SPHERA
(High Resolution REAnalysis over Italy): development of the system and first assessments

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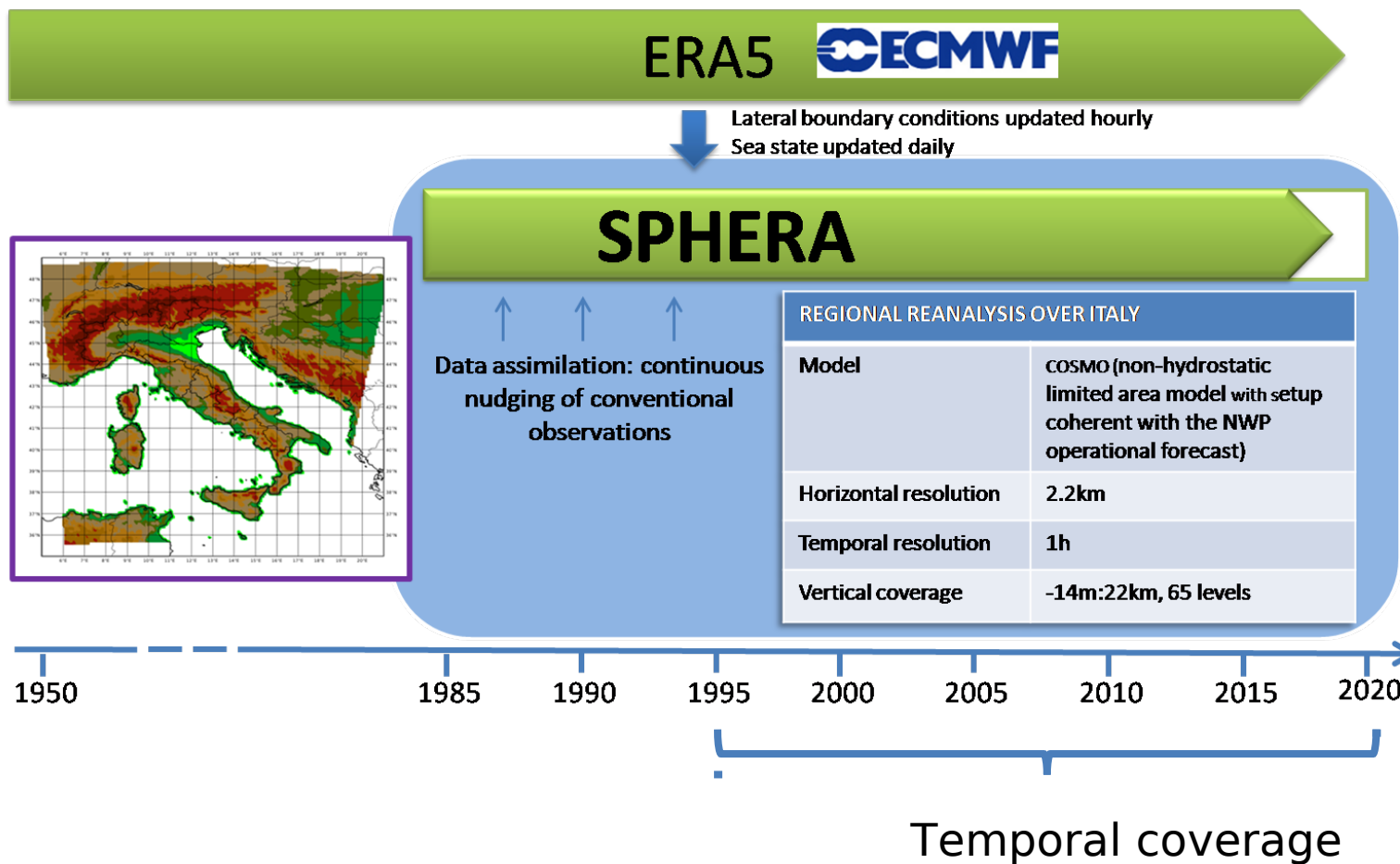*ARPAE-Emilia Romagna SIMC, Bologna*

