The organic materials used for writing in antiquity have a durability running to thousands of years in the natural climate over large areas of the earth.

Here are two famous examples of physical durability and enduring influence.

[Codex Runicus is 200 pages from about 1300, on parchment, describing the laws of the region of Scania.

Codex sinaiticus is an incomplete bible dated to the middle of the 4th c. It is on parchment. Since the mid nineteenth c. portions have been held in 4 separate institution.]

Of equal importance as chemistry to the survival of such artefacts is the durability of the institution which cares for them.

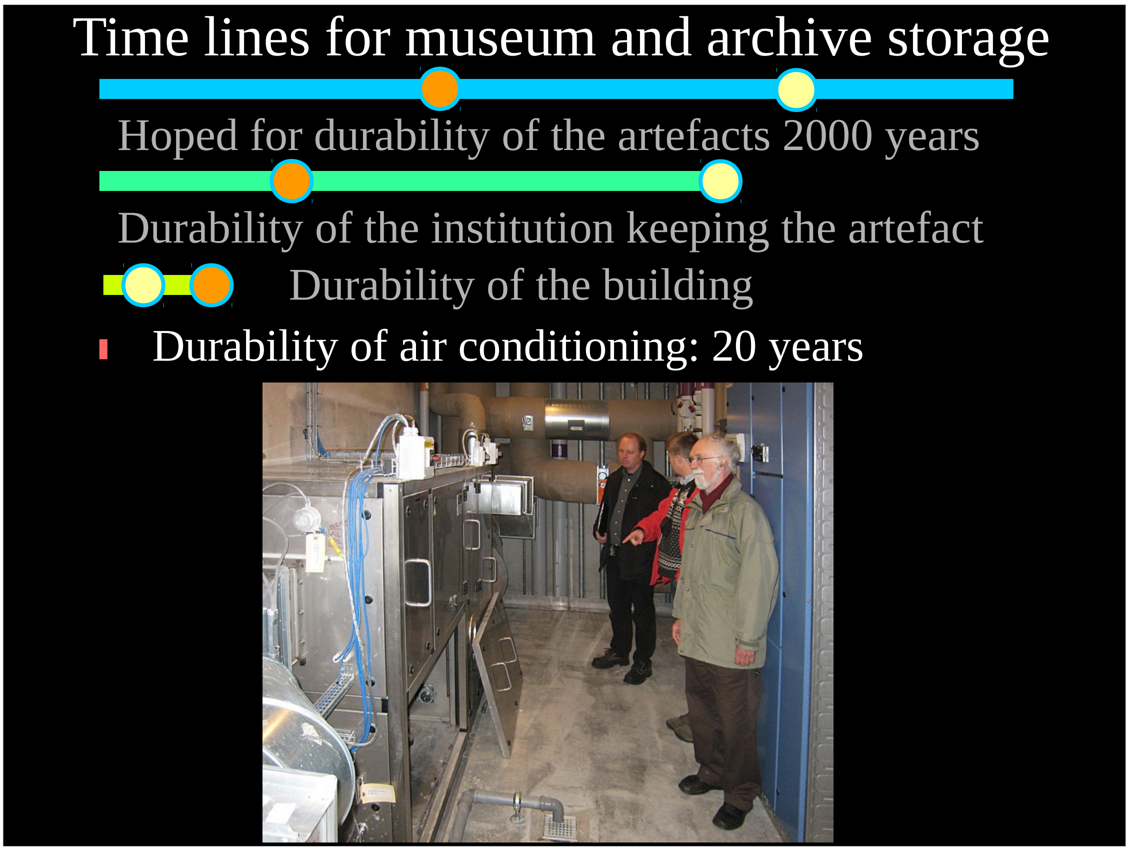
St Catherine's Monastery in Egypt is a rare survivor from the sixth c AD. Elsewhere, monasteries have been dissolved by rulers or by religious upheavals.

The durability of universities has proved to be astonishingly reliable; hardly any have disappeared since their invention in the 13th c. AD.

