How reliable are the models to study recent climate change ? A study of heat/cold waves and radiative fluxes trends over 1900-2010 using the model MAR in Belgium

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1. CONTEXT

Regional Climate Models (RCM) are one of the most used tools to study the potential climate changes. The results of these models are useful to policymakers to take decisions which help to fight global warming and its impacts (solar energy production, greening cities, etc).

The RCM MAR (**"**Modèle Atmosphérique Régional**"**) has recently been chosen to be part of the EURO-CORDEX project. The model outputs are available on the FTP site of the Laboratory of Climatology: ftp://ftp.climato.be/fettweis/MARv3.6/CORDEX-BE/

Therefore, this research aims to assess the ability of the MAR model forced by several reanalyses to reconstruct the observed twentieth century climatology of extreme events and solar radiation in Belgium, as a necessary condition for reliable future projections.

2. CLIMATE SIMULATIONS

Simulations were performed using the RCM MAR at a spatial resolution of 5 km.

MAR was forced every 6h at its boundaries by:

- Air temperature
- Sea surface temperature
- Humidity
- Wind speed and direction
- Pressure

MAR was forced by 3 reanalyses:

- **ERA-20C** (1900-2010) → MAR-ERA-20C
- **ERA-40** (1958-1978)/**ERA-Interim** (1979-2010) → MAR-ERA
- **NCEP/NCAR-v1** (1948-2010) → MAR-NCEP1

MAR validation over Belgium is presented in Wyard *et al.* (2016).

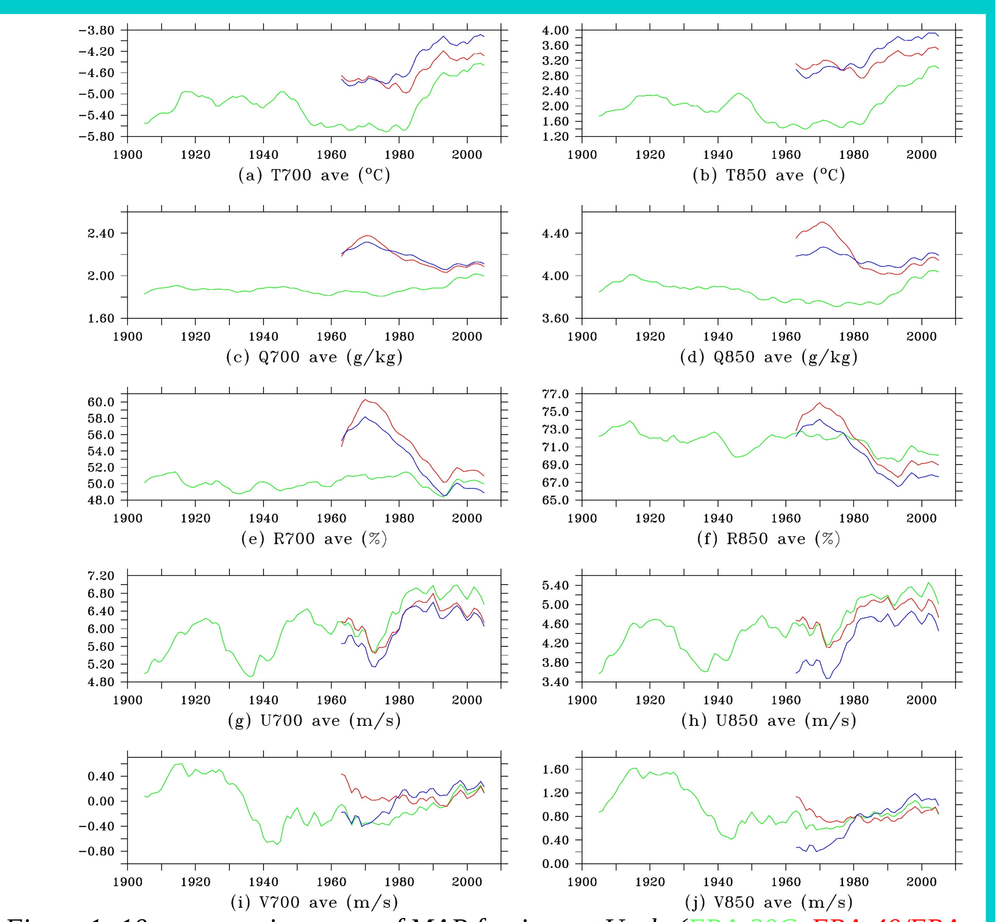

Figure 1: 10-year running mean of MAR forcings at Uccle (ERA-20C, ERA-40/ERA-Interim, NCEP/NCAR-v1) at 700 and 850 hPa : temperature (T), specific and relative humidity (Q and R), wind components (U and V).

