# Multivariate bias corrections of climate simulations: Which benefits for which losses ?


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## 1. Context and objectives : can MBCs really do what we expect?

Climate simulations have **biases**, e.g.:

- Inter-variable
- Spatial
- Marginal properties

} can differ from refererences (obs. or reanalyses)

⇒ Corrections are needed, e.g. for impact studies.

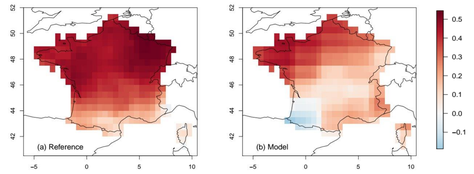



Figure 1: Maps of temperature vs. precipitation Spearman correlation computed at each grid cell for reference and model data.

- Most bias correction methods are univariate.
- Only a few **multivariate** bias correction (MBC) methods exist.

⇒ Objective: Understand MBC's differences in applicability and assumptions

Here, intercomparison of four MBC's**:**

- **R²D²** [1]
- **dOTC** [2]
- **MBCn** [3]
- **MRec** [4]

## 2. Applications

**Data:** daily **temperature** (T2) and **precipitation** (PR) data

Reference: **WFDEI** Model: **IPSL**

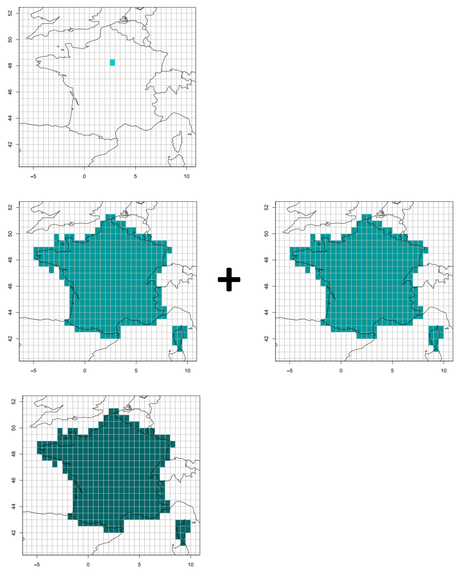
⇒ over **France** (321 grid cells) during winter (1979-2016)

**MBC's configurations:** three different dimensional versions

2d-version
**MBC(T2,PR)**
*321 corrections in 2d*

Spatial-version
**MBC(all T2) and MBC(all PR)**
*2 corrections in 321d*

Full-version
**MBC(all T2, all PR)**
*1 correction in 642d*



## 3. Results... contrasted!

Various criteria have been evaluated: marginal, inter-variable, spatial, temporal and non-stationary properties.
⇒ Here, illustrations for inter-variable, spatial and temporal criteria.

### Inter-variable criteria

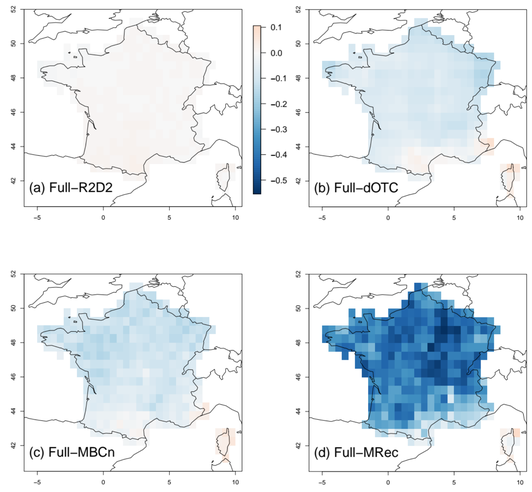



Figure 2: Difference of temperature vs. precipitation Spearman correlation computed at each grid cell between WFDEI reference and bias-corrected data (only Full-versions).

