The Avilés Canyon system: morphology and sediment transport

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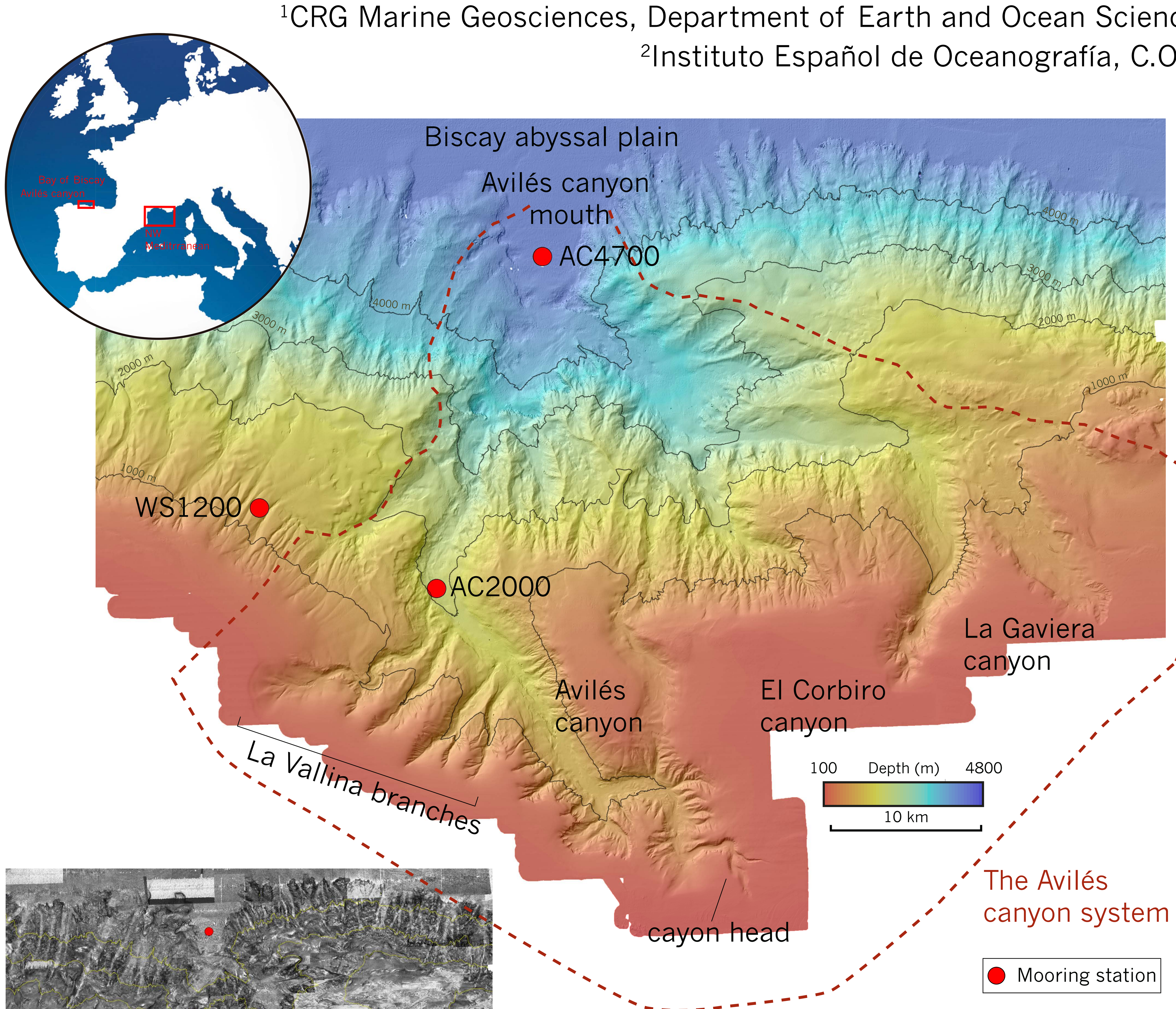


We present a detailed multibeam bathymetry mapping of the Avilés submarine canyon system carried out in the frame of the Spanish DOS MARES research project, jointly with a year-round (March 2012 to April 2013) monitoring of environmental variables and particle fluxes. Remote sensing images and meteorological and hydrographical data are also incorporated.

