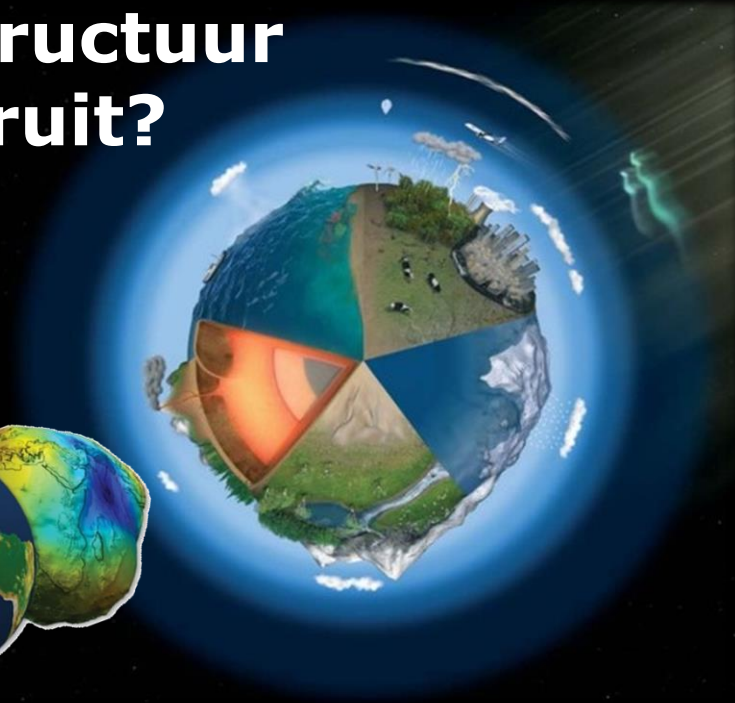
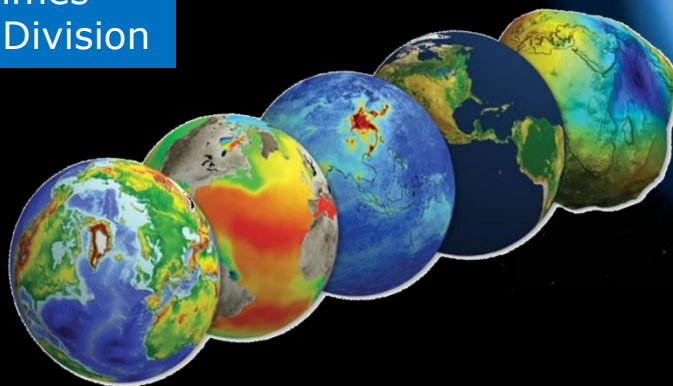


Hoe ziet de satelliet infrastructuur (ontwikkeld door ESTEC) eruit?

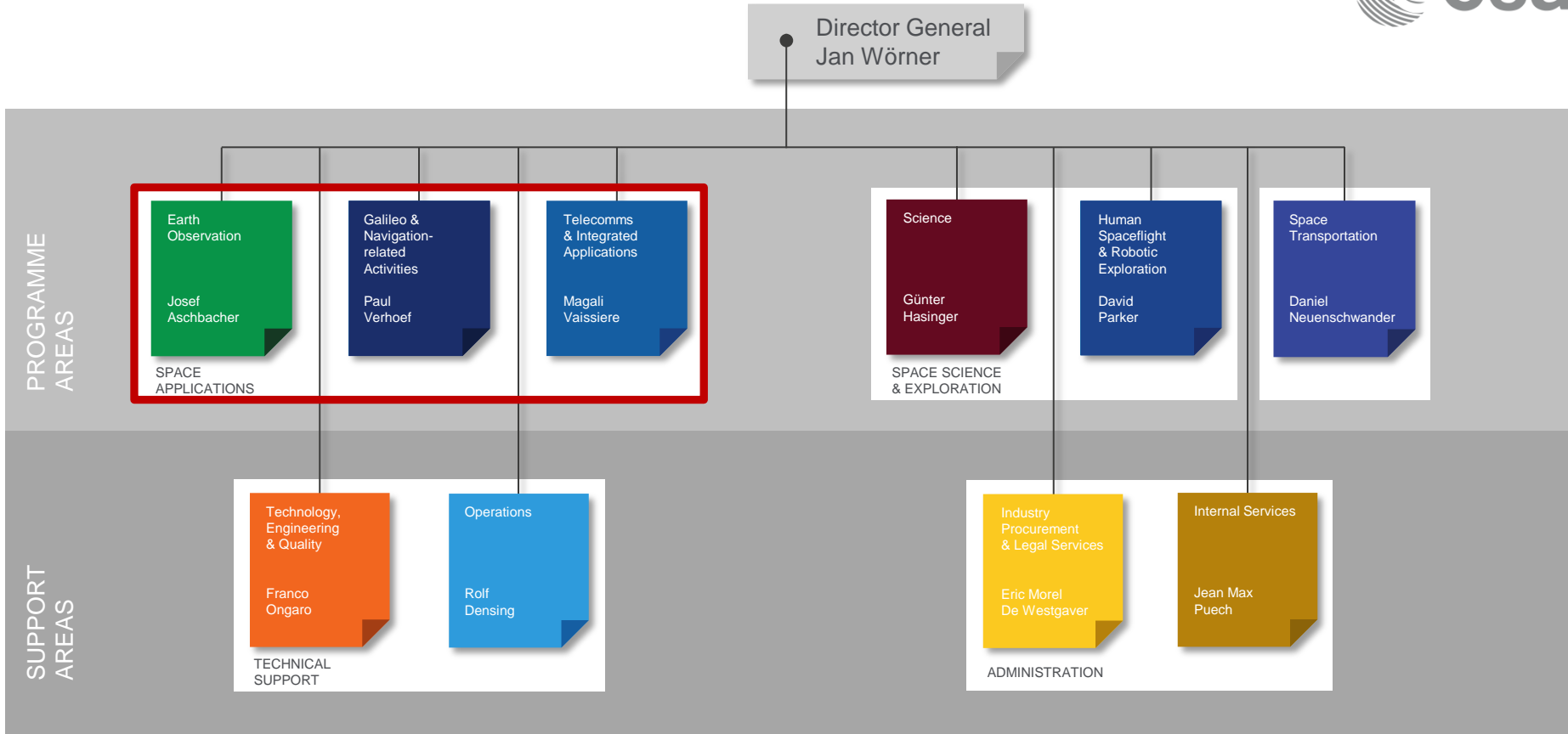
Roger Haagmans
Earth Observation Programmes
Earth and Mission Science Division

9 Maart 2018

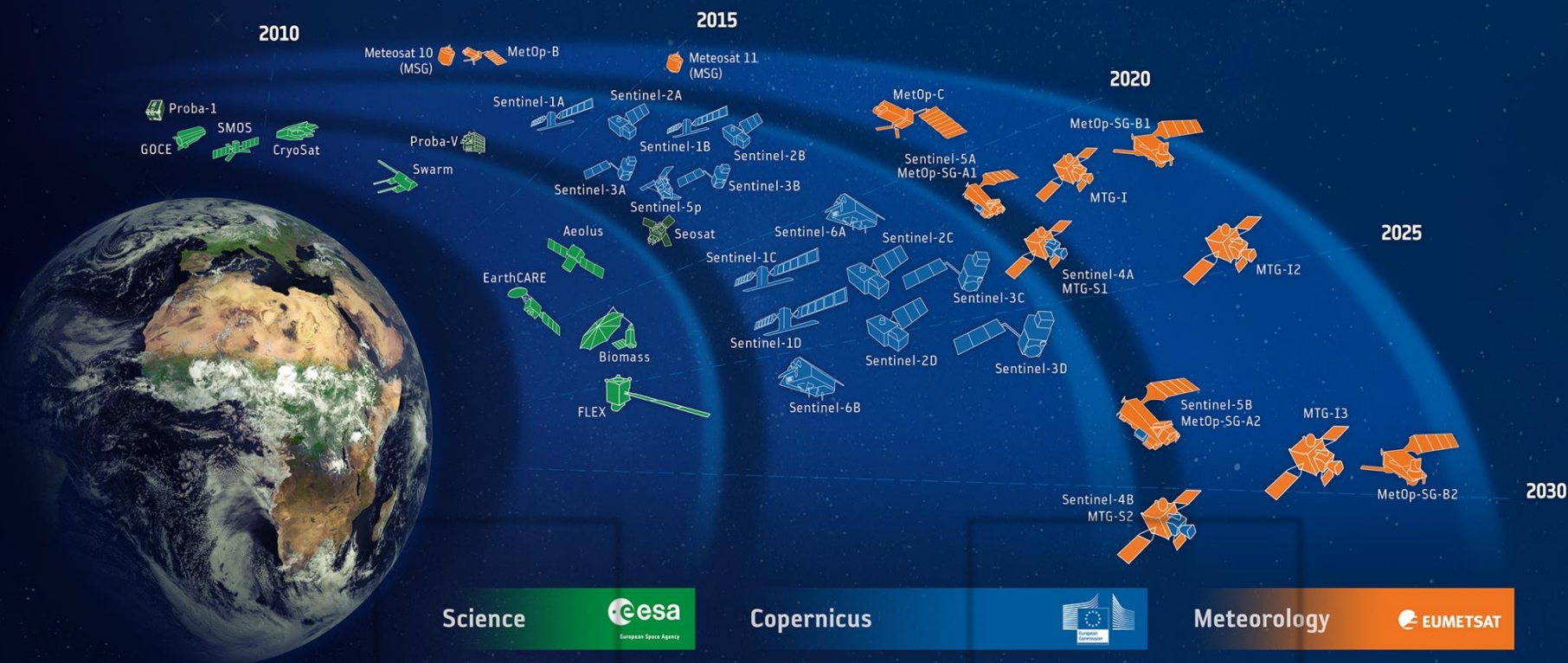


ESTEC is de incubator van de Europese ruimtevaart activiteiten. Hier worden de meeste ESA projecten geboren en door de verschillende fasen van ontwikkeling geleid.





