Cold Regions Warming

As shown at The Whyte Museum,
Banff, Alberta
October, 2022 - January, 2023

Global Water Futures – Canadian Rockies Science

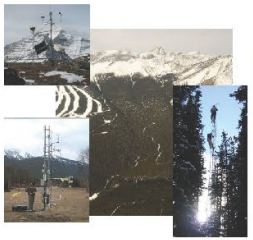
Understanding and Predicting Changes in Water Cycling using the Canadian Rockies Hydrological Observatory

GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

Field-Based Research Activities in the Rockies

COLUMBIA ICEFIELD & ATHABASCA GLACIER, JASPER NATIONAL PARK, AB.

- Hydrological apex of North America and the largest glacial mass in the Rockies.
- Research here has focused on measuring snow accumulation patterns and their transformation into glacial ice, effects of wildfire smoke and soot on glacier melt, and characterization of local scale meteorological conditions and cold drainage winds as they influence snow and ice melt.

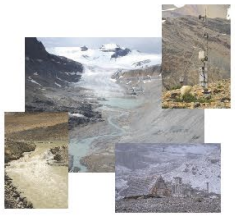


MARMOT CREEK, KANANASKIS, AB.

- Situated in the relatively drier Front Ranges and mostly covered by forest, alpine tundra, and rock.
- Research here focusses on forest and alpine snow processes, groundwater and surface hydrology, research on impacts of deforestation on streamflow, and long-term hydro-climatic change; the site has observations going back to 1962.

PEYTO GLACIER, BANFF NATIONAL PARK, AB.

- Part of the Wapta Icefield, among the larger glacial masses in the Rockies.
- A long-term benchmark site for mass balance (annual balance of snow accumulation vs. snow and ice melt), with observations dating back to 1965.
- Recent scientific activities include studies of the glacier's surface meteorology and computer model development and testing to simulate mass balance and meltwater runoff from this and other glaciated basins.

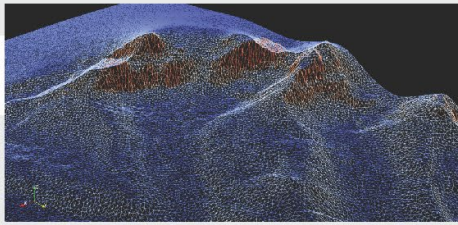


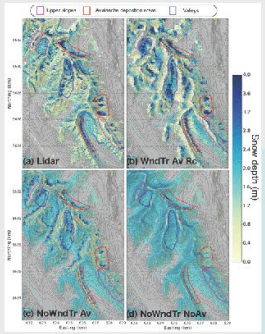
Development of Modelling and Prediction Tools

SNOWCAST FORECASTING SYSTEM AND THE CANADIAN HYDROLOGICAL MODEL (CHM).

- An experimental product that takes Environment and Climate Change Canada weather model forecasts, together with simulations from the Canadian Hydrological Model, to provide high-resolution snowpack forecasts.
- Accounts for the physics of variable wind-flow, avalanching, solar radiation, precipitation, and temperature over complex terrain.

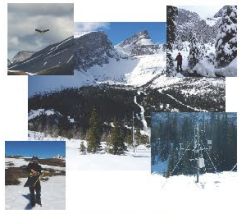
SnowCast
www.snowcast.ca





Right: CHM represents cold region hydrological processes and is spatially distributed over a flexible grid to capture fine details where they are needed while saving on computing resources. It can be run over areas from small headwater streams to vastly large river basins.

Left: An example of snow depth measured using airborne Lidar (a), simulation results accounting for avalanches and blowing snow (b), and simulations that did not account for blowing snow (c) or avalanching (d).



FORTRESS MOUNTAIN, KANANASKIS, AB.

- Located in the Kananaskis Valley and more abundant snowfall than areas further east in the Front Ranges.
- Research efforts are directed at studies of blowing snow transport, redistribution, and melt, as well as groundwater hydrology and forest–snow interactions.
- A testbed site for new instrumentation and snow measurement techniques, including airborne drones.

Future Changes in Climate, Landscapes, and Water Cycling

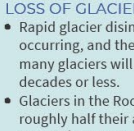
Air temperatures have increased by as much as 2°C since the 1960s and even more in the winter and spring months. Future projections confidently indicate a rise of at least several more degrees by late this century. It is also likely the region will experience greater variability and extremes in the amount, type, timing, and intensity of precipitation.

LOSS OF GLACIERS

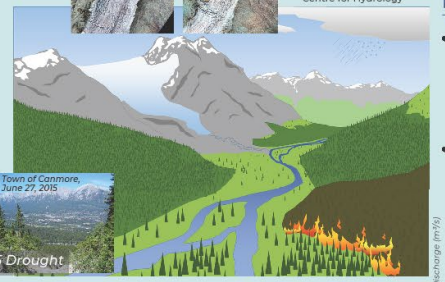
- Rapid glacier disintegration now occurring, and the lower portions of many glaciers will disappear in decades or less.
- Glaciers in the Rockies will lose roughly half their area and volume by mid-21st century and from 75 to 95% by end of century.

VARYING EXTREMES – FLOODS AND DROUGHTS

- Increased future risk of rain-on-snow and rainfall driven flooding.
- Reduced snowpack and loss of glaciers causing low river flows in drier years. Groundwater storage cannot compensate for this.



Peyto Glacier
329 m terminal retreat
2019–2022
M. Harasyn, P. Harder
Centre for Hydrology

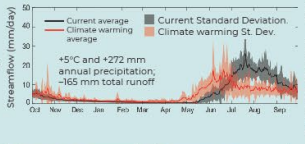


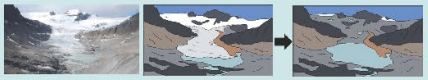
Cougar Creek, Canmore
June 20, 2013

ALTERED WATER CYCLING

- Earlier rising and peak flows, reduced peak flows (in general), and decreasing flows in summer and fall.
- Wildfire and loss of montane forests are likely to have a notable impact on flow regime in future.

Future Water from Peyto Glacier
De-glaciation by late 21st century under projected warming
C. Aubry-Wake, J. Pomeroy; Centre for Hydrology



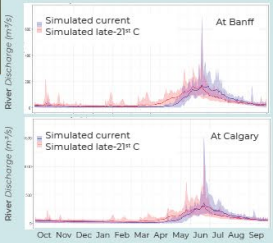


SHIFT FROM SNOW TO RAIN, AND DECLINING SEASONAL SNOWPACKS

- Snowpack is sensitive as early spring (and sometimes winter) temperatures approach 0°C for extended periods of time.
- Slight warming shifts the balance of snow and rain dramatically.

INCREASING WILDFIRE AND TREELINE ADVANCE

- Warmer and drier conditions will cause the intensity and extent of wildfires to increase significantly, bringing about a shift in valley bottom ecosystems from forests to grasslands.
- At high elevations, treeline forest cover and shrubs are advancing and infilling in many areas.



Future Flow of the Bow River
Simulated under climate and landcover change by late-21st century
Z. Tesemma, J. Pomeroy; Centre for Hydrology

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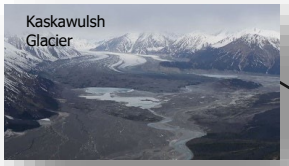
Canada's Water Crisis in the 21st Century

Rapid Glacier Loss

Retreating glaciers creating hazards, loss of water storage. Disappearance of Slims River and loss of inflow to Kluane Lake, YT.



Snowmelt Flooding
July 2021

Unprecedented flooding in Whitehorse and Southern Lakes area.

Ice-Jam Flooding
May 2022

Unprecedented ice jams and flooding, Hay River, NT.

Water Shortage
August 2022

City of Iqaluit declares emergency due to water shortage caused by lack of rainfall.

Drinking Water Advisories

As of 2022 there are 31 long-term advisories in 27 Indigenous communities

Fort McMurray Wildfire
May 2016

Direct and indirect damages totaled almost **$10 Billion**. 88,

Rainfall-Driven and Rain-on-Snow Flooding

Devastating and unprecedented flooding cost $ Billions and affects:

- Eastern Prairies (2011, 14)
- Southern Ontario and Quebec (2017)
- New Brunswick (2018, 19)
- Nova Scotia and Newfoundland (2021)

Increasing Wildfires

Series of recent record-breaking fire seasons in central and western Canada, increasing costs and area burned.

B.C. Lower Mainland Flooding
November 2021

Cost of rebuilding estimated at

Southern Alberta Flood
June 2013

City of Calgary and surrounding communities sustained over **$5 Billion** in damages. 100,000 people evacuated.

Severe Drought 2000–2002

Prairie drought at turn of century cost **$5.8 Billion**. Drought recurrence since has cost many billions more. Crop insurance payout of **$2.4 Billion** in SK, 2021.

Large and Sustained Algal Blooms

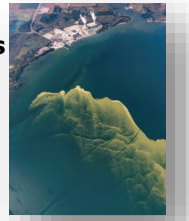
Increasing frequency and severity of algal blooms in Lake Winnipeg.

Greater Toronto Area Flooding
July 2013

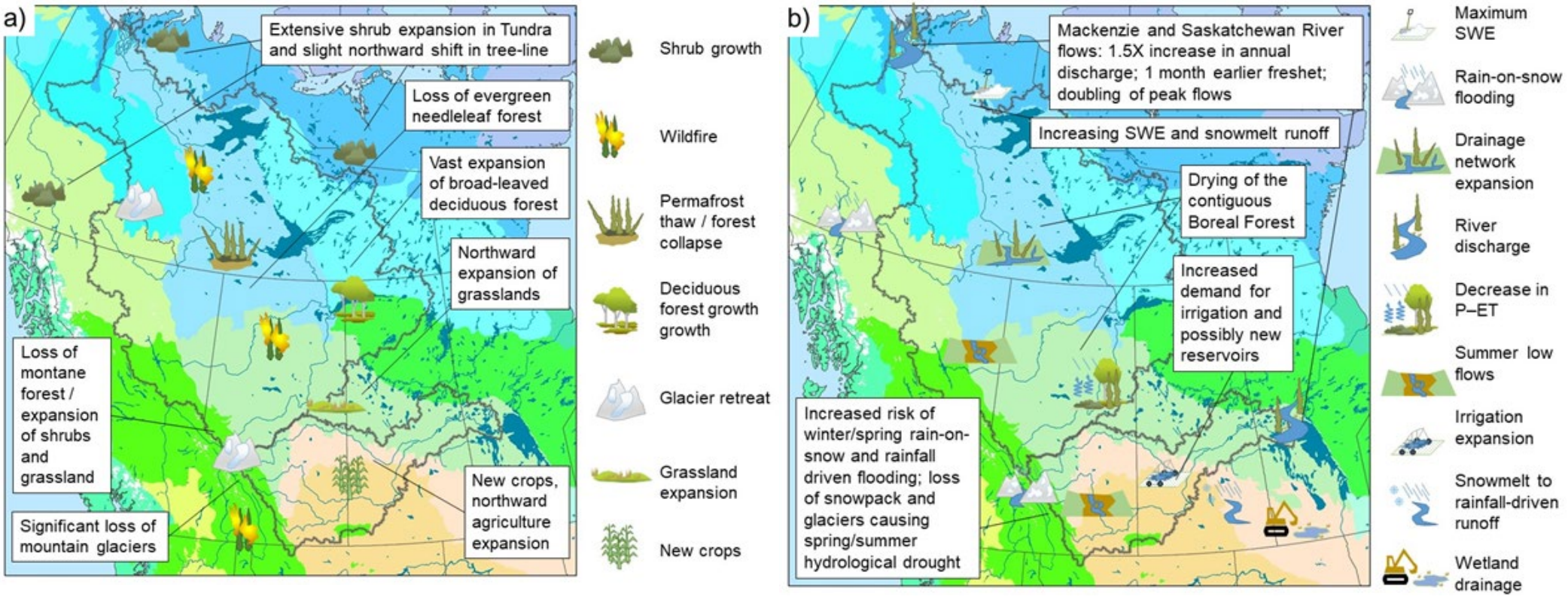
Toronto flood caused almost **$1 Billion** in damage and is the costliest flood disaster in Ontario history.

Threats to Great Lakes Ecosystems

Economic costs of eutrophication estimated at **$270 Million per year** for the Canadian side of Lake Erie.

