NOAA GOES-R Air Quality Proving Ground (AQPG)
Summer 2011 Near Real-Time Testbed of Proxy ABI Aerosol Products
July 12-30, 2011
Summary of User Feedback

1. Introduction and Overview of the Process for Generating Proxy ABI Aerosol Products

In Summer 2011, the NOAA GOES-R Air Quality Proving Ground (AQPG) conducted a near real-time testbed of proxy aerosol products that will be available from the GOES-R Advanced Baseline Imager (ABI). This experiment marked the first time that proxy GOES-R retrievals were streamed to users in near real-time. The goals of the testbed were to:

1. Test the generation of GOES-R ABI aerosol products using simulated radiances
2. Distribute the products to users in near real-time
3. Obtain feedback from users on the usability of the products.

The AQPG team generated hourly GOES-R ABI proxy data for 12:00 – 23:00 UTC daily during the period July 12-30, 2011. The experiment was conducted during the NASA DISCOVER-AQ field campaign in order to take advantage of available aerosol vertical profiles and other physical/chemical properties for proxy ABI data validation.

The GOES-R ABI proxy products were based on 00:00 UTC runs of the Community Multi-scale Air Quality (CMAQ) model, provided by AQPG team member Prof. Sundar Christopher, University of Alabama-Huntsville (UAH). The UAH CMAQ model was chosen for the experiment because it incorporates the NESDIS smoke product. The UAH CMAQ model has the following configuration:

- Forecast period: 48 hours
- Time step: 1 hour
- Domain: Southeastern United States
- Horizontal grid: 12 × 12 km
- Vertical layers: 21 (22 terrain following sigma-levels)
- CMAQ options:
  - Carbon Bond IV (CB-IV) module with Euler Backward Iterative (EBI)
  - fourth-generation CMAQ aerosol code (AE4)
  - aqueous phase chemistry (AQ)
- CMAQ runs with local plus fire emissions

The GOES-R ABI will measure radiances in 16 spectral bands, from visible to near-IR wavelengths. To generate the ABI aerosol proxy products for the near-real time testbed, a subset of 6 simulated ABI spectral band radiances (0.47 μm, 0.66 μm, 0.86 μm, 1.36 μm, 1.6 μm, and 2.25 μm) was generated by running CMAQ model output through the Community Radiative Transfer Model (CRTM). Subsequently, these simulated radiances were used as input into the GOES-R ABI aerosol algorithm, which produced the ABI aerosol products, including aerosol optical depth (AOD) and aerosol type.

2. Overview of Proxy ABI Aerosol Products and Internet Delivery System

An example of the ABI proxy **AOD** product from the near real-time testbed is given in Figure 1. AOD is a measure of the scattering and absorption of visible light by particles in a vertical column of the atmosphere, from the surface of the Earth to the top of the atmosphere. Clouds block the measurement of AOD. It is a unit less measurement; higher values of AOD correspond to higher concentrations of particles in the atmosphere. AOD is useful for identifying and tracking areas of high particulate concentrations that correspond to an air quality event, such as a wildfire, dust storm, or haze event.

