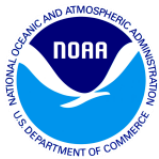


Two Frigid 2014 Snow Storms – A Look at Snow to Liquid Ratios

Kevin Cadima

2014 Southern New England
Weather Conference





Overview



- 2 storms last January
- Not classic blockbusters
- Both storms occurred during anomalously cold surface temps
- Snow to liquid ratios (SLR) did not behave according to commonly used empirical techniques
- Discuss why
 - Focus on microphysics and mid level temp anomalies



What happened?

- January 2-3 Storm
 - Temps in the teens falling into single numbers to near zero
 - 6 to 10" with Snow to Liquid Ratios (SLR) 10-15:1
 - Localized 2 ft amounts with SLR up 35:1
- January 21-22 Storm
 - Temps in the teens
 - 6-12" with locally up to 18"
 - SLR 20-30+:1



Snowfall to Estimated Meltwater Conversion Table



From NWS Observing Handbook

(based solely on surface temp)

Temp

SLR

34-28°

10:1

27-20°

15:1

19-15°

20:1

14-10°

30:1

9-0°

40:1

MELT WATER EQUIVALENT (INCHES)	NEW SNOWFALL (INCHES)						
	Temperature (F)						
	34 to 28	27 to 20	19 to 15	14 to 10	9 to 0	-1 to -20	-21 to -40
trace	trace	0.1	0.2	0.3	0.4	0.5	1
0.01	0.1	0.2	0.2	0.3	0.4	0.5	1
0.02	0.2	0.3	0.4	0.6	0.8	1	2
0.03	0.3	0.5	0.6	0.9	1.2	1.5	3
0.04	0.4	0.6	0.8	1.2	1.6	2	4
0.05	0.5	0.8	1	1.5	2	2.5	5
0.06	0.6	0.9	1.2	1.8	2.4	3	6
0.07	0.7	1.1	1.4	2.1	2.8	3.5	7
0.08	0.8	1.2	1.6	2.4	3.2	4	8
0.09	0.9	1.4	1.8	2.7	3.6	4.5	9
0.1	1	1.5	2	3	4	5	10
0.11	1.1	1.7	2.2	3.3	4.4	5.5	11
0.12	1.2	1.8	2.4	3.6	4.8	6	12
0.13	1.3	2	2.6	3.9	5.2	6.5	13
0.14	1.4	2.1	2.8	4.2	5.6	7	14
0.15	1.5	2.3	3	4.5	6	7.5	15
0.16	1.6	2.4	3.2	4.8	6.4	8	16
0.17	1.7	2.6	3.4	5.1	6.8	8.5	17
0.18	1.8	2.7	3.6	5.4	7.2	9	18
0.19	1.9	2.9	3.8	5.7	7.6	9.5	19
0.2	2	3	4	6	8	10	20
0.21	2.1	3.1	4.2	6.3	8.4	10.5	21
0.22	2.2	3.3	4.4	6.6	8.8	11	22
0.23	2.3	3.4	4.6	6.9	9.2	11.5	23
0.24	2.4	3.6	4.8	7.2	9.6	12	24
0.25	2.5	3.8	5	7.5	10	12.5	25
0.3	3	4.5	6	9	12	15	30
0.35	3.5	5.3	7	10.5	14	17.5	35
0.4	4	6	8	12	16	20	40
0.45	4.5	6.8	9	13.5	18	22.5	45
0.5	5	7.5	10	15	20	25	50
0.6	6	9	12	18	24	30	60
0.7	7	10.5	14	21	28	35	70
0.8	8	12	16	24	32	40	80
0.9	9	13.5	18	27	36	45	90
1	10	15	20	30	40	50	100
2	20	30	40	60	80	100	200
3	30	45	60	90	120	150	300

This figure can only be used in determining amounts of newly fallen snow. It cannot be used for determining the water equivalency (933RRR) of "old" snow. Packing and melting/refreezing have substantial effects on the density of the snow pack and are not accounted for by this figure.



Factors which modulate Snow Density



- In cloud processes that affect shape/size of ice crystals → microphysics
 - Dendrites best for high SLR
- Sub cloud processes
 - Warm layers, dry layers
 - Modify ice crystals as they fall
- Ground level compaction
 - What happens to the snow when it reaches the ground

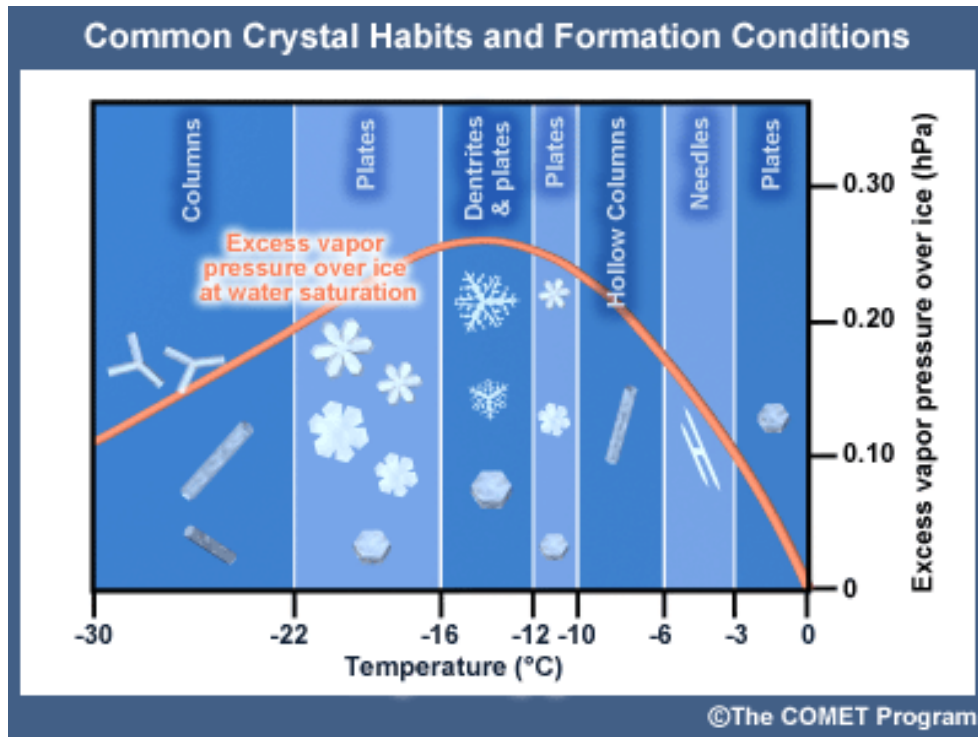
Ice Crystal Growth Occurs in 3 ways

- Accretion
 - Ice crystals collide with supercooled water droplets and freeze on contact
- Aggregation
 - Merging of ice crystals
- Deposition
 - Process where water vapor deposits on ice in liquid form and freezes immediately



Deposition

Dominant Ice Crystal Growth Process



- Ice crystal growth from deposition maximizes at temps around -15C
- Dendritic Growth Zone (DGZ) → -12 to -18C
- This is where dendrites are preferred crystal type
- Higher SLR due to extra space between each crystal

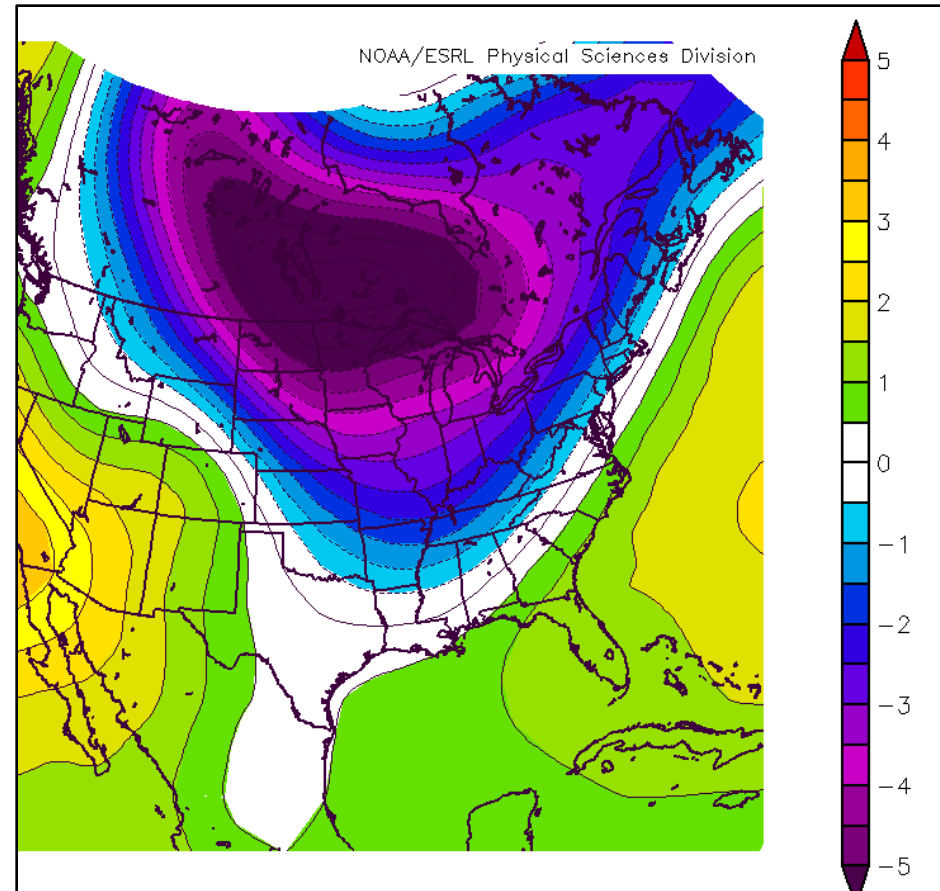


Omega vs DGZ

- Dendrites are favored where vertical motion (ω) maximums intersect the DGZ (-12 to -18C)
 - Can be as warm as -8 to -10C in SNE (near coastal regions) due to warmer ice nuclei activation temps of salt water
 - High SLR
- If max ω is below the DGZ
 - Warmer environment → more supercooled water
 - Could be indicative of shallow lift
 - Low SLR
- If max ω is above the DGZ
 - Snowflakes dominated by columns and plates
 - Fine consistency to snow
 - Low SLR

Roebber, Shultz et al. (2002)

- SLR is determined by the vertical temperature profile
- Vertical temp profile colder (warmer) than normal → higher (lower) than average SLR
- Focus on 700 mb temp anomalies or where ice crystal growth is occurring

