Forschungszentrum Karlsruhe
Technik und Umwelt

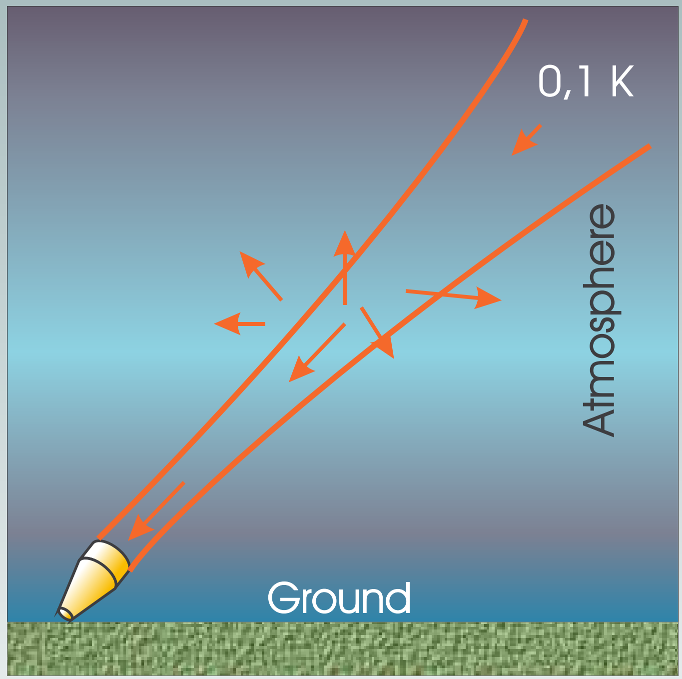
The Potential of Ground Based Millimeter Wave Solar Occultation Measurements

Outline

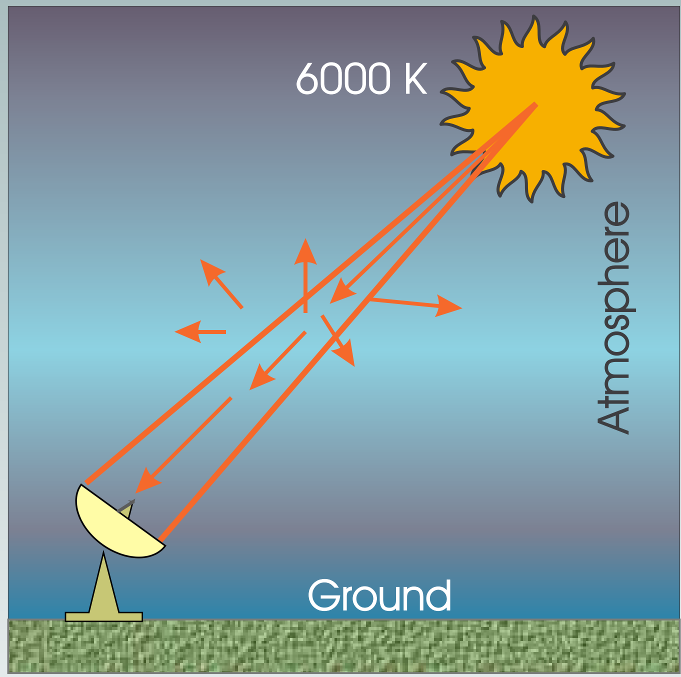
- Introduction
- Signature contrast, relative signature contrast
- Comparison of emsission and absorption measurements by model calculations
- Conclusions, known problems

