N88-17617

NASA WIND SHEAR MODEL

SUMMARY OF MODEL ANALYSES

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OUTLINE

I. INTRODUCTION AND MODEL DESCRIPTION
II. MICROBURST DYNAMICS AND STRUCTURE
  A. BASELINE CASE - DENVER 30 JUNE 82 SOUNDING
  B. HIGH RESOLUTION, AXISYMMETRIC SIMULATION OF DFW MICROBURST
III. SENSITIVITY STUDIES
  A. SENSITIVITY TO ENVIRONMENT
  B. SENSITIVITY TO PRECIPITATION TYPE (i.e.,HAIL GRAUPEL, RAIN, SNOW)
  C. SENSITIVITY TO PRECIPITATION RATE
  D. SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT (i.e., DIAMETER OF DOWNDRAFT)
IV. SUMMARY AND CONCLUSIONS
V. FUTURE WORK

TERMINAL AREA SIMULATION SYSTEM (TASS)

- O TIME-DEPENDENT NEWTONIAN EQUATIONS FOR COMPRESSIBLE NONHYDROSTATIC FLUIDS

- O BOTH 3-D AND 2-D VERSIONS

  PROGNOSTIC EQUATIONS FOR 11 VARIABLES:

1. 3-COMPONENTS OF VELOCITY	5. CLOUD ICE CRYSTALS
2. PRESSURE	6. RAIN
3. TEMPERATURE	7. SNOW
4. LIQUID CLOUD DROPLETS	8. HAIL

- O SMAGORINSKY TURBULENCE CLOSURE WITH RICHARDSON NUMBER (BOUYANCY) DEPENDENCE

- O OPEN LATERAL BOUNDARY CONDITIONS

- O BULK PARAMETERIZATIONS OF CLOUD MICROPHYSICS INCLUDING: EVAPORATION OF RAIN, MELTING OF SNOW AND HAIL, SUBLIMATION OF HAIL AND SNOW, AND SUBSEQUENT LATENT HEAT EXCHANGES

- O SURFACE FRICTION LAYER BASED ON MONIN-OBUKHOV SIMILARITY THEORY

INPUT FOR AXISYMMETRIC MODEL

AMBIENT CONDITIONS

- O VERTICAL PROFILE OF AMBIENT TEMPERATURE
- O VERTICAL PROFILE OF AMBIENT HUMIDITY

TOP BOUNDARY SPECIFICATIONS (USUALLY AT 5 km AGL)

- O RADIUS OF PRECIPITATION SHAFT
- O TYPE OF PRECIPITATION AT TOP BOUNDARY (e.g., RAIN, SNOW, GRAUPEL, OR HAIL)
- O PEAK RADAR REFLECTIVITY OR MIXING RATIO OF PRECIPITATION

2-D AXISYMMETRIC SIMULATIONS

O DOMAIN SIZE 5 KM X 5 KM
O CONSTANT GRID SIZE 40 M
O MICROBURST TRIGGERED BY ALLOWING PRECIPITATION FOR FALL FROM TOP BOUNDARY
O DOWNDRAFT DEVELOPS AS RESULT OF MICROPHYSICAL COOLING AND MASS LOADING DUE TO WEIGHT OF PRECIPITATION

SENSITIVITY EXPERIMENTS

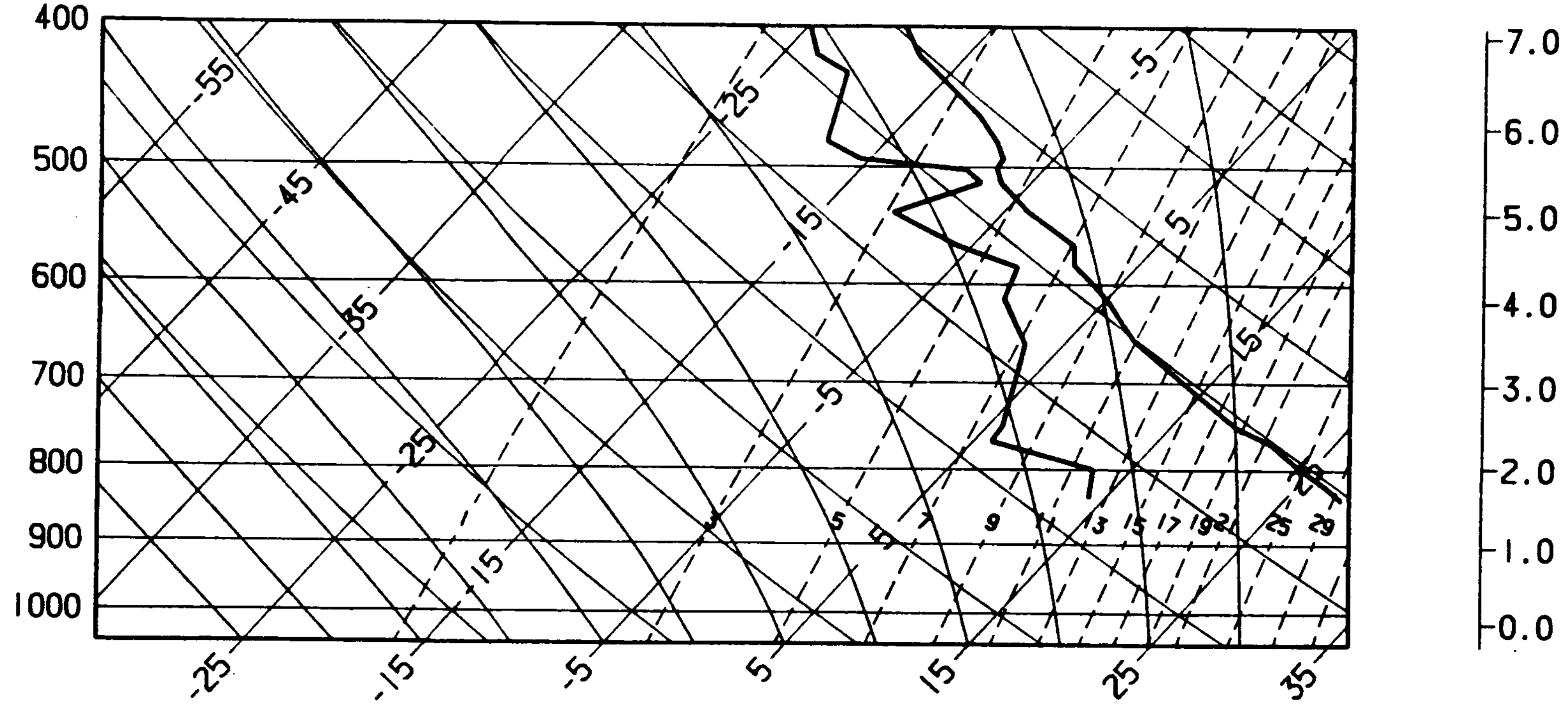
O PARAMETERS VARIED

1. ENVIRONMENTAL SOUNDING
2. TYPE OF PRECIPITATION AT TOP BOUNDARY (HAIL, GRAUPEL, RAIN ,SNOW)
3. INTENSITY OF PRECIPITATION
4. WIDTH OF PRECIPITATION SHAFT

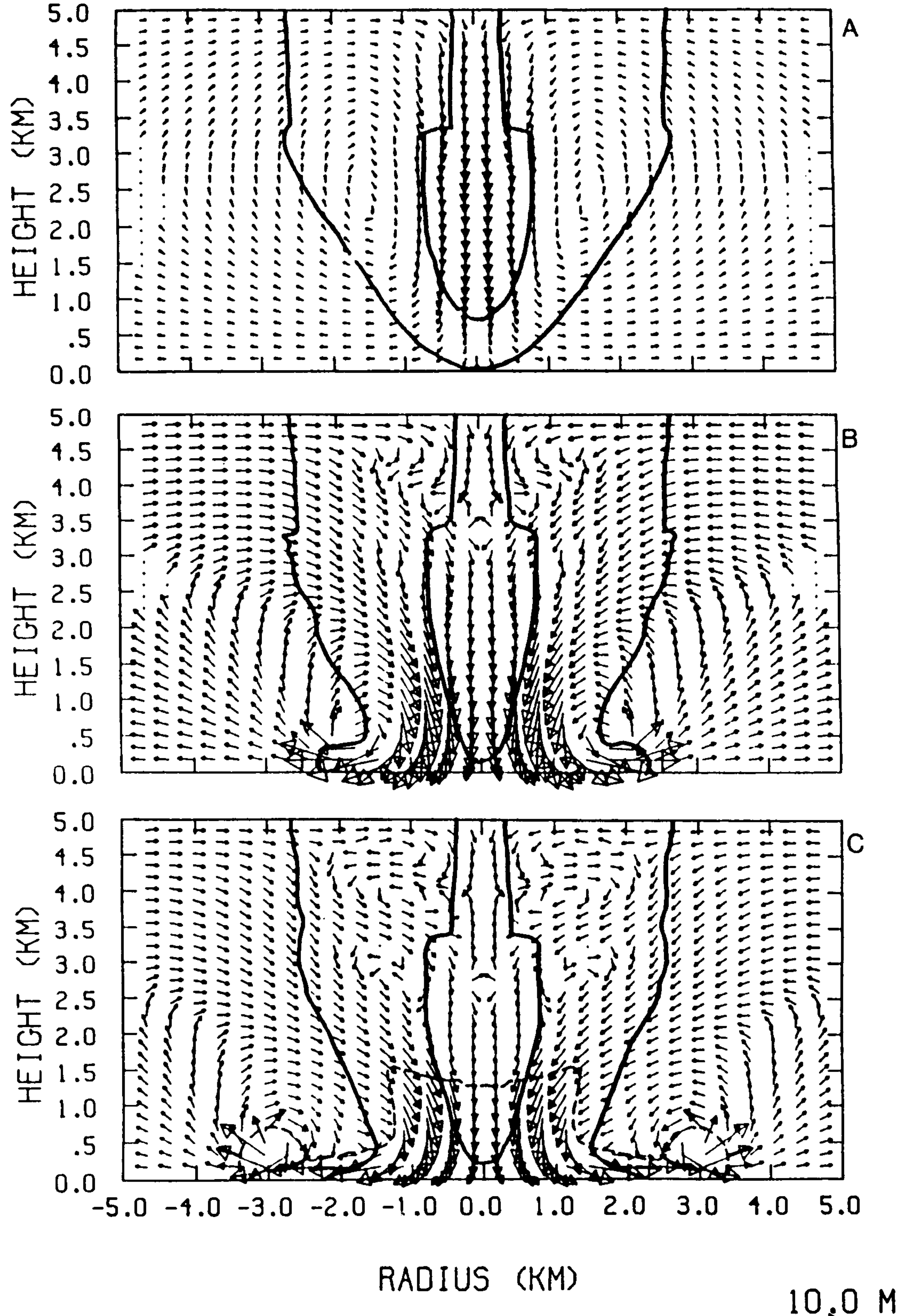
DEFINITIONS

- MICROBURST CLASSIFIED AS HAVING $\Delta U \geq 10$ M/S AND A DISTANCE BETWEEN OUTFLOW PEAKS LESS THAN 4 KM
- DRY MICROBURST VS. WET MICROBURST
  WET IF 0.01" (0.25 MM) OR MORE IS MEASURED DURING THE EVENT
- A MICROBURST MAY BE ISOLATED, OCCUR WITHIN LINES, OR CLUSTERS
- THIS STUDY WILL CONCENTRATE ON ISOLATED MICROBURST, BOTH WET AND DRY

