Aerosol Updates in the GEOS-FP upgrade to GEOS-5.44.5

GEOS Forward Processing (GEOS-FP) has been heavily reliant on the MODIS instrument aboard the Aqua and Terra satellites to provide the primary source of aerosol optical depth (AOD) used for data assimilation as well as to generate biomass burning emissions that are an input to the model. As a preparation for the decommissioning of the Terra and Aqua satellites, transitioning to the VIIRS sensor provides a critical path for maintaining continuous, high-quality aerosol data assimilation and emissions. Efforts were taken to ensure consistency during the transition from MODIS with the data assimilation using a Neural Network Retrieval algorithm to generate bias-corrected observations of AOD at 550 nm from VIIRS on NOAA-20 (Buchard et al., 2026). Biomass burning emissions from version 3 of the Quick Fire Emissions Dataset (QFED) used observations of fire radiative power from VIIRS aboard NOAA-20 and NOAA-21 with consistency to MODIS maintained from a global, annual scaling followed by an additional regional and biome level scaling for emissions (Collow et al., 2026). GEOS experiments were performed independently for the assimilation of VIIRS-based AOD and biomass burning emissions to determine their individual impacts as well as combined for the net effect of transitioning from MODIS to VIIRS.

Individually and combined, the assimilation of the new VIIRS NNR AOD at 550 nm products and the input of QFED 3 biomass burning emissions within GEOS maintained strong global correlations and comparable error metrics in comparison to control experiments that used MODIS. While overall statistical performance is highly consistent globally, notable regional and seasonal differences emerge from the analysis. Despite both AOD datasets being bias-corrected through the NNR algorithm, residual differences persist in the assimilated fields, reflecting differences in instrument sampling characteristics, retrieval sensitivities under varying atmospheric conditions, and distinct temporal and spatial coverage patterns. Because of these combined instrument and sampling differences, relative performance varies by aerosol regime: VIIRS's finer spatial resolution and greater observation density provide an advantage in complex, dust-dominated environments, whereas the dual-satellite MODIS system occasionally shows a slight advantage capturing peak wildfire smoke, likely because its two daily overpasses may better track rapid diurnal changes. Furthermore, the finer spatial resolution of VIIRS allows for small fires to be detected for the generation of emissions that would not have been observed by MODIS. It should be noted that performance differences observed in current operational GEOS-FP versions are also influenced by the orbital drift of the MODIS satellites, which has become substantial in 2026.

References

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