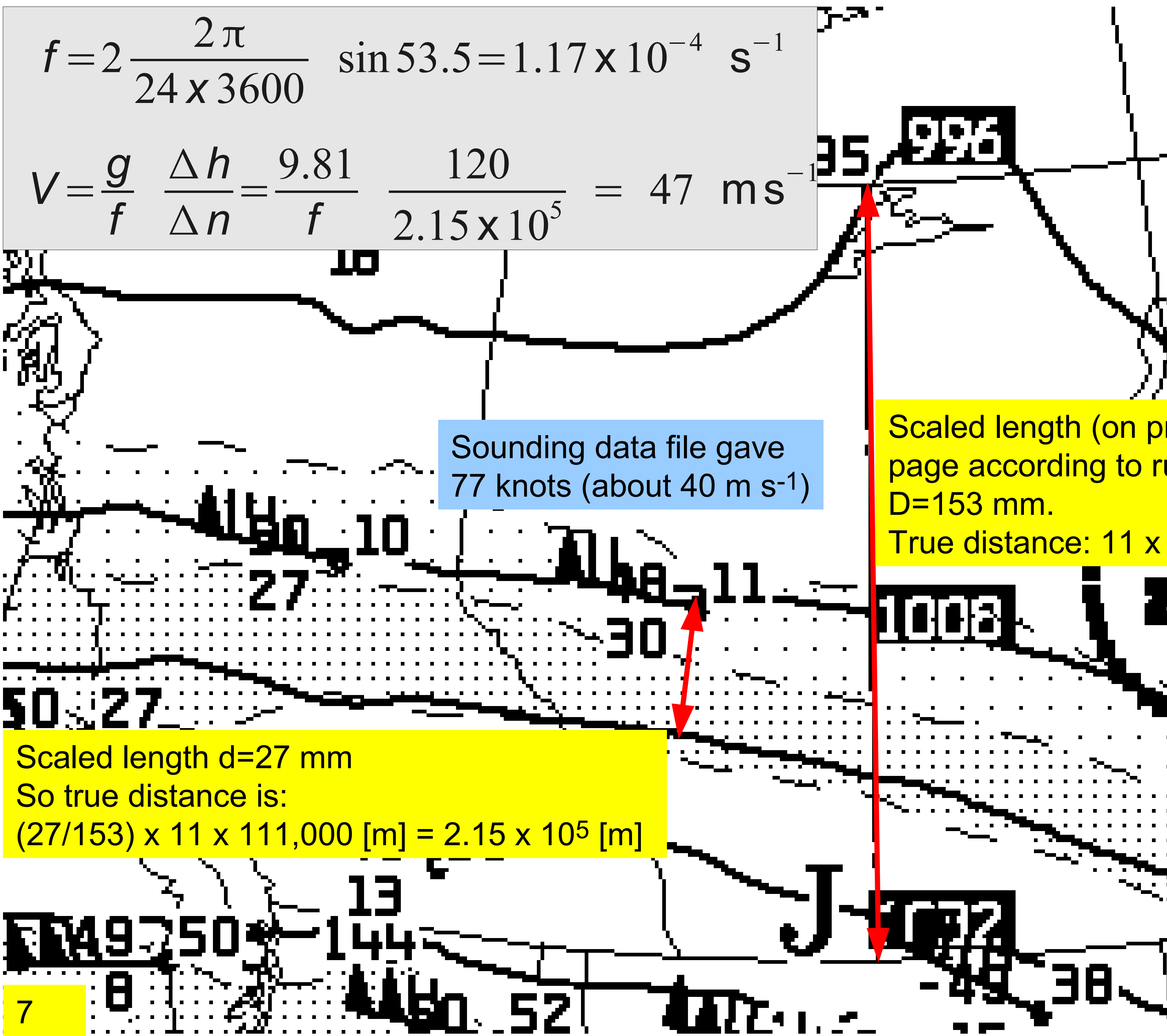
250 hPa GEM HEIGHT-HAUTEUR WIND-VENT

HEIGHT - HAUTEUR ⊗ H L ...1032, 1044, 1056... dam

WIND VENT J 60 90 120 150 180 KNOT NOEUD

$$f = 2\frac{2\pi}{24 \times 3600} \sin 53.5 = 1.17 \times 10^{-4} \ \mathrm{s}^{-1}$$

$$V = \frac{g}{f}\frac{\Delta h}{\Delta n} = \frac{9.81}{f}\ \frac{120}{2.15 \times 10^{5}} = 47 \ \mathrm{m\,s}^{-1}$$