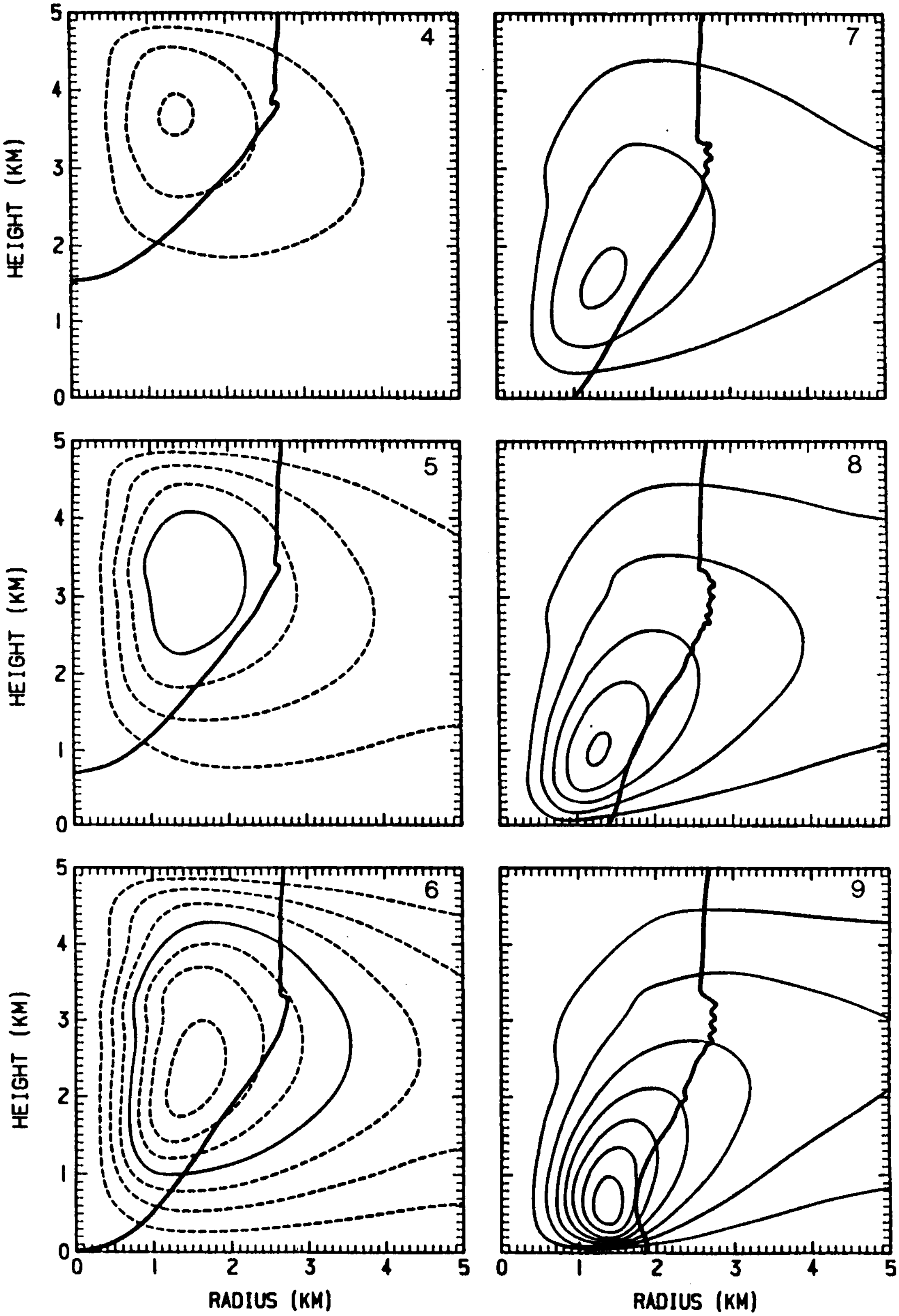
AMBIENT TEMPERATURE AND HUMIDITY PROFILES OBSERVED 2300 GMT 30 JUNE 1982 DENVER



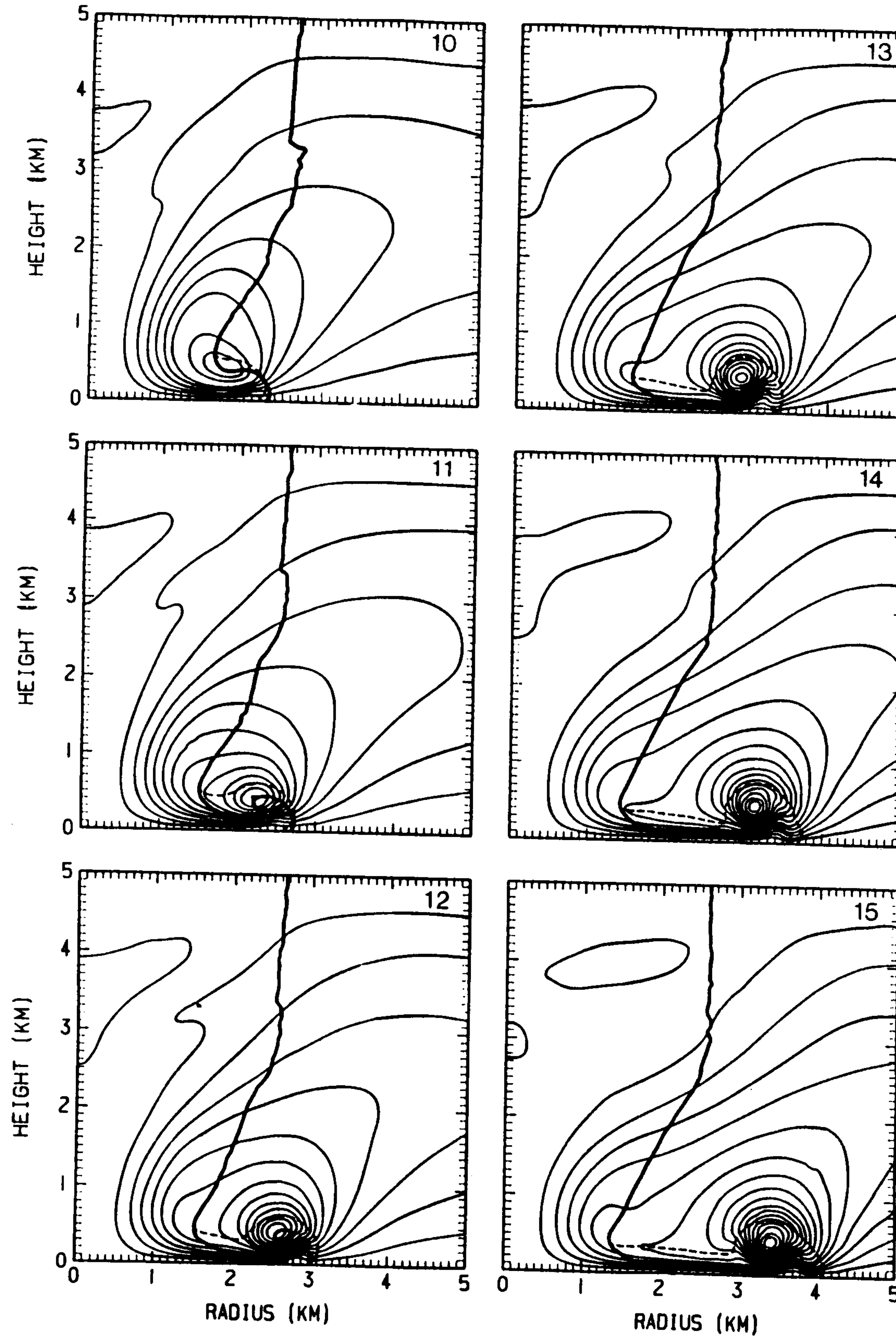
WIND VECTORS IN VERTICAL PLANE THROUGH MICROBURST CENTER FOR 30 JUNE 82 (BASELINE) SIMULATION



