Edition 4.2 EBAF: Surface

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Edition 4.2 algorithm change from Edition 4.1

• Only MODIS and VIIRS retrieved cloud properties are used. (i.e. No cloud properties derived from geostationary satellites is used.)

• MERRA-2 provides temperature and humidity profiles and skin temperature. However, MODIS and VIIRS cloud properties are derived using GEOS-5.4.1.

• Climatological adjustment is applied to Terra only (March 2000 through June 2002) and NOAA20 only (April 2022 onward) periods.
  • Climatologically adjusted flux $\hat{F}_x^t$ for Terra only and NOAA20 only periods is the Terra+Aqua climatological mean flux + anomalies derived from Terra or NOAA20.

$$\hat{F}_x^t = \bar{F}_x^{ta} + \Delta F_x^t$$ and $$\hat{F}_x^{n20} = \bar{F}_x^{ta} + \Delta F_x^{n20}$$
Global monthly mean all-sky surface downward shortwave irradiance

Red:
No climatological adjustment

\[
\hat{F}_x^{n20} = \bar{F}_x^{n20} + \Delta F_x^{n20} = \bar{F}_x^{ta} + [(\bar{F}_x^{n20} - \bar{F}_x^{ta}) + \Delta F_x^{n20}]
\]

Blue:
Climatological adjustment to NOAA 20 data

\[
\hat{F}_x^{n20} = \bar{F}_x^{ta} + \Delta F_x^{n20}
\]
Global monthly mean all-sky surface downward longwave irradiance

Red:
No climatological adjustment

\[
\hat{F}_{x}^{n_{20}} = \bar{F}_{x}^{n_{20}} + \Delta F_{x}^{n_{20}} = \bar{F}_{x}^{ta} + [(\bar{F}_{x}^{n_{20}} - \bar{F}_{x}^{ta}) + \Delta F_{x}^{n_{20}}]
\]

Blue:
Climatological adjustment to NOAA 20 data

\[
\hat{F}_{x}^{n_{20}} = \bar{F}_{x}^{ta} + \Delta F_{x}^{n_{20}}
\]
Regional downward shortwave irradiance

Northeast Pacific

Southeast Pacific

Edition 4.2 EBAF
Terra&Terra+Aqua&NOAA20
Edition 4 SYN1deg NOAA20
## Standard deviation and RMS difference tables

<table>
<thead>
<tr>
<th>Region</th>
<th>Standard deviation (Wm$^{-2}$)</th>
<th>RMS difference (Wm$^{-2}$)</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terra common period</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOAA 20 common period</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Terra common period</td>
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### Downward shortwave irradiance

<table>
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<tr>
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<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
<td>0.612</td>
<td>0.120</td>
<td>0.986</td>
</tr>
<tr>
<td><strong>NE Pacific</strong></td>
<td>5.55</td>
<td>0.611</td>
<td>0.993</td>
</tr>
<tr>
<td><strong>SE Pacific</strong></td>
<td>7.93</td>
<td>1.07</td>
<td>0.988</td>
</tr>
</tbody>
</table>

### Downward longwave irradiance

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</thead>
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<tr>
<td><strong>Global</strong></td>
<td>0.551</td>
<td>0.078</td>
<td>0.991</td>
</tr>
<tr>
<td><strong>NE Pacific</strong></td>
<td>2.70</td>
<td>0.114</td>
<td>0.999</td>
</tr>
<tr>
<td><strong>SE Pacific</strong></td>
<td>3.59</td>
<td>0.209</td>
<td>0.998</td>
</tr>
</tbody>
</table>
Evaluation of climatological adjustment concept with surface observations

SYN1deg Edition 4 WHOI Stratus buoy data
Full: All observations
TE: Terra overpass time
TA: Terra+Aqua overpass time
N20: NOAA20 overpass time
Difference from Edition 4.1
60S-60N Land+Ocean

[G-5.4.1 Anomalies] – [ERA-5 Anomalies]

After 2016, GEOS-5.4.1 temperature and humidity anomalies are lower.

