







TROPOMI

applications of TROPOMI data & data science

Jos de Laat KNMI
R&D satellite observations laatdej@knmi.nl

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TROPOMI: flagship of Dutch earth observation



- TROPOMI (sentinel 5 – precursor mission)
- introduction
- concept
- data volumes, rates, resolution
- data products
- data applications
- TROPOMI within international earth observation

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Satellite measures colors

Tropomi compares sunlight with light reflected by the atmosphere

Certain gases absorb light from different parts of the color spectrum, so Tropomi can recognize many gases

Satelliet meet kleuren

Tropomi vergelijkt het zonlicht met licht dat weerkaatst uit de atmosfeer.

Omdat elk gas een ander deel van het kleurenspectrum uit het licht absorbeert, kan Tropomi veel soorten gas herkennen.

Kleuren die Tropomi kan zien

ULTRAVIOLET ZICHTBAAR SPECTRUM INFRAROOD

Stikstof dioxide (NO₂) Ozon (O₃) Wolken
 Formaldehyde Zwaveldioxide (SO₂)

Methaan (CH₄) Koolstofmonoxide (CO)

KNMI Principle Investigator (PI = "scientific lead")
 SRON co-PI

2014 William B. Eberly Award for Excellence in Earth Observation

White Light Prism

STIKSTOFDIOXIDE OZON FORMALDEHYDE
 METHAAN KOOLSTOFMONOXIDE ZWAVELDIOXIDE

TROPOMI

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Red Green and Blue: your smartphone camera

TROPOMI

- **True color:**
- 3 colors
- 8 bits per color
- $2^8 = 256$ shades per color
- 16.7×10^6 colors per groundpixel

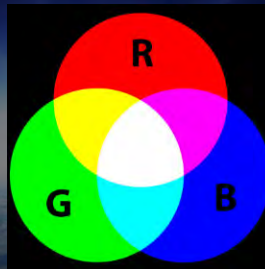
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Red Green and Blue: TROPOMI



- **True color:**
- 3 colors
- 8 bits per color
- $2^8 = 256$ shades per color
- 16.7×10^6 colors per groundpixel
- **TROPOMI color:**
- 4000 colors
- 19 bits per color
- $2^{19} = 524287$ shades per color
- 10^{23000} colors per groundpixel



```
[pc160040]->python3
Python 3.7.4 (default, Jul 9 2019, 16:48:28)
[GCC 8.3.1 20190223 (Red Hat 8.3.1-2)] on linux
Type "help", "copyright", "credits" or "license()" for more
>>> print('{0:200.2e}'.format(10**23000))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
OverflowError: int too large to convert to float
>>>
[pc160040]->idl
IDL Version 8.5 (linux x86_64 m64). (c) 2015, Exelis Visual Infor
Installation number: 809086.
Licensed for use by: RW Meteorological Institute
IDL> 10**23000.
      Inf
* Program caused arithmetic error: Floating overflow
```

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~~25~~ 25 million pixels per day @ ~~5.5~~ 5.5 x 3.5 km in nadir

