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ISSN: 2703-9072

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Vol. 4.3(2024)
Pp 111–114

Bond Cycles and the Influence of The Sun on Earth's Climate

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Keywords: Bond cycles; solar influence, Earth's climate

Submitted 2024-11-25, Accepted 2024-11-29. https://doi.org/10.53234/scc202412/28

Summary of presentation

Bond cycles are named after Gerard Bond, the first author on a seminal paper published in the journal Science in 2001 (from now on simply "Bond"):

> Persistent Solar Influence on North Atlantic Climate During the Holocene
> Gerard Bond, *et al.*
> *Science* **294**, 2130 (2001);
>
> DOI: 10.1126/science.1065680

At the heart of Bond's work are two important geological / geochemical processes:

1. *Sedimentary provenance analysis* is the methodology of linking a sedimentary sequence to its source area. Most sediments and sedimentary rocks have origins in erosion products in uplifted areas of the continental masses. These erosion products are gathered by river systems and transported to the sea where they accumulate on the continental shelves. The main tools employed to determine provenance are:
    a. Bulk chemistry
    b. Mineralogy, especially exotic minerals
    c. Isotope composition
    d. Sedimentary structures
2. *Cosmogenic isotope variations.* Cosmogenic isotopes are formed in the atmosphere by the action of galactic cosmic rays on existing isotopes of N and O most notably to produce ^{14}C and ^{10}Be. Both of these isotopes are naturally radioactive and decay to 14N and ^{10}B respectively.

Bond studied core samples from two deep drilling sites in the N Atlantic. Site MC52 lies to the west of Ireland and site MC21 lies SE of Newfoundland close to the site where the Titanic struck an ice berg and sank (Figure 1). The focus of Bond's work was the abundance and type of ice rafted debris (IRD) where three types with distinctive provenance were identified, namely a) Icelandic volcanic glass, b) hematite-stained grains (red coloured) from Svalbard and east Greenland and c) detrital carbonate derived from the areas surrounding Baffin Bay and the Labrador Sea (Figure 1). IRD in the N Atlantic is formed when icebergs, that entrained sediment in glaciers or ice shelves, float eastwards or southwards and melt with the result that the IRD drizzles on to the ocean floor. Ice bergs are rare off Newfoundland and are absent west of Ireland today with the implication that in the past, ocean currents and winds periodically had a configuration very different to today with a larger N to S component.

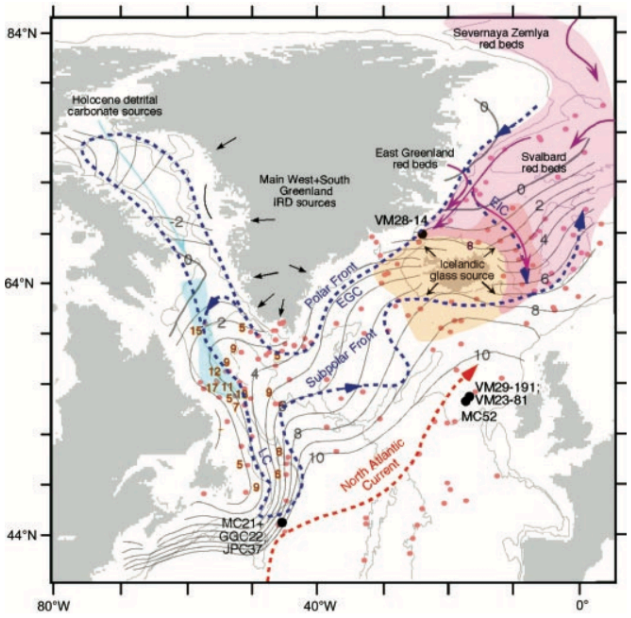

Figure 1. Map showing the locations of drilling sites MC21 and MC52 with the complex interpretation of Bond superimposed.

