TERRA_URB: Assessment of the new scheme in the Naples domain STATUS AND PLANS

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27th COSMO General Meeting - Basel, Switzerland 01-05 September 2025

Parallel Session WG PHY / PP CITTA' (Urban Modelling) – 02 Sept 2025

- CIRA activities in Task 3 of COSMO Priority Project CITTA
  - SubTask 3.3 - Numerical Experiments: Naples
    - Domain and Time Window description
  - ICON settings
- Investigations Summary:
  - TU on vs TU off
  - interaction of Urban Canopy Schemes with grid size, soil, turbulence
- Results
  - Spatial Analyses
  - Temporal Analyses
  - UHI
- Conclusion and planning

Simulated Period:

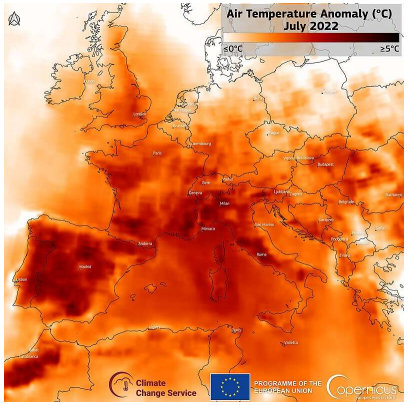
- Heat waves over Europe from June to August 2022
- July 2022: severe heat waves over Italy
- ICON forecast run from 18 to 24 July 2022

Computational Domain:

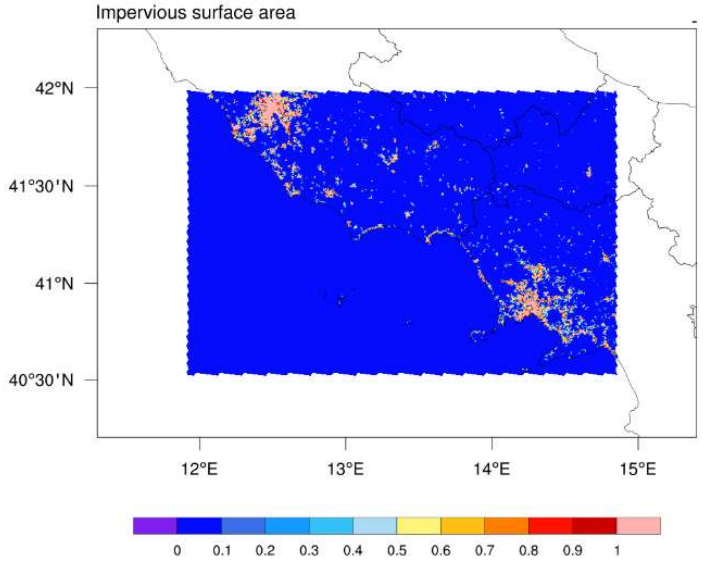
- Lazio-Campania Southern Italy regions
  - REF grid: ncells = 109860; ~ 0.6 Km (R02B12)
- Vertical resolution:
  - levels: 65
  - First level: 20 m; Top height: 22.000 m

Focus on:

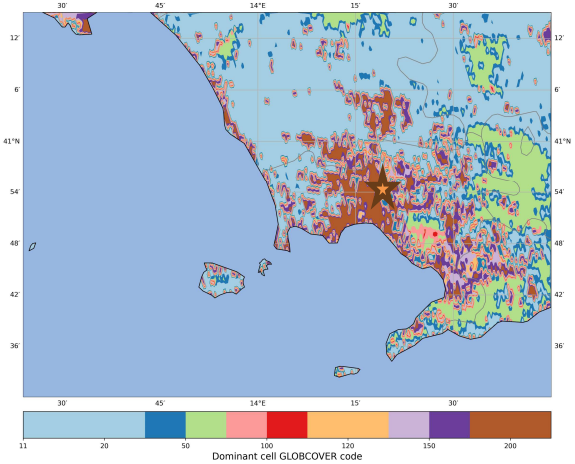
- Naples Large Metropolitan Area
  - **Piana Campana**: vaste planar area on which urban conurbation of Caserta and Napoli cities is growing
  - Area includes also parts of Caserta, Benevento and Salerno province.



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



Land cover type



Main ICON LAM settings (Reference Configuration - REF) - icon.2024.1 :

BC's and IC's:

- IC: **DWD Soil + IFS** Analysis @ 18:00
- Forecast time: 30h
- BCs reads @ IFS forecast every 3h
- Timestep size
  - 6 s

REF Iterra_urb Parameters

- Urban Albedo
- Antropogenic Heat Flux contribution active
  - AHF = const. = 15 w/m^2
  - *urb_isa* bounds = (1.0, 1.0)
- itype_kbmo = 2 [Brutsaert-Kanda parameterisation for bluff-body elements]
- itype_eisa =3 [evaporation from impervious surface Area - PDF-based puddle evaporation]
- Terra Soil Tiles = 3

Parameterization schemes

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

Land use & Orography

- Land use: GLOBCOVER 2009
- Orography: ASTER

ANALYSES PERFORMED

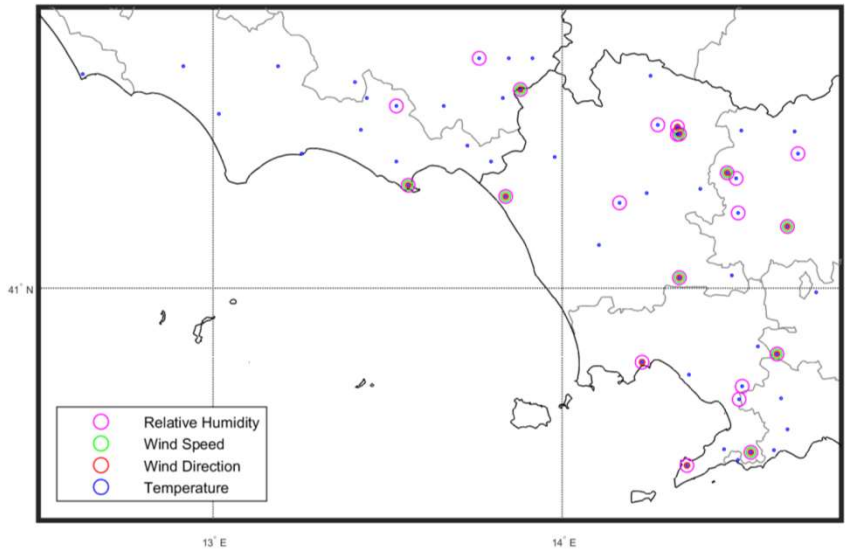
- Investigations on the interaction of Urban Canopy Schemes with:
  - *GRID resolution*
    - grid at 1.2km (R02B11) **vs** 0.6 km (R02B12)
  - *SOIL initialization*
    - IC's : IFS Soil + **IFS** Analysis @ 18:00 **vs** ICON soil
  - *Turbulence models*
    - COSMO diffusion and transfer: TURBDIFF and TURBTRAN (Raschendorfer (2001))
      - surface heat fluxes with ***three tiles (3)*** in TERRA
      - Test with ***one tile*** in TERRA
    - Smagorinsky-Lilly model (Dipankar A., (2015)): 3D sub-grid model of Smagorinsky (1963) with the stability correction of Lilly (1962)
      - (surface heat fluxes **with one** tile in TERRA)
  - *Antropogenic Heat Flux* terms in TERRA_URB:
    - AHF: const. vs. ***AHF(T2m,clm)***

ICON CONFIGURATION RESULTS COMPARISON

- Comparison of:
  - **REF**(0.6 km; Icon Soil; 1D turb; TU on, tiles=3) **vs:**
    - **REF-1km** (***1.0 km***; Icon Soil; 1D turb; TU on; tiles=3)
    - **LES** (0.6 km; Icon Soil; ***3D turb***; TU on; tiles=1)
    - **IFS** (0.6 km; ***IFS Soil***; 1D turb; TU on; tiles=3)
    - **AHF** (0.6 km; Icon Soil; 1D turb; ***AHF(T)***, tiles=3)
    - **REF-1 Tile** (0.6 km; Icon Soil; 1D turb; TU on, ***tiles=1***)
  - Results
    - Diurnal cycles:
      - T2m,Rh2m,Ws10m,Wd10m, Sensible Hf Qs; Latent HF Qle; Bowen Ratio (Qs /Qle); UHI
    - 2D Fields:
      - T2m,Rh2m, UHI

❑ Ground Stations

- Model evaluation: comparison with ground observations downloaded from MISTRAL portal
- Station selected in a box defined as [12.00, 14.75, 40.5, 41.5]



Variable	Stations	Altitude, z		Soil type		
		200 m	200m	Rural	Hybrid	Urban
T2m	57	37	20	43	7	2
Rh2m	24	18	6	18	3	2
Ws 10m	12	9	3	6	2	2
Wd 10 m	15	12	3	8	2	1

Number of stations available:

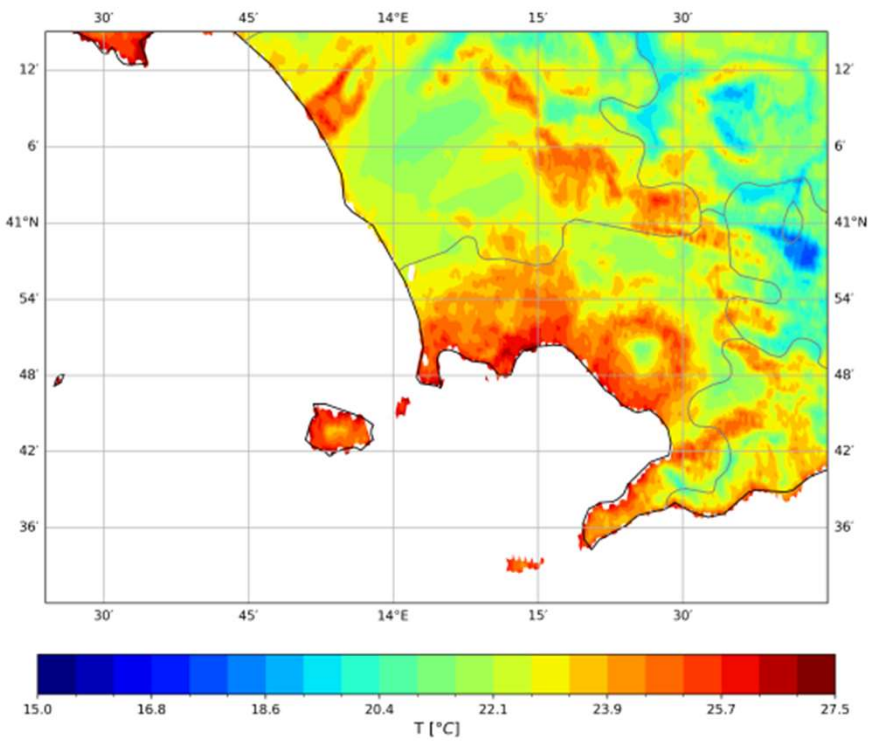
- ✓ T2m: 57
- ✓ WS10m: 24
- ✓ RH2m: 12
- ✓ WD10m: 15

Stations Sets:

- ***urban_fraction:***
  - *> 0,75 urban;*
  - 0.25 < hybrid >0.75;
  - *< 0,25 rural;*
- ***Altitude (z)***
  - <200m;
  - >200m;

