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Data quality in different paleo-archives and covering different time scales:
A key issue in the study of tipping elements.

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1. Introduction to TiPES WP1 key issues

1. The notion of abruptness remains questionable, as it refers to a time scale that is difficult to constrain properly.
2. The tipping elements listed in Lenton et al. (2008) rely on long-term instrumental observations under controlled conditions.
3. Currently identified tipping elements are mostly related to recent climate change and thus, directly or indirectly, to anthropogenic forcing. Their understanding, though, must still rely on former instances of tipping, as detected in past records, especially from studies of abrupt climatic transitions in paleoclimate proxy records.
4. Moreover, recent studies have shown that addressing abrupt transitions in the past raises the issue of data quality of individual records, including the precision of the time scale and the quantification of associated uncertainties (see Boers et al. 2017).



1. Introduction to TiPES WP1 key issues (continued)

5. Investigating past abrupt transitions and the mechanisms involved requires the best data quality possible. This can be a serious limitation when considering the sparse spatial coverage of high-resolution paleo-records, where dating is critical and corresponding errors are often hard to control (Boers et al., 2017).
6. In theory, this would therefore limit our investigations to ice-core records of the last climate cycle, because they offer the best possible time resolution. However, recent work shows that abrupt transitions can also be identified in deeper time with lower-resolution records. Such records may still reveal changes or transitions that have impacted the dynamics of the Earth system globally.
7. TiPES Work Package 1 is addressing these issues by collecting paleorecords that allow one to describe the temporal behavior of tipping elements in past climates.
8. To do so, the first step is identifying objectively the abrupt transitions.



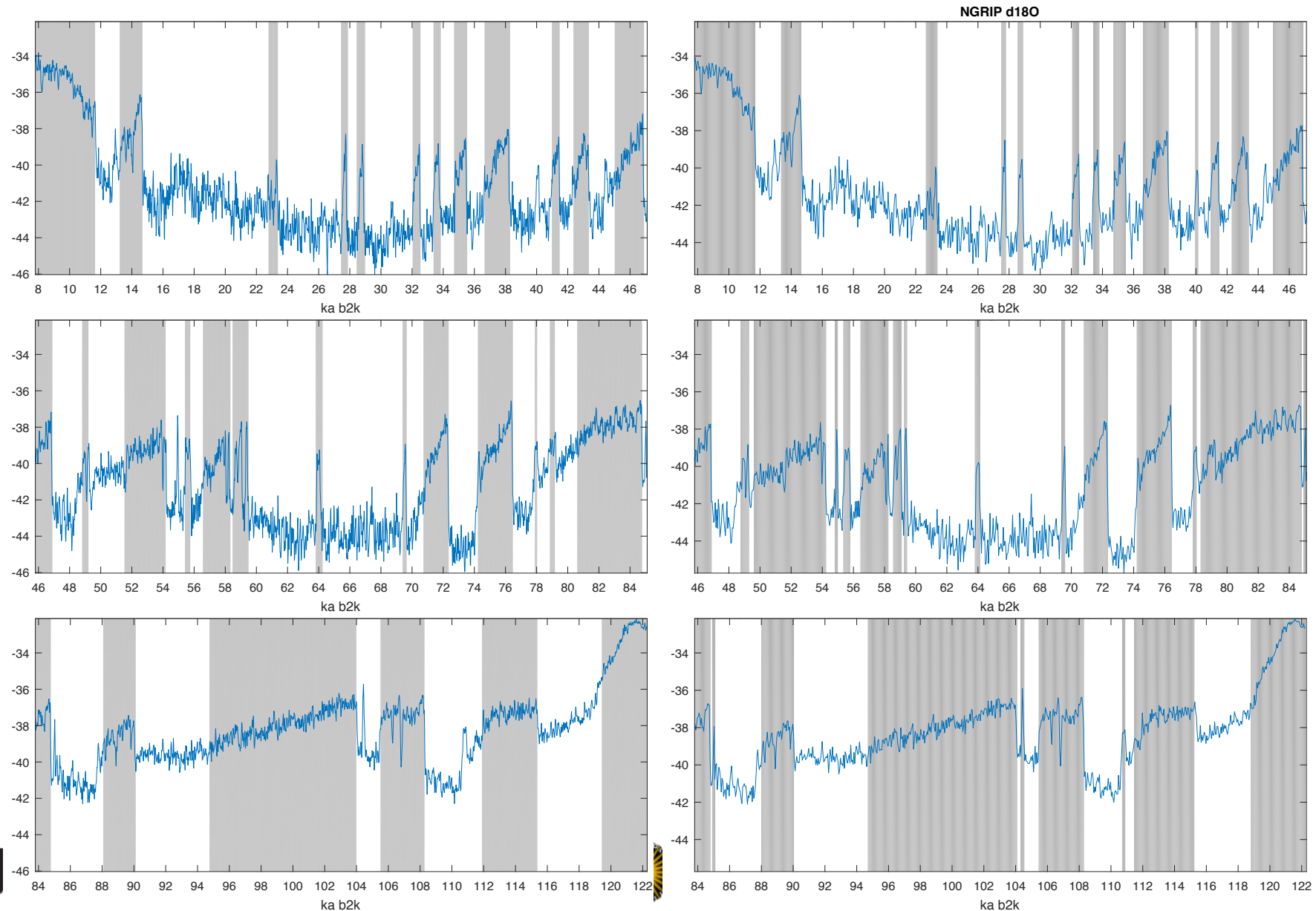
2. Preliminary results.....adapted to the “chat” format

