REPRODUCIBILITY OF SCIENTIFIC FINDINGS

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Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

REPRODUCIBILITY OF SCIENTIFIC FINDINGS

Why?

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

- Proposals for Safeguarding **Good Scientific Practice**
  - 'The primary test of a scientific discovery is its reproducibility.'
  - 'Experiments and numerical calculations can only be repeated if all important steps are reproducible. '
  - 'Every publication based on experiments or numerical simulations includes an obligatory chapter on "materials and methods" summing up these records in such a way that the work may be reproduced in another laboratory.'

- **Collaboration** with data from different HPC platforms
- **Store or redo** simulations

THE 3 ENEMIES OF REPRODUCIBILITY

Helmholtz-Zentrum Geesthacht
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COPAT efforts

- Reproducibility of regional climate simulations – machine dependency of results

Daniel Lüthi Mariano Mertens Klaus Keuler Edoardo Bucchignani
Susanne Brienen Hendrik Wouters Beate Geyer Andrew Ferrone

- Reproducibility of regional climate simulations – internal variability

Daniel Lüthi

- Reproducibility of scientific findings due to 'changing truth': eObs data through the ages 2013-2017

ENEMY 1 - MACHINE DEPENDENCY

Set up

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- Simulation period 1981-2000
- Equal forcing, namelists and model version at 8 computer systems (DKRZ: blizzard & mistral)

  ERAint, namelist CON502, model version cosmo_131108_5.00_clm2

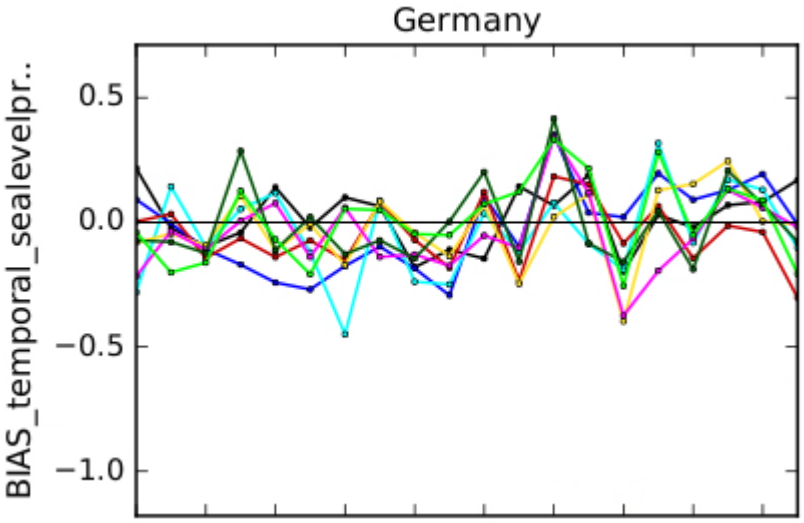
or

- Equal forcing, namelists and model version at one computer systems, but different compilers

ENEMY 1 - MACHINE DEPENDENCY

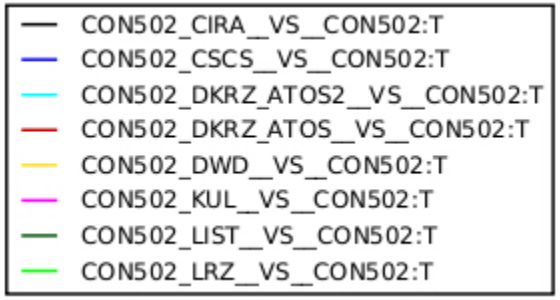
PMSL yearly mean differences to CON502 for 1981-2000

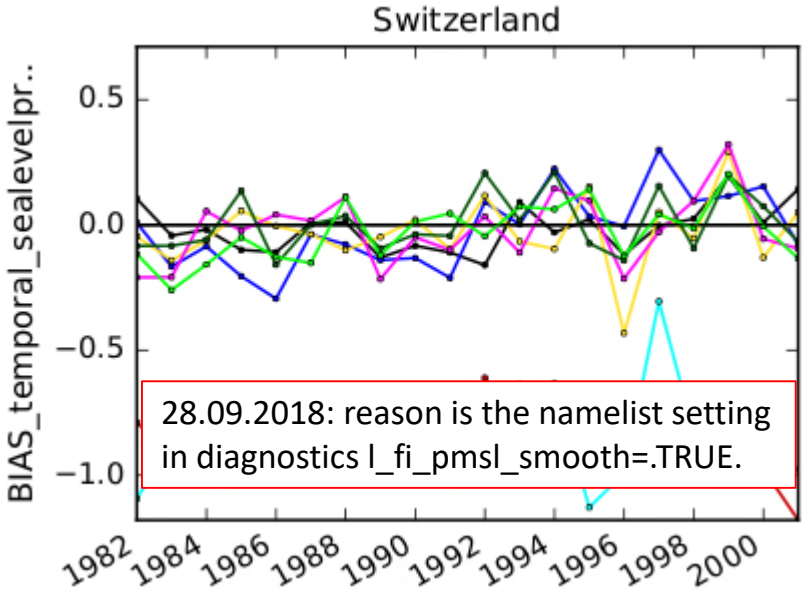
Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research



most countries look like Germany

CON502 at blizzard (DKRZ) as reference





Spain and Austria look like Switzerland

28.09.2018: reason is the namelist setting in diagnostics l_fi_pmsl_smooth=.TRUE.

Range: ±0.3 hPa + strange mistral-values
Max. of 20-year-mean differences: -0.05-0.03hPa

ENEMY 1 - MACHINE DEPENDENCY

PMSL mean differences to CON502 for 1981-2000

Helmholtz-Zentrum Geesthacht
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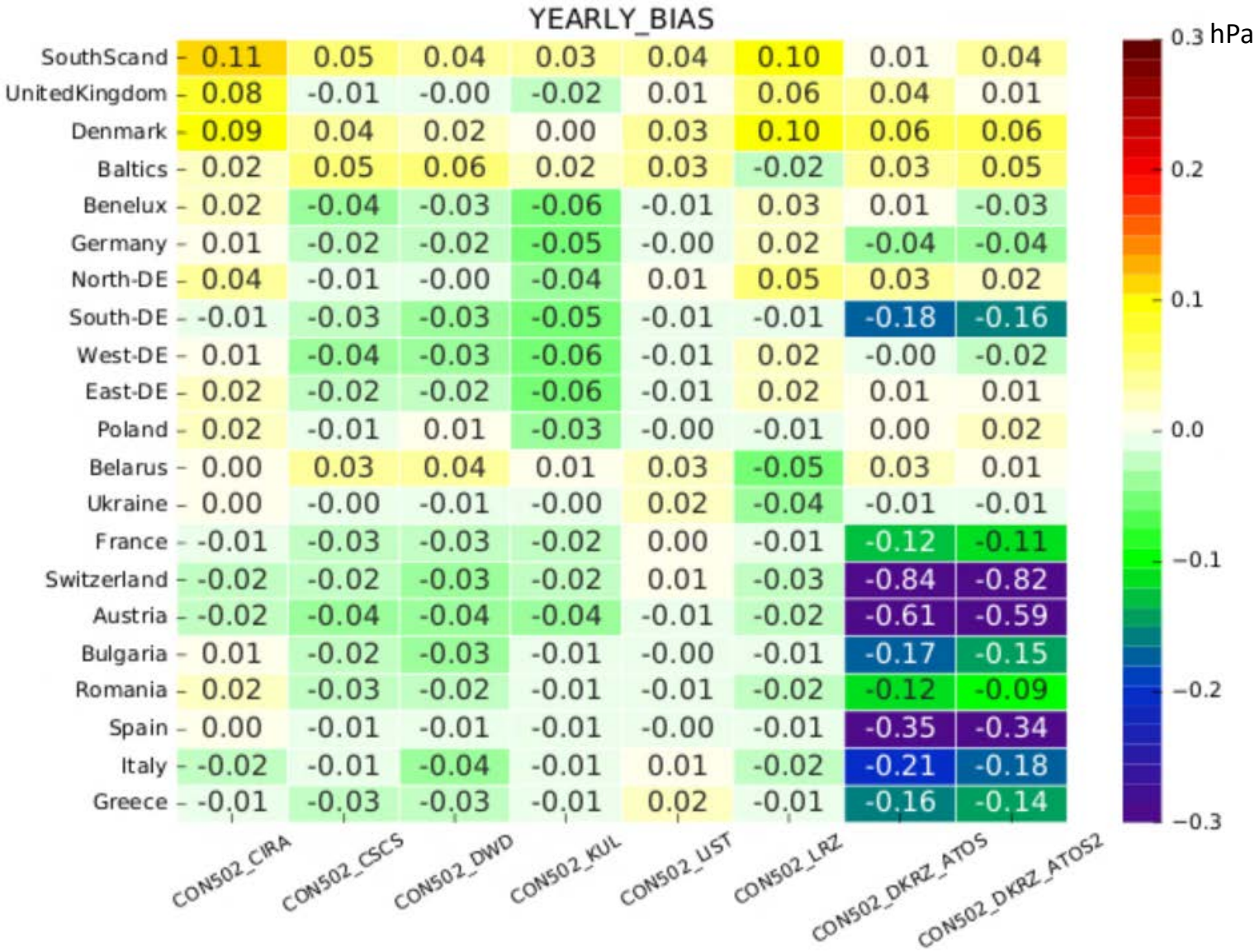
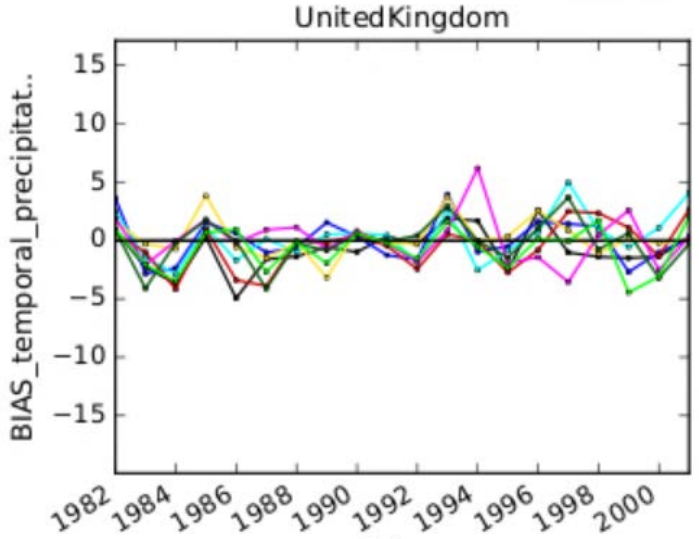
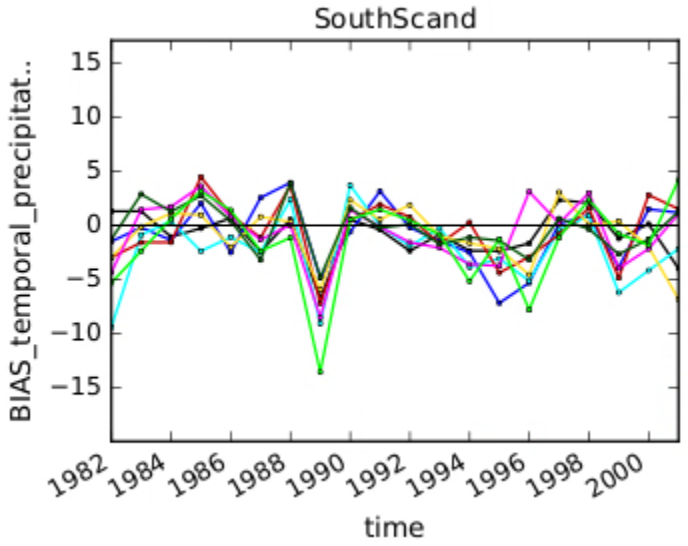


