Using MACC-derived products to predict clear-sky irradiance at surface

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Importance of the clear-sky model

Under any sky,
irradiance I = Iclear-sky for null albedo
*
F(ground albedo,
atmospheric spherical albedo,
cloud properties,
~~clear-sky properties~~)

Any error in clear-sky irradiance impacts irradiance under any sky!

Why a new model?

To benefit from the science in MACC

1. recent advances in MACC on aerosols properties

2. MACC products on ozone and water vapour

and from

3. pre-operational aspects of MACC and

4. its sustainable future.

This justifies our investment in this development.

The McClear model for clear-sky

For clear sky :

irradiance I = Iclear-sky for null albedo

* [1 / (1 – S r)]

S: atmosphere spherical albedo
r: ground albedo

Expected outcomes: direct and diffuse components.

Challenges

1. Should reproduce RTM outputs with low differences : bias < 3 W/m2, and P95 < 20 W/m2

2. Reduce computational burden. A RTM run is more than 8 h for one year of hourly values and a given location. Target : 5 s, i.e. 5000 times faster.

Abaci / LUT approach

Use of abaci (LUT) and interpolation functions to speed up computations.

Parameters of the abaci:

- total column contents in ozone and water vapor,
- aerosols properties (AOD 550, Angstrom coeff, type OPAC)
- SZA,
- altitude of site and elevation,
- atmospheric profile.

Abaci and speed

The less the number of nodes, the faster the code, but the less accurate the output.

Optimisation of the nodes and interpolation functions to be fast and accurate :

bias < 3 W/m2, and P95 < 20 W/m2

Volume, computation burden

1674 abaci, one abaci per atmospheric profile and type of aerosol.

Abaci computed by runs of libRadtran, approx. 6 months.

Contents of the abaci

Four clearness indices (= irradiance / TOA)

1. for direct for null ground albedo

2. for global for ground albedo = 0.0,

0.1,

0.9

Inputs to McClear

User inputs :

1. a period
2. a geographical location
3. a summarization : 1 min, 15 min, 1 h, 1 d

Masked inputs :

1. MACC database on ozone and water vapour
2. MACC aerosols, total and partial AODs
3. MODIS ground reflectances
4. SRTM digital terrain elevation