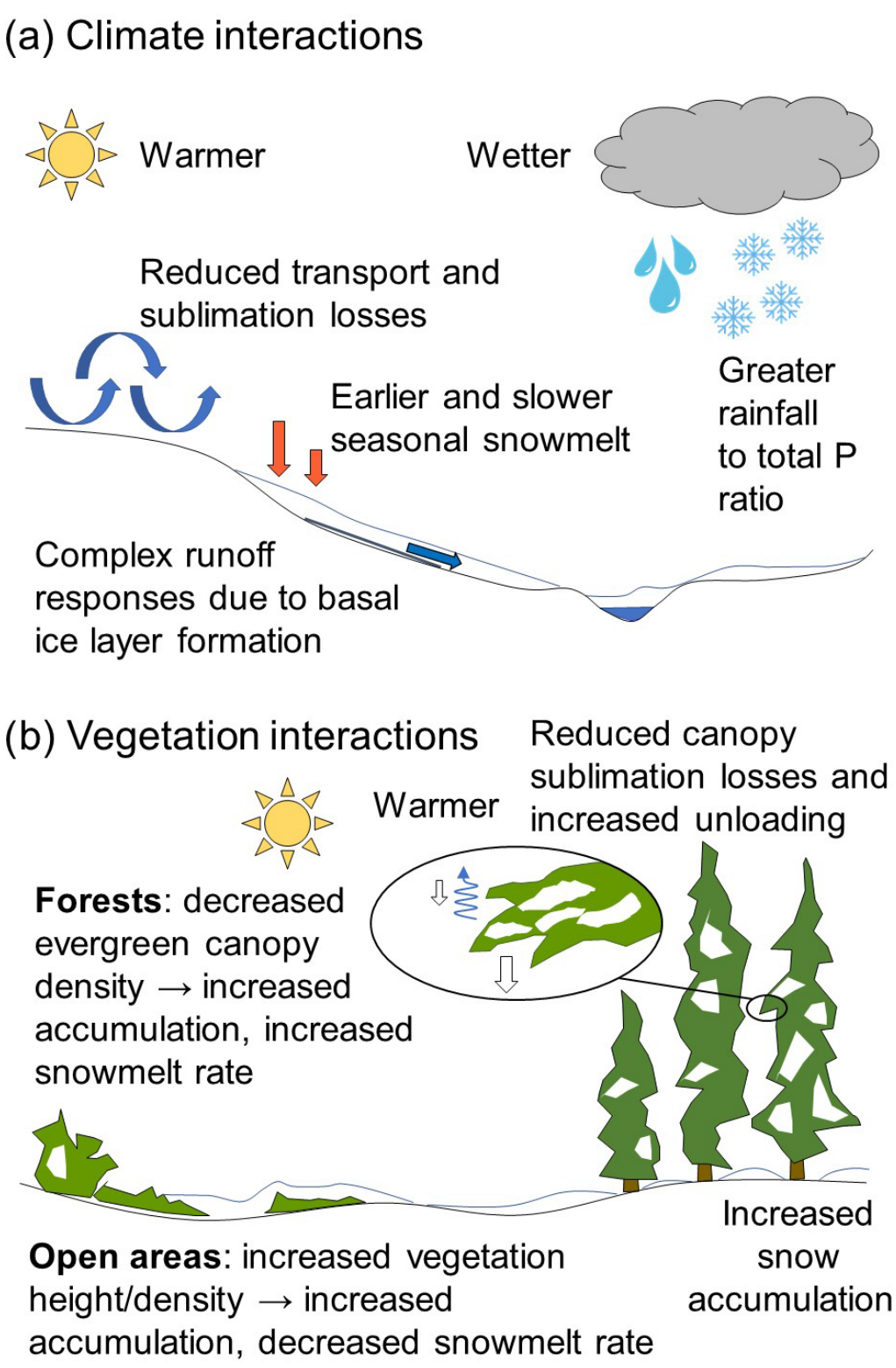


Western Canada's Water Future – late 21st C



from DeBeer, Wheater, Pomeroy, et al., 2021
Hydrol. Earth Syst. Sci., 25, 1849–1882, 2021
https://doi.org/10.5194/hess-25-1849-2021

Changing Snow Processes with Climate Change



Conceptual schematic of expected snow change in Western and Northern Canada and similar cold regions. Warmer conditions lead to less snow, whilst wetter conditions can lead to more or less snow; warmer and wetter conditions can be partially compensatory. Other changes complicate the snow–climate interactions, and spatial patterns of vegetation change with respect to snow processes control snow response.

from DeBeer, Wheater, Pomeroy, et al., 2021
Hydrol. Earth Syst. Sci., 25, 1849–1882, 2021
https://doi.org/10.5194/hess-25-1849-2021

Global Water Futures

Building water security for Canadians

Canada is warming at 2 to 3 times the global average. Water is the messenger that brings climate change to your front door and infrastructure, institutions, ecosystems and human health will all be tested by our changing climate. The grand challenge for researchers is finding ways to forecast, prepare, adapt, and manage water in the face of increasing risks. GWF is building the tools for a resilient water future.

The climate crisis is a water crisis.

GWF is positioning Canada as a global leader in water research by focusing on 3 key areas:

1. Delivering new capability for providing disaster warning
2. Diagnosing and predicting change to water futures
3. Developing new models, tools and approaches to manage water-related risks

Global Water Futures is a seven-year, University of Saskatchewan-led research program established and funded in part by a $77.8-million grant from the Canada First Research Excellence Fund. GWF has grown to be the largest and most published university-led water research program in the world.

Awarded $77.84 M

over 7 years 2016 - 2023

from Canada First Research Excellence Fund / Apogée Canada

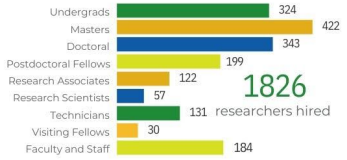
65 Projects & Core Teams

- 23 Canadian universities
- 213 faculty investigators
- 531 partners
- 1921 publications
- 2699 presentations
- 4021 media stories

27 Deployable measurement systems

76 In situ freshwater and hydrological observation sites

31 University-based environmental and aquatic analysis facilities



1826 researchers hired

GWF supports

4 Global Programs

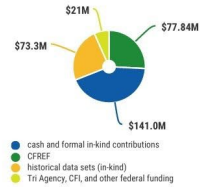
futureearth research for global sustainability

WCRP World Climate Research Programme

UNESCO

World Meteorological Organization

$313.0M GWF Project & Core Team Funding



What we do for Canada and the World

- Established a national network of 76 observatories to track changing water systems
- Contributing to the first national flood forecasting system
- Proposing local and national solutions for improved, evidence-based water management
- Created novel airborne and satellite-based remote sensing techniques for monitoring snow, water quality, and soil moisture
- Developed the world's most advanced snowpack forecasting model
- Co-creating tools for decision making with Indigenous communities and other stakeholders
- Invented novel snowpack and soil moisture instruments
- Building water prediction models for the Great Lakes, Saskatchewan-Nelson, Yukon, Columbia, Fraser, St. John, and Mackenzie River Basins
- Using eDNA technology from a few drops of water to find invasive species in water bodies
- Operating programs that monitor wastewater for SARS-CoV-2
- Advancing equity, inclusion, and diversity in water research

Canada First Research Excellence Fund | Apogée Canada | University of Saskatchewan | University of Waterloo | McMaster University | Laurier

Find us at: globalwaterfutures.ca

VIRTUAL WATER GALLERY

SHARING SCIENTIFIC KNOWLEDGE & ENCOURAGING DIALOGUE THROUGH ART

Water is life. Water-related challenges affect everyone. We believe that art can be a catalyst in the co-creation of new knowledge to benefit society.

The Virtual Water Gallery is a space to encourage dialogue between artists, scientists, Indigenous peoples, and a wider public through art. Together, over 30 artists & Global Water Futures scientists provided a beautiful visual exploration of water challenges across Canadian landscapes, from the mountains to the shore.

Lead curator: Louise Arnal
Co-curators: John Pomeroy, Martyn Clark & Stacey Dumanski

GLOBAL WATER FUTURES

UNIVERSITY OF SASKATCHEWAN

UNIVERSITY OF CALGARY

SSHRC CRSH

virtualwatergallery.ca

The Cold Regions Warming Team

This exhibition is produced by Norwich, England-based **GWF Artist-in-Residence** Gennadiy Ivanov, in collaboration with scientists Professors Trevor Davies and John Pomeroy. Cold Regions Warming is an art-science endeavour focussing on water security and climate change and is part of the Global Water Futures (GWF) research programme which is directed by Pomeroy (Canada Research Chair in Water Resources and Climate Change, Coldwater Laboratory, University of Saskatchewan, Canmore). Davies is a former Director of the Climatic Research Unit, Dean of the School of Environmental Sciences, and Pro Vice Chancellor for Research, University of East Anglia, Norwich, UK.

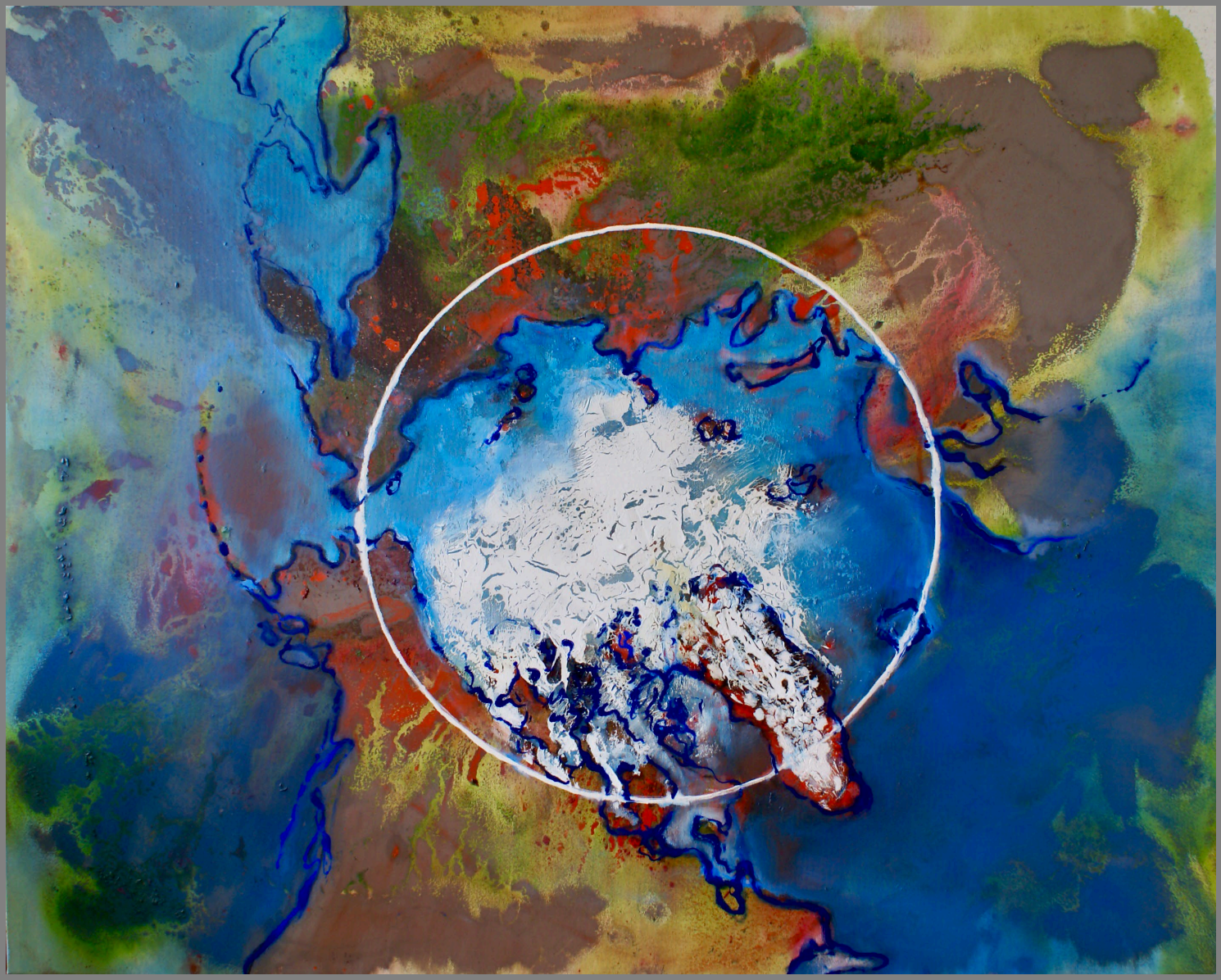
Over the last three years, the Cold Regions Warming team have collaborated on scientific missions to GWF field sites in western and Arctic Canada, sometimes in remote and severe environments. Ivanov produces rapid field paintings, and then uses these, photographs, videos, and his memory to produce large studio oils in an impressive range of styles. At every stage he is in close collaboration with the scientists to ensure that his painted messages marry, and are consistent, with the science. The scientists play a significant role in the written explanations and interpretations.