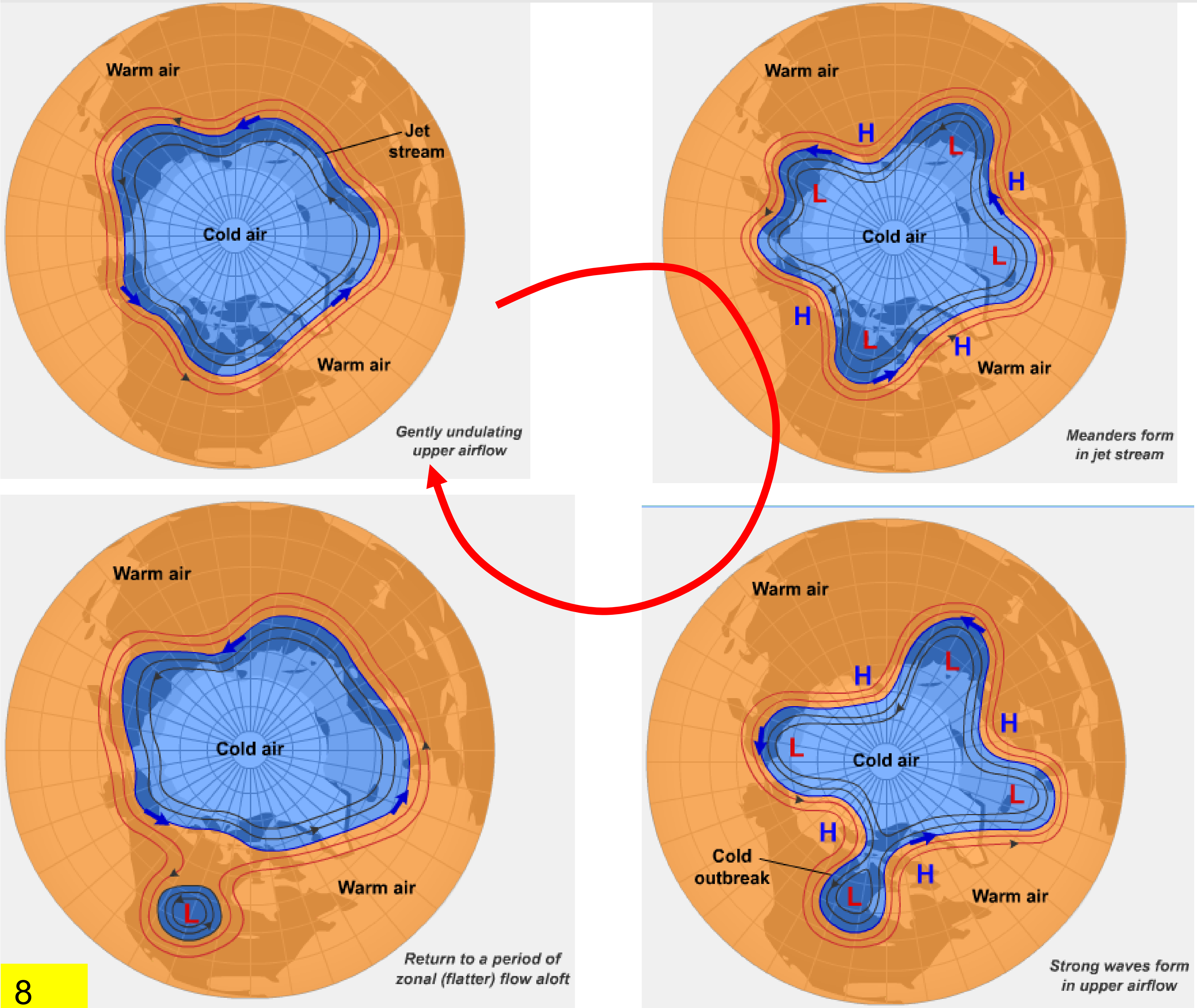


Sounding data file gave 77 knots (about 40 m s^{-1})

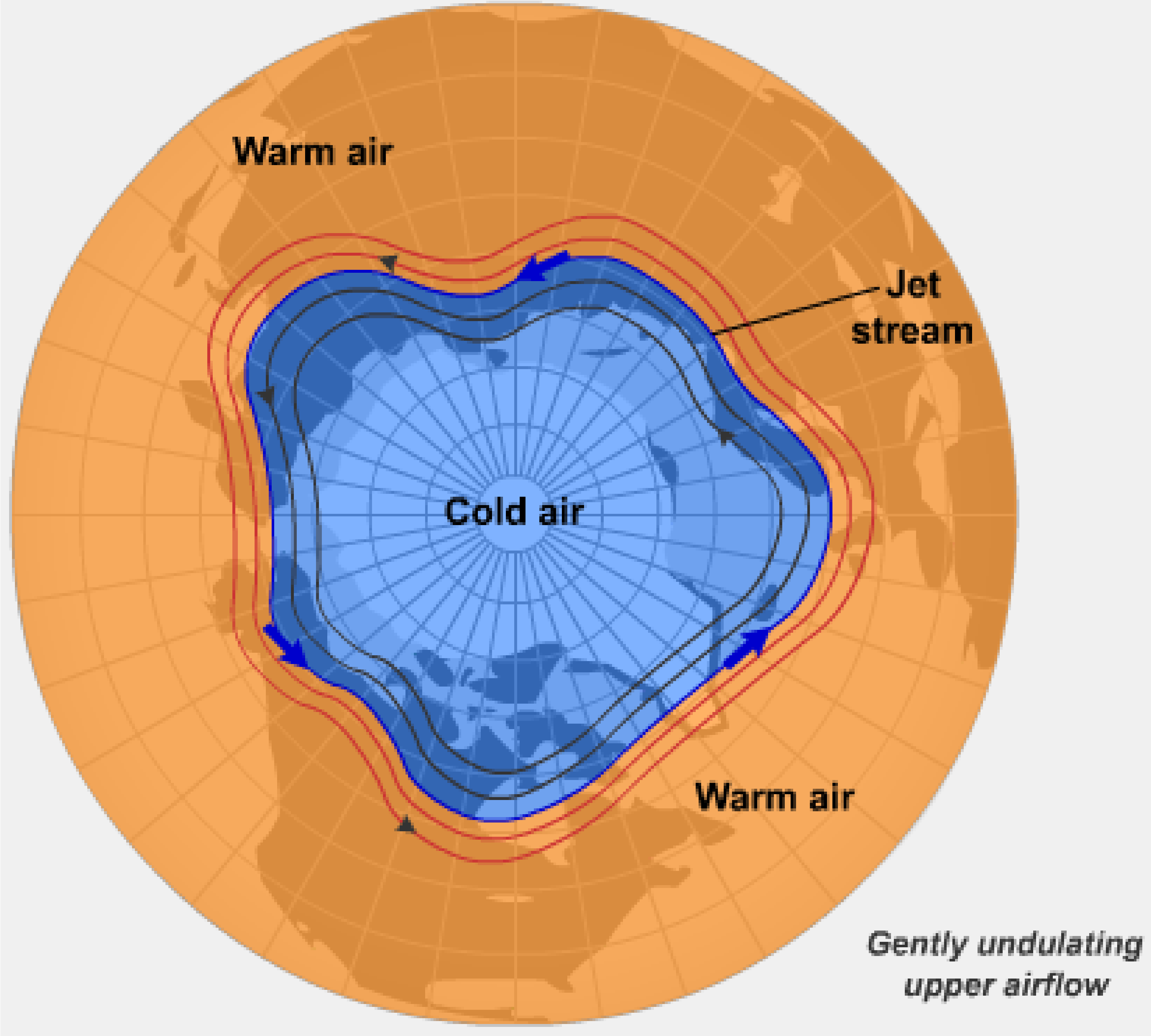
Scaled length (on printed page according to ruler): D=153 mm.
True distance: 11 x 111 km

Scaled length d=27 mm
So true distance is:
(27/153) x 11 x 111,000 [m] = 2.15 x 10^5 [m]

