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COSMO-E update

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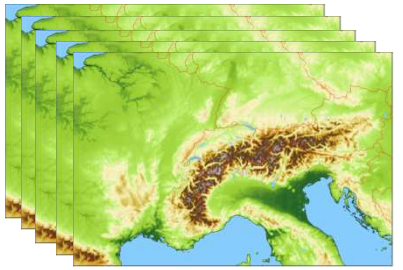
MeteoSwiss

COSMO General Meeting, 11. – 15. September 2017

Outline

- Setup and implementation
- Status of SPPT code
- **COSMO-E forecast quality vs. ECMWF IFS-ENS**
- Outlook

COSMO-E operational setup



- 21 members (control and 20 perturbed runs)
- 2.2 km horizontal mesh-size, 60 vertical levels
- two forecasts per day (00 and 12 UTC) up to +120h
- initial condition (perturbations): KENDA assimilation cycle
  - KENDA ensemble mean for control
  - KENDA members 1-20 (out of 40)
- lateral boundary condition (perturbations): ECMWF IFS-ENS (18 & 06 UTC, i.e., 6h older LBCs)
  - ENS control for control
  - ENS members 1-20 (out of 50)
- model uncertainty: SPPT
- COSMO version 5.0+/GPU, single precision

Implementation & performance on Piz Kesch

- 12 computational nodes per rack with
  - 8 dual GPU cards (NVIDIA Tesla K80)
  - 2 Intel Haswell (2.6GHZ, 12-core) CPUs

- COSMO-E Setup
  - 21 members in parallel
  - 2 members per node (1 member: 1 CPU + 8 GPUs)

- Performance: 97 min for +120h forecast

Status of SPPT code

- MeteoSwiss version includes
  - same random pattern with gnu, pgi, and cray compiler
  - possibility to switch off SPPT when and where targeted diffusion is active
  - technical changes (e.g., SPPT tracer attribute for qx)
  - ported to GPU
- pull request for cosmo-prerelease ready
- has to be approved by SCA Uli Schättler
- aim: available with COSMO v5.6

Temperature anomaly problem

- 5th order advection scheme can produce temperature anomalies
- mitigated by physics and targeted diffusion (switch *l_diff_cold_pools)*
- however, if physics tendencies are significantly reduced by SPPT, there is a higher chance for temperature anomalies
  - switch *ltargetdiff_mask* to switch off SPPT (for the next time step) where targeted diffusion is active
- nevertheless, T anomalies still occur in COSMO-E (as well as in COSMO-1 (!))
- we thus test a new targeted diffusion additionally applied to u & v and increase the application domain from 1 to 9 grid points → results are promising!

Current COSMO-E SPPT setup

SPPT namelist switches for COSMO-E (changes since last COSMO GM in red):

```
&EPSCTL
  itype_vtaper_rn=2,
  itype_qxpert_rn=2,
  itype_qxlim_rn=0,
  npattern_rn=1,
  imode_rn=1,
  hinc_rn=6,
  dlat_rn=5.0,
  dlon_rn=5.0,
  stdv_rn=1.0,
  range_rn=0.8,
  lgauss_rn=.TRUE.,
  lhorint_rn=.TRUE.,
  ltimeint_rn=.TRUE.,
  ltargetdiff_mask=.TRUE.
```

COSMO-E forecast quality

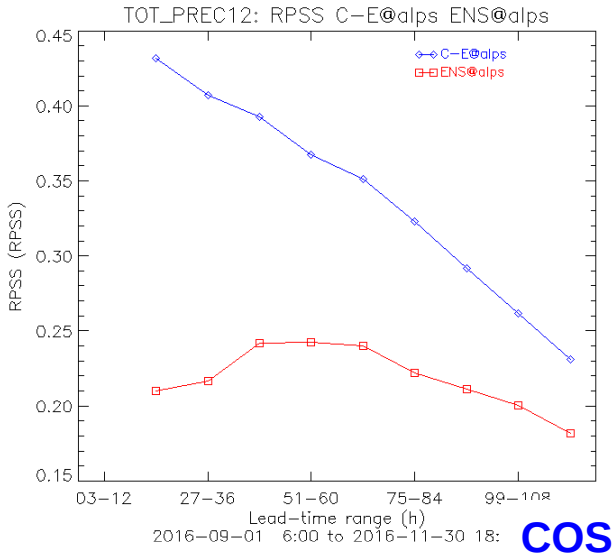
- last 4 seasons (SON 2016 to JJA 2017) for all SYNOP stations over full domain
- precipitation; T2m & Td2m
- probabilistic: RPSS; spread-skill, rank histogram
- deterministic: performance diagram, mean error
- comparison against the driving model IFS-ENS
- Note: COSMO-E outperformed COSMO-LEPS **over Switzerland** for a number of seasons before becoming operational in May 2016 when the generation of COSMO-LEPS products at MeteoSwiss has been discontinued.

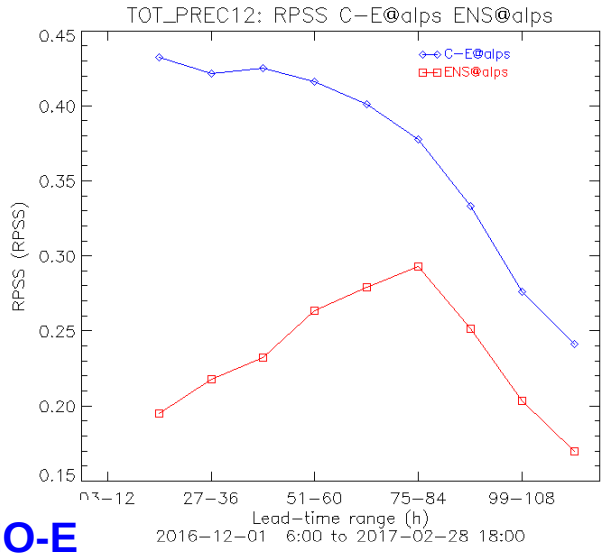
COSMO-E vs. ENS

	COSMO-E	ECMWF IFS-ENS
grid-spacing	2.2 km (0.02°)	~20 km
domain	Alps	Global
forecast range	+120h	+240h
deep convection	explicit	Tiedtke-Bechtold convection scheme
subgrid-scale orographic drag	roughness length	SSO scheme & roughness length
initial conditions	KENDA (LETKF)	4D-Var + SVs & EDA
boundary conditions	ENS -6h	-
physics perturbations	SPPT	SPPT & SKEBS
availability (+120h)	3:45h after analysis time	7:20h after analysis time

12h precipitation; RPSS

SON

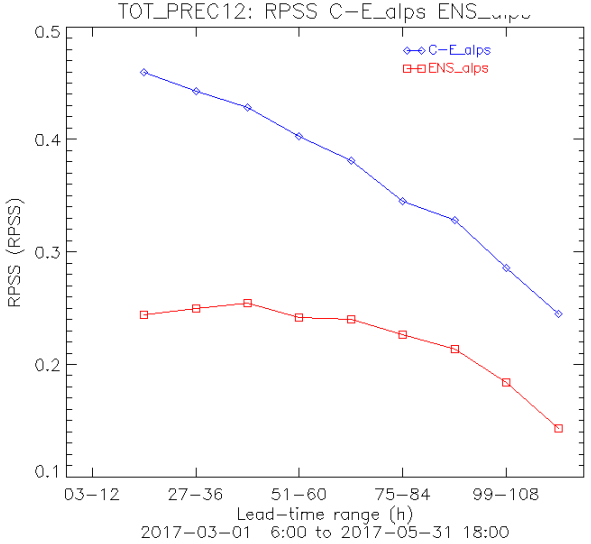


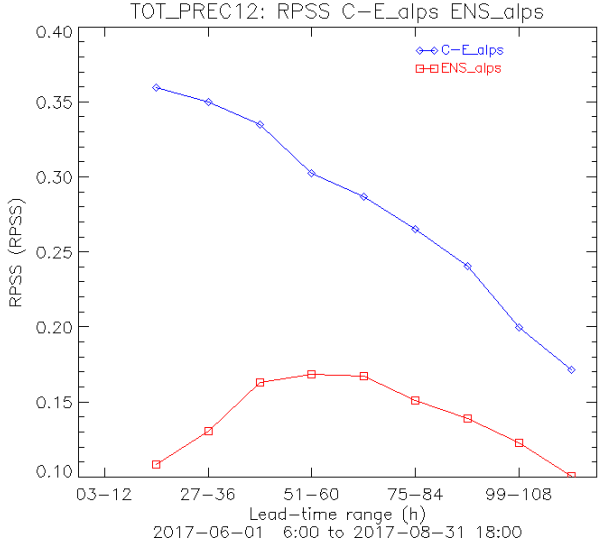


DJF

COSMO-E ENS

MAM



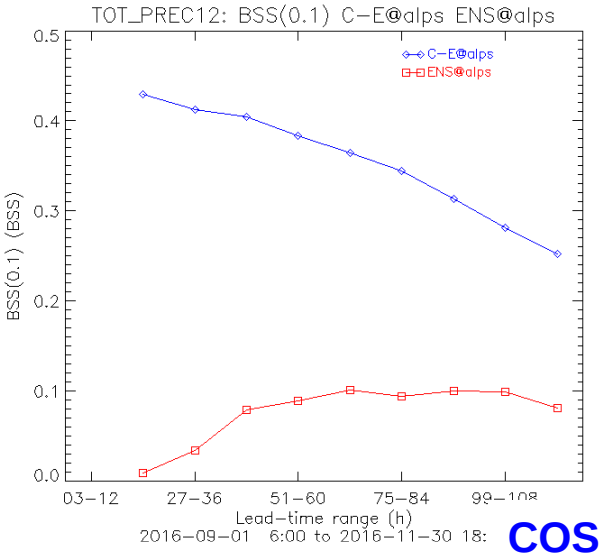


JJA

Thresholds: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 30, 50 mm/12h

12h precipitation; BSS, 0.1mm/12h

SON



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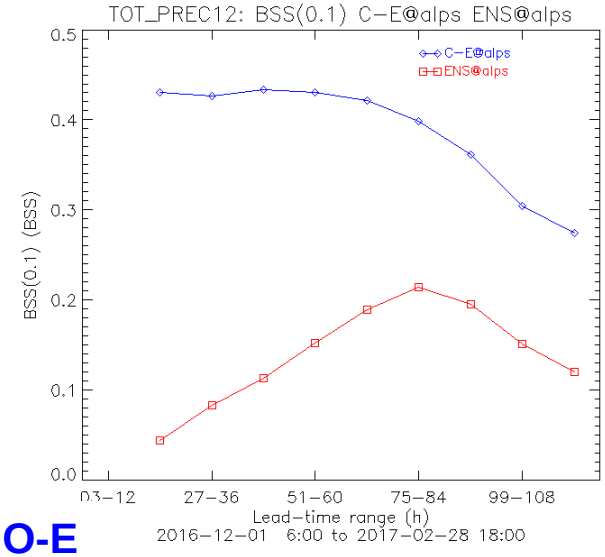

