On going activities at CIRA-CMCC on ICON configuration over Italy

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COSMO GM – PP C2I
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Centro Euro-Mediterraneo sui Cambiamenti Climatici

The ICON Environment

- *Software configuration*: ICON Version: icon-2.6.2.2, ICONTOOLS Version: 2.4.12
- Compiler used: Intel parallel studio XE v.19.5 and Intel-mpi v.19.5

- *CMCC cluster specifications* :
  Operating System: Linux CentOS 7.6 x86_64;
  Processor: Intel Xeon Gold 6154 (18 cores);
  Processor Speed: 3.0 GHz;
  # of processor cores: 12528;
  # of nodes: 348 (dual processors nodes);
  Memory per node: 96 GB;
  Interconnection: Infiniband EDR (100Gbps);

- *Grid:* an R2B10 and is made up of 451384 triangular cells, with a spatial resolution of about 2.5 km.
  The geometrical centre of the grid is positioned in Gaeta (longitude 13.802°E latitude 41.560°N);

- *Forcing data*: ECMWF IFS (resolution of 0.075°);

- *Test cases considered*:
  1. August 16 to August 31, 2020;
  2. January 01 to January 14, 2019.

ICON Sensitivity: preliminary tests

Reference configuration: provided by DWD with some modifications by Pavel Khain

Vertical levels

- 65 ---- runtime: 16.5 min for each day simulated
- 50 ---- runtime: 13.2 min for each day simulated **>>>>> -20%**
- 90 ---- runtime: 22.5 min for each day simulated **>>>>> +36%**

Time step

- dt=24s ---- runtime: 16.5 min for each day simulated
- dt =12s ---- runtime: 30 min for each day simulated **>>>>> +81%**
- dt=32s ---- runtime: 12.7 min for each day simulated **>>>>> -23%**

Domain size

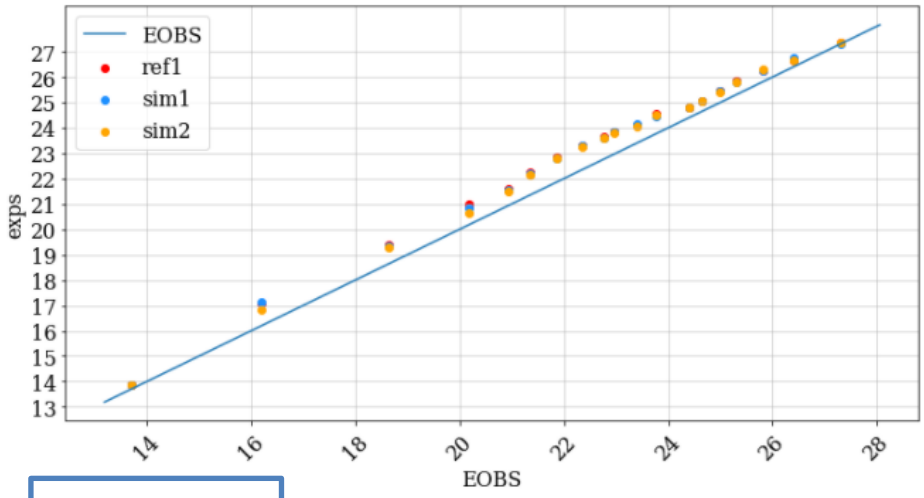
- 451384 triangles cells ---- runtime: 16,5 min for 1 day simulated
- 498712 triangles cells (larger of about 50km on each side)
  Runtime: 18,5 min per day **>>>>> +11%**
- 562240 triangles cells (larger of about 100km on each side).
  Runtime: 20.6 min per day **>>>>> +20%**

Sensitivity ICON over different domains

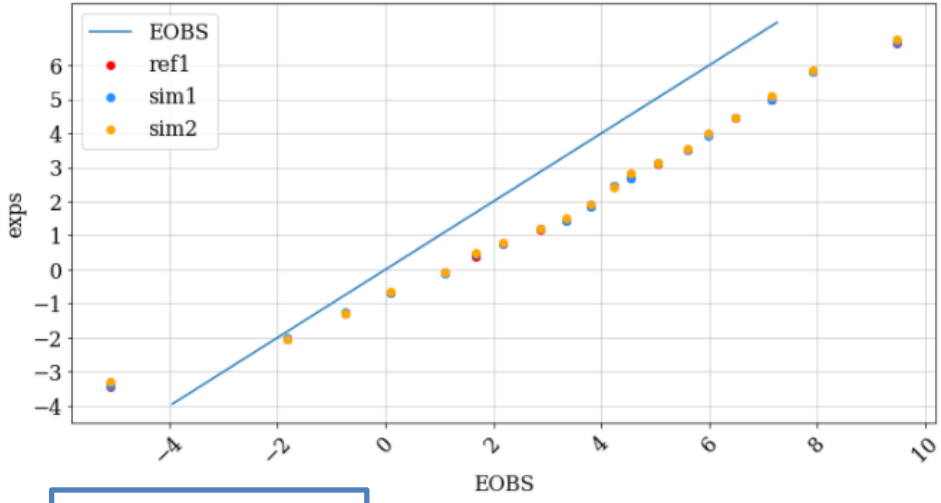
- For all simulations: 65 vertical levels, the timestep is 24s

Id_simulation	Domain	Runtime (m) 1 day
ref1	Italy (451384 cells)	16.1
sim1	Large_Italy_20pt (498712 cells)	18.1
sim2	Large_Italy_40pt (562240 cells)	20.7

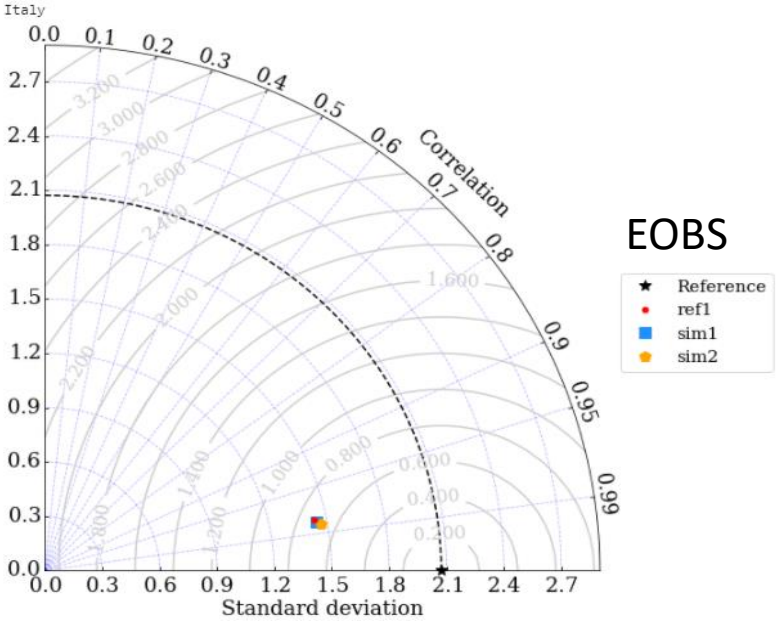
T_2M results of different domains

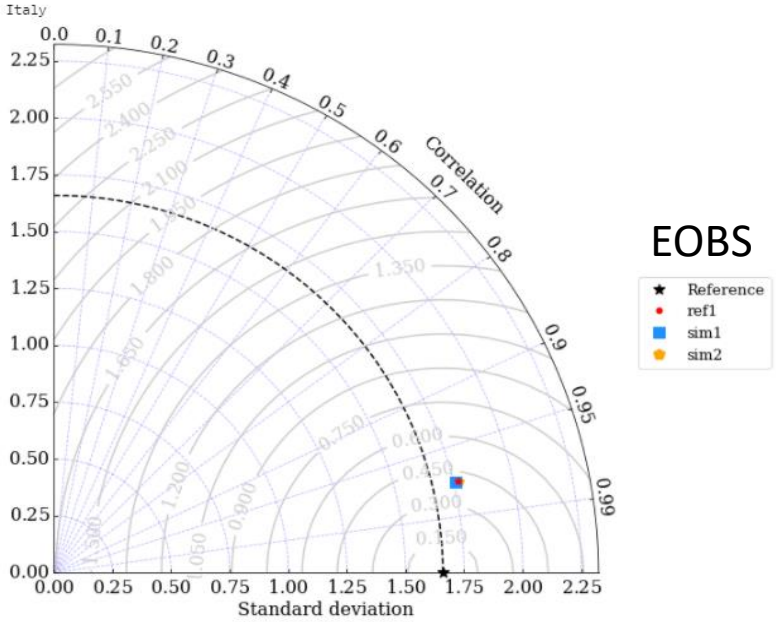


2020



2019





ICON Italy: List of sensitivity tests

Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	inwp_convection	lshallowconv_only	inwp_radiation	inwp_gscp	inwp_surface	inwp_cldcover	inwp_turb
#1_ref1	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)*	1: COSMO diffusion and transfer*
#2	Tiedtke/Bechtold convection (1)	FALSE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#3	Tiedtke/Bechtold convection (1)	TRUE	RRTM radiation (1)	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#4	Tiedtke/Bechtold convection (1)	TRUE	Ritter-Geleyn radiation (2)	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#5	Tiedtke/Bechtold convection (1)	TRUE	PSRAD (3)	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#6	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	Two-moment microphysics by A. Seifert (4) **	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#7	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	as 1, but with improved ice nucleation scheme by C. Koehler (3)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#8	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	Kessler scheme (9)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#9	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	3: clouds from COSMO SGS cloud scheme	1: COSMO diffusion and transfer
#10	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	4: clouds as in turbulence (turbdiff)	1: COSMO diffusion and transfer
#11	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	5: grid scale clouds	1: COSMO diffusion and transfer
#12	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	2: GME turbulence scheme
#13	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	5: Classical Smagorinsky diffusion

ICON tests: physics schemes - CONVECTION

Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	inwp_convection	**lshallowconv_only**	**inwp_radiation**	**inwp_gscp**	**inwp_surface**	**inwp_cldcover**	**inwp_turb**
#1_ref1	Tiedtke/Bechtold convection (1)	**TRUE**	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#2	Tiedtke/Bechtold convection (1)	**FALSE**	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer

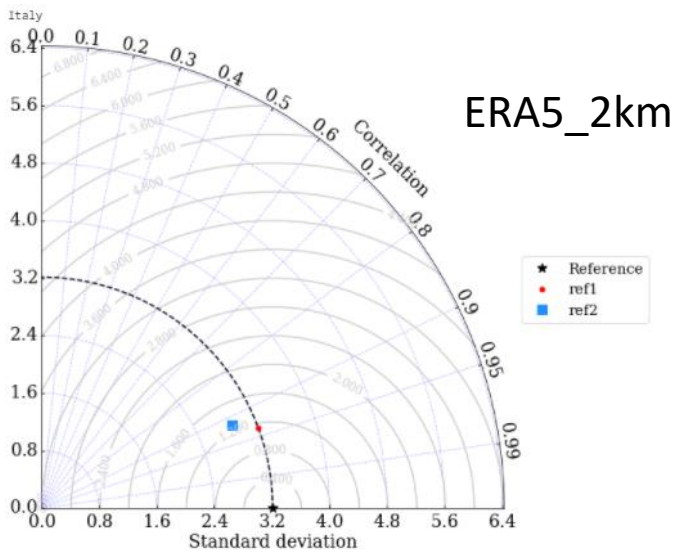
Full convection vs shallow convection only:

- ref1 and ref2 generally overestimate precipitation over North Italy in winter 2019 and over South Italy in summer 2020
- Simulation ref1 shows better performances in summer 2020 thanks to the explicit treatment of deep convection.
- The differences between the two simulations are generally limited to 1 mm/day.

