Towards a 20-member COSMO-LEPS: updates and challenges

Andrea Montani, Chiara Marsigli, Tiziana Paccagnella

Arpae Emilia-Romagna Servizio IdroMeteoClima, Bologna, Italy

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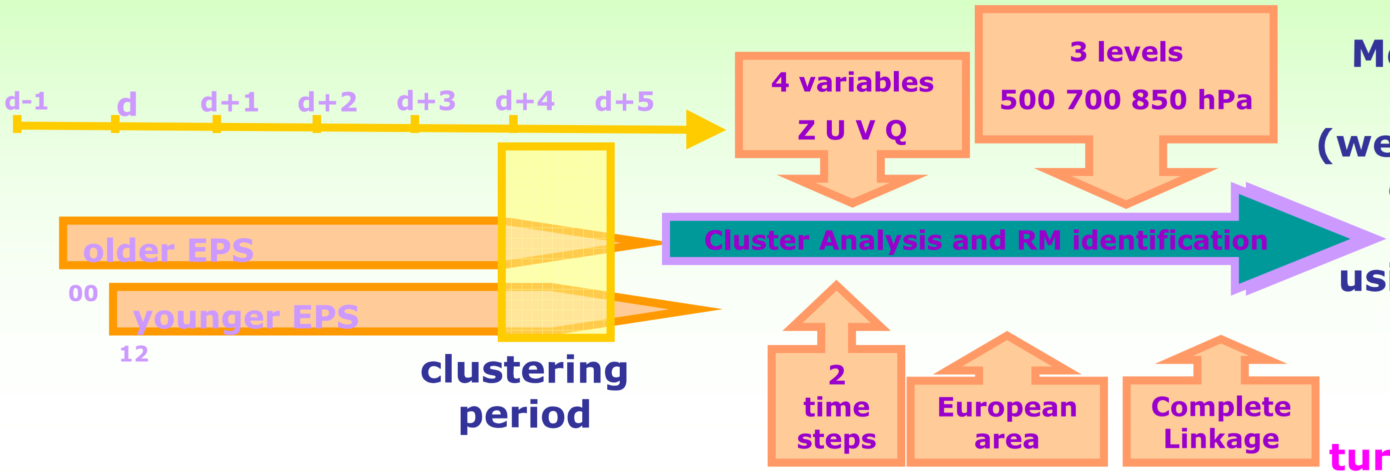
CONSORTIUM FOR SMALL SCALE MODELING

Outline

- Present status of COSMO-LEPS.
- Experimentations with 20 members:
  - meteorological aspects
  - computational aspects
- Results and plans.

COSMO-LEPS suite @ ECMWF: present status



16 Representative Members driving the 16 COSMO integrations (weighted according to the cluster populations)

using Tiedtke convection scheme

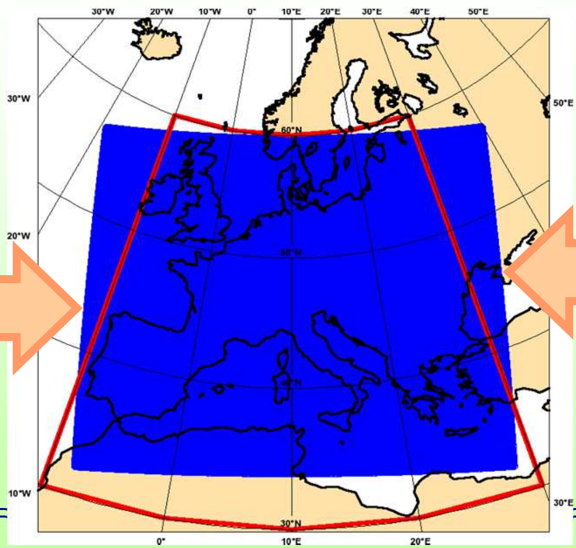
+

perturbations in turbulence scheme and in physical parameterisations

+

soil initial conditions from COSMO-EU

COSMO-LEPS clustering area



COSMO-LEPS Integration Domain

- suite runs as a "time-critical application" managed by ARPA-SIMC; runs at both 00 and 12TC;
- Δx ~ 7 km; 40 ML; fc+132h;
- COSMO v5.03 since 1 February 2016,
- computer time (57 million BUs for 2016) provided by the COSMO partners which are ECMWF member states.

Recent news_1

- **December 2015**
  - 30-day tests of COSMO-LEPS with ICON-EU soil fields: no noticeable impact on short-range forecast skill of TP, T2M, TD2M.
- **1 February 2016: suite upgrade**
  - COSMO version update (5.01 → 5.03); int2lm 2.0;
  - Production and archive of 100 metre U and V wind component;
  - Archive of P, T, U, V at model levels 35, 36, 37, 38, 39, 40.
- **19 February 2016: int2lm**
  - ECMWF fields (from test dissemination) with longitudeOfFirstGridPoint = 335000 (instead of longitudeOfFirstGridPoint = -25000) made int2lm fail;
  - a patch was applied to handle ECMWF GRIB1 files with longitudes greater than 180°.
- **25 February 2016: field production to ARPA-Liguria**
  - Dissemination of COSMO-LEPS fields in GRIB2 format.

