Weather & Climate
Laboratory
Report 2

FRONTS

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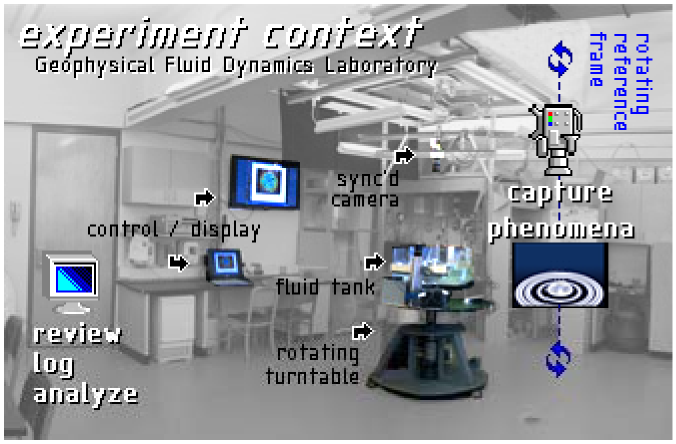
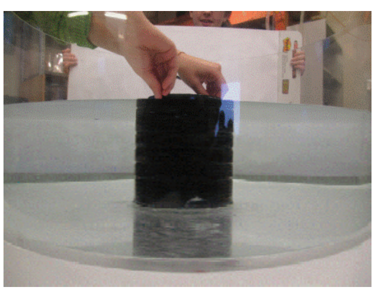
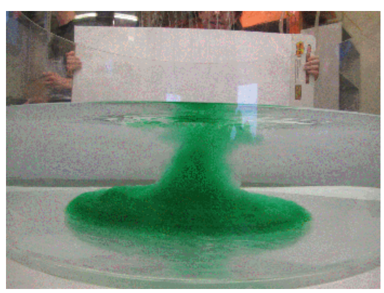
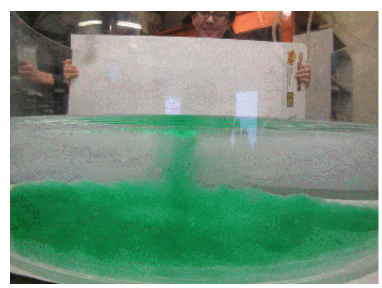
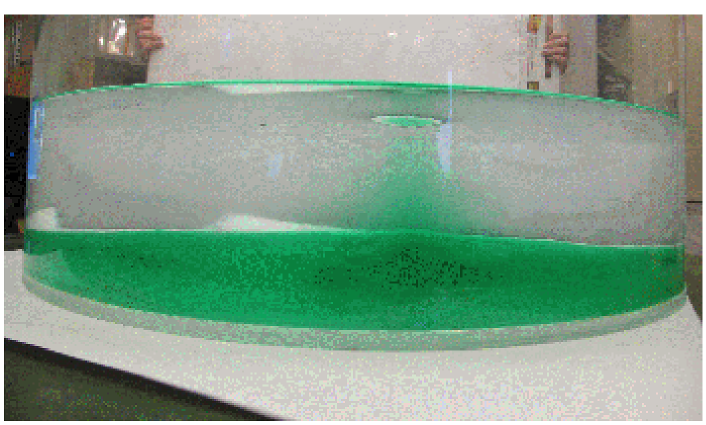


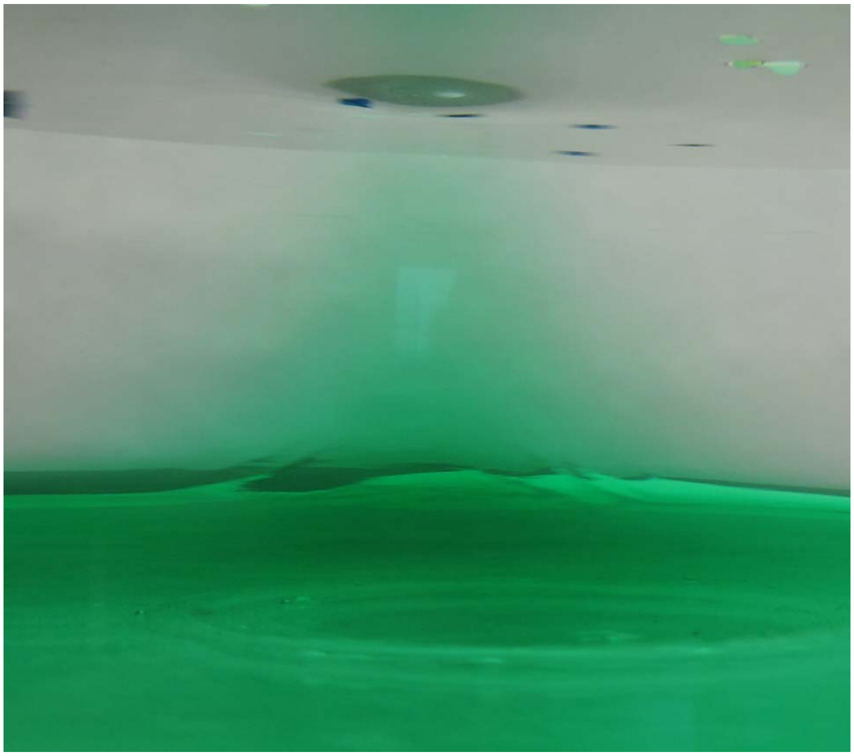
Calculation Set 1:
Experiments in the Tank



