Automatic benchmarking of series homogenization packages

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The problem of inhomogeneities

- Station relocation, changes of instrumentation or observation practices, etc, add inhomogeneities to the climate signal in real series.
- These inhomogeneities can mislead the climatologist to make incorrect assesments about variability and trends of the series.
- Many detection/correction methods have been used since long to overcome this problem, and reviews have been published comparing their results when applied to synthetic series.
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COST Action ES0601 (2007-2011) about climate series homogenization was a great success, allowing fruitful discussions between developers and other specialists. But the homogenization method comparison had some flaws:

- Complex structure of the benchmark data-set directory tree, with many simulated networks:
  - Manual methods could homogenize only a reduced subset
  - Many automatic methods had post-processing errors (not due to their homogenization algorithms)
- Problem series had a high number of random inhomogeneities and local trends
- $\Rightarrow$ Method performance difficult to compare

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Objective

- Although the benchmark data-set tried to be highly realistic, it was composed by long series only, with few missing data, while in the real world many short series are present in the climatological records.
- Some homogenization packages are able to use this short series, but this potential advantage remained untested in HOME COST Action.
- Moreover, many homogenization packages have improved thanks to this Action, but it is not likely that this complex intercomparison will be repeated in a near future.
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Synthetic master networks

- 100 random points chosen on a 4 x 3° lon-lat area
- Seasonal cycle taken from monthly averages of maximum daily temperatures of 53 stations from the central area of the Duero river basin, Spain (t_i, °C):

  7.9 10.5 14.2 16.3 20.6 25.8 29.9 29.3 25.2 18.7 12.2 8.3

- First station: 60 years of random monthly values taken from $\mathcal{N}(t_i, 1.5)$
- The nearest station is assigned the same values plus noise from $p \cdot \mathcal{N}(0, 1.5)$, where $p = 0.20, 0.40, 0.80$
  (Three master series are then produced: TA20, TA40, TA80)
- Continue until all 100 stations have been filled with values
- All series are then adjusted for altitude, their annual range is varied by ±20%, and a trend of 2°C/Century is added

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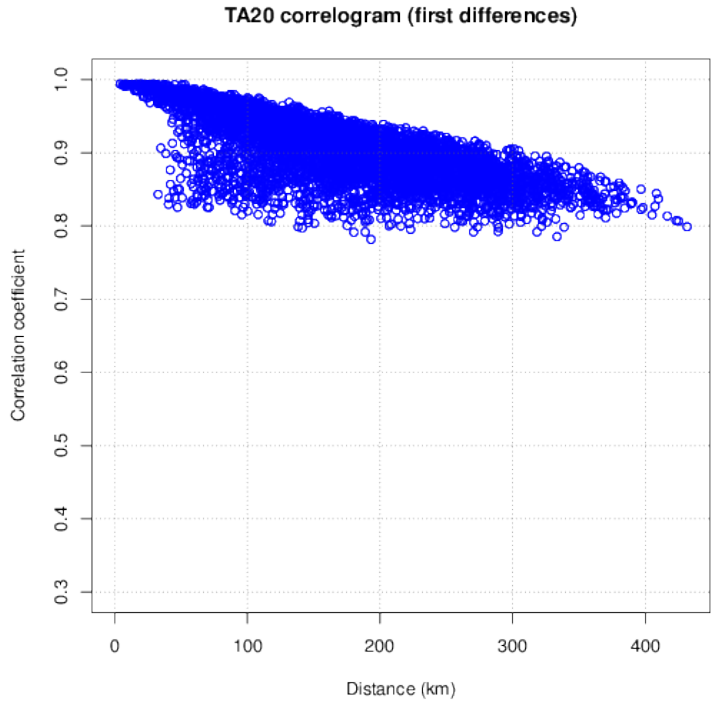
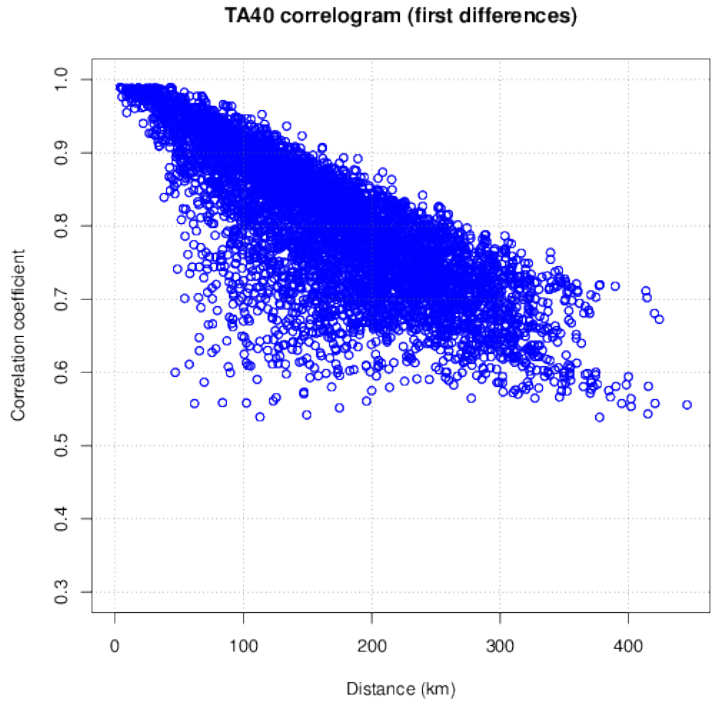
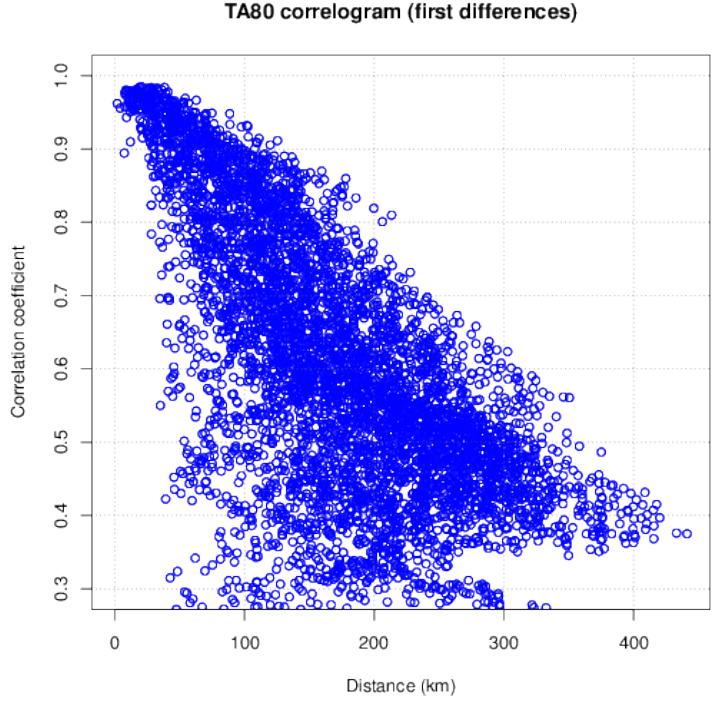
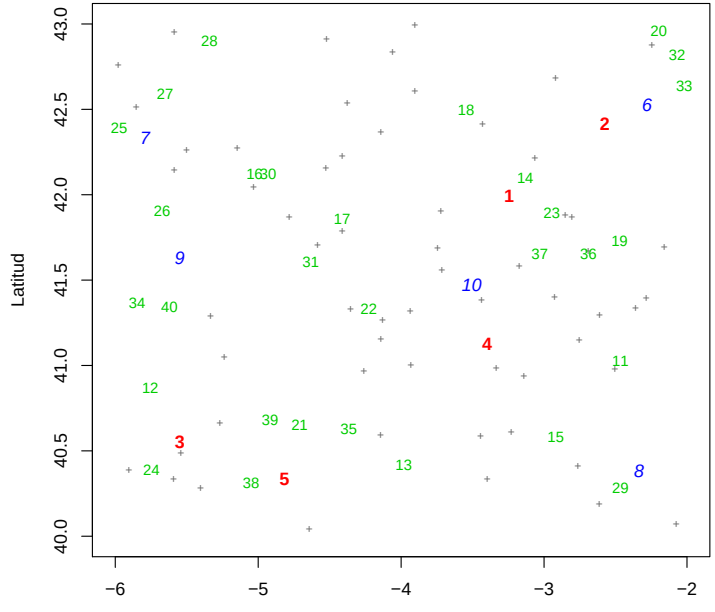