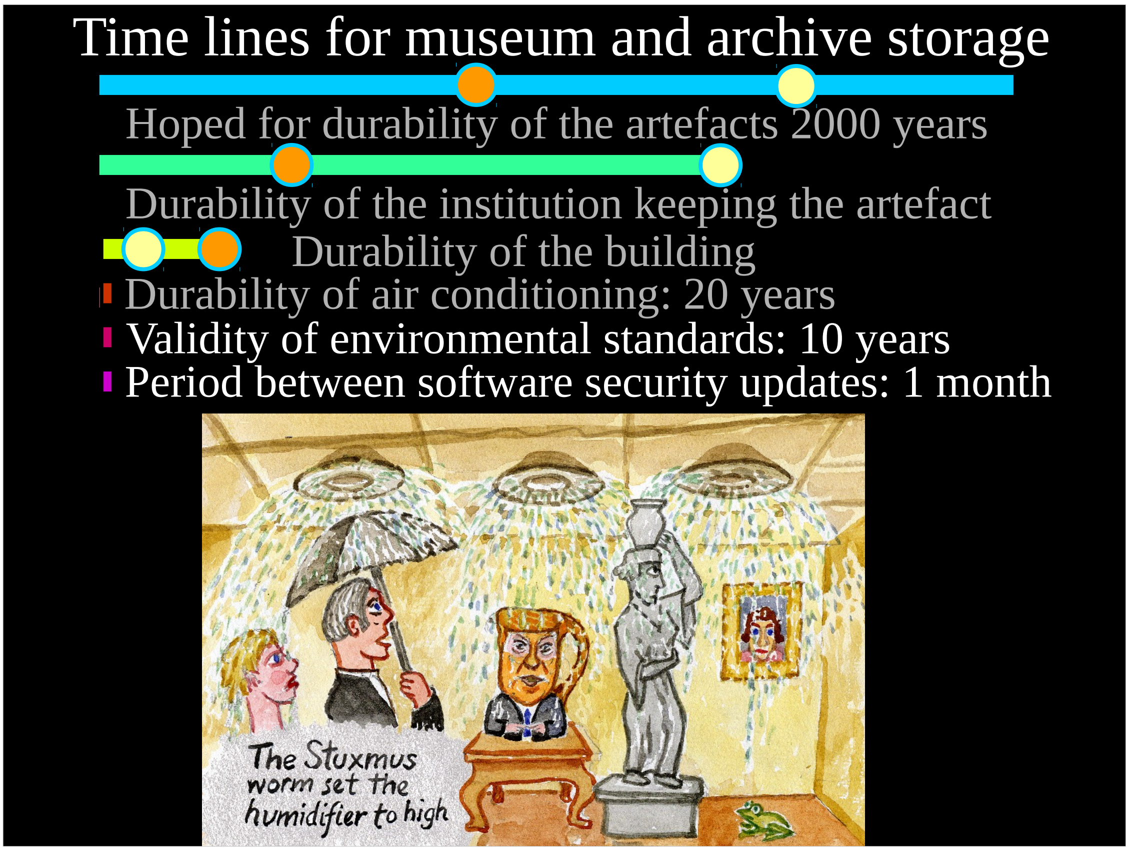
The durability of the building containing the artefact is generally much shorter.

The St Catherine's library has just emerged from a major renovation, after less than 70 years of existence.

The Arnamagnæan Archive, behind the blank bit of the facade, is soon to be moved, after 13 years in its present home.

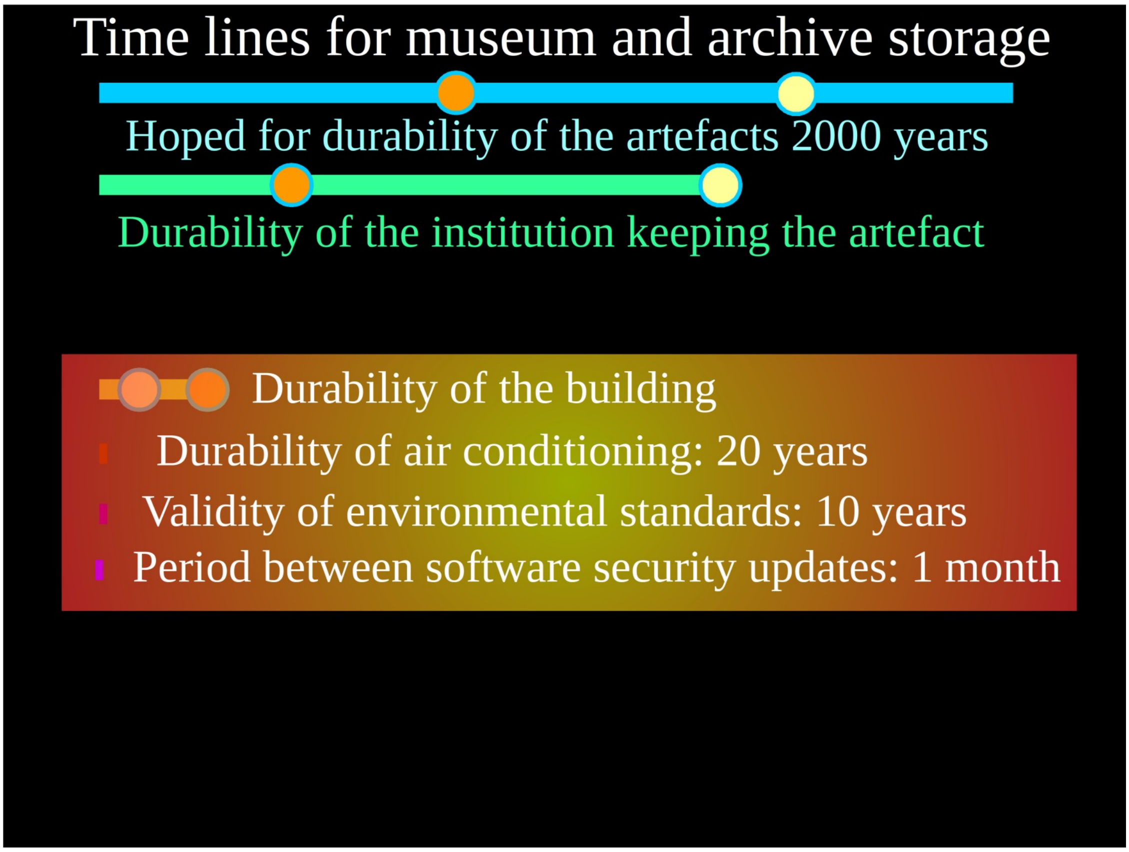


One must also note the youth of air conditioning technology, around 100 years, and the short lifetime of its installations, typically 20 years.



