The Thermal Structure of the Upper Mesosphere and its Relationship to Layered Phenomena

Franz-Josef Lübken

Leibniz-Institut

für Atmosphärenphysik

Ostseebad Kühlungsborn

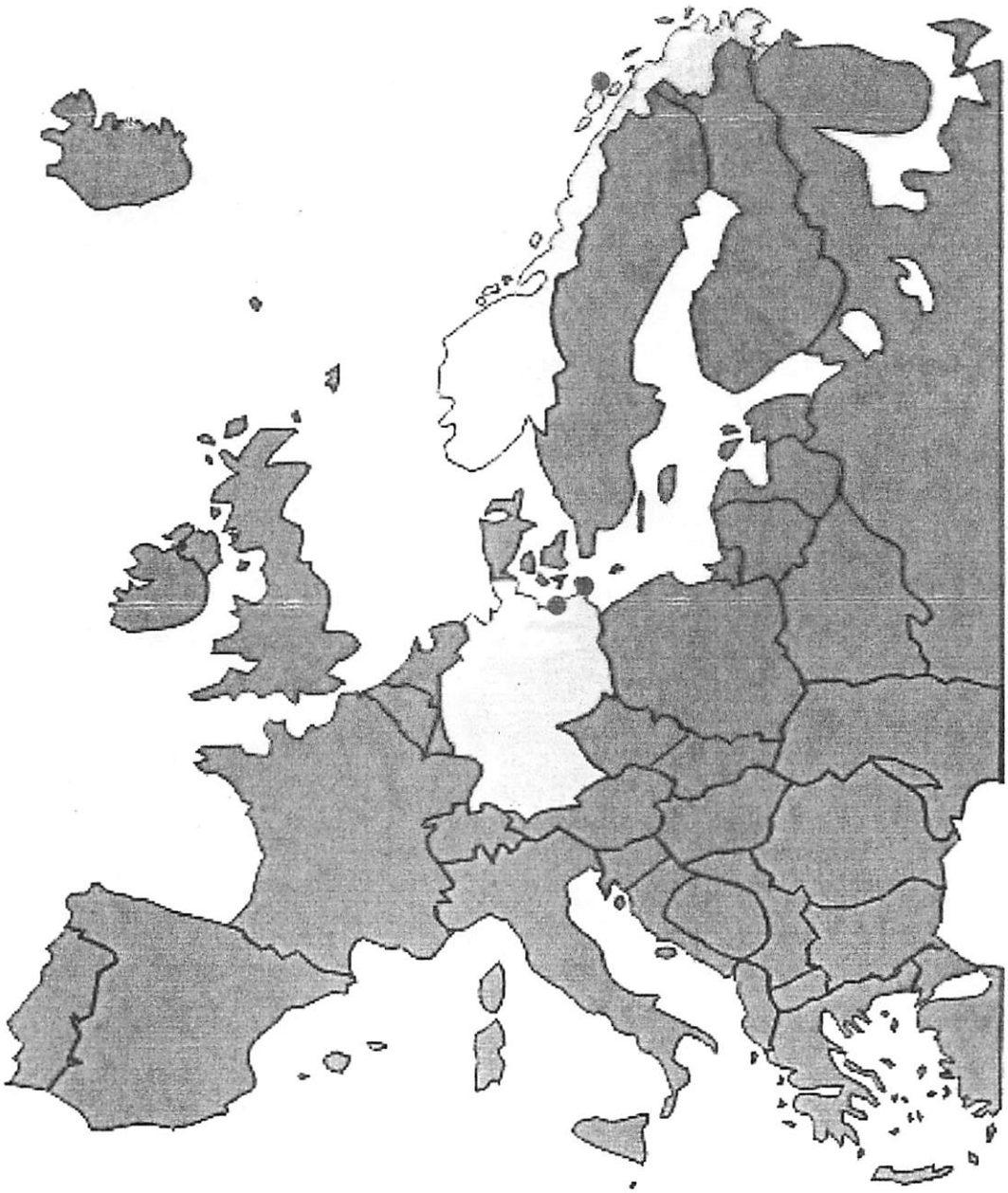
Germany

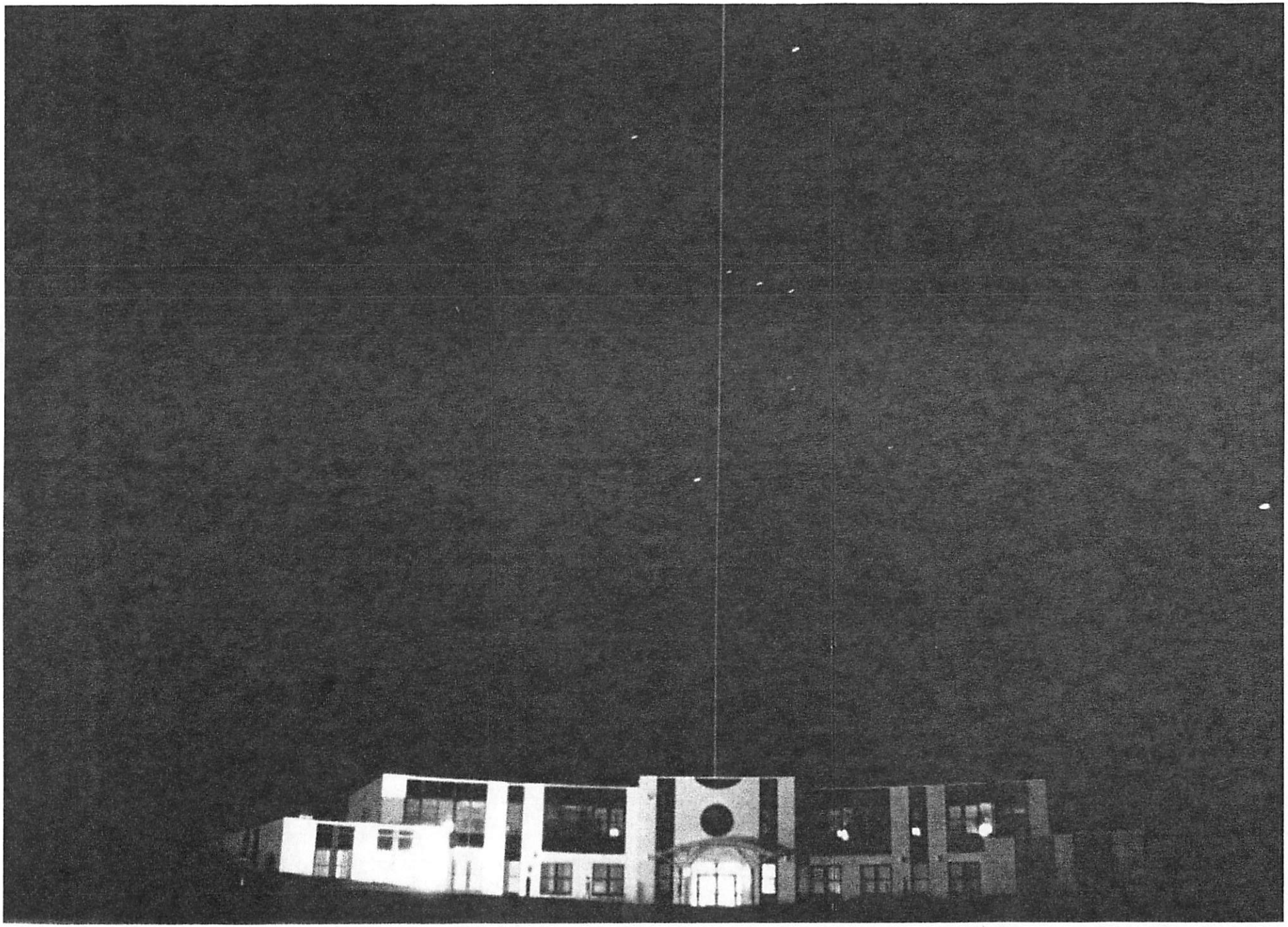
Invited paper presented at the CEDAR meeting on June 28, 2000, in Boulder, Col, USA

Andenes
(69°17'N; 16°01'O)

Juliusruh
(54°38'N,13°24'O)

Kühlungsborn
(54°07'N; 11°46'O)



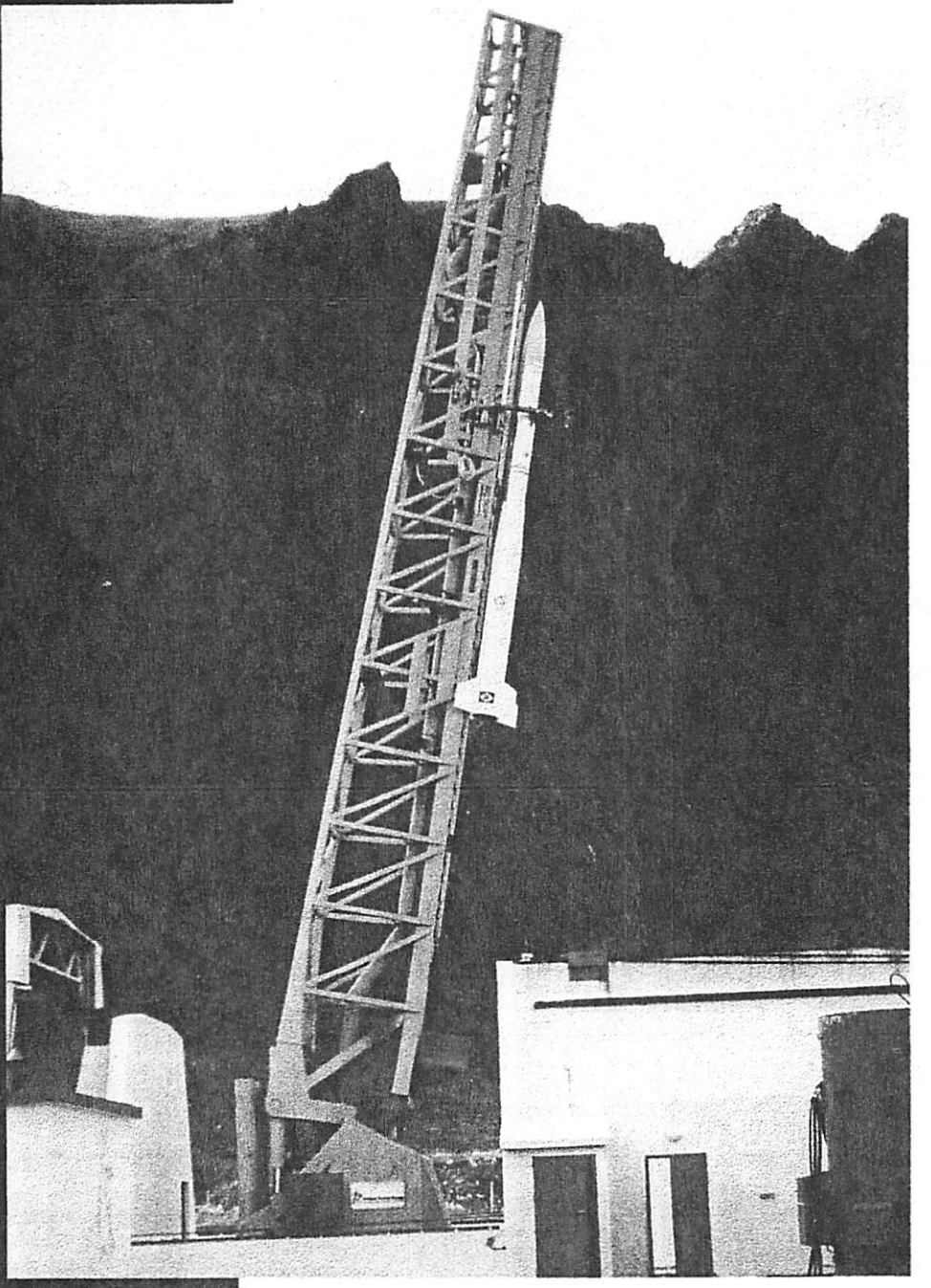


Courtesy of G. Baumgarten, Univ. Bonn, Germany

ISSN: 0003-6935

Applied Optics

Optical Technology and Biomedical Optics



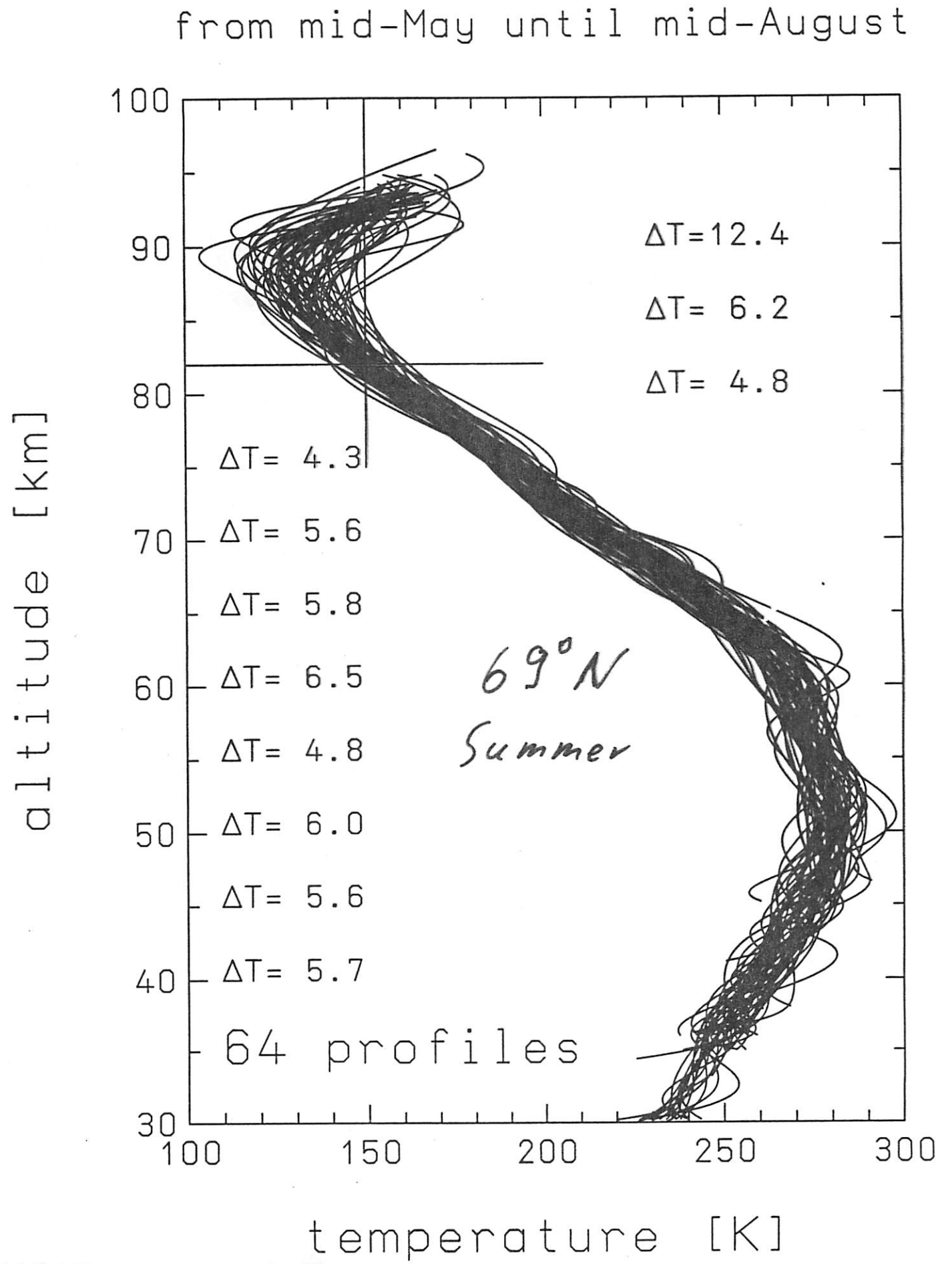
OSA
Optical Society of America

1 September 1999

Overview

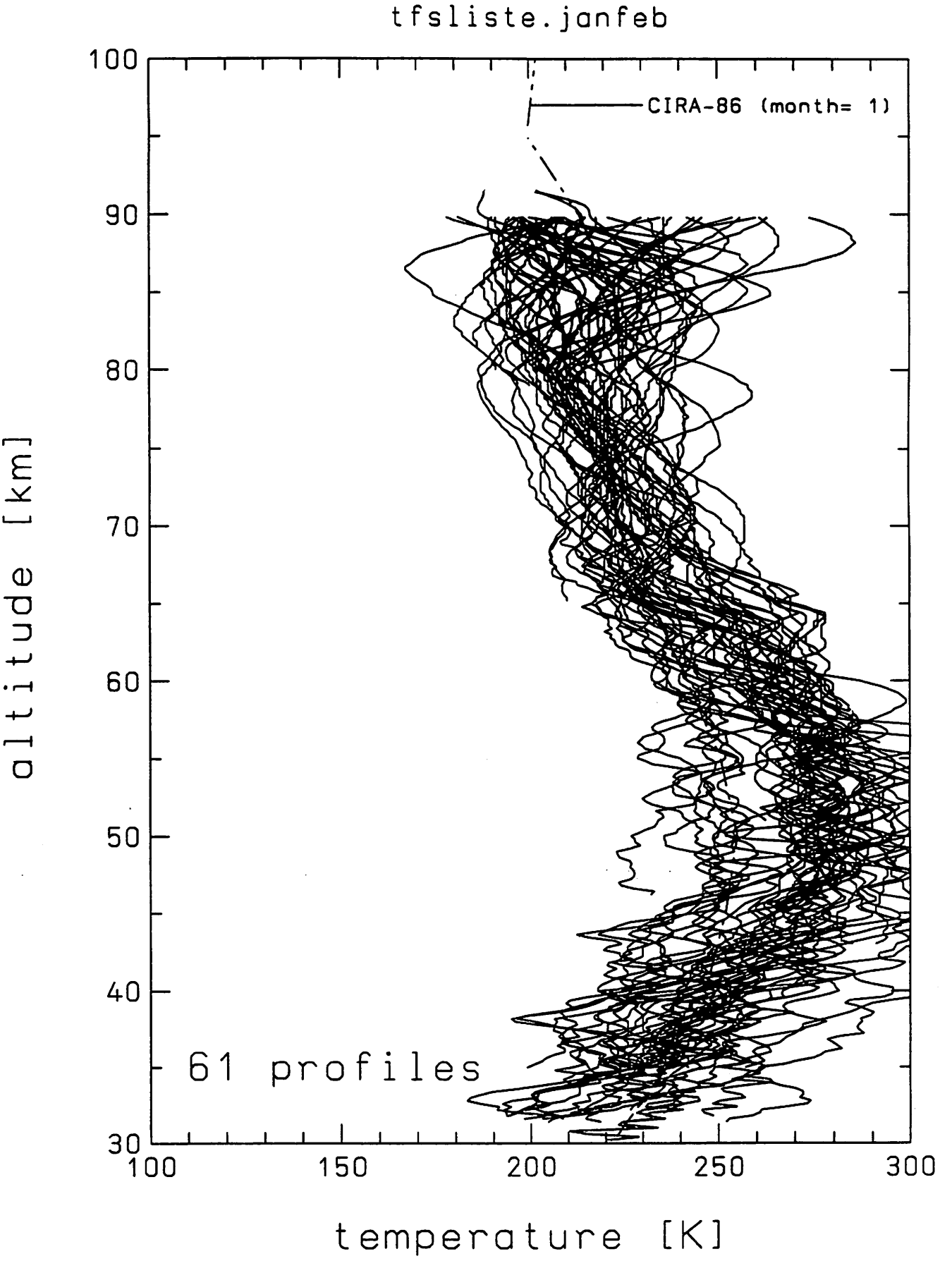
- Introduction
- Thermal structure in the Arctic
  - Update from rocket data
  - Double mesopause
- Turbulence
- NLCs
  - ... from lidars
  - ... connection to T(z)
- PMSE
  - ... and turbulence (Schmidt number)
  - Particle charging
  - Heating experiment
- Thermal structure in the Antarctic
- Temperature trends in the mesosphere
- Summary + Conclusion

F.-J. Lübken, JGR, 104, 9135-9149, 1999.



WINTER (69°N)

January and February (WINE-84; DYANA-90)



-J. Lübken, JGR, 1999.

