Sentinel Vision
EVT-379
10 January 2019

3D Layerstack

Cyclone Kenanga examined by Sentinel-5P

Sentinel-5P TROPOMI CLOUD acquired on **15 December 2018** from 06:08:24 to 07:53:25 UTC
Sentinel-5P TROPOMI CLOUD acquired on **17 December 2018** from 07:13:25 to 08:58:25 UTC
Sentinel-3 OLCI FR & SLSTR RBT acquired on **20 December 2018** from 04:15:33 to 04:21:33 UTC
Sentinel-5P TROPOMI CLOUD, HCHO & O3 acquired on **20 December 2018** from 07:53:25 to 07:58:25 UTC
Sentinel-5P TROPOMI CLOUD acquired on **21 December 2018** from 07:38:25 to 09:18:24 UTC

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Keyword(s): Atmosphere, cloud, cyclone, hurricane, Indian Ocean

Fig. 1 - S5P TROPOMI (15.12.2018) - Cloud fraction - The tropical storm Kenanga starts to rotate. 3D view

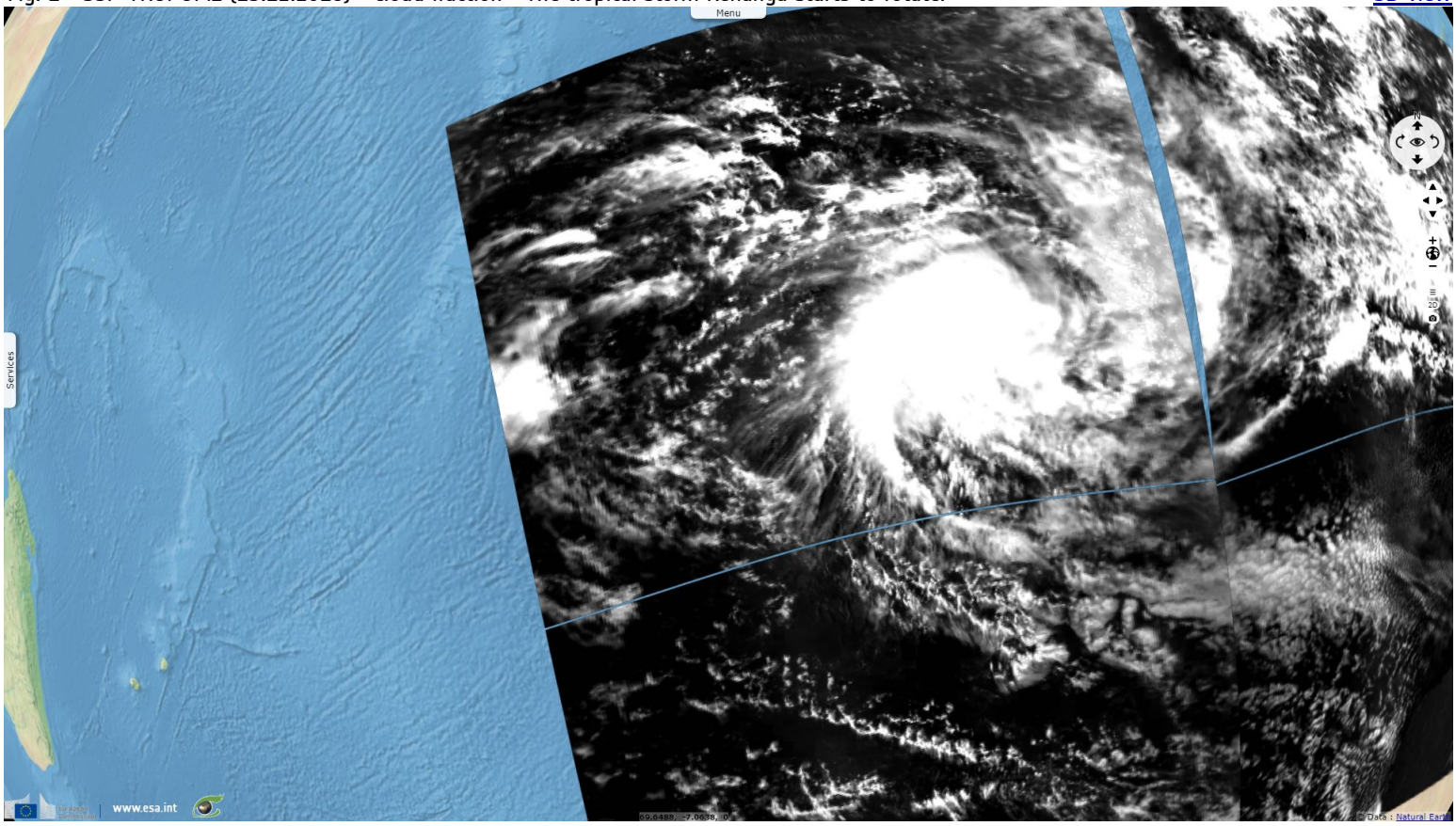
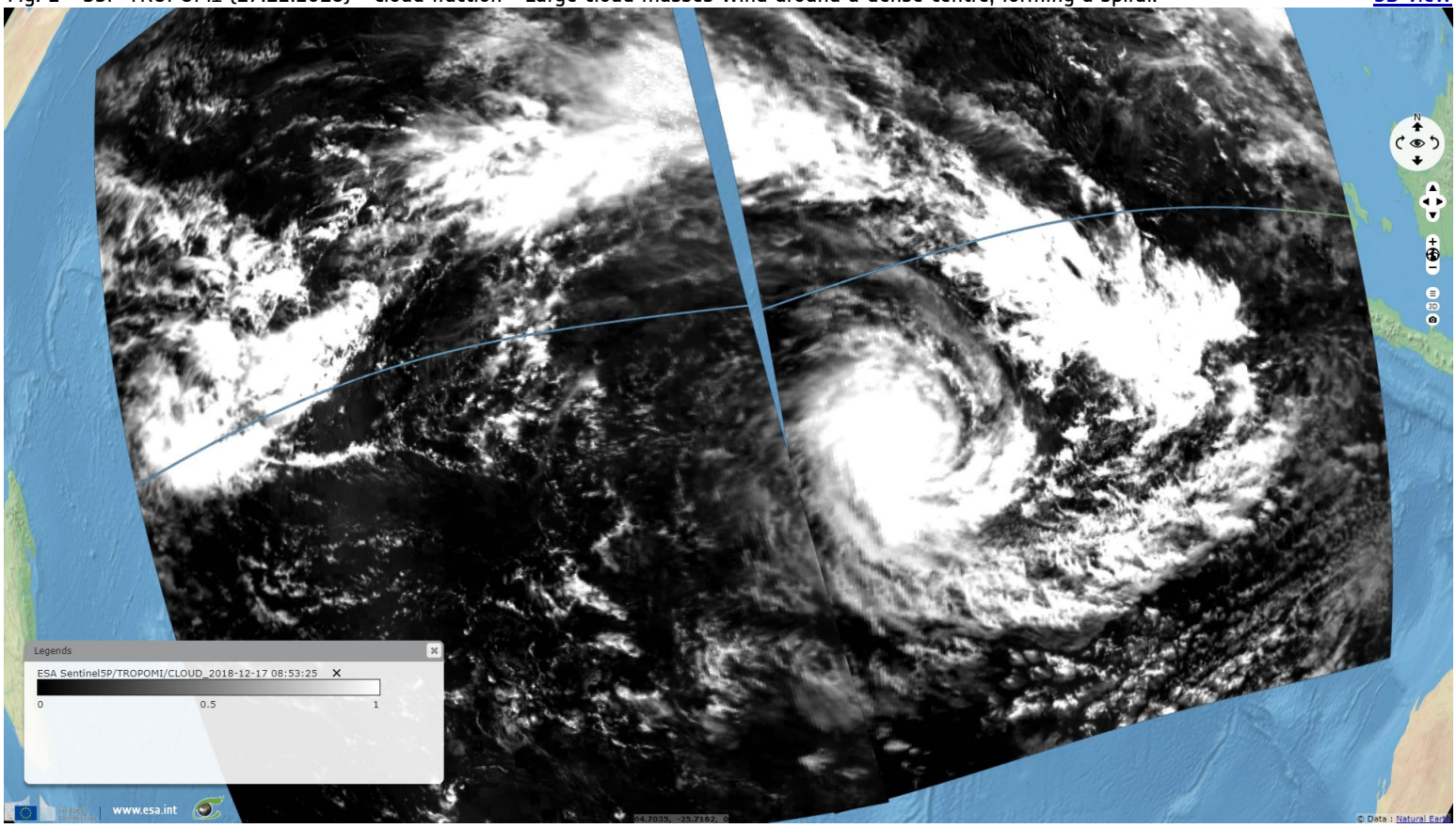
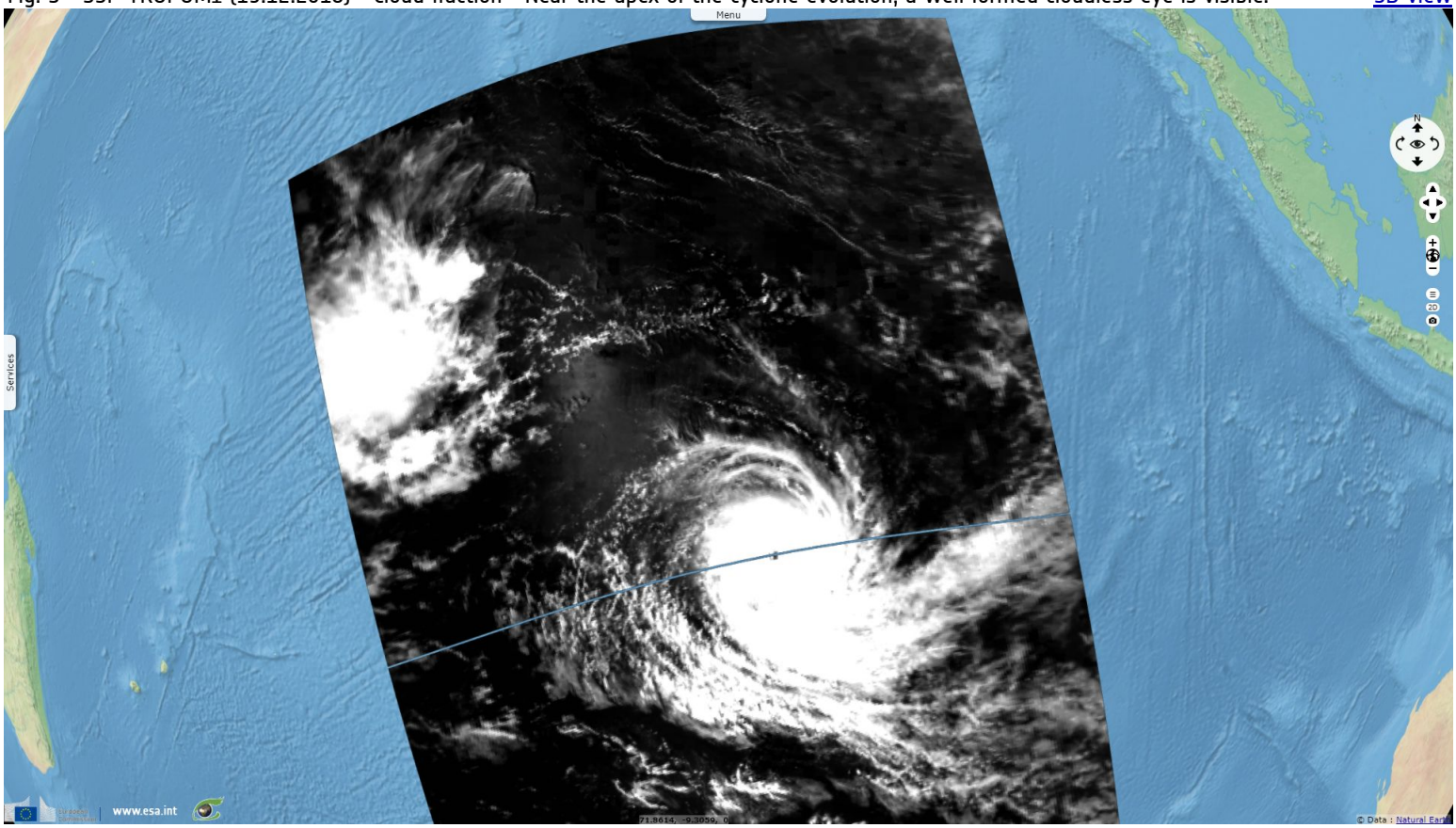


