Surface Atmosphere Radiation Budget (SARB) working group update

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Outline of this presentation

• MATCH aerosol transport model

• Surface downward shortwave irradiance anomalies during COVID-19 period (January, February, and March 2020).

• Effect of Australia fire on radiation budget in January 2020

• Level 3 surface radiation data product (SYN1deg) after Terra starts to drift in 2021.
  • Edition 4.1: (Terra+Aqua+GEOs ->) Aqua+GEOs -> NOAA-20(+Aqua)+GEOs
  • Edition 5: TBD
    • Quantify GEO artifacts and diurnal cycle of surface irradiances
Work done after the 2020 spring meeting

• Edition 4.1 EBAF and SYN1deg
  • Extended through March 2020
• Fu-liou code k-distribution and CKDMIP
• MATCH aerosol validation
  • Processing (the first day of the month) issue
  • COVID-19
  • January 2020 Australian fires
    • MATCH AOD under partly cloudy conditions
    • Dust aerosols in the no-assimilation run (March 2020).
• Aqua only SYN run
  • A Bug in the MATCH input preparation code leads to a problem in 2004 (July through December).
    • Documented in SYN1deg Data Quality Summary
  • Comparison of 201907 5 cases: Ed4.1. vs. Aqua+GEO vs. Aqua with no GEO vs. Terra with no GEO etc.
• SYN1deg Aqua only (Ed 4.1) versus SYN1deg NOAA-20 (Edition 1)
  • Polar night clouds
  • Thin cirrus over tropics
• MOSAiC data analysis
• GMAO telecon
• Edition 5 SYN (produced the list of variables to be included in TSI)
• C3M revision (Seung-Hee Ham’s presentation)
• CRS (Ryan Scott’s presentation)
• Fingerprinting
MATCH aerosol transport model (Edition 4)

- Climatological aerosol source from the surface.
  - Sea salt and dust might depend on surface wind speed
- Anomalies (deviation from the climatology) of aerosol loading come from MODIS aerosol optical thickness.
- MATCH learns deviations from climatological mean aerosols from MODIS.
- Time to take MATCH to learn aerosol anomalies depends on individual case.
- Wind vectors determine spatial distribution of aerosols
- Precipitation is needed for aerosol sink (scavenging)
- Some chemistry modeling (e.g. oxidize sulfur to produce sulfate)
Aerosol optical thickness sources

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<tr>
<th>Satellites</th>
<th>Retrieval algorithm</th>
<th>Starting periods</th>
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<tbody>
<tr>
<td>Terra</td>
<td>Dark target + Deep blue</td>
<td>March 2000</td>
</tr>
<tr>
<td>Aqua</td>
<td>Dark target + Deep blue</td>
<td>July 2002 (begins JD 185)</td>
</tr>
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<td>Terra+Aqua</td>
<td>Dark target + Deep blue</td>
<td>July 2002 (begins JD 185)</td>
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<td>NPP</td>
<td>Dark target or Deep blue</td>
<td>February 2012 (begins JD 019)</td>
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<tr>
<td>NOAA-20</td>
<td>Depending on availability of VIIRS aerosol products</td>
<td>February 2018</td>
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MATCH assimilation of MODIS aerosol optical depth
1) Terra and Aqua Deep Blue and Dark Target hourly data are extracted and gridded into 192lon x 94lat daily files.

2) The four AOT fields are merged into a single daily gridded file.

3) The merged daily field is sliced in to hourly 15 degree longitude bands

- Modis data is not directly assimilated at the overpass time
- Instead it is gridded averaged and assimilated at near Local Solar Noon

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MATCH pre-processed level2 hourly MOD04 into four Daily gridded fields (192x94)
MATCH merges these 4 fields into a single Daily gridded AOT field (192x94)

Combined Ocean Land Deep Blue Aerosol Optical Depth

Data Min = 0.0, Max = 4.8, Mean = 0.2
The daily field is then sliced up by longitude band into hourly AOT fields (192x94) that are the input for the hourly Match assimilation.

Note: Animation is for July 31 2019. This is just to illustrate the assimilation. Hourly bands moving across the globe.
Comparison with AERONET: Beijing China, March 2018
Comparison with AERONET: Beijing China, June 2011
Comparison with AERONET: Beijing China, February 2012
EBAF surface downward shortwave irradiance anomalies January 2020 Clear-sky total region

All-sky anomalies

Clear-sky anomalies

AOD anomalies

CERES_EBAF_Ed4.1

Surface Shortwave Flux Down - Clear-Sky (for total region) ** Anomaly Field ** (W m^-2)

January - 2020

Generated at https://ceres.larc.nasa.gov
EBAF surface downward shortwave irradiance anomalies February 2020 Clear-sky total region
EBAF surface downward shortwave irradiance anomalies March 2020 clear-sky total region

Anomaly is ~10Wm^-2 over land but water vapor anomalies affect the downward shortwave irradiance
Aerosol optical thickness anomalies in 2020
Aerosol anomalies in January 2020

Clear-sky correction applied to clear-sky downward shortwave with observed sampling is ~20% larger than a mean correction. Aerosol under cloudy conditions largely come from MATCH model, i.e., need validation by surface aerosol optical depth observations.
January 2020 Australian fires
Comparison with AERONET AOD: January 2020

Tumbarumba, Australia
Comparison with AERONET AOD: January 2020

CEILAP Rio Gallegos, Argentina
SYN processing plans after Terra starts to drift
Testing Aqua+ GEO (no Terra) SYN (to form radiation budget timeseries with NOAA-20 + GEO)

Mean local time for equator crossing
(Loeb and Doelling 2020)

Global mean TOA reflected shortwave
Aqua only climatological mean is within 0.01 Wm$^{-2}$ of Terra+Aqua with a standard deviation of 0.13 Wm$^{-2}$

Regional mean TOA reflected shortwave
Aqua only climatological mean is within 1.0 to 1.5Wm$^{-2}$ and local differences can reach 5 Wm$^{-2}$.

