26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

When dust meets cloud: overcoming satellite monitoring gaps in high-impact pollution events across Australasia

Miles Sowden [a]

[a] *Curtin School of Population Health, Curtin University,*
Kent Street, Bentley Western Australia, 6102, Australia
Email: miles.sowden@curtin.edu.au

Abstract: The escalating impact of both dust storms and smoke haze across Australia and Southeast Asia poses a growing challenge for satellite-based air quality monitoring systems. These events are no longer episodic or isolated: 2019–2020 marked a watershed year in which Australia experienced record-breaking dust activity, while severe regional haze from peatland fires in Indonesia and a post-monsoonal haze event in Hanoi (1 November 2024) underscored the limitations of current detection systems across the tropics (CSIRO/BOM 2024, IPCC 2023)).

This poster synthesises findings from two related studies addressing the dual failures of detection under (i) bright land surfaces during dust mobilisation and (ii) high fractional cloud cover during haze events. In both domains, standard aerosol optical depth (AOD) products, whether MODIS-based (Deep Blue, Dark Target) or derived from Himawari-8, exhibit systematic blind spots (Sowden et.al 2018). Dust is misclassified or missed entirely over semi-arid terrain due to high surface reflectance, while haze under cloud regimes is masked or flattened in thermal and near-infrared channels.

We present a fused methodology using Himawari-8/9 data (500 m, 10-minute intervals) across the full Australian observational domain, with selected extensions to Southeast Asia. The system processes full-disc Level 1b imagery through a high-frequency pipeline developed using GDAL, CDO, and NCO, implemented on the NCI supercomputing facility. CAMS aerosol reanalysis products supplement speciation and concentration context but are shown to under-sample peak events due to coarse spatial resolution and smoothing, particularly over rugged terrain and near urban peripheries.

Case studies include:

- Dust Events: The East Coast storm (22 Nov 2019) and January 2020 event in NSW, with dust fronts that penetrated urban zones in less than an hour, evading detection in reanalysis and standard AOD fields.
- Cloud-Masked Haze: The Hanoi haze (Nov 2024) and Kalimantan fire episode (Sept 2019), both showing near-zero satellite response despite surface monitors indicating hazardous PM levels.

Our pixel-level reconstruction method (Sowden et.al 2024) , developed initially for bushfire smoke, is adapted here for coarse PM detection under cloud and dust-obscured conditions. Using spectral gradients, temporal deltas (dX/dt), and thermal emissivity anomalies, we infer particulate presence without relying on conventional AOD inputs. This allows dynamic adjustment even under marginal or masked observation.

Animations demonstrate clear advantages: dust wall incursions are visible where CAMS fails, and haze events re-emerge in thermal space through derivative enhancement. These reconstructions help close the gap between model outputs and observed risk, especially where satellite data alone is misleading.

Policy Implications: These findings support a paradigm shift in how satellite-derived exposure indices are constructed. Single-source systems are increasingly inadequate. Climate adaptation policies must integrate fused, high-frequency approaches to address emerging airborne hazards shaped by both natural variability and anthropogenic intensification.

Acknowledgements: Full-disc Himawari-8 Level 1b data were acquired through the Bureau of Meteorology and processed on the NCI supercomputing infrastructure. Processing used open-source geospatial tools GDAL, CDO, and NCO in a high-frequency analysis pipeline. CAMS global aerosol data were used to inform speciation context and scaling.

Keywords: *Himawari-8, Dust Storms, Cloud Masking, Air Quality, Satellite Aerosol Monitoring, CAMS Reanalysis*

© MSSANZ and The Authors, CC-BY

REFERENCES

CSIRO; & Bureau of Meteorology (2024) **State of the Climate 2024**. Canberra, Australia. Available from: https://www.bom.gov.au/state-of-the-climate/2024/documents/2024-state-of-the-climate.pdf

Intergovernmental Panel on Climate Change (IPCC), 2023, Sixth Assessment Report of the Intergovernmental Panel on Climate Change Working Group II Observed and Projected Impact Assessment Database v1.0, NASA Socioeconomic Data and Applications Center (SEDAC), IPCC DDC, https://doi.org/10.7927/dkf1-wj68

Sowden, M, Mueller, U, & Blake, D (2018) Review of surface particulate monitoring of dust events using geostationary satellite remote sensing. *Atmospheric Environment* 183, 154-164.

Sowden, M, & Hanigan, I.C., Robbins, D.J.V., Cope, M., Silver, J.D., Noonan, J. (2024) Characterizing smoke haze events in Australia using a hybrid approach of satellite-based Aerosol Optical Depth and Chemical Transport Modeling. *Remote Sensing* 16 (7), 1266.

© MSSANZ and The Authors, CC-BY