Influence of the optically-active turbulence on astronomical seeing at Concordia station - Dome C, Antarctica

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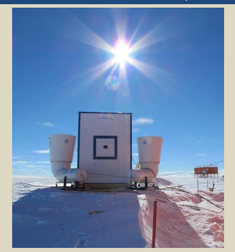
The study of the distorting action due to the atmospheric turbulence is important to understand the reason of the astronomical seeing variability, and to propose reliable methods to estimate the seeing quality. The influence of the atmospheric surface layer thermal turbulence on distortion of astronomical images was investigated at Concordia astronomical observatory, Dome C during winter 2012. An experiment was carried out to determine the behaviour and the contribution of the optically-active atmospheric turbulence in the lowest tens meters.
The surface layer in the interior of Antarctica during winter is extremely stably stratified with the difference of temperature between the surface and the top of the inversion reaching 20-35 C. In spite of such strong static stability, the considerable thermal optically–active turbulence occurs sometimes and extends up to several tens of metres.

INSTRUMENTATION

SLM SODAR – special surface layer high-resolution sodar measures vertical profiles of the strength of thermal turbulence from ~ 2 m with a step of ~ 1 m



The intensity of thermal turbulence measured with a sodar is characterized by the ***temperature structure parameter*** C_T^2.
The intensity of optically-active turbulence is described by the ***refraction index structure parameter*** C_n^2.
These parameters are connected directly

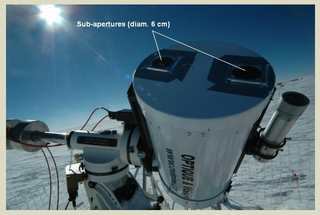
$$C_n^2(h) = B(p, T)\, C_T^2(h).$$

The coefficient $B(p, T) = (79.2 \cdot 10^{-6}\, pT^{-2})^2$, where p is the air pressure in mb, T is the absolute temperature in K.
The ***turbulent optical factor*** **(TOF)**

$$OF = \int C_n^2(h)dh$$

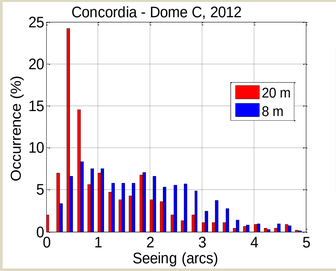
evaluates a degree of degradation of a stellar image by turbulence localized in the layer at altitudes from h_1 to h_2.

DIMM



To measure the seeing the DIMM (**Differential Image Motion Monitor**) is used. The DIMM is a small telescope (a Celestron 11" was used) with a twin-hole mask at its entrance pupil. In our case the holes are 6cm diameter separated by 20 cm. A glass prism is placed on one of the hole, a small deviation (1 arcmin) prism on the other one. At the focus, a fast CCD camera gives twin images, moving according to the turbulence strength. In 2012 two DIMMs were used: at 8 m (see photo) and at 20 m (at the roof of the quit building)

Histograms of the Seeing values measured at heights 8 and 20 m from April to October 2012

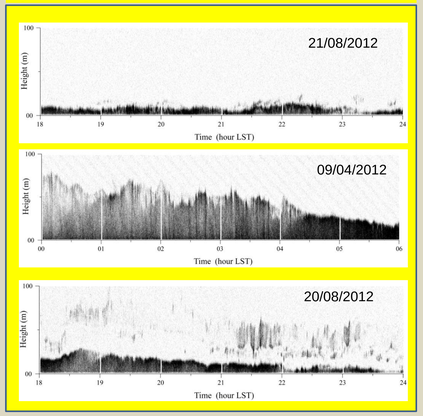


Seeing values averaged over Apr-Oct 2012

DIMM Heigth (m)	Mean (arcs)	Median (arcs)	std (arcs)
8	2.2	2.0	1.4
20	1.5	0.9	1.8

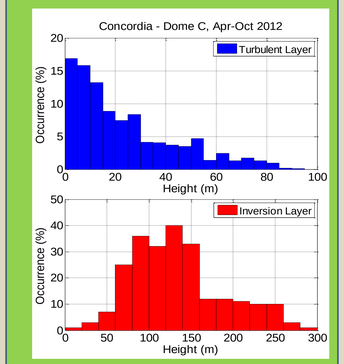
Analysis of sodargrams

Some typical cross-section patterns of the Surface–based Turbulent Layer (STL) depicted by sodargrams



Greyscale intensity is proportional to the strength of thermal optically-active turbulence characterised by the structure refraction index parameter C_n^2

Depth of the Surface Turbulent Layer (from sodar) and Height of the Inversion Layer (from radiosonde)

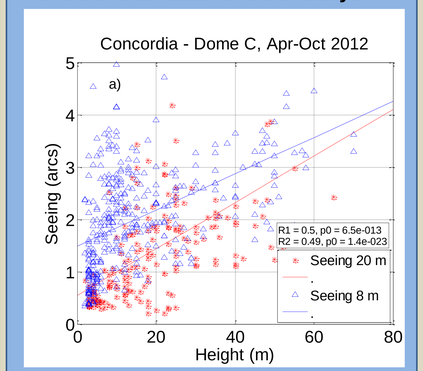


The STL higher than 20 m is observed at 40% of the total time

Depth of the Surface Turbulent Layer and Height of the Inversion Layer averaged over Apr-Oct 2012

