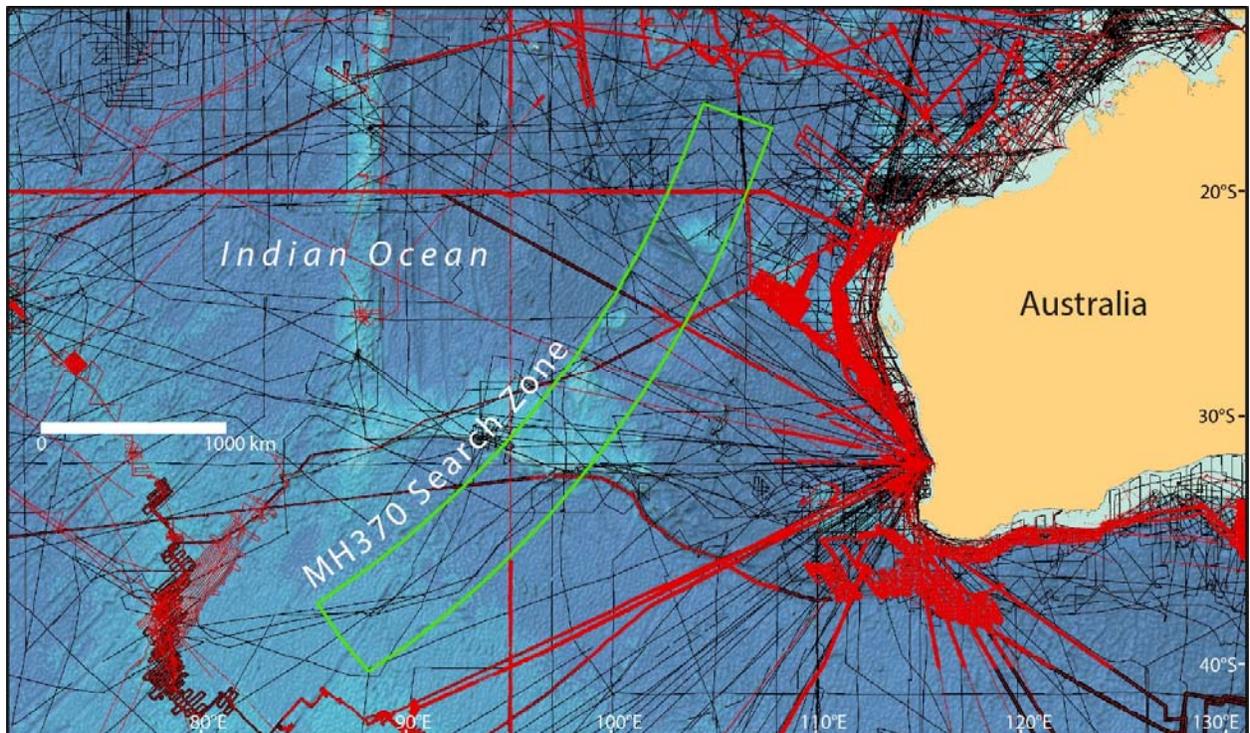