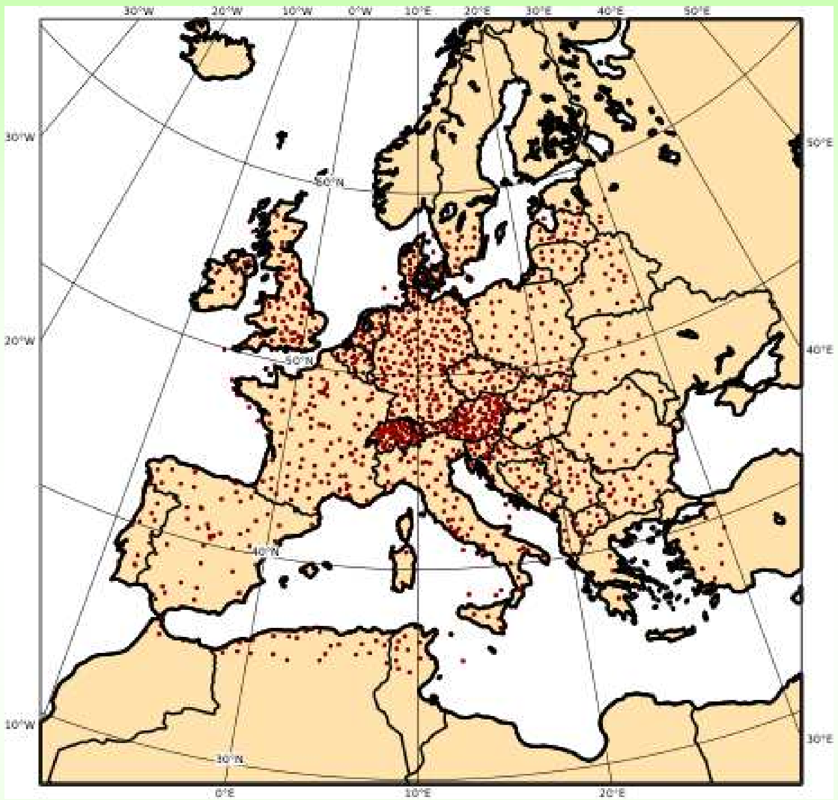
Recent news_2

- **6 June 2016: ECMWF upgrade**
  - Change of processors on ECMWF super-computers (from IvyBridge to Broadwell) ➔ change of geometry in COSMO and int2lm configurations; no impact on users; change of costs.
- **11 June 2016: beginning of esuite**
  - Start of experimentation of COSMO-LEPS with 20 members in single precision (**20_sp**) and comparison against operational COSMO-LEPS (16 members in double precision, **16_dp**).
    - Meteorological aspects
    - Computational aspects

Meteorological aspects

- COSMO v5.03: inter-comparison of **16_dp (no SPPT)** and **20_sp (with SPPT) .**
- Same soil initial conditions from COSMO-EU.
- Both the cluster analyses and the random choice of perturbation parameters are performed separately for 16_dp and 20_sp.
- **51 days of test (from 11/6 to 31/7/2016)**, starting at 00UTC.
- Consider performance in terms of:
  - 2-metre temperature,
  - 10-metre wind-speed,
  - 12-hour cumulated precipitation.

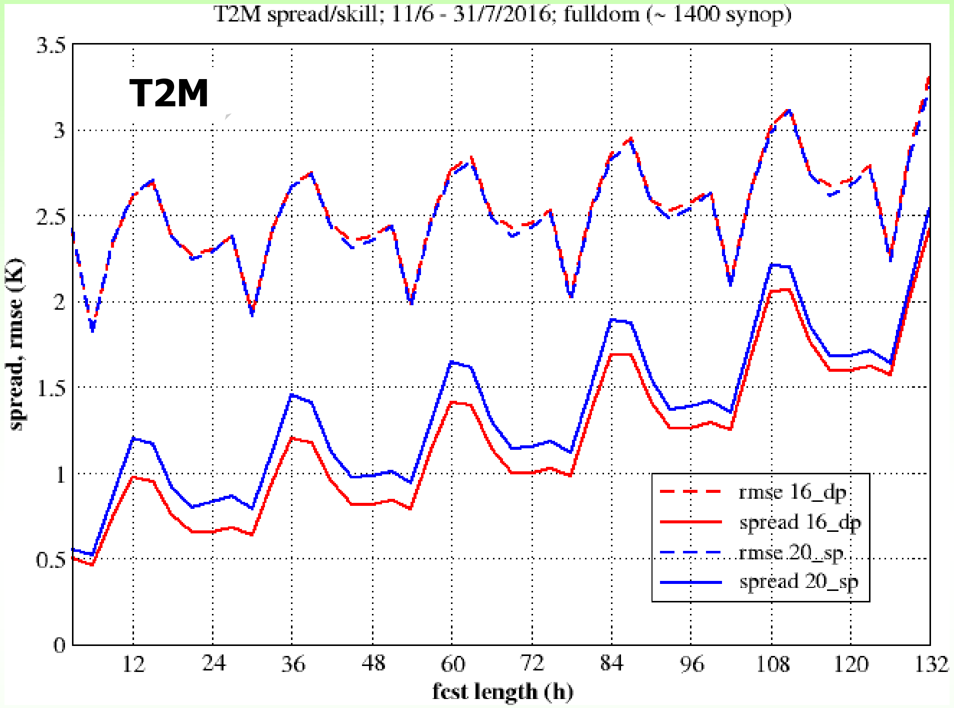
  (thresholds:1, 5, 10, 15, 25, 50 mm/12h).