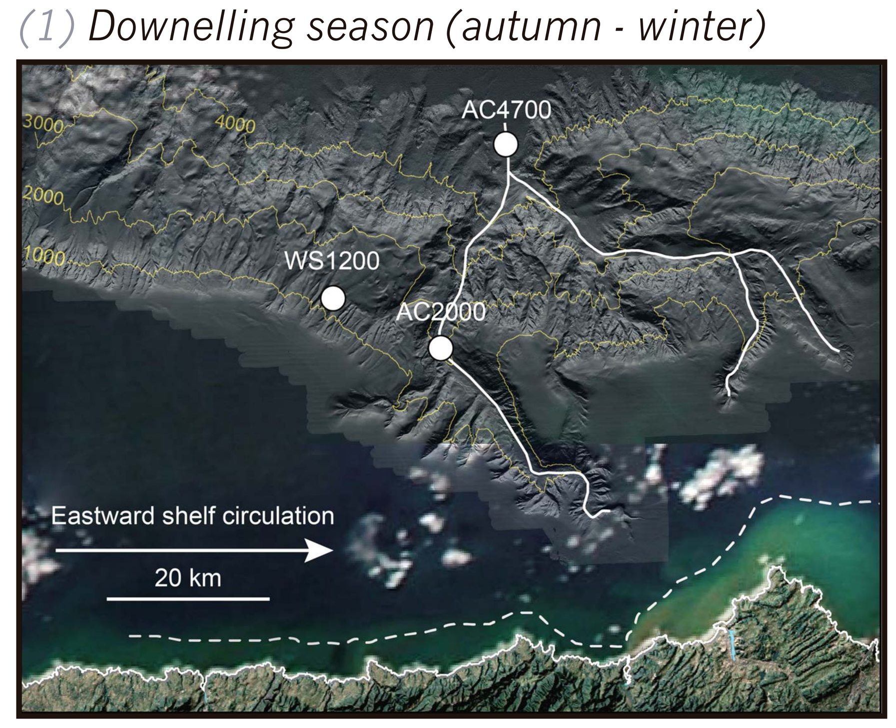
1. Morphology

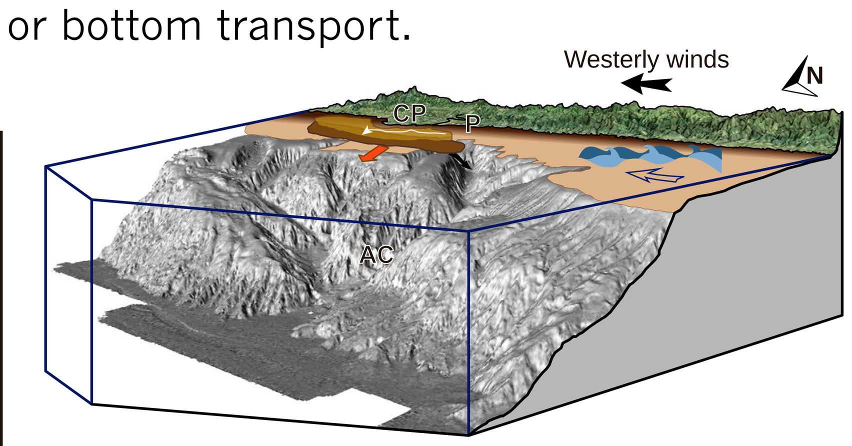
The Avilés submarine canyon system is one of the largest in Europe. It **INCISE**s the central Cantabrian margin in the Bay of Biscay extending down to the Biscay abyssal plain where it opens at 4765 m of water depth. The Avilés Canyon (AC) is the main, 80 km long trunk of such a canyon system and consists of three main branches with contrasting morphologies: the El Corbiro and La Gaviera canyons to the east and the Avilés Canyon itself to the west. A large number of smaller tributaries, of which the most significant ones are a shelf-incising set of tributaries known as La Vallina branches, enter the main Avilés Canyon trunk through its western side.

2. Sediment transport regime

Storms are the main driver of particle fluxes in the Avilés Canyon area. Wind direction and wind-driven currents determine whether resuspended shelf particulate matter may reach the canyon, and if this will occur by surface or bottom transport.