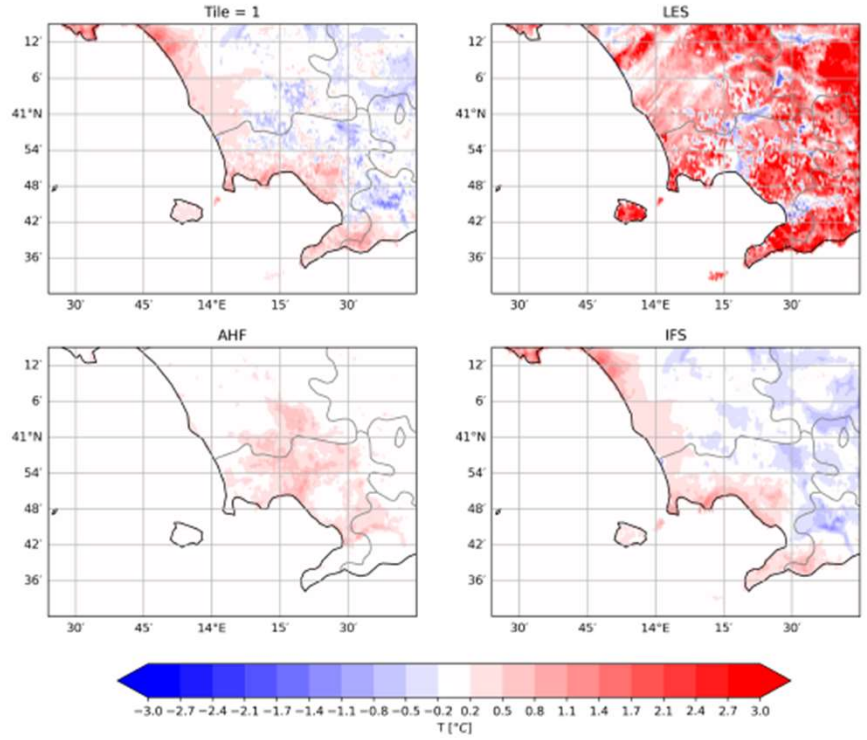
SPATIAL PATTERN: T2M

Averaged at 4:00 am



(a) T2m field obtained with Ref configuration

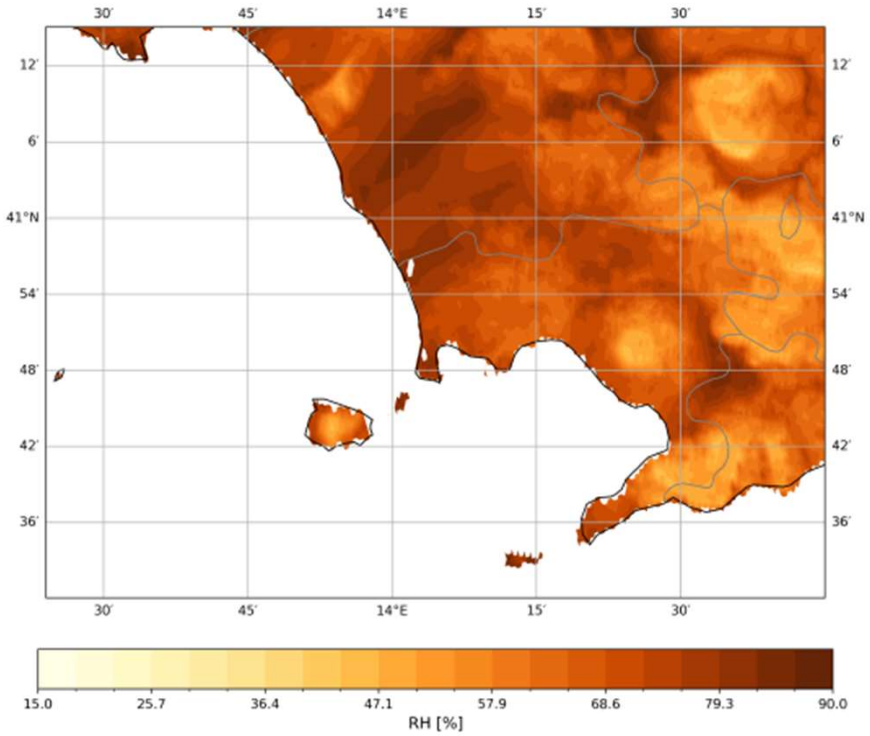
$T2M_{REF} - T2M_{EXP,i}$



(b) Maps of differences with respect to Ref configuration.

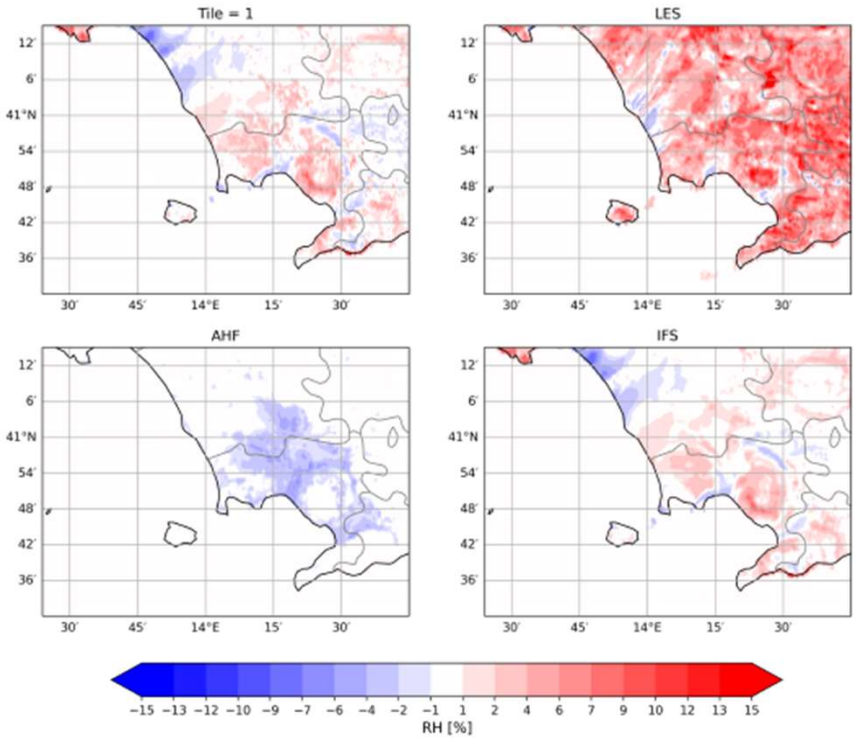
Cinquegrana et al, *The impact of grid resolution, turbulence model and soil forcing over performances of ICON model with TERRA-URB at hectometric scale*., submission is **UNDER REVIEW** at *Meteorology and Atmospheric Physics*

Averaged at 4:00 am



(a) Rh2m field obtained with Ref configuration

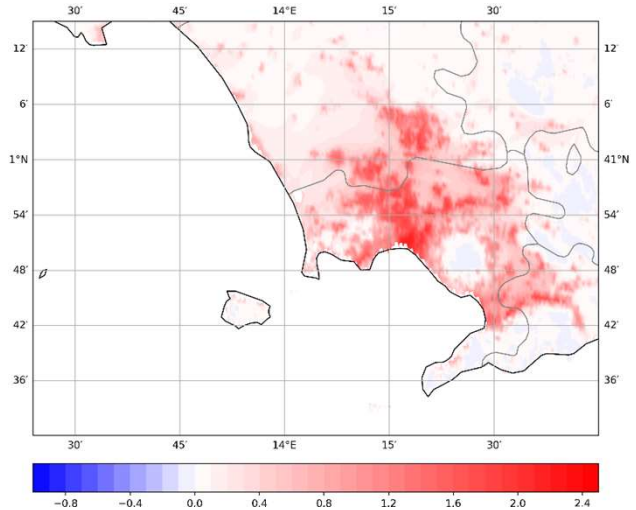
$RH2M_{REF} - RH2M_{EXP,i}$



(b) Maps of differences with respect to Ref configuration

NightTime
(18.00 – 6.00)

REF



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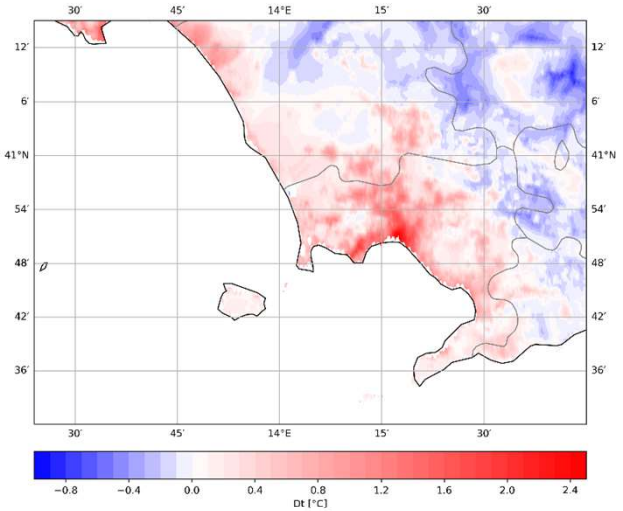
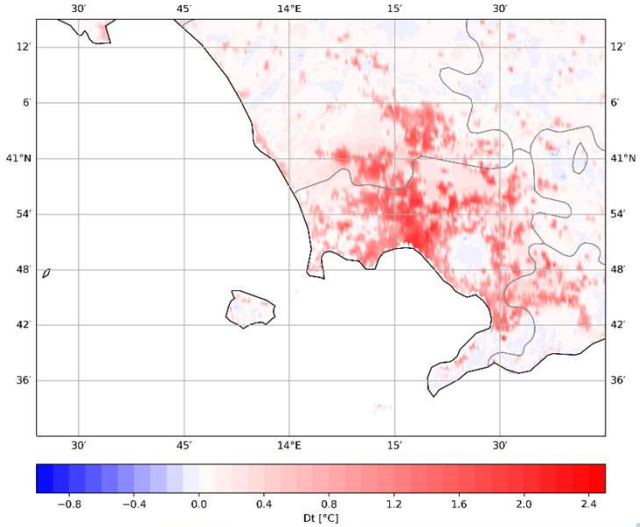


LES



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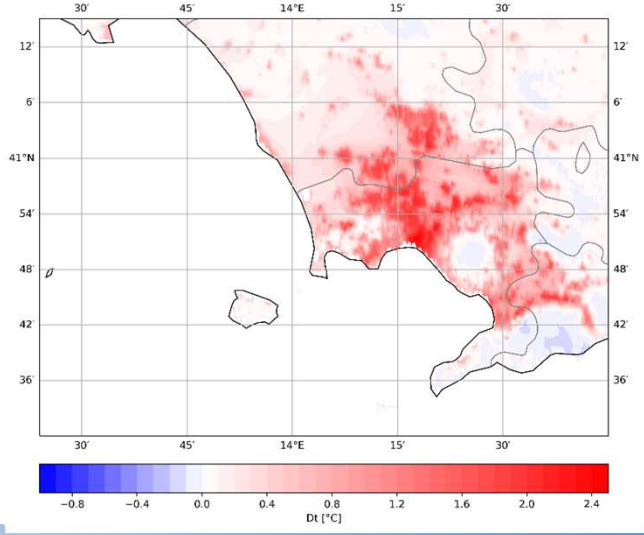

