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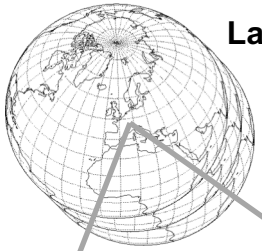
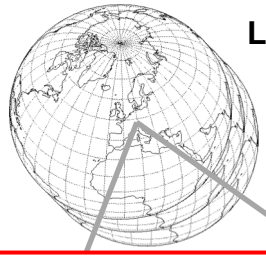
Verification highlights of the new MeteoSwiss models COSMO-1E and COSMO-2E

ModInterim project team: André Walser, Pirmin Kaufmann, Jean-Marie Bettems, Andreas Pauling, Jan-Peter Schulz, *and many more*

COSMO-1E & COSMO-2E



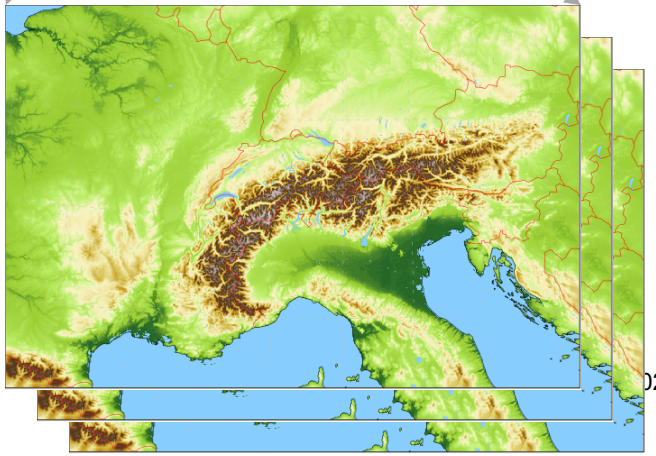
Lateral boundary conditions:
IFS ENS & HRES
18km / 0.2°
4x per day



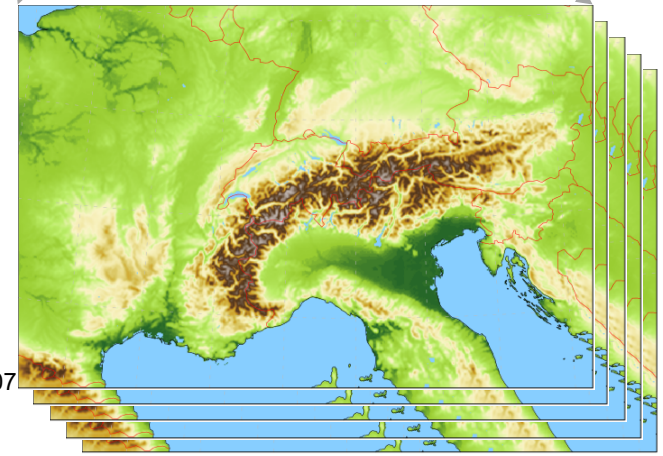
Lateral boundary conditions:
IFS ENS
18km / 0.2°
4x per day

ensemble data assimilation: LETKF at 1.1km

COSMO-1E: 33 hour forecasts, 8x per day
1.1km grid size (convection permitting)
11 ensemble members



COSMO-2E: 5 day forecasts, 4x per day
2.2km grid size (convection permitting)
21 ensemble members



Migration to COSMO version 5.07 (from 5.0++)