Measurements in Emisssion and Absorption Geometry

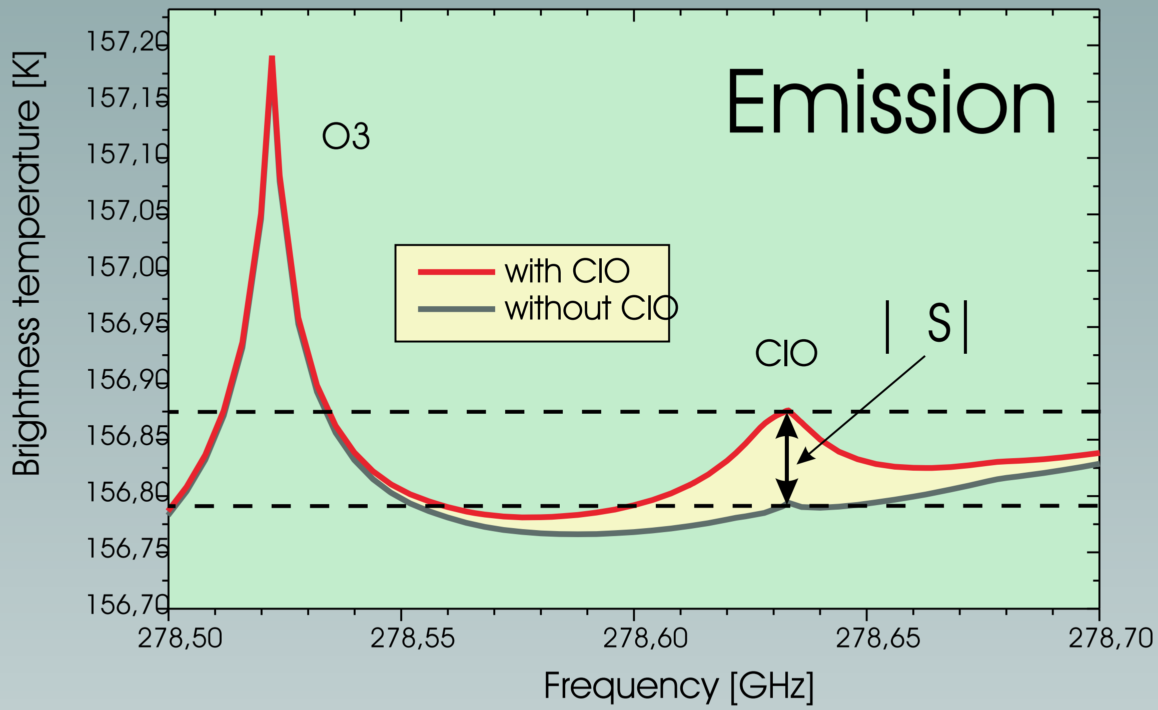
Emission Geometry

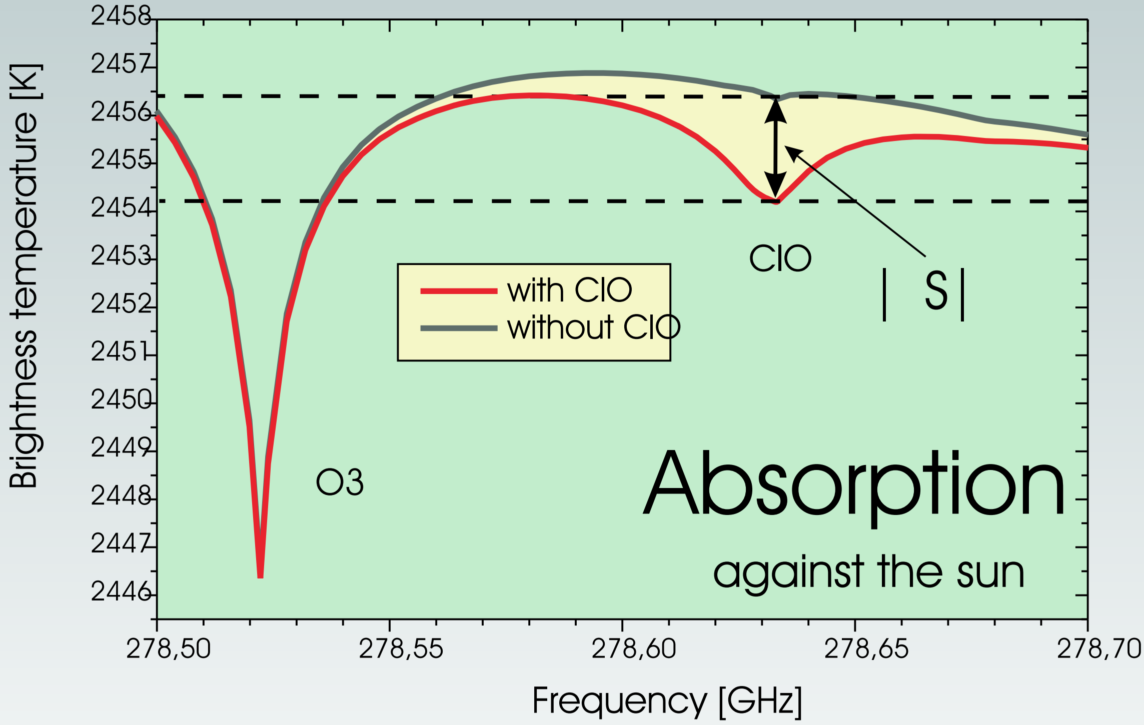


Absorption Geometry



Definition of the Signature Contrast





The Signature Contrast

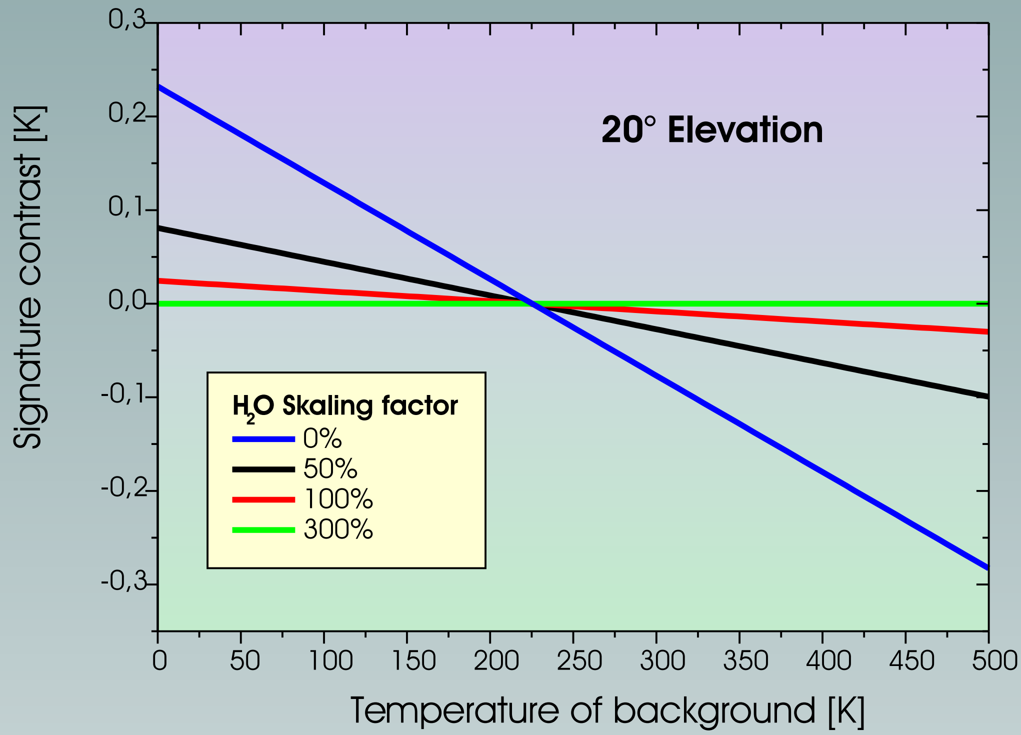
$$\delta S := T_b^{with}(\nu_{center}) - T_b^{without}(\nu_{center})$$

