Turbulence optique dans la couche-limite et comparaison avec les mesures in-situ

Boundary-Layer optical turbulence as compared with in-situ measurements

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Basé sur les mesures des estivants et hivernants
Présenté par F.X. Schmider

Astronomy in Antartica

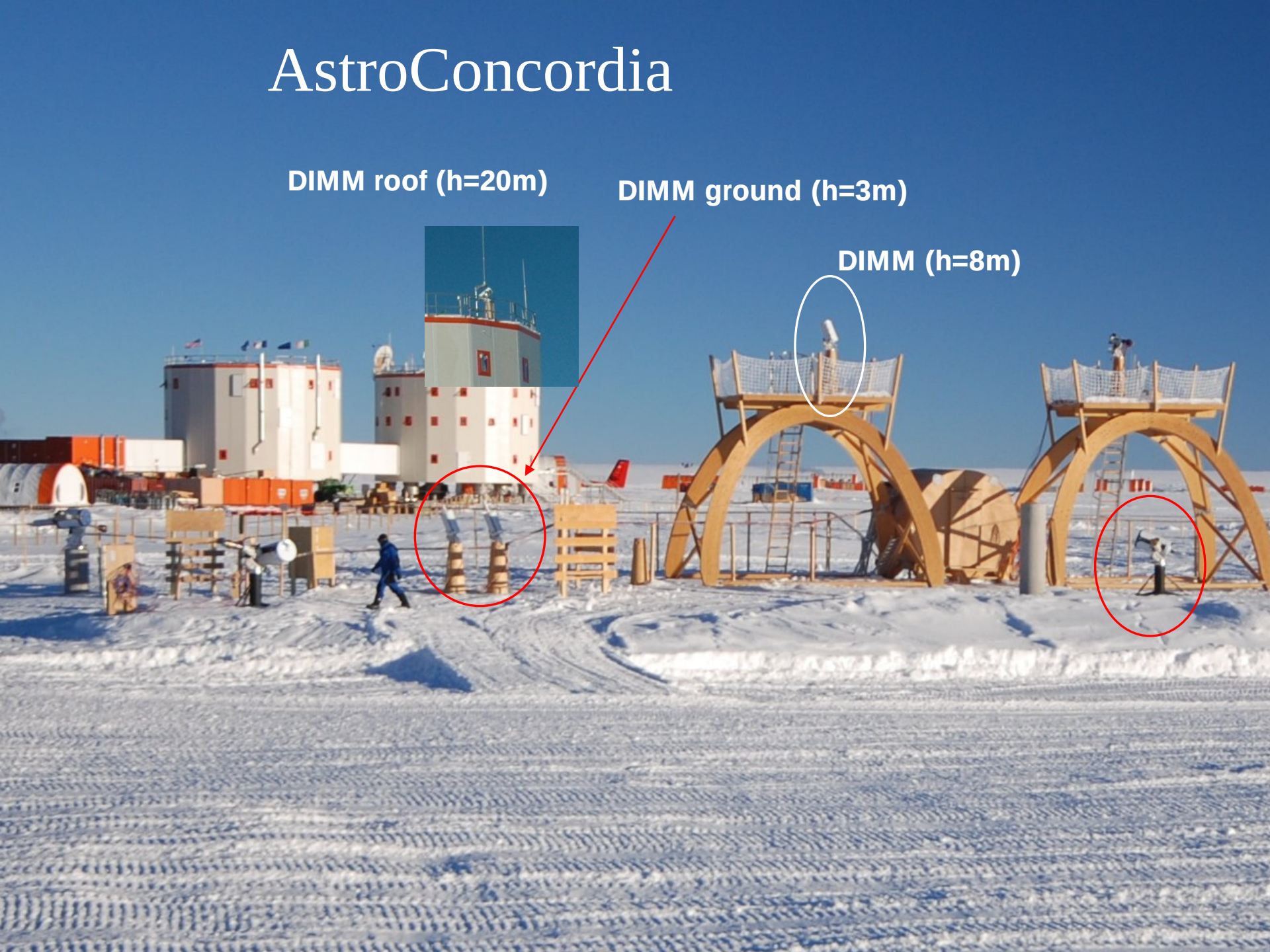
Novembre 1979 at South Pole
Gérard Grec, Eric Fossat
Continuous observations for 5 days:
First measurement of solar oscillations

Astronomy at Dome C

- December 1992
  - Colloquium of the French Académie des Sciences on French Sciences in polar regions
  - first mention of Concordia station as potential site for astronomy
- November 1995
  - Exploration run at Dome C:
  - 4 stratospheric balloons
- December 1999
  - Start of Concordia station buidling
  - CONCORDIASTRO: Pluri-annual programme for site qualification (IPEV)
- December 2004
  - First wintering-over
  - Concordiastro becomes Astroconcordia
  - Officialy finished December 2012

- Cold: <-50°
- Dry
- Integrated water vapor:100-150 μm
- Clear sky > 90 %
- Continuous observations
- Low wind ~ 8 m/s up to 100 m
- Day seeing with no equivalent from earth
- Night seeing could be excellent but…
  - Over the boudary-layer (30 m high)
- Relative humidity > 50% (icing)

AstroConcordia



Balloon-borne microthermals (2005) : first C_n^2 profiles (~35 balloons)

American tower (45m high)

Sonic anemometers
[Microthermals 2005/06]

On-site experiments between 2003 and 2012

DIMM : seeing @8m ; DIMM_ground : seeing @3m; DIMM_roof : seeing @20m

Balloons : Cn^2 / wind speed profile (vert. res. 5m) whole atm.
SSS : Cn^2 / wind speed profile (vert. res. 1km) whole atm.
PBL : Cn^2/w. speed/outer scale profile (vert. res. 100m) whole atm.

