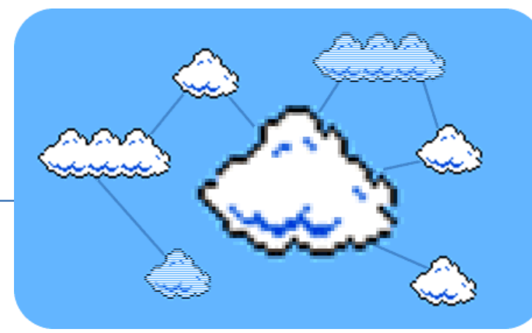


THEORY

MODELS

OBSERVATIONS

ENVIRONMENTS

CONVECTION

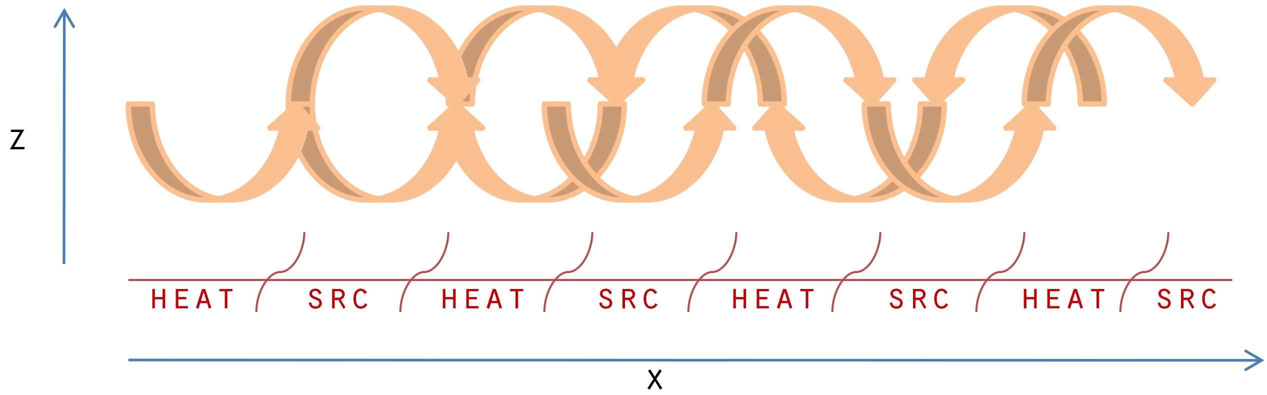
TANK:ONE 2

ATMOS:ONE 3

TANK:TWO 1

ATMOS:TWO 4

WHAT IS THE NATURE OF THE CONVECTIVE PROCESS?

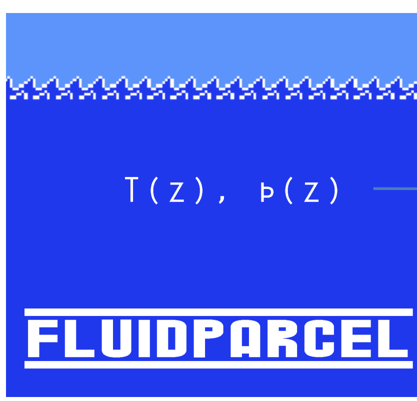


OVERTURNING OF A FLUID
(X-SCALING DEPENDENT ON UNSTABLE LAYER'S Z-DEPTH!)

TWO MEDIUMS FOR THE CONVECTIVE PROCESS

FIRST: *INCOMPRESSIBLE CASE*

DENSITY INDEPENDENT OF PRESSURE
DENSITY DEPENDENT ON TEMPERATURE



$\rho = \rho_{ref}(1 - \alpha T)$

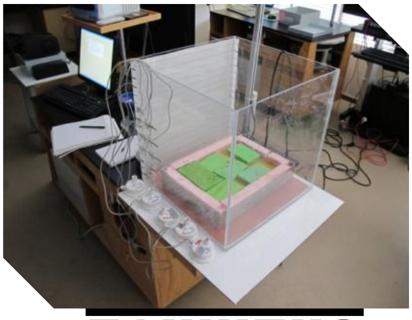
Z_0

COMPRESSIBLE CASE

AN INITIALLY STABLY STRATIFIED FLUID

CONVECTION SETUP

OBSERVER RECORDS
- THERMOCOUPLES (4)
- HUMAN -TRANSCRIPT-
- CAMERA [VIDEO]



TANK:TWO

heat on @ 4:10

FILLING TANK

∞ HEATING

FILLING TANK

(stratified temperatures)

- OVERFILL for diffuser displacement
- INCREMENT 8 & 9 | 44º | sensor 5 submerged
- INCREMENT 7 | 42º |
- INCREMENT 6 | 40º | sensor 4 submerged
- INCREMENT 5 | ~37º | sensor 3 quickly submerged
- INCREMENT 4 | ~34º | sensor 3 [duct3] touches water
- INCREMENT 3 | 31º |
- INCREMENT 2 | 29º | sensor 2 [E] submerged
- INCREMENT 1 | 26.5º |
- INCREMENT 0 | 24º | sensor 1 [5/S] half-submerged

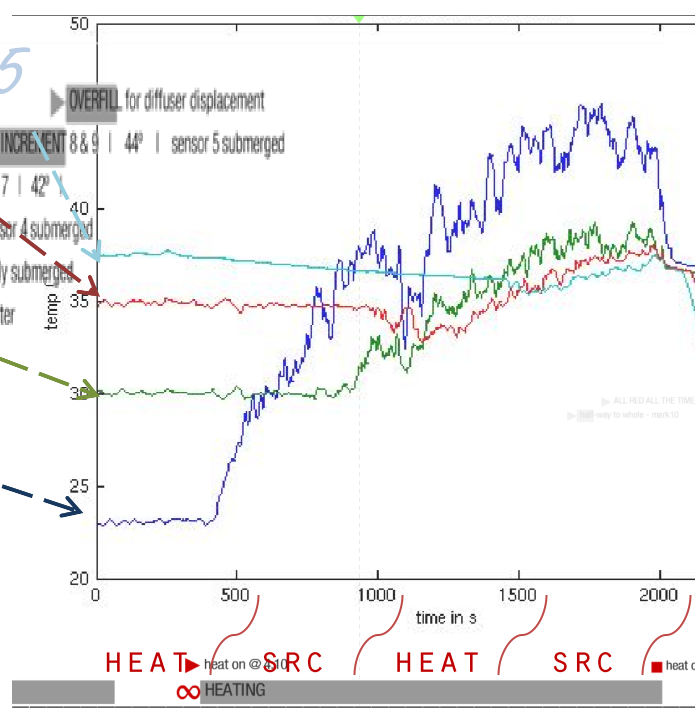
FILLING + HEATING TANK

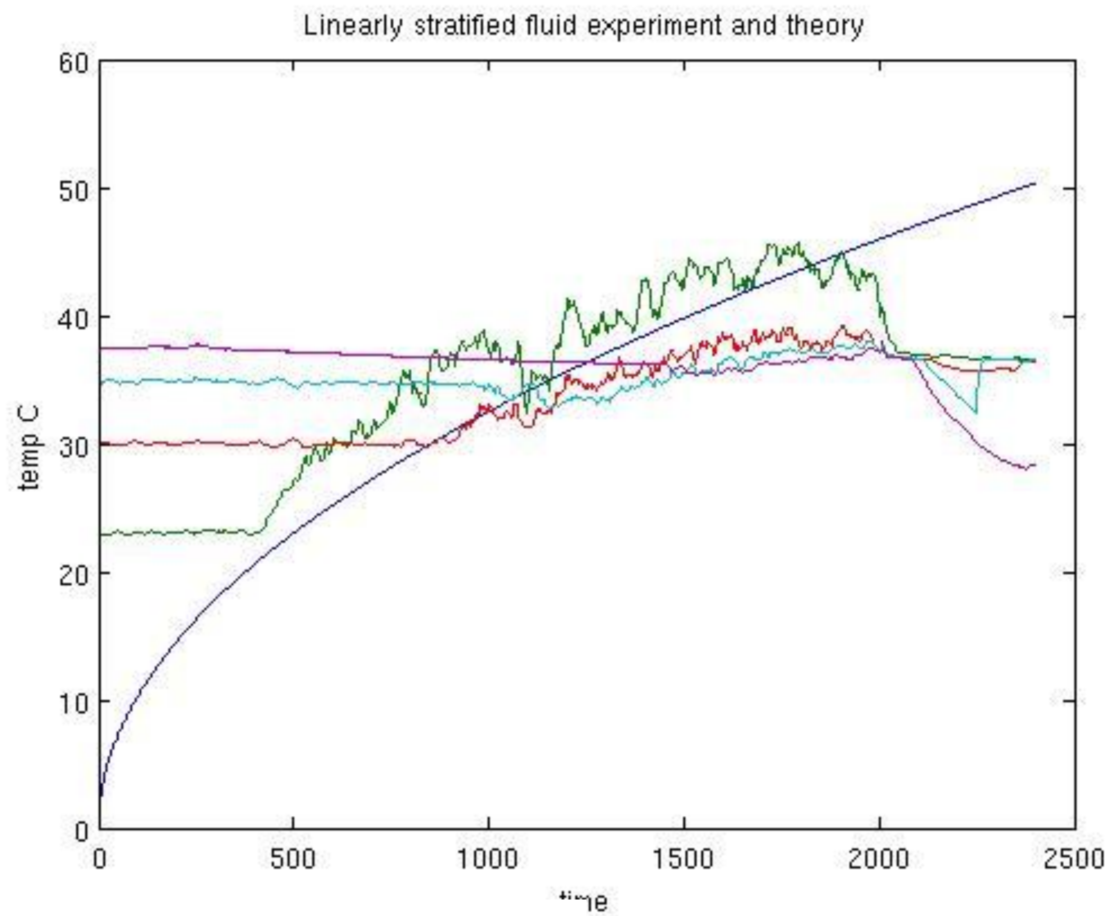
thermocouplers

- OVERFILL for diffuser displacement
- INCREMENT 8 & 9 | 44º | sensor 5 submerged
- INCREMENT 7 | 42º |
- INCREMENT 6 | 40º | sensor 4 submerged
- INCREMENT 5 | ~37º | sensor 3 quickly submerged
- INCREMENT 4 | ~34º | sensor 3 [duct3] touches water
- INCREMENT 3 | 31º |
- INCREMENT 2 | 29º | sensor 2 [E] submerged
- INCREMENT 1 | 26.5º |
- INCREMENT 0 | 24º | sensor 1 [5/S] half-submerged

5 4 3 2

1 (no data)





$$h = \left(\frac{2\mathcal{H}t}{\rho c_p \overline{\overline{T}}_z}\right)^{\frac{1}{2}}$$

From this, we may claim $h \propto t^{1/2}$

height of convective layer should be proportional to the square root of time

we could attempt proof of this in a variety of ways.