3. RESULTS

Trends and their significance have been computed over 1958-2010 on the basis of the MAR outputs. A 10-year running mean has also been applied to the MAR outputs in order to show the interdecadal variability of climate.

HEAT WAVES: All three MAR simulations show a significant increase in their frequency, duration and intensity (**Figure 2**) and show similar interdecadal oscillations (**Figure 3**)

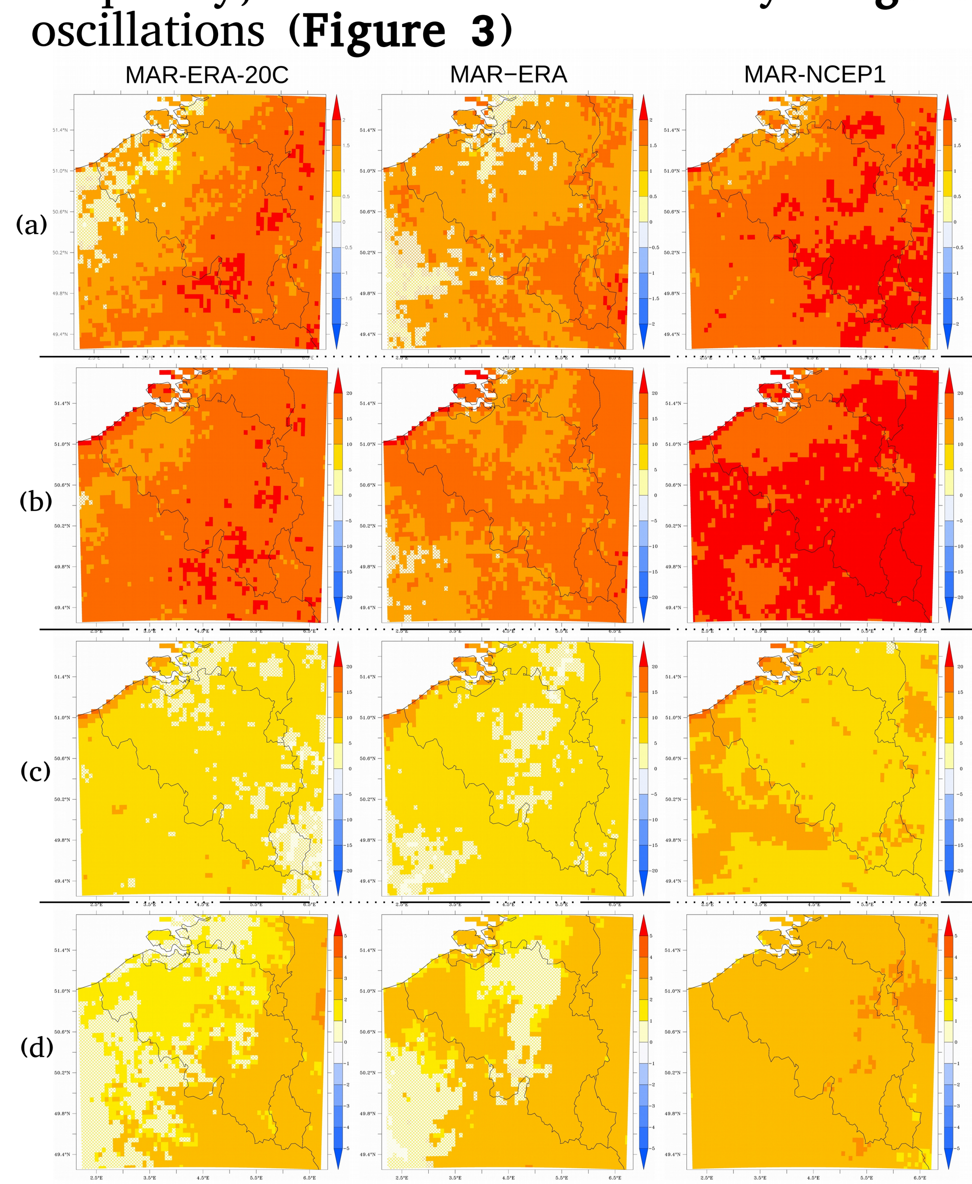

