Local Turbulence at GREGOR

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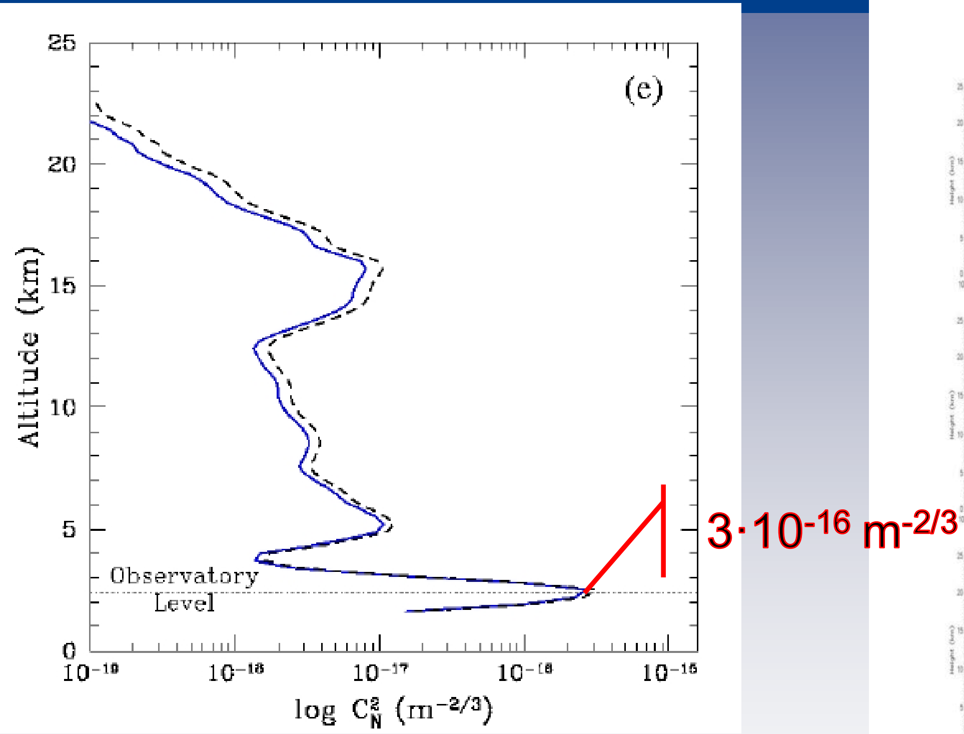
Motivation

- Is there a local effect on turbulence on the GREGOR platform?

- Measure C_n^2 („optical turbulence“) at telescope height in the free atmosphere and compare to measurements on the GREGOR platform

