

# Convección y Microfísica de Nubes

Tema: Celdas Ordinarias

1º Cuatrimestre 2010

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# Organización de los temas a dar en esta parte de la materia

- ❖ Características observadas de las tormentas y posible clasificación de las mismas
- ❖ Mecanismos físicos que controlan el crecimiento y evolución de distintas estructuras celulares dependiendo de la cortante vertical del viento y del grado de inestabilidad térmica presentes en el entorno
- ❖ Resultados útiles, guías y avances en el pronóstico del tipo y severidad de la tormenta
- ❖ Unicelular, ordinaria o tormenta de masa de aire. Dura típicamente 20-30 minutos. Tormentas pulsantes pueden producir fenómenos de tiempo severo tales como downbursts, granizo, precipitación intensa y ocasionalmente tornados débiles.

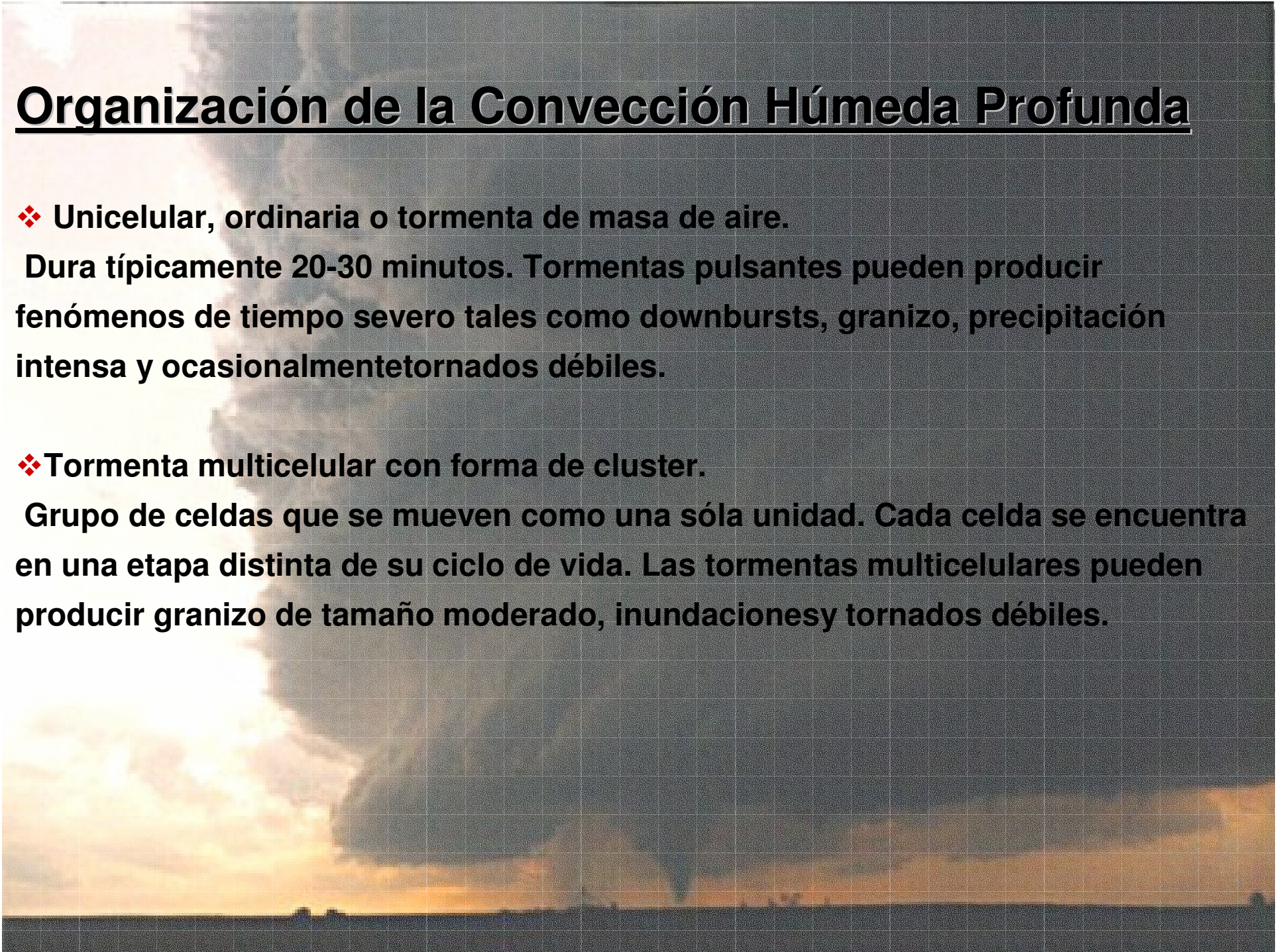
# Organización de la Convección Húmeda Profunda

❖ **Unicelular, ordinaria o tormenta de masa de aire.**

Dura típicamente 20-30 minutos. Tormentas pulsantes pueden producir fenómenos de tiempo severo tales como downbursts, granizo, precipitación intensa y ocasionalmente tornados débiles.

❖ **Tormenta multicelular con forma de cluster.**

Grupo de celdas que se mueven como una sola unidad. Cada celda se encuentra en una etapa distinta de su ciclo de vida. Las tormentas multicelulares pueden producir granizo de tamaño moderado, inundaciones y tornados débiles.



# Organización de la Convección Húmeda Profunda

## ❖ Tormentas multicelulares con forma de líneas

Consiste en una línea de tormentas con un frente de ráfaga continuo y bien desarrollado en la parte delantera de la línea. Pueden producir granizo de tamaño pequeño a moderado, inundaciones ocasionales y tornados débiles.

❖ Superceldas Se define como una tormenta convectiva con una ascendente rotante. En más del 90% pueden ser severas. Pueden producir fuertes downbursts, granizo grande, inundaciones ocasionales y tornados débiles a violentos.

## ❖ Sistemas convectivos de Mesoescala (MCS)

MCS Organizados en Líneas

MCS Organizados en Cluster (conglomerados)

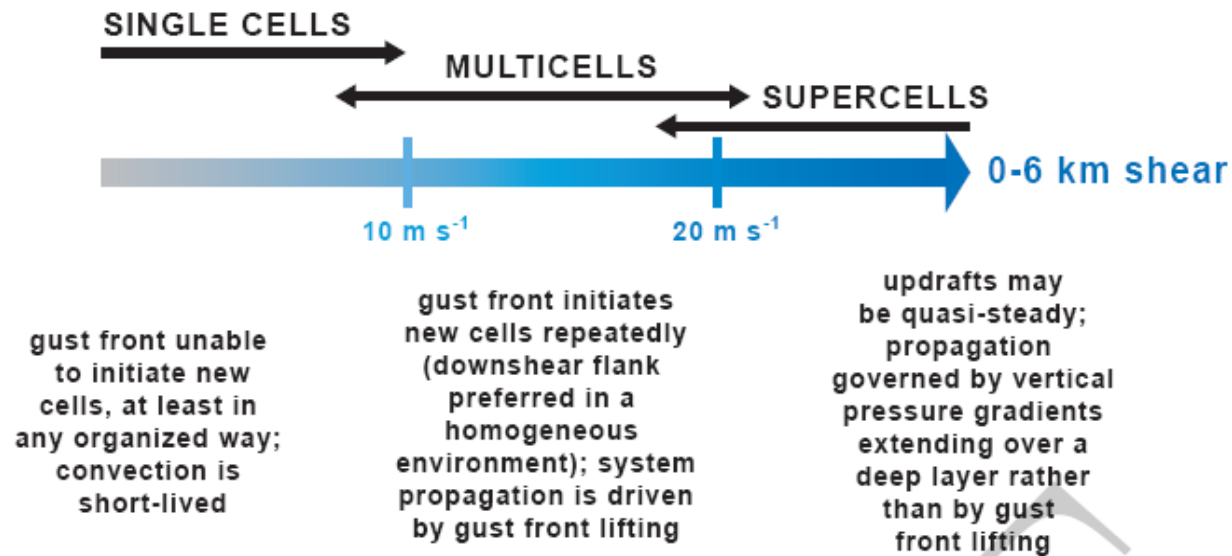


**Si bien existe todo un espectro de tormentas aisladas los procesos físicos que controlan los distintos tipos de celdas convectivas son básicamente:**

❖ **CELDAS ORDINARIAS:** Procesos térmicos (empuje):  
ascendente/descendente,

❖ **MULTICELULARES:** Procesos asociados al frentede ráfagas:  
Disparo de nuevas celdas que coexisten en distintas etapas de su ciclo de vida

❖ **SUPERCELDAS:** Procesos dinámicos: ascendente rotante, forzante dinámico asociado al gradiente vertical de presión



**Figure 8.5.** Spectrum of storm types as a function of vertical wind shear. Although the vertical shear exerts the greatest influence on storm type, other secondary factors also can affect the mode of convection (e.g., vertical distribution of buoyancy, moisture, and shear, as well as the means by which storms are initiated); thus, some overlap among storm types exists in this simple single-parameter depiction. The relationship between vertical wind shear magnitudes and the nature of cell regeneration/propagation also is shown.

## **Fenómenos en superficie asociados a convección profunda (umbrales para fenómenos severos)**

- ❖ Ráfagas de viento convectivas ( $\geq 50$  nudos  $\sim 25$  m/s)
- ❖ Diámetros de granizo ( $\geq 2$  cm) o acumulación de granizos pequeños
- ❖ Cualquier tipo o intensidad de tornado
- ❖ Actividad eléctrica
- ❖ Inundación asociada a precipitación, precipitación superior a 20 mm/hora leve

## Tormenta ordinaria o de “masa de aire”

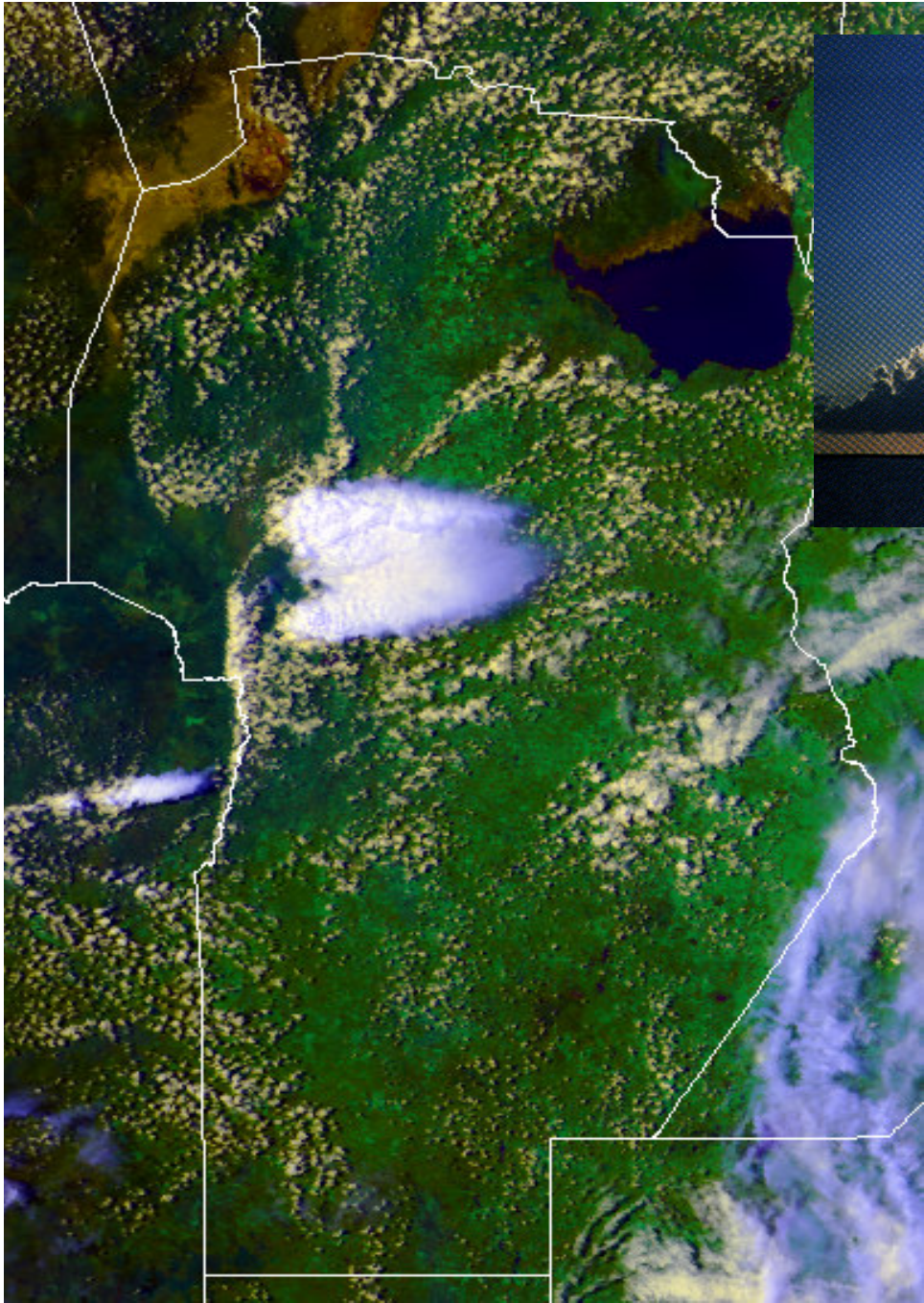
Características principales:

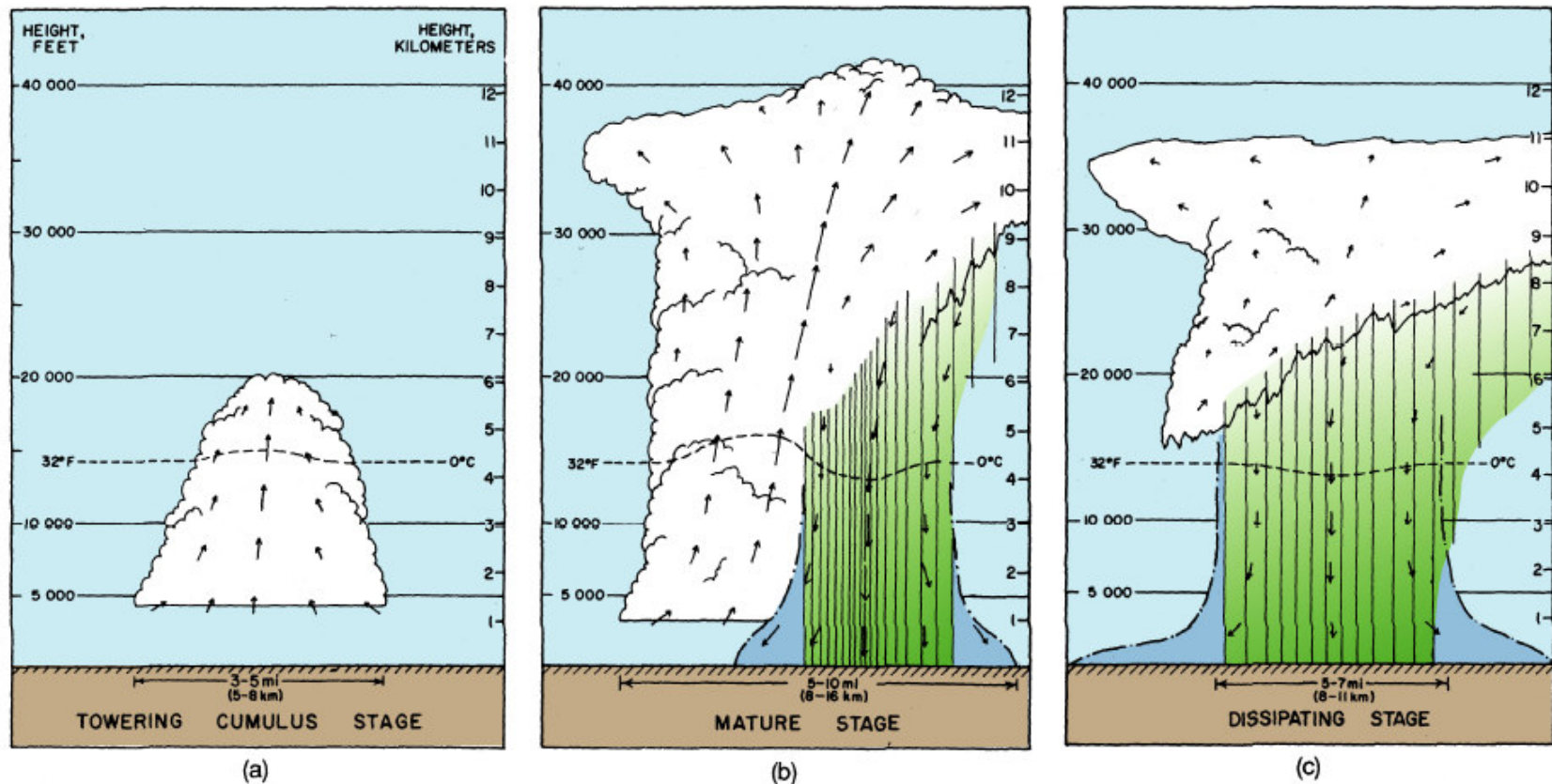
- ❖ Consiste en una sólo celda (un par ascendente/descendente)
- ❖ Se forma en entornos caracterizados por gran inestabilidad condicional y cortante vertical débil
- ❖ Eje vertical genera su propio mecanismo de autodestrucción
- ❖ Puede producir vientos intensos en línea o microbursts
- ❖ Ciclo de vida es generalmente  $< 1$  hora, usualmente 30-45 min
- ❖ Estas tormentas se forman en entornos con forzantes sinópticos débiles y están gobernadas principalmente por la inestabilidad convectiva más que por los vientos del entorno.
- ❖ Se denominan también tormentas de “masade aire” porque se forman en masas de aire caracterizadas por un dominio de homogeneidad en la horizontal.





**Figure 8.6.** Photographs of DMC in environments containing weak vertical wind shear. Note the location of the precipitation shafts relative to the updrafts (upper left, right) and the fairly symmetrical, circular anvils (lower left). Photo credits: Jim LaDue (upper left), Roger Edwards (lower left), Thomas Sävert (right).





**Figure 8.8.** The three stages of an ordinary cell: (a) towering cumulus stage, (b) mature stage, and (c) dissipating stage. [Adapted from Byers and Braham (1949) and Doswell (1985).]

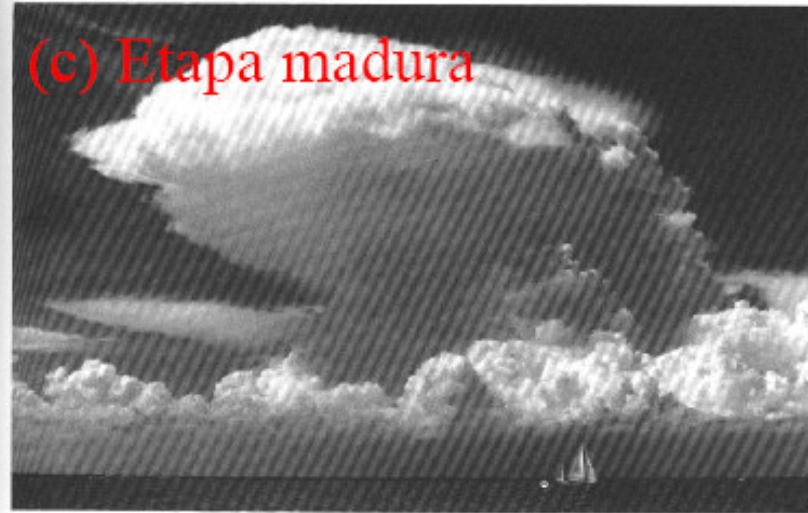
(a) – etapa de desarrollo



(b) – continúa su crecimiento



(c) Etapa madura

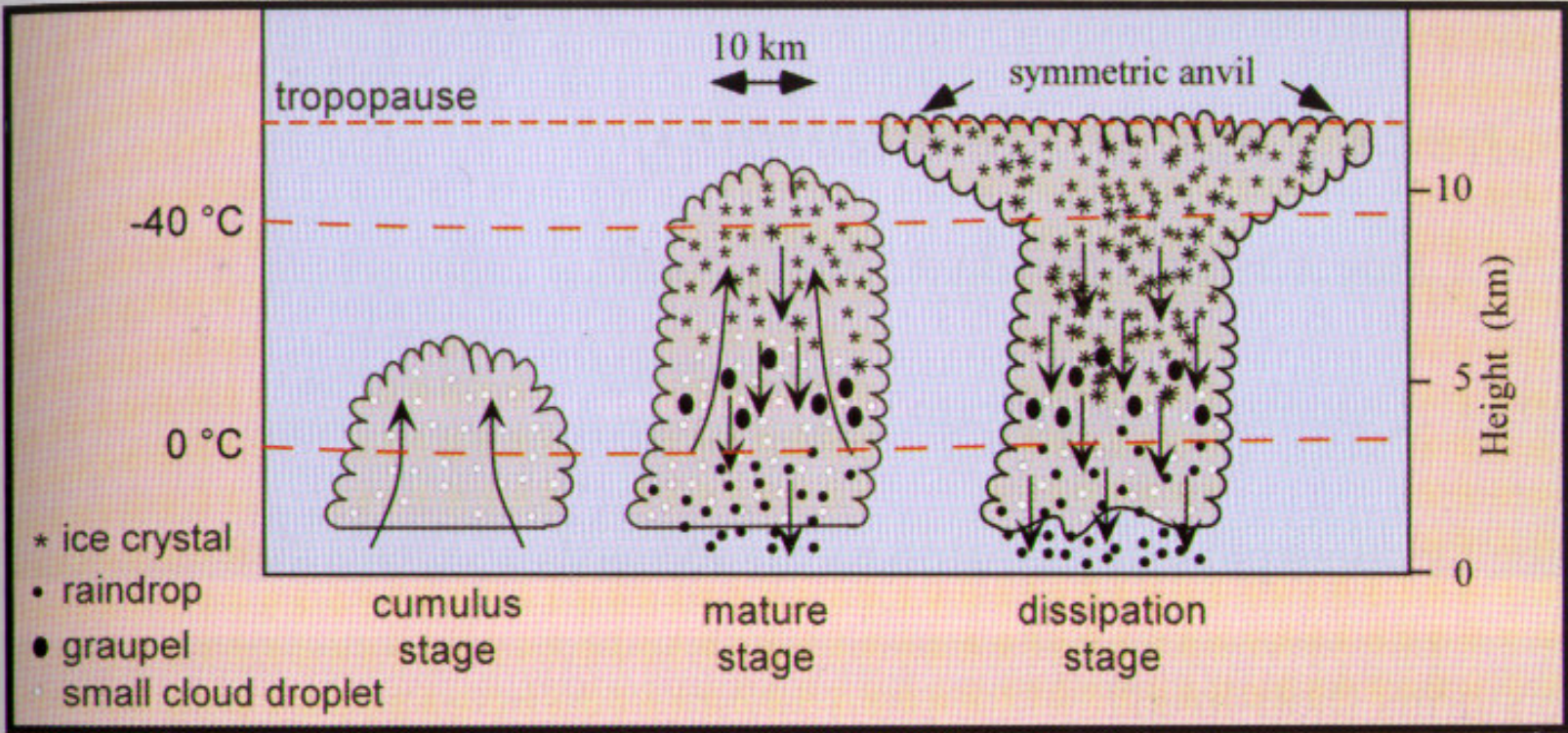


(d) – Etapa de disipación



**Figure 3.16** Photographs of the (a) towering cumulus, (b), (c) mature, and (d) dissipating stages of a thunderstorm. (a)–(c) were taken August 28, 1971, off the southeast coast of Florida, looking westward; (d) was taken August 28, 1973, near Naples, Florida, looking westward over the Gulf of Mexico (photographs copyright Howard B. Bluestein).

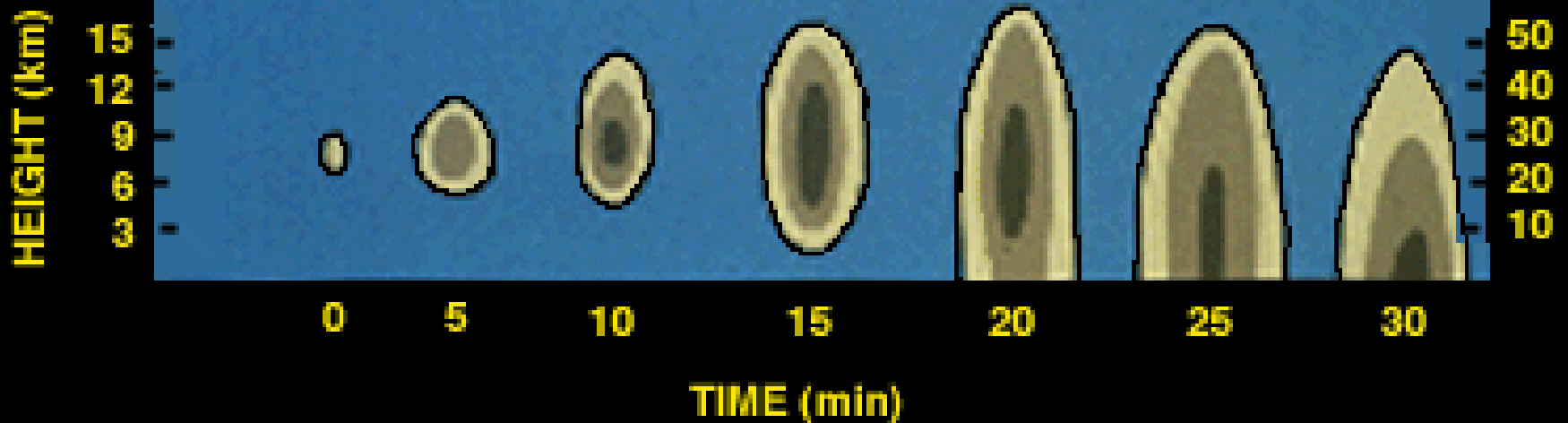
**Figure 3.16** (cont.)



