CROSS VALIDATION OF SATELLITE RADIATION TRANSFER MODELS

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Solar and Wind Energy Resource Assessment (SWERA) project

- multinational project financed by UNEP-GEF
- aimed at:
  - performing a detailed survey of solar and wind energy resources in several developing countries
  - employing the most modern available modeling techniques and using country available ground data
- in response to the international concerns on the increasing demands for energy in developing countries
- to provide reliable information necessary to conciliate development and environment protection

Solar Assessment

Radiative Transfer Models used in SWERA project

- **BRASIL-SR model:** a spectral model that combines satellite data, climatological information and the "*two-stream* approach" to solve the radiative transfer equation
- **SUNY-Albany model:** statistical satellite method based on the Kasten's formulation and cloud index obtained from satellite images
- **DLR model:** method for direct normal irradiance using the cloud transmittance obtained from an empirical expression of the cloud index derived from IR and VIS satellite images
- **NREL model:** climatic-based model for global solar irradiance estimation using gridded cloud fraction coverage assembled by the US Air Force

Goals

One of most important task of SWERA-solar component is the cross validation among the project's core radiation transfer models

In this presentation I will report the first results from two of the models: BRASIL-SR and SUNY-Albany and use HELIOSAT as reference model

Reference model

HELIOSAT model:

- ✓ method that uses:
  - Linke turbidity to parameterize atmospheric contribution to radiative transmittance and
  - cloud index derived from satellite images to model cloud extinction
- ✓ a reliable model with many good results published for Europe and Africa in scientific journals
- ✓ uses METEOSAT data to derive cloud index used to model cloud extinction

Description of ground sites

The three sites were chosen because:

- provide high quality radiation data and
- represent different climatic/environmental regions and different ground cover.

Site 1 – Caicó (06°28′01″S – 037°05′05″W / 176m)

Site 2 – Florianópolis (27°34′18″S – 048°31′42″W / 10m)

Site 3 – Balbina (01°55′07″S – 059°25′59″W / 230m)

Basic description of ground sites

Site 1 - Caicó (06°28'01"S – 037°05'05"W / 176m)

- Semi-arid region of the Brazilian northeast
  - Annual precipitation less than 700 mm
  - Flat land area with sparse brushwood type vegetation
  - Average albedo 13.3%
  - Large insolation - about 120 days/year
  - High annual mean temperature - 22 to 33 ^{o}C
- Nice place for clear-sky bias model fine tuning
- Producing data for global and direct incident horizontal solar radiation since November 2002.

Basic description of ground sites

Site 1 - Caicó (06°28'01"S – 037°05'05"W / 176m)

Basic description of ground sites

Site 2 - Florianópolis (27°34'18"S – 048°31'42"W / 10m)

- Located at coastal area of the Brazilian South region
  - In a medium size city (under 400,000 inhabitants)
  - Rains is fairly well distributed along the year
  - Summer is hot and the winter is mild with some few cold days
- Installed in 1991 as part of the BSRN and provides data of global, direct, and diffuse radiation.

Basic description of ground sites

Site 2 – Florianópolis (27°34’18”S – 048°31’42”W / 10m)

Basic description of ground sites

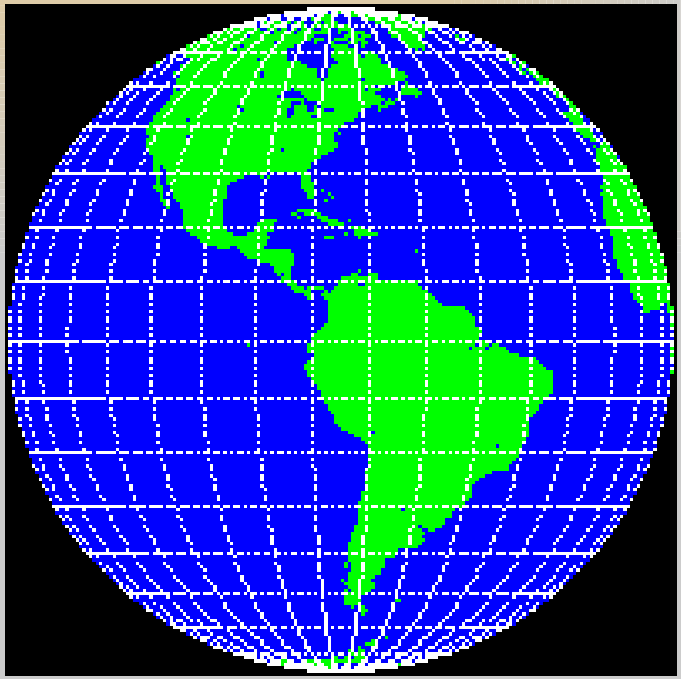
Site 3 – Balbina (01°55'07"S – 059°25'59"W / 230m)

- It is a BSRN station located in a small village :
  - Close to a large hydroelectric power plant
  - In the middle of the Brazilian rain forest in the Amazon region.
  - Temperatures are high along the year - ?? to ?? ^{o}C
  - Precipitation is high and concentrated in the November to April range
- This station has some operating problems and provided only global radiation during the cross validation time period.