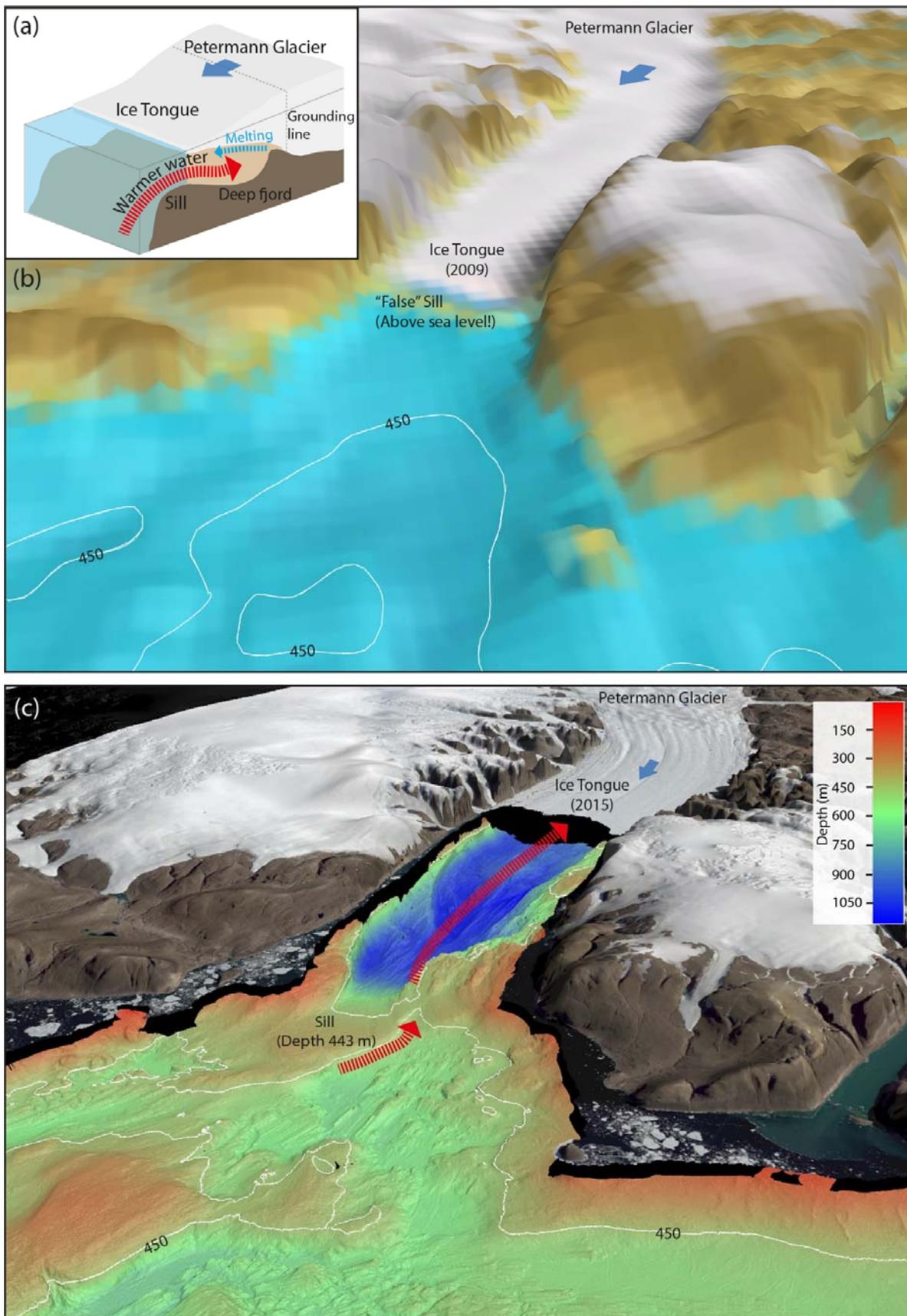


