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Eidgenössisches Departement des Innern EDI
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

Performance differences between COSMO and ICON

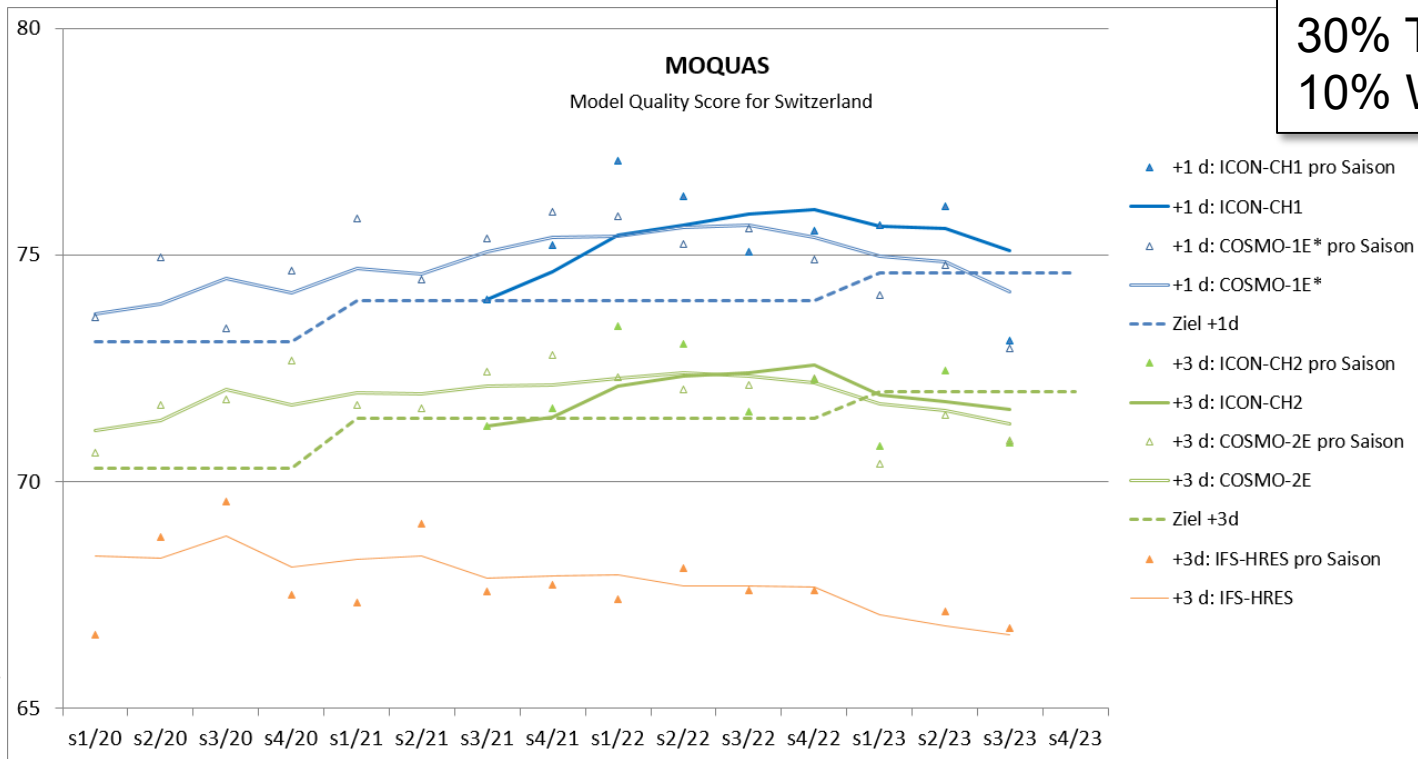
COSMO GM 2023 WG5

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Administrative Score

Param. Weights
30% Precipitation
30% Cloud Cover
30% Temperature
10% Wind Speed



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ICON-CH1 versus COSMO-1E Control

