united nations
educational, scientific
and cultural
organization

international atomic
energy agency

the
abdus salam
international centre for theoretical physics

H4. SMR/1247
Lecture Note: 13

WORKSHOP ON PHYSICS OF MESOSPHERE-STRATOSPHERE-TROPOSPHERE INTERACTIONS WITH SPECIAL EMPHASIS ON MST RADAR TECHNIQUES

(13 - 24 November 2000)

SYNOPTIC SCALE METEOROLOGY AS OBSERVED WITH MST RADAR

Prof. Röttger Jürgen

Max-Planck Institut Fur Aeronomie
Katlenburg-Lindau
GERMANY

SYNOPTIC SCALE METEOROLOGY AS OBSERVED WITH MST RADAR

MST radars operated over longer periods in the stratosphere-troposphere (ST radar) mode can observe the tropopause structure and its variations, tropopause foldings during passages of synoptic-scale disturbances (cyclones) and the structure of frontal systems related to the synoptic-scale disturbances.

Some references:

Röttger, VHF radar observations of a frontal passage, Journal Applied Meteorology, 18, 85-91, 1979.

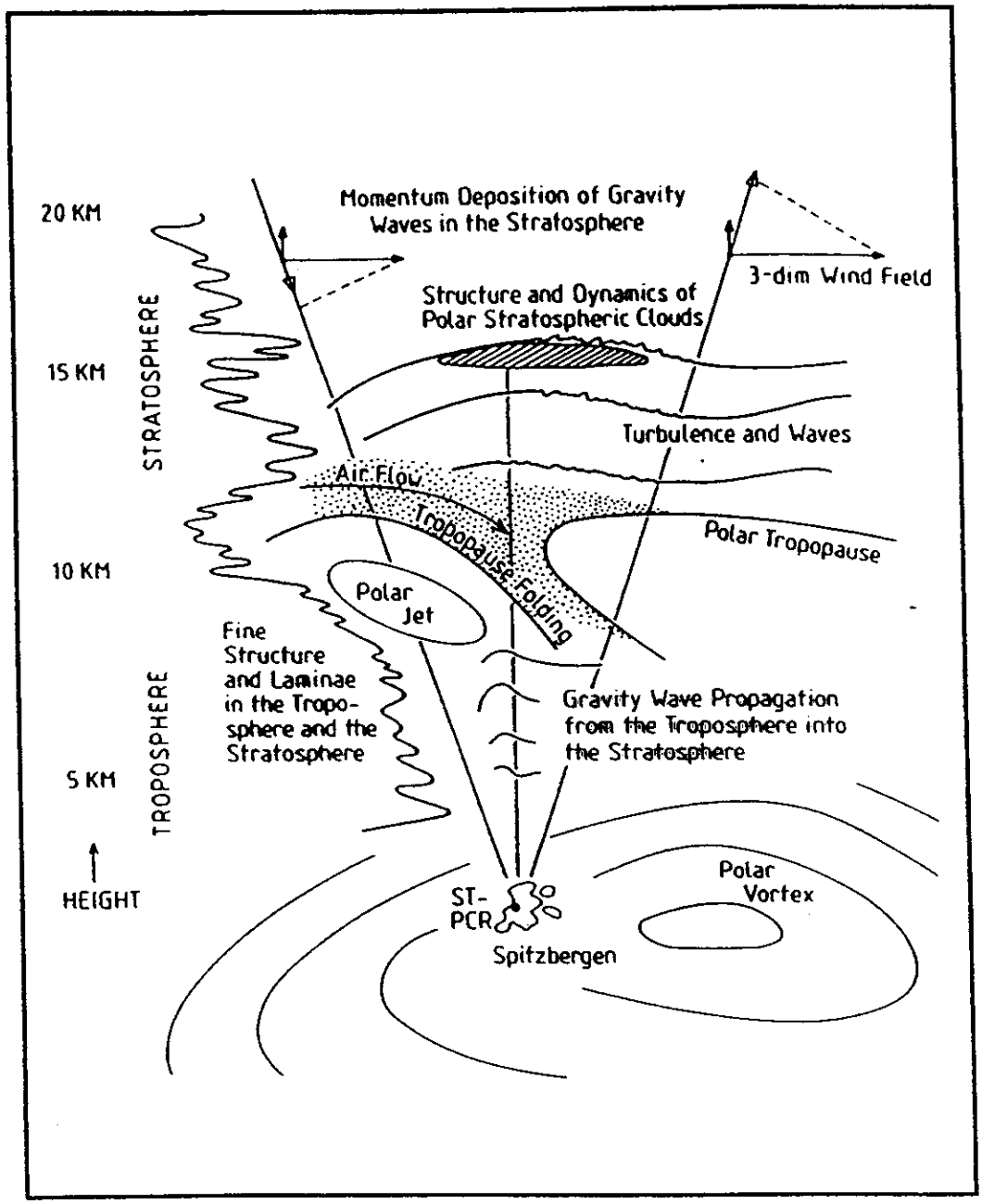
Röttger and Schmidt, Characteristics of frontal zones determined from spaced antenna VHF radar observations, Proc. 20th Conf. on Radar Meteorology (AMS), 30-37, 1981.

Larsen and Röttger, VHF and UHF Doppler radars as tools for synoptic research, Bulletin American Meteorological Society (AMS), 63, 996-1008, 1982.

Larsen and Röttger, Observations of frontal zone and tropopause structures with VHF Doppler radar and radiosondes, Radio Science, 20, 1223-1232, 1985.

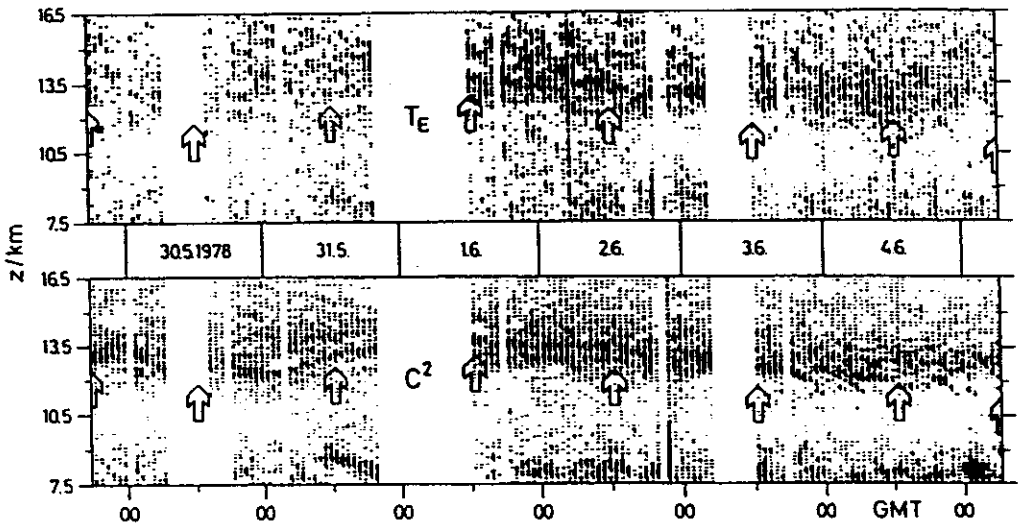
Röttger and Larsen, UHF / VHF radar technologies for atmospheric research and wind profiler applications, in Radar in Meteorology, Amer. Met. Soc., 235-281, 1990.