Fig. 2 - S5P TROPOMI (17.12.2018) - Cloud fraction - Large cloud masses wind around a dense centre, forming a spiral. 3D view



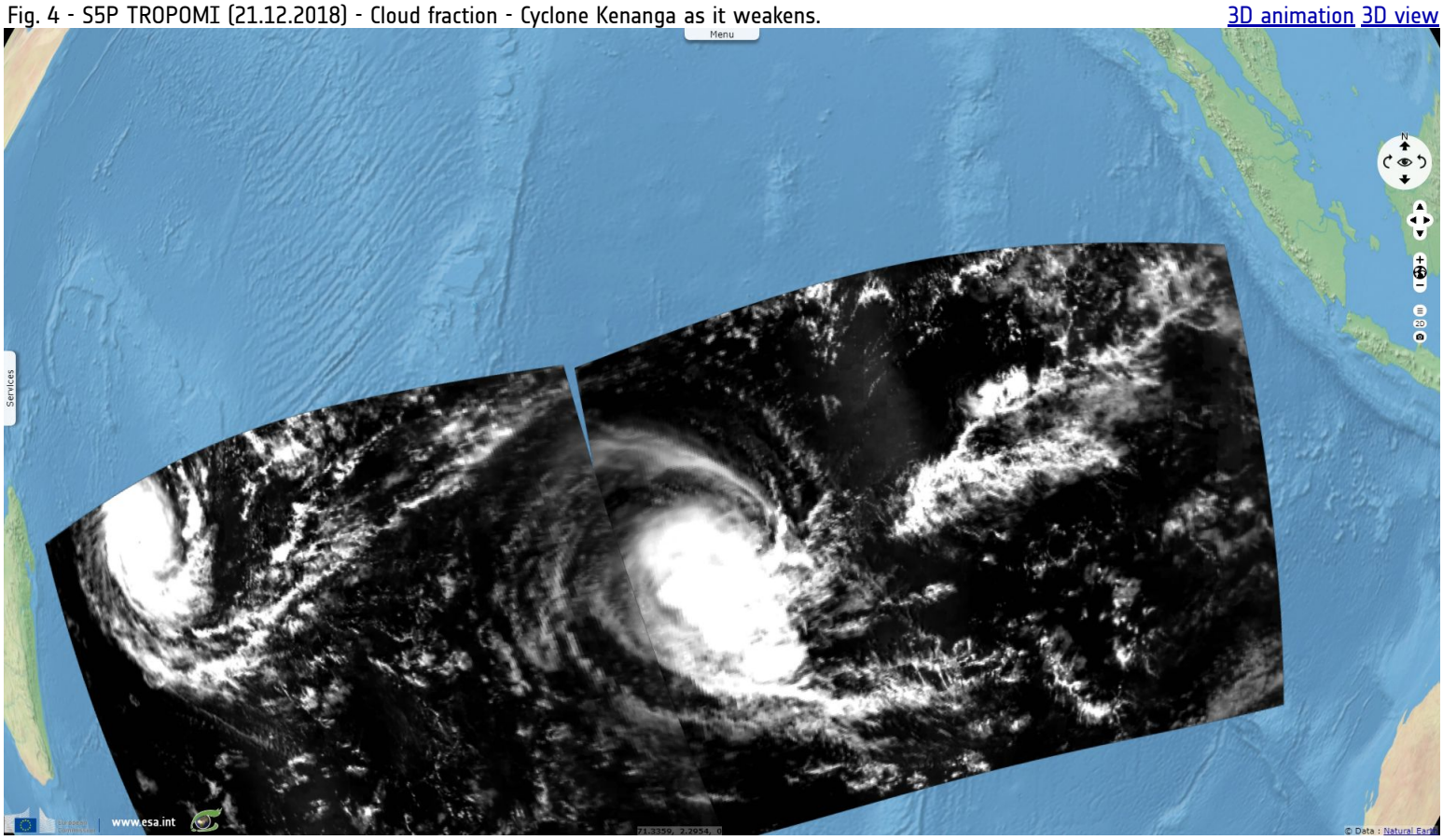
At the same time cyclone Cilida was approaching Mascareignes, another cyclone named Kenanga was roaming the eastern part of the Indian Ocean. The Copernicus constellation can count on the large swath of both Sentinel-3 platforms but also on Sentinel-5P near-daily global cover to follow such phenomena.

