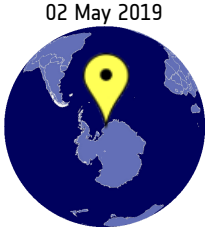
Sentinel Vision
EVT-443
02 May 2019



2D Layerstack

Failure of an emperor colony

Sentinel-2 MSI acquired on **13 November 2016** at 10:11:12 UTC
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Sentinel-2 MSI acquired on **16 October 2017** at 10:00:51 UTC
Sentinel-1 CSAR IW acquired on **22 November 2017** at 03:50:29 UTC
Sentinel-2 MSI L2A acquired on **07 February 2019** at 09:40:19 UTC

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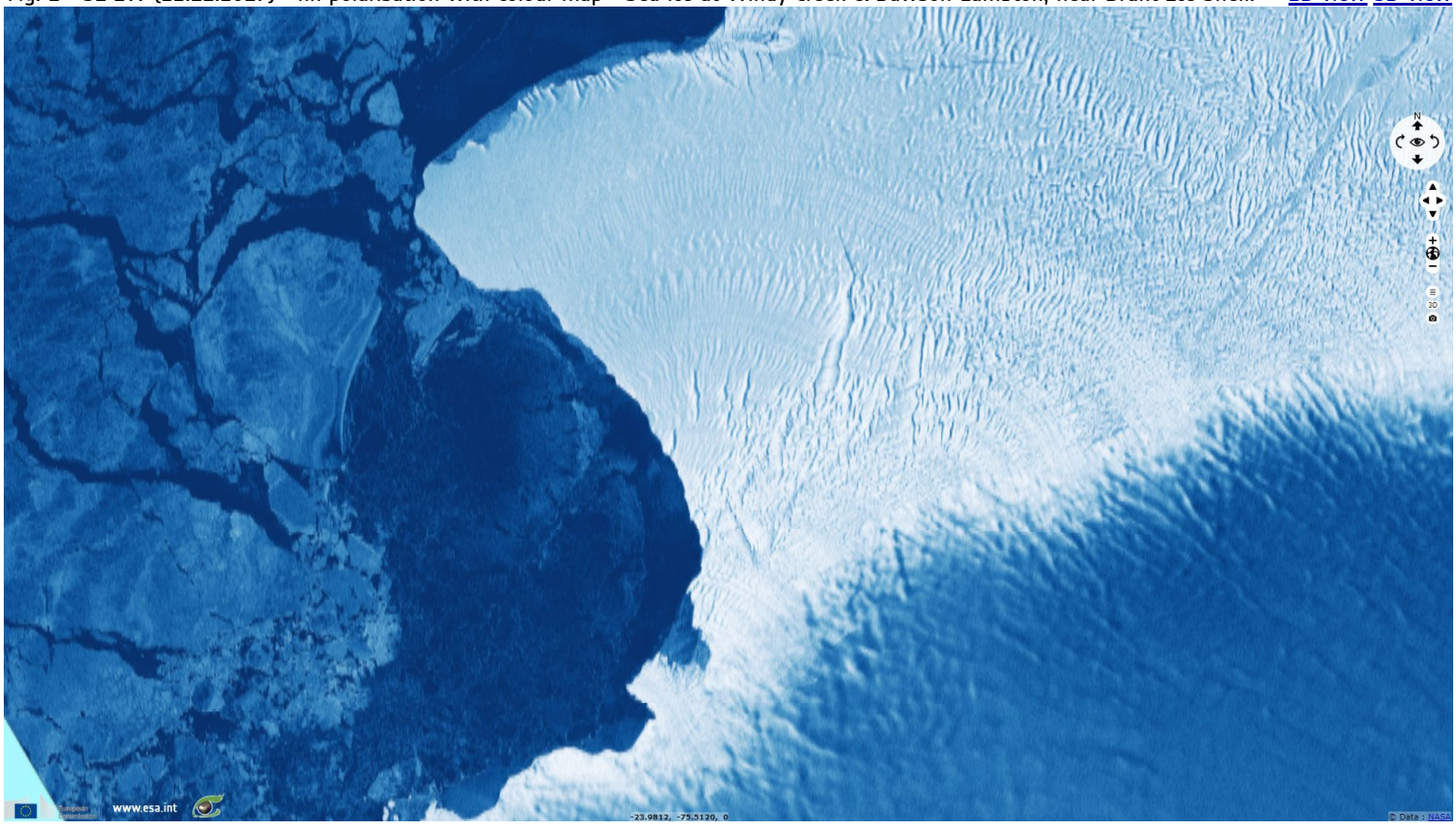
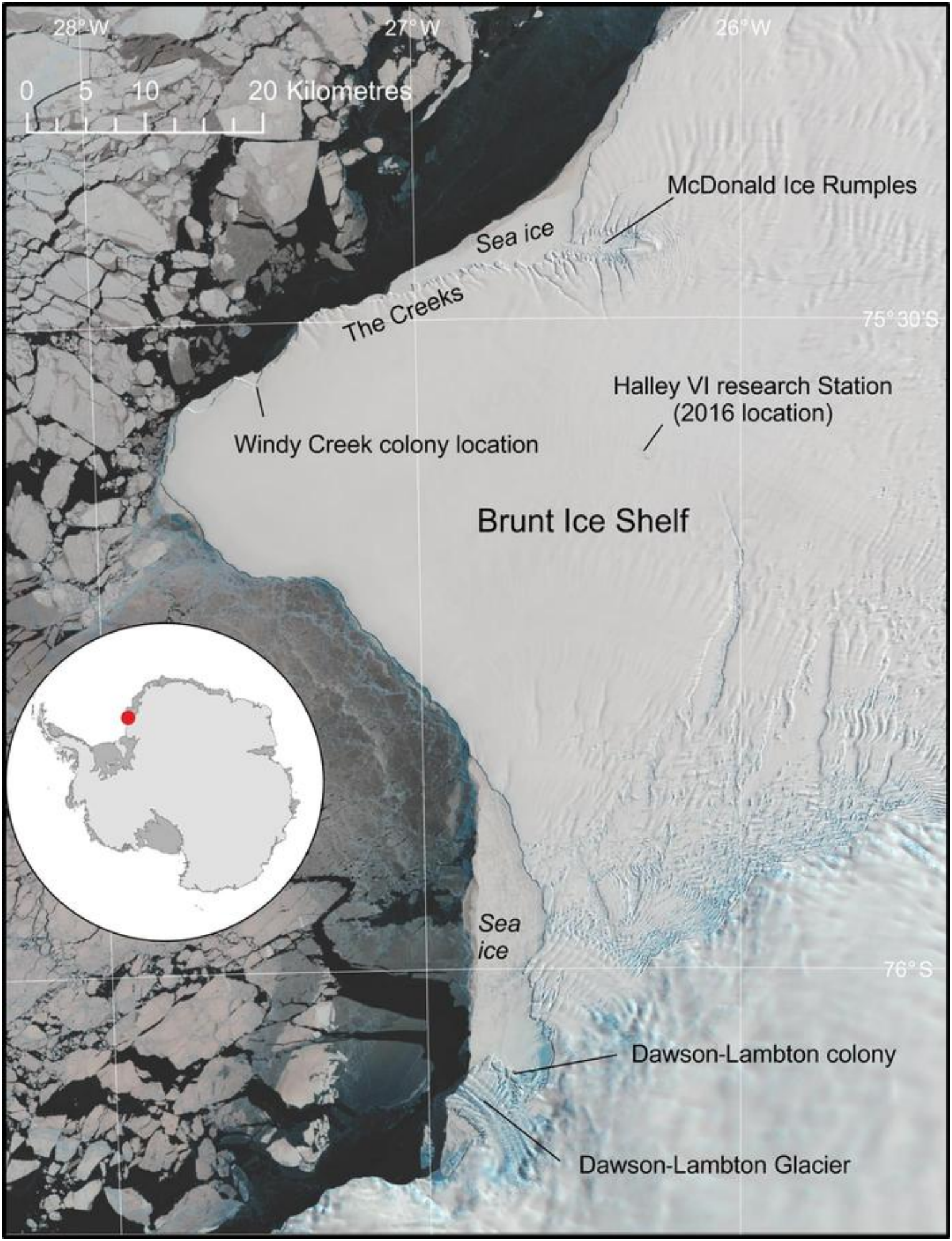
Keyword(s): Polar, coastal, cryosphere, biodiversity, climate change, sea ice, ice melt, ice shelf, Antarctica