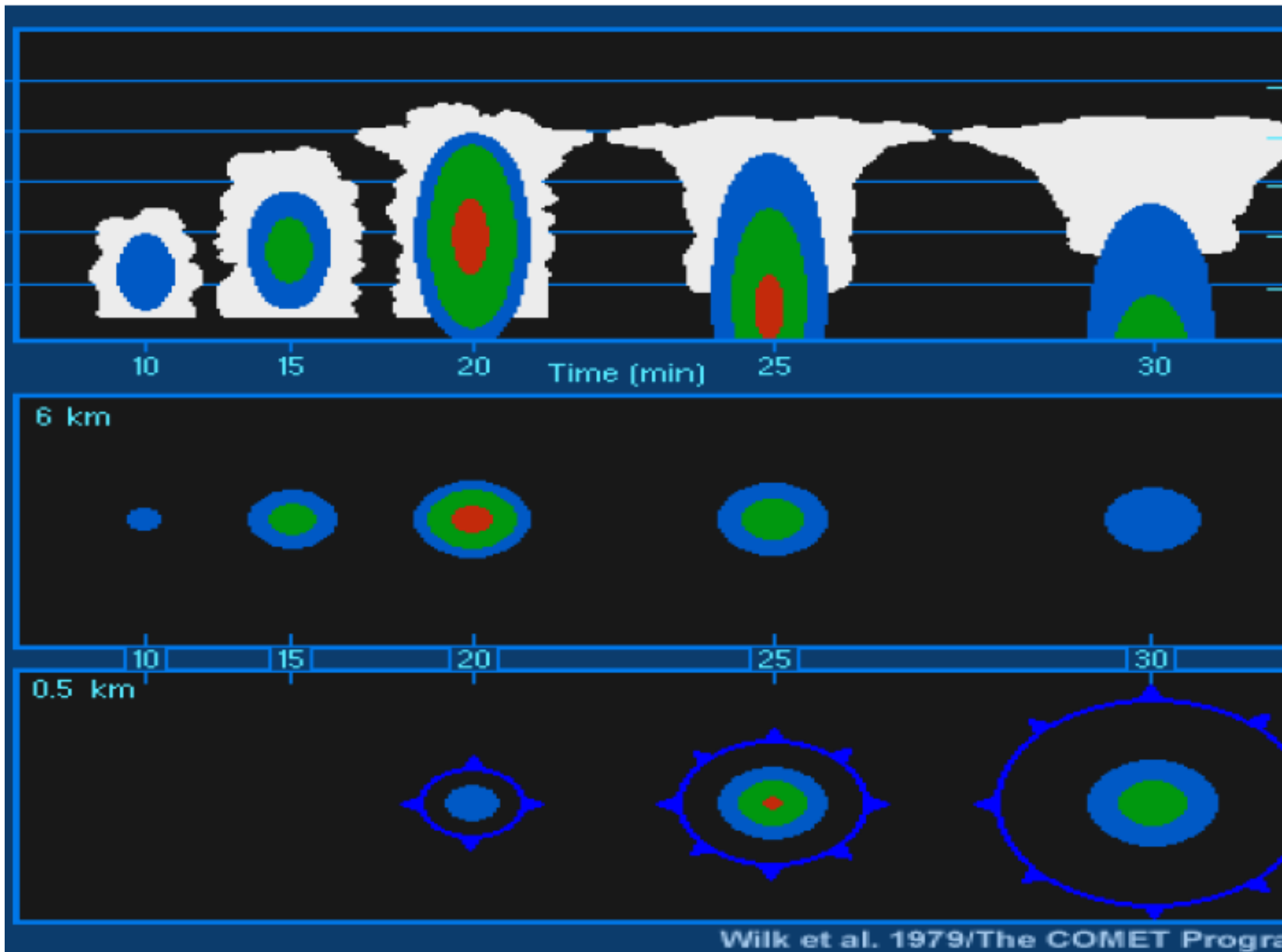
# ORDINARY THUNDERSTORM



# "PULSE" SEVERE THUNDERSTORM



Adapted from Wilk *et al.*, 1977



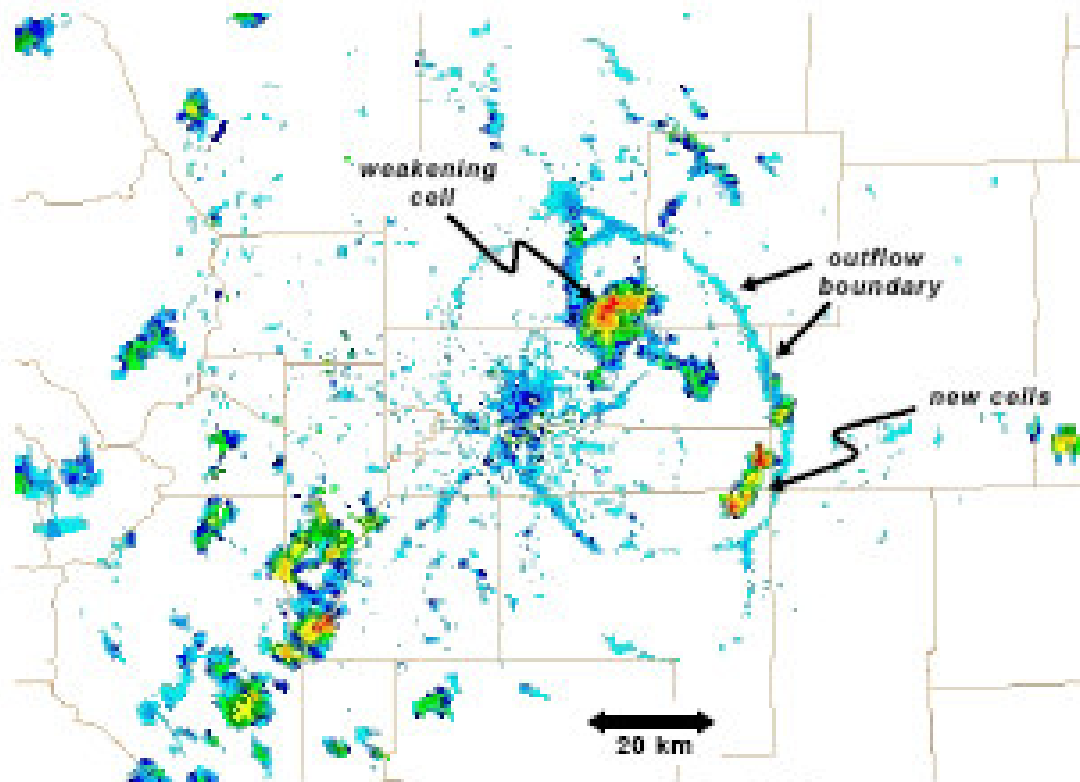
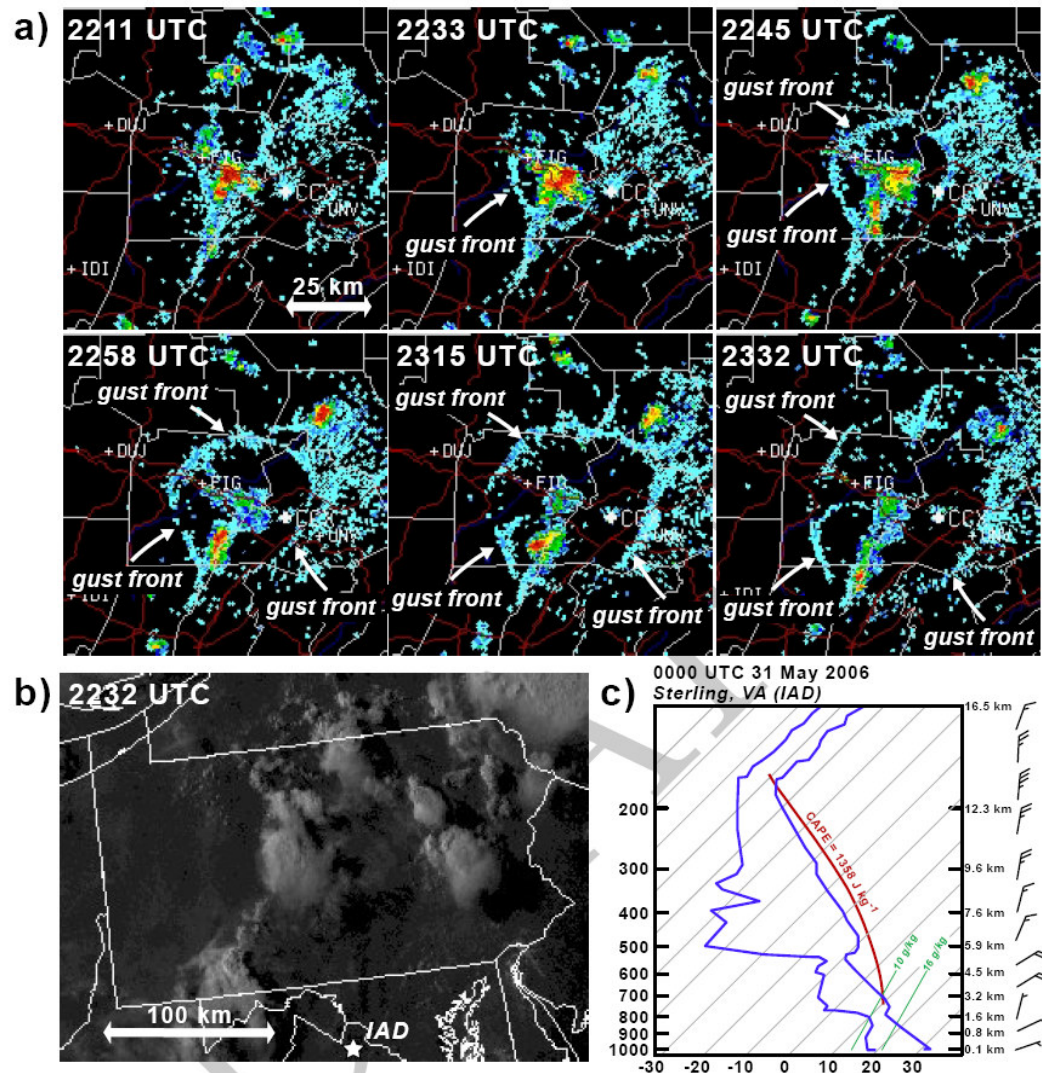


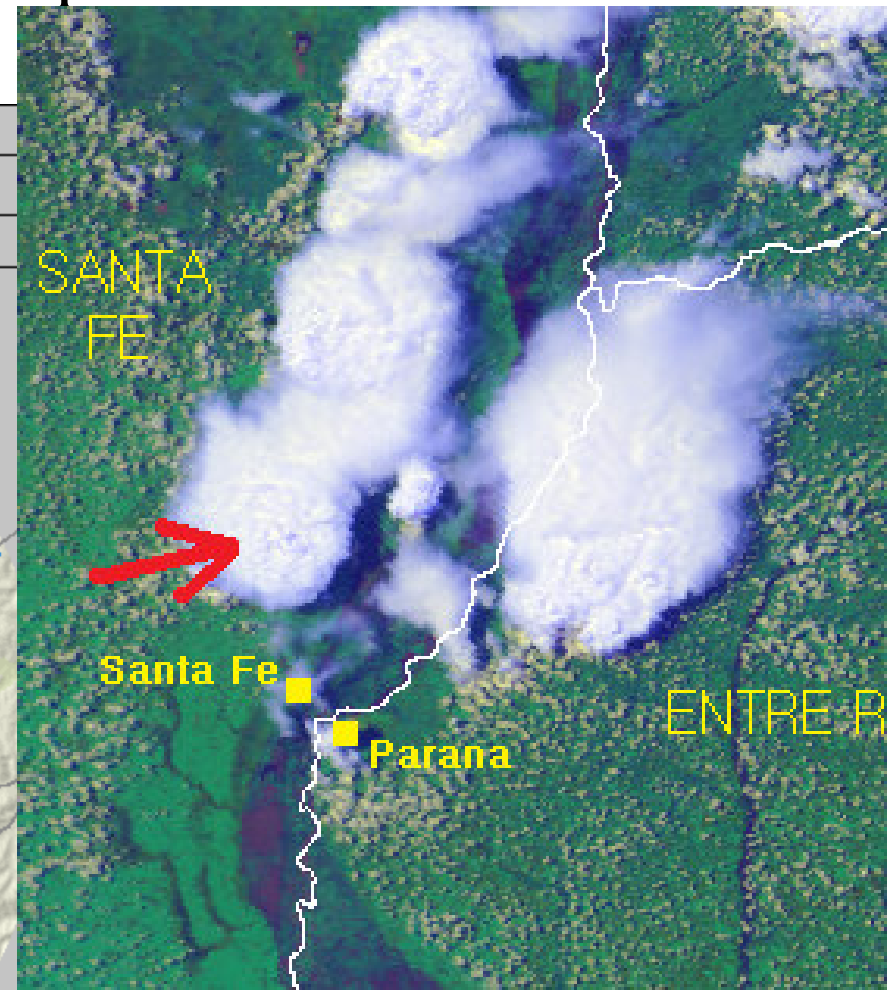
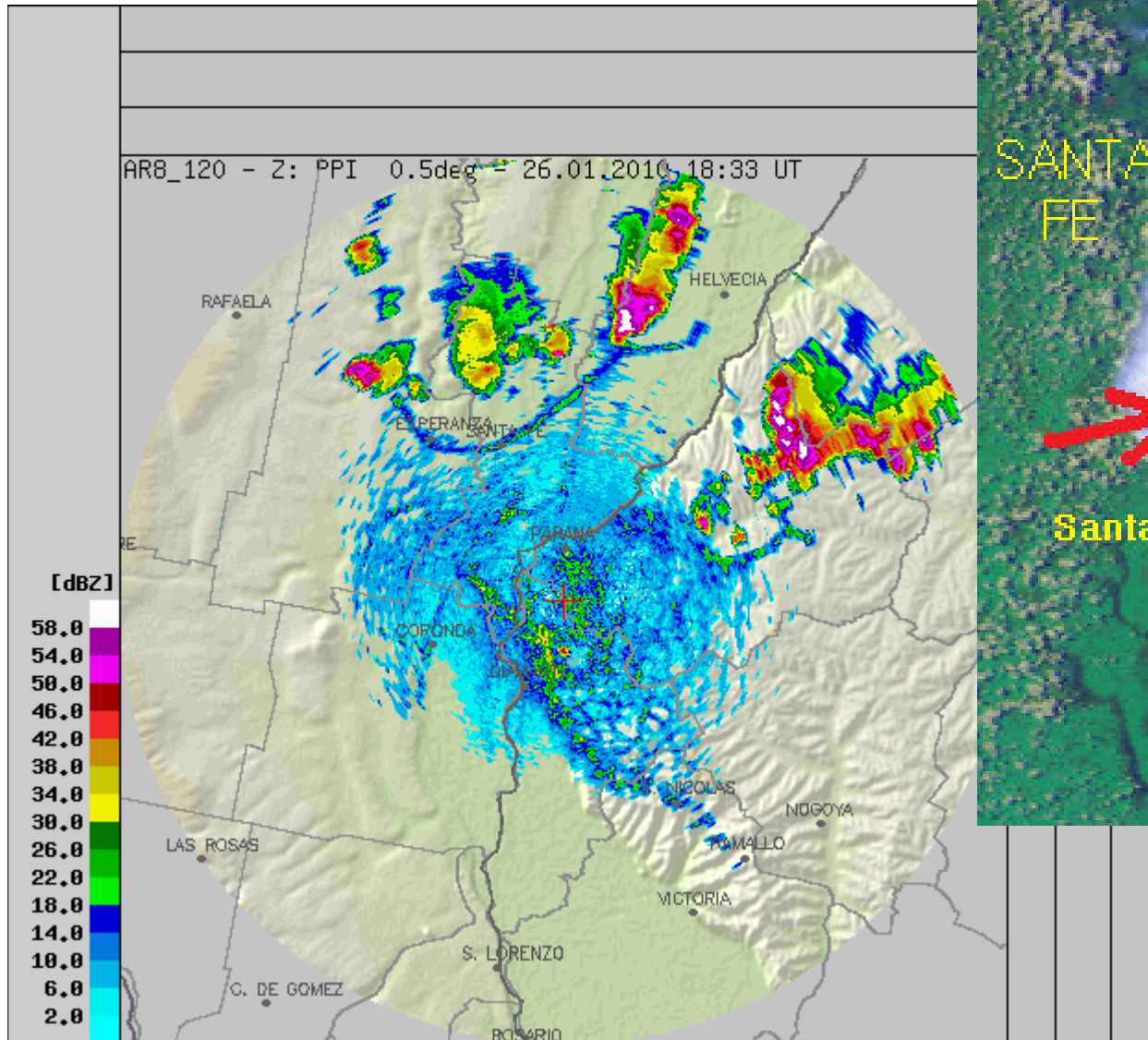
Figure 5.21. Radar reflectivity image showing a nearly circular outflow boundary produced by storms east of Denver, Colorado, manifested as a reflectivity fine-line.