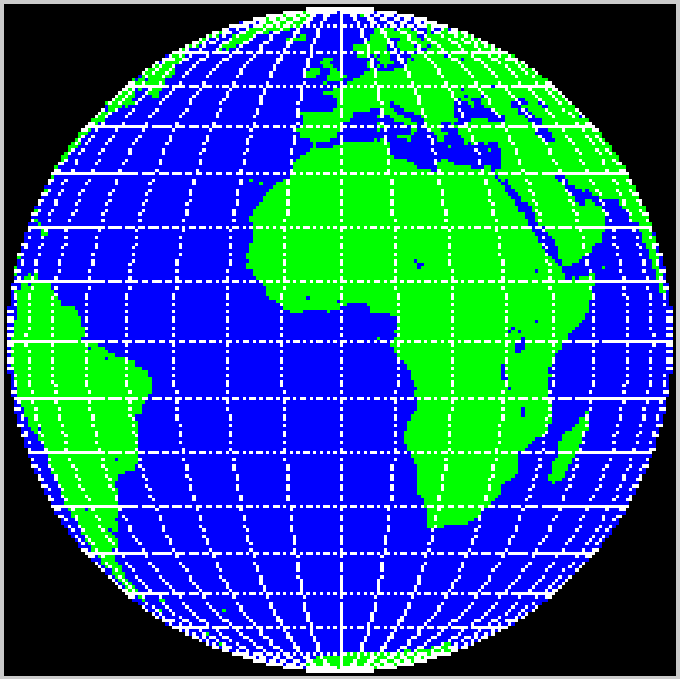
Basic description of ground sites

Site 3 – Balbina (01°55’07”S – 059°25’59”W / 230m)

Satellite Data

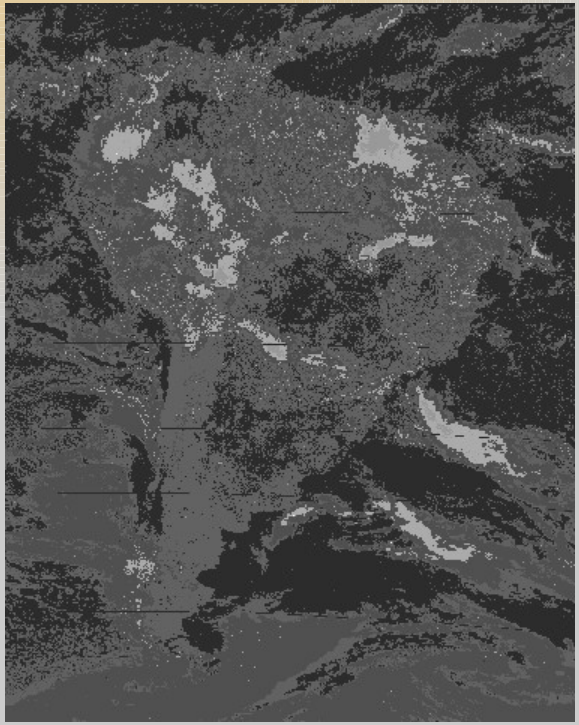


Coverage area map of GOES-EAST
(0°- 75°W/36,000 km)

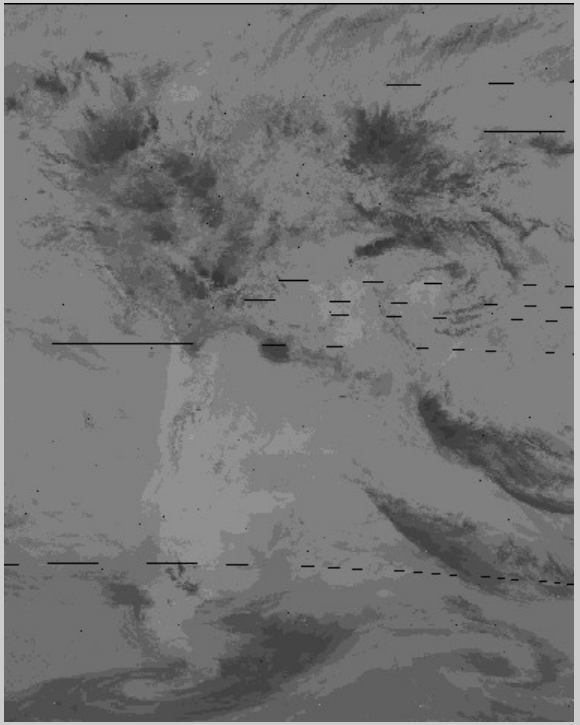


Coverage area map of METEOSAT
(0°- 0°/36,000 km)

GOES-8 images for South America



visible channel (0.52 - 0.75□m)



infrared channel (10.2 - 11.2□m)