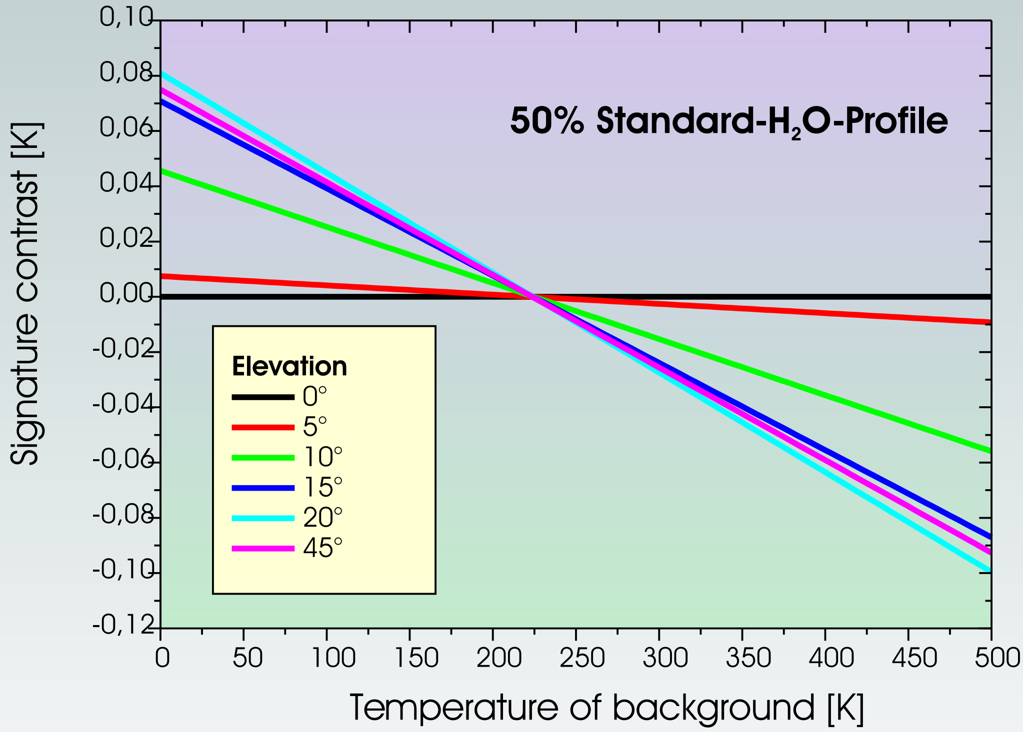
Use radiative transfer equation:

$$\Rightarrow \quad \delta S = \underbrace{T_{b\infty}(\nu_{center})\left(e^{-\tau_{\nu_{center}}^{with}(h_\infty)} - e^{-\tau_{\nu_{center}}^{without}(h_\infty)}\right)}_{T_{abs}^*} + \underbrace{T_{emiss}^{with} - T_{emiss}^{without}}_{T_{emi}^*}$$

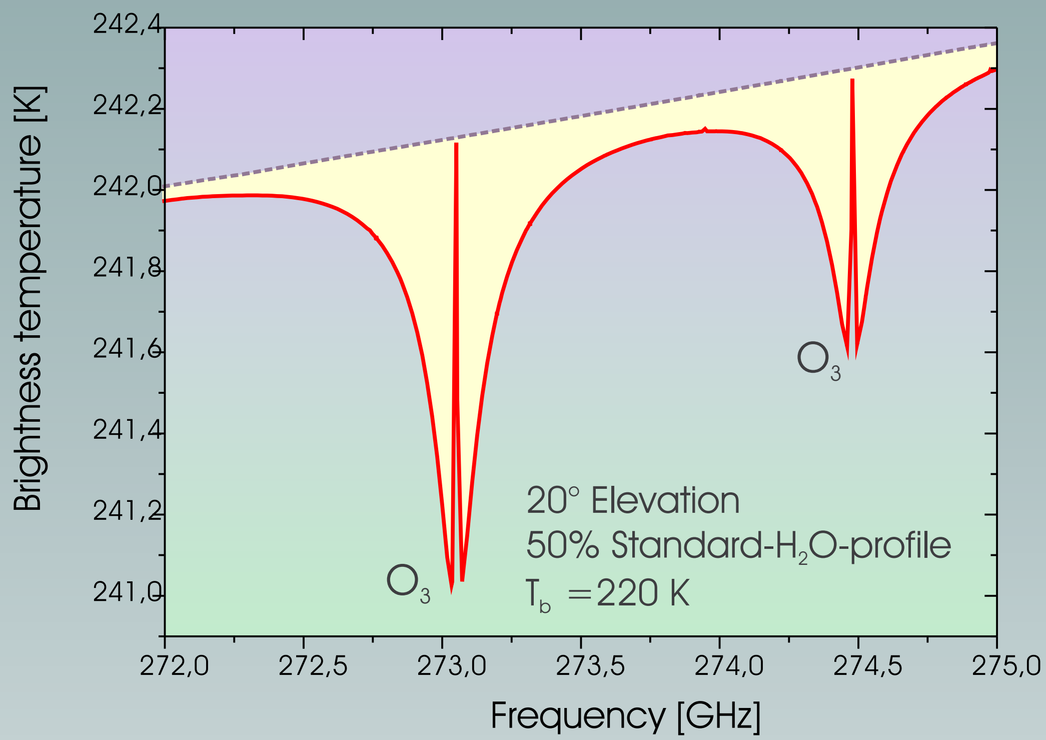
Linear dependence between δS and $T_{b\infty}(\nu_{center})$

