Comparison against satellite radiation data

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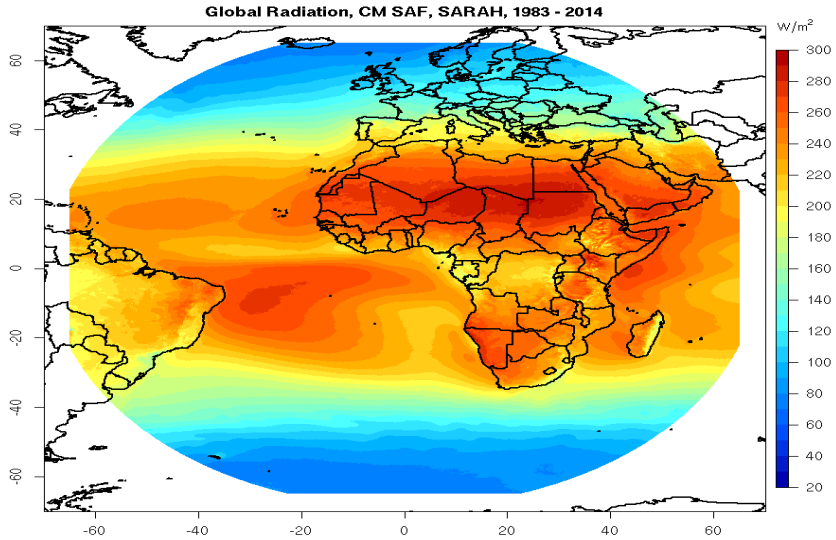
Outline

- References used: SAHRA SIS by CM SAF and HelioMont by MeteoSwiss
- Reanalyses used: COSMO-REA6/-REA12, UKMO, HARMONIE, MESCAN
- Annual and monthly data used for year 2008
- Results
  - Biases over the European and Alpine Region
  - Correlation and RMSE

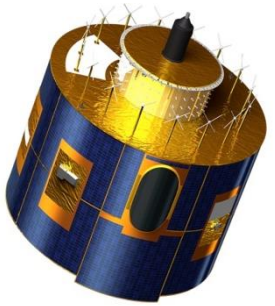
Surface Solar Radiation Dataset – Heliosat (SARAH)

- **Variables**
  - Global irradiance (SIS)
  - Surface Direct Irradiance (DNI, SID)
  - Effective cloud albedo (CAL)
- **Resolution**
  - Spatial: 0.05° × 0.05°
  - Temporal: instant and hourly means, daily means, monthly means
- **Coverage**
  - Spatial: METEOSAT-Prime Full disk
  - Temporal: 1983 to 2015



- **Satellites / Instruments**
  - METEOSAT 2 to 10 (MVIRI / SEVIRI)

Meteosat Second Generation
HelioMont Solar Radiation Climatology

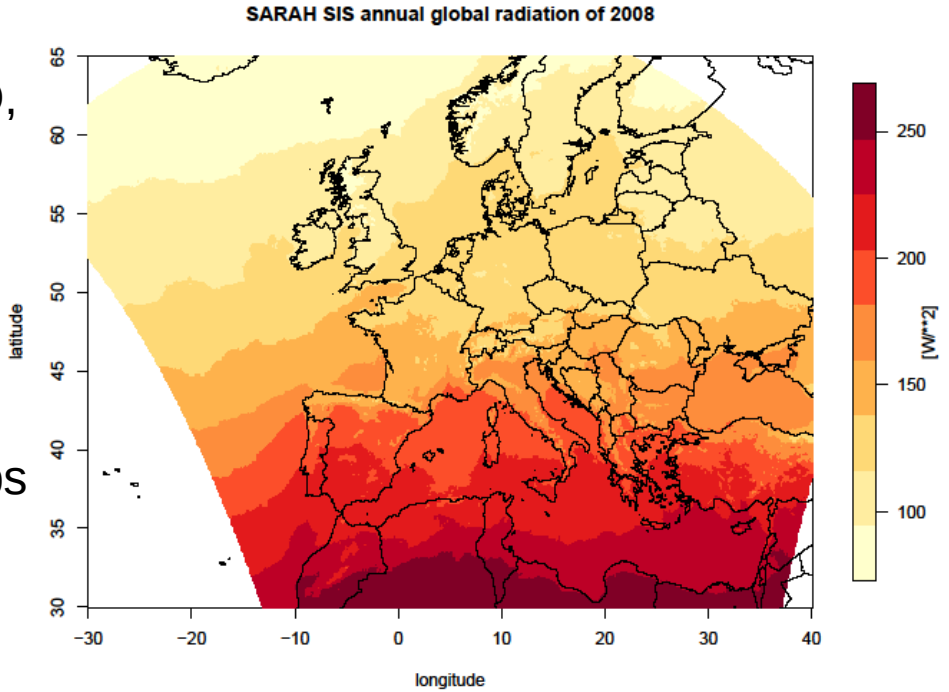


- Multi-channel algorithm with cloud-snow separation, terrain shadow, snow radiative effects, radiative transfer model
  1. Physically-based Model of the Atmosphere and Clouds
  2. Separate Clouds from Snow
  3. Exploit high temporal resolution of Geostationary Satellite data
  4. Calculate Topographic Effects
- **Coverage:** 2004 – now, Alps (Europe, Africa on request)
- **Resolution:** 15' – yearly, 25 m – 2 km
- **Uncertainty:** 5-10 W m^{-2} for monthly means

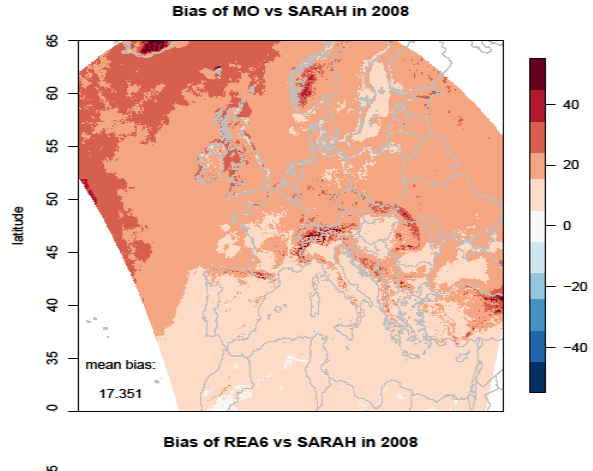
R. Stöckli (2013). The HelioMont Surface Solar Radiation Processing. Scientific Report 93, MeteoSwiss, 122 pp.

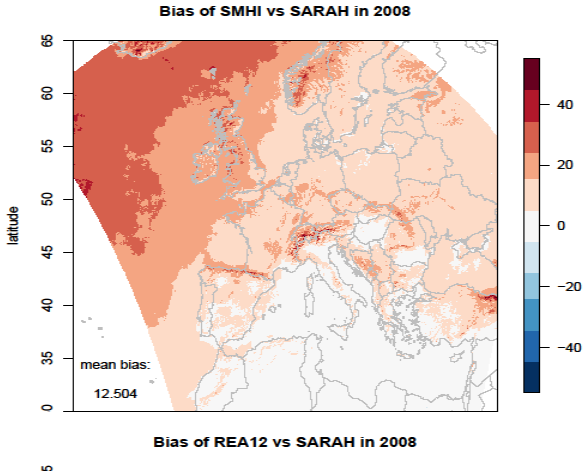
Evaluation method

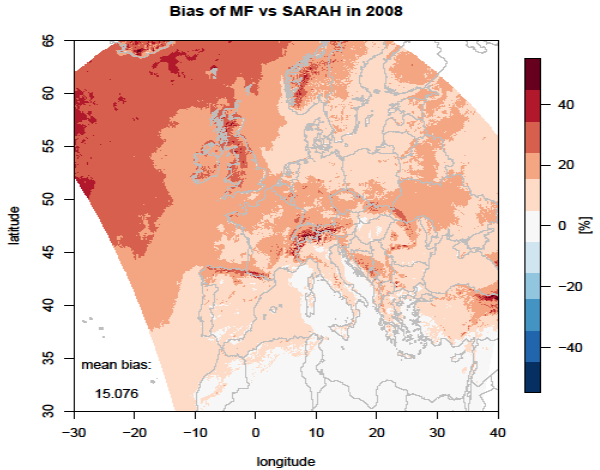
- C-REA6, C-REA12, SMHI, MF, UKMO, and SARAH SIS
- Common grid of 0.1° spatial resolution
- Common spatial coverage (domain)
- Common temporal coverage: 2008
- Convert Js to W/m^2 at hourly time steps