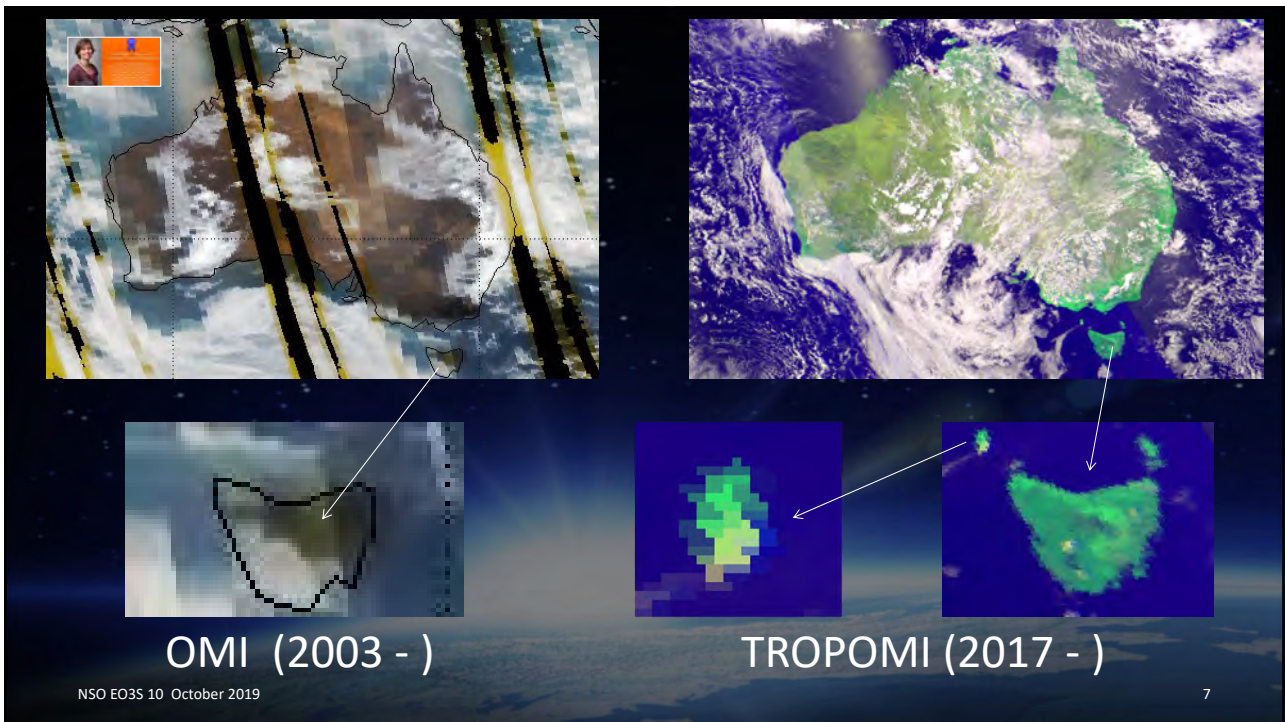


- 1 scanline per second
- 440 spectra per scanline
- 3000 scanlines per orbit
- 15 orbits per day
- ~~20~~ 25 million groundpixels per day
- ~~225~~ ~300 Gbyte raw (uncalibrated) data per day
- > 1 Tbyte L1b (calibrated) data per day