Previous measurements



Garcia-Lorenzo et al. 2009

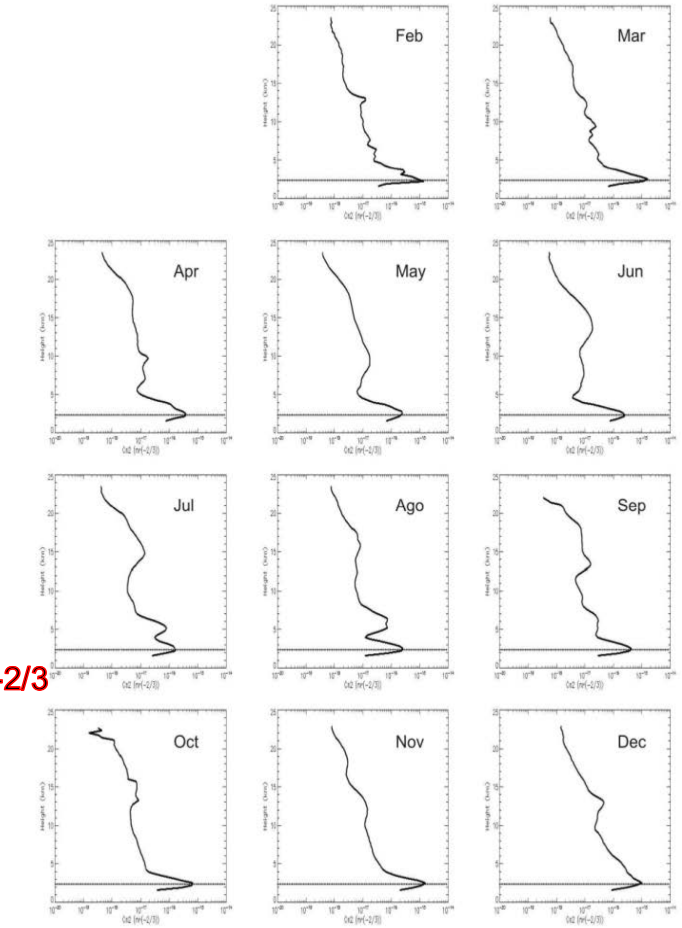


Fig. 3. Average profiles of C_N^2 at each month of 2004. Each value is the mean of all data to its height. The systematic measurements with cute-SCIDAR instrument in JKT began on February 2004. The vertical axis is the height above the sea level in km. The horizontal lines indicate the observatory height (2.4 km). The X axis is the logarithmical scale of the C_N^2 in unit of $m^{-2/3}$ (the range goes from 10^{-20} to 10^{-14} $m^{-2/3}$).

SCIDAR measurements at Izana 2002 - 2009
Monthly averages of vertical profiles

Free Atmosphere Turbulence

Transmitter at the VTT

Laser Scintillometer SLS40 (SCINTEC)

- wavelength 670 nm, time resolution: 1 minute
- measurements between September 2012 and March 2016 (with gaps)

Receiver at GREGOR

- horizontal distance 75 m
- path orientation NO (45°)
- height: 30 m above ground

Laser-Scintillometer SLS40 transmitter

Local Turbulence Measurements

- Three Sonic anemometers (2x Gill-HS50 (GB) and 1x Thies (Germany))
- Measurements between May 2015 and March 2016

- measurement of time series of
  - 3 wind components u,v,w
  - sound velocity ➔ $T_s \approx T_v$
- time resolution 0.02 s
- FFT-analysis on time periods of 5 min

➔ C_T^2 ➔ C_n^2

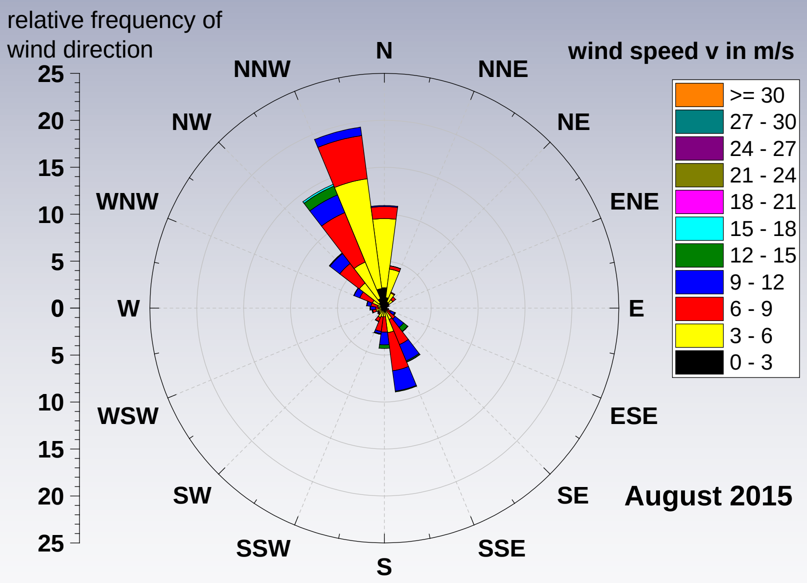
$$C_n^2 = \left(79.2 \cdot 10^{-6} \frac{\overline{P}}{\overline{T}^2} \right)^2 \cdot C_T^2$$

