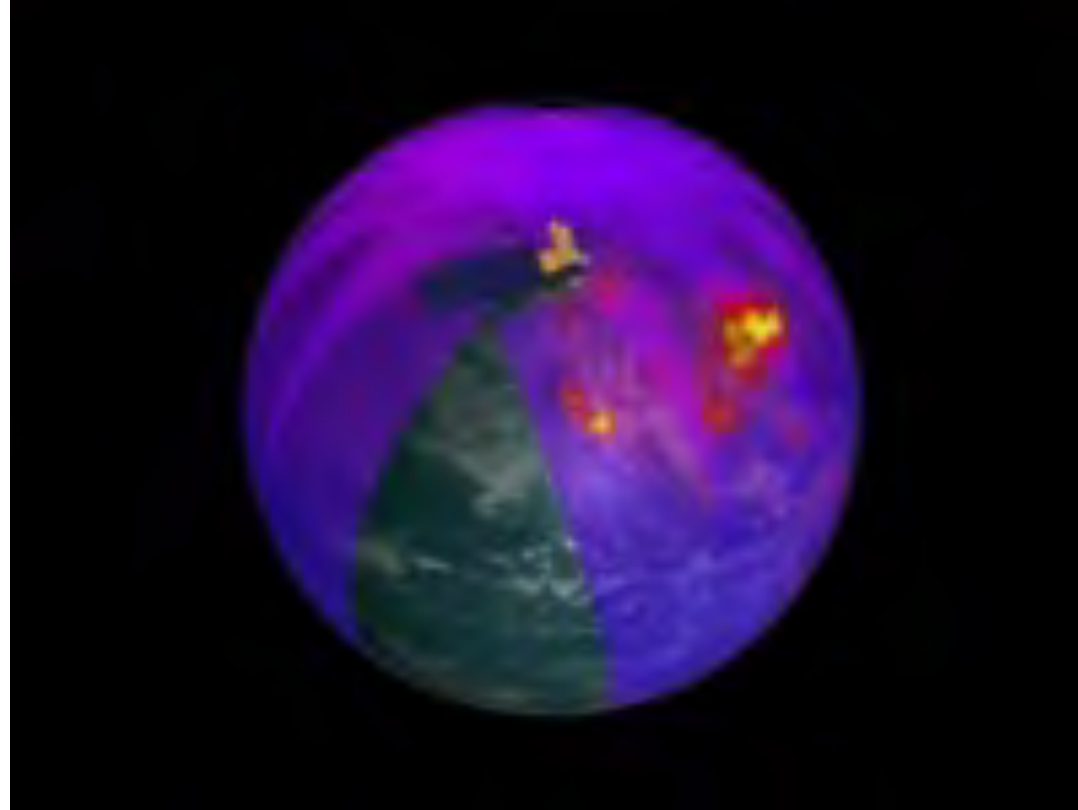


# Space-based remote sensing of air quality

NERC London DTP Induction Week



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1 October 2021

# UCL Atmospheric Composition and Air Quality Group

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



+ Bex  
(1<sup>st</sup> yr PhD  
student)



Karn



Rob



Kavitha



Gongda



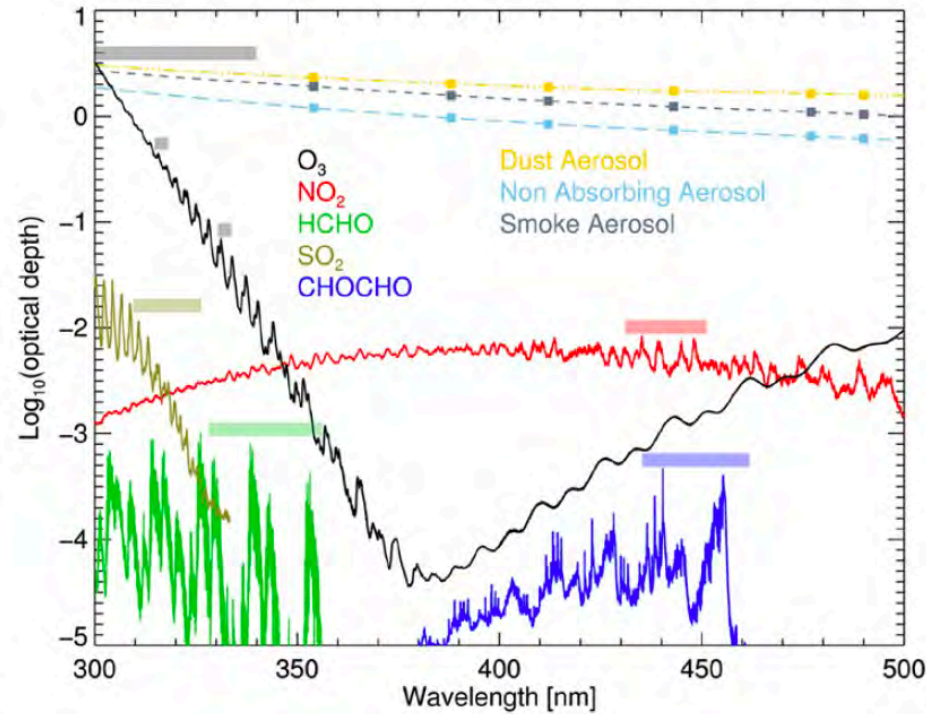
Nana



Jamie

# Absorption spectra of air pollutants measured from space

UV-visible

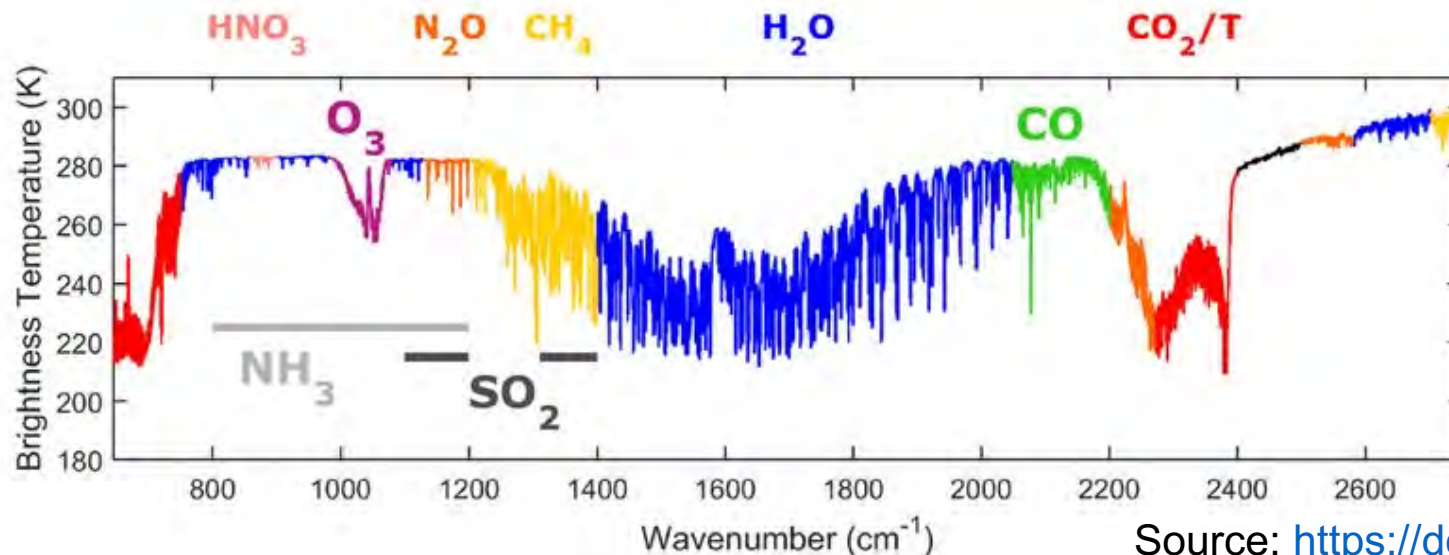


Nitrogen dioxide (NO<sub>2</sub>)  
Formaldehyde (HCHO)  
Glyoxal (CHOCHO)  
Sulfur dioxide (SO<sub>2</sub>)  
Ozone (O<sub>3</sub>)

Also Aerosol Optical  
Depth (AOD)

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

Infrared (IR)