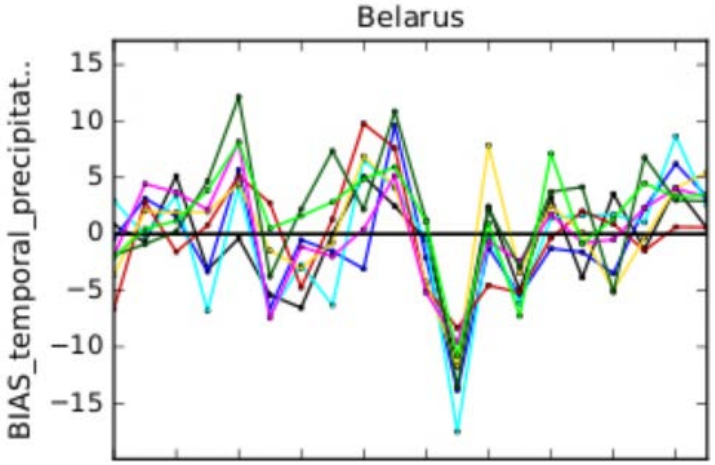
ENEMY 1 - MACHINE DEPENDENCY

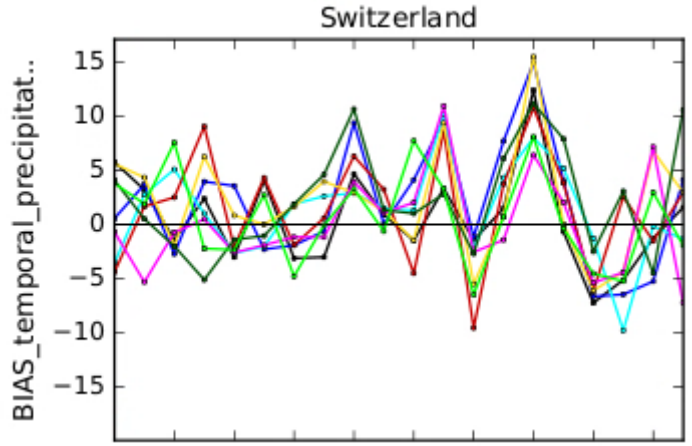
TOT_PREC yearly mean differences to CON502 of monthly sums

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research









- Range: W: ±5mm/month
- Range: E: ±10 mm/month

❖ Max. of 20-year-mean differences: -2.7-2.3 mm/month

ENEMY 1 - MACHINE DEPENDENCY

T_2M yearly mean differences to CON502

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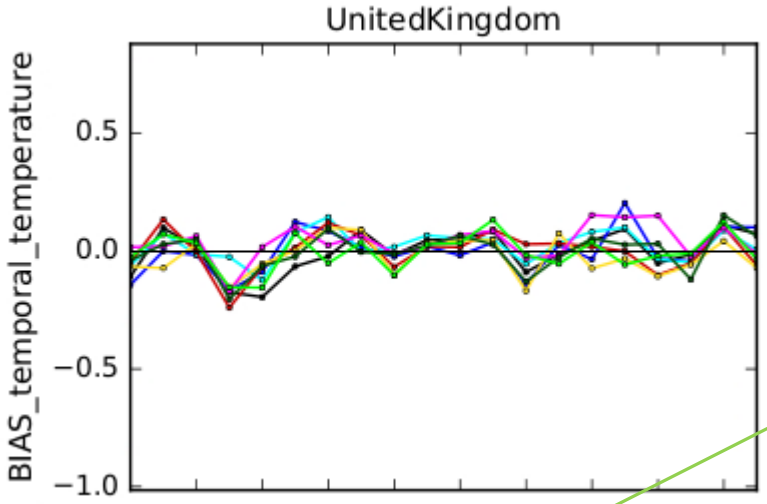
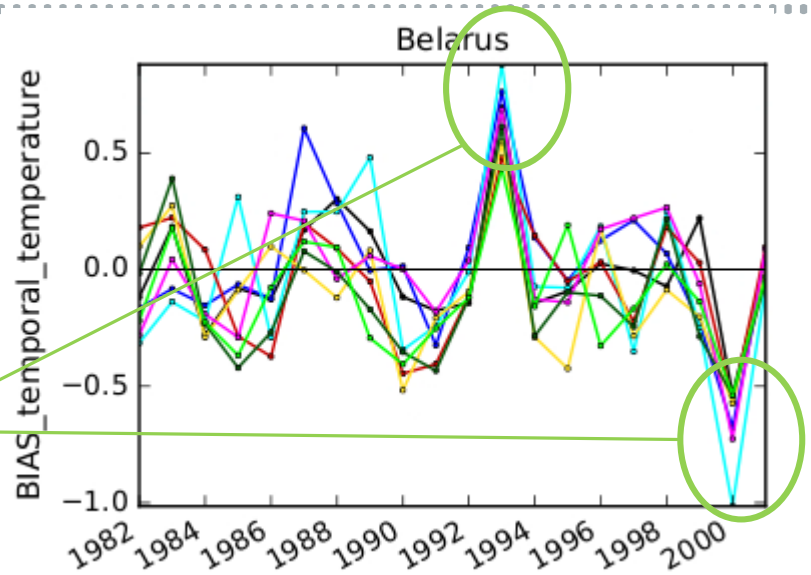


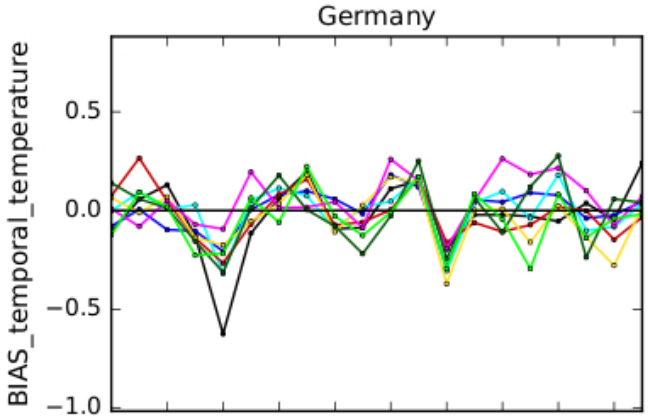


- E: UK, Ital., France, Spain with ±0.2K
- W: Belarus ±0.5K
- ❖ Max. of 20-year-mean differences: -0.12K – 0.7K

All simulations differ in the same direction from CON502 (by chance blizzard-simulation)

A measure for uncertainty (e.g. 2σ; in this talk inspection bye eye) would be dependent on the choice of the reference

Solutions??



ENEMY 1 - MACHINE DEPENDENCY

CLCT yearly mean differences to CON502

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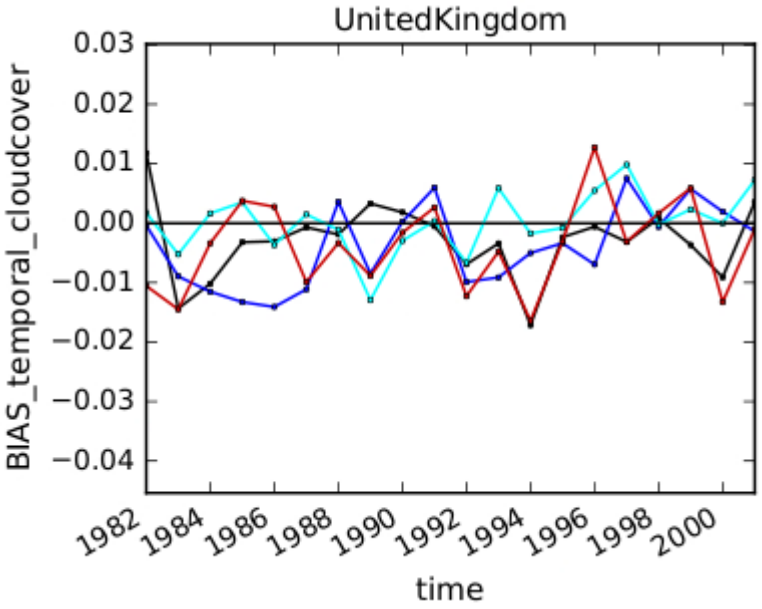
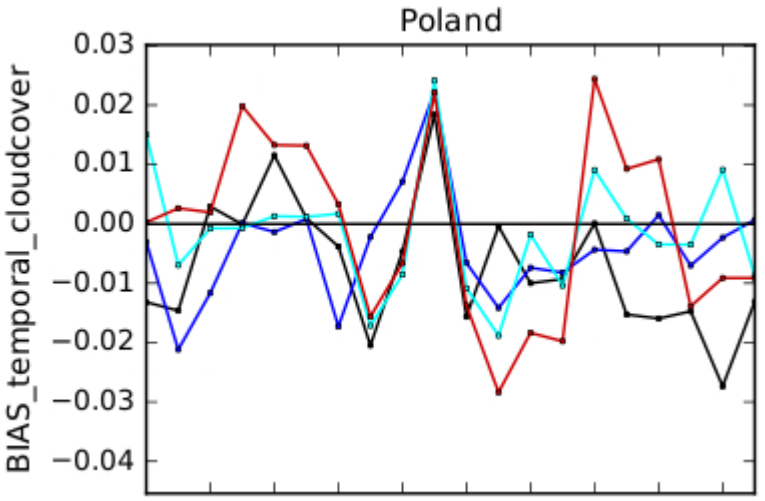
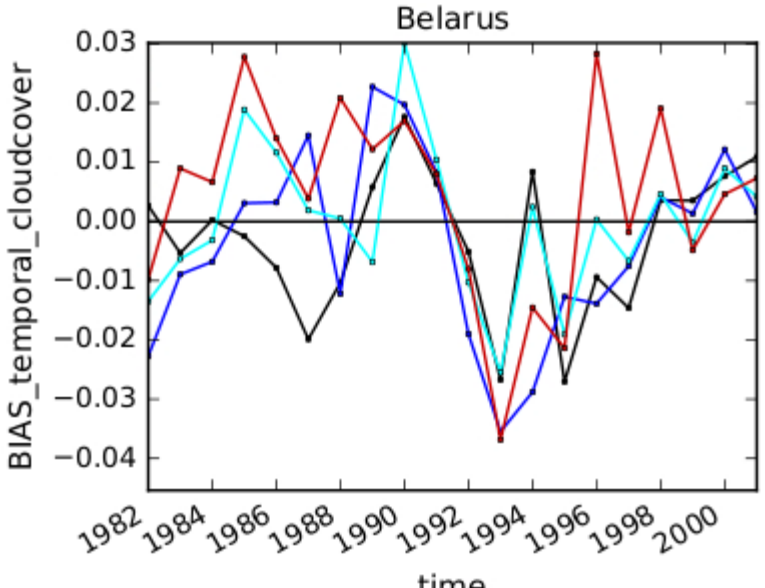
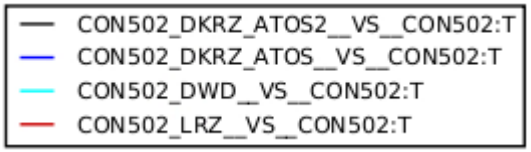






