ICON-LEM SIMULATION OVER SOUTHERN-ITALY REGION AT 600M GRID RESOLUTION

D. Cinquegrana, M. Montesarchio, A. Zollo, E. Bucchignani

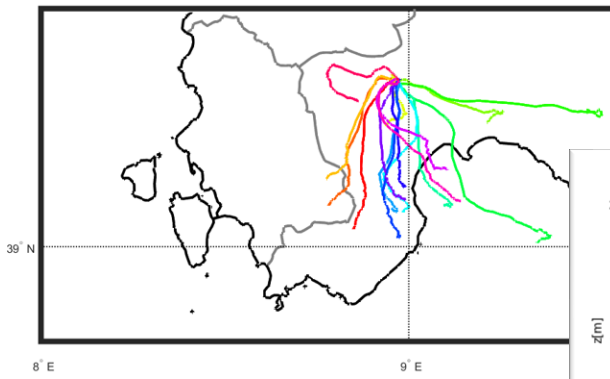
METE Lab , CIRA – Italian Aerospace Research Center, Capua CE Italy

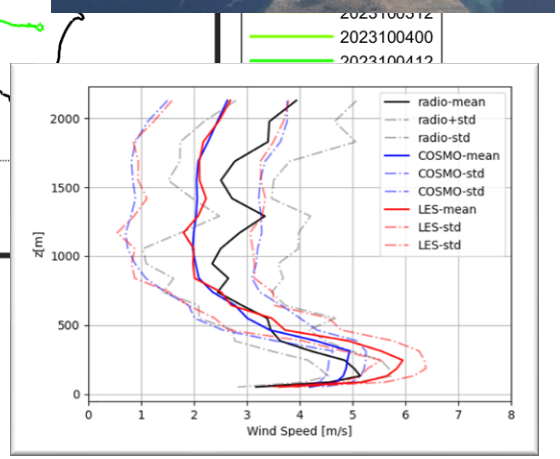
PHY-EPS hectometric Workshop

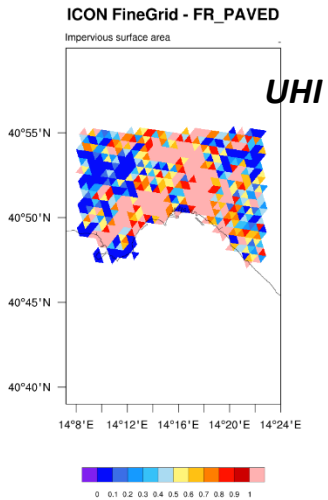
5-7 February 2024 – Deutscher Wetterdienst, Offenbach am Main, Germany

- CIRA - Meteorology lab LES applications
- Domain and Period definition
- ICON LAM/LEM Numerical Settings
- Observational Data sources
- LAM vs LEM: Results
  - 3D data: Radiosonde profiles
  - 2D data: Ground stations

- **Wind characterization of baloon launching Site**
  - accurate wind forecasts in the early stage of ascending trajectory of a stratospheric balloons
  - AIM: support a future mission of the stratospheric platform developed at the Italian Aerospace Research Center (CIRA), scheduled in October 2024 at the Tortolì military airport (Sardinia, Italy)
- **Numerical experiment of urban parametrization scheme available in ICON model (COSMO project CITTA)**
  - evaluation results of the Terra Urb scheme in high-resolution simulations over the Italian regions of Campania-Lazio (focus on Naples)
  - AIM: capturing the UHI intensity and improving air temperature forecasts for urban areas.







UHI on Naples

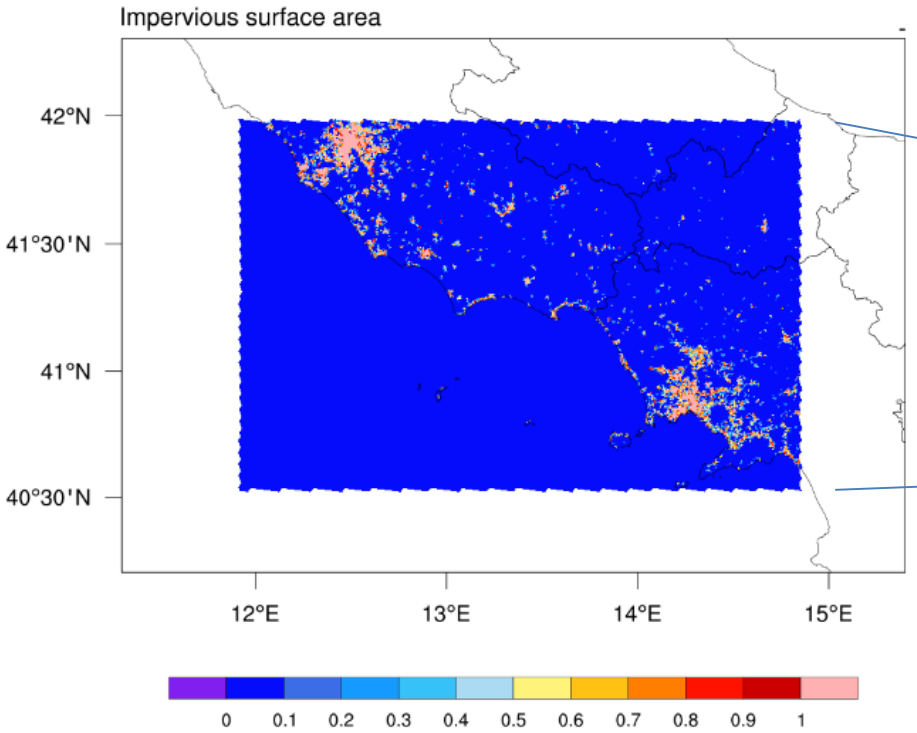
Domain and Period

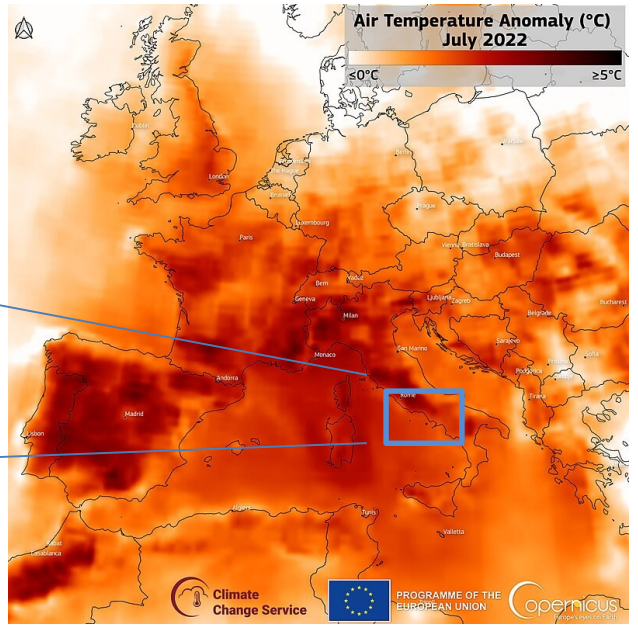
Domain:

- Lazio-Campania Southern Italy regions
- Horizontal resolution = ~ 0,6 Km (R02B12)
- ncells = 109860; vertical levels: 65
- First level: 20m; Top height: 22.000 m

Simulated Period:

