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The re-establishment of HA04, Crozet Islands, France

After several years of sustained efforts, the re-establishment of HA04, at the Crozet Islands, a Natural Reserve in the French Southern and Antarctic Territories (TAAF), was completed in December 2016. This major engineering and logistical undertaking marks the completion of the installation of the hydroacoustic component of the International Monitoring System (IMS). While still in its testing phase, HA04 sends continuously quality data to the International Data Centre (IDC), pending official certification and full promotion to CTBTO Operations in June, 2017.

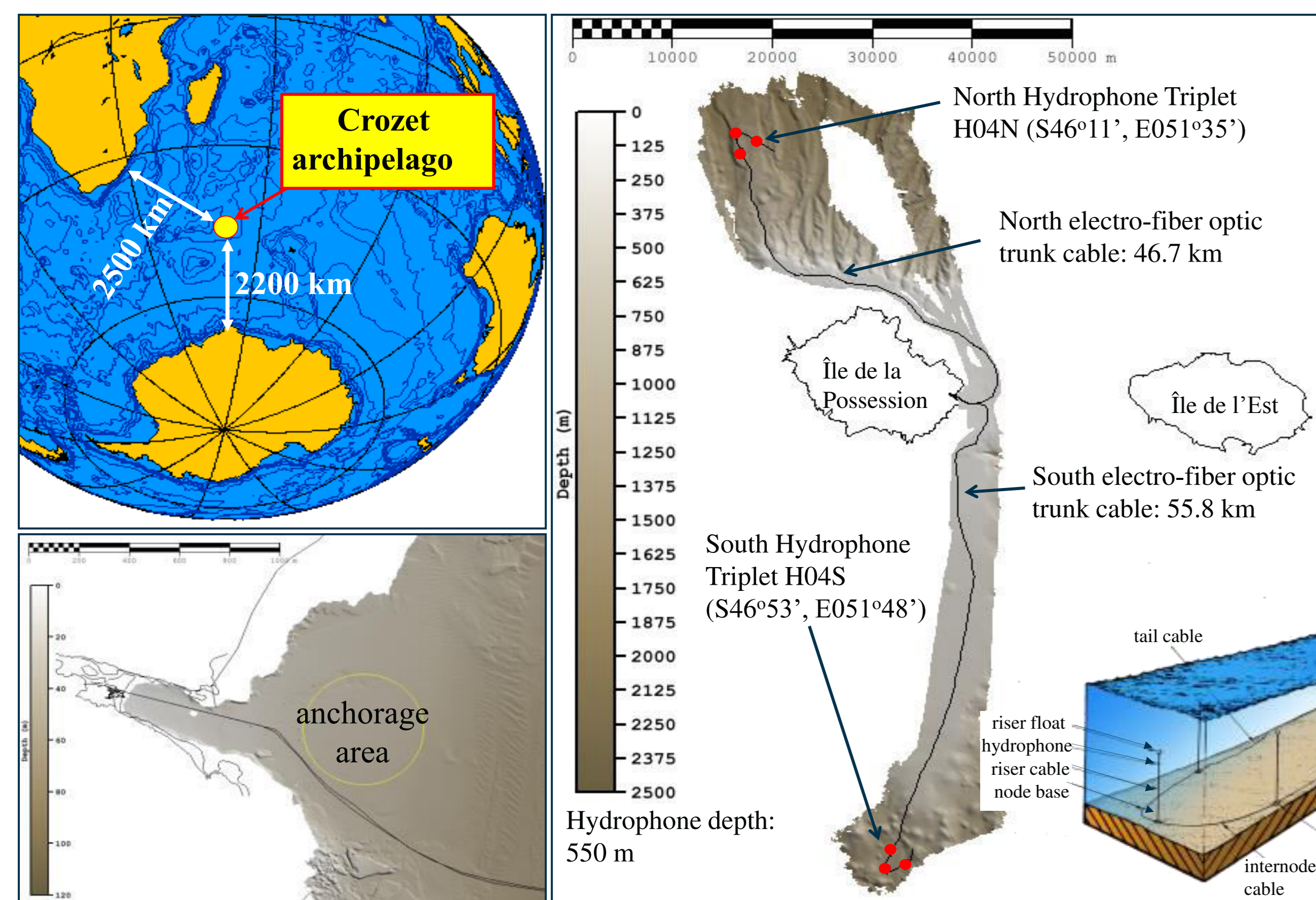


Figure 1. (Top left) Location of the Crozet archipelago in the Southern Indian Ocean in the “roaring forties” (S46°25', E051°51'). (Top right) HA04 triplet locations, deployed trunk cable routes and multibeam sonar bathymetries acquired during the February 2016 preparatory mission conducted by the CTBTO and the French Polar Institute (IPEV) with the French Oceanographic and Supply Ship Marion Dufresne II (MDII). Inset triplet schematic courtesy of L-3 MariPro, USA. (Bottom left) Detail of the HA04 trunk cable landings in Baie du Marin, on Île de la Possession.