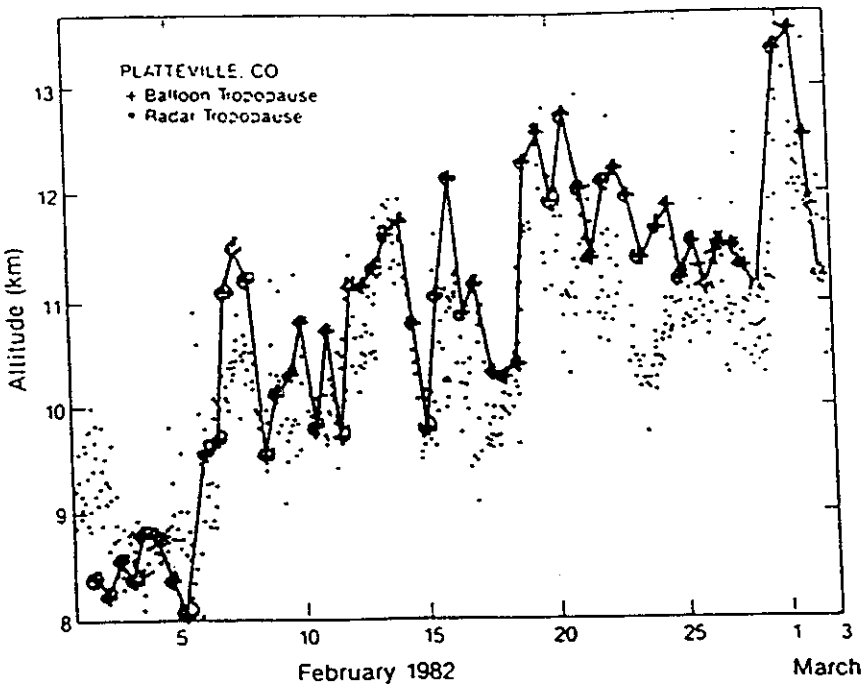
J. Röttger, Max-Panck-Institut fuer Aeronomy
D-37191 Katlenburg-Lindau, Germany
<roettger@linmpi.mpg.de>



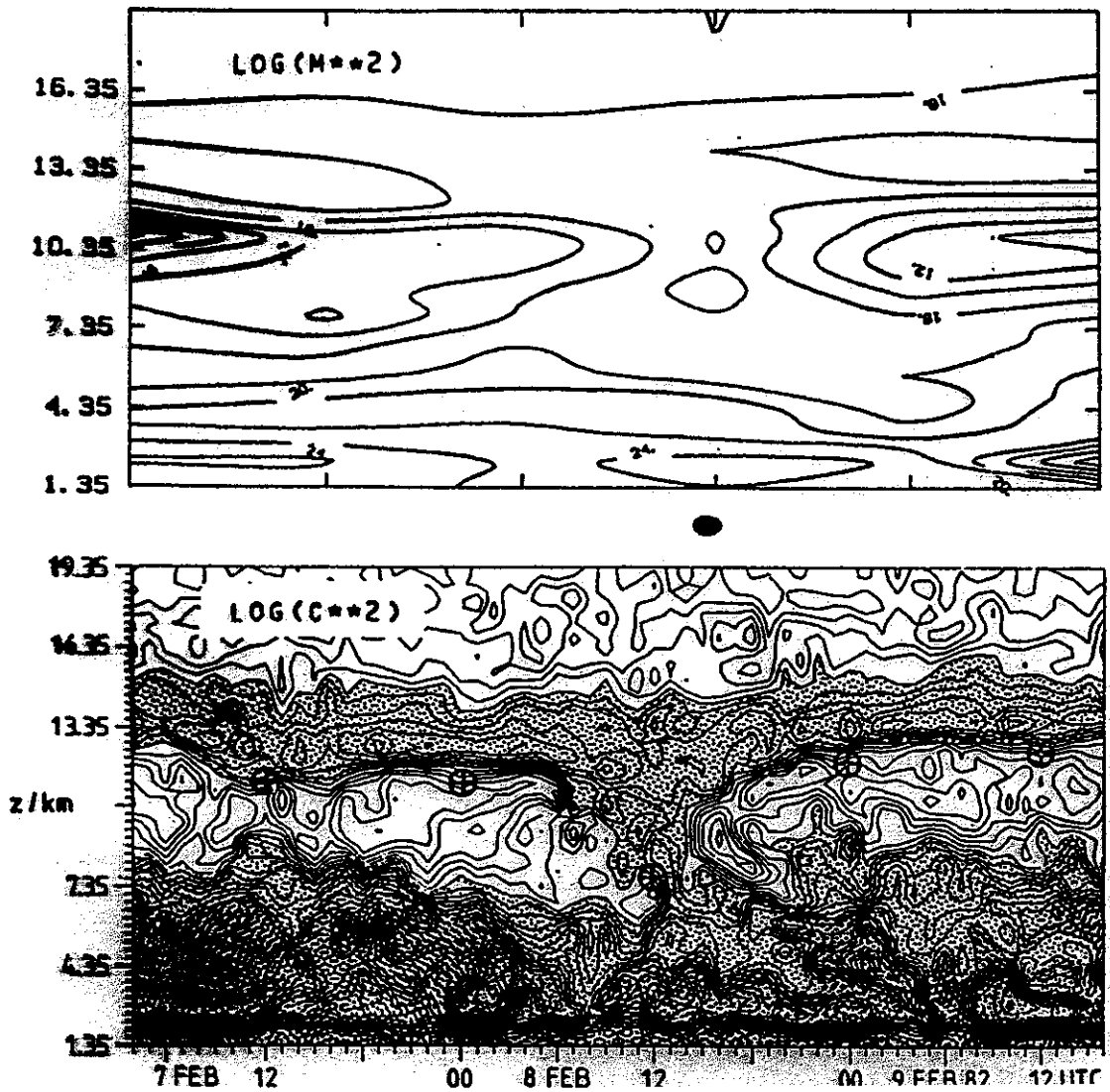
Dynamical processes to be studied with radar in the Arctic stratosphere and troposphere