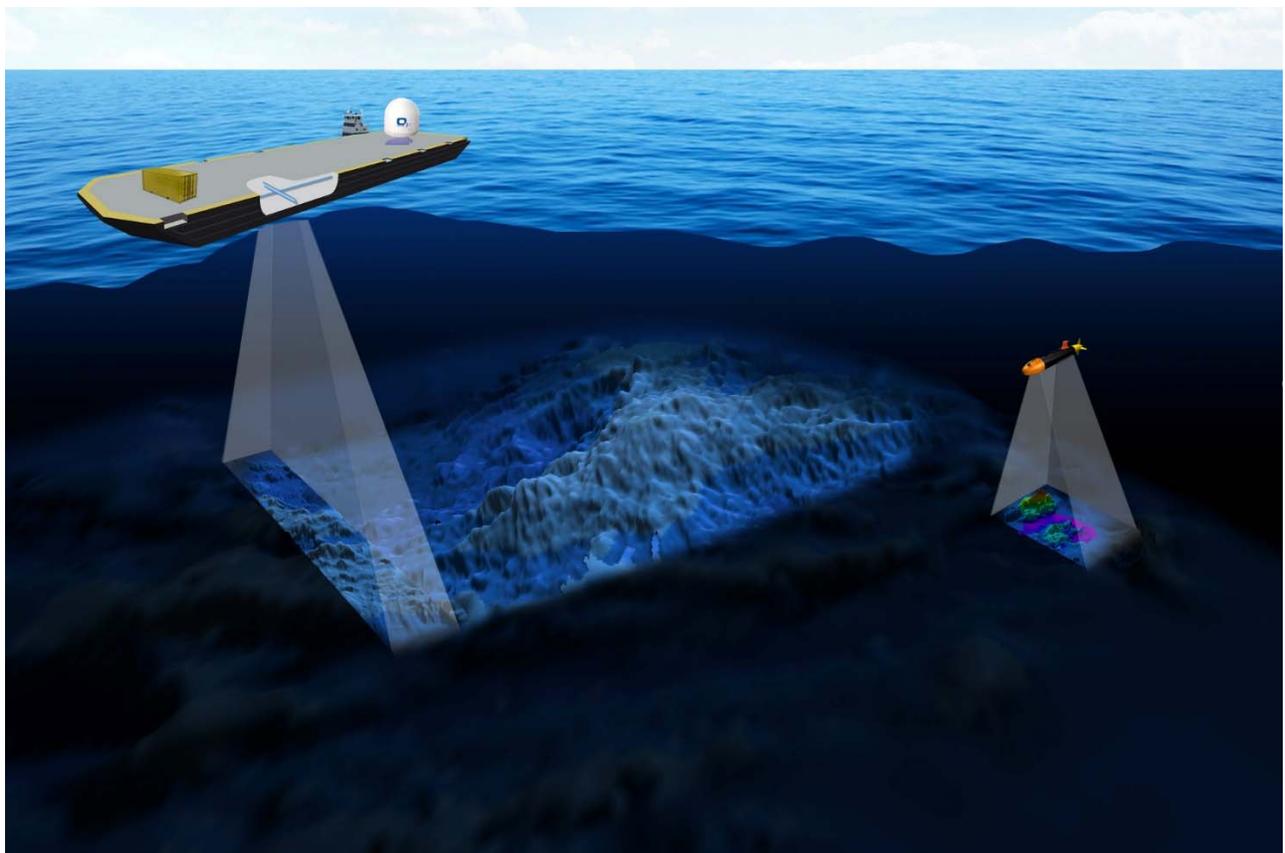
**Figure 3.1:** Illustration showing the bathymetry's role for the tsunami propagation following the earth quake 26 December 2004 outside of Sumatra. The left globe shows the seafloor bathymetry as portrayed by the GEBCO grid and the globe to the right has the tsunami amplitude overprinted (data from Titov et al., 2005). The seafloor ridges acted as efficient wave guides. The epicenter of the earth quake located approximately 260 km southwest of Banda Aceh, Sumatra, is marked with a yellow star. The illustration is modified from Jakobsson and Hell (2006).