Chronology of the HA04 installation

Operation	Marion Dufresne II	Cable Ship C/S Decisive	Fishing boat Osiris
Transit	Shore team departure from La Reunion 2 nd December	Departure from Newington (USA) 12 th November 2016	-
	Shore team arrival at Crozet 7 th December	Arrival at Cape Town 11 th December	-
	10 th December MDII leaves Crozet	13 th December C/S departs Cape Town	-
On-shore Installation preparation	8 th – 19 th December on-island preparations	Transit	-
At-sea Installation	-	20 th – 30 th December Installation at Crozet	-
System Acceptance Testing, island close-out and Return	-	Departure 30 th Dec, Arrival at Cape Town 6 th Jan	Departure shore team from Crozet on 6 th January 2017

Figure 2. Timeline of the HA04 installation at Crozet. The logistics associated with these islands, which are among the most remote and isolated locations on earth, required the coordination of three ships.

On 7 December 2016, the shore team was brought to Île de la Possession by helicopter from the French oceanographic and supply ship Marion Dufresne II anchored in Baie du Marin. The MDII left Crozet a few days later to continue its logistical mission in the Southern Ocean. The support offered to the shore team by the Administration of the French Southern and Antarctic Territories (TAAF), the Natural Reserve Supervision, the executive agent CEA (French Commission for Atomic and Alternative Energies) who provided a team member for the shore team, the Crozet base personnel and the scientists working at Crozet, proved to be indispensable during the entire mission.

While on-island preparations continued, the TE SubCom cable ship “C/S Decisive” completed its passage from the East Coast of the United States, where it had previously loaded the HA04 Underwater System (UWS) on-board, and arrived at Cape Town on 11 December. On 13 December, the maritime installation team departed Cape Town en route to the Crozet Islands on-board the C/S Decisive.

The installation of the HA04 UWS at Crozet commenced on 20 December 2016 and was continuously supported by three teams until the issuance of the Provisional Acceptance Certificate on 6 January 2017: the underwater system installation team on-board the cable ship, the shore team at Crozet and the Vienna team at CTBTO for data quality control and coordination.

The cable shore landing operations began soon after arrival of the C/S Decisive at Crozet on 20 December. Although the installation of HA04 was planned during the austral summer, the weather conditions turned out to be extremely challenging: experts familiar with the area confirmed that this month had one of the worst weather patterns observed to date during this period. The on-site teams faced storms with hurricane force winds, torrential freezing rain, snow and hail pounding the area several times per week. In spite of these difficulties, on 23 December 2016 and on 30 December 2016 the deployment of the South and North hydrophone triplets respectively was successfully completed by the C/S Decisive.



Figure 3. (Left) The Marion Dufresne II rolling in Force 8 seas during transit to Crozet on 6 December. (Right) The C/S Decisive holding station near Île de la Possession on 20 December, just a few hours after completion of the first cable landing, in a storm with sustained winds of 54 knots (100 km/h) and gusts of 80 knots (150 km/h). The inset shows the ship anemometer readings.



Figure 4. The overboarding of the last node/hydrophone of the North HA04 triplet from the cable ship C/S Decisive on the evening of the 29th December 2016, photographed from a drone.

Data quality control and analysis

During the installation, data from the station arrived at CTBTO in real time from the HA04 Hydroacoustic Laboratory (HL) on Île de la Possession. The Vienna team conducted data quality checks and provided feedback and daily reports to the shore team and the cable ship. After the H04N triplet was deployed, the hydrophones were released from the nodes on the sea-floor and were lifted by the riser floats to their final position in the water column. From this moment on the station was in its final configuration and no longer connected to the installation vessel.

High quality data sent by the station made it possible to detect several events, demonstrating its performance. In figure 5, the spectrograms of seismic and hydroacoustic signals recorded at H04N from two different events on the Southwest Indian Ridge (Ev.1) and off the Coast of Northern Sumatra (Ev.2) are shown.