1. Preliminary results from Witold Bagniewski, attending this chat, aim at defining a gold standard of abrupt transitions to be applied to any record (last climate cycle, Quaternary or older) investigated in TiPES.
2. To do so, we decided to investigate first the well-known NGRIP record, as described in Rasmussen et al. (2014).
3. These preliminary results are obtained using the Kolmogorov–Smirnov (KS) test to identify discontinuities in the time series. A threshold for the minimum rate of change is established, based on the standard deviation and the long-term trend in the record.



1. a) Early test of method applied to the $\delta 180$ record in NGRIP (20-yr mean left) and (50-yr mean right):
impact of time resolution

Most of the original DO events (Dansgaard et al., 1993) have been identified at both resolutions, but the detailed subdivisions introduced by Rasmussen et al. (2014) have not all been resolved, and a few events are missing.

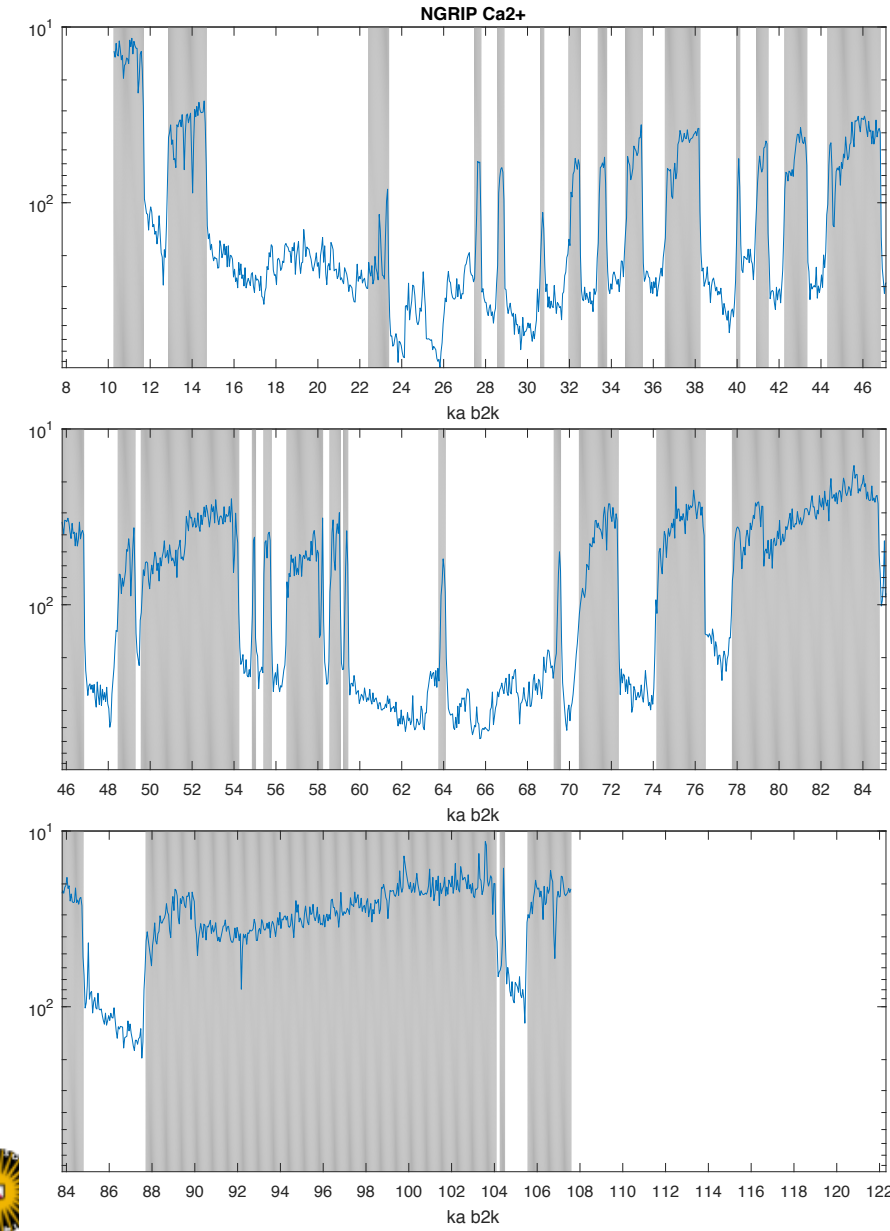
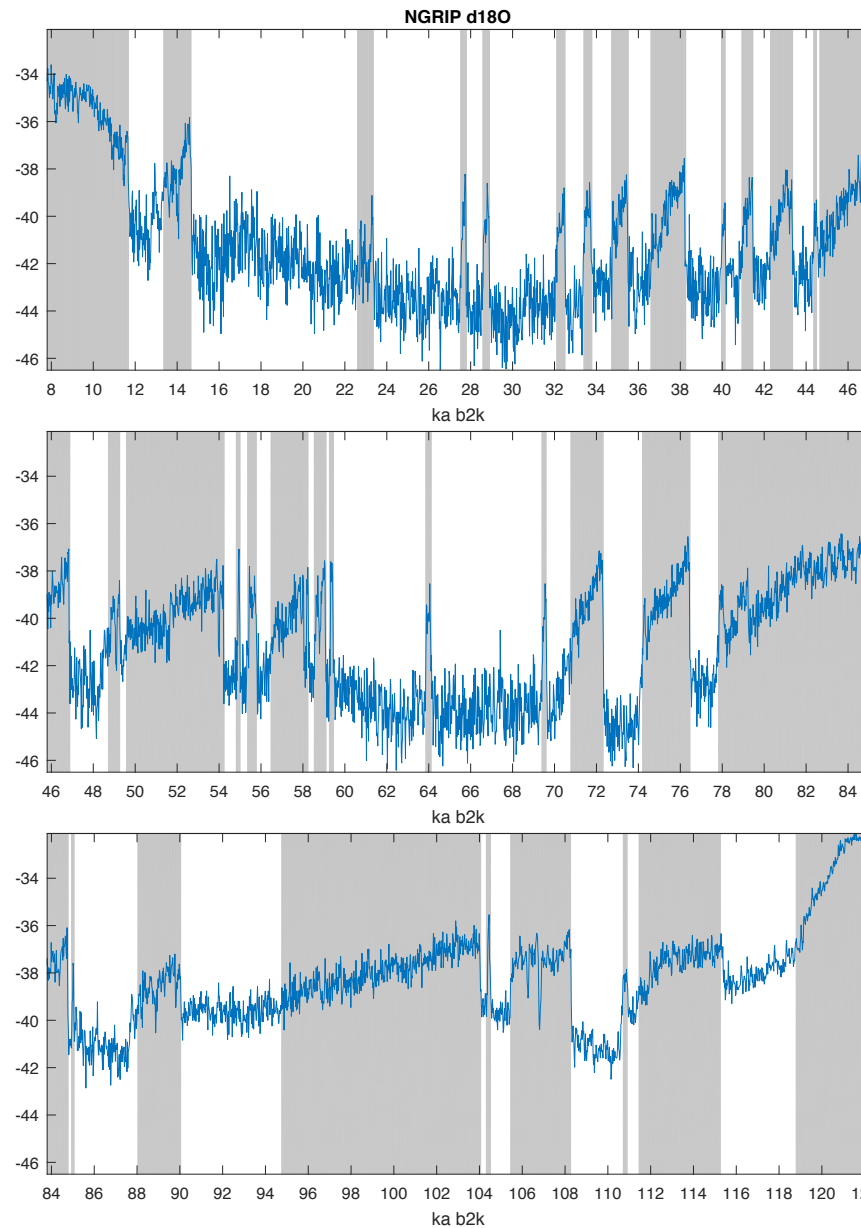


1. b) Early test of method applied to the $\delta^{18}\text{O}$ (left) and Ca^{2+} NGRIP records (20-yr mean)



