



# Validation and comparison of incoming solar radiation satellite databases on the Atlantic coast of Central Africa

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# Validation and comparison of incoming solar radiation satellite databases on the Atlantic coast of Central Africa.

Amine OUHECHOU, Nathalie PHILIPPON and Béatrice MOREL



# • Objectives

- ❖ Analyze the mean spatial and temporal variations of solar radiation (light availability for tree photosynthesis)
- ❖ Document the specificity of the Atlantic coast
- ❖ Determine which satellite estimate(s) (in the absence of sufficient in-situ measurements) is the most suitable for the study of solar radiation on the Atlantic coast.

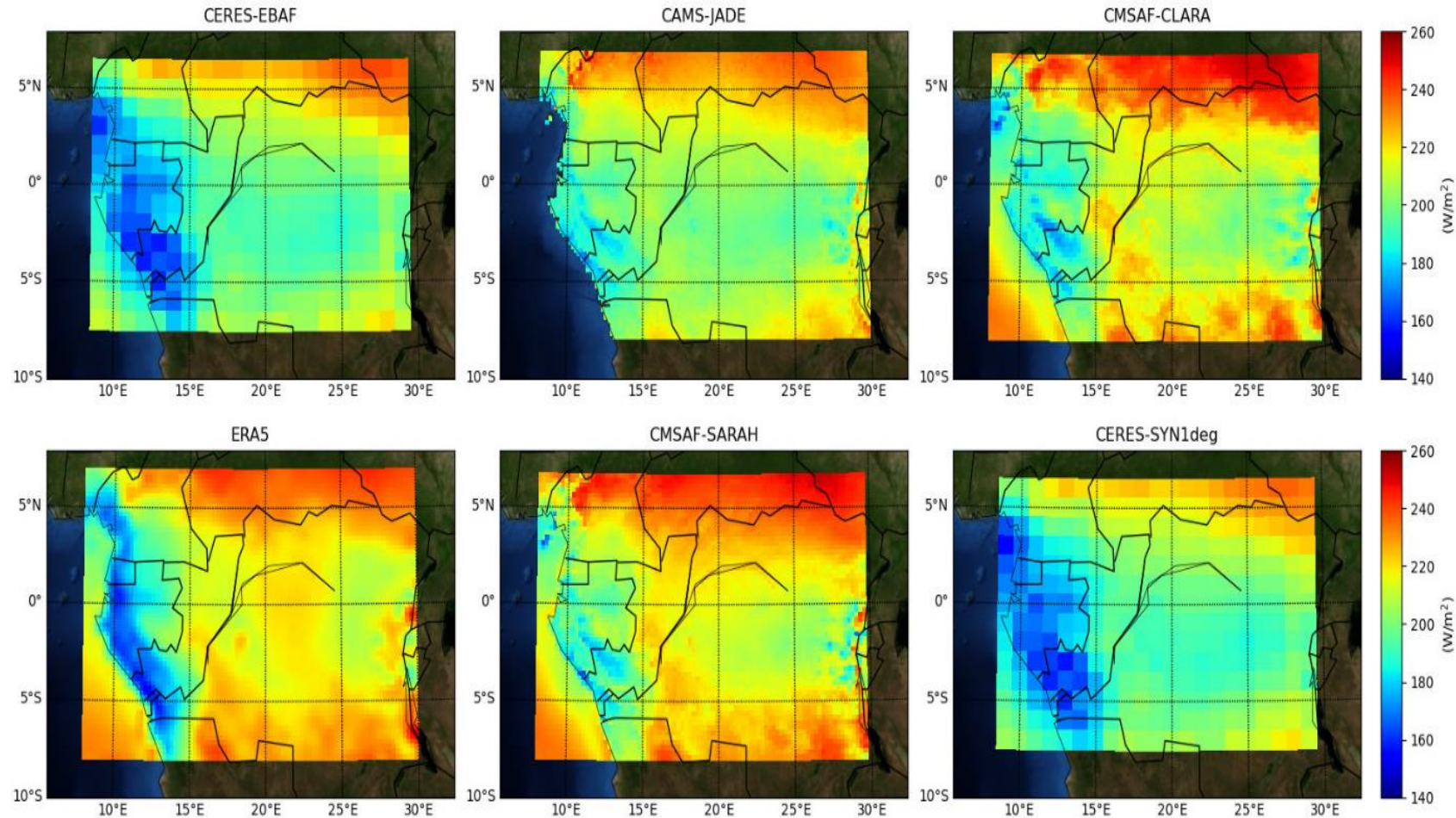
# • Data used



| Data set                         | Spatial resolution | Temporal resolution | Temporal range    | Satellite                                                           | orbit type             |
|----------------------------------|--------------------|---------------------|-------------------|---------------------------------------------------------------------|------------------------|
| CERES-EBAF                       | 1° × 1°            | Monthly             | 2000-03 / 2019-11 | Terra + Aqua                                                        | Heliosynchronous orbit |
| CERES-SYN1deg                    | 1° × 1°            | Hourly              | 2000-03 / 2019-11 | Terra + Aqua                                                        | Heliosynchronous orbit |
| Ré-analyses ERA5                 | 0.25° × 0.25°      | Monthly             | 1979-01 / 2020-12 | ---                                                                 | ---                    |
| CM SAF-CLARA-A2                  | 0.25° × 0.25°      | Monthly             | 1982-01 / 2015-12 | AVHRR sensors on series of NOAA satellites and the METOP satellite. | polar orbit            |
| CAMS-JADE                        | 0.2° × 0.2°        | 15 minutes          | 2005-01 / 2018-12 | MVIRI/SEVIRI on METEOSAT MSG                                        | geostationary orbit    |
| CM SAF-SARAH 2                   | 0.05° × 0.05°      | Hourly              | 1983-01 / 2020-12 | MVIRI/SEVIRI on METEOSAT MSG                                        | geostationary orbit    |
| FAO stations                     | N/A(station)       | Monthly means       | ---               | ---                                                                 | ---                    |
| Original meteorological stations | N/A(station)       | 15min to daily      | ---               | ---                                                                 | ---                    |