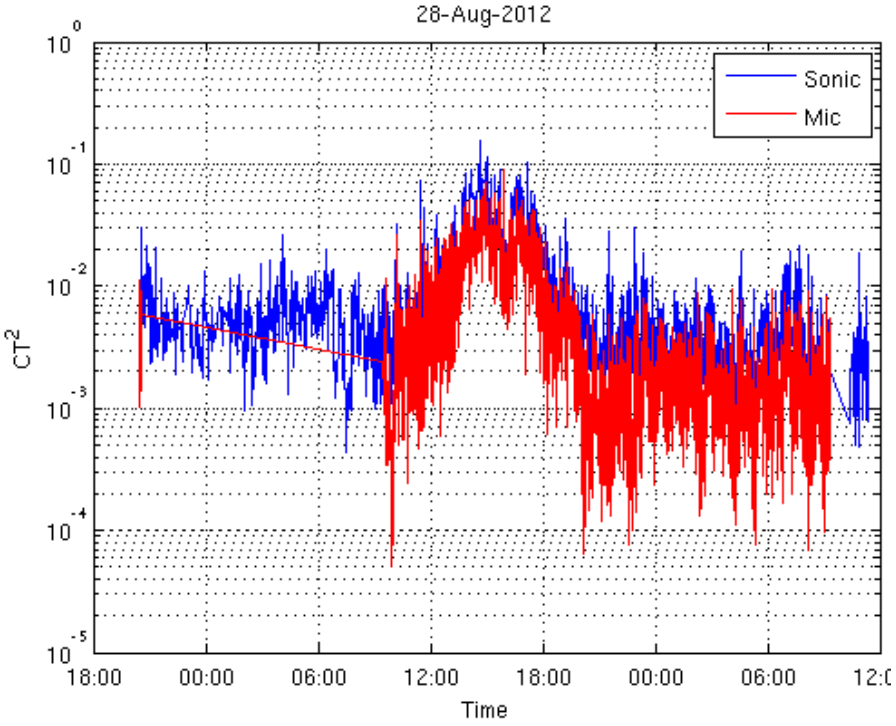
+ integrated params
Seeing, isop. angle,
coh. time

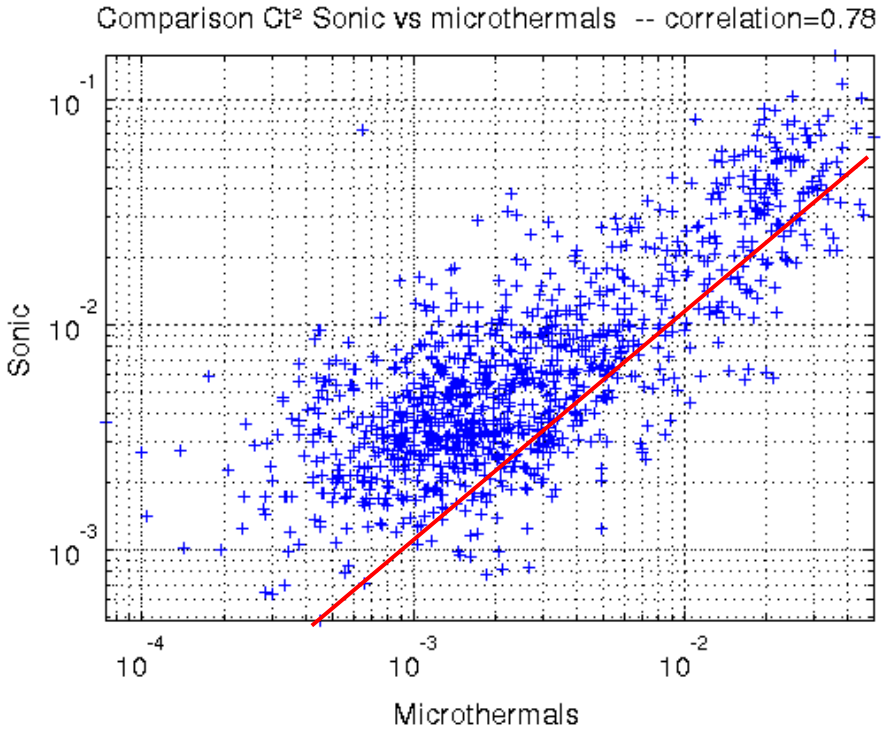
SONIC : local Cn^2/wind speed (6 sonics between 8 and 45m)

