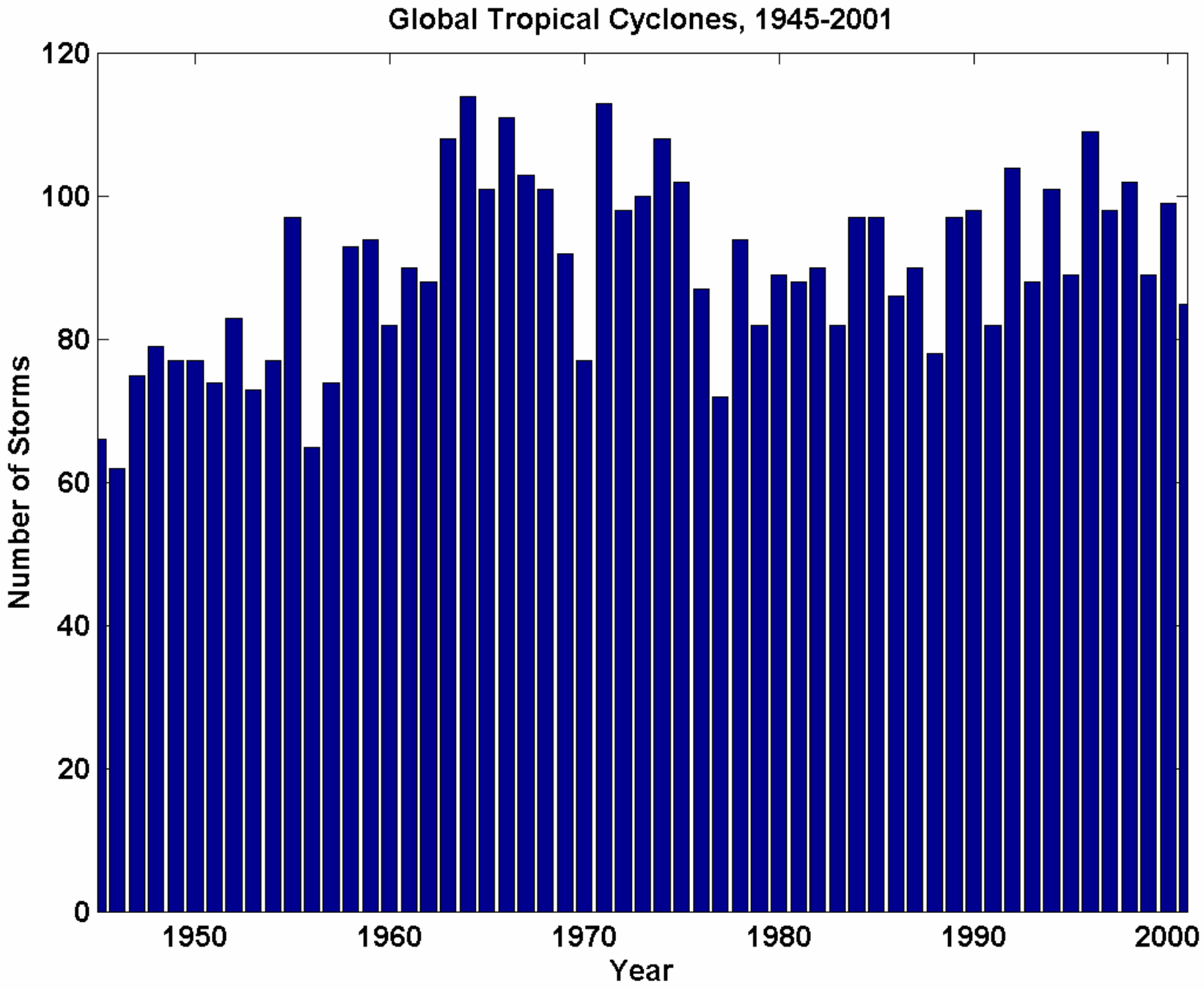
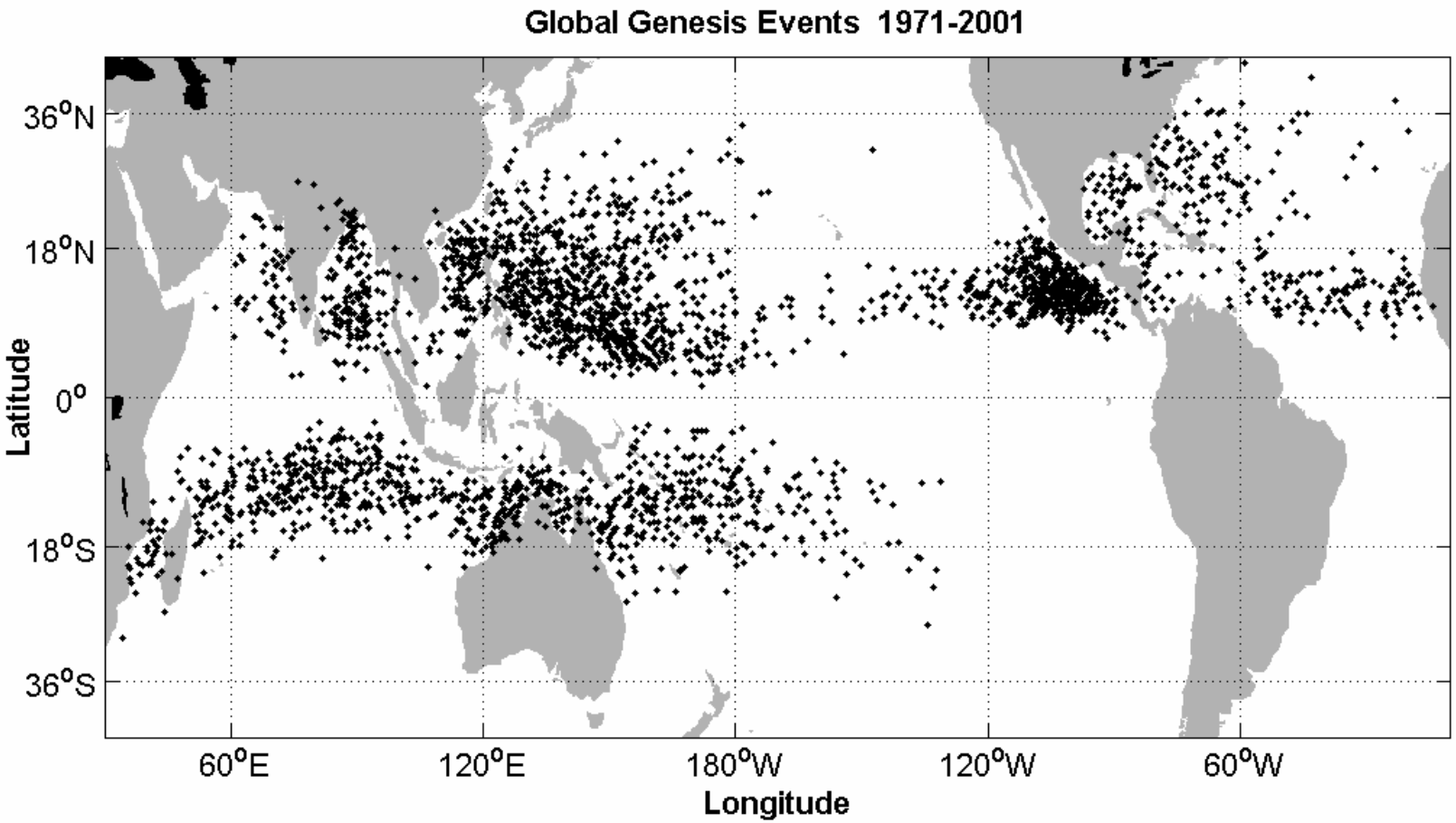
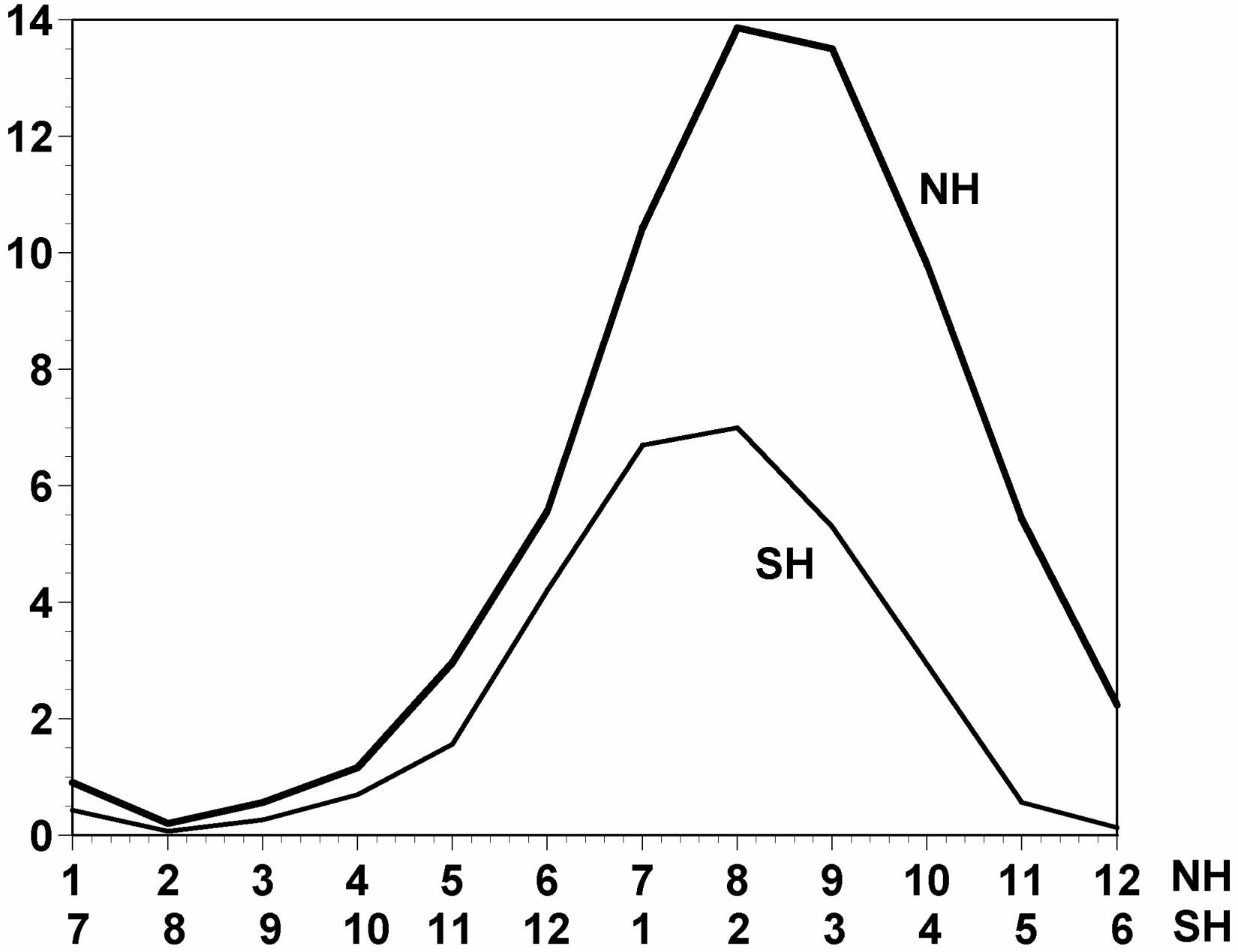
Genesis


Global Tropical Cyclones, 1945-2001
Number of Storms
Year
0
20
40
60
80
100
120
1950
1960
1970
1980
1990
2000


Global Genesis Events 1971-2001
36°N
18°N
0°
18°S
36°S
Latitude
60°E
120°E
180°W
120°W
60°W
Longitude

Number of Genesis Events per Month



Key Aspects of Genesis:

- Tropical cyclones results only from finite-amplitude perturbations of the normal state of the tropical atmosphere
- Empirically favors regions of large potential intensity, large low-level vorticity, and humid middle tropopshere with little vertical wind shear
- Evidence from field experiments suggest that TCs often originate in cold-core mesosystems

Empirical Approach to Environmental Control of TC Frequency:

Develop an empirical index based on monthly re-analysis data

Test index against geographic, seasonal and interannual variability

Empirical Index:

$$I = \left| 10^5 \eta \right|^{3/2} \left(\frac{\mathcal{H}}{50} \right)^3 \left(\frac{V_{pot}}{70} \right)^3 \left(1 + 0.1 V_{shear} \right)^{-2},$$

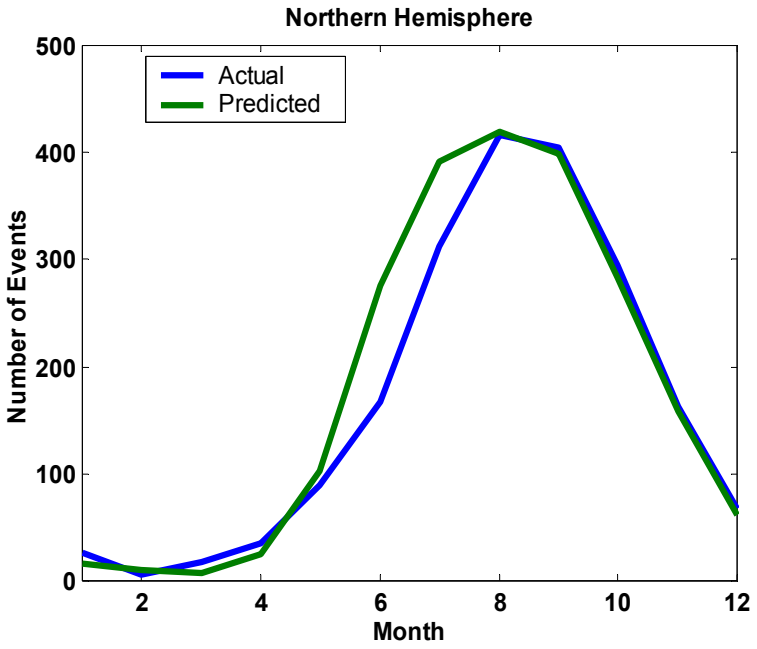
$$\eta \equiv \textit{absolute vorticity}\ (s^{-1}),$$

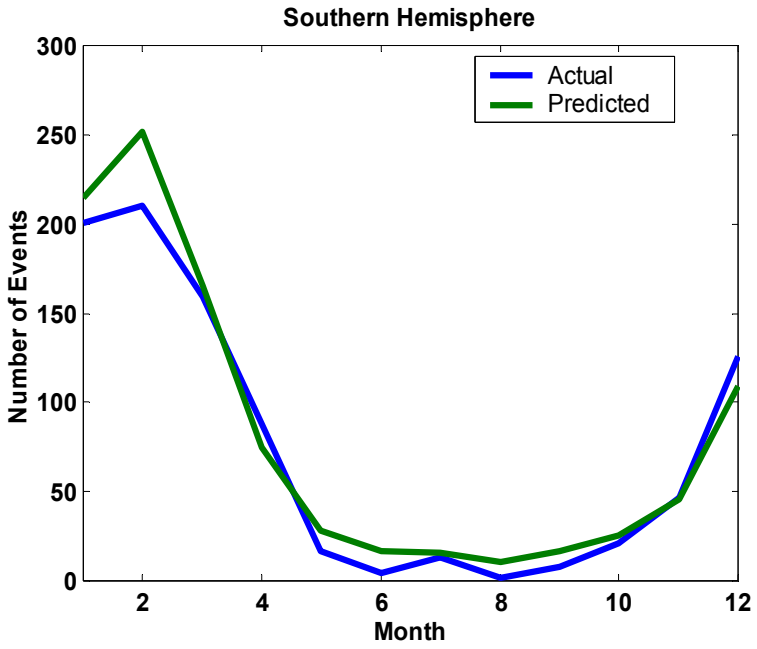
$$V_{pot} \equiv \textit{Potential wind speed}\ (ms^{-1}),$$

$$\mathcal{H} \equiv 600\,\textit{mb relative humidity}\ (\%),$$

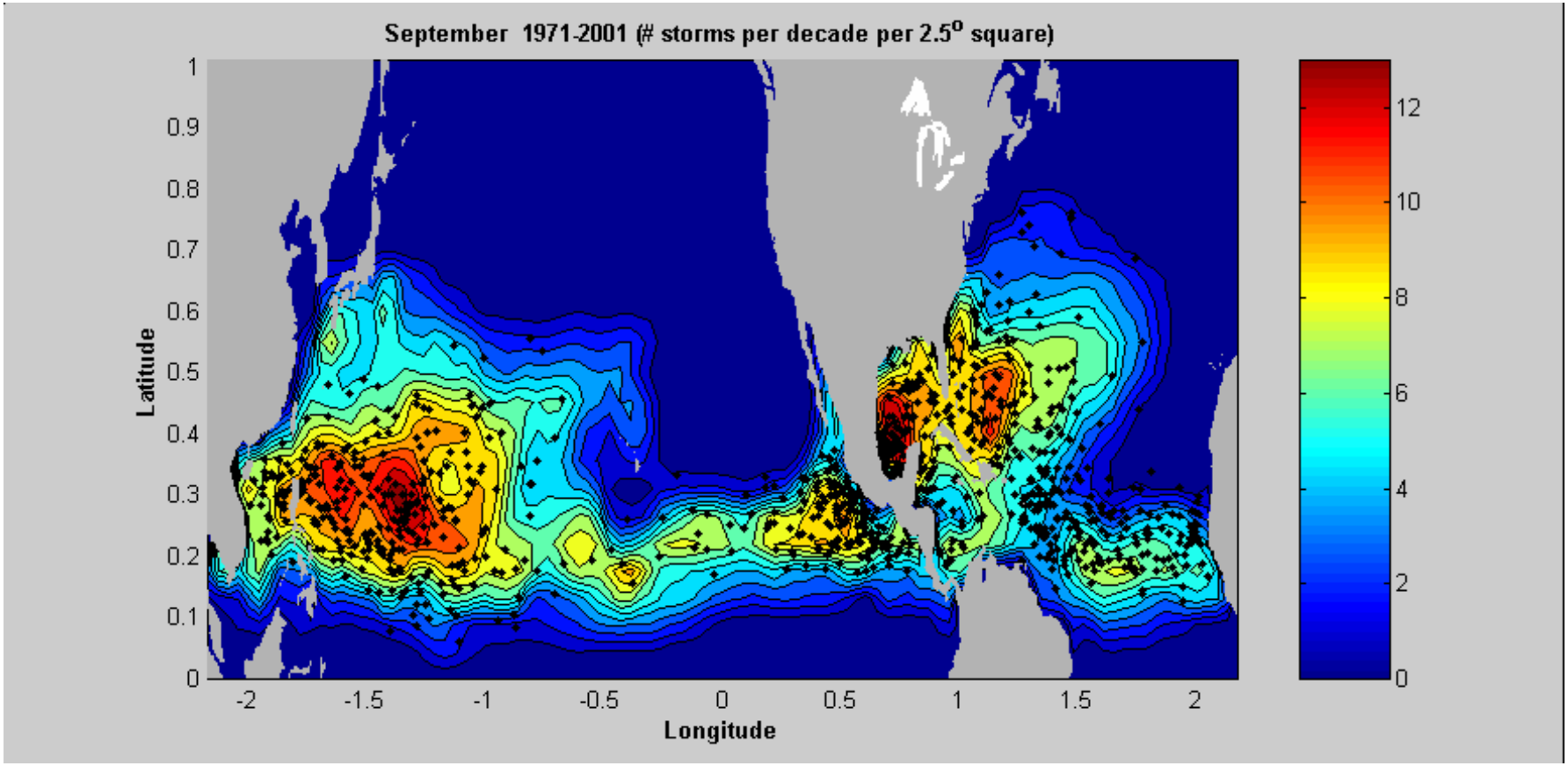
$$V_{shear} \equiv \left| \mathbf{V}_{850} - \mathbf{V}_{250} \right| \quad (ms^{-1}).$$

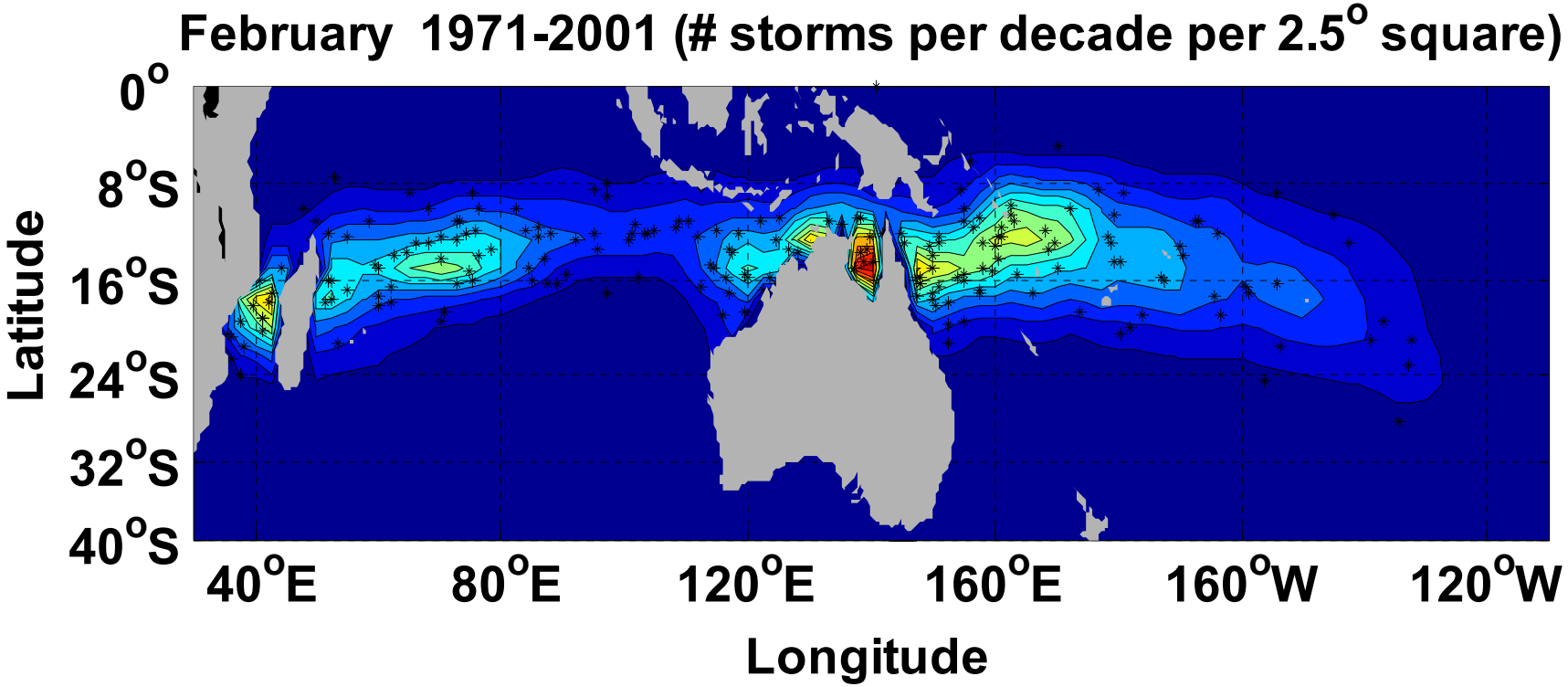
Seasonal Variability:





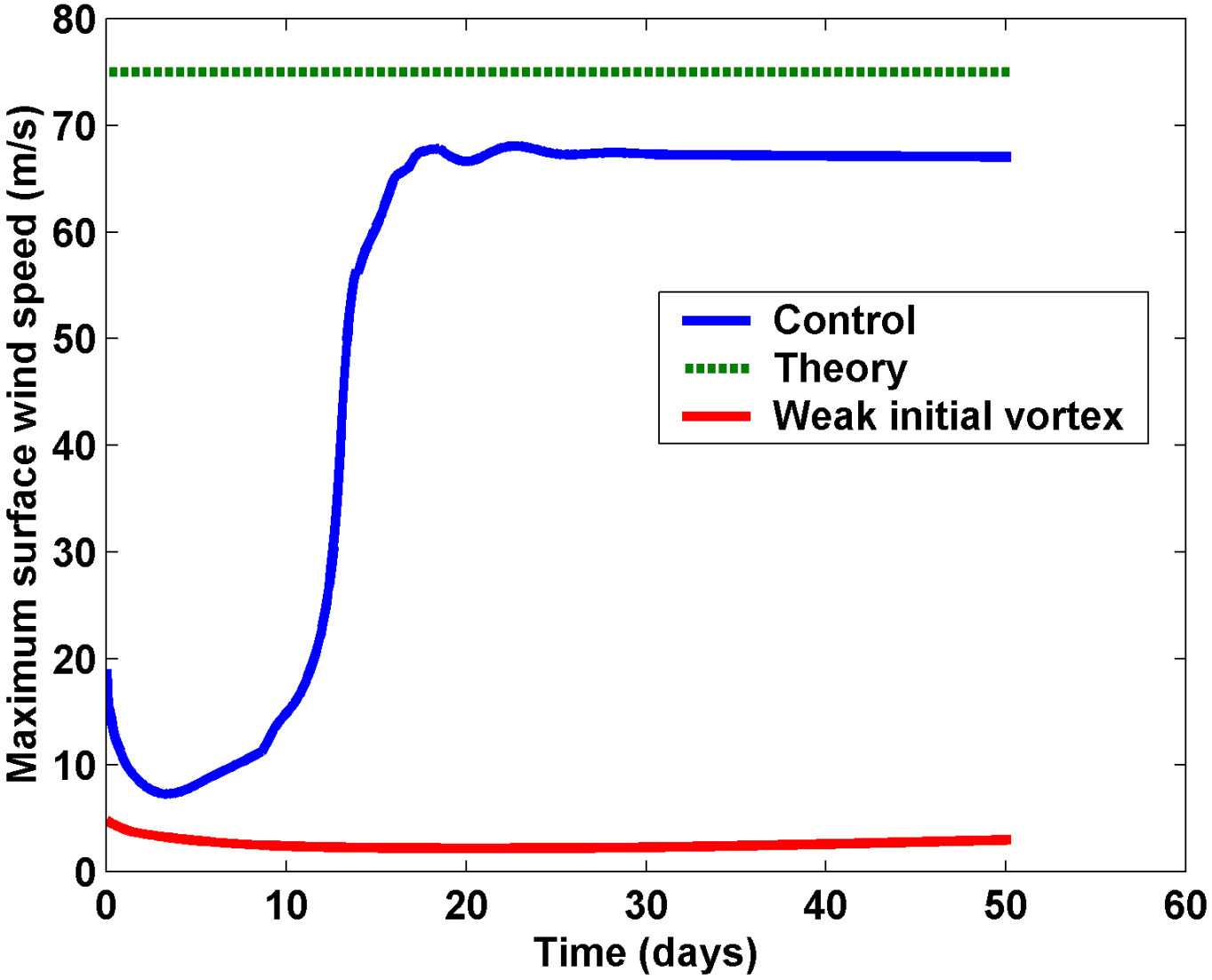
Spatial Variability:



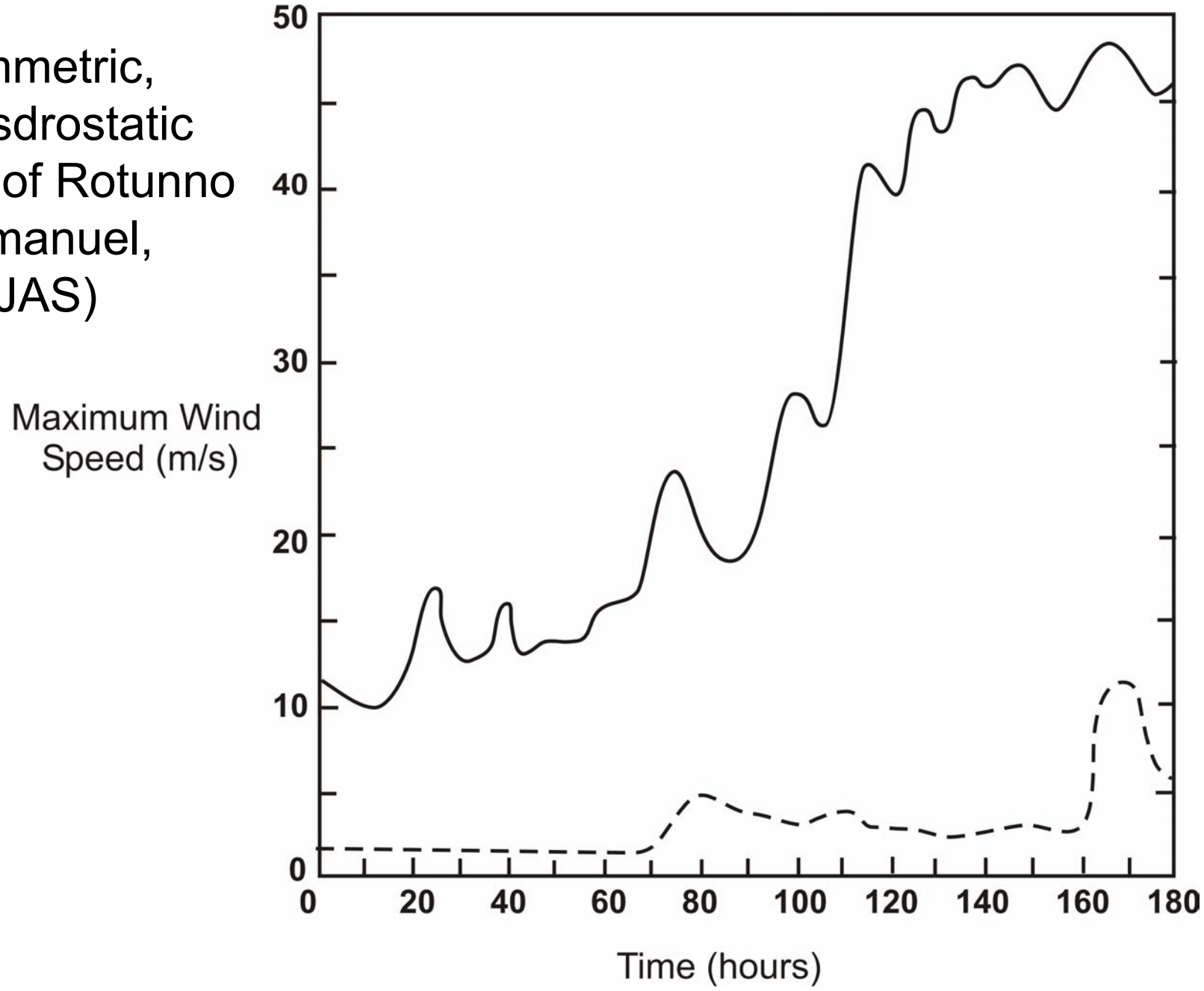

February 1971-2001 (# storms per decade per 2.5° square)
0°
8°S
16°S
24°S
32°S
40°S
Latitude
40°E
80°E
120°E
160°E
160°W
120°W
Longitude

Model Behavior

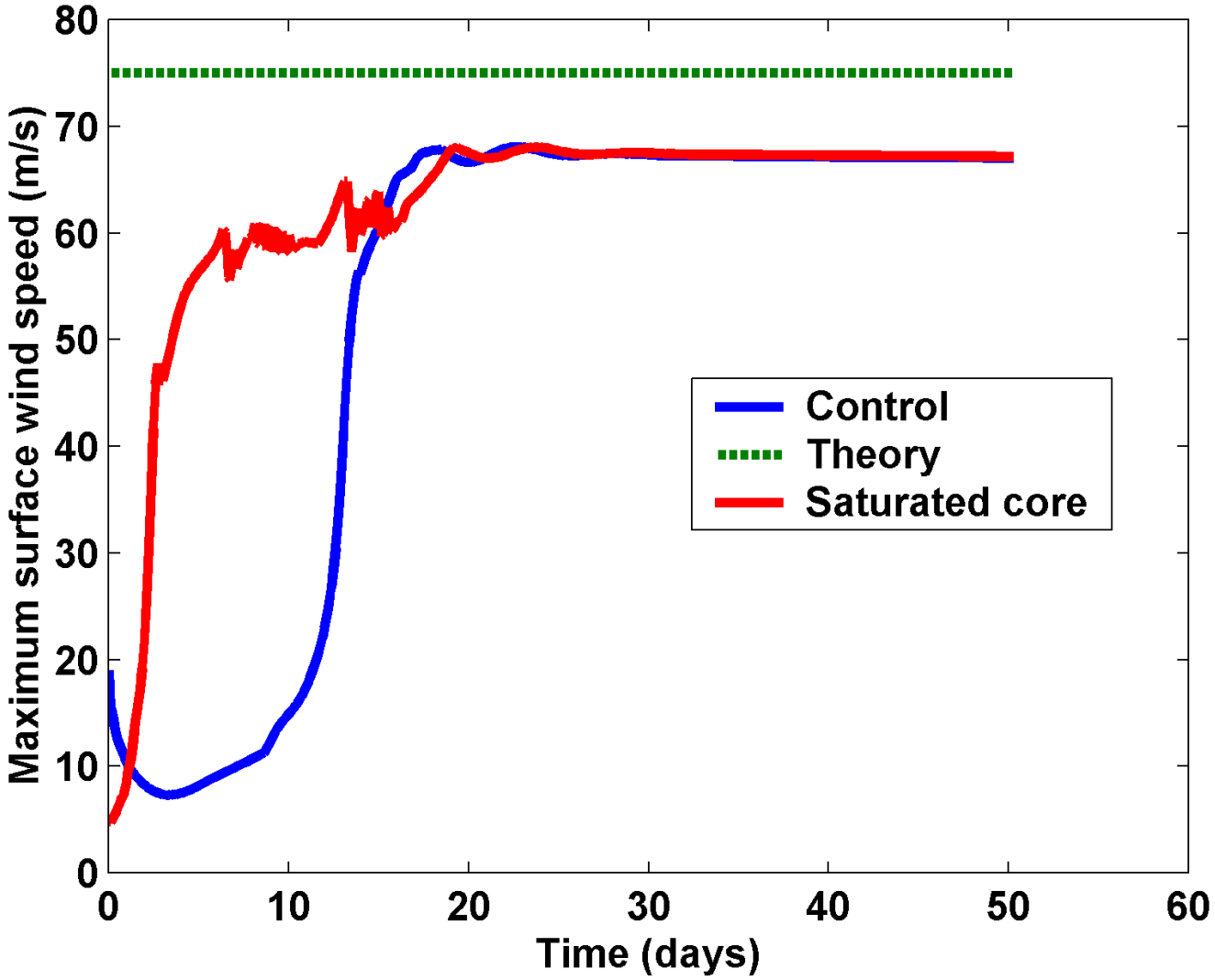
Model behavior



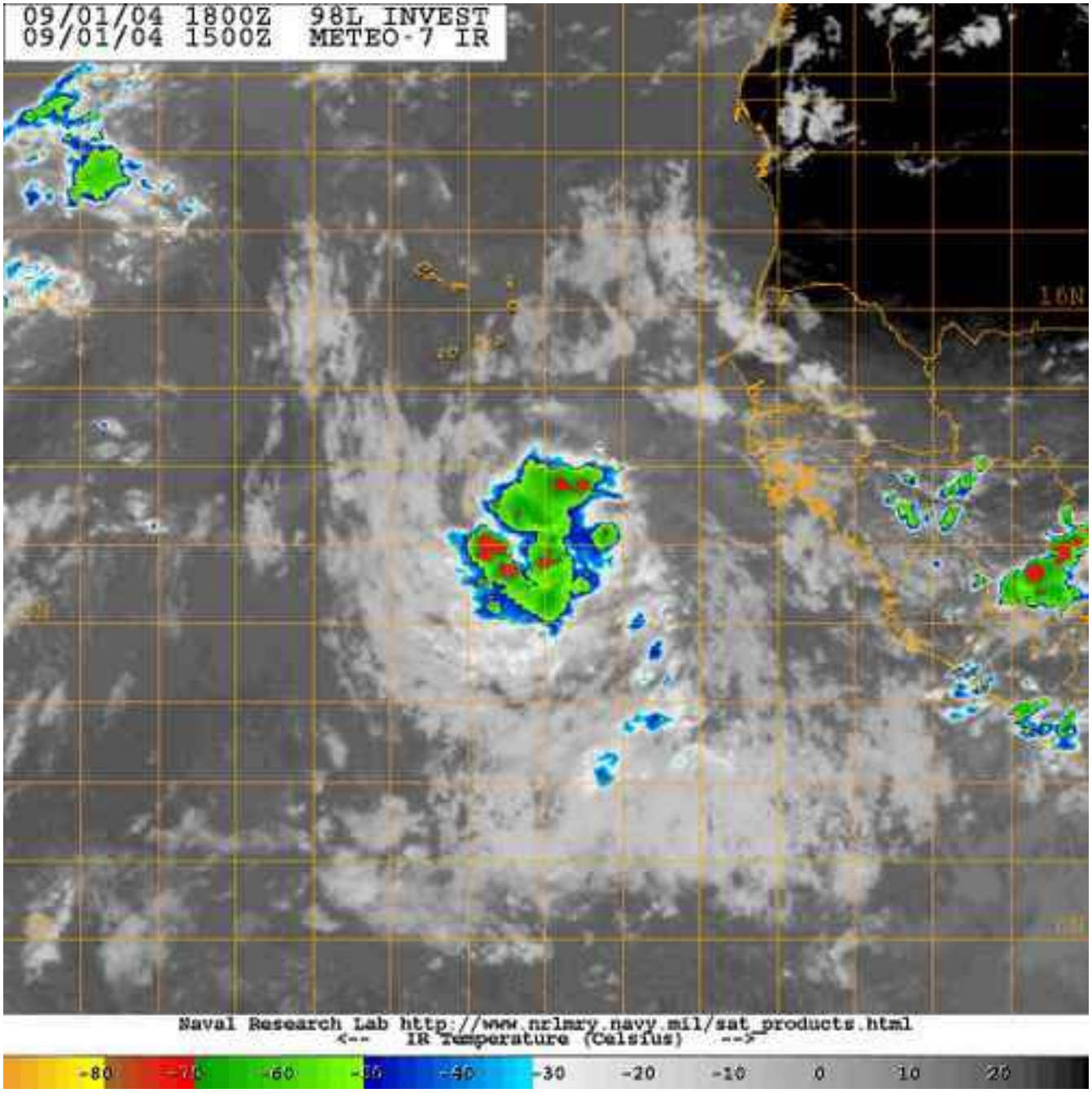
Axisymmetric, nonhysdrostatic model of Rotunno and Emanuel, 1987 (JAS)

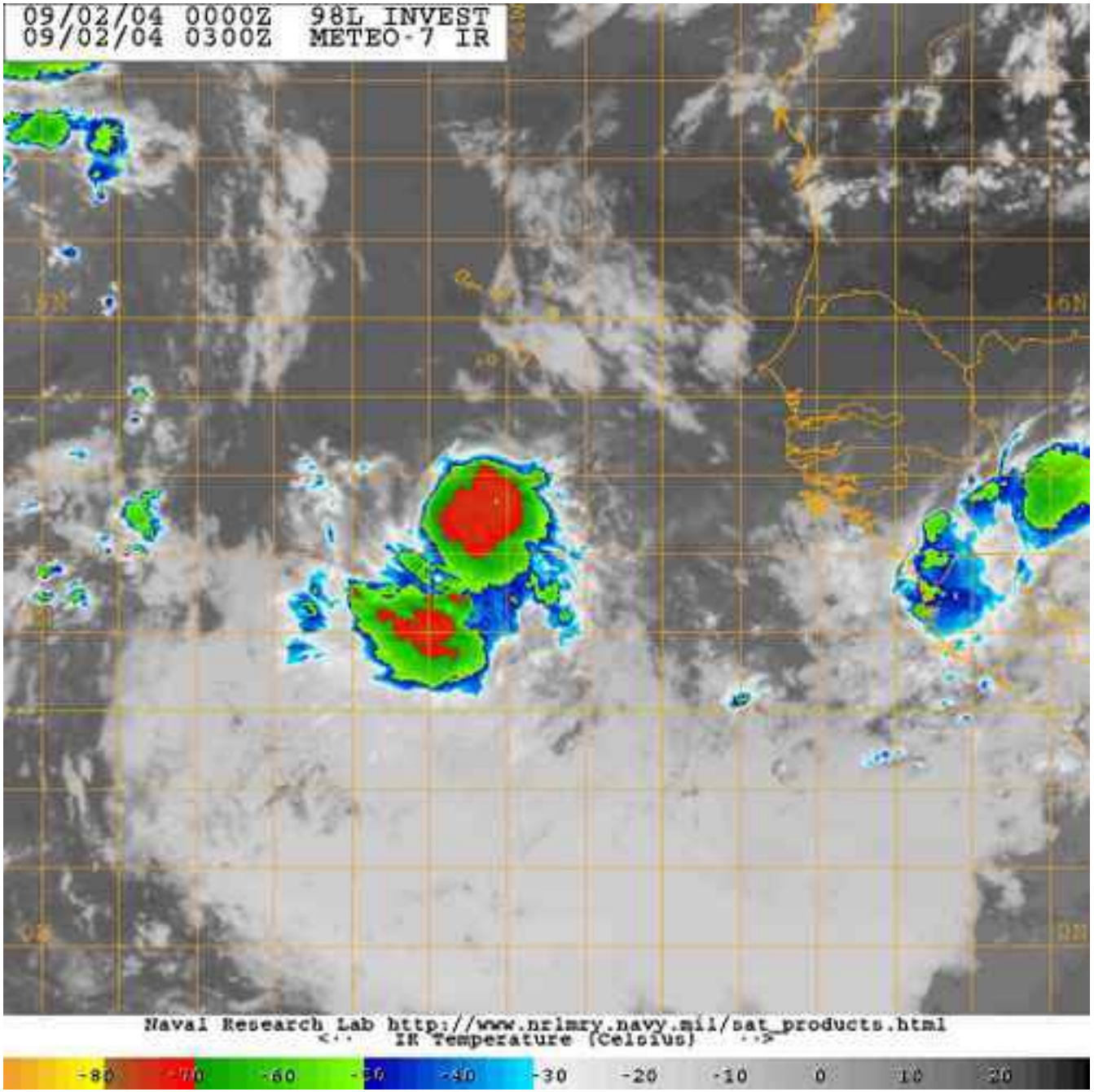


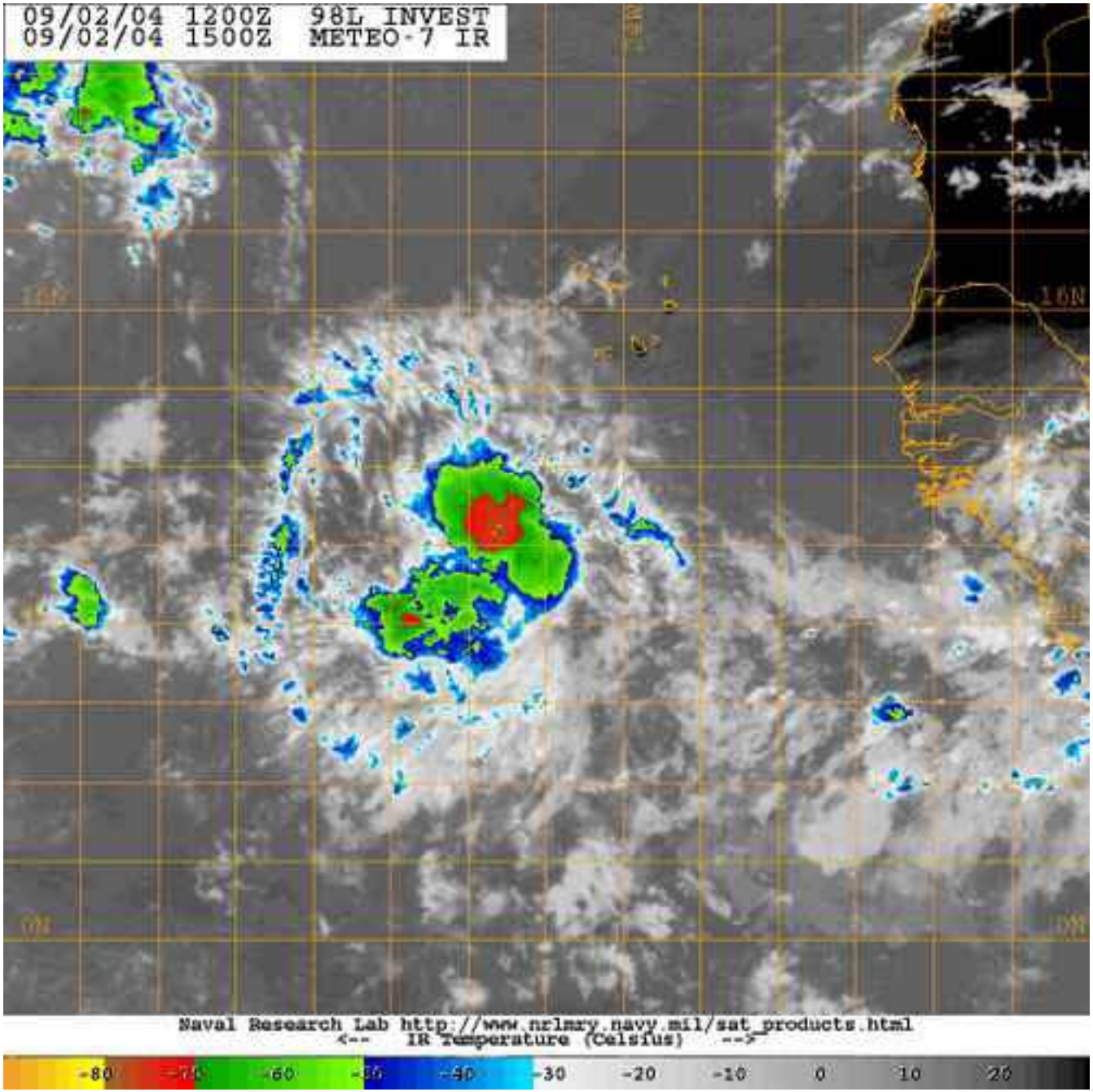
Saturate troposphere inside 100 km in initial state:

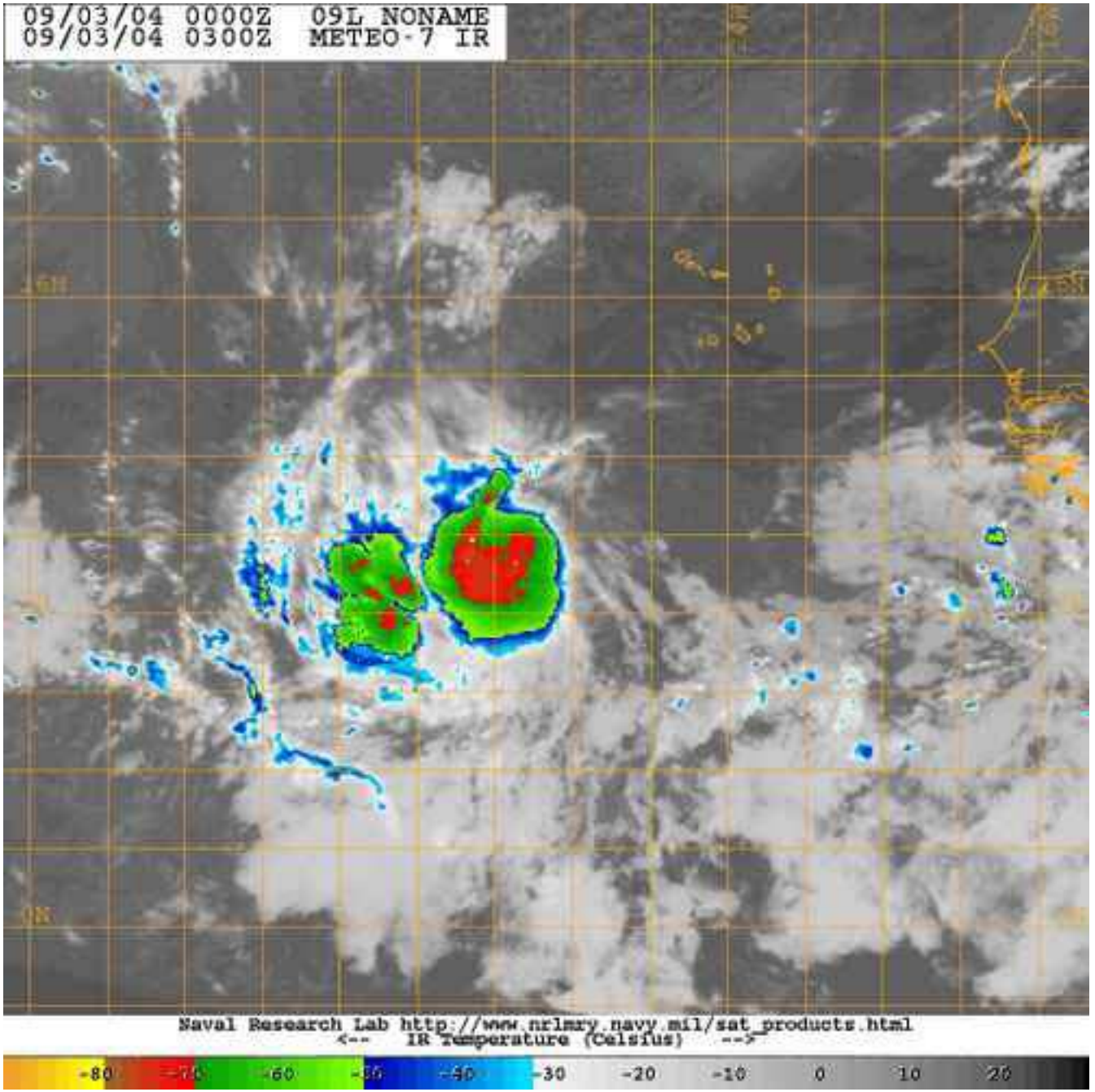


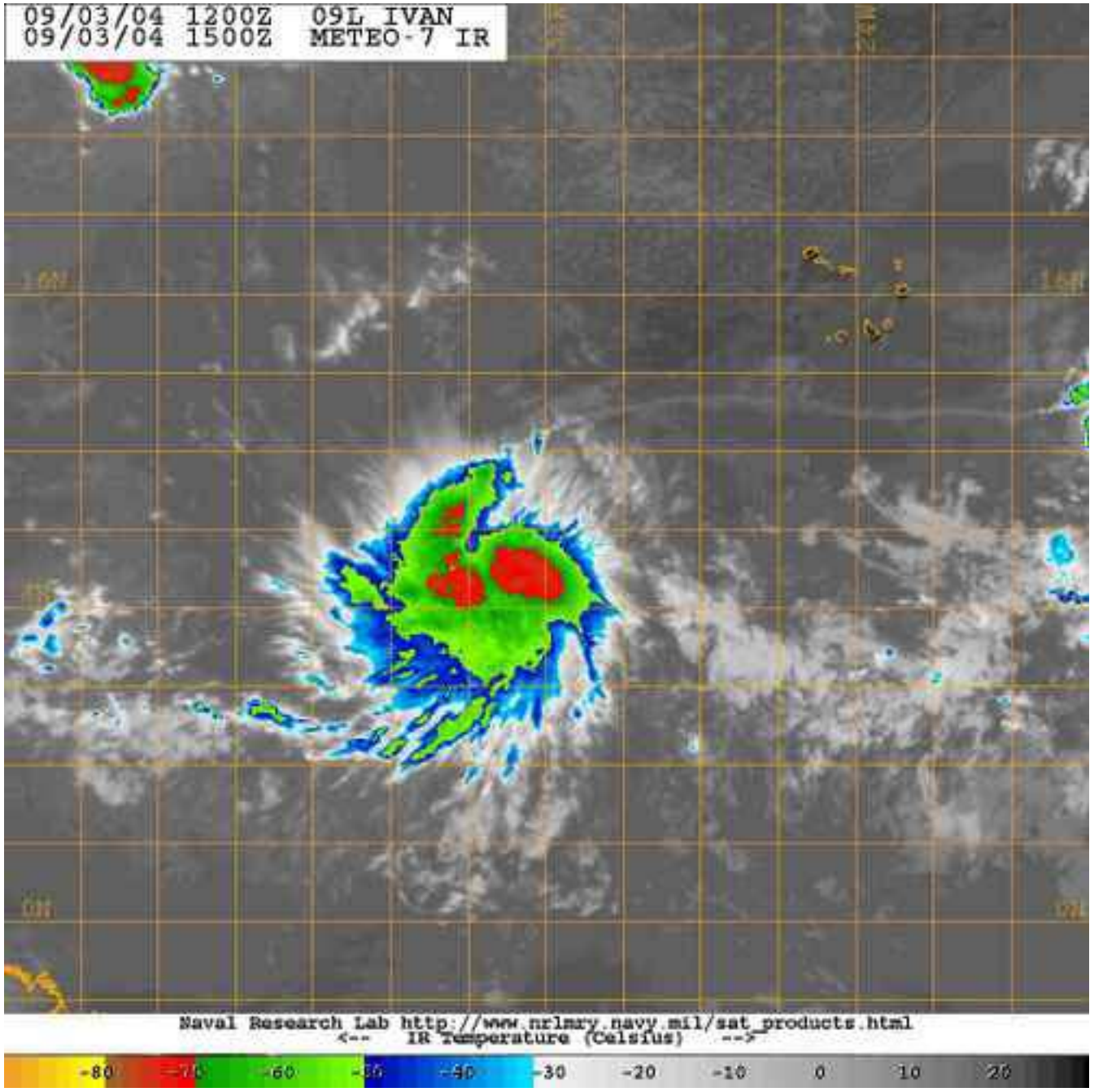
The View from Space: Ivan, 2004


09/01/04 1800Z 98L INVEST
09/01/04 1500Z METEO-7 IR
16N
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20


09/02/04 0000Z 98L INVEST
09/02/04 0300Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20


09/02/04 1200Z 98L INVEST
09/02/04 1500Z METEO-7 IR
16N
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20


09/03/04 0000Z 09L NONAME
09/03/04 0300Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20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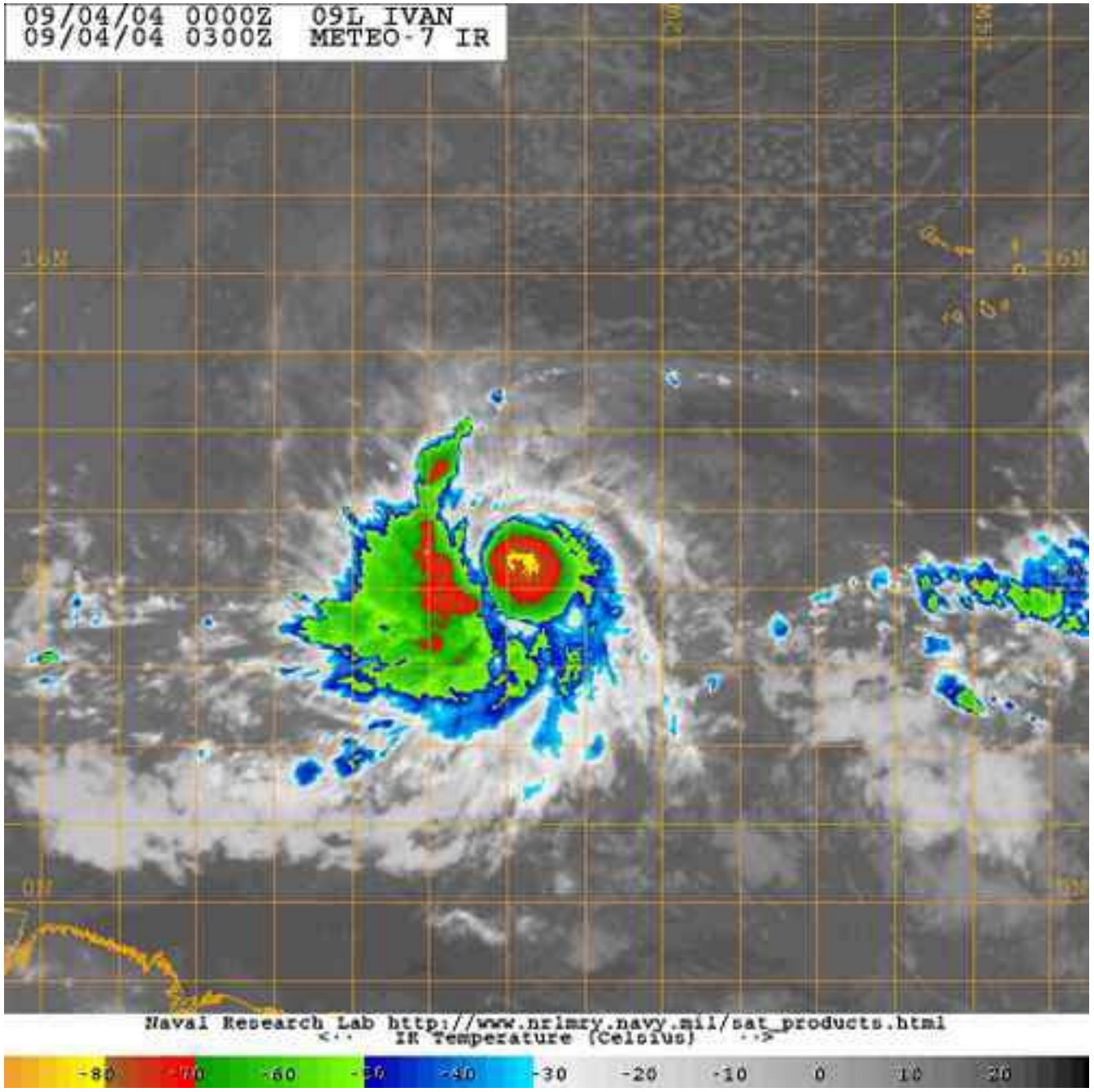
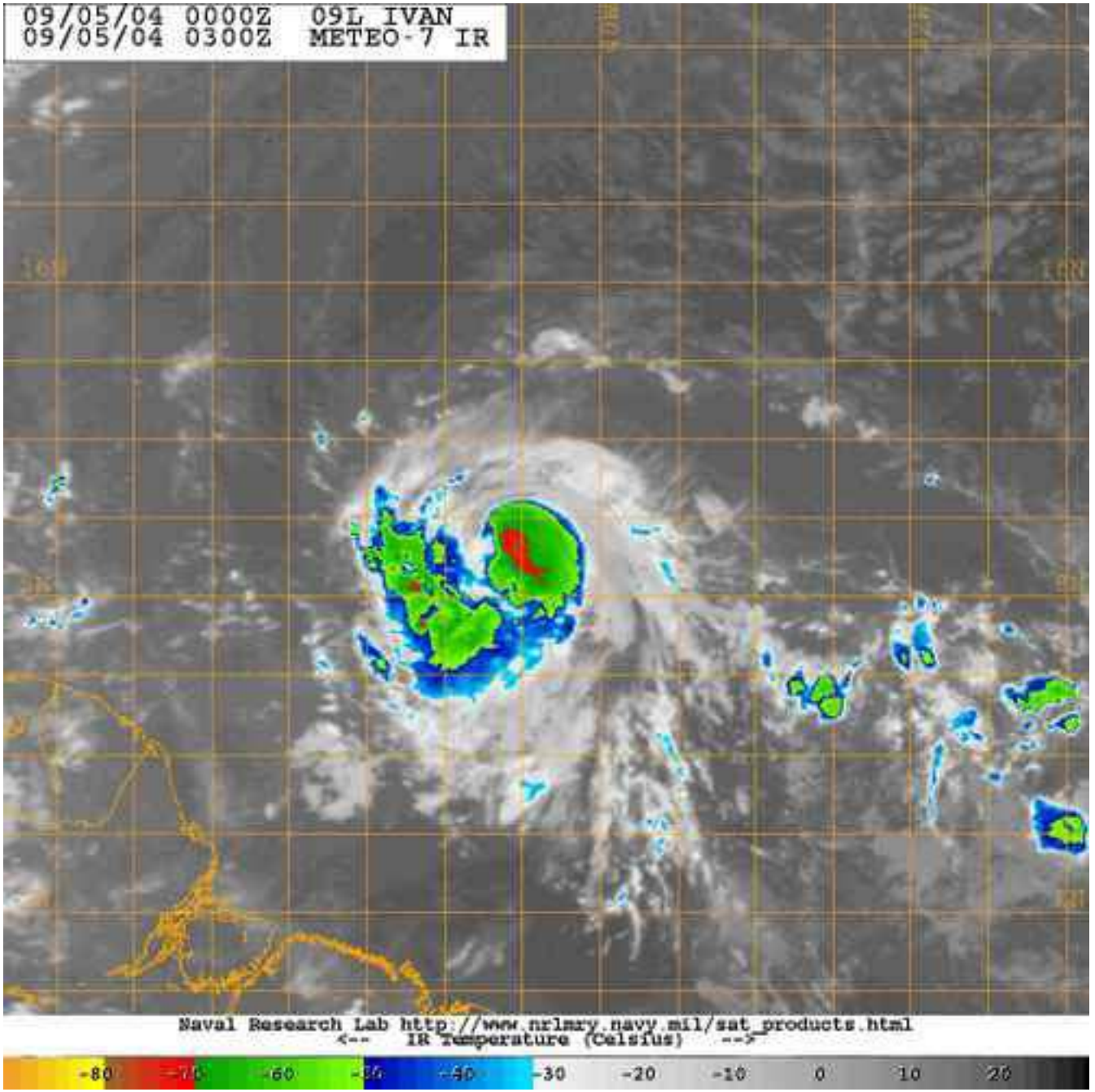
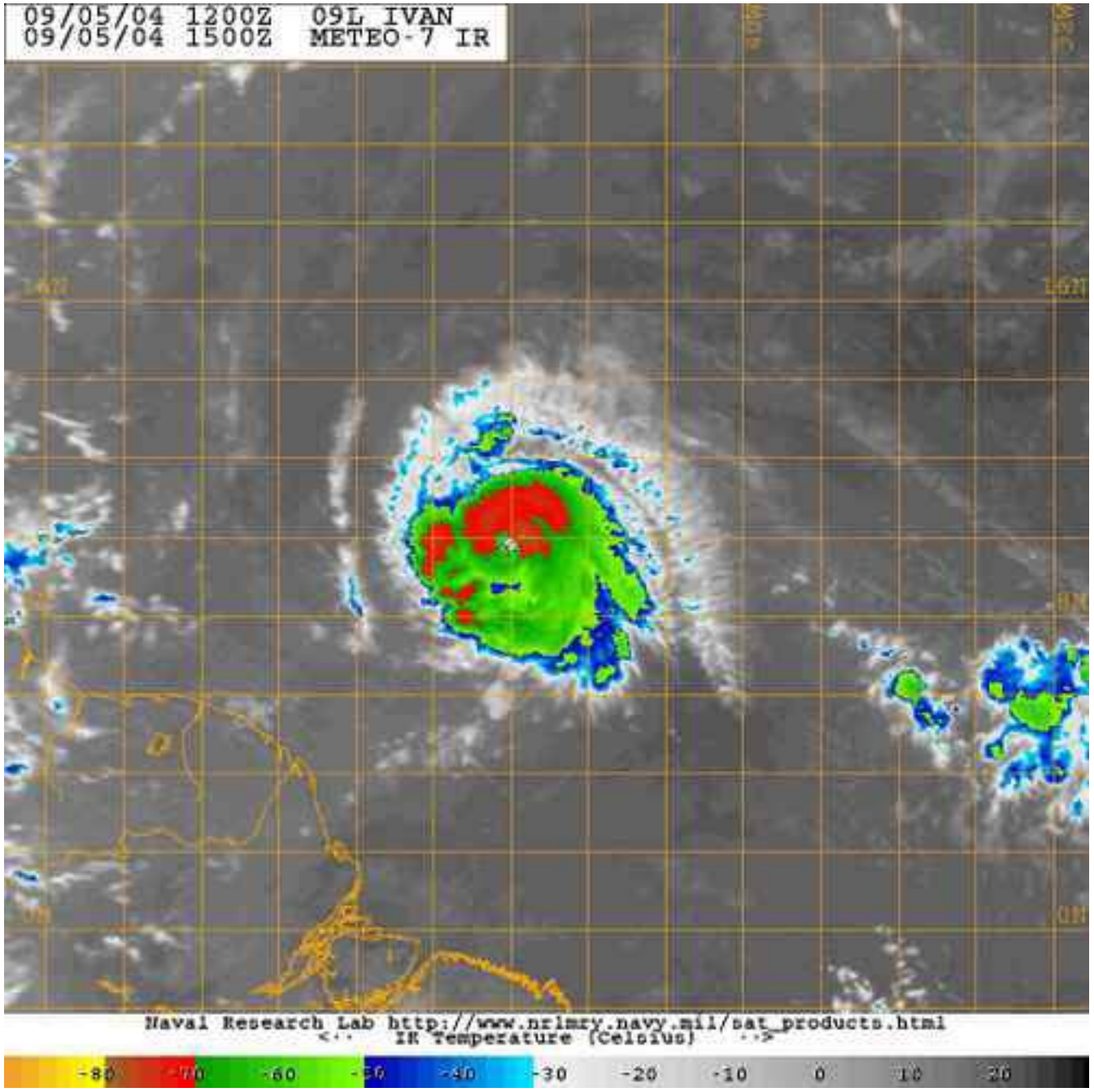
09/03/04 1500Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20


09/04/04 0000Z 09L IVAN
09/04/04 0300Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20


09/05/04 0000Z 09L IVAN
09/05/04 0300Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20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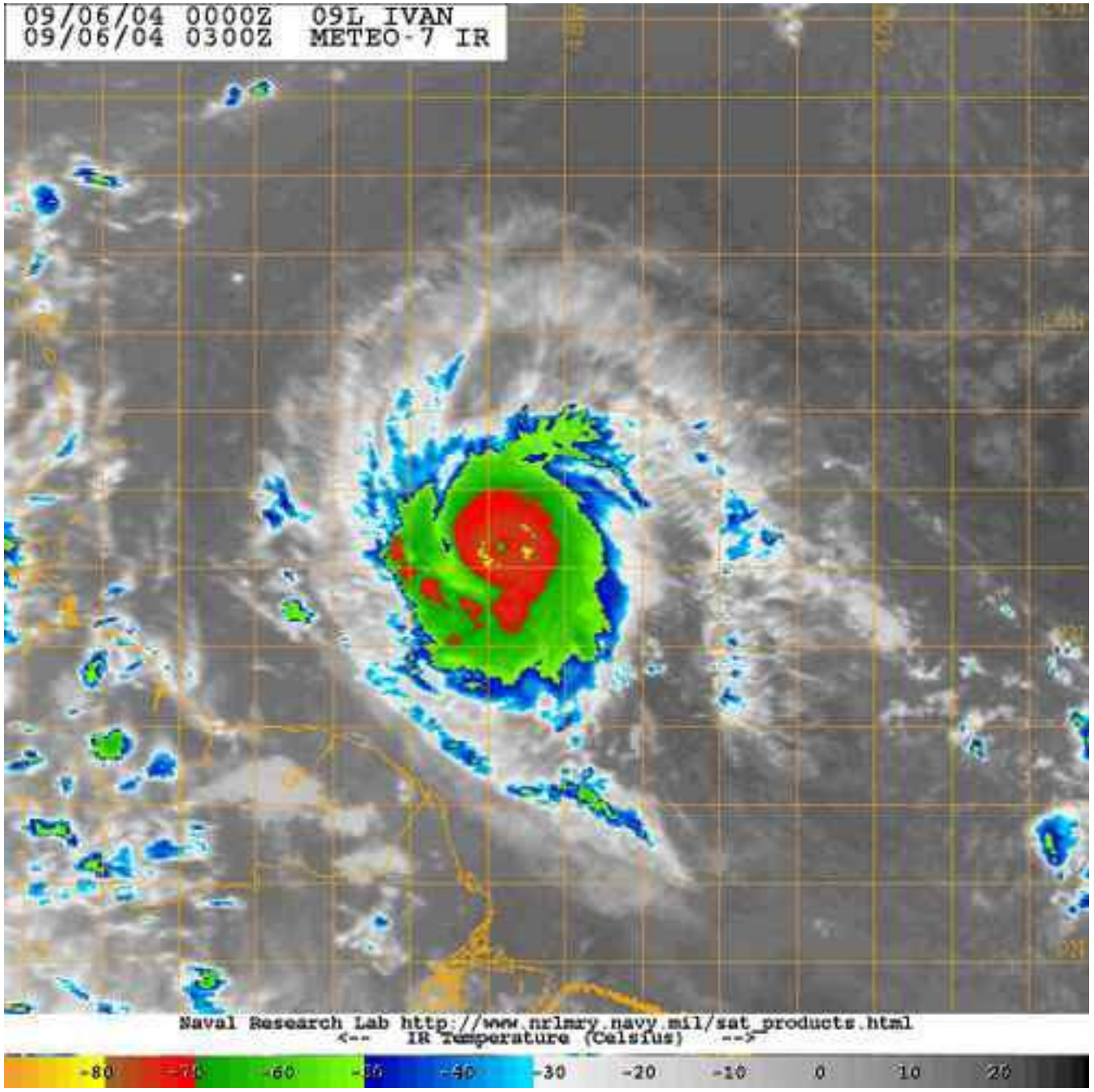
09/05/04 1500Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20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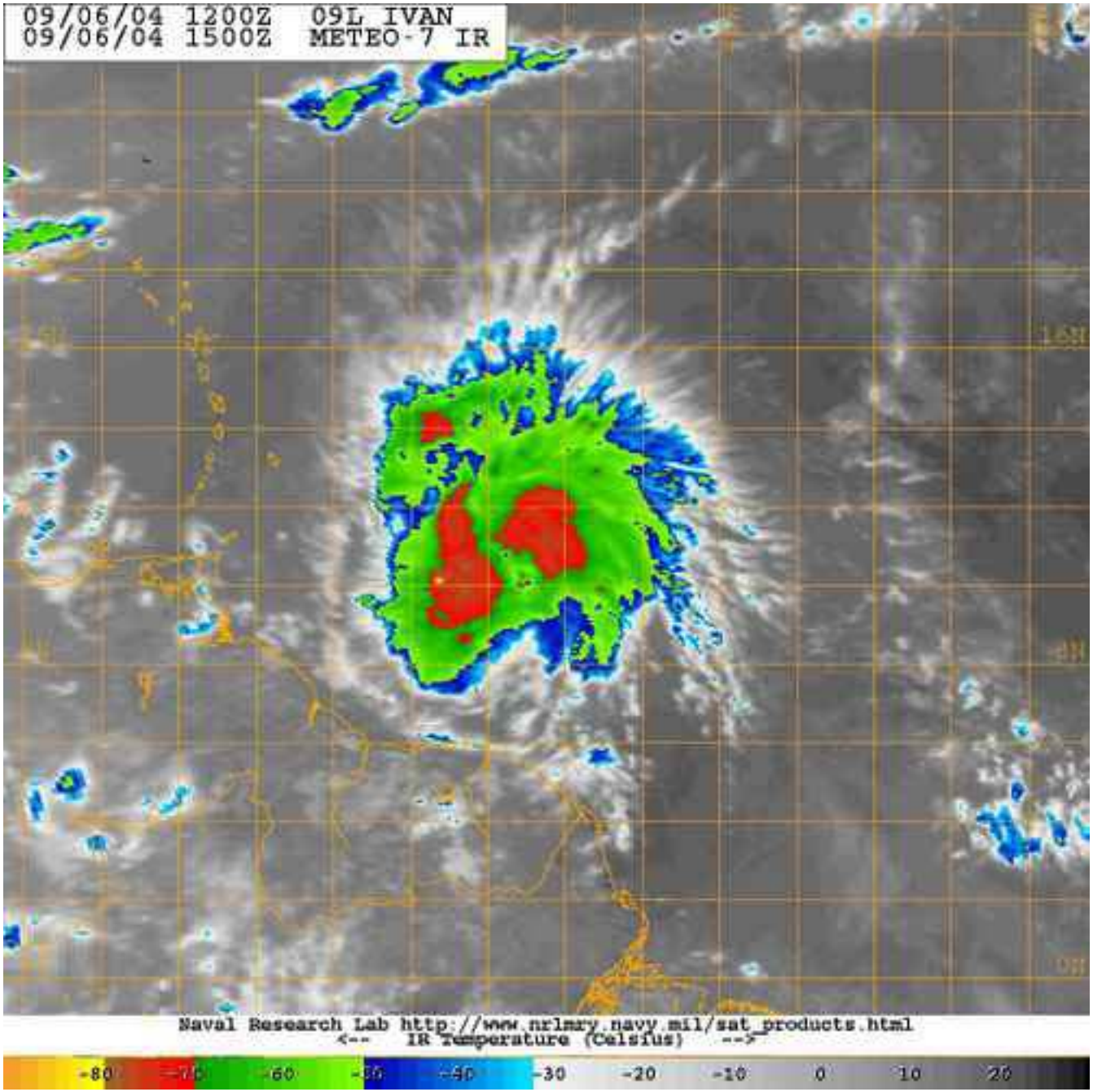
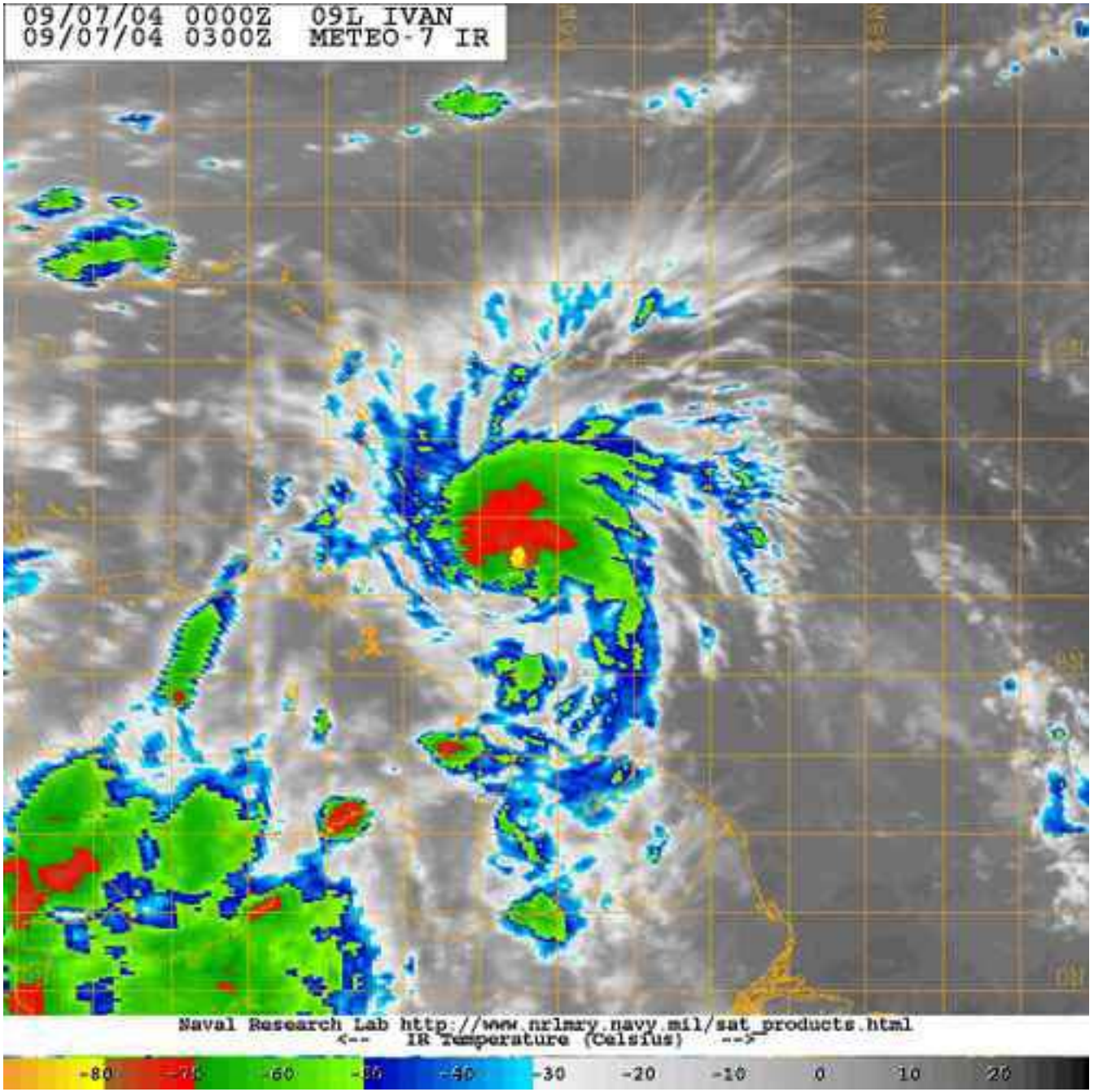
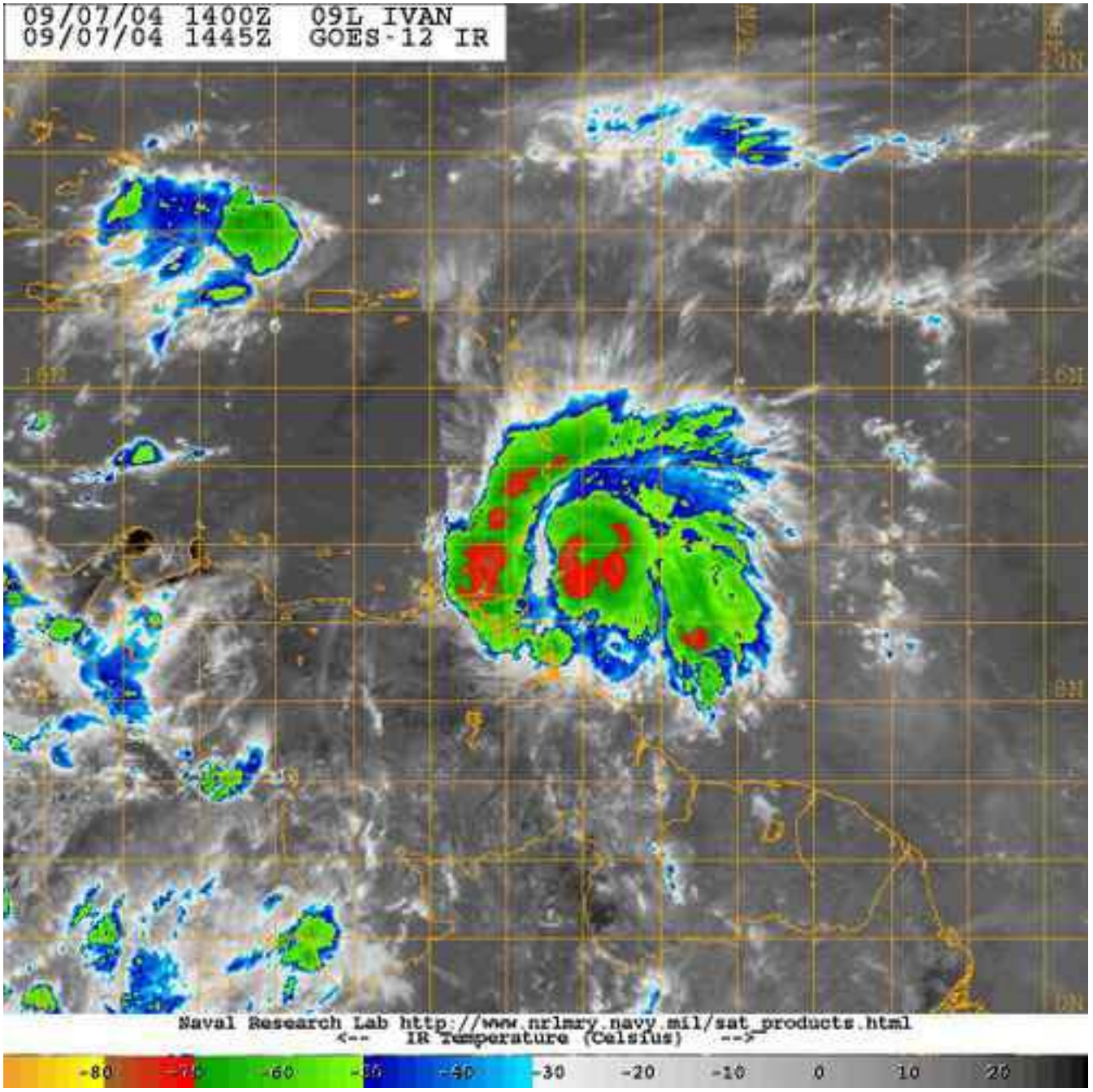
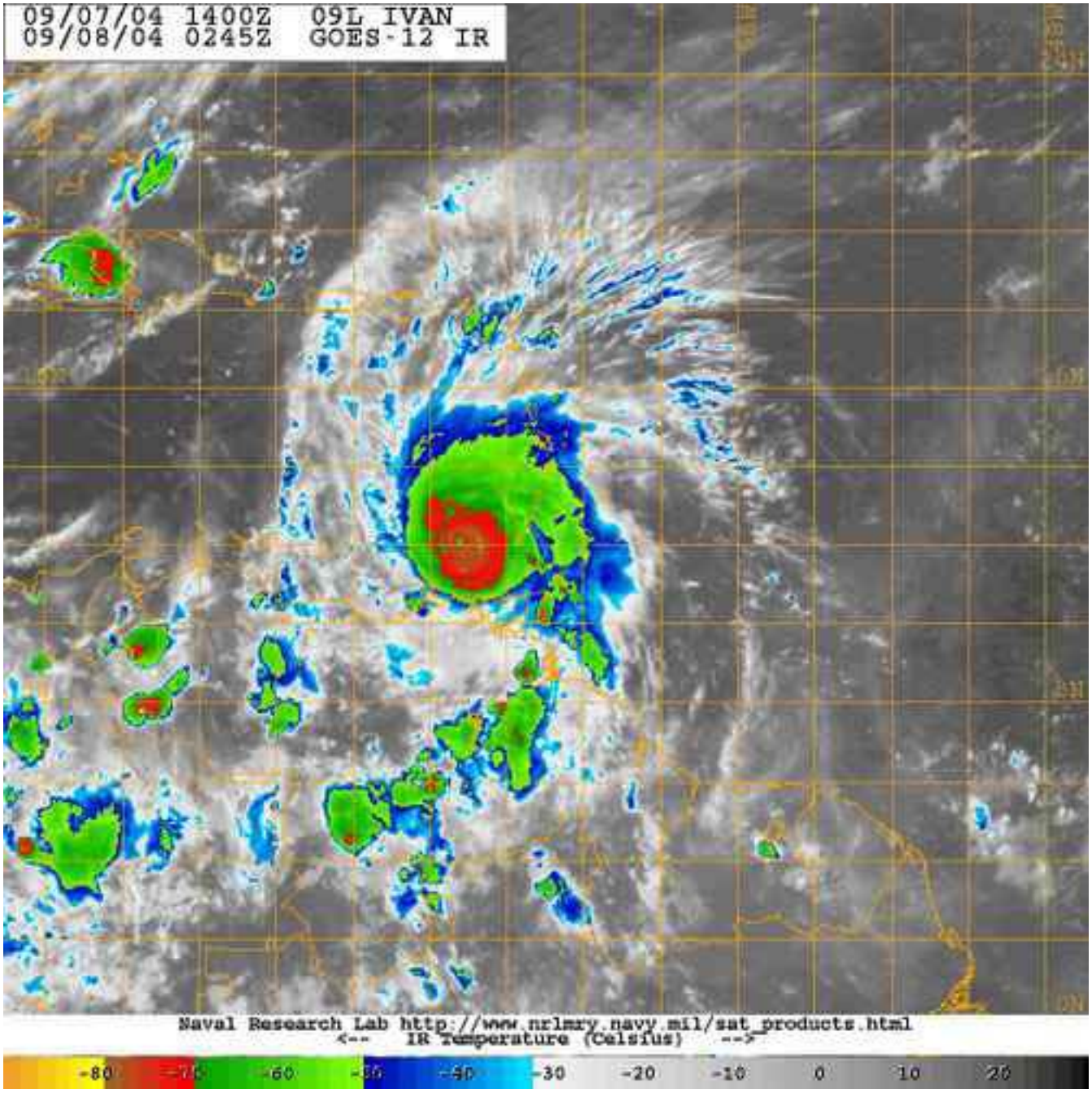
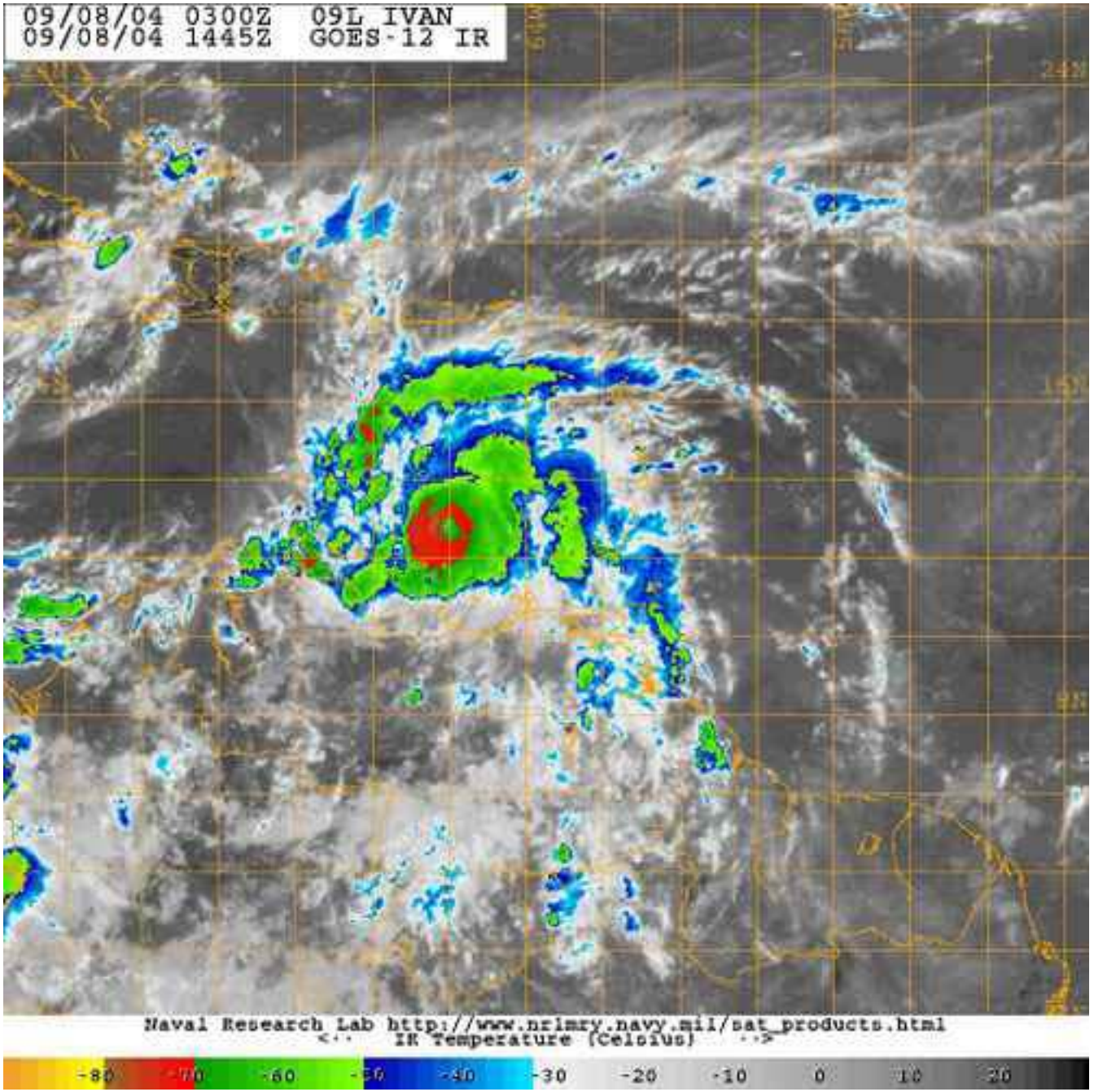
09/06/04 0300Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20


09/06/04 1200Z 09L IVAN
09/06/04 1500Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20


09/07/04 0000Z 09L IVAN
09/07/04 0300Z METEO-7 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20


09/07/04 1400Z 09L IVAN
09/07/04 1445Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20


