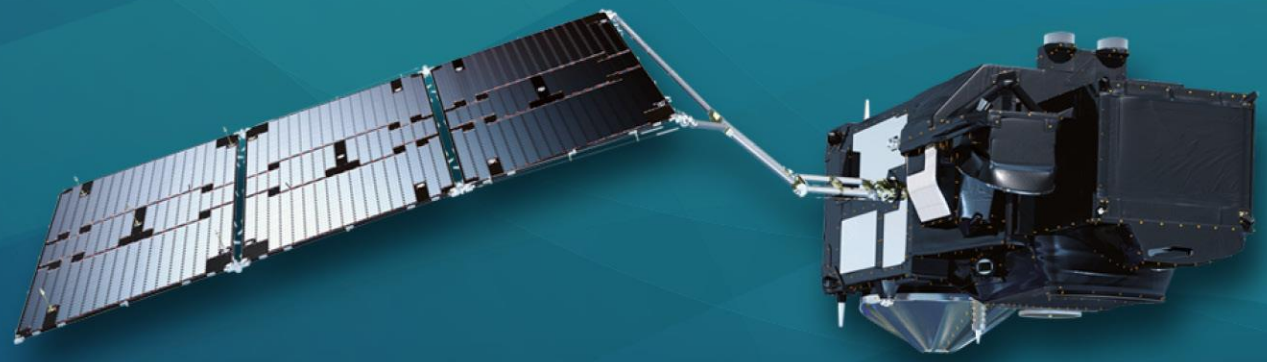
PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

EUMETSAT

co-funded with esa



# 9th Sentinel-3 Validation Team meeting 2026

30 March–01 April 2026 | ESA–ESRIN | Frascati (Rome), Italy

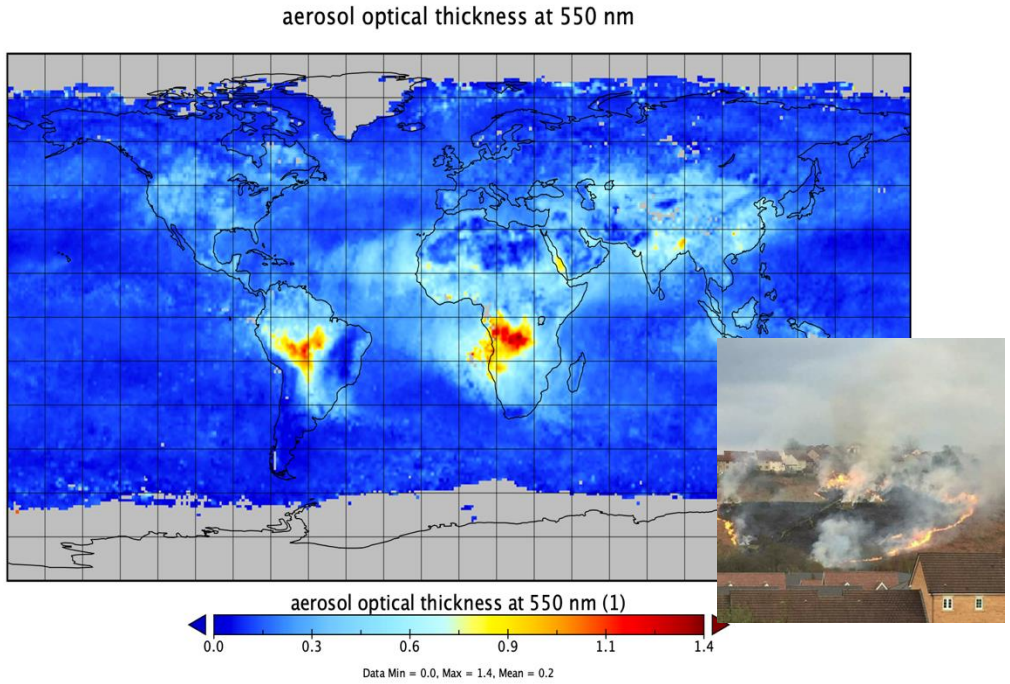
# Long term records of atmospheric aerosol and particulate matter from Sentinel-3

*Peter North[1], Kevin Pearson[1], Iain Bye[1], Thomas Popp[2], Larisa Sogacheva[3], Stefan Kinne[2], Michael Eisinger[4]*

*1 Swansea University UK; 2 DLR Germany; 3 FMI Finland; 4 European Space Agency UK*

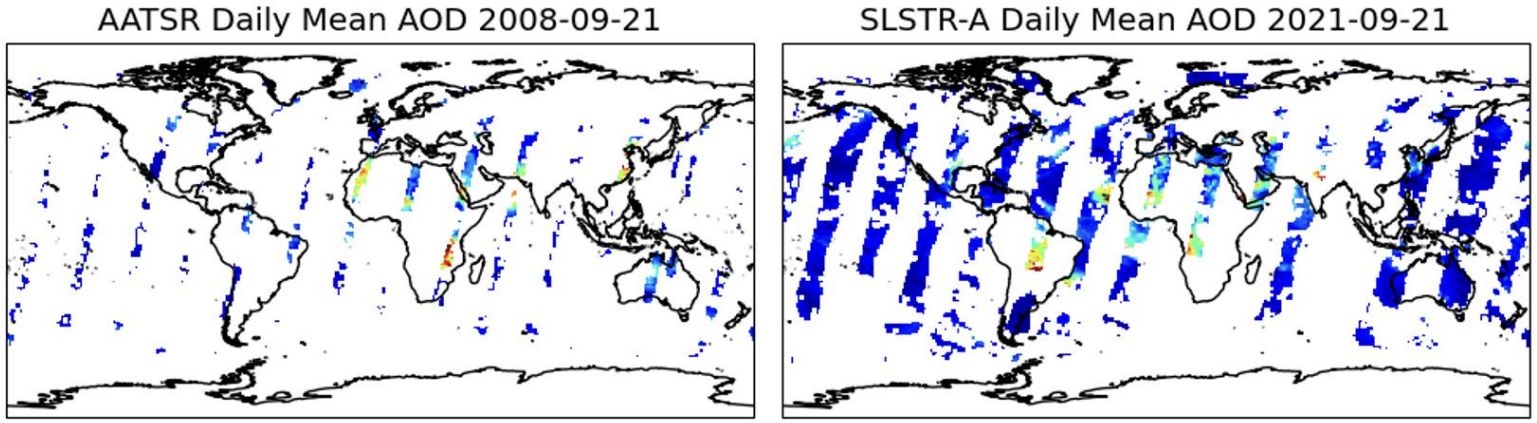
# Long term records of atmospheric aerosol and particulate matter from Sentinel-3

1. **New climate datasets: ATSR-2 (1995-2003), AATSR (2002-2012), SLSTR 3A (2016-), S3B (2018 -)**
2. **Validation and inter sensor comparisons**
3. **Analysis of anomalies**
4. **Relation to surface PM2.5/PM10**
5. **Summary and future challenges**




Prof. Peter North, Swansea University
Contact: p.r.j.north@swan.ac.uk

# (A)ATSR - SLSTR global aerosol (1995-2026)



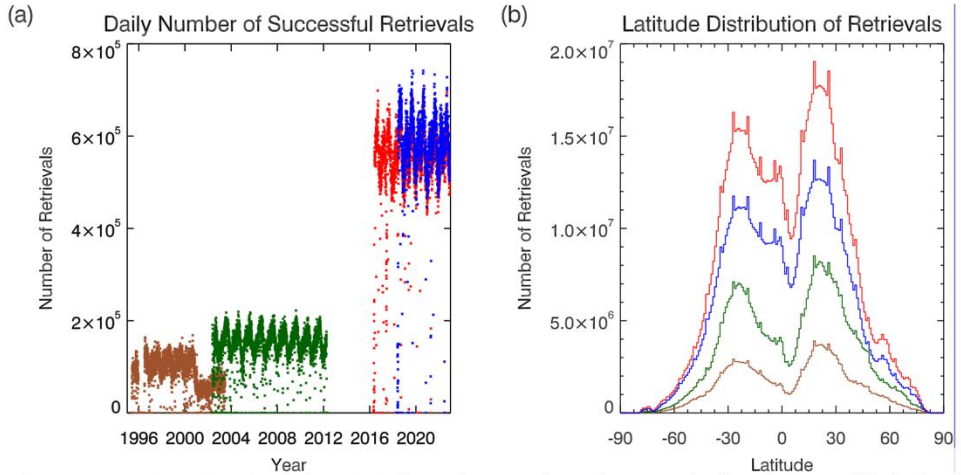
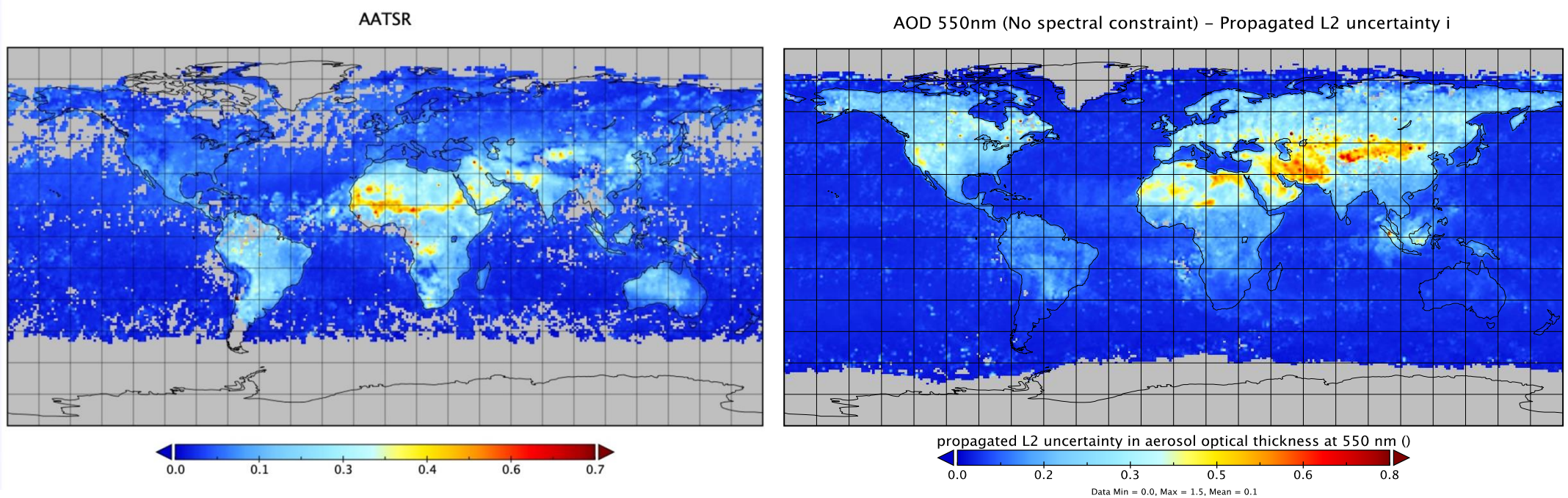