- Heat waves hit Europe from June to August 2022
- July 2022: severe heat waves over Italy
- ICON forecast run from 18/7 to 24/7 2022





By Contains modified Copernicus Sentinel data 2022, Attribution, https://commons.wikimedia.org/w/index.php?curid=132519157

ICON model:

- exact local mass conservation and mass consistent tracer transport.
- The dynamical core is formulated on an icosahedral-triangular Arakawa C-grid.
- Time integration is performed with a two-time level predictor–corrector fully explicit scheme

ICON LAM/LEM :

BC's and IC's:

- IC: ECMWF-IFS Analysis @ 18:00
- Forecast time: 30h
- BCs reads @ ECMWF-IFS forecast every 3h

- Timestep size= 6 s
- lterra_urb Parameters
  - Antropogenic Heat Flux contribution active

Parameterization schemes

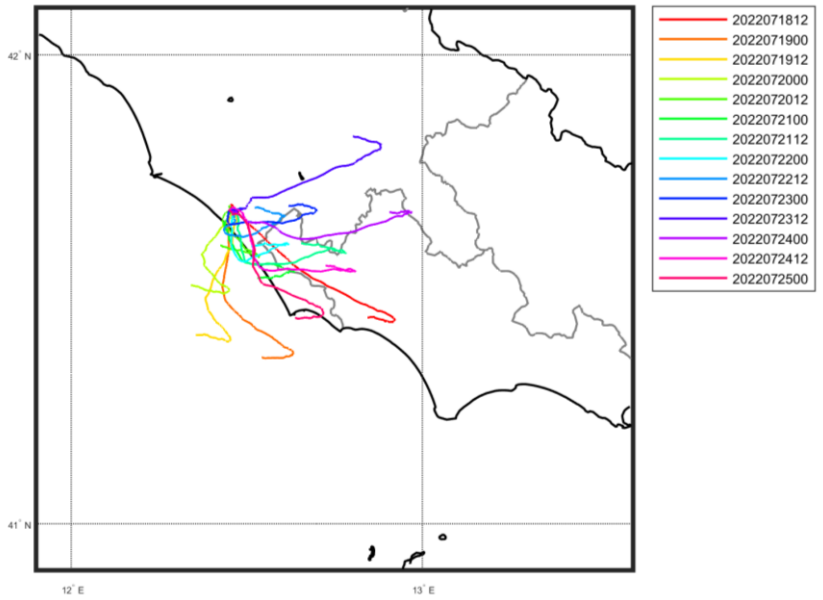
- Shallow convection parameterization active
- Deep and mid-level convection switched off
- Single moment cloud microphysics
- Diagnostic Kohler cloud cover

Turbulence models comparison:

- COSMO diffusion and transfer vs 3D Smagorinsky-Lilly model (LES)
  - COSMO diffusion and transfer: TURBDIFF and TURBTRAN (Raschendorfer (2001))
  - Smagorinsky-Lilly model (Dipankar A., (2015)): 3D sub-grid model of Smagorinsky (1963) with the stability correction of Lilly (1962)

- Radiosounding
  - Data range: 18/7 – 24/7 2022
  - For each day, data at 00 and 12 UTC are considered
  - Format: WMO BUFR
  - Source: ECMWF, archived at NOAA NCEI (National Centers for Environmental Information).
  - Data include also time, latitude and longitude displacement.

Radiosounding tracks for the selected week



Sonde description:

- type: Vaisala RS41 with pressure derived from GPS height/AUTOSONDE (Finland)
- Serial no: U2221312
- Frequency: 405.8 MHz
- SW version: MW41 2.17.0
- humidity correction: Solar radiation and time lag correction provided by the manufacturer
- humidity sensor: Humicap capacitance sensor with active de-icing method
- Temperature sensor: Resistive sensor
- geopotential height: calculated from GPS height

Site description:

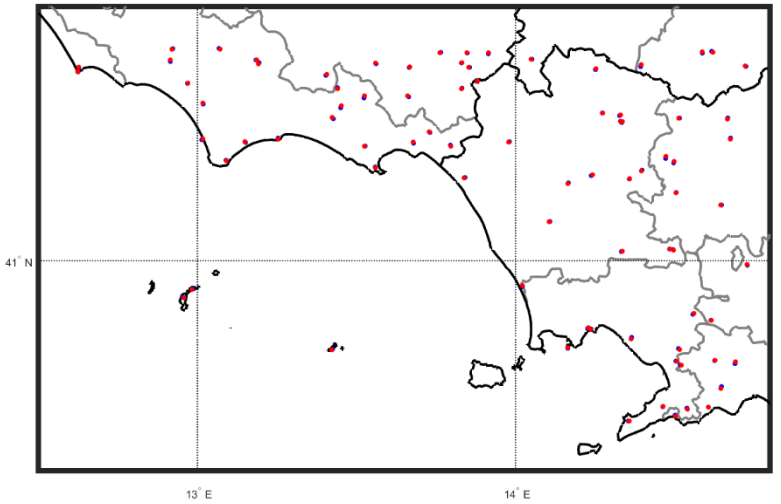
- Pratica di mare (LIRE)
- WMO code: 16245
- Lat = 41,65
- Lon = 12,45
- Alt = 32 m

- Ground Stations
- Model evaluation: comparison with ground observations downloaded from MISTRAL portal:
  - data provided by Italian Environmental Protection Agencies (ARPA)
  - T data loss in the week: 1.3 %
  - WS data loss in the week: 11%
  - RH data loss in the week: 2.9 %

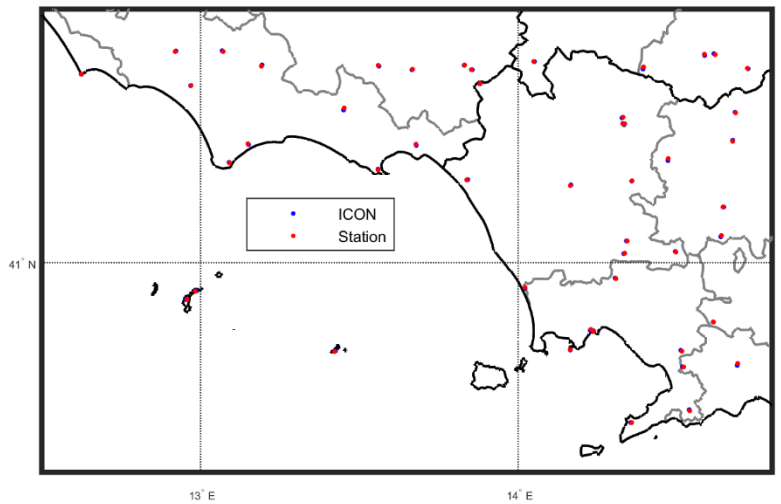
Source: https://www.mistralportal.it/it/