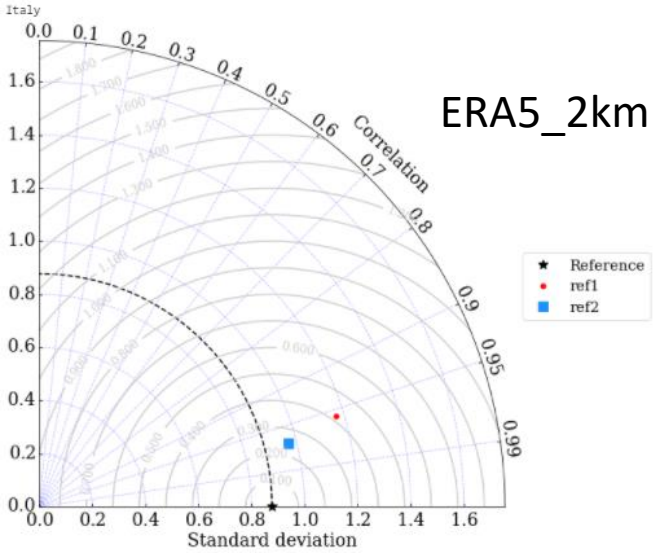
Daily Cumulative Precipitation

2020

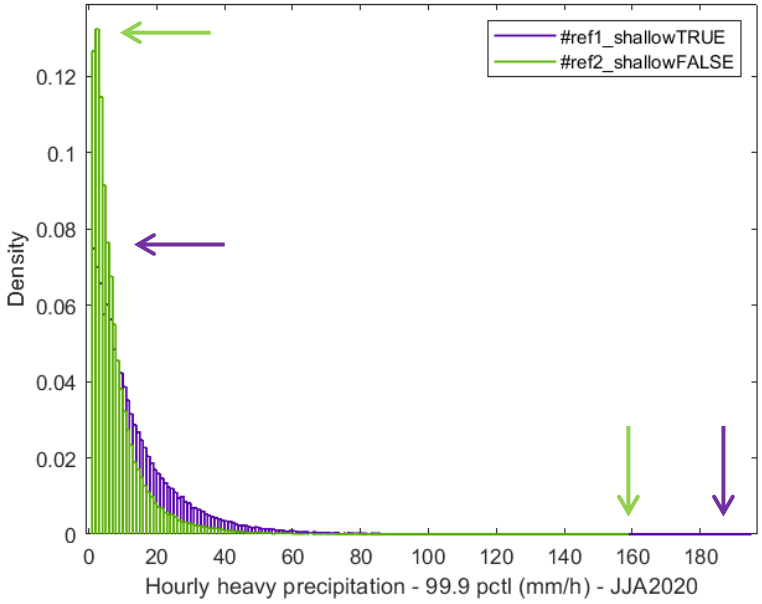
2019

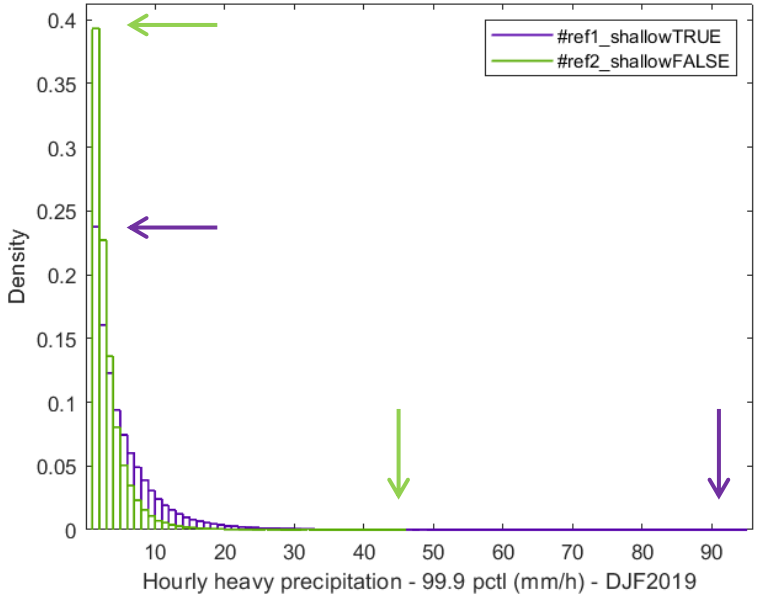


ERA5_2km



ERA5_2km





ICON tests: physics schemes - RADIATION

Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	inwp_convection	**lshallowconv_only**	**inwp_radiation**	**inwp_gscp**	**inwp_surface**	**inwp_cldcover**	**inwp_turb**
#1_ref1	Tiedtke/Bechtold convection (1)	TRUE	**ecRad (4) ***	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#3	Tiedtke/Bechtold convection (1)	TRUE	**RRTM radiation (1)**	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#4	Tiedtke/Bechtold convection (1)	TRUE	**Ritter-Geleyn radiation (2)**	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#5	Tiedtke/Bechtold convection (1)	TRUE	**PSRAD (3)**	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer

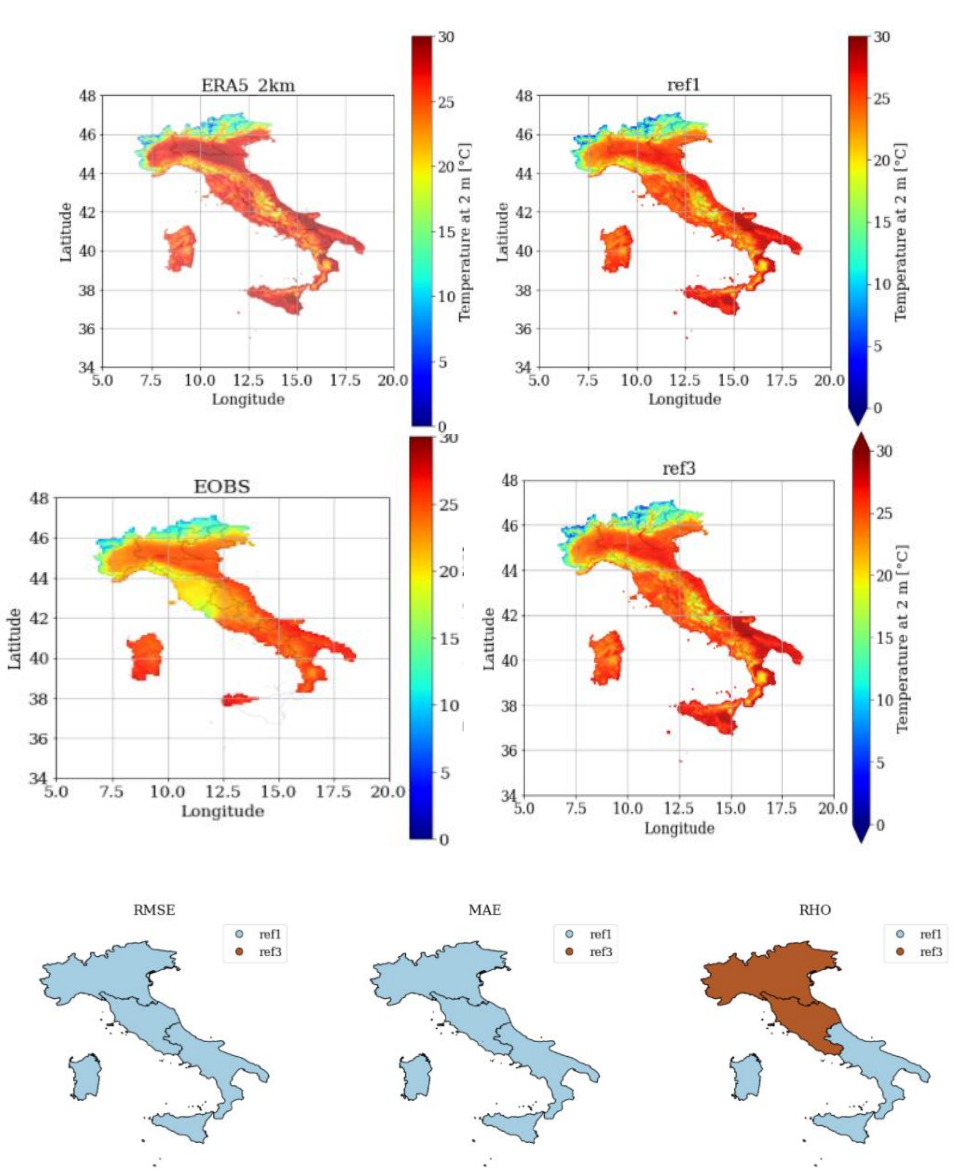
Simulation 5 crashed (in fact, in the new ICON version it will be removed)
Simulation 4 produces unrealistic results.

A slight better behavior of Simulation 1 in summer and a better one of Simulation 3 in winter.

