

Introducing an Improved SolarAnywhere® Historical Irradiance Product

Benchmarking Against BSRN

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A blended approach



- From the forecast world, we already know blending different NWP's together tends to reduce error
- This is because uncorrelated noise cancels (e.g. destructive interference) and the different NWP's take different approaches to calculating irradiance , therefore their errors are less correlated.
- We also know that spatial averaging tends to reduce error as well for similar reasons.
- Let's take these approaches and apply them to historical data using SolarAnywhere + NASA CERES



+



NASA CERES vs. SA historical

- NASA's Clouds and the Earth's Radiant Energy System (CERES) project
 - "CERES is the only project worldwide whose prime objective is to produce global climate data records of ERB¹ from instruments designed to observe the ERB."

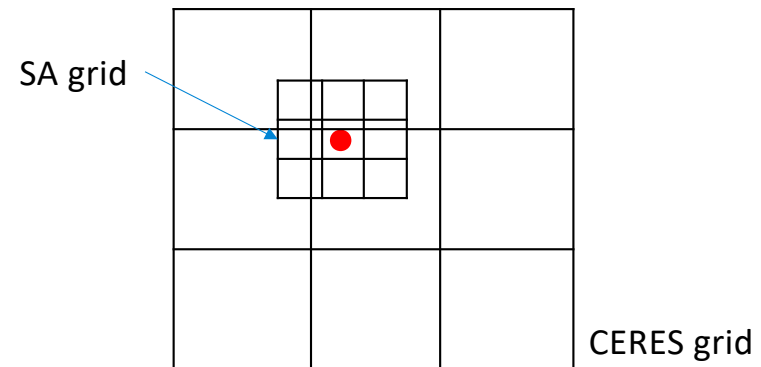
	NASA CERES	SA historical
Spatial coverage	Global	±60°
Spatial resolution	1°/100km	10km/1km/500m
Time coverage	2001 – 3 months from now	1998 – 45 days from now
Time resolution	hourly	15min/5min
Cloud properties	Polar-orbiting (Aqua/Terra) and geostationary satellites	Geostationary satellites only
Aerosols	Aqua/Terra/NASA-assimilated	MERRA2
Modeling	Physical, NASA proprietary	Albedo-based, semi-empirical
Validation	BSRN	BSRN and other sources

**we also have
realtime up to the
minute as a separate
product for
control/operation*

¹ Earth's Radiation Budget

How to improve SA historical data with NASA CERES

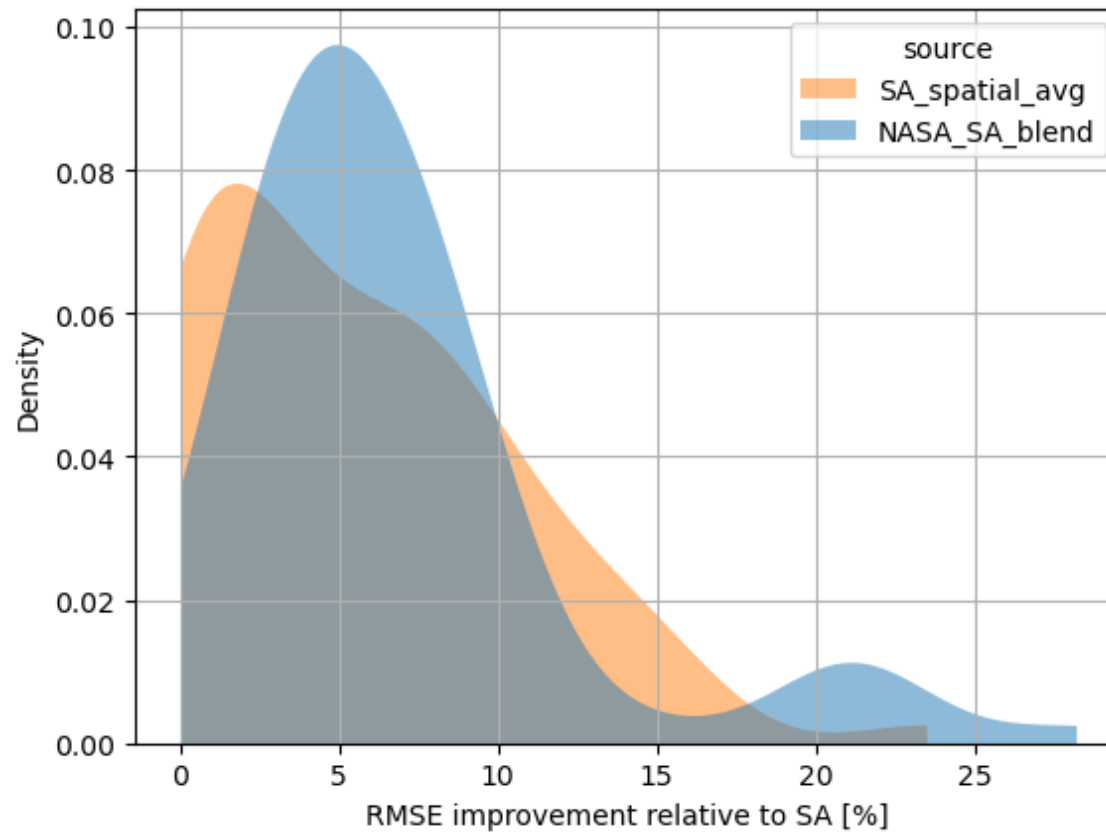
- Linearly blending SA and CERES
 - SA v3.7, 0.01°, 15min averaged to hourly
- SA spatial averaging
 - SA v3.7, 0.01°, 15min averaged to hourly
 - 1°×1° gridbox centered on site locations
 - 0.1° apart, 11×11 = 121 points extracted each site
- 72 siteyears extracted worldwide as shown
 - BSRN/solrad/surfrad
- Metrics of GHI
 - RMSE
 - Bias
 - MAE
 - Pearson correlation
 - Temporal variability $\equiv \sigma(\Delta\text{GHI}(t))$