COSMO-E

ENS

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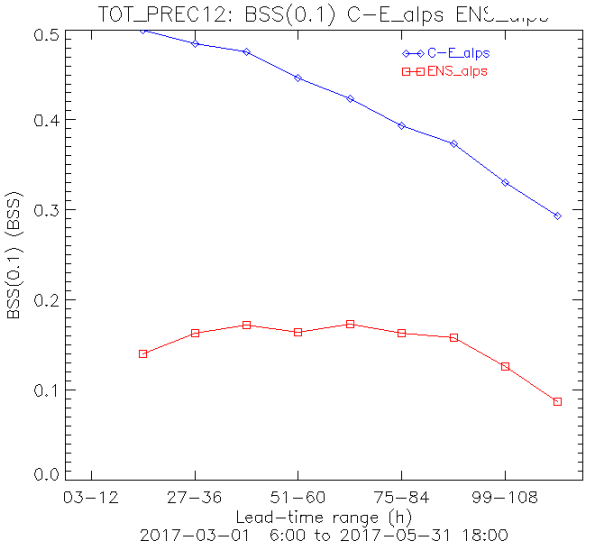

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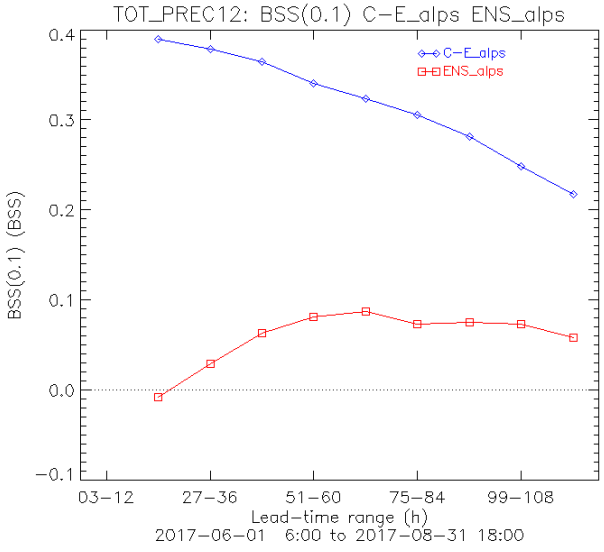
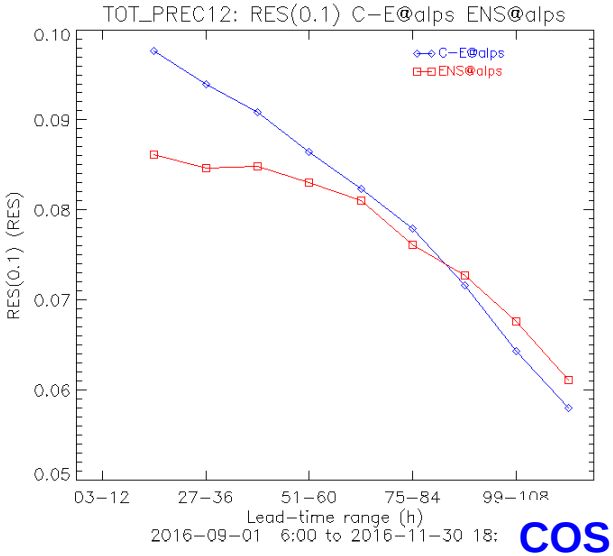


12h precipitation; RES, 0.1mm/12h

SON



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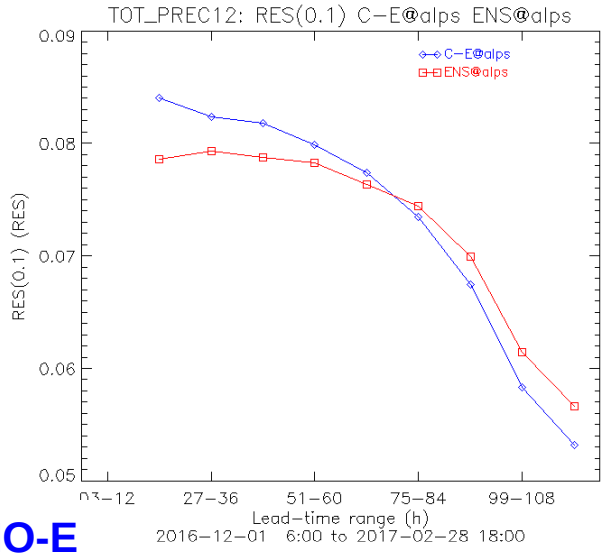

COSMO-E

ENS

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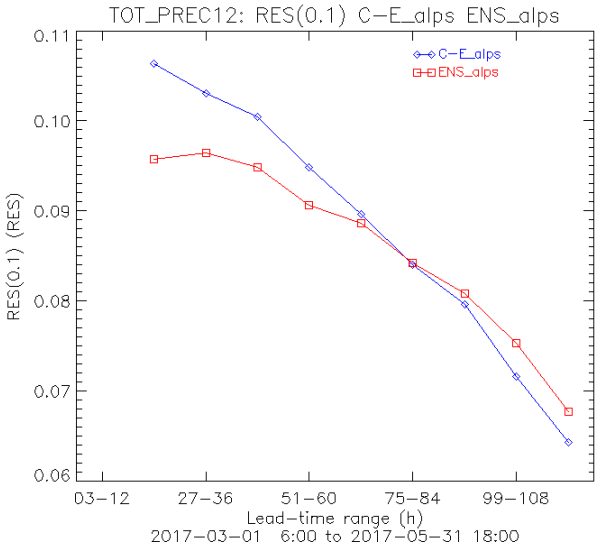

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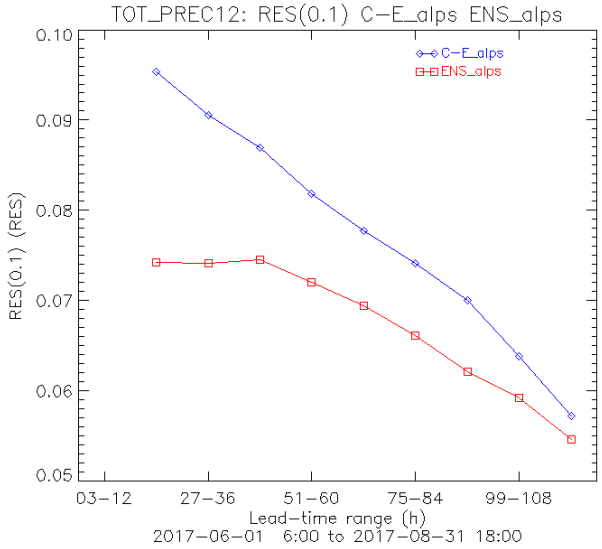
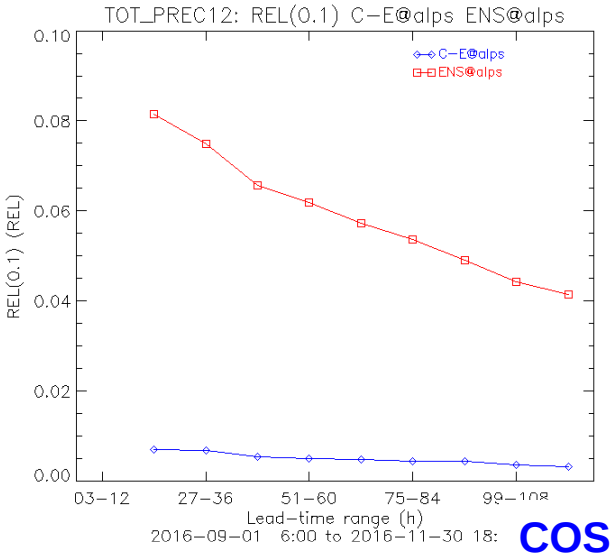
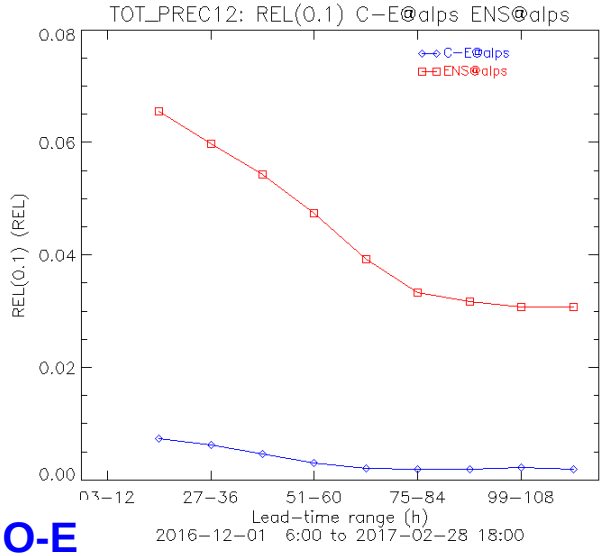


12h precipitation; REL, 0.1mm/12h

SON





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COSMO-E

ENS

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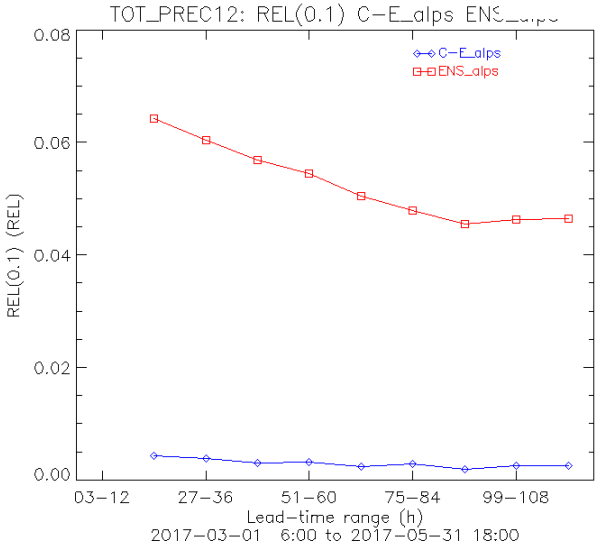
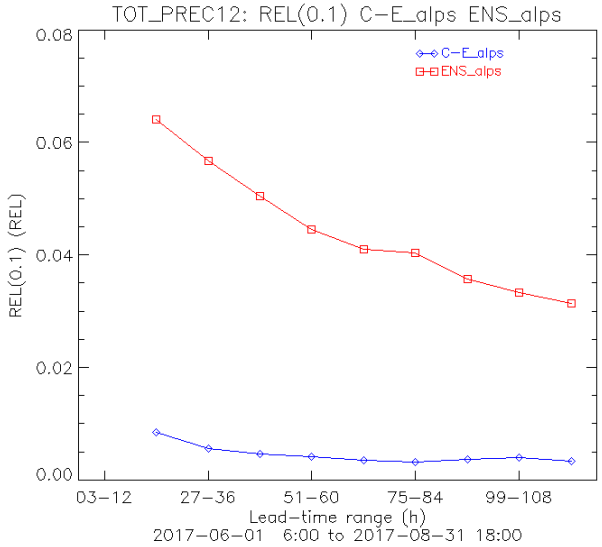
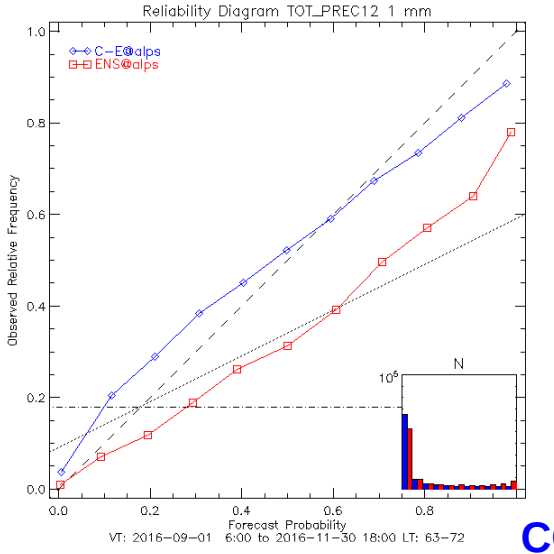