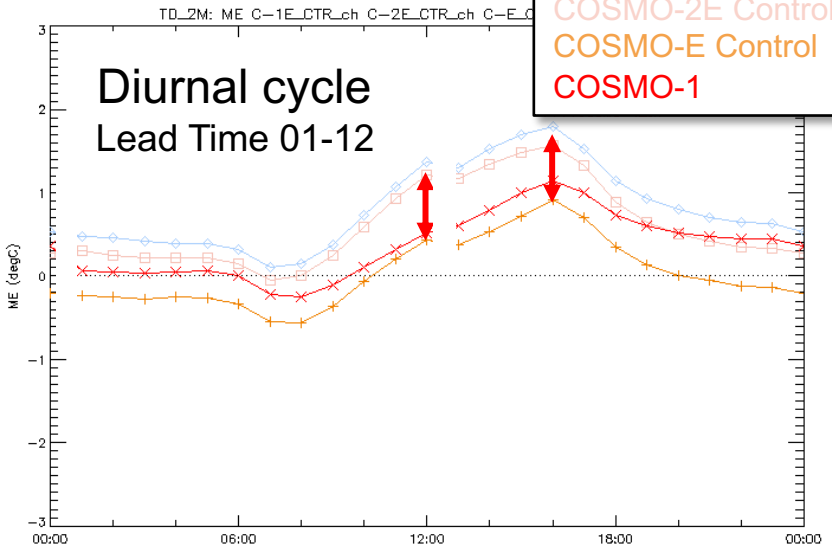
- Namelist settings: “Standard”, i.e. no “fundamental” differences to neither COSMO-E nor COSMO-D2-EPS

- Problem in pre-operational runs observed in early spring:
    - Td2m too high (too moist), especially in spring 2020
    - soil much wetter than for COSMO-E

Problem (!): Td2m in March 2020

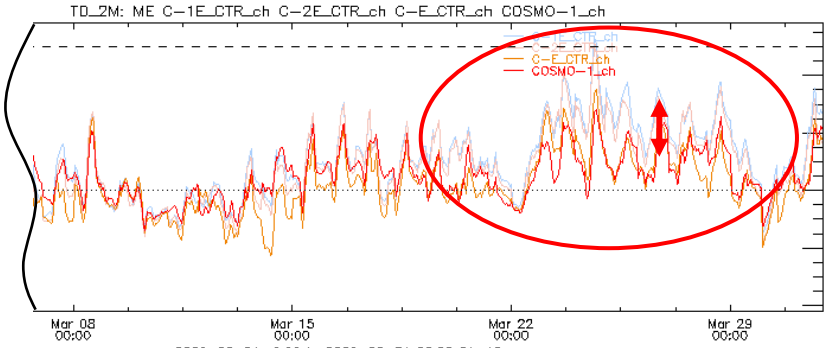
Bias T_d 2 m

COSMO-1E Control
COSMO-2E Control
COSMO-E Control
COSMO-1



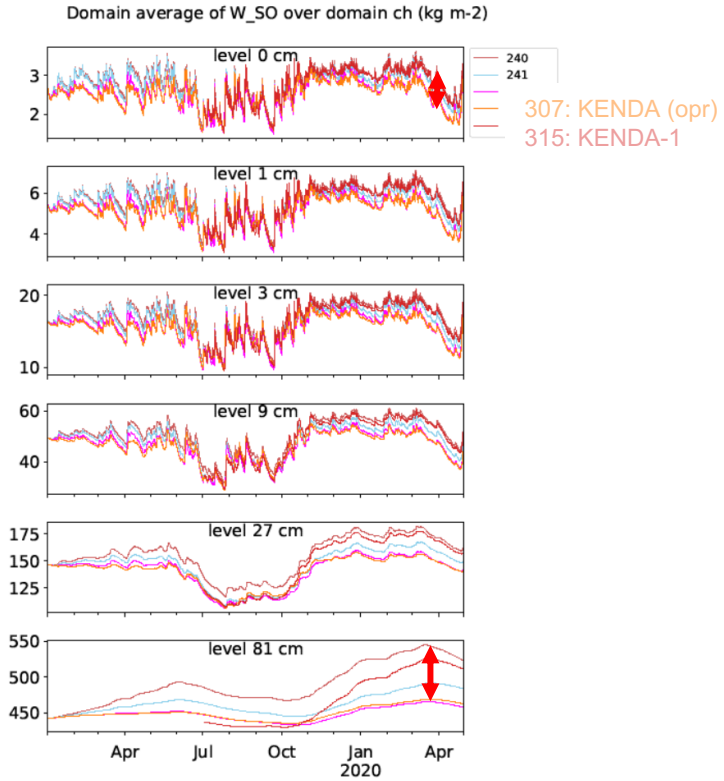
Daytime

Time series



Time

Problem (?): soil water (W_SO)



substantial loss of soil water in COSMO-1 and COSMO-E due to a **programming bug** (fixed in COSMO v5.04):
on average ≈ 200-300 mm/y