Aardobservatie in ESA



Aardobservatie – door menselijke ogen



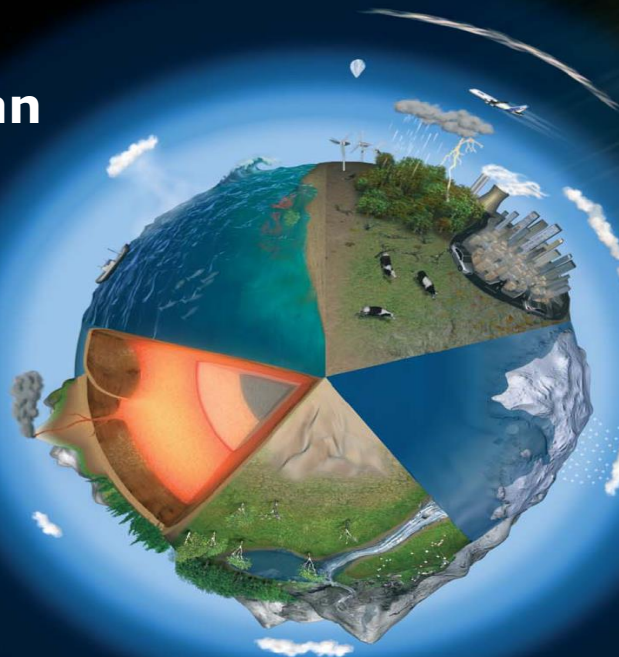
Wat kunnen we waarnemen vanuit de ruimte?



Binnenste van de aarde

Oceaan

Atmosfeer

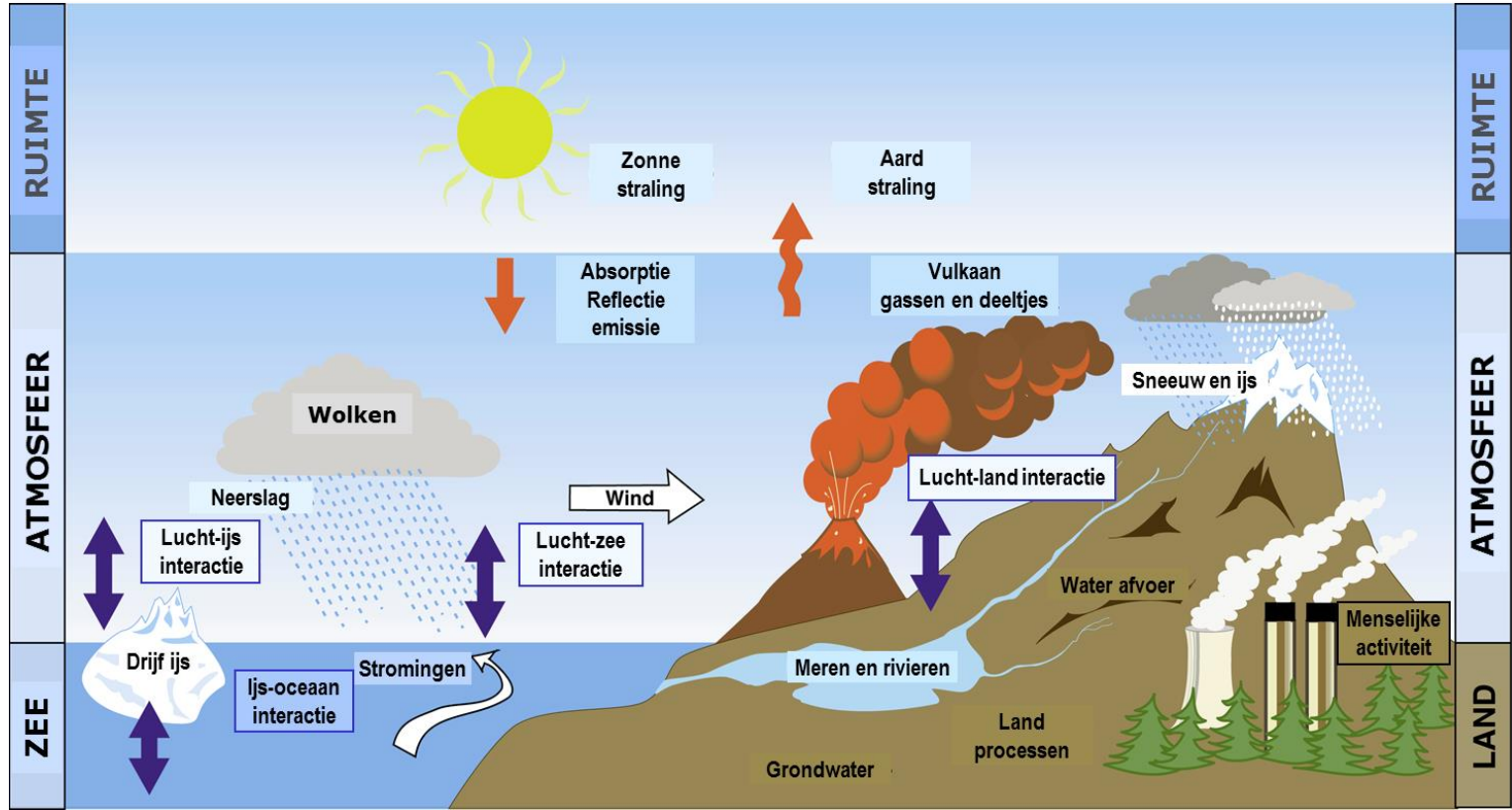


Sneeuw en ijs

Land



Aspecten van de aarde



Aardobservatie – stoomcursus...



Aardobservatie vanuit de ruimte

Type satelliet baan	Hoogte boven aardoppervlak	Hoogte boven schaalmodel tangible Earth
'Laag'	200 -1200 km	2 -12 cm
'Hoog'	36.000 km	\pm 3.5 m

**Diameter aarde:
12800 km**



**Schaal model
 \sim 128 cm**

Aardobservatie vanuit de ruimte

Kenmerken banen:

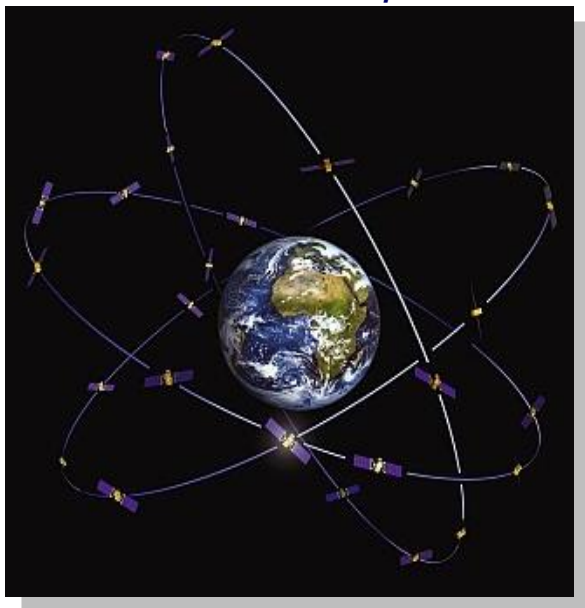
- Lage banen: *omloop tijd \pm 90 - 100 minuten*
24 uur = 1440 minuten dus 14-16 omlopen per dag
- Polaire banen: over beide polen



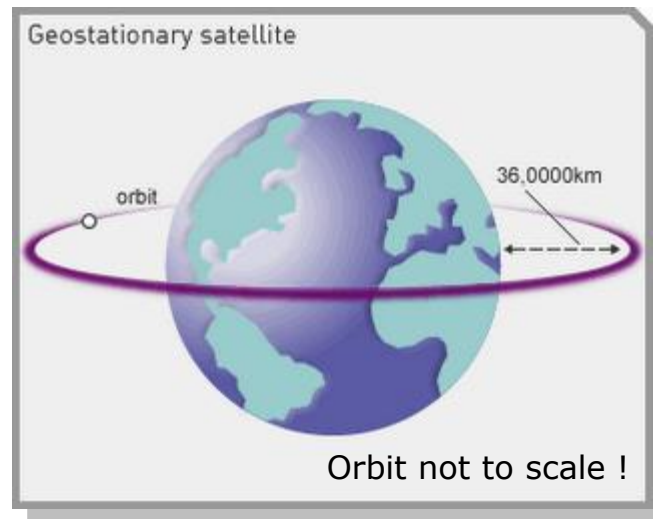
Aardobservatie vanuit de ruimte

Kenmerken banen:

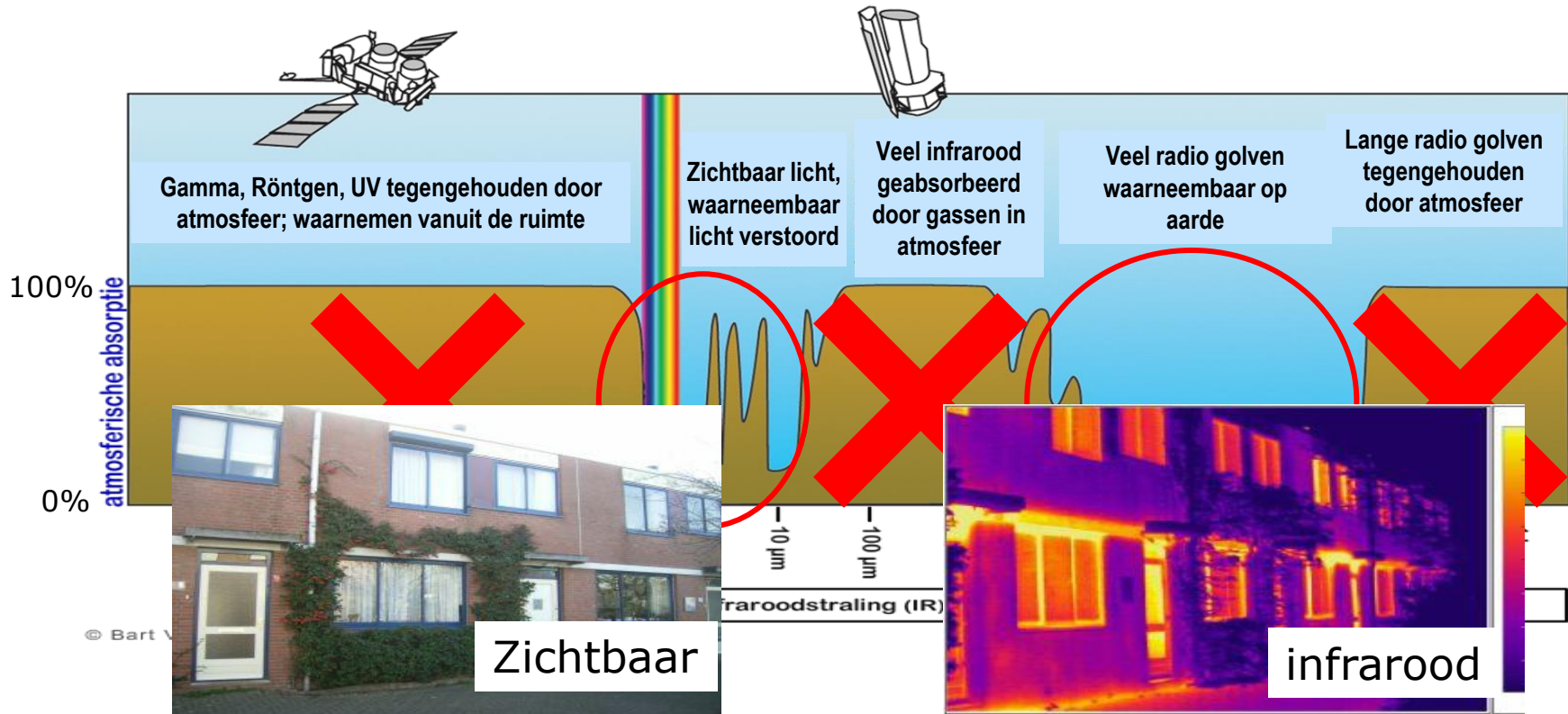
- Medium banen: *GPS & Galileo satellieten*
 $\pm 23000 \text{ km}$
 $1 \text{ omloop} \pm 14u \ 23 \text{ min}$



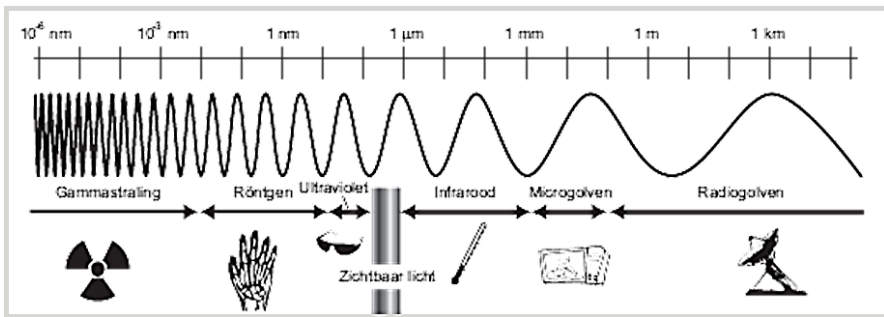
- Hoge banen: Geostationaire satellieten
 hoogte $\pm 36000 \text{ km}$
 "vast punt" boven evenaar
Weather, telecom, tv



Straling - de basis... en de atmosfeer 10-20km



Kijken, waarnemen en observeren



“passief”

Foto: zichtbaar licht

Temperatuur: onzichtbaar

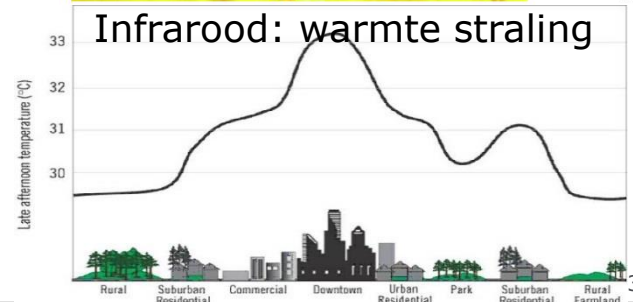
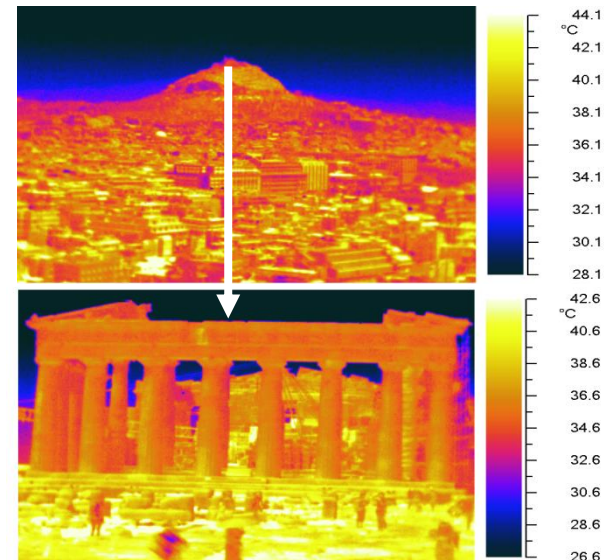
“actief”

Afstand: meetlat (laser)

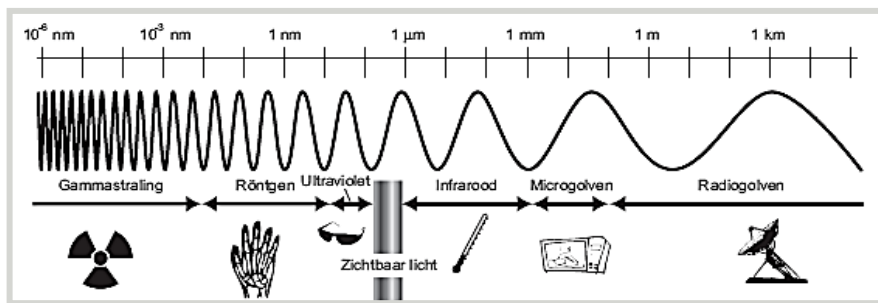
Snelheid: omwentelingen wiel

Röntgen foto

Echografie (onhoorbaar geluid)



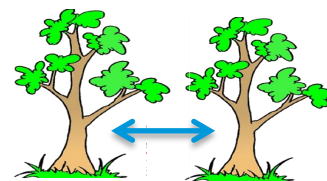
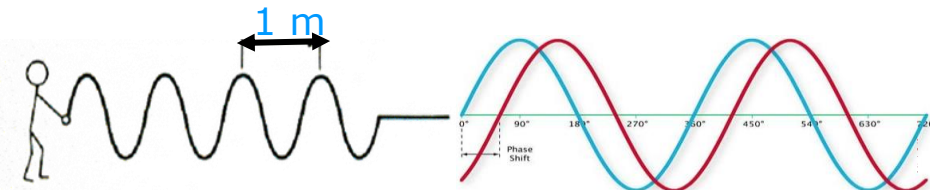
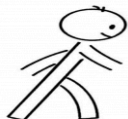
Meten, waarnemen en observeren (2)



1 m
 \longleftrightarrow
 1 sec



Heen en weer duurt 20 sec
 dus de afstand tot de boom is?