*Figure 1 Comparison of retrievals by ATSR-2 (brown), AATSR (green), SLSTR-A (red) and SLSTR-B (blue): a) number of successful daily retrievals; b) total number of retrievals for each 1° of latitude.*

*Pearson, K., North, P. et al. Atmospheric aerosol measurements from the ATSR-SLSTR series of dual-view satellite instruments 1995–2022. Sci Data 12, 410 (2025). https://doi.org/10.1038/s41597-025-04694-6*

**Climate datasets:** ATSR-2 (1995-2003), AATSR (2002-2012), SLSTR 3A (2016-), S3B (2018 -)

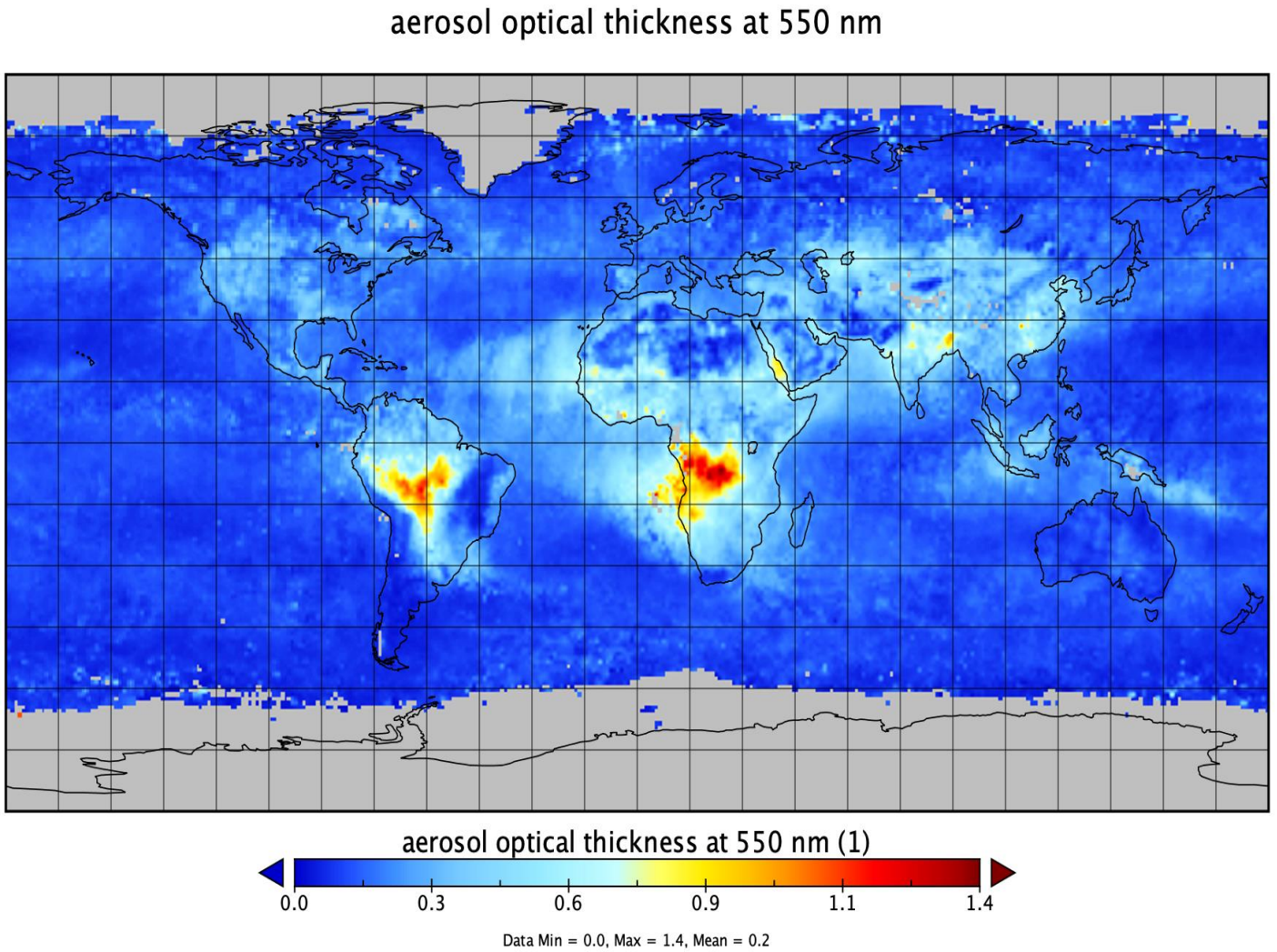
# (A)ATSR vs SLSTR AOD Uncertainty

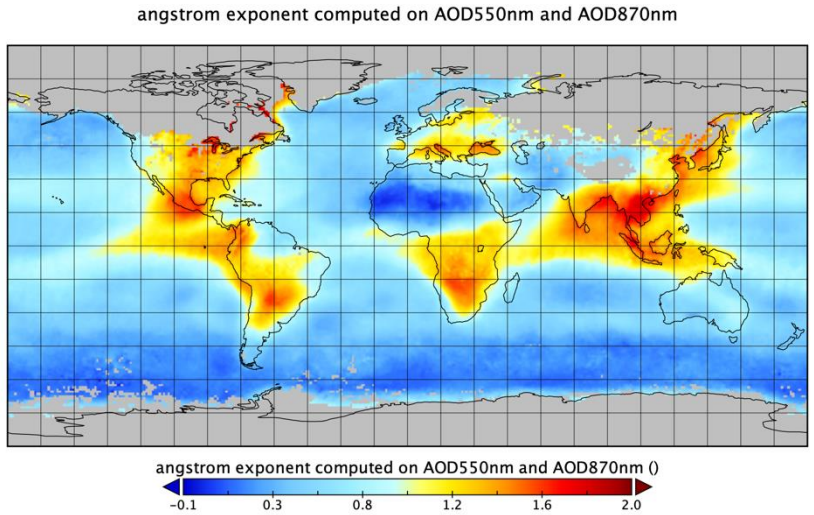



Pearson, K., North, P. et al. 2025, Nature Scientific Data,
doi: 10.1038/s41597-025-04694-6

- Propagated L2 Uncertainty in retrieval
- High in ‘backscatter’ direction
- Opposite hemispheric pattern (A)ATSR vs SLSTR

# SU/CCI SLSTR Aerosol properties




- L3 Daily and monthly 1° products, L2 4.5km
- NetCDF format: AOD, fine mode AOD, uncertainty, Angstrom, SSA etc
- Data avail: eocis.org (1.14), C3S (1.12)
- See Pearson, North et al. *Sci Data* 2025

# Slide Title

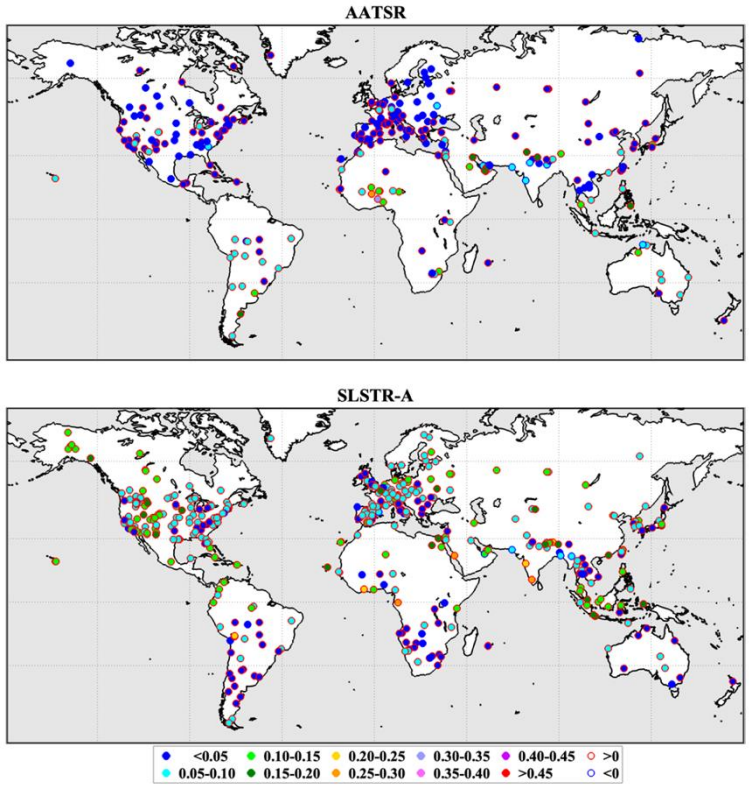
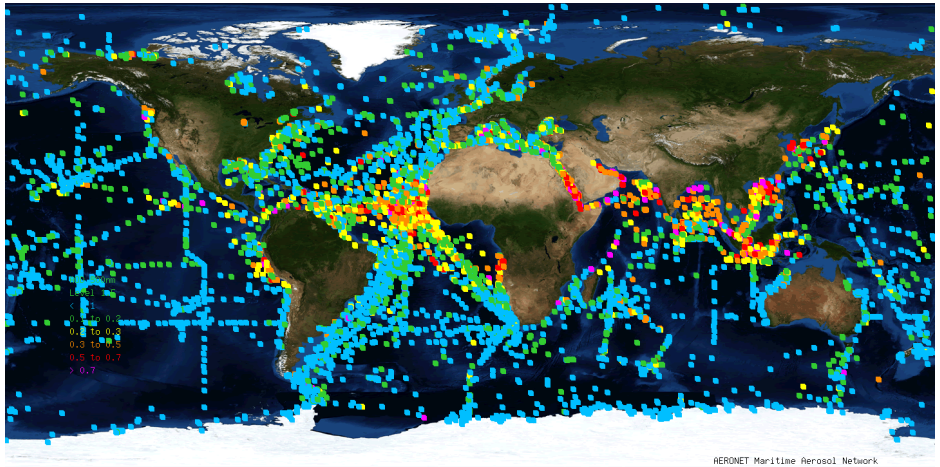