soil of KENDA-1, COSMO-1E, and COSMO-2E is significantly wetter (and most likely more realistic …) than in COSMO-1 and COSMO-E (and, yes, also in COSMO-D2-EPS …)

needed to re-tune the model …

Help from Jan-Peter Schulz and Gerd Vogel

Use of namelist settings recommended by WG3b based on paper by Jan-Peter Schulz and Gerd Vogel («Improving the Processes in the Land Surface Scheme TERRA: Bare Soil Evaporation and Skin Temperature", Atmosphere 2020, 11, 513; https://doi.org/10.3390/atmos11050513; see http://www.cosmo-model.org/content/tasks/workGroups/wg3b/docs/TERRAsettings.pdf for the list of namelist settings)

Schulz & Vogel: main changes

- improved bare soil evaporation
  - less evaporation for medium-wet to wet soil conditions, thereby leading to smaller Td2m and larger T2m values as well as to a larger diurnal temperature range
  - more evaporation for medium-dry to dry soil conditions, thereby leading to larger Td2m and smaller T2m values as well as to a smaller diurnal temperature range
- skin layer temperature (new; to simulate vegetation canopy effect)
- interception reservoir activated (new)
- a few more smaller changes; *still unsatisfactory: plant transpiration*

→ additionally needed for mitigation of poorly tuned model:
→ artificially reduced evapotranspiration