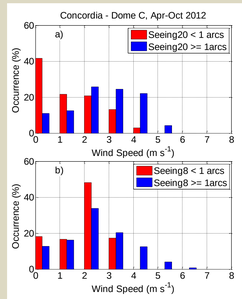
Heigth (m)	Mean (m)	Median (m)	Std (m)
Turbulent Layer	23	16	20
Inversion Layer	133	125	63

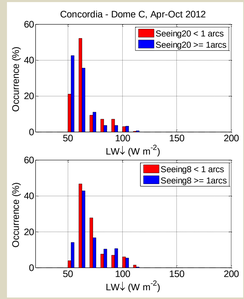
Correlation between Seeing and Depth of the Surface-base Turbulent Layer

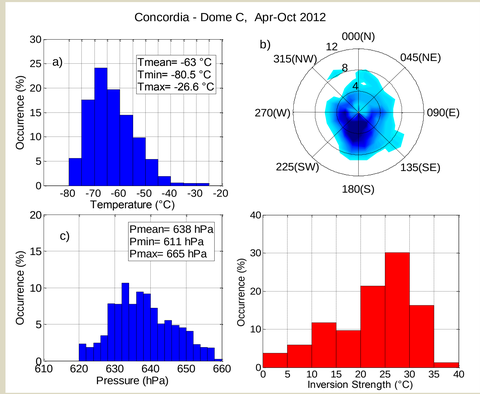


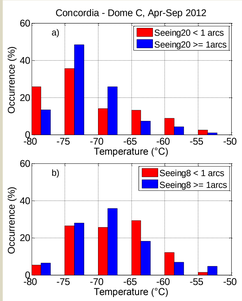
The best image quality (lowest seeing values) are observed for lower heights of the STL.

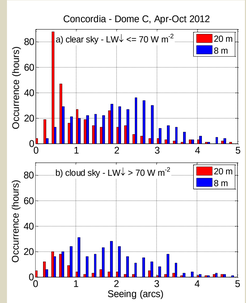
Influence of Meteorological Conditions on Seeing in Winter

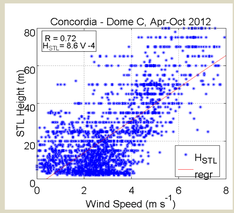




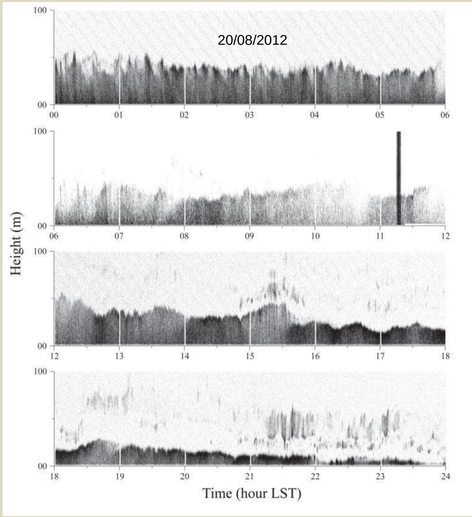




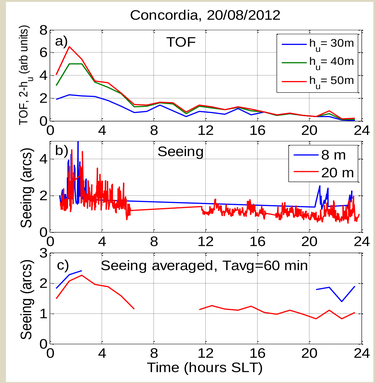




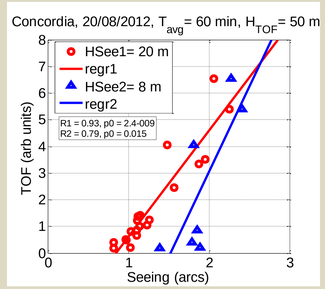
Height of Surface-based Turbulent Layer increases with Wind Speed



Correlation between Seeing from DIMM and Turbulence Strength measured by Sodar



Time series of turbulent optical factor measured by sodar for 3 layes (top panel – 1-hour average TOF) and seeing measured by optical method DIMM at 2 heights (middle panel – 2-min average, bottom panel – 1-hour average)



Correlation between turbulent optical factor values measured by sodar and seeing measured by optical method DIMM at 2 heights

CONCLUSIONS

In spite of the surface layer in the interior of Antarctica during winter is extremely stably stratified with the difference of temperature between the surface and the top of the inversion reaching 20-35 C, the considerable thermal optically–active turbulence occurs sometimes and extends up to several tens of metres. The STL higher than 20 m is observed at 40% of the total time.
A correlation exists between the seeing quality and the intensity of thermal turbulence determined by sodar.
The determination of the statistics of turbulent optical factor (TOF) for different layers within the surface layer for the total period to give recommendations on choosing an optimal height for the installation of the astronomical instrumentation is the subject of the further study.

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