Dichotomic Verification **Spring** 2023

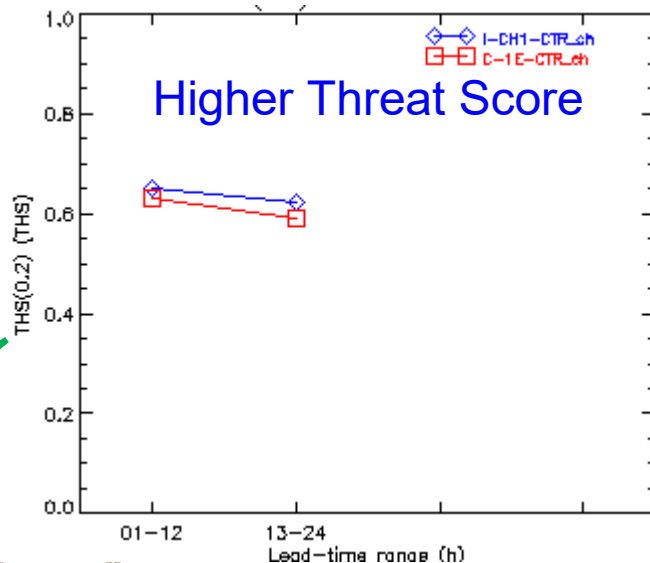
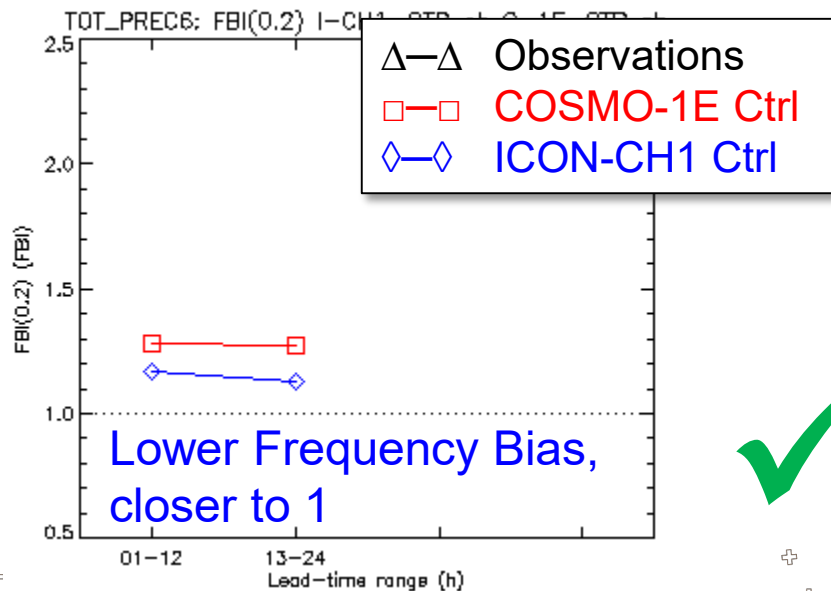
Deterministic Verification **ICON-CH1** versus **COSMO-1E** Control

Parameter	THS				FBI			
	ch		ch-sp		ch		ch-sp	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
TOT_PREC6 ≥ 0.2	-2 %	-3 %	-1 %	-2 %	-12 %	-15 %	-7 %	-8 %
TOT_PREC6 ≥ 1	-1 %	-4 %	-1 %	-2 %	-10 %	-15 %	-4 %	-6 %
TOT_PREC6 ≥ 5	-1 %	-3 %	+2 %	-3 %	-1 %	-9 %	-9 %	+4 %
CLCT ≥ 2.5	-1 %	-0 %	-0 %	+0 %	-3 %	+0 %	-0 %	+3 %
CLCT ≥ 6.5	+2 %	+2 %	+1 %	+1 %	-17 %	-13 %	-9 %	-6 %
VMAX_10M6 ≥ 12.5	-0 %	-0 %	-4 %	-5 %	-10 %	+1 %	-60 %	-66 %
VMAX_10M6 ≥ 20	-3 %	-2 %	-6 %	-5 %	-31 %	-15 %	-59 %	-69 %



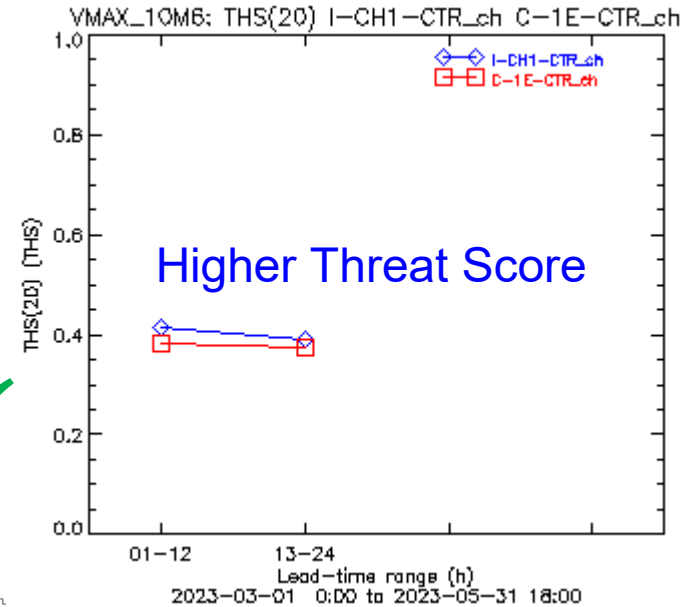
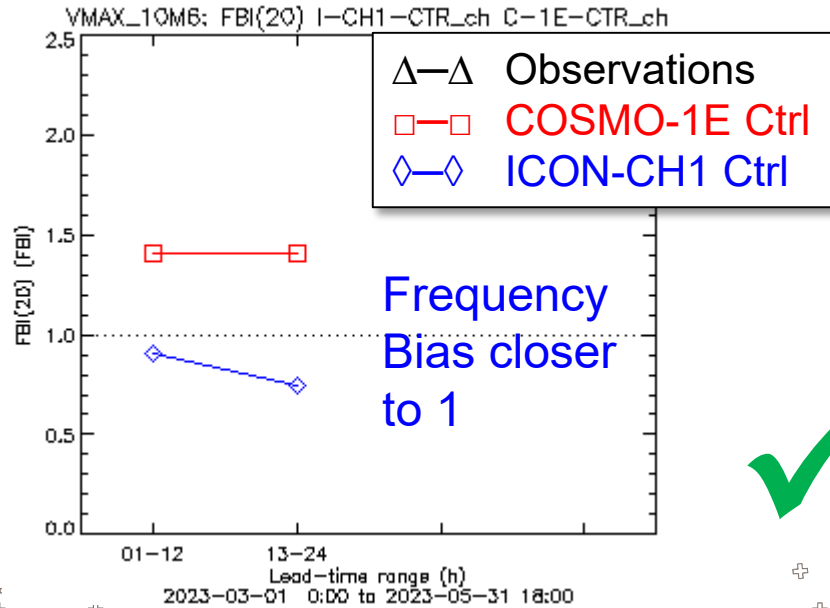