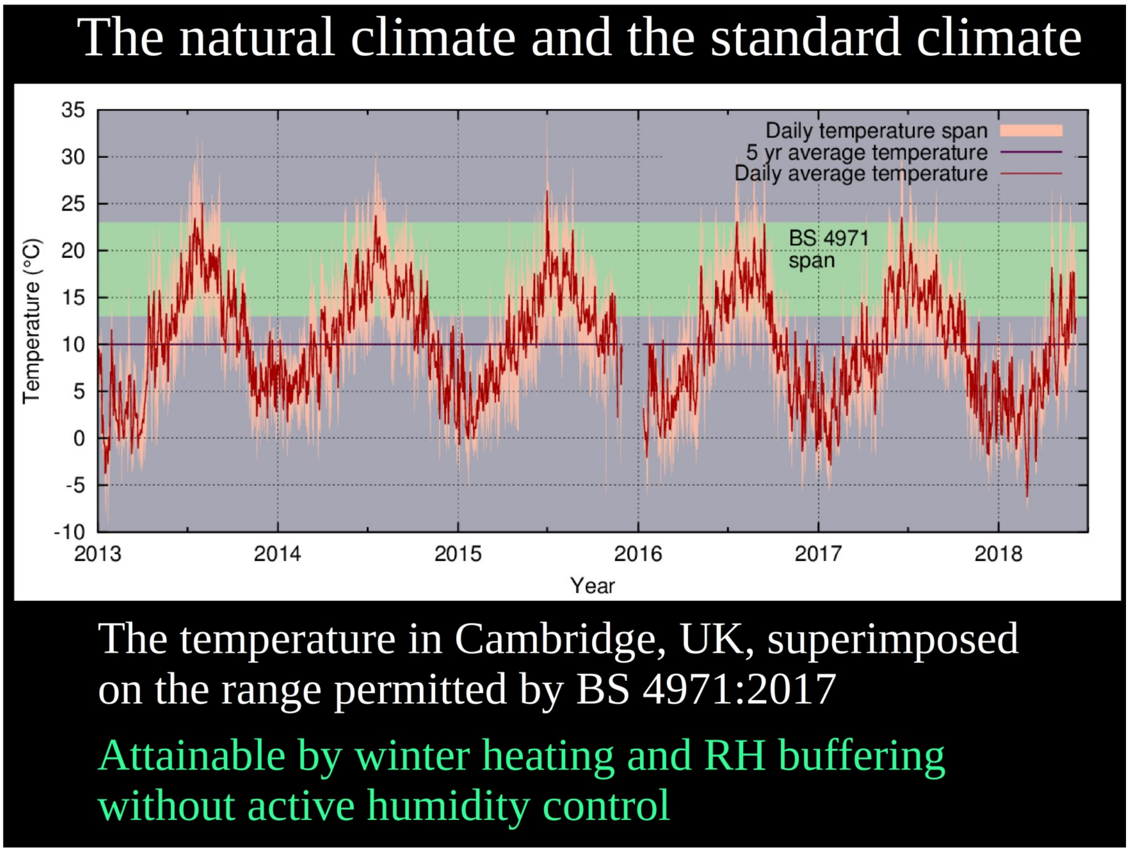
Even more short lived are the standards which define the storage environment. A revision frequency of 10 years is normal. And the changes are substantial, from the environment designer's viewpoint.

Finally one must note the growing disquiet over the safety of our digital control systems operating over the internet, itself less than 40 years old and subject to constant ill-intentioned interference.



There is a striking difference between the durability of artefacts, demonstrated over centuries, and the relatively very brief durability of our environmental decisions and of the technology of building materials, sensors and algorithms that implements these ever changing rules.

We re-examine how to secure a preservative environment, in the light of the long durability we aim for, which will surely extend over periods of social and economic decline, warfare and natural calamities, and less dramatically, the decay of maintenance services and knowledge of the functioning of complicated technical equipment.

