Results and tools for evaluation and monitoring of GOES-R/ABI absorbed shortwave radiation at surface product

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I. Abstract

The ABI absorbed shortwave radiation at surface (ASR) algorithm is composed of two algorithms. The physical algorithm is used when all atmosphere inputs are available, while the statistical algorithm is applied when one or more atmosphere inputs are missing. The physical algorithm is based on forward radiative transfer calculations represented in look-up-tables. The statistical algorithm is based on a statistical relationship between the broadband top-of-atmosphere albedo and the surface absorbed flux. The ABI ASR algorithm have been evaluated with ten years of MODIS/Terra and MODIS/Aqua data over ten ground stations.

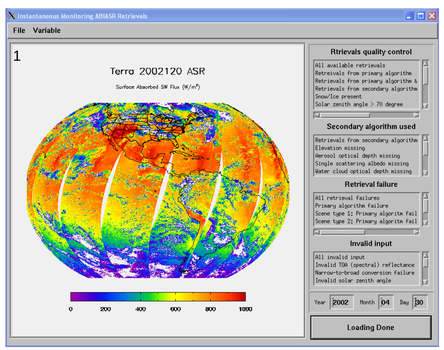
For monitoring and validation of ASR the tools developed for the baseline ABI shortwave radiation budget algorithm have been adapted. The tools visualize instantaneous ASR retrievals in terms of overall retrieval quality, the retrieval algorithm applied, and reasons for using the statistical algorithm. The validation tools include routine and deep-dive validation over selected ground stations showing the accuracy and precision, and a time series of these for each station. The validation tools are applied to ASR retrievals from the year 2002 MODIS/Terra data. Examples of the evaluations and the tools used are shown in the poster.

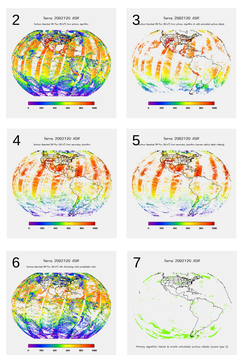
IV. Validation tools: Instantaneous Monitoring

- ► Visualize instantaneous ASR retrievals.
- ► Pull-down menu 'Variable' includes metadata (ascii file output, not shown), ASR (image), and quality flag (image, not shown).
- ► From the GUI the user can choose retrieval quality, reasons for using the statistical algorithm, retrieval failure from each algorithm, and retrieval failure due to invalid input.

Figure 1. Instantaneous monitoring GUI
Figure 2. Retrievals from physical algorithm.
Figure 3. Retrievals from physical algorithm with valid calculated surface albedo*.
Figure 4. Retrievals from statistical algorithm.
Figure 5. Retrievals from statistical algorithm due to missing aerosol optical depth.
Figure 6. Retrievals using climatology total precipitable water.
Figure 7. Retrieval failure from physical algorithm in scene type 3 (ice cloud) with invalid calculate surface albedo*.

* The physical algorithm can calculate surface albedo from atmosphere inputs. A valid calculated surface albedo indicates TOA albedo and atmosphere inputs are consistent (closure).





II. Data

ABI ASR physical algorithm is evaluated extensively in clear sky with different atmospheric inputs and CERES TOA albedo. Retrievals are compared with existing products.

- CERES/ARM Validation Experiment (CAVE) Clouds & Radiation Swath (CRS) data.
  - • CAVE atmosphere inputs are all tuned (or "constrained") values.
  - • Surface flux from CRS (tuned).
- MODIS atmosphere inputs: 25km average centered on ground station.
- Ground measurements are from ten stations (Table):
  - • 15-min average before 06/2006 (Terra) and 02/2005 (Aqua) and 30-min average after that.
  - • Surface types are determined by webpage description when available and pictures where down looking instrument is located.

ABI ASR physical algorithm is evaluated in all sky with ten year MODIS data. TOA albedo is converted from MODIS TOA spectral reflectance for this test.

Station Label	Station Name	Network	Latitude	Longitude	Elevation(m)	Surface type
BON	Bondville	SURFRAD	40.05	-88.37	213	Agricultural area
DRA	Desert Rock	SURFRAD	36.63	-116.02	1007	Open shrub
FPK	Fort Peck	SURFRAD	48.31	-105.10	634	Grass
GWN	Goodwin Creek	SURFRAD	34.25	-89.87	98	Grass
PSU	Penn State	SURFRAD	40.72	-77.93	376	Agricultural area
SXF	Sioux Falls	SURFRAD	43.73	-96.62	473	Grass
TBL	Table Mountain	SURFRAD	40.13	-105.24	1689	Grass
COV	Chesapeake Bay	COVE	36.90	-75.71	30	Water
E13	E13	ARM	36.61	-97.48	318	Grass
BOU	BOU	GMD	40.05	-105.01	1584	Grass