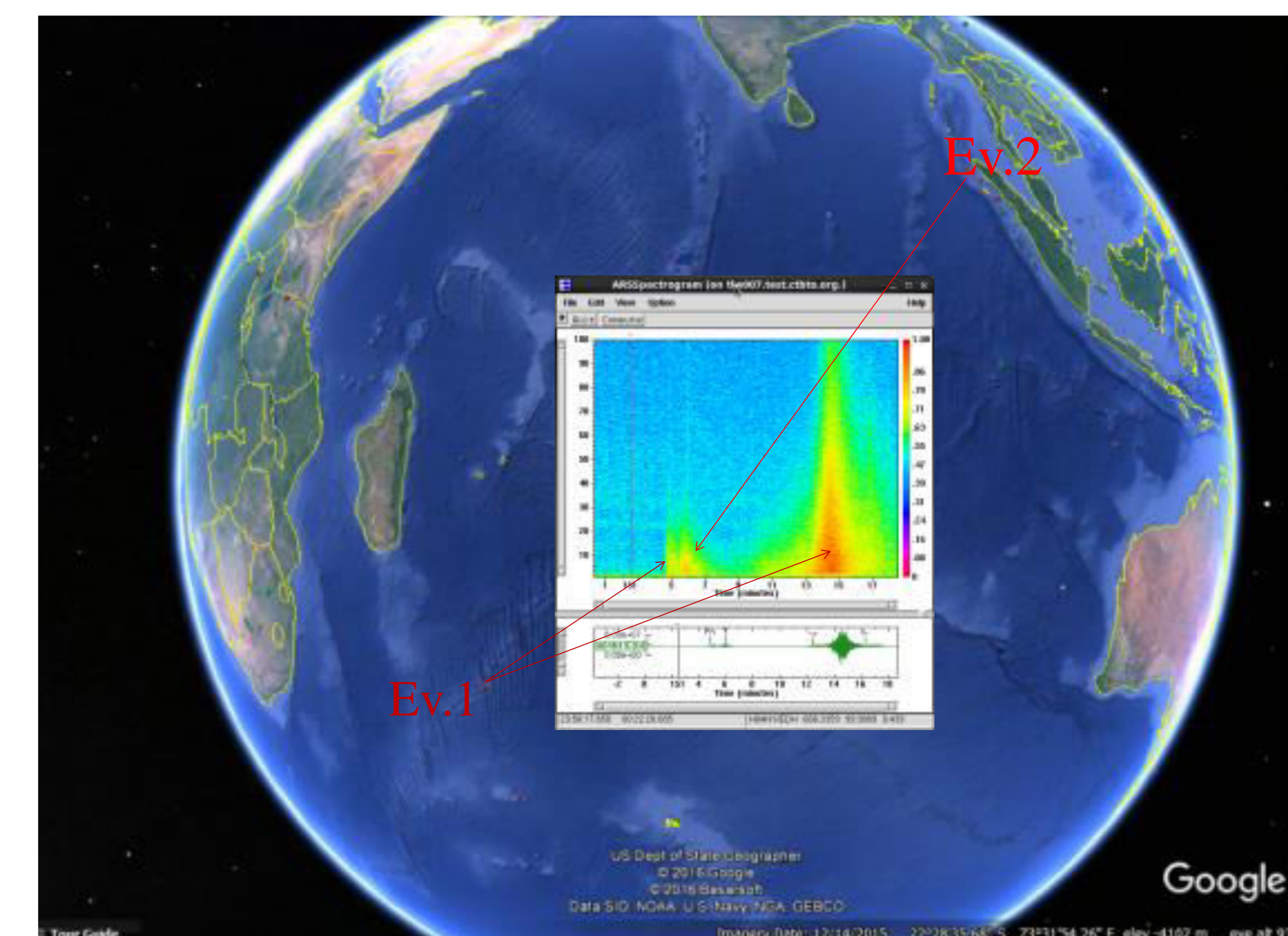


Figure 5. Signal recorded at H04N from two different events: Southwest Indian Ridge (Ev.1) and off the coast of Northern Sumatra (Ev.2).

The spectrograms of signals recorded on the north and south triplets of HA04 for these two events are compared in Figure 6. The early arrivals are seismic (Pn) signals from both events, while the late arrival is the T-phase associated with a southwest Indian ridge event.

