Numerical simulations of the wintertime optical turbulence in Antarctica with the mesoscale model MESO-NH

Lascaux Franck

Masciadri Elena, Hagelin Susanna, Stoesz Jeff

INAF – Osservatorio Astrofisico di Arcetri, Florence, Italy

PLAN

I/ Configuration of the model

-Low horizontal resolution, monomodel.

-High horizontal resolution with the grid-nesting technique.

II/ Forecasting of the standard meteorological parameters

-Mean vertical profiles at Dome C of wind speed and temperature.

-Surface values at Dome C.

III/ Simulations with the astro-meso-nh package (forecasting of optical turbulence) - Examples

-Temporal evolution of the vertical profiles of Cn^2 at Dome C for three different winter nights.

IV/ Simulations with the astro-meso-nh package (forecasting of optical turbulence) – Statistics over 16 nights

-Median of simulated Cn^2 vertical profiles, comparison with observations (Trinquet et al., 2008).

-Computations of the surface layer thickness: test of 2 criteria.

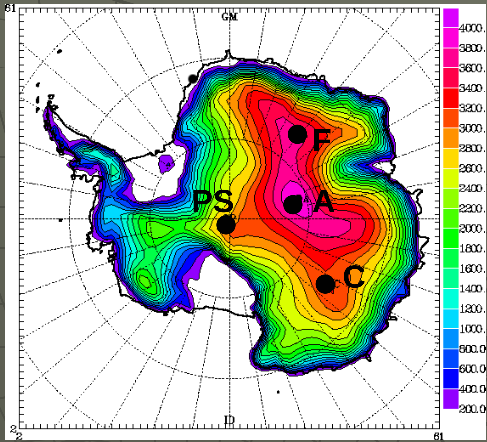
-Seeing.

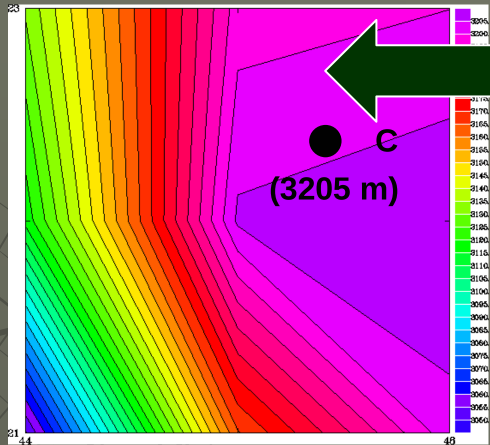
V/ Conclusions

MESO-NH CONFIGURATIONS

More details in **Lascaux et al.** (SPIE 2008)

6000 km



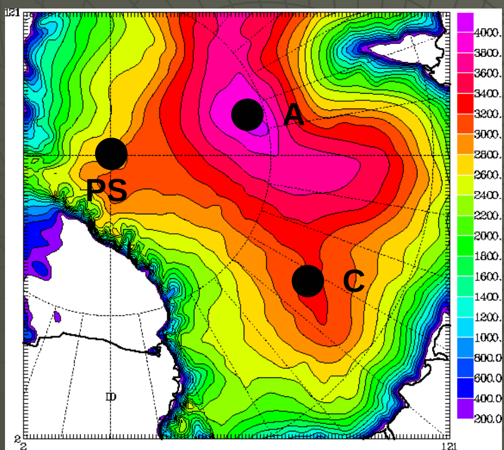


Zoom over Dome C Area

-Low horizontal resolution **monomodel** simulation: Δx=100 km.

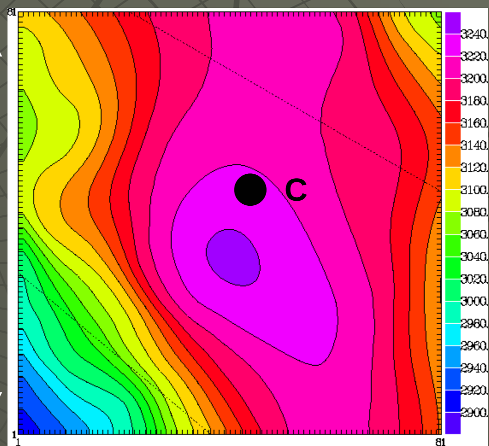
-***Grid-nested*** simulation: Δx=1 km in the innermost domain.