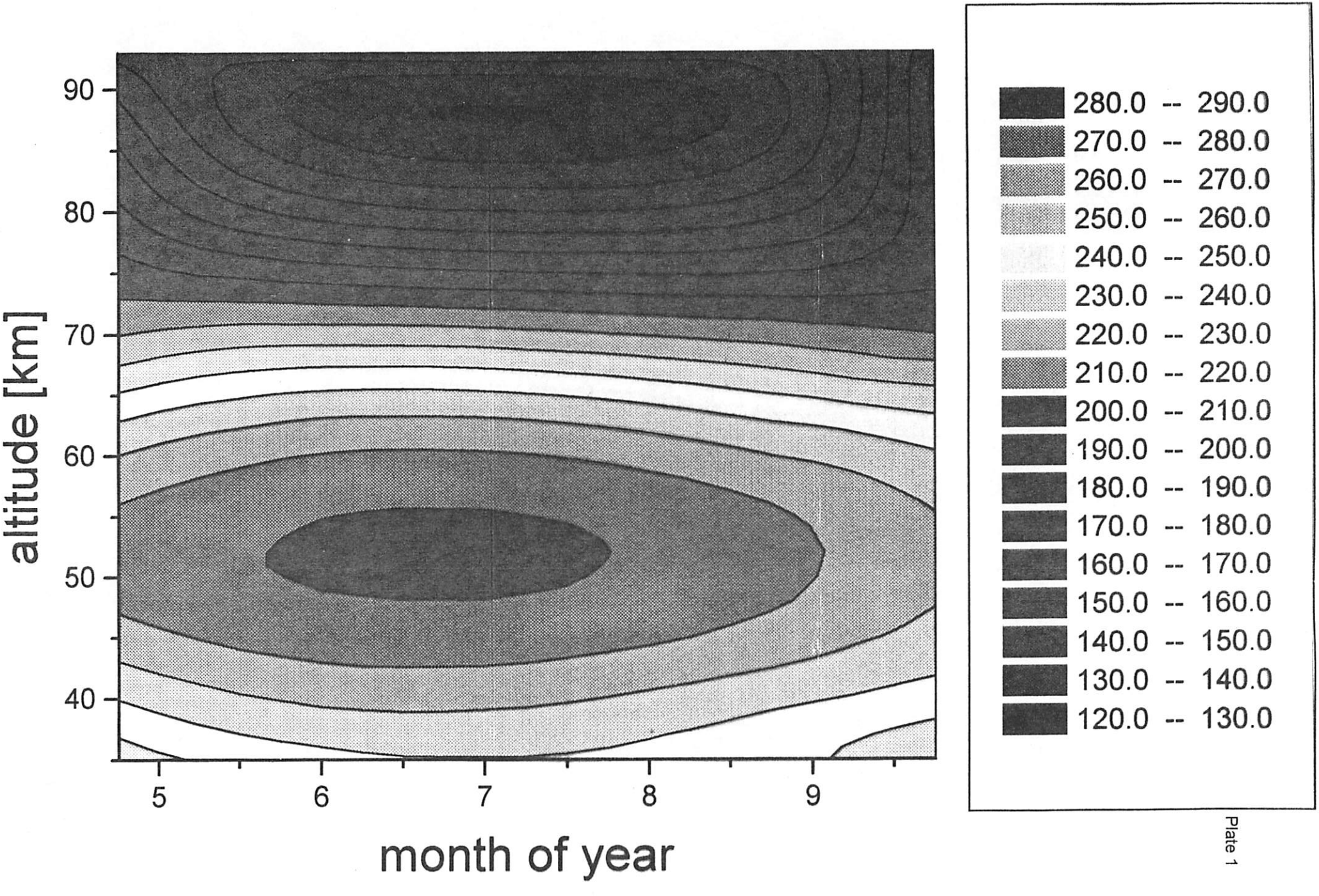
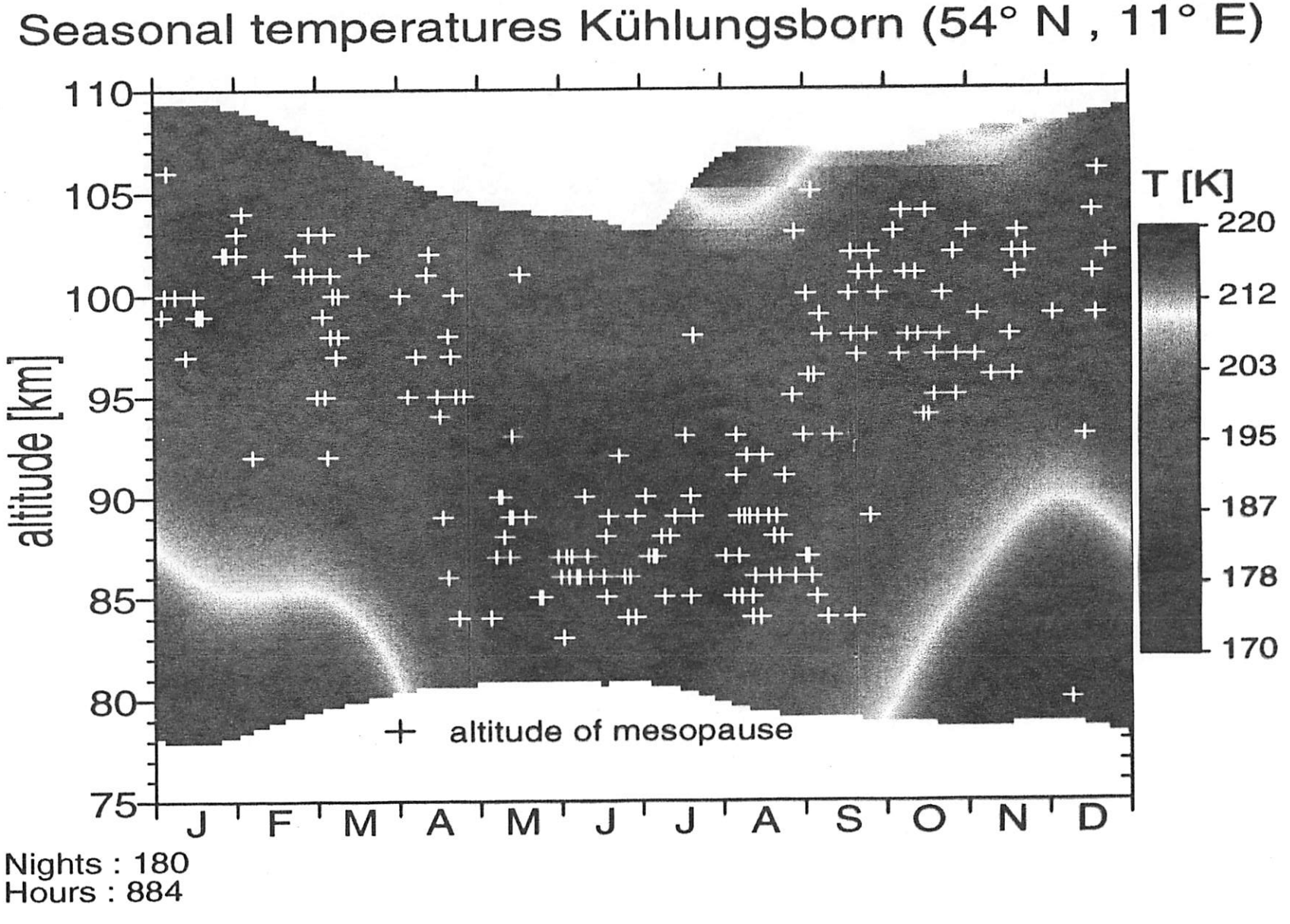
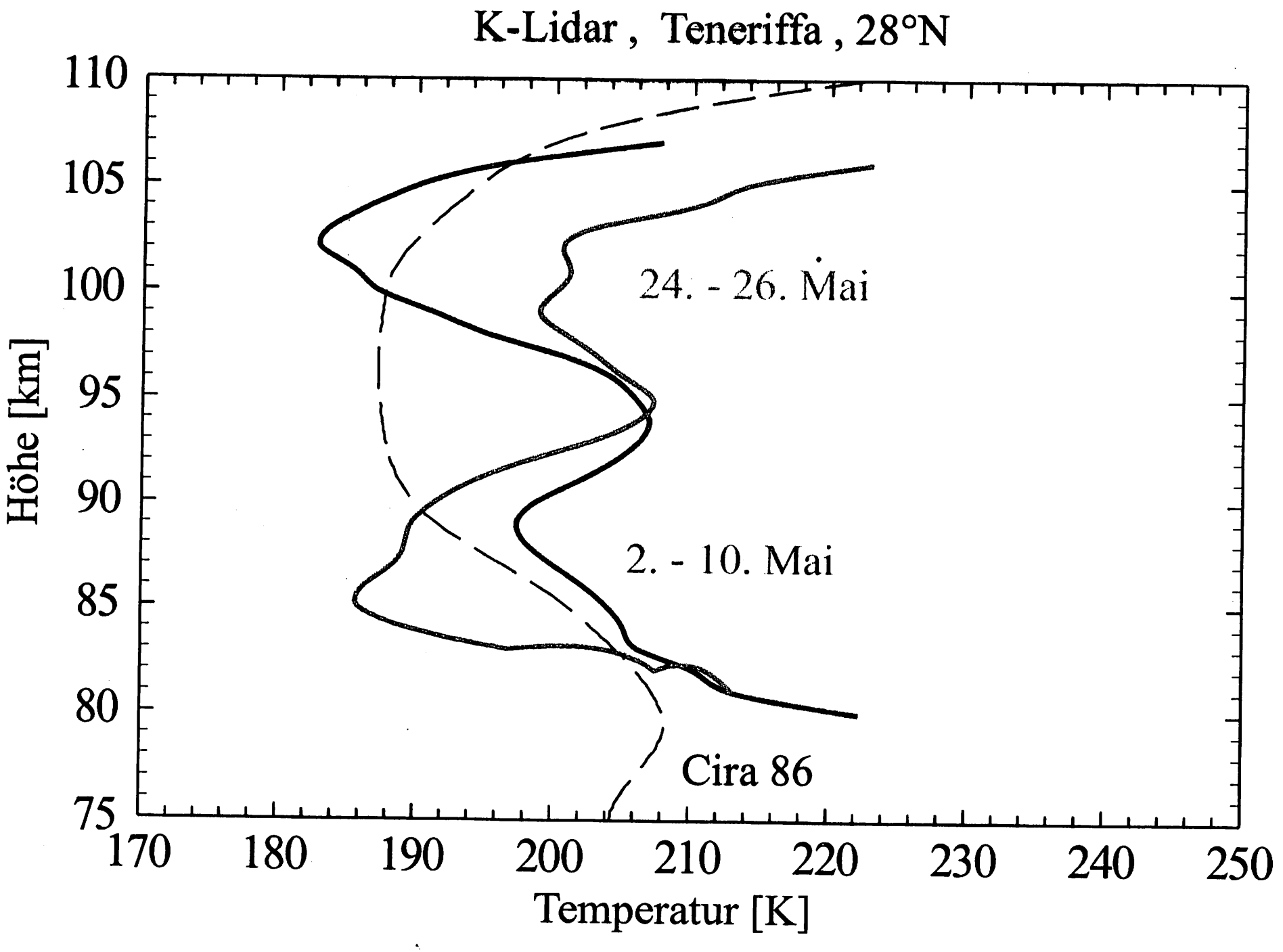


Plate 1



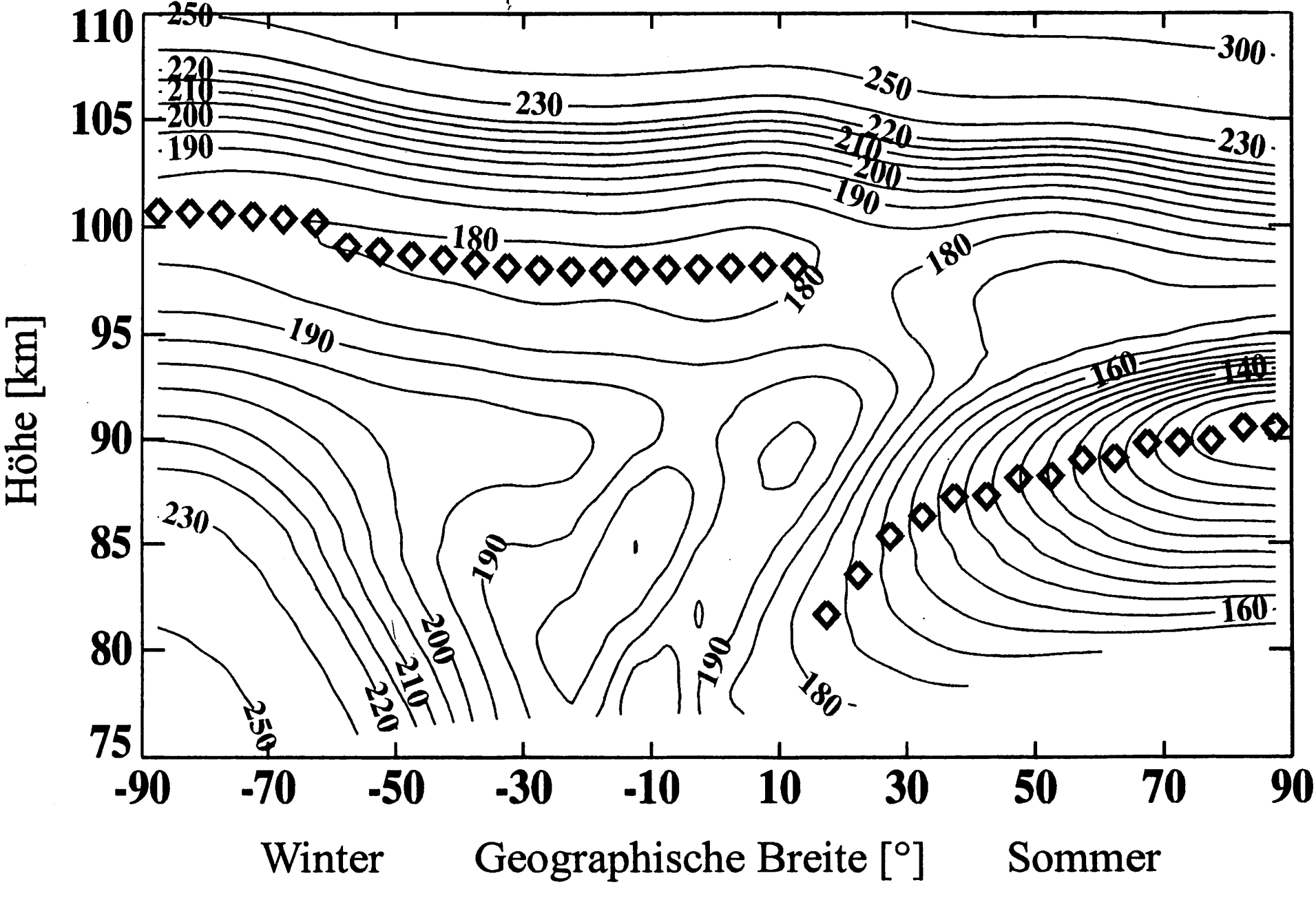


U. von Zahn, IAP, 1998.

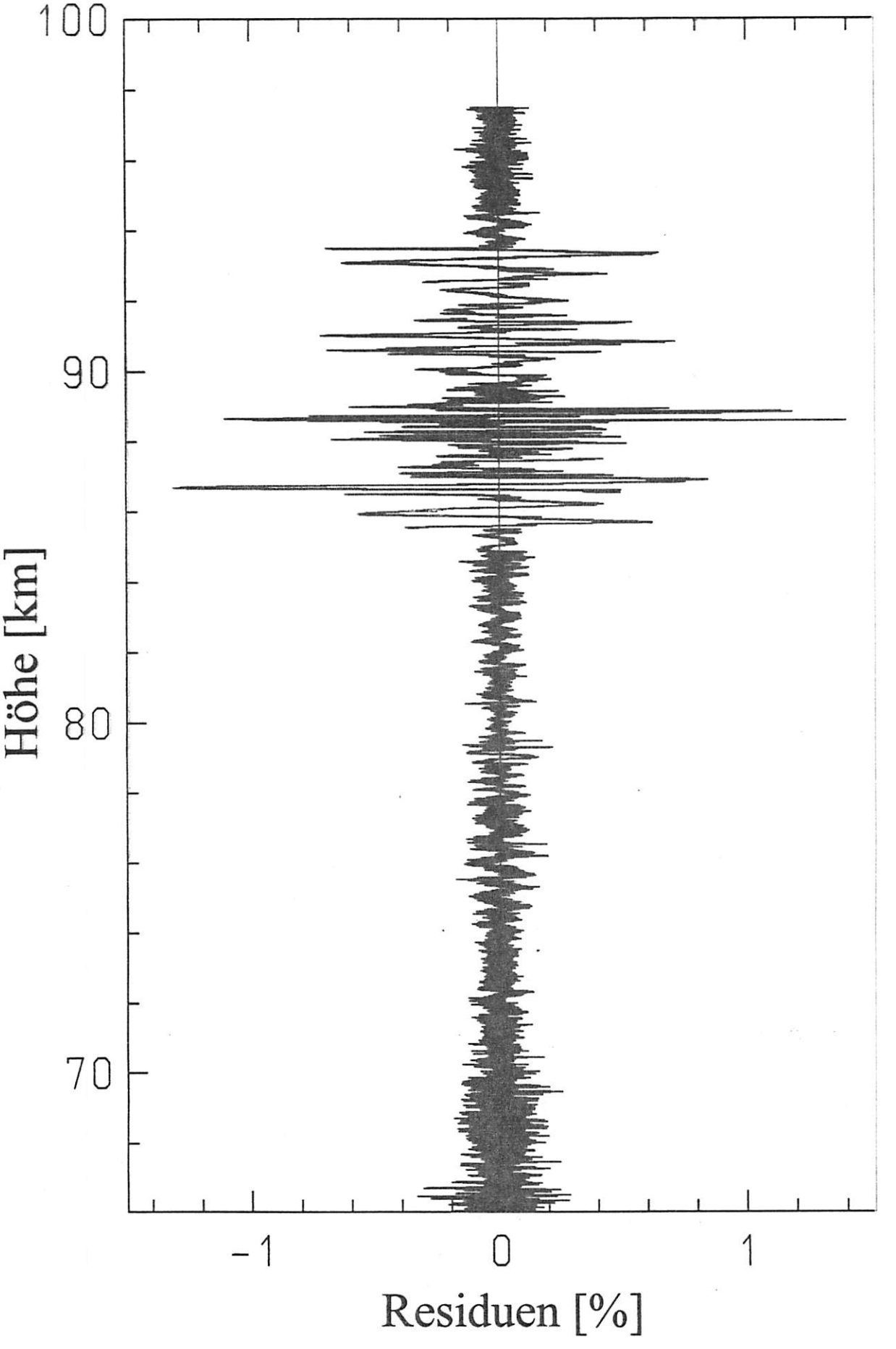
U. Berger & U. v. Zahn
JGR, 1999.

COMMA/IAP-Model

Temperaturen [K] 21. Juni , 22:00 - 4:00 UT



Lübken, JGR, 1997.