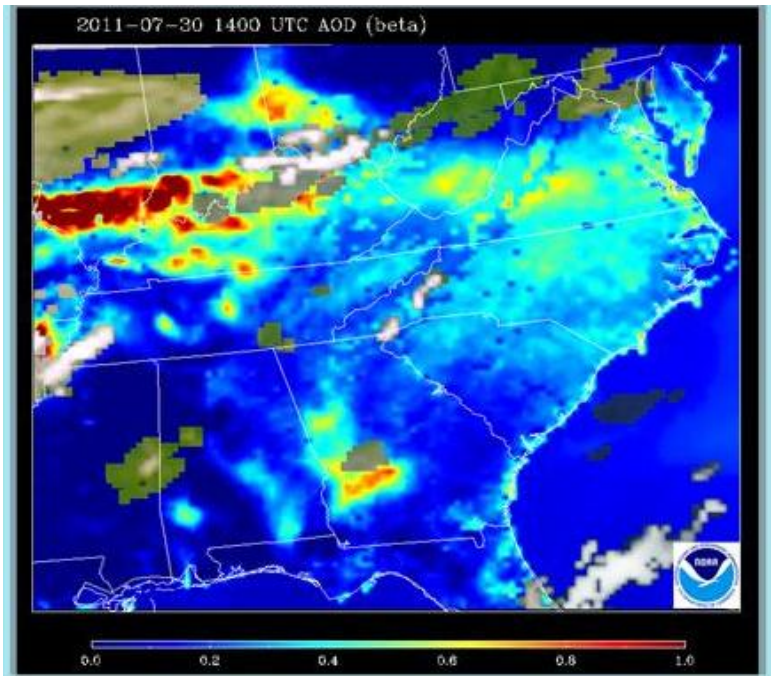

Figure 1. Example of ABI proxy AOD product for July 30, 2011, 14:00 UTC.

An example of the proxy **aerosol type** product from the near real-time testbed is given in Figure 2. Aerosol type is a new product from GOES-R that is not available currently. It is a qualitative product based on the AOD radiances scaled to concentrations of 4 different aerosol types: dust, smoke, urban, and generic. The aerosol type product is useful for distinguishing between smoke and dust, but it can be noisy, especially at low aerosol concentrations.

To help with interpretation of the aerosol products, the AQPG team also generated **synthetic natural color (RGB)** images, which represent a combination of the visible bands of the ABI. An example of the proxy RGB product from the near real-time testbed is given in Figure 3. Since the ABI will not have a green (0.55 μm) band, the AQPG team simulated it using a linear combination of the red (0.66 μm) and blue (0.47 μm) band radiances. RGB images provide a complement to AOD; they are useful because they provide visible information about areas of smoke, haze, or dust.

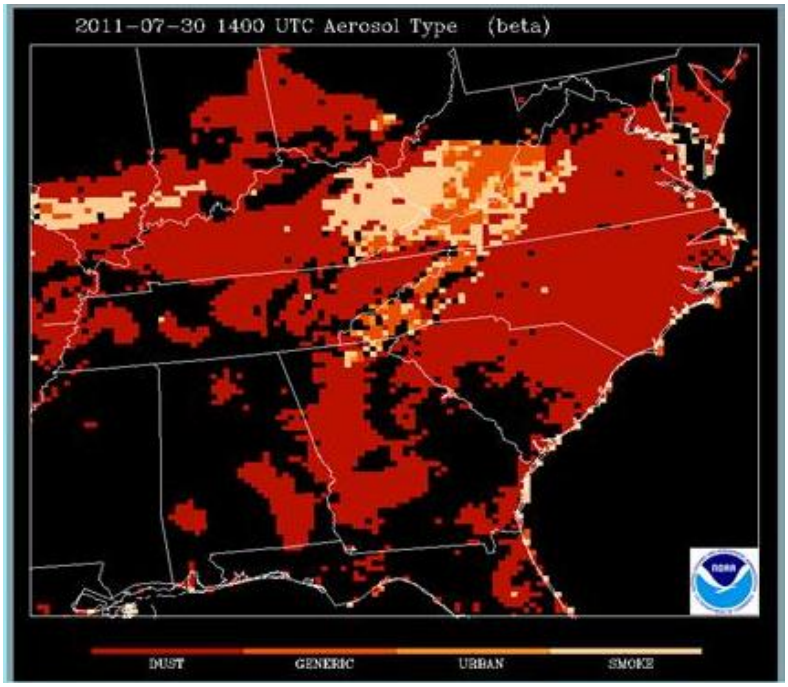

Figure 2. Example of ABI proxy aerosol type product for July 30, 2011, 14:00 UTC.

Figure 3. Example of ABI proxy RGB product for July 30, 2011, 14:00 UTC.

The proxy ABI aerosol products were streamed to users via an interactive web display as part of the NOAA NESDIS IDEA website (http://www.star.nesdis.noaa.gov/smcd/spb/aq/aqpg/). An example of the web display is shown in Figure 4. Users could select the day/time of interest using a pull-down menu and flip between the three ABI proxy products using radial buttons. Based on user feedback, an animation control feature was added that allowed users to control the speed of the animation loop and stop it at any point.