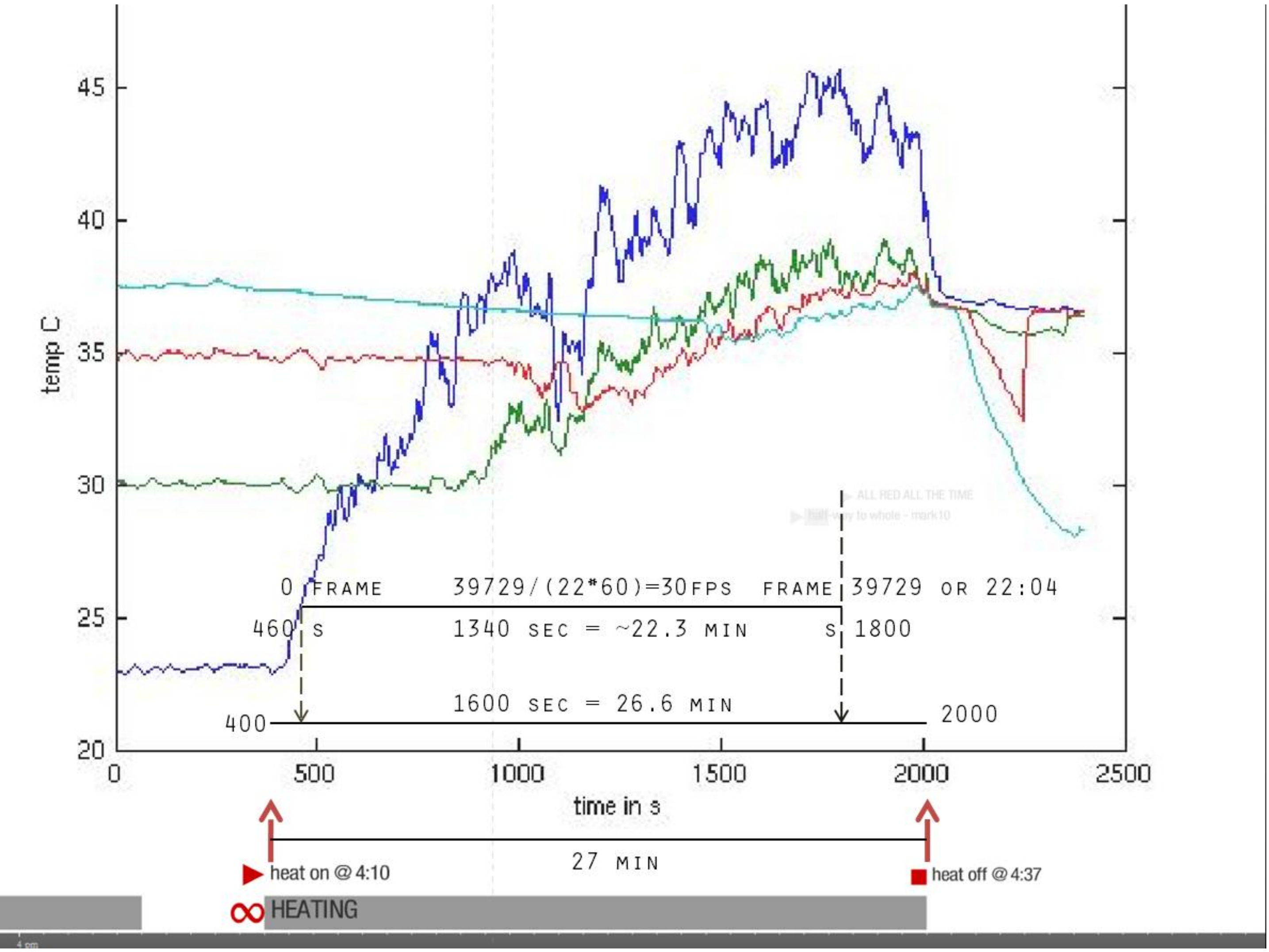
$h^2 \propto t$ $\qquad \ln[h] \propto (1/2)\ln[t]$ $\qquad \frac{dh}{dt} \propto \frac{1}{2} t^{-1/2}$

let's work with the first, arguably the simplest to check.

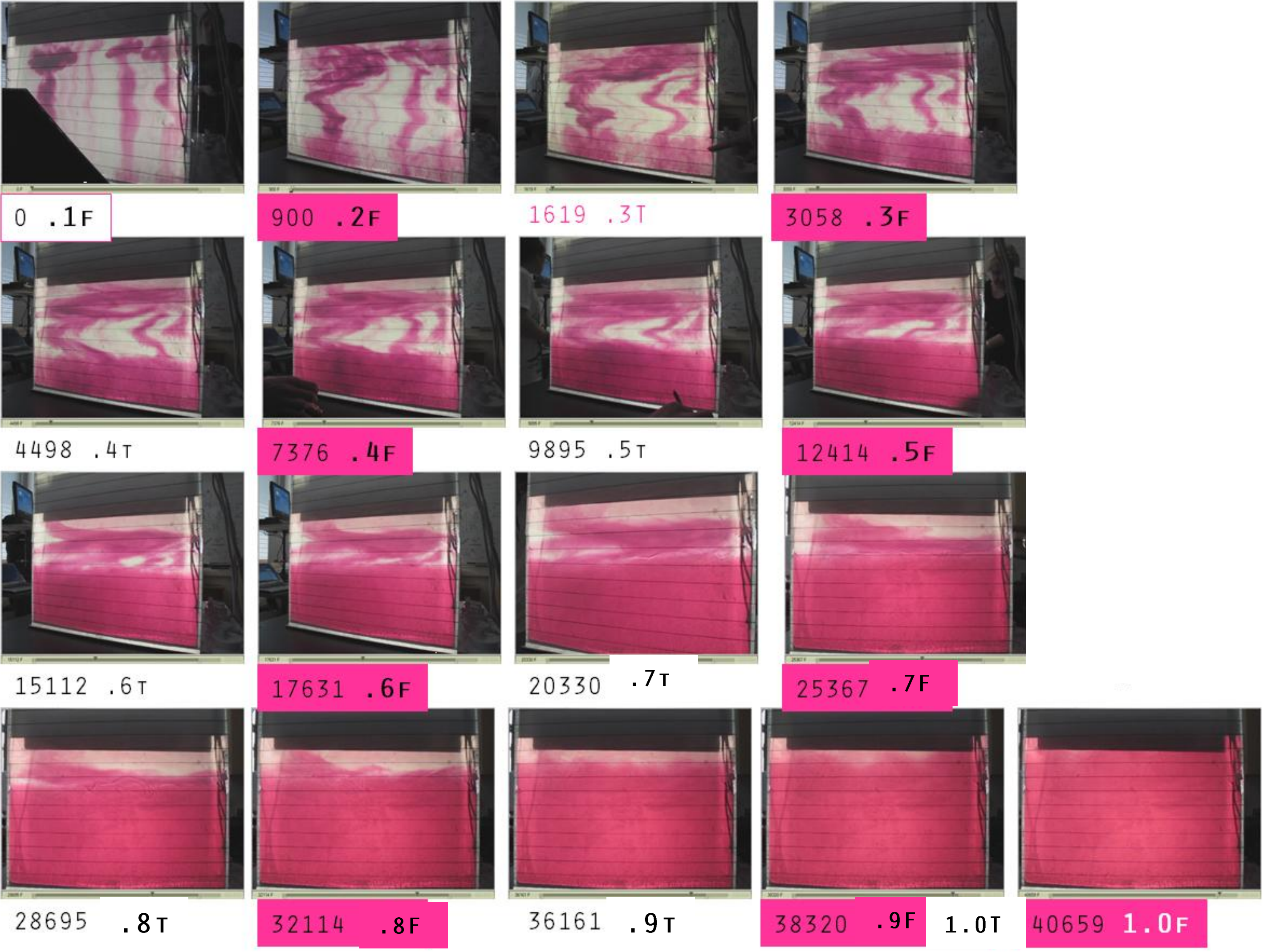
the logarithm route was often taken in class.

Logarithm / power relationship would give us a direction constant of proportion-ality, that a linearization might not have with it's y-intercept?

let's work with the first, arguably the simplest to check.



TIME CALIBRATION OF VIDEO LOGS
WITH HUMAN TRANSCRIPT & THERMOCOUPLE LOGS



SIGNIFICANT VIDEO FRAMES OF CONVECTION IN A TANK WITH LINEARLY STRATIFIED TEMPERATURE.

"F" **OR PINK** TAGS TELL WHEN A HEIGHT MARKER HAS BECOME ENTIRELY **FILLED** (LIKELY OR SOON TO BECOME "NEUTRALIZED") BY THE CONVECTIVE PROCESS.

FRAME(F#) HEIGHTMRK(.H)

"T" **OR WHITE** TAGS TELL WHEN A HEIGHT MARKER BEEN **TOUCHED** (BY BUOYANTLY RISING & PROMPTING INVERTING PLUMES) BY THE CONVECTIVE PROCESS.