Waves in the upper flow and formation of large quasi-2D eddies



Waves in the upper flow and formation of large quasi-2D eddies



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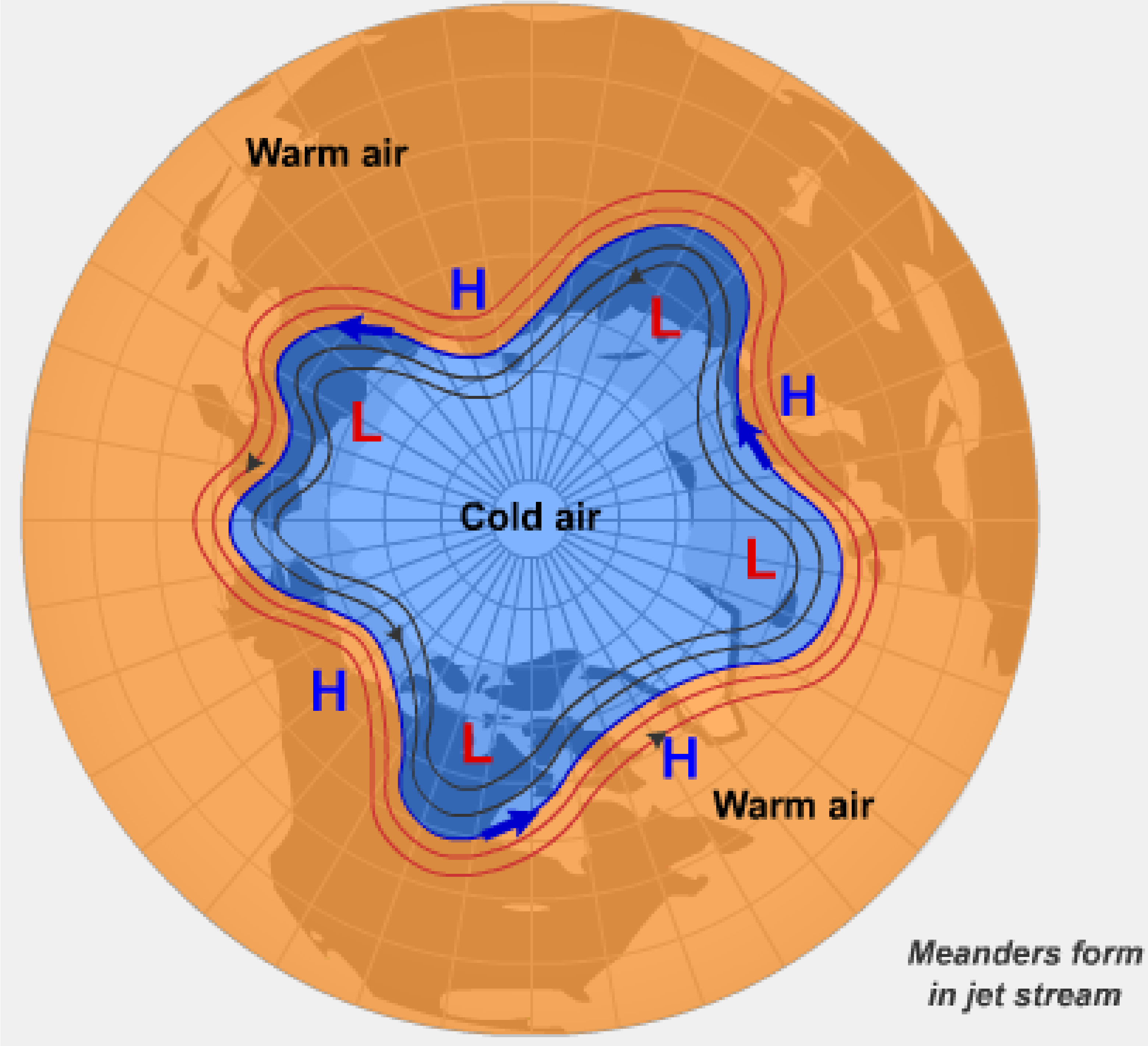

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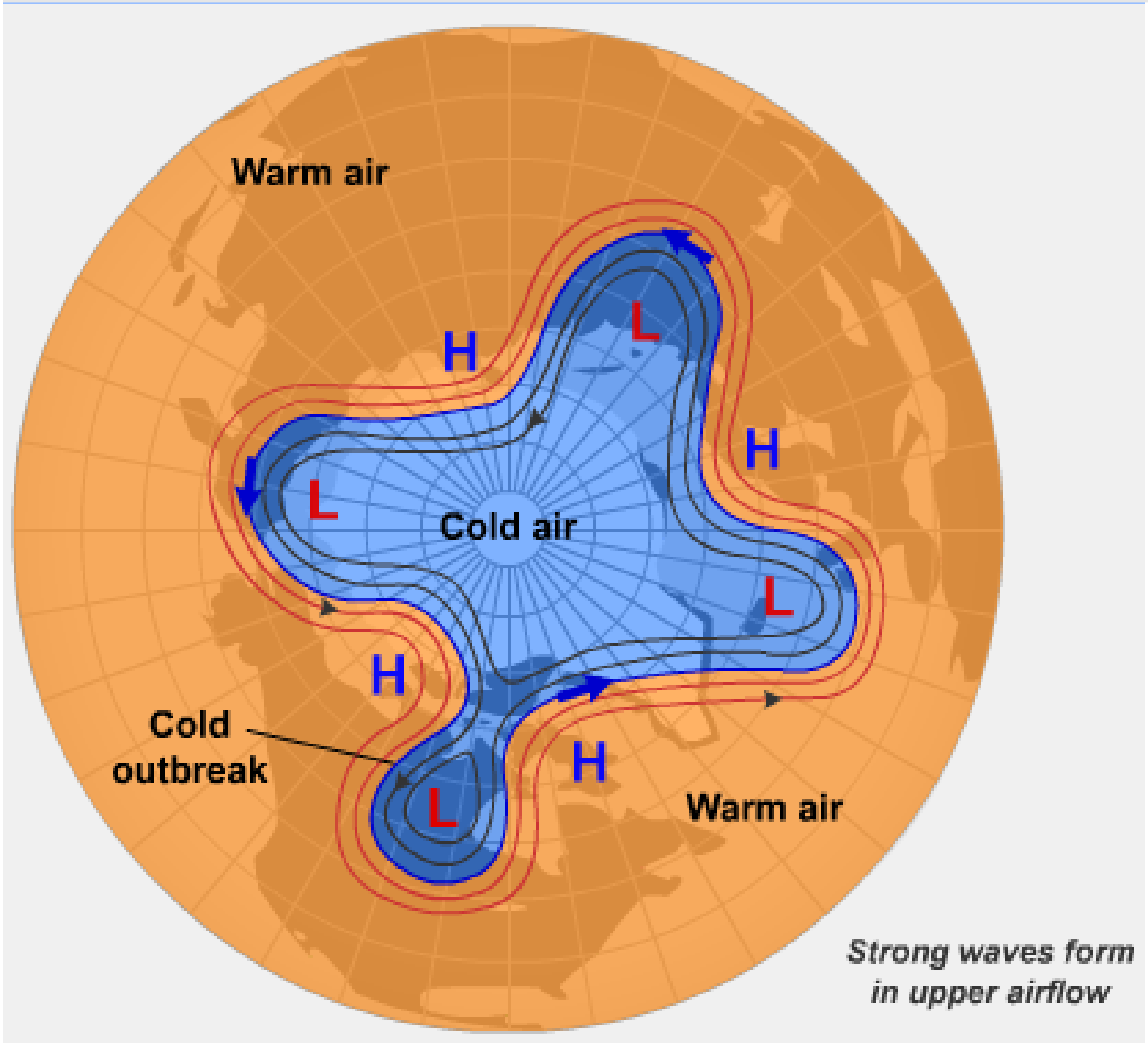