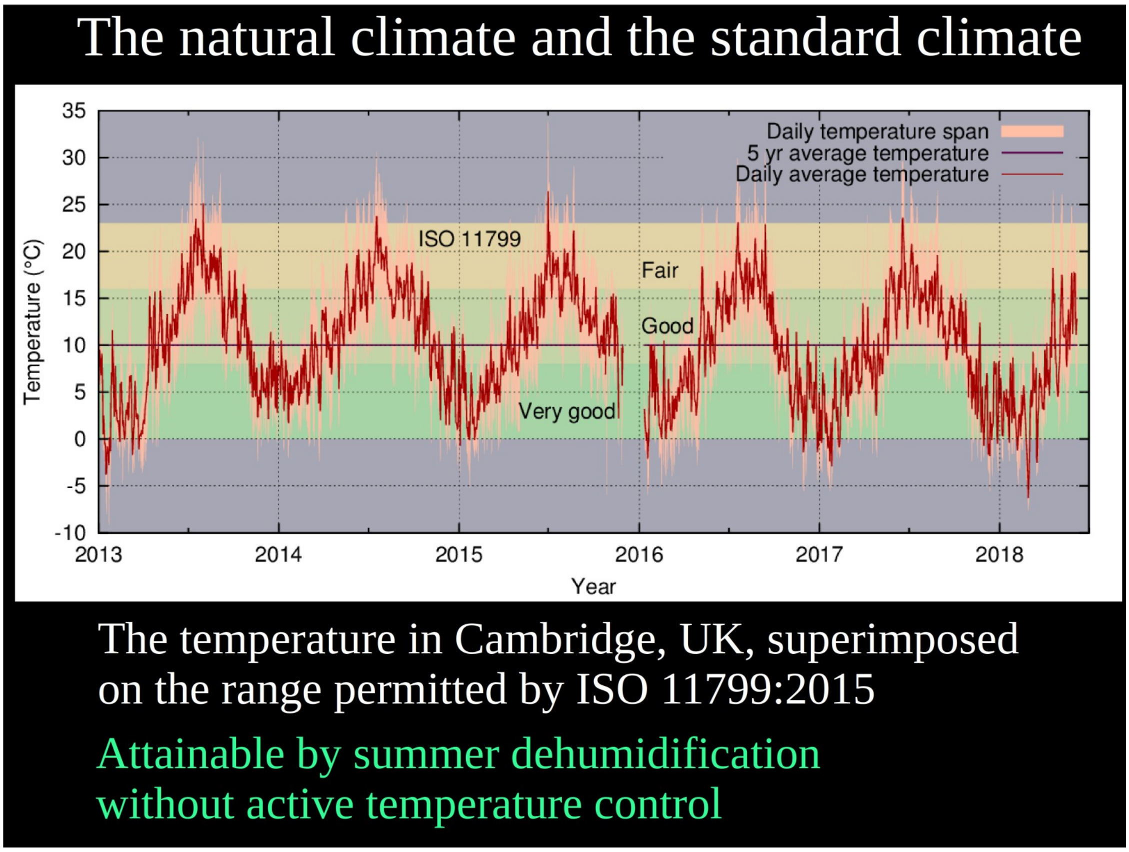


The weather is, in a general way, fairly constant over thousands of years. Here we take just the last five years in a typical northern European town.

The green area marks the temperature range acceptable for a mixed collection, according to the current British Standard for archives.

The steady dark line is the average temperature in Cambridge - ten degrees.

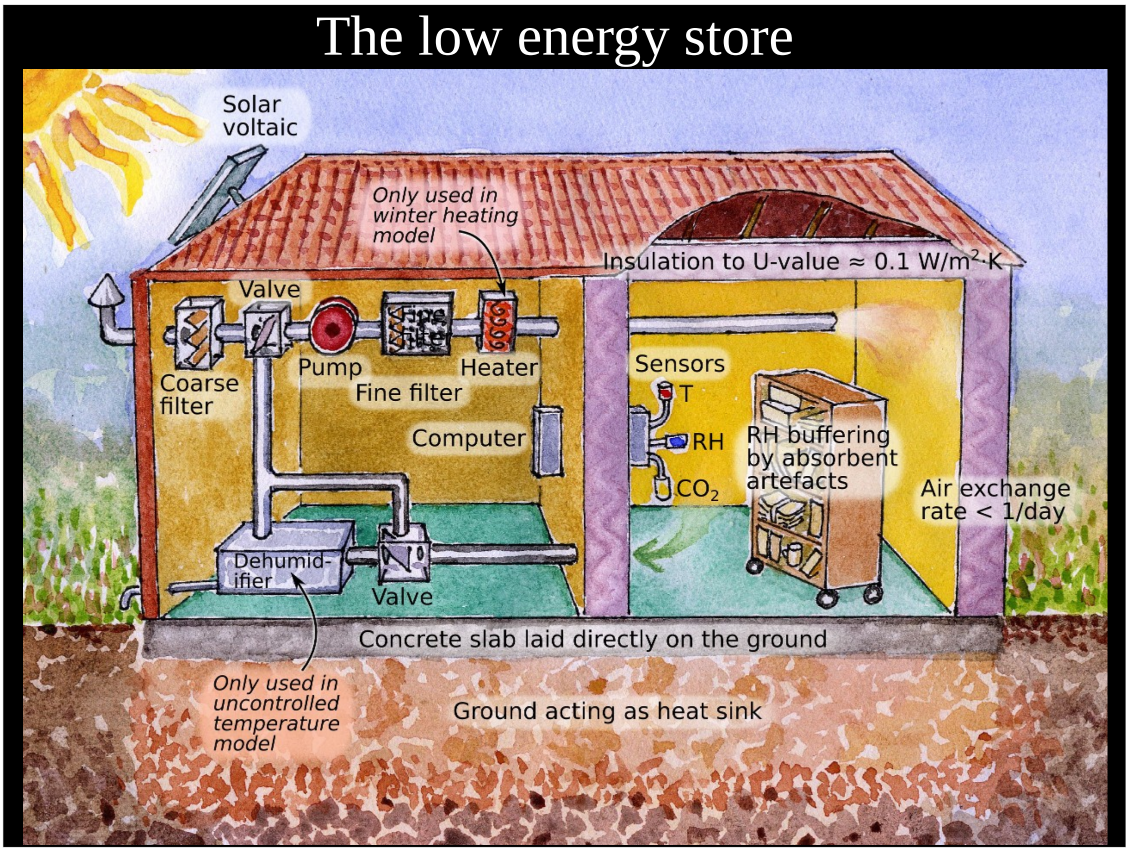
The standard therefore demands heating for several months in the year. It will be a while before global warming matches the acceleration of thermal degradation imposed by the standard.