FRAME(F#) HEIGHTMRK(.H)

LEADINGLAG@F#G ” H%

When fit with a regression, the dataset so formulated will give a relation in strange unit: %^{2} of water's height / frame

this can be converted into cm or m/s, but this is unnecessary in determining whether the two numbers are proportionally related. This is where I realize logarithms might have been a safer bet for proving the propto

	≤ 0	10	≤ 0	
450				900
	~450 (Interpolated, not recorded)	20	900	
1169				2158
	1619	30	3058	
2879				4318
	4498	40	7376	
5397				5038
	9895	50	12414	
5217				5217
	15112	60	17631	
5218				7736
	20330	70	25367	
8365				6747
	28695	80	32114	
7466				6206
	36161	90	38320	
2159				2339
	38320	100	40659	

Late start in video capture + immediacy of convection next to heat source suggests setting a lower bound on data set will give the most accurate fit

Between marks 5 and 6, the buoyant plumes and the convection's neutralization rose at the same rate

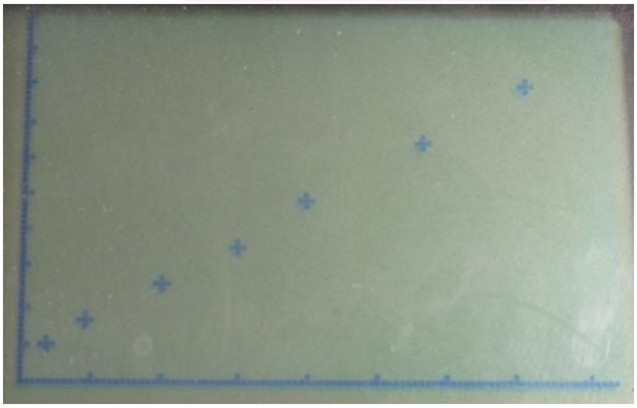
Similar threshold effects make removing our datasets endpoints an appealing option for confirming the proportionality of the process' operation

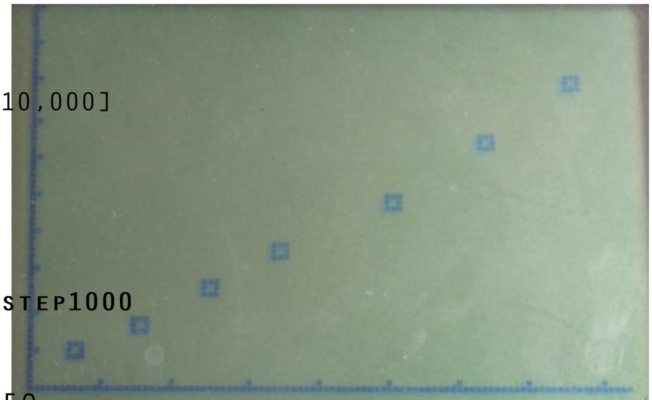
If the height is related to the square root of time, if we square our height, we should get a linear relationship between that & the frame number that implies they are proportionally related to each other.

There are obviously some subtleties in the fluctuating rates of the convective layer and its rising plumes that would warrant deeper investigation through calculus methods.

DATASET 2
"TOUCHING/
LEADING"

DATASET 1
"FILLING/
LAGGING"

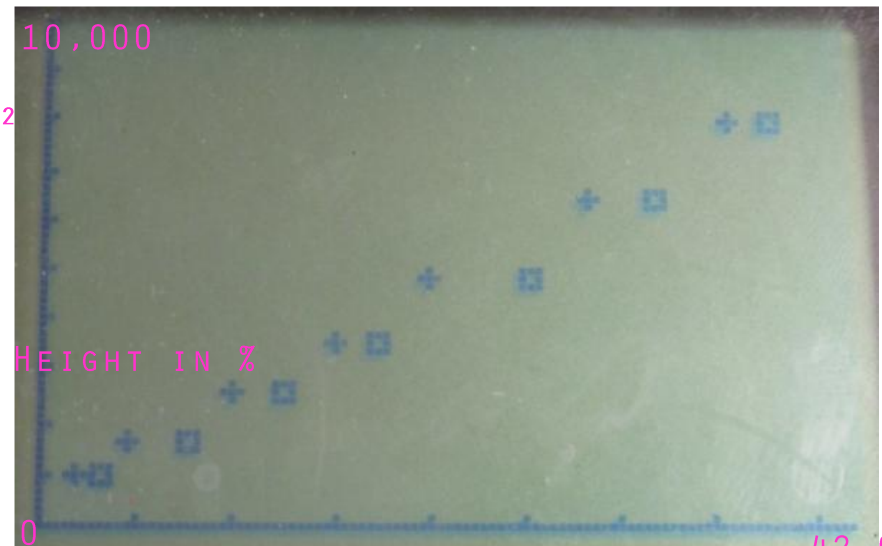




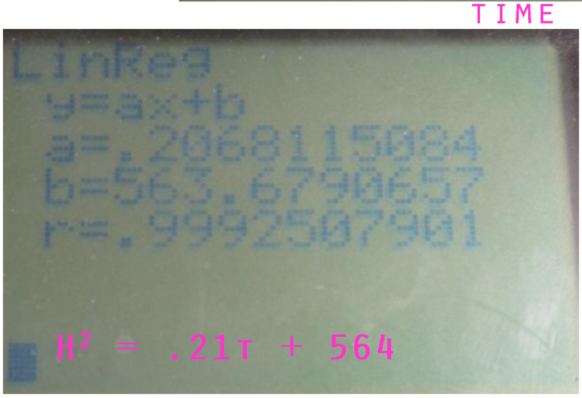
Y: H%² = {900, 1600, 2500, 3600, 4900, 6400, 8100}

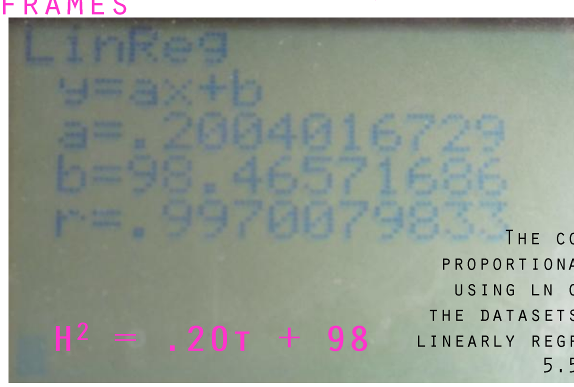
[0 STEP5000 42,000]

X: F# = PLOT [DATASET2,1]



TIME IN FRAMES 42,000





THE CONSTANT OF PROPORTIONALITY WHEN USING LN ON BOTH OF THE DATASETS AND THEN LINEARLY REGRESSING IS 5.58 * [1/2] = 2.79 WITH A +C OF -2. THE R VALUE FOR LN IS .992

$h^2 = .20t + C$ h α .45SQRT(t)

R VERY CLOSE TO 1 TELLS THAT THE POINTS ALIGN VERY, VERY CLOSELY ALONG A LINE. THE LEADING BUOYANT PLUME IS A LITTLE "MORE LINEAR" BUT THIS IS HARD TO EXTEND INTO A GENERAL PRINCIPLE BECAUSE OF THE ACCURACY OF OUR INITIAL FRAME SELECTION AND HOW "FILLED" A FILLED LAYED MUST APPEAR. YOU MIGHT SAY THAT THE PLUMES ARE GUIDING OR BUILDING THE ADVANCEMENT OF THE FILLED LAYER; IN ADDITION, IT IS EASIER TO SEE THE "FIRST CONTACT" VERSUS "GENERALLY FILLED" BEING MUCH MORE SUBJECTIVE QUALIFIER.

FRAMES

0

VIDEO

15000
+500s

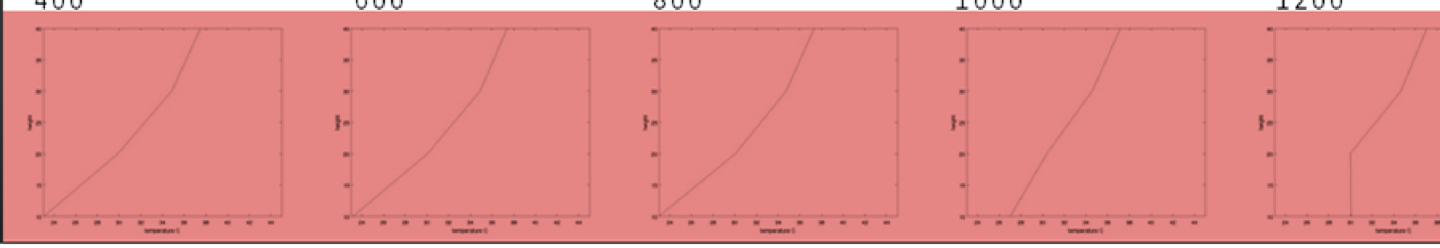
20000
+666s

400 580 760 940 1120

SECONDS

Temperature profiles

400 600 800 1000 1200

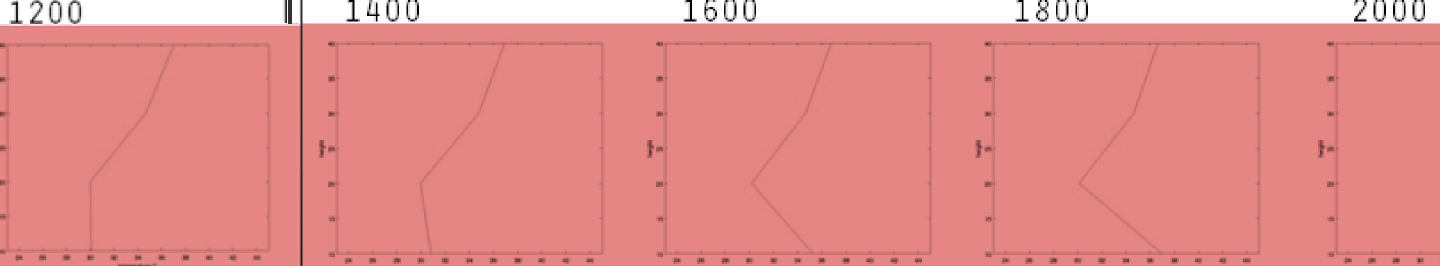


Initially we see that the temperature profile of the tank is stable—this is a result of deliberate care putting layers of increasingly warm water through a diffuser to prevent them from mixing due to disturbance. this is the linear stratification of the tank, it is a confirmed to be a stable conformation because $dT/dz > 0$

By 1200 seconds, we can see the convection has proceeded, overtaking at least visually the 6 lowermost vertical markers tankside [.6F or 60% using the invented notation] In the profile, the neutrality in the convective layer can be observed where $dT/dz = 0$. This neutrality ends about one third of the overall profile, before it becomes stable where $dT/dz > 0$. this is interesting, as it suggests the neutralizing effect may, at times, only cue us into half of the phenomena's total active span.