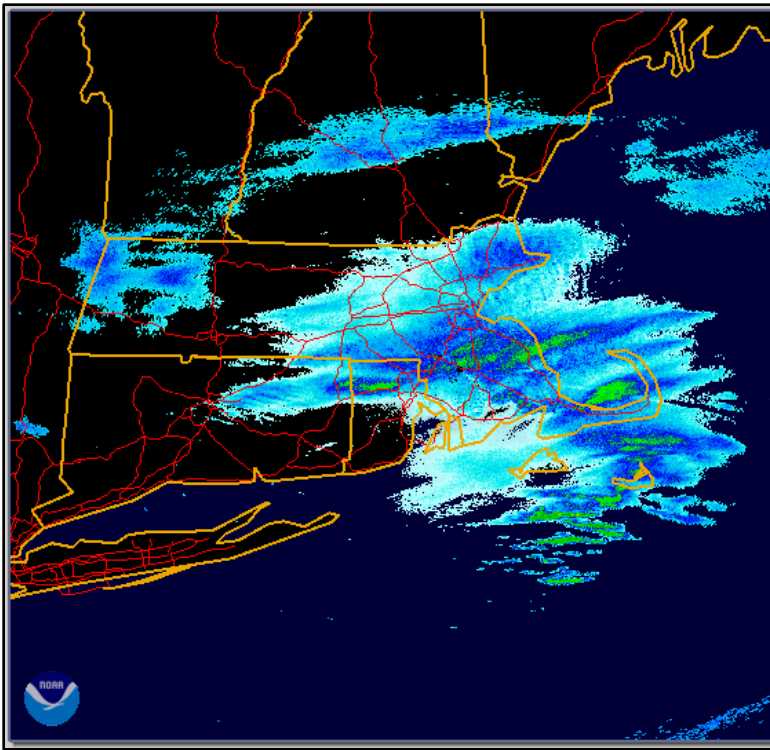


January 2-3 Storm

Radar and Surface Temps
Time Sections and Temp Anomalies

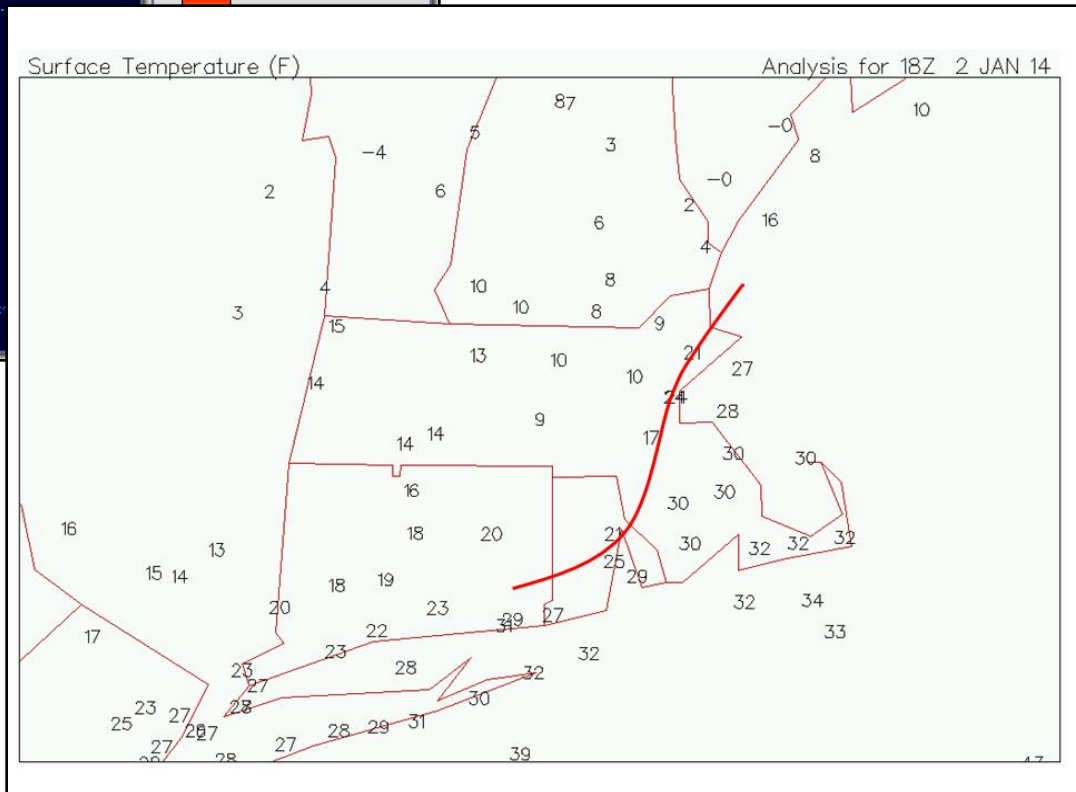
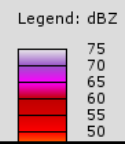


1800 UTC, 2014 January 2

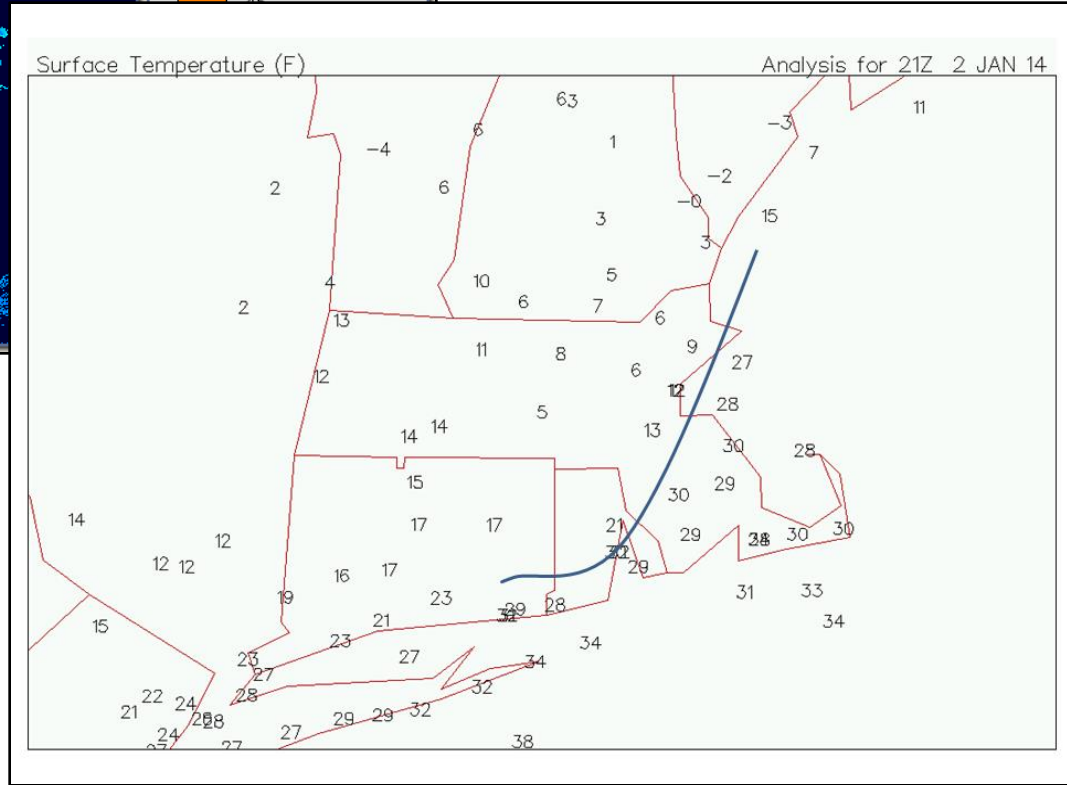
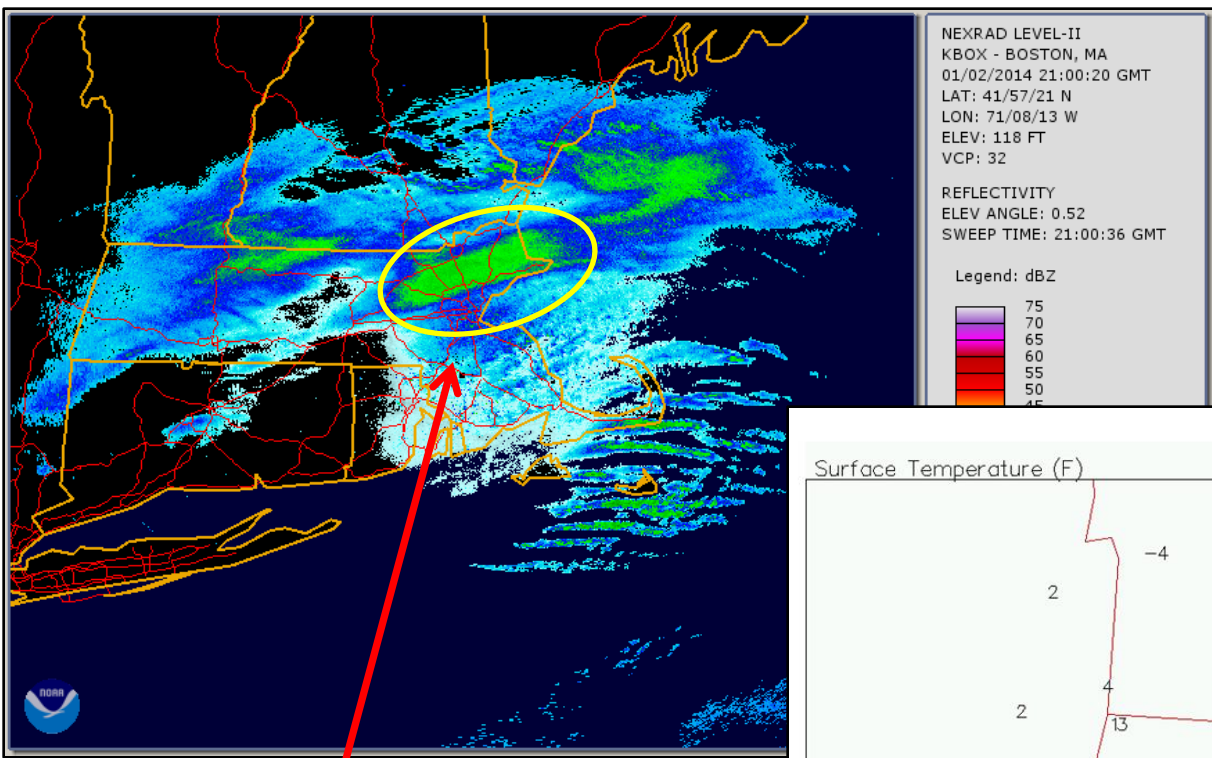


