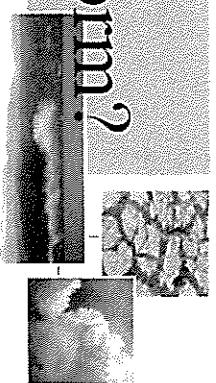


What caused the thunderstorm-hailstorm?



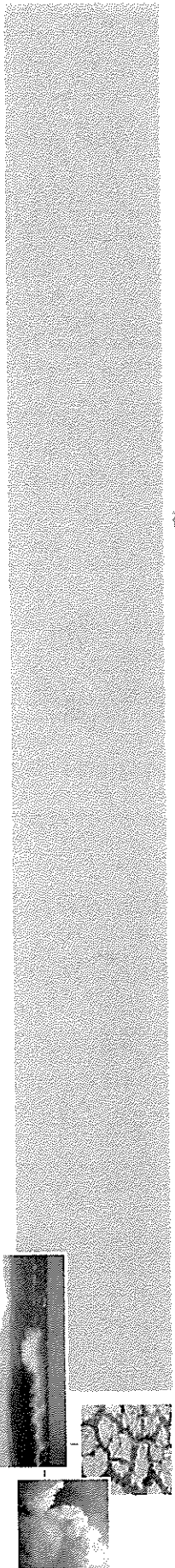
**2. Low-level vertical wind shear – creates rotation
from the thunderstorm updraft – Leads to long-lived,
self-organised supercell thunderstorms**



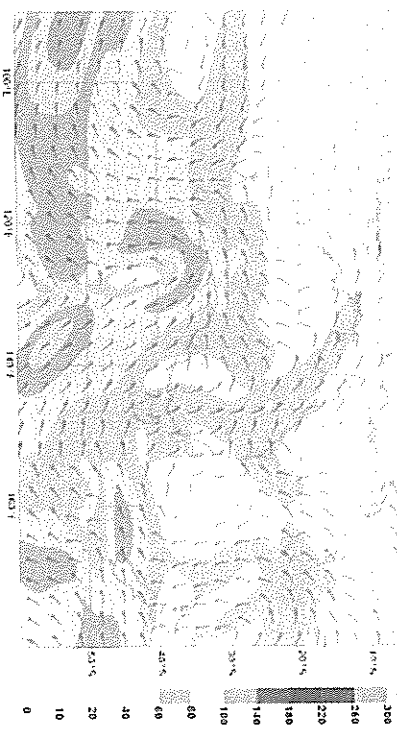
The Centre for Australian Weather and Climate Research A
partnership between CSIRO and the Bureau of Meteorology



Australian Government
Bureau of Meteorology



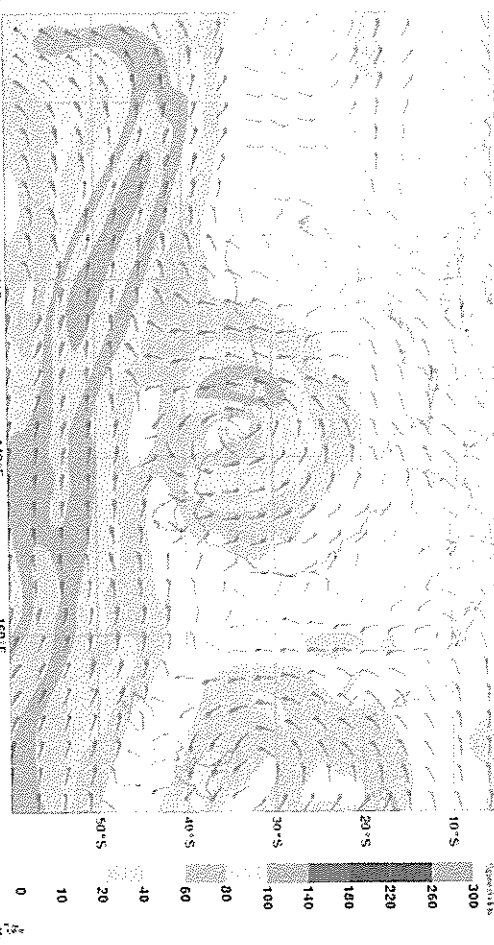
500hPa winds
Valid 18Z Thu 04 Mar 2010
ACCESS-Global
t4-006



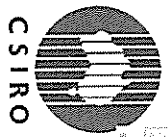
500hPa winds
Valid 18Z Fri 05 Mar 2010
ACCESS-Global
t4-006



500hPa winds
Valid 18Z Sat 06 Mar 2010
ACCESS-Global
t4-006



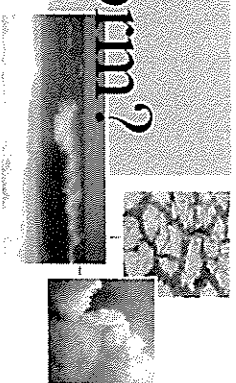
Upper level wind analyses
(500 hPa)
Showing passage across
Victoria of an upper
level westerly trough –
this provided the wind
shear at low levels



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Australian Government
Bureau of Meteorology

What caused the thunderstorm-hailstorm?



3. Upper level jet-streak equatorial entrance or poleward exit zone ... giving upper level divergence (or strong outflow) across thunderstorm top

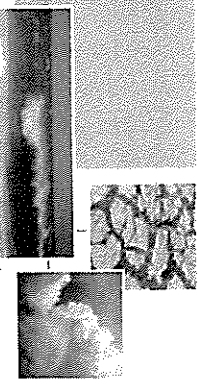


The Centre for Australian Weather and Climate Research A partnership between CSIRO and the Bureau of Meteorology

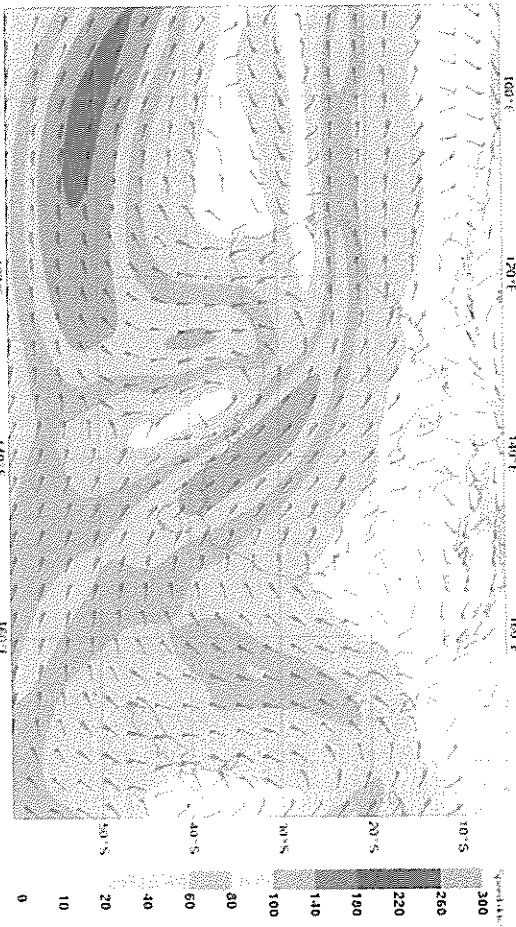


Australian Government
Bureau of Meteorology

ACCESS Operational model forecast 200 hPa wind fields for Sat 6 March



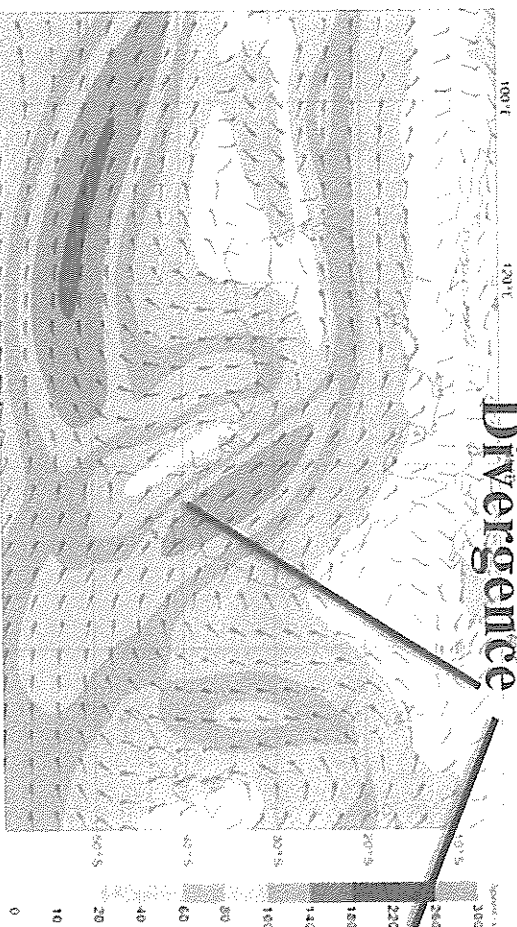
200hPa winds
Valid 18Z Fri 05 Mar 2010
ACCESS-Global
1+006



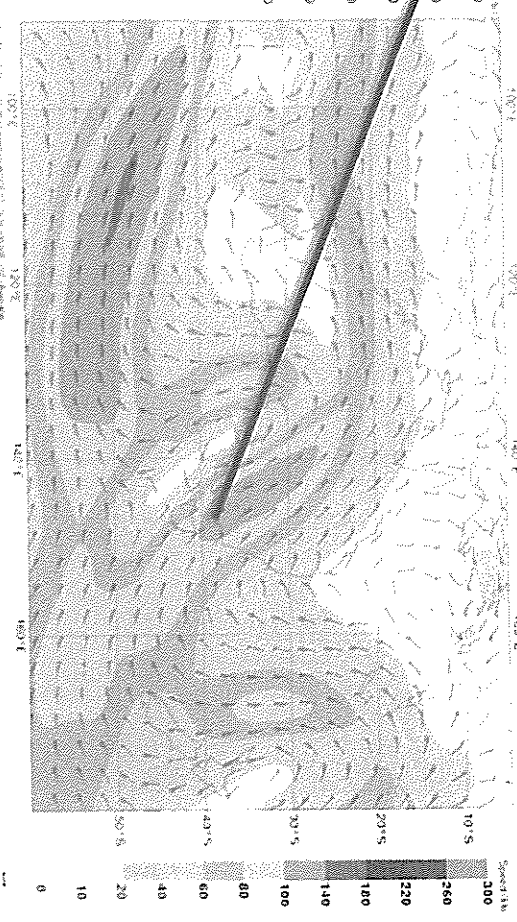
200hPa winds
Valid 00Z Sat 06 Mar 2010
ACCESS-Global
1+012