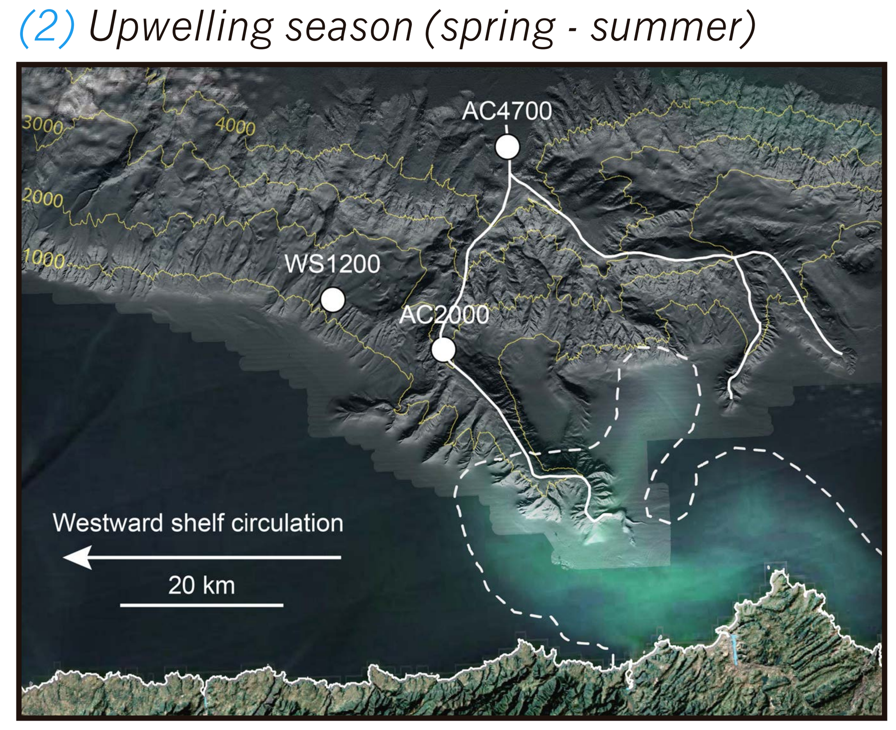
(1) Downelling season (autumn - winter)

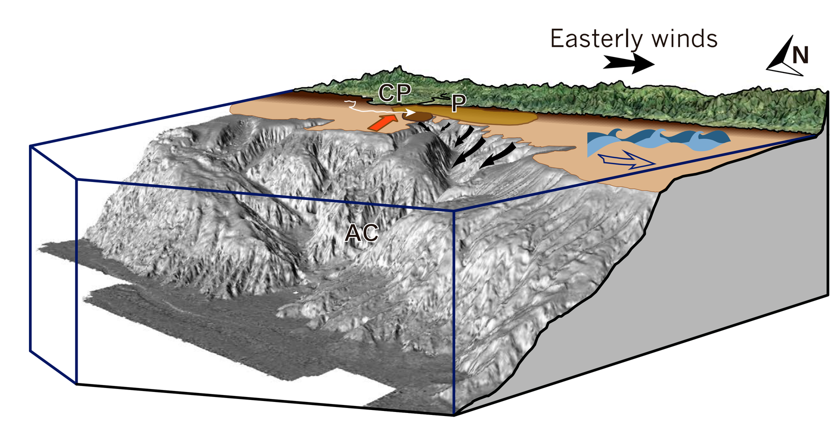


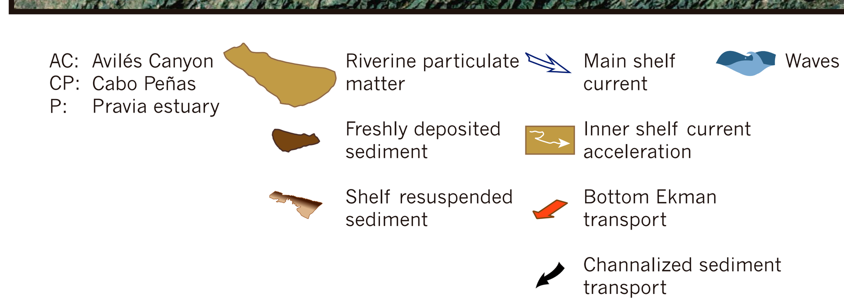


Winds blowing from the west induce an onshore surface Ekman transport that pushes river-sourced and shelf resuspended sedimentary particles away from the Avilés canyon head and upper course. However, under the same situation, the bottom Ekman transport is directed offshore and, therefore, favours the injection of particles into the AC and the adjacent slope via bottom nepheloid layers, which are detected mainly by increases in Lateral Fluxes (LF), see *(1)* in section 3.