NEXRAD LEVEL-II
KBOX - BOSTON, MA
01/02/2014 18:01:58 GMT
LAT: 41/57/21 N
LON: 71/08/13 W
ELEV: 118 FT
VCP: 32

REFLECTIVITY
ELEV ANGLE: 0.52
SWEEP TIME: 18:02:15 GMT



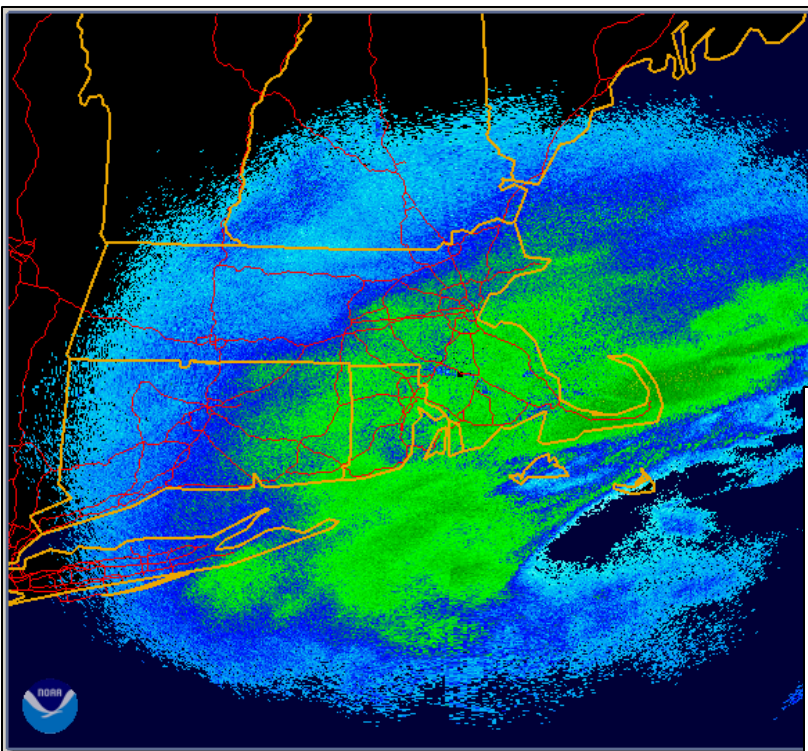
2100 UTC, 2014 January 2



Mesoscale banding signature

- Enhanced snowfall rates
- Higher SLR?

0300 UTC, 2014 January 3

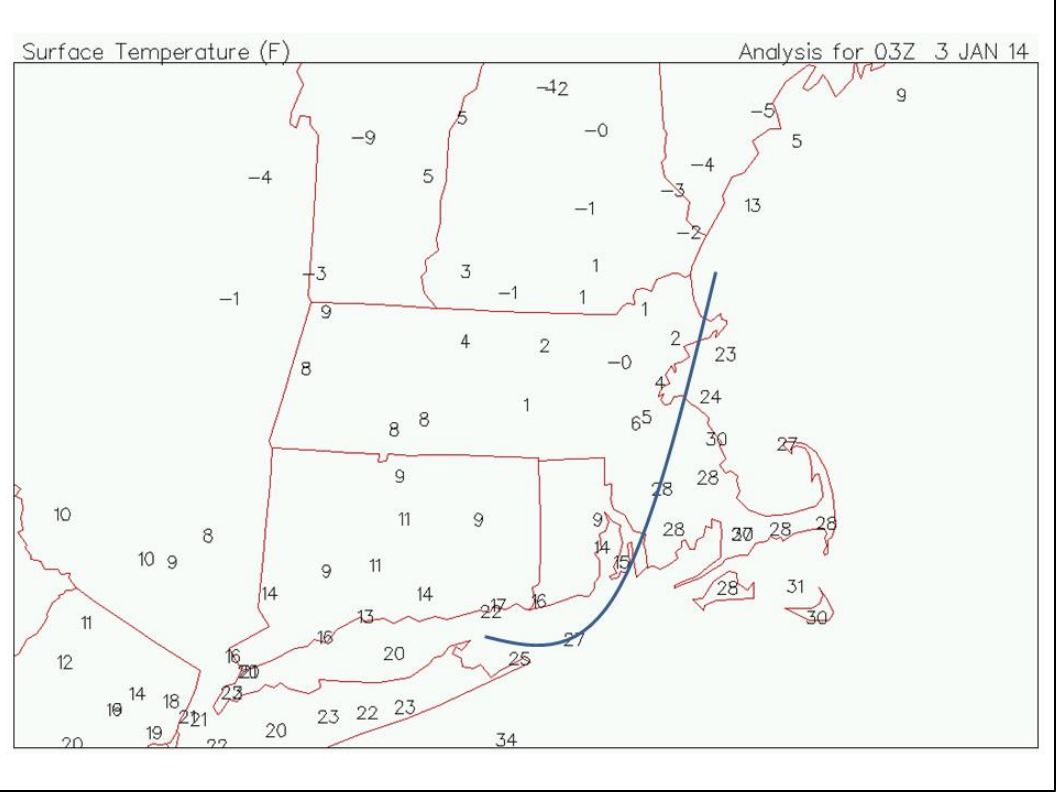


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LON: 71/08/13 W
ELEV: 118 FT
VCP: 21

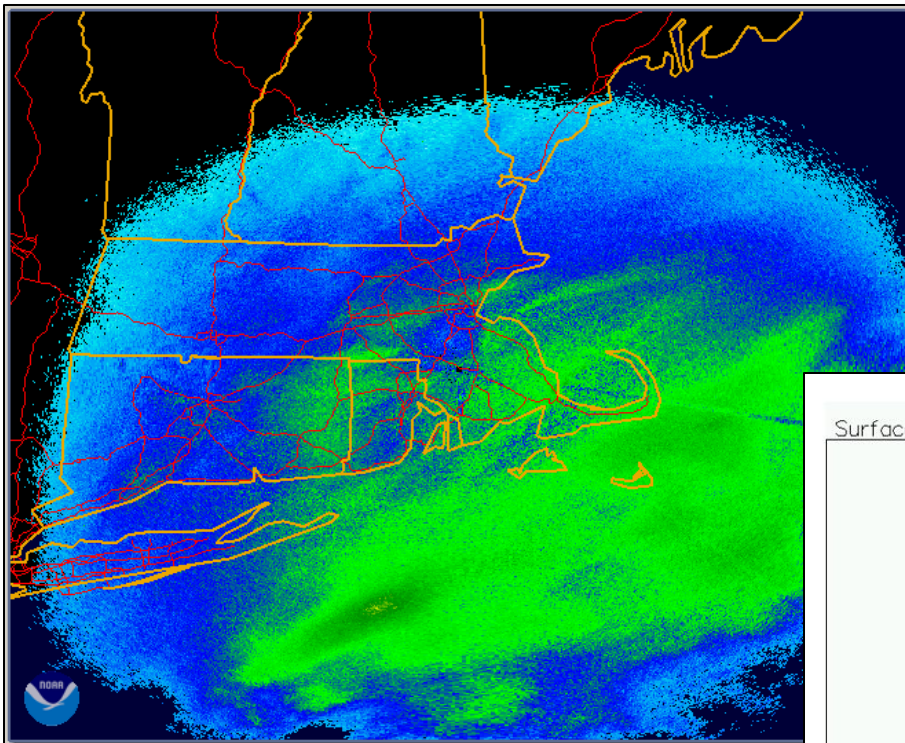
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Legend: dBZ

75
70
65
60
55
50



0600 UTC, 2014 January 3

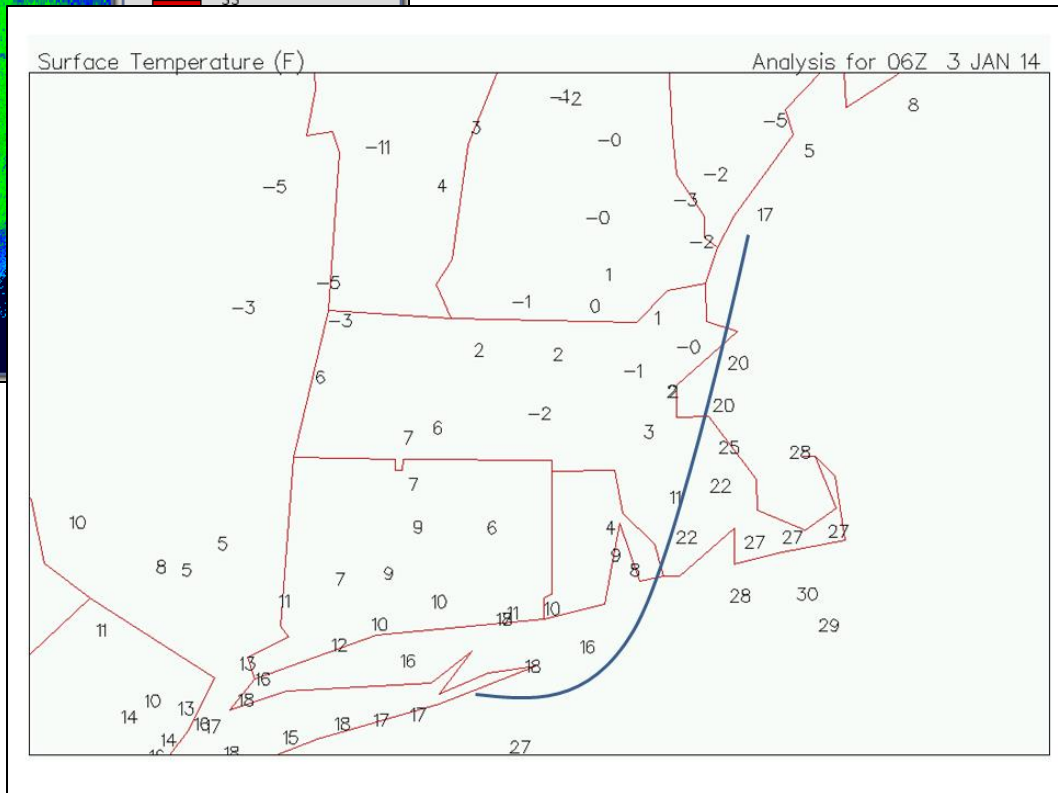


NEXRAD LEVEL-II
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 ELEV: 118 FT
 VCP: 32