Source: <https://doi.org/10.1117/12.2584500>



# Spectrometers in the Lab



# Spectrometers in Space

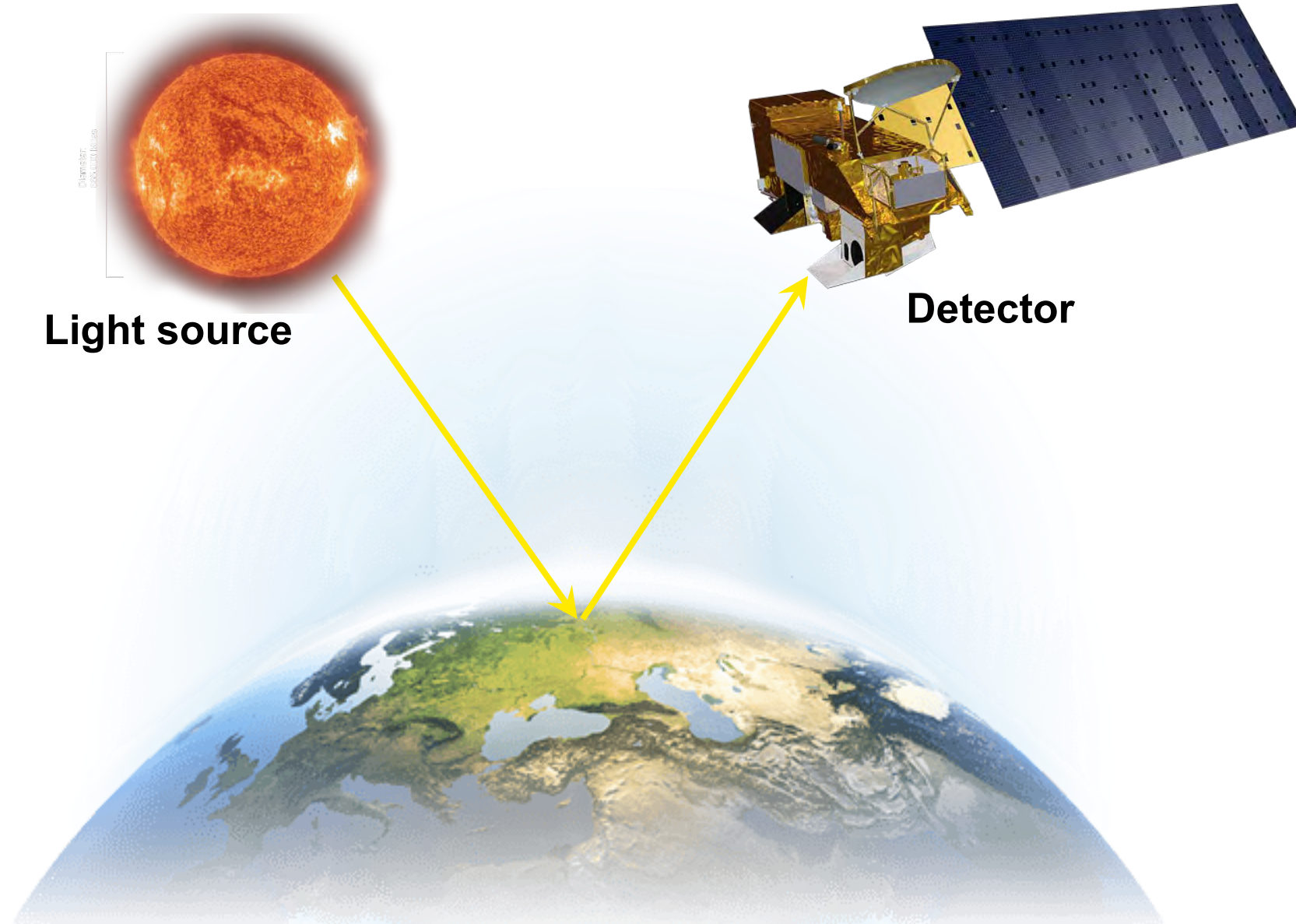




# Spectrometers in Space



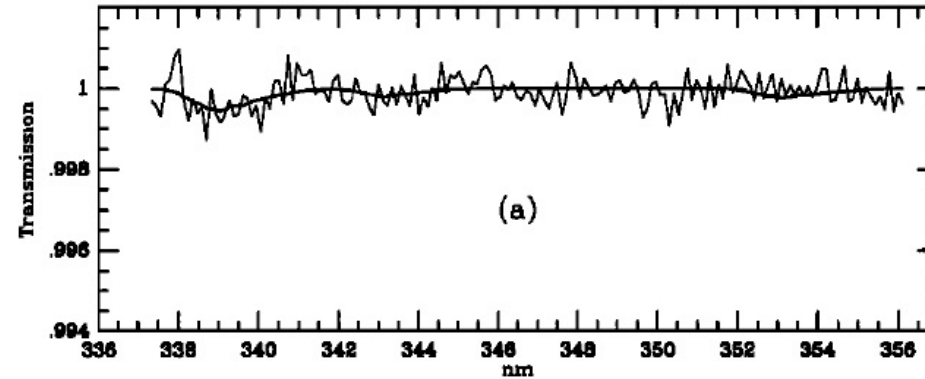
# UV-visible Spectrometers in Space



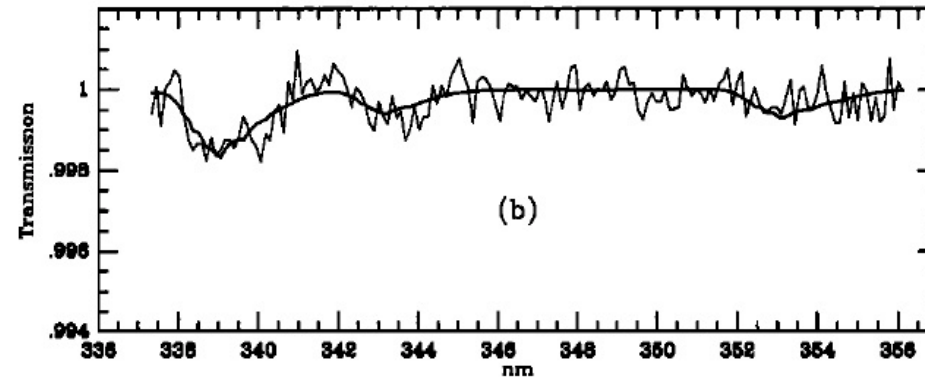
# Spectral Fit

## Formaldehyde (HCHO):

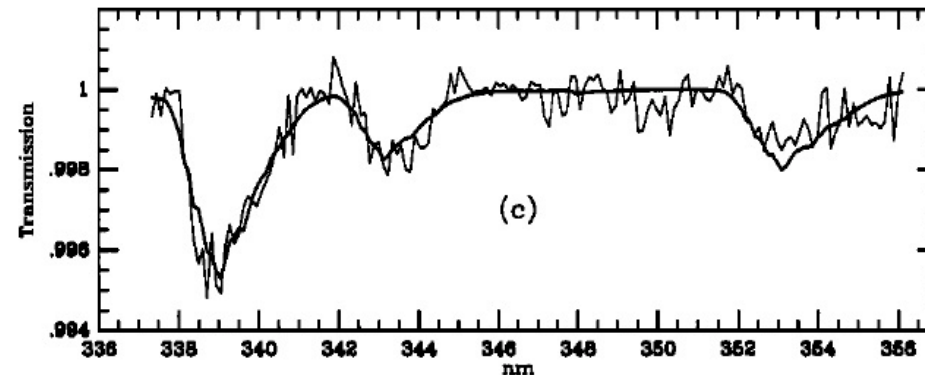
Prompt, high-yield oxidation product of non-methane volatile organic compounds



$1.0 \times 10^{16}$  molecules HCHO cm<sup>-2</sup>



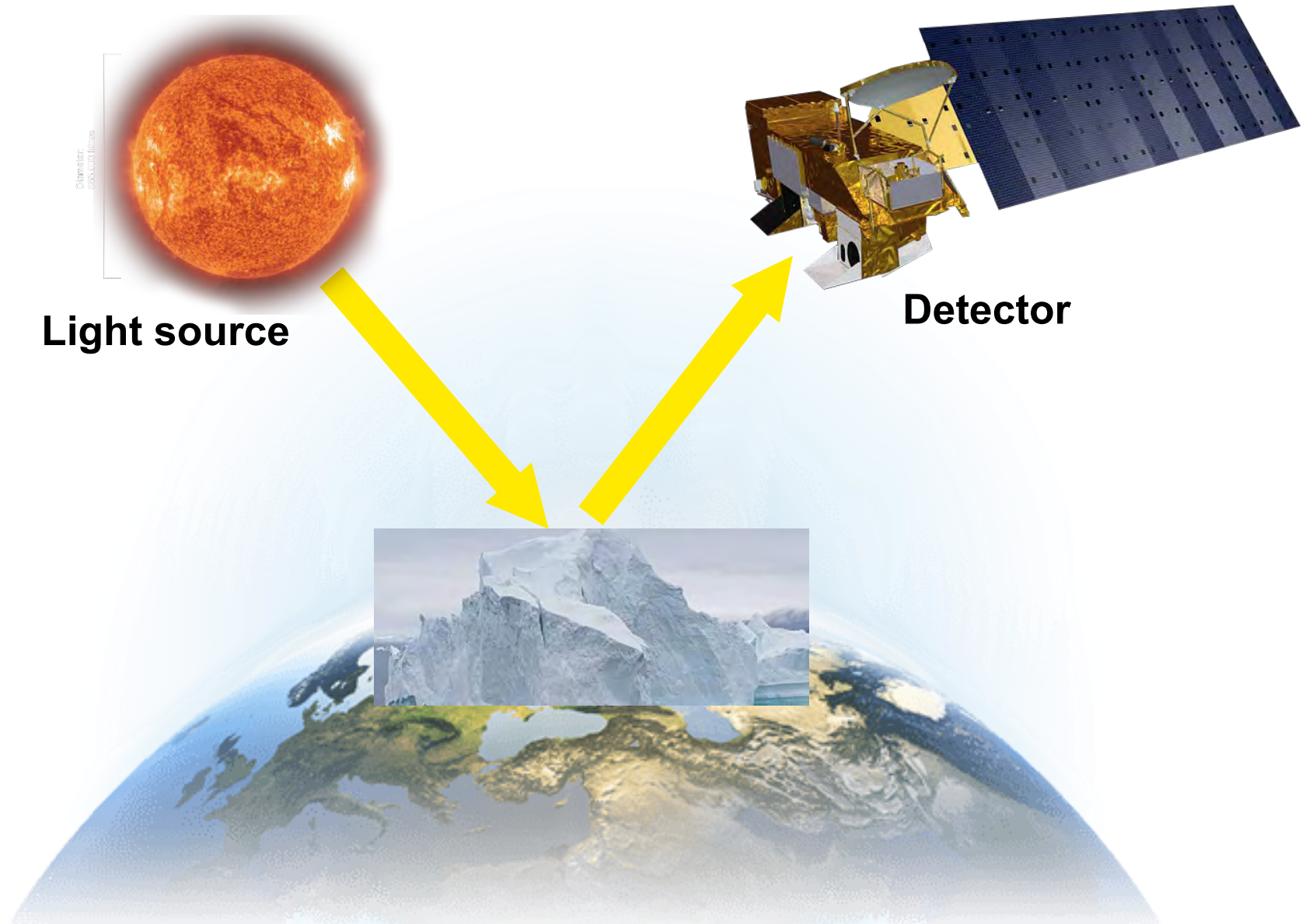
$3.0 \times 10^{16}$  molecules HCHO cm<sup>-2</sup>