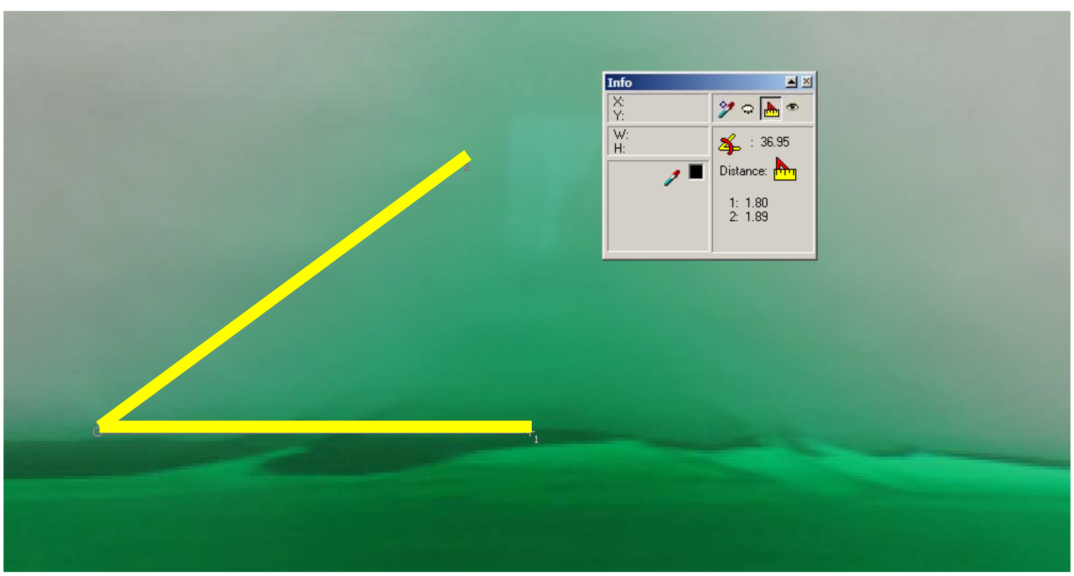


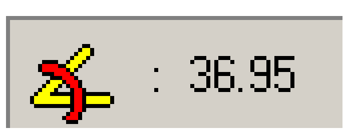


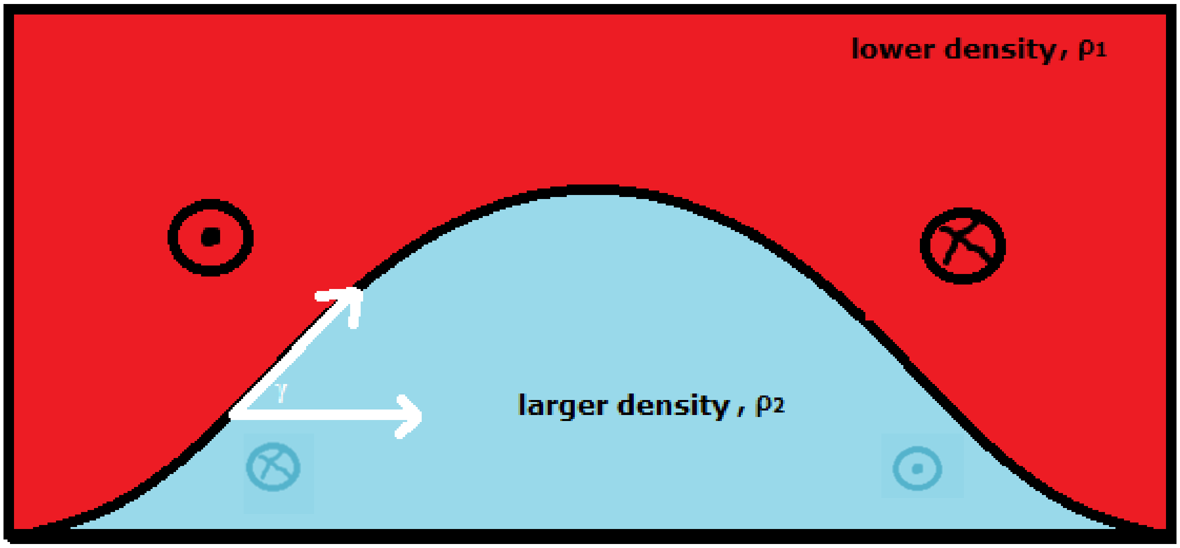




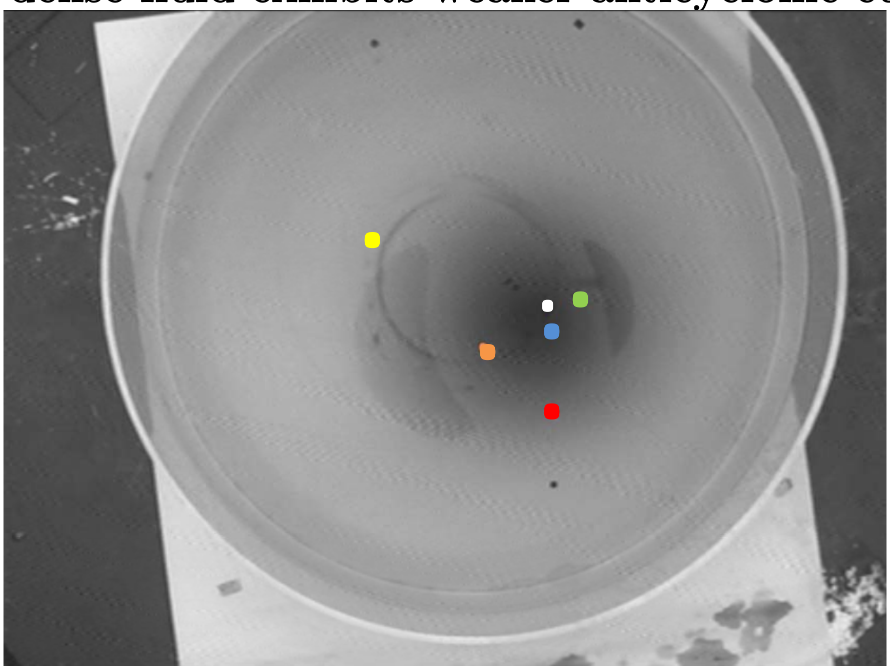
Dense fluid forms a stable dome along tank's bottom.
Steepest angle of the fluid interface can be visually approximated.