All-site stats

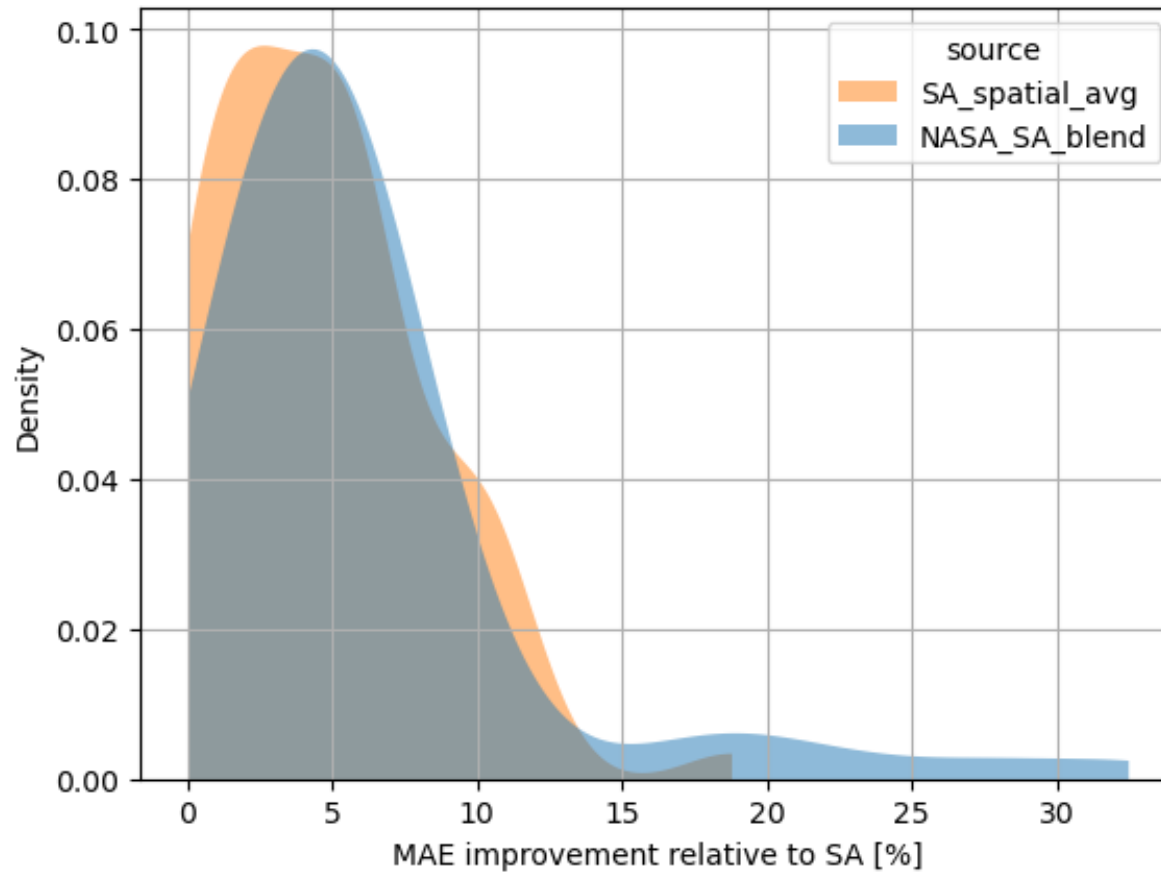


RMSE improvement relative to SA [%]



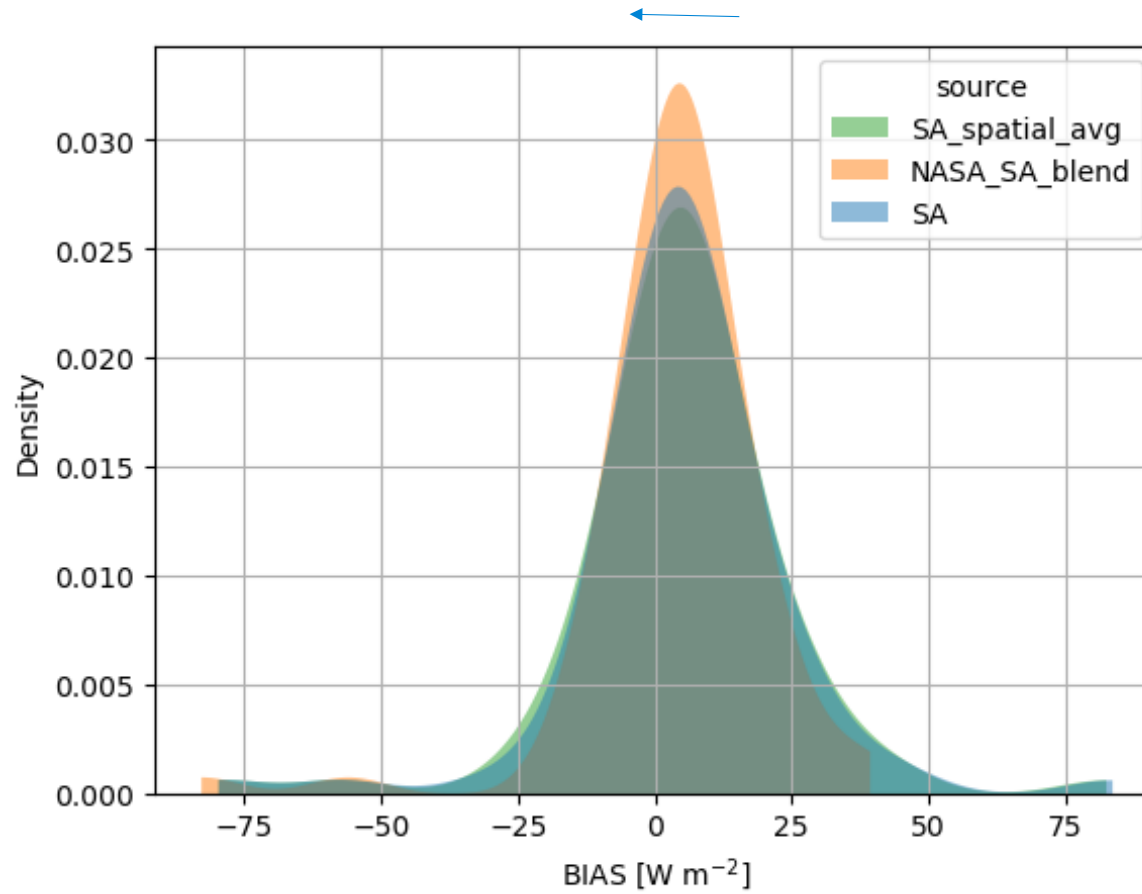
*RMSE improves with NASA
blending and SA spatial averaging*