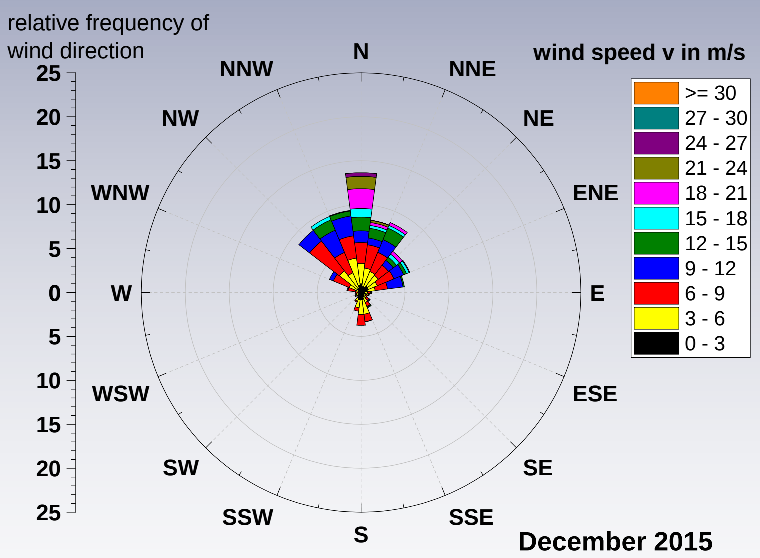
T: temperature
T_s: Sonic temperature
T_v: virtual temperature
n: refraction index
p: air pressure
C_T^2: structure function parameter of temperature
C_n^2: structure function parameter of refraction index

Meteorological data

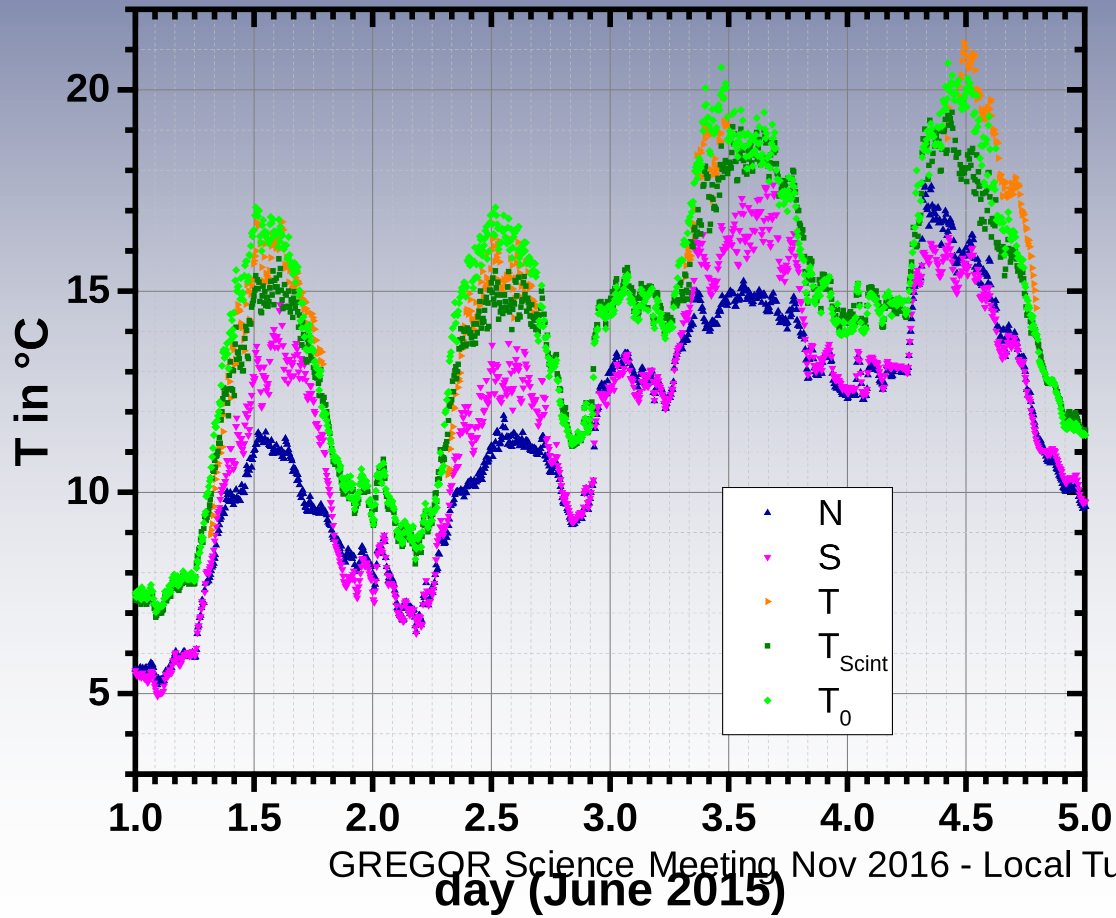
- Temperature at the height of the receiver of the scintillometer (0.3 m above telescope base level)
- Temperature 1.3 m above telescope base
- Temperature and relative humidity close to the sonic anemometers (additional sensors)
- Air pressure
- Wind direction (derived from sonic data)
- Windspeed (derived from sonic data)