3000 km



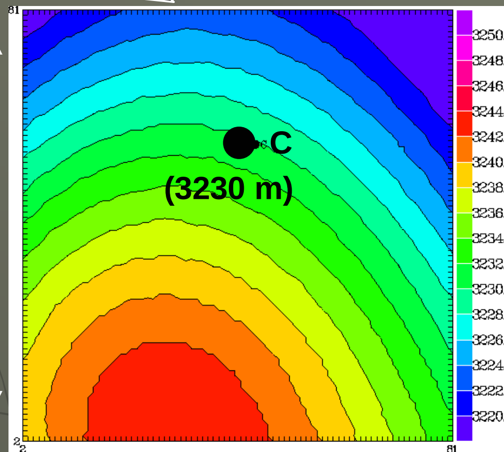
Domain 1: Δx=25 km

400 km



Domain 2: Δx=5 km

80 km



Domain 3: Δx=1 km

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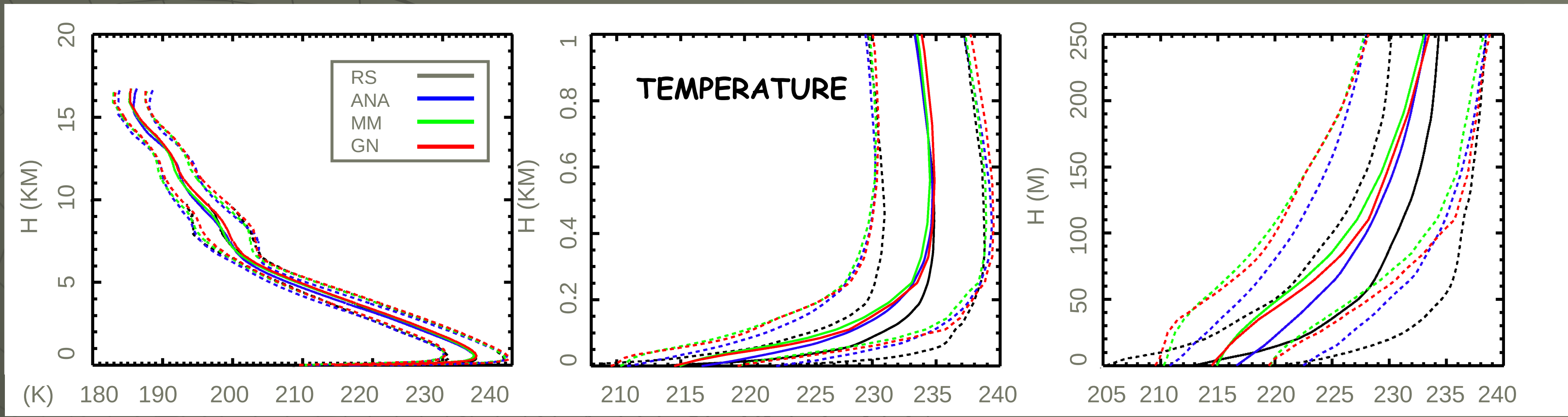
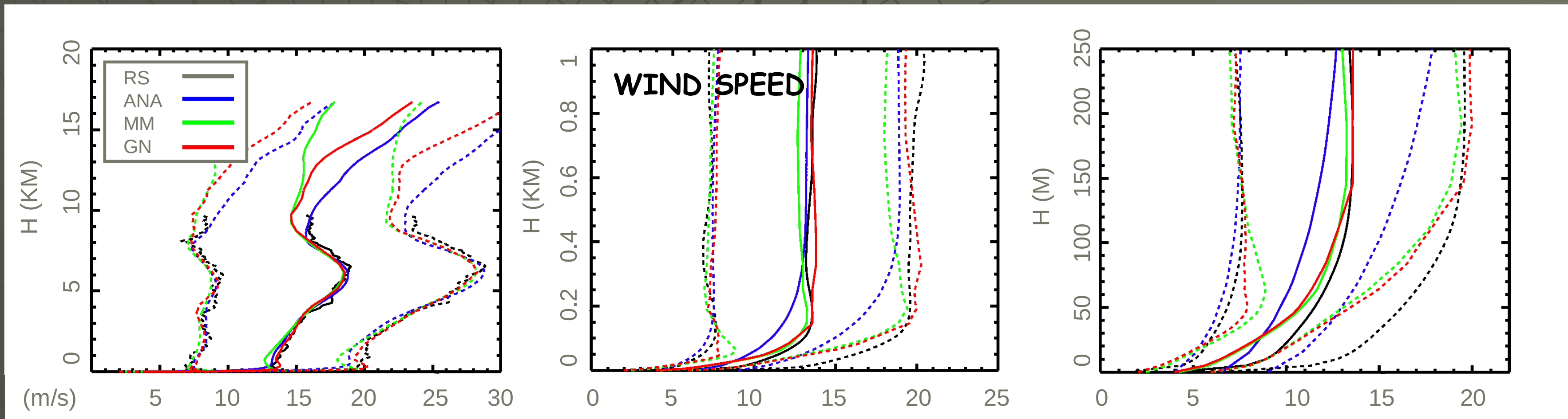
SIMULATED VERTICAL PROFILES ABOVE DOME C

