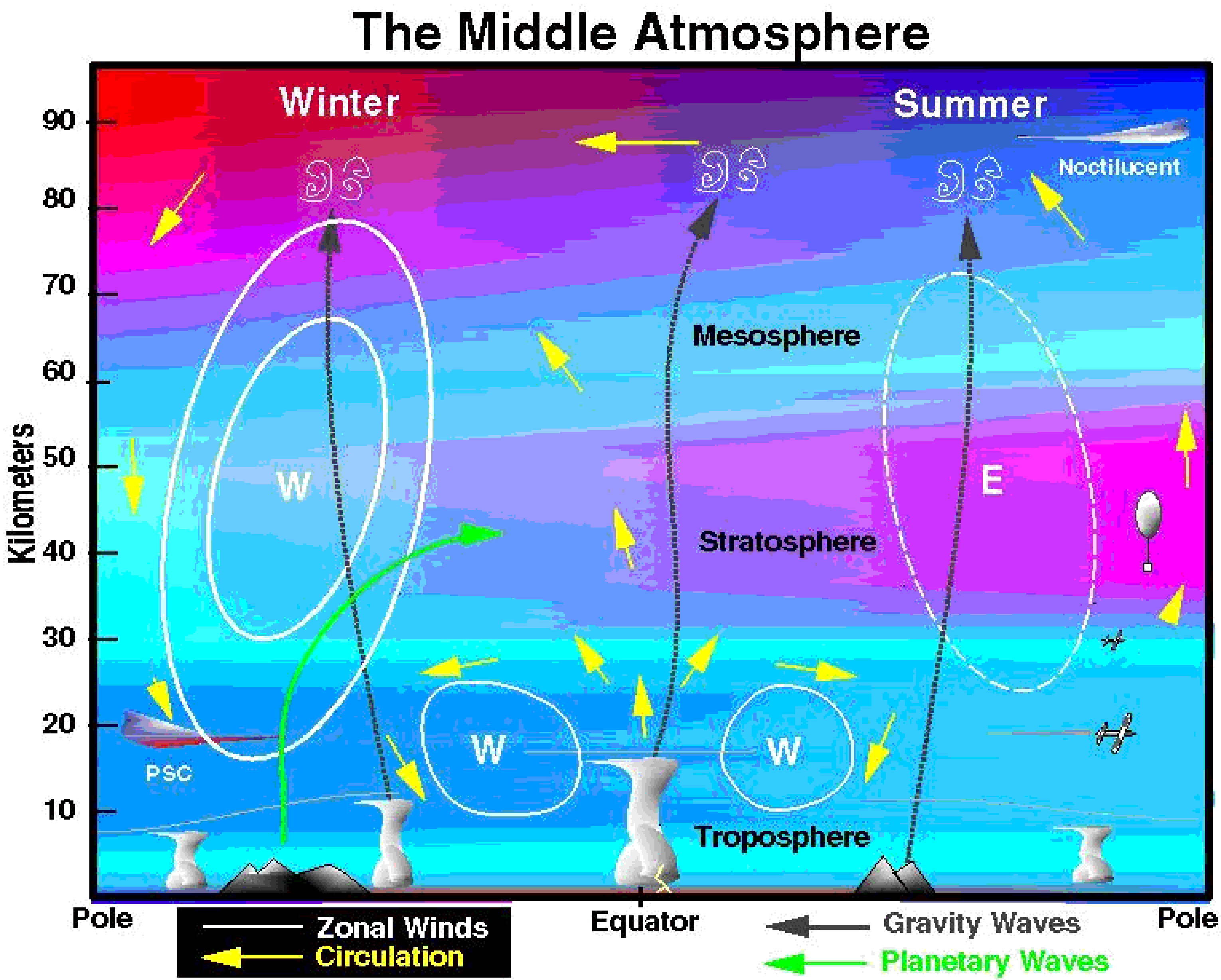
Radio Aeronomy

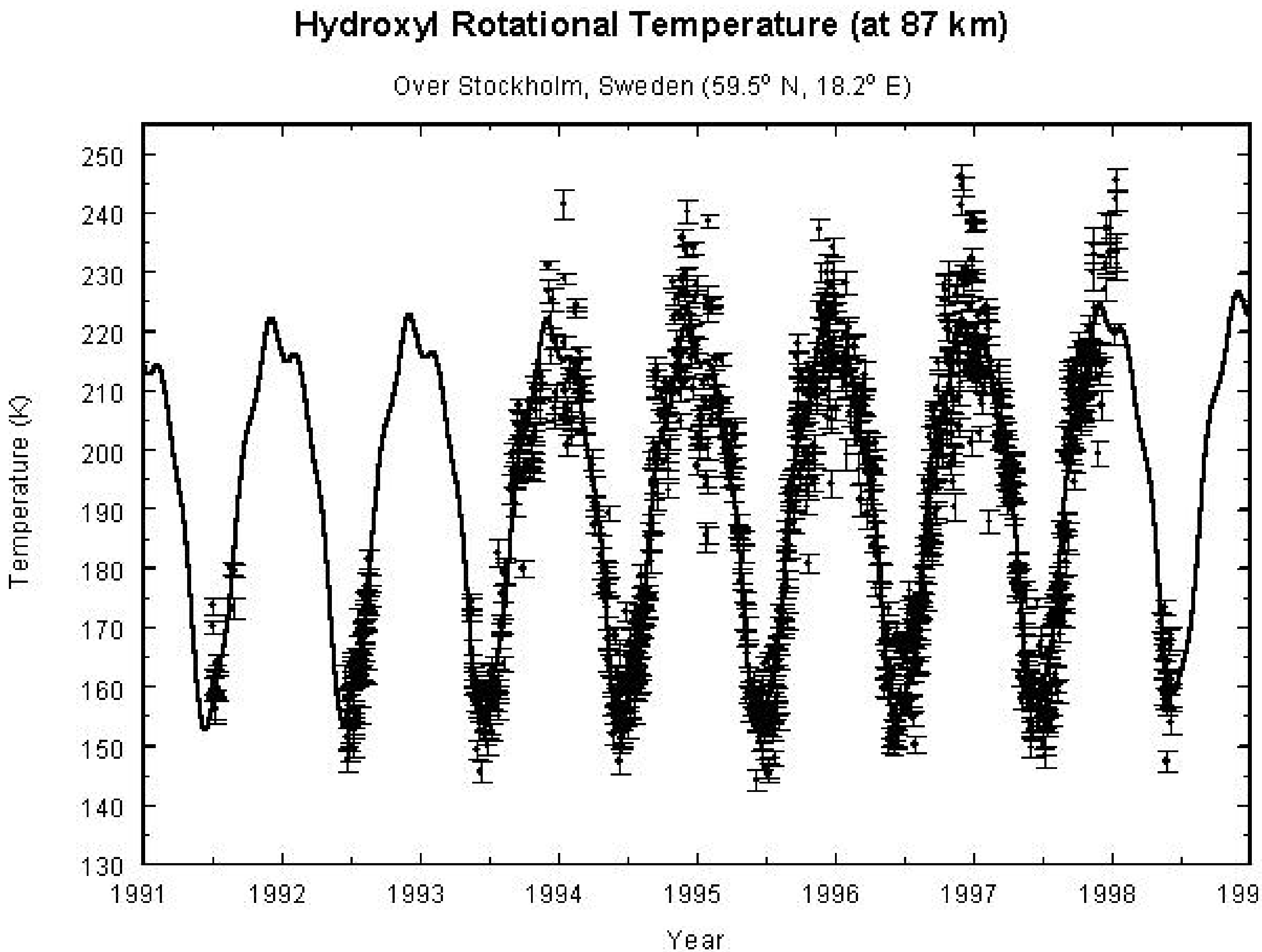
at Onsala Space Observatory

Peter Forkman
forkman@oso.chalmers.se



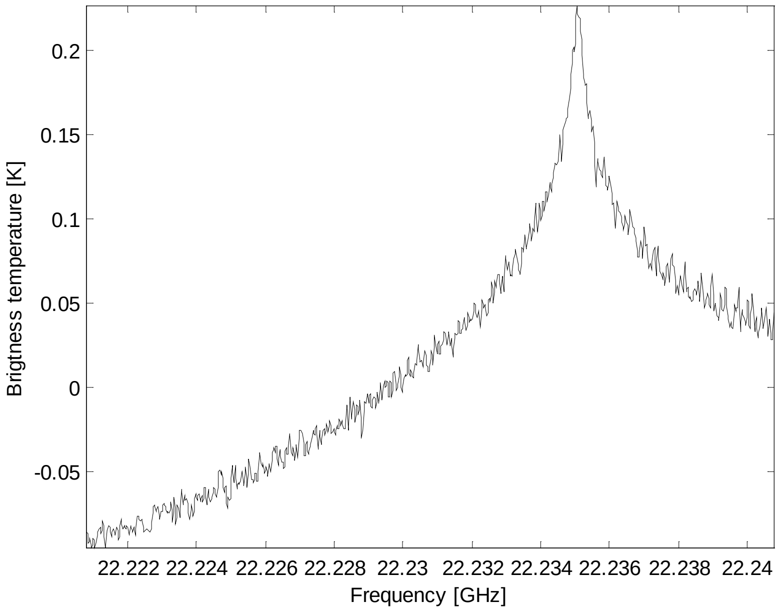
The Middle Atmosphere
Winter
Summer
Noctilucent
Mesosphere
Stratosphere
Troposphere
W
W
W
E
PSC
Kilometers
90
80
70
60
50
40
30
20
10
Pole