If you are worried about this increased degradation rate, you can choose a different standard!

The ISO standard for archive storage gives the individual curator more freedom of decision and is more relaxed about the lower temperature limit.

This allows us to let the temperature wander uncontrolled, but smoothed, throughout the year, but in most climates it also requires dehumidification during the summer.



Both the standards mentioned can be accommodated in much the same building style, with a small difference in the mode of operation.

The first requirement is to ensure a slowly varying but not a constant temperature. This is achieved by using the ground below the building as a heat reservoir, moderating the winter and summer extremes.

Day to day moderation of the temperature, as well as temperature uniformity, is ensured by insulation in the walls and ceiling.

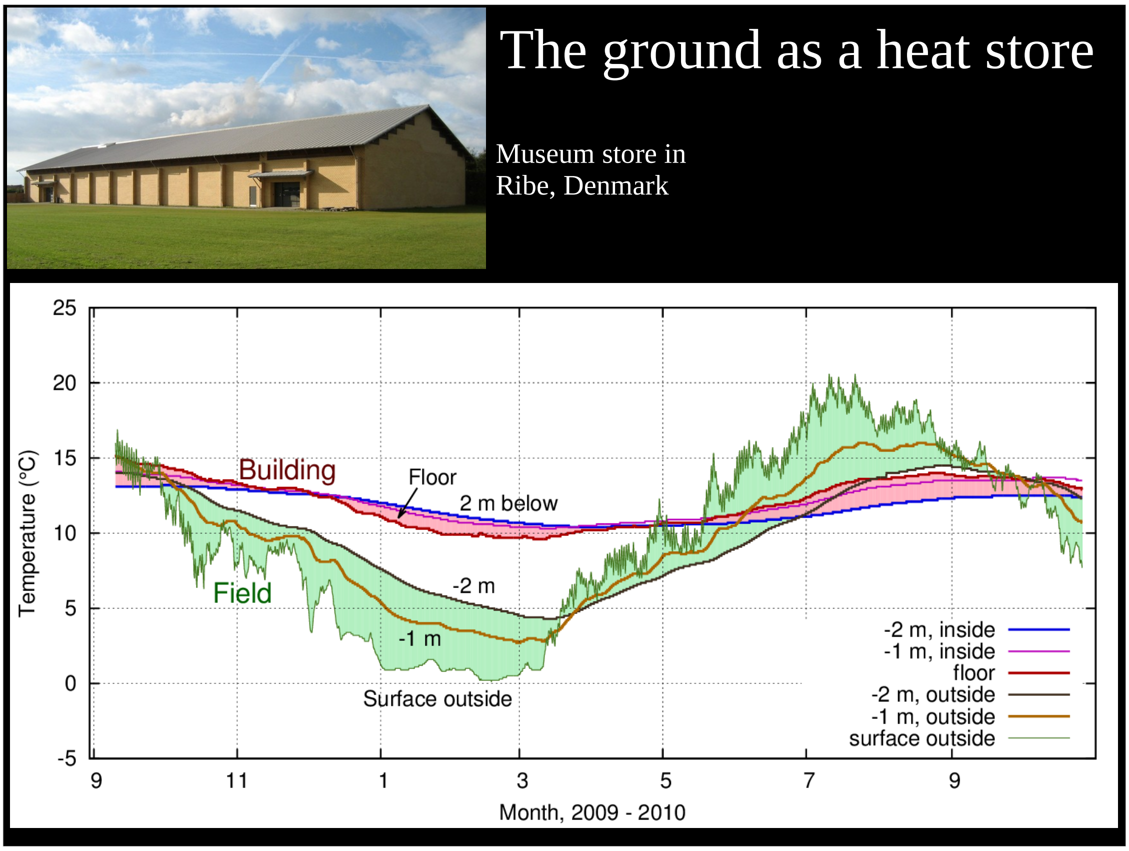
A useful aid to climate constancy is humidity buffering by the stored materials. This only works if the air exchange rate is low.

The RH will nevertheless eventually reach the annual average outside, which is usually too high. Artificial dehumidification is therefore needed in summer, or heating is needed in winter, but not both.

Depending on the nature of the collection, absorption of internally generated pollutants may be a sensible precaution. This needs a recirculation rate of about once every two hours.