Overview

1. Setup development

2. Production and performance in comparison with other regional reanalyses

3. Conclusions

Reanalysis in Europe

Reanalysis	Domain	Resolution	Model	Forcing	DA	Coverage	Developing group
ERA 5	Global	31km	IFS (2016)	-	IFS Cycle 31r2	1979-now (1950-now)	ECMWF
RRA	Europe	5.5km	ALADIN-HARMONIE	ERA 5	3D-Var	(1950-now, will be avail. second half 2019)	Copernicus Climate Change Service
SHMI RRA	Europe	11km	ALADIN-HARMONIE	Era Interim	3D-Var	1961-now	SHMI
COSMO-REA6	Europe	6km	COSMO	Era Interim	Cont. nudging	1995-now	DWD/Hans-Ertel Z.
COSMO-REA2	Germany	2km	COSMO	COSMO-REA6	Cont. nudging	2007-2013 (2013-2017)	DWD/Hans-Ertel Z.
3D-Var RRA	Europe	22km	HIRLAM	Era Interim	3D-Var	1989-2010	SHMI
4D-Var RRA	Europe	12km	UM	Era Interim	4D-Var	1979-1990, 2000-2014	UKMO
SPHERA	Italy	2.2km	COSMO	ERA 5	Cont. nudging	(1995-2020)	ARPAE

SPHERA setup

ERA5 **ECMWF**

Lateral boundary conditions updated hourly
Sea state updated daily

SPHERA

Data assimilation: continuous nudging of conventional observations

REGIONAL REANALYSIS OVER ITALY	
Model	COSMO (non-hydrostatic limited area model with setup coherent with the NWP operational forecast)
Horizontal resolution	2.2km
Temporal resolution	1h
Vertical coverage	−14m:22km, 65 levels

1950   1985   1990   1995   2000   2005   2010   2015   2020

Temporal coverage

Open issues in the setup development

Which **nesting modality** should we use for stepping from ERA5 (31km) into SPHERA (2.2km)?

➢ **"2step" :** using an intermediate COSMO integration at 10km (traditional 1:3-1:5 step)

➢ **"1step"** : direct nest from ERA5 (save computing time, some evidences of neutral/better performance)

Which **bottom boundary condition** should we provide to the **soil** (bottom level at -14.58m)?
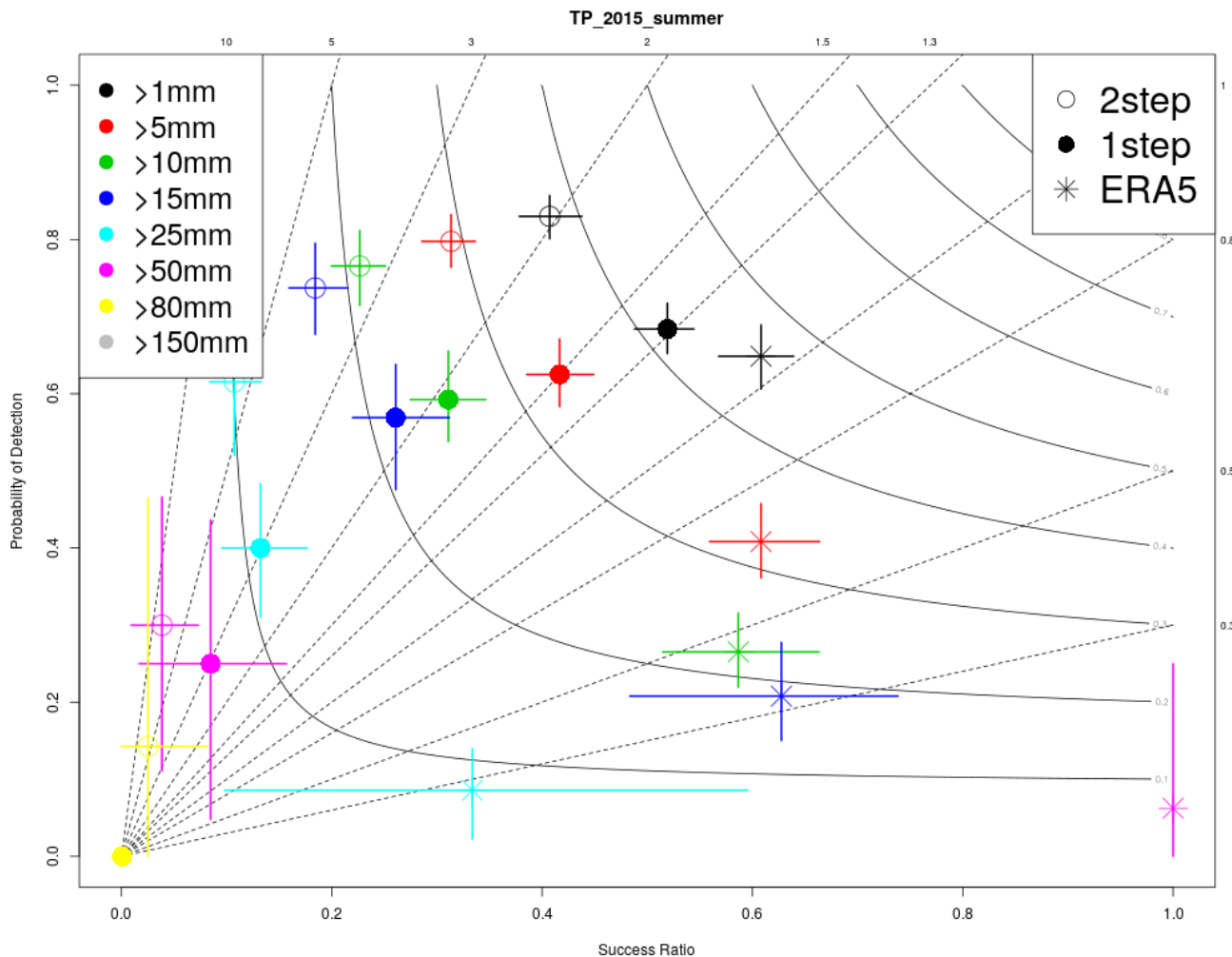
➢ ERA5 has the bottom soil level at -1.9m