TA20 correlogram (first differences)
Correlation coefficient
Distance (km)
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
100
200
300
400


TA40 correlogram (first differences)
Correlation coefficient
Distance (km)
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
100
200
300
400


TA80 correlogram (first differences)
Correlation coefficient
Distance (km)
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
100
200
300
400


Latitud
Longitud
40.0
40.5
41.0
41.5
42.0
42.5
43.0
−6
−5
−4
−3
−2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
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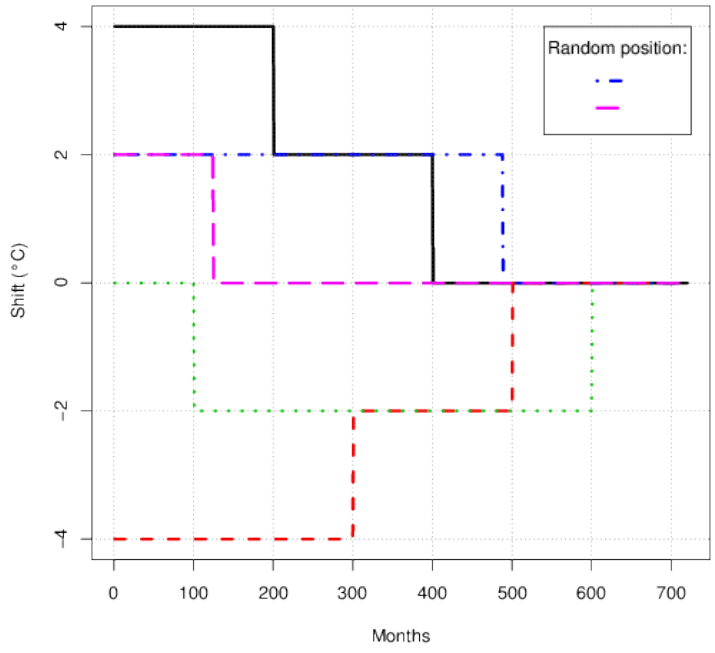
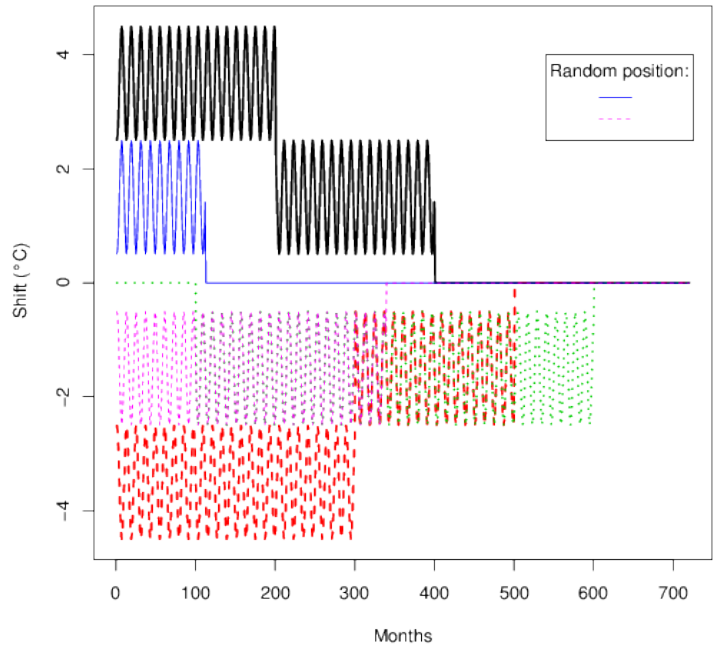
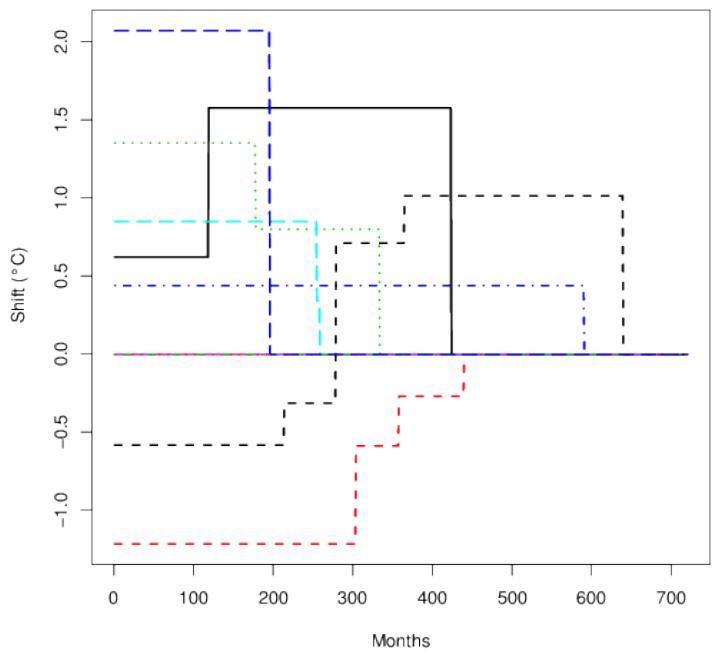
39
40

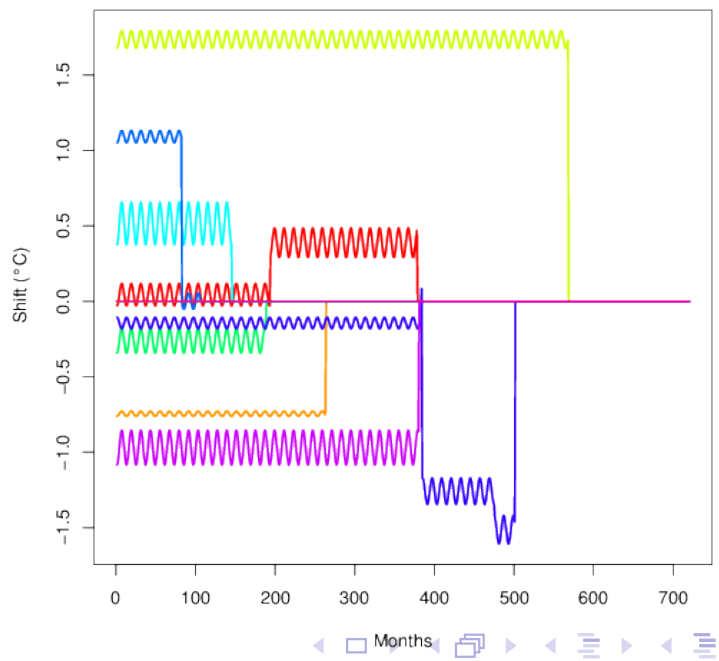


All random (no seasonality)