Calibration of sonic data (C_T^2) with microthemal pairs

Simultaneous measurements at Nice Observatory in 2012

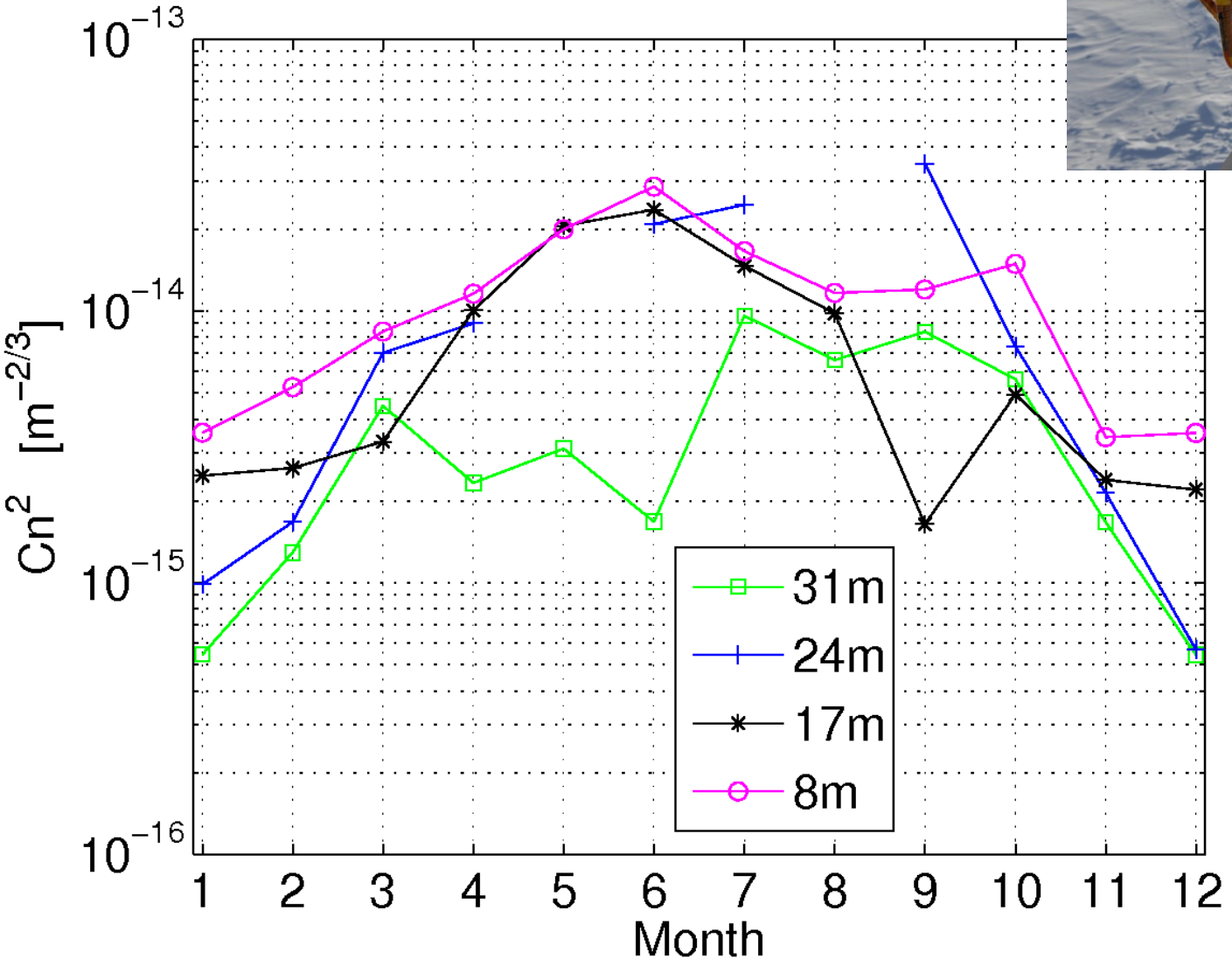
$$C_n^2 = 6.24\,10^{-9}\; C_T^2\, P^2\, T^{-4}$$



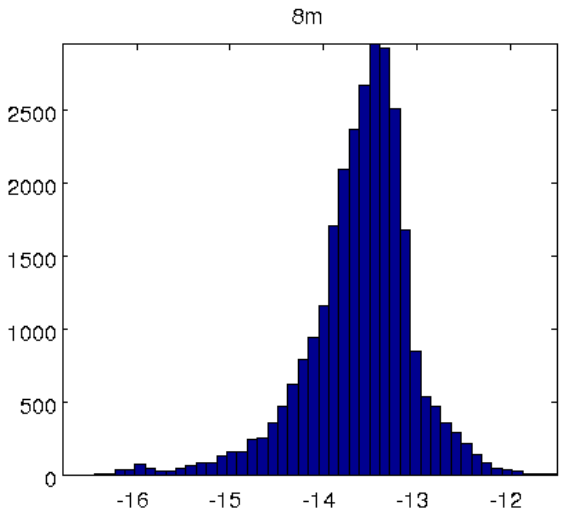


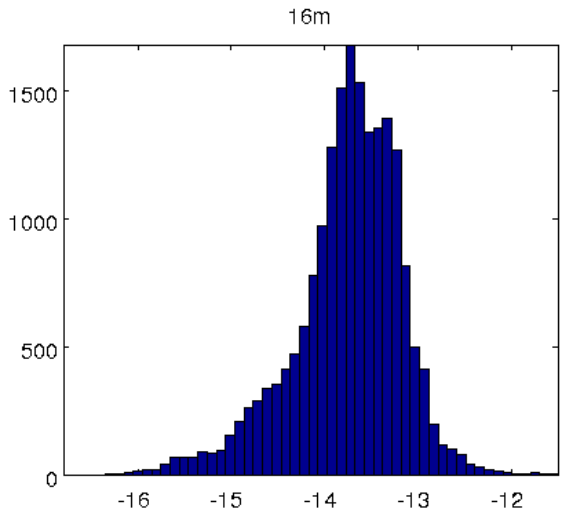
Good agreement between the data, but there is a small bias, still to be investigated !

