Homogenisation of GERB and CERES fluxes.

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Overview

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2. Nature of expected errors
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Context: Climate Monitoring SAF

- Sattelite Aplication Facilities (SAF’s): project initiated by EUropean METeosat SATellite (EUMETSAT) organisation for better exploitation of (future) satellite data
- Climate Monitoring SAF: aims to derive satellite products with good quality and which are consistent in time
Role of RMIB in CM SAF

- Derive radiative fluxes at top of atmosphere
- Input sources for incoming solar irradiance: solar irradiance measurements
- Input sources for reflected solar irradiance and emitted thermal irradiance: GERB and CERES
Flowchart for incoming solar radiance

1. Continuous TSI measurements
2. Reference TSI measurements
3. TSI homogenisation
4. Daily mean SARR solar irradiance at 1 A.U.
5. Three hours mean incident solar flux over grid boxes
6. Averaging

Daily/monthly and monthly diurnal
Flowchart for reflected solar and emitted thermal irradiance

- High resolution 15' GERB fluxes
- Collocation
- Database of collocated flux pairs
- Statistical analysis
- Objective characterisation of systematic errors
- A posteriori correction
- A posteriori correction
- Three hours mean calculation and merging
- Averaging
- Homogenised daily/monthly and monthly diurnal

Feedback for a priori correction
Homogenisation of GERB and CERES fluxes

- Homogenisation = merge datasets without introducing discontinuities
  - statistical analysis: estimation of systematic differences in function of known parameters
  - a posteriori correction: removal of systematic differences
Nature of expected errors

- **Satellite measurement -> Unfiltered radiance**
  - processing: calibration, unfiltering
  - expected errors depend on scene type

- **Unfiltered radiance -> Flux**
  - processing: angular modelling
  - expected errors depend on scene type and viewing angles
To homogenise the data from two sources, a comparison and the choice of a reference is needed.

\[
\text{Difference} = \text{source 1} - \text{source 2} \\
= (\text{source 1} - \text{reference}) - (\text{reference} - \text{source 2}) \\
= \text{error 1} - \text{error 2}
\]
3.2 Definition of comparison cases and bins

- Comparison/homogenisation can be done independently for number of cases $c$:
  - radiances, thermal flux: 3 surface scene types ocean, land, desert
  - solar flux: 3 surface scene types x solar zenith angle intervals
Comparison method = regression

- e.g. flux comparison

\[ \text{F}_{\text{CERES}} = A + B \text{F}_{\text{GERB}} \]

- perfect agreement \( \leftrightarrow \) \( A=0, B=1 \)

- cloud classes are treated implicitly
  - solar: low values \( \leftrightarrow \) clear sky
    high values \( \leftrightarrow \) cloudy sky
  - thermal: low values \( \leftrightarrow \) cloudy sky
    high values \( \leftrightarrow \) clear sky
For every comparison case $c$ data has to be compared for different angular bins $b$:

- radiances: viewing zenith angle intervals
- fluxes: viewing zenith and relative azimuth angle intervals
Radial Radiance homogenisation

Use co-angular radiances only

Reference = (GERB + CERES)/2

$\text{error}_{\text{GERB}} = (\text{GERB} - \text{CERES})/2$

$\text{error}_{\text{CERES}} = (\text{CERES} - \text{GERB})/2$
2 Practical implementation

- regress CERES versus GERB radiances
  \[ L_{\text{CERES}} = A + B \cdot L_{\text{GERB}} \]

- homogenise radiances
  \[ L_{\text{homog. CERES}} = -\frac{A}{2} + \left[ 1 + \frac{1-B}{2} \right] L_{\text{CERES}} \]
  \[ L_{\text{homog. GERB}} = \frac{A}{2} + \left[ 1 - \frac{1-B}{2} \right] L_{\text{GERB}} \]

- homogenise fluxes - step 1
  \[ F_{\text{homog. CERES}} = -\pi \frac{A}{2} + \left[ 1 + \frac{1-B}{2} \right] F_{\text{CERES}} \]
  \[ F_{\text{homog. GERB}} = \pi \frac{A}{2} + \left[ 1 - \frac{1-B}{2} \right] F_{\text{GERB}} \]
Flux homogenisation

- good reference = mean flux averaged over all viewing angles
  - removes most of the systematic errors dependent on angles
- problem GERB: mostly backscatter measurements

$$\text{reference} = \frac{\sum_b \text{CERES} \cos(\theta_{vz}) \sin(\theta_{vz})}{\sum_b \cos(\theta_{vz}) \sin(\theta_{vz})}$$
2 CERES flux homogenisation

- choose GERB data for one fixed GERB viewing angle bin $b_{\text{GERB}}$ as intermediate reference
- For every possible CERES viewing angle bin $b$:
  regress CERES fluxes versus GERB fluxes for fixed GERB viewing angle bin $b_{\text{GERB}}$:

$$F_{\text{CERES}}(b) = A(b) + B(b) \, F_{\text{GERB}}(b_{\text{GERB}})$$
calculate reference regression parameters

\[ A = \frac{\sum_b A(b) \cos(\theta_{\nu z}) \sin(\theta_{\nu z})}{\sum_b \cos(\theta_{\nu z}) \sin(\theta_{\nu z})} \]

\[ B = \frac{\sum_b B(b) \cos(\theta_{\nu z}) \sin(\theta_{\nu z})}{\sum_b \cos(\theta_{\nu z}) \sin(\theta_{\nu z})} \]

homogenise CERES fluxes relative to reference

\[ F_{\text{CERES, homog.}} = A - A(b) + (1 + B - B(b)) F_{\text{CERES}}(b) \]
8 GERB flux homogenisation

- GERB fluxes for all possible bins can be homogenised by regression against homogenised CERES fluxes
Needed data

- CERES in RAPS mode: all viewing zenith angles and relative azimuth angles are covered.
- All surface scene types and solar zenith angle intervals need to be covered in METEOSAT field of view.
- e.g. 6 RAPS days in August 1998 for TRMM.
Conclusions

- A method has been proposed to homogenise GERB and CERES fluxes.
- The method removes the angular dependent systematic differences between GERB and CERES.
- The method will be tested using the 6 CERES RAPS days in August 1998 using GERB like data derived from METEOSAT.