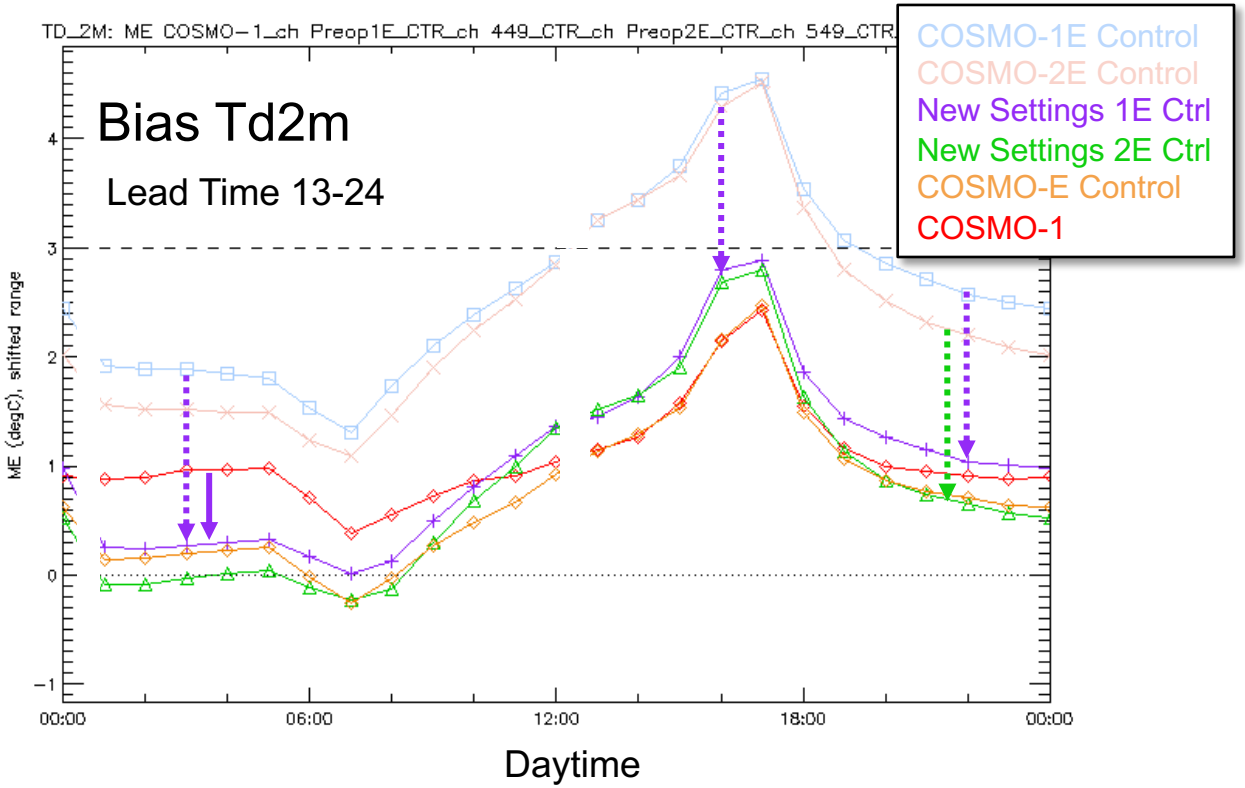
Operational configuration

Namelist settings recommended for **loldtur = .TRUE.** (see http://www.cosmo-model.org/content/model/releases/cosmo-icon-physics.htm **as well as by WG3b based on paper by Schulz & Vogel** (see http://www.cosmo-model.org/content/tasks/workGroups/wg3b/docs/TERRAsettings.pdf), *except for*

- c_soil = **0.8** (instead of 1.0 **to decrease evaporation**)
  Surface area density of the (evaporative) soil surface
- RSMIN = min(RSMIN,150)***1.5** (**to decrease transpiration**; lstomata=.TRUE.)
  External parameter field for the minimum stomata resistance of plants
- *for 1.1km: cimpl = **250** (instead of 150)*
  Stability parameter for the computation of the skin temperature
- *for 1.1km: SKC = max(SKC,**40**) where FR_LAND>0.5 (instead of SKC ∈ [10., …])*
  External parameter field for skin conductivity

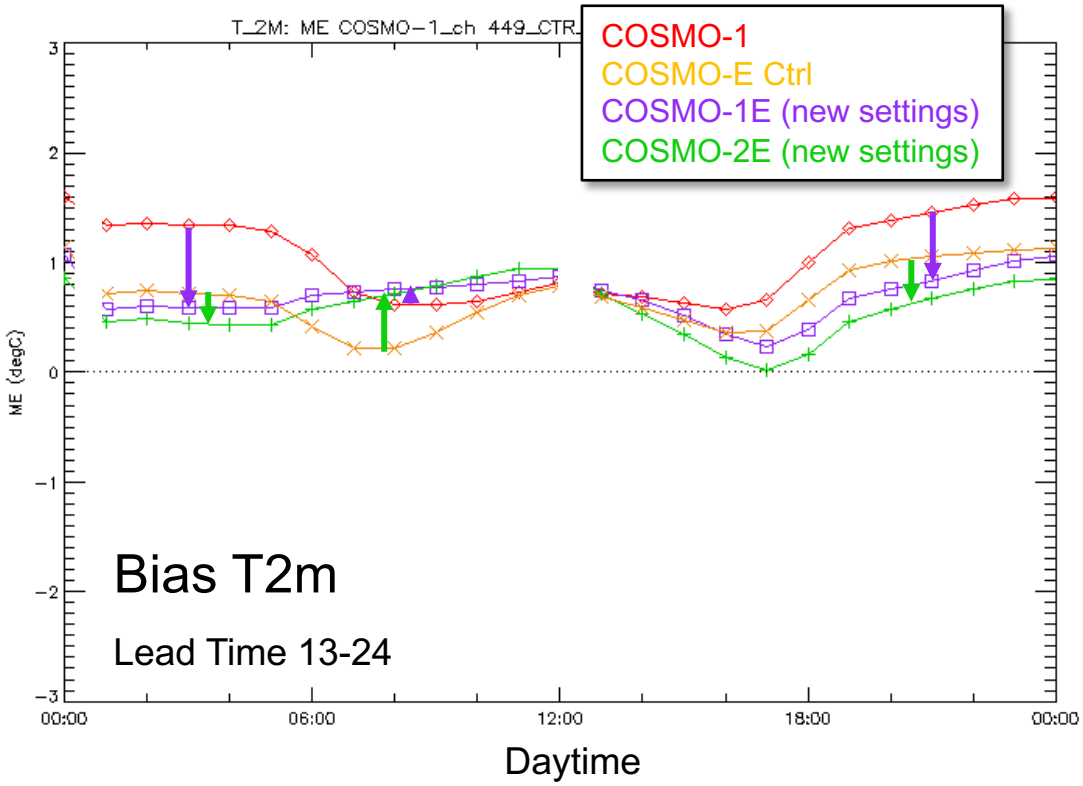
2m Dewpoint Spring 2020 (15d)

