CONSORTIUM FOR SMALL SCALE MODELING

COSMO

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

COSMO Priority Task ÆVUS2

Analysis and EValuation of TERRA_URB Scheme 2

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POLITECNICO DI TORINO

Sistema Nazionale per la Protezione dell'Ambiente

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Overview

1. **SubTask1:** Code developments and tests, related to new urban canopy parameters
2. **SubTask2:** Testing of new external parameters
3. **SubTask3:** Calibration of the COSMO model for urban areas
4. **SubTask4:** Test with different driving models
5. **SubTask5:** Towards TERRA URB implementation in ICON
6. **SubTask6:** Production of the final report

	Time	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11	12
Task		2019			2020												
1		■	■	■	■	■	■	■	■	■							
2			■	■	■	■	■	■	■	■	■						
3				■	■	■	■	■	■	■	■	■	■	■			
4												■	■	■			
5						■	■	■	■	■	■	■	■	■	■		
6															■	■	■

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Subtask1

Code developments and tests, related to new urban canopy parameters

1. **COSMO_191119_5.05_urb5** provided by Uli November 19th 2019

2. **COSMO_5.05urb5up** and **INT2LM_2.06up** available since December 2nd 2019 that includes the updates on the urban external parameters (Mikhail)

3. **COSMO_5.05urb6up4** and **INT2LM_2.06up2** available since July 4th 2020 that includes bug fixes and updates on the urban external parameters (Mikhail)

installed on ECMWF

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Testing of new external parameters

Different datasets of external parameters have been tested:

1) provided by ExtPar → used when TERRA-URB is switched off

2) modified through an R script developed by Arpa Piemonte, where the external parameters affected by the "double-counting effect" have been recalculated according to the functions implemented in ExtPar but weighted excluding land use class 19 (urban) → used when TERRA-URB is switched on

3) LCZ based urban external parameters provided by Matthias Demuzere

Calibration of the COSMO model for urban areas

- different turbulence schemes
- urban scheme on/off
- canopy scheme / skin conductivity scheme

Part I

- no intermediate step (9km → 1km)
- no spin-up of the soil
- boundary and initial conditions by ICON (subtask4)

Part II

- sensitivity test on AHF
- sensitivity test on urban parameter (H/W, H, etc)
- LCZ based external parameters

Part III

Piemonte domain

Part I

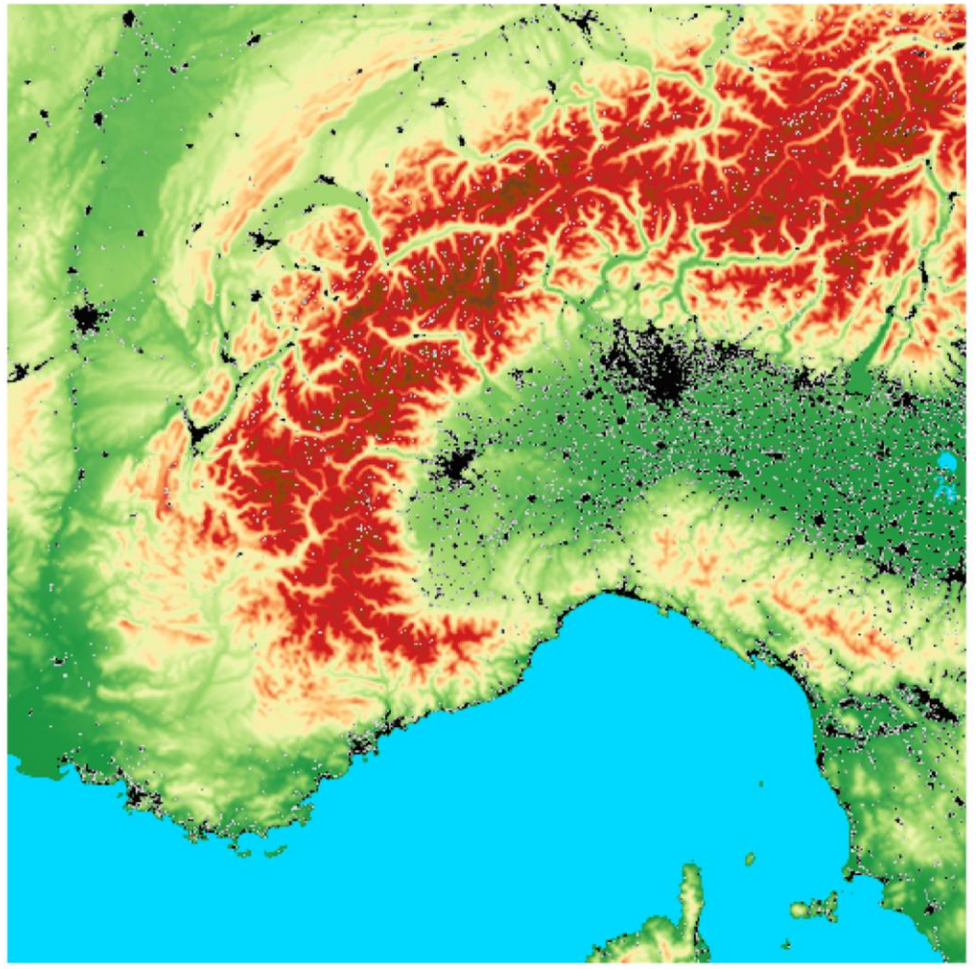
9 km → 5 km → 1 km

(IFS) (COSMO) (COSMO)