Equator
Pole
Zonal Winds
Circulation
Gravity Waves
Planetary Waves

Infrared OH-airglow instrument

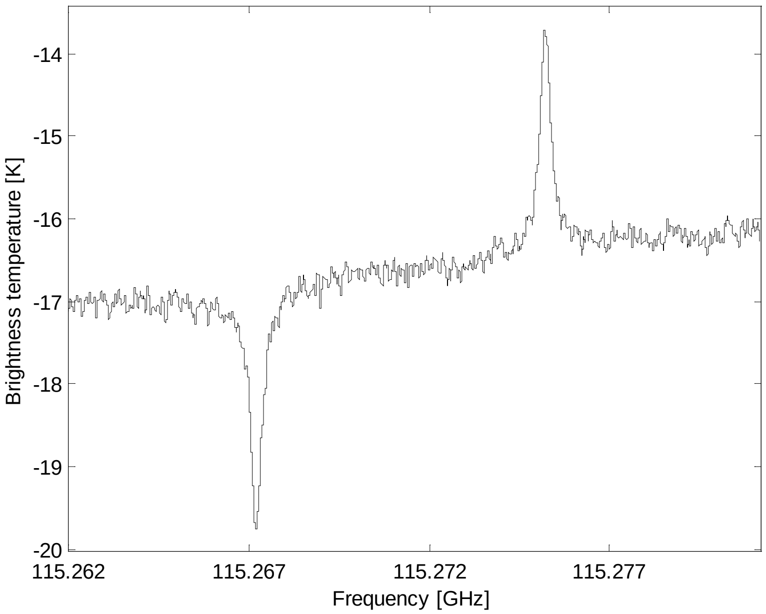


Hydroxyl Rotational Temperature (at 87 km)
Over Stockholm, Sweden (59.5° N, 18.2° E)
Temperature (K)
Year
130
140
150
160
170
180
190
200
210
220
230
240
250
1991
1992
1993
1994
1995
1996
1997
1998
1999