The Cold Regions Warming Team has mounted several successful exhibitions both in Canada and in the UK, including at the UN COP26 Climate Change Meeting in Glasgow, November 2021 and in the Virtual Water Gallery in Canmore, June 2022.

Gennadiy Ivanov

Trevor Davies

John Pomeroy



COLD REGIONS WARMING
Oil on canvas, 100 x 150 cm, 2020

The vast cold regions of Russia, especially, and Canada extend far southwards of the Arctic Circle. This summer in the Northern Hemisphere has been the hottest on record. The Arctic sea-ice is thinning and contracting. The Greenland ice-sheet is melting at unprecedented rates. Vast tracts of the permafrost zones in Russia and Canada are collapsing. Vegetation and peat fires are now extensive. The red hues in this painting of the circumpolar regions by Gennadiy Ivanov are an artistic metaphor for these dramatic changes.

Fire- Global Warming’s Shockwave
Oil on canvas, 90 x 90 cm, 2019

Fire has been a recurring theme of the Transition’s team experience and represents the shockwave of global warming: more frequent, more intense and larger wildfires burning forests, grasslands, tundra, homes, and communities.Wildfires can spread faster than a human can run and the accounts of fires from the oil train derailments in Saskatchewan and Quebec and the partial burning of the City of Fort McMurray by wildfire in 2016, the most expensive natural disaster in Canadian history, haunted the team.

Wildfires are an important part of natural ecosystem renewal and small wildfires were part of how Indigenous peoples managed forests and grasslands and prevented larger wildfires.Modern global warming-driven wildfires are large, intense and dangerous and can also cause increased flooding after fires have burned soils and vegetation and so reduce the natural ability of river basins to retain and evaporate water from snowmelt and rainfall.

Artist's Note: “This painting is based on a bonfire I saw near Saskatoon, set during a wet period in a rural area that had almost burned down in the previous record-dry spring due to a grass wildfire. It is menacing and foreshadows the greater destructions that wildfire can cause.”

FIRE ACROSS THE ICE
Oil on canvas, 80 x 80 cm, 2020

The Arctic Ocean has undergone a massive warming in the last 40 years, with the loss of over half of its multi-year sea ice. This ocean is surrounded by the Arctic lands of Russia, Canada, Greenland and Scandinavia – much of which are warming three times faster than the rest of the world – and receives the warmer and increasing freshwater flows from the major northward flowing rivers of Russia and Canada such as the Ob, Yenisei, Mackenzie, Lena etc. as well as freshwater from melting glaciers and ice sheets. Here, the view from the Arctic coast of Canada looks across the remaining ice to Russia, a view that foretells the increasing temperatures, permafrost thaw, greenhouse gas emissions, wildfires, floods and streamflow volumes that span the circumpolar North. The bubbles in the ice remind us of methane emissions from permafrost through lake ice that are ubiquitous in northern peatlands.

The Sky River,
Oil on canvas 130 x 170cm, 2021

This painting reflects the record setting rainfall, extensive flooding and destruction of transportation infrastructure, homes and farms that occurred due to an “atmospheric river” of heavy rainfall onto melting mountain snowpacks that occurred in November 2021 in southwestern British Columbia. The resulting floods were the costliest in BC’s history at $US7.5 billion and were devastating to farms in the Fraser Valley where more than 600,000 farm animals perished.

THE LAST BEAR SERIES ‘POWERFUL AND VULNERABLE’

Oil on canvas, 100 x 100 cm, 2018

This reflects the last stand of nature as the melting cryosphere leaves many species stranded. The polar bear is an iconic symbol of a cold regions animal that is threatened by declining sea ice in much of its range. It needs the sea ice to hunt and so looks vulnerable without it.

Peyto Glacier Series

Peyto Crevasses
Oil on canvas, 91 x 116 cm, 2019

Peyto Glacier has developed extensive crevasse networks in its lower toe area as the ice stagnates and melts at the fastest rate ever. These crevasses conduct meltwater to the bottom of the glacier where they rush out the snout to form Peyto Creek that flows into Peyto Lake and then to the Mistaya River and eventually the North Saskatchewan River.

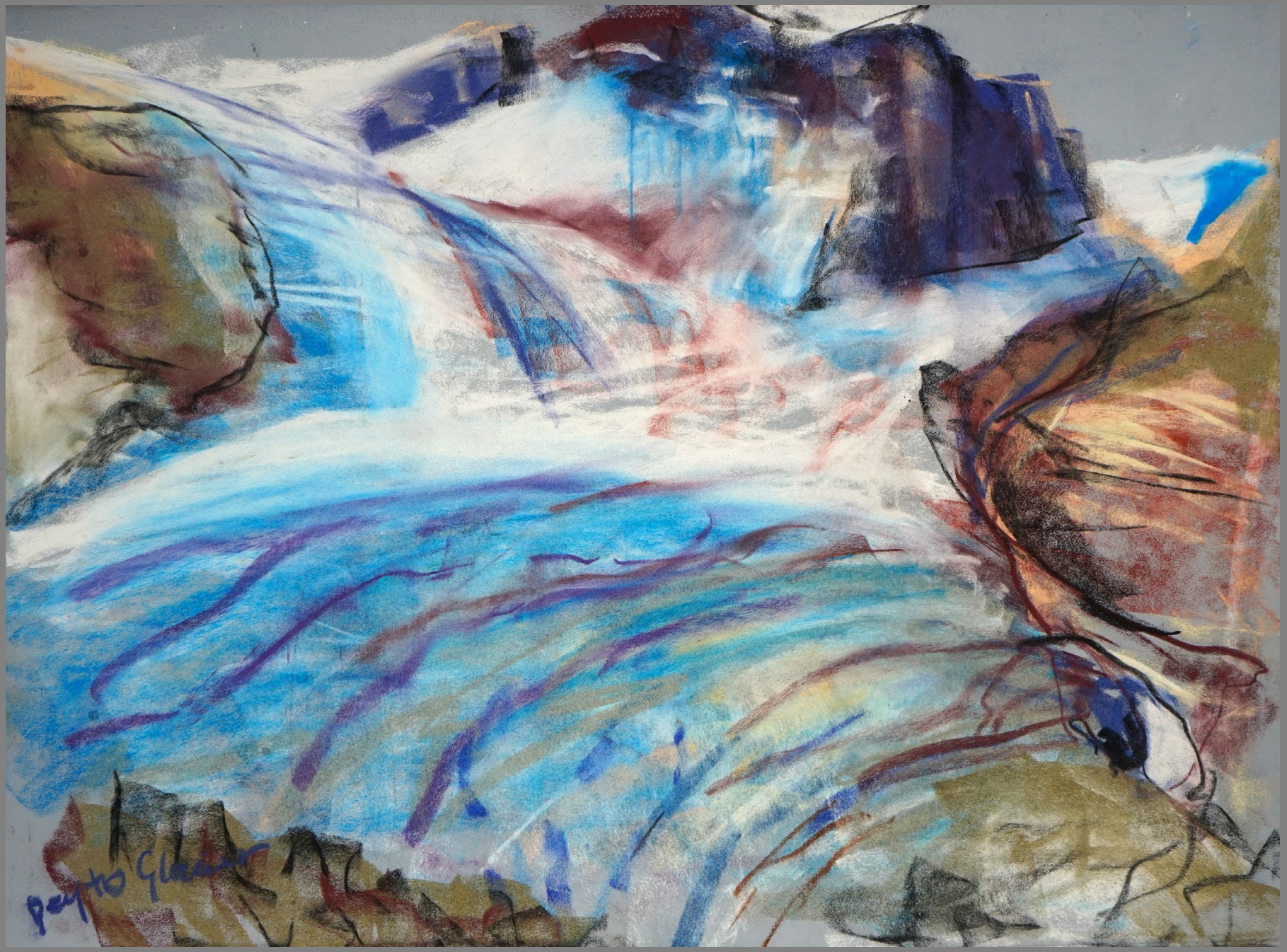
Peyto Crevasses
Oil on canvas, 91 x 116 cm, 2019

The decline and “mortality” of Peyto Glacier is portrayed in this skull-like impression of crevasses and broken ice masses near the toe, coloured by algae and soot.

Peyto crevasses
Oil on canvas, 91 x 116 cm, 2019

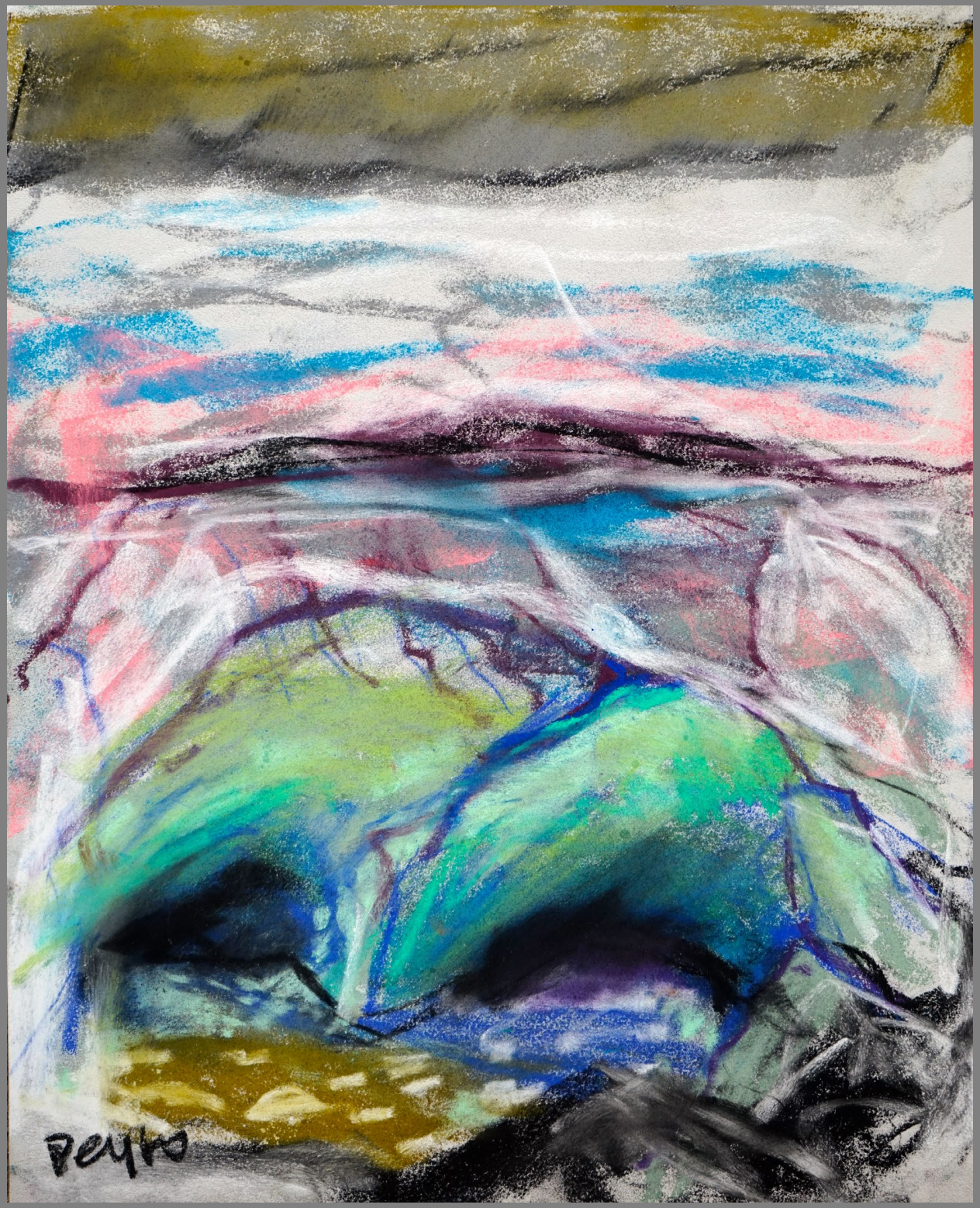
Peyto Crevasses
Pastel on paper, 45 x 65 cm, 2019

Peyto Glacier
Pastel on paper, 18 x 24 cm, 2019



Peyto Glacier
Pastel on paper, 18 x 24 cm, 2019

Peyto Glacier
Pastel on paper, 18 x 24 cm, 2019



Peyto Glacier
Pastel on paper, 24 x 18 cm, 2019

Peyto Glacier
Pastel on paper, 33 x 45 cm, 2019
Looking downstream from the toe of Peyto Glacier at the newly formed and rapidly growing “Lake Munro” and the creek that flows to Peyto Lake. This scene would have been under the ice 15 years ago.