Fig. 1 - S1 IW (22.11.2017) - hh polarisation with colour map - Sea ice at Windy Creek & Dawson-Lambton, near Brunt Ice Shelf. 2D view 3D view



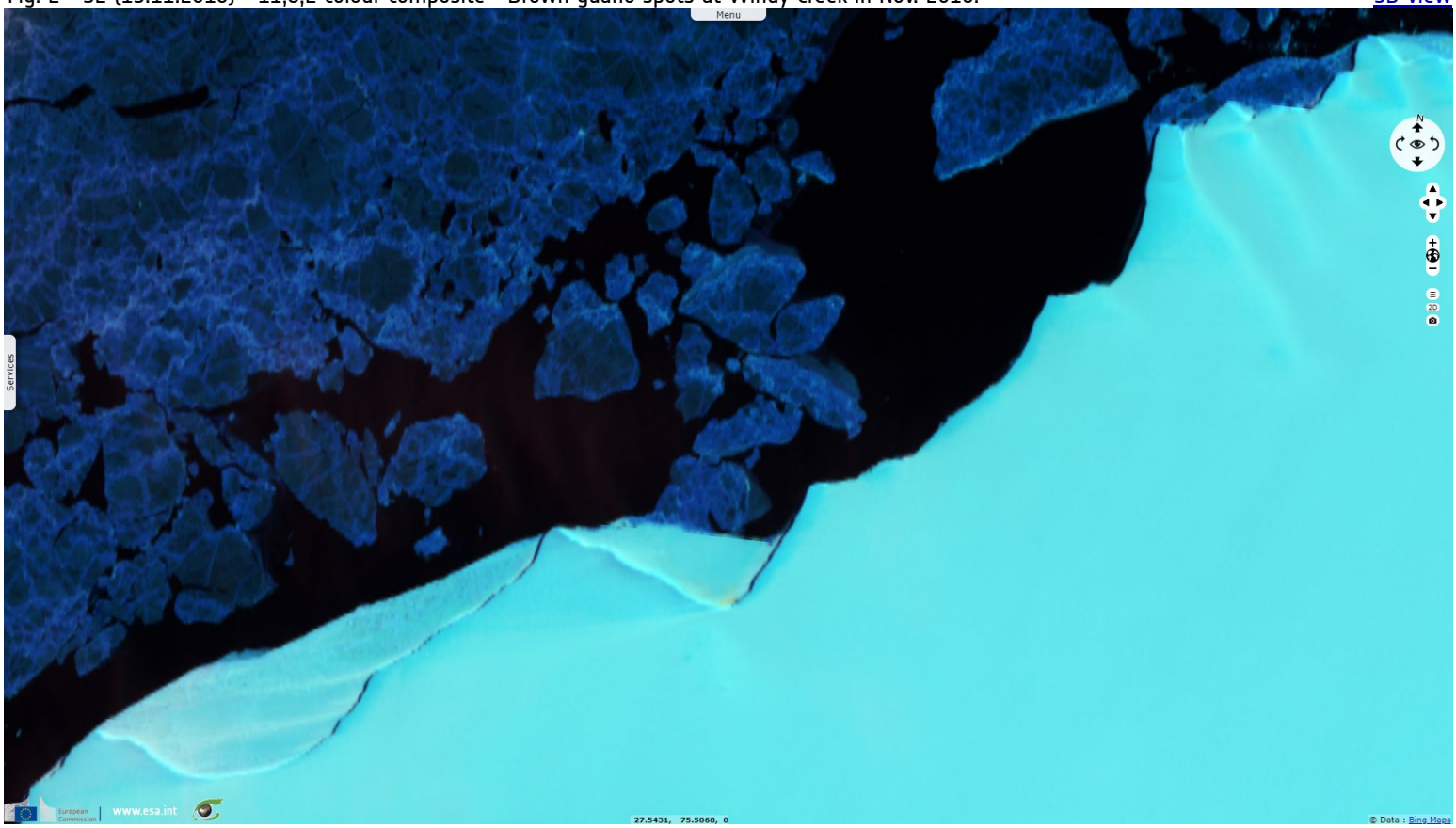
The 25 April 2019, Dr Peter T. Fretwell and Dr Philip N. Trathan published an article called "Emperors on thin ice: three years of breeding failure at Halley Bay" in Antarctic Science. Using remote sensing to monitor emperor penguin colonies, they showed how early sea ice disruption caused several consecutive breeding failures at one of the largest colonies: "*The emperor penguin colony at Halley Bay was one of the largest colonies in Antarctica, second only in size to that at Coulman Island in the Ross Sea (Fretwell et al. 2012). The colony is located on the northern side of the Brunt Ice Shelf and, for the past two decades, has been situated in a bay, locally named 'Windy Creek'. Although no organized science has been conducted on the colony, it has been visited by staff from the Halley Research Station sporadically from 1956–2012 and estimates of size vary between approximately 14 300–23 000 pairs (Woehler 1993, British Antarctic Survey (BAS) unpublished data, H.J. Gillett personal communication 2018).*

It is likely that the colony is associated with foraging on the shallow McDonald Bank and McDonald Ice rumples, to the north and east of the site and the coastal polynya that forms north of the Brunt Ice shelf each summer season (Hodgson et al. 2018). Although this polynya is a consistent feature, the sheltered bays bordering the ice shelf usually retain fast ice until December and often the ice remains all summer. This ensures that emperors are able to raise their chicks at the site as their young fledge between mid-December and early January."



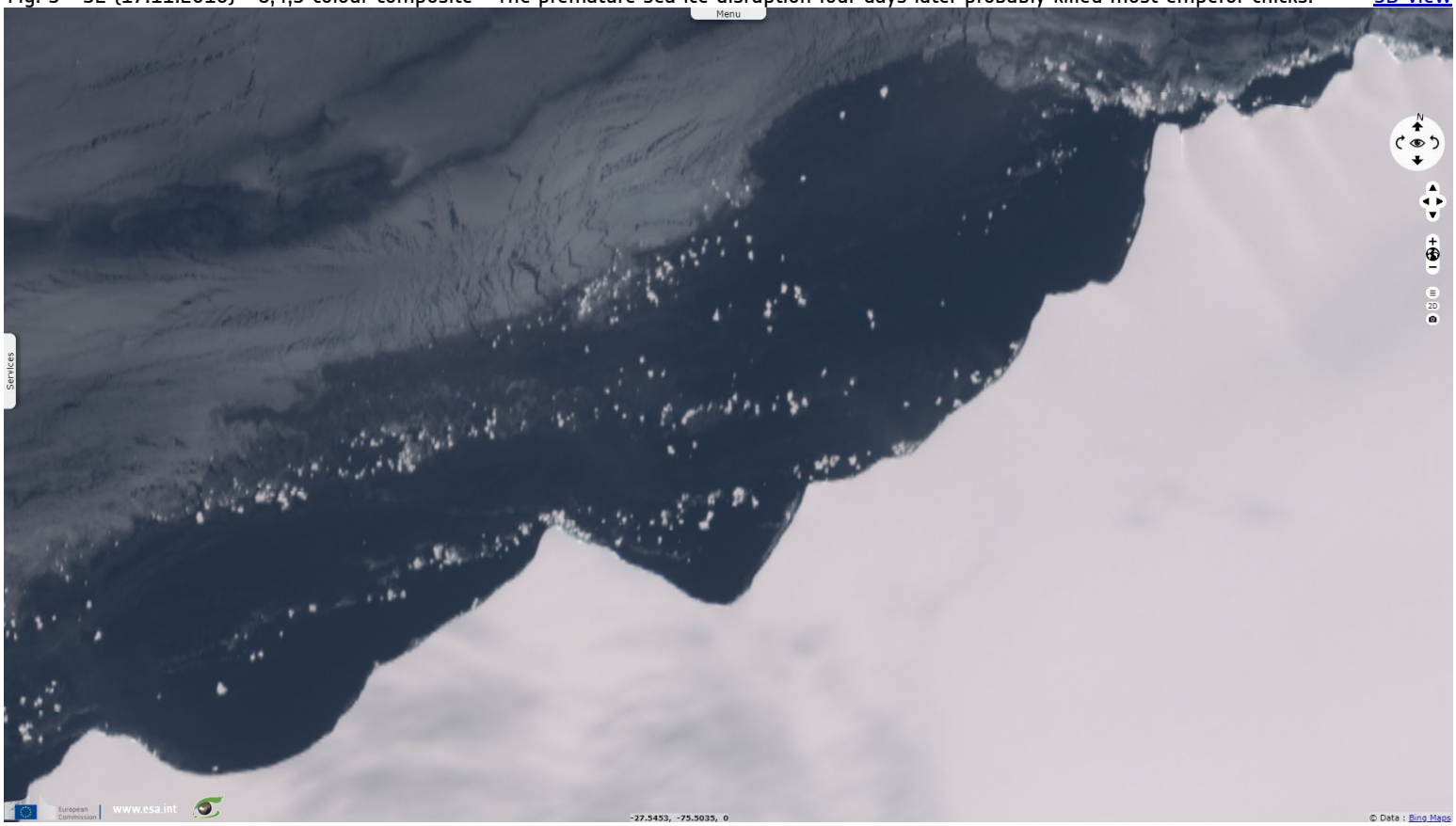
"*Overview of the Brunt Ice Shelf, showing the location of Halley Bay and Dawson-Lambton emperor penguin colonies. The underlying image is a Landsat-8 image from October 2016.*" - Source: Dr Peter T. Fretwell and Dr Philip N. Trathan