Fig. 3 - S5P TROPOMI (19.12.2018) - Cloud fraction - Near the apex of the cyclone evolution, a well formed cloudless eye is visible. 3D view



On 19.12.2018, Hal Pierce and Lynn Jenner published in the hurricane section of the NASA blog: "*NASA found very cold cloud top temperatures within the Southern Indian Ocean's Tropical Cyclone Kenanga that indicate powerful thunderstorms reaching high into the troposphere. Those storms were generating very heavy rainfall as confirmed by the Global Precipitation Measurement mission or GPM core satellite.*"

Fig. 4 - S5P TROPOMI (21.12.2018) - Cloud fraction - Cyclone Kenanga as it weakens. 3D animation 3D view



Two days later, they added: "*On December 20, 2018, NASA's Global Precipitation Measurement mission or GPM core observatory satellite passed over the Tropical Cyclone Kenanga and captured the storm beginning to weaken as predicted. The GPM satellite had an excellent view of the Kenanga when the tropical cyclone's maximum sustained winds were at [167 kph]. GPM's pass showed the eye of the storm, visible the day before, had since filled in.*

GPM's instruments including the Microwave Imager (GMI) and the Dual-Frequency Precipitation Radar (DPR) revealed that the powerful storms south of Kenanga's center are still producing very heavy rainfall at the rate of 214 mm per hour in that area. The rainfall in the northern half of the storm had decreased significantly."

Track of cyclonic system Kenanga - Source: meteo-reunion.fr/

This "*view of Kenanga showed extremely powerful storms south of Kenanga's deteriorating eye were returning very strong reflectivity values which help to map the severity of the storm and the rainfall totals. The storm tops of the eyewall which had remained intact on the western side of the cyclone were reaching heights of 12.7 km.*

The Joint Typhoon Warning Center predicts that Kenanga will continue to weaken rapidly as the dry air within the storm gets colder and heavier causing downdrafts. It is the dry air higher aloft that contributes to stronger convective wind gusts and therefore stronger storms. Kenanga is forecast to dissipate in the next 72 hours as it tracks within the northeast periphery of Tropical Cyclone Cilida."

Fig. 5 - S3 OLCI (20.12.2018) - 10,6,3 natural colour - OLCI view of cyclone Kenanga in natural colour. 3D view

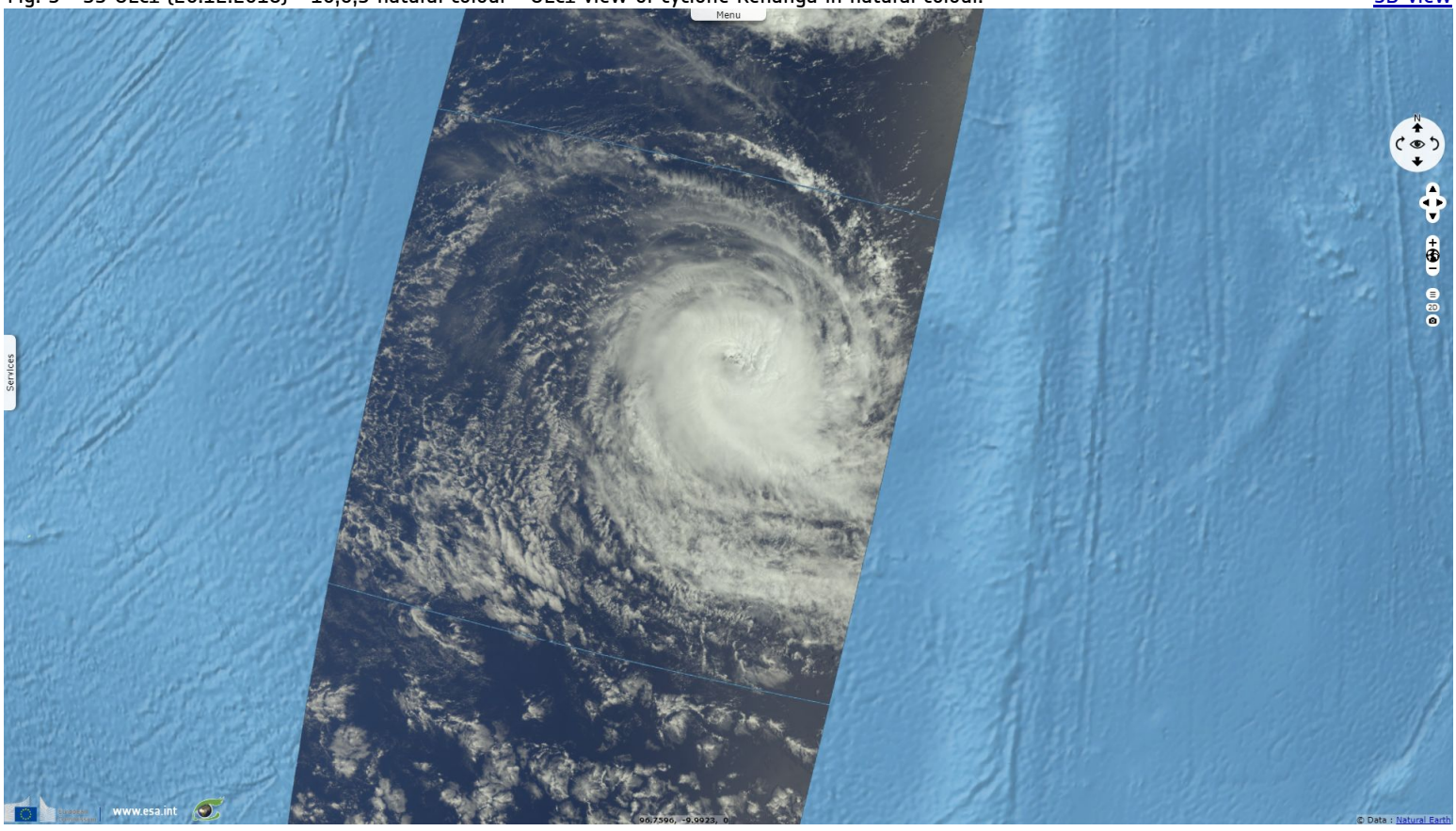


Fig. 6 - S5P TROPOMI (20.12.2018) - Cloud fraction - TROPOMI image of the cloud fraction acquired 4 hours later. 3D view