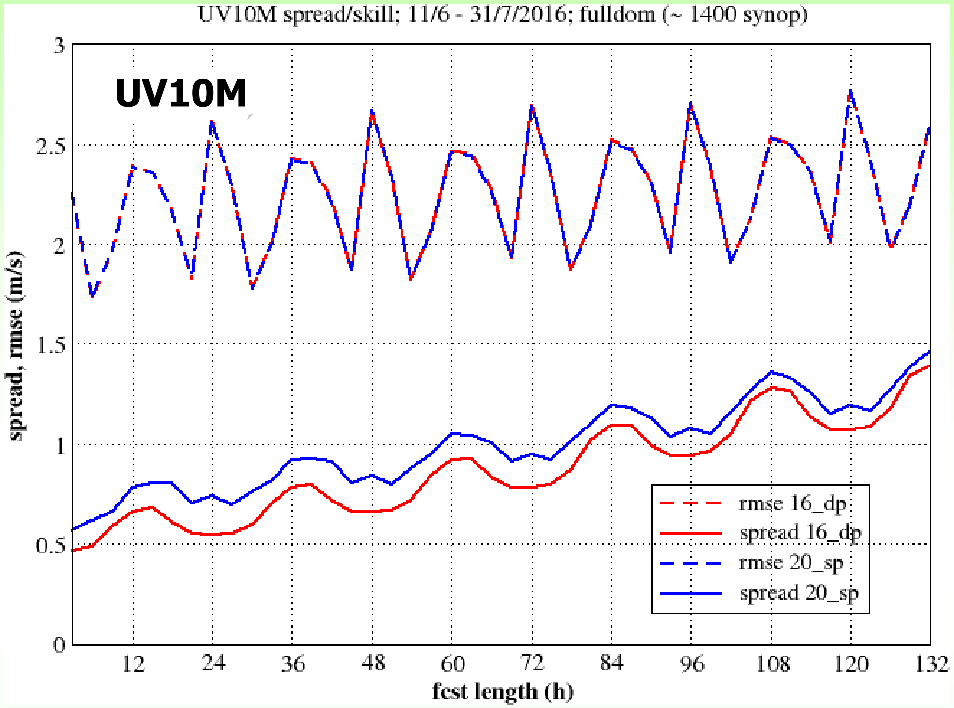


Verification area: full domain

(~ 1400 synop reports).

