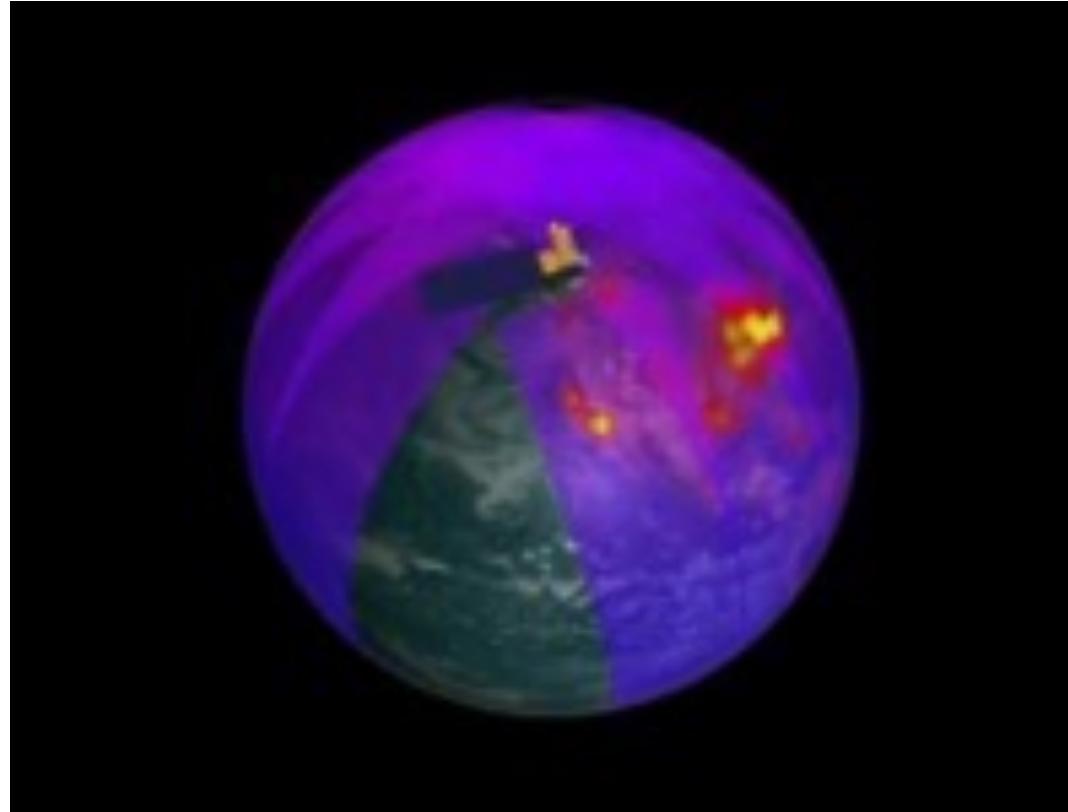


Space-based remote sensing of air quality

NERC London DTP Induction Week



Dr Eloise Marais

Associate Professor in Physical Geography, North West Wing, Room 109

e.marais@ucl.ac.uk

1 October 2021

UCL Atmospheric Composition and Air Quality Group

(<https://maraisresearchgroup.co.uk/>)



+ Bex
(1st yr PhD
student)



Karn



Rob



Kavitha



Gongda



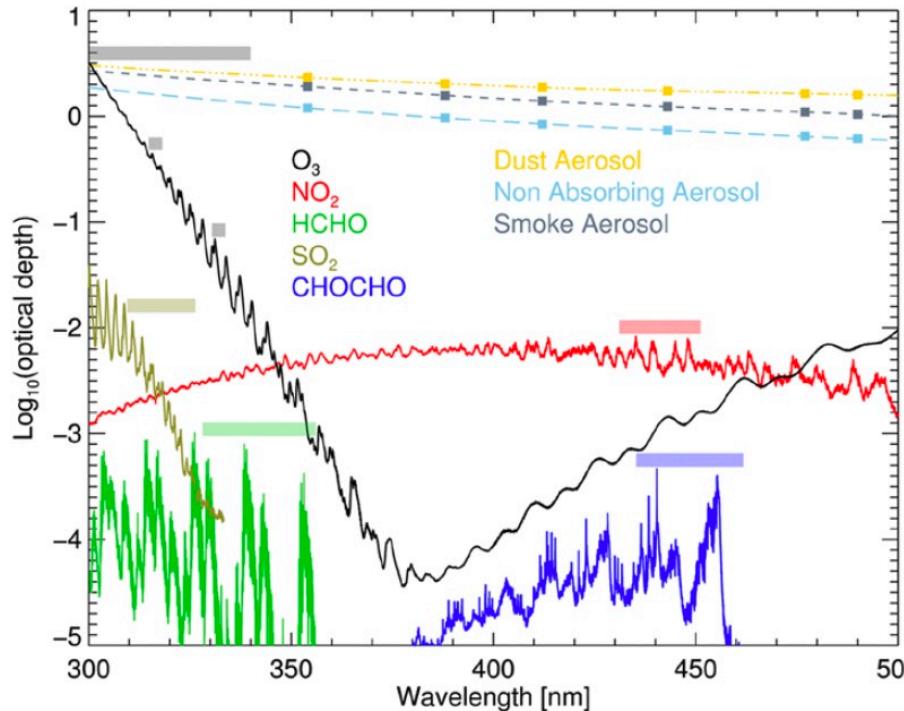
Nana



Jamie

Absorption spectra of air pollutants measured from space

UV-visible

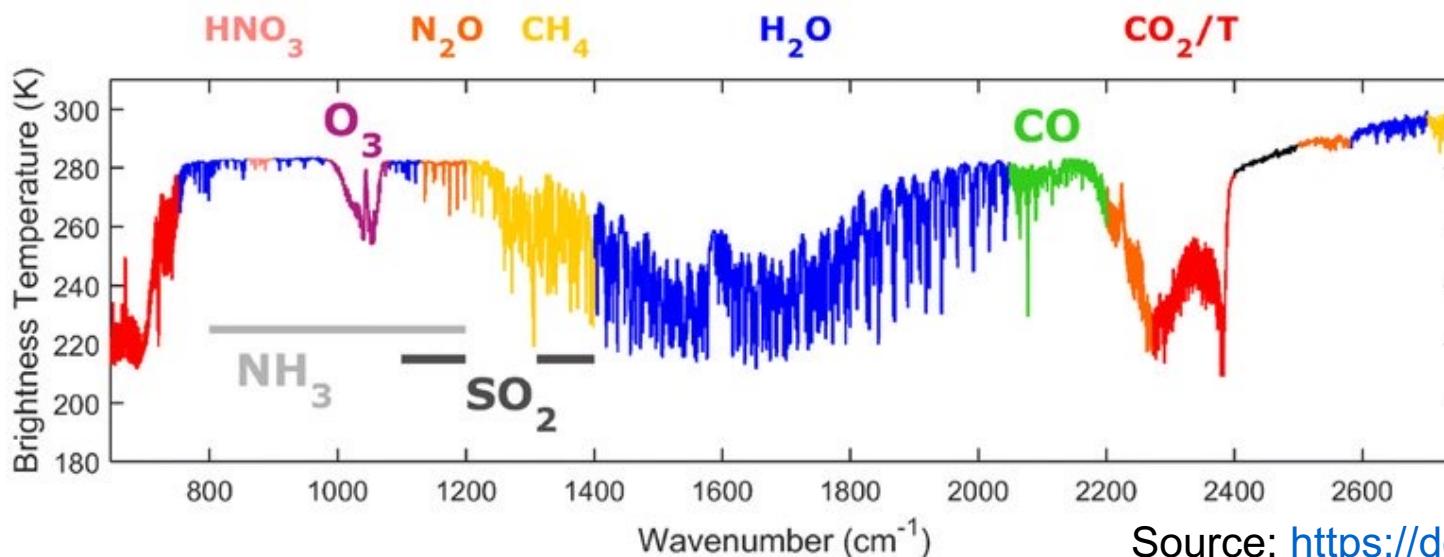


Nitrogen dioxide (NO₂)
Formaldehyde (HCHO)
Glyoxal (CHOCHO)
Sulfur dioxide (SO₂)
Ozone (O₃)

Also Aerosol Optical Depth (AOD)

Source: <https://doi.org/10.1175/BAMS-D-18-0013.1>

Infrared (IR)