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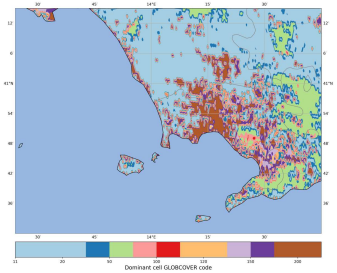

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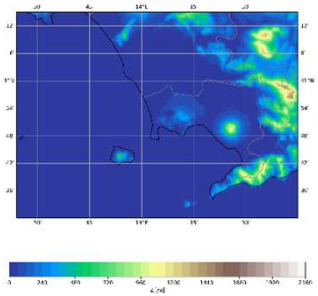
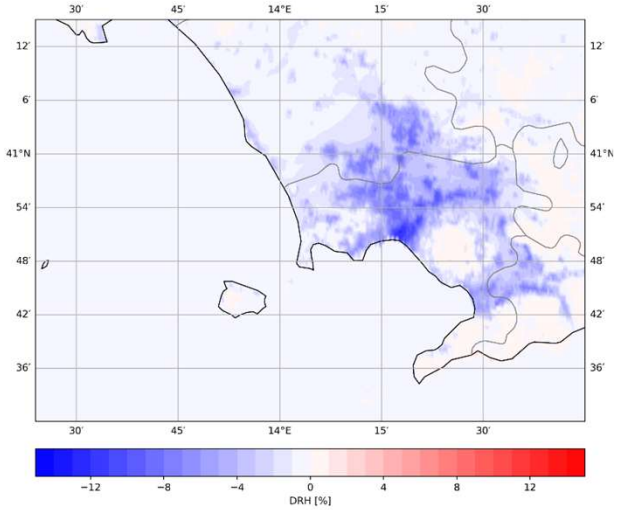


SPATIAL PATTERN - UDI : TU ON – TU OFF

NightTime
(18.00 – 6.00)

REF



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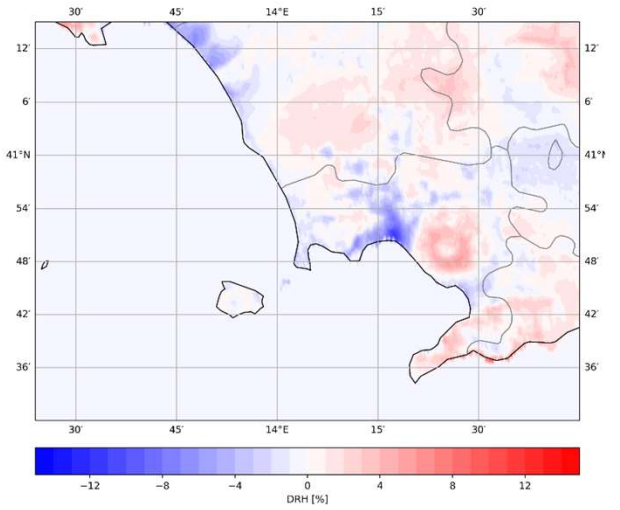
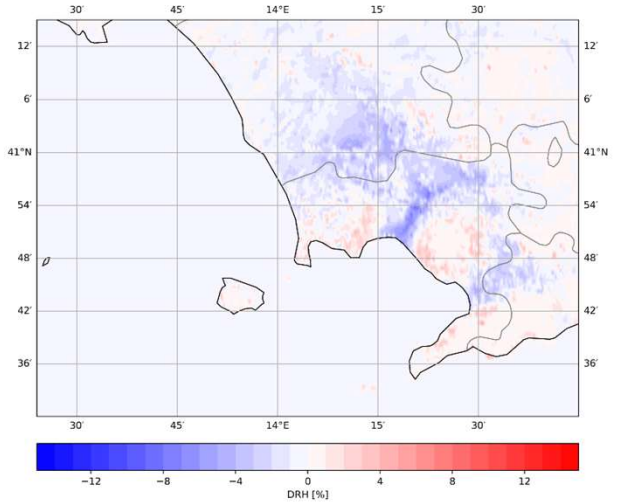
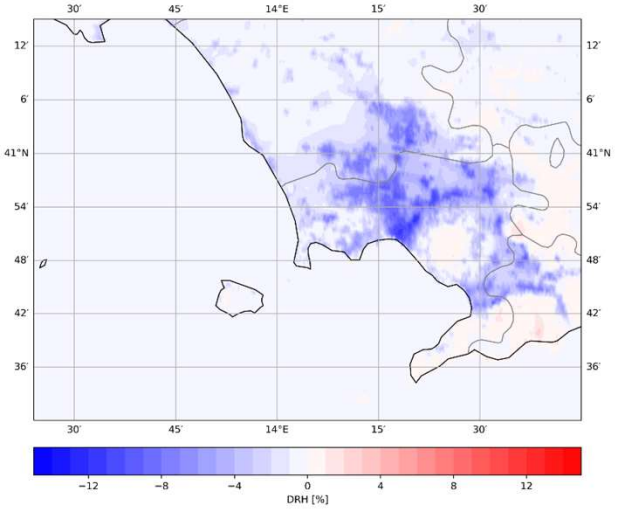


LES



IFS-SOIL



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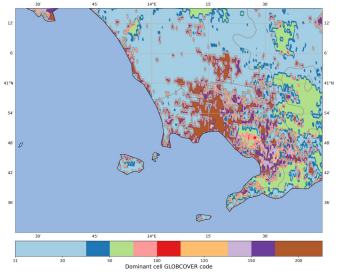

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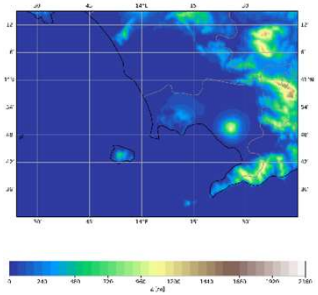
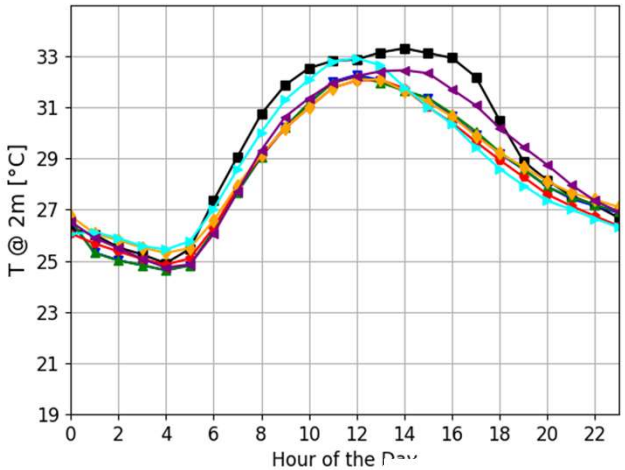


urban



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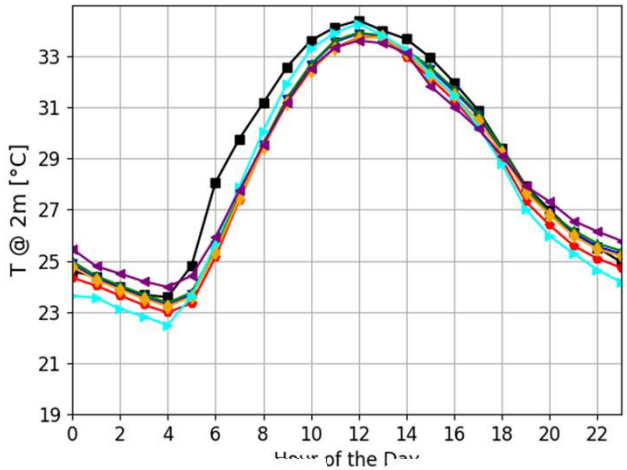
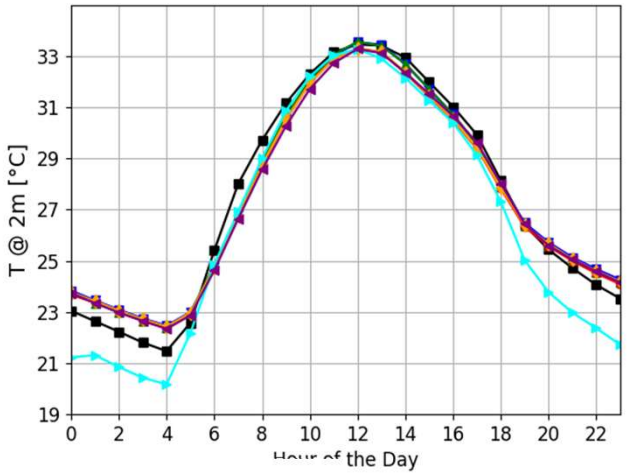
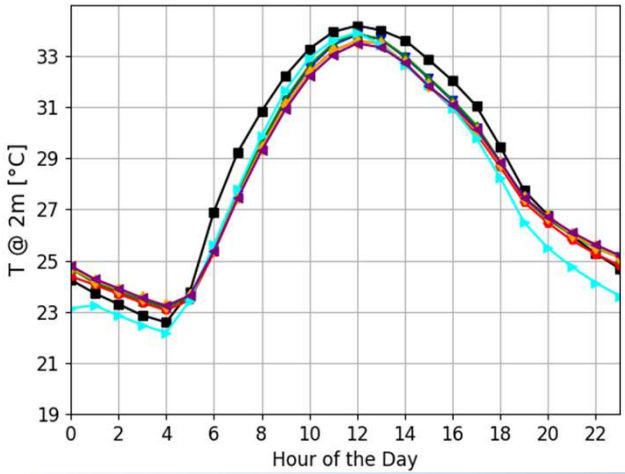


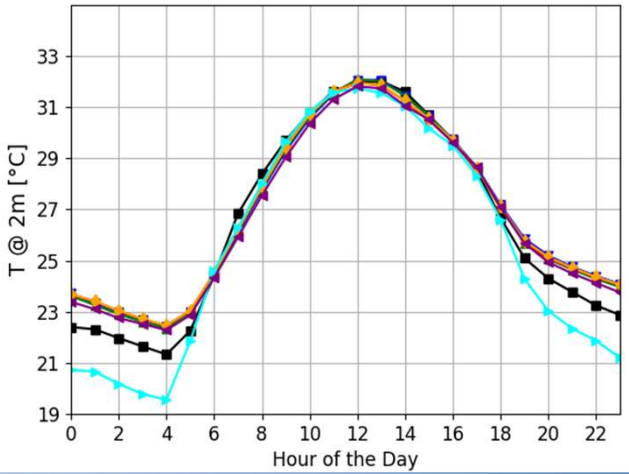
rural



< 200 m

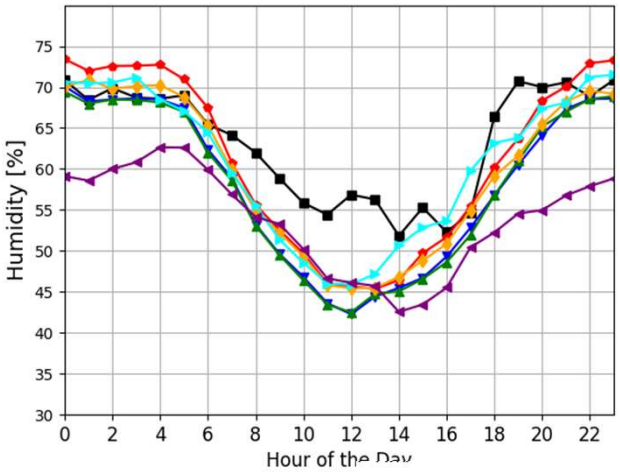


> 200 m

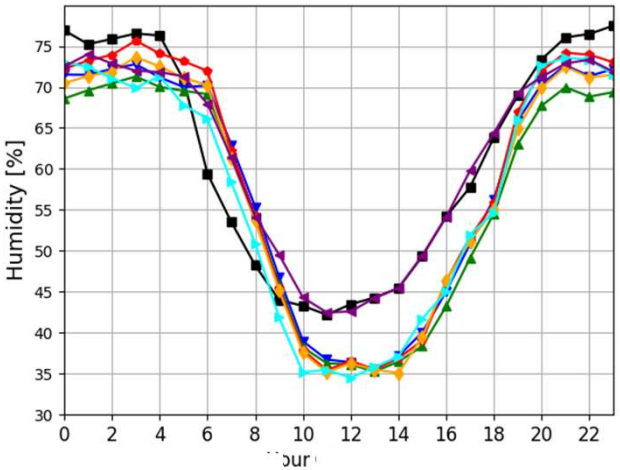


Obs. avg | Soil(IFS) | Tiles=1 | AHF(T) | REF | Turb(LES) | Grid(1km)