Wind statistics





Measured temperature above the GREGOR-platform



T_0: Temperature T just above the surface of the platform

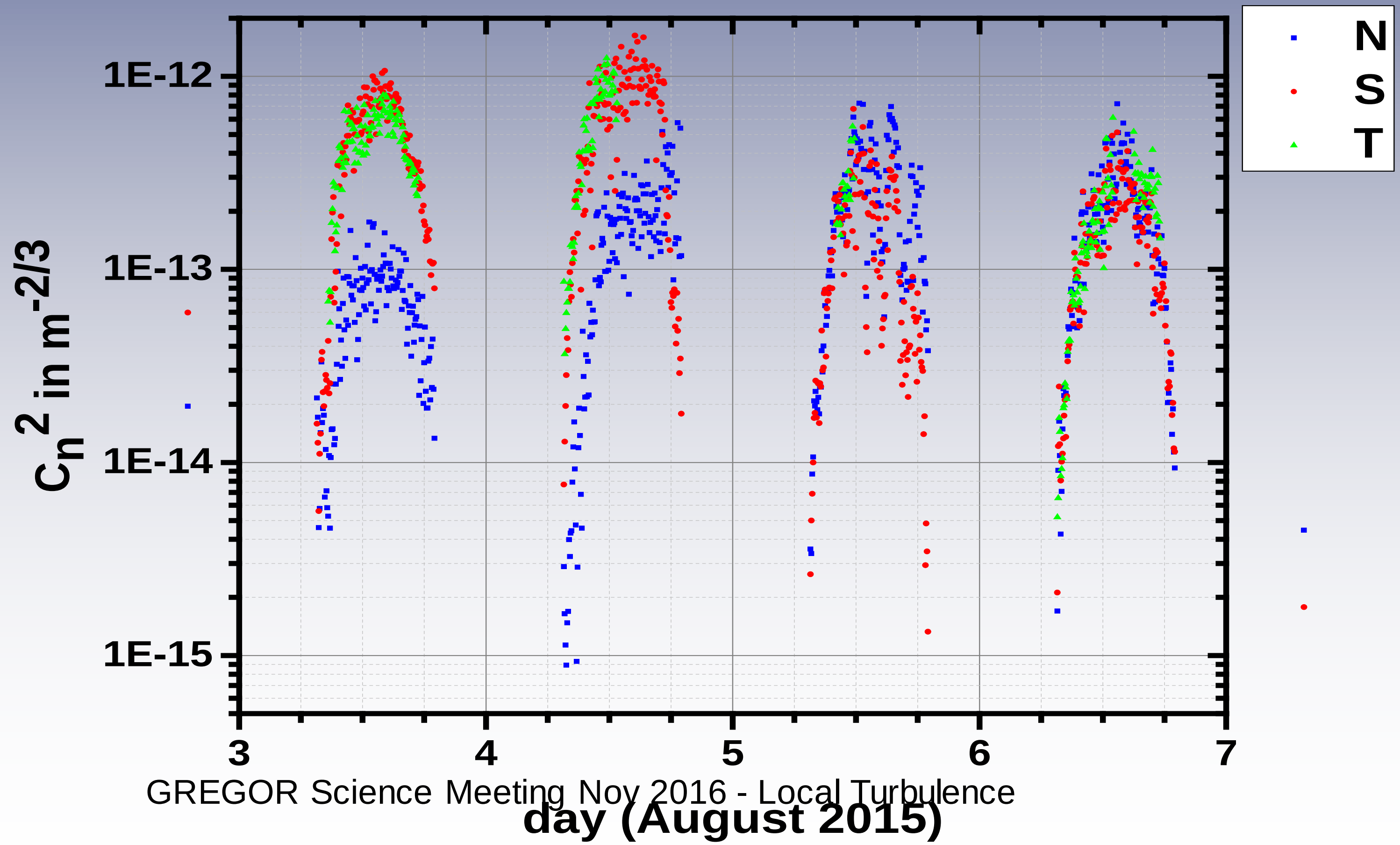
T_{scint}: Temperature at the receiver of the scintillometer