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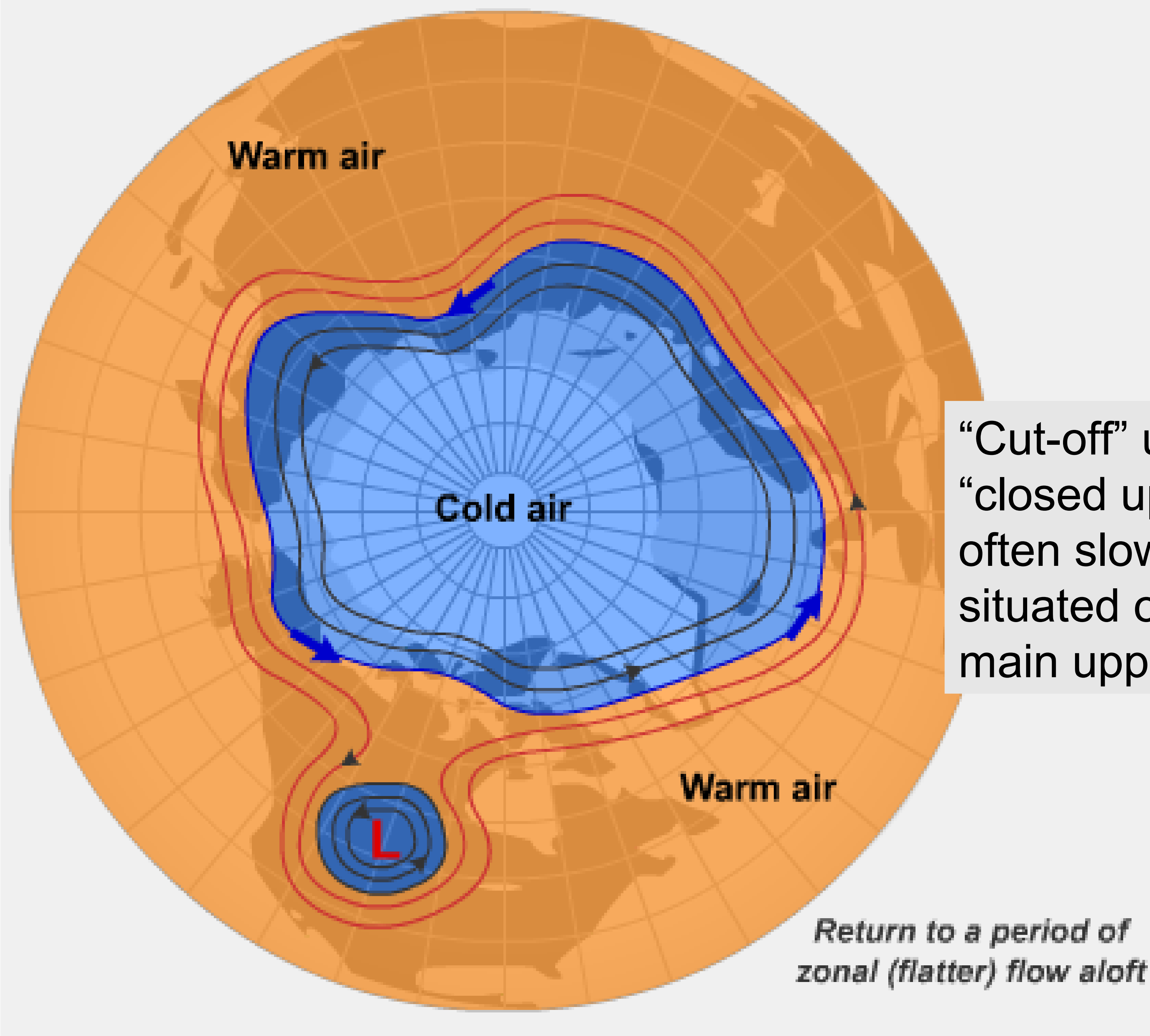


“Cut-off” upper low or “closed upper low” – often slow moving as situated out of the main upper stream

Troughs and Ridges

- troughs and ridges are a corollary of there being these waves in the height contours

- we've marked these ridges/troughs on the CMC analyses several times

- position in relation to troughs and ridges has much to do with weather, as succeeding chapters will emphasize; in particular, they are associated with zones of convergence (air accumulation) and divergence aloft

- so the ridges/troughs (equivalently, the waves) are important

- so then, what causes the waves? We'll focus on waves in the free troposphere, and begin with the longest:

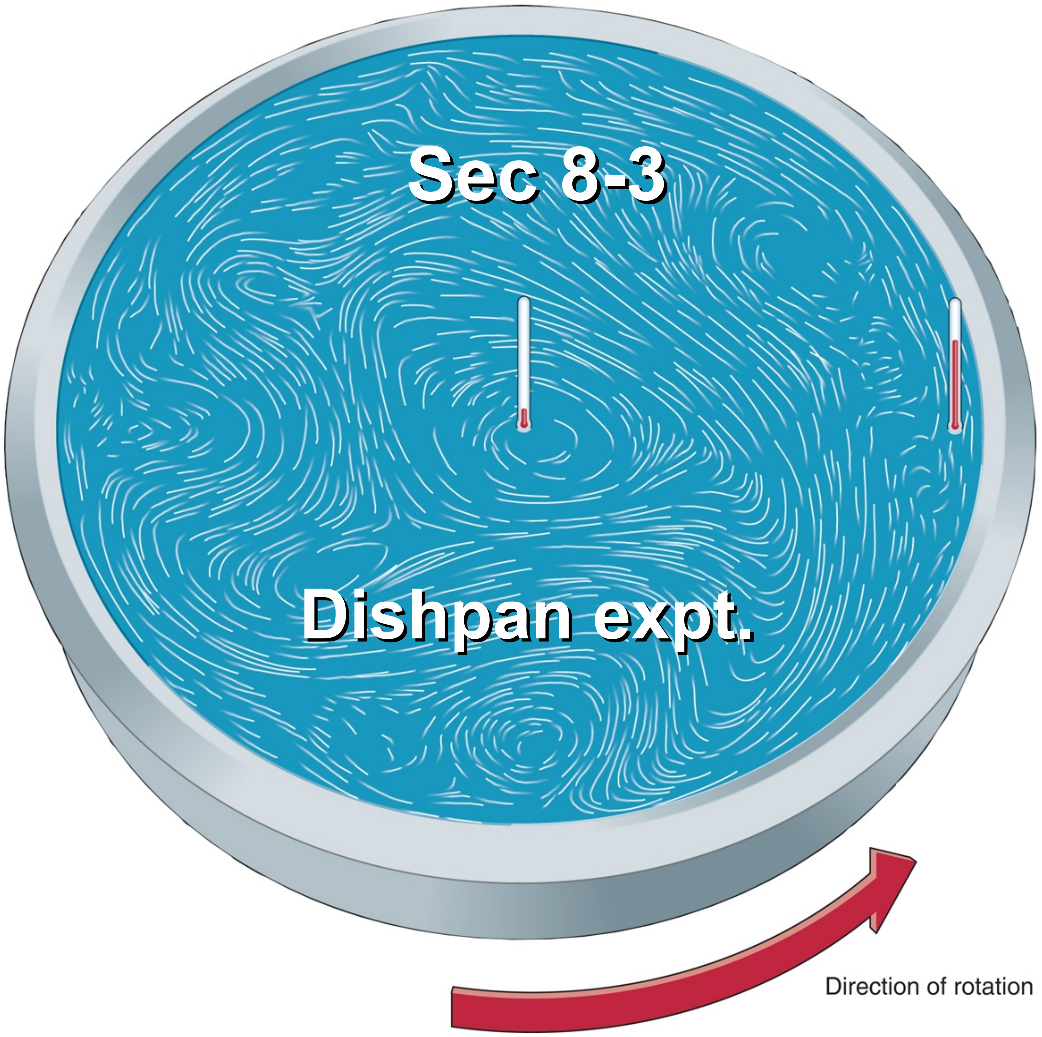
Cause/nature of the (transient) Planetary Waves?