(2) Upwelling season (spring - summer)

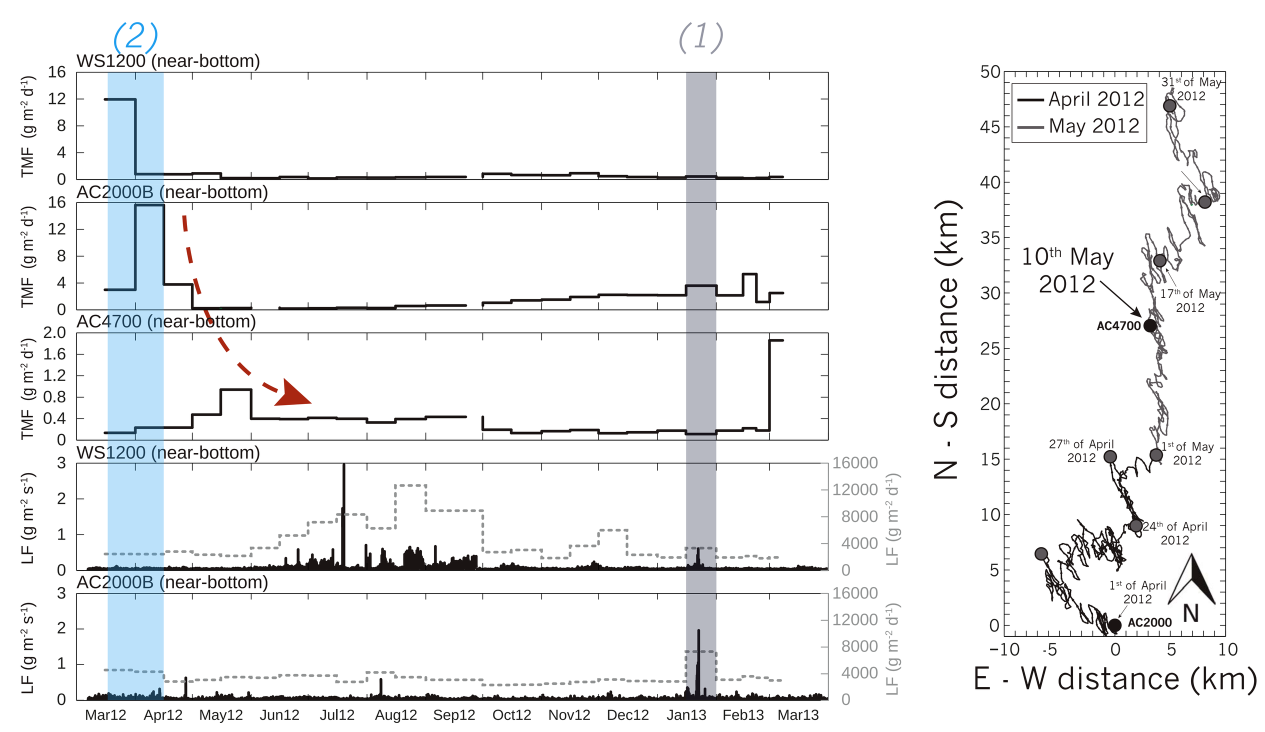






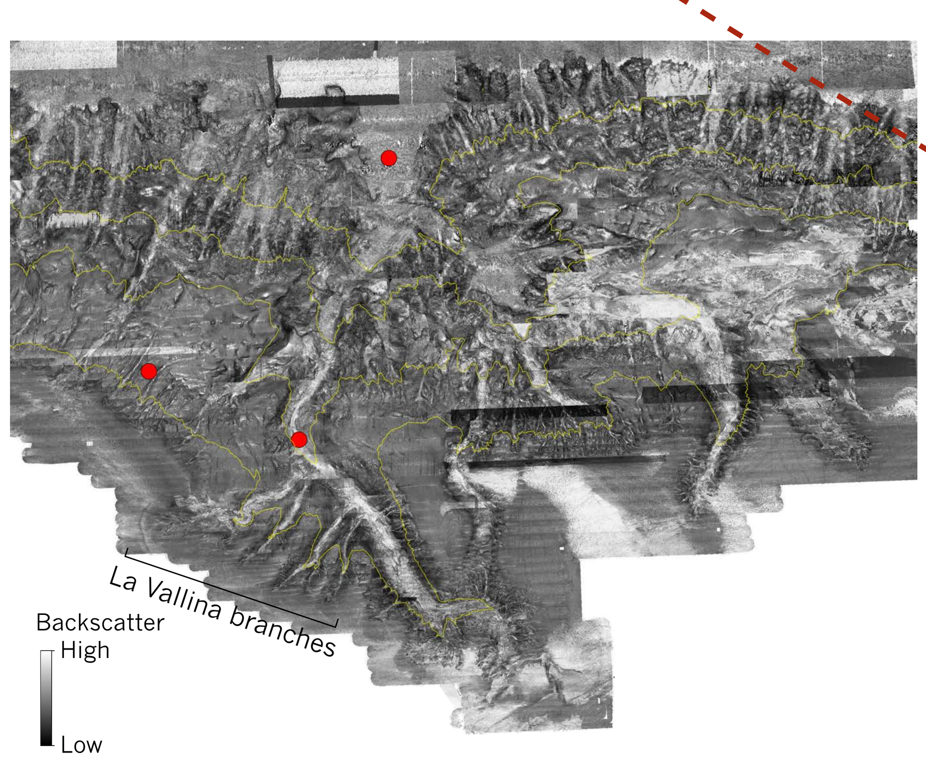
In contrast, winds blowing from the east induce coastal upwelling and ease the advection in the surface layer of particulate matter towards the AC and the adjacent slope west of it. This situation favours the subsequent settling of particulate matter into the AC down to depths of at least 2000 m (see increases in Total Mass Fluxes (TMF) in section 3 highlighted by *(2)*). The same wind forcing triggers a bottom Ekman transport favouring the retention of resuspended sediments on the shelf.

3. Measured Particle fluxes



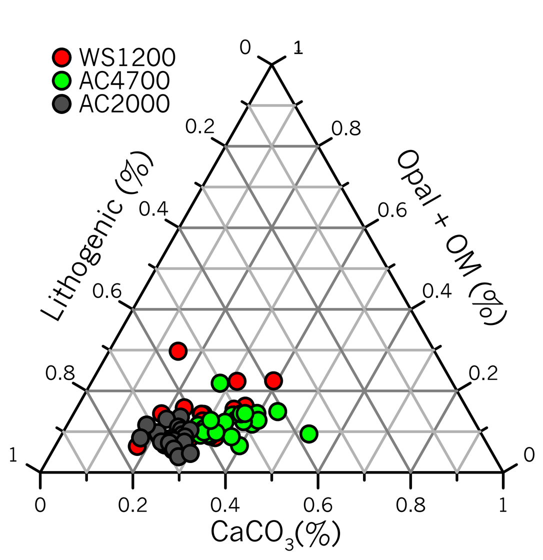
The pattern of increments in Total Mass Fluxes (TMF) first in AC2000 (middle canyon course, near bottom) in April 2012, and 30 days later in AC4700 (lowermost canyon course, near bottom) points to an effective horizontal along canyon transport. The trajectory of particles between AC2000 and AC4700 presented in the composition shown at top-right, points to an effective horizontal along canyon transport, at least at the depth level of AC2000.

4. Seafloor backscatter imagery



The axis of the Avilés submarine canyon displays high backscatter intensities, which contrasts with its low reflective walls. This high backscatter could be an evidence of the delivery of large volumes of coarse shelf sediment into the canyon. Its transport down the canyon axis in the form of bed load within sediment flows may be the main erosive mechanism along the axis. High backscatter intensities can also be observed along the axes of La Vallina branches, also evidencing a remarkable degree of activity along the gullies draining the western canyon wall down the shelf.