Peyto Glacier
Pastel on paper, 18 x 24 cm, 2019

Peyto Gacier
Oil on canvas, 18 x 24 cm, 2019

Looking downstream towards Lake Munro, Peyto Creek under a smoky sky in abnormally hot weather. The heat dome of July 2021 say Peyto's highest ever temperature on ice, 23 ^{o}C.

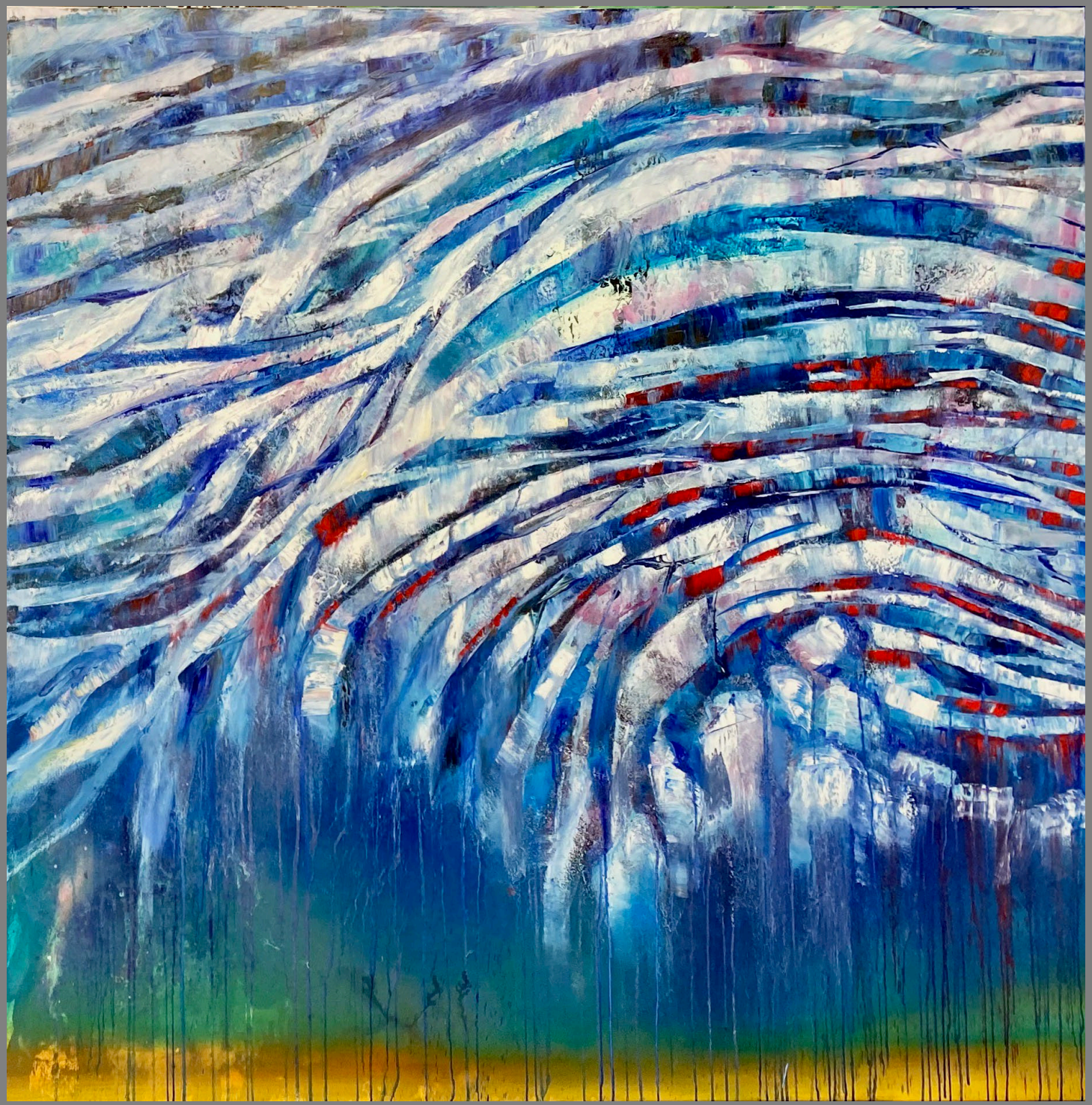
Peyto Glacier
Oil on canvas, 18 x 24 cm, 2019

Peyto Glacier
Oil on canvas, 18 x 24 cm, 2019

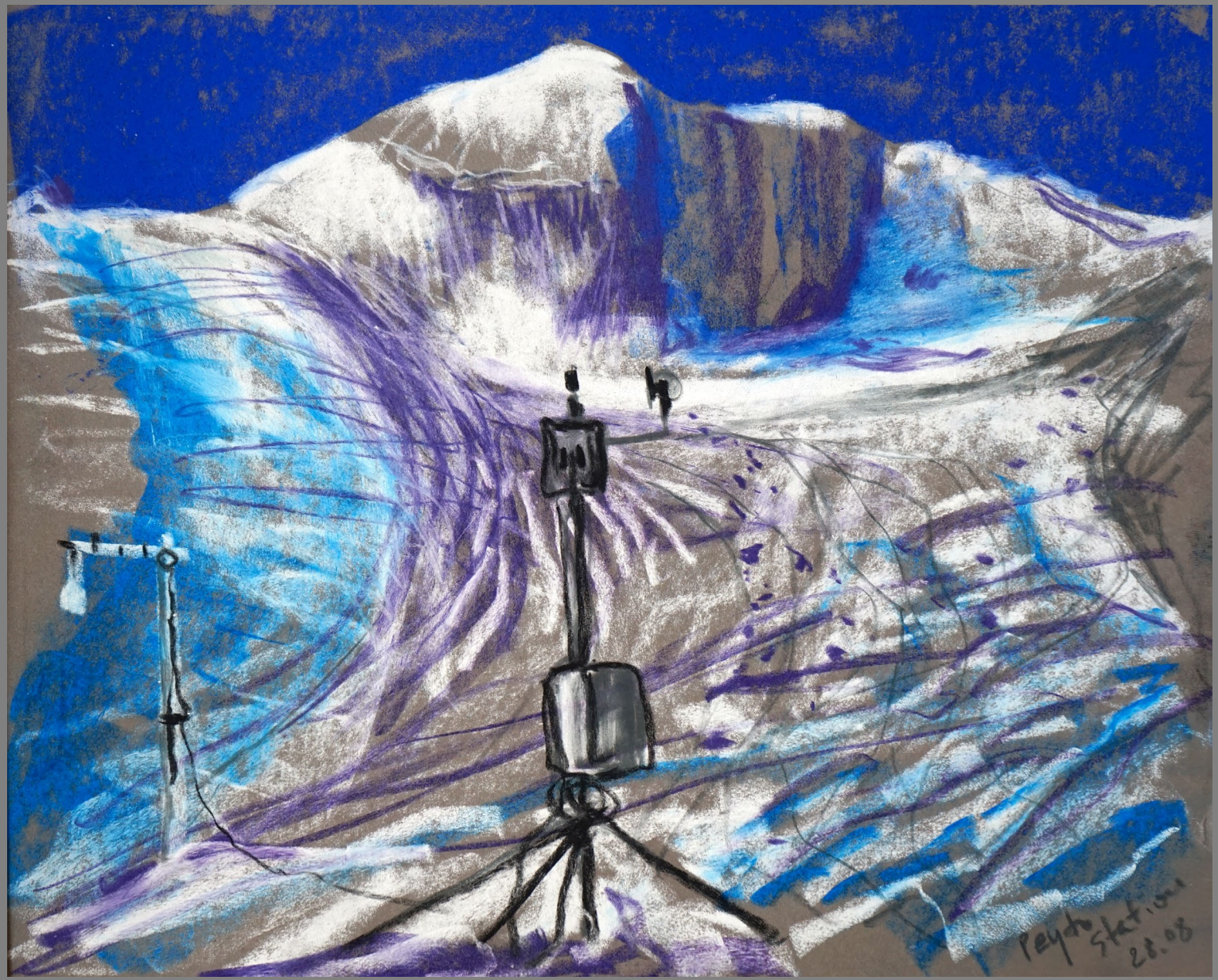
Peyto Gacier
Oil on canvas, 13x18 cm, 2019

Poorly Peyto
Virtual Water Gallery Project Oil on canvas ,160 x 160cm, 2021

Here the crevasses of Peyto are portrayed as bloodied ribs as on a dying animal. The contrast with the blue meltwater cascading down the slopes and ice is stunning.



Bleeding Peyto Glacier
Oil on canvas, 160 x 160 cm, 2021



Peyto Glacier
Pastel on paper, 18x24 cm, 2019

Showing the Peyto Ice Station in the foreground.

Glacier Decline
Charcoal on paper, 180 x 100 cm

In the distance in the first slide top drawing the glacier is covered by snow. In the foreground are strange deposits of black cryoconite. The cryoconite accumulates on the ice surface and, each year, is washed off by the copious summer meltwater to form mini-mountain ranges, a metre or so high, beyond the glacier snout. Cryoconite comprises of ash and soot from wildfires, bacteria, fungi and algae. It has become more abundant in recent years. It darkens the glacier's surface, reducing its reflectivity, and exacerbating melt.

This slide drawing, fore-fronting the now-exposed strata which were once the side of the glacier valley are deposits of glacial silt which have accumulated below the glacier snout. I have shown how these silt deposits crack in summer heat.

Artist's Note: "Perhaps ironically, my other paintings in the Virtual Water Gallery are amongst the most brightly-coloured I have produced in the Transitions project. One of the reasons is because on the occasion of my summer visit, in August, it was a brilliantly-clear blue sky day. My other visit was in the preceding April, on a cloudy cold grey day. The glacier was still mostly hidden beneath snow-cover. It was a miserable day; better fitting the emotions which I now feel about this departing feature of the dramatic mountain landscape. I have transposed my darker emotions into these drawings."

Scientist Note (Pomeroy) "I like this drawing because it gives the illusion of the glacier transforming into a river delta – it speaks to glacial hydrology and the loss of these glaciers and their replacement by terrestrial hydrological systems. And that sediment and cracking can also be dangerous – look at India recently."

WILD BILL WOULDN'T RECOGNISE IT
Oil on canvas, 90 x 150 cm, 2019

The Peyto Glacier in Alberta is named after "Wild" Bill Peyto, who was born in England. On moving to Canada, he became, from the 1890s onward: pioneer, railway labourer, trapper, prospector, horse outfitter, packer, legendary mountain guide, and eventually one of the first wardens of Banff National Park. One of many stories about Bill is when he released a lynx in a bar. The Peyto is one of the world's longest-studied glaciers. It has lost more than 70% of its volume since the beginning of the 20th Century with the most rapid loss being in the last decades. It is losing 3.5million cubic metres of water each year. Observation stations placed on the glacier in recent years have been lost because the ice is melting so rapidly. Where there was once ice, there are now banks of silt and mud. In the distance, perched on a bank of mud, is a form of transport Bill didn't have access to. The painting with the finer detail portrays ice remnants, discoloured by mud and silt.

CHANGING PALETTE ON PEYTO 1/2
Field drawing pastel on paper, 30 x 42 cm, April 2019

This view down-valley from a former position of the glacier snout shows the Government of Canada's research huts and weather stations, which were installed conveniently near the glacier's edge in 1965. They are now stranded atop the bluff on the left more than 1km from the ice and hundreds of meters above it.

