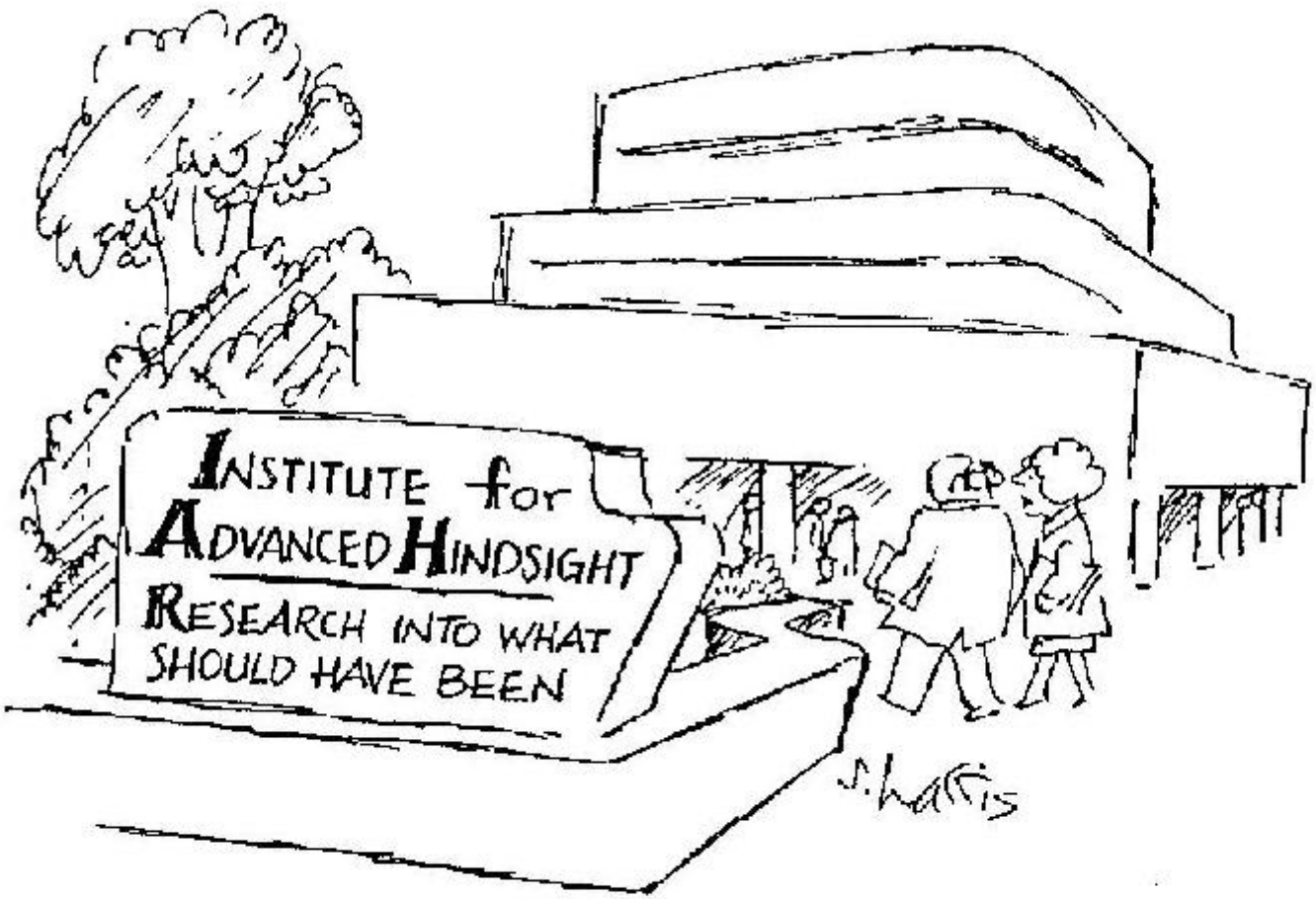
Nowcasting Thunderstorm Potential from Satellite

Robert M Rabin

NOAA/National Severe Storms Laboratory
Norman, OK USA

Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin
Madison, WI USA


INSTITUTE for
ADVANCED HINDSIGHT
RESEARCH INTO WHAT
SHOULD HAVE BEEN
J. Harris

“PRE-SATELLITE FORECAST ACTIVITIES”

- **1951 FAWBUSH AND MILLER ESTABLISHED SEVERE STORMS FORECAST CENTER FOR AIR FORCE FACILITIES IN 48 STATES**
- **1952 WBAN ANALYSIS CENTER SEVERE STORMS FORECAST UNI**
- **1952 FIRST WATCH ISSUED**
- **1953 RENAMED "SELS" -- AROUND THE CLOCK COVERAGE**
- **1954 SELS TRANSFERRED TO KANSAS CITY (911 WALNUT)**
- **1955 FIRST CONVECTIVE OUTLOOK**

SELS upper-air map analysis (Apr 1956, 911 Walnut, KC)
(left-right): J. Galway, H. Hanks, D. House

THE FIRST PICTURES

TIROS-I

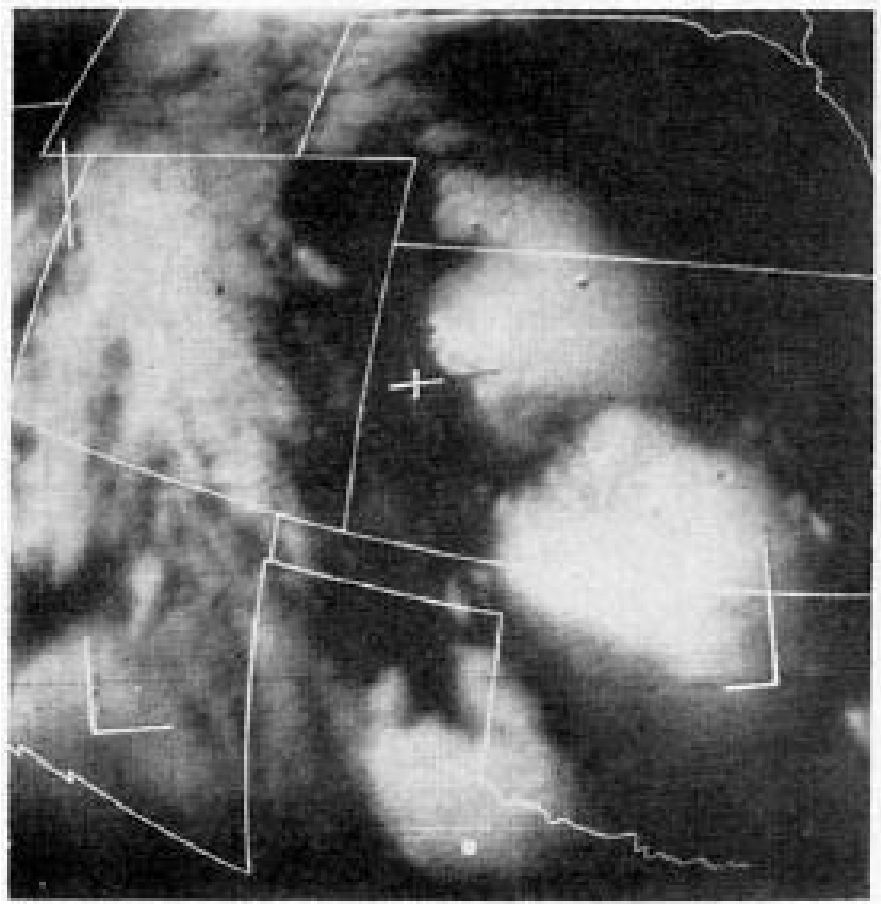
27 May 1960, 1719 LST

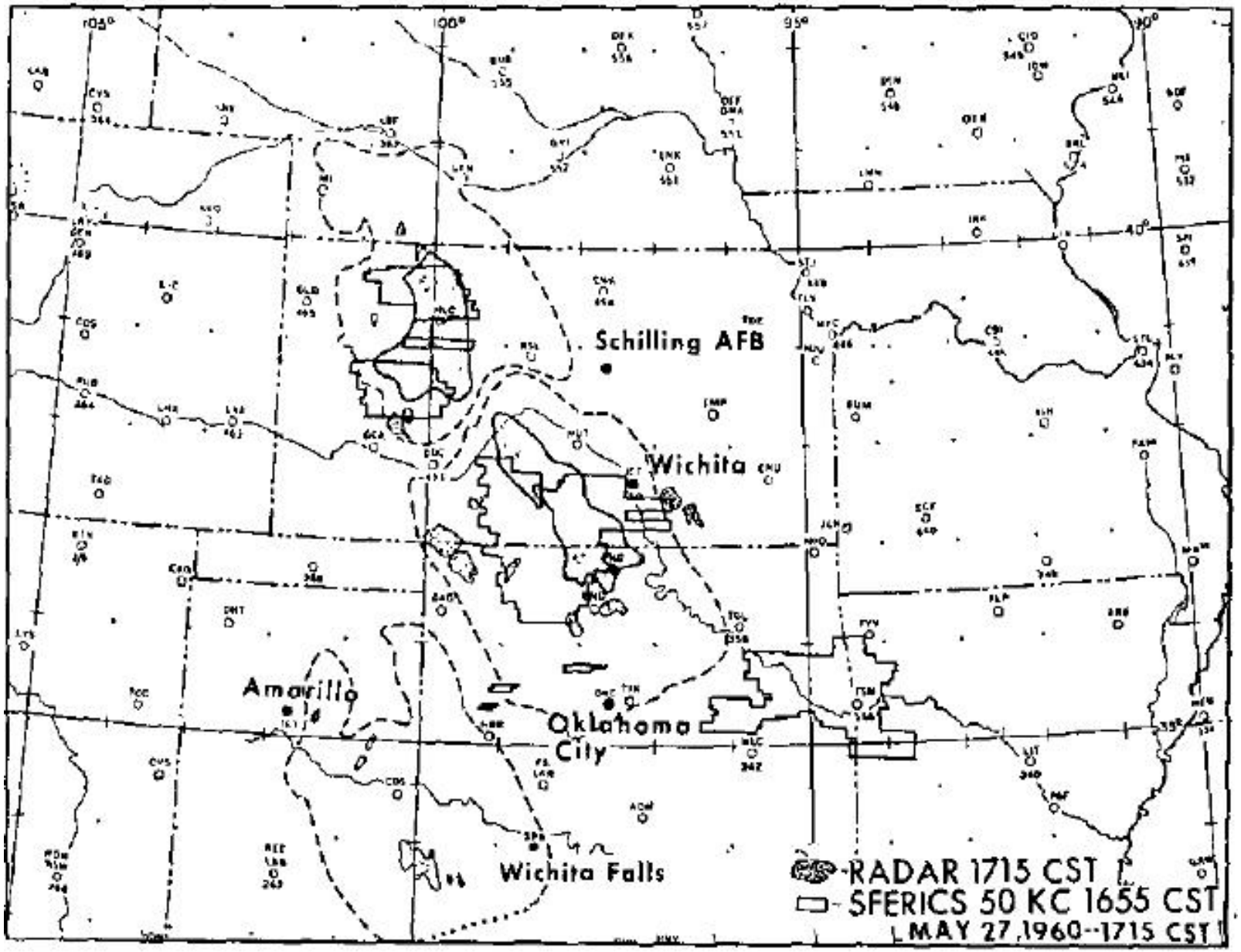
from: L. Whitney

JAM 1963:

Severe Storm Clouds

as seen from TIROS





From: L. F. Whitney, 1963, JAM, figure 3

1966 RENAMED NSSFC AND MOVED TO
601 E. 12TH STREET, KANSAS CITY MO

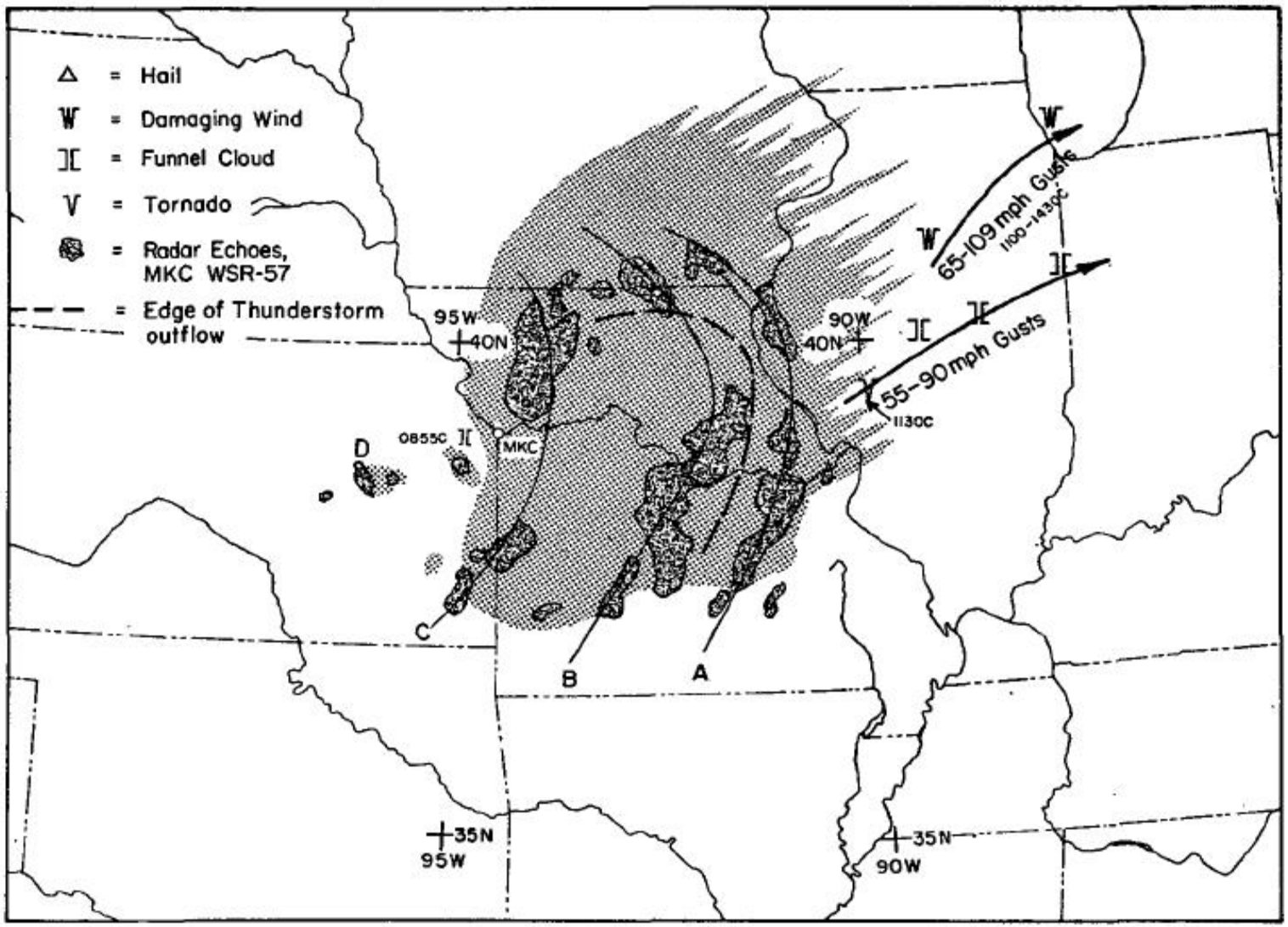
1966 FIRST GEOSTATIONARY: ATS-1

Relationships between size of cirrus shields and severity

R.J. Boucher 1967, JAM

TIROS IV-VII

17 cases
1962-1964



From: Fig. 2

Satellite imagery and severe weather warnings

James F.W. Purdom, 1971

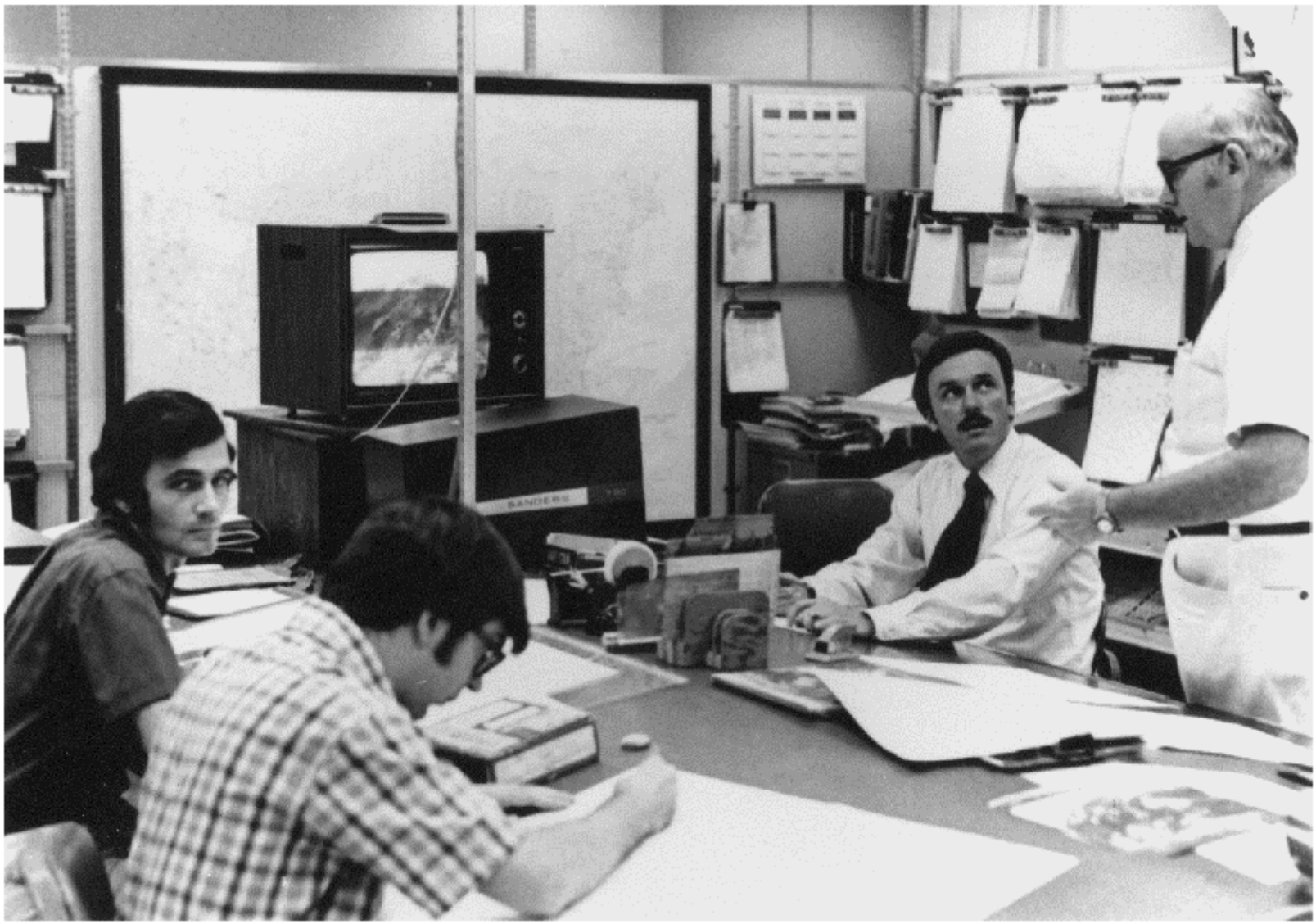
Polar orbiting: NOAA-1

- Squall lines: characteristic appearance, narrowing to south
- Locations of jets: polar and subtropical
- Shear with height: thermal ridge and amount of veering

ATS-3 Visible imagery (1971): 11-minute updates on demand

- Early detection of squall lines as compared to radar
- Isolation of areas under threat for severe weather:
  - Often southern portion of convective clusters
- Growth of anvil:
  - Pause in expansion linked time of tornado occurrence
  - McCann(1979) linked collapsing tops to downdraft and tornado formation

1972 SFSS (SATELLITE FIELD SERVICES STATION) ESTABLISHED AT MKC



SELS forecast desk, 1976; l to r: Don Wales (communications), Tim Oster (assistant forecaster), Larry Wilson (lead forecaster) and Bill Henry (administrative support).

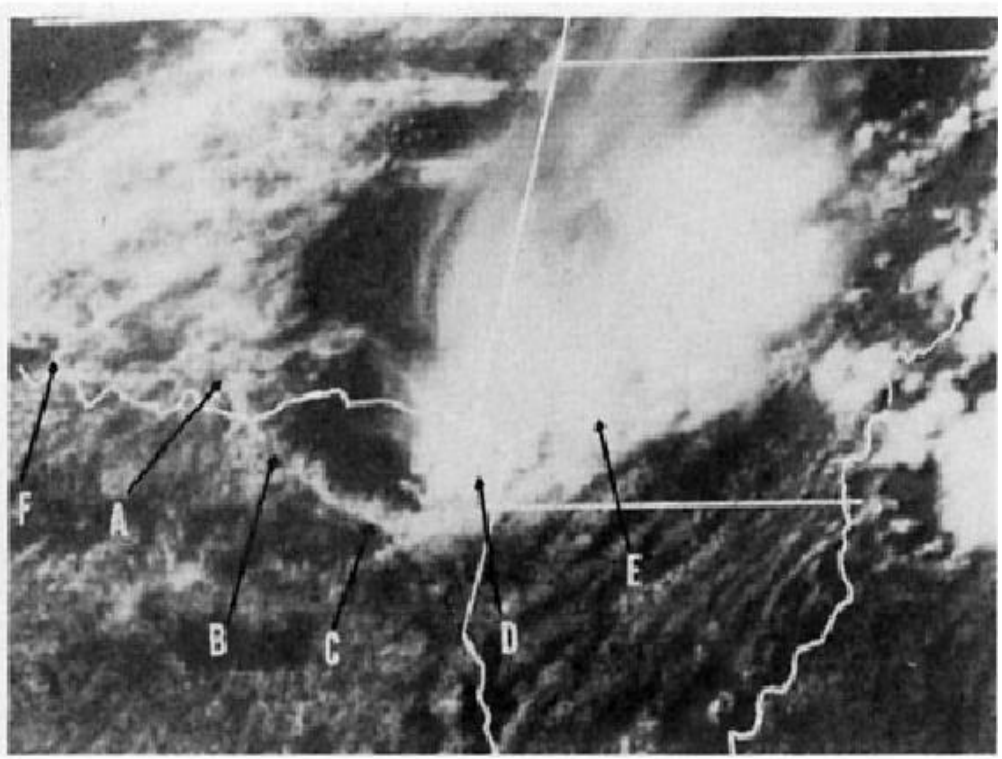
1974 First SMS

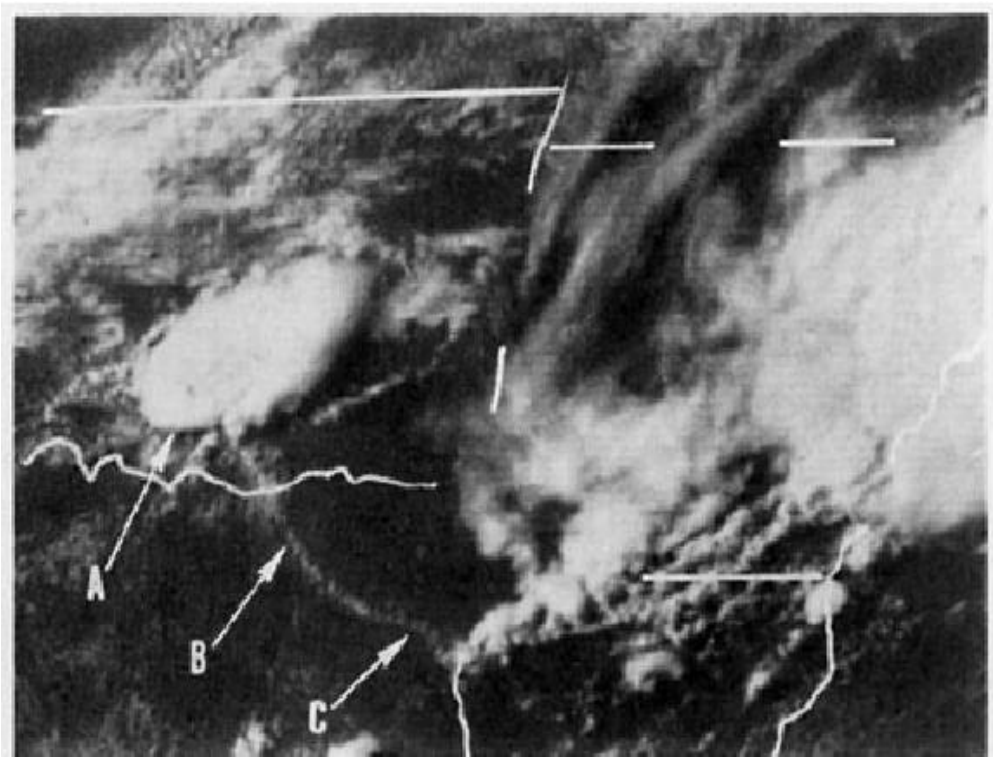
1975 GOES-1

CONVECTIVE INITIATION

Some uses of high-resolution GOES imagery in the mesoscale forecasting of convection and its behavior

James F.W. Purdom, 1976 MWR





EXPLORATION OF INFRARED IMAGERY

Anvil outflow patterns as indicators of tornadic thunderstorms

Charles E. Anderson, 1979

- Observed characteristics of cirrus plumes of severe storms (limited cases)

  - Displaced to the right of the ambient wind
  - Anticyclonic rotation
  - Spiral bands
  - Similarity to hurricanes

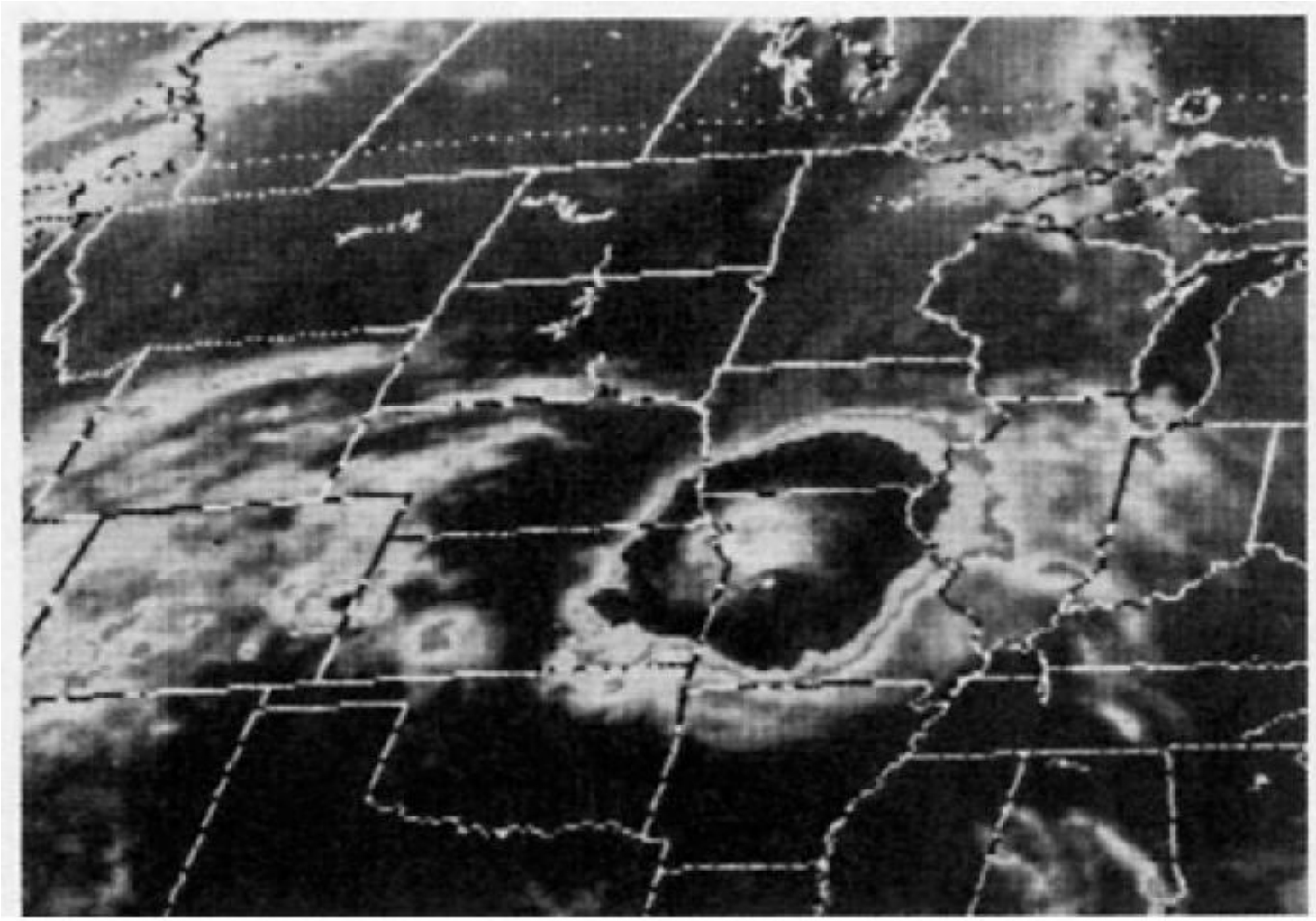
On overshooting-collapsing thunderstorm tops

Donald W. McCann, 1979

- Previously observed by aircraft (Fujita, 73;Umenhofer, 75)
- Collapse does NOT cause tornado
- May be related to acceleration of gust front:
  - Occlusion of mesolow
  - Strong surface outflow (i.e. bow echo)