### Spatial criteria

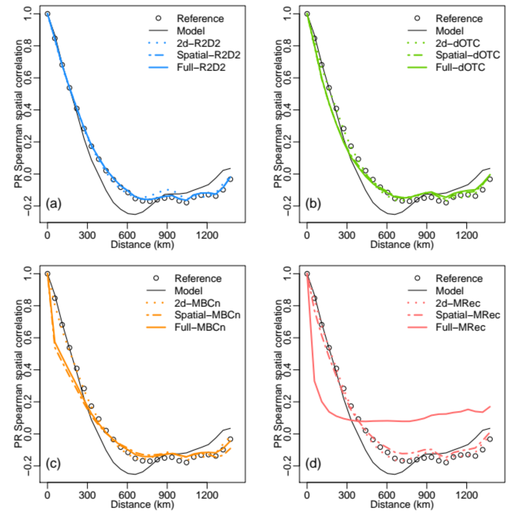



Figure 3: Mean Spearman correlation in function of distance for precipitation.

### Temporal criteria

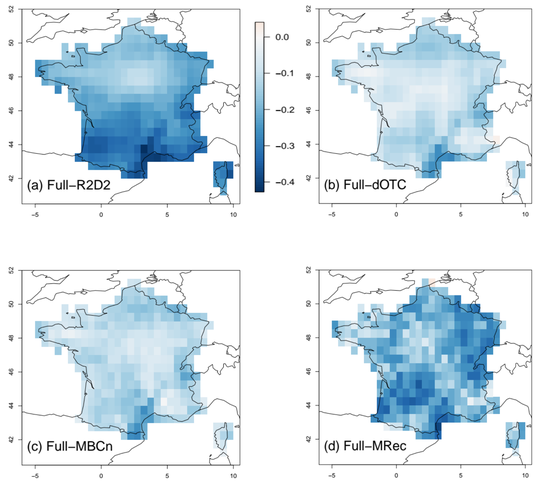



Figure 4: Difference of autocorrelation of order 1 for precipitation between WFDEI reference and bias-corrected data (only Full-versions).

- **Increasing the number of dimensions ⇒ can deteriorate inter-variable and/or spatial properties.**

⇒ **These MBCs are not designed to correct temporal properties.**

## 4. Conclusion: caution has to be taken by end-users!

- **Instability** of some methods in high-dimensions (MBCn, MRec)
- Temporal properties are not considered ⇒ potential **unexpected behaviors**
- Non-stationary properties: not all methods are designed for them (not shown)

⇒ **Depending on their needs, caution has to be taken by end-users before applying MBC methods.**

| Characteristics | $R^2D^2$ | dOTC | MBCn | MRec |
|---|---|---|---|---|
| Correction of univariate distrib. prop. | ✓ | ✓ | ✓ | ✓ |
| Modification of the correlations of the model | ✓ | ✓ | ✓ | ✓ |
| Capacity to correct inter-var. prop. | ✓ | ✓ | ✓ | ✓ |
| Capacity to correct spatial prop. | ✓ | ✓ | ~ | ~ |
| Capacity to correct temporal prop. | ✗ | ✗ | ✗ | ✗ |
| Preserve the rank structure of the model | ~ | ~ | ~ | ~ |
| Capacity to correct small geographical area | ✓ | ✓ | ✓ | ✓ |
| Capacity to correct large geographical area | ~ | ~ | ~ | ✗ |
| Allow for evolution of the rank dependence | ✗ | ✓ | ~ | ✓ |

Table 1: Summary of recommendations with respect to different assumptions.

### Perspectives

⇒ How does the quality of MBC results influence impact studies?
⇒ Developing new MBC methods:

- How to account for temporality in MBC?
- Including some physical processes


References:
[1] Vrac, 2018, Hydrology and Earth System Sciences.
[2] Robin et al., 2019, Hydrology and Earth System Sciences.
[3] Cannon, 2018, Climate Dynamics.
[4] Bárdossy and Pegram, 2012, Water Resources Research.
[5] François et al., Multivariate bias corrections of climate simulations: Which benefits for which losses?, Submitted.