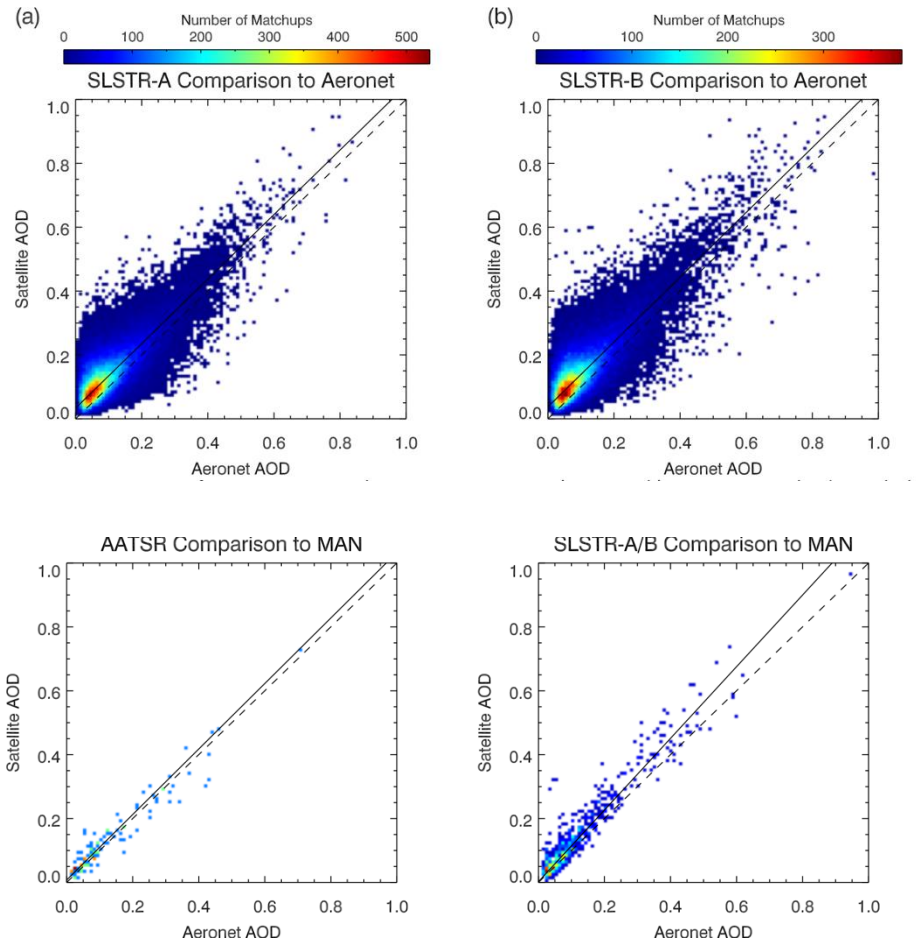

*Figure 7 Global distribution of the difference between satellite and AERONET AOD for Aeronet locations with at least 10 matches for AATSR and SLSTR-A.*




**AERONET (Land): ~180,000 matchups**
**Ocean (MAN): ~ 700 matchups**

Pearson, North et al. *Sci Data* 2025

# (A)ATSR, SLSTR V1.14: Validation




| Sensor | Mean AOD | Bias | RMSE | Correlation | GCOS fraction | GCOS_b fraction | Matches |
|---|---|---|---|---|---|---|---|
| ATSR-2 | 0.165 | 0.026 | 0.101 | 0.853 | 46.9 | 45.1 | 1,750 |
| AATSR | 0.175 | 0.011 | 0.094 | 0.864 | 53.4 | 54.1 | 24,554 |
| SLSTR-A | 0.140 | 0.044 | 0.097 | 0.832 | 34.3 | 42.4 | 88,904 |
| SLSTR-B | 0.138 | 0.049 | 0.099 | 0.827 | 32.2 | 41.4 | 62,551 |

| Sensor | Mean AOD | Bias | RMSE | Correlation | GCOS fraction | GCOS_b fraction | Matches |
|---|---|---|---|---|---|---|---|
| AATSR | 0.136 | 0.006 | 0.036 | 0.960 | 72.7 | 73.6 | 110 |
| SLSTR-A/ SLSTR-B | 0.123 | 0.028 | 0.049 | 0.955 | 62.7 | 63.5 | 611 |

Pearson, North et al. *Sci Data* 2025

# SU SLSTR v1.14: C3S evaluation

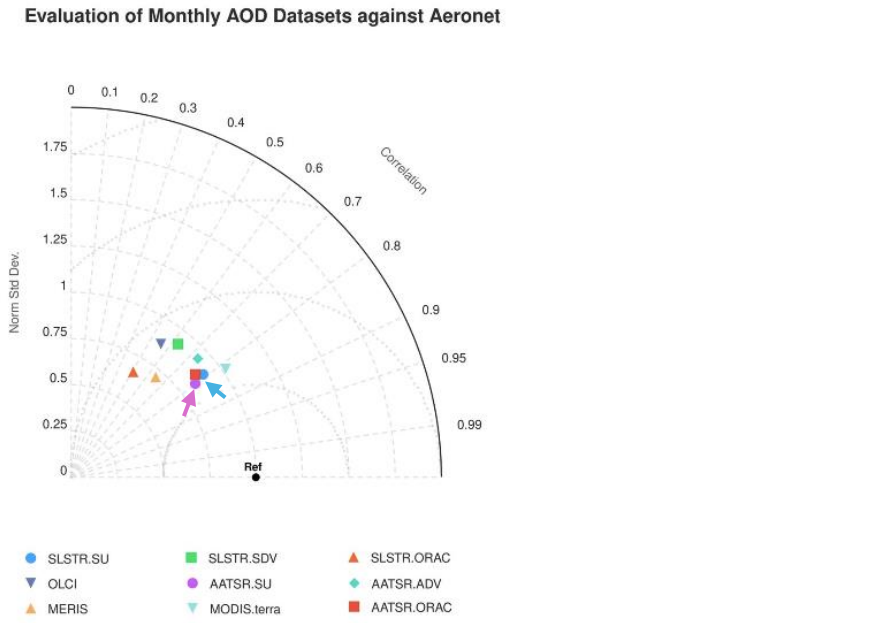
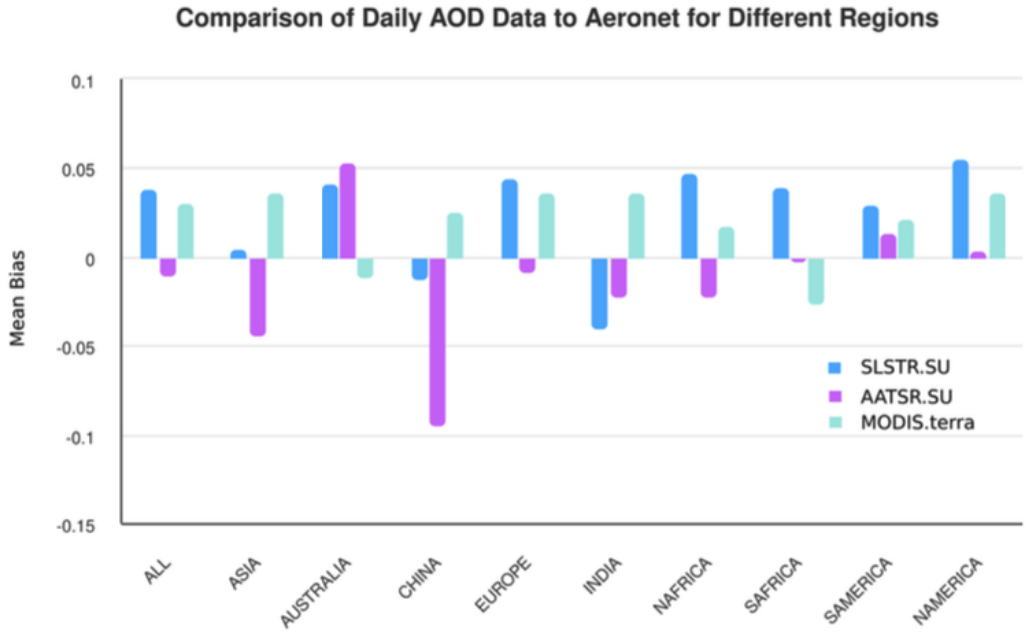



Fig. 13 Taylor diagram comparing the performance of several L3 monthly AOD datasets using AERONET data as a reference. Points are plotted for AATSR and SLSTR-A from the datasets presented here as well as for those generated using the ORAC and ADV/SDV algorithms. Monthly AOD derived from MERIS, OLCI and MODIS (on the Terra platform) are also shown.

