

The ~4 kyr cyclicity of major cooling events in the last 18,000 years

The Holocene, as the most recent and ongoing interglacial, has been a period of relatively consistent climate. However, three episodes stand out as periods of cooler climate, in the Northern Hemisphere if not across the entire globe, during the Holocene. Stepping back into the latest Pleistocene, a major cooling event

interrupting the transition from Pleistocene glaciation to the Holocene interglacial was the Younger Dryas (also known as Greenland Stadial 1), and before it was Greenland Stadial 2.1a. If one puts these five cooling events in sequence, as in the table below, a pattern emerges: they occurred about every four thousand years.

<i>Cooling event</i>	<i>Time range</i>	<i>Duration</i>	<i>Relative magnitude</i>	<i>Midpoint in time</i>	<i>Time elapsed</i>
Little Ice Age	0.5 – 0.1 ka BP	0.4 kyr	1	0.3 ka	3.75 kyr
4.2 ka event	4.2 – 3.9 ka BP ¹	0.3 kyr	1	4.05 ka	4.15 kyr
8.2 ka event	8.4 – 8.0 ka BP ¹	0.4 kyr	2	8.2 ka	4.1 kyr
Younger Dryas (GS1)	12.9 – 11.7 ka BP ²	1.2 kyr	3	12.3 ka	3.8 kyr
Oldest Dryas (GS2.1a)	17.5 – 14.7 ka BP ³	2.8 kyr	2 or 3	16.1 ka	

¹ Walker, M.J.C., et al., 2012, Formal subdivision of the Holocene Series/Epoch: a Discussion Paper by a Working Group of INTIMATE (Integration of ice-core, marine and terrestrial records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). *Journal of Quaternary Science* 27(7) 649–659

² Carlson A.E. (2013) The Younger Dryas Climate Event. In: Elias S.A. (ed.) *The Encyclopedia of Quaternary Science*, vol. 3, pp. 126-134. Amsterdam: Elsevier.

³Rasmussen, S.O., 2014. A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. *Quaternary Science Reviews* 106 (2014) 14–28.

This document follows the convention of Aubry et al. (2009) in using “ka” for thousands of years *ago* and “kyr” for thousands of years *as a duration of time* (so that 3 kyr passed from 5 ka to 2 ka). “BP” indicates “Before Present”, where “Present” is defined as AD or CE 1950.