T: T at the Sonic anemometer close to the Telescope

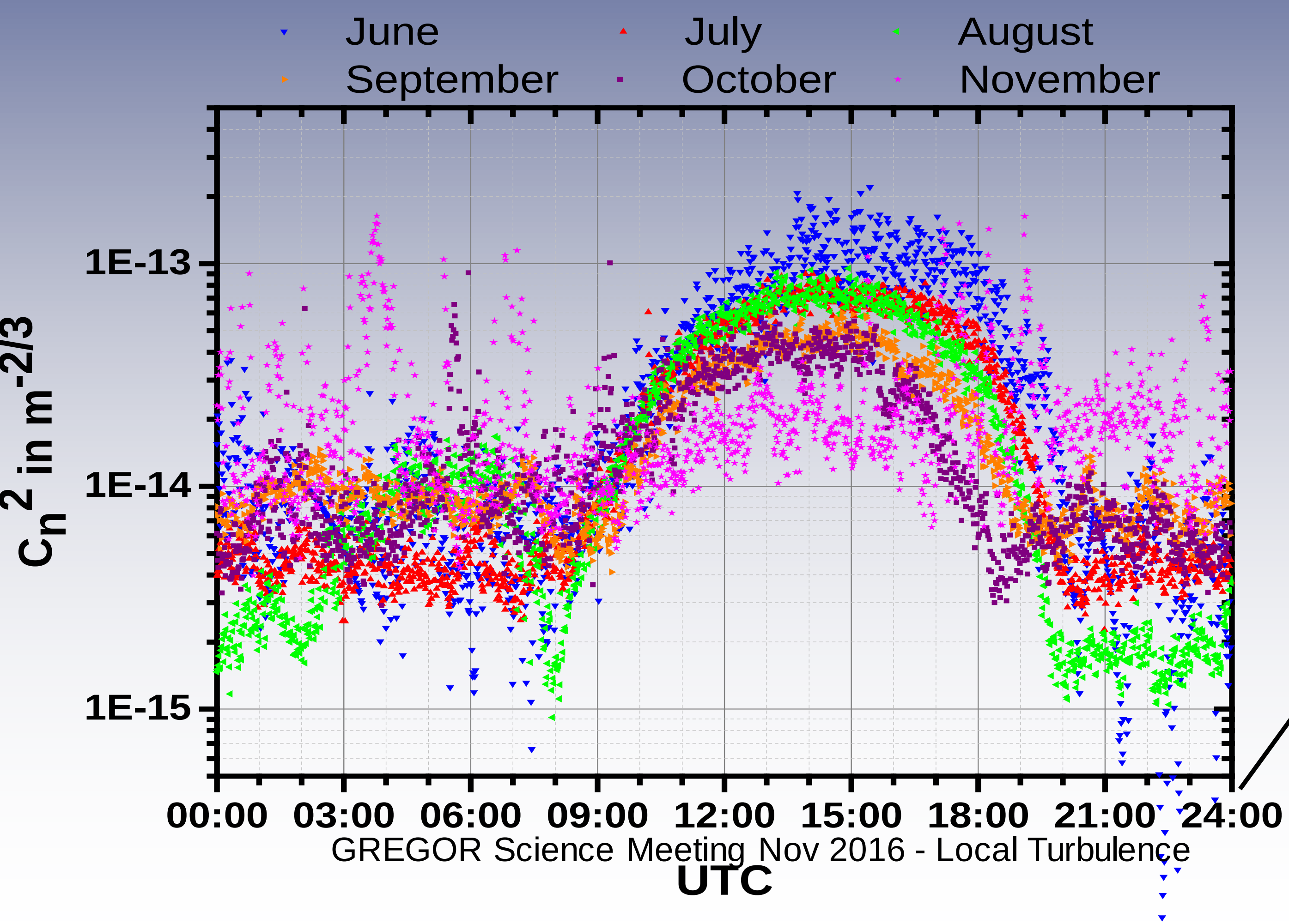
S: T at Sonic anemometer at the south end