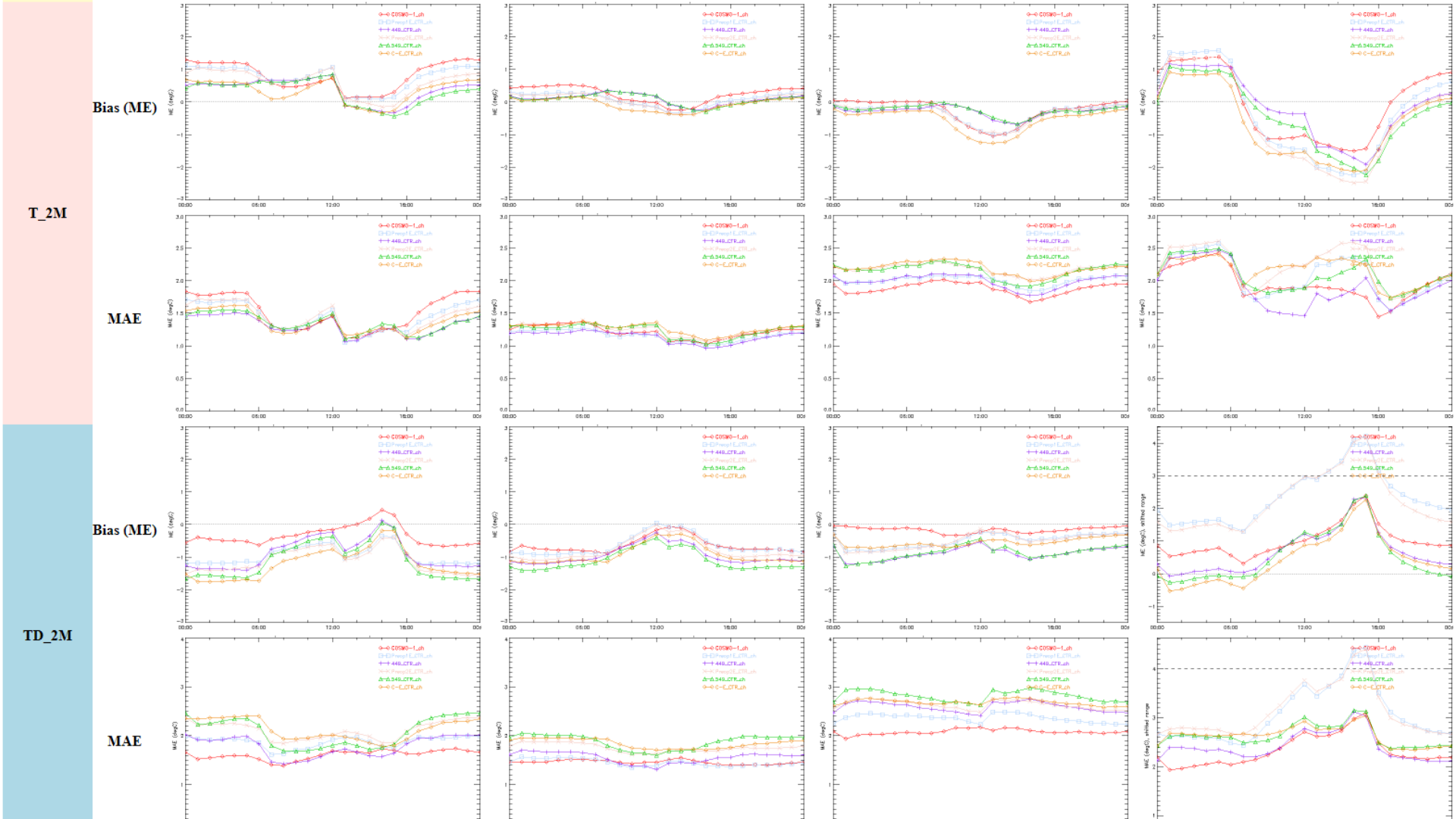
T_d bias almost back to normal (afternoon) or even improved (night, morning)