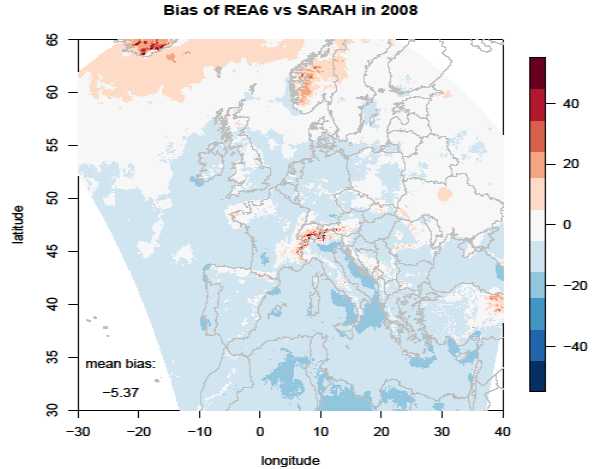


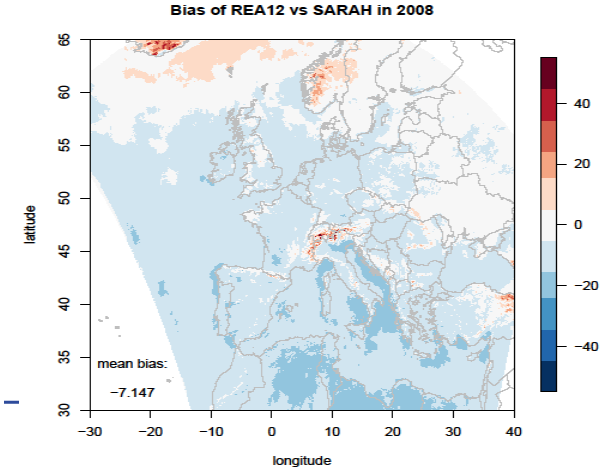
Annual bias – European domain





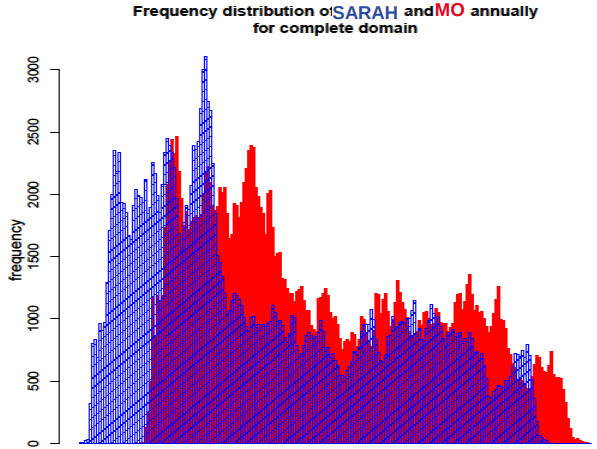


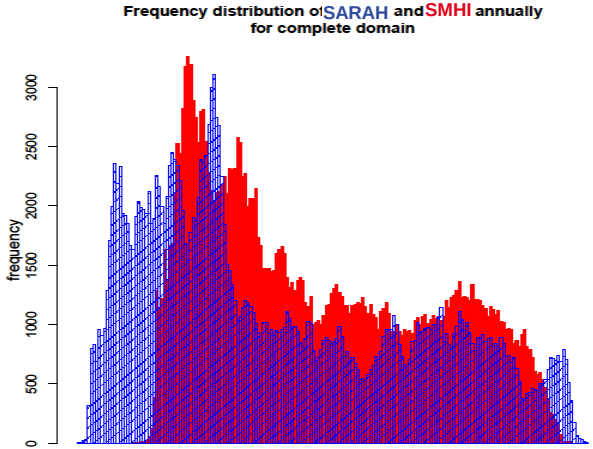


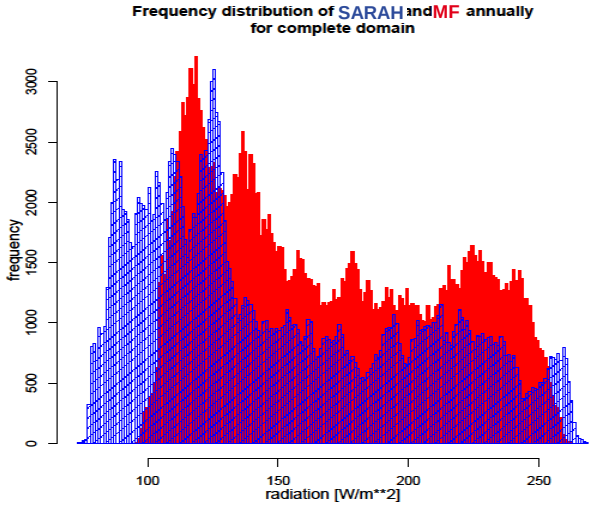


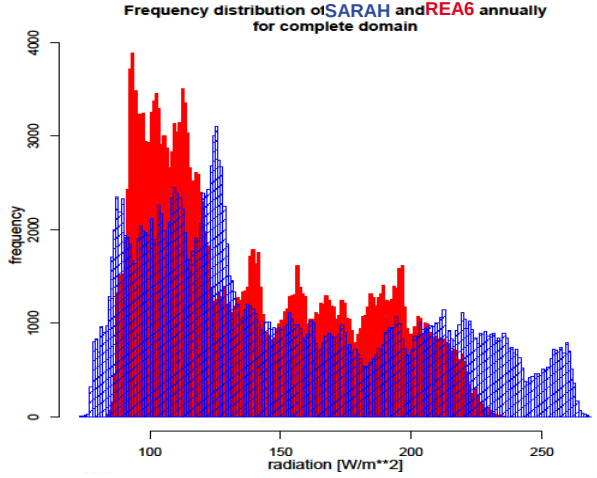
- Overestimation over the North Atlantic for UKMO, SMHI, MF
- Underestimation over western Europe and Mediterranean for REA6 and REA12