6h-Precipitation, Threshold 0.2 mm/6h





Gusts, 6h-Max, Threshold 20 m/s





ICON-CH1 versus COSMO-1E Control

Dichotomic Verification Summer 2023

Deterministic Verification **ICON-CH1** versus **COSMO-1E** Control

ch-sp Swiss Plateau
ch-am Alpine Mountains
ch-av Alpine Valleys

Parameter	THS								FBI							
	ch		ch-sp		ch-am		ch-av		ch		ch-sp		ch-am		ch-av	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
TOT_PREC6 ≥ 0.2	-0 %	-0 %	-0 %	+1 %	-0 %	-2 %	-1 %	-1 %	-9 %	+0 %	+2 %	+3 %	-4 %	-2 %	-19 %	-21 %
TOT_PREC6 ≥ 1	-1 %	-1 %	-3 %	+0 %	-1 %	-2 %	-1 %	-2 %	-2 %	+2 %	-3 %	+7 %	+4 %	+5 %	-16 %	-22 %
TOT_PREC6 ≥ 5	-4 %	-2 %	-3 %	-2 %	-4 %	-3 %	-6 %	-3 %	+3 %	-12 %	-17 %	-2 %	-6 %	-1 %	+1 %	-21 %
CLCT ≥ 2.5	-1 %	-1 %	-0 %	-2 %	-2 %	-2 %	-0 %	-1 %	+4 %	+3 %	+5 %	+2 %	+3 %	+2 %	+5 %	+4 %
CLCT ≥ 6.5	+1 %	+1 %	-0 %	+1 %	+1 %	+1 %	+2 %	+1 %	-16 %	-16 %	-11 %	-14 %	-17 %	-8 %	-18 %	-16 %
VMAX_10M6 ≥ 12.5	+0 %	+2 %	-3 %	-1 %	+3 %	+2 %	+4 %	+7 %	-9 %	-6 %	-70 %	-72 %	+20 %	+24 %	+17 %	+17 %
VMAX_10M6 ≥ 20	-1 %	-0 %	-6 %	-7 %	+1 %	+2 %	+4 %	-0 %	-27 %	-30 %	-61 %	-83 %	+5 %	+15 %	+13 %	+18 %



Except weak gusts within
complex terrain of Alps

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ICON-CH1 versus COSMO-1E Control

Continuous Verification **Spring** 2023

Deterministic Verification **ICON-CH1** versus **COSMO-1E** Control

STDE indicates better spatial and temporal structure in ICON



Parameter	STDE				ME			
	ch		ch-sp		ch		ch-sp	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
ATHD_S	-10 %	-12 %	-13 %	-14 %	+13 %	+30 %	+28 %	+27 %
GLOB	-5 %	-4 %	-5 %	-5 %	+13 %	+14 %	+12 %	+10 %
DURSUN1	+11 %	+9 %	+3 %	+0 %	+14 %	+21 %	+16 %	+13 %
T_2M	-12 %	-13 %	-8 %	-11 %	-8 %	-1 %	-1 %	-10 %
TD_2M	-5 %	-7 %	-7 %	-11 %	+6 %	+9 %	-0 %	+3 %
RELHUM_2M	-7 %	-10 %	-7 %	-10 %	+9 %	+9 %	-4 %	-4 %
FF_10M	-2 %	-4 %	-8 %	-10 %	+18 %	+17 %	-21 %	-25 %
DD_10M	-6 %	-8 %	-6 %	-8 %	+1 %	+1 %	+0 %	+1 %
PS	+8 %	-3 %	-11 %	-18 %	+18 %	+8 %	+3 %	-9 %
PMSL	-7 %	-17 %	-8 %	-17 %	-8 %	-2 %	+2 %	-13 %