Source: <https://doi.org/10.1111/12.2584500>

Spectrometers in the Lab



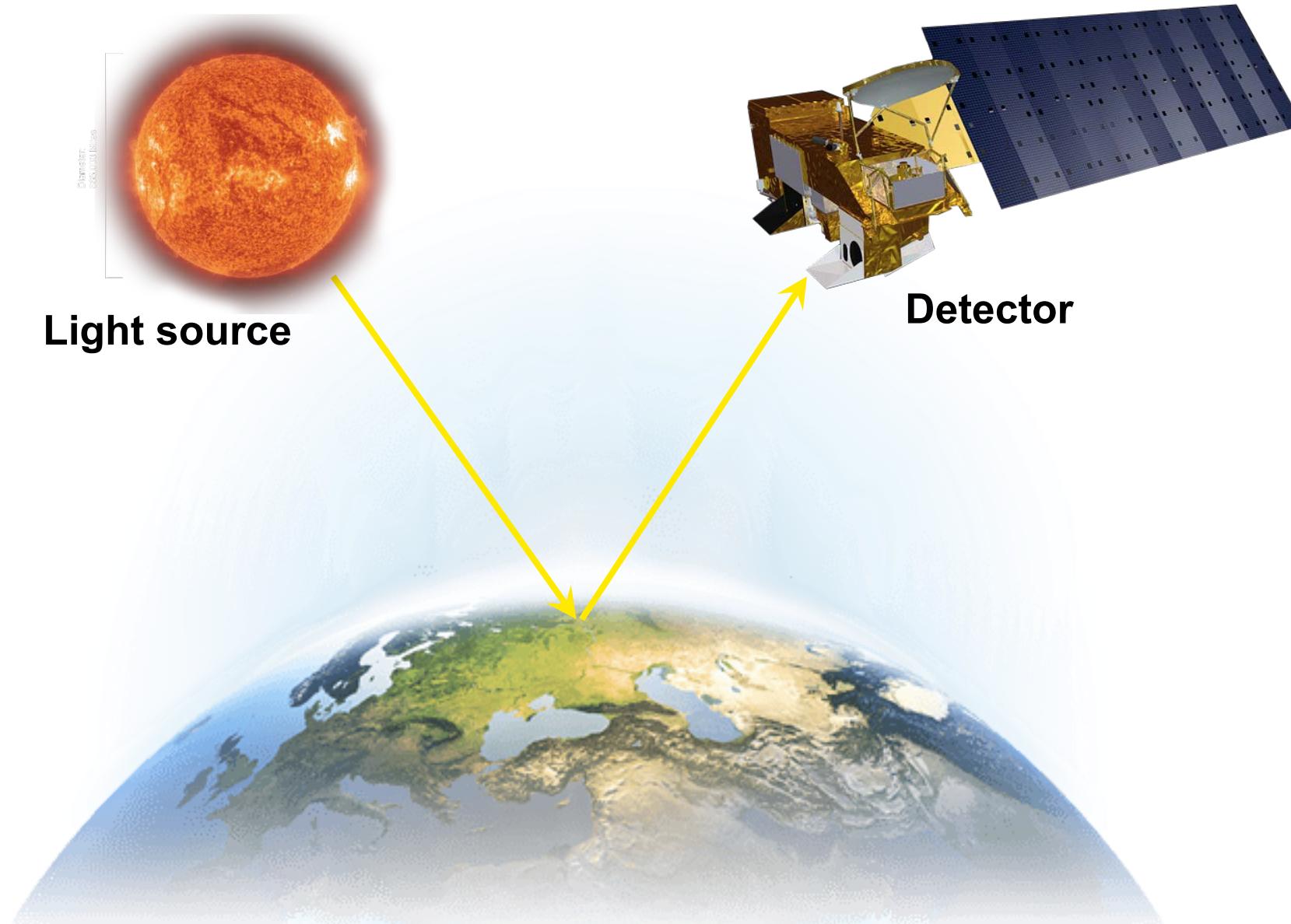
Spectrometers in Space



Spectrometers in Space



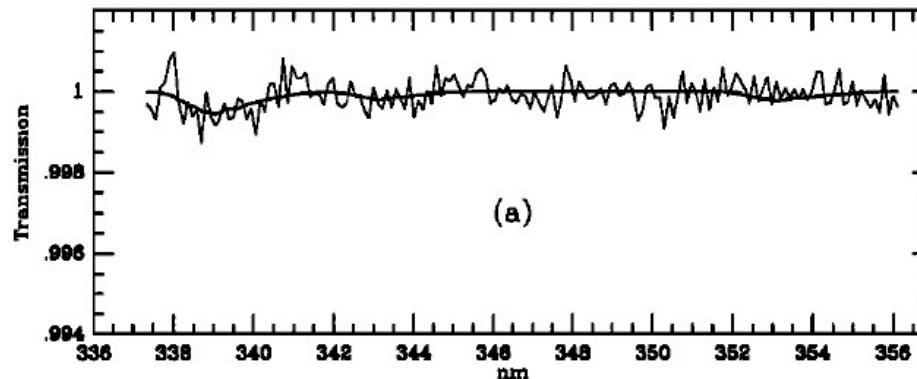
UV-visible Spectrometers in Space



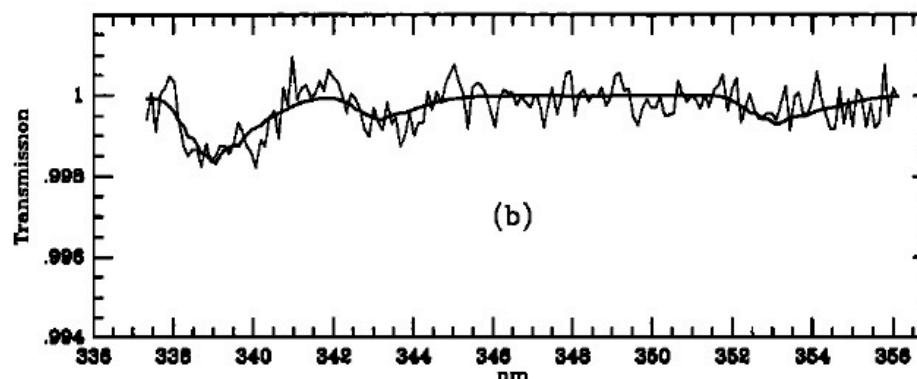
Spectral Fit

Formaldehyde (HCHO):

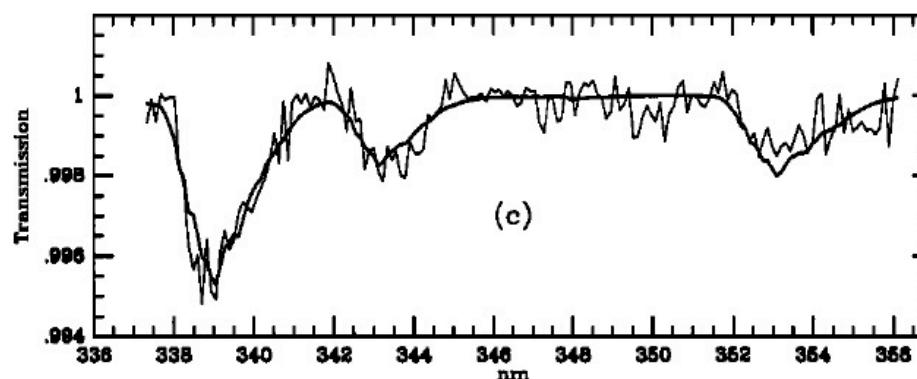
Prompt, high-yield oxidation product of non-methane volatile organic compounds