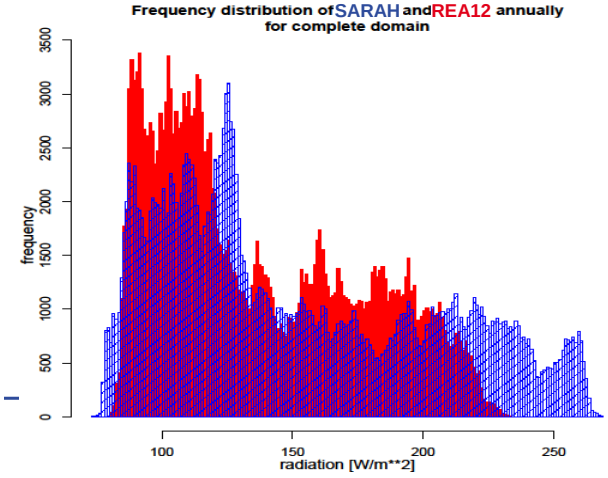
Annual frequency distribution







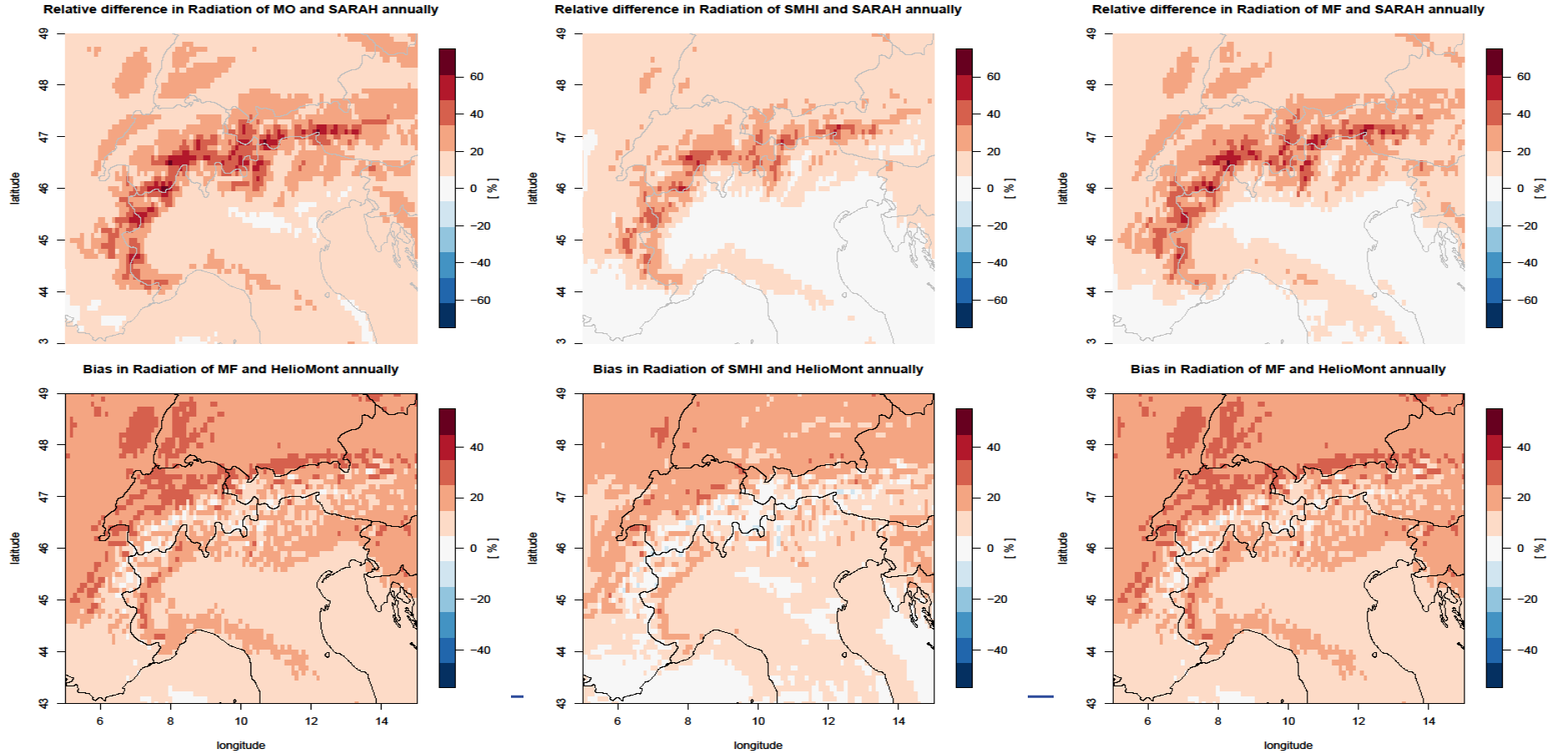




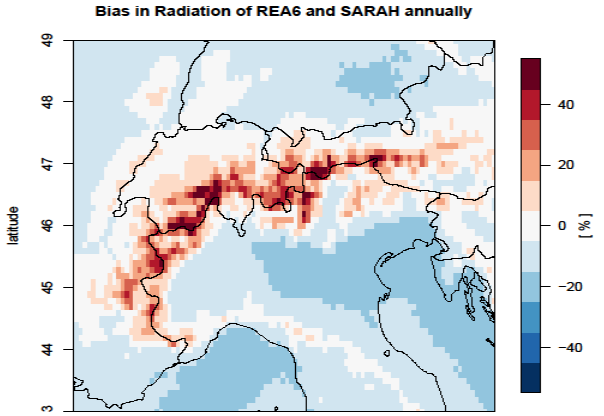
- Overestimation of low values for UKMO, SMHI, MF
- Underestimation of high values for REA6 and REA12

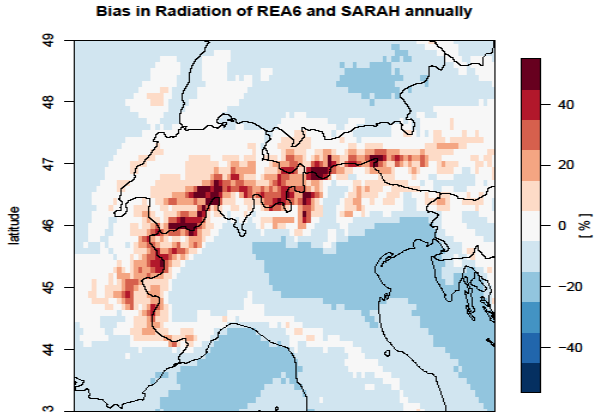
Annual bias – Alpine region

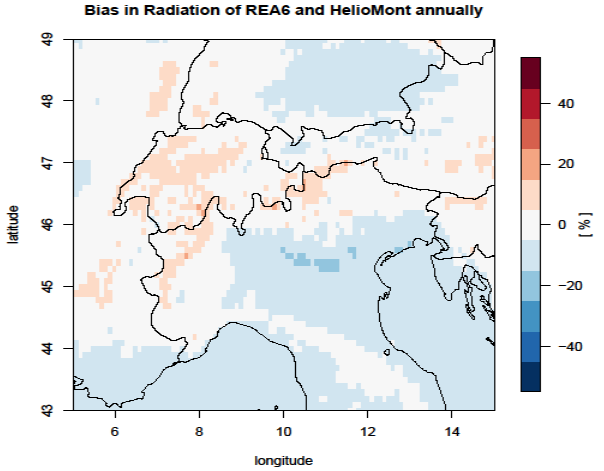
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