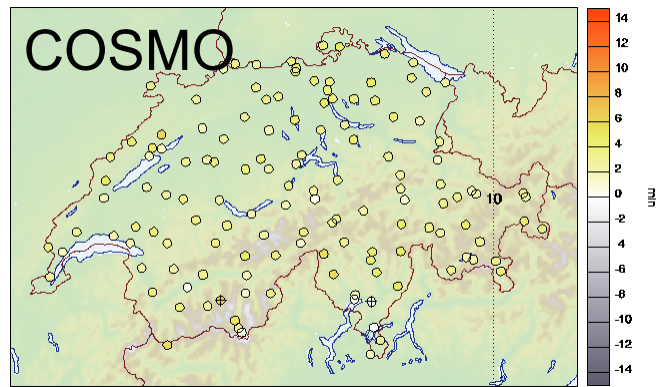
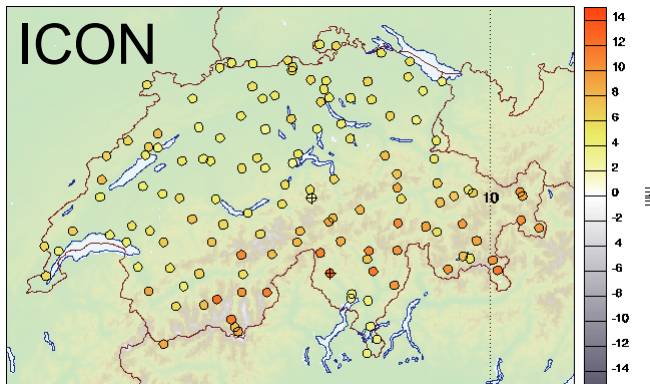
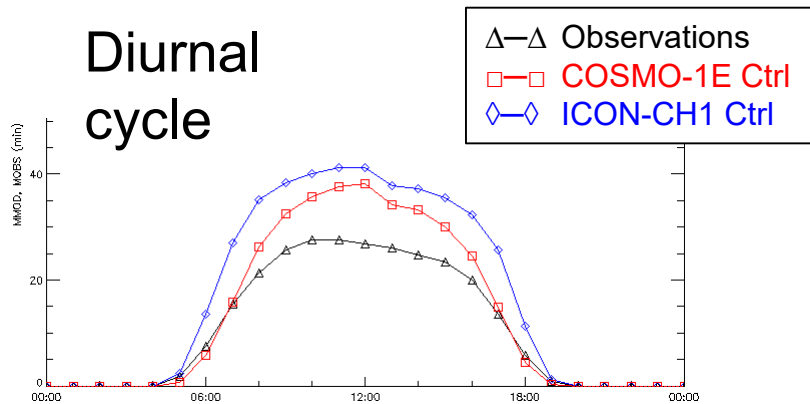


Sunshine Duration

Sunshine = direct shortwave radiation > 200 W m⁻²

- **ICON** stronger overestimation
- Mostly south side of Alps

Diurnal cycle



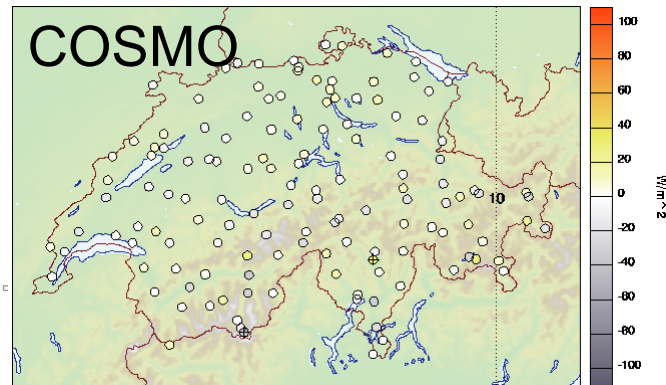
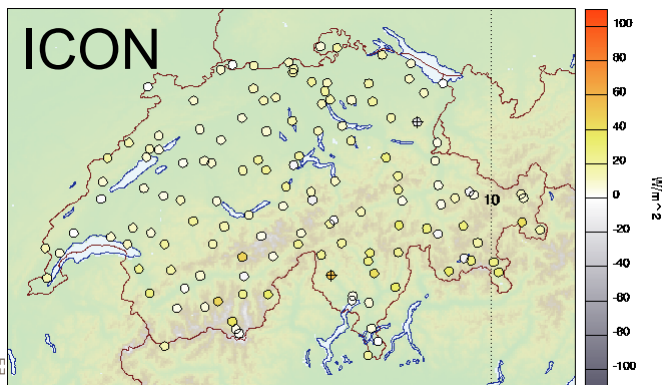
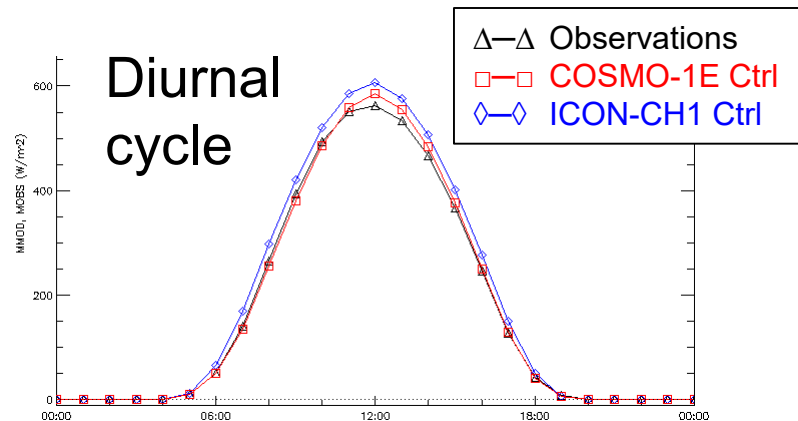
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Shortwave (Global) Radiation

- **ICON** only slightly stronger overestimation
- → Problem due to partitioning between direct and diffuse