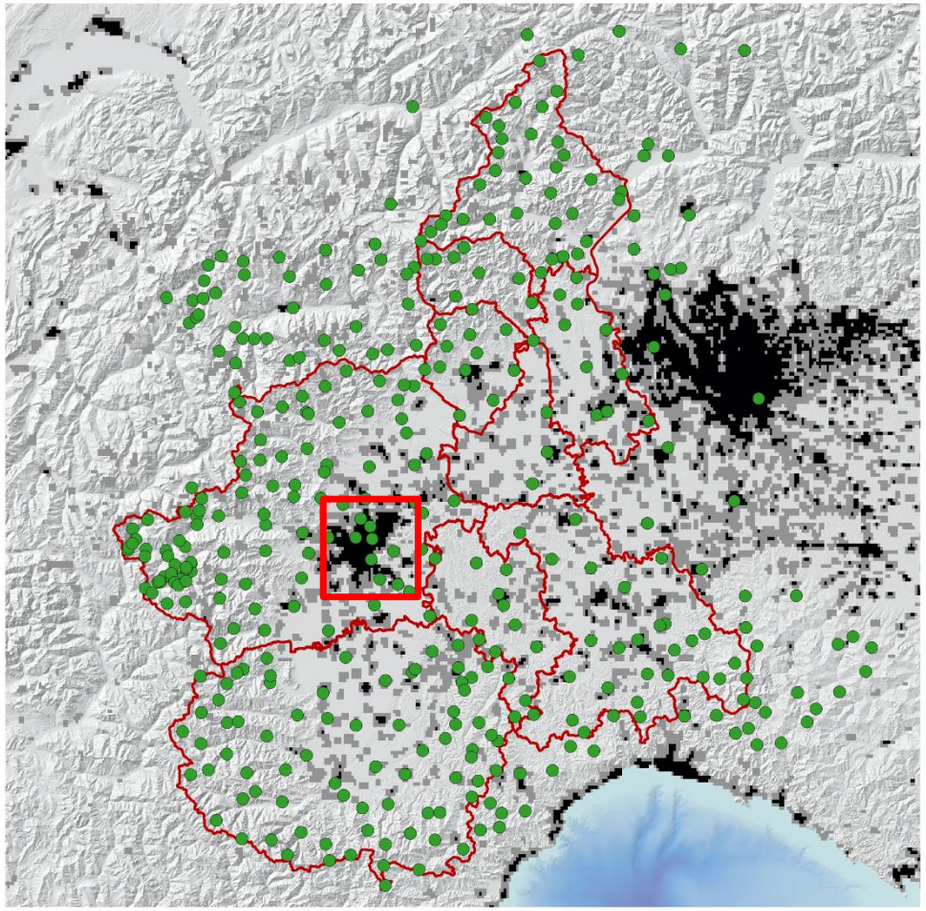
Part II & Part III

9 km → 1 km

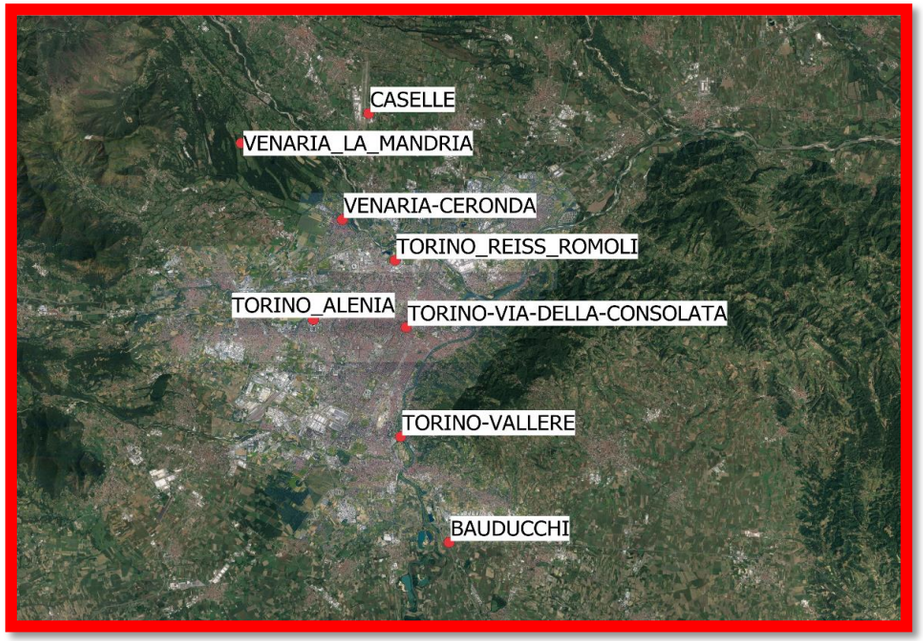
(IFS) (COSMO)



Verification



The different model configurations have been evaluated by comparing the results with observations provided by the Arpa Piemonte network (few urban stations, many non-urban stations)



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PART I

6 different configurations have been tested in order to evaluate the different model parametrisations:

1. urban scheme ON/OFF
2. different turbulence schemes
3. canopy scheme / skin temperature scheme

Each simulation runs from 15th (00:00) to 29th October 2017 (00:00): the first 7 days are used to assess the soil of the model ("spin-up"), while the comparison have been done for the test-case week **22-29th October 2017**

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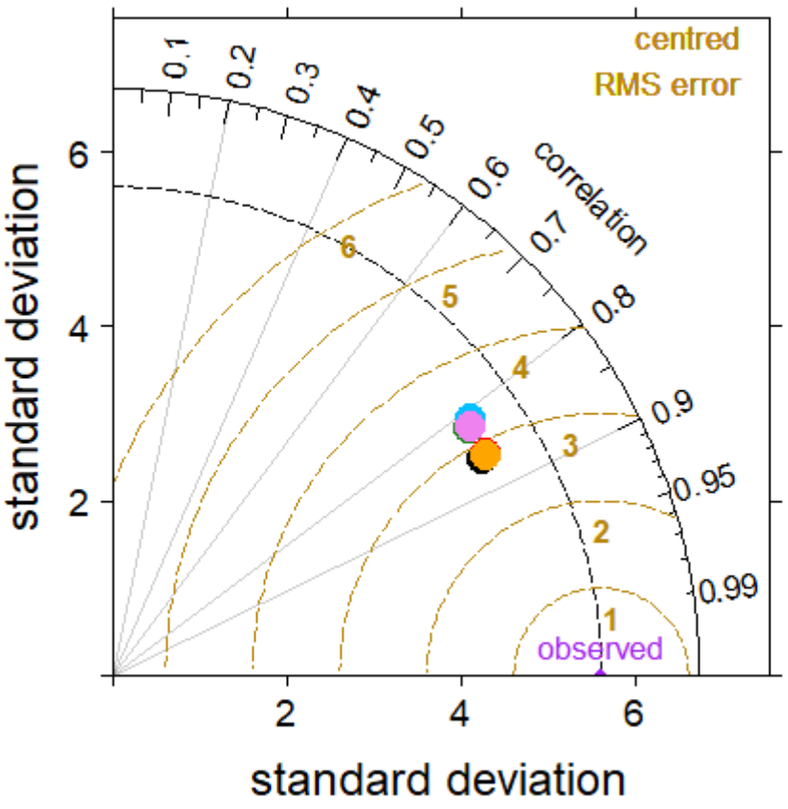
PART I

	sm0	sm1	sm2	sm3	sm4	sm5
OLDTUR	FALSE	TRUE	TRUE	TRUE	FALSE	FALSE
TERRA_URB	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
itype_canopy	1	1	1	2	1	2