Figure 2: Trends over 1958-2010 computed from MAR-ERA-20C, MAR-ERA and MAR-NCEP1 outputs of yearly heat wave (a) frequency, (b) total number of days, (c) maximum duration (d) maximum intensity. Filled pixels indicate that the trend is significant.

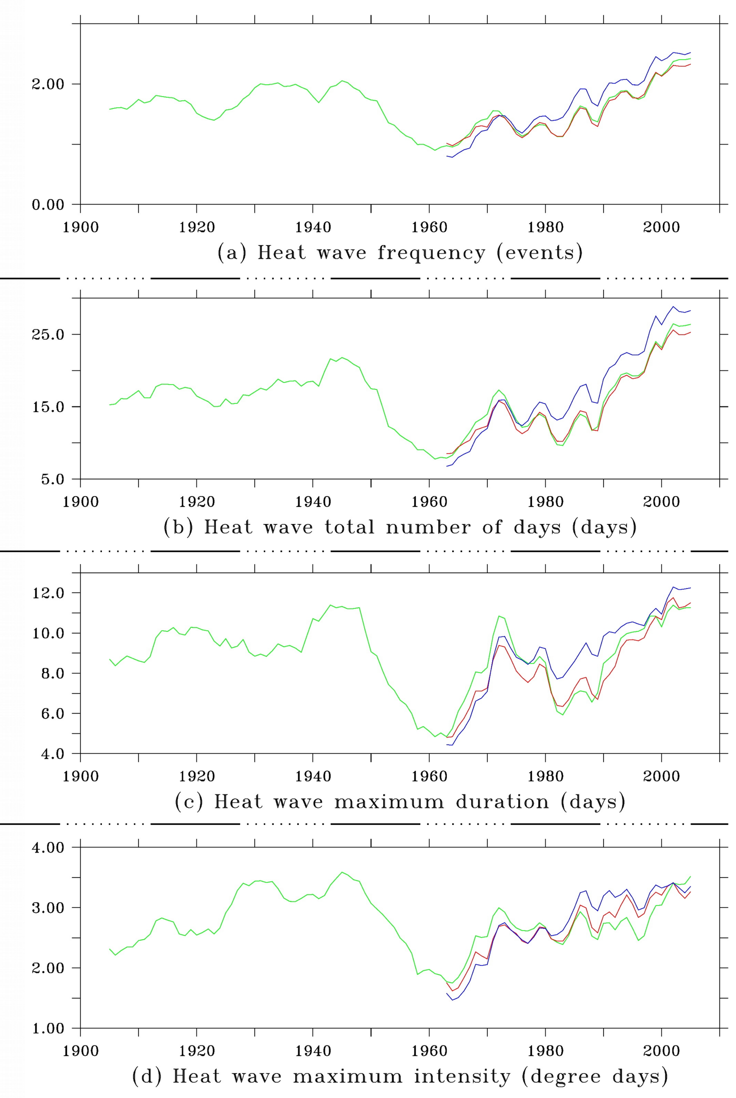

Figure 3: 10-year running mean of yearly heat wave (a) frequency, (b) total number of days, (c) maximum duration, (d) maximum intensity, computed from MAR-ERA-20C, MAR-ERA, MAR-NCEP1 outputs.