Meteorological parameters (1)





Mean vertical profiles of temperature and wind speed above Dome C for 47 winter nights.
RS = radiosoundings ; ANA = ECMWF Analyses ;
MM = Meso-NH monomodel simulation ; GN = Meso-NH grid-nested simulation.

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SIMULATED VERTICAL PROFILES ABOVE DOME C

Meteorological parameters (2)

- At the surface:

	Radiosondes	ECMWF	Monomodel	Grid-nesting
Wind speed (m/s)	4.02 ± 2.55	6.51 ± 2.51	4.23 ± 1.77	3.98 ± 1.95
Temperature (K)	212.90 ± 7.64	216.64 ± 5.83	214.92 ± 4.64	214.50 ± 4.97

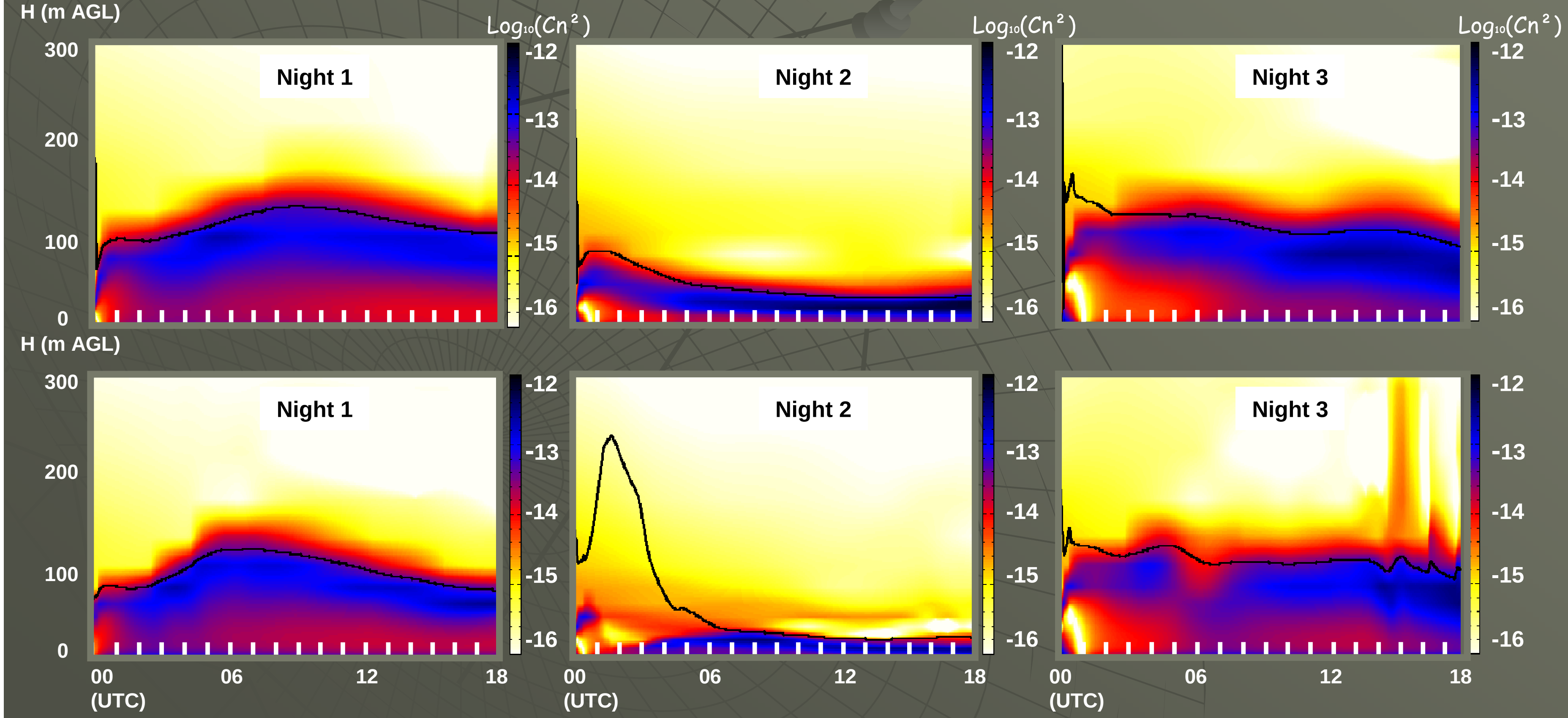
Mean values of temperature and wind speed at the surface above Dome C for the 47 winter nights.