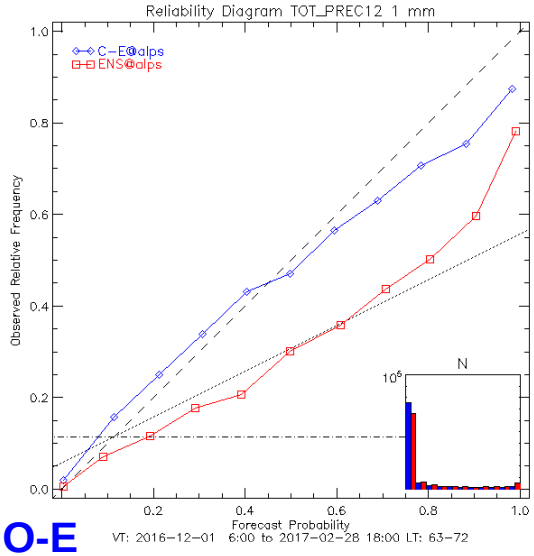


JJA

12h precipitation; reliability, 1mm/12h

SON





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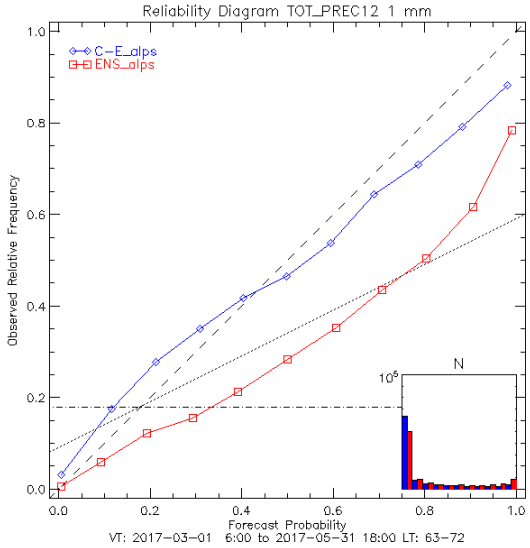
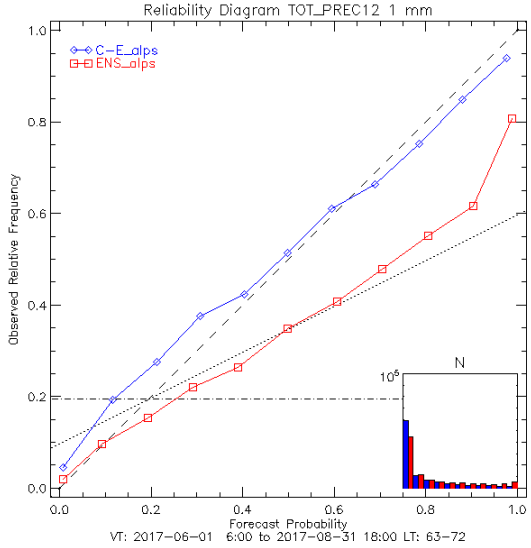
COSMO-E

ENS

63-72

MAM

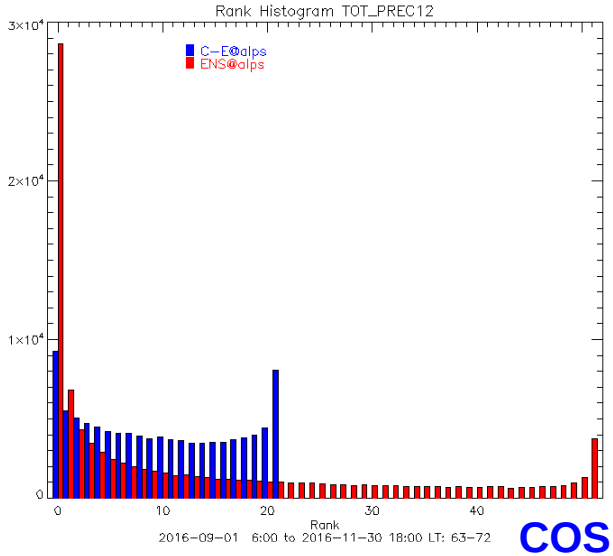


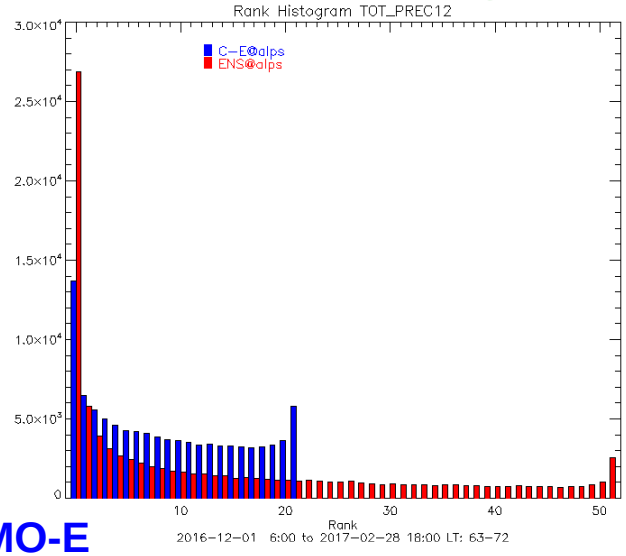


JJA

12h precipitation; rank histogram

SON





DJF

COSMO-E

ENS

63-72

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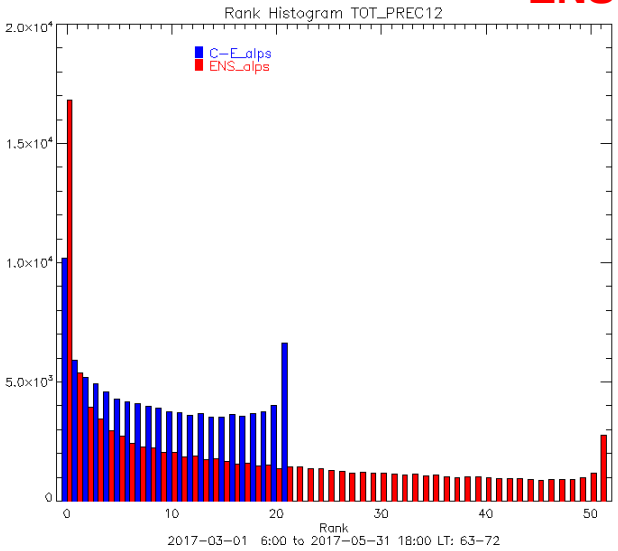
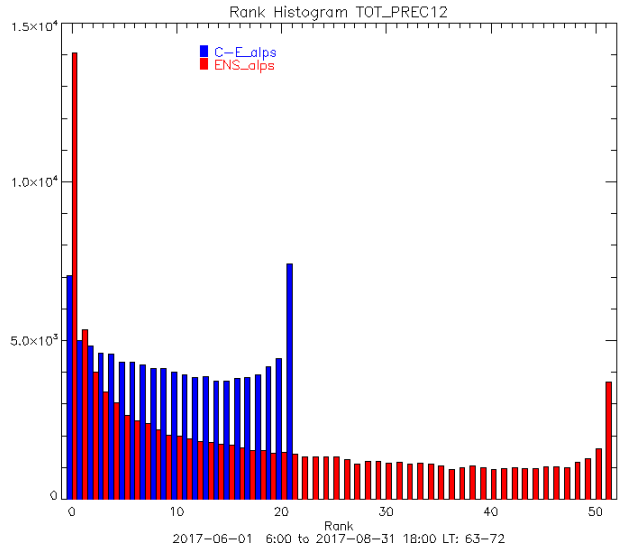
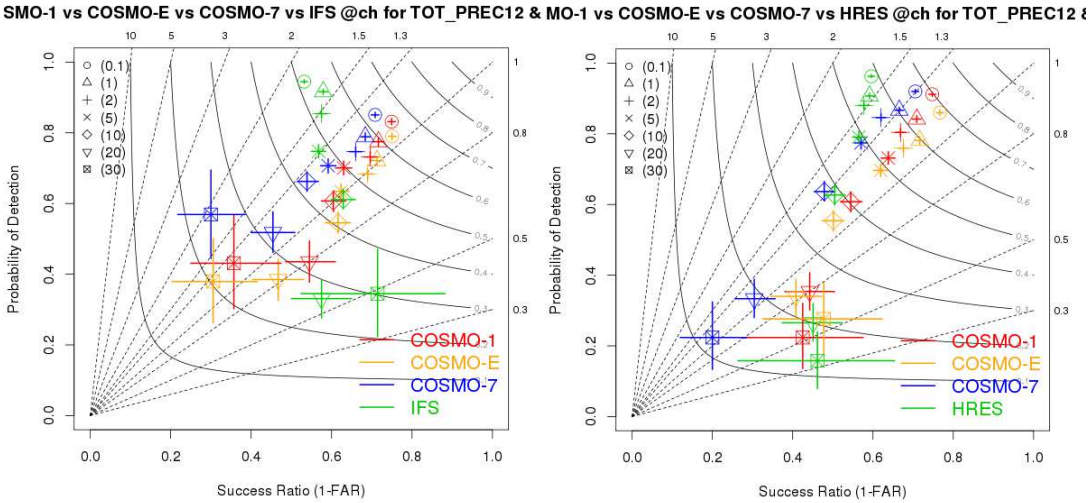




JJA

12h precipitation; perf diag of ctrl

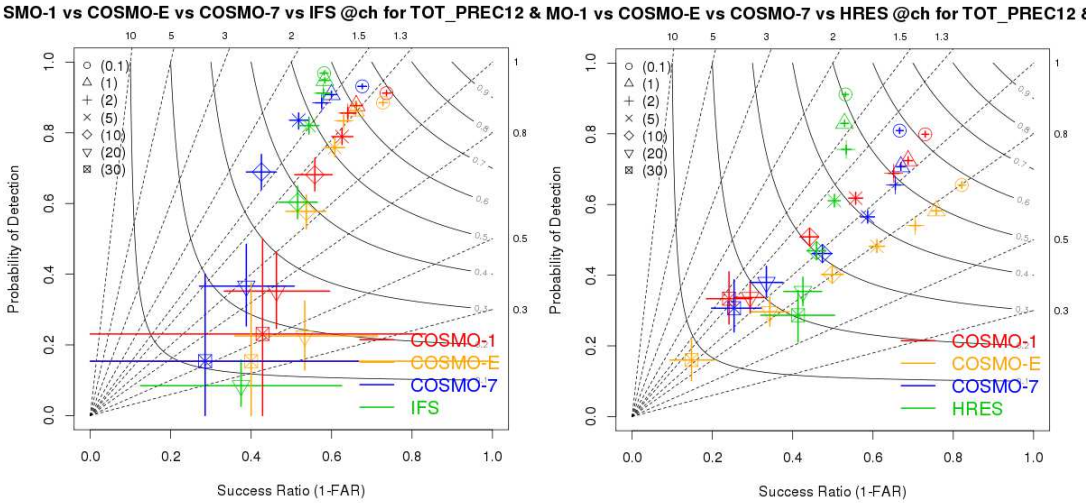
SON



DJF

CH, only!