Spread/skill for T2M and UV10M



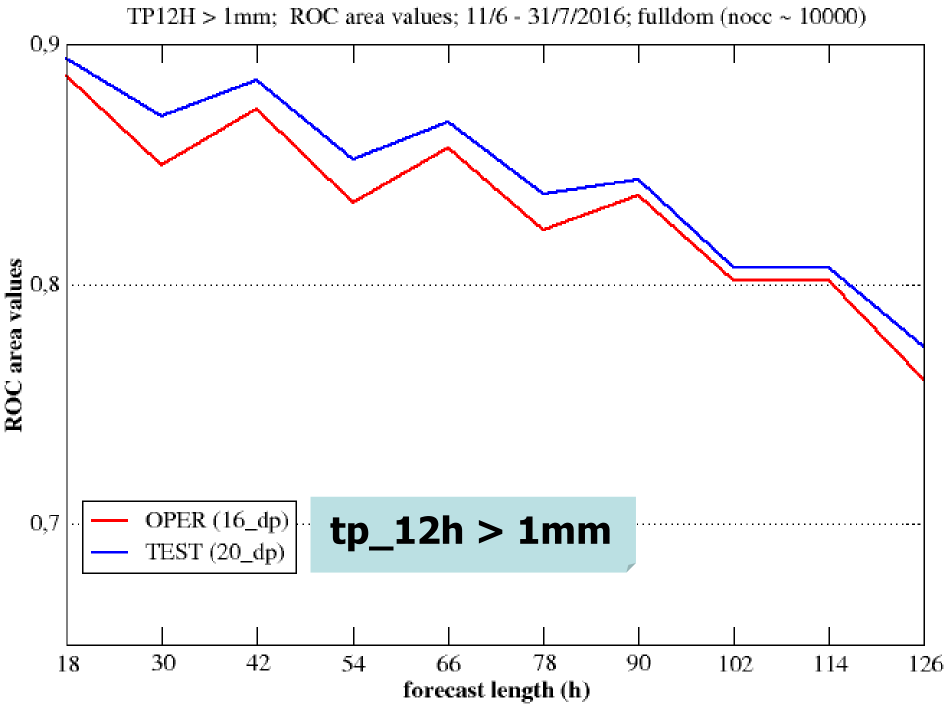


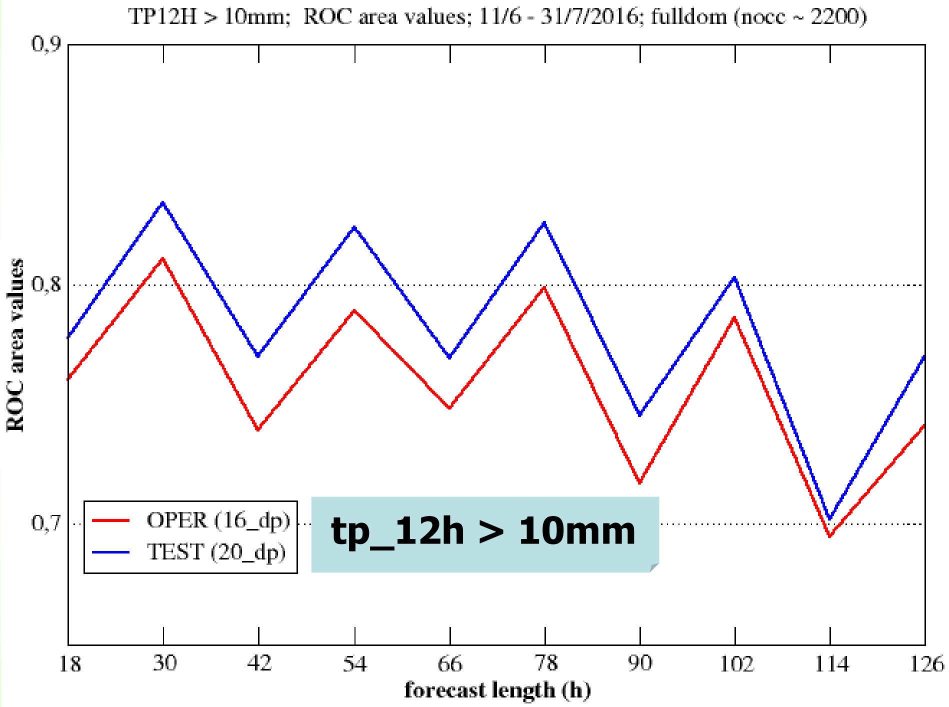
- more solid results with respect to those presented in June (51 days of experimentation).
- **Larger spread for 20_sp for both variables**; in either cases, lack of spread in the short range.
- T2M: the daily cycle of the spread follows to a certain extent the cycle of the error.
- **Limited impact** (if any) **on the forecast skill** of the ensemble mean.

It seems we are going in the right direction.

Probabilistic prediction of tp: ROC area

- Area under the curve in the HIT rate vs FAR diagram; the higher, the better …
- Valuable forecast systems have ROC area values > 0.6.
- Consider two events: 12-hour precipitation exceeding 1 mm and 10 mm.