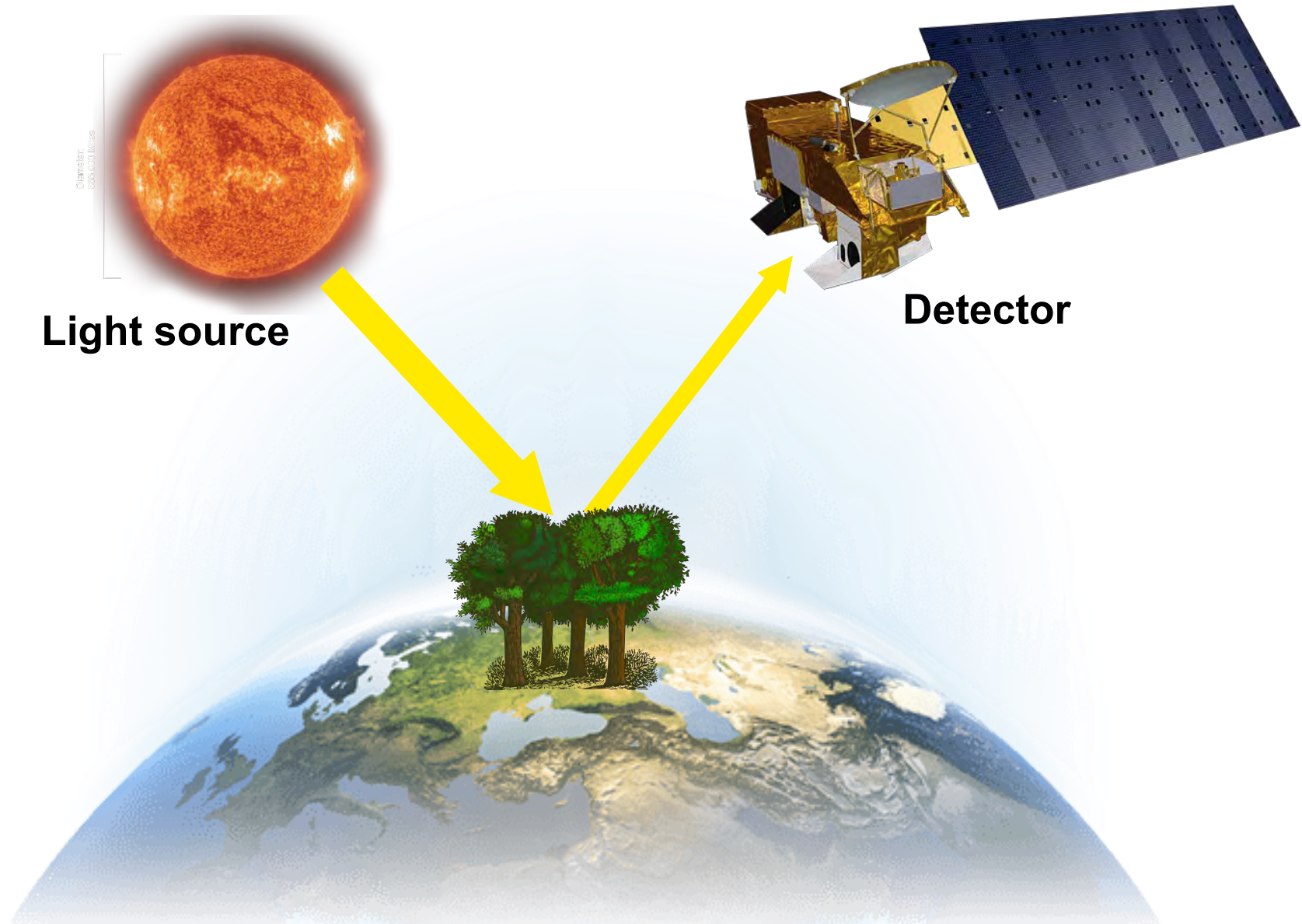
$8.4 \times 10^{16}$  molecules HCHO cm<sup>-2</sup>