1.0×10^{16} molecules HCHO cm⁻²



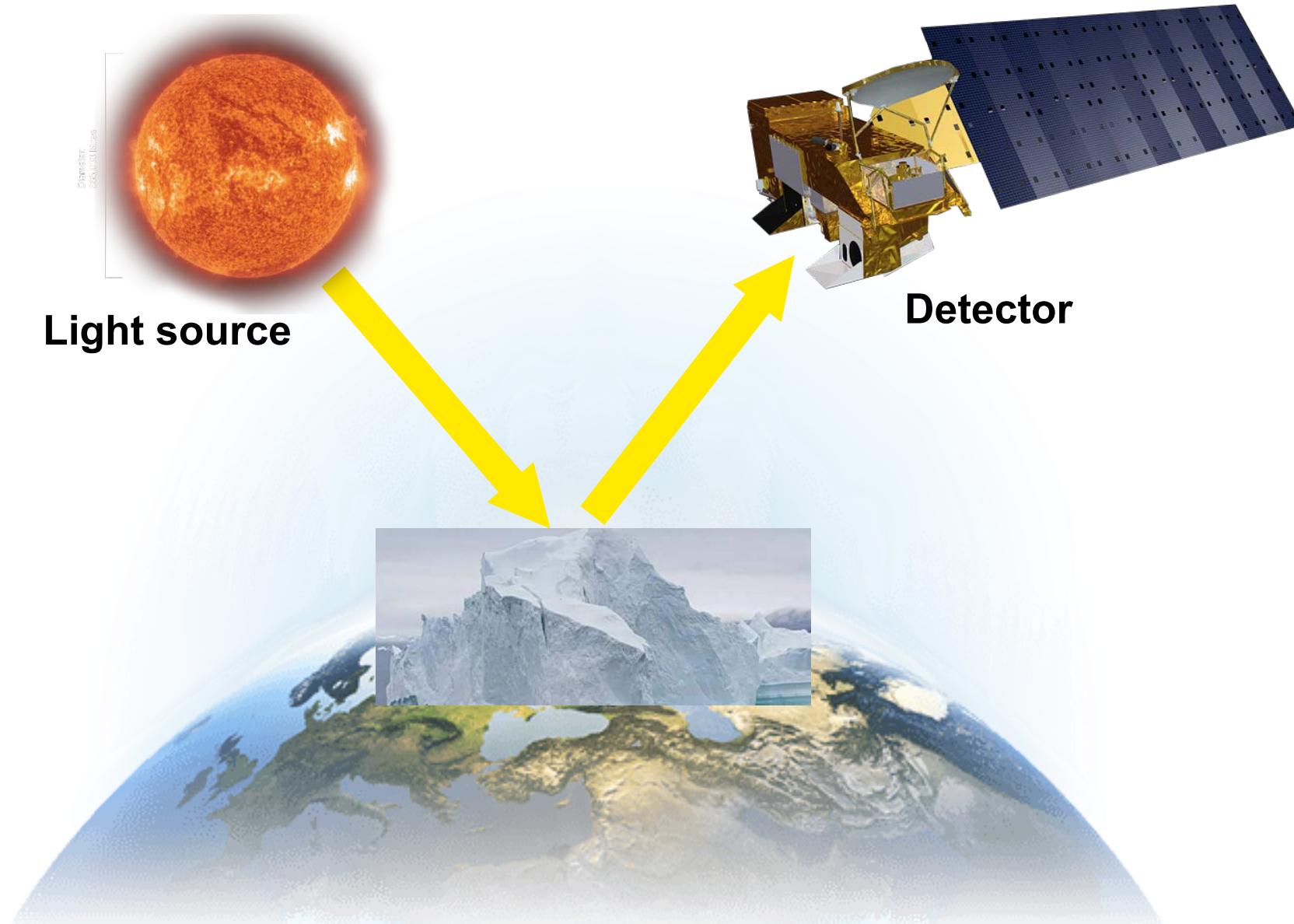
3.0×10^{16} molecules HCHO cm⁻²



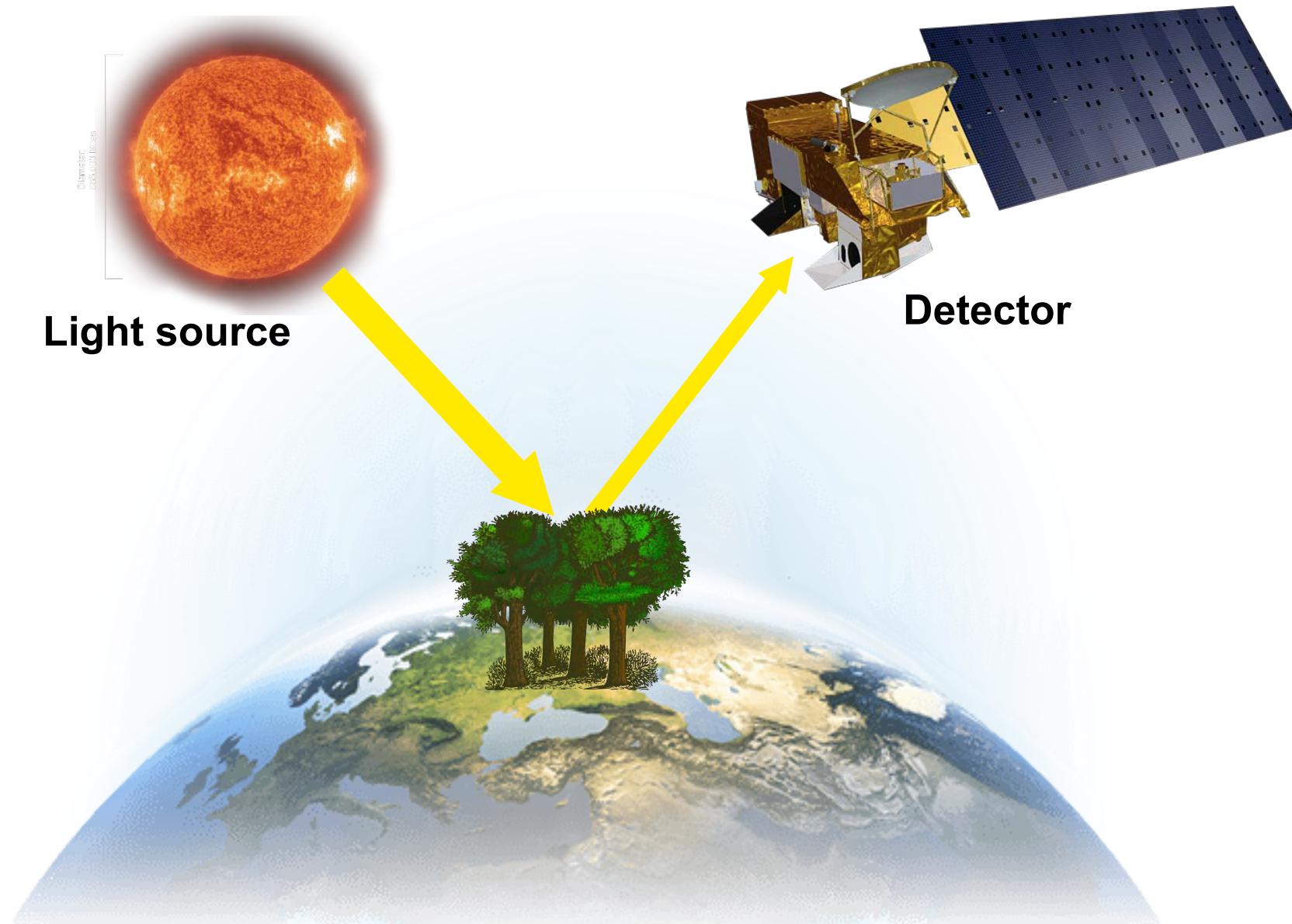
8.4×10^{16} molecules HCHO cm⁻²

Source: Chance et al. 2000,
<https://doi.org/10.1029/2000GL011857>

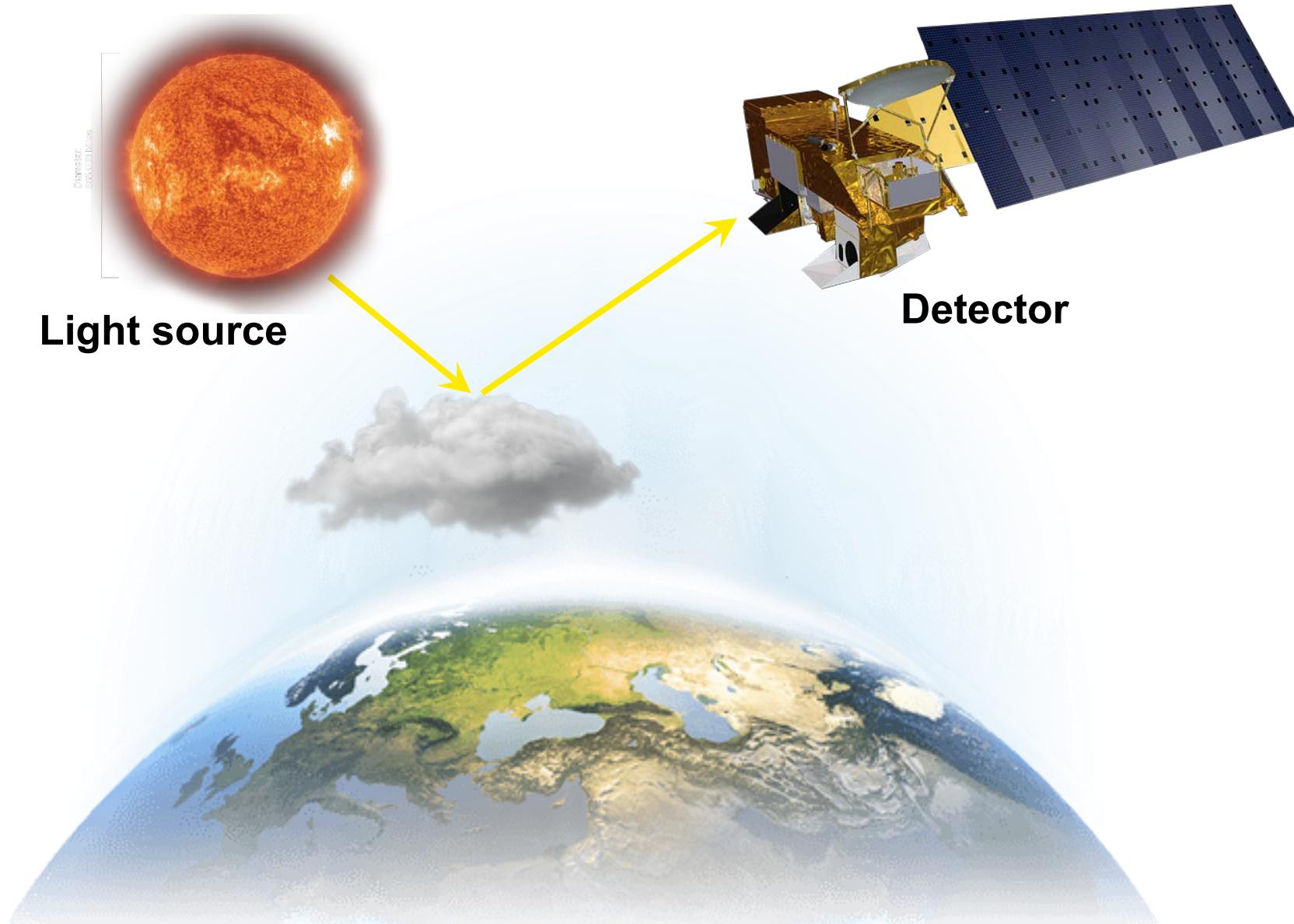