MAE improvement relative to SA [%]



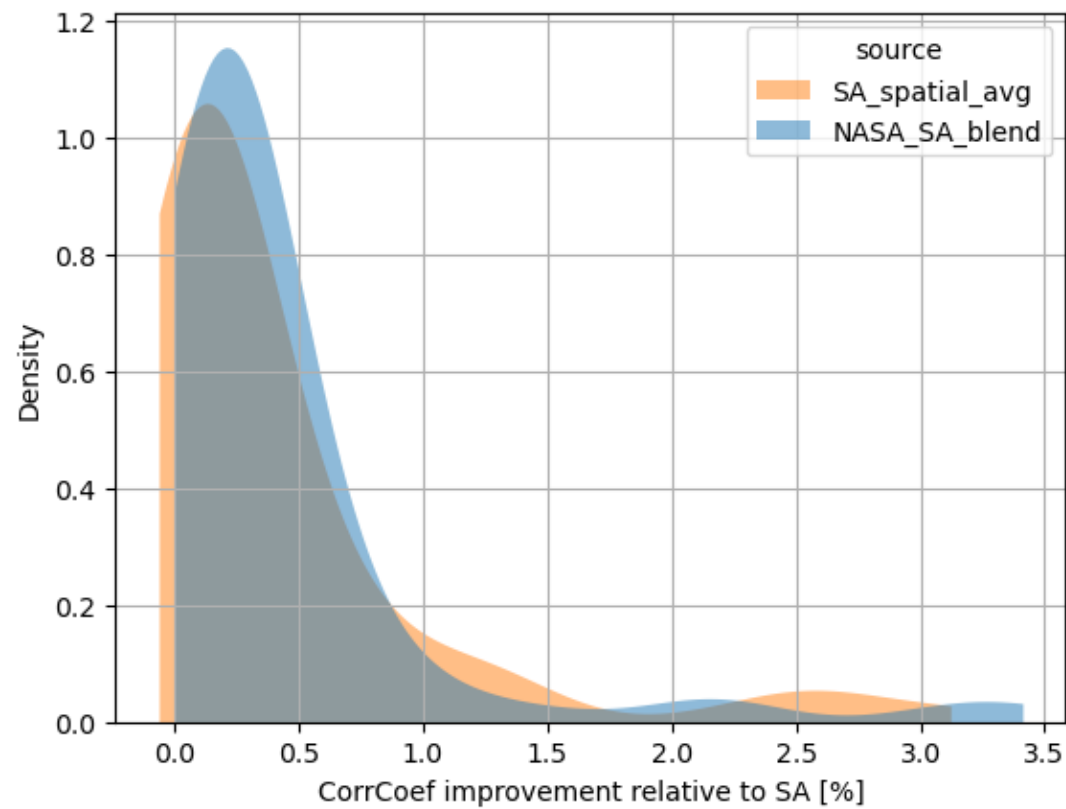
MAE improves with NASA blend & Spatial averaging

BIAS



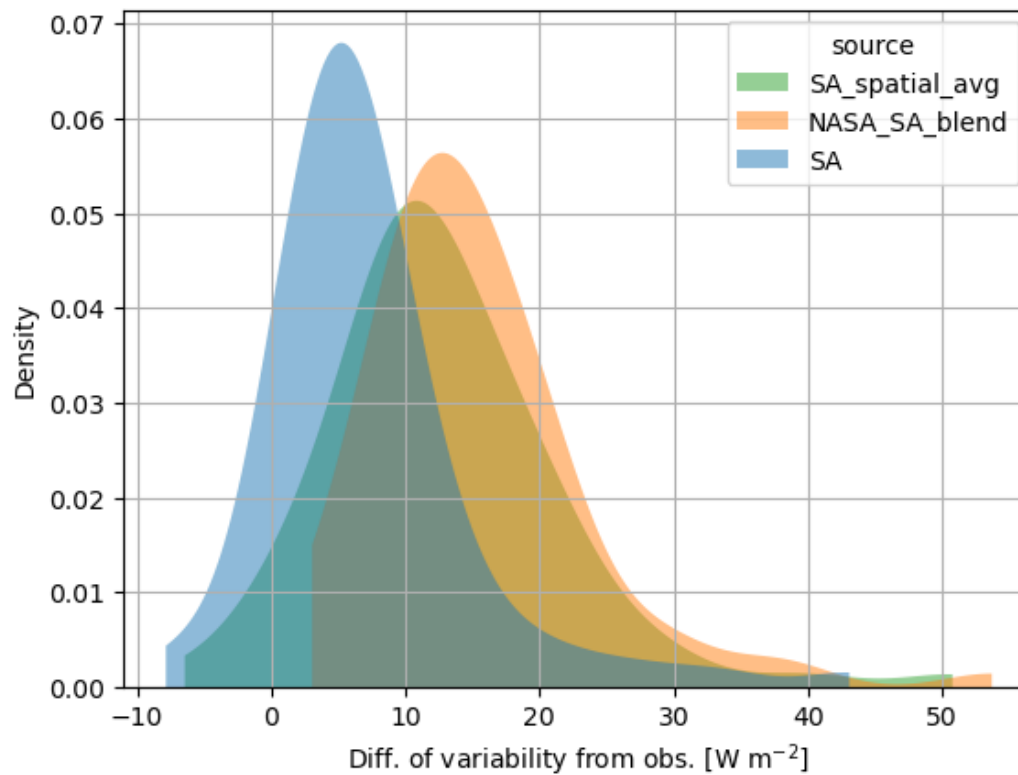
Bias slightly improves with NASA blending while spatial averaging makes it slightly worse.

