A revised Greenland ice-core chronology for the last 3800 years: the GICC21.

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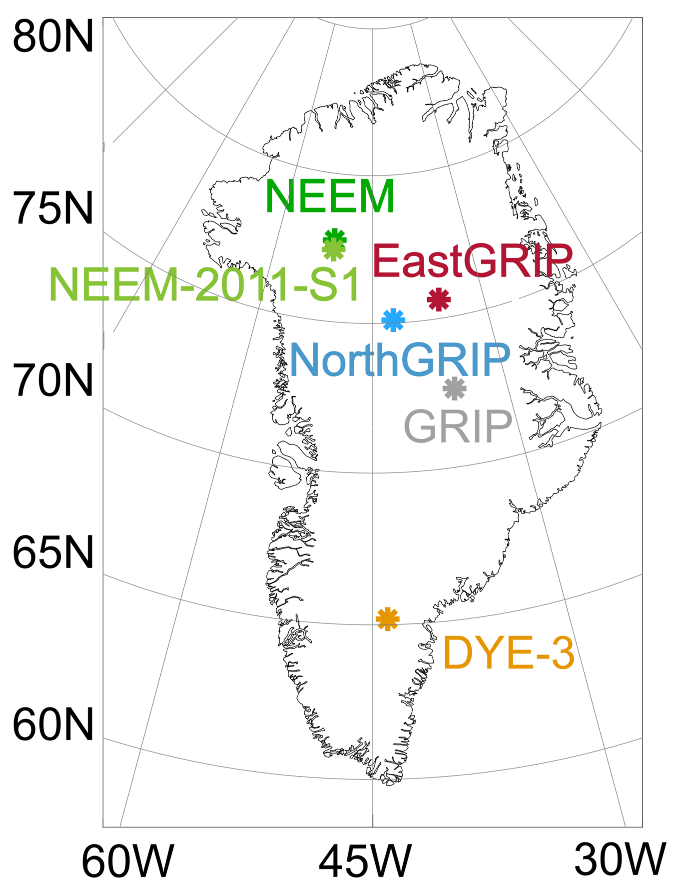
Why a new chronology for ice cores?

Ice-core chronologies help us understand the signals preserved in ice cores from e.g. Greenland.

In the Holocene, the current chronology (**GICC05**; Vinther et al., 2006) **accumulates a decadal offset** from the **tree-rings** (Adolphi & Muscheler, 2016) and from the Antarctic ice chronology (**WD2014;** Sigl et al., 2022).

A revision of the Greenland chronology over the Holocene is therefore advised.
Here, we focus on the latest 3835 years b2k (before 2000 CE).

