

Loch Goil and its Ice Age landscape

Loch Goil and Lochgoilhead viewed from the top of the Steeple



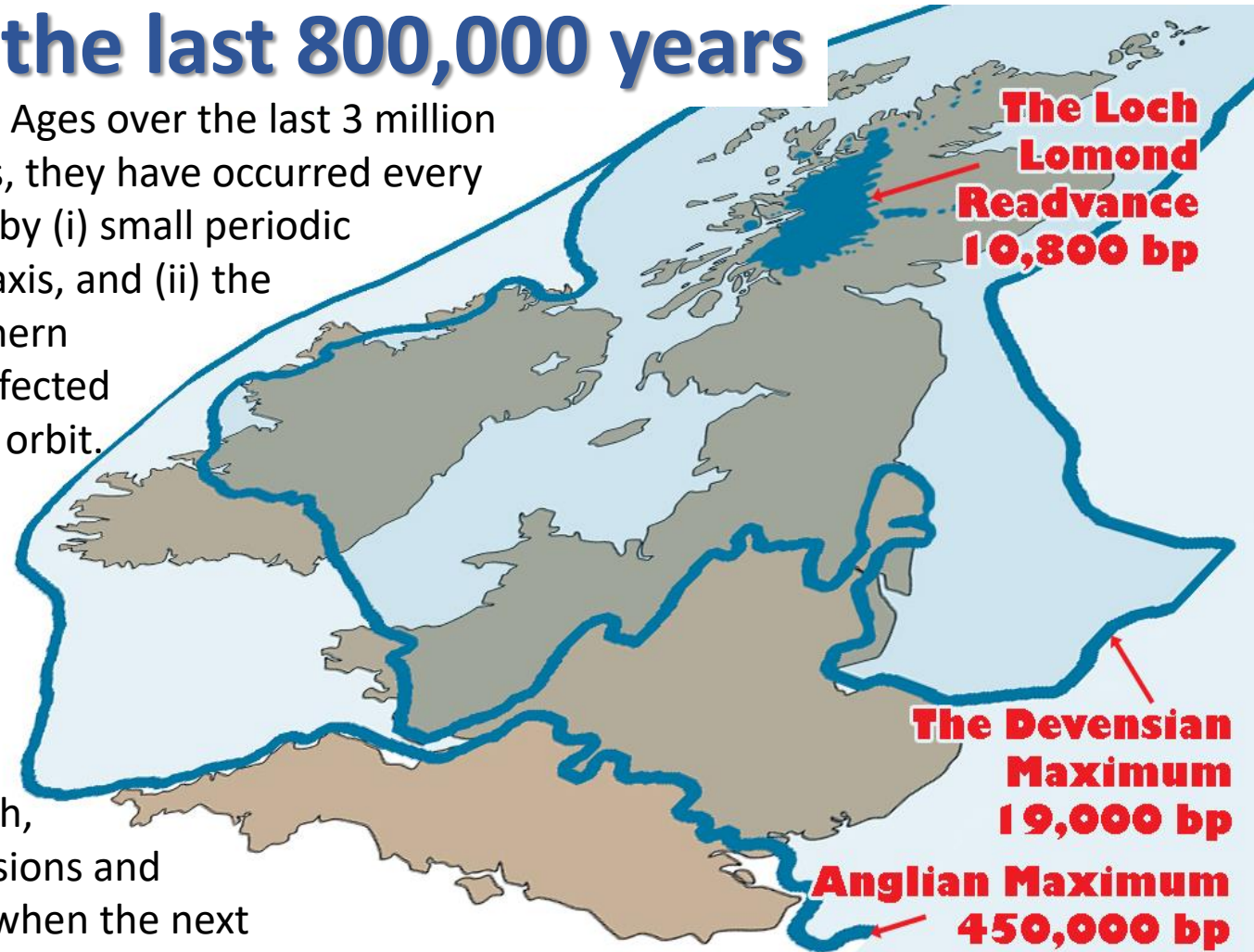
Jim Thomson

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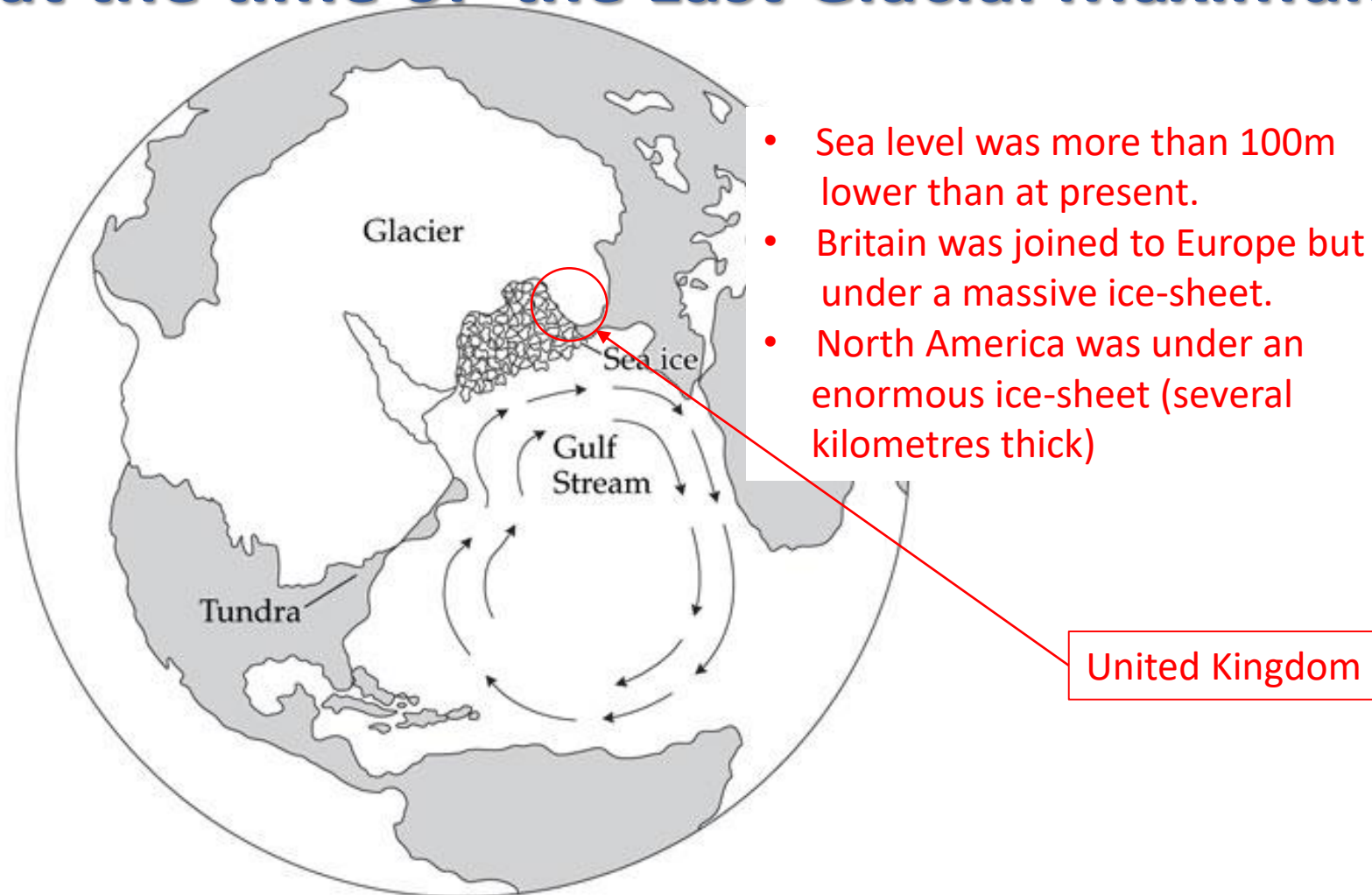
Ice Age Britain: the last 800,000 years

The Earth has seen repeated Ice Ages over the last 3 million years. For the last 800,000 years, they have occurred every 100,000 years. They are caused by (i) small periodic changes to the angle of Earth's axis, and (ii) the distance to the Sun during northern hemisphere summer which is affected by the elliptical shape of Earth's orbit. Both of these factors determine how much of the previous winter's snow will melt during the summer.