Pearson correlation



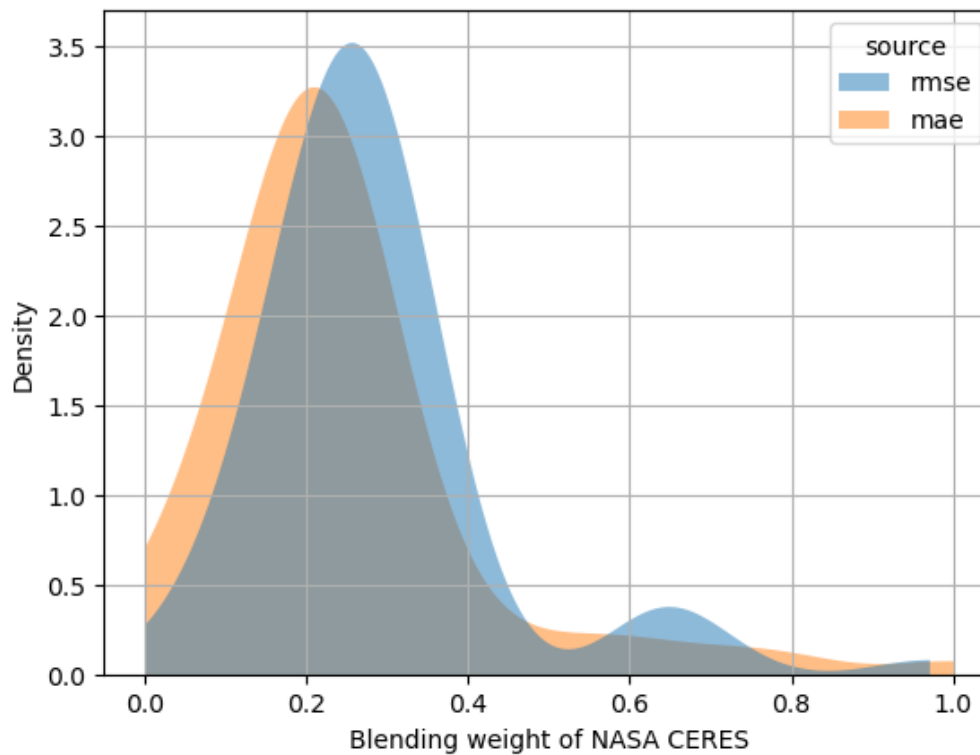
New blending techniques improve correlation to reality (BSRN)

Difference of variability from observation



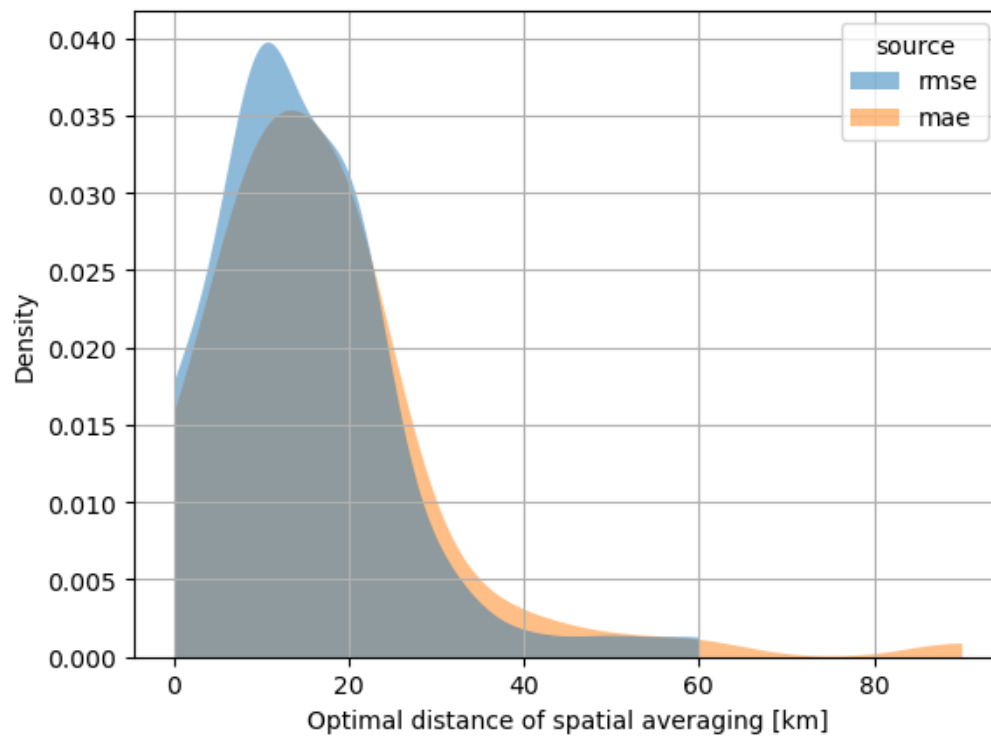
Spatially averaging, both from using the coarser NASA data & geographically averaging SA decreases aggregate variability and reflects reality less.

What blending weights yield optimal RMSE / MAE reductions?



~20% NASA CERES in our historical product optimizes RMSE & MAE improvement

What degree of spatial averaging on SA improves error the most?

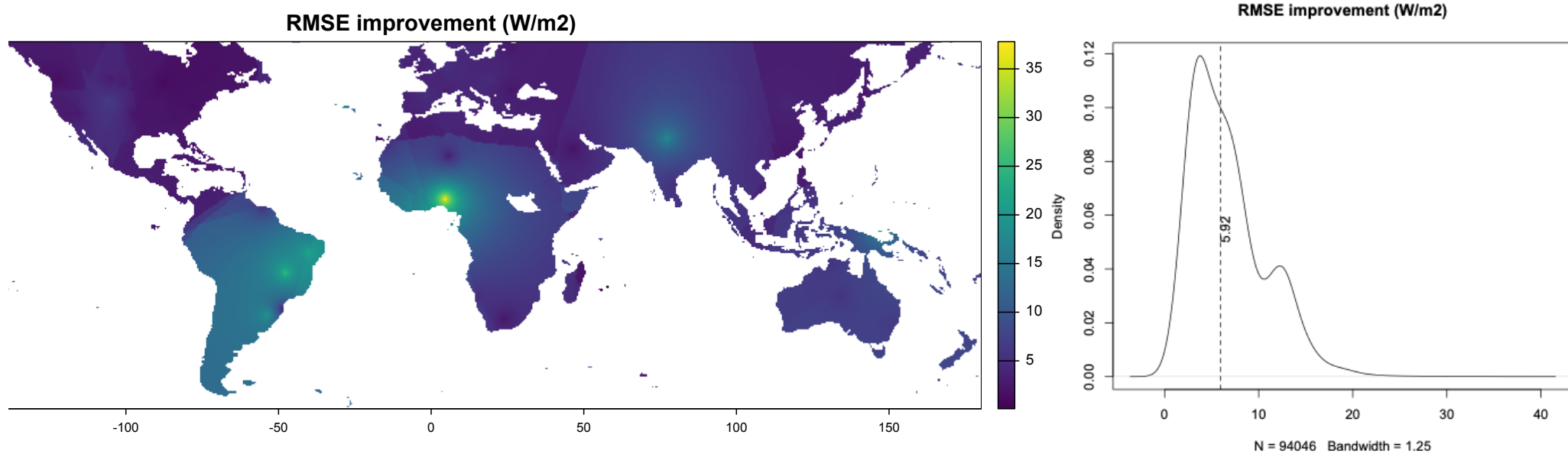


Spatially averaging across a ~12km encompassing box size is optimal for improving RMSE & MAE