Validation. Ground measurements

11 BSRN stations worldwide :

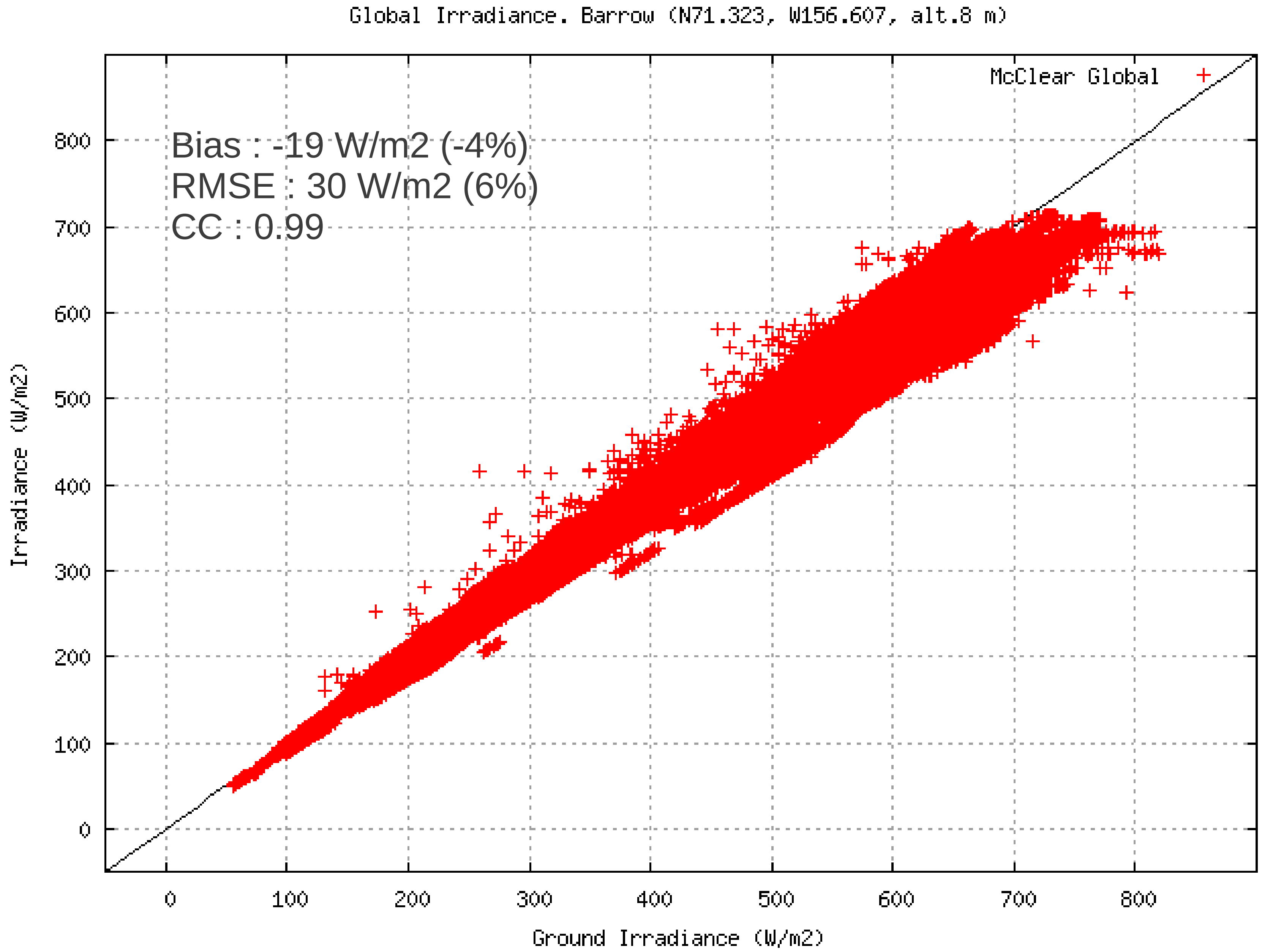
- Brazil (1), USA (1),
- France (2), Switzerland (1),
- China (1), Japan (1),
- Algeria (1), Israel (1),
- Australia (1), New Zealand (1)

Direct and global 1-min measurements.