➢ Very few observations available at depths larger than 0.5m

➢ Long inertia of soil → signals relevant on long temporal scales

Either 1step or 2steps nest into ERA5?
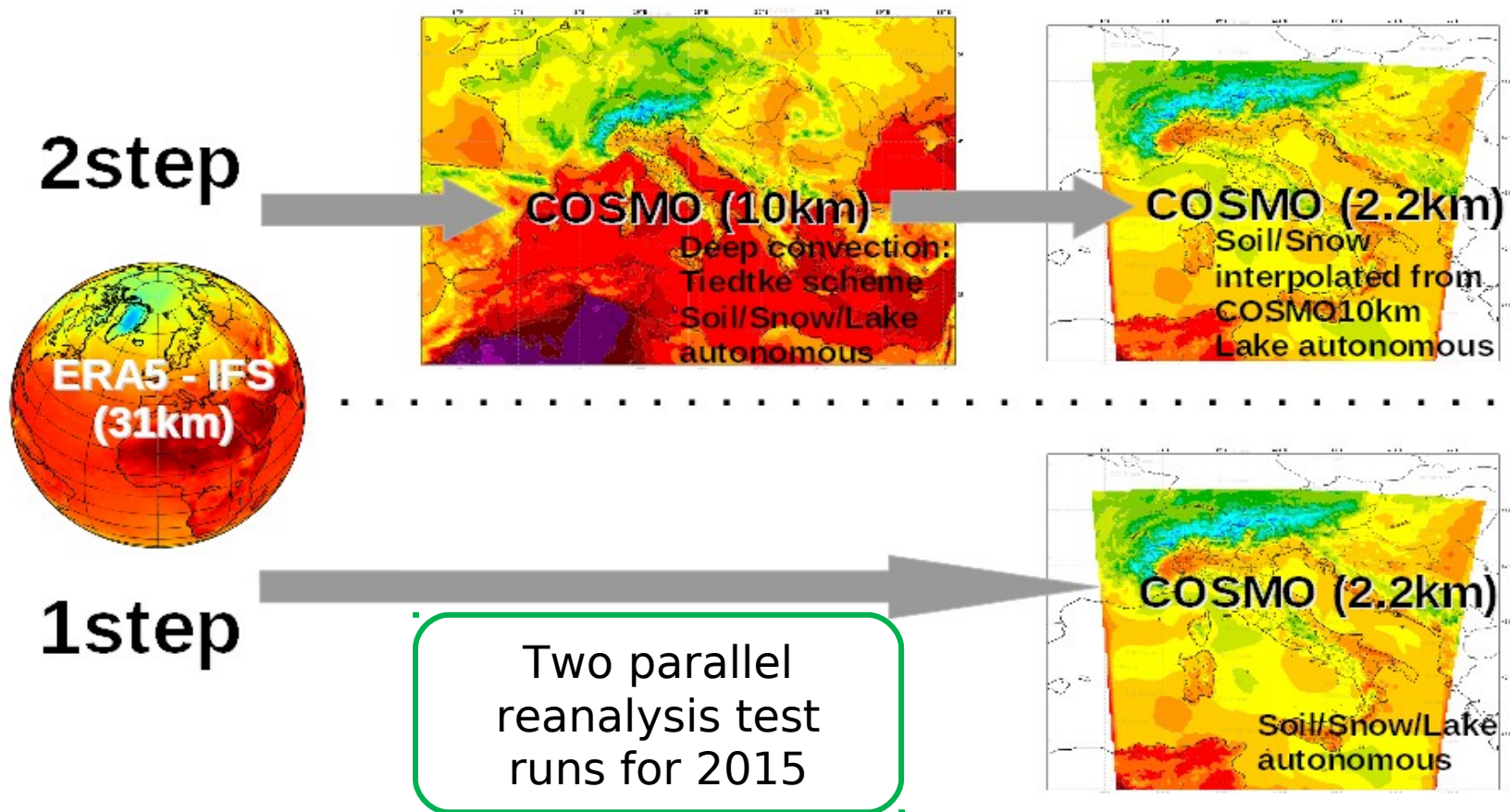
Either 1step or 2steps nest into ERA5?