Less dense fluid spins cyclonically with the tank.
More dense fluid exhibits weaker anticyclonic currents.



Particle	Rot. radius	Period	Velocity
Blue	2.96 cm	1.3 sec	14.3 cm/sec
Green	4.03 cm	1.5 sec	16.9 cm/sec
Orange	9.5 cm	2.5 sec	23.6 cm/sec
Red	13.4 cm	5.2 sec	16.4 cm/sec
Yellow	24.2 cm	25 sec	6.08 cm/sec

Upper fluid's current speed peaks in the middle radii, corresponding with the steepest slope (largest gradient) of the frontal surface between differing fluid densities.

Margules' formula offers a connection between this angle, the rotation rate of the system, fluid densities, and current velocities.

$$v_2 - v_1 = \frac{g' \tan\gamma}{f} \qquad g' = g\frac{(\rho_2 - \rho_1)}{\rho_2} \qquad f = 2\Omega$$

The values set or obtained for our experiment are as follows.

v_2=˜0 cm/s (difficult to measure, presumable as 0 or even a negative number)
v_1= 23.6 cm/s (peak measured speed of a mid-radii particle on prior page)
ρ_2= 1.05 g/cm^3
(this number is potentially a measurement from before the water was released into the lighter fluid, so it is also worth testing 1.025 , a measurement obtained from another group's dome)

ρ_1= 1.005 g/cm^3 (the less dense fluid)
g=980cm/s^2
f=1528 millif=1.528 sec^{-1}

$$g' = 980 * \frac{(1.05 - 1.005)}{1.05}$$

ALTERNATE CALCULATION

$$980 * \frac{(1.025 - 1.005)}{1.025}$$

g'= 42 cm/s^2 ?or? 19.12 cm/s^2

$$-23.6\ [\text{cm/s}] = \frac{g' \tan y}{f} = \frac{g' \tan y}{1.528}\ [\text{sec}^{-1}]$$