# • Results and Discussion

## Spatial distribution of the annual mean of incoming solar radiation

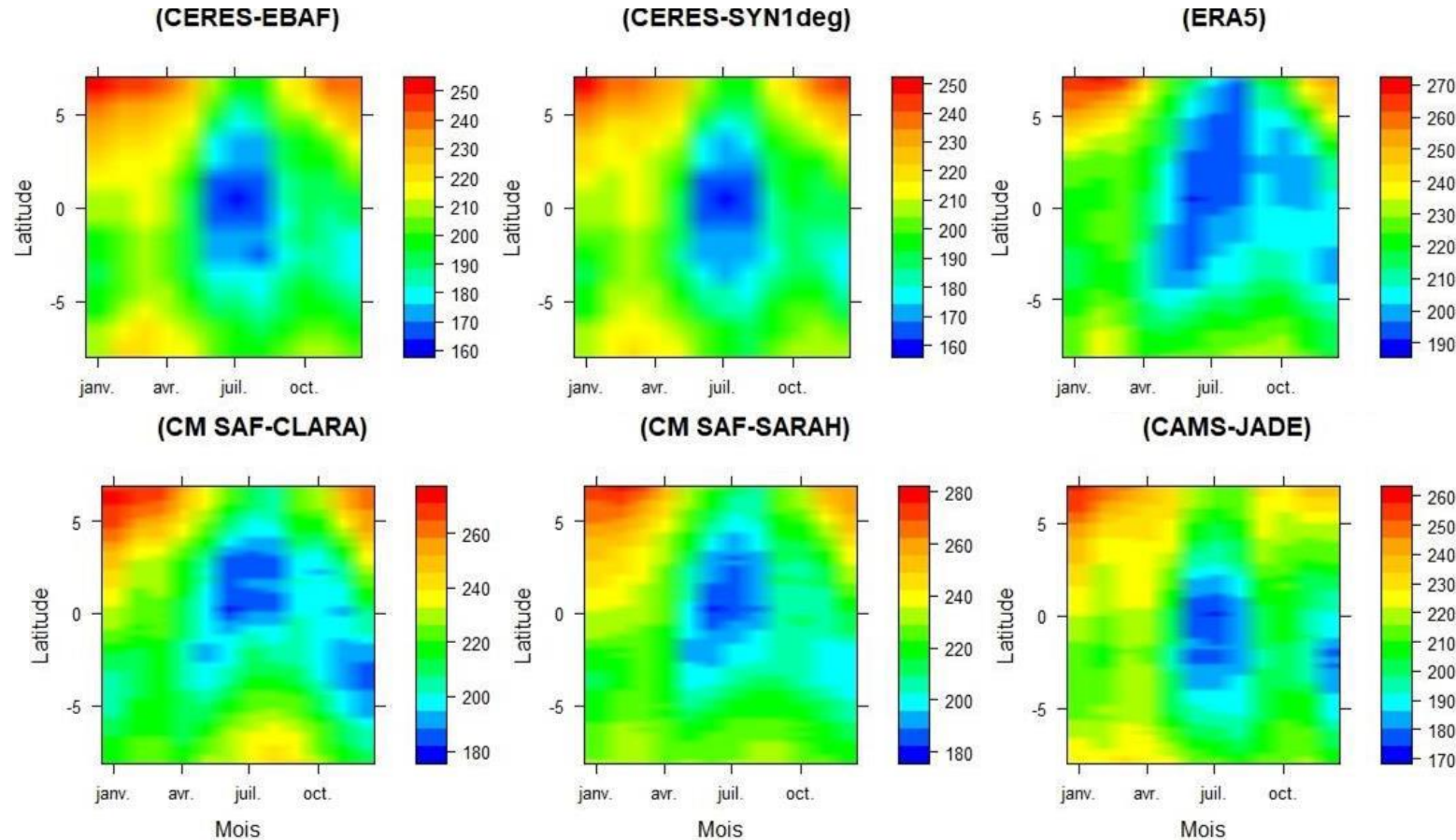


☐ The Atlantic coast receives the least quantity of solar radiation

☐ Satellite products from MSG are the brightest

# • Results and Discussion

## Hovmöller diagram



□ The longitudinal extent is 8° - 30°E

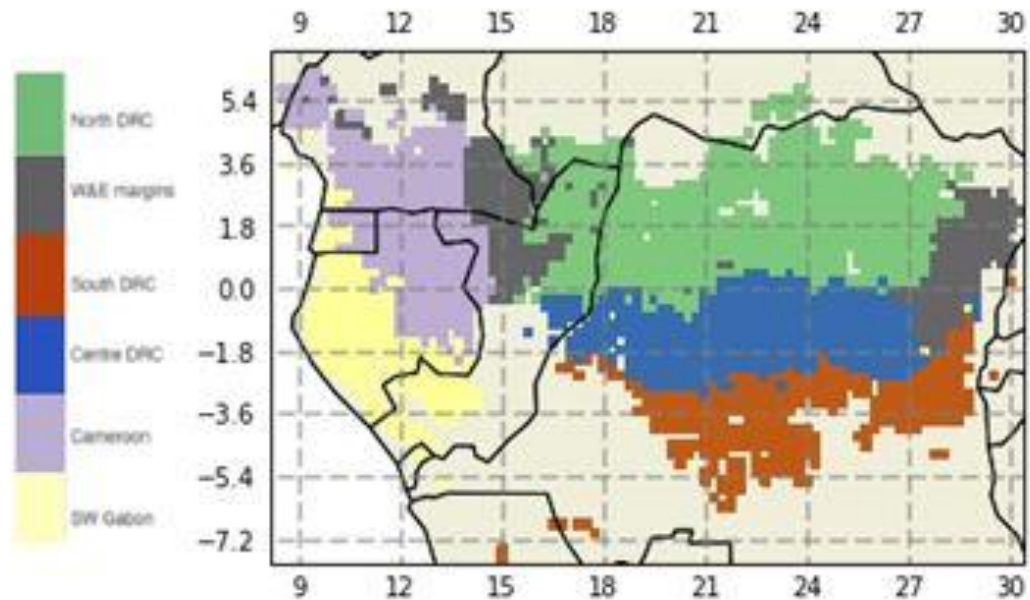
□ The minimum of solar radiation is observed in June-August