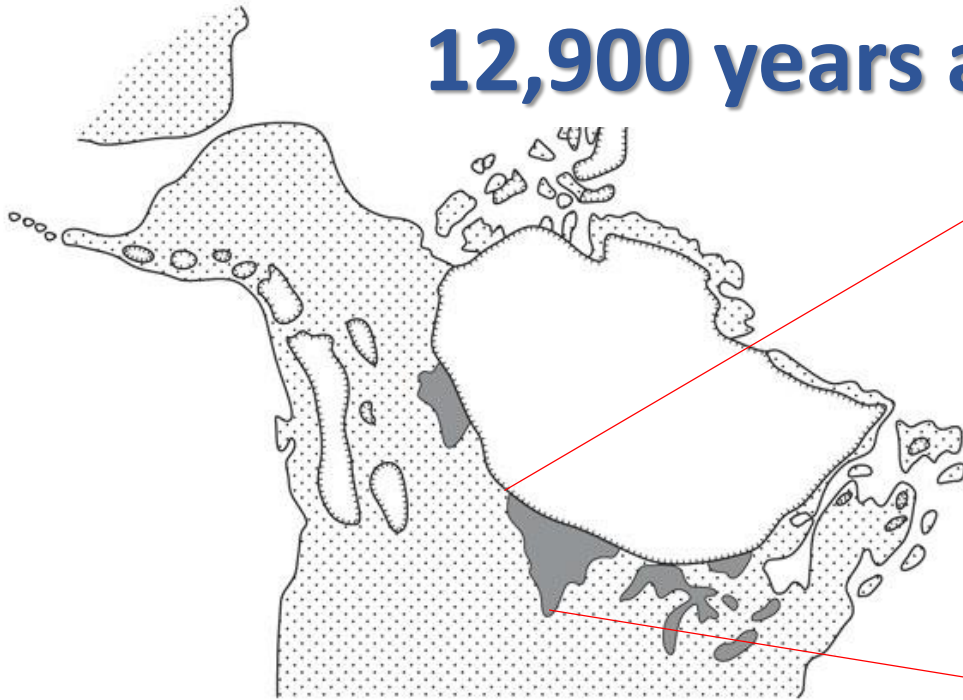
We are currently in the middle of an interglacial period although, because of carbon dioxide emissions and global warming, no-one is sure when the next Ice Age will occur - if ever!



The Northern Hemisphere 19,000 years ago, at the time of the Last Glacial Maximum



North America 12,900 years ago

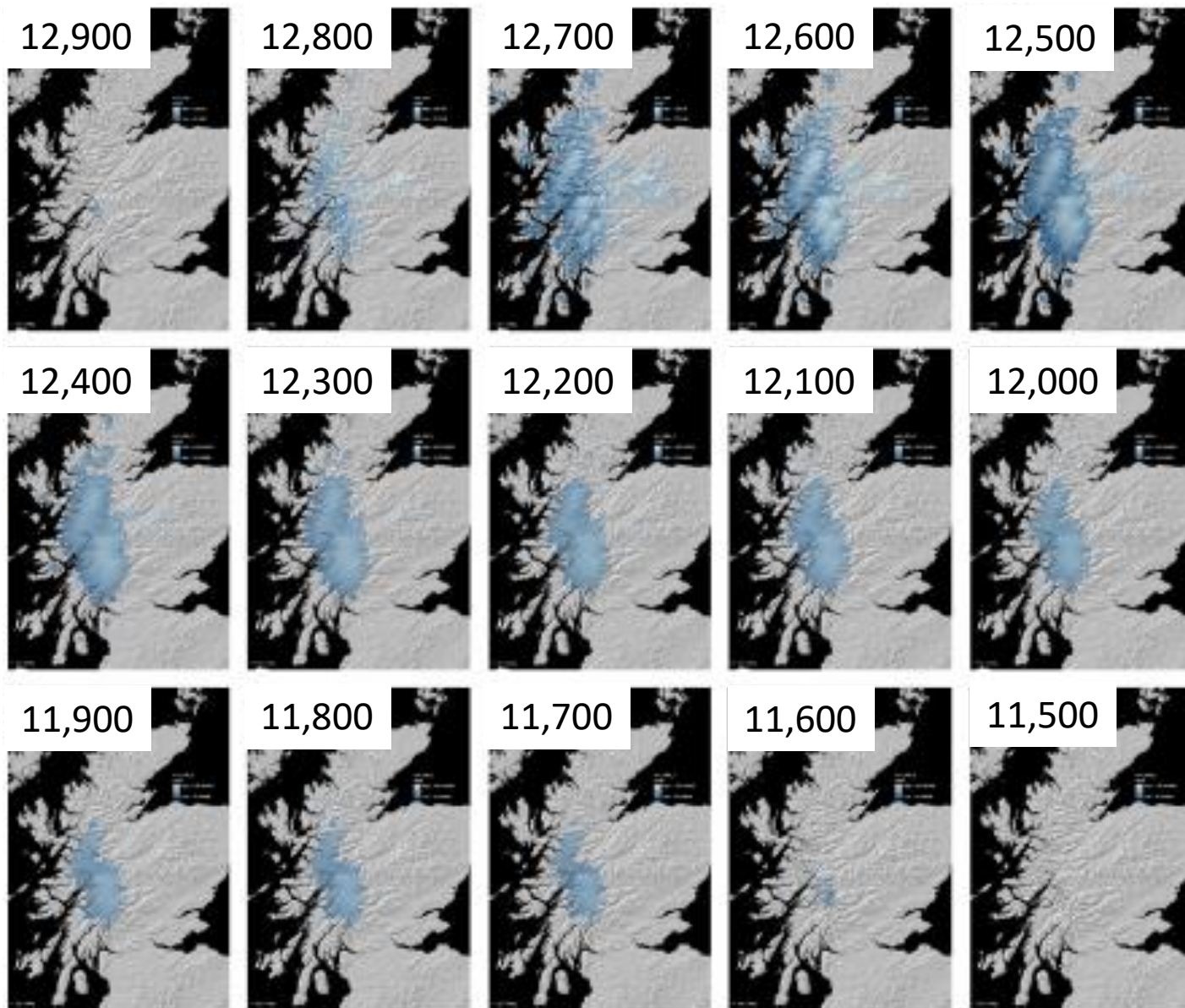


BIOGEOGRAPHY, Third Edition, Figure 9.2 (Part 3) © 2006 Sinauer Associates, Inc.



At the end of the last Ice Age 12,900 years ago, glacial **Lake Agassiz in modern Canada** was dammed by ice. When the ice melted, the ice dam burst and an enormous amount of cold fresh water flooded into the North Atlantic. This water stopped the Gulf Stream, which led to sudden dramatic cooling of northern Europe.

As a result, the Ice Age returned to Northern Europe for a further 1200 years – the so-called '**Loch Lomond Re-advance**' (also known to geologists as the '**Younger Dryas**').



Golledge, Hubbard and Sugden (2008), "High-resolution numerical simulation of Younger Dryas glaciation in Scotland", *Quaternary Science Reviews*, 27, 888-904