CROSS-SECTIONS OF STREAM FUNCTION FIELD AT 1 MIN INTERVALS FROM BASELINE SIMULATION



CROSS-SECTIONS OF STREAM FUNCTION FIELD AT 1 MIN INTERVALS FROM BASELINE SIMULATION



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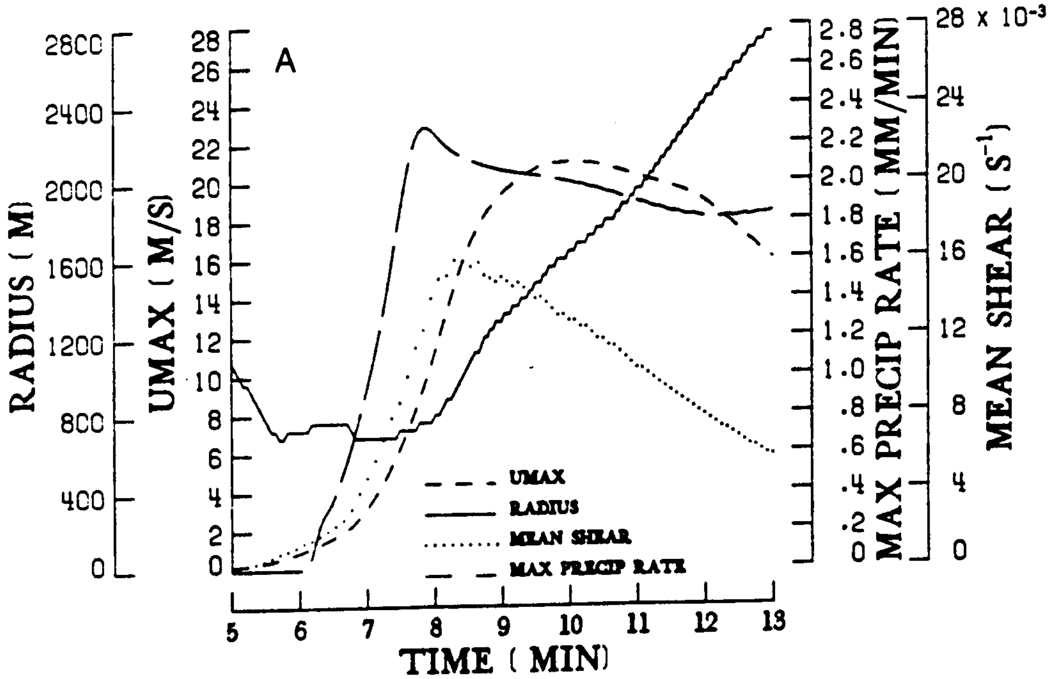
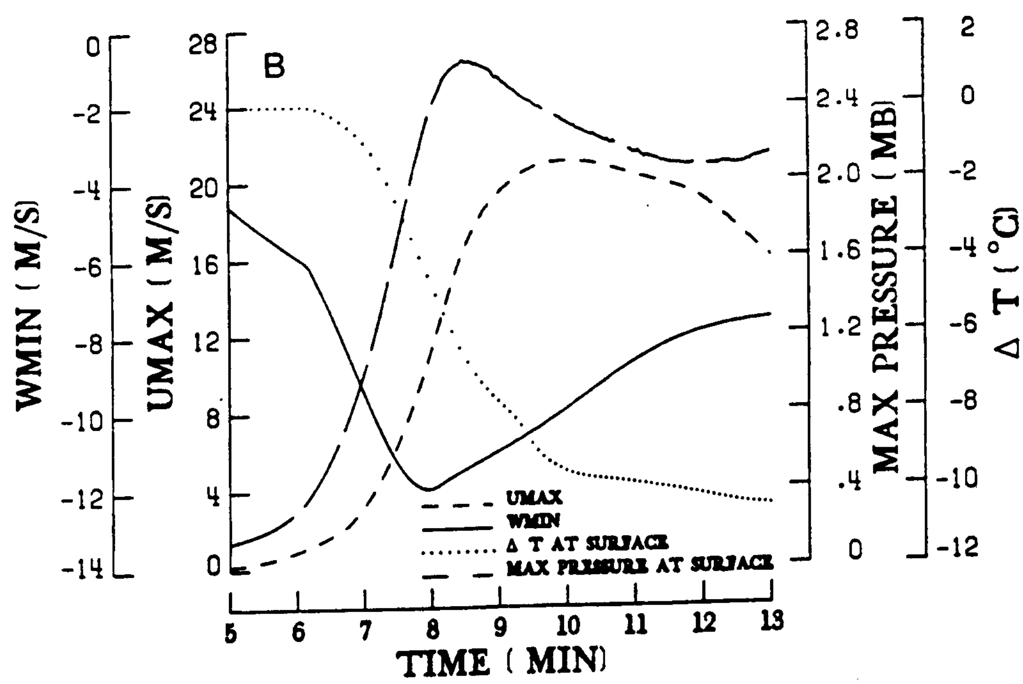
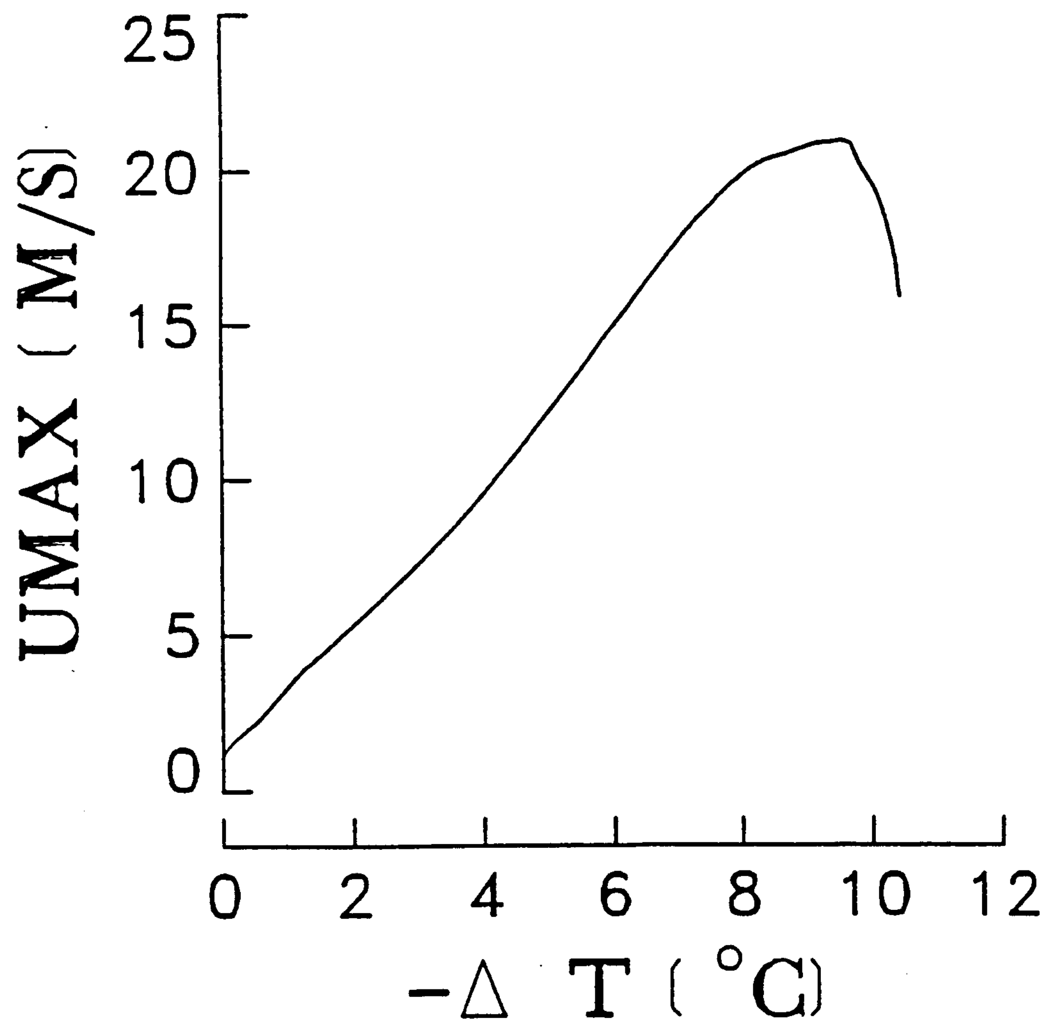
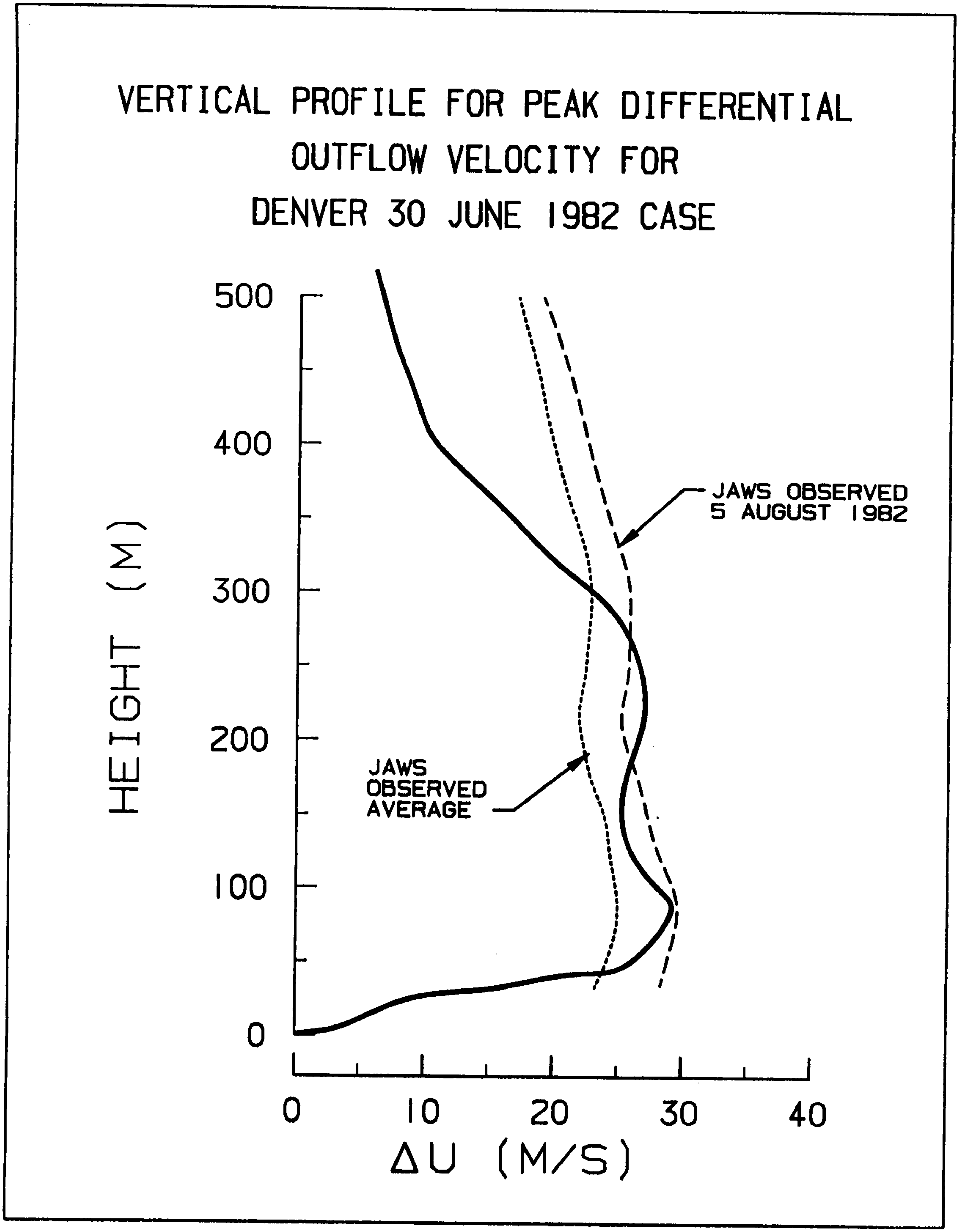
PEAK VALUES VS. TIME FOR BASELINE SIMULATION