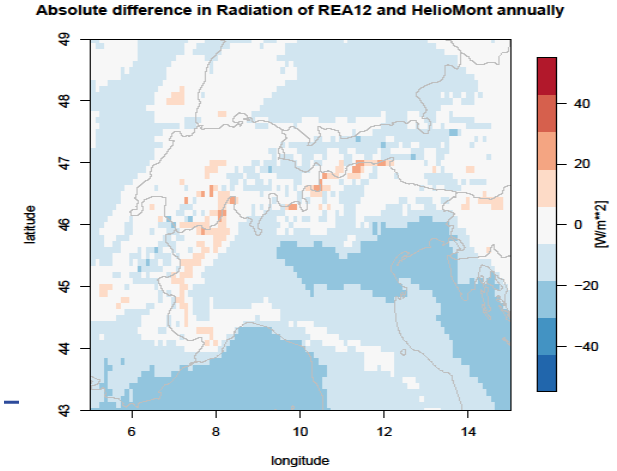


Annual bias – Alpine region





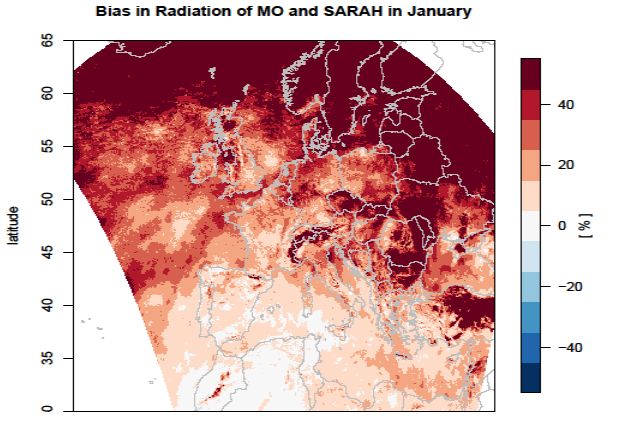


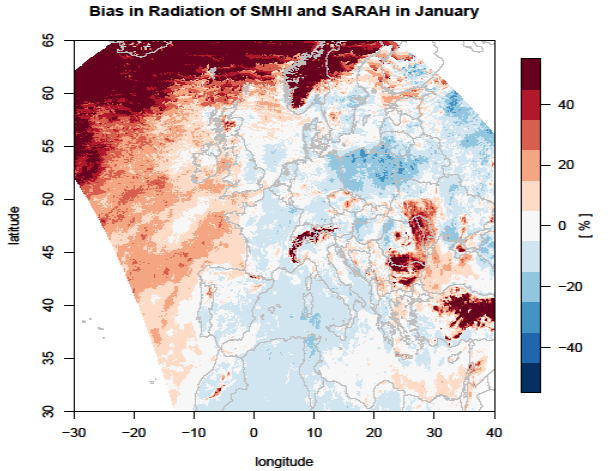


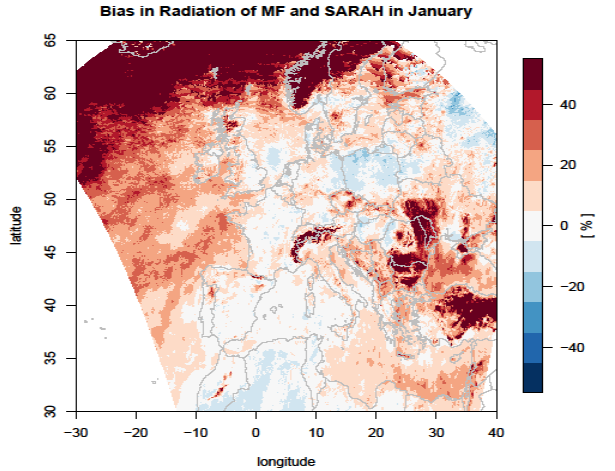
- Over snow and mountainous regions HelioMont performs much better than SARAH SIS
- HelioMont does not perform better elsewhere (sometimes even worse)
- Next step:
  - Evaluate at BSRN point measurements

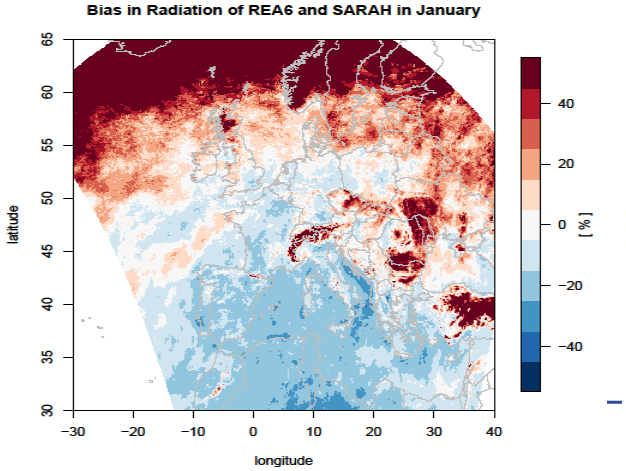
Comparison in January

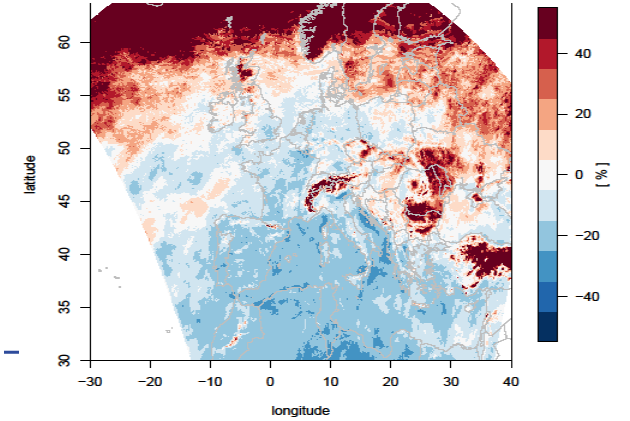
Deutscher Wetterdienst
Wetter und Klima aus einer Hand







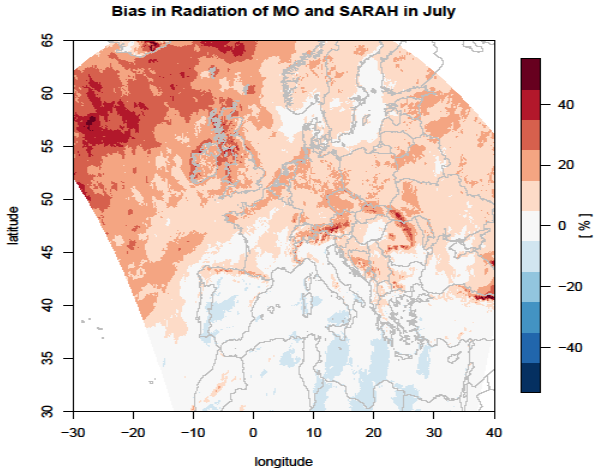


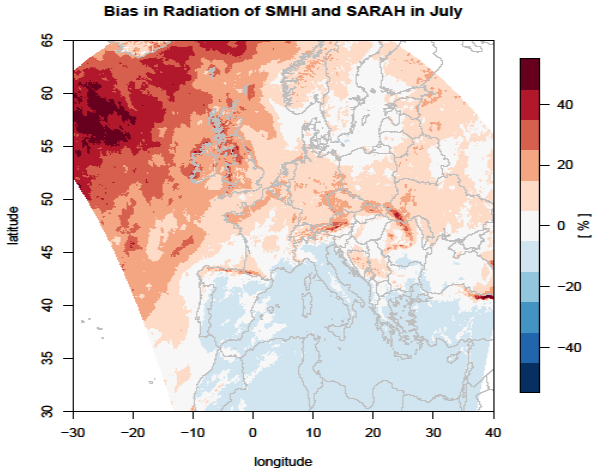


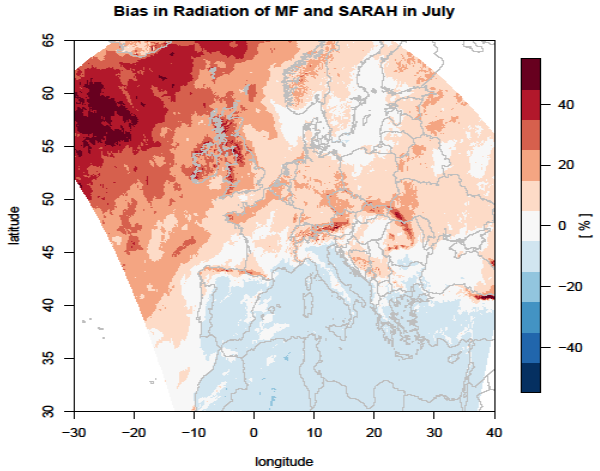
- Reference unusable north of 60° in winter and snow-covered regions
- Strong overestimation over the North Atlantic (also by C-REA)
- Underestimation of SMHI and C-REA over central Europe, Med and North Africa

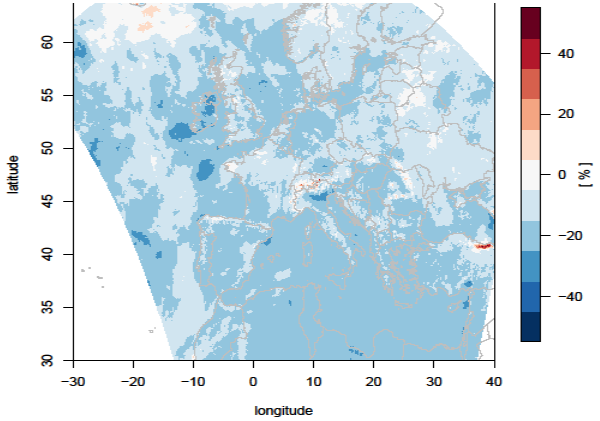
Comparison in July

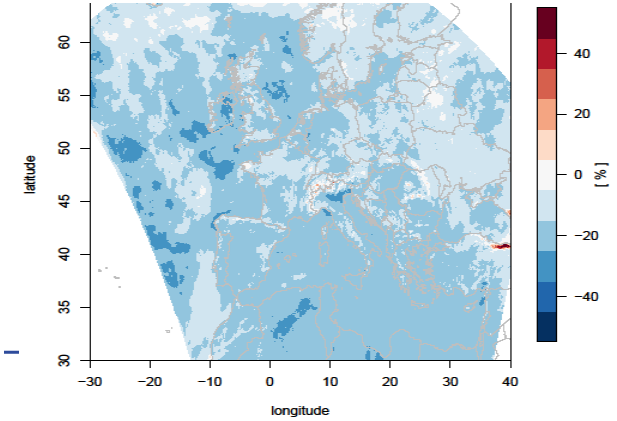
Deutscher Wetterdienst
Wetter und Klima aus einer Hand