-> Meso-NH better reproduces the surface temperature and wind speed at Dome C than the ECMWF analyses.
-> The grid-nested high horizontal resolution configuration gives results closer to the observations than the low horizontal configuration.

TEMPORAL EVOLUTION OF Cn^2 PROFILES

-16 nights between 16 June 2005 and 21 September 2005 (winter) have been observed by Trinquet et al. (2008). We simulated these nights using the astro-meso-nh package developed by the team.

- Examples of simulations for 3 of these nights: monomodel (top row) and grid-nested (bottom row)



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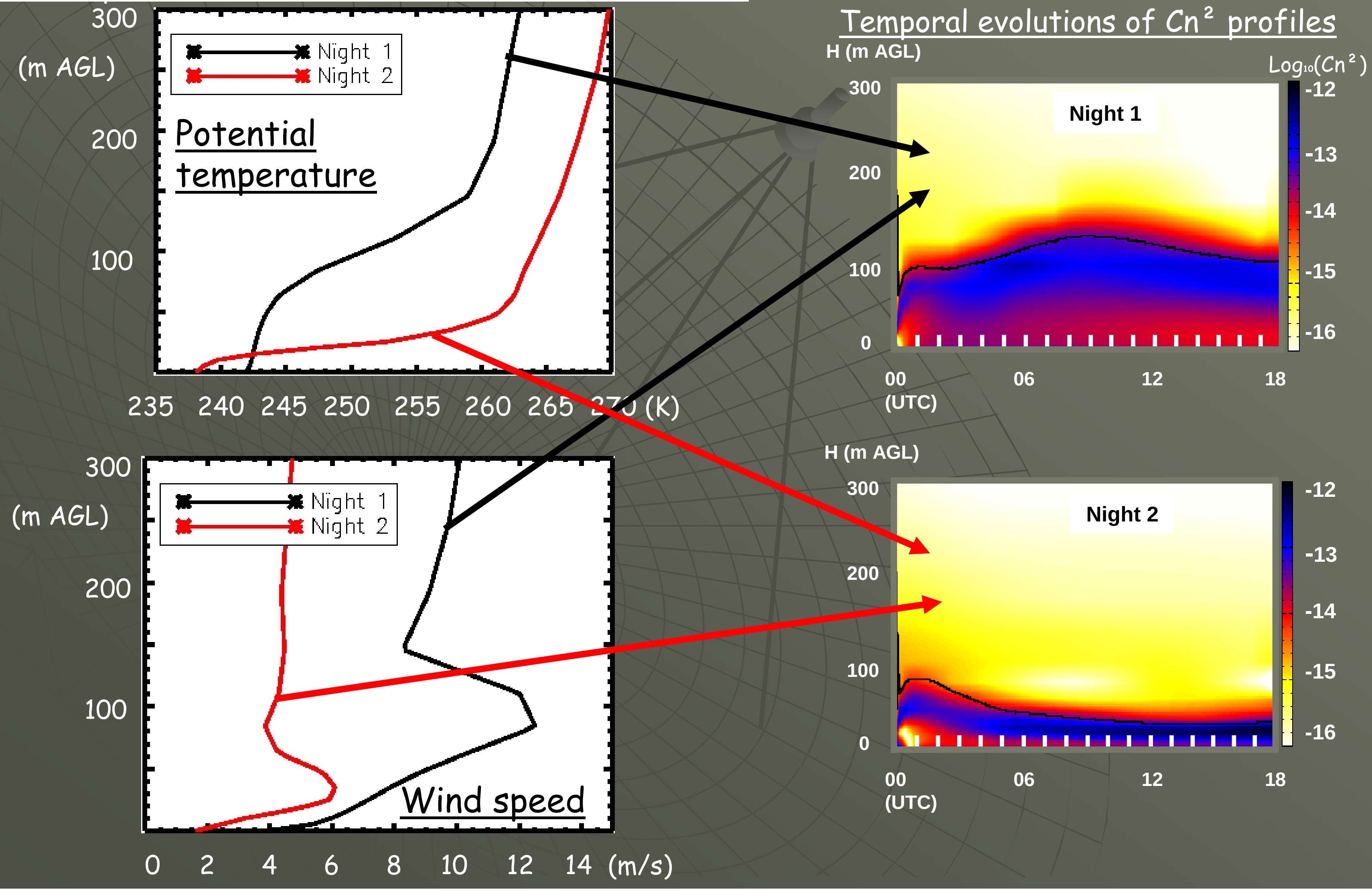
SIMULATED VERTICAL PROFILES ABOVE DOME C

Examples

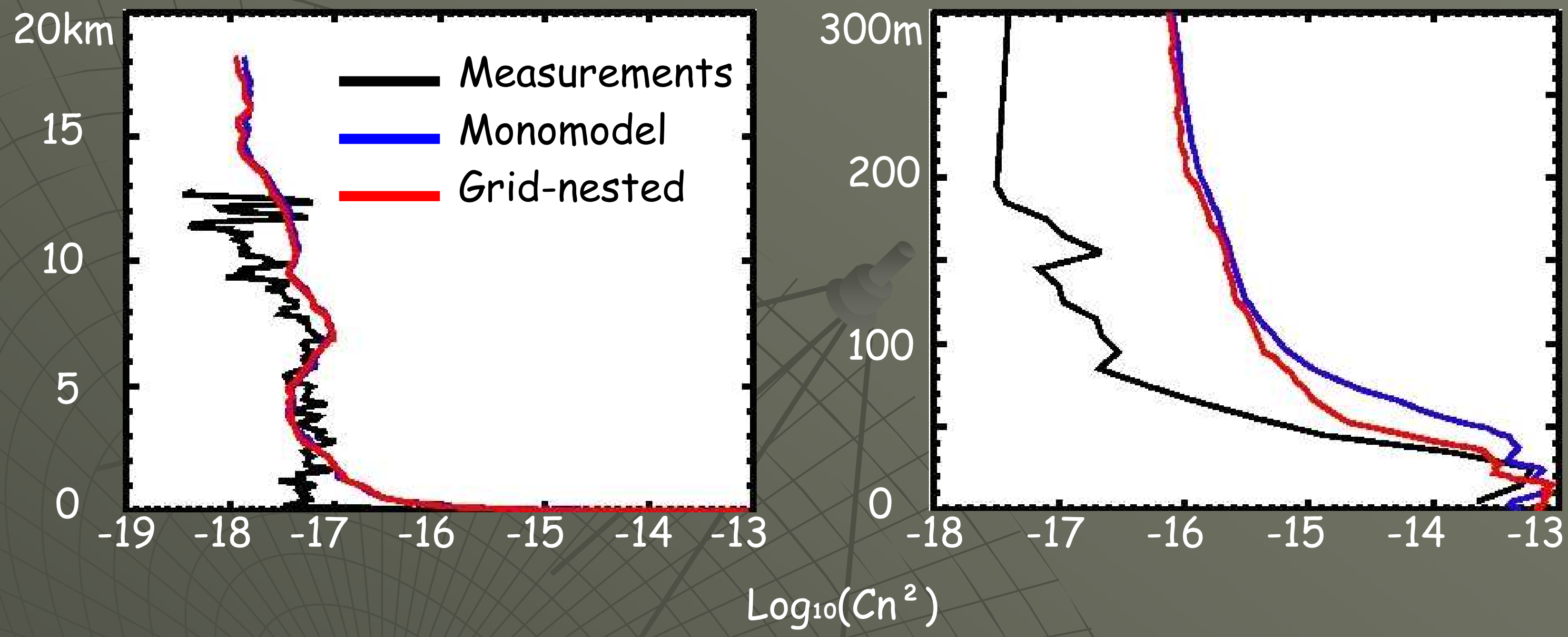
We show here the results for two different nights in winter 2005.