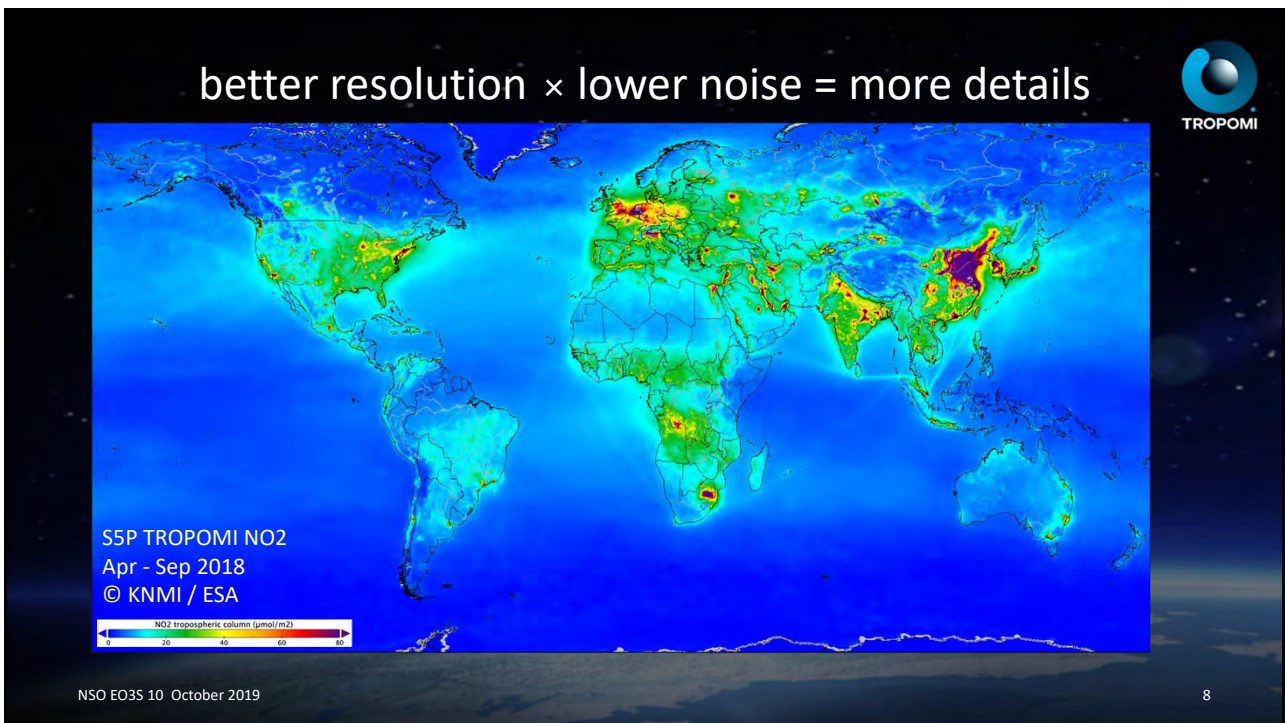
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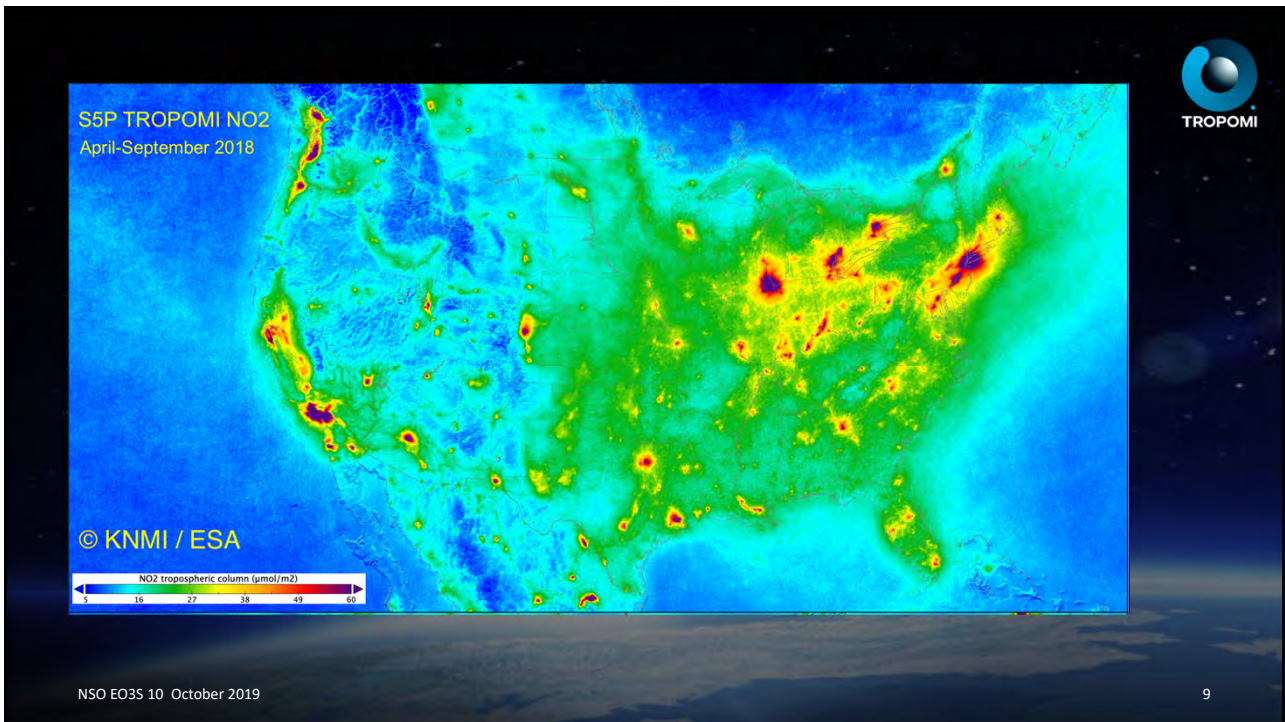
6



