**1 - BACKGROUND**

- Studying the last glaciation is crucial to better understand relationships between climate and glacier response.
- Thus, in recent years, transient ice model (Parallel Ice Sheet Model, Winkelmann et al. 2011) simulations of the European Alps glacier evolution (0-120 ka) were conducted (Seguinot et al. 2018, Jouvet et al. in rev.).
- This is the first attempt to compare these ice model simulations with speleothem data.

**REFERENCES**

- Jouvet, G. (2004). Speleothem δ13C data agrees with model results: Fig. 2 - METHODS

**2 - METHODS**

**2.1. Speleothem proxies**

- We use speleothems from caves located at different altitudes in the Alps (Fig. 1).
- First, we compare speleothem δ13C with simulated ice thickness.
  - We set the min. host rock δ13C of ~1% (Buggisch and Mann 2004) for soil presence/absence (Fig. 2).
  - Second, we compare speleothem growth with simulated pressure-adjusted T at the glacier base → T needs to be close to 0°C, because only a warm-based glacier allows water infiltration into the karst and, thus, speleothem growth.

**2.2. Model simulations**

- We focus on the glacial period (12115 ka).
- Seguinot et al. (2018) used a distortion of present-day climate based on different T proxy records (NE Atlantic SST, Martrat et al. 2007; Antarctic ice core [EPICA] δD-based T, Jouvet et al. 2007) as transient forcing.
- We consider a location as being glaciated when simulated ice thickness is > 20 m (results are similar when using > 5 m).

**3 - RESULTS**

**3.1. δ13C vs ice thickness**

- Most speleothem δ13C data agrees with model results (model-data agreement #1 to #3, Fig. 3).
- For simulation runs using NE Atlantic SST as T input, we find model-data agreement for >95% of data points.
- For EPICA T-driven simulations only about 80-85% of the points agree.

**3.2. Growth vs T at glacier base**

- We compare data which is showing model-data agreement #2, i.e. for which the model indicates glacier coverage and speleothem δ13C indicates soil absence, with simulated pressure-adjusted temperature at the glacier base (Fig. 4).
- EPICA T-driven simulation of Jouvet et al. (in rev.) and NE Atlantic SST-driven simulations of Seguinot et al. (2018) show the best agreement in terms of basal ice temperatures.

**Four scenarios:**

**Model-data agreement #1:** δ13C < -1‰ & ice thickness < 20 m

**Model-data agreement #2:** δ13C -1 to +1‰ & ice thickness > 20 m

**Model-data agreement #3:** δ13C +1 to +3‰ & ice thickness < 20 m

**Model-data disagreement:** δ13C > +3‰ & ice thickness > 20 m

**4 - CONCLUSIONS**

- Here we demonstrated that speleothem growth and δ13C can serve to assess the performance of last glacial glacier coverage models. They provide unique data to validate modelled glacier reconstructions in a transient manner considering that these models were mostly assessed for the Last Glacial Maximum before.
- First results indicate that using the Northern Hemisphere temperature signal (NE Atlantic SST) as model input leads to better agreement of simulations with speleothem data than using the Antarctic ice core temperature proxy in terms of both simulated glacier coverage and thermo-dynamical states at the base of the glaciers.

**REFERENCES**


**Figure 1**: Map of simulated LGM ice extent (EPICA temperature as model input, Seguinot et al. 2018) in the European Alps with cave sites utilized in this study. Cave site surface altitude ~500 m a.s.l., ~3°-5° C below present-day surface water temperatures on the LGM (left). Four climate states: warming inland during the LGM (right).

**Figure 2**: Sketches describing the external conditions we infer from speleothem δ13C observations: (left) carbonate dissolution due to biogenic CO2 in the water (e.g. karst river) and (right) carbonate precipitation due to pyrite oxidation. A glacier might be present above the cave.

**Figure 3**: Percentage of speleothem δ13C values indicating each of the four scenarios. cp = constant precipitation amount, pp = T-adjusted precipitation amount. T = temperature.

**Figure 4**: Percentage of simulated pressure-adjusted T at the glacier base indicating a warm-based glacier at cave sites where speleothem growth.