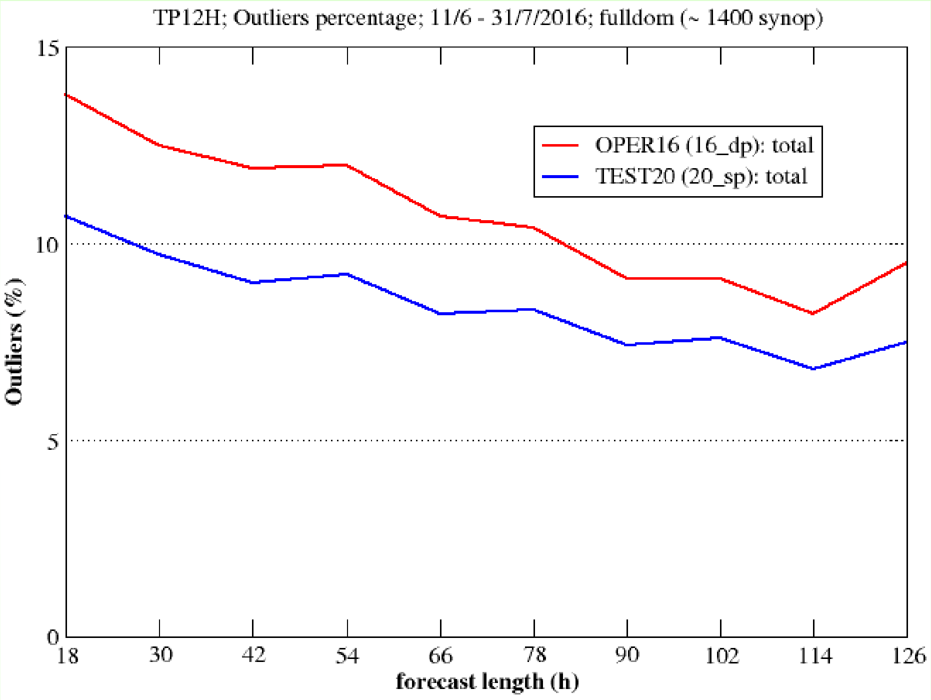


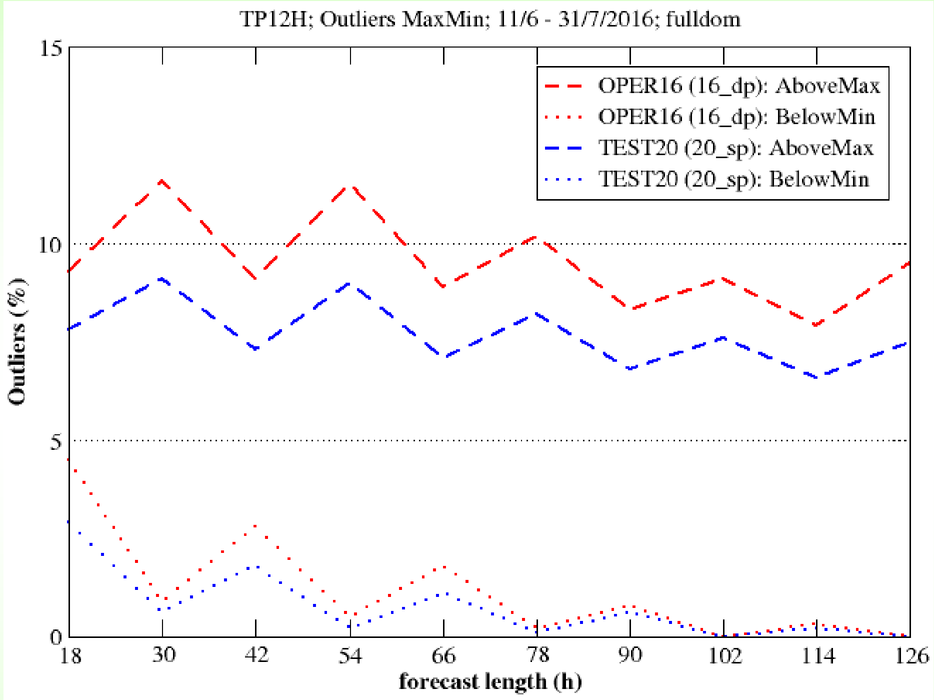


- Better performance by **20_sp** for both thresholds.
- Impact more evident in the short range.

Probabilistic prediction of tp: OUTLIERS

- How many times the analysis is out of the forecast interval spanned by the ensemble members.
- … the lower the better …