All random (with seasonality)





Tested homogenization packages

- Climatol 2.2 (Guijarro): 10, 20 and 40 stations, with constant ('cl1', 'cl2', 'cl4') and variable ('Cl1', 'Cl2', 'Cl4') corrections
- ACMANT 1.2 (Domonkos): 'Acm'
- MASH 3.03 (Szentimrey): 'MSH'
- RHTestV3 (Wang & Feng): 'RHa', 'RHA', 'RHr', 'RHR', where a|A stand for absolute homogenization and A|R indicate that a quantile adjustment has been performed. *(The nearest homogeneous series was provided as reference, since this method does not builds their own references, and therefore it was not tested when all series could be randomly affected by shifts)*
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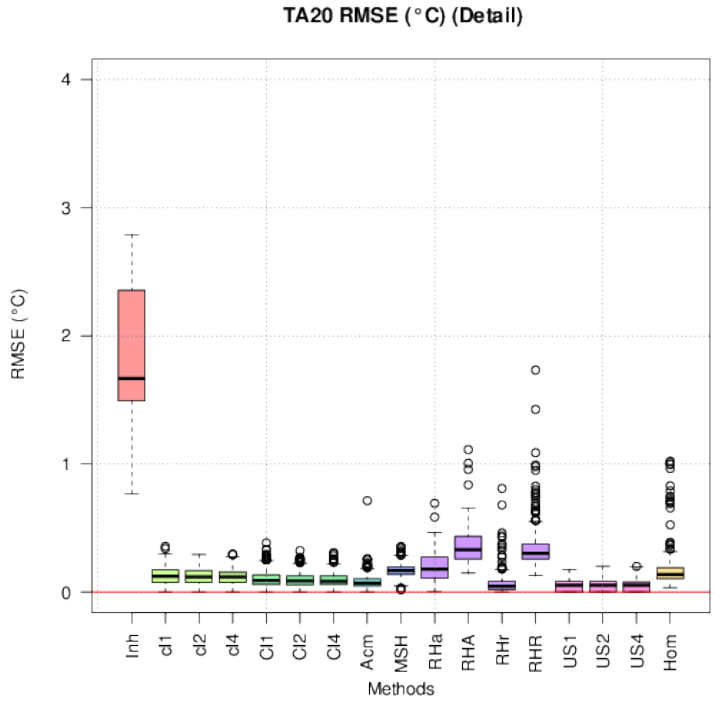
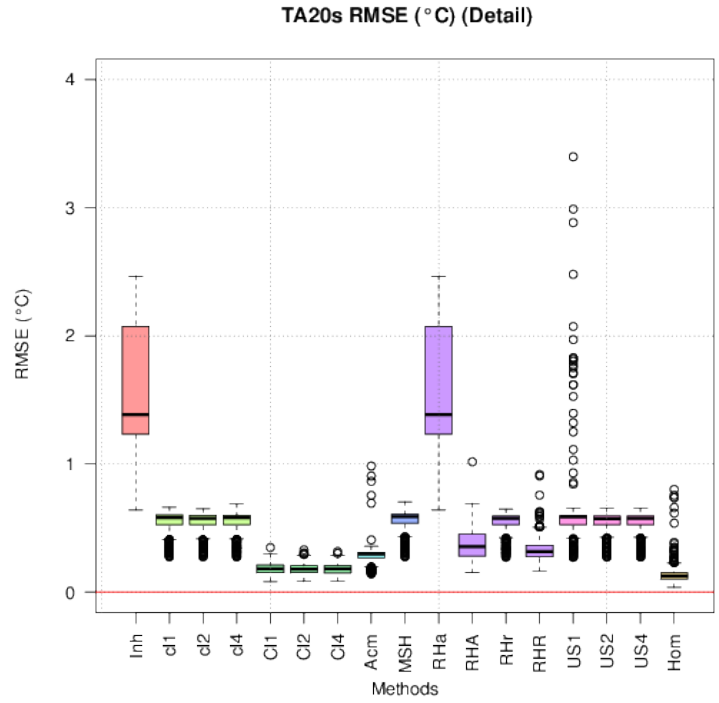
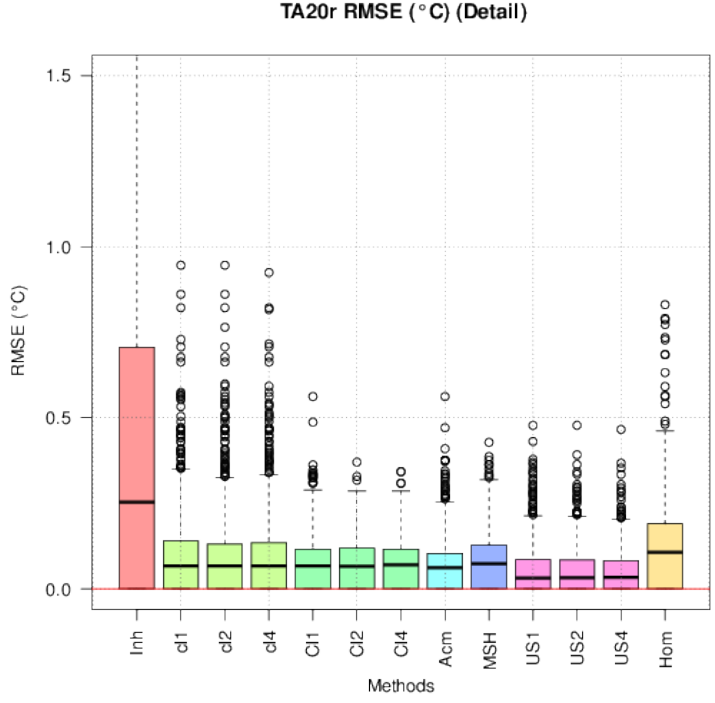
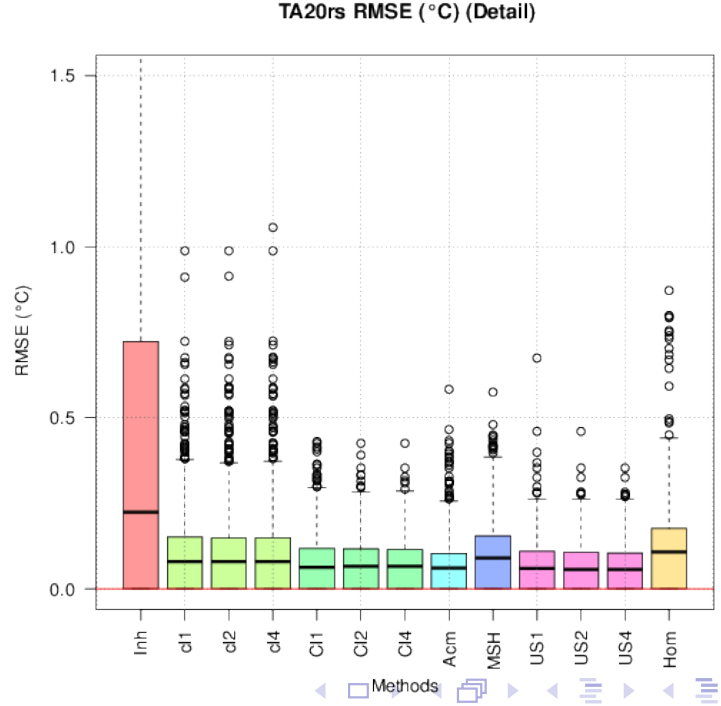
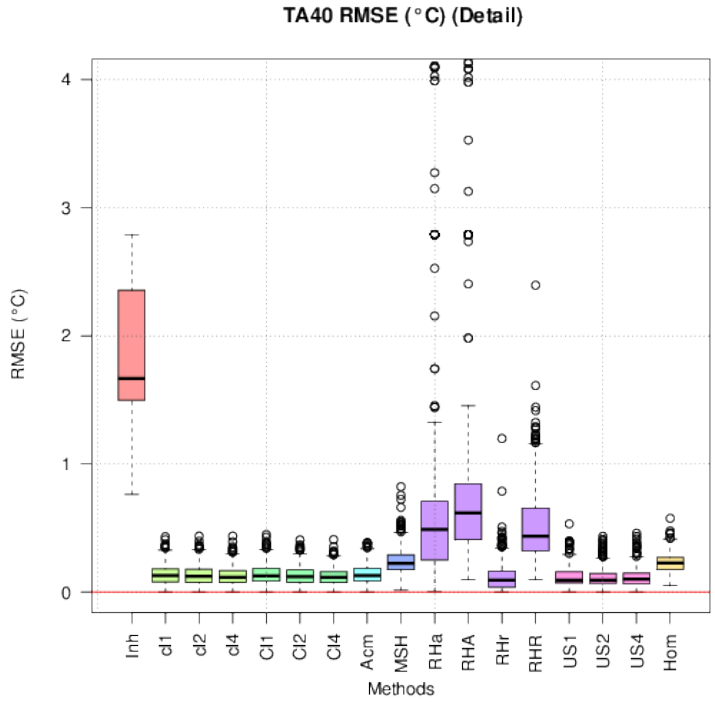
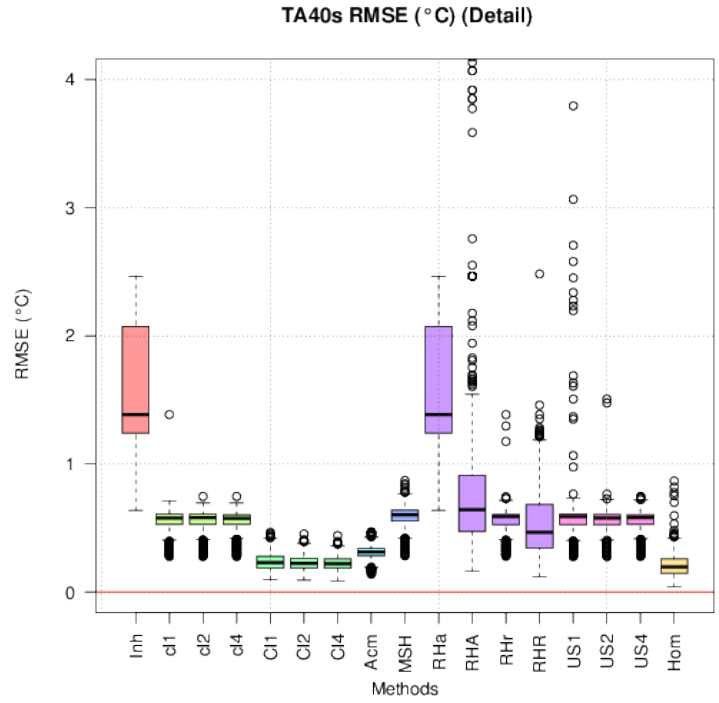