Spatial analysis



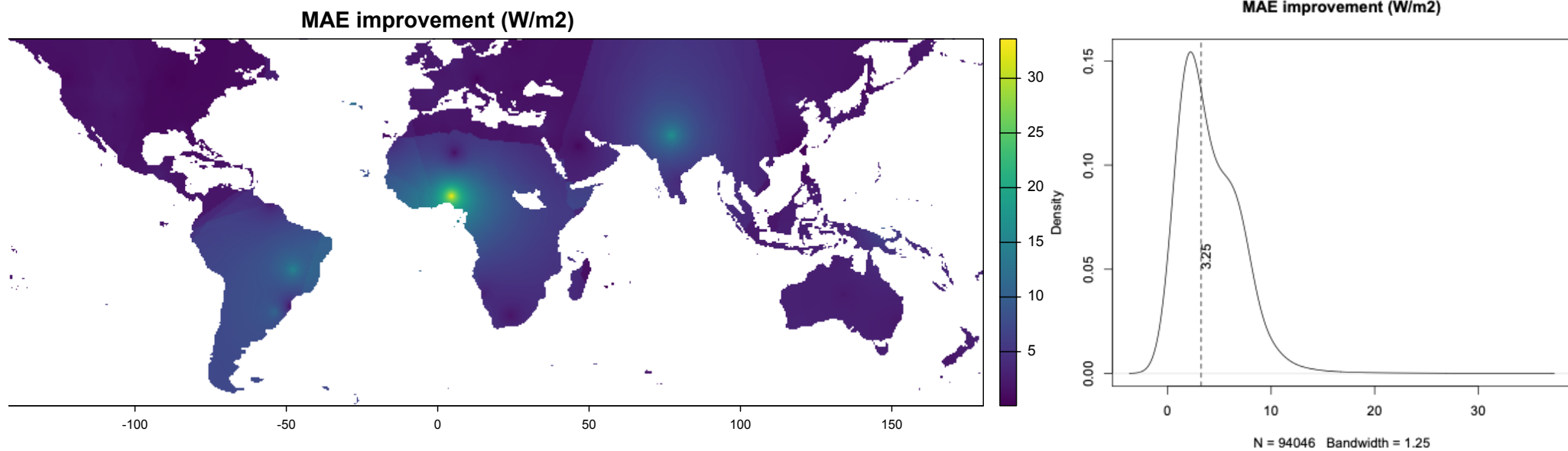
Interpolation of RMSE improvement across all BSRN sites



*Median RMSE improvement of **5.92 W/m2***

RMSE improves with NASA uniformly. There are outliers worthy of investigation in Nigeria, India and Brazil

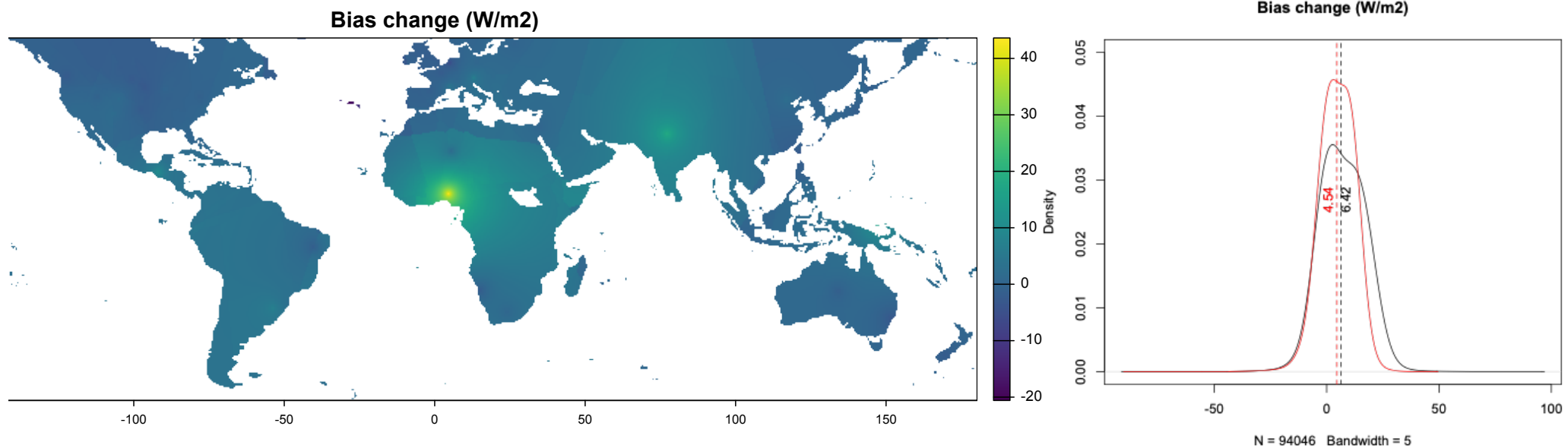
Interpolation of MAE improvement across all BSRN sites