N: T at Sonic anemometer at the north end

Time series C_n^2 (day time) sonic anemometers

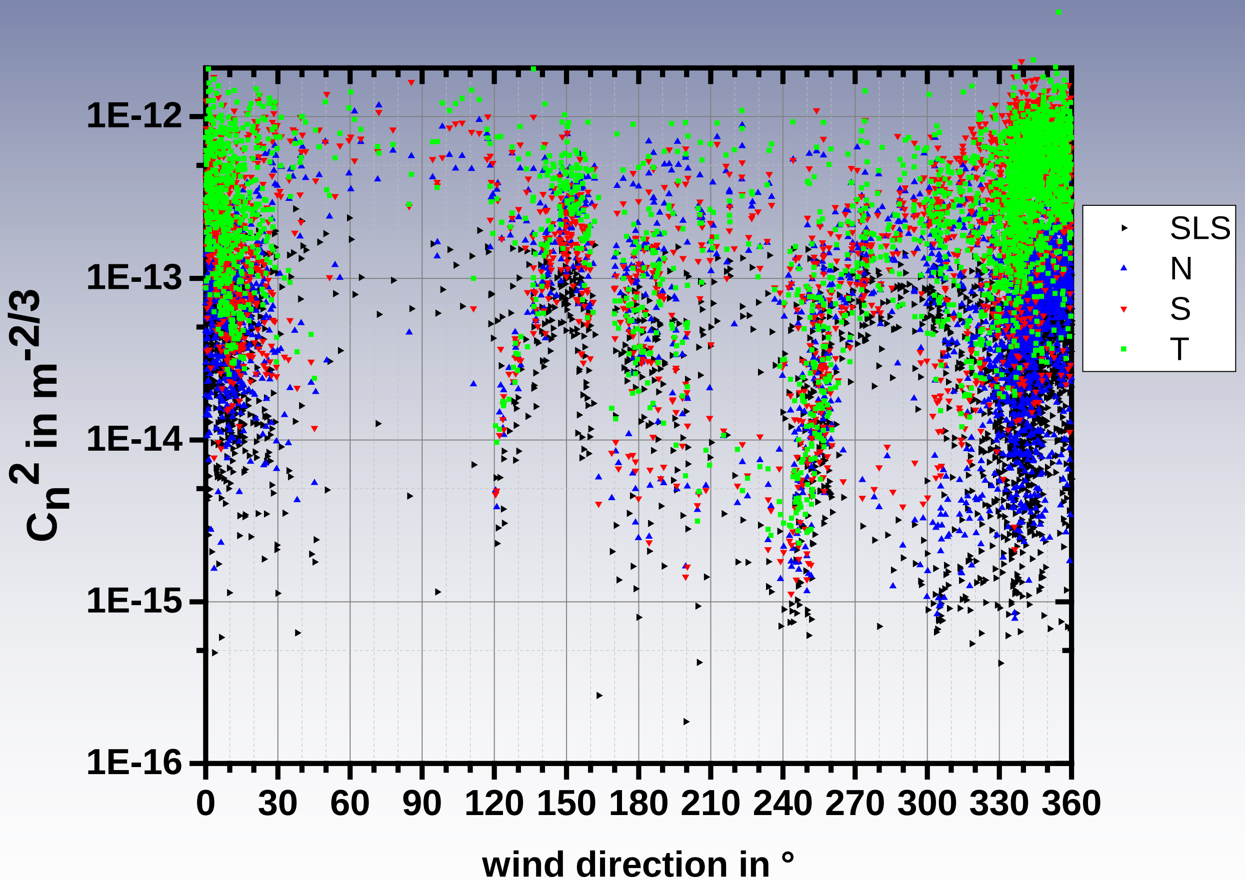


C_n^2 diurnal variations, Scintillometer
(monthly from June – November 2014)

