SURFACE SOLAR RADIATION MODELLING OVER 1900-2014: COMPARISON BETWEEN THE REGIONAL CLIMATE MODEL MAR AND REANALYSES

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CONTEXT

- Surface solar radiation (SSR) undergoes substantial decadal variations.
- These variations are thought to impact various aspects of the climate system (e.g. global warming, intensity of the hydrological cycle, terrestrial carbon uptake).
- As major tools in climate research, it is important for climate models to be able to simulate these variations in SSR.
- The regional climate model MAR has recently been chosen to be part of the EURO-CORDEX project through the Belgian CORDEX project
  → **We investigate the ability of MAR to simulate SSR over 1900-2014 with respect to reanalyses**.

CONCLUSION

- MAR is able to simulate the interannual variations in SSR more accurately than the reanalyses.
- The different forcing reanalyses can drive divergent trends despite even if, contrary to global climate models, they assimilate observations and are supposed to represent the same climate.
- The reanalyses covering the entire 20th century (ERA-20C and 20CRV2C) do not simulate the past decadal variations in SSR.
- Aerosols should be better taken into account by MAR to improve our results.

1. The MAR model and simulations

- The "**M**odèle **A**tmosphérique **R**égional" is a hydrostatic model.
- MAR is forced every 6h at its boundaries by GCM outputs or reanalyses (**Figure 1**).

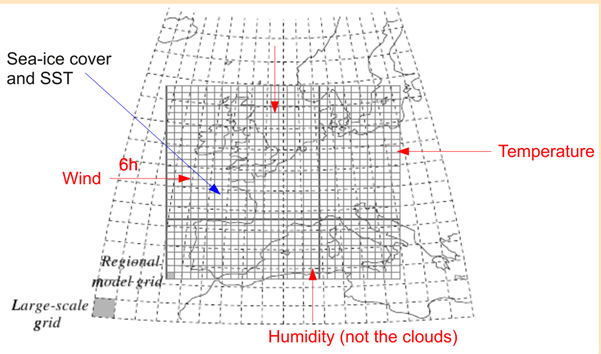

Figure 1: NESTING of input into the MAR integration domain

- 4 reanalyses were used as MAR forcings:
  - ERA40 (1958–1978)/ERA-interim (1979–2014)
  - NCEP/NCAR-v1 (1948–2014)
  - ERA-20C (1900–2010)
  - 20CRV2C (1900–2010)
- Simulations were performed at a resolution of 5 km over Belgium (**Figure 2**).

2. Observations

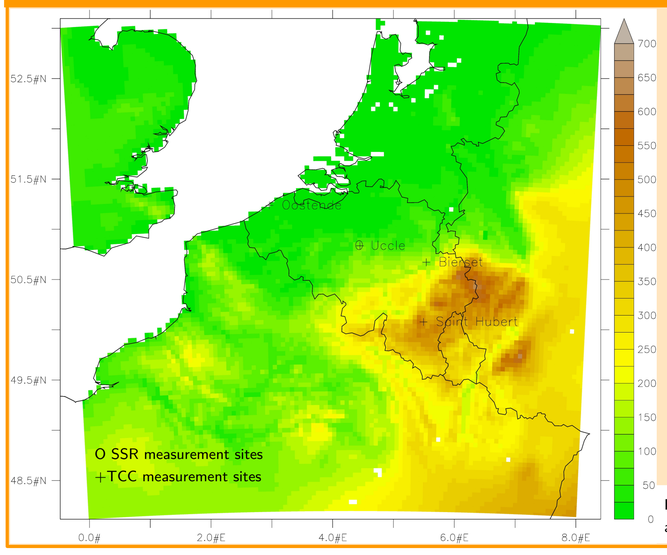

Figure 2: Integration domain and orography from MAR, and location of SSR and TCC measurement sites

- SSR data (1 station)
  → GEBA
- Cloud cover (TCC) data (4 stations)
  → Belgocontrol and RMI
- 1966-2007

3. MAR vs reanalyses vs observations

SSR (Figure 3)

- Correlation (R) between MAR and observations reaches 0.84 (MAR-ERA) while it only reaches 0.70 (20CRV2C) between the reanalyses and observations.
- MAR mean biases (MB) range from +0.2 to +4.9 W m^{-2} yr^{-1} while reanalysis MB range from +34.4 to +55.5 W m^{-2} yr^{-1}.

