GOES-R AWG Radiation Budget Team: Upward Longwave Radiation - Surface (ULR)

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LW ERB Team

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Outline

- Executive Summary
- Requirements Specification
- Algorithm Description
- ADEB and IV&V Response Summary
- Validation Strategy
- Validation Results
- Summary

Executive Summary

- The ABI **Surface Upward Longwave Radiation algorithm** generates the upward component of the thermal infrared radiative flux at the earth's surface. It is an Option 2 product, but follows Baseline schedule.
- ATBD (100%) is on track for a September 2010 delivery.
- Version 4 upgrades broadband emissivity for seawater and uses land/sea mask for surface temperature selection.
- Validation tools have been developed and applied to 12 months of offline runs with GOES-Imager retrieval products. Ground truth is obtained from NOAA SURFRAD down-looking Precision Infrared Radiometer (PIR) three-minute-average measurements.
- Validation results indicate spec compliance for F&PS requirements.

Requirements

Name	User & Priority	Geographic Coverage (G, H, C, M)	Vertical Resolution	Horizontal Resolution	Mapping Accuracy	Measurement Range	Measurement Accuracy	Product Measurement Precision	Refresh Rate/Coverage Time Option (Mode 3)	Refresh Rate Option (Mode 4)	Vendor Allocated Ground Latency
Upward Longwave Radiation : Surface	GOES-R	C	N/A	25 km	5 km	50 - 900 W/m^2	**30 W/m^2**	**20 W/m^2**	60 min	5 min	3236 sec
Upward Longwave Radiation : Surface	GOES-R	FD	N/A	25 km	5 km	50 - 900 W/m^2	**30 W/m^2**	**20 W/m^2**	60 min	5 min	3236 sec

C – CONUS FD – Full Disk

Qualifiers

These are made with the following qualifiers.

- Day and night
- Clear conditions associated with threshold accuracy
- Quantitative out to Local zenith angle 70 degrees (was 62 degrees) and qualitative at larger LZA

Algorithm Description

Algorithm Summary

- ABI Surface Upward Longwave Radiation algorithm generates the upward component of the thermal infrared radiative flux at the earth's surface.
- Physical method: the ULR algorithm is formulated as grey body emission with ABI-retrieved skin temperature and prescribed broadband emissivity.
- Revision: Broadband emissivity over ocean is changed from 1 to 0.971 based on CRTM v.1.2 seawater non-Lambertian emissivity database.
- Development surrogate system includes GOES Imager/Sounder and MODIS retrieval products.

Methodology (1)

- Follow Stefan-Boltzmann law that the surface can be considered as a grey body whose emission is characterized by the surface temperature T_{sfc} and an effective broadband emissivity ε_{sfc}, plus the reflected component. At the first order estimate, the ULR can be written

