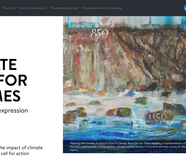
A CLIMATE MURAL FOR OUR TIMES

Global science, local expression



A new collaboration to paint the impact of climate change in Norfolk is a rallying call for action

Norfolk's rich history and unique landscape are loved by those who live here and are a delight for visitors to discover. Its counterpoints and coastline are revered for their beauty and biodiversity. Norfolk is also a place where the effects of our changing climate are keenly felt: coastal communities bear the impacts of erosion, our farmland suffers the impact of droughts. In Norwich, the Climate Research Unit (CRU) at the University of East Anglia has been at the forefront of understanding our climate since it was founded 50 years ago.

Norfolk and Norwich also have a proud and unconventional cultural and social history of storytelling, of artistic expression, of rebellion and of inclusivity. Norwich is a City of Sanctuary, a City of Sanctuary and a City of Independent thinkers, writers and artists.

Now, as CRU marks its 50th anniversary and world leaders return from COP 27, an exciting collaboration harnesses the powers of art and science to set our understanding of our changing climate - and makes a rallying call to us all to keep the climate in mind when considering our actions - from politics to the personal.

A Climate Mural for our Times is a 10m wide work in Norwich City Council's debating chamber that depicts climate change over 66 million years. Painted by artist Connolly Yarrow, its placement is meant as a continuous reminder to our representatives that policy decisions must be made with climate change in mind.

The work is a collaboration between Norwich City Council, CRU, the Transition Arts Science Project on Climate Change, and Global Water Futures.

Connolly Yarrow in the studio creating one of the panels from *A Climate Mural for our Times*

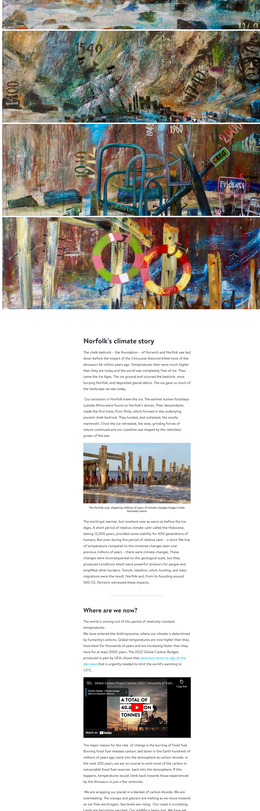
Collaboration at the heart of creativity

The painting of the mural was a result of interaction between the artist, scientists, local residents, students, the Mayor and representatives of museums, and others. The mural will be the keystone of an exciting arts science community and civic governance project.

Painting the history of Norwich through the lens of our changing climate has been challenging. City years is seven into changes in our geological fabric and coupled to changes in the global image: drifting continents, distant volcanoes, changing oceans, one shared atmosphere. Climate science wrote the musical score of the climate stripes, with the beat of the thermal drum always there.

Community leaders wanted to ground the mural in our local human history, and so providing the vision for how we can begin to a sustainable future. A vision is nothing if not seen, shared, participated in by those for whom it is created. What matters most is you - and moving you. Wherever the voyage takes us, we are all crew on it.

Join us as we take a deep dive into the stories behind these amazing artworks.



Norfolk's climate story

The chalk bedrock – the foundation – of Norwich and Norfolk was laid down before the impact of the Chicxulub Asteroid killed most of the dinosaurs. Mammals, birds, insects, plants and fungi evolved in the world that they are today and the world was completely free of ice. Then came the Ice Ages. The ice ground and sculpted the bedrock, once burying Norfolk, and deposited glacial debris. The ice gave us much of the landscape we see today.

Our ancestors in Norfolk lived like ice. The arctic human hunters outside Africa were found on Norfolk's shores. Their descendants made the first tools, from flints, which formed in the underlying ancient chalk bedrock. They hunted, and sustained, the woolly mammoth. Once the ice retreated, the slow grinding forces of nature continued and our coastline was shaped by the relentless power of the sea.