It is apparent that the T-phase generated by Ev.1 (Indian Ridge) was the most prominent arrival at the north triplet, not only due to its proximity to the epicenter, but also because the Crozet islands plateau partially blocks the acoustic energy propagating in the water column along the path from the source to the south hydrophone triplet.

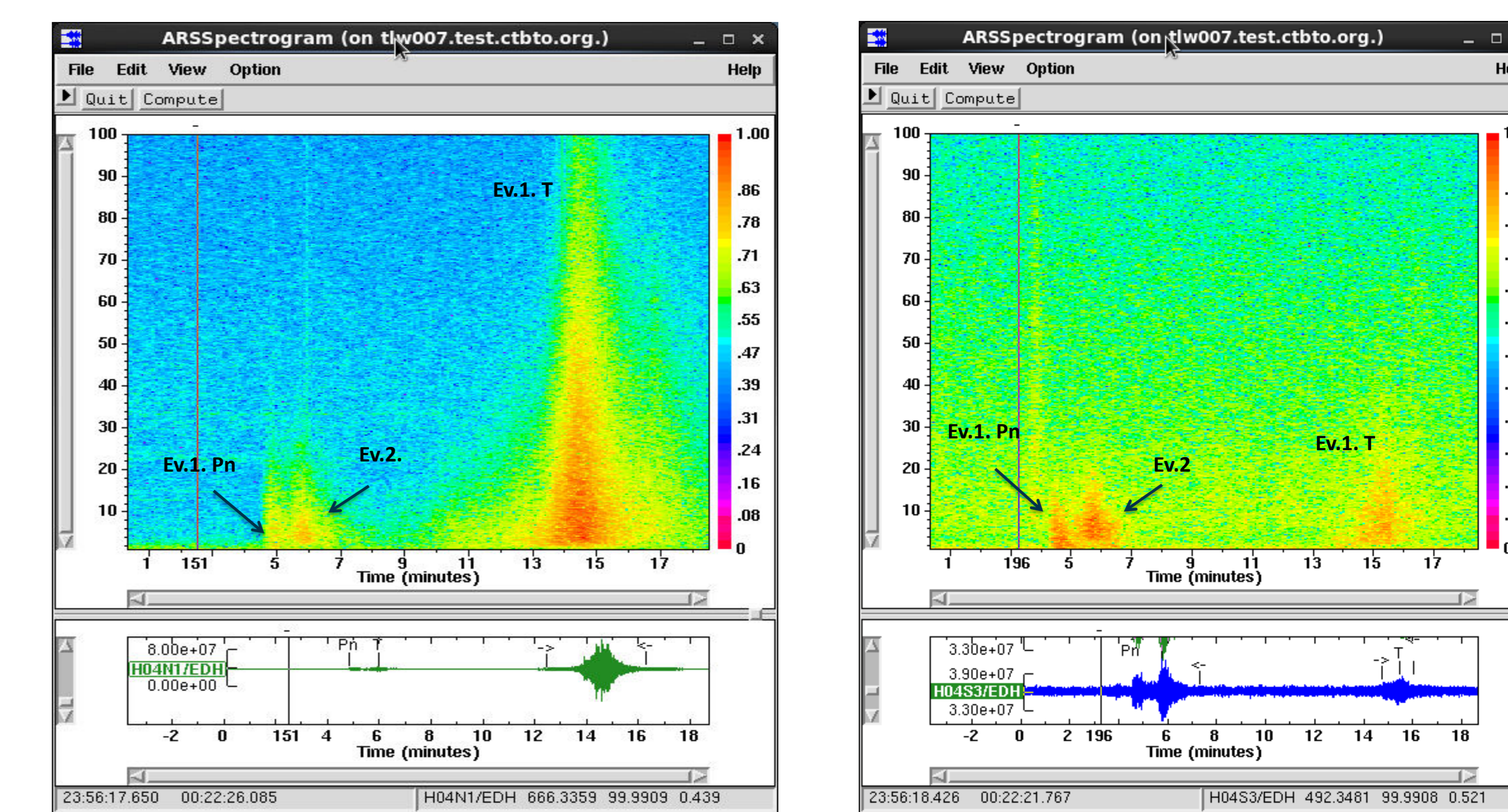


Figure 6. Comparison of signals recorded at H04N (left) and H04S (right) from the Southwest Indian Ridge (Ev.1) and off the coast of Northern Sumatra (Ev.2).