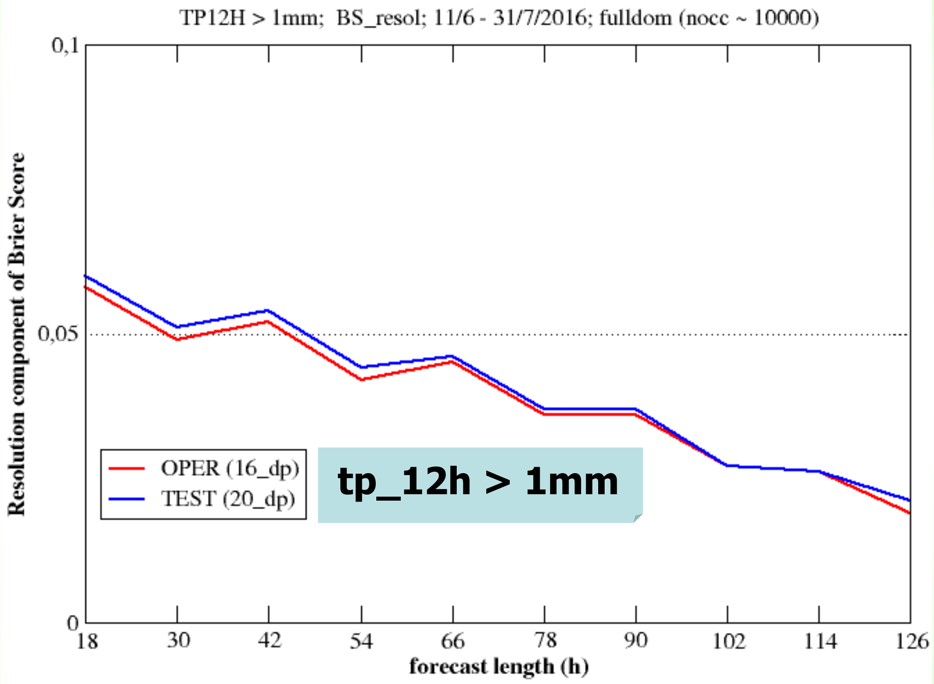


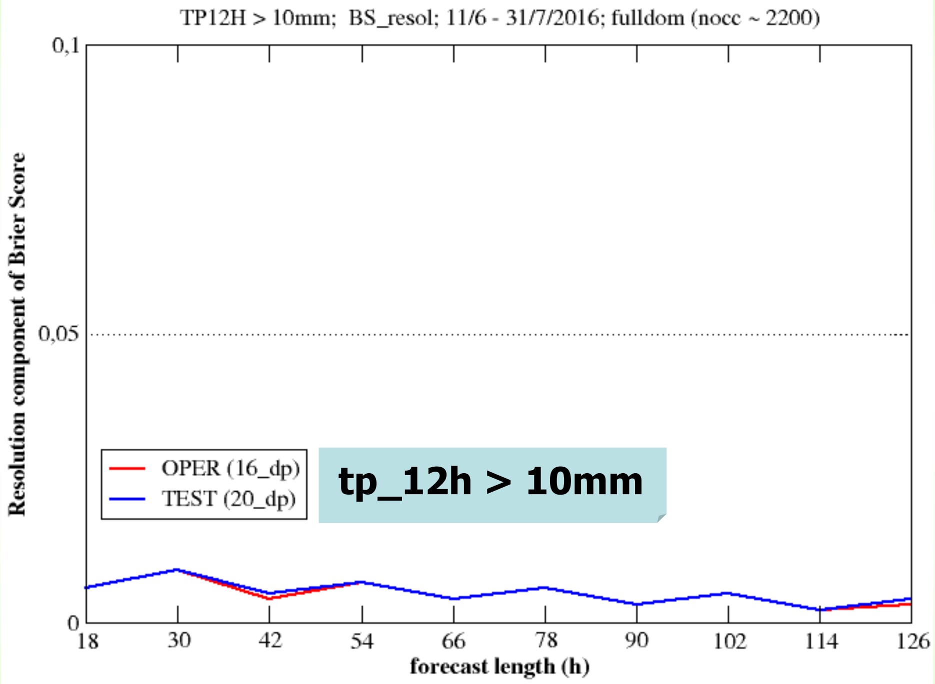
• Reduction of outliers for **20_sp** COSMO-LEPS for all forecast ranges.

• Decrease of outliers especially AboveMax (in 20_sp, it happens less frequently that all ensemble members predict lower precipitation than what observed).

Probabilistic prediction of tp: Resolution

- Resolution component of the Brier Score: describes the ability of the system to distinguish among events in different categories; the higher, the better …
- Consider two events: 12-hour precipitation exceeding 1 mm and 10 mm.

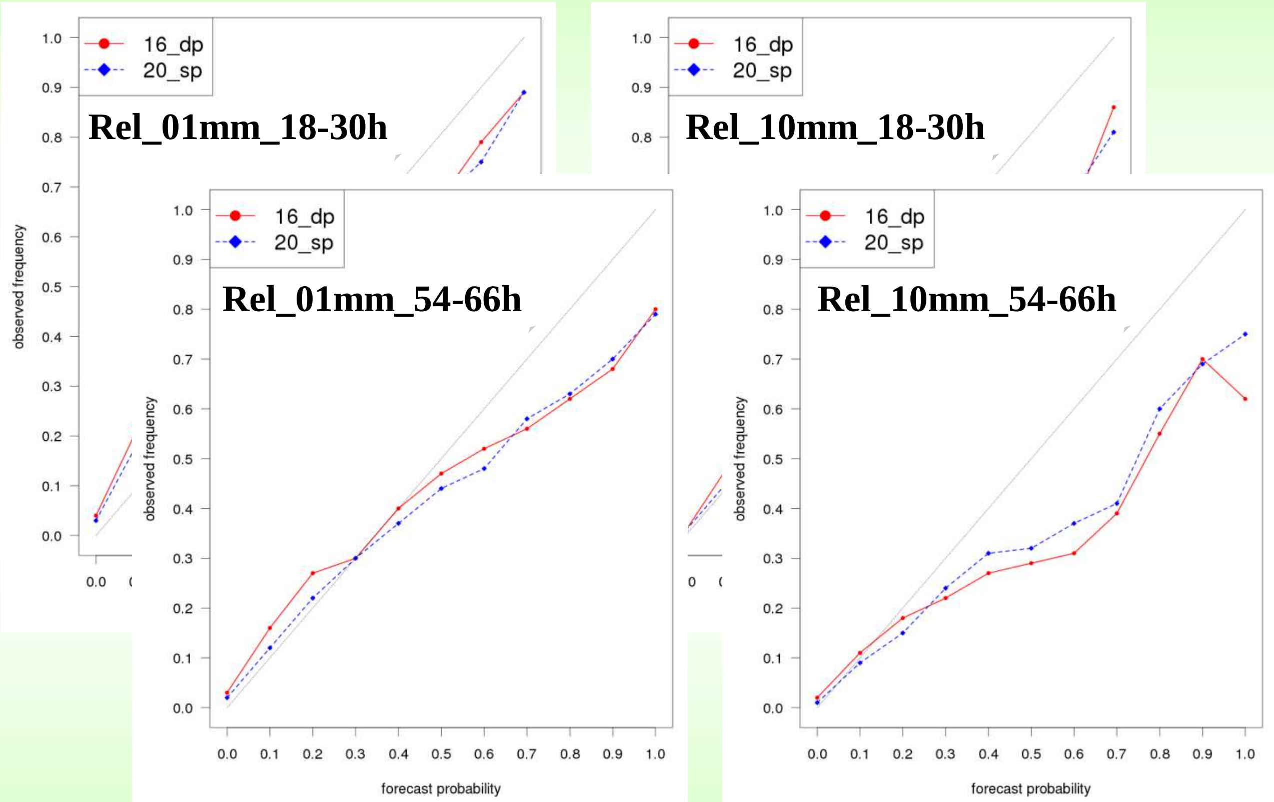




- Slightly better performance by **20_sp** only for the lower threshold.
- Impact more evident in the short range for 1mm threshold.

