IODP³

INTERNATIONAL OCEAN DRILLING PROGRAMME

PROPOSAL 1104-S

SIGNALS - Stratigraphic InteGration of North Atlantic Legacy Sites

IODP^3 Proposal Cover Sheet

Proposal Title:

SIGNALS - Stratigraphic InteGration of North Atlantic Legacy Sites

Project Abstract

The North Atlantic plays a crucial role in regulating global climate due to its proximity to major ice sheets and sensitivity to changes in the Atlantic Meridional Overturning Circulation (AMOC). Over millennial and orbital timescales, the region has experienced abrupt climate shifts with significant global implications. Despite the wealth of sediment cores recovered from North Atlantic legacy sites through IODP and predecessor programs, many remain underutilized due to challenges in stratigraphic correlation and integration. The **SIGNALS (Stratigraphic InteGration of North Atlantic Legacy Sites)** project aims to synthesize and integrate these legacy records into a coherent, four-dimensional stratigraphic framework to provide a regional reconstruction of past climate variability on millennial to orbital timescales since the late Miocene.

SIGNALS will enhance stratigraphic correlation, refine age models, and synchronize proxy datasets for multiple legacy sites across the North Atlantic spanning a wide range of climatic and bathymetric gradients. The project will capitalize on advanced methods, including machine learning and signal correlation algorithms, to rapidly produce high-resolution data by automated processing of core images, point counting, and precise stratigraphic correlation. The **SIGNALS** Expedition Science Team will work collaboratively to produce training datasets to refine AI models, stratigraphic correlation methods, and age models.

SIGNALS will address methodological issues associated with estimating uncertainty in stratigraphic correlations and the limits of temporal resolution at each site given varying sedimentation rates, bioturbation, and sampling frequency. Furthermore, we will develop process models to understand how orbitally-driven climatic changes are expressed as cycles in the stratigraphic record of each site. By analyzing high-resolution geochemical and sedimentological proxies in a robust stratigraphic framework, the project will reconstruct climate evolution and ocean circulation changes across the North Atlantic since the late Miocene. The project will focus on major climatic transitions and provide robust regional paleoclimate data for numerical modeling and assimilation studies.

Beyond research advancements, **SIGNALS** will foster collaboration by developing user-friendly computational tools, training early-career researchers, and making data publicly accessible through open repositories. The project will contribute to other programs, such as PAGES PMIP, CVAS, TIMES, Beyond-EPICA Oldest Ice, by providing robust paleoclimatic information for assimilation and comparison. **SIGNALS** aligns with key objectives of the IODP 2050 Science Framework, including: Earth’s Climate System, Feedbacks in the Earth System, Tipping Points in Earth History, and Global Cycles of Energy and Matter. Additionally, it addresses the themes of Technology Development and Big Data Analytics through machine learning applications and automated data collection.

Scientific Objectives

The **SIGNALS** project aims to construct a comprehensive, 4-D stratigraphic framework to study climate variability across the North Atlantic on orbital and millennial timescales since the late Miocene. By integrating legacy data from ODP/IODP drill sites, **SIGNALS** will refine stratigraphic correlations and chronologies and link existing and new proxy records across multiple locations along climatic and bathymetric gradients to evaluate the role of the North Atlantic in global ocean-climate interactions.

Key scientific objectives include:

1. Reconstructing North Atlantic Climate Evolution – Investigate how the Earth transitioned from the warm Miocene to the glacial-interglacial cycles of the Pleistocene, with a focus on orbital-scale climate variability and feedbacks.
2. Understanding Millennial-Scale Climate Variability (MCV) – Reconstruct the timing and spatial patterns of abrupt climate change in the Quaternary and their relationship to changing Atlantic Meridional Overturning Circulation (AMOC).
3. Linking Surface and Deep Ocean Changes– Examine how variations in sea surface temperatures (SST), ice-rafted debris (IRD), and deep-water circulation influenced past climate shifts and carbon cycle dynamics.
4. Marine-Ice-Terrestrial correlations – Precisely correlate climate signals in marine sediment cores to the polar ice cores and terrestrial records to link oceanic, atmospheric, and terrestrial climate and environmental changes.
5. Advancing Stratigraphic Correlation Techniques – Develop and apply automated signal correlation algorithms to synchronize sediment records at orbital and suborbital timescales, along with estimated uncertainties.
6. Core Imaging & Computer Vision – process high-resolution core images using neural networks to automatically segment and remove unwanted disturbances from bioturbation, redox changes, and core disturbance.

Science Communication Plain Language Summary

The North Atlantic Ocean plays a major role in shaping regional and global climate through its effect on atmospheric circulation and the transport of heat and salt through the global ocean. This region has experienced dramatic climate shifts, including the abrupt warming and cooling events that coincided with growth of ice sheets and changes in deep ocean circulation. These changes affected the movement and storage of heat, salt, and carbon in the deep ocean, influencing Earth’ s climate on both long and short timescales. Understanding how and why these shifts occurred in the past is relevant to future climate change given warnings of a potential slowdown of the Atlantic deep overturning circulation in response to global warming,

The **SIGNALS** project aims to integrate sediment core data from key legacy sites recovered by deep-sea drilling expeditions across the North Atlantic. No one location fully captures past climate change and thus one major goal of **SIGNALS** is to align data from multiple drill sites to develop a regional picture. The SIGNALS Expedition Science Team will develop and apply advanced computational tools for signal alignment and image analysis to more accurately correlate climatic signals at a higher resolution than previously possible. The project will also develop user-friendly tools and resources to train the next generation of paleoclimate researchers. The methods and data will be shared openly, allowing scientists worldwide to build on this work.

Understanding the history of climate change in the North Atlantic is important because similar processes continue to shape our climate today. Studying past ocean and climate interactions will help us better anticipate future changes, especially those related to rising temperatures, melting ice sheets, and disruptions in deep ocean circulation. The knowledge gained from **SIGNALS** will contribute to global efforts to understand and predict future climate change.