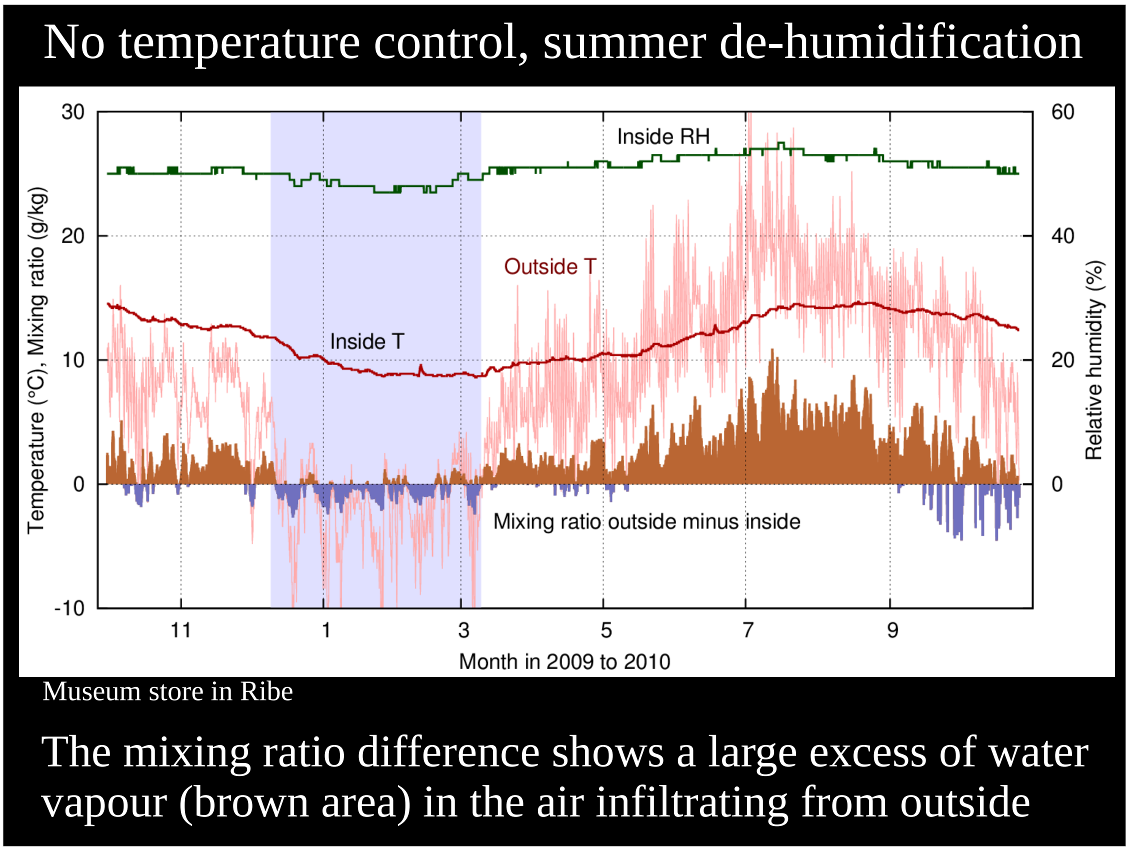
Finally, it is possible to fine-tune the RH by pumping in air from outside when its water vapour content will drive the interior towards the target.

I will describe these requirements systematically. Not all the devices shown in this diagram are needed in a particular building.



The earth beneath a building constitutes a vast heat sink. Over several years it will come to equilibrium with the building above. The final temperature gradient between the floor surface and the constant temperature at depth is so small that no insulation is needed.

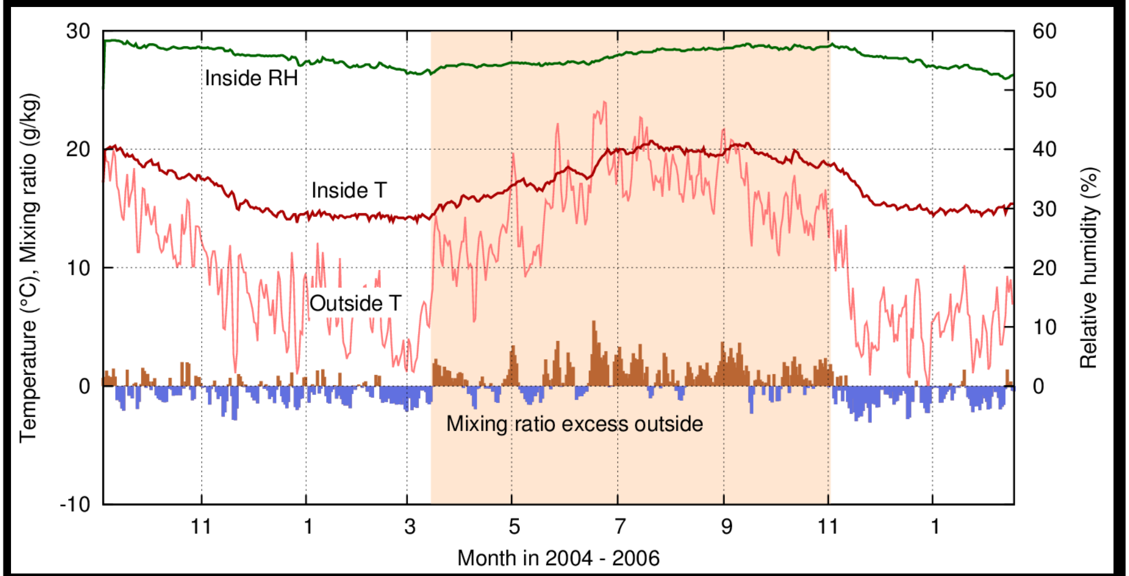
Temperature uniformity within the 6 metre high building is achieved by good and well distributed insulation, by the small difference from the outdoor temperature and by the lack of internal sources of heat.