- UK, France, Spain: ±1%
- Poland, Ukraine, Baltics: ±2%

❖ Max. of 20-year-mean differences: -1%



SUMMARY-TABLE

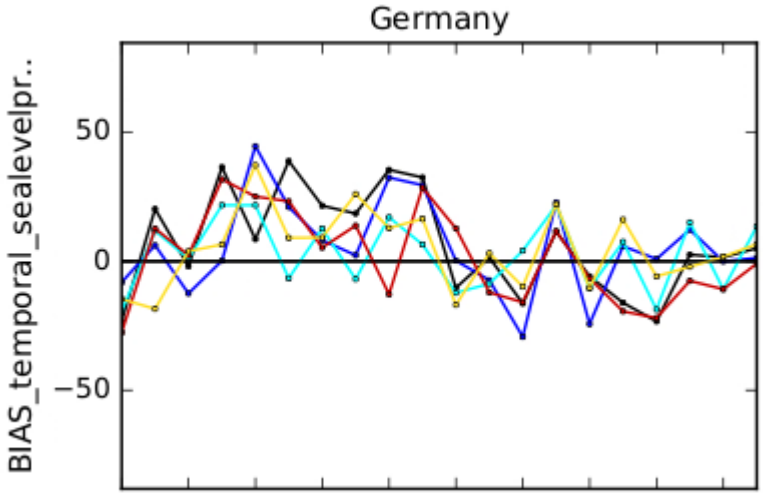
Helmholtz-Zentrum Geesthacht

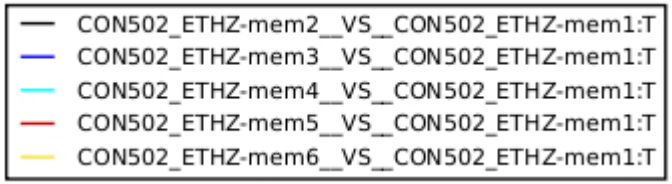
Element	Range / max. 20yearØ Machine dependency	Range / max. 20yearØ Internal variability	Range / max. 20yearØ Changing Observations
PMSL	● ±0.3 hPa ● Switzerland, Austria, Spain: 2 outlying simulations (-0.5—1.0hPa) ❖ -0.05—0.03hPa		
TOT_PREC	● West: ±5mm/month ● East: ±10mm/month ❖ -2.7-2.3 mm/month		
T_2M	● West:±0.2K ● East: ±0.5K ❖ W: 0.04K; E: -0.12K		
TMIN_2M	● As T_2M		
TMAX_2M	● As T_2M		
CLCT	● W: ±1% ● E: ±2%-±3% ❖ -1%		

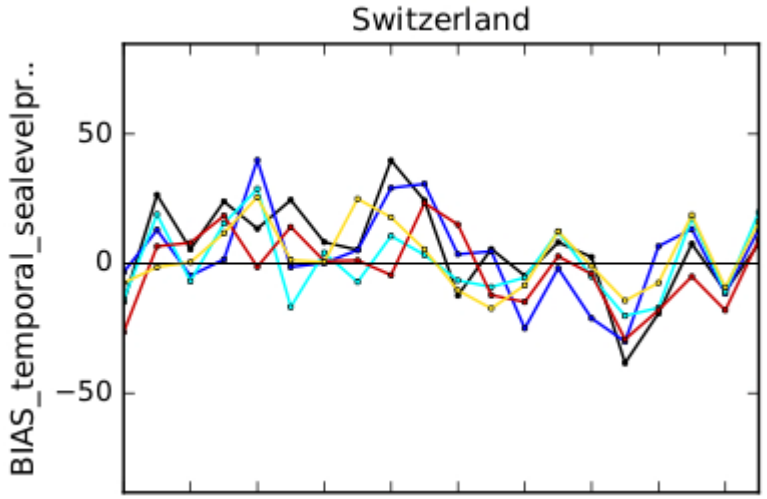
ENEMY 2 – INTERNAL VARIABILITY

PMSL [Pa] yearly mean differences to ETHZ member 1 for 1981-2000

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research







- Range: ±0.4hPa
- Max. of 20-year-mean differences: -0.04-0.11hPa

ENEMY 2 – INTERNAL VARIABILITY

TOT_PREC yearly mean differences of monthly sums

Helmholtz-Zentrum Geesthacht
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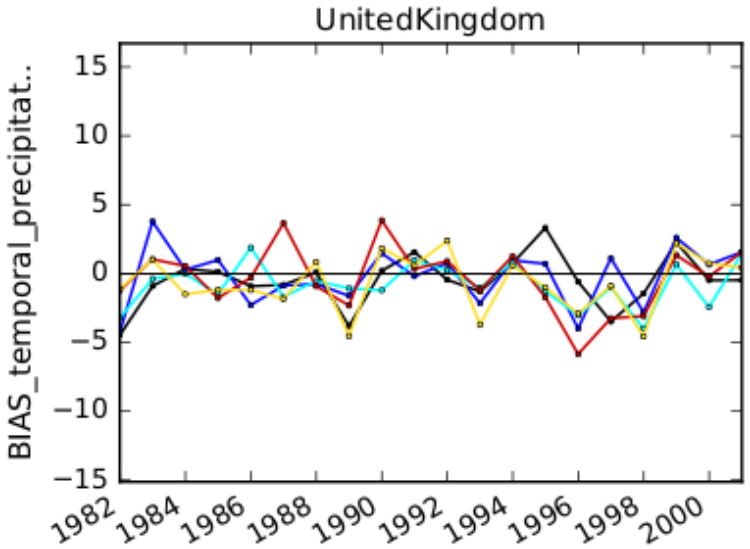

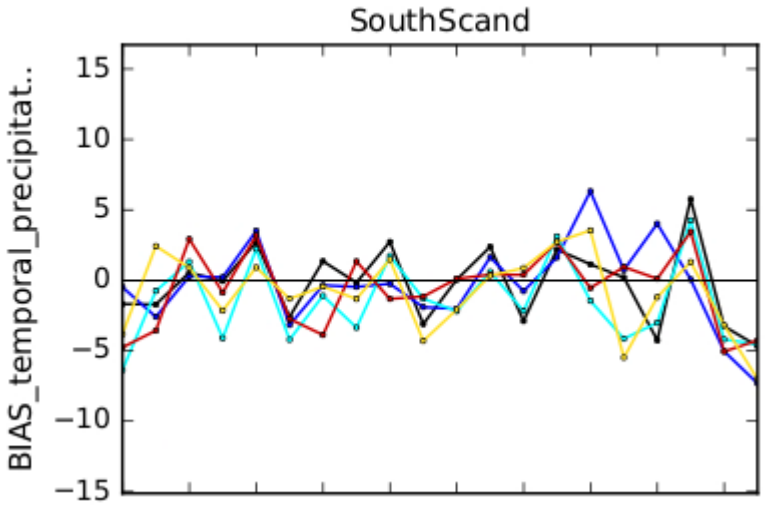

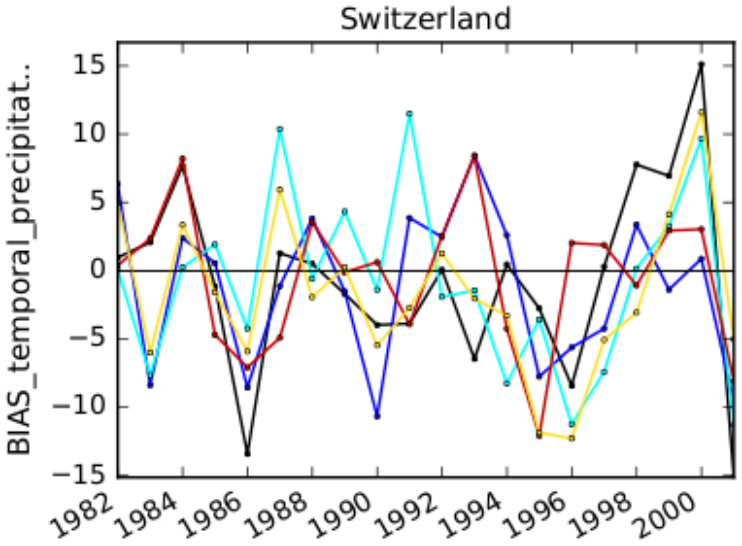

- W: ±5mm/month
- E: ±10mm/month

❖ Max. of 20-year-mean differences:

-2.2 – 1.6 mm/month

ENEMY 1 AND 2

TOT_PREC yearly mean differences of monthly sums

Helmholtz-Zentrum Geesthacht
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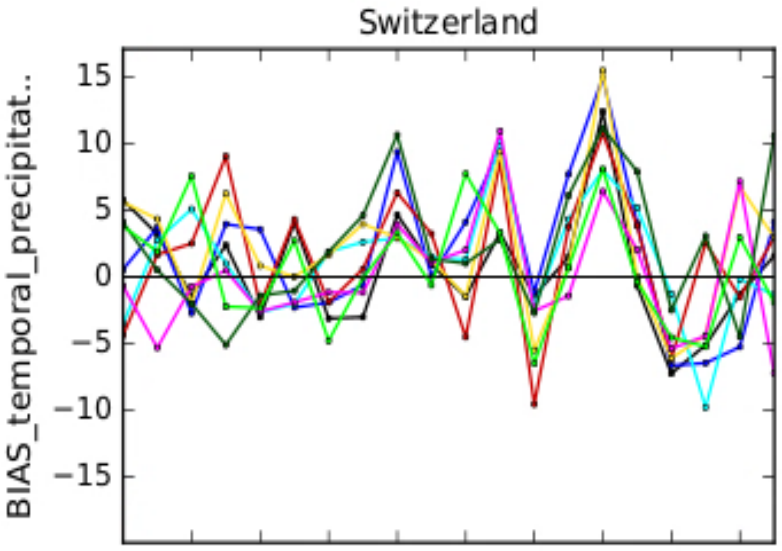
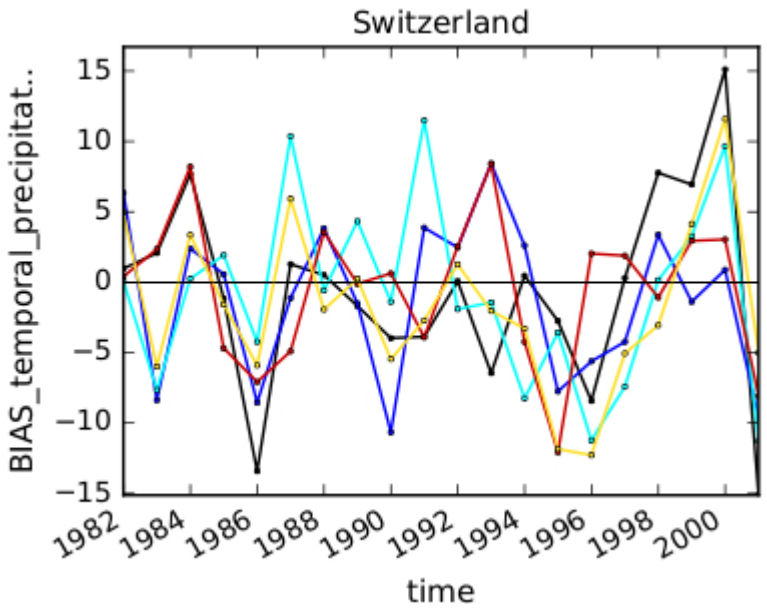
Machine dependency (to **CON502**)



Internal variability (to **ETHZ member 1**)



ENEMY 2 – INTERNAL VARIABILITY

T_2M yearly mean differences to ETHZ member 1 for 1981-2000

Helmholtz-Zentrum Geesthacht
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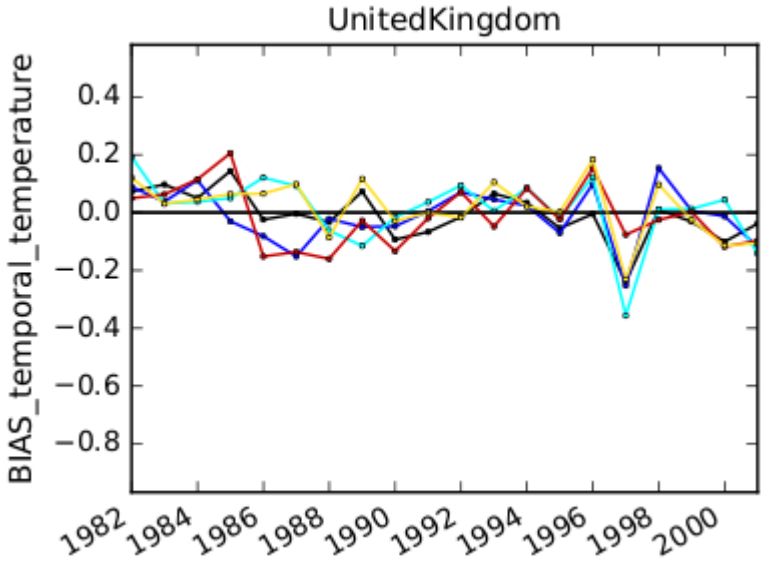

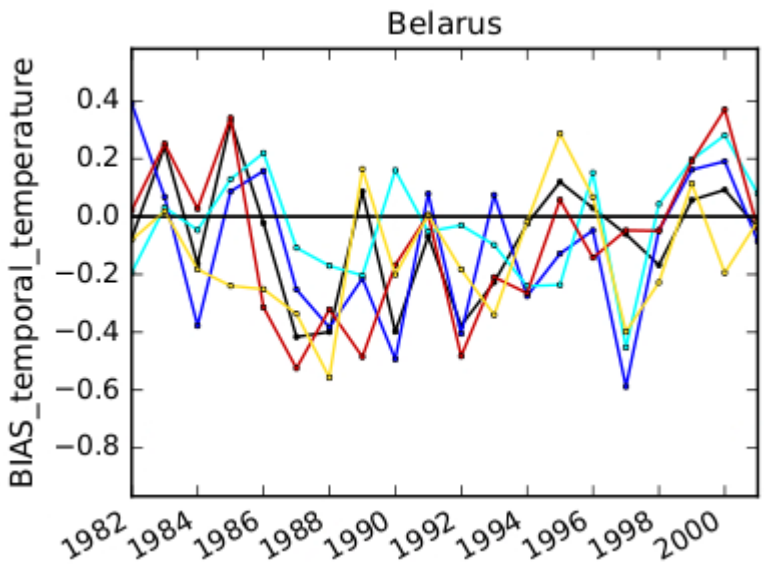

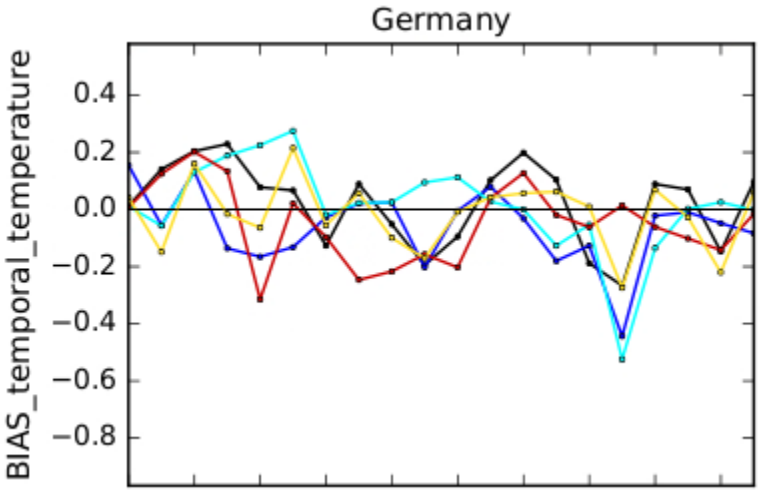

- W: ±0.2K
- E: ±0.4K

❖ Max. of 20-year-mean differences:

-0.15-0.05K

ENEMY 2 – INTERNAL VARIABILTY

T_2M, TMIN_2M, TMAX_2M

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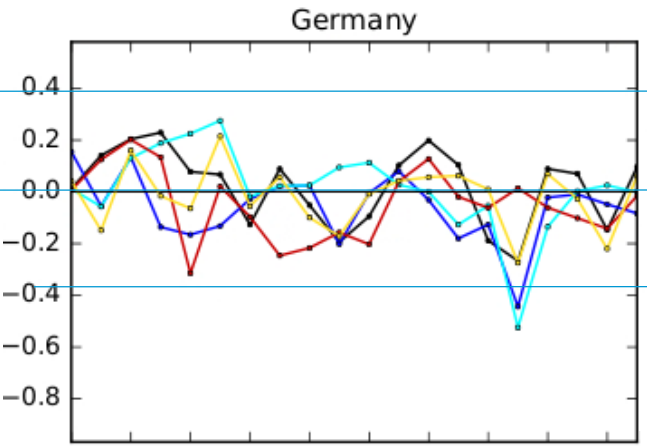
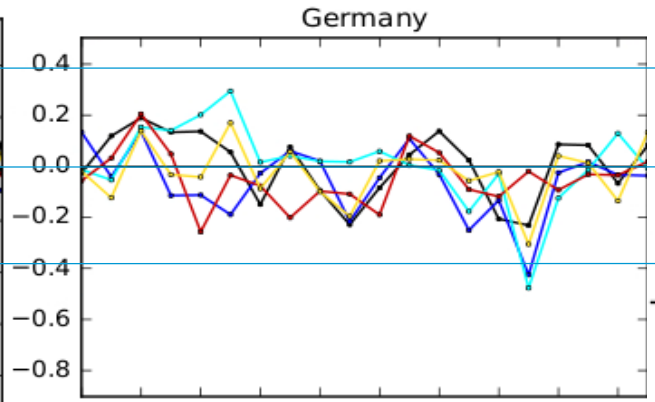
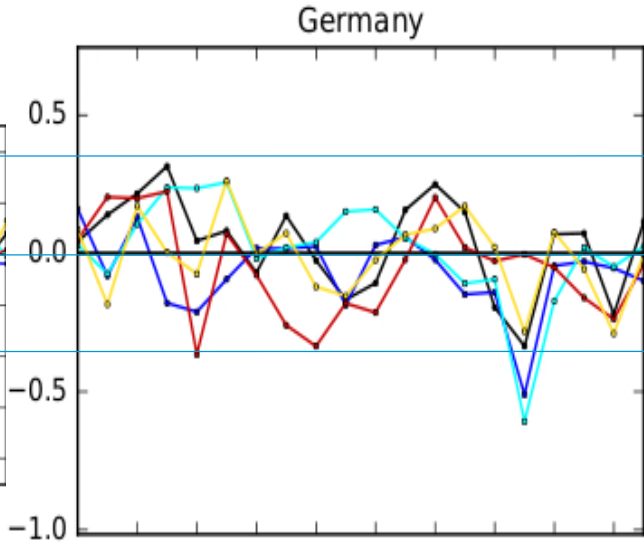
T_2M