Beweging van de boom = phase verschuiving

Copernicus Sentinel Lancements



S-1



Radar

A 
3 Apr. 2014

B 
25 Apr. 2016

S-2



High
Resolution
Optical

A 
23 Jun. 2015

B 
6 Mar. 2017

S-3



Medium
Resolution
Optical &
Altimetry

A 
16 Feb. 2016

B
2018

S-4



Atmospheric
Chemistry
(GEO)

A
2021

B
2027

S-5P



Atmospheric
Chemistry
(LEO)

A 
13 Oct. 2017

S-5

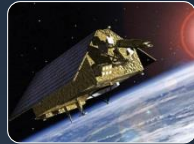


Atmospheric
Chemistry
(LEO)

A
2021

B
2027

S-6



Altimetry

A
2020

B
2025

Copernicus' Sentinel Satellieten



Sentinel 1 (A/B/C/D)
SAR Imaging

Weersonafhankelijk, dag en nacht opnames,
deformatie



Sentinel 2 (A/B/C/D)
Multispectral Imaging

Land toepassingen: steden, bossen, landbouw,
... voortzetting van Landsat, SPOT



Sentinel 3 (A/B/C/D)
Ocean & Global Land Monitoring

Kleur van de oceaan (qualiteit), vegetatie,
zee/land oppervlakte temperatuur, zee spiegel



Sentinel 4 (A/B)
Geostationary Atmospheric

Samenstelling van de atmosfeer, luchtvervuiling;
instrument op de MTG satellieten



Sentinel 5 (A/B/C) & Precursor
Low-Orbit Atmospheric

Samenstelling van de atmosfeer; instrument
op MetOp-SG satellieten

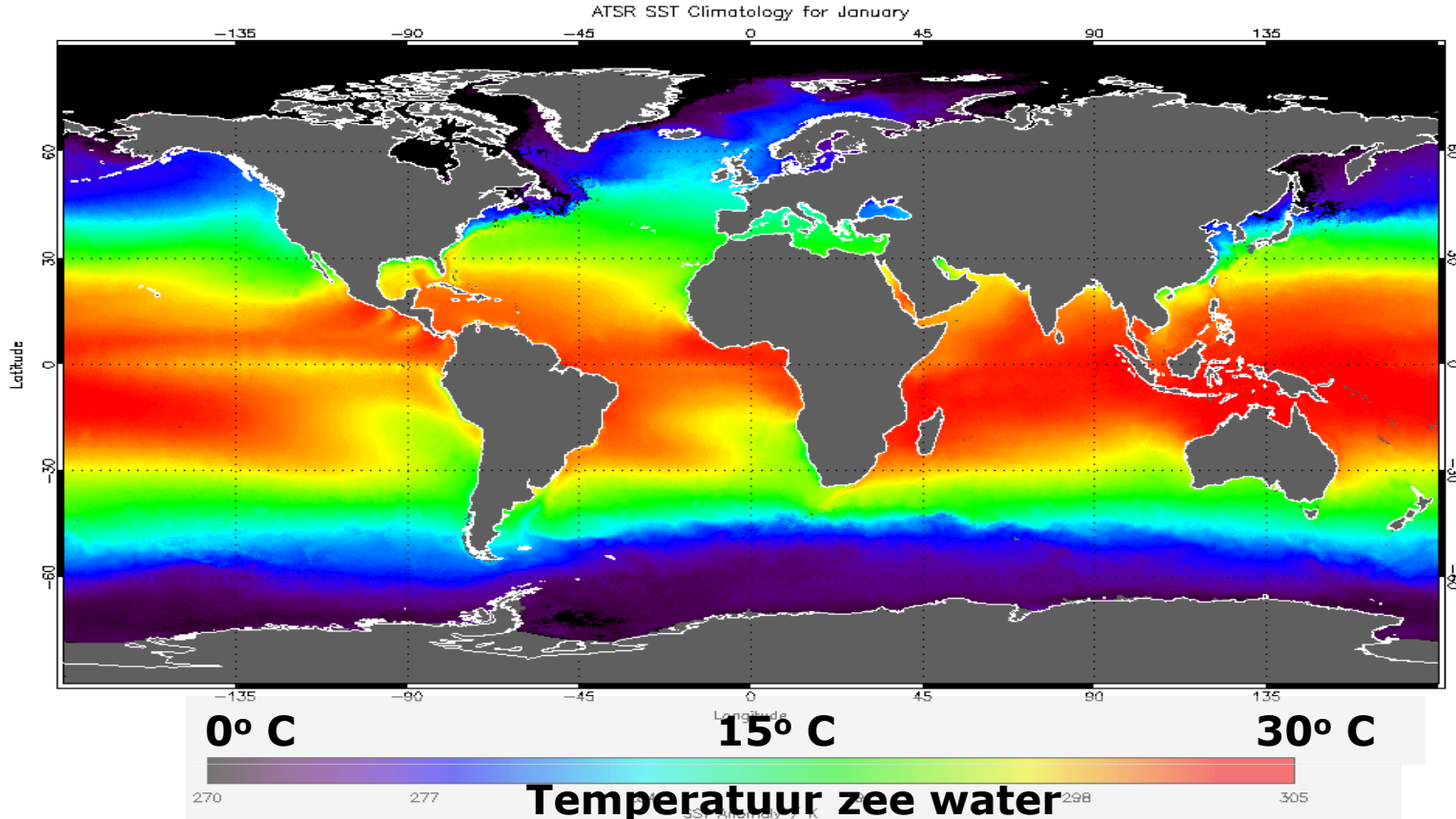


Sentinel 6
Jason CS (A/B)

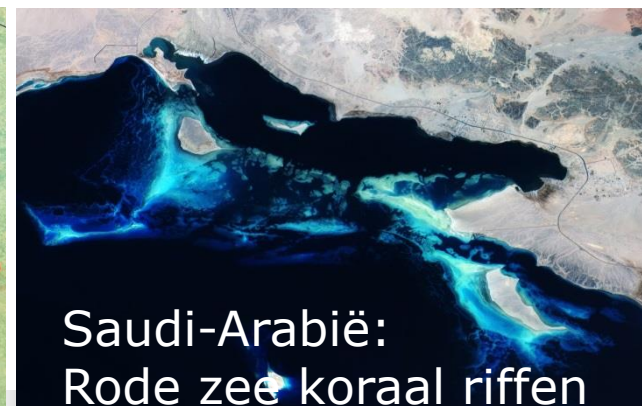
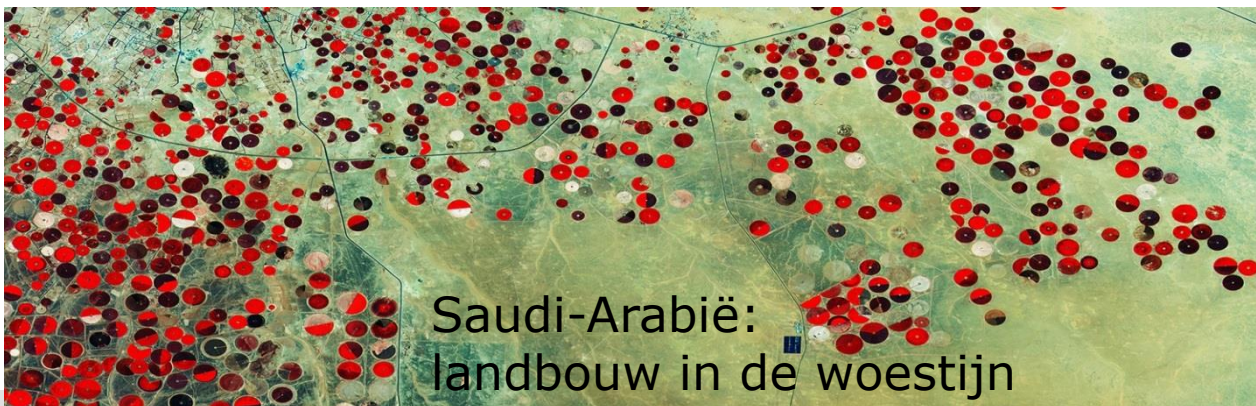
Satelliet hoogtemetingen, zee spiegel