Vertical profiles at 12 UT, after 12 hours of simulation

Temporal evolutions of Cn^2 profiles



MEDIAN Cn² VERTICAL PROFILE



Medians of the mean vertical profiles of Cn^2 (between 11 UT and 17 UT) over the 16 nights observed in Trinquet et al. (2008), above Dome C.

→ For each night, using the Cn^2 vertical profile, we deduce the surface layer thickness of the Dome C site.

SURFACE LAYER THICKNESS AT DOME C

Computation criteria

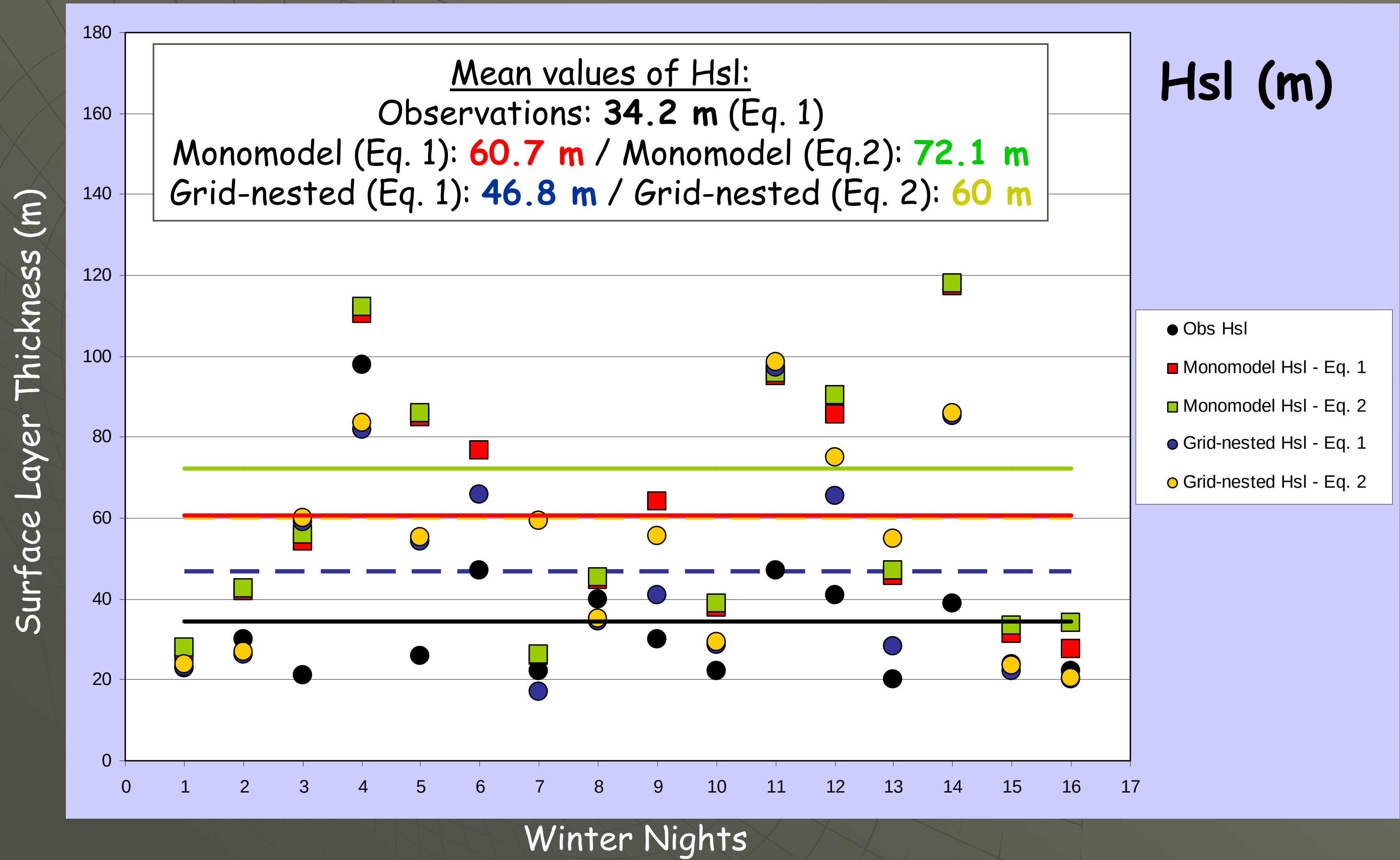
$$\frac{\int_{8m}^{Hsl} C_n^2(z)dz}{\int_{8m}^{1km} C_n^2(z)dz} < 0.90 \quad \text{(Eq. 1)}$$

$$\frac{\int_{8m}^{Hsl} C_n^2(z)dz}{\int_{8m}^{20km} C_n^2(z)dz} < 0.90 \quad \text{(Eq. 2)}$$

Eq. 1: used in Trinquet et al. (2008) to compute the surface layer thickness (Hsl) deduced from observations.