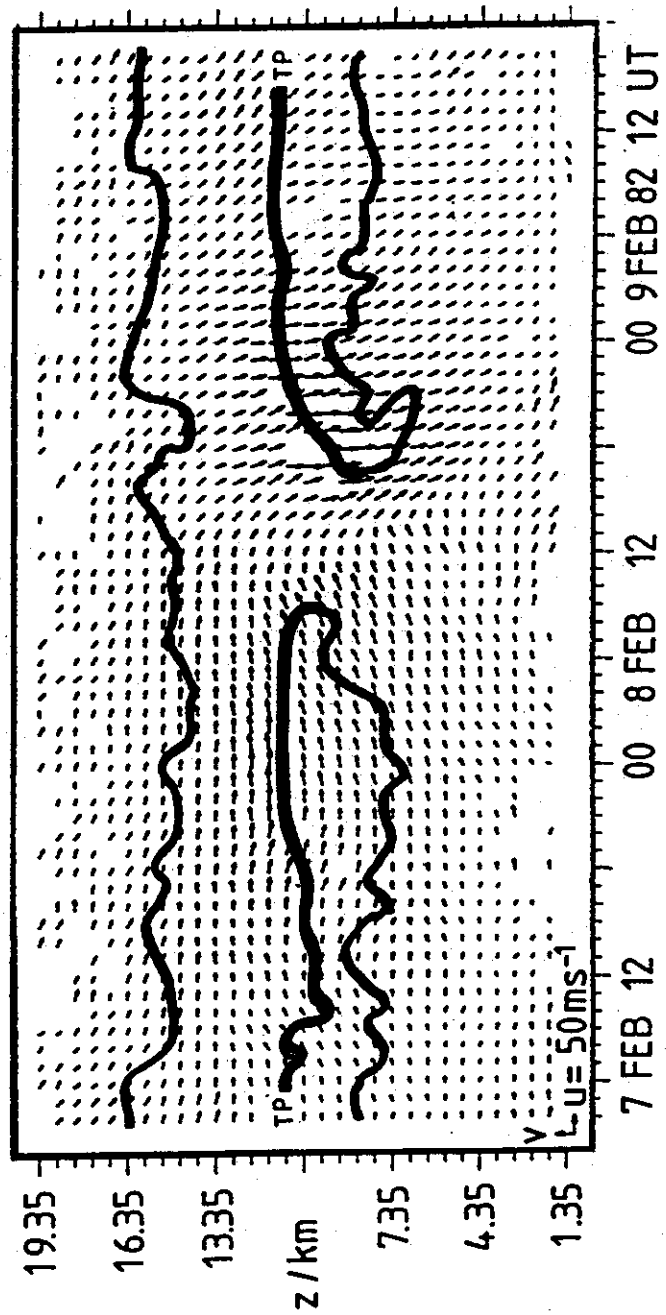
Tropopause detection by ST radar



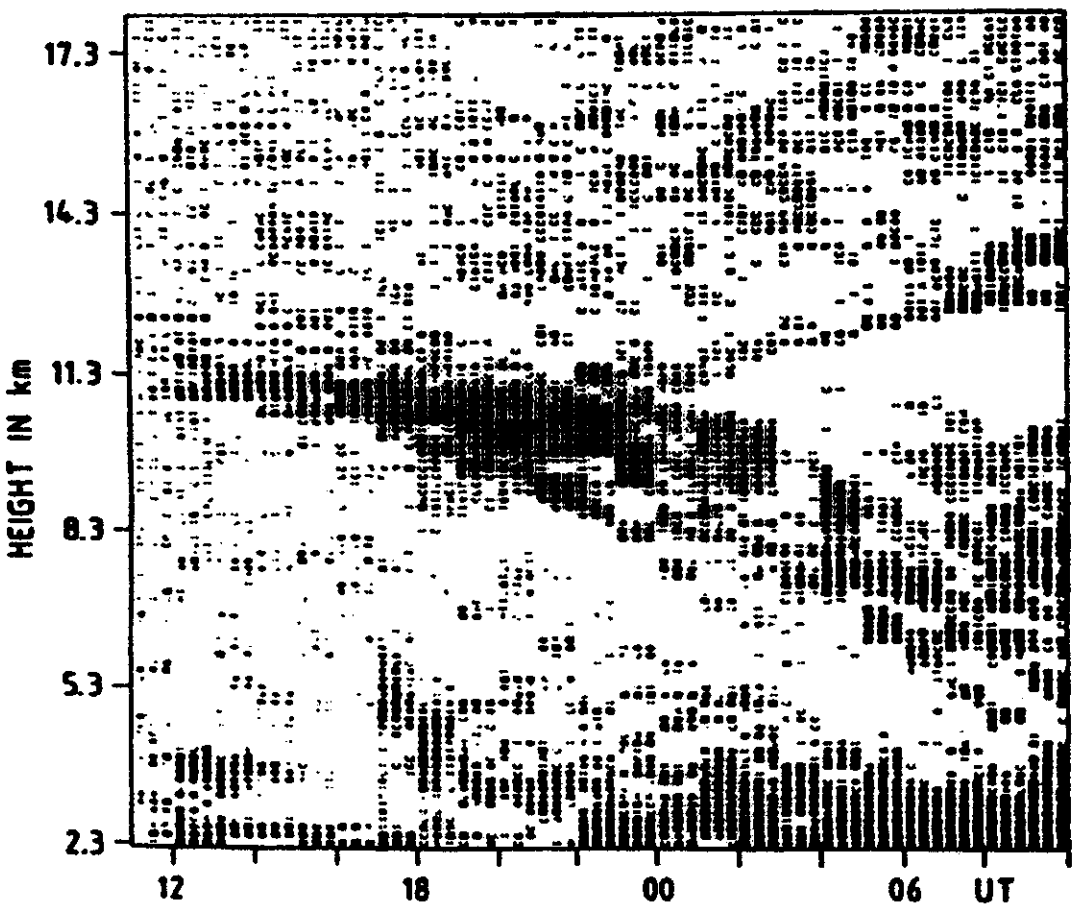


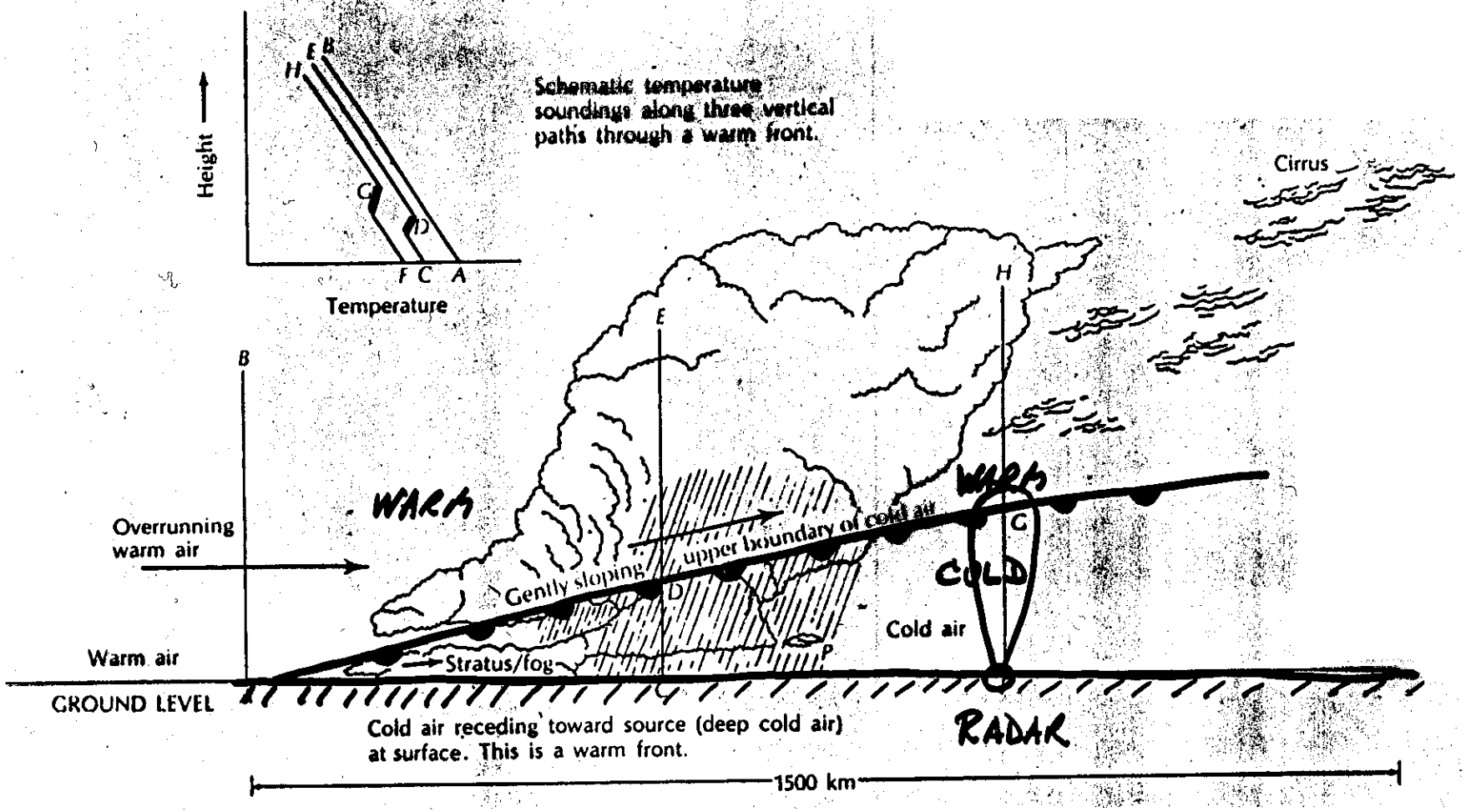
Tropopause Folding Observed by VHF ST Radar Wind Profiler




19.35
16.35
13.35
z/km
7.35
4.35
1.35
TP
TP
7 FEB 12
00
8 FEB
12
00
9 FEB 82
12 UT
L u = 50 ms⁻¹