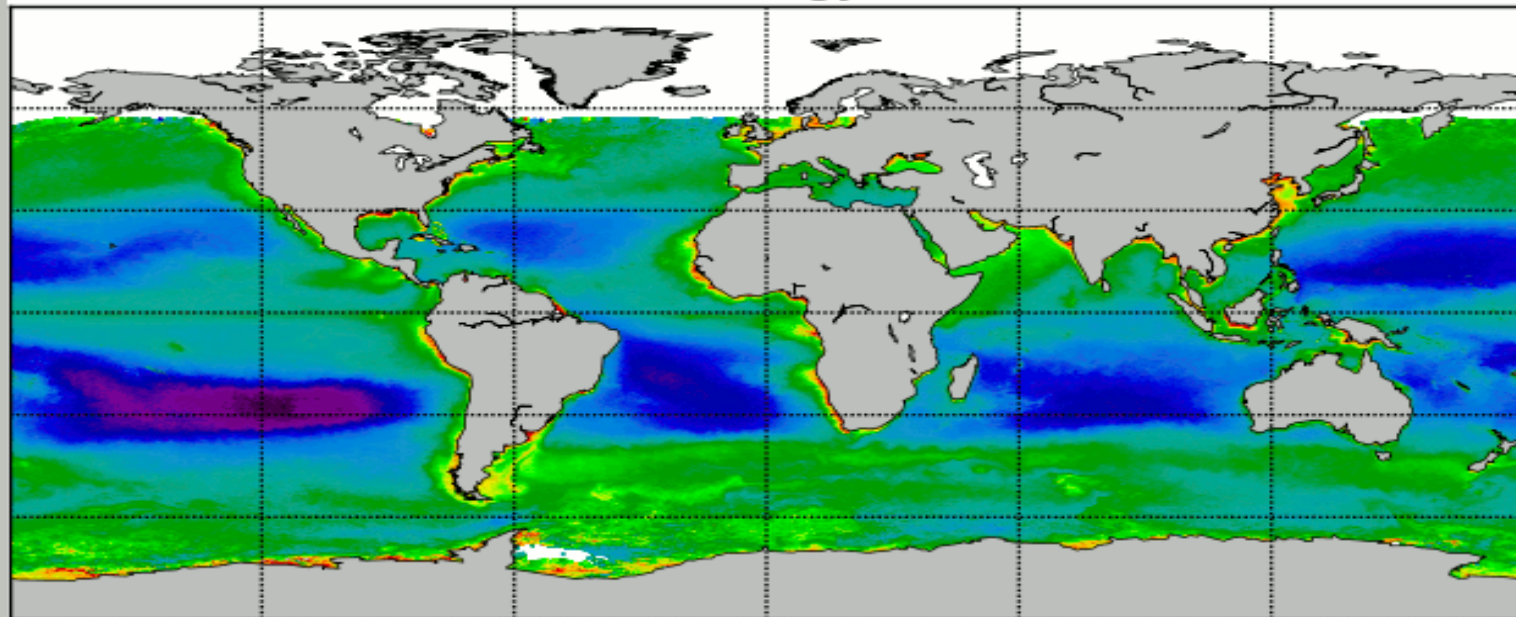
Meten "temperatuur" vanuit de ruimte



Sentinel-2A: Kleuren visie (hoge ruimtelijke resolutie (multispectral imager 13 bands))



CCI-V1.0 climatology of month 01



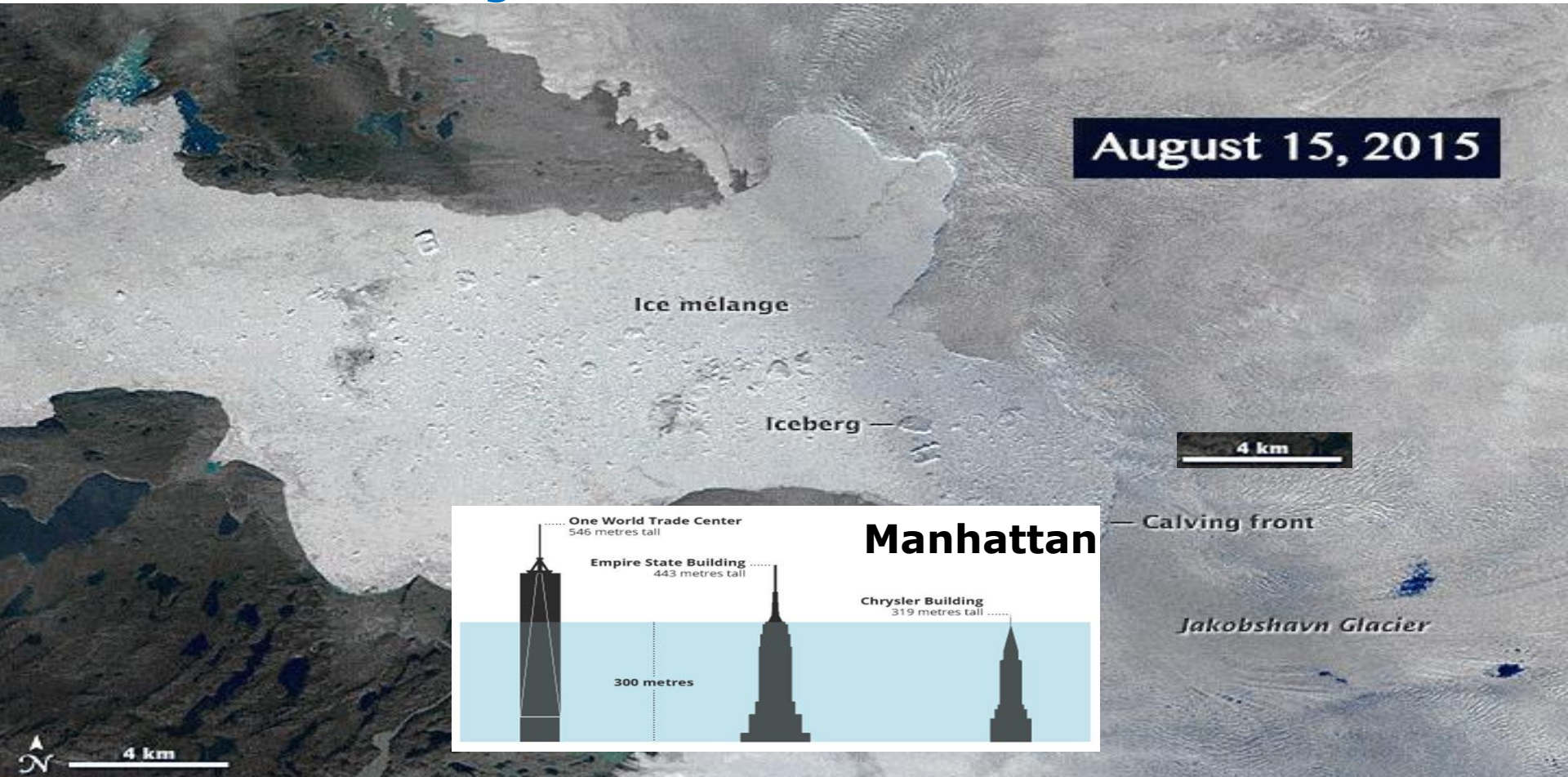
Acknowledgement: ESA Ocean Colour Climate Change Initiative Team product created using data from ESA and NASA.



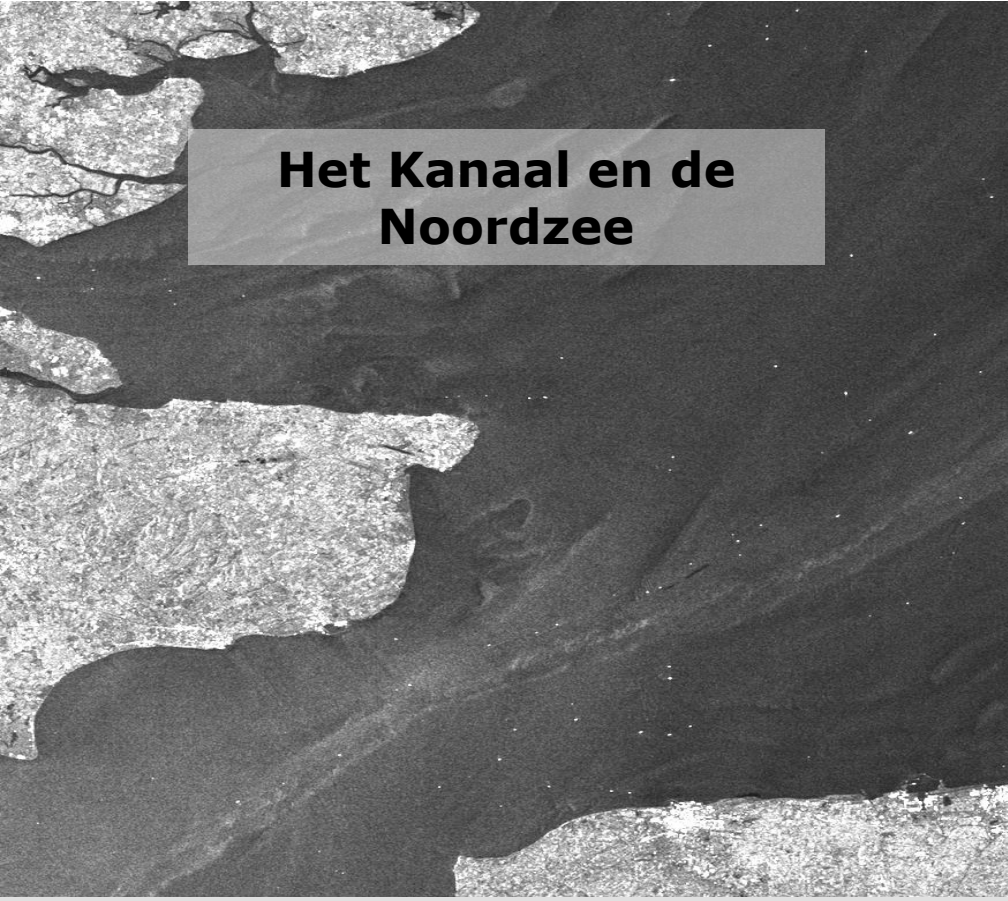
Chlorophyll-*a* concentration ($mg.m^{-3}$)