Whether Aqua only Edition 4 SYN needs to be produced depends on the schedule of MODIS Collection 7 and new GMAO reanalysis product.
Aqua only SYN1deg (July 2019)

- **SYN1deg-Aqua EXP#1**
  - TSI-Aqua only with current code
  - GGE0 where cloud code used MATCH Terra+Aqua
  - Surface Albedo History map, Aqua-only
  - MATCH Aqua-only

- **SYN1deg-Aqua EXP#2**
  - TSI-Aqua only with current code but with different GGE0
  - GGE0 where cloud code uses MATCH Aqua-only (rerun GEO netCDFs)
  - Surface Albedo History map, Aqua-only
  - MATCH Aqua-only

- **SYN1deg-Aqua EXP#3**
  - TSI-Aqua only with new x86b code (TISA bugs fixed, snow models chosen correctly, for NOAA20 too)
  - GGE0 where cloud code used MATCH Terra+Aqua
  - Surface Albedo History map, Aqua-only
  - MATCH Aqua-only

- **SYN1deg-NOAA20 EXP#4**
  - TSI-NOAA20 only with new x86b code (bugs fixed, snow models chosen correctly, for NOAA20 too)
  - GGE0 where cloud code used MATCH Terra+Aqua
  - Surface Albedo History map, NOAA20-only (Tom has delivered)
  - MATCH Aqua-only

- **SYN1deg-Aqua Exp#5**
  - Aqua Only constant meteorology extraction/extension from Ed4.1 production TAG(TSIB)
Cloud amount test with Aqua only MATCH (Case 2)

GEO code runs with Tera+Aqua.

Difference of GEO cloud amount with Aqua only and Terra+Aqua is over ocean only and small.

We conclude that Terra+Aqua MATCH can be used for Aqua+GEO test

Bottom two plots are essentially the same
CASE 3, 4, and 5 surface downward shortwave regional differences from Edition 4 Terra+Aqua+GEO

Aqua+GEOs  
Differences are due to Terra Aqua sampling and cloud diurnal cycle

NOAA-20+GEOs  
Aqua only no GEOs  
Differences are due to cloud diurnal cycle and GEO artifacts
CASE 3, 4, and 5 surface downward longwave regional differences from Edition 4 Terra+Aqua+GEOs

NOAA-20+GEOs

Aqua only

GEO artifacts more apparent because temperature diurnal cycle is included in Aqua only longwave computations
• When Terra starts to drift in 2021, switching to Aqua+GEOs introduces up to ~5 Wm$^{-2}$ regional discontinuity in downward shortwave and longwave irradiances between 60°N to 60°S.

• When Aqua starts to drift in ~2022, switch to NOAA-20 for daytime and keeping Aqua for nighttime globally. This minimizes cloud change (clouds during polar night and cirrus in the tropics).
  • The cloud working group is working to minimize cloud property differences between those derived from VIIRS NOAA-20 and MODIS Aqua. The result of this may change the plan.
Diurnal variability of surface irradiance due to diurnal variability of cloud properties
Diurnal surface irradiance variability
Aqua only – Terra only (no GEOs)

Generally, less clouds over marine stratocumulus regions and more convective clouds over lands in the afternoon
GEO artifacts—needs to be corrected in the EBAF process

• Using the mean surface irradiances computed with Terra and Aqua clouds, we analyze the effect of GEO artifacts on surface irradiances using July 2019 SYN.
  • Effects of GEO artifacts on surface downward shortwave irradiance are mostly taken out by the EBAF process.
  • The largest effects of GEO artifacts on surface downward longwave irradiance come from nighttime cloud optical thickness (and depend on GEO).
  • GEOs used in July 2019 are, MET-11, MET-8, Himawari-8, GOES-15, and GOES-16.
(Terra+Aqua) – SYN and (Terra+Aqua) – EBAF downward shortwave irradiance

GEO artifacts are largely taken out by the EBAF process
(Terra+Aqua) – SYN and (Terra+Aqua) – EBAF
downward longwave irradiance
(Terra+Aqua) – SYN daytime and nighttime downward longwave irradiance

Daytime

Nighttime

New generation GEOs (Himawari-8 and GOES-16): Positive difference at large viewing zenith angle at nighttime
Other GEOs: Negative difference.
Nighttime cloud amount and optical thickness differences

Nighttime optical thickness inconsistency between GEOs and Terra/Aqua and among GEOs is the largest problem. For new generation GEOs, both cloud amount and optical thickness differences are probably due to viewing zenith angle differences.
Summary

• The effect of a smaller aerosol optical thickness over China in March 2020 on the monthly regional mean surface downward shortwave irradiance is ~10 Wm\(^{-2}\).

• Clear-sky sampling correction to the downward shortwave irradiance increased by 20% in January 2020 due to Australia fires.

• Regional discontinuity of surface downward shortwave and longwave irradiance caused by switching Terra+Aqua+GEOs to Aqua+GEOs or NOAA-20+GEOs can be as large as 5 Wm\(^{-2}\).

• The largest GEO artifact affecting downward longwave irradiances in July 2019 is nighttime cloud optical thickness artifacts.
Publications