Images obtained through GOES-8 on 02/18/1999 at 14h45 UTC

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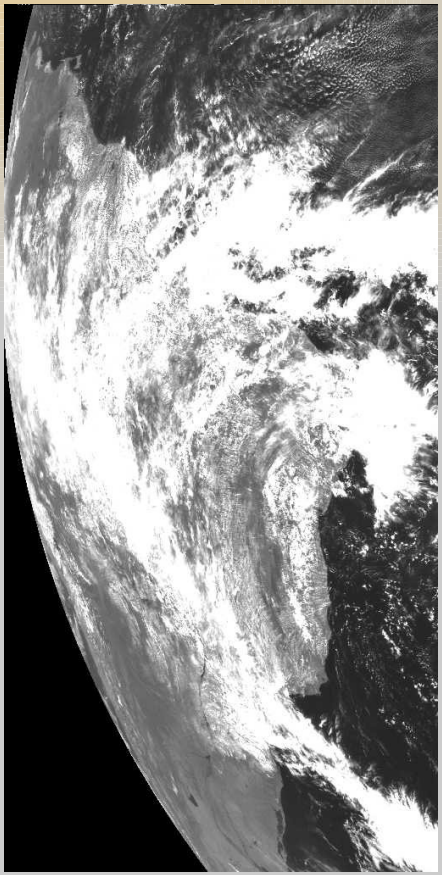
METEOSAT images for South America



visible channel (0.45 - 1.0 m)

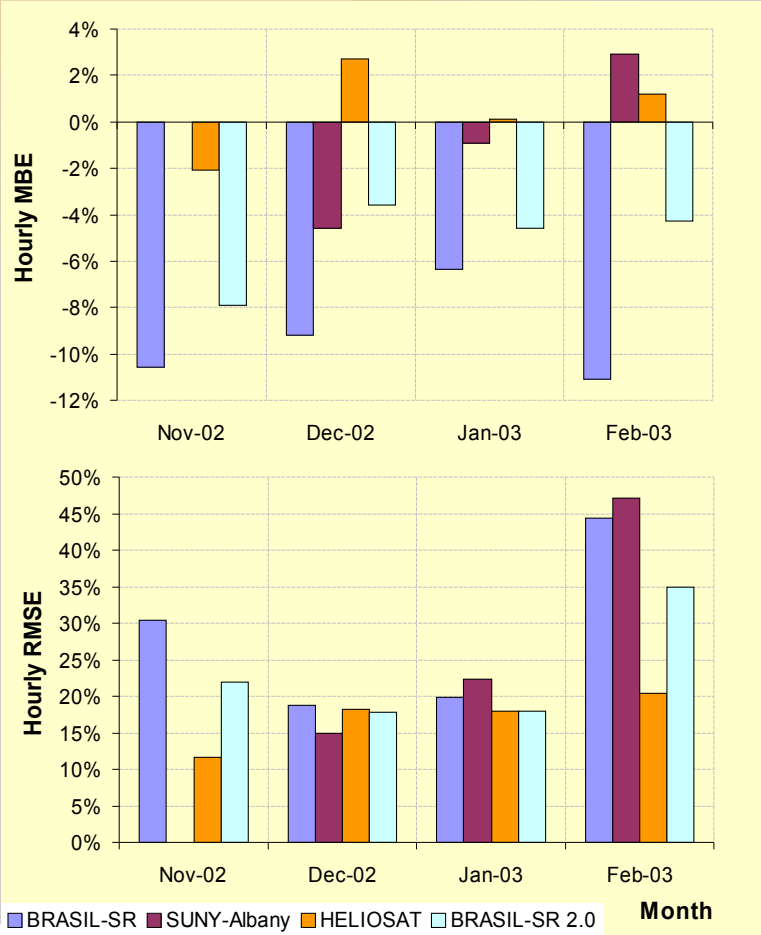
Images obtained through GOES-8 on 01/21/2003 at 15h00 UTC