CHANGING PALETTE ON PEYTO 2/2
Field drawing pastel on paper, 30 x 42 cm, April 2019

The Peyto Glacier, in the Rockies of Alberta, has receded dramatically, particularly in the last 50 years where it has retreated about 3 km. This rapid recession has produced a changing palette of colours; more greys, browns, and sludges as the vanishing ice – which produces more blues, whites and silvers - leaves behind banks of mud. The helicopter landed on one such bank, sticky and cloying, not frozen, because of the exceptionally warm spring. The suction and additional weight on the helicopter skis required extra thrust for it to take off.

BIRTH OF THE RIVER, DEATH OF THE GLACIER
Oil on canvas, 91 x 116 cm, 2019

The rapidly retreating Peyto Glacier reveals a former sub-glacial channel that is emerging as a large stream beside the glacier. The stream is fed from melting ice and snow and is choked with ice that has collapsed from tunnel walls within the glacier and now will flow with the river to melt downstream. The cold water from these streams provides ideal conditions for native trout in the Canadian Rockies. This cold water has become even more important as recent hot summers have warmed river temperatures above the cool conditions that trout require. Glacial meltwater can also be an important water supply to support river flows to the Canadian Prairies and British Columbia in years of drought. The ice above this channel has now collapsed, leading to a 50 m drop in the glacier surface since this painting was made in 2019.

Former Peyto Glacier
Pastel on paper, 45 x 65 cm, 2019

Artist's Note: “Here I attempt to capture the criss-cross patterns of crevasses and melt channels on the glacier; to give a sense of the collapse of the ice mass. So much of the foreground detail in this painting was hidden on my first visit to Peyton in April 2019. We walked over this landscape, but it was mainly snowcovered and frozen. In August the deposits of glacial silt and black cryoconite accumulations - surrounded by, and saturated with, water – are next-to-impossible to walkover. They give way and suck you down up to your knees; they want to drag you down. Although, again, a colourful painting, when I look at my own painting as a spectator the bare moraines and sediments left by the retreating ice give me a sense of destruction, darkness and decay borne in rapid deglaciation initiated by human-caused climate change. It is a disturbing task to task to try to represent the sense of decay during an azure day which produced vivid contrasts and colorations.”

GLACIER DECLINE; EMERGENCE OF STRANGE NEW LANDSCAPE
Oil on canvas, 150 x 100 cm, 2020

The Peyto Glacier in Alberta, Canada, is one of the world's longest-studied glaciers. It is rapidly receding because of climate change, having lost more than 70% of its volume since the beginning of the 20th Century and has retreated more than 330 m since 2019. Here, the remaining ice is seen in the distance, behind strange deposits of black cryoconite, and glacial silt in the foreground. The cryoconite accumulated on the ice surface and is then washed off by the copious summer meltwater; it consists of ash and soot from wildfires, bacteria, fungi and algae. Each year it darkens the glacier's surface, reducing its reflectivity, and exacerbating melt. The deposits of glacial silt are cracking in the summer heat.

Glacier Decline
Charcoal & ink on paper drawings, 170 x 100 cm, 2021

Artist's Note: Perhaps ironically, my other paintings in the Virtual Water Gallery are amongst the most brightly-coloured I have produced in the Transitions project. One of the reasons is because on the occasion of my summer visit, in August, it was a brilliantly-clear blue sky day. My other visit was in the preceding April, on a cloudy cold grey day. The glacier was still mostly hidden beneath snow-cover. It was a miserable day; better fitting the emotions which I now feel about this departing feature of the dramatic mountain landscape. I have transposed my darker emotions into these drawings.

In the distance in the top drawing the glacier is covered by snow. In the foreground are strange deposits of black cryoconite. The cryoconite accumulates on the ice surface and, each year, is washed off by the copious summer meltwater to form mini-mountain ranges, a metre or so high, beyond the glacier snout. Cryoconite comprises s of ash and soot from wildfires, bacteria, fungi and algae. It has become more abundant in recent years. It darkens s the glacier’s surface, reducing its reflectivity, and exacerbating melt.

The lower drawing, fore-fronting the now-exposed strata which were once the side of the glacier valley are deposits of glacial silt which have accumulated below the glacier snout. I have shown how these silt deposits crack in summer heat.
John Pomeroy comments “I like this drawing because it gives the illusion of the glacier transforming into a river delta – it speaks to glacial hydrology and the loss of these glaciers and their replacement by terrestrial hydrological systems. And that sediment and cracking can also be dangerous – look at India recently."

The Requiem for the Peyto
Oil on canvases, 100 x 80, 2021

Artist's Note: I enjoy surreal painting. It helps me express my emotions; something which is important to me. I know that scientists also have emotional responses to what they are seeing and studying. But, in their public statements, they are careful to express themselves in objective terms, based on the rational methods and reporting of science. Because I am an artist, I am allowed to portray myself in a way which expresses some of my feelings.

Here I am below the current snout of the Peyto Glacier, amidst the new and barren landscape revealed by the glacier's rapid retreat. Modelling by the scientists shows that the glacier could have almost completely vanished by the end of the Century. Although barren, the newly-emerged post-glacial depositional landscape does show tiny specks of green – the first plants are already moving in. They are shown in my glass. Also in my glass is the beige-yellow glacial silt of the depositional landscape, and cryoconite. Cryoconite, the scientists explained to me, is a cocktail of materials which accumulates each year on the glacier's surface. It consists of ash and soot from vegetation fires, algae, bacteria, viruses, and seeds. It has been growing in abundance over the years, accelerating the glacier's decline, and is washed-off by the annual melt-water to form dark deposits below the snout. It aids the growth of seedlings and moss. It is an important part of the greening process, driven by the quickly-warming climate. At what point in the future will the blue-white icescape behind me be transformed to green?

I also audio-record the sound of the glacier. The ice-driven katabatic wind; the wind-driven snow particles in late winter; the torrents of meltwater in summer; the splitting and crashing of the collapsing glacier. The record-player is my surreal expression of this. It is also a way, for me, to emphasise the importance of the painstaking recording of scientific data on Peyto the glacier. Observations first started more than 120 years ago, making it the longest-studied glacier in North America, and are continuing with the sophisticated instrumental network of Global Water Futures. In another 120 years there will only be the record left.

Code Red for Peyto Glacier
Oil on canvas, 91 x 116 cm, 2021

This plays on the quote from the UN Sec General that climate change was code red for humanity. As UN Secretary General António Guterres said a recent report summarizing the science of climate change "is a code red for humanity." Climate scientists have said a catastrophe can be avoided if the world acts fast, and they predict that deep cuts in emissions of greenhouse gases can limit rising temperatures. However, the modest reductions in emissions promised at the COP26 Climate Summit in Glasgow were inadequate to limit climate change sufficiently to permit the survival of mountain glaciers like Peyto Glacier. This painting shows a conceptual, blood red, lava-like flow replacing the glacier and its meltwater and the rapid, catastrophic melt of the remaining ice. Such rapid melt occurred in the record hot summer of 2021 when Peyto Glacier retreated 200 m, roughly ten times its recent rate. The valley is flooded, as were many mountain rivers draining glaciers in Western Canada during the 2021 heatwave.

Athabasca Series

Athabasca Heat
Oil on canvas, 20 x 20 cm, 2019

The Athabasca Glacier normally experiences an Icefield Wind - a windy, cold and thick layer of air draining from the Columbia Icefield heights towards its toe. This has helped to slow the melt of the Athabasca Glacier. But recently warm air is penetrating this stable air layer and temperatures exceeding 15 C are now common on the ice.

The Athabasca Mountain
Oil on canvas, 30 x 30 cm, 2019

The glaciers and snowpacks of Mount Athabasca are not what they used to be and the routes to climb this mountain that were viable in the 1980s are no longer suitable. What will be left in another 40 years?

The Athabasca Glacier
Oil on canvas, 30 x 30 cm, 2019

SUMMER AT THE ATHABASCA GLACIER
Pastel on paper, 38 x 58 cm, 2019

ATHABASCA GLACIER
Pastel on paper, 38 x 58 cm, 2019

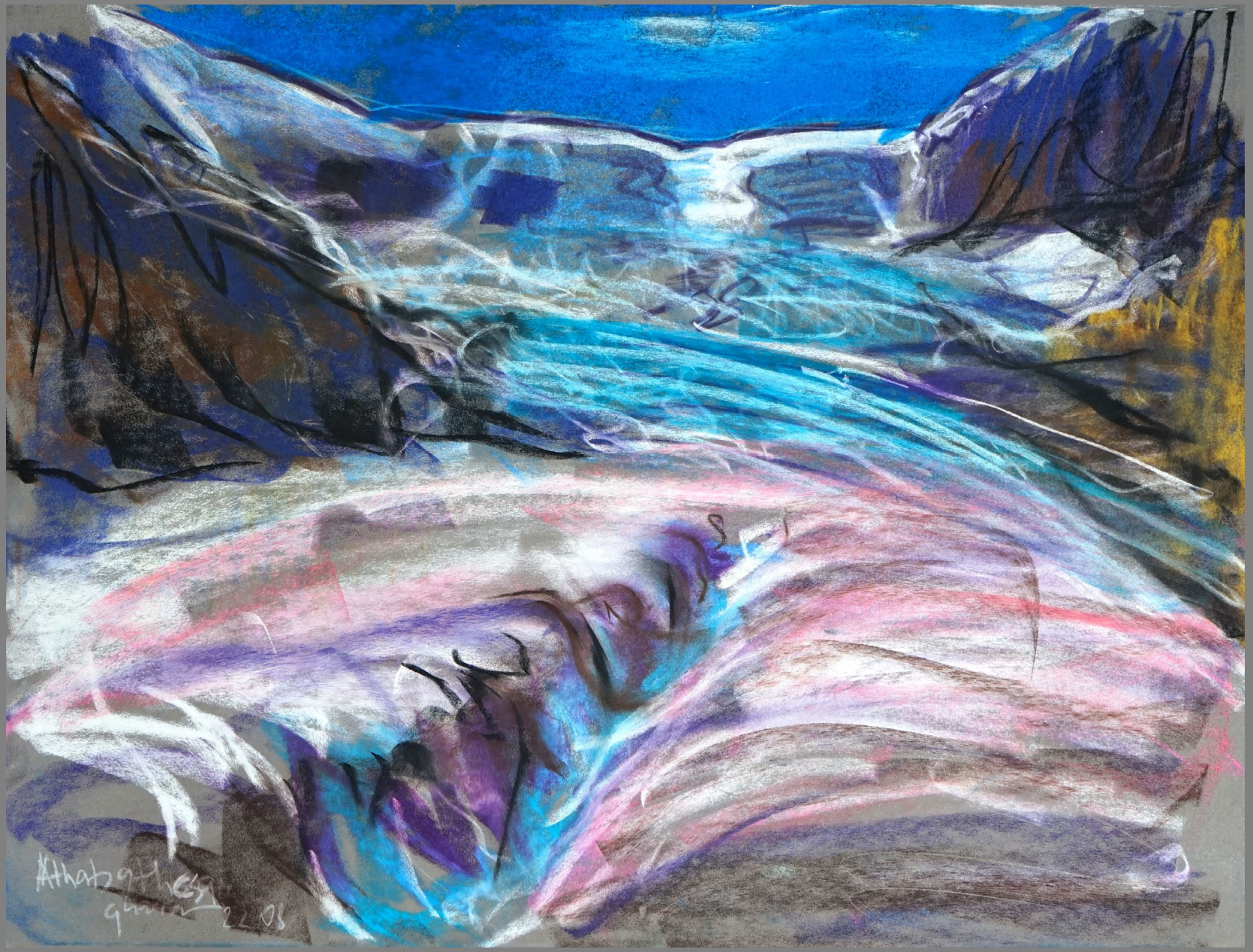
Athabasca Glacier Station II
Pastel on paper, 47 x 62 cm, 2019

In 2003 the University of Saskatchewan Centre for Hydrology installed a hydrometeorological station on the ice of Athabasca Glacier, a few hundred metres above where the buses turn-around. This station measures air temperature, humidity, wind speed, radiation, snow depth, ice surface height in a very challenging location as the ice surface is melting downwards about 6 m per year. The deep purple algae, wildfire soot and sediments are reducing the reflectivity of the ice and accelerating the melt rates.