Fig. 2 - S2 (13.11.2016) - 11,8,2 colour composite - Brown guano spots at Windy Creek in Nov. 2016. 3D view



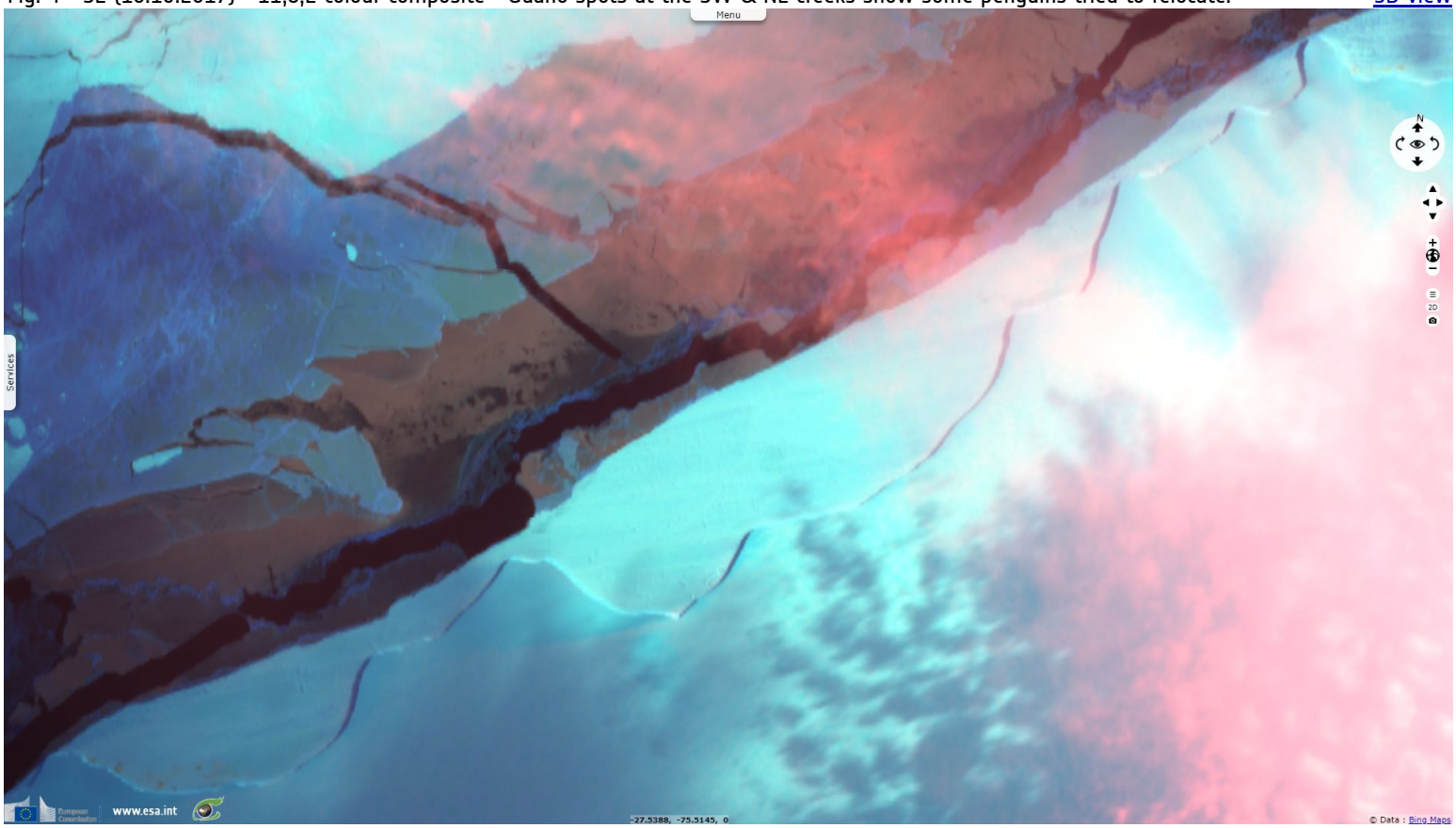
"*Although the recorded population has varied, the colony is consistently the largest in the Weddell Sea, over twice the size of any other colony in the region. There have been no previously recorded instances of total breeding failure at the site. It possibly represents 6.5–8.5% of the total global population and, as it is situated at high latitudes, it plausibly represents an important climate change refugia (Ainley et al. 2010, Jenouvrier et al. 2017).*"

Fig. 3 - S2 (17.11.2016) - 8,4,3 colour composite - The premature sea ice disruption four days later probably killed most emperor chicks. 3D view



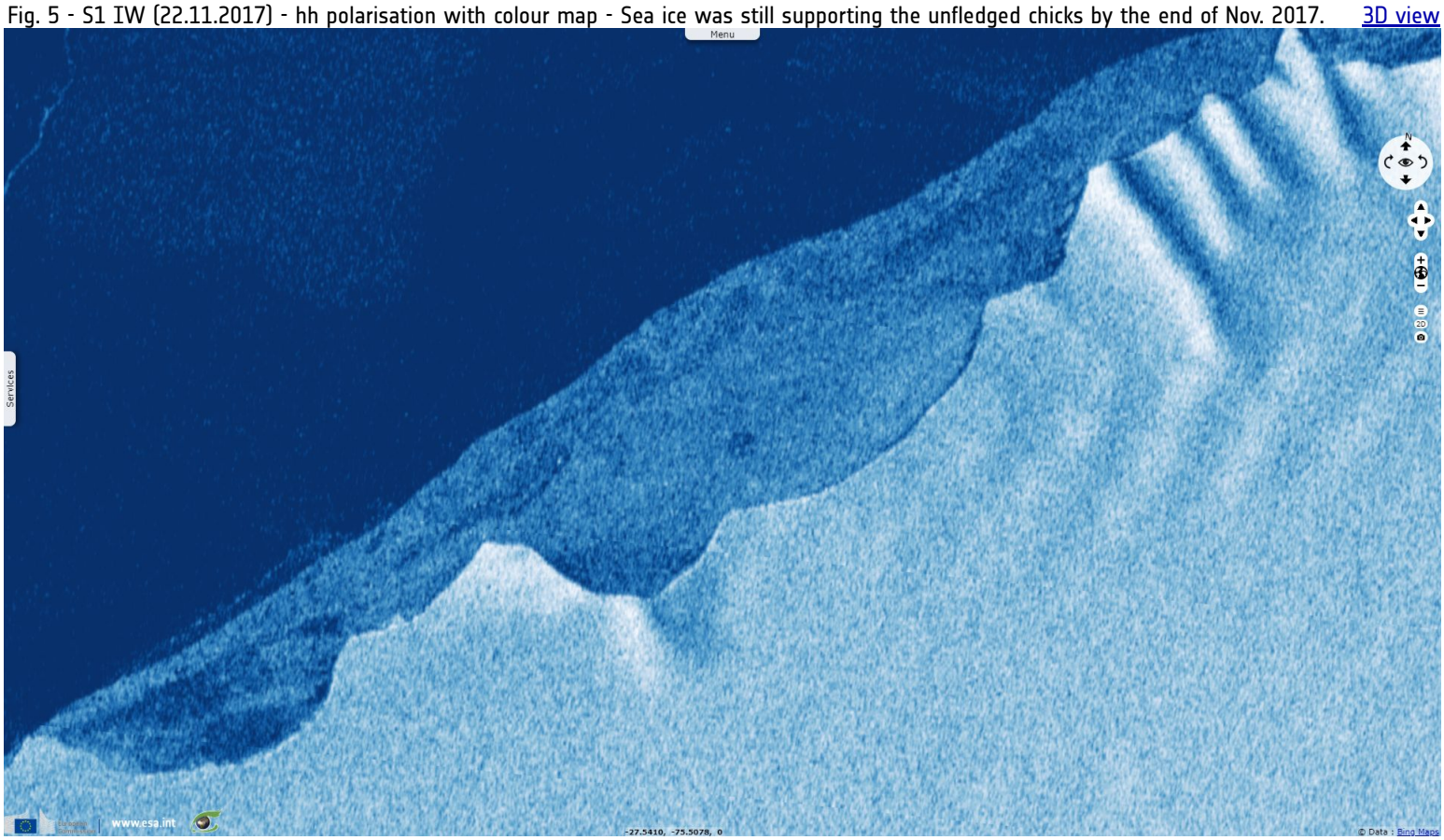
"*The nearest colony to the Halley site is the Dawson-Lambton colony, some 55 km to the south, located where the Brunt Ice Shelf joins the continental coast (Fig. 1). Geographically this is an unusually small distance between emperor colonies (Ancel et al. 2017). Only the Mertz Ice Shelf colonies have a smaller distance between them, and these two colonies originated from a single site before the recent calving of the Mertz Ice Tongue in 2010 (Ancel et al. 2014). However, recent monitoring has shown that the Halley Bay colony has suffered catastrophic breeding failure, whilst the nearby Dawson-Lambton colony has markedly increased in size.*"