TA20 RMSE (°C) (Detail)
RMSE (°C)
0
1
2
3
4
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom
Methods


TA20s RMSE (°C) (Detail)
RMSE (°C)
0
1
2
3
4
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom
Methods


TA20r RMSE (°C) (Detail)
RMSE (°C)
0.0
0.5
1.0
1.5
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom
Methods


TA20rs RMSE (°C) (Detail)
RMSE (°C)
0.0
0.5
1.0
1.5
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom
Methods


TA40 RMSE (°C) (Detail)
RMSE (°C)
0
1
2
3
4
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom
Methods


TA40s RMSE (°C) (Detail)
RMSE (°C)
0
1
2
3
4
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
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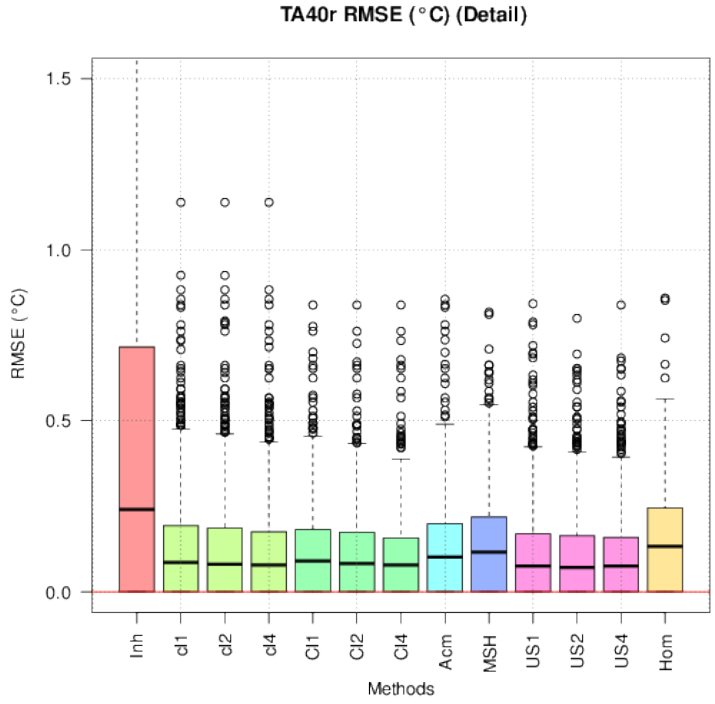
TA40r RMSE (°C) (Detail)
RMSE (°C)
0.0
0.5
1.0
1.5
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
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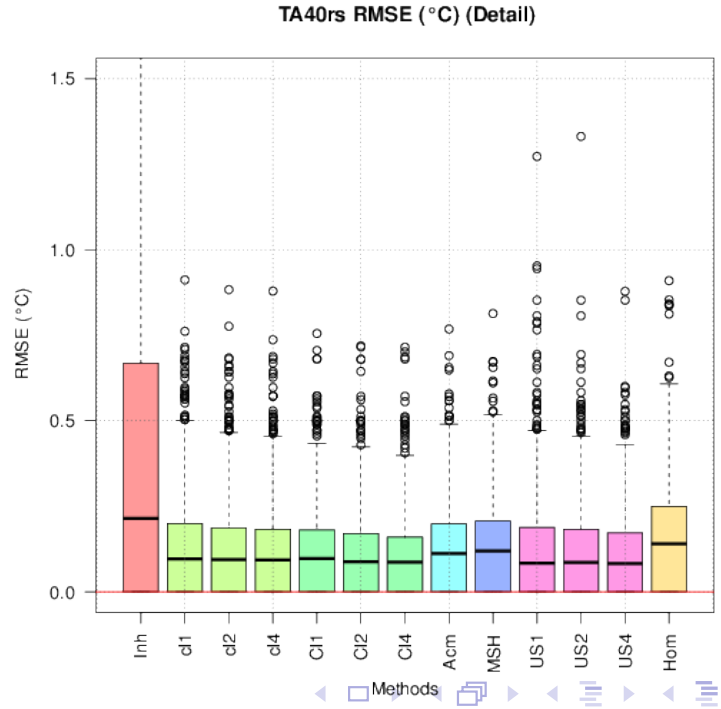
US1
US2
US4
Hom
Methods