□ CLARA and ERA5 have a second minimum during the October-November rainy season

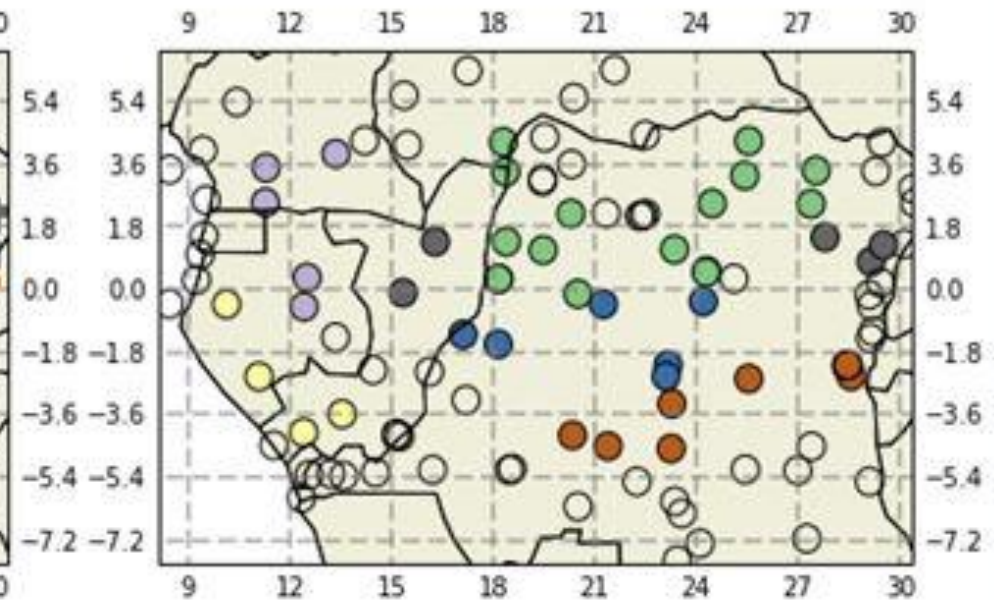
# • Results and Discussion

Evaluation of products on sub-regions using FAO's  
in situ measurements

Climate regionalization of Central Africa



Location of the FAO stations



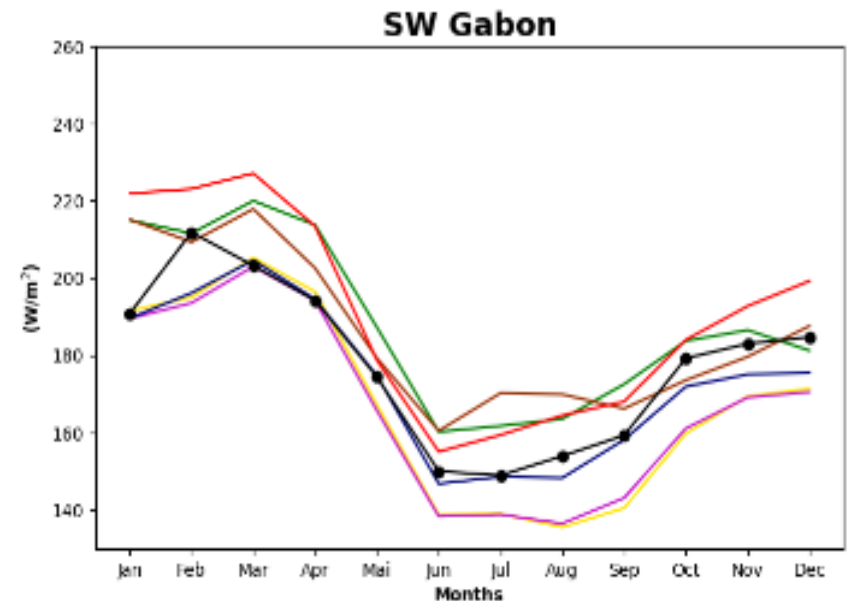
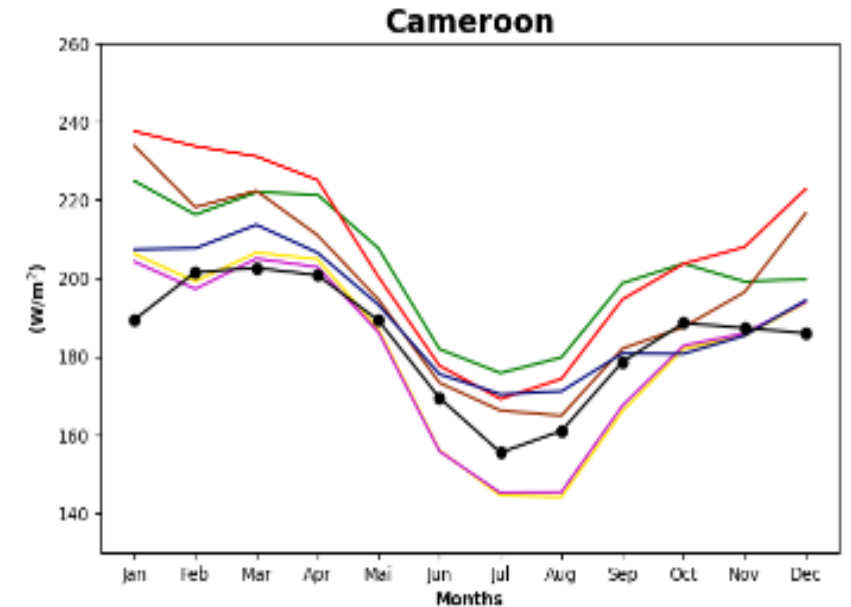
Philippon,N et al. (2018). CYCLES DIURNES DE RAYONNEMENT SOLAIRE ET FORETS EN AFRIQUE CENTRALE.

# • Results and Discussion

| Products      | Correlation | Bias                   | Spatial resolut° |
|---------------|-------------|------------------------|------------------|
| CERES-EBAF    | 0,85        | -2,32 W/m <sup>2</sup> | 1° x 1°          |
| CERES-SYN1deg | 0,85        | -3,51 W/m <sup>2</sup> | 1° x 1°          |
| ERA5          | 0,81        | 13 W/m <sup>2</sup>    | 0,25° x 0,25°    |
| CMSAF-CLARA   | 0,76        | 11 W/m <sup>2</sup>    | 0,25° x 0,25°    |
| CMSAF-SARAH   | 0,77        | 15 W/m <sup>2</sup>    | 0,05° x 0,05°    |
| CAMS-JADE     | 0,75        | 8 W/m <sup>2</sup>     | 0,2° x 0,2°      |

- ❑ The cycle is well reproduced by all the products ( R>0,75 )
- ❑ CERES underestimates and the other products overestimate
- ❑ The maximum in February-March and the minimum in July-August