Meteo Italian Supercomputing Portal

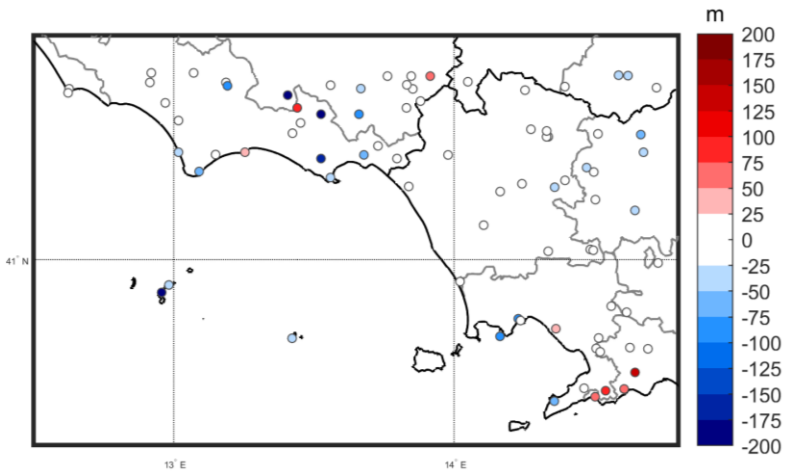
Temperature @ 2m Stations

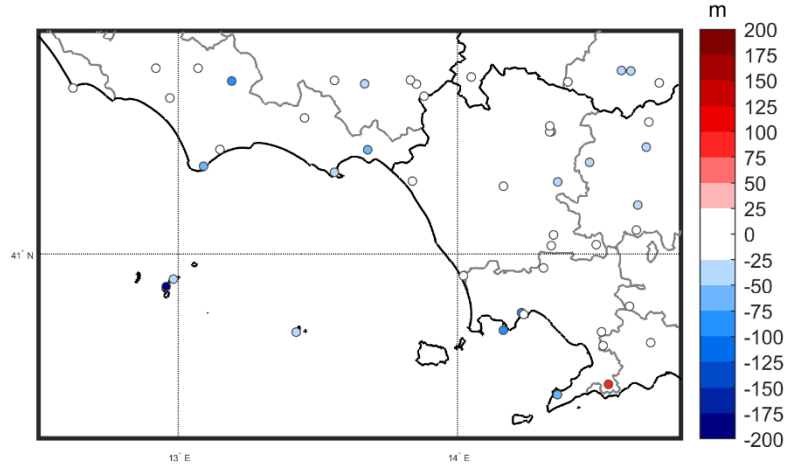


Wind Speed @ 10m Stations



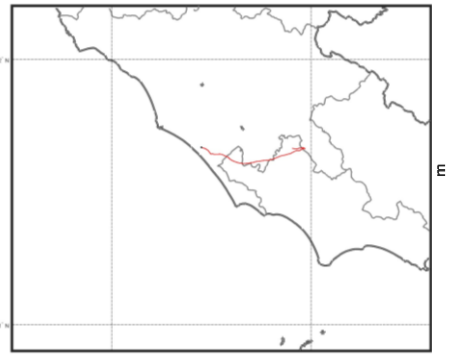
Stations height difference [m]