TA40rs RMSE (°C) (Detail)
RMSE (°C)
0.0
0.5
1.0
1.5
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
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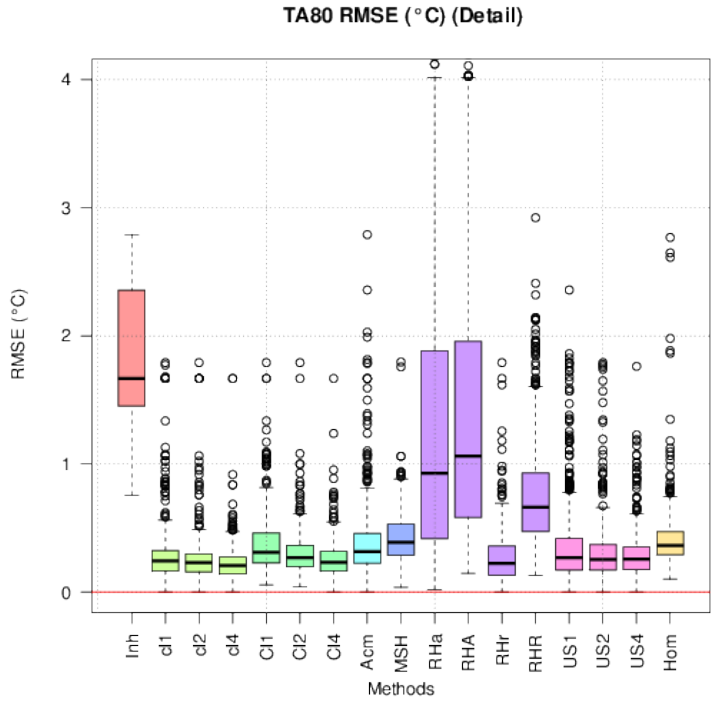
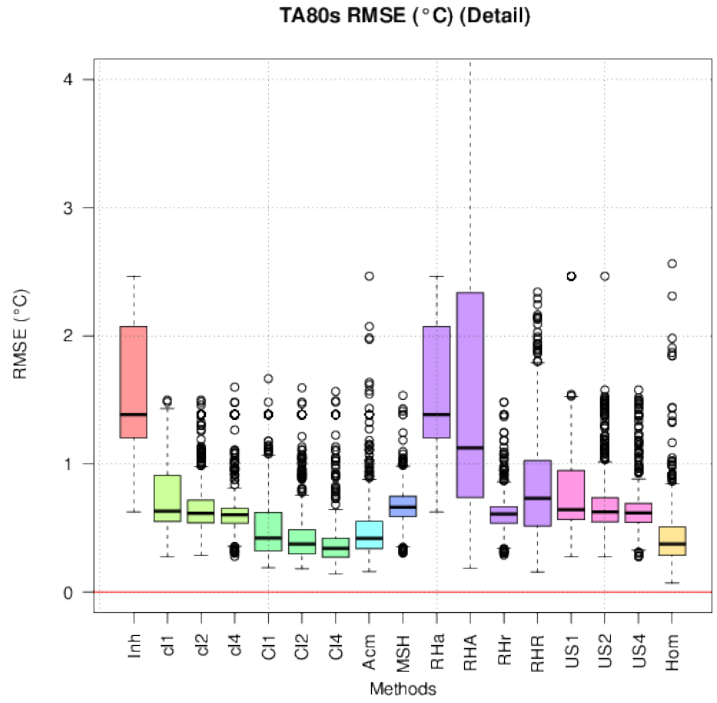
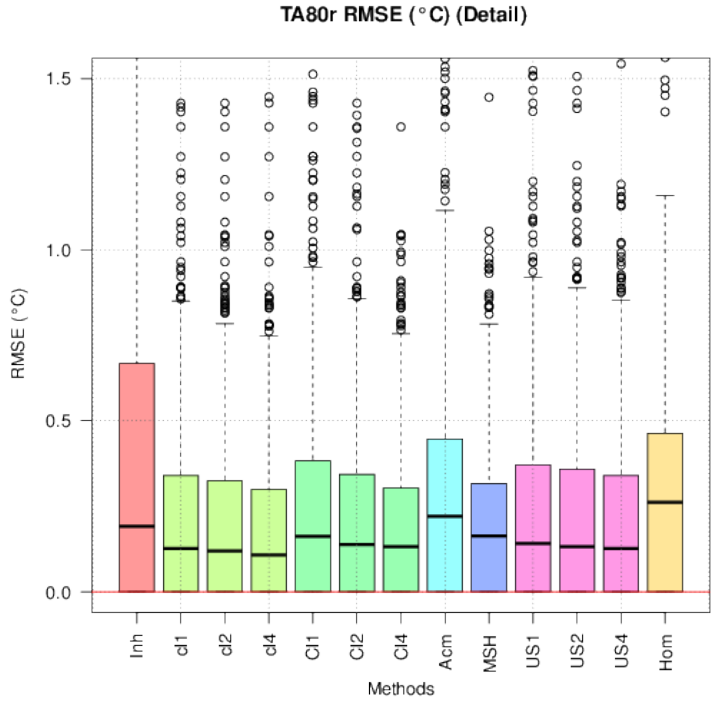
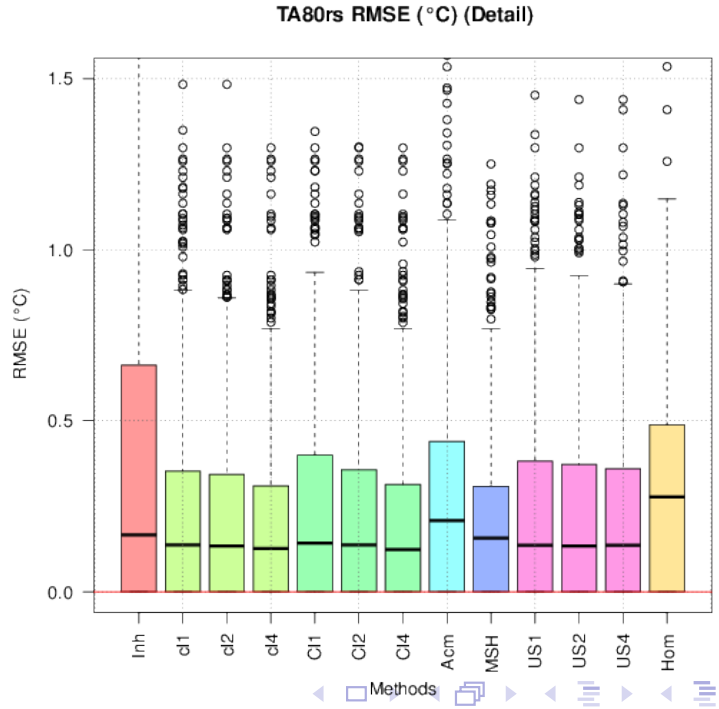
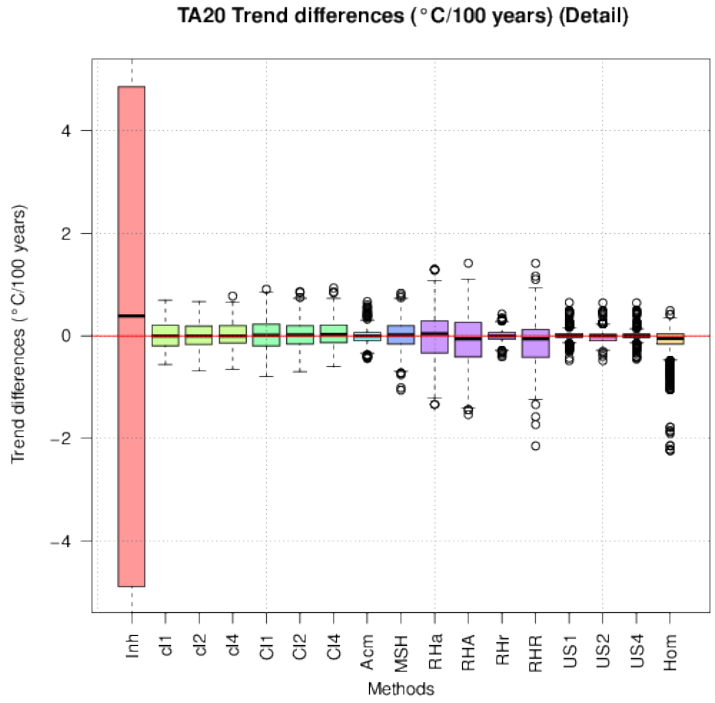
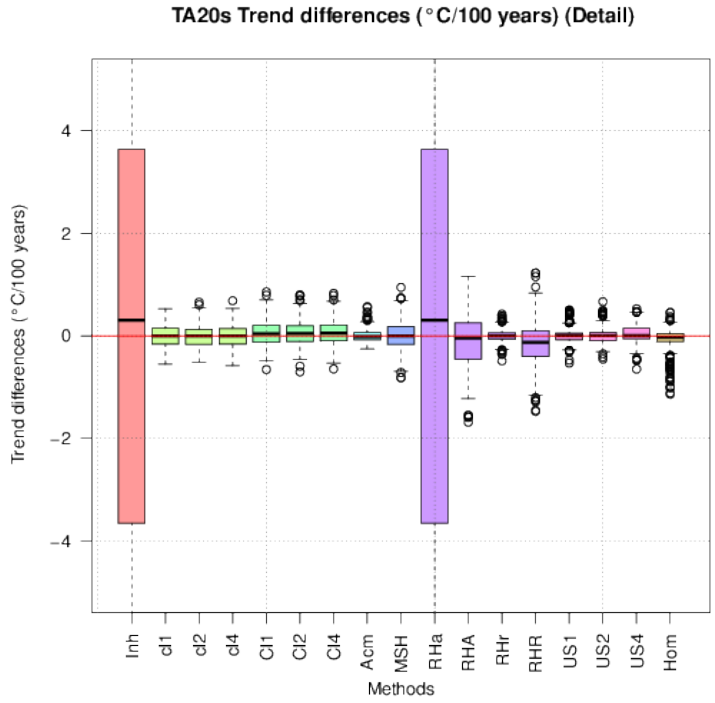