TMIN_2M



TMAX_2M



- TMIN_2M range as T_2M
- TMAX_2M a bit higher deviations

ENEMY 2 – INTERNAL VARIABILTY

CLCT yearly mean differences to ETHZ member 1 for 1981-2000

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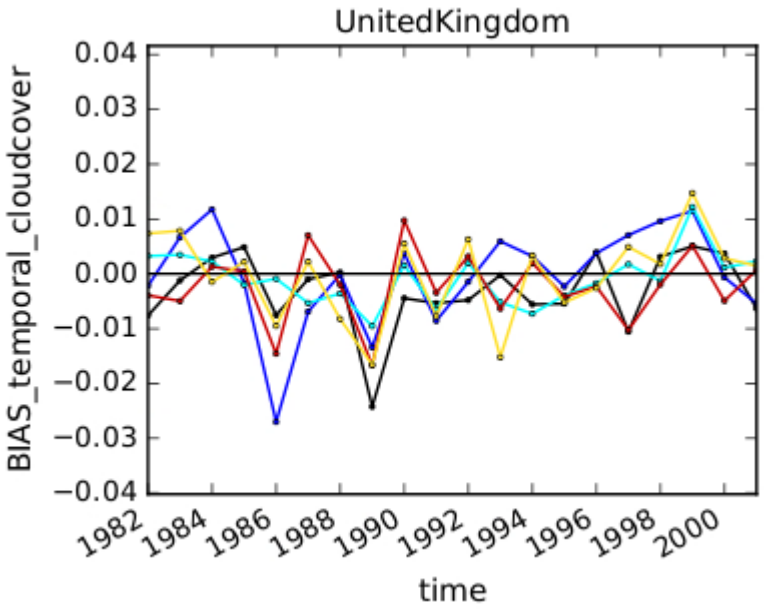

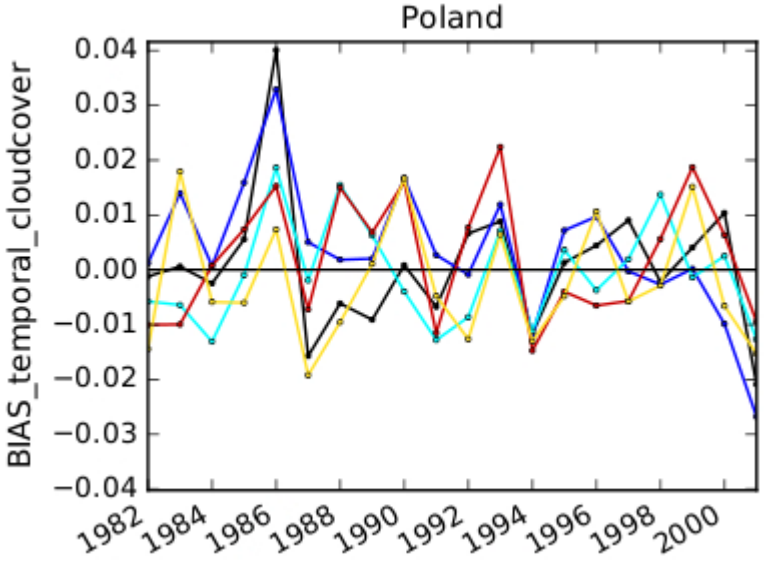

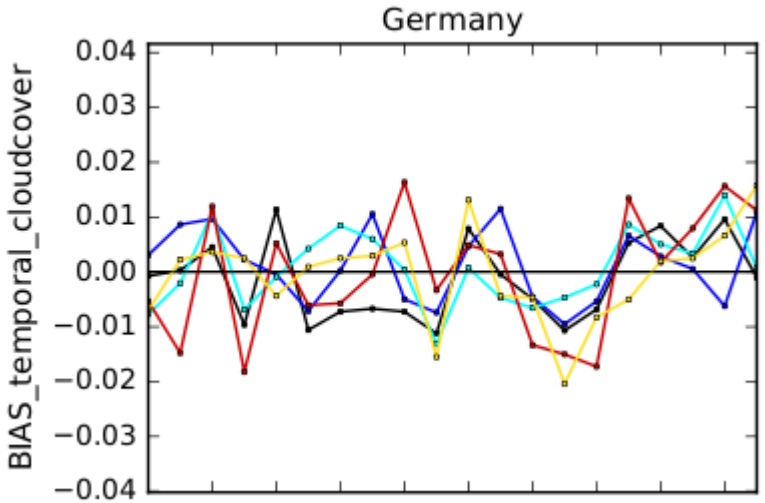

- W: ±1%
- E: ±2%

❖ Max. of 20-year-mean differences: ±1%

SUMMARY-TABLE

Helmholtz-Zentrum Geesthacht

Element	Range / max. 20yearØ Machine dependency	Range / max. 20yearØ Internal variability	Range / max. 20yearØ Changing Observations
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TOT_PREC	● West: ±5mm/month ● East: ±10mm/month ❖ -2.7-2.3 mm/month	● West: ±5mm/month ● East: ±10mm/month ❖ -3.1 —1.6mm/month	
T_2M	● West:±0.2K ● East: ±0.5K ❖ W: 0.04K; E: -0.12K	● W: ±0.1K ● East: -0.5—0.4K ❖ W: 0.02K; E: -0.15K	
TMIN_2M	● As T_2M	● West:±0.2K ● E: as T_2M ❖ -0.12K - 0.01K	
TMAX_2M	● As T_2M	● West:±0.2K ● East: ±0.5K ❖ W: 0.1K; E: -0.17K	
CLCT	● W: ±1% ● E: ±2%-±3% ❖ -1%	● W: ±1% ● E: ±2%-±3% ❖ ±1%	

ENEMY 3 - CHANGING TRUTH

Measurement data example: eObs data set

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- For COPAT version 10.0 was used
- Yearly or half yearly updates: not all changes were improvements
- Changes in data base are mostly at country scale (!)

Version Number	Covered Period
10.0	1950-20**13**-12-31
11.0	1950-20**14**-12-31
12.0	1950-20**15**-06-30
13.1	1950-20**15**-12-31
14.0	1950-20**16**-08-31
15.0	1950-20**16**-12-31
16.0	1950-20**17**-08-31
17.0	1950-20**17**-12-31

ENEMY 3 - CHANGING TRUTH

Example TOT_PREC in 2000 – differences to eObs17.0

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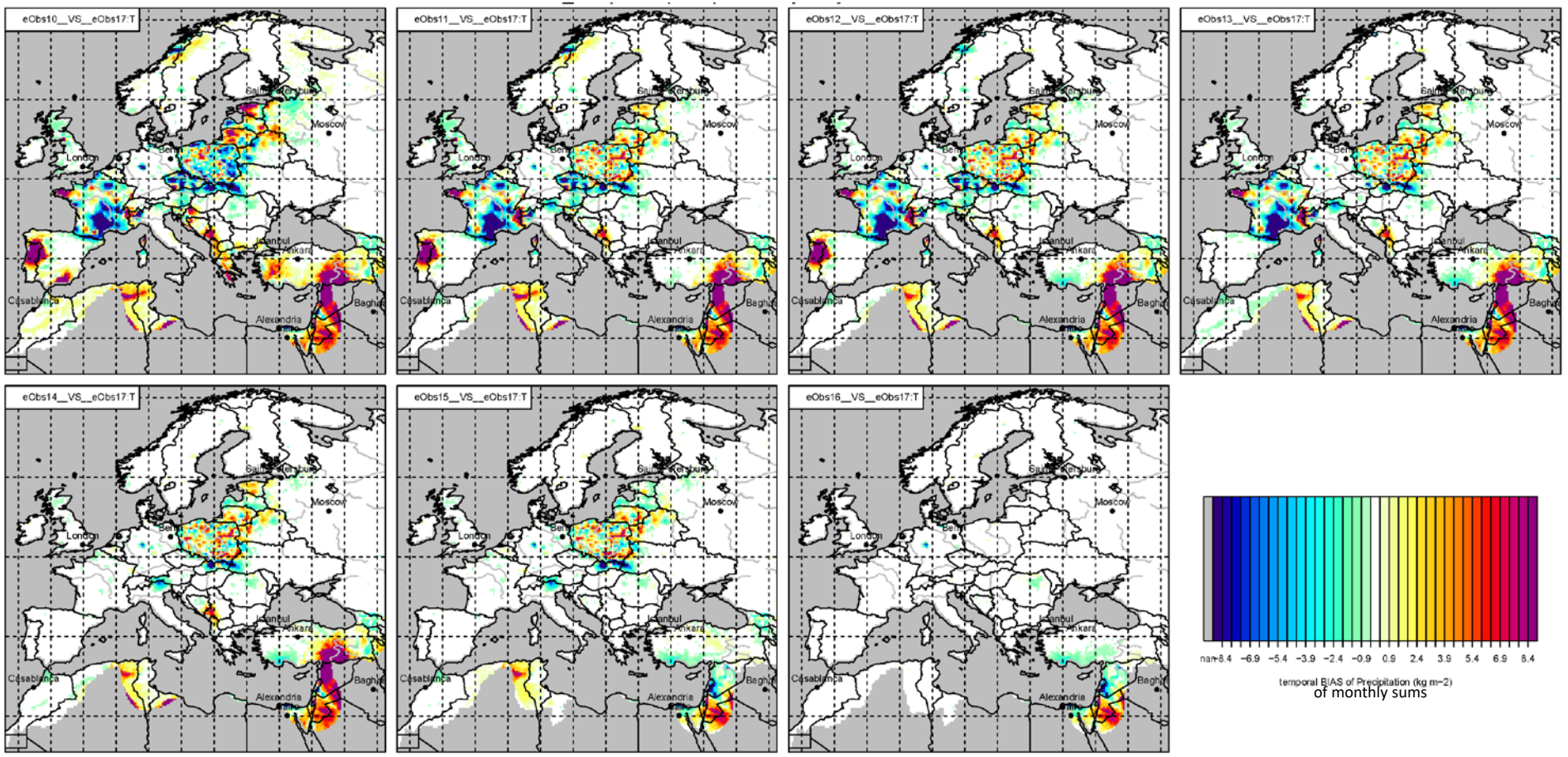