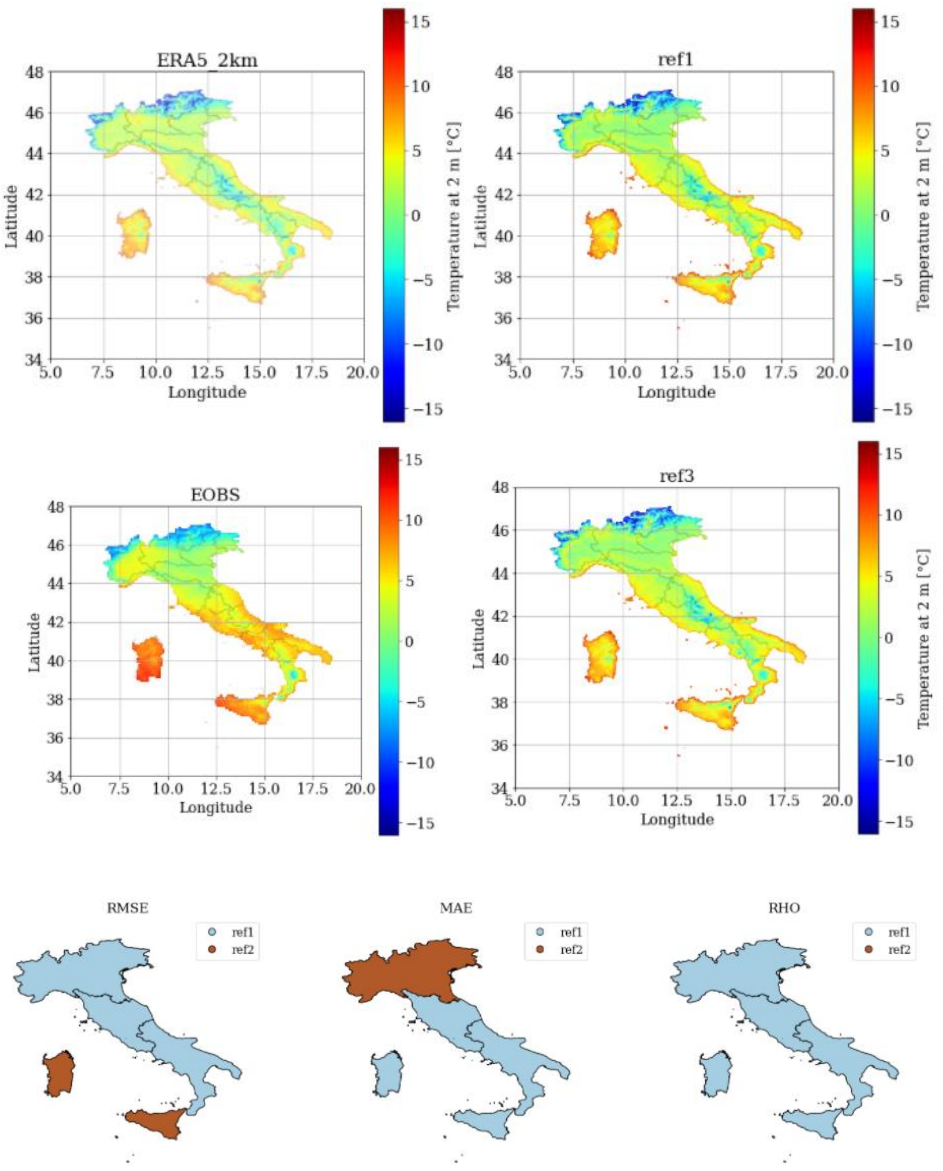
Mean TEMPERATURE at 2m

2020

2019



Max difference: 0.2°C



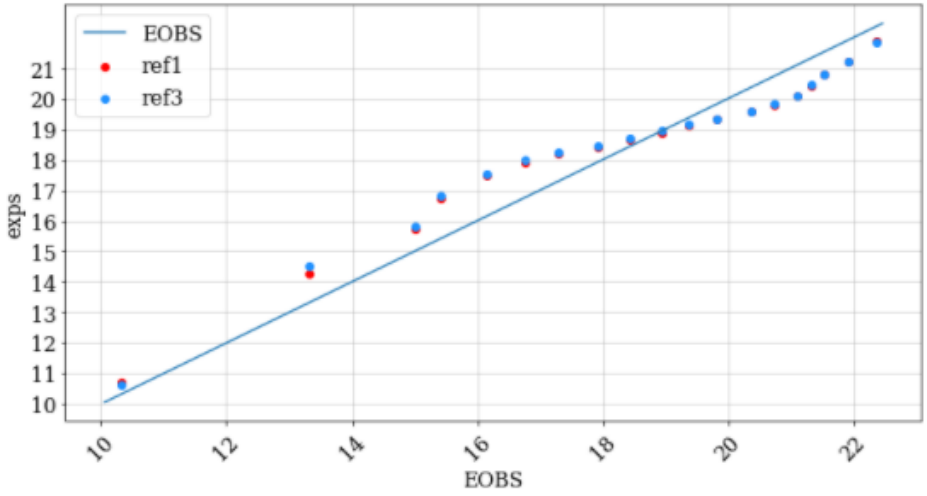
Max difference: 0.25°C

2020

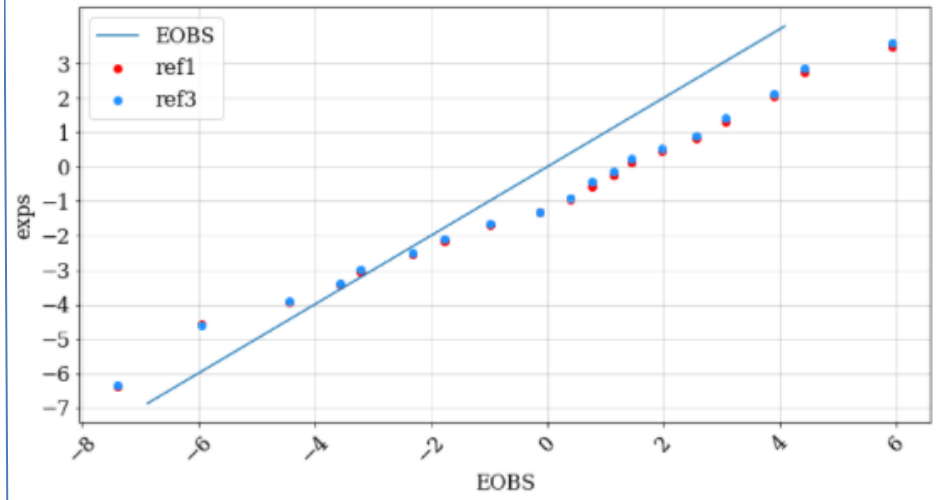
Min and Max TEMPERATURE

2019

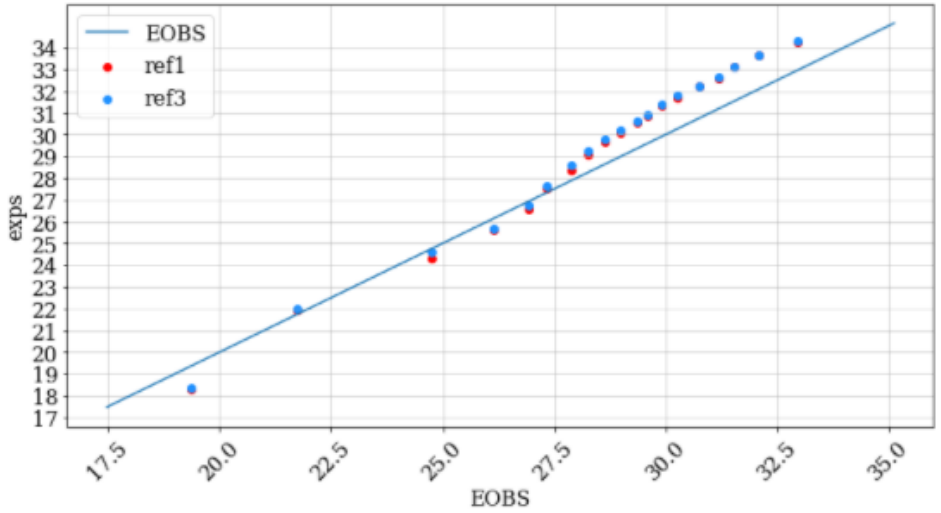
Min TEMPERATURE



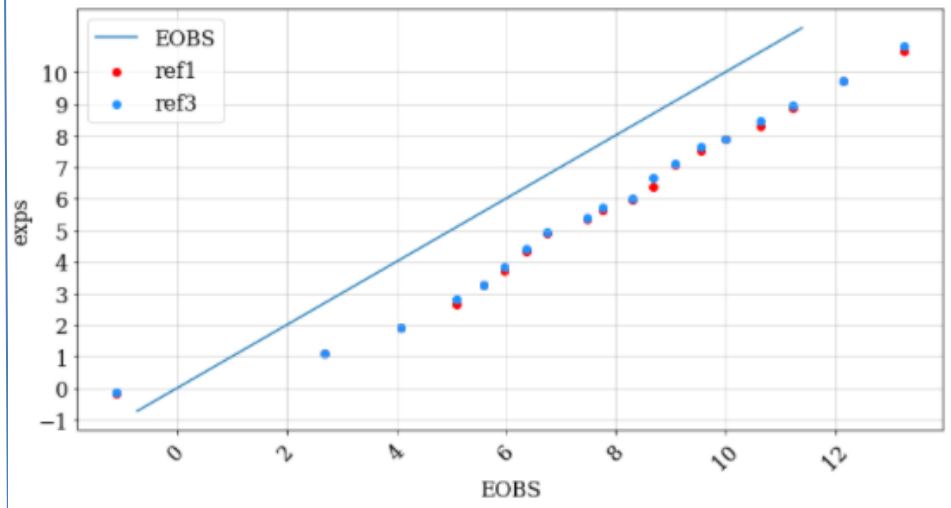
Min TEMPERATURE



Max TEMPERATURE



Max TEMPERATURE



ICON tests: physics schemes - CLOUD MICROPHYSICS

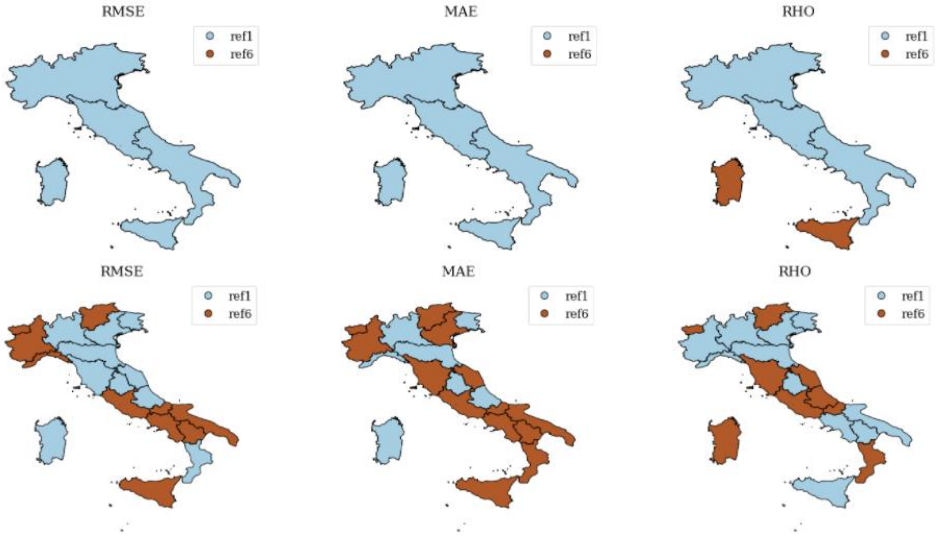
Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	inwp_convection	**lshallowconv_only**	**inwp_radiation**	**inwp_gscp**	**inwp_surface**	**inwp_cldcover**	**inwp_turb**
#1_ref1	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	**hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)**	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#6	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	**Two-moment microphysics by A. Seifert (4) ****	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#7	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	**as 1, but with improved ice nucleation scheme by C. Koehler (3)**	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer
#8	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	**Kessler scheme (9)**	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	1: COSMO diffusion and transfer

Simulations 7 and 8 produce unrealistic results.