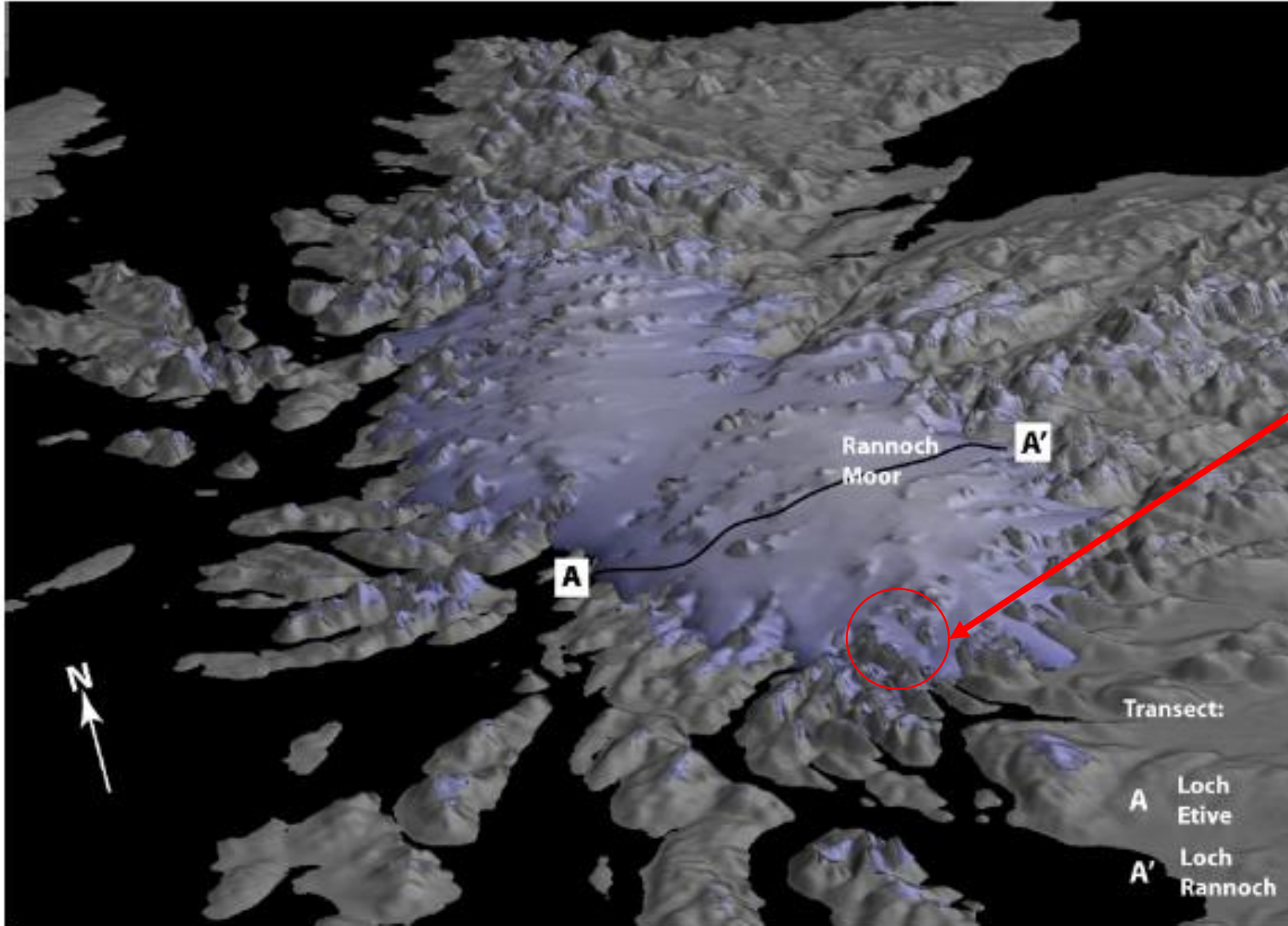
Growth and shrinkage of the West Highland Icecap during the Loch Lomond Re-Advance, 12,900 to 11,500 years ago.

The release of water from Lake Agassiz caused the North Atlantic to cool and ice built up over western Scotland.

Then very suddenly, 11,700 years ago, the Gulf Stream re-started and Europe got warmer, possibly by 7 degrees C in less than 50 years.

The ice melted and we entered the modern era.

Plants and animals quickly moved north across the land bridge between Britain and Europe.

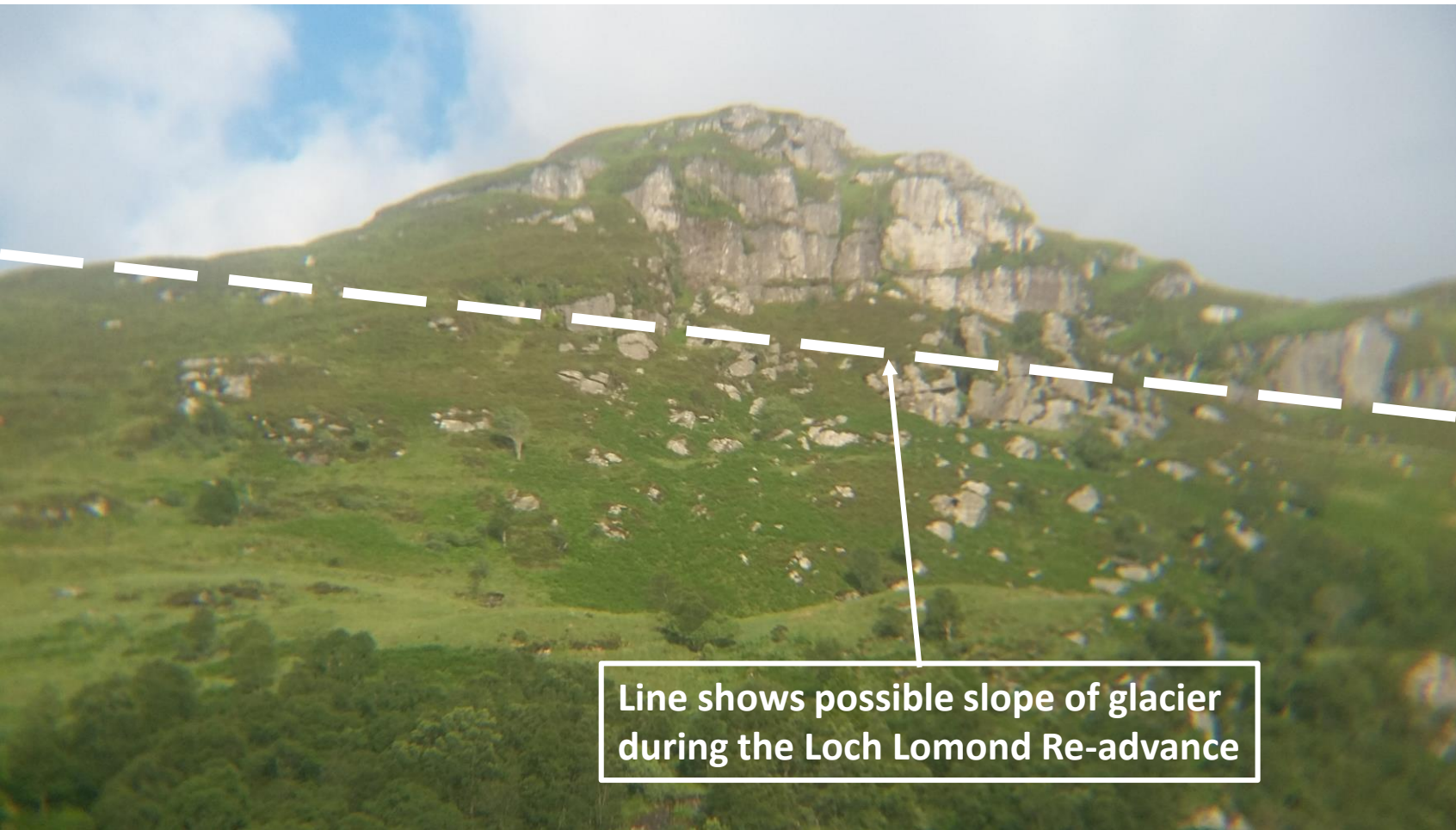


The Loch Lomond Re-Advance at its maximum extent, about 12500 years ago.

Loch Goil under 200-300 metres of ice.

Each period of glaciation has destroyed most of the evidence of previous glaciations.

What we see today around Loch Goil is evidence of the Loch Lomond Re-advance.



Line shows possible slope of glacier during the Loch Lomond Re-advance

The Steeple photographed from Lochgoilhead.

Near the top of the Steeple, at about 250 metres, you can see cliffs of exposed rock. This is called a **nunatak**, which show where the summit of the Steeple rose above the glacier moving down Loch Goil.

Nunatuks form where rock is exposed to temperature extremes of freezing and also sunlight causing periodic melting. These extremes lead to the rock shattering, leaving exposed faces and rock debris underneath.

These nunataks formed during the Loch Lomond Re-advance about 12,500 years ago.