TA80 RMSE (°C) (Detail)
RMSE (°C)
0
1
2
3
4
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom
Methods

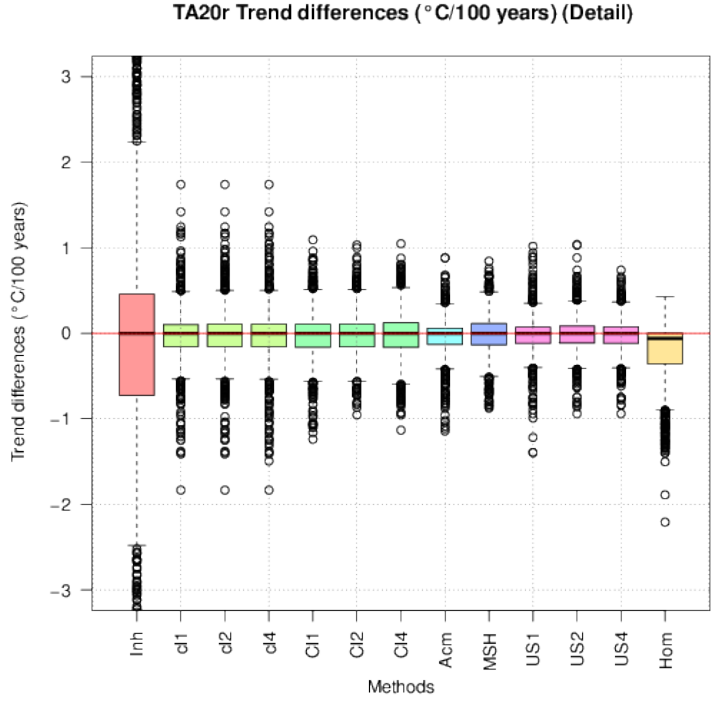

TA80s RMSE (°C) (Detail)
RMSE (°C)
0
1
2
3
4
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom
Methods

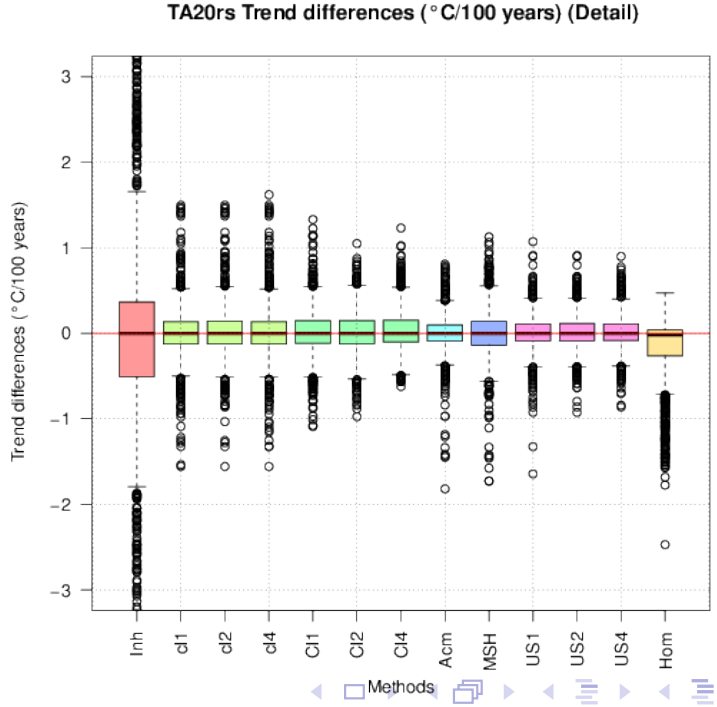

TA80r RMSE (°C) (Detail)
RMSE (°C)
0.0
0.5
1.0
1.5
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom
Methods