Afkalven van gletschers in Groenland

August 15, 2015



Scheepvaart en vervuiling (radar)



**Het Kanaal en de
Noordzee**

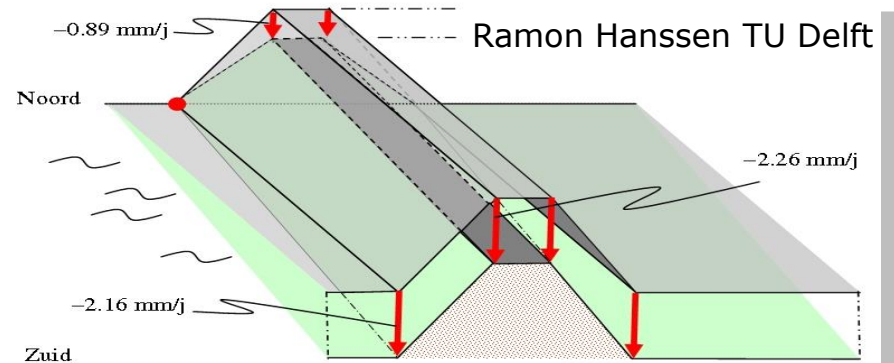
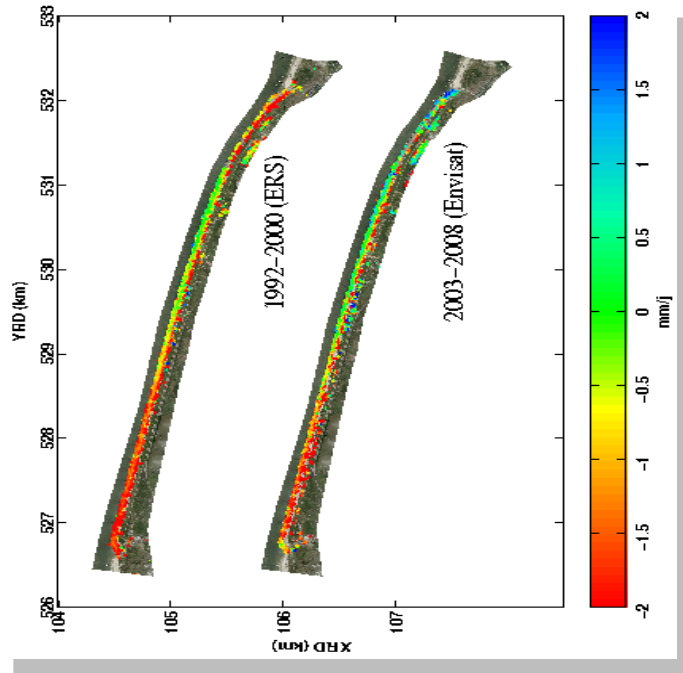