Probabilistic prediction of tp: Reliability

- Match between fcst probability and obs frequency for a certain event; the closer to the diagonal, the better ....
- Consider **four** events: 12-hour precipitation exceeding 1 and 10 mm at the ranges 18-30h and 54-66h.

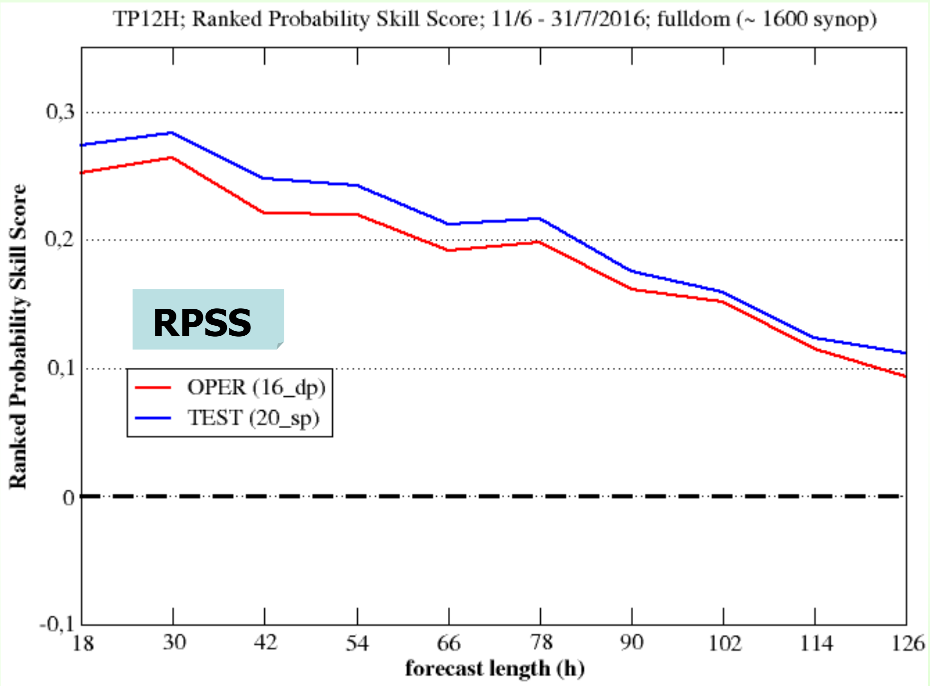


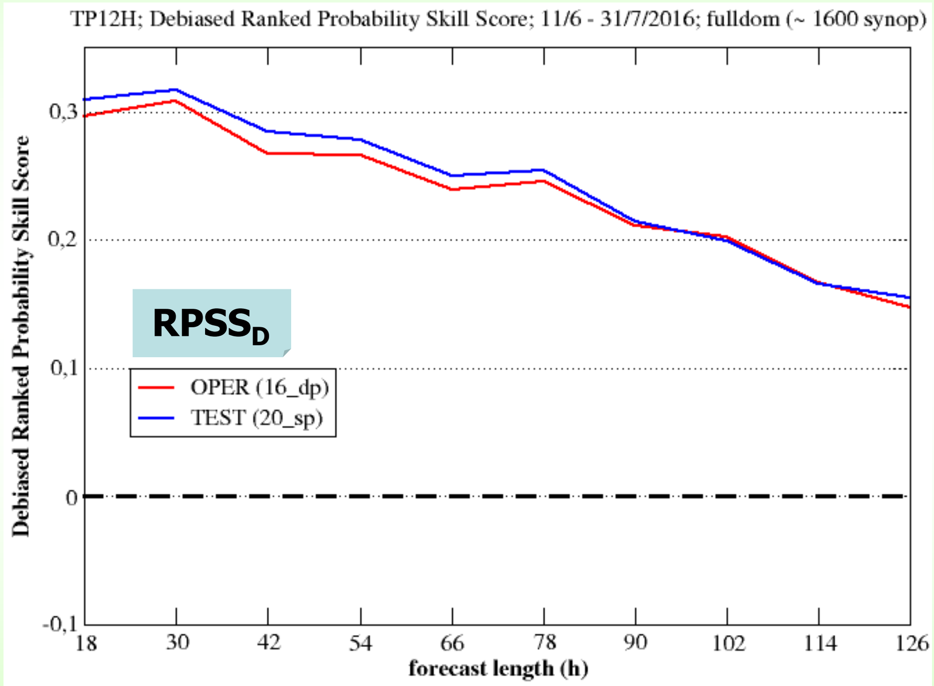
• COSMO-LEPS overconfidence increases with both threshold and forecast range (fcst_prob > obs_freq) for both **16_dp** and **20_sp**.

• Not clear positive impact of enlarged ensemble size.