MAM



JJA

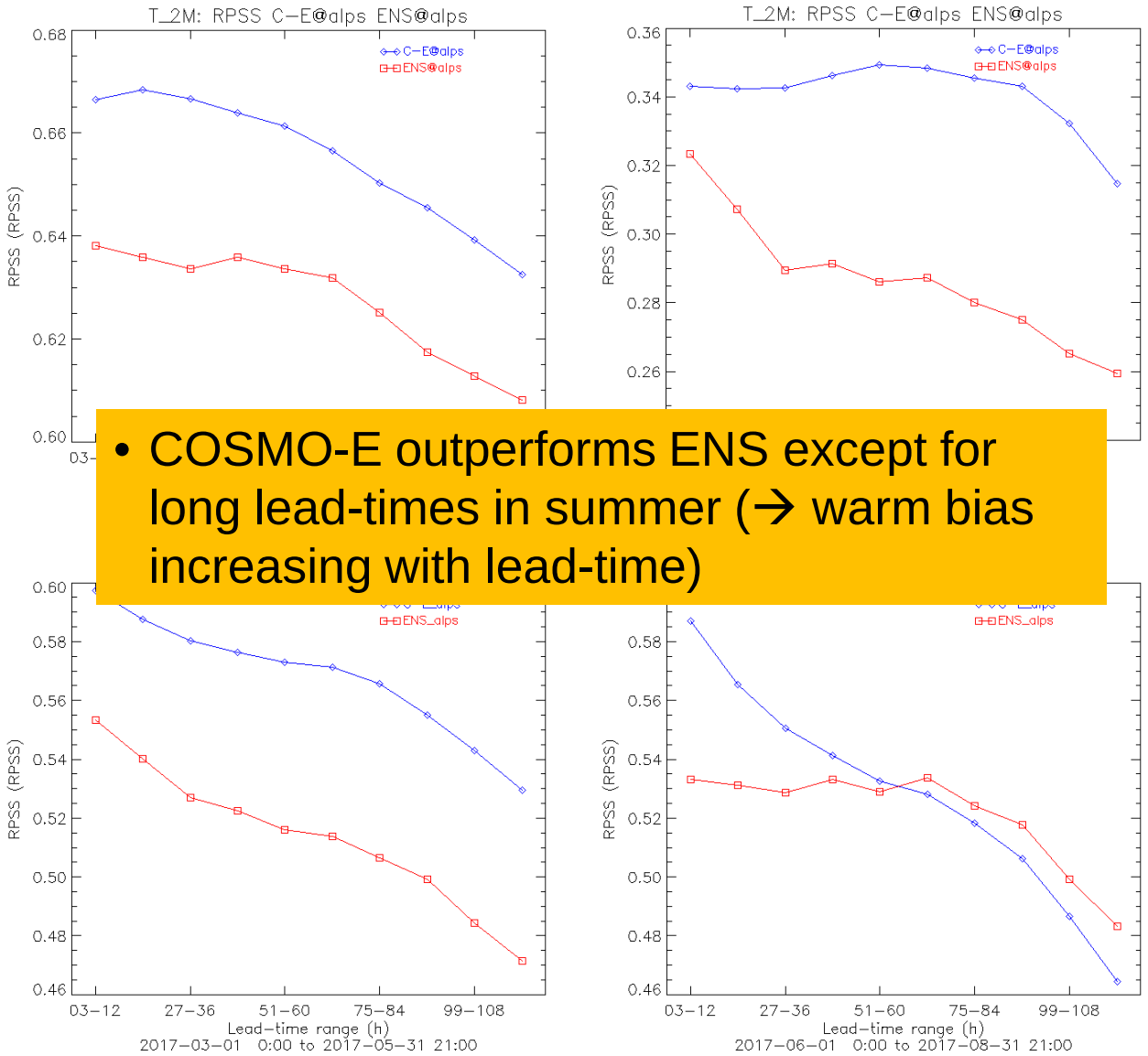
T2m; RPSS

SON

DJF

MAM

JJA

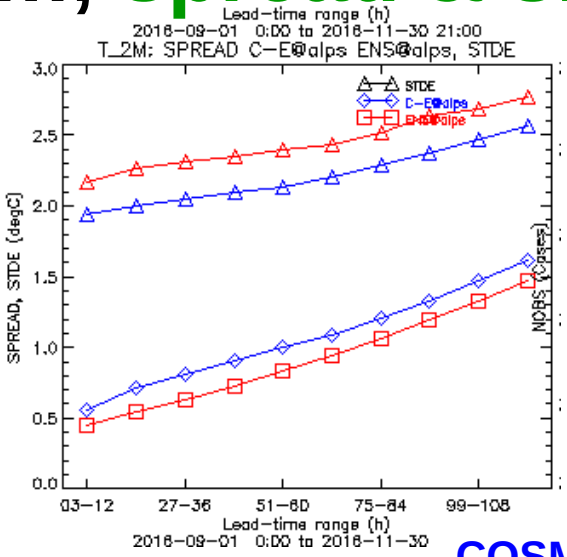


- COSMO-E outperforms ENS except for long lead-times in summer (→ warm bias increasing with lead-time)

Thresholds: -5, 0, 5, 10, 15, 20, 25, 30, 35 degrees Celsius

T2m; spread & skill (STDE)

SON



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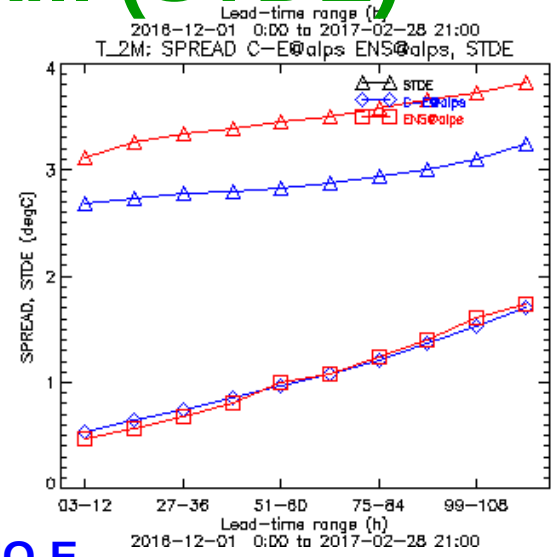
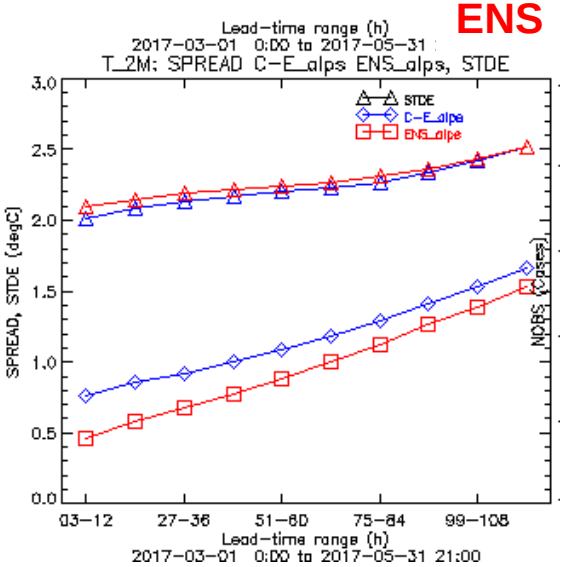


COSMO-E ENS

MAM



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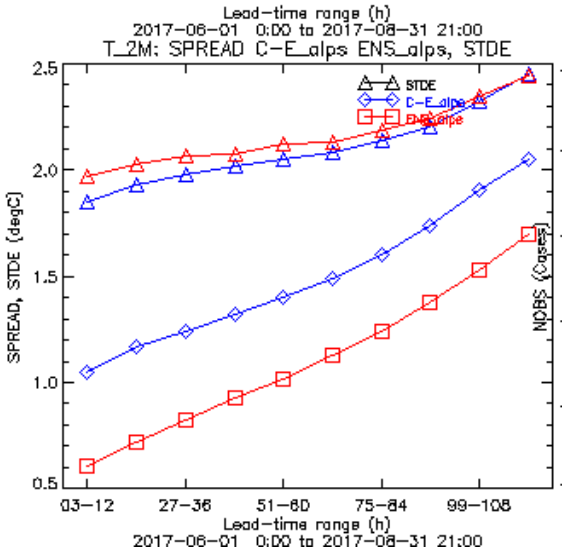
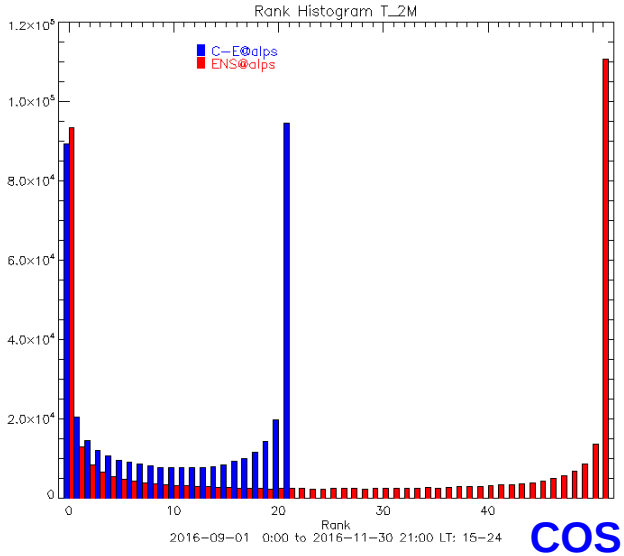
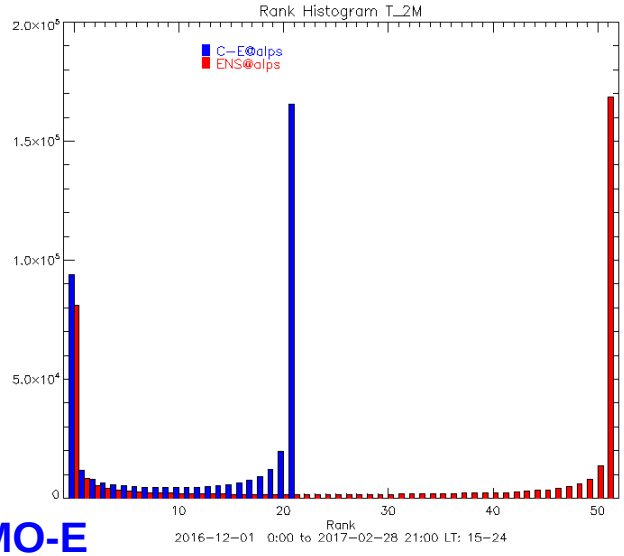