COLD WAVES : All three MAR simulations show no significant trend except MAR-ERA-20C (**Figure 4**) but show similar interdecadal oscillations (**Figure 5**)

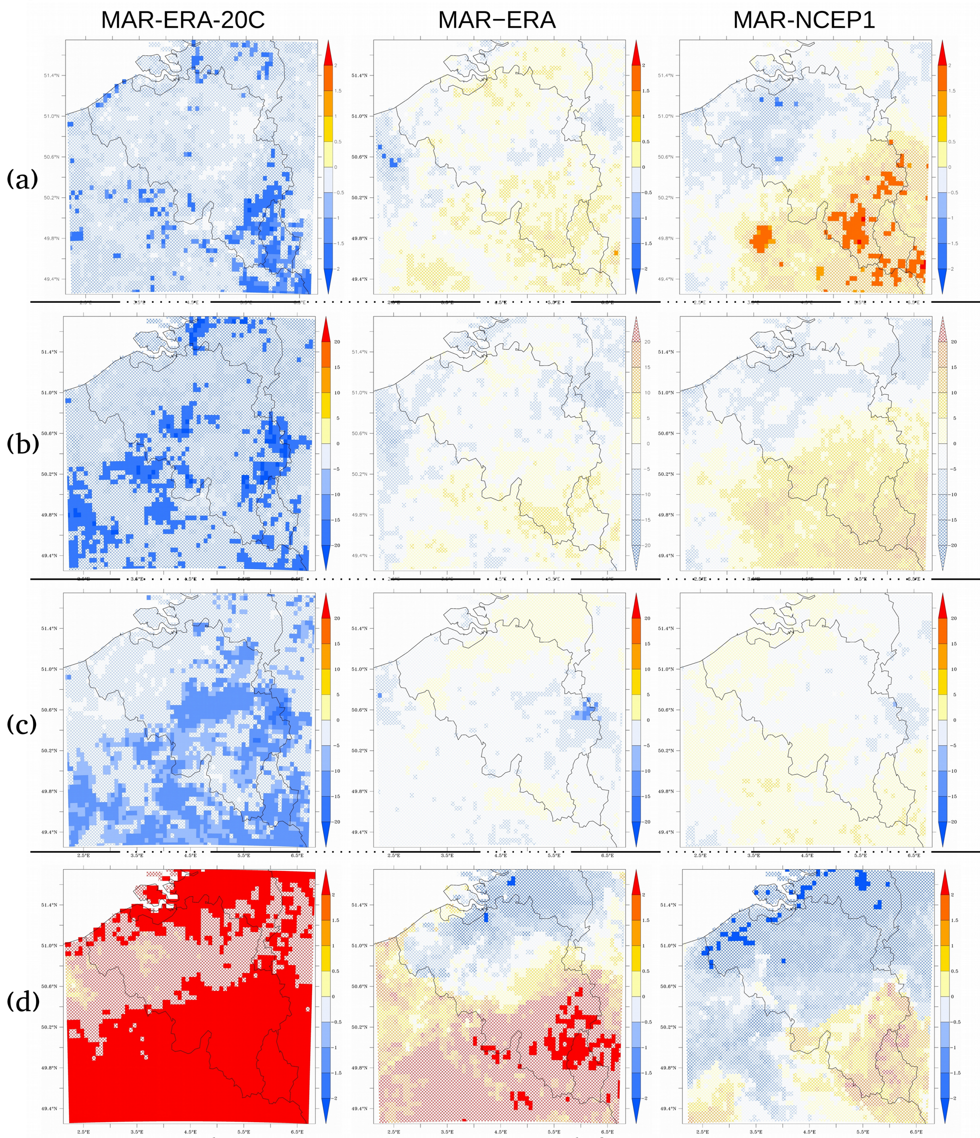

Figure 4: Trends over 1958-2010 computed from MAR-ERA-20C, MAR-ERA and MAR-NCEP1 outputs of yearly cold wave (a) frequency, (b) total number of days, (c) maximum duration (d) maximum intensity. Filled pixels indicate that the trend is significant.