Athabasca Glacier Station I
Pastel on paper, 47 x 62 cm, 2019

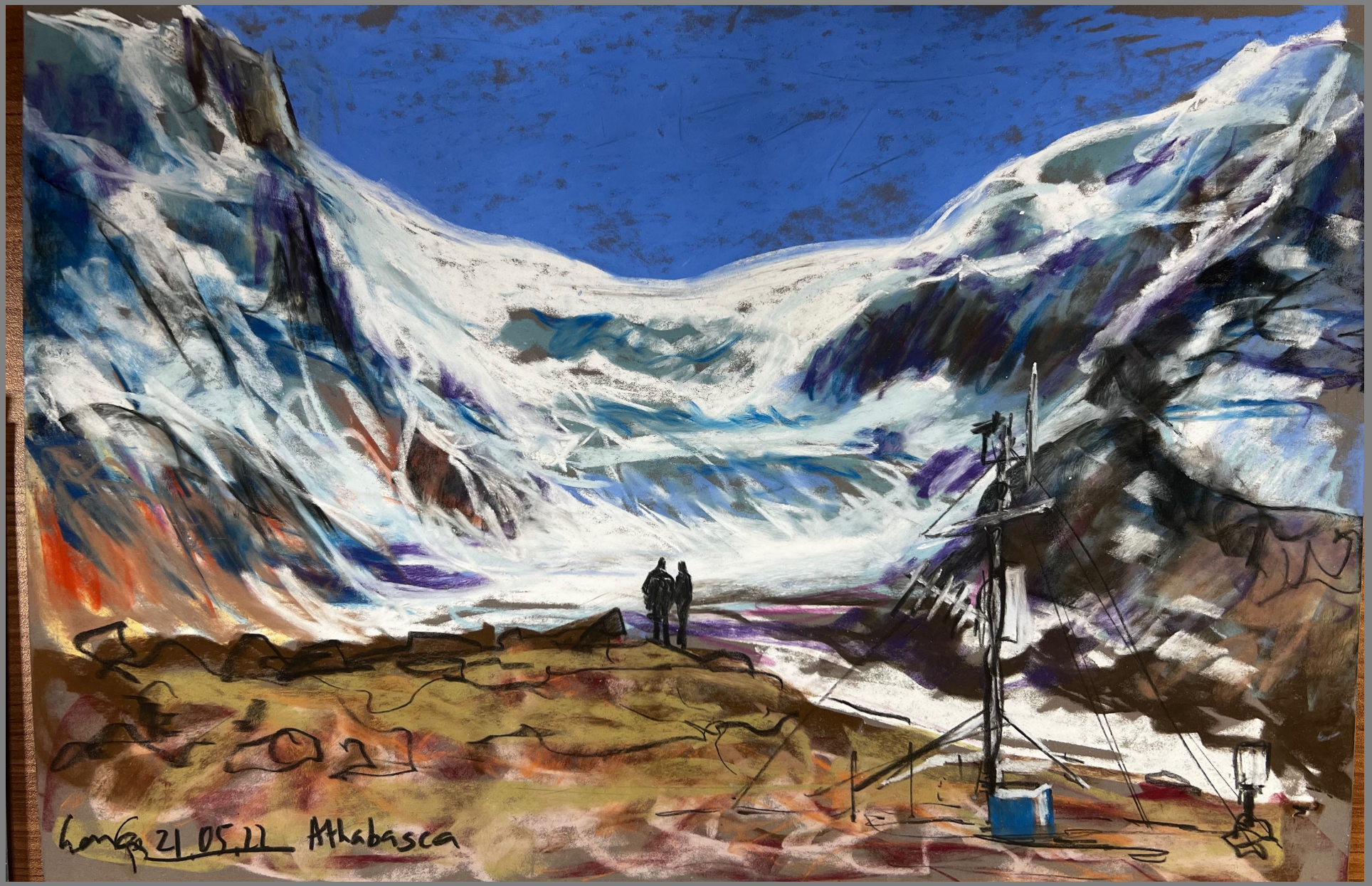
This forefield automatic weather station east of Athabasca Glacier was instrumented by the University of Saskatchewan Centre for Hydrology in 2013 to provide a baseline of the climate downwind of the Athabasca Glacier and Columbia Icefield. It measures temperature, wind speed, humidity, snow depth soil temperature and moisture content, and precipitation at a site that was glaciated almost a century ago and helps to understand the newly developing postglacial climate.

Athabasca Glacier
Pastel on paper, 33 x 45 cm, 2019



Athabasca Glacier
Pastel on paper, 33 x 45 cm, 2019

Athabasca Glacier
Oil on canvas, 18 x 24 cm, 2019



Athabasca Glacier
Pastel on paper, 45 x 33 cm, 2022

Scientists view the receding Athabasca Glacier from the Forefield Station. Three lakes have formed downstream of the glacier, giving a glimpse of the new landscape emerging from the ice.

DEEP WATER, ATHABASCA GLACIER
Oil on canvas, 108 x 150 cm, 2019

The Athabasca Glacier is the headwaters of the Sunwapta River which flows into the Athabasca River and eventually to the Mackenzie River and Arctic Ocean. During the “Heat Dome” and exceptionally hot summer of 2021, the glacier melted faster than ever recorded, and the Sunwapta River experienced a peak daily streamflow that was 80% higher than the long-term average and summer discharge that was 36% higher than the long-term average.

Athabasca Glacier Runoff
Oil on canvas, 91 x 116 cm, 2019

Wildfires create smoky days and deposit soot on the Columbia Icefield, darkening the surface and accelerating melt by up to 10%. This, combined with global heating has caused the Athabasca Glacier to recede 1.5 km and lose over half its volume in the last century. The snow and icemelt forms runoff which forms streamflow. Runoff from the Columbia Icefield feeds rivers that flow to the Pacific Ocean (Columbia), Arctic Ocean (Mackenzie) and Atlantic Ocean (Nelson) making it a triple point continental divide and the Hydrological Crown of North America.

Stanley Glacier and Valley

Stanley Glacier
Oil on canvas, 100 x 100 cm, 2021

Stanley Glacier in Kootenay National Park, British Columbia is a headwaters of the Columbia River and is retreating rapidly as are other glaciers in the area. Its valley has been swept by wildfire in 1968 and 2003. The Burgess Shale reveals 508-million-year-old fossils that show the strange and wonderful life after the “Cambrian Explosion” of biological diversification. Most of these organisms became extinct about 20 million years later during a glaciation.

Waterfalls Near Stanley Glacier
Pastel on paper, 24 x 30 cm, 2019

Stanley Glacier
Pastel on paper, 33 x 45 cm, 2019

Stanley Glacier is in Kootenay National Park in British Columbia, just over the provincial border with Alberta and in the headwater of the Columbia River which supplies water for ecosystems, food and energy in vast areas of British Columbia and the US Pacific Northwest. Although not as intensively monitored as glaciers like Peyto of Athabasca it, too, is receding rapidly. On the trek up to a convenient vantage point to paint, there is still much remaining evidence of the Vermilion Pass forest fire which destroyed 2,500 hectares over 18 days in 1968 and subsequent fires in 2003 and 2018. Forests in these locations take a long time to recover. The ground squirrels were inquisitive.

The Stanley Glacier
Oil on canvas, 30x30 cm, 2019

Near Stanley Glacier
Pastel on paper, 24 x 30 cm, 2019

Near Stanley Glacier
Pastel on paper, 24 x 30 cm, 2019

Vermillion Pass Forest Fire Oil on canvas, 30 x 30 cm, 2019

Vermillion Pass Forest Fire. Stanley Creek
Pastel drawing, 65 x 45 cm, 2019

Impressions of Glaciers

Artist's Note: "I have used my field paintings (pastels), photographs, and my memory of the incredible Rockies' landscapes to produce a painted record of impressions of melting and vanished glaciers."

WANING POWER
Field drawing pastel on paper.,18 x 24 cm, April 2019

The Victoria Glacier above Lake Louise is an ever-diminishing shadow of even its recent former self, because of human-induced climate change. On geological time-scales the former immensity of its power is evident from the deep U-shaped valley, which it scoured out. Its vestigial form may vanish by the end of the century.

"The Melting Glacier" series Mixed media on canvas, 100 x 100 cm, 2019

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"The Melting Glacier" series Mixed media on canvas, 100 x 100 cm, 2019

"The Melting Glacier" series Mixed media on canvas, 100 x 100 cm, 2019

Melting Glacier
Oil on canvas, 24 x 30 cm, 2020

RECEDING GLACIER
Oil on wooden panel, 60 x 80 cm, 2019

An impressionistic painting inspired by spectacular views seen of the Athabasca, Peyto, and Stanley Glaciers.

Melting Glacier
Oil on canvas, 24 x 30 cm, 2020

Melting Glacier
Oil on canvas, 24 x 30 cm, 2020

ANGELS & DEVILS I
Oil on canvas, 90 x 60 cm, 2020

The Angel Glacier of Jasper National Park is iconic and a major feature of Mount Edith Cavell, itself named after a heroic Norwich-born nurse of the First World War who was viewed by by many as an “angel” in a dark time. The Angel Glacier is beset by burning forests and wildfire in this impressionistic painting showing that both fire and ice are dominating the era of rapid global change in this high mountain environment. The icefall of part of the adjacent Ghost Glacier into Cavell Lake in 2012 also represents the darker side of glaciers. The icefall triggered a small tsunami that destroyed parking lots, roads and trails in a popular area. Fortunately it happened at night with no loss of life. Similar events have caused massive loss of life in India including after an icefall and land avalanche into the upper Ganga River.

ANGELS & DEVILS II
Oil on canvas, 90 x 70 cm, 2020

GHOST GLACIER
Oil on canvas, 91x116 cm, 2019

Inspired by the Rock Glacier in Kluane Park, Yukon, sitting in the distance above the ribbon of rock is the ghost of a glacier, shrouded in snow re-suspended by the wind from one of the north-facing sides of a mountain gully. In the foreground are the waters of Dezadeash Lake, which is still drip-fed by the waters flowing beneath the rock glacier, the rocky remains of what was once a glacier of ice. Rock glaciers will be all that remains of many Canadian Rockies glaciers by the end of this century due to enhanced melt from anthropogenic global heating.

Glacier Melt Accelerant

CRYCONITE SEDIMENT I
Oil on canvas, 80 x 60 cm, 2019

Artist’s Note: "One of the most fascinating outcomes of conversations with scientists has been my growing realisation of how interconnected the world is and how something that is very small can affect the whole planet."

CRYCONITE SEDIMENT II
Oil on canvas, 80 x 60 cm, 2019

Artist's Note: "One of the most fascinating outcomes of conversations with scientists has been my growing realisation of how interconnected the world is and how something that is very small can affect the whole planet." (Gennadiy Ivanov).

WORLDS WITHIN WORLDS
Oil on canvas, 20 cm diameter, 2019

There is a strong connection between the rate of melting of the ice and the "brightness" (the albedo, in scientific terms) of the ice surface. Clean ice is very bright and melts slowly and dark ice absorbs solar energy and melts more quickly. Rapid ice melt leads to sea level rise and deglaciation. This dark material is known as cryoconite, and is teaming with life, including pollen and living organisms such as algae and bacteria. Cryoconite accelerates glacier melt. It can be
studied through the technique of scanning electron microscopy (SEM), which produces images at, typically, around 10,000 magnification. These World Within World paintings are based on SEM images of cryoconite samples from the Peyto Glacier –collected and analysed by Global Water Futures scientists. This normally unseen "microworld" has profound impacts on our Earth - the accelerated glacier melt caused by these microorganisms even contributes to the sea level rise that low-lying coastal regions such as East Anglia in the UK are experiencing.

WORLDS WITHIN WORLDS
Oil on canvas, 20 cm diameter, 2019

WORLDS WITHIN WORLDS
Oil on canvas, 20 cm diameter, 2019

WORLDS WITHIN WORLDS
Oil on canvas, 50 cm diameter, 2019

WORLDS WITHIN WORLDS
Oil on canvas oval, 2019

BREAKFAST WITH SCIENTISTS
Oil on canvas, 150 x 120 cm, 2019

Artist's Note: “A vital part of the Transitions climate-art project is discussion with the scientists, not only in the field but also in reflection. This conceptualisation of a breakfast conversation with Professor John Pomeroy (left) and Professor Trevor Davies occurred the morning after our exhausting day on the Peyto Glacier in August 2019. On the table is an accumulation of cryoconite; a strange material which consists of ash and soot from wildfires and air pollution, dust, bacteria, fungi, algae and other organisms. It collects on the surface of the glacier and has been increasing over the years as greater more frequent and more extensive wildfires deposit more soot which feeds the algae and microbes, darkens the glacier and contributes to increasing melt rates. Summer melt washes some of it off the glacier surface, and it accumulates in weird formations below the snout of the glacier. Scientists from Global Water Futures are examining its composition by various techniques, including scanning electron microscopy and DNA sequencing and showing how it is accelerating glacier melt and ultimately sea level rise.”