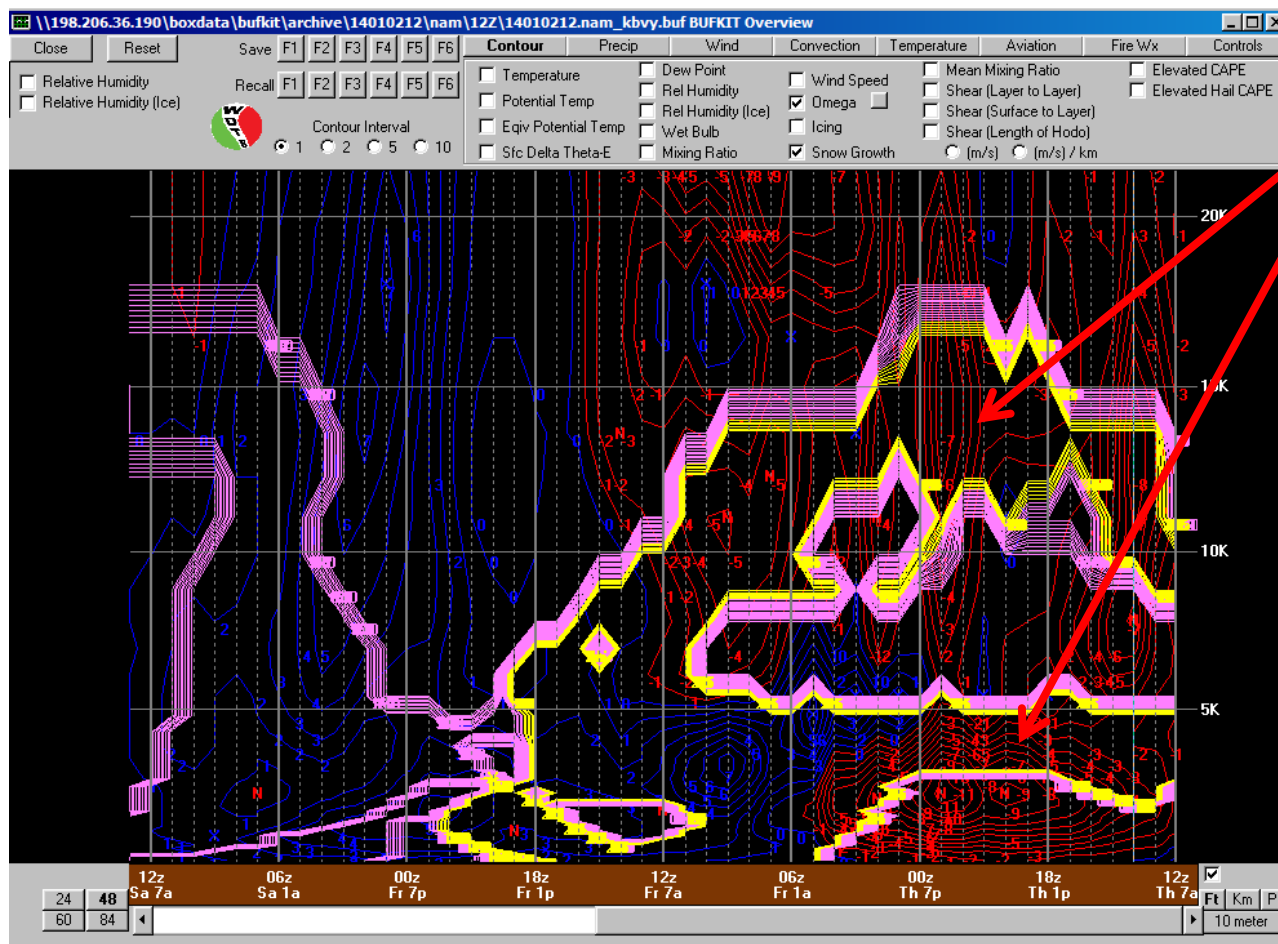
REFLECTIVITY
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 SWEEP TIME: 06:02:49 GMT

Legend: dBZ

75
70
65
60
55



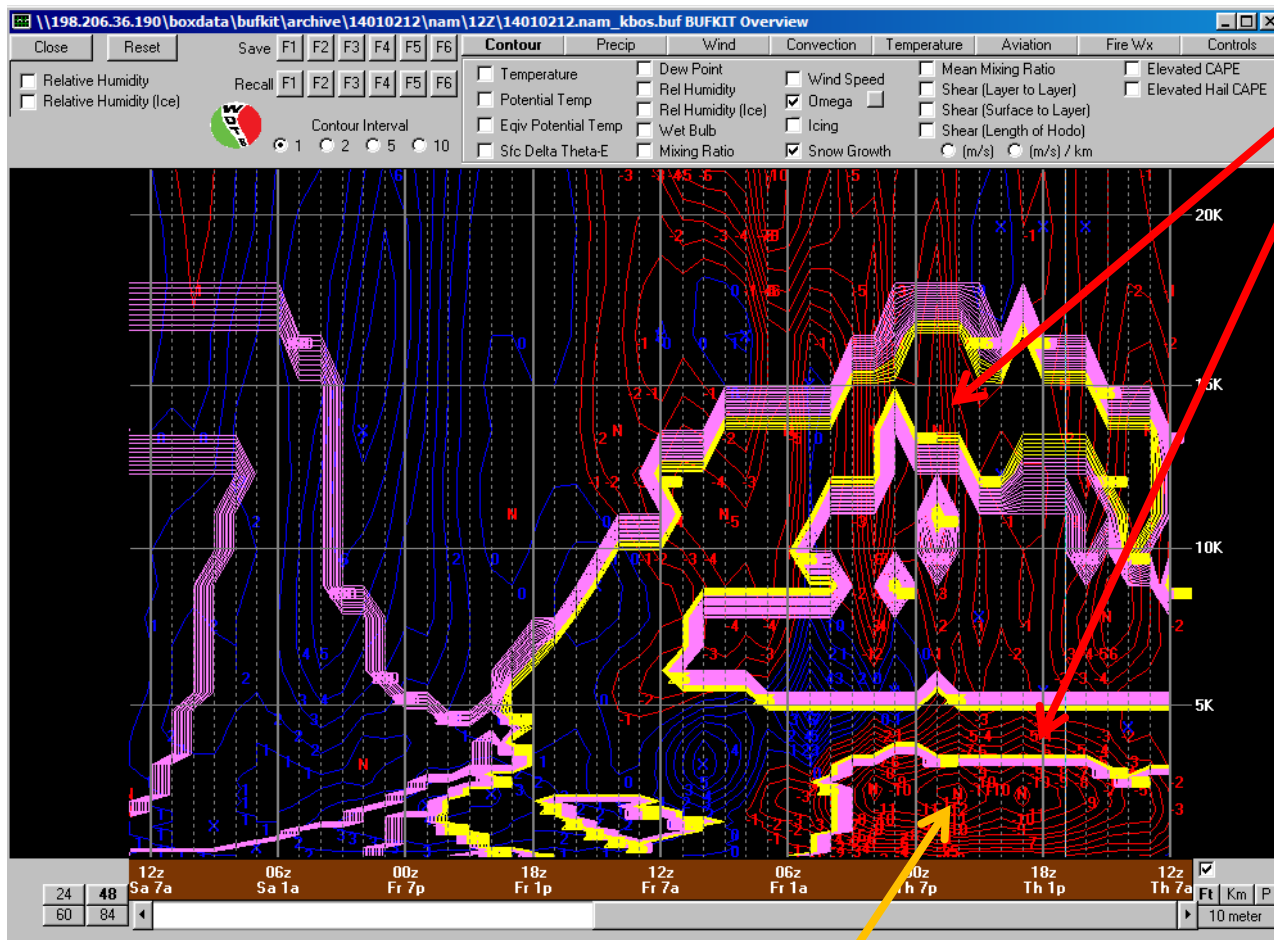
BVY Snow Growth/Omega Jan 2-3 Storm



Snow Growth Region

- Modest omega in snow growth region at 10-15K ft
- Note secondary snow growth region below 5K ft with stronger omega intersecting
- Profile favors high SLR

BOS Snow Growth/Omega Jan 2-3 Storm

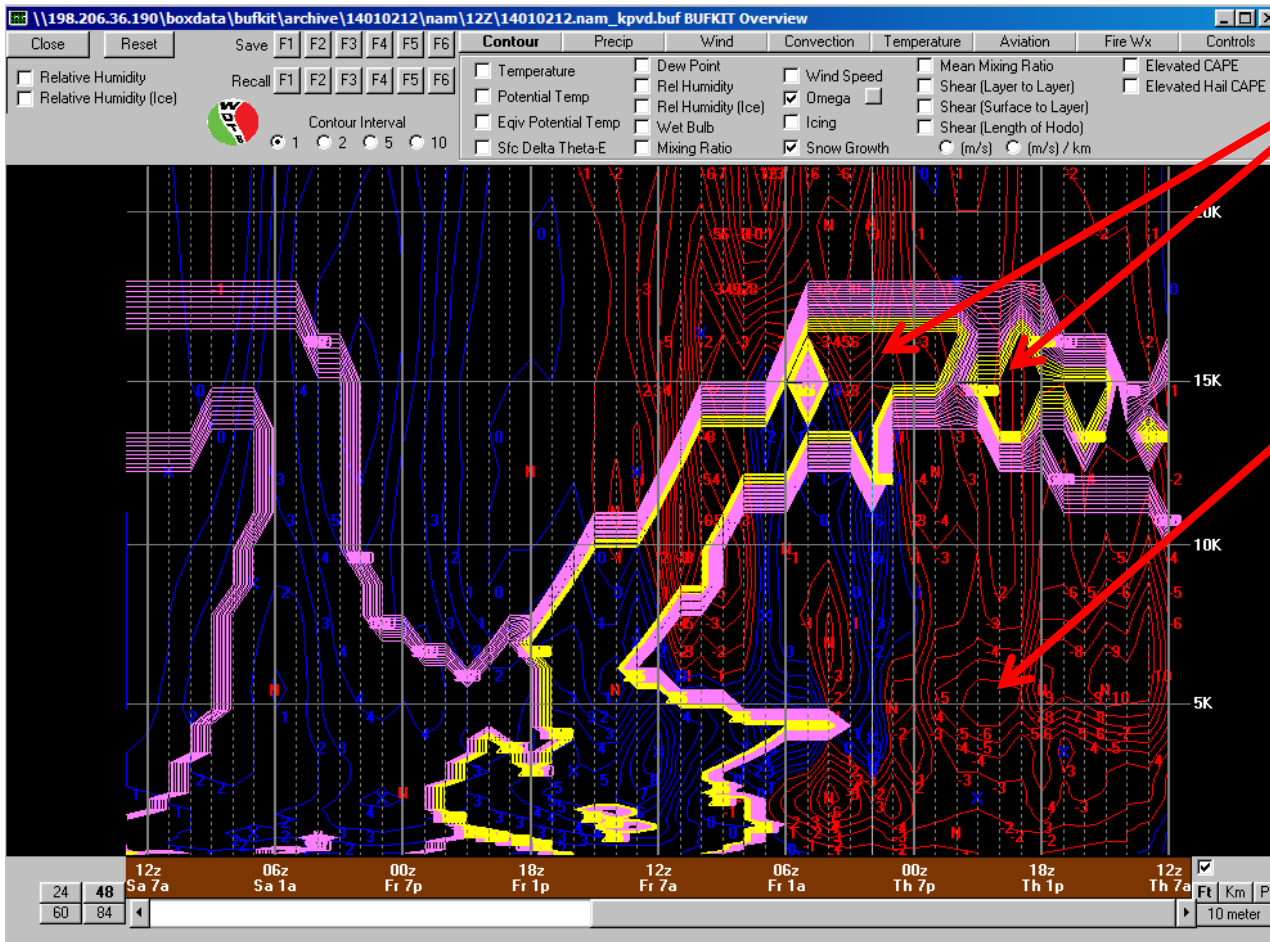


Snow Growth Region

- Strong omega below 5K ft near or just below DGZ (temps -8 to -10C)
- Strong low level omega associated with ocean enhancement processes played a significant role in high SLR near the NE MA coast