T2m; rank histogram

SON





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COSMO-E
ENS

15-24

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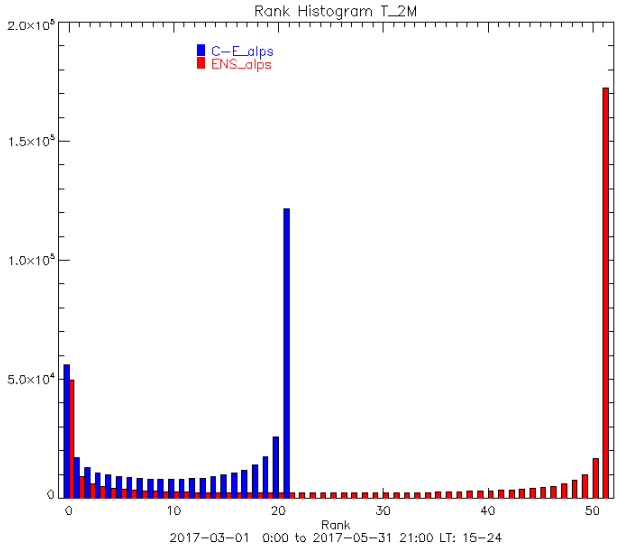
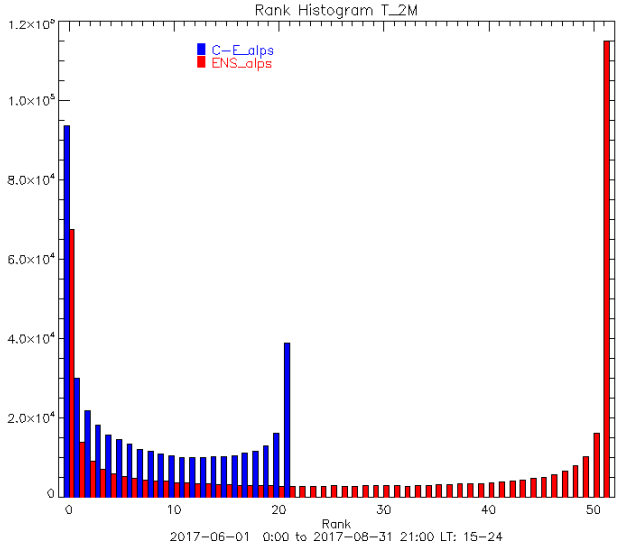
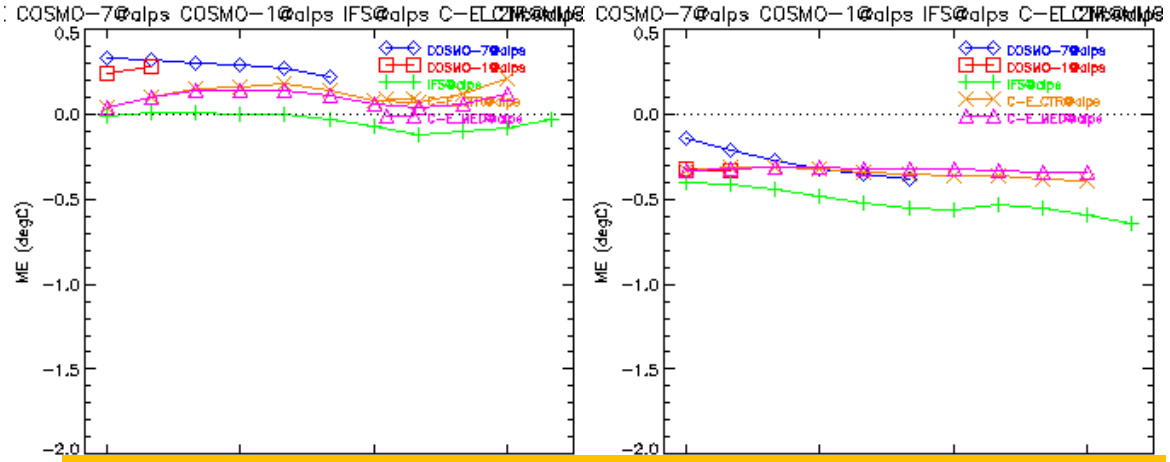




JJA

T2m; mean error of ctrl/median

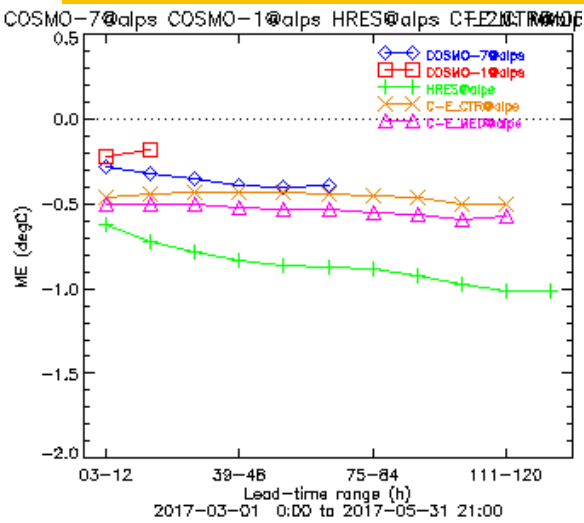
SON



DJF

- systematic drift for COSMO-E in summer: warm bias increasing with lead-time

MAM



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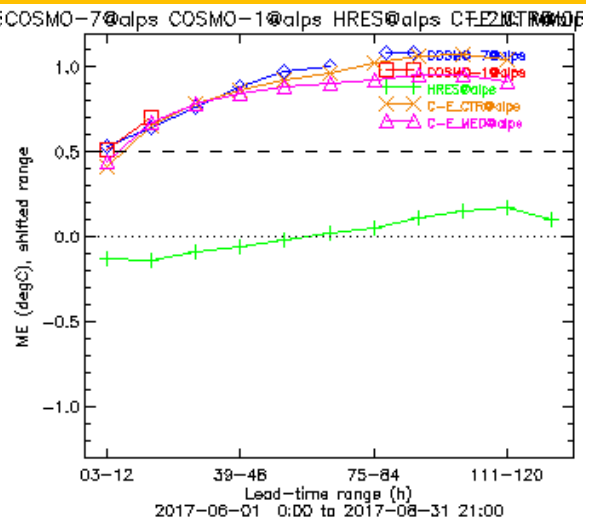

Td2m; RPSS

SON

DJF

MAM

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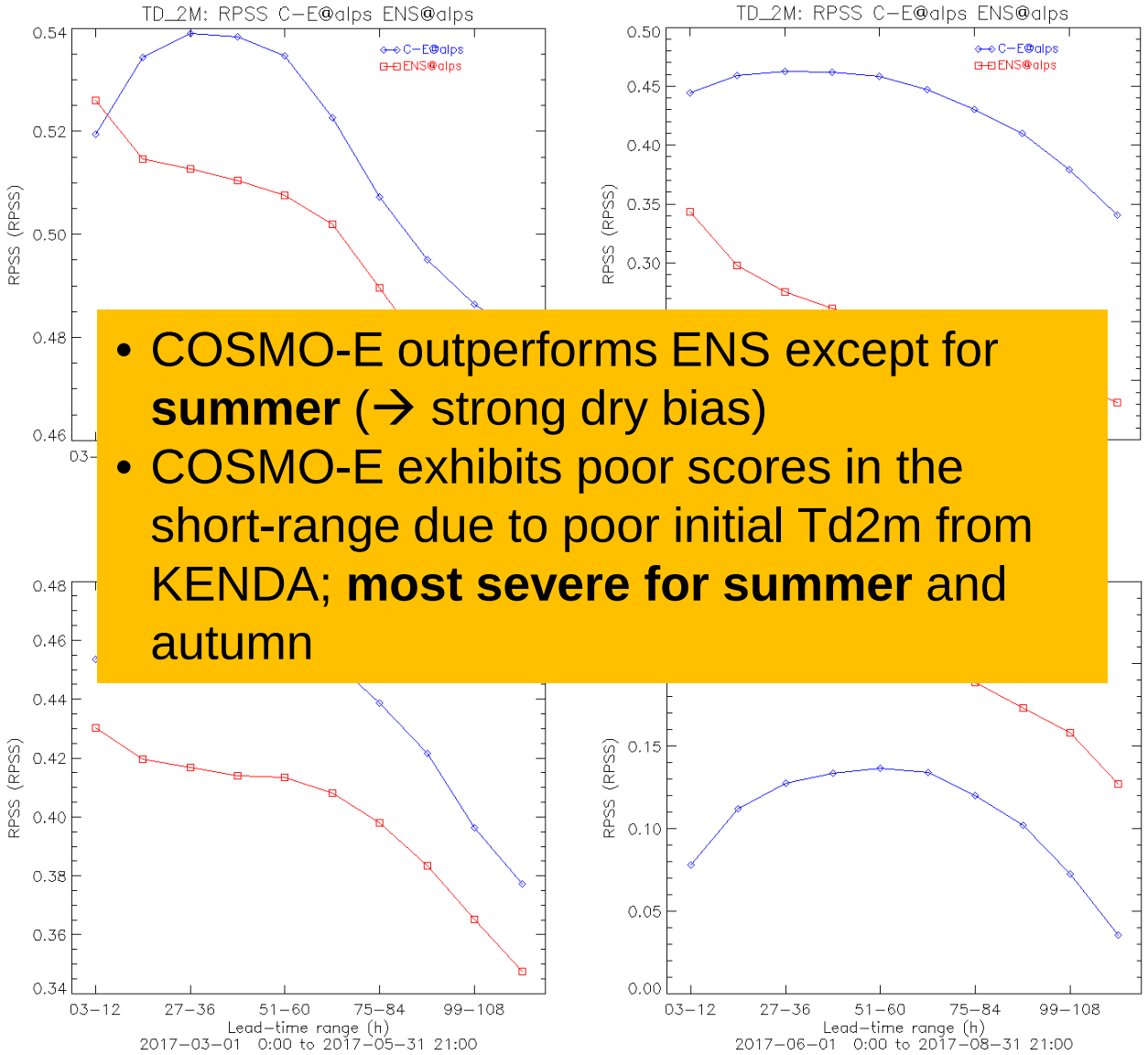


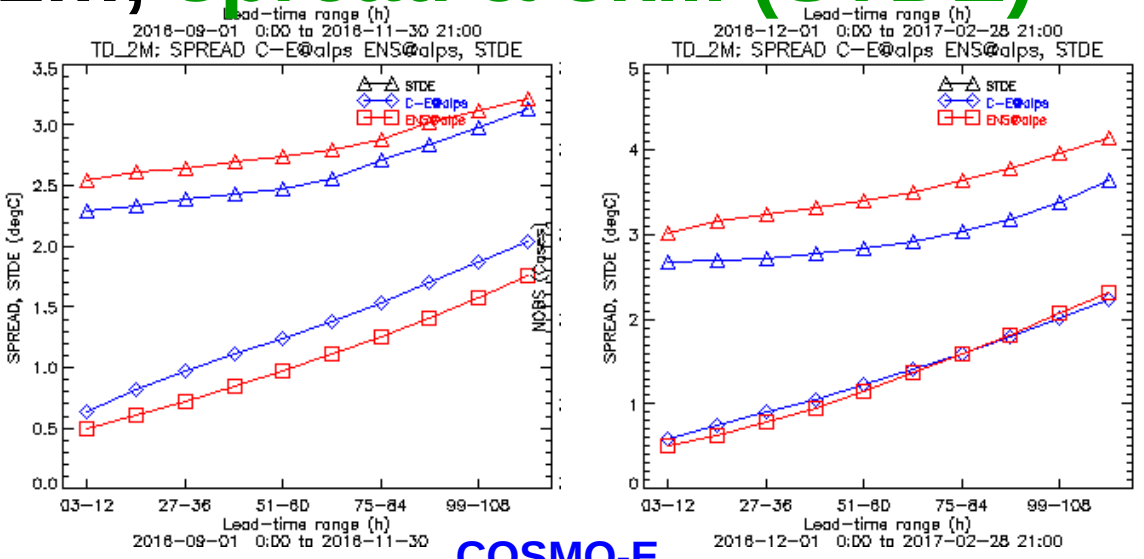
- COSMO-E outperforms ENS except for **summer** (→ strong dry bias)
- COSMO-E exhibits poor scores in the short-range due to poor initial Td2m from KENDA; **most severe for summer** and autumn