Mesoscale convective complexes

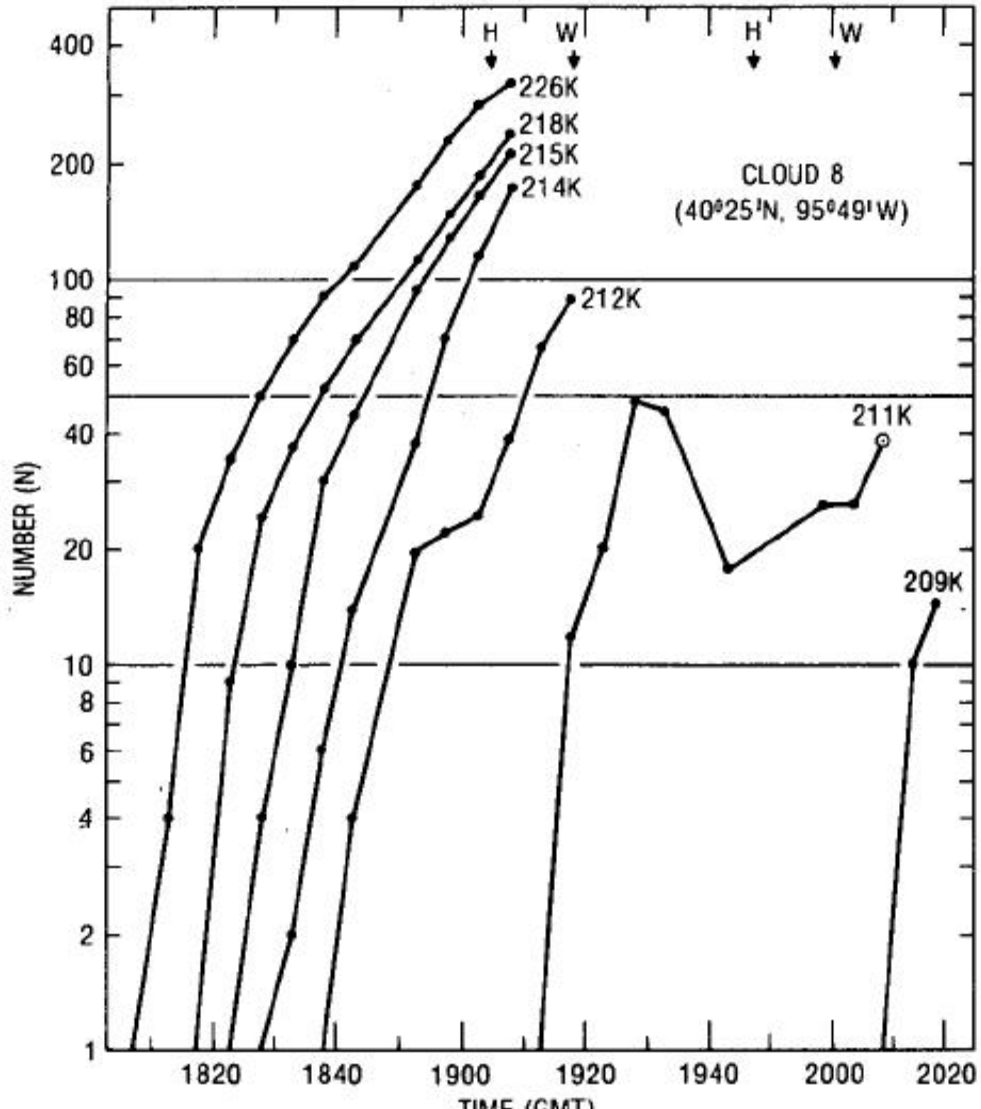
Robert Maddox, 1980 BAMS

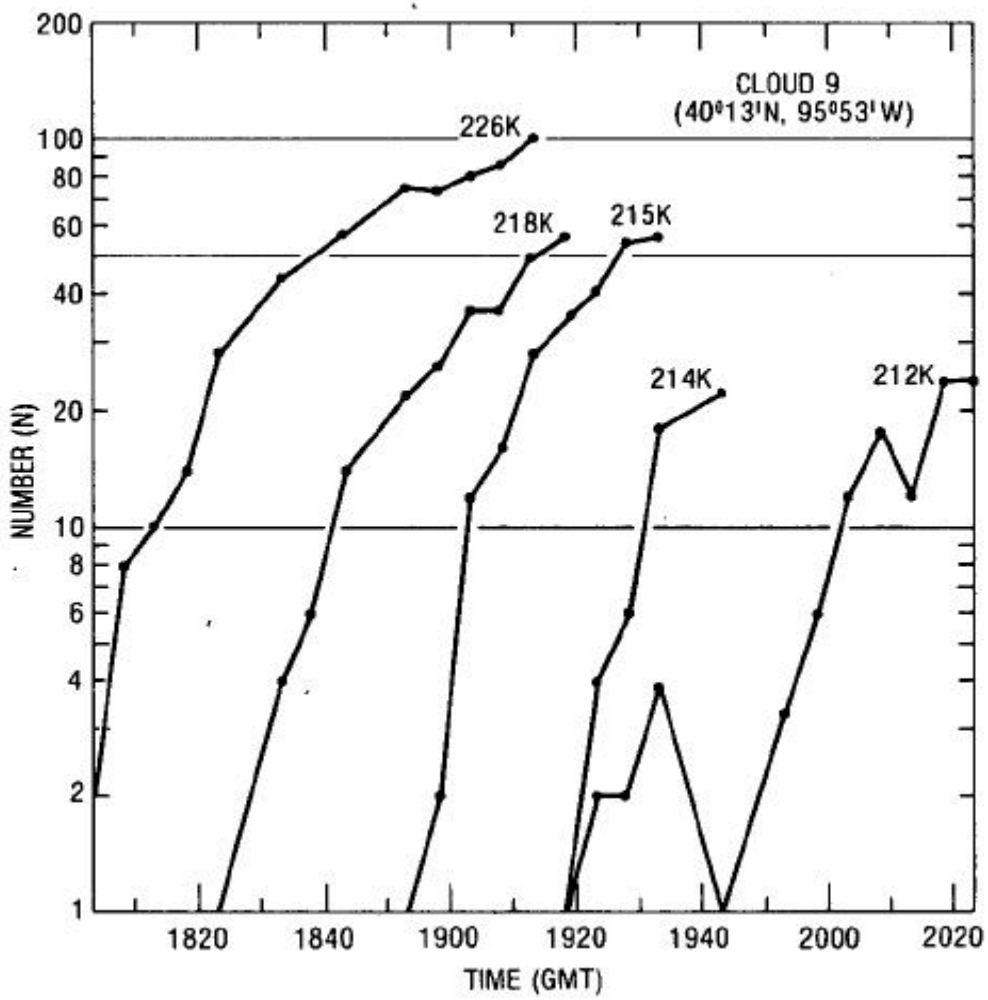


GROWTH RATES

Thunderstorm intensity as determined from satellite data (SMS 2: IR 5-minute)

Robert Adler and Douglas Fenn, JAM 1979

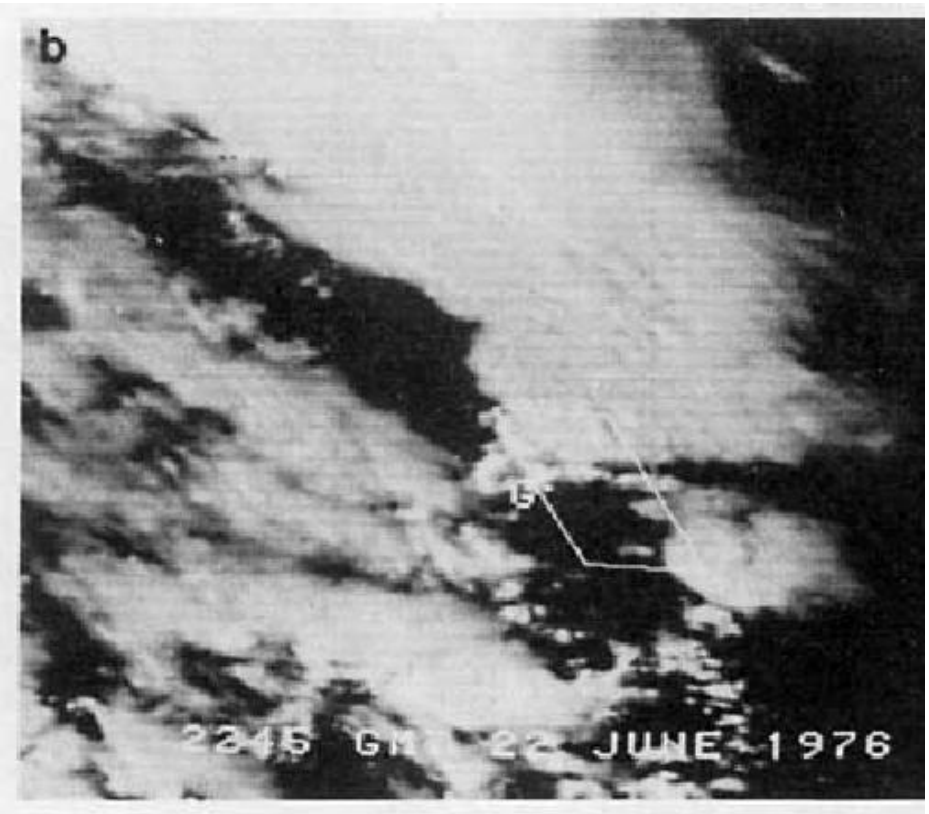


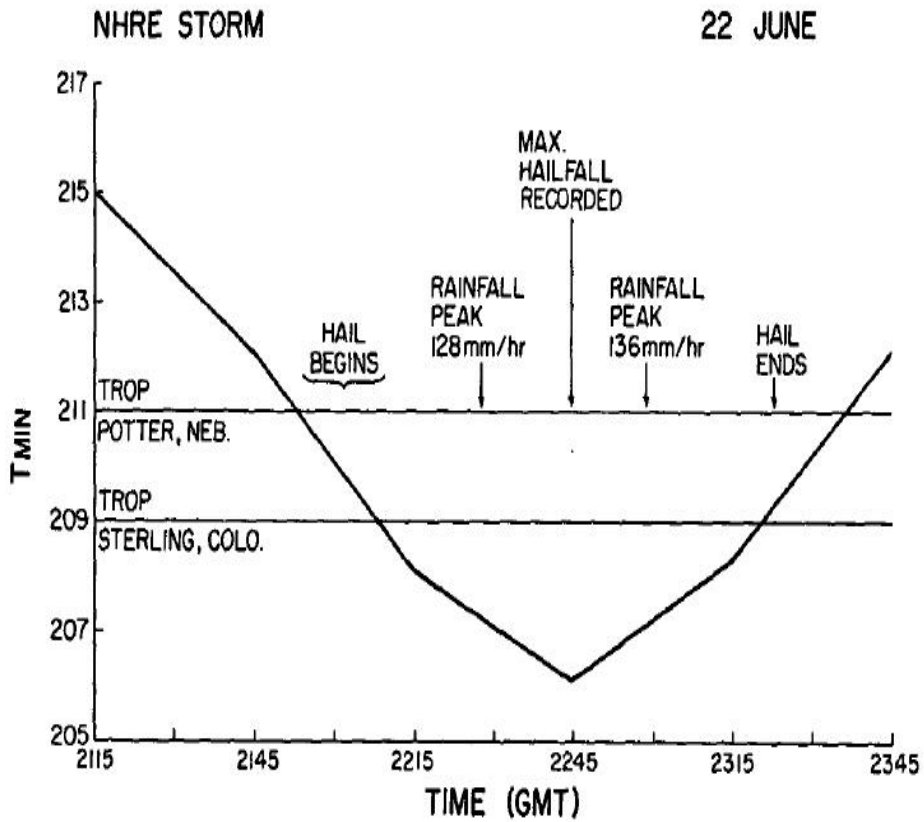


Observations of damaging hailstorms from geosynchronous satellite digital data

(GOES 30-minute data: 9 storms)

David W. Reynolds, 1980 MWR



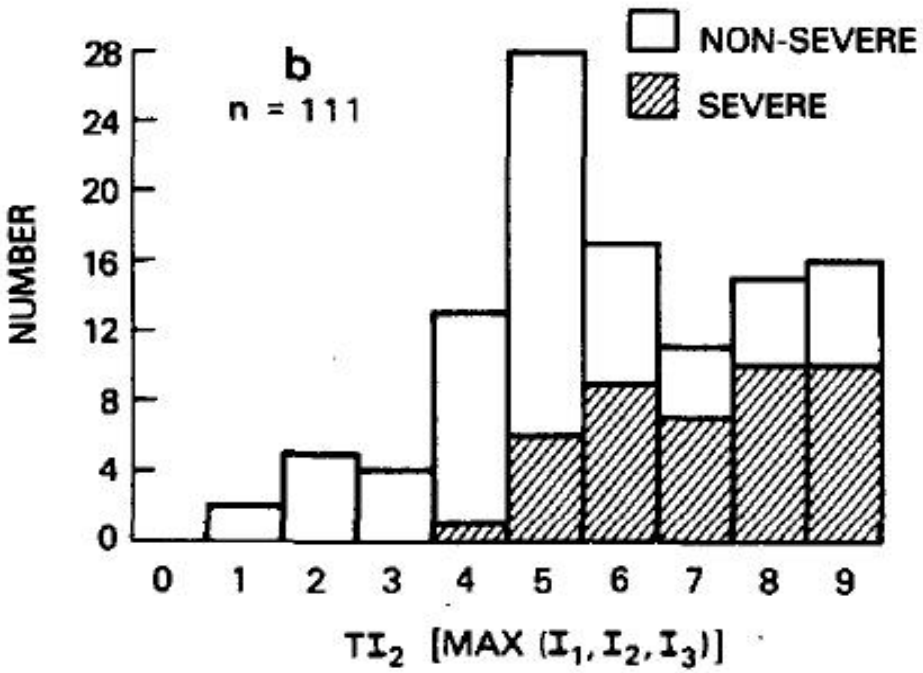


Detection of severe Midwest thunderstorms using geosynchronous satellite data

SMS-2 and GOES-1: ~5 minute data

Robert Adler, Michael Markus, Douglas Fenn

MWR 1985

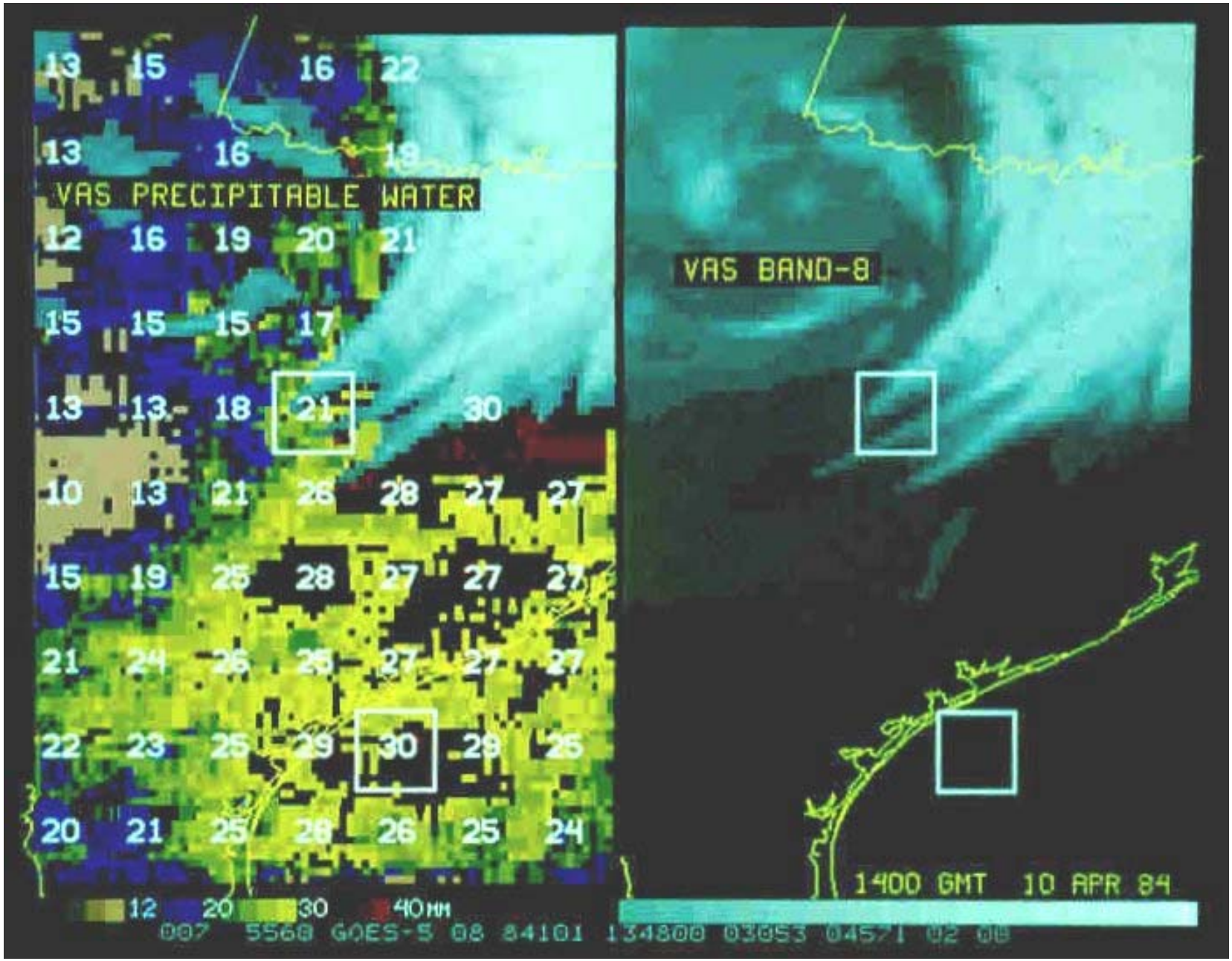


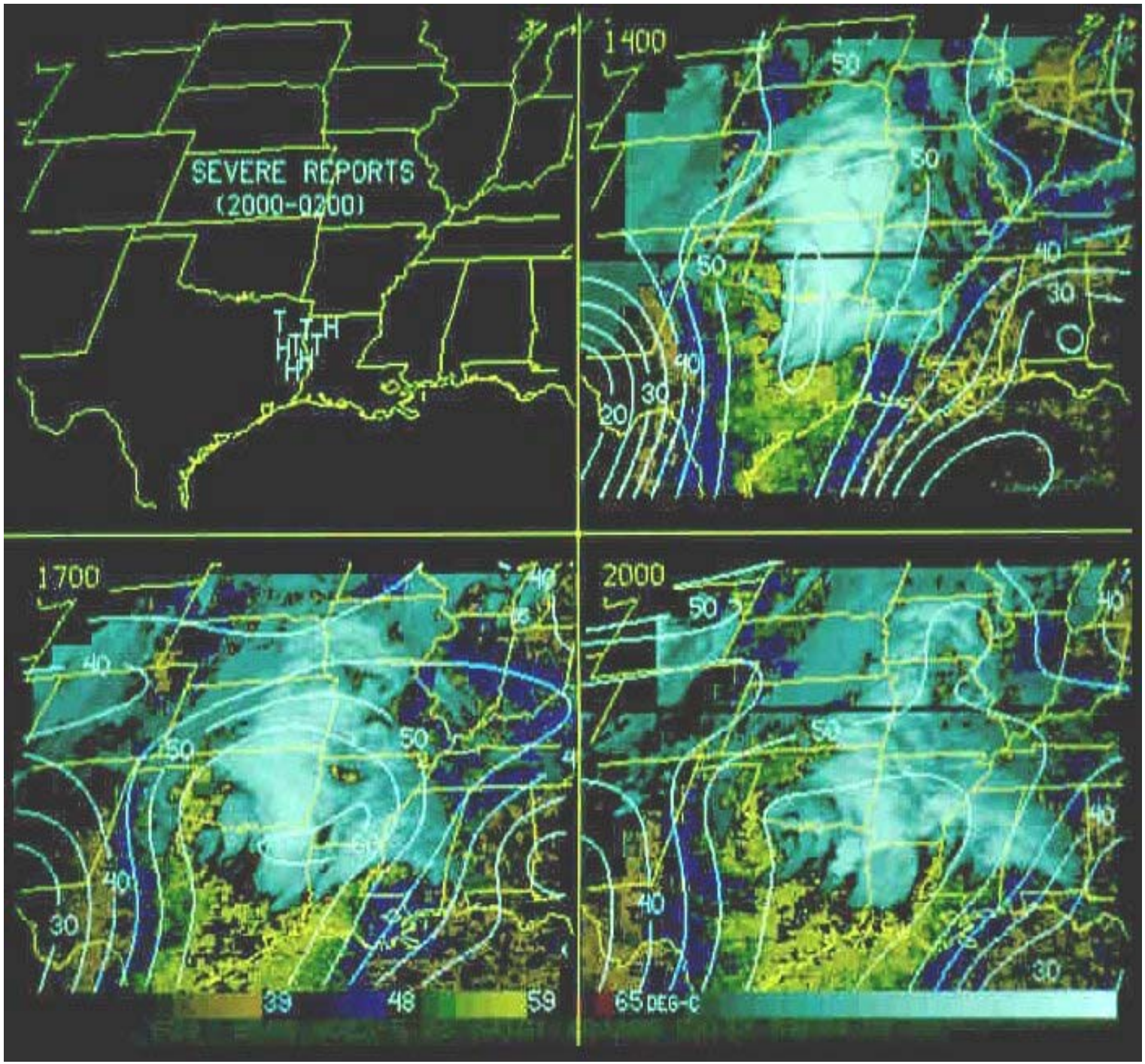
1980: FIRST GOES VAS "DWELL SOUNDINGS" (GOES-4)