**Figure 3.2:** The need for high-resolution bathymetry also in the deep ocean became strikingly evident also outside of the scientific community following the disappearance 8 March 2014 of Malaysia Airlines flight MH370, on the route from Kuala Lumpur to Beijing. The seafloor in the projected search area (Green box) was extremely poorly mapped at the time the search for parts of the fuselage could begin (Smith and Marks, 2014). Black lines are ship track lines along where single beam echo sounding data have been collected and red show multibeam bathymetry available at the time the search began. The bathymetric data coverage was far from even sufficient to send down underwater vehicles for close inspections of the seafloor. In essence, a search for a lost object of the size of an aircraft would have a better start if it was lost on the planet Mars, which is substantially better mapped the World Ocean.

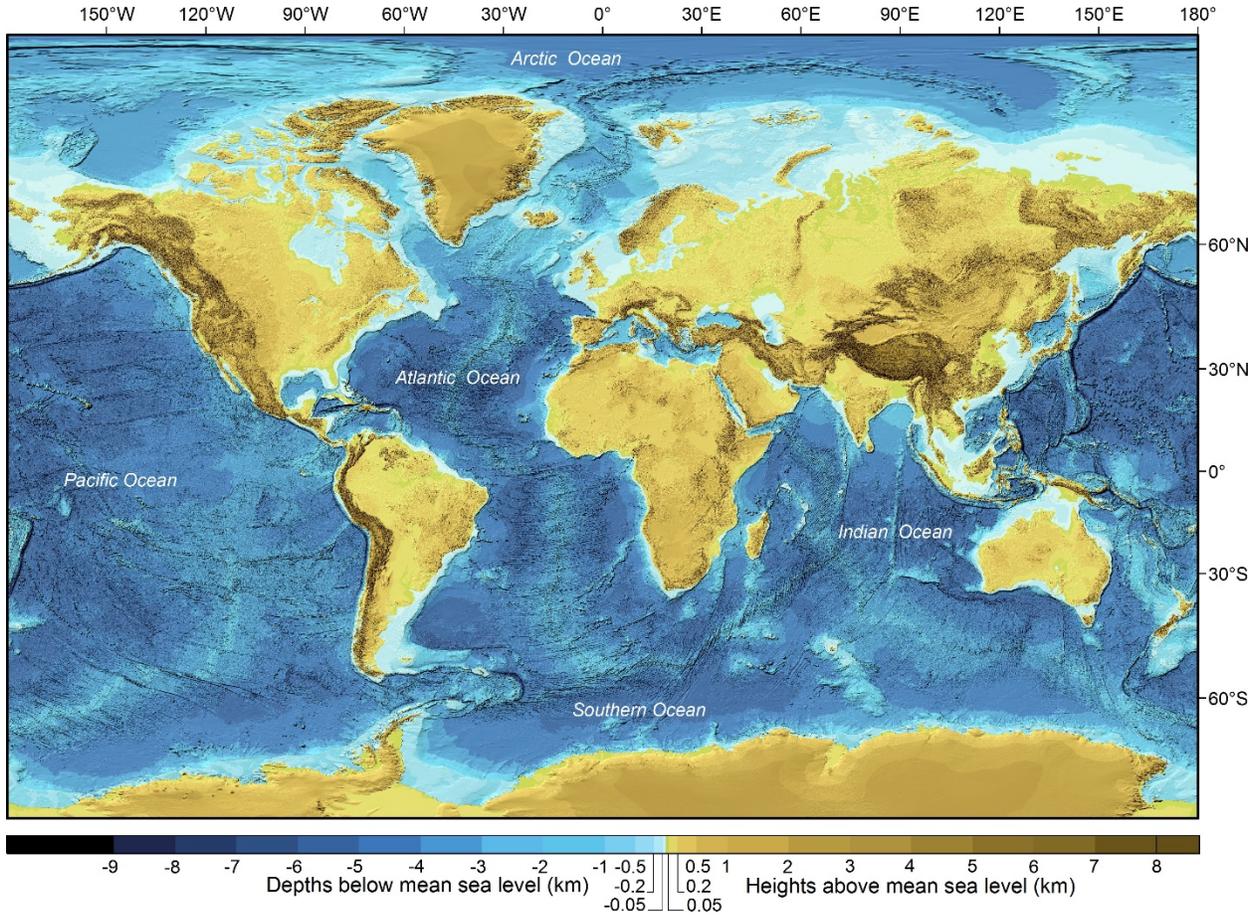


**Figure 3.3:** The importance of knowing the shape and depth of the seafloor can be shown with many specific examples. One such example is the influence of a fjord's bathymetry on outlet glaciers' sensitivity to inflow of warmer sub-surface ocean water (Holland et al., 2008). The dynamic behavior of glaciers suddenly subjected to warmer ocean water may change and lead to rapid mass loss of ice, in turn causing sea-level rise that impacts living conditions far beyond the Polar Regions. **a)** Conceptual illustration of glaciers draining large ice sheets, such as the Greenland or Antarctic ice sheets, into the ocean. These glaciers commonly have a large floating parts referred to as ice shelves or ice tongues, when constrained in a fjord. Shallow bathymetric sills at the fjord entrance will help making the ice tongue and feeding glacier less sensitive to ocean warming and changes in ocean current regimes, which has been observed in several Polar areas and attributed as an effect of a warmer climate (Jacobs et al., 2011; Mouginit et al., 2015; Rignot et al., 2013). The illustration in **a** is for example representative for the Petermann Glacier, located on northwestern Greenland and draining about 6% of the entire Greenland Ice Sheet. The Petermann ice tongue appeared stable and located near the fjord's sill until 2010 and 2012, when Manhattan-sized pieces broke off and reduced the ice tongue with about 30-40% (Münchow et al., 2014). **b)** The Petermann Fjord as portrayed in IBCAO Version 3.0. The grid model had only a few single echo sounding measurement in the fjord area resulting in crude bathymetry and a false bathymetric sill appearing in the gridded model due to extremely sparse data. This sill appeared even to have sections above sea level. Such shallow sill would make the Petermann Glacier less sensitive to influx of warmer water. **c)** Complete multibeam mapping of the Petermann Fjord was carried out with Swedish icebreaker Oden in 2015 (Mix et al., 2015). The seafloor portrayal is in **c** is based on a 15 x 15 m multibeam grid. The true nature of the bathymetric sill was revealed. The sill is generally deeper than 350 m, which a deepest passage of 453 m. This implies that the Petermann Glacier is much more sensitive to warmer subsurface water than IBCAO Ver. 3.0 suggest, which may explain the recent retreat history with massive calving events 2010 and 2012. The multibeam bathymetry also reveal the past extension and behavior of Petermann Glacier from a complex seafloor morphology consisting of glacial landforms.