Median MAE improvement of 3.25 W/m2

MAE improves with NASA uniformly though the same outliers are present

Interpolation of Bias change across all BSRN sites

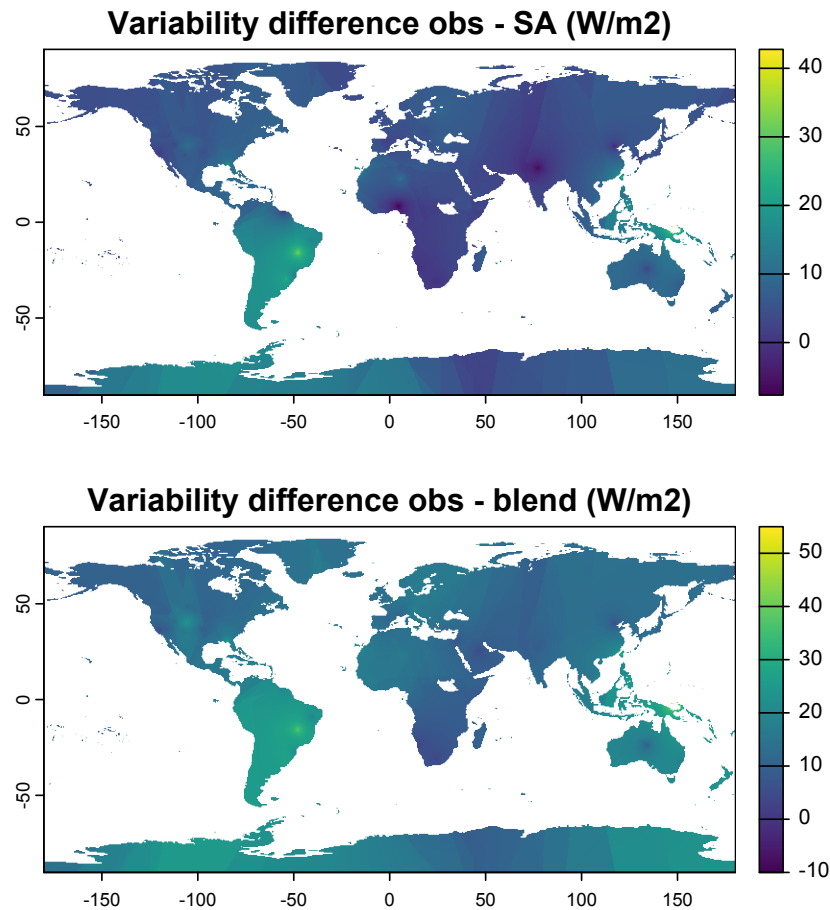


When blending NASA in, we reduce bias by roughly 2 W/m2

Bias slightly improves with NASA blending uniformly across the globe save the outliers.

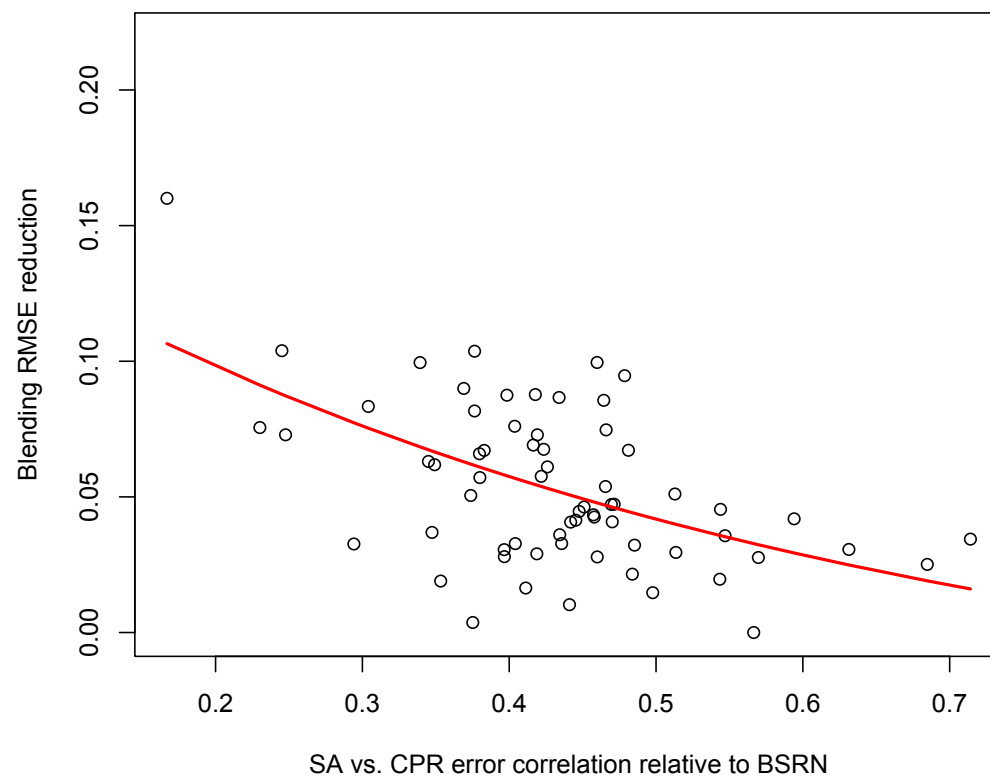
Notably, we reduce the spread; less heterogeneity in bias

Interpolation of variability deviation from the BSRN record



$\sigma\Delta\text{GHI}$ is the variability characteristic we're looking at.
Blending w/ NASA deteriorates variability match to BSRN record; because of spatial averaging effect

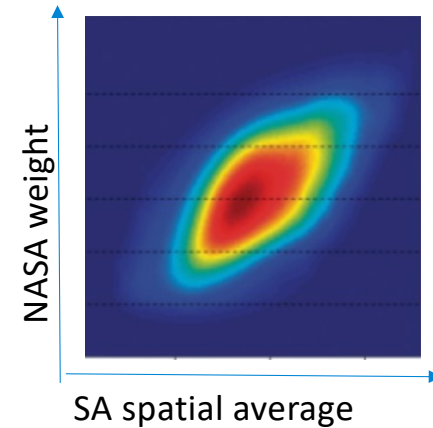
The link between error correlation & reduction in error



Conclusions

- SA accuracy can be systematically improved by blending with NASA CERES data and/or performing spatial averaging.
 - Optimal blending weight is ~20% NASA
 - RMSE/MAE can be reduced by ~5%
 - Bias slightly shrinks but notably reduces spatial heterogeneity
 - Optimal distance of SA spatial averaging is ~10km
 - Temporal variability will degrade.
 - The blending approach works better than the spatial averaging approach.
 - Combining two approaches to gain further improvement is possible.