Thresholds: -15, -10, -5, 0, 5, 10, 15, 20, 25 degrees Celsius

Td2m; spread & skill (STDE)

SON

DJF



COSMO-E

ENS

MAM

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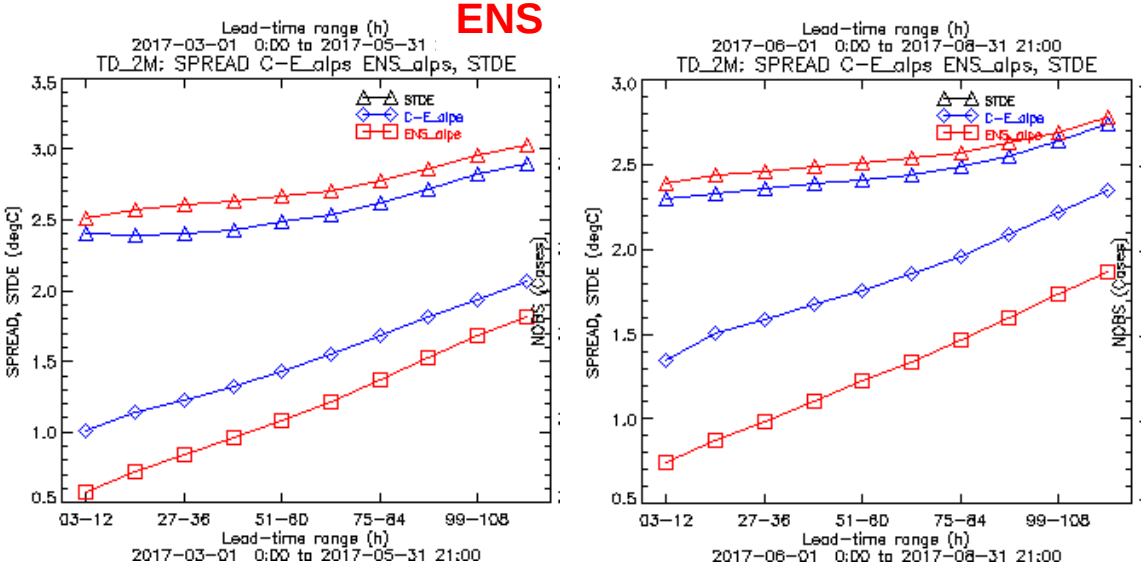
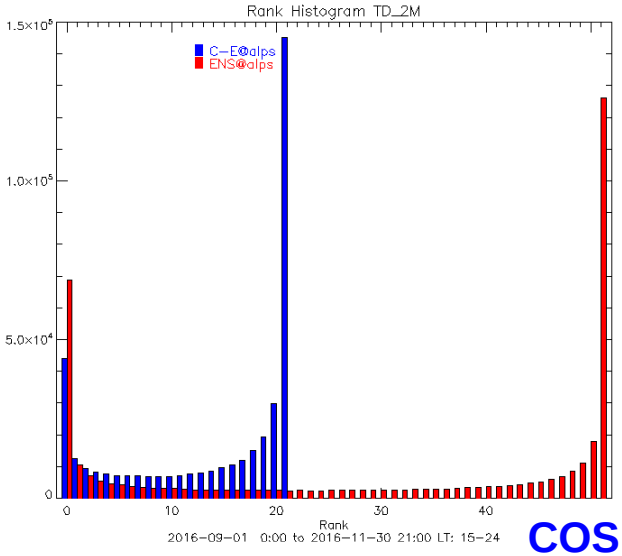
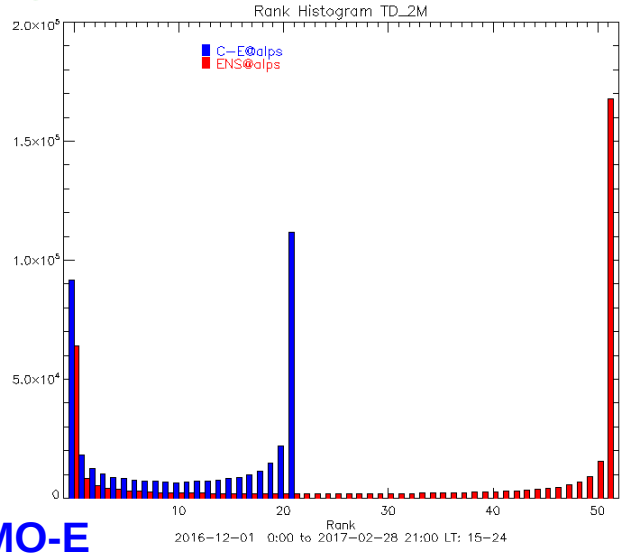


Td2m; rank histogram

SON





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COSMO-E

ENS

15-24

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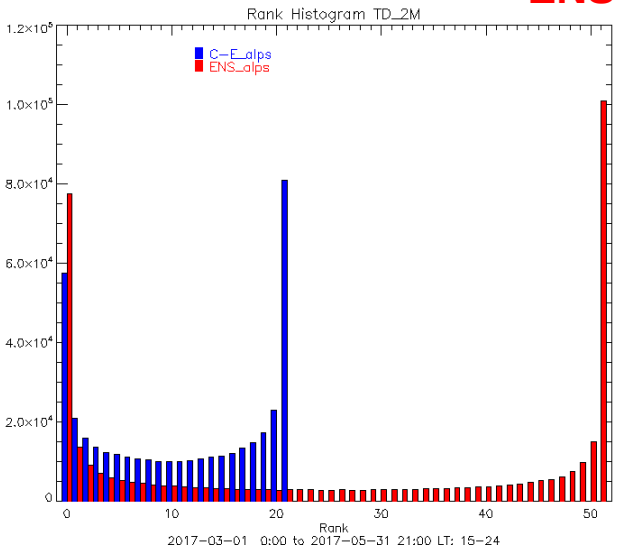
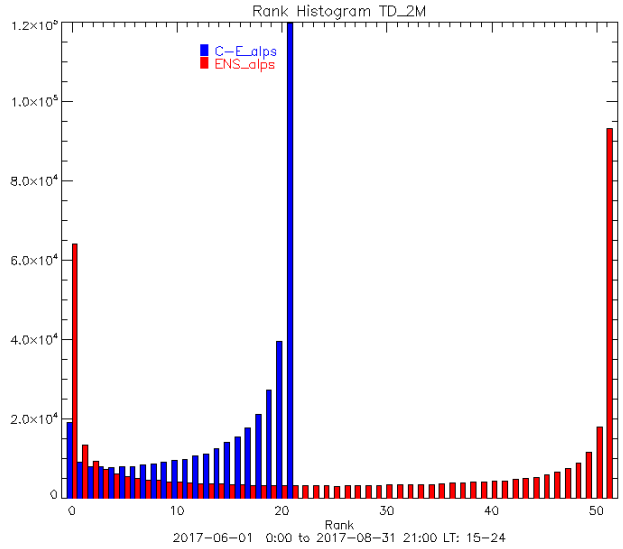