- Differences in certain regions, not always country border restricted

ENEMY 3 - CHANGING TRUTH

Example TOT_PREC differences to eObs 17.0 for 1981 – 2000

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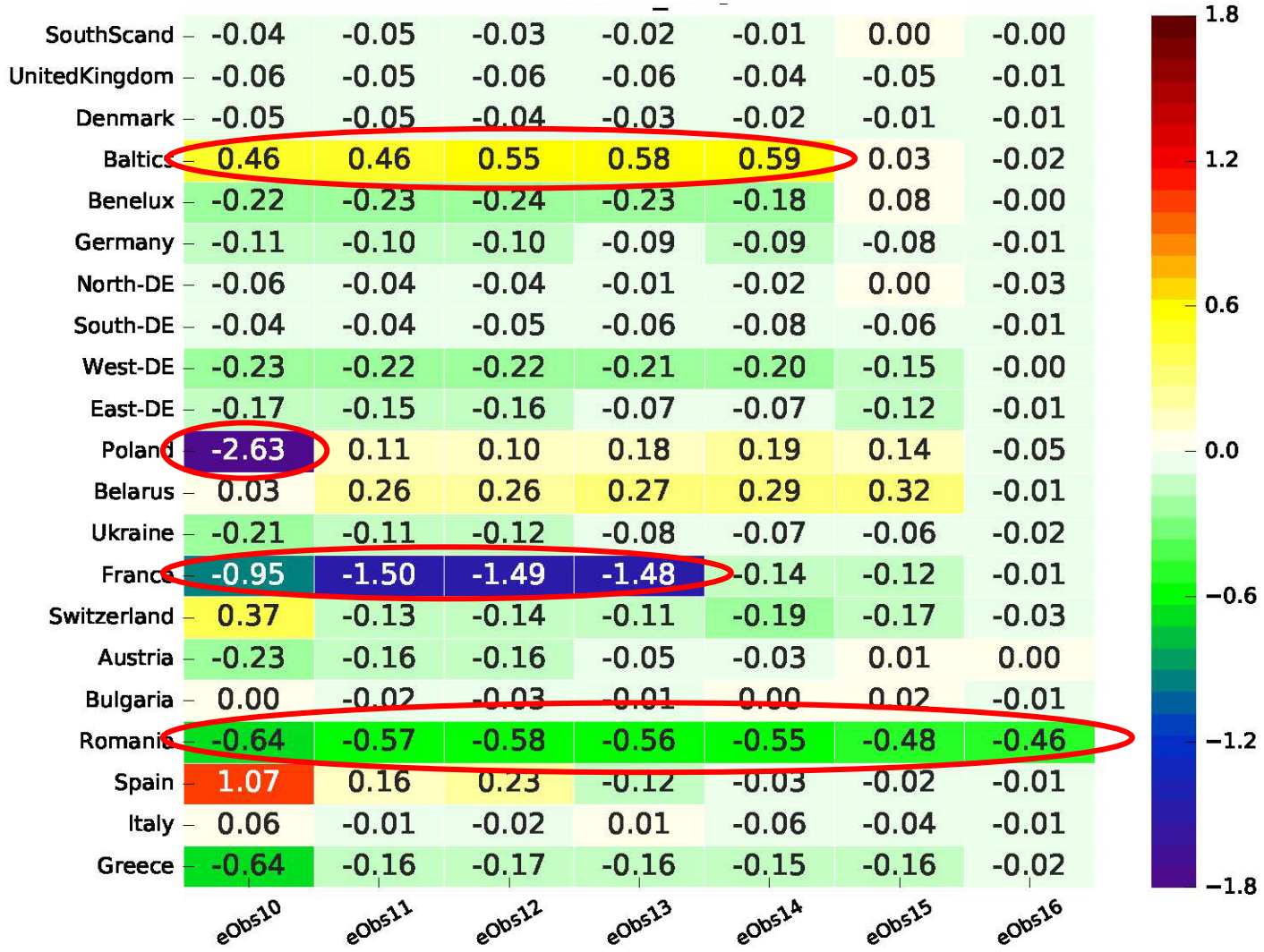
Mean bias of monthly precipitation



ENEMY 3 - CHANGING TRUTH

TOT_PREC country mean differences of monthly sums to eObs17

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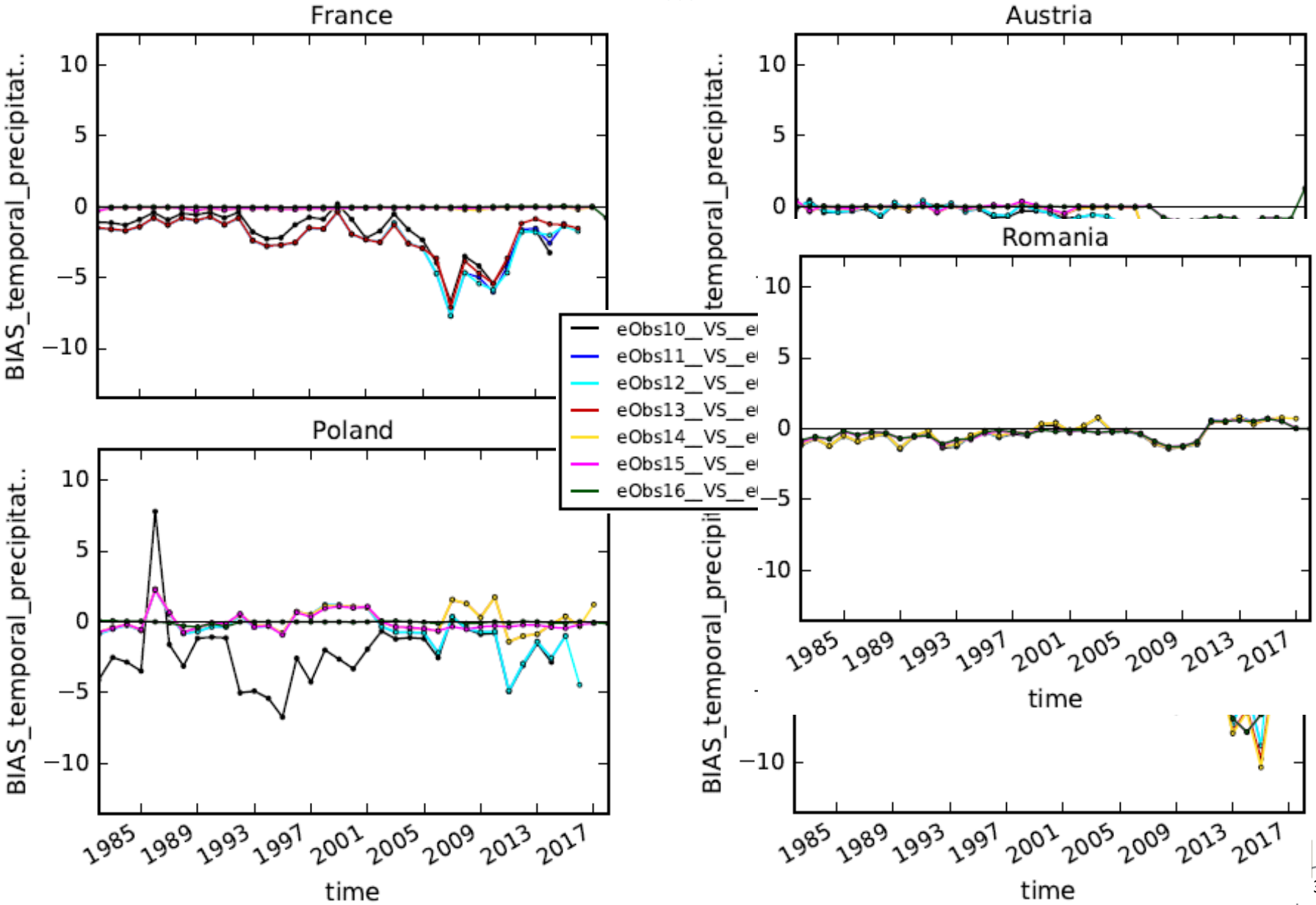