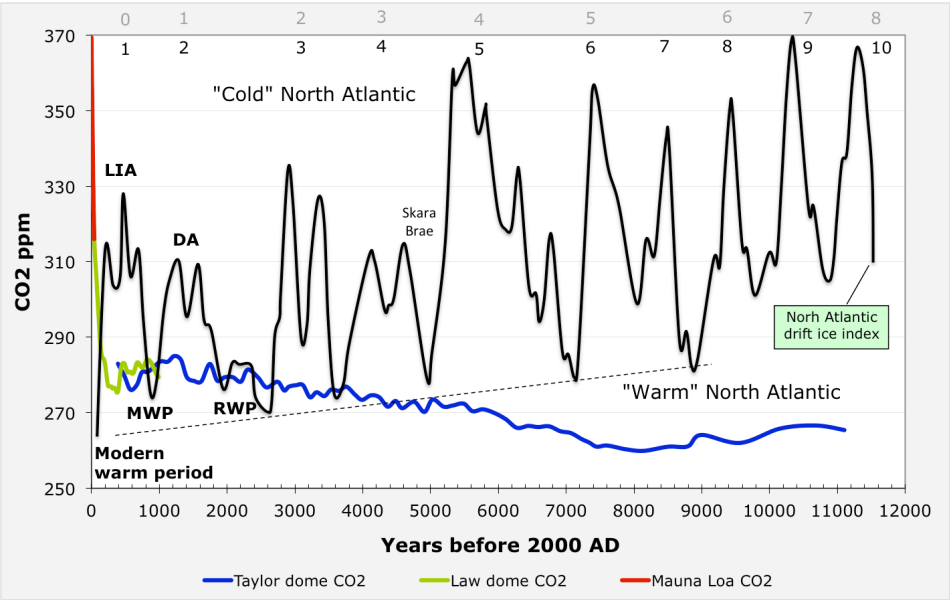

Figure 2 *Drift ice index (black solid) displaying Bond Cycles and CO_2 concentrations from Taylor Dome (blue) and Law Dome (orange), showing that variance in CO_2 has little influence on the drift ice cycles that are believed to be controlled by solar variability. LIA=Little Ice Age, MWP=Medieval Warm Period, DA-Dark Ages, RWP=Roman Warm Period.*

Bond summarised the complex provenance – depth profiles for 4 records into a single smoothed and de-trended graph that is reproduced in Figure 2. Ten major cycles representing the waxing and waning of drift ice quantities are recognised (solid black line in Figure 2). These cycles have become known as Bond cycles or Bond events.

Bond went on to compare these ice rafted debris cycles with the cosmogenic isotope production rates of ^{14}C and ^{10}Be and found a sufficiently good co-variation to suggest that variations in solar geomagnetic field strength played a key role in modulating N Atlantic Ocean currents and atmosphere circulation (Figure 3).

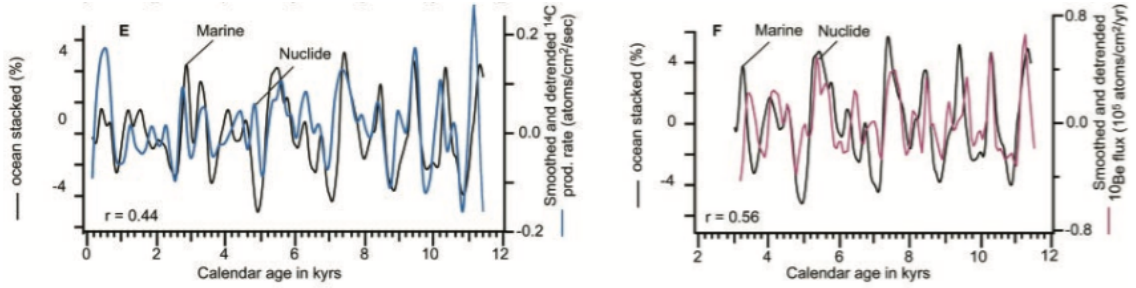

Figure 3 *Comparison of drift ice index (black line) labelled as "marine" with cosmogenic isotopes labelled as "nuclide", ^{14}C left (blue line) and ^{10}Be right (grey line) extracted from Figure 3 of Bond et al (2001).*

Changes in total solar irradiance of the order -0.04% over the last 50 years are both too small and have the wrong sign to explain recent warming. This is used by the climate alarm community to discount the role of the Sun in influencing Earth's climate. The trouble with this rationale is that accurate measurements of the Sun cover a far too short time span to be meaningful on the millennial time scale. The Sun may have phases of activity that have not yet been accurately observed or measured directly. Ineson et al (2011) report that variations in ultraviolet emissions are much larger than previously assumed. This could be part of a holistic explanation.

Bond's work is significant for showing that historic climate cycles like The Modern Warm Period, Little Ice Age, Medieval Warm Period, Dark Ages Cold and Roman Warm Periods (Figure 2) are all synchronous with Bond cycles and by inference, these cycles are linked to variations in Solar magnetic field strength. Similar cyclical variation in the length of Alpine glaciers (Joerin et al 2006) also demonstrate these cyclical variations in N Atlantic climate. The sinking of the Viking Grønland Knarr by sea ice off Greenland, circa 1380, also testifies to an increase in sea ice extent as the N Atlantic realm was entering the Little Ice Age. Permafrost in the foundations of Viking houses on Greenland today certainly was not there when the houses were built. Arguably, it is much colder today than it was 1000 years ago when the Vikings settled Greenland.

If we take the mean length of the Bond cycle as 1200 years and the depth of the Little Ice Age as 400 years before 2001 (~1600AD), then we can anticipate another 200 years of warming before the N Atlantic climate once again begins to cool. This is great news for Mankind.

A footnote on calendar dates and years before present

I sometimes find it a little confusing switching between calendar dates (datum birth of Christ) and years before present (years ago). Here I provide a simple ready reckoner. See table overleaf.

Period	*Calendar Date*	*Years ago*
Roman Warm Period	-250 to 400	2274 to 1624
Birth of Christ	0	2024
Medieval Warm Period	~950 to 1250	1074 to 774
Vikings settle Greenland	After 986	1038
Battle of Hastings	1066	9587
Hvalsey Church built	~1300	724
Little Ice Age	~1300 to 1850	724 to 174
Sinking of Greenland Knarr	~1380	644
Vikings abandon Greenland	~1450	574
Present day	2024	0

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