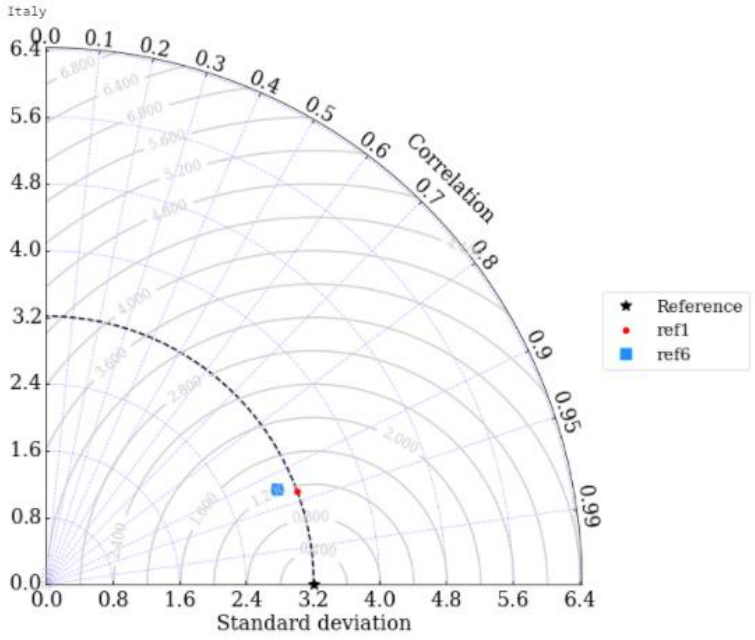
Simulation 1 performs better in both seasons, also in terms of correlation and standard deviation.

Daily Cumulative Precipitation

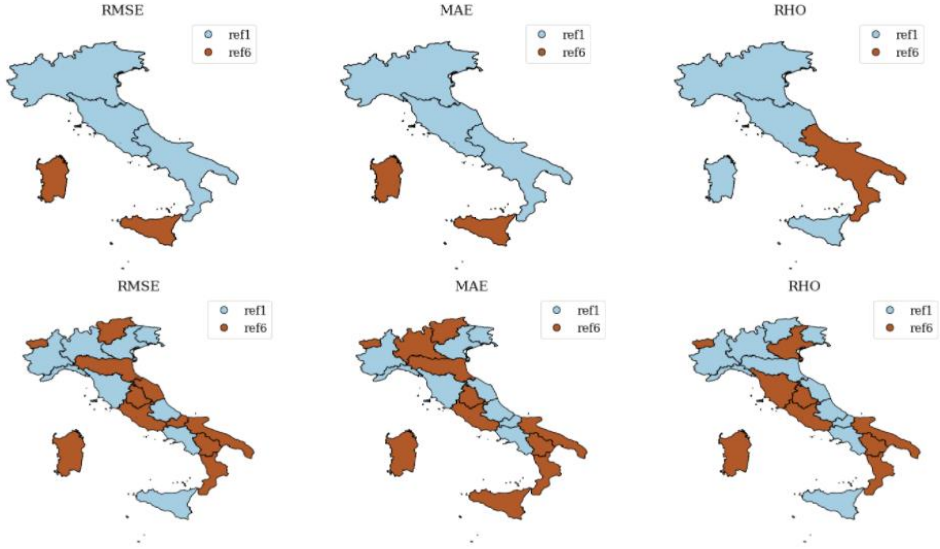
2020



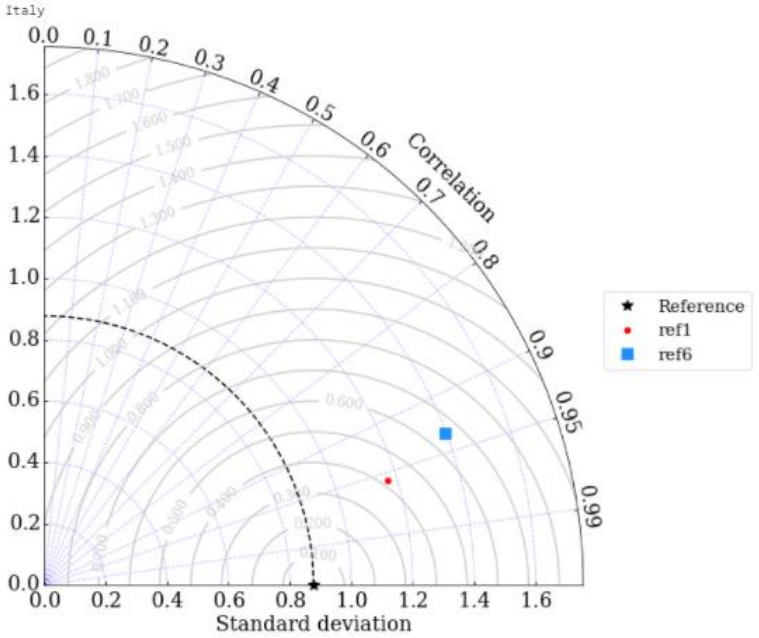
Max difference: 3 mm in Friuli



2019



Max difference: 2.4 mm in Trentino



ICON tests: physics schemes - CLOUD COVER

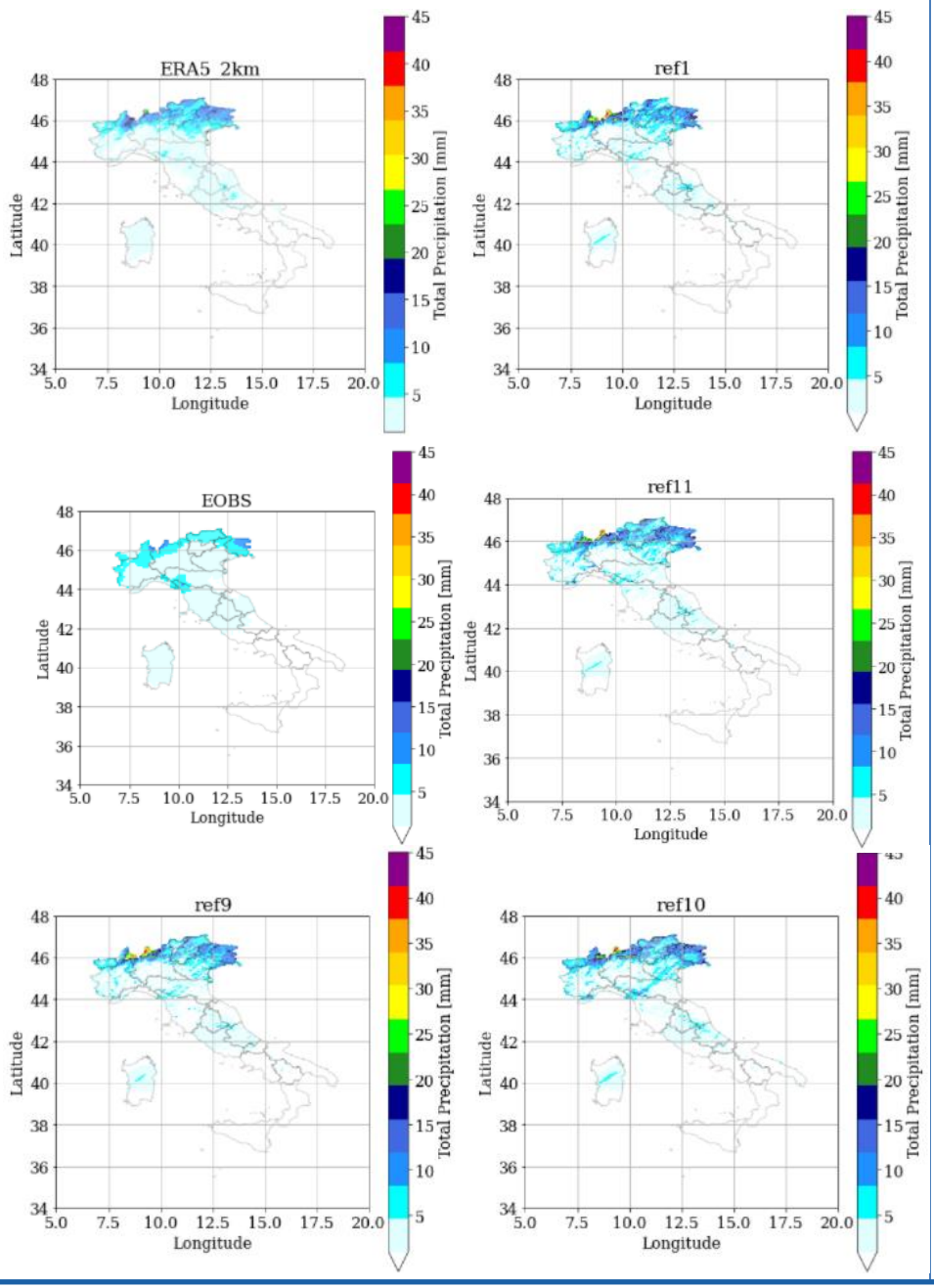
Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	inwp_convection	**lshallowconv_only**	**inwp_radiation**	**inwp_gscp**	**inwp_surface**	**inwp_cldcover**	**inwp_turb**
#1_ref1	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	**1: diagnostic cloud cover (by Martin Koehler)**	1: COSMO diffusion and transfer
#9	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	**3: clouds from COSMO SGS cloud scheme**	1: COSMO diffusion and transfer
#10	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	**4: clouds as in turbulence (turbdiff)**	1: COSMO diffusion and transfer
#11	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	**5: grid scale clouds**	1: COSMO diffusion and transfer

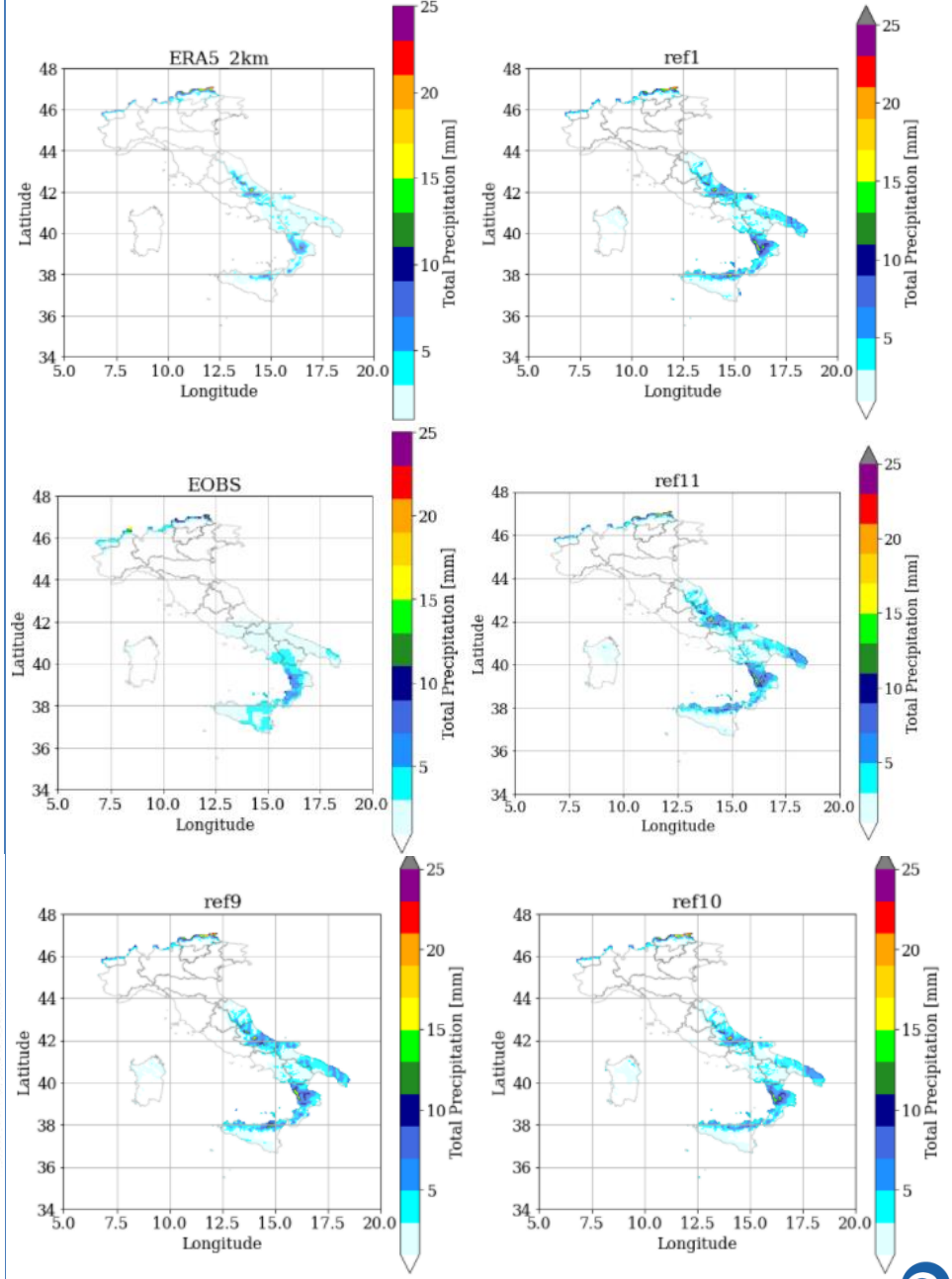
The problem of precipitation overestimation over the Alpine region is partially mitigated by Simulation 10.