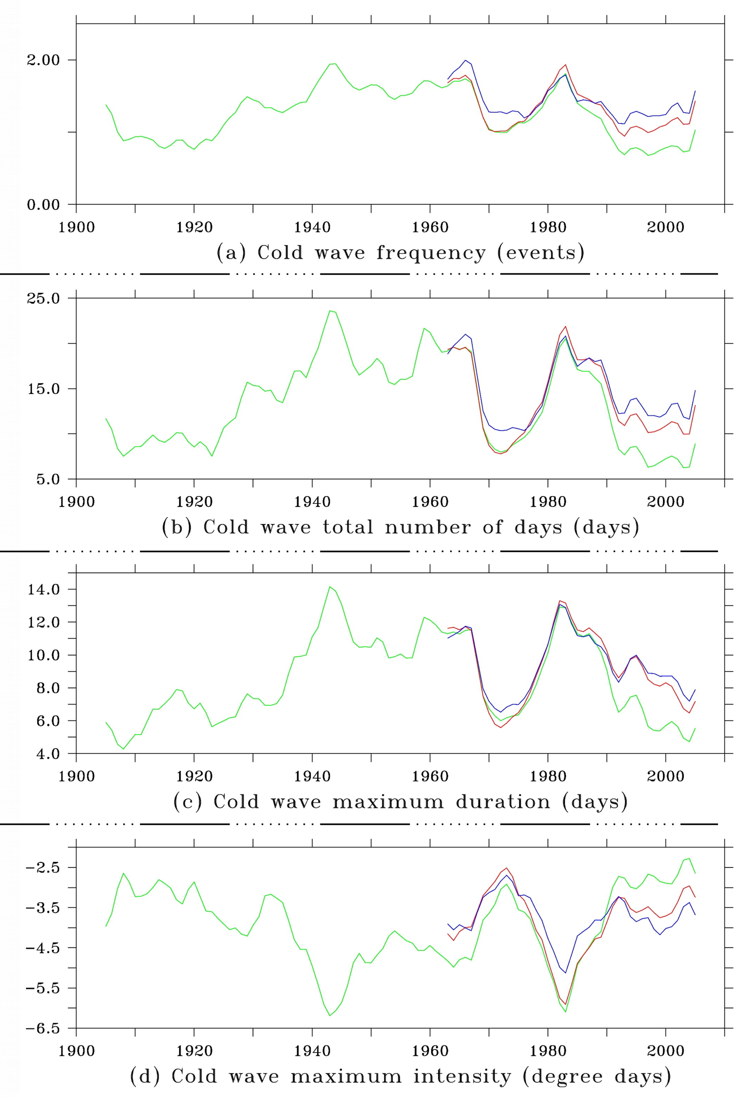

Figure 5: 10-year running mean of yearly heat wave (a) frequency, (b) total number of days, (c) maximum duration, (d) maximum intensity, computed from MAR-ERA-20C, MAR-ERA, MAR-NCEP1 outputs.

SOLAR DOWNWARD RADIATION: The simulations suggest an increase in solar downward radiation (**Figure 6 and 7**) as a result of a decrease in low clouds (**Figure 8 and 9**). This decrease in low clouds is explained by decreasing relative humidity due to warmer air temperature (**Figure 1**). The trends computed from MAR-ERA could be underestimated before 1979 because the forcing ERA40 reanalysis is known to be too wet (**Figure 1**). Trends and interdecadal oscillations computed from MAR-ERA-20C are not in agreement with those computed from MAR-ERA and MAR-NCEP1 (**Figure 6 to 9**).

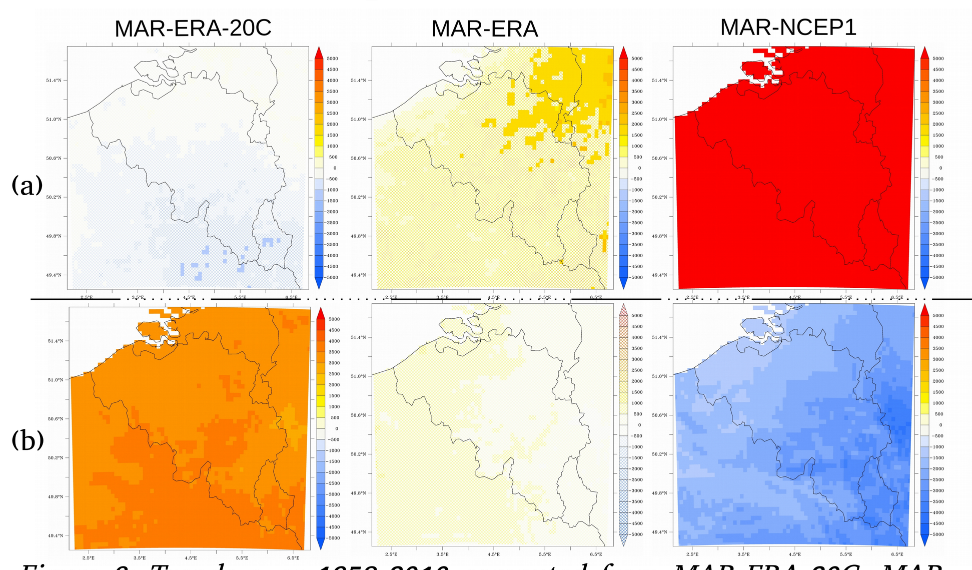

Figure 6: Trends over 1958-2010 computed from MAR-ERA-20C, MAR-ERA and MAR-NCEP1 outputs of total annual (a) solar downward radiation, (b) IR downward radiation. Filled pixels indicate that the trend is significant.