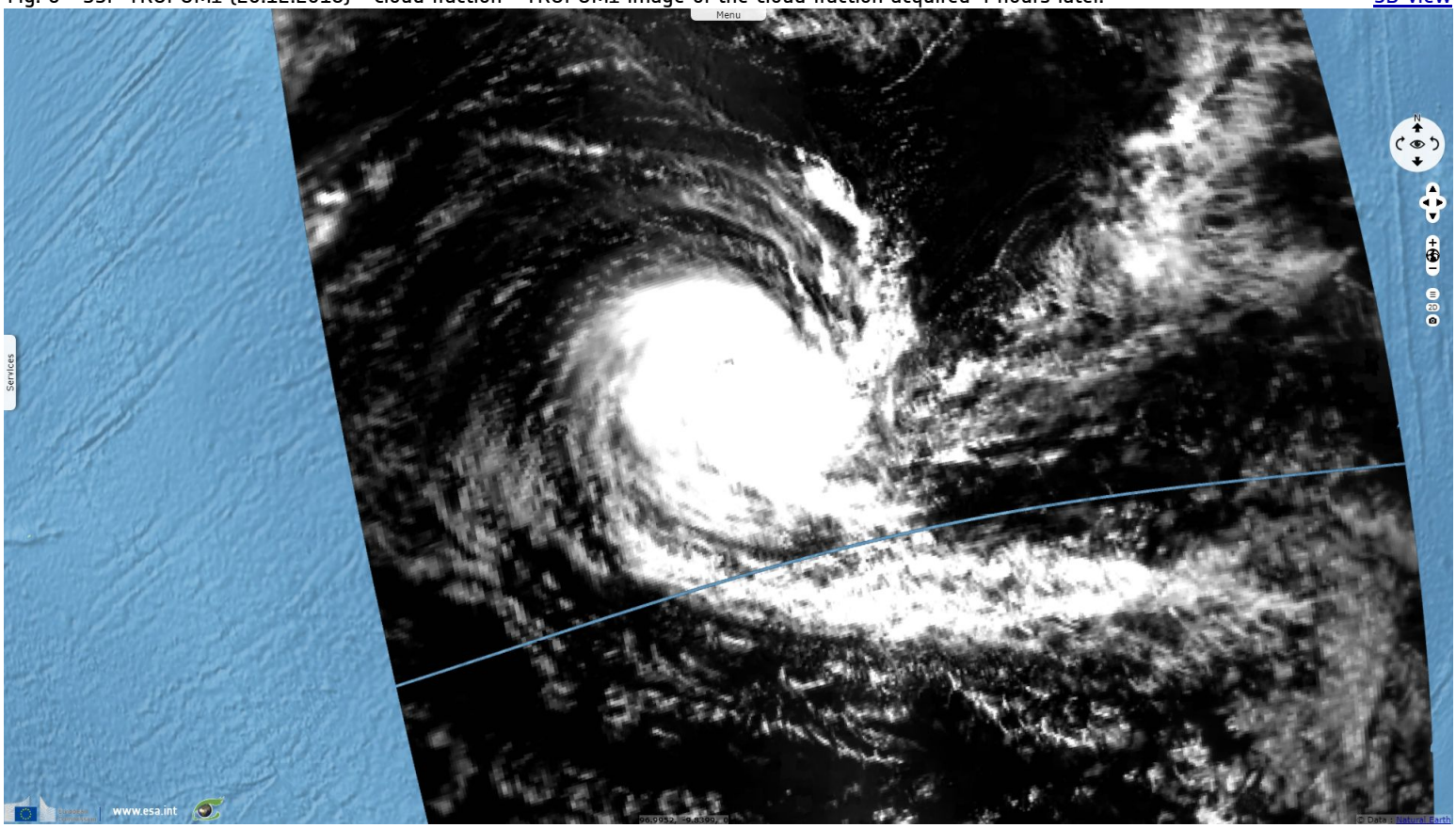
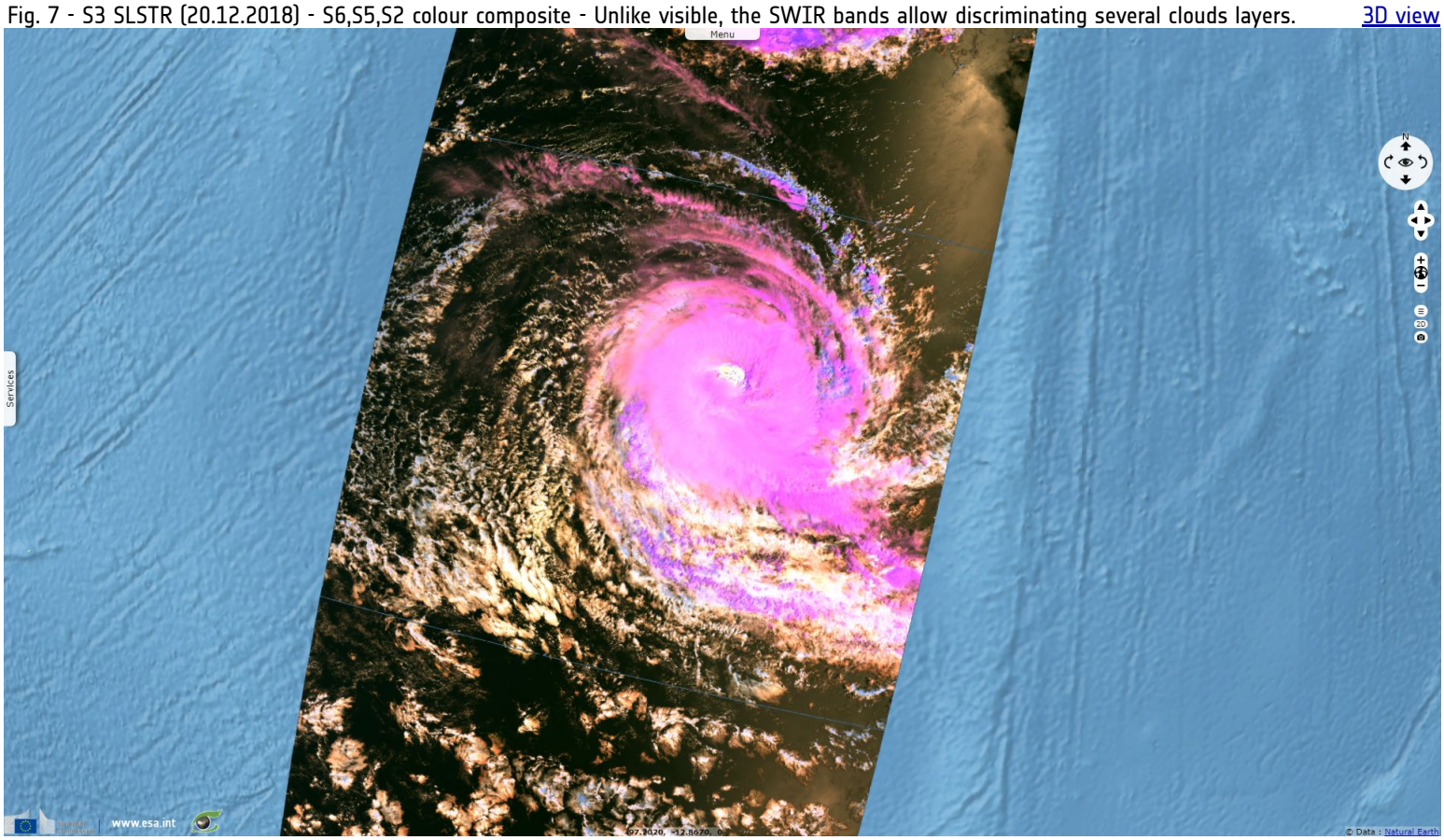


Fig. 7 - S3 SLSTR (20.12.2018) - S6,S5,S2 colour composite - Unlike visible, the SWIR bands allow discriminating several clouds layers. 3D view



While all cloud layers reflect the 659nm band (blue channel), they reflect differently in the 2 SWIR bands in 1610nm (green) & 2250nm (red) bands.