Daily Cumulative Precipitation

2020

2019

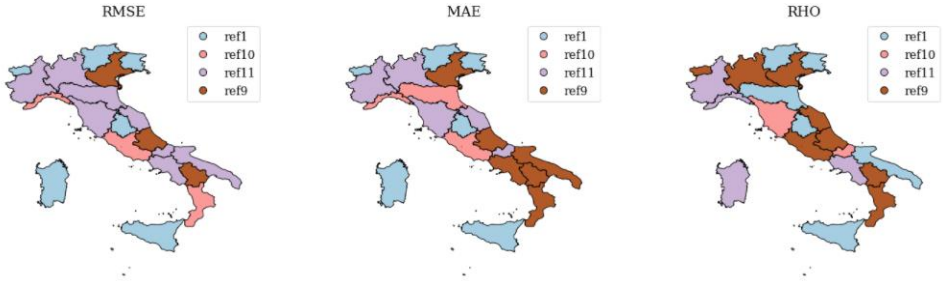




Daily Cumulative Precipitation

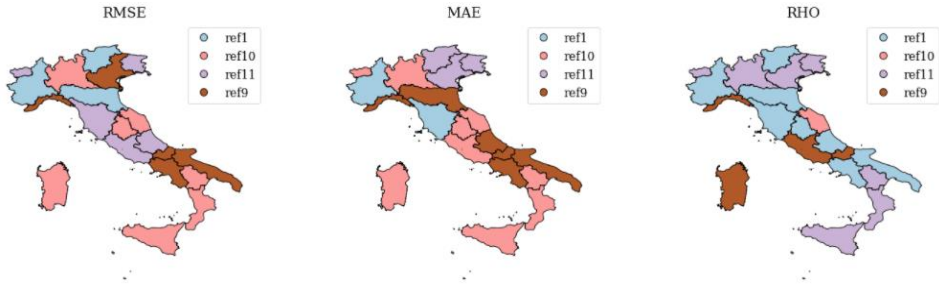
2020

Max difference: 1.2 mm



2019

Max difference: 0.3 mm



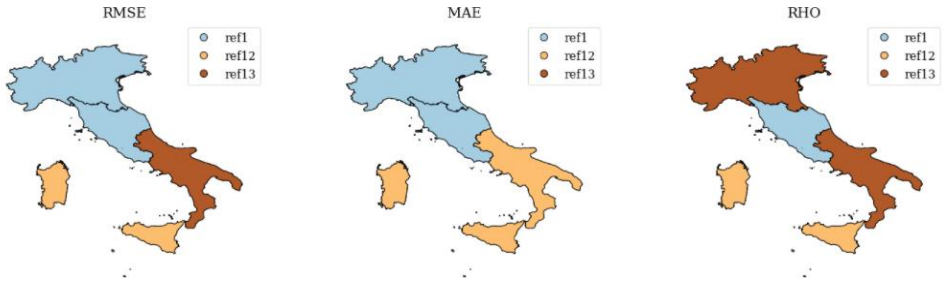
ICON tests: physics schemes - TURBOLENT TRANSFER

Sim	Convective scheme	Shallow conv	Radiation scheme	Cloud Microphysics	Land Surface	Cloud Cover	Turbulent transfer
	inwp_convection	**lshallowconv_only**	**inwp_radiation**	**inwp_gscp**	**inwp_surface**	**inwp_cldcover**	**inwp_turb**
#1_ref1	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	**1: COSMO diffusion and transfer**
#12	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	**2: GME turbulence scheme**
#13	Tiedtke/Bechtold convection (1)	TRUE	ecRad (4) *	hydci_gr (COSMO-DE microphysics, 3-cat ice: cloud ice, snow, graupel) (2)	TERRA (1)	1: diagnostic cloud cover (by Martin Koehler)	**5: Classical Smagorinsky diffusion**

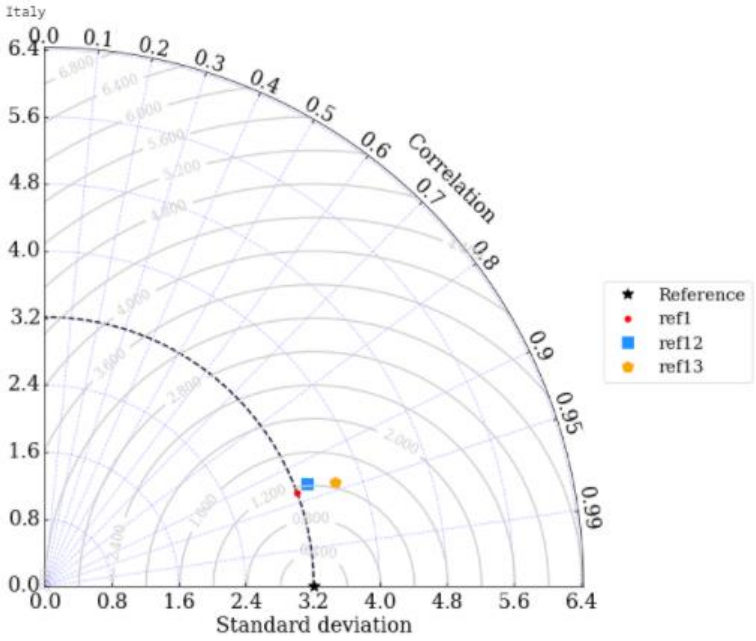
In winter 2019, the precipitation overestimation over South Italy is partially mitigated by Simulation 12