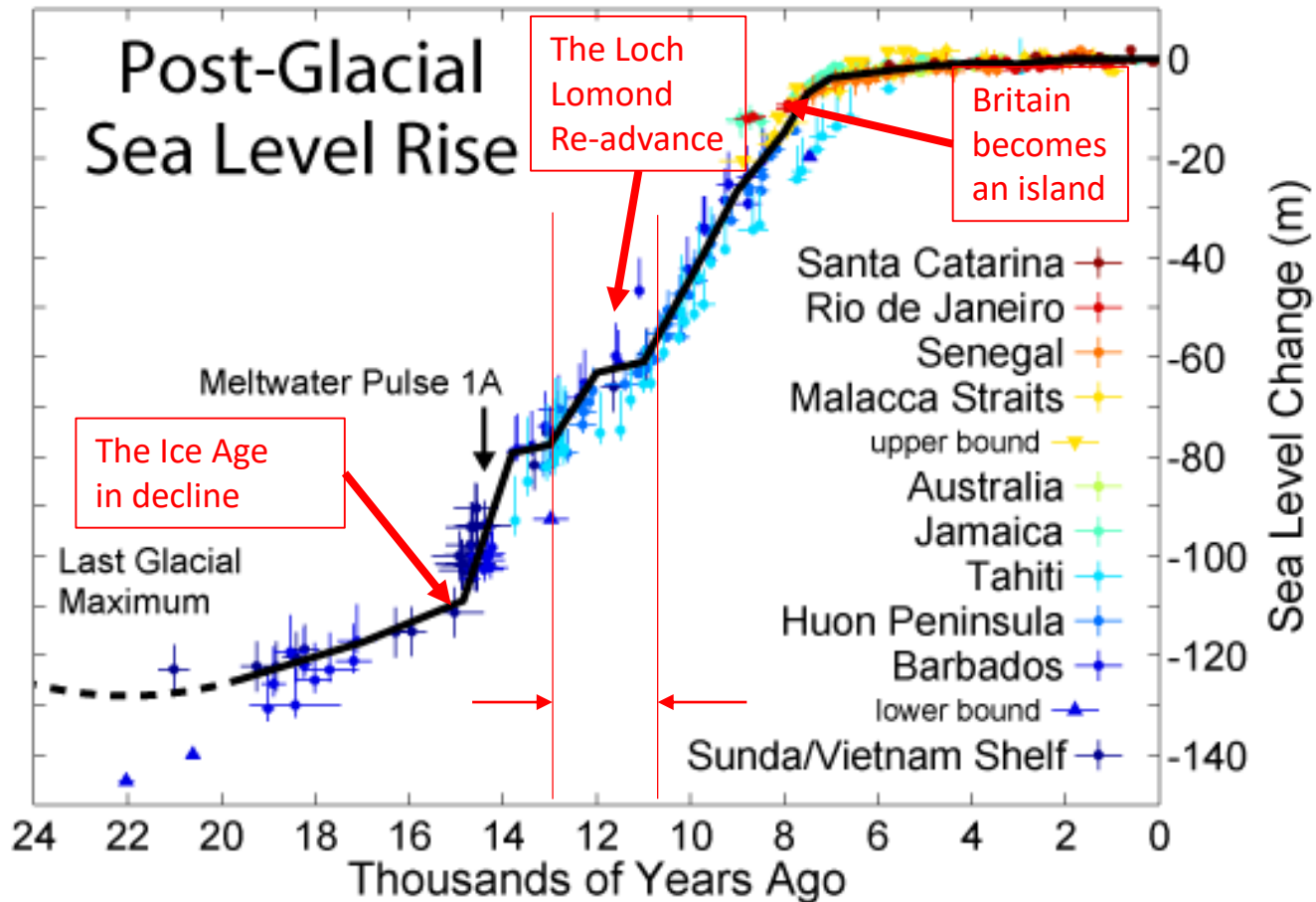
Glacial Erratics

The Loch Lomond Re-advance also left behind **glacial erratics**, which are massive boulders – some must be several hundred tonnes - that are distributed at random. These were left behind by the receding glaciers 11,700 years ago.

The photo shows one such glacial erratic on Inverlounin Road, on the eastern side of Loch Goil. It has been cut in half to enable road widening

Lots of glacial erratics can be seen in Glen Croe during the drive up the A83 from Ardgarten to Rest-and-Be-Thankful. Some of the glacial erratics around Loch Goil have been semi-buried under tree roots and other vegetation.

Foliated Dalradian mica-schist in a glacial erratic that has been cut in half, Inverlounin Road, Lochgoilhead, June 2015 (modelled by Jane!)



https://upload.wikimedia.org/wikipedia/commons/1/1d/Post-Glacial_Sea_Level.png

20,000 years ago, the sea level was so low that the coast nearest to Lochgoilhead will have been in the current Clyde estuary. The sea may have been covered in sea-ice for much of each year.

During the Loch Lomond Re-advance, at about 12,500 years ago, the glacier along present-day Loch Goil extended out into, and merged with, the glacier in present-day Loch Long.

Because the sea level was low, due to large amounts of water in the polar ice caps, Britain was connected to Europe until about 8000 years ago (8000 BP).

The area between Britain and Germany is called Doggerland. It is known that humans and animals lived there – their remains have been picked up by trawlers.

10000BP



7000BP



Elevation (m)
relative to MSL



Smith, Harrison, Firth and Jordan (2011)
The early Holocene sea level rise,
Quaternary Science Reviews, 30, 1846-1860

The view up Glen Mhor 7000 years ago?



This photo actually shows a present-day glacier in Alaska but, 7000 years ago, this might have been the view from Pole Farm at the north end of Glen Goil, looking up Glen Mhor.

7000 years ago, the grazing land that now forms the banks of the Goil river would likely have been underwater, while the glacier in Glen Mhor was still receding.

The Goil river valley would have been in a shallow tidal bay or salt marsh. Things have changed since 7000 years ago because:

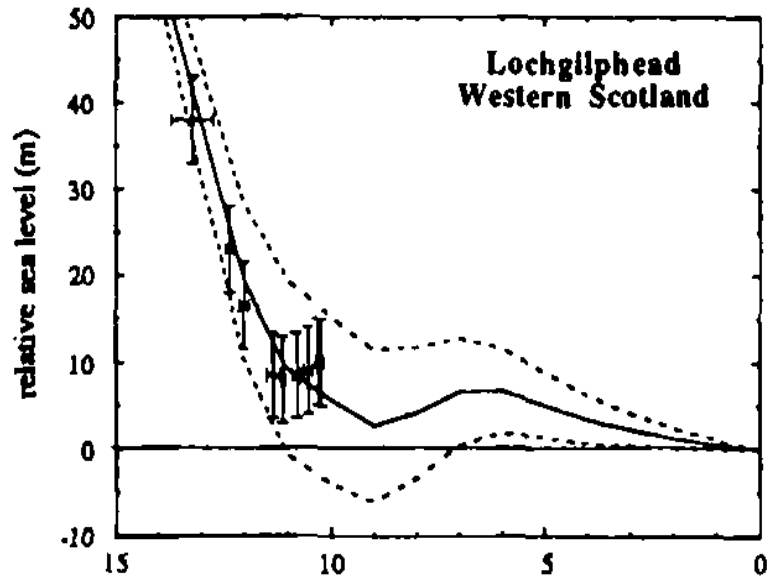
- (i) Rock debris and vegetation will have washed down into the valley, raising the sea floor, and
- (ii) The Earth's crust in Scotland has risen because the weight of the massive ice sheet has been removed, and the Earth's crust has bounced back. This is called **glacial-isostatic rebound**.

(At the same time, Loch Lomond was a sea loch.)

Glacial-isostatic rebound around Loch Goil

The Earth's crust rebounded after the weight of the Ice Age ice-cap was removed from the land. At Lochgoilhead, the land may have rebounded by 14 metres over the last 10000 years.