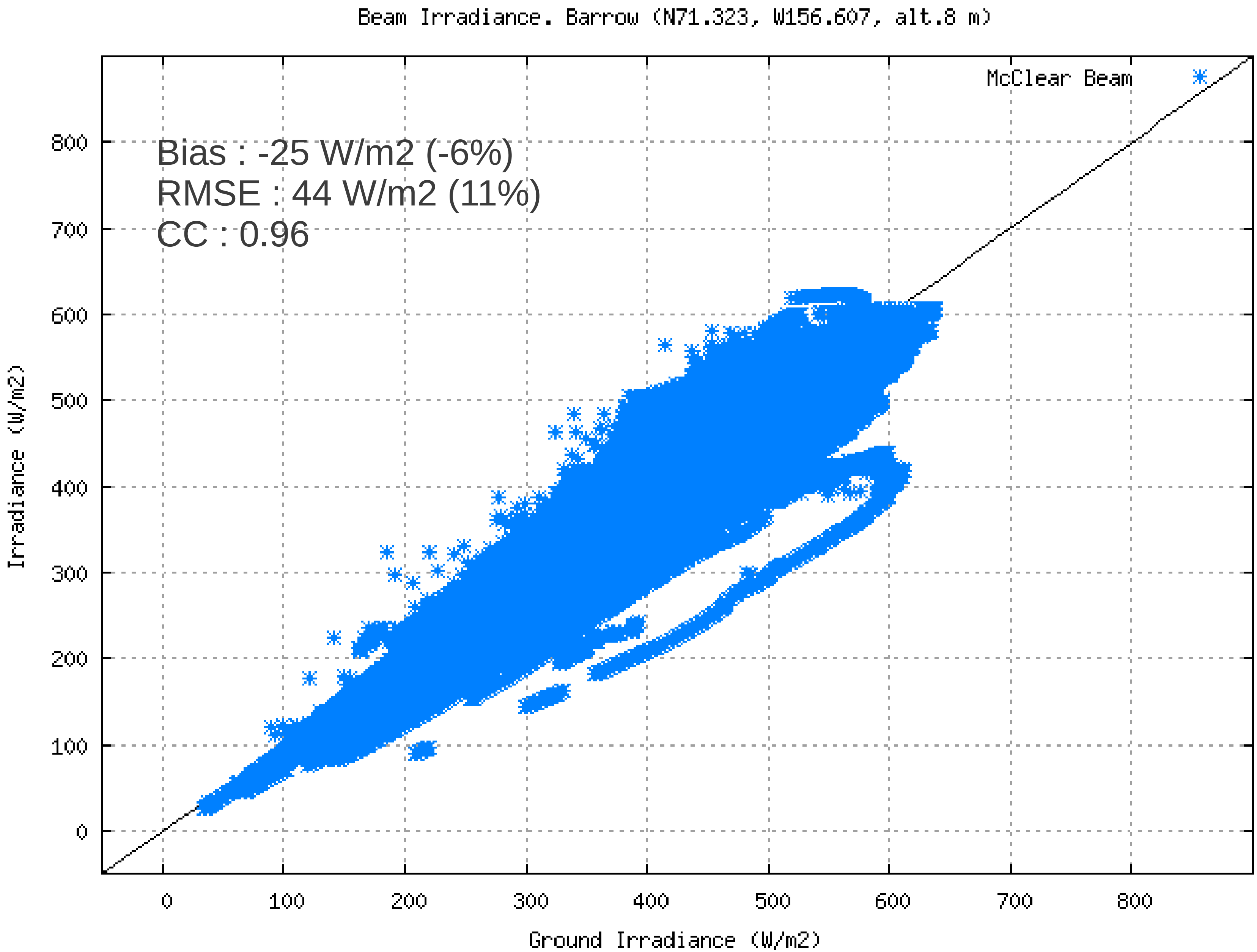
Four years : 2005-2008.

Quality check, only clear-sky instants are kept.