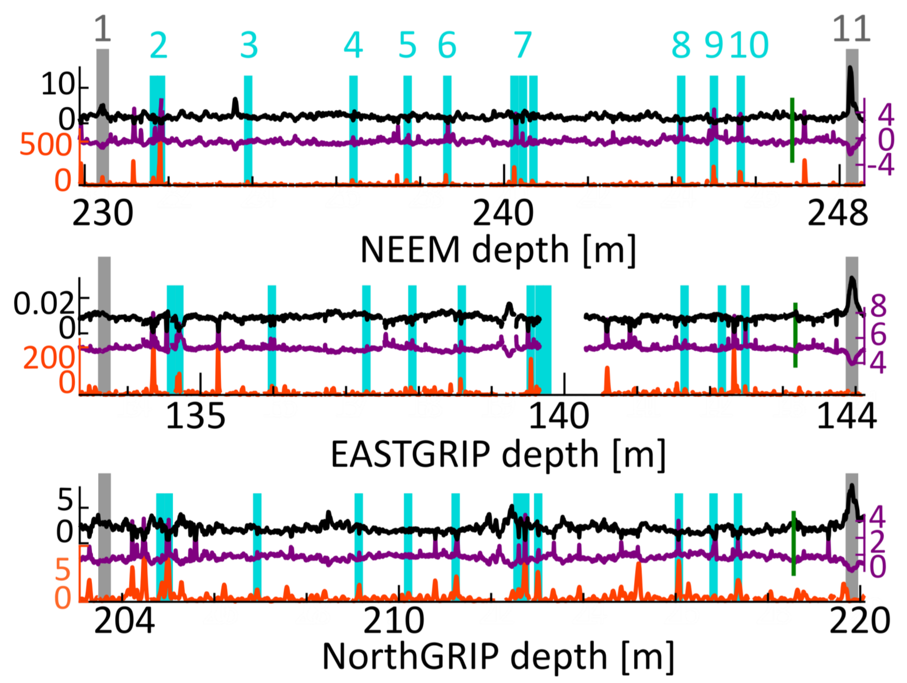


Methods

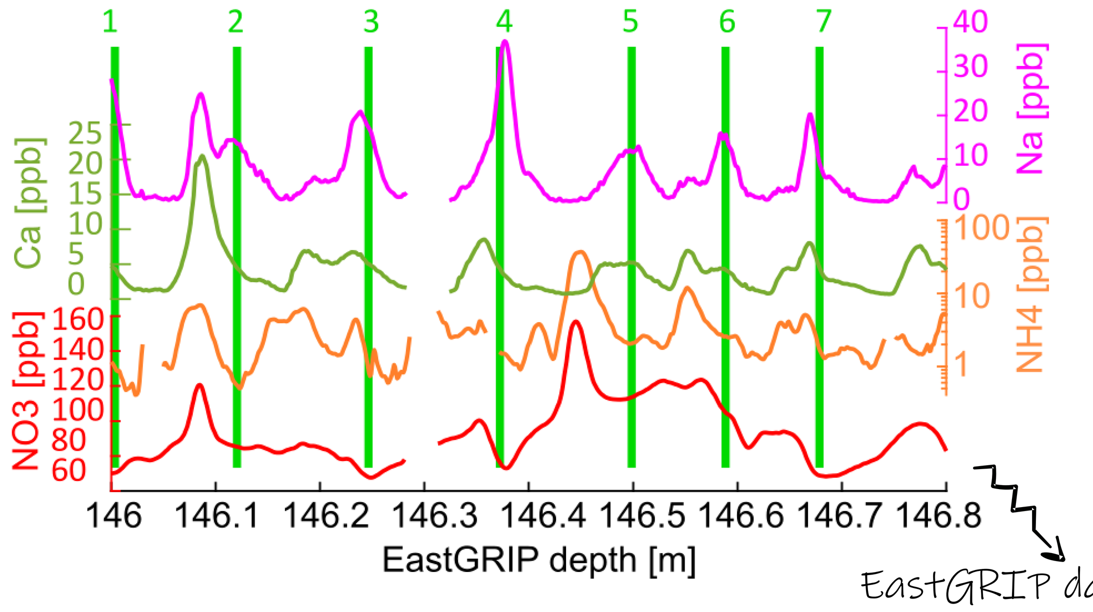
Annual-layer impurity data from 7 deep ice cores was used to construct the integrated ice-core chronology, called GICC21.

The timescale was constructed in 3 steps:

1. *Ice core matching* of synchronous volcanic eruptions, wildfires, and solar events.