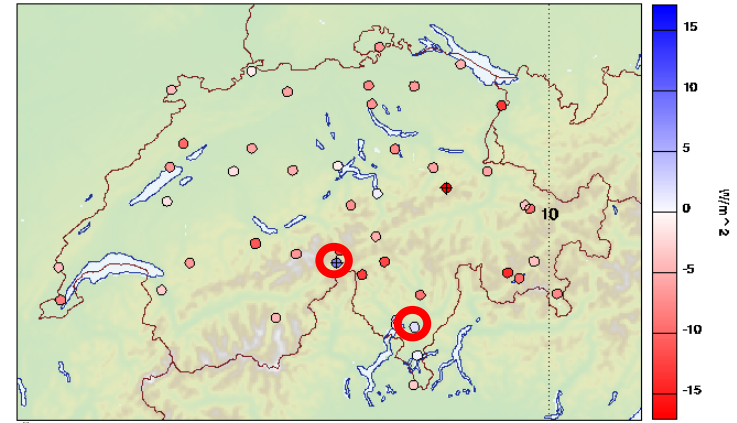
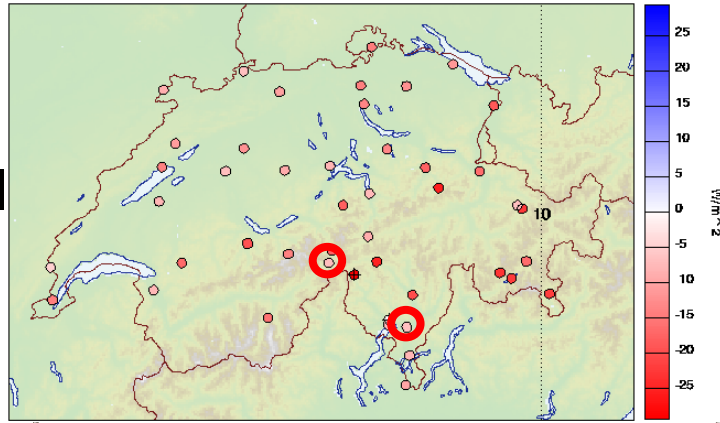
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Longwave Radiation

- **ICON** less radiation and thus more underestimation in general
- Less overestimation at few stations





ICON-CH1 versus COSMO-1E Control

Deterministic Verification **ICON-CH1** versus **COSMO-1E** Control

Parameter	STDE				ME			
	ch		ch-sp		ch		ch-sp	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
ATHD_S	-10 %	-12 %	-13 %	-14 %	+33 %	+30 %	+28 %	+27 %
GLOB	-5 %	-4 %	-5 %	-5 %	+13 %	+14 %	+12 %	+10 %
DURSUN1	+11 %	+9 %	+3 %	+0 %	+24 %	+21 %	+16 %	+13 %
T 2M	-12 %	-13 %	-8 %	-11 %	-8 %	-1 %	-1 %	-10 %
TD_2M	-5 %	-7 %	-7 %	-11 %	+6 %	+9 %	+0 %	+3 %
RELHUM_2M	-7 %	-10 %	-7 %	-10 %	+9 %	+9 %	+4 %	-4 %
FF_10M	-2 %	-4 %	-8 %	-10 %	+18 %	+17 %	-21 %	-25 %
DD_10M	-6 %	-8 %	-6 %	-8 %	+1 %	+1 %	+0 %	+1 %
PS	+8 %	-3 %	-11 %	-18 %	+18 %	+8 %	+3 %	-9 %
PMSL	-7 %	-17 %	-8 %	-17 %	-8 %	-2 %	+2 %	-13 %

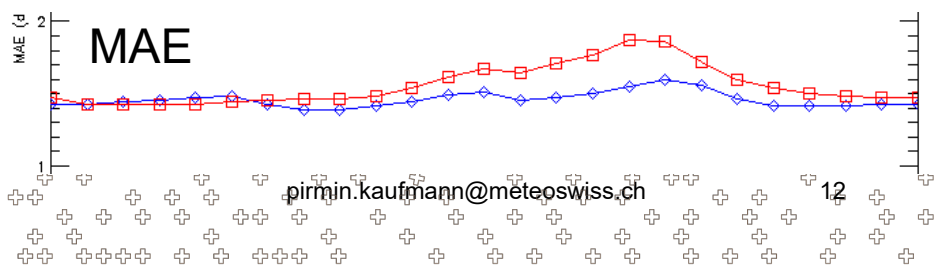
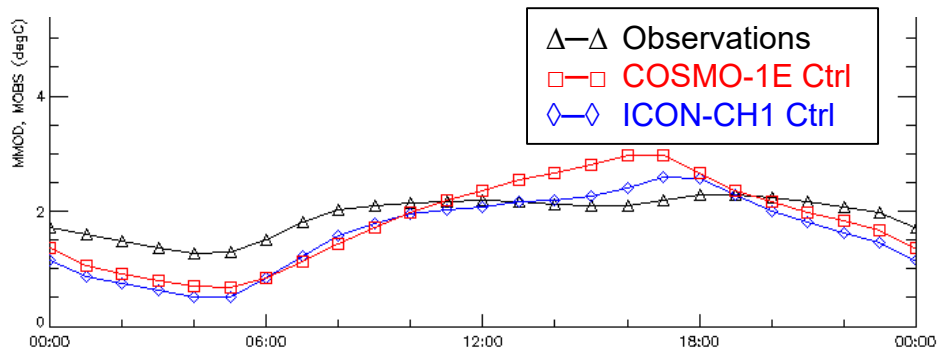


2 m Dewpoint Temperature

- **ICON**: **negative** bias at night, almost **no** bias during day
- **COSMO**: **negative** bias at night, **positive** bias during day

- **Error compensate** in COSMO but not in ICON
- Total ICON bias is worse despite ICON being **closer to observations**
- MAE (also STDE, RMSE) shows this **better quality of ICON**