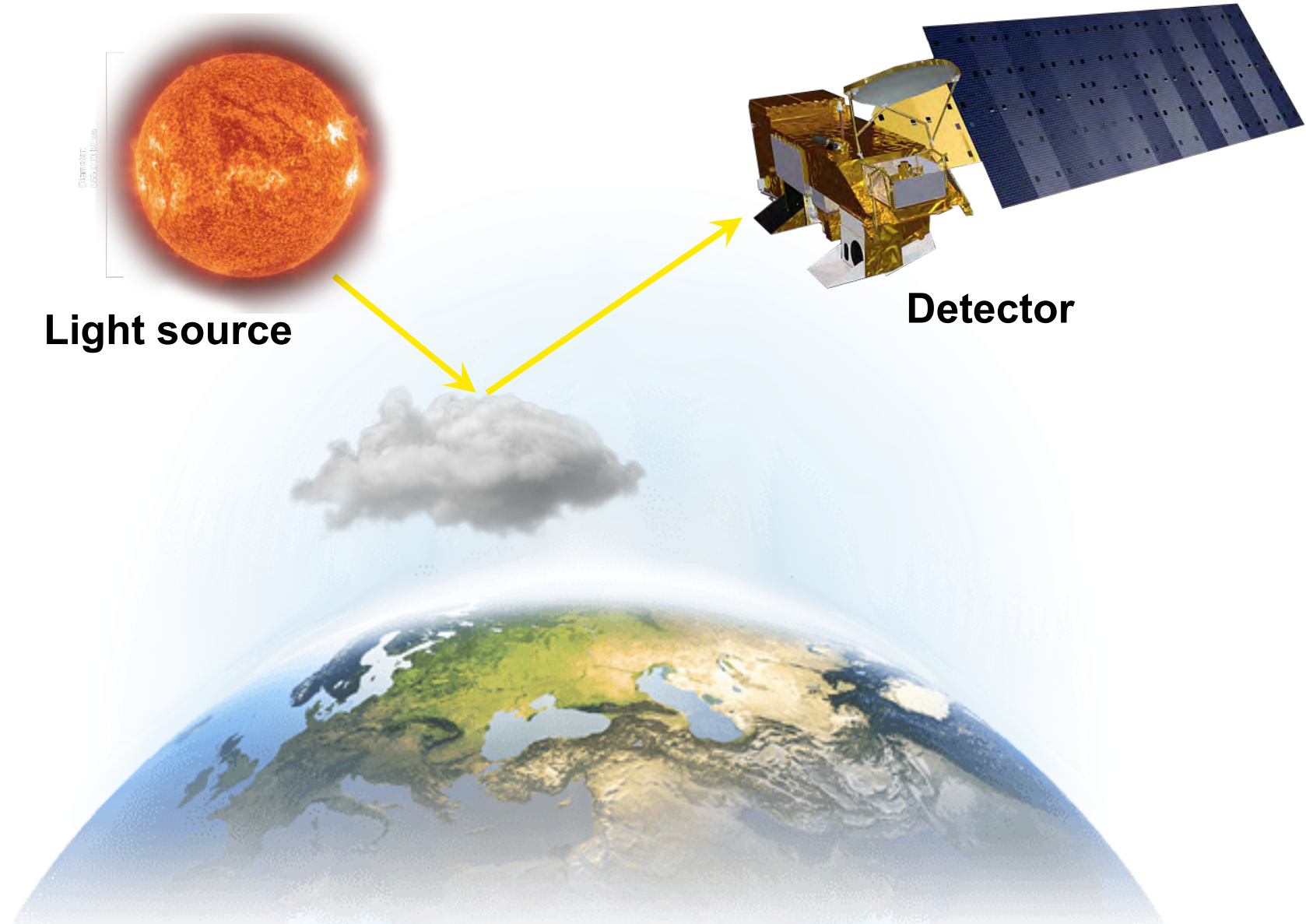
# Surface Reflectivity



# Surface Reflectivity

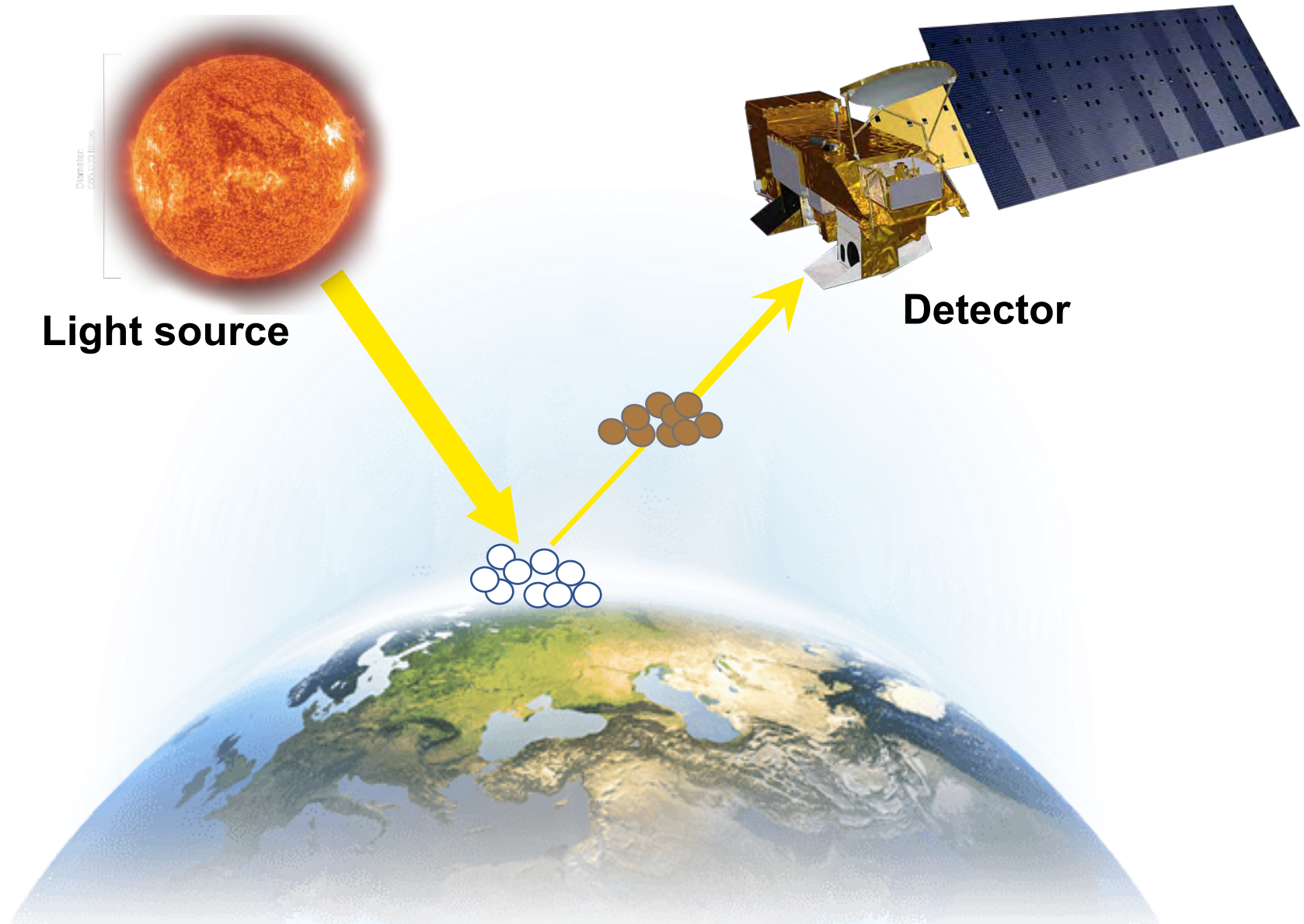


# Clouds





# Aerosols

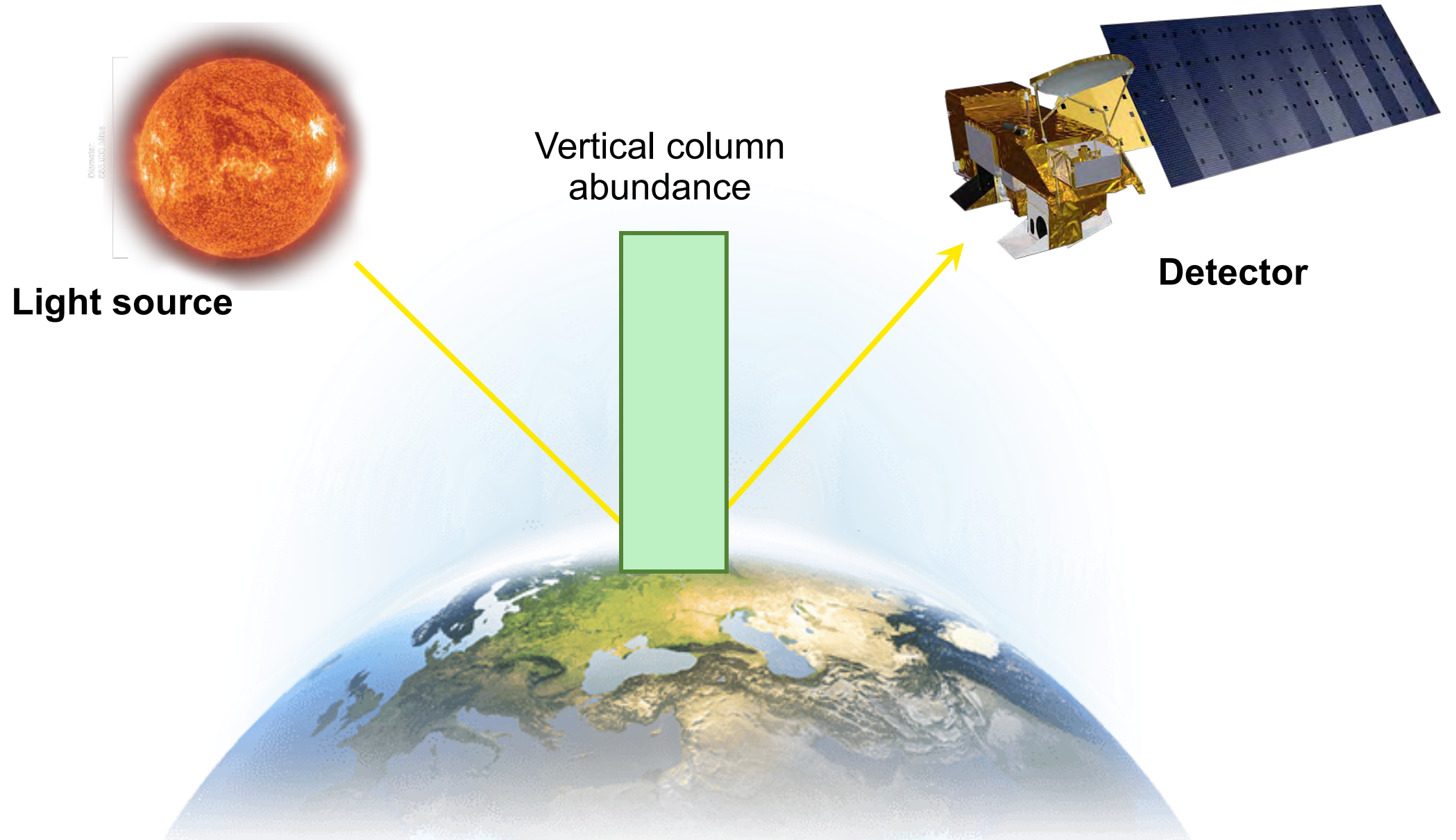


**Light source**

**Detector**

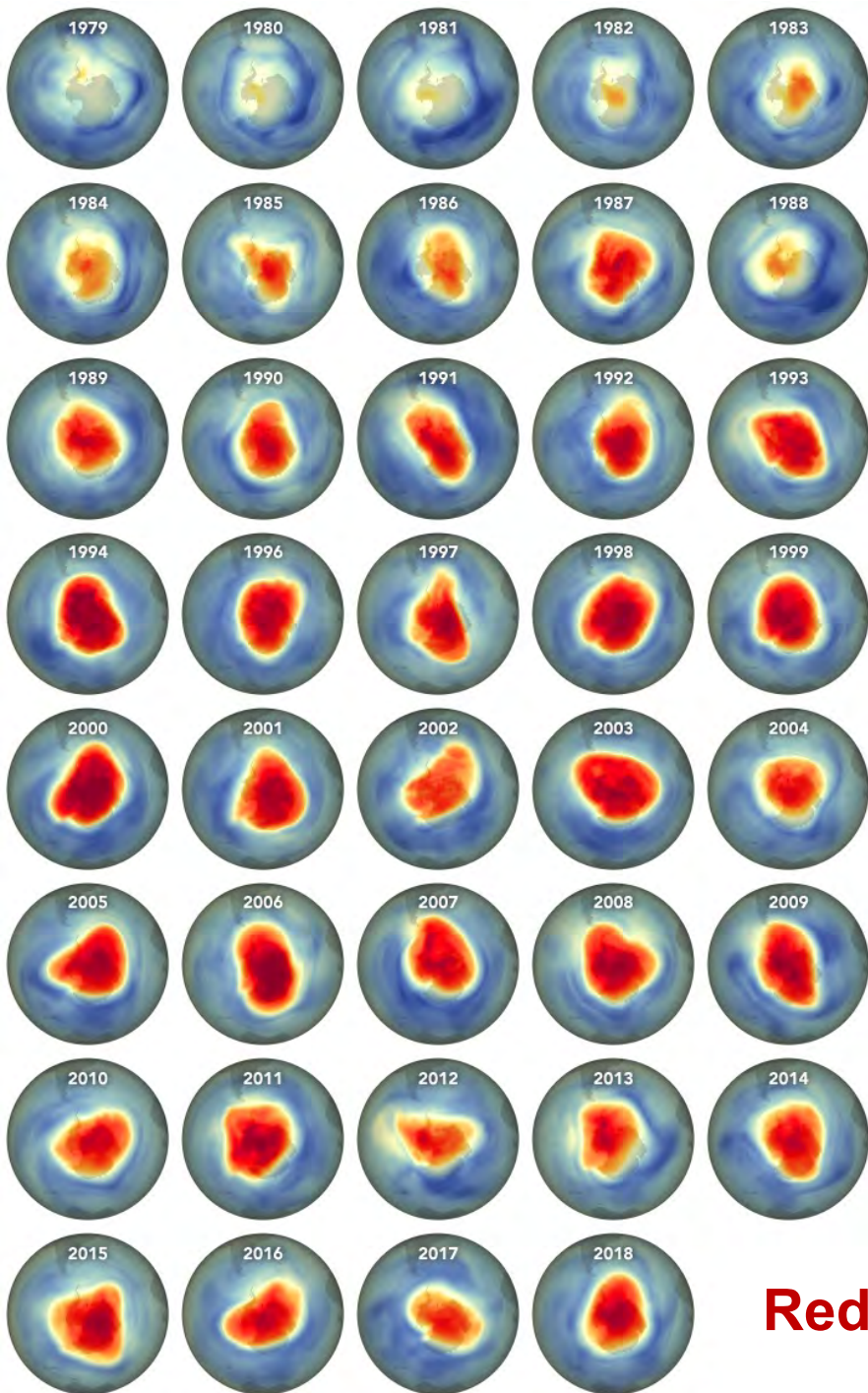
Character  
conditions

# "True" Vertical Column





# The hole in the ozone layer



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