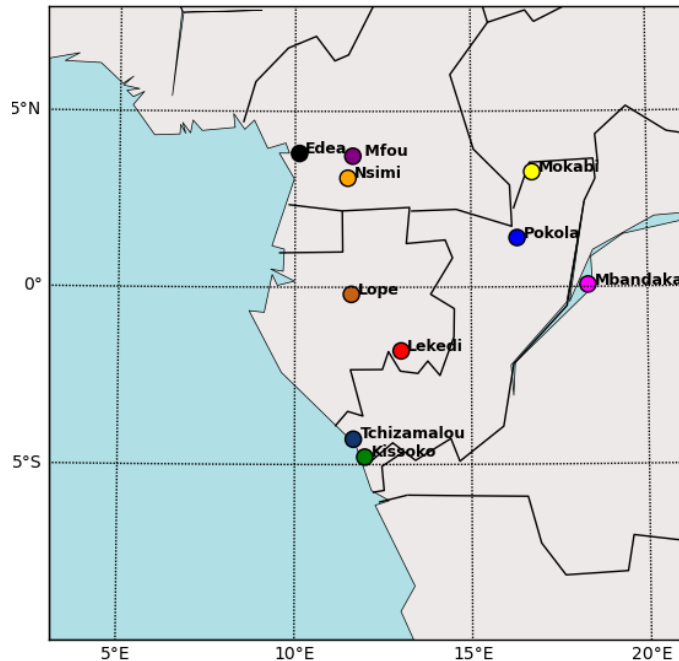
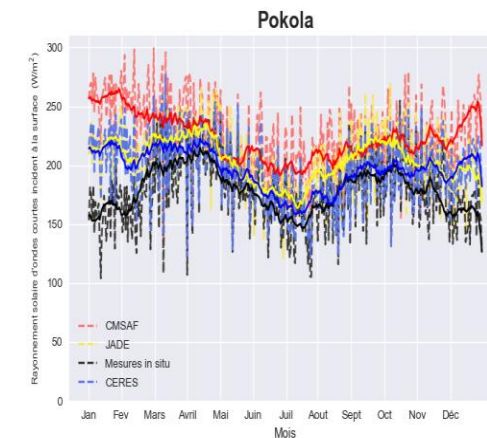
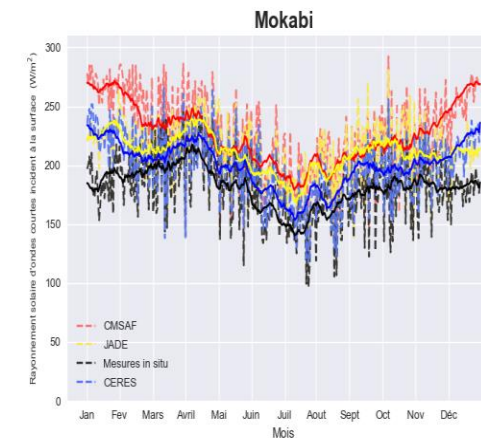
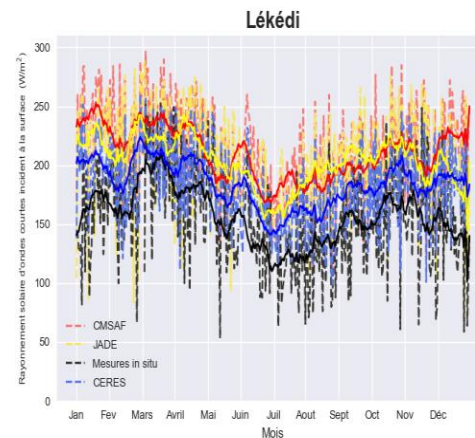
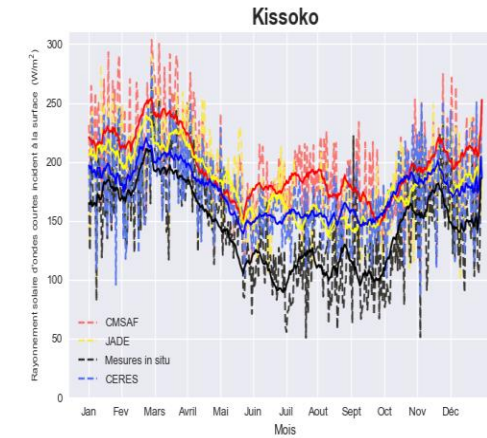
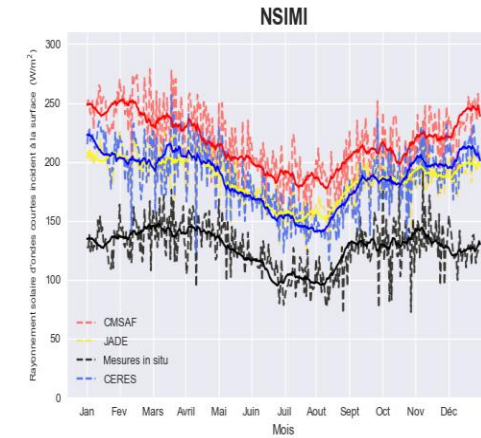
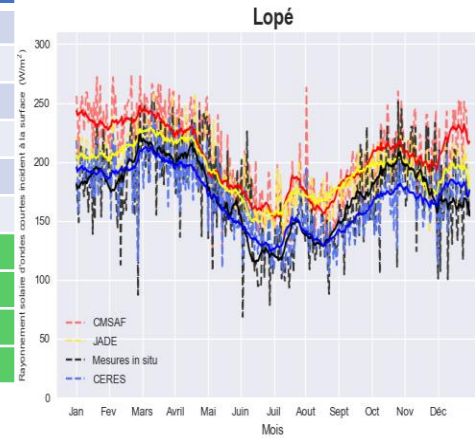
## Mean annual cycle of incoming solar radiation