Performance diagram of the daily cumulated precipitation for **JJA 2015**

Verification using boxes of 0.25°x0.25°, with observations not ingested in data assimilation

1step performs better than 2step at almost all thresholds (less FA, less BIAS, less precipitation)

SPHERA improves against ERA5 for precipitation >10mm (more POD and FA)

Either 1step or 2steps nest into ERA5?
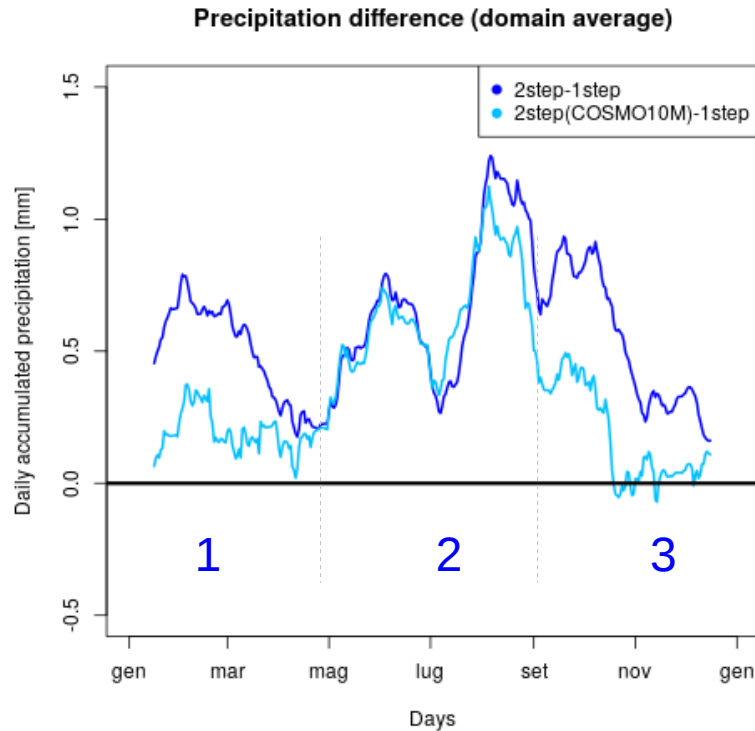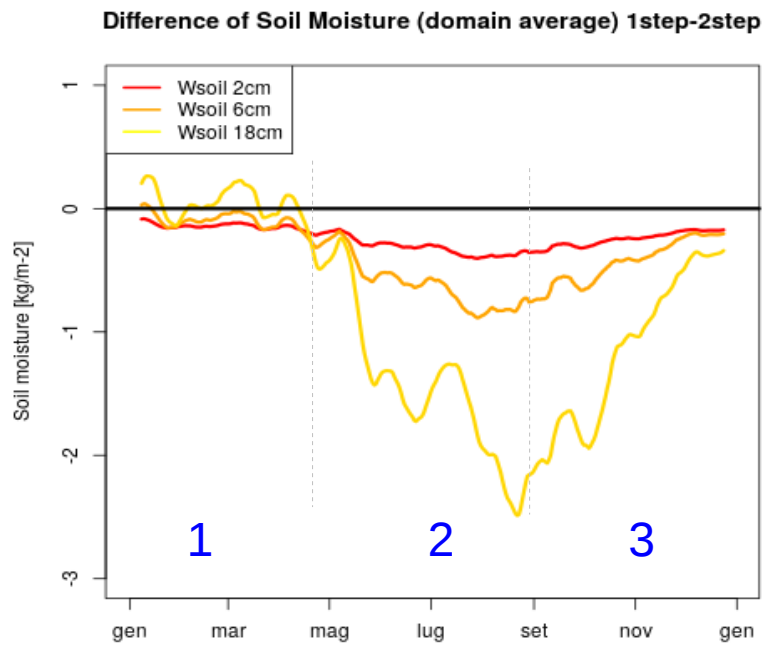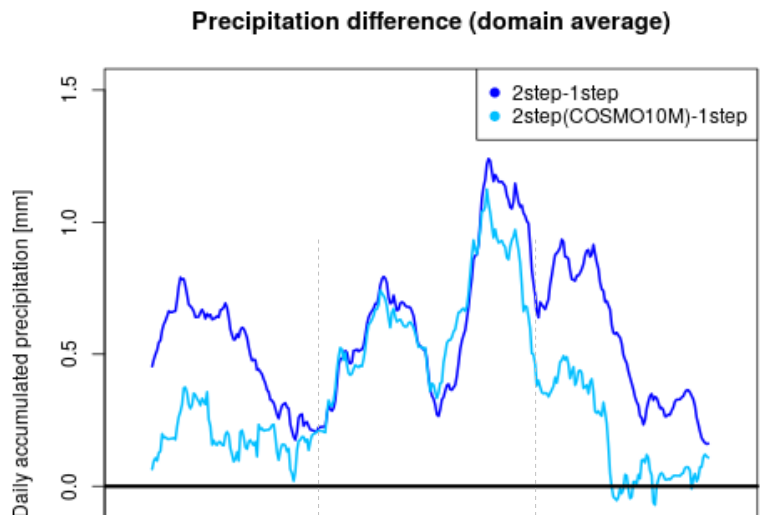
Precipitation difference (domain average)