ENEMY 3 - CHANGING TRUTH

Monthly precipitation sums - means for 2012

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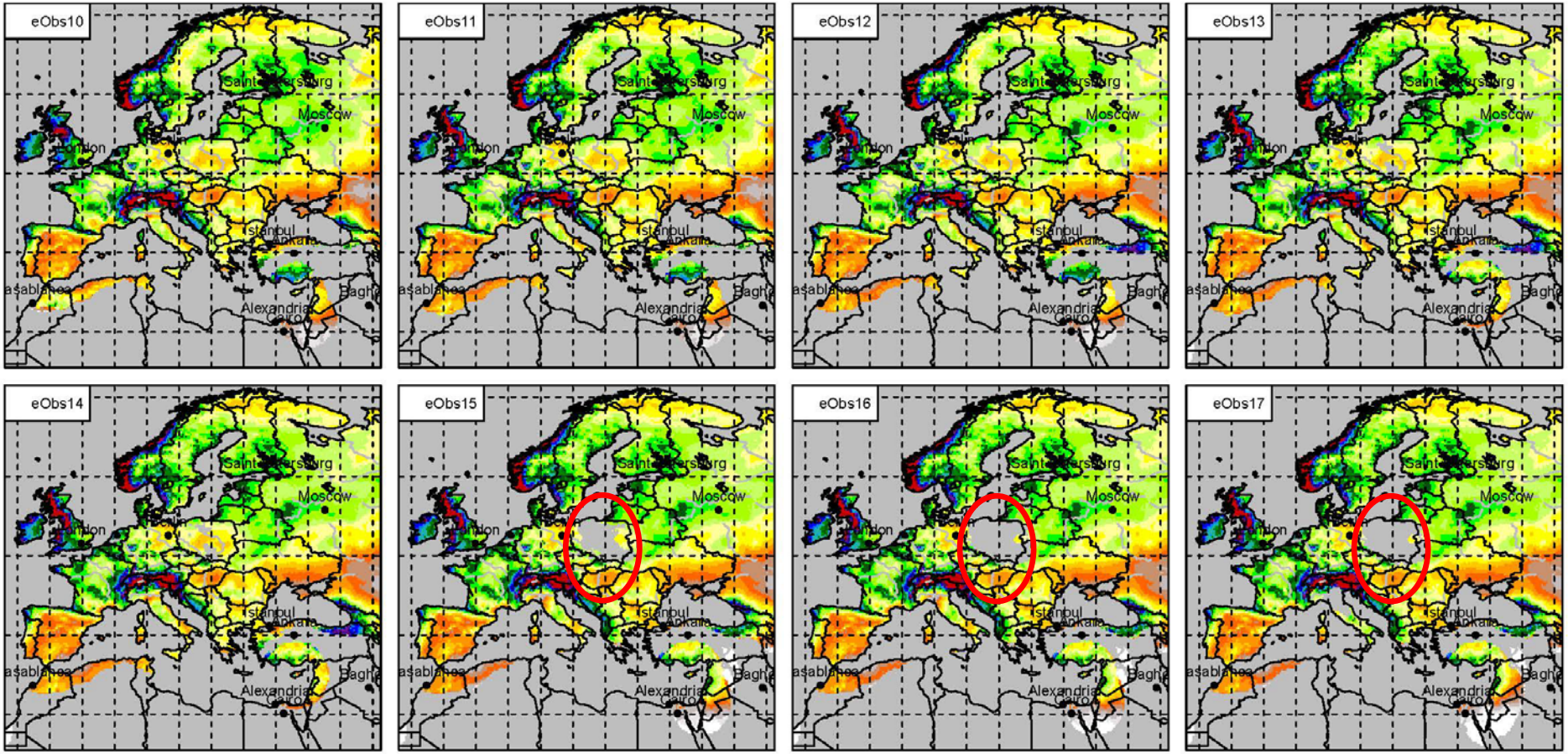
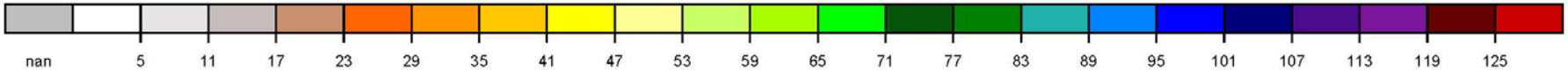


Poland: missing data from eObs 15 onward



ENEMY 3 - CHANGING TRUTH

PMSL yearly mean differences

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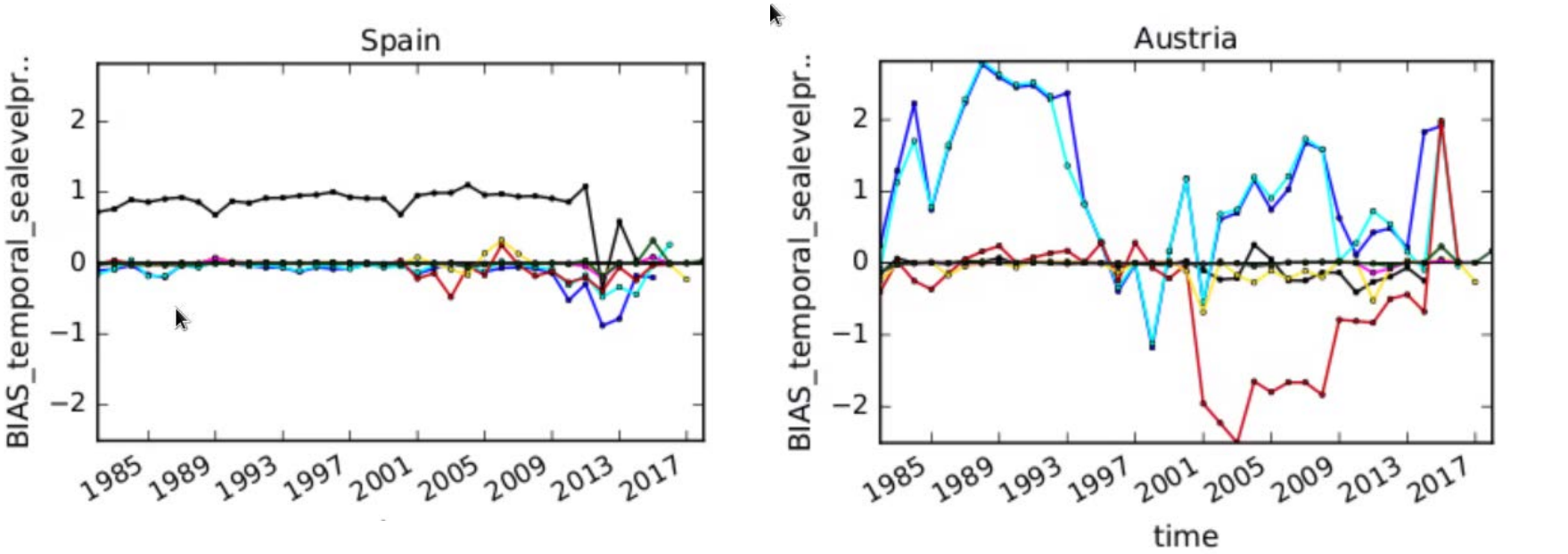
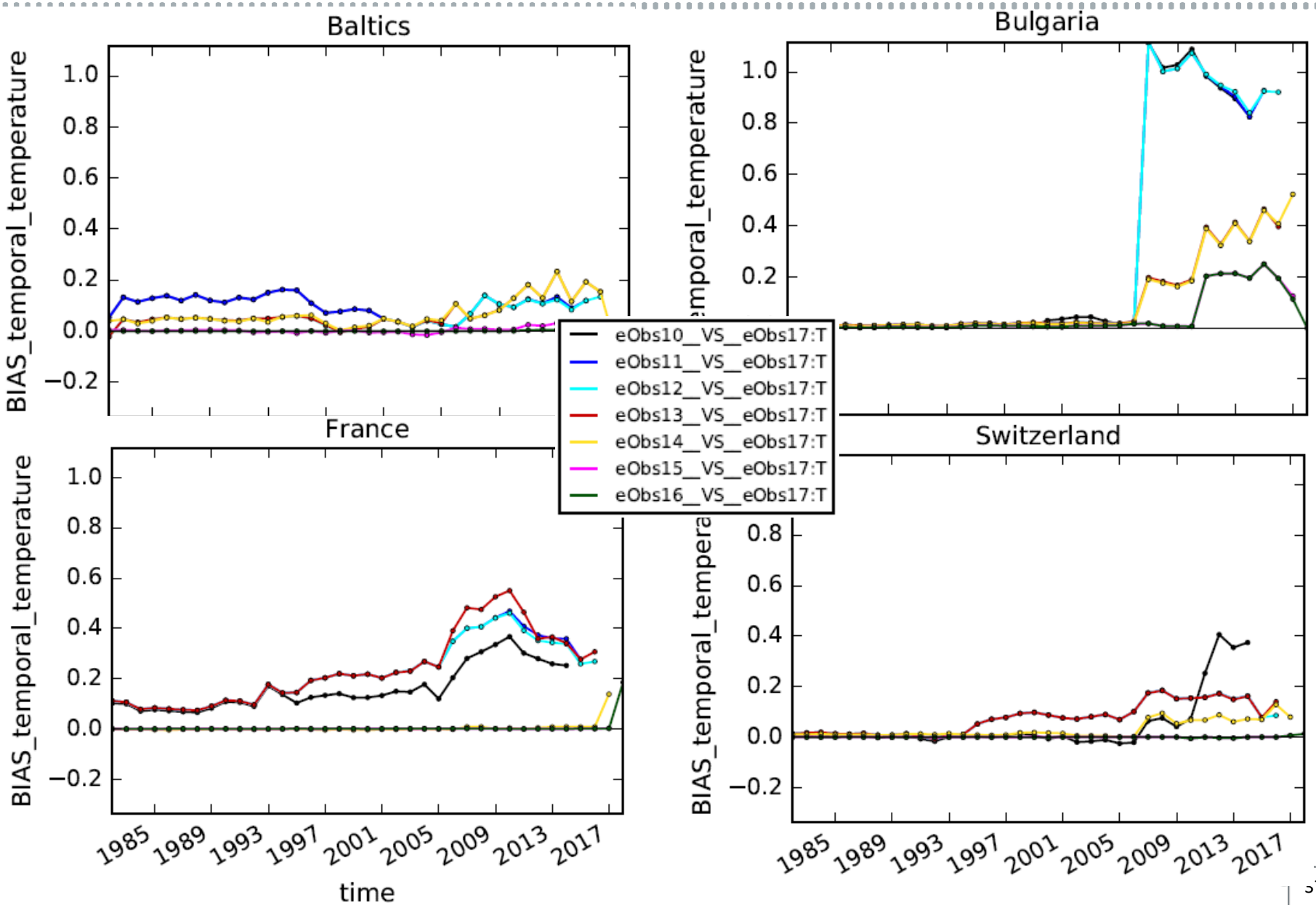


ENEMY 3 - CHANGING TRUTH

T_2M yearly mean differences to eObs17

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research



ENEMY 3 - CHANGING TRUTH

TMAX_2M differences to eObs17.0

Helmholtz-Zentrum Geesthacht
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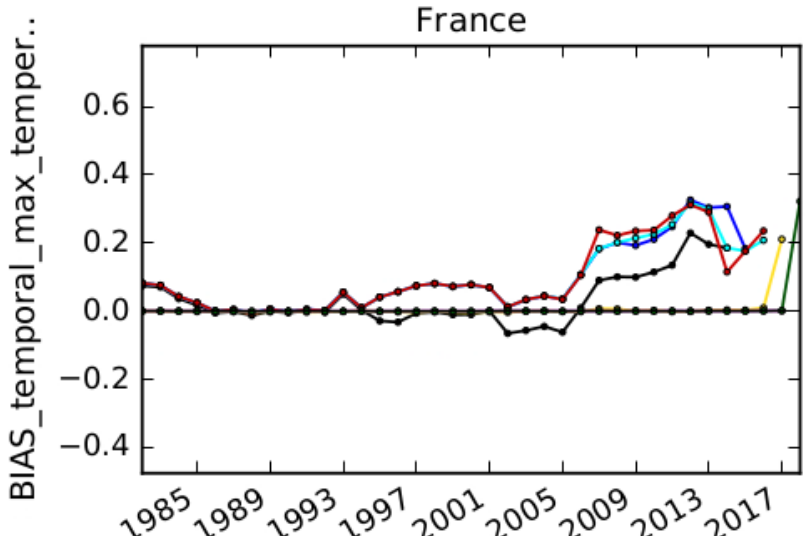