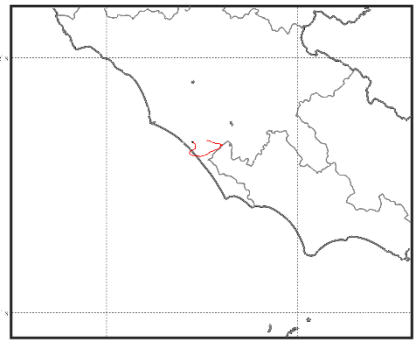
- T, Wind speed on horizontal plane

20220724 h00

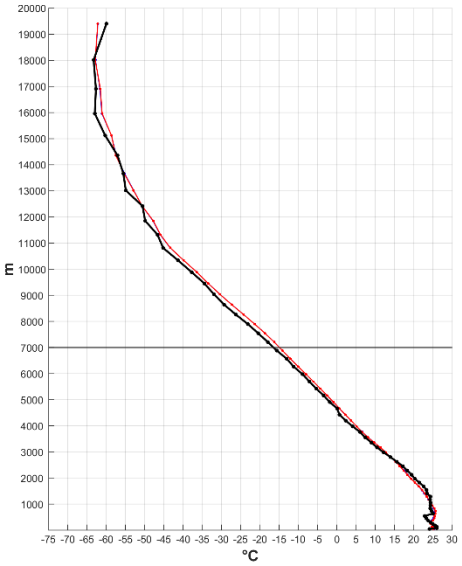


2d track, T, WS

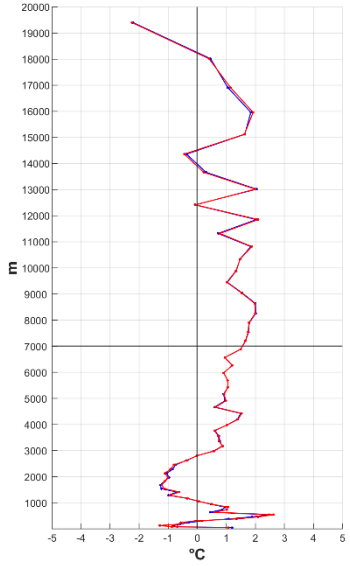
20220722 h12



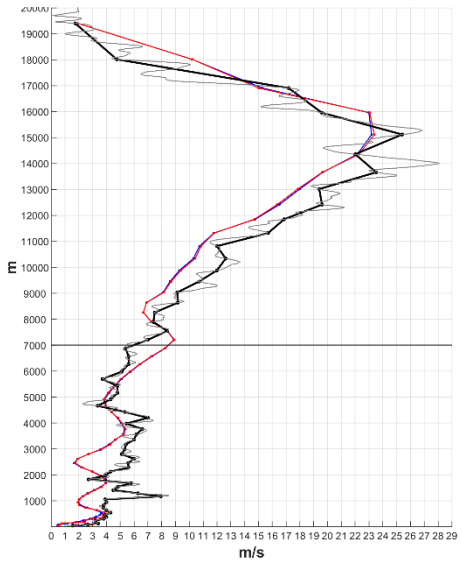
T



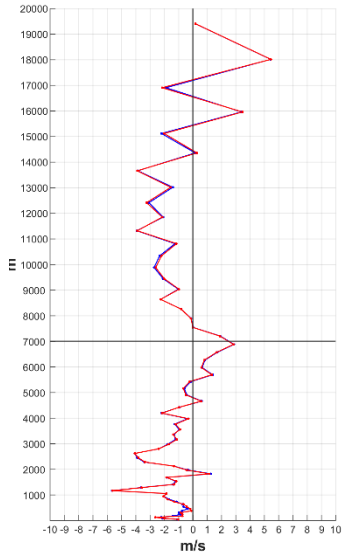
bias

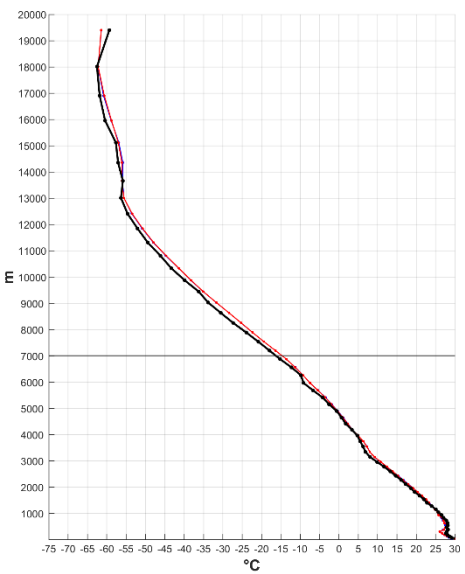


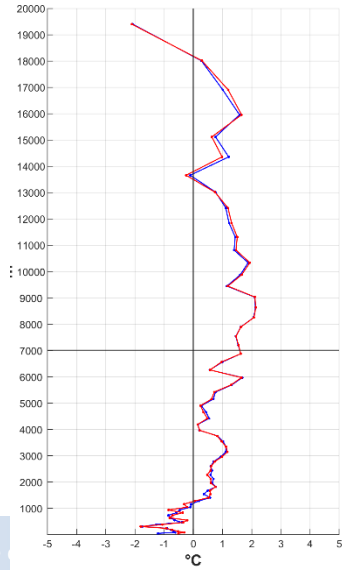
WS

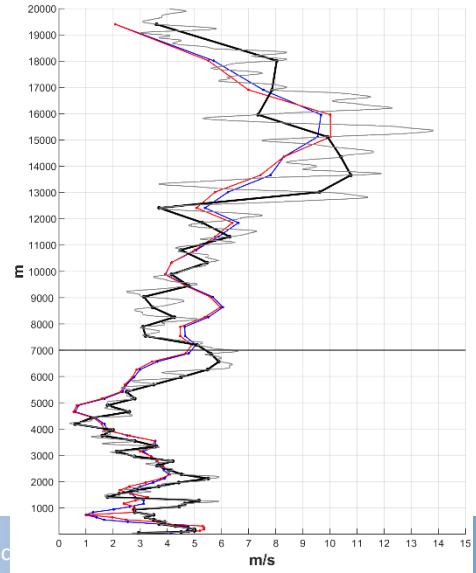


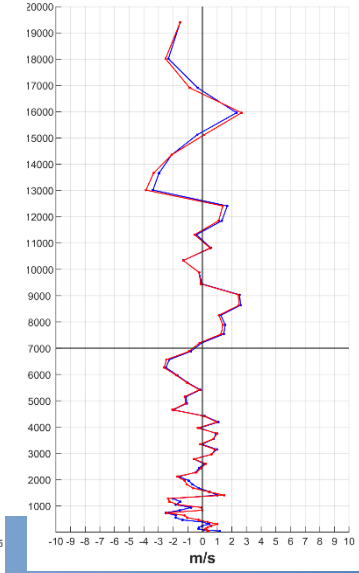
bias

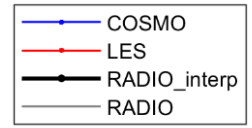










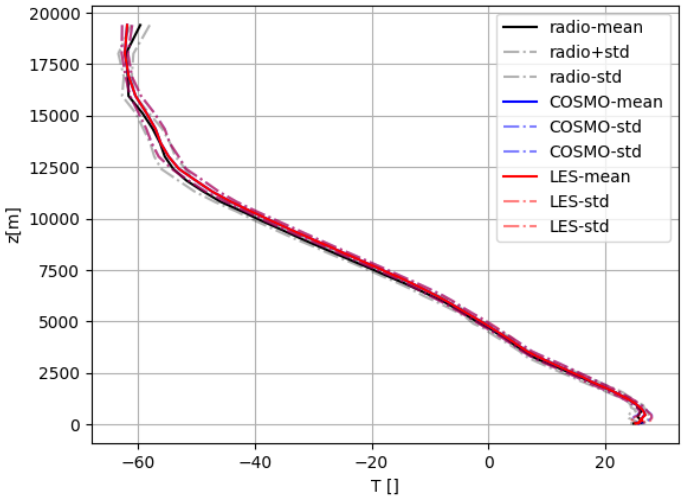


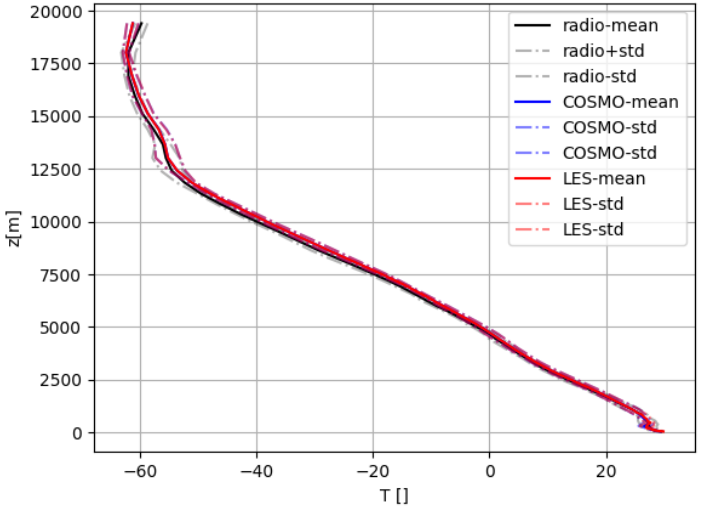
- Profiles averaged over the week, by time