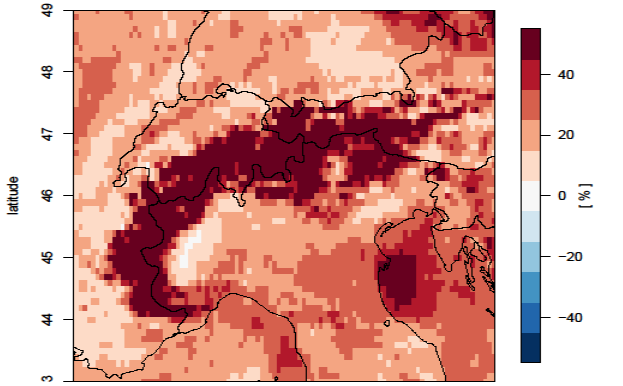


- Strong overestimation over the North Atlantic of MO, SMHI, MF
- Slight underestimation of SMHI and MF over Med and North Africa
- Underestimation of REA6 and REA12 overall

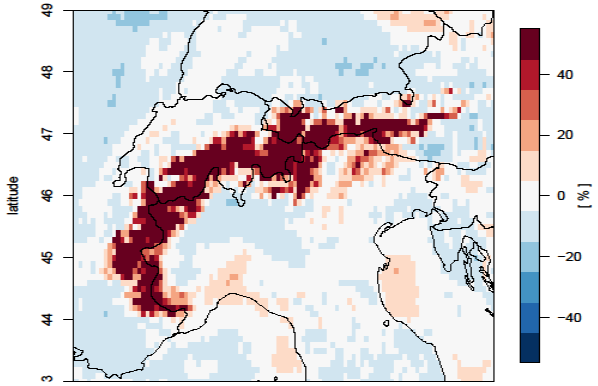
Comparison in January – The Alpes

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

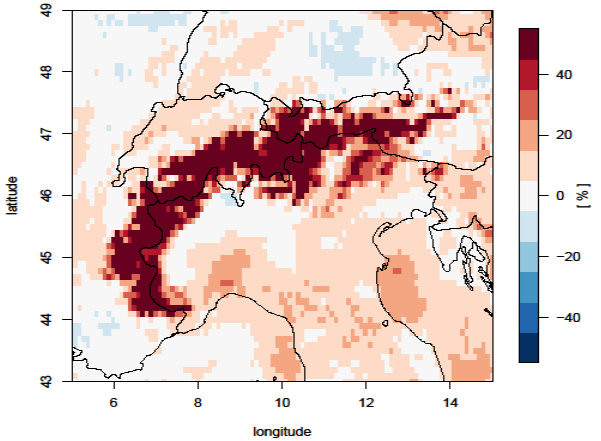
Bias in Radiation of MO and SARAH in January



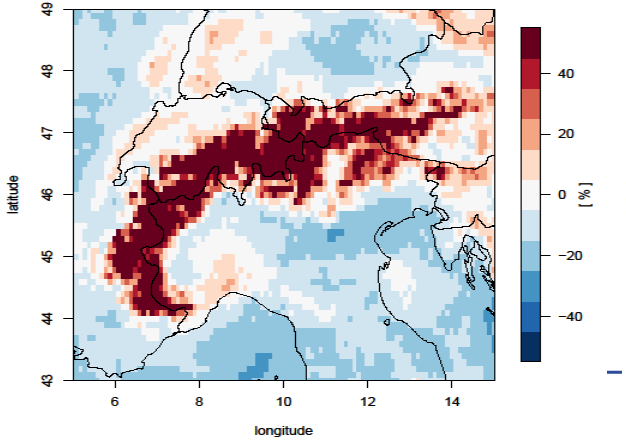
Bias in Radiation of SMHI and SARAH in January



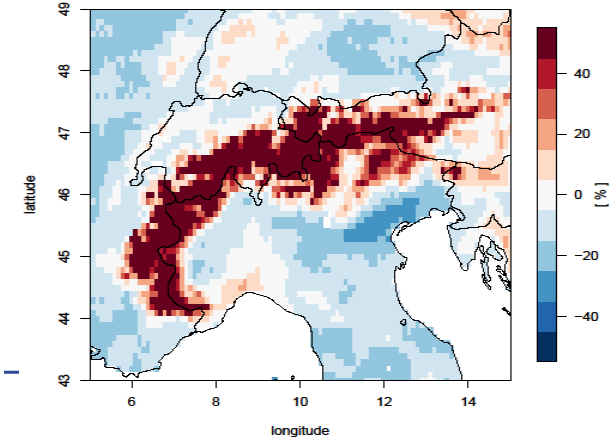
Bias in Radiation of MF and SARAH in January



Bias in Radiation of REA6 and SARAH in January

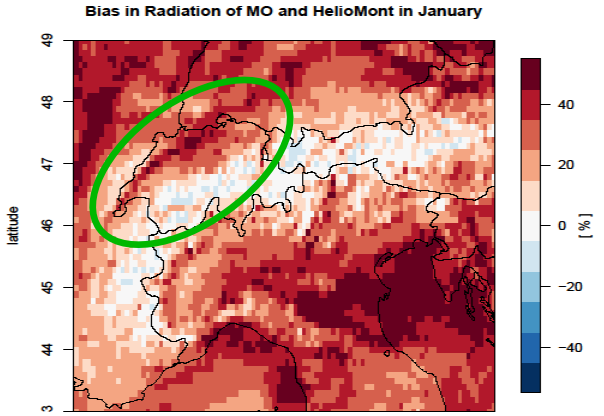


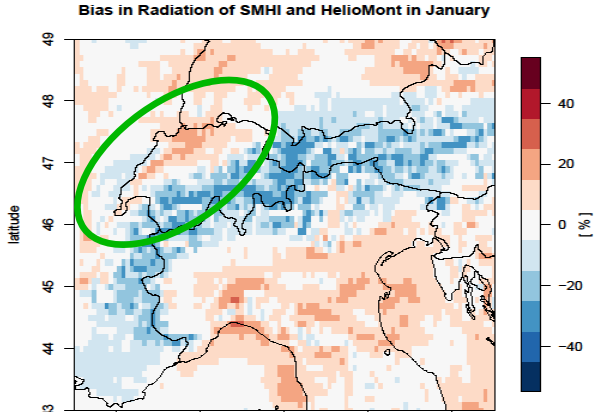
Bias in Radiation of REA12 and SARAH in January