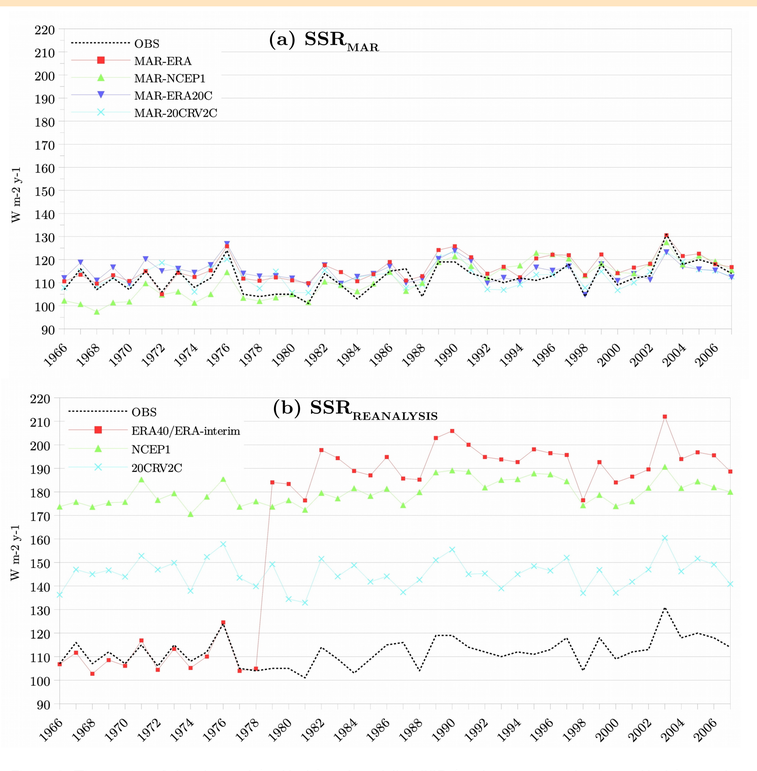

Figure 3: Time series of the observed (at Uccle) and modelled SSR (at the nearest grid point to Uccle) over the period 1966-2007. SSR data from ERA-20C were not available.

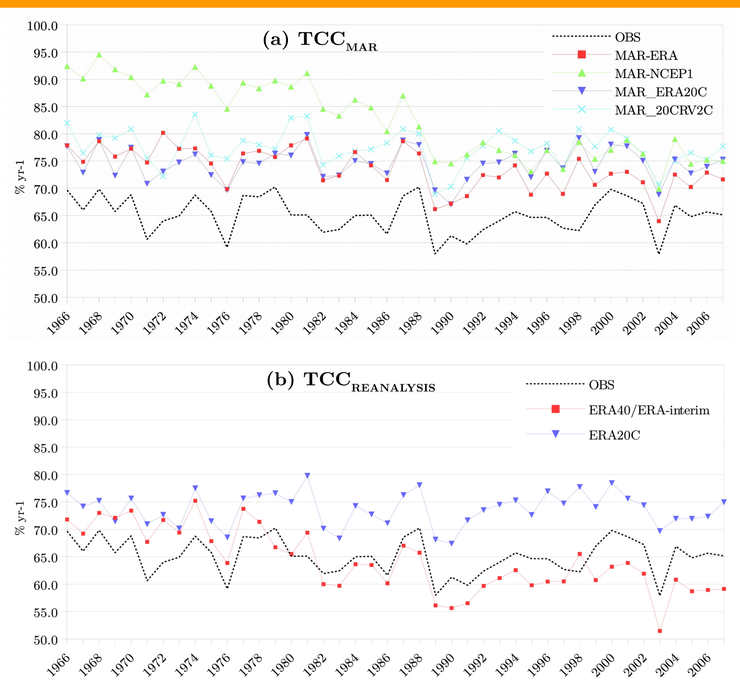

Figure 4: Time series of the observed (at Bierset) and modelled TCC (at the nearest grid point to Bierset) over the period 1966-2007. TCC data from NCEP/NCAR-v1 and 20CRV2C were not available.

TCC (Figure 4)

- R between MAR and observations reaches 0.72 (MAR-ERA) and MB range from +5 and +15%.
- Reanalyses present results similar to MAR.
- SSR biases are mainly explained by biases in TCC.
  - Bias differences in SSR between MAR and the reanalyses are mainly explained by more reflective clouds in MAR.
  - Cloud reflectivity was also larger in ERA40 than in ERA-interim.

Linear trends over 1966-2007 (Table 1)

- MAR forced by the reanalyses covering the entire 20th century (MAR-ERA-20C and MAR-20CRV2C) does not show the significant positive signal in SSR found in observations, MAR-ERA, and MAR-NCEP1.
- MAR overestimates the trends in SSR and TCC because it does not properly simulate neither the direct nor the indirect impact of aerosols on SSR.

	SSR (Uccle)		TCC (Uccle)	
	Trend (W m^{-2} yr^{-1})	Range	Trend (% yr^{-1})	Range
OBS	**0.20**	0.15	-0.05	0.08
MAR-ERA	**0.25**	0.11	**-0.15**	0.07
MAR-NCEP1	**0.53**	0.11	**-0.50**	0.08
MAR-ERA-20C	-0.01	0.11	-0.01	0.07
MAR-20CRV2C	0.07	0.12	-0.06	0.07
ERA40/ERA-interim	**2.62**	0.58	**-0.36**	0.09
Corrected ERA40/ERA-interim *	0.10	0.19		
NCEP1	**0.20**	0.12	n.a.	n.a.
ERA20C	n.a.	n.a.	-0.001	0.08
20CRV2C	0.04	0.16	n.a.	n.a.