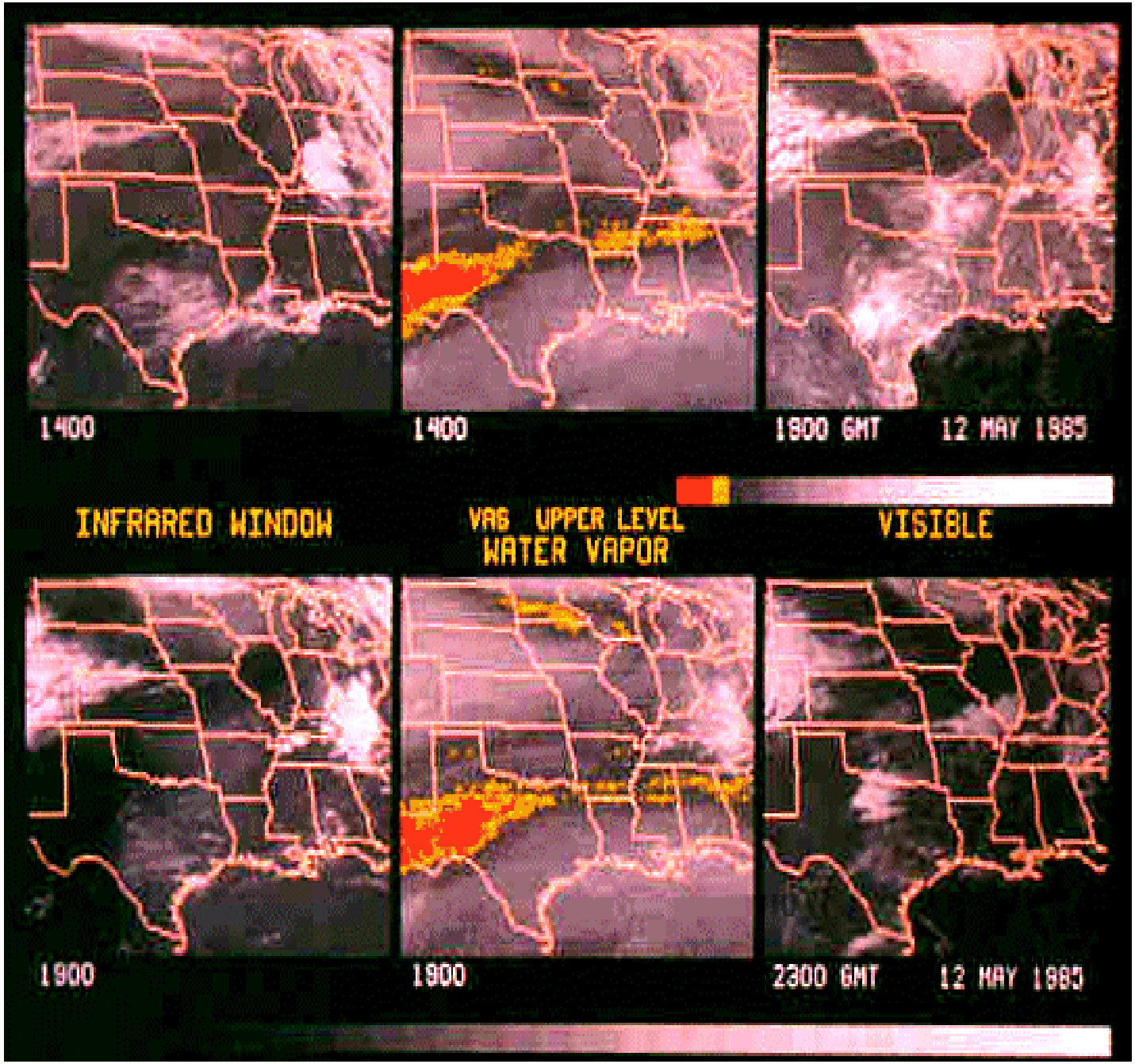
1980 *Cooperative Institute for Meteorological Satellite Studies* founded

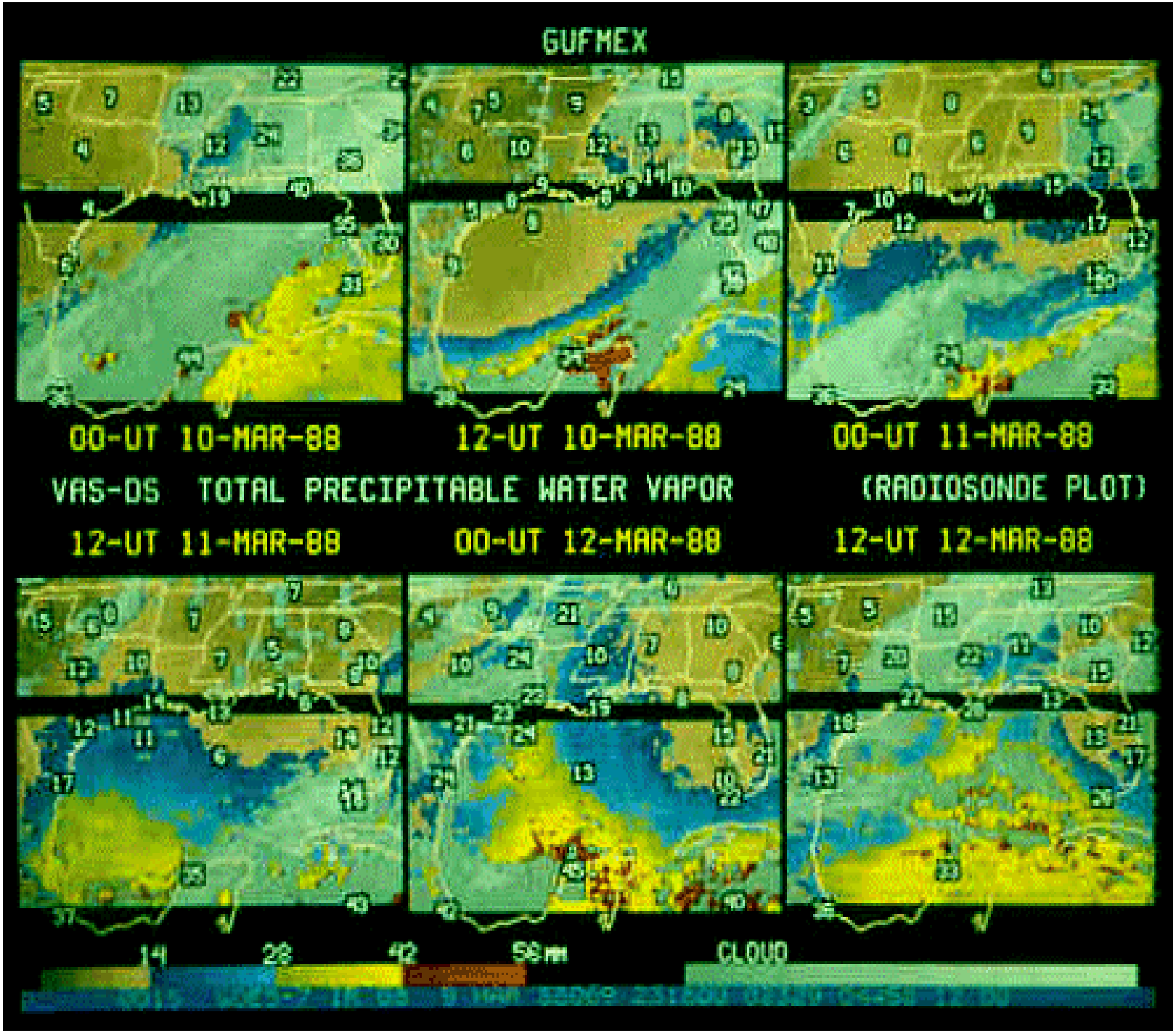
1982 CSIS -- FIRST OPERATIONAL McIDAS WORKSTATION -- INSTALLED

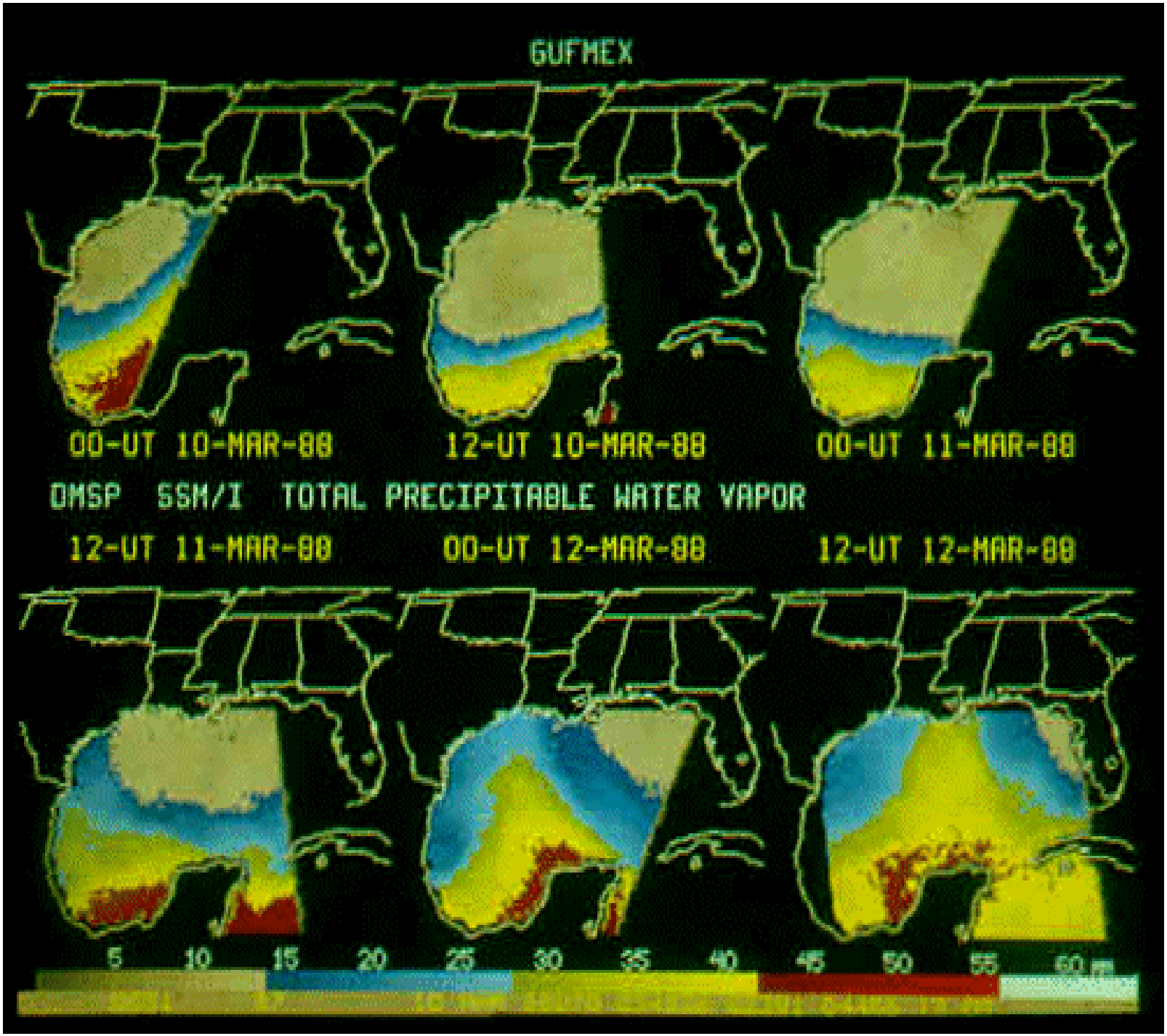
1983 SFSS BECOMES PART OF NSSFC


VAS PRECIPITABLE WATER
VAS BAND-8
12 20 30 40 MM
1400 GMT 10 APR 84


SEVERE REPORTS
(2000-0200)
1400
1700
2000
39
48
59
65 DEG-C


1400
1400
1800 GMT 12 MAY 1985
INFRARED WINDOW
VAS UPPER LEVEL
WATER VAPOR
VISIBLE
1900
1900
2300 GMT 12 MAY 1985


GUFMEX
00-UT 10-MAR-88
12-UT 10-MAR-88
00-UT 11-MAR-88
VAS-DS TOTAL PRECIPITABLE WATER VAPOR
(RADIOSONDE PLOT)
12-UT 11-MAR-88
00-UT 12-MAR-88
12-UT 12-MAR-88
14
28
42
56 mm
CLOUD


GUFMEX
00-UT 10-MAR-88
12-UT 10-MAR-88
00-UT 11-MAR-88
DMSP SSM/I TOTAL PRECIPITABLE WATER VAPOR
12-UT 11-MAR-88
00-UT 12-MAR-88
12-UT 12-MAR-88
5
10
15
20
25
30
35
40
45
50
55
60 mm