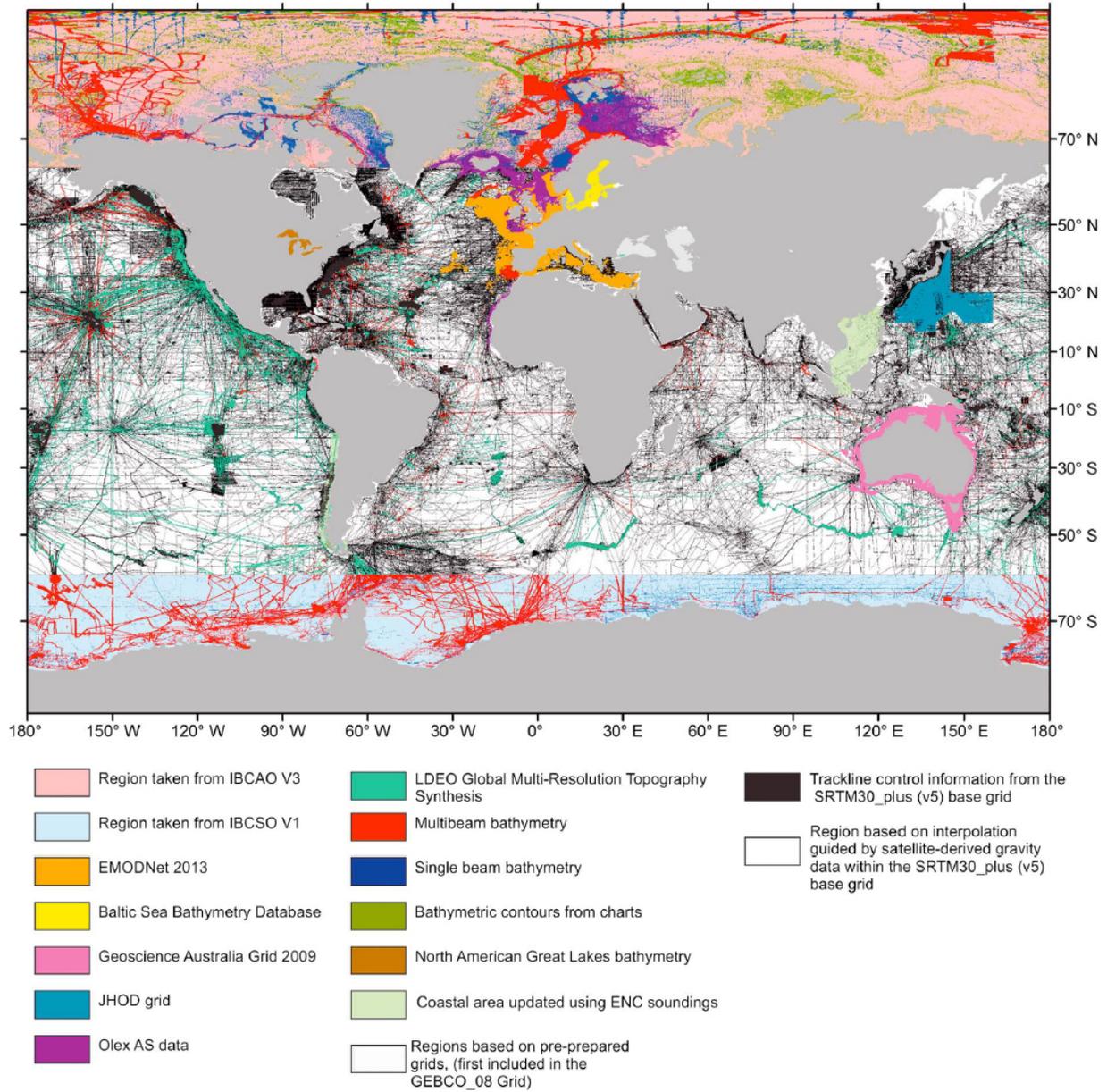


**Figure 3.4:** The concept of an unmanned mapping barge, steered by satellite communication and equipped with an ultra-narrow beam deep-water multibeam (left). Such a barge would be able to systematically map the deepest sections of the open ocean from the surface at even higher resolution than 100 x 100 m. The sub-meter level of detail sometimes needed to investigate small scale processes at the seabed is today possible to acquire in the deep ocean using AUVs (right) equipped with high-resolution high