Surface Reflectivity



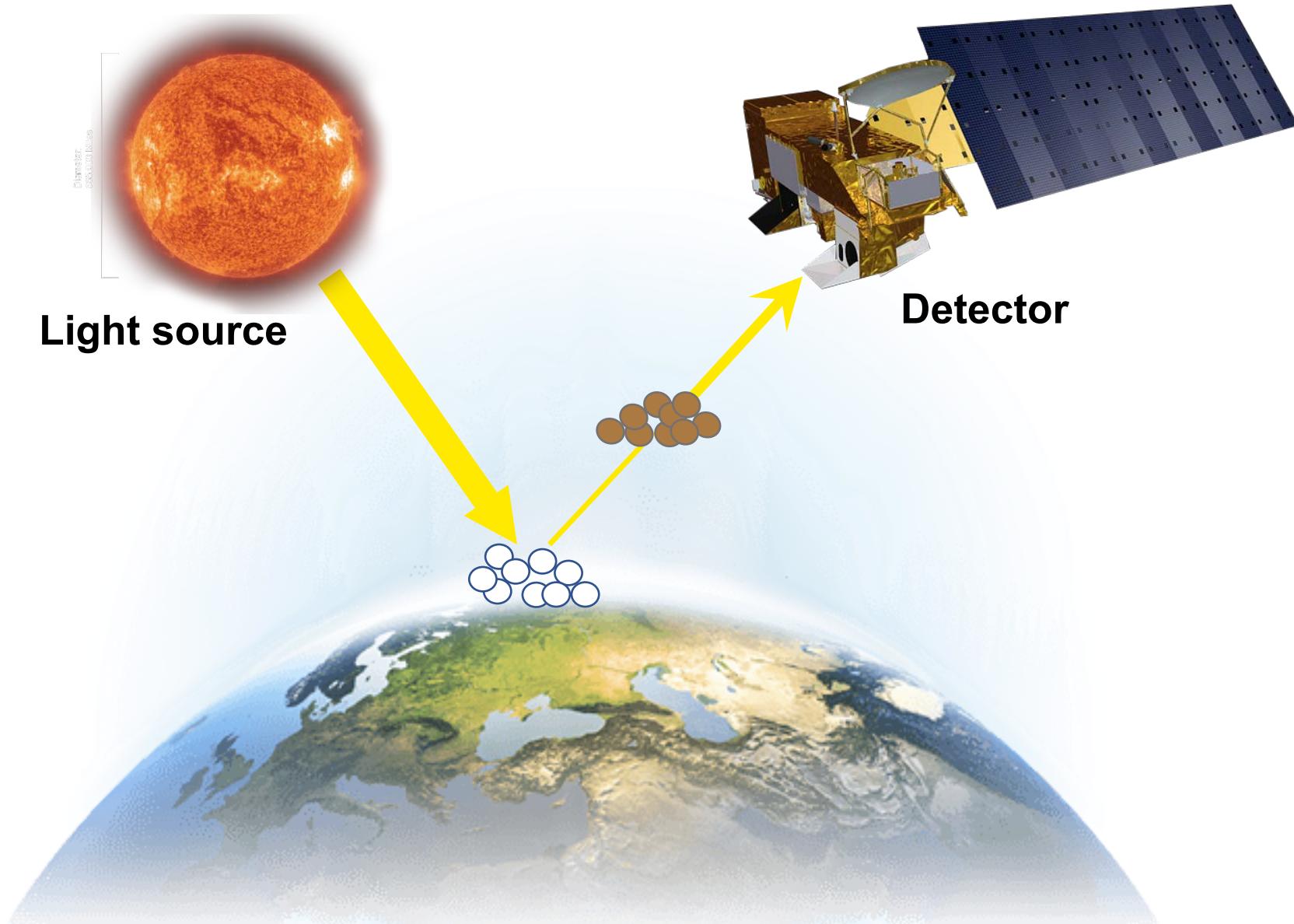
Surface Reflectivity



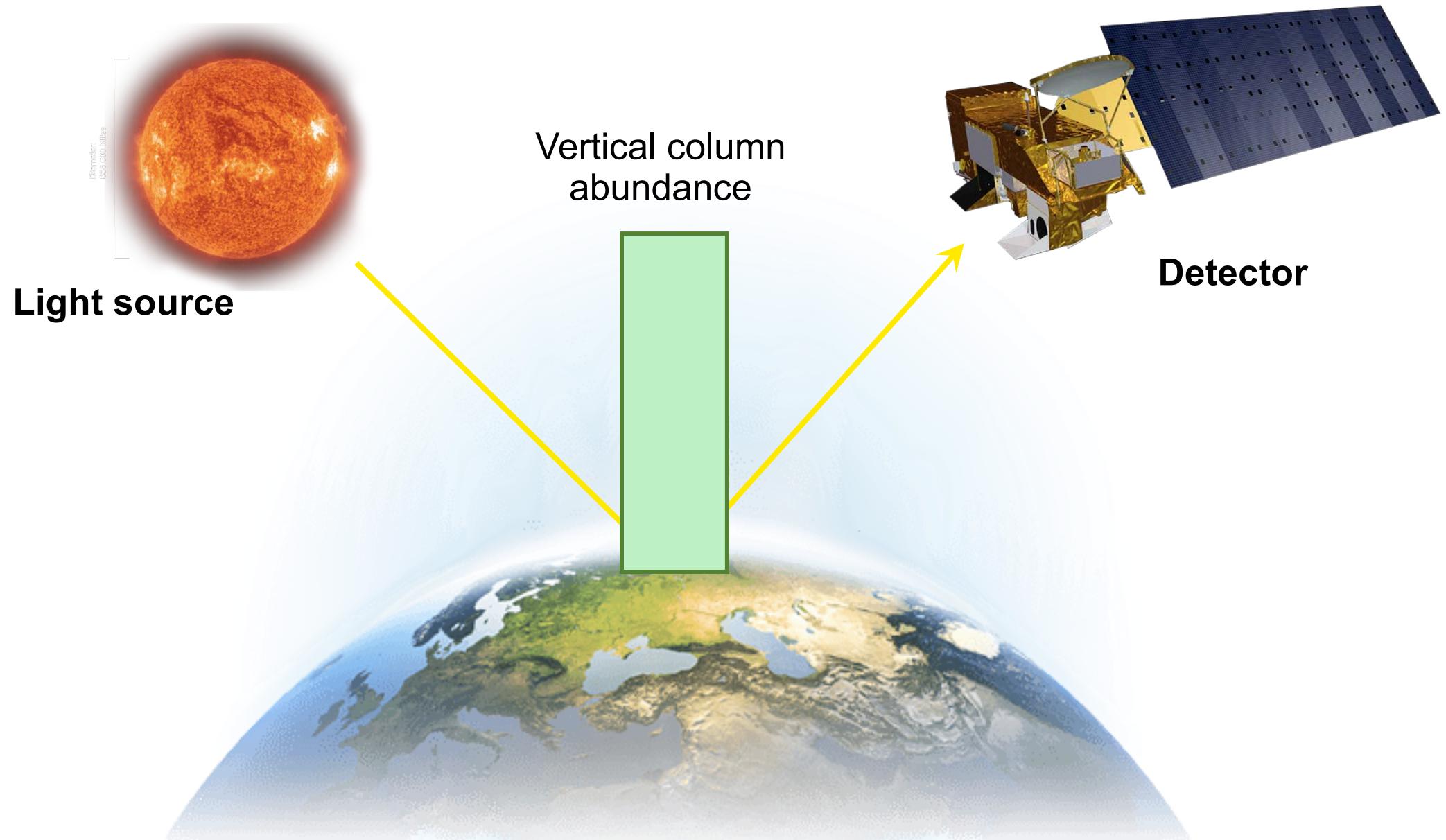
Clouds

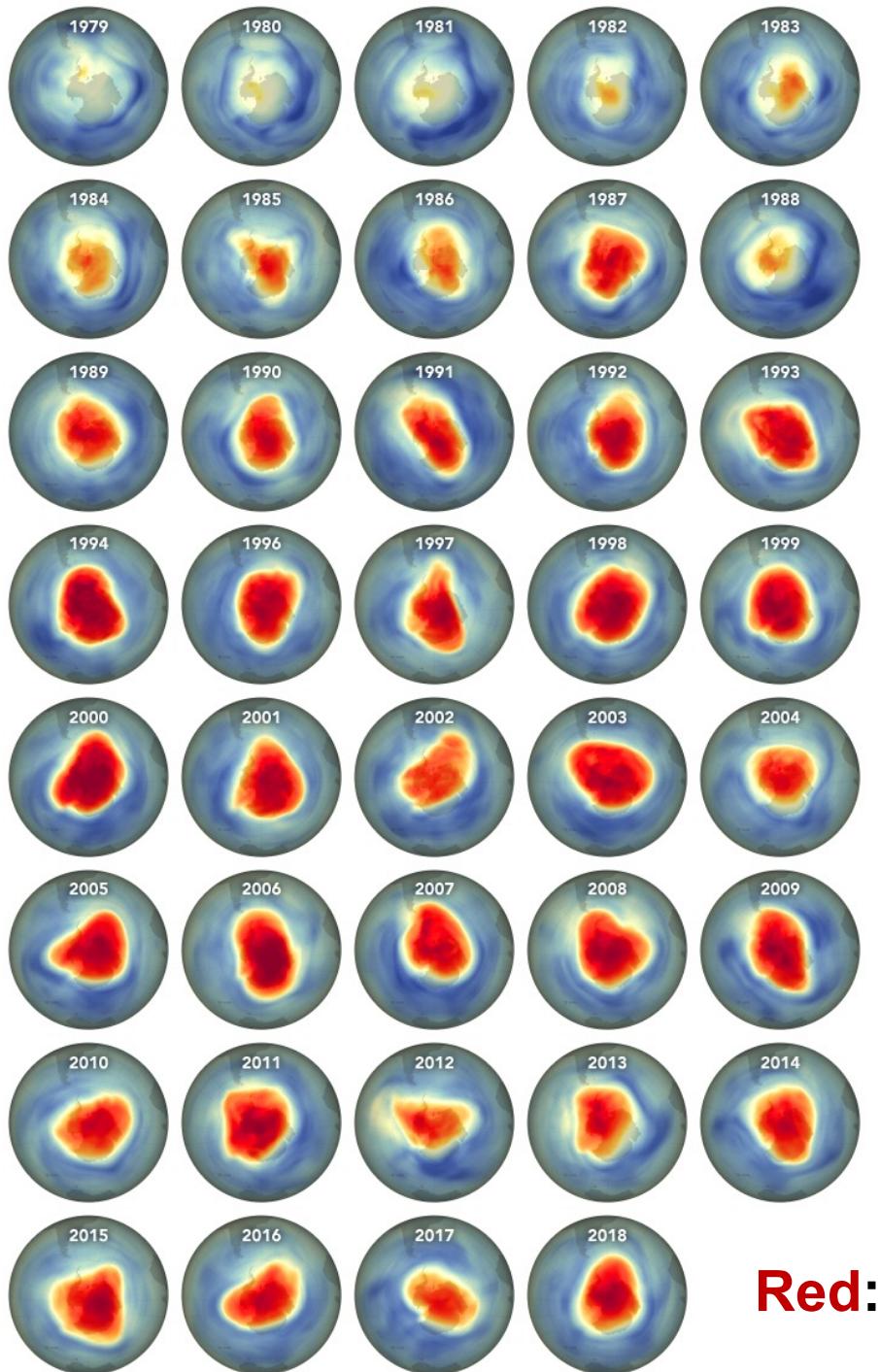


Aerosols



“True” Vertical Column





The hole in the ozone layer



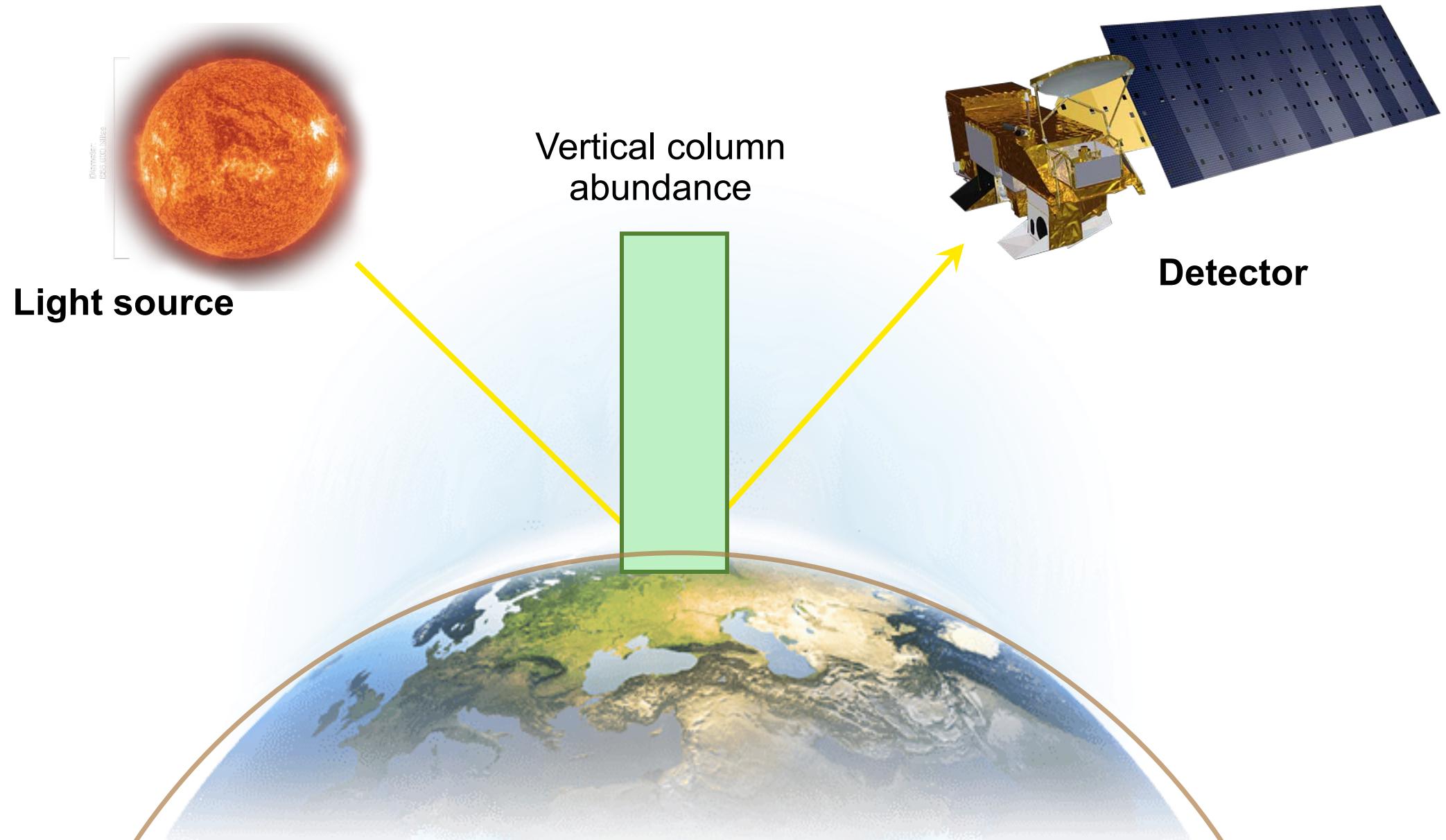