The lowest trace in this graph of the weather in the Ribe store shows the mixing ratio difference between the air inside and outside the building, with a brown fill indicating more water vapour outside than inside. The mixing ratio is the amount of water vapour in a given weight of air. It is maybe an unfamiliar unit of moisture to some of you, but it is convenient for following what happens when a building exchanges air with its surroundings, because it is unchanged by the expansion of air on entering a warmer space.

Because of the low temperature in the store, there is nearly always a higher concentration of water vapour in the infiltrating air, so dehumidification is necessary most of the time outside the winter period marked by the blue background.

Winter heating to a fixed temperature - no RH control



Suffolk Record Office, Ipswich, UK

The mixing ratio difference is in balance over the year. Humidity buffering ensures a slow RH cycle around a constant annual average.

Many archivists specify a relatively warm winter temperature, because the archive is busy, with frequent picks to the study room, which is held at a human-comfortable temperature.

This can be achieved with the same basic building structure, with control by a thermostat set at 15 °C. The summer RH is held to a moderate value by buffering by the collection against the more humid infiltrating air. No mechanical dehumidification is needed.

The lowest trace shows the difference in water vapour concentration between inside and outside. The disequilibrium in summer, is balanced by the opposite disequilibrium in winter. The RH is therefore stable as a long term average. The brown shaded area shows the period of passive “dehumidification” by the stored materials.

Why is there suspicion of simplicity?

The National Archive of France at Pierrefitte, Paris

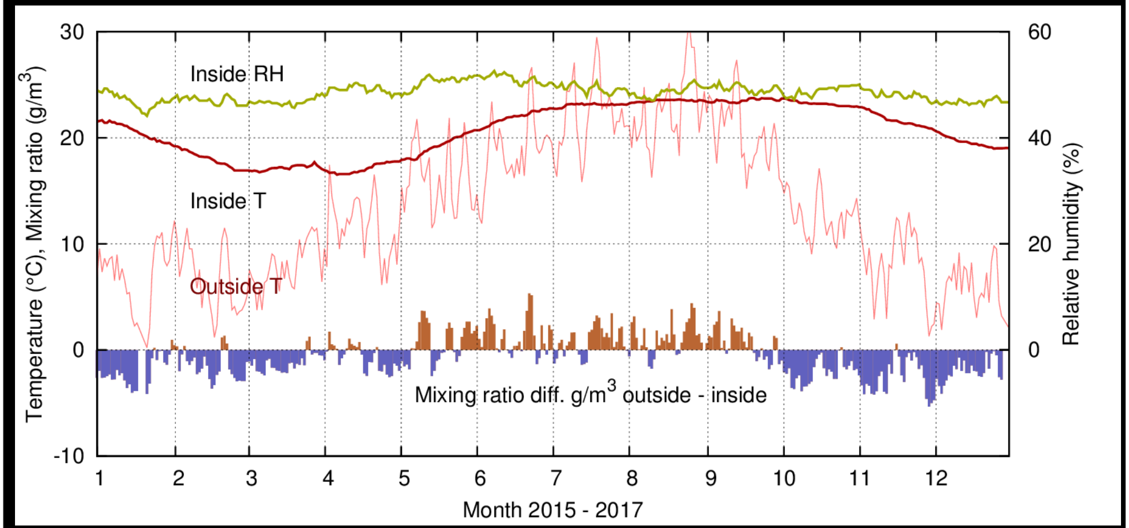
Our experience has been that archivists, standards committees, engineers, even conservators, are distrustful of inertial guidance of the temperature and the RH, respectively, which is inherent in these two models of archive and storage climate design.

Some standards are not helpful in this respect. They set exact temperature limits which have no immediate consequences if they are briefly exceeded.

The standard set for the Pierrefitte archive was quite relaxed, to save energy.

It is, however, fully air conditioned, because the role of the archived materials was explicitly excluded from the design process.