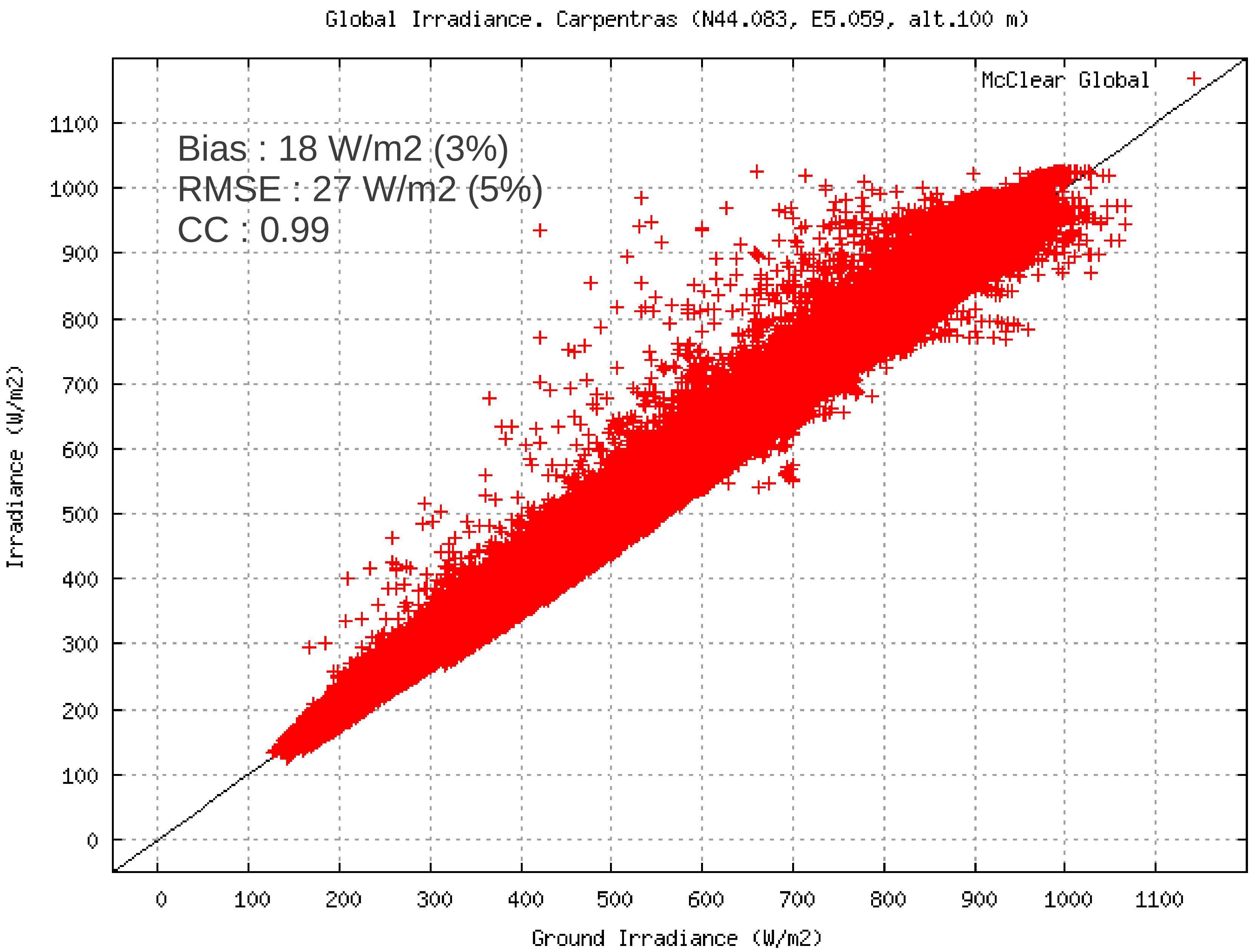
Validation. Barrow, Alaska (71 N)