$$1 \text{ DU} = 2.69 \times 10^{16} \text{ molecules ozone cm}^{-2}$$



[Source: <https://eoimages.gsfc.nasa.gov/>]

Red: large ozone depletion

“True” Vertical Column



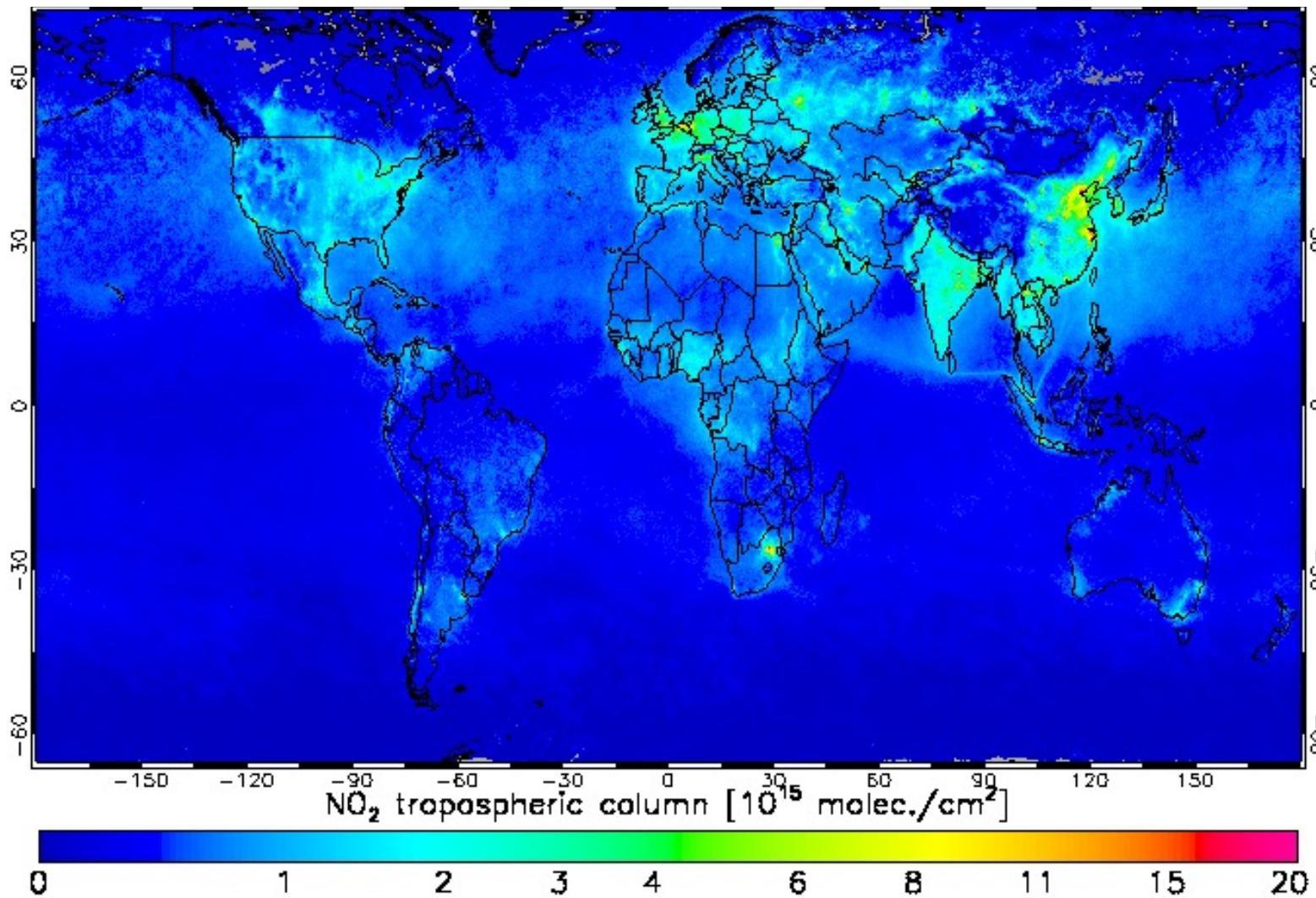
Air quality from surface monitors



[Source: <https://aqicn.org/map/world/>]

