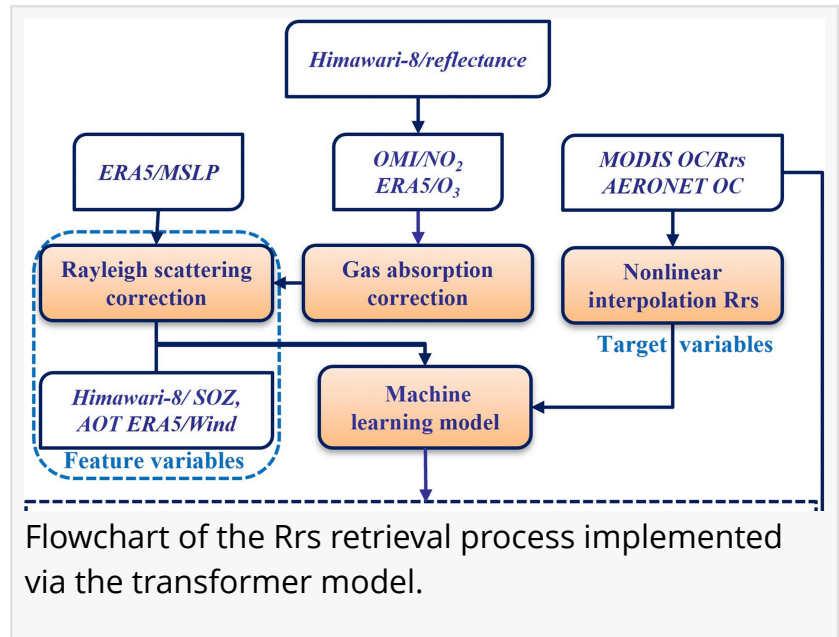


AI unlocks 10-minute ocean color from himawari-8

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/EINPresswire.com/ -- A novel machine learning algorithm retrieves remote sensing reflectance (Rrs) from Himawari 8 geostationary data at 10 minute intervals – an unprecedented frequency for this meteorological [satellite](#). By integrating high accuracy Moderate Resolution Imaging Spectroradiometer (MODIS) observations with a transformer model, the method overcomes the sensor's low signal to noise ratio. Validation shows substantial error reductions compared to standard hourly products, enabling near real time monitoring of coastal and open ocean optical properties across the Asia Pacific region.



Ocean color remote sensing is essential for assessing marine ecosystems, primary productivity, and algal blooms. Polar-orbiting satellites like Moderate Resolution Imaging Spectroradiometer (MODIS) provide accurate Rrs but miss diurnal variations. Geostationary satellites such as Himawari-8 offer high temporal resolution, yet they are not dedicated ocean color sensors: low signal-to-noise ratios (SNR) and standard hourly composites introduce systematic biases – underestimation in turbid waters and overestimation in clear waters. Consequently, rapid minute-scale changes in coastal regions remain poorly captured. Based on these challenges, there is an urgent need to develop a dedicated approach that leverages machine learning to fuse multi-source observations and retrieve reliable, high-frequency remote-sensing reflectance (Rrs) from Himawari-8.

On 15 May 2026, researchers from the Chinese Academy of Sciences, Inner Mongolia Normal University, the University of Oslo, and other partners published a study in the Journal of Remote Sensing. They developed a transformer-based algorithm that retrieves Rrs from Himawari-8 multispectral data at 10-minute resolution – a first for this geostationary meteorological satellite. The method addresses a critical real-world problem: Himawari-8's low SNR, which

degrades ocean color accuracy. By learning from high-quality MODIS observations, the algorithm significantly improves R_{rs} estimates, enabling reliable monitoring of rapid optical changes in dynamic coastal waters.

The new algorithm outperforms official Himawari-8 Level-3 hourly products across all visible bands. Validation against AERONET-OC (Aerosol Robotic Network-Ocean Color) in situ data shows root-mean-square error reductions of 34%, 26%, and 12% at 470, 510, and 640 nm, respectively. The transformer model achieves correlation coefficients >0.98 on test data – substantially higher than the random forest baseline (0.95) and the operational product (0.84). Crucially, it corrects systematic biases: the underestimation of R_{rs} at 470/510 nm in turbid coastal waters and the overestimation at 640 nm in clear waters. Comparisons with MODIS ocean color products reveal strong spatial and temporal consistency ($R > 0.96$). This is the first demonstration of accurate, 10-minute R_{rs} retrieval from a geostationary meteorological satellite.

The algorithm integrates a classic atmospheric correction (AC) framework with a transformer neural network. First, gas absorption (O_3 and NO_2) is corrected using ECMWF Reanalysis v5 (ERA5) reanalysis and Ozone Monitoring Instrument (OMI) data, and Rayleigh scattering is removed via a lookup table from a coupled atmosphere-ocean radiative transfer model. The transformer – chosen for its self-attention capability – learns the nonlinear relationship between top-of-atmosphere reflectance and R_{rs} . Input features include solar zenith angle, six Himawari-8 reflectance bands (470–2257 nm), aerosol optical thickness (AOT), and wind speed. Training targets are high-quality MODIS Aqua R_{rs} products (spectrally interpolated to Himawari-8 bands) and AERONET-OC in situ measurements. Nearly 475 million samples were collected (9:1 train-test split). The model retrieves R_{rs} at 470, 510, and 640 nm with 5 km resolution. Validation demonstrates that the transformer reduces hourly product errors by 4–12.5% and captures rapid coastal R_{rs} changes within a 1-hour window – features invisible to standard composites. The algorithm maintains stable performance across seasons and varying AOT.

“Himawari-8 was not built for ocean color, but our machine-learning approach compensates for its hardware limitations,” said Dr. Chong Shi, corresponding author. “By learning from the high-quality MODIS record, the transformer effectively ‘corrects’ sensor noise and retrieval biases. This unlocks diurnal tracking of coastal water optics at 10-minute intervals – critical for managing fisheries, algal blooms, and water quality.”

The team first performed gas absorption (O_3 , NO_2) and Rayleigh scattering corrections using ERA5 pressure, OMI NO_2 columns, and a radiative-transfer lookup table. Himawari-8 Level-1 top-of-atmosphere reflectances (bands 1–6) were matched within ± 10 minutes to MODIS Aqua R_{rs} products and AERONET-OC in situ data. A transformer model with multi-head self-attention was trained on 427.5 million samples. Inputs included viewing geometry, AOT, and wind speed. Model performance was evaluated using mean bias error, root-mean-square error, and correlation coefficient.

This algorithm transforms a meteorological satellite into a powerful ocean color monitor, enabling near-real-time observation of coastal dynamics, harmful algal blooms, and sediment transport across the Asia-Pacific region at 10-minute intervals. Future work will expand training samples for better generalizability, incorporate sun glint correction, and apply the framework to other geostationary satellites (e.g., GK-2A, FY-4). Longer time-series validation will assess seasonal stability. Ultimately, the approach could be extended to hyperspectral sensors like PACE, offering consistent, high-frequency ocean color products from both geostationary and polar-orbiting platforms.

References

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Lucy Wang

BioDesign Research

+ +86 177 0518 5080

[email us here](#)

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