09/07/04 1400Z 09L IVAN
09/08/04 0245Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20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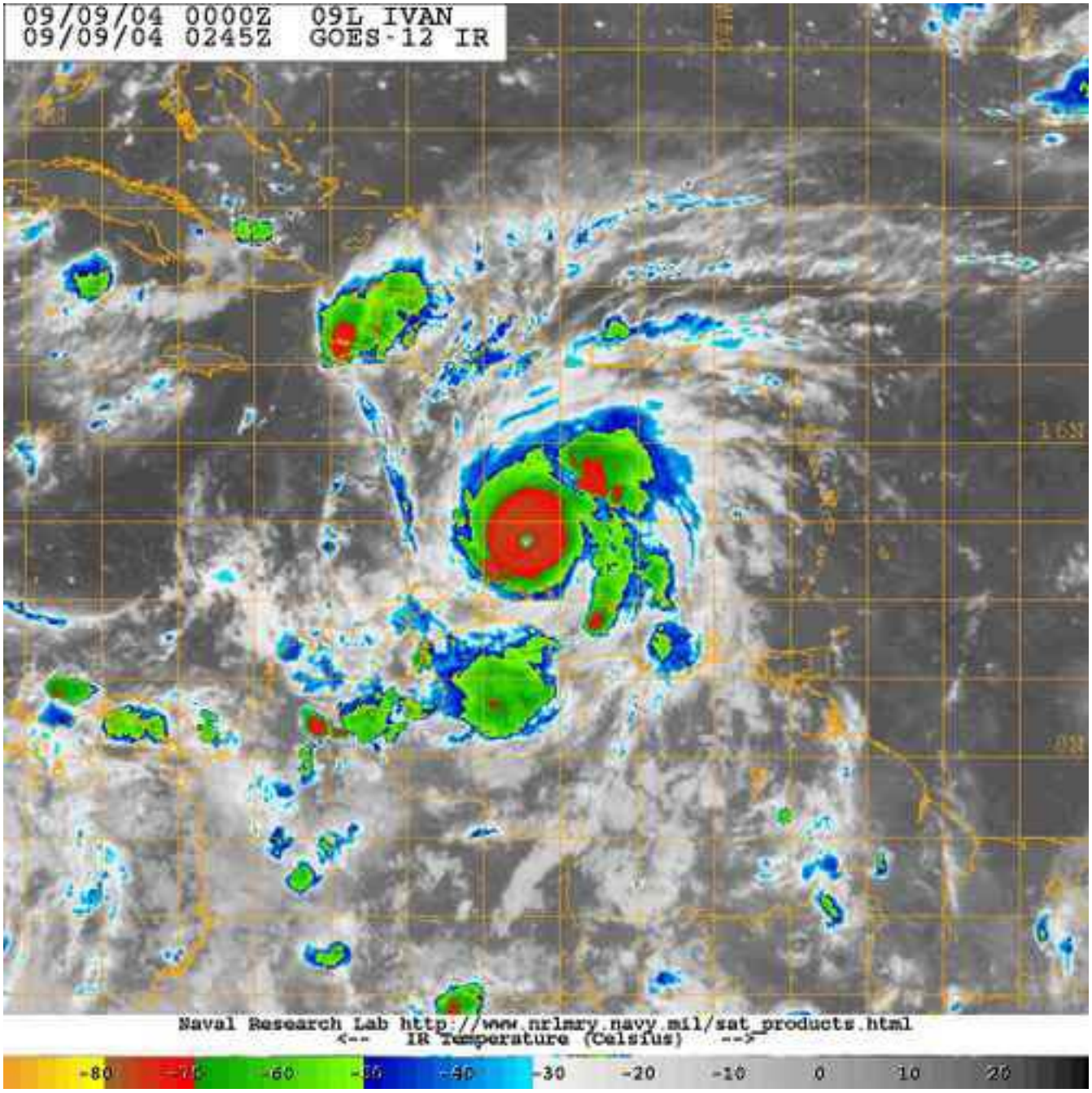
09/08/04 1445Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20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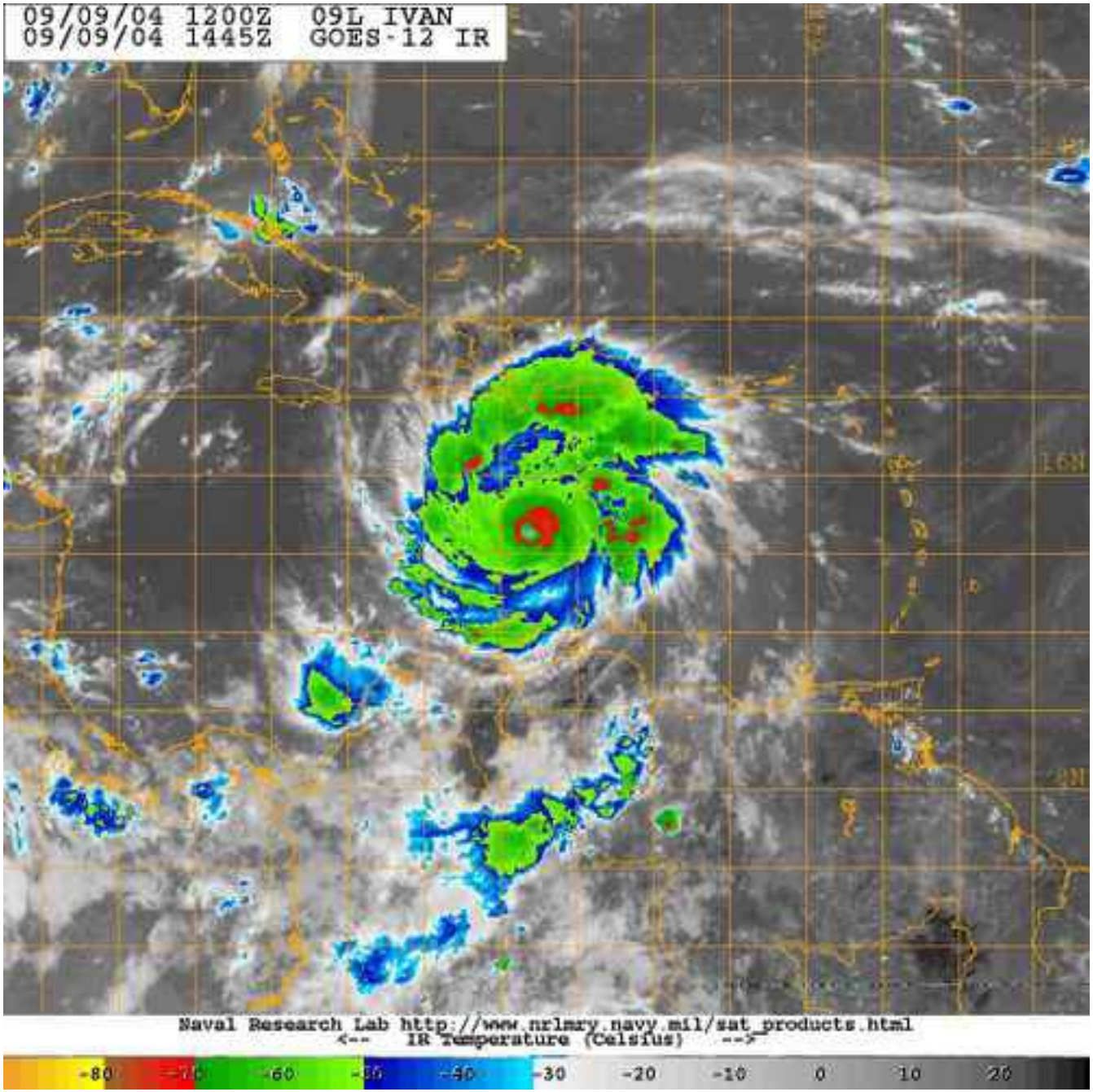
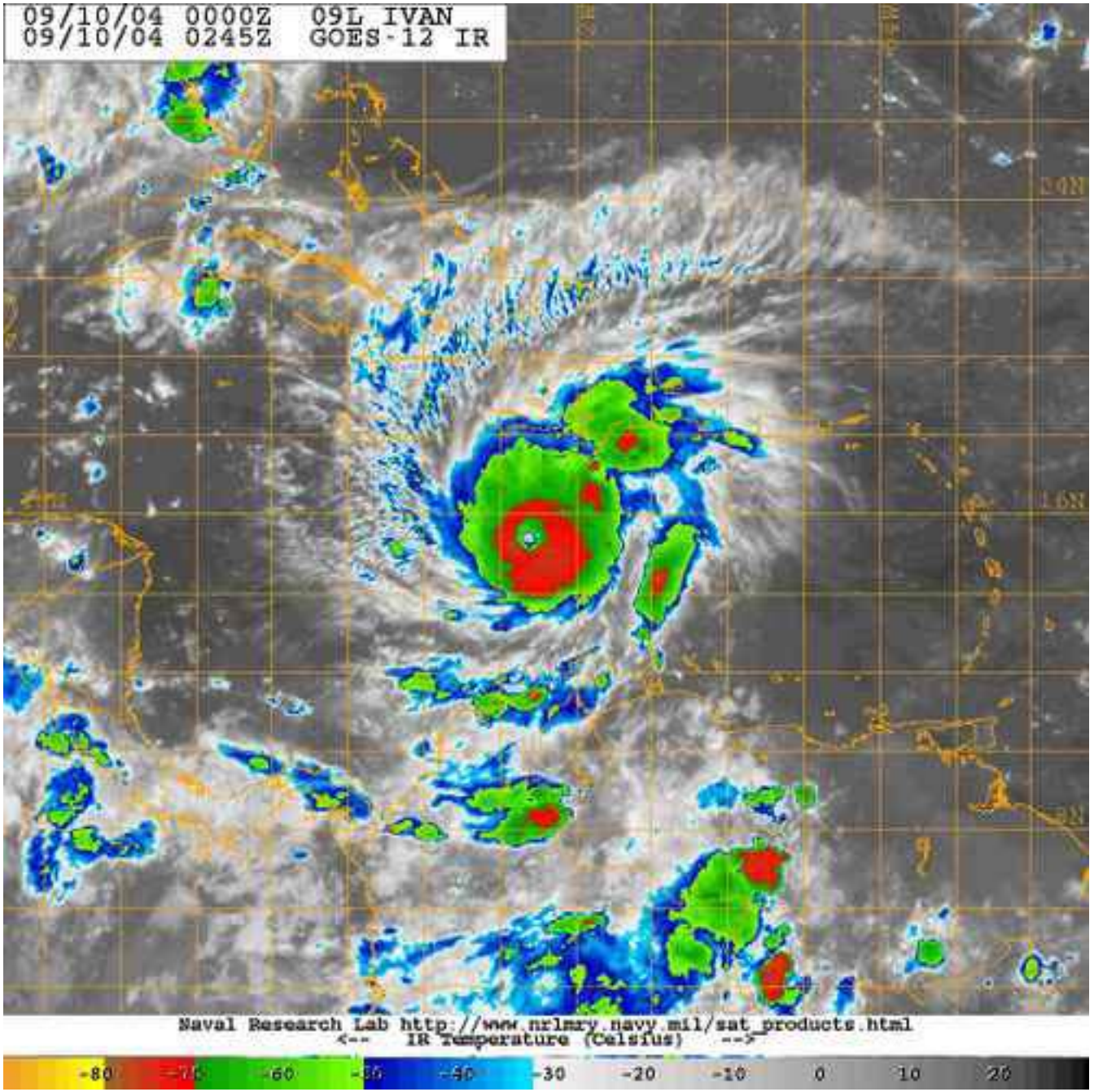
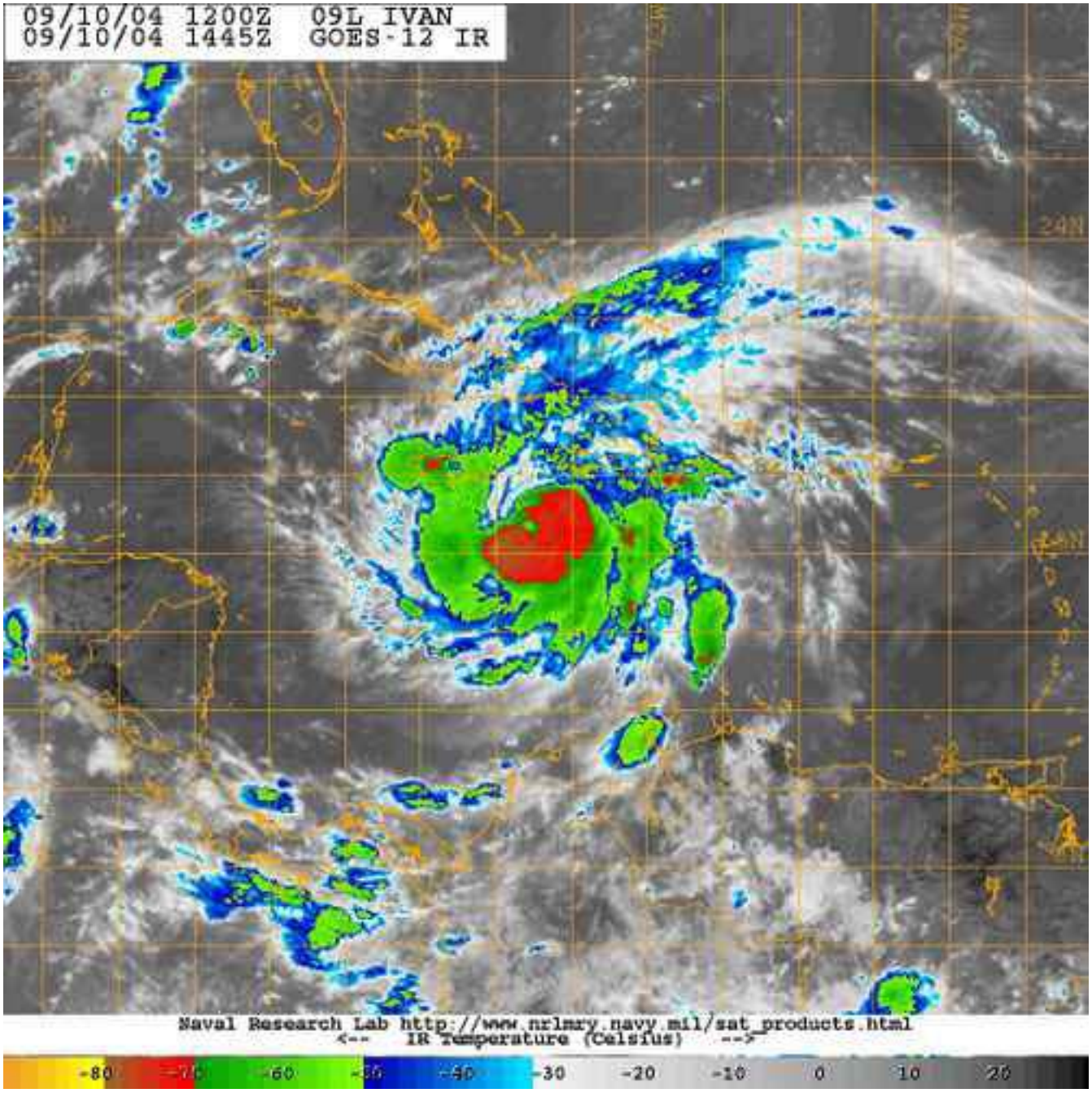
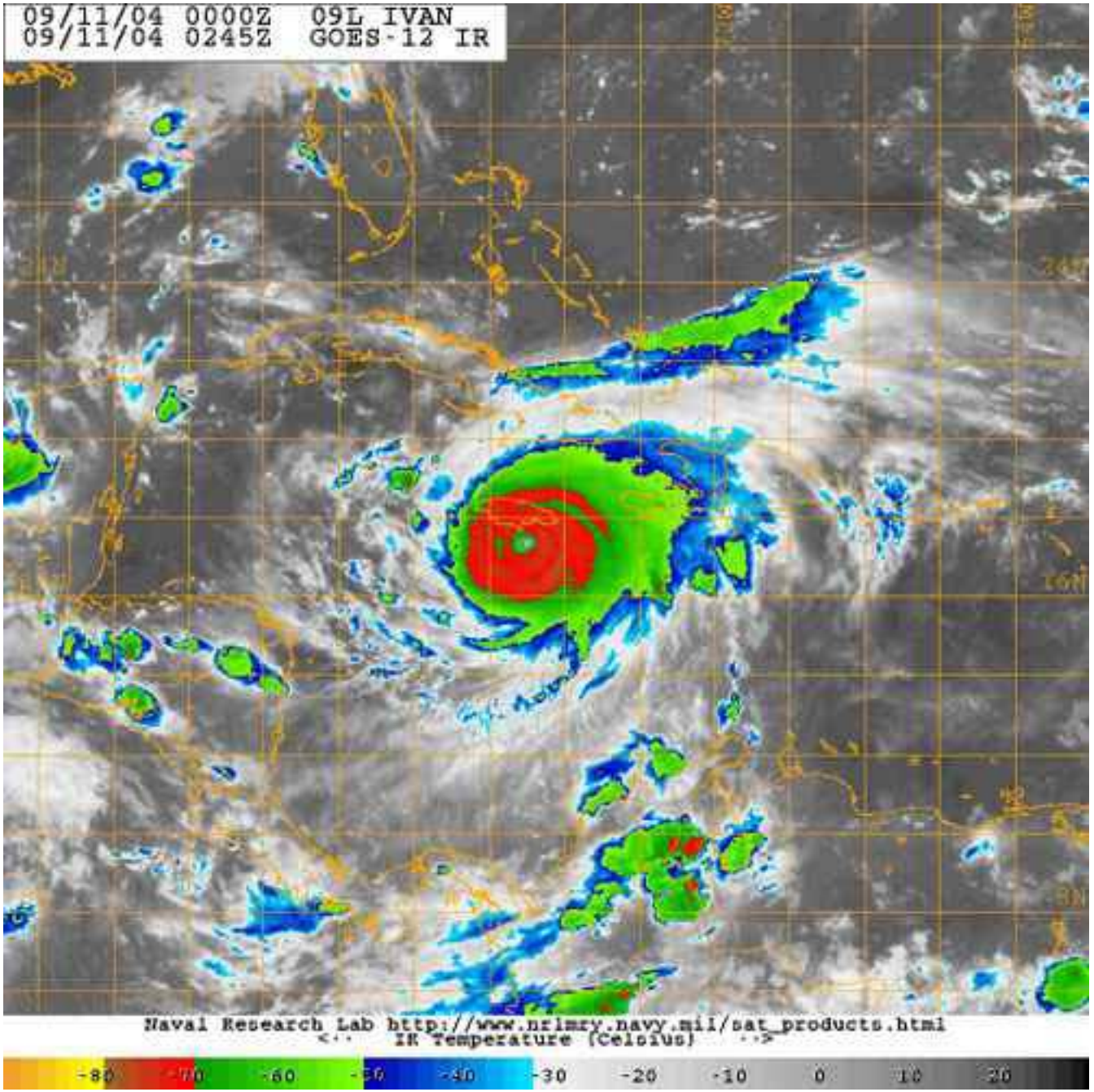
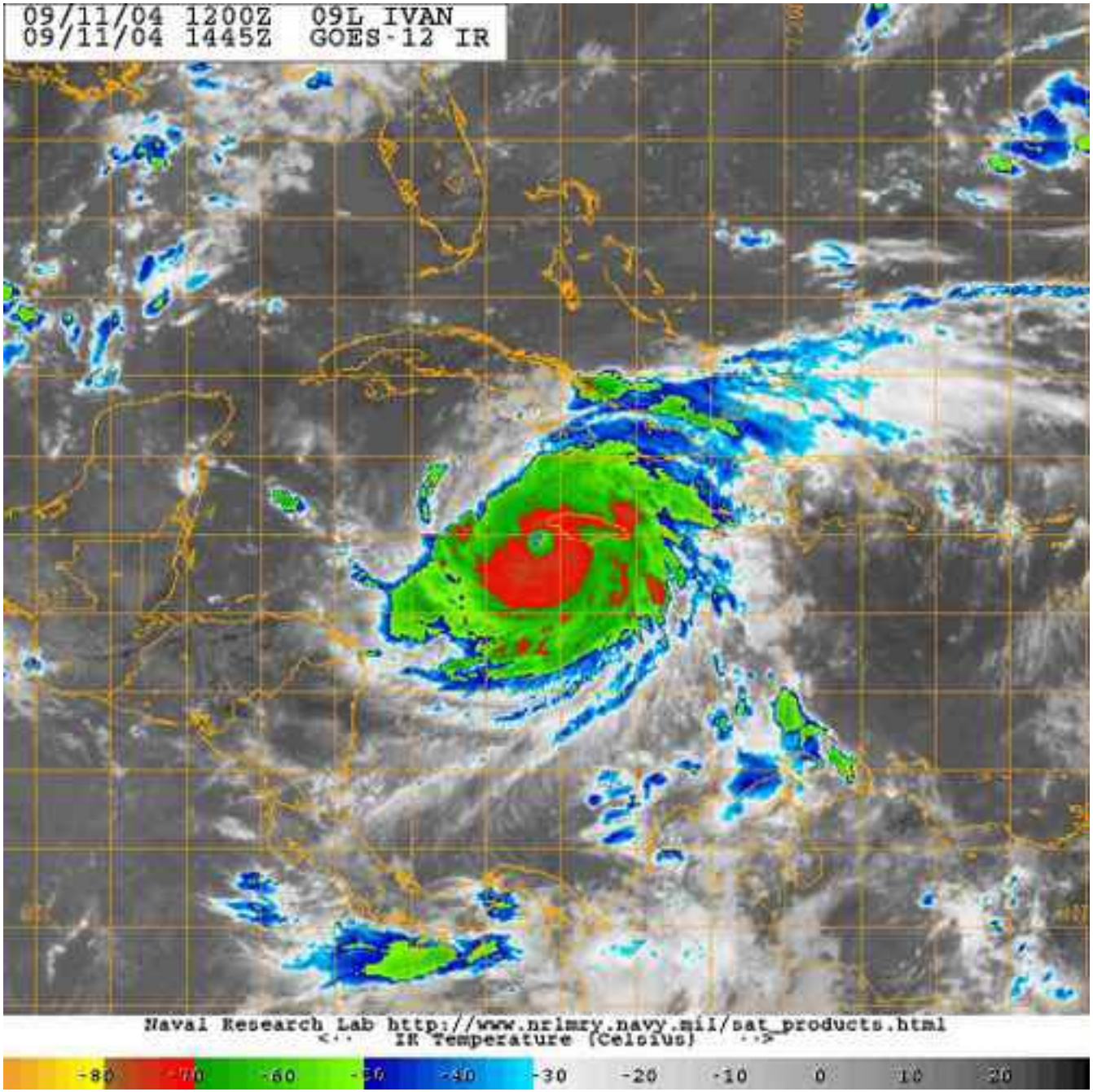
09/09/04 0245Z GOES-12 IR
16N
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20

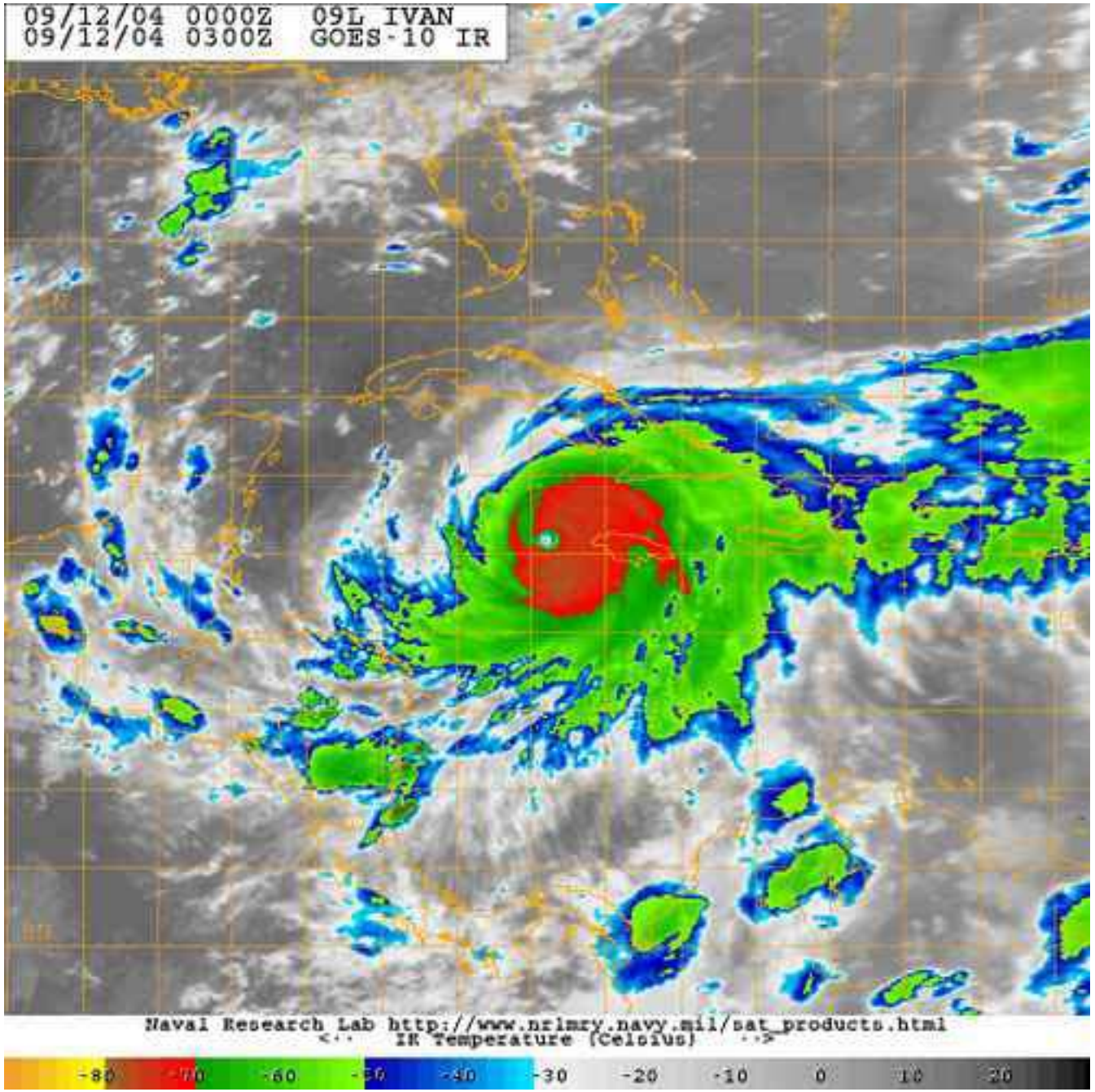

09/09/04 1200Z 09L IVAN
09/09/04 1445Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20


09/10/04 0000Z 09L IVAN
09/10/04 0245Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20

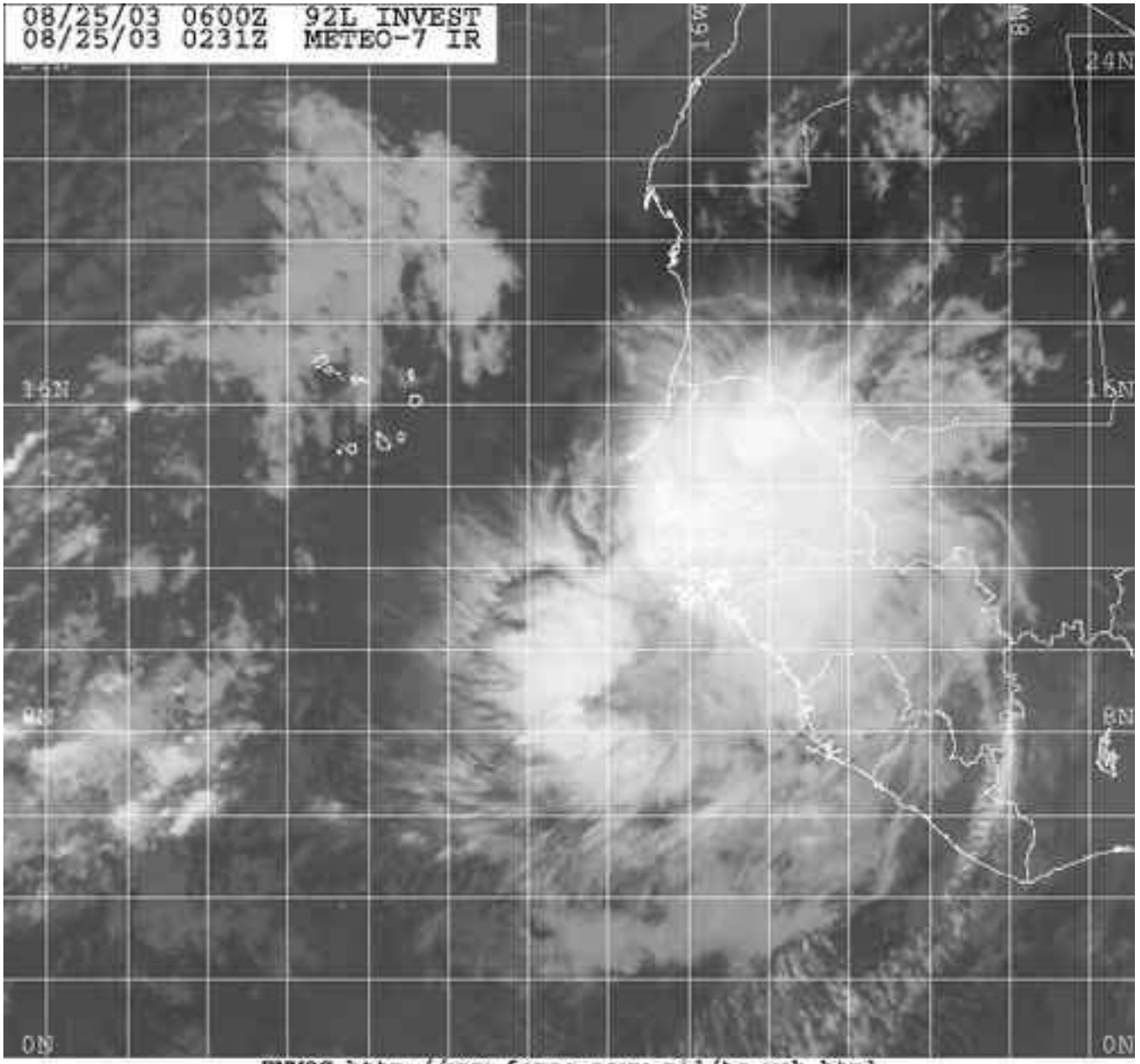

09/10/04 1200Z 09L IVAN
09/10/04 1445Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20

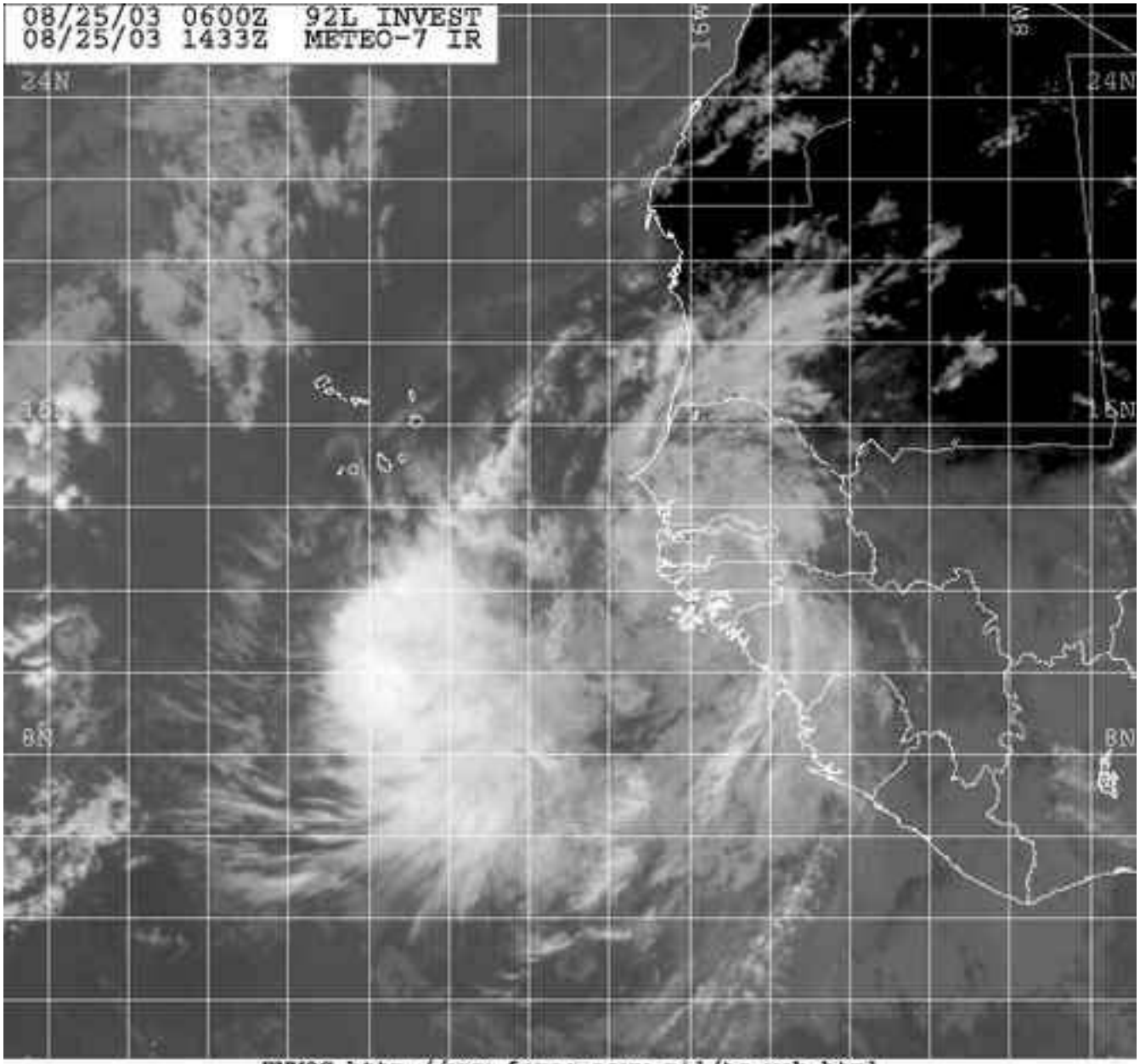

09/11/04 0000Z 09L IVAN
09/11/04 0245Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20

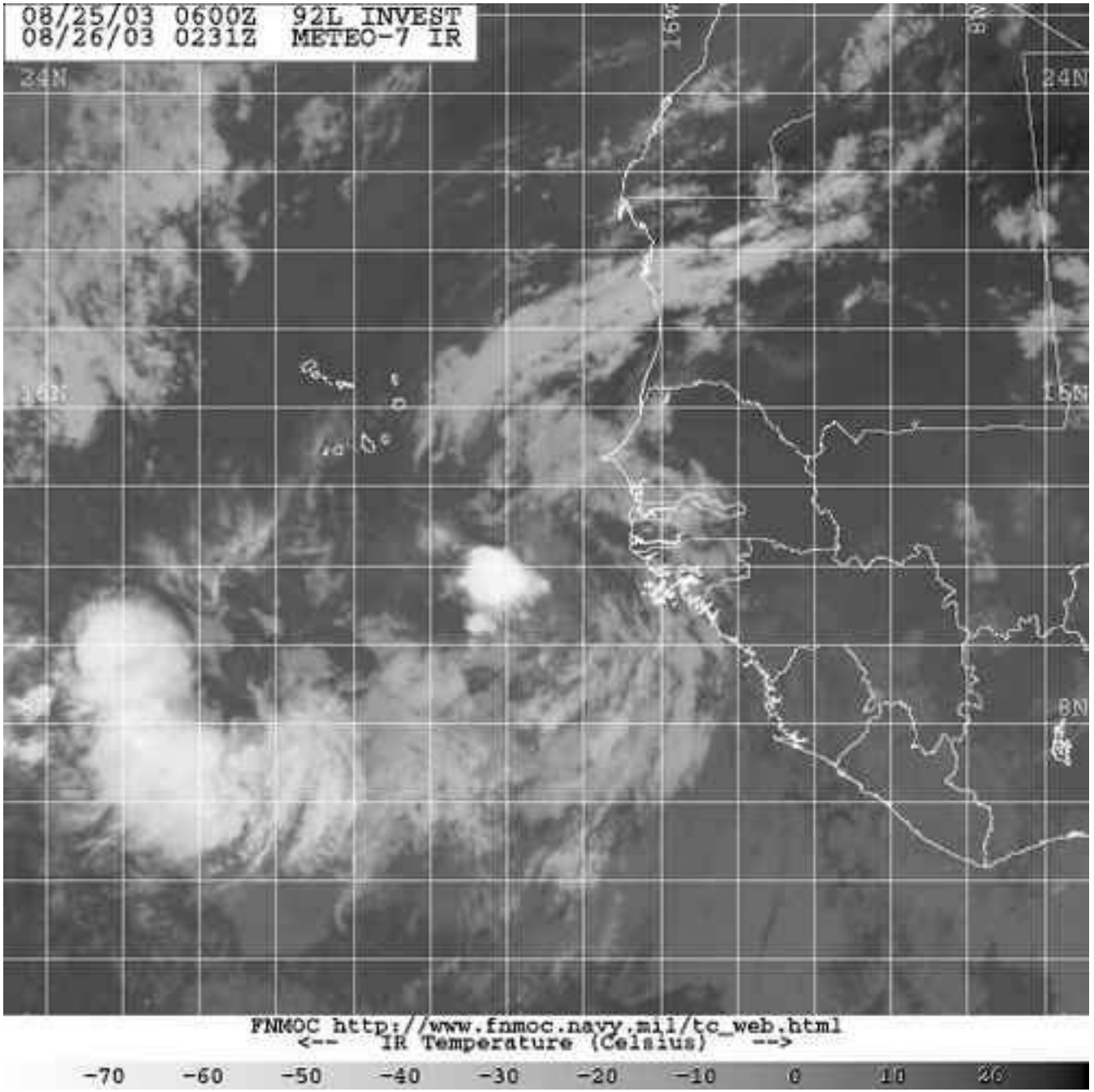

09/11/04 1200Z 09L IVAN
09/11/04 1445Z GOES-12 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20

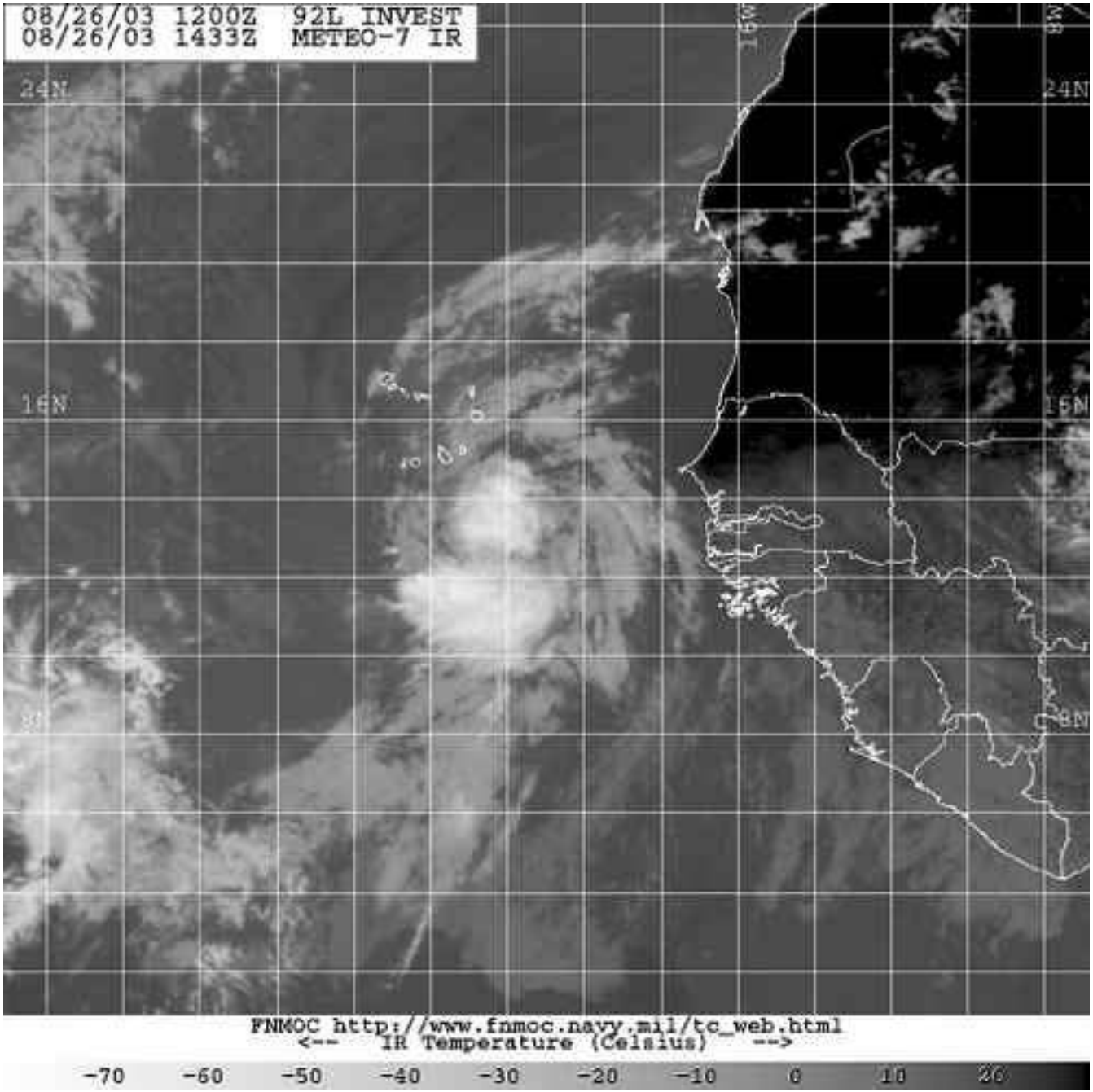

09/12/04 0000Z 09L IVAN
09/12/04 0300Z GOES-10 IR
Naval Research Lab http://www.nrlmry.navy.mil/sat_products.html
<-- IR Temperature (Celsius) -->
-80 -70 -60 -50 -40 -30 -20 -10 0 10 20

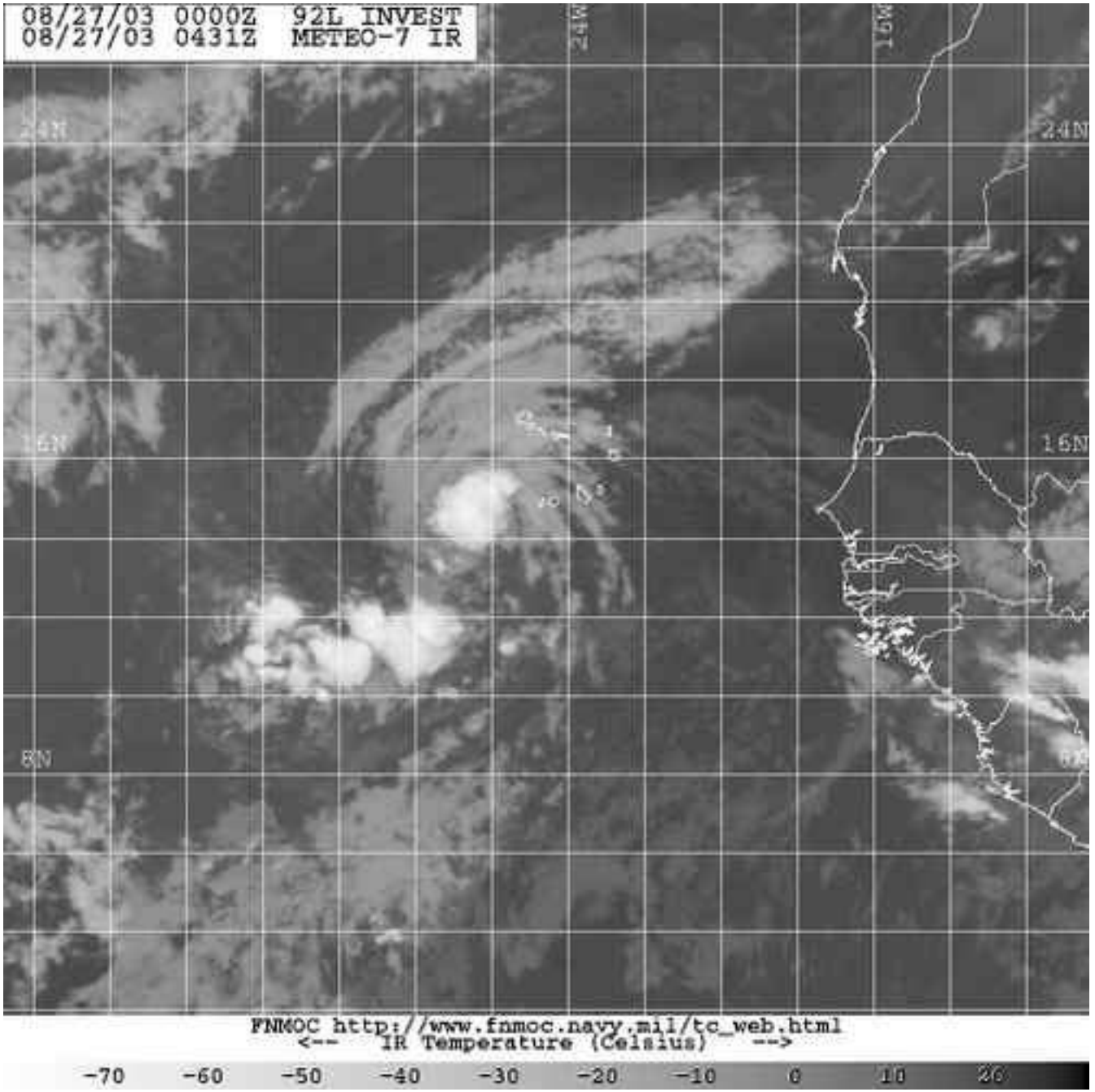
Genesis as seen in satellite and 850 hPa NCEP re-analysis data: Fabian, 2003

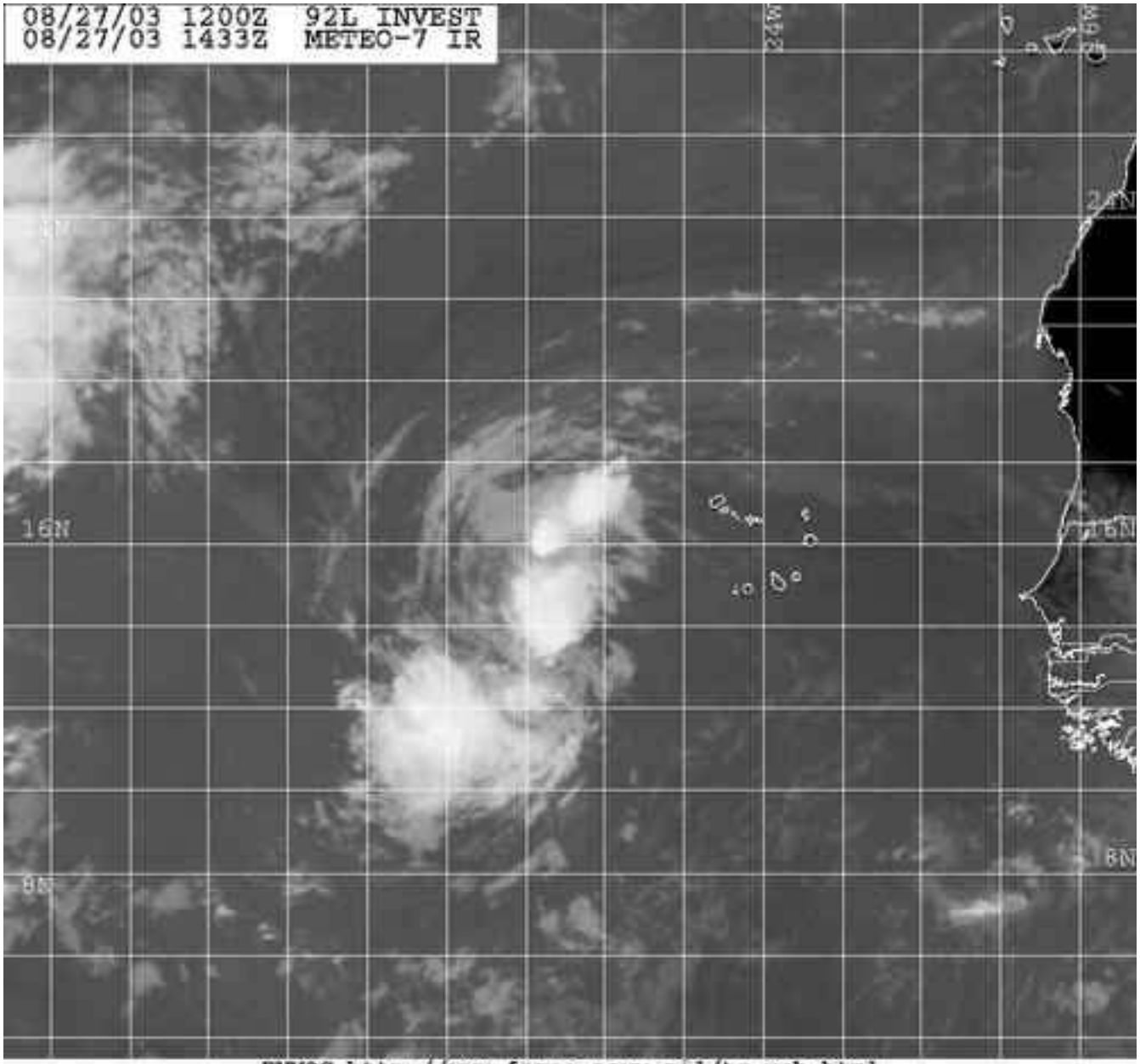

08/25/03 0600Z 92L INVEST
08/25/03 0231Z METEO-7 IR
24N
16N
8N
0N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

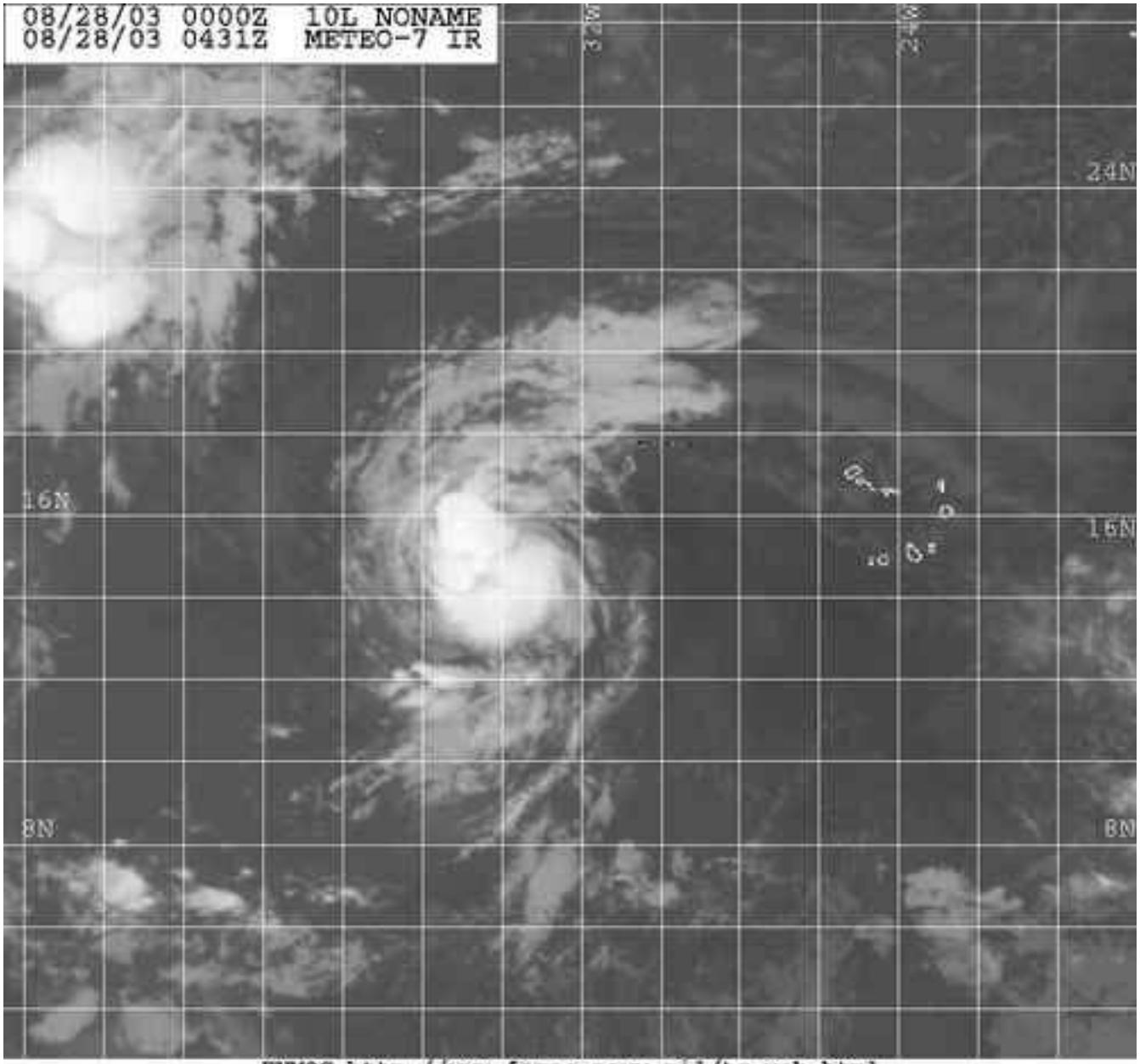

08/25/03 0600Z 92L INVEST
08/25/03 1433Z METEO-7 IR
24N
16N
8N
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

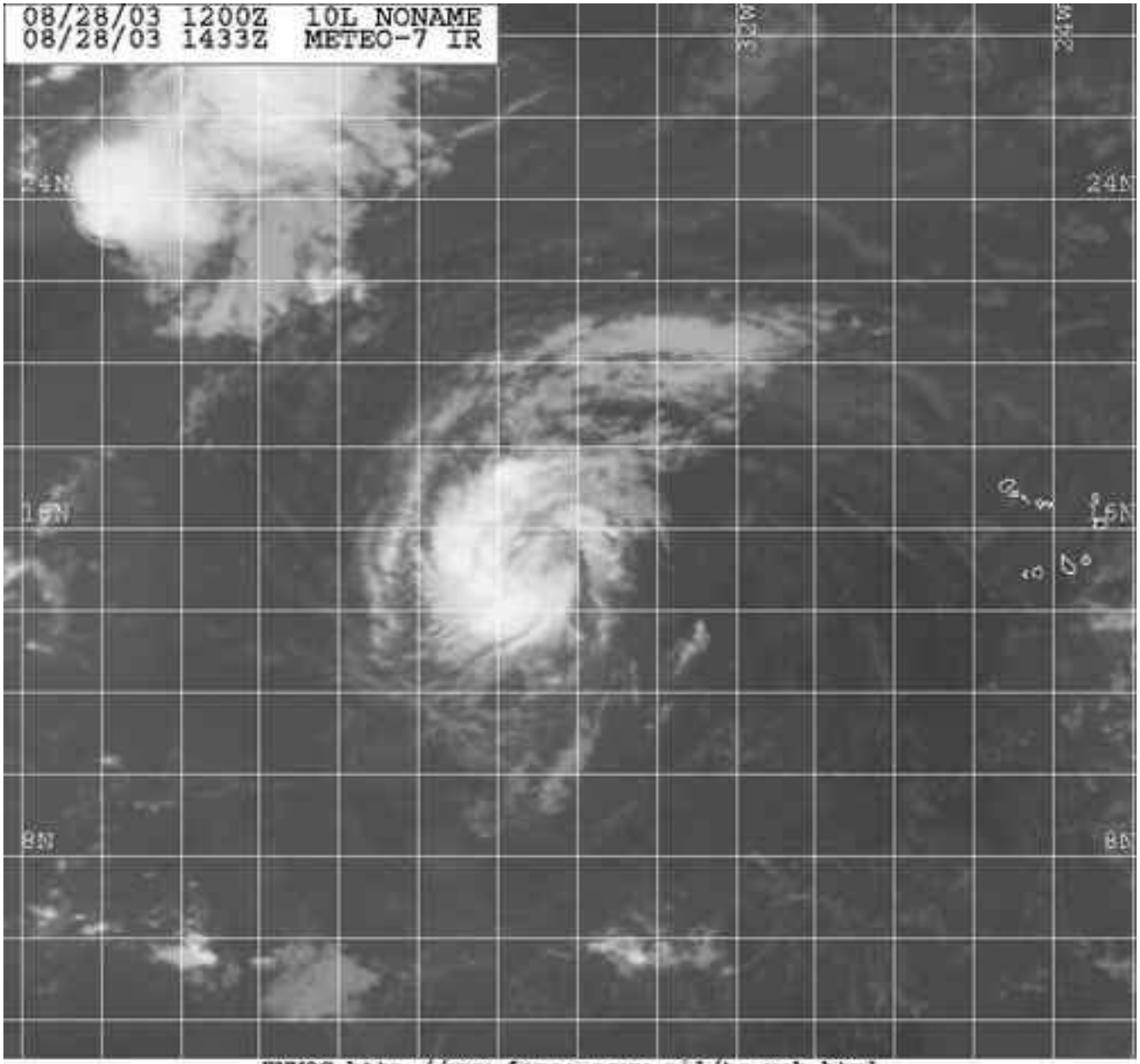

08/25/03 0600Z 92L INVEST
08/26/03 0231Z METEO-7 IR
24N
24N
15N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