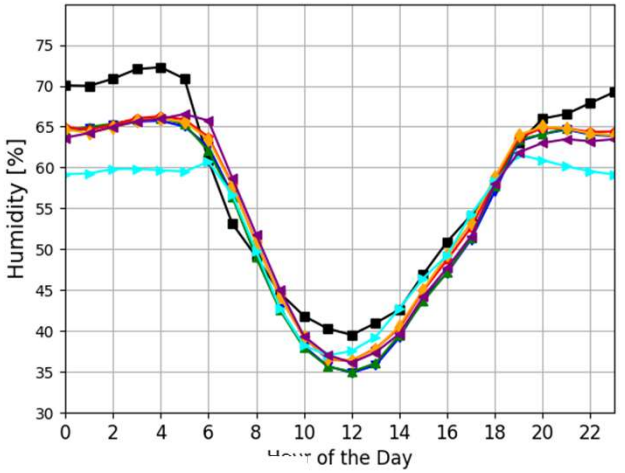
urban



hybrid



rural



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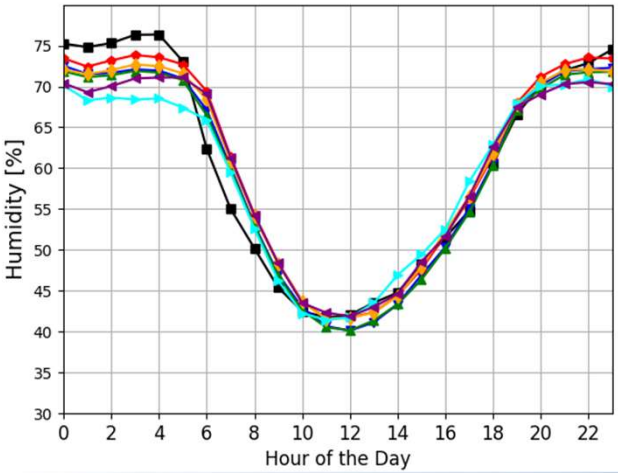

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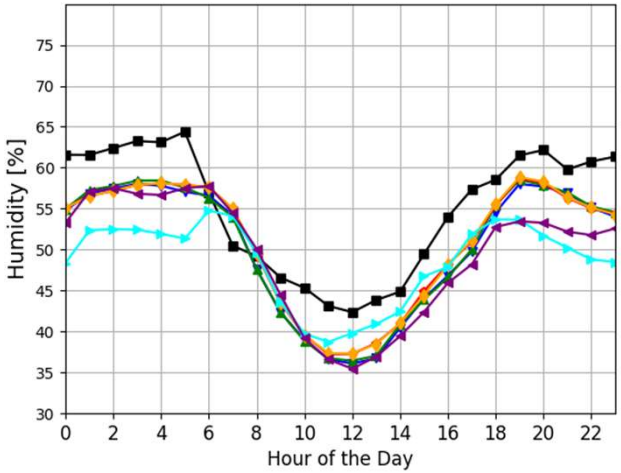
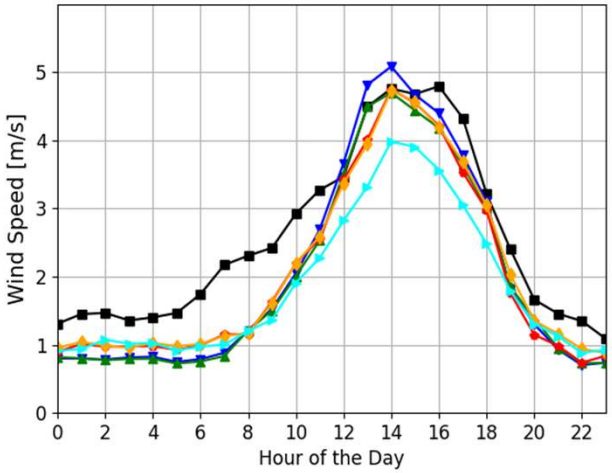
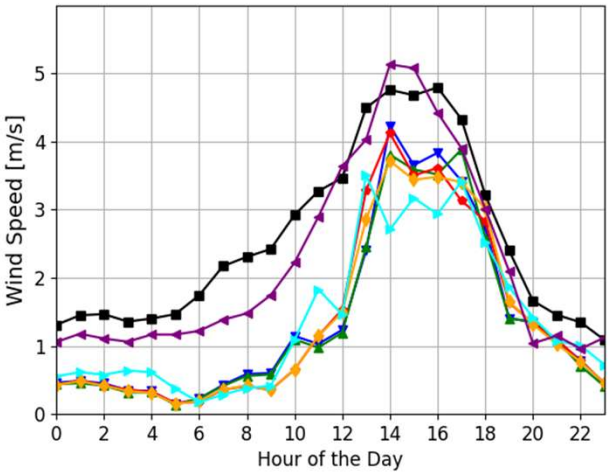


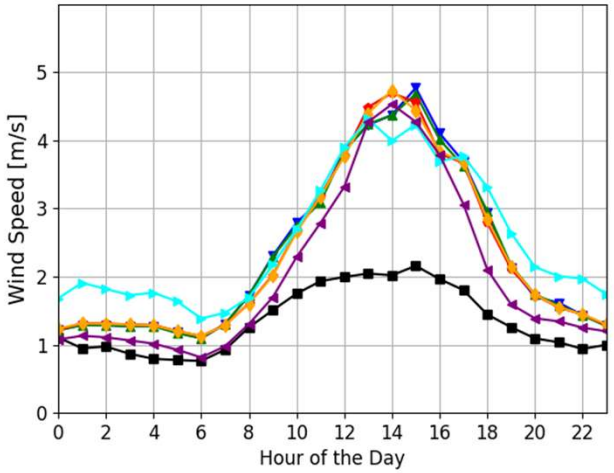
urban



Hybrid



Rural



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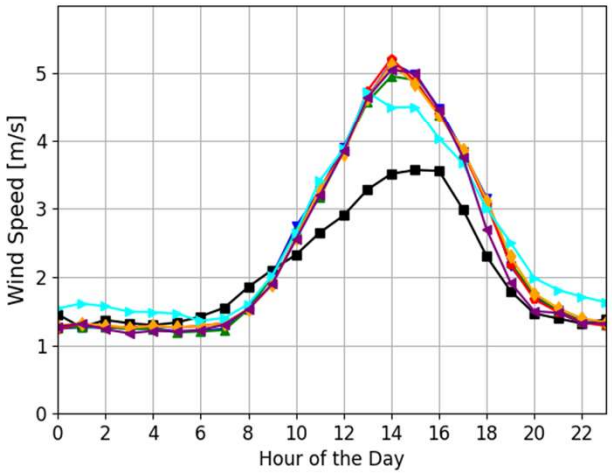

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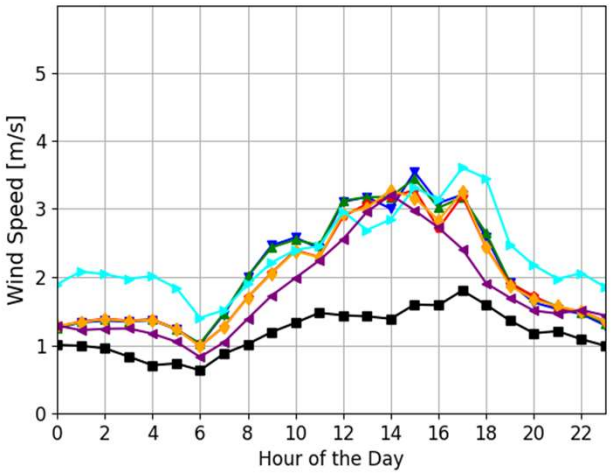

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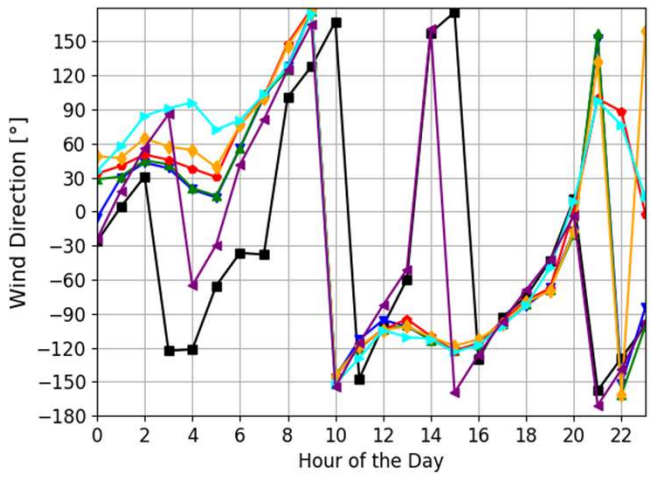
urban



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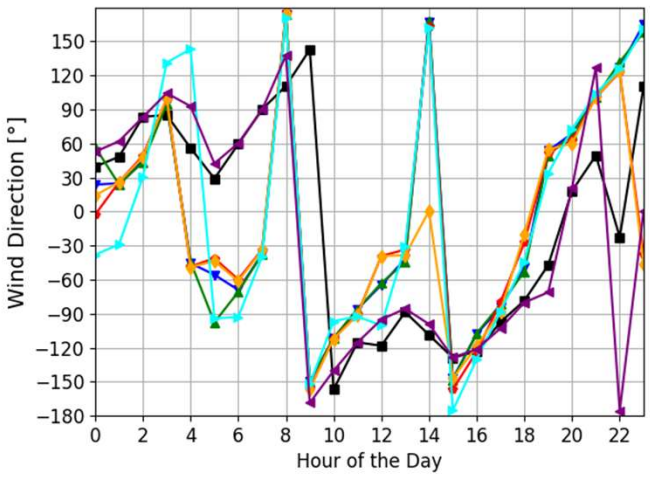