The Norfolk coast, shaping millions of years of climate changes *Image Credit: Gabriella Yarrow*

The world got warmer, but routines near as warm as before the Ice Ages. A short period of relative climate calm called the Holocene, lasting 12,000 years, provided some stability for 400 generations of humans. But even during this period of relative calm – a short flat line in the temperature graph – there were climate changes. Unlike previous millions of years – there were climate changes. These changes were inconsequential on the geological scale, but they produced conditions which were powerful stresses for people and amplified other burdens. Tumult, rebellion, witch hunting, and mass migrations were the result. Norfolk and, from its founding around 500 CE, Norwich witnessed these impacts.

Where are we now?

The world is nearing out of the period of relatively constant temperatures.

We have entered the Anthropocene, where our climate is determined by humanity's actions. Global temperatures are now higher than they have been for thousands of years and are increasing faster than they have for at least 2000 years. The 2023 Global Carbon Budget, produced in part by UEA, shows that emissions show no sign of the peak in sight, that is urgently needed to limit the world's warming to 1.5°C.

The major reason for the rate of change is the burning of fossil fuel. Burning fossil fuel releases carbon, laid down in the Earth hundreds of millions of years ago, back into the atmosphere as carbon dioxide. In the next 200 years, we are on course to emit most of the carbon in fossil fuels that the Earth has stored in the atmosphere of its beginnings. Temperature would climb back towards those experienced by the dinosaurs in just a few centuries.

We are wrecking our planet in a blanket of carbon dioxide. We are destroying the conditions that have made our civilisations possible and we are free world again. Sea levels are rising. Our coast is crumbling. Lands are becoming parched. Our wildlife is being lost. We have all course to return to climates perhaps 5 degrees warmer than before the Industrial Revolution.

We still have choices. Shall we act as guardians of the Earth for future generations? Or shall we leave those future generations to pay the consequences of us doing too little?

Bringing art and science together

Our climate history is a rich and powerful story, explained by ground breaking research. The human story is also rich, punctuated by innovation, achievements, triumphs, mistakes, despair, and destruction. These stories are intertwined and we need a way of communicating and recording that richness.

Our ancestors survived predators, ice, fire, famine and flood. They even survived themselves. They told the stories of their survival and their innovations through paintings, song, dance, and drama.

Art can encapsulate, project, and communicate rich stories. It can inform and inspire. It can provoke. It can pose questions in the mind of the viewer. It can uncage the mind.

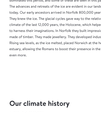
If we are to avoid the very worst consequences of climate change, we need to break out of the cages of denial, avoidance, or despair. We need to be reminded, and led, by those young people who understand that our future is endangered. But they can see the opportunities in rising to the challenge.

Norwich has a history, and a reputation for being, a revolutionary city. We go back to history in bringing together art, science and civic governance to paint a mural that represents our climate history. With *A Climate Mural for our Times*, we also foresee possible outcomes dependent on current and future decisions - and place them at the centre of civic governance. Norwich has been a cradle for art and global climate science. It could be a cradle for changing mindsets.

The elements paintings

Each of the five elements paintings complements a panel of the mural, depicting social and natural events related to or influenced by the climtic changes seen in the panels. Explore them below.

Our climate origins: 66-3 million years ago



Beth Chopra, in the *Fire* elements painting, Chopp has dinosaur bones as well as an Inuit sled made of bones, a sign of Norfolk's ancient ancestors

This painting portrays the links between the climates and geology of the periods even before the time of the start of the mural and today's Norfolk and Norwich. They include the character of the internationally important chalk rivers of the County, including the Wensum. The dinosaur fossils have been found in Norfolk, but Chopp asked Norwich in 2020.

From his standpoint of time before the collision of the asteroid which wiped out most of his relatives, he is pondering on possible fate. He sees our much shorter time on Earth as ending in a live crash (dinosaurs think big). A famous consequence of Norwich being built on chalk bedrock was the double decker bus being partially swallowed by a local chalk sinkhole - pictures of which went around the world.

3 million years ago–500CE

Norfolk's ancient ancestors, after changes of Ice Age life through the ice ages and the first relative calm of the Holocene *© Connolly Yarrow*

Cycles of ice ages, all of which had a profound effect on Norfolk, dominated this period, and some of these are seen in this painting. The advances and retreats of the ice are evident in our landscapes today. Our early ancestors arrived in Norfolk 800,000 years ago. They knew the ice. The glacial cycles gave way to the relatively stable climate of the last 12,000 years, the Holocene, which helped humans to harness their imaginations. In Norfolk they built impressive circles, made of timber. They made jewellery. They developed industries. Rising sea levels, or the ice melted, pressed Norwich at the head of an estuary, allowing the Romans to boost their presence in the county even more.