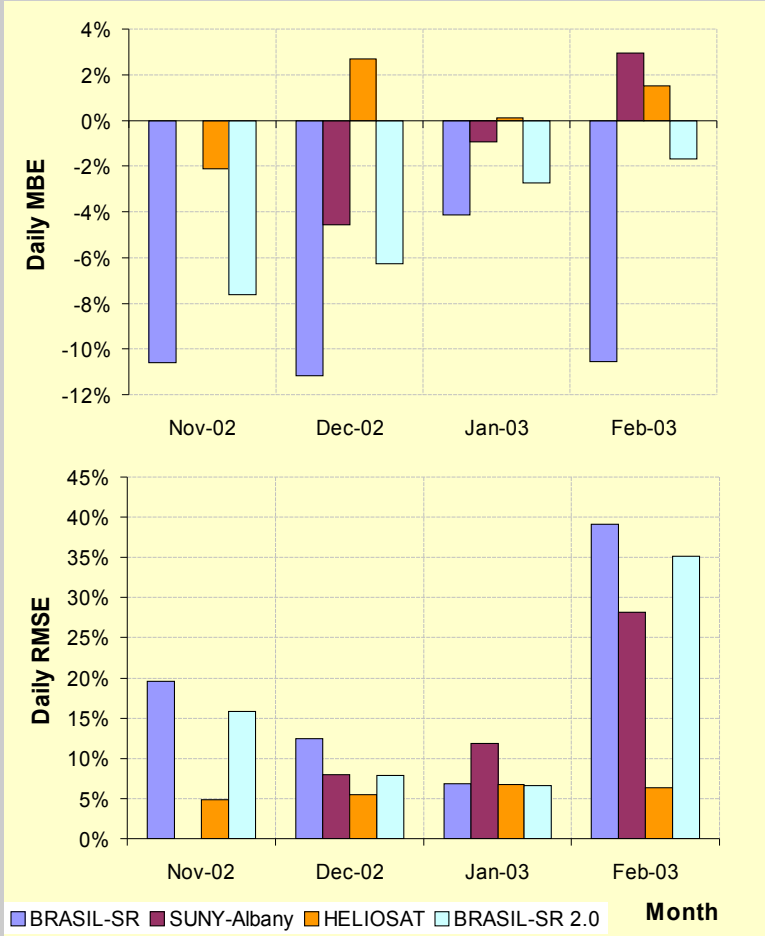
Cross Validation

Preliminary Results

- Cross validation period begun in November/2002 and is still being carried out
- Only BRASIL-SR and SUNY-Albany results are here presented
- NREL and DLR models are not yet available, but they will be included in the comparison analysis in a latter phase of the project
- Three benchmarks were used to evaluate the quality of global solar estimates:
  - relative mean bias error (rMBE)
  - relative root mean square error (rRMSE)