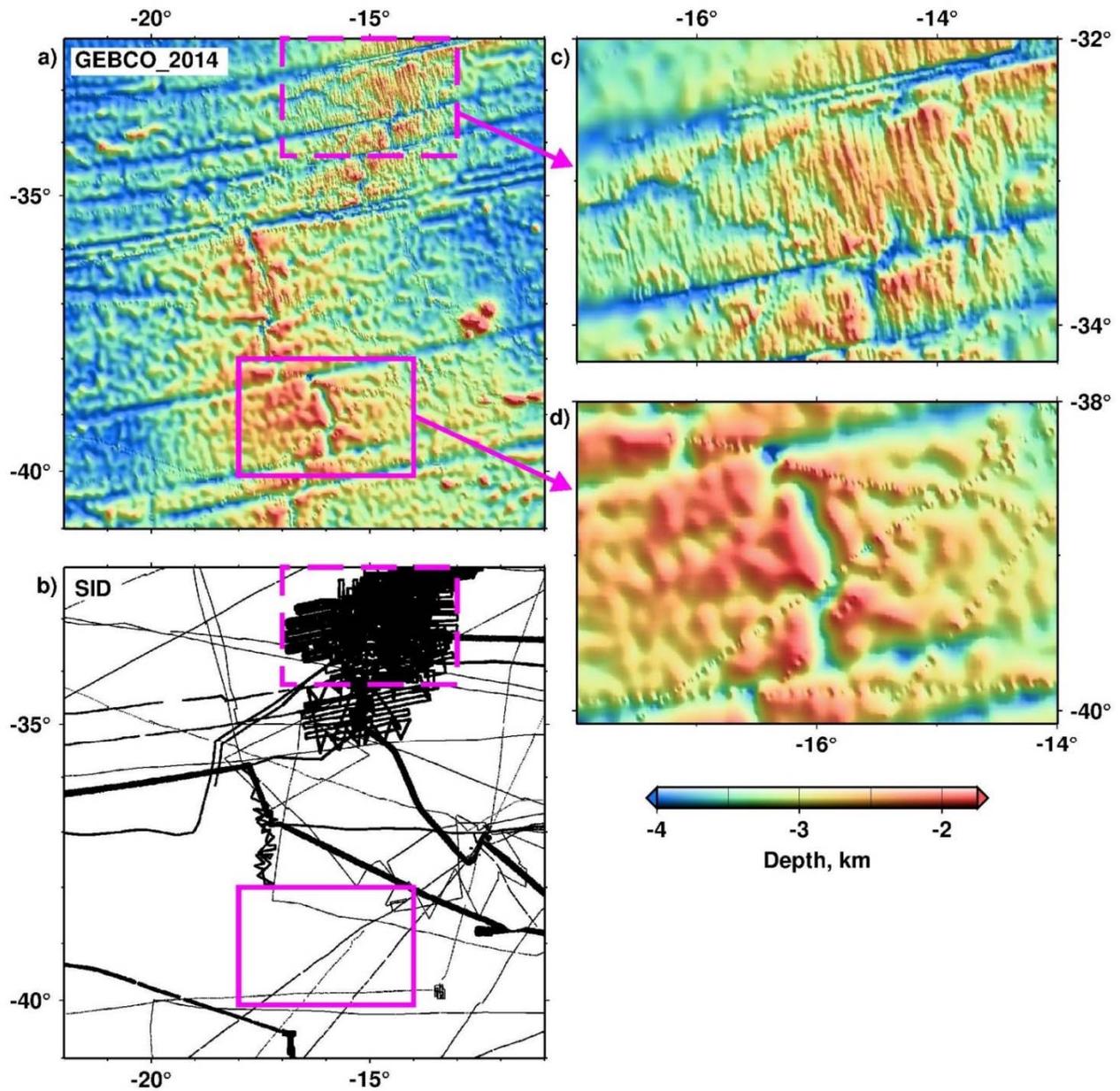
frequency multibeam systems. These AUVs would serve as excellent complements to the mapping barge, but their present endurance, cost, and swath cover does not make them the tool for mapping the entire World Ocean floor.