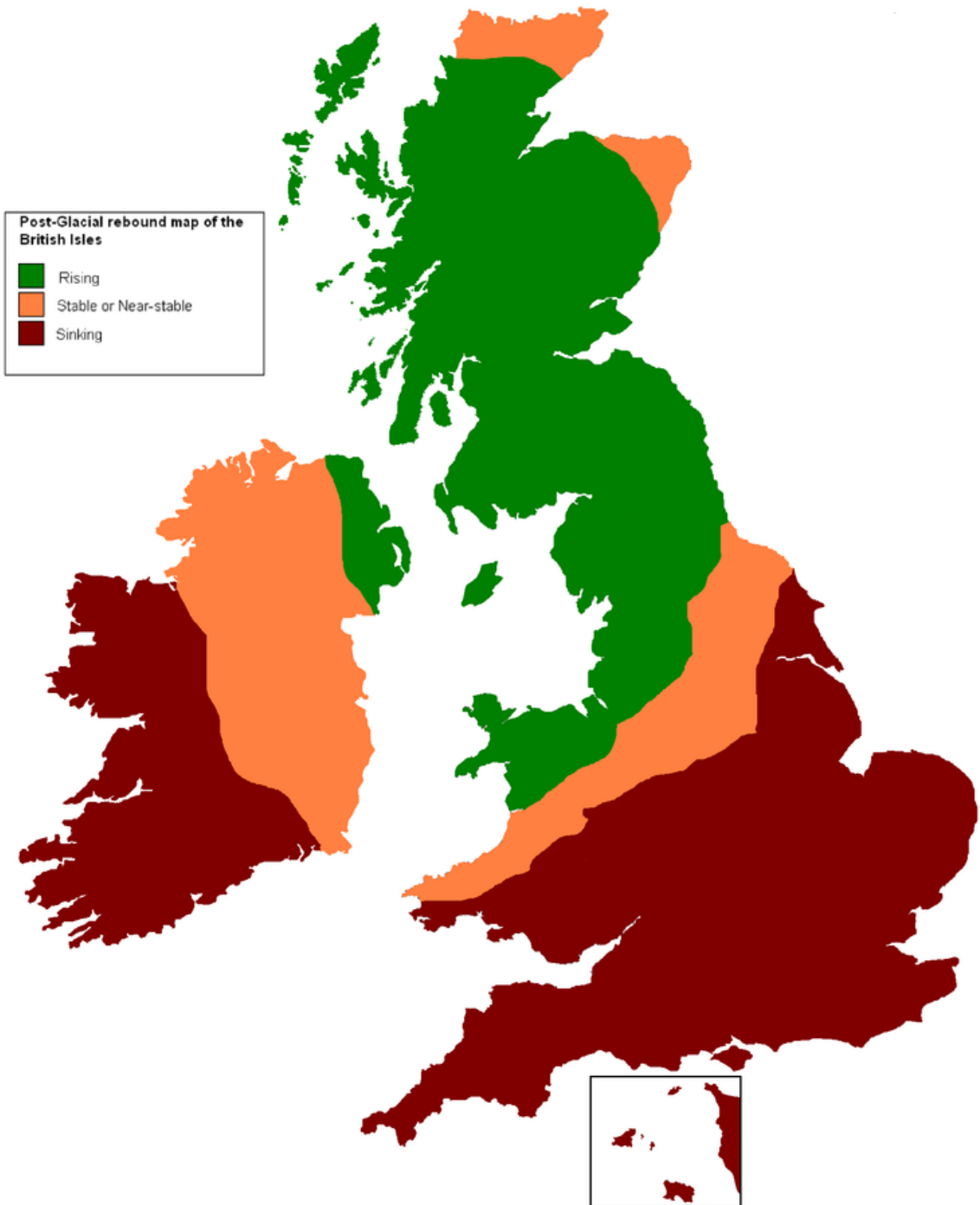
(Dawson (1984) Quaternary sea-level changes in western Scotland, Quaternary Science Reviews, 3, 345-368)



Glacial-isostatic rebound in nearby Lochgilphead (about 10km from Lochgoilhead)

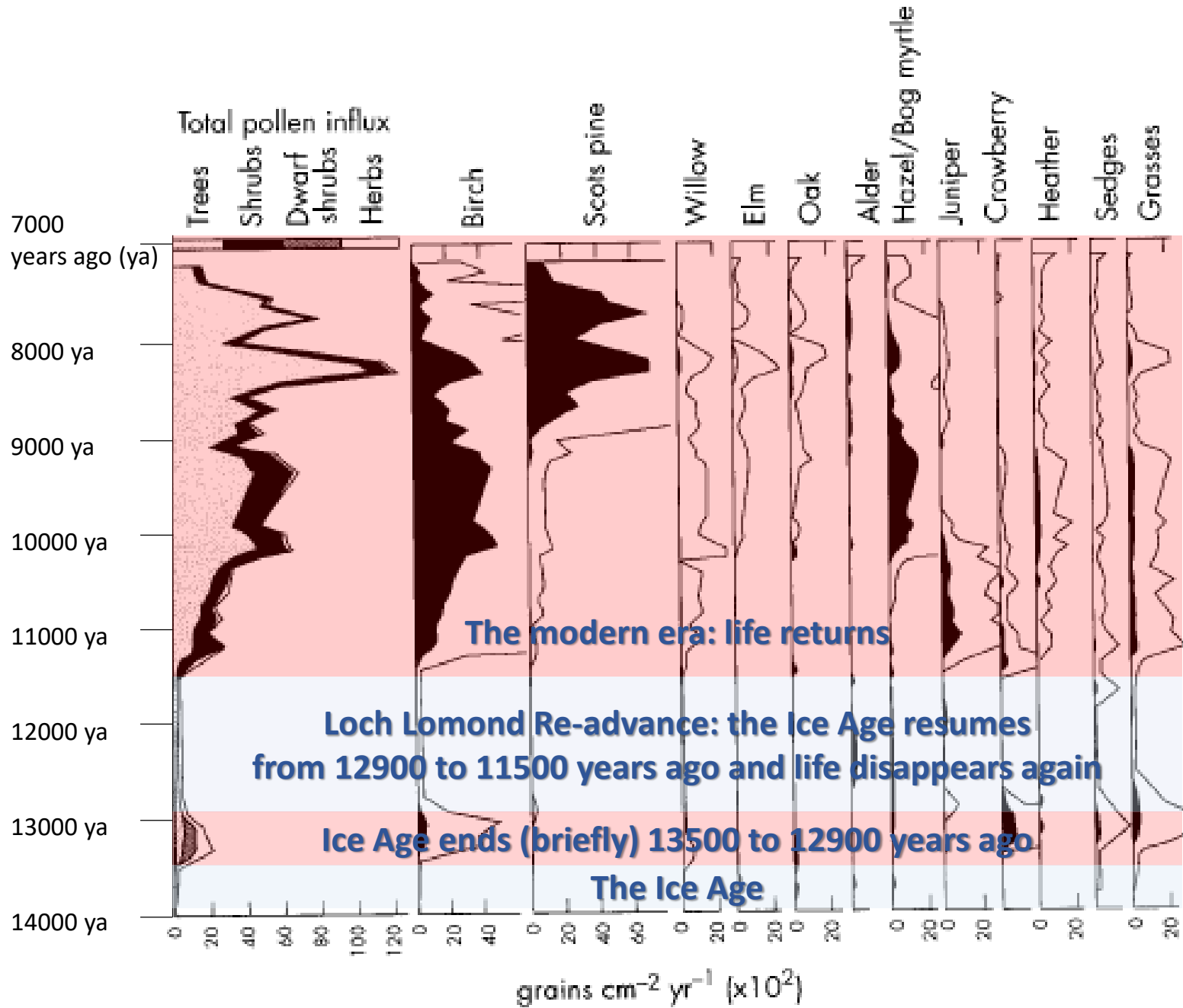
(Lambeck, Glacial rebound and sea-level change in the British Isles, Terra Nova, vol.3, pp.379-389)