Diurnal cycle





ICON-CH1 versus COSMO-1E Control

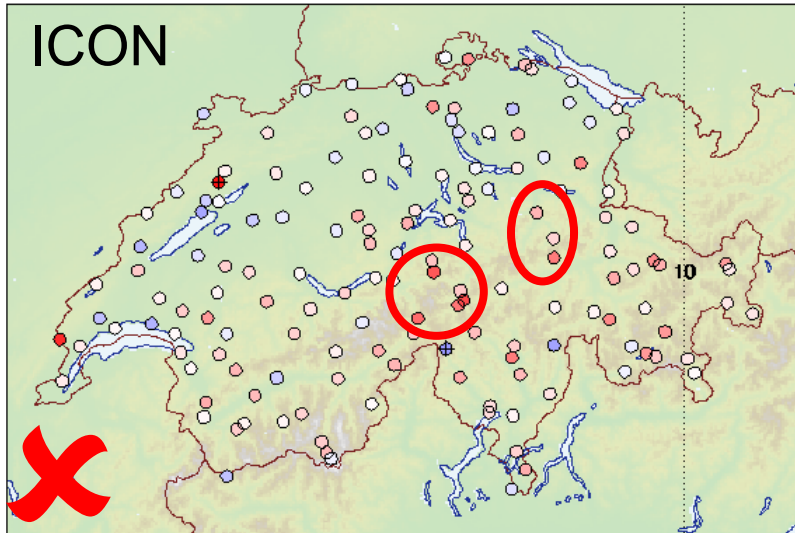
Deterministic Verification **ICON-CH1** versus **COSMO-1E** Control

Parameter	STDE				ME			
	ch		ch-sp		ch		ch-sp	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
ATHD_S	-10 %	-12 %	-13 %	-14 %	+33 %	+30 %	+28 %	+27 %
GLOB	-5 %	-4 %	-5 %	-5 %	+13 %	+14 %	+12 %	+10 %
DURSUN1	+11 %	+9 %	+3 %	+0 %	+24 %	+21 %	+16 %	+13 %
T_2M	-12 %	-13 %	-8 %	-11 %	-8 %	-1 %	-1 %	-10 %
TD_2M	-5 %	-7 %	-7 %	-11 %	+6 %	+9 %	-0 %	+3 %
RELHUM_2M	-7 %	-10 %	-7 %	-10 %	+9 %	+9 %	-4 %	-4 %
FF_10M	-2 %	-4 %	-8 %	-10 %	+18 %	+17 %	-21 %	-25 %
DD_10M	-6 %	-8 %	-6 %	-8 %	+1 %	+1 %	+0 %	+1 %
PS	+8 %	-3 %	-11 %	-18 %	+18 %	+8 %	+3 %	-9 %
PMSL	-7 %	-17 %	-8 %	-17 %	-8 %	-2 %	+2 %	-13 %

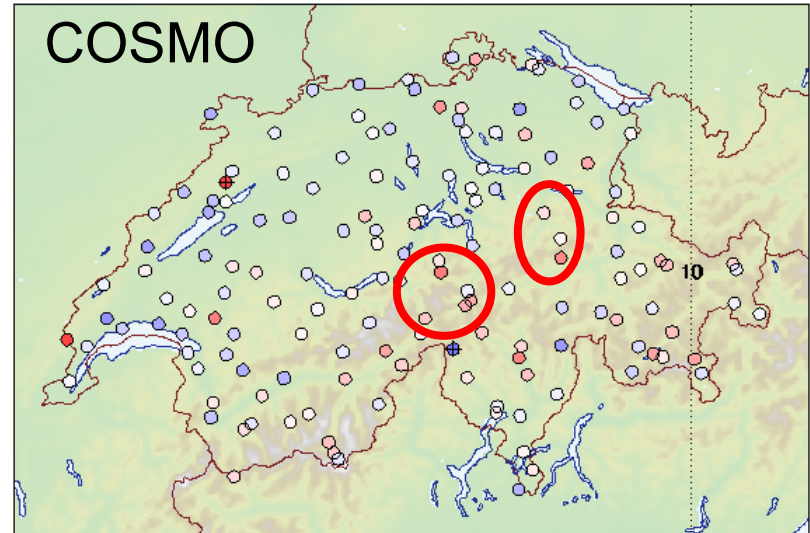


Wind Speed

ICON underestimates wind speeds in complex terrain (mountain tops, narrow valleys) more than COSMO



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ICON-CH1 versus COSMO-1E Control