**Olie vlekken
resulteren in een
vlak zee oppervlak**

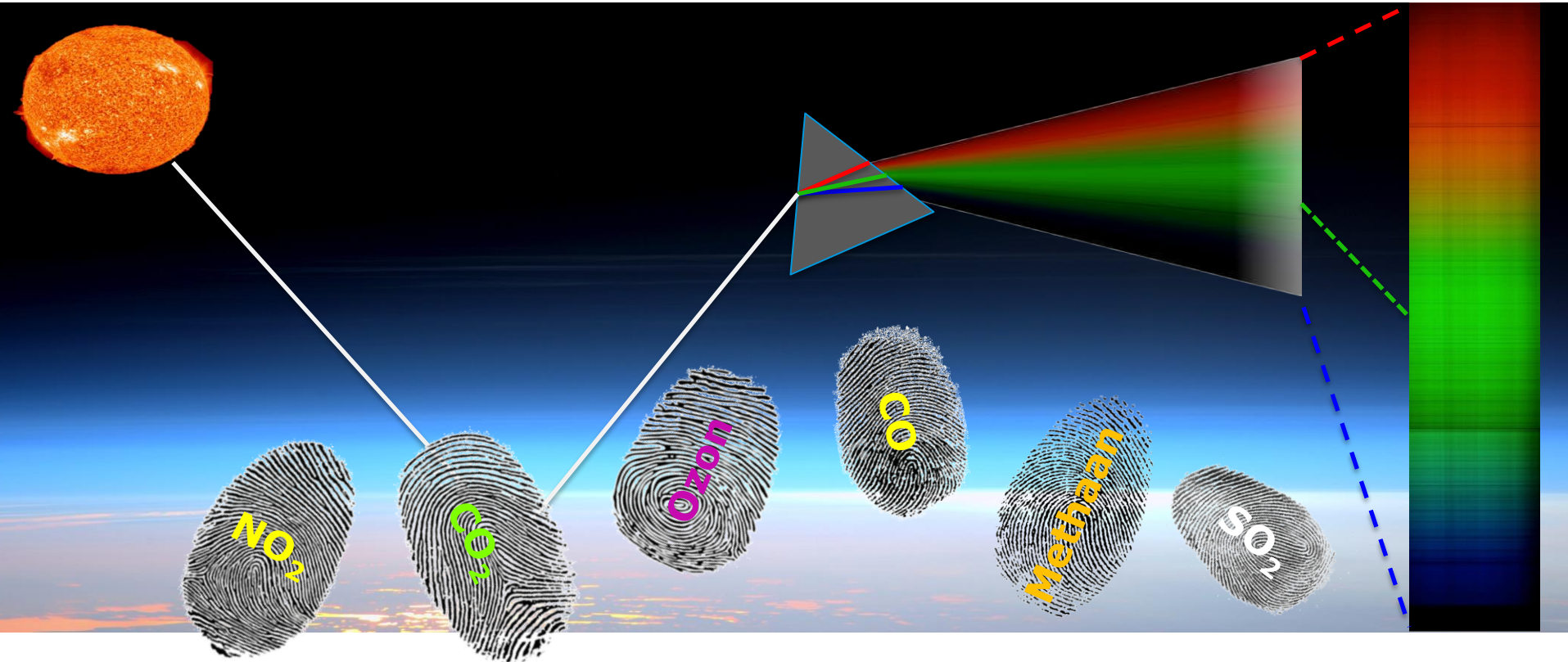


Monitoren van de dijken mbv radar opnames

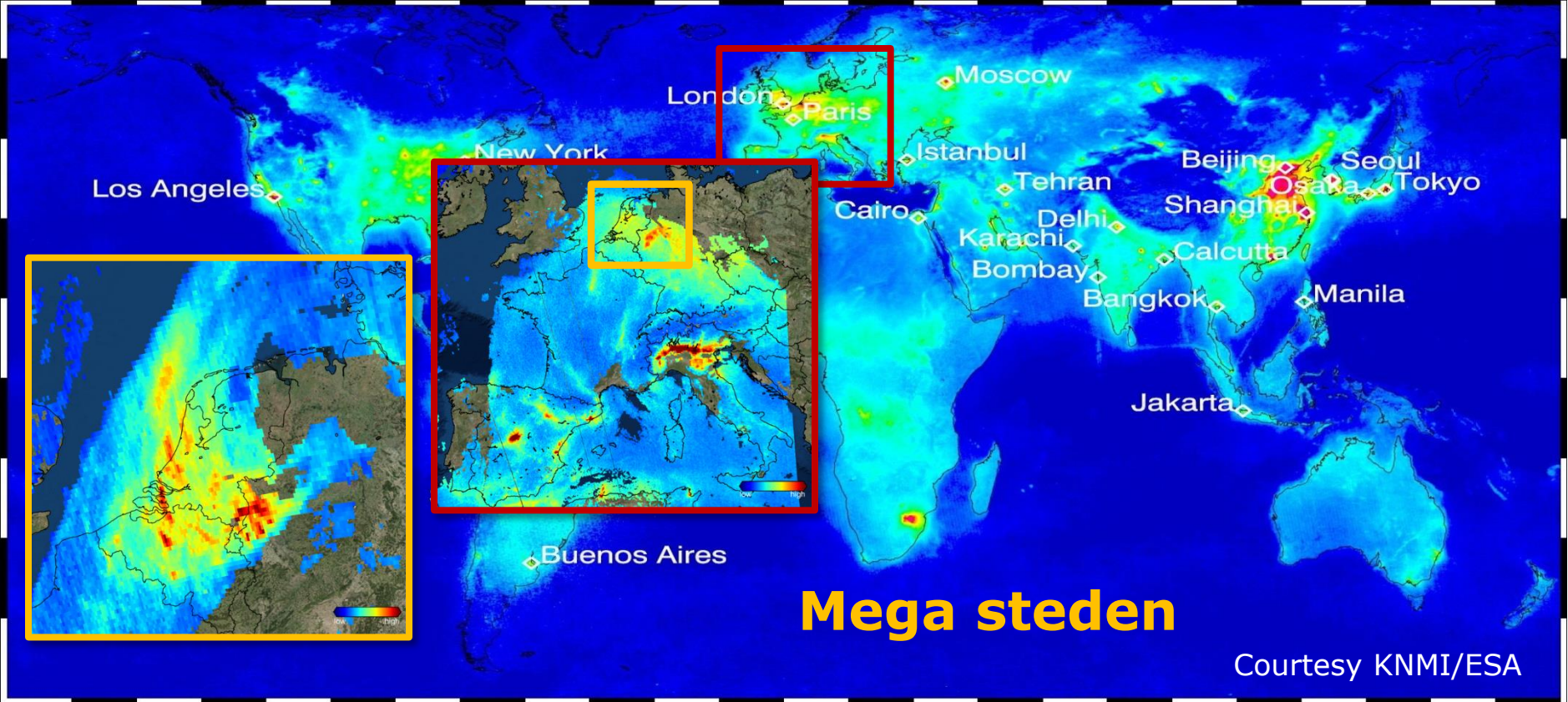
Hondsbossche zeekering



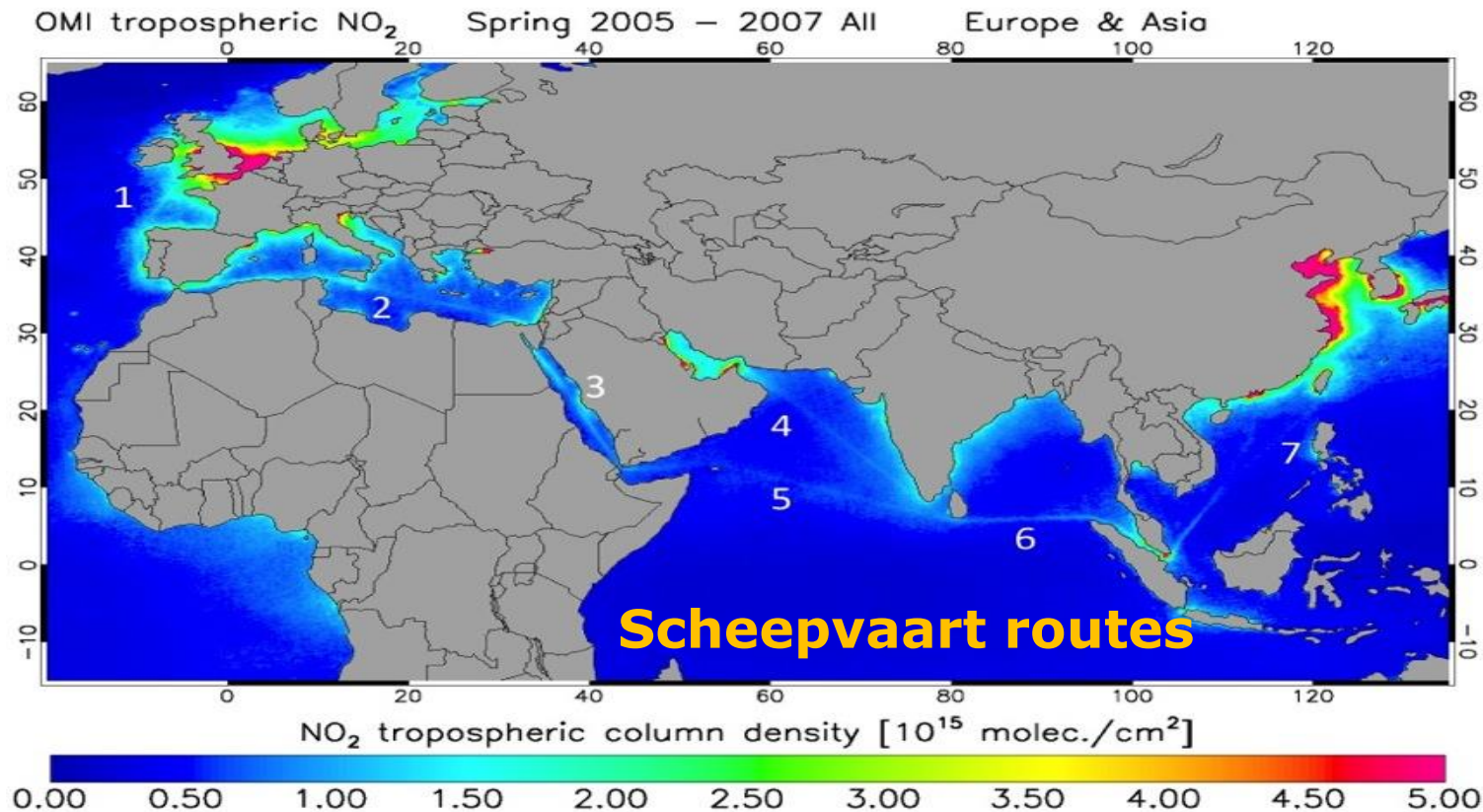
Hoe meten we gassen in de atmosfeer?



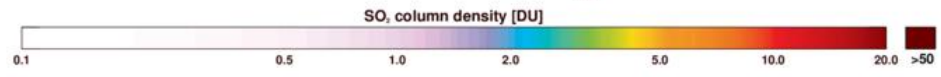
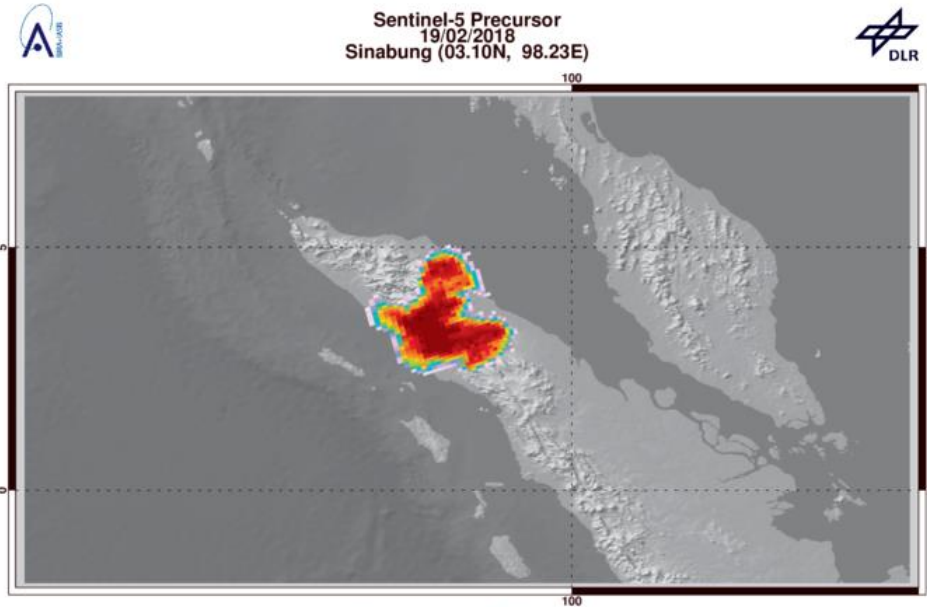
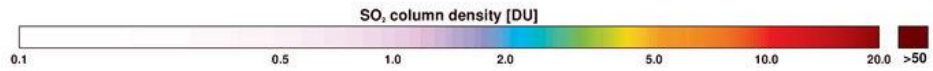
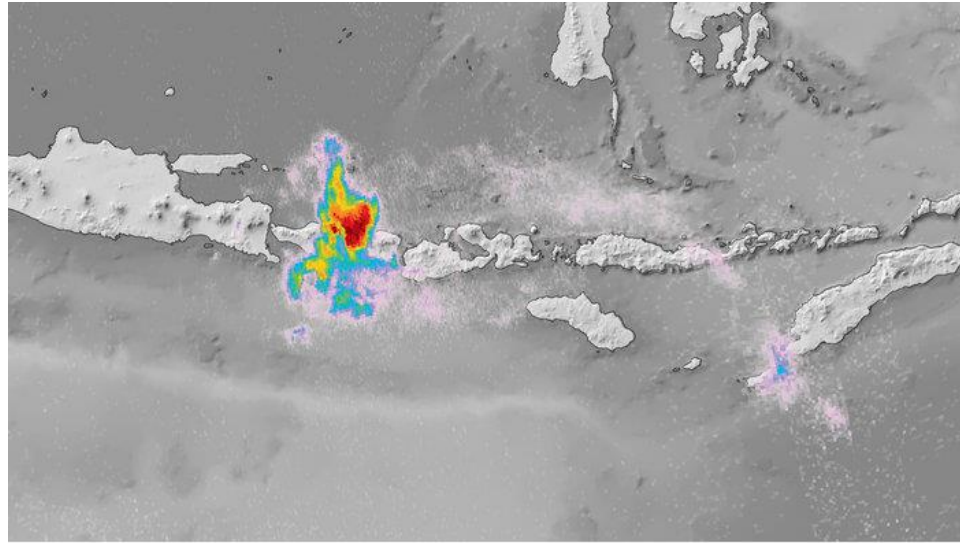
Luchtvervuiling- NO₂ (van OMI & TROPOMI op Sentinel-5p)