2. From May to September all the difference between 2step (COSMO-2.2km) and 1step originates in the intermediate integration domain of 2step (effect of the convection parametrization?)

3. From September to January only a small component originates in COSMO-10km (higher moisture stored in the soil in 2step?)

1. From January to May (other effect?)

Either 1step or 2steps nest into ERA5?

Precipitation difference (domain average)

Legend:
- 2step-1step
- 2step(COSMO10M)-1step

Y-axis: Daily accumulated precipitation [mm]

Difference of Soil Moisture (domain average) 1step-2step

Legend:
- Wsoil 2cm
- Wsoil 6cm
- Wsoil 18cm

Y-axis: Soil moisture [kg/m-2]

X-axis: gen, mar, mag, lug, set, nov, gen

Regions: 1   2   3

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➢ **"1step"** : direct nest from ERA5 (save computing time, some evidences of neutral/better performance)

It avoids the wet drift due to the coarse resolution in the intermediate run

Which **bottom boundary condition** should we provide to the **soil** (bottom level at -14.58m)?

➢ ERA5 has the bottom soil level at -1.9m

➢ Very few observations available at depths larger than 0.5m

➢ Large inertia of soil → signals relevant on long temporal scales

Which soil deep temperature?

Two parallel test runs for 2015-2016 (plus 6months of initialization):

1. Fix Tdeep: deep temperature fixed (equal to intial state) and equal to ERA5 at -1.9m

2. Var Tdeep: deep temperature parametrized as a function of ERA5 soil T → time evolving Tdeep, dependent on the soil features in each grid point
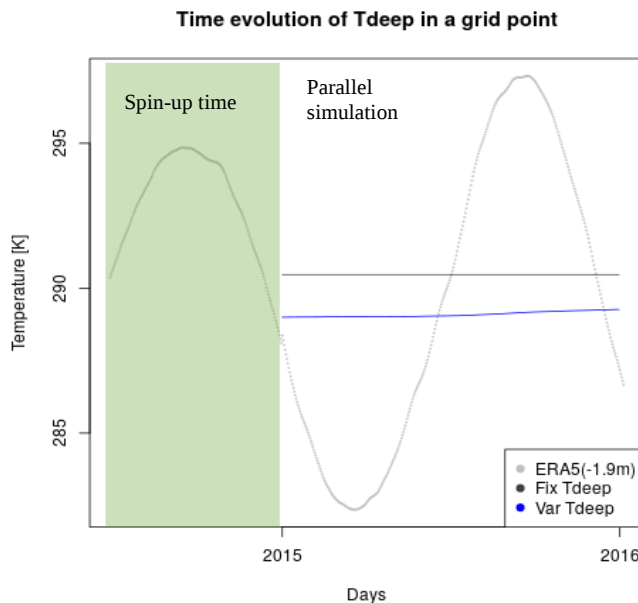