Warmer IN activation temps (-8 to -10C) near the coast place max omega within DGZ

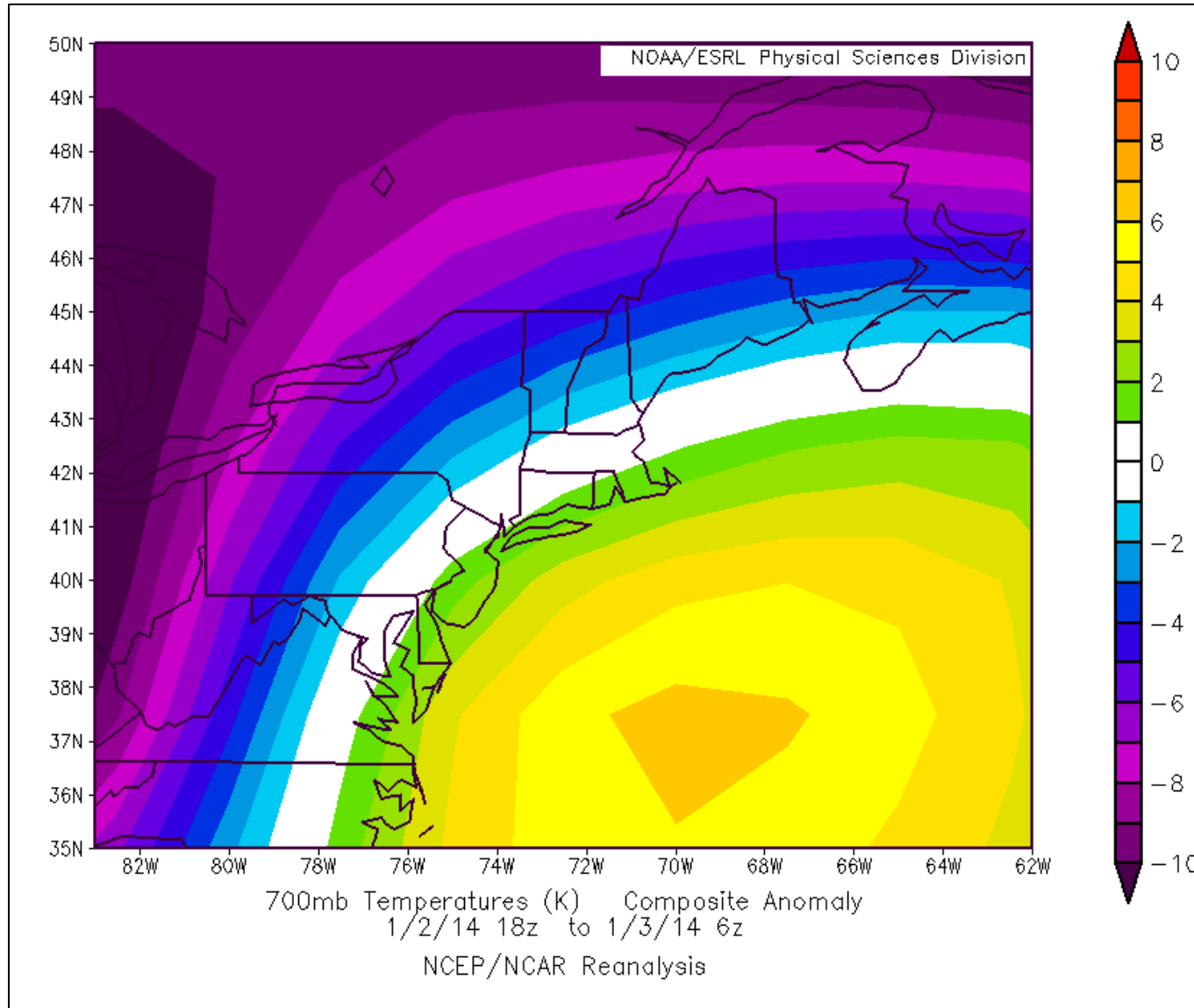
PVD Snow Growth/Omega Jan 2-3 Storm



Snow Growth Region

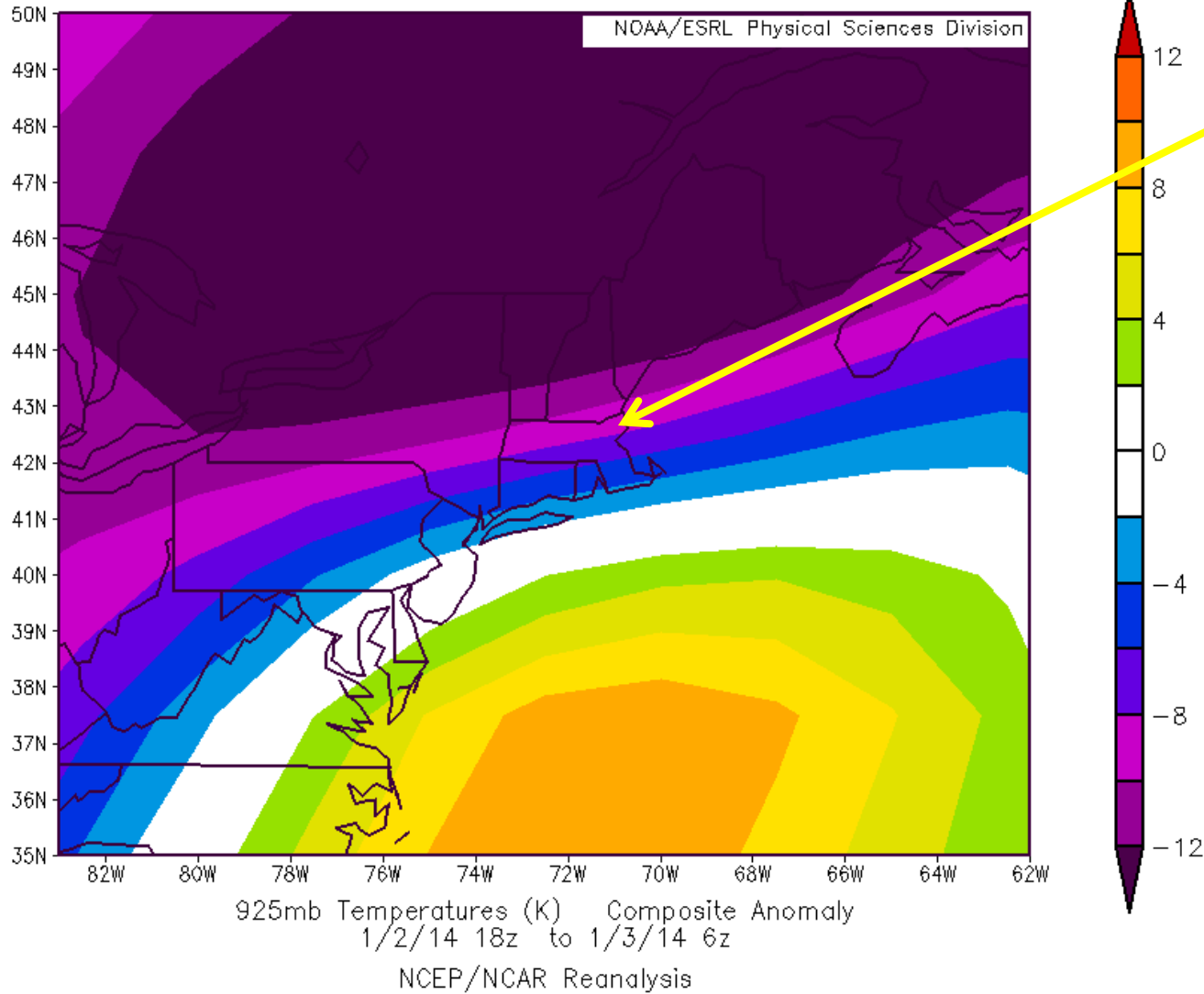
- Generally weak omega all below favorable DGZ
- Lower SLR despite cold surface temps

Jan 2-3 700 mb Temp Anomalies



700 mb temp anomalies near or slightly above normal suggesting SLR close to climatology

Jan 2-3 925 mb Temp Anomalies



Main ice crystal growth region below 5000 ft.