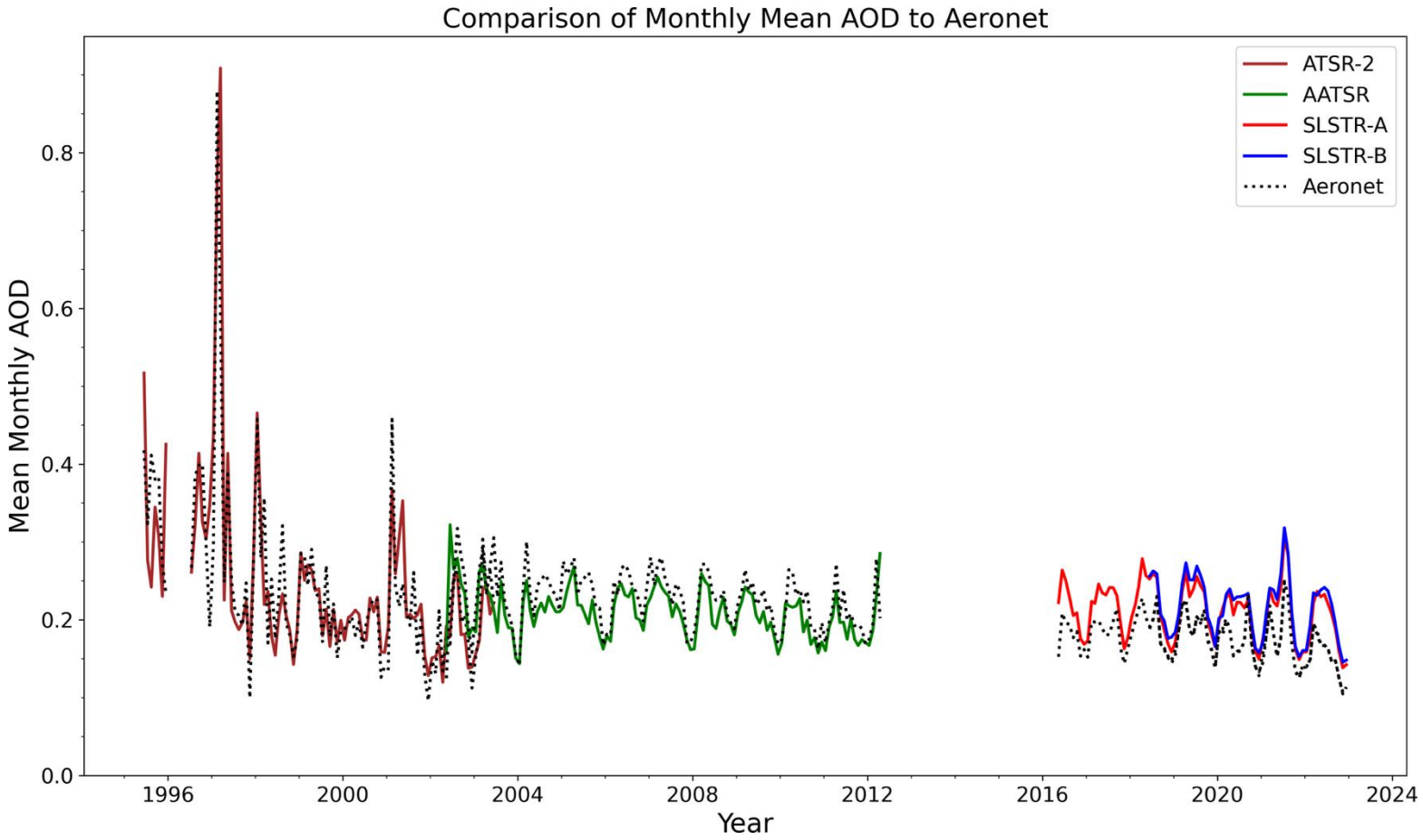



**C3S / Aerocom evaluation**

- See https://aeroval.met.no
- Comparison with AERONET (monthly)
- Correlation, RMS, bias…

*Pearson, K., North, P., Heckel, A. et al. Atmospheric aerosol measurements from the ATSR-SLSTR series of dual-view satellite instruments 1995–2022. Sci Data 12, 410 (2025). https://doi.org/10.1038/s41597-025-04694-6*

# (A)ATSR - SLSTR v1.14 Time Series

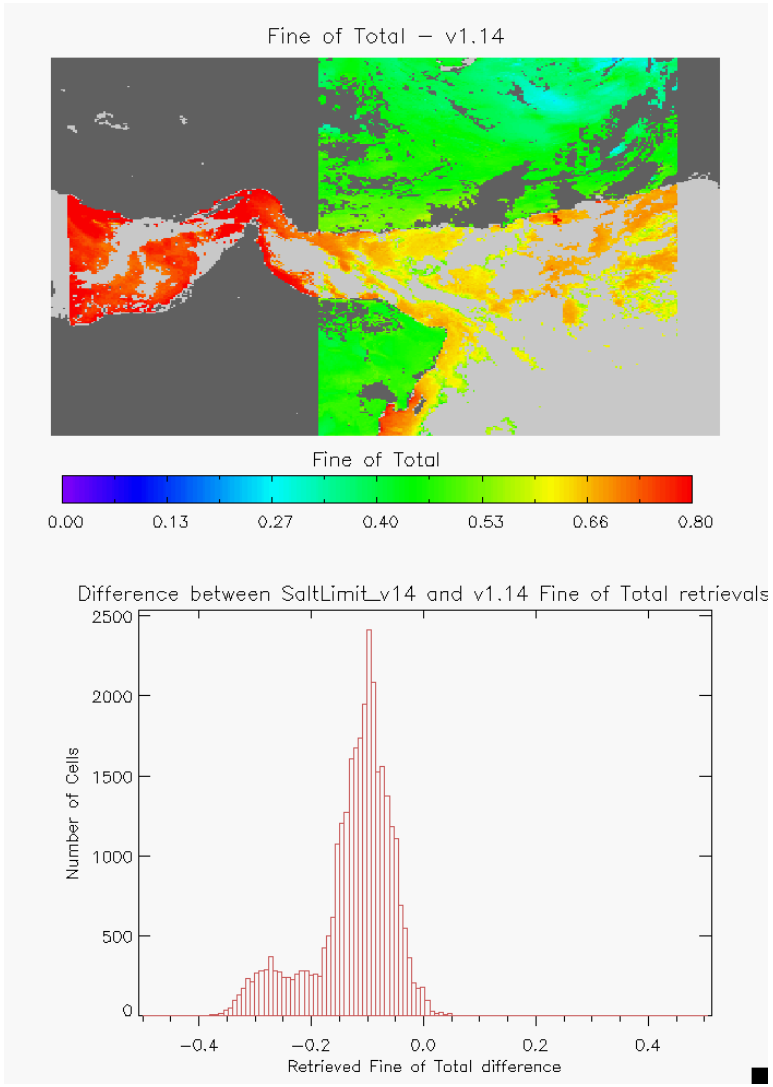



**C3S / Aerocom evaluation**

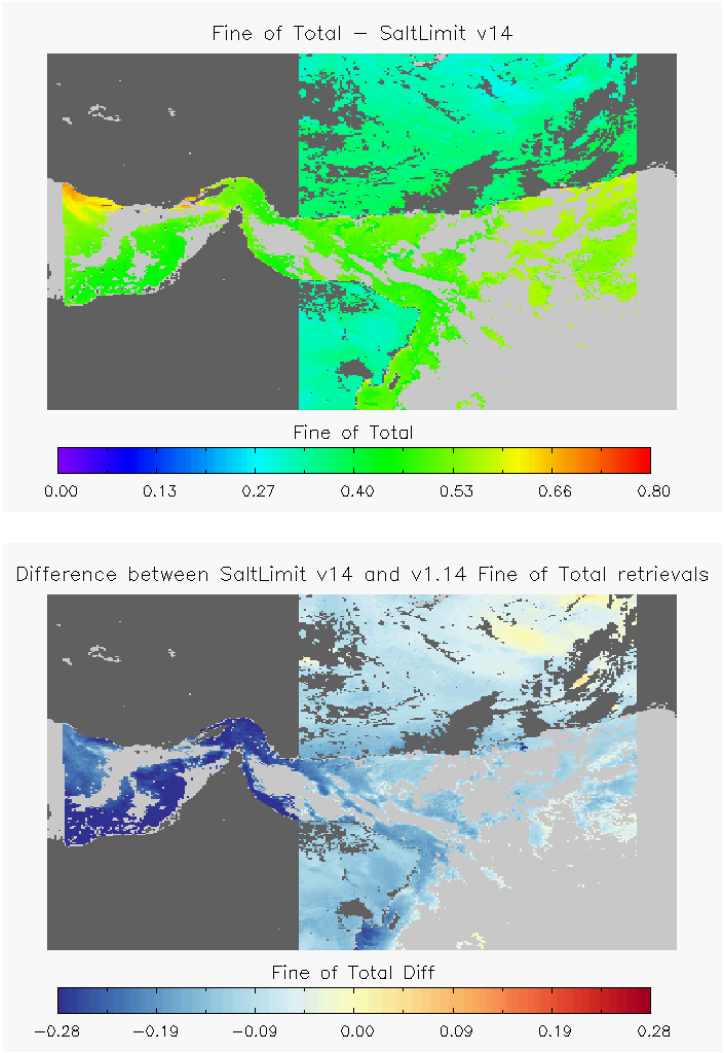
- See https://aeroval.met.no
- Comparison with AERONET (monthly)