Pressure broadening

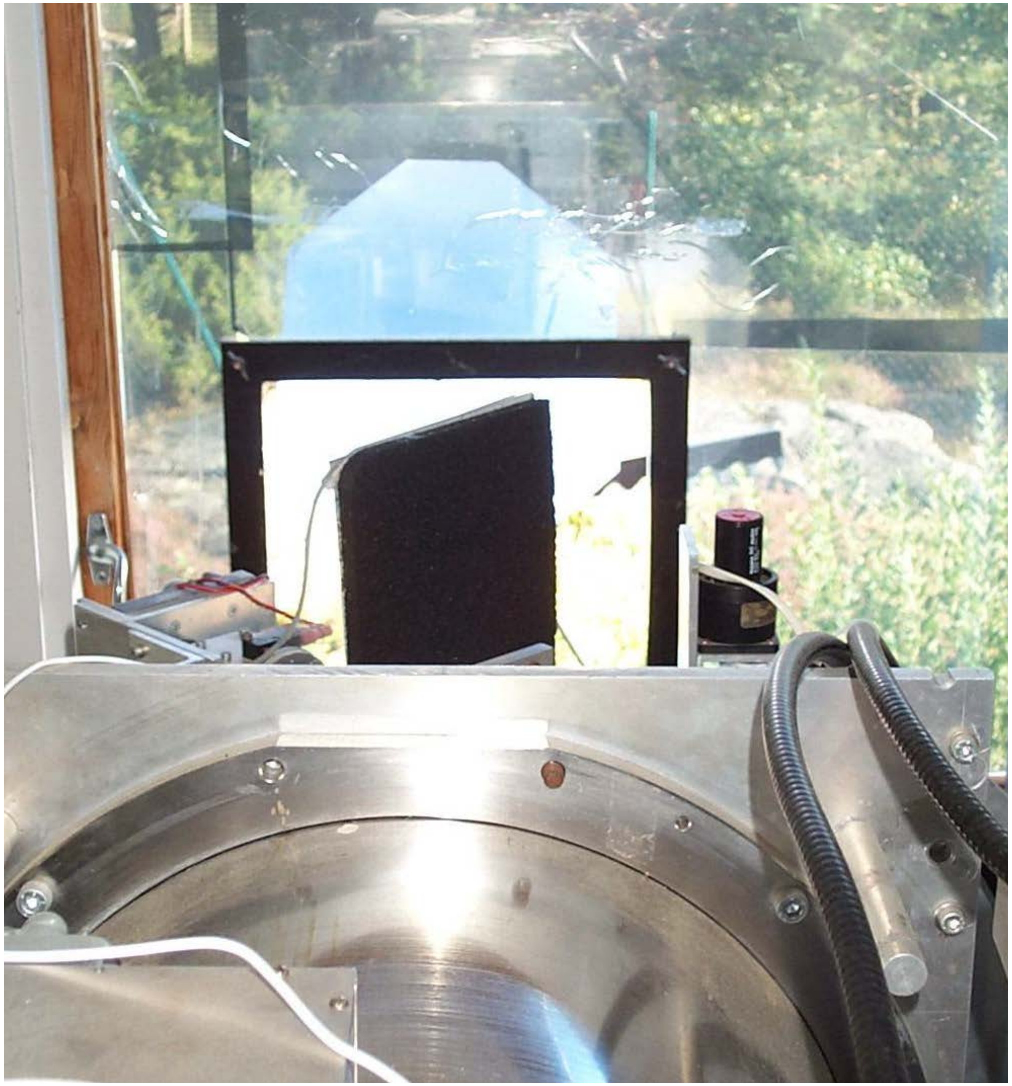


Sky switched H_2O at 22 GHz

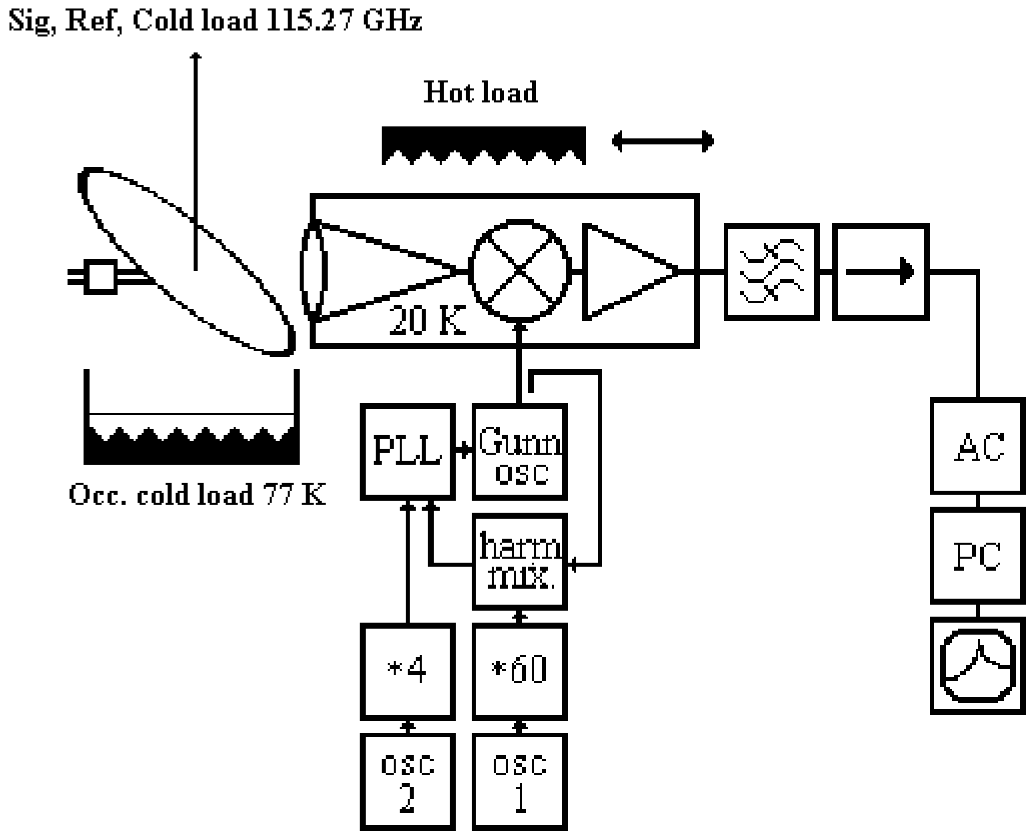


Frequency switched CO at 115 GHz

CO at 115.27 GHz