200hPa winds
Valid 06Z Sat 06 Mar 2010
ACCESS-Global
1+018



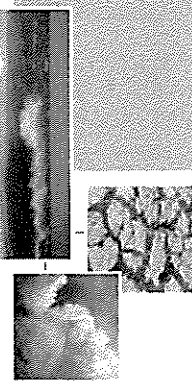
200hPa winds
Valid 12Z Sat 06 Mar 2010
ACCESS-Global
1+024



Divergence

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Forecast Guidance from the National Thunderstorm Forecast Guidance (NTFGS)



National Thunderstorm Forecasting Guidance

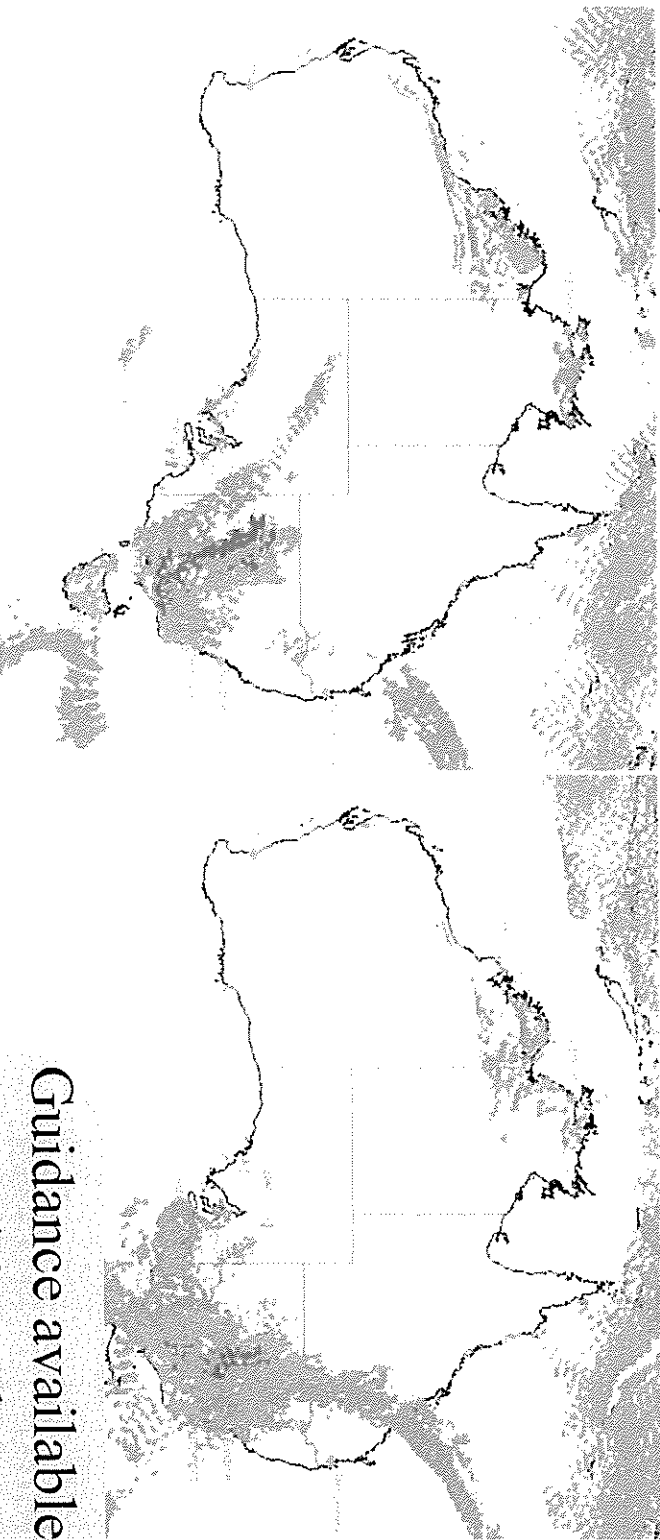
[New Archive]

Version 2.0 Guidance Current Model Run 18Z-05/03/2010 (Previous Run)

➤ Saturday 6 March 2010 (18-15Z)

➤ Sunday 7 March 2010 (15-15Z)

HINTS - Click on Arrows to View Storm-Matching Tests, Click on Map to toggle between Australia and States



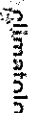
Guidance available
around 8am that
morning

■ Thunderstorm ■ Severe Convective Weather ■ Supercell

[MesoViewer] [Training] [FAQ] [Soundings] [Hodotool] [National Radar] [Satellite Imc] [24 hr lightning commsite] [IR/Infrared] [NSW TS/Dave] [Dave] [D] [D]

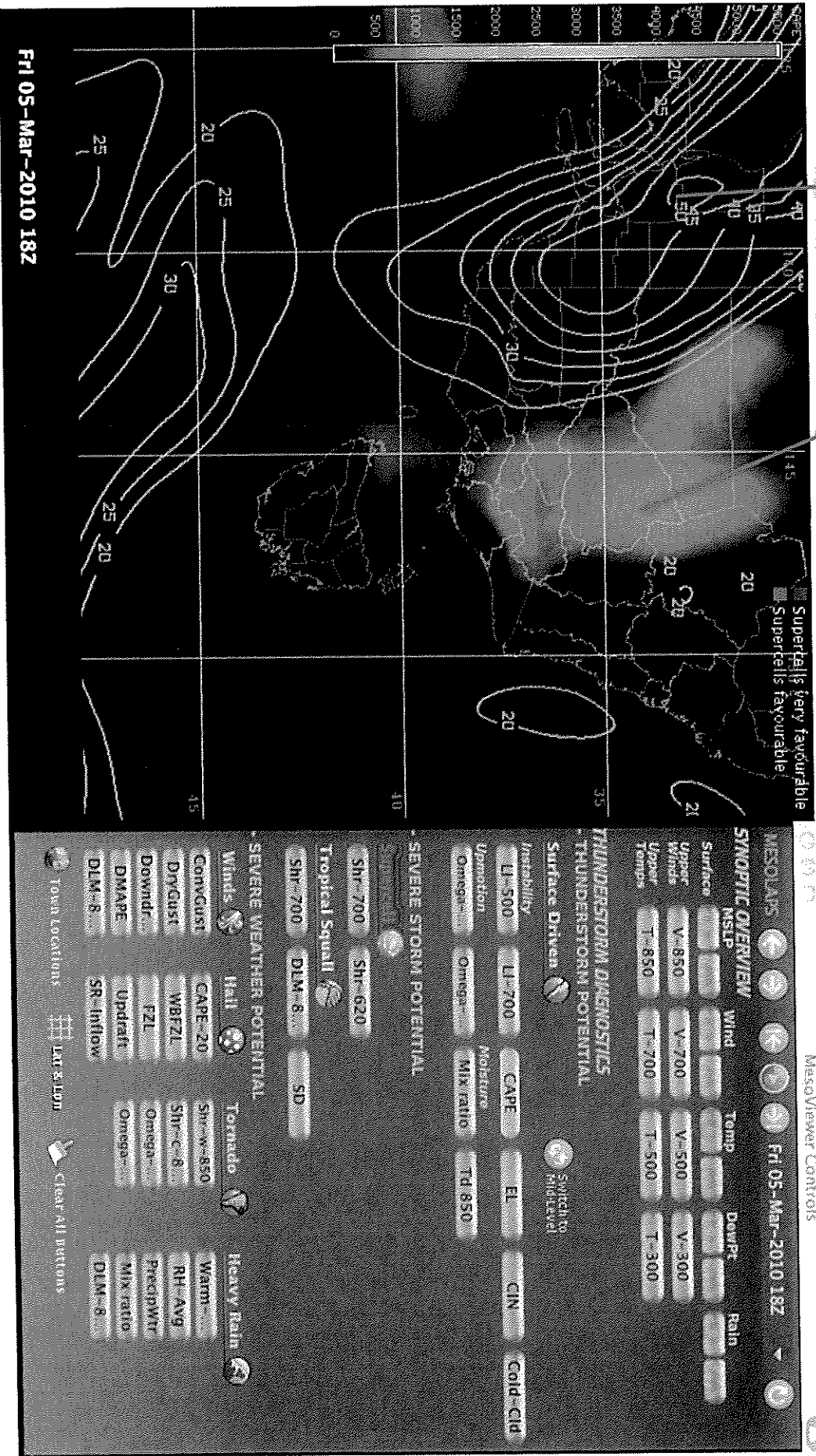


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CAPE (Instability) associated with deep low-level moisture

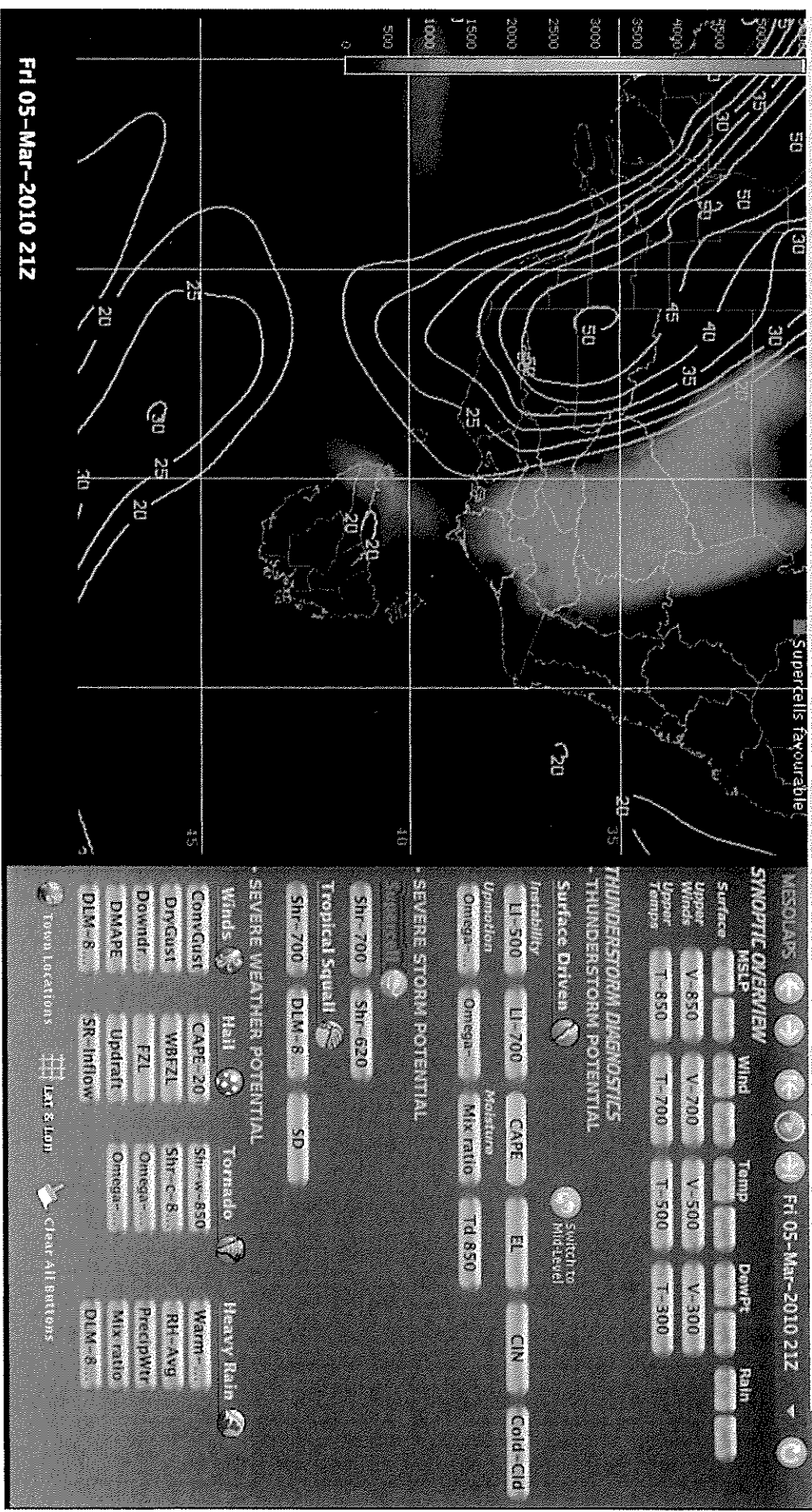
Wind shear between sfc and 700 hPa as upper level trough moves across