00:00

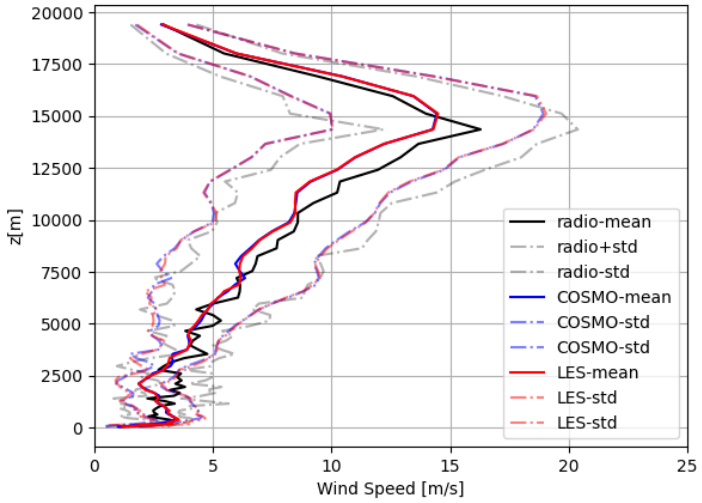
12:00

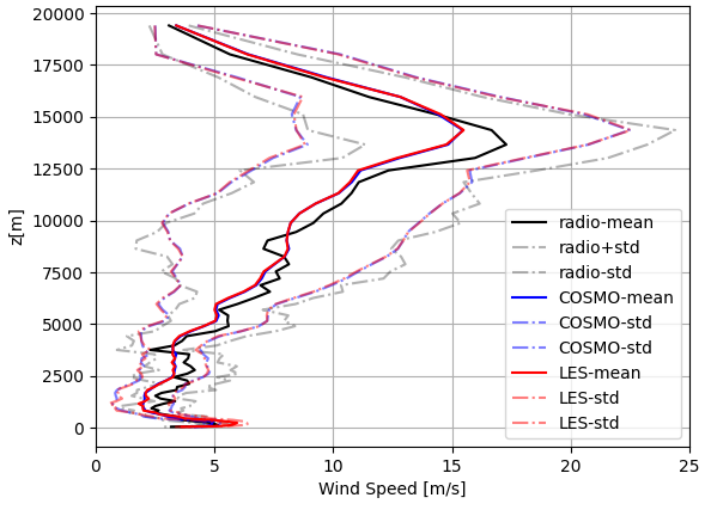
Temperature





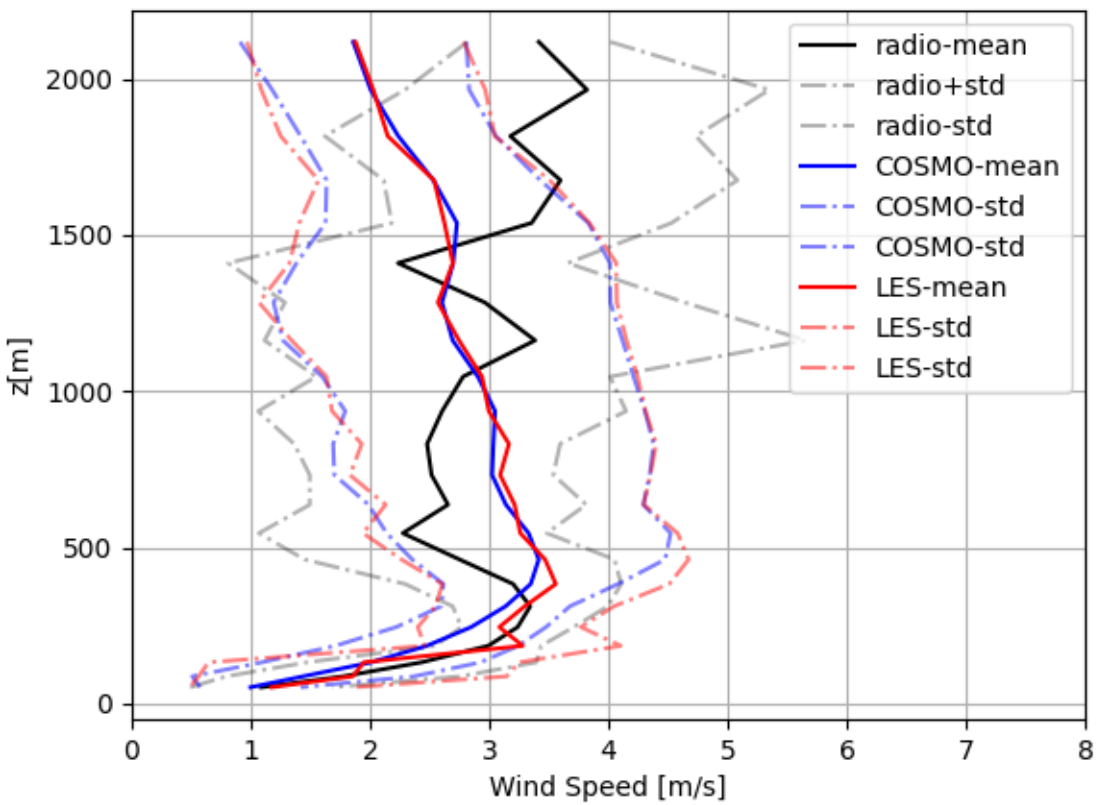
Wind Speed



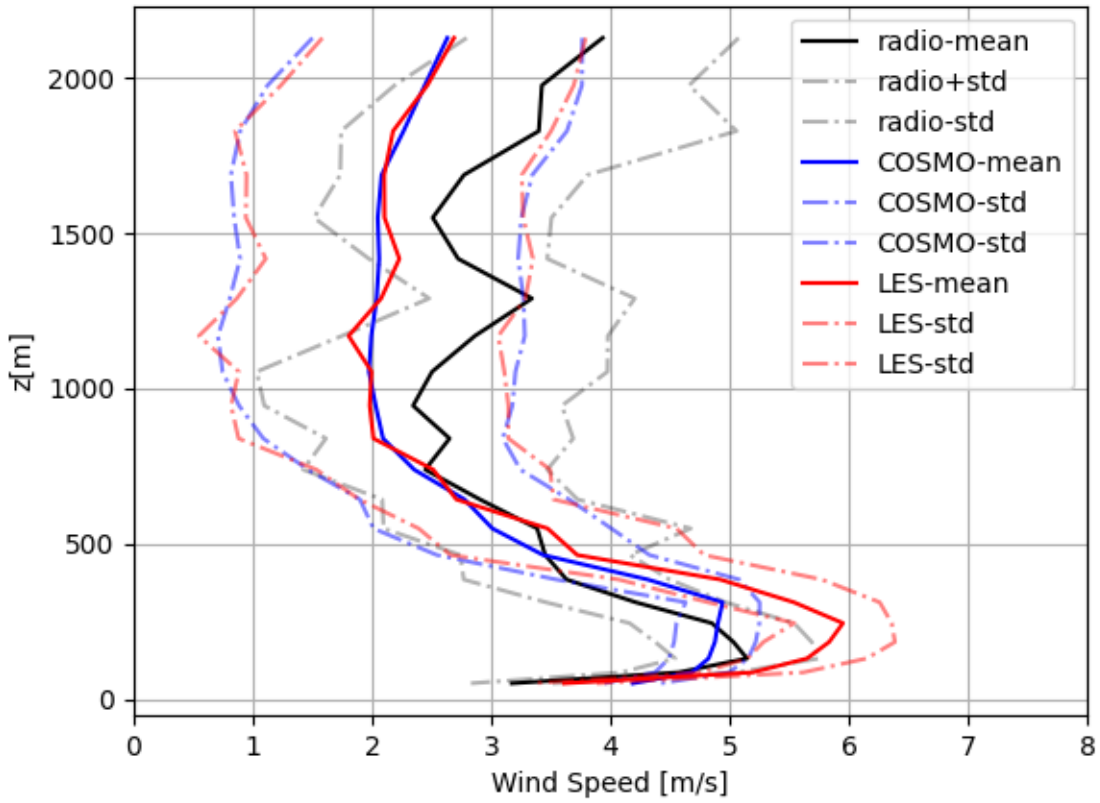


ZOOM: Wind Speed Averaged radiosounding

00:00

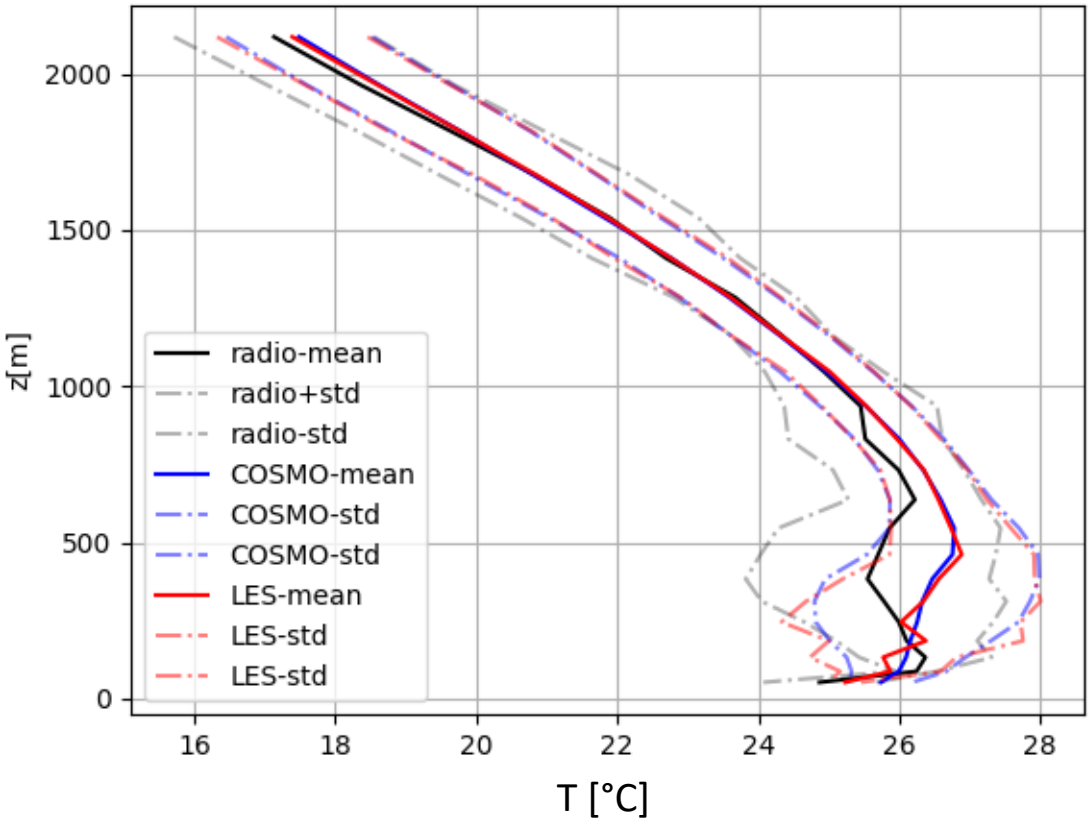


12:00

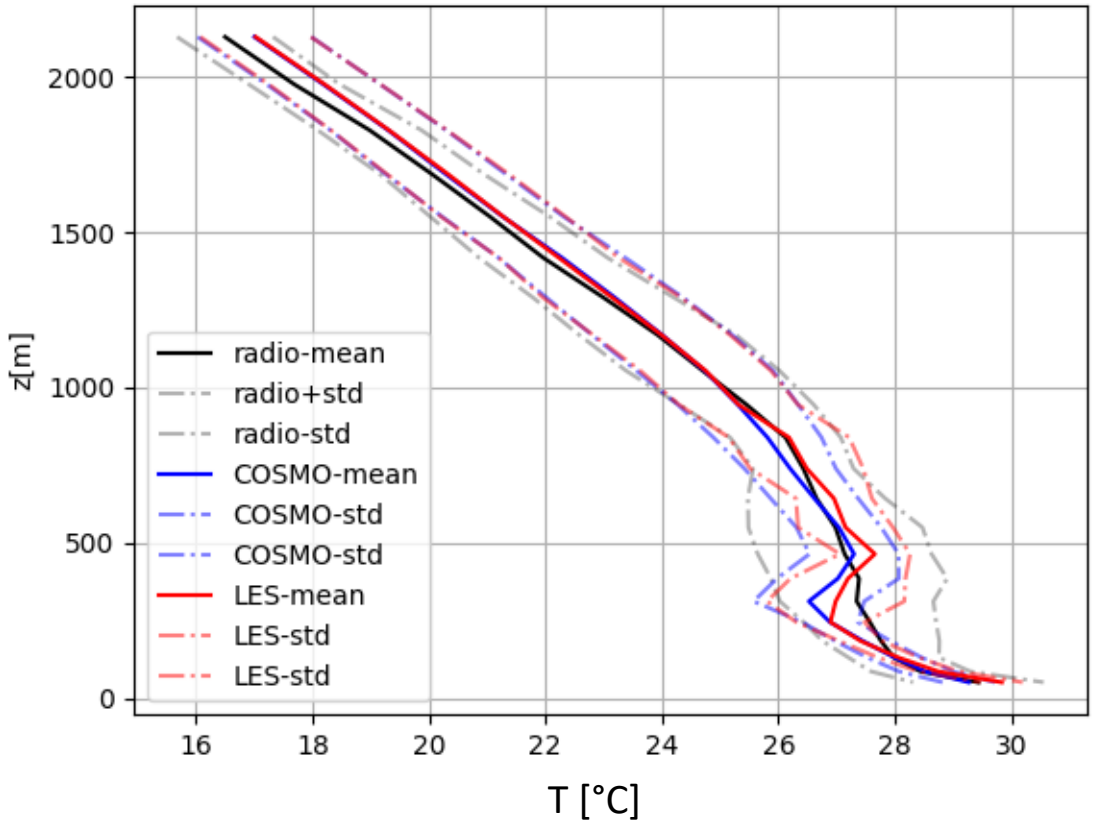


ZOOM: Temperature Averaged radiosounding

00:00

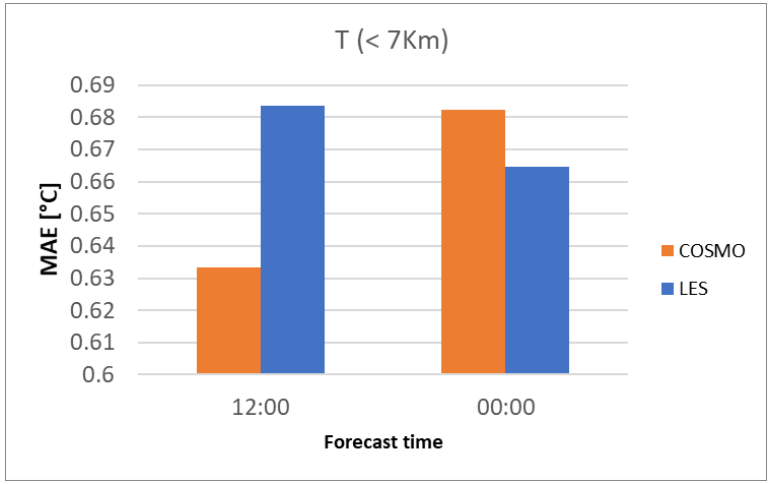


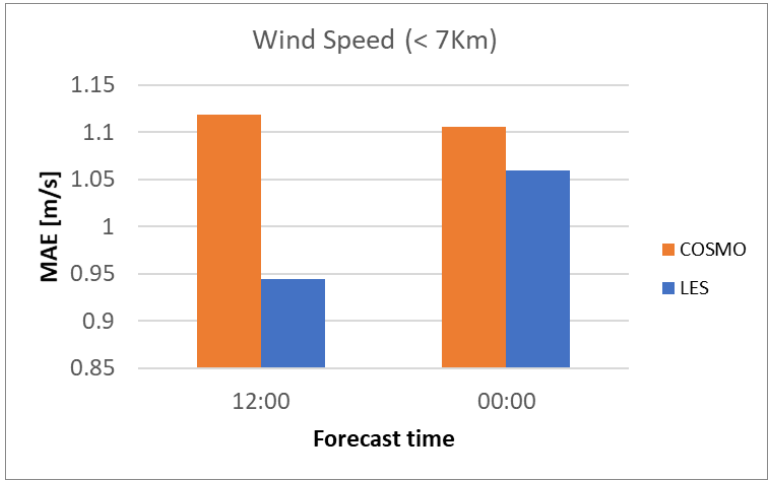
12:00

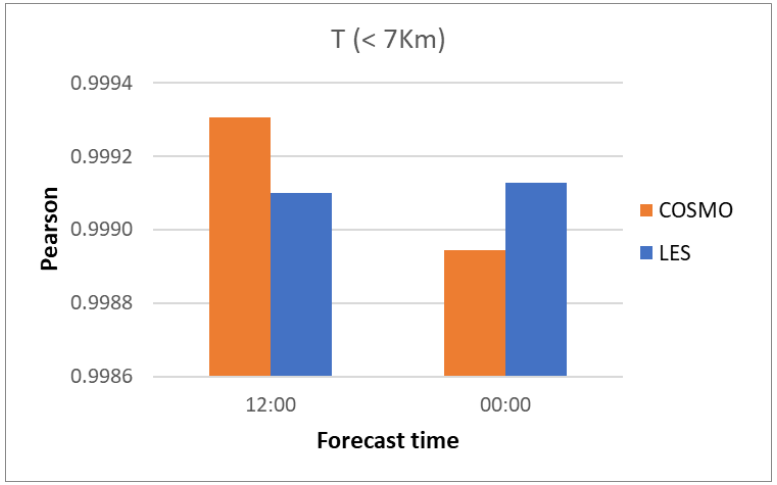


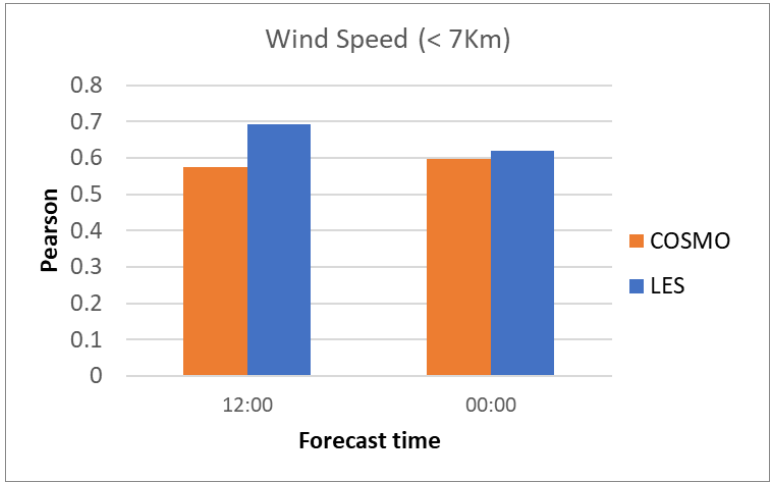