Fig. 8 - S3 SLSTR (20.12.2018) - S8 thermal band with colour map - The cloud top temperature is related to its altitude by the lapse rate. 3D view

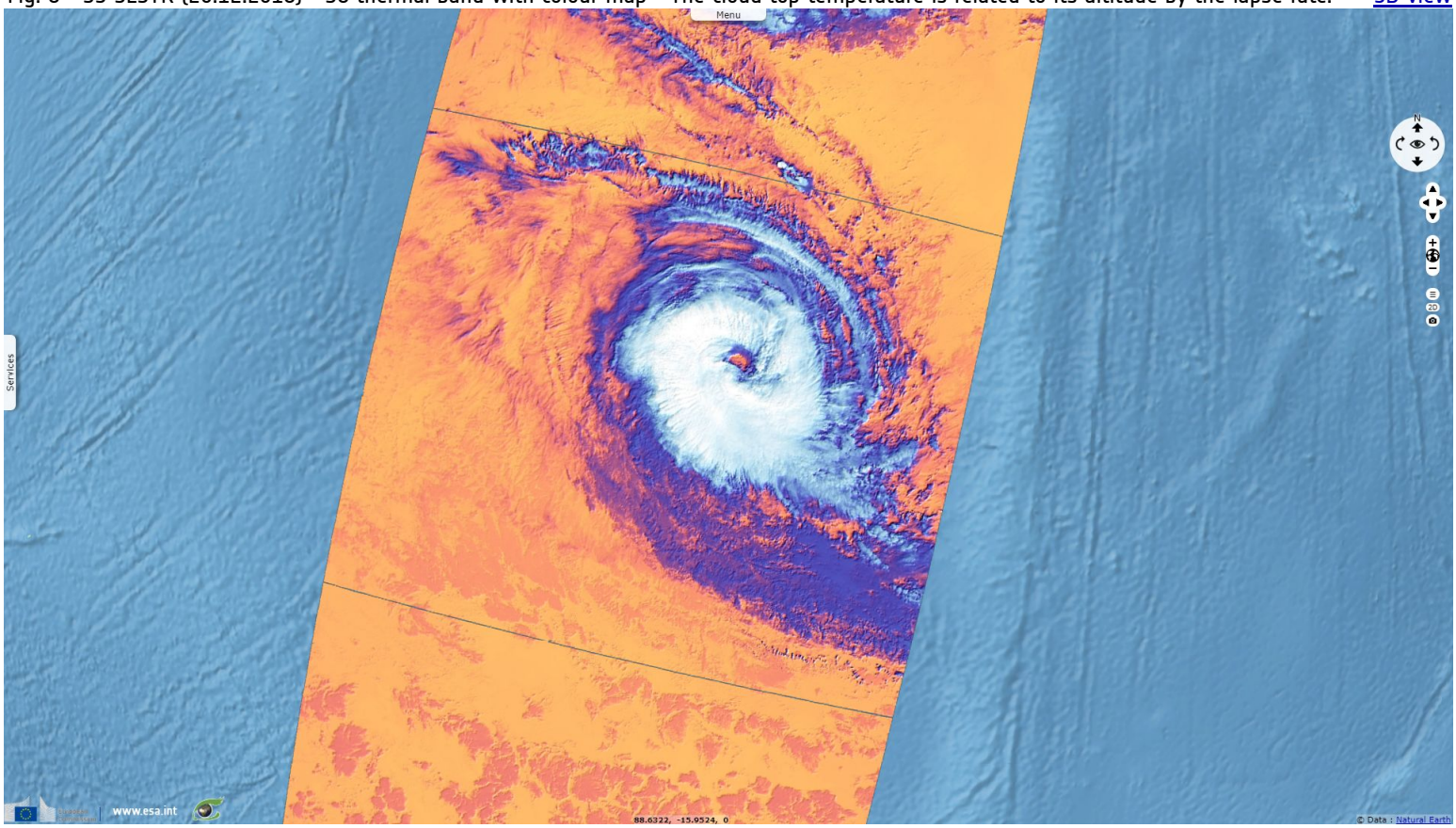


Fig. 9 - S5P TROPOMI (20.12.2018) - Cloud top height - Which shows when comparing with Kenanga's cloud top height mesured 4h later. 3D view