1300 1300 1480 1660 1840

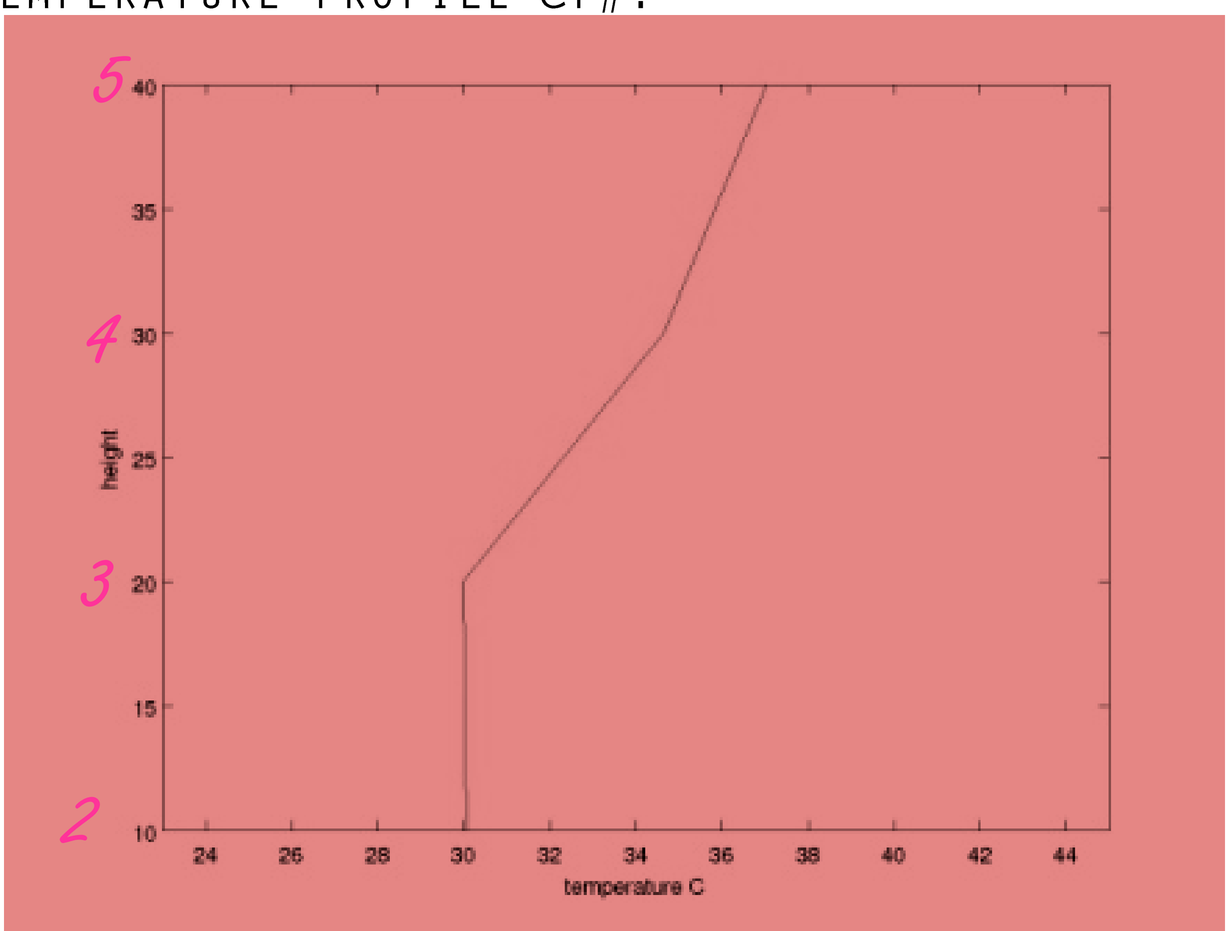
1200 1400 1600 1800 2000



VIDEO @F#: 1120 1300

CLOSER ANALYSIS OF THE GRAPH SHOWS THAT OUR PRIOR ASSUMPTION WAS INCORRECT. THE GRAPH STARTS AT 10 CM, SO THE PLOT WINDOW IS CONCEALING HALF OF THE CONVECTIVE LAYERS NEUTRALIZATION. THIS IS MUCH MORE IN LINE WITH WHAT WE ARE OBSERVING IN VIDEO TO THERMOCOUPLE RELATION.

TEMPERATURE PROFILE @F#: 1200



14s/4.5bars
= 3.11 s/bar

13.9 or ~14s

416f avg

Avg ht 4.5 unit

325 425 400 400 430 512 440 413 395 380 450 450 390 5410/13

Between 15000 – 20000, took 13 measurements of frames for a convection plume to rise

15000
+500s

20000
+666s

760 940 1120 1300

Law of vertical heat transport.

$$H = \rho c_p w T$$

Research stub.

H = 1600W
W = .32 bars / second
height of a bar = ~5cm
T obtainable from graph on prior page.
.