925 mb temp anomalies as much as 8C below normal across NE MA

This combined with excellent snow growth suggest SLR much higher than climatology

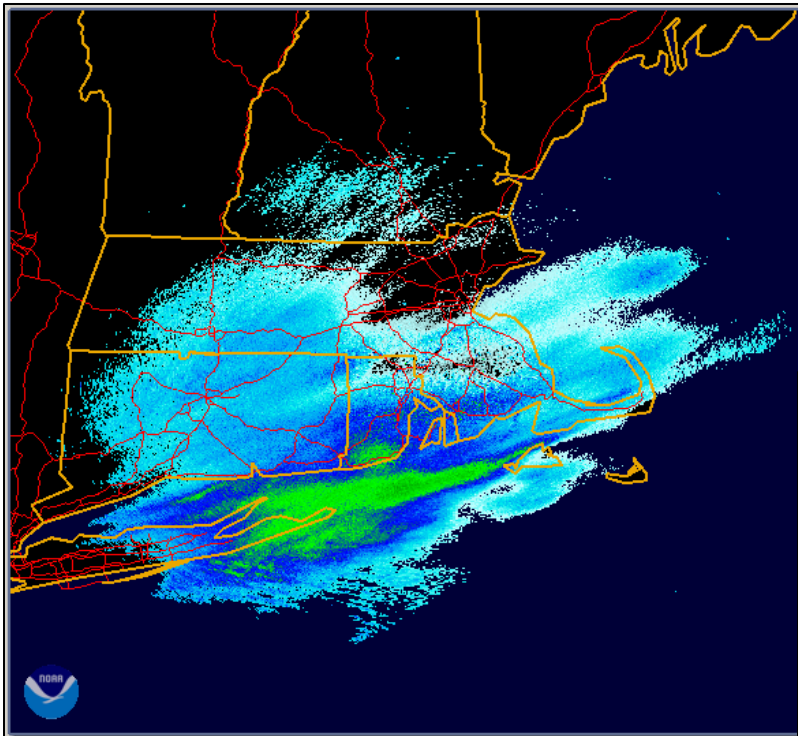
January 21-22 Storm

Radar and Surface Temps
Time Sections and Temp Anomalies





1800 UTC, 2014 January 21

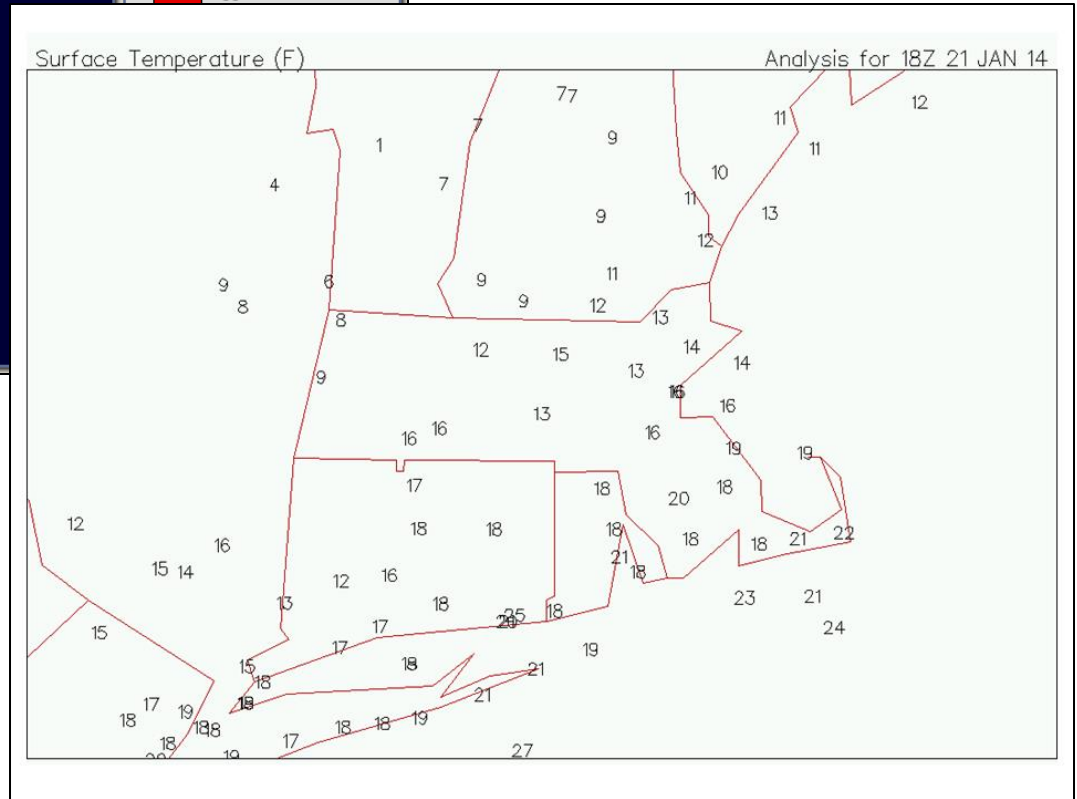


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VCP: 32

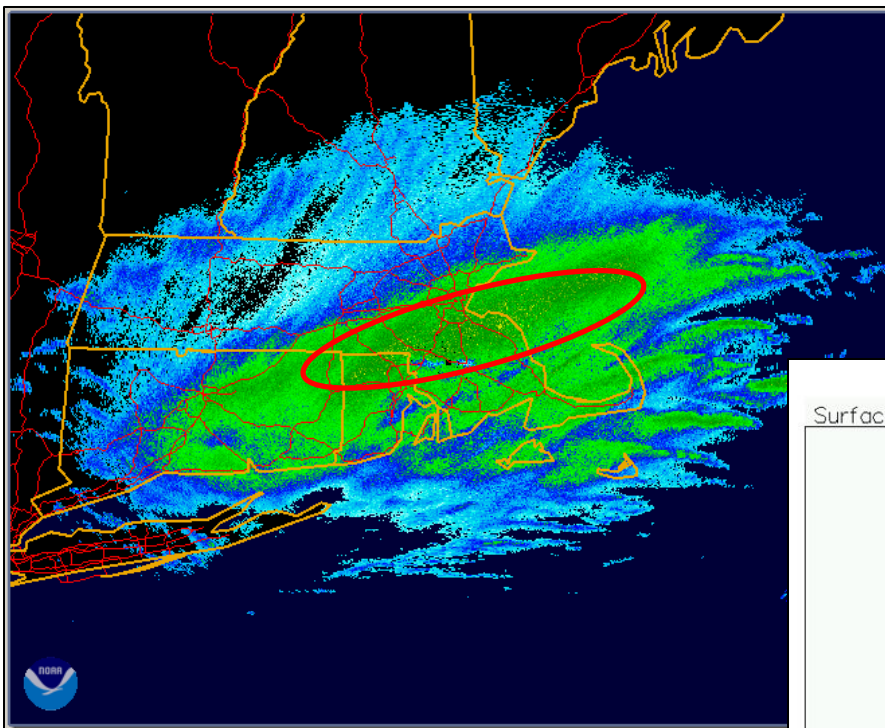
REFLECTIVITY
ELEV ANGLE: 0.52
SWEEP TIME: 18:05:41 GMT