**Figure 8.7.** (a) Sequence of radar reflectivity images ( $0.5^\circ$  elevation angle) from the State College, Pennsylvania, WSR-88D on 30 May 2006 from 2211–2332 UTC showing the evolution of single-celled convection (*disorganized convection* would perhaps be more appropriate terminology in this case). (b) Visible satellite image at 2232 UTC. (c) Sounding from Sterling, Virginia [IAD; the location is indicated with a star in (b)] at 0000 UTC 31 May 2006. Note the weak vertical wind shear (the 0–6 km shear vector magnitude is approximately  $5 \text{ m s}^{-1}$ ).

# ➔ Frentes de ráfaga de otras celdas previas

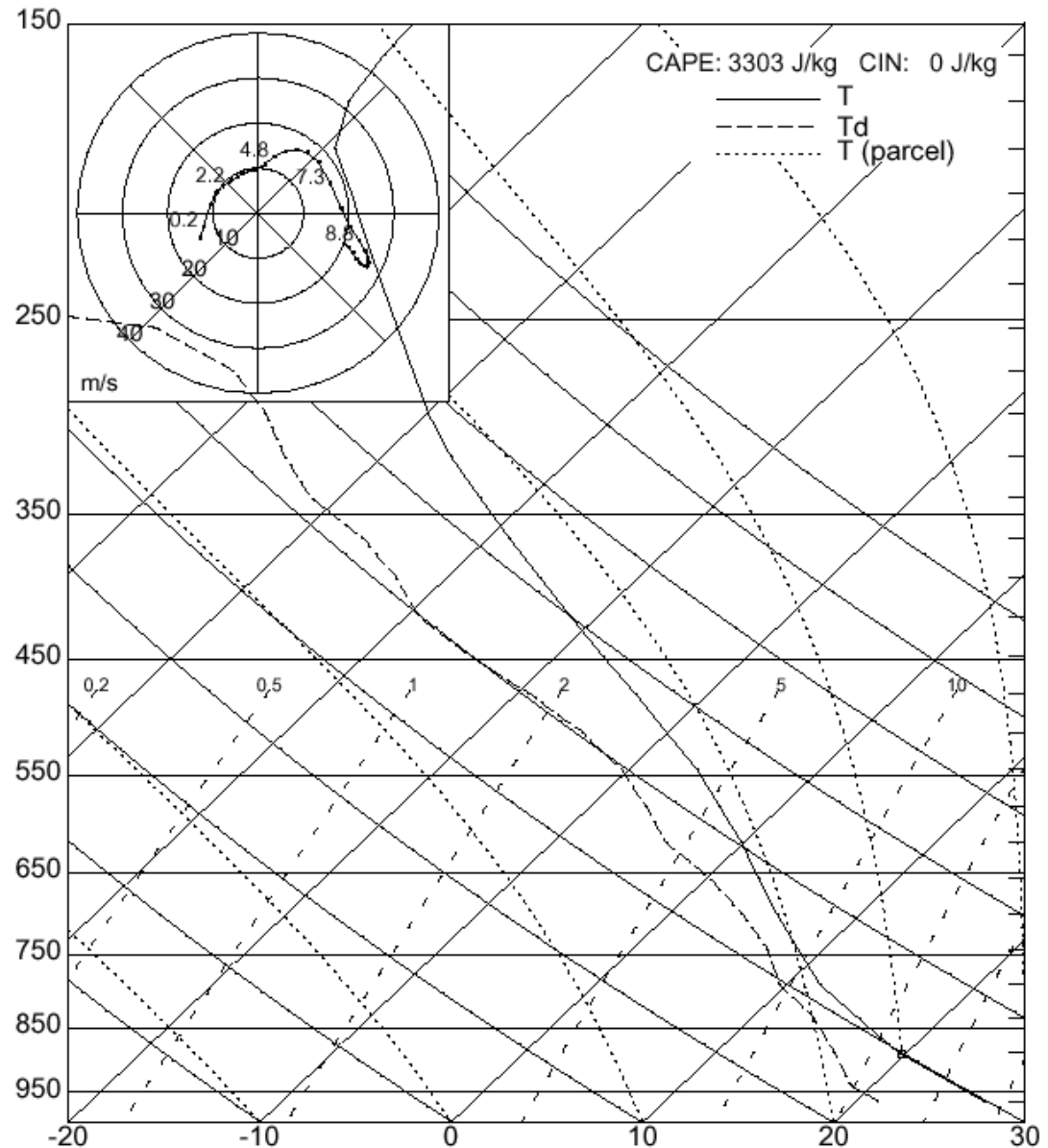


Recordemos la ecuación de movimiento vertical

$$\frac{dw}{dt} = -\frac{1}{\rho} \frac{\partial p'}{\partial z} + g \left( \frac{\theta'}{\theta} + 0.61 q_v' \right) - gL + F_w$$

# ARPS Simulation of a Single Cell Storm

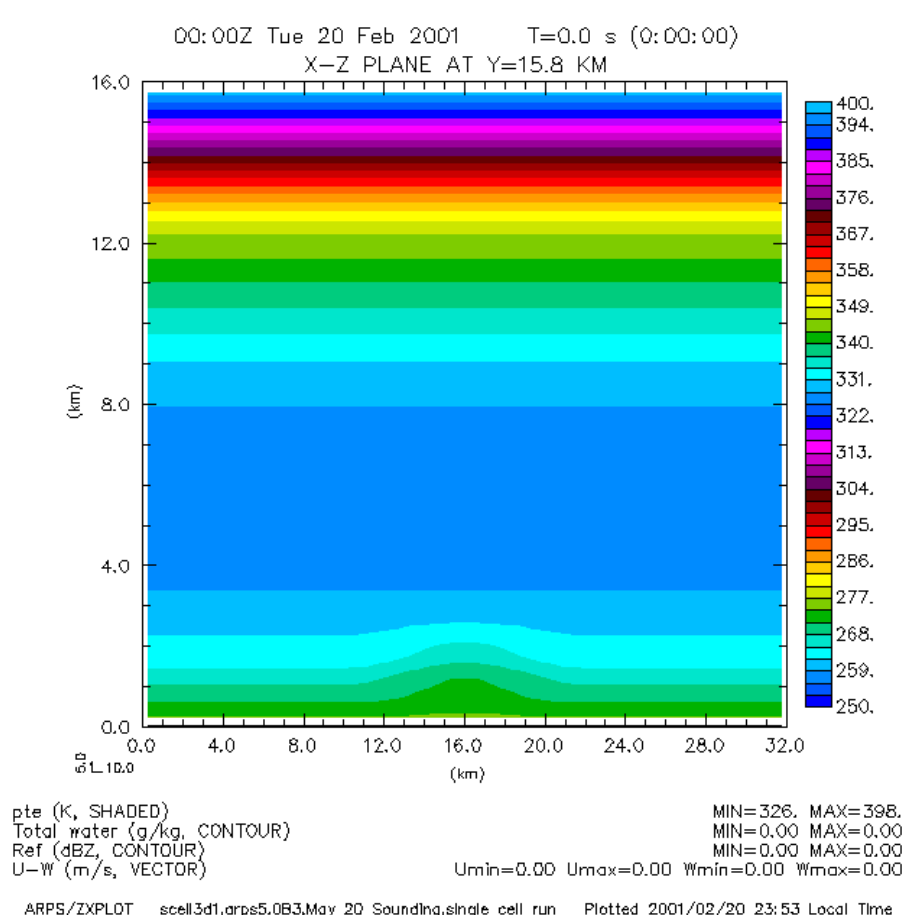
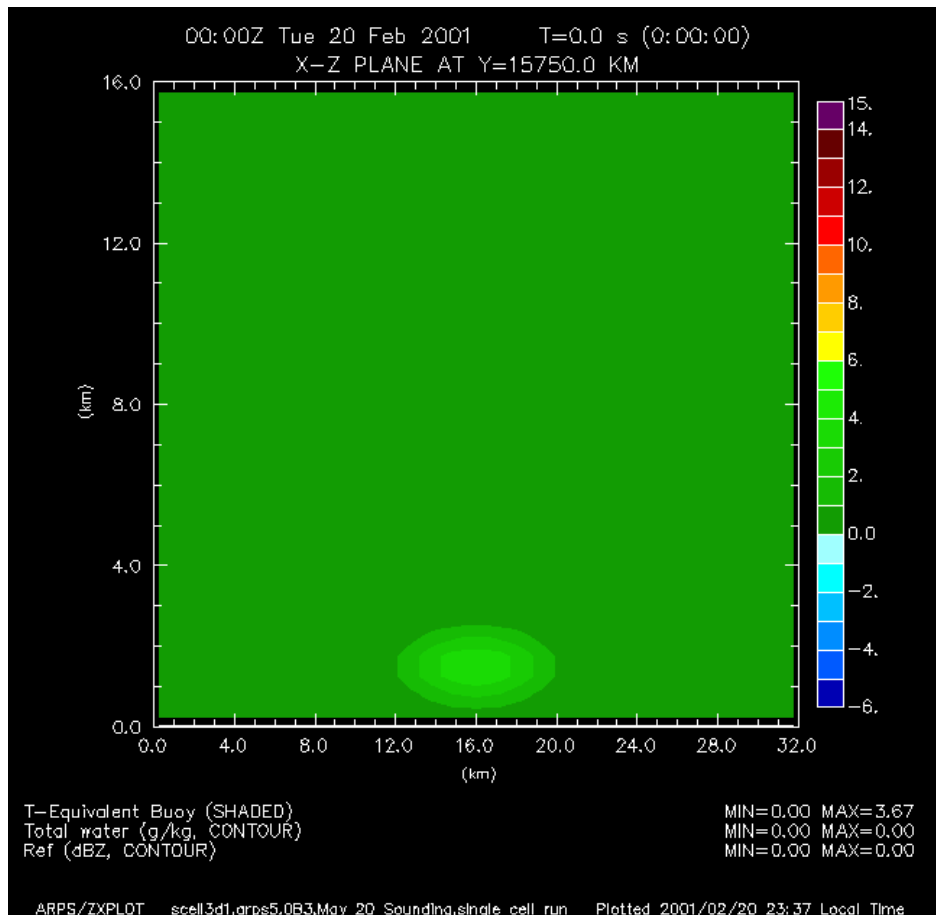
- May 20, 1977 Del City Supercell Storm Sounding – used without environmental winds



# ARPS Simulation of a Single Cell Storm

T-equivalent buoyancy+qw+ref

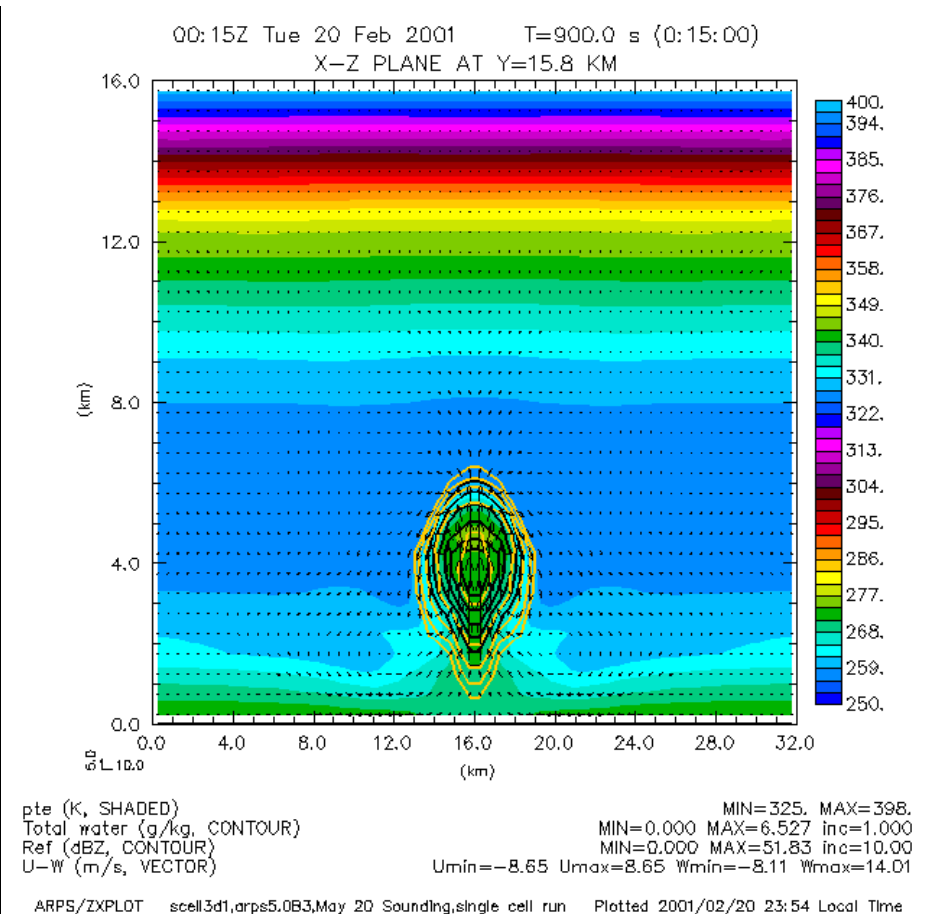
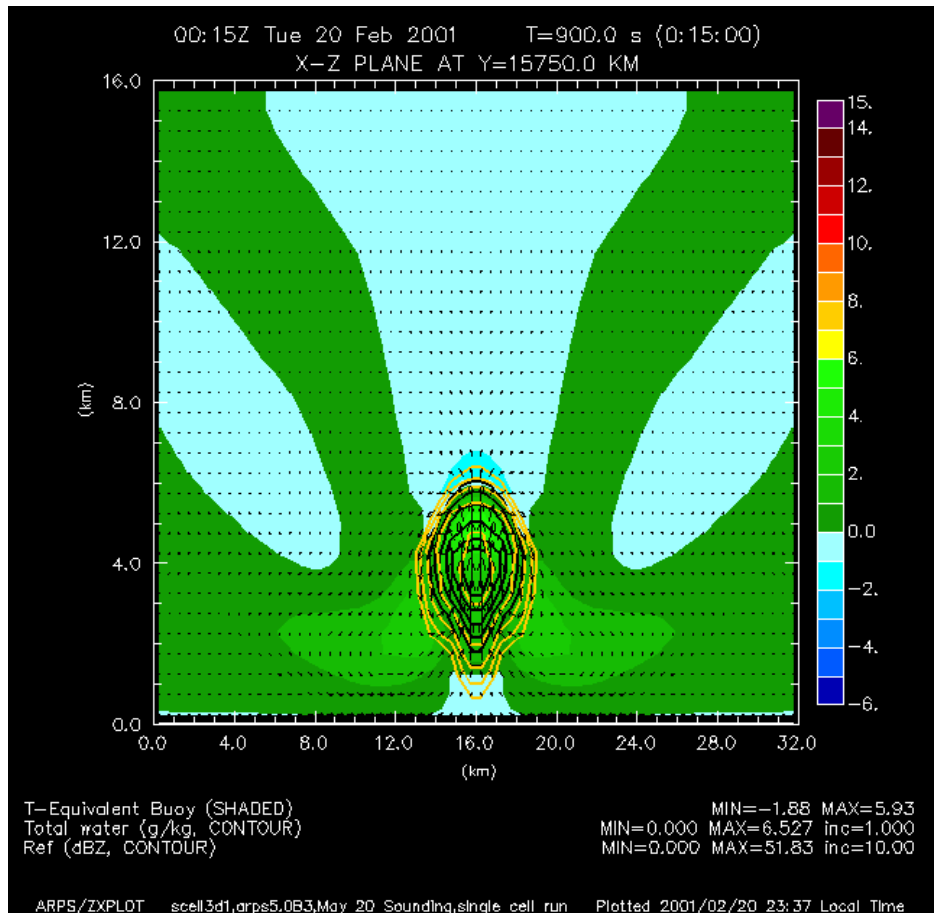
Eq. Pot. Temp.+qw+Ref+wind t=0