Daily Cumulative Precipitation

2020

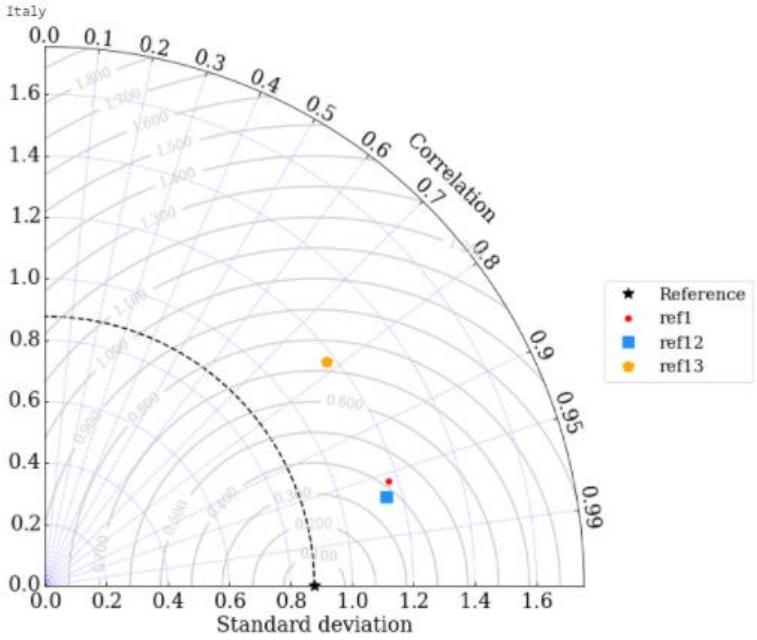


Max difference: 1.4 mm



2019

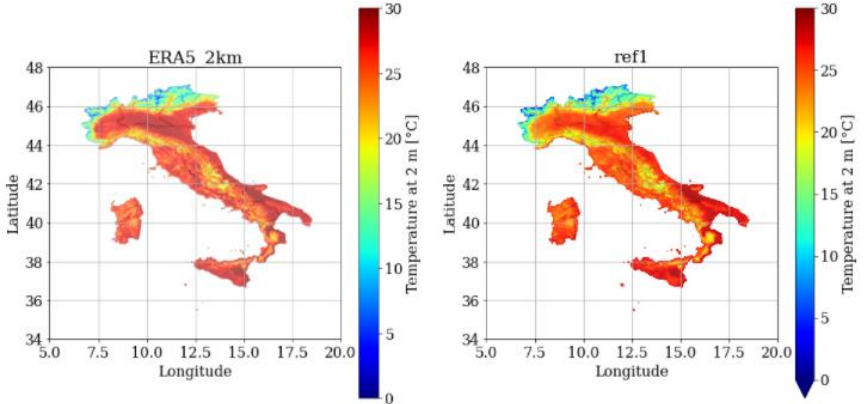
Max difference: 5.3 mm *

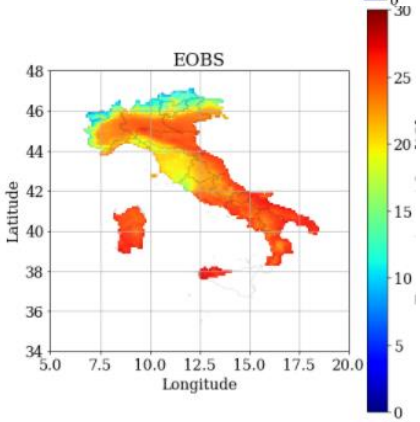


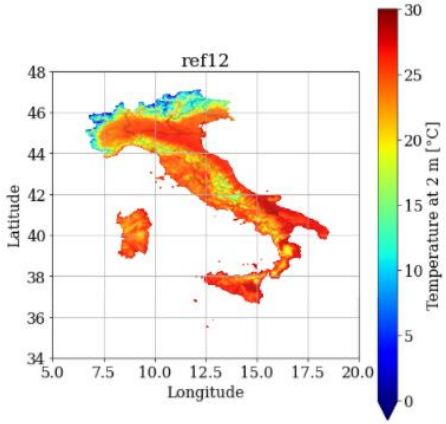
Mean TEMPERATURE at 2m

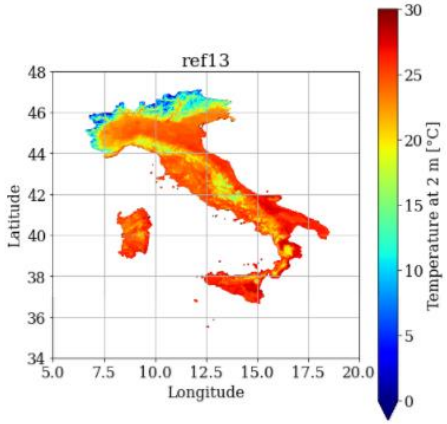
2020

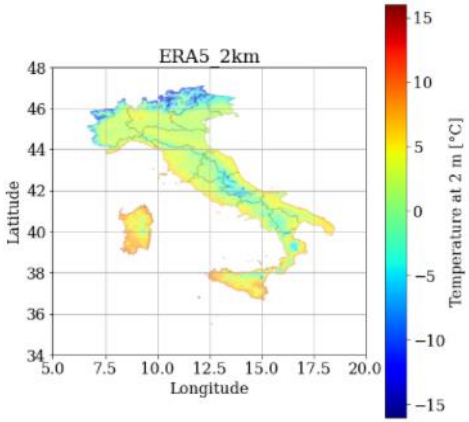
2019

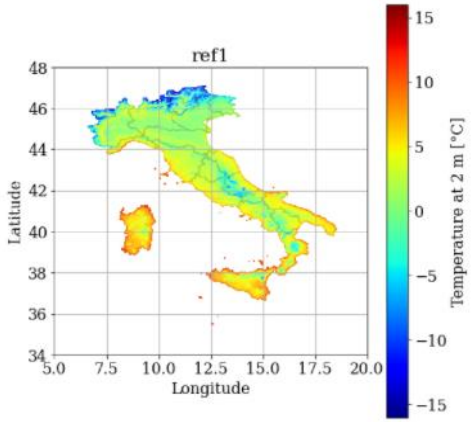


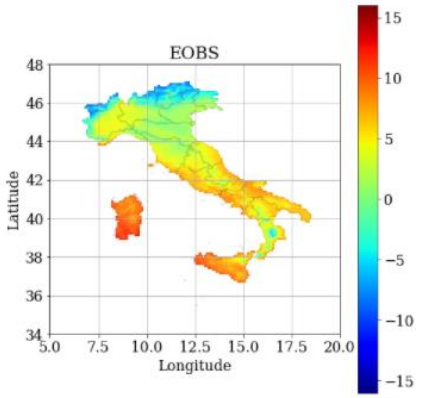


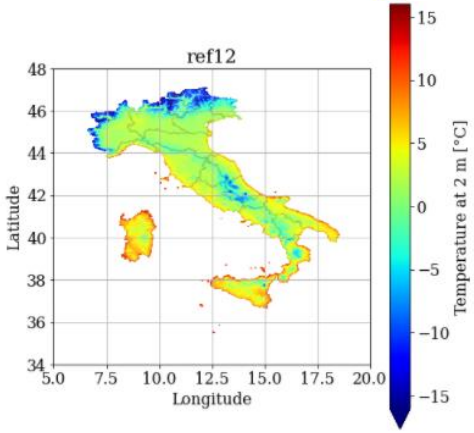


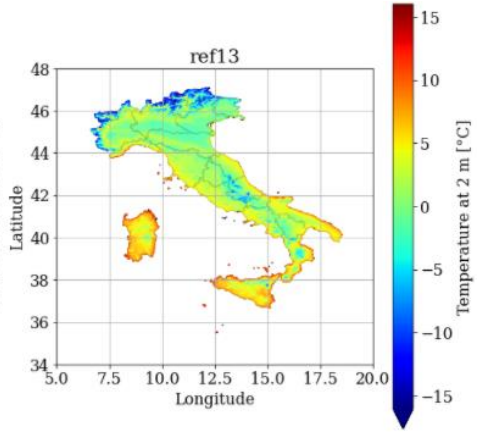












Thank you for your attention

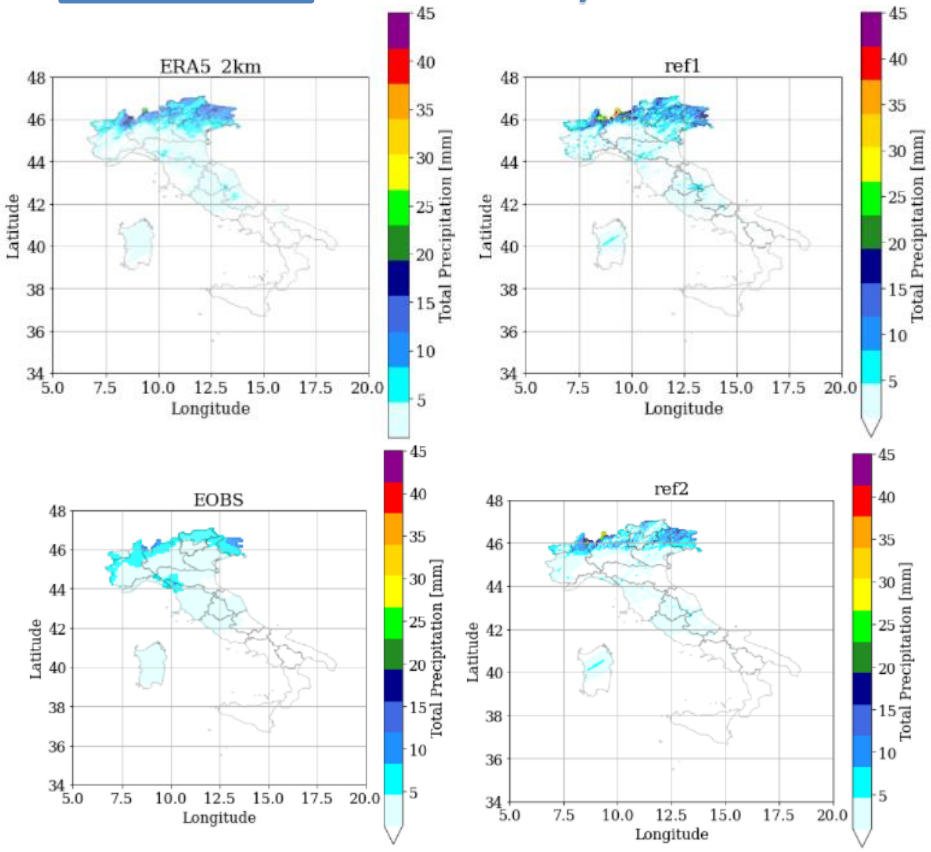
Dataset & variables for the validation

- **ERA5 at 2km**
  - Mininum Temperaure at 2 m
  - Maximum Temperature at 2 m
  - Mean Temperature at 2 m
  - Total precipitation

- **EOBS**
  - Mininum Temperaure at 2 m
  - Maximum Temperature at 2 m
  - Mean Temperature at 2 m
  - Total precipitation

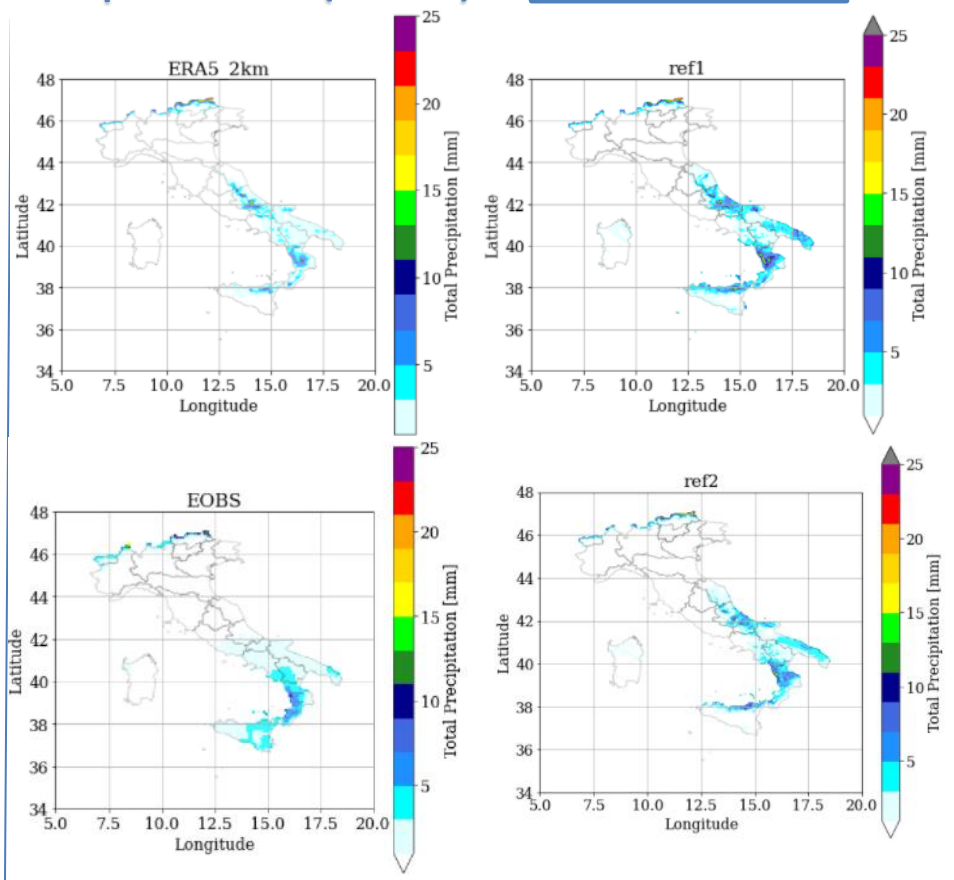
Daily Cumulative Precipitation (conv)

2020



Max difference: 0.9 mm

2019

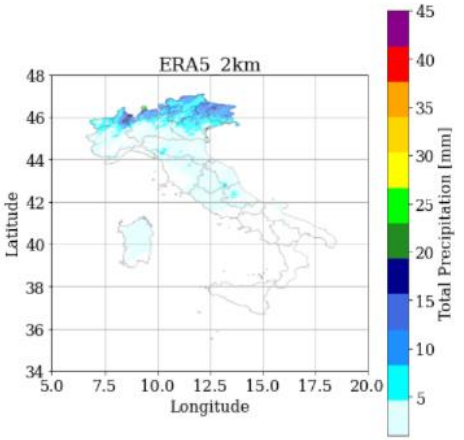


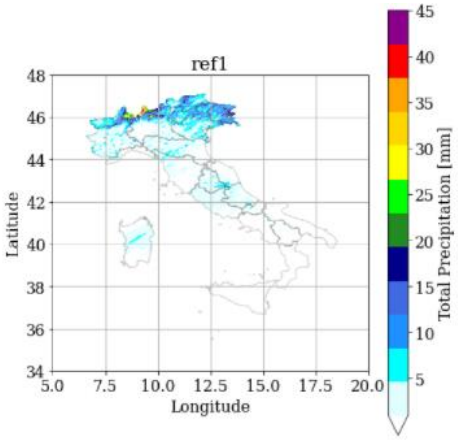
Max difference: 2 mm *

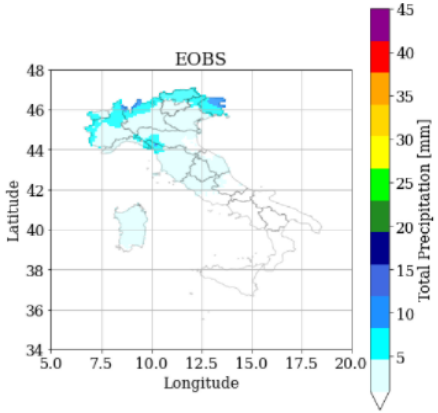
2020

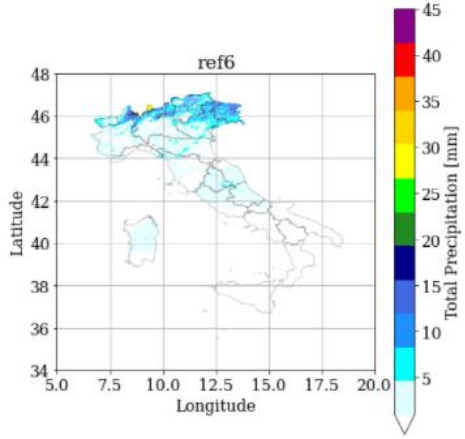
Daily Cumulative Precipitation (micro ph)