# Results and Discussion

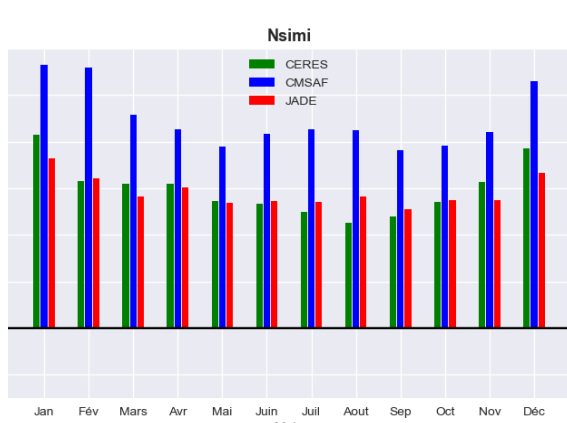
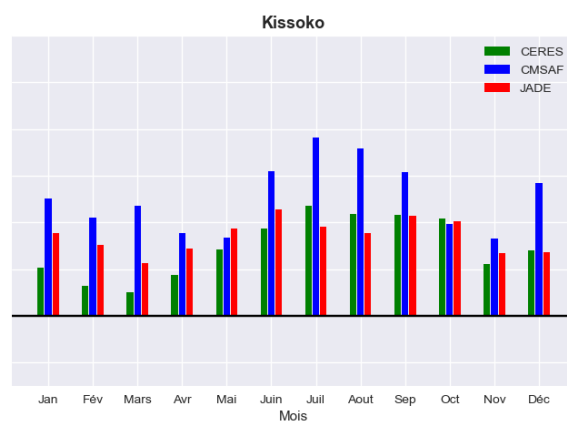
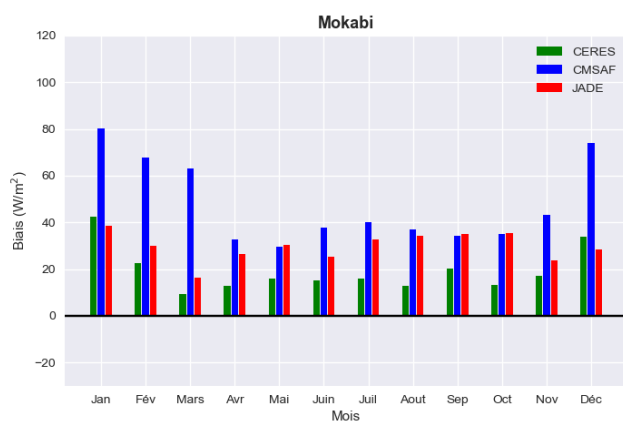
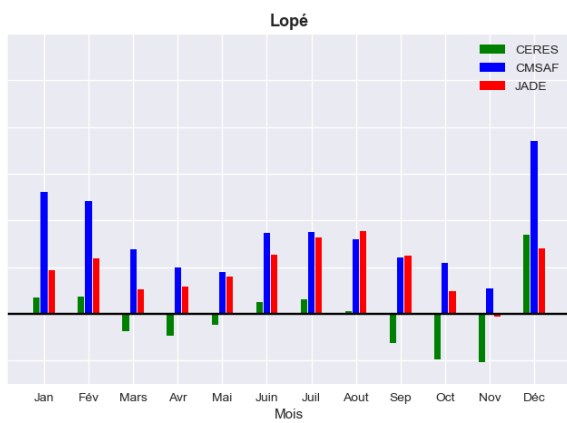
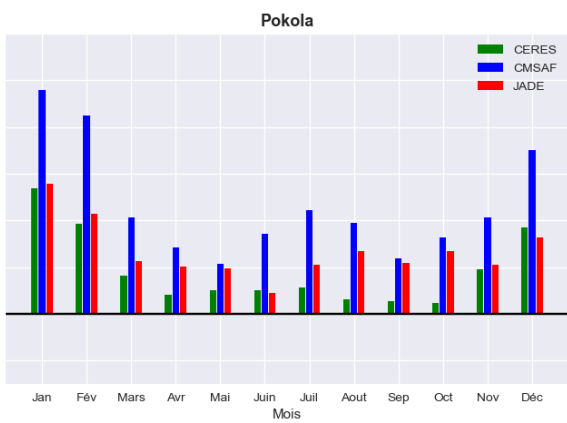
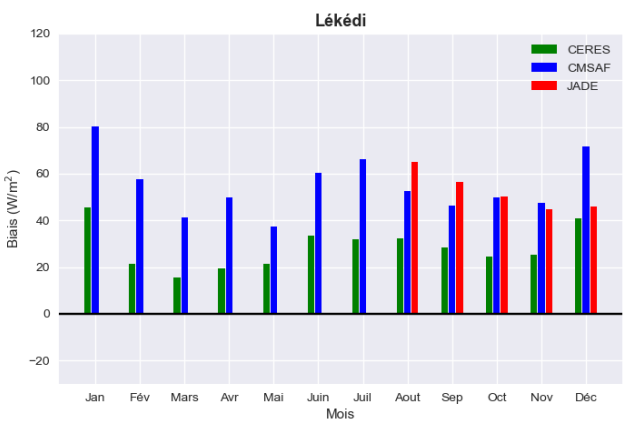
Validation and inter-comparison of (CERES-SYN1deg , CMSAF-SARAH and CAMS-JADE) on a daily scale with original meteorological data.