ENVIRONMENTS

ATMOS:ONE 3

COMPRESSIBLE CASE

THEORY

MODELS

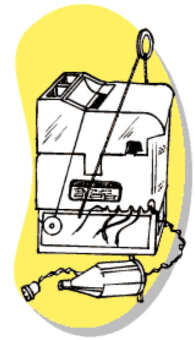
OBSERVATIONS

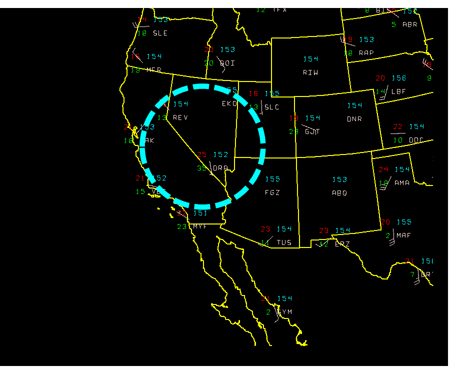
CONVECTION

OBSERVER RECORDS

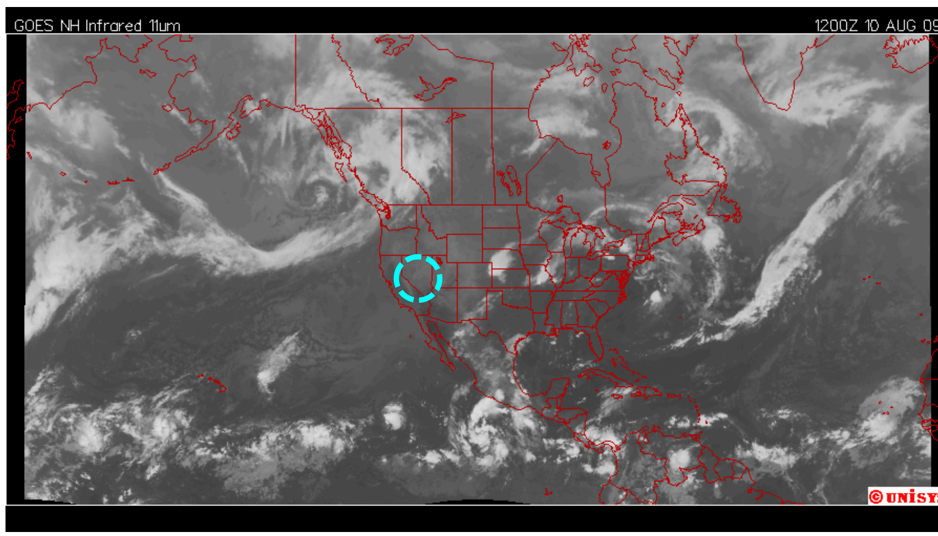
SATELLITES

RADIOSONDES

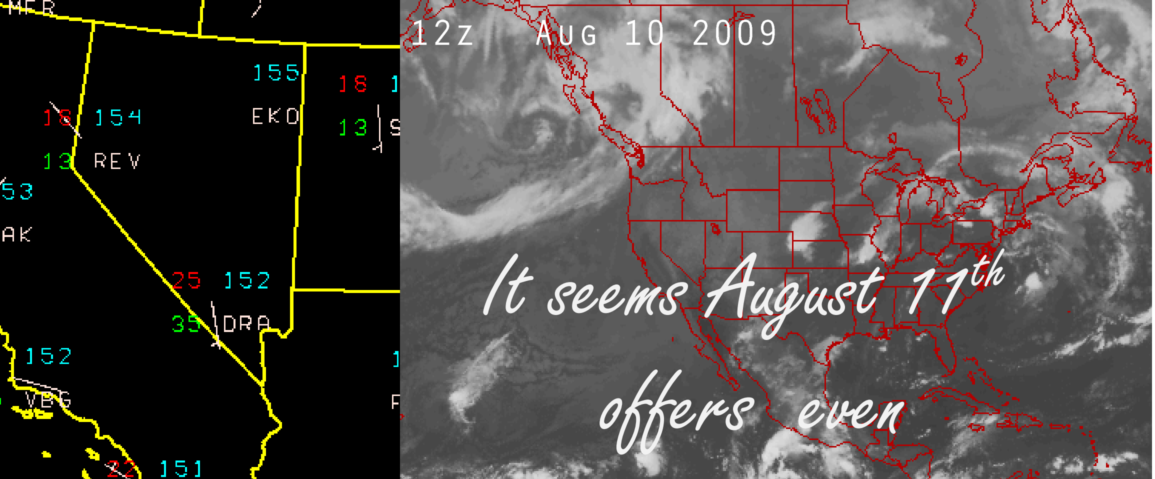




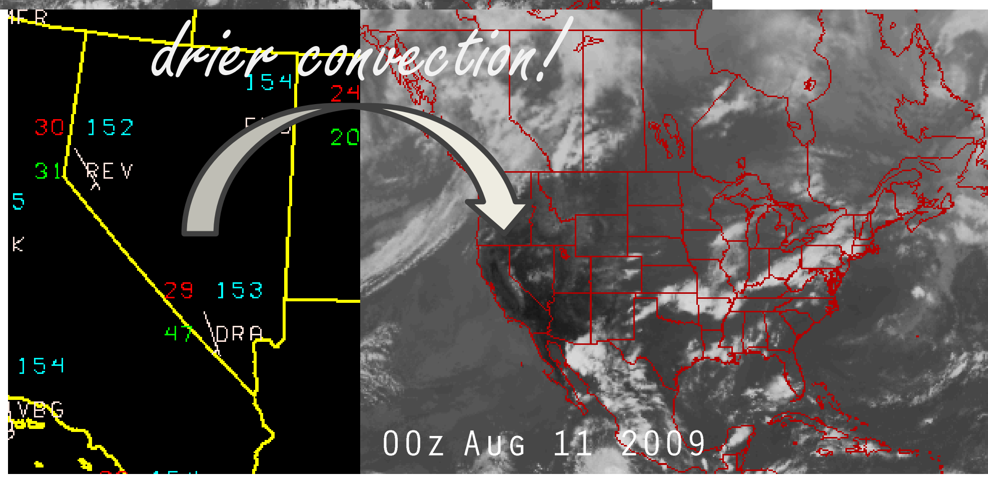
WE SEEK DRY AIR CONVECTION, AS MOISTURE IN THE AIR ADDS AN ADDITIONAL LEVEL OF COMPLEXITY

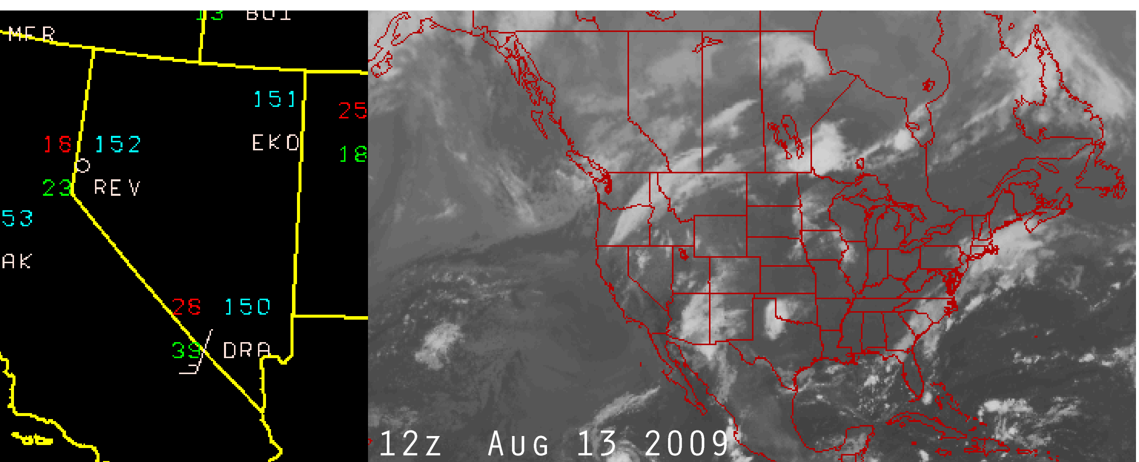


Water vapor imagery confirms very little moisture in the southwest on August 10, 2009.

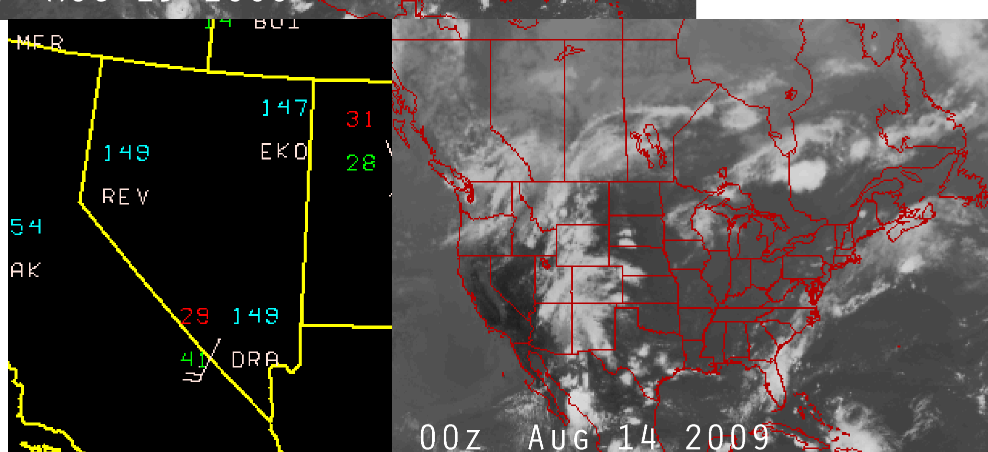


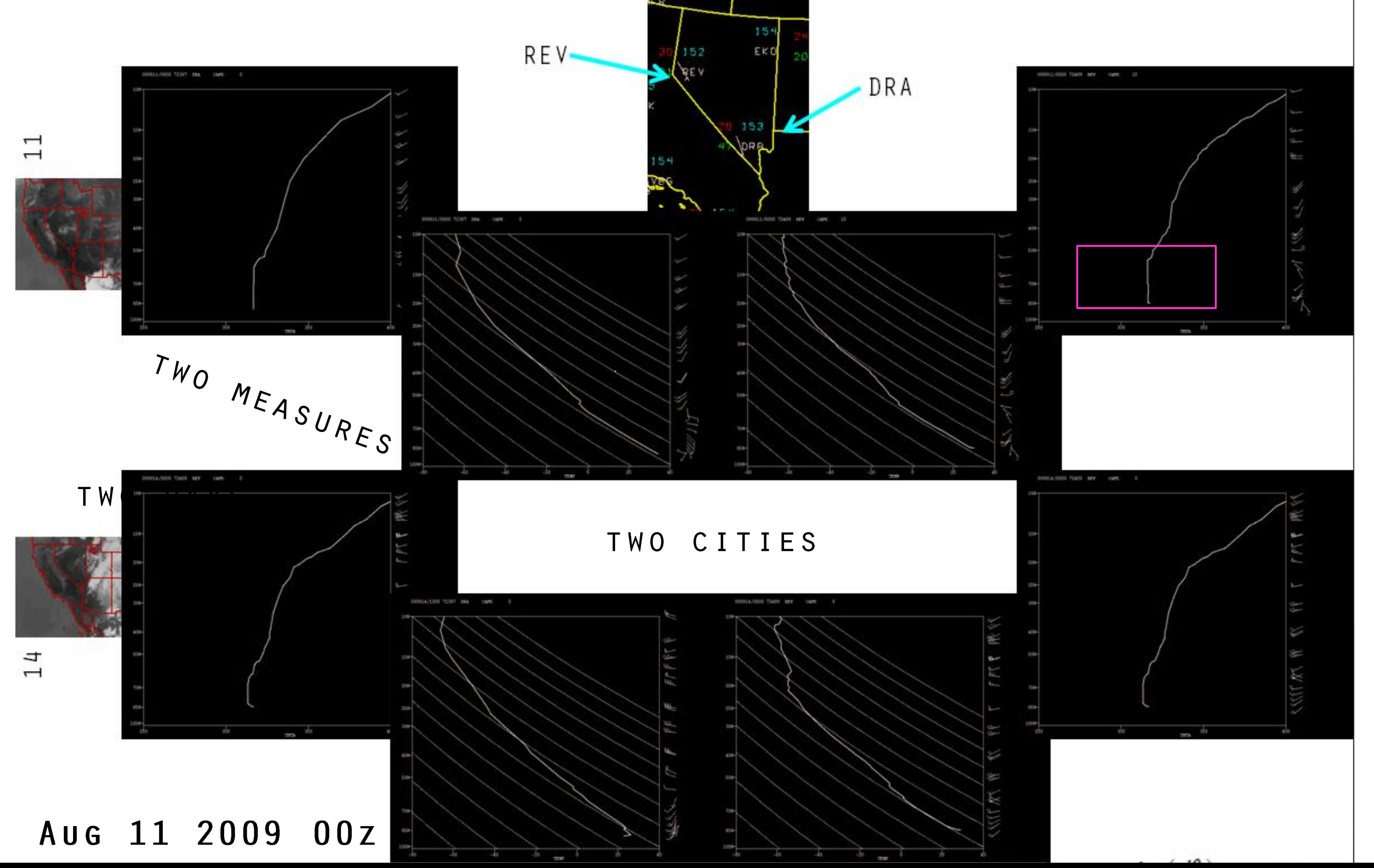
It seems August 11th offers even drier convection!