# Improving Fine Mode Fraction estimation

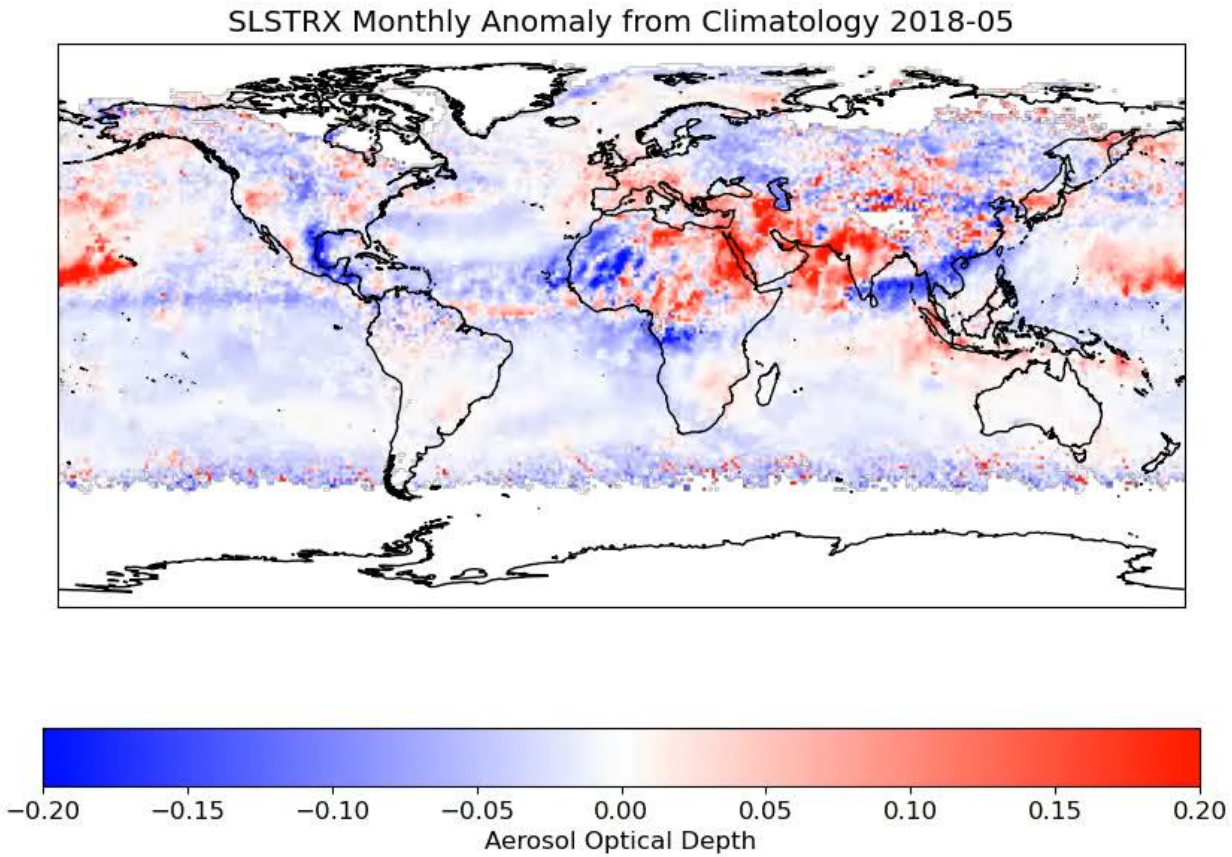
V1.14.1

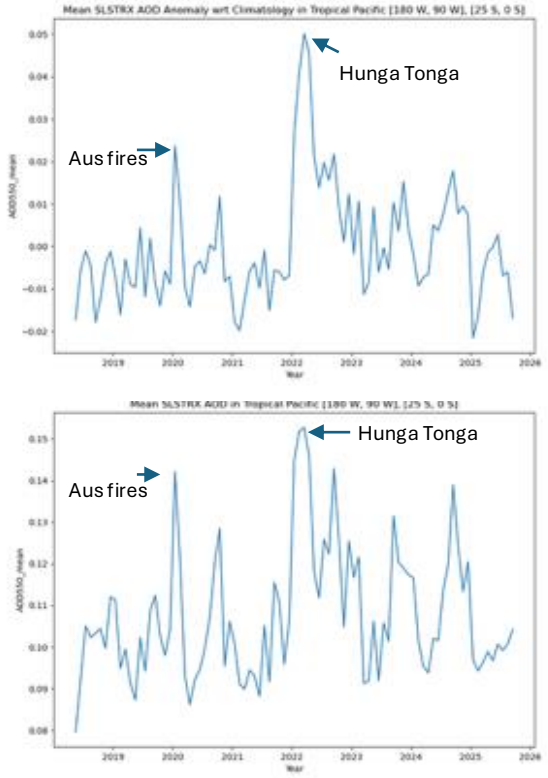



V1.15

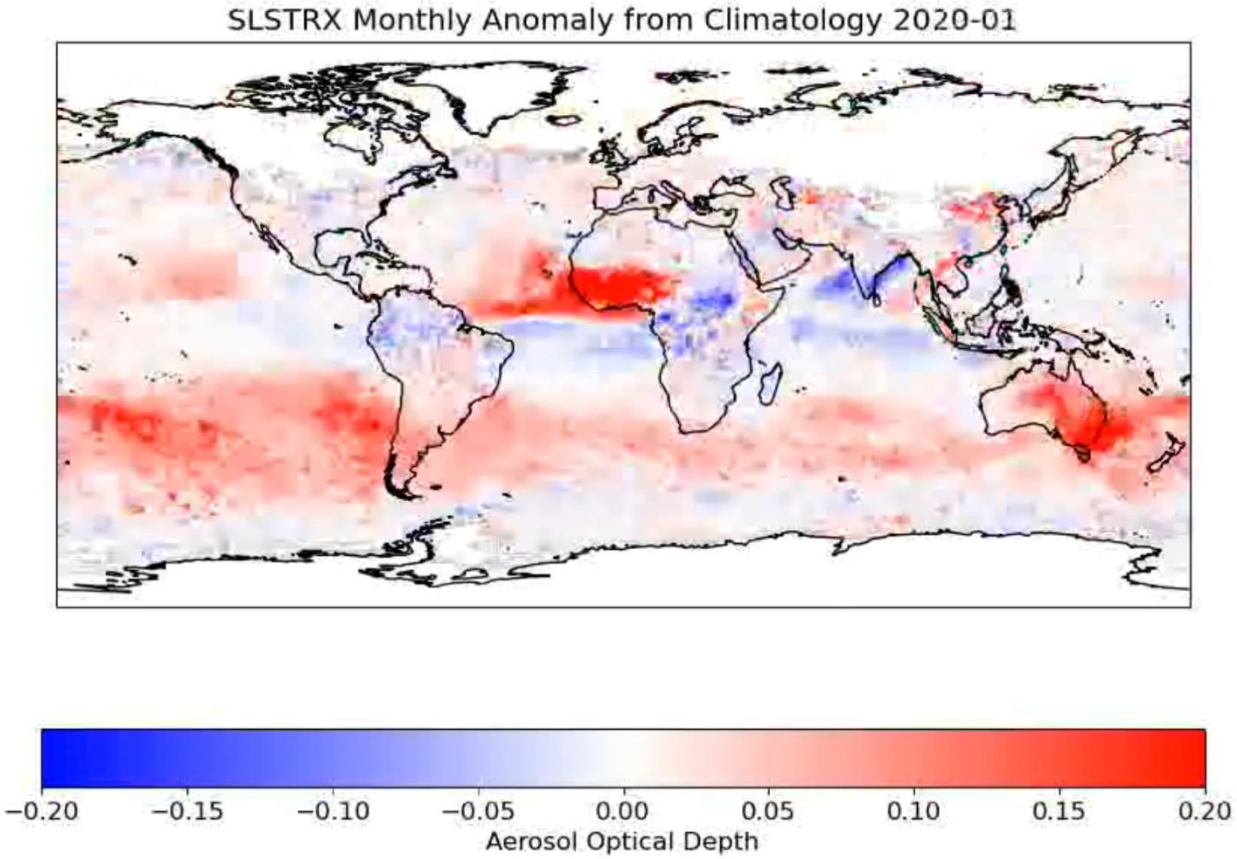


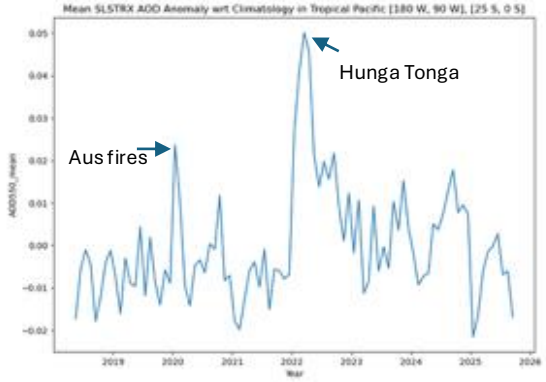
# SLSTR AOD Anomalies

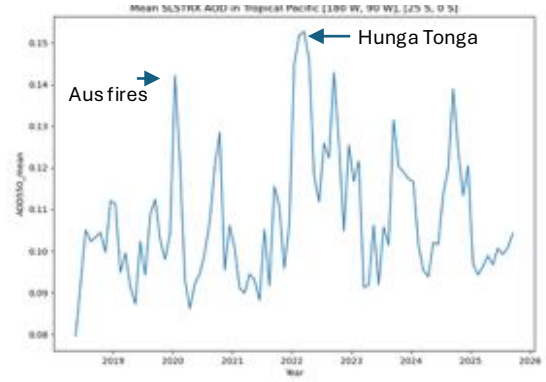


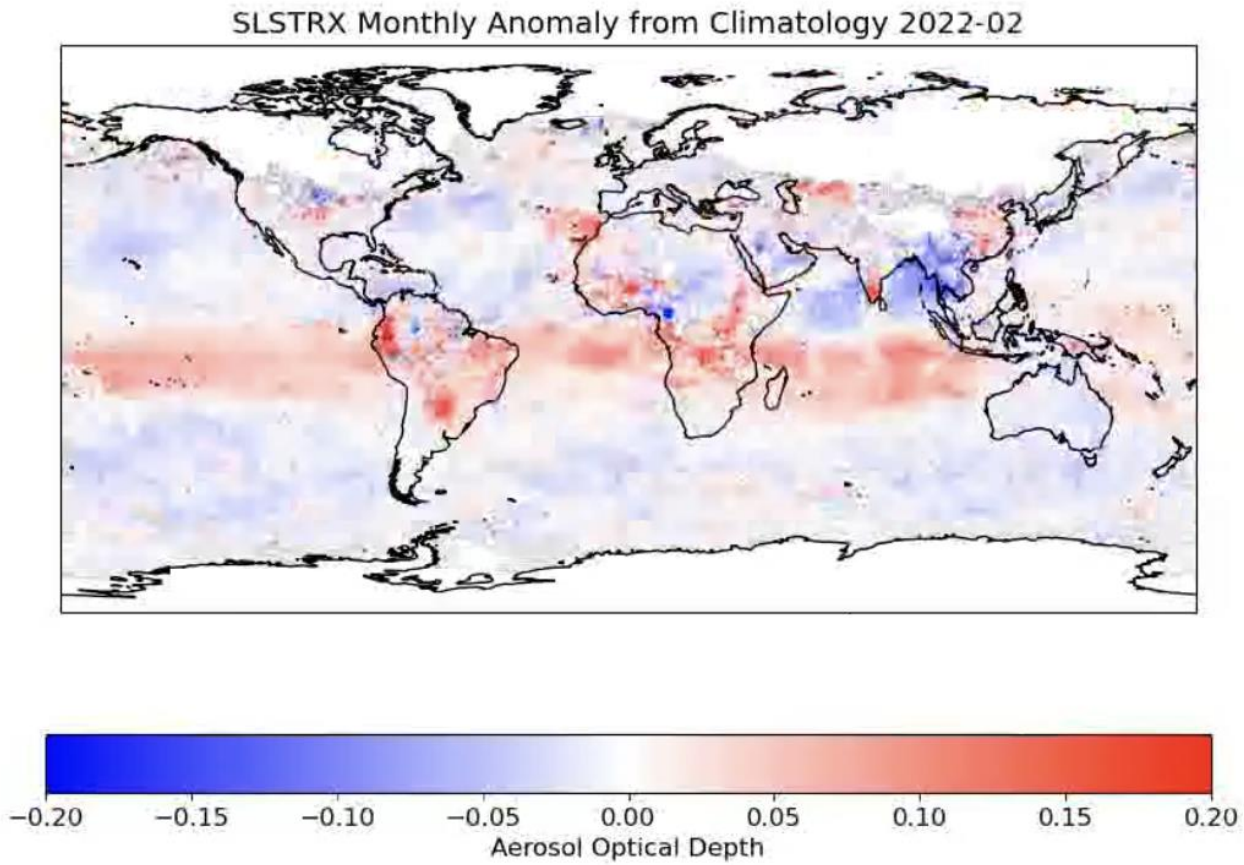
# SLSTR AOD Anomaly:  Australian fires 2020-01

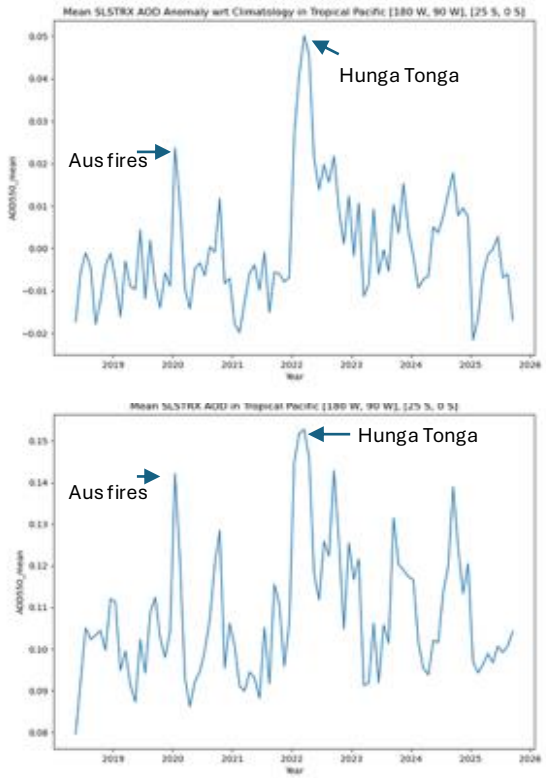