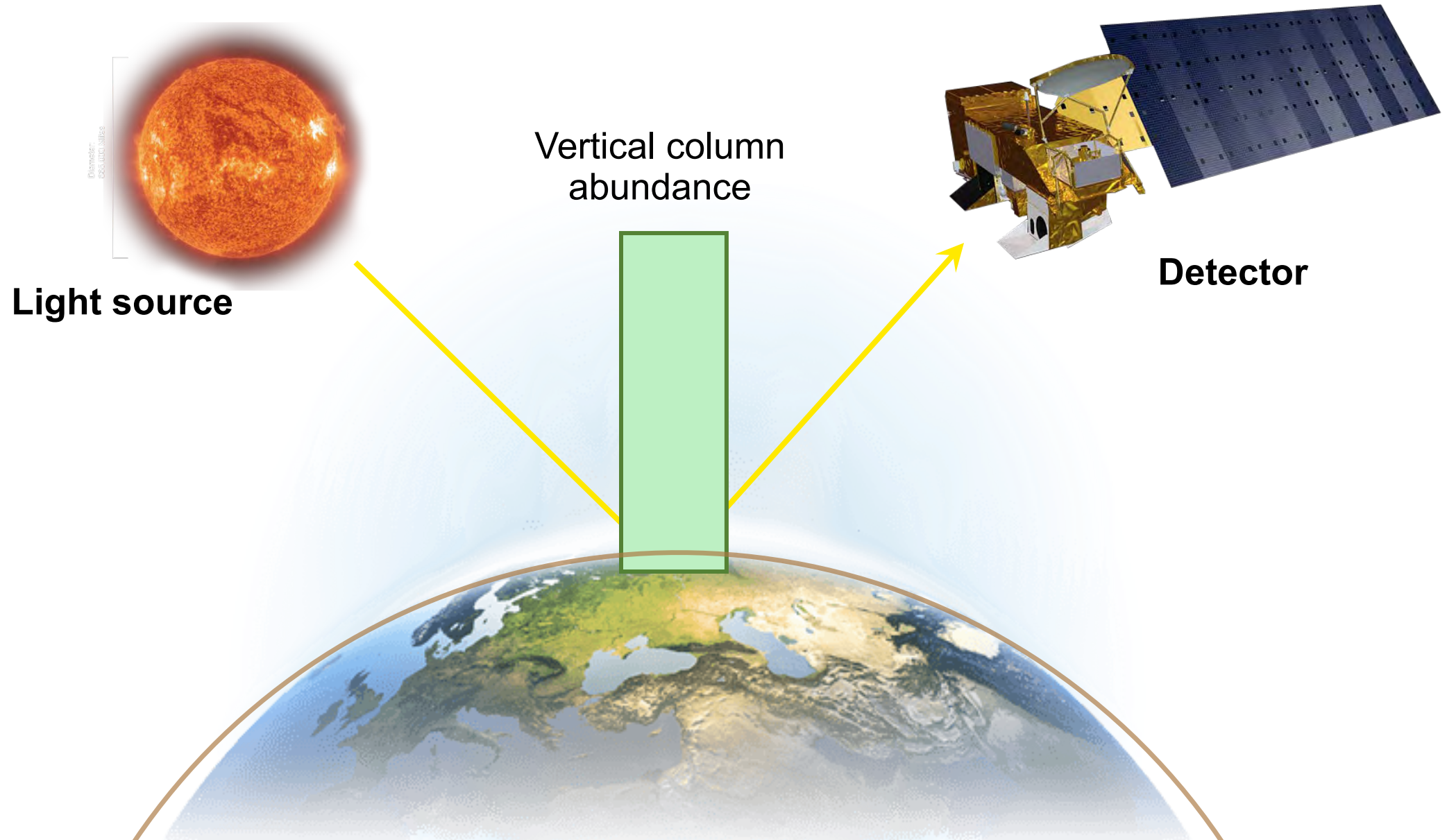


[Source: <https://eoimages.gsfc.nasa.gov/>]

**Red:** large ozone depletion



# "True" Vertical Column



# Air quality from surface monitors

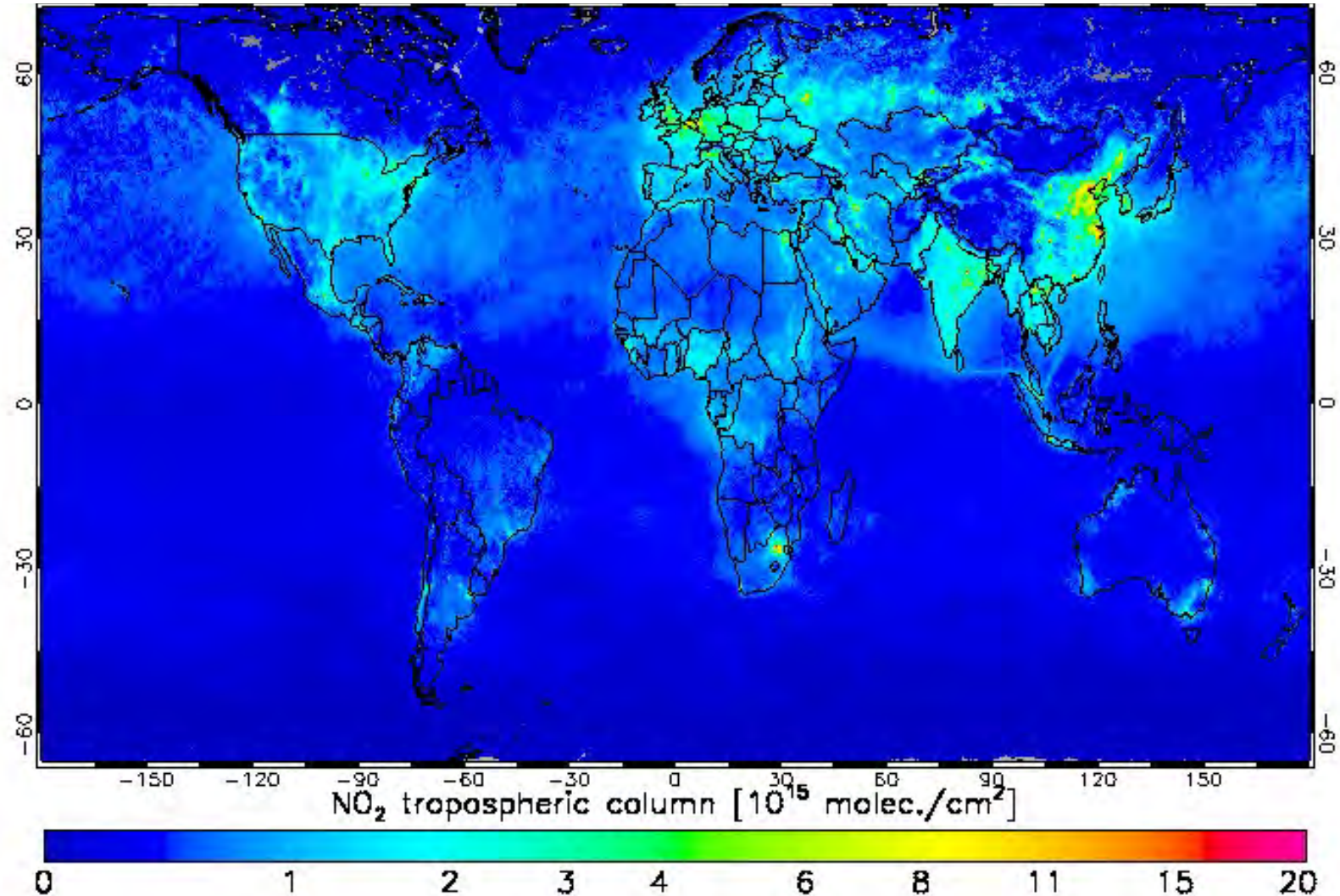


[Source: <https://aqicn.org/map/world/>]



# Air quality from space-based instruments

Vertical column density of nitrogen dioxide (NO<sub>2</sub>)