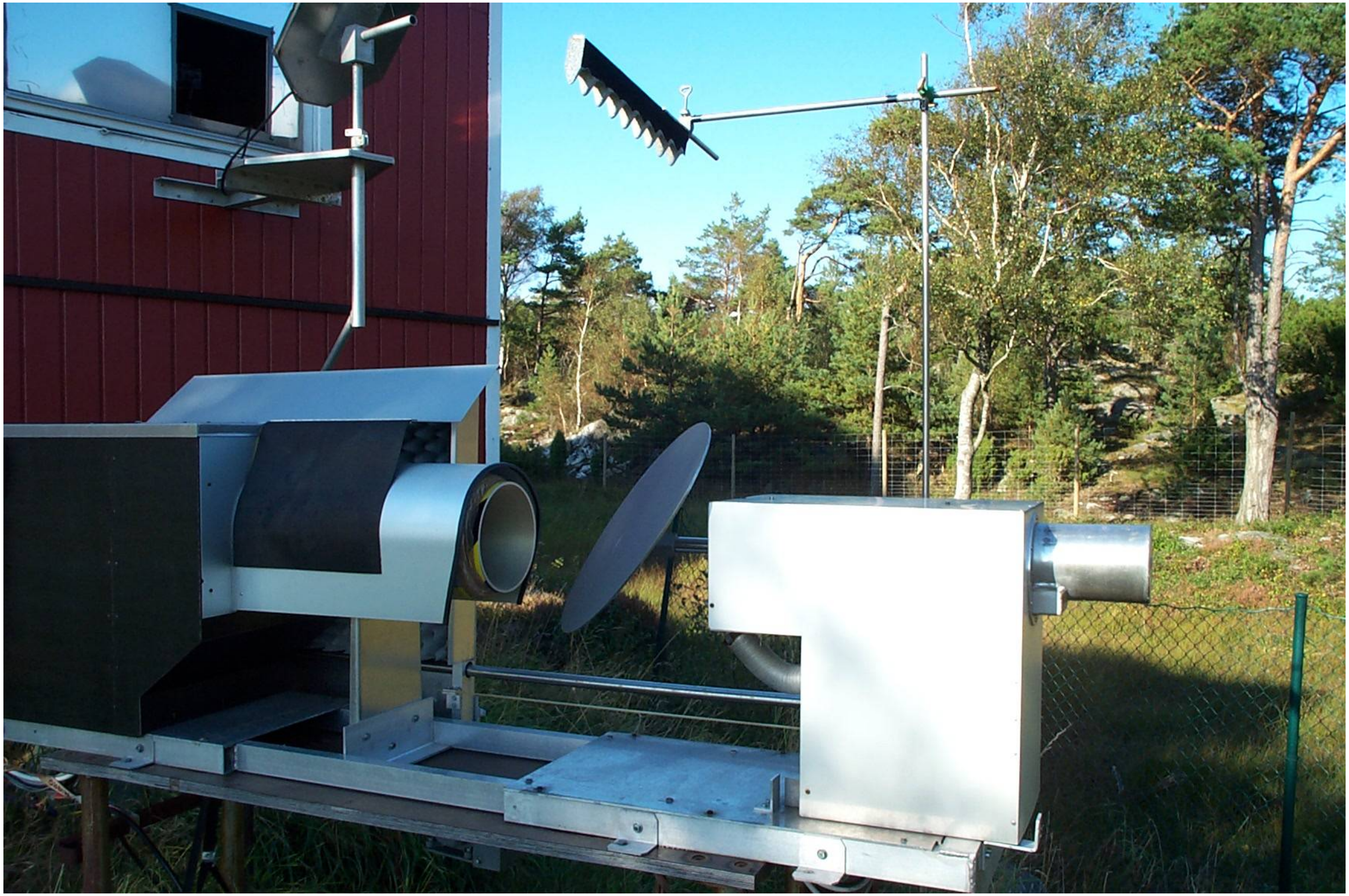


CO receiver



Sig, Ref, Cold load 115.27 GHz
Hot load
20 K
PLL
Gunn osc
harm mix.
*4
*60
osc 2
osc 1
Occ. cold load 77 K
AC
PC