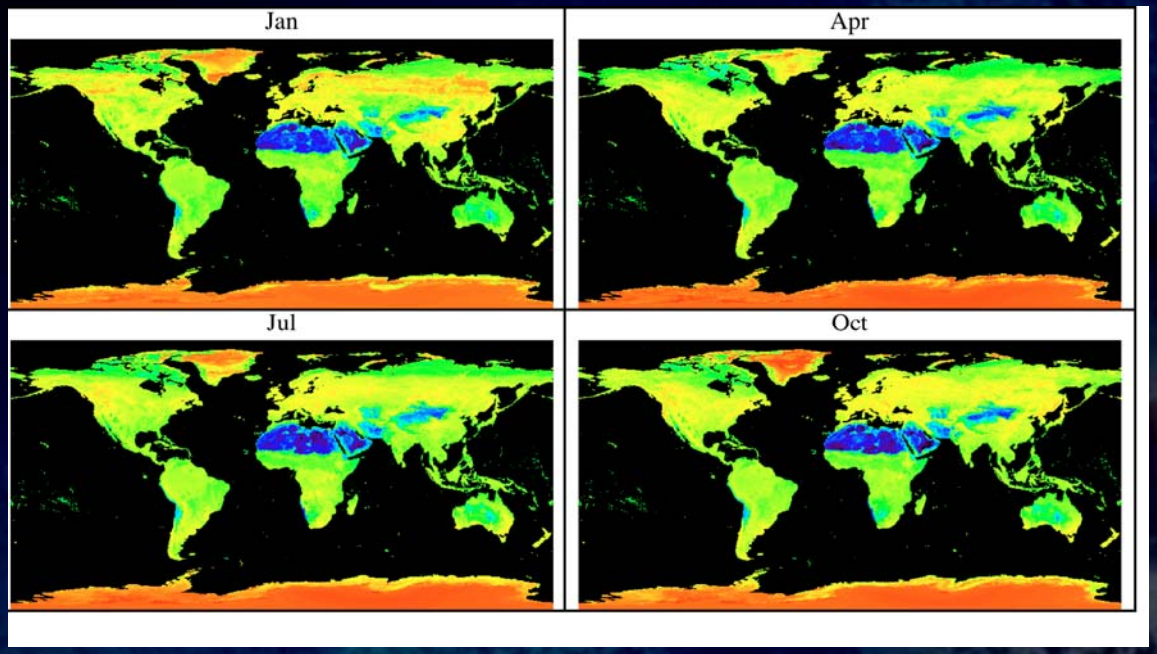
$$ULR = \varepsilon_{LW} \cdot \sigma T_{sfc}^4 + (1 - \varepsilon_{LW}) \cdot DLR$$

Surface emission Reflected LW

- The surface temperature is obtained from the ABI retrieval products at each pixel: Land skin temperature (LST) or Sea surface temperature (SST)

Methodology (2)

- Climatological broadband emissivity over land is derived from UW/CIMSS SeeBor baseline fit infrared emissivity database and NCEP Reanalysis-2 surface temperature climatology.