**Figure 4.1:** A shaded relief of the GEBCO\_2014 grid. Figure is from Weatherall et al. (2015).



**Figure 4.2:** GEBCO 2014 bathymetric data coverage. At this scale the World Ocean appears much better covered with ship soundings than it is. The fact is that the available bathymetric data used to compile GEBCO\_2014 provided depth control points to only 18 % of all the 30 arc-second (926 m at the equator) grid cells. Figure is from Weatherall et al. (2015).



**Figure 4.3:** The GEBCO\_2014 grid model over a portion of the southern Mid-Atlantic ridge where multibeam bathymetry is blended with a coarser grid based on interpolation using sparse single beam echo soundings guided by satellite altimetry. a) Overview of the Mid-Atlantic ridge section. b) The ship track lines along where bathymetric soundings were gathered and used in the model. c) An area that has been surveyed using multibeam. Details in the ridge morphology are readily evident in the incorporated multibeam survey. d) A segment of the spreading ridge where the depths estimated primarily from satellite altimetry. Only a hint of the ridge morphology is seen. The reason for the lack of detail in d is that the satellite altimetry cannot resolve small features due to the altimeter track spacing, and a physical limitation of the gravity method known as downward continuation. Figure us from Weatherall et al. (2015).

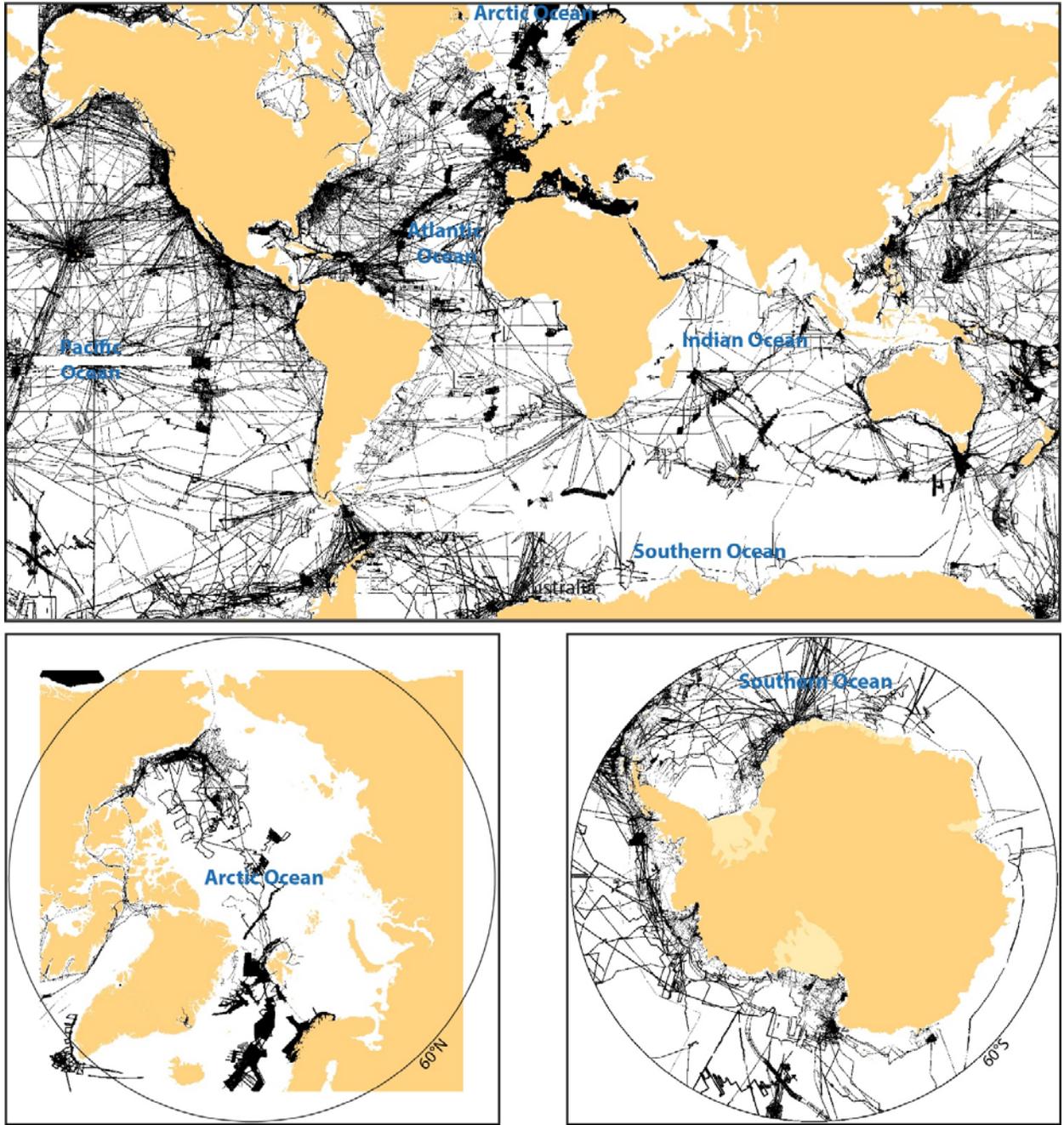


Figure 4.4. Multibeam bathymetry included in the GEBCO\_2014 grid.

# GEBCO Nippon Foundation Seabed 2030 Project Governance and Management

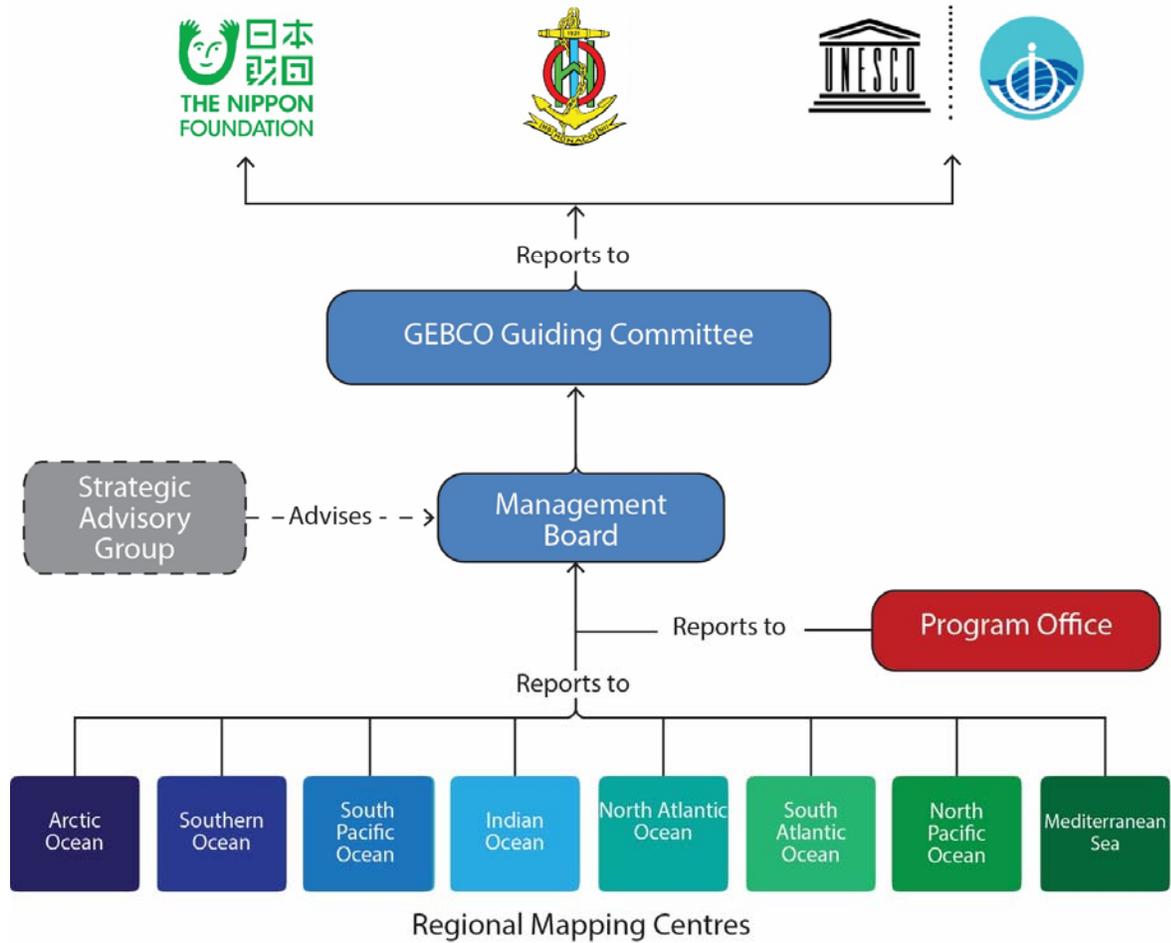


Figure 5.1. Structure of Seabed 2030.