# GOES-R AWG Radiation Budget Team: Downward Longwave Radiation - Surface (DLR)

*Presented By:* Hai-Tien Lee
CICS/ESSIC-NOAA, University of Maryland

# LW ERB Team

- **Radiation Budget AT chair:** Istvan Laszlo
- **LW ERB Team**
  - » Hai-Tien Lee (Lead)
  - » Arnold Gruber (retired)
  - » Ellsworth G. Dutton, John A. Augustine
- **Others**
  - » Nicolas Clerbaux, Jacqueline Russell, Shashi Gupta, David P. Kratz, Fred G. Rose
  - » AWG Land Team and SST Team
  - » Aiwu Li

# Outline

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

# Executive Summary

- The ABI Surface Downward Longwave Radiation algorithm generates the downward 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 corrects overestimation in superheated surface conditions by applying a lapse rate threshold to the tropospheric boundary layer.
- Validation tools have been developed and applied to 9 months of offline runs with GOES-Sounder atmospheric profile products. Ground truth is obtained from NOAA SURFRAD up-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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Downward Longwave Radiation : Surface | GOES-R | C | N/A | 25 km | 5 km | 50 - 750 $W/m^2$ | **25 $W/m^2$** | **20 $W/m^2$** | 60 min | 5 min | 3238 sec |
| Downward Longwave Radiation : Surface | GOES-R | FD | N/A | 25 km | 5 km | 50 - 750 $W/m^2$ | **25 $W/m^2$** | **20 $W/m^2$** | 60 min | 5 min | 806 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 and qualitative at larger LZA

# Algorithm Description

# Algorithm Summary

- The ABI Surface Downward Longwave Radiation algorithm generates the downward component of the thermal infrared radiative flux at the earth's surface.
- Heritage: NASA Langley Parametric Longwave Algorithm (LPLA) currently adapted by the CERES Surface-only products and GEWEX Surface Radiation Budget (SRB) products.
- The clear sky DLR is estimated as approximately grey body emission parameterized with lower layers of tropospheric temperatures and total column precipitable water.
- Revision: Gupta et al (2010) devised the 10° K/100hPa lapse rate threshold for the tropospheric boundary layer to reduce overestimations in superheated surface conditions.
- Development surrogate system uses GOES Sounder and MODIS profile products.

# Methodology

- The clear sky DLR is estimated approximately as grey body emission parameterized with an effective emitting temperature $T_e$ determined from the temperatures of the lowest 300 hPa atmospheric layers, and an effective emissivity determined by the total column precipitable water.

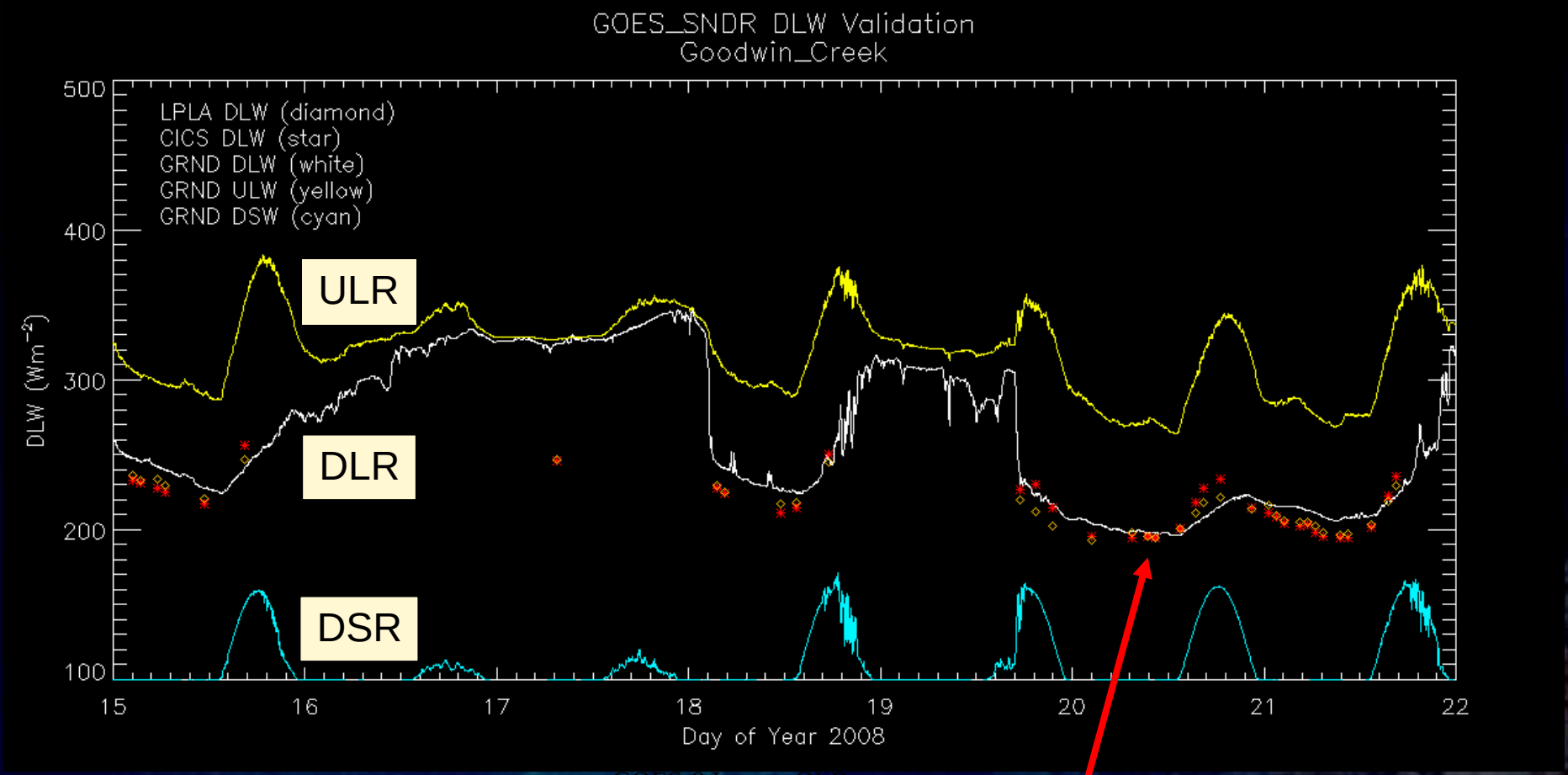
$$DLW_{clr} = (A_0 + A_1 V + A_2 V^2 + A_3 V^3) \cdot T_e^{3.7}$$

