Characterization and correction of the spatio-temporal mismatch between satellite and in situ measurements

INTRODUCTION

Satellite and in situ sensors do not observe the same measurand. This introduces a mismatch between both types of measurements in the spatial, temporal & spectral domains. The mismatch can be the dominant component in the comparison and needs to be removed for validating satellite products.

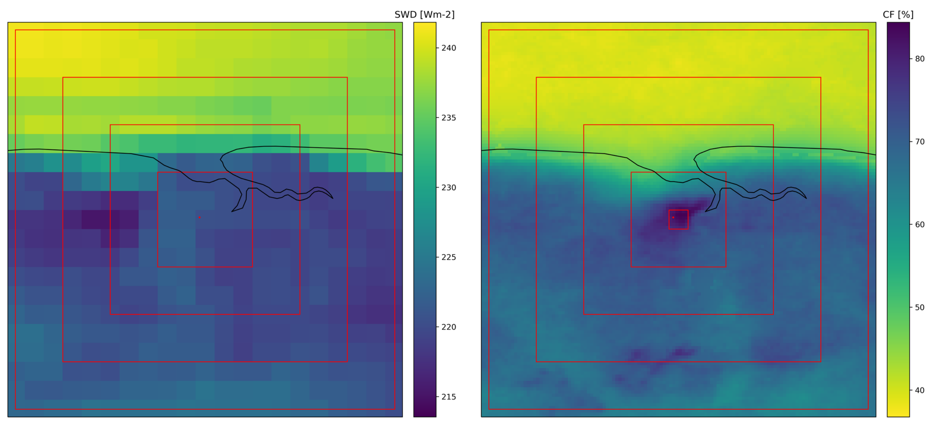
GOAL: Propose a general methodology to characterize and correct the mismatch between satellite and in situ measurements using independent high-resolution products.

CASE STUDY: shortwave downwelling radiation (SWD). In-situ measurements (BSRN), satellite observations to be validated (NASA/GEWEX, 1x1deg), high-resolution product (SARAH-2 0.05x0.05deg). The poster analyzes the spatial mismatch at 3 BSRN stations. The temporal domain & all BSRN stations are analyzed in the upcoming manuscript.

MISMATCH CHARACTERIZATION

mismatch = highres product mean inside the satellite pixel validated – highres product mean inside the extent covered by the in situ sensor

- Mismatch = smoothing (≠ resolution, *points*) + sampling (≠ alignment, *errorbars*)
- Analysis at different spatial and temporal scales.
- Main driver of solar radiation mismatch: cloud cover variability.

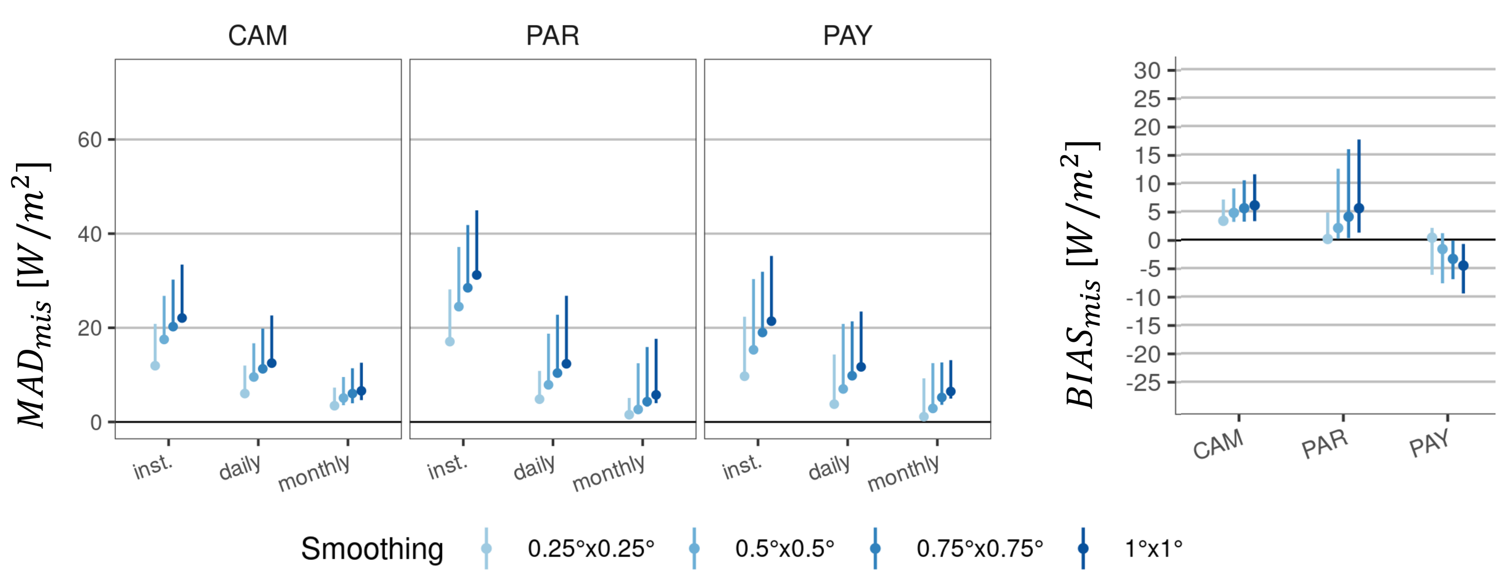


Correlation between
- solar radiation variability (left)
- cloud cover variability (right)