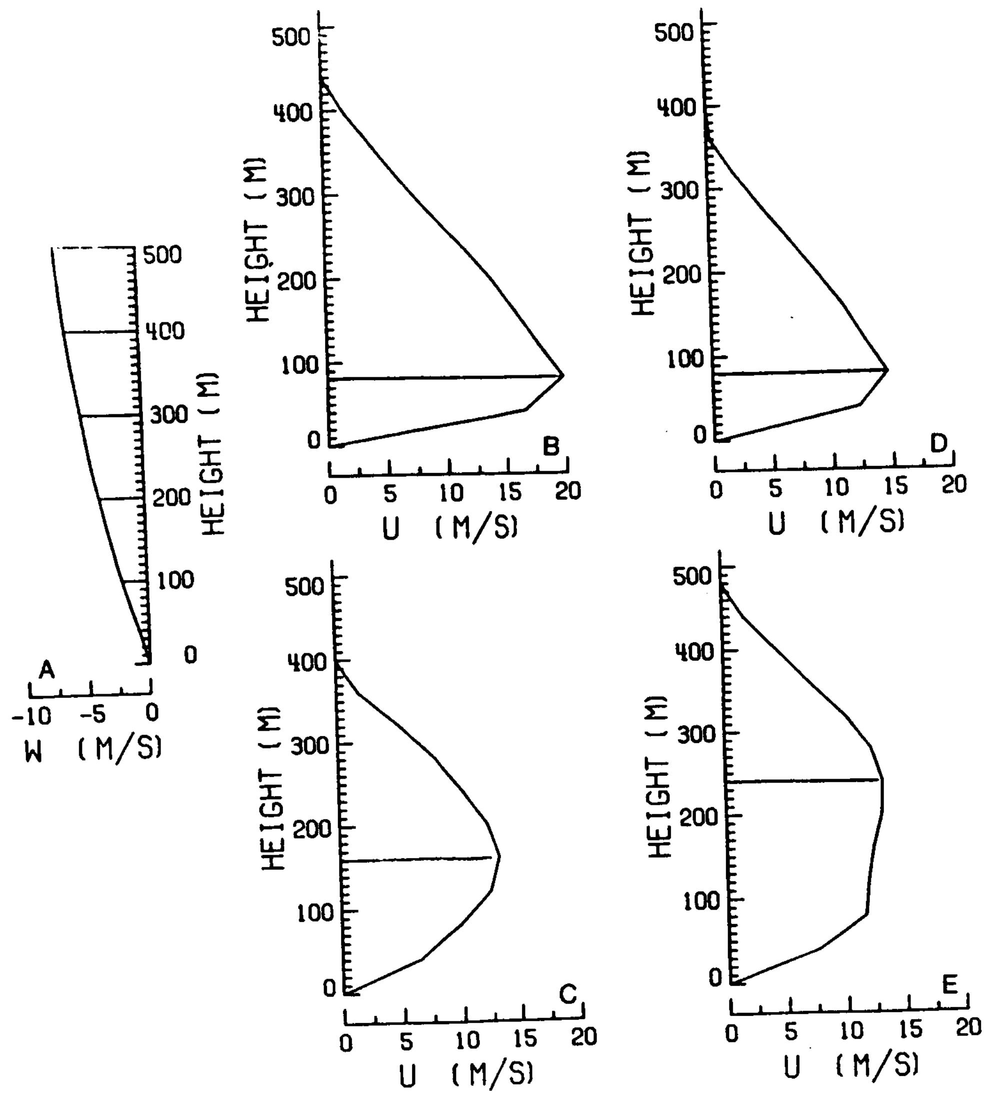


PEAK RADIAL VELOCITY VS. PEAK TEMPERATURE DROP FROM AMBIENT FOR BASELINE SIMULATION

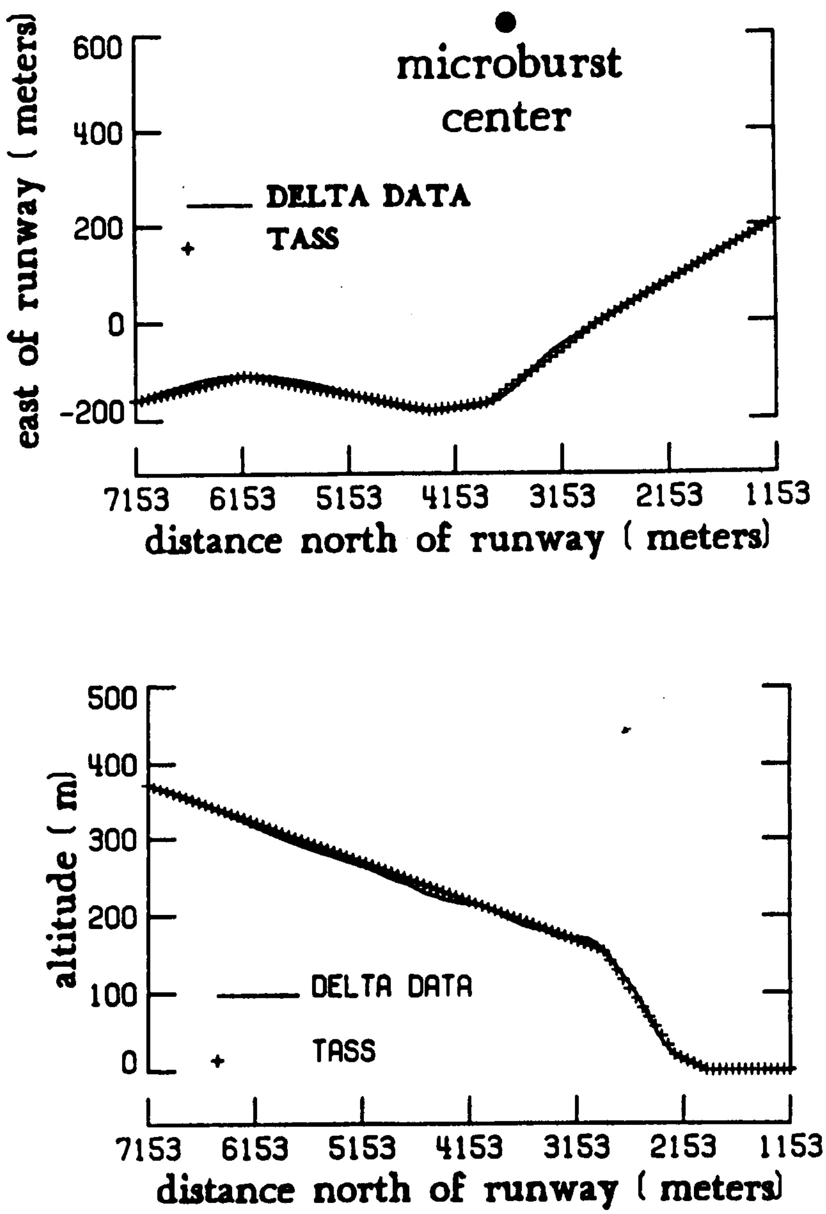



VERTICAL PROFILE FOR PEAK DIFFERENTIAL
OUTFLOW VELOCITY FOR
DENVER 30 JUNE 1982 CASE
HEIGHT (M)
500
400
300
200
100
0
JAWS OBSERVED
5 AUGUST 1982
JAWS
OBSERVED
AVERAGE
0
10
20
30
40
ΔU (M/S)

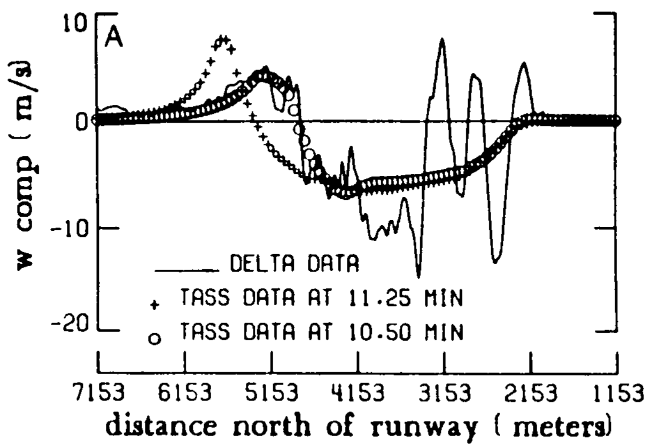
VERTICAL PROFILES FROM BASELINE SIMULATION

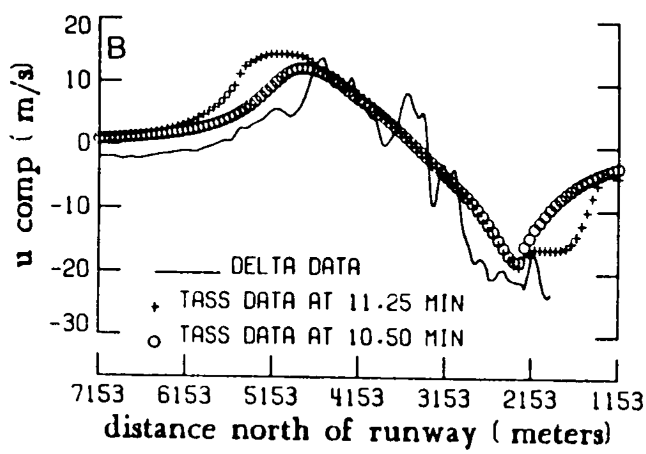


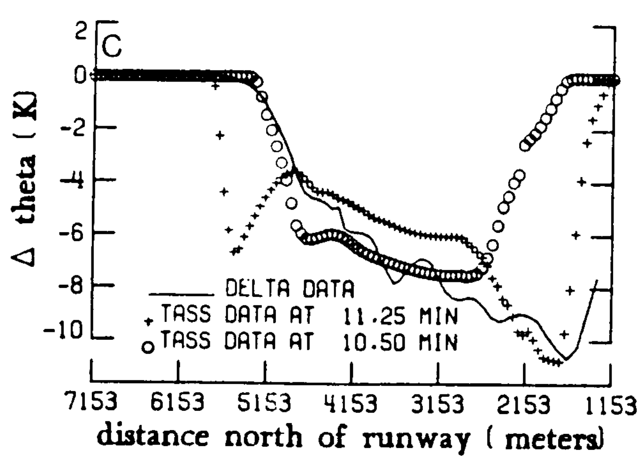
LOCATION OF DELTA 191 FLIGHT PATH AND DFW MICROBURST CENTER



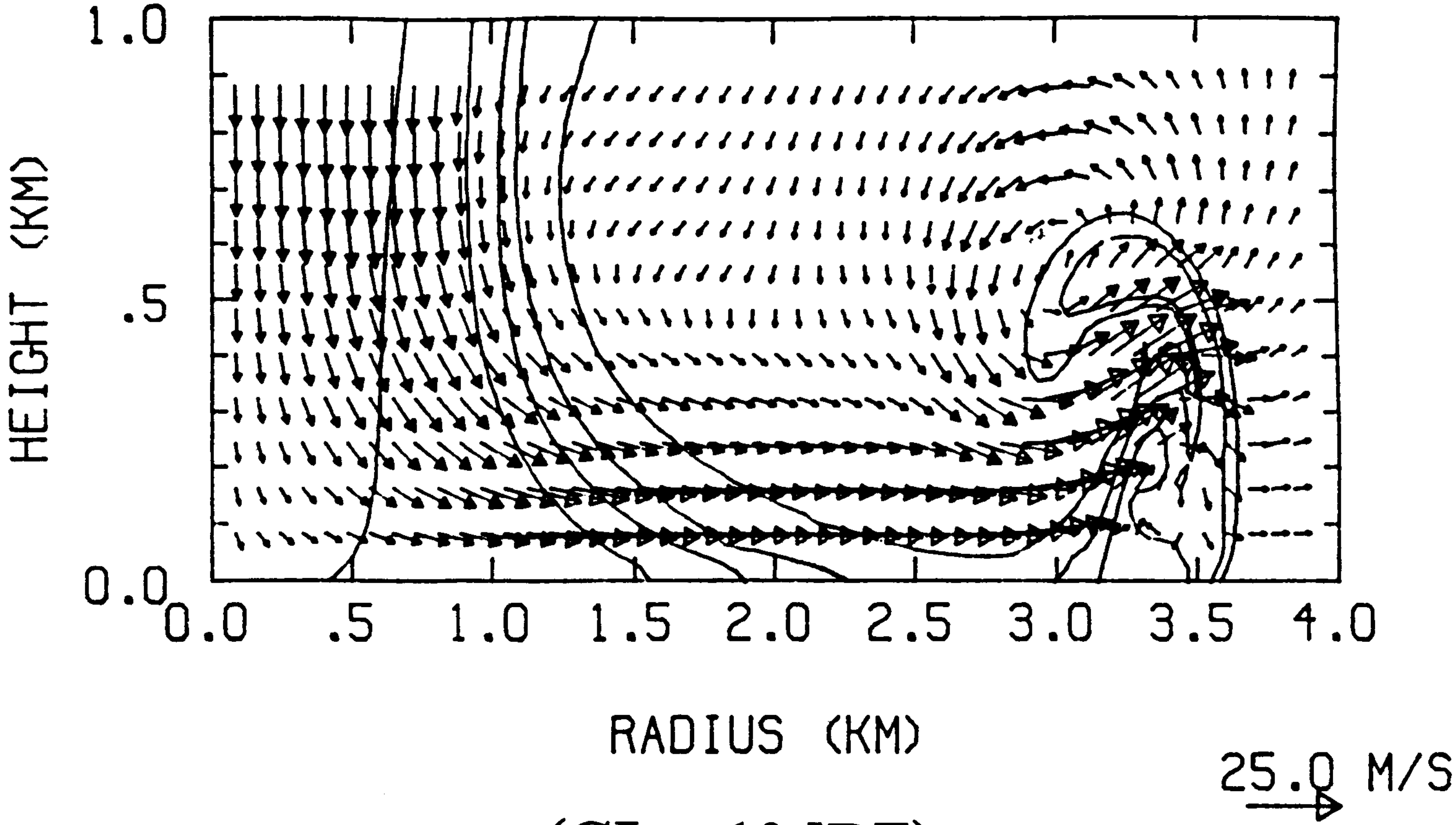
COMPARISON OF MODEL SIMULATED PROFILES AND ACTUAL PROFILES DERIVED FROM DELTA 191 FLIGHT RECORDER DATA







CROSS-SECTION OF RADAR REFLECTIVITY AND SUPERIMPOSED WIND VECTORS FOR DFW SIMULATION



(CI = 10dBZ)

SENSITIVITY EXPERIMENTS

MICROBURST SENSITIVITY TO ENVIRONMENT

KEY PARAMETERS FOR WET MICROBURST

O DEPTH OF THE MELTING LAYER (LAYER IN WHICH T > 0 deg C)

O MEAN LAPSE RATE WITHIN THE MELTING LAYER

O HUMIDITY WITHIN MELTING LAYER

INDEX FOR WET-MICROBURST POTENTIAL

$$I = \frac{\sqrt{H_M \left\{ T_S - 5.5 \times 10^{-3} H_M + \left[Q_V(1 \text{ km AGL}) - 1.5\, Q_V(H_M) \right] / 3 \right\}}}{5}$$

H_M - HEIGHT OF MELTING LEVEL (M AGL)

T_S - SURFACE TEMPERATURE (°C)

Q_V - VAPOR MIXING RATIO (G/KG)

$I > 50$	INTENSE
$45 \leq I \leq 50$	SEVERE
$36 \leq I < 45$	HAZARD
$25 \leq I < 36$	CAUTION

MODEL SIMULATION VS. INDEX FOR WET-MICROBURST POTENTIAL

SOUNDING LOCATION	SOUNDING DATE	MODELED ΔU (M/S)	I	DEPTH OF GROUND BASED ISOTHERMAL LAYER
DEN	30 JUN 82	42	37	
DEN	7 JUL 80	44	45	
DEN	14 JUL 82	43	41	
DEN	5 AUG 82	41	42	
DFW	2 AUG 85	54	54	
CHS	10 SEP 85	27	28	
DCA	4 JUL 56	23	33	
DEN	2 JUN 82	8	0	
DEN	30 JUN 82	31	29	500 M*
DEN	30 JUN 82	21	9	1000 M*

*SOUNDING ARBITRARILY MODIFIED.