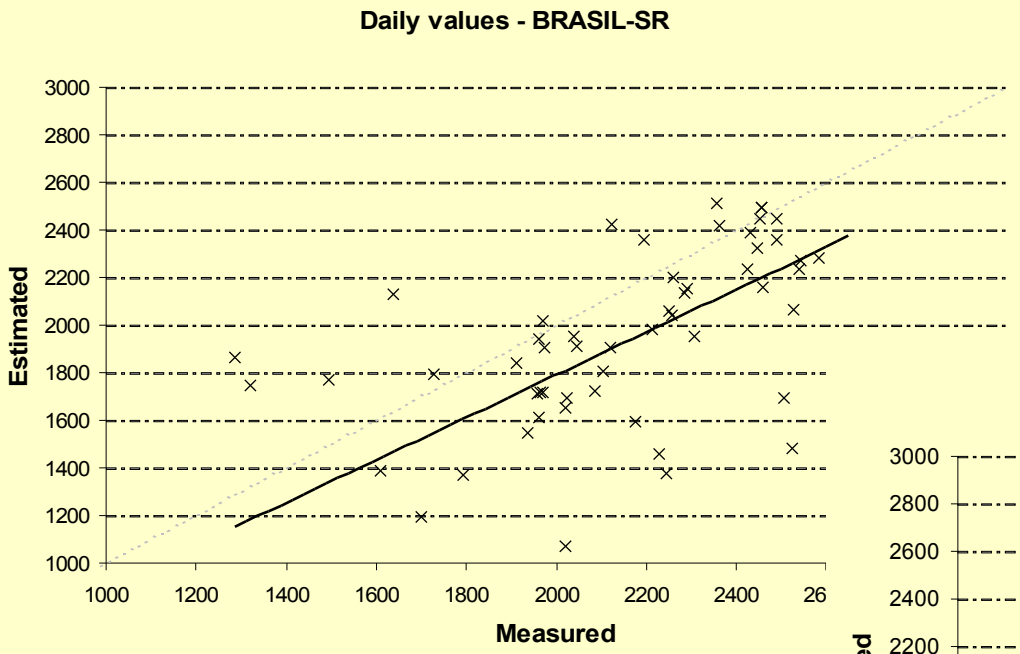
Benchmarks for Caicó

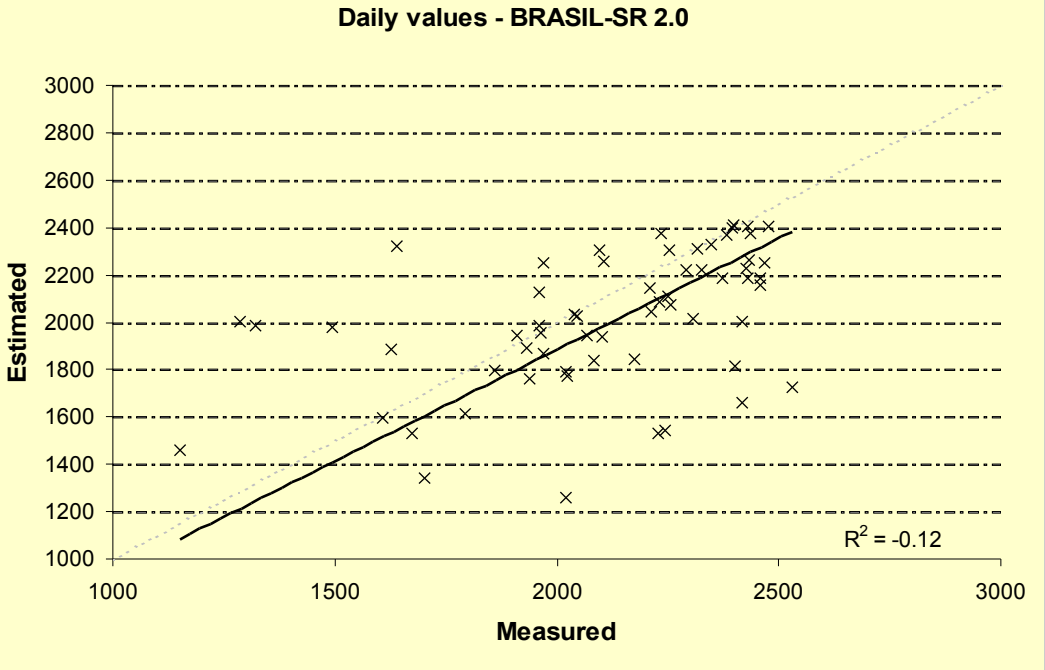




Comparison for daily data

Site 1 – Caicó





Units: **W.h.m^{-2}**