H_2O at 22.2 GHz



T_{cold} can be estimated assuming constant T_{rec}

$$A = \frac{P_{cold}}{P_{hot} - P_{cold}} = \frac{T_{rec} + T_{cold}}{T_{hot} - T_{cold}}$$

$$T_{cold} = \frac{A \cdot T_{hot} - T_{rec}}{A + 1}$$

$$\frac{dT_{cold}}{dT_{rec}} = -\frac{1}{A+1} = -\frac{T_{hot} - T_{cold}}{T_{hot} + T_{rec}}$$

$$\frac{dT_{cold}}{dT_{rec}}(CO) \approx -\frac{280 - 130}{280 + 325} = -0.25$$

$$\frac{dT_{cold}}{dT_{rec}}(H_2O) \approx -\frac{280 - 30}{280 + 250} = -0.50$$

Sky as cold load

$$T_b(\nu) = T_{bg} e^{-\tau} + T_{eff} \left(1 - e^{-\tau}\right)$$

$$e^{-\tau} = \frac{T_{eff} - T_b}{T_{eff} - T_{bg}}$$

$$\Delta T_b\left(z_T\right) = \frac{\Delta P}{P_{hot} - P_{cold}} \left(T_{hot} - T_{cold}\right) \cdot e^{\tau}$$

$$\Delta T_b\left(z_T\right) = \frac{\Delta P}{P_{hot} - P_{cold}} \left(T_{hot} - T_{cold}\right) \frac{T_{eff} - T_{bg}}{T_{eff} - T_{cold}}$$

$$\left(\Delta T_b\left(z_T\right) = \frac{\Delta P}{P_{hot} - P_{cold}} T_{amb} \quad \left(if \;\; T_{eff} = T_{amb} \right) \right)$$

T_{eff} is estimated from radiosonde data

Traditionally $T_{eff} = 0.95T_{ground}$

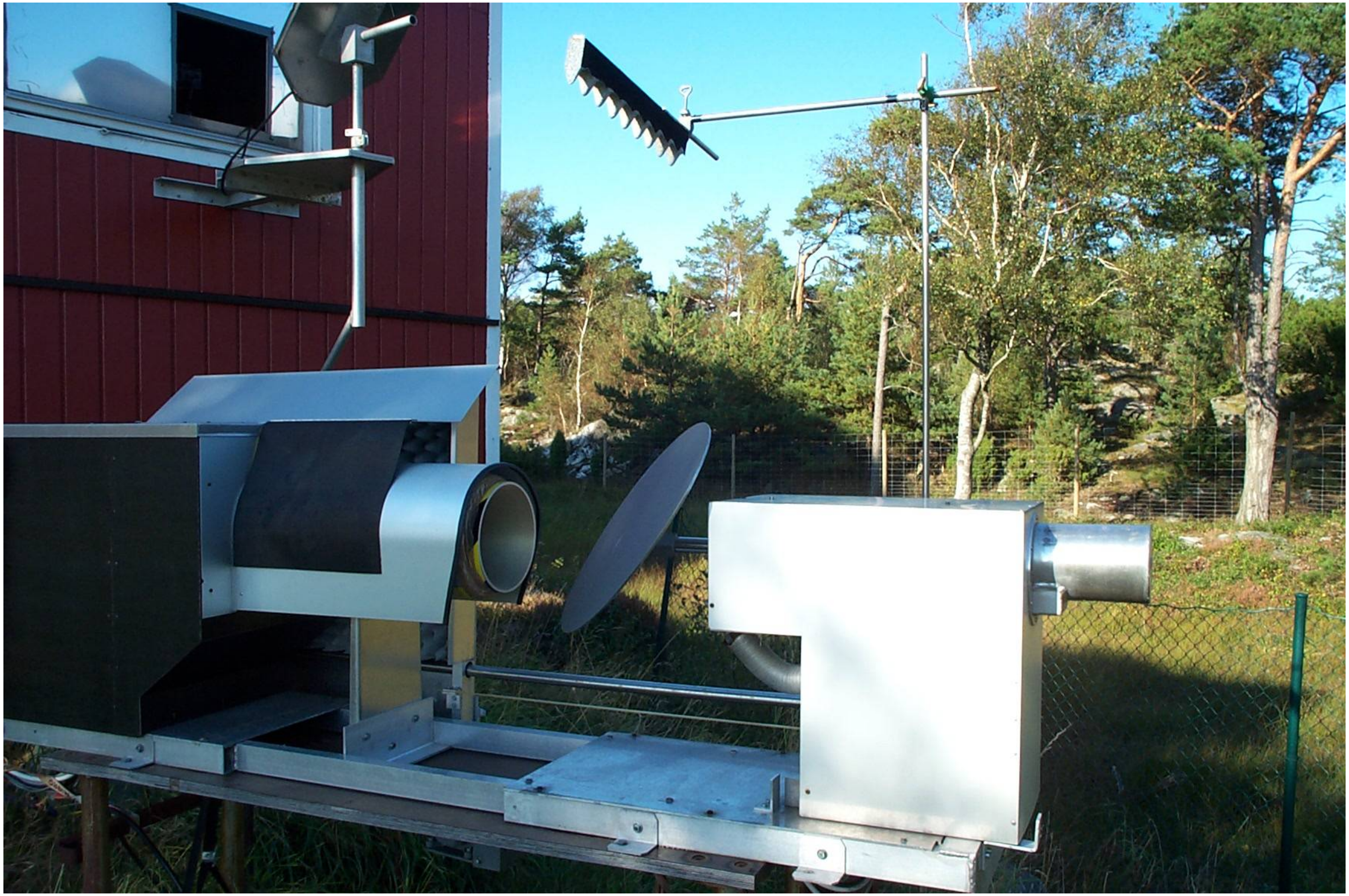
$$T_{eff}(\nu) = \alpha T_{ground} + \beta T_b(\nu, 90°)$$