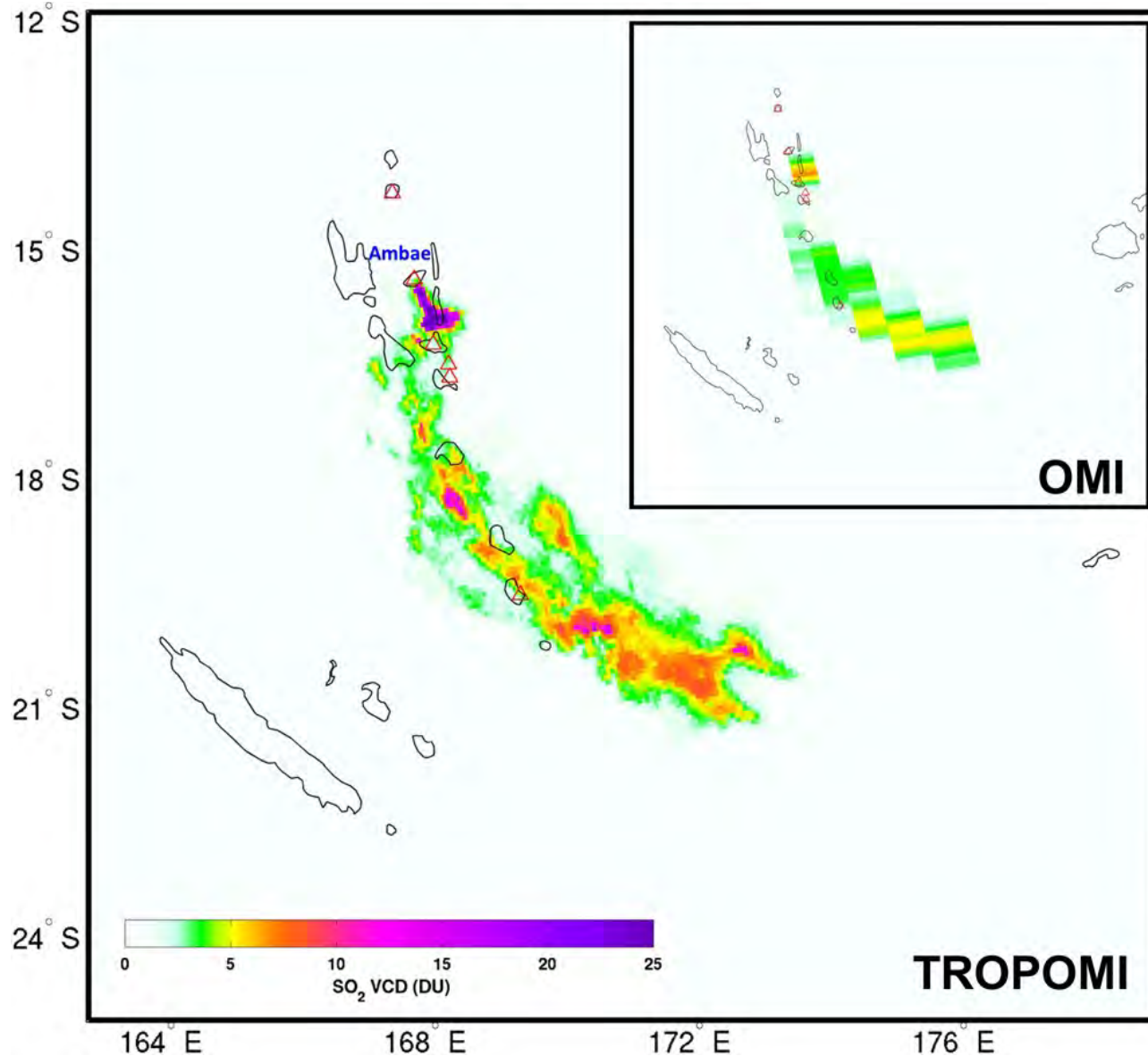


[Source: <https://www.temis.nl/airpollution/no2.php>]

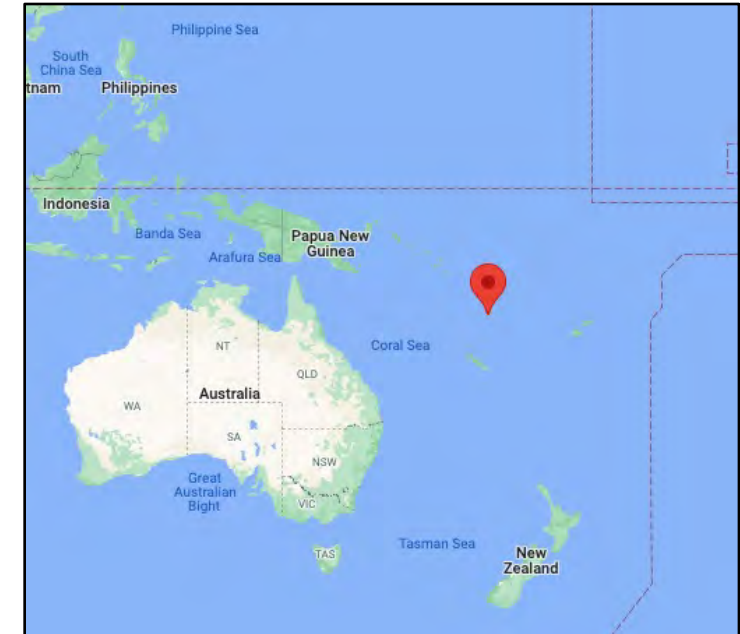


# Air quality from space-based instruments

SO<sub>2</sub> from Ambae volcano on 21 November 2017



Vanuatu

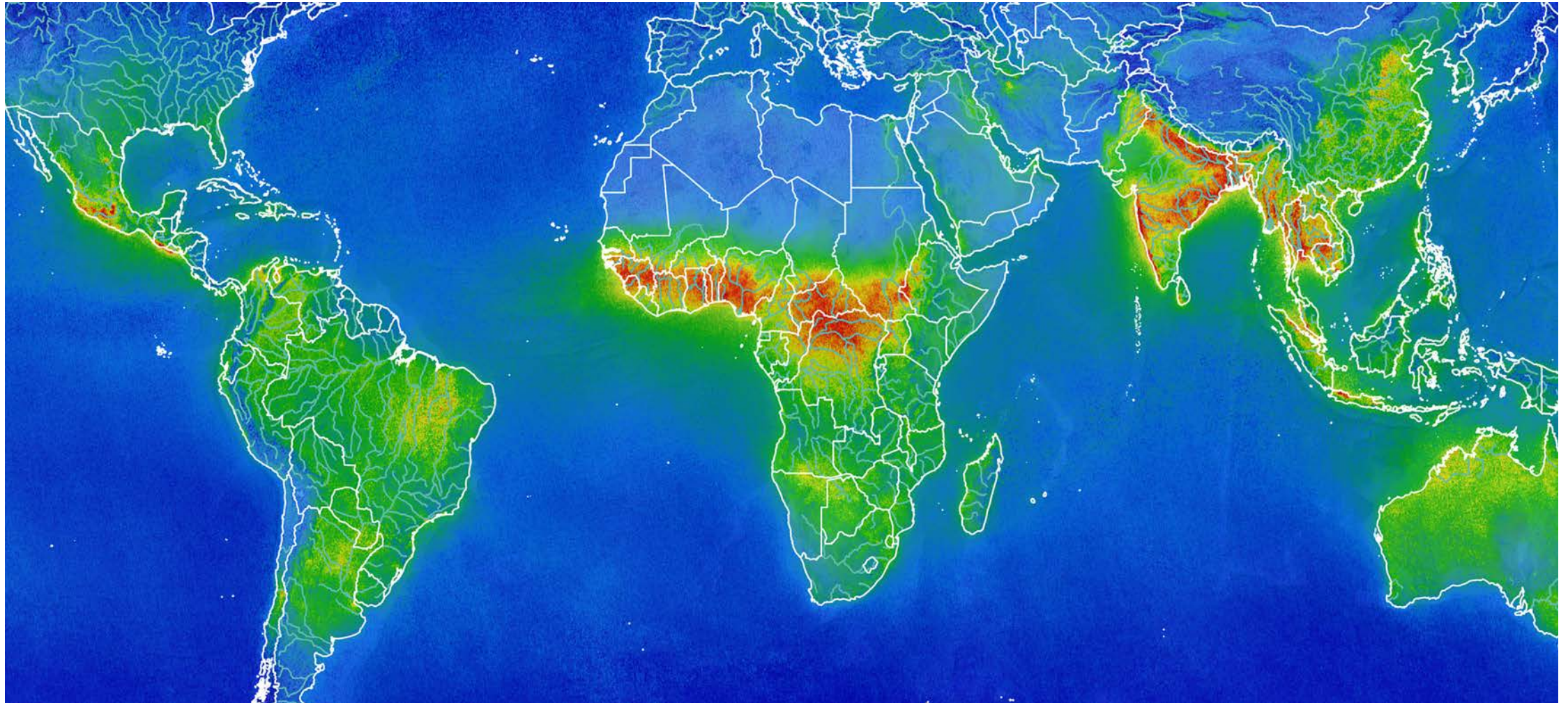


[Source:  
<https://www.nature.com/articles/s41598-019-39279-y>]



# Air quality from space-based instruments

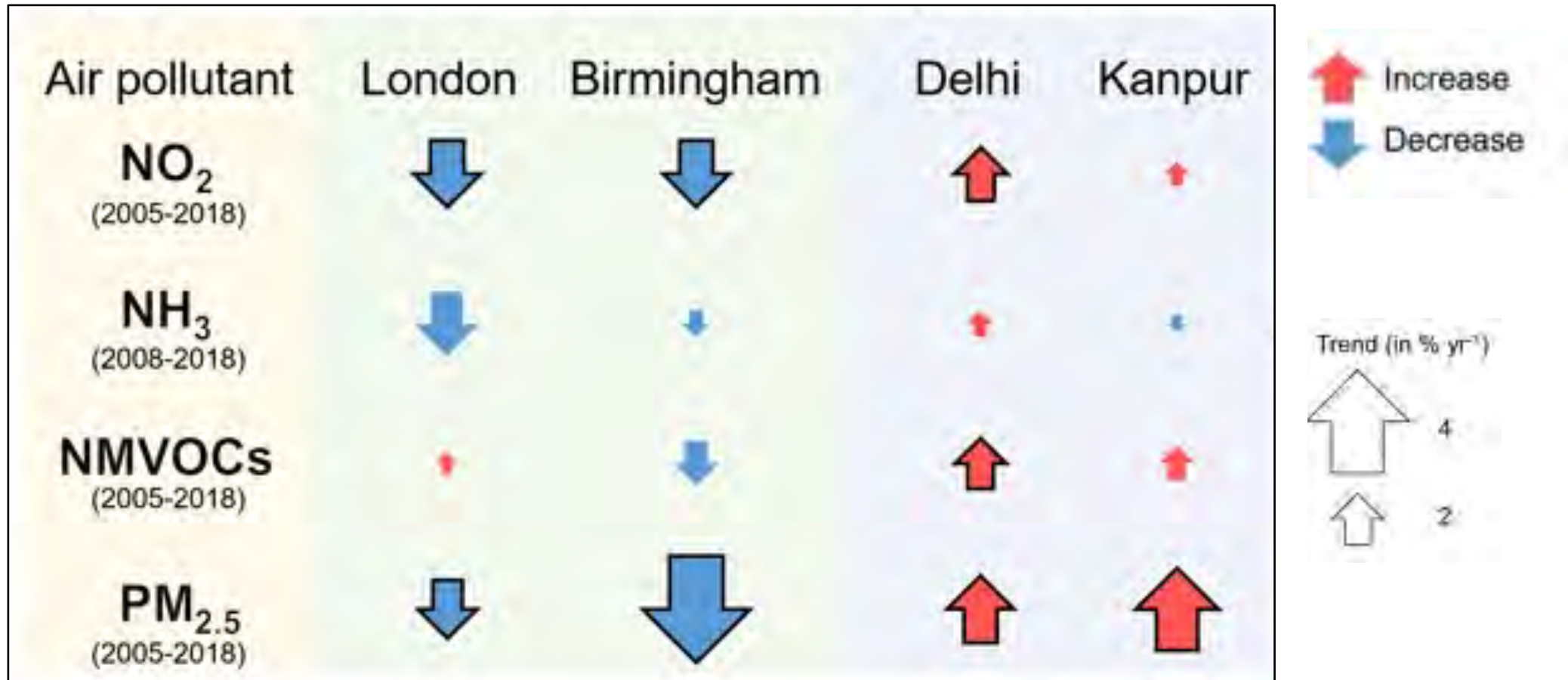
Vertical column density of formaldehyde (HCHO)