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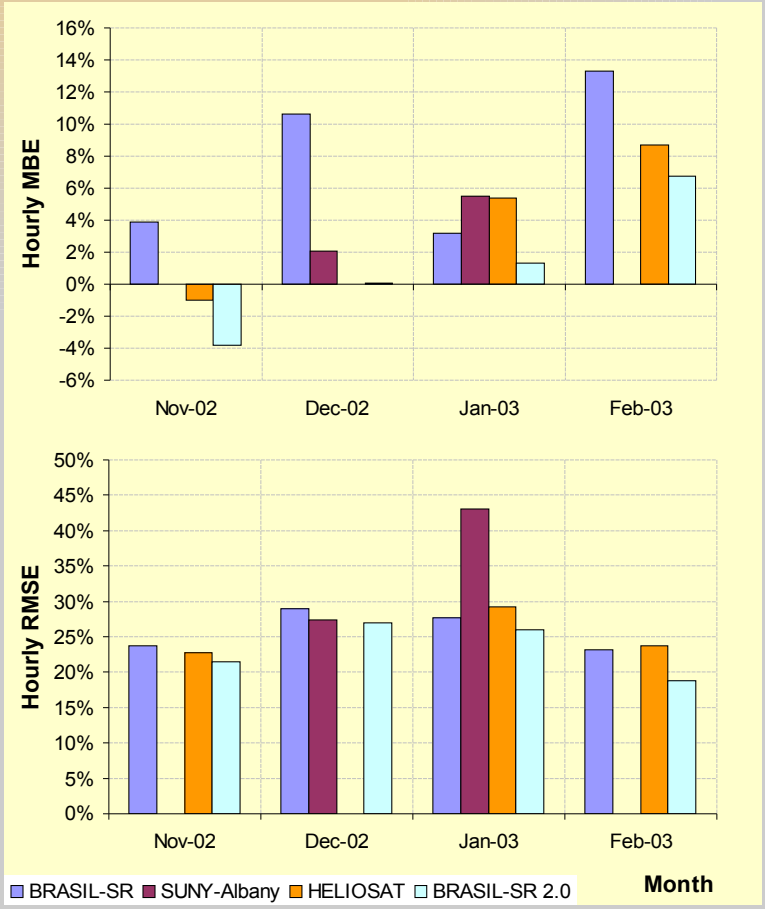
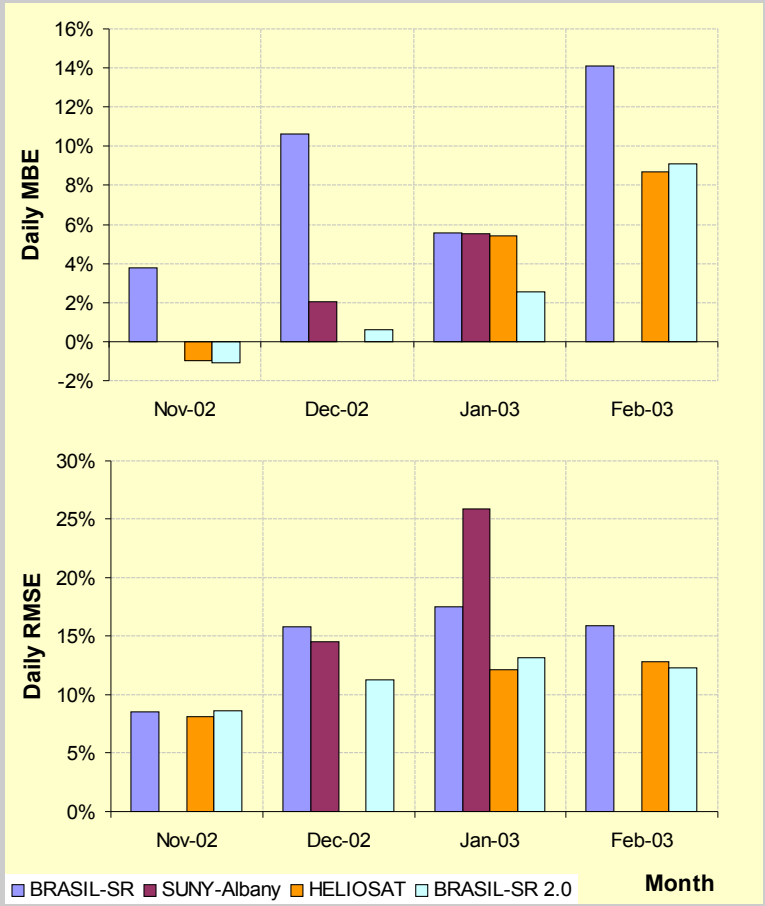
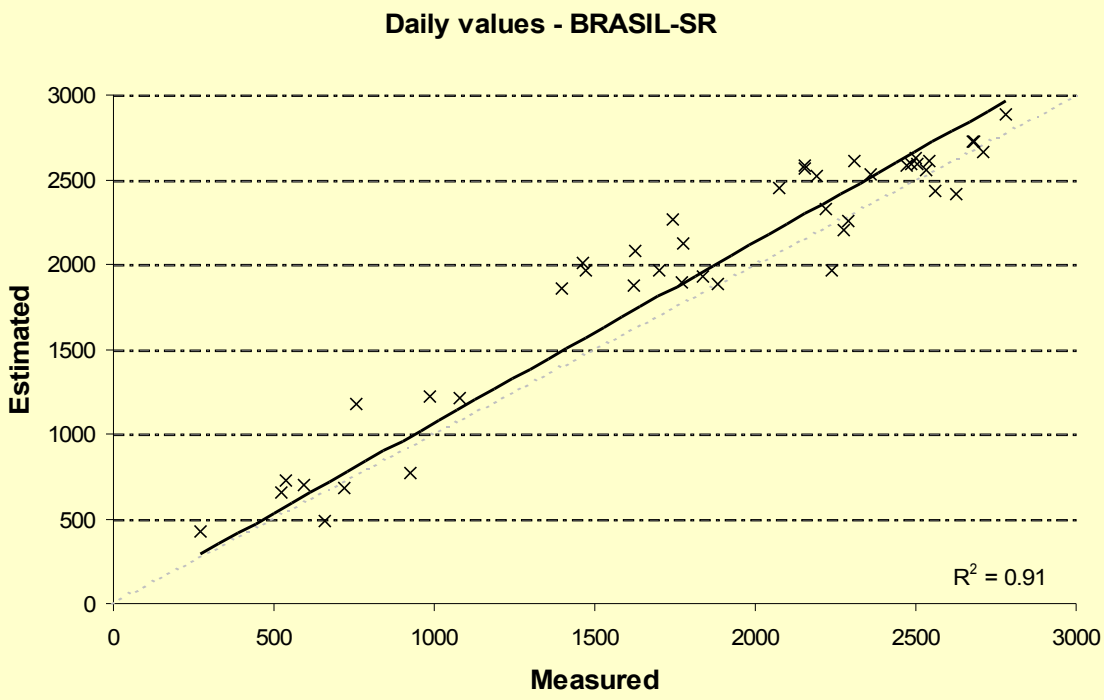
Benchmarks for Florianópolis