$$-36.1\ [\text{cm/s}^2] = g' \tan y$$

g' = 42 g' = 19.12

tan y = 8595 ?or? 1.888

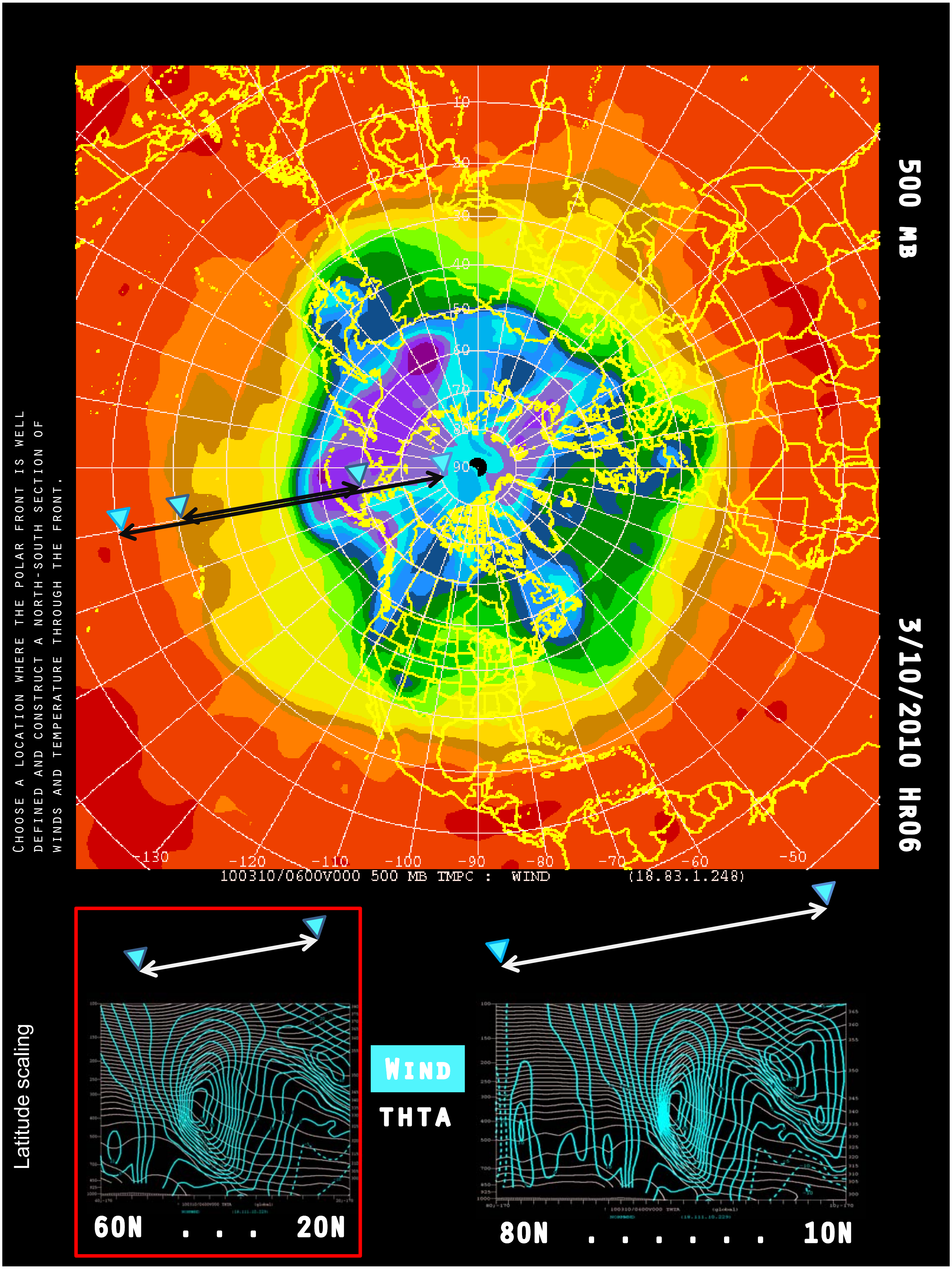
y = 40.68° 62.09°

Observed angle 36.95°. 37/40.68=.91 or 40.68/37 = 1.099, within ˜10% accuracy
37/62.09=.60 or 62.09/37 = 1.68

Reverse calculation w/ 37° to obtain the necessary density difference p_2-p_1 with p_1 = 1.005 would suggest a difference of .0517 g/cm^3

Further calculations initialized with lower particle velocity 16.4 cm/s predicts a lower slope of approximately 30.8° degrees, which coincides with the dome's visible decrease in slow both towards and away from the middle radii.

Calculation Set 2:
Atmospheric Data Analysis


500 MB
3/10/2010 HR06
CHOOSE A LOCATION WHERE THE POLAR FRONT IS WELL DEFINED AND CONSTRUCT A NORTH-SOUTH SECTION OF WINDS AND TEMPERATURE THROUGH THE FRONT.
100310/0600V000 500 MB TMPC : WIND (18.83.1.248)
Latitude scaling
WIND
THTA
60N . . . 20N
80N 10N

THEORY

Margule's formula has an application for atmospheric cases, using ideal gas relation.

The formula may be simplified in cases where $T_1/T_2 = \tilde{}1$

atmospheric relation:

$$\tan(y) = \frac{f\,(v_2 - v_1)}{g(T_1 - T_2)\,/\,T}$$

$$f = 2O$$

$$O = \frac{2(pi)}{T} = \frac{2(pi)}{24\text{ hrs}} \times 3600\text{ s/hr}$$

$$O = 7.272 \times 10^{-5}$$

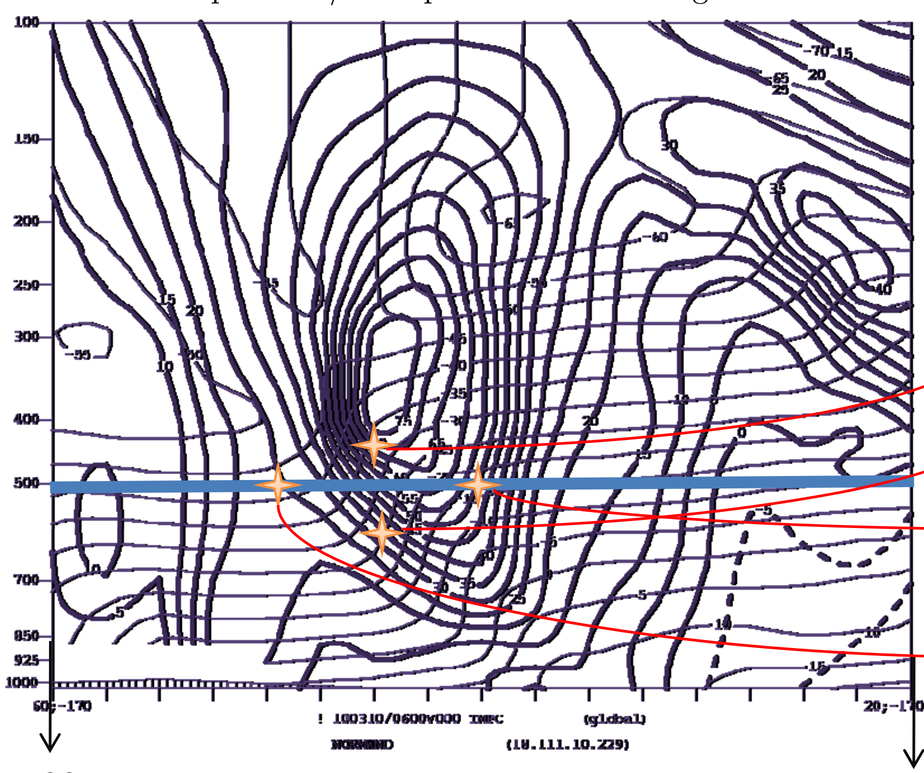
$$f = 1.454 \times 10^{-4}$$

T_{mean}

vertical wind shear about a pressure isobar

horizontal temperature difference across the frontal surface

a temperature/wind plot of the -170 longitudinal



500 mb is often the most convenient, "de facto" pressure level for viewing these interactions.