Our climate history

501-1400CE

City of Norwich. The painted centre Norwich source for little ice of the mural *Image Credit: Gabriella Yarrow © Connolly Yarrow*

Much of what we know about the climate of this period comes from tree rings and documentary records. The first 600 years saw a relatively benign climate, and these favourable conditions enabled the Vikings to make their forays. By 1000, Norwich had become one of the most prosperous cities in the land, and the building of the Cathedral soon started. A rapid deterioration of climate began around 1100. A growing demand for fuel led to more peat digging, and the resulting flooding created the Broads. Storms, floods and wetter climate, giving us today's Norfolk Broads. The growing inclemency of the climate started to have a big impact on people's lives, often exacerbating other social and economic factors. Famines made people more susceptible to the Black Death.

1401-1850

Waves and storms. This period saw loss of crops and livestock, as seen in this painting showing Wells harbour. Nathan Wallace and Anne R Bromley Collection

The climate worsened into "The Little Ice Age". Norfolk villages were abandoned and shipwrecks were abundant. Bad weather set the precautions for Kett's Rebellion in 1549. Scapegoats were sought and "witches" accused of causing bad weather were persecuted. The political instability of the 1600s, set off a long train of events culminating in the Civil War, followed by the Restoration and the Revolutionary City. The Agricultural Revolution, spearheaded by Turnip Townshend, provided greater resilience. But adverse climate impacts continued, contributing to a wave of emigration from Norfolk in the 1600s. While etching became fashionable on the Frozen Broads, the shrinkage of the Industrial Revolution began spewing out carbon dioxide. The catastrophic volcanic eruption of Tambora caused the "year with no summer" in 1816, forcer Inland with Mary Shelley's creation – Frankenstein.

Our climate present

1851-present

Climate science is an issue in The Great Union Old period Film when there was a Great Flood in Norfolk. Climate change is a contributor to the increased risk of flooding in Norfolk. Climate change is also a contributor to greater extremes of weather, such as the hot summer of 2018 and the cold winter of 2018/19.

In 1850 the UK was by far the world's top emitter of fossil carbon dioxide. In this decade the American scientist Eunice Newton Foote discovered the greenhouse effect. In the 1860s, the Victorian polymath, by the independent work of Irish physicist, John Tyndall. By 1870 the UK had emitted 50% of the world's cumulated emissions. In the 1960s, annual global emissions reached 10 billion tonnes and by 1990, cumulated emissions topped 1 trillion tonnes.

Norfolk has played important roles in North Sea energy: both from fossil sources and now from renewable sources for the future.

Extreme weather events associated with global warming have hit Norfolk in recent years. The hottest day ever recorded in Norwich was 40°C in July 2022, extremely rare in the present climate. If a similar weather pattern to the month projection were to occur, it would bring temperature extremes topping 43°C in 2050 and 46°C in 2080.

It was also during the period shown in this panel that our scientific understanding of climate change became firmly established, and with it the realisation that it is human activity that is responsible. To determine what actions are necessary to stabilise our climate, CRU was established in 1972 and has spearheaded research into global warming since. Its mission since its founding is to investigate and understand the changing climate. CRU and its partner, the Tyndall Centre for Climate Change Research, continue to shine a scientific light for the future.

Norwich City Council is also shining a light on the future. Addressing climate change is a central pillar of its 2040 vision. It has much to build on. Award-winning energy-efficient buildings are seen at UEA and in the City – in particular in Goldsmith Street. In 2002, UEA, Norwich City Council and others established the Norwich area community carbon reduction project, which was successful and it was the catalyst by the combination of the 2007-8 global financial crisis, and the 2008 attack which resulted in Chrysalis. A lesson which should be well learned: not prioritising action on climate change now will cost so much more to cure later.