THE ENHANCED-V

AND RELATED STRUCTURE

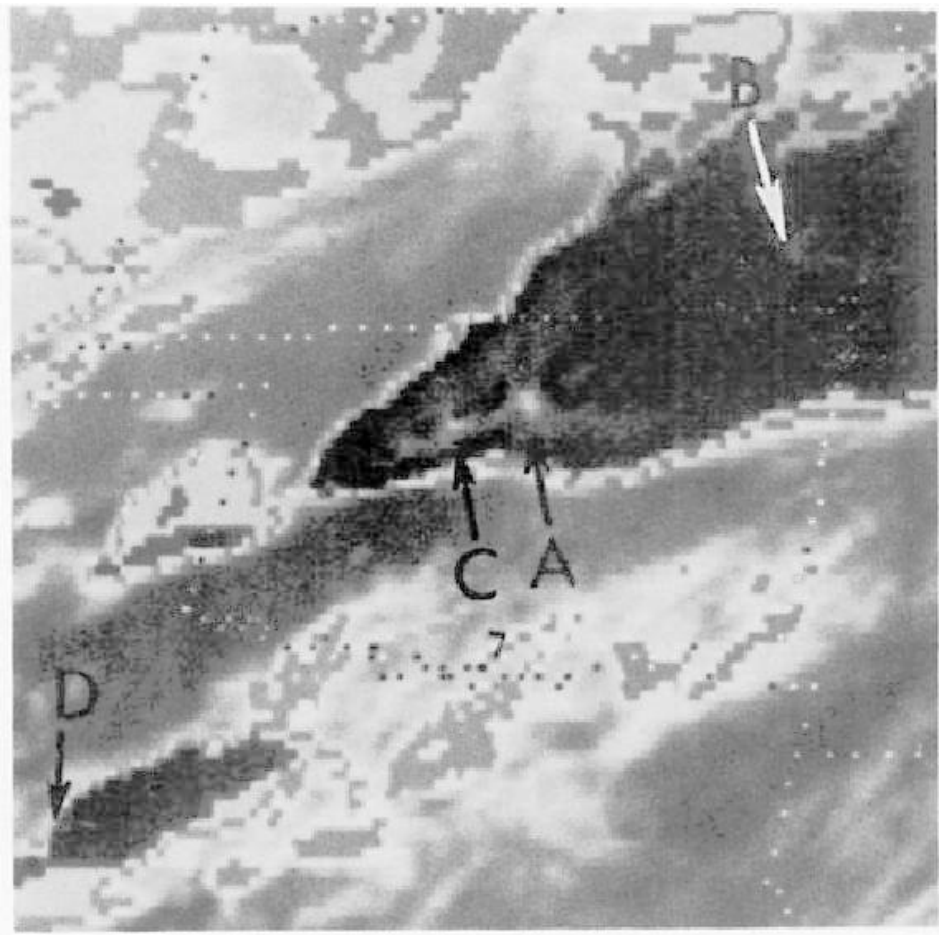
Detection of tropopause penetrations by intense convection with GOES enhanced infrared imagery

Peter Mills, Elford Astling, 1977, 10th SLS

- First observations of warm spots on anvil
- Near tropopause penetrations
  - confirmed by radar
- Possible causes
  - higher emissivity above updraft
  - stratospheric cirrus
  - rapid sinking

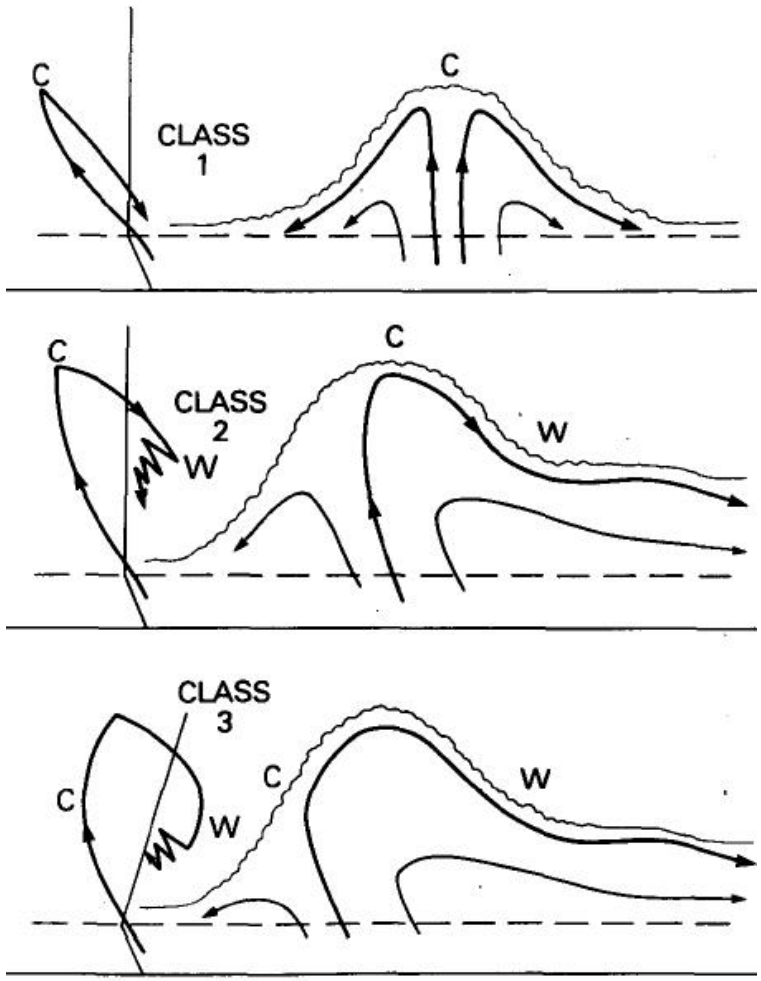
The enhanced-V: a satellite observable severe storm signature

Donald W. McCann 1983, MWR



Thunderstorm cloud top dynamics as inferred from satellite observations and a cloud top parcel model

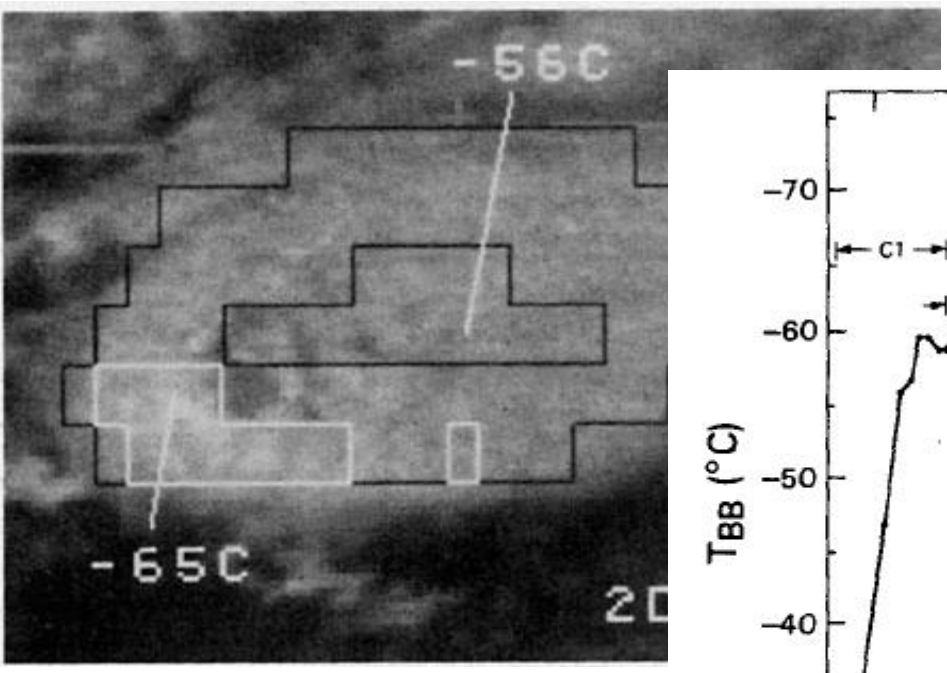
Robert Adler, Robert Mach, 1986 JAS

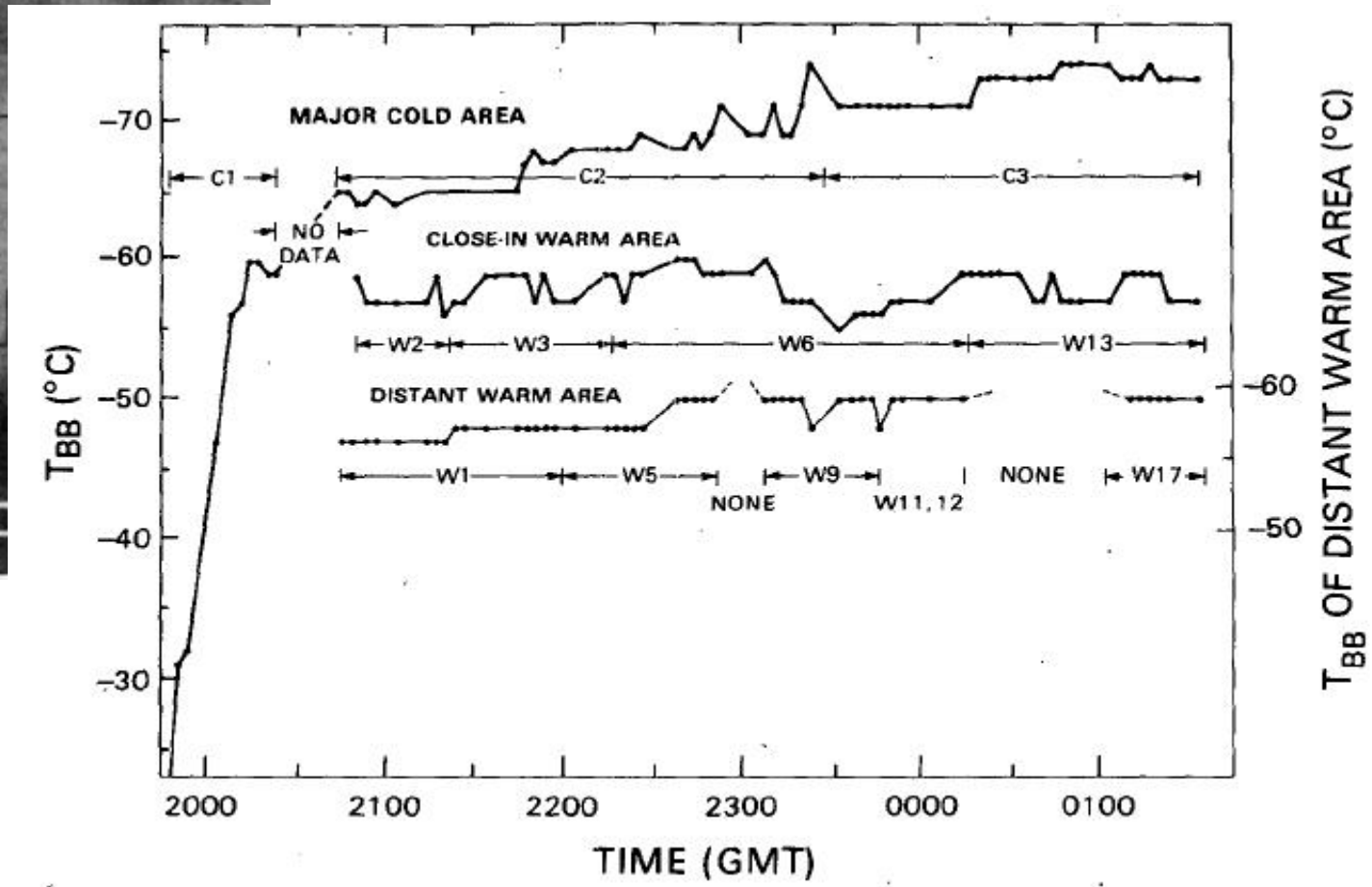


Upper-level structure of Oklahoma tornadic storms on 2 May 1979, I: Radar and satellite observations