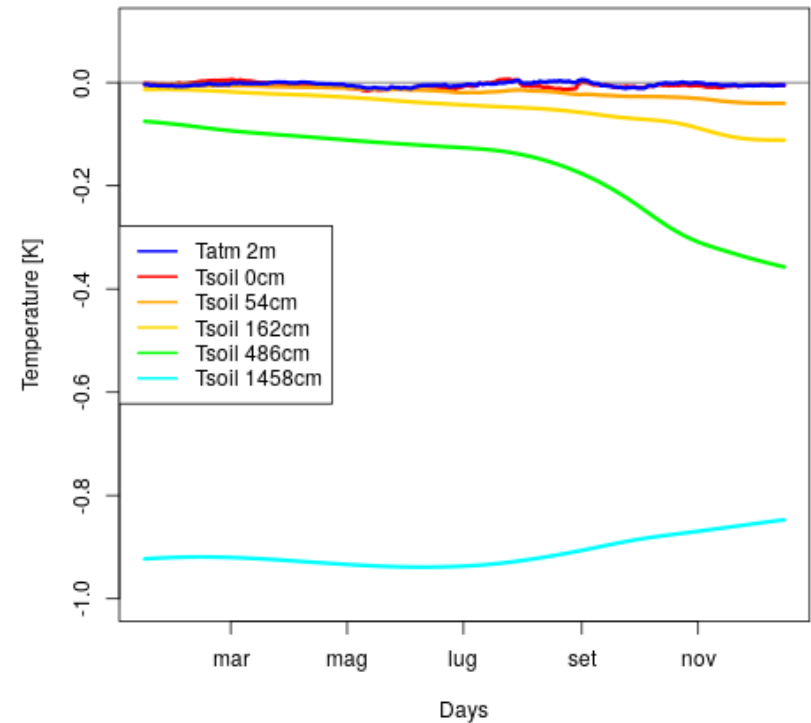Difference of Soil Temp (domain avg): Var Tdeep - Fix Tdeep

Legend:
- Tatm 2m
- Tsoil 0cm
- Tsoil 54cm
- Tsoil 162cm
- Tsoil 486cm
- Tsoil 1458cm

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Difference of Soil Temp (domain avg): Var Tdeep - Fix Tdeep

Time evolution of Tdeep in a grid point

- Average difference at -14.58m of ~1K (in single point can be >5K): it depends on the month of initialization and on the soil type
- Signal propagated upward: after 12months (+6months) reaches -0.5m

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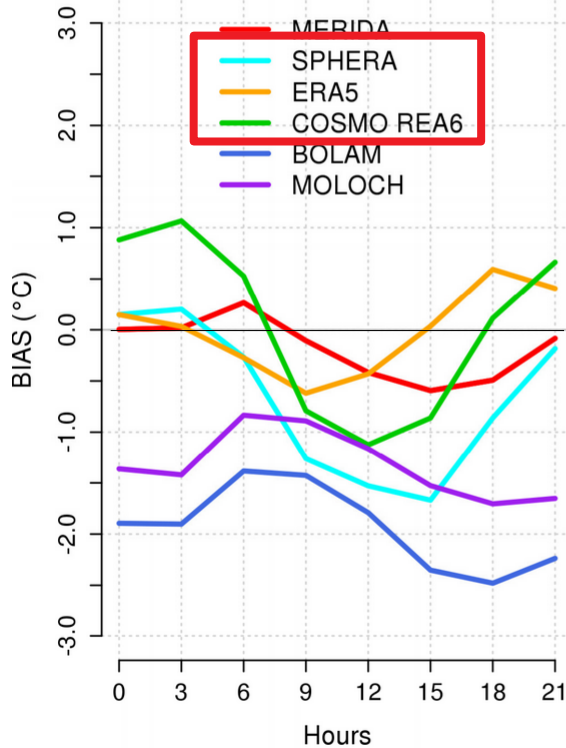➤ Large inertia of soil → signals relevant on long temporal scales