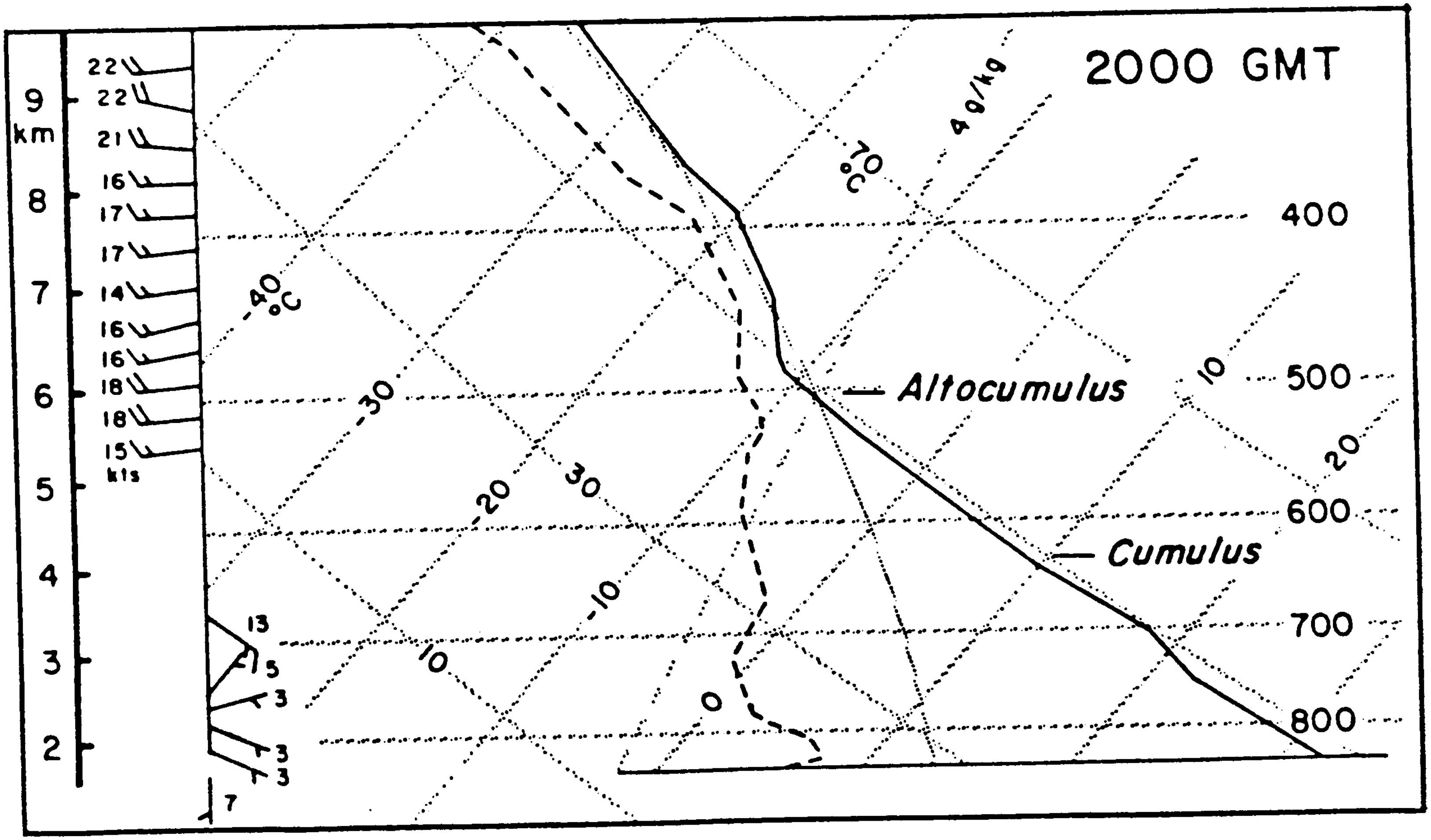
MODEL EXPERIMENTS BASED ON 61 DBZ HAILSHAFT WITH RADIUS OF 3 KM AT 5 KM AGL.

SENSITIVITY TO PRECIPITATION TYPE AT THE MODEL TOP BOUNDARY

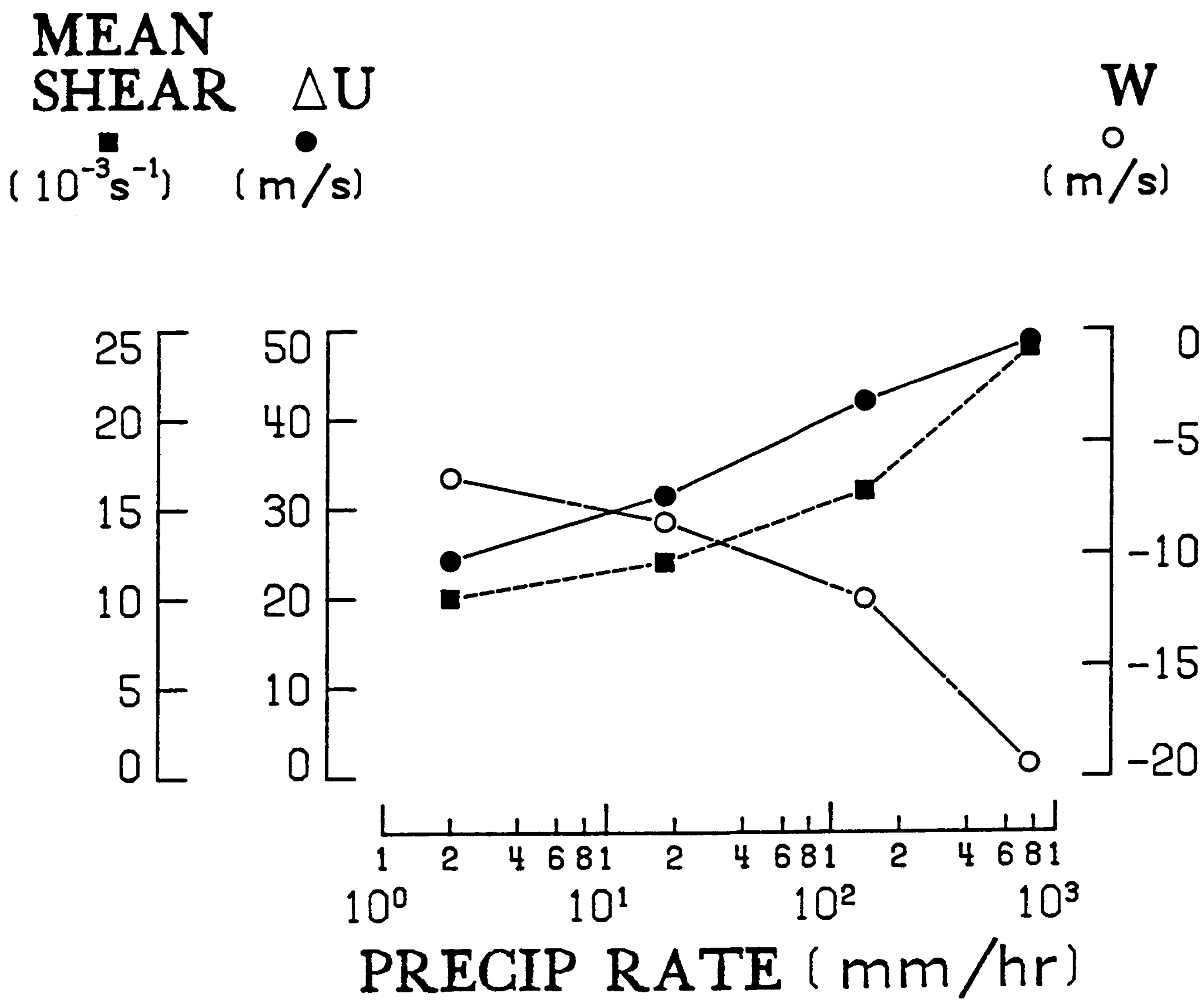
[RADIUS = 3000 M, Q(Z*) = 4.27 G KG^{-1} FOR ALL SIMULATIONS]

SOUNDING LOCATION	SOUNDING DATE	TOP BOUNDARY PRECIPITATION TYPE	ΔU (MS^{-1})	WMIN (MS^{-1})	ΔT ($^{\circ}C$)	OUTFLOW DEPTH (M)
DEN	30 JUN 82	HAIL	42	-12	-11	450
DEN	30 JUN 82	GRAUPEL	40	-15	-9	450
DEN	30 JUN 82	RAIN	34	-13	-8	400
DEN	30 JUN 82	SNOW	23	-13	-3	300
DEN	14 JUL 82	HAIL	43	-18	-13	475
DEN	14 JUL 82	SNOW	54	-31	-6	350

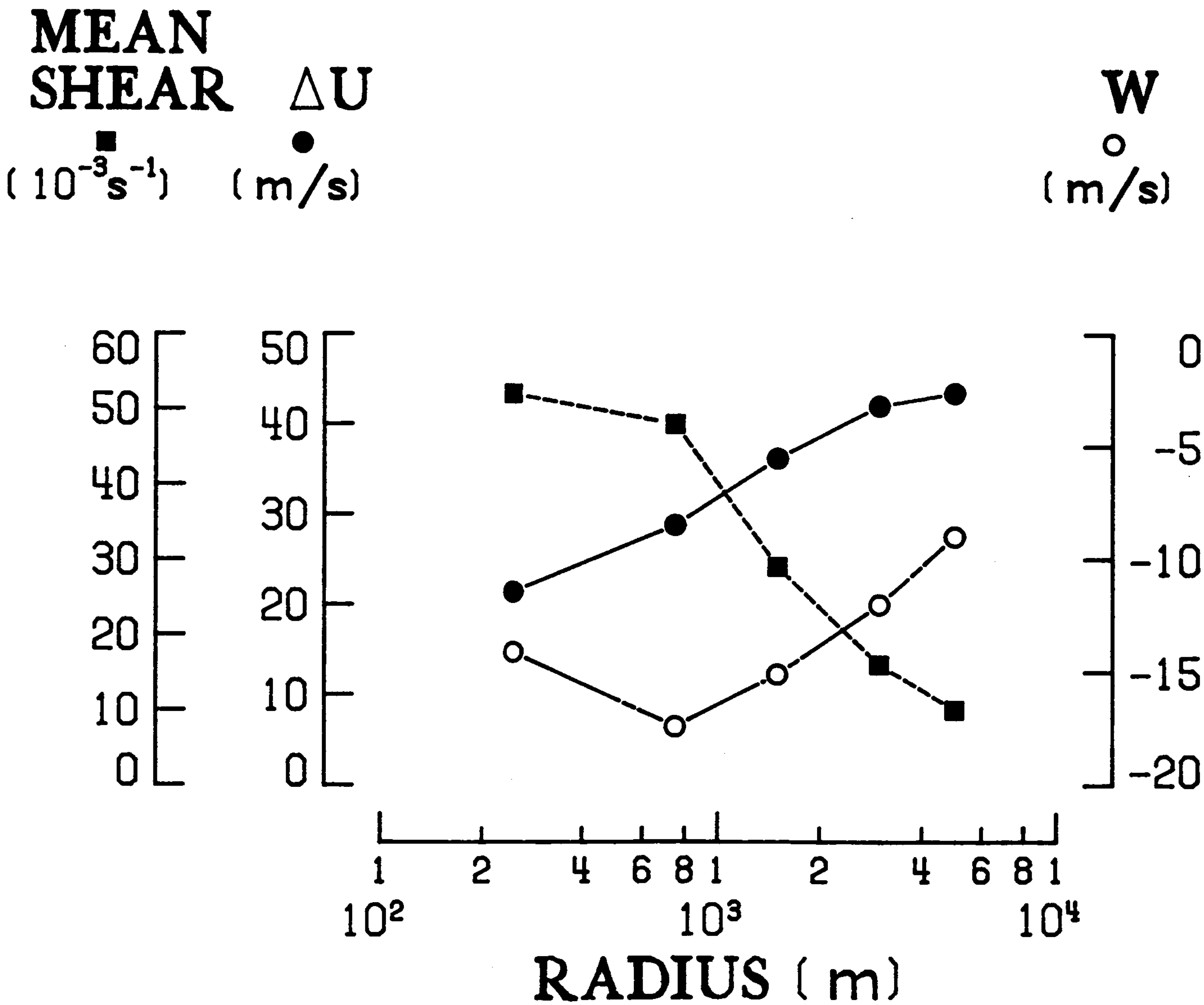
AMBIENT ENVIRONMENT OBSERVED 14 JULY 1982
DENVER – TYPICAL DRY MICROBURST SOUNDING