$$\alpha(H_2O) = 0.95, \beta(H_2O) = 0.05$$

$$\alpha(CO) = 0.90, \beta(CO) = 0.10$$

$$\sigma(T_{eff}) < 5K$$

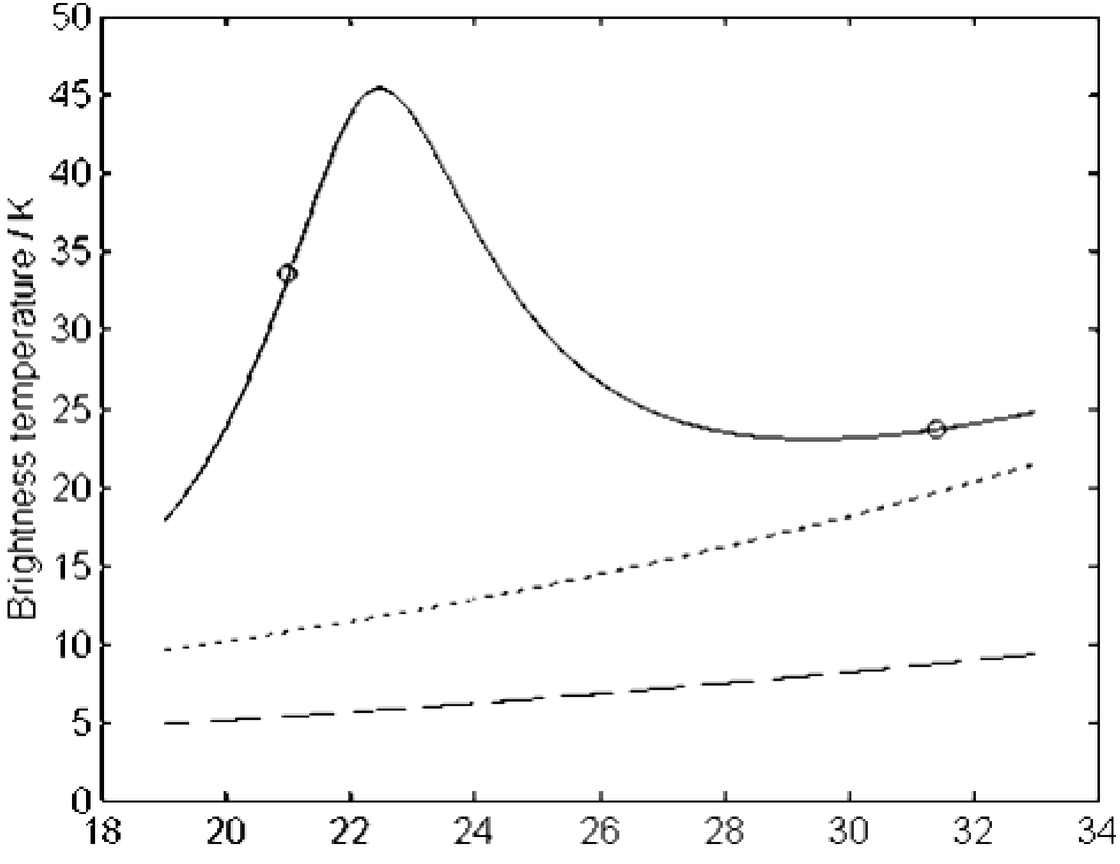
H_2O at 22.2 GHz



21/31.4 GHz radiometer

$$T_b\,(22.2\text{ GHz},\,90°) = f_1\left[T_b\left(21\text{ GHz},\,90°\right),T_b\left(31\text{ GHz},\,90°\right)\right]$$

Syntetic spectra 18-34 GHz



Stand alone calibration using skydip method

$$\Delta T_b = \frac{\Delta P}{P_{hot} - P_{cold}} \left(T_{hot} - T_{cold} \right)$$