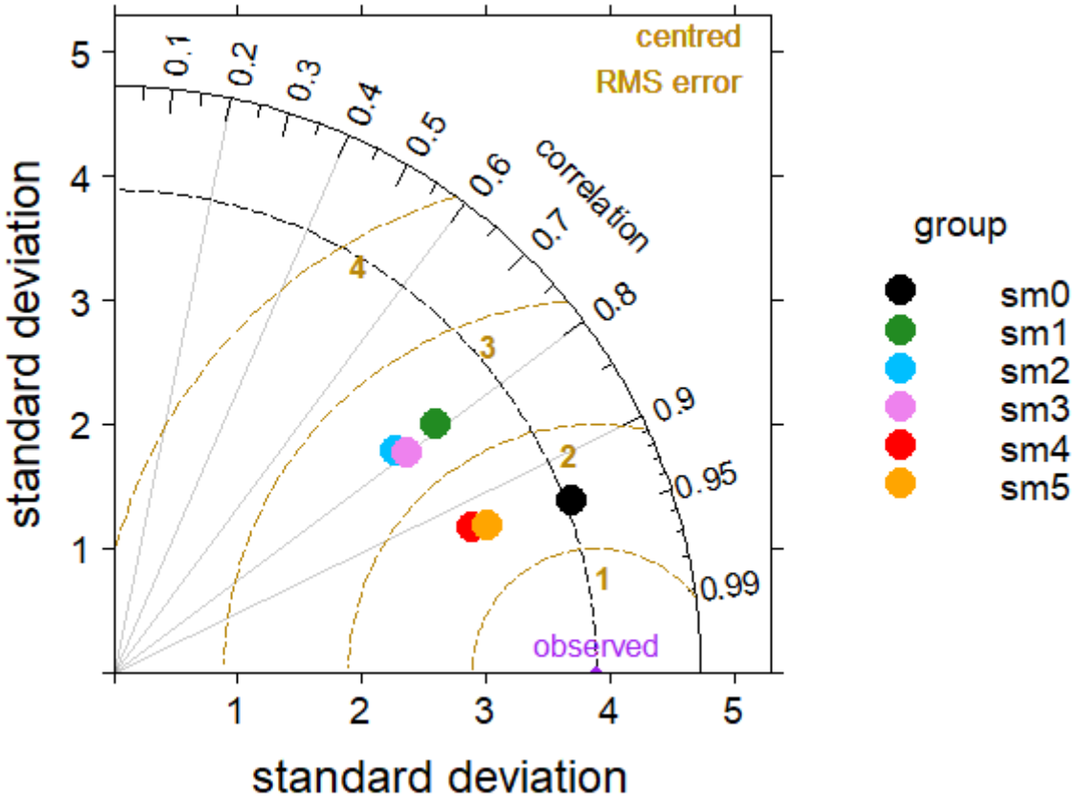
- sim 0 and sim 1 → ExtPar dataset (TERRA_URB = false)
- sim 2, 3, 4 and 5 → ExtPar dataset modified to prevent the double counting effect on urban tile (TERRA_URB = true)

Taylor diagrams: t2m

All stations



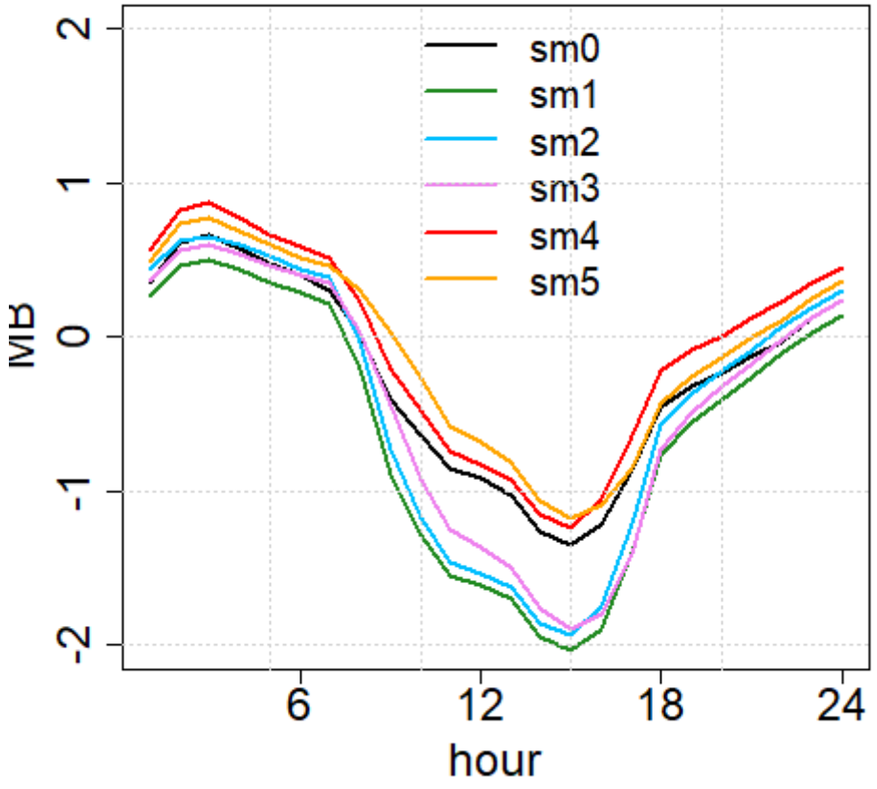
Urban stations (Turin)