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

# Air quality trends from space

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

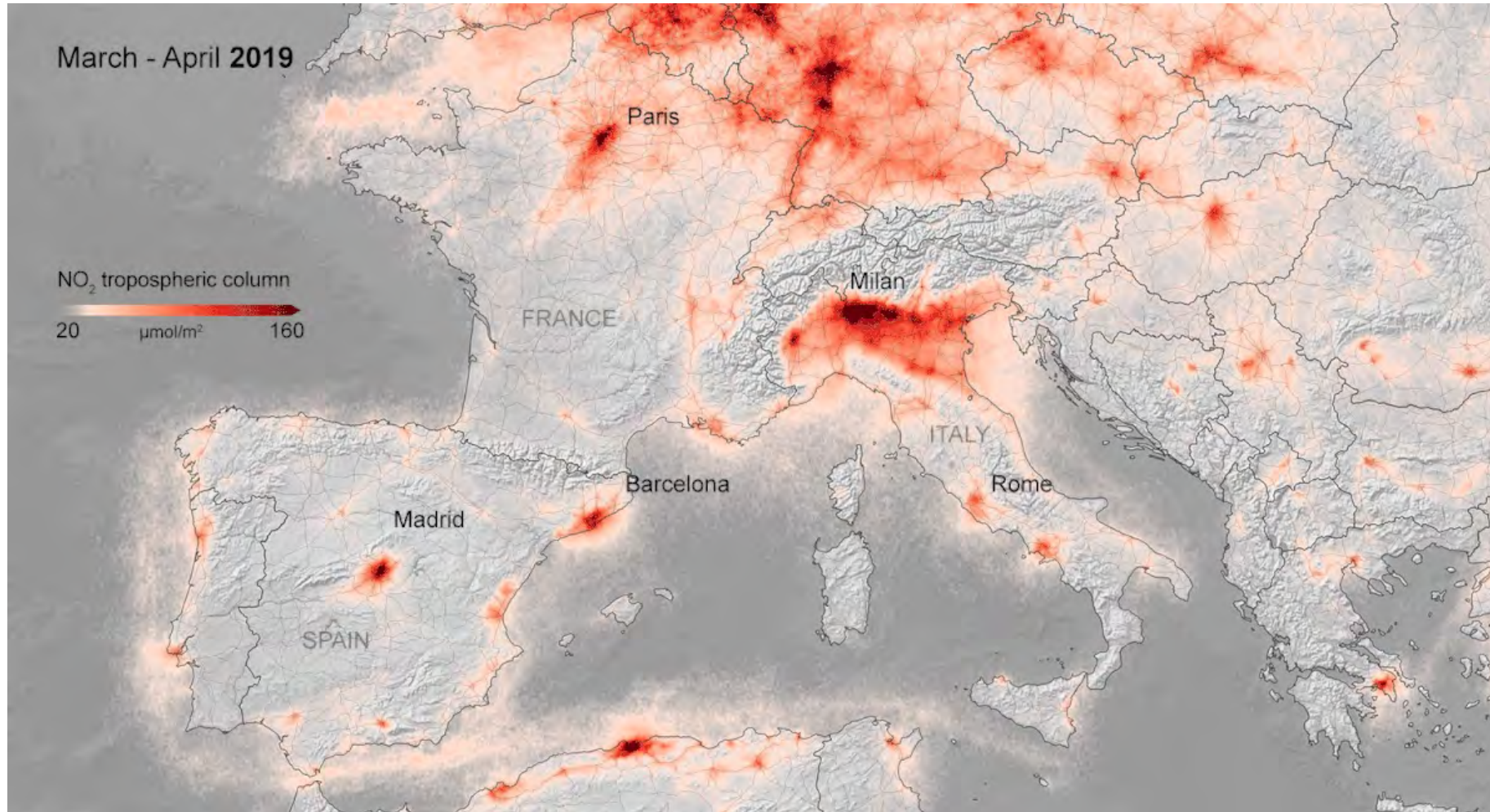


[Source: Vohra et al., 2021, <https://doi.org/10.5194/acp-21-6275-2021>]