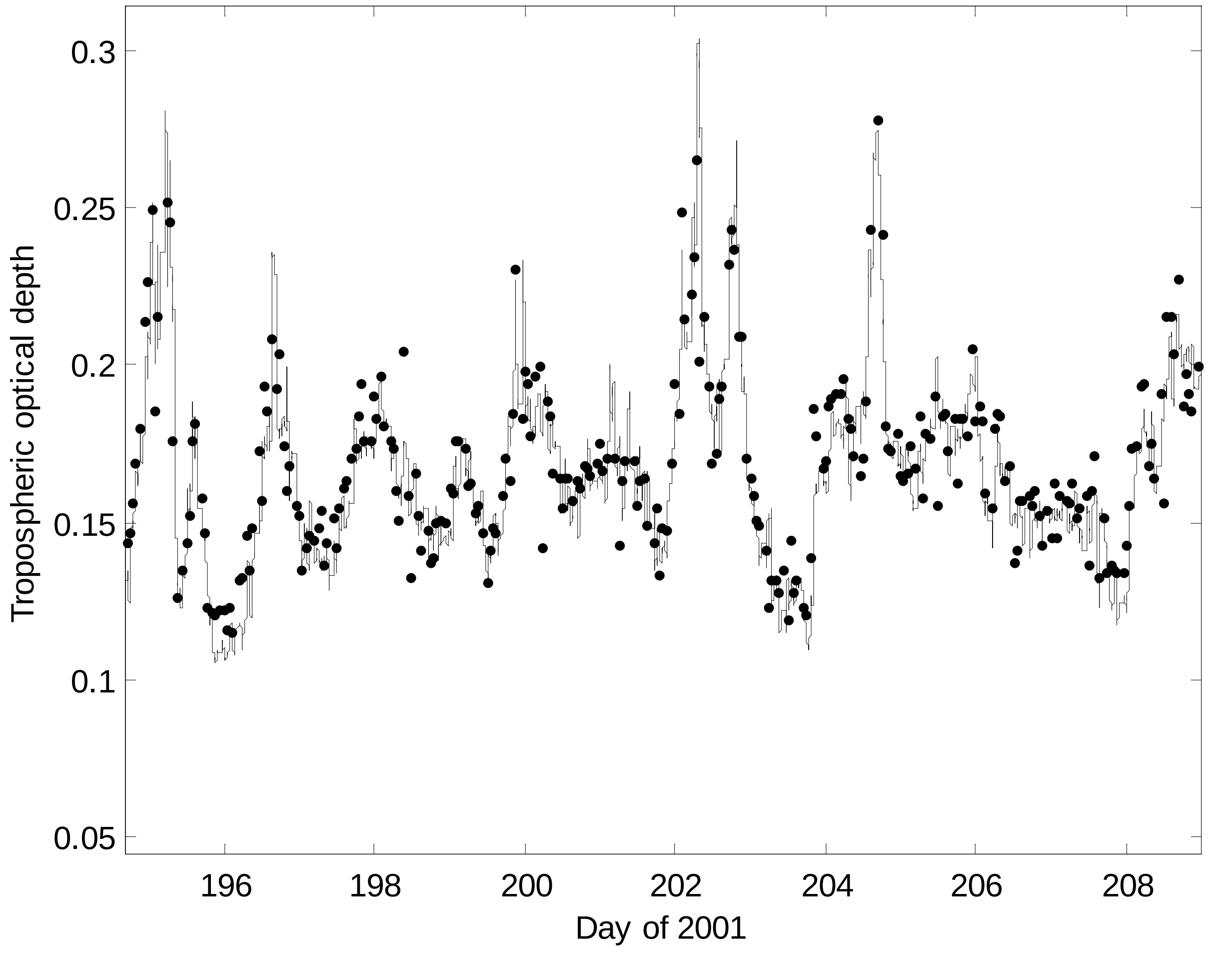
$$T_b(\nu) = T_{bg} e^{-\tau} + T_{eff} \left(1 - e^{-\tau} \right)$$

$$\Delta T_b = T_b(\nu, l) - T_b(\nu, h) = \left(T_{eff} - T_{bg} \right) \left(e^{-\tau/\sin(h)} - e^{-\tau/\sin(l)} \right)$$

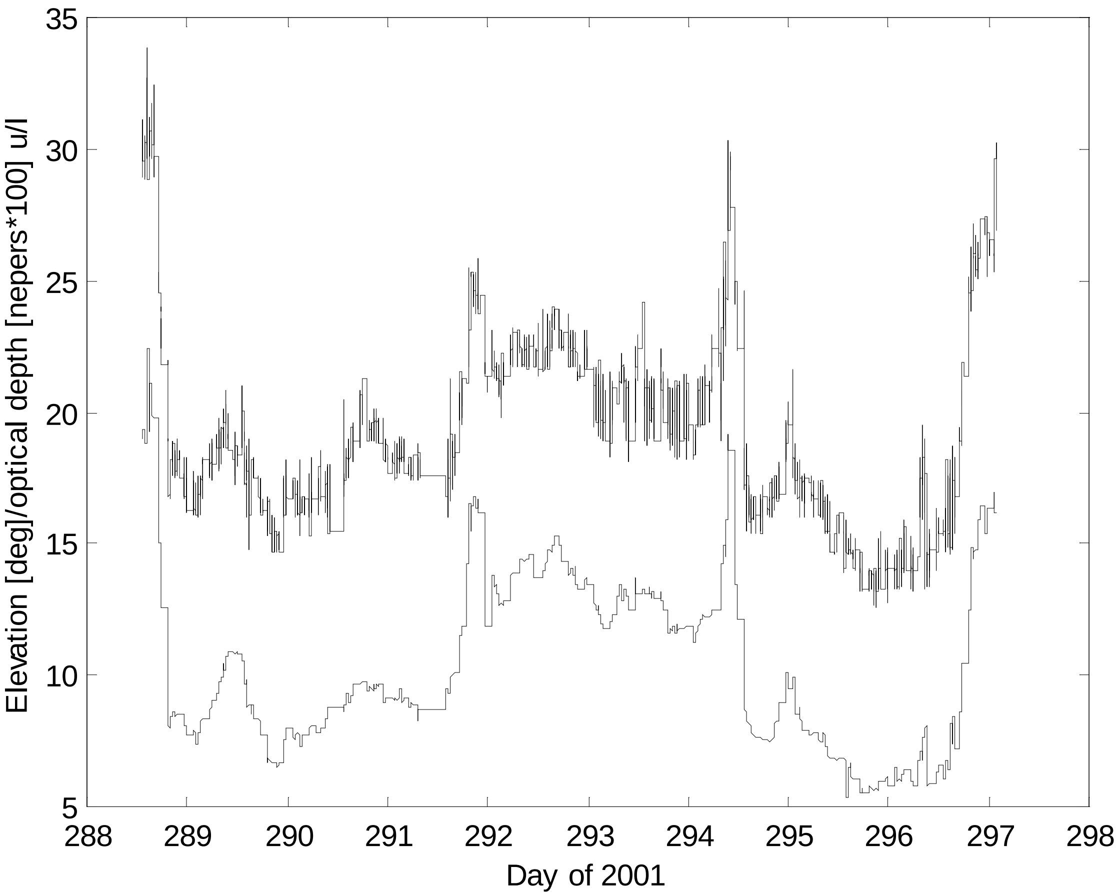
$$\Delta T_b = \frac{\Delta P}{P_{hot} - P_{cold}} \left(T_{hot} - \left(T_{bg} e^{-\tau/\sin(h)} + T_{eff} \left(1 - e^{-\tau/\sin(h)} \right) \right) \right)$$