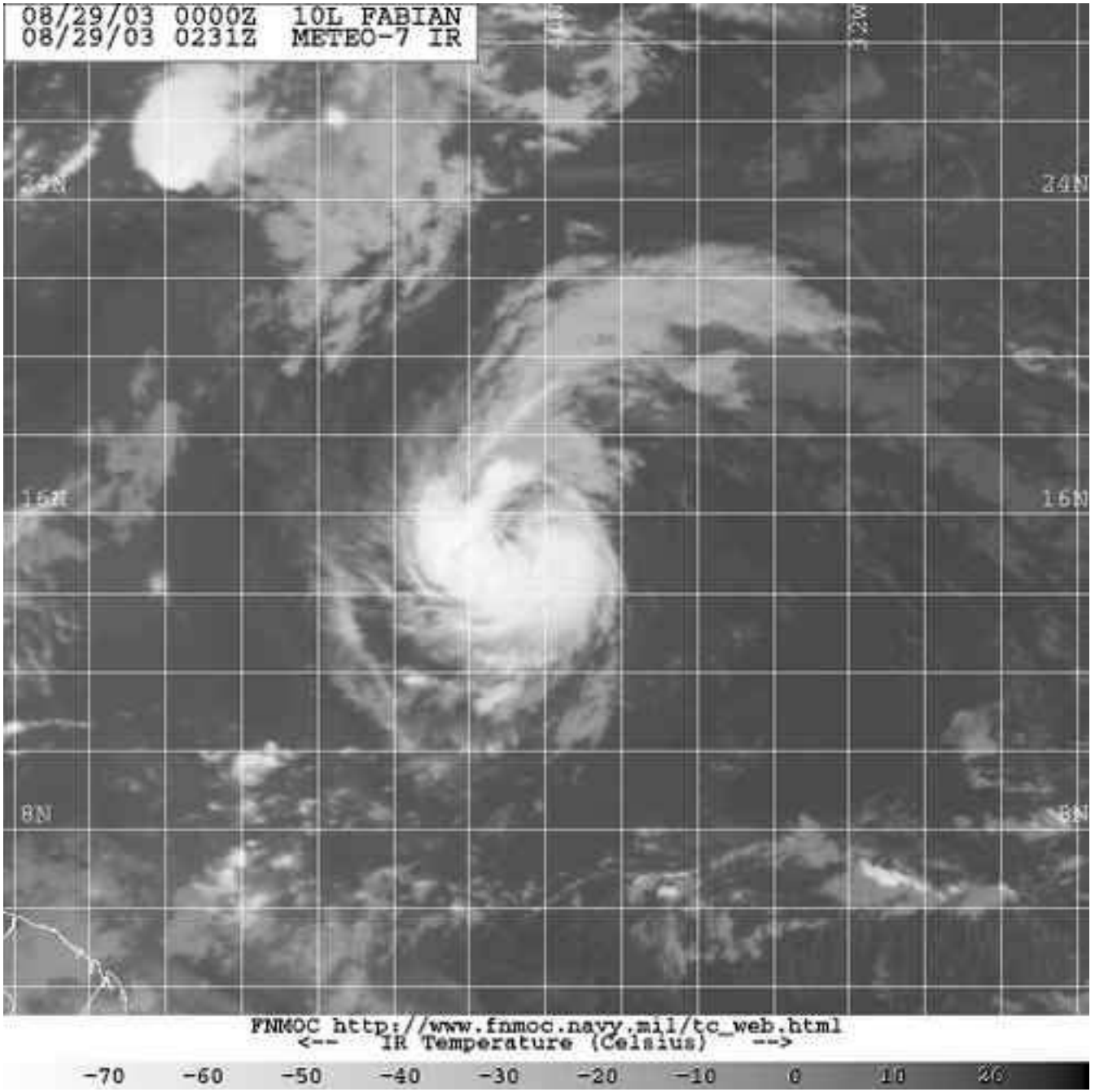

08/26/03 1200Z 92L INVEST
08/26/03 1433Z METEO-7 IR
24N
16N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

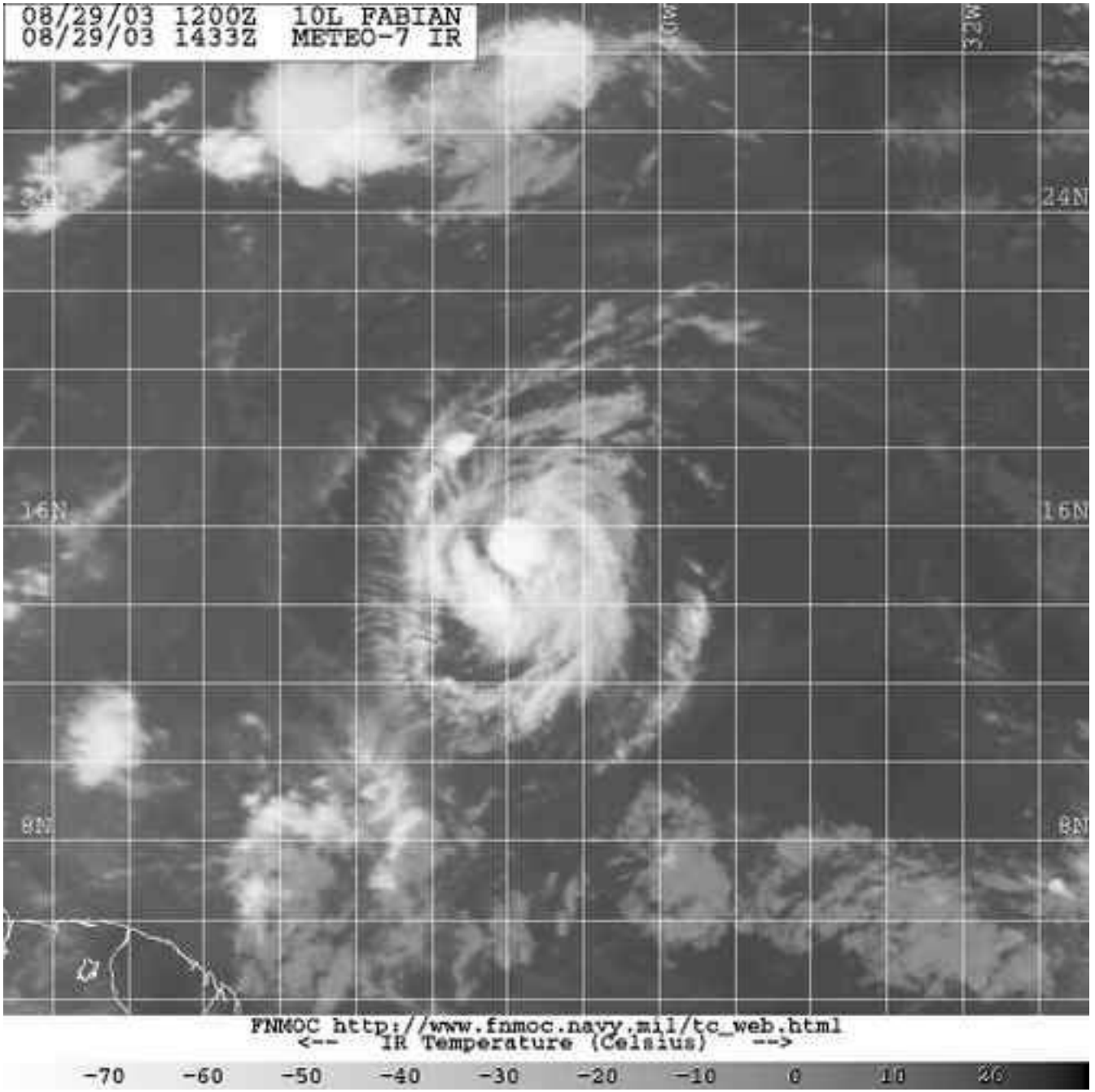

08/27/03 0000Z 92L INVEST
08/27/03 0431Z METEO-7 IR
24W
16W
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

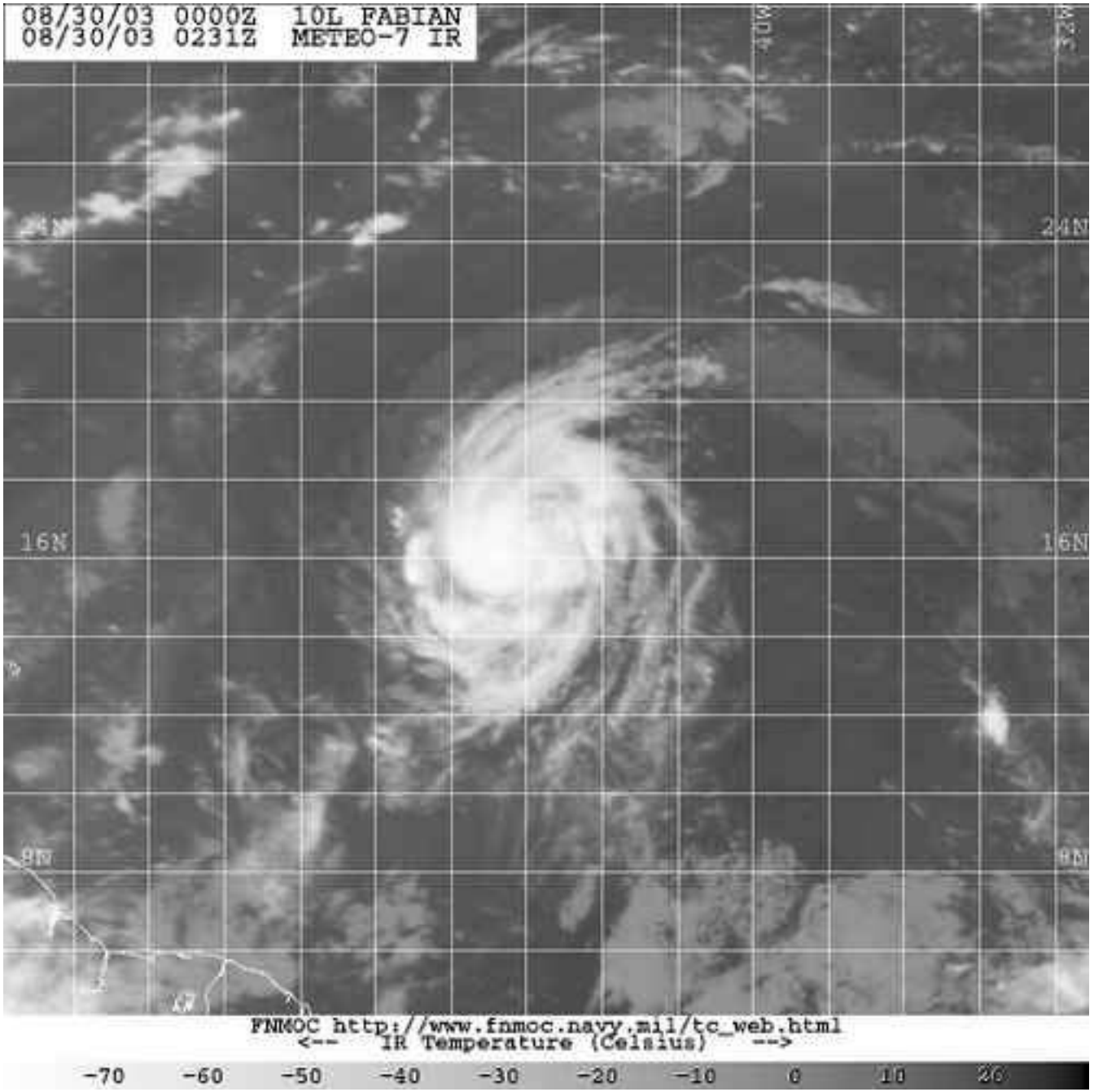

08/27/03 1200Z 92L INVEST
08/27/03 1433Z METEO-7 IR
24W
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

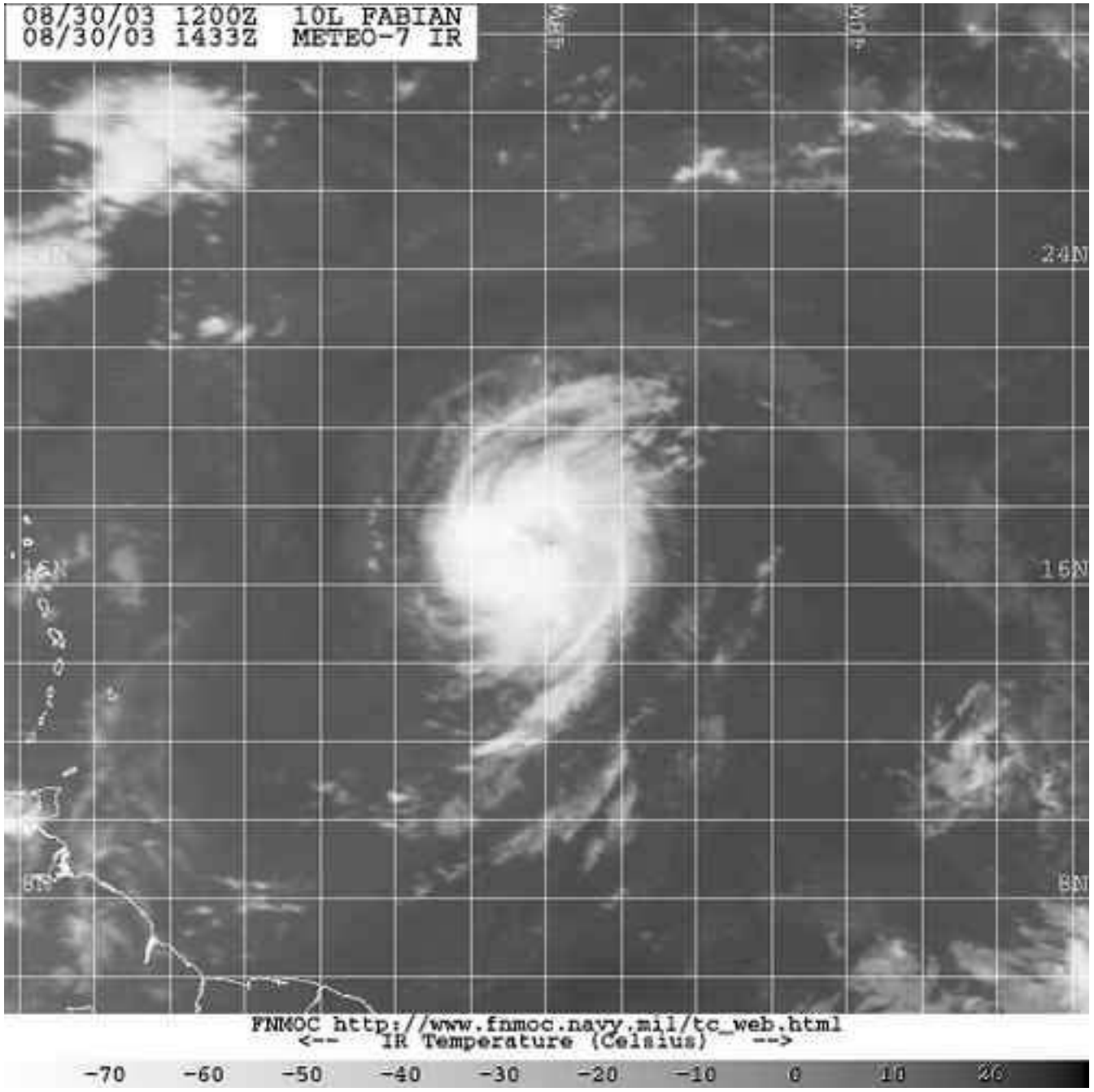

08/28/03 0000Z 10L NONAME
08/28/03 0431Z METEO-7 IR
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

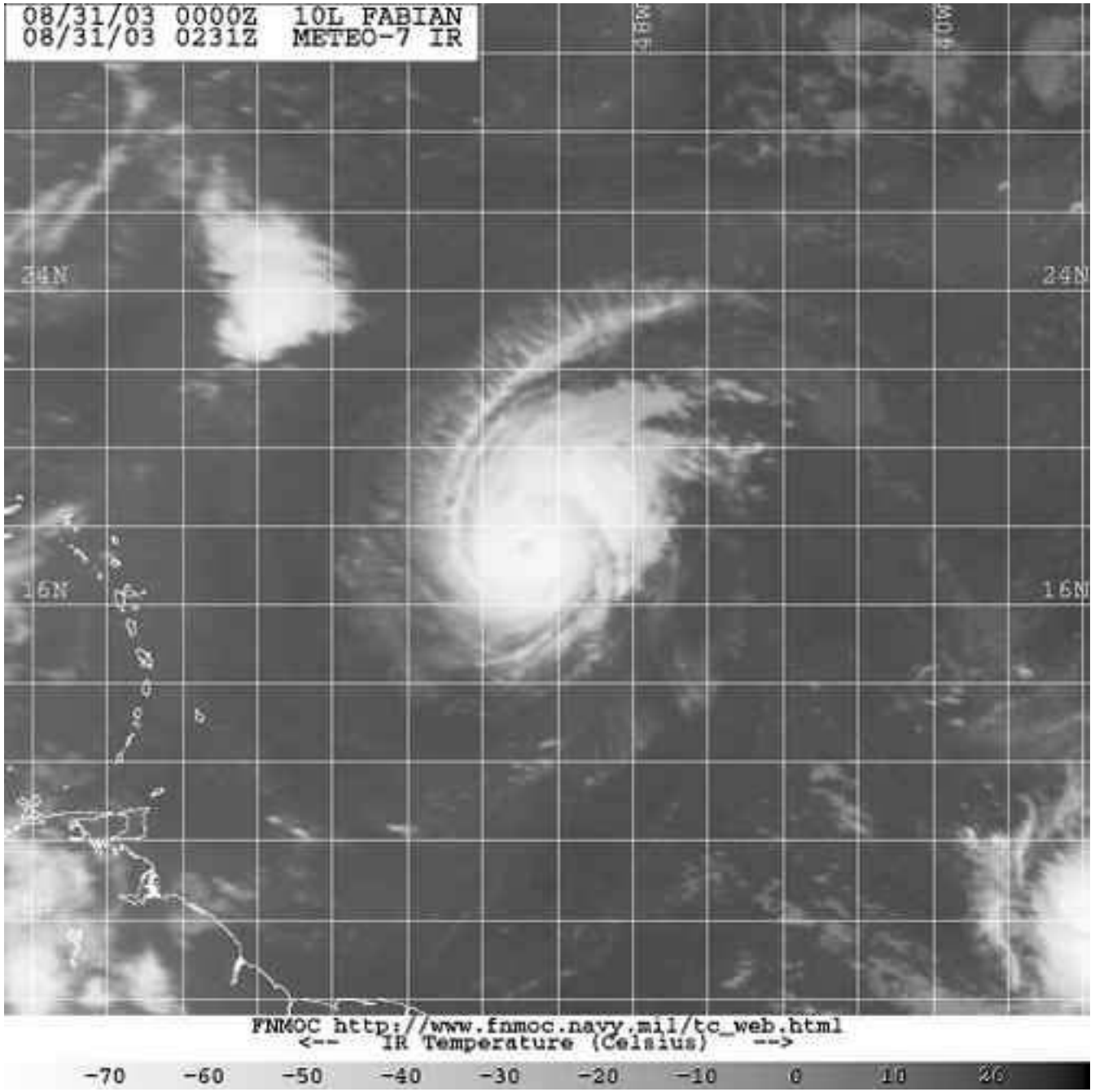

08/28/03 1200Z 10L NONAME
08/28/03 1433Z METEO-7 IR
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

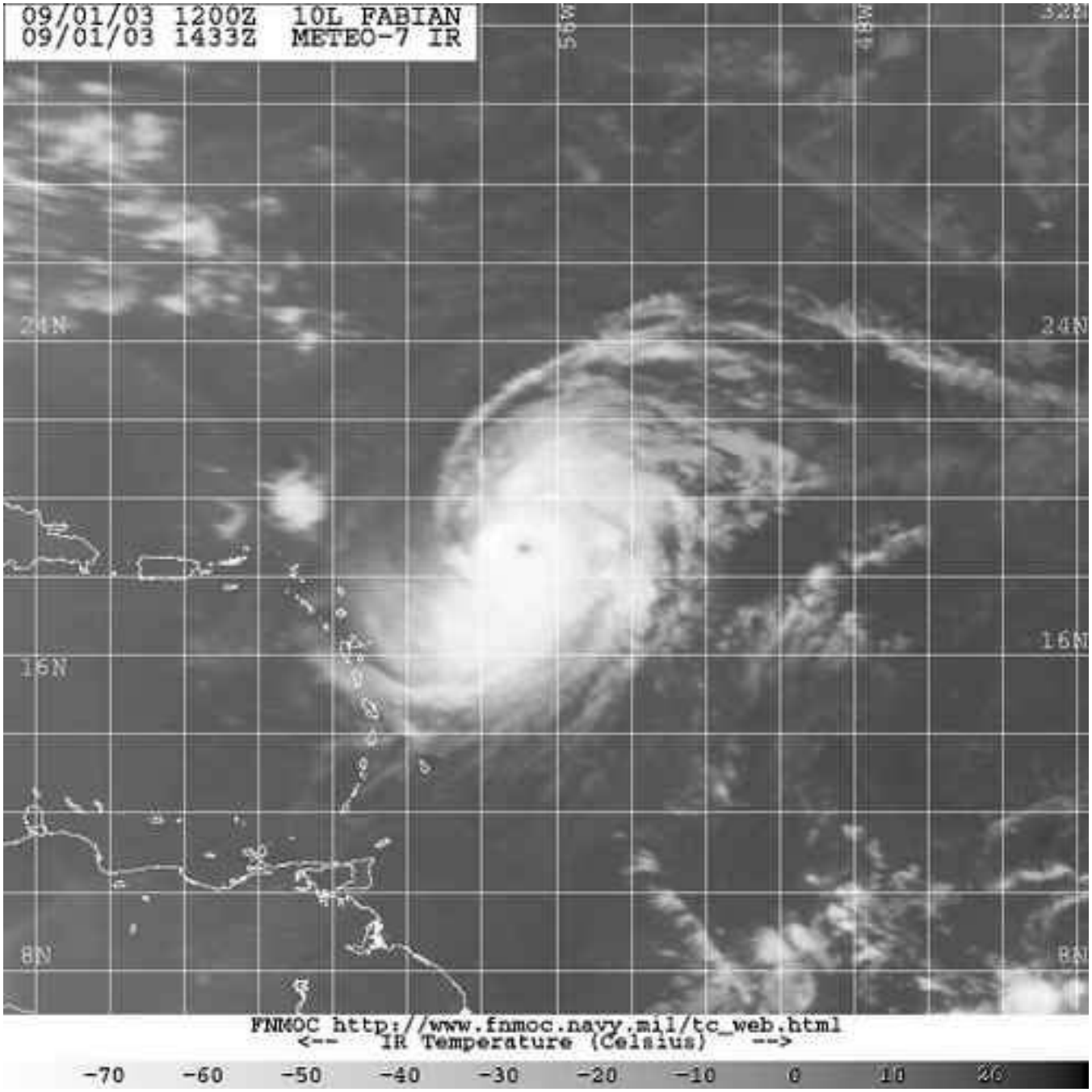

08/29/03 0000Z 10L FABIAN
08/29/03 0231Z METEO-7 IR
24N
24N
16N
16N
8N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

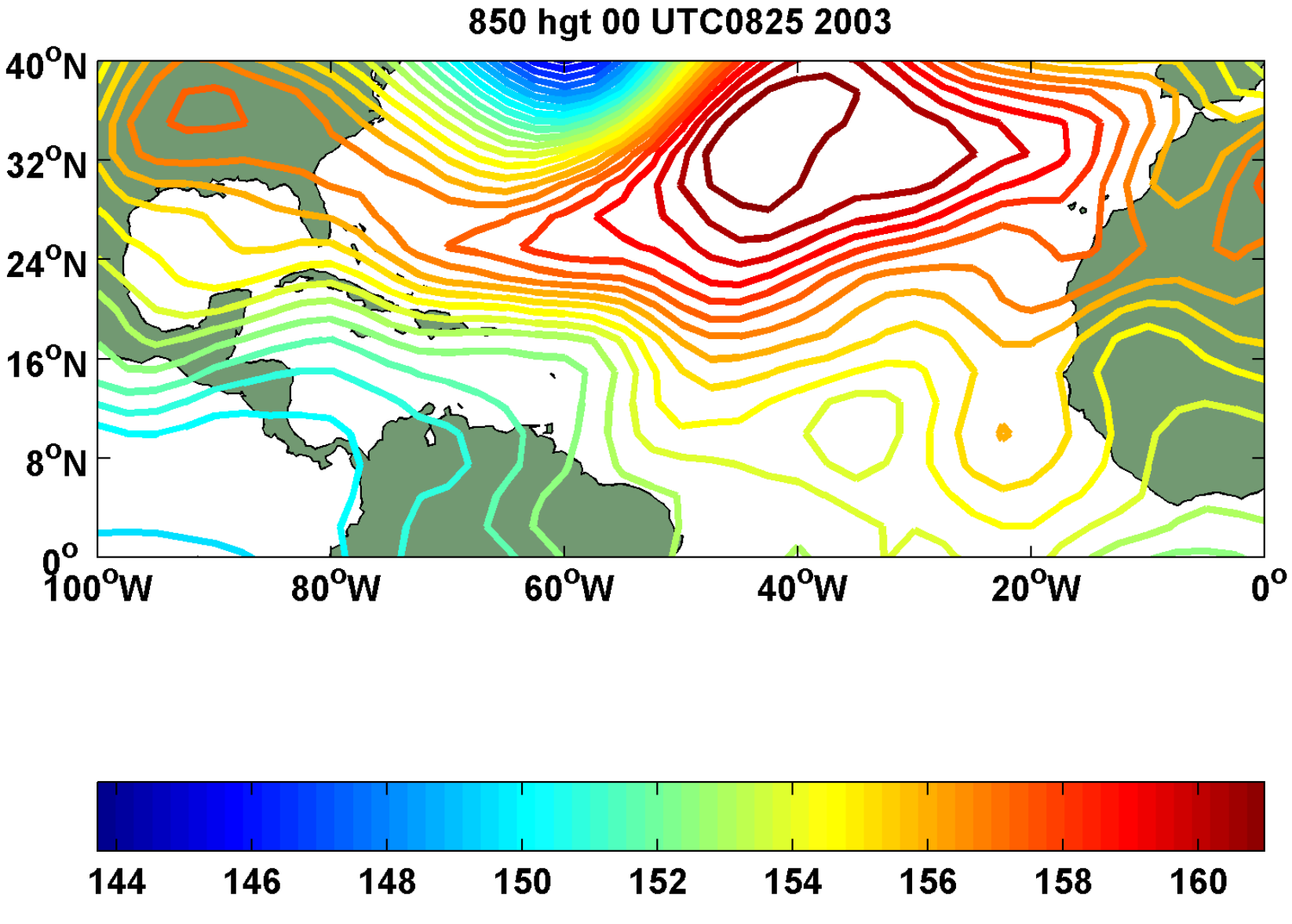

08/29/03 1200Z 10L FABIAN
08/29/03 1433Z METEO-7 IR
32W
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

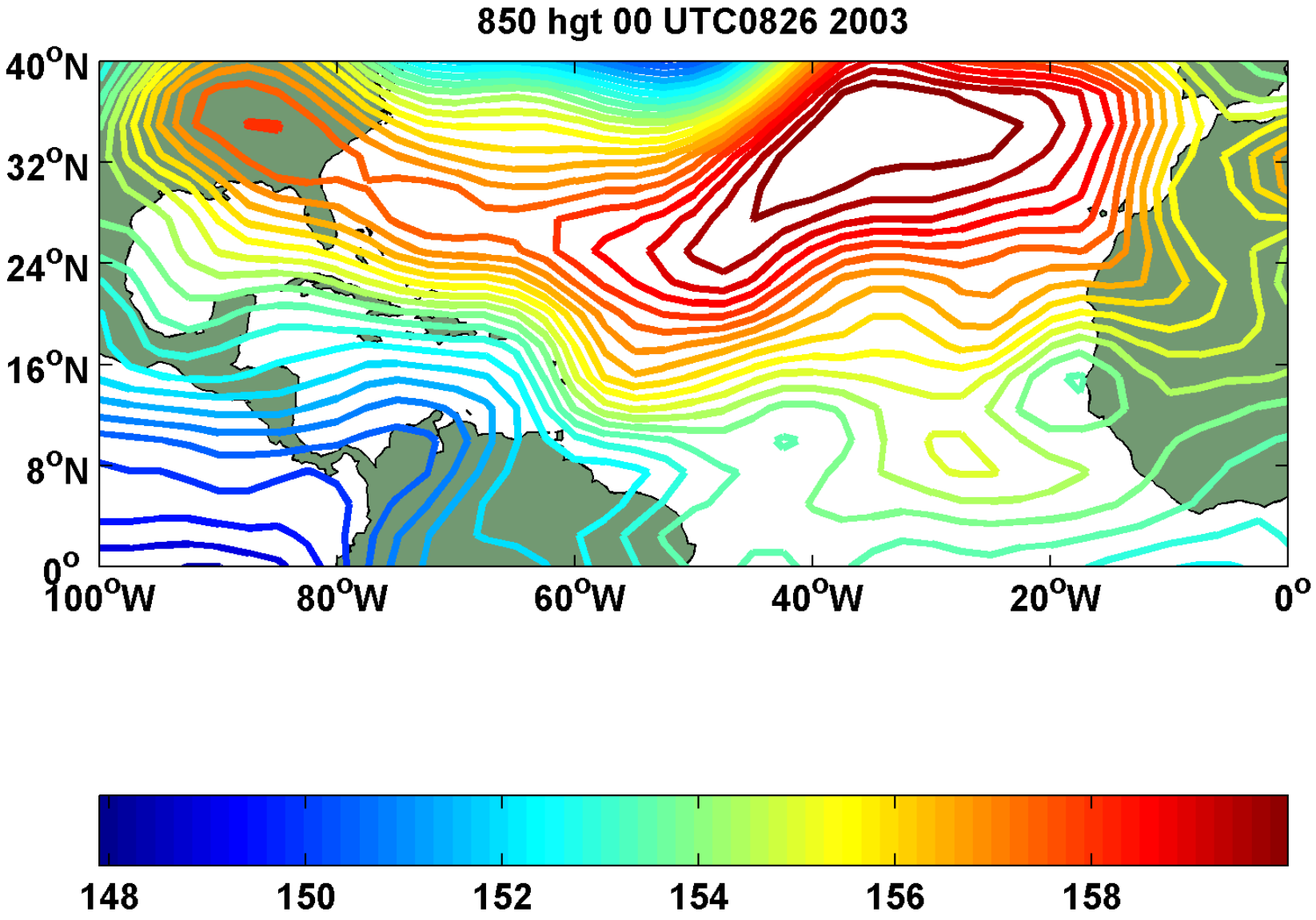

08/30/03 0000Z 10L FABIAN
08/30/03 0231Z METEO-7 IR
24N
24N
16N
16N
8N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

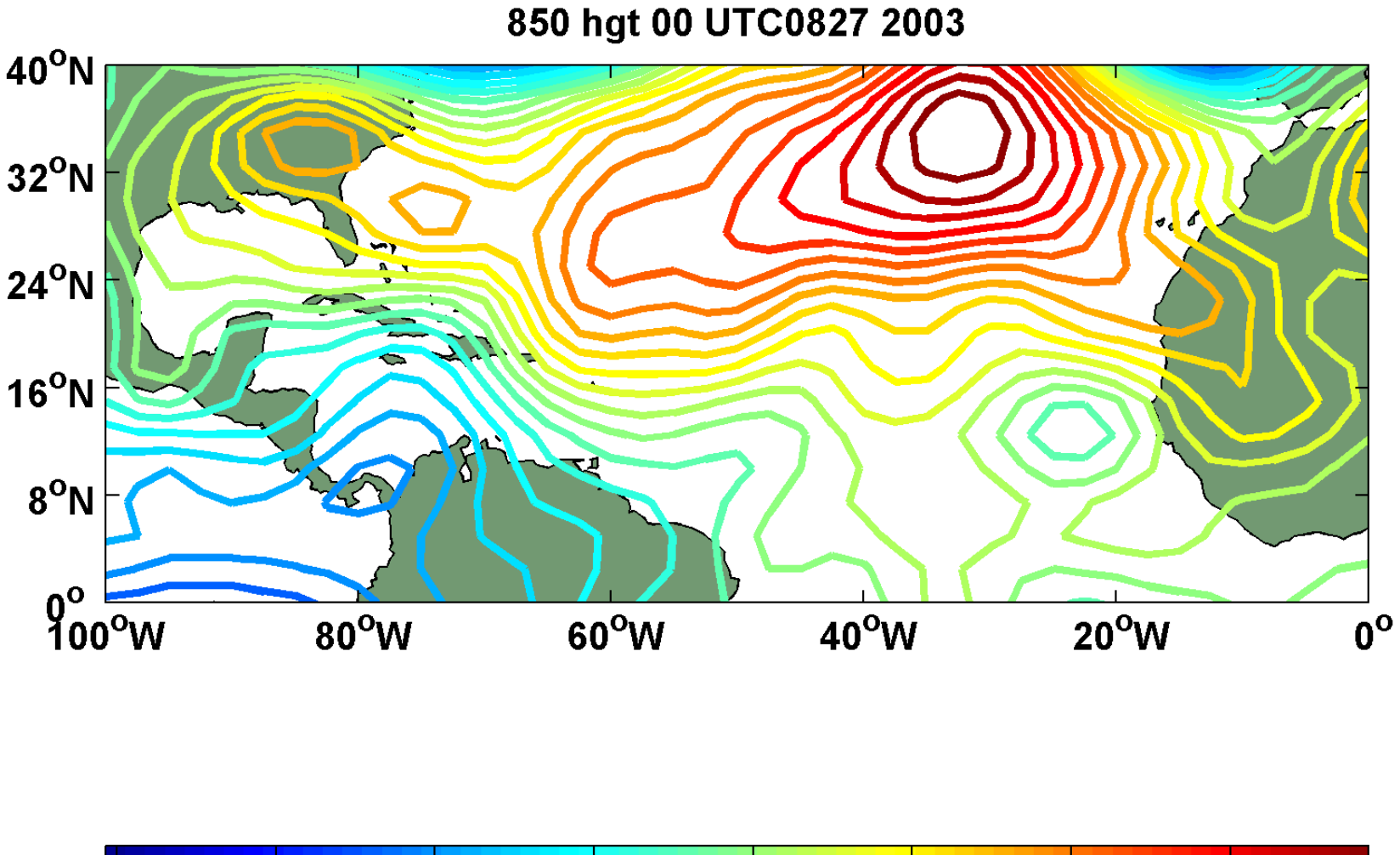

08/30/03 1200Z 10L FABIAN
08/30/03 1433Z METEO-7 IR
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20

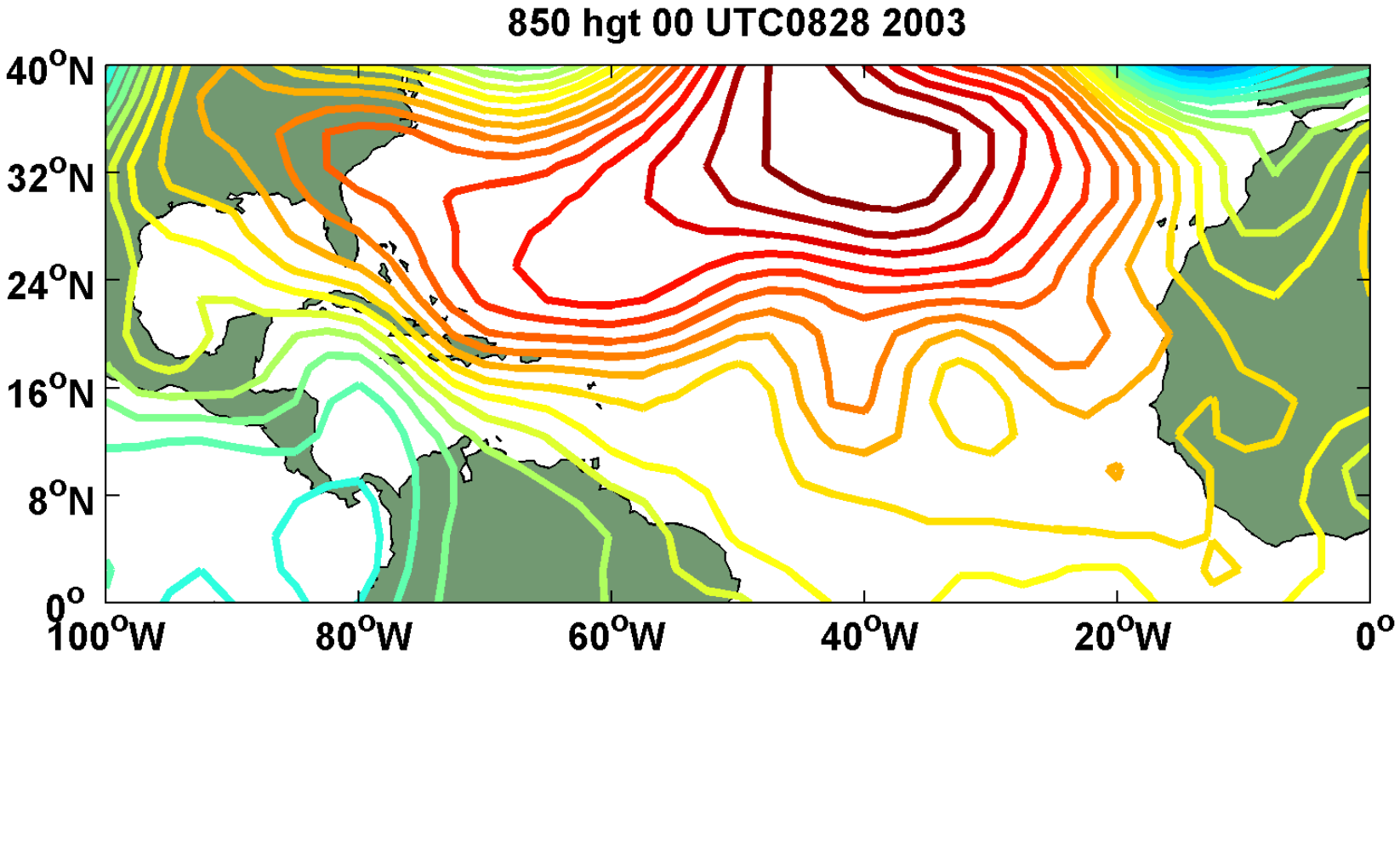

08/31/03 0000Z 10L FABIAN
08/31/03 0231Z METEO-7 IR
24N
24N
16N
16N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20


09/01/03 1200Z 10L FABIAN
09/01/03 1433Z METEO-7 IR
56W
48W
24N
16N
8N
FNMOC http://www.fnmoc.navy.mil/tc_web.html
<-- IR Temperature (Celsius) -->
-70 -60 -50 -40 -30 -20 -10 0 10 20


850 hgt 00 UTC0825 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
144
146
148
150
152
154
156
158
160


850 hgt 00 UTC0826 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
148
150
152
154
156
158


850 hgt 00 UTC0827 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
146
148
150
152
154
156
158
160


850 hgt 00 UTC0828 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
142
144
146
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158
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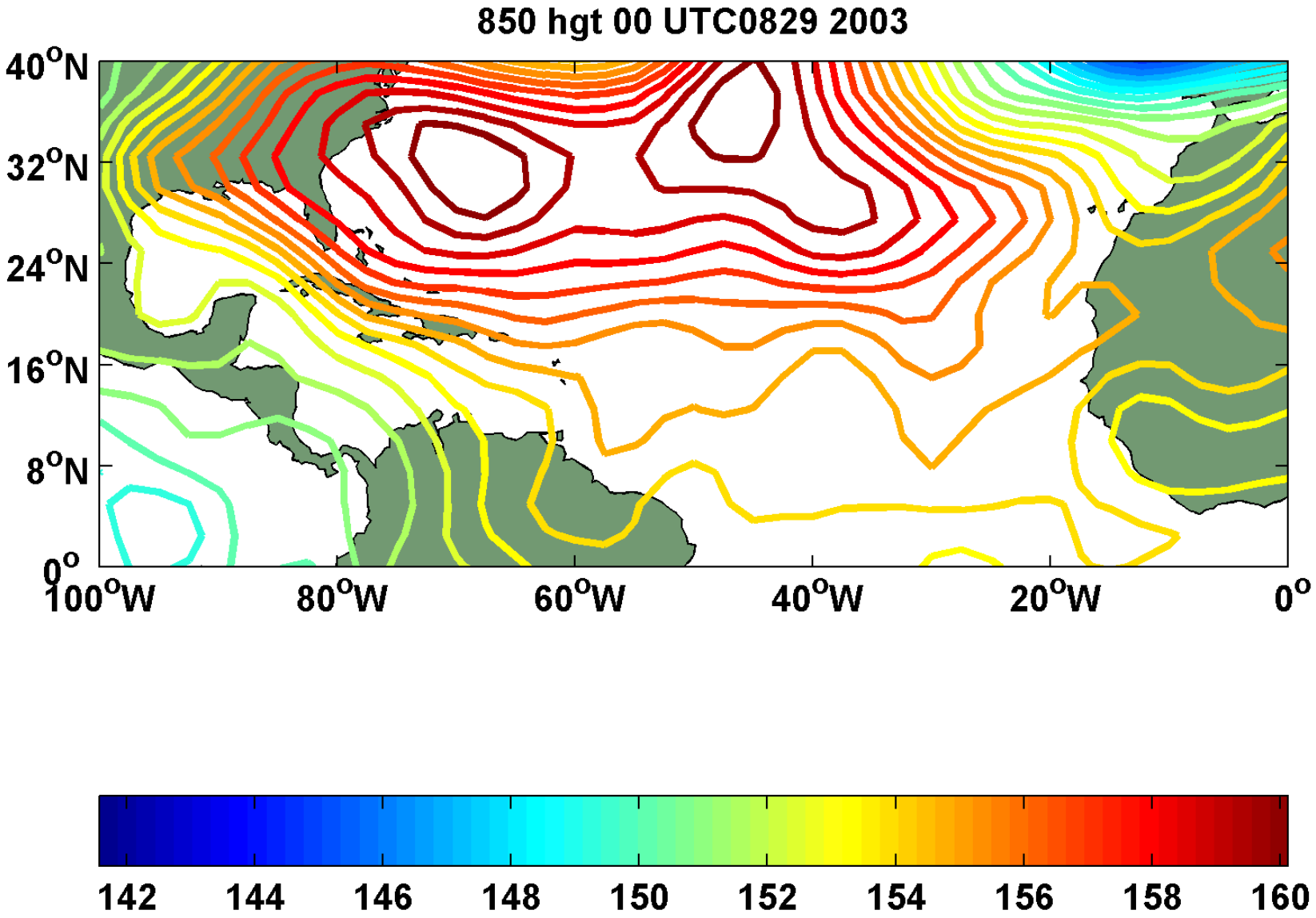
850 hgt 00 UTC0829 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
142
144
146
148
150
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154
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158
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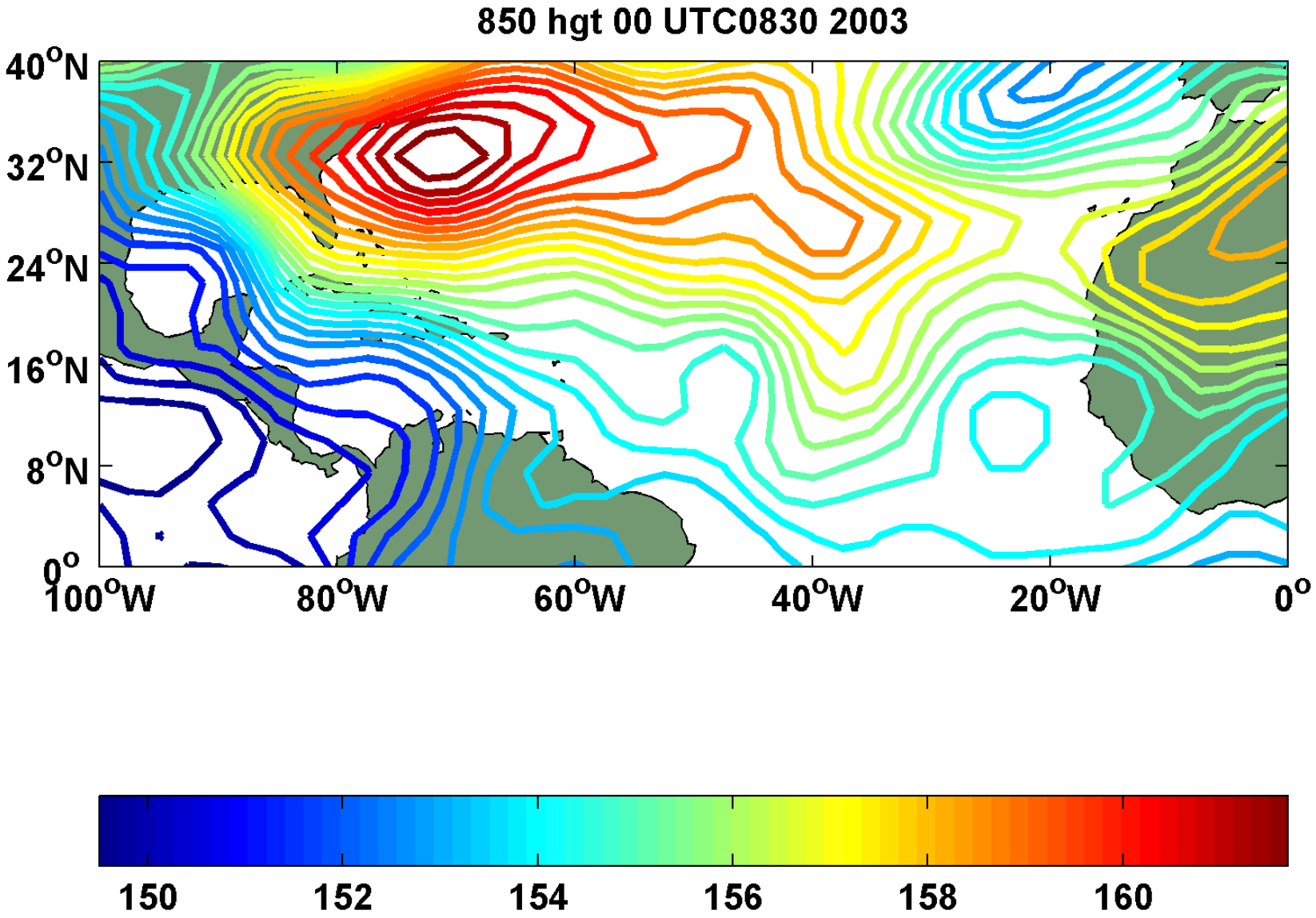
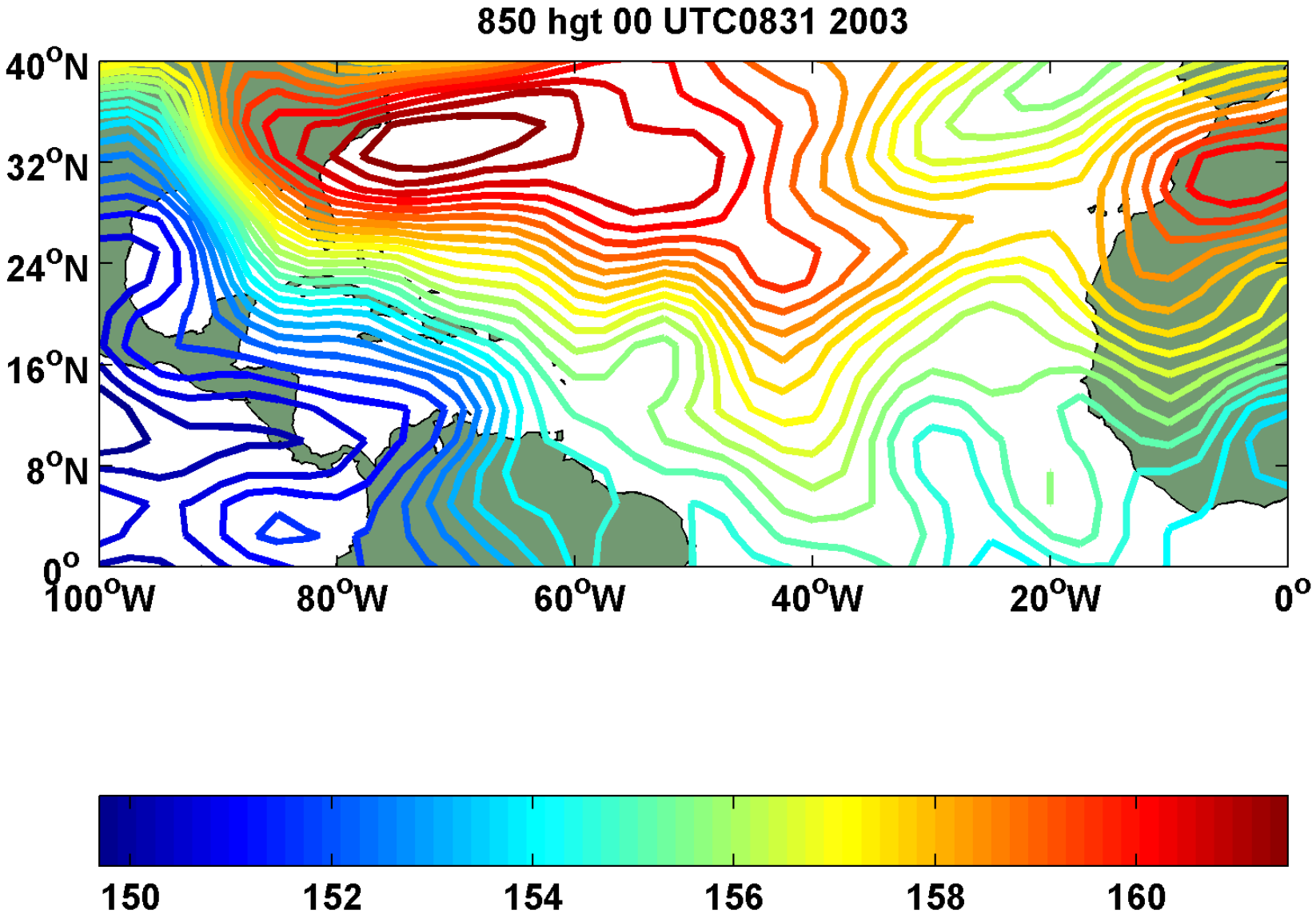
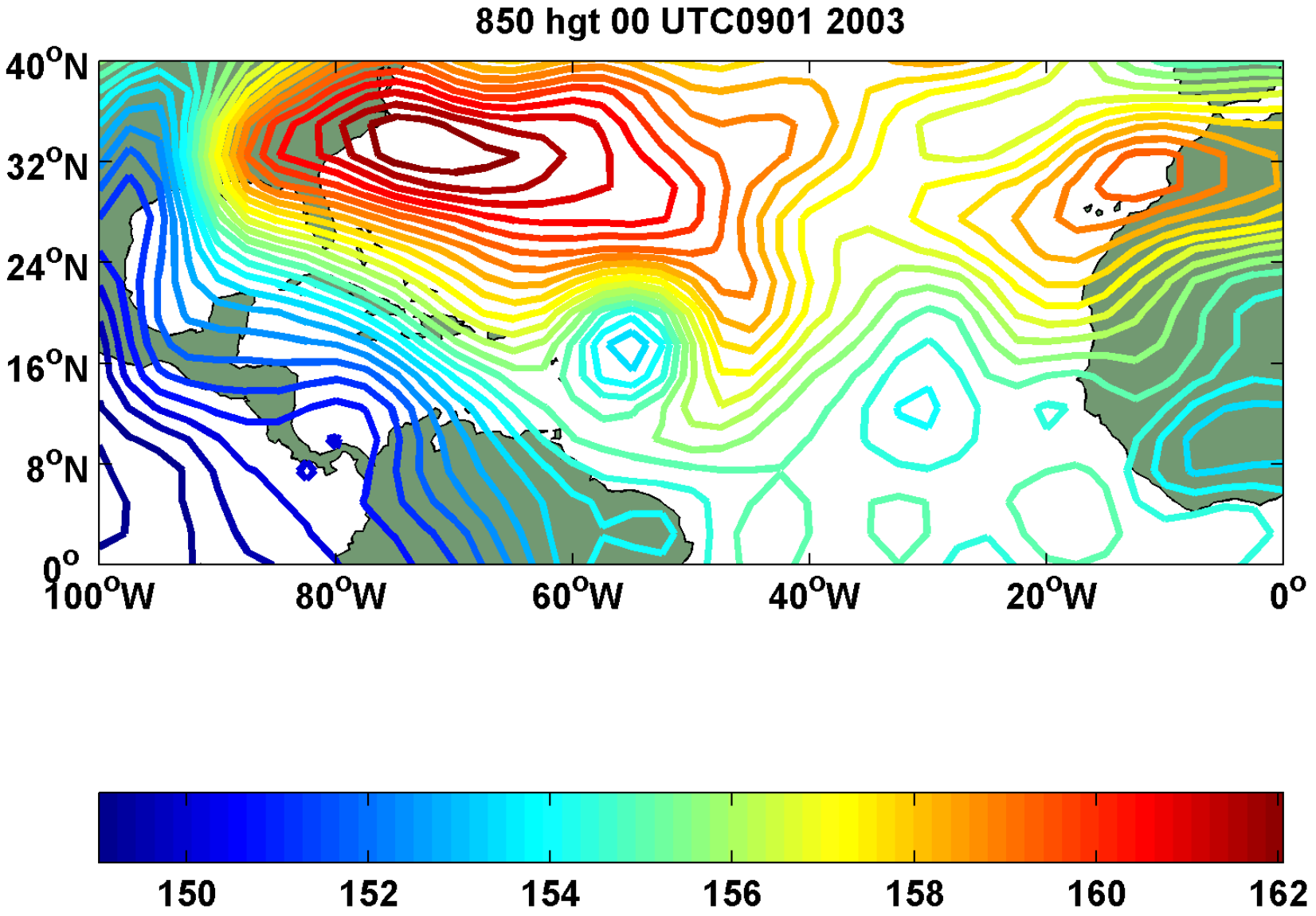