Fig. 4 - S2 (16.10.2017) - 11,8,2 colour composite - Guano spots at the SW & NE creeks show some penguins tried to relocate. 3D view



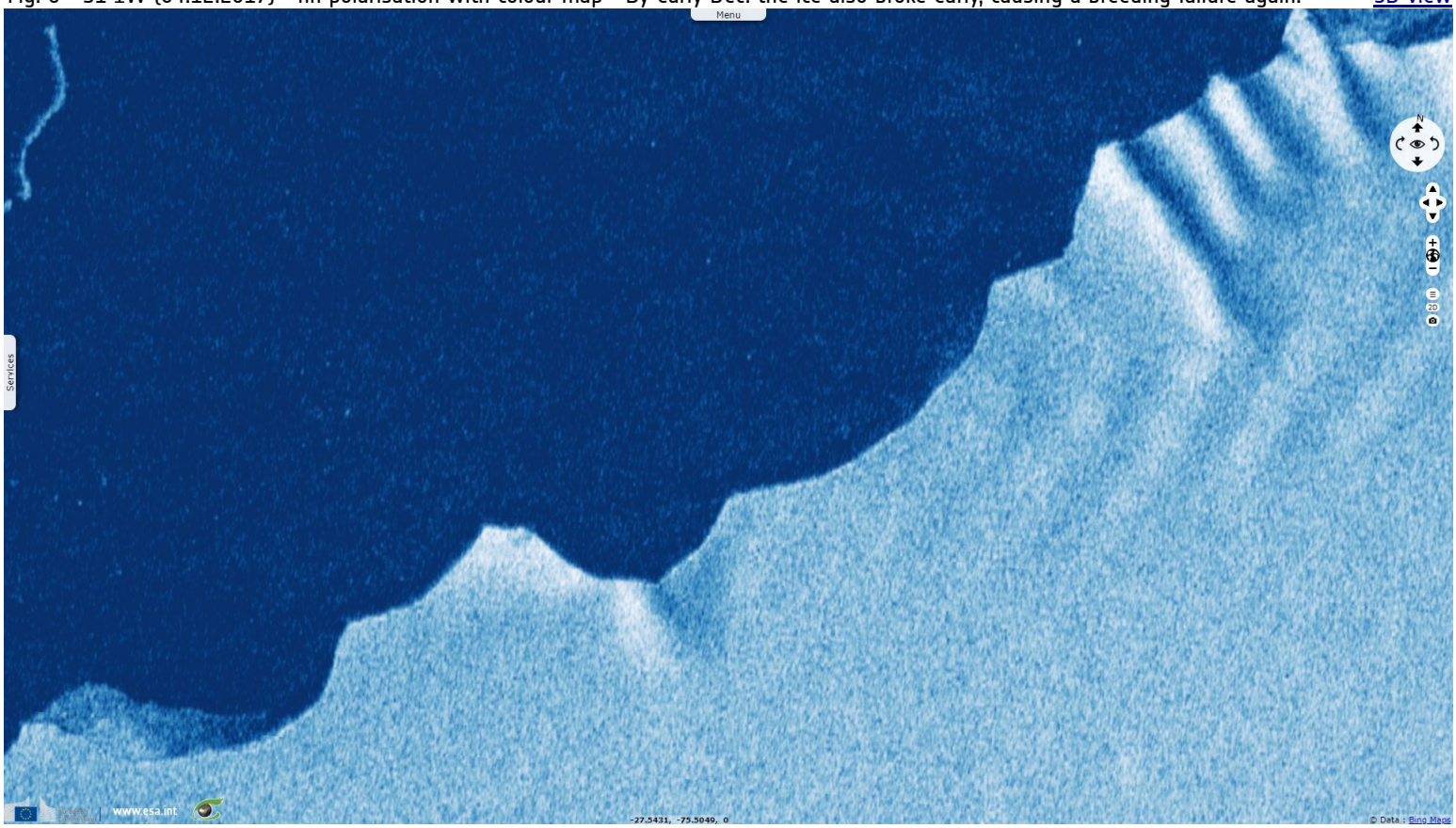
"*Satellite imagery over a ten-year period has confirmed considerable variation in colony size (Fig. 2). More importantly, the images have revealed that since 2015 the population has crashed with almost no breeding success in 2016, 2017 and 2018. In 2016 and 2017, low sea ice extent and early breakout of sea ice in spring (October/November; the crèche period of the emperor's breeding cycle) resulted in complete breeding failure. Satellite observations for this phenomenon were verified by ground observations from staff at the Halley VI research station in November 2016. In 2017 early breakout of fast ice in mid-November confirmed another year of breeding failure (Fig. 2). In 2018 the colony reformed, but with only a few hundred adults present at the breeding site (~2% of the recent population).*"

Fig. 5 - S1 IW (22.11.2017) - hh polarisation with colour map - Sea ice was still supporting the unfledged chicks by the end of Nov. 2017. 3D view



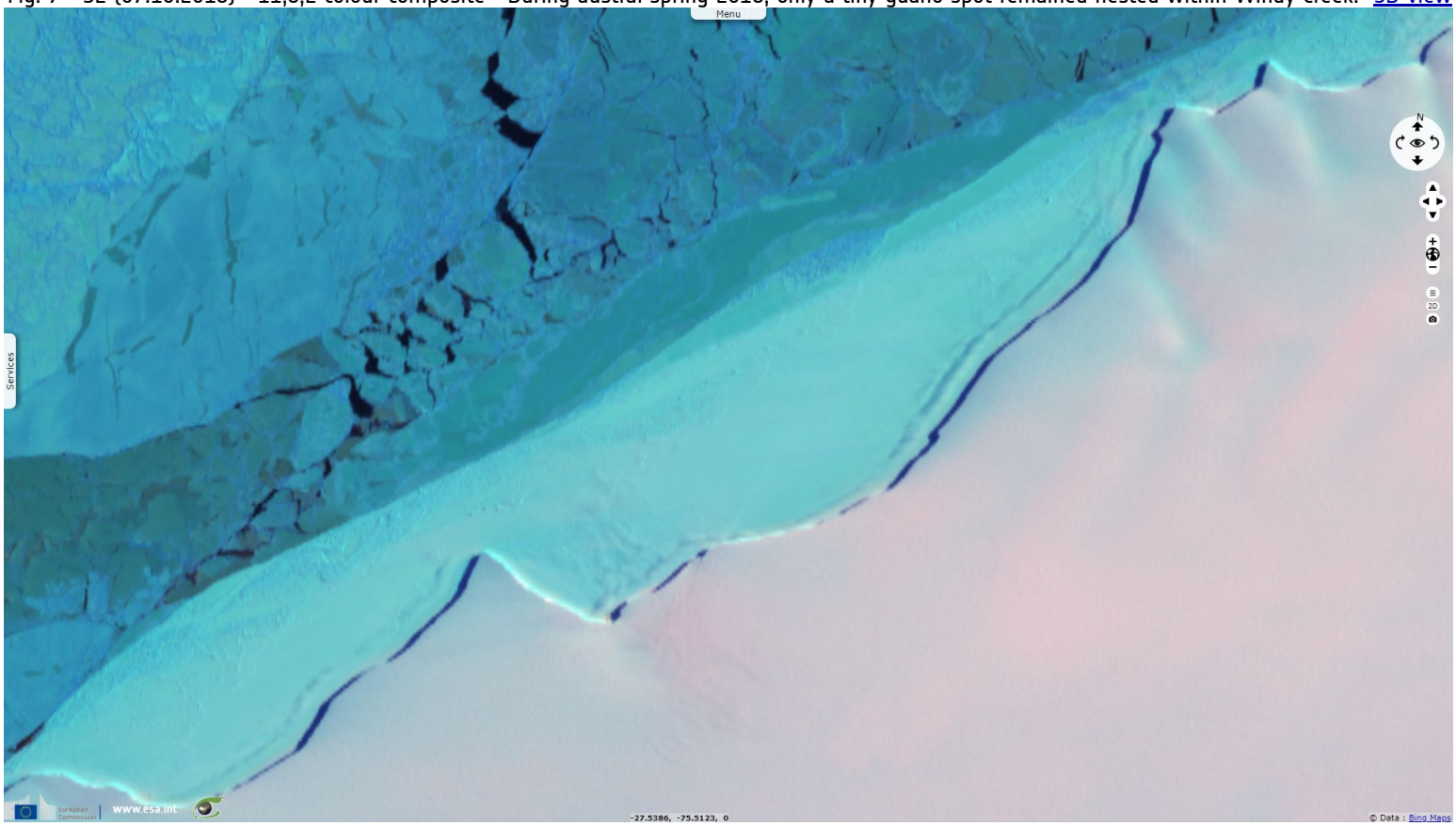
"*Emperors do not breed or habitually feed their young at the ice edge as its position is dynamic and the high risk of breakup would pose a danger to unfledged chicks. Whether the adult birds here were failed breeders or non-breeders is difficult to assess from imagery alone. Subsequent Landsat8 and Sentinel2 imagery shows that by 29 November 2018, all of the fast ice on the north side of the Brunt Ice Shelf had gone, highlighting a third year of probable total breeding failure.*"