Legend: dBZ

75
70
65
60
55



0000 UTC, 2014 January 21

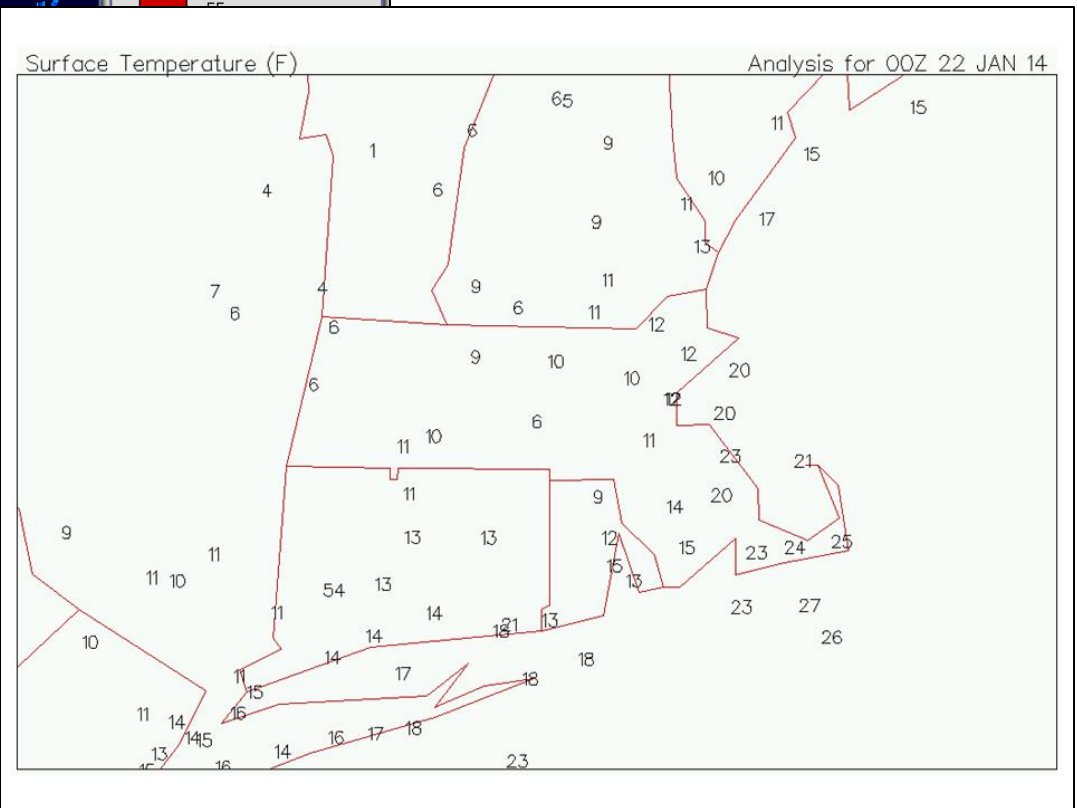


NEXRAD LEVEL-II
KBOX - BOSTON, MA
01/21/2014 23:57:07 GMT
LAT: 41/57/21 N
LON: 71/08/13 W
ELEV: 118 FT
VCP: 21

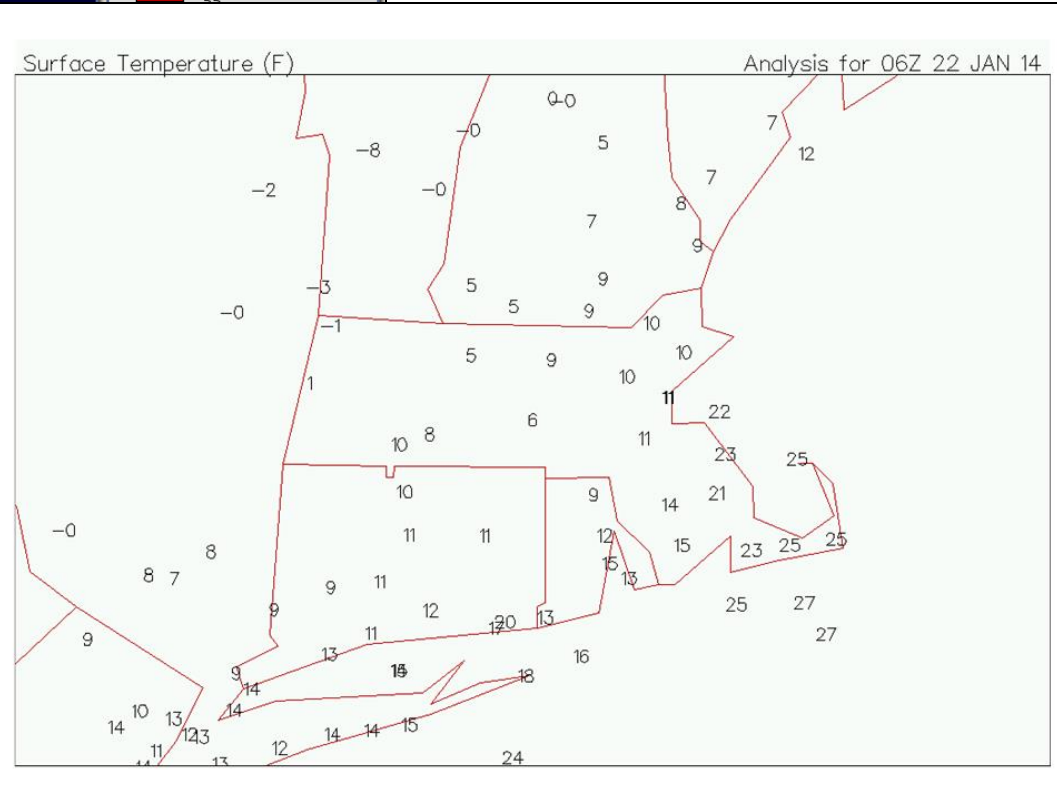
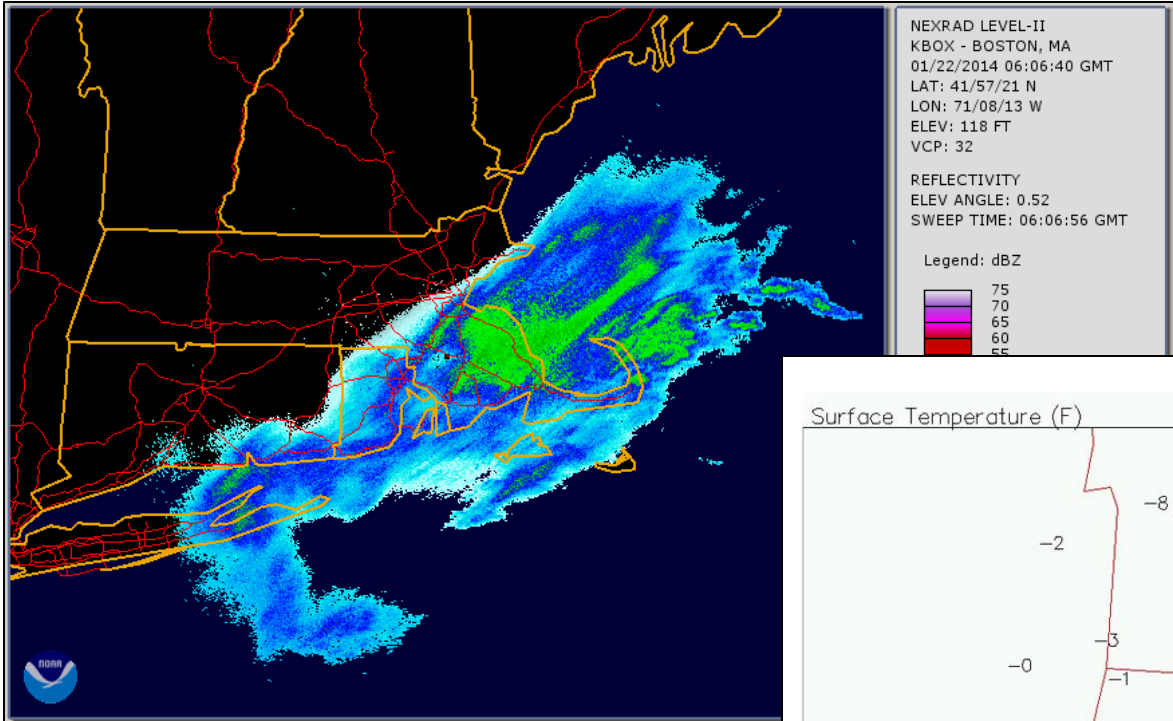
REFLECTIVITY
ELEV ANGLE: 0.54
SWEEP TIME: 23:57:13 GMT