# ARPS Simulation of a Single Cell Storm

T-equivalent buoyancy+qw+ref

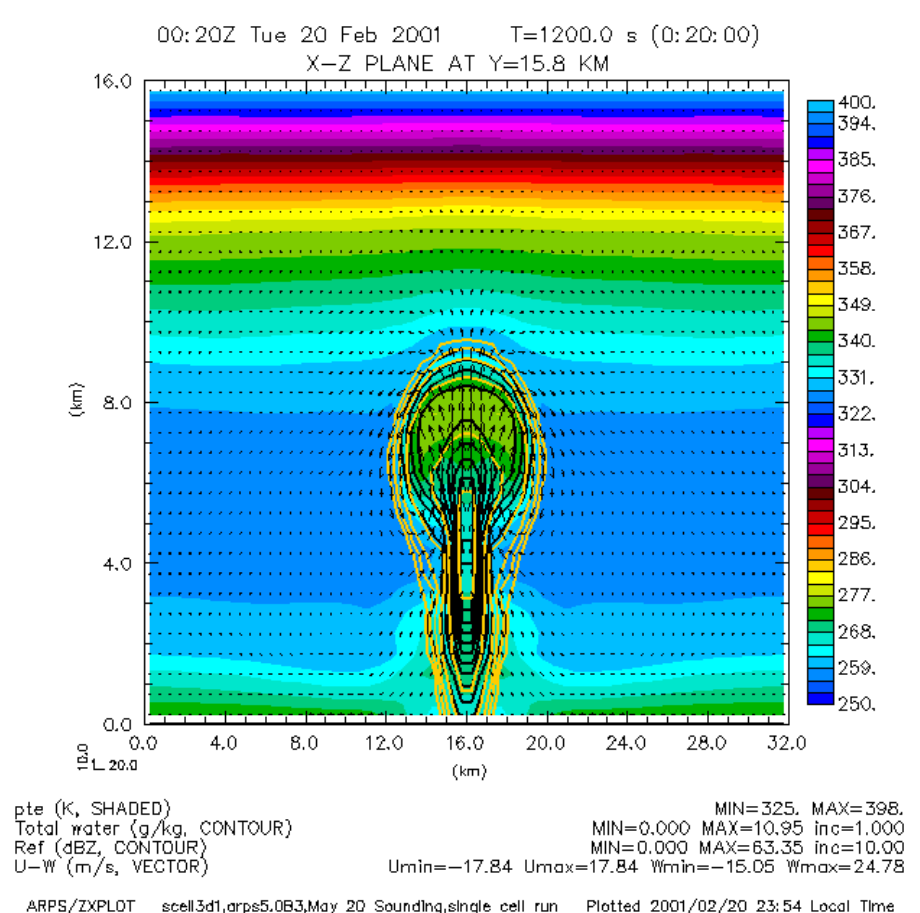
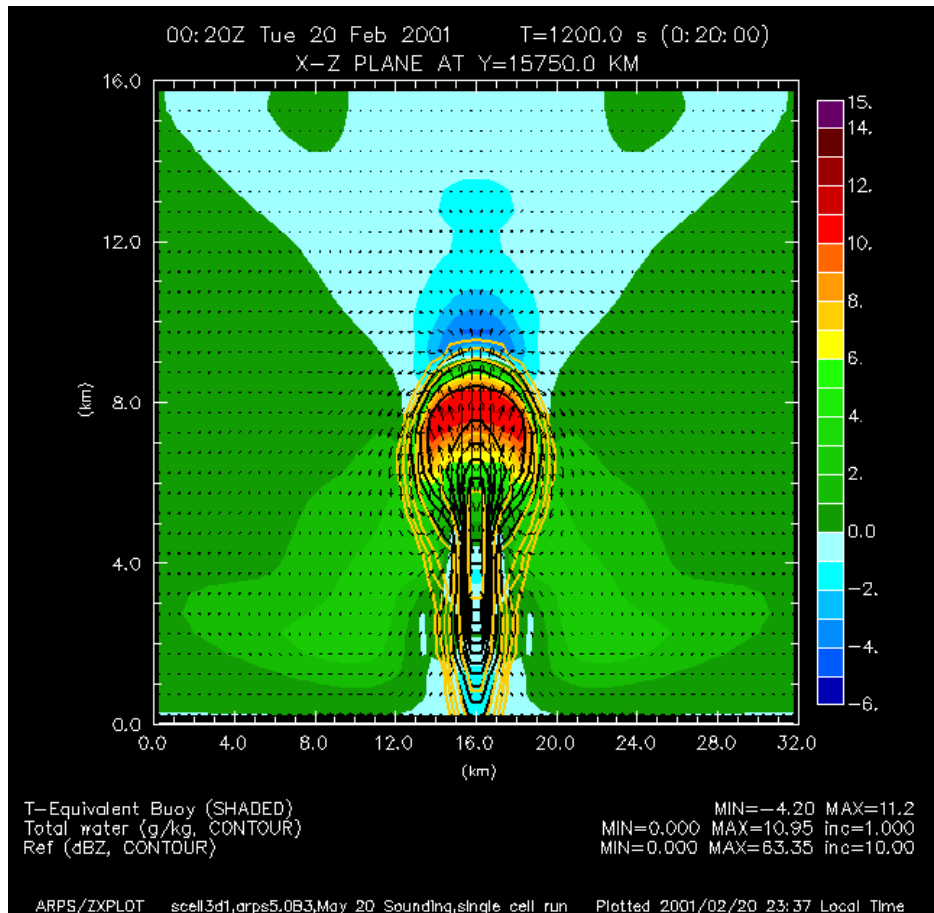
Eq. Pot. Temp.+qw+Ref+wind t=15min



# ARPS Simulation of a Single Cell Storm

T-equivalent buoyancy+qw+ref

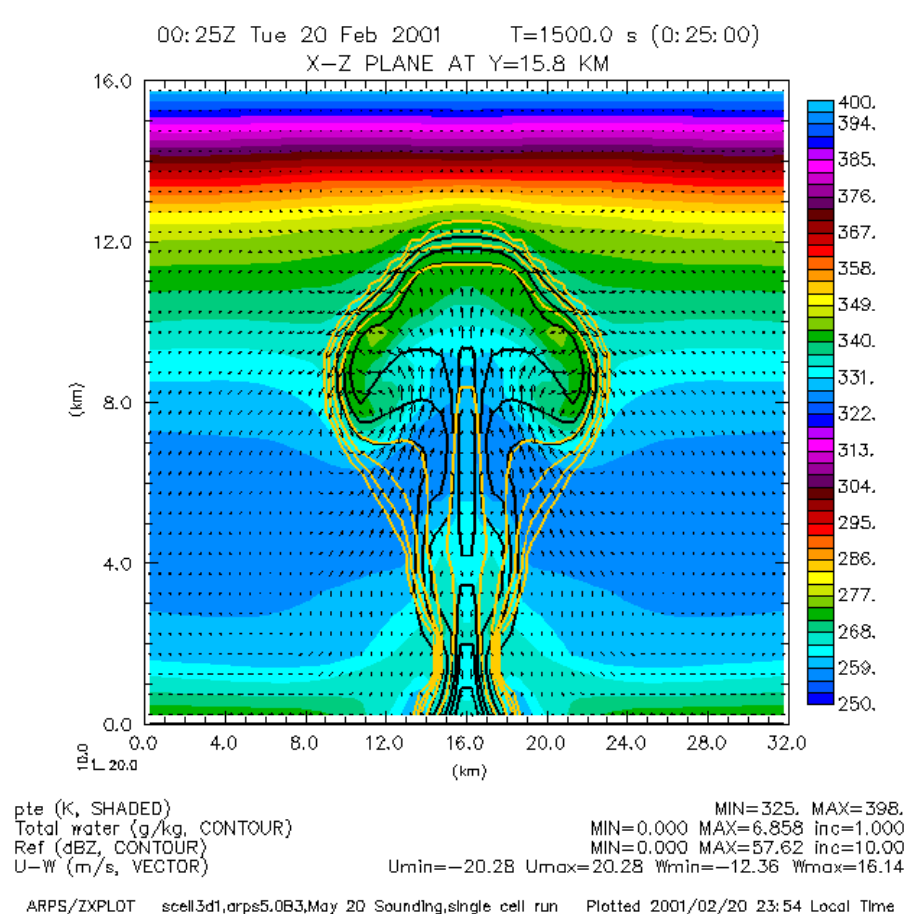
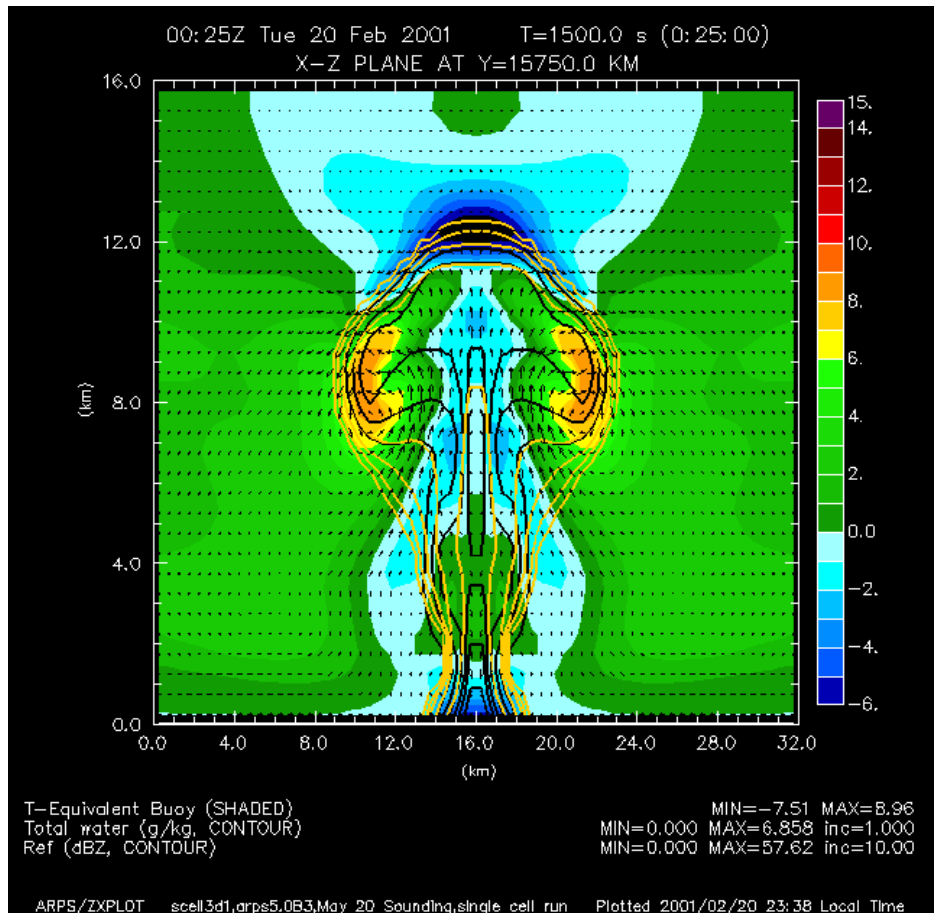
Eq. Pot. Temp.+qw+Ref+wind t=20min