Peyto Glacier: Glacier Ice and Water
Oil on canavs, 80 x 80 cm, 2019

Distributed amongst the terminal moraines, just below the glacier snout, are the strange black accumulations of cryoconite, some of which resemble mountain ranges in miniature form, 1-2m in height. The view down the glaciated U-shaped valley, from a point beneath the present glacier snout, gives a very clear impression of the scale of Peyto in recent decades.

WATERMELON SNOW
Mixed media on canvas, 80 x 100 cm, 2019

Snow cover turning pink or reddish during spring and summer has been a long-observed phenomenon. In recent years it has been commonly called watermelon snow. Blooms of algae cause it with a red pigmentation for protection against high-levels of ultraviolet radiation. The blooms appear when there is melt-water present in the snow-cover. The red colouration makes the snow-cover less reflective (typically around 15%) to radiation from the Sun, causing even more melting. Increasing temperatures due to global warming has produced earlier and more melt-water in the snow-cover, and the resultant greater red algae growth, in turn, results in more melt-water in the snowpack - a positive feedback.

Fortress Mountain,
Kananaskis Valley

The Fortress Mountain
Oil on canvas, 46 x 25 cm, 2019

Fortress Mountain in Kananaskis is not only a recreational site for skiing but an outdoor scientific laboratory where Global Water Futures scientists research how water and energy are cycled by the mountain ecosystem, how snow is redistributed by wind and gravity, sublimated, intercepted in forest canopies and melts to form streamflow and replenish soil moisture and groundwater flow. It is a particularly well instrumented part of the Canadian Rockies Hydrological Observatory.

The Fortress Mountain
Oil on canvas, 30 x 30 cm, 2019

The Fortress has a debris covered glacier buried in the cirque valley at its base. Here, remaining glacier ice slowly melts, feeding a small lake and complex groundwater flow systems.

The Fortress End of Summer
Pastel on paper, 45 x 65 cm, 2019

Despite the long snowy winter at Fortress Mountain Research Basin, the summer can be dry and soil moisture reserves that were replenished by June snowmelt, can be depleted by late August unless rains are frequent. Alpine vegetation has adapted to this short summer and as it moves into senescence, adopts brilliant colours that bring exceptional beauty to the high mountain tundra.

THE SLOW NUCLEAR EXPLOSION AT FORTRESS MOUNT
Oil on canvas, 90 x 70 cm, 2019

This painting was inspired by the words of the Chief of the Gwich'in Indigenous People, who said in April 2019, that climate change was "like watching a slow nuclear explosion". Although his People's land is further north, this seemed a good location to start developing representations of slow nuclear explosions as a metaphor for the impacts of human-induced climate change across Northwest Canada. This one is starting near the site of the GWF station, which has already been destroyed, on the edge of a cirque, which was once home to a glacier. Even Fortress Mountain can be stormed.

THE FORTRESS MOUNT NOW
Oil on canvas, 130 x 170 cm, 2019
Fortress Mountain Research Basin is an iconic location in the Rockies in Alberta. Its dramatic countenance has appeared in many Hollywood films. It is an important site for one of the GWF observation stations which automatically records atmospheric, snow and soil conditions. These observations are part of the Global Water Futures Observatories network, which monitors changes over time and provided invaluable information to help develop predictive models; a necessity for successful prediction of water supplies from the high mountain headwater basins that supply most of western Canada with rivers and life-giving freshwater.

THE FORTRESS MOUNT NOW
Pastel on paper, 2019

Fortress Mountain is an iconic location in the Rockies in Alberta and an important research basin in the Canadian Rockies Hydrological Observatory, part of the Global Water Futures Observatories network of 76 research basins across Canada.

NEAR FORTRESS MOUNTAIN
Field drawing pastel on paper, 18 x 24 cm, April 2019

Accessing the GWF observation station beneath Fortress Mountain requires significant logistical support: snowmobiles, and so on. These pastels were painted as we awaited the arrival of the GWF support team of the logistics camp.

NEAR FORTRESS MOUNTAIN
Field drawing pastel on paper, 18 x 24 cm, April 2019

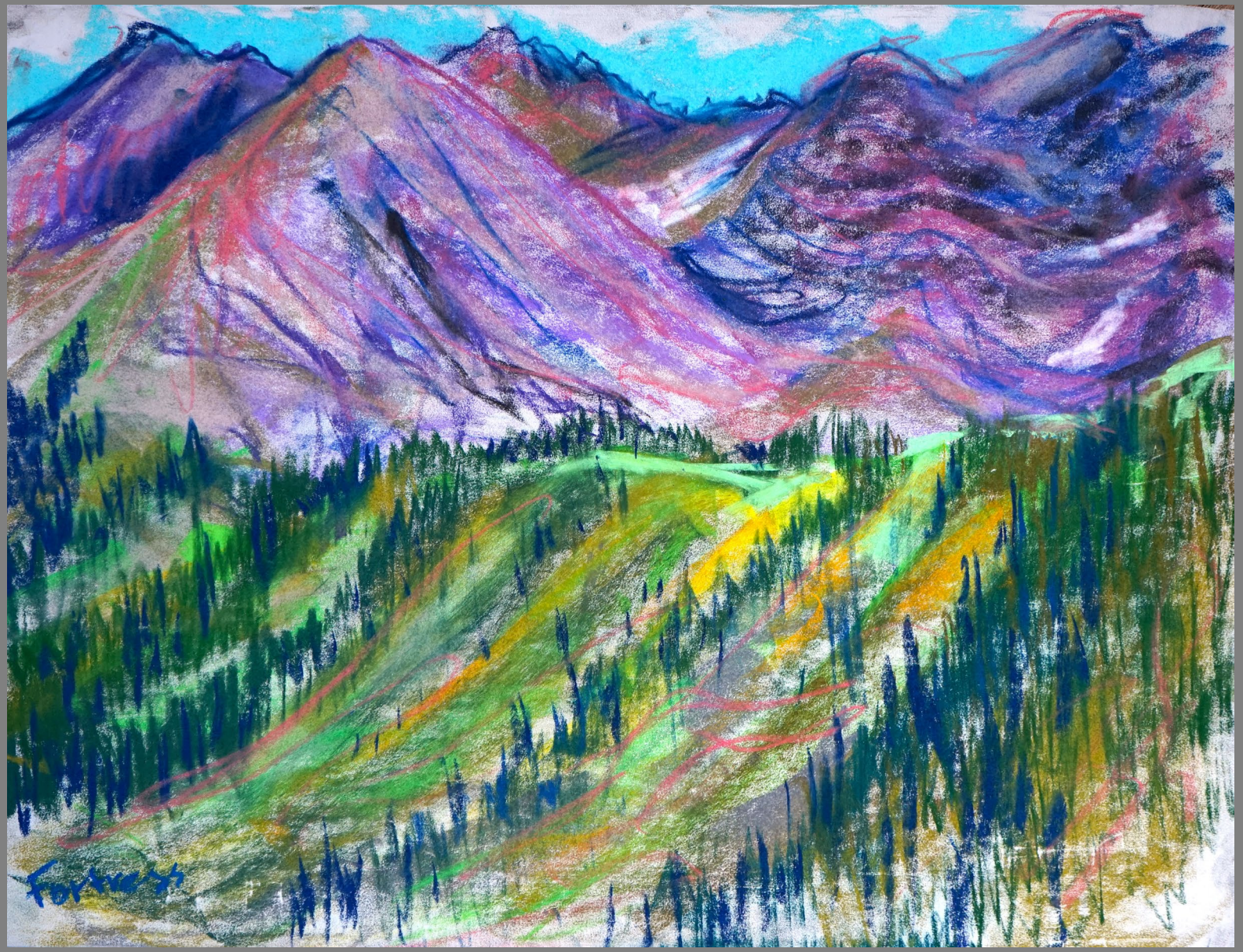
Accessing the GWF observation station beneath Fortress Mountain requires significant logistical support: snowmobiles, and so on. These pastels were painted as we awaited the arrival of the GWF support team of the logistics camp.

THE STATION OF FORTRESS MOUNTAIN RESEARCH BASIN: END OF SUMMER BY FORTRESS MOUNTAIN
Pastel drawing on paper, 33 x 45 cm, 2019

Fortress Mountain Research Basin is where GWF scientists are discovering the fundamental processes that govern the interaction between climate, high mountains, snow, ecosystems and streamflow generation. It shows that mountain hydrology can be sensitive to climate change and that ecosystem processes mediate this response to cause a very different future ability of mountain catchments to generate source waters.
Artist's Note: “The paintings I produced of the Fortress Mountain Research Basin, during and after the Transitions visit in March-April, when snow blanketed the flatter surfaces and an icy gale was blowing, were – viewers told me – amongst the most dramatic of my paintings. The landscape is dramatic. I wanted to capture its very different demeanour in summer. To my astonishment, rather than wind-hardened snow, the land around the automatic weather station closest to the dramatic peak had a green alpine meadow appearance. Just a kilometre away, and a little lower, another weather station was surrounded by shrubs and small trees. I painted Fortress Mountain at the end of summer but. Already, I could sense its return to its icy winter wilderness”.

NUCLEAR EXPLOSION IN SLOW MOTION
Oil on canvas, 150 x 100 cm, 2020

For many scientists in the Global Water Futures research programme, this location is iconic –because of the dramatic scenery, and the importance of this automatic observation station, and others in the near-vicinity. The location is Fortress Mountain in the Canadian Rockies. The observation network has been built to improve understanding of rapid climate and environmental changes which have occurred in recent decades and to further develop predictive models of the effect of future climate change on the local hydrology – a particular challenge is such complex terrain.
Ivanov has produced a number of paintings of the nuclear explosion in slow motion (a phrase attributed to a Gwich'in Chief when describing what it is like to witness the profound changes caused by climate change of the landscape of his people in Northwest Territories. The cauldron where once a valley glacier flourished is the seat of Ivanov's slow nuclear explosion.



Fortress Mountain Research Basin
Pastel on paper, 20 x 20 cm, 2019

Kananaskis Valley
Oil on canvas, 20 x 20 cm, 2019

The view of the Kananaskis Valley from Canadian Ridge in Fortress Mountain Research Basin

Fortress Mountain Hanging Tree
Pastel on paper, 30 x 24 cm, 2022

This well instrumented research station with a weighed, suspended tree, “the hanging tree” is Tower Ridge Station, Fortress Mountain Research Basin. It is a cut, suspended, weighed fir tree to measure interception of snowfall and rainfall and the storage of intercepted snow and rain in the subalpine canopy. This helps us to predict the impacts of forest cover change on water supply