Legend: dBZ

75
70
65
60
55



0600 UTC, 2014 January 21

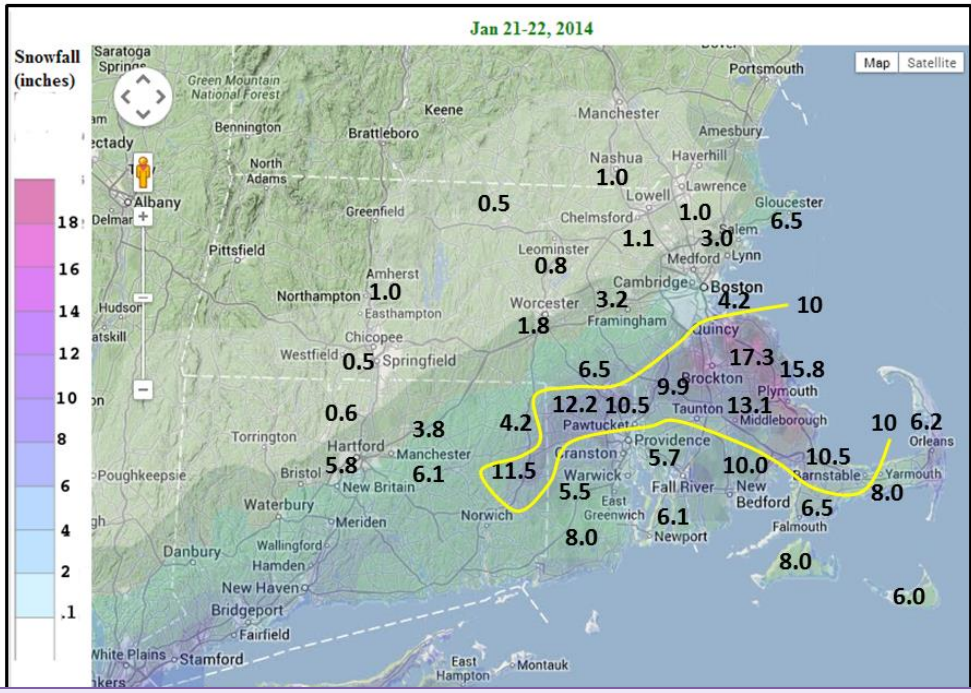




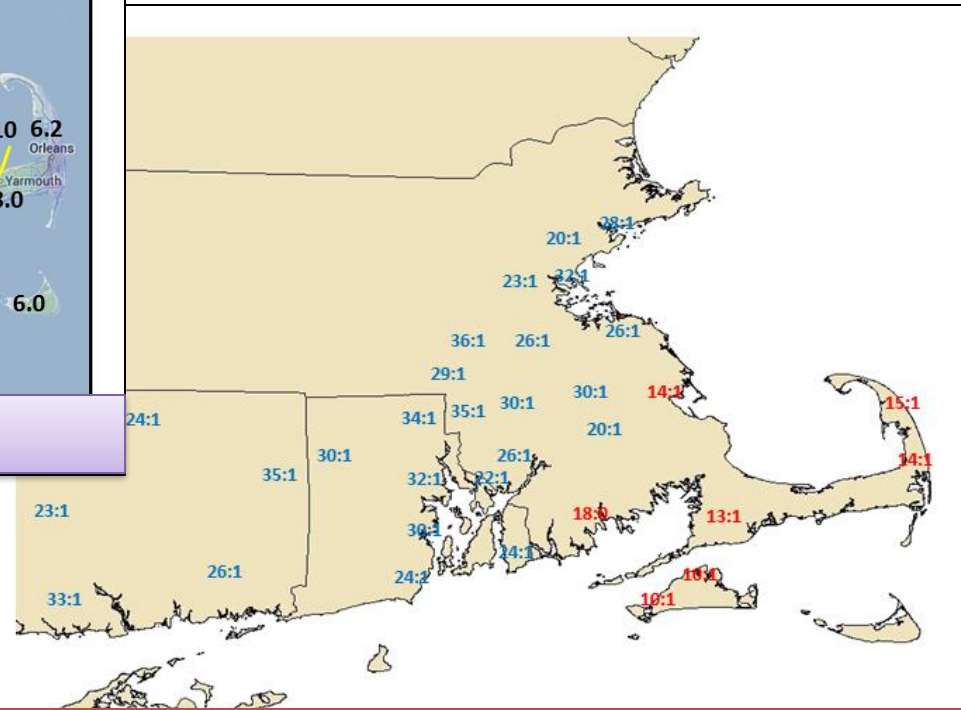
Snow Accumulation and Snow Liquid Ratio



January 21-22

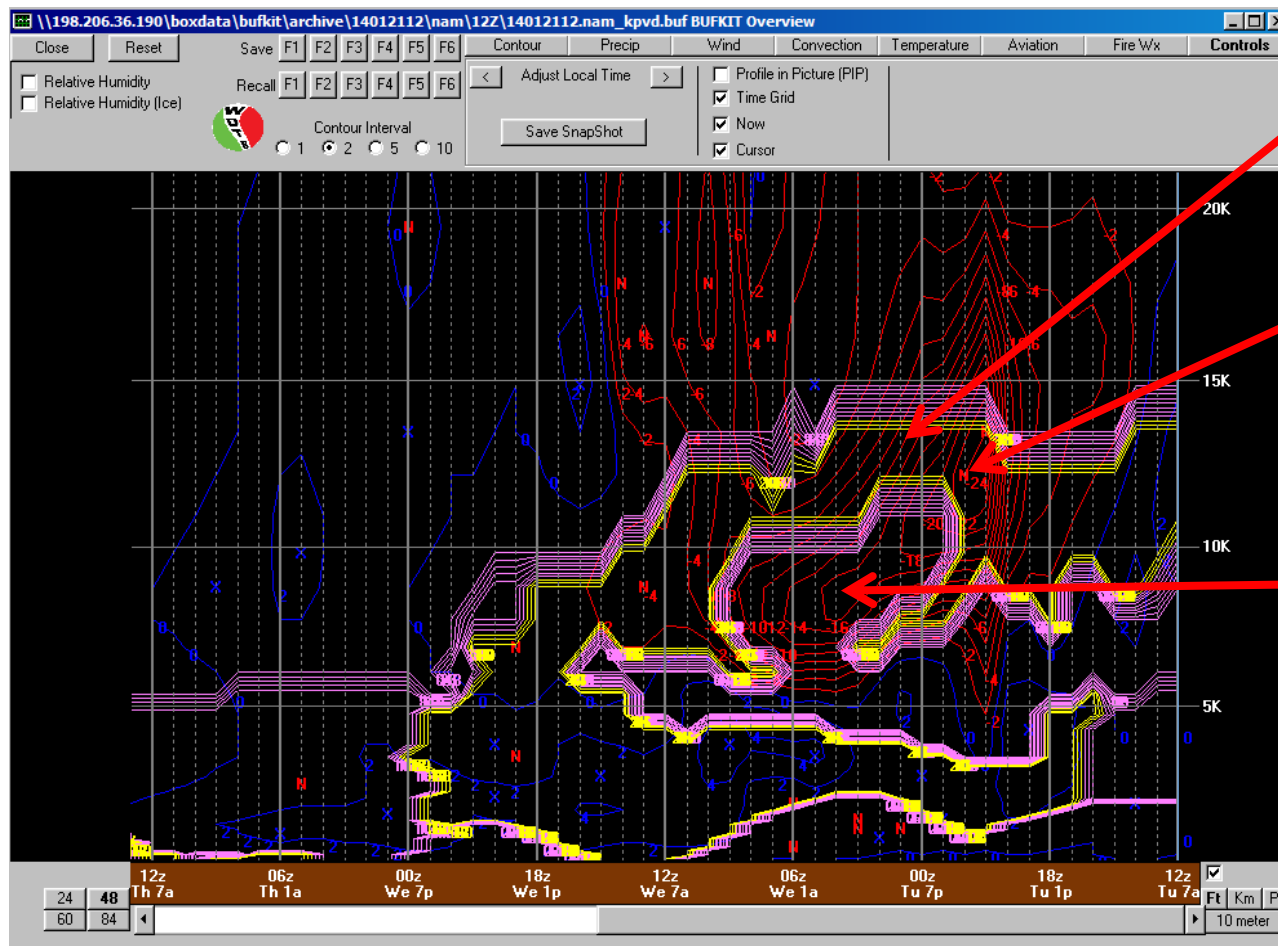


Snowfall Accumulation



Snow: Liquid Ratio

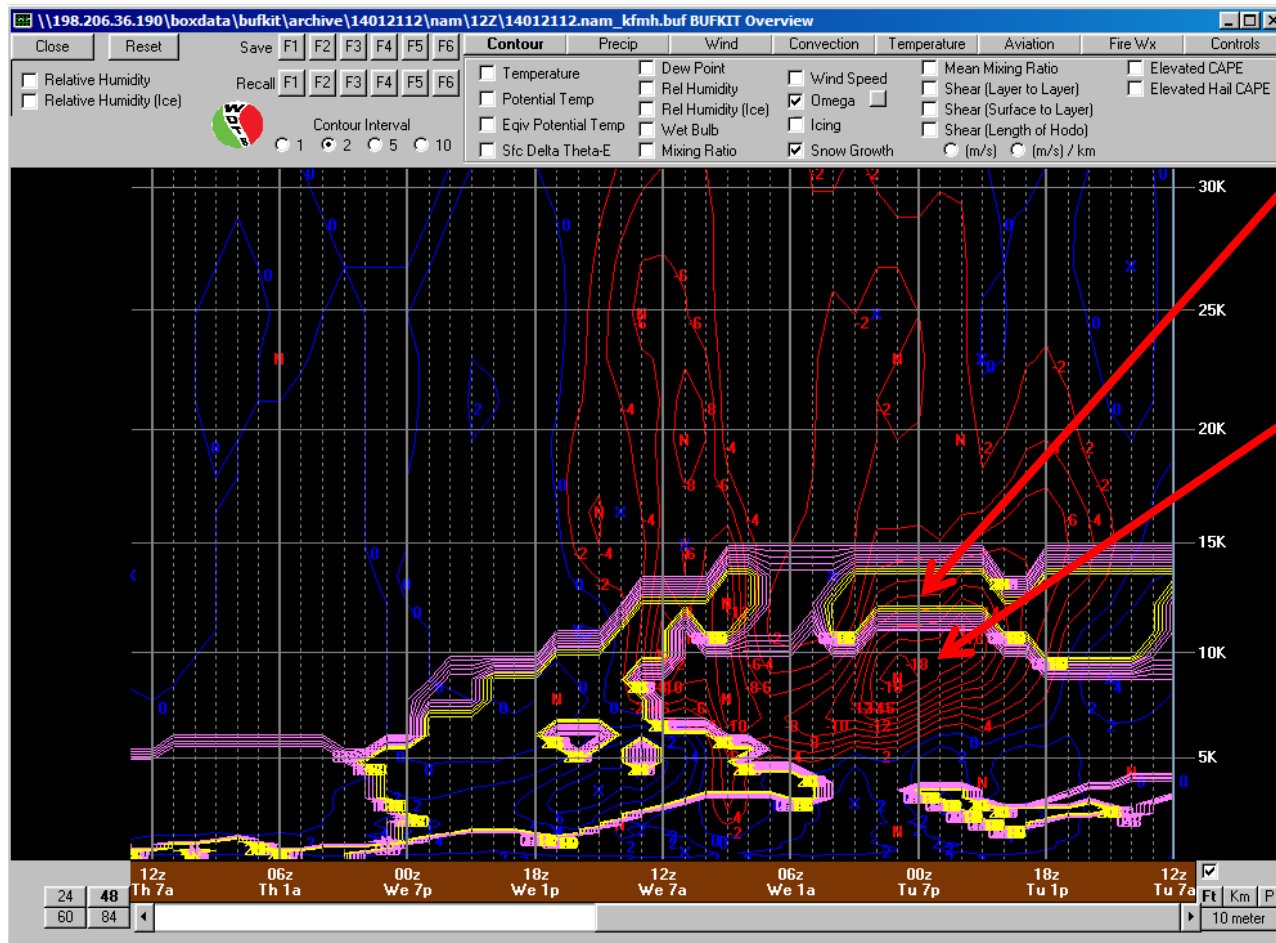
PVD Snow Growth/Omega Jan 21-22 Storm



Snow Growth Region

- Strong omega in snow growth region at 10-15K
- Omega appears to descend below DGZ after 00z (temps -10C) but warmer IN activation temps near the coast suggest omega well within DGZ
- Profile favors high SLR

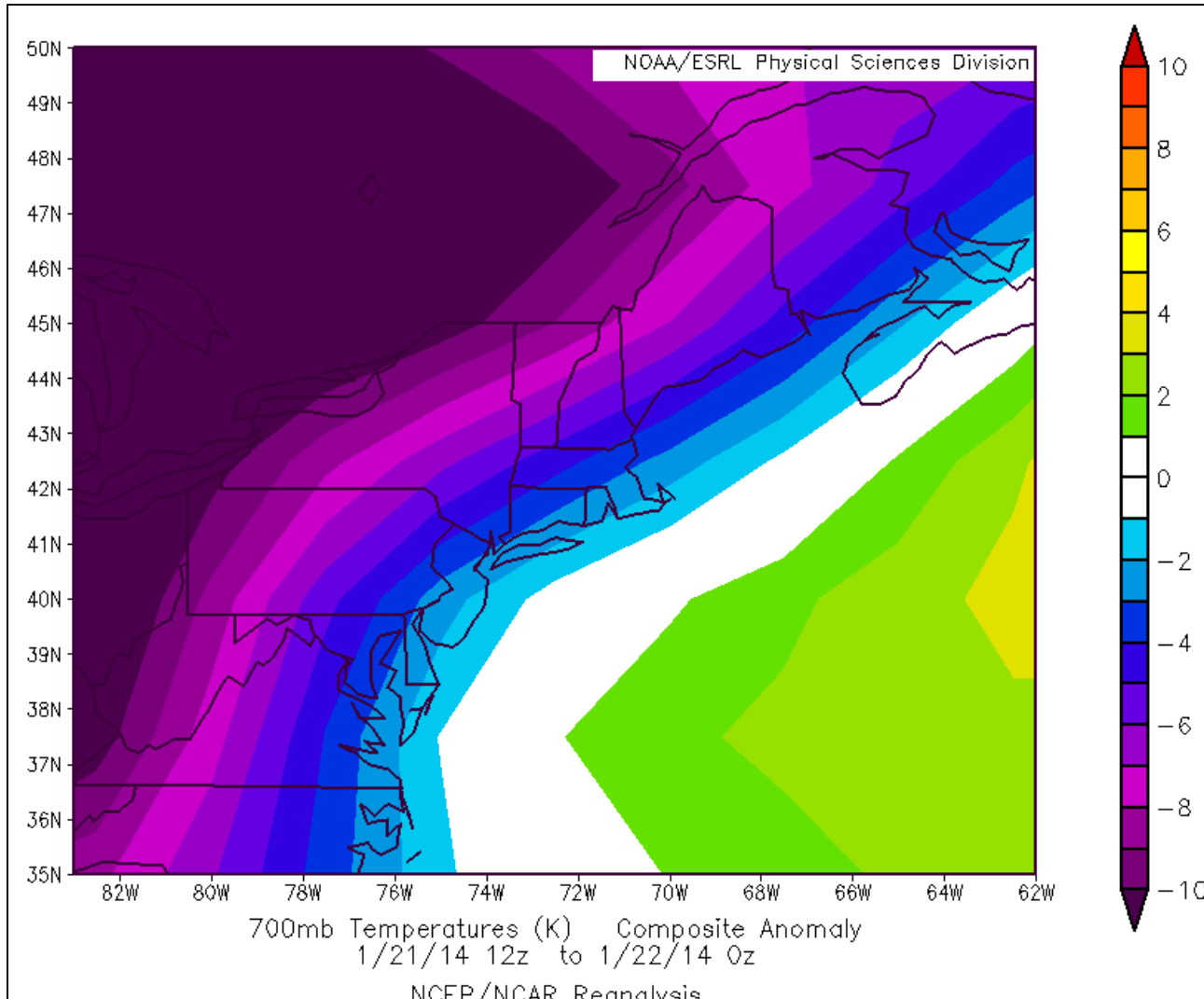
FMH Snow Growth/Omega Jan 21-22 Storm



Snow Growth Region

- Strongest omega is mostly below the favorable DGZ
- Temps -6 to -8C where best omega favoring lower SLR

Jan 21-22 700 mb Temp Anomalies



700 mb anomalies are several degrees below normal

Negative temp anomalies combined with excellent snow growth favors SLR well above climatology



Summary



- Two winter storms with anomalously cold surface temps produced a wide range of snow liquid ratios
- 10:1 vs 35:1 SLR for the Jan 2-3 storm with surface temps in the single numbers
- 20-30+:1 SLR for the Jan 21-22 storm with surface temps in the teens
- Move away from strictly using surface temps to derive SLR
 - Look at microphysics and where ice crystal growth is occurring
- Focus on omega in the snow growth region
 - Can be as warm as -8 to -10C near the coast due to higher IN activation temps
- Look at temp anomalies where ice crystal growth is maximized

Questions??