$v_1 = 70$ m/s

$v_2 = 35$ m/s

$T_1 = -18^oC$
255K

$T_2 = -37^oC$
236K

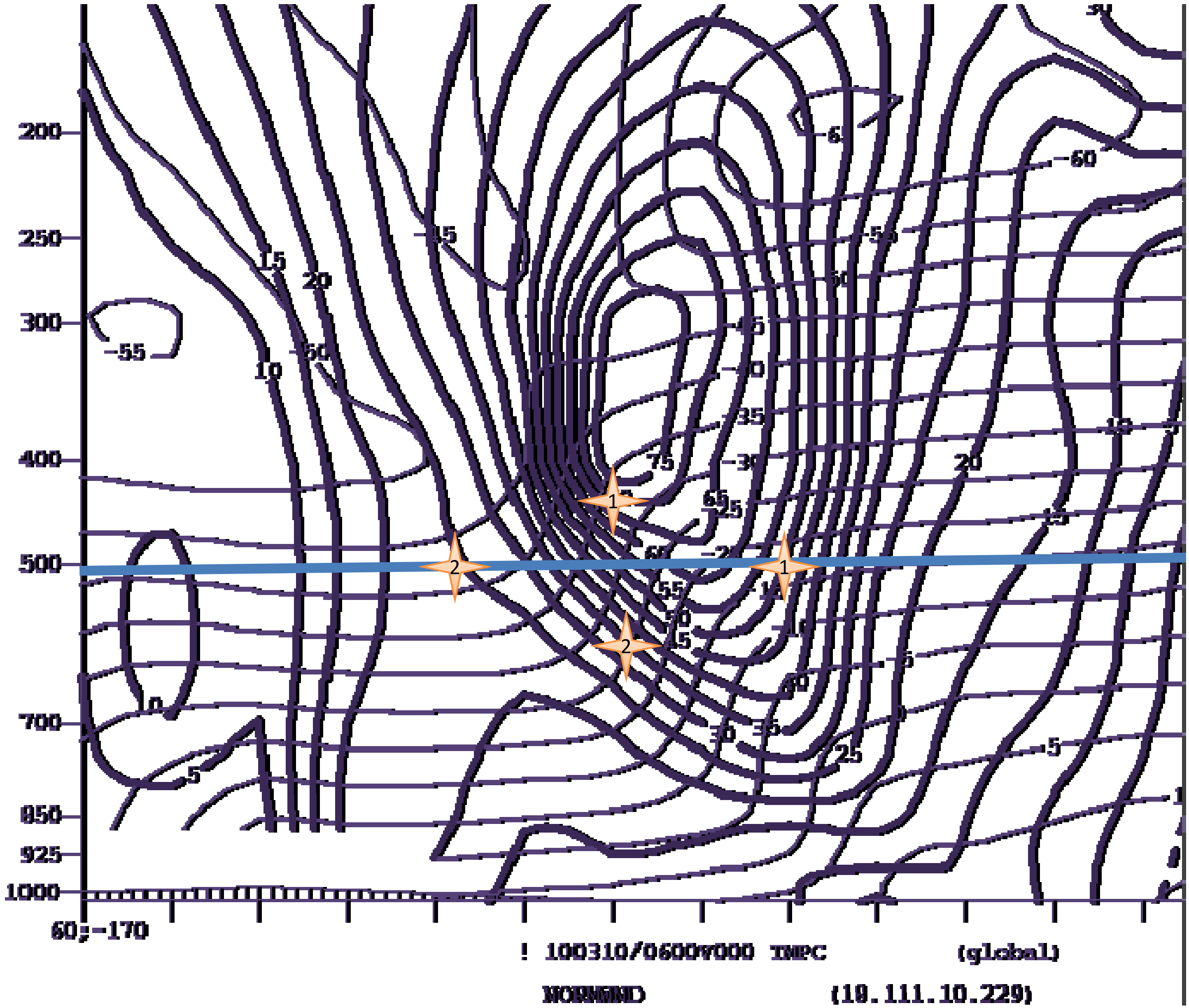
60

40 degrees latitude / 16 graphical increments = 2.5 degrees per increment (useful later)

20

$T_{mean} = 245.5$

A closer version of this graph with visible data labels is available on the following page.