Mountains

Three Sisters Mountains
Oil on canvas, 20 x 20 cm, 2019

An iconic scene from the Bow River in Canmore, Alberta

Three Sisters Mountains, Alberta
Oil on canvas, 30 x 30 cm, 2019

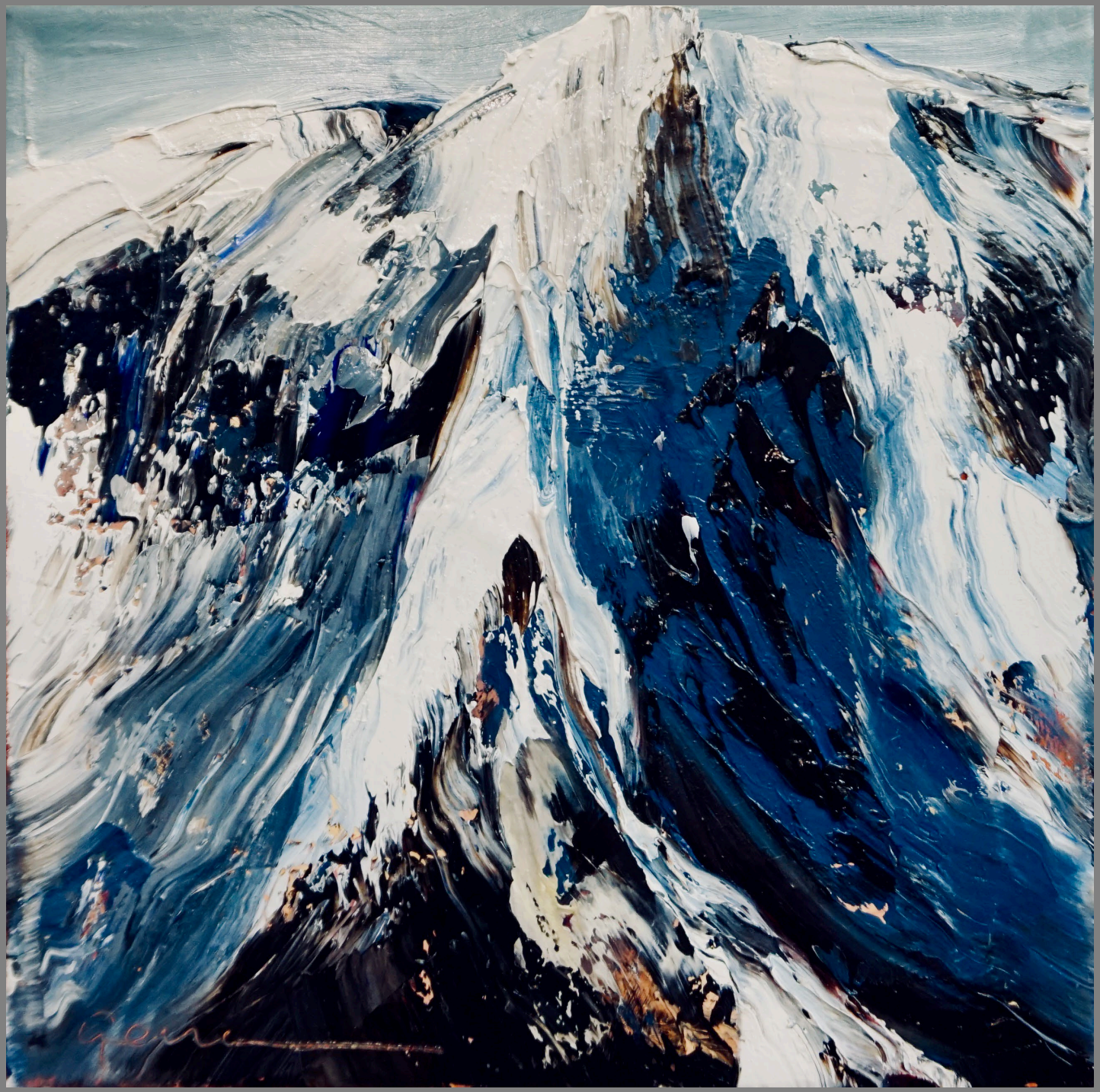
A view of Three Sisters from a dry channel of the Bow River in Canmore, Alberta after a dry period in the summer.

Mount Robson
Pastel on paper, 45 x 33 cm, 2022

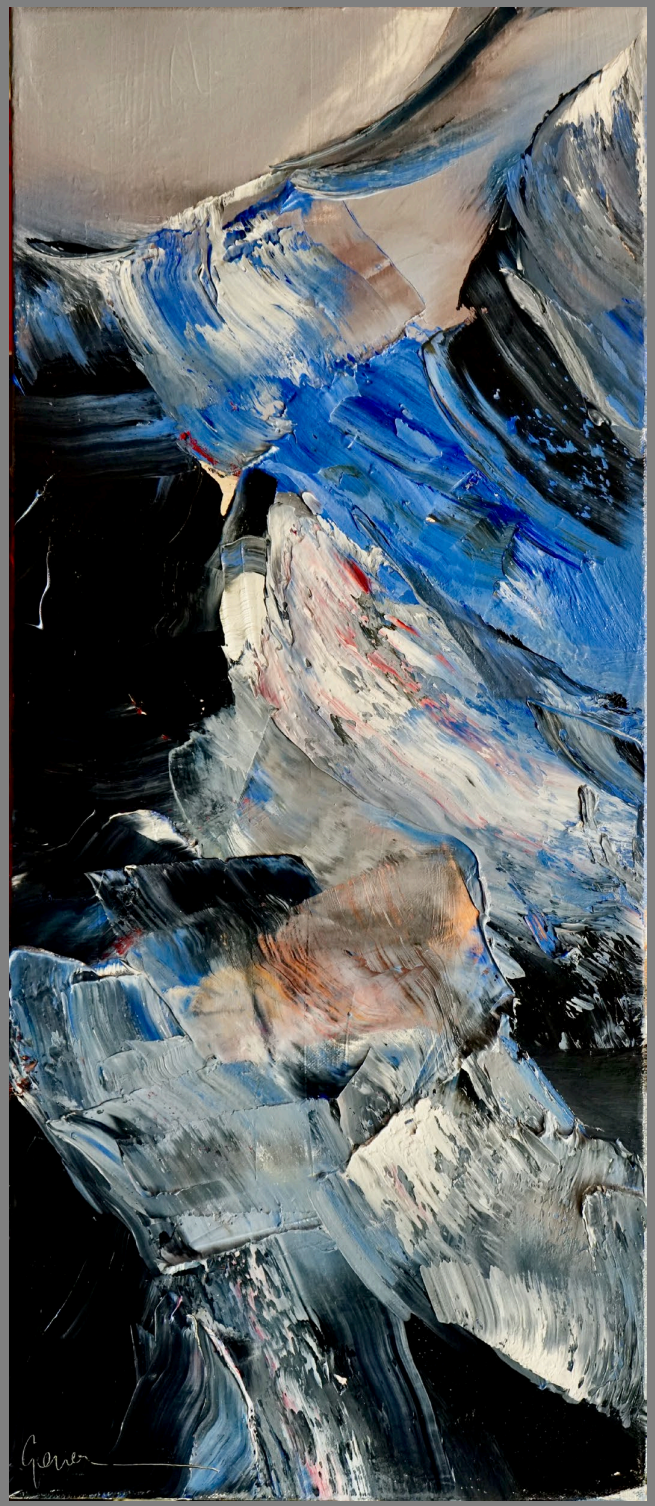
Mount Robson, British Columbia in May after an exceptionally high snowfall season.

Impressions of Mountains

Artist's Note: “The dramatic Rocky mountains and their glaciers burrowed into my brain, giving me never-ending inspiration for my impressionistic paintings.”



"Mountains and Glaciers" Series
Oil on canvas, 30 x 30 cm, 2020



"Mountains and Glaciers" Series
Oil on linen, 70 x 30 cm, 2020

"Mountains and Glaciers" Series
Oil on canvas, 30 x 30 cm, 2020

"Mountains and Glaciers" Series
Oil on canvas, 30 x 30 cm, 2020

SNOWY MOUNTAINS
Oil on canvas, 76 x 50 cm, 2020

“The substantial change that loss of snow-packs and glaciers is having on the planet is something the international scientific and policy community needs to address quite urgently. These changes have led to, and will continue to cause, serious unsustainability of freshwater as a result of the impact of climate change”.(John Pomeroy, World Meteorological Organization’s High Mountain Summit, Geneva, October 2019).

"Mountains an d Glaciers" Series
Oil on canvas, 30 x 30 cm, 2020

SNOWLIGHT
Oil on canvas, 80 x 80 cm, 2019

Artist's Note: “A sudden windstorm blew snow from the mountain sides, temporarily obscuring the Sun, but producing fantastic plays of light. The changes were too quick for me to catch in a field painting, but they were etched into my memory.”

Forests

Marmot Creek
Oil on canvas, 20 x 20 cm, 2019

Marmot Creek Research Basin in Kananaskis, Alberta has been instrumented since 1962 and is a research site where climate change impacts on hydrology have been diagnosed and the impacts of forest cover on intercepting snow and slowing snowmelt have been explored. It has been the outdoor water laboratory for dozens of scientists and is a key part of the Global Water Futures Observatories Network

Athabasca River
Pastel on paper, 30 x 24 cm, 2022

Impact of pine bark beetle infestation in killing the lodgepole pine forests along the banks of the Athabasca River, Jasper National Park, Alberta
The pine beetle thrives in warmer winters and in intact forests – both of which prevail in Jasper Park due to human caused climate change and overmature pine canopies from decades of excessive wildfire suppression.

OCHRE RIVER
Pastel field drawing, 24 x 30 cm, 2019

Vermilion Pass gets its name from the colouration which originates in mineral springs of iron oxide. These ochre springs are important for the indigenous people, and are known as the paint pots. Scientifically, it is an interesting location because of the pronounced influence of groundwater chemistry on surface waters. “This felt a special – and elemental – place to me. The paint pots and the stream-water downstream were amongst the most vivid colourations I have seen in nature.” (Gennadiy Ivanov)

Impressions of Forests

Vermillion Pass Forest Fire
Oil on canvas, 80 x 80 cm, 2019

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Spring Now Brings Floods and Fires
Oil on canvas 160 x 160cm, 2021

MOUNTAIN TINDERBOX AND ASHES
Oil on canvas, 90 x 70 cm, 2020

A major reason for the increase in forest fires across the cold regions is the growing areas of dead and dying trees, representing a tinderbox primed for the ravages of fire. Amongst the most serious of pests are bark beetles attacking pine trees. Rising temperatures reduce the widespread winter die-off of beetle larvae. The beetles also hatch earlier and reproduce more frequently. Some entomologist call beetles “first responders” because they are so sensitive to climate and environmental change. In this painting Ivanov portrays swathes of dead and burnt trees; although an impressionistic painting, many photographs of forested landscapes affected by pests and ravaged by fire would give a similar impression.

BURN!
Oil on canvas, 100 x 100 cm, 2019

Early, and less, snowmelt combined with higher temperatures prime the vegetation for burns (fires), even in April, in northern and western Canada. The mountains behind the still-frozen lake fringed by its newly exposed silty desert are bereft of even their thin snow cover. A wisp of cloud resembles a glacier arm still clinging on. The burst of yellow and red on the mountains are ‘burn’!

Lakes and Rivers

JOHNSON LAKE
Pastel field drawing, 24 x 30 cm, 2019

Johnson Lake is a 20 ha reservoir, at an elevation of 1,426m, near Banff in Alberta.
Artist's Note: "I made a small field painting of this lake because I was struck, and depressed by the fact, that although - to my eyes – it looked pristine, there were recent notices warning that the lake's trout were suffering from an out-break of whirling disease."
Whirling disease is caused by a myxosporean parasite which induces the fish to swim with a whirling motion. It was first observed in the USA, and has spread across international and provincial borders through recreational activities. Although not related to climate change, it was an example of the multitude of stresses which human activity can place on aquatic environments.

Upper Kananaskis Lake
Pastel on paper, 30 x 24 cm, 2022

Brule Lake
Pastel on paper, 30 x 24 cm, 2022

Artist's Note: “As I sat painting this scene, one of the never-ending trains rumbled past. The steel tracks of the Rockies have witnessed dramatic changes in the landscape through which they were cut.”

Maligne Lake
Pastel on paper, 30 x 24 cm, 2022

Maligne Lake, Jasper National Park, Alberta with a high snowpack and very late snowmelt in late May 2022 – very little melt had occurred to this point and the lake is still frozen and snowcovered.

Maligne Lake
Pastel on paper, 45 x 33 cm, 2022

Medicine Lake
Pastel on paper 45 x 33 cm, 2022

Low water levels in Medicine Lake, Jasper National Park, Alberta during a late spring where snowmelt from high elevations had not begun in late May. Snowmelt raises the water levels in this natural lake substantially in June.

Kinbasket Lake
Pastel on paper, 45 x 33 cm, 2022

This reservoir on the Columbia River system fills with snowmelt in most years, but this May despite local snowmelt it remains very low and its dry lakebed is subject to dust storms. The summer of 2022 was record dry in parts of British Columbia and low streamflows impacted hydroelectricity production, community water supply and led to high salmon mortality

Lower Kananaskis Lake
Pastel on paper, 45 x 33 cm, 2022

In May, snowmelt had yet to occur at high elevations and so this reservoir remains low with an exposed lake bed. It will fill from near-record high snowpacks later in the summer

Maligne Canyon Falls
Pastel on paper, 33 x 45 cm, 2022