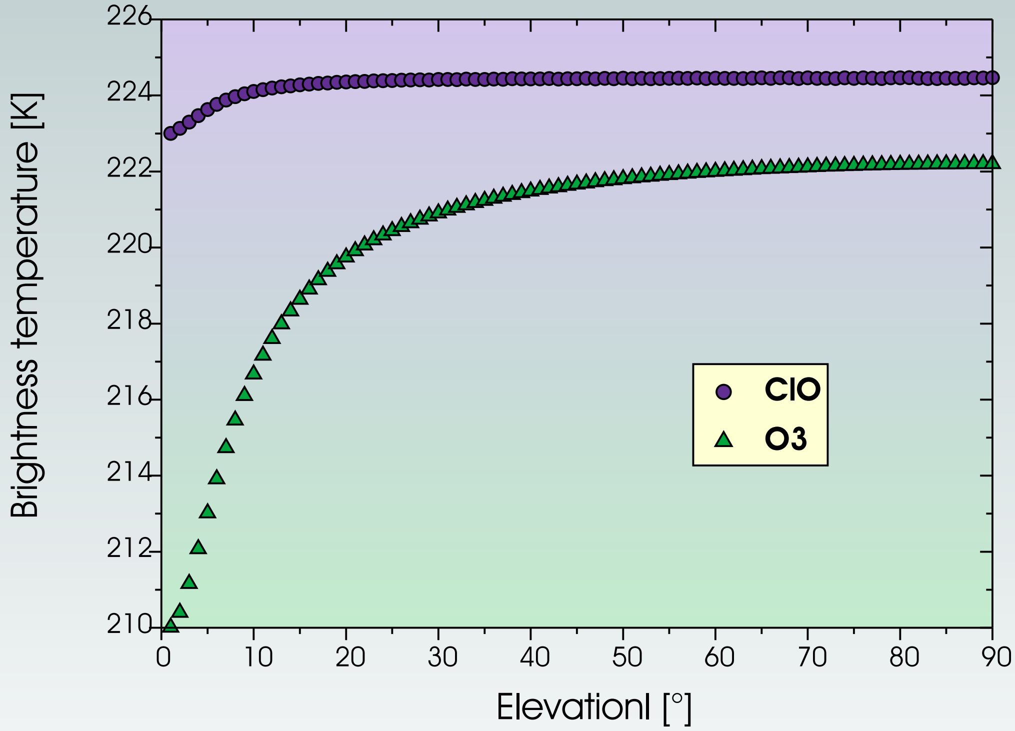
Signature Contrast of ClO



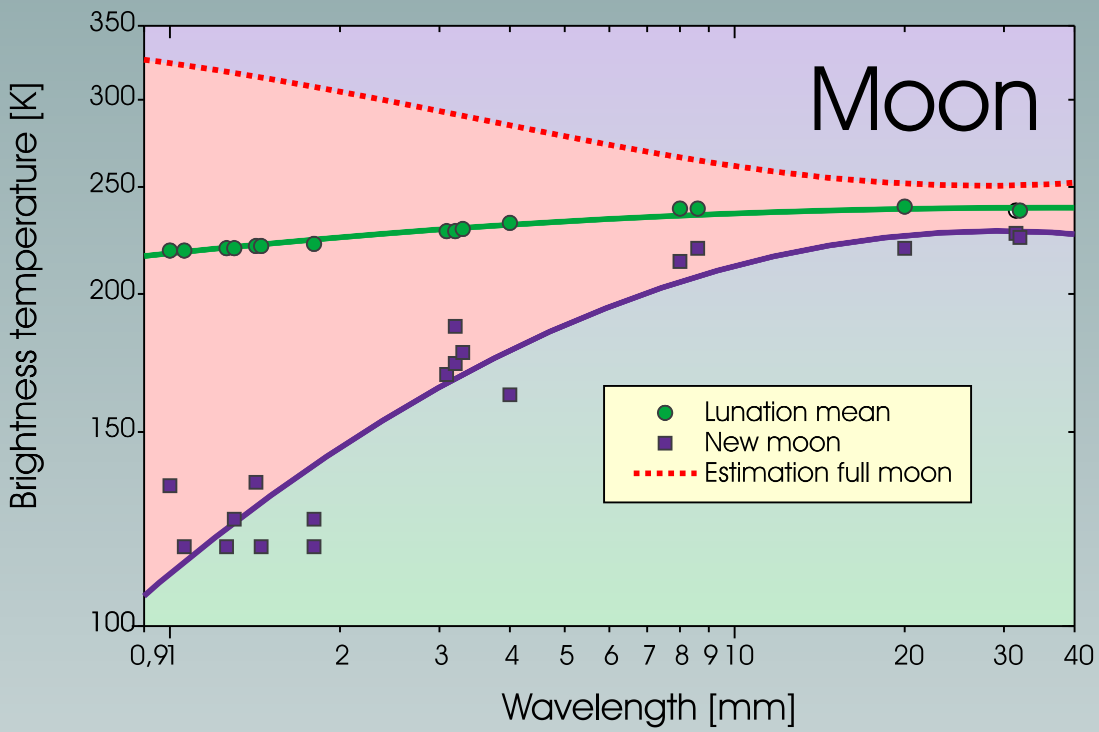


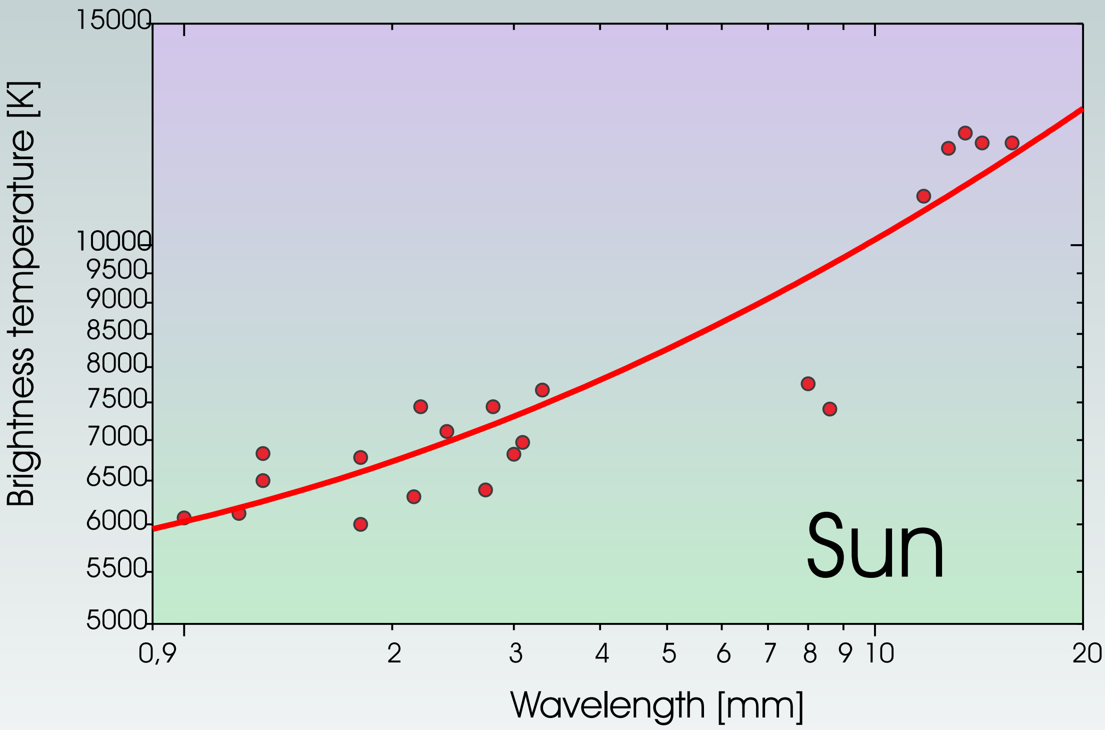
Absorption Cancels Emission





Brightness Temperature of the Sun and the Moon





Measurements taken from:
Linsky J. L., *A recalibration of the quiet sun millimeter spectrum based on the moon as an absolute radiometric standard*, Solar Physics 28, 1973

Relative Signature Contrast

$$\sum := \frac{|\delta S|}{T_{sys}} = \frac{|\delta S|}{T_{ant} + T_{rec}}$$

$$\Delta T = \frac{T_{sys}}{\sqrt{B\,\tau_{int}}}$$ Radiometric resolution

$$\frac{|\delta S|}{\Delta T} = \sum \cdot \sqrt{B\,\tau_{int}}$$

δS	Signature contrast
T_{sys}	System noise temperature
T_{ant}	Antenna temperature
T_{rec}	Receiver noise temperature
ΔT	Radiometric resolution
B	Bandwidth
τ_{int}	Integration time