Fig. 6 - S1 IW (04.12.2017) - hh polarisation with colour map - By early Dec. the ice also broke early, causing a breeding failure again. 3D view



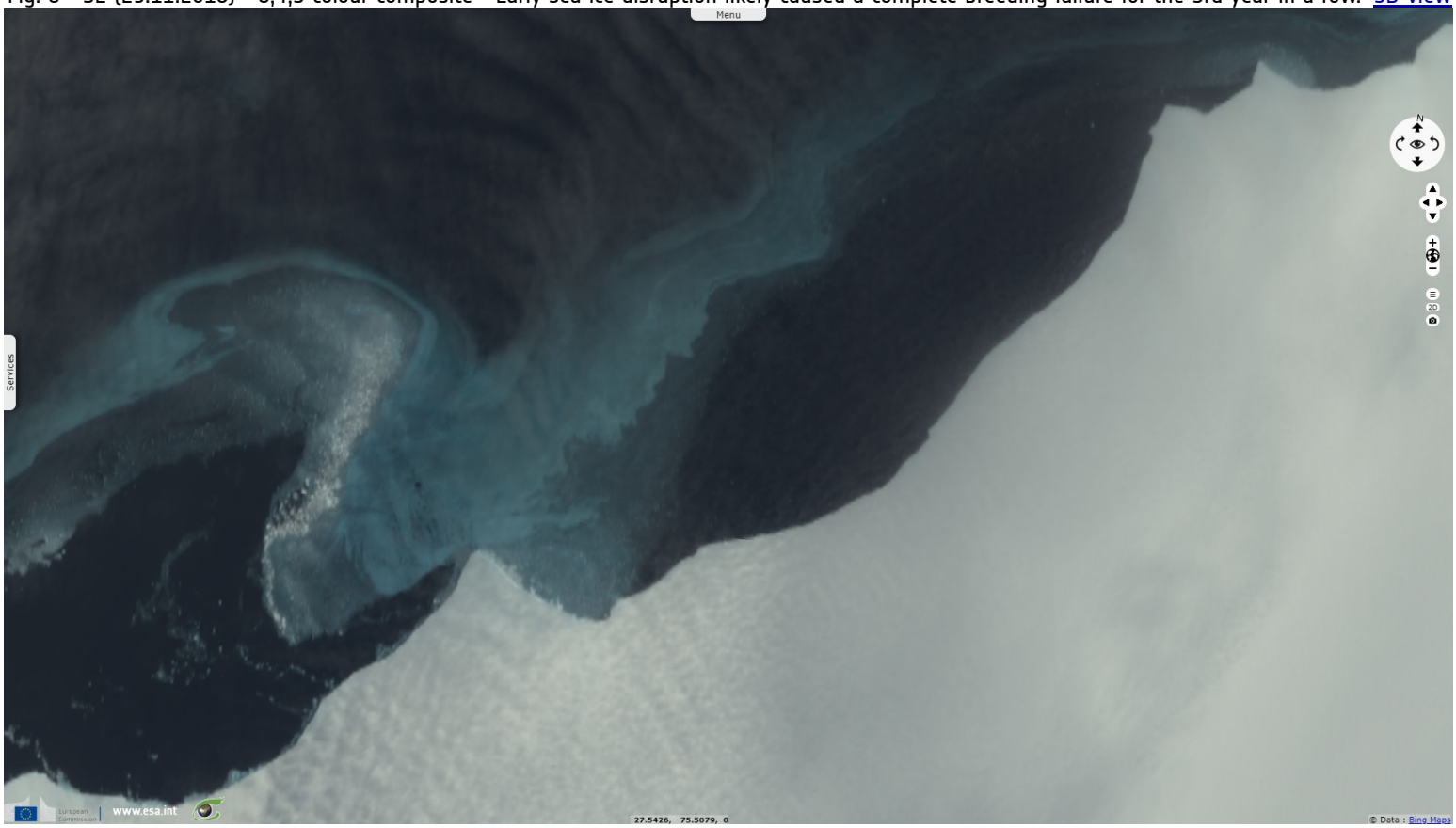
"*Between 2016 and 2018, a massive increase in the numbers of birds at the nearby Dawson-Lambton Glacier colony (76°04'S, 26°40'W), some 55 km to the south was found. The number of pairs estimated by satellite at this colony had steadily decreased from 3690 pairs in 2010 to 1280 pairs in 2015. However, numbers suddenly increased to 5315 in 2016, 11 117 pairs in 2017 and 14 612 pairs in 2018, an increase of over 1000% from the 2015 estimate.*"

Fig. 7 - S2 (07.10.2018) - 11,8,2 colour composite - During austral spring 2018, only a tiny guano spot remained nested within Windy Creek. 3D view