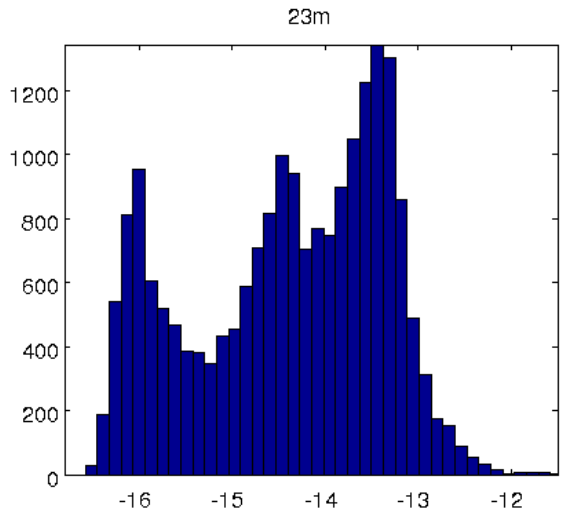
C_n^2 from Sonic anemometers

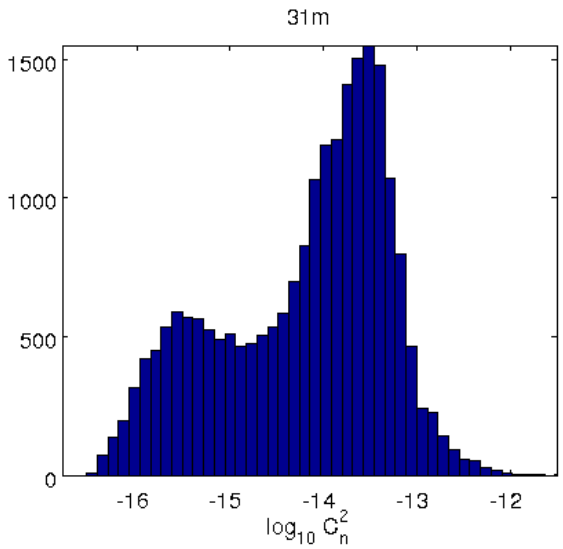


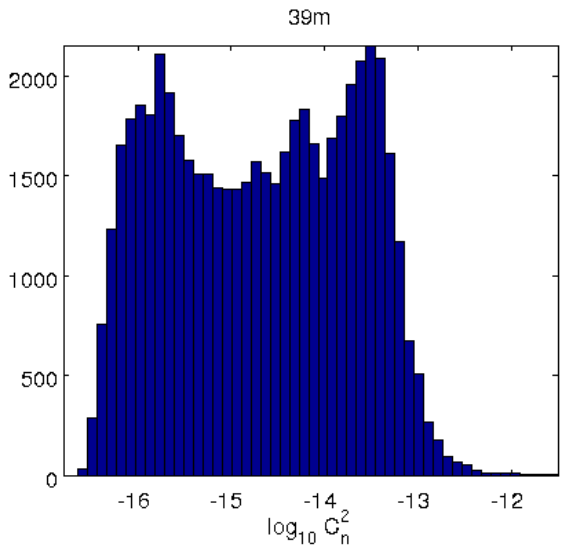
Sonic C_n^2 winter histograms (Apr-Sep, 2008-2011)

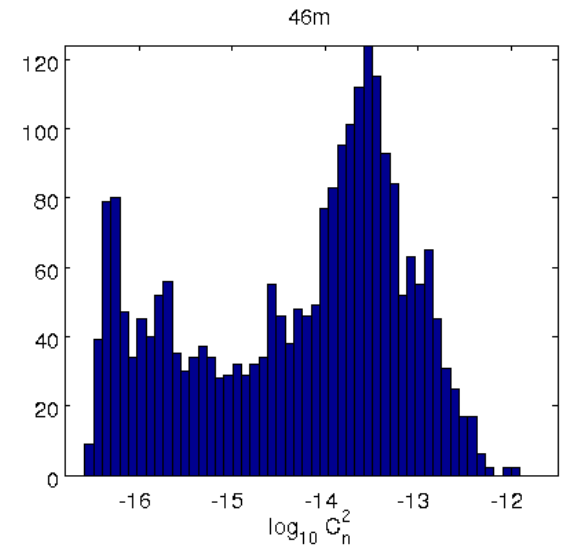




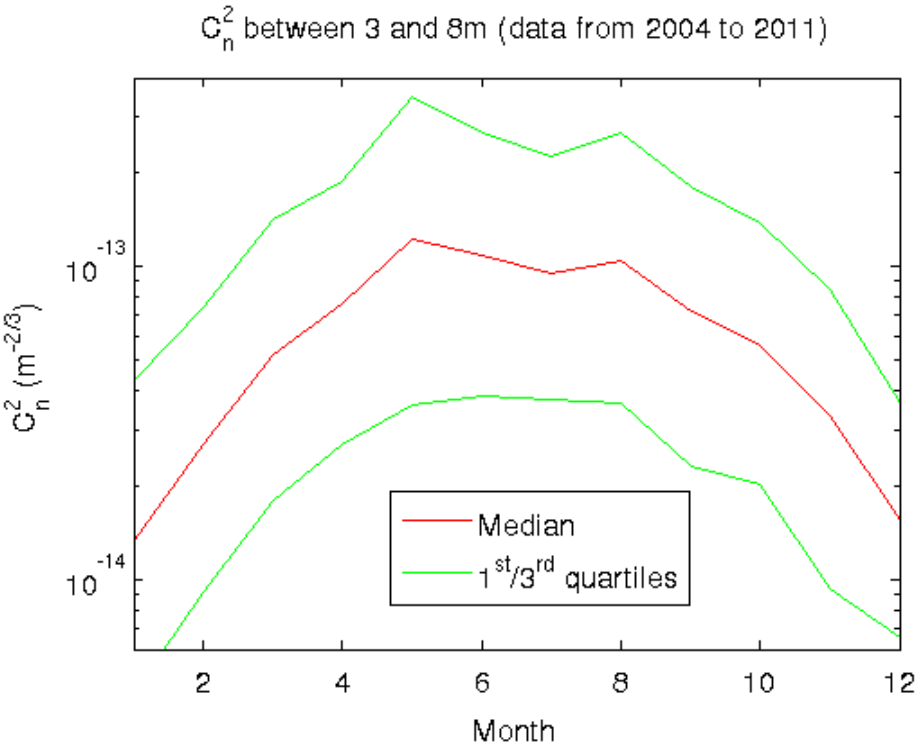






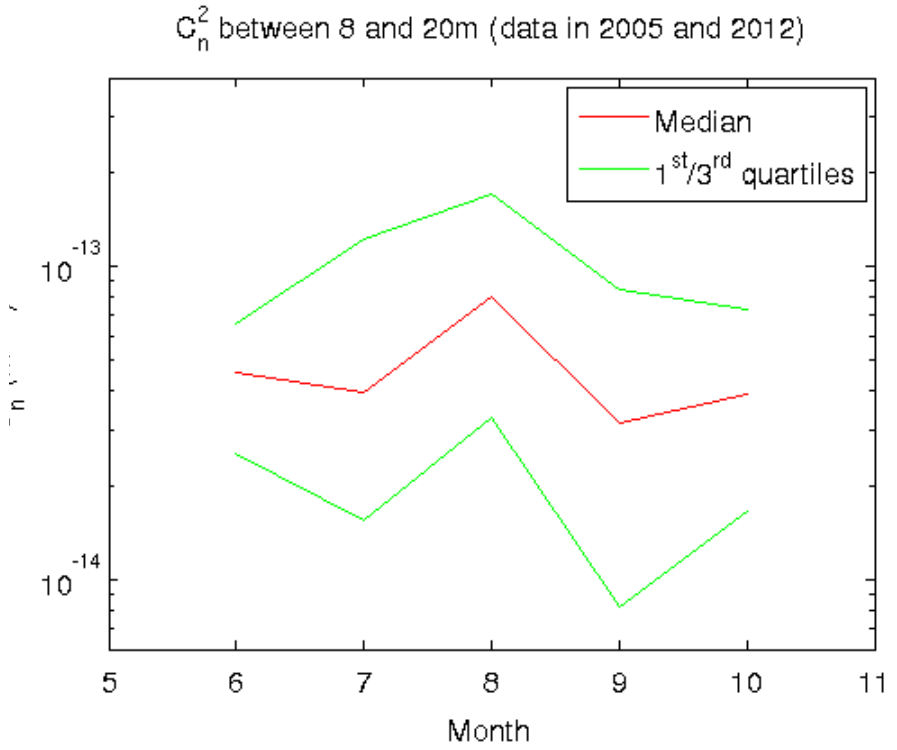


C_n^2 from 2 DIMM pairs



24000 points from DIMMs @3m and 8m (1 mn coincidence intervals)