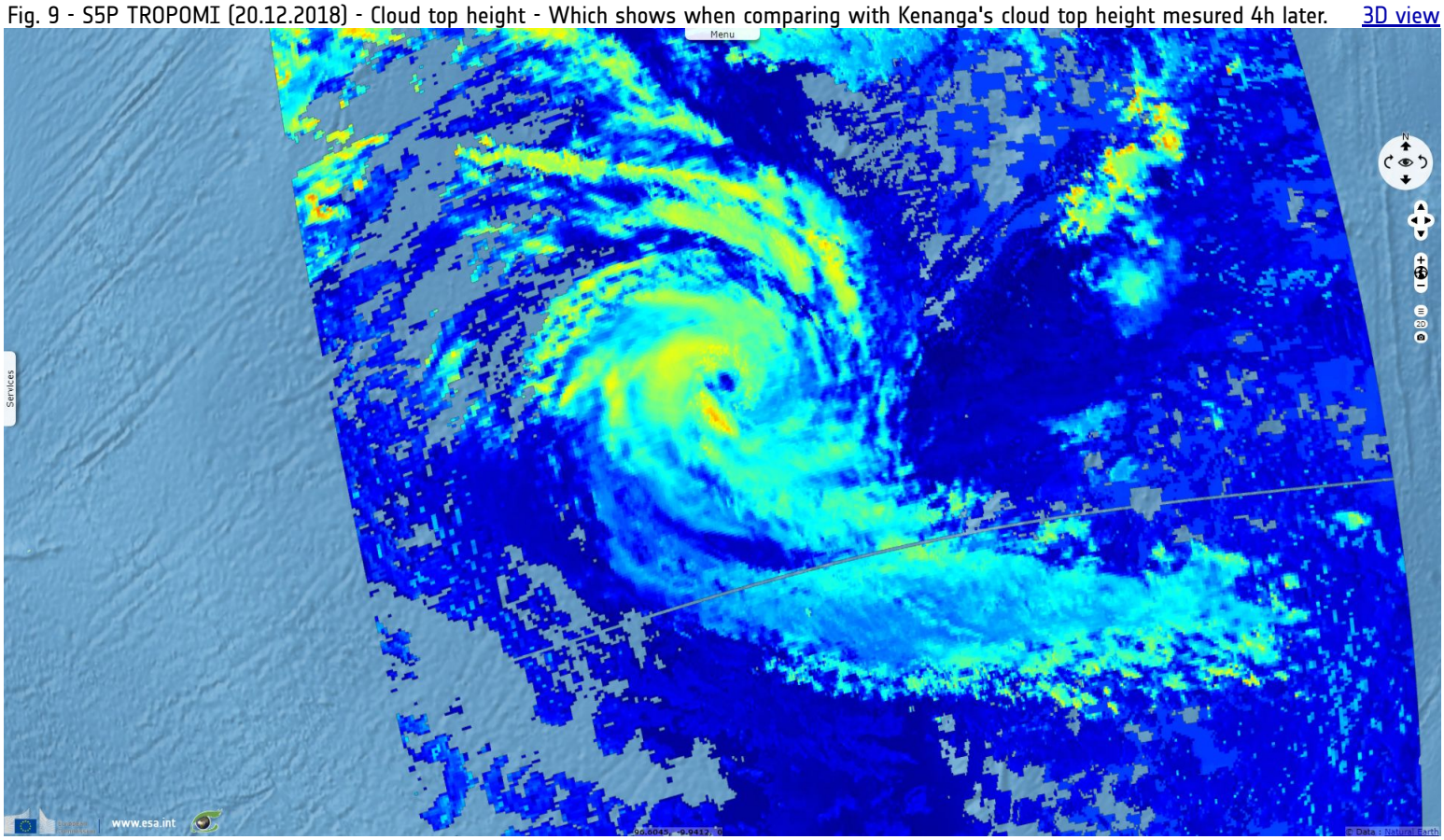
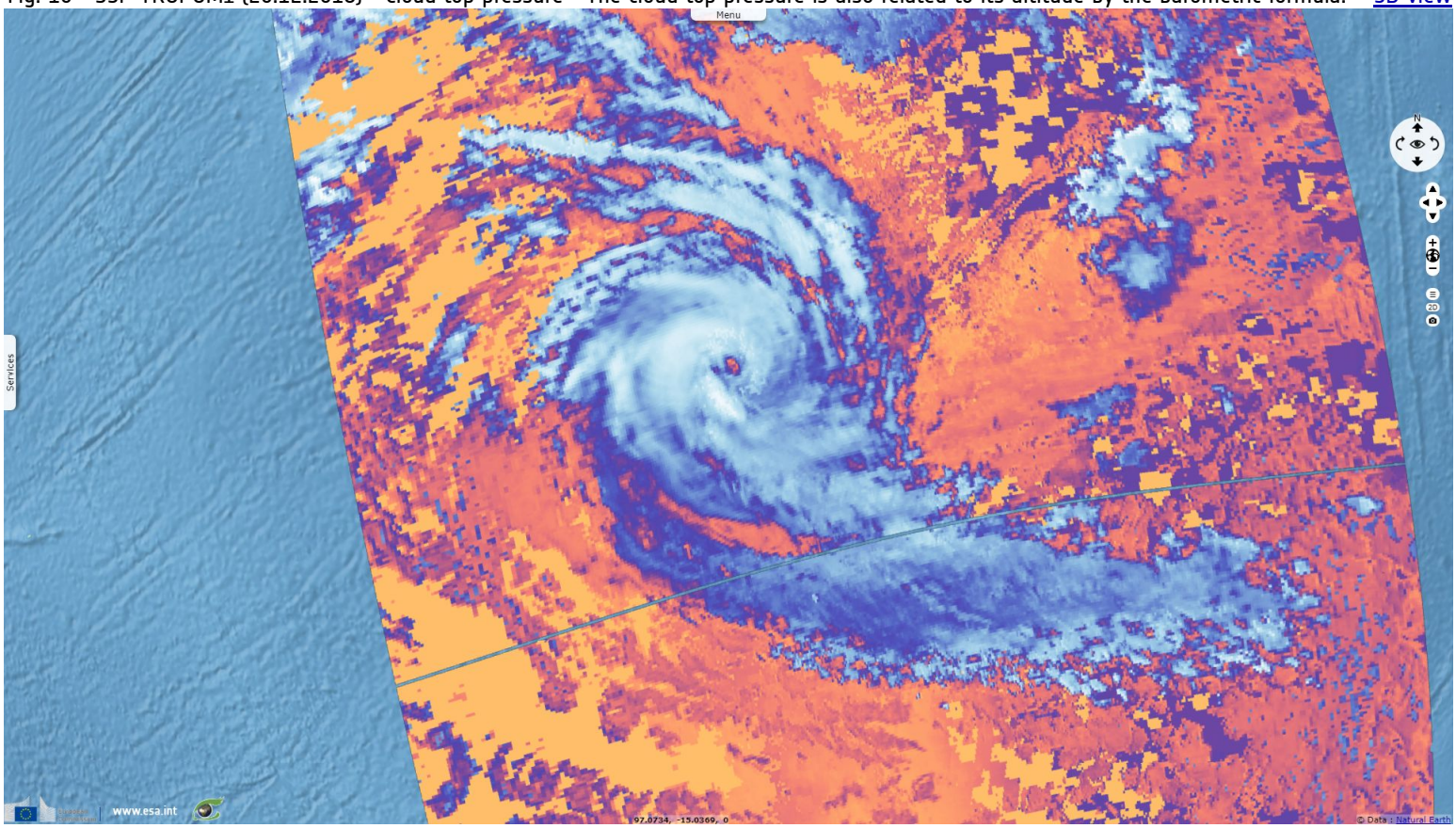
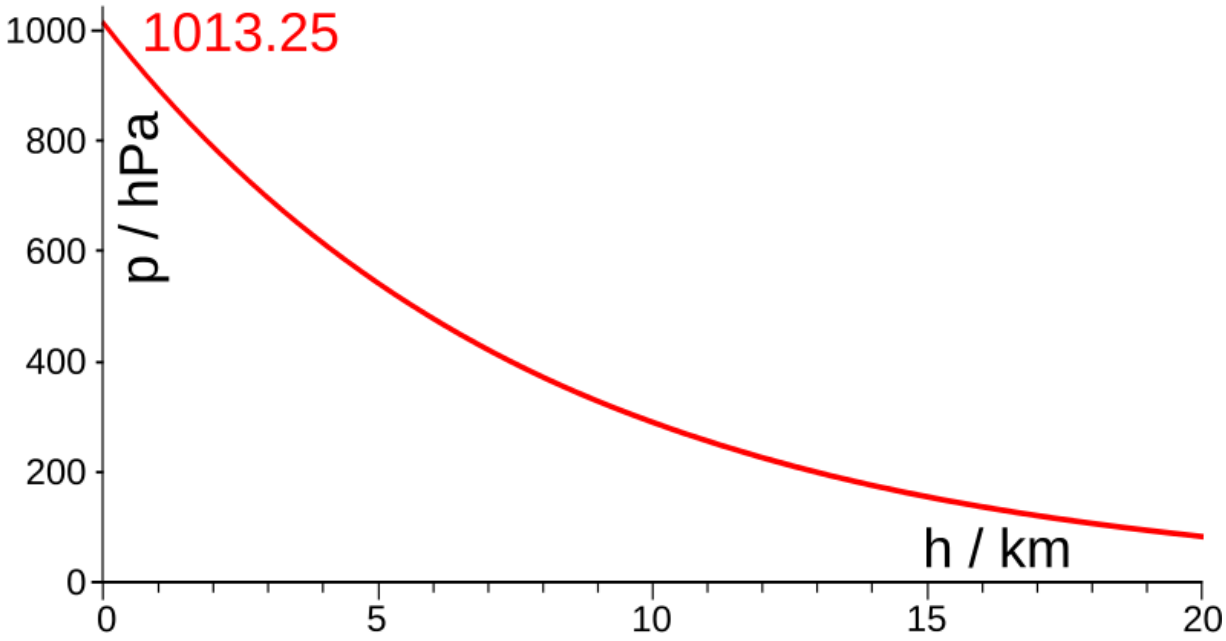