$$V \equiv \ln(PW)$$

$$T_e \equiv k_s T_s + k_1 T_1 + k_2 T_2$$

- *PW* is total precipitable water. $T_s$ is skin temperature, $T_1$ and $T_2$ are the mean temperatures for the two lowest 150 hPa atmospheric layers. *A's* and *k's* are constant coefficients determined from regression analysis based on a collection of theoretical simulations.

# Example DLR Output




Examples of good DLR retrievals (diamonds) that follow the ground-observed DLR variations (white curve).

# Algorithm Changes from 80% to 100%

- Implemented the lapse rate threshold to reduce overestimation in superheated surface conditions.
- Modified to use TPW directly.
- Implemented AWG land/sea mask for skin temperature input source selection
- Retrieval performed on Sounding target of 5x5 pixels.
- 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 Strategy

# Validation Approach

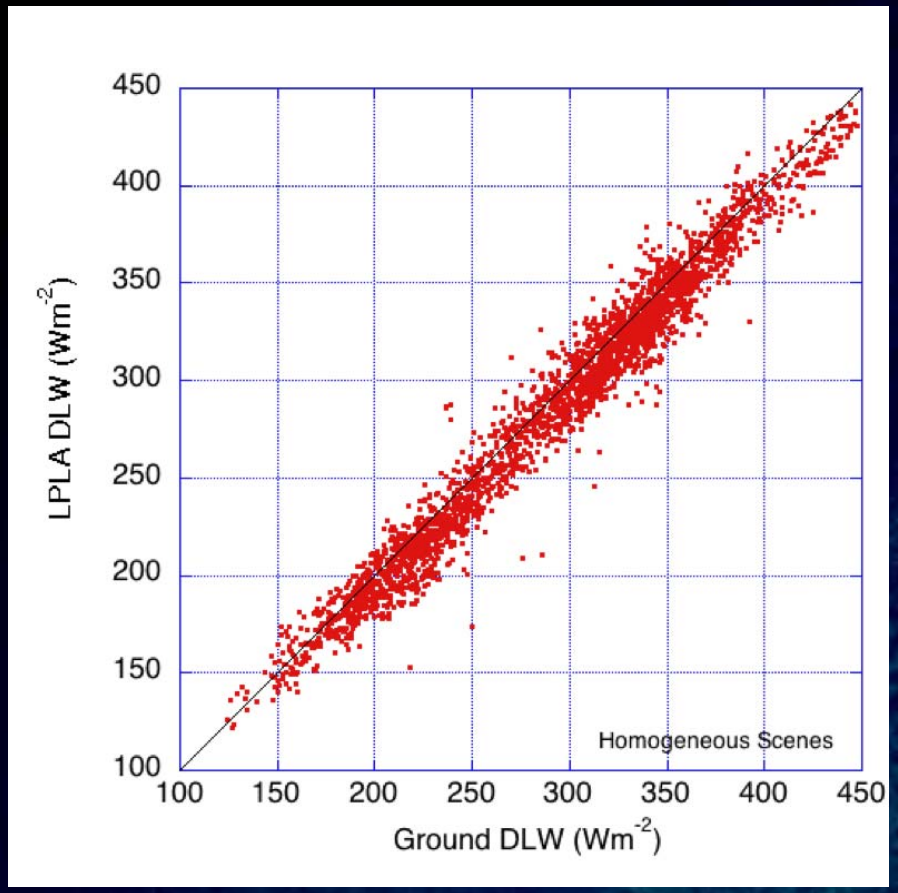
- Ground truth is from SURFRAD up-looking Precision Infrared Radiometer (PIR) three-minute-average measurements.
- Collocation uses the nearest satellite pixel (within 5 km) or 25-km grid box to the ground stations.
- Derive 15-minute average of ground observations encompassing satellite observation time to reduce temporal sampling uncertainties.
- Constraint for scene homogeneity to reduce spatial sampling errors.