- unequal heating
- rotation

(Rossby proved theoretical existence of the long waves by analyzing simplified equations of motion, in which the Coriolis parameter *f* varied linearly with latitude)

- thermodynamic perspective: these waves are nature's spontaneous disordering of an otherwise ordered (i.e. low entropy) distribution of heat

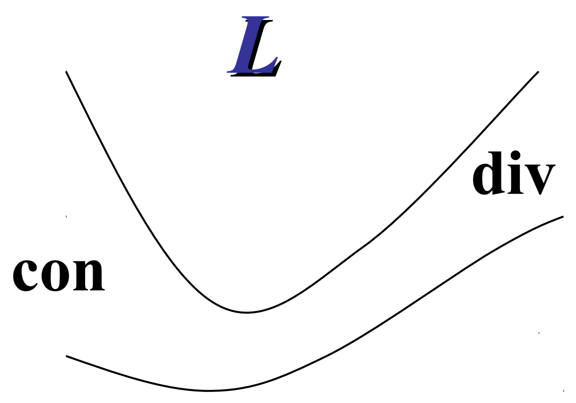
- "superimposed on the long waves are smaller-scale eddies"

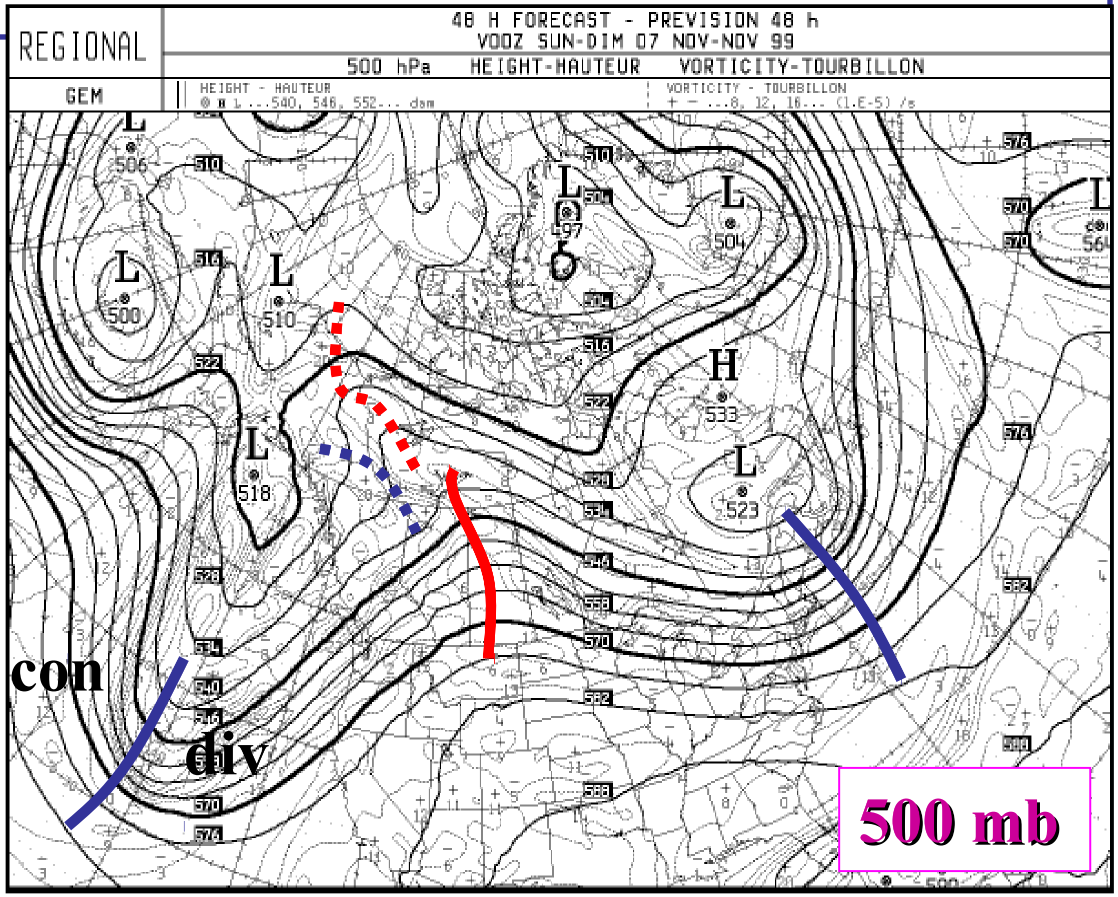


Waves in mid-latitude mid/upper troposphere causing convergence and divergence aloft...