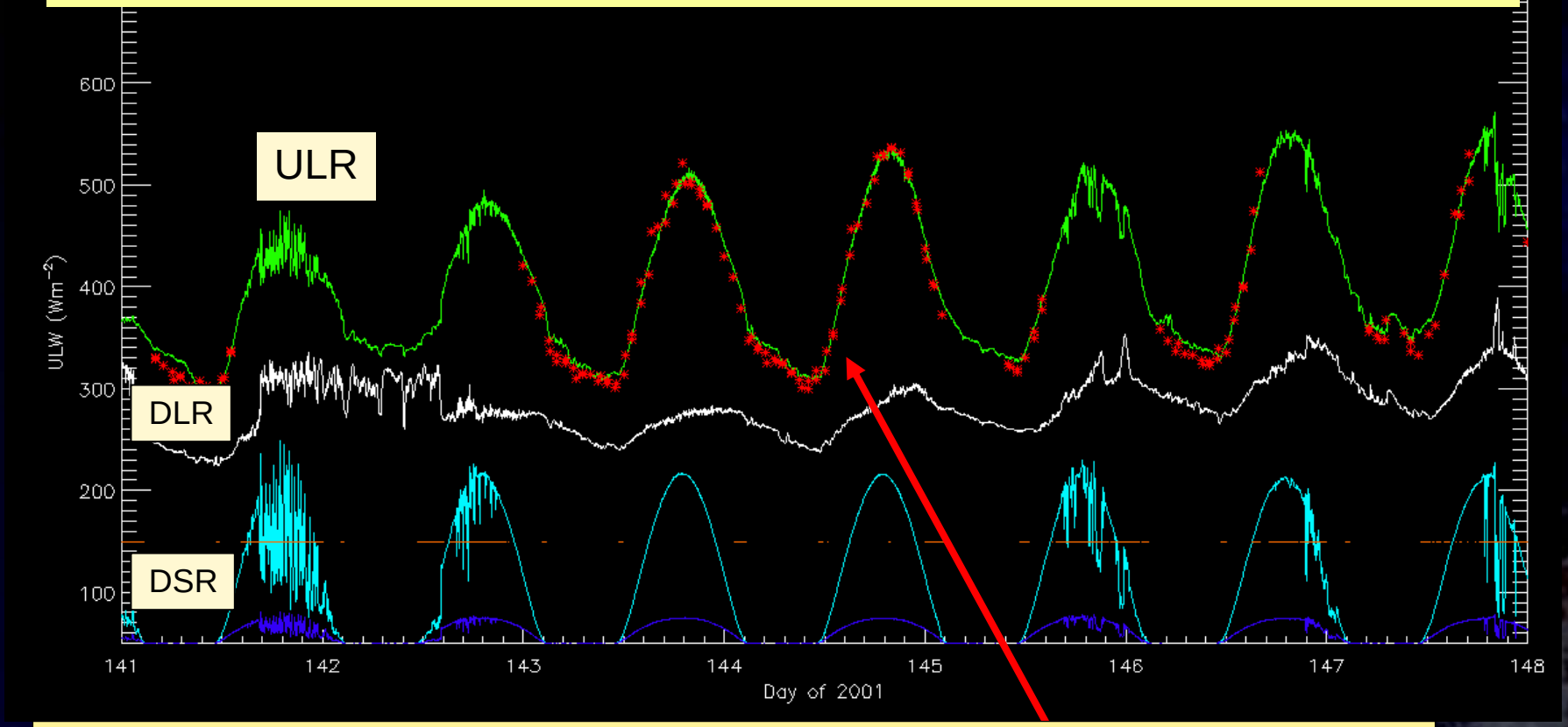


Contour ranges from 0.95 to 1.

- A constant broadband emissivity 0.971 over ocean is determined from CRTM v.1.2 non-Lambertian seawater emissivity database at assumed temperature of 288° K, wind speed of 7.5 m/s, and unity emissivity in far IR.

Example ULR Output

"ABI" ULR retrievals (red dots) for day 141-148, 2001 for Fort Peck, MT with GOES Imager LST retrievals.



Example of clear sky ULR retrievals that capture the variability compared accurately to the ground observed ULR (green curve)

Algorithm Changes from 80% to 100%

- Upgraded Sea water broadband emissivity.
- Used AWG land/sea mask for skin temperature input source selection
- Metadata (standardized statistics) defined.
- Quality flags defined and added.

ADEB and IV&V Response Summary

- No feedback required for Option 2 products at this stage.

Validation Approach

Validation Approach

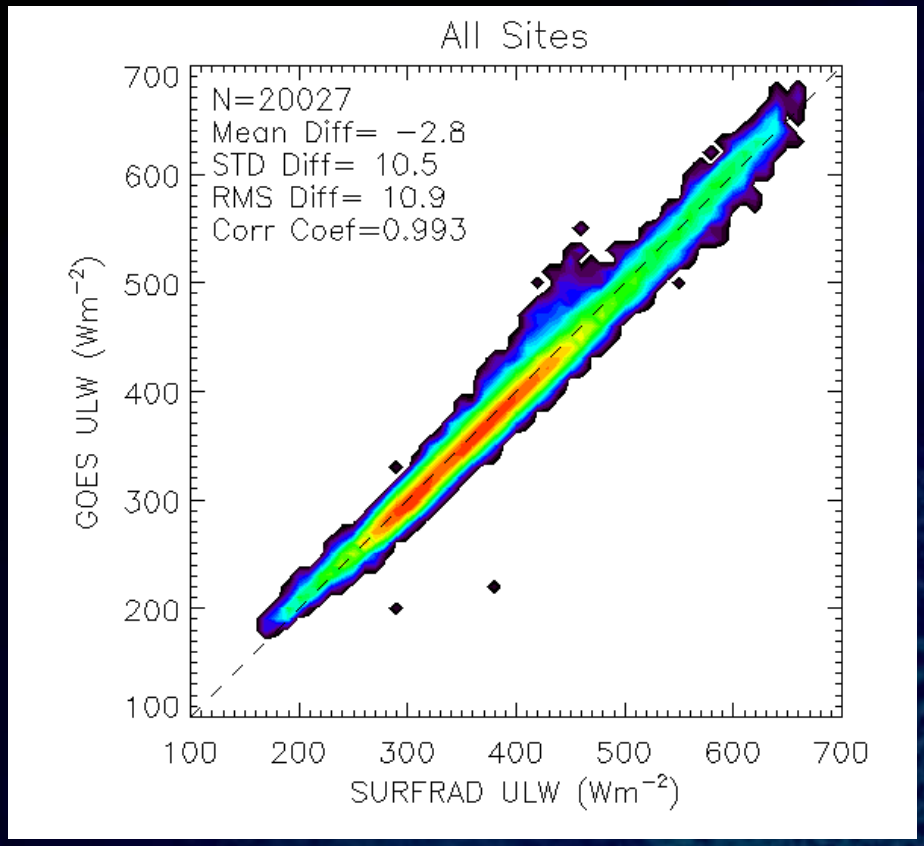
- Ground truth taken from SURFRAD down-looking Precision Infrared Radiometer (PIR) three-minute-average measurements.
- Collocate the nearest satellite observations to the ground stations within 5 km.
- Three-minute average of ground observations is used in FOV retrieval validation. Fifteen-minute average of ground observations is used for 25-km grid product validation.
- Manual cloud filtering for optimal quality of validation data