in a 1x1deg square around the station

MISMATCH METRICS: BIAS, SD (standard deviation), MAD (mean abs difference)

(metrics derived from the PDF of repeated mismatch estimates over time)

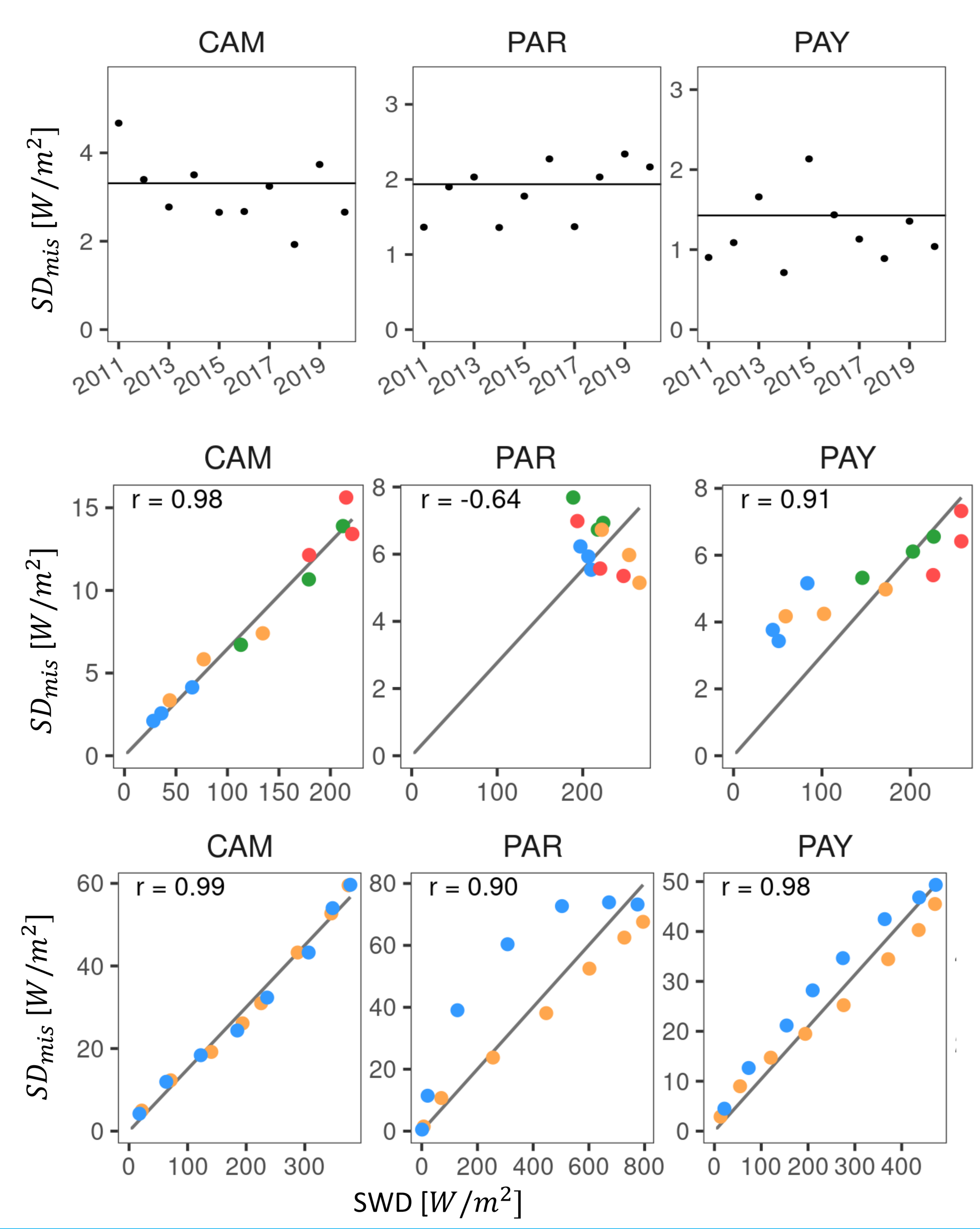


TEMPORAL EVOLUTION OF THE MISMATCH

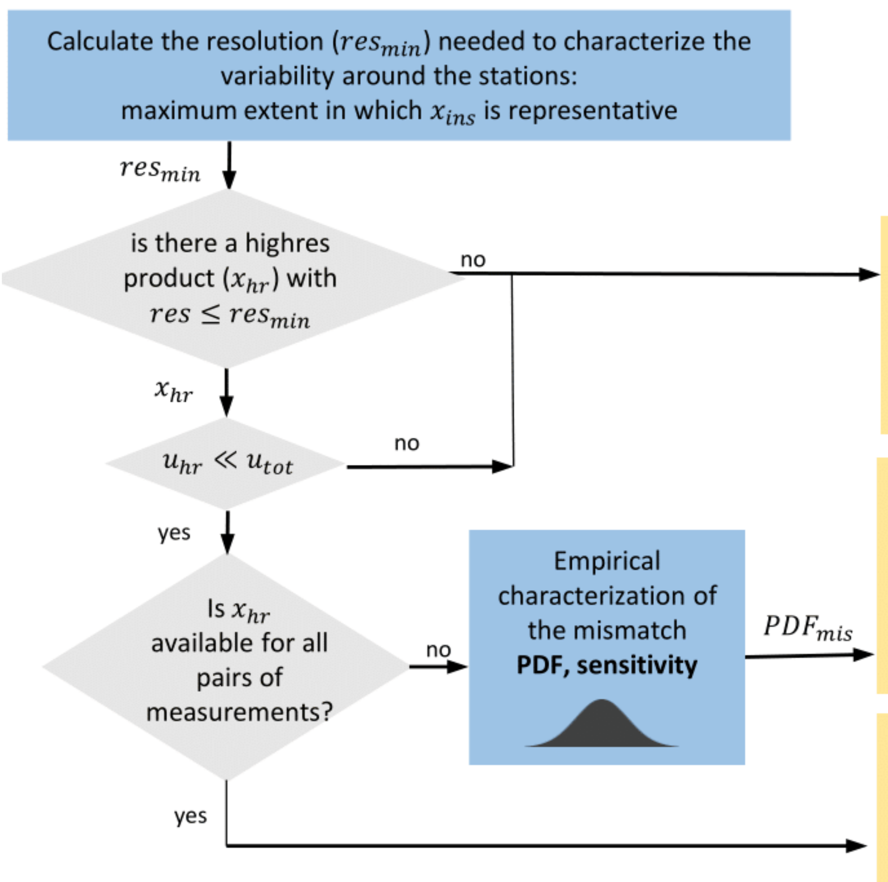
Year-to-year
only random variations, 5 years are sufficient to characterize them.

Seasonal
non-linear variation at many sites, driven by the monthly cloudiness (local climatological patterns).

Diurnal
non-linear variation at many sites, with a typically larger mismatch in afternoons than in mornings due to increasing cloudiness during the day



METHODOLOGY



x_{ins} = insitu measurement
x_{sat} = satellite measurement
x_{hr} = high-res measurement
δ_{mis} = mismatch
u = uncertainty

No correction

$$\delta_{tot} = x_{sat} - x_{ins} + \delta_{mis}$$

$$u_{tot} = \sqrt{u_{ins}^2 + u_{sat}^2 + u_{mis}^2}$$

Correction type B: model to extrapolate mismatch correction

$$\delta_{tot} = x_{sat} - x_{ins,corB} + \delta_{mis,rnd} \quad \text{with } x_{ins,corB} = f(x_{ins}, PDF_{mis})$$

$$u_{tot} = \sqrt{u_{ins,corB}^2 + u_{sat}^2 + u_{mis,rnd}^2} \quad \text{with } u_{ins,corB} = f(u_{ins}, u_{hres})$$