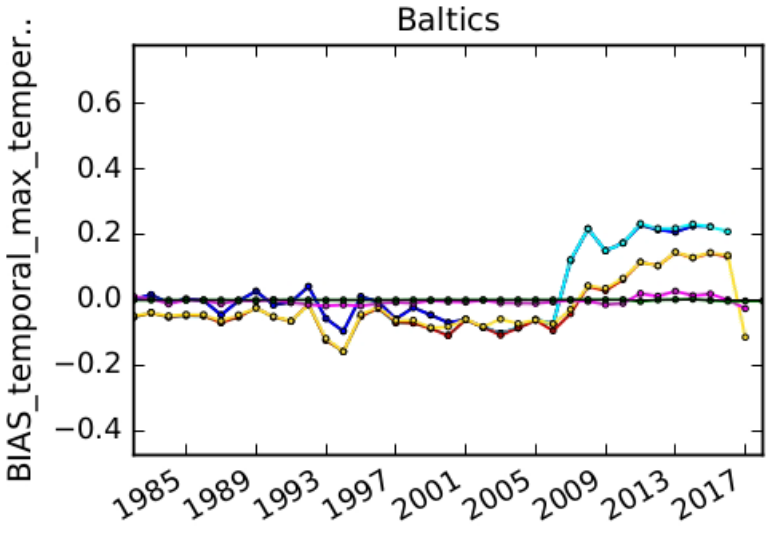

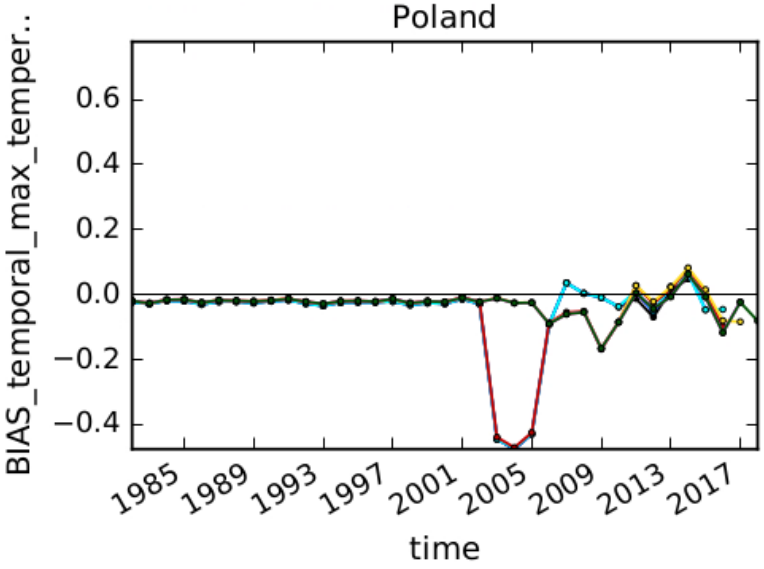

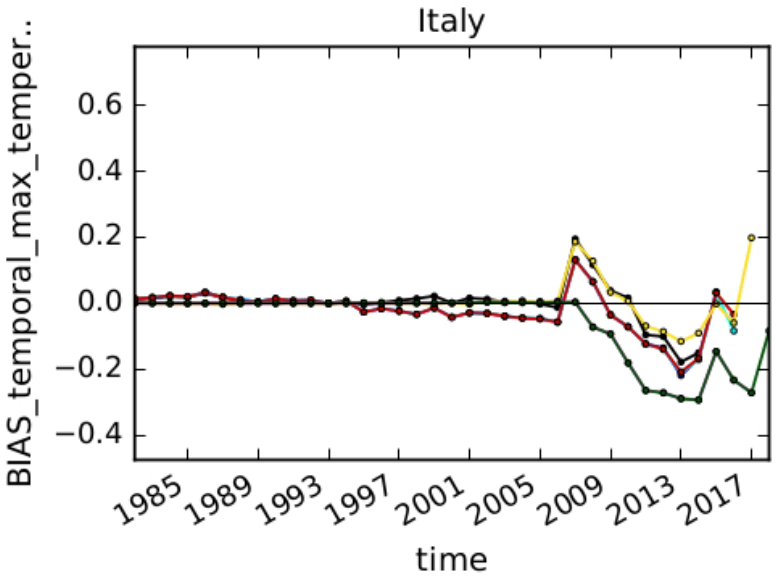

ENEMY 3 - CHANGING TRUTH

TMIN_2M differences to eObs17.0

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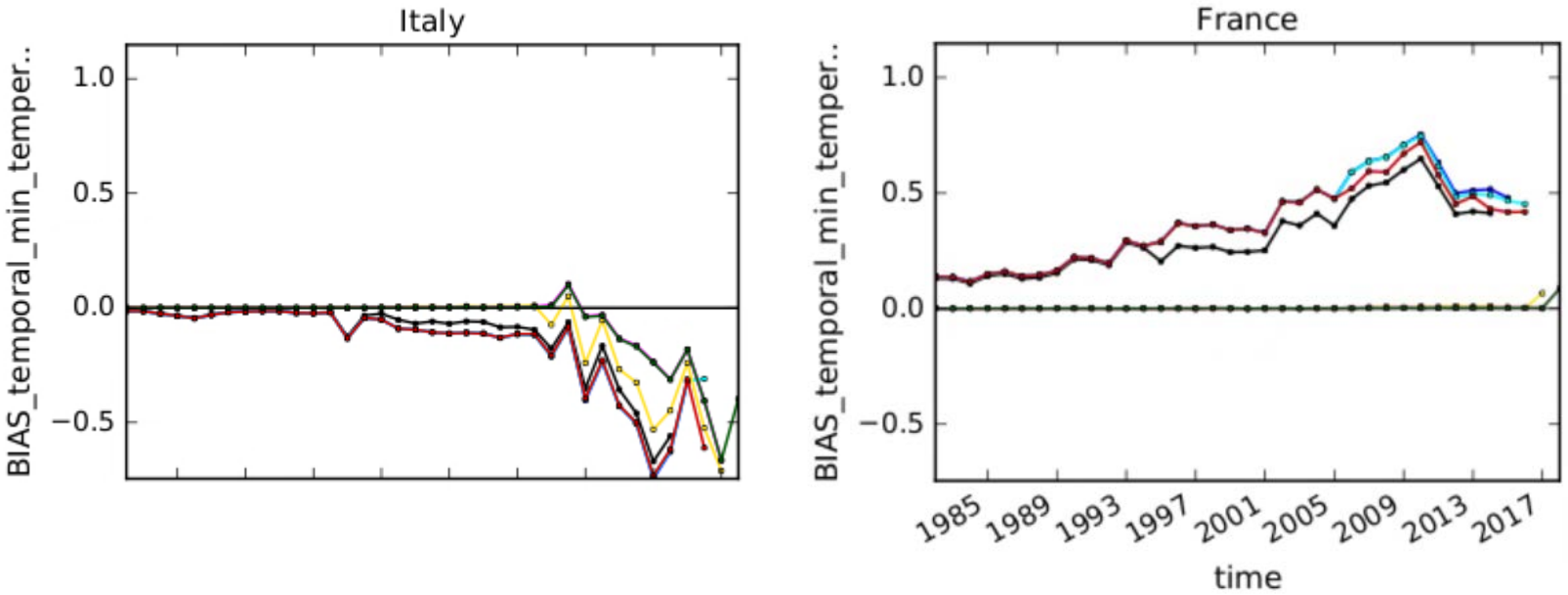

- Similar to T_2M but for Italy stronger pronounced (up to -0.7K compared to -0.3K)

SUMMARY-TABLE

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Element	Range / max. 20yearØ Machine dependency	Range / max. 20yearØ Internal variability	Range / max. 20yearØ Changing Observations
PMSL	● ±0.3 hPa ● Switzerland, Austria, Spain: 2 outlying simulations (-0.5—1.0hPa) ❖ -0.05—0.03hPa	● ±0.4 hPa ❖ -0.04-0.11hPa	● I: version 11/12 problematic ● Main differences in Austria and Spain with -0.5 to 1hPa
TOT_PREC	● West: ±5mm/month ● East: ±10mm/month ❖ -2.7-2.3 mm/month	● West: ±5mm/month ● East: ±10mm/month ❖ -3.1 —1.6mm/month	● PL:>-5mm/month and missing data!
T_2M	● West:±0.2K ● East: ±0.5K ❖ W: 0.04K; E: -0.12K	● W: ±0.1K ● East: -0.5—0.4K ❖ W: 0.02K; E: -0.15K	● F+CH: -0.5K ● BG: 1K
TMIN_2M	● As T_2M	● West:±0.2K ● E: as T_2M ❖ -0.17K-0.01K	● I: -0.5K ● F:+0.23K
TMAX_2M	● As T_2M	● West:±0.2K ● East: ±0.5K ❖ W: 0.08K; E: -0.17K	● UK: 0.2K ● BG: -0.5K (from 2006) ● CH: -0.1K (from 1995)
CLCT	● W: ±1% ● E: ±2%-±3% ❖ -1%	● W: ±1% ● E: ±2%-±3% ❖ ±1%	● NA

SUMMARY

- Differences are small, but in worst case they would sum up to remarkable values
- ENEMIES depend on geographic position: ENEMY 1 (machine) & 2 (internal variability) Distances to the left boundary ENEMY 3: affiliation to country

  Generally **spectral nudging helps** to reduce the noise – I'm interested in how much!

  Does someone volunteers to simulate CON502 with spectral nudging on his machine?

- 'Changing' observations are a trap – especially the case of Poland precipitation data shows that there is no reason to trust observational data without detailed checks

BIAS-, AME- and RMSE-Plots for the listed countries for TOT_PREC, PMSL, T_2M, TMIN_2M, TMAX_2M, CLCT are stored at /pool/data/CCLM-EVAL/plots_reproducibility/

Discussion of further details - but in WG Eval not possible…

FOR PEOPLE AND THEIR FUTURE ENVIRONMENT

Thank you! - for your attention and thanks to Ronny, who developed the HZG-Evaluation-Suite

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