Air quality from space-based instruments

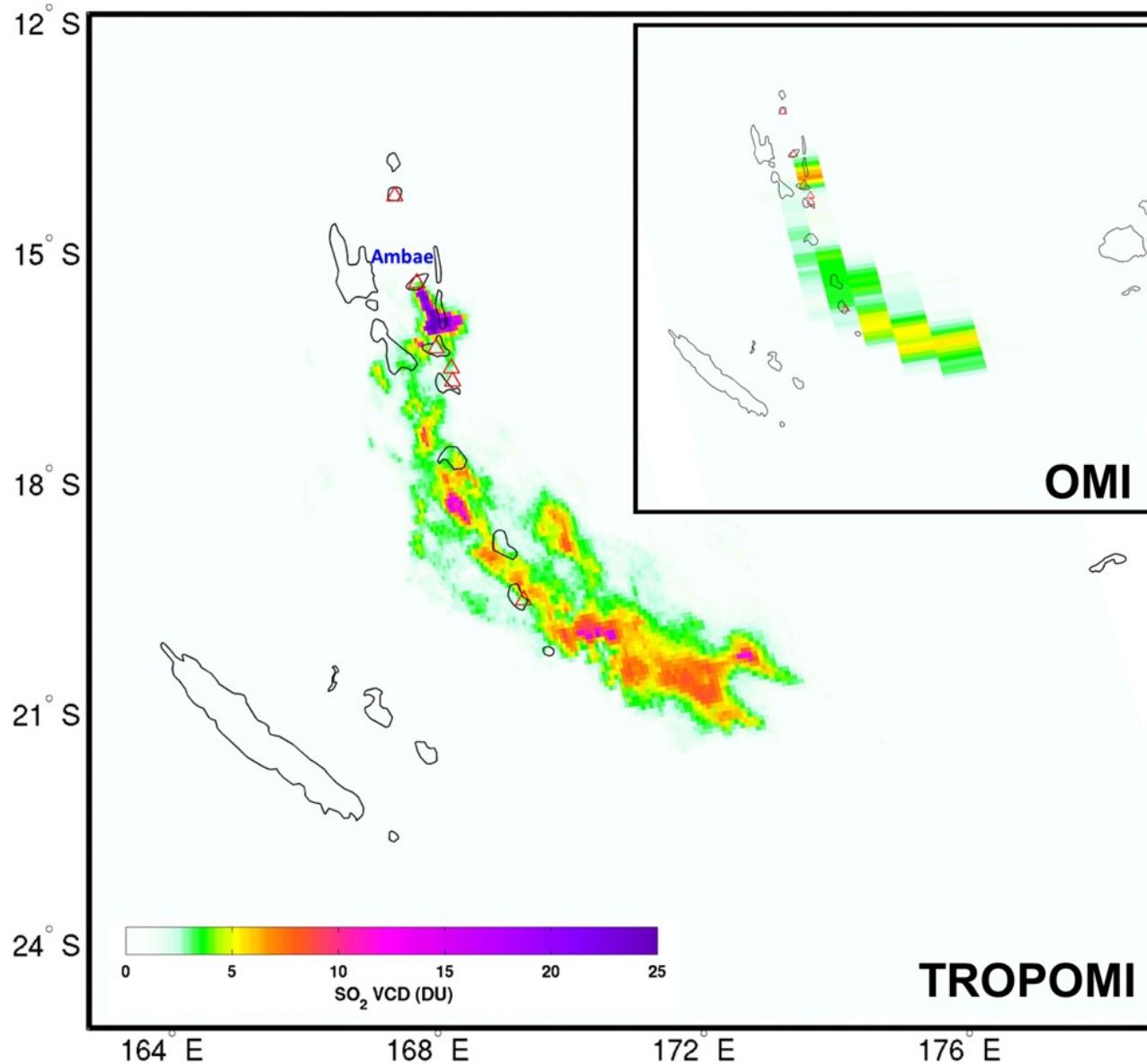
Vertical column density of nitrogen dioxide (NO_2)



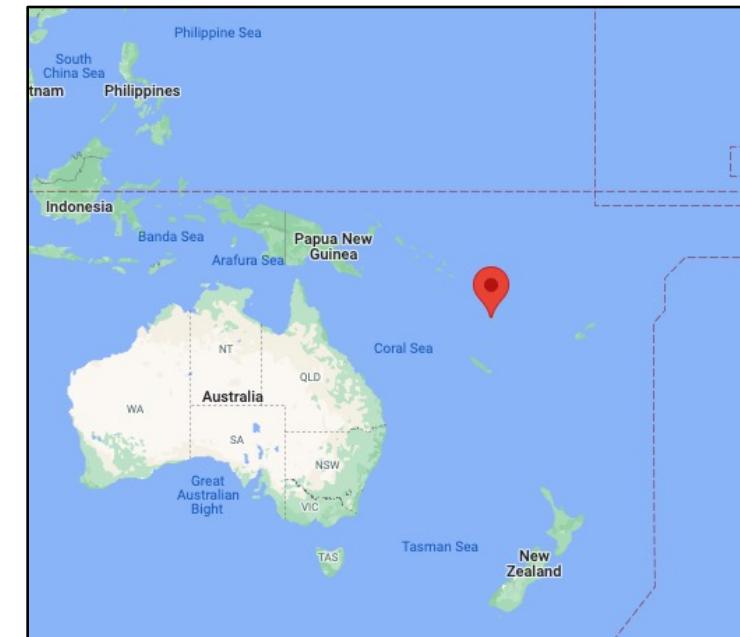
[Source: <https://www.temis.nl/airpollution/no2.php>]

Air quality from space-based instruments

SO₂ from Ambae volcano on 21 November 2017



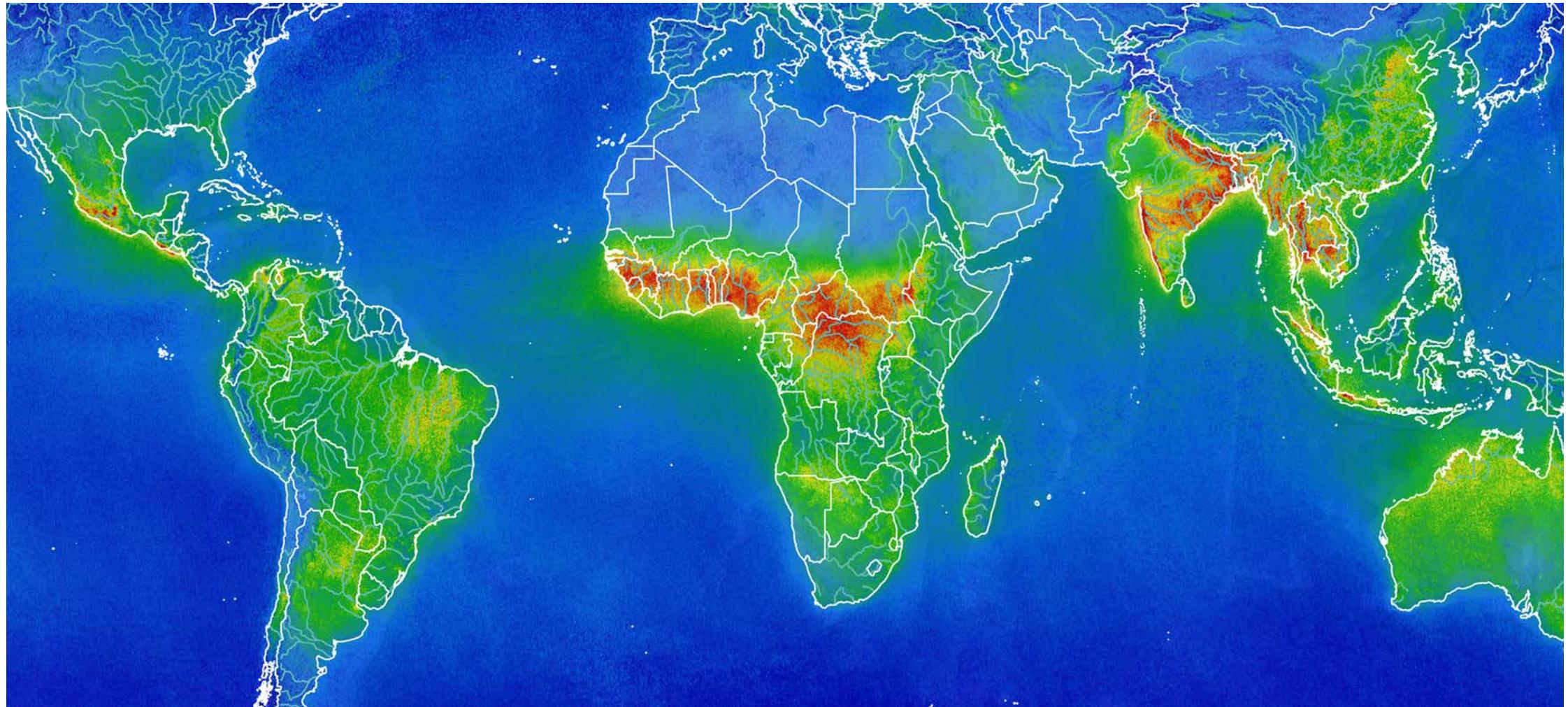
Vanuatu



[Source:
<https://www.nature.com/articles/s41598-019-39279-y>]