JGR, 98, 20369, 1993

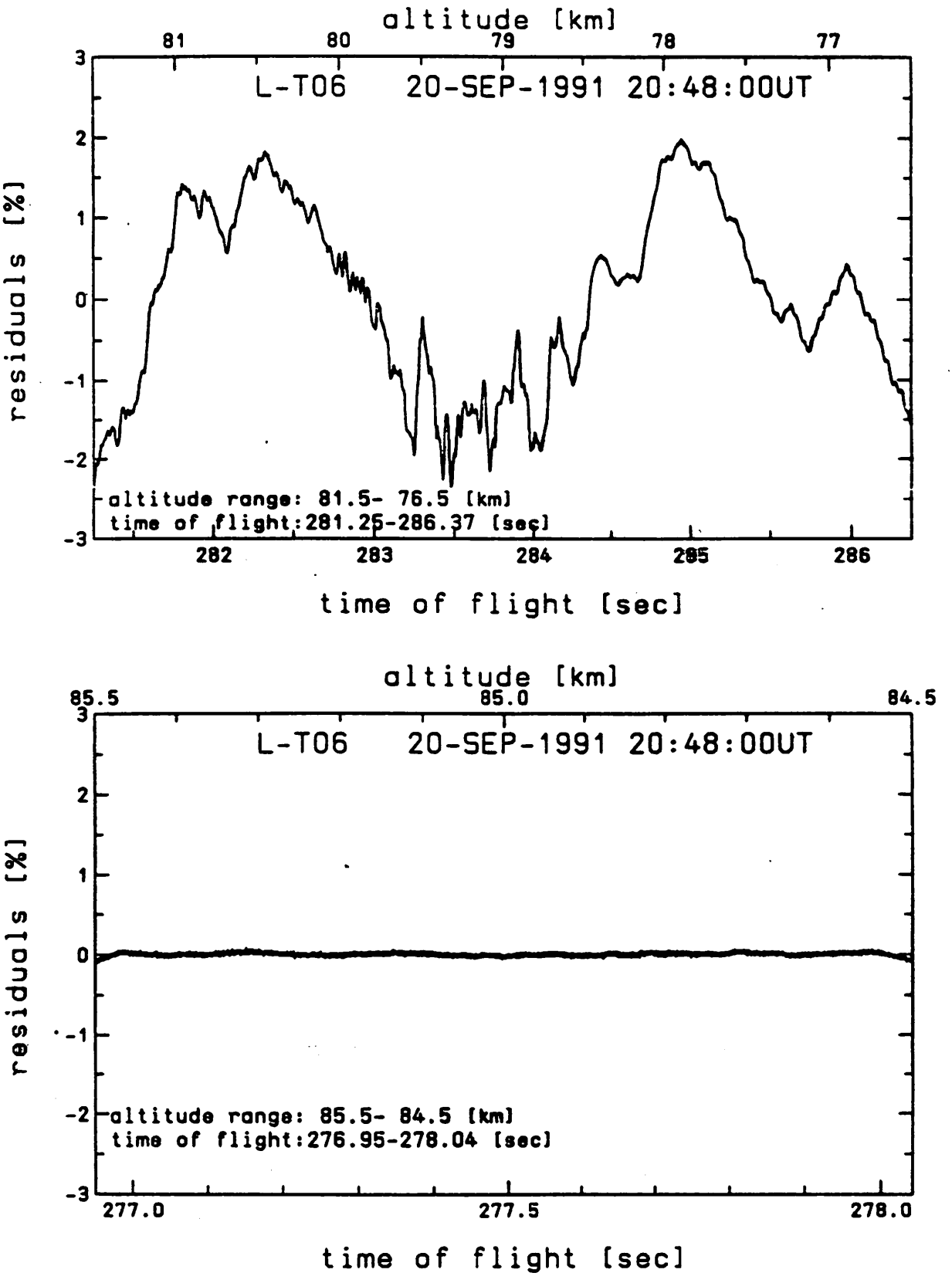
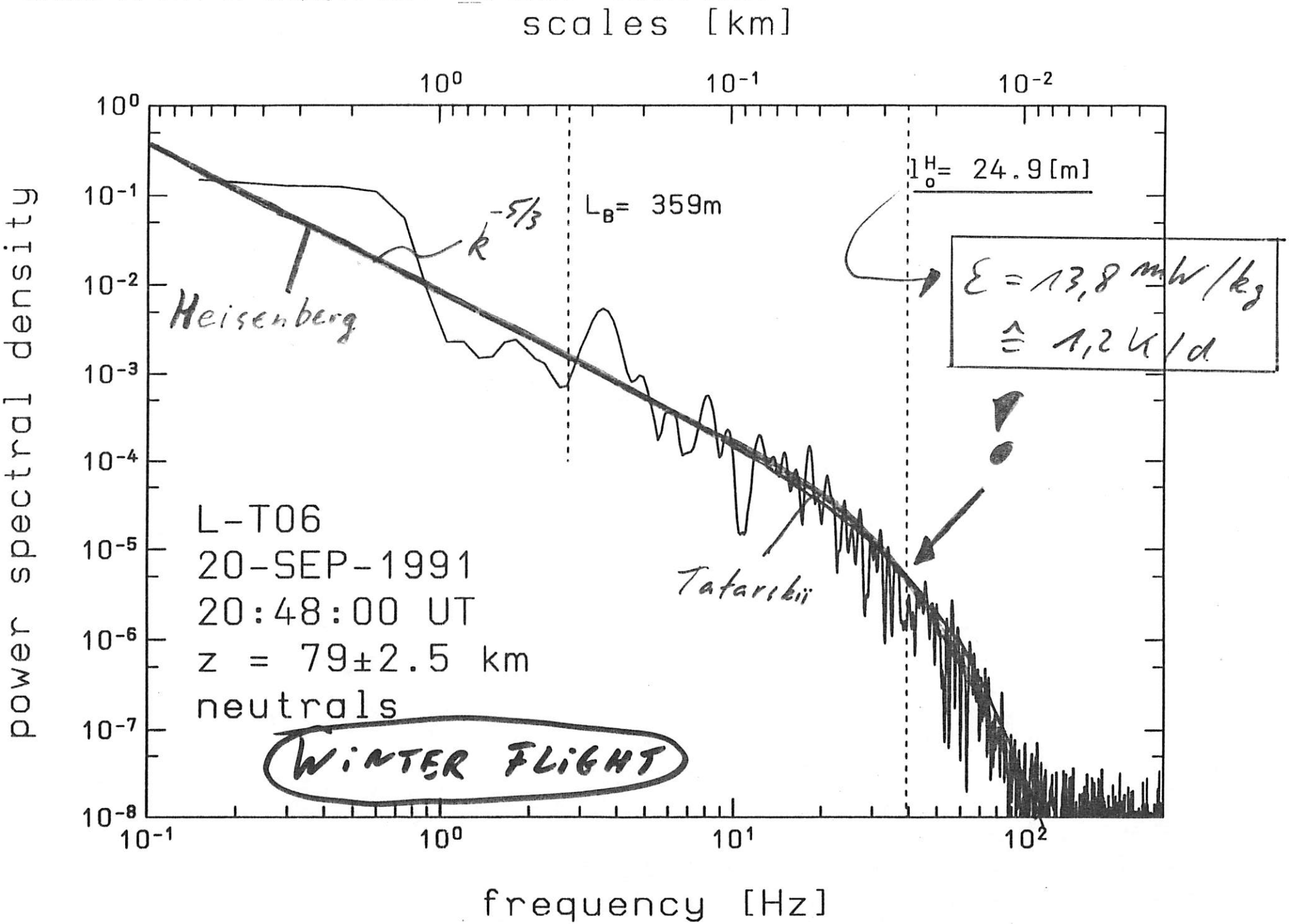
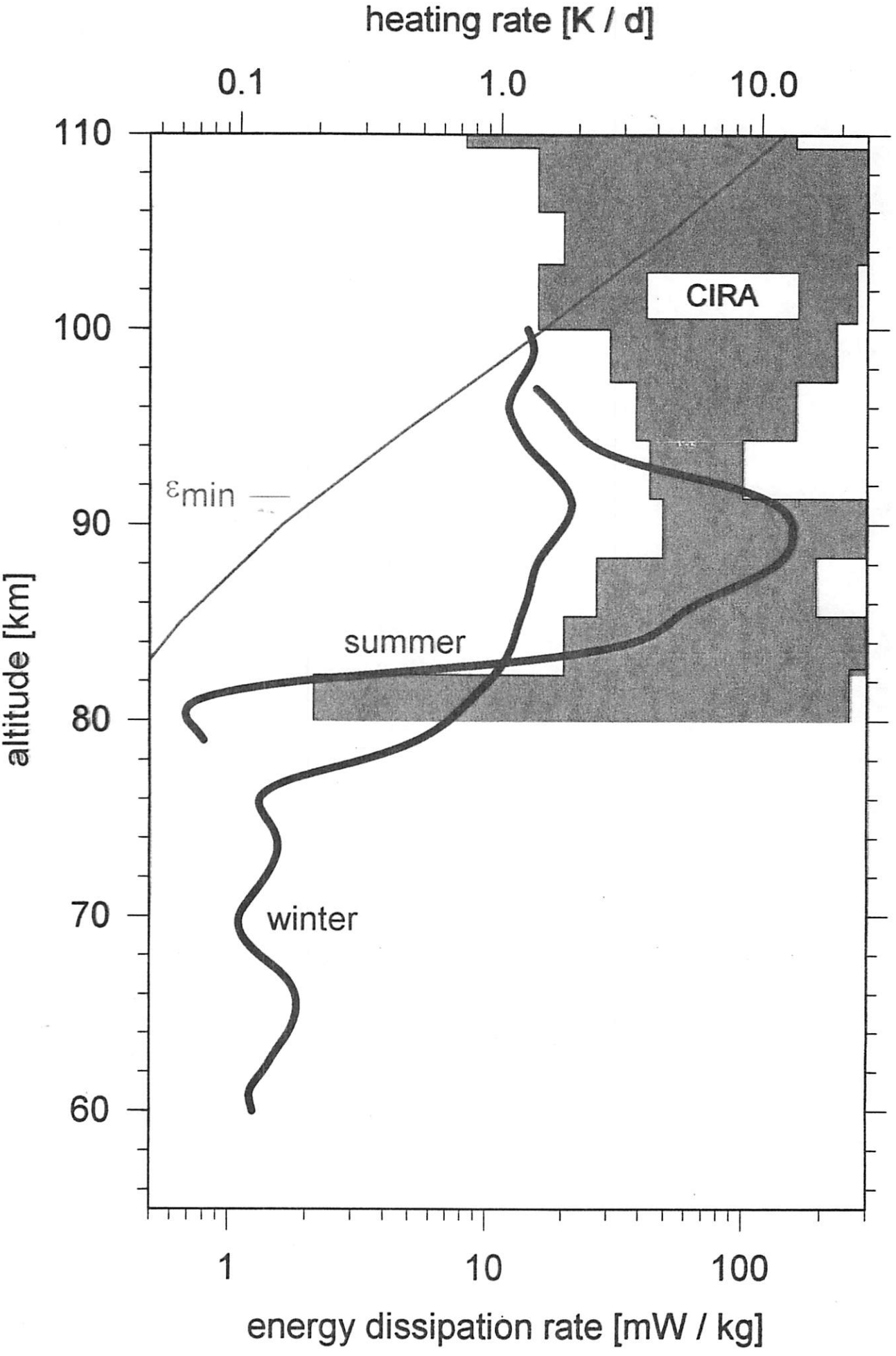


Fig. 3. Relative density fluctuations (residuals) for METAL flight LT6. (top) From 81.5–76.5 km (time of flight: 281.25–286.37 s). Strong fluctuations presumably caused by turbulent motions are present in this altitude bin. (bottom) From 85.5–84.5 km (time of flight: 276.95–278.04 s). No density fluctuations are observed in this altitude regime. The remaining small fluctuations of <0.1% are due to instrumental noise.

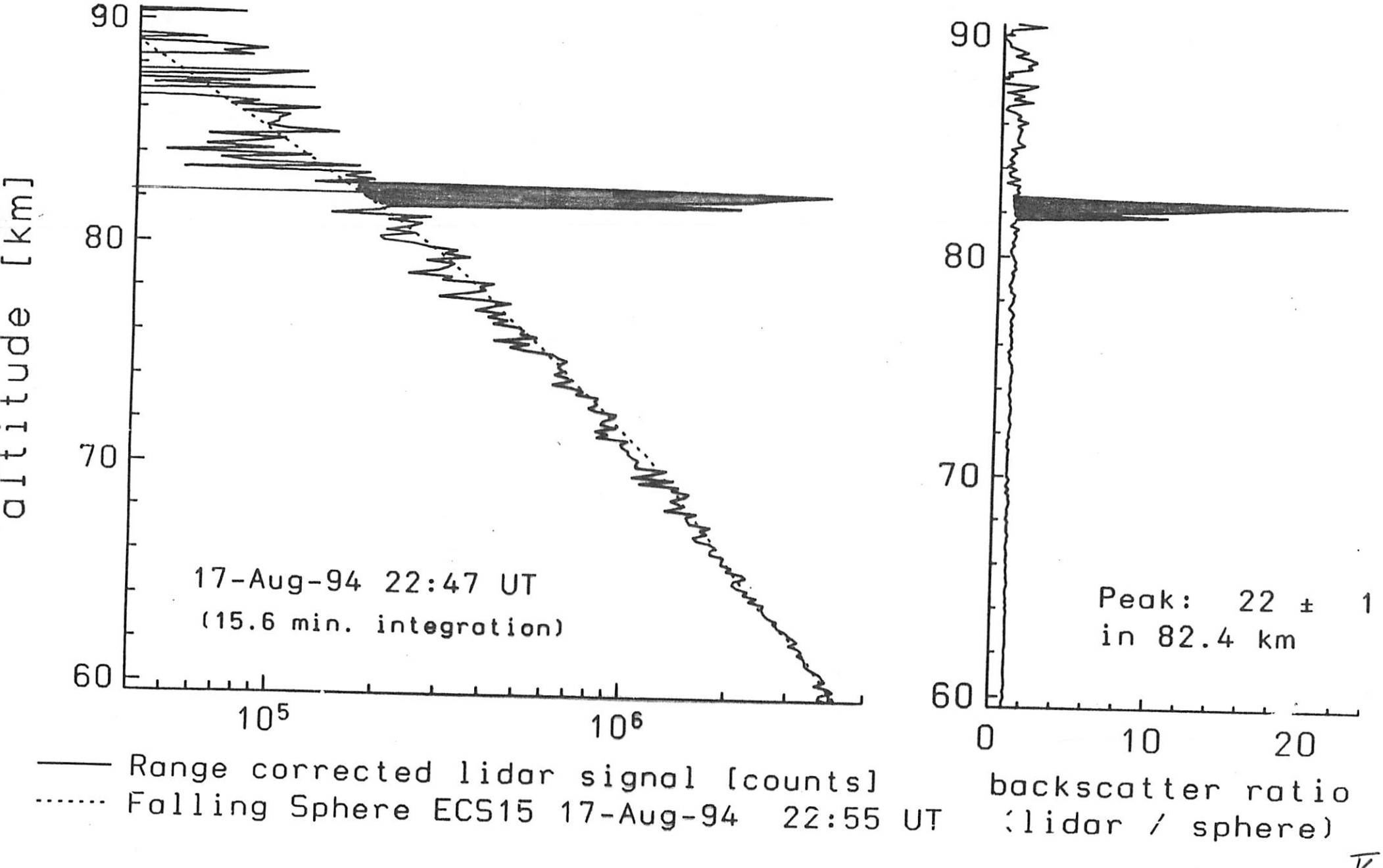
Lübken et al., J. Geophys. Res 98, 20369 - 20384, 1993.



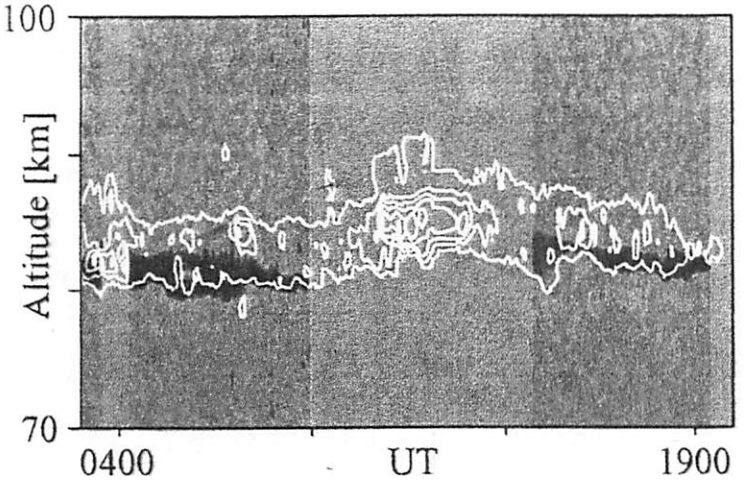
from: *F.-J. Lübken, J. Geophys. Res., 102, 13441-13456, 1997.*



Lübken et al., "Noctilucent clouds and the thermal structure ...",
J. Geophys. Res., 1996. 9489 - 9508



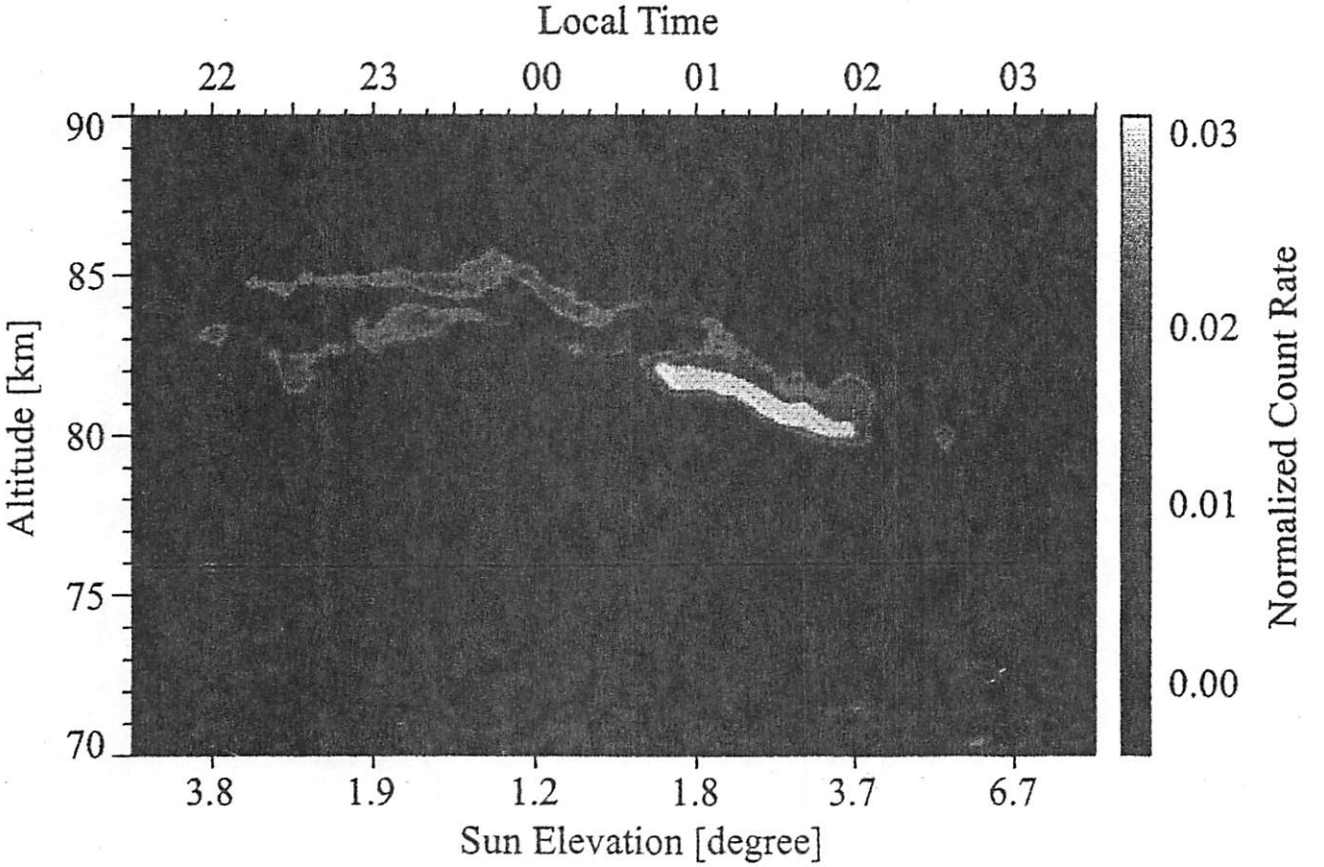
V.1



Geophysical Research Letters

JUNE 1, 1999
VOLUME 26 NUMBER 11
AMERICAN GEOPHYSICAL UNION

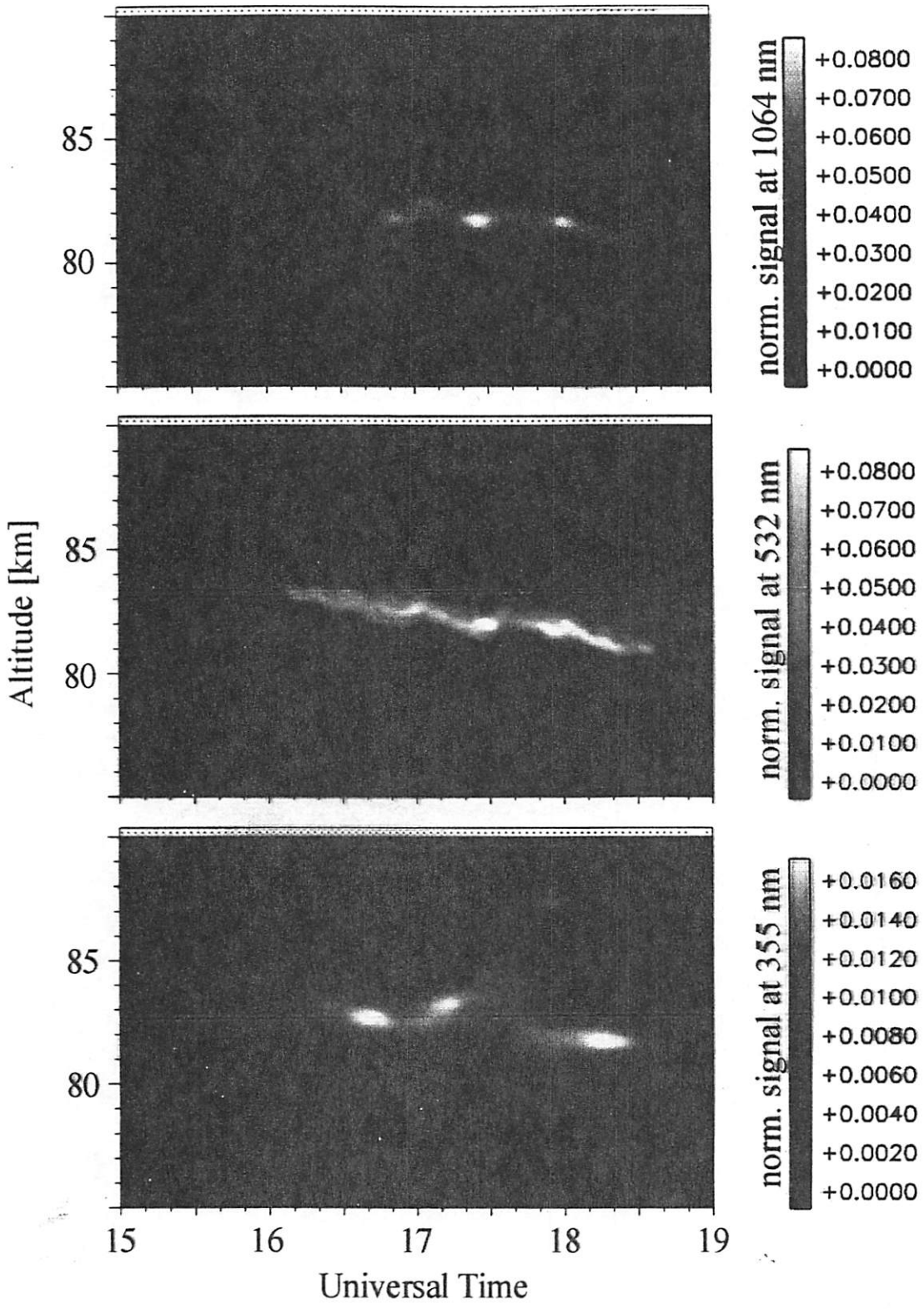
Geophysical Research Letters



MAY 1, 1998

Volume 25 Number 9

AMERICAN GEOPHYSICAL UNION



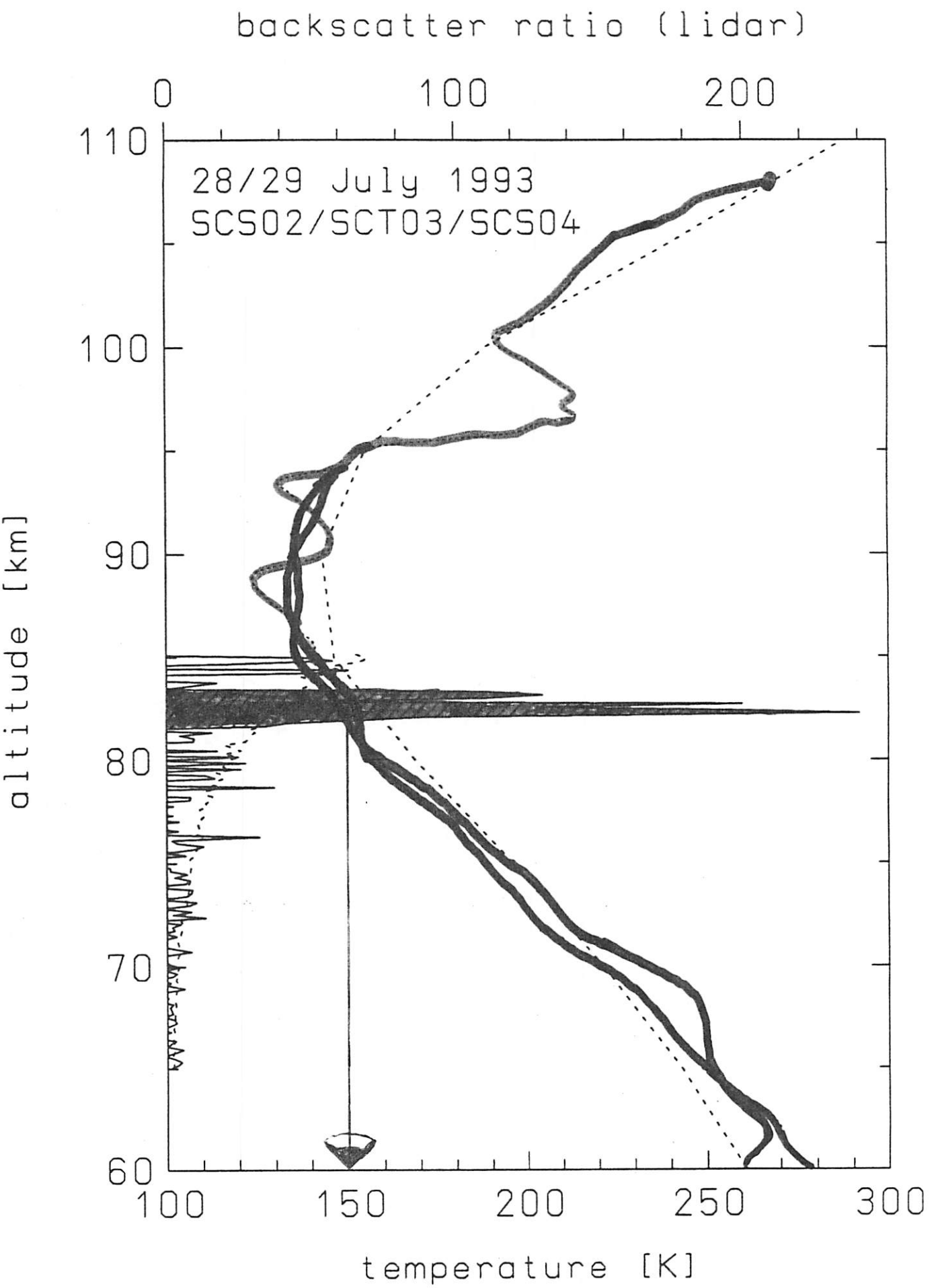
ALOMAR Rayleigh/Mie/Raman Lidar: 3-Color NLC Observation on 1998-07-16