Median : 7.7 [2.5 --- 21] 10^{-14} $m^{-2/3}$



6200 points from DIMMs @8m and 20m

Median : 4.8 [1.7 --- 11] 10^{-14} $m^{-2/3}$

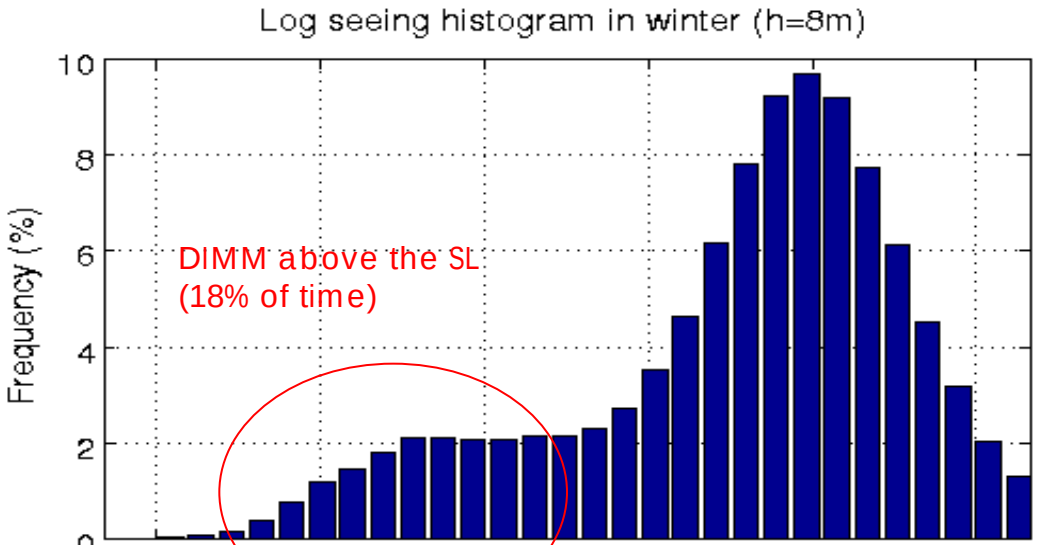
Seeing from Cn² profile :

$$C_n^2 = 6.24\,10^{-9}\; C_T^2\, P^2\, T^{-4}$$

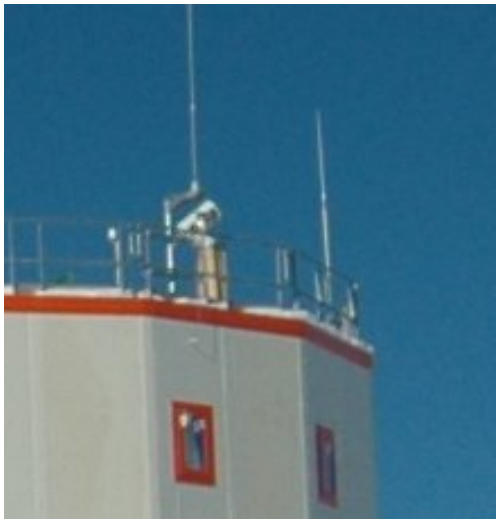
$$\epsilon^{5/3} = 16.1\;\lambda^{-\frac{1}{3}} \int_{h_1}^{\infty} C_n^2(h)\; dh$$