Warmfront Passage Over a VHF Radar Wind Profile Causing a Tropopause Fold

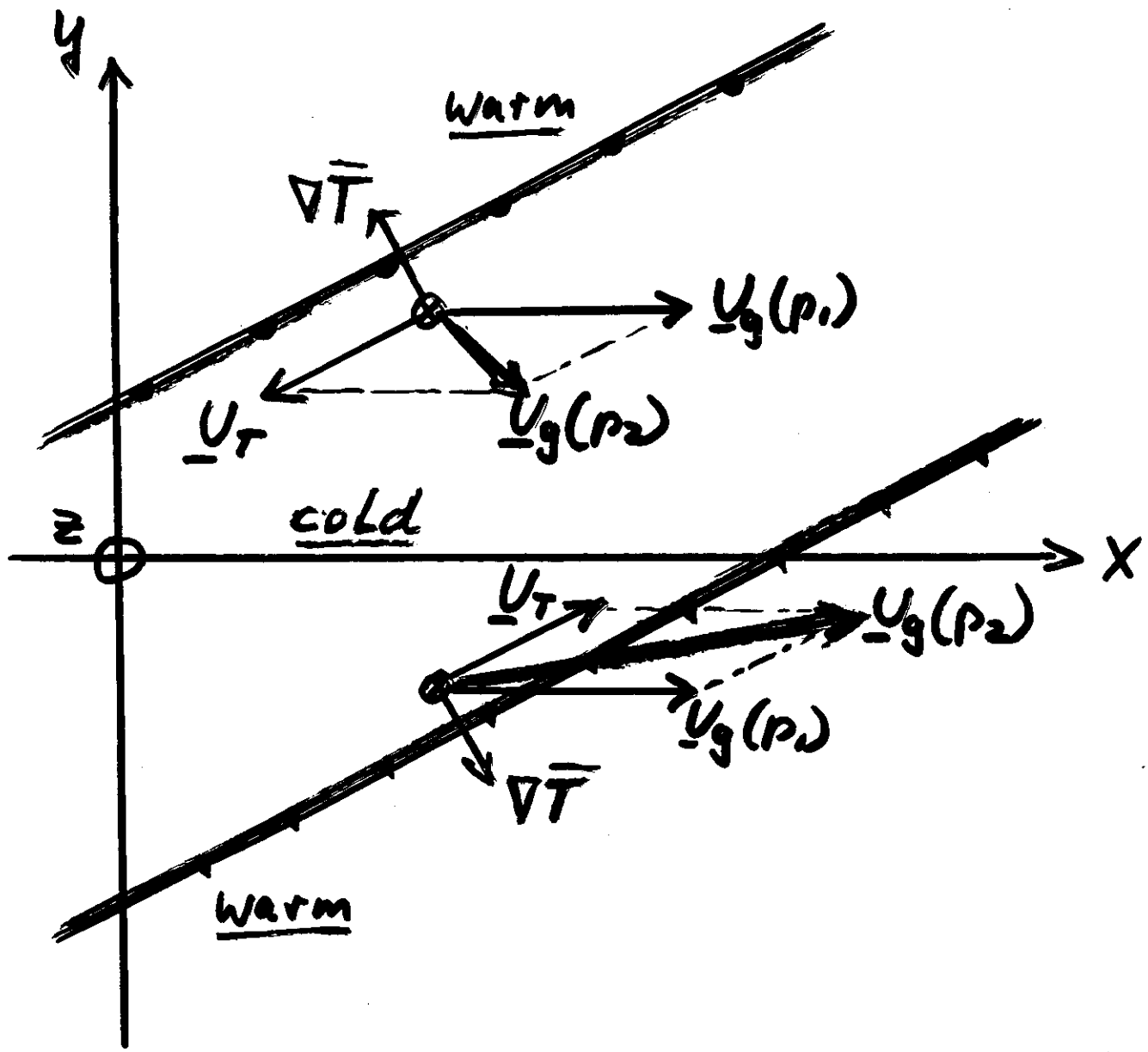


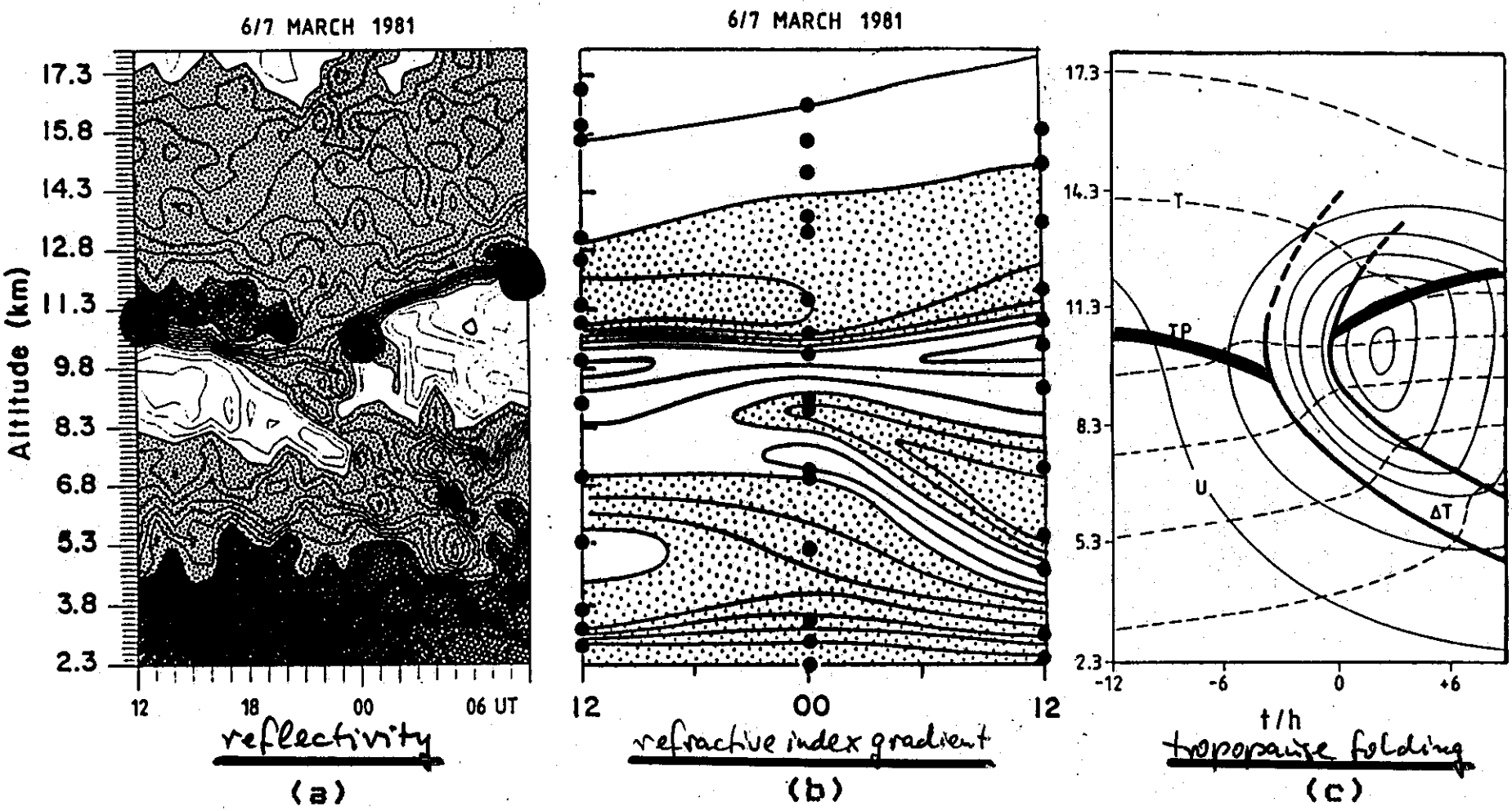

Height
H
E
B
G
D
F C A
Temperature
Schematic temperature soundings along three vertical paths through a warm front.
Cirrus
H
E
B
WARM
Overrunning warm air
Gently sloping upper boundary of cold air
WARM
G
COLD
D
Cold air
Warm air
Stratus/fog
P
GROUND LEVEL
Cold air receding toward source (deep cold air) at surface. This is a warm front.
RADAR
1500 km