- 3D Error Estimation
  - metrics:
    - Pearson's coeff (RHO); MAE and MSE
  - Space sets:
    - Full profile, (0 – 22 km)
    - higher profile (> 7 km),
    - Lower profile (< 7 km)
  - Run time sets:
    - +17h (12:00)
    - + 29h (00:00)
  - Variables:
    - 3D T
    - 3D Wind Speed (on plane xy)
- Comments:
  - Better behavior of LES for WS
    - Lower MAE, higher RHO
  - COSMO is quite better for T, in the early forecast hours

Lower profiles: focus of MAE and RHO









- 3D Summary

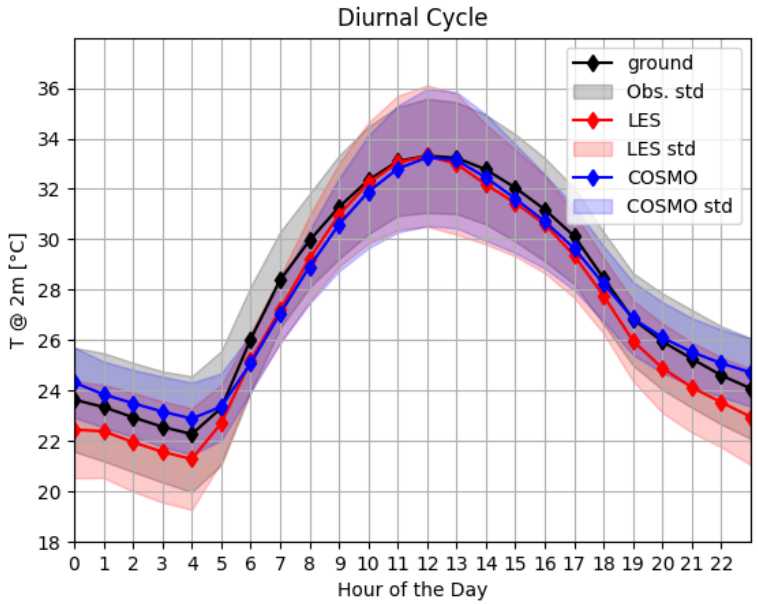
	12:00		
	full	>7 km	< 7 Km