Probabilistic prediction of tp: RPSS

- ➢ BSS "cumulated" over all thresholds. RPSS is written as $1\text{-}RPS/RPS_{ref}$. **Sample climate** is the reference system. RPS is the extension of the Brier Score to the multi-event situation.
- ➢ Useful forecast systems for RPSS > 0; RPSS depends on the ensemble size, penalising small ensemble sizes.
- ➢ Consider debiased RPSS: $RPSS_D = 1 - (RPS/(RPS_{ref} + RPS_{ref}/N))$





- In either cases (RPSS or $RPSS_D$), better performance of **20_sp** COSMO-LEPS, more evident for short ranges.

Computational aspects

#PBS –l EC_nodes=20

#PBS –l EC_total_tasks=720

....

what do you gain if you run in single precision?

Last year (with COSMO v5.1 and old ECMWF processors with different geometry):

the gain was highly variable from day to day (min: ~10%; max: ~50%), but

➔ *average saving: ~ 35% x run*

this year (with COSMO v5.03)

	Elapsed time (sec)	Cost of 1 member (ECMWF BU)
double_precision	**960**	**3100**
single_precision	**500**	**1600**

➔ **average saving: ~ 48%** x run

→ **16_dp cost ~ 49600 BU**

→ **20_sp cost ~ 32000 BU**

Despite the 25% increase in ensemble size, **20_sp** is still **35% cheaper** than **16_dp**!!!

But…

Frequent explosions of COSMO in single precision with SPPT (5-6 crashes every day!)

- Namelist changes did not cure the problem with COSMO v5.03.
- Need of code modifications (bug fix in divergence damping, targeted diffusion to prevent significant temperature anomalies, ...) not yet available in v5.03.

“Plaster” during experimentations:

When the task failed, COSMO was resubmitted with SPPT=.false. (and then the task ran successfully).

Results and road-map

20_sp COSMO-LEPS:

- has better spread/skill relation for temperature and wind-speed,
- provides more accurate probabilistic prediction of precipitation,
- is cheaper,
- is faster

than the operational system (**16_dp COSMO-LEPS**).

SON2016: perform a few more experiments and start test-dissemination of 20_sp COSMO-LEPS.

- For the moment, use SPPT=.false.; once COSMO v5.05 is available, the explosion problems should be fixed and we can switch to SPPT=.true.
- **Go operational before Christmas 2016?!?!!?**

Future work

- By the end of October: migrate from COSMO-EU to Icon-Regional for the provision of soil-moisture analysis fields.
- Use high resolution boundaries from ECMWF ENS (already tested).
- Implement and use weighted products (e.g. weighted ensemble mean).
- Upgrade Fieldextra.
- Listen to users.
- ....

Thanks for your attention !

Types of perturbations (2016)

As for types and values, the results from CSPERT experimentation were followed (* denotes default values for COSMO):

•convection_scheme: Tiedtke* (members 1-16), ←

•tur_len (either 150, or 500*, or 1000),

•pat_len (either 500*, or 2000),

•crsmin (either 50, or 150*, or 200),

•rat_sea (either 1, or 20*, or 40),

•rlam_heat (either 0.1, or 1*, or 5),

•mu_rain : either 0.5* (with rain_n0_factor =0.1) or 0 (with rain_n0_factor =1.0),

•cloud_num (either 5x10^8* or 5x10^7).

COSMO-LEPS with SPPT: namelist

```
&RUNCTL
 ....
 leps    =.TRUE.,
 lsppt   =.TRUE.,
/END
```

```
cat >! $workingDir/INPUT_EPS << EONL
 &EPSCTL
  iepsmem=$MEMBER,
  iepstot=$LM_NL_EPSMEMBERS,
  iepstyp=203
  imode_rn=1,
  itype_vtaper_rn=2,
  itype_qxpert_rn=2,
  itype_qxlim_rn=0,
  npattern_rn=1,
  hinc_rn=6,
  dlat_rn=5.0,
  dlon_rn=5.0,
  stdv_rn=1.0,
  range_rn=0.9,
  lgauss_rn=.TRUE.,
  lhorint_rn=.TRUE.,
  ltimeint_rn=.TRUE.,
 /END
EONL
```

But…

Frequent explosions (5-6 every day!) of COSMO in single precision with SPPT.

- Namelist changes did not cure the problem with COSMO v5.03.
- Plaster for experiments: when the task failed, COSMO was resubmitted with SPPT=.false. (and the task ran successfully).
- Need of code modifications ("Meteoswiss" approach) not yet available in the official release.

Computational aspects

#PBS –l EC_nodes=20

#PBS –l EC_total_tasks=720

………

what do you gain if you run in single precision?

Last year (with COSMO v5.1 and old ECMWF processors with different geometry) :

the gain was highly variable from day to day (min: ~10%; max: ~50%), but

➔ *average saving of about 35% x run*

THIS YEAR (COSMO v5.03)

	double precision	single precision
• Cost of 1 COSMO-LEPS run (ECMWF Billing Units)	3100	1600
• Elapsed time (sec)	960	500

➔ **average saving of about 48%** x run

(impact of SPPT is negligible in terms of computer time)

Despite the 25% increase in ensemble size, **20_sp is cheaper than 16_dp!!!**