# ARPS Simulation of a Single Cell Storm

T-equivalent buoyancy+qw+ref

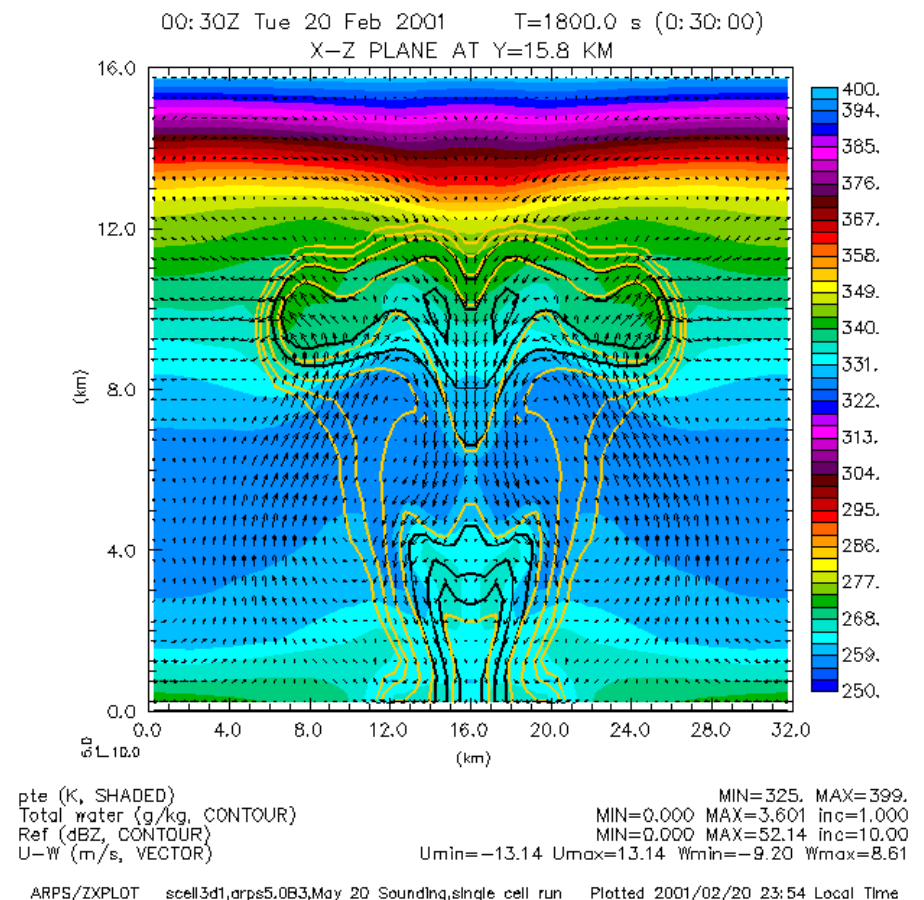
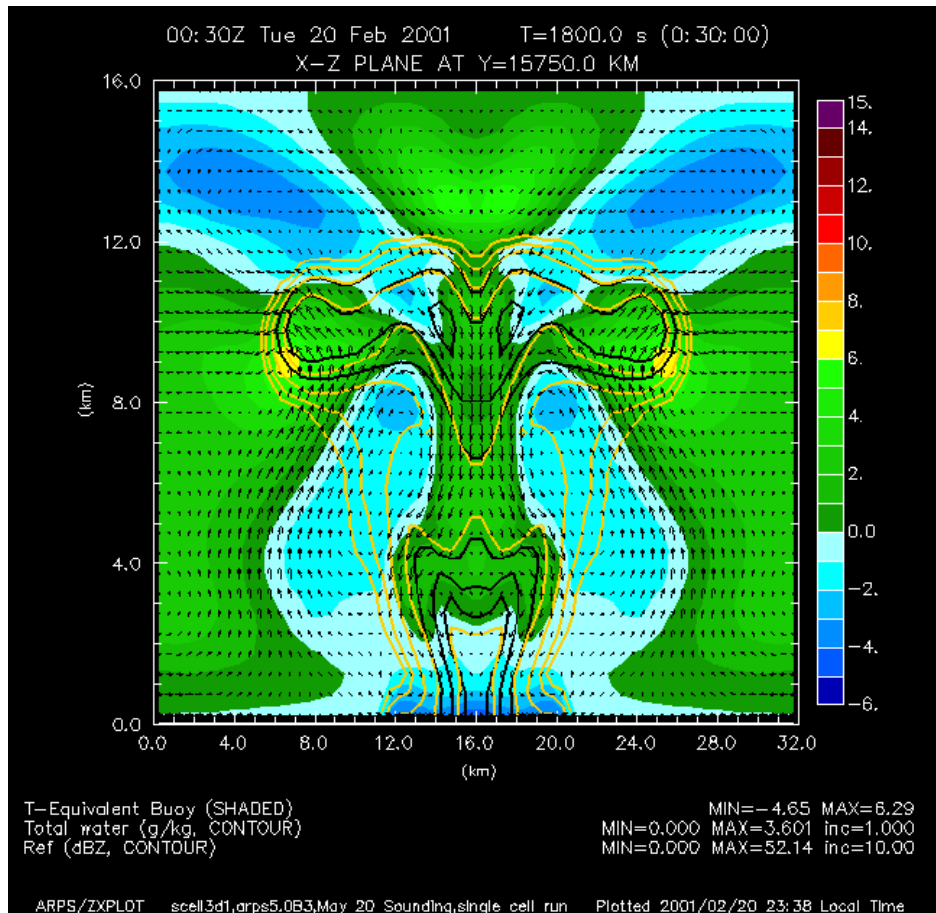
Eq. Pot. Temp.+qw+Ref+wind t=25min





# ARPS Simulation of a Single Cell Storm

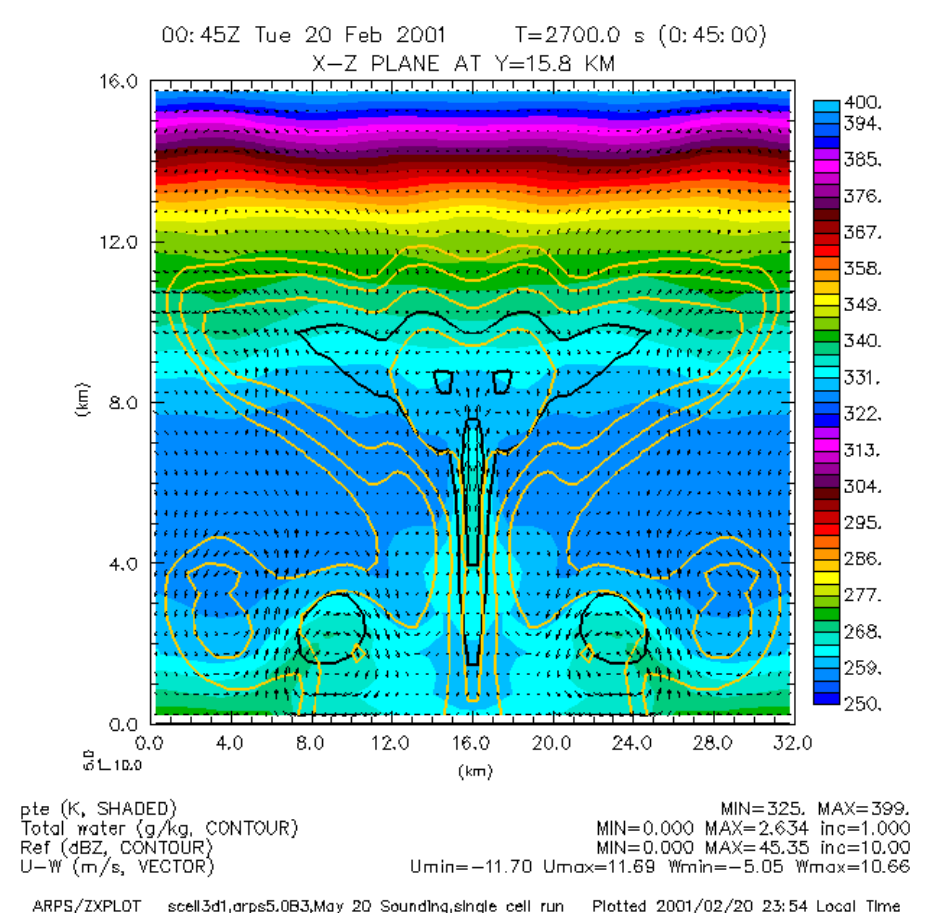
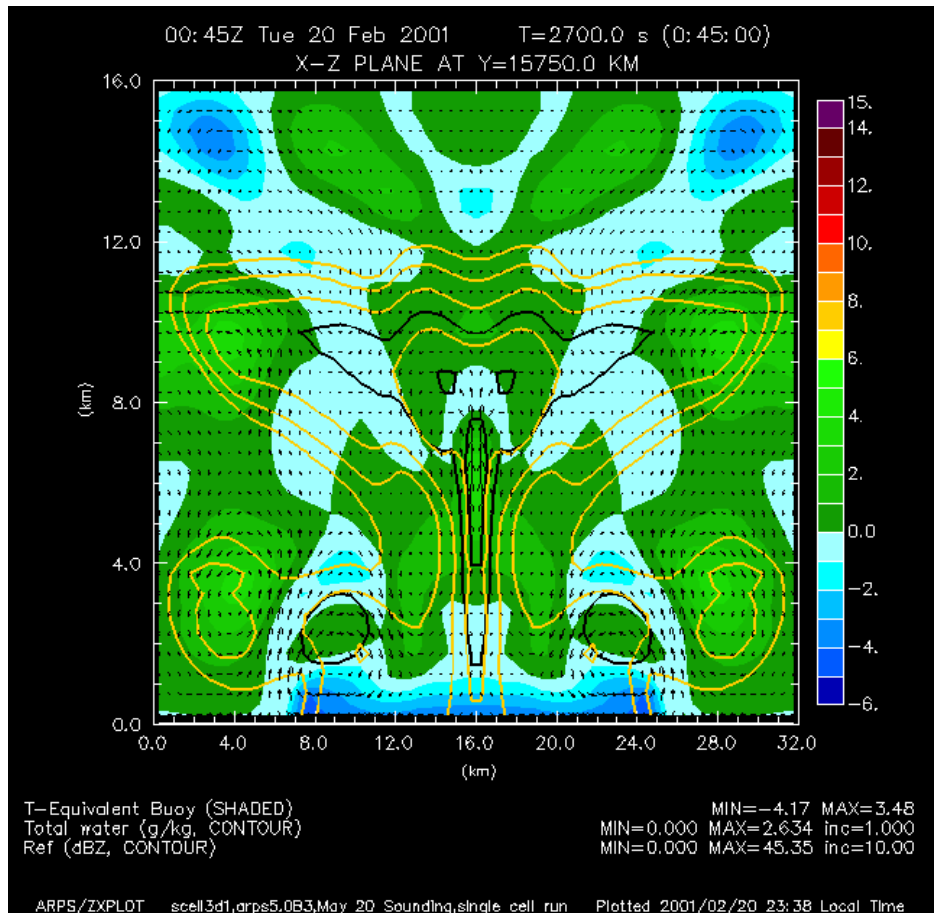
T-equivalent buoyancy+qw+ref Eq. Pot. Temp.+qw+Ref+wind t=30min



# ARPS Simulation of a Single Cell Storm

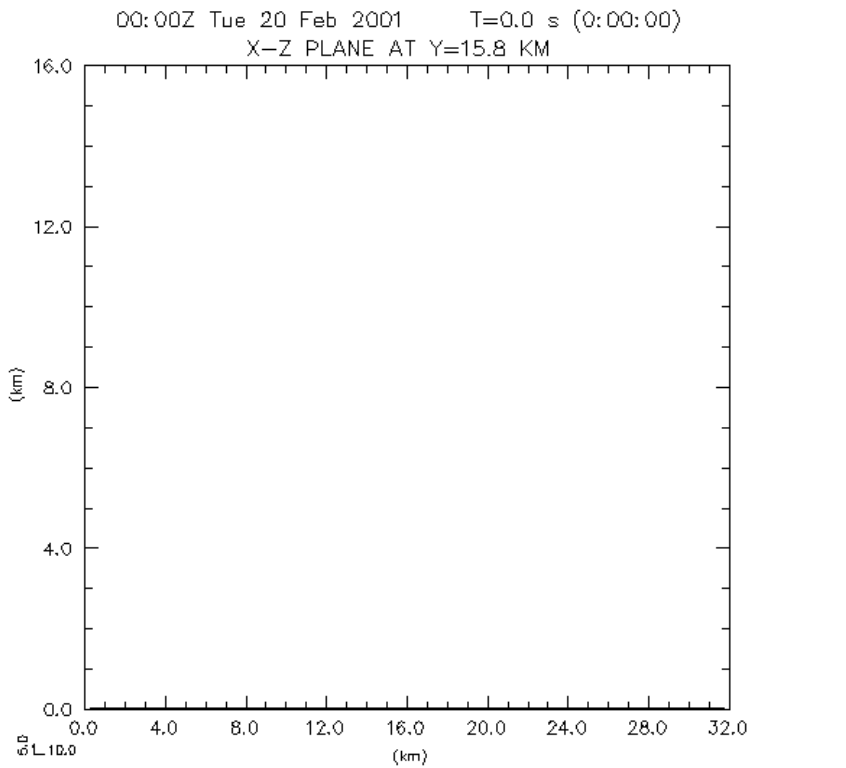
T-equivalent buoyancy+qw+ref

Eq. Pot. Temp.+qw+Ref+wind t=45min



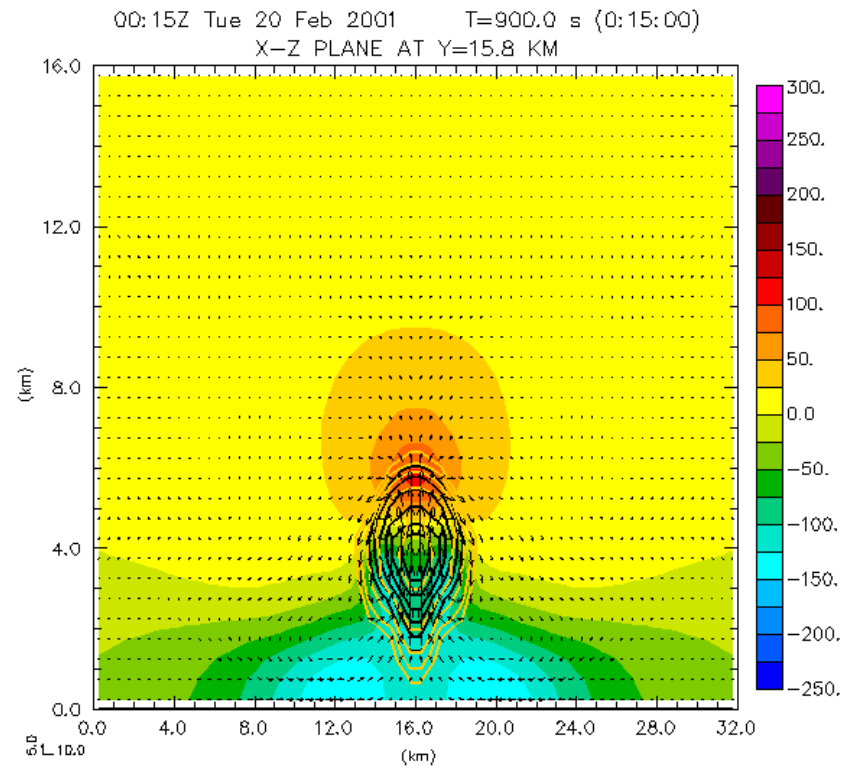
# ARPS Simulation of a Single Cell Storm