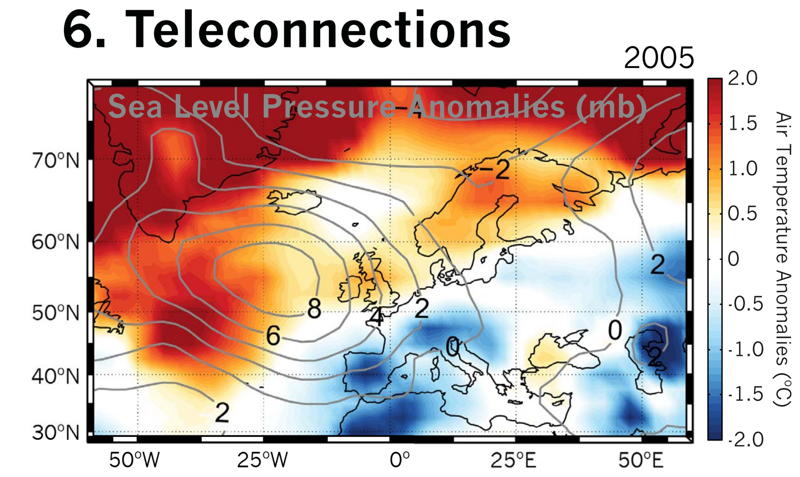
5. Relative composition

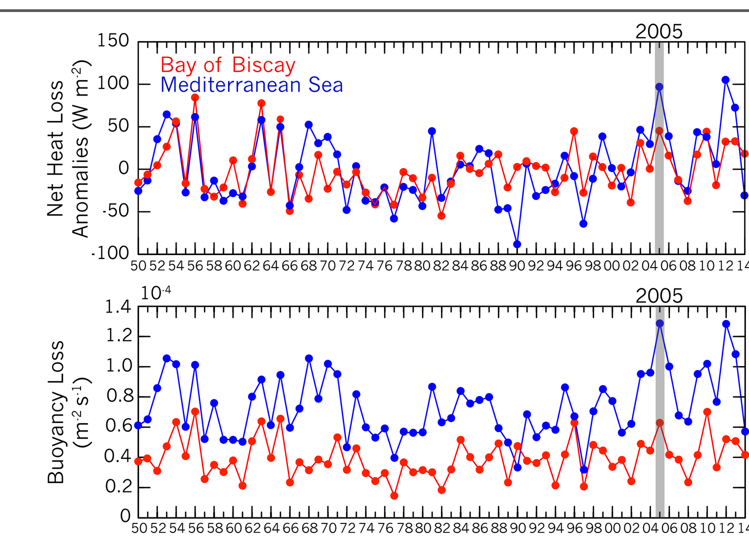


The data presented in the ternary diagram shows a strong bias towards the lithogenic fraction, which allowed us to confirm that sediments delivered by rivers represent the principal source of particles both in the adjacent shelf and open slope of the Avilés canyon. Nevertheless, Organic Matter (OM), opal and calcium carbonate fluxes represent more than 30% of the total mass flux which translates the impact of seasonal high primary production events on mass fluxes.

It is also possible to distinguish that particles collected in AC4700 (green dots) present a higher abundance of $CaCO_3$. According to its better conservation, $CaCO_3$ shells can be preserved long after its production and resuspended and transferred down-canyon during transport events without suffering a notable dissolution.

6. Teleconnections





The occurrence of an anomalous high-pressure center and its prevailing location during winter appears to be a key factor determining atmospheric teleconnections linking the oceanographic conditions between the Bay of Biscay and the NW Mediterranean. The maximum expression associated with teleconnections is achieved during especially severe winters (e.g. winter 2005) and leads to intense and concomitant ocean to atmosphere heat and buoyancy losses both over the NW Mediterranean Sea, and the Bay of Biscay. The synchronic atmospheric forcing ultimately favours a concomitant hydrographic response leading to intense events of dense water cascades and open-sea convection in the NW Mediterranean, and to extreme events of intermediate convection in the Bay of Biscay.