2m Temperature Summer 2019 (15d)

Considerably smaller bias late afternoon and night ↓, some degradation during few morning hours ↑




T_2M
Bias (ME)
MAE
TD_2M
Bias (ME)
MAE

COSMO-1E vs COSMO-(2)E Control

T-003: **449 CTRL** vs **549 CTRL** and **COSMO-E CTRL**
All lead-time ranges (avail: 01-12, 13-24), deterministic scores

Summer	(2019s3)	18.08. – 02.09.	
Parameter	**Bias**	**MAE**	**STDE**
Precipitation (6h)	Better	Slightly worse	Slightly worse
Cloud amount	Slightly worse	Similar	Similar
Global radiation	Slightly worse	Similar	Similar
Sunshine duration	Slightly better	Slightly worse	Similar
Temperature	Slightly worse	Similar	Slightly better
Dewpoint	Better	Much better	Better
Wind speed	Slightly better*	Similar	Similar
Gusts	Slightly better*	Similar	Similar
Wind direction	Slightly better	Slightly better	Slightly better
Pressure	Slightly worse	Much better	Much better
Parameter	**Freq.-Bias**	**POD**	**FAR**
Precipitation > 0.2 mm/6h	Similar	Slightly better	Slightly worse
Precipitation > 5 mm/6h	Better	Better	Slightly better
Cloudiness > 2.5 okta	Slightly worse	Similar	Similar
Cloudiness > 6.5 okta	Slightly worse	Slightly better	Slightly worse
Gusts > 12.5 m/s	Slightly better**	Better	Slightly worse

Autumn	(2019s4)	22.10. – 07.11.	
Parameter	**Bias**	**MAE**	**STDE**
Precipitation (6h)	Similar	Slightly better	Slightly better
Cloud amount	Slightly worse	Similar	Similar
Global radiation	Similar	Similar	Similar
Sunshine duration	Similar	Slightly better	Slightly better
Temperature	Slightly better*	Slightly better	Slightly better
Dewpoint	Slightly better*	Much better	Much better
Wind speed	Slightly better*	Slightly better	Slightly better
Gusts	Slightly better*	Slightly better	Slightly better
Wind direction	Similar	Slightly better	Slightly better
Pressure	Slightly better	Much better	Much better
Parameter	**Freq.-Bias**	**POD**	**FAR**
Precipitation > 0.2 mm/6h	Slightly worse	Slightly better	Similar
Precipitation > 5 mm/6h	Similar	Slightly better	Similar
Cloudiness > 2.5 okta	Similar	Similar	Similar
Cloudiness > 6.5 okta	Slightly worse	Slightly better	Similar
Gusts > 12.5 m/s	Slightly better	Much better	Slightly worse

*Overall larger bias due to less compensating negative station biases

Winter	(2020s1)	22.12. – 07.01.	
Parameter	**Bias**	**MAE**	**STDE**
Precipitation (6h)	Similar	Similar	Similar
Cloud amount	Slightly worse	Similar	Similar
Global radiation	Slightly worse	Similar	Slightly better
Sunshine duration	Slightly better	Slightly better	Slightly better
Temperature	Similar	Better	Better
Dewpoint	Slightly better*	Slightly better	Better
Wind speed	Slightly better*	Better	Better
Gusts	Similar*	Slightly better	Slightly better
Wind direction	Better	Slightly better	Slightly better
Pressure	Better	Much better	Much better
Parameter	**Freq.-Bias**	**POD**	**FAR**
Precipitation > 0.2 mm/6h	Similar	Similar	Similar
Precipitation > 5 mm/6h	Similar	Similar	Similar
Cloudiness > 2.5 okta	Similar	Similar	Similar
Cloudiness > 6.5 okta	Slightly better	Slightly better	Slightly worse
Gusts > 12.5 m/s	Better	Much better	Slightly worse