Correction type A: mismatch correction fully based on x_{hr}

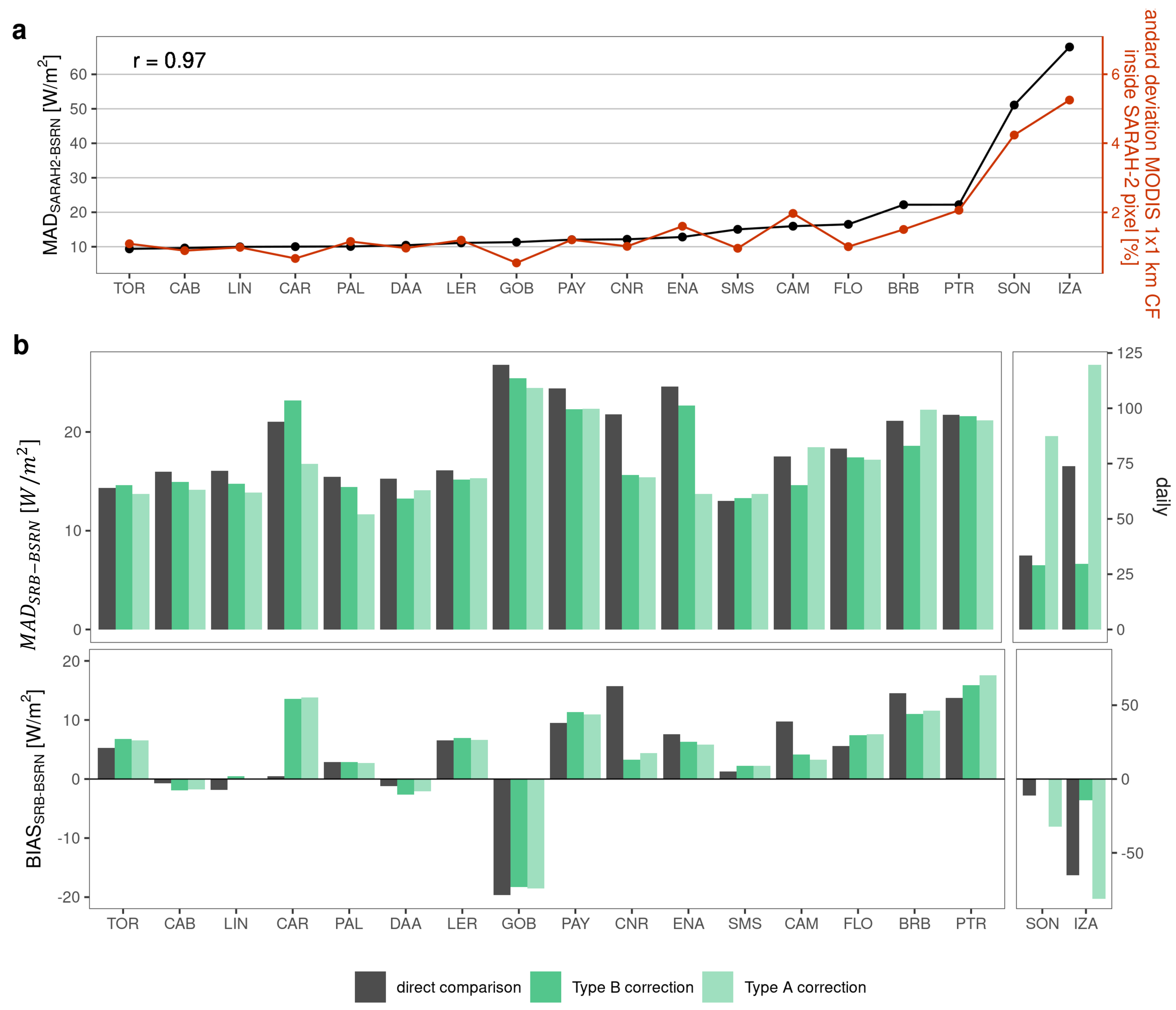
$$\delta_{tot} = x_{sat} - x_{ins,corA} \quad \text{with } x_{ins,corA} = f(x_{ins}, x_{hr})$$

$$u_{tot} = \sqrt{u_{ins,corA}^2 + u_{sat}^2} \quad \text{with } u_{ins,corA} = f(u_{ins}, u_{hr})$$

MISMATCH CORRECTION

High-resolution data co-simultaneous with all pairs of measurements compared ?

- Yes: TYPE A correction. Individual correction (upscaling) factor for each pair of measurements
- No: TYPE B correction. Characterize the mismatch in the period when highres data is available and train a model to extrapolate the mismatch outside this period.



- TYPE A correction yields better results at stations where the quality of highres data is good (removing both random & systematic mismatch), but is worse than direct comparison at stations where the quality of highres data decreases (fully propagating the uncertainty of highres product to the corrections).
- TYPE B only removes the systematic part of the mismatch, but is more robust to the quality of highres measurements (improving the direct comparison in almost all stations).
- Removing the mismatch can increase the bias, as the mismatch bias can offset the true bias of the satellite product validated.

CONCLUSIONS & FUTURE WORK

- New methodology to characterize/correct the mismatch between satellite & in-situ measurements
  - Applicable to other domains besides the spatial one: temporal, spectral.
  - Other applications besides satellite product validation: assimilation of point observations into gridded models, use of satellite data as point estimates, selection of best location for cal/val sites.
- Spatial mismatch estimates (plots, values for specific spatial grids) could be provided as metadata of cal/val sites.
- Need for a better protocol to identify when a highres product is good enough (uncertainty low enough) to correct the mismatch (upscale in-situ data).
- Uncertainties (in situ, satellite, highres) are needed for uncertainty budget closure and conformity testing.

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