Since the proxy ABI products were generated using CMAQ model data, the 12-hour loops of the proxy products were completely available in the morning of each day in the testbed period. The AQPG team staggered the delivery of each hour's images, however, in order provide a realistic delay corresponding to actual GOES-R data observation and processing. Thus, for example, users visiting the site at 13:00 UTC saw data for 12:00 UTC only, and each subsequent hour of data was added accordingly throughout the day.

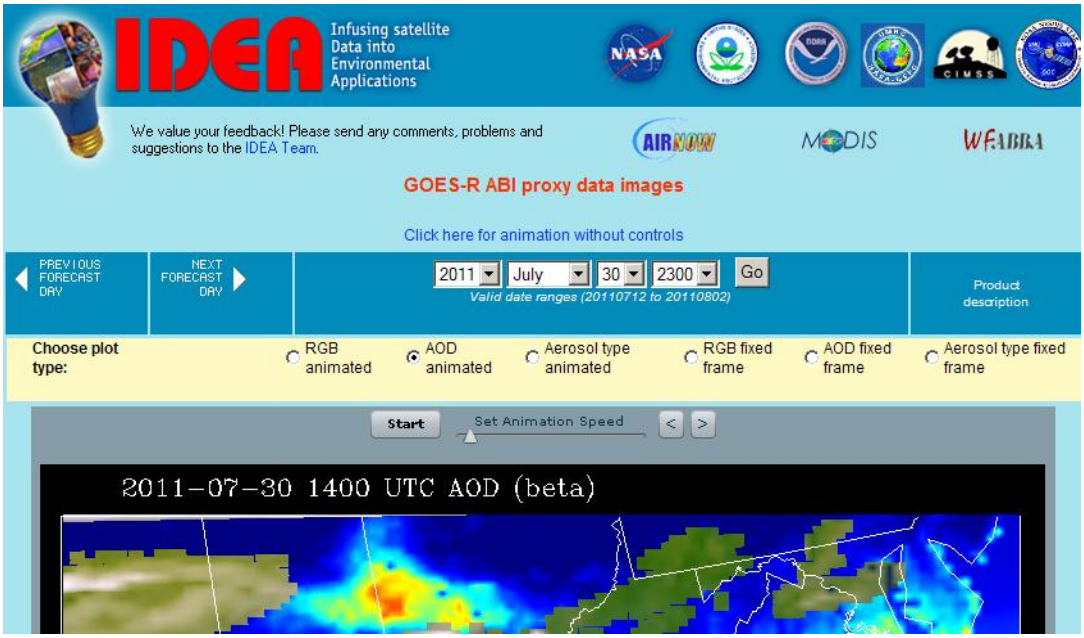

Figure 4. Example of the interactive web display used to stream proxy ABI products to users, showing pull-down menu for selecting date/time, radial buttons for choosing proxy data, and animation controls.

3. Spatial and Temporal Resolution of Proxy ABI Products

The proxy ABI RGB and AOD products were interpolated from 12 km native resolution (set by the CMAQ model resolution) to 2 km resolution, in order to match the spatial resolution that actual GOES-R ABI aerosol products will have. As a result of the spatial downscaling, some pixilation existed in the proxy images – this was an artifact of the spatial resolution of the model data and will not be present in actual ABI images once GOES-R launches. Similarly, the proxy ABI products had a temporal resolution of 1 hour, set by the CMAQ runs, but actual ABI aerosol products will have a temporal resolution of 15-30 minutes.

4. Summary of User Feedback on Streaming Proxy ABI Products

The proxy ABI products were designed to give the air quality user community an idea of the aerosol products that will be available from GOES-R. Selected members of the air quality community provided feedback to the AQPG team on the usability of the proxy images. These users are all members of the AQPG Advisory Group. They included:

- Bill Ryan, air quality forecaster for Philadelphia, Pennsylvania
- Dan Salkovitz, air quality forecaster for the state of Virginia
- Mike Goldstein, air quality forecaster for Memphis/Shelby Counties, Tennessee
- Geoffrey Healan, air quality forecaster for the state of Alabama

Users reviewed the proxy ABI images daily and provided feedback via email. In all cases, users responded positively to the proxy products and provided suggestions for improvements. A summary of the users' main points is below.