Courtesy of G. von Cossart, IAP, Germany

XIII.2

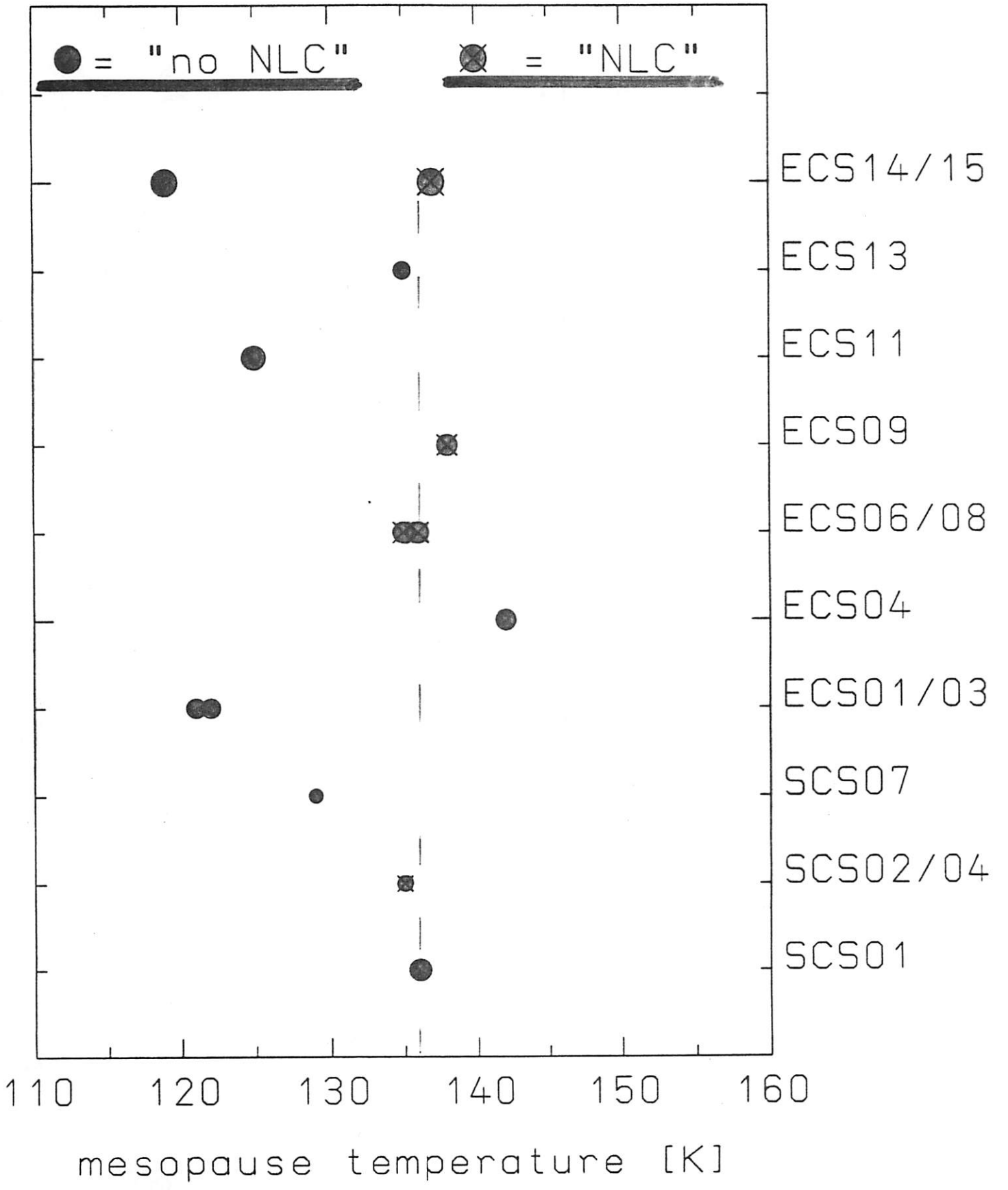
Lübken et al., J. Geophys. Res, 1996 (~~in press~~). 8985-9508

(5a)

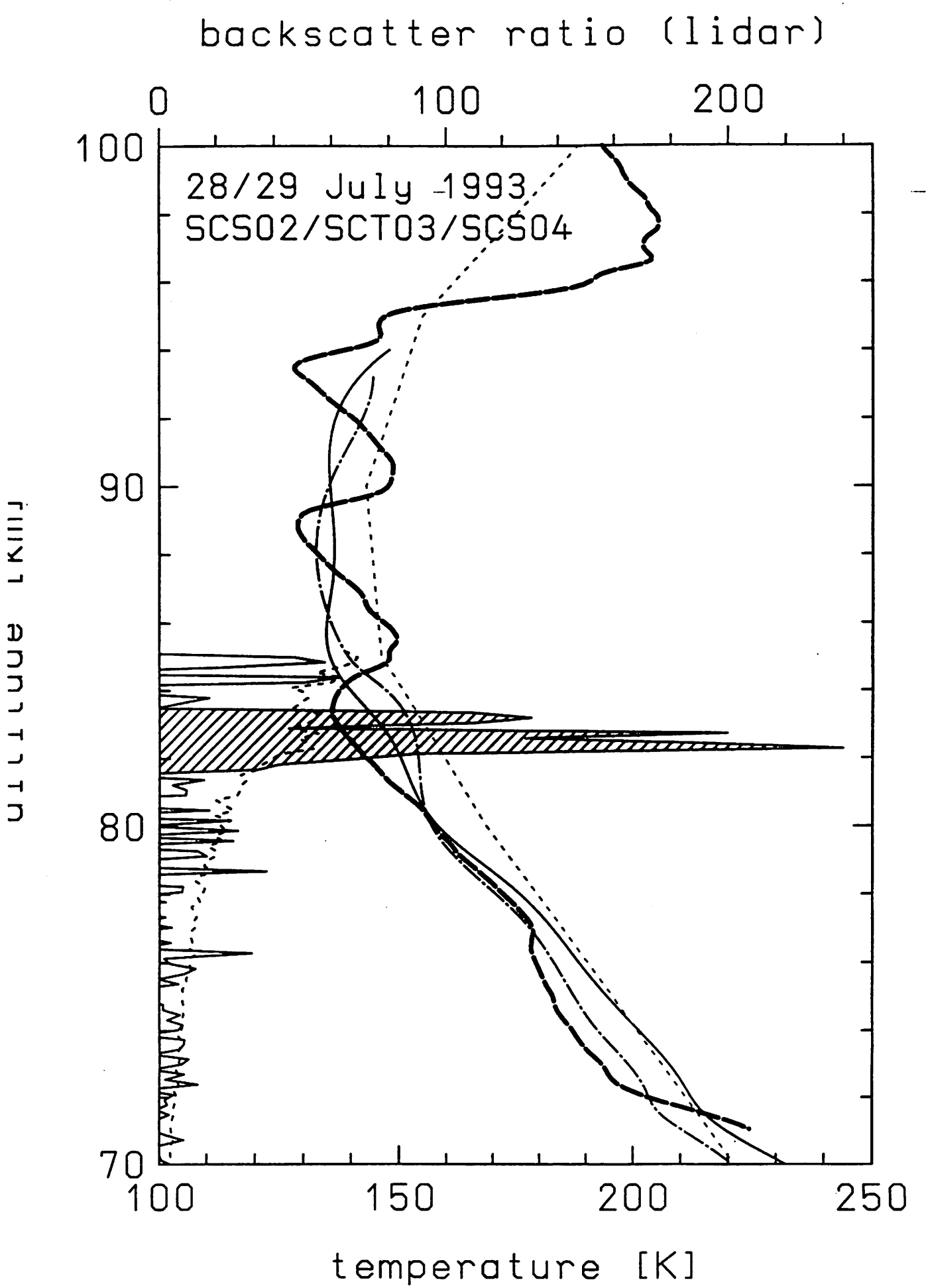


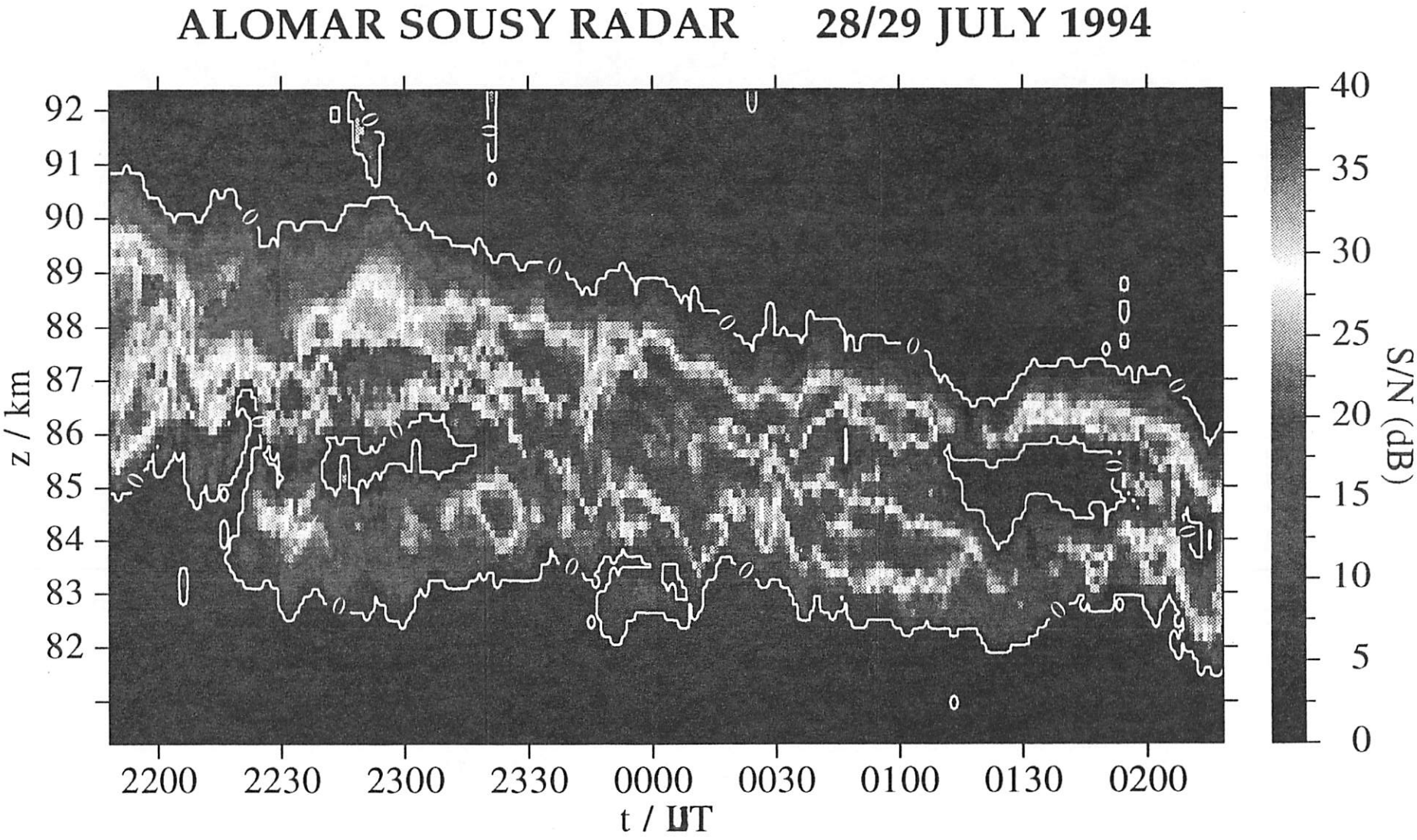
9489-9508

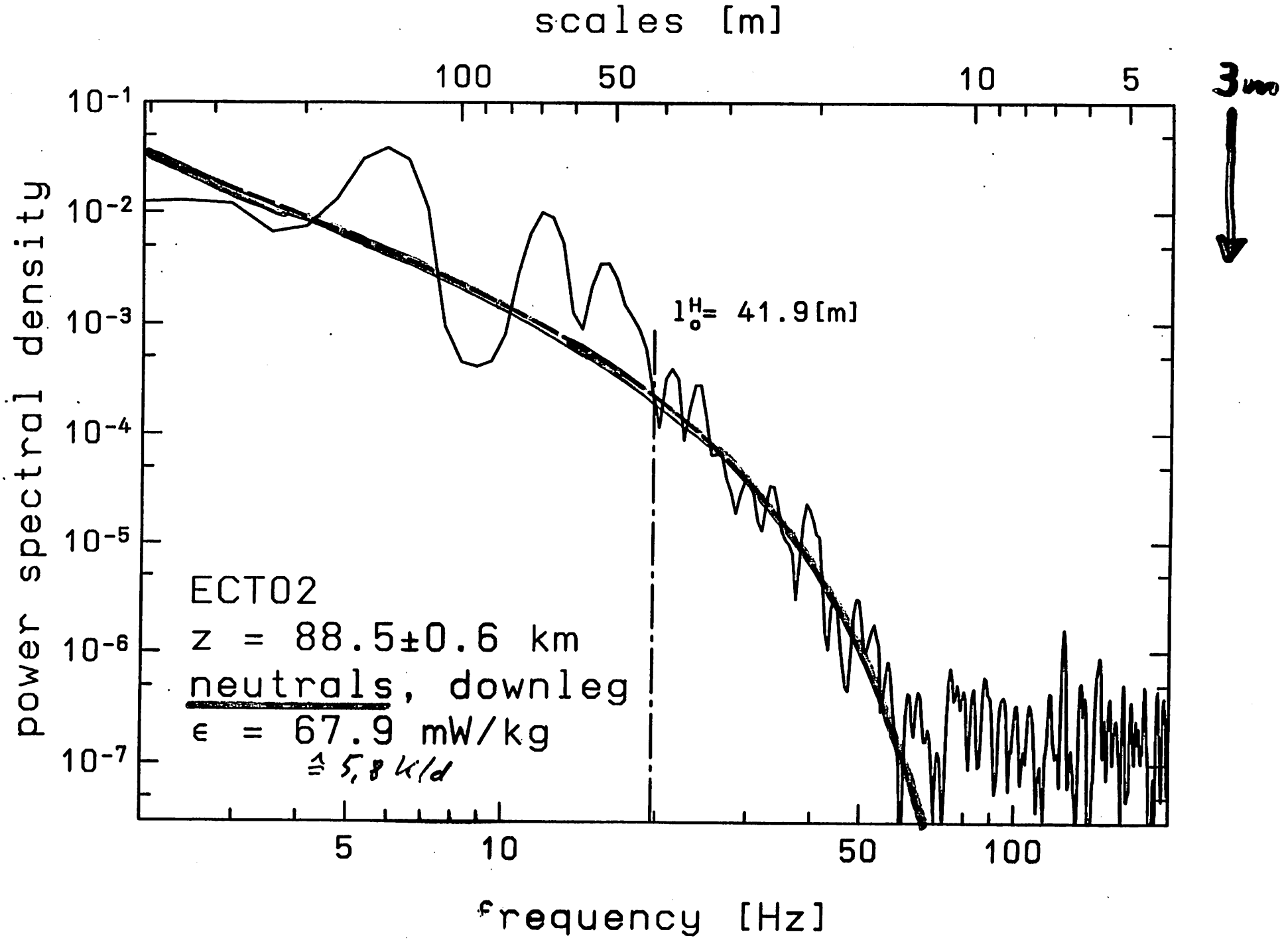
(8)


● = "no NLC"
⊗ = "NLC"
ECS14/15
ECS13
ECS11
ECS09
ECS06/08
ECS04
ECS01/03
SCS07
SCS02/04
SCS01
110
120
130
140
150
160
mesopause temperature [K]

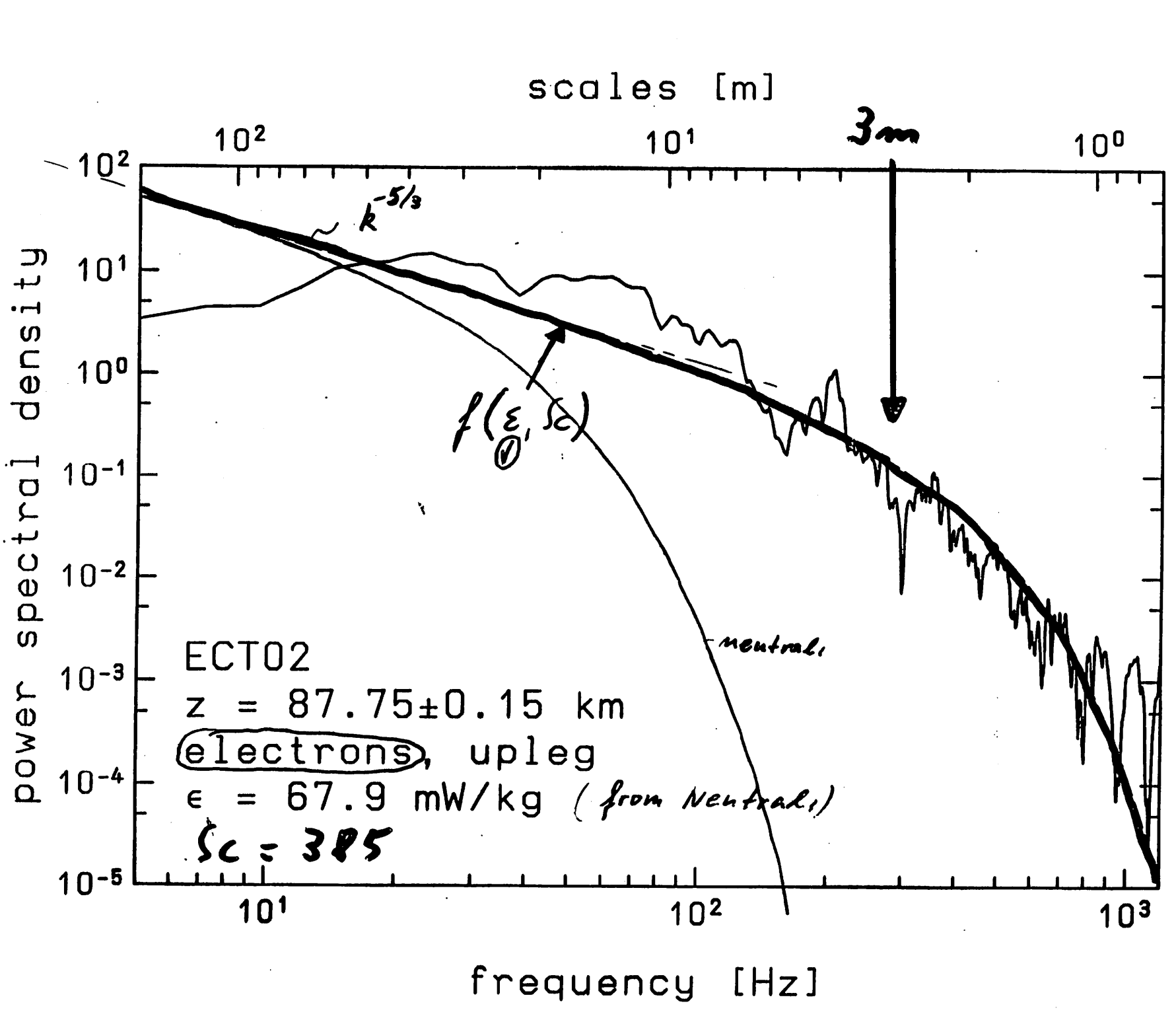
Lübken, unpublished, ...