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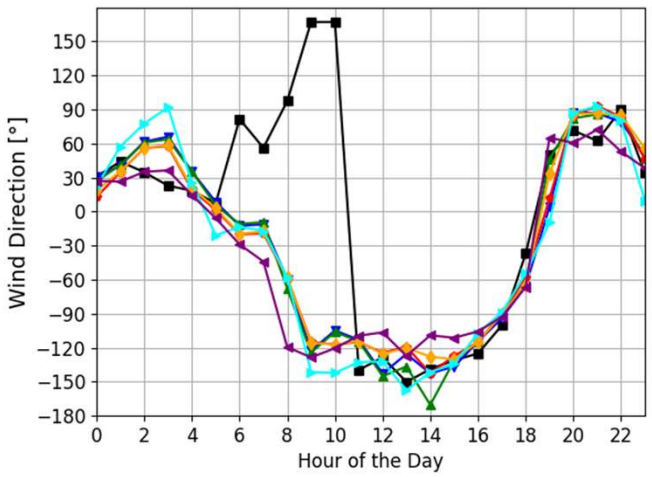

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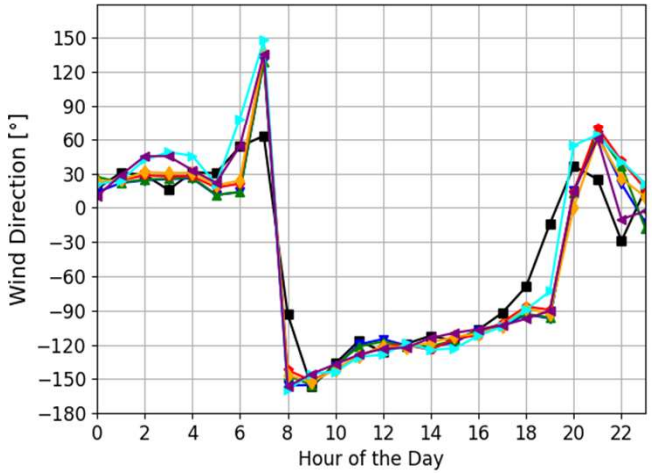

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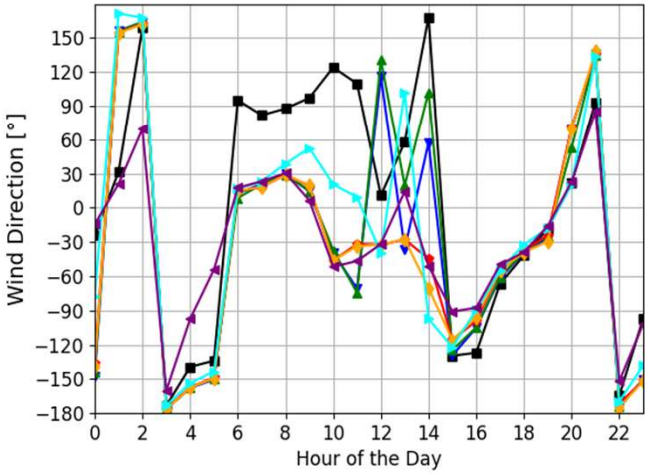
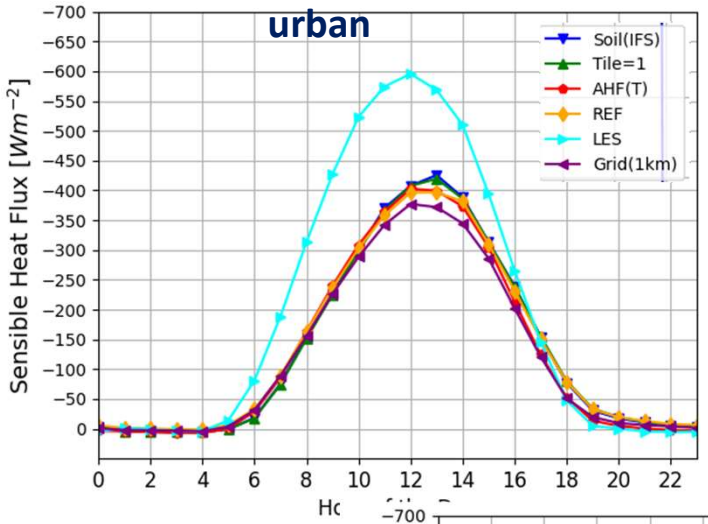
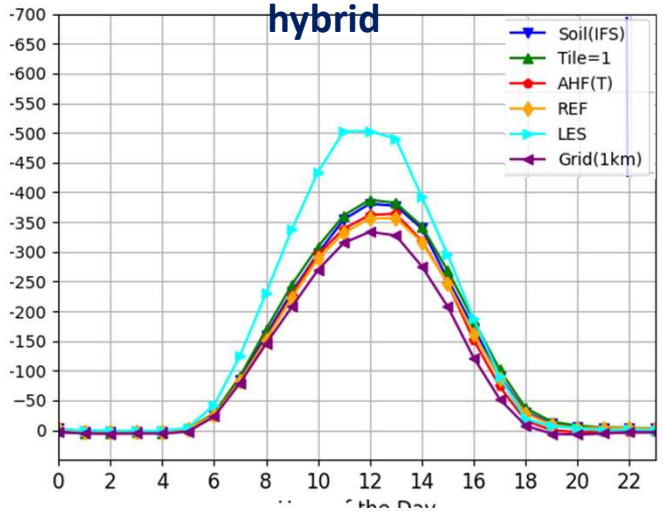
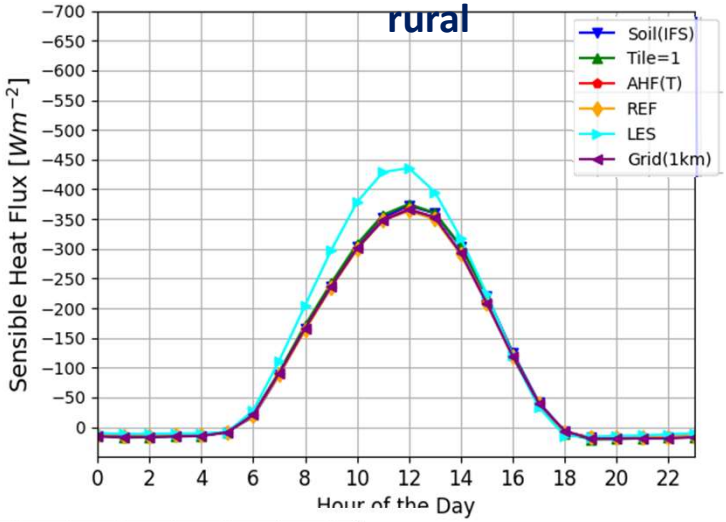
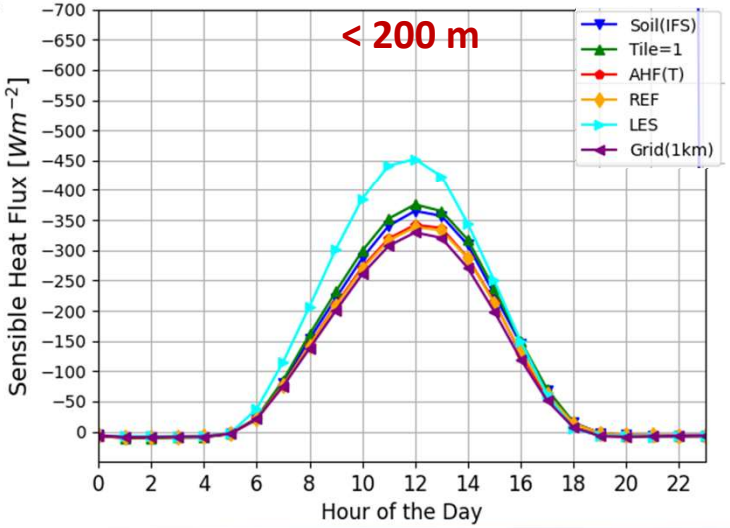
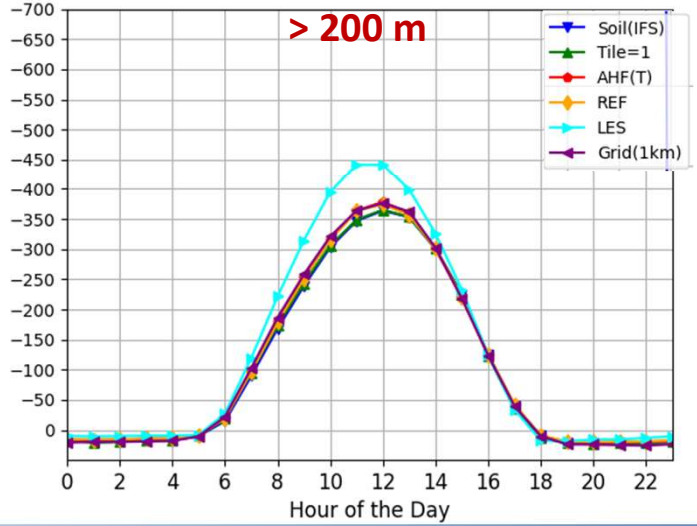