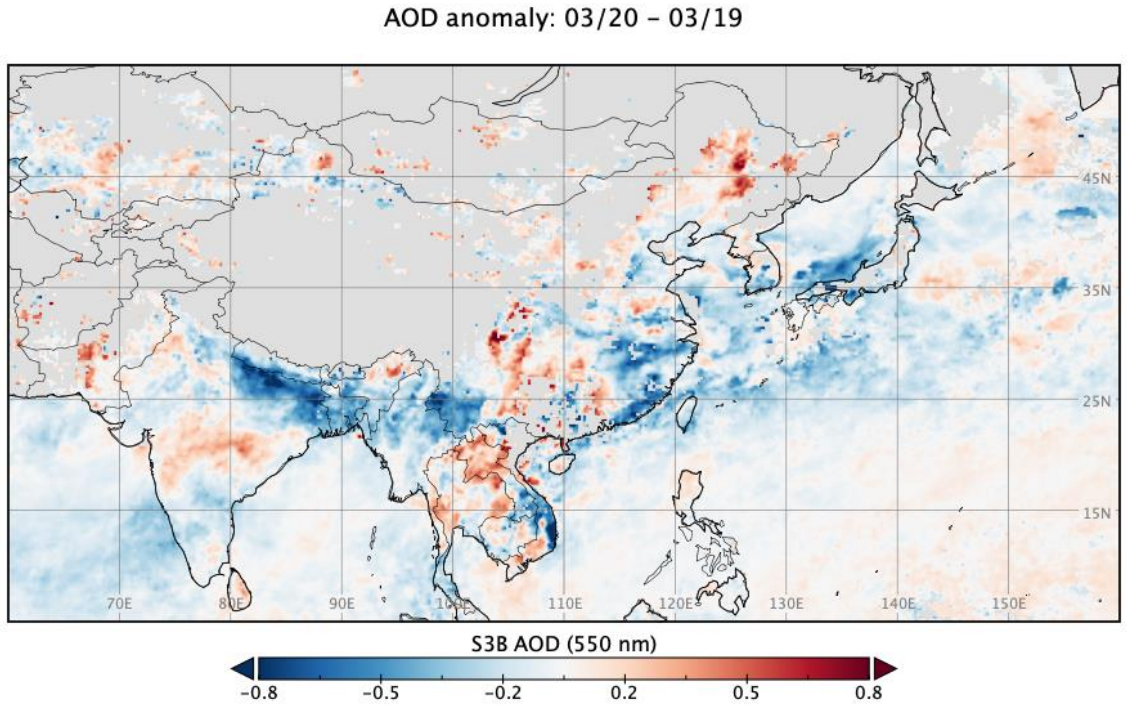



# SLSTR AOD Anomaly: Hunga Tonga 2022-02



# March 2020 – S. Asia AOD anomaly



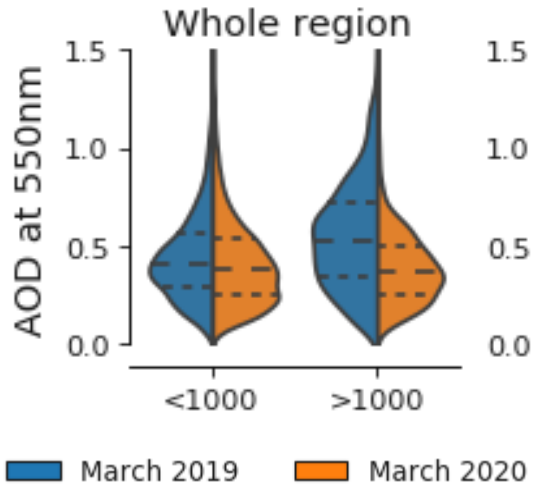




**Figure 1. AOD anomaly from Sentinel-3B (March 2020)**. The image shows difference between March 2020 and March 2019 monthly mean observations of AOD at 550nm over the Asian region. Blue shows reduction in aerosol, red shows increase. From Nikonovas et al. *in prep*.