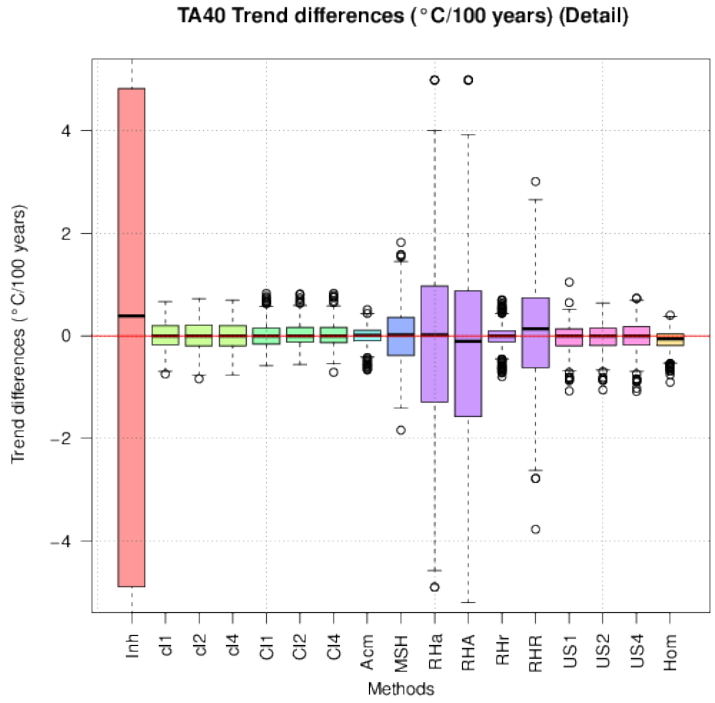

TA80rs RMSE (°C) (Detail)
RMSE (°C)
0.0
0.5
1.0
1.5
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom
Methods