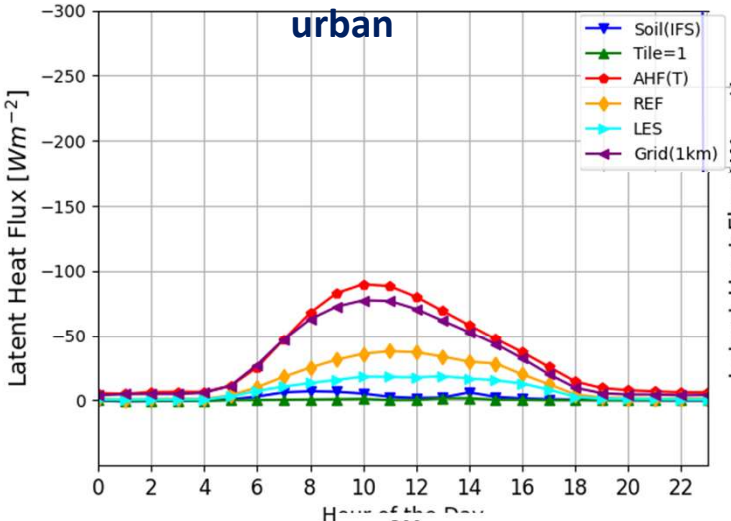


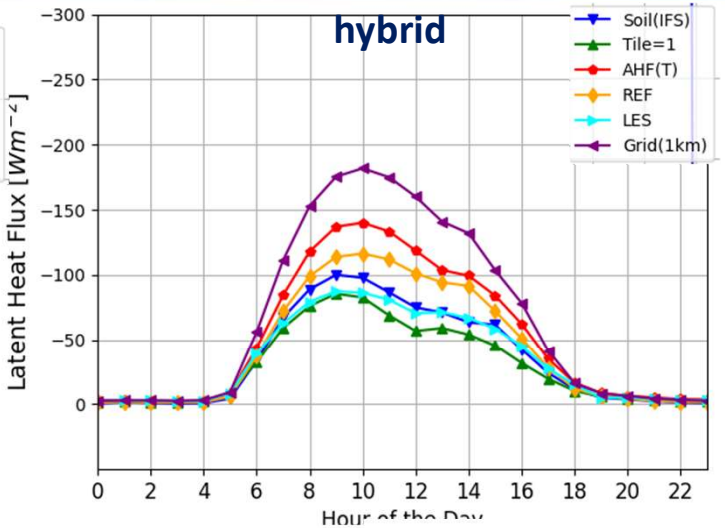


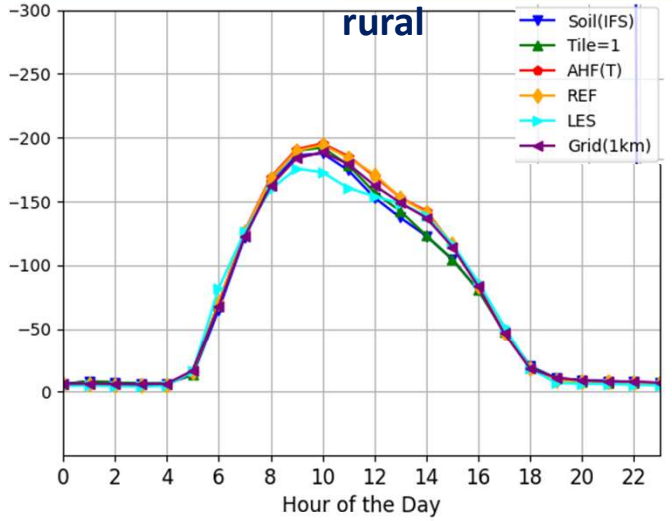


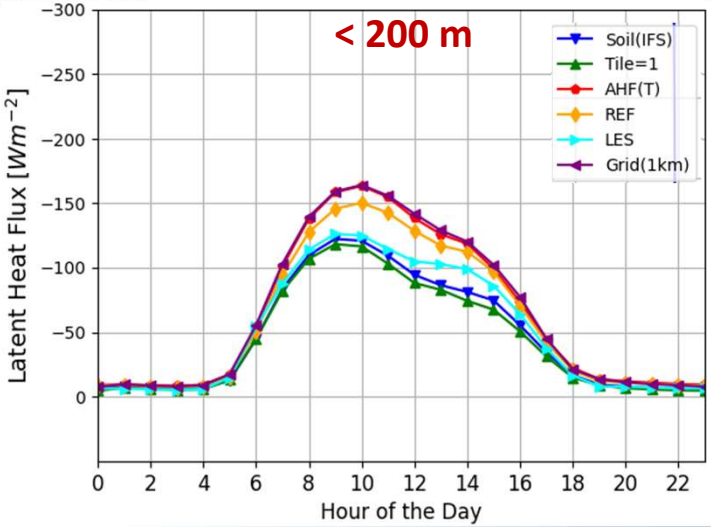


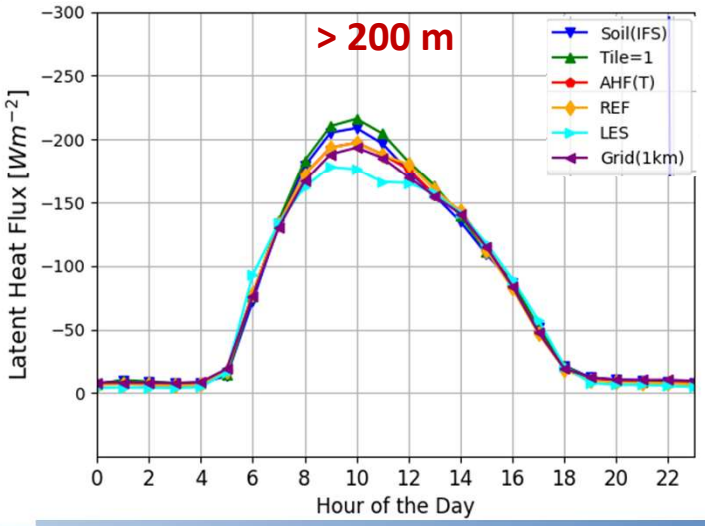




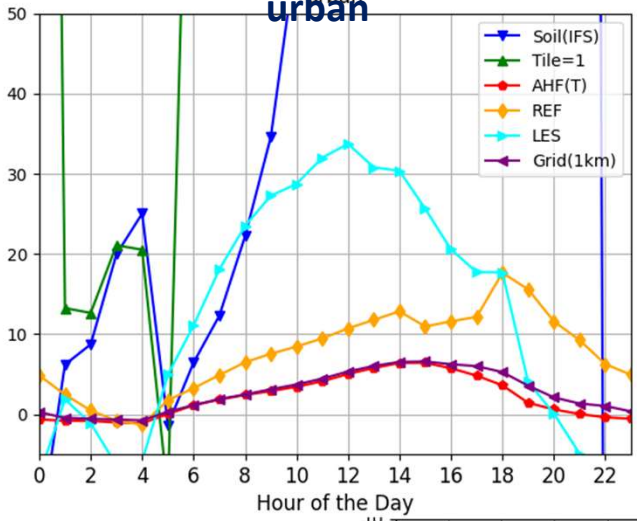




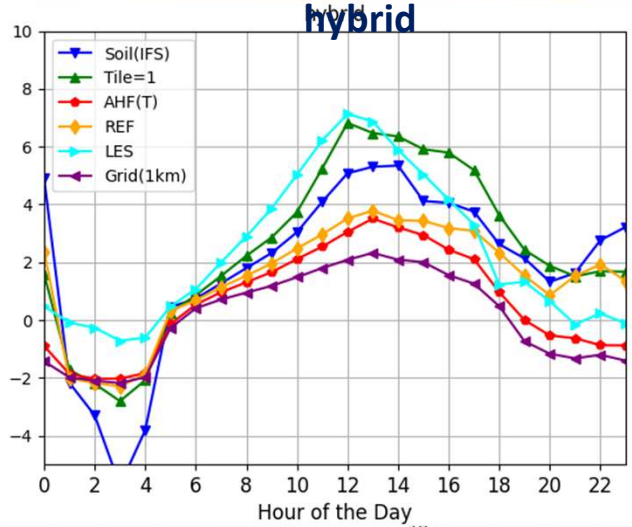