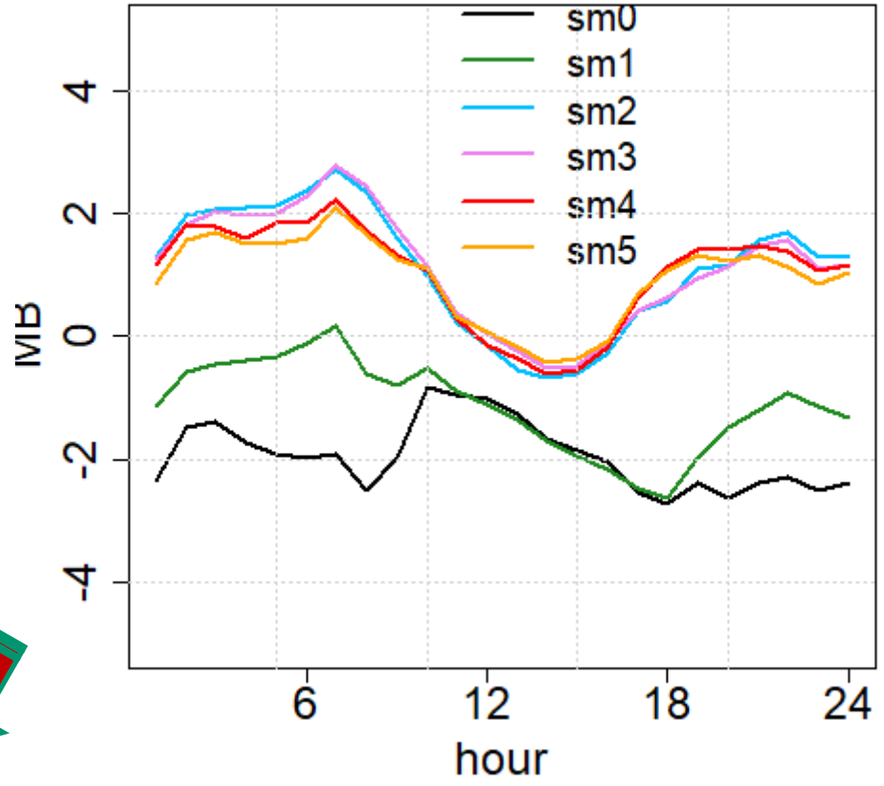
New turbulence better than old turbulence!