RHO T	COSMO	COSMO	COSMO
mae T	COSMO	LES	COSMO
mse T	LES	LES	COSMO
rho WS	LES	COSMO	LES
mae WS	LES	LES	LES
mse WS	LES	LES	LES

	00:00		
	full	>7 km	< 7 Km
RHO T	LES	LES	LES
mae T	LES	LES	LES
mse T	LES	LES	LES
rho WS	LES	LES	LES
mae WS	LES	LES	LES
mse WS	LES	LES	LES

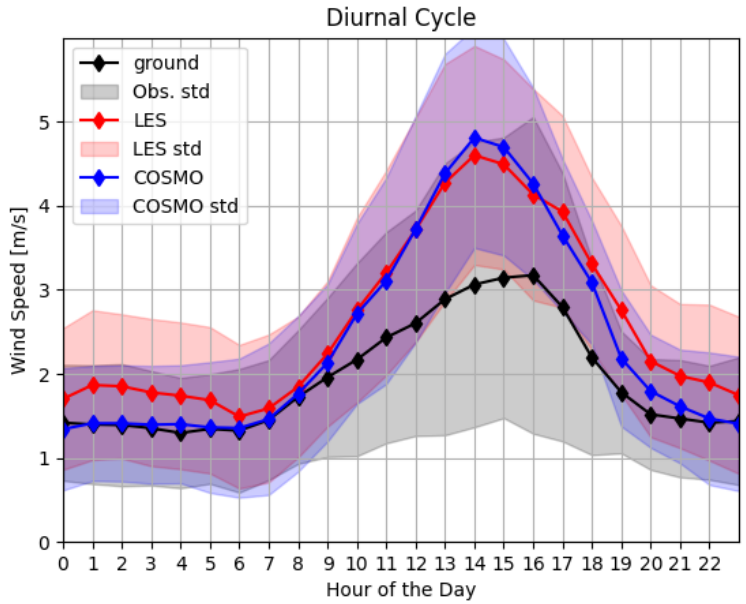
- Best metrics comparison:
  - 3D Temperature metrics shows better behaviour of COSMO turb in the lowest atmosphere layer.
  - Longer forecast run shows a better behaviour for LES turb model (00:00 @ 29h forecast time).
  - 3D wind speed LES metrics overperforms COSMO