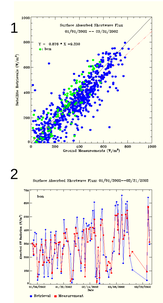
V. Validation tools: Routine/ Deep-dive Validation Over Ground Stations

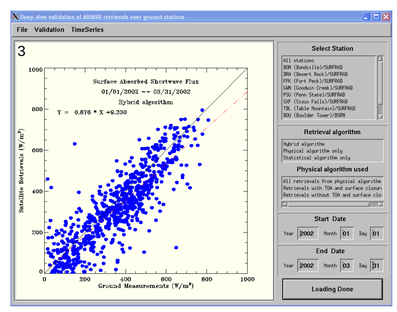
- ► Routine validation over ground stations evaluates the ASR hybrid algorithm performance by comparing satellite retrievals and ground measurements.
- ► Ground measurements are averaged using a 30-minute time window centered on the satellite overpass time and satellite retrievals within 10-km radius centered on ground station are averaged.
- ► Match-ups between ground measurements and satellite retrievals can produce scatter plot or time series by choosing "Validation" or "Time-series" in menu.
- ► From the GUI, stations can be selected and statistics are saved in ascii file (not shown) when 'all stations' are selected.

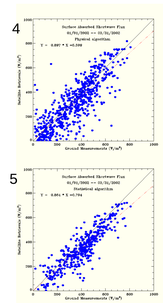
Figure 1. ASR validation with Bondville/SURFAD station.
Figure 2. Time series of Bondville/ SURFRAD station.

- ► Deep-dive validation over ground stations shows validation with retrieval algorithm applied.
- ► Applied algorithm or stations can be selected from the GUI.
- ► Scatter plot or time series can be selected from menu.

Figure 3. Deep-dive validation over ground station GUI: retrievals from hybrid algorithm.
Figure 4. Retrievals from physical algorithm.
Figure 5. Retrievals from statistical algorithm.





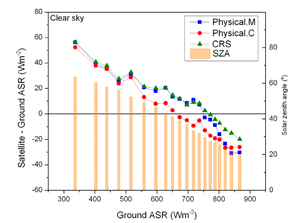


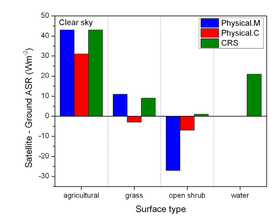
III. Results

The Physical algorithm is tested with MODIS atmosphere inputs (physical.M) and CAVE atmosphere inputs (physical.C) for clear sky. TOA albedo for both cases is from CERES observation. CRS surface flux is also compared with ground measurements. CRS surface flux is calculated by subtracting upwelling flux from down-welling flux while both physical algorithm retrieve ASR without direct surface information.

Errors depend on the magnitude of ground ASR and over(under) estimation is observed at small(large) ground ASR.

Retrievals for each surface type are compared with ground ASR; estimation errors are shown in the figure on the right. Agricultural area data are from Bondville and Penn state, open shrub data are from Desert rock, water data are from Chesapeake bay light house, and grass data are from other six stations. Both physical algorithms show the best estimation in water and CRS shows the best estimation in open shrub. The physical algorithm with CAVE atmosphere input shows the best overall accuracy (2 Wm^{-2}), while CRS shows the best overall precision (35 Wm^{-2}); the physical algorithm with MODIS atmosphere is between them (9 Wm^{-2} and 39 Wm^{-2} for accuracy and precision).





When the physical algorithm is tested with MODIS data for all sky (clear, overcast, and partial cloudy sky) retrievals meet the requirements (see Table below). (TOA albedo is converted from MODIS spectral TOA reflectance for this test.)

Table. Physical algorithm validation with all sky MODIS data for ten years

Range	Accuracy (requirement)	Precision (requirement)
100	19 (90)	74 (75)
400	33 (45)	77 (95)
800	-2 (55)	58 (75)

VI. Conclusion

- ► Physical algorithm is tested with all sky MODIS data for ten years where TOA albedo is converted from MODIS TOA spectral reflectance. Retrievals meet the requirement in all three ranges.
- ► Physical algorithm with CAVE atmosphere input shows the best accuracy (0%) and CRS shows the best precision (5%) in clear sky. Physical algorithm with MODIS atmosphere input is in the middle (1% and 6% for accuracy and precision).
- ► Physical algorithm shows better estimation in water than CRS and CRS shows better estimation in open shrub than physical algorithm. CRS shows similar error pattern to physical algorithm with MODIS atmosphere input in agricultural area and grass.
- ► ASR retrievals from physical algorithm, which does not require surface information, are comparable with existing products (CRS) which use surface albedo.
- ►Visualization and validation tools to monitor and validate ABI ASR retrievals are shown. They are applied to the ASR retrievals with MODIS data over the western hemisphere at 5km spatial resolution for year 2002.