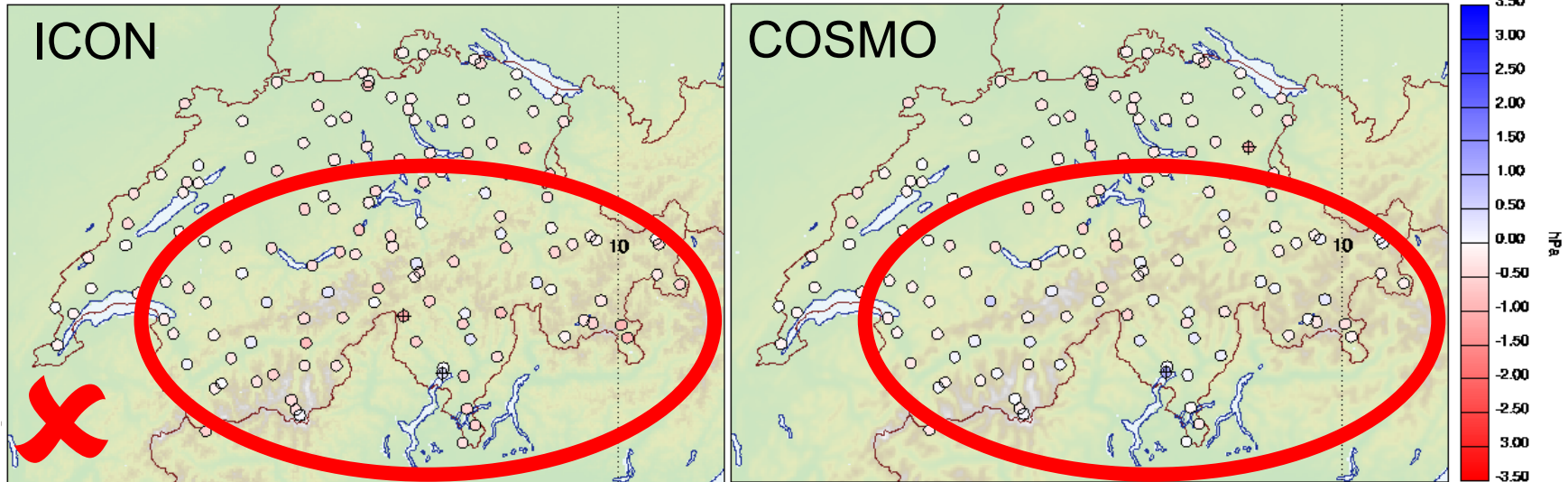
Deterministic Verification **ICON-CH1** versus **COSMO-1E** Control

Parameter	STDE				ME			
	ch		ch-sp		ch		ch-sp	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
ATHD_S	-10 %	-12 %	-13 %	-14 %	+33 %	+30 %	+28 %	+27 %
GLOB	-5 %	-4 %	-5 %	-5 %	+13 %	+14 %	+12 %	+10 %
DURSUN1	+11 %	+9 %	+3 %	+0 %	+24 %	+21 %	+16 %	+13 %
T_2M	-12 %	-13 %	-8 %	-11 %	-8 %	-1 %	-1 %	-10 %
TD_2M	-5 %	-7 %	-7 %	-11 %	+6 %	+9 %	-0 %	+3 %
RELHUM_2M	-7 %	-10 %	-7 %	-10 %	+9 %	+9 %	-4 %	-4 %
FF_10M	-2 %	-4 %	-8 %	-10 %	+18 %	+17 %	-21 %	-25 %
DD_10M	-6 %	-8 %	-6 %	-8 %	+1 %	+1 %	+0 %	+1 %
PS	+8 %	-3 %	-11 %	-18 %	+18 %	+8 %	+3 %	-9 %
PMSL	-7 %	-17 %	-8 %	-17 %	-8 %	-2 %	+2 %	-13 %



Station Pressure

ICON tends to underestimate pressure within and south of the Alps



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ICON-CH1 versus COSMO-1E Control

Continuous Verification Summer 2023

Parameter	STDE								ME							
	ch		ch-sp		ch-am		ch-av		ch		ch-sp		ch-am		ch-av	
	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24	01-12	13-24
ATHD_S	-16 %	-19 %	-23 %	-23 %	-21 %	-21 %	-14 %	-18 %	+18 %	+19 %	+14 %	+18 %	-8 %	-8 %	+32 %	+29 %
GLOB	-6 %	-6 %	-5 %	-5 %	-9 %	-9 %	-5 %	-5 %	+5 %	-1 %	-21 %	-13 %	+1 %	-0 %	+2 %	+4 %
DURSUN1	-0 %	-2 %	-5 %	-6 %	-7 %	-6 %	+6 %	+3 %	+13 %	+11 %	+9 %	+6 %	+5 %	+5 %	+18 %	+17 %
T_2M	-9 %	-11 %	-9 %	-12 %	-20 %	-21 %	-7 %	-7 %	+17 %	+11 %	-6 %	+10 %	-19 %	-16 %	+15 %	+11 %
TD_2M	-6 %	-10 %	-9 %	-13 %	-5 %	-7 %	-7 %	-12 %	+0 %	+3 %	-5 %	+8 %	+21 %	+19 %	+4 %	+5 %
RELHUM_2M	-8 %	-10 %	-10 %	-12 %	-8 %	-11 %	-8 %	-11 %	+7 %	+6 %	+11 %	+13 %	+9 %	+8 %	+8 %	+6 %
FF_10M	-5 %	-6 %	-10 %	-11 %	-0 %	-3 %	-8 %	-9 %	+10 %	+8 %	-20 %	-22 %	+28 %	+30 %	+10 %	+9 %
DD_10M	-6 %	-7 %	-9 %	-8 %	-7 %	-7 %	-2 %	-5 %	+0 %	+0 %	-1 %	-1 %	+5 %	+5 %	-3 %	-2 %
PS	-10 %	-13 %	-27 %	-29 %	+24 %	+19 %	-4 %	-6 %	+24 %	+13 %	+16 %	-1 %	+22 %	+18 %	+31 %	+21 %
PMSL	-4 %	-6 %	-4 %	-8 %	n.a.	n.a.	-5 %	-5 %	-22 %	-9 %	-16 %	-0 %	n.a.	n.a.	-29 %	-20 %

... but
some
stronger
biases
(ME) do
occur

STDE indicates better spatial and
temporal structure in ICON ...