ALOMAR SOUSY RADAR 28/29 JULY 1994
z / km
92
91
90
89
88
87
86
85
84
83
82
2200
2230
2300
2330
0000
0030
0100
0130
0200
t / UT
S/N (dB)
40
35
30
25
20
15
10
5
0

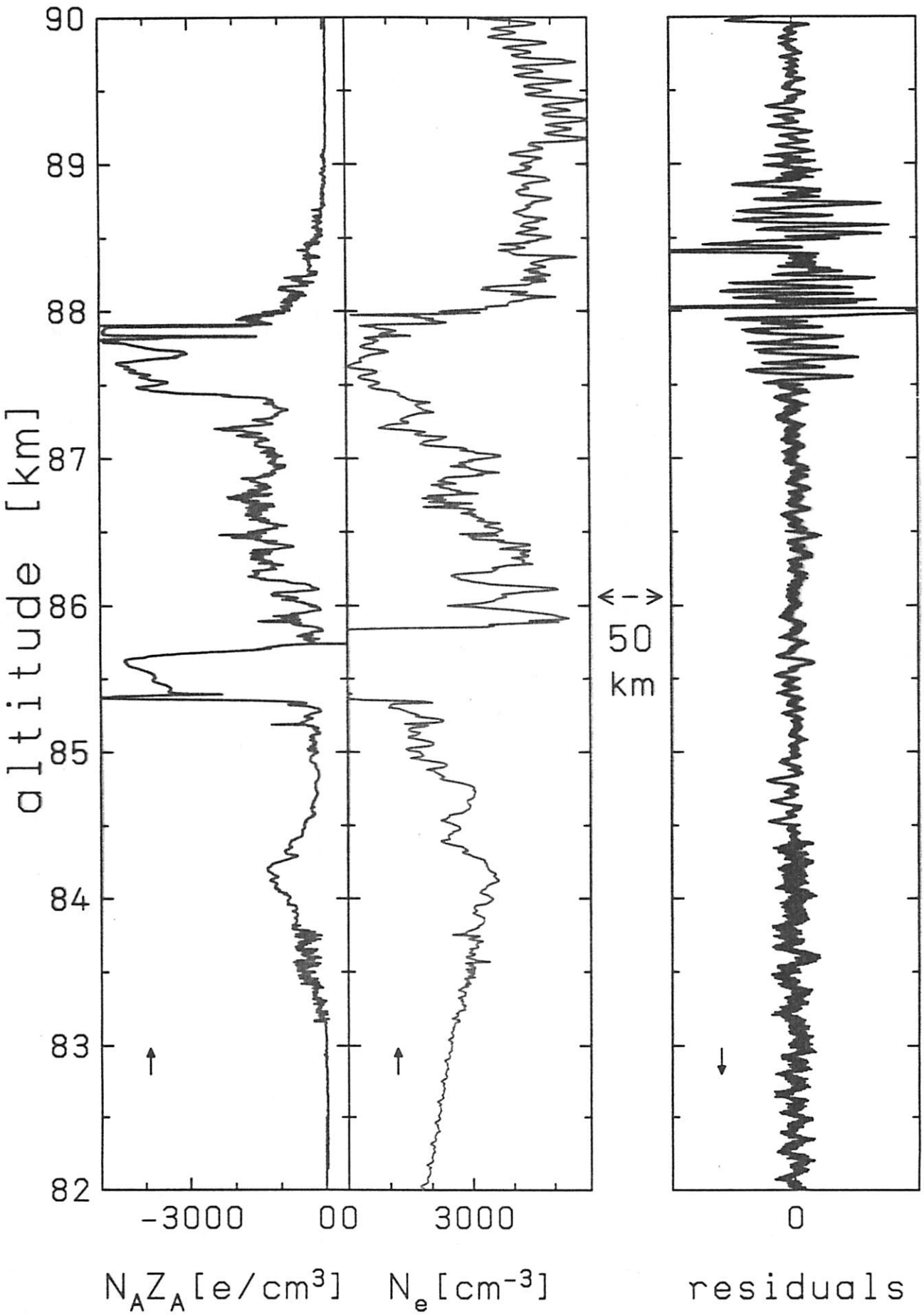


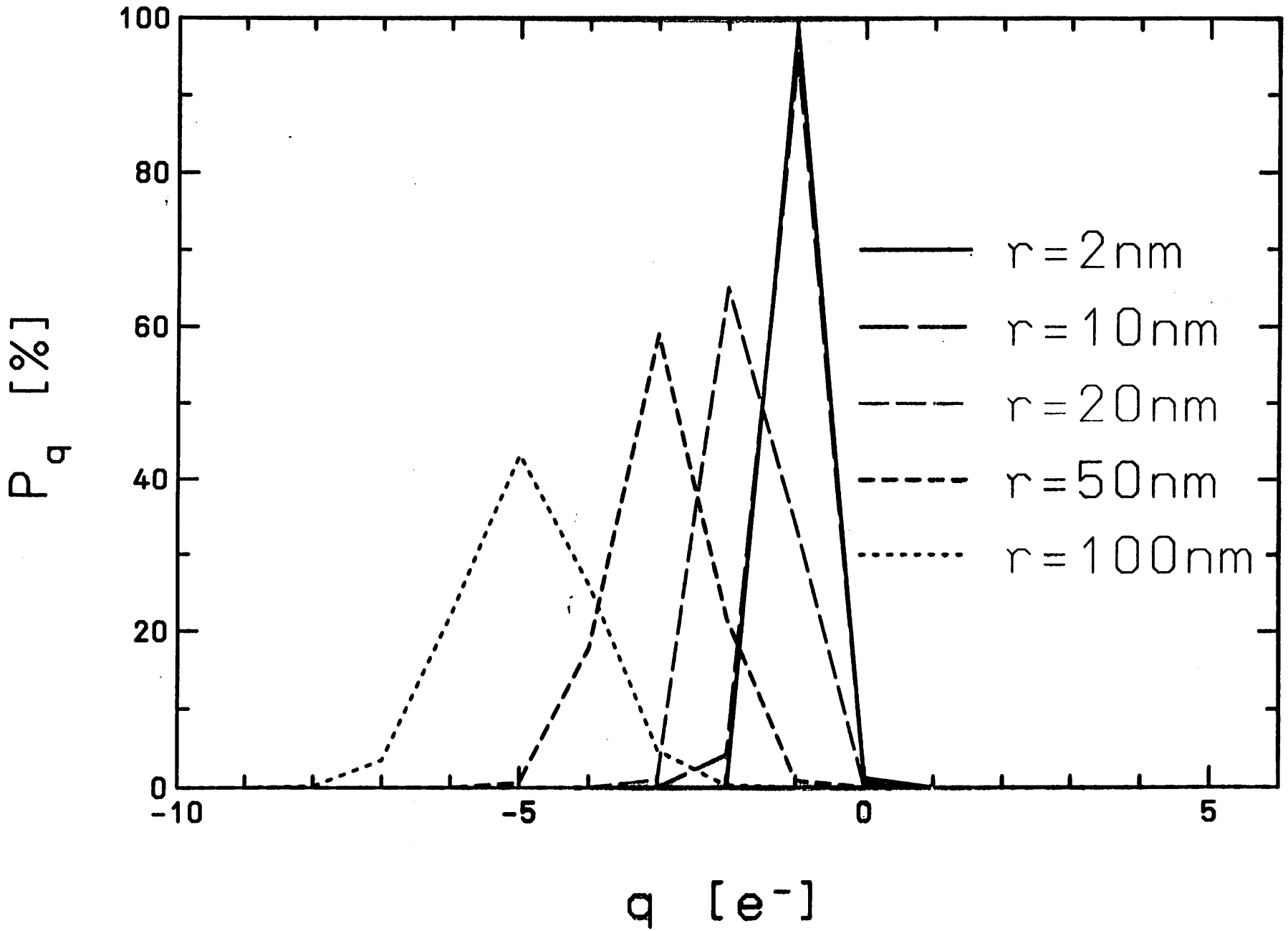
Lübken et al., Geophys. Res. Lett., 25, 693-696, 1998



Lübken et al., Geophys. Res. Lett., 25, 693-696, 1998

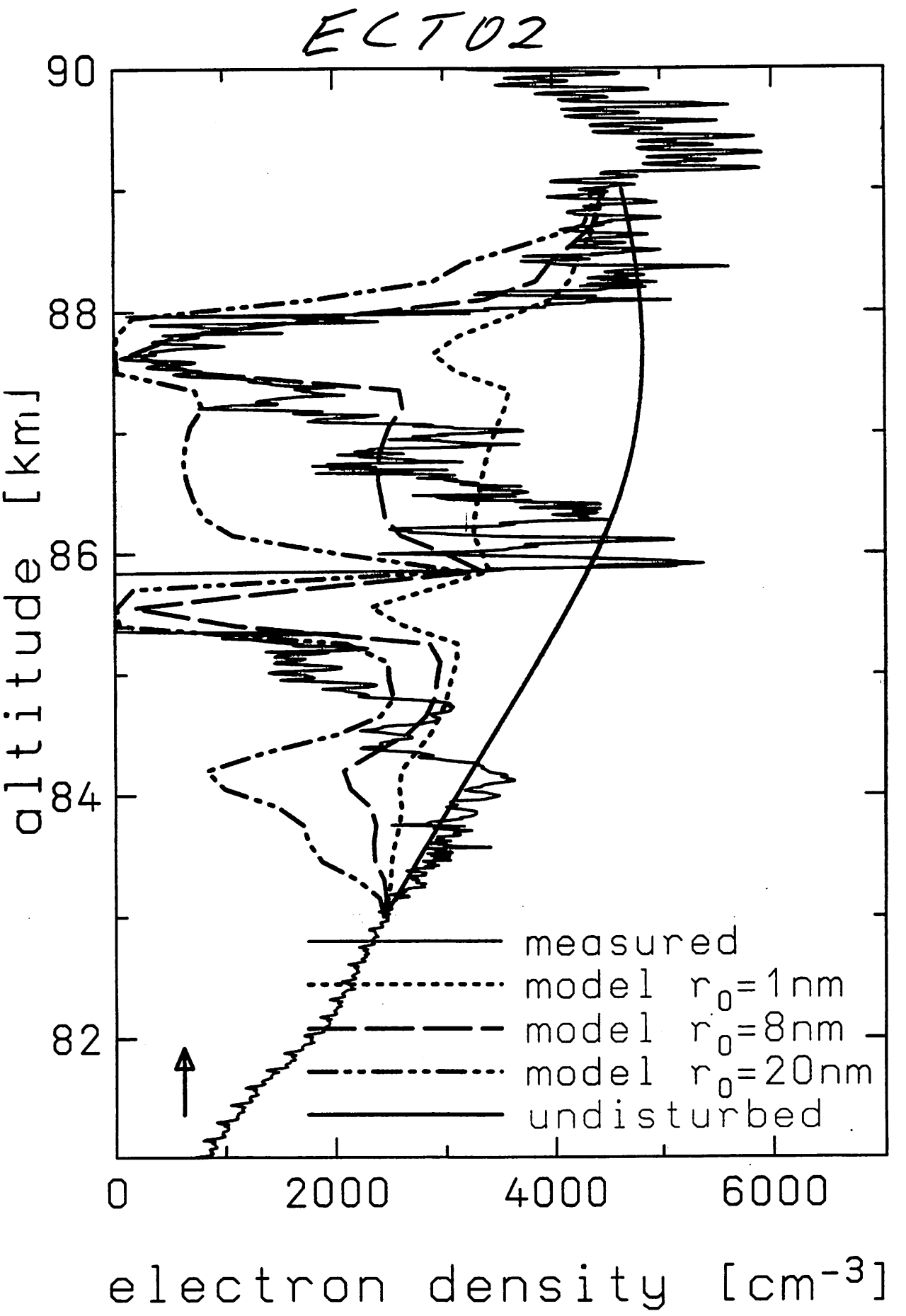
Lübken et al, GRL, 25, 893-896, 1998



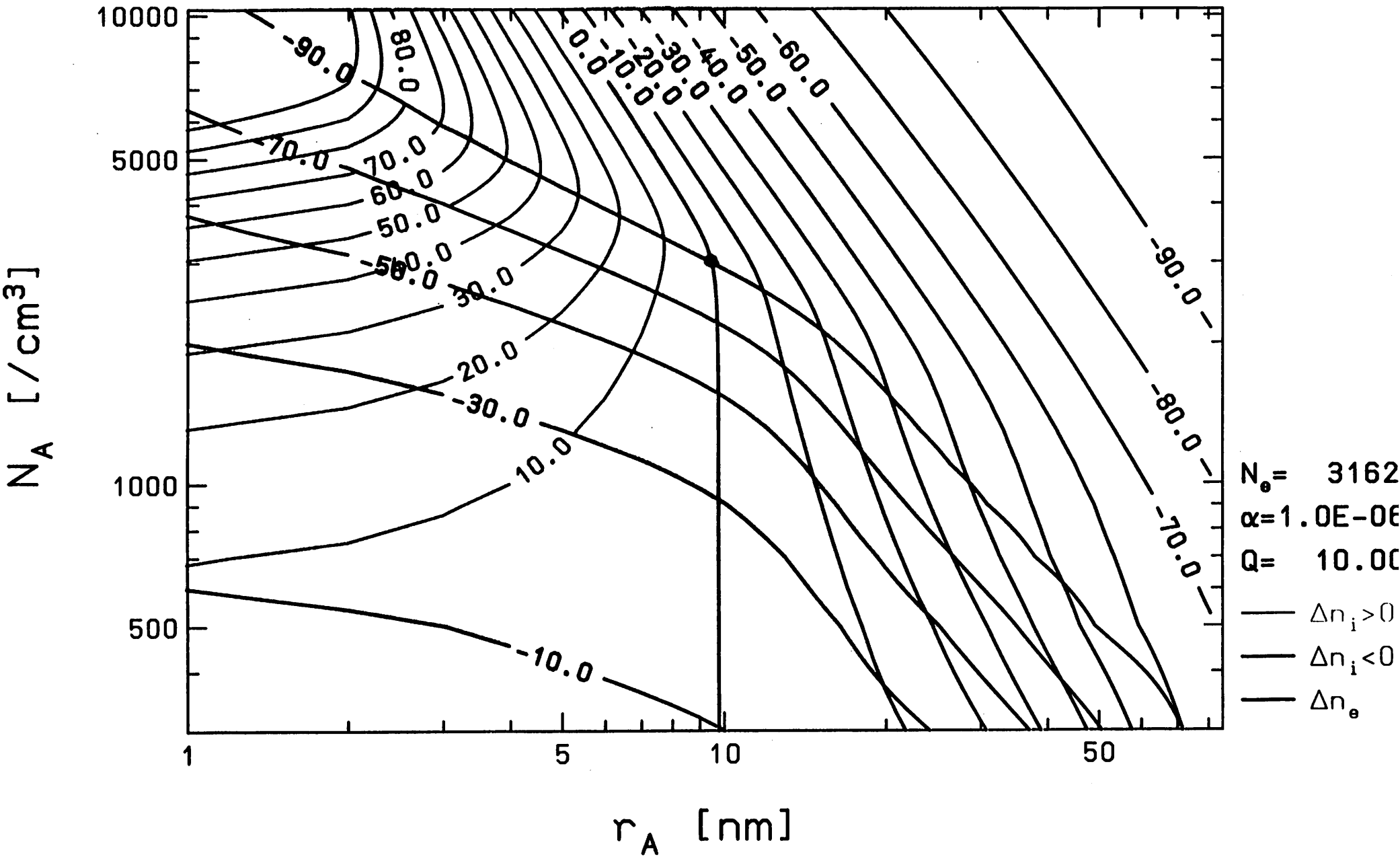


Rapp & Lübken, Earth, Plan. Space Sci., 799, 1999.

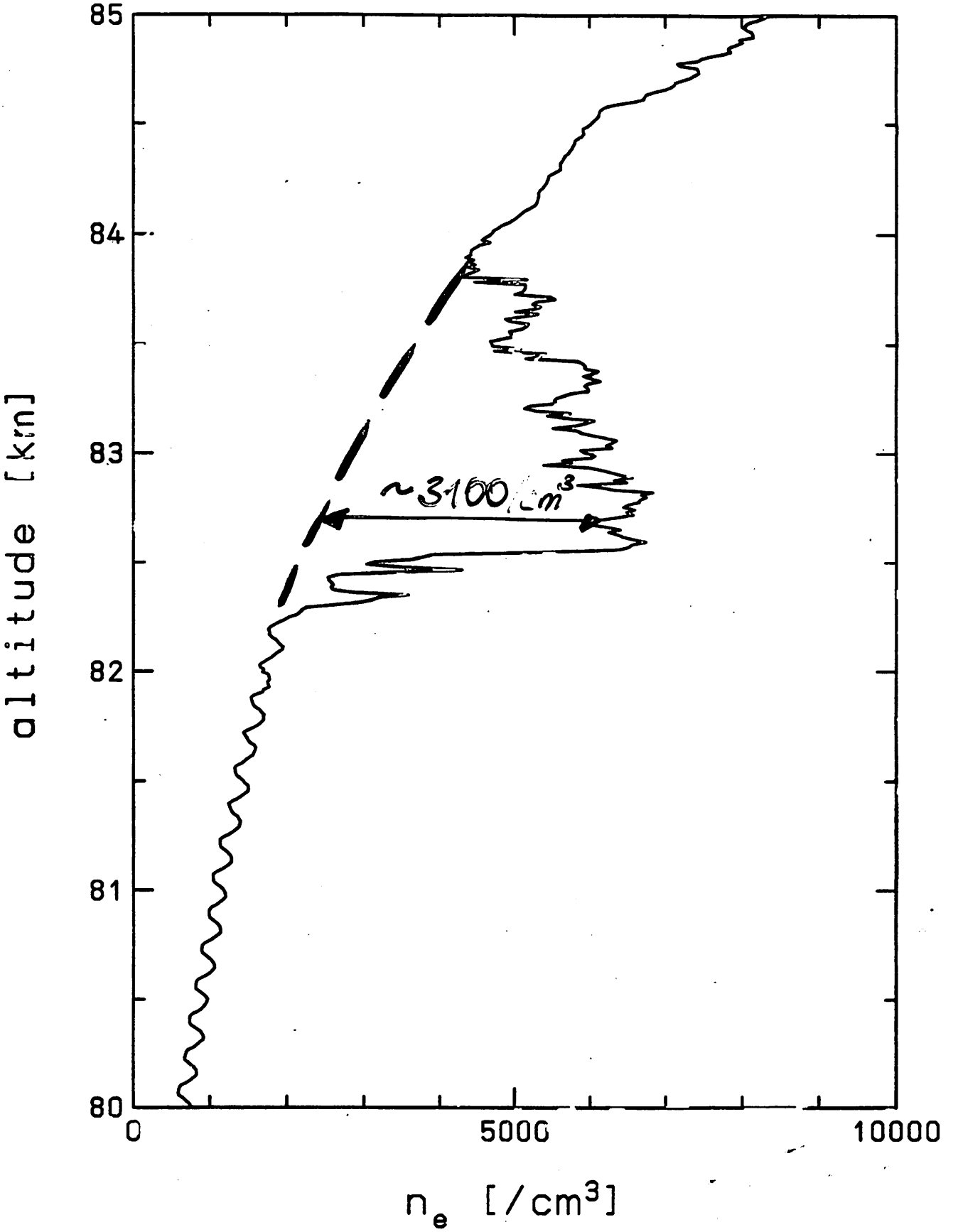
Luebken et. al., GRL, vol 25, p.893-896, 1998



Lapp & Lindner, JAS 71, ----.