AOD Product:

- Clarify in product description that white areas are clouds and grey areas correspond to missing data.
- Utilize colors for AOD that correspond more directly to $PM_{2.5}$ AQI color codes; example colors provided in Figure 5. User recognizes that AOD is not a direct measure of air quality, but says that forecasters are accustomed to using the progression of color from green to red.
- Create 3-6 hour composite images of AOD.
- Add 1-2 contours in 3-6 hour composite AOD images that correspond roughly to moderate and unhealthy $PM_{2.5}$ air quality (0.4 and 0.7 AOD values). Example of contouring is given in Figure 5. Contours would serve to focus the area of most interest.
- Interest in product like current IDEA 48-hr aerosol trajectory forecast using GOES-R ABI AOD data to provide projections of AOD into the future, which will help with air quality forecasting.
- Request to for ability to zoom into the city-level for more in-depth analysis.
- Request for an overlay of satellite derived average wind speeds (at different altitudes/pressure levels indicated by colored arrows) over AOD, which would provide insight when forecasting both long and short range transport of pollutants.

Aerosol Type Product:

- What does "generic" aerosol type mean?
- The aerosol type colors are difficult to interpret for anyone with color blindness.
- There is an obvious "shift" in the aerosol type indication each day. The aerosol type throughout the domain seems to start off each day as "dust" but shifts to "generic" then "urban" and then "smoke" around 20:00-21:00 UTC. This was a consistent pattern each day.

Synthetic Natural Color Product:

- Images became blurry and brighter after approximately 18:00-21:00 UTC daily.
- Clarify in product description that white areas are clouds and grey areas correspond to smoke or haze.

General:

- It would be nice to have an animation that can be stopped at any point as opposed to the continuous animation or fixed frames (multiple requests). [NOTE: this comment was addressed early in the experiment, and animation controls were added as described in Section 2.]

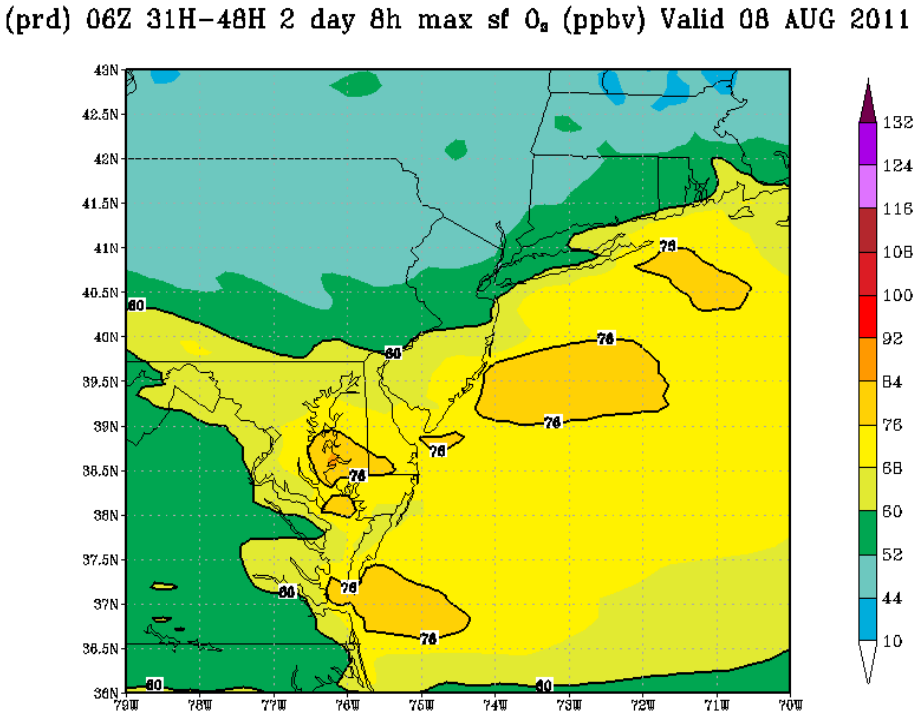

Figure 5. EMC ozone forecast image showing example of recommended colors and contours for proxy ABI AOD product.