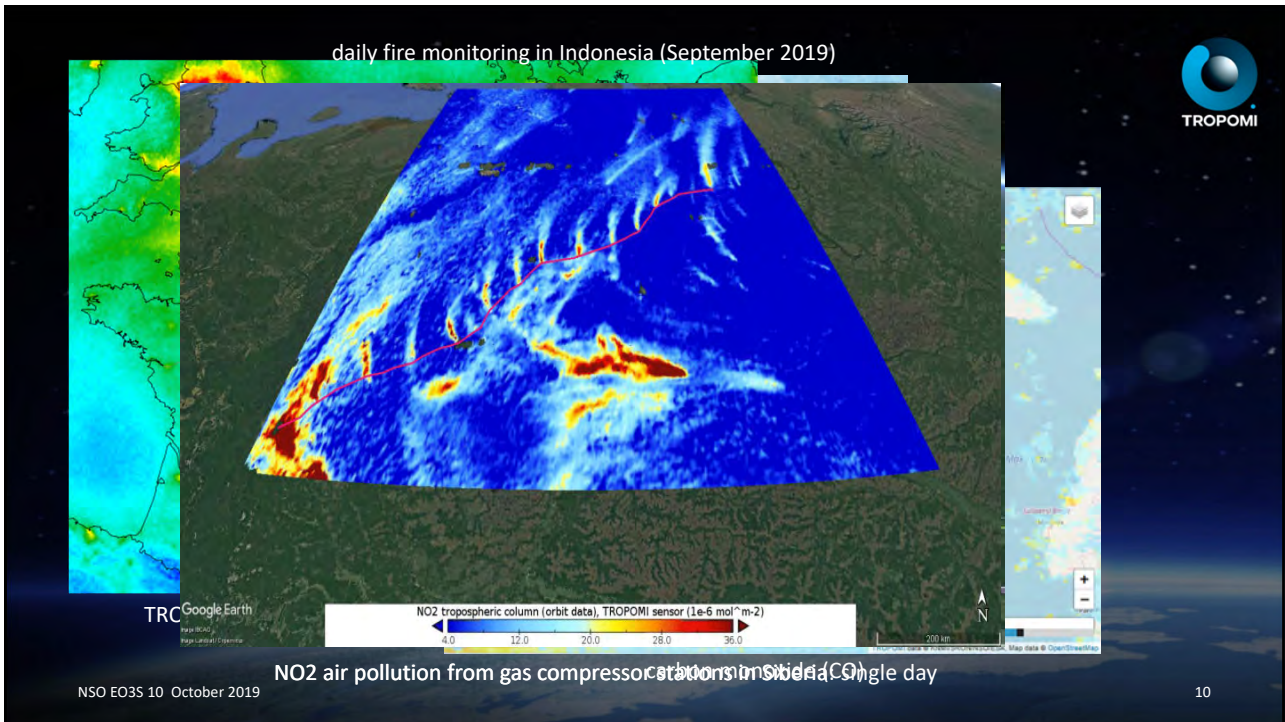
7



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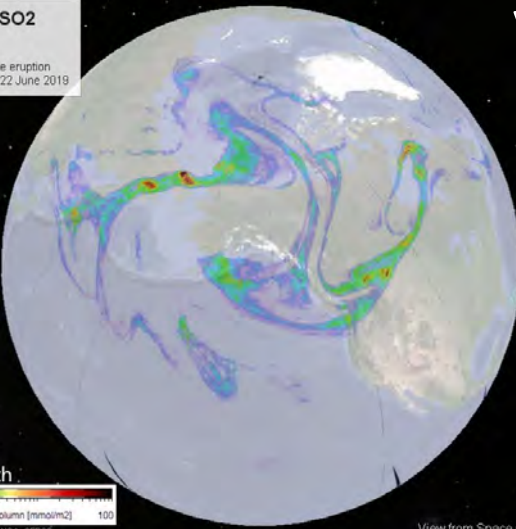

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TROPOMI SO2
4 July 2019
- SO2 from Raikoke eruption
- Raikoke eruption 22 June 2019

volcano !!!

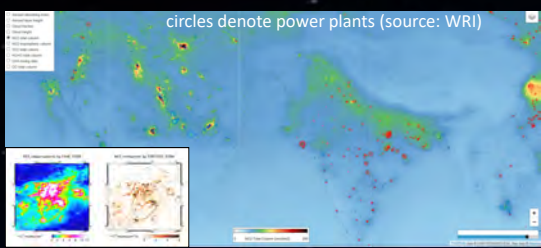
Google Earth
View from Space (Altitude: 10553 km)

Raikoke eruption as seen from ISS (source: NASA)

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a few data applications

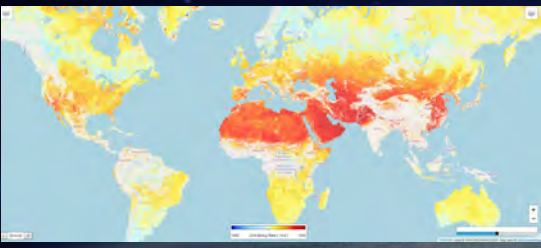


circles denote power plants (source: WRI)

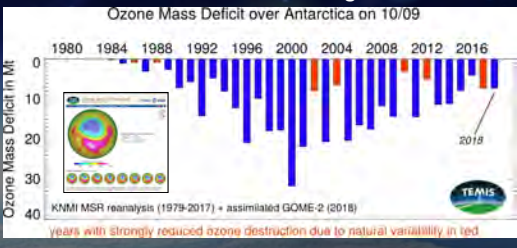
air pollution emission monitoring
(individual power plants; forest fires, maybe even ships)



near-real-time aviation
hazard monitoring



methane emissions



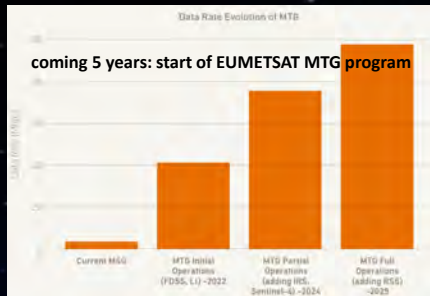
Ozone Mass Deficit over Antarctica on 10/09

ozone layer monitoring

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international context



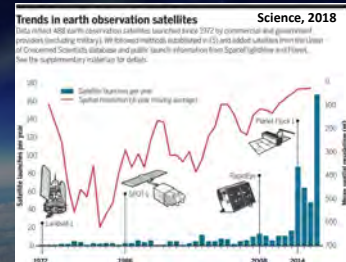
earth observation 2.0

“from exploration (2000-2020) to application (> 2020)”

- rapid increase in earth observation capacity & data volume
- EU/ESA/EUMETSAT COPERNICUS program (2015 to 2040)
- USA, Japan, Korea, China, India ...
- publicly accessible data
- commercialization



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applications of TROPOMI data: wrap-up



- TROPOMI & earth observation: bright future (more, more ...)
- earth observation 2.0: great potential for development of applications
- reality @KNMI/SRON: we can't do it all ...
- towards bridging the gap between data and information (→ EO3S)

thank you for your attention and I'll take any question

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