$$\tan(y) = \frac{f\,(v_2 - v_1)}{g(T_1 - T_2)\,/\,T}$$

$f = 1.454 \times 10^{-4}$

$v_2 = 35$ m/s

$v_1 = 70$ m/s

$T_1 = 255$K

$T_2 = 236$K

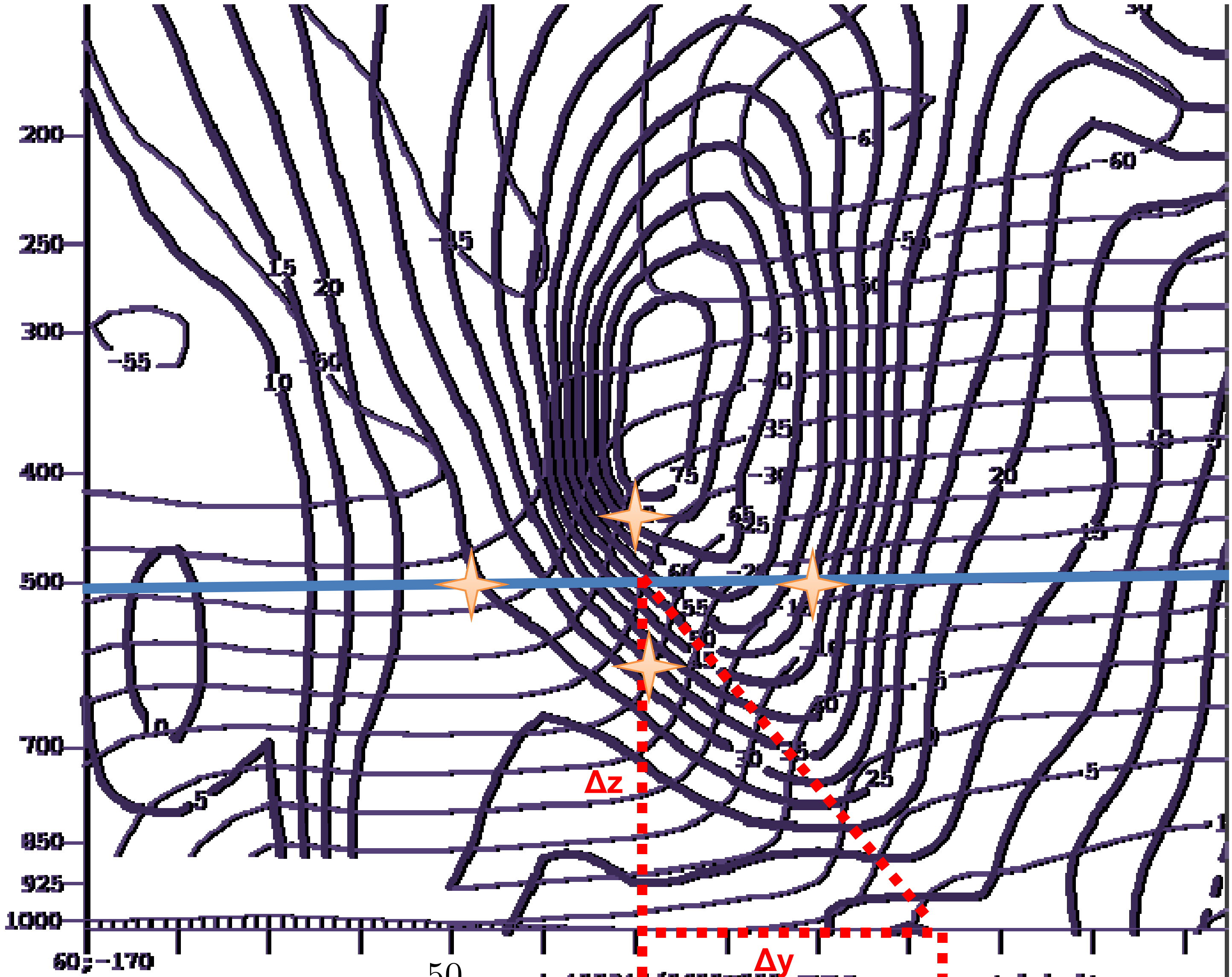
$T_{mean} = 245.5$

$$\tan(y) = \frac{(1.454*10^{-4}) * (35)}{(9.8)(19)\,/\,(245.5)}$$

$$\tan(y) = \frac{(1.454*10^{-4}) * (8592.5)}{(186.2)}$$

$$\tan(y) = (1.454*10^{-4}) * (46.15)$$

$$\tan(y) = 0.0067$$



We may check the quality of our theoretically approximated slope with the atmospheric plot. Unlike the experiments in the lab, we cannot do this with visual methods, because the plot is drastically skewed relative to the actual distribution of air on earth; appropriate scaling of the latitude distances relative to the actual thickness of the atmosphere would be an impractical aspect ratio to attempt study.

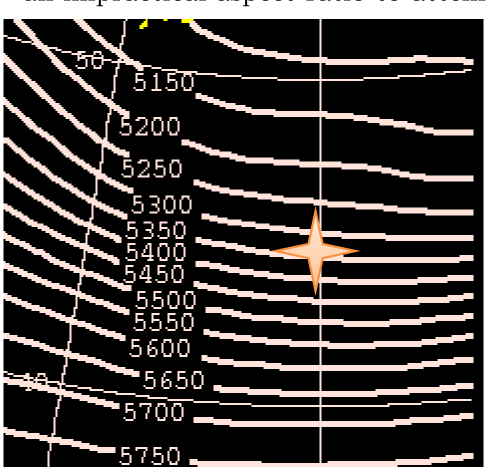
3.3 increments
* 2.5 degrees [latitude]/ inc =
8.25 degrees
* 110 km / degree =
907.5 km = Δy