850 hgt 00 UTC0830 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
150
152
154
156
158
160


850 hgt 00 UTC0831 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
150
152
154
156
158
160


850 hgt 00 UTC0901 2003
40°N
32°N
24°N
16°N
8°N
0°
100°W
80°W
60°W
40°W
20°W
0°
150
152
154
156
158
160
162

A case study using rawinsonde and surface observations
(From Hawkins and Rubsam, *Mon. Wea. Rev*., 1968)

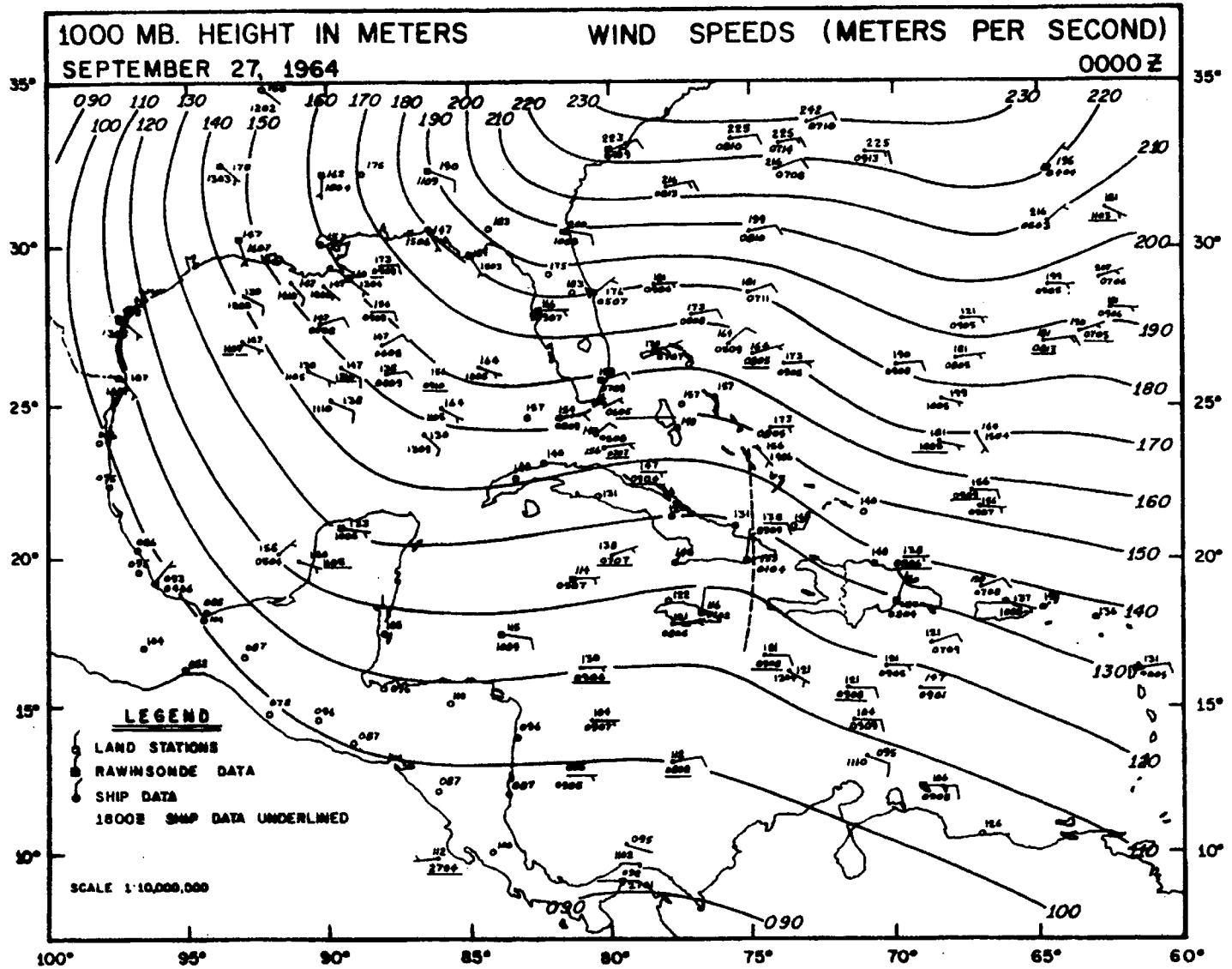


FIGURE 5.—1000-mb. contours for 00 GMT, September 27 showing a barely perceptible easterly wave over eastern Cuba, the first low level evidence of the disturbance that became hurricane Hilda.

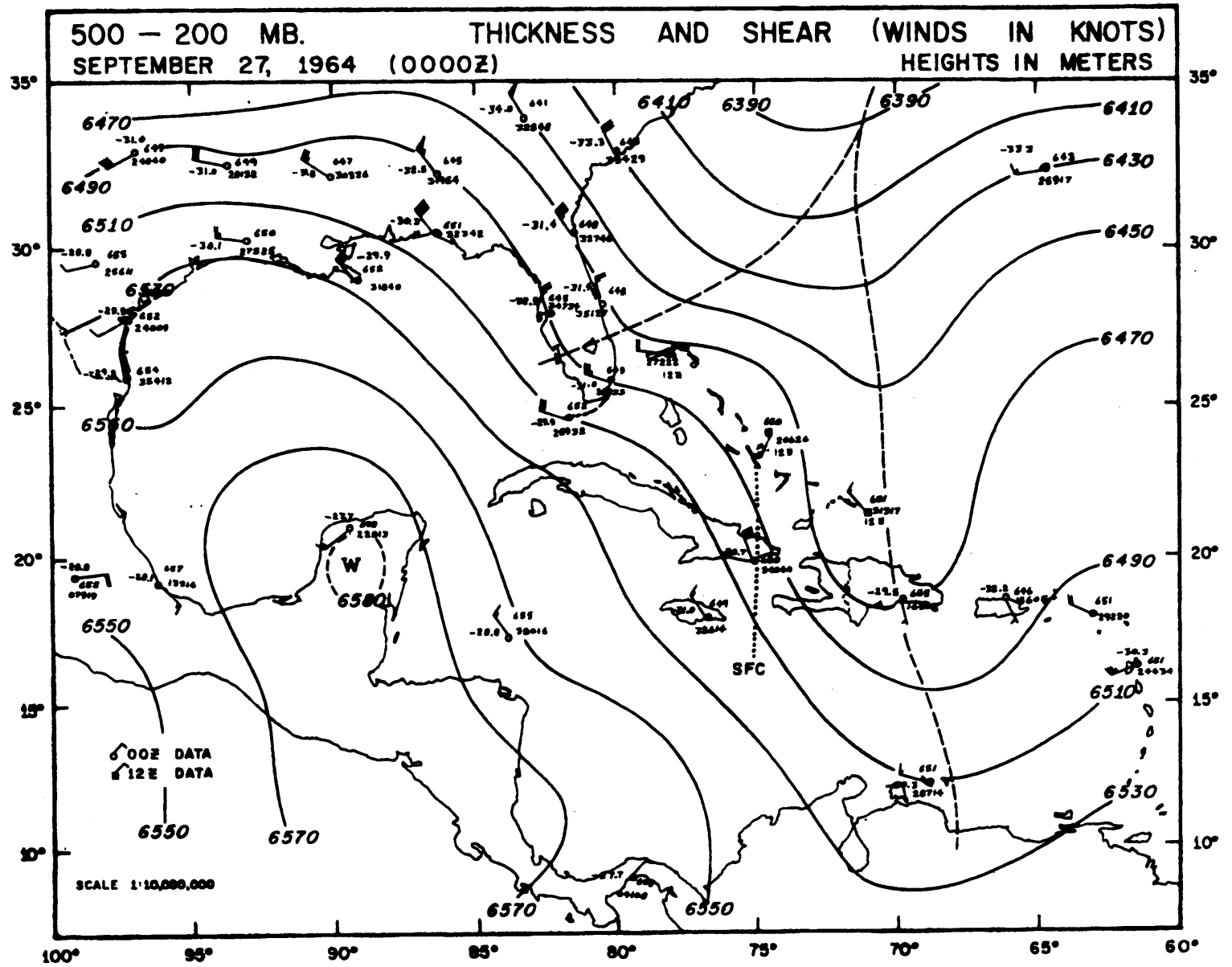


FIGURE 6.—The surface trough (dotted) almost midway between the trough-ridge system in the 500- to 200-mb. thickness.

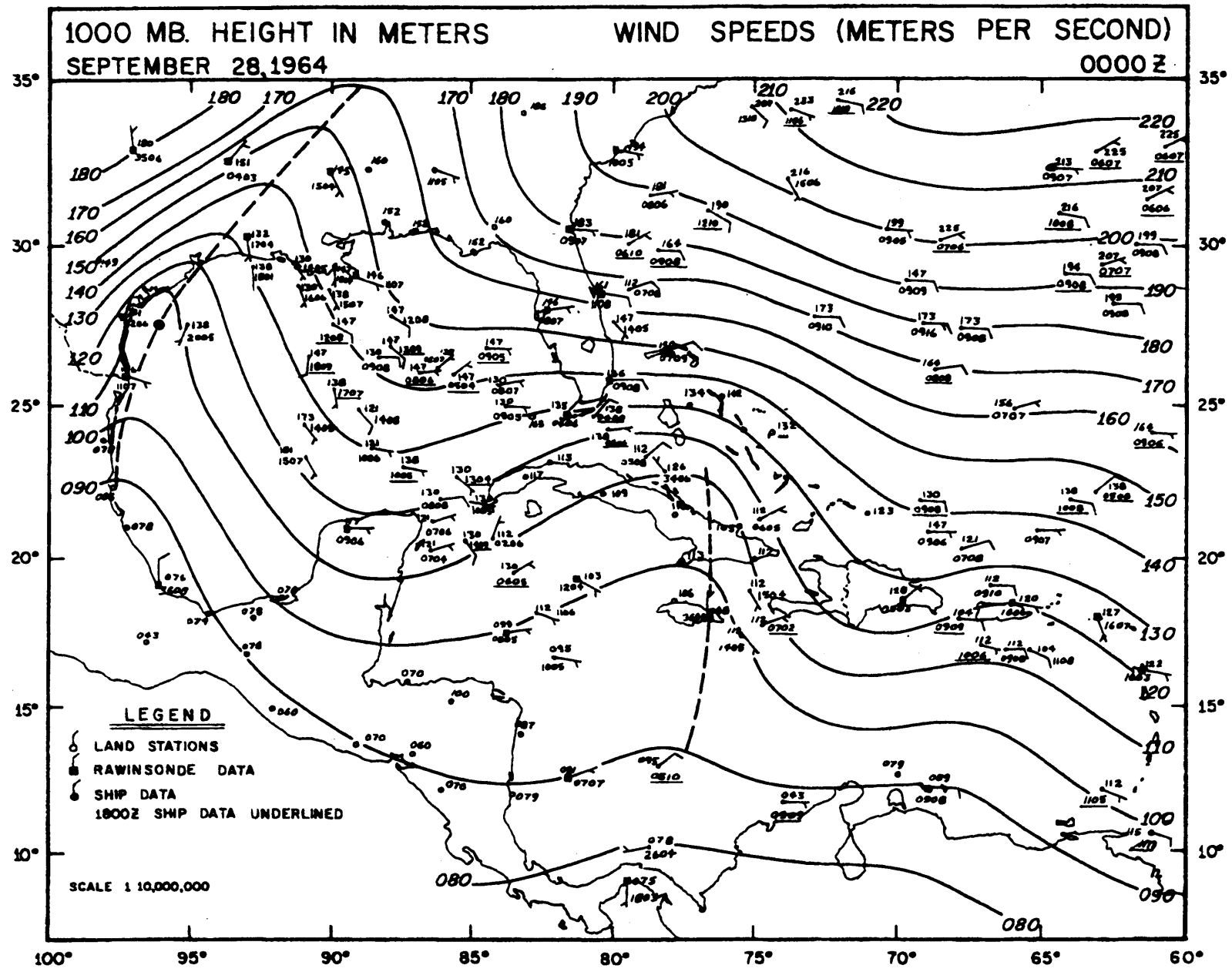


FIGURE 8.—Developing easterly wave over eastern Cuba and Jamaica.

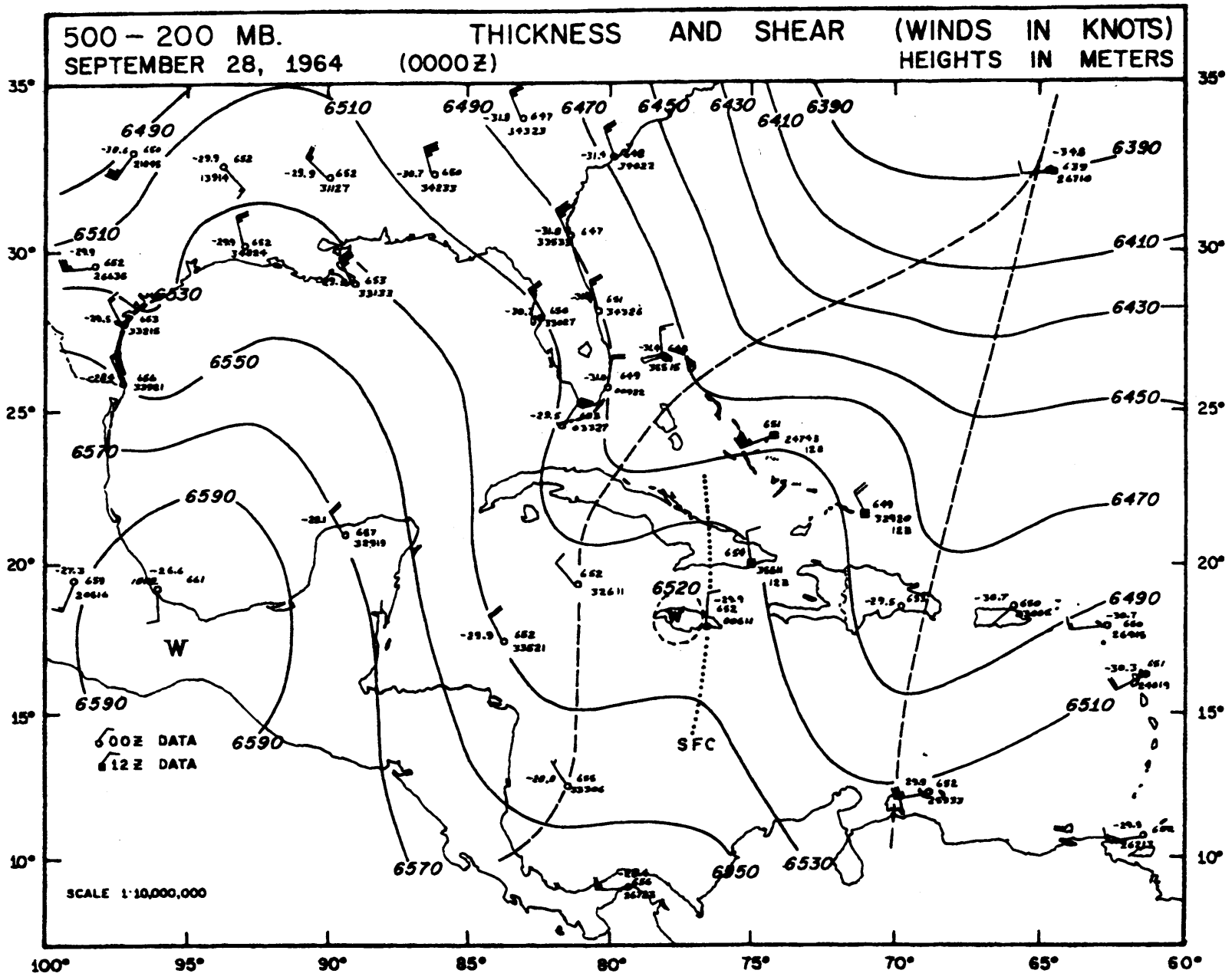


FIGURE 9.—Surface trough (dotted) now located in the 500- to 200-mb. thickness ridge.

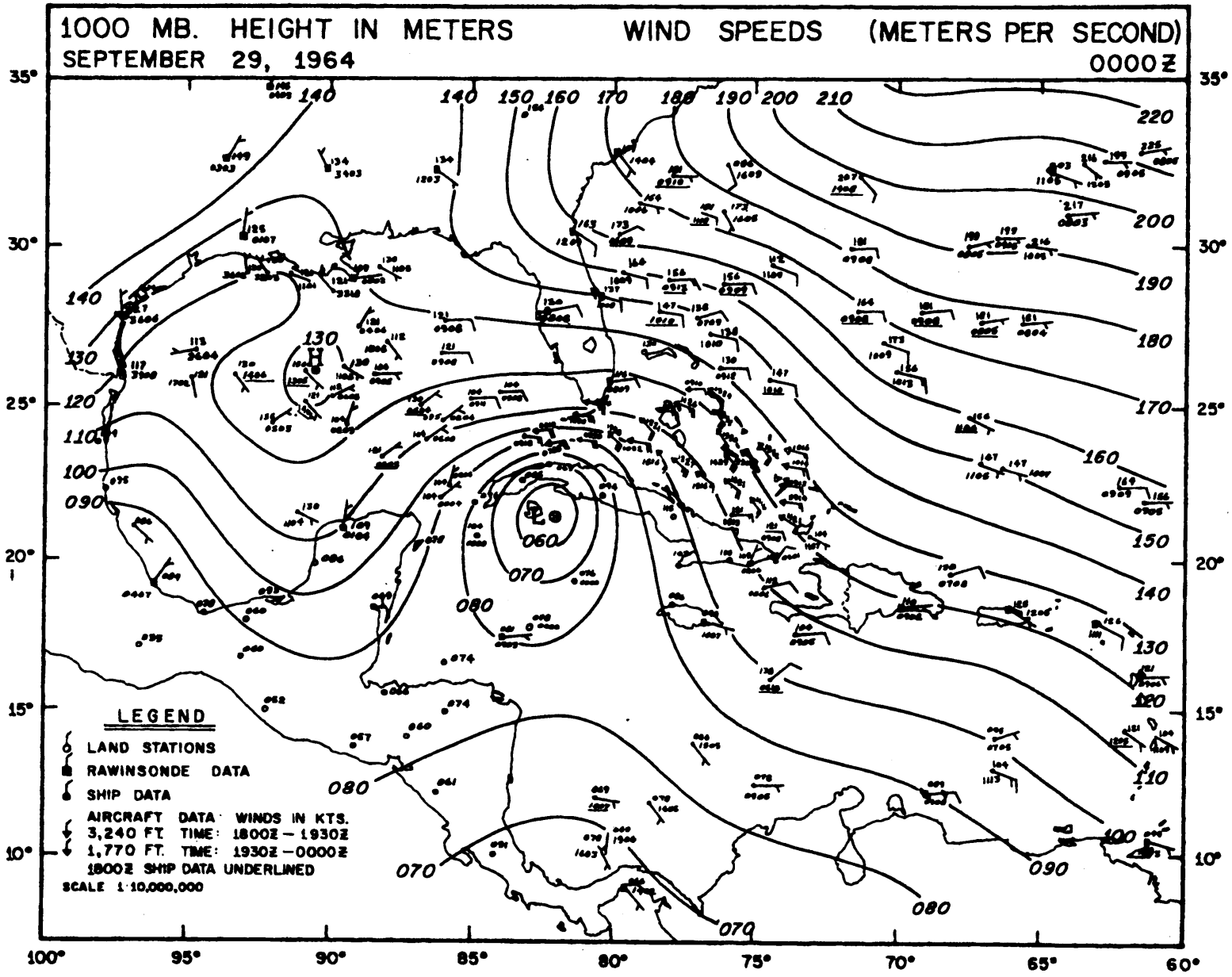


FIGURE 12.—Tropical depression (Hilda) at 00 GMT, September 29.

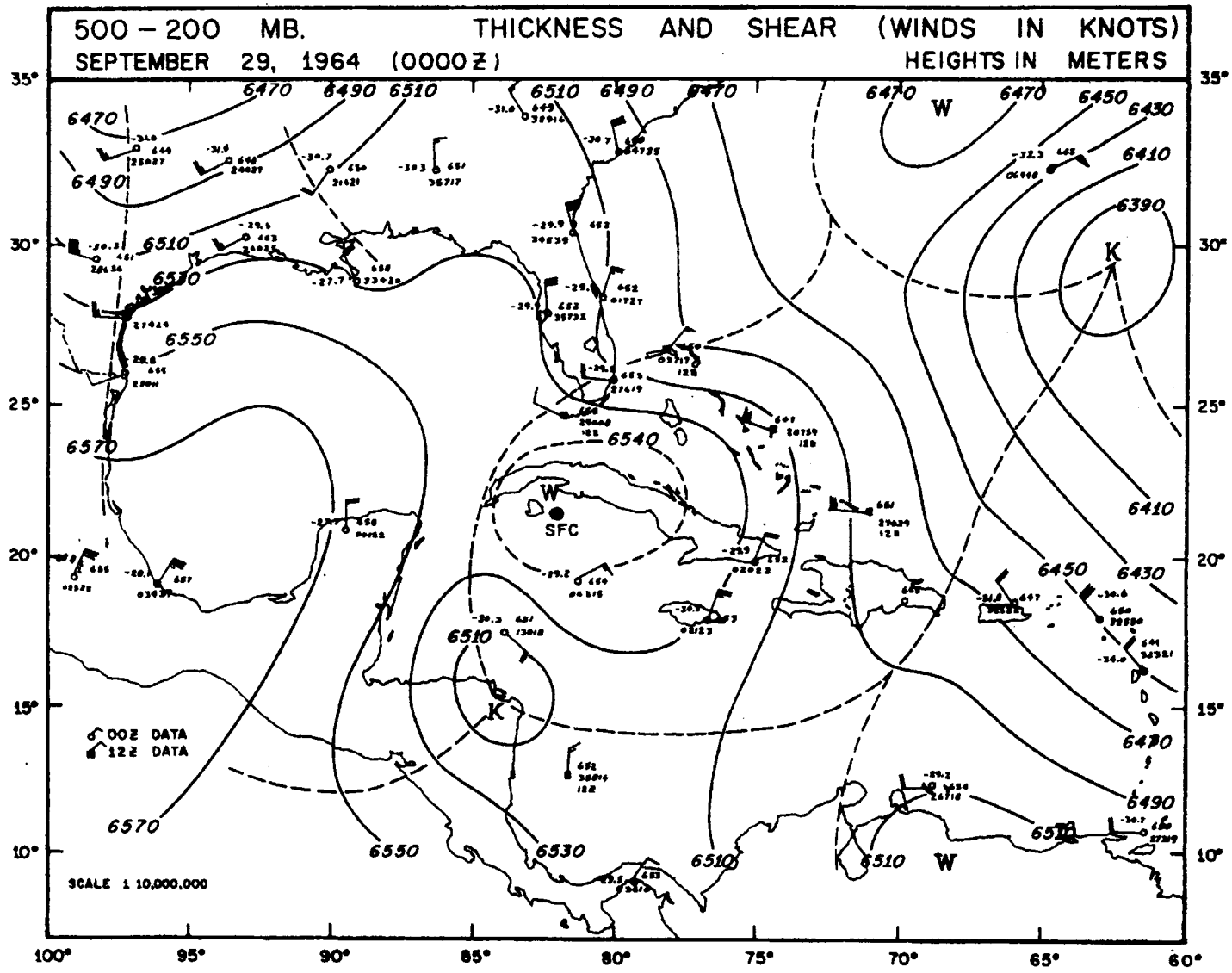


FIGURE 14.—Further marked warming in the 500- to 200-mb. layer. Shear winds clearly define the presence of anomalous warmth.

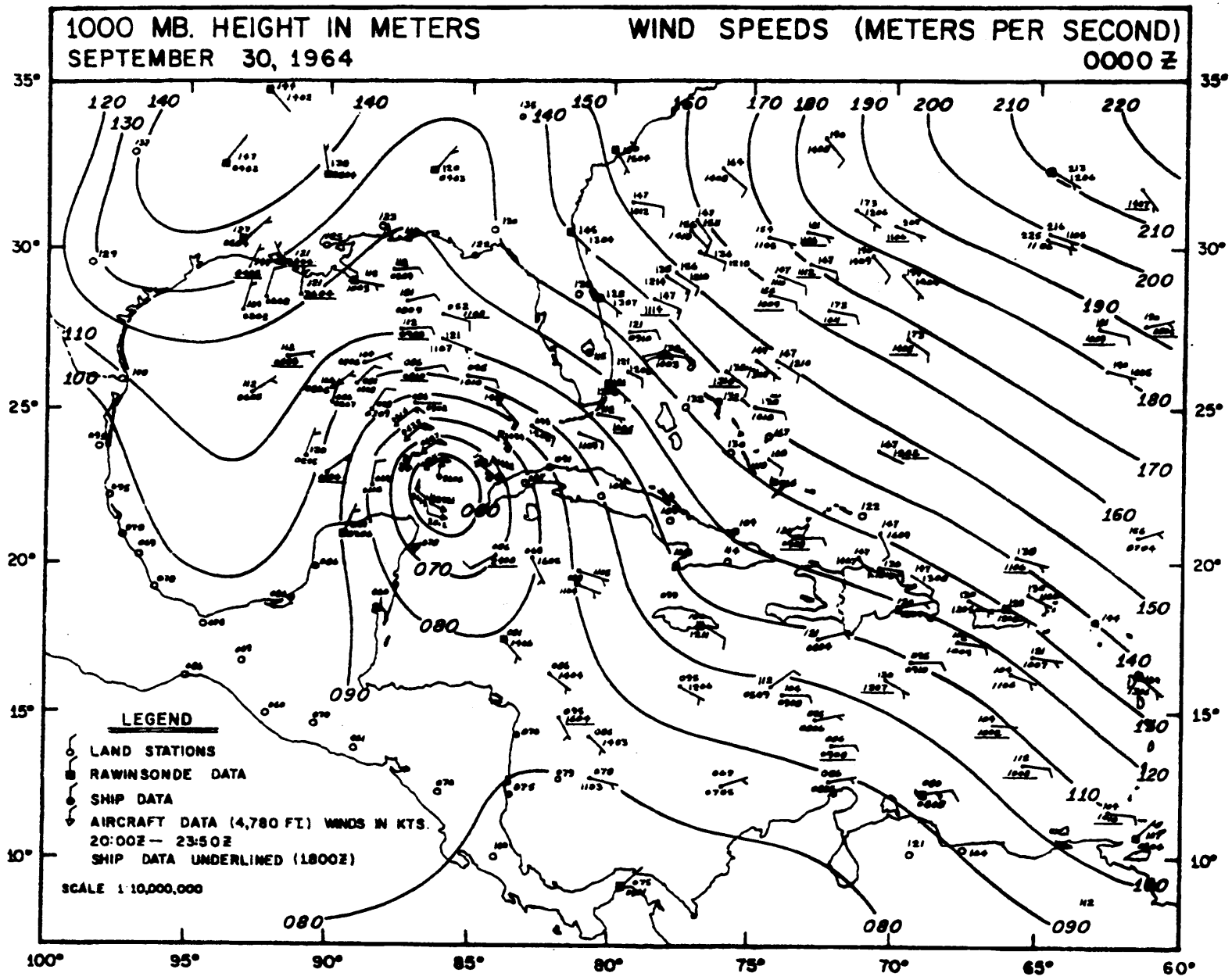


FIGURE 17.—Tropical storm Hilda at 00 GMT, September 30.

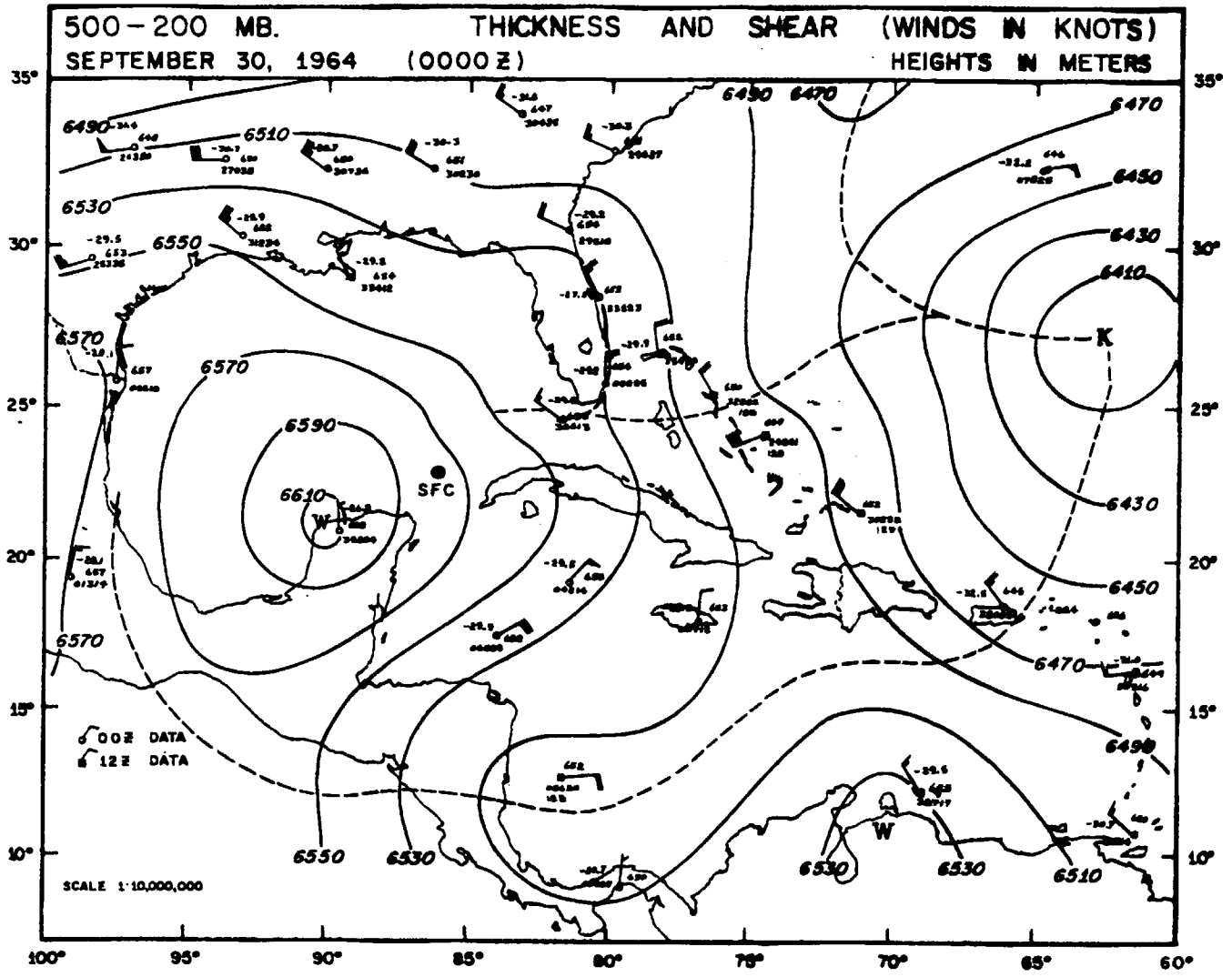


FIGURE 21.—Lack of data prohibited more detailed analysis of thickness over the storm area, but there is little doubt of the larger scale pattern.

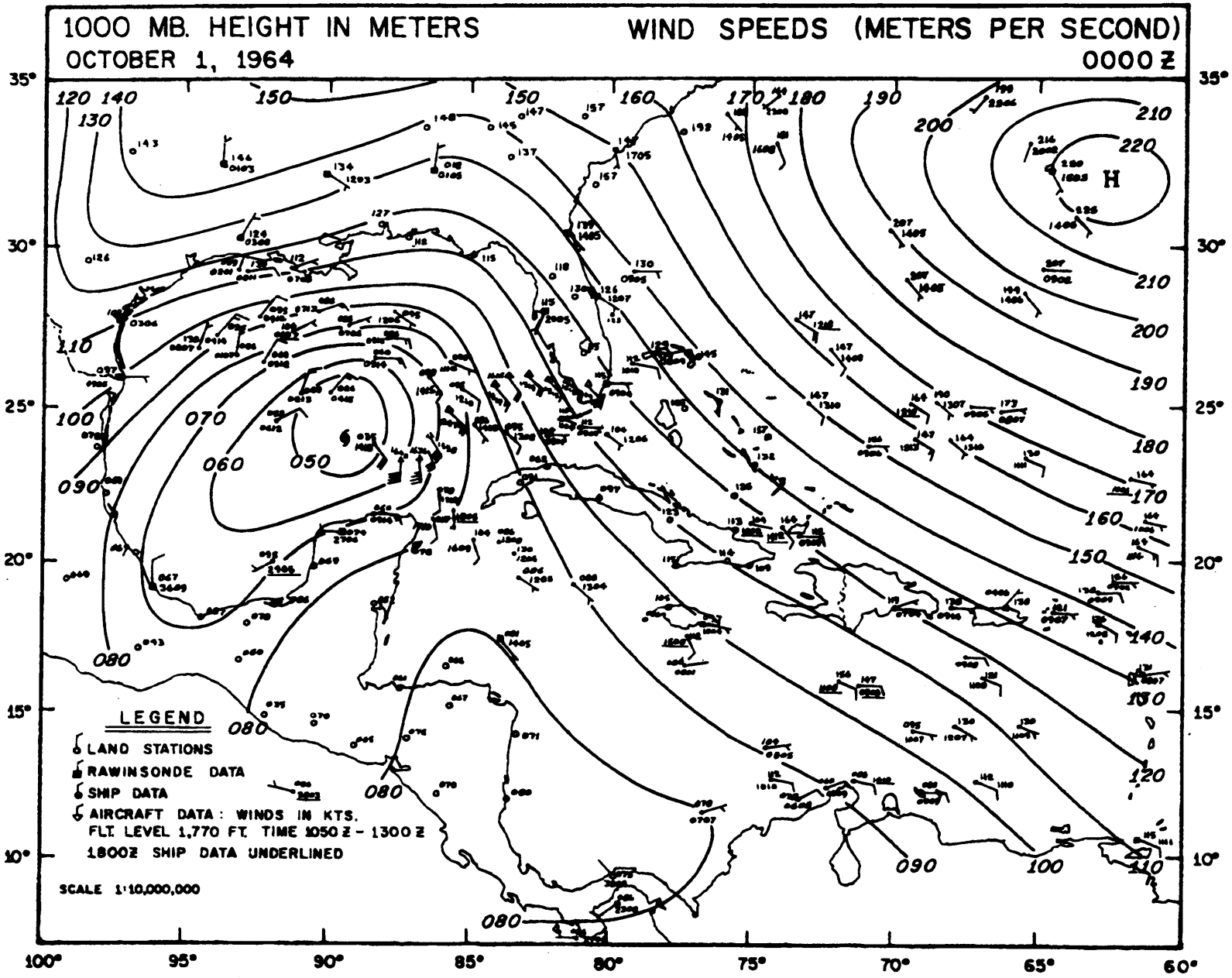


FIGURE 23.—Hurricane Hilda deepening rapidly near the center of the Gulf of Mexico.

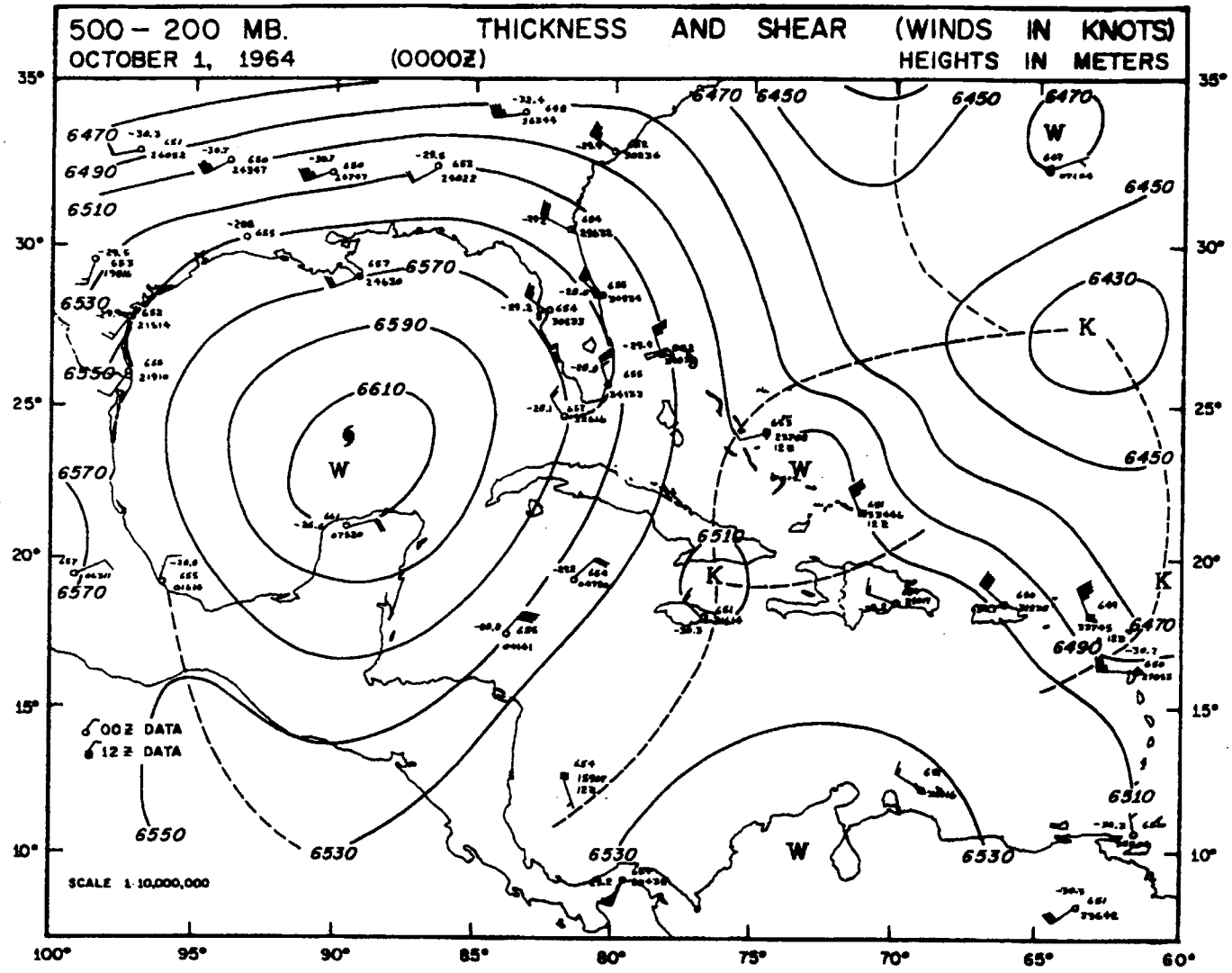


FIGURE 25.—The only shear winds that do not reflect the prevailing upper level warm pool accompanying Hilda over the Gulf are the weak winds at Vera Cruz, Mexico.

Tropical Experiment in Mexico (TEXMEX)
July 1 – August 10 1991

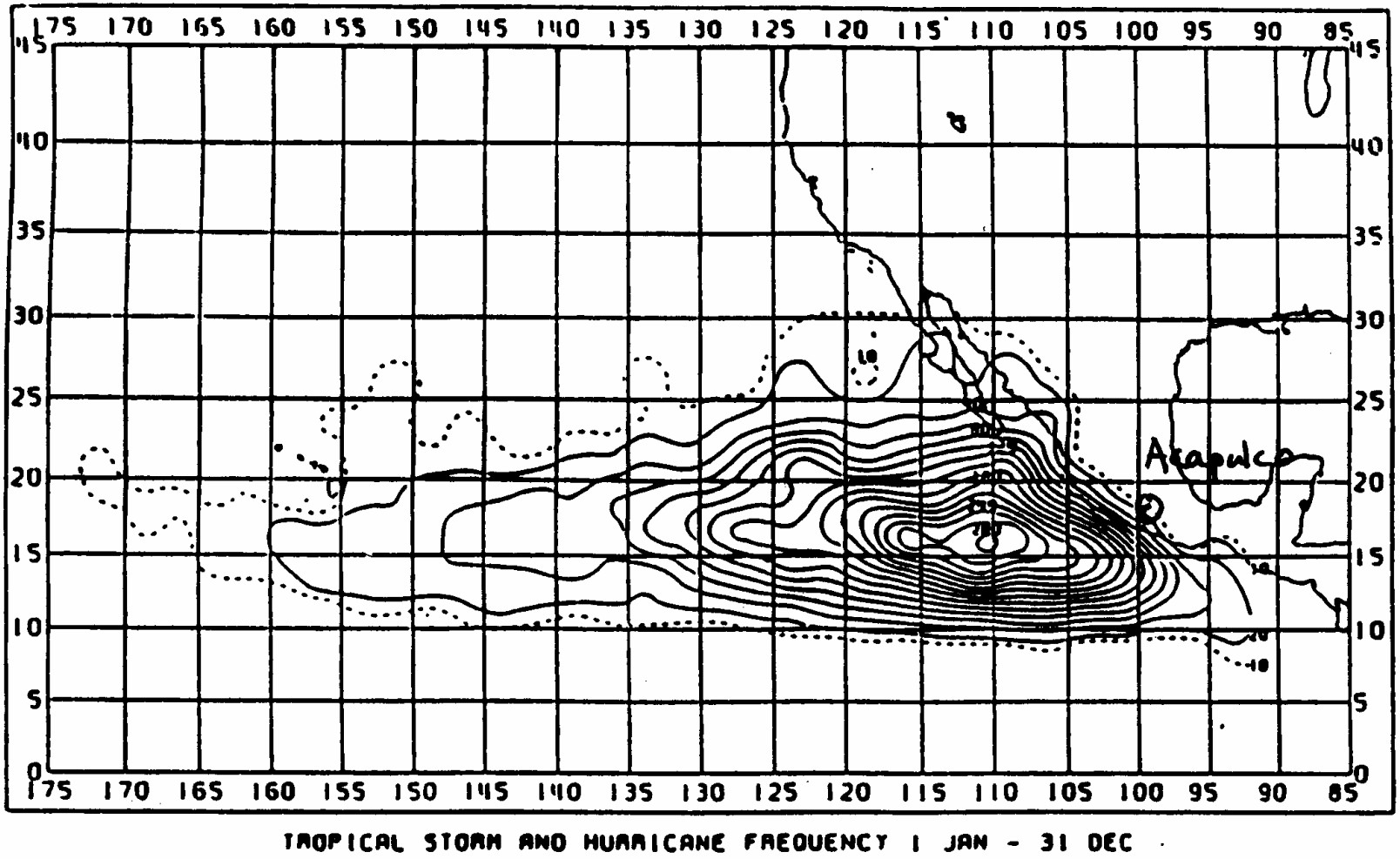


Fig. 3 Number of storms passing within 75 n. mi. of points in the eastern North Pacific region. The numbers of storms passing through a grid of overlapping equal-area circles was counted for the years 1966–1984 and normalized to give the frequency for a 100-year period (provided by C. Neumann).

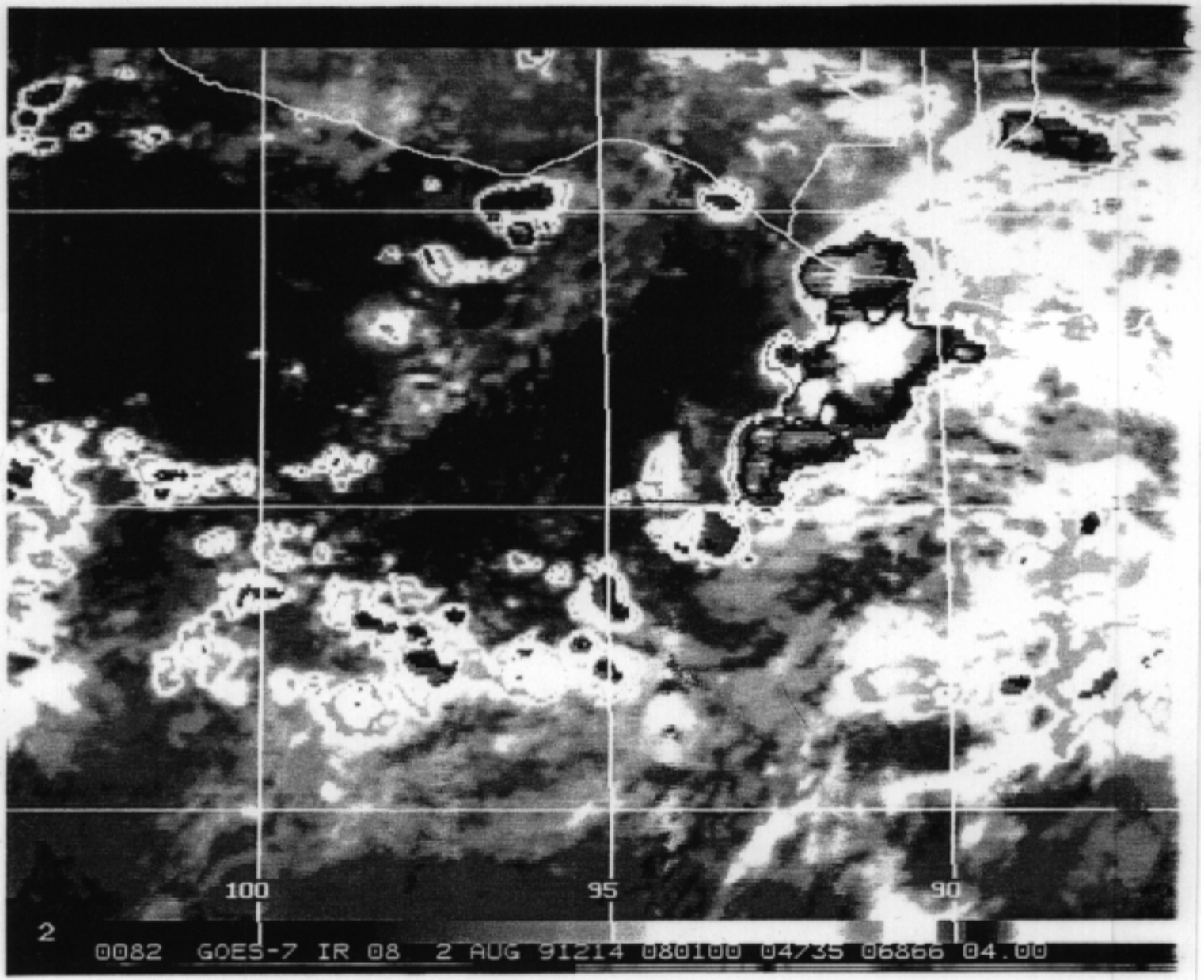


Figure 50: IR Satellite picture for 08:01 UTC 2 August.