Fig. 10 - S5P TROPOMI (20.12.2018) - Cloud top pressure - The cloud top pressure is also related to its altitude by the barometric formula. 3D view



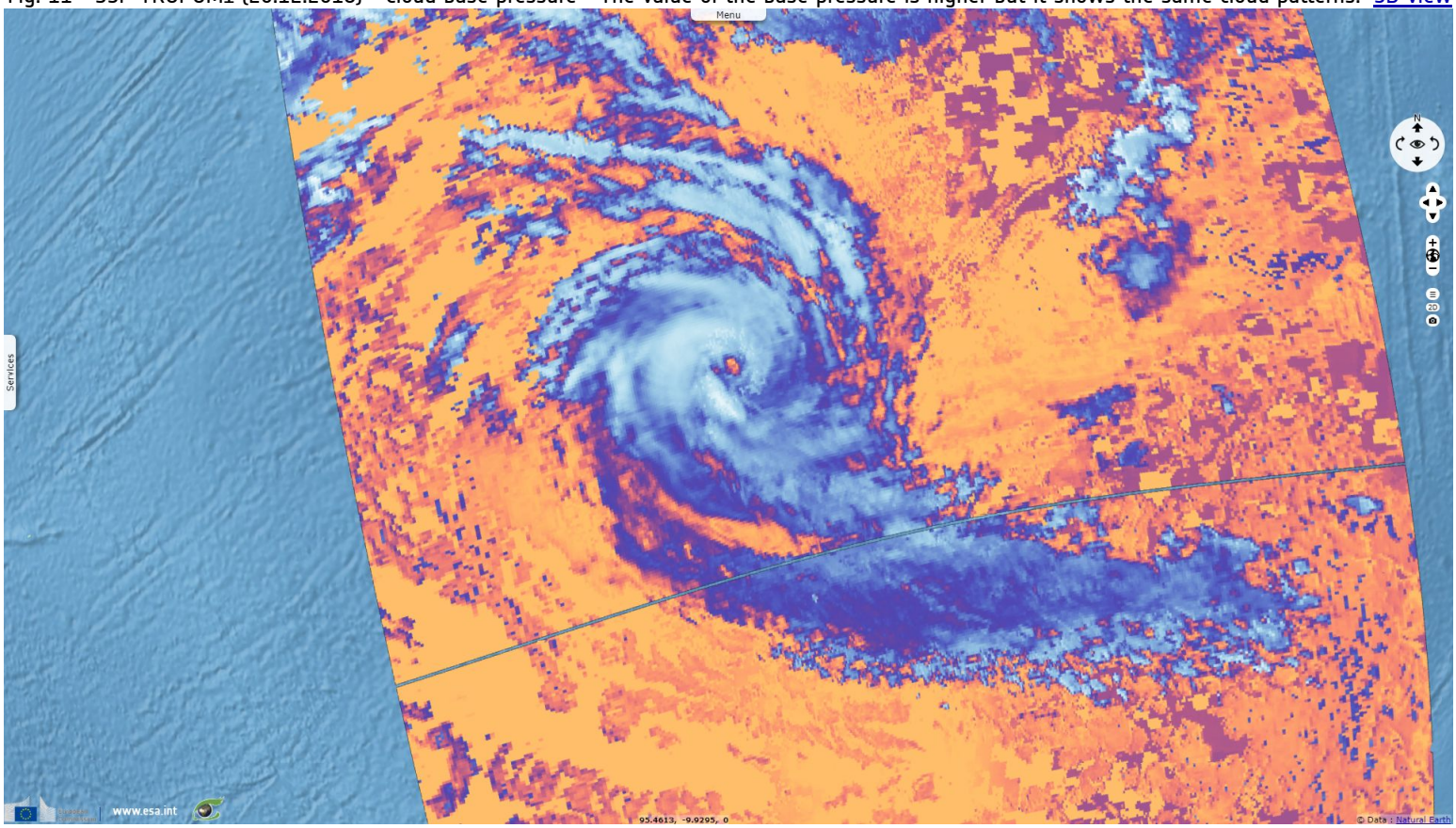
$$p(h) = p_0 \cdot e^{-\frac{\rho \cdot g \cdot h}{p_0}}$$

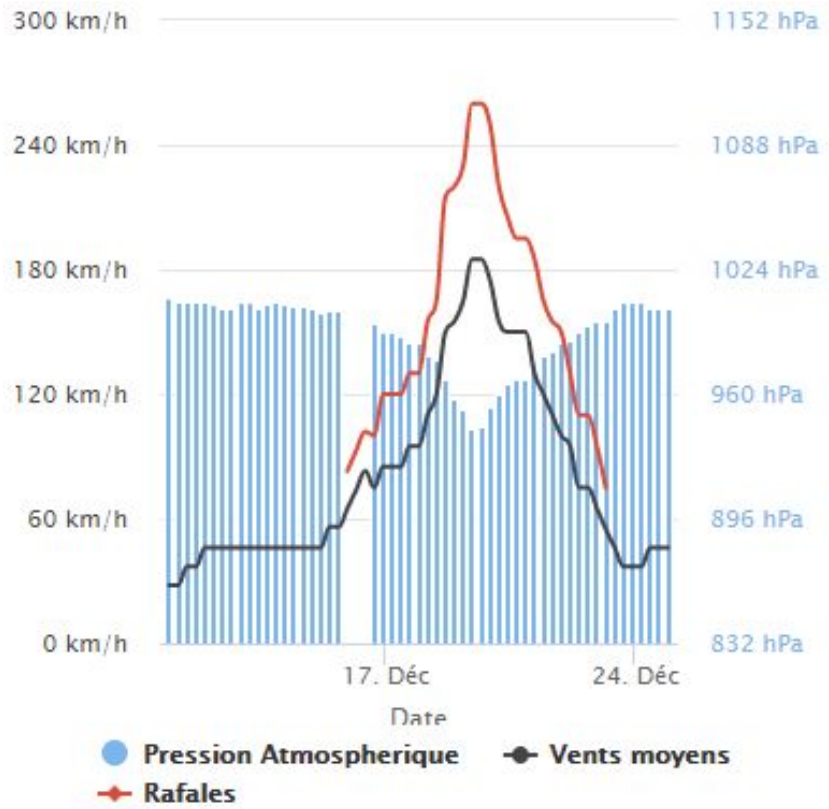
Barometric formula - Source: Klaus-Dieter Keller



Air pressure p as a function of the altitude h - Source: Klaus-Dieter Keller

Fig. 11 - S5P TROPOMI (20.12.2018) - Cloud base pressure - The value of the base pressure is higher but it shows the same cloud patterns. 3D view





Evolution of cyclonic system Kenanga (sustained wind speed in black, gusts wind speed in red, central pressure in blue - Source: meteo-reunion.fr/

Fig. 12 - S5P TROPOMI (20.12.2018) - Ozone total column - The values of the ozone total column seem lower where the pressure is low. 3D view