@170° longitude, 45° latitude:
z = 5350m = 5.35 km

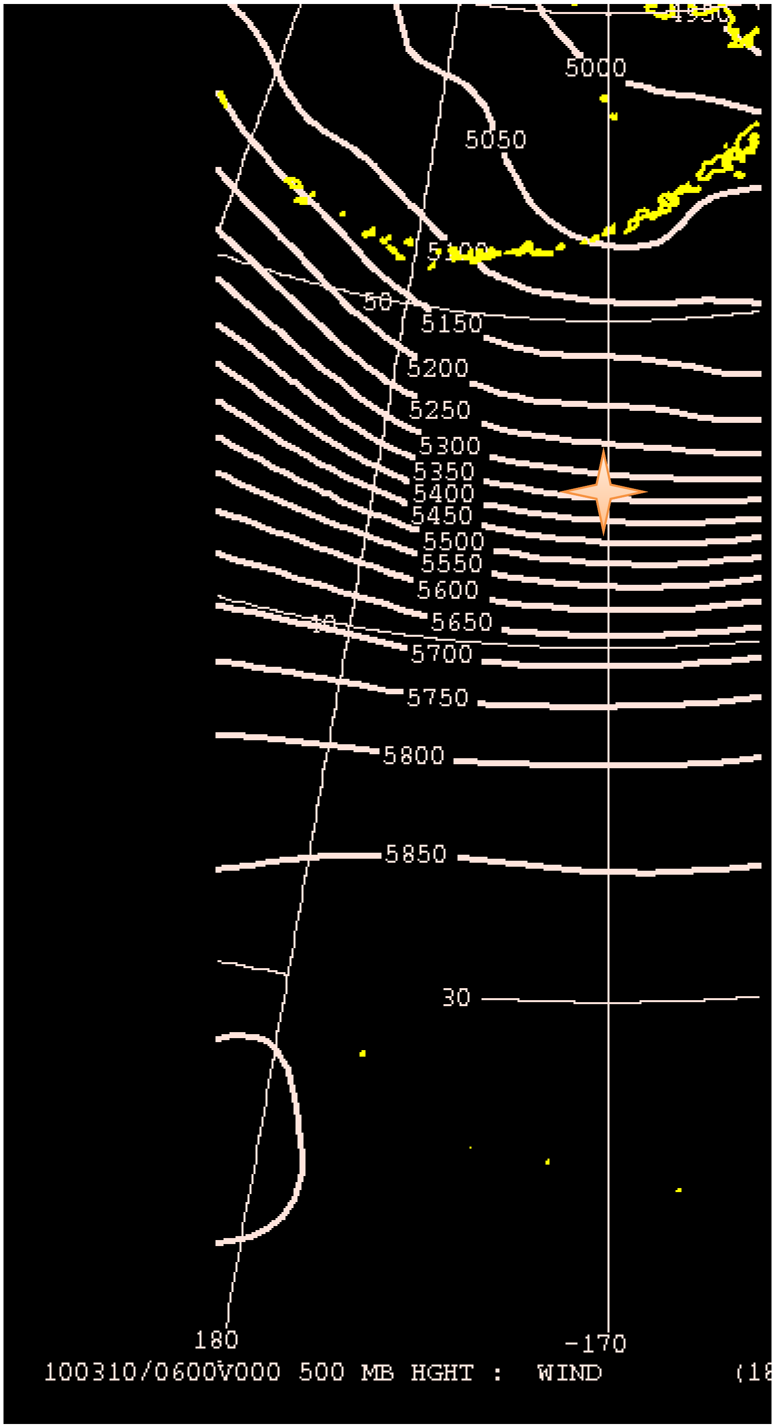
$$\frac{\Delta z}{\Delta y} = \frac{5.35}{907.5} = 0.0059$$