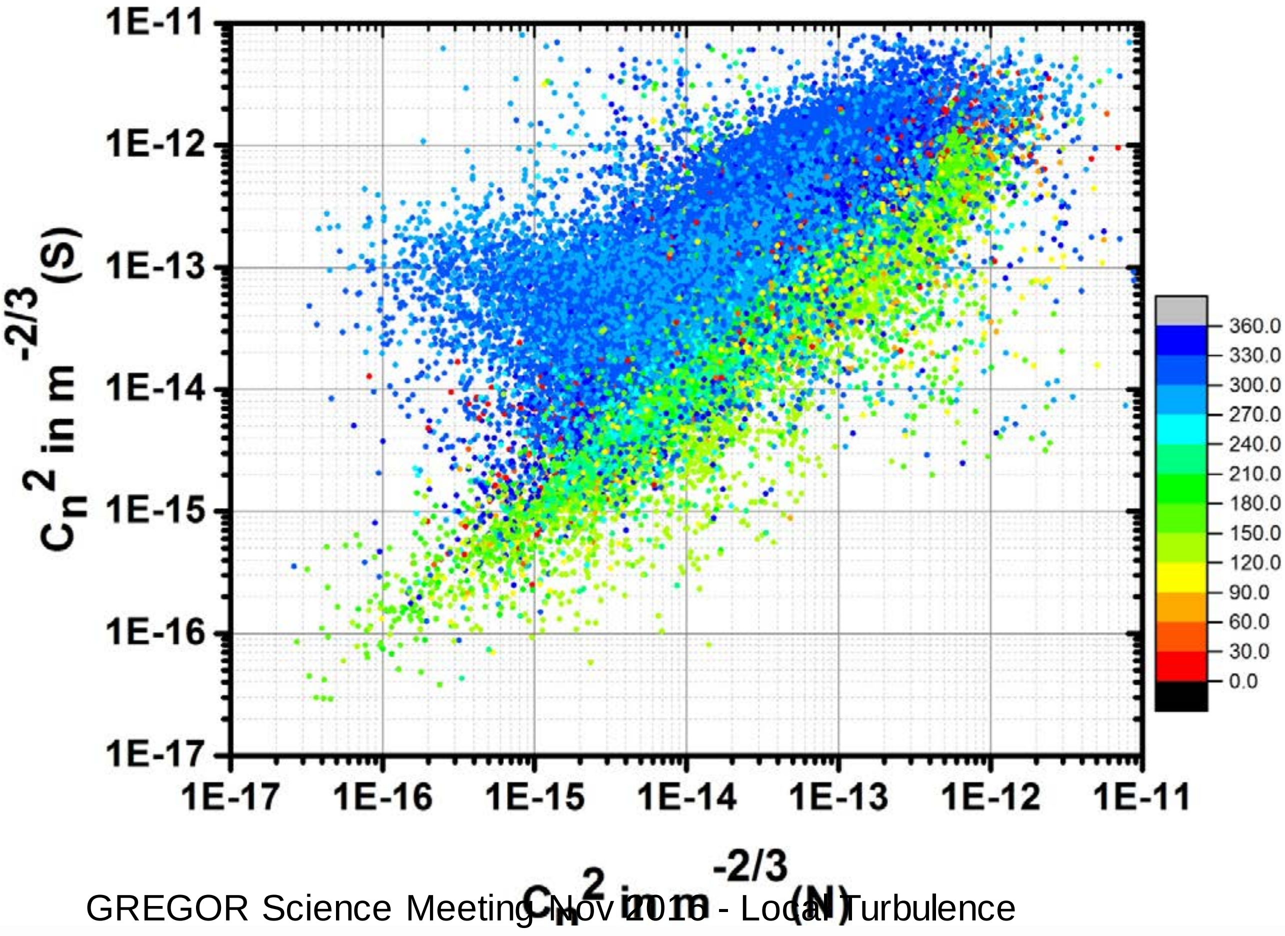


Fuensalida et al.: $3 \cdot 10^{-16}$ m$^{-2/3}$

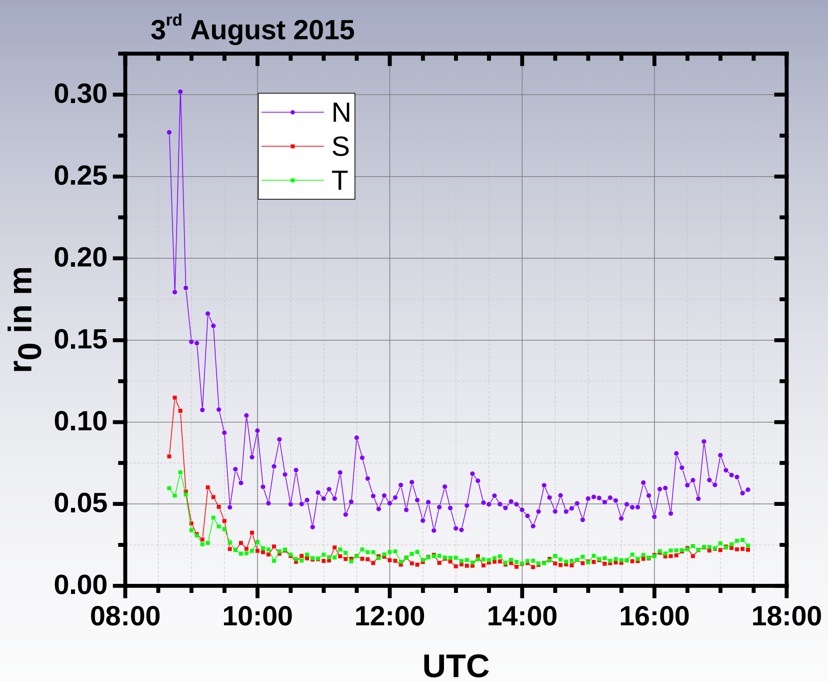
All C_n^2-data (5-min averages), June 2015 dome open