Spring	(2020s2)	31.03. – 14.04.	
Parameter	**Bias**	**MAE**	**STDE**
Precipitation (6h)	Similar	Similar	Similar
Cloud amount	Slightly better	Similar	Similar
Global radiation	Slightly worse	Similar	Similar
Sunshine duration	Slightly better	Slightly better	Slightly better
Temperature	Better	Better	Better
Dewpoint	Slightly worse	Better	Better
Wind speed	Better	Slightly better	Slightly better
Gusts	Slightly better	Slightly better	Slightly better
Wind direction	Slightly better	Better	Slightly better
Pressure	Similar	Better	Better
Parameter	**Freq.-Bias**	**POD**	**FAR**
Precipitation > 0.2 mm/6h	Slightly worse	Similar	Slightly worse
Precipitation > 5 mm/6h	Slightly better	Similar	Similar
Cloudiness > 2.5 okta	Slightly worse	Slightly better	Slightly worse
Cloudiness > 6.5 okta	Slightly worse	Slightly better	Similar
Gusts > 12.5 m/s	Slightly better	Much better	Worse

Not significant, only very few cases

Verification highlights

Higher resolution versus higher number of ensemble members – can the smaller COSMO-1E ensemble with 11 members beat the bigger COSMO-2E ensemble with 22 members?

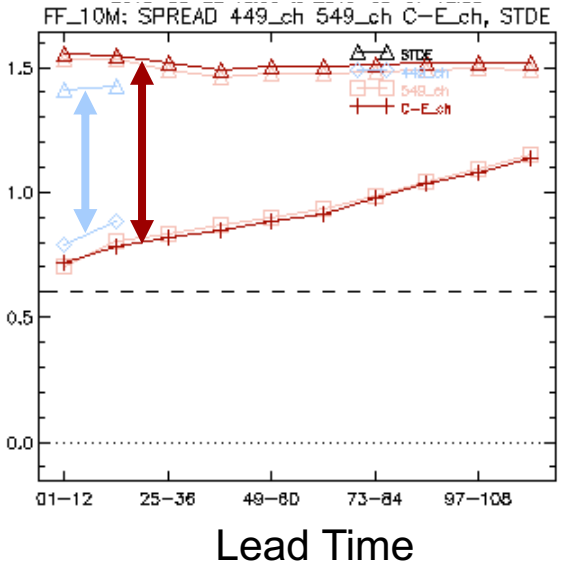
Spread / Error Relation

The spread/error relation for the 1.1 km model COSMO-1E is similar for most parameters and **for some even better** than for the 2.2 km models COSMO-2E and COSMO-E

Example: wind speed, summer 2019

Δ COSMO-E Error
Δ COSMO-2E Error
Δ COSMO-1E Error

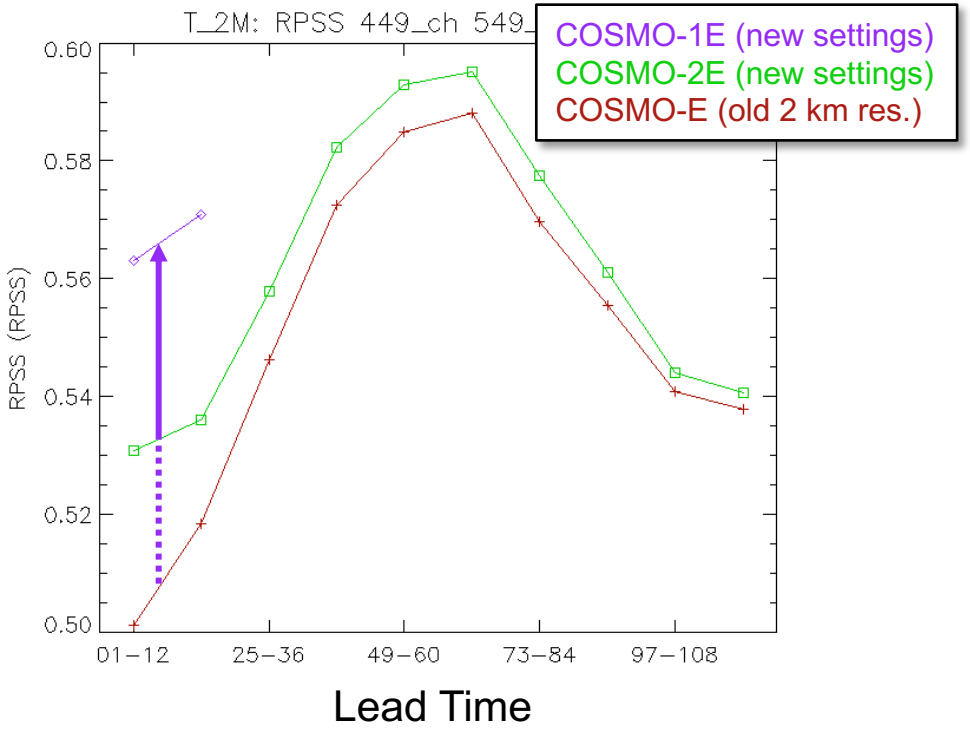
Δ COSMO-1E Spread
□ COSMO-2E Spread
+ COSMO-E Spread