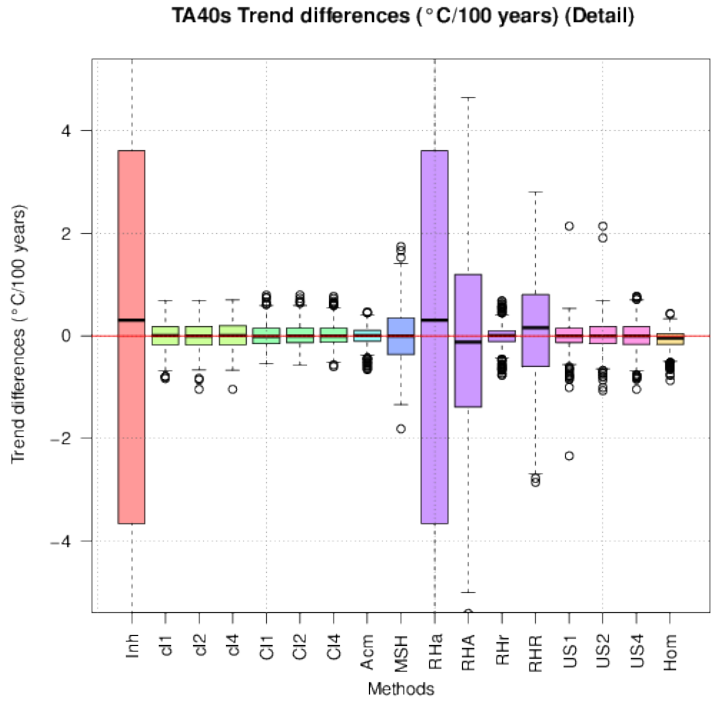

TA20 Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom

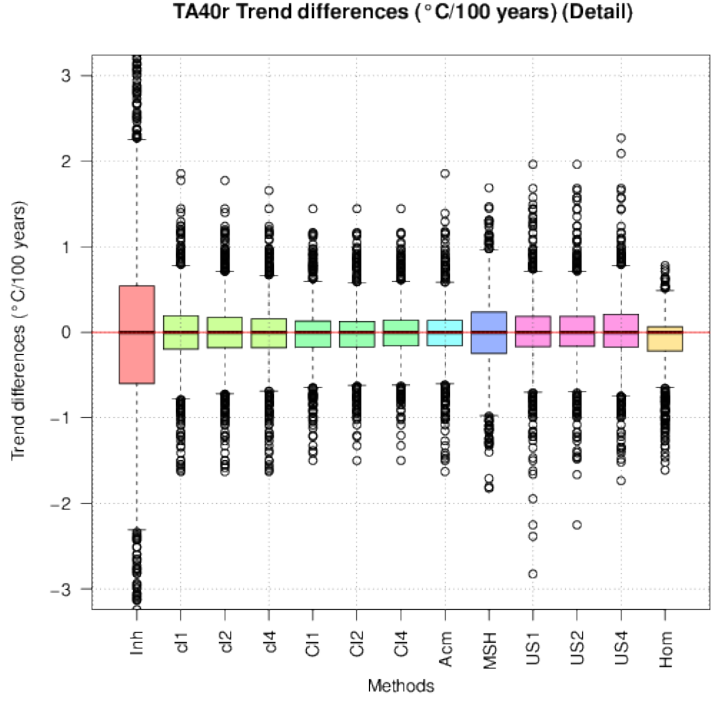

TA20s Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom

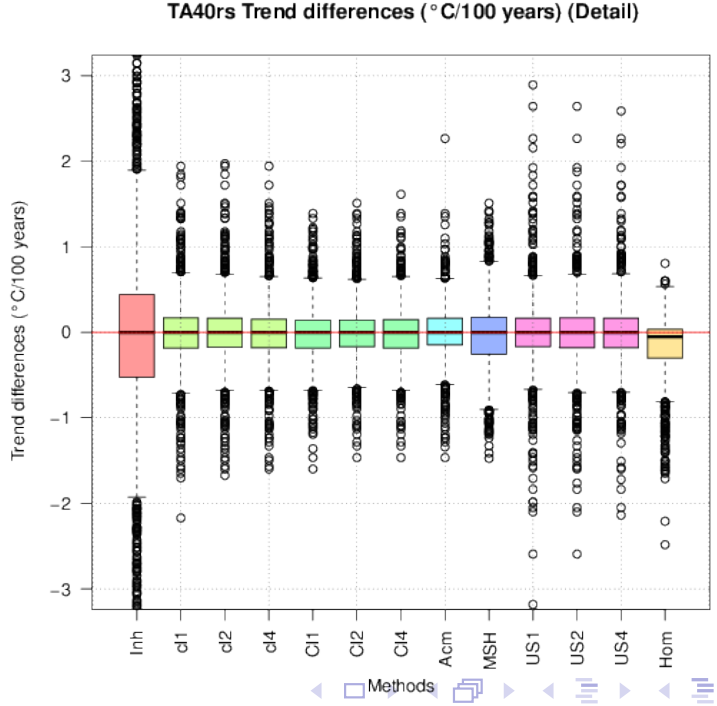

TA20r Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom

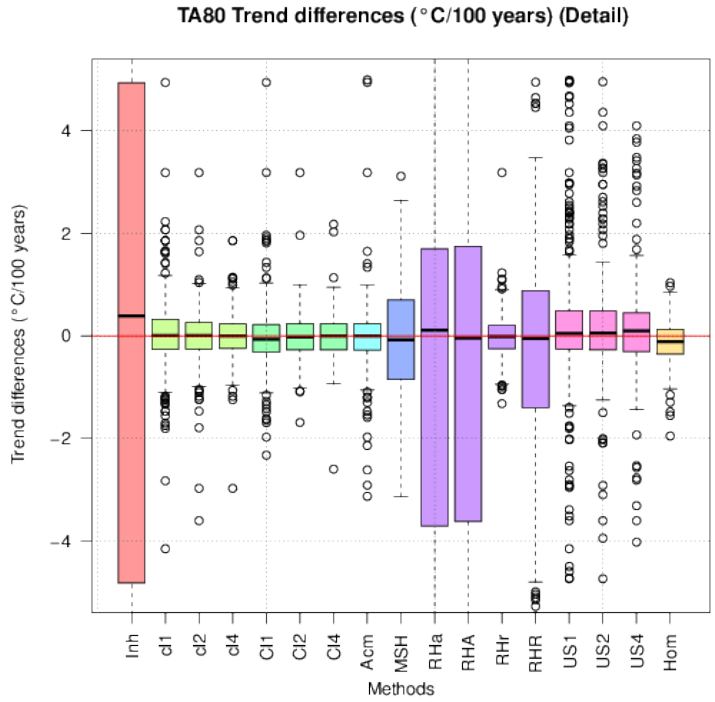

TA20rs Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom

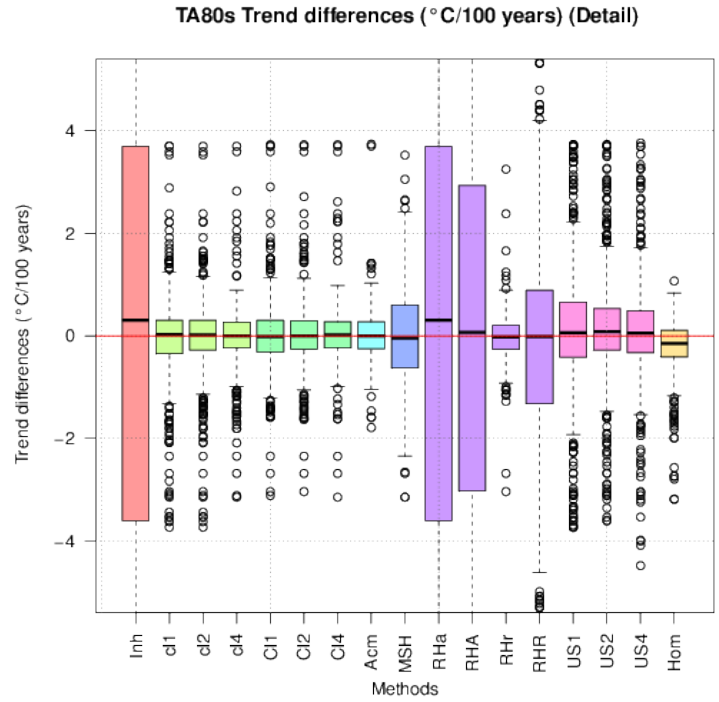

TA40 Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom

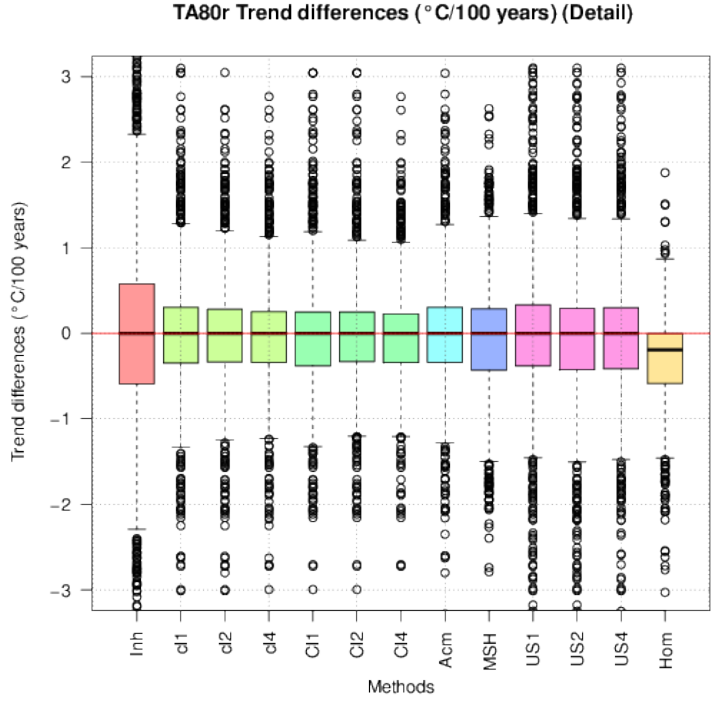

TA40s Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom


TA40r Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom


TA40rs Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
US1
US2
US4
Hom


TA80 Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom


TA80s Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
RHa
RHA
RHr
RHR
US1
US2
US4
Hom


TA80r Trend differences (°C/100 years) (Detail)
Trend differences (°C/100 years)
Methods
Inh
cl1
cl2
cl4
Cl1
Cl2
Cl4
Acm
MSH
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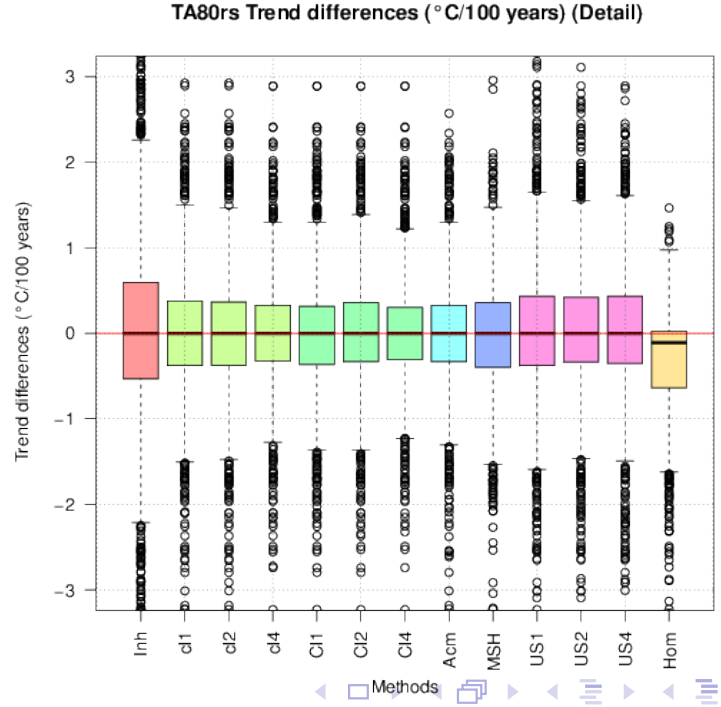
TA80rs Trend differences (°C/100 years) (Detail)
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Conclusions

- The benefit of using short series is only noticeable with low correlations (but the reconstruction of short series can be very useful for mapping, climate monitoring, etc)
- Most methods produced relatively good results in this exercise. Exception: RHTestV3 absolute homogenization and quantile adjustment with poor correlations
- Anyway, different characteristics of the problem series allow the assessment of the packages strengths and weaknesses.
- Future work: To test the methods with simulated precipitation series
- **More information about homogenization methods:**
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