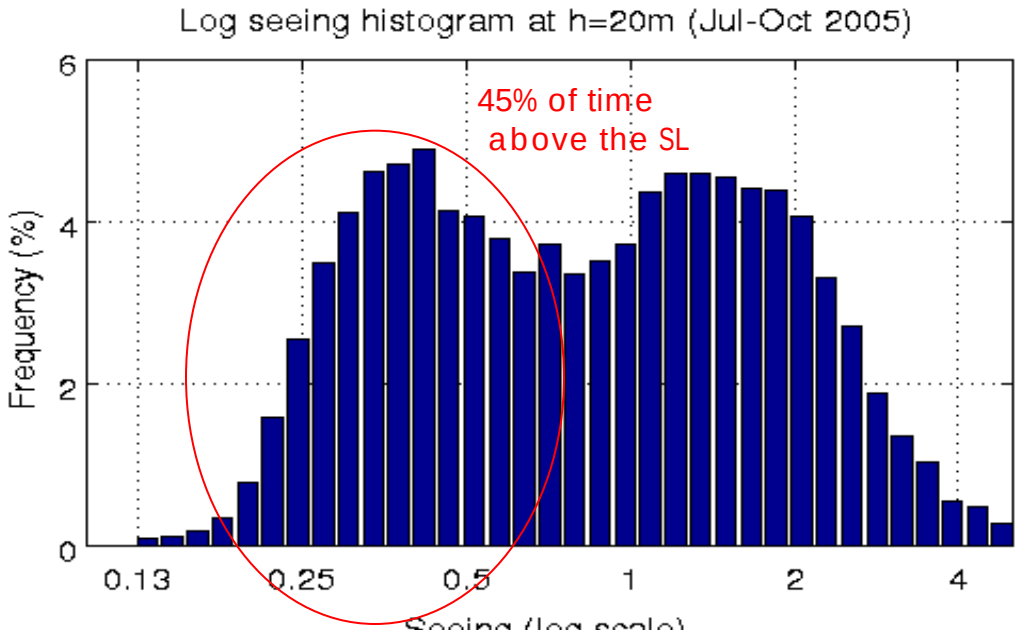
The surface layer is very sharp

DIMM h=8m

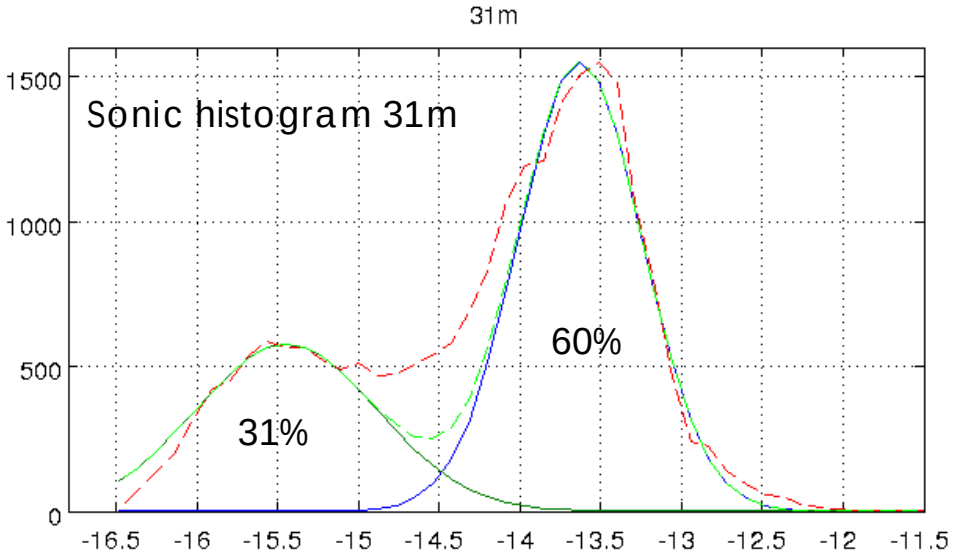


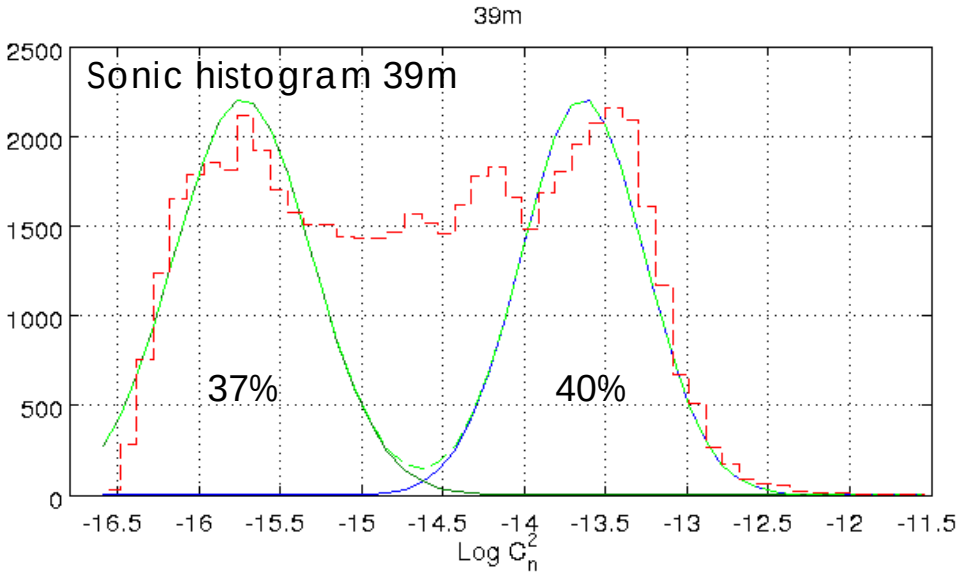
DIMM h=20m





Thickness of the surface layer from sonic histograms (winter)





From SONIC @31m and 39m :

H_{BL} ~35m

(median thickness)

From balloon profiles[1]

H_{BL} =33m

From DIMM data @3m, 8m, 20m[2]