| Stations    | Country  | Temporal resolution | Availability period |
|-------------|----------|---------------------|---------------------|
| Pokola      | Congo    | 15 min              | 03/2016 – 12/2020   |
| Lopé        | Gabon    | Daily               | 01/2012 – 10/2015   |
| Lékédi      | Gabon    | 15/30 min           | 07/2018 – 07/2019   |
| Mokabi      | Congo    | 15 min              | 03/2016 – 12/2020   |
| NSIMI       | Cameron  | Daily               | 04/2004 – 03/2008   |
| Kissoko     | Congo    | 30 min              | 04/2004 – 06/2006   |
| Tchizamalou | Congo    | 15 min              | 06/2006 – 12/2009   |
| Edea        | Cameroun | 15 min              | 01/2020 – 12/2020   |
| Mbandaka    | RDC      | 15 min              | 11/2018 – 12/2020   |
| Mfou        | Cameron  | 15 min              | 09/2018 – 12/2020   |



# • Results and Discussion

## Monthly variation of bias results.



- ☐ The strongest biases are observed during the 2 dry seasons.
- ☐ Strong biases in January-February when it is in the North of the equator and the opposite when it is in the South.

|             | CERES-SYN1deg  | CAMS-JADE      | CMSAF-SARAH  |
|-------------|----------------|----------------|--------------|
| Correlation | [0.55 – 0.91 ] | [0.58 – 0.87 ] | [0.6 – 0.9 ] |
| Bias        | [-20 – 51 ]    | [23.8 – 52 ]   | [34.7 – 86 ] |
| RMSE        | [8.8 – 83 ]    | [19 – 73 ]     | [21 – 113 ]  |

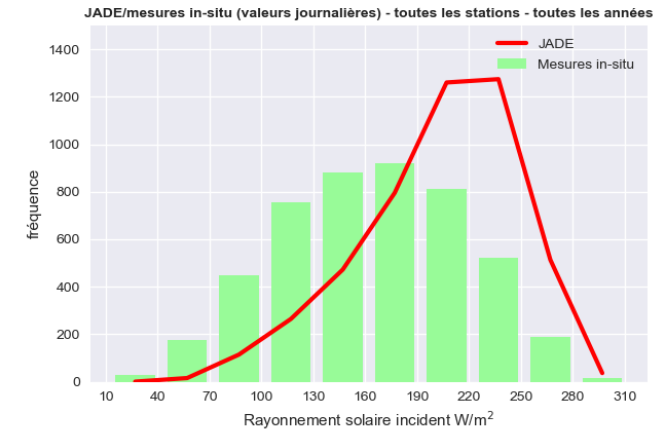
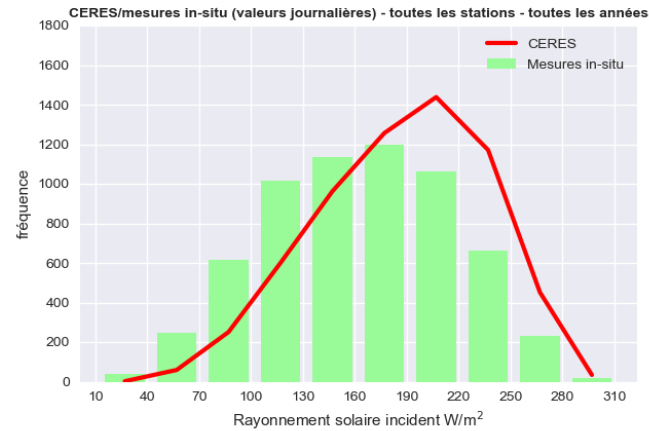
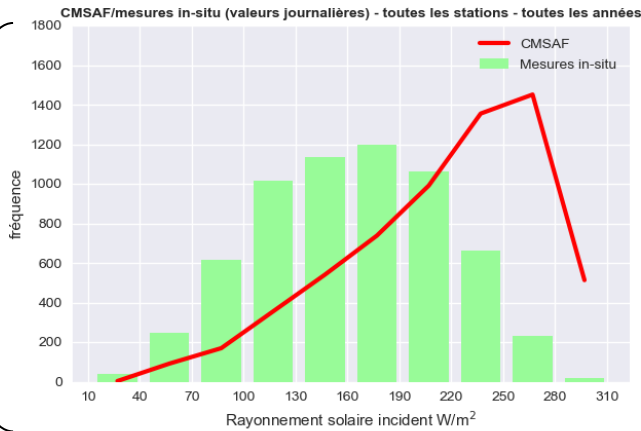
# • Results and Discussion