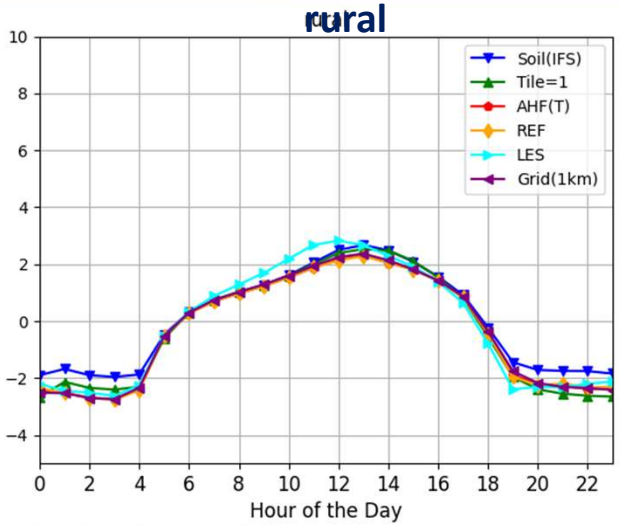
urban



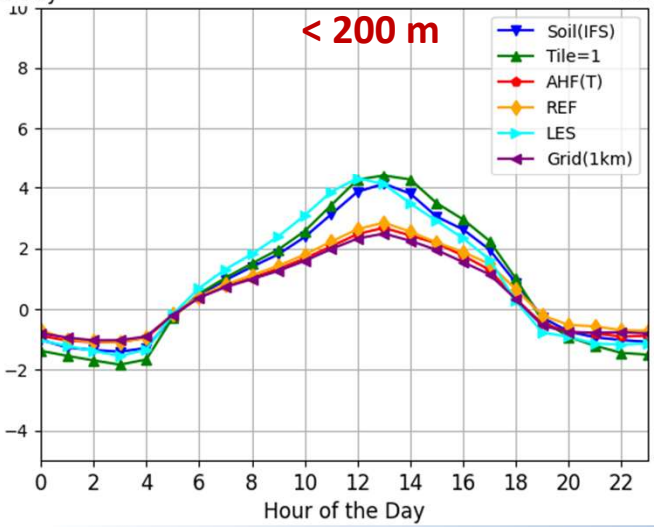
hybrid



rural



< 200 m



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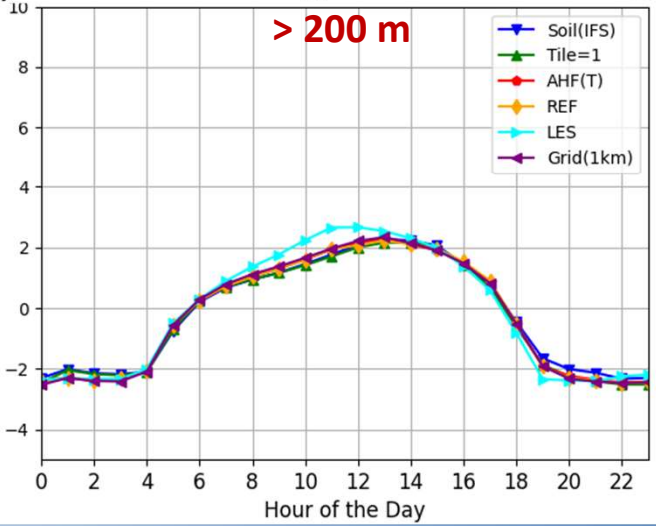
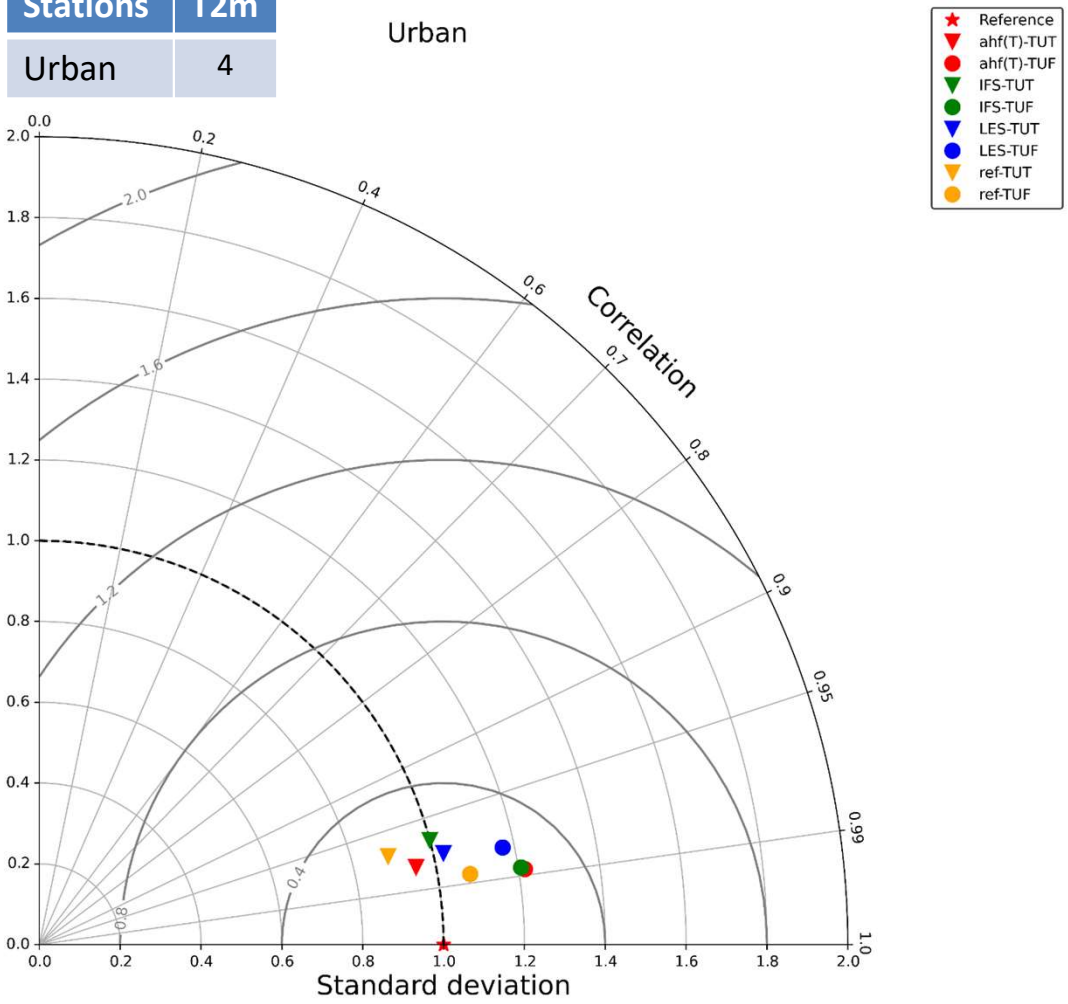
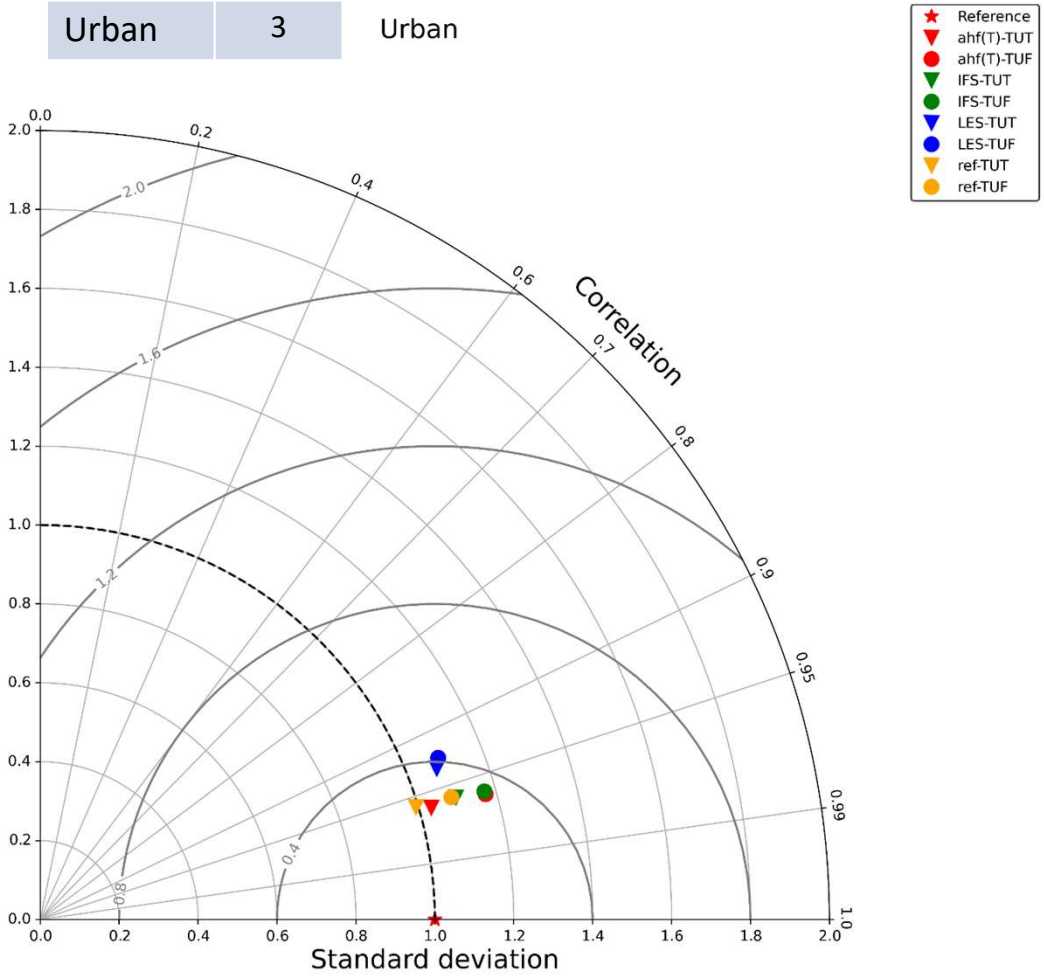