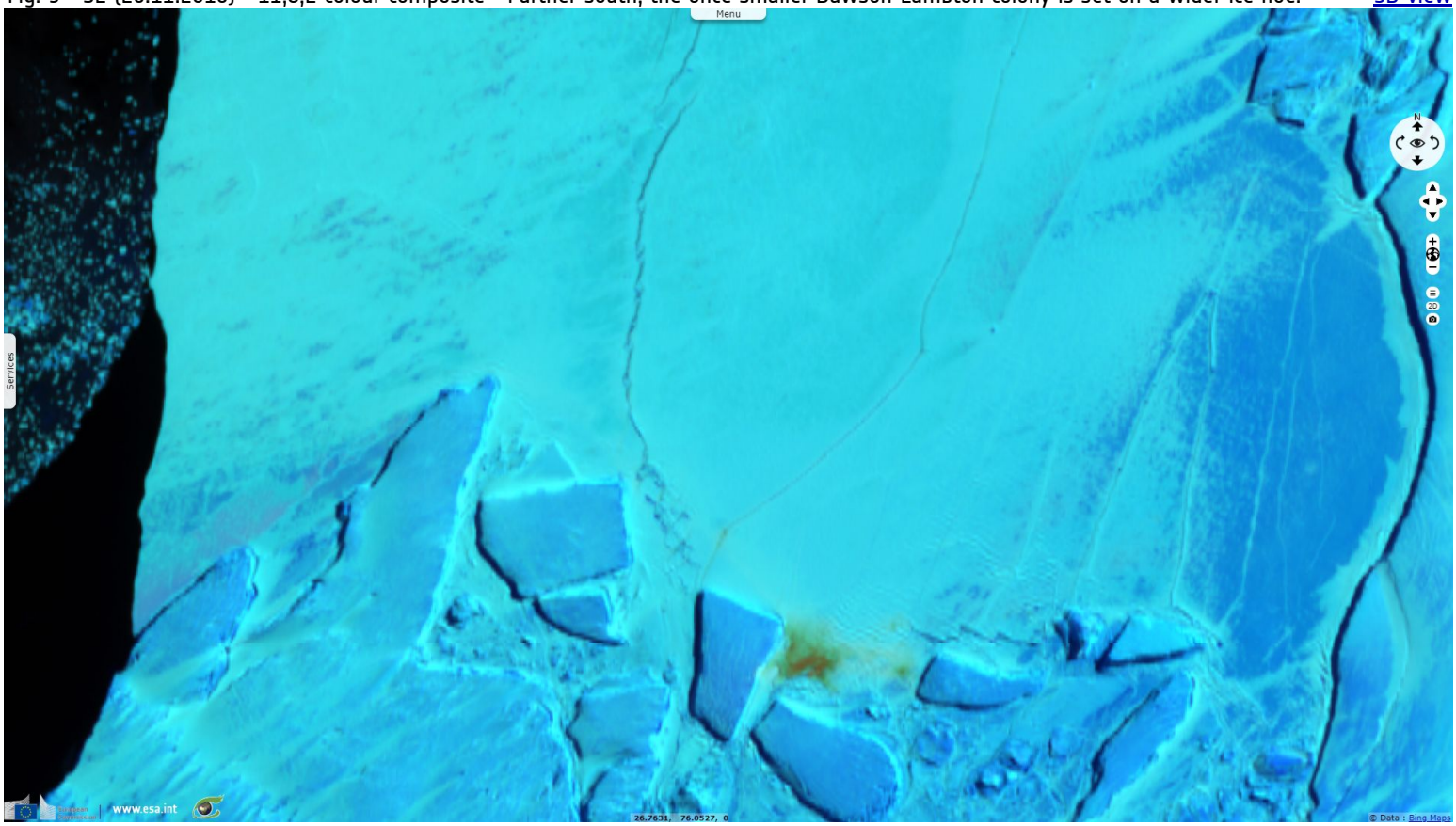
"*The satellite images used to estimate bird numbers showed that, in 2016 and 2017, although breeding birds were evident at Dawson-Lambton, the distribution of birds around the colony was non-typical. Usually breeding birds congregate in loose groups, but in the images from these two years, most birds were widely dispersed over the sea ice, often individually or in groups of less than ten. Many thousands of them were positioned along cracks in the ice and the lack of guano staining in these areas (as opposed to the areas around the more usual breeding location) indicated that they had not been there for long.*"

Fig. 8 - S2 (29.11.2018) - 8,4,3 colour composite - Early sea ice disruption likely caused a complete breeding failure for the 3rd year in a row. 3D view



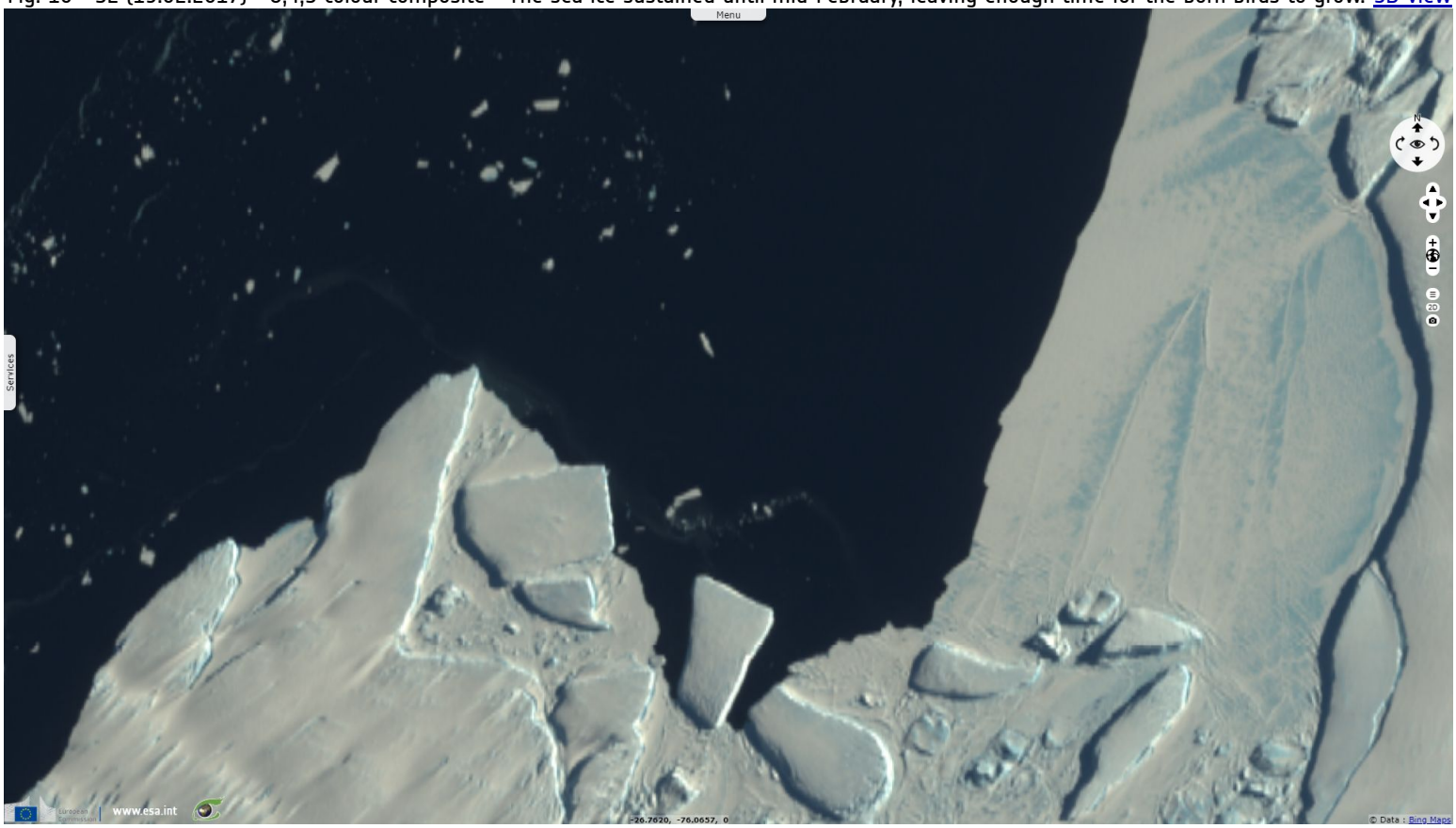
"*In 2018, this pattern had changed; there was no loose dispersion of birds and imagery indicated that they had congregated into two distinct groups, with heavy guano staining at each site. One group was in approximately the position occupied over the last five years, but a larger group, approximately 2.5 times the size of the other, was in a new site located 1.4 km to the west.*"

Fig. 9 - S2 (20.11.2016) - 11,8,2 colour composite - Further south, the once smaller Dawson-Lambton colony is set on a wider ice floe. 3D view