Validation Data

- Offline evaluation (12 months)
  - » Jan-Dec 2001
  - » AWG Land Team provided Skin Temperature retrievals and the match-up validation datasets
  - » Collocation is about ±4 km from the station, within ±3 minutes window.

Validation Results

Offline Validation (1)



Validation Results:

No. of cases = 20,027

Mean diff = -2.8 Wm^{-2}

STD of diff = 10.5 Wm^{-2}

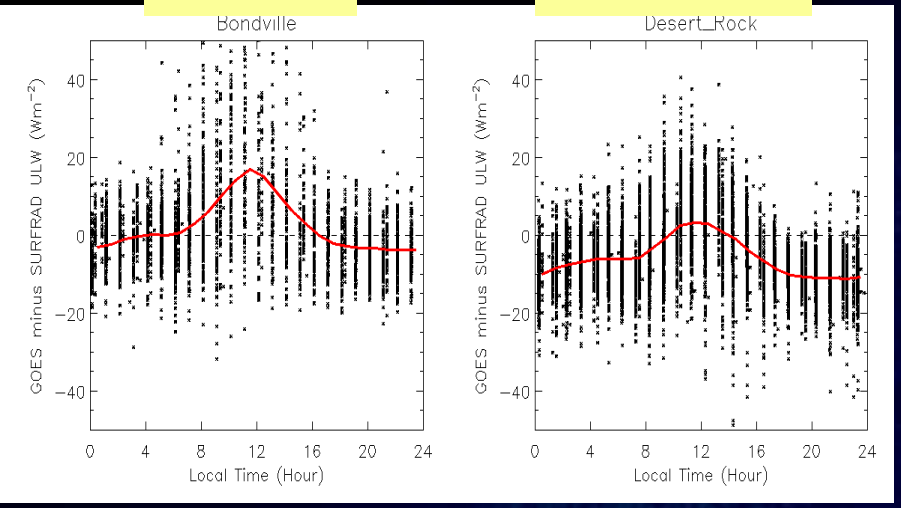
RMS diff = 10.9 Wm^{-2}

for manually cleared cases

Comparison of ULR retrievals with ground measurements for all seven SURFRAD sites. ULR was derived with grey body surface assumption given broadband emissivity consistent to the LST retrievals.