5. Summary of Proxy ABI AOD Product Validation

The proxy ABI AOD images were validated by comparison with MODIS AOD and GASP imagery over the course of the near real-time test bed. In general, the CMAQ model was able to accurately simulate observed AOD, but there were some notable exceptions.

Proxy ABI AOD images contained too few areas of clouds compared to MODIS AOD and GASP observations. In areas where the proxy ABI AOD images contained too few clouds, they tended to have high areas of AOD that did not correspond to observed conditions. Figure 6 is an example from July 14, 2011 that illustrates this issue. GASP shows a wide band of clouds across south-central Georgia and Alabama, but the corresponding area in the proxy ABI AOD image indicates an area of AOD with values of approximately 0.4 to 0.8.

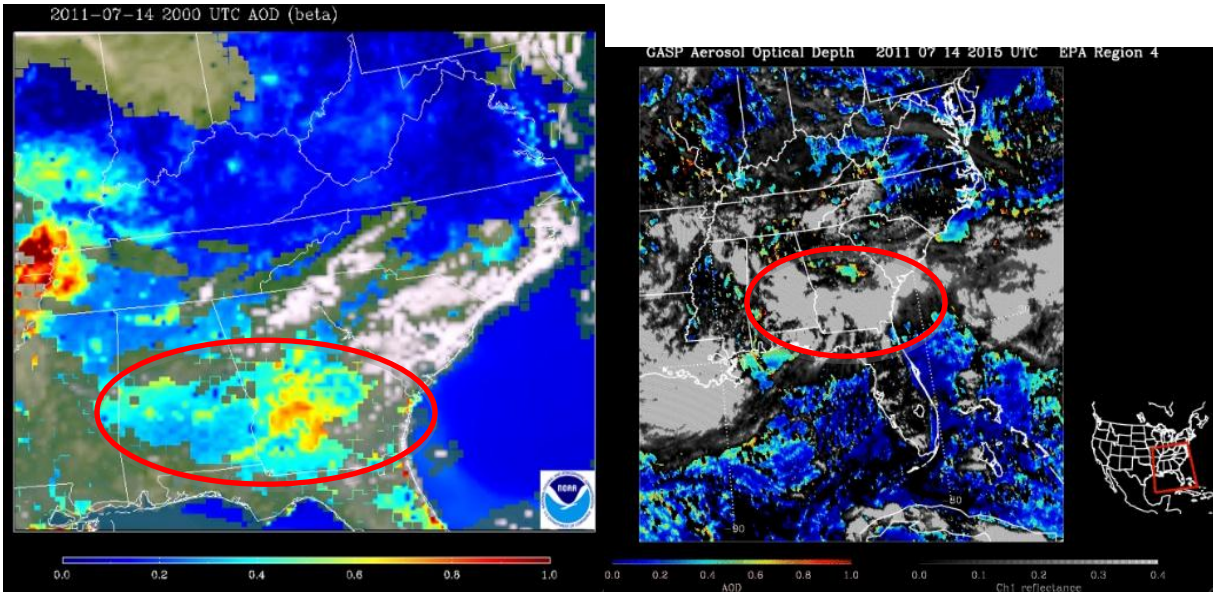

Figure 6. Comparison of proxy ABI AOD at 20:00 UTC (left) and observed GASP at 20:15 (right) for July 14, 2011.

In addition, proxy ABI AOD images consistently had an area of high AOD in the western portion of the domain. This artifact was not observed in corresponding MODIS AOD or GASP. Figure 7 shows examples of proxy ABI AOD images with this signature from July 14, 17, 21, and 26, 2011.

6. Conclusions

The AQPG was successfully able to conduct a near real-time testbed of proxy ABI aerosol products during July 2011 and stream the products to users. This experiment was the first time that a subset of the NOAA GOES-R Proving Ground was able to provide proxy ABI retrievals to users in near real-time. User feedback focused on the process of receiving streaming images of dynamic, high accuracy, high temporal resolution (once per hour) aerosol imagery. This level of accuracy and resolution is different from the current satellite products that are available to the air quality community (e.g., two static MODIS AOD images per day or lower spatial resolution GASP loops). The AQPG intends to incorporate user feedback from the summer experiment and stage another near real-time testbed during Winter/Spring 2012.