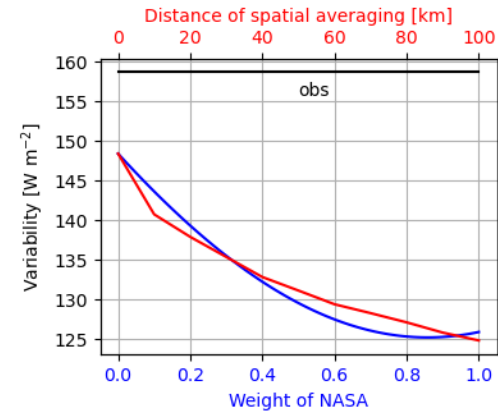
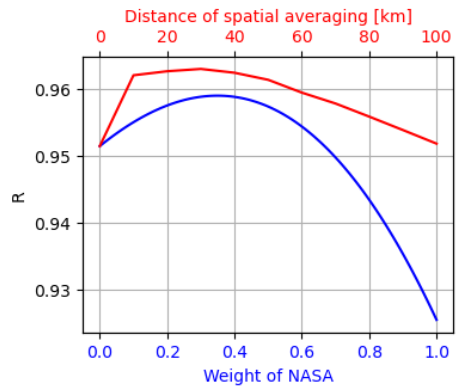
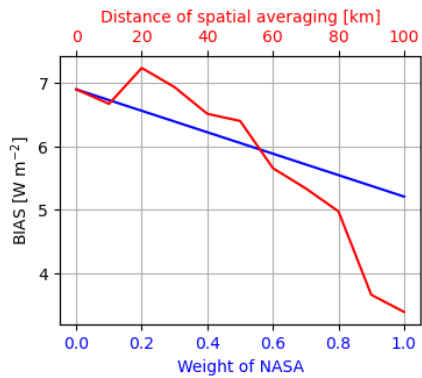
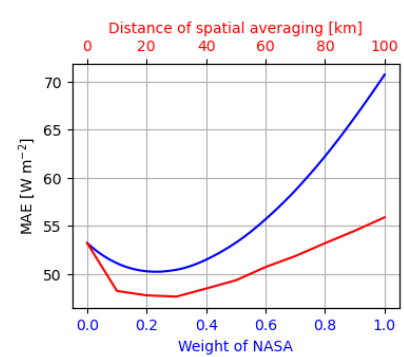
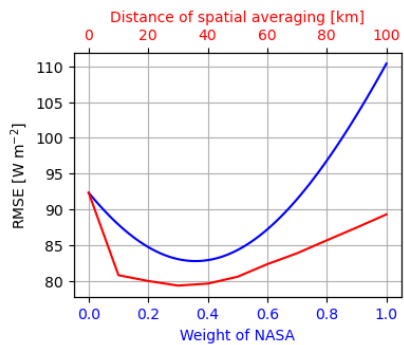
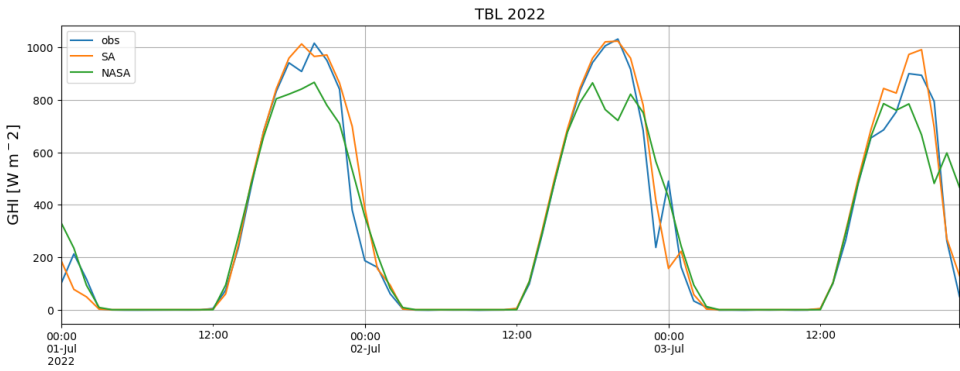
Future work 2D optimization



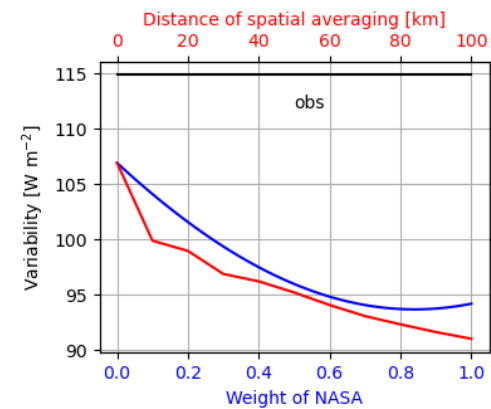
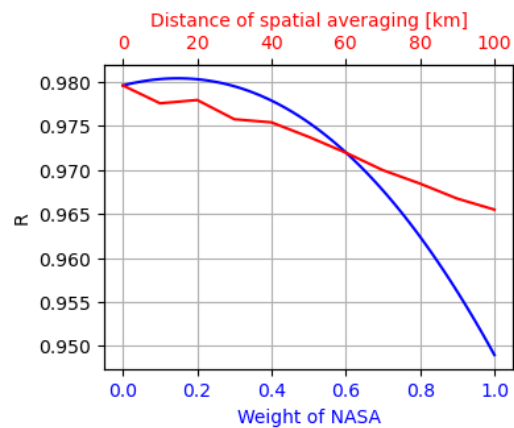
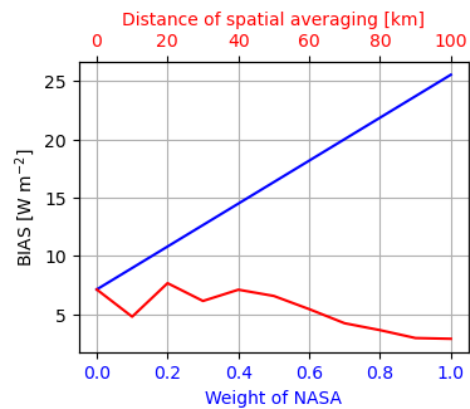
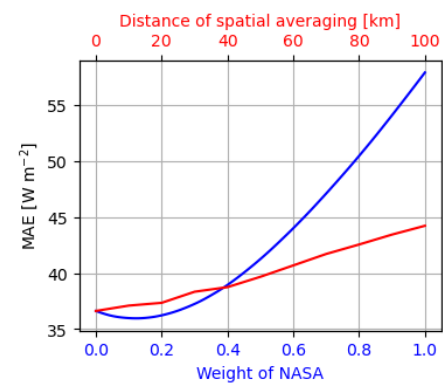
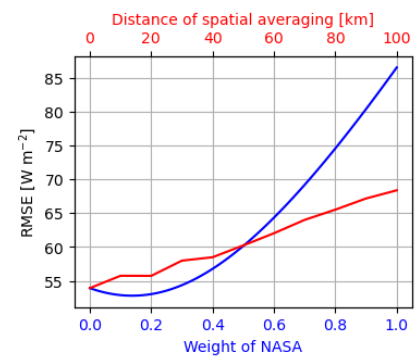
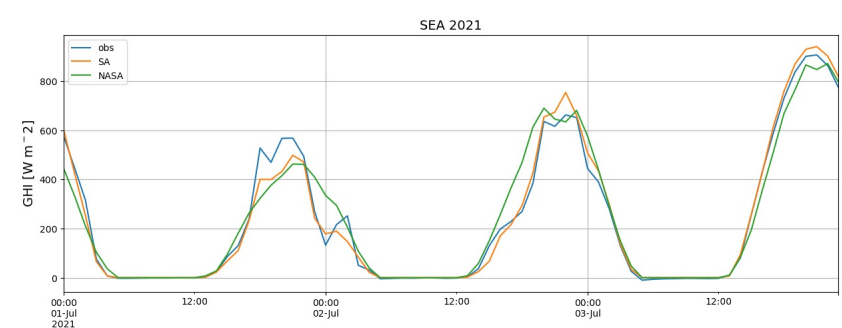
Questions and Discussion