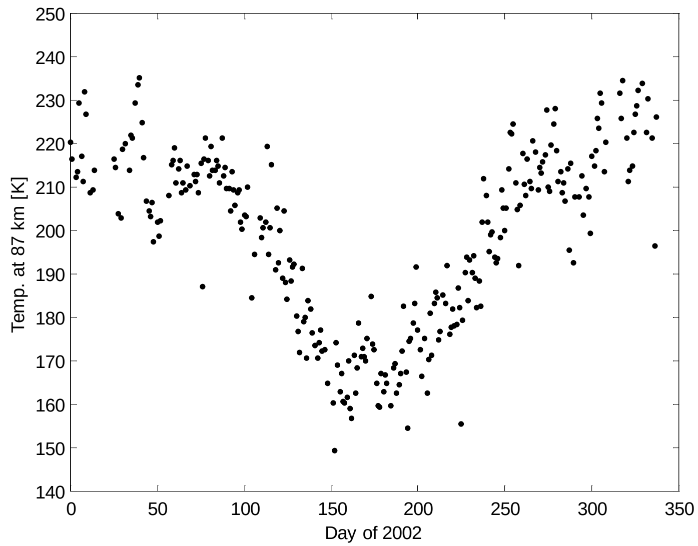
τ can be calculated

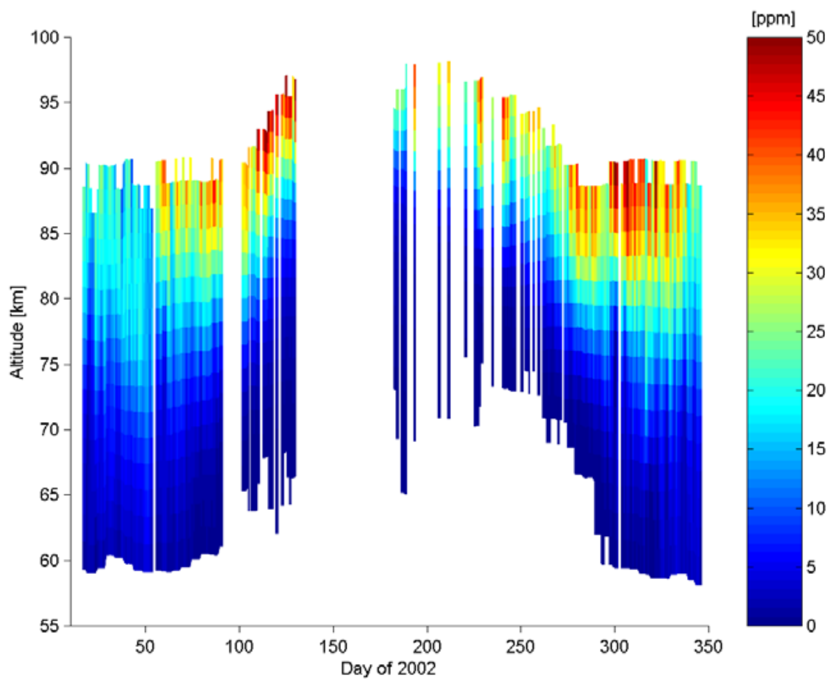
Optical depth from skydip and dual channel radiometer

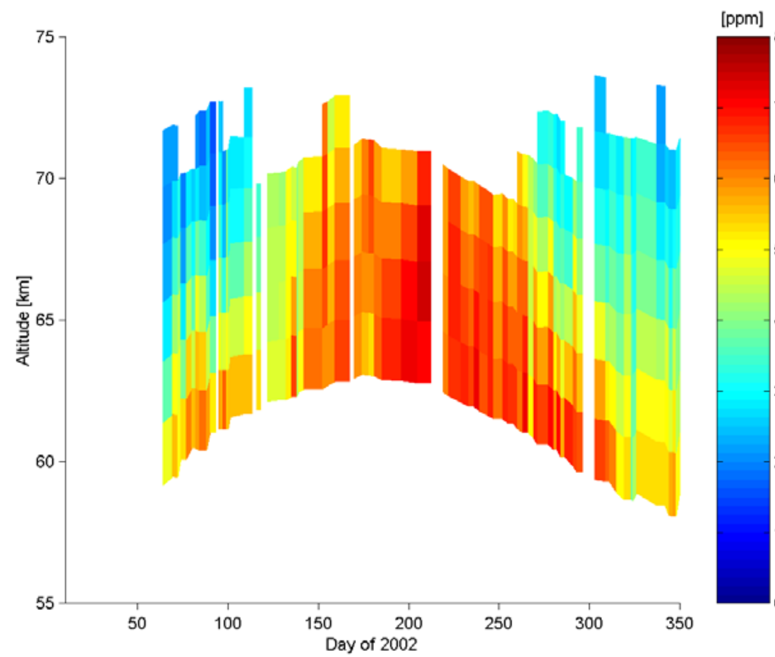


Elevation and tropospheric opacity change at 22 GHz




Temp. at 87 km [K]
250
240
230
220
210
200
190
180
170
160
150
140
0
50
100
150
200
250
300
350
Day of 2002


Altitude [km]
100
95
90
85
80
75
70
65
60
55
50
100
150
200
250
300
350
Day of 2002
[ppm]
50
45
40
35
30
25
20
15
10
5
0


Altitude [km]
75
70
65
60
55
50
100
150
200
250
300
350
Day of 2002
[ppm]
8
7
6
5
4
3
2
1
0

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Peter Forkman
forkman@oso.chalmers.se