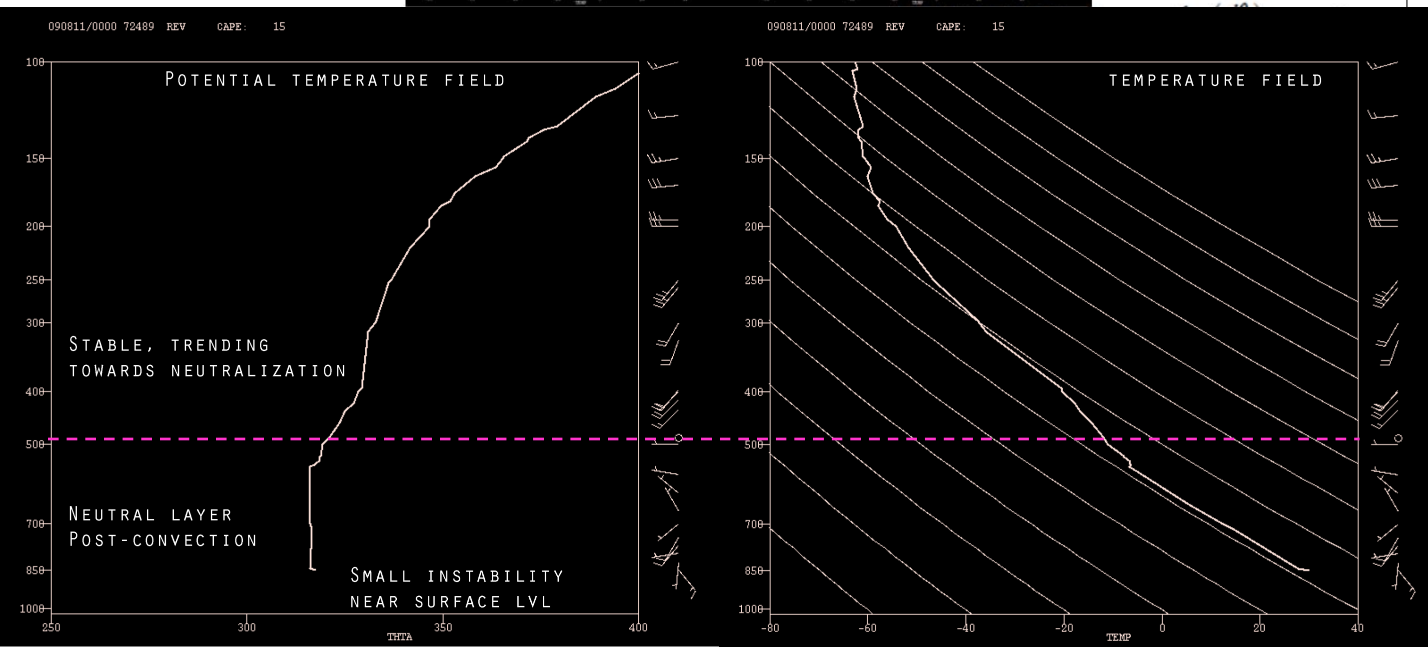




14 LOOKS DRY, BUT ALSO CLOSE TO A WEATHER SYSTEM. QUICK STUDY OF WHICH OFFERS THE BETTER EXAMPLE OF CONVECTIVE NEUTRALIZING

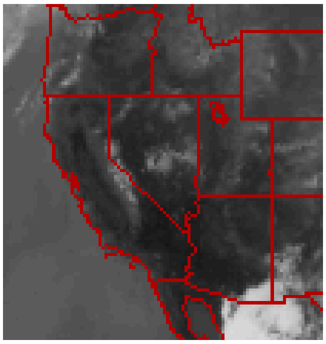


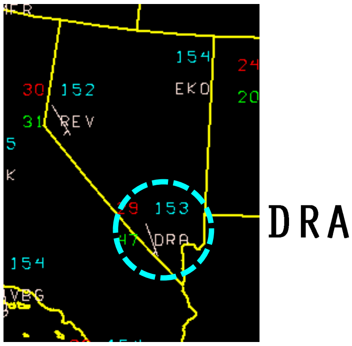




$$\theta = T\left(\frac{p_0}{p}\right)^{\kappa}$$

$$\left.\begin{array}{c}\text{UNSTABLE}\\ \text{NEUTRAL}\\ \text{STABLE}\end{array}\right\}\ \text{if}\ \left\{\begin{array}{l}\left(\frac{d\theta}{dz}\right)_E < 0\\ \left(\frac{d\theta}{dz}\right)_E = 0\\ \left(\frac{d\theta}{dz}\right)_E > 0\end{array}\right.$$





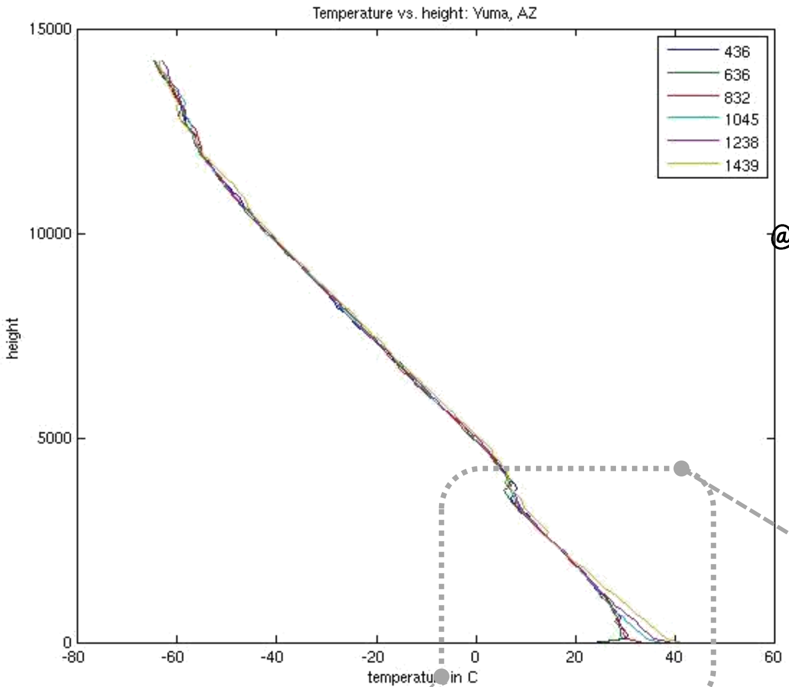
ENVIRONMENTS

ATMOS:TWO 4

OBSERVER RECORDS — TIMES

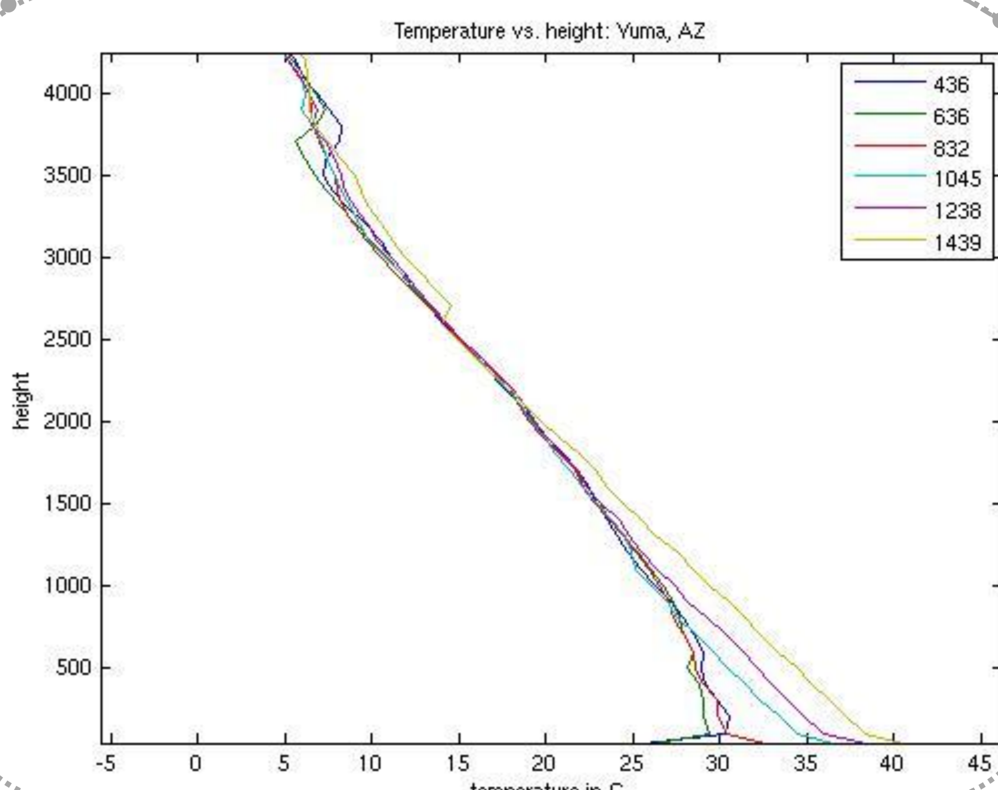
RADIOSONDES (6)