# Validation Data

- Offline evaluation (9 months)
  - » Jan-Sep 2008
  - » Operational sounding product from GOES Sounders
  - » SURFRAD stations (7)
  - » Average of five 3-min up-looking PIR observations encompassing GOES observation time over SURFRAD stations

# Validation Results

# Offline Validation (1)




**Validation Results:**

*No. of cases = 2,700*

*Mean diff = -6.4 $Wm^{-2}$*

*STD of diff = 12.1 $Wm^{-2}$*

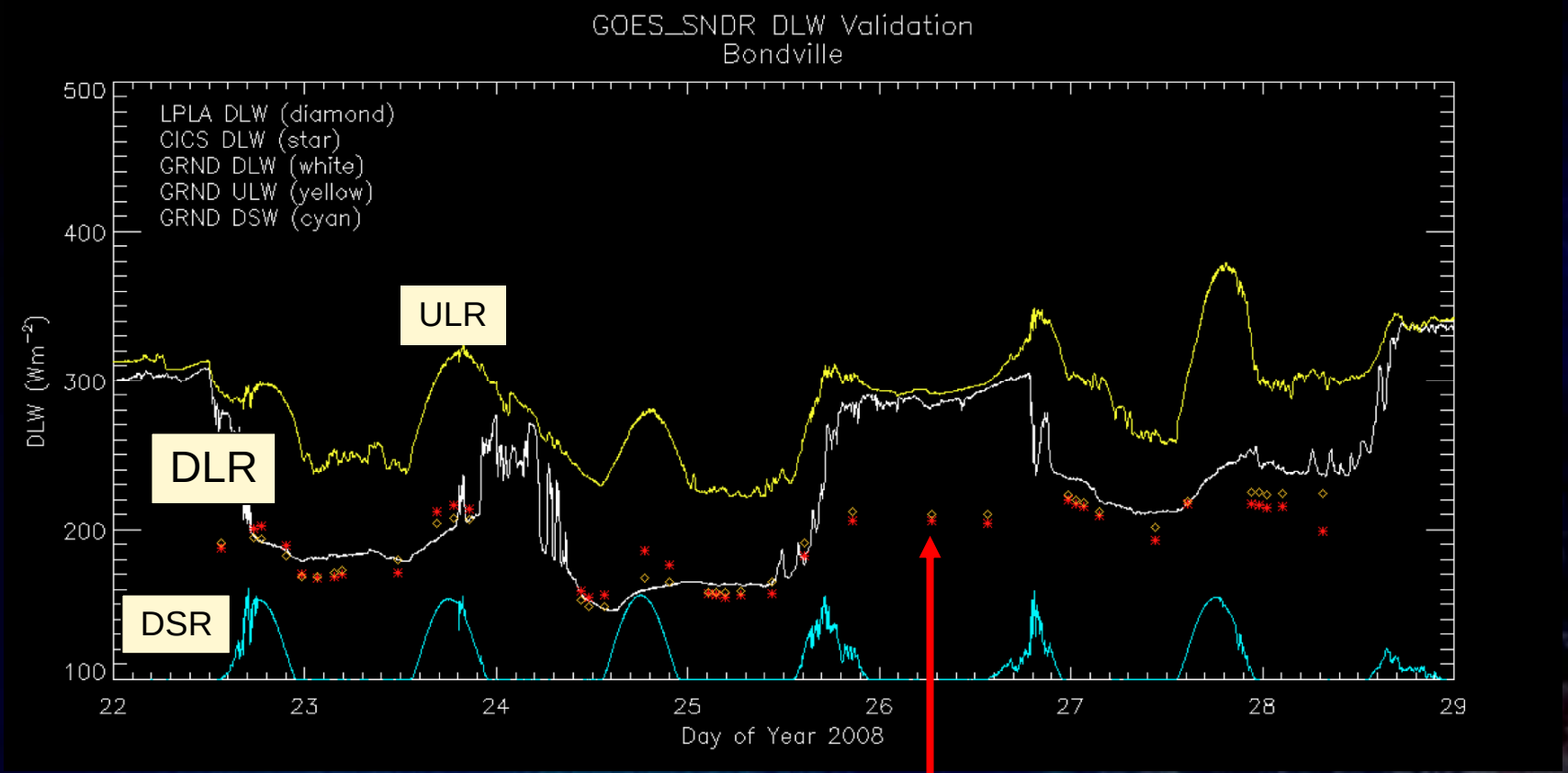
*RMS diff = 13.7 $Wm^{-2}$*

at homogeneous scenes

**Homogeneity requirements:**

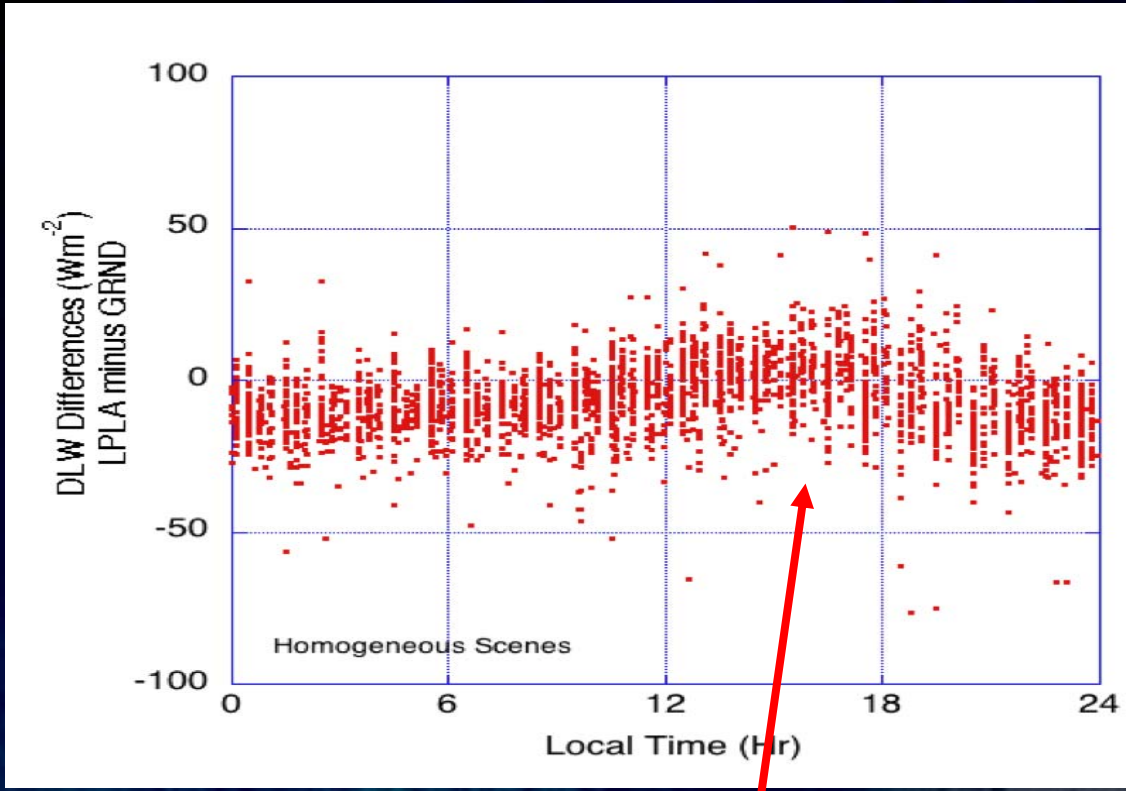
- STD of satellite DLR < 10 $Wm^{-2}$ in 0.5° circle surround the station
- STD of ground DLR < 3 $Wm^{-2}$ for the 15 minutes window

# Offline Validation (2)




Misidentification of scene conditions affects assessment quality. An empirical cloud scene filter was devised.

# Offline Validation (3)




DLR estimation errors show some local time dependence – error sources not confirmed yet.

# Validation Results Summary

| | F&PS | | | Algorithm Evaluation | | |
|---|---|---|---|---|---|---|
| | Accuracy | Precision | Range | Accuracy | Precision | |
| DLR ($Wm^{-2}$) | 25 | 20 | 50-750 | 6 | 12 | Offline |

# Summary

- ABI DLR algorithm provides the downward thermal infrared radiative flux component for the earth radiation budget at the earth's surface.
- Version 4 corrects overestimation at superheated surface conditions by applying a lapse rate threshold to the lowest atmospheric layer.
- Version 4 destined for the 100% ATBD complies with spec for F&PS requirements.