Gerald Heymsfield, Roy Blackmer, Steven Schotz

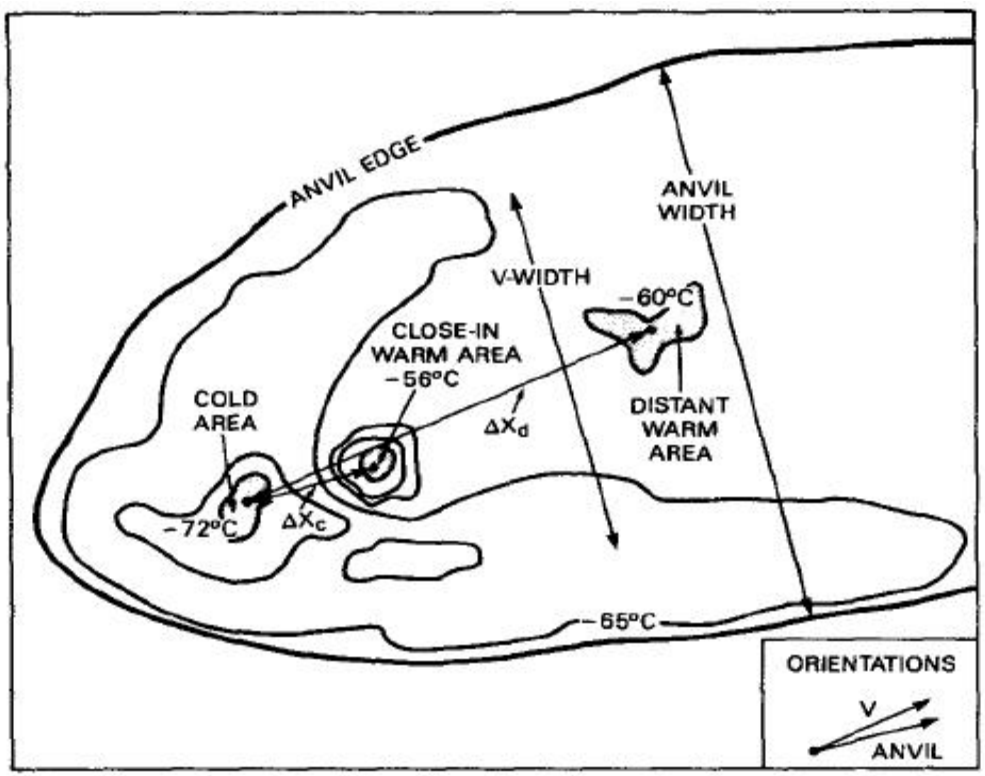
JAS, 1983

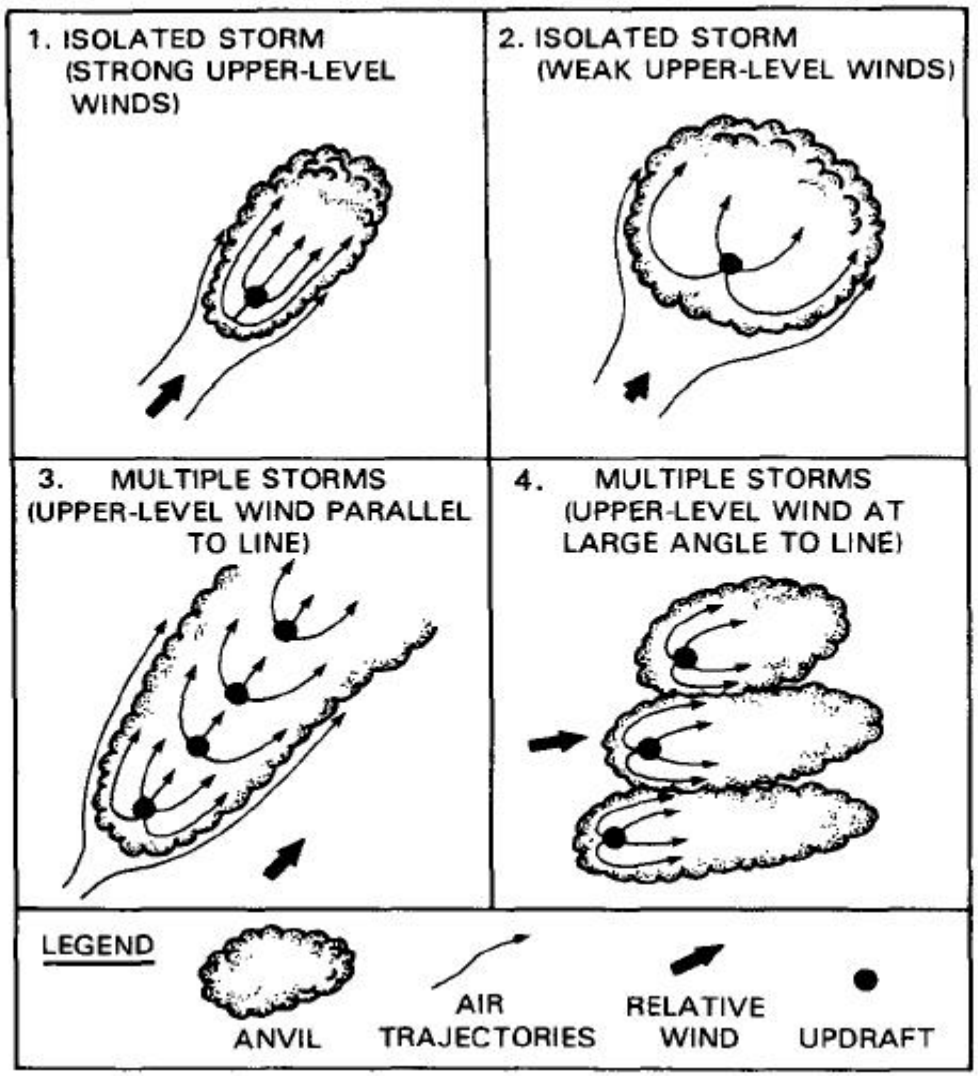




Satellite-observed characteristics of Midwest severe thunderstorm anvils

Gerald Heymsfield, Roy Blackmer, MWR 1988





1991 VDUC (ENHANCED McIDAS WORKSTATION) -- INSTALLED TO REPLACE CSIS

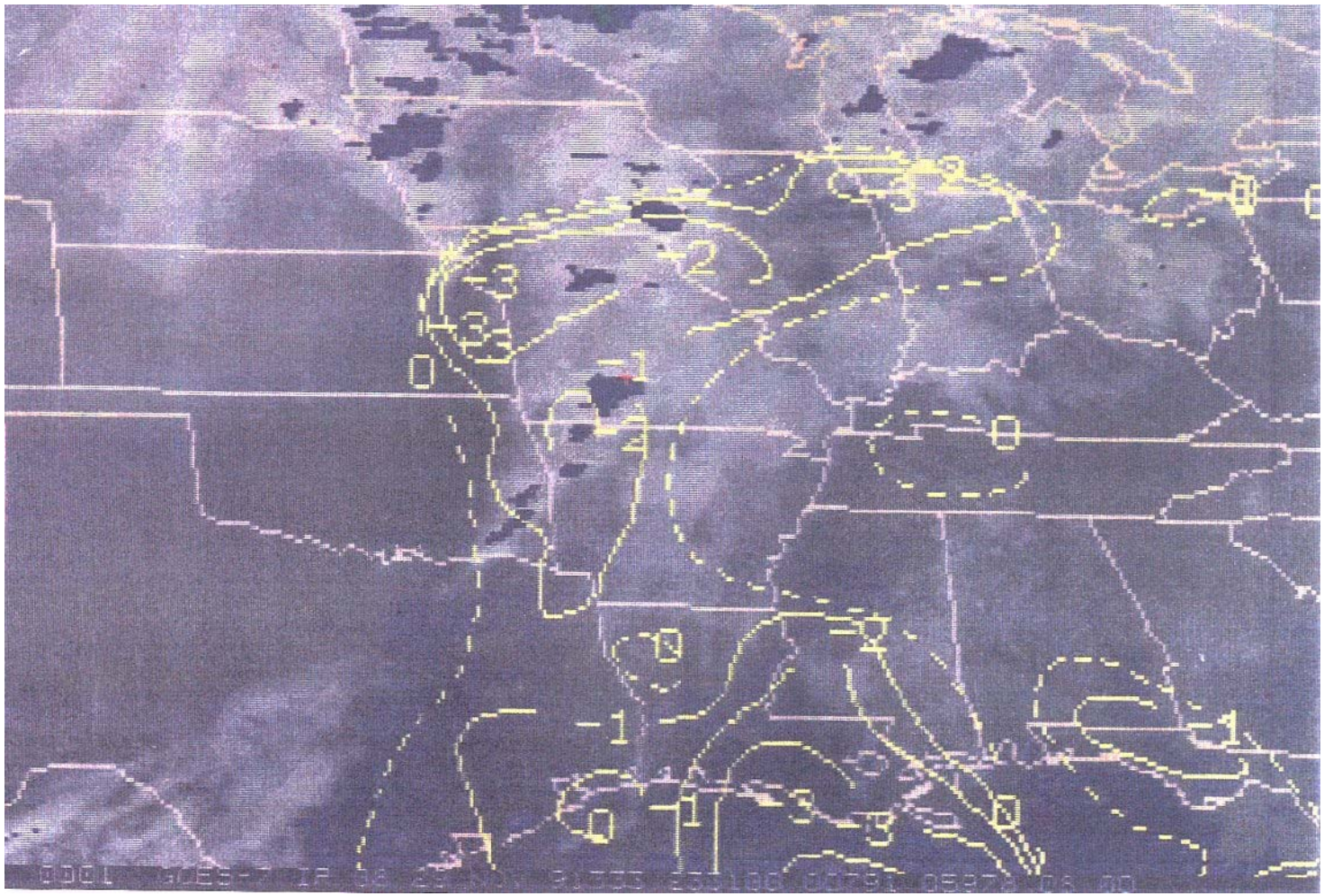
1994 FIRST INDEPENDENT GOES SOUNDER (GOES-8)

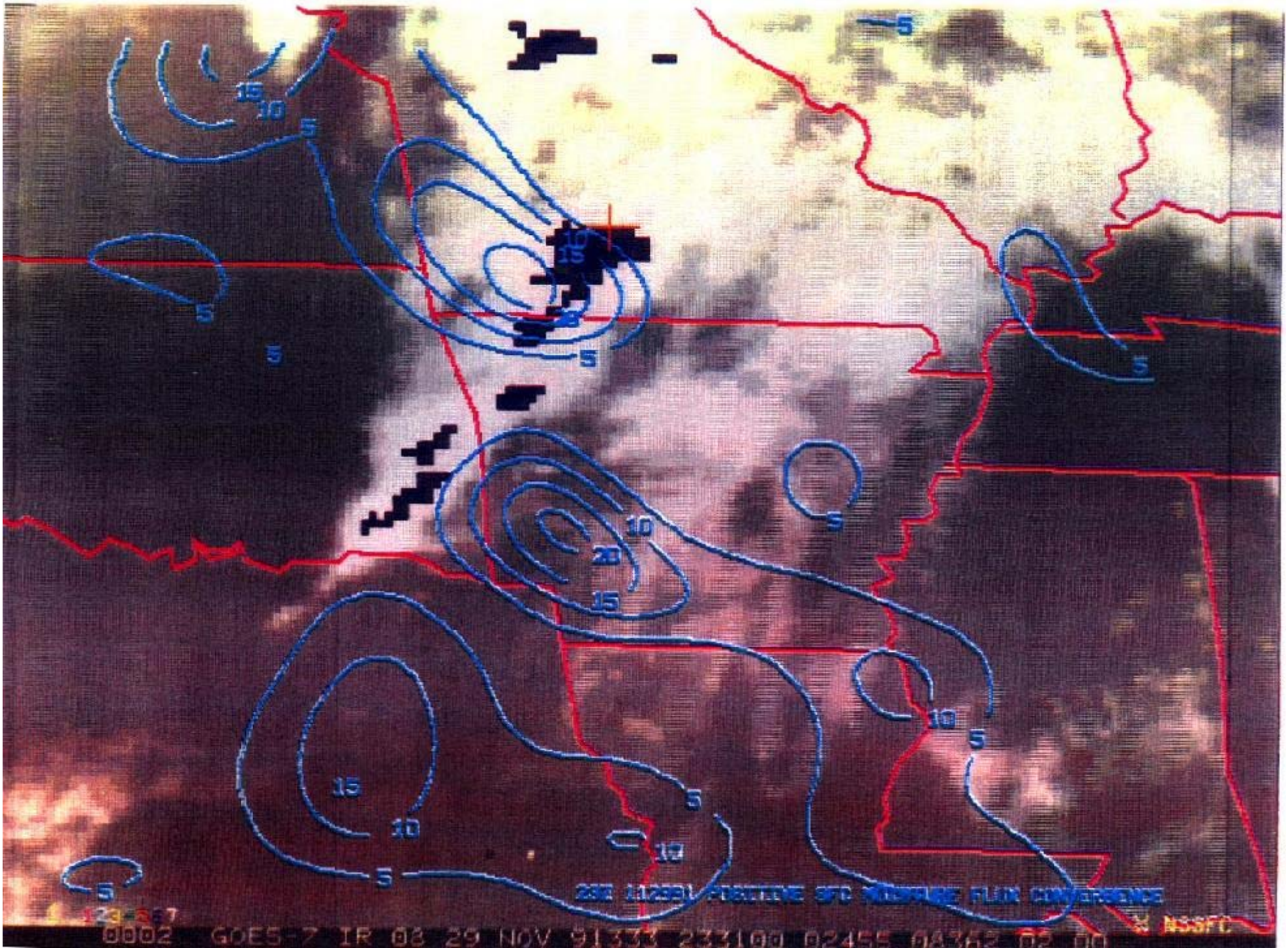
1995 SELS BECOMES SPC, NAWAU BECOMES AWC (AVIATION WEATHER CENTER)

1997 SPC COMPLETES MOVE TO NORMAN OK

1999 AWIPS WORKSTATIONS INSTALLED

SPC Lead Forecaster's area in NSSL building, early 1998. Mike Vescio monitors ongoing severe storms (overhead PC flashes a Pittsburgh warning) while writing the Day-2 outlook.

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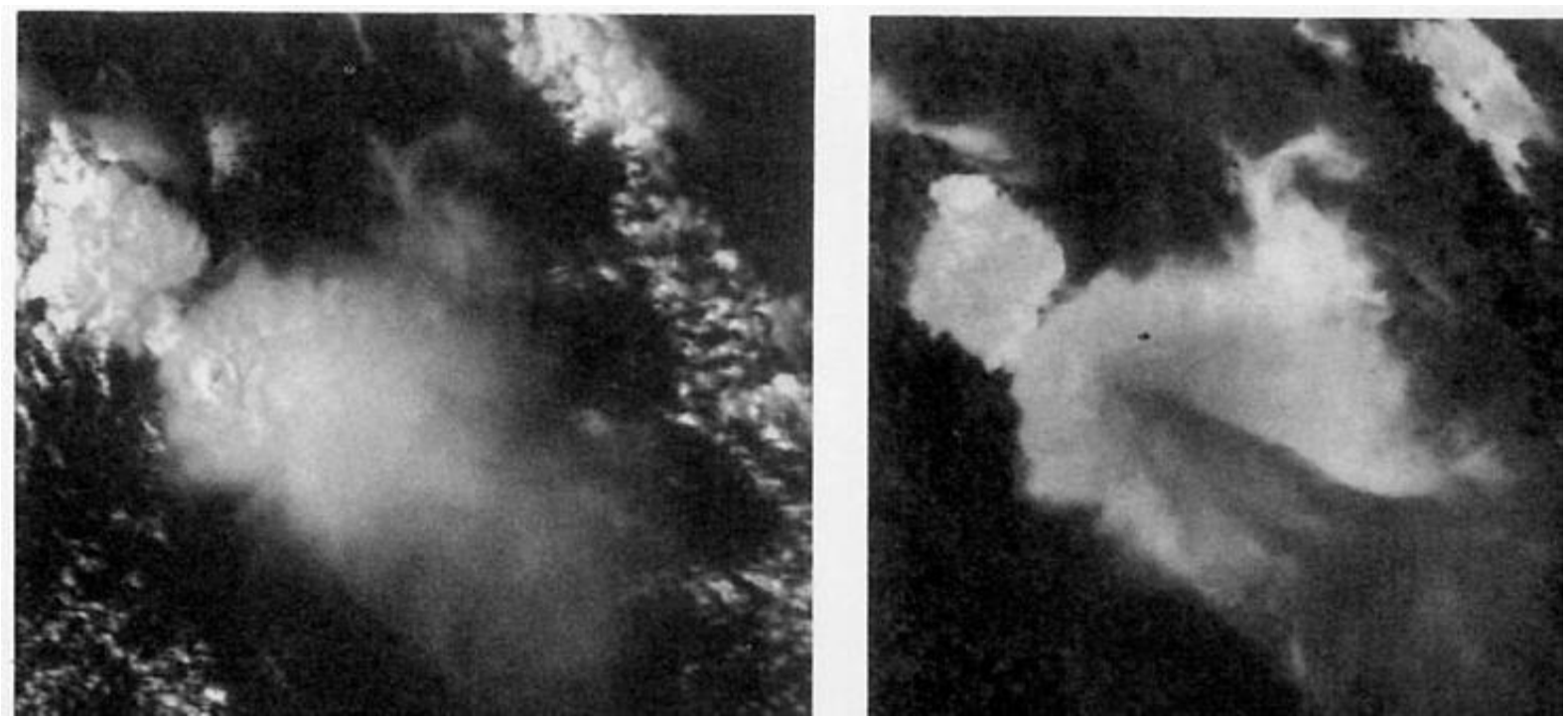
0002 GOES-7 IR 08 29 NOV

PLUMES:

SHORT WAVE IR REFLECTANCE

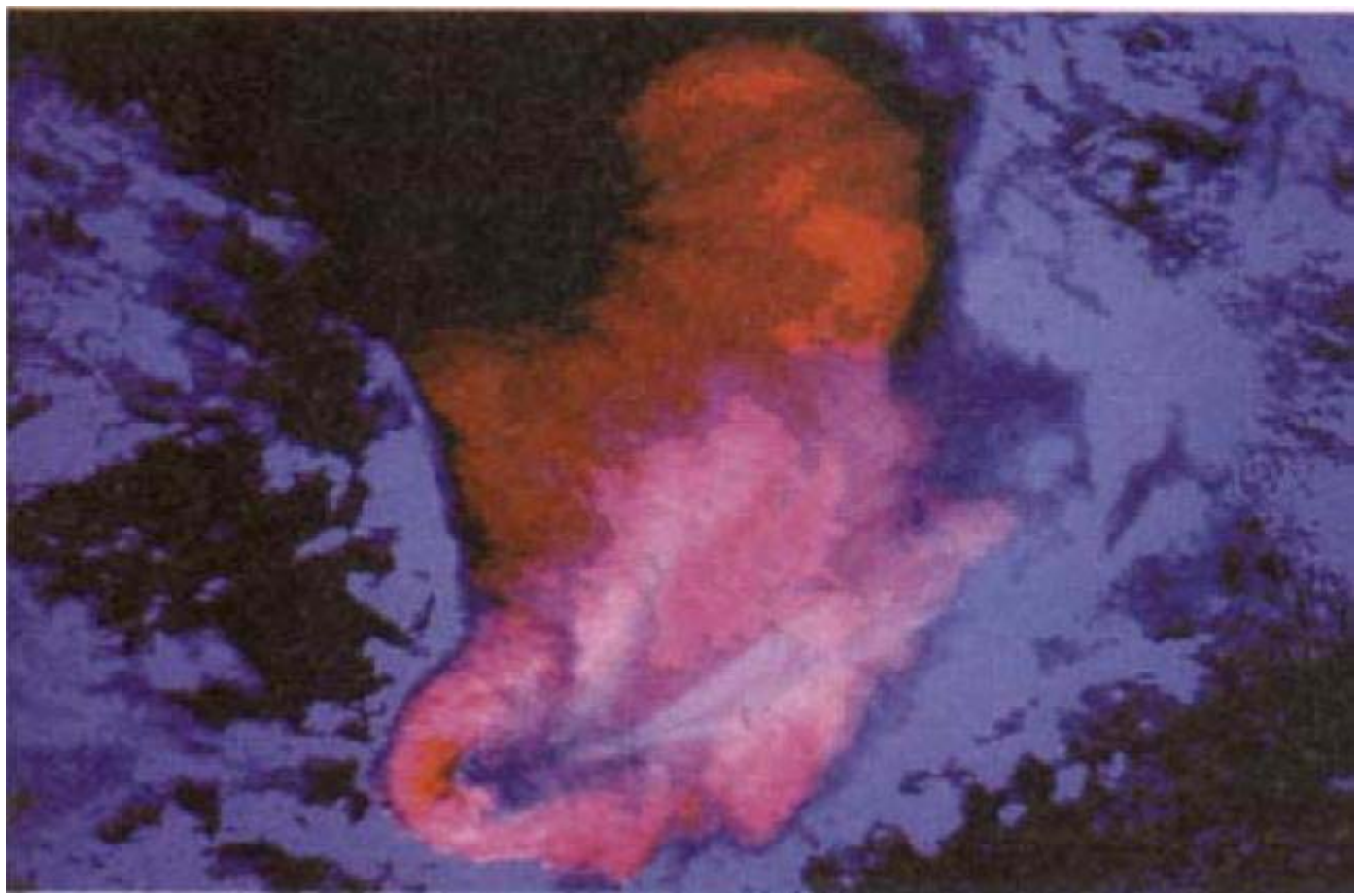
The AVHRR channel 3 cloud top reflectivity of convective storms