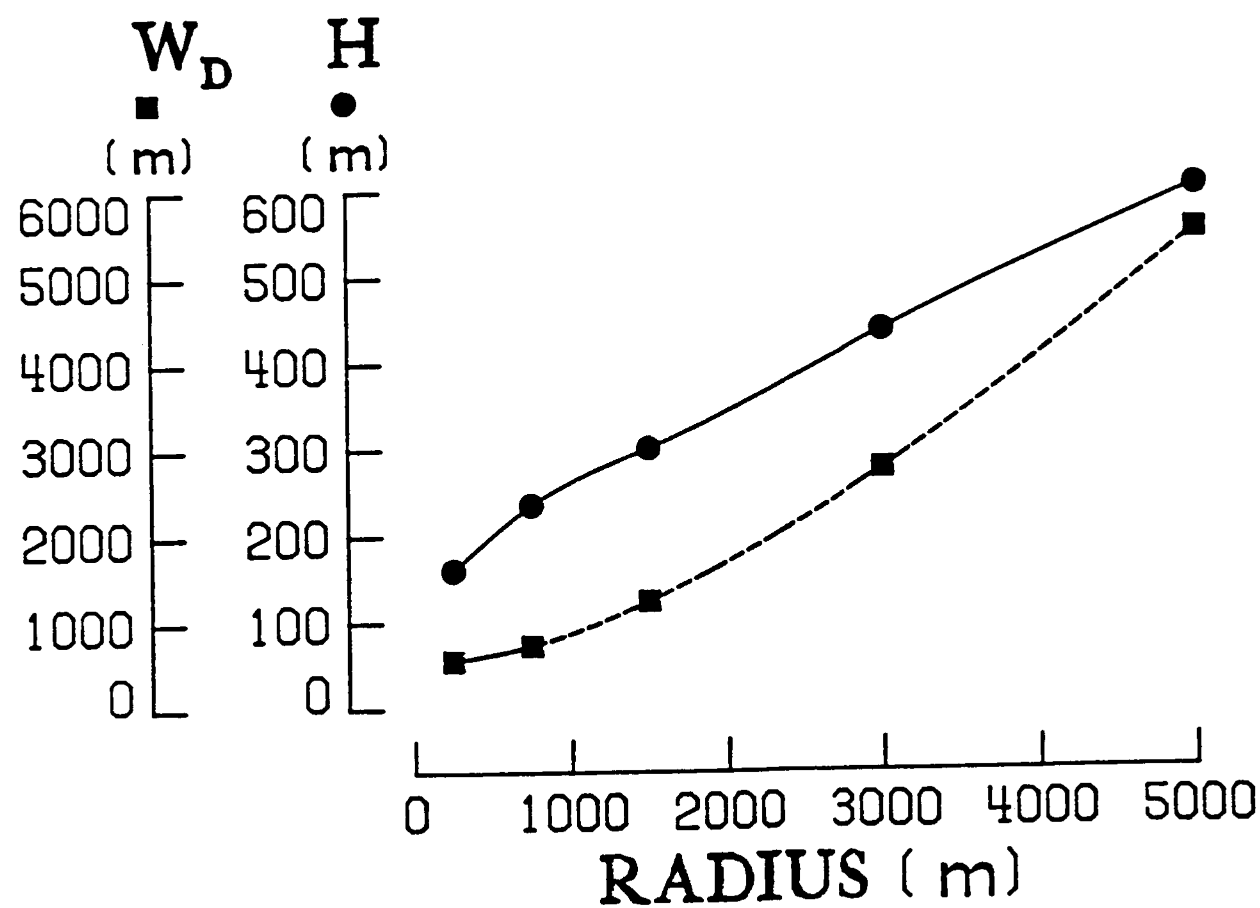
BASELINE MICROBURST SENSITIVITY TO PEAK PRECIPITATION RATE AT GROUND



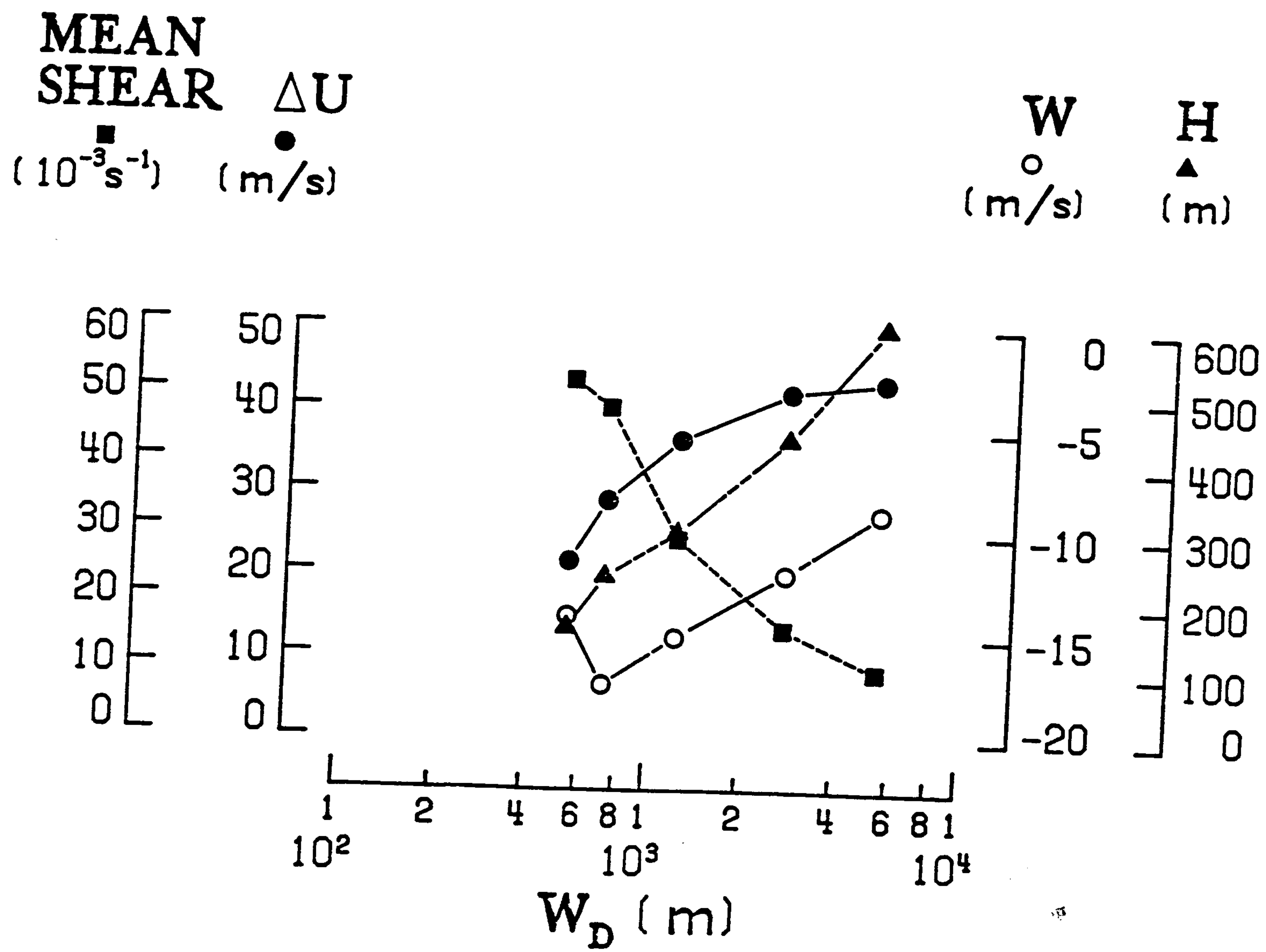
BASELINE MICROBURST SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT (AT 5KM AGL)

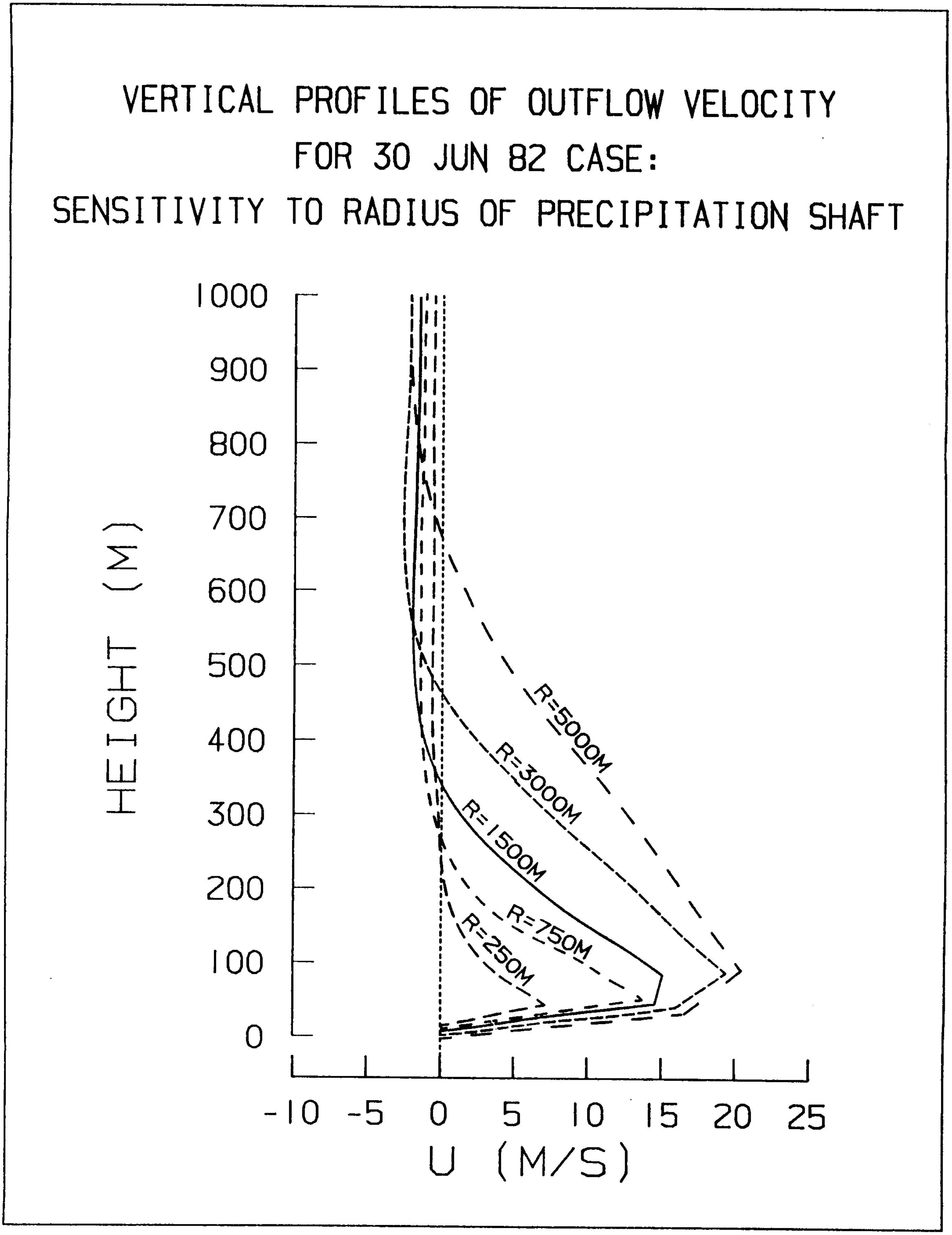


RELATION BETWEEN RADIUS OF PRECIPITATION SHAFT, DOWNDRAFT DIAMETER (WD), AND MEAN DEPTH OF OUTFLOW (H)