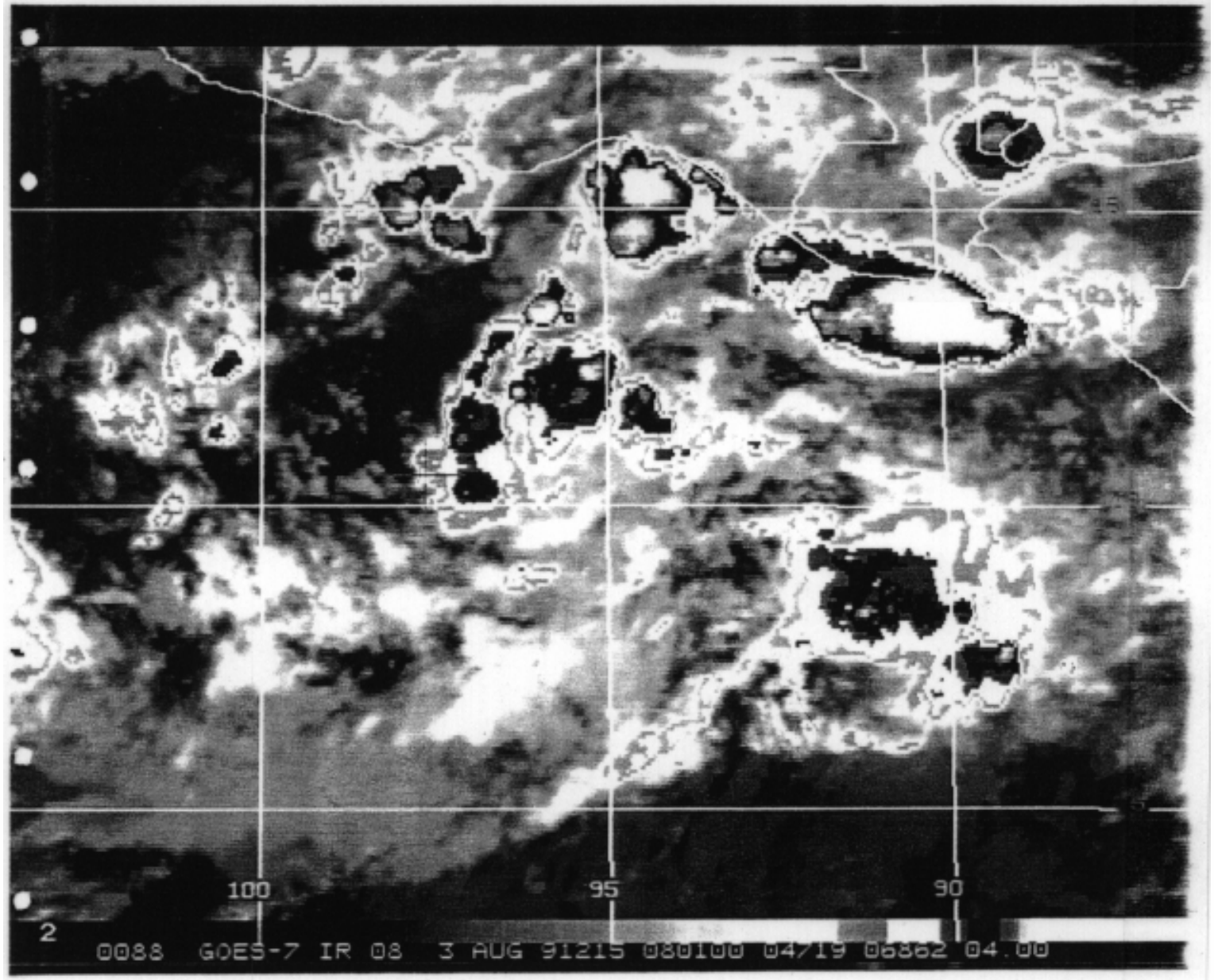


Figure 51: IR Satellite picture for 08:01 UTC 3 August.

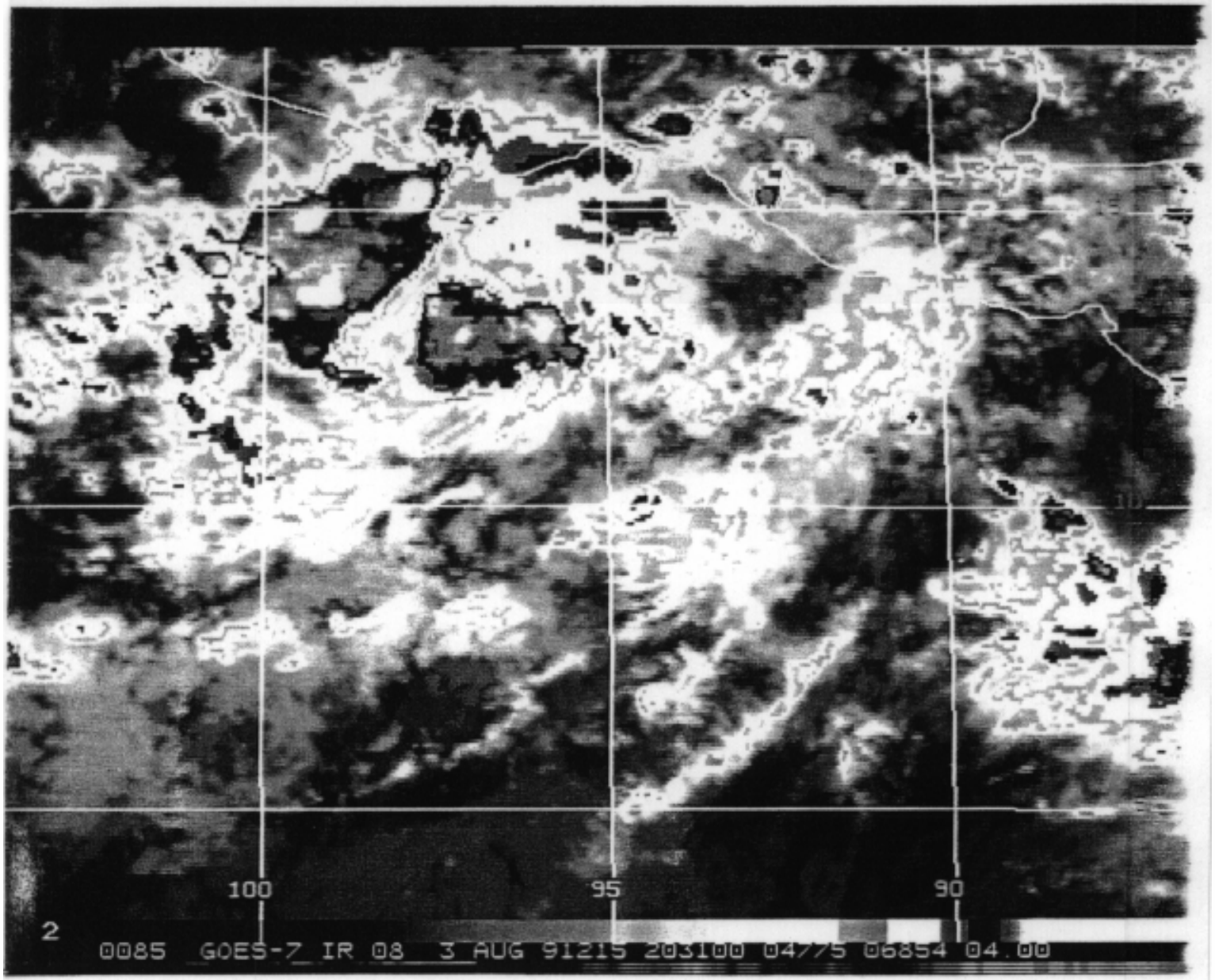


Figure 52: IR Satellite picture for 20:31 UTC 3 August.

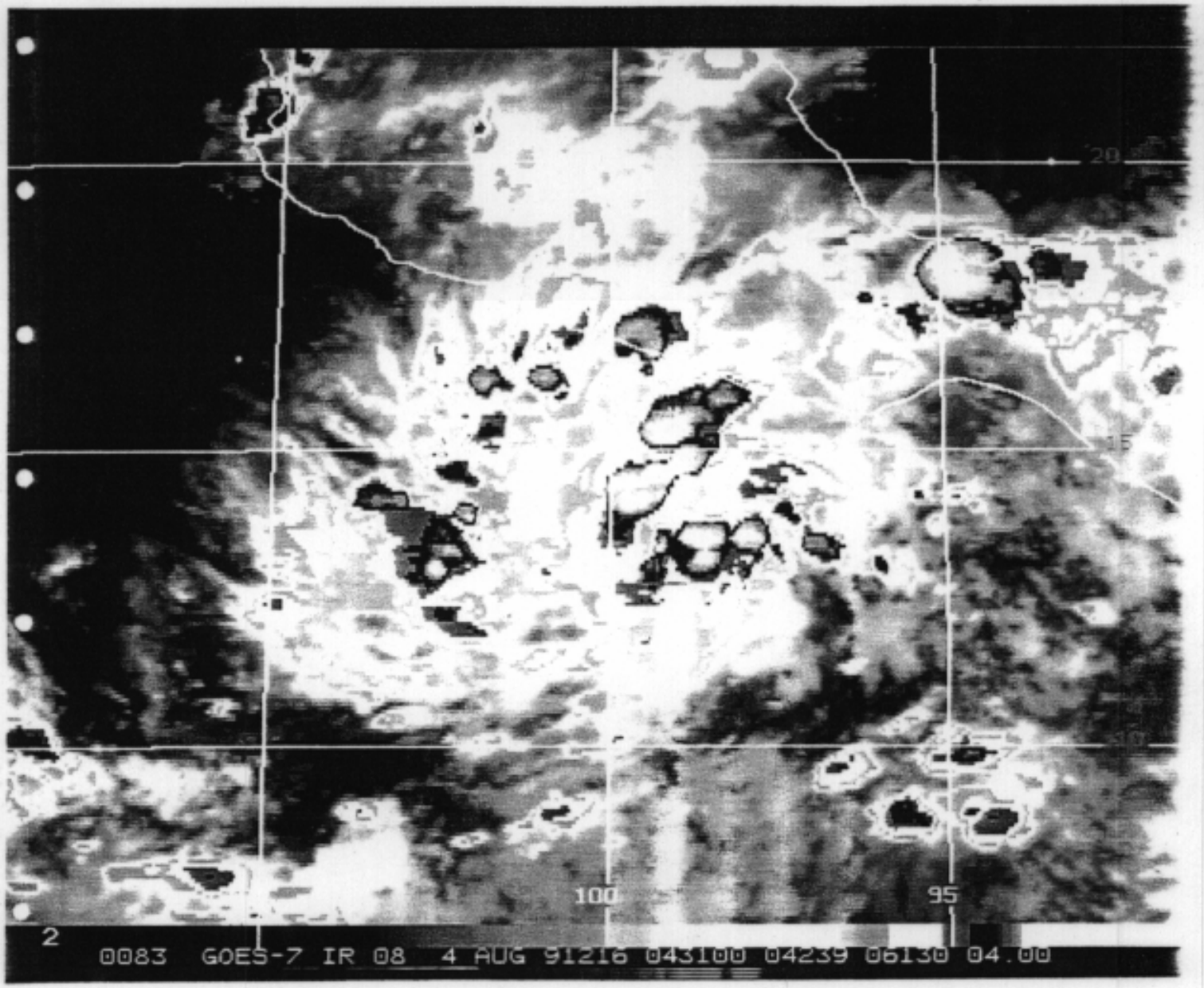


Figure 53: IR Satellite picture for 04:31 UTC 4 August.

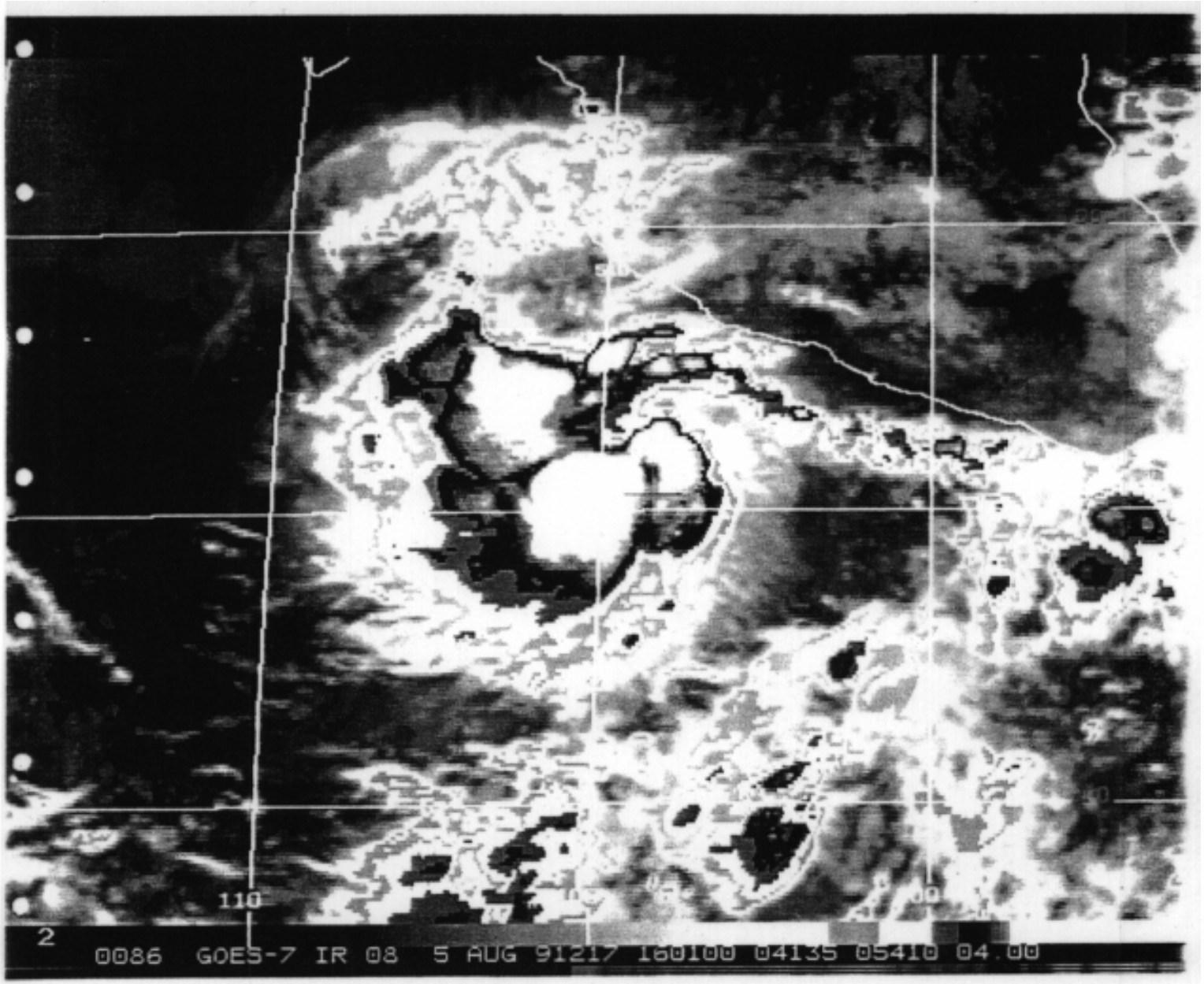
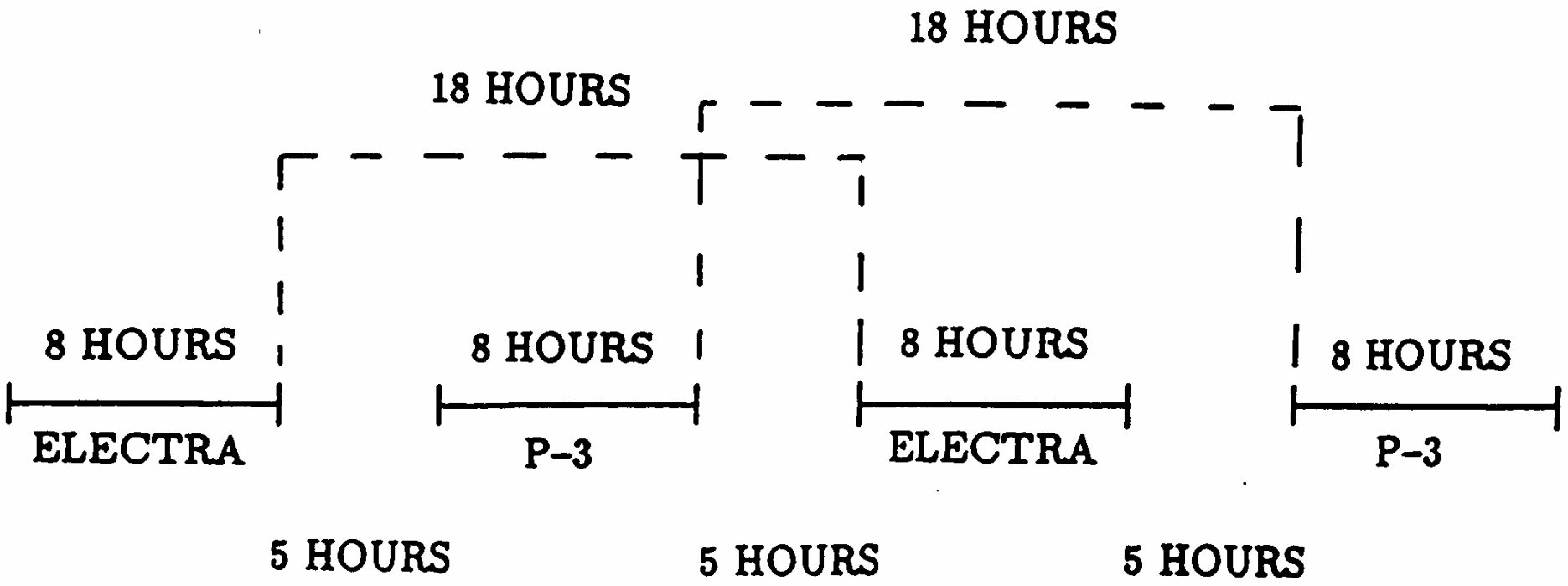
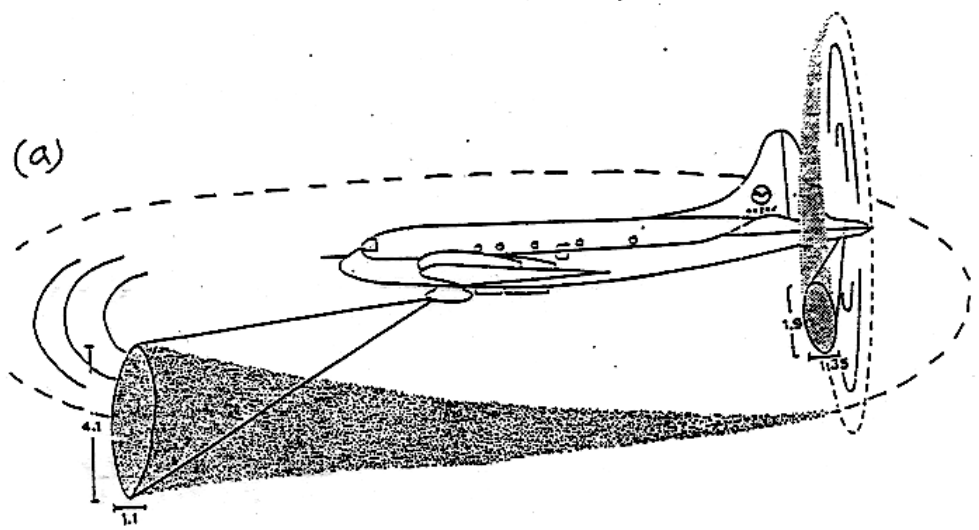


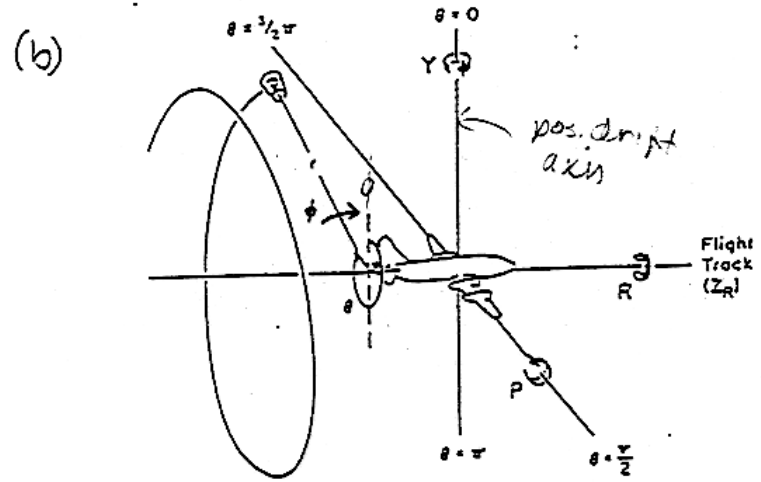
Figure 55: IR Satellite picture for 16:01 UTC 5 August.

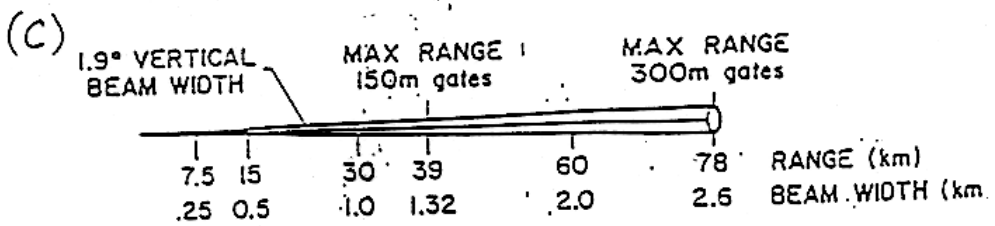
Flight Scheduling



WP-3D radars


(a)
4.1
1.1
1.9
1.35


(b)
θ = 3/2 π
θ = 0
Y
pos. dr. A
axis
Flight
Track
(Z_R)
R
P
θ = π
θ = π/2


(C)
1.9° VERTICAL
BEAM WIDTH
MAX RANGE
150m gates
MAX RANGE
300m gates
7.5 15 30 39 60 78 RANGE (km)
.25 0.5 1.0 1.32 2.0 2.6 BEAM WIDTH (km

Tail Doppler Scanning Strategy

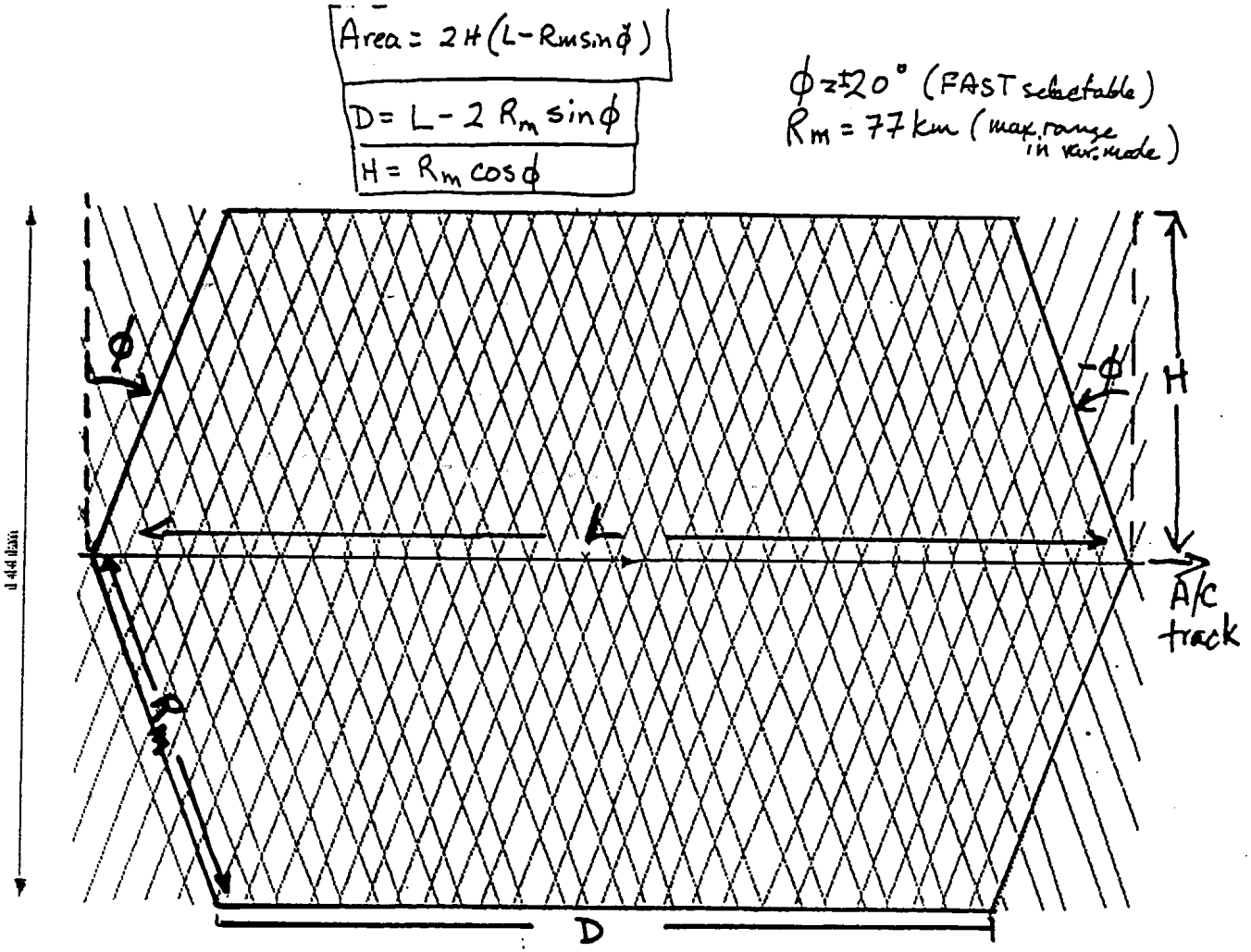
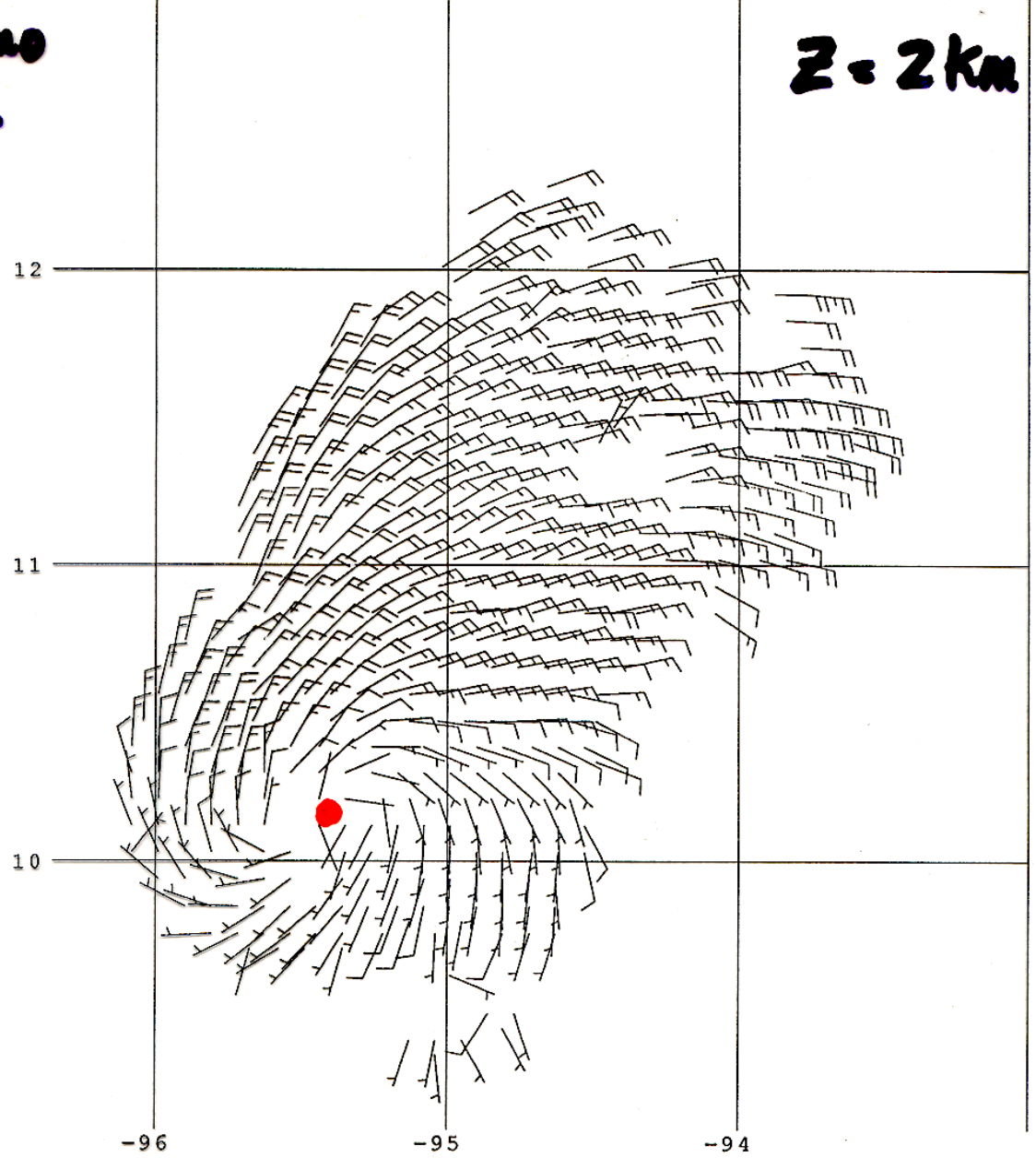


Fig. IV–2. Horizontal psuedo-dual Doppler coverage for tail Doppler radar for FAST scanning.

Guillermo
910802

Z = 2 km

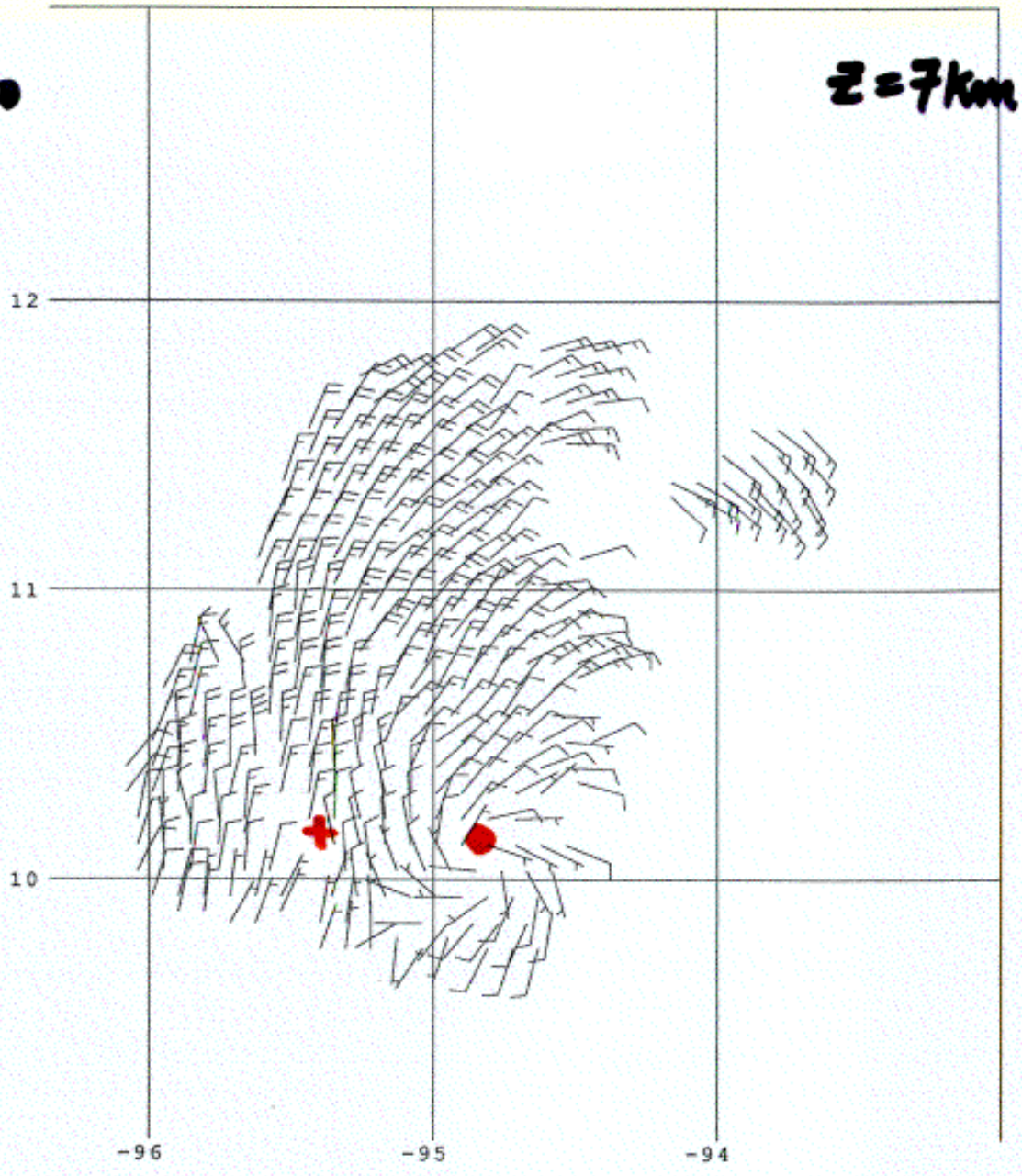


910802 TRANS level 04 WIND

5 knots
no knots

Guillermo
910802

z=7km



910802 TRANS level 14 WIND

+2km 5

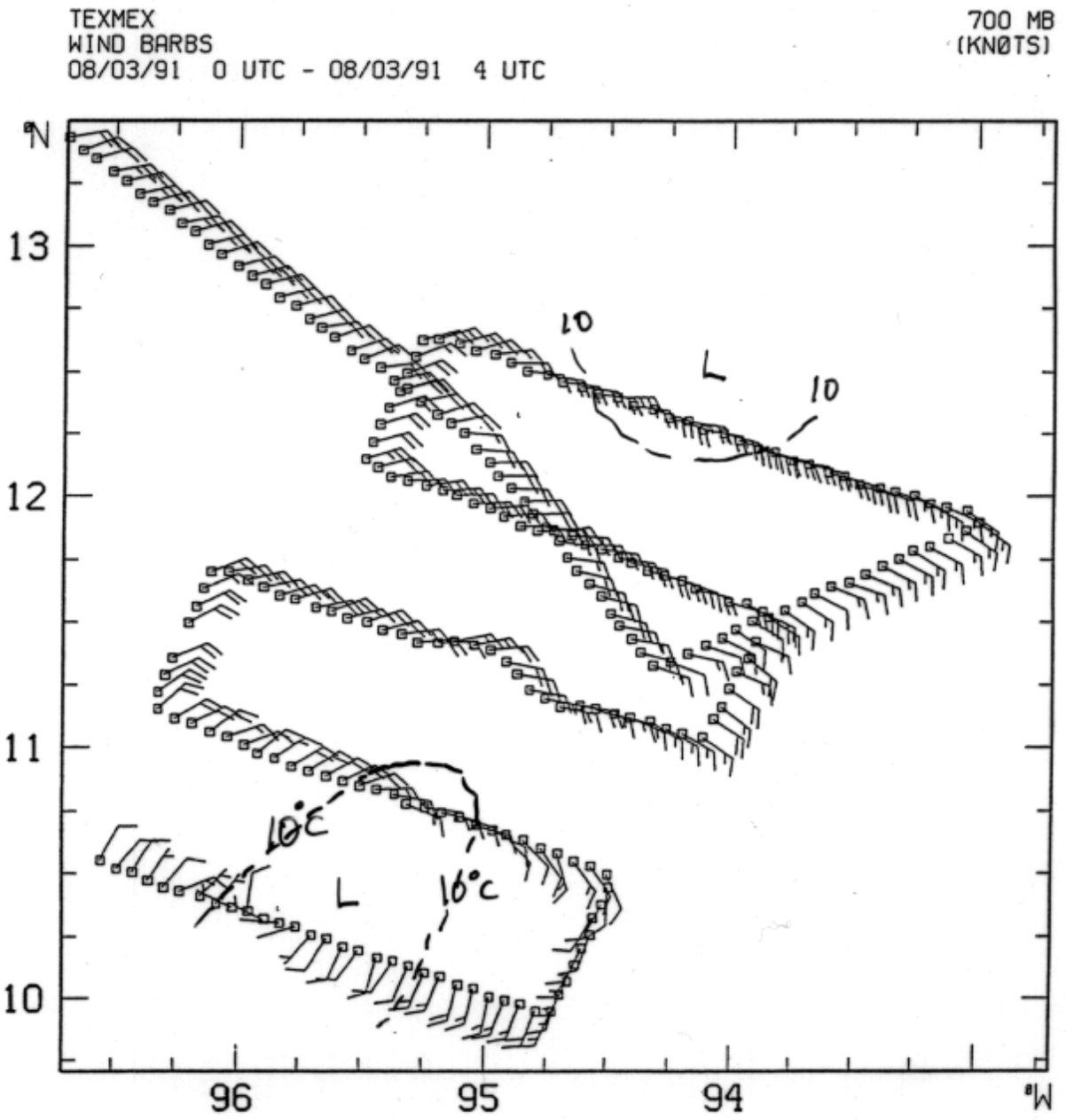


Figure 66: The 700 hPa pattern for flight 910802H.

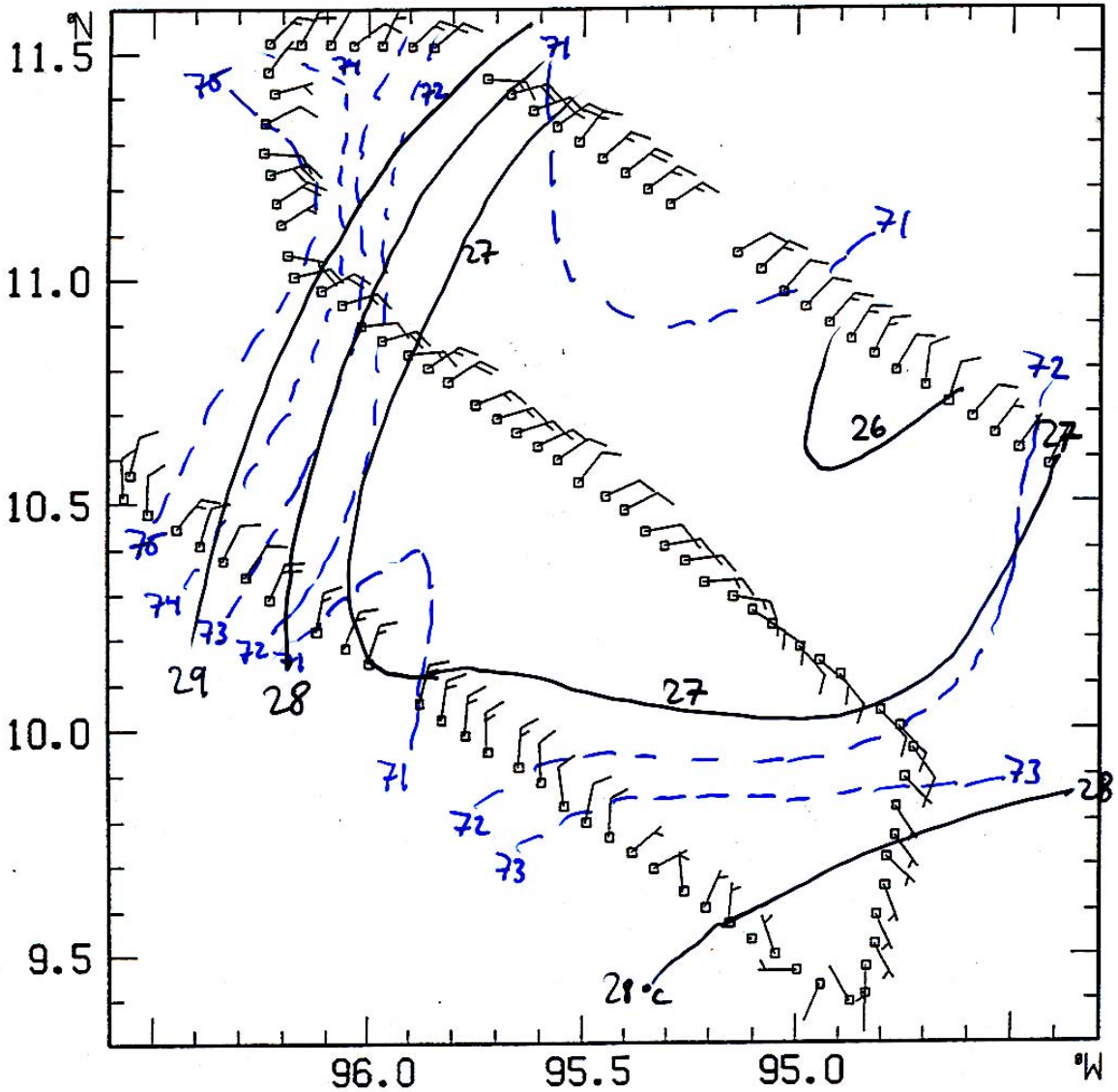


Figure 67: The 975 hPa pattern for flight 910802H.

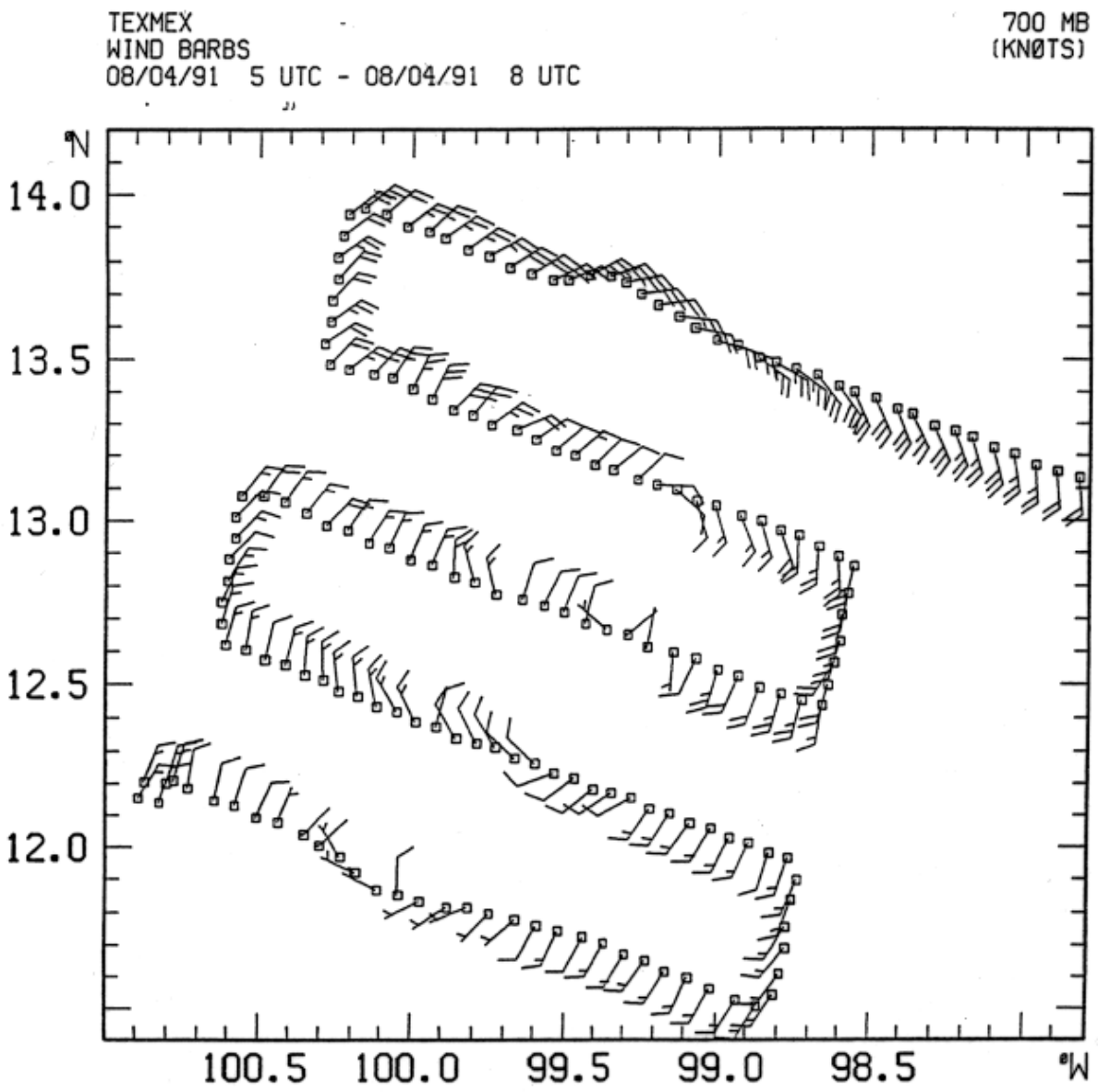


Figure 71: The ~~075~~ 700 hPa pattern for flight 910804H.

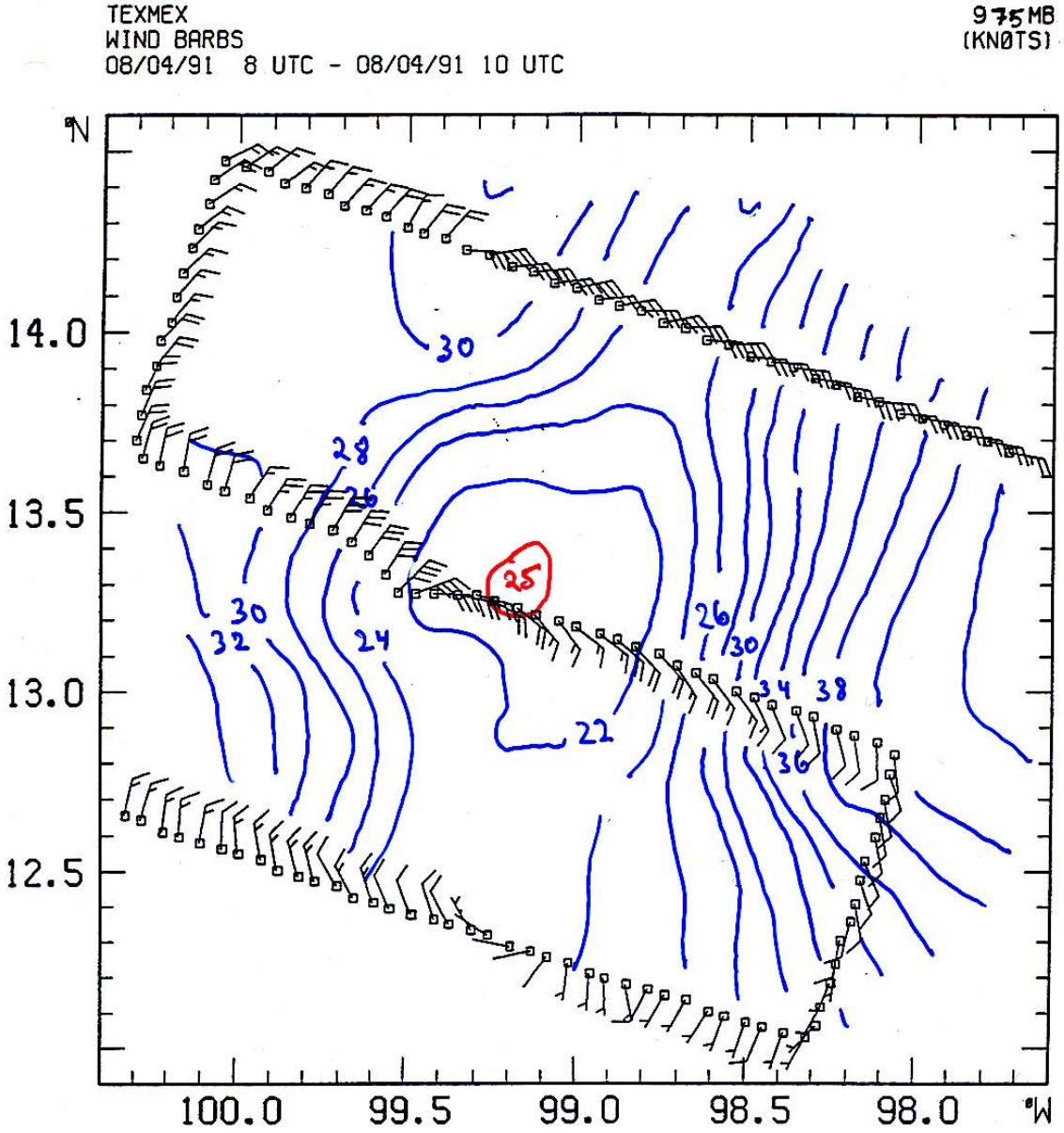


Figure 70: The ~~700~~ 975 hPa pattern for flight 910804H.