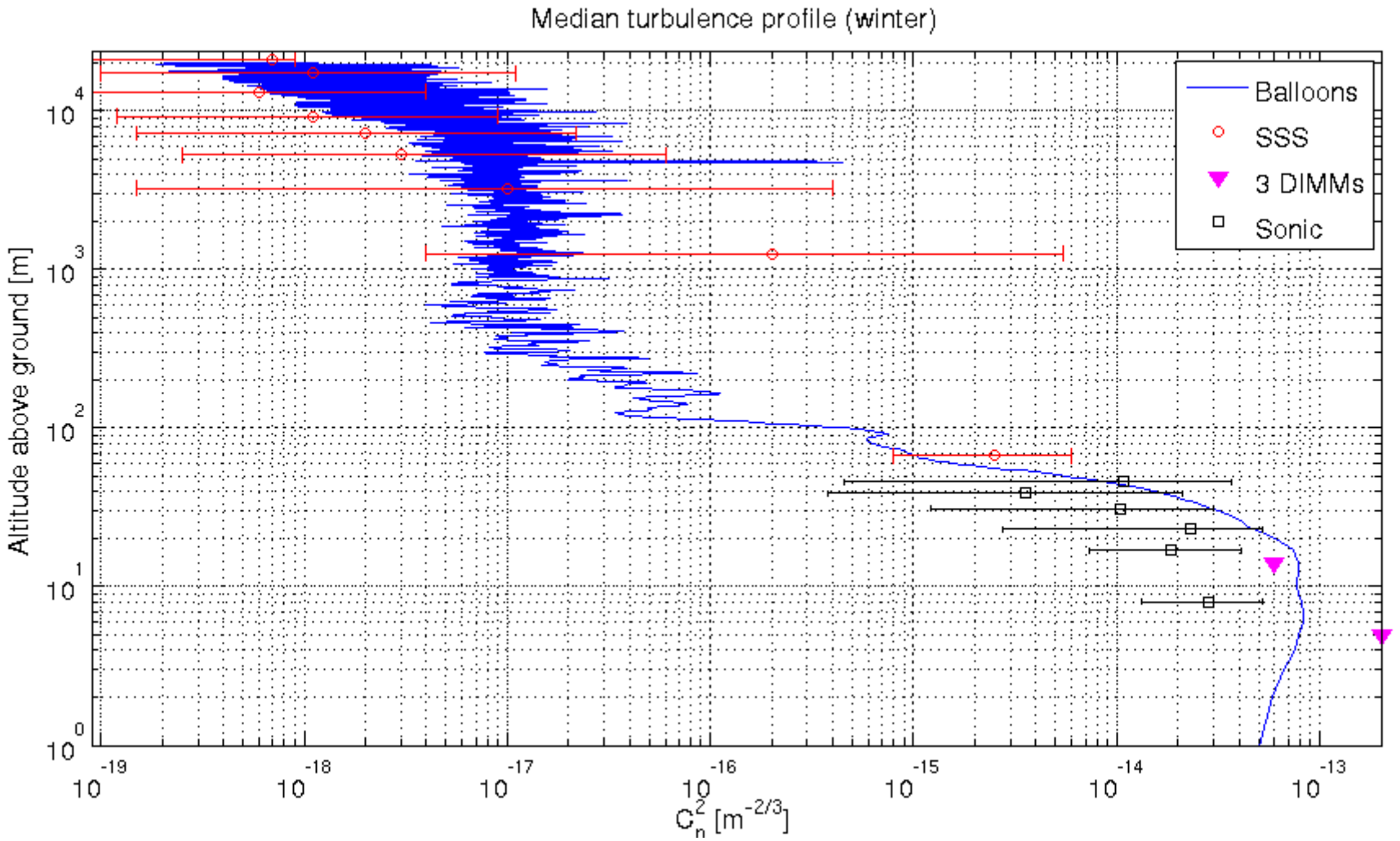
(4 months in winter/spring 2005)

H_{BL} =27m

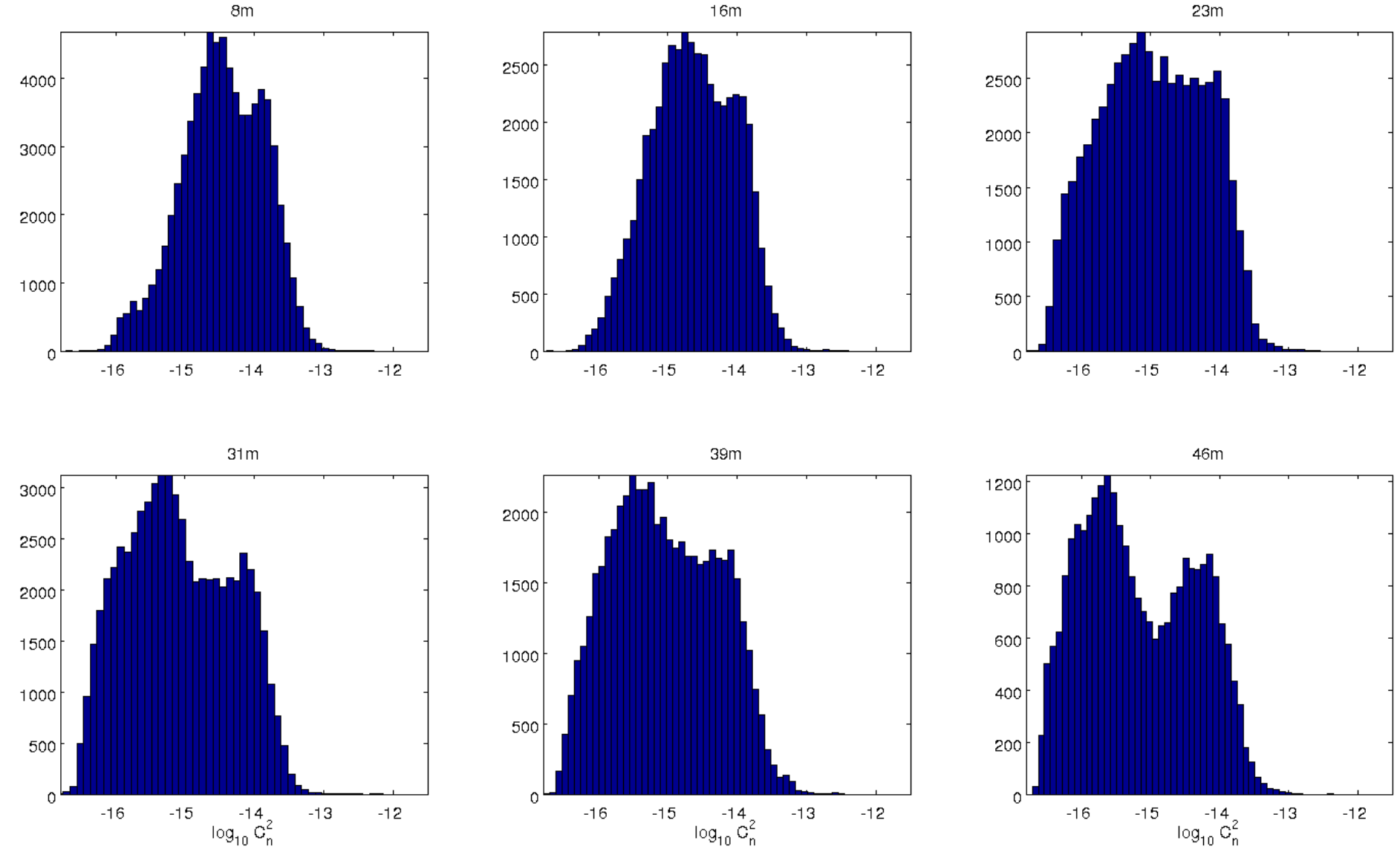
Numerical simulations[3] H_{BL} =44+/-23m

[1]Trinquet et al, 2008
[2]Aristidi et al, 2009
[3]Lascaux et al 2011

Median C_n^2 profile (Apr-Sep)