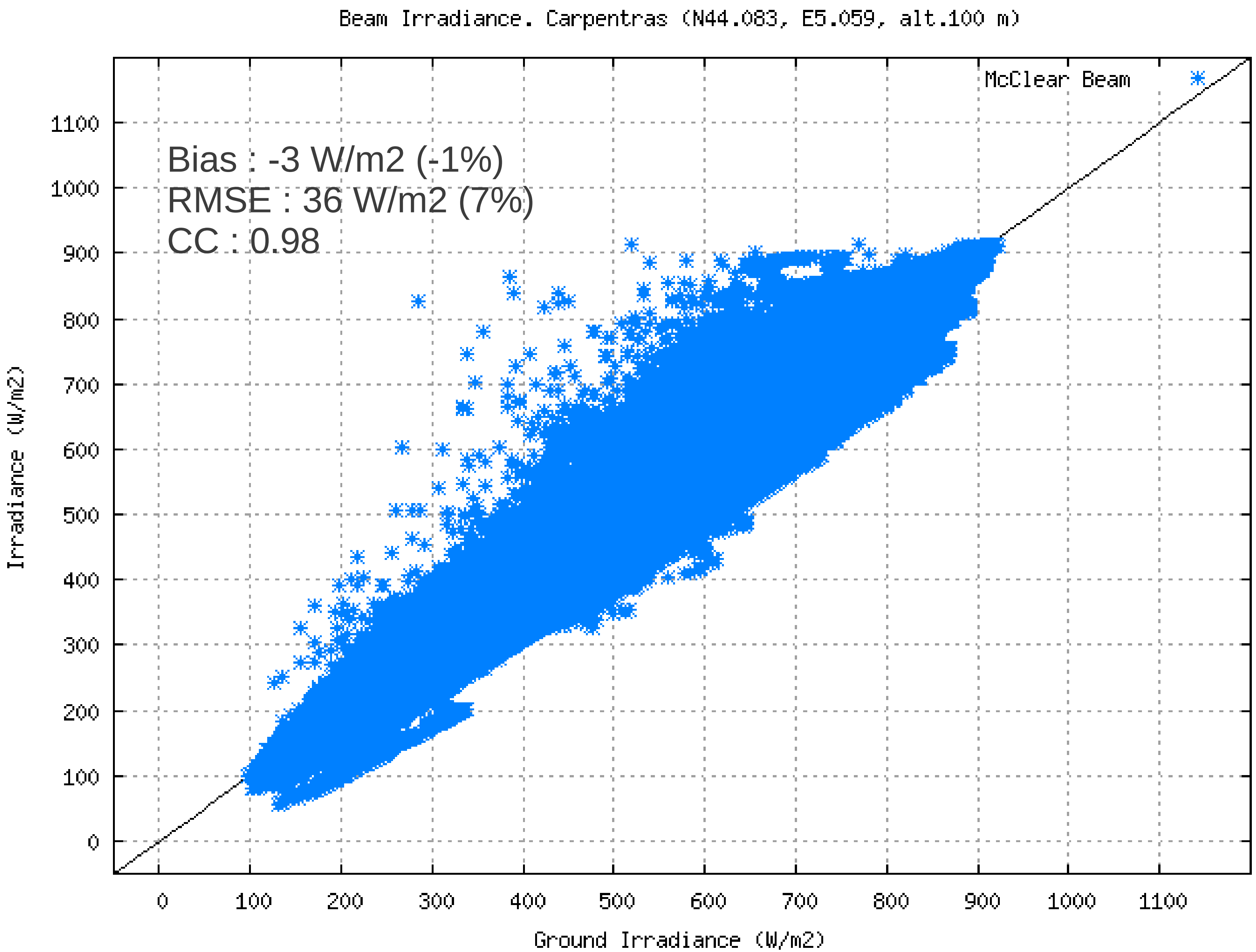
Validation. Barrow, Alaska (71 N)



Validation. Carpentras, France (44 N)



Validation. Carpentras, France (44 N)