Mean Bias: t2m

All stations

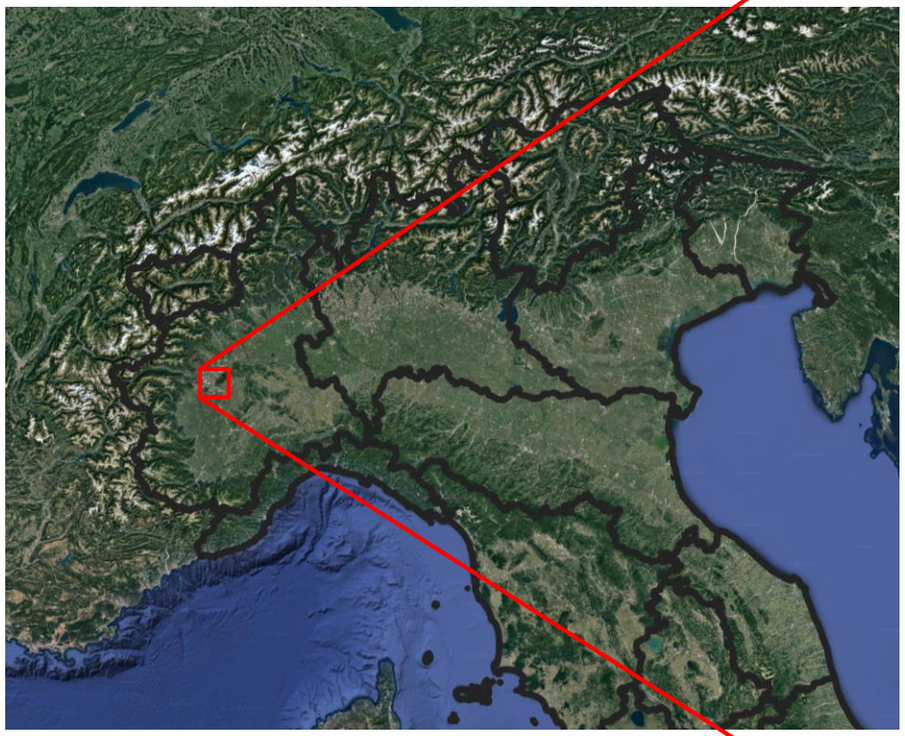


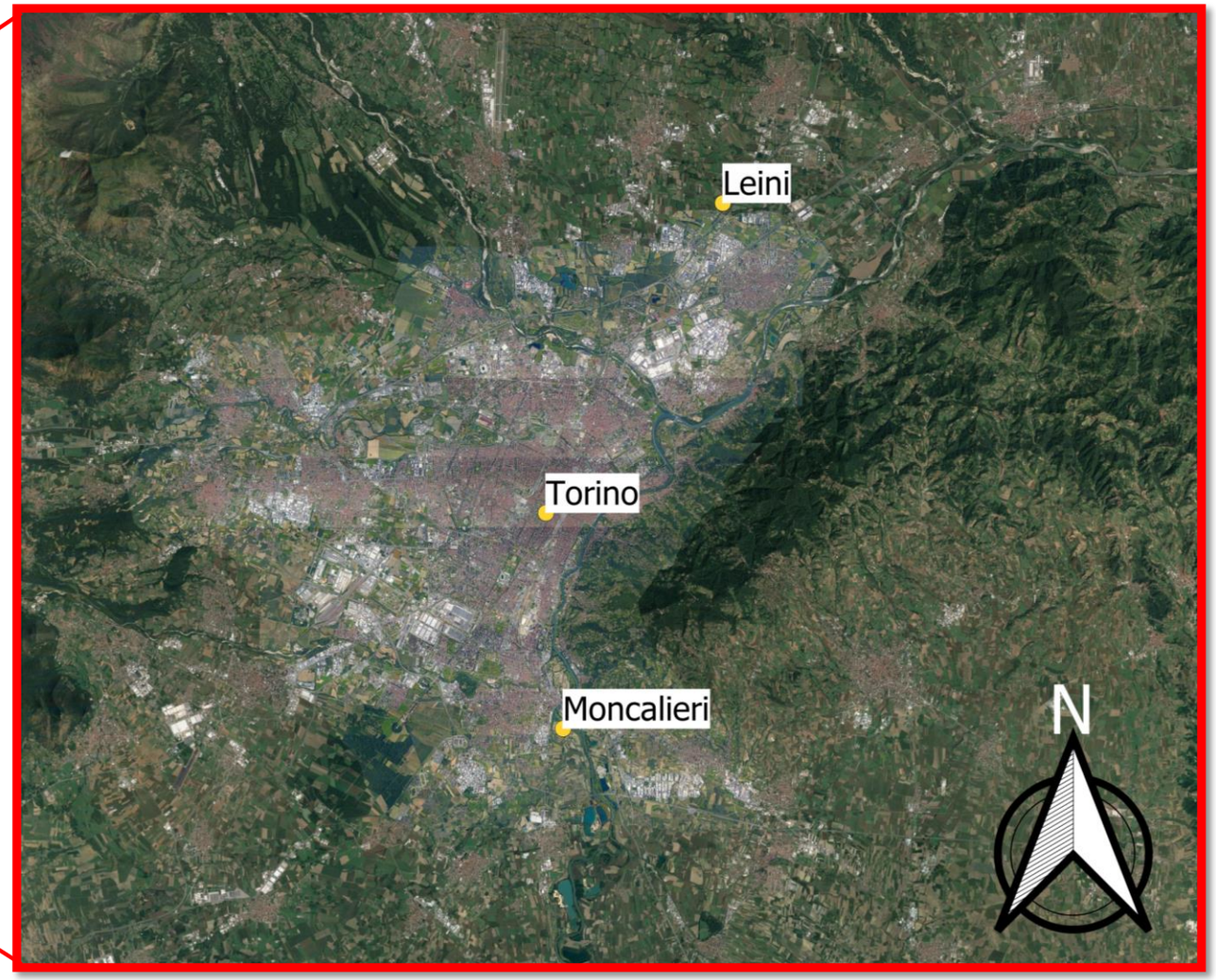
Urban stations (Turin)



TERRA-URB improves 2m temperature forecast in urban area during day but overheats during night

Vertical T profiles
Radiometers position

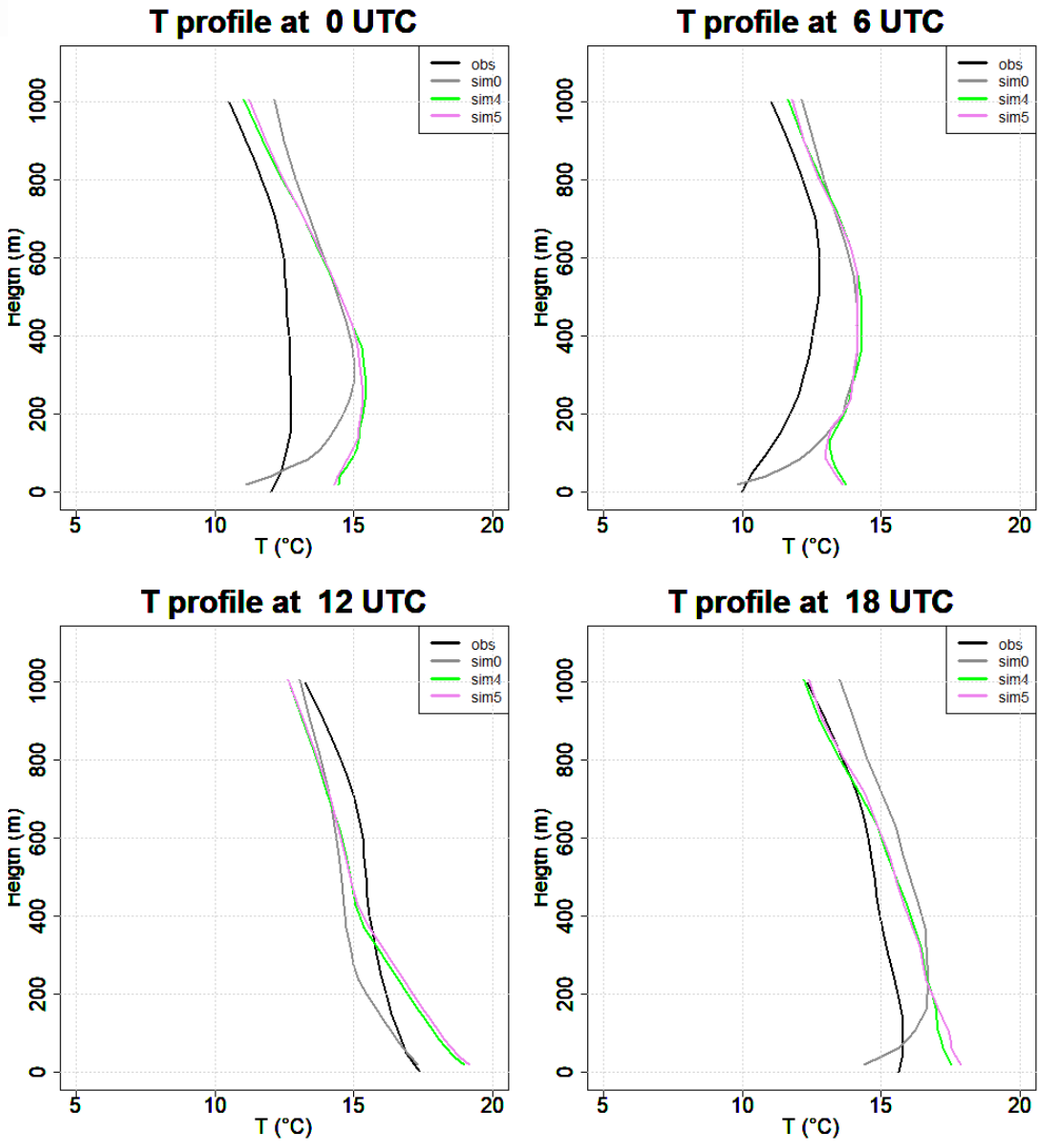




Vertical T profiles

Torino city center

rather unsatisfactory behaviour for all the radiometers concerning the vertical profiles (both urban and rural)