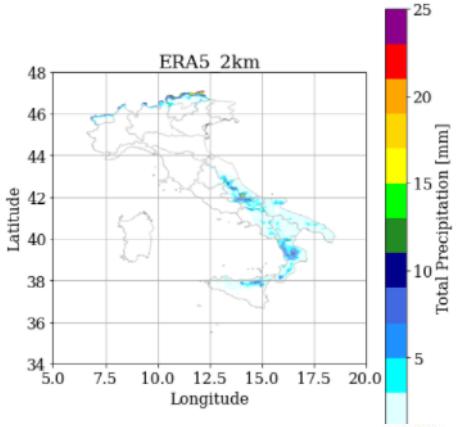
2019

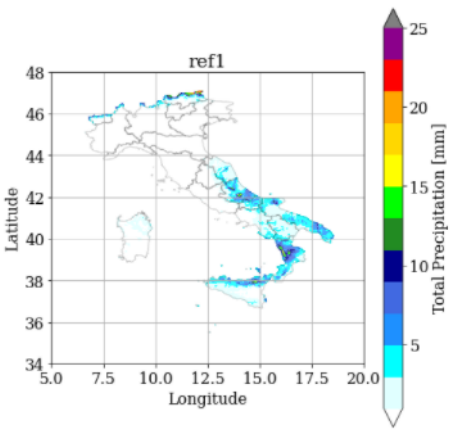


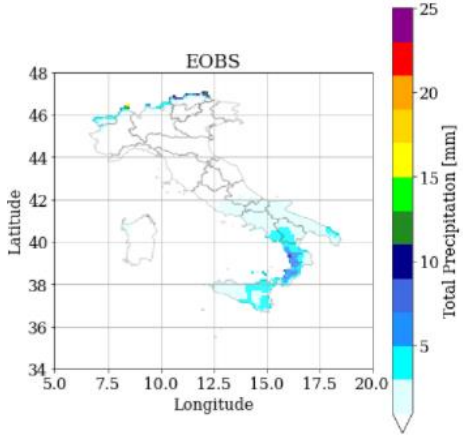


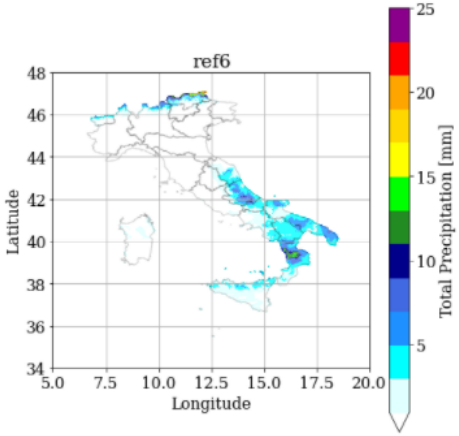








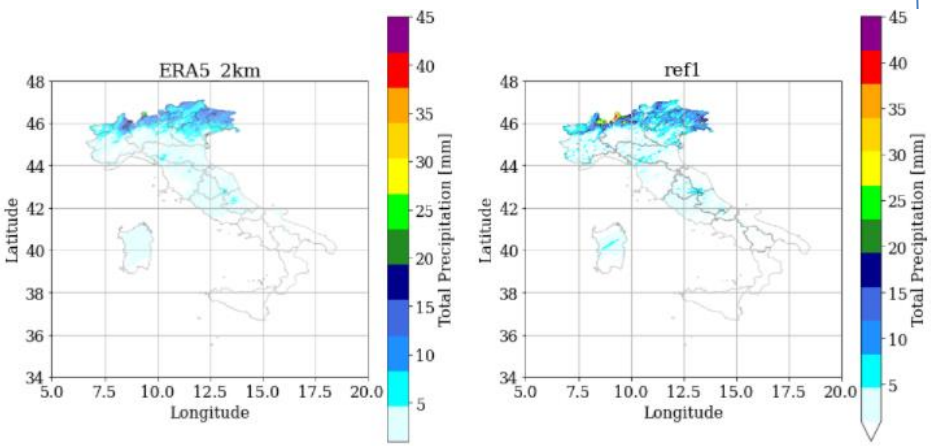


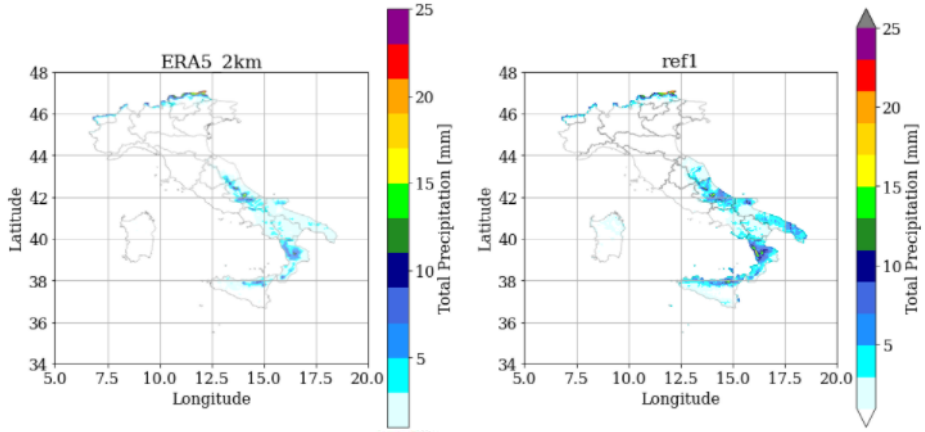


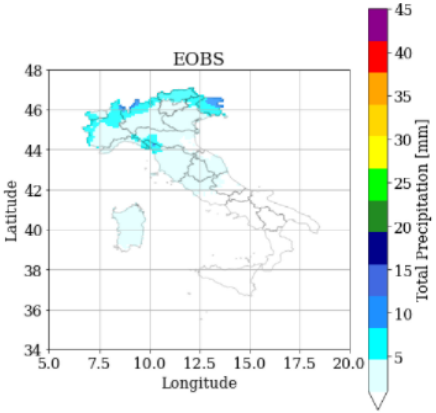
Daily Cumulative Precipitation (turb)