- The differences between G541 and ERA5 are similar to those between G541 and MERRA-2.
- This implies that the differences are mainly driven by G541 problems.

Temperature (K)

Water Vapor (g/kg)

Pressure (hPa)

Pressure (hPa)

- Loss of MHS (microwave humidity sounder) November 2019
- Fewer instruments are assimilated so that the impact is larger in GEOS-5.4.1
- Tropical standard ATM Water vapor mixing ratio @ 400 hPa
  ~0.6 g/kg
  ~20 to 30% drift
Correction to GEOS-5.4.1 temperature and humidity profiles were made after November 2019.

The effect on the mitigation of MHS loss is limited.
Surface shortwave net irradiance trends (Wm\(^{-2}\) dec\(^{-1}\))
20003 - 202212

Edition 4.1

Edition 4.2

Regions with a difference outside the 5% - 95% confidence interval
Surface longwave net irradiance trends ($\text{Wm}^{-2} \text{dec}^{-1}$)

Edition 4.1 – Edition 4.2

Regions with a difference outside the 5% - 95% confidence interval
Net longwave irradiance trend \((Wm^{-2} \text{ dec}^{-1})\)

Regions with a trend over March 2000 to December 2022 outside the 5% - 95% confidence interval
Trends of net surface irradiances in the period from March 2000 through December 2022

Net total trend: Ocean trend is dominated by SW and land trend is dominated by LW
All-sky longwave irradiance trend over land and ocean

- Downward longwave anomaly (Wm$^{-2}$)
  - Land: $\sigma = 1.552$, $\rho_{\text{anomaly}} = 0.724$ (0.989/decade)
  - Ocean: $\sigma = 0.955$, $\rho_{\text{anomaly}} = 0.748$ (0.838/decade)

- Upward longwave anomaly (Wm$^{-2}$)
  - Land: $\sigma = 1.753$, $\rho_{\text{anomaly}} = 0.724$ (1.861/decade)
  - Ocean: $\sigma = 0.852$, $\rho_{\text{anomaly}} = 0.748$ (0.961/decade)

Year
Summary

• Surface irradiances for Edition 4.2 EBAF are computed using only MODIS and VIIRS derived cloud properties (i.e. no geostationary satellite derived clouds).

• Cloud properties derived from one orbit (i.e. Terra only or NOAA20 only) are sufficient to derive surface irradiance anomalies.

• Uncertainty in Edition 4.2 surface irradiance anomalies is significantly smaller than the uncertainty in Edition 4.1 surface irradiance anomalies.

• Negative total area clear-sky upward shortwave irradiances occur in both TOA and surface near the boundary of daytime and nighttime.
Back-ups
Determine monthly $1\degree \times 1\degree$ mean TOA shortwave and longwave irradiance differences

$$\Delta F_{\text{TOA}} = F_{\text{SYN,\text{TOA}}} - F_{\text{CERES}}$$

Determine surface, atmosphere, and clouds property adjustments $\Delta x$ by the Lagrange multiplier method

Correct the bias error of TOA and surface irradiances

Determine surface irradiance adjustments $\Delta F_{\text{Sfc}}$ by Jacobian

Produce monthly $1\degree \times 1\degree$ mean surface irradiances

$$F_{\text{EBAF,Sfc}} = F_{\text{SYN1,Sfc}} + \Delta F_{\text{Sfc}}$$

Computed clear-sky irradiances to be adjusted (SYN1deg-Hr, hourly, clear-sky fraction weighted mean)

Computed all-sky irradiances (SYN1deg-Month noGEO)

Reference observed TOA irradiances (EBAF-TOA)

Difference of T, and q profiles from AIRS (CLIMCAPS), and MERRA-2

T and q Jacobians generated with SYN1deg-Hr (3 hourly)

T, q, and cloud Jacobians generated with SYN1deg-Month

Input datasets

Algorithms and tools

Validation with surface observations

Climatological adjustment of monthly mean $1\degree \times 1\degree$ surface irradiances
Anomaly time series with and without climatological adjustment: global monthly anomalies

Downward shortwave

Downward longwave