** This time series was "corrected" by removing the mean bias of each part of the time series from the corresponding part (part 1: ERA40 from 1966 to 1978 ; part 2: ERA-interim from 1979 to 2007).*

Table 1: Trends and their uncertainty range of Snedecor for the 95th confidence interval computed over 1966-2007. The values in bold indicate that the trends are statistically significant, namely that they are larger than the associated uncertainty range.

4. Decadal trends over 1900-2014

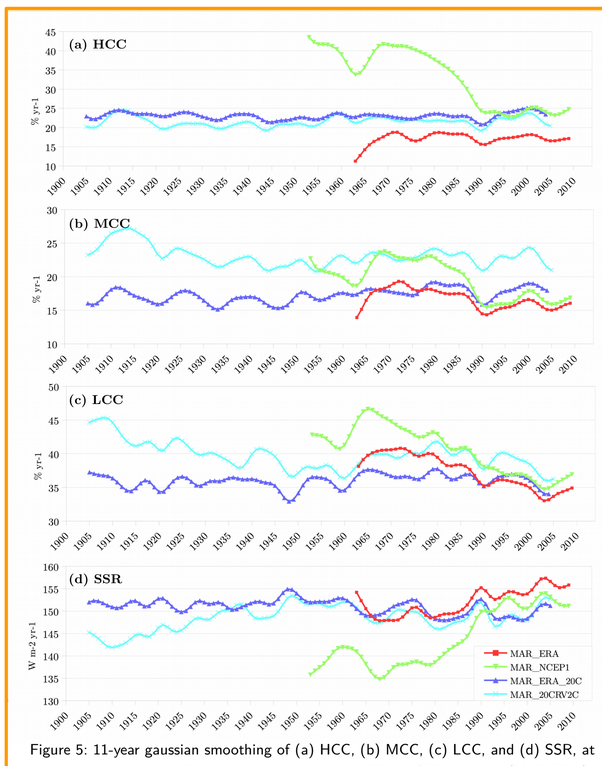

Figure 5: 11-year gaussian smoothing of (a) HCC, (b) MCC, (c) LCC, and (d) SSR, at Uccle, modelled by MAR forced by four reanalyses: ERA40/ERA-interim (MAR-ERA), NCEP/NCAR-v1 (MAR-NCEP1), ERA-20C (MAR-ERA20C), and 20CRV2C (MAR-20CRV2C).

Dimming and brightening (Figure 5)

- Contrary to MAR-ERA-20C and MAR-20CRV2C, MAR-ERA and MAR-NCEP1 simulate the historical dimming (1960-1985) and brightening (1985-).
- The dimming period is not as marked in MAR as in observations because aerosols are almost completely neglected in MAR.
- The increase in SSR over the brightening period results from a decrease in low cloud cover (LCC) and medium cloud cover (MCC).

Origin of cloud variations (Figure 6)

- The decrease in LCC and MCC coincides with increasing air temperature and decreasing specific humidity. This could result from:
  - A northward shift of the polar jet which could induce more frequent advections of tropical air.
  - The decrease in aerosol atmospheric concentration which could inhibit cloud development. Less clouds induce higher temperature and lower relative humidity.

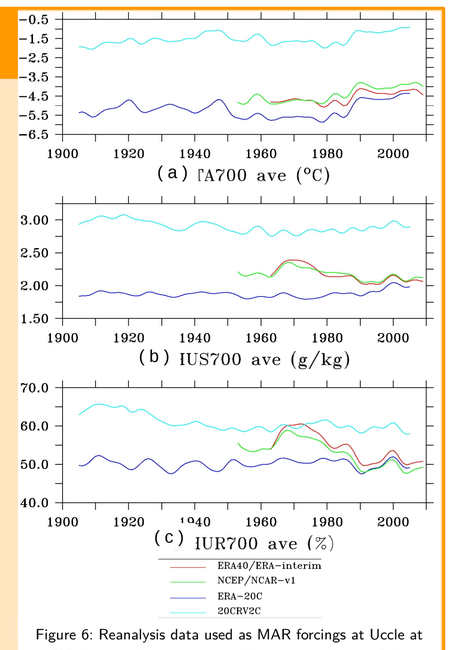

Figure 6: Reanalysis data used as MAR forcings at Uccle at 700hPa (a) air temperature (TA), (b) specific humidity (HUS), (c) relative humidity (HUR).

References

Wild M, 2009: Global dimming and brightening: A review. J. Geophys. Res., 114, D00D16. doi:10.1029/2008JD011470.

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EMS Annual Meeting: European Conference for Applied Meteorology and Climatology 2017 | 4–8 September 2017 | Dublin, Ireland