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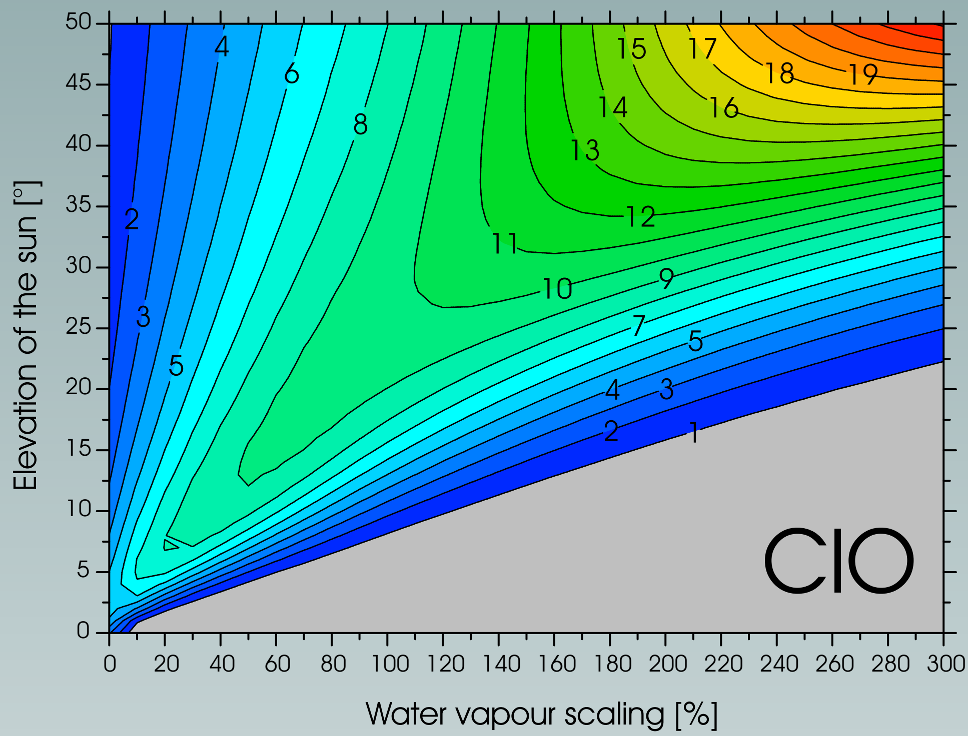
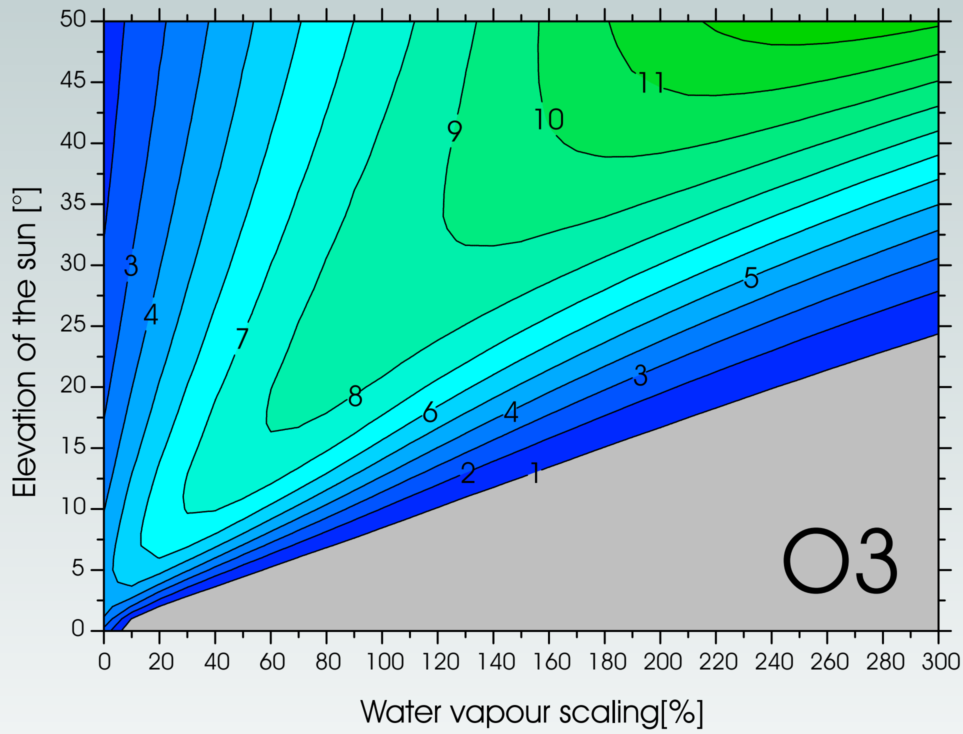
Superiority of Absorption Measurements over Emission Measurements