Full air conditioning - instant response



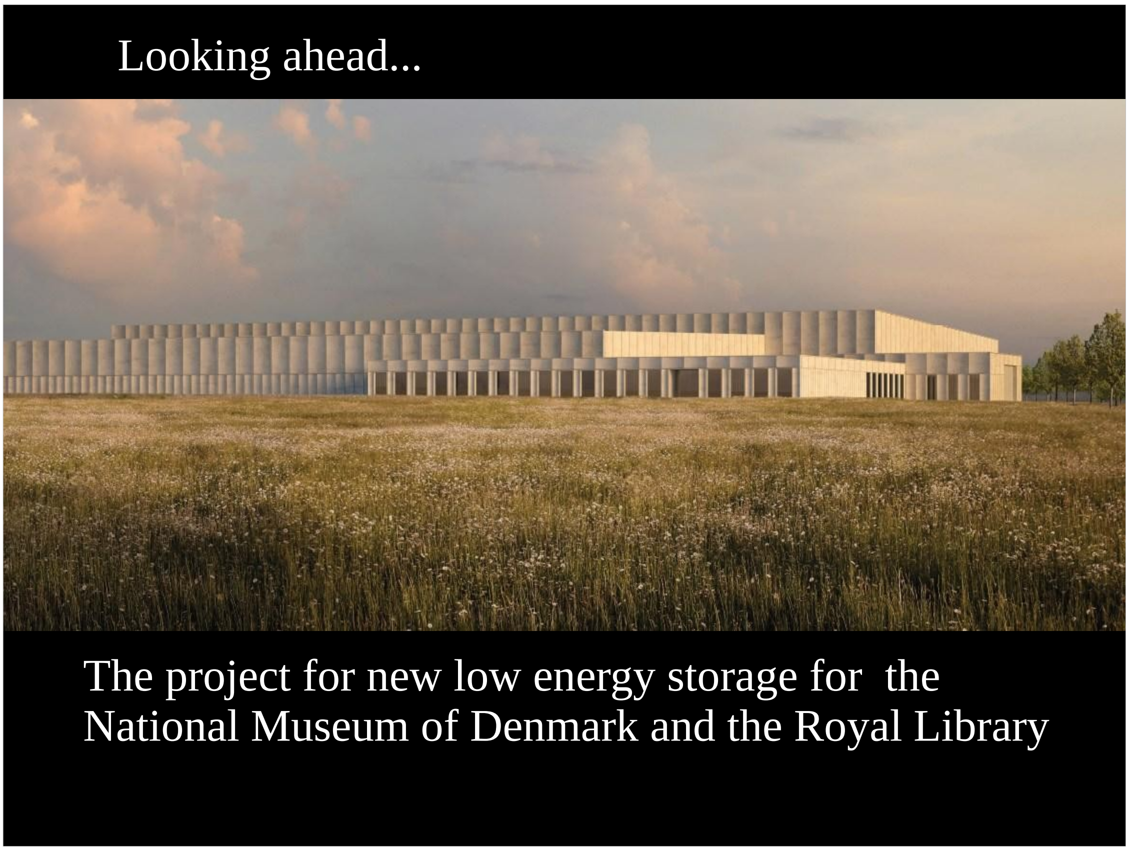
The National Archive of France at Pierrefitte, Paris

The water vapour deficit in winter (blue area) is not compensated in summer, so humidification is needed.

The Pierrefitte archive has an internal climate that is instantaneously adjusted by air conditioning. It is however very close to the climate achieved in the Suffolk archive by a thermostat set at a constant temperature.

The negative mixing ratio difference in winter, shown by the dominance of the blue over the brown area of the lowest trace, forces humidification in winter.

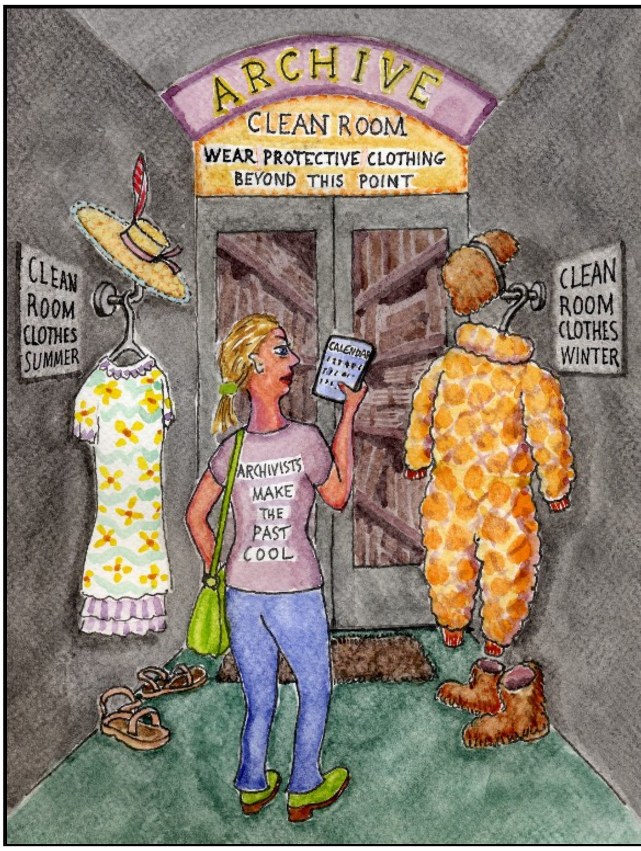
the smaller excess vapour outside in summer suggests that the RH could be moderated by buffering, without need for dehumidification. But the insistence on acclimatising an empty building forced the installation of dehumidification.



There is a temptation for clients to skim-read the environmental standards for archives and elevate the headline numbers to a specification, for which one will never be criticised.

The concept of low energy use combined with good preservation and minimal complexity, outlined in this lecture, is however gaining acceptance.

Here is a sketch of the proposed new storage building for a consortium of The National Museum of Denmark and the Royal Library.



Acknowledgements

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For a complete explanation of our design concept, and to see this lecture again, please visit:
www.conservationphysics.org/coolstorage

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There is a permanently available web version of this lecture and also an article which expands the arguments presented in this brief lecture and in the congress preprints.

We propose returning to simplicity of design for the simple task of keeping a calm climate around the artefacts we want to keep for thousands of years.