Perturbation Pressure +qw+ref +wind t=0, 15min



pprt (Pa, SHADED) MIN=0.00 MAX=0.00  
 Total water (g/kg, CONTOUR) MIN=0.00 MAX=0.00  
 Ref (dBZ, CONTOUR) MIN=0.00 MAX=0.00  
 U-W (m/s, VECTOR) Umin=0.00 Umax=0.00 Wmin=0.00 Wmax=0.00

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundng,shgle cell run Plotted 2001/02/21 00:05 Local Time

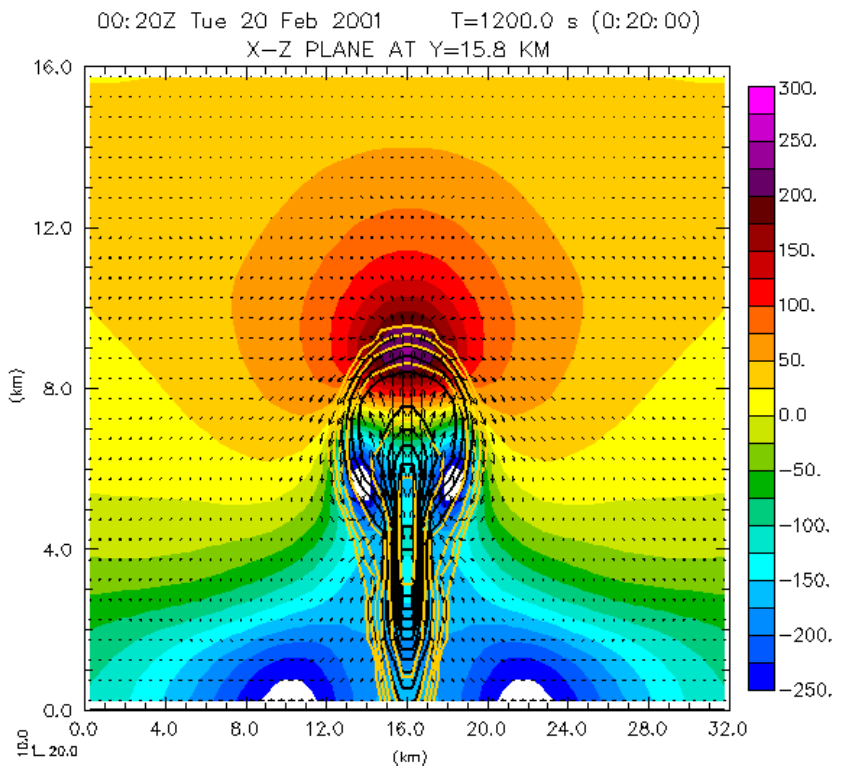


pprt (Pa, SHADED) MIN=-150. MAX=108.  
 Total water (g/kg, CONTOUR) MIN=0.000 MAX=6.527 inc=1.000  
 Ref (dBZ, CONTOUR) MIN=0.000 MAX=51.83 inc=10.00  
 U-W (m/s, VECTOR) Umin=-8.65 Umax=8.65 Wmin=-8.11 Wmax=14.01

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundng,shgle cell run Plotted 2001/02/21 00:05 Local Time

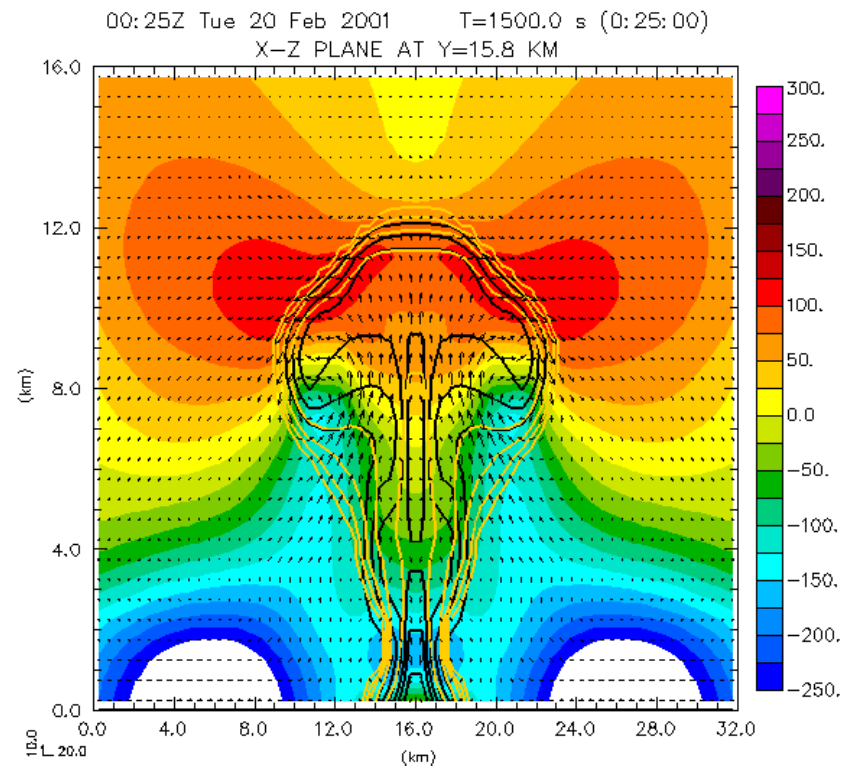
# ARPS Simulation of a Single Cell Storm

Perturbation Pressure +qw+ref +wind t=20, 25min



pprt (Pa, SHADED) MIN=-285. MAX=227.  
Total water (g/kg, CONTOUR) MIN=0.000 MAX=10.95 inc=1.000  
Ref (dBZ, CONTOUR) MIN=0.000 MAX=63.35 inc=10.00  
U-W (m/s, VECTOR) Umin=-17.84 Umax=17.84 Wmin=-15.05 Wmax=24.78

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundng,shlgle cell run Plotted 2001/02/21 00:05 Local Time

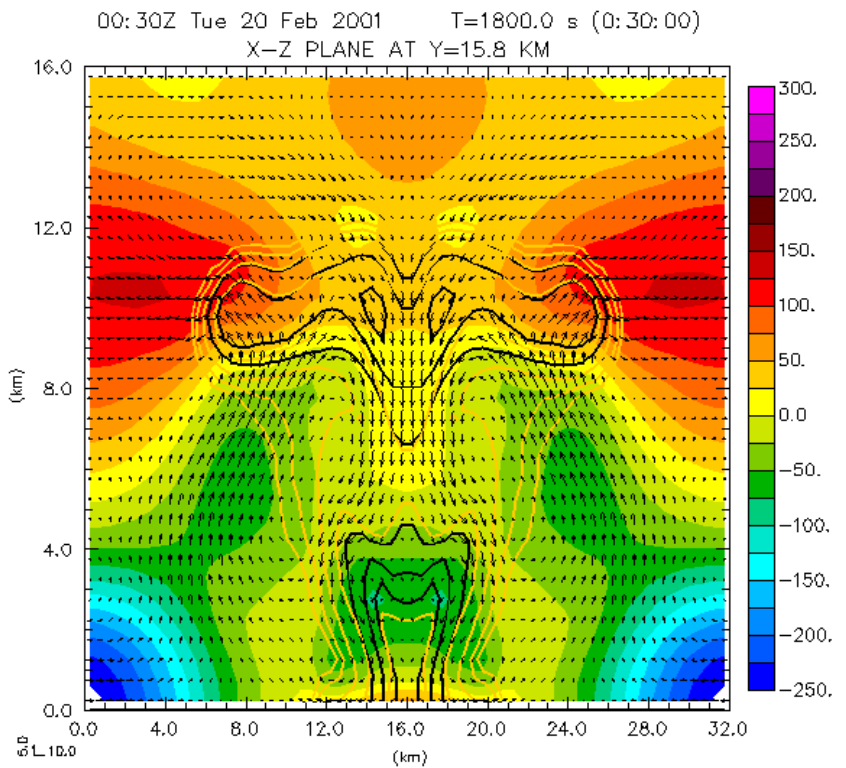


pprt (Pa, SHADED) MIN=-322. MAX=130.  
Total water (g/kg, CONTOUR) MIN=0.000 MAX=6.858 inc=1.000  
Ref (dBZ, CONTOUR) MIN=0.000 MAX=57.62 inc=10.00  
U-W (m/s, VECTOR) Umin=-20.28 Umax=20.28 Wmin=-12.36 Wmax=16.14

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundng,shlgle cell run Plotted 2001/02/21 00:05 Local Time

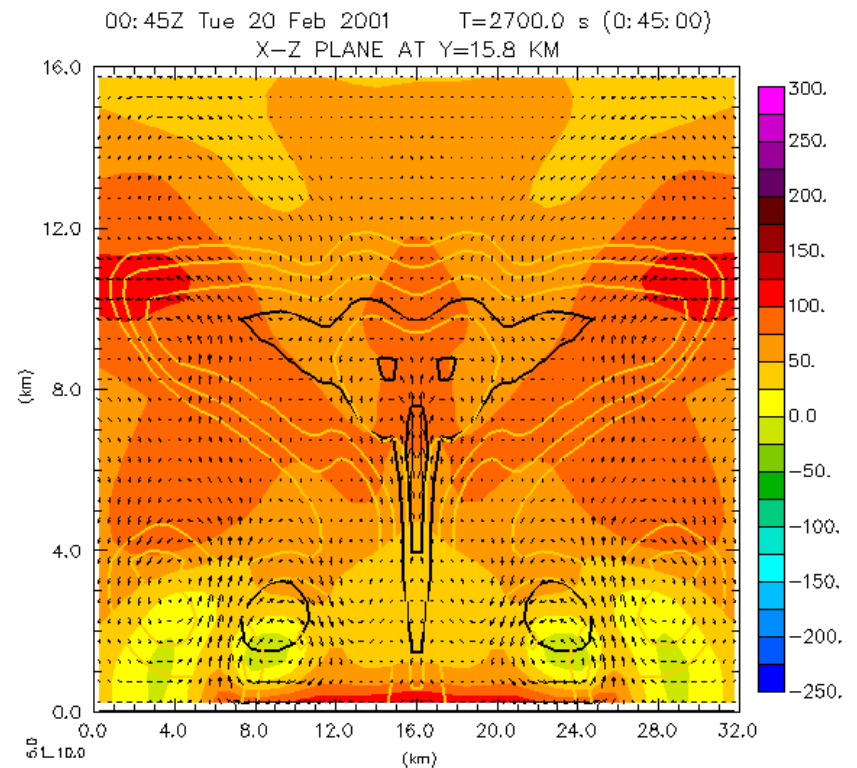
# ARPS Simulation of a Single Cell Storm

Perturbation Pressure +qw+ref +wind t=30, 45min



pprt (Pa, SHADED) MIN=-258. MAX=127.  
Total water (g/kg, CONTOUR) MIN=0.000 MAX=3.601 inc=1.000  
Ref (dBZ, CONTOUR) MIN=0.000 MAX=52.14 inc=10.00  
U-W (m/s, VECTOR) Umin=-13.14 Umax=13.14 Wmin=-9.20 Wmax=8.61

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundng, single cell run Plotted 2001/02/21 00:05 Local Time

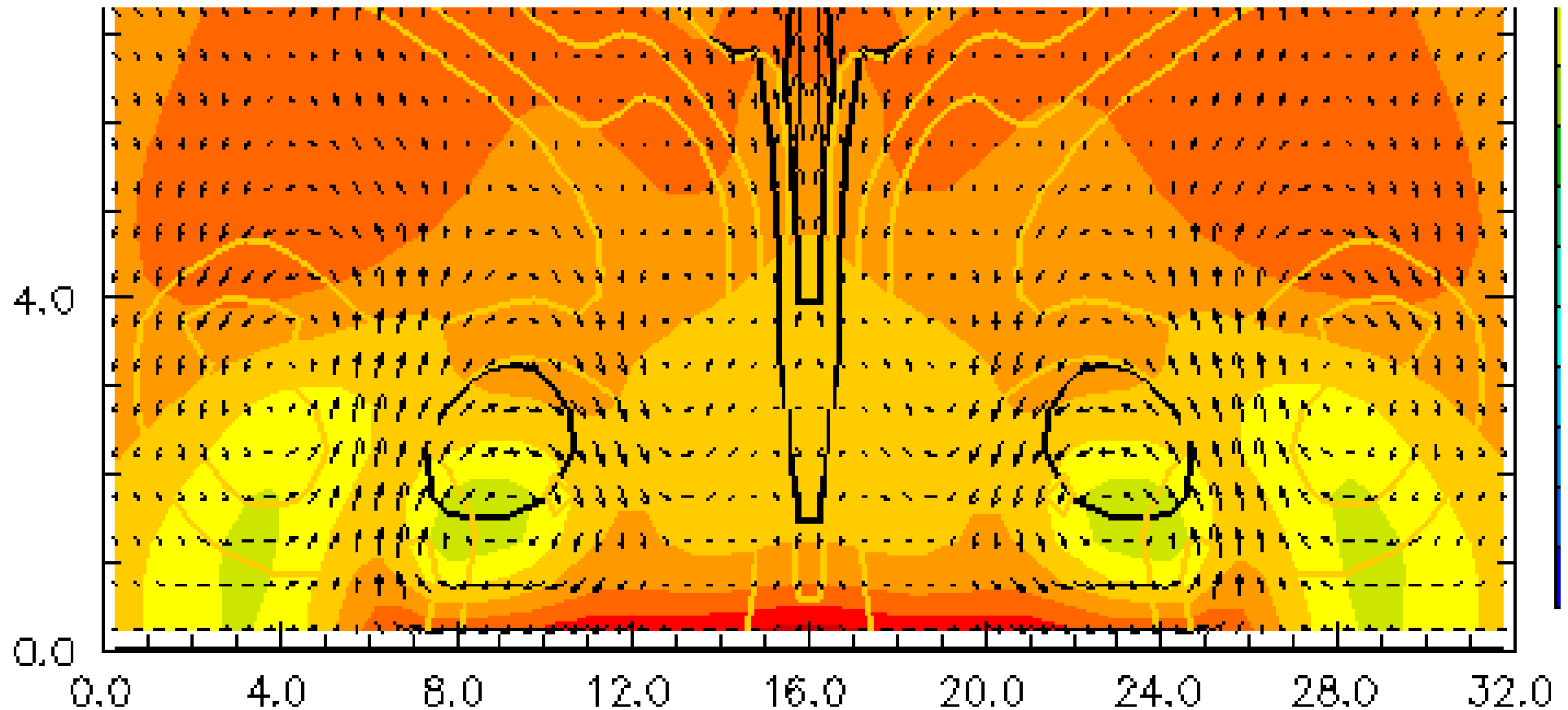


pprt (Pa, SHADED) MIN=-18.0 MAX=134.  
Total water (g/kg, CONTOUR) MIN=0.000 MAX=2.634 inc=1.000  
Ref (dBZ, CONTOUR) MIN=0.000 MAX=45.35 inc=10.00  
U-W (m/s, VECTOR) Umin=-11.70 Umax=11.69 Wmin=-5.05 Wmax=10.66