**CMSAF-SARAH**

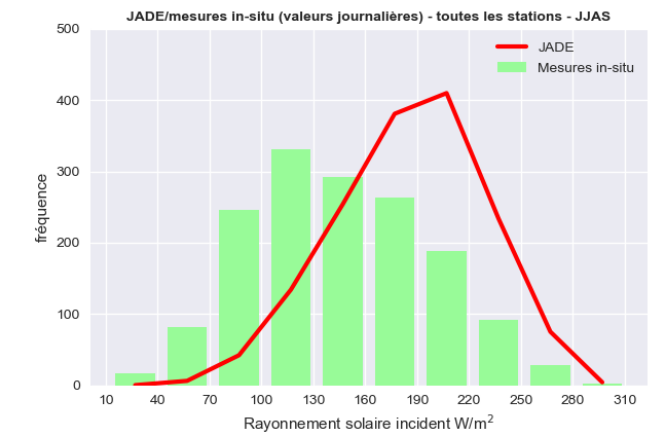
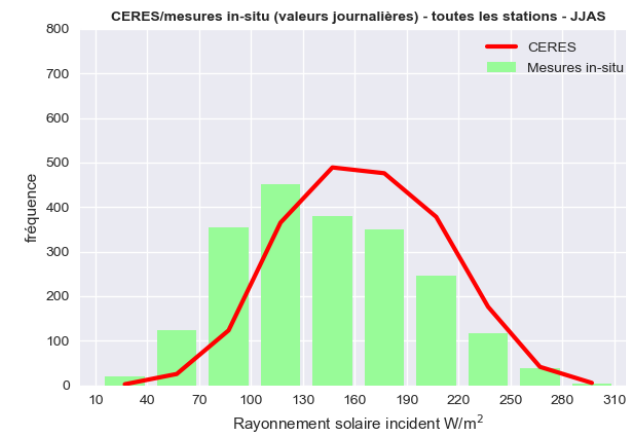
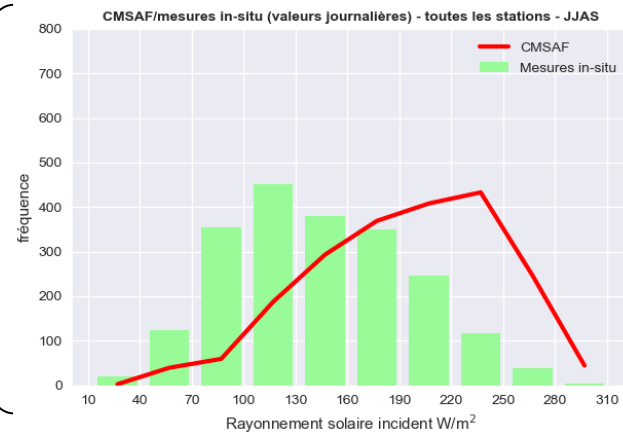
**CERES-SYN1deg**

**CAMS-JADE**

All years



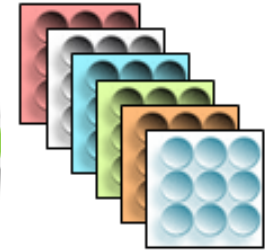
Dry season JJAS



❑ Products see too many bright days and fewer obscure days

# • Conclusion

The incoming solar radiation data from 5 satellite estimates, including CERES-EBAF, CERES-SYN1deg, CMSAF-SARAH, CMSAF-CLARA and CAMS-JADE, as well as the ERA5 reanalyses



The comparison of the six products shows that the Atlantic coast of Central Africa receives the least amount of solar radiation in all products.

Less of Bias for CERES-EBAF and CERES SYN1deg products which underestimate the incident solar radiation while the other satellite products overestimate it. CMSAF-SARAH overestimates the most.



The satellite products represent well the spatial distribution, and reproduce well the mean annual cycle of incident solar radiation