Post-Glacial rebound map of the British Isles





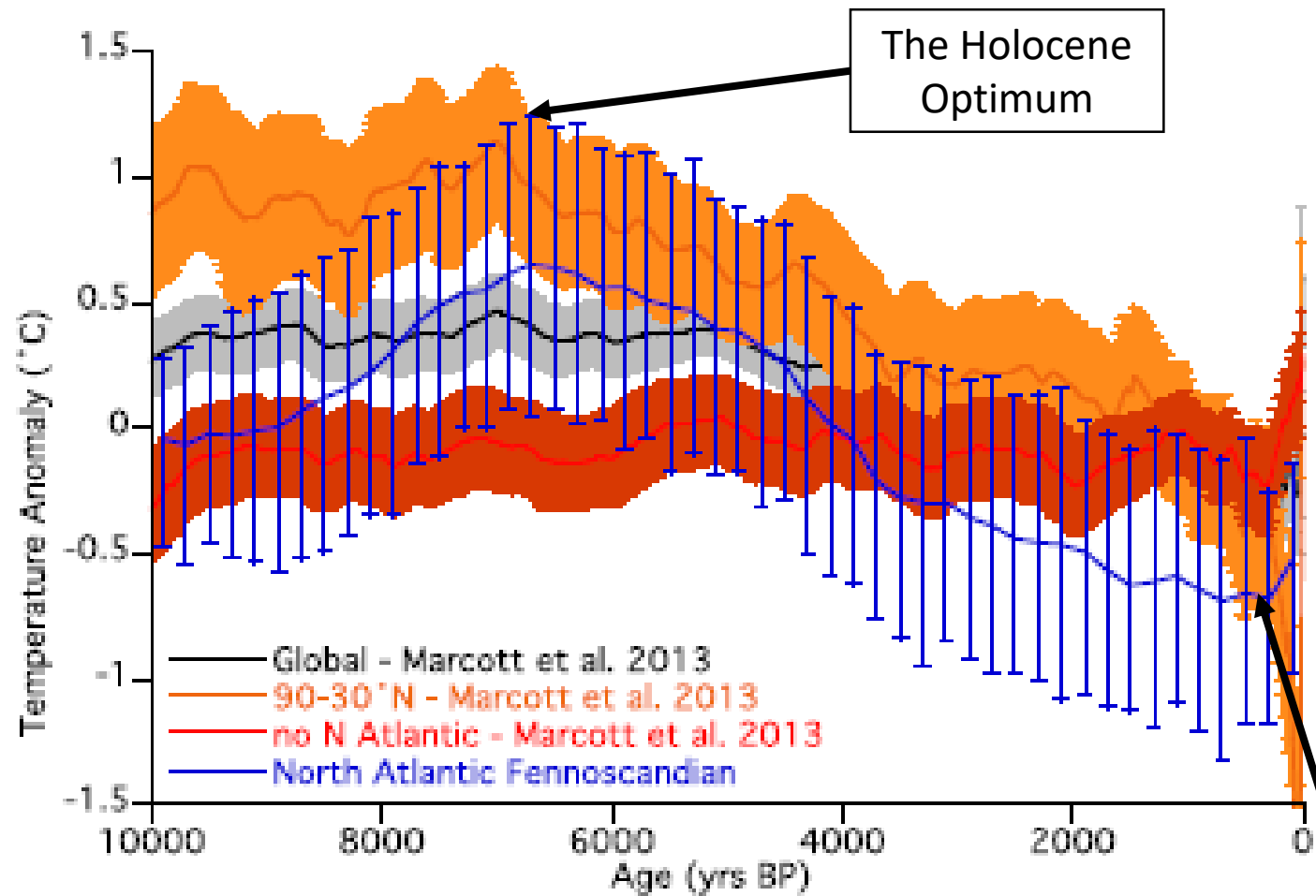
A view from the Steeple, looking towards the grazing land in Glen Goil. This area was probably shallow sea 10,000 years ago.



The effect of the Loch Lomond Re-advance on life in Scotland

This diagram shows the density of spores and pollen in soil samples from Abernethy Forest, Inverness-shire, from 14,000 years ago to 7,000 years ago. Prior to 13,500 years ago, there were no spores or pollen, because Scotland was still in the Ice Age. After a brief return, life again disappeared during the Loch Lomond Re-advance. After 11,500 years ago, life returned as the Modern Era (the **Holocene**) began.

Adapted from "The Great Ice Age",
The Open University, 2007



North Atlantic average temperatures Rose until about 7000 years ago – the ‘Holocene Optimum’ – and since then temperatures have fallen by about one degree.

However, since the start of the Industrial Era, temperatures have begun to rise again due to the release of greenhouse gases (notably carbon dioxide, CO₂) released by combustion of fossil fuels such as coal, oil and natural gas.

Climate models suggest that, in the coming centuries, Earth’s temperature will warm by several degrees more unless drastic action is taken to reduce fossil fuel usage.

Start of current global warming

Summer temperature variation over the North Atlantic for the last 10000 years

Sejrup, Seppa, McKay, Kaufman, Geirsdottir, Vernal, Renssen, Husum, Jennings, Andrews (2016), "North Atlantic-Fennoscandian Holocene climate trends and mechanisms", Quaternary Science Reviews, 147, 365-378

Loch Goil: Evidence from the Loch Lomond Re-advance

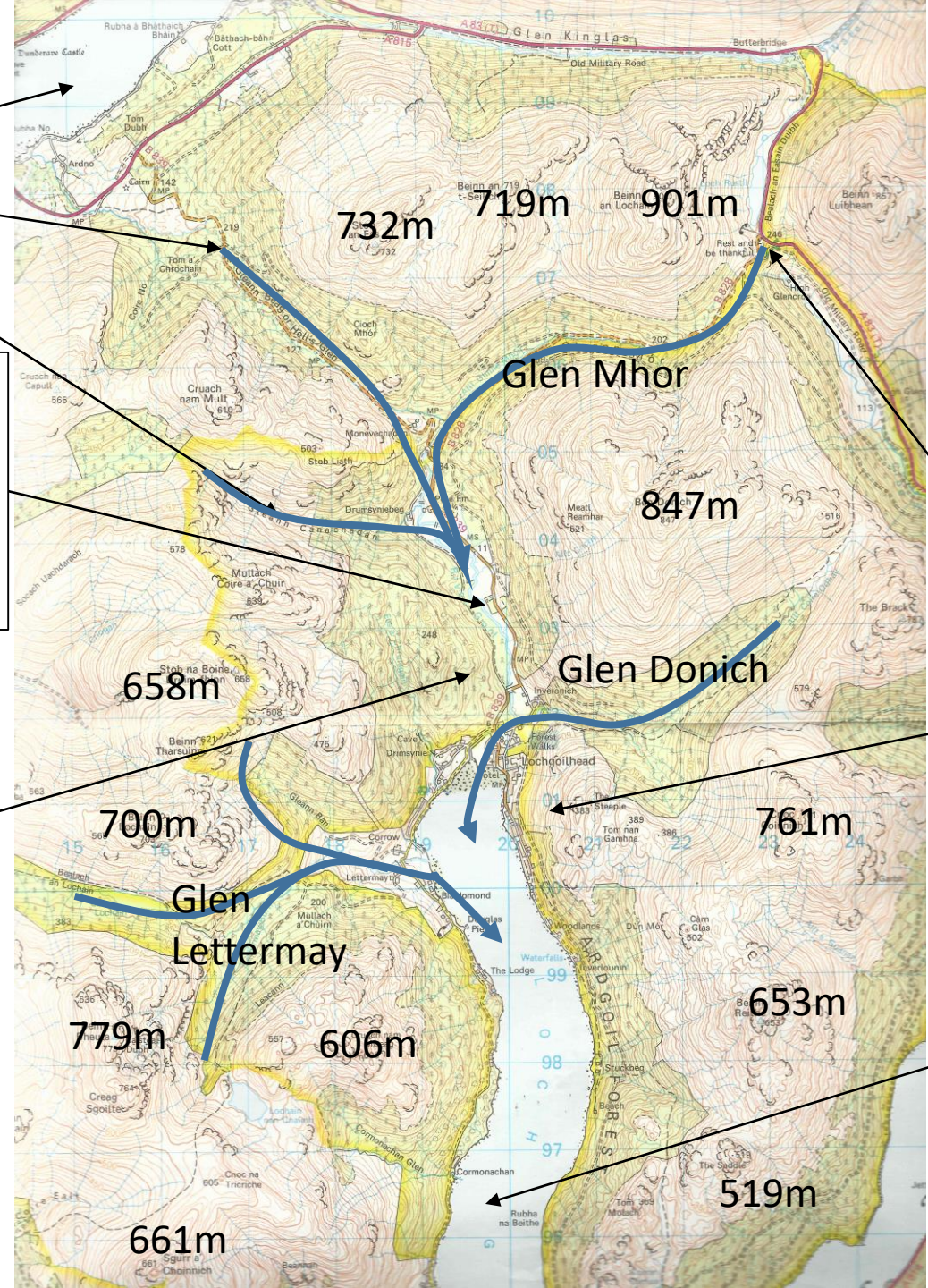
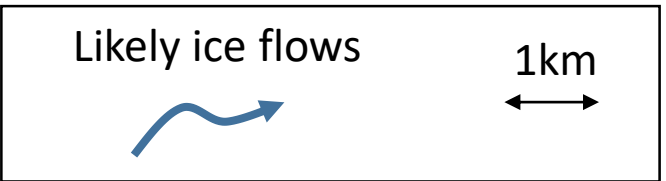
Loch Fyne (sea-loch)

Hell's Glen, 219m

Glen Canachadan, >300m

The narrow River Goil floodplain, less than 10m above sea level, was unflooded by post-glacial rebound since the end of the Loch Lomond Re-advance.