Fri 05-Mar-2010 18Z

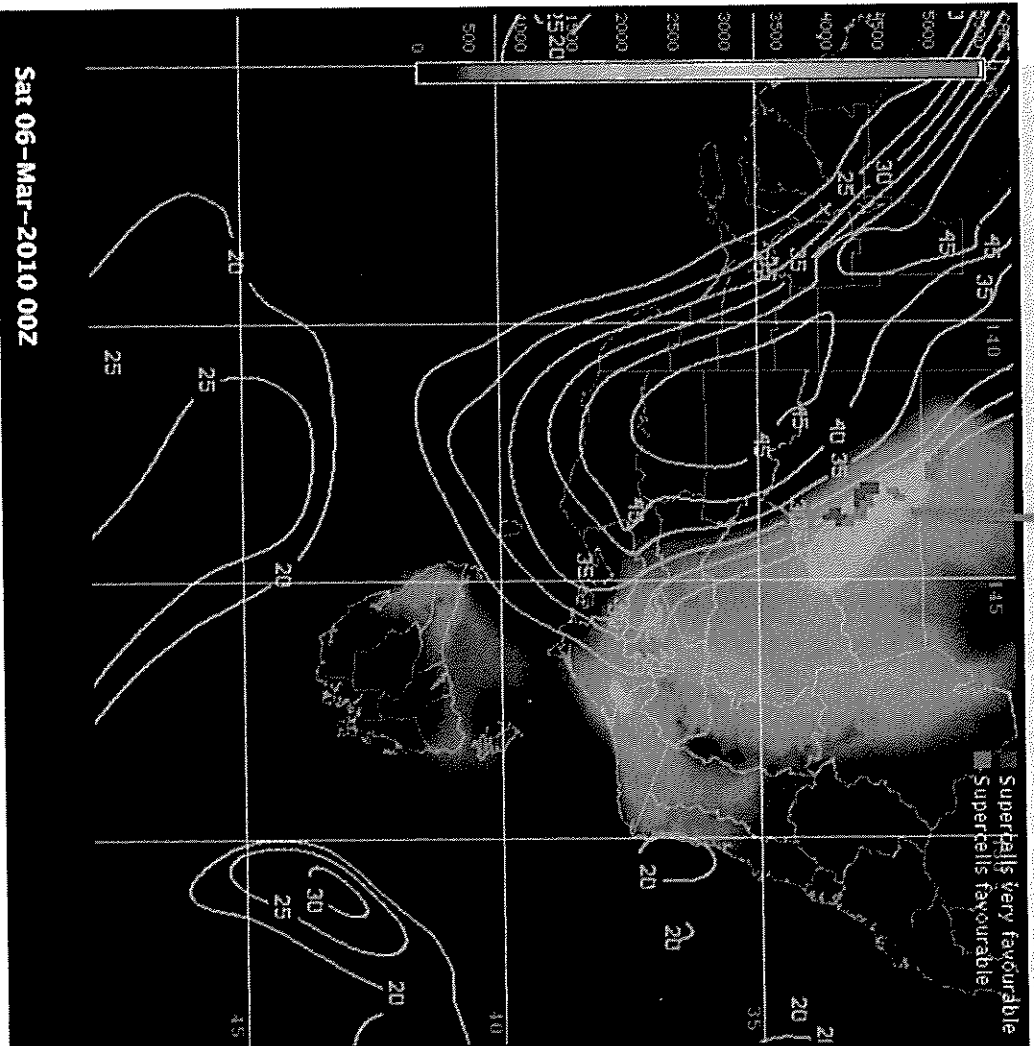
3 hours later:
 CAPE (Instability) associated with deep low-level moisture

Wind shear between sfc and 700 hPa as upper level trough moves
 across



Fri 05-Mar-2010 21Z

3 hours later – 00UTC (11am)
 Diagnostics of supercells (red area)
 when the shear overlays the region of
 (CAPE)



Sat 06-Mar-2010 00Z

MesoViewer Controls

MEQIARS [Left Arrow] [Right Arrow] [Home] [Back] [Forward] [Refresh] [Close]

Sat 06-Mar-2010 00Z

SYNOPTIC OVERVIEW

MSLP	Wind	Temp	DewPt	Rain
Surface				
Upper Winds	V-850	V-700	V-500	V-300
Upper Temp	T-850	T-700	T-500	T-300

THUNDERSTORM DIAGNOSTICS

THUNDERSTORM POTENTIAL

Surface Driven [Switch to Midlevel]

Inequality [U-500] [U-700] [CAPE] [EL] [GIN] [Cold-Cld]

Moisture [Omega] [Mix ratio] [Td/850]

SEVERE WEATHER POTENTIAL

SEVERE WEATHER POTENTIAL

Supercells [Shr-700] [DLM-8] [SD]

Tropical Squall [Shr-700] [DLM-8] [SD]

Shr-700 [Shr-620]

Winds [Hail] [Tornado] [Heavy Rain]

ConvGust [CAPE-20] [Shr-850]

DryGust [WBZFL] [Shr-C-8]

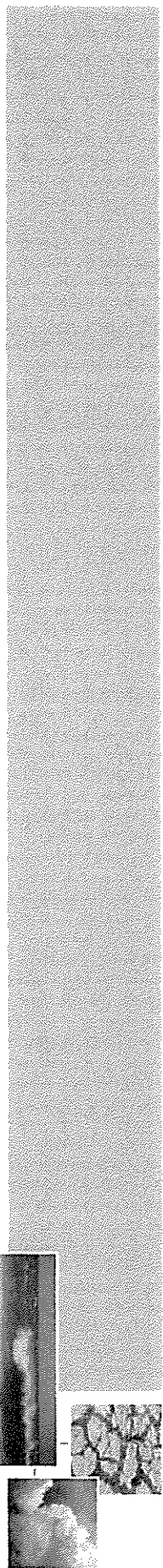
Downdr [FZL] [Omega]

DMAPE [Updraft] [Omega]

DLM-8 [SR-Inflow] [Omega]

Warm [RH-Avg] [PrecipWtr] [Mix ratio] [DLM-8]

Tornado locations [Lat/Long] [Clear All Buttons]



Sat 06-Mar-2010 03Z

MesoViewer Controls

Sat 06-Mar-2010 03Z

SYNOPTIC OVERVIEW

MSLP	Wind	Temp	DewPt	Pair
Surface				
Upper Winds	V-850	V-700	V-500	V-300
Upper Temps	T-850	T-700	T-500	T-300