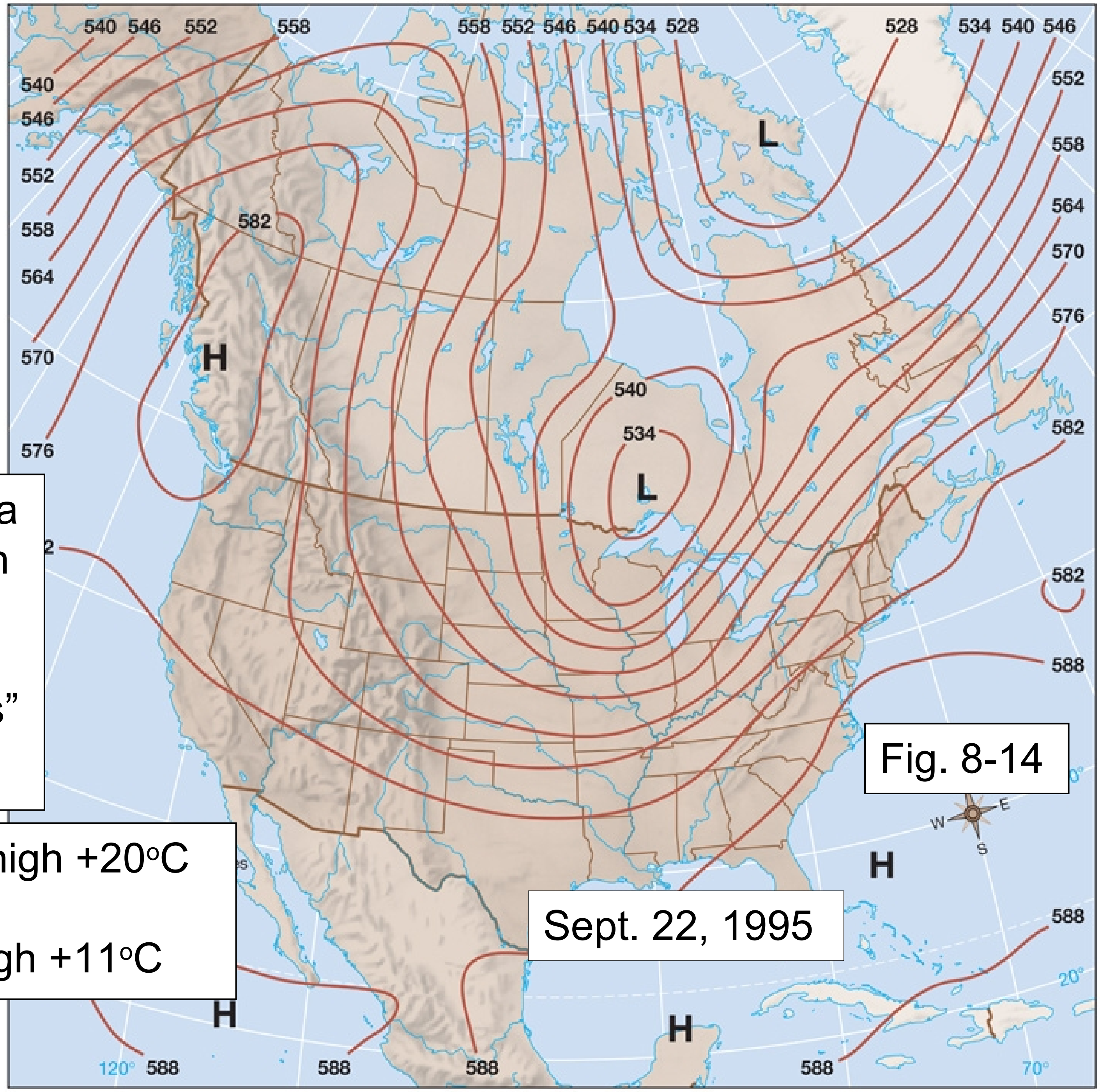
Long (Planetary/Rossby) Waves —

- wavelength ~ order 1000's of kilometers
- typically 3 - 7 around globe (fewer, longer, stronger in winter)
- not always unambiguously identifiable - but can be shown mathematically to exist in ideal atmos. due to N-S variation of Coriolis force
- (usually) move slowly eastward





Example of high amplitude Rossby wave over N. America



“Rossby waves exert a tremendous impact on day-to-day weather, especially when they have large amplitudes”