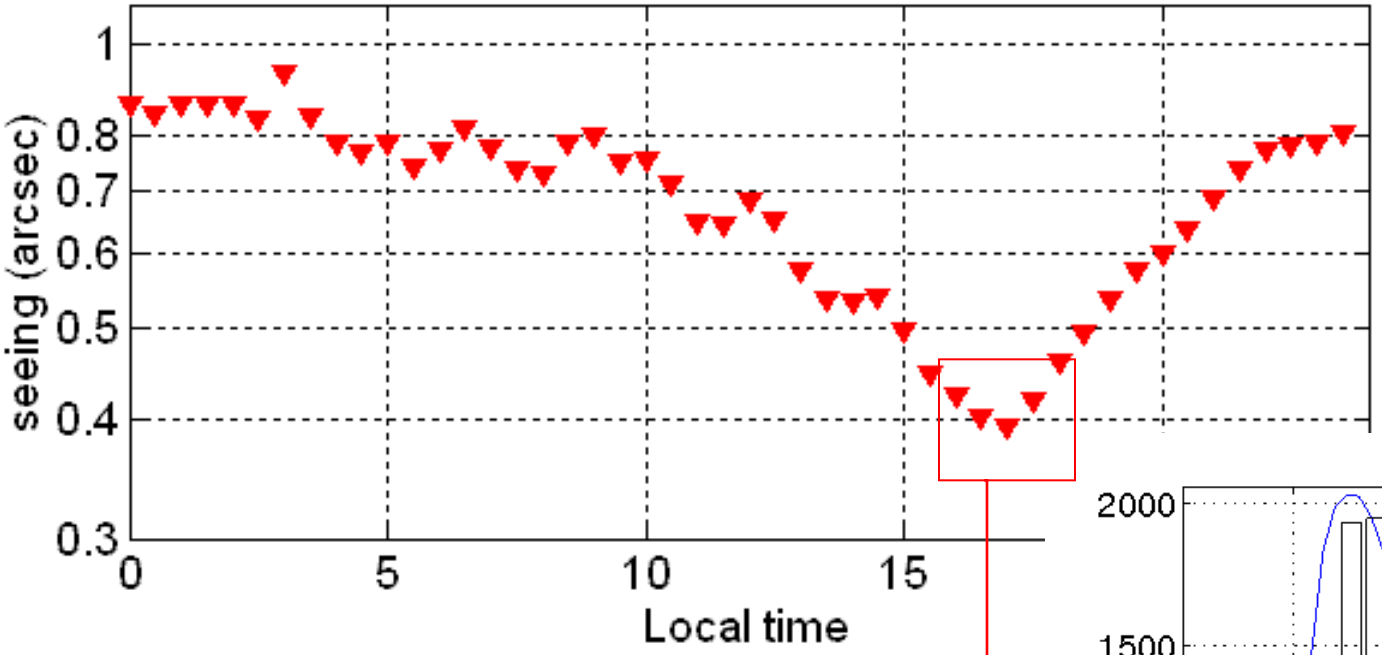


Sonic C_n^2 summer histograms (Dec-Jan, 2008-2011)

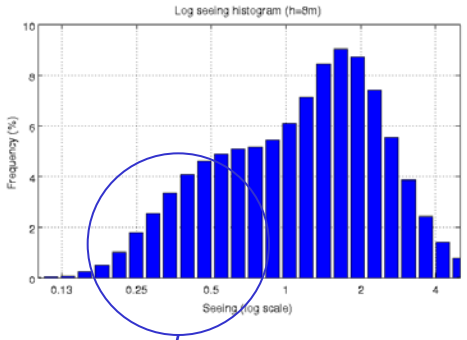


The summer situation

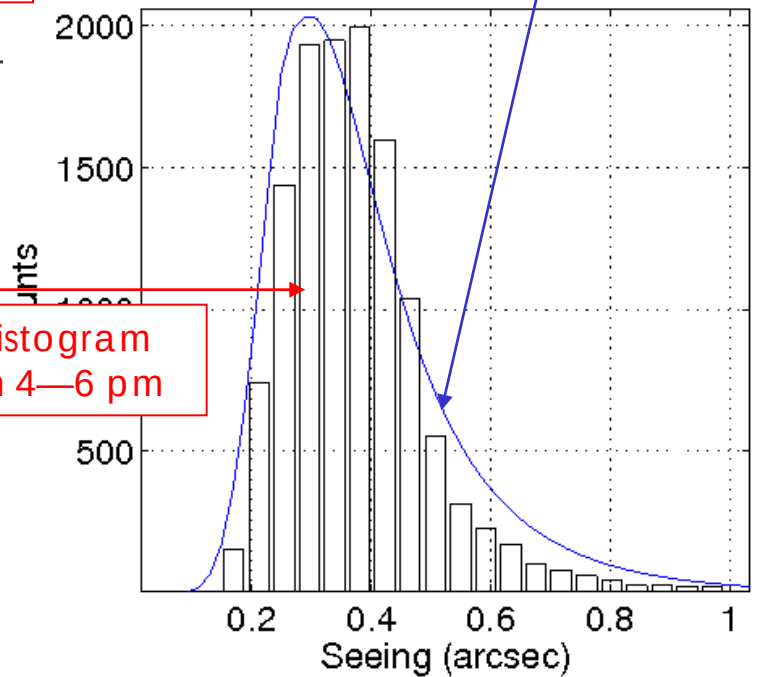
Seeing @8m (dec—jan)



Seeing histogram (total)



Free-atmosph. bump of the histogram



Seeing histogram between 4—6 pm

- **In summer the DIMM @8m is in the free atmosphere every day between 4 and 6pm**.

Seeing=0.4'' [0.3 – 0.5]

Conclusion

- Sonic and micro-thermal (balloon profiles) measurements give comparable values
- In-situ turbulence measurements and optical measurements are in good agreement
- Turbulent profiles confirm a sharp boundary layer in winter
- Median height: ~ 31 m ± 4 m
- More measurements with Sonics above 30 m would be useful
- At least one more year of profile measurement with PBL + Sonics expected