- Diurnal Cycles of 2D variables

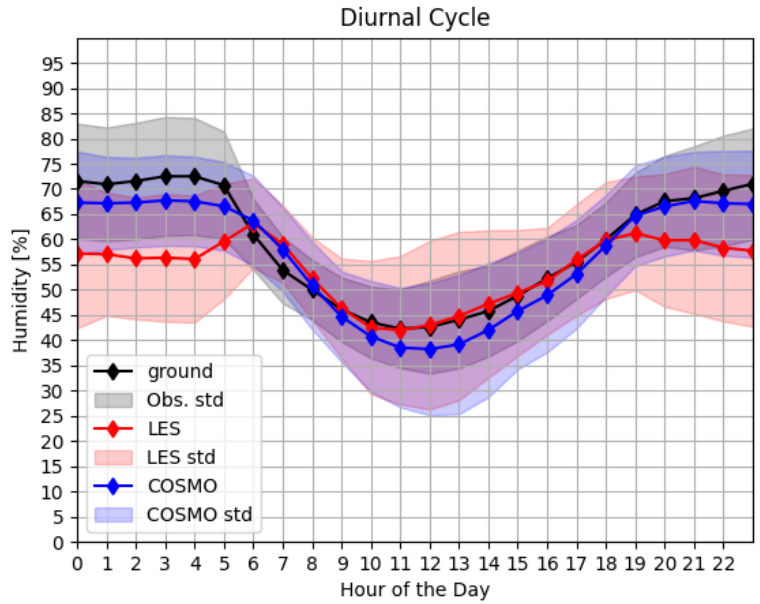
T @ 2m



Wind Speed @ 10m



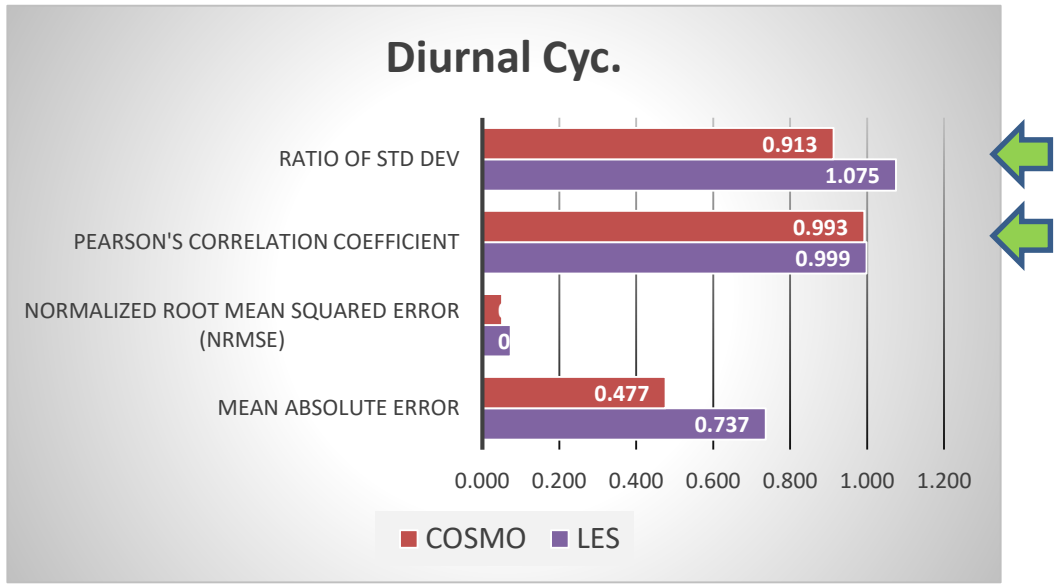
RH @ 2m



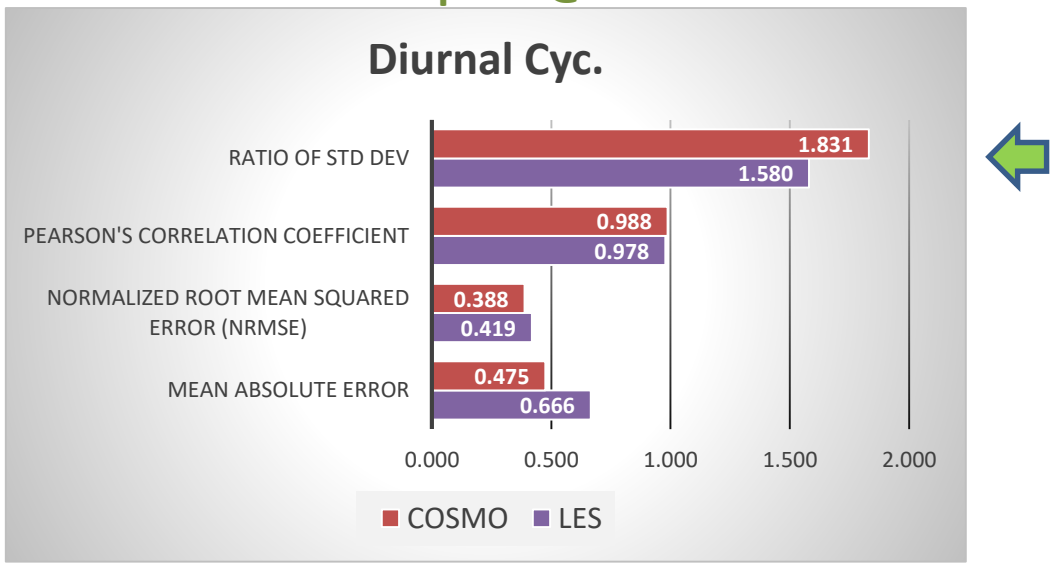
- **T @ 2m**: LES underpredicts during nighttime; slightly better in the morning (up to 12:00)
- **Wind Speed @ 10m**: LES overpredicts during nighttime; better in the afternoon (only in terms of decreasing rate)
- **RH @ 2m** : LES overperforms from 6:00 to 18:00, then underestimates

- Diurnal Cycle metrics

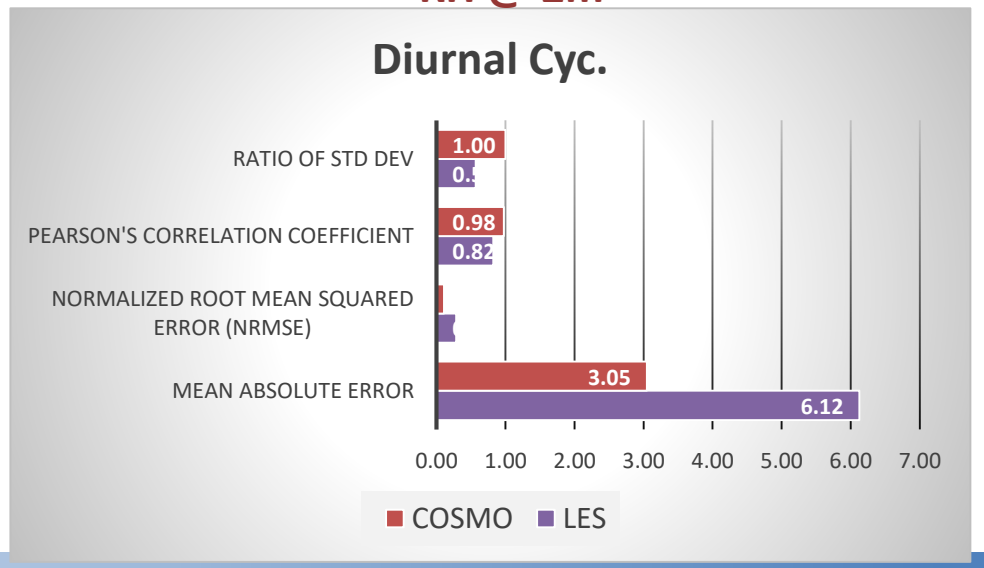
T @ 2m



Wind Speed @ 10m



RH @ 2m



highlights of LES better performance metrics:

- Comparison of ICON –LAM vs ICON-LEM performed over a region in Southern Italy
  - 7-day simulation, considering a week with a severe heat wave in July 2022
  - Observational data considered to quantify models error:
    - Good performance of LES with 3D profiles
    - Some investigations are due on ground stations comparison

THANK YOU FOR YOUR ATTENTION!