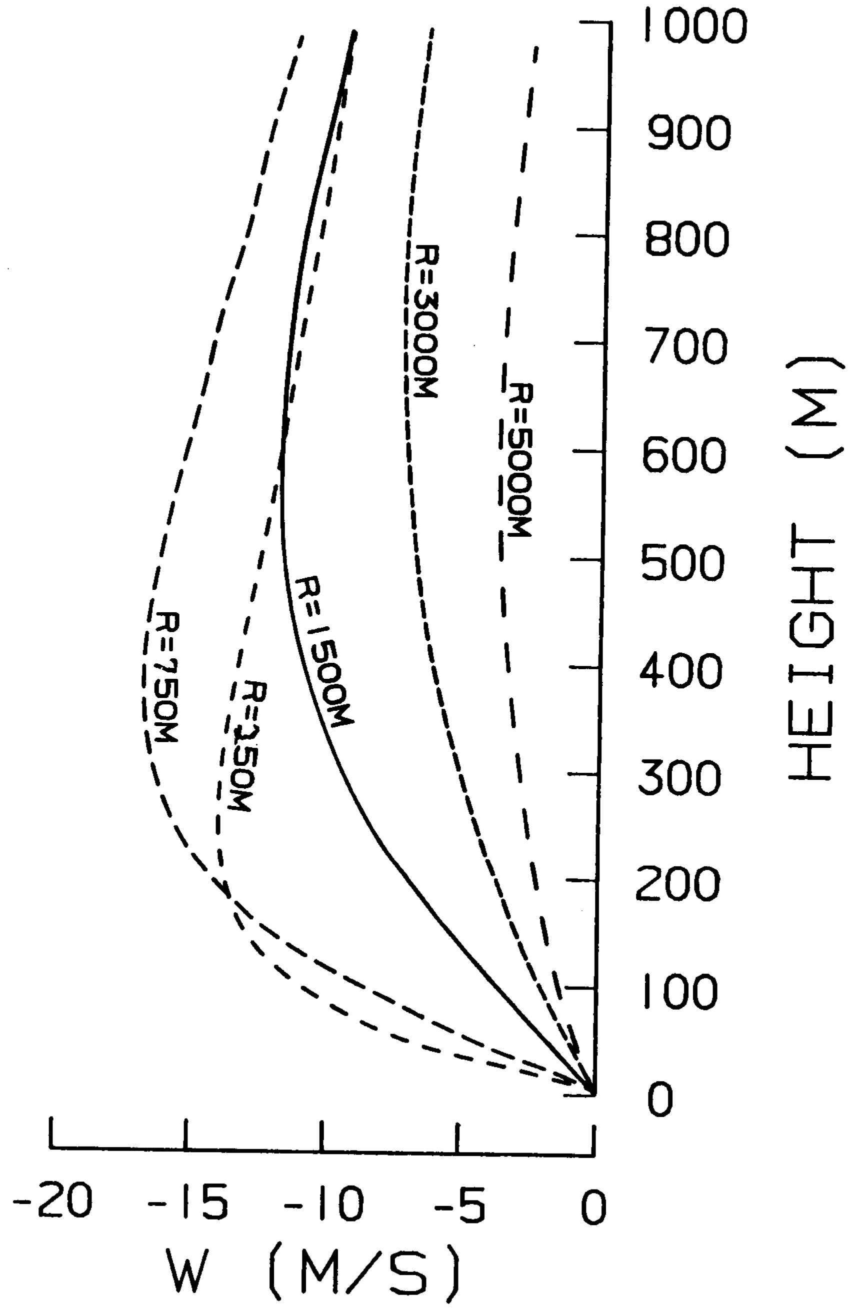


BASELINE MICROBURST SENSITIVITY TO DIAMETER OF DOWNDRAFT

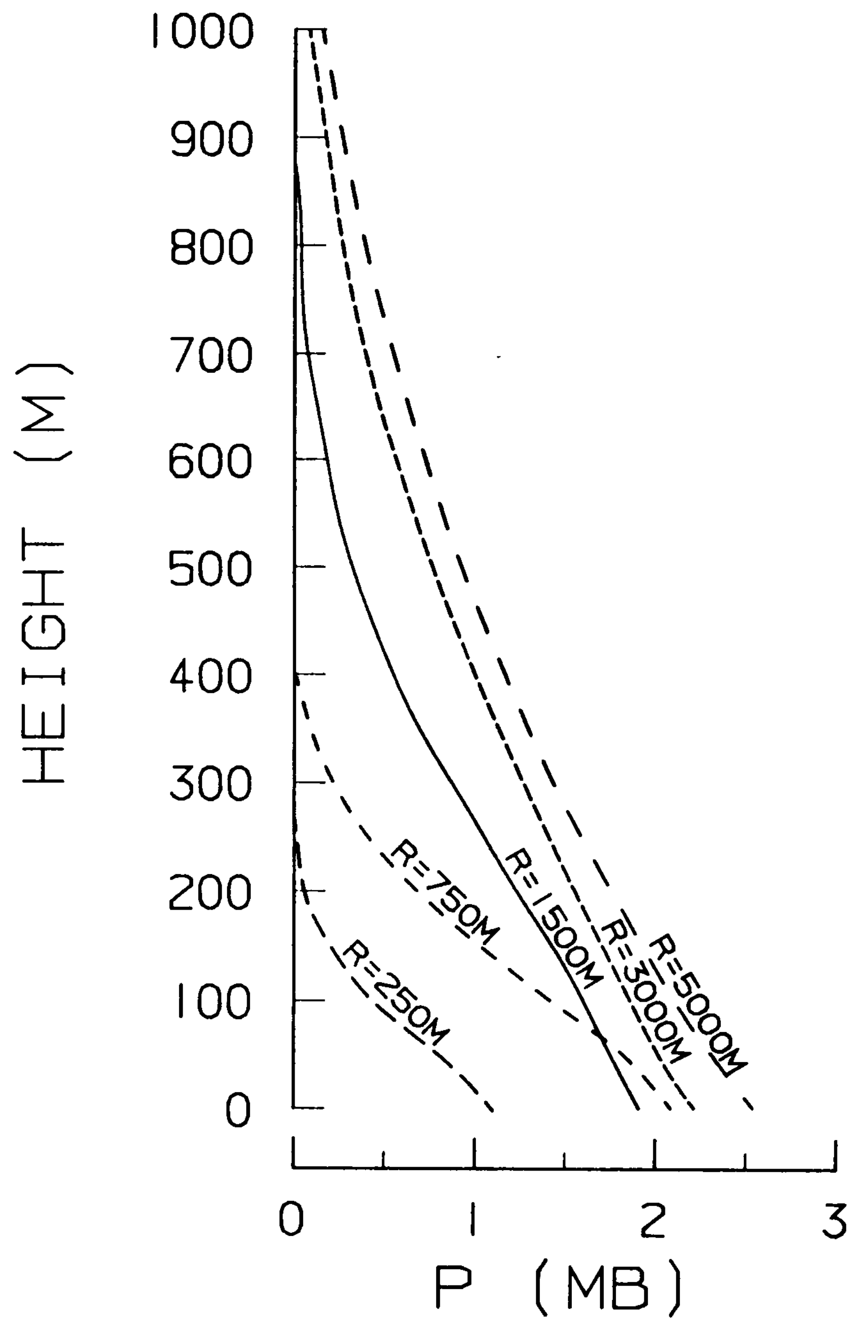



VERTICAL PROFILES OF OUTFLOW VELOCITY
FOR 30 JUN 82 CASE:
SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT
HEIGHT (M)
1000
900
800
700
600
500
400
300
200
100
0
-10
-5
0
5
10
15
20
25
U (M/S)
R=5000M
R=3000M
R=1500M
R=750M
R=250M

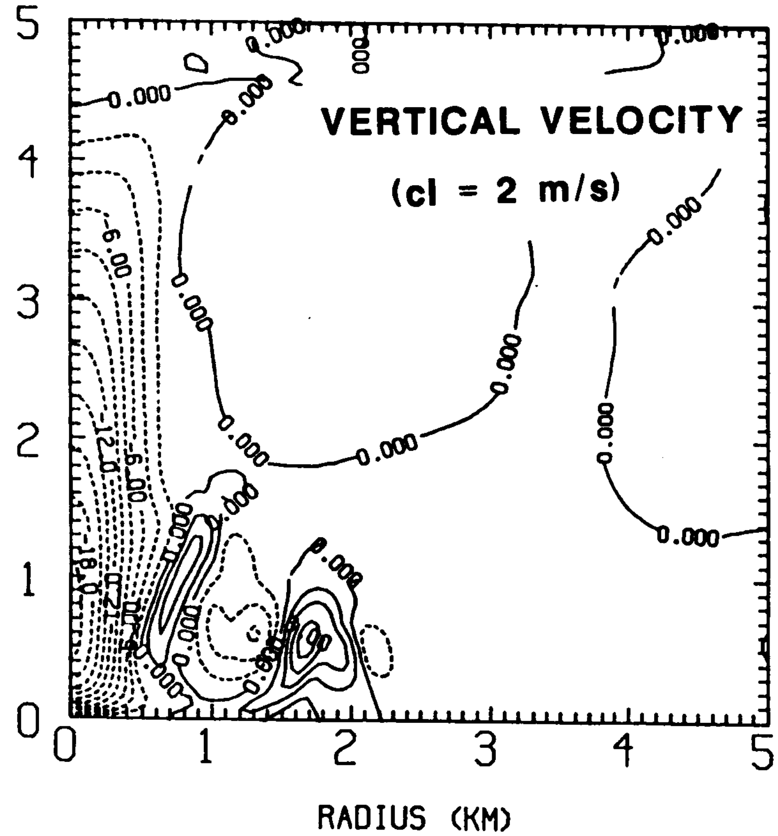
VERTICAL PROFILES OF VERTICAL VELOCITY FOR 30 JUN 82 CASE: SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT

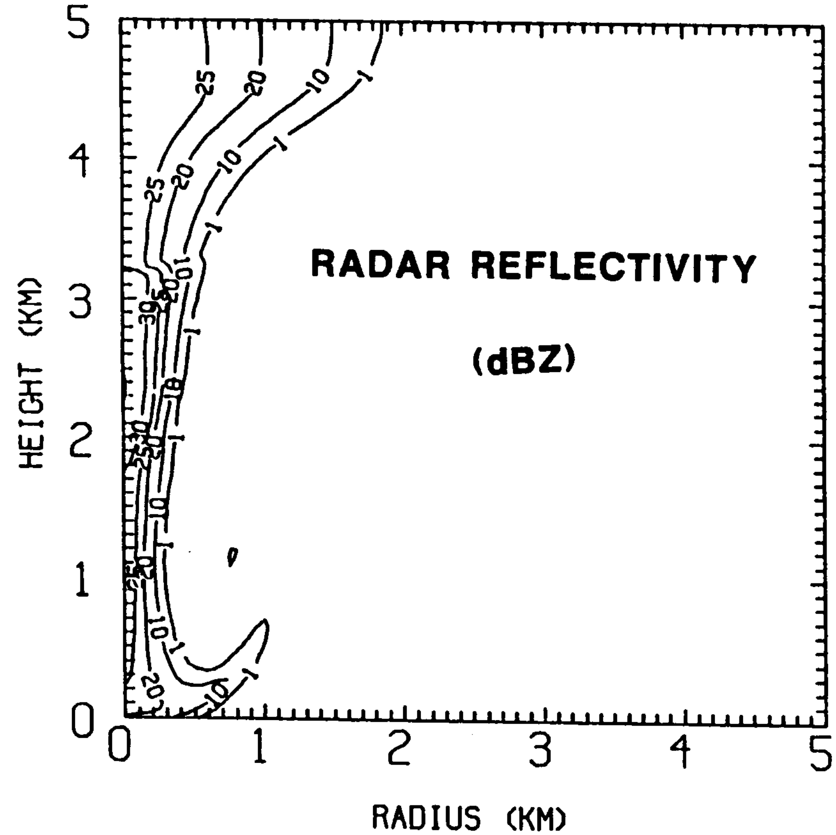


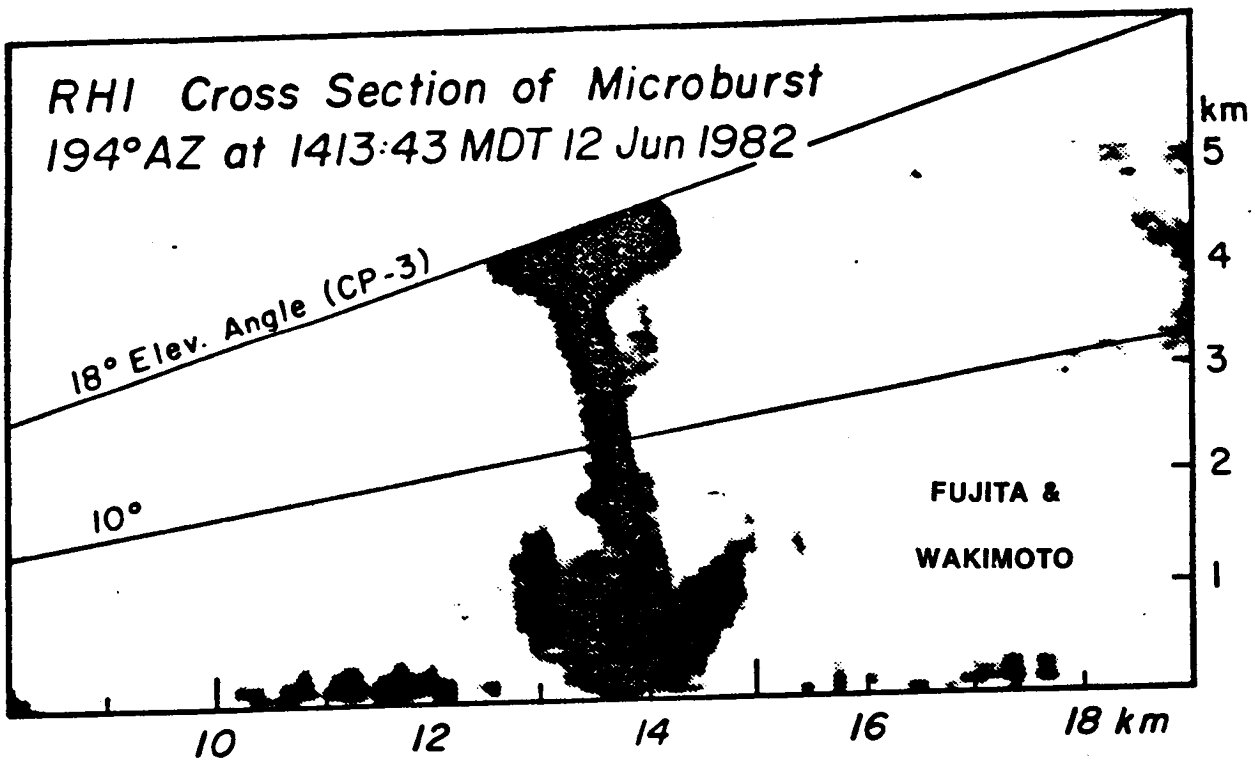
VERTICAL PROFILES OF PRESSURE DEVIATION
FOR 30 JUN 82 CASE:
SENSITIVITY TO RADIUS OF PRECIPITATION SHAFT