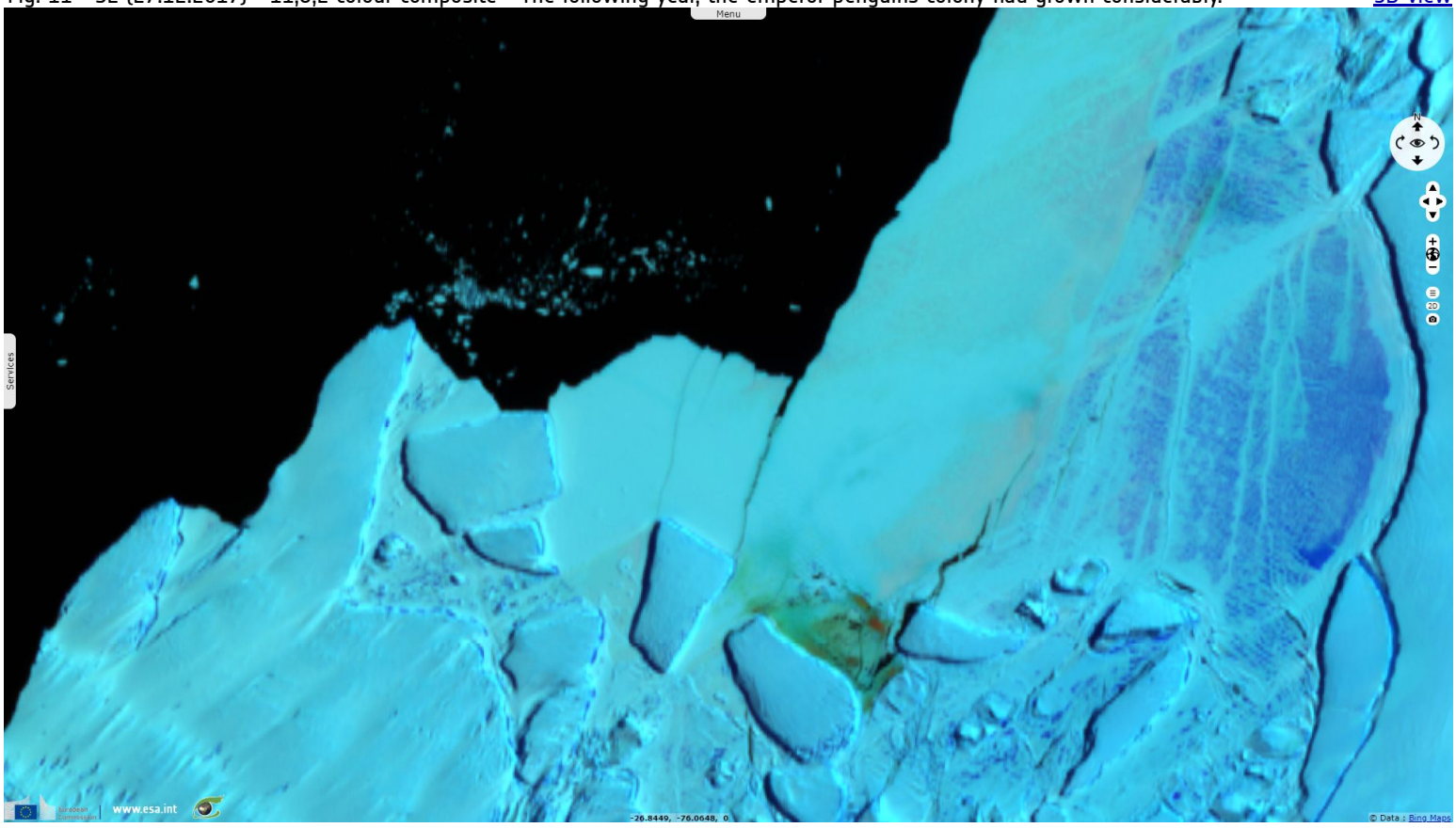
"*It appears that many of the birds from Halley Bay have relocated to Dawson-Lambton, with the rest remaining at Halley Bay, but not breeding successfully. This number seems to be diminishing on an annual basis as more failed breeders move to the nearby colony. It is possible that some emperors could have formed a new colony elsewhere, but an exhaustive search using Sentinel-2 imagery shows no new colony locations in the region. It is also possible that some birds could have moved to other colony locations further away, but due to the natural variability in colony sizes, small increases in population would be difficult to detect.*"

Fig. 10 - S2 (19.02.2017) - 8,4,3 colour composite - The sea ice sustained until mid-February, leaving enough time for the born birds to grow. 3D view



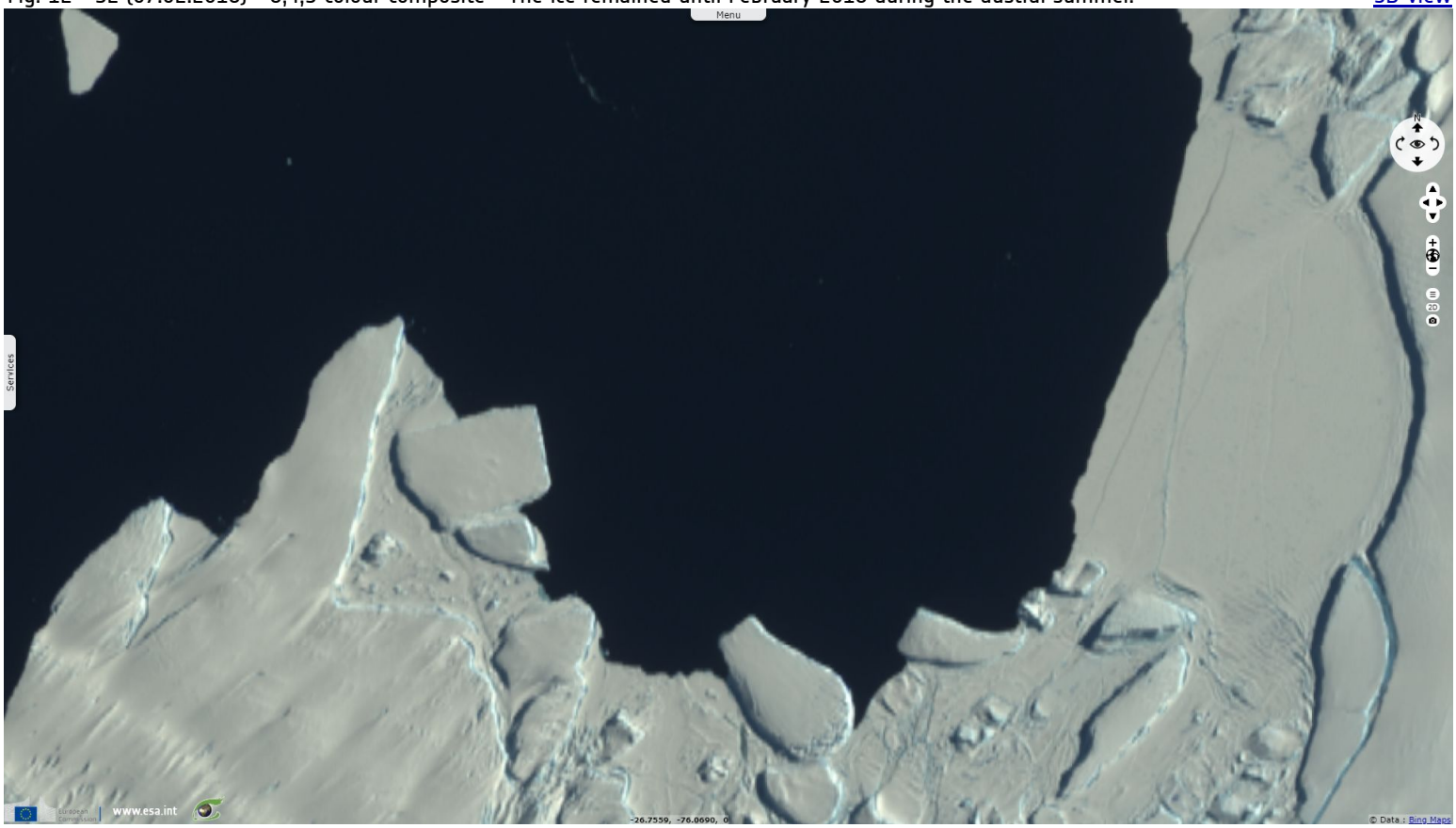
"*Another alternative explanation is that some adults have skipped breeding over these years and will return to breed at the original site when conditions there improve. Observations made in the present study emphasize that emperor penguins move between colony sites (LaRue et al. 2015) and, when large colonies move, it can take a number of years for resettlement to occur, similar to the recent situation at the Mertz colony (Ancel et al. 2014).*"

Fig. 11 - S2 (27.12.2017) - 11,8,2 colour composite - The following year, the emperor penguins colony had grown considerably. 3D view