Air quality from space-based instruments

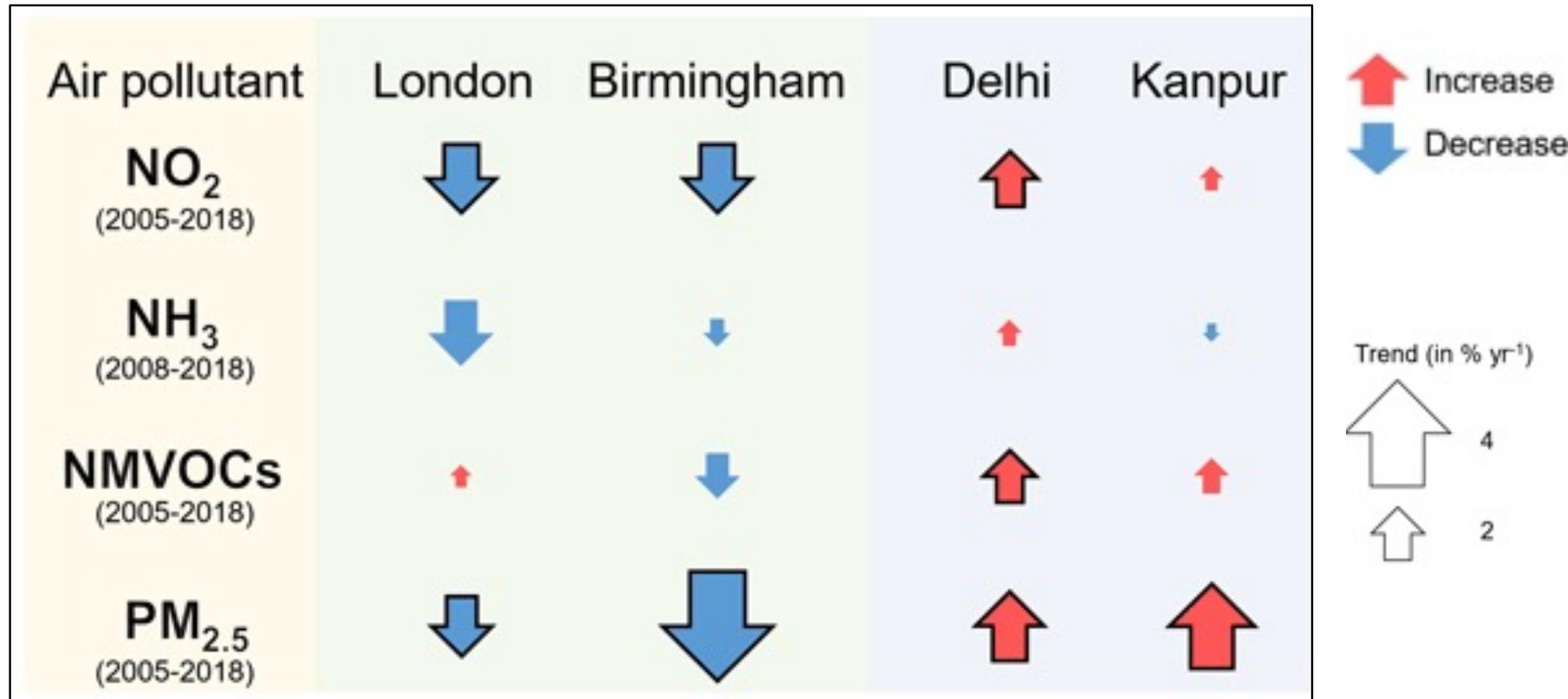
Vertical column density of formaldehyde (HCHO)



[Source: <https://uv-vis.aeronomie.be/>]

Air quality trends from space

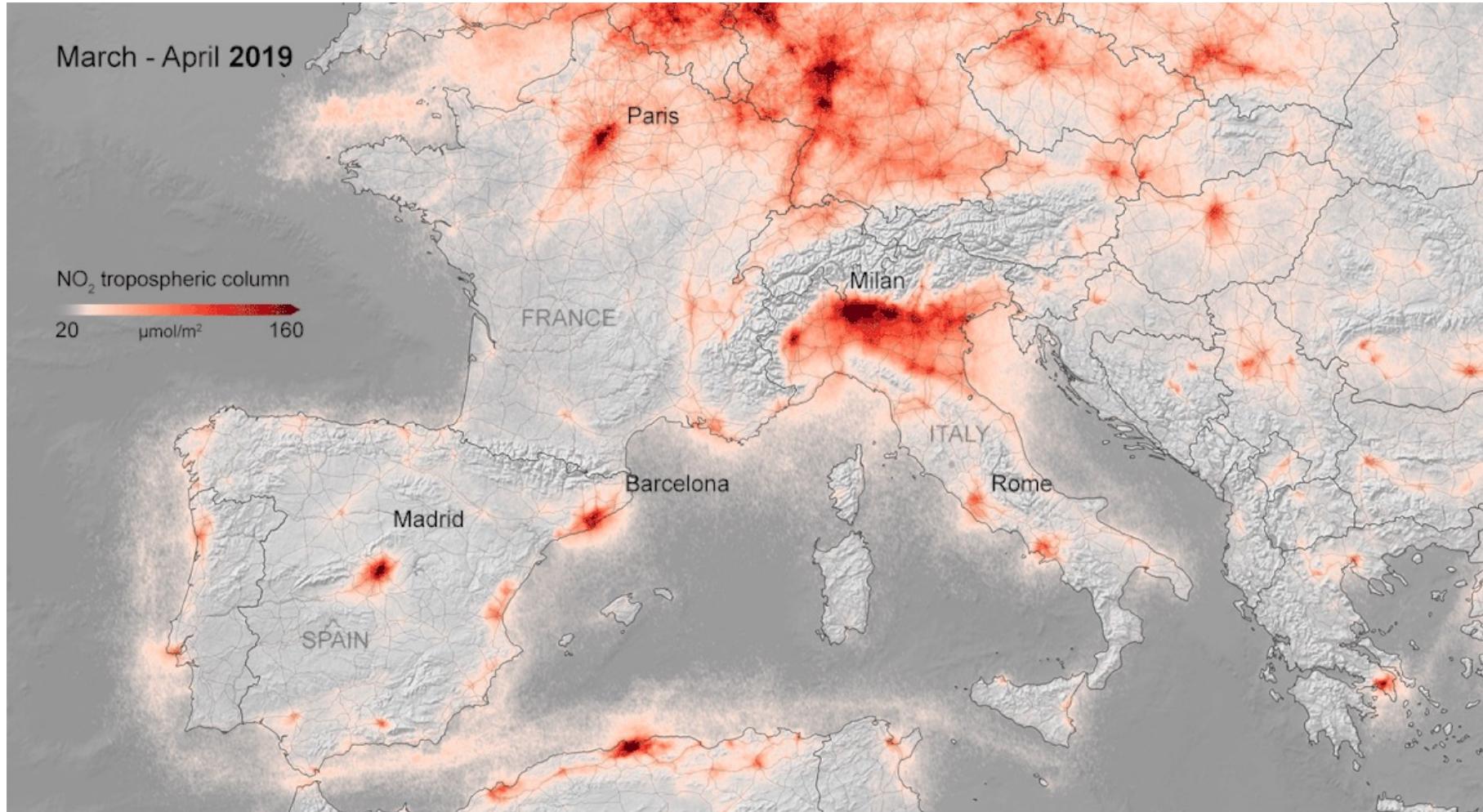
Trends in cities with (UK) and without (India) well-established policies



[Source: Vohra et al., 2021, <https://doi.org/10.5194/acp-21-6275-2021>]