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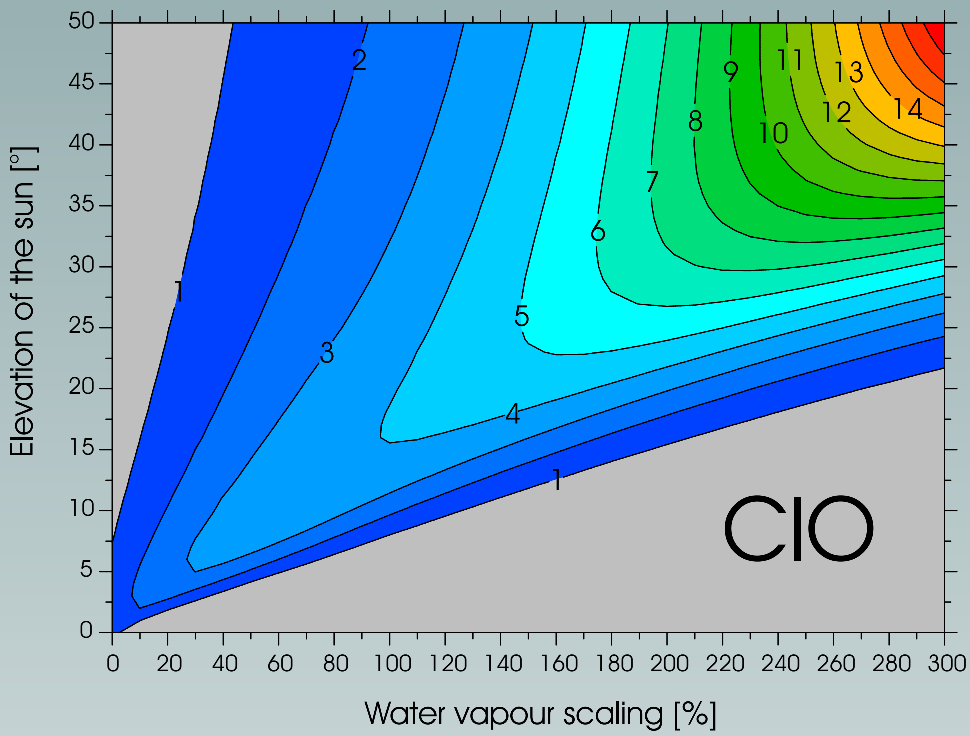
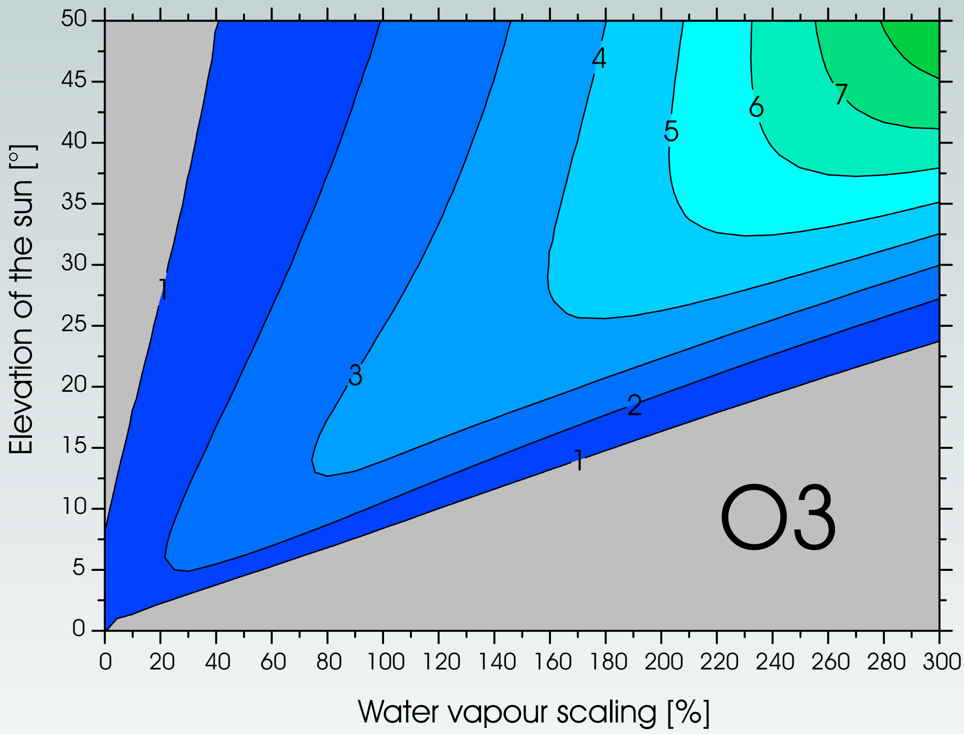
Superiority of Balanced Absorption Measurements over Emission Measurements