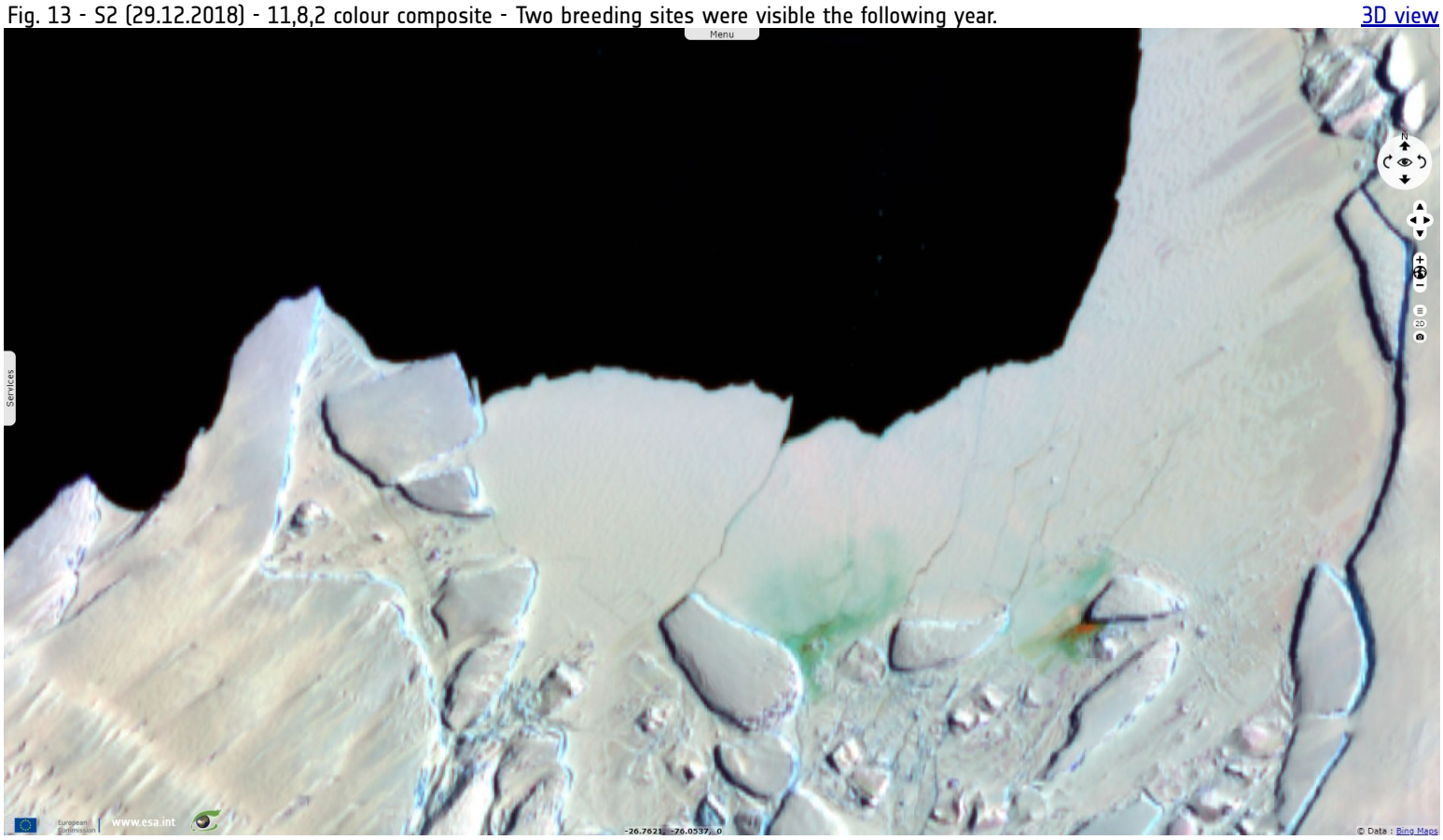
"*It is highly likely that the regional population in the Weddell Sea was impacted following the loss of at least three consecutive breeding seasons. Halley comprised a significant proportion of the regional emperor population (on average approximately 23% of the population of the colonies between 90–0°W) and complete breeding failure in three consecutive seasons will have been important.*"

Fig. 12 - S2 (07.02.2018) - 8,4,3 colour composite - The ice remained until February 2018 during the austral summer. 3D view



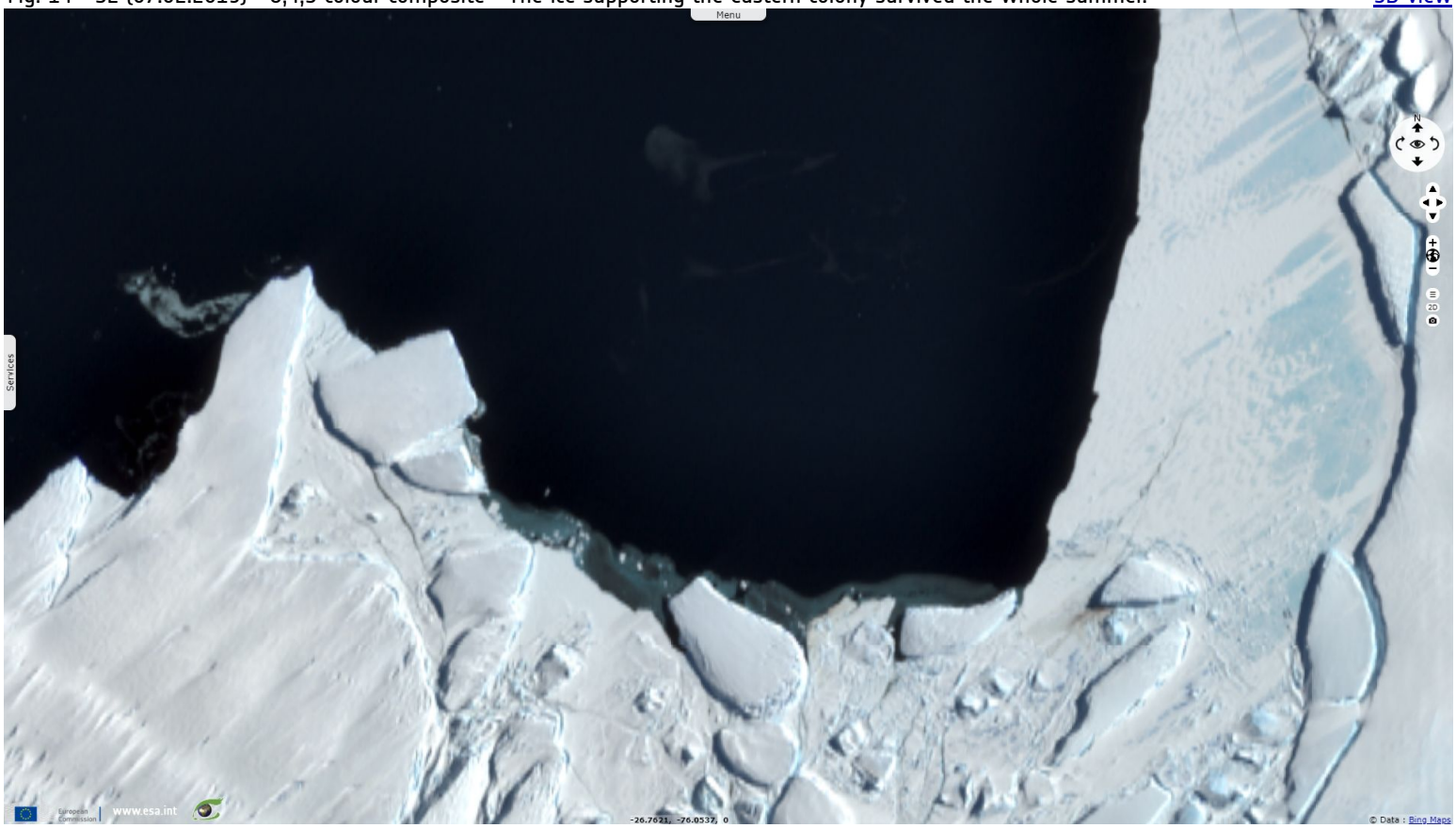
"*At Halley, another important factor influencing the stability of the fast ice around the colony could be the dynamic nature of the creek in which it is located. Until recently, the colony was situated within a sheltered ice creek, on the northern side of the Brunt Ice Shelf, informally named Windy Creek. Over the past 60 years, the colony has occasionally moved to other adjacent sheltered creeks (H.J. Gillett personal communication 2018, BAS records). With the fast-ice breakout in 2016, ice shelf morphology changed and the resulting more open nature of the creek may now be less suitable for fast-ice retention.*"

Fig. 13 - S2 (29.12.2018) - 11,8,2 colour composite - Two breeding sites were visible the following year. 3D view



"*The Brunt Ice Shelf is a fast-moving and dynamic environment (Hodgson et al. 2018). Over the last two decades the creek has gradually moved westwards by over 600 m per year and it is possible that the migration and changing topography of Windy Creek has made it a less favourable site for emperor penguins. Any future breeding at Halley will almost certainly depend upon the juxtaposition of sheltered, stable fast ice, foraging opportunities, including over the nearby McDonald Bank, and the longer-term processes that will happen once the Brunt Ice Shelf calves, which at present rates will be within the next two years.*"

Fig. 14 - S2 (07.02.2019) - 8,4,3 colour composite - The ice supporting the eastern colony survived the whole summer. 3D view



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