Martin Setvak, Charles Doswell, 1991 MWR



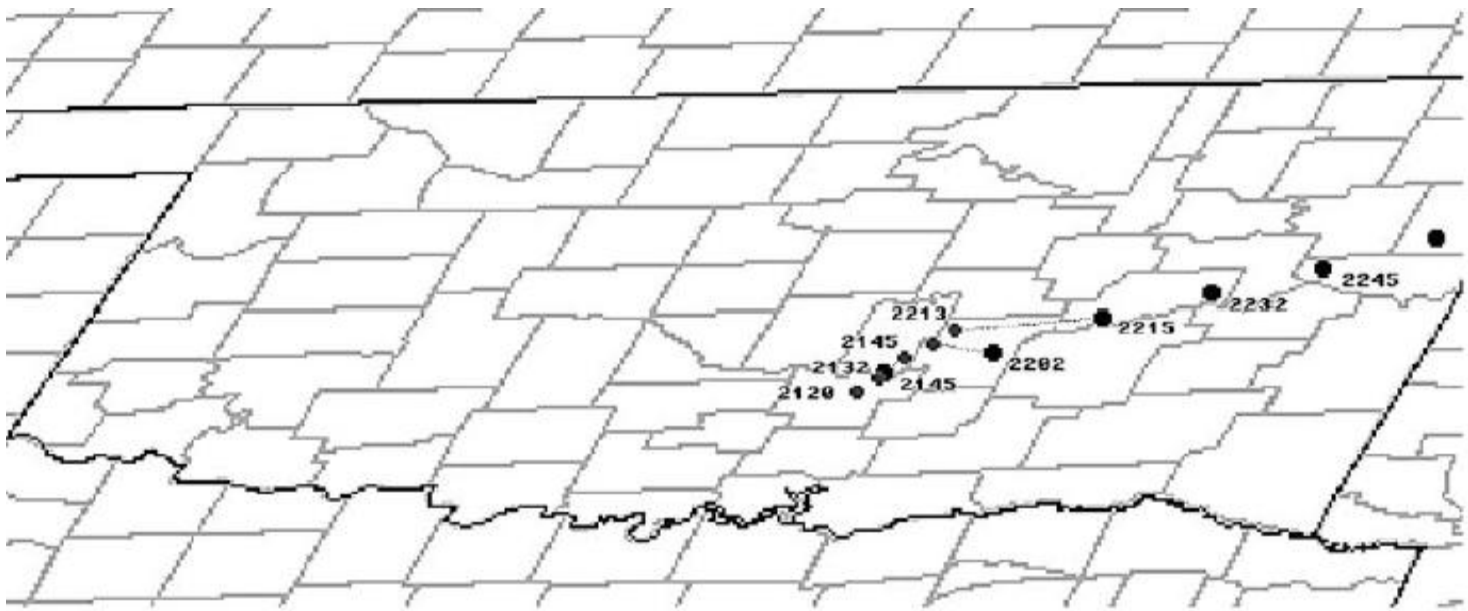
Multispectral high-resolution satellite observations of plumes on top of convective storms

Vincenzo Levizzani, Martin Setvak, 1996 JAS



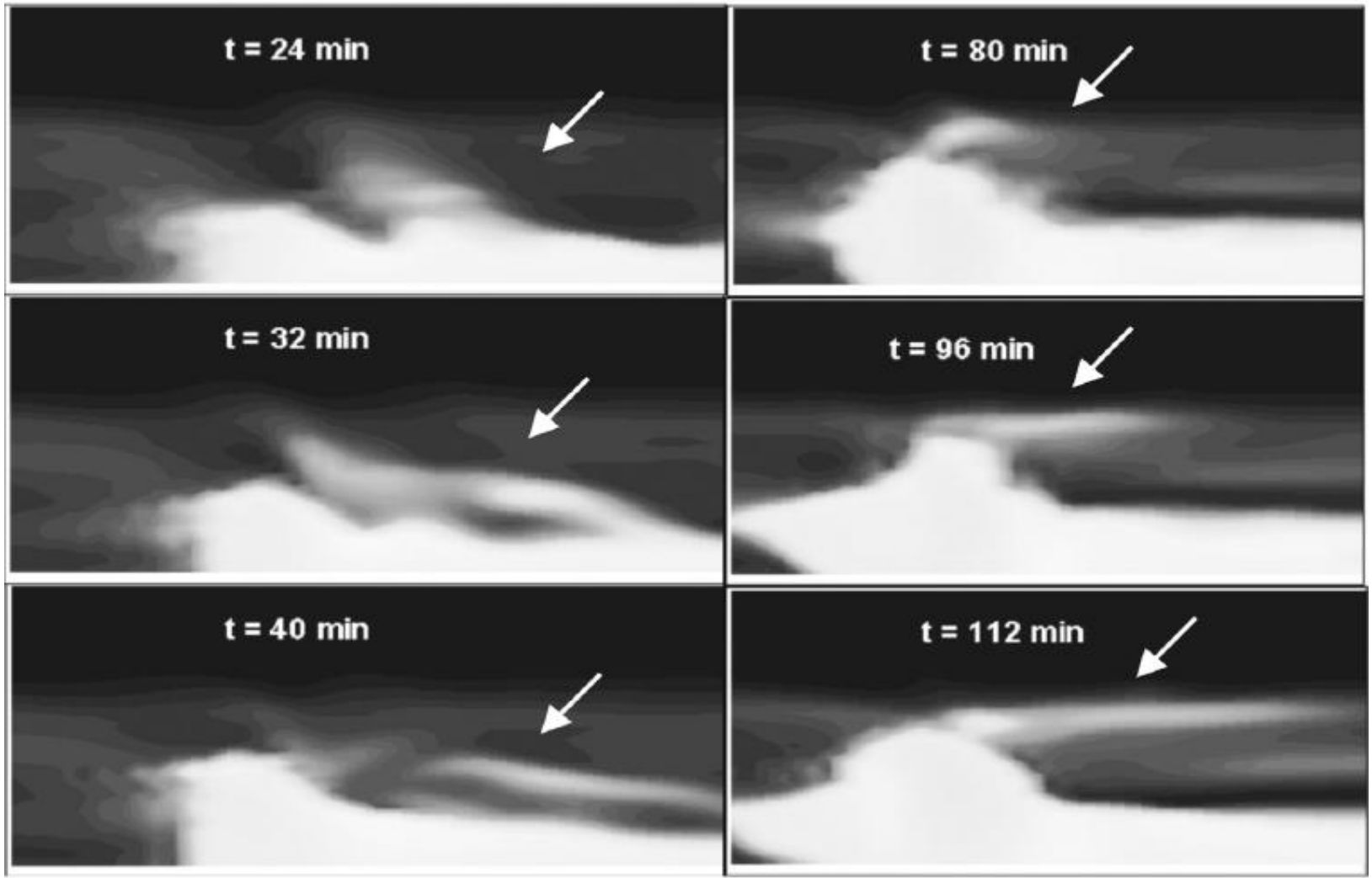
Satellite observations of convective storm tops in the 1.6, 3.7 and 3.9 spectral bands

Martin Setvak, Robert Rabin, Charles Doswell,
Vincenzo Levizzani, 2003 Atmos. Res.



Moisture plumes above thunderstorm anvils and their contributions to cross-tropopause transport of water vapor in midlatitudes

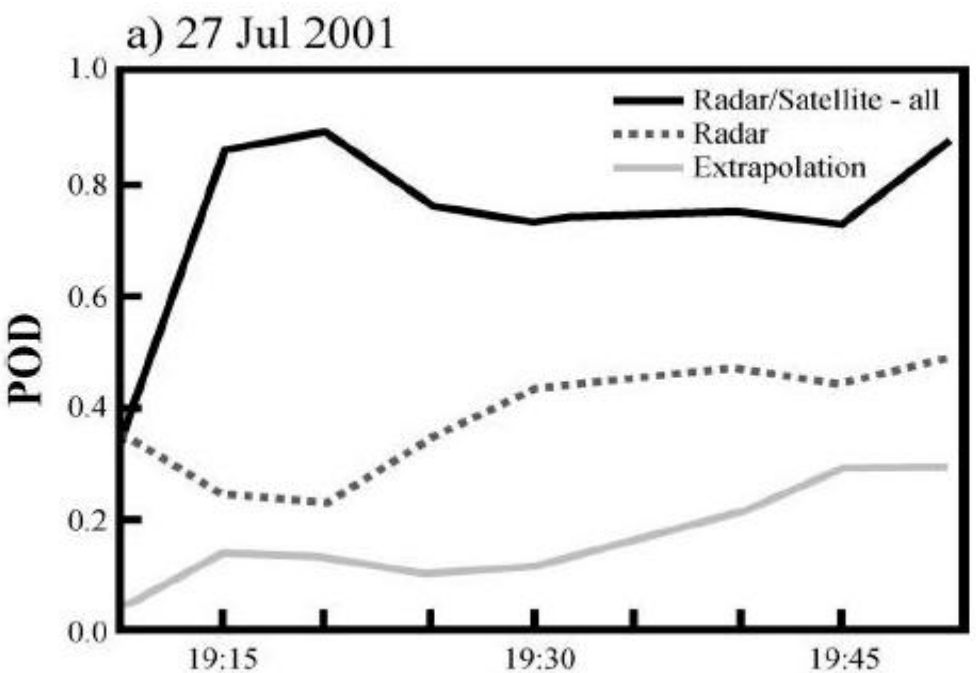
Pao Wang, 2003, JGR

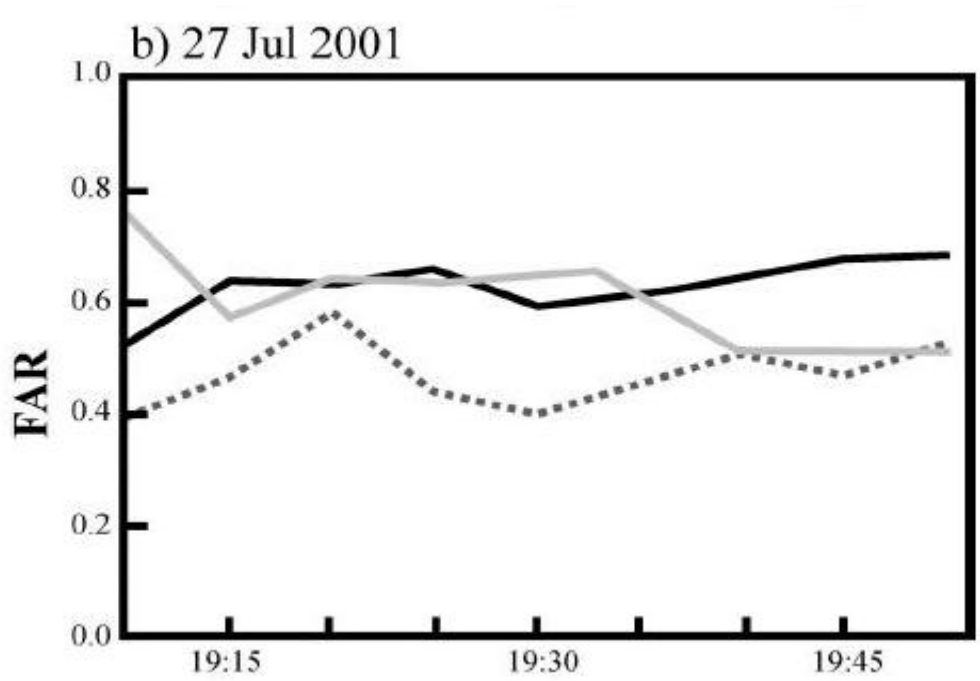


CURRENT APPLICATIONS

Nowcasting storm initiation and growth using GOES-8 and WSR-88D data

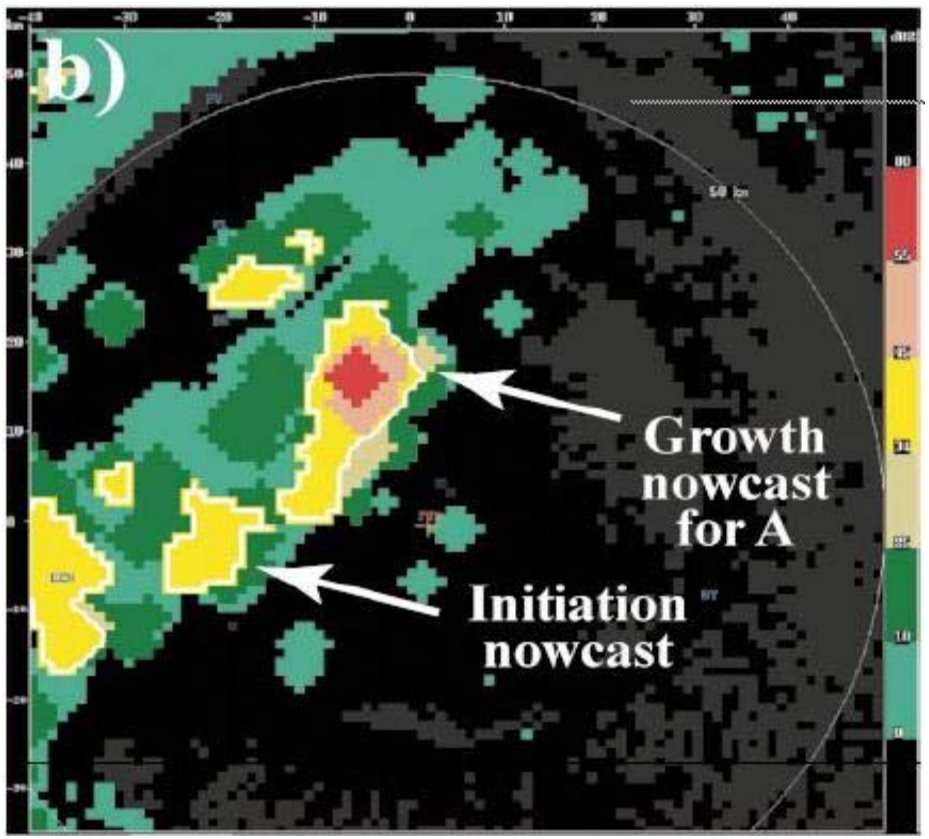
Rita Roberts, Steven Rutledge, 2003 WF

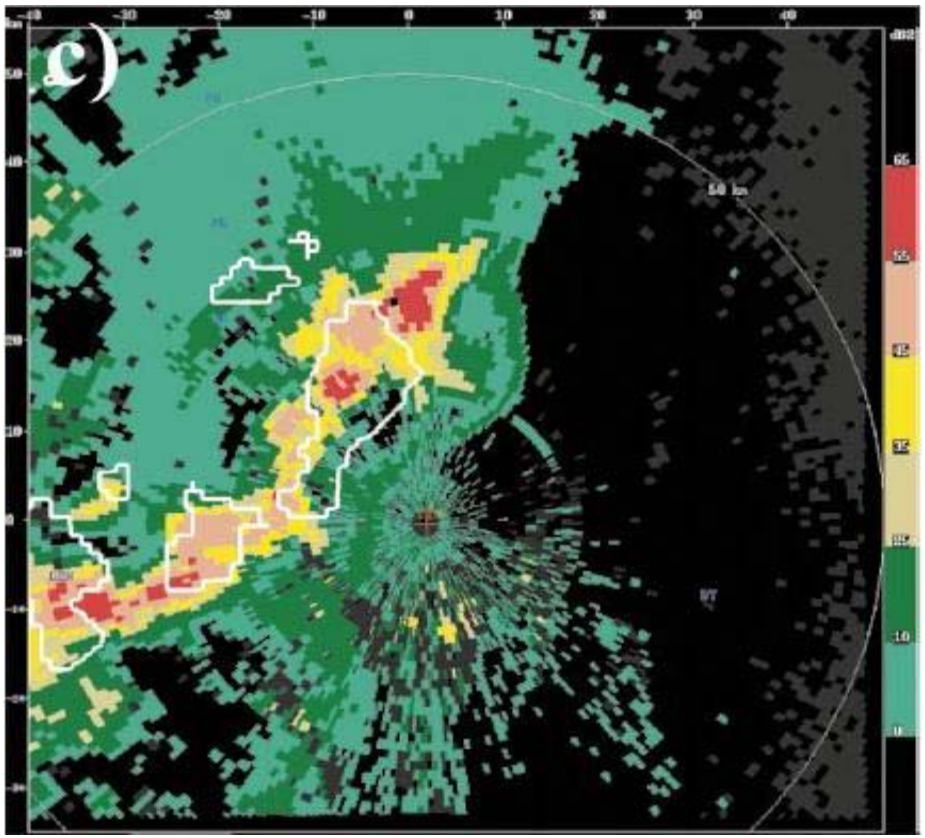




NCAR auto-nowcast system

Cindy Mueller et al, 2003, WF



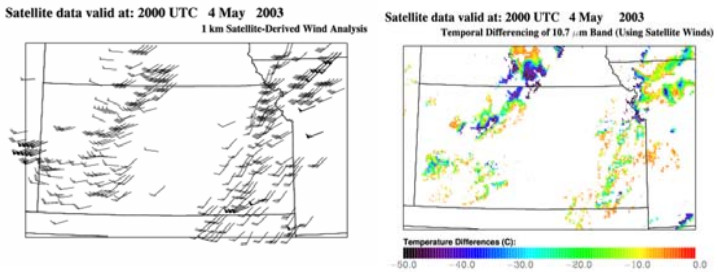


UW-CIMSS Satellite Convective Storm Nowcasting

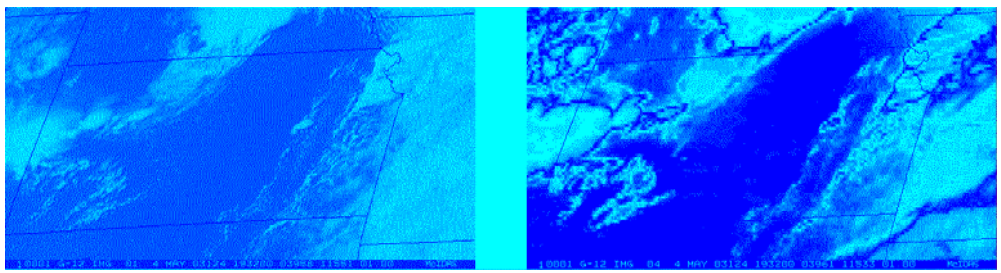
Incorporate Satellite-Based Convective Cloud Analyses for Nowcasting Convective Initiation (CI)