Our climate future: Present-2200

The future is yet to be written. It is for all of us to decide and to produce. The solutions to climate change are imaginal, and what Norwich, Norfolk – and the world – will look like are yet to be painted. Our imaginations will be so great that we will need many canvases for the future.

We are intertwined with our planet. Our natural world nourishes and sustains us and has provided what we needed to evolve. But we have outgrown ourselves. Overshoot Day, the day we have used up the ecological resources that the Earth can regenerate in a year is getting earlier each year. This year it was July 28. For a sustainable future it should be around 31st December. It is now quite clear that our consumption of the planet is driving climate change. Our ever-increasing consumption growth on a finite planet is driving the Sixth Extinction over here. We need to quickly innovate, for better lives within unending growth. To give Earth, and ourselves, time to renew.

The science behind the paintings

Paleoclimate archives

The signature of nature's heartbeat is all around us. And the Earth has been pulsating to life for many millions of years. Ever since the Hadean eon, at around 4.6 billion years ago, the Earth has generated a late tack left the tales of thousands of years of climate history in the width of their annual rings and in the composition of their wood.

Temperature through time, derived from various proxies and global average surface temperature from 1850 to 2020 (in the left-hand panel) and projections for the 21st century (in the right-hand panel). The projections are based on the Intergovernmental Panel on Climate Change's Fifth Assessment Report (AR5) and the Fourth Climate Assessment (AR4). The AR5 and AR4 provide projections for the 21st century under two different scenarios, the Representative Concentration Pathways (RCP) 8.5 and the Special Report on Emissions Scenarios (SRES) A1B. Figure by Ed Gillespie

Every season's snowfall compacts surface ice, and ice cores break out of Arctic and Antarctic ice sheets, some kilometres long, contain ancient samples of our atmosphere trapped in their bubbles of air. Alongside ice cores, scientists have found the history of Earth's climate in all manner of archives: stalactites, sediments in lakes, and the growth bands of tropical corals to name a few.

Climate reconstructions

Temperatures are reconstructed for the Age of Mammals from many different sources. Oxygen isotopes in the remnants of deep sea creatures, for example, can be used to infer ice volume, which can take us back to the climate at the beginning of the heat. Tree rings take us back a thousand years or so. Thermometer measurements keep track of the Earth's temperature since industrialisation.

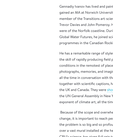
Global measurements, a map of the world showing the location of weather stations and the data they record, and a reconstruction of temperature through time. The data in panel (c) is based on the global gridded data set compiled by Michael Mann & Michael Hughes. Figure by Ed Gillespie

Each source has its own time interval between measurements. The oldest reconstructions measure the temperature every thousand years. Tree rings provide a record for each individual year. Modern automatic weather stations, seen on the map of Global stations above, record the temperature every minute.

The global temperature record

The vertical thermometer measurements in CRU's archives date from 1850. Our annually-resolved weather station dataset goes back to 1880. Our monthly-resolved weather station dataset goes back to 1850 and currently have monthly average temperatures from 5,853 weather stations all over the world's surface, providing data each is sample of the world's most inhospitable places from the deserts to the poles.

Gridded data extends the coverage to almost every square km. Since year's in their ship's logs. Design of drifting buoys to measure the sea surface temperature every hour of the day. CRU's scientific research is represented directly within the artwork.



Details in the city: Global temperature departures from the average during 1961-90 and 1991-2020 (the 30-year period used by the World Meteorological Organization). Data is a combination of land and sea surface temperature data. Land data is from the Global Historical Climate Network (GHCN) and sea surface temperature data is from the Extended Reconstructed Sea Surface Temperature (ERSST) dataset. Data is from the GHCN version 3 and ERSST version 5. Figure by Ed Gillespie

The dip of the most depicts climate history land possible climate Rainwater in the form of Professor Ed Hawkins' Climate Stripes. This is the panel covering the period 1850-2020 is a direct depiction of the Global Land Surface Temperature chart (GLST) dataset with the UK Met Office. The predictions in the panel for the future are also influenced by this dataset. Climate models, selecting only those climate models that can match the amount of historical warming that we have actually seen.

The future of climate models

The most complex computer models of the Earth's climate system are grouped, that have resulted at the only Swedish pole the is a Nobel Prize winner Svante Arrhenius. Climate is not the only thing that morph, we tunneling the Earth's climate system. Climate models are complex but still capable of capturing the links between our emissions of greenhouse gases and the rise in global temperature.