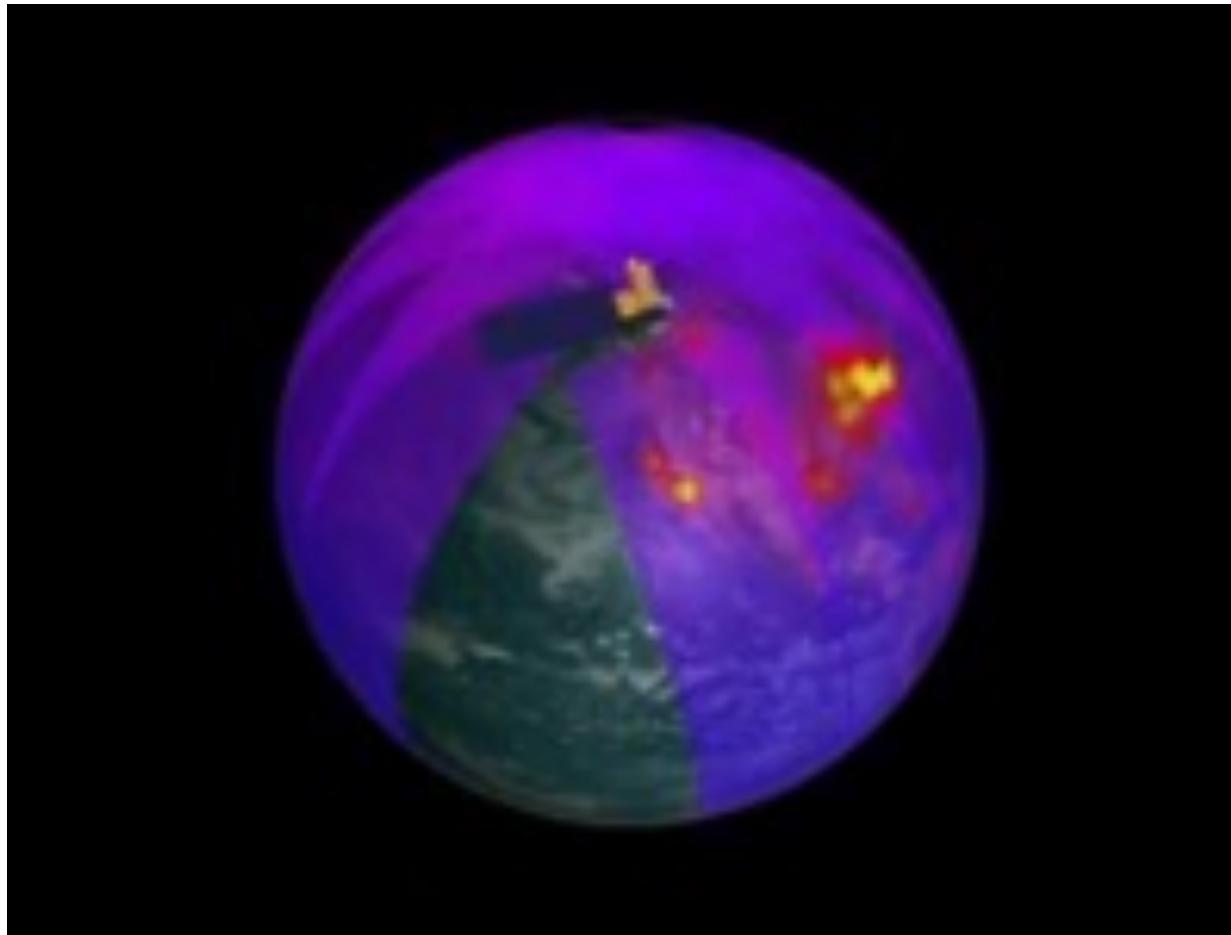
Air quality trends from space

Impact of COVID-19 lockdowns on air quality



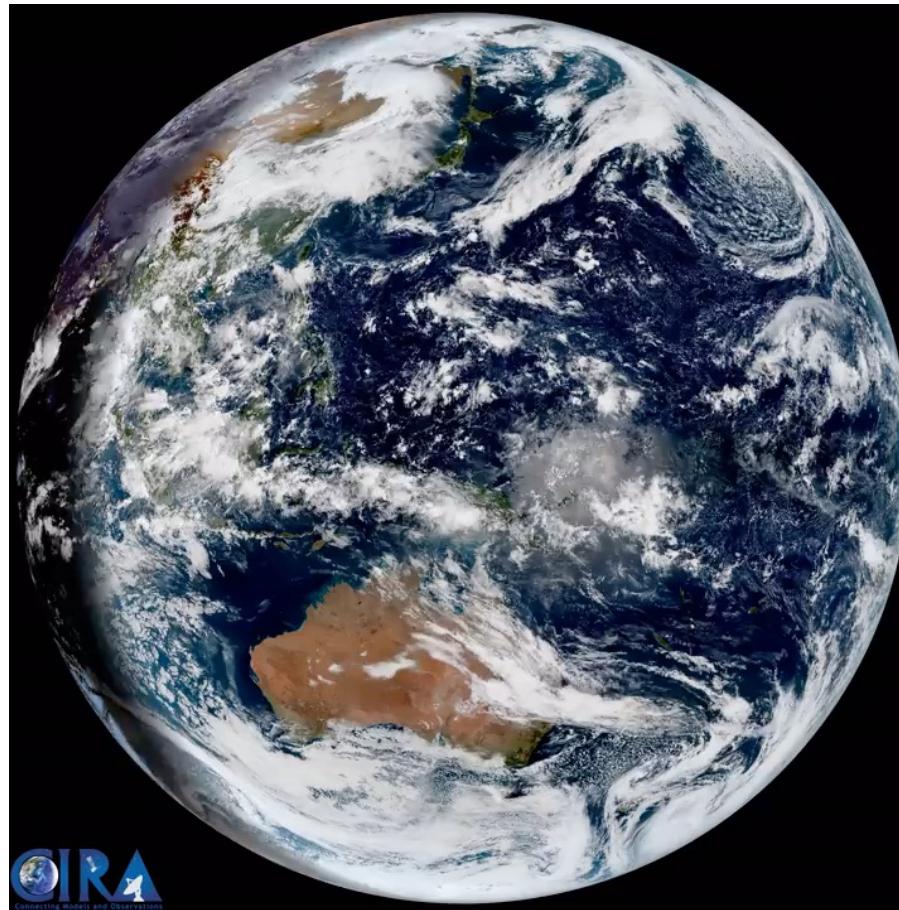
[Source: ESA]

Low-Earth Orbiting Satellites



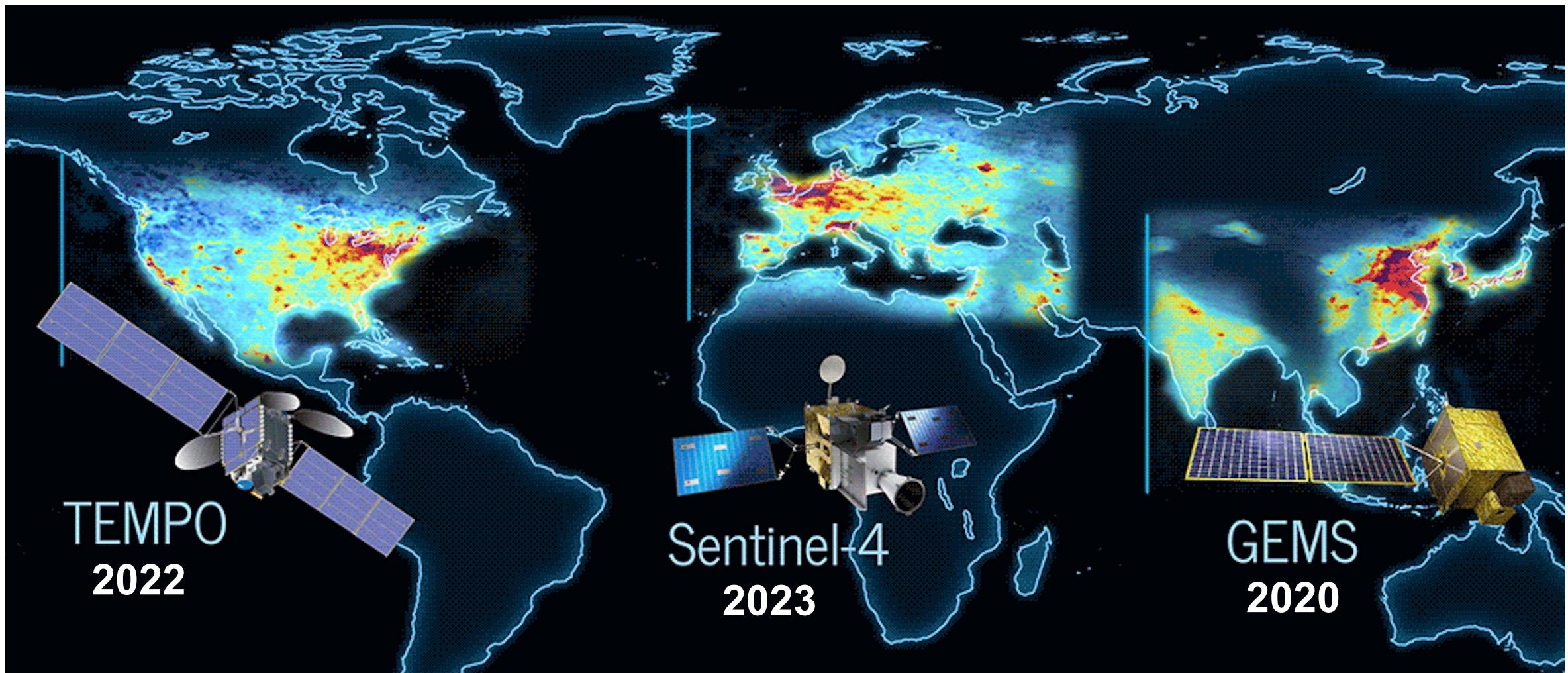
One observation per day. Typically global coverage

Geostationary Satellites



Multiple observations per day (~hourly) over limited domain

The Dawn of the Geostationary Observing Network



Lots on the Horizon