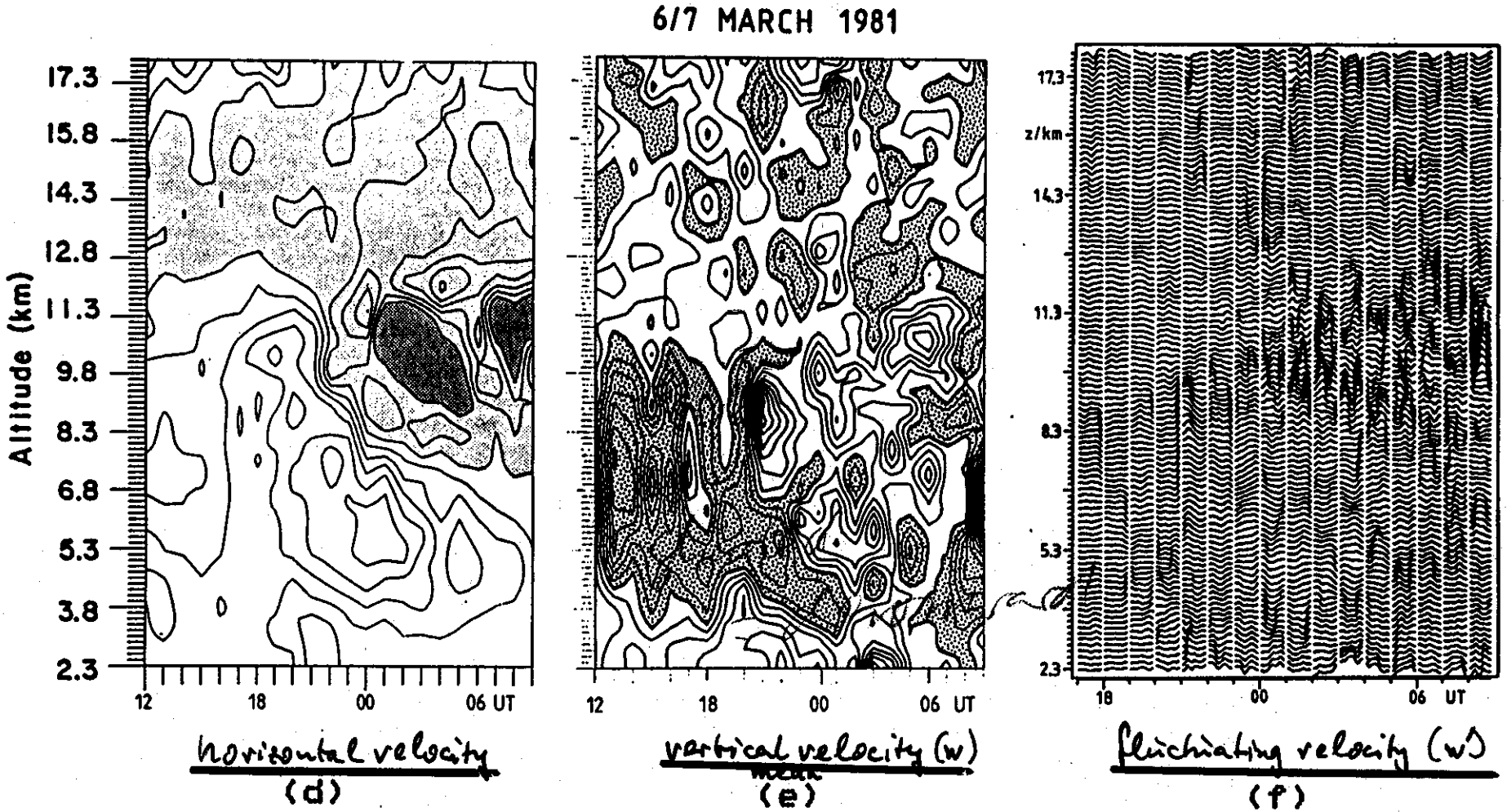
Thermal wind $\underline{U}_T$

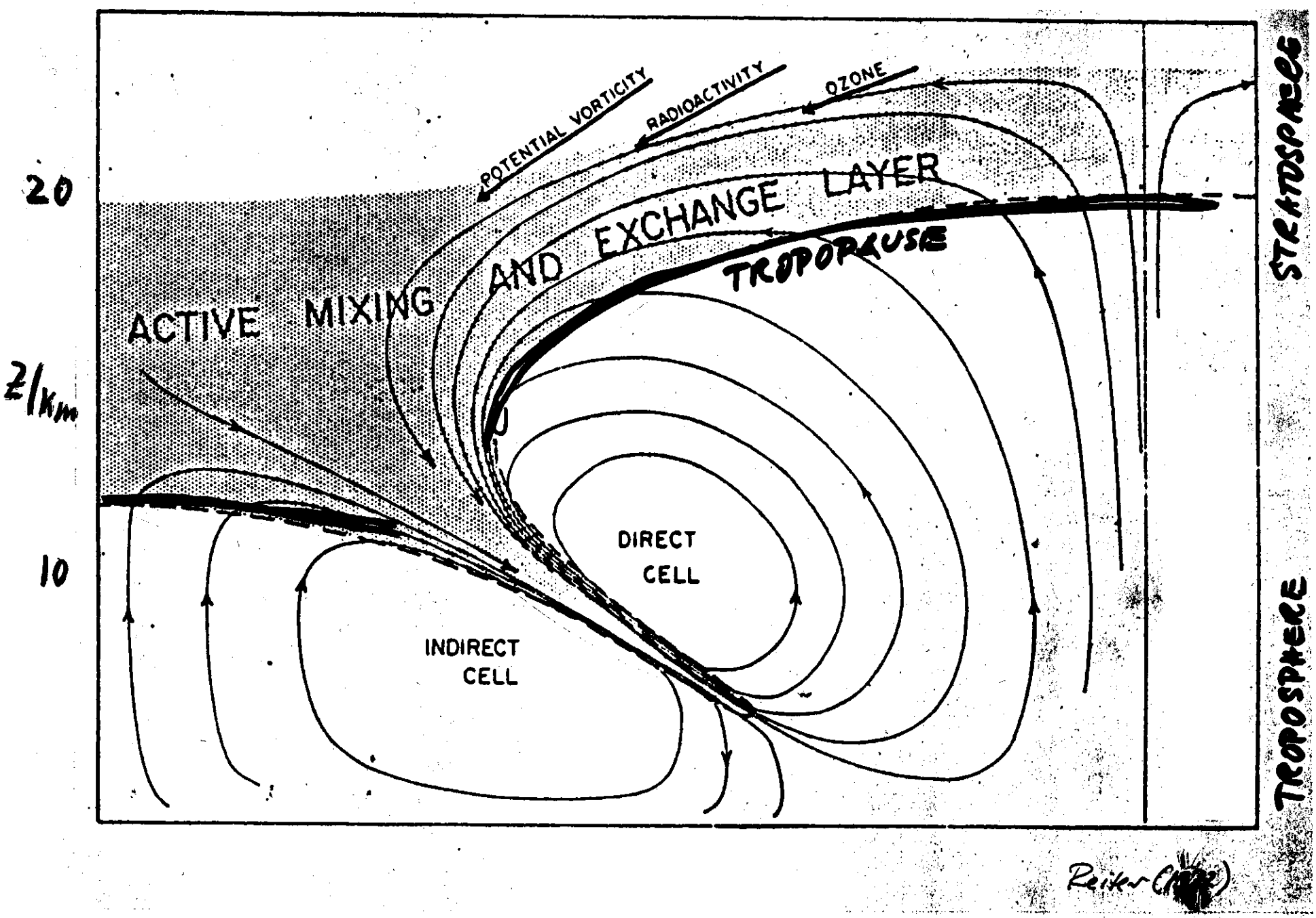
$$\underline{U}_T = \underline{U}_g(p_1) - \underline{U}_g(p_2) \qquad p_2 < p_1$$

$$= \frac{R}{f} \ln \frac{p_1}{p_2} \left(\underline{z} \times \nabla \bar{T}\right)$$