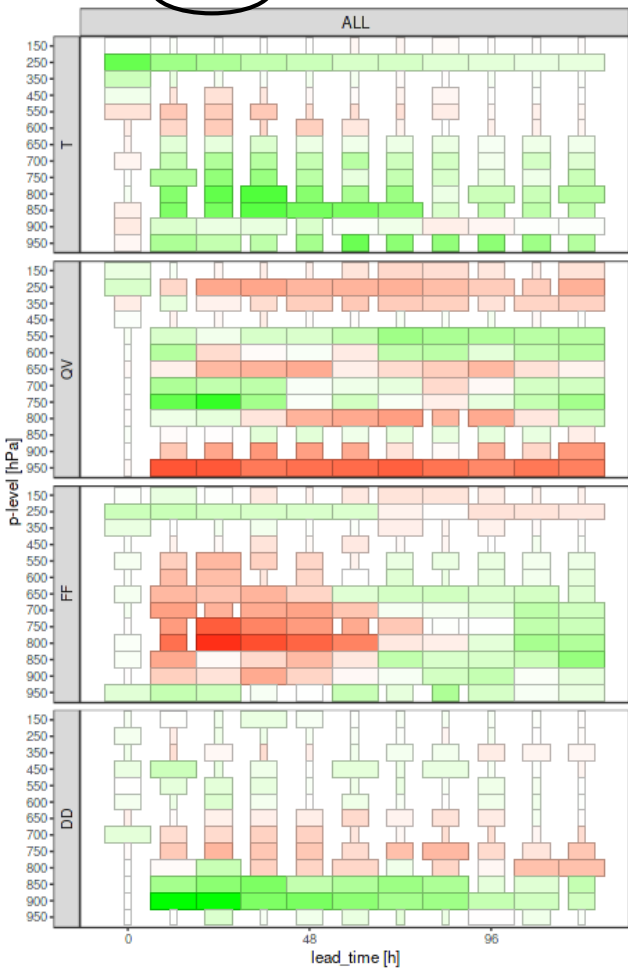
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 Reduction of ME normalized by reference SD

TEMP Verification

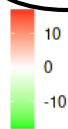
Spring 2023

Left panels:

- **Mean error** (Bias) of ICON-CH2 **partially larger** than bias of COSMO-2E CTRL

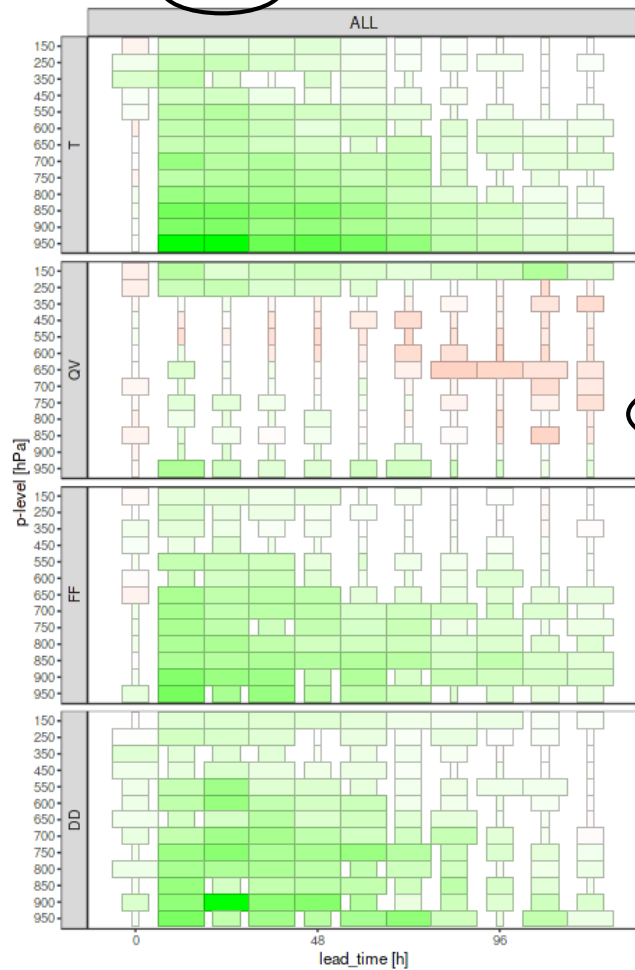


I-2E CTRL vs
C-2E CTRL



Right panels:

- **SD** (standard deviation of the error) of ICON-CH2 **much smaller** than SD of COSMO-2E CTRL



I-2E CTRL vs
C-2E CTRL





Ranked Probability Skill Score

Probabilistic Verification **Summer 2023**

Parameter	ICON-CH1 EPS	COSMO-1E
TOT_PREC (6h sum)	38%	33%
CLCT	19%	20%
T_2M	62%	61%
TD_2M	43%	39%
FF_10M	4.2%	5.7%
VMAX_10M (6h max)	20%	17%



Summary

- Structure (spatial and temporal) better in ICON than COSMO for all parameters, also for profile verification
- ICON has larger bias for
 - Radiation (long- and shortwave) (only small difference to COSMO)
 - Sunshine duration (due to partitioning: more direct, less diffuse)
→ Improvement ready
 - Wind speed (in complex topography) → Improvement ready
 - Station pressure (Alps and south of Alps)
- Probabilities similar or better in ICON, especially for precipitation
- Overall ICON-CH1/2-EPS generally better than COSMO-1/2E



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