Luchtvervuiling- NO₂



Sentinel-5P: meet SO₂ uitstoot van vulkanen op Bali en Sumatra



Credit: DLR/BIRA/ESA

Earth Explorers: EO onderzoeks missies



GOCE	2009 - 2013
SMOS	2009 - Nu
CryoSat	2010 - Nu
Swarm	2013 - Nu
Aeolus	2018
EarthCARE	2019
Biomass	2021
FLEX	2022
EE9 (SKIM/FORUM)	2025

ESA Earth Explorers



GOCE

Zwaartekrachtsveld



17 March 2009

ADM-Aeolus

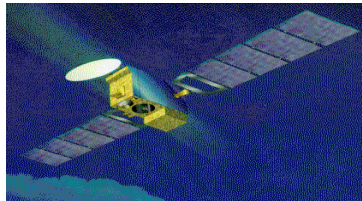
Wind missie



End 2018

EarthCARE

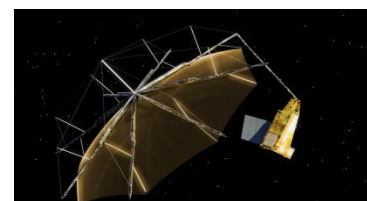
Wolken, aerosolen & straling



End 2020

BIOMASS

Biomassa in bossen



2021

Earth Explorers

2 November 2009

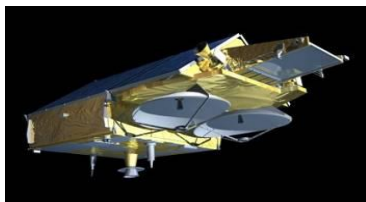


SMOS

Bodem vocht en zoutgehalte in de zee

ESA UNCLASSIFIED - For Official Use

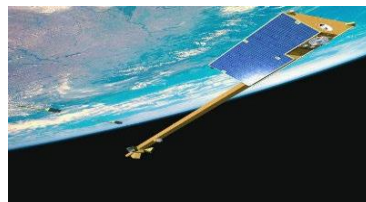
8 April 2010



CryoSat

Zee ijs dikte en verandering van ijskappen

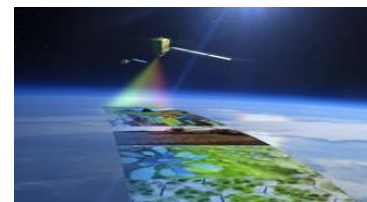
22 November 2013



Swarm

Aards magneetveld en interactie met de zon

2022



FLEX

Fluorescentie en planten

Core

Opportunity

ESA | 01/01/2016 | Slide 28



FLEX: Herbiciden experiment – stress detectie

Behandeling met herbiciden wat
photosynthese beïnvloed
Metingen 2-3 uur na de
behandeling

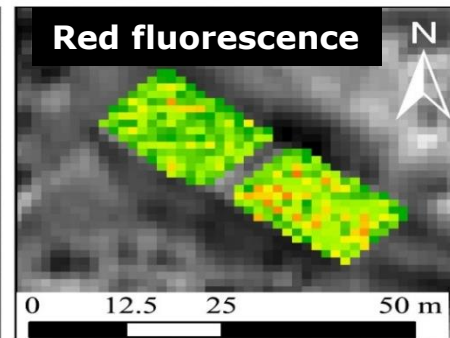
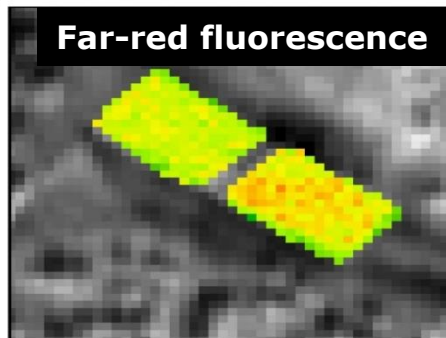
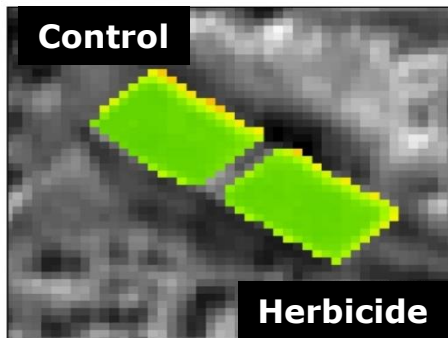


FLEX: zijn de planten gezond?

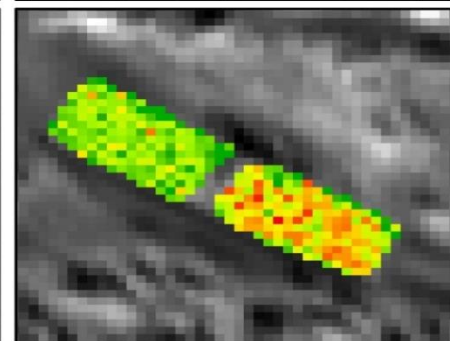
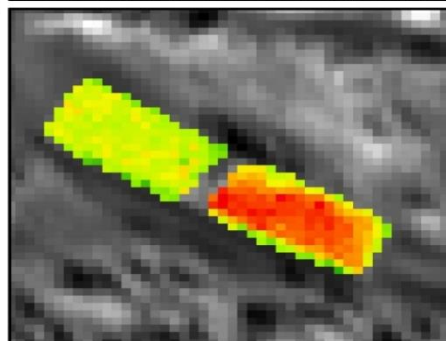
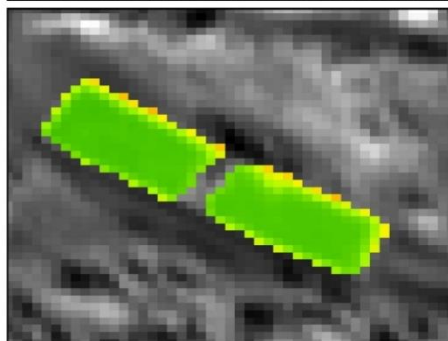
Fluorescentie bevat de verandering in fotosynthese



Lage
concentratie



Hogere
concentratie



NDVI



F_{FR} ($mW m^{-2} sr^{-1} nm^{-1}$)



F_R ($mW m^{-2} sr^{-1} nm^{-1}$)



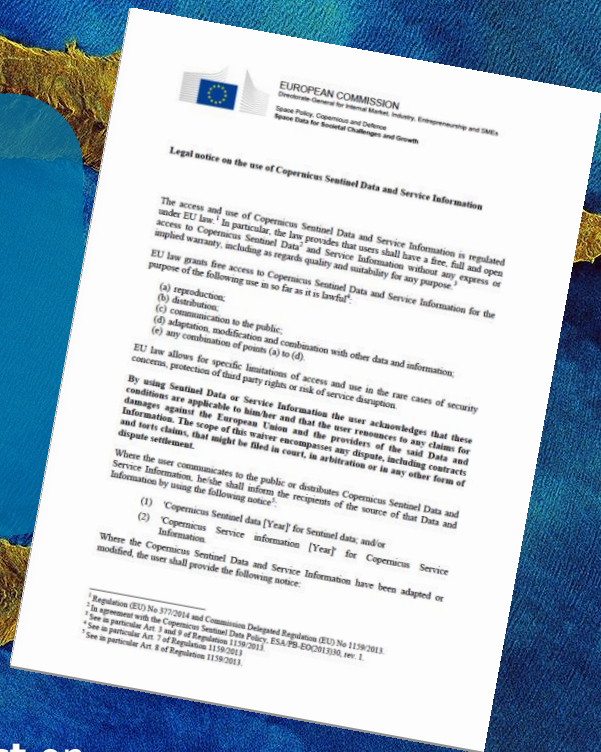
Rossini et al. (2015) *Geophysical Research Letters*, 42, doi:10.1002/2014GL062943

Copernicus Sentinel Data Policy



Sentinel data zijn beschikbaar:

- ✓ Vrij, volledig en open*
- ✓ Over hele lange periode
- ✓ Systematisch, operationeel



* **ESA Sentinel Data Policy** (Sep 2013) and **EU Delegated Act on Copernicus Data and Information Policy** (Dec 2013)



Financierings mogelijkheden in ESA



In diverse ESA programmas bijv. aard observatie, navigatie en Galileo (zie NSO presentatie)

ESA U

/01/2016 | Slide 32



Aardobservatie in ESA



Wij brengen aardobservatie naar de maatschappij