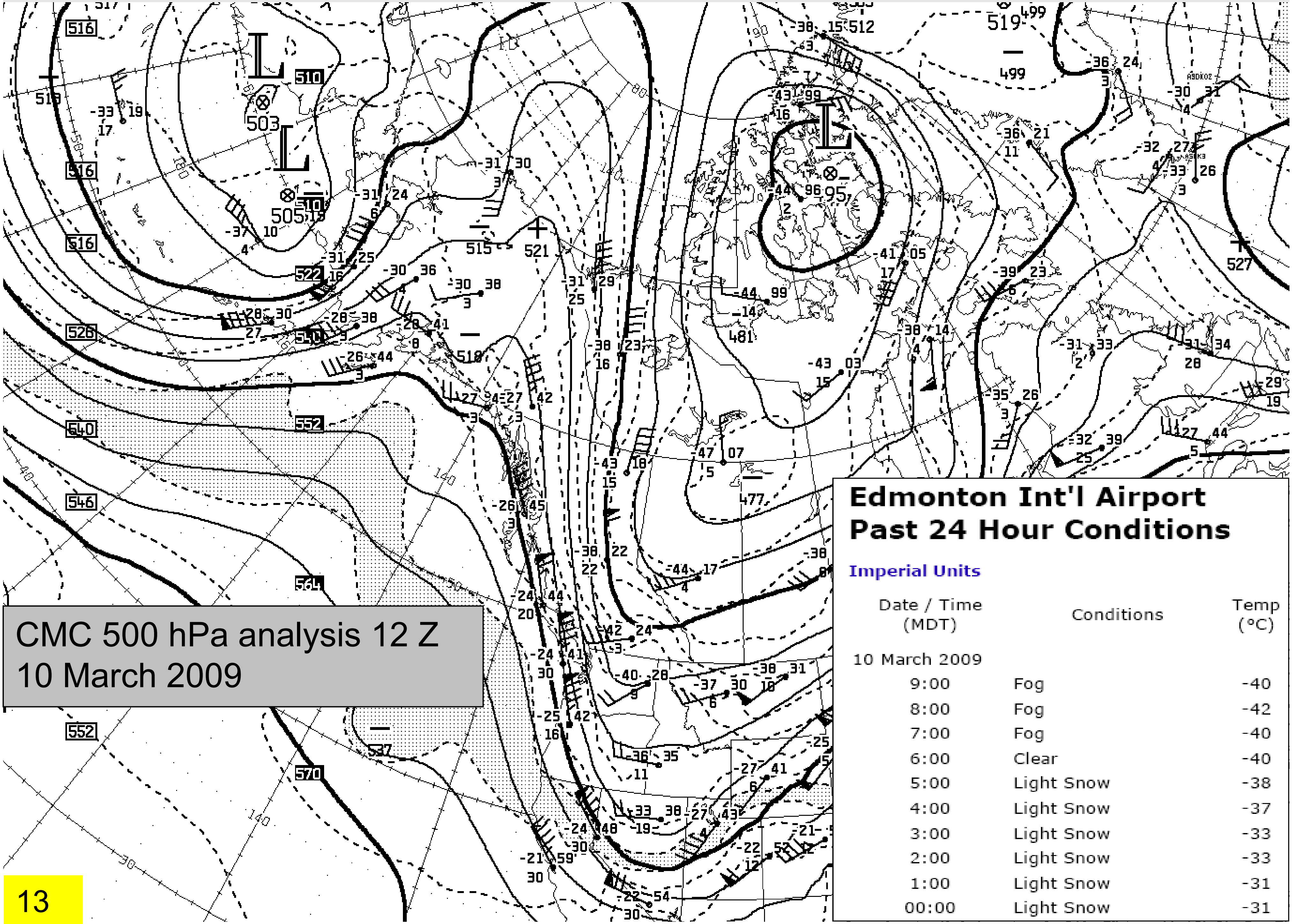
Edmonton low +4°C, high +20°C

Winnipeg low -2°C, high +11°C

Fig. 8-14

Sept. 22, 1995

Another example of high amplitude Rossby wave



CMC 500 hPa analysis 12 Z
10 March 2009

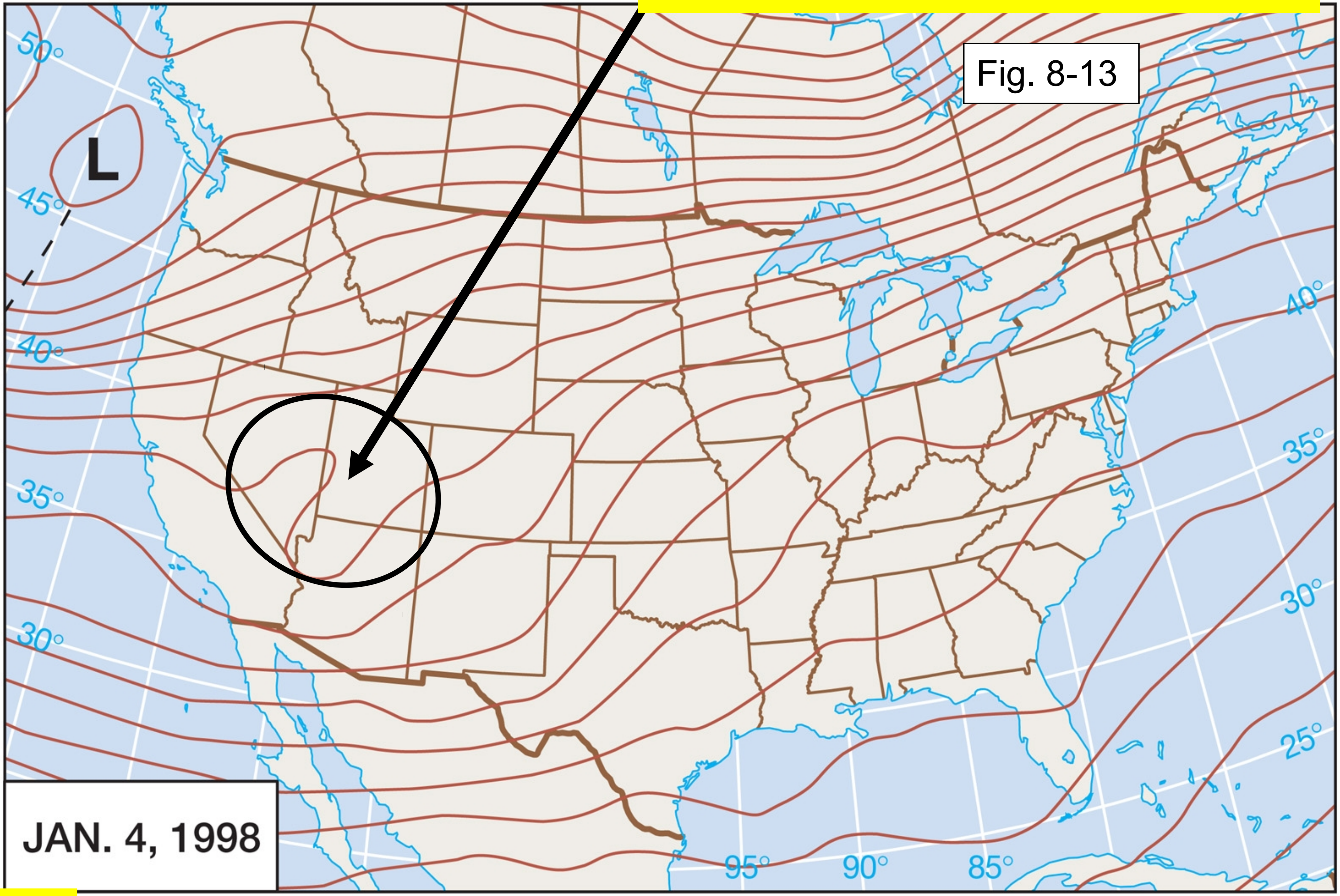
Edmonton Int'l Airport
Past 24 Hour Conditions

Imperial Units

Date / Time (MDT)	Conditions	Temp (°C)
10 March 2009		
9:00	Fog	-40
8:00	Fog	-42
7:00	Fog	-40
6:00	Clear	-40
5:00	Light Snow	-38
4:00	Light Snow	-37
3:00	Light Snow	-33
2:00	Light Snow	-33
1:00	Light Snow	-31
00:00	Light Snow	-31

