Effect of Row Anomaly on Long-Term OMAERUV Aerosol Record

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- The row anomaly affecting OMI observations since early 2008 has reduced by over 50% the sensor viewing capability.
- Most remaining rows are located on the left side of nadir (rows 1-30).
- We have investigated the effect of the row anomaly on the usability of the OMI aerosol products for trend analyses.
Across-scan bias of OMAERUV aerosol products

- Use first three years (2005-2007) of the OMI record to examine across-scan biases in retrieved aerosol products.

- Calculate separate regional monthly averages of OMAERUV aerosol products (AOD, SSA, AAOD and Al) using rows 1-30 (L) and 31-60 (R).

- Large differences between the retrievals on both sides of nadir would indicate the existence of biases after 2008 when most rows on the left side of nadir (1-30) are no longer available.

- Results are presented for the Saharan desert and Southern Africa regions where predominant aerosol types are, respectively, desert dust and carbonaceous aerosols.
Minimum across-scan biases are observed over the Southern African region. Similar results were obtained over other regions where carbonaceous and sulfate aerosols predominate.

A surprisingly large across-scan AI bias is observed.
Large L-R differences in retrieved AOD, SSA and AAOD parameters are observed. Close agreement in calculated AI is obtained. The observed differences may be associated with the assumption of spherical particles.
Across-scan scattering angle variability over the Saharan

At the range of scattering angles associated with OMI observations there are significant differences in the scattering phase function of spherical and non-spherical particles.
The inadequate phase function assumption may introduce scattering angle-dependent errors in retrieved parameters.

A new set of look-up tables was generated using the spheroid-shape representation.
Using the non-spherical aerosol model significantly reduces the across scan biases observed with the spherical particle assumption.
Across-scan biases over the Saharan Desert

AOD

SSA

AAOD
What is the source of AI scan bias in Southern Africa?

A major difference between the Saharan Desert and Southern African regions is the presence of clouds.

The regional difference in across-scan AI bias may be explained by the way clouds are handled in the calculation of the Aerosol Index.
Across-scan scattering angle variability over Southern Africa
The marked across-scan AI difference is the result of not accounting for the angular dependence of cloud scattering effects.
Aerosol Index Concept

Comparison of satellite measured \( I_\lambda^* \) and calculated \( I_\lambda^{cal} \) spectral contrast at any two wavelengths \( \lambda \) and \( \lambda_0 \), in the range 330-390 nm where \( \lambda_0 \) is the reference wavelength. Generally, \( \lambda_0 > \lambda \)

\[
AI = -100 \left\{ \log \left( \frac{I_\lambda^*}{I_{\lambda_0}^*} \right) - \log \left( \frac{I_\lambda^{cal}}{I_{\lambda_0}^{cal}} \right) \right\} \quad (1)
\]

AI should be zero when all radiative transfer processes are adequately accounted for in the radiative transfer calculations.

Calculated radiances must account for the presence of clouds.
Governing Radiative Transfer Equation

\[ I_\lambda (0, \mu, \varphi) = I^0_\lambda (0, \mu, \varphi) + \frac{R_\lambda T_\lambda (\tau^*, \mu, \varphi)}{(1 - R_\lambda S_\lambda)} \]  \hspace{1cm} (2)

The measured radiance at the top of a purely molecular atmosphere is modeled as the combined effect of radiances originating from two pressure levels in the atmosphere: a surface term \( I^s_{\lambda_0} \), and a cloud term \( I^c_{\lambda_0} \).

LER approximation

Clouds are assumed to be at the surface level.

For all values of \( I^*_{\lambda_0} \) an effective reflectivity (also referred to as Lambert Equivalent Reflectivity or LER), is calculated by simply solving for \( R \) in equation (1) yielding

\[ R_{\lambda_0} = \frac{I^*_{\lambda_0} - I^0_{\lambda_0}}{T_{\lambda_0} + S_{\lambda_0} (I^*_{\lambda_0} - I^0_{\lambda_0})} \]  \hspace{1cm} (3)

The resulting reflectivity is assumed to be \textit{wavelength independent} and used back in equation (1) to find \( I^{\text{cal}}_{\lambda} \) at wavelengths other than \( \lambda_0 \).

\[ I^{\text{cal}}_{\lambda} = I^0_{\lambda} + \frac{R_{\lambda_0} T_\lambda (\theta, \theta_0, p_0)}{1 - R_{\lambda_0} S_\lambda (p_0)} \]  \hspace{1cm} (4)
Mie-Theory-based Approximation

$I^c_\lambda$ cloud terms are calculated using Mie scattering theory. A model representative of water clouds, at prescribed cloud top and bottom pressure levels, and cloud optical depth (COD) 10 is assumed.

$I^s_\lambda$ terms are calculated using wavelength-dependent, climatology-based values of surface albedo.

A *wavelength independent* cloud fraction is calculated for all values of $I^*_\lambda_0$ as

$$f = \frac{I^*_\lambda_0 - I^s_\lambda_0}{I^c_\lambda_0 - I^s_\lambda_0} \quad (5)$$

If $f > 1.0$, overcast sky conditions are assumed (i.e., $f = 1.0$), and a COD that matches the observed $I^*_\lambda_0$ is derived.

$I^{cal}_\lambda$ values are calculated as

$$I^{cal}_\lambda = [1 - f] I^s_\lambda + f I^c_\lambda \quad (6)$$
The more accurate representation of clouds significantly reduces the AI across-scan bias.
Long-term trends (AOD, SSA, AAOD) after retrieval algorithm upgrades

Southern Africa (Lon=15E−35E, Lat=25S−5S)

Sahara (Lon=10W−30E, Lat=15N−30N)

Last three years not plotted due to recently discovered bug (CO data)
Long-term Aerosol Index trends

Southern Africa

Saharan Desert

The Mie-based AI significantly reduces the across-scan bias resulting from the application of The LER AI definition
Conclusion

The assumption of spherical particles in the retrieval of desert dust aerosol properties introduces large across-scan biases in retrieved products. Those biases are significantly reduced by using a more realistic non-spherical shape approximation.

The spherical shape approximation works well in the retrieval of carbonaceous and sulfate aerosols.

The LER approximation introduces across-scan biases (up to ~0.5) in the calculation of The Aerosol Index. The use of Mie-Theory to represent clouds significantly reduces those across-scan differences.

The inclusion of the non-spherical particle shape approximation for the retrieval of dust aerosol properties, and the implementation of the Mie-based calculation of the Aerosol Index improves the long-term reliability in spite of the row anomaly.