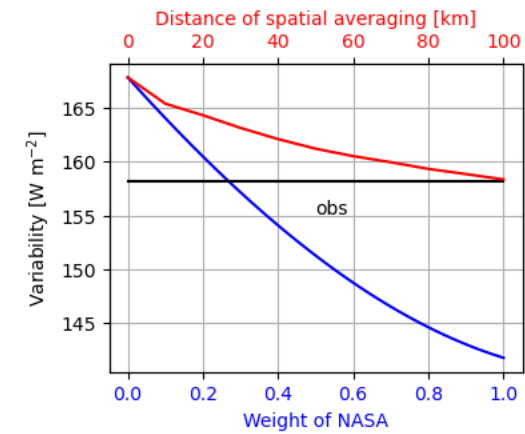
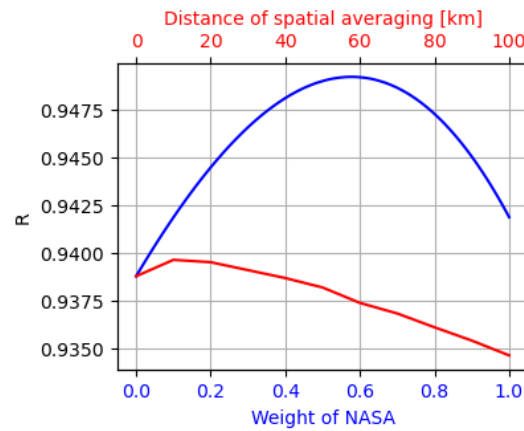
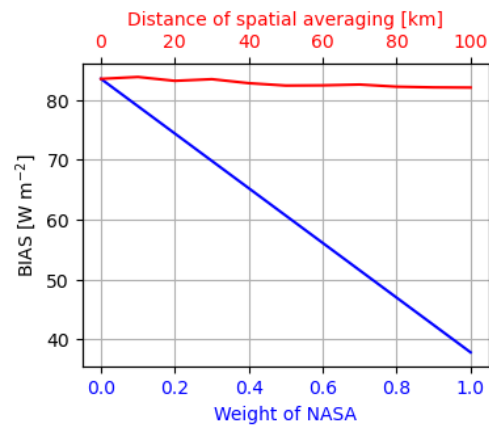
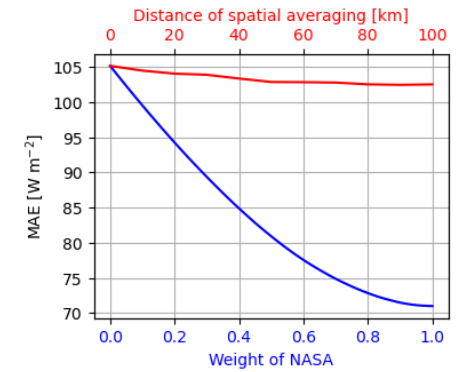
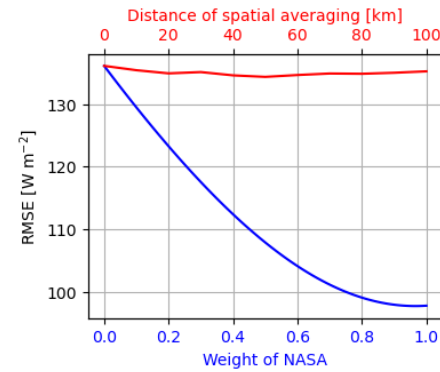
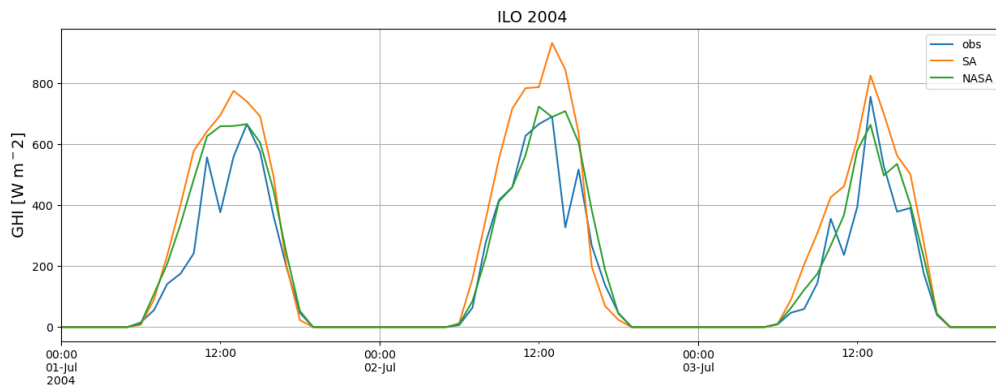
Table Mountain (TBL), Boulder CO 2022



Seattle 2021



Ilorin (ILO) Nigeria 2004



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