deep temperature prescribed as a function of ERA5 soil T

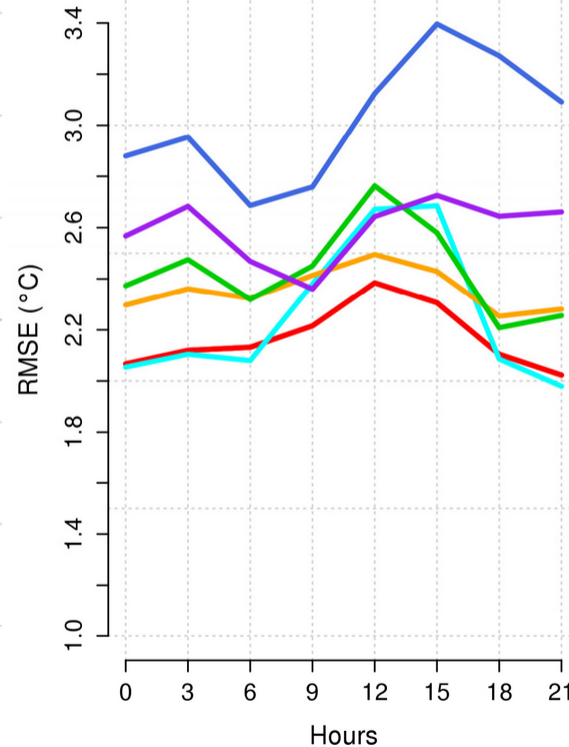**Production 2003-2016 using COSMOv5.05 in double precision**

Comparison with other regional reanalyses

Verification of temperature at 2m – 2015 yearly average
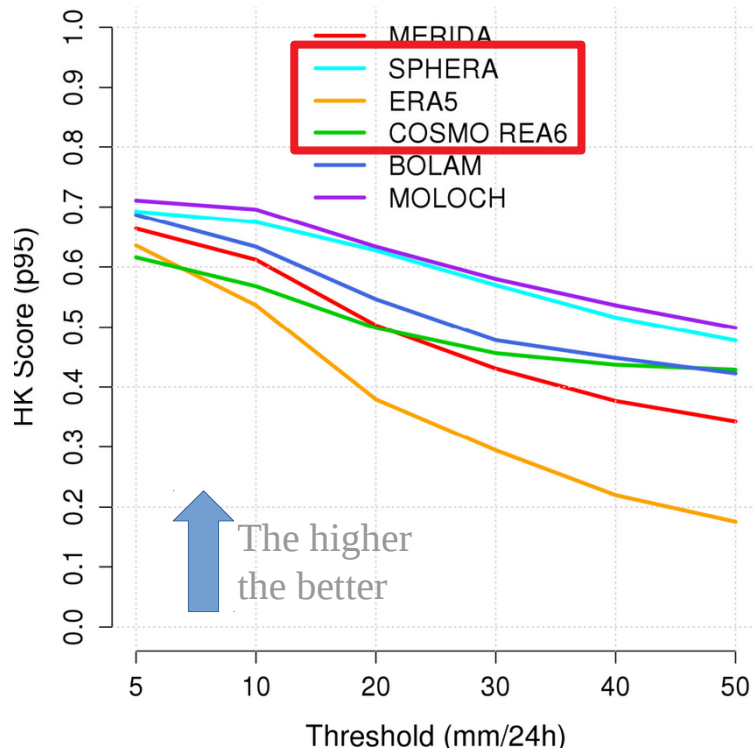
BIAS

RMSE

Bilinear interpolation on the stations of the Civil Protection Network

- Different diurnal cycle of bias, but similar cycle of RMSE

- COSMO-based reanalyses report similar pattern, better for SPHERA

Comparison with other regional reanalyses

Verification of daily cumulated precipitation – 2015

HK (POD-POFD)

Verification using boxes of 0.4°x0.4°, using stations of the Civil Protection Network

Clustering as a function of resolution

Conclusions

SPHERA is a regional reanalysis archive over Italy at 2.2km resolution and it will cover the period 1995-2020

➤ First release for years 2003-2016 in June 2019, publicly available

➤ SPHERA data will include the hourly 3D model output:
1. State of the atmosphere (65 vertical levels)
2. Surface state (including over lake, sea, snow)
3. Soil state (7 vertical levels)
4. Wind components at high temporal resolution in the lowest 500m

Use and test is very welcome!