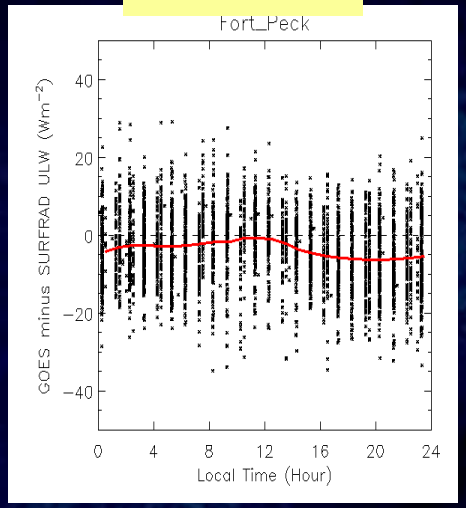
Offline Validation (2)

Bondville, IL

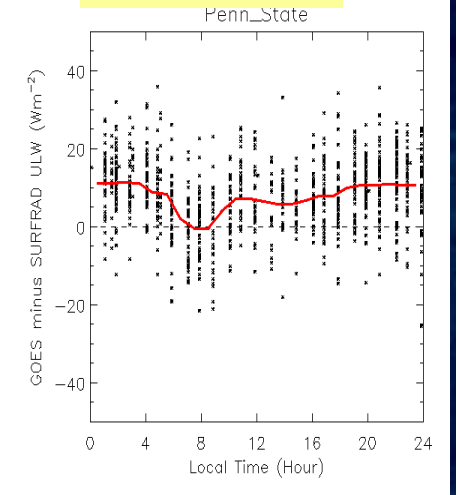


Desert Rock, NV

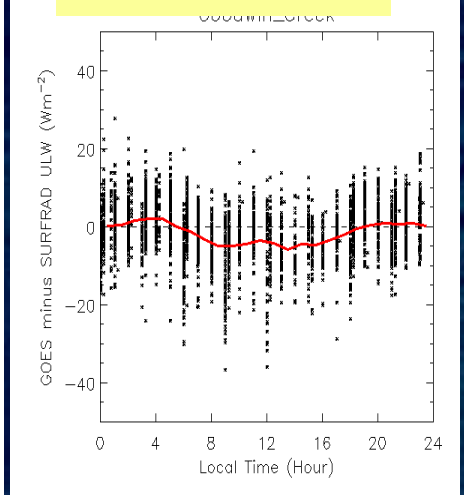
Fort Peck, MT



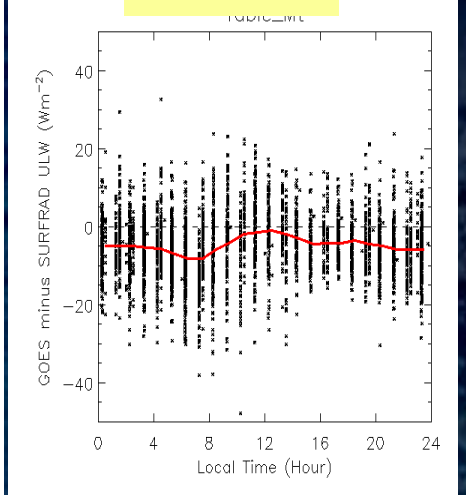
Penn State, PA



Goodwin Creek, MS



Boulder, CO



The ULR retrieval errors from GOES Imager data appeared to have different degrees of diurnal dependencies - most apparently in Bondville and Desert Rock with noontime over-estimations. As the GOES sounder based validation did not show such pattern, it seems that the Imager LST retrieval algorithm might be sensitive to the day time surface heating.

Validation Results Summary

	F&PS			Algorithm Evaluation		
	Accuracy	Precision	Range	Accuracy	Precision	
ULR (Wm^{-2})	30	20	50-900	3	11	Offline (land)

Summary

- The ABI ULR algorithm provides the upward thermal infrared radiative flux component for the earth radiation budget at the earth's surface.
- Version 4 upgrades broadband emissivity for non-Lambertian sea surface.
- Site-varying diurnally dependent ULR errors observed, but unexplained.
- Version 4 destined for the 100% ATBD complies with F&PS requirements.