- Identify pre-CI signatures in GOES Visible and IR data using:
  1) convective cloud masking techniques
  2) multi-spectral band differencing
  3) cloud-top temperature trend assessments
- Develop CI nowcasts (0-1 hour) by accumulating pre-CI satellite indicators attributed to the first occurrence of a $\geq$ 30 dBZ radar echo

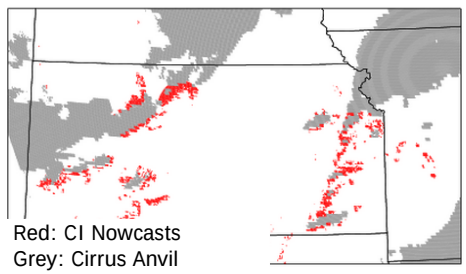
Cloud-top Cooling Estimates Using Satellite-Derived Winds



GOES-12 1 km Visible and 4 km Imager: 4 May 2003

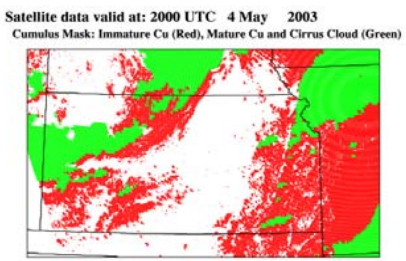


CI Nowcast Algorithm

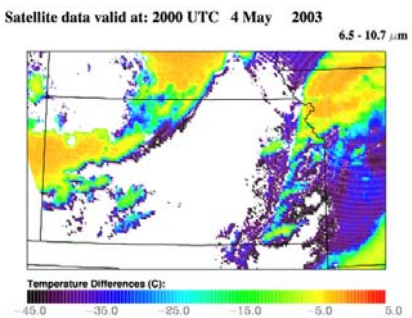


Red: CI Nowcasts
Grey: Cirrus Anvil

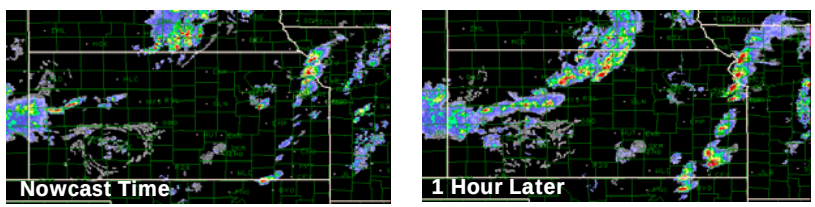
Convective Cloud Mask



Multi-spectral Techniques



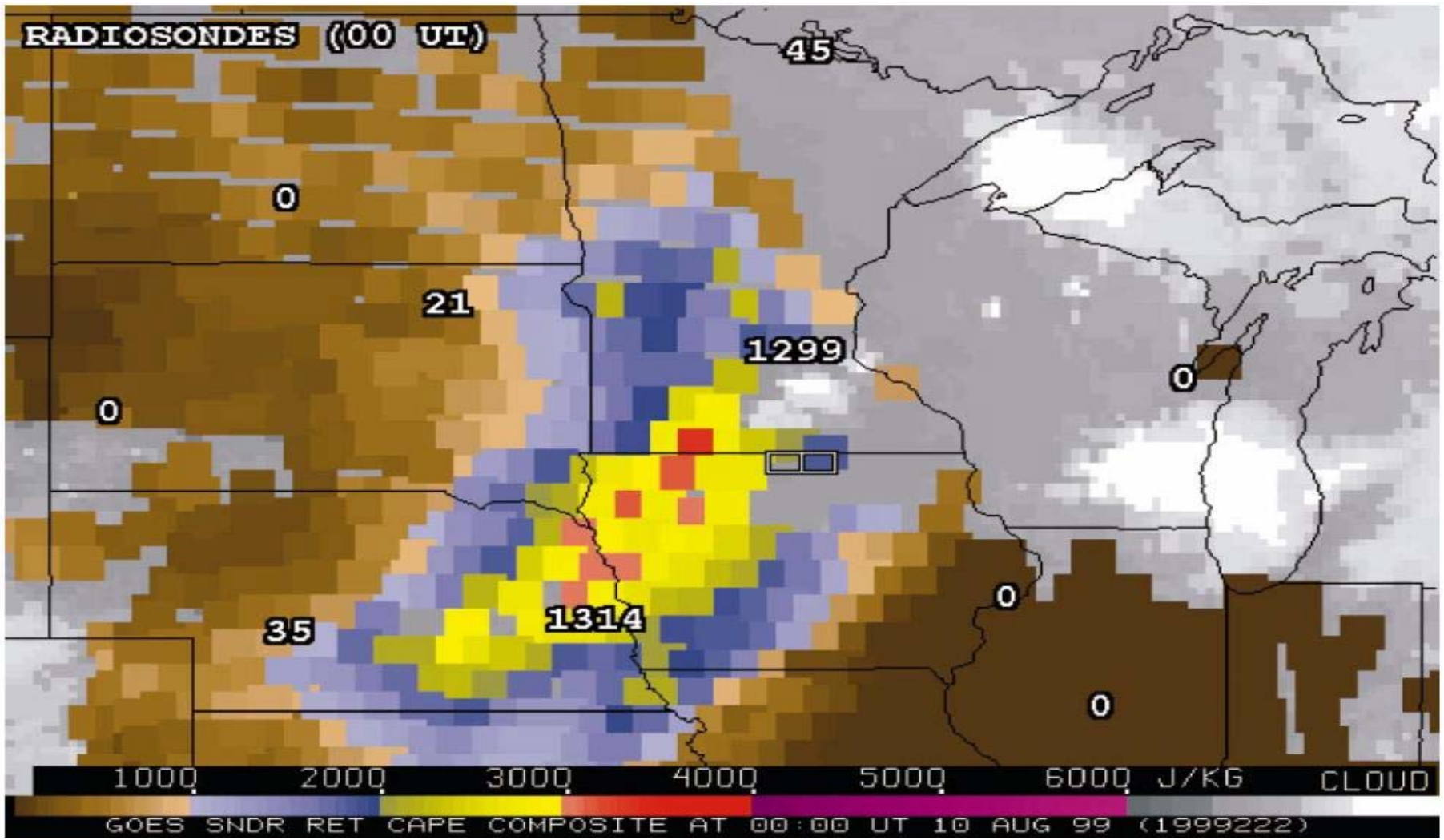
Doppler Radar for Validation



Kristopher Bedka and John Mecikalski, 2004 EUMETSAT Satellite Conference

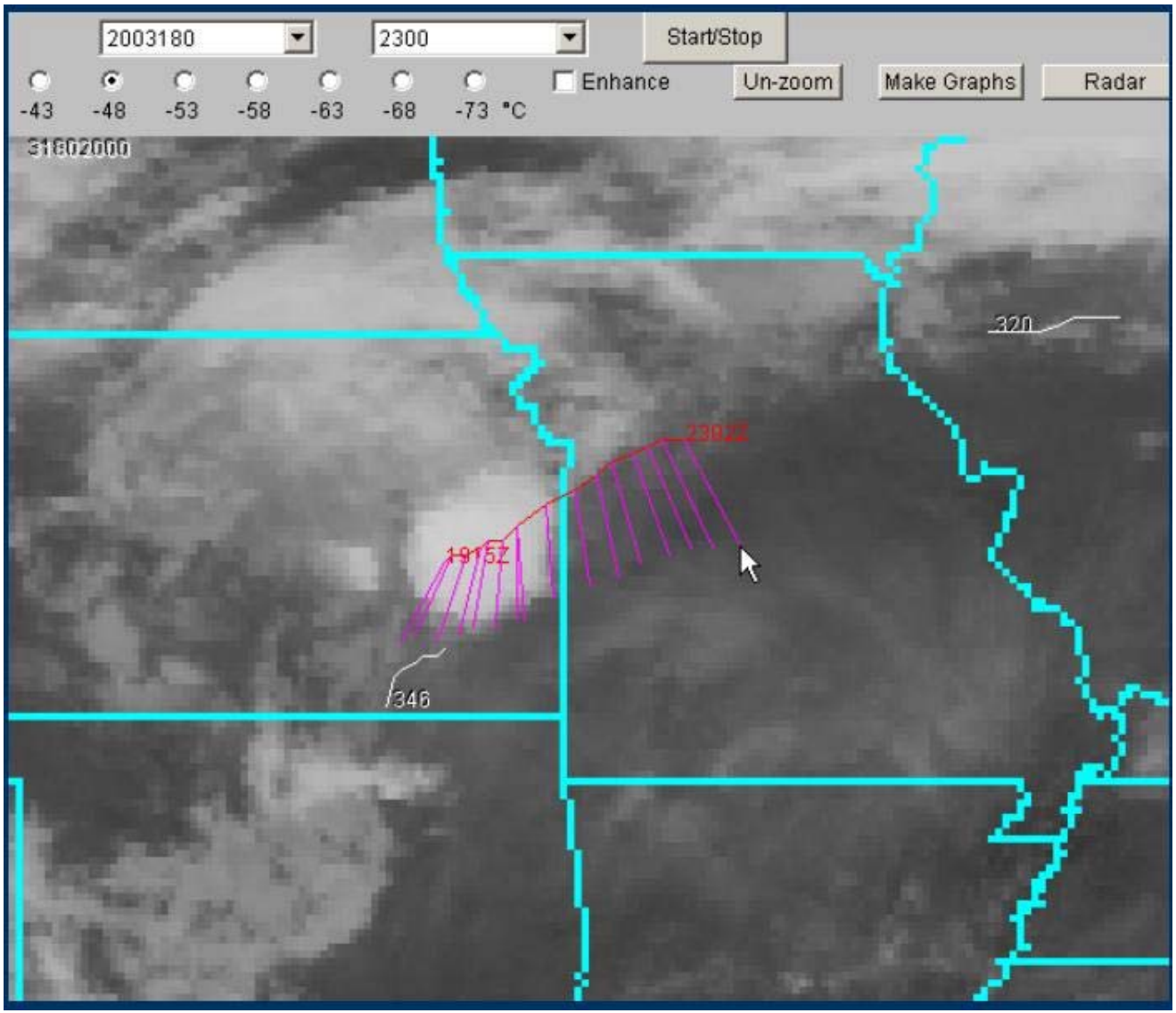
Validation and use of GOES sounder information

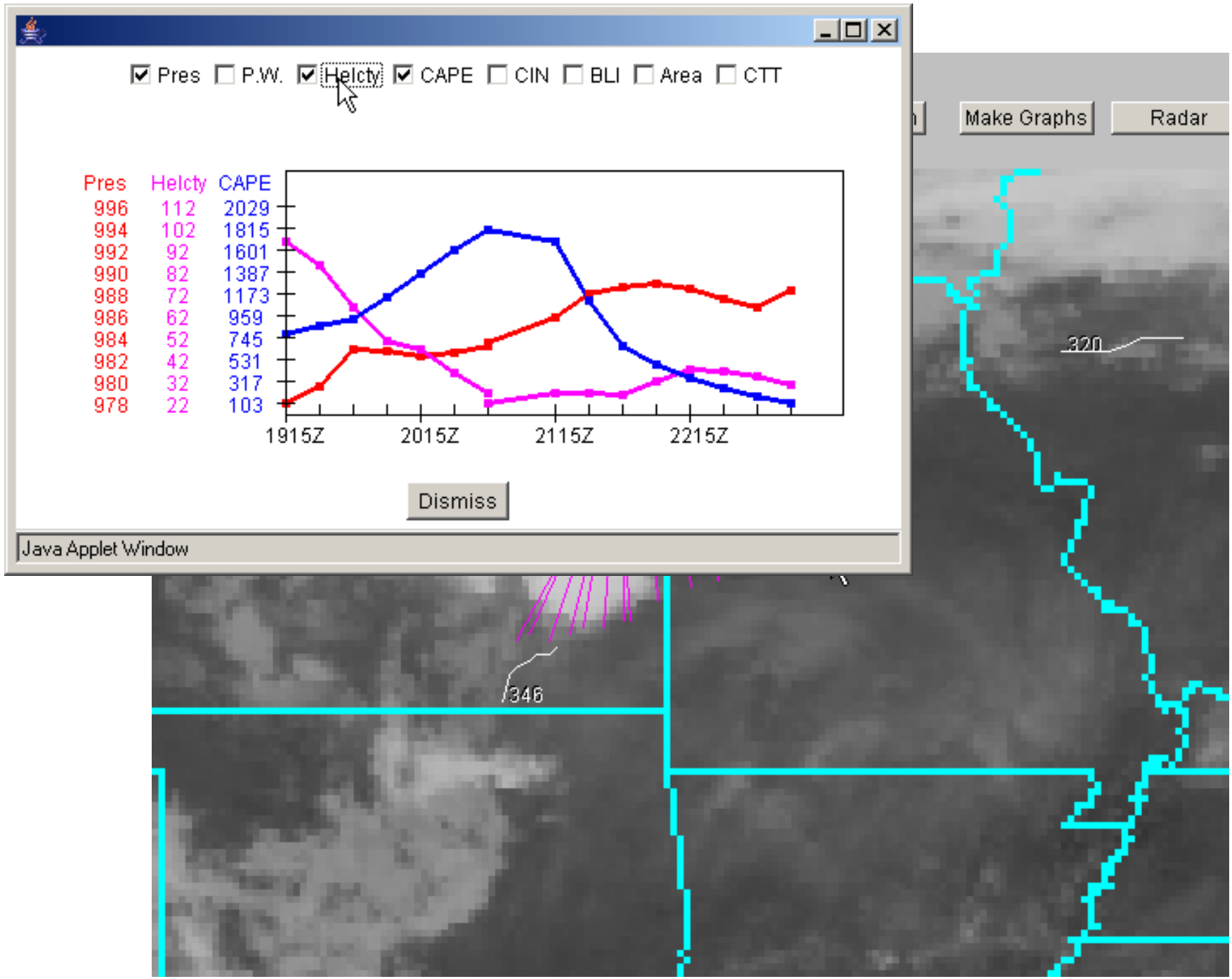
Tim Schmit, et al., 2002 WF



Storm tracker
A Web-based tool for monitoring MCS

Robert Rabin, Tom Whittaker 2004




Pres
P.W.
Helcty
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988 72 1173
986 62 959
984 52 745
982 42 531
980 32 317
978 22 103
1915Z
2015Z
2115Z
2215Z
Dismiss
Java Applet Window
Make Graphs
Radar
320
346

SUMMARY

- 40 year history of satellite research
- Hot research topic through 1980's
- Limits to Operational use of early ideas
  - Advent of Doppler radar network
  - Resolution limitations
  - Limited early access
- Greatest impact: qualitative use of imagery

THE FUTURE?

- MSG (now)
- AWIPS
- GOES-R (2013)
- Space-borne Radars?