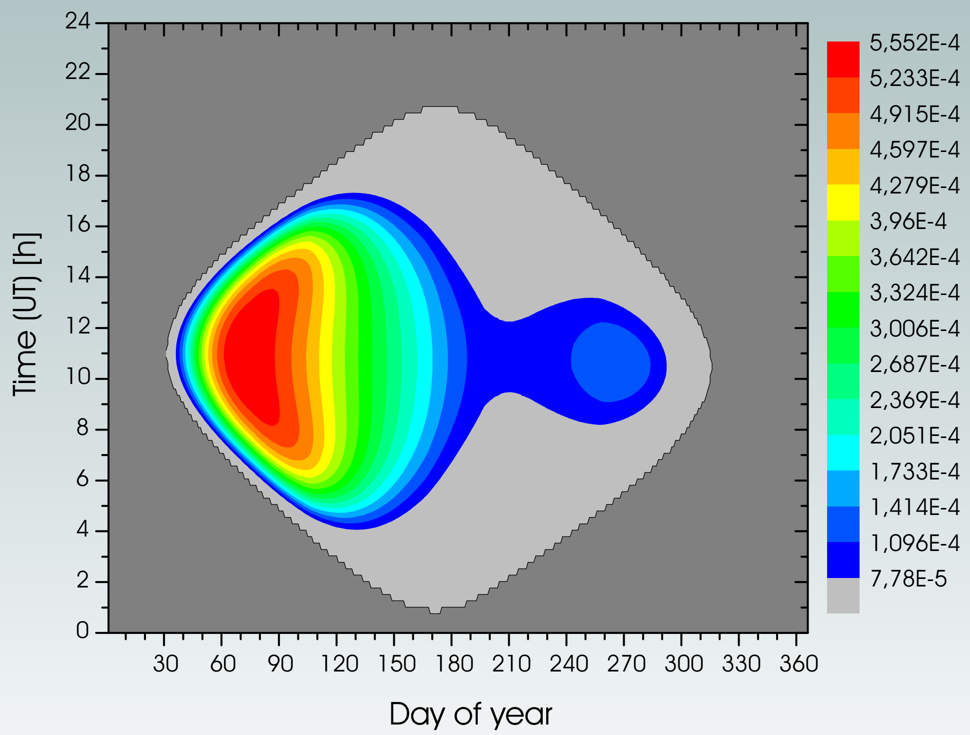




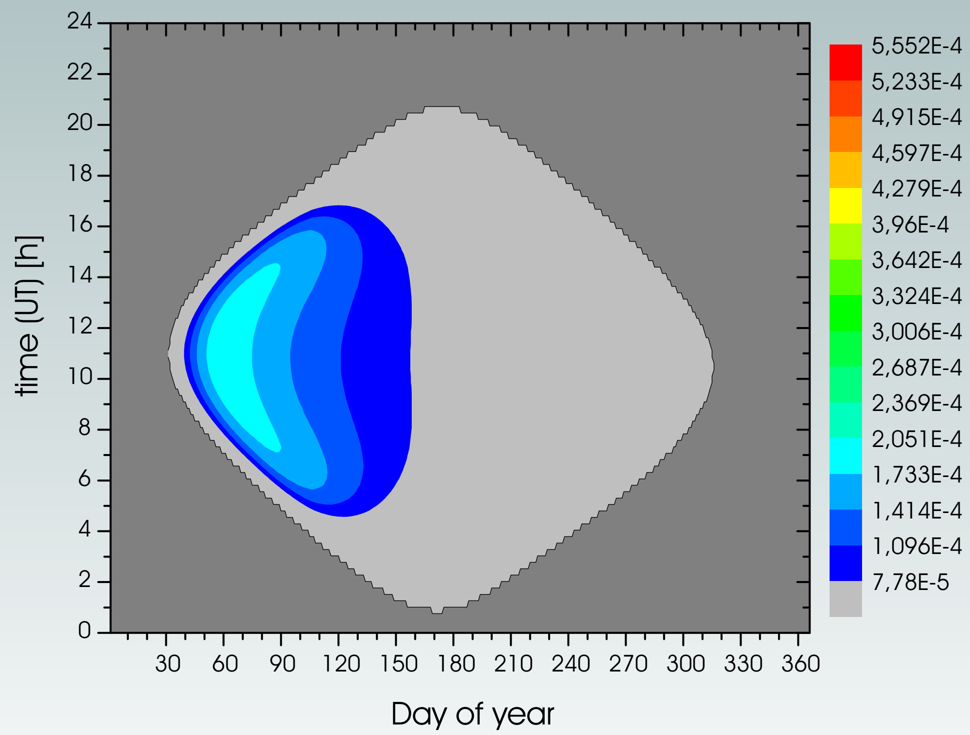
Loss in Signature Contrast due to the Damping Element needed for Balanced

Model calculations for ClO over Kiruna using standard profiles

Ideal radiometer

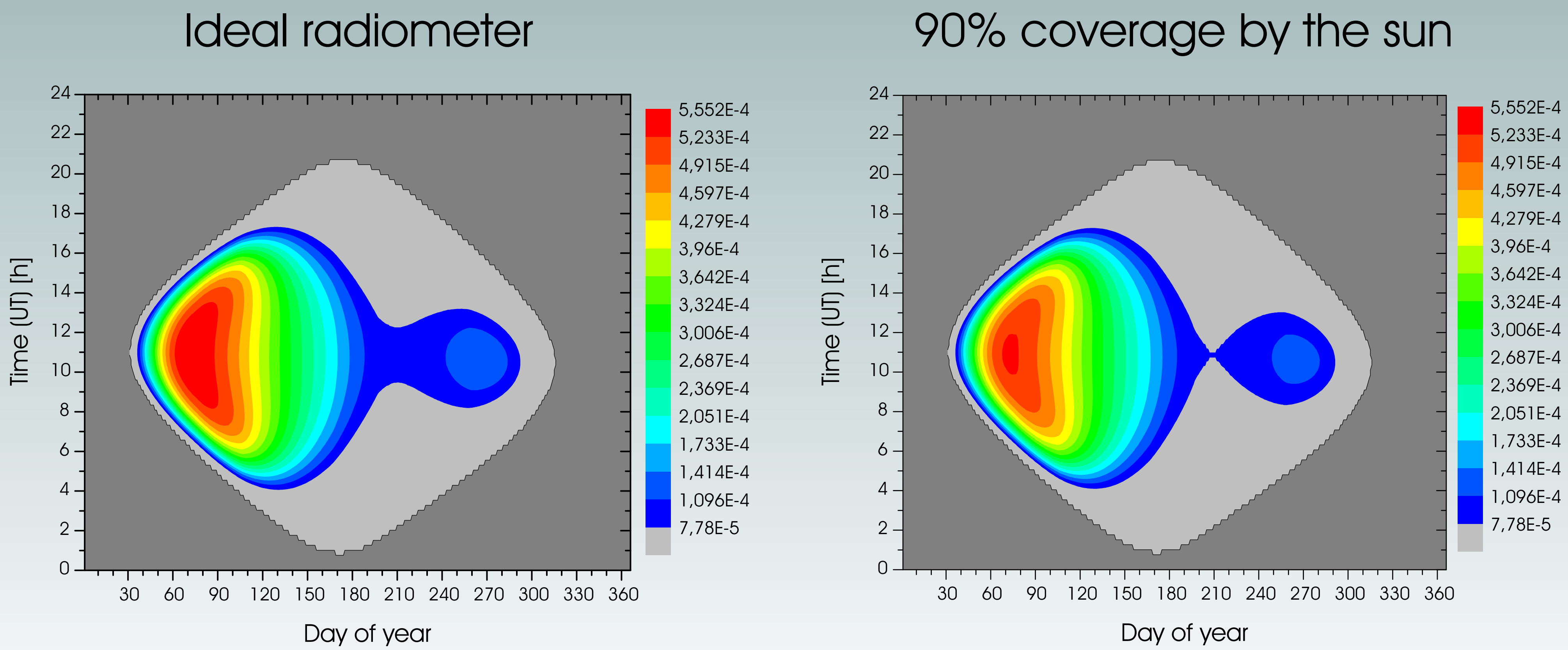


Balanced calibration



Influence of the Antenna Beam Width

Model calculations for ClO over Kiruna using standard profiles



Conclusions

- Superiority of absorption measurements over emission measurements only if $T_{back} > 450$ K
- Absorption spectra measured against the sun using an ideal radiometer are always superior to emission measurements if elevation > 20°
- For balanced calibration the radiation has to be damped which increases the receiver noise temperature, but absorption measurements are nevertheless superior to emission measurements, especially in arctic spring

Problems

- Need of a large antenna to get a sufficient narrow beam. Furthermore an adjustable azimuth and elevation, a sun tracker and a good pointing is needed
- Knowledge of the beam characteristics which determines the background radiation needed for forward calculations
- Solar brightness temperature is not constant (solar flares)
- Additional baseline problems due to the damping element?