But what of these greenhouse gas emissions in the future? It is up to us to choose our pathway. Possible pathways are interwoven with how we generate and use the energy that supports our society and its economy. What type of technology? How much do we take the natural world? How do we alleviate poverty while providing an environment which is safe for all?

We illustrate three possible futures with two Shared Socioeconomic Pathways (SSPs). A high emission future (SSP5-7.0) where we continue to dump carbon dioxide in the atmosphere into the next Century and beyond. Or a more benign future (SSP1-2.6) with emissions reduced to net zero and a higher chance of meeting the goals of the Paris Agreement and stabilising climate change soon after 2050.

Connections: Making the mural possible

Global Water Futures

The Transitions Art-Science Project and Global Water Futures

John Pomeroy spent two years at UEA in the 1980s, working with Trevor Davies, and they have collaborated ever since. John is now Director of the international Global Water Futures (GWF) research programme which is based at the University of Saskatchewan in Canada. It is the largest university-based freshwater research programme in the world, with a focus on the prediction and management of freshwater supply and quality as the climate undergoes rapid change.

Some of the largest and most rapid climate changes in the world have been seen in the cold regions of Canada, with devastating impacts in that country. There are also "transformed" impacts, for example, the melting of the Greenland Ice Sheet and the loss of Arctic Sea Ice. When Trevor and Carnesally approached John with their idea of an arts-science Transitions project, he immediately saw the promise in portraying these changes and impacts in art, informed by science, and accompanied by accessible scientific descriptions.

He was able to support Transitions within his scientific outreach programme, otherwise Carnesally's art became an important part of GWF's scientific communication. Transitions played a vital important part in the Canadian Government's decision to set up a new National Water Agency and has led to arts-science collaborations with UNESCO.

The Climate Research Unit

Climatic Research Unit and GloSAT

CRU's contribution to this project was supported by the UK's Natural Environment Research Council via the GloSAT project. Together with the UK Met Office, CRU has tracked the course of global temperatures during the Industrial Era based on direct climate observations.

CRU has undertaken novel work to extend this both backwards and forwards in time by bringing together the palaeoclimate record and future climate projections over the period spanned by the mural. The record provides a central feature of the mural – the day. Each stripe shows the temperature relative to the pre-industrial climatological average (1850-1900). The stripes in the future show the changes of the climate stripes very across the 5 panels of the mural from millions, to thousands, to yearly intervals, to accommodate the increasingly detailed information available as we move forward in time.

About the artist

Carnesally Ivanov has lived and painted in Norwich for 17 years. He gained an MA at Norwich University of the Arts. He is a founding member of the Transitions arts science project, along with scientists Trevor Davies and John Pomeroy. His first climate related paintings were of the Norfolk coastline. Drawing on artists in residency with Global Water Futures, he joined scientists on field research programmes in the Canadian Rockies and the Arctic.

He has a remarkable range of styles and techniques, and perfected the skill of rapidly producing field paintings in the element of conditions in the remotest of places. He used these field paintings, alongside photographs, to create the Transitions mural, which depicts all the time in conversation with the scientists. His unique paintings, together with scientific captions, have been exhibited many times in the UK and Canada. They were shown at COP 26 in Glasgow, and at the UN General Assembly in New York. He has become a Foremost exponent of climate art, all the time rooted in the science.

Because of the scope and overwhelming significance of climate change, it is important to reach people emotionally and intellectually, the problem is so big and so profound. This collaboration with CRU over a year mural installed at the heart of City Hall, informed by CRU's science, has given full rein to his imagination and allowed him to deepen the way he works with scientists. Scientific numbers and graphs, and impacts on society, are turned into powerful visual messages.

With thanks to Carnesally Ivanov (artist), John Pomeroy (University of Saskatchewan), Trevor Davies (GLWI), Tim Osborn (CRU), Michael Taylor (UEA, supported by NERC GloSAT), Alan Waters (Norwich City Council).

With acknowledgements to Ed Hawkins (University of Reading) and Julian Andrews (UEA).

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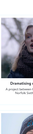

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