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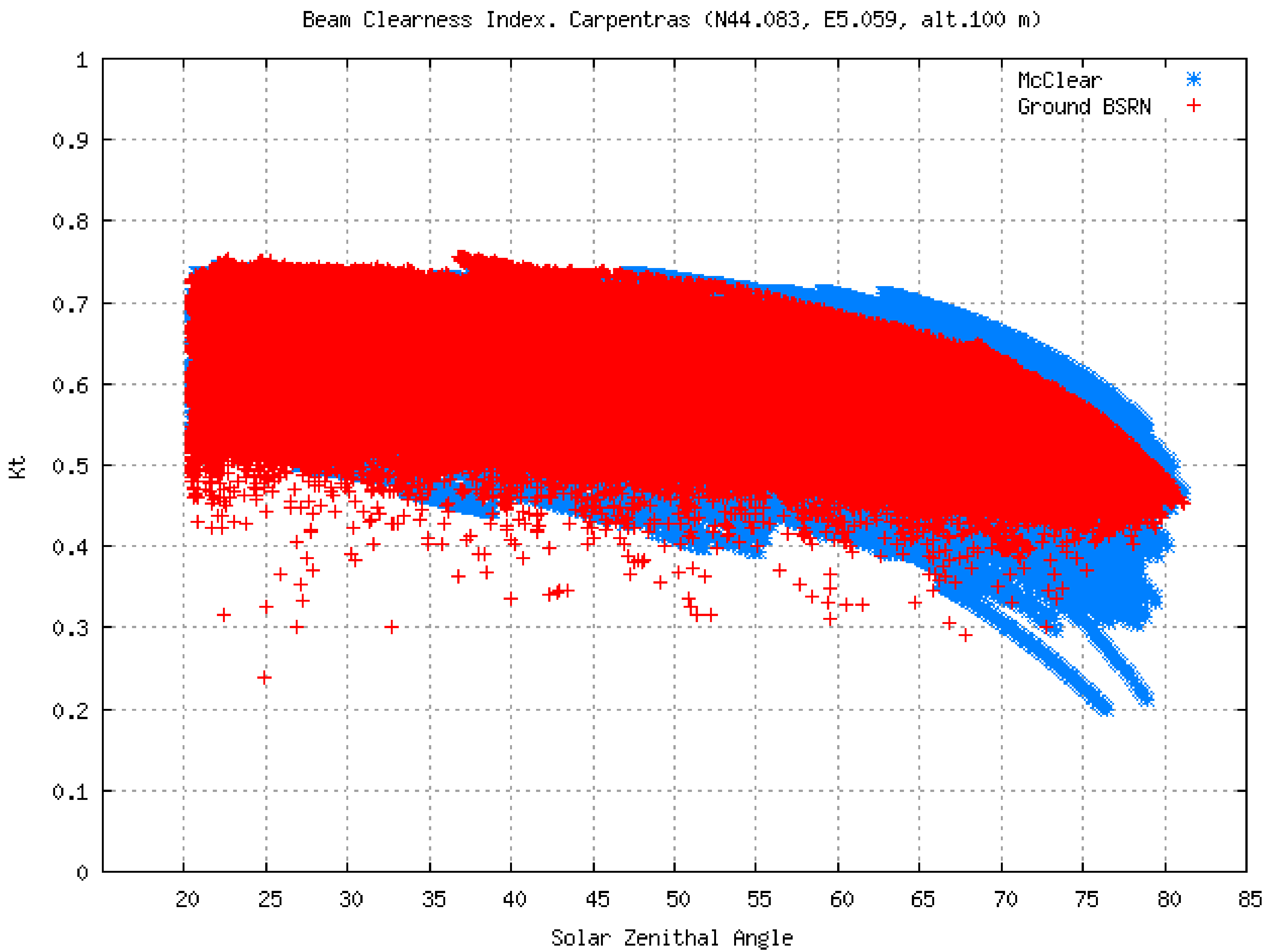