THUNDERSTORM DIAGNOSTICS

Surface Driven Switch to mid-level

Instability: LI-500 LI-700 CAPE EL CIN Cold-Cld

Upsearation: Omega- Mix ratio TD 850

SEVERE STORM POTENTIAL

Shr-700 Shr-620

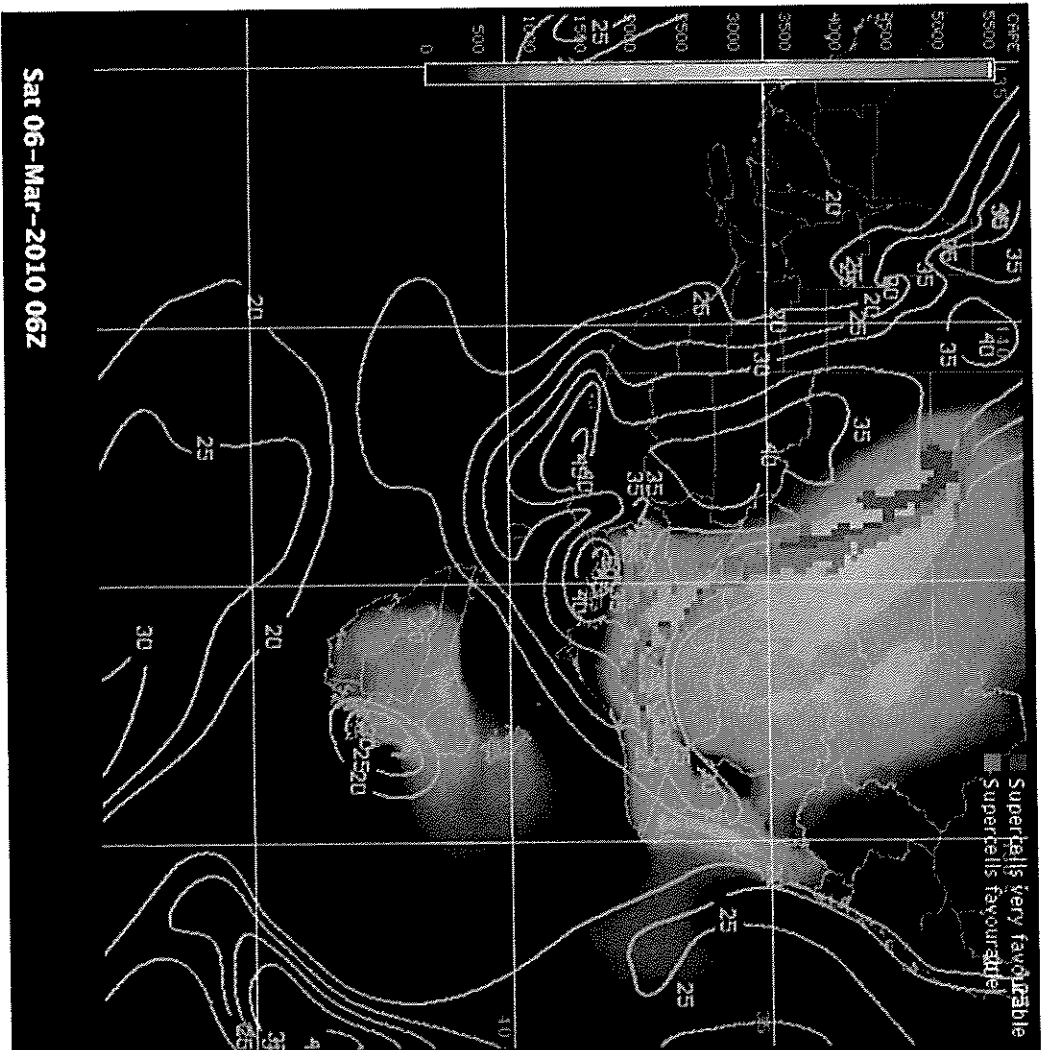
Tropical Squall DLM-8 SD

SEVERE WEATHER POTENTIAL

Winds	Hail	Tornado	Heavy Rain
ConvGust	CAPE-20	Shr-A-850	Warm
DmgGust	WBFL	Shr-C-8	RH-Avg
Downdr	FZL	Omega-	PrecipWtr
DMAPE	Updraft	Omega-	Mixratio
DLM-8	SR-Inflow		DLM-8

Load locations: [Icons] Clear all buttons

0600 UTC... the time when we had the L-shaped region of bright echoes on the radar



MesoViewer Controls

Sat 05-Mar-2010 06Z

SYNOPTIC OVERVIEW

MSLP	Wind	Temp	DewPt	Rain
Surface				
Upper Winds	V-850	V-700	V-500	V-300
Upper Temps	T-850	T-700	T-500	T-300

THUNDERSTORM DIAGNOSTICS

Surface Driven Subject to Radar

Instability: LI-500 LI-700 CAPE EL CIN Cold-CID

Updation Omega- Mix ratio Td 850

SEVERE STORM POTENTIAL

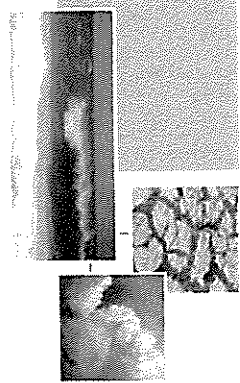
SH-700 SH-620
Tropical Squall SH-700 DLM-8 SD

SEVERE WEATHER POTENTIAL

Winds	Hail	Tornado	Heavy Rain
ConvGust	CAPE-20	Shr-850	Warm
DryGust	WRFZL	Shr-C-8	RH-AVG
Downdr	FZL	Omega-	PrecipWt
DMAPE	Updraft	Omega-	Mix ratio
DLM-8	SR-Inflow		DLM-8

Restrictions: Lat/Long Clear All Buttons

Sat 06-Mar-2010 06Z



0900 UTC (8pm)



MesoViewer Controls

Sat 06-Mar-2010 09Z

SYNOPTIC OVERVIEW

Surface	Upper Winds	Upper Temps	Wind	Temp	DewPt	Rain
MSLP	V-850	T-850				
	V-700	T-700				
	V-500	T-500				
	V-300	T-300				

THUNDERSTORM DIAGNOSTICS

Surface-Driven

Instability: LI-500, LI-700, CAPE, EL, CIN, Cold-Cld

Updraft: Omega-, Omega-, Mix ratio, Td 850

SEVERE WEATHER POTENTIAL

Tropical Squall: Sh-700, DLM-8, SD

SEVERE WEATHER POTENTIAL

Winds: Hall, Tornado

COHV GUST: CAPE-20, SR-v-850

DNV GUST: WBFZL, SR-c-8

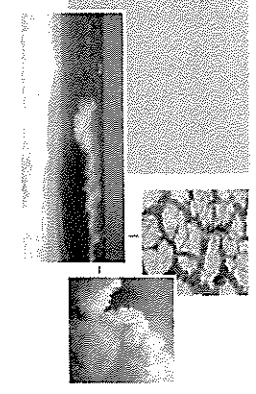
Downdr: FZL, Omega-, Omega-

DMAPE: Updrat, Omega-

DLM-8: SR-Inflow, Heavy Rain

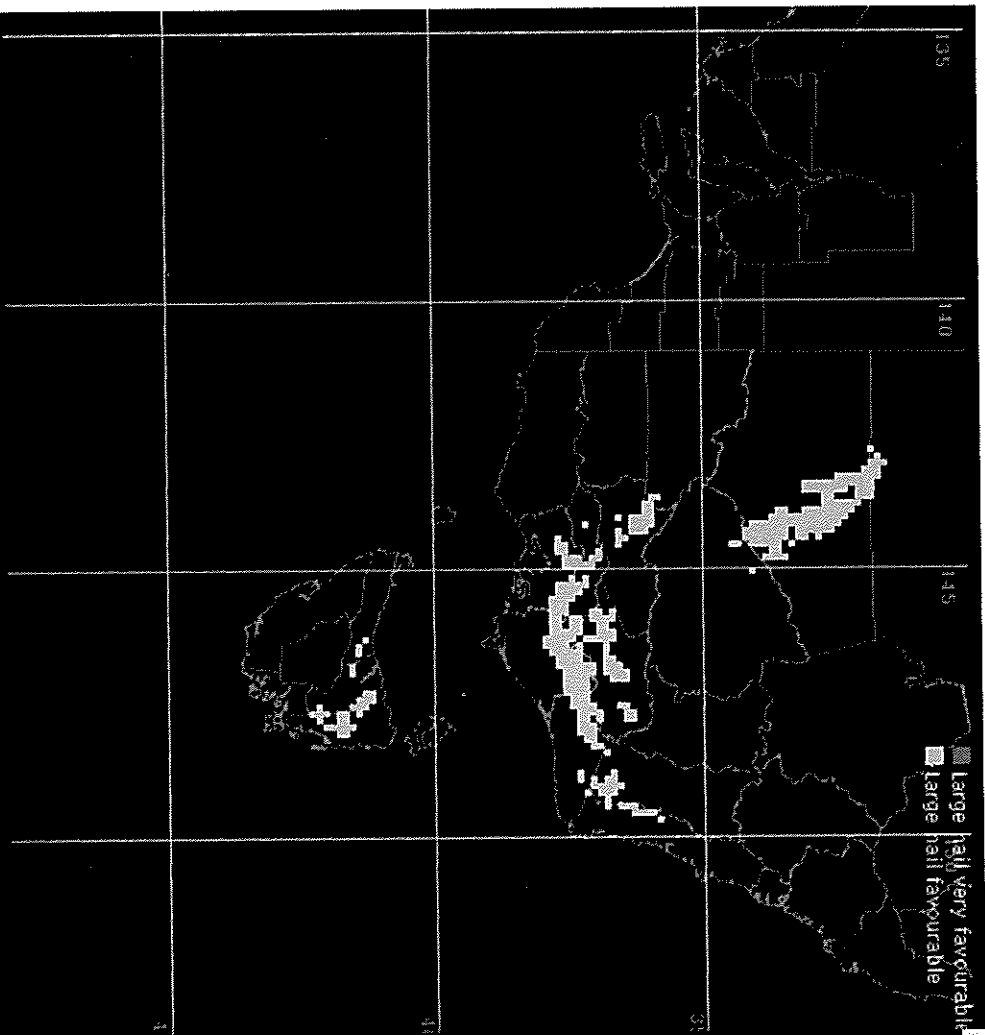
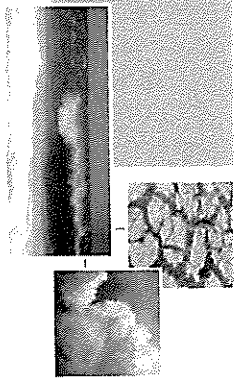
Warm, RH-Avg, PrecipWt, Mix ratio, DLM-8

Track Locations: List & Load, Clear All Outflows



Sat 06-Mar-2010 09Z

Hail diagnostic



MesoViewer Controls Sat 06-Mar-2010 06Z

SYNOPTIC OVERVIEW

Surface MSLP	Wind	Temp	DWPT	Rain
Upper Winds V-850	V-700	V-500	V-300	
Upper Temps T-850	T-700	T-500	T-300	

THUNDERSTORM DIAGNOSTICS

Surface Driven Switch to Rfdiaveil

Probability: LI-500 LI-700 CAPE EL CIN Gold-CID

Updraft Omega- Omega- Mix ratio Td 850

SEVERE STORM POTENTIAL

Supercell Str-700 Str-620

Tropical Squall Str-700 DLM-8 SD

SEVERE WEATHER POTENTIAL

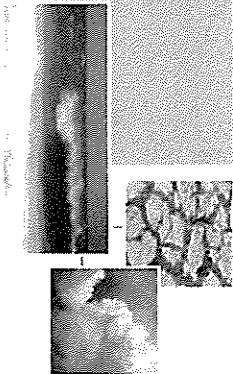
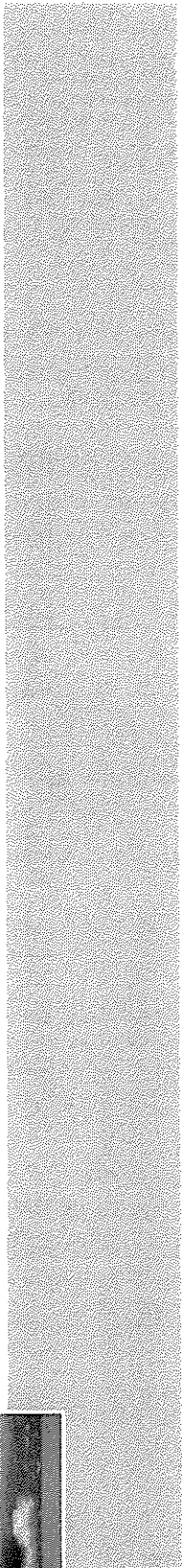
Winds	Hail	Tornado	Heavy Rain
ConvGust	CAPE-20	Str-A-850	Warm
DryGust	W8FZL	Str-C-8	RH-Avg
Downdr	FZL	Omega-	PrecipWtr
DMAPE	Updraft	Omega-	Mix ratio
DLM-8	SR-Inflow		DLM-8

Show Locations Lat & Lon Clear All Buttons

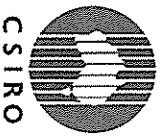
Sat 06-Mar-2010 06Z

CSIRO

Bureau of Meteorology



Can we forecast these events?