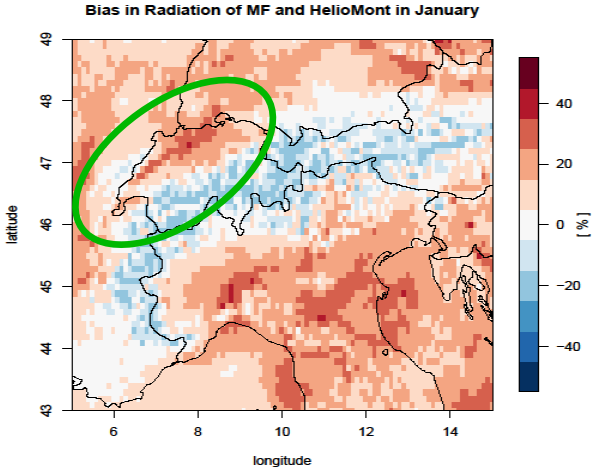


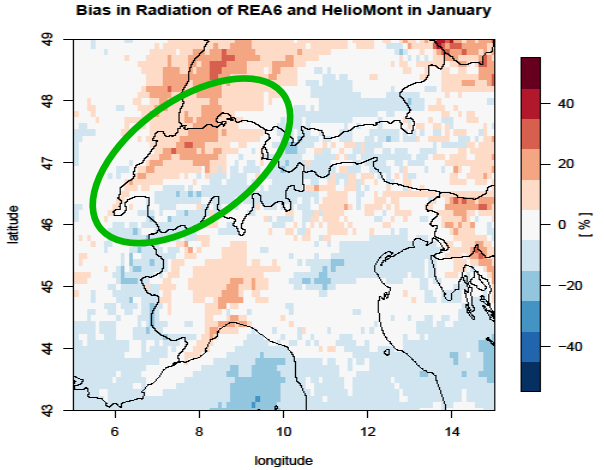
Comparison in January – The Alpes

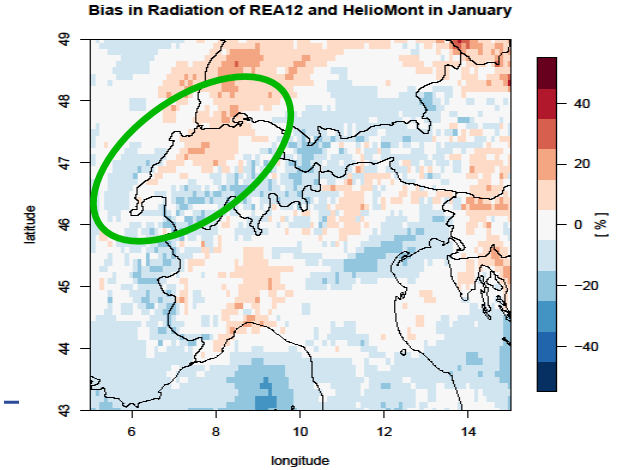
Deutscher Wetterdienst
Wetter und Klima aus einer Hand











- HelioMont is a better reference over snowy and mountainous regions
- HelioMont does not perform better elsewhere, showing in increased biases

Comparison in July – The Alpes

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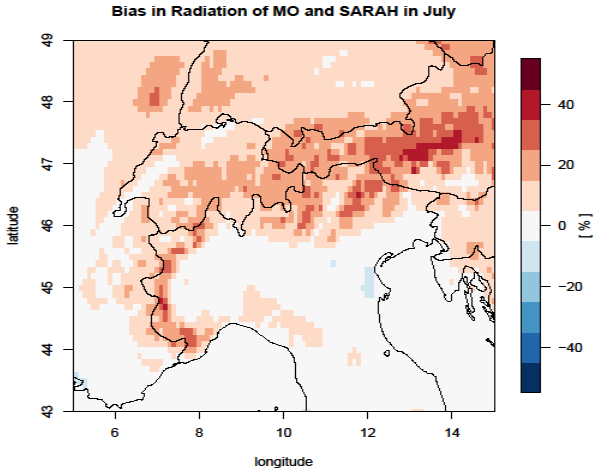
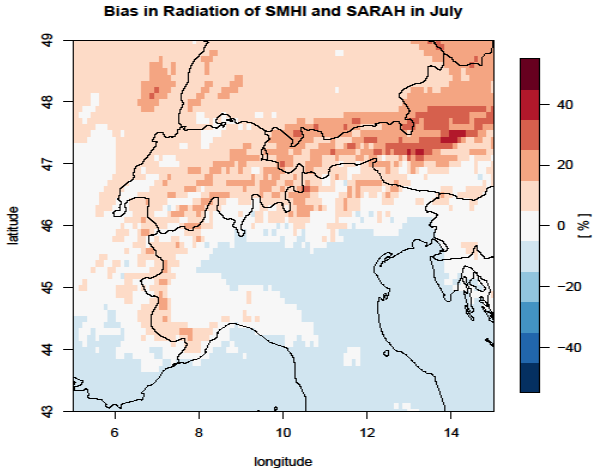
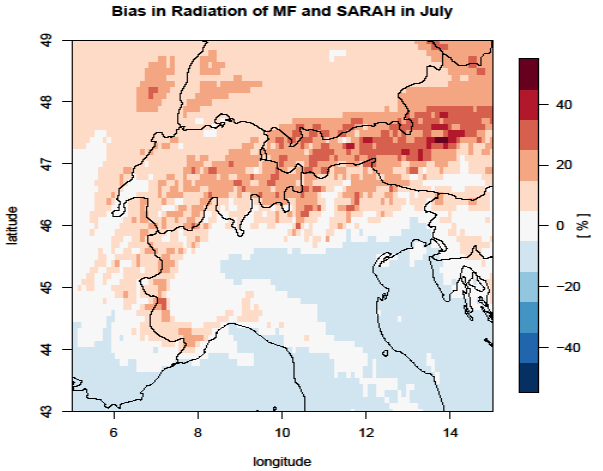
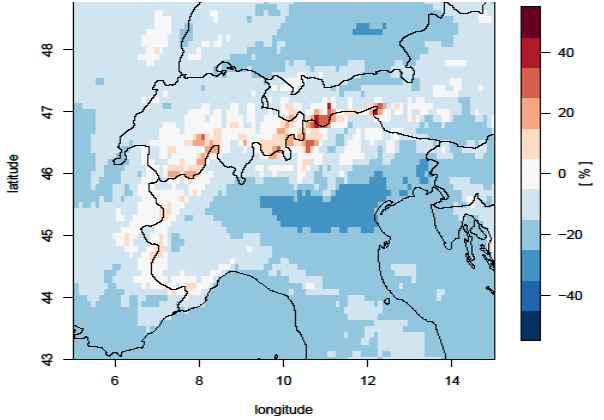
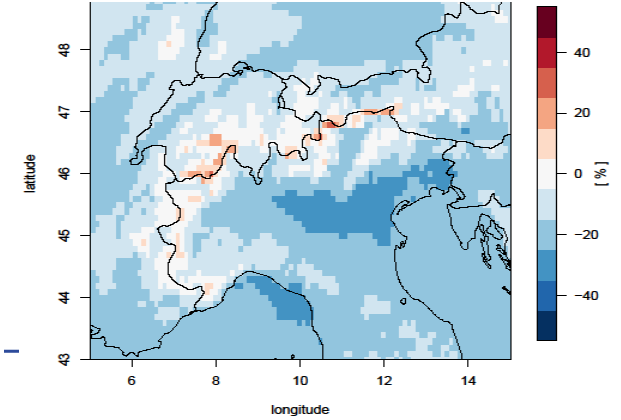
Wetter und Klima aus einer Hand