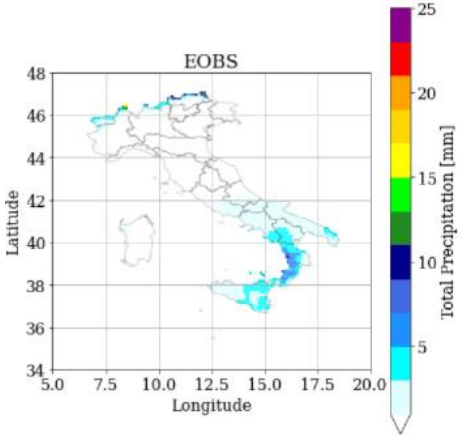
2020

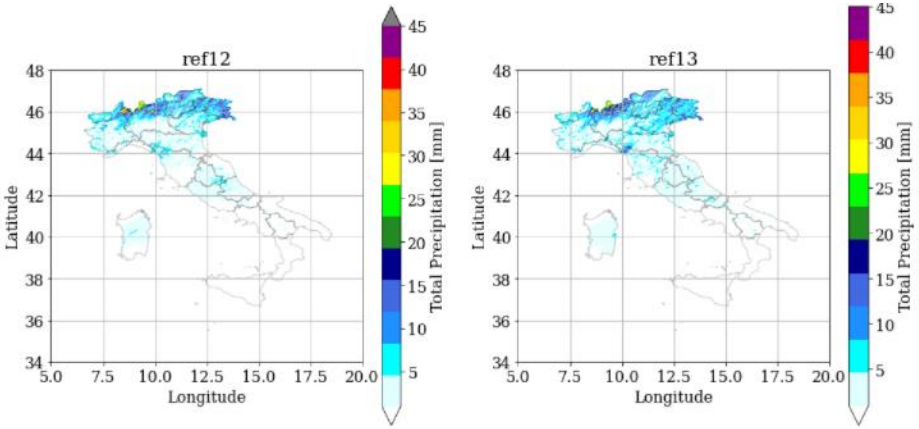
2019

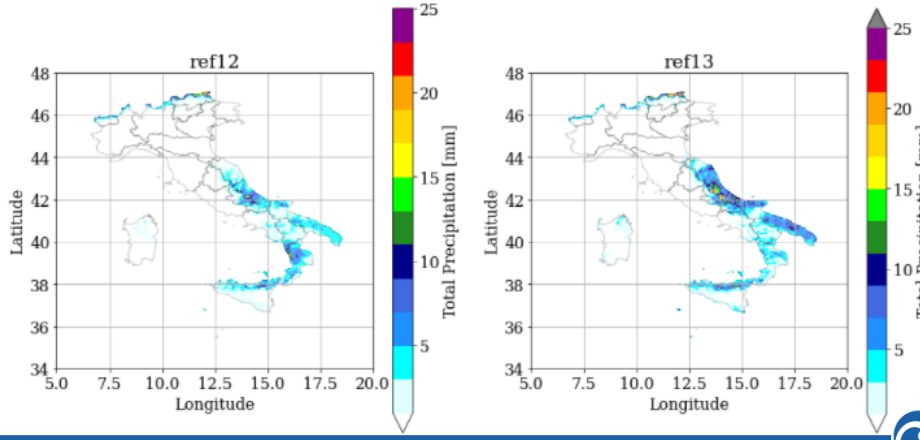








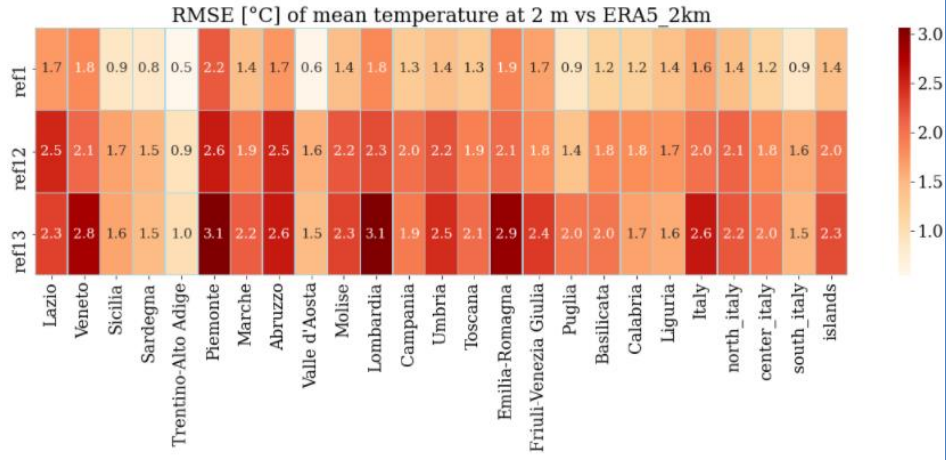


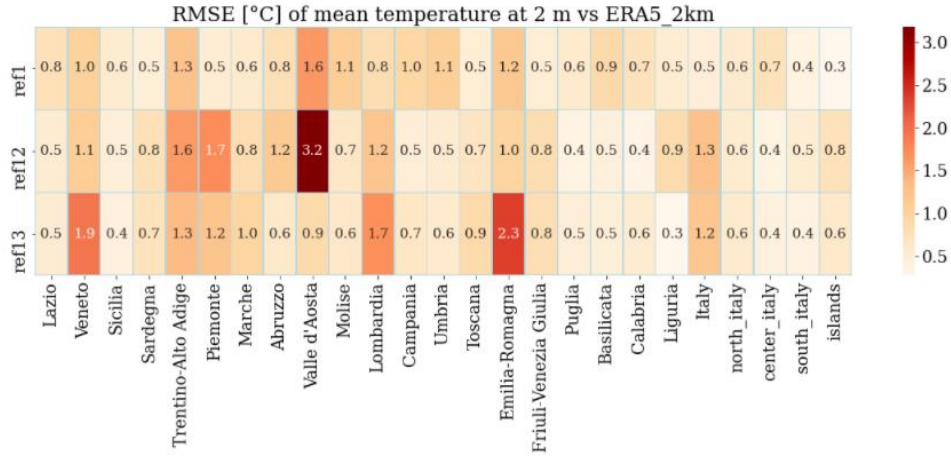


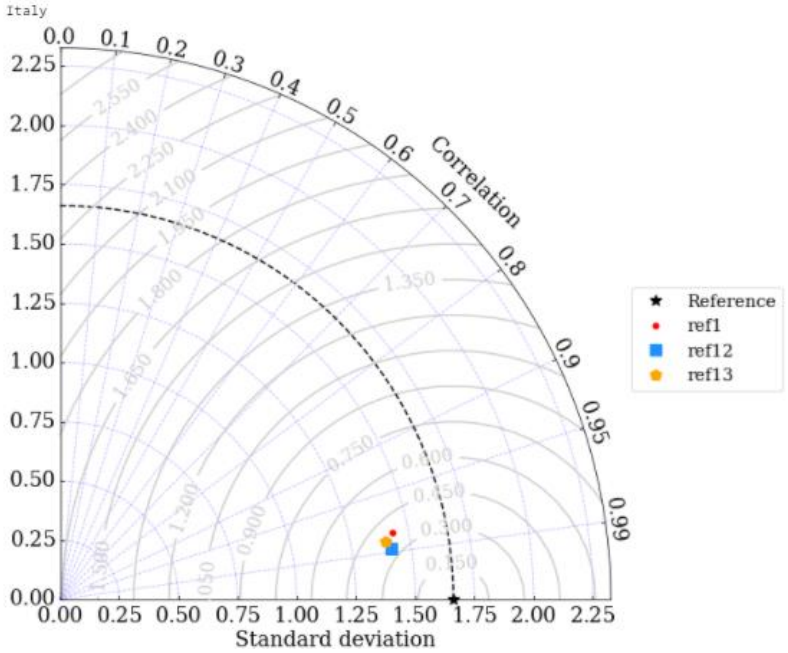
2020

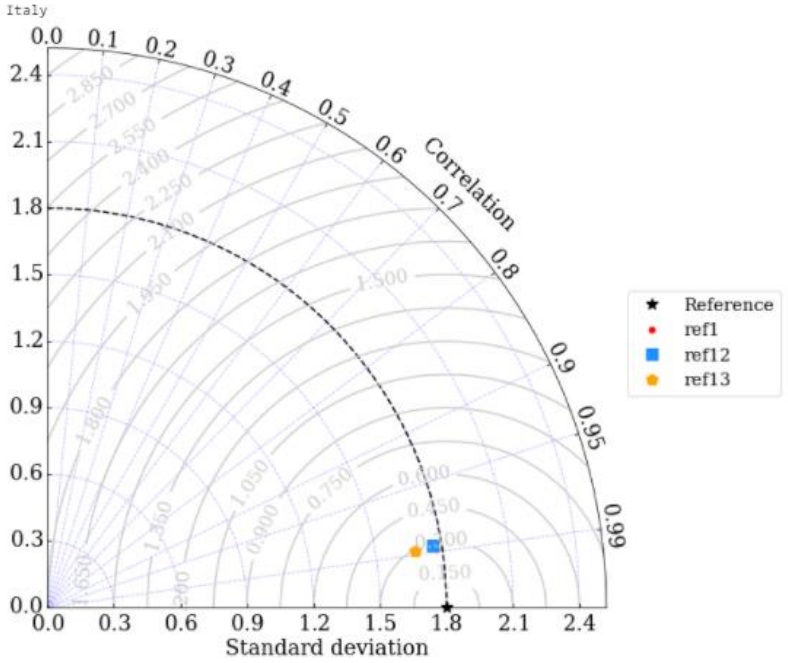
Mean TEMPERATURE at 2m (turb)

2019







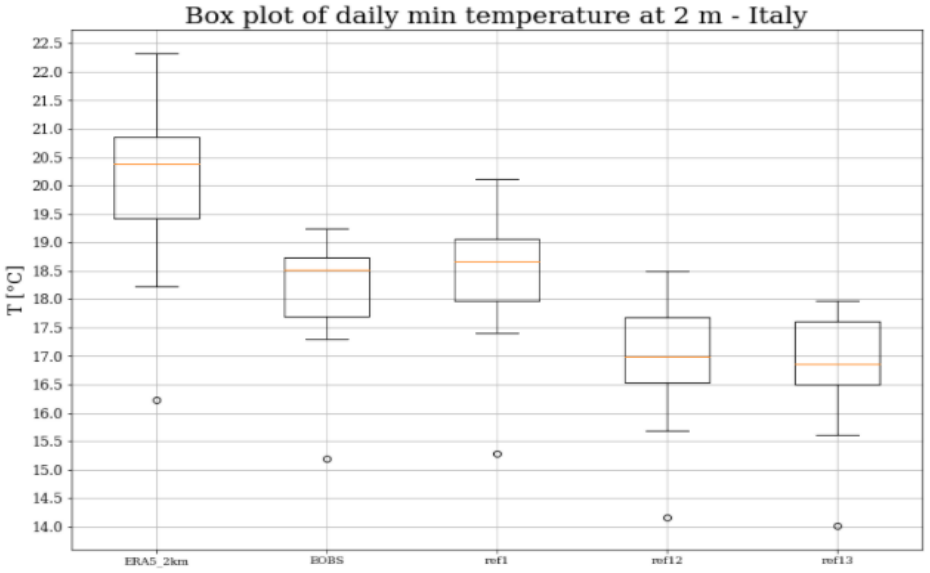


2020

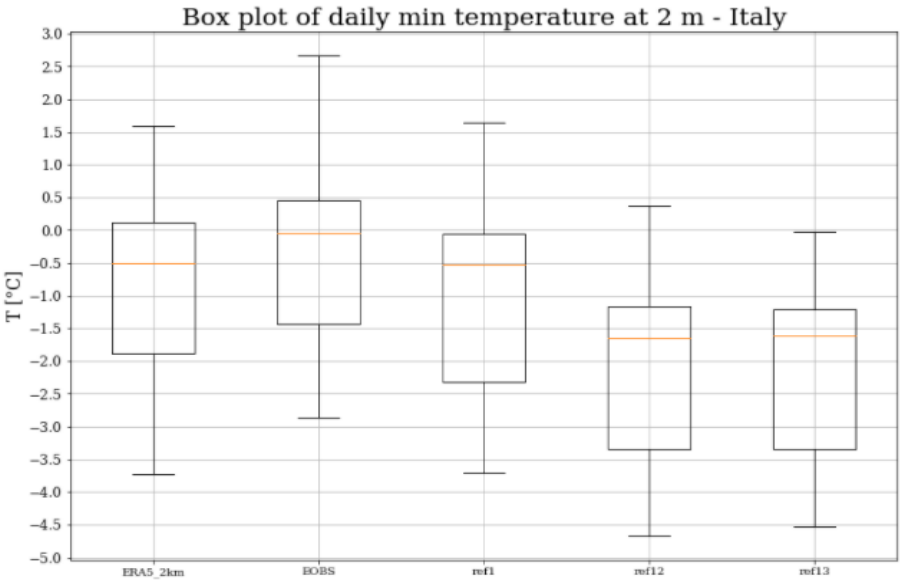
Min and Max TEMPERATURE (turb)

2019

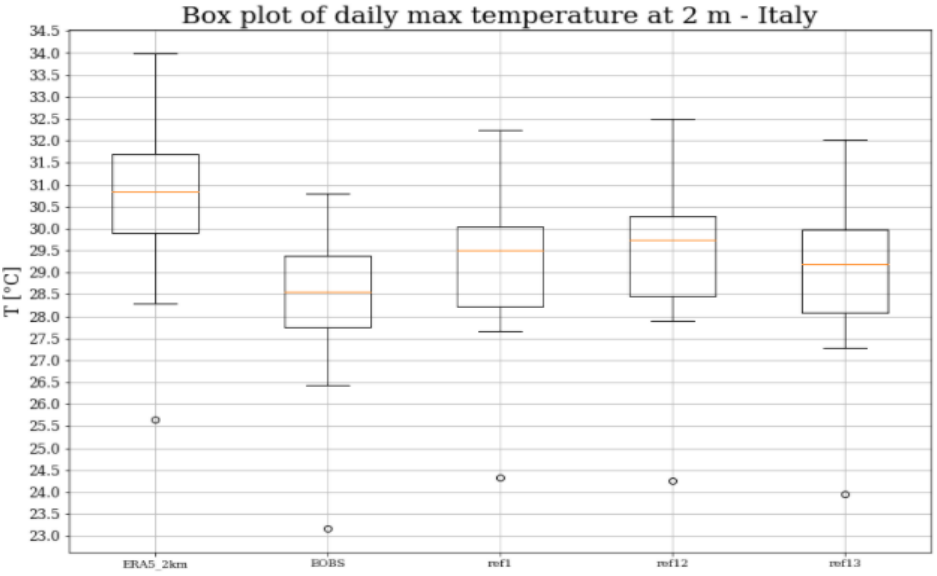
Min TEMPERATURE



Min TEMPERATURE



Max TEMPERATURE



Max TEMPERATURE