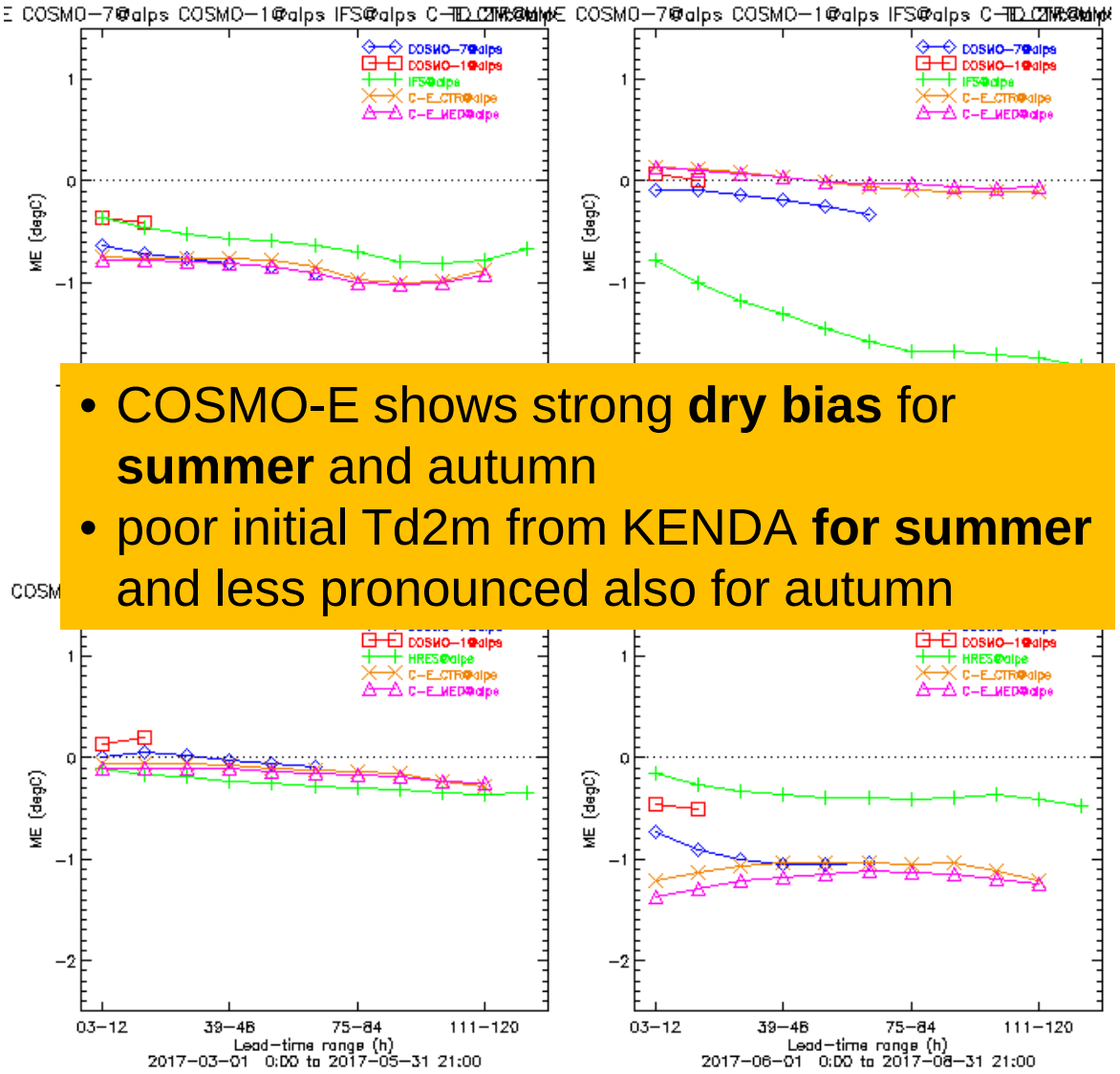


JJA

Td2m; mean error of ctrl/median

SON

DJF



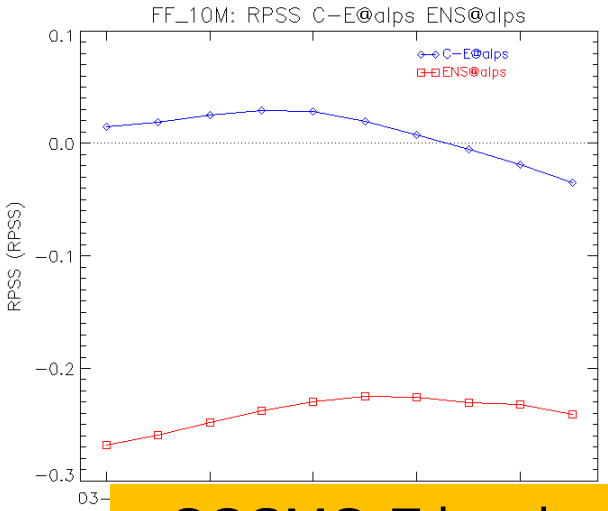
- COSMO-E shows strong **dry bias** for **summer** and autumn
- poor initial Td2m from KENDA **for summer** and less pronounced also for autumn

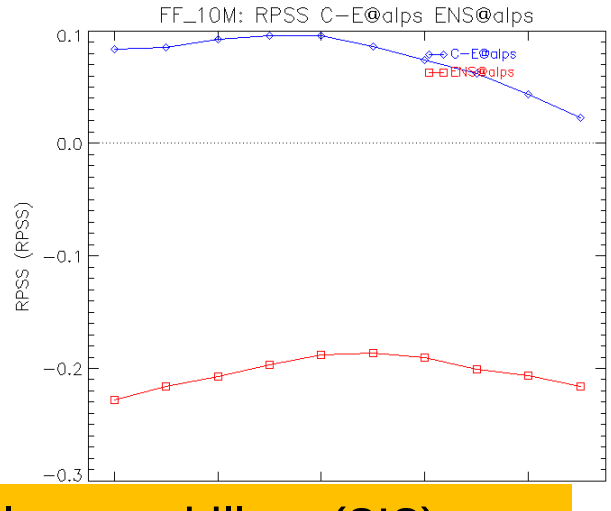
MAM

JJA

ff10m; RPSS

SON



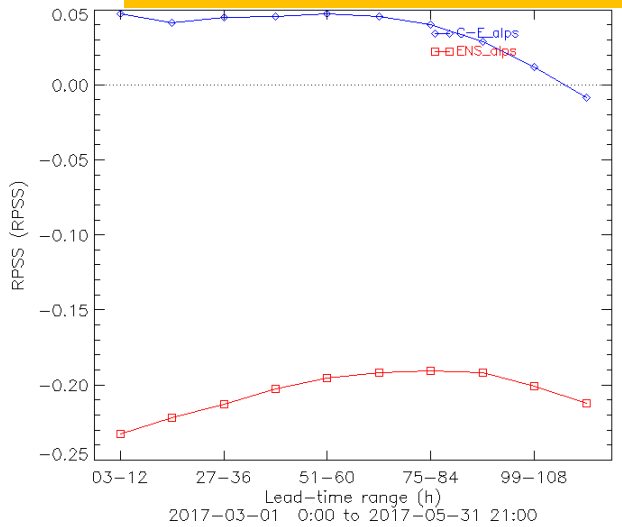


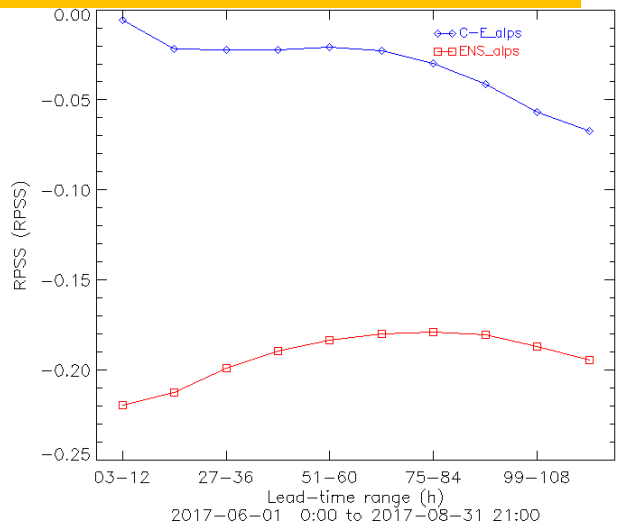
DJF

- COSMO-E has hardly any skill … (?!?)
- … - but is still more skilful than ENS!

???

MAM



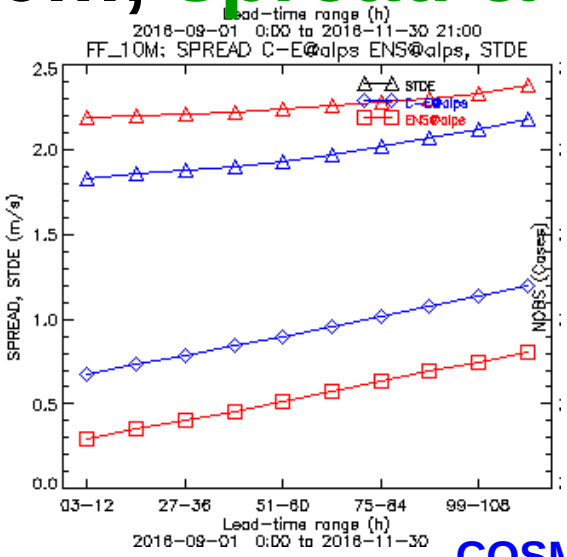


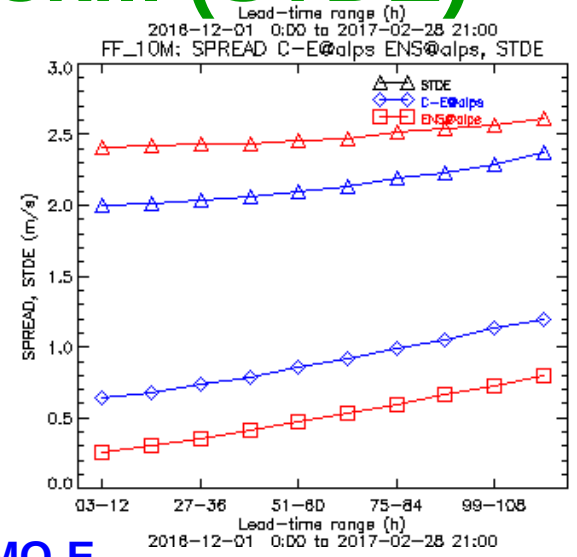
JJA

Thresholds: 2.5, 5.0, 7.5, 10, 15, 20 m/s

ff10m; spread & skill (STDE)