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Australian Government
Bureau of Meteorology

Melbourne Forecast

Issued at 4:20 pm EDT on Wednesday 3 March 2010

Forecast for Saturday

Cloudy. Isolated thunderstorms during the morning. Scattered showers. Winds north to northwesterly averaging up to 20 km/h becoming northwesterly up to 30 km/h during the morning.

City **Chance of storms.** Min 17 Max 21

Melbourne Forecast

Issued at 4:23 pm EDT on Thursday 4 March 2010

Forecast for Saturday

Cloudy. Scattered showers and the chance of thunderstorms. Winds north to northwesterly averaging up to 40 km/h becoming northwesterly up to 30 km/h during the morning.

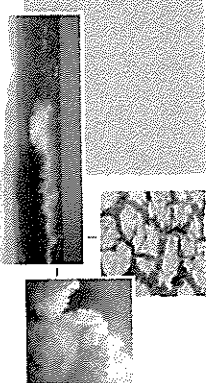
City **Chance of storms.** Showers. Min 17 Max 23

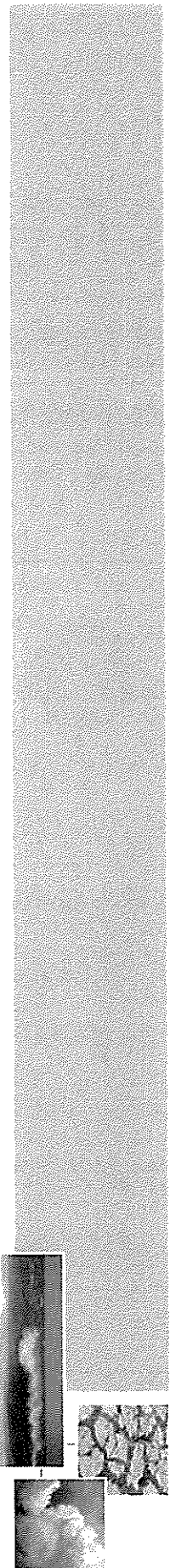


CSIRO

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Australian Government
Bureau of Meteorology





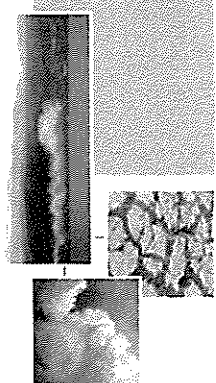
Melbourne Forecast

Issued at 4:29 pm EDT on Friday 5 March 2010

Forecast for Saturday

Local morning fog. Isolated showers and **the chance of thunderstorms**. Winds generally light and variable.

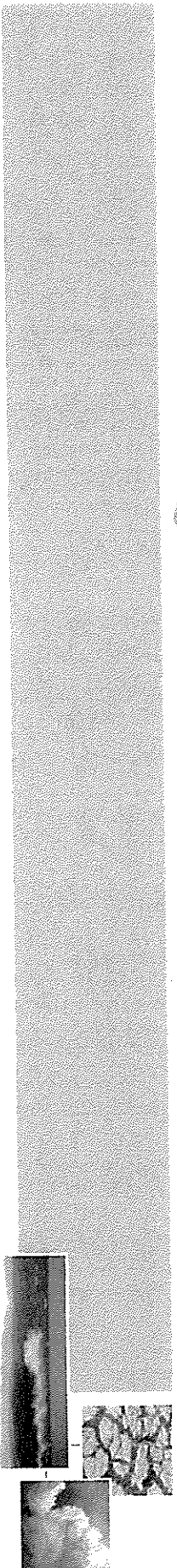
City Shower or two. Min 19 Max 25



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Bureau of Meteorology



Melbourne Forecast

Issued at 5:00 am EDT on Saturday 6 March 2010

for the period until midnight EDT Friday 12 March 2010.

Warning Summary at issue time Nil.

Forecast for the rest of Saturday

Partly cloudy. Isolated showers developing this morning **then increasing to scattered heavy showers during the afternoon with local thunderstorms.** Light winds.

City Showers. **Chance of storms.** Max 27

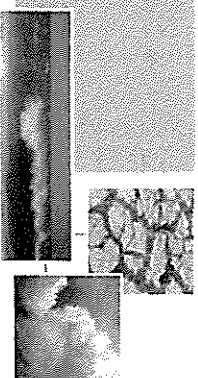


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Australian Government
Bureau of Meteorology

Forecast Guidance from the National Thunderstorm Forecast Guidance (NTFGS)



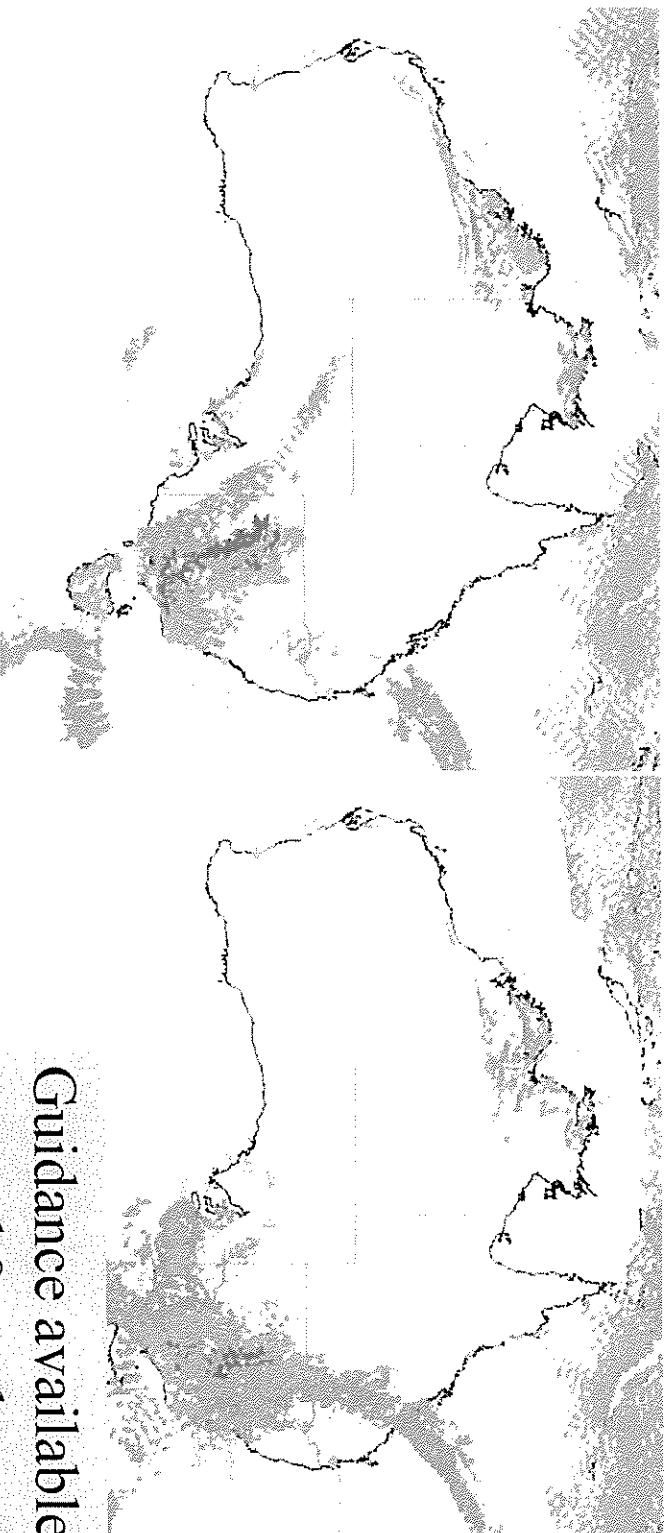
National Thunderstorm Forecasting Guidance

[View](#)
[Archive](#)

Version 2.0 Guidance [Current Model Run: 18Z-05/03/2010](#) (Previous Run)

[Saturday 6 March 2010 \(18-15Z\)](#)

[Sunday 7 March 2010 \(15-15Z\)](#)



Guidance available
around 8am that

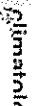
morning

■ Thunderstorm ■ Severe Convective Weather ■ Supercell

[\[MesoViewer\]](#) [\[Training\]](#) [\[FAQ\]](#) [\[Soundings\]](#) [\[Hodolool\]](#) [\[National Radar\]](#) [\[Satellite Imc\]](#)
[\[24 hr lightning probability\]](#) [\[IR/reflectivity\]](#) [\[NSW TS \(Dav1 Dav2\)\]](#) [\[N\]](#)