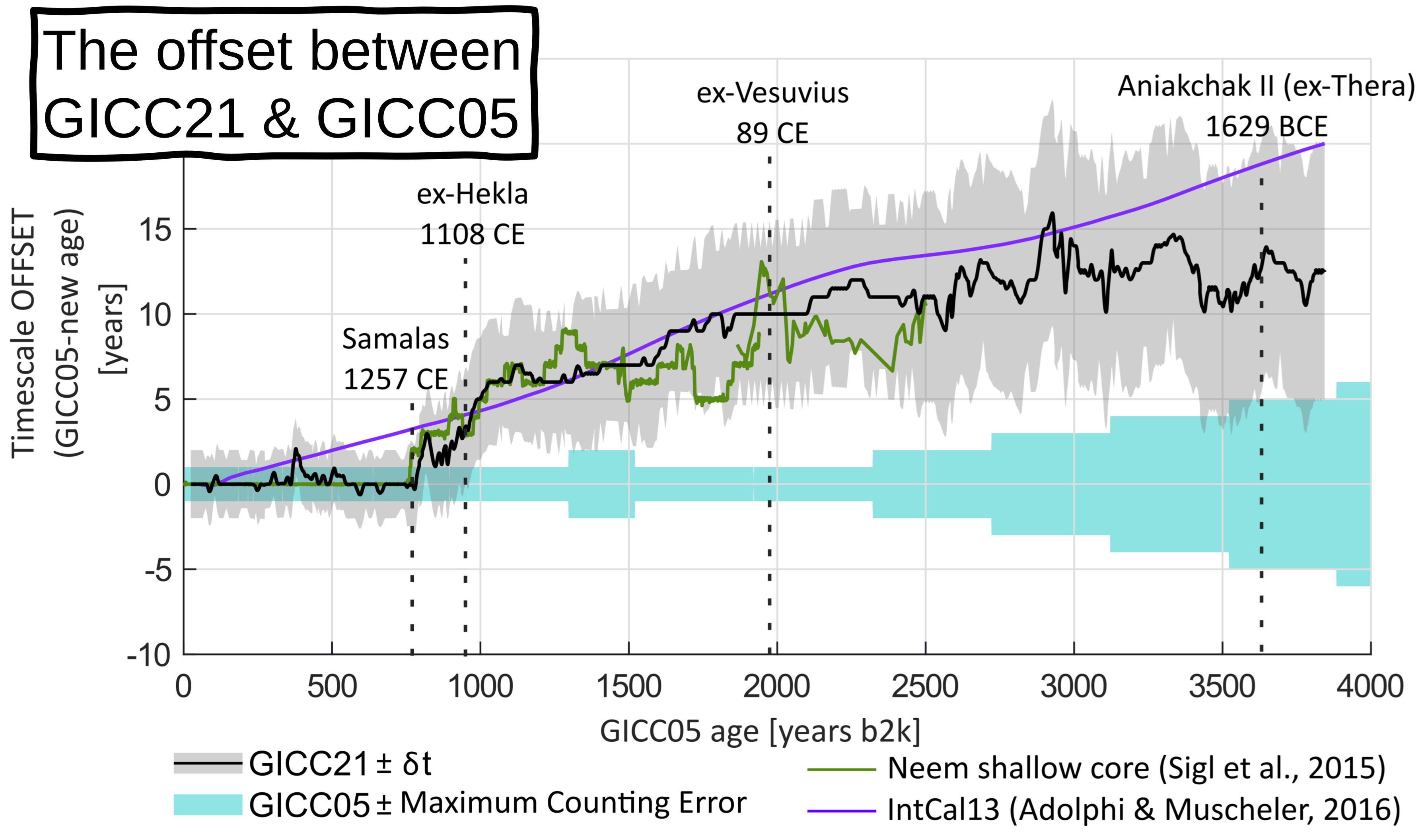
2. *Automated counting of layers*, using the StratiCounter algorithm (Winstrup et al., 2012)



3. *Fine tuning of layers* This was done by multiple observers in several sessions, in order to ensure the same number of layers across all matching horizons.