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundng, single cell run Plotted 2001/02/21 00:06 Local Time

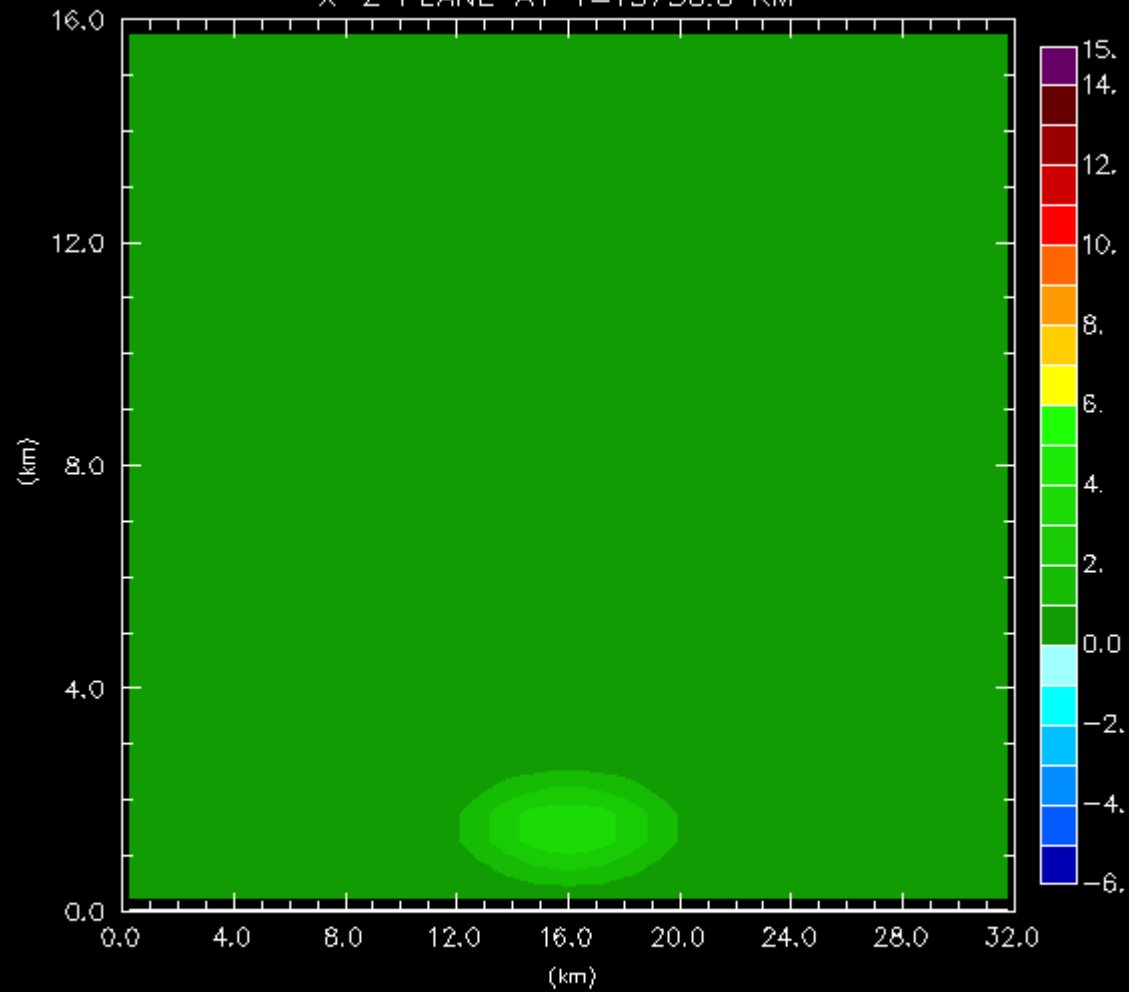
# ARPS Simulation of a Single Cell Storm

Perturbation Pressure +qw+ref +wind t=45min



El modelo representa el alta de presión en la parte inferior de la cold pool. La circulación en el frente de ráfagas produce un fuerte ascenso

00:00Z Tue 20 Feb 2001 T=0.0 s (0:00:00)  
X-Z PLANE AT Y=15750.0 KM

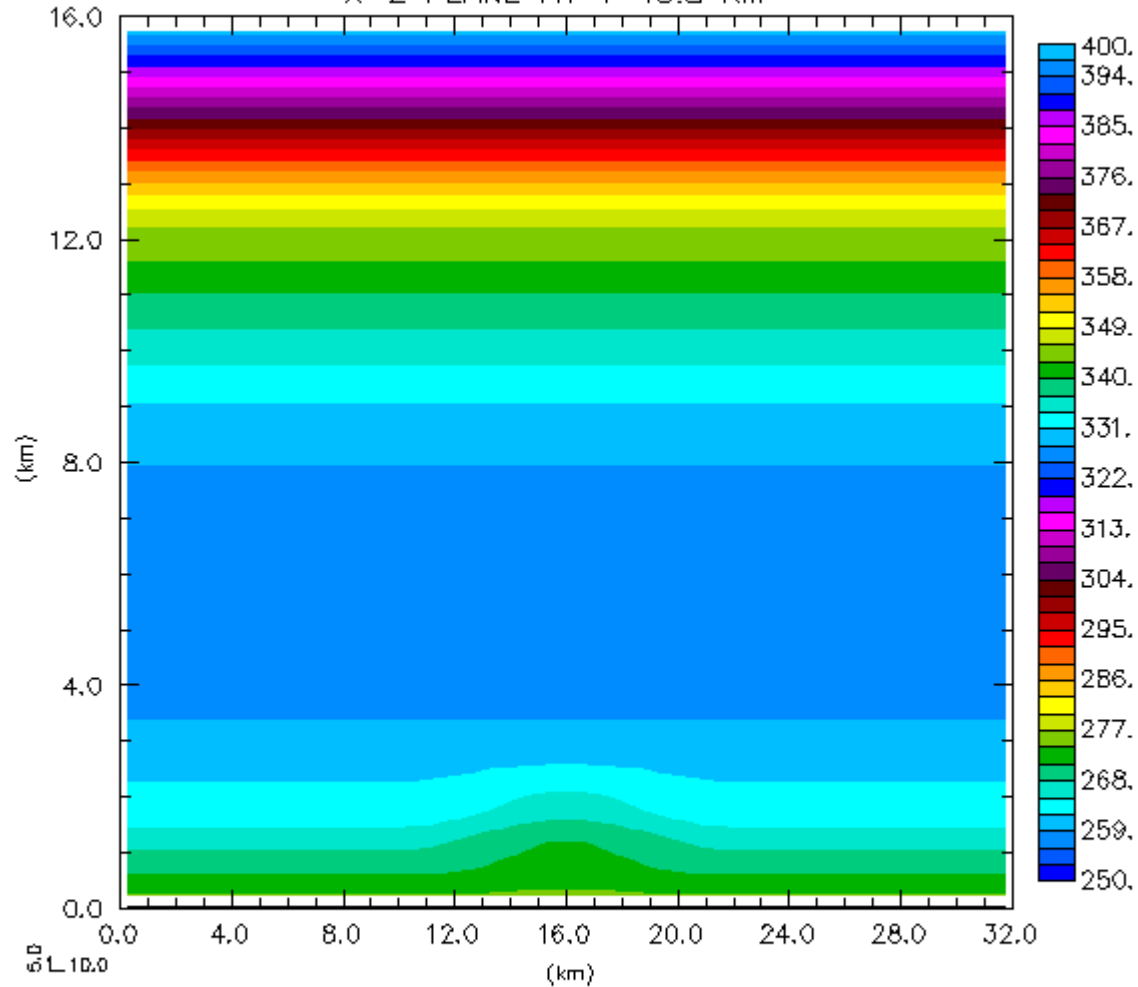


T-Equivalent Buoy (SHADED)  
Total water (g/kg, CONTOUR)  
Ref (dBZ, CONTOUR)

MIN=0.00 MAX=3.67  
MIN=0.00 MAX=0.00  
MIN=0.00 MAX=0.00

00:00Z Tue 20 Feb 2001 T=0.0 s (0:00:00)

X-Z PLANE AT Y=15.8 KM



pte (K, SHADED)  
Total water (g/kg, CONTOUR)  
Ref (dBZ, CONTOUR)  
U-W (m/s, VECTOR)

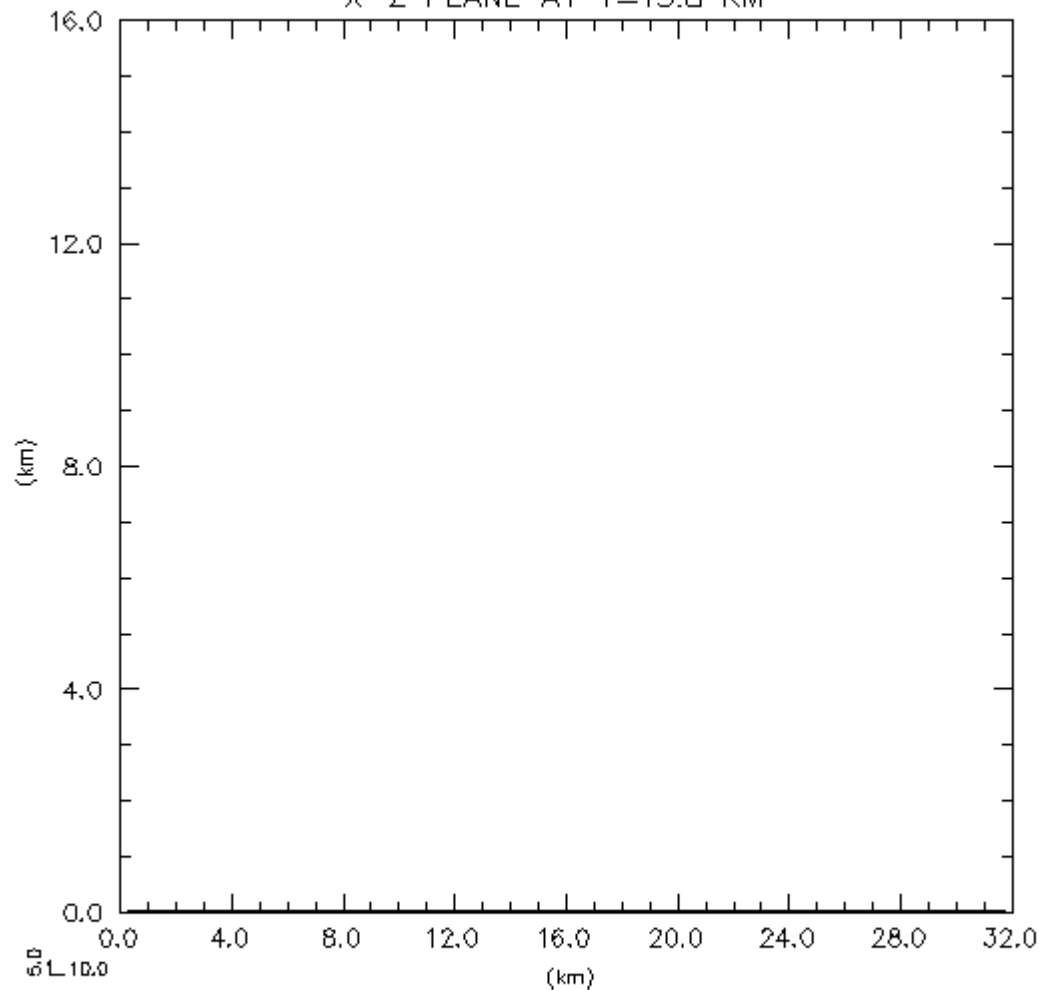
MIN=326. MAX=398.  
MIN=0.00 MAX=0.00  
MIN=0.00 MAX=0.00  
Umin=0.00 Umax=0.00 Wmin=0.00 Wmax=0.00

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Sounding,single cell run Plotted 2001/02/20 23:53 Local Time



00:00Z Tue 20 Feb 2001 T=0.0 s (0:00:00)

X-Z PLANE AT Y=15.8 KM



pprt (Pa, SHADED)	MIN=0.00 MAX=0.00
Total water (g/kg, CONTOUR)	MIN=0.00 MAX=0.00
Ref (dBZ, CONTOUR)	MIN=0.00 MAX=0.00
U-W (m/s, VECTOR)	Umin=0.00 Umax=0.00 Wmin=0.00 Wmax=0.00

ARPS/ZXPLOT scell3d1,arps5.0B3,May 20 Soundfng,single cell run Plotted 2001/02/21 00:05 Local Time