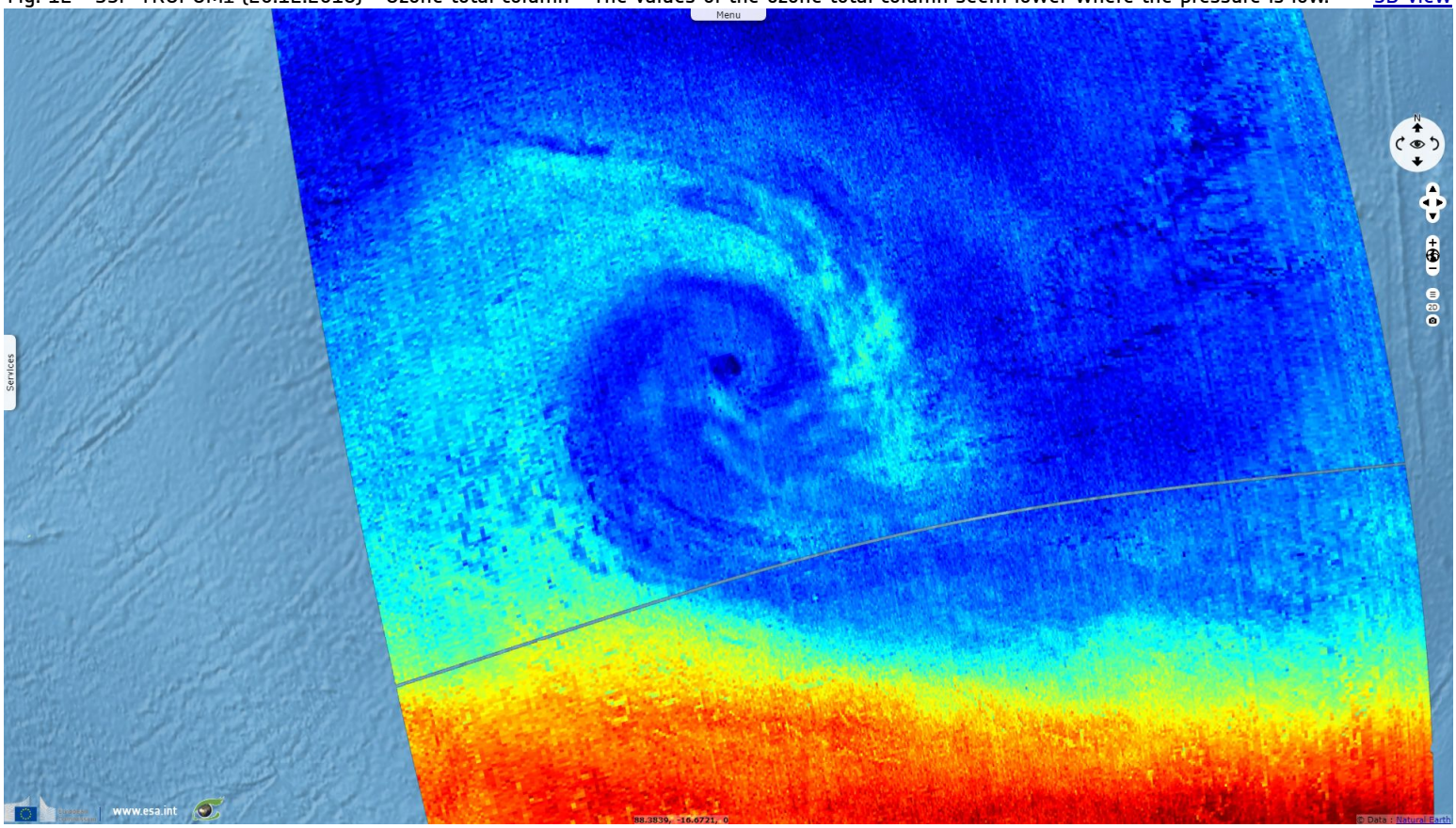
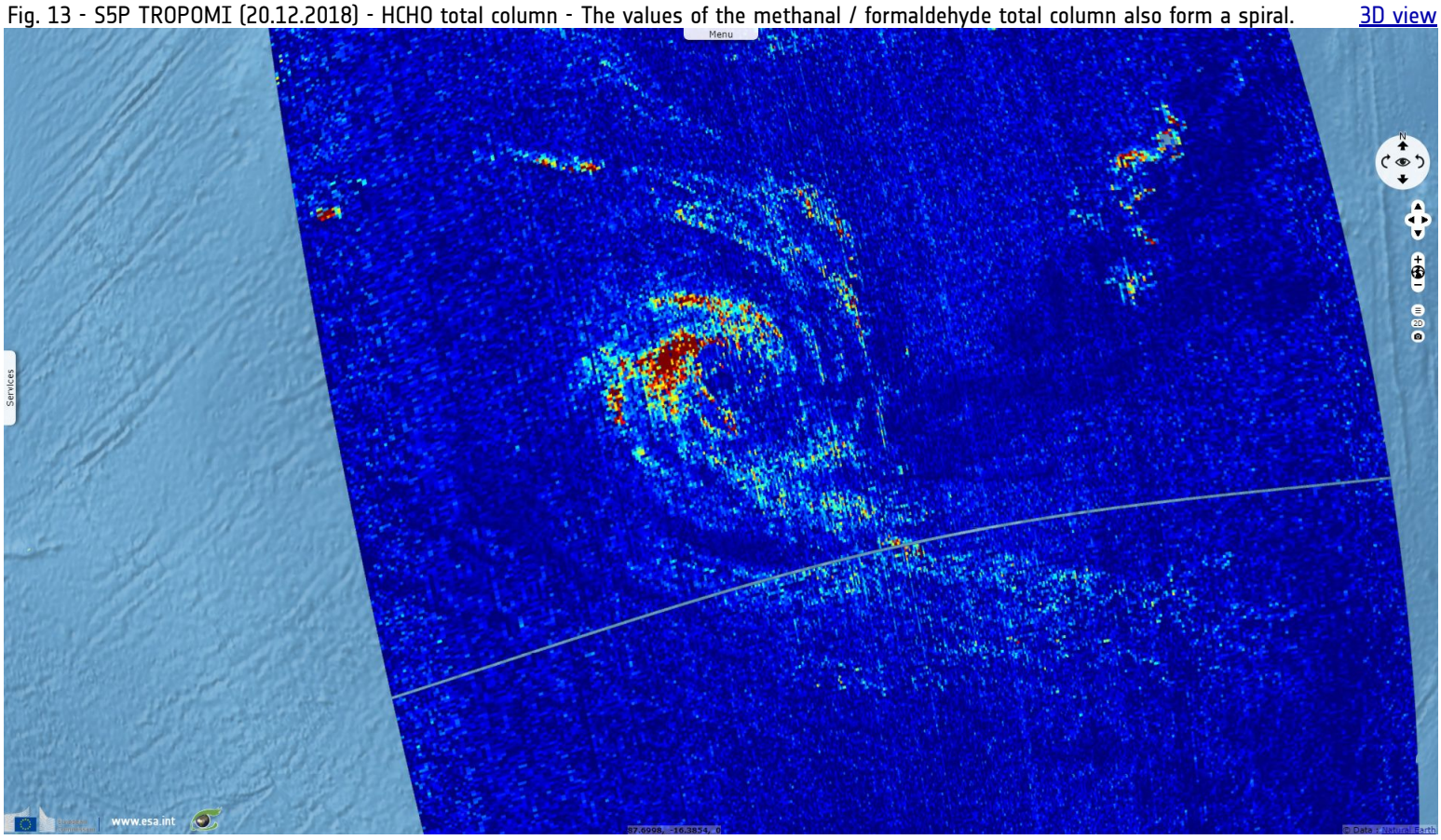


Fig. 13 - S5P TROPOMI (20.12.2018) - HCHO total column - The values of the methanal / formaldehyde total column also form a spiral. 3D view



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