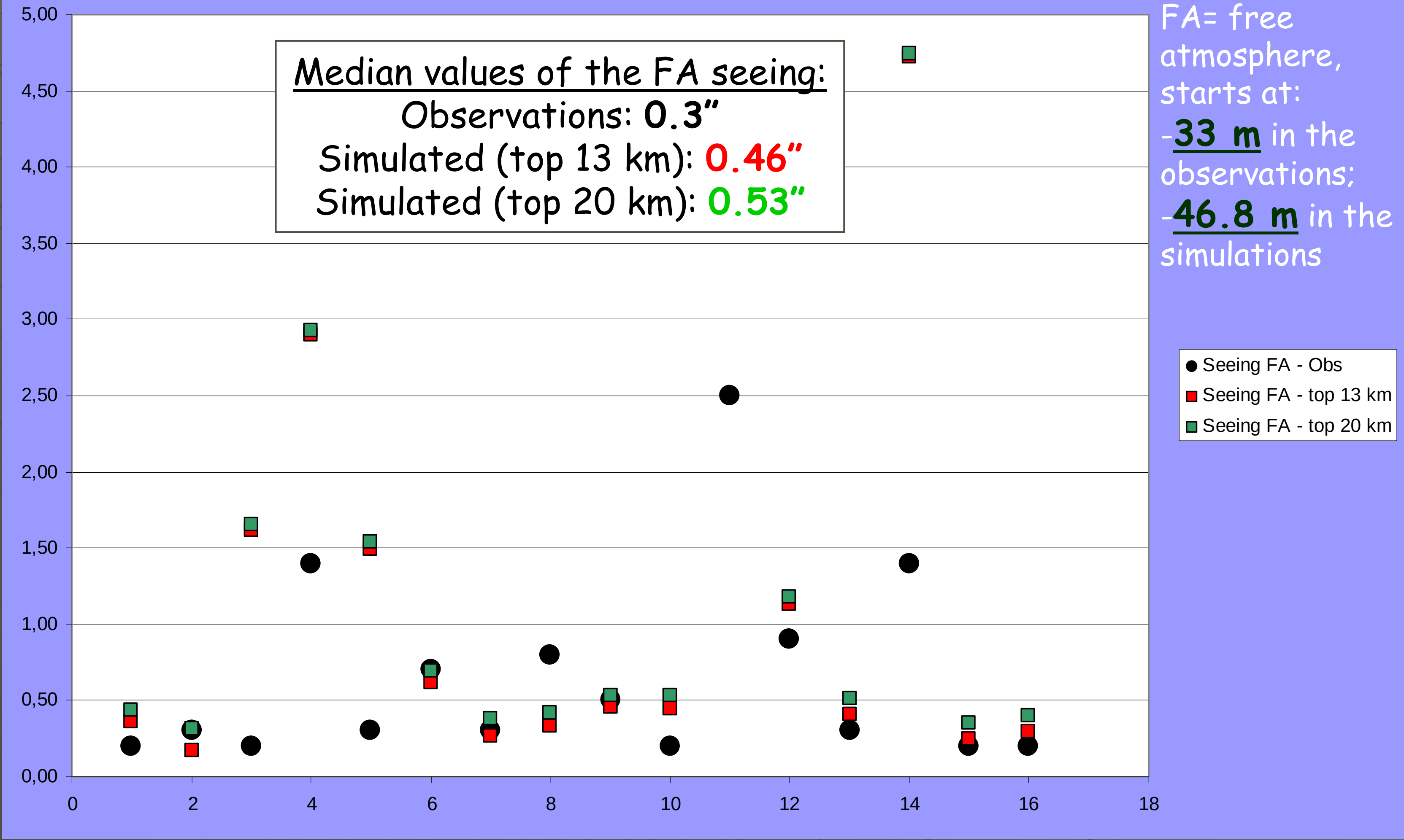
Eq. 2: proposed equation to compute the Hsl more accurately with the Meso-NH model.

SURFACE LAYER THICKNESS AT DOME C



SEEING

Computed seeing (mean between 11 UT and 17 UT) for the same 16 nights.



FA= free atmosphere, starts at:

-**33 m** in the observations;

-**46.8 m** in the simulations

CONCLUSIONS (1)

-We presented here a detailed study of the wintertime optical turbulence at Dome C, Antarctica, using a mesoscale weather model – Meso-NH – in which our team included an astronomical package allowing for the forecasting of optical turbulence (the astro-meso-nh package, only available at the Osservatorio Astrofisico di Arcetri).

-The wind vertical gradient near the surface was better reproduced by Meso-NH than in the analyses from the ECMWF. The Meso-NH temperature of the first vertical grid point was closest to the observations than the ECMWF analyses which were generally two warm.

-We highlighted the necessity to use high horizontal resolution with the grid-nesting interactive technique, which gave better results for meteorological fields than a monomodel low horizontal resolution configuration.

CONCLUSIONS (2)

-Concerning the Optical Turbulence, both configurations gave generally higher estimates of the surface layer thickness, but the order of magnitude was well respected. Here again, the grid-nested method gave estimates closer to the observations.

-We found that the criterion used in Trinquet et al. (2008) is misleading (it underestimates the typical thickness of the surface layer). Our criterion gave values higher of around 12 m. This may have important implications from an astronomical point of view.

-Finally, we compared the median seeing deduced from the numerical simulations with the one deduced from observations for the same nights. The value of 0.46" for the contribution of the free atmosphere (starting at 46.8 m instead of 33 m for the observations) is a little bit higher than the observed 0.3" value from Trinquet et al. (2008).

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