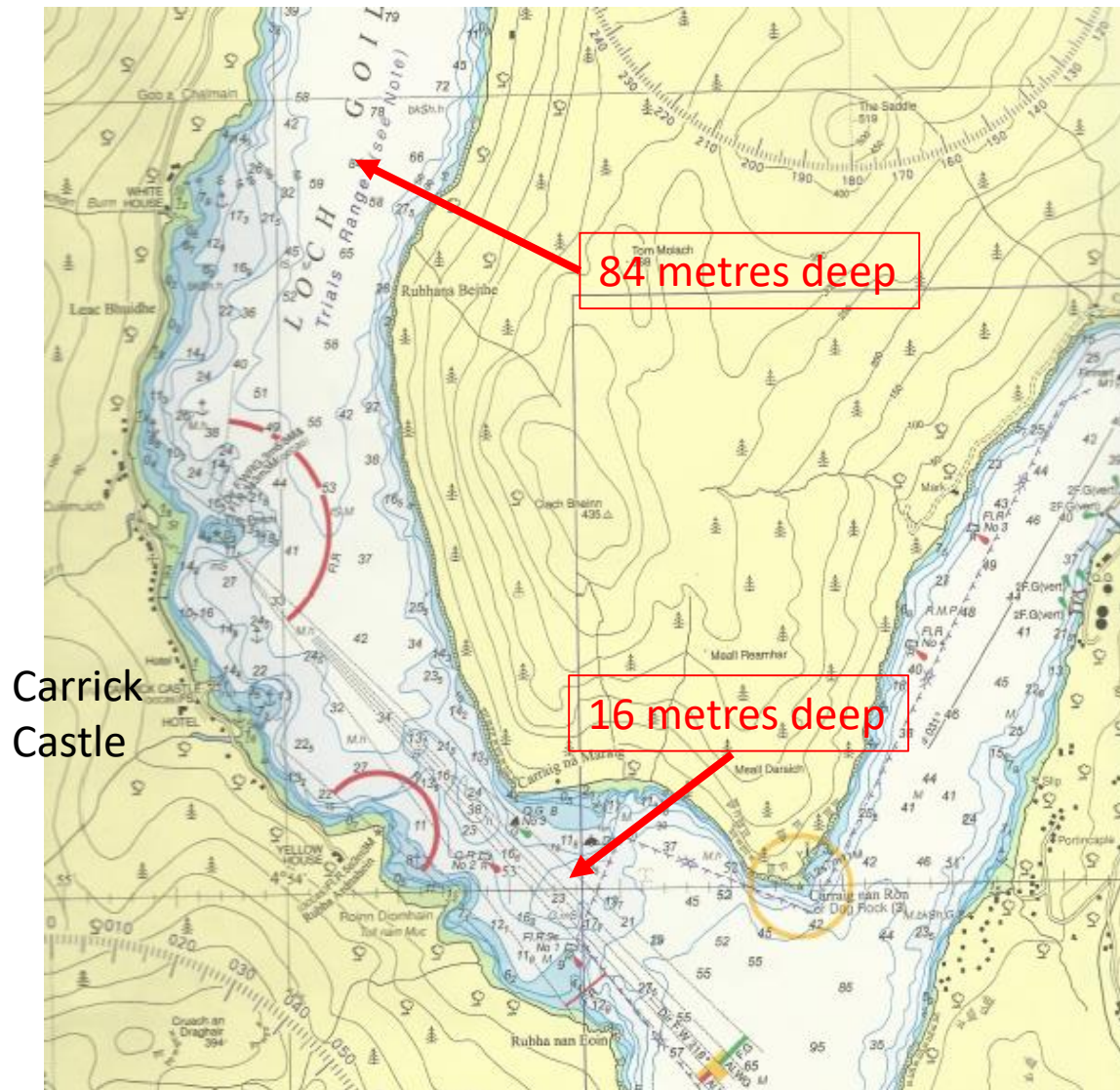
Dense temperate rainforest (natural and plantation) over much of the valley conceals possible evidence from the period immediately after the Loch Lomond Re-advance.



Rest-and-be-thankful, 246m (A83 Glasgow to Inveraray)

- Nunatuks at about 250m
- Evidence of glaciation
 - Also numerous large glacial erratics

Loch Goil (sea-loch) has a depth of 85m with a rise near its southern end where it merges with Loch Long. This area is close to the southern end of glaciation during the Loch Lomond Re-advance.



Carrick
Castle

The Admiralty Chart of Loch Goil shows a maximum depth of 84 metres. However, it also shows that, just south of Carrick Castle near where it merges with Loch Long, Loch Goil is only some 16 metres deep.

This rise is probably where the glacier terminated for a while when receding, about 11,800 years ago, and left behind lots of rocky debris called **glacial moraine**.

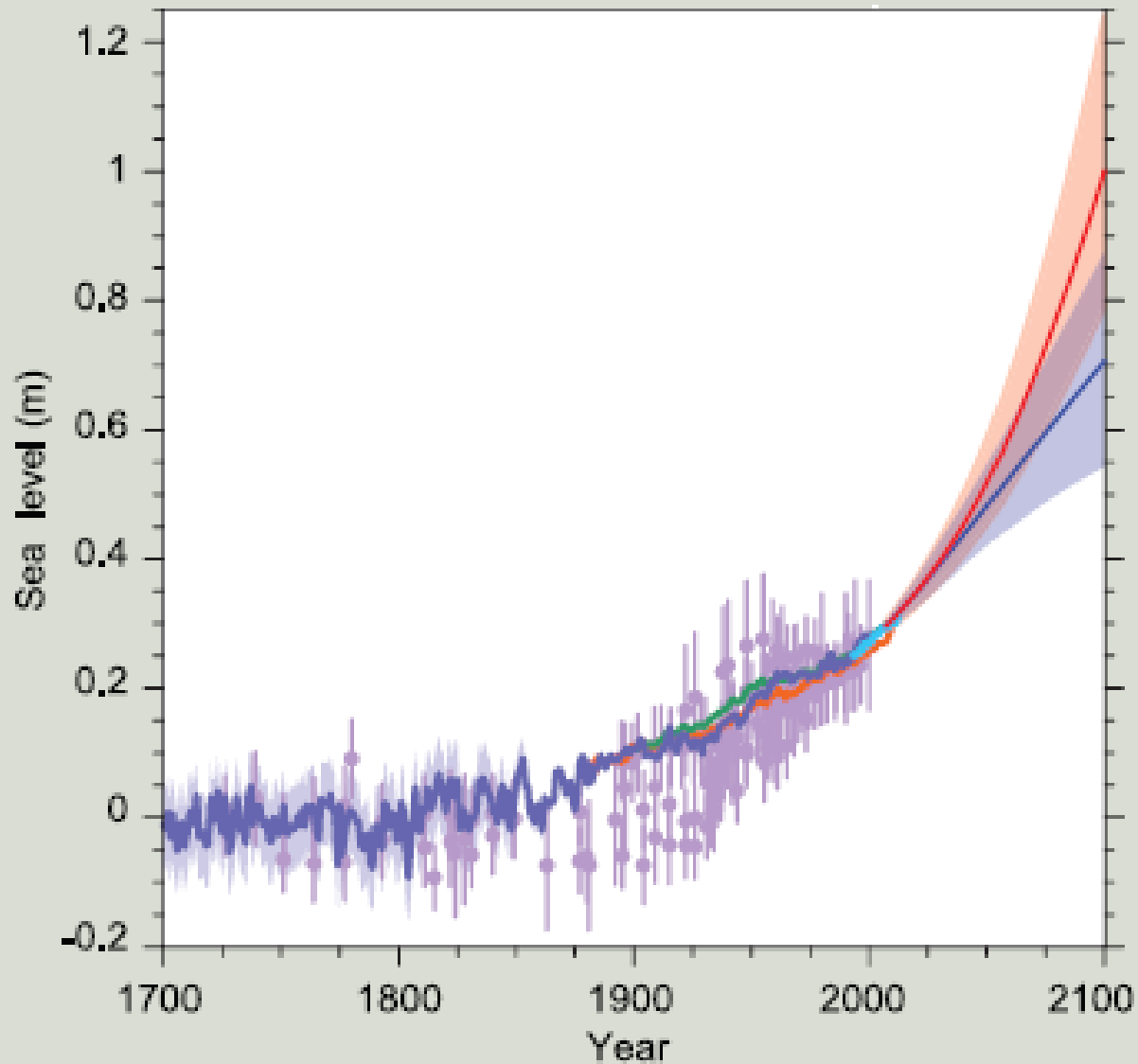
This also means that, perhaps for a few millennia as sea level was still rising, Loch Goil may have been a fresh water loch, trapped between the receding glacier and the glacial moraine. Eventually, though, sea level rose and breached the moraine barrier.