EastGRIP data is available at Erhardt et al., 2022

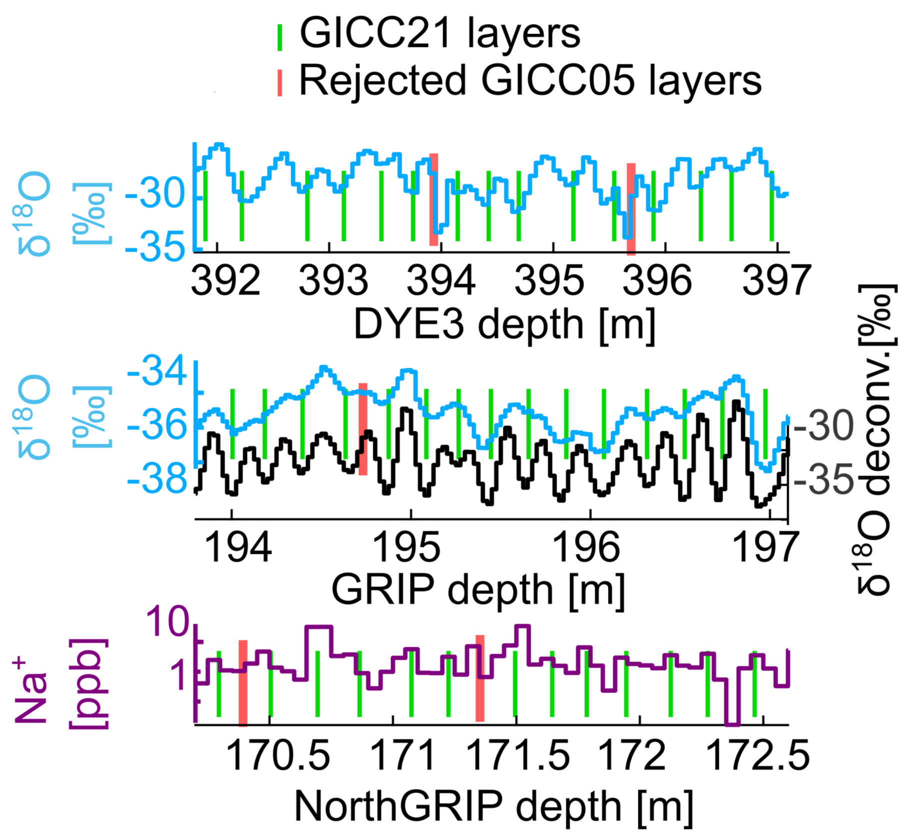
Results



The curve above shows the **accumulated offset**, in years, between the GICC05 and GICC21 (**black**).

The **origin of the offset** in this time period is likely to be attributed to a **bias** towards some famous volcanic eruptions of the last 3800 years.

To the right, we examine some of the spurious layers (red) that were included in GICC05 to match the biased age assumptions.



The uncertainty of the GICC21

Straticounter cannot, at present, process multiple ice cores at once. Data gaps are also an issue for the algorithm.

On average, this amounts to **1 layer of uncertainty per century**, beyond the virtually certain Samalas eruption of 1257 CE.

Conclusions

- We obtained an **updated version of the Greenland ice core chronology**.
- We **quantify offsets** of similar directions and magnitude to those of previous studies.
- We **remove the Vesuvius eruption** as a volcanic tie point in GICC21.
- We report an age of 1629±7 BCE for the eruption identified as **Aniakchak II.**

Future directions

A revision of the rest of the Holocene is underway. Presented in "Evaluating the accuracy of the GICC" by Sune O. Rasmussen (on Tuesday).

- Beyond 3835 years b2k, larger data gaps in NEEM and EastGRIP increase as both ice cores enter the *brittle ice zone*.
- A StratiCounter algorithm that better handles the data gaps would be a great asset. In the meantime, manual layer counting is a viable option for estimating the age of EastGRIP and NEEM over the rest of the Holocene.
- A complete revision of the Holocene timescale will provide additional information about e.g. the age of numerous eruptions in the ice cores.

Literature Cited

Adolphi, F., & Muscheler, R. Synchronizing the Greenland ice core and radiocarbon timescales over the Holocene–Bayesian 760 wiggle-matching of cosmogenic radionuclide records. Climate of the Past, 12, 15–30, 2016
Erhardt, Tobias; Jensen, Camilla Marie; Fischer, Hubertus (2022): High resolution aerosol records over the past 3.8ka from the EastGRIP ice core. PANGAEA.
Sigl, M., M. Toohey, J. R. McConnell, J. Cole-Dai, and M. Severi. 'Volcanic Stratospheric Sulfur Injections and Aerosol Optical Depth during the Holocene (Past 11\,500 Years) from a Bipolar Ice-Core Array'. Earth System Science Data 14, no. 7 (2022): 3167–96.
Winstrup, M., Svensson, A. M., Rasmussen, S. O., Winther, O., Steig, E. J., & Axelrod, A. E. An automated approach for annual layer counting in ice cores. Climate of the Past, 8(6), 1881-1895, 2012

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Abstract

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Questions? Happy to talk! **giulia.sinnl@nbi.ku.dk**