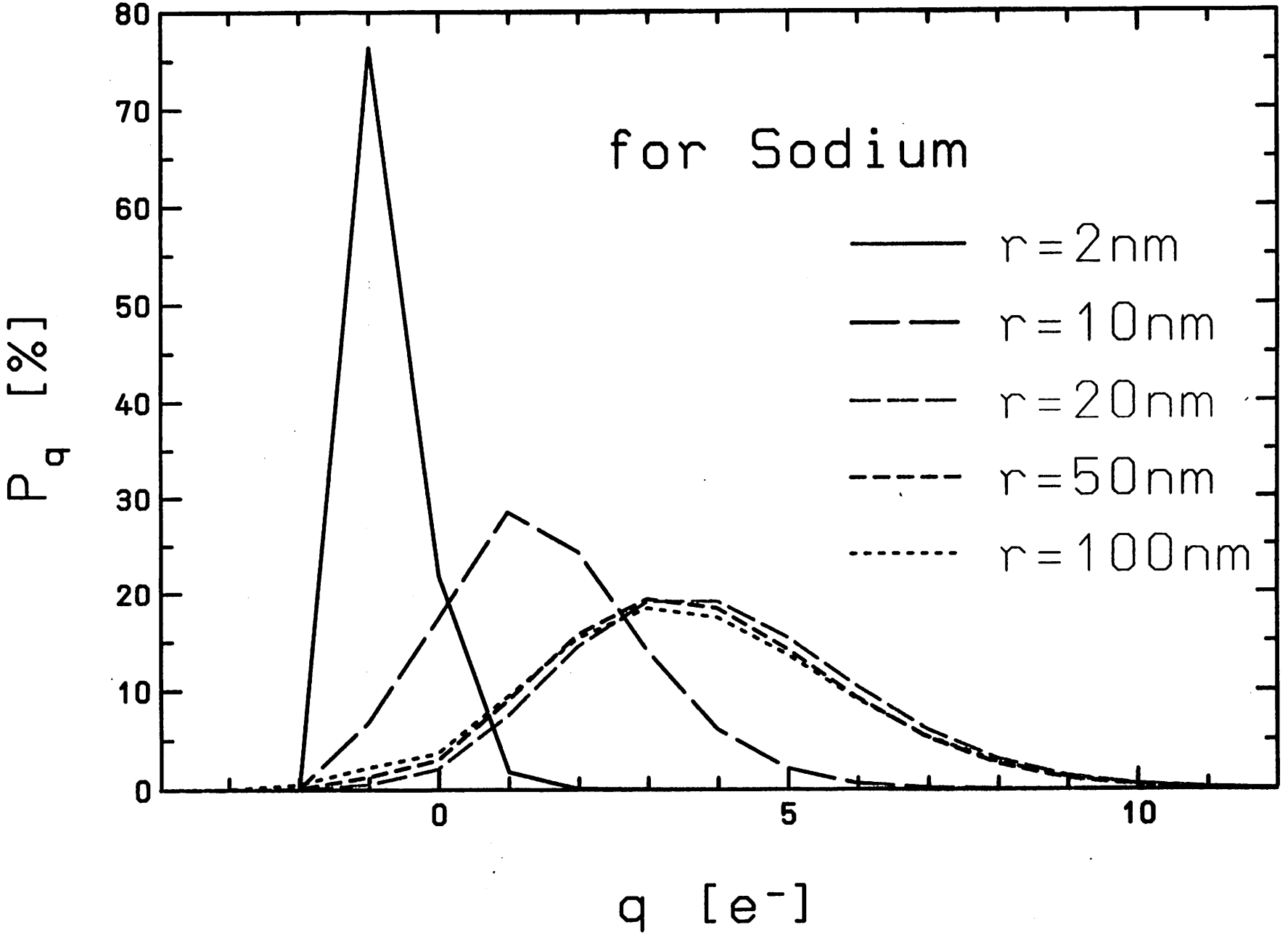


Blix, ESA-SP370 1995 ECT-07 CONE



XI.10

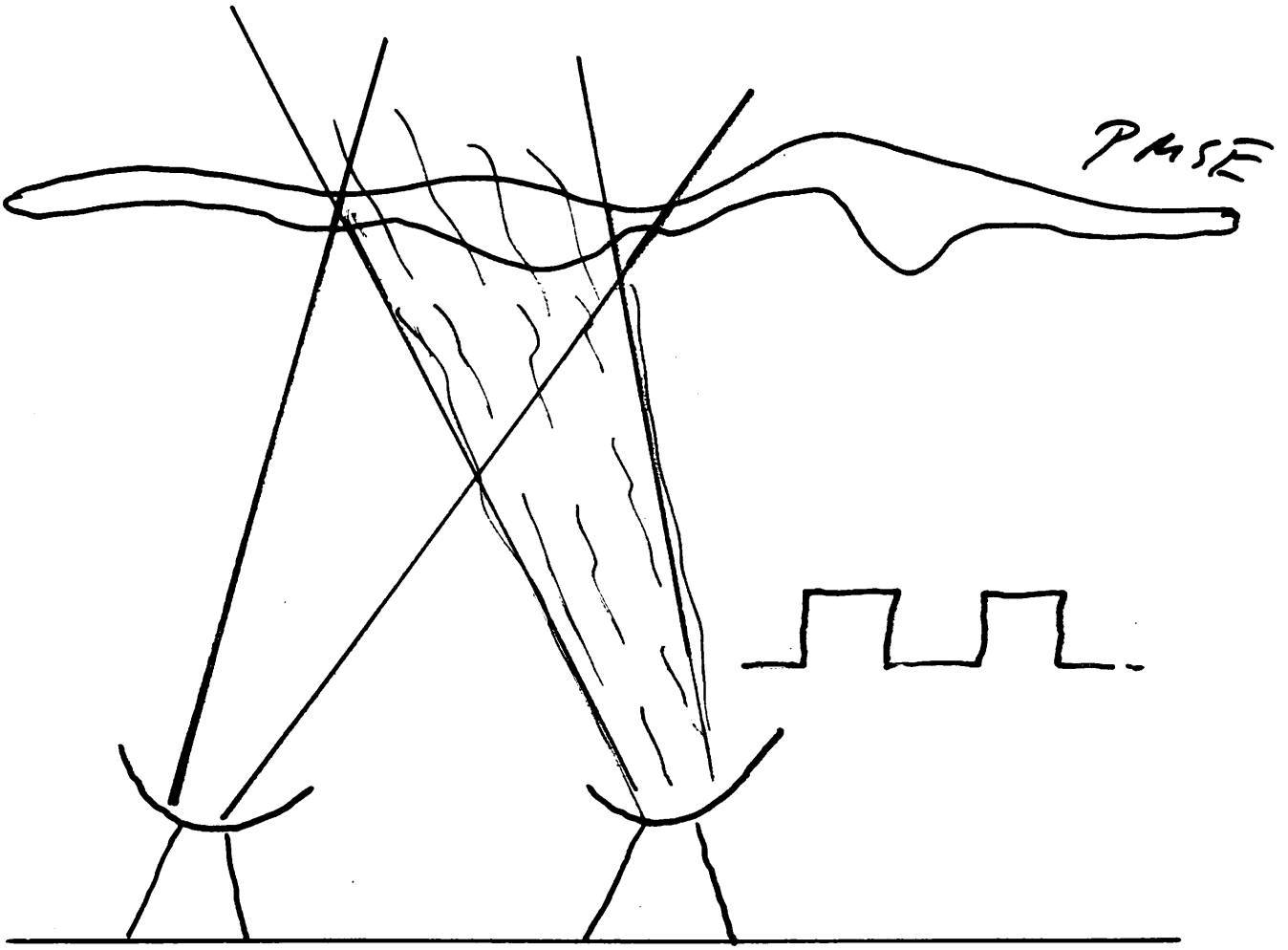
Rapp & Lübken, Earth Plan. Space, 1999.



Heating Experiment

EISCAT

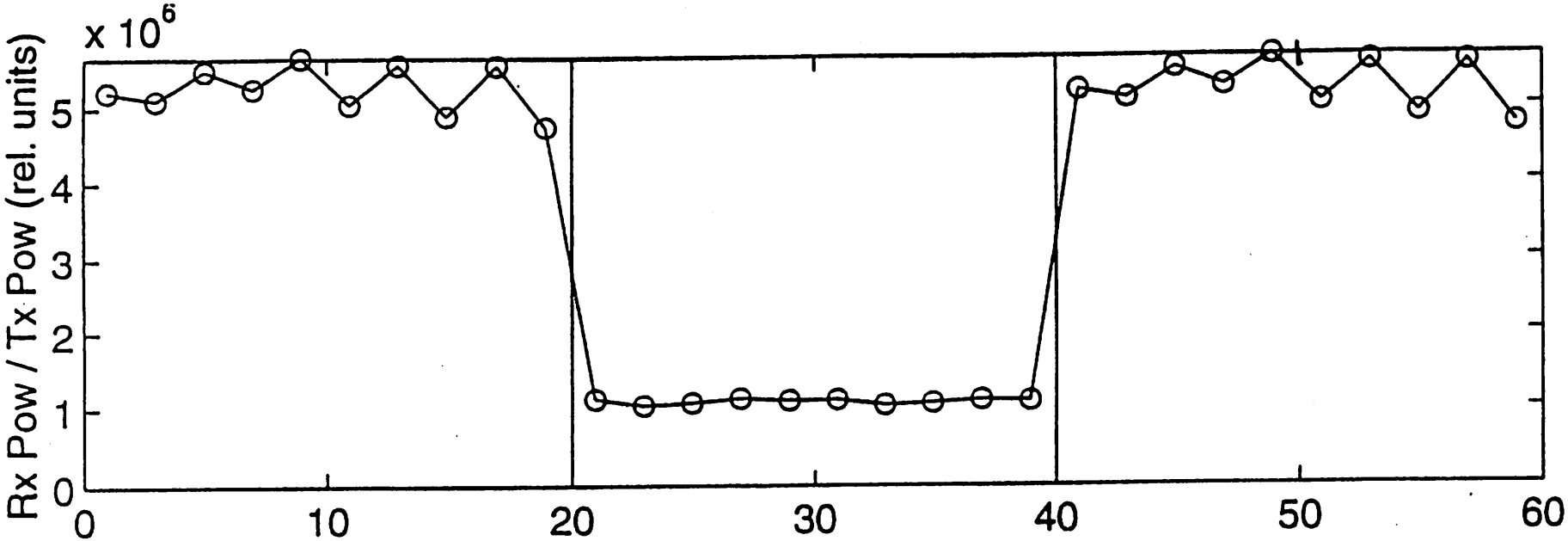
(Chilson et al., submitted to GRL, 2000.)



EISCAT, Tromsø
224 MHz

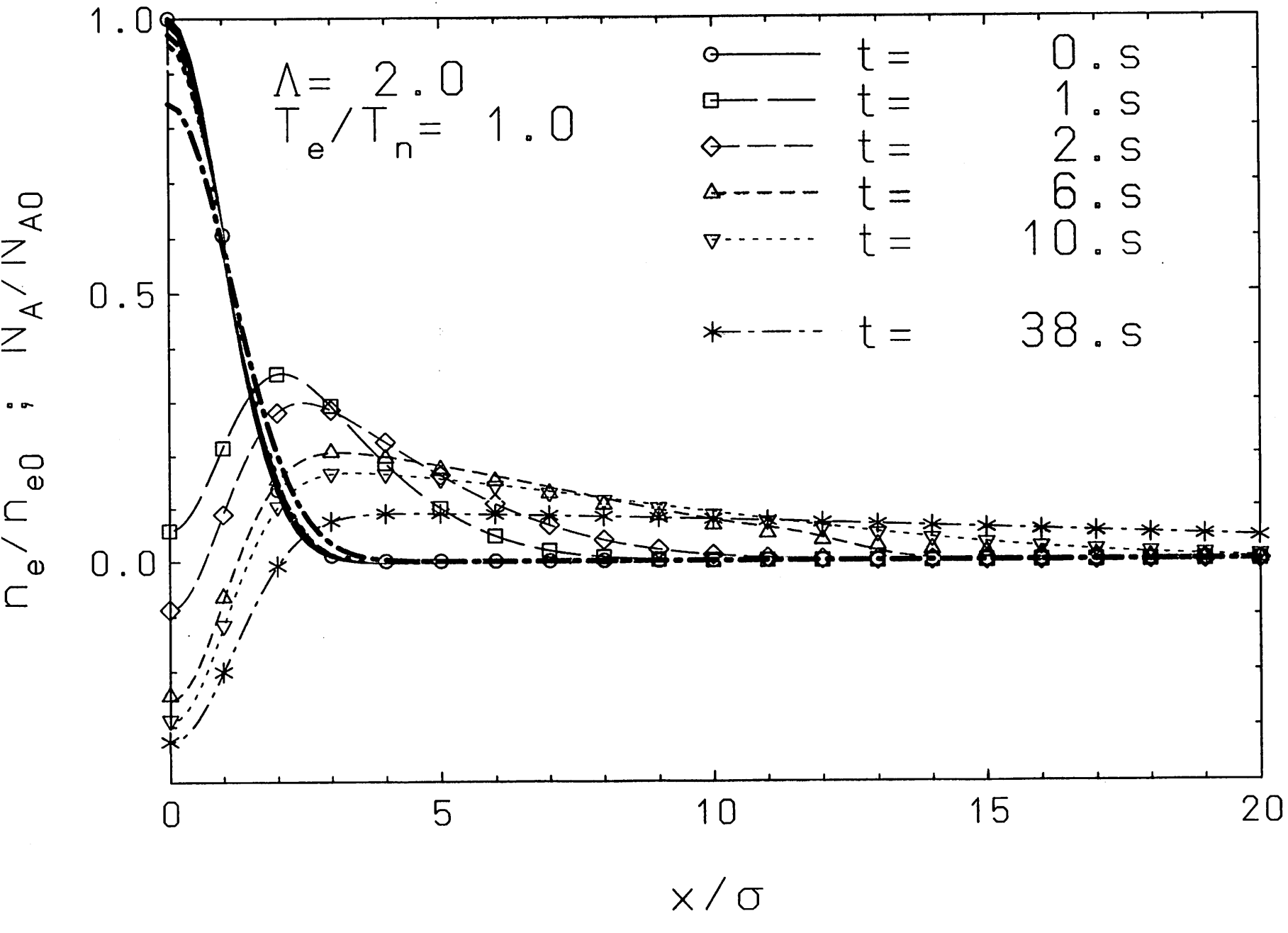
Heater
5,4 MHz
1200 MW (?)
$\sim T_e \approx 3000$ K

Chilson et al., GRL, 2000

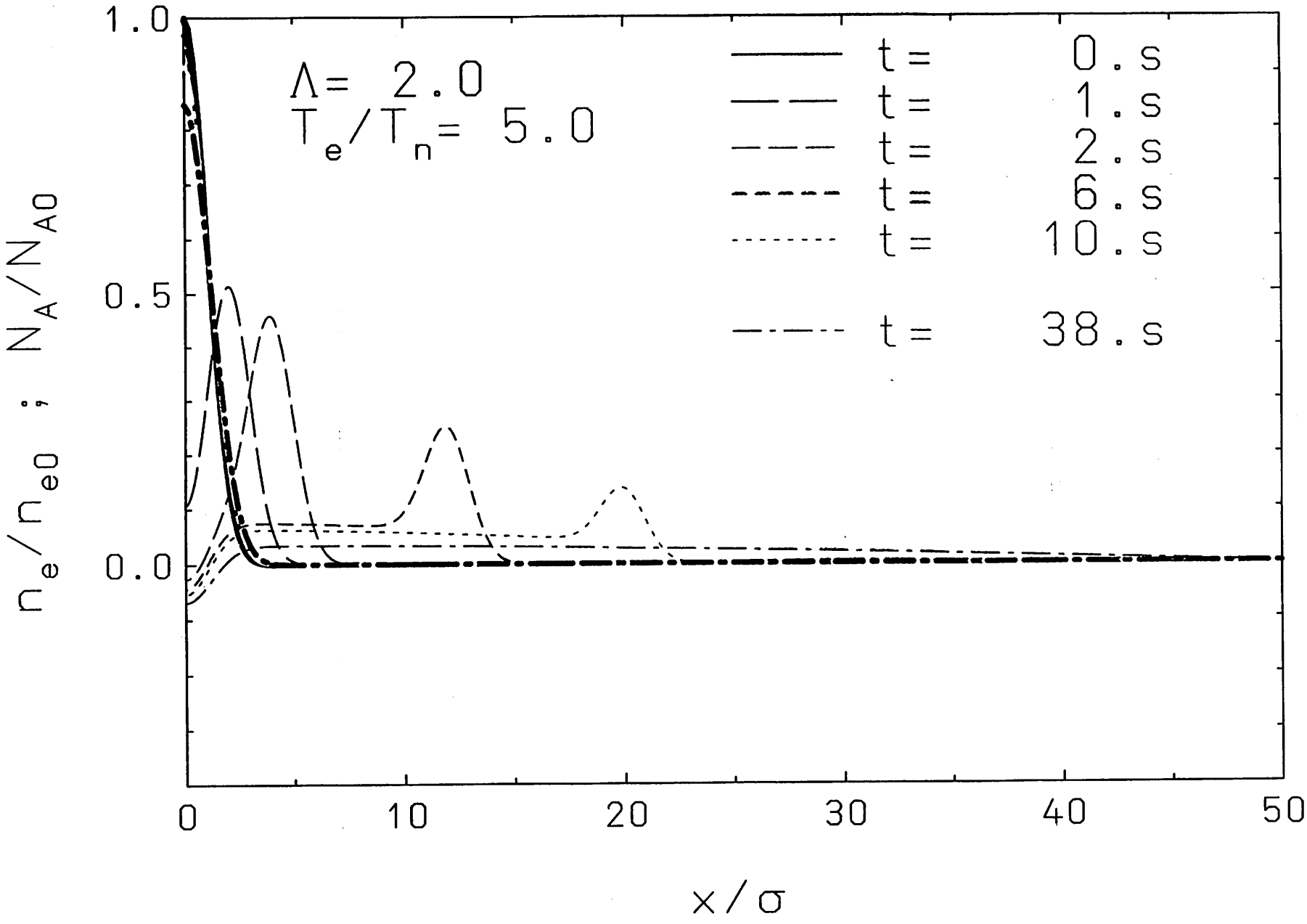


Heater off | Heater on | Heater off

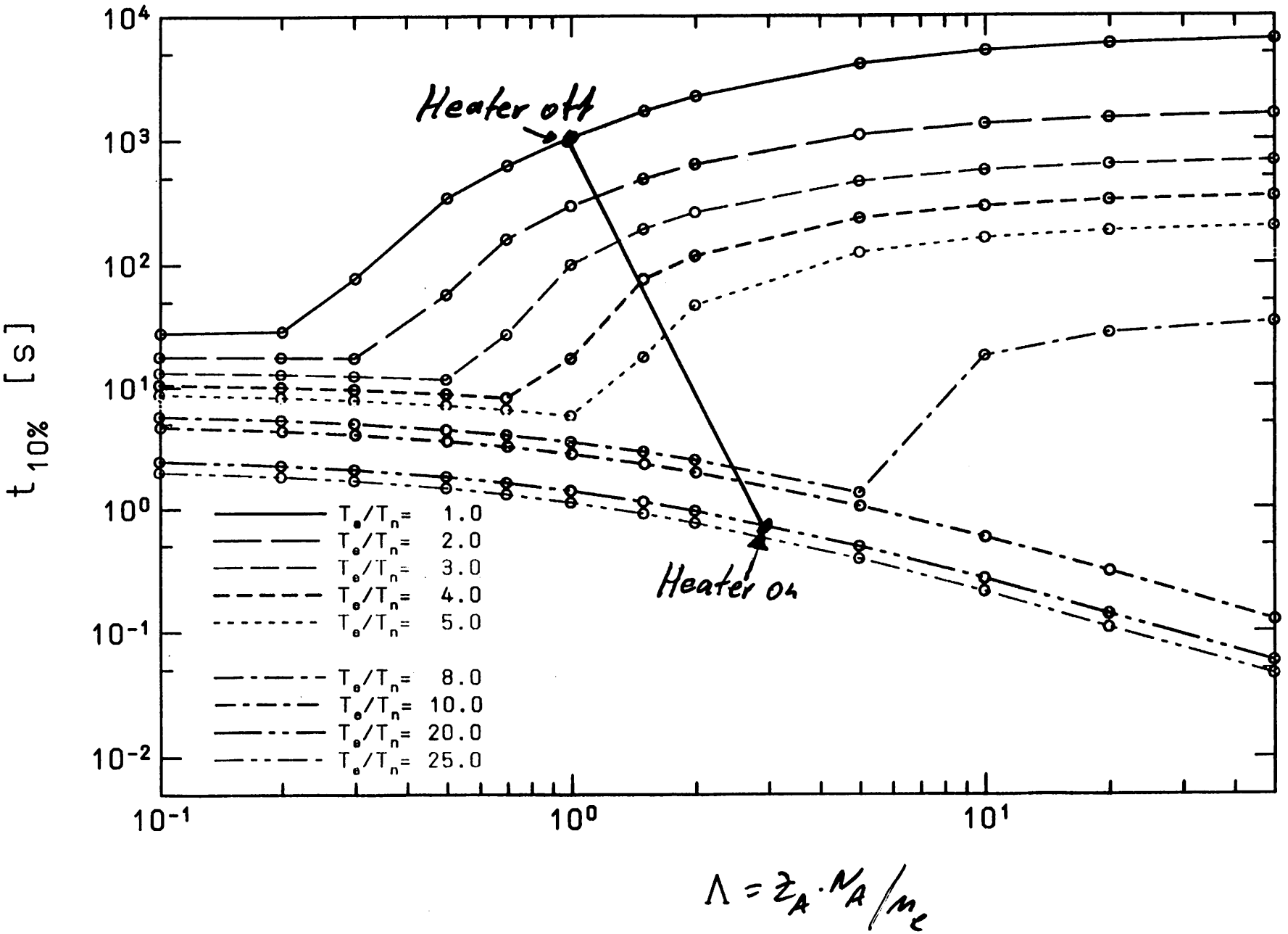
Rapp & Lübken, submitted to GRL 2000.