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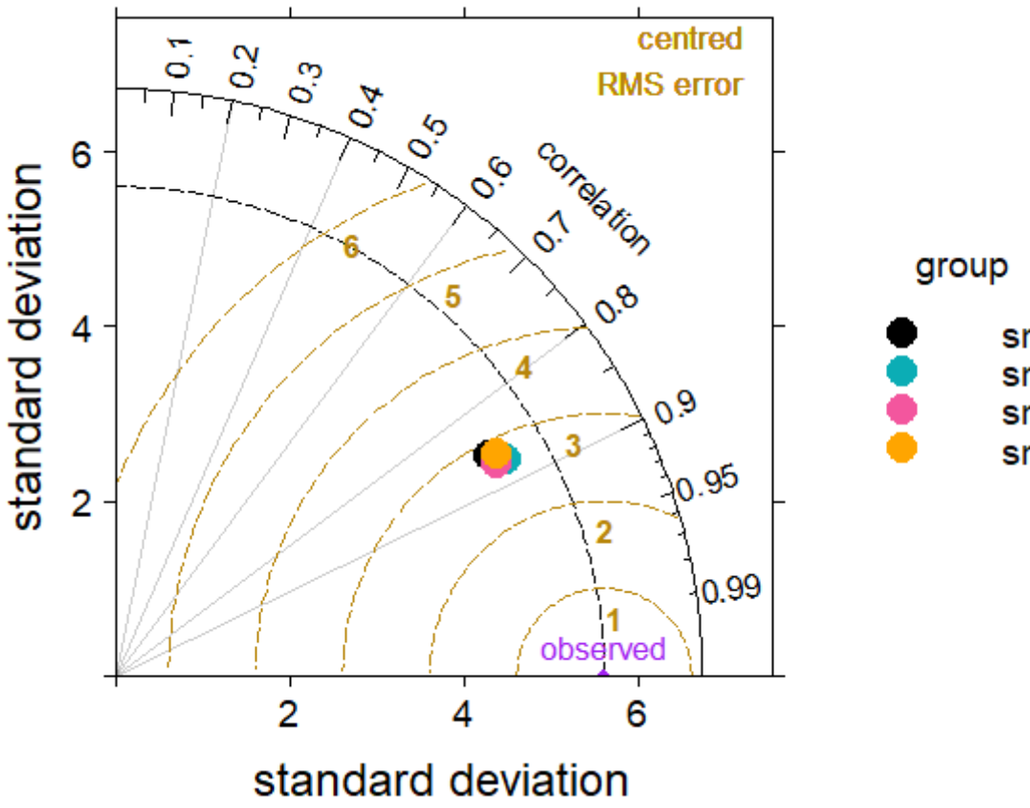
PART II

A best configuration has been pointed out from PART I and will be adopted in PART II → **sim5**: **new** turbulence, TERRA_URB **on** and itype_canopy = **2**

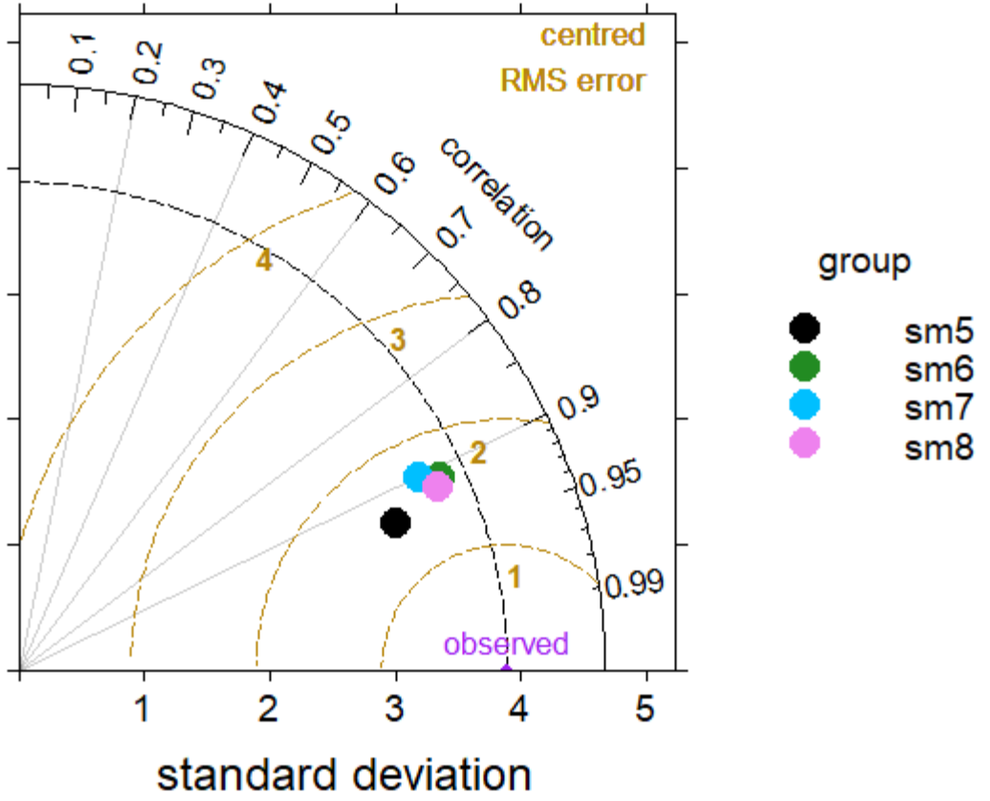
	sm5	sm6	sm7	sm8
ICBC	IFS 9km→5km→1km	**IFS** 9km→1km	**IFS** 9km→1km	ICON 13km→1km
soil spin-up	YES	YES	NO	YES