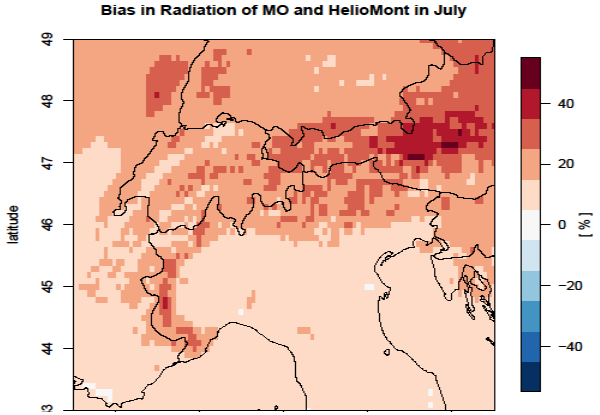


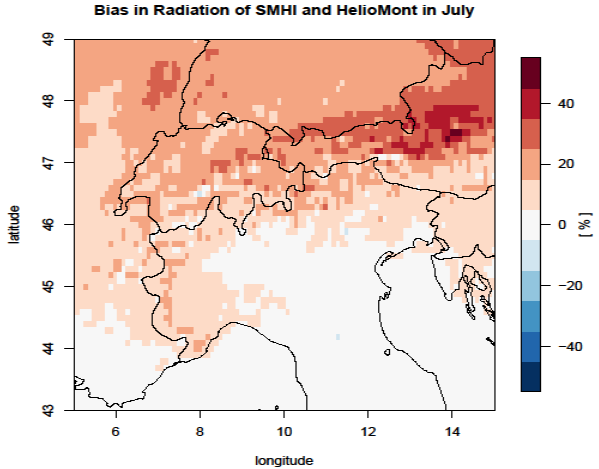


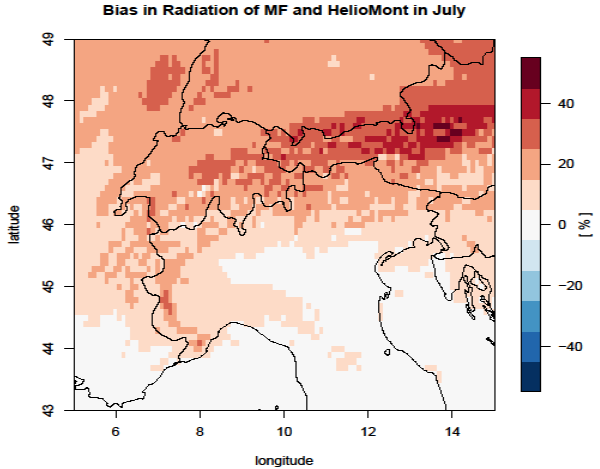


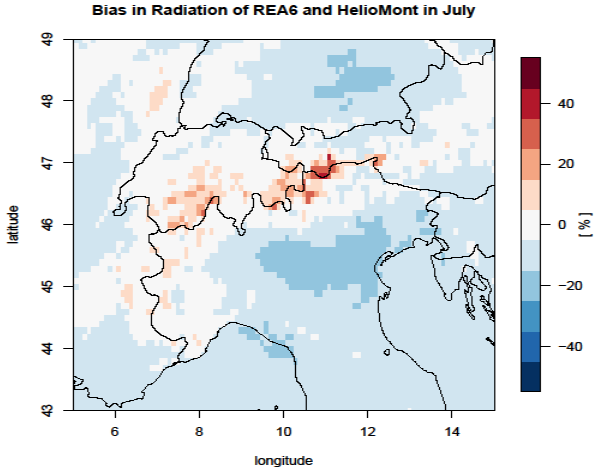
Comparison in July – The Alpes

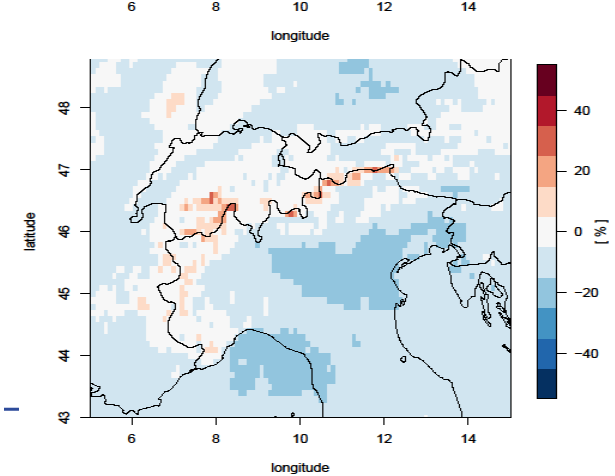
Deutscher Wetterdienst
Wetter und Klima aus einer Hand









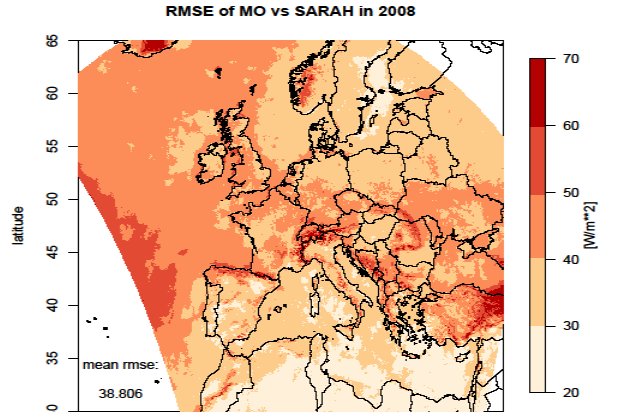


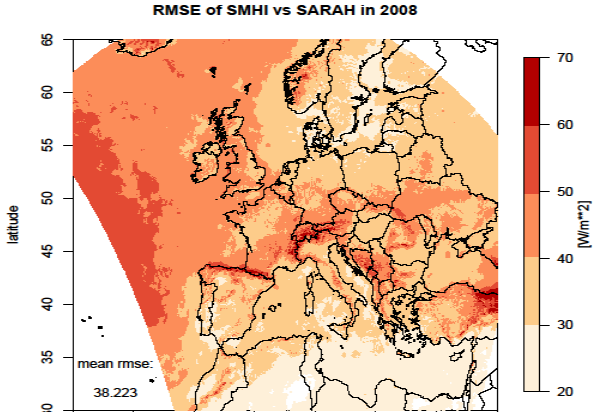
- In summer, there does not seem to be a noticeable advantage of the HelioMont reference
- Outside the Alpine ridge, the bias increases

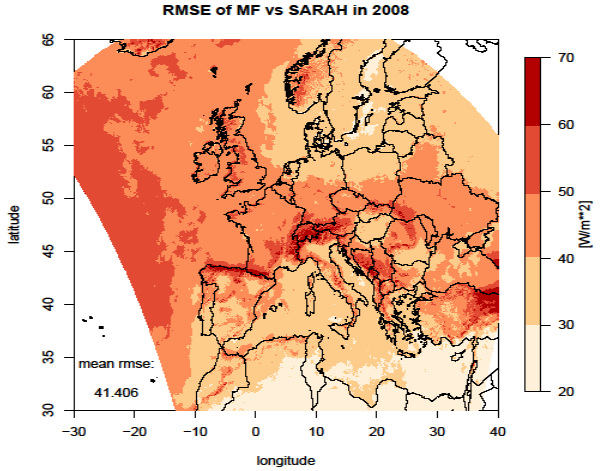
Summary for the bias

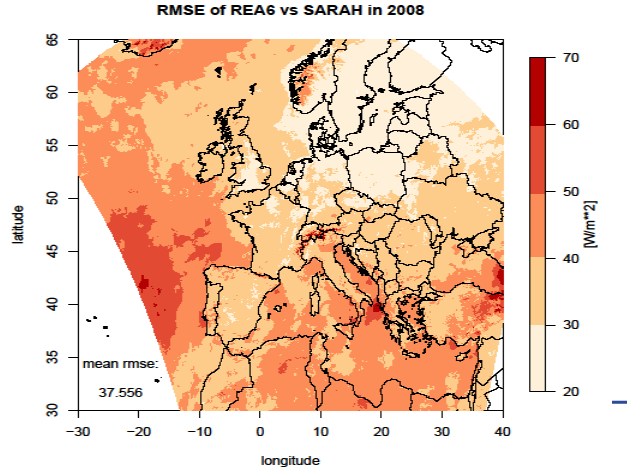
- ➔ It is very difficult to find a good (spatial) reference for all domains, times and situations.
- ➔ Maybe we are at the point where the reanalyses help to estimate the quality of the reference data.