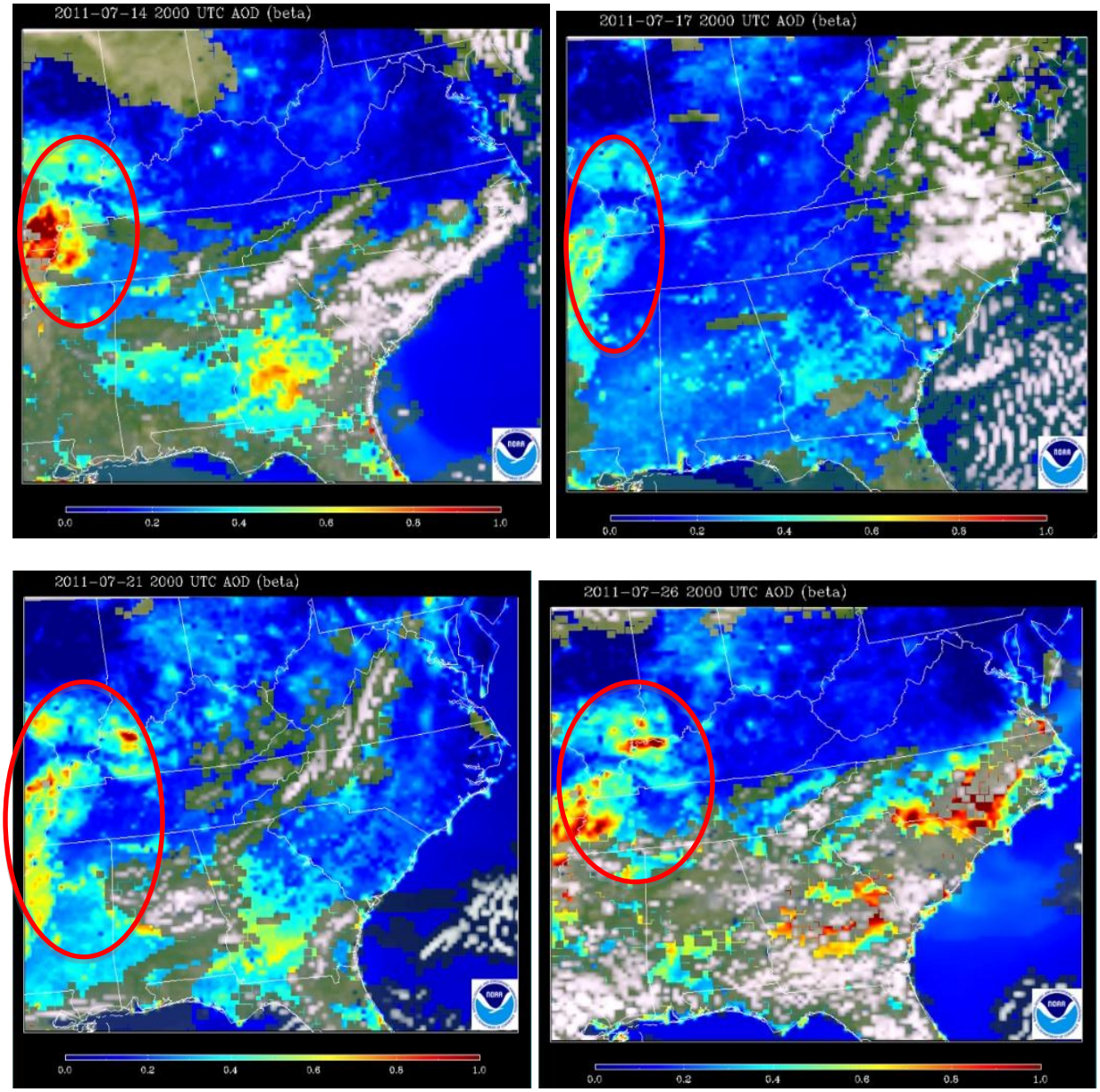

Figure 7. Proxy ABI AOD images from July 14 (top left), 17 (top right), 21 (bottom left), and 26 (bottom right) showing high AOD artifact in the western portion of the domain.