# Anthropogenic aerosol forcing

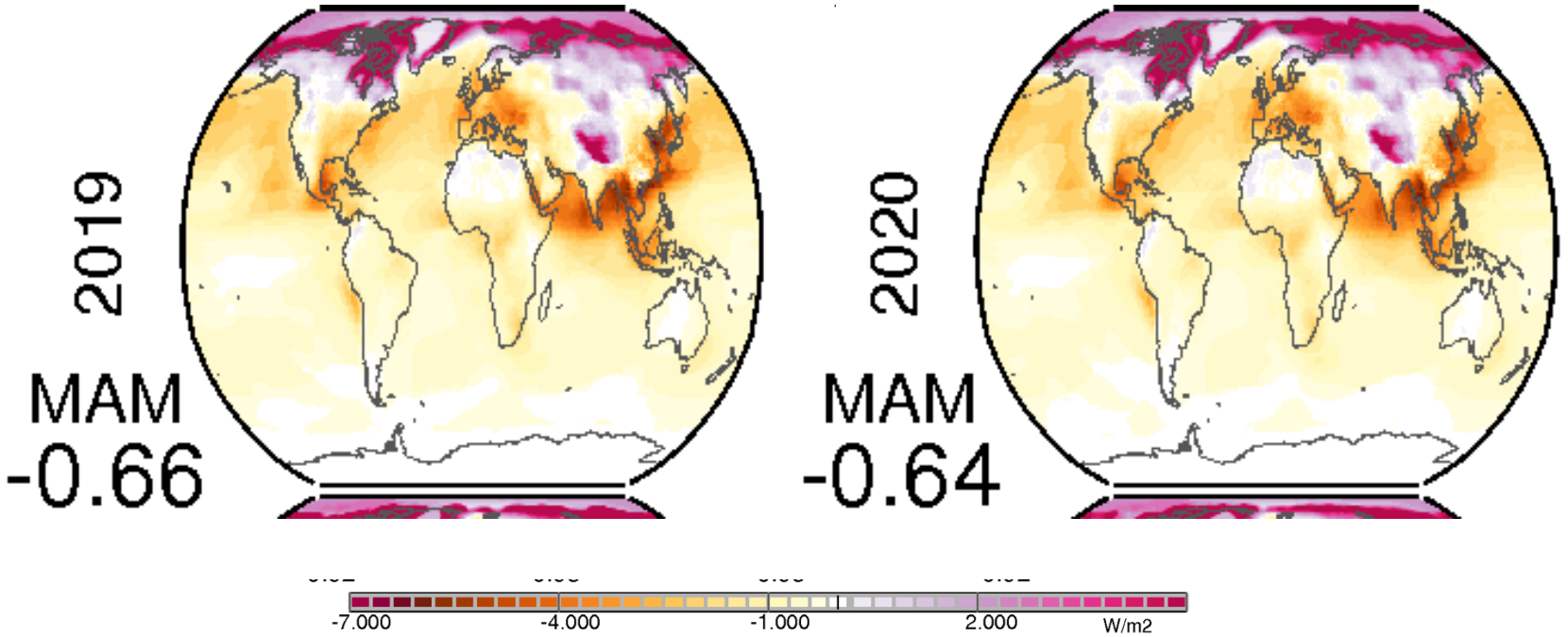
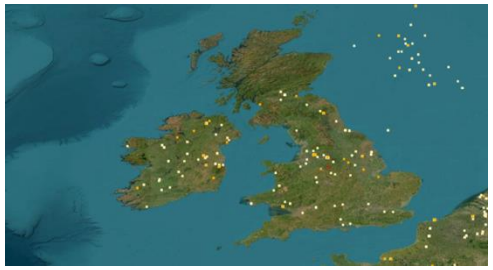
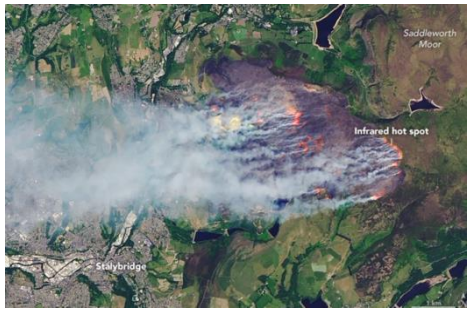
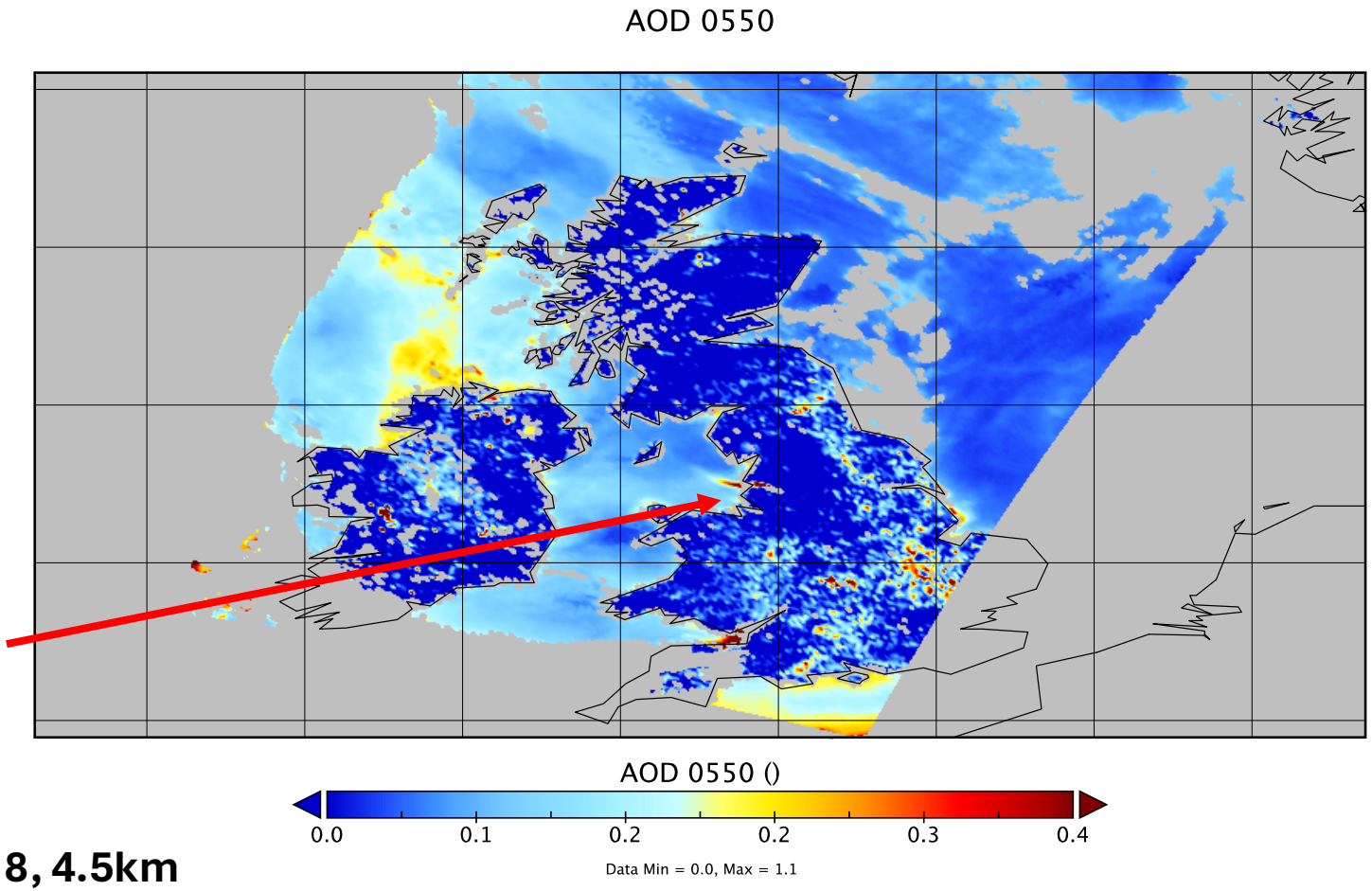



**Figure 3b. Total anthropogenic aerosol forcing 2019-2020.** Seasonal maps of simulated anthropogenic aerosol radiative effects at TOA with AODf data from SLSTR 2019 - 2020. Positive values represent a warming and negative values a cooling. Combined direct and indirect (via modified clouds) impact maps are presented. From Kinne et al. *in prep*.