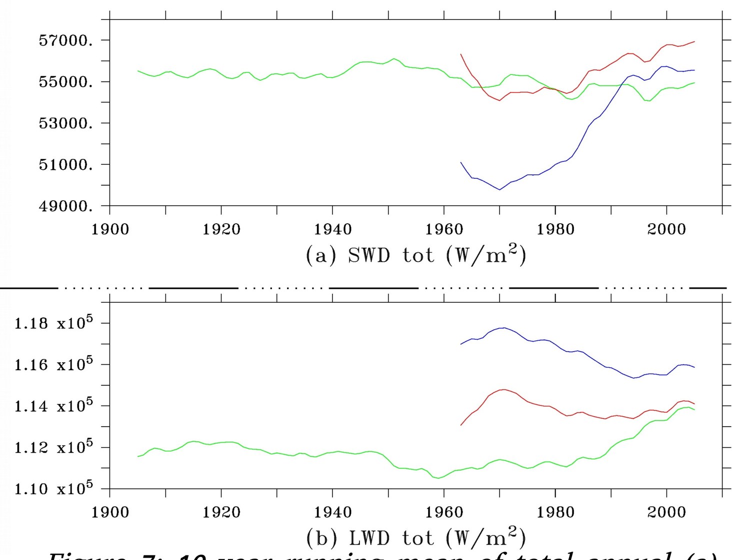

Figure 7: 10-year running mean of total annual (a) solar downward radiation, (b) IR downward radiation, computed from MAR-ERA-20C, MAR-ERA, MAR-NCEP1 outputs.