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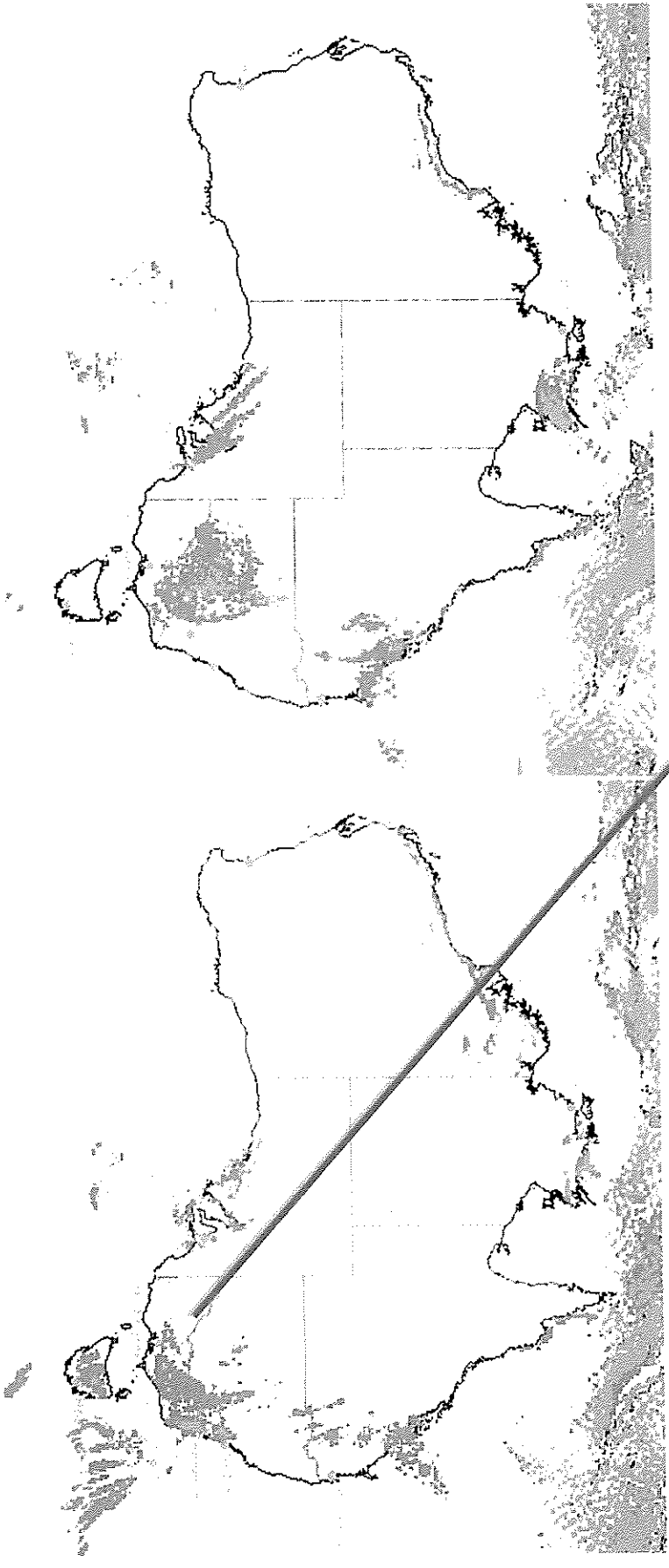

Australian Government
Bureau of Meteorology

Guidance available the preceding day (Friday morning)

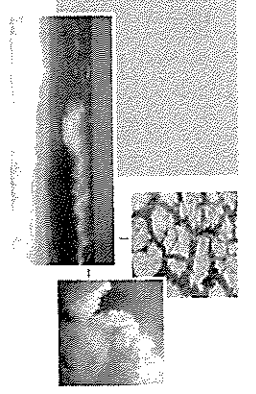
Note – No forecast of supercells on Saturday, thunderstorms only)

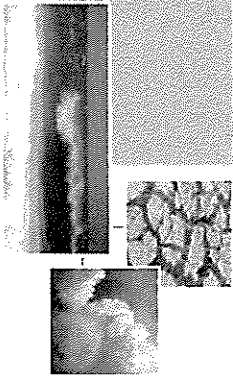
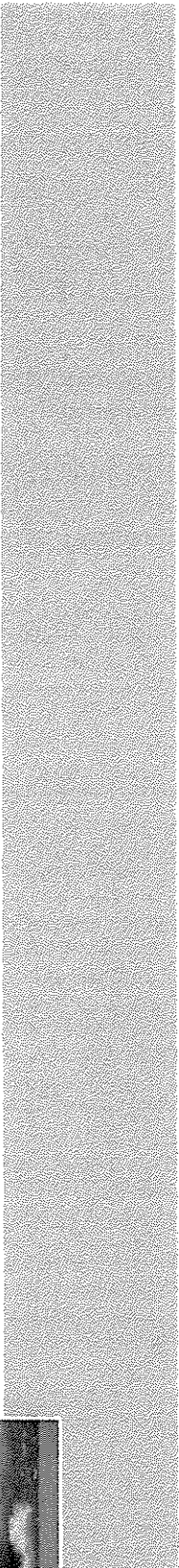
Friday 5 March 2010 [00-15Z]

Saturday 6 March 2010 [15-15Z]



Thunderstorm Severe Convective Weather Supercell Thunderstorm





So,

What has changes between the forecast from a day earlier (which does not get supercells) and the forecast that morning (supercells?)

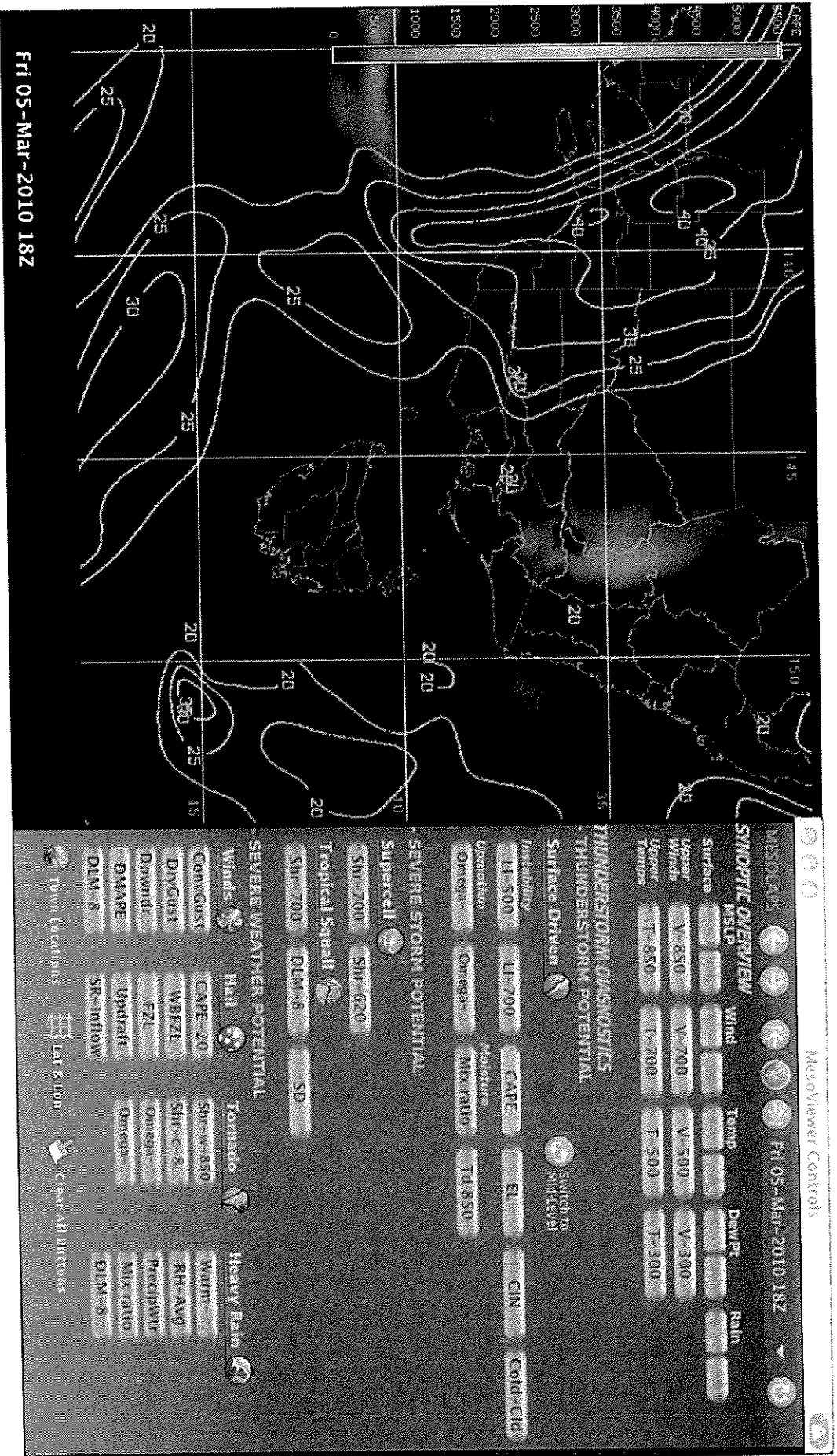


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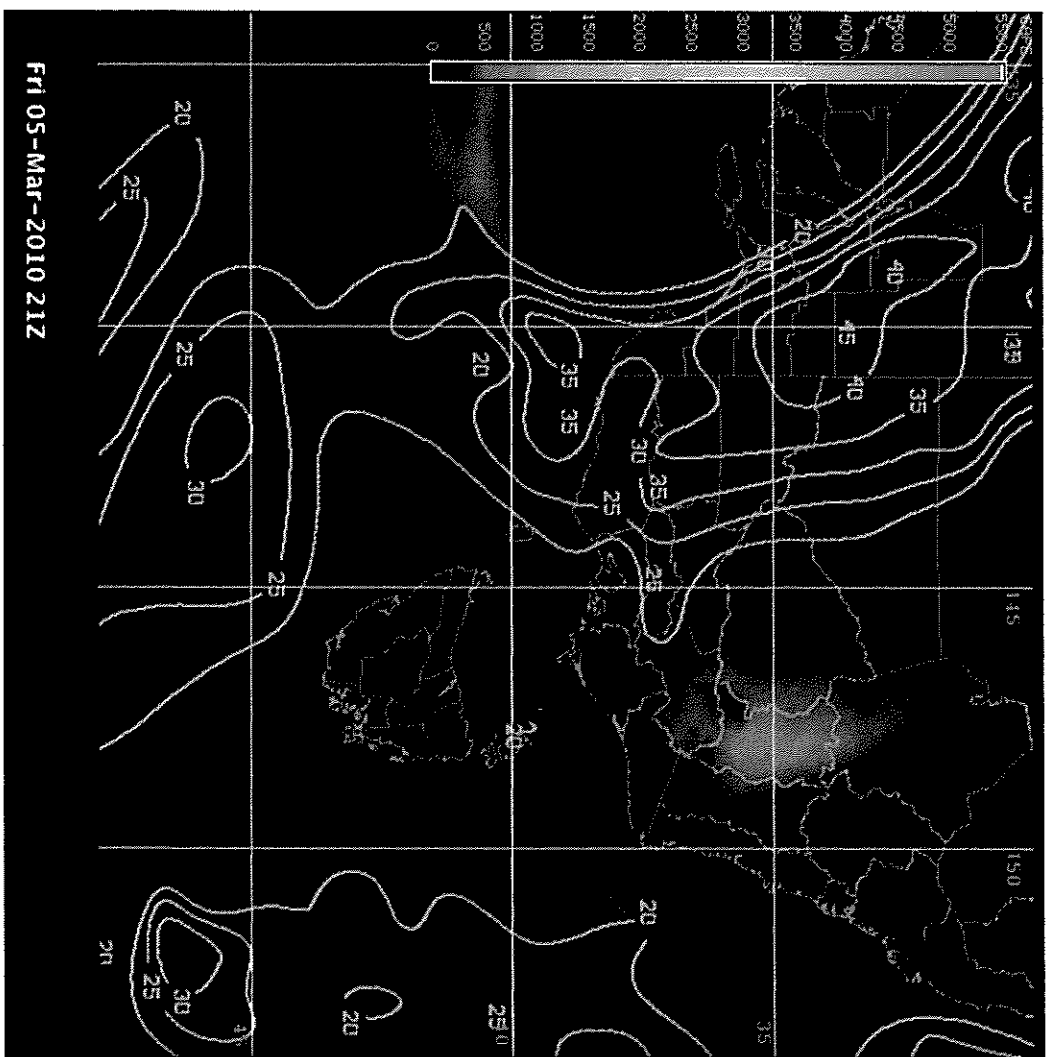
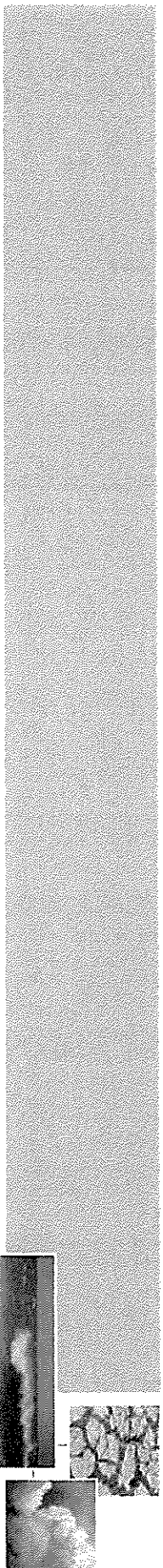