0.0059 / 0.0067 = 0.88
0.0067 / 0.0059 = 1.13

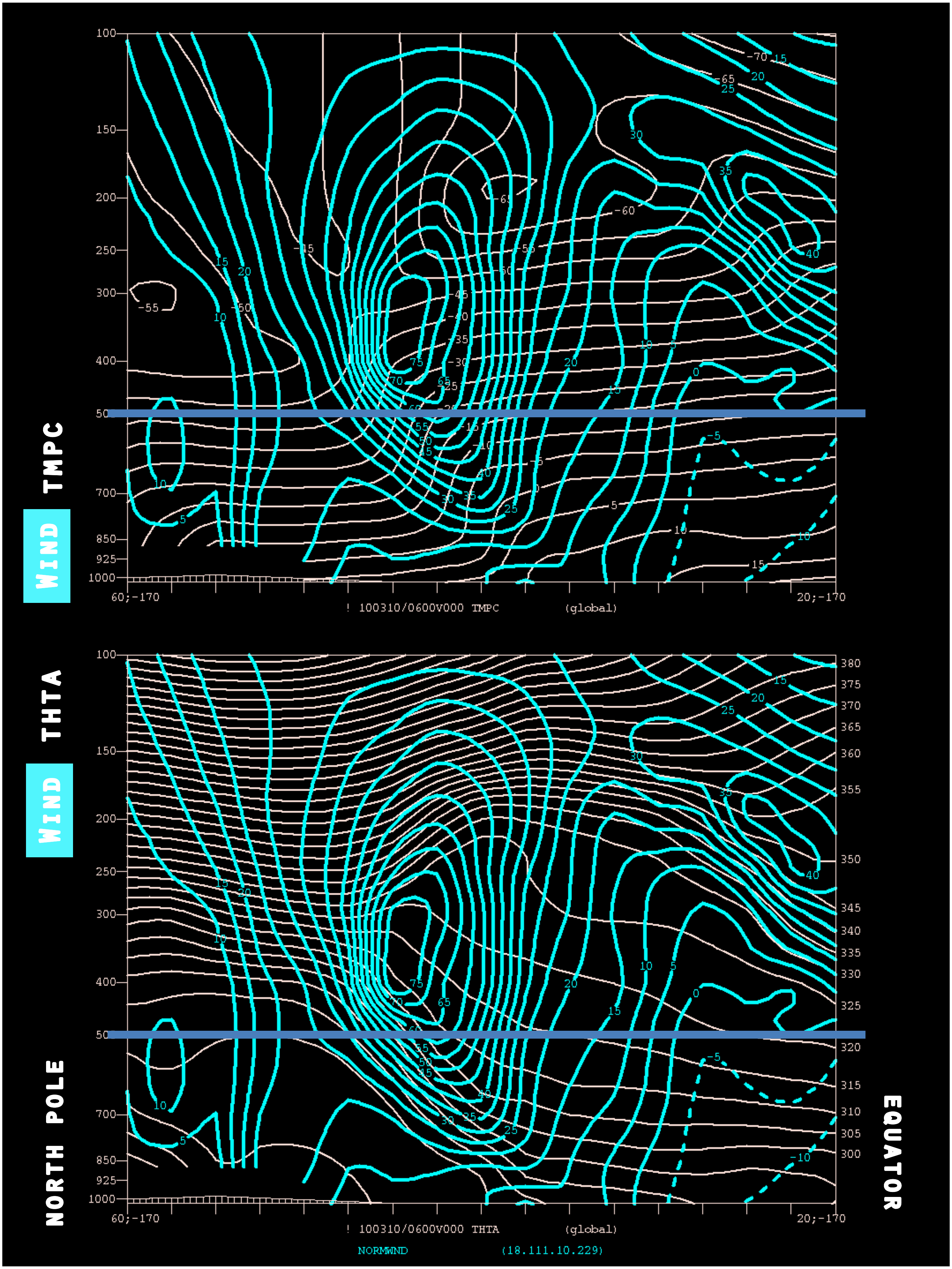
a match within ~ 12.5 %



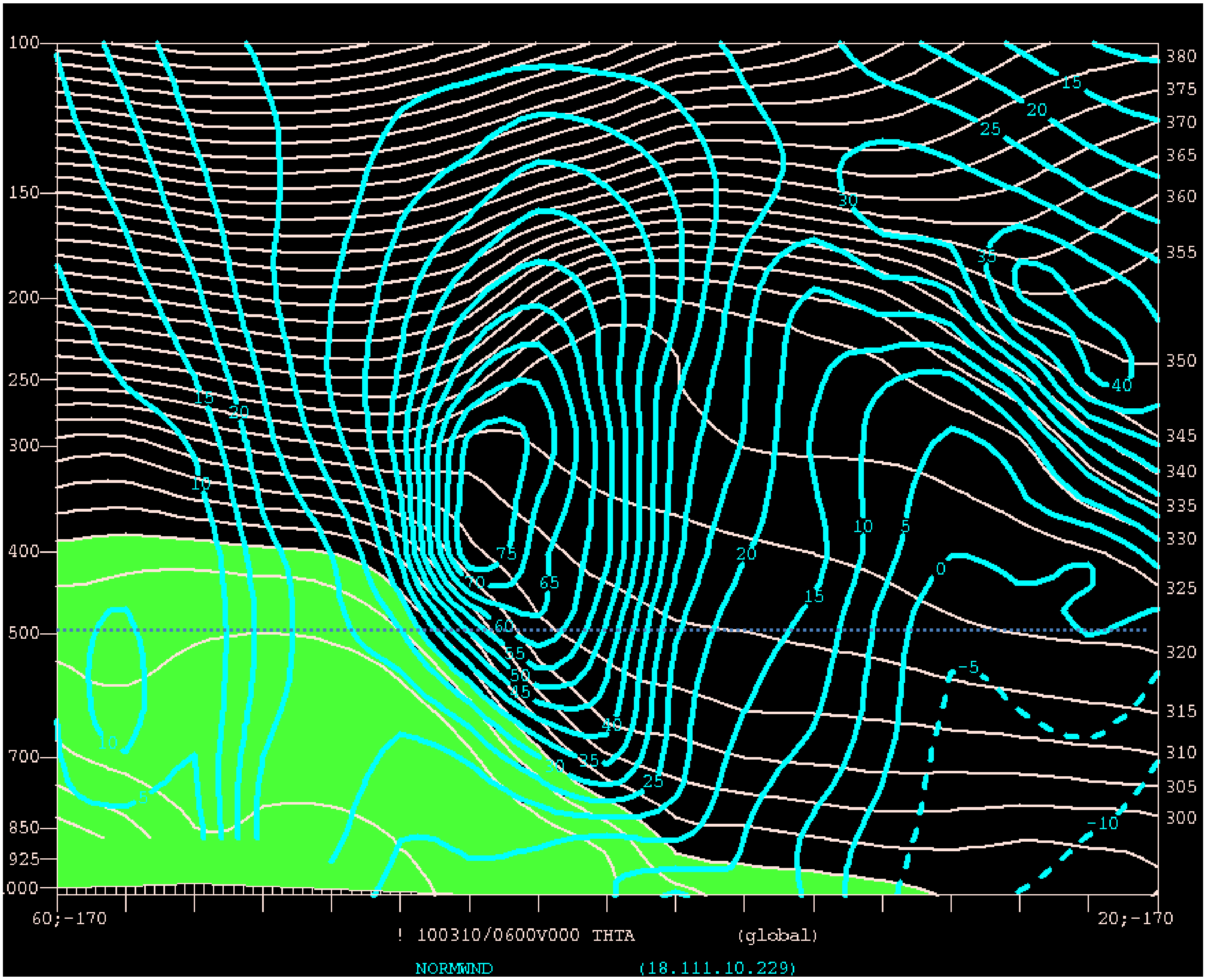
Once again, a larger version of this graph is on the following page.



This plot shows the height of the 500 mb pressure surface for the displayed latitudes and longitudes. Since the point about which we measured our horizontal temperature difference & vertical velocity difference was @ -170W, 45N, this position is marked and the height is used in an in-atmosphere tangential slope calculation.



WIND TMPC
WIND THTA
NORTH POLE
EQUATOR
60;-170
20;-170
! 100310/0600V000 TMPC (global)
! 100310/0600V000 THTA (global)
NORMWND (18.111.10.229)



A graph of air's potential temperature will more clearly display the sort of temperature w.r.t. density relationship that is exhibited in the dome of denser fluid formed during our controlled, constrained tank experiments.

Viewing direct plots of temperature over the -170 longitude, we observe that the area of greatest wind shear occurs in direct relation to where the temperature gradient is steepest.