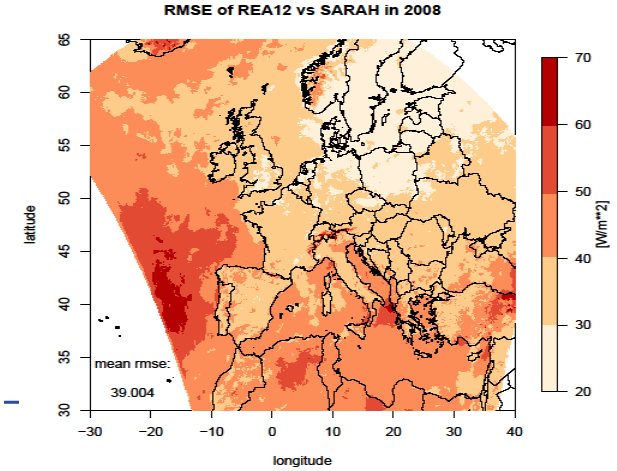
Annual RMSE





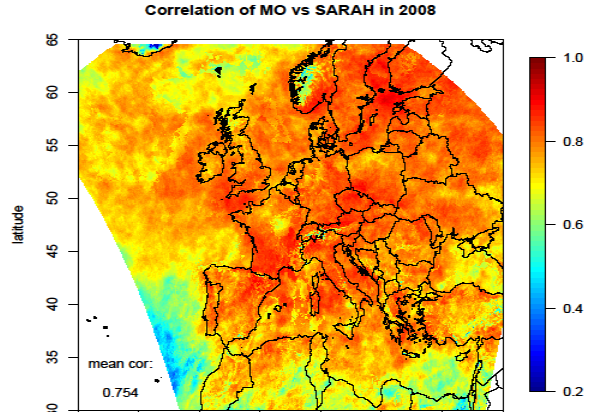


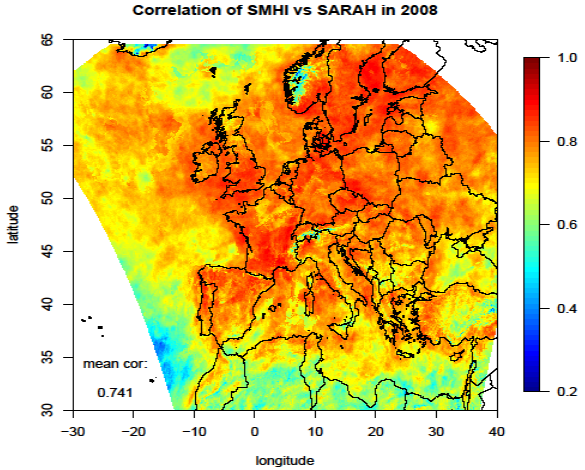


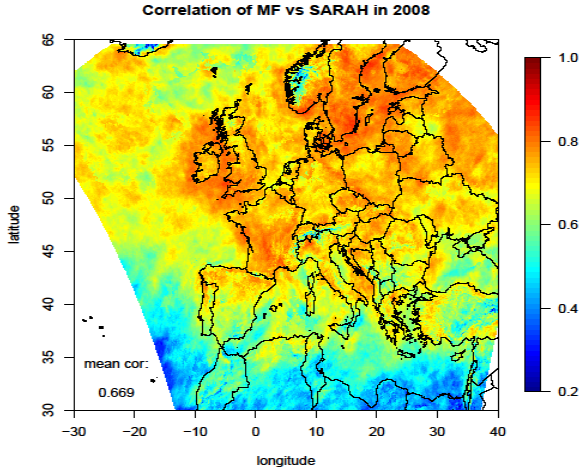


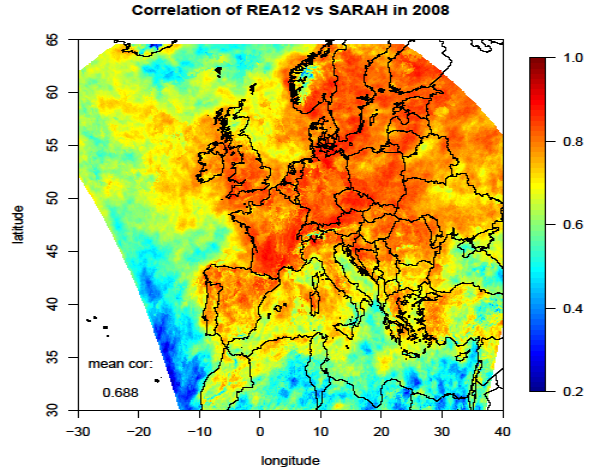
- RMSE is lowest over North Africa for UKMO, SMHI, MF
- RMSE is lowest over Northeast Europe for C-REA
- RMSE is largest over mountainous regions and the North Atlantic for all RRAs

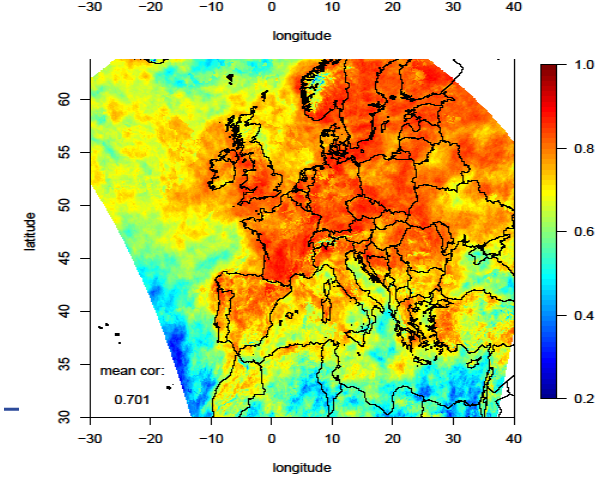
Annual correlation











- Correlation is larger over land than over the ocean
- Over most land areas it is >0.8 except for MF
- MO and SMHI extent of >0.8 correlation over North Sea and North Atlantic

Summary

➔ Choice of independent reference data is important and neither easy nor obvious

- With different reference data, different quality aspects may be investigated

➔ Quality of RRA depends on product, time, and location

- Overestimation over the North Atlantic for UKMO, SMHI, MF
- Underestimation over western Europe and Mediterranean for REA6 and REA12
- RMSE is lowest over North Africa for UKMO, SMHI, MF
- RMSE is lowest over Northeast Europe for C-REA
- RMSE is largest over mountainous regions and the North Atlantic for all RRAs
- Correlation is larger over land than over the ocean
- Over most land areas it is >0.8 except for MF
- MO and SMHI extent of >0.8 correlation over North Sea and North Atlantic

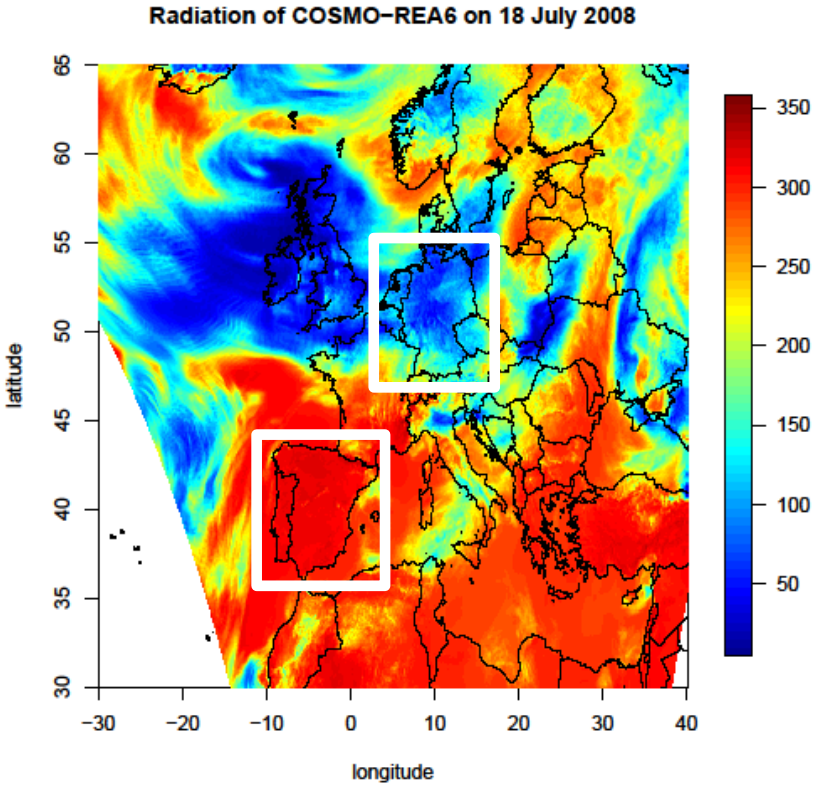
Outlook and future work

- ➔ Include ERA5 (ERA-Interim) into this analysis
- ➔ Perform point-wise independent evaluation on BSRN stations (has been done to evaluate the reference products)
- ➔ Perform long-term climatological analysis

Thank you for your attention

Daily means

- Fairer comparison with other RRAs in mind: use daily means
- Area mean over Germany and Iberian Peninsula
- Using SMHI and REA6 for this evaluation



Annual cycle of daily means