Australian Government
Bureau of Meteorology

This is previous day's run
 Low level shear and CAPE
 - NOTE shear is the same, CAPE is much smaller



Fri 05-Mar-2010 18Z



Fri 05-Mar-2010 21Z

MESOLARS Fri 05-Mar-2010 21Z

SYNOPTIC OVERVIEW

MSLP	Wind	Temp	DewPt	Rain
Surface				
Upper Winds	V-850	V-700	V-500	V-300
Upper Temps	T-850	T-700	T-500	T-300

THUNDERSTORM DIAGNOSTICS

Surface Driven Switch to Mid-Level

Instability: LI-500 LI-700 CAPE EI CIN Gold-GIB

Updation: Omega- Omega- Moisture: Mix ratio Id-850

SEVERE STORM POTENTIAL

Supercell

SIU-700 SIU-620

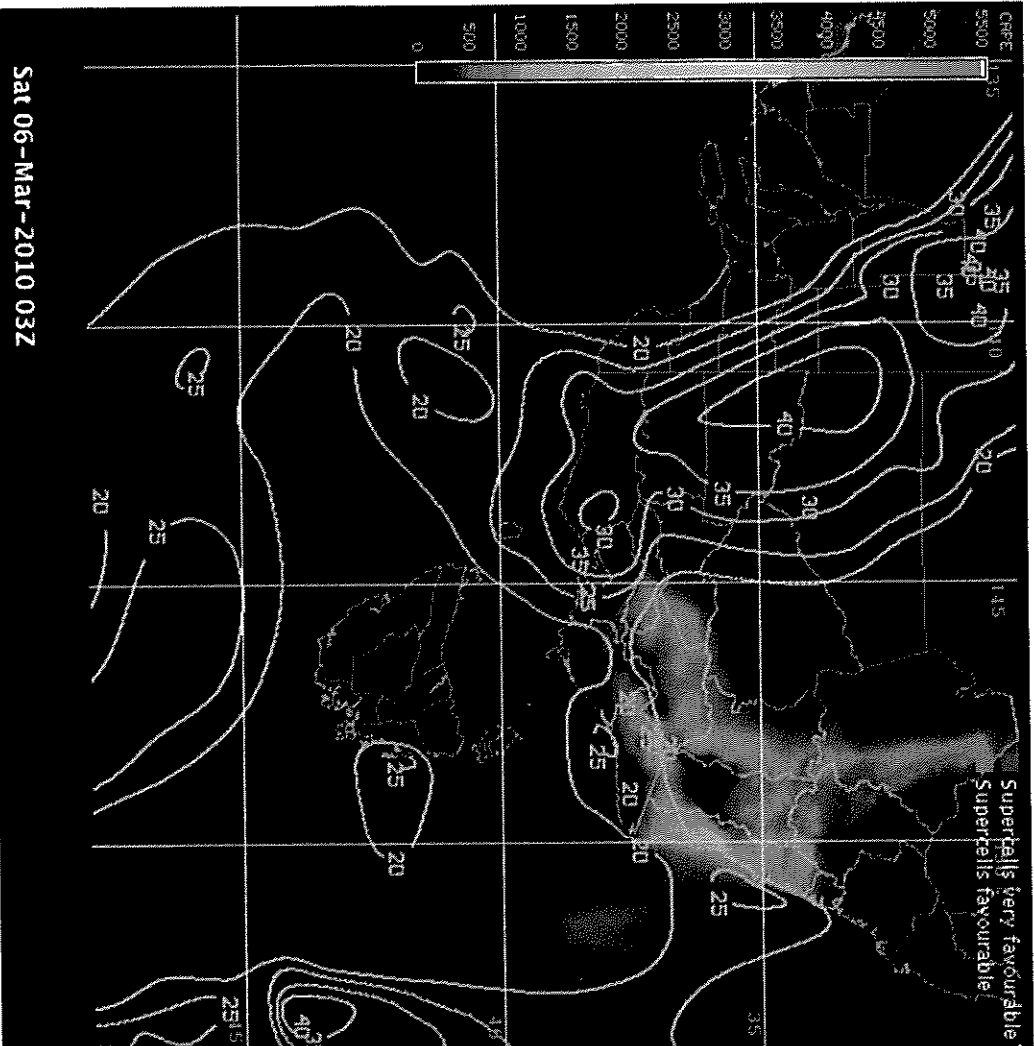
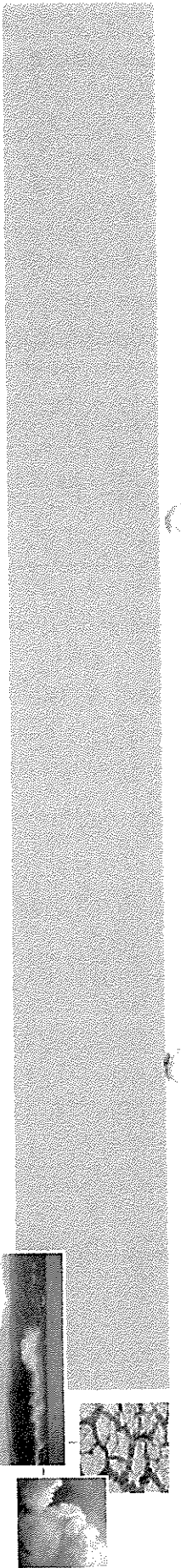
Tropical Squall

SIU-700 DLM-8 SD

SEVERE WEATHER POTENTIAL

Winds	Hail	Tornado	Heavy Rain
ConvGust	CAPE-20	SHR-850	Warm
DmgGust	WBFLZ	SHR-C-8	RH-Avg
Downdr	FZL	Omega-	PrecpWt
DMAPE	Updrift	Omega-	Mix ratio
DLM-8	SR-Inflow	DLM-8	DLM-8

Top Locations: Lat & Lon Clear All Buttons



Sat 06-Mar-2010 03Z

NASVIEWER Controls

Sat 06-Mar-2010 03Z

SYNOPTIC OVERVIEW

MSLP	Wind	Temp	Dewpt	Rain
Surface				
Upper Winds	V-550	V-200	V-500	V-300
Upper Temps	T-550	T-200	T-500	T-300

THUNDERSTORM DIAGNOSTICS

THUNDERSTORM POTENTIAL

Surface Driven Switch to Radar

Invertibility

LI-500 LI-700 CAPE EL CIN Cold-Cld

Upnocton Omega Moisture

Omega Mixratio Td 850

SEVERE WEATHER POTENTIAL

SEVERE WEATHER POTENTIAL

SR-700 SR-620

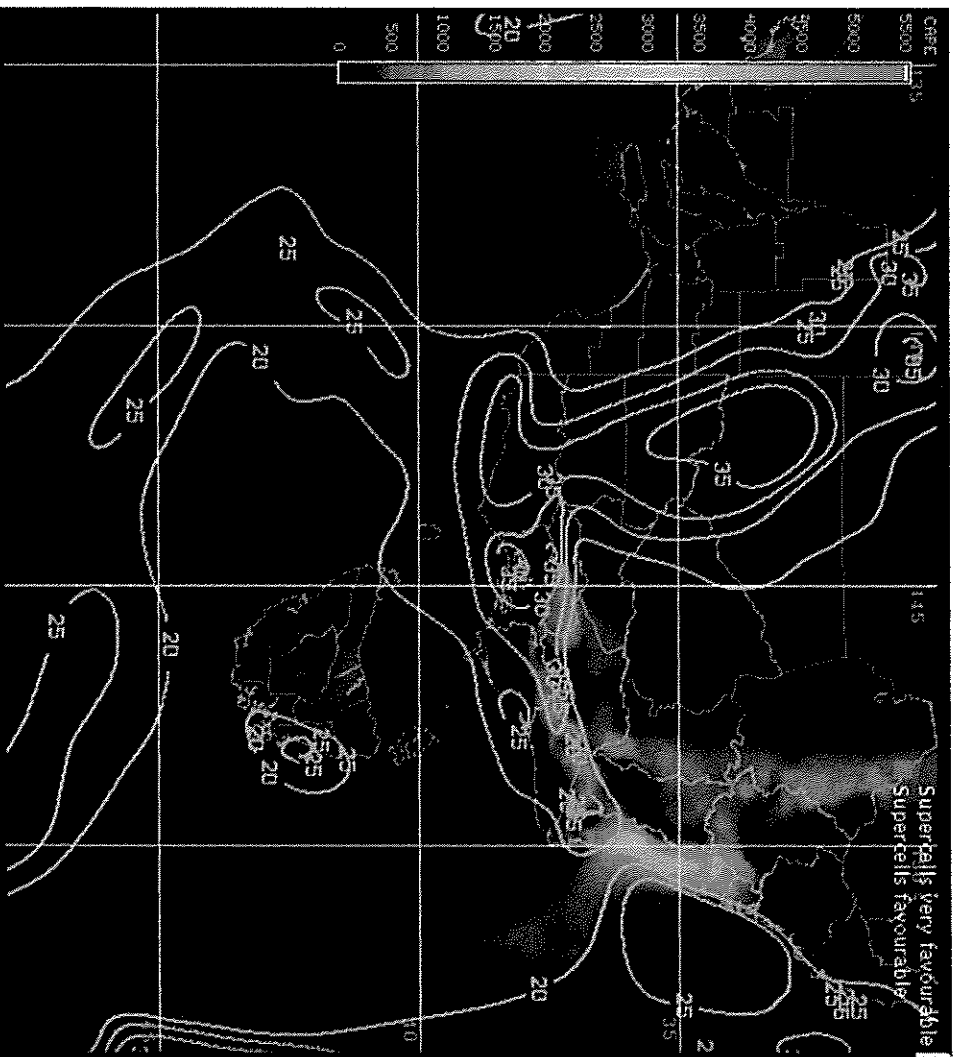
Tropical Squall DLM-8 SD

SEVERE WEATHER POTENTIAL

Winds	Hail	Tornado	Heavy Rain
CONVUST	CAPE-20	SR-W-850	Warm
Dry-Gust	WBFZL	SR-C-8	RR-Avg
Downdr	FZL	Omega	PrecipWt
DMAPE	Updraft	Omega	Mix Ratio
DLM-8	SR-Inflow		DLM-8