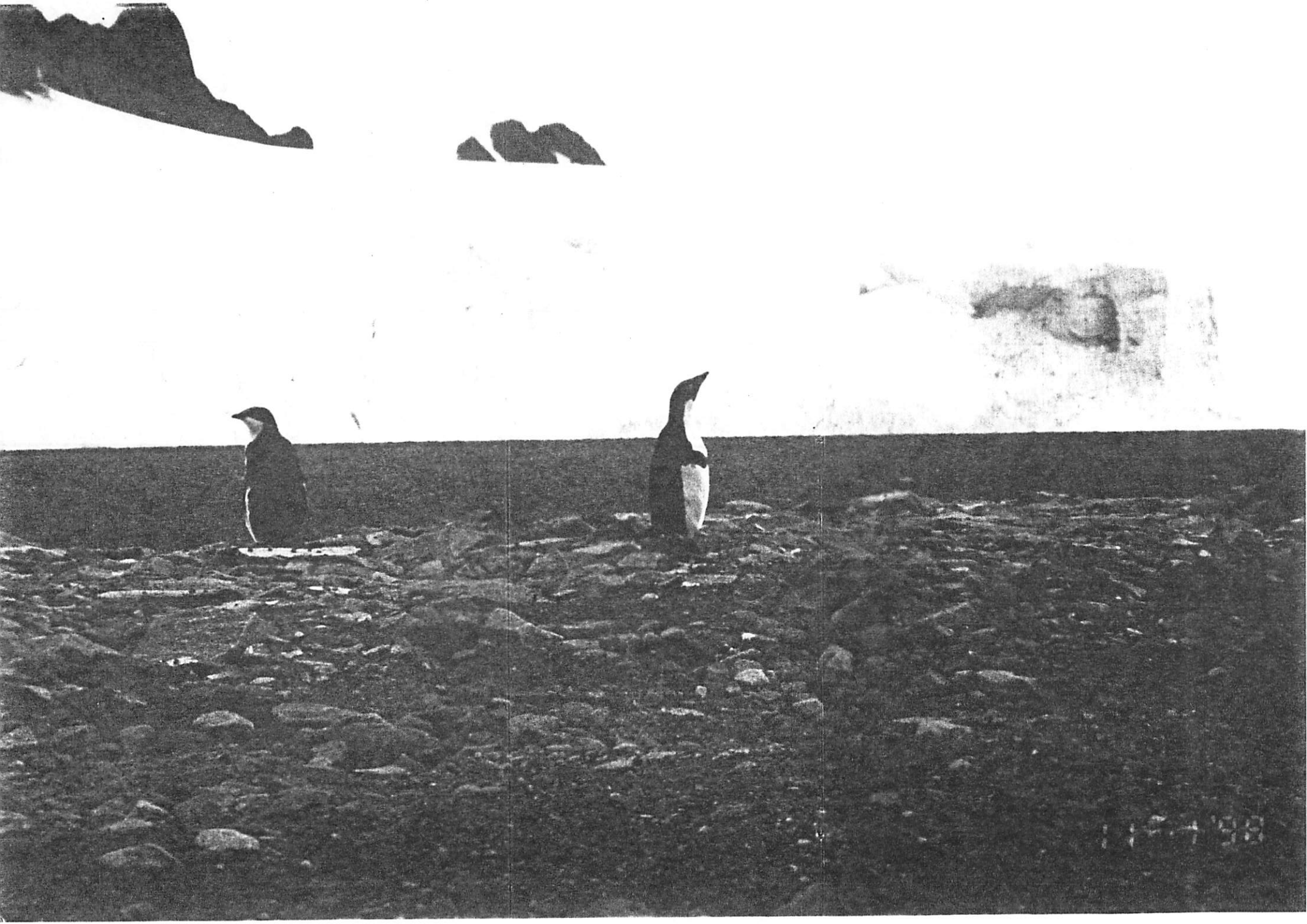
Kapp & Lübken, submitted to GRL 2000

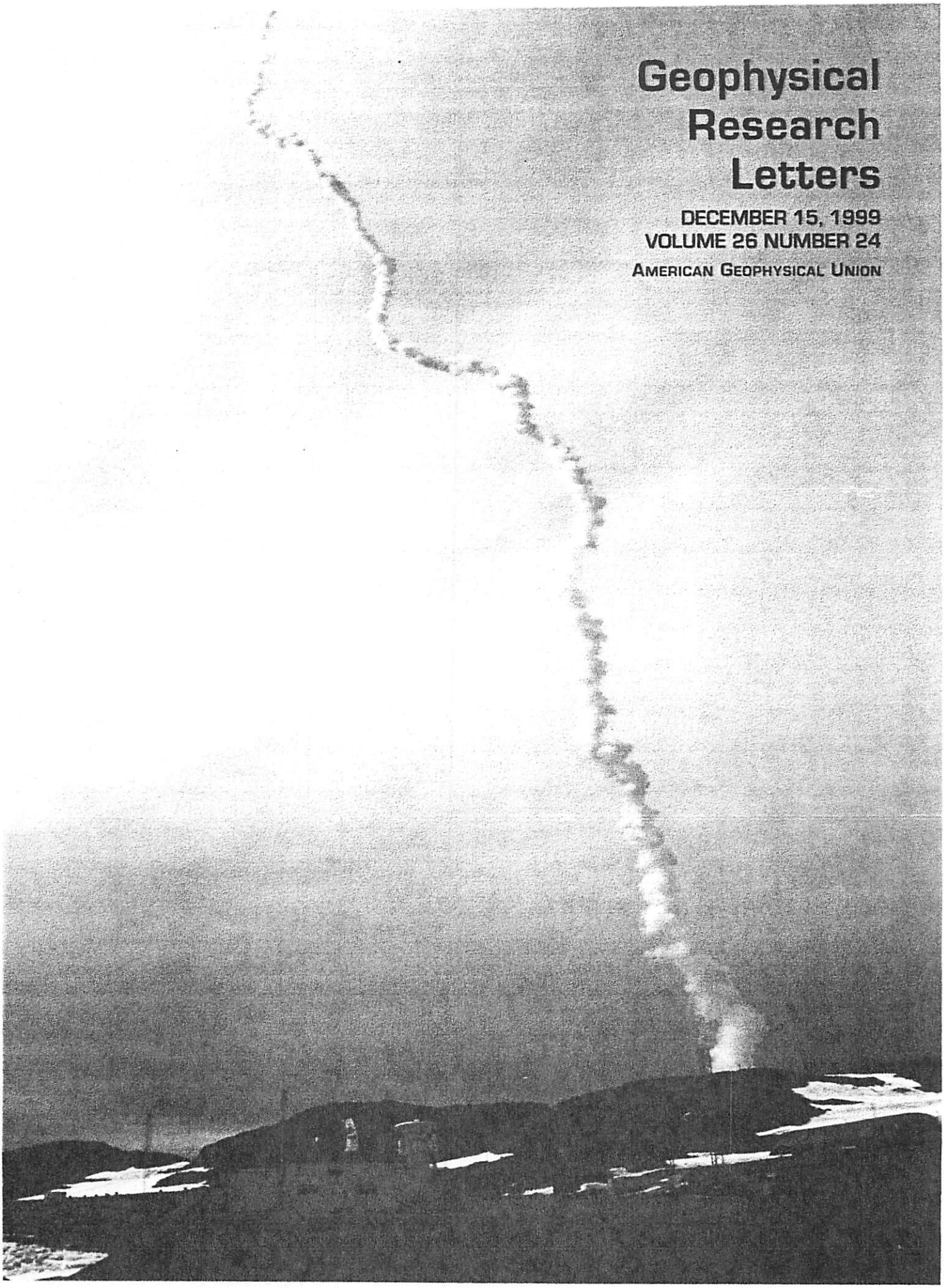


Rapp & Lübken, submitted to GRL, 2000.



B.14

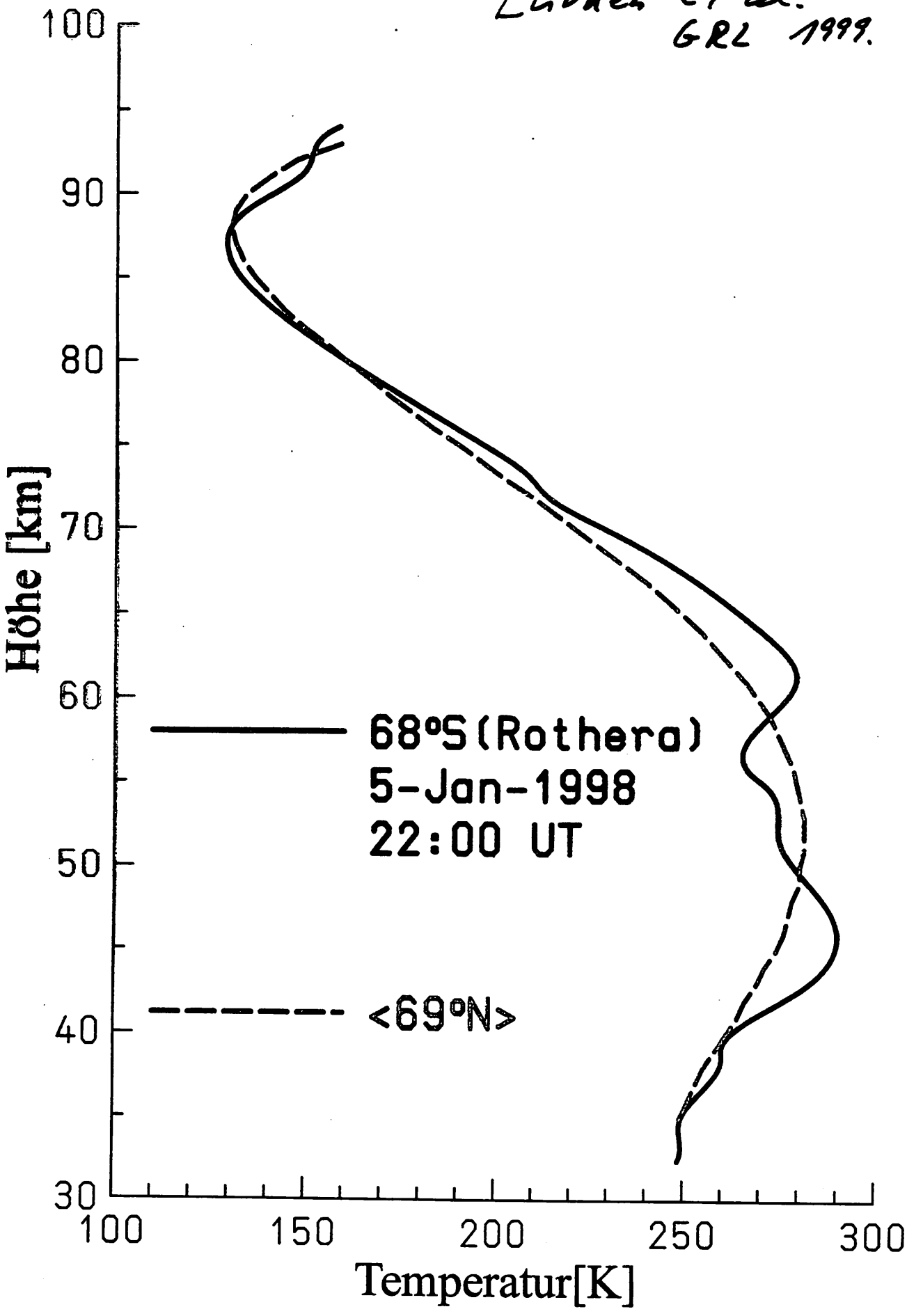




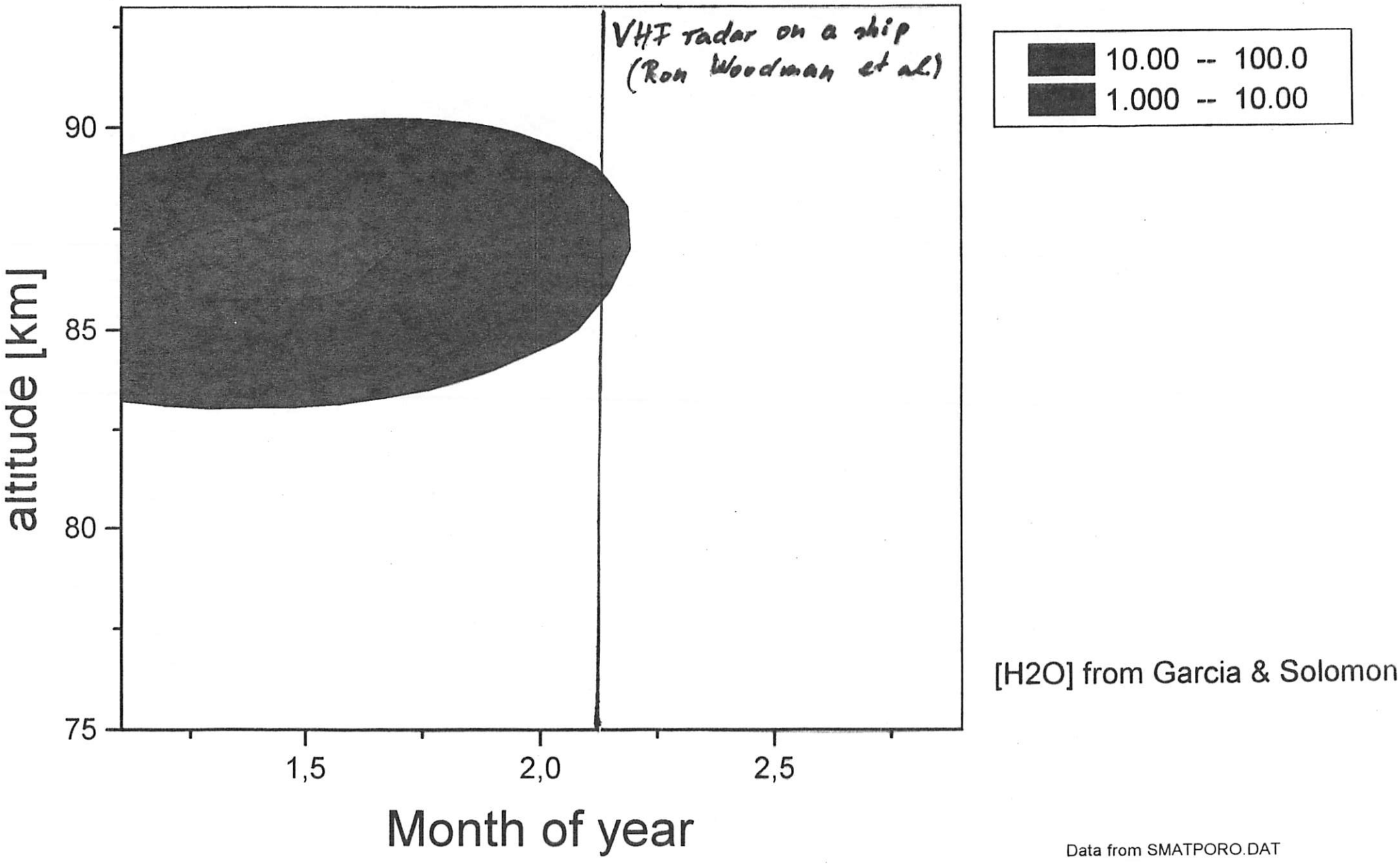
Geophysical Research Letters

DECEMBER 15, 1999
VOLUME 26 NUMBER 24
AMERICAN GEOPHYSICAL UNION

Lübken et al.
GRL 1999.



Degree of Saturation (Rothera, 68S)



[H2O] from Garcia & Solomon

Data from SMATPORO.DAT

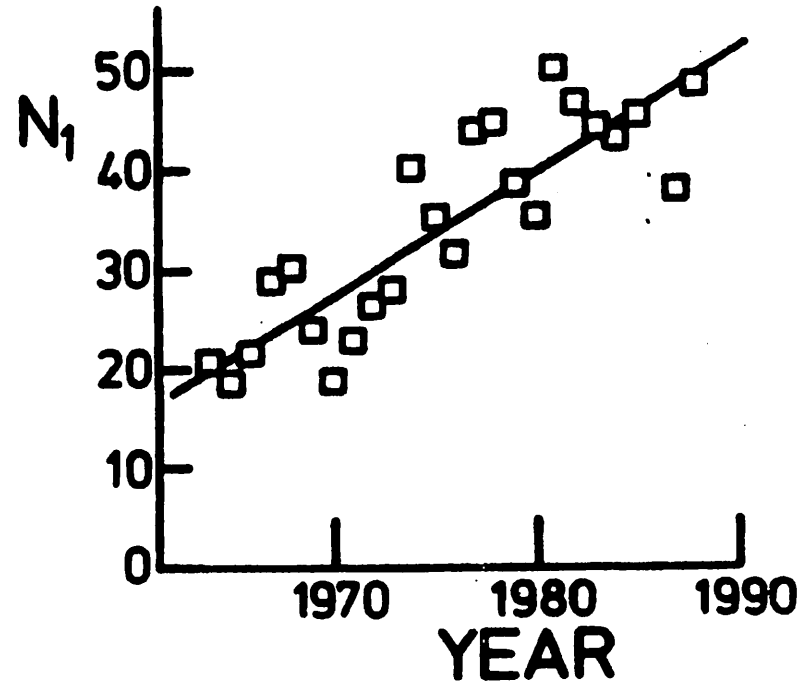
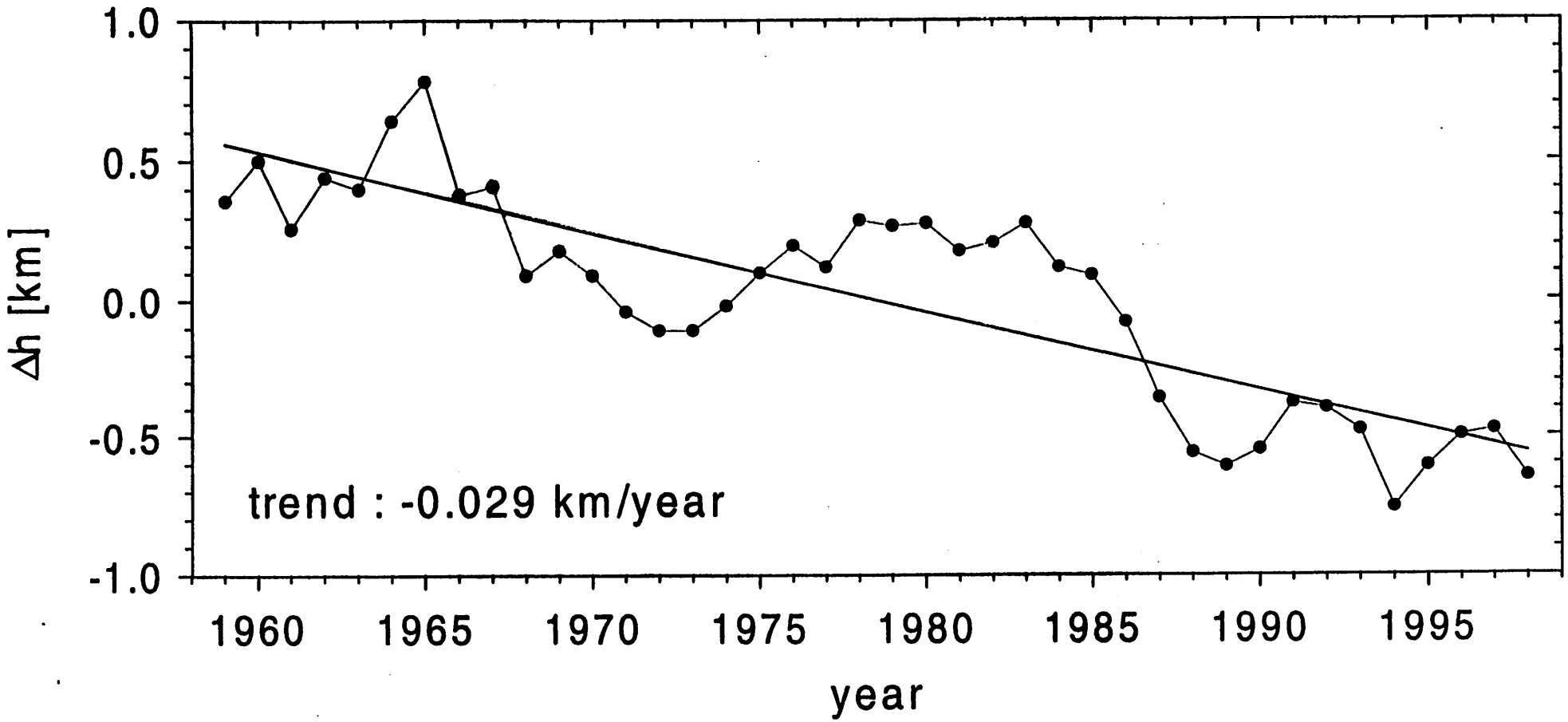


Fig. 2. The data of Fig. 1, with the effect of solar activity removed, to give N, the number of nights per year on which NLCs would have been seen were there to be no solar-cycle variation. The straight line through the data points is the regression equation, which shows a secular change in frequency of occurrence of NLCs.

aus JATP, Vol.52, No.4, pp.247-251,1990
M.Gadsen, "A secular change in noctilucent cloud accurrence"

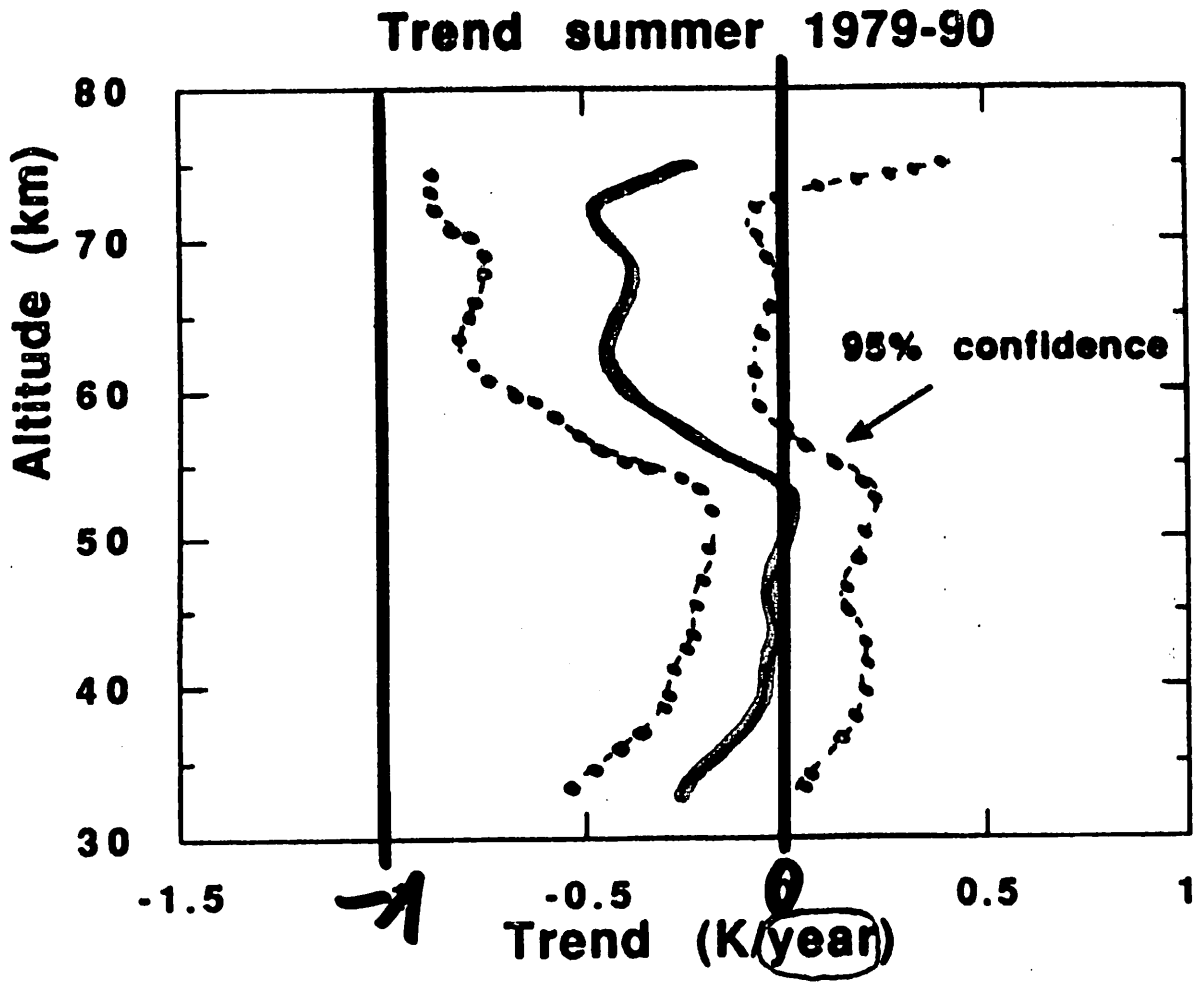
~ Gadsden: -74 /(20-70y)

Bremer, private communication, 1995



Reflektionshöhe von Langwellen ($p \approx 10^{-2}$ mbar ; $z \approx 82$ km)

Hauchecorne et al., JGR, 16, 17,171-17,181, 1991.



mid-latitude (44°N)

Fig. A1. Linear trend of the lidar temperature during summer months (data from 1979 to 1990).