Rossby wave moving eastward

Notice the “short wave” here; covered later – are associated with storms



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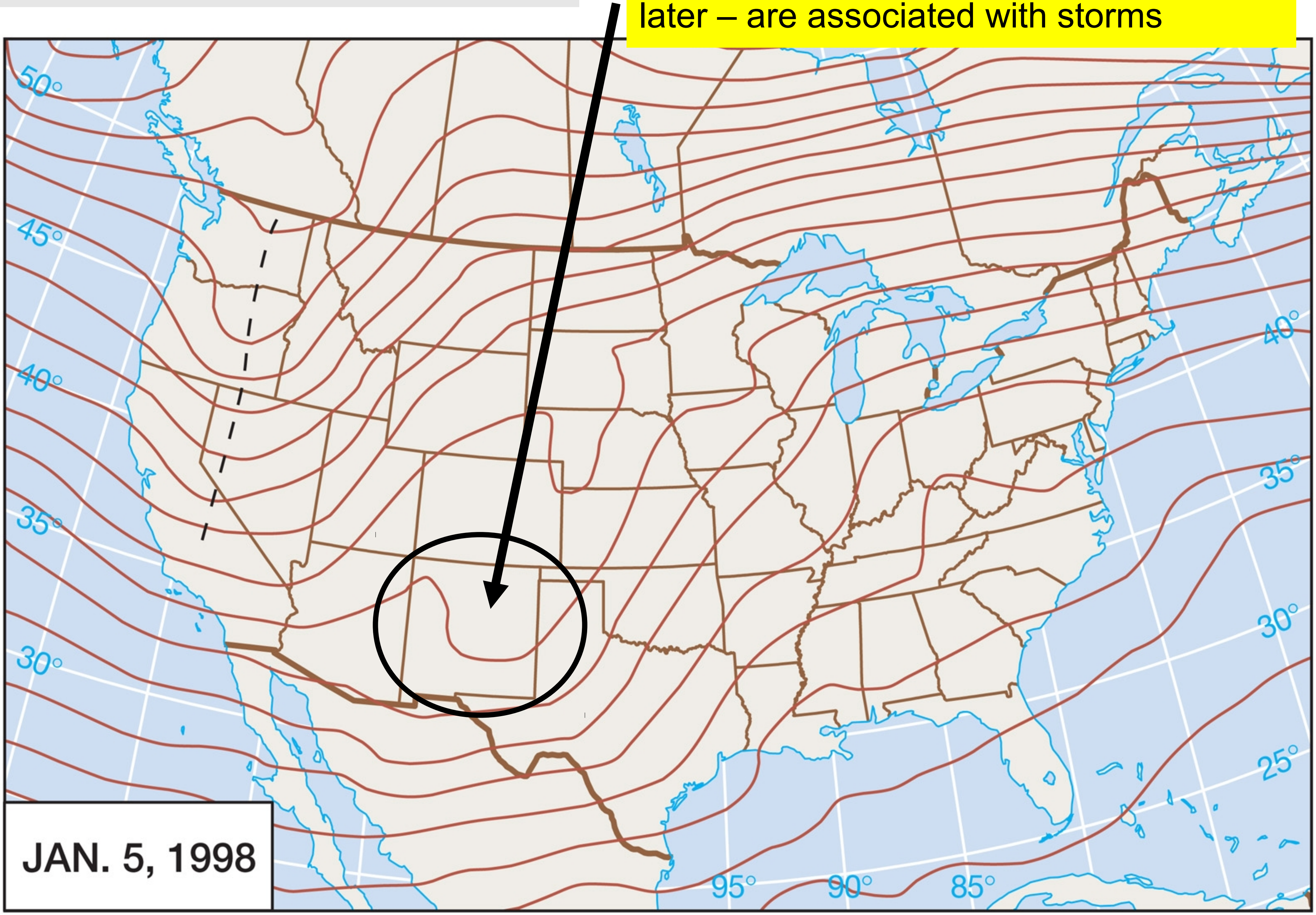

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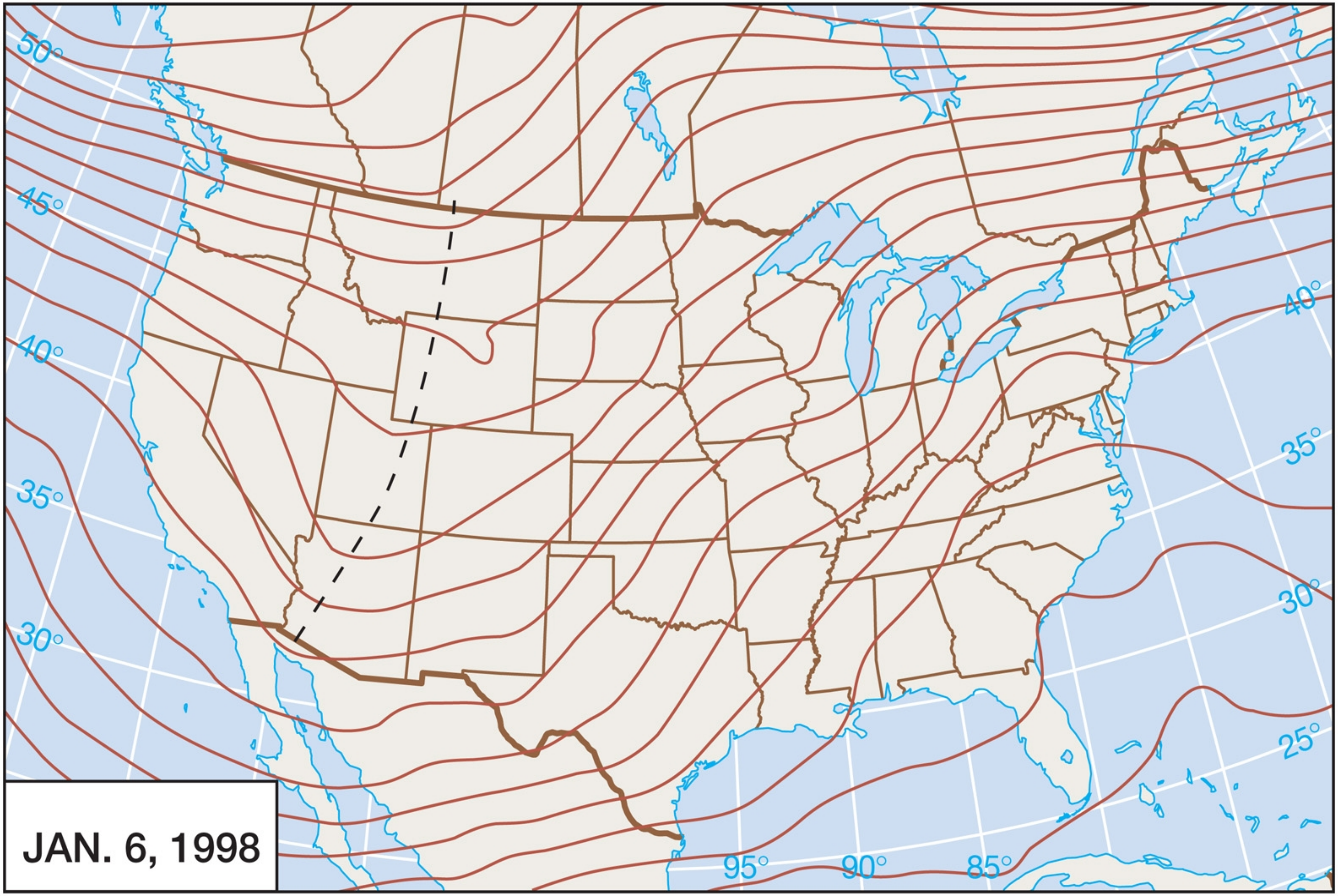

Rossby wave moving eastward