Ranked Probability Skill Score RPSS

The RPSS of COSMO-1E is **better for most parameters** and most seasons

Example: RPSS T2m, autumn 2019



COSMO-1E vs COSMO-(2)E probabilistic

T-003: **449** vs **549** and **COSMO-E**

All lead-time ranges (avail: 01-12, 13-24), ensemble scores

Summer	(2019s3)	18.08. – 02.09.		
Parameter	**Spread / Error**	**RPSS**	**Reliab. Diag. (low thr.)**	**Reliab. Diag. (high thr.)**
Precipitation (6h)	Similar	Slightly better	Similar	Similar
Cloud amount	Slightly better	Slightly worse	Similar	Similar
Temperature	Similar	Slightly worse	Similar	Similar
Dewpoint	Better	Slightly better	Similar	Similar
Wind speed	Better	Better	Similar	Similar
Gusts	Slightly better	Better	Slightly worse	n.a.
Pressure	Slightly worse	n.a.	n.a.	n.a.

Winter	(2020s1)	22.12. – 07.01.		
Parameter	**Spread / Error**	**RPSS**	**Reliab. Diag. (low thr.)**	**Reliab. Diag. (high thr.)**
Precipitation (6h)	Slightly better	Slightly better	Similar	Similar
Cloud amount	Slightly better	Slightly better	Similar	Similar
Temperature	Slightly better	Better	Similar	n.a.
Dewpoint	Better	Much better	Slightly worse	n.a.
Wind speed	Much better	Much better	Slightly better	Similar
Gusts	Slightly better	Much better	Similar	Similar
Pressure	Much better	n.a.	n.a.	n.a.

Autumn	(2019s4)	22.10. – 07.11.		
Parameter	**Spread / Error**	**RPSS**	**Reliab. Diag. (low thr.)**	**Reliab. Diag. (high thr.)**
Precipitation (6h)	Similar	Slightly better	Similar	Similar
Cloud amount	Slightly better	Similar	Similar	Similar
Temperature	Slightly better	Slightly better	Similar	Similar
Dewpoint	Better	Much better	Similar	Similar
Wind speed	Much better	Much better	Similar	Similar
Gusts	Slightly better	Better	Similar	Similar
Pressure	Much better	n.a.	n.a.	n.a.

Spring	(2020s2)	31.03. – 14.04.		
Parameter	**Spread / Error**	**RPSS**	**Reliab. Diag. (low thr.)**	**Reliab. Diag. (high thr.)**
Precipitation (6h)	Slightly worse	Slightly worse	Slightly worse	Similar
Cloud amount	Similar	Slightly worse	Slightly worse	Similar
Temperature	Better	Better	Slightly better	n.a.
Dewpoint	Better	Better	Similar	n.a.
Wind speed	Better	Much better	Slightly better	Similar
Gusts	Slightly better	Much better	Similar	Similar
Pressure	Slightly worse	n.a.	n.a.	n.a.

Not significant, only very few cases

Verification Summary

- COSMO-1E **better than** COSMO-2E and COSMO-E
- COSMO-2E **as good as** (profile) or **slightly better than** (surface) COSMO-E
- COSMO-1E CTRL at short lead times is **slightly better than** (profile) or **as good as** (surface) COSMO-1
- COSMO-1E CTRL at long lead times is **as good as** (profile) or **slightly better than** (surface) COSMO-1

Thanks,
Jan-Peter & Gerd!

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