Taylor diagrams: t2m

All stations



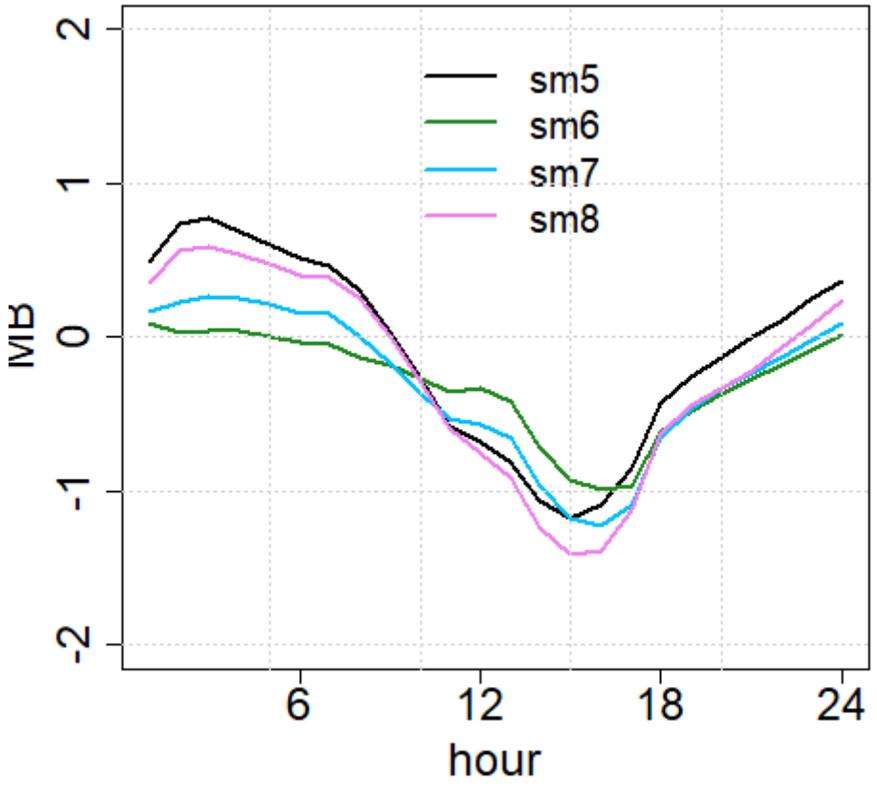
Urban stations (Turin)



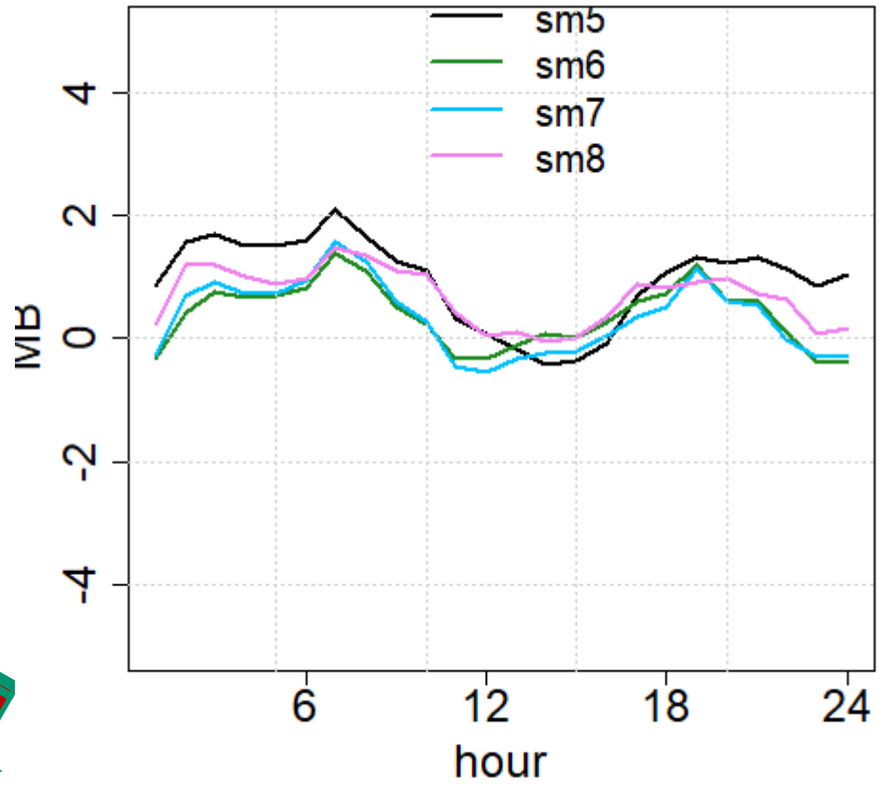
9km→1km works better especially for urban areas

Mean Bias: t2m

All stations



Urban stations (Turin)



The best configuration is sim6: **new** turbulence, TERRA_URB **on**, itype_canopy = **2** and ICBC 9km→1km

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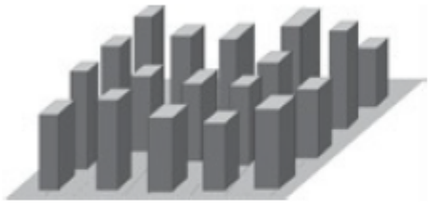
Part III
urban parameters

LCZ = Local Climate Zones*

Built types	Definition
1. Compact high-rise 	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.
2. Compact midrise 	Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.
9. Sparsely built 	Sparse arrangement of small or medium-sized buildings in a natural setting. Abundance of pervious land cover (low plants, scattered trees).

	H/W (a)	Building surface fraction (b)	Mean height of canopy [m]
LCZ 1	>2	0.4-0.6	>25
LCZ 2	0.75-2	0.4-0.7	10-25
LCZ 9	0.1-2.5	0.1-0.2	3-10
sim 6 *	1.5	0.67	15

(a): mean height-to-width ratio of street canyons
(b): ratio of building plan area to total plan area
* : default parameters of TERRA_URB

Which parameters for Turin?

* I. D. Stewart e T. R. Oke, Local Climate Zones for Urban Temperature Studies, *Bulletin of the American Meteorological Society* 93, n. 12 (2012): 1879–1900.