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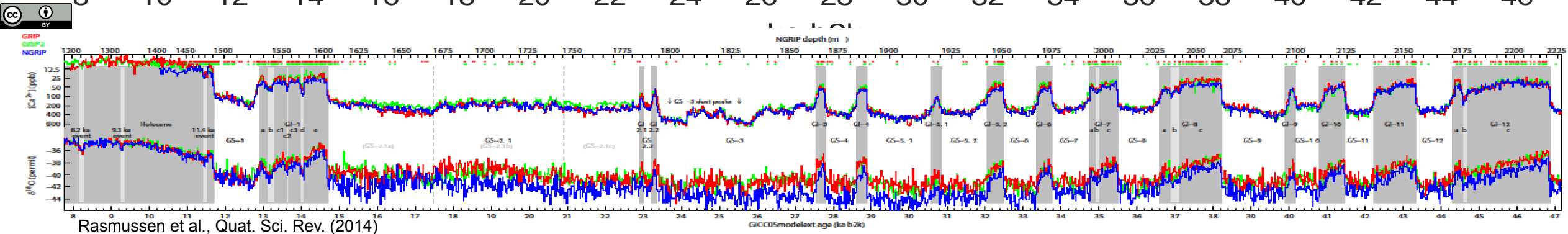
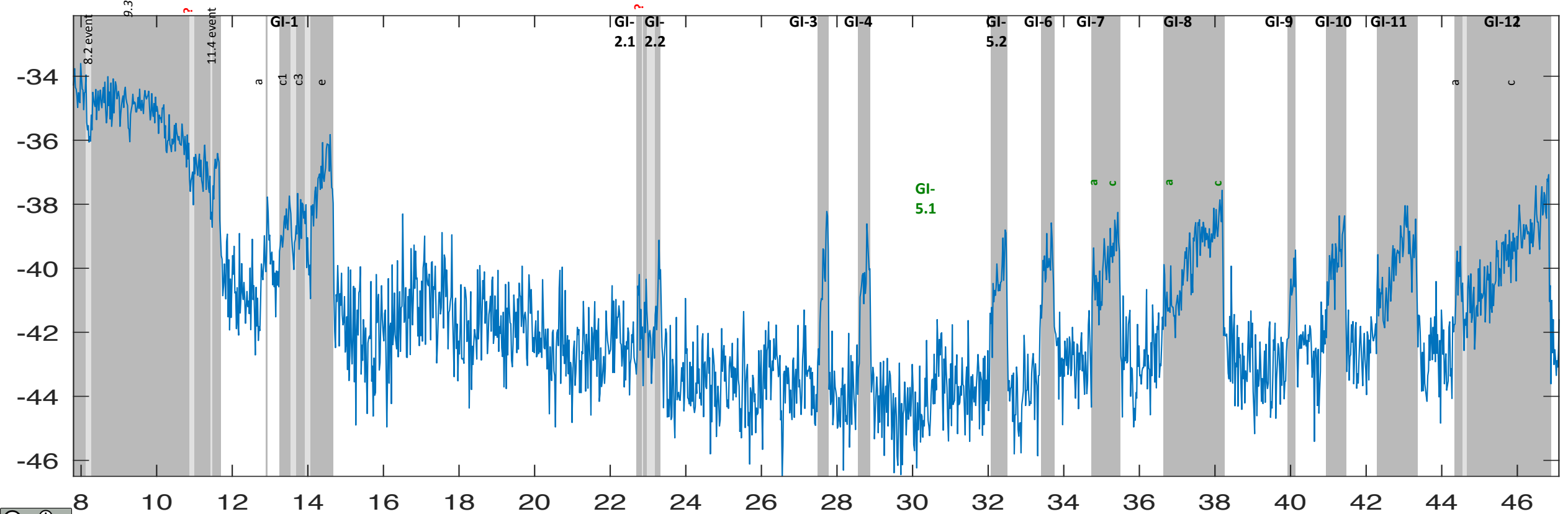
Most of the original DO events (Dansgaard et al., 1993) have been identified in both the $\delta^{18}\text{O}$ and Ca^{2+} datasets; the details mentioned as missing in the previous slide are also missing in the Ca^{2+} record.



2. Recent test of the detection method on NGRIP records (20-yr mean dataset) for the time interval 8-46ka b2k

? = not described in Rasmussen et al. (2014)

GI-5.1= sub-event not detected in the present test



Rasmussen et al., Quat. Sci. Rev. (2014)

3. Take-home message

These results are promising, but still need to be refined and validated.

More to come through the TiPES project: stay tuned! <https://www.tipes.dk/>

Thank you for your attention.