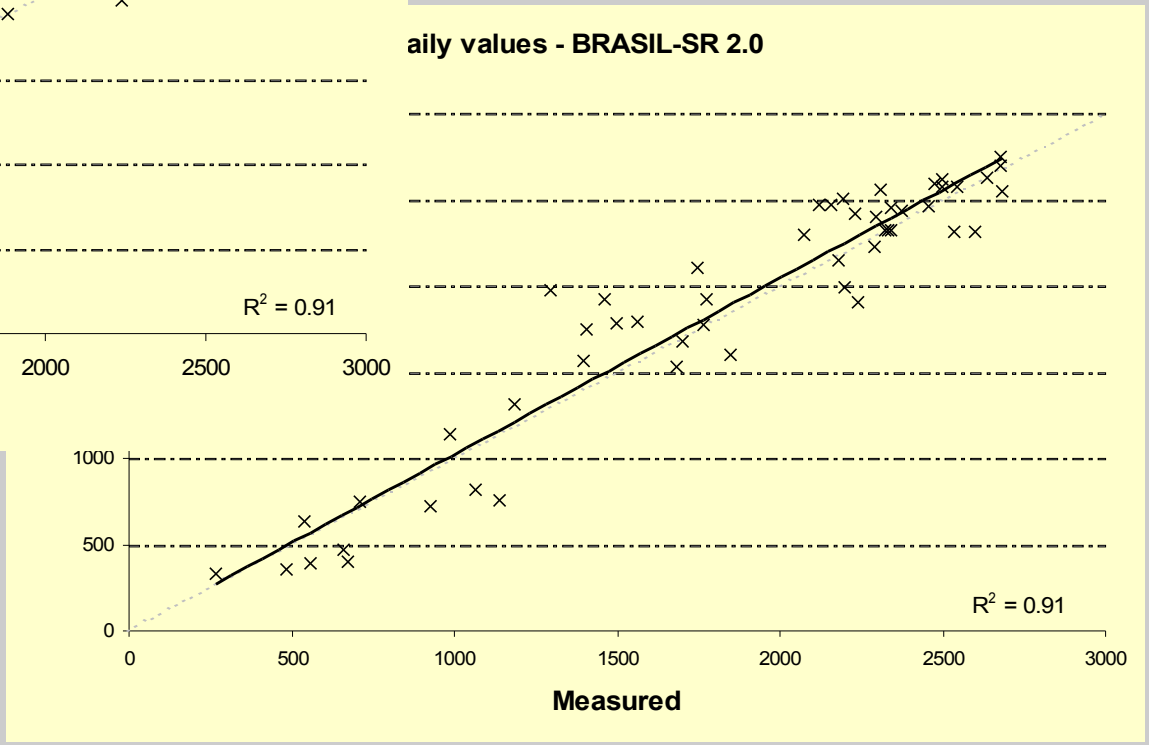




Comparison for daily data

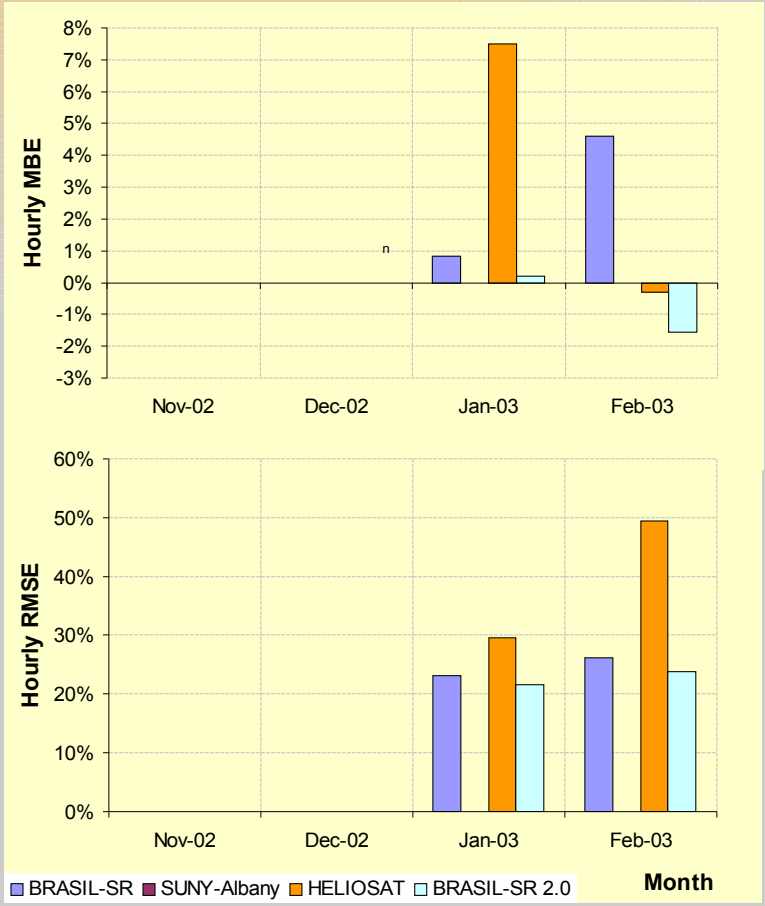
Site 2 – Florianópolis

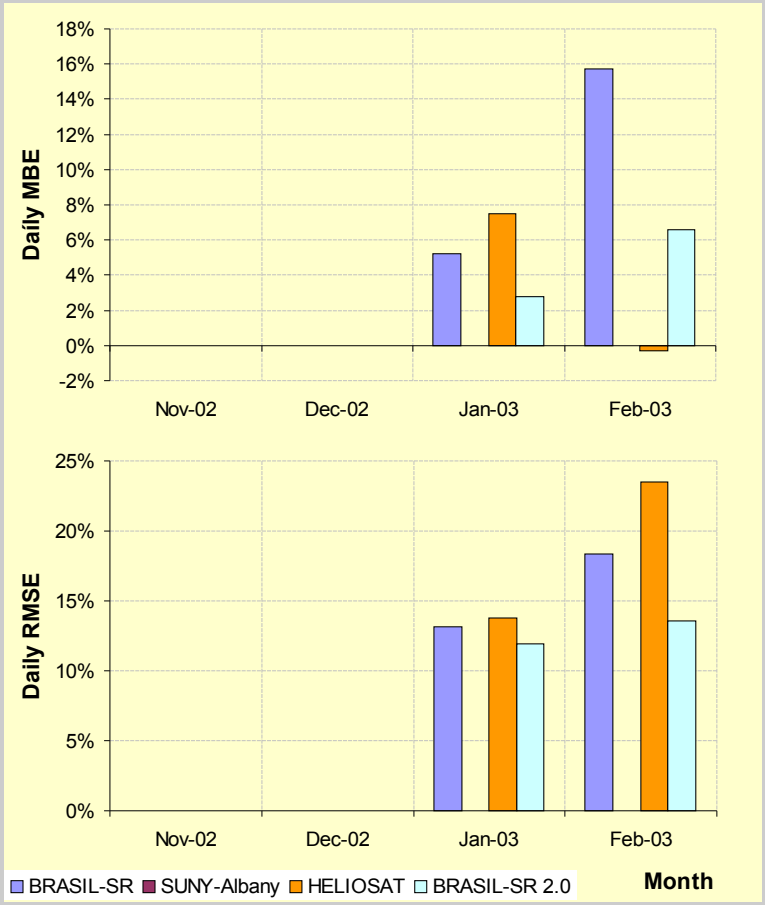




Units: **W.h.m^{-2}**

Benchmarks for Balbina





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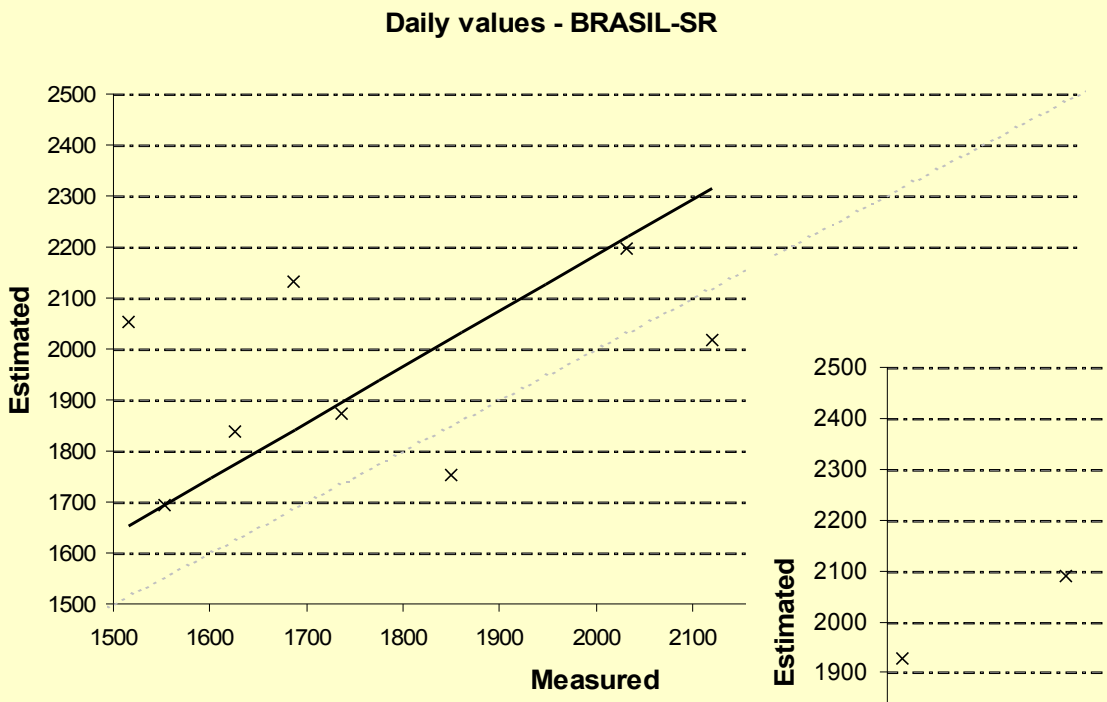
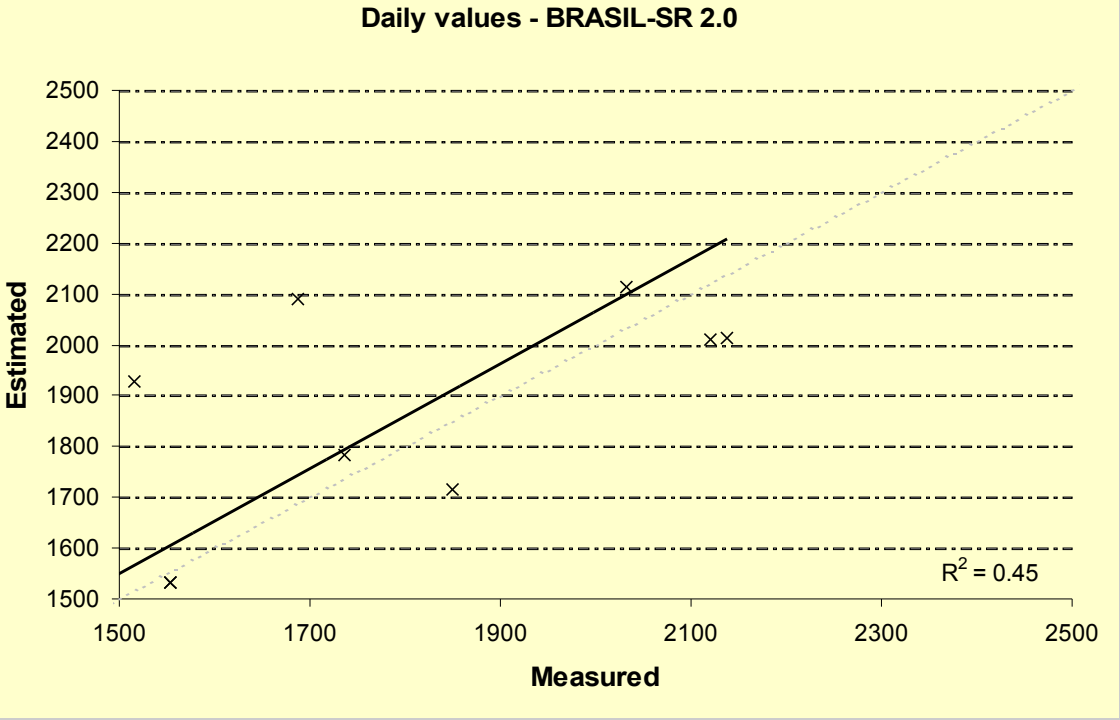
Comparison for daily data

Site 3 – Balbina





Units: **W.h.m^{-2}**

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Conclusions

From the preliminary cross-validation we concluded that:

- Both BRASIL-SR and the SUNY-Albany produced estimates that are statistically comparable for the studied sites
- Correlation factors are good in both core models for hourly and daily estimates
- There is a need to improve the both methods to obtain better estimations of cloud cover index in order to cope with situations where the sky is cloudless most of the year such as in Caicó
- There still remains a lot to do in terms of validation and model adjustments before operational procedures using the core models