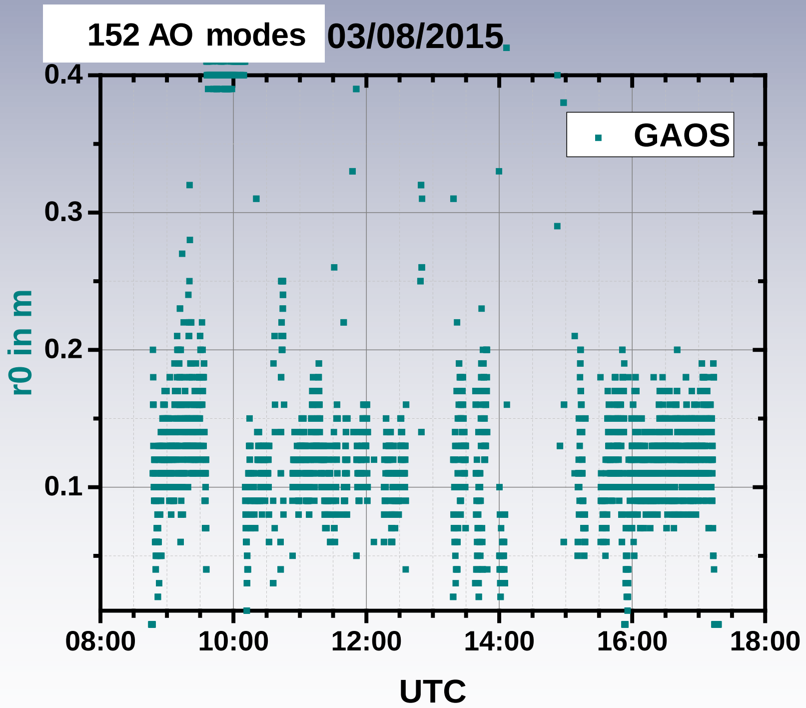


C_n^2 comparison measurements at the North site and at the South site of the GREGOR platform



Comparison r_0, 3rd August 2015





GAOS estimate of $r_{0,500}$

- Fried parameter $r_{0,500}$ derived from variance of the total mode wavefront error measured by the GAOS wavefront sensor (mode index N)

$$r_0 = D \cdot \left[\frac{\sigma^2_{N,\mathrm{GAOS}}}{1.19 \cdot \sigma^2_{N,\mathrm{theor}}} \right]^{-\frac{3}{5}}$$

- Low order modes (N=2,3,4 – i. e. defocus and ast) known to result in unrealistically high r_0 estimates – outer scale of turbulence?
- Including higher order modes gives r_0 values which are consistent with quality of observations

Ground Layer contribution

- Assume that all of GAOS r_0 is caused by a strong ground layer – how thick is it?

$r_{0,500}$ [m]	$C_n^2 = 3 \cdot 10^{-13}\ m^{-2/3}$	$C_n^2 = 3 \cdot 10^{-14}\ m^{-2/3}$
0.05	7.4	73
0.10	2.3	23
0.20	0.7	7.3

Ground layer thickness in [m]

Preliminary Conclusions

- C_n^2 measurements consistently significantly higher that ground layer from Fuensalida et al., (2009) – height resolution of sodar?
- C_n^2 measurements comparable to low altitude (10m) data from Haleakala (ATST Site testing report)
- Diurnal and seasonal variations at the telescope level
- Northern wind directions result in a gradient of C_n^2 towards S, with the N and the SLS consistently showing mountain ridge conditions
- Southern winds cause nearly the same strength of turbulence at all sensors
- The inferred Fried parameter from GAOS indicate that the high turbulence must be confined to a thin ground layer