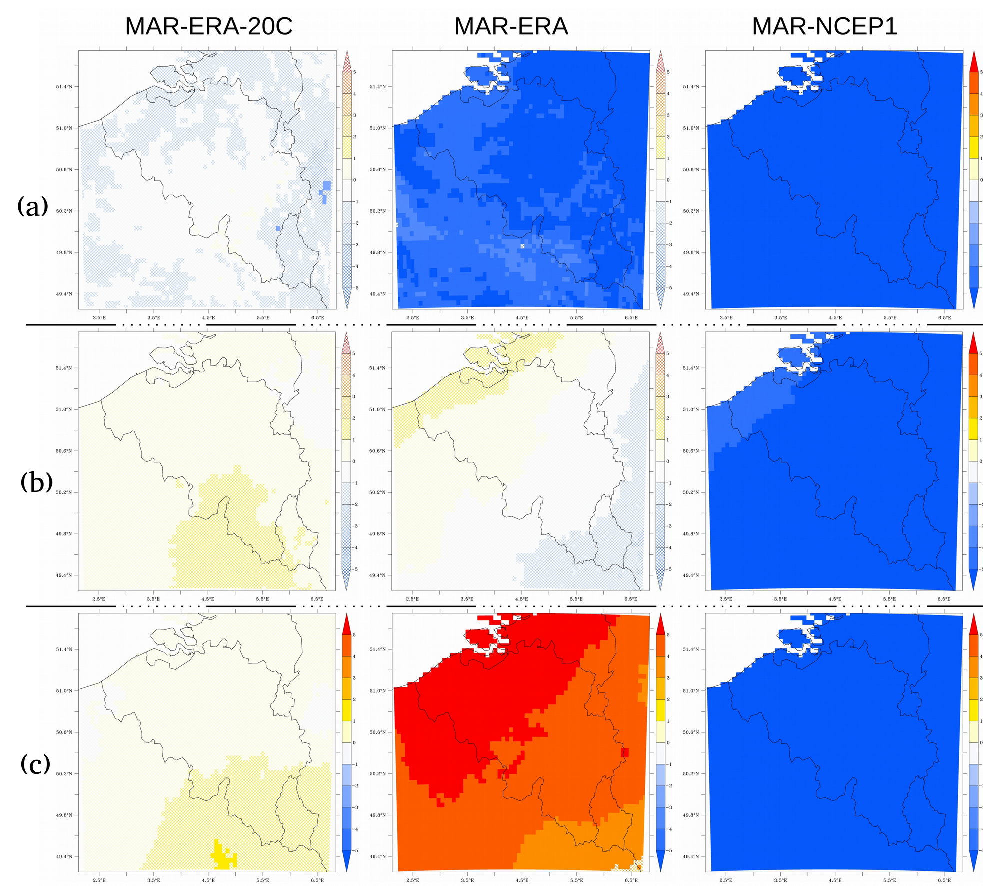

Figure 8: Trends over 1958-2010 computed from MAR-ERA-20C, MAR-ERA and MAR-NCEP1 outputs of average annual (a) low clouds, (b) middle clouds, (c) high clouds. Filled pixels indicate that the trend is significant.

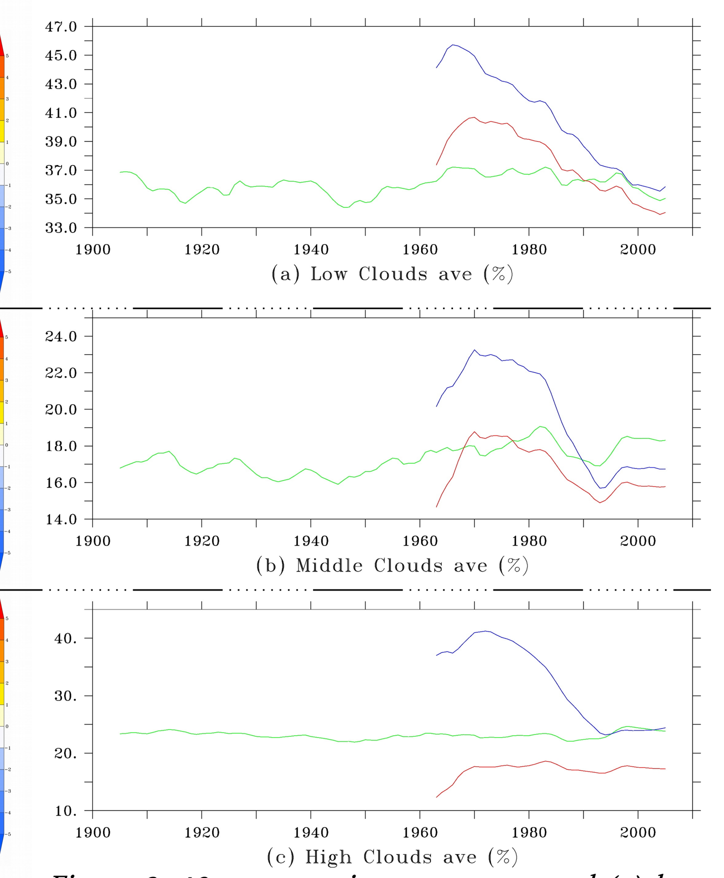

Figure 9: 10-year running average annual (a) low clouds, (b) middle clouds, (c) high clouds, computed from MAR-ERA-20C, MAR-ERA, MAR-NCEP1 outputs.

4. CONCLUSIONS

As many previous studies, this research illustrates the dependency between RCMs and their forcings. The forcing **reanalyses can generate divergent trends while contrary to Global Climate Models (GCM), the reanalyses assimilate observations and are supposed to represent the same climate**. It is therefore necessary to perform simulations using several RCMs forced by several reanalyses or GCMs in order to draw solid conclusions.

This study suggests that **increasing air temperature** would have generated **decreasing relative humidity** which would have lead to a **decrease in cloudiness** and an **increase in solar downward radiation**. If these trends are validated by in-situ data, it would be a good news for, for instance, solar energy production.

REFERENCES

Wyard C., *et al.*, 2016 : Decrease in climatic conditions favouring floods in the south-east of Belgium over 1959-2010 using the regional climate model MAR. *International Journal of Climatology, doi: 10.1002/joc.4879.*

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