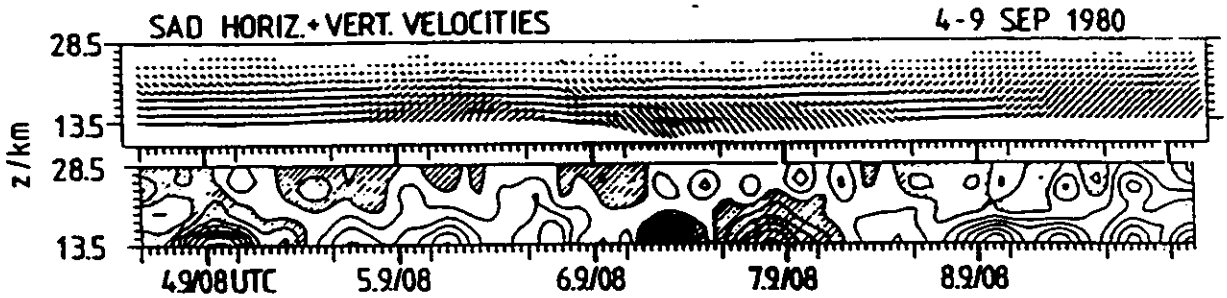


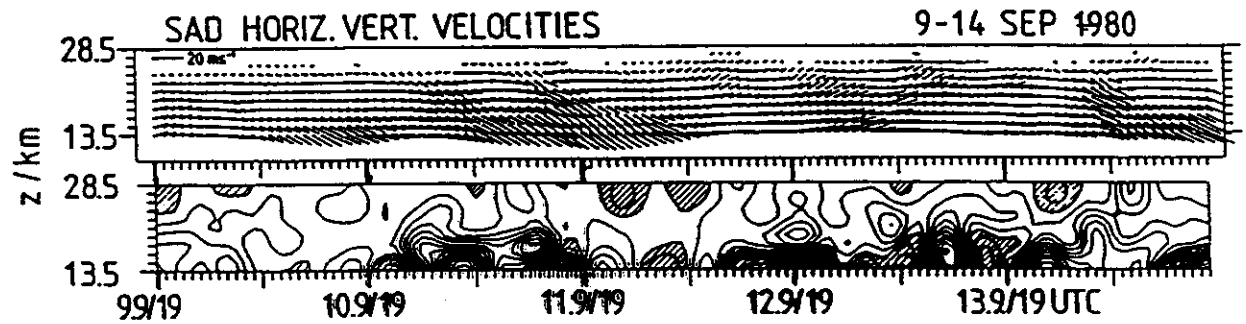

6/7 MARCH 1981
Altitude (km)
17.3
15.8
14.3
12.8
11.3
9.8
8.3
6.8
5.3
3.8
2.3
12
18
00
06 UT
reflectivity
(a)
6/7 MARCH 1981
12
00
12
refractive index gradient
(b)
17.3
14.3
11.3
8.3
5.3
2.3
T
TP
U
ΔT
-12
-6
0
+6
t/h
tropopause folding
(c)

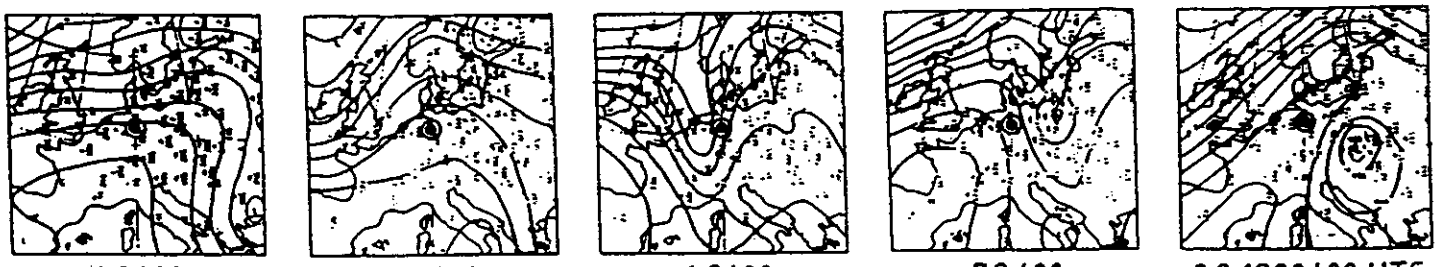

6/7 MARCH 1981
Altitude (km)
17.3
15.8
14.3
12.8
11.3
9.8
8.3
6.8
5.3
3.8
2.3
12
18
00
06 UT
z/km
horizontal velocity
(d)
vertical velocity (w)
(e)
fluctuating velocity (w')
(f)

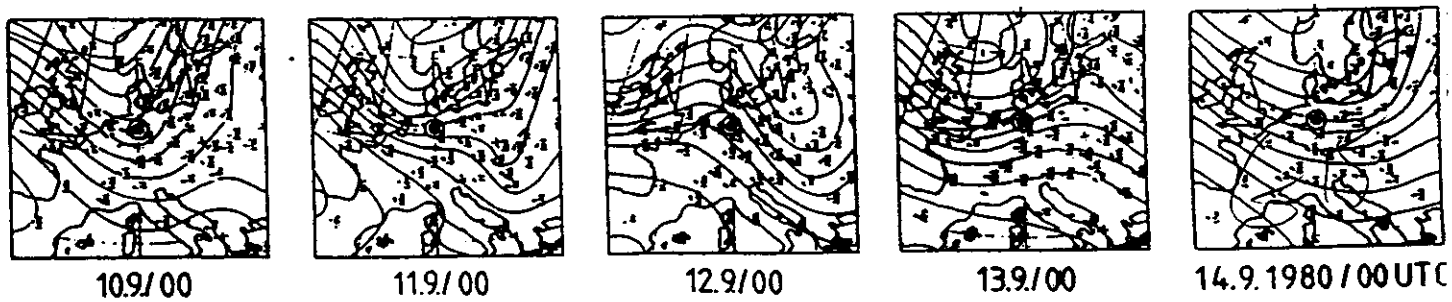

20
Z/km
10
POTENTIAL VORTICITY
RADIOACTIVITY
OZONE
ACTIVE MIXING AND EXCHANGE LAYER
TROPOPAUSE
DIRECT CELL
INDIRECT CELL
STRATOSPHERE
TROPOSPHERE
Reiter

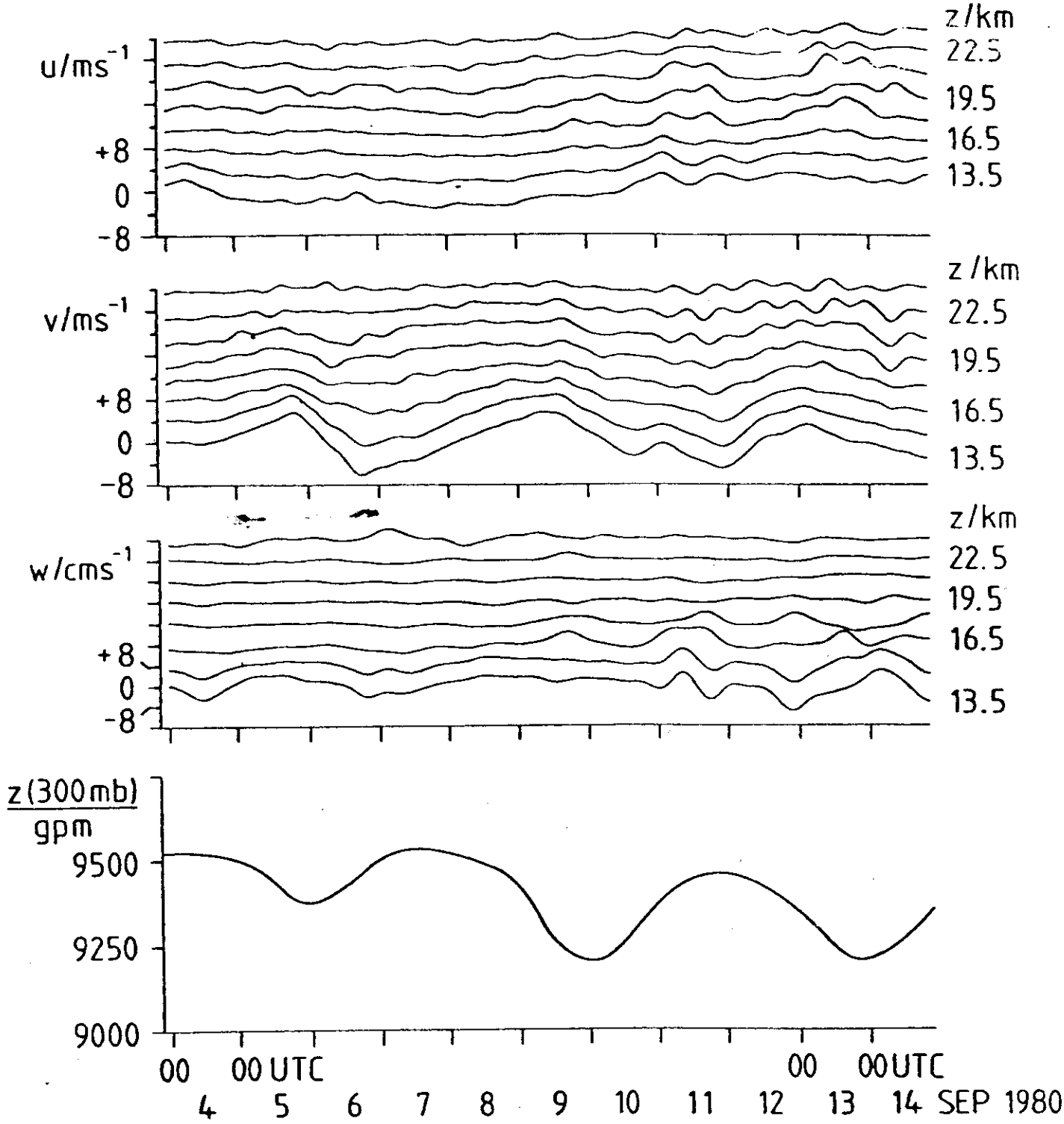
Synoptic scale stratosphere observations by ST radar