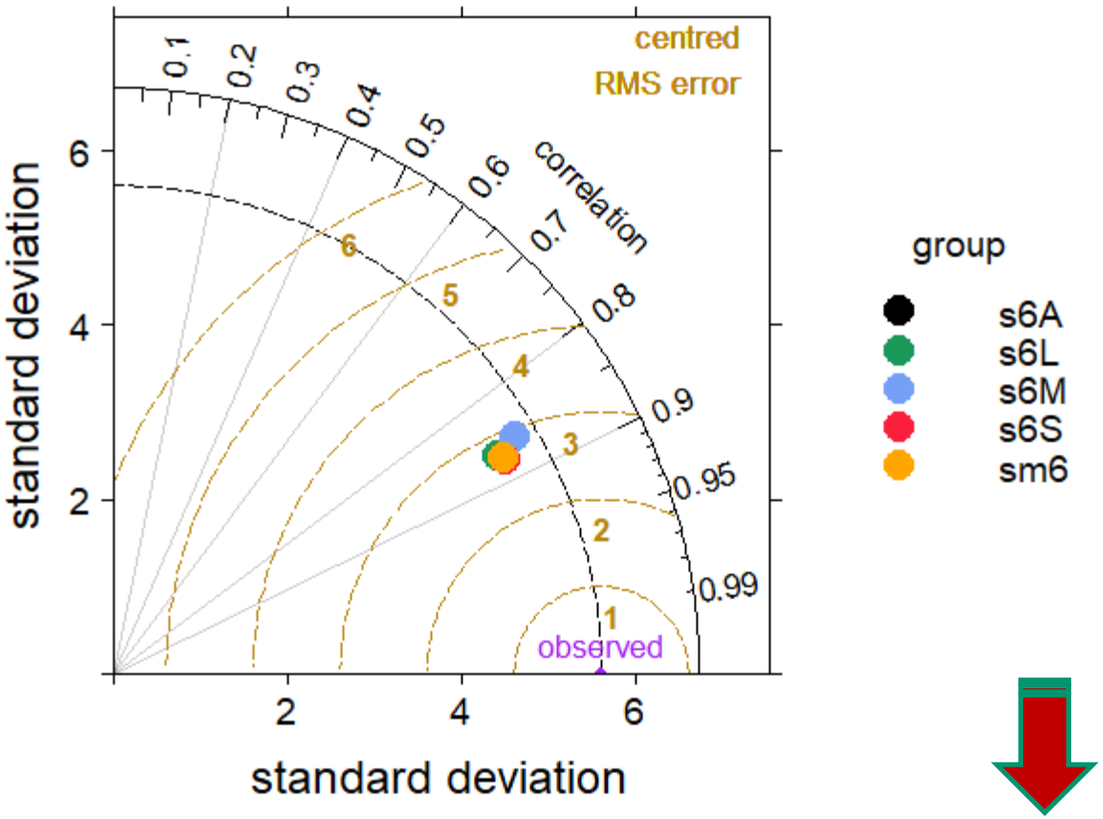
PART III

The best configuration highlighted in PART II has been adopted in PART III → **sm6**: **new** turbulence, TERRA_URB **on**, itype_canopy = **2** and ICBC 9km→1km

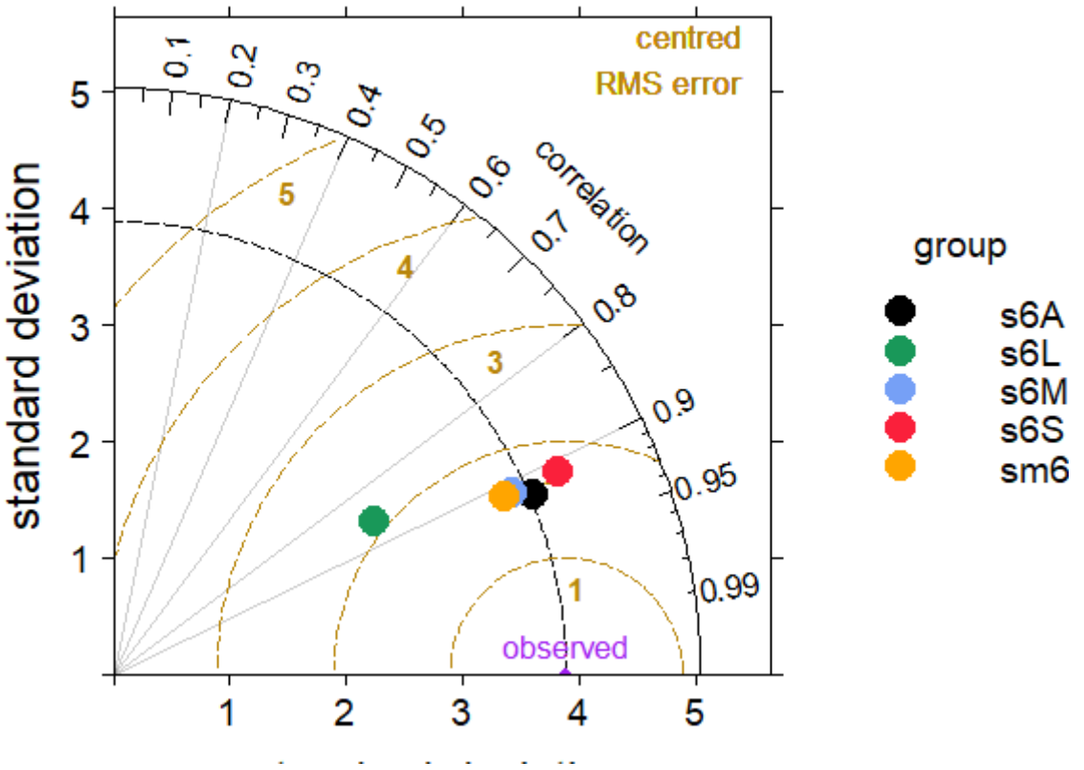
	sm6	s6A	s6M	s6S	s6L
AHF	ExtPar	2*ExtPar	ExtPar	ExtPar	**LCZ**
ISA	URBAN	URBAN	URBAN	URBAN	**LCZ**
curb_h2w	1.5	1.5	1.5	**0.2**	**2D (LCZ)**
curb_bldfr	0.67	0.67	0.67	**0.2**	**2D (LCZ)**
curb_bldh	15	15	15	**3**	**2D (LCZ)**

Taylor diagrams: t2m

All stations



Urban stations (Turin)



Sensitivity to urban parameters, but but further investigation is needed to draw some conclusions!

Conclusions

- TERRA_URB = ON provides a good impact on the results
- The Skin Temperature formulation is more representative of reality, indeed itype_canopy = 2 works better
- The new physics implementation yields to results closer to the observed data
- There is a further improvement in simulating without intermediate step
- The soil does not show the spin-up effect
- ICON initial and boundary conditions are almost the same as IFS

- Rural areas north of Turin are not well represented
- Vertical temperature profiles are distant from observed data and worse than temperatures at 2m

Further investigations!