(You can see something similar near the bottom of Glen Croe – there is a narrow pass that the A83 goes through, with steep rocks on either side and only enough space for the road and the river to get through.)

Global warming and future sea level rise up until 2100

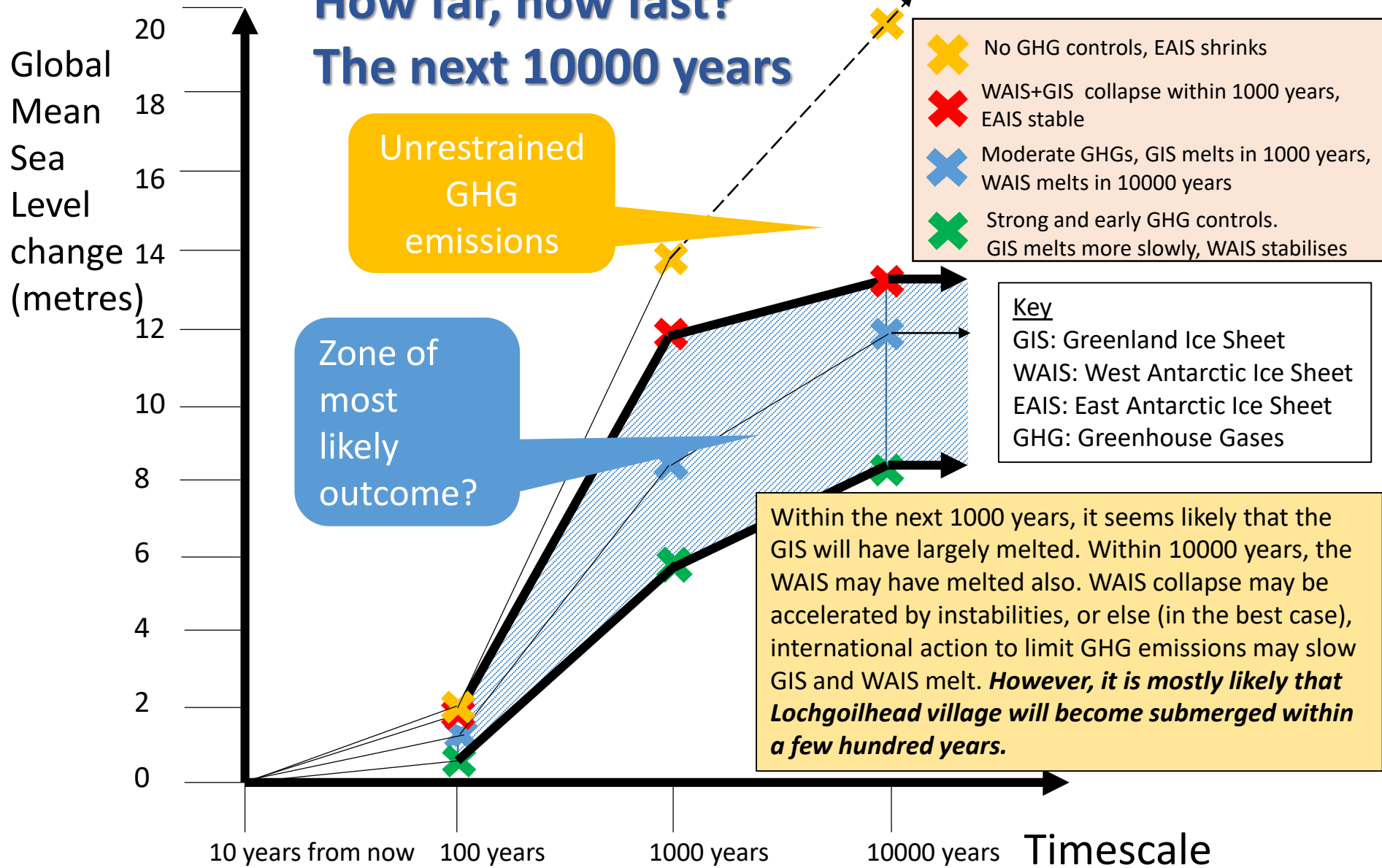
Sea level is most likely to rise by about 1 metre before 2100.

This will mean that the Lochgoilhead Post Office will become even more prone to flooding in winter storms!

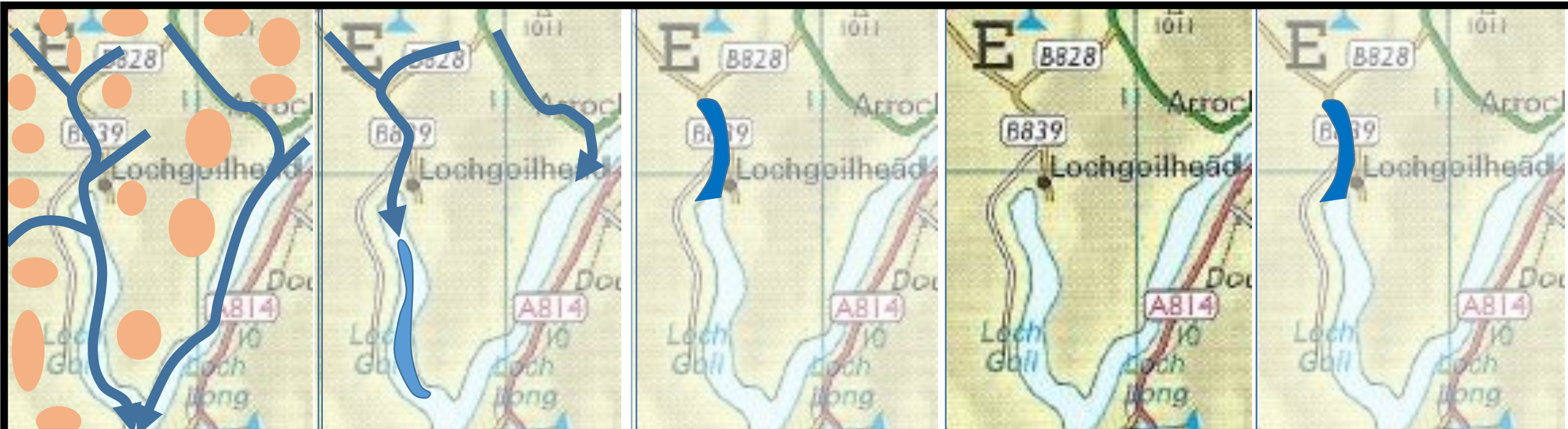


Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan and S.-P. Xie (2013). *Technical Summary*. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

How far, how fast? The next 10000 years



Loch Goil: The last 12,500 years, and the next 1000



12,500 years ago:

The whole loch was glaciated to about 250 metres, with hilltops sticking out (nunataks) above the ice.

About 11,000 years ago:

The glaciers were receding but the sea level was still low, and there was a moraine dam near Carrick, so Loch Goil was fresh water.

About 7000 years ago:

Global sea level was near its 21st century level, and Loch Goil had become a sea loch, but the land was still bouncing back from the weight of ice. Glen Goil was a shallow tidal bay.

Present day:

Glacial-isostatic rebound has lowered the sea level in west Scotland in the last few thousand years, so Glen Goil has unflooded.

1000 years in the future:

Sea level will rise due to melting of the Greenland ice sheet, and Lochgoilhead village will become submerged.