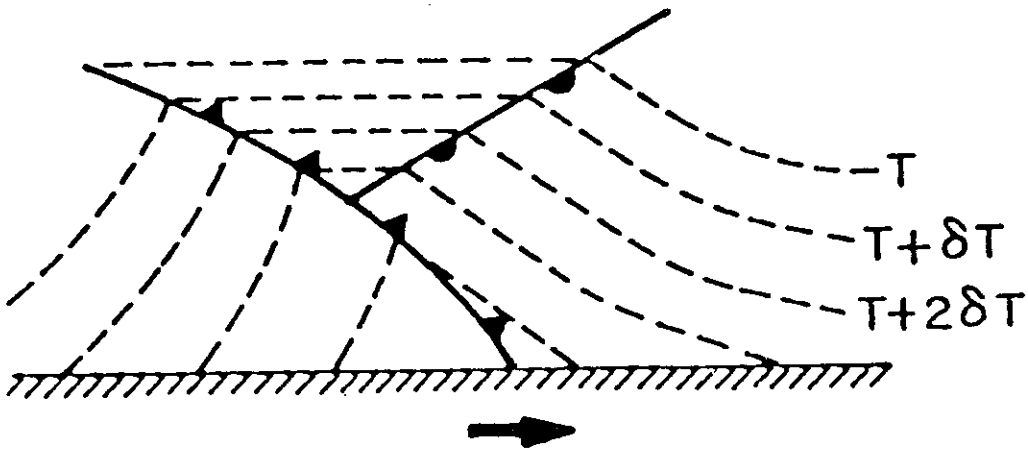


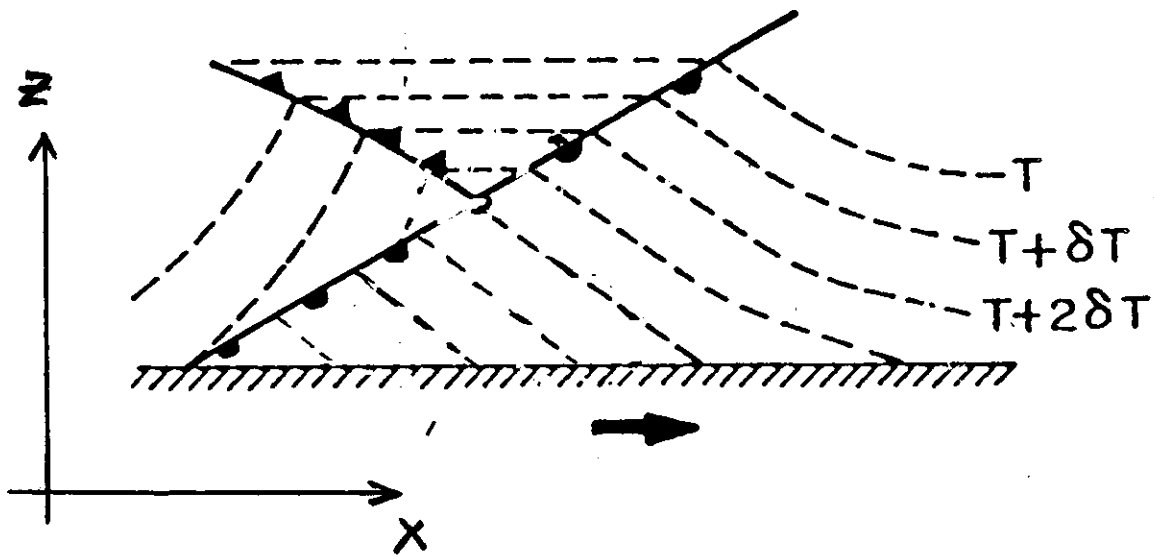


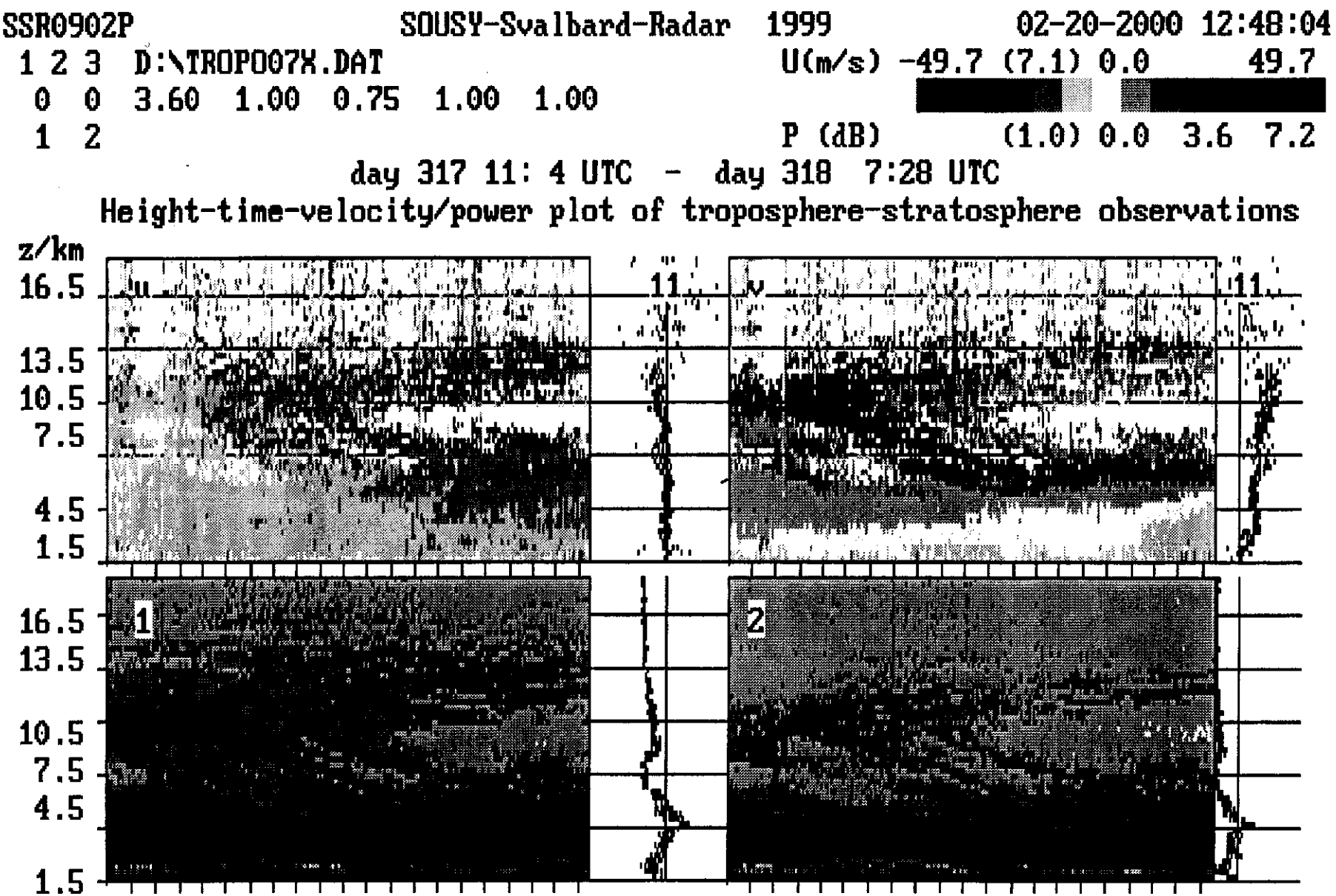


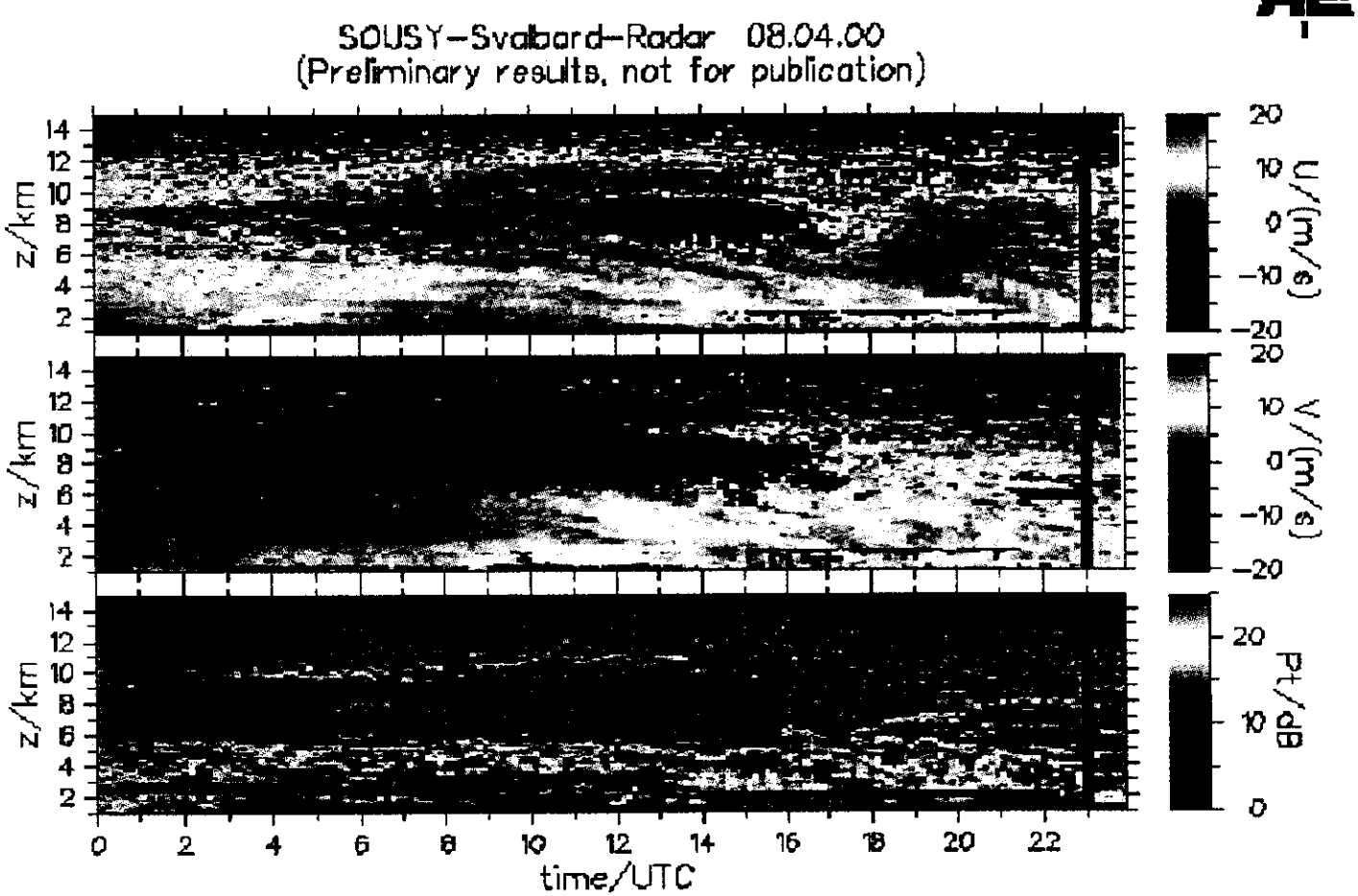



z/km
u/ms⁻¹
22.5
19.5
16.5
13.5
+8
0
-8
z/km
v/ms⁻¹
22.5
19.5
16.5
13.5
+8
0
-8
z/km
w/cms⁻¹
22.5
19.5
16.5
13.5
+8
0
-8
z(300mb)
gpm
9500
9250
9000
00 00 UTC
00 00 UTC
4 5 6 7 8 9 10 11 12 13 14 SEP 1980

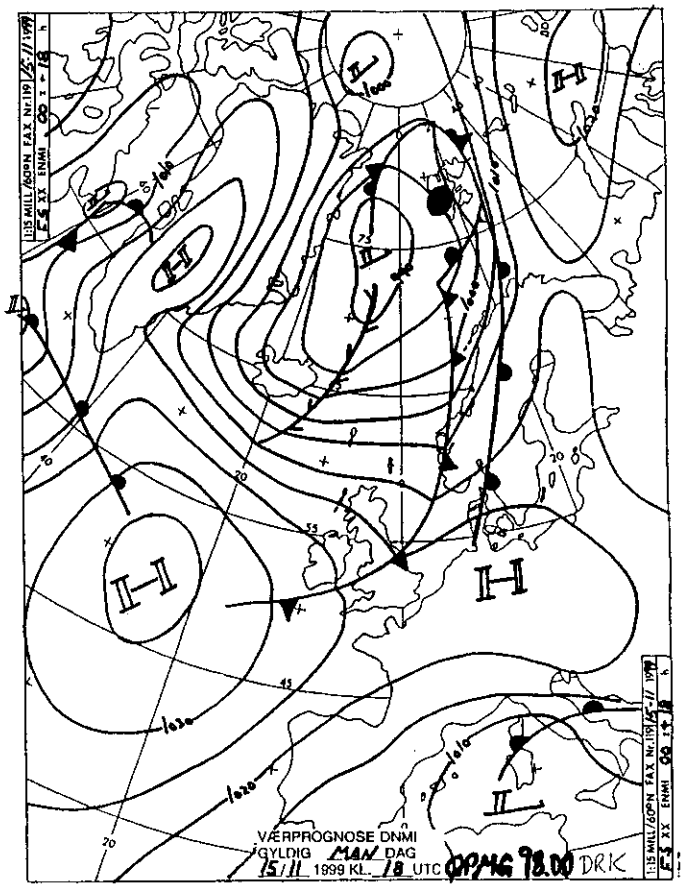

T
T+δT
T+2δT


Z
X
T
T+δT
T+2δT


SSR0902P
SOUSY-Svalbard-Radar 1999
02-20-2000 12:48:04
1 2 3 D:\TROPO07X.DAT
0 0 3.60 1.00 0.75 1.00 1.00
1 2
U(m/s) -49.7 (7.1) 0.0 49.7
P (dB) (1.0) 0.0 3.6 7.2
day 317 11: 4 UTC - day 318 7:28 UTC
Height-time-velocity/power plot of troposphere-stratosphere observations
z/km
16.5
13.5
10.5
7.5
4.5
1.5
u
v
11
11
1
2


SOUSY-Svalbard-Radar 08.04.00
(Preliminary results, not for publication)
z/km
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
18
20
22
time/UTC
20
10
0
-10
-20
U/(m/s)
V/(m/s)
BP/dB

15.11.99 (319), 12:16 UTC (NOAA-14, Ch4)



15.11.99 (319), 18 UTC forecast (DNMI)

courtesy of Longyearbyen airport