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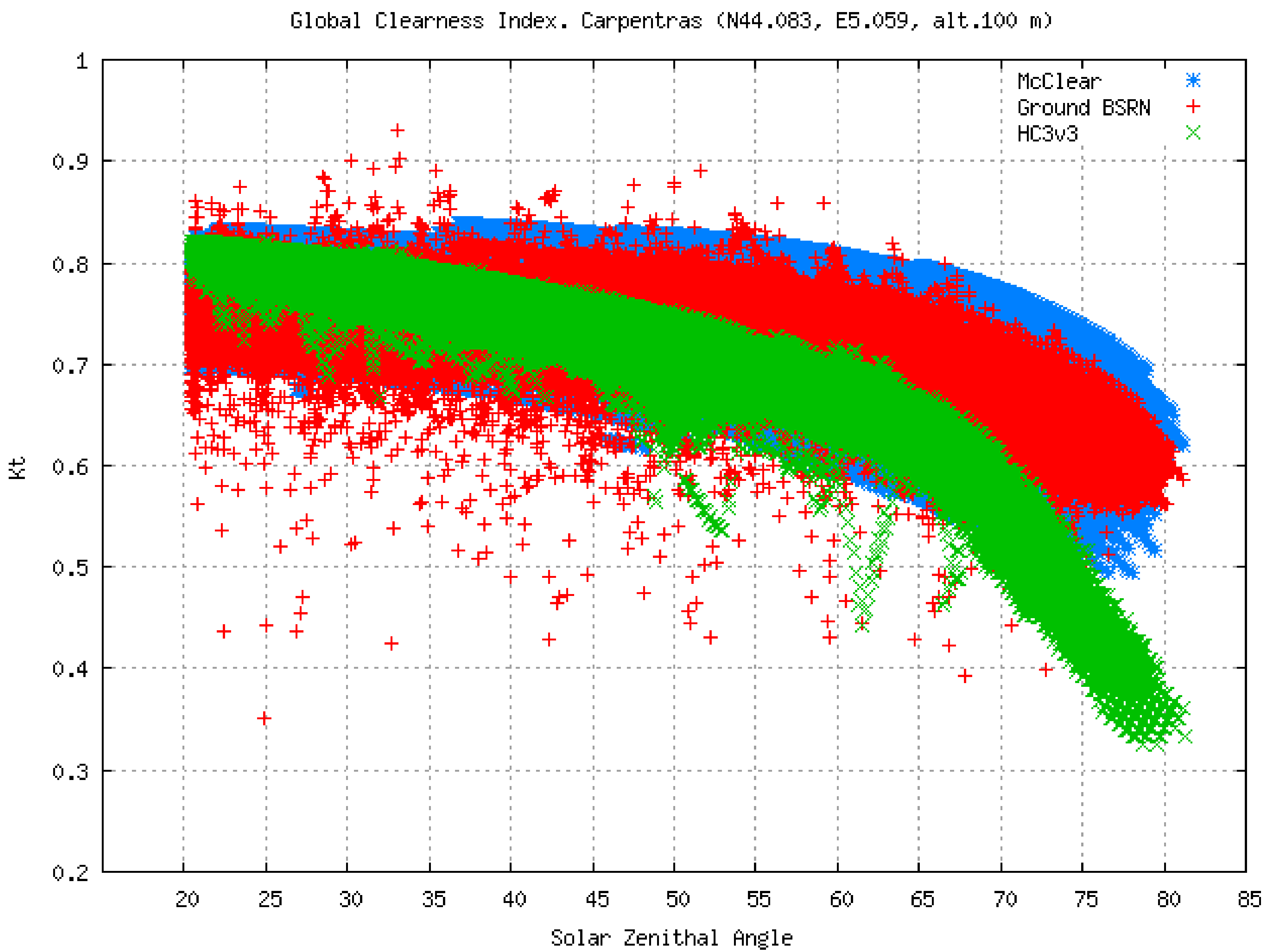

Global irradiance

Station	Mean observed value W/m²	Bias W/m²	Rel. bias %	RMSE W/m2	Rel. RMSE %	Squared correl. coeff.
Barrow	498	-19	-4%	30	6%	0.98
Palaiseau	598	+2	+0%	24	4%	0.99
Carpentras	596	+18	+3%	28	5%	0.99
Payerne	629	+19	+3%	29	5%	0.99
Xianghe	790	-10	-1%	38	5%	0.90
Tateno	590	+15	+3%	32	6%	0.98
Sede-Boqer	785	+7	+1%	30	4%	0.98
Tamanrasset	791	+8	+1%	24	3%	0.99
Brasilia	649	+16	+2%	27	4%	0.99
Alice-Springs	715	+14	+2%	22	3%	1.00
Lauder	600	+12	+2%	23	4%	0.99

Direct irradiance

Station	Mean observed value W/m²	Bias W/m²	Rel. bias %	RMSE W/m²	Rel. RMSE %	Squared correl. coeff.
Barrow	406	-25	-6%	44	11%	0.93
Palaiseau	492	-7	-1%	37	7%	0.96
Carpentras	505	-3	-1%	36	7%	0.97
Payerne	530	+3	+1%	40	7%	0.96
Xianghe	642	-26	-4%	70	11%	0.69
Tateno	485	-12	-3%	42	9%	0.94
Sede-Boqer	667	-52	-8%	65	10%	0.95
Tamanrasset	653	+16	+3%	46	7%	0.95
Brasilia	560	+27	+5%	44	8%	0.97
Alice-Springs	634	+6	+1%	33	5%	0.98
Lauder	544	-27	-5%	43	8%	0.98

Conclusions

MACC products are accurate and reliable.

They enable accurate assessment of surface solar irradiance for clear-sky.

1st version of McClear runs fast and is accurate.

Will be exploited to develop the new Heliosat-4 for all skies (see poster).

A Web service should be made available.