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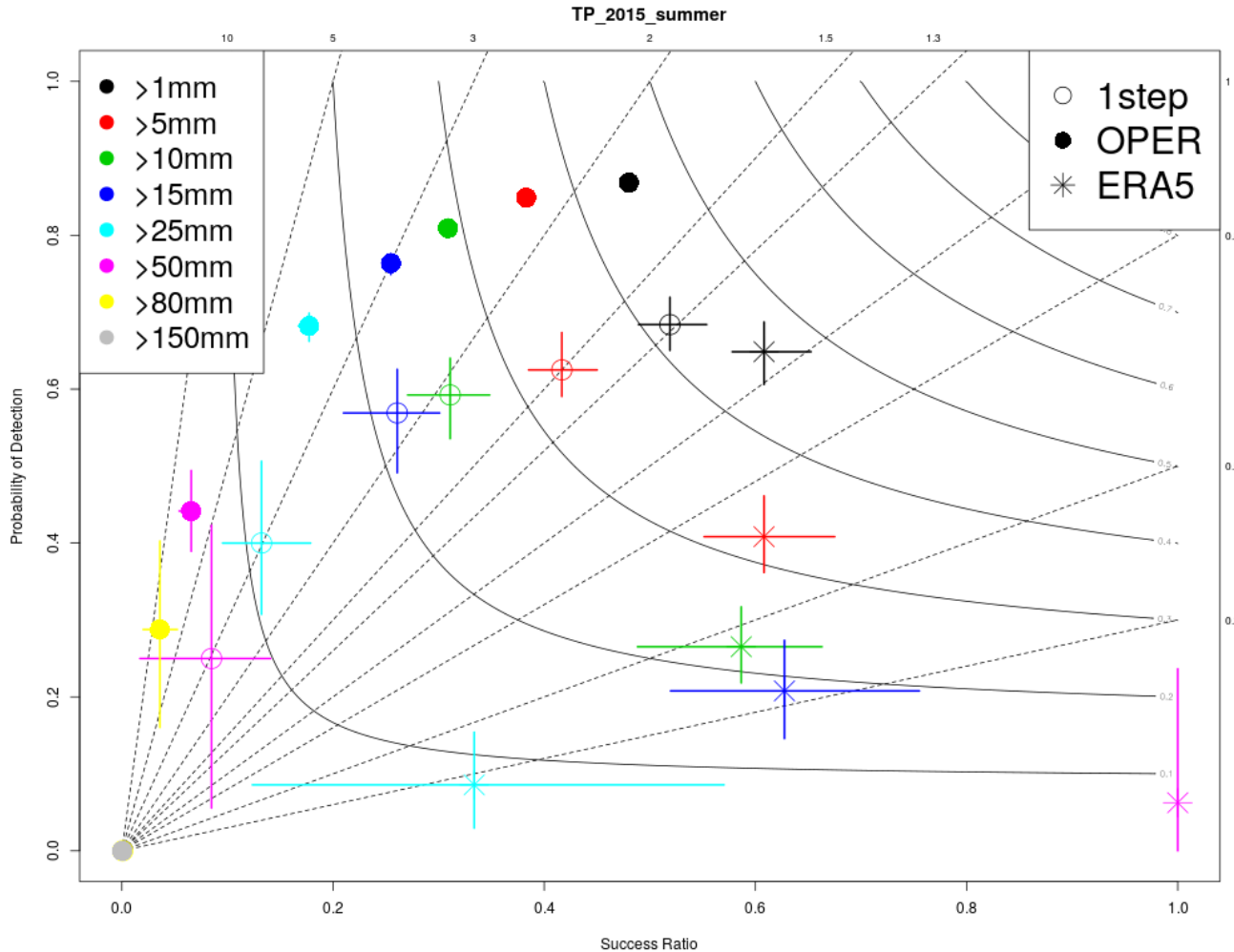
Thank you for your attention,

Ines Cerenzia
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ARPAE-Emilia Romagna
E-mail: icerenzia@arpae.it

Operational performance

Performance diagram of the daily cumulated precipitation for **JJA 2015**

Verification using boxes of 0.25°x0.25°, with observations not ingested in data assimilation

OPER performs better than 1step at thresholds > 10mm, but larger bias

(effect of using COSMO in double precision rather than in single one?)