DRY MICROBURST SIMULATION: 14 JULY 82 DEN SOUNDING – MODIFIED FOR 500 M DEEP STABLE LAYER AT GROUND







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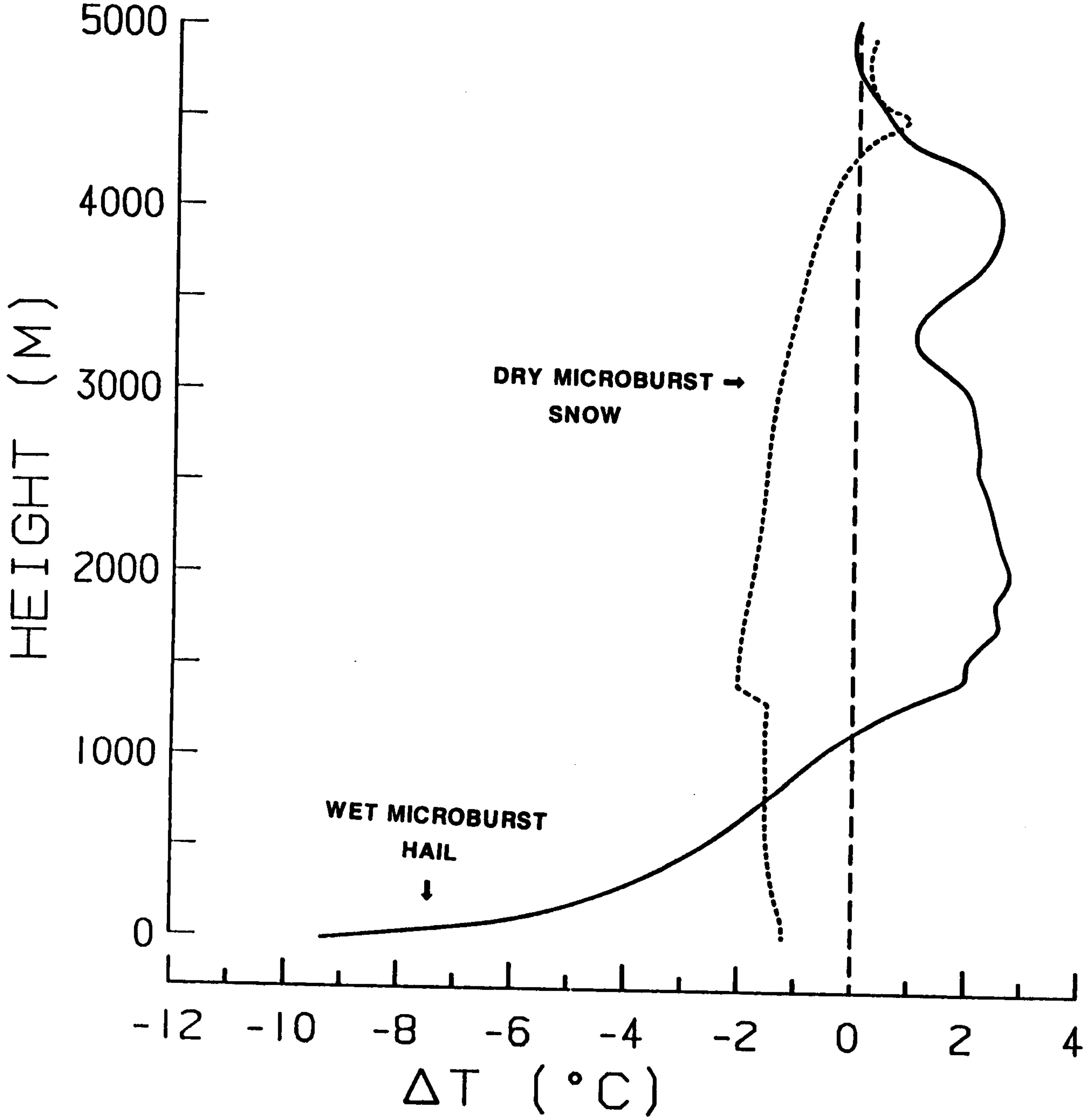
COMPARISON OF AXIAL PROFILES FOR TEMPERATURE DEVIATION FOR BOTH HAIL AND SNOW CASES

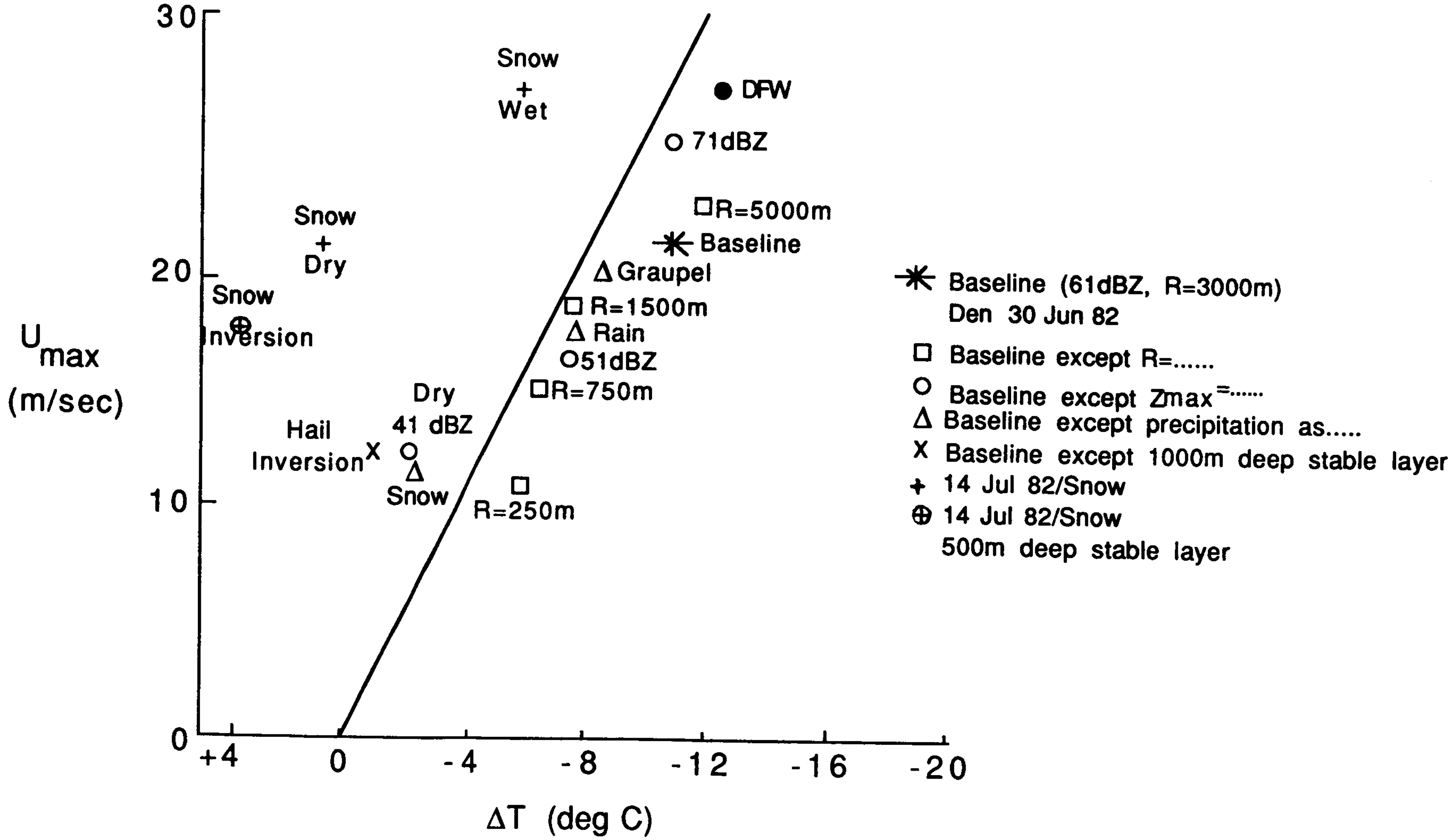


RELATION BETWEEN MAXIMUM TEMPERATURE DROP AND PEAK OUTFLOW SPEED

UMAX = 2.5 ΔT
(MKS UNITS)

DOES NOT HOLD FOR EITHER: SNOW CASES, DRY MICROBURSTS, OR IF GROUND BASED STABLE LAYERS ARE PRESENT

SENSITIVITY STUDIES: MAXIMUM TEMPERATURE DROP VS. MAXIMUM OUTFLOW SPEED



CONCLUSIONS

STRUCTURE

- O TOP OF MICROBURST DOWNDRAFT NEAR MELTING LEVEL
- O RING VORTEX DESCENDS FOLLOWING LEADING EDGE OF PRECIPITATION SHAFT THEN EXPANDS OUTWARD FOLLOWING LEADING EDGE OF BURST FRONT
- O STRONGEST OUTFLOW SPEEDS OCCUR WITHIN 100M ABOVE GROUND AND ASSOCIATED WITH RING VORTEX
- O PEAK HORIZONTAL WINDS ABOUT 4 MIN AFTER INITIAL PRECIPITATION AT GROUND
- O PEAK HORIZONTAL WIND SHEAR PRIOR TO PEAK OUTFLOW INTENSITY
- O PEAK PRECIPITATION RATE AND VERTICAL VELOCITY AT TIME OF PEAK HORIZONTAL WIND SHEAR
- O DEEPEST OUTFLOW WITHIN BURST FRONT HEAD

CONCLUSIONS

SENSITIVITY

- O INTENSITY OF MICROBURST DEPENDS UPON:
  1. ENVIRONMENT TEMPERATURE AND HUMUDITY PROFILE
  2. DIAMETER OF MICROBURST DOWNDRAFT
  3. TYPE OF PRECIPITATION
  4. PRECIPITATION RATE
- O DEPTH OF OUTFLOW LAYER DEPENDS PRIMARILY UPON DIAMETER OF DOWNDRAFT
- O DRY MICROBURST MORE LIKELY PRODUCED BY PRECIPITATION INITIALLY FALLING AS SNOW
- O INTENSE MICROBURSTS PRODUCED BY SNOW FALLING WITHIN CLASSICAL DRY MICROBURST ENVIRONMENT
- O RELATIONSHIP BETWEEN OUTFLOW SPEED AND TEMPERATURE DROP FOR SOME OF THE WET-MICROBURST CASES

FUTURE WORK

- O 3-D SIMULATIONS OF INTERACTING MULTIPLE MICROBURSTS
- O 3-D SIMULATIONS OF MICROBURSTS WITHIN VERTICALLY SHEARED ENVIRONMENTS