# Aerosol, PM2.5, PM10 - Machine learning

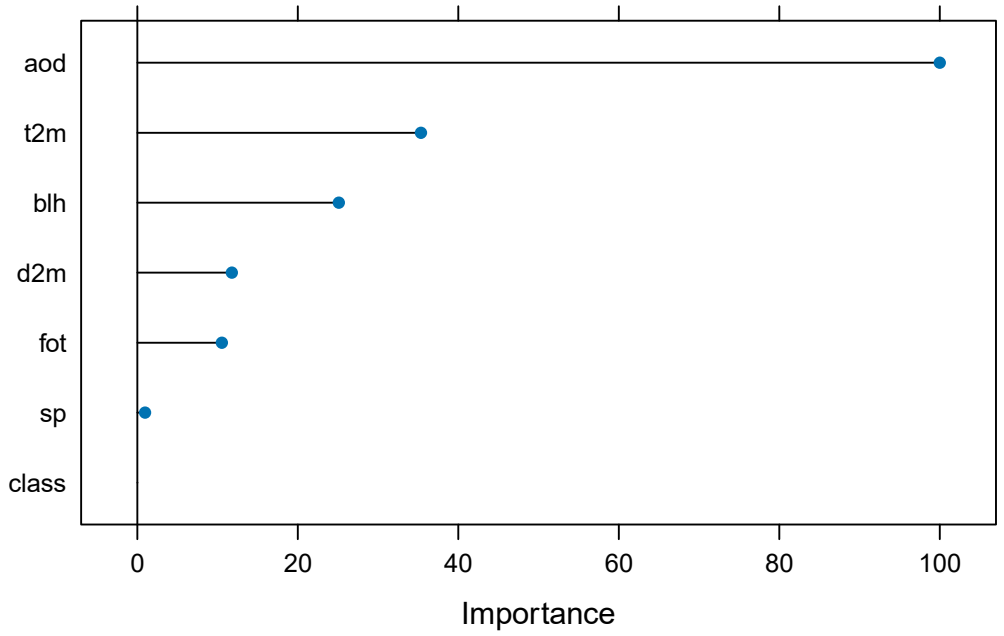




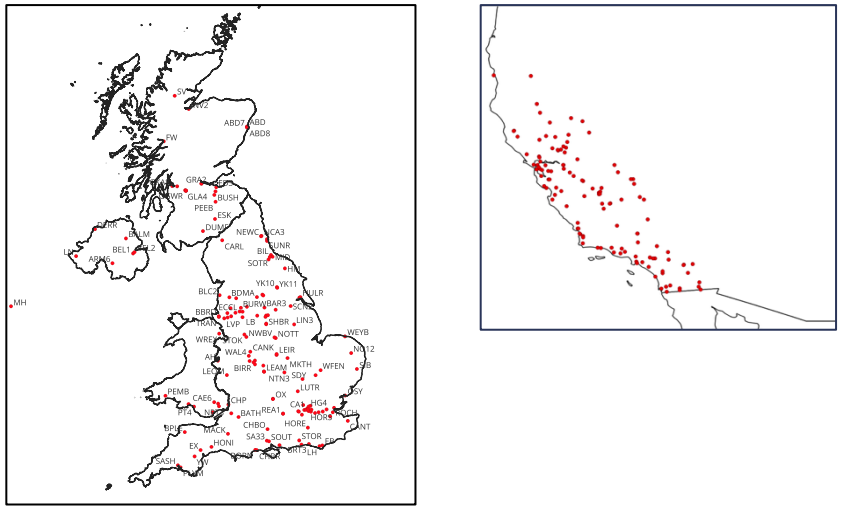

- **SLSTR_3A 30th June 2018, 4.5km resolution L2 AOD tile**
- Saddleworth Moor fire

# Aerosol, PM2.5, PM10 - Machine learning




Generalised Linear Model

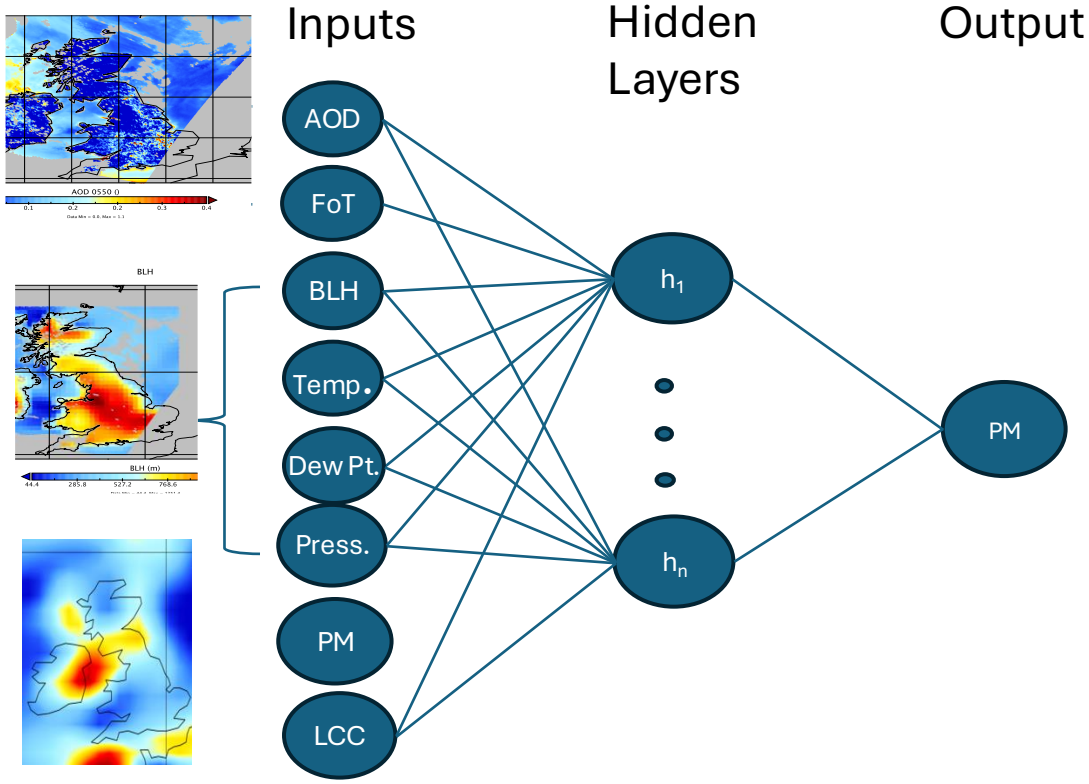
- Relative importance of retrieval factors

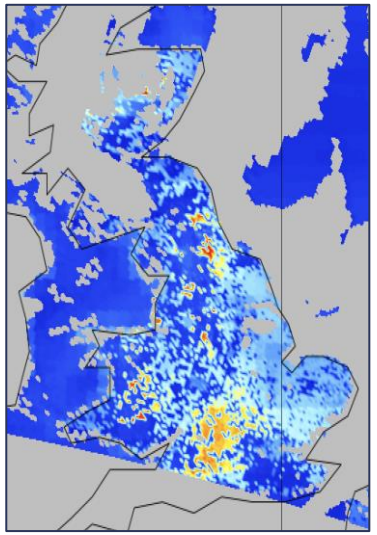


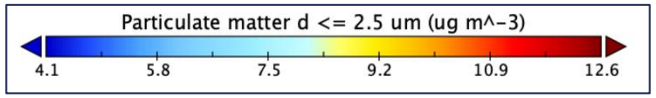
**Machine learning approach**

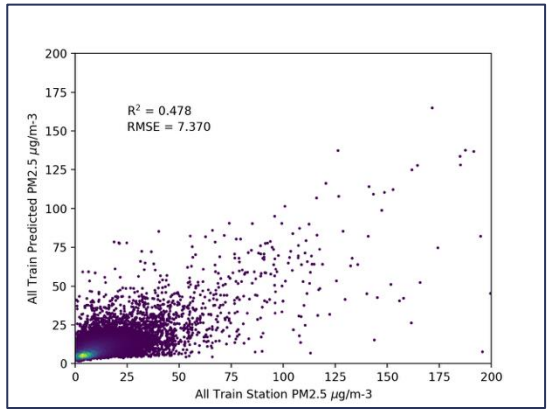
- ~8500 AOD / AURN + CA EPA matchups 2016 – 2022
- AOD + climate variables (ERA5)
- GLM: AOD > t2m > blh > d2m
- MLP/BP, 16 nodes, 2 hidden layers, 4k epoch

# Aerosol, PM2.5, PM10 - Machine learning





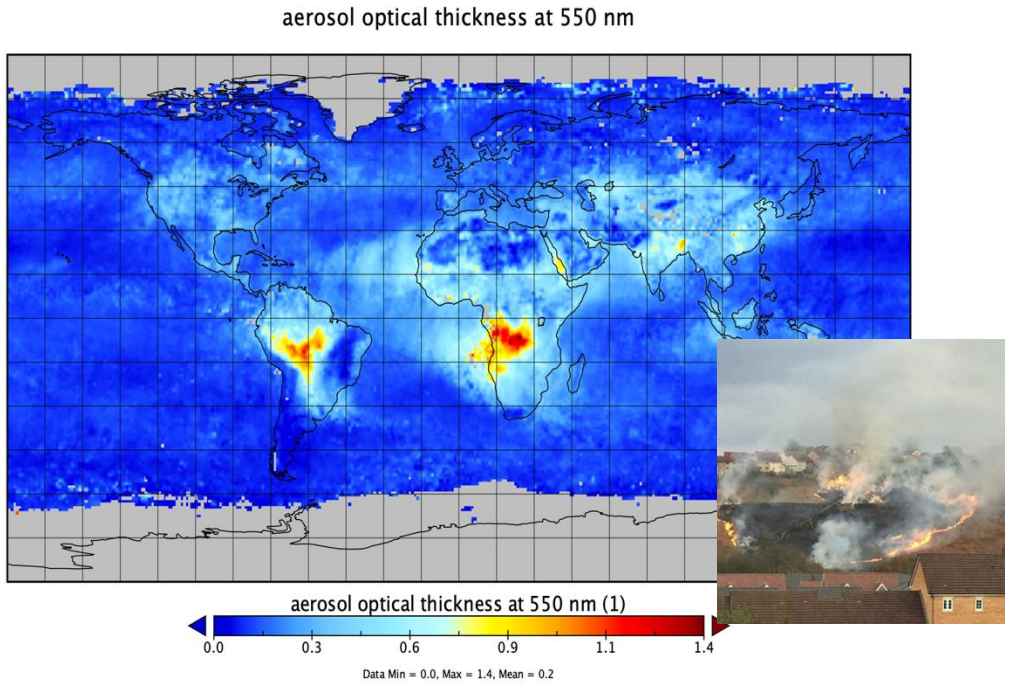




**Machine learning approach**

- Initial results promising ($r^2$ = 0.3-0.5)
- Application to further geographic regions
- Projection to CHUK grid, daily/monthly
- Potential for further inputs

# Long term records of atmospheric aerosol and particulate matter from Sentinel-3

1. **New climate datasets: ATSR-2 (1995-2003), AATSR (2002-2012), SLSTR 3A (2016-), S3B (2018 -)**
2. **Validation and inter sensor comparisons**
3. **Analysis of anomalies**
4. **Relation to surface PM2.5/PM10**
5. **Future challenges:**
   - Further improve quality, -> GCOS requirements
   - Improve FM AOD discrimination
   - Coverage in extreme plumes, polar regions




Data avail eocis.org, C3S

Prof. Peter North, Swansea University
Contact: p.r.j.north@swan.ac.uk