TOWN Locations
 LARS Light
 Clear All buttons

Nothing happens at 0300 and 0600
 The shear is the same, but the CAPE
 is weak



MesaViewer Controls

Sat 06-Mar-2010 06Z

SNOPTIC OVERVIEW

MSLP	Wind	Temp	DewPt	Rain
Surface				
Upper Winds	V-850	V-700	V-500	V-300
Upper Temps	T-850	T-700	T-500	T-300

THUNDERSTORM DIAGNOSTICS

THUNDERSTORM POTENTIAL

Surface Driven

Switch to Mid-Level

Instability

LI-500 LI-700 CAPE EI CIN Cold-Cld

Updrafts Omega- Omega- Mik-1000 TD-850

SEVERE STORM POTENTIAL

Supercell

SIT-700 SIT-620

Tropical Squall

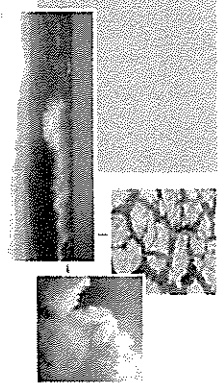
SIT-700 DLM-5 SD

SEVERE WEATHER POTENTIAL

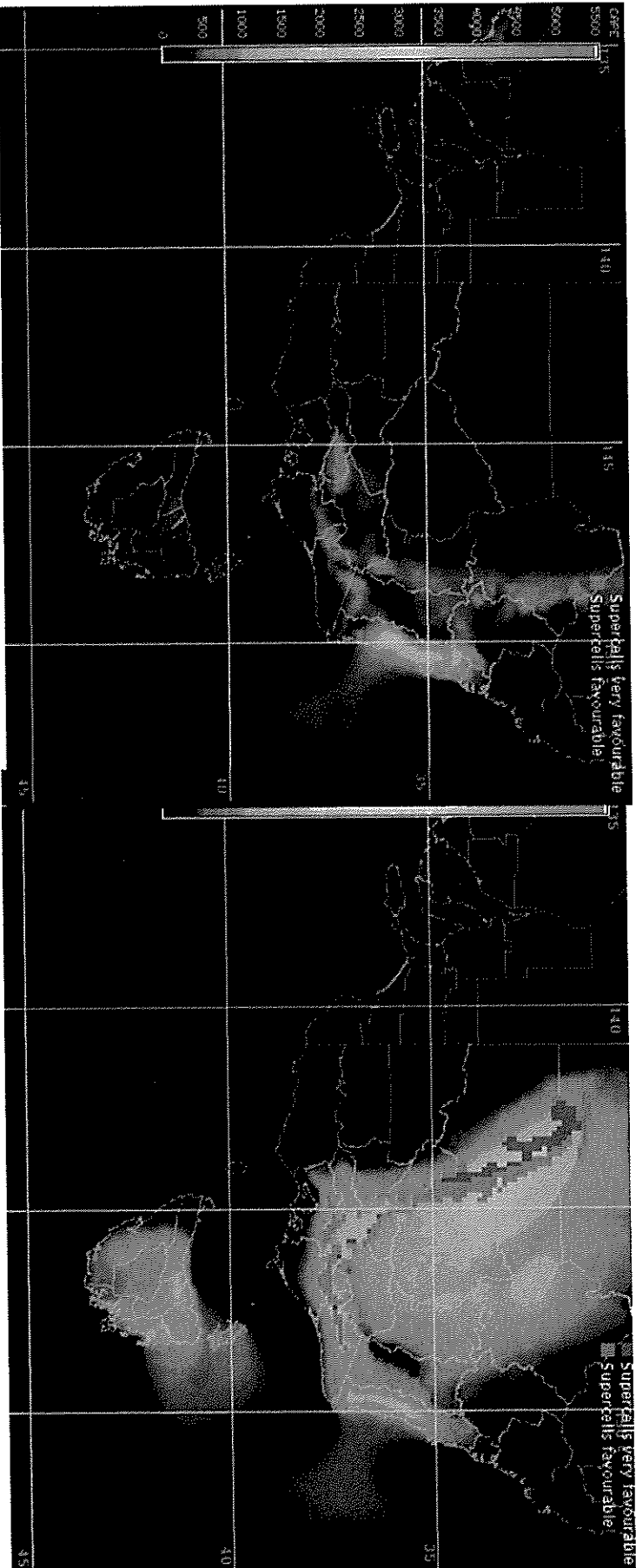
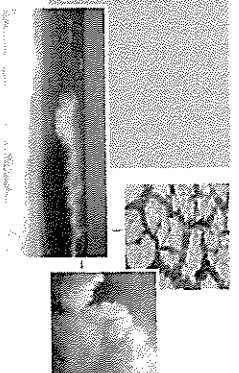
Winds	Hail	Tornado	Heavy Rain
ConvGust	CAPE-20	Shr-0-390	Warm
DryGust	WBZL	SH-C-8	RH-Avg
Downdr	FZL	Outega	PrecipYtr
DVAVE	Updraft	Omega-	Micratio
DLM-8	SR-Inflow		DLM-8

Town Locations: Lat & Lon Clear All Buttons

Sat 06-Mar-2010 06Z



CAPE differences – That morning's run versus 24 hours earlier



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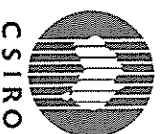
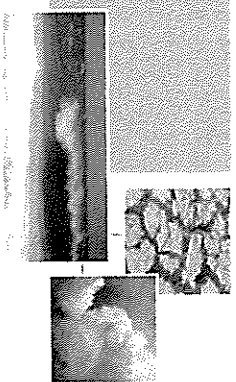
Predictability

Several days ahead could predict likelihood of thunderstorm

Prediction of major supercell/hail event was made only at about 12 hours notice

Reason for this: Dynamical fields, low-level shear, mid level uplift, upper level divergence, uplift on sea-breeze convergence all predicted well in advance

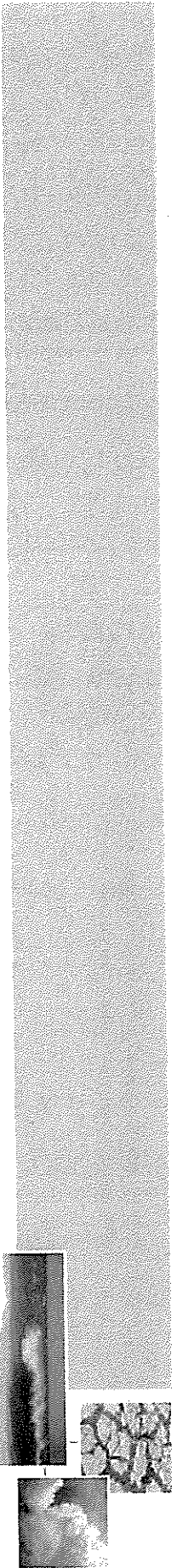
Extreme thermodynamic conditions, deep low-level moisture layer, high moisture content in boundary layer etc not simulated until 12 hours before.



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So possibly these extreme thunderstorm events cannot be predicted days in advance, as they depend on getting the boundary layer moisture correct

Well, not with the current deterministic model running the NTFGS

Since the differences would mainly have been in analysis of moisture, I doubt that ACCESS would have got it

It would be interesting to see if an Ensemble Prediction System would have picked this up.



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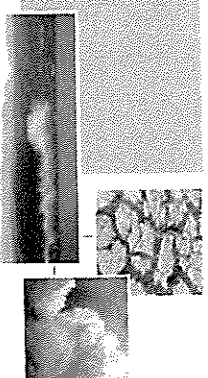


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Summary

- weak low level flow fields
- Passage of strong upper level westerly trough
 - Gave strong low level shear (rotation of updraft – supercell)
 - Gave upper level divergence (exit of jet streak)
 - Gave mid-level uplift (eastern side of trough)
- Warm easterly flow in preceding days (low freezing level, large warm-rain depth)
- Remains of large scale monsoon low (very high moisture content)

• High Instability (CAPE) and large low-level shear



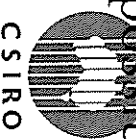
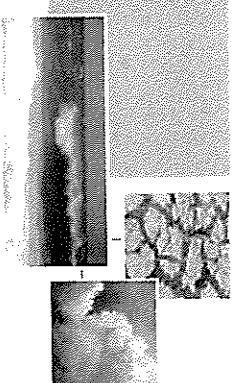
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This talk

- Will go down as a classic even (the storm, not the talk)
- Large hail to 10 cm
- Hail right across Metropolitan area (many reports have been collected)
- Terrific test-bed for radar algorithms of hail, severe storm signature et
- Showed radar sequence – very long-lived, large scale, organised supercell (with rotation, 70 dBZ echoes, hook echo, Bounded weak Echo region, and other major severe storm signatures
- Warnings
- Predictability --- Excellent diagnosis by the National Forecast Guidance System, for both prediction and understanding
- It was not forecast a day ahead --- because the low level moisture fields were not forecast (possibly not predictable)



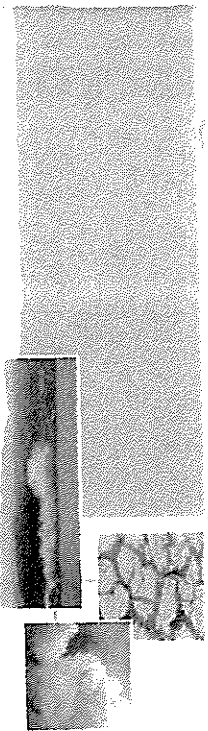
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Thank You

Questions?



The
part