CONST. VS AHF(T2M): T2M URBAN

Stations	T2m
Urban	4

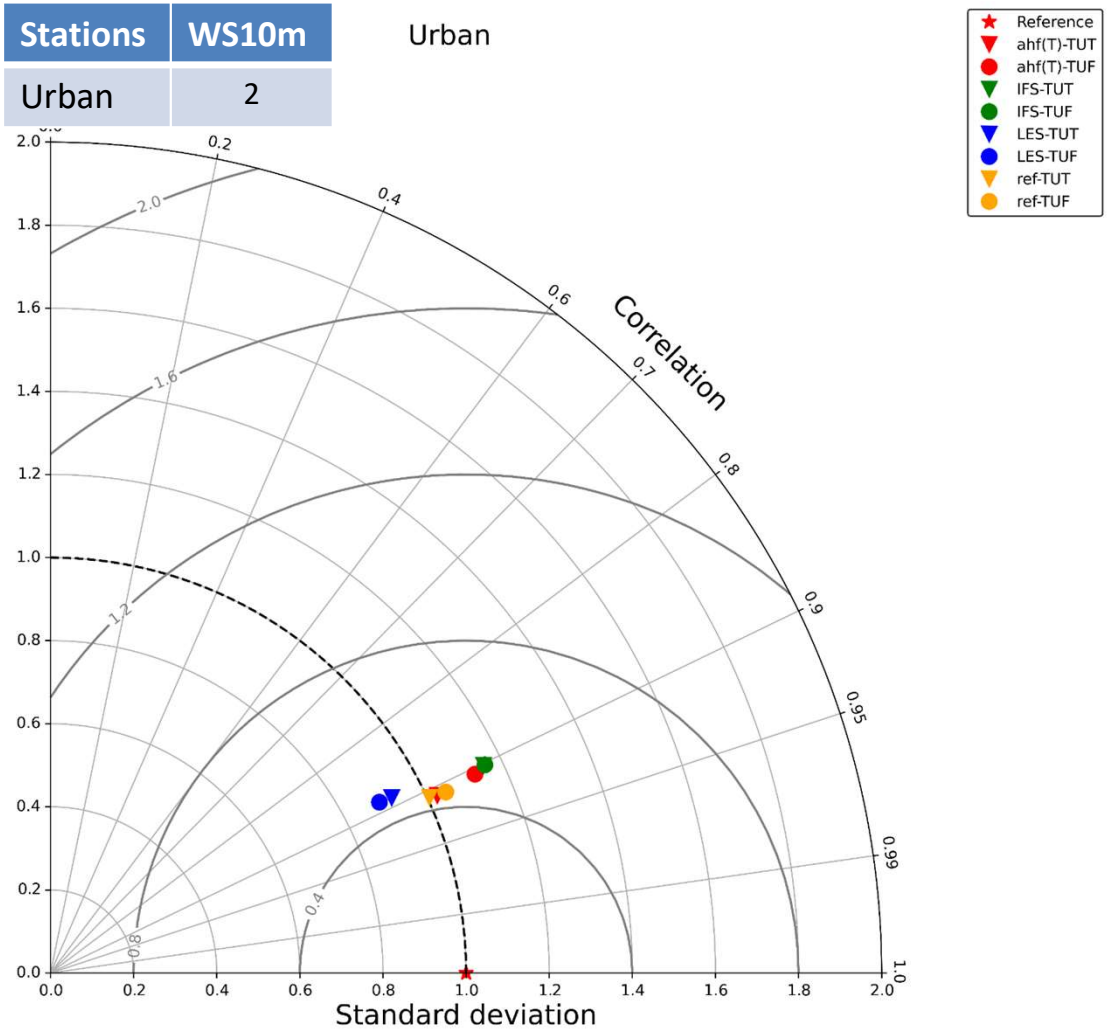


Stations	RH2m
Urban	3



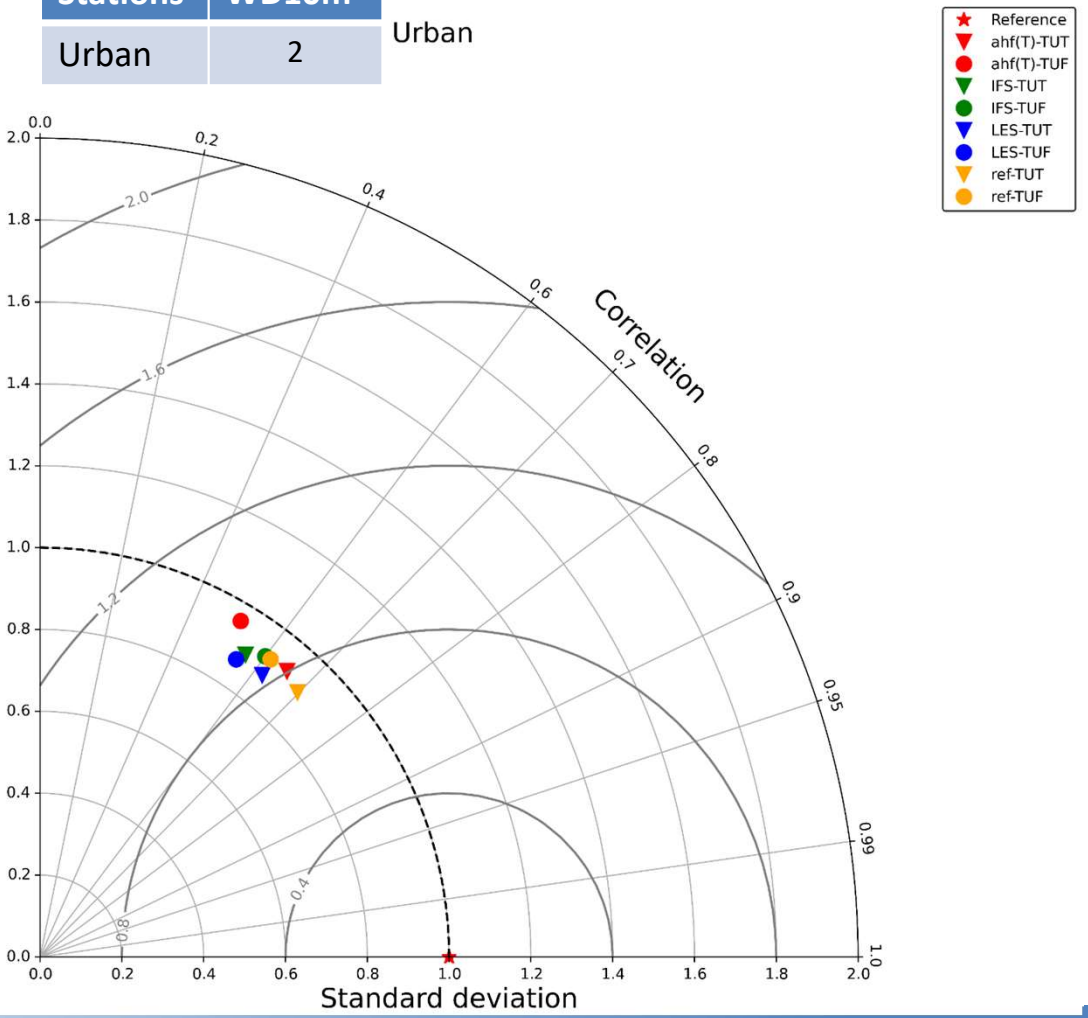
Stations	WS10m
Urban	2

Urban



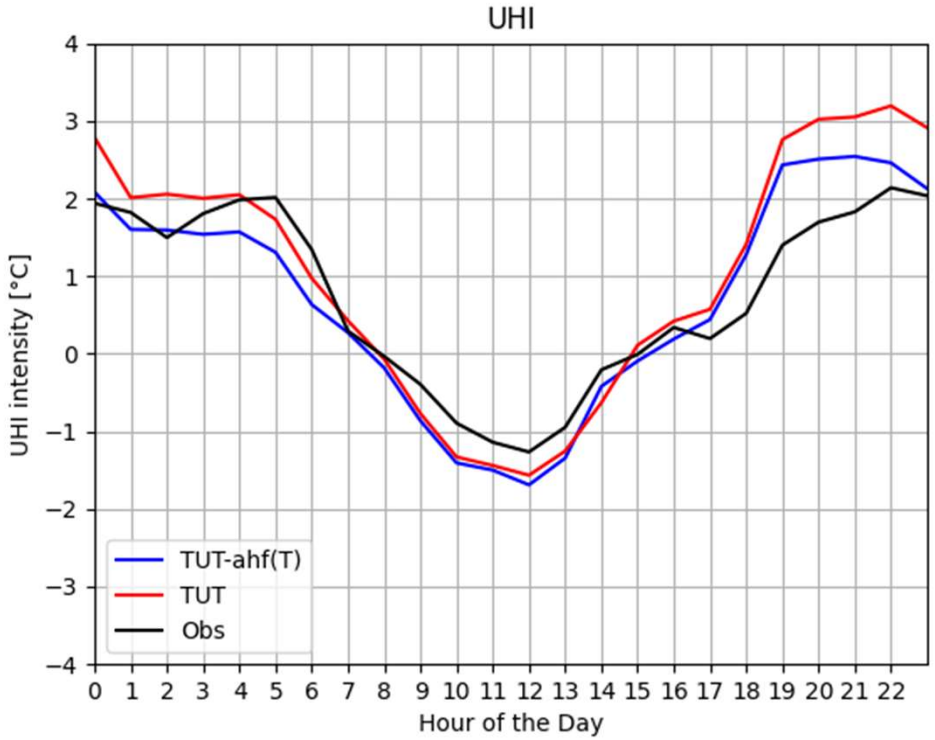
Stations	WD10m
Urban	2

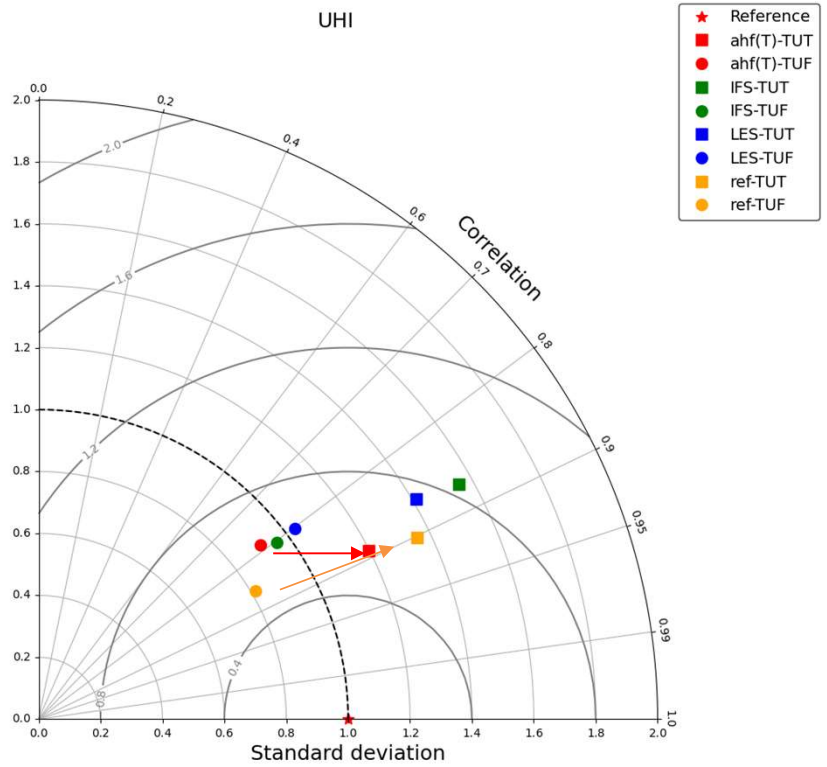
Urban



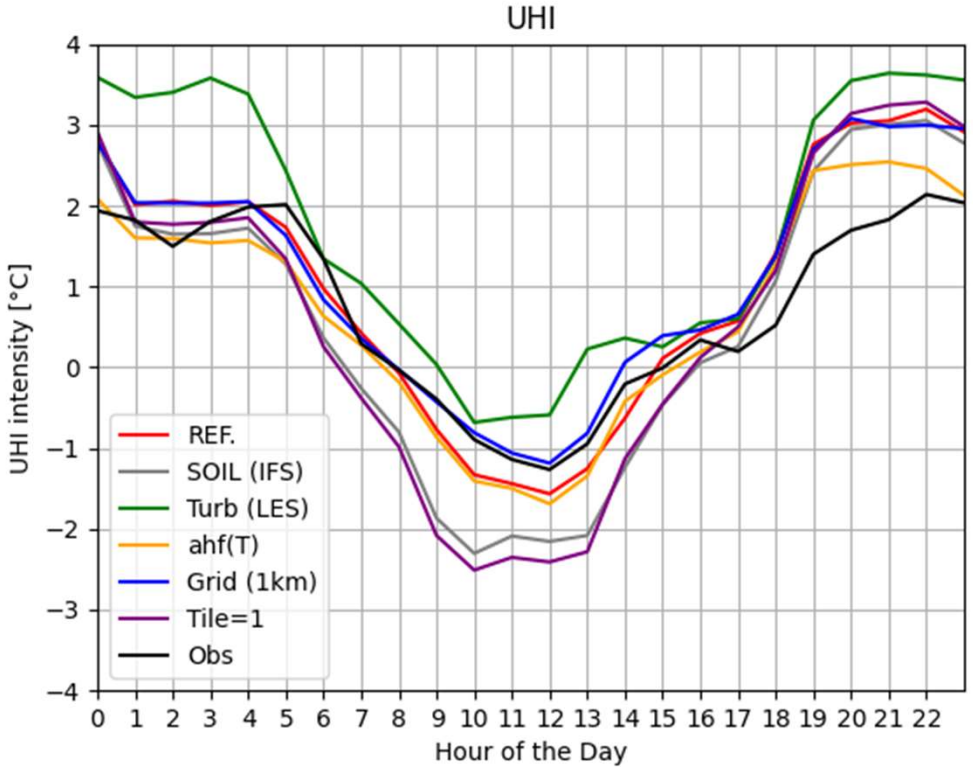
Switch from TUF (o) to TUT (square) deteriorates in terms of devst, while correlation is enhanced

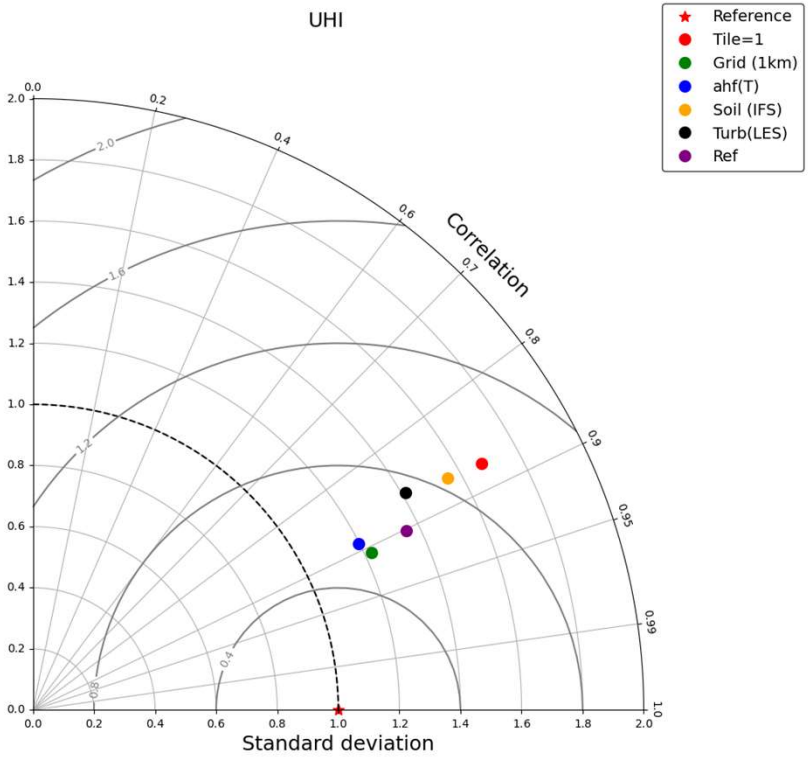
Ahf(T)-TUT vs REF-TUT shows an enhancement in terms of standard deviation and CRMSE, comparable in terms of correlation





Interaction with Urban Heat Island (UHI)





COMMENTS

- Evaluation of updated Terra_URB scheme on ICON –LAM
  - 7-day simulation, considering a week with a severe heat wave in July 2022
- Comparing const. vs AHF(T2m_clm):
  - Diurnal Cycles
    - ✓ Week diurnal T2m cycles enhanced in urban areas
    - ✓ Rh2m, ws10m and wd10m not affected or sliglty worst
  - UHI and UDI:
    - ✓ Beneficial effect std.dev and crmse
    - ✓ Beneficial effect
- Generally TU is observed an increases std.dev and crmse

- Interaction of Antropogenic activities with UHI, by means of physical downscaling to high resolved urban domain:
  - Machine Learning/Deep Learning based model to help in capturing AHF behavior and help in empirical modeling
  - VOC/Aerosol tracking with dispersion models and interaction with UHI
  - DA with Satellite product like LST and Non-professional Weather Station engagement;
  - Optimal Tuning Parameters for Advanced Turb Models (LES)
- Deliverables: Physical Downscaling for Urban Heat Island prediction
- Involved scientists: Davide Cinquegrana (CIRA), Edoardo Bucchignani (CIRA)
- FTEs: 1.0 FTE (??. 2026-??. 2028)

THANK YOU FOR YOUR ATTENTION!

CIRA – Italian Aerospace Research Center