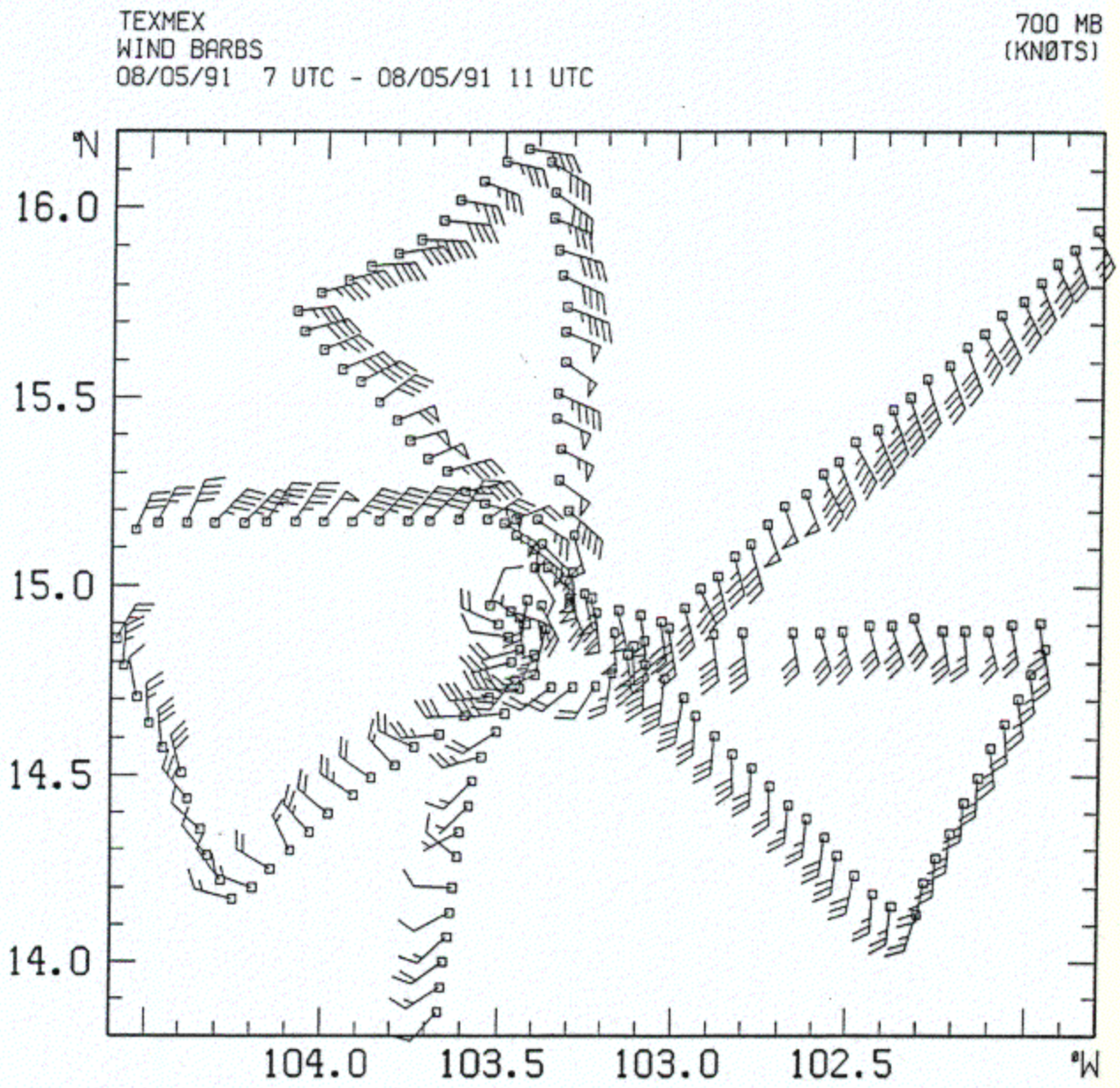


Figure 74: The 700 hPa pattern for flight 910805H.

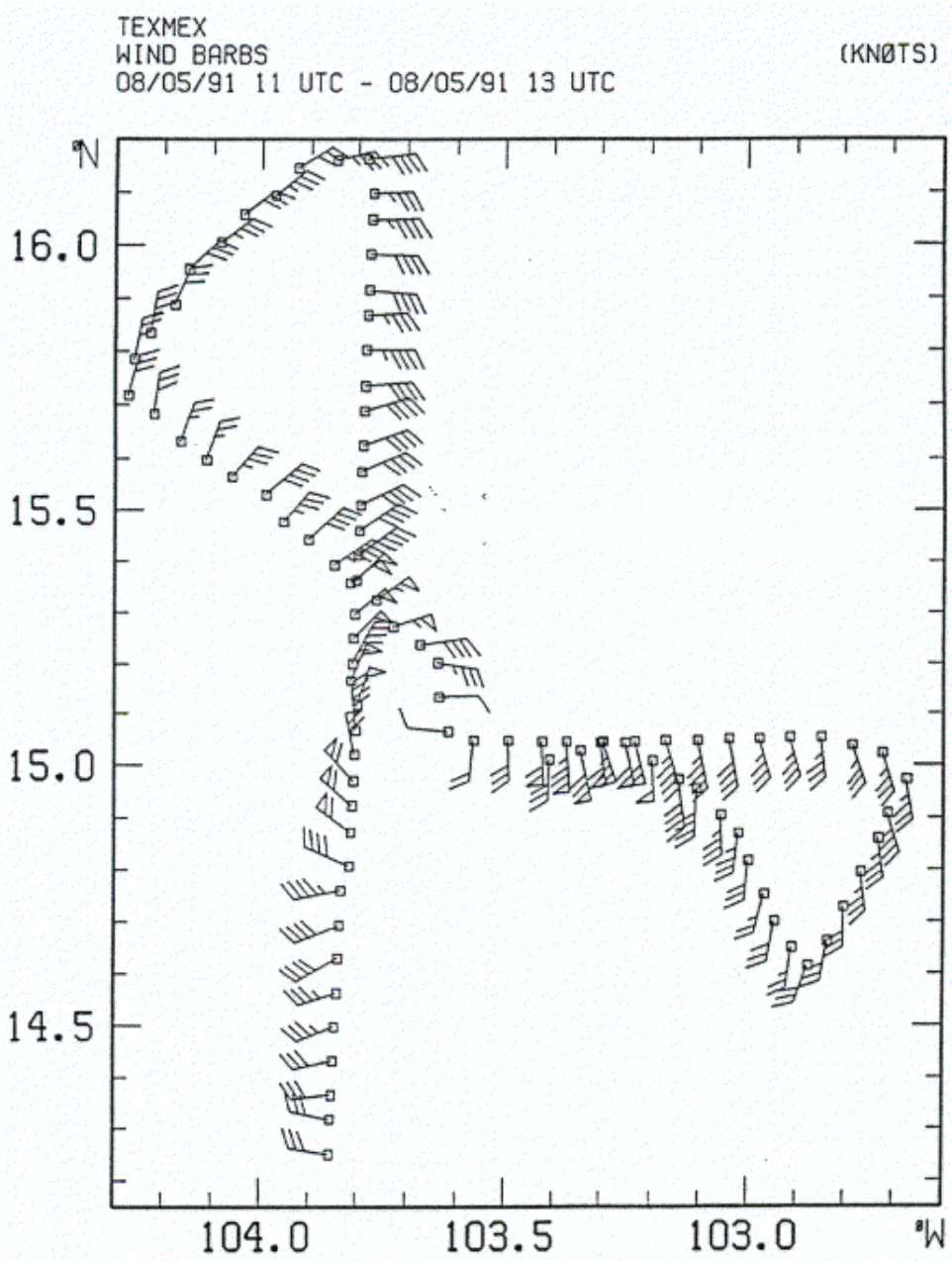
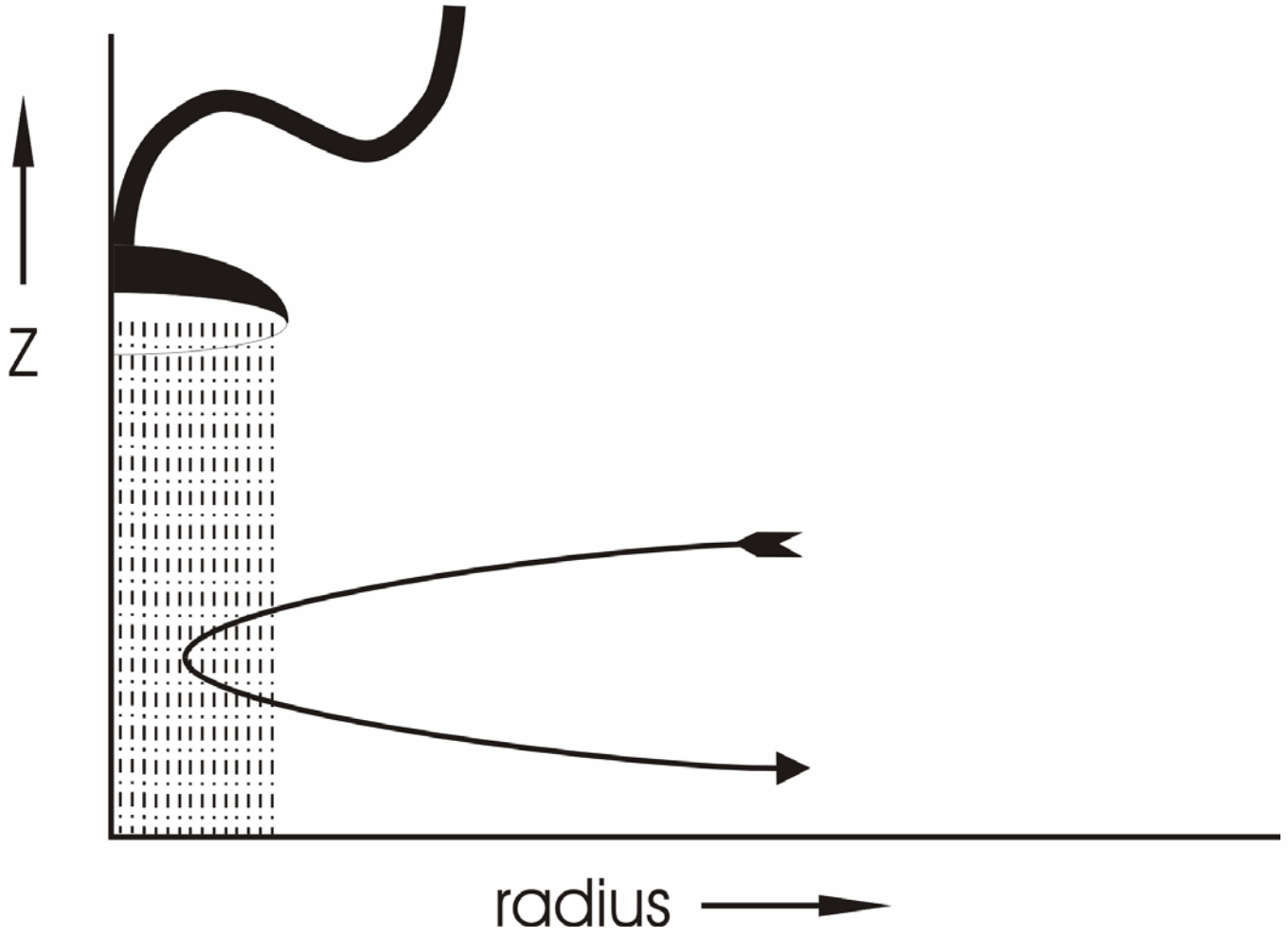
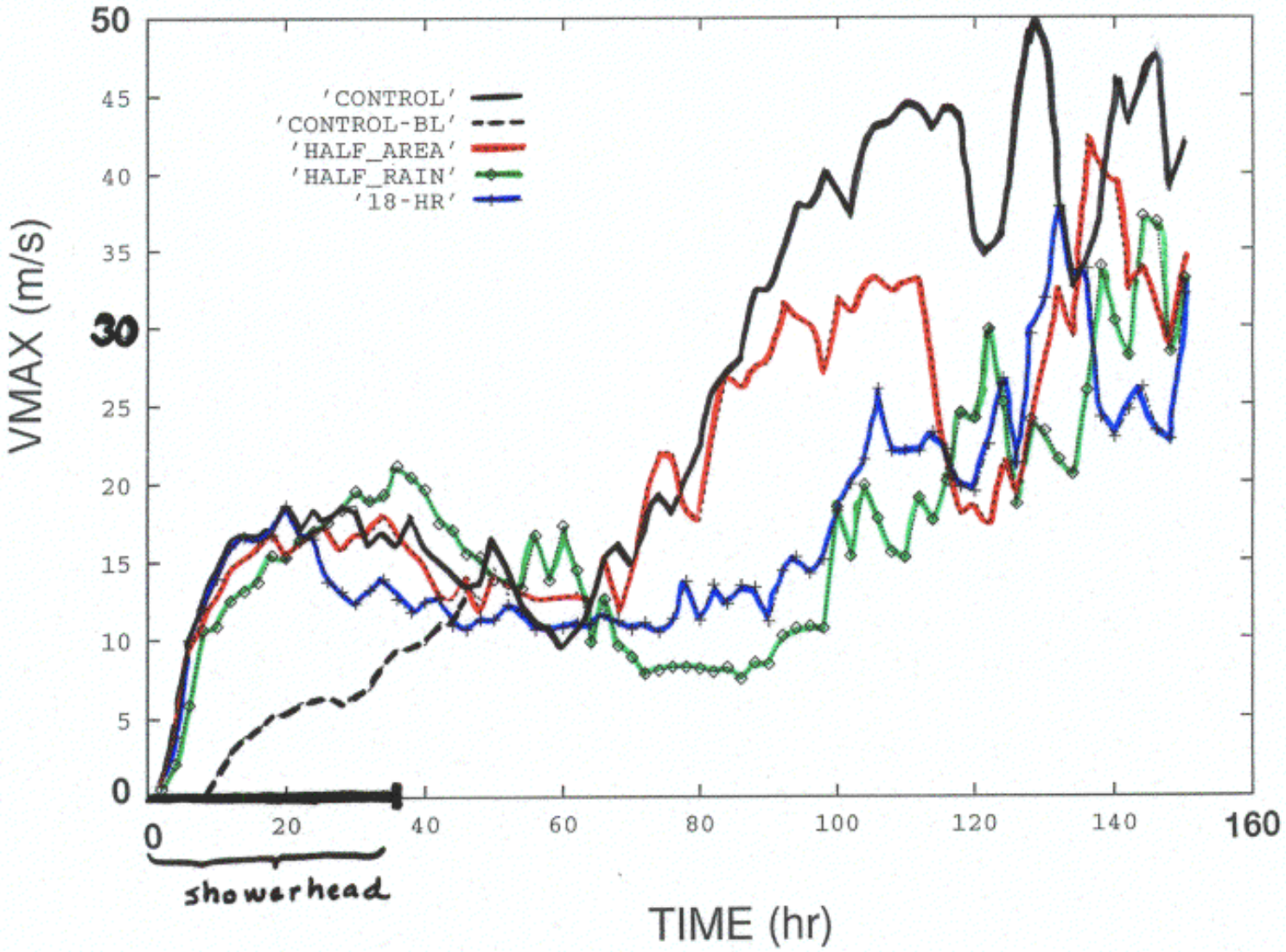


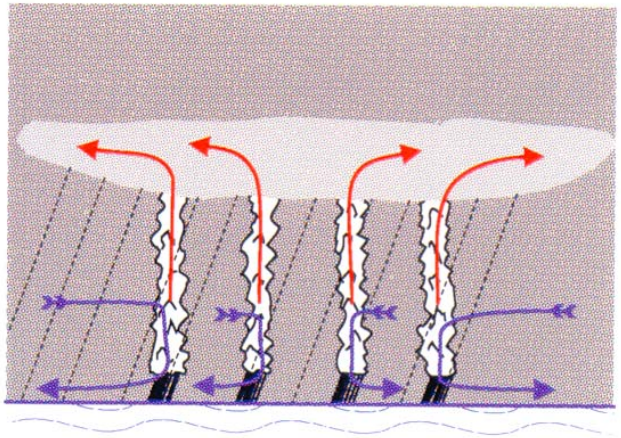
Figure 75: The 975 hPa pattern for flight 910805H.


Z
radius

Maximum tangential wind velocity

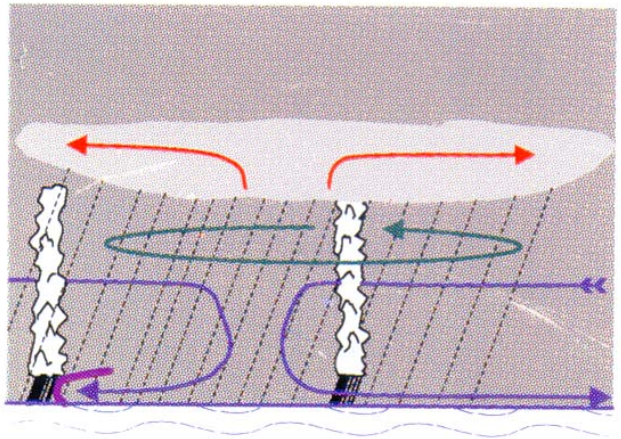


1. TRIGGERING



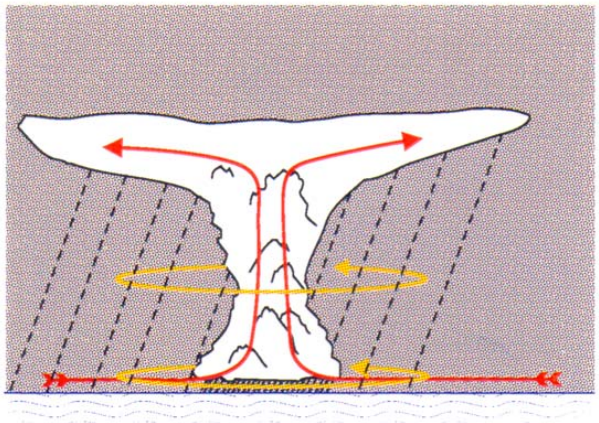
- Formation of long-lived mesoscale stratiform anvil
- Appears to require large-scale ascent in the upper troposphere
- Reduction of subcloud layer entropy by downdrafts

2. Gestation



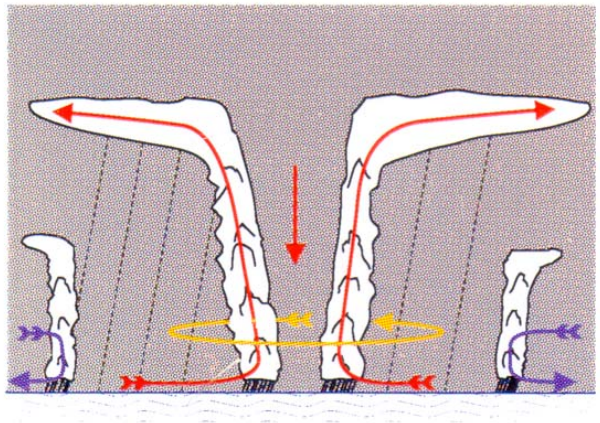
- Light to moderate stratiform rain; little deep convection, except at periphery
- Formation of middle tropospheric mesoscale cyclone cold core in the lower troposphere
- *High relative humidity* develops in core
- Subcloud layer entropy recovers

3. Ignition



- New episode of convection that is *free of downdraft* forms near core
- Strong surface *in*flow, strong surface heat fluxes
- Carnot engine switched on

4. Intensification

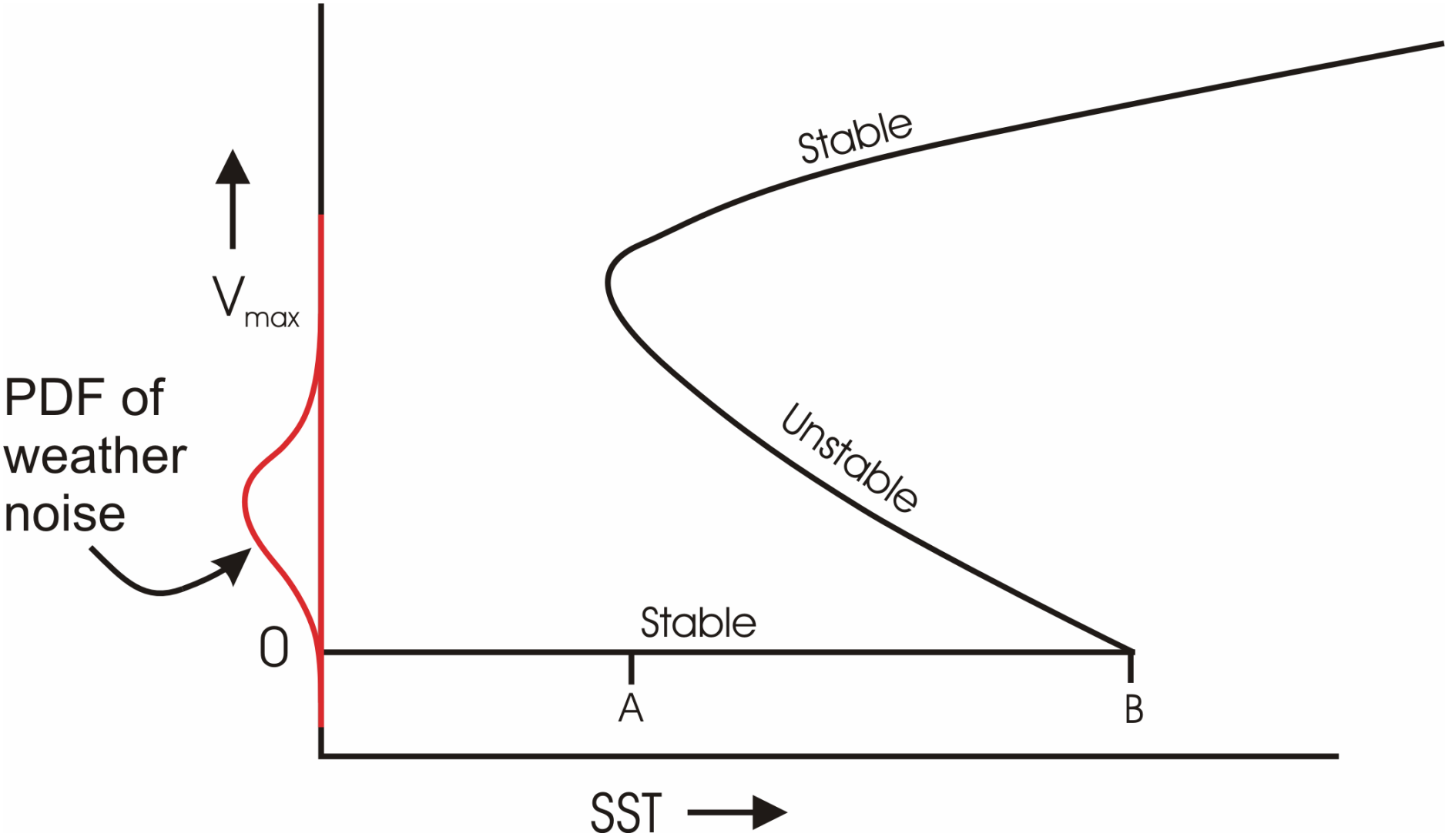


5. Maturity

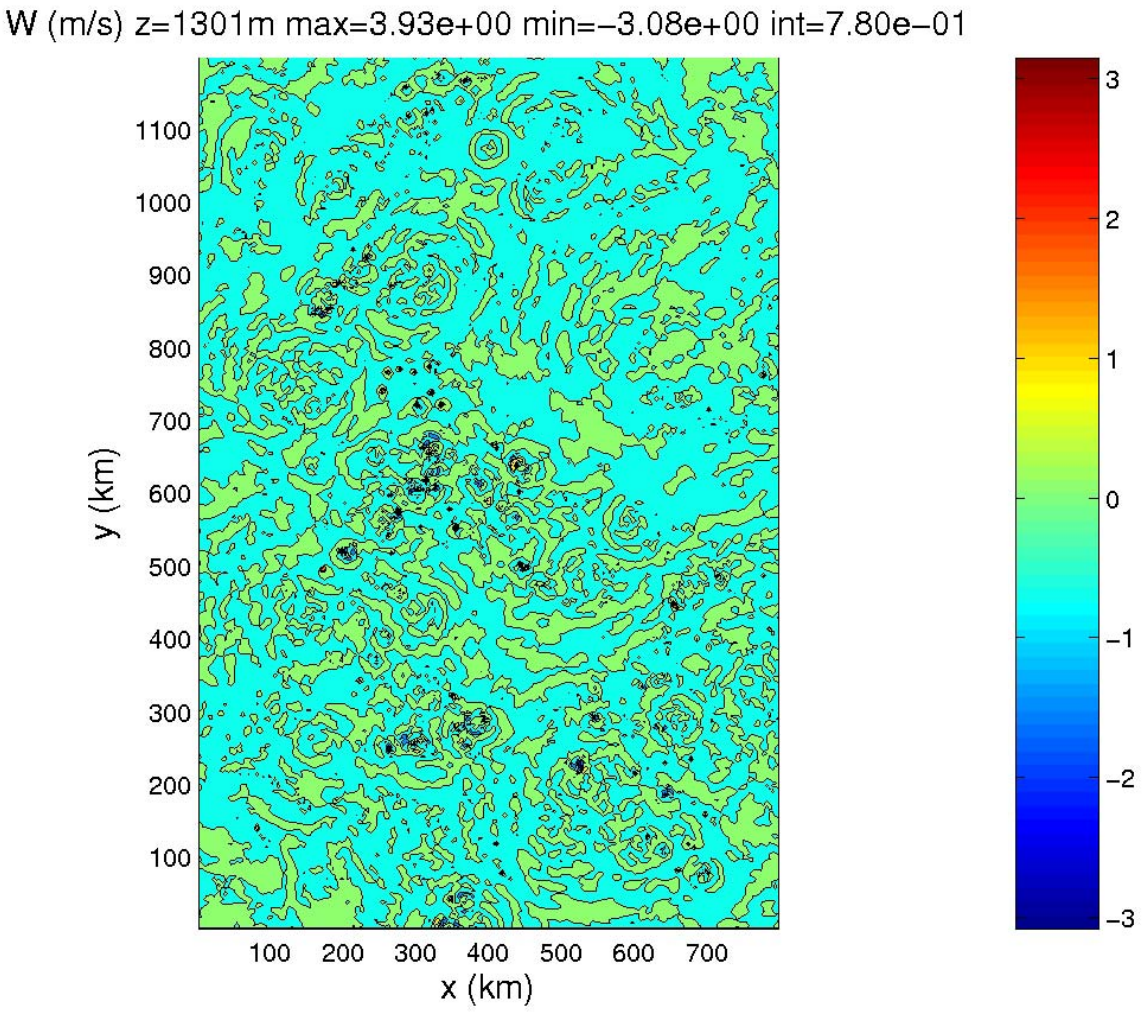
6. Dissipation

Hypothesis

- Tropical cyclones result from a subcritical bifurcation of the normal state of the tropical atmosphere

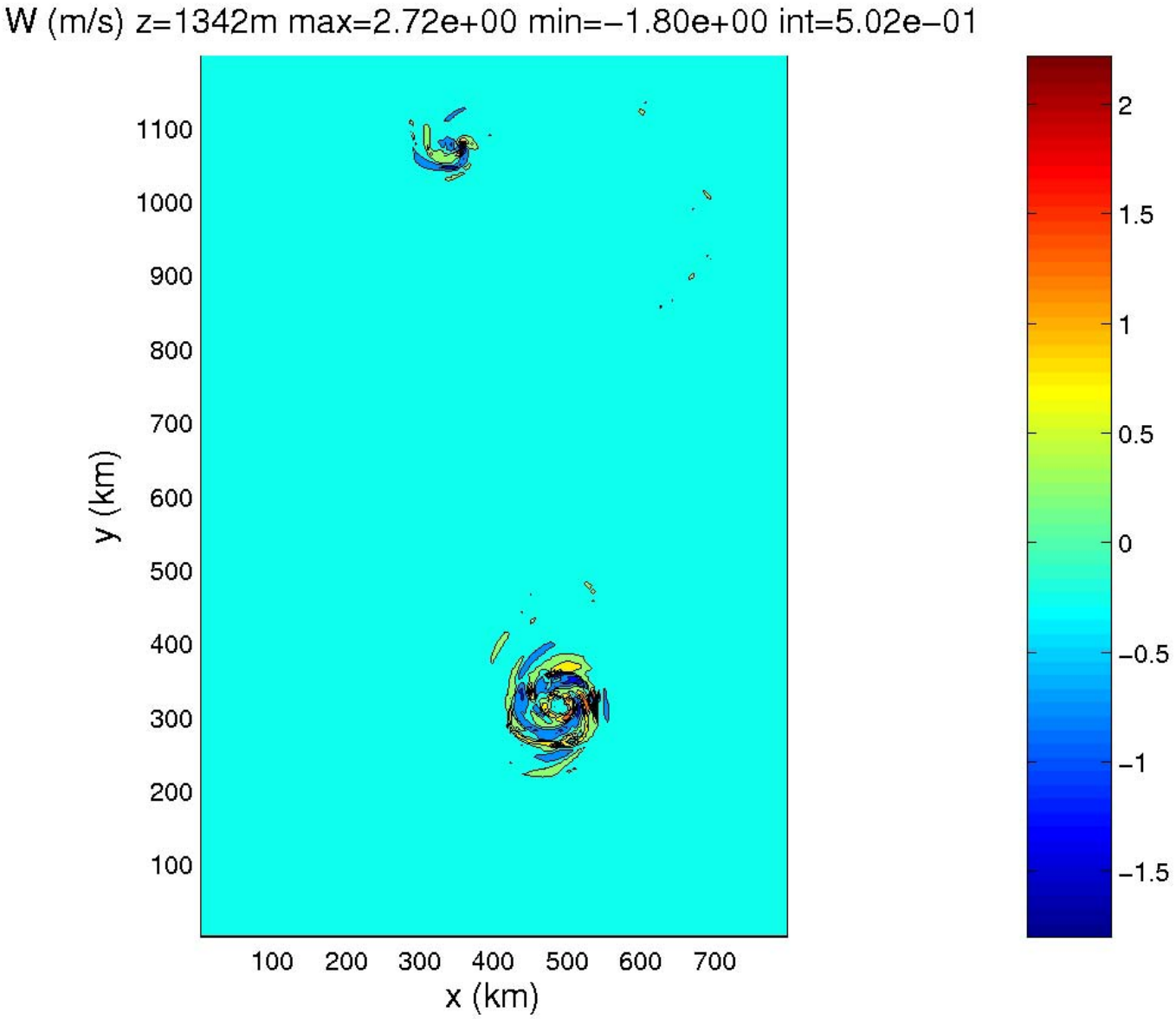

Stable
V_{max}
PDF of
weather
noise
Unstable
Stable
0
A
B
SST

SST = 30°C



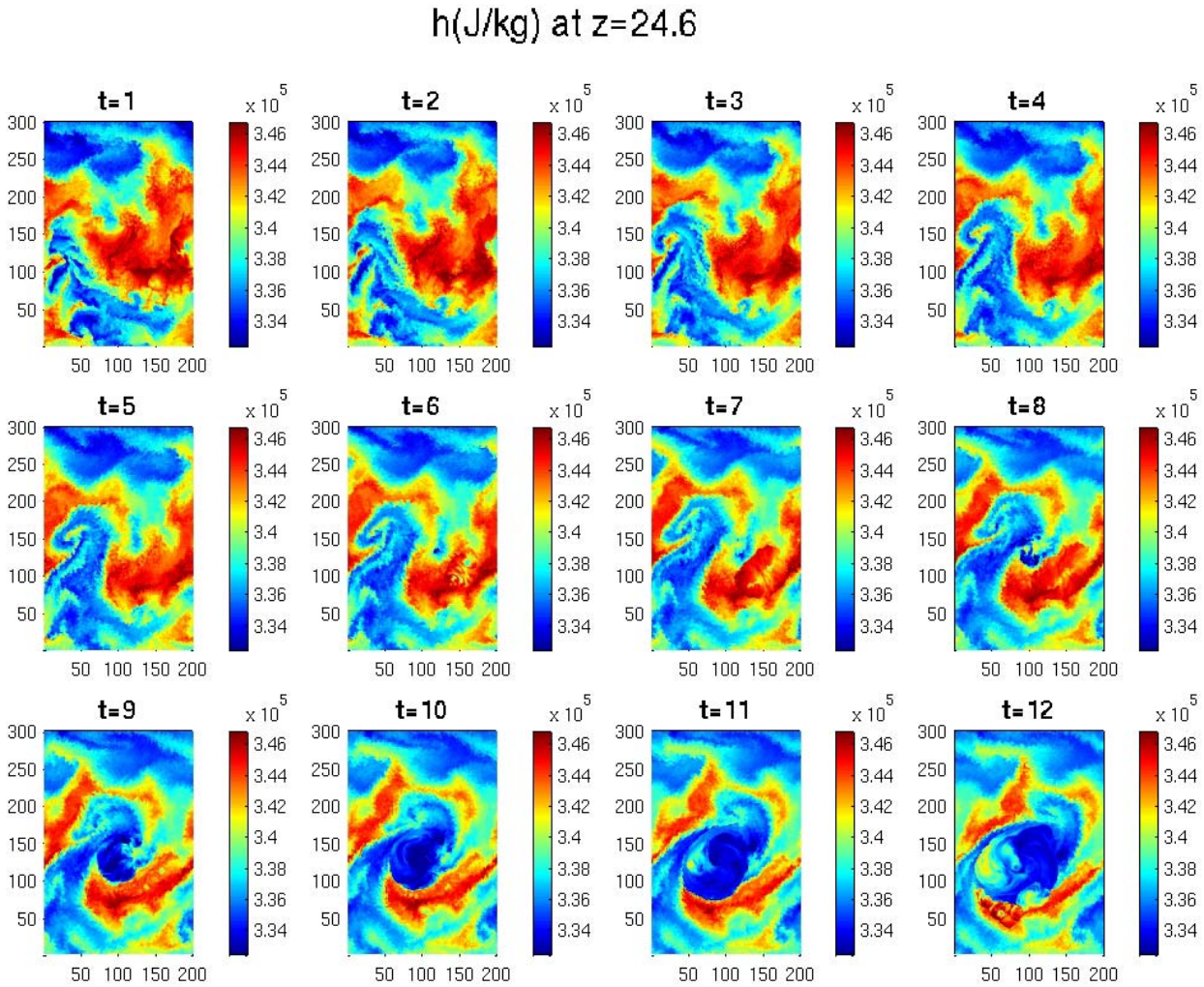
Integrations of a 3-D cloud system-resolving model in radiative-convective equilibrium with fixed SST, by David Nolan

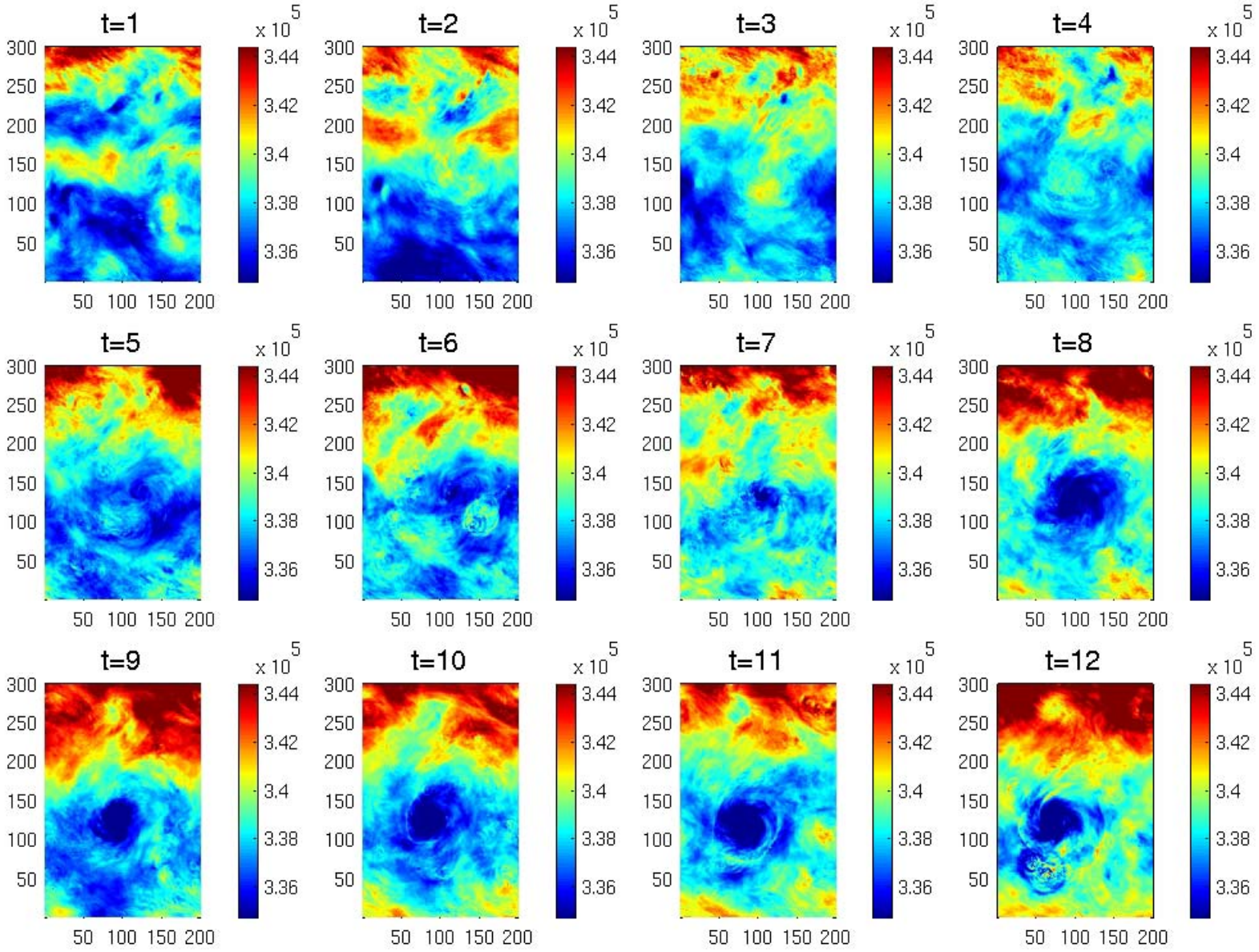
SST = 35°C

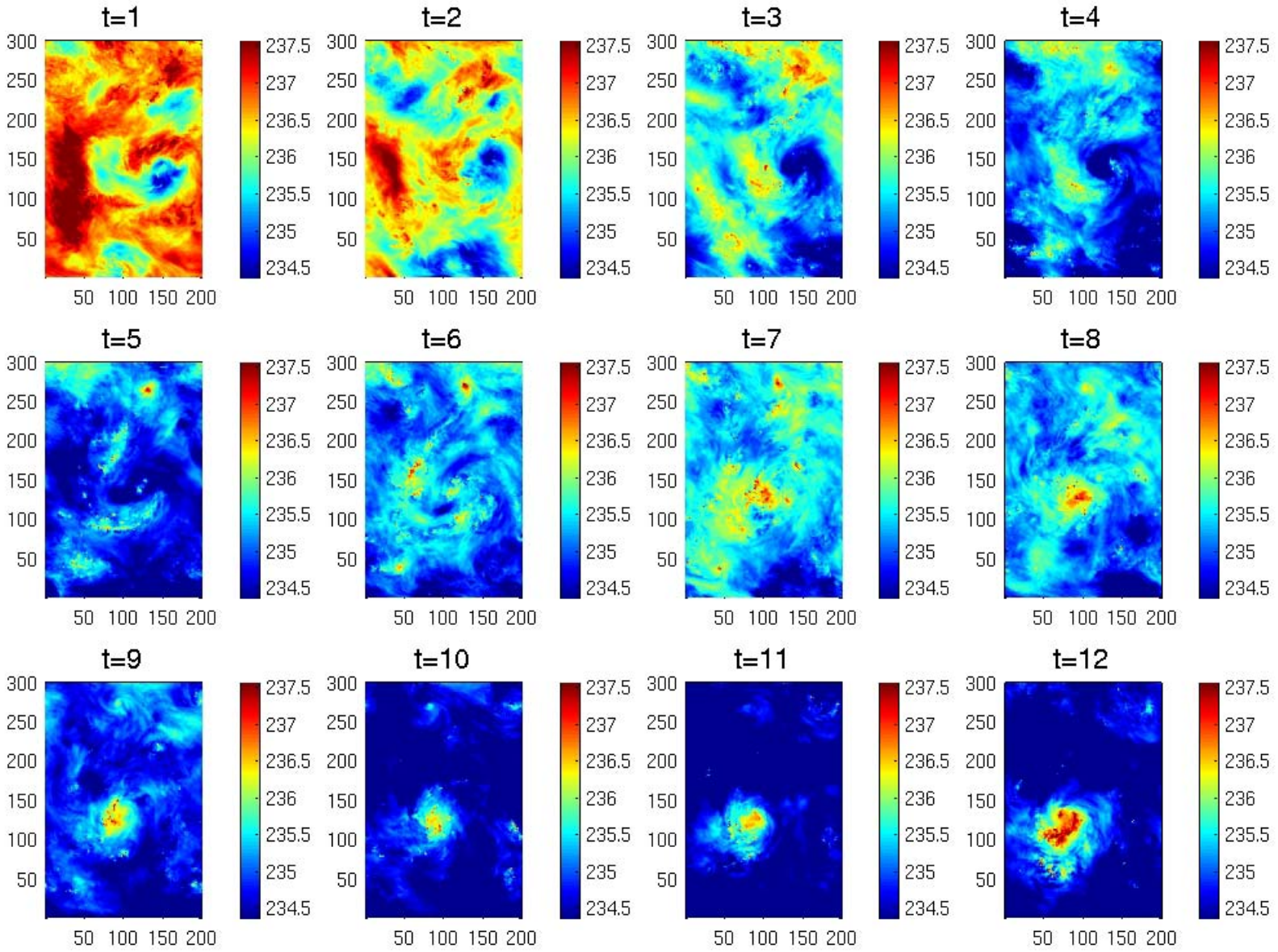

W (m/s) z=1342m max=2.72e+00 min=−1.80e+00 int=5.02e−01
y (km)
1100
1000
900
800
700
600
500
400
300
200
100
100 200 300 400 500 600 700
x (km)
2
1.5
1
0.5
0
−0.5
−1
−1.5

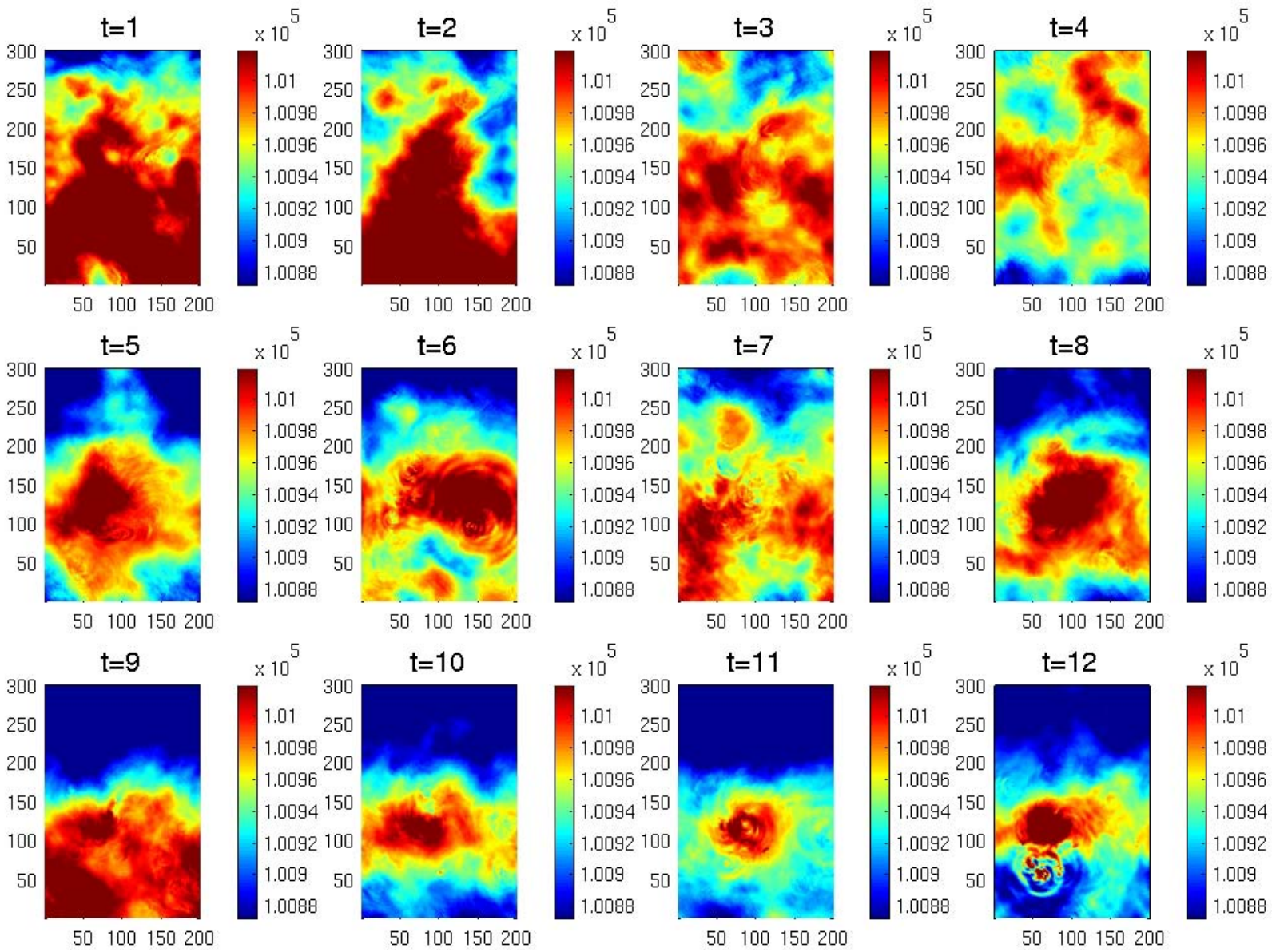
Initial development begins as mesoscale downdraft:

Moist static energy at 25 m

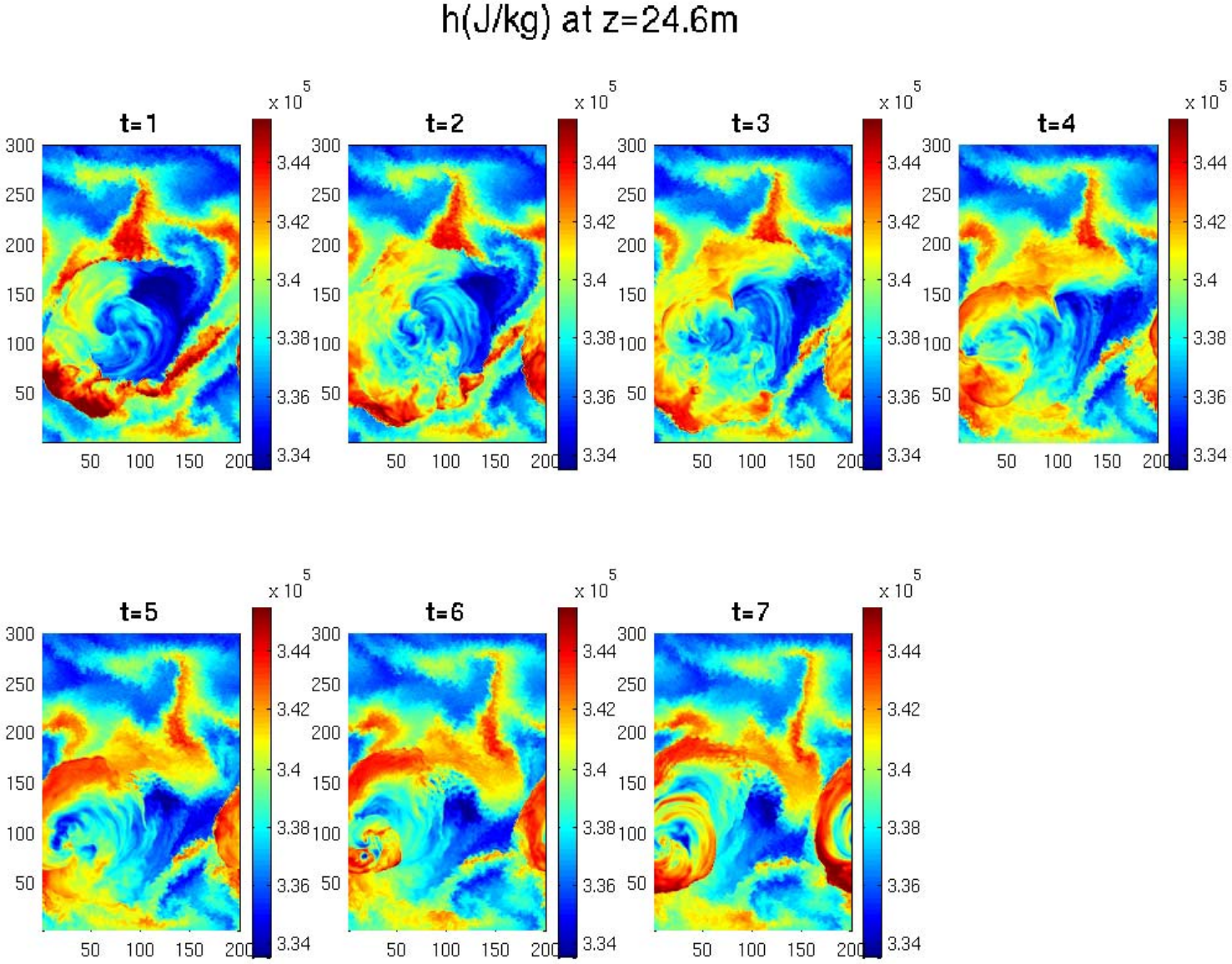



h*(J/kg) at z=3810
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
x 10^5
3.44
3.42
3.4
3.38
3.36
300
250
200
150
100
50
50 100 150 200

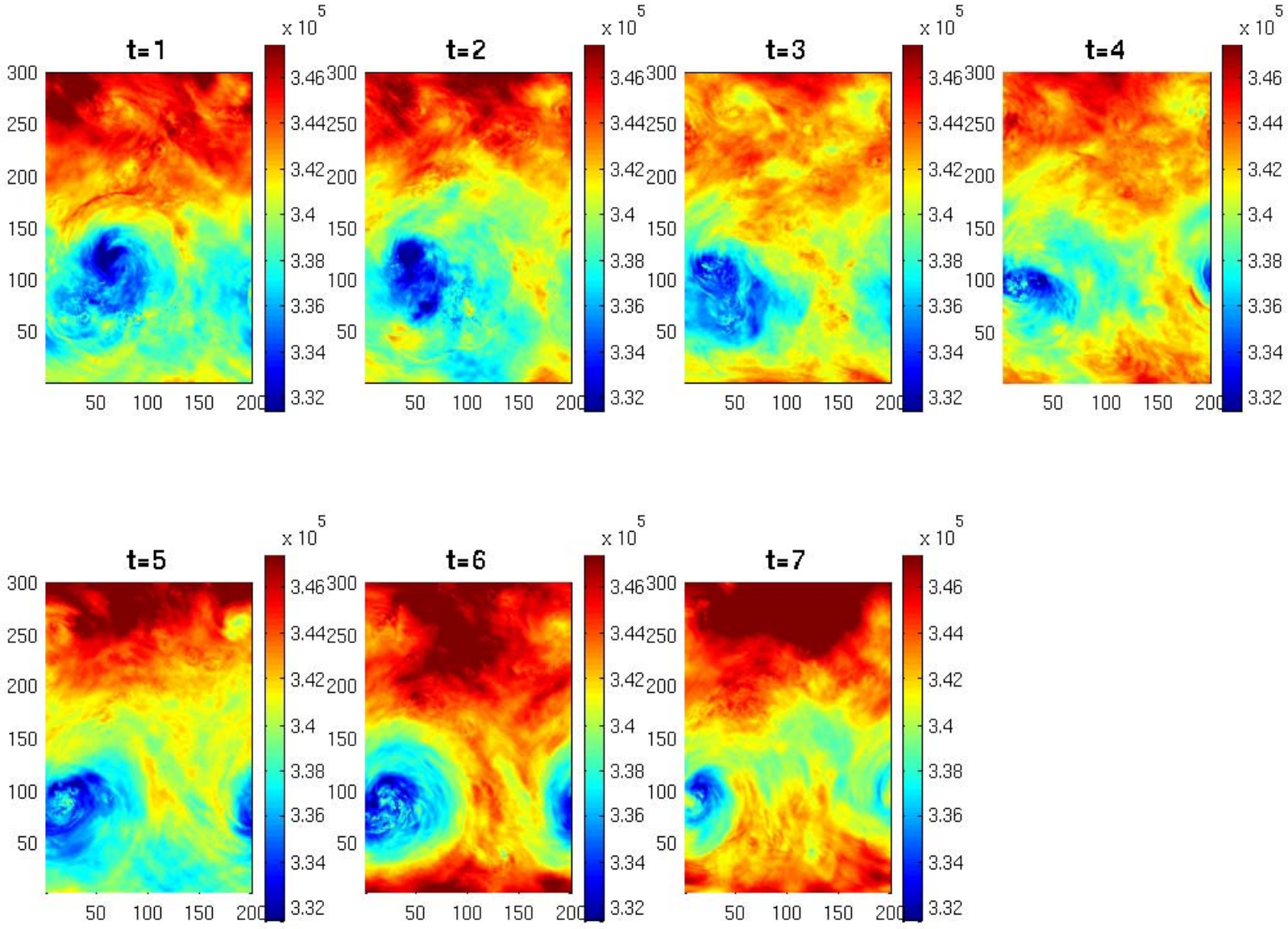

T(K) at z=9675
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
300
250
200
150
100
50
50 100 150 200
237.5
237
236.5
236
235.5
235
234.5

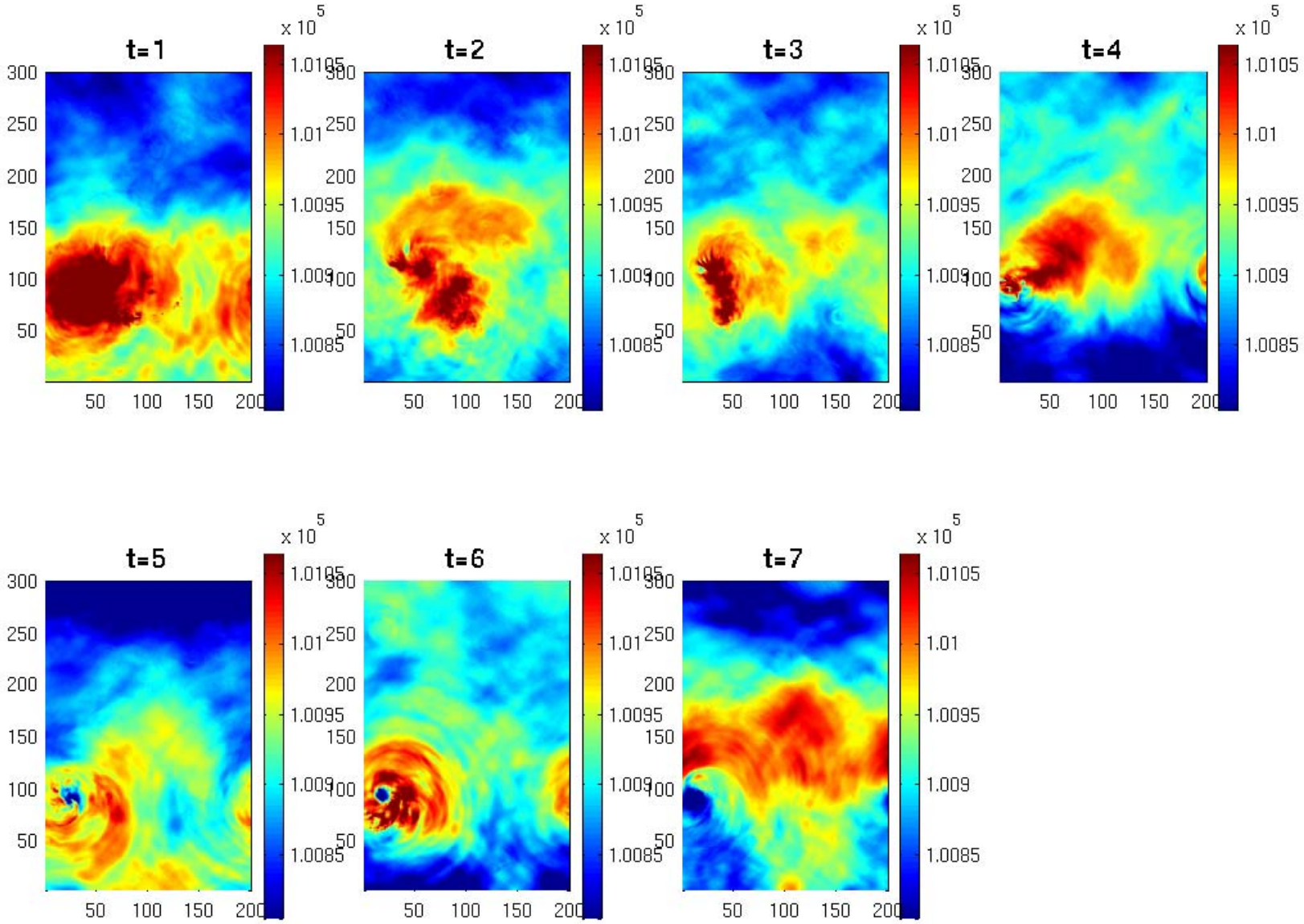

P(Pa) at z=24.6
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
x 10^5
1.01
1.0098
1.0096
1.0094
1.0092
1.009
1.0088
300
250
200
150
100
50
50 100 150 200

Intermediate times

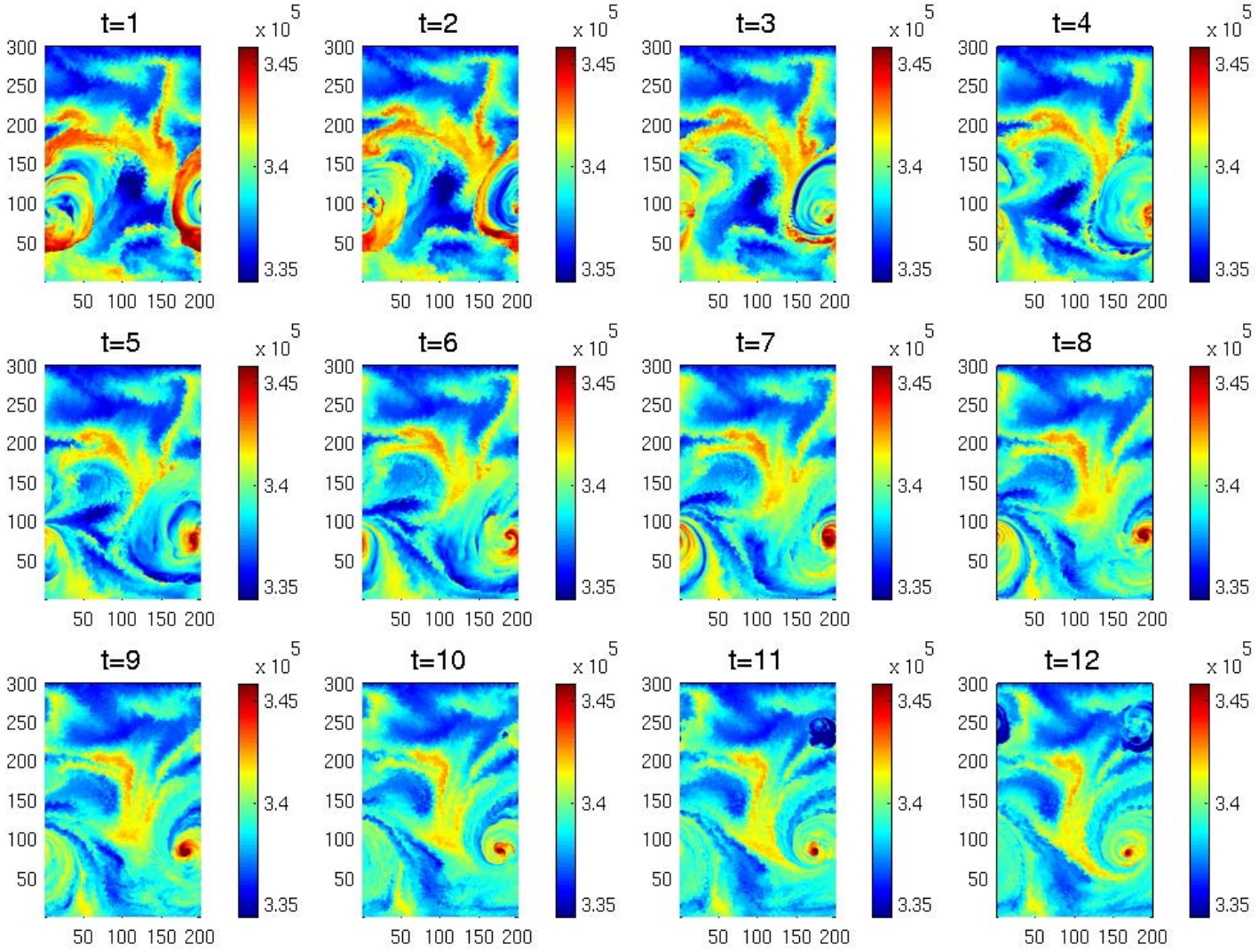


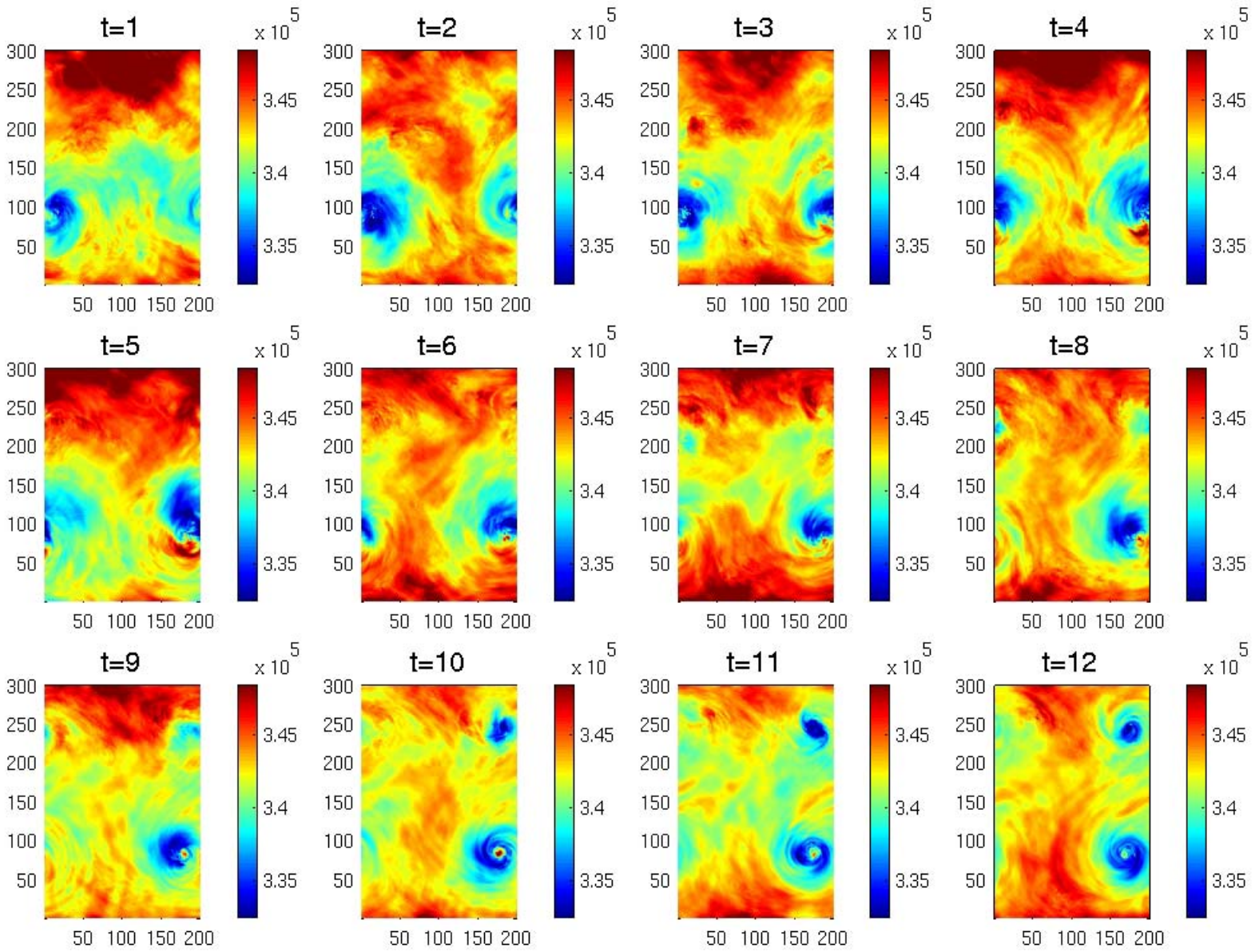
h*(J/kg) at z=3810m



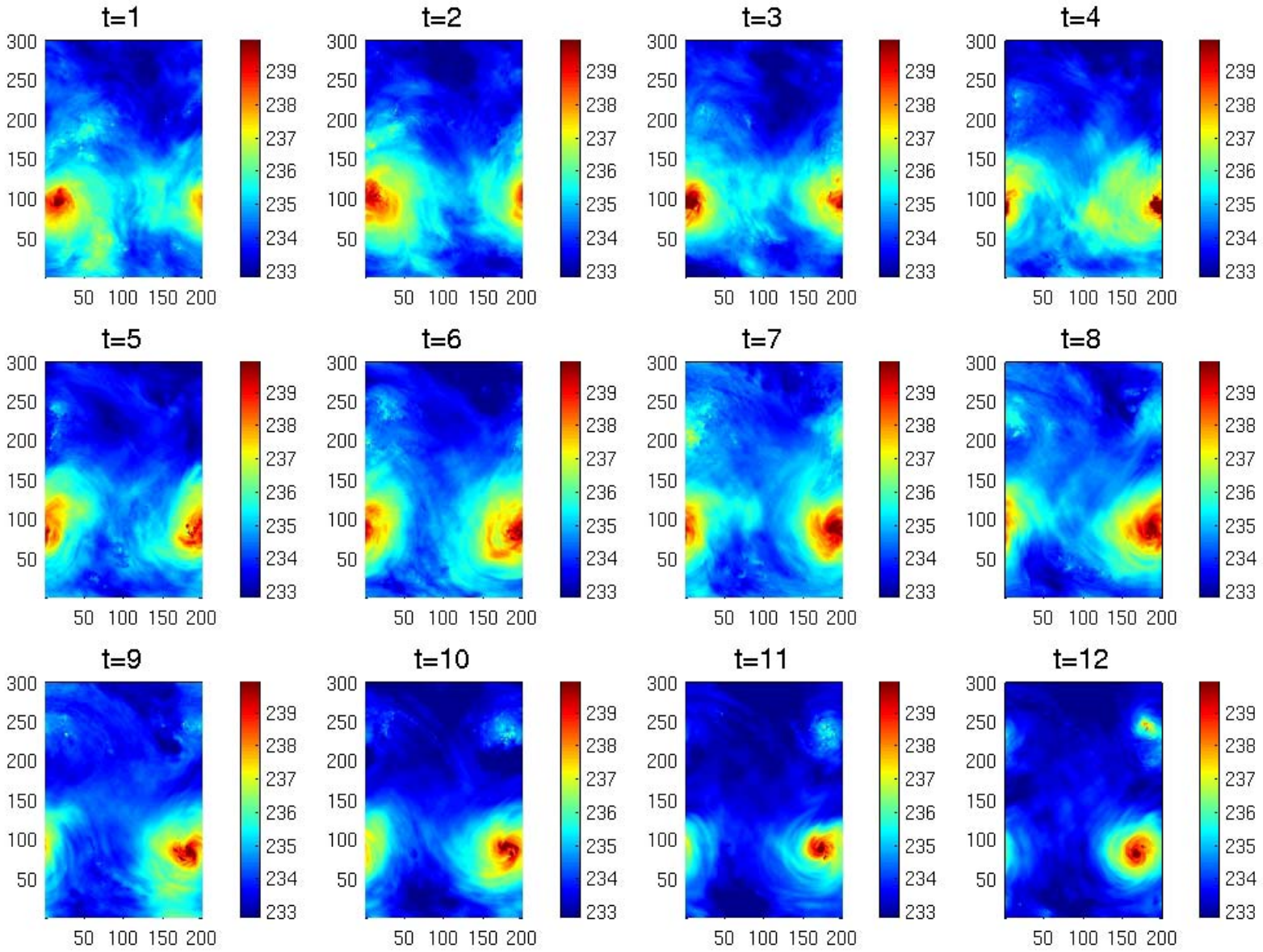

P(Pa) at z=24.6m
t=1
t=2
t=3
t=4
t=5
t=6
t=7
x 10^5
1.0105
1.01
1.0095
1.009
1.0085
50
100
150
200
250
300

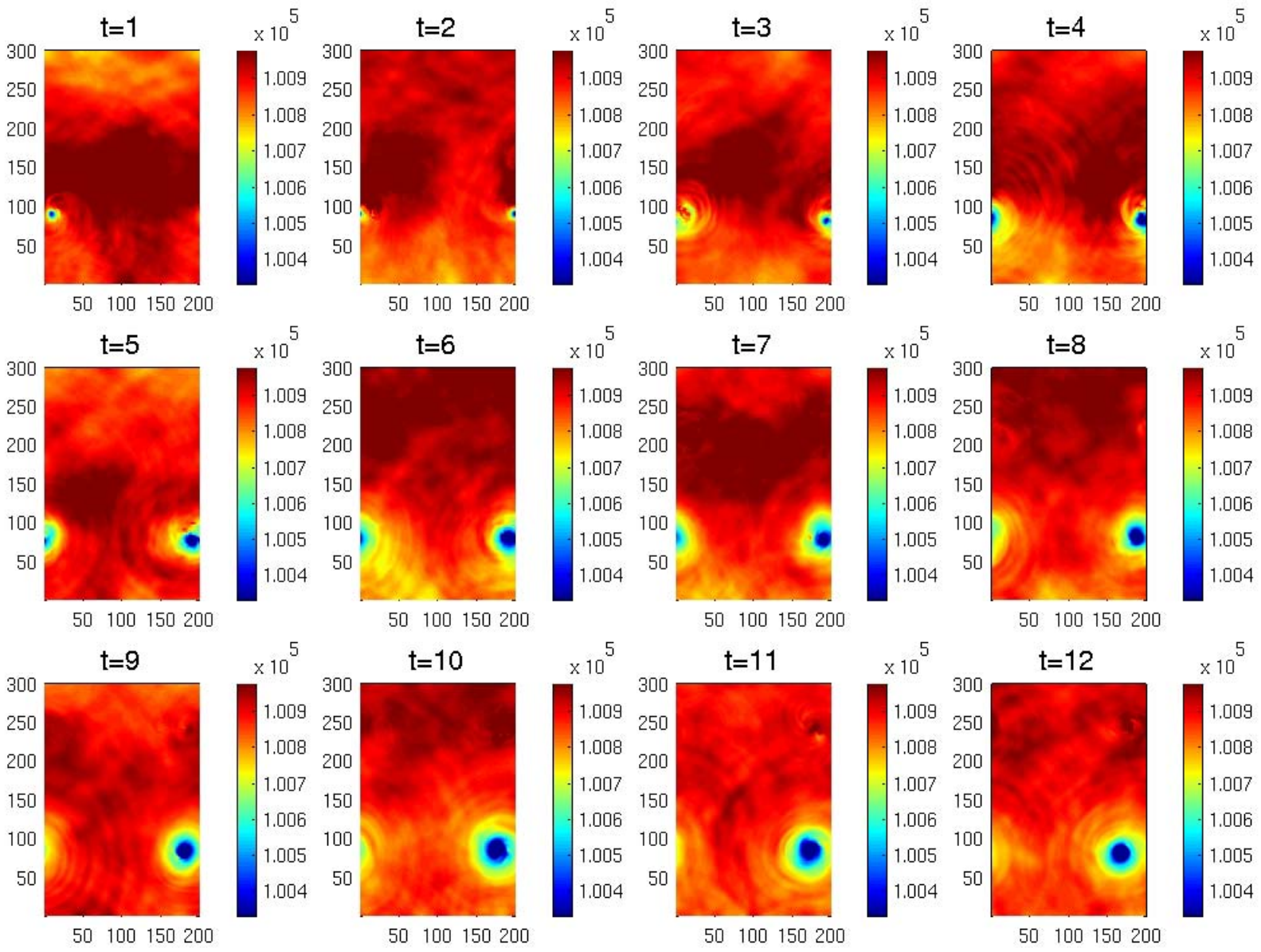
Later times:


h(J/kg) at z=24.6m
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
x 10^5
3.45
3.4
3.35
300
250
200
150
100
50
50 100 150 200

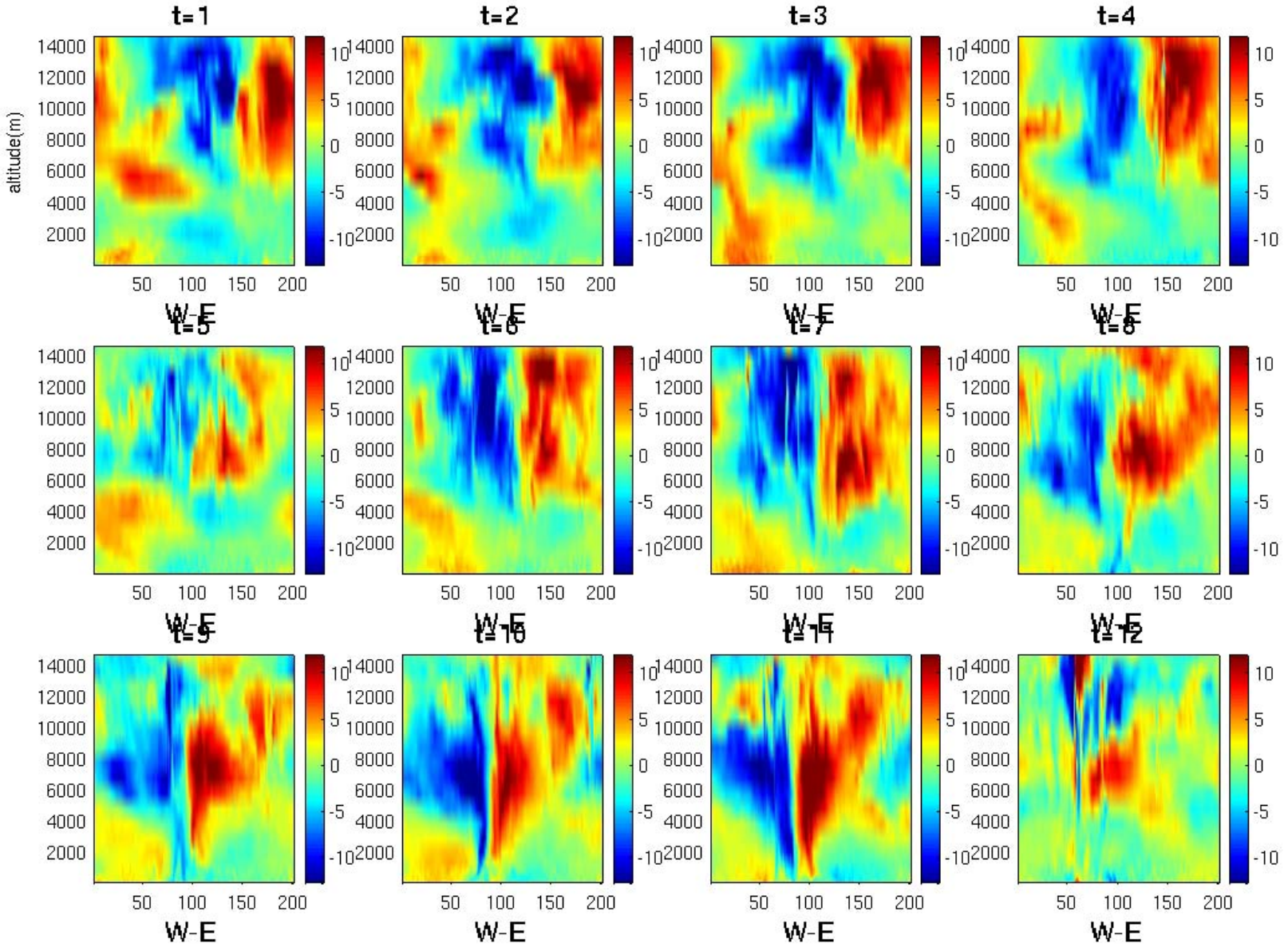

h*(J/kg) at z=3810m
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
x 10^5
3.45
3.4
3.35
300
250
200
150
100
50
50 100 150 200

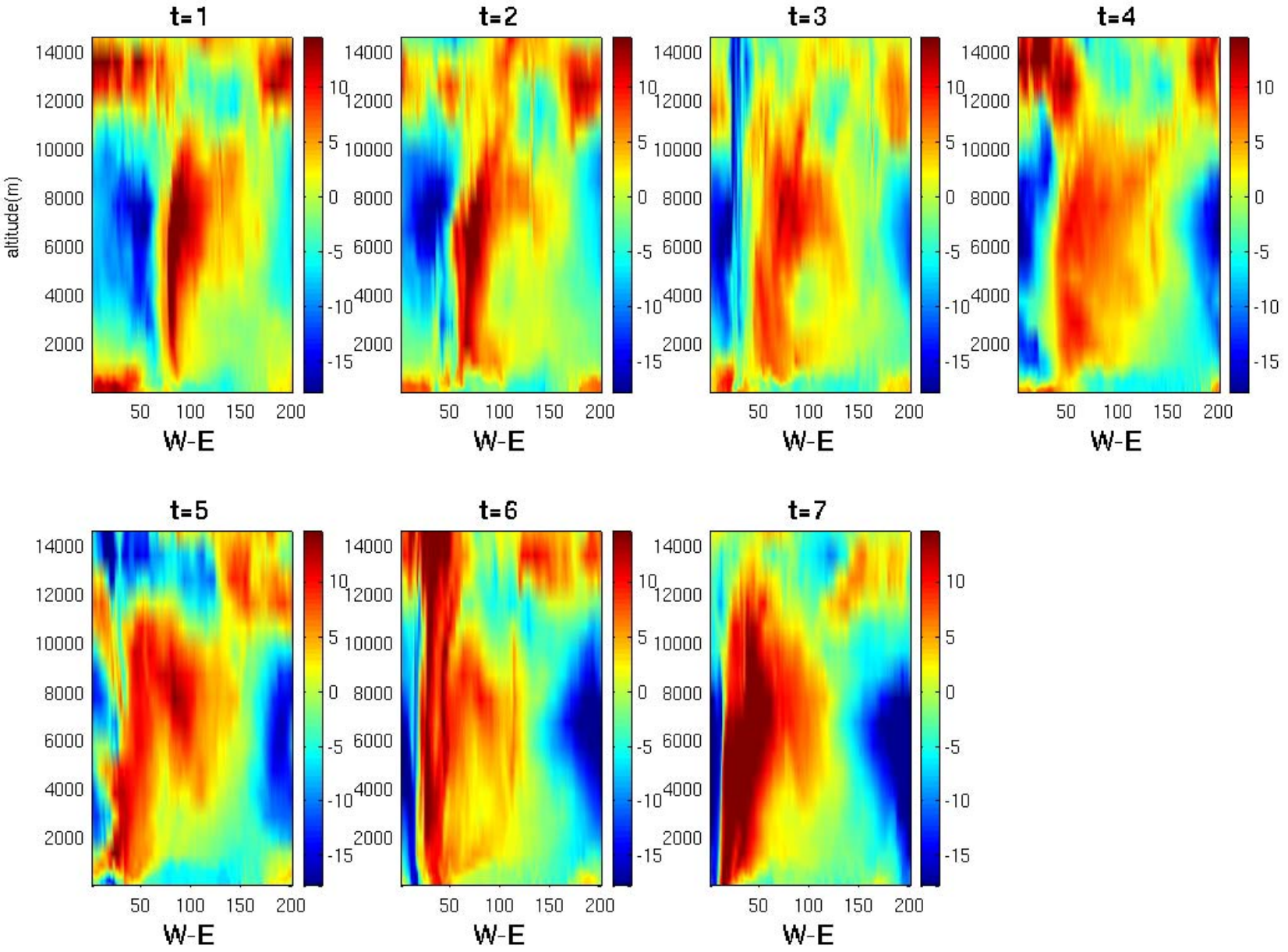
T(K) at z=9675m

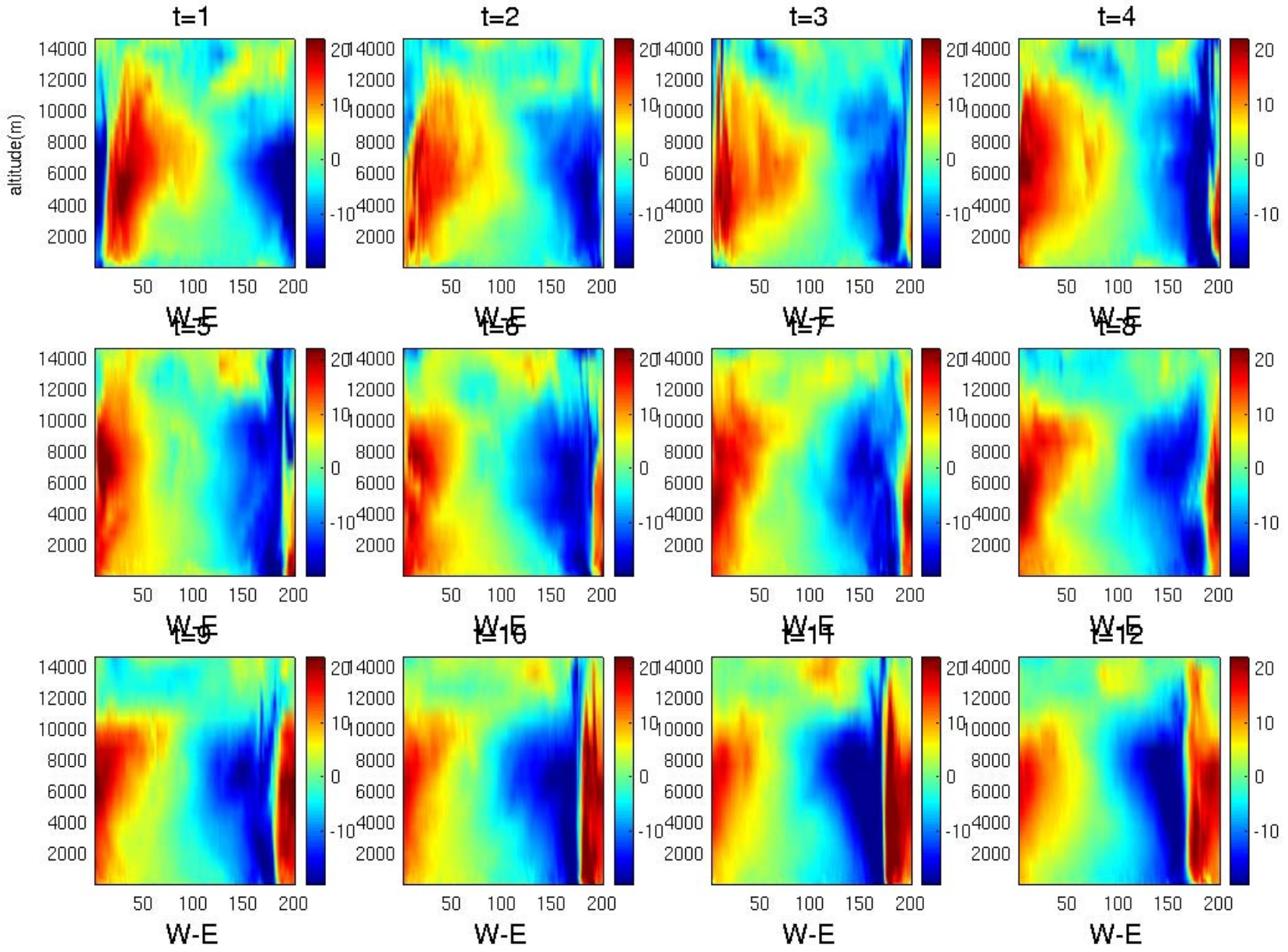

t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
300
250
200
150
100
50
50 100 150 200
239
238
237
236
235
234
233


P(Pa) at z=24.6m
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
x 10^5
1.009
1.008
1.007
1.006
1.005
1.004
300
250
200
150
100
50
50 100 150 200

Evolution of v in E-W cross-sections

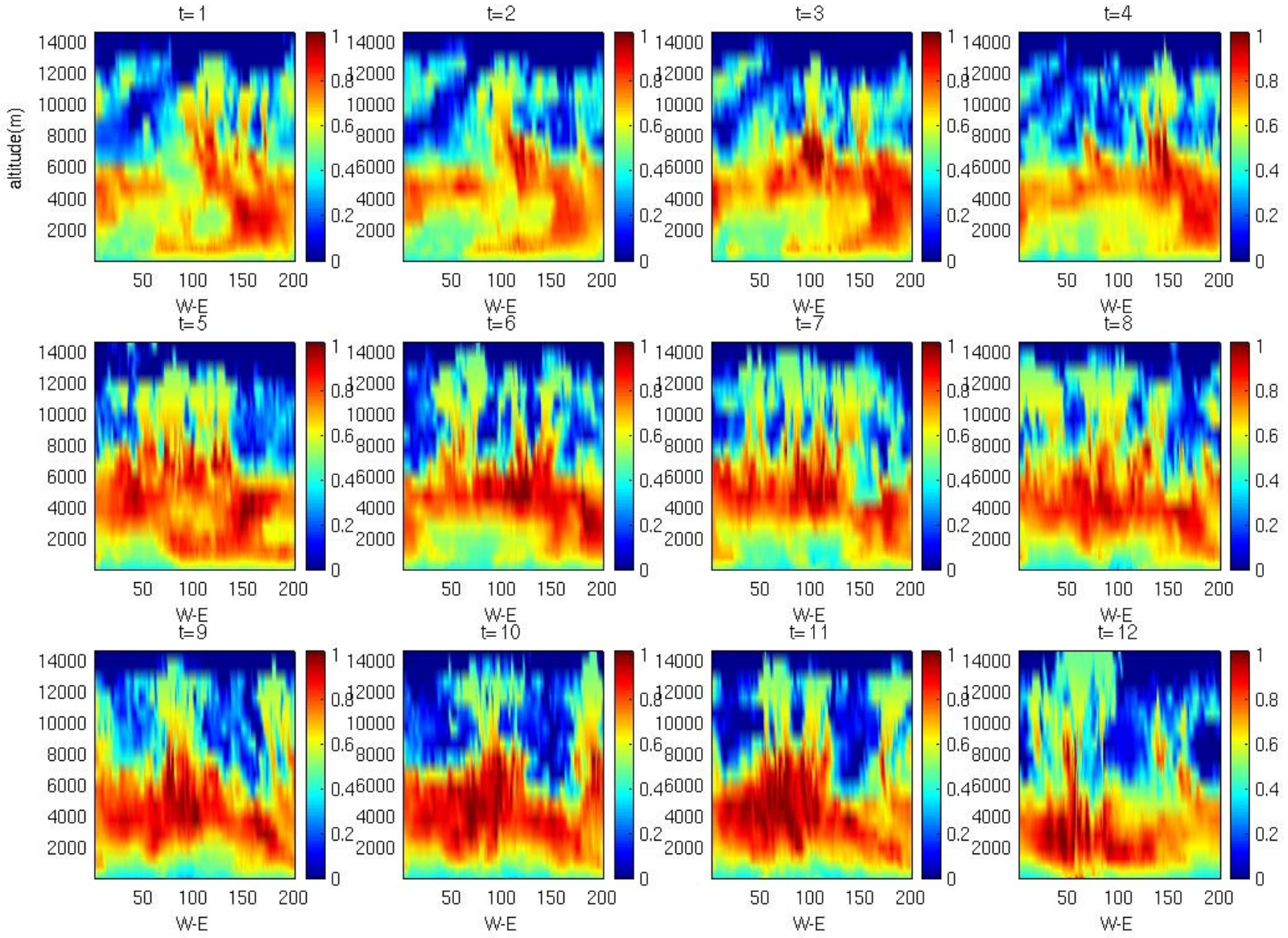


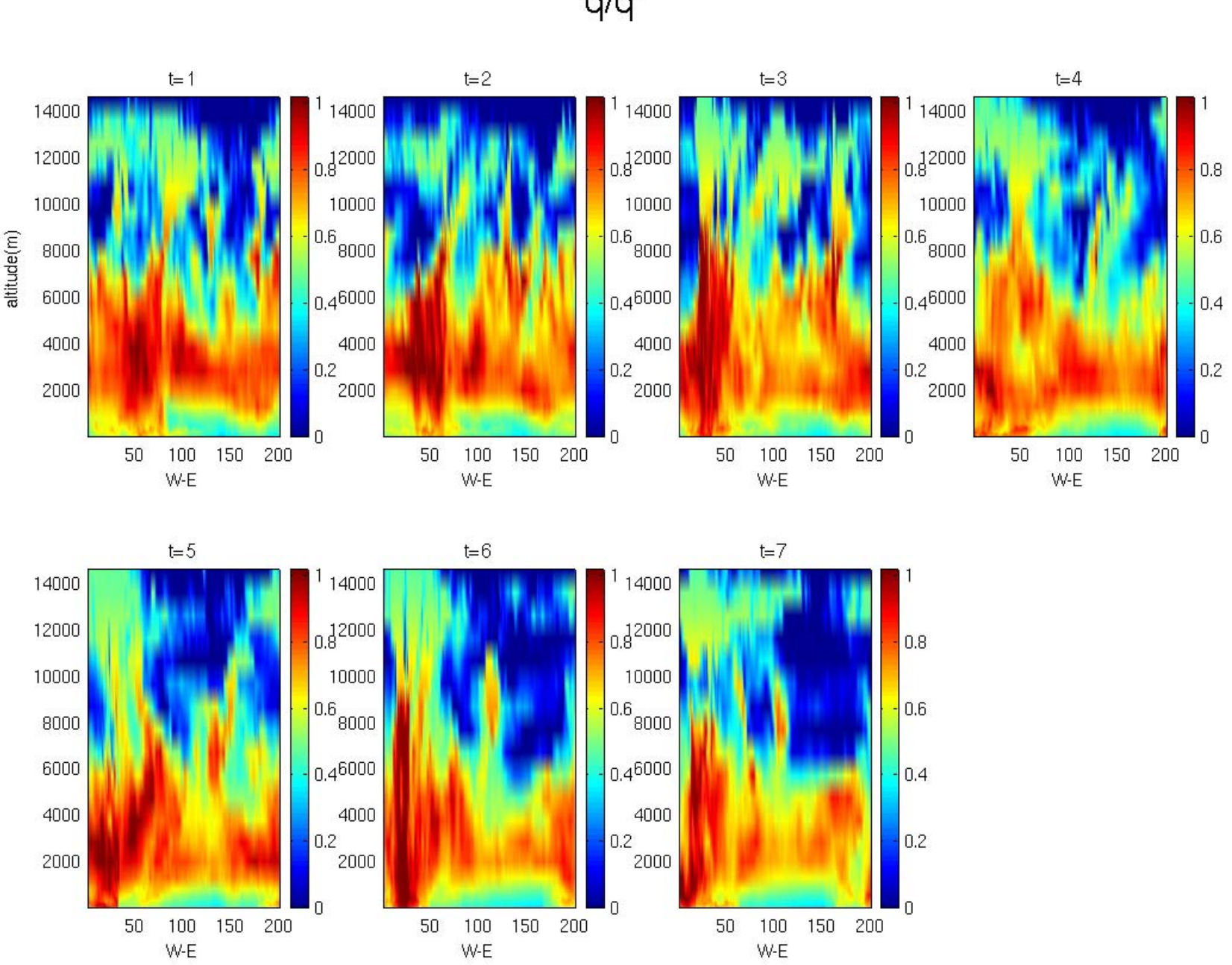

v-wind(m/s)
t=1
t=2
t=3
t=4
t=5
t=6
t=7
altitude(m)
14000
12000
10000
8000
6000
4000
2000
50
100
150
200
W-E
10
5
0
-5
-10
-15

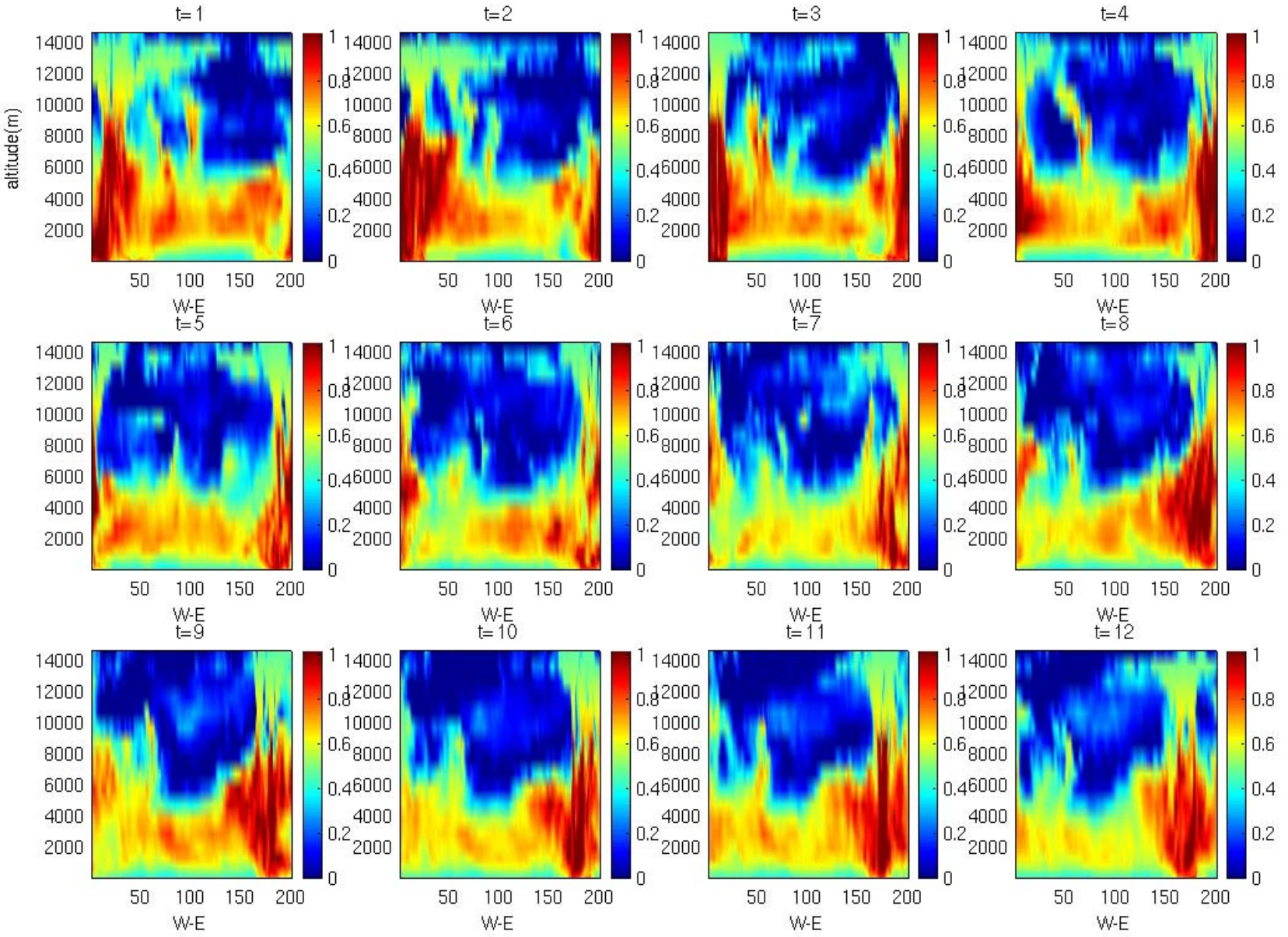

v-wind(m/s)
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
altitude(m)
14000
12000
10000
8000
6000
4000
2000
50
100
150
200
20
10
0
-10
W-E

Evolution of RH in E-W cross-sections

q/q*




q/q*
t=1
t=2
t=3
t=4
t=5
t=6
t=7
altitude(m)
14000
12000
10000
8000
6000
4000
2000
50
100
150
200
W-E
1
0.8
0.6
0.4
0.2
0


q/q*
t=1
t=2
t=3
t=4
t=5
t=6
t=7
t=8
t=9
t=10
t=11
t=12
altitude(m)
W-E
14000
12000
10000
8000
6000
4000
2000
50
100
150
200
1
0.8
0.6
0.4
0.2
0