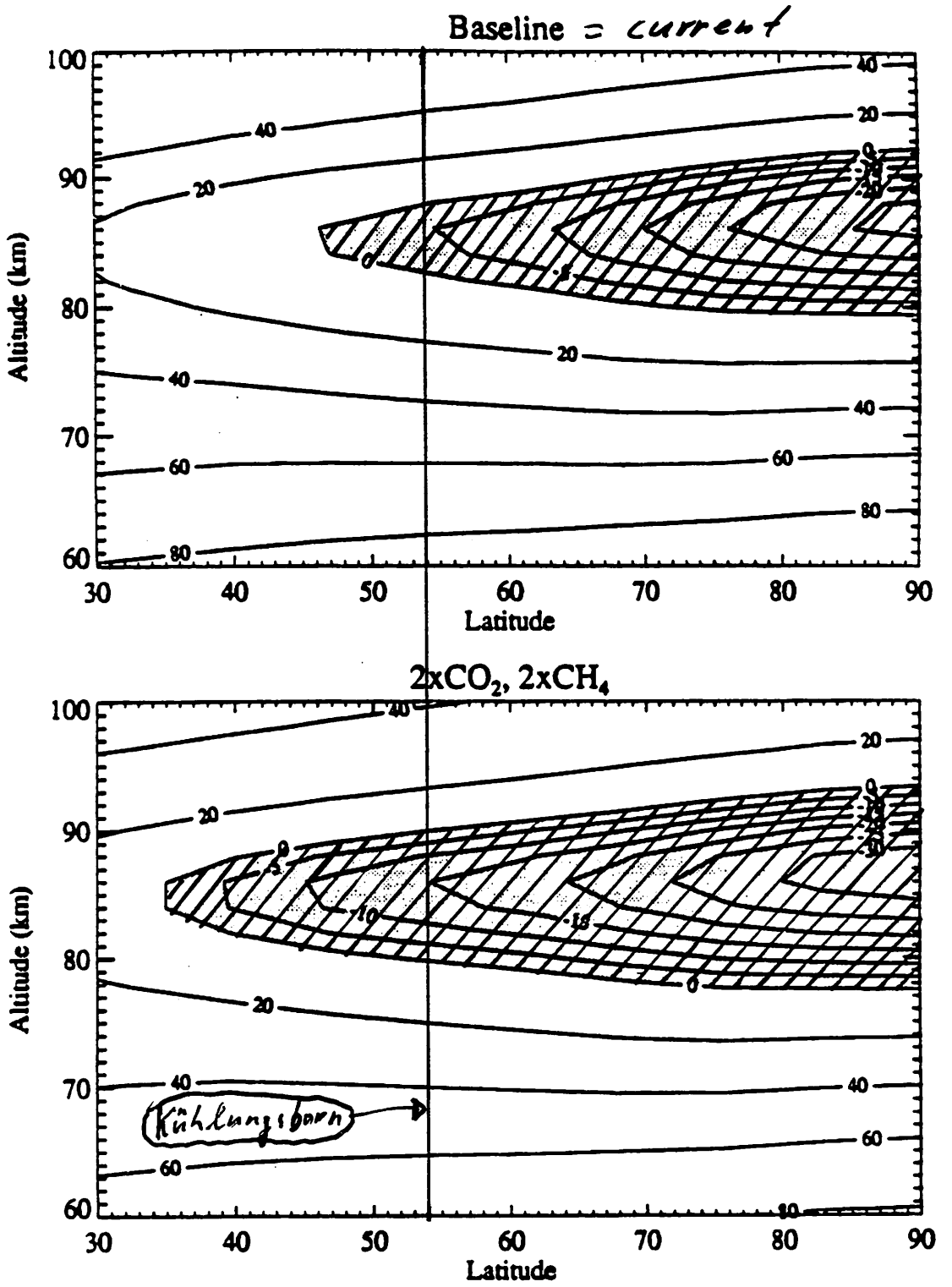
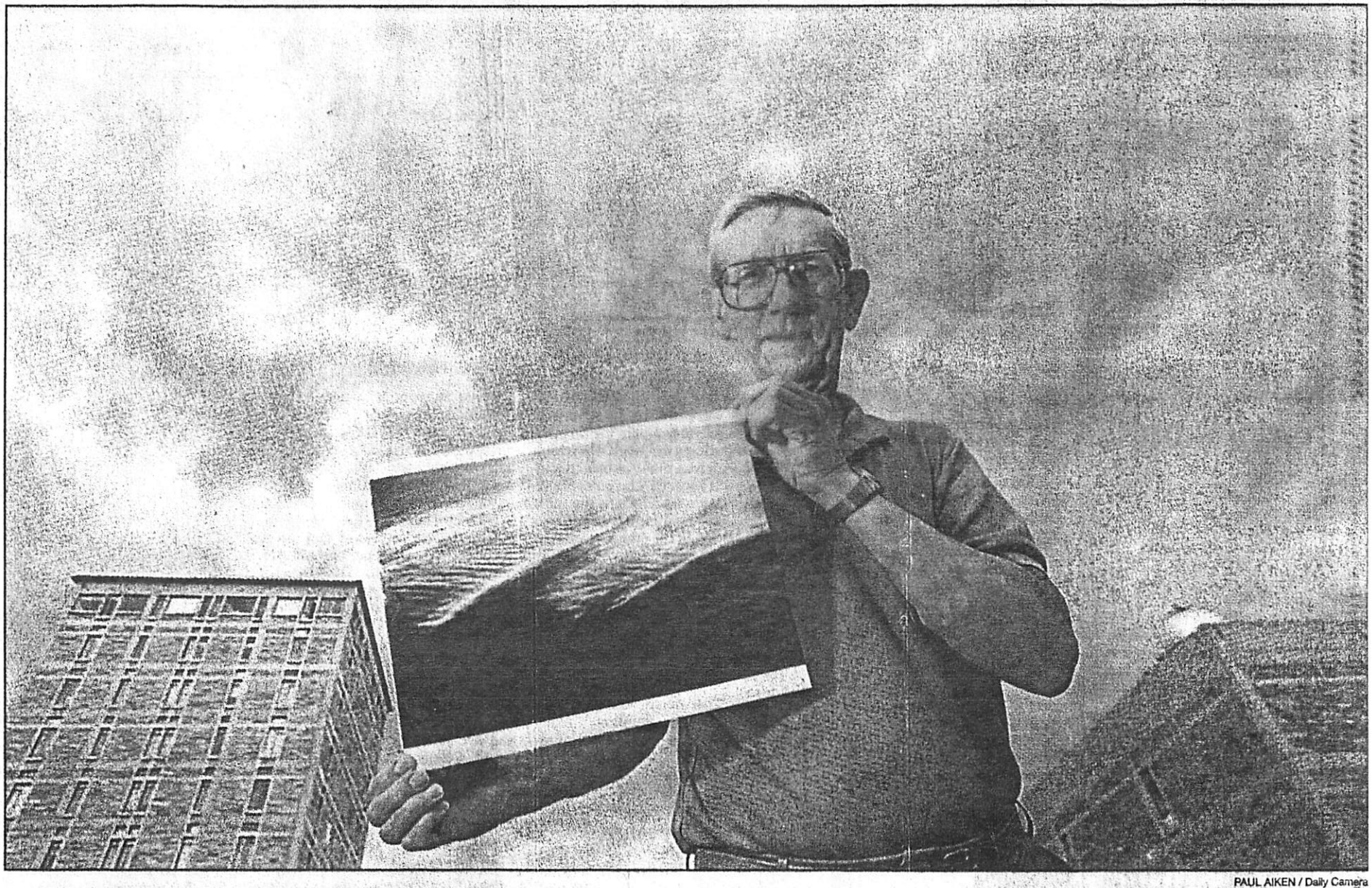


Fig. 18. Contours of modeled values of the atmospheric temperature minus the frost-point temperature. Shaded values are negative. Upper panel: current conditions. Lower panel: doubled carbon dioxide-methane scenario (Portmann, 1994).

G.E. THOMAS, YATP 96, SR, pp. 1625–1650, 1996.

VI.13

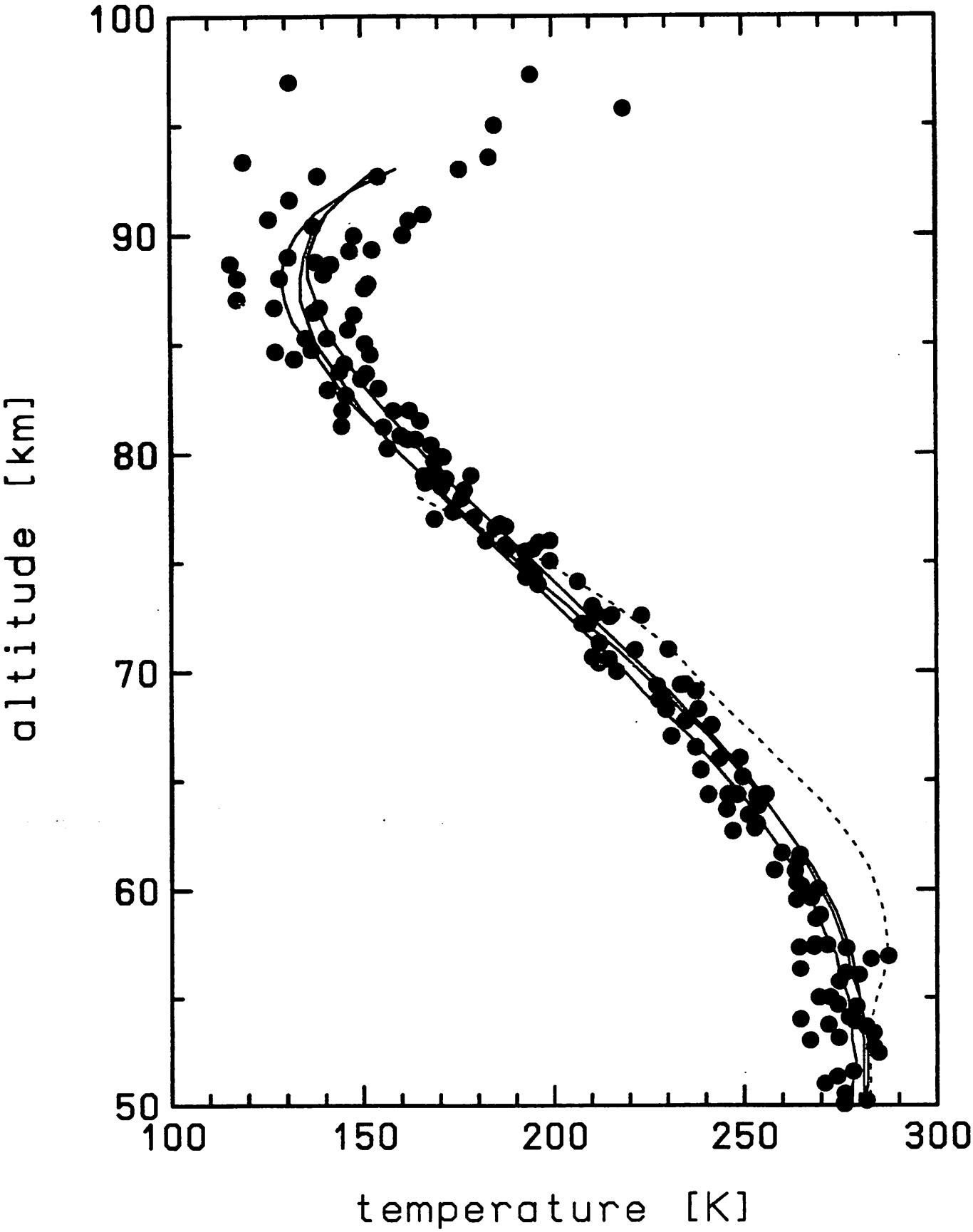


PAUL AIKEN / Daily Camera

Gary Thomas of the University of Colorado holds a photograph of an unusual type of clouds — normally spotted in polar regions — that have been sighted recently in the Boulder area. The clouds, called noctilucent, could be indicators of global climate change.

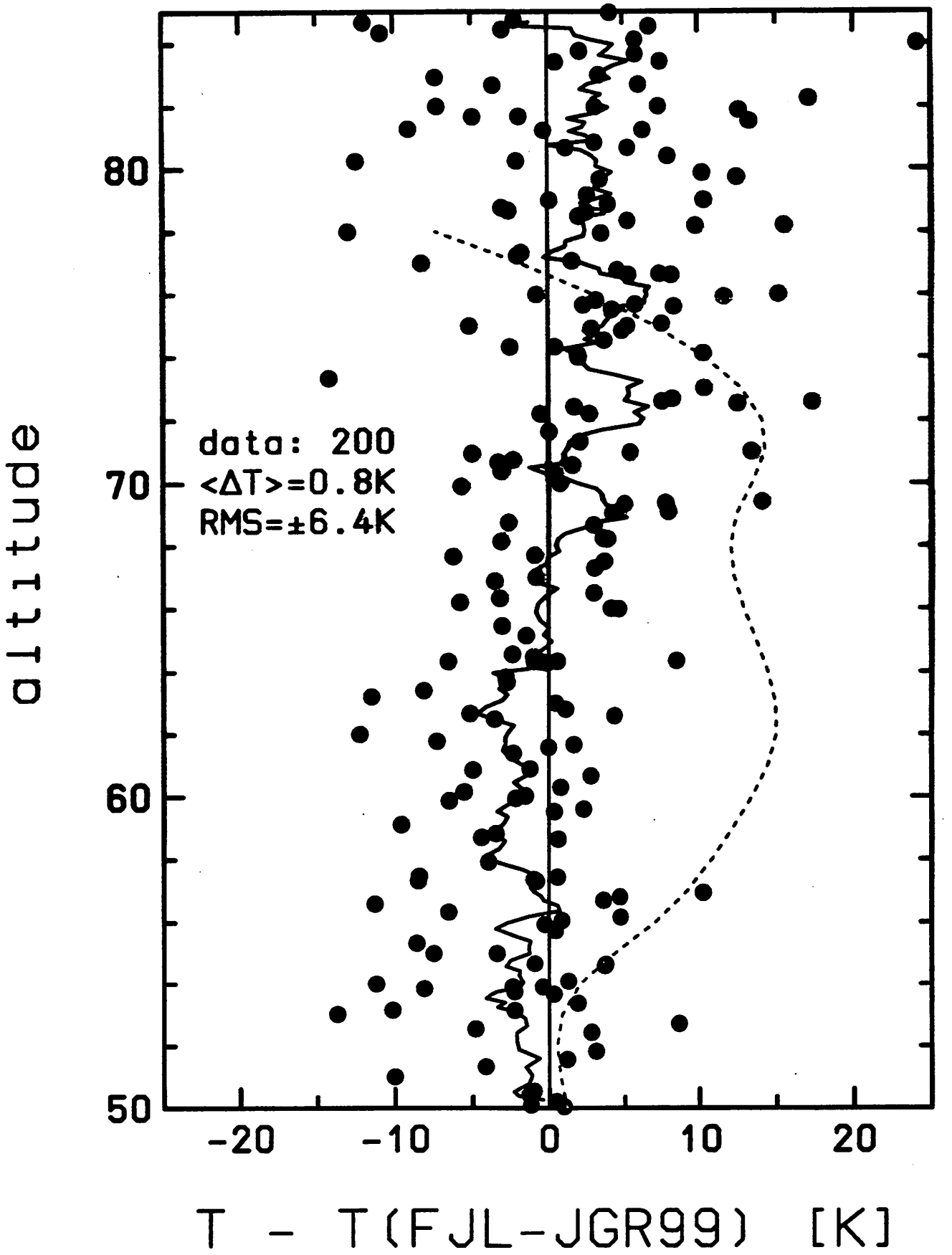
F.-J. Lübken, submitted to GRL, 2000

Fig. 1



F.-J. Lübken, submitted to GRL, 2000

Fig. 2



F.-J. Lübken, submitted to GRL, 2000

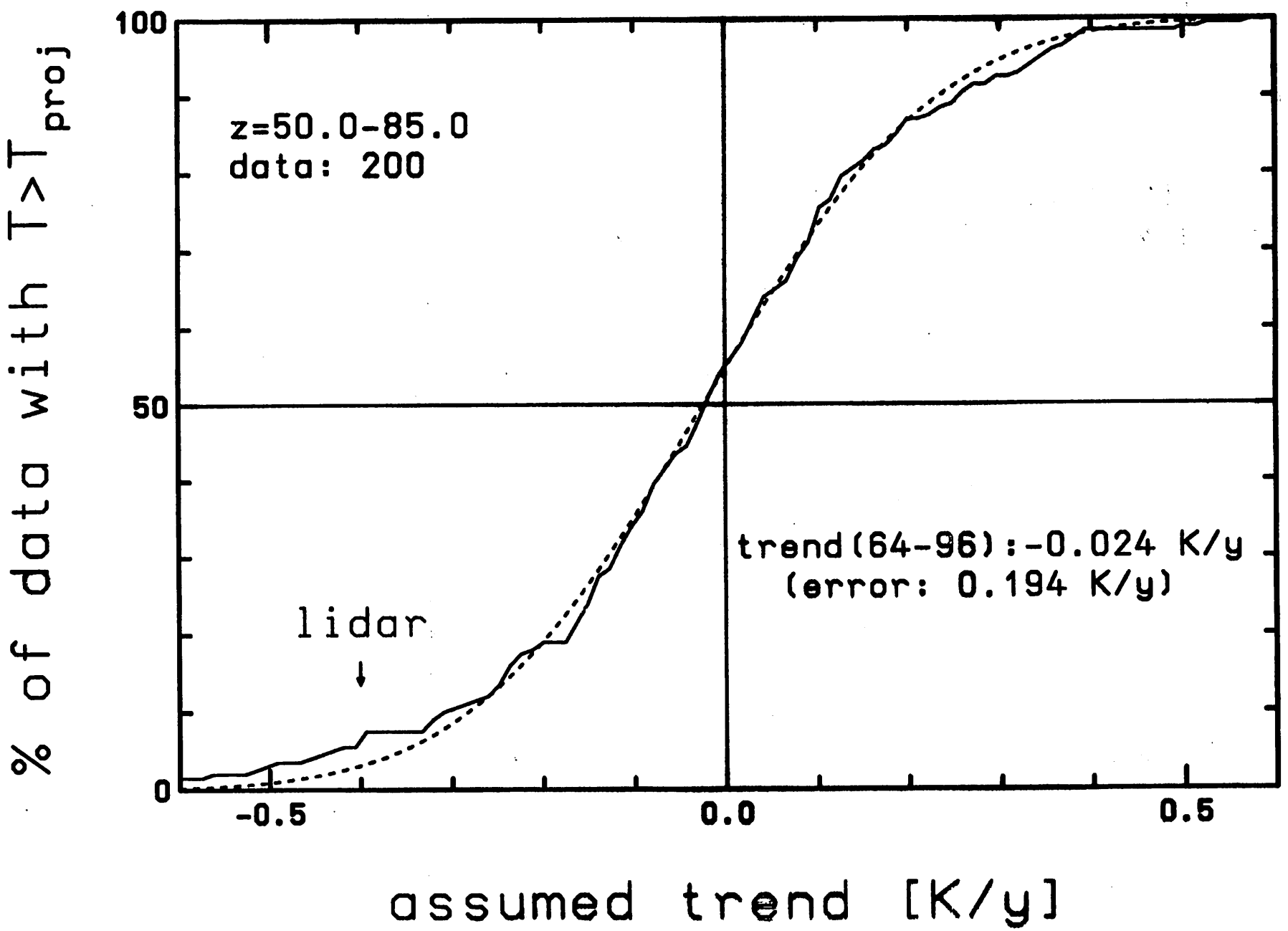


Fig.3