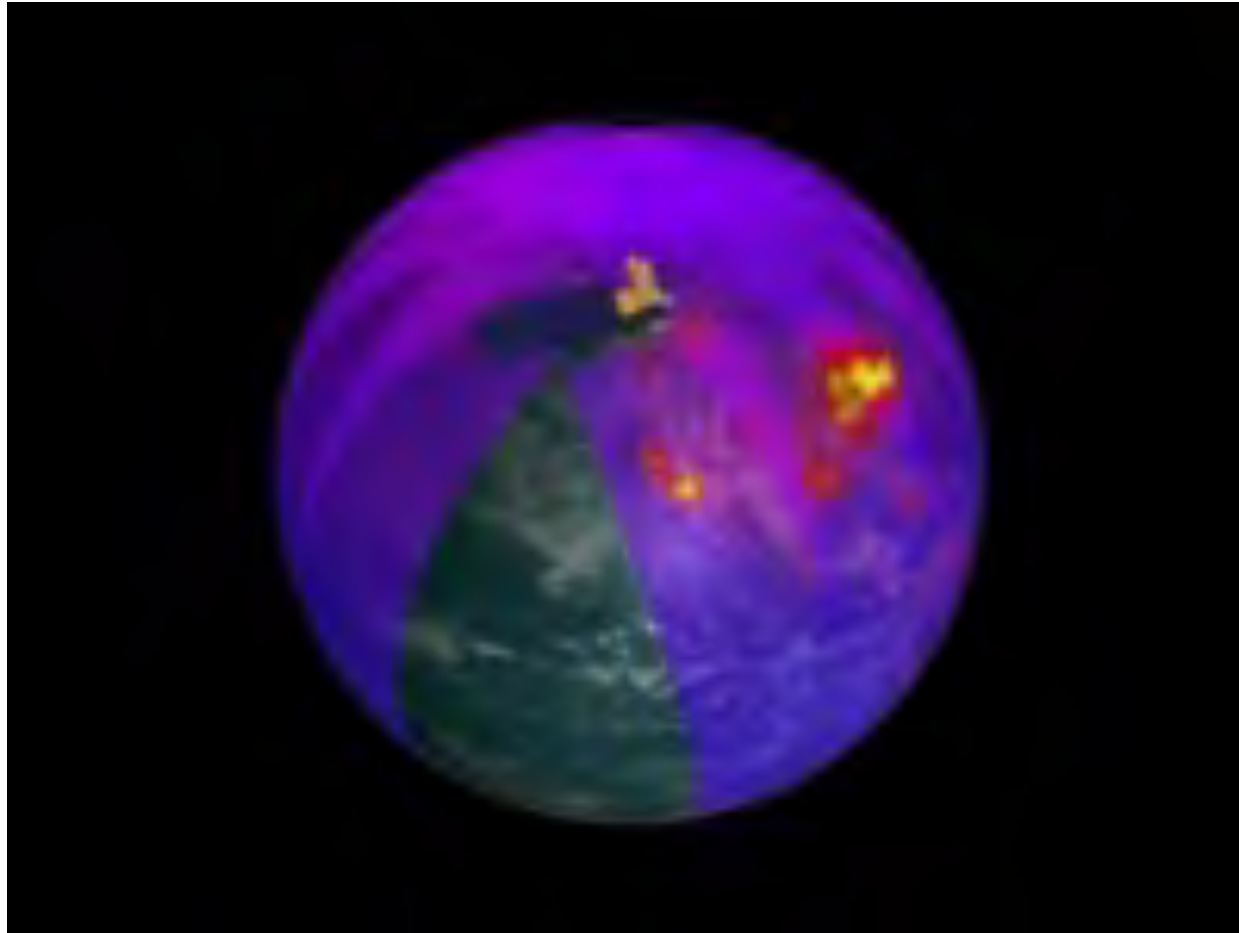
# Air quality trends from space

## Impact of COVID-19 lockdowns on air quality



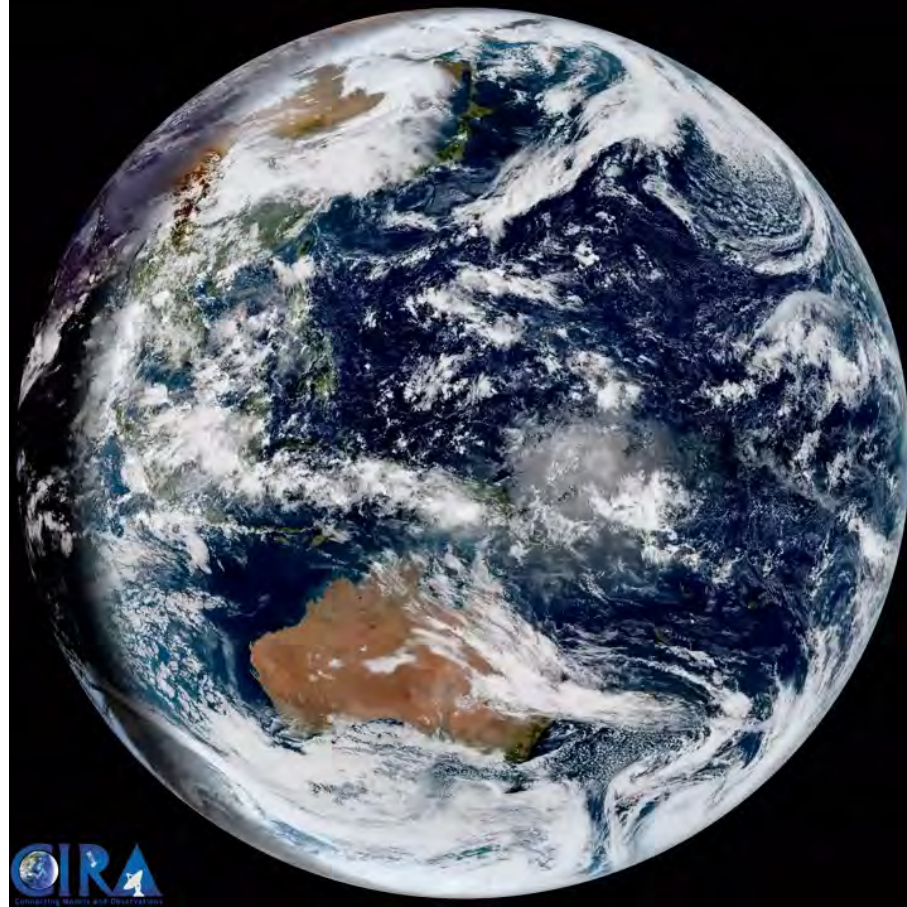
[Source: ESA]

# Low-Earth Orbiting Satellites



One observation per day. Typically global coverage

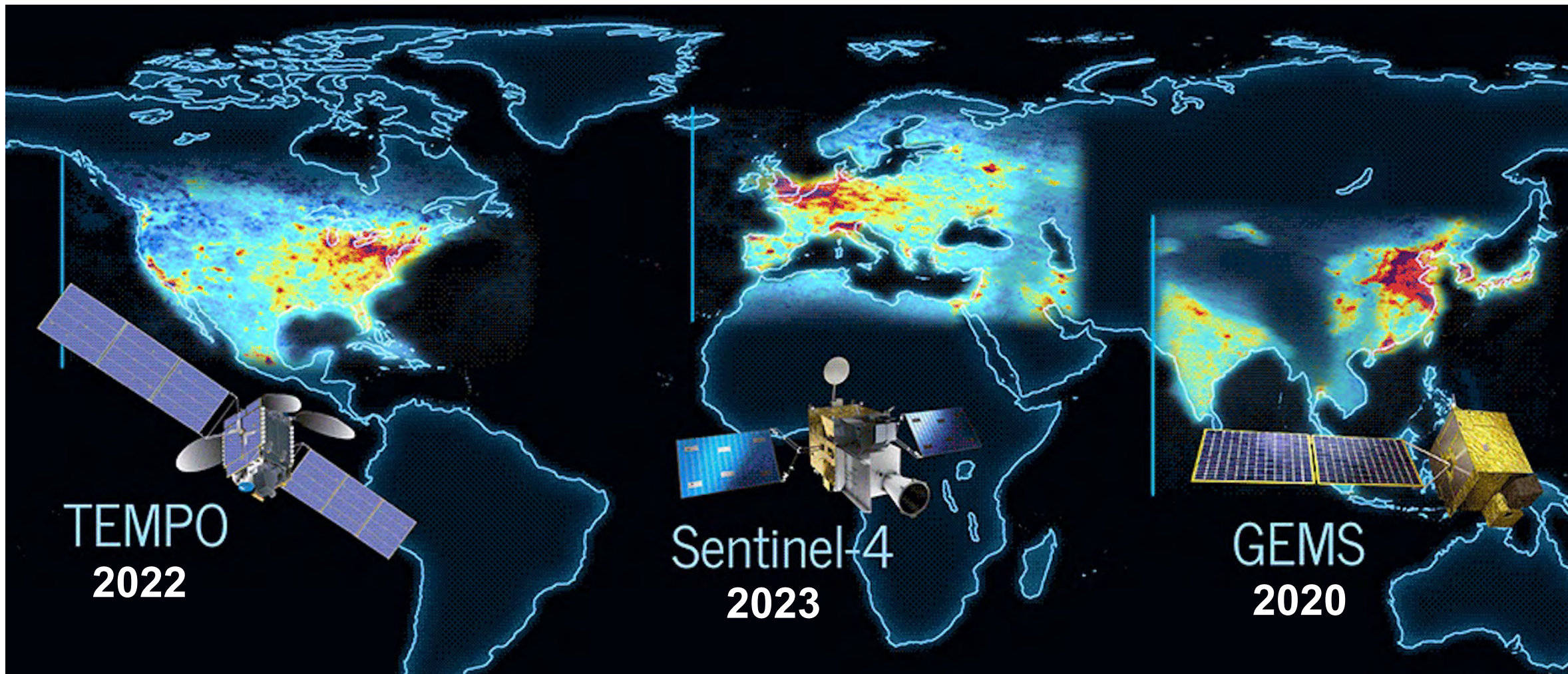
# Geostationary Satellites



Multiple observations per day (~hourly) over limited domain

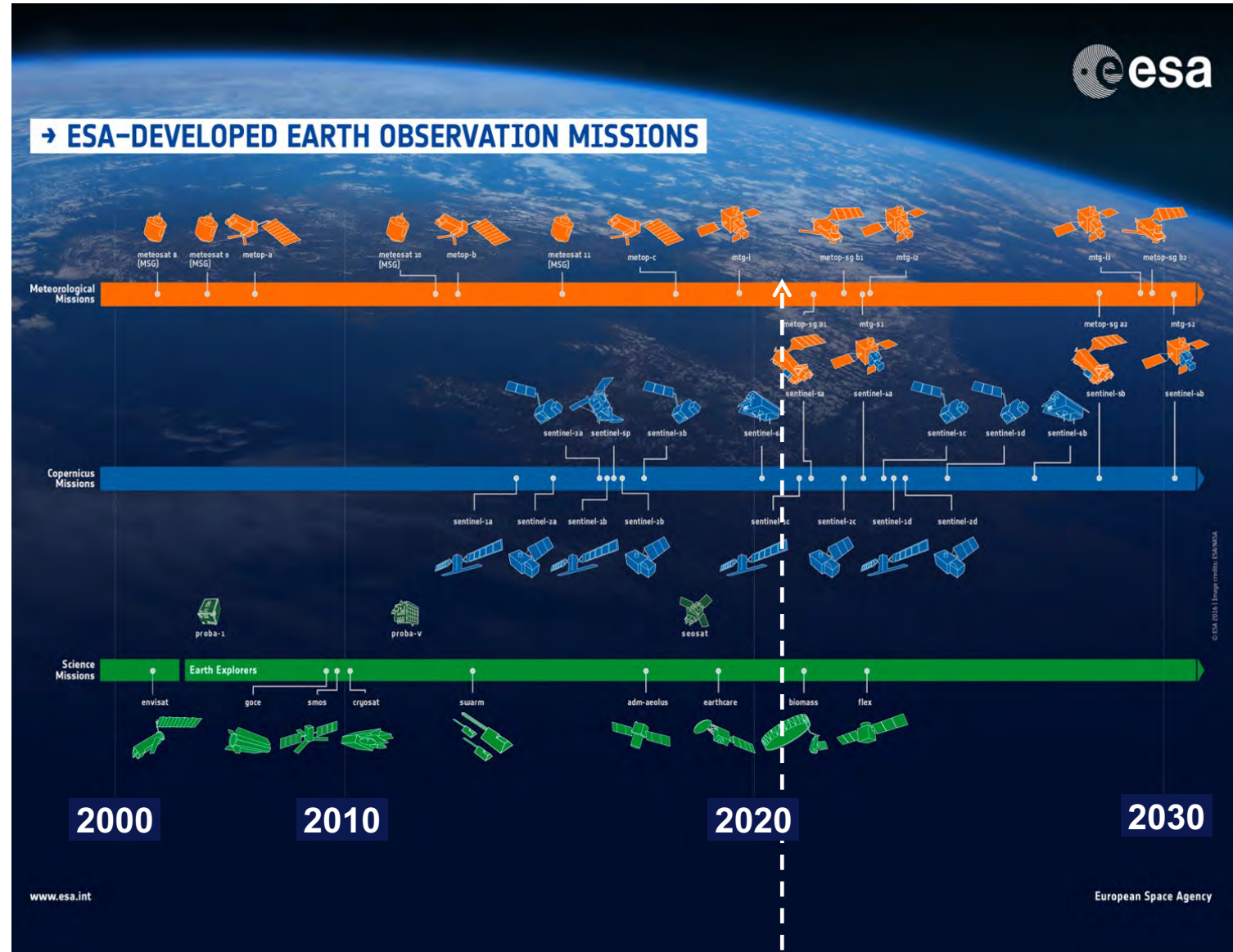


# The Dawn of the Geostationary Observing Network





# Lots on the Horizon



2021