1136Z
1336Z
1532Z
1745Z
1938Z
2139Z

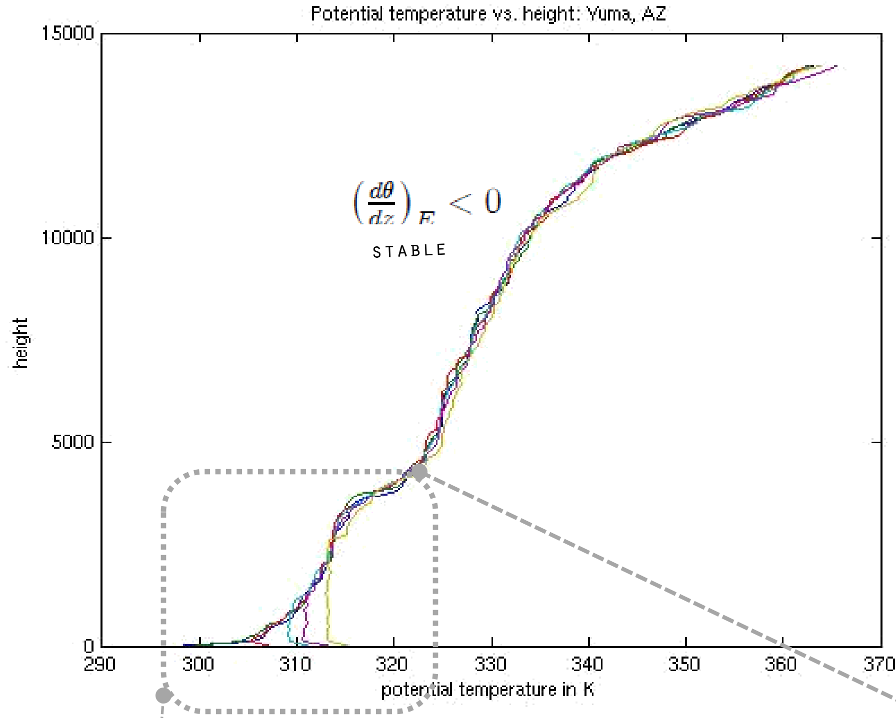


@ YUMA, ARIZONA
JUNE 18, 2007 — GMT -7

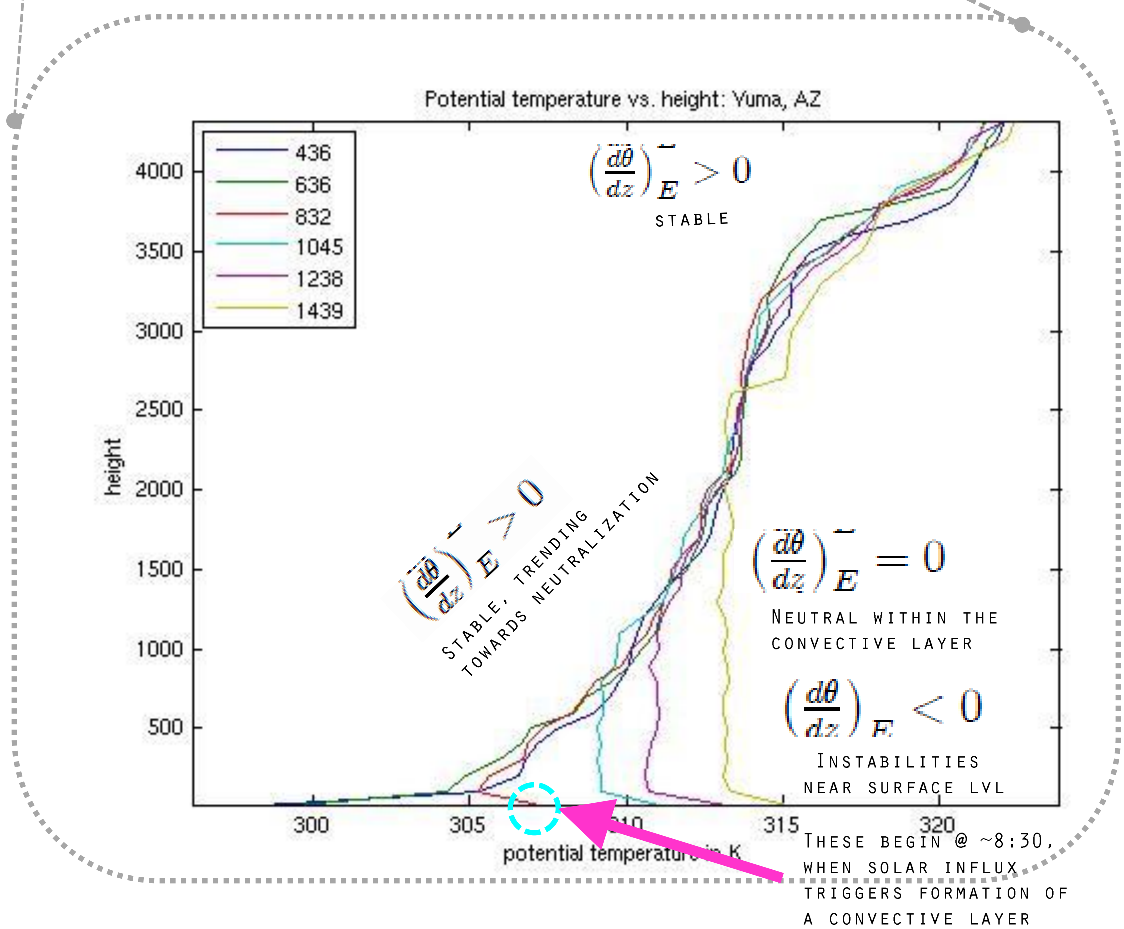
AS WE MIGHT EXPECT, THE TEMPERATURE AT THE SURFACE INCREASES THROUGHOUT THE DAY FROM MIN~25 TO MAX~40 DEGREES C. BUT THIS TELLS US VERY LITTLE ABOUT THE PROGRESSION OF THE CONVECTIVE BOUNDARY LAYER THROUGHOUT THE DAY.



VERTICAL PROFILES OF **TEMPERATURE** FOR SIX RADIOSONDE RELEASES



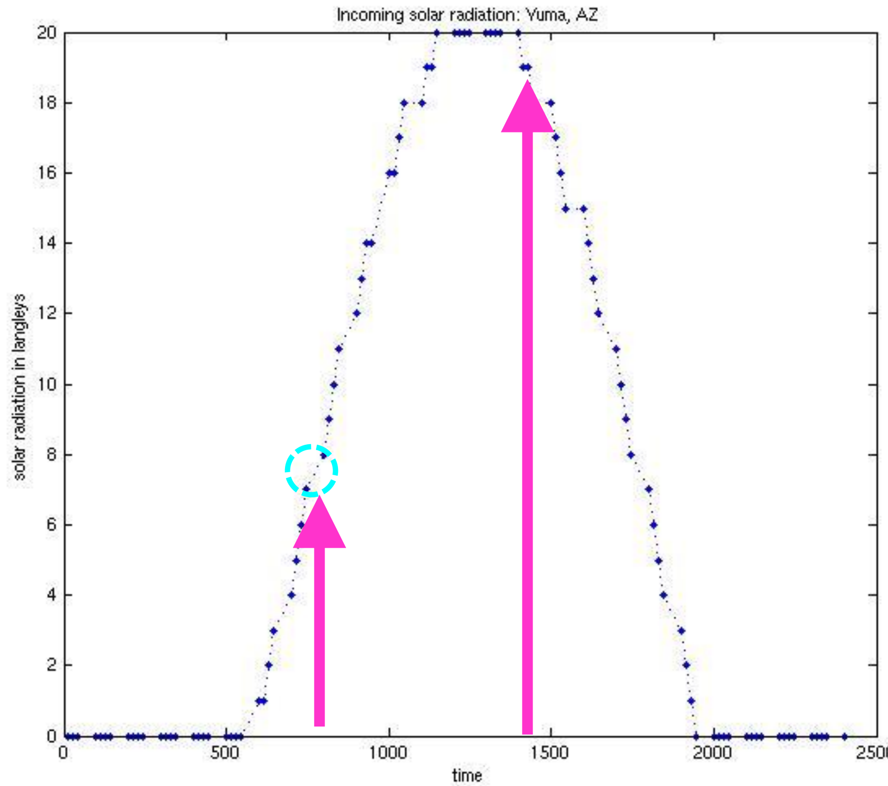
For that we turn to potential temperature. As we outlined in the Nevada case just prior, you can identify unstable parts of the convection close to the surface [analogous with rapid plumes at heating pad] fading into a neutralized zone that grows over the course of the day, again in line with our experiences viewing the tank's outwardly visible progression and inwardly sensed temperature profiles.

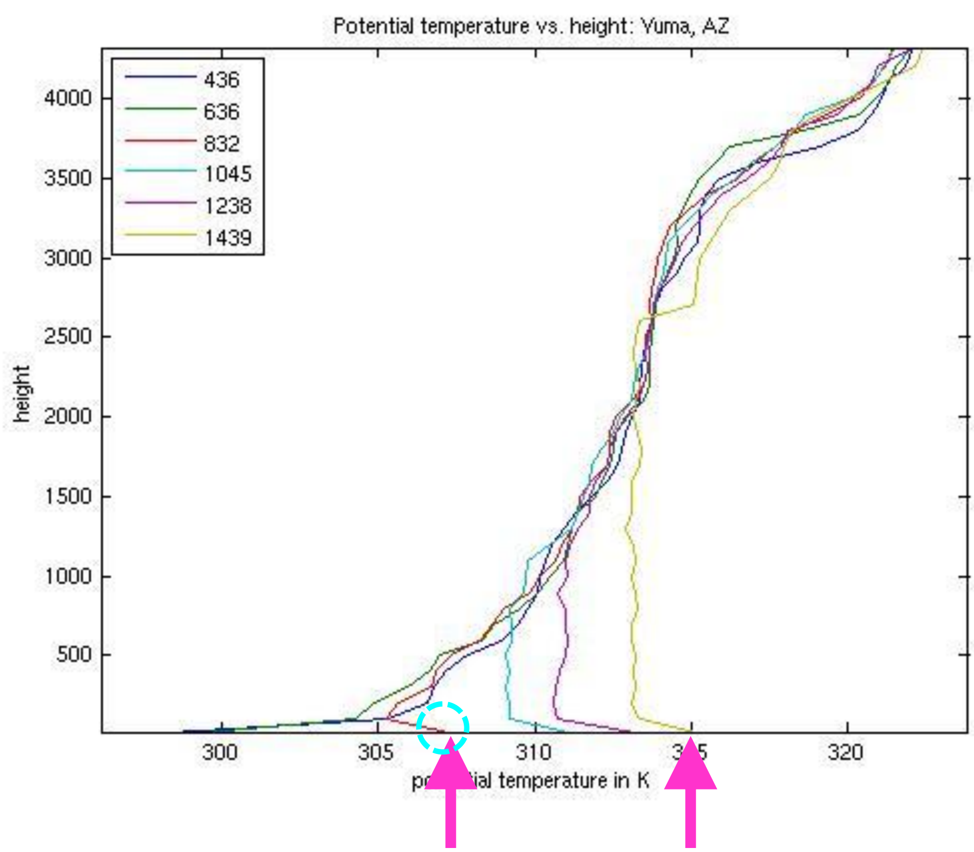


VERTICAL PROFILES OF **POTENTIAL TEMPERATURE** FOR SIX RADIOSONDE RELEASES

$$H\Delta t = \frac{c_p}{g} \sum_{i=1}^{N} \Delta T_i \delta p_i$$

The surface inversions That initiate the convective Cell may be related to a Threshold of incoming solar radiation (say, 8 hadleys), but it's likely also impacted by the accumulated integral of solar radiation that day – say, what minimum energy is necessary in order to give parcels of air with enough buoyancy to rise into next layer, creating the overturning, neutralizing motion.





By the time it Is past the Peak of Solar radiation Neutralization has progressed upwards of 2500 ft.