SON



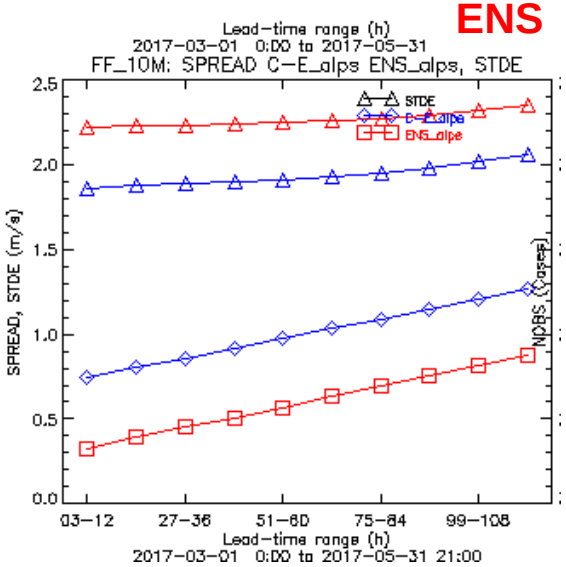


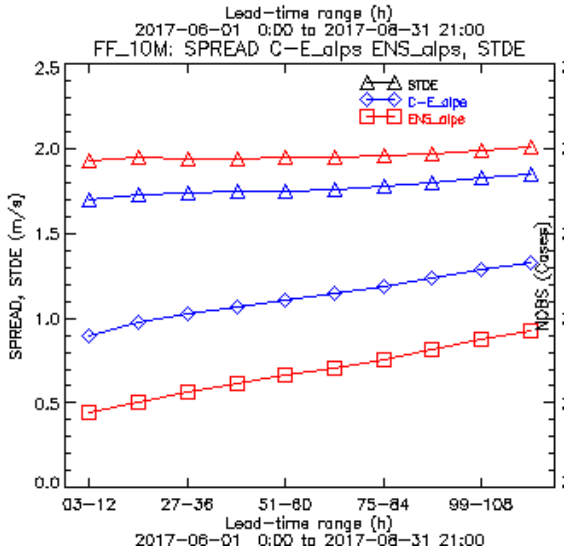
DJF

COSMO-E

ENS

MAM

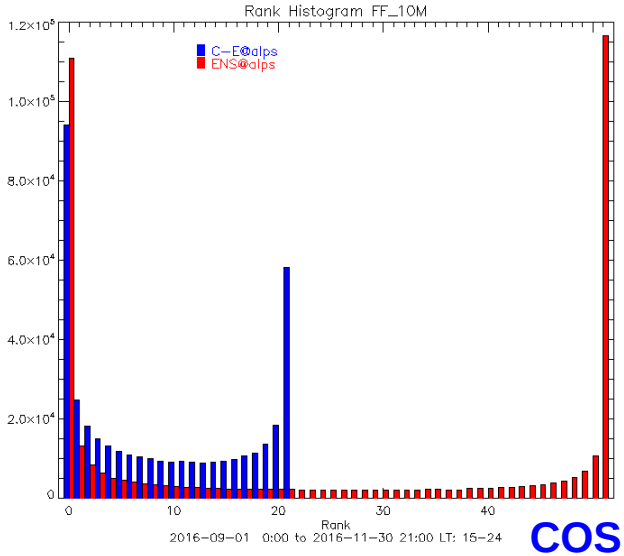


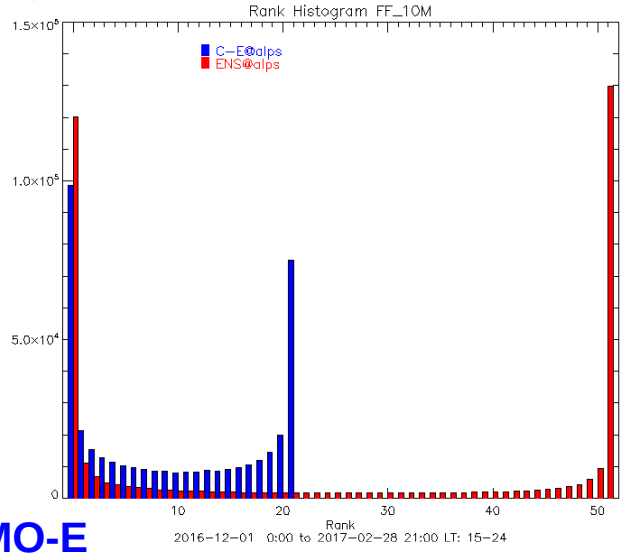


JJA

ff10m; rank histogram

SON





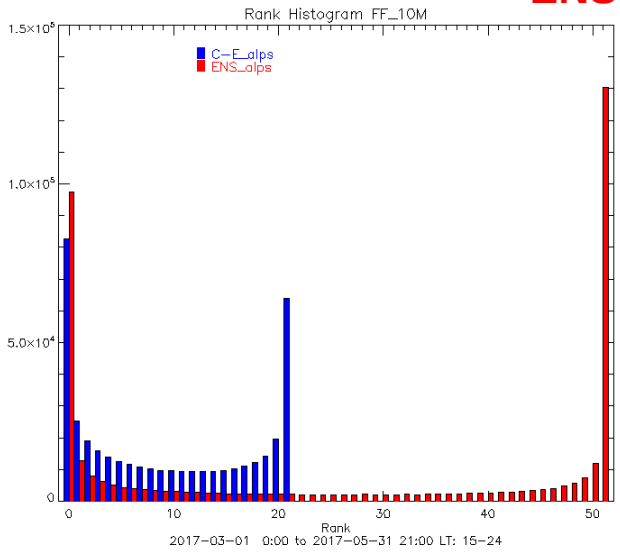
DJF

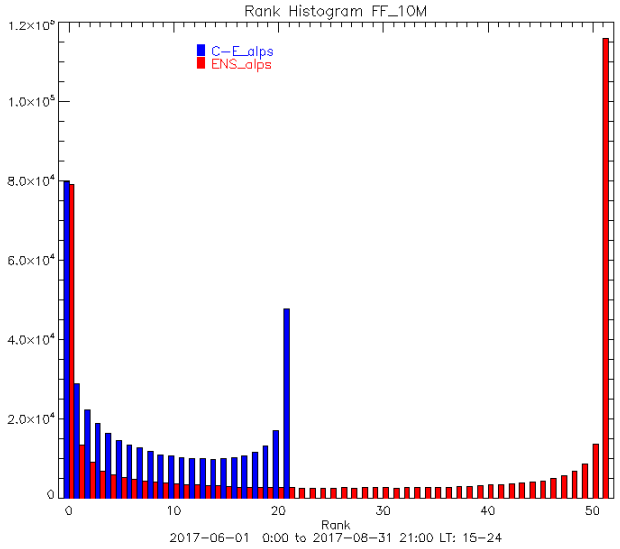
COSMO-E

ENS

15-24

MAM

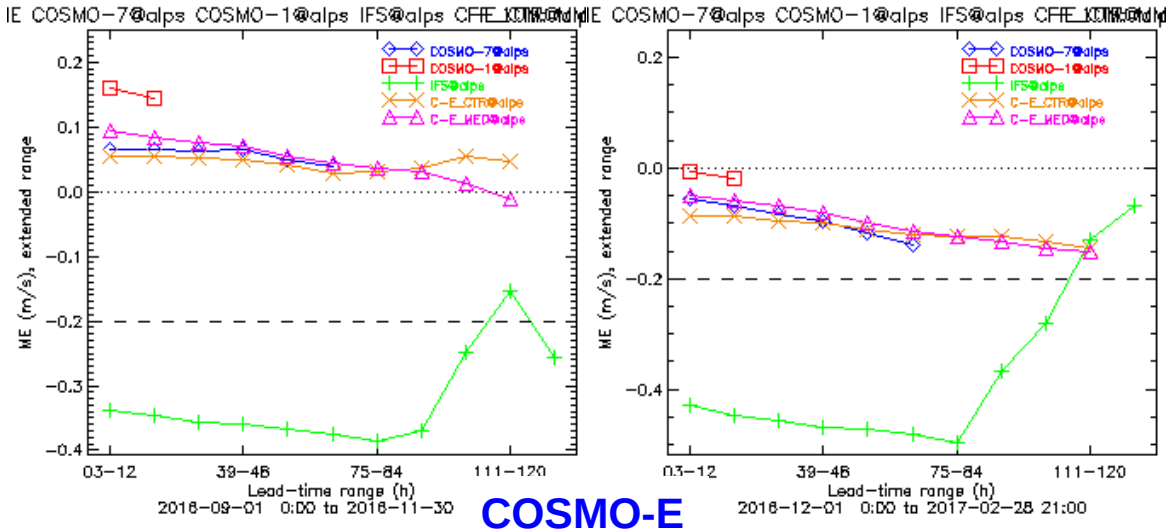




JJA

ff10m; mean error of ctrl/median

SON



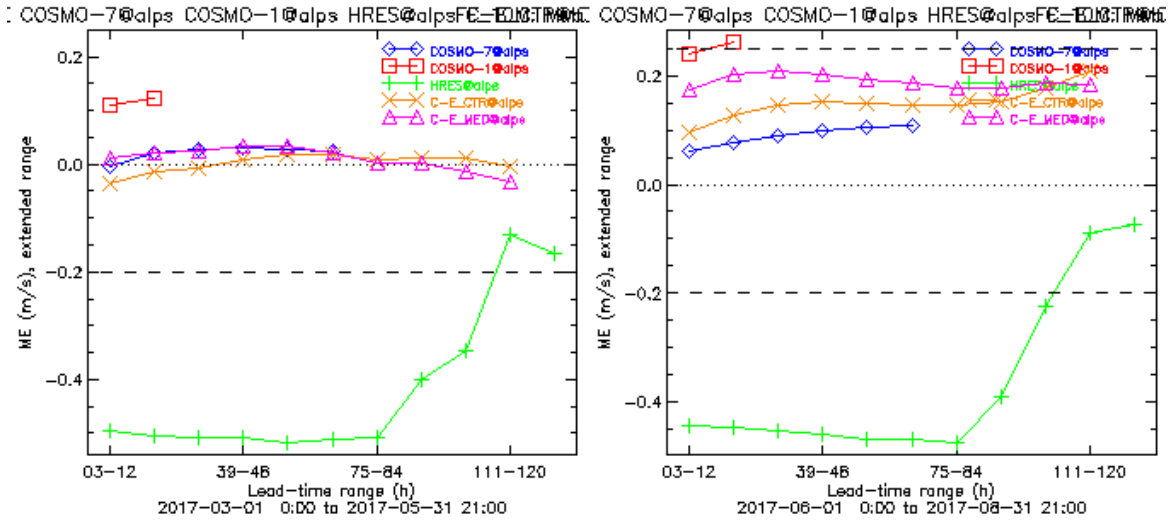
DJF

COSMO-E

ENS

???

MAM

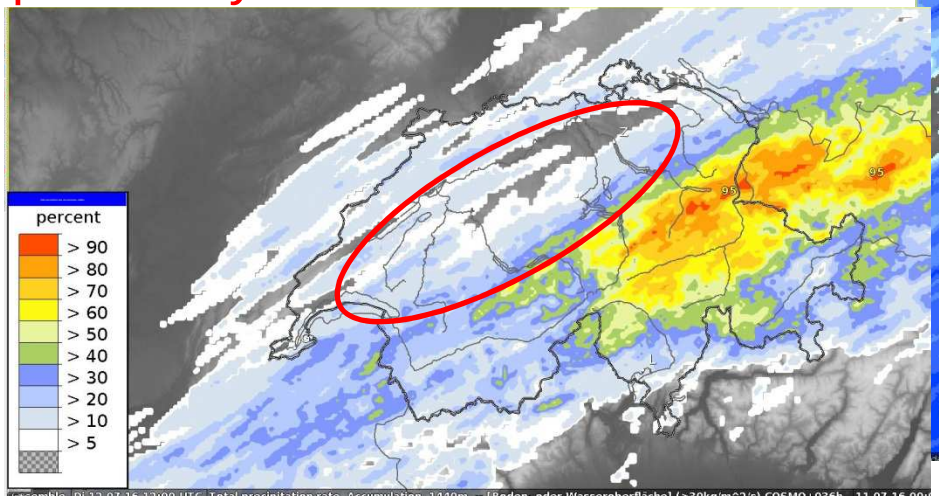


JJA

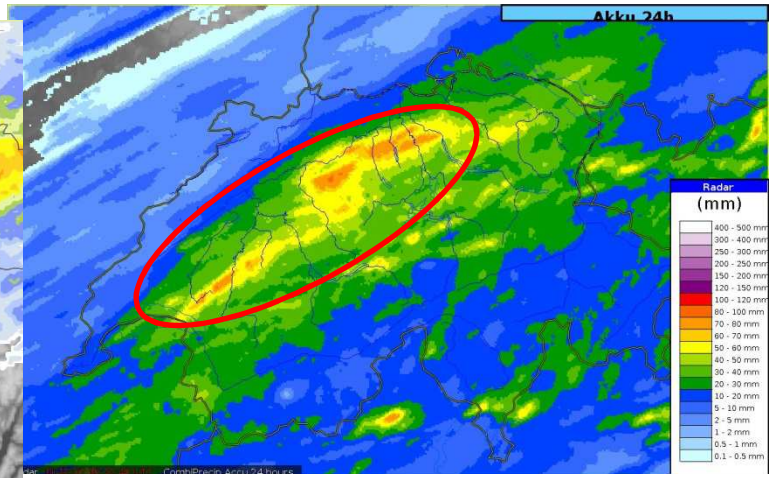
Main feedbacks from forecasters

- COSMO-E often triggers convection over the Alps only and misses it over the Swiss plateau:
  → lack of convective precipitation
  → missed warnings for thunderstorms
  → in particular with weak synoptic forcing
- Example:

probability TP > 30mm/24h:



TP sum, up to 70mm/24h:



Forecast quality summary

- COSMO-E **outperforms** ENS for the full Alpine domain for most variables and most seasons (despite 6h older LBCs).
- COSMO-E is still **underdispersive** in the PBL, most severely in the short-range (caveat: no obs error included).
- In **summer**, COSMO-E exhibits a **strong warm and dry bias**. – The warm bias is equally large for COSMO-1 and COSMO-7.
- **Forecast quality of COSMO-E critically depends on the quality of KENDA … – and vice versa!**
- *Not shown: problems in convection triggering without orographic forcing observed in 2016 (less so in 2017?).*

Outlook

- experiments *(by Seraina Klaus; internship)* for convective cases to investigate
  - impact of a setup proposed by PP CALMO
  - sensitivity to turbulence length scale (tur_len)
  - boundary layer perturbations (T, w, qv) based on Kober and Craig (2016)

- implementation of member selection by clustering *(by Stephanie Westerhuis, MSc-thesis)* into operational suite
- experiments with rescaled (i.e., amplified) KENDA ICs (and later maybe also ENS LBCs)

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