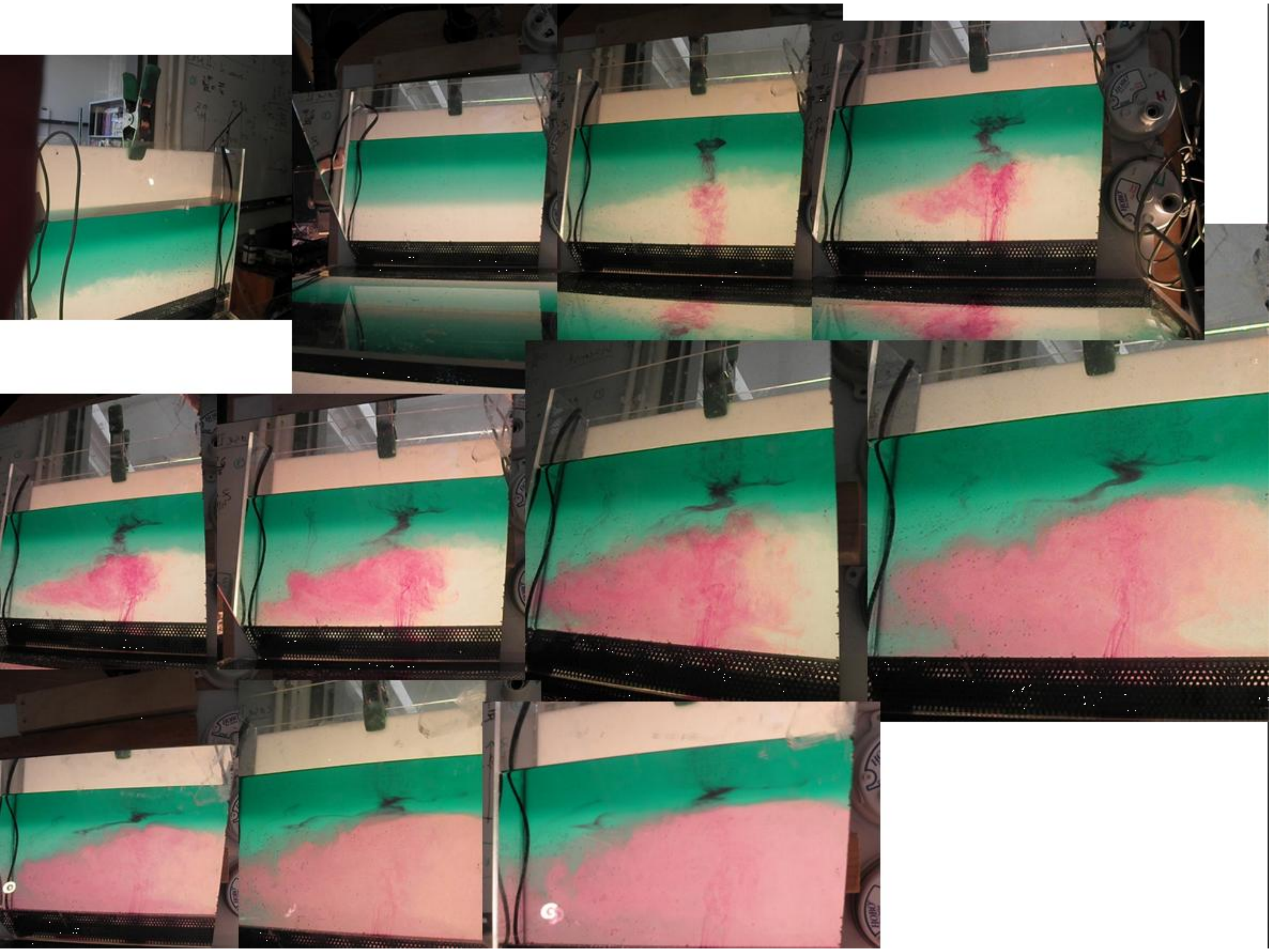
TANK:ONE 1

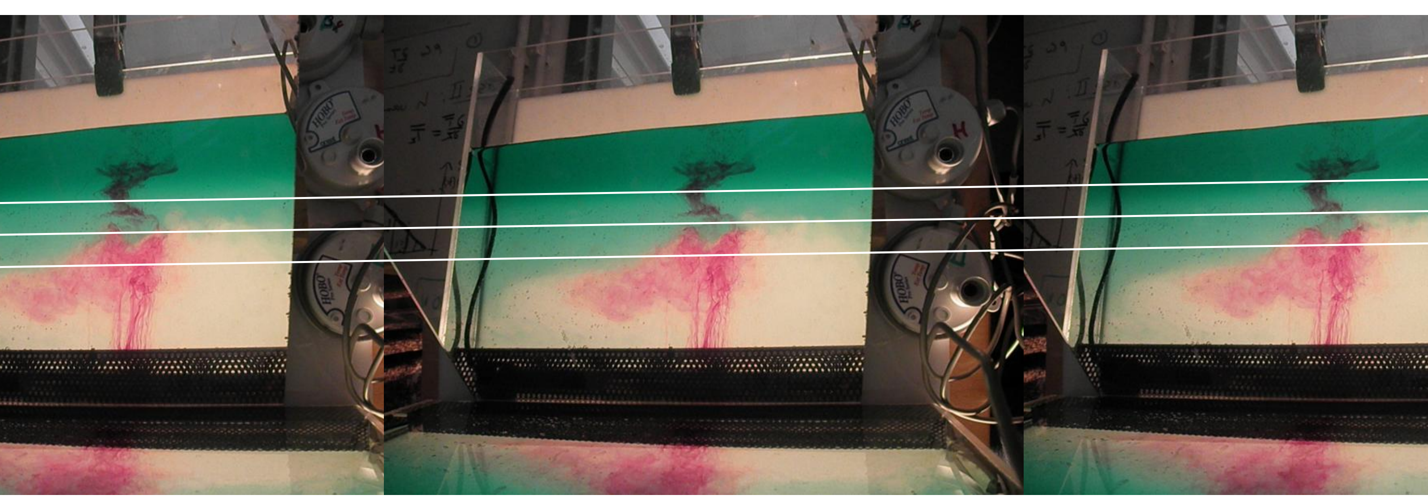
CONVECTION IN AN 2-LAYER SYSTEM

OBSERVER RECORDS

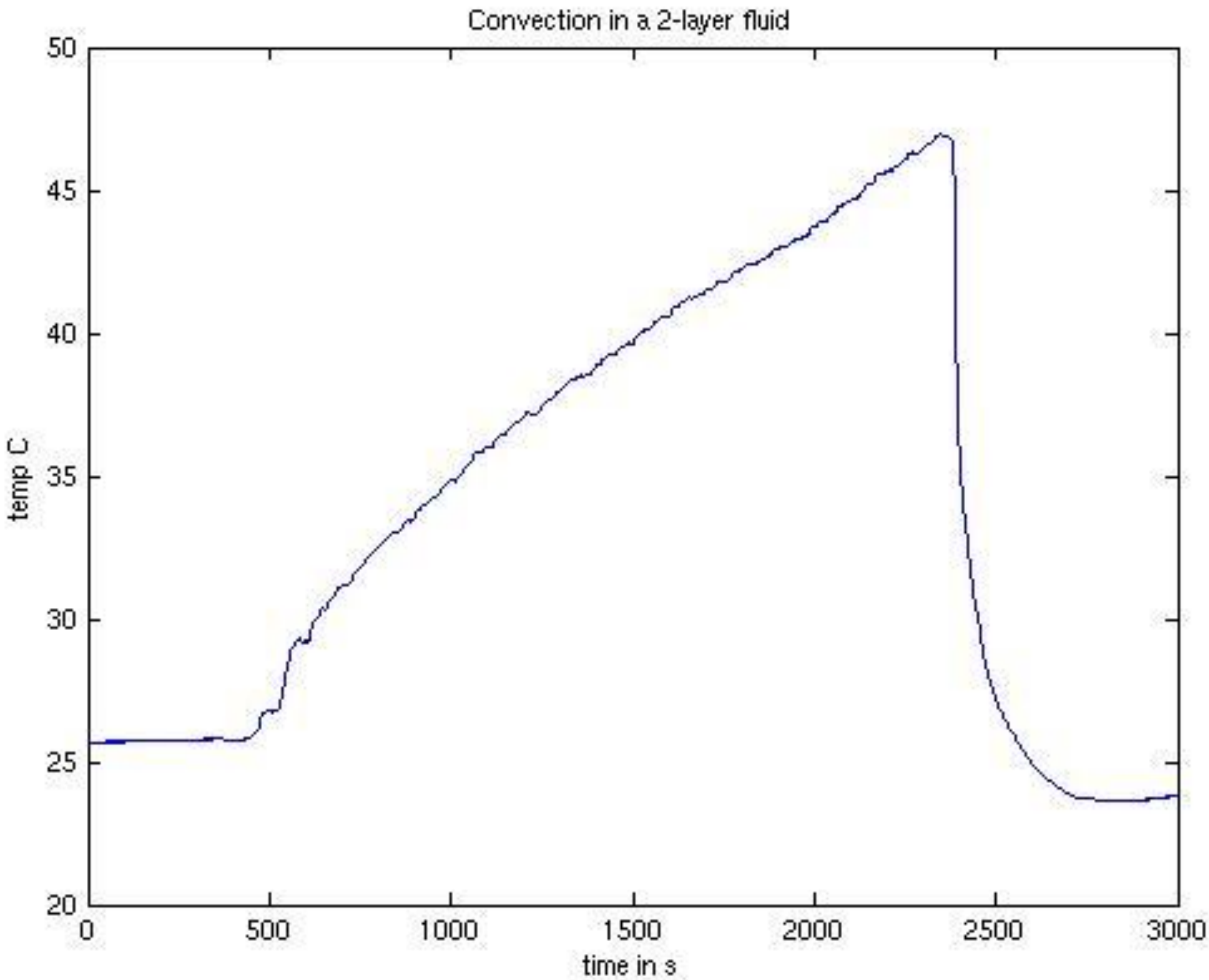
THERMOCOUPLE (1)

CAMERA [PHOTO]





50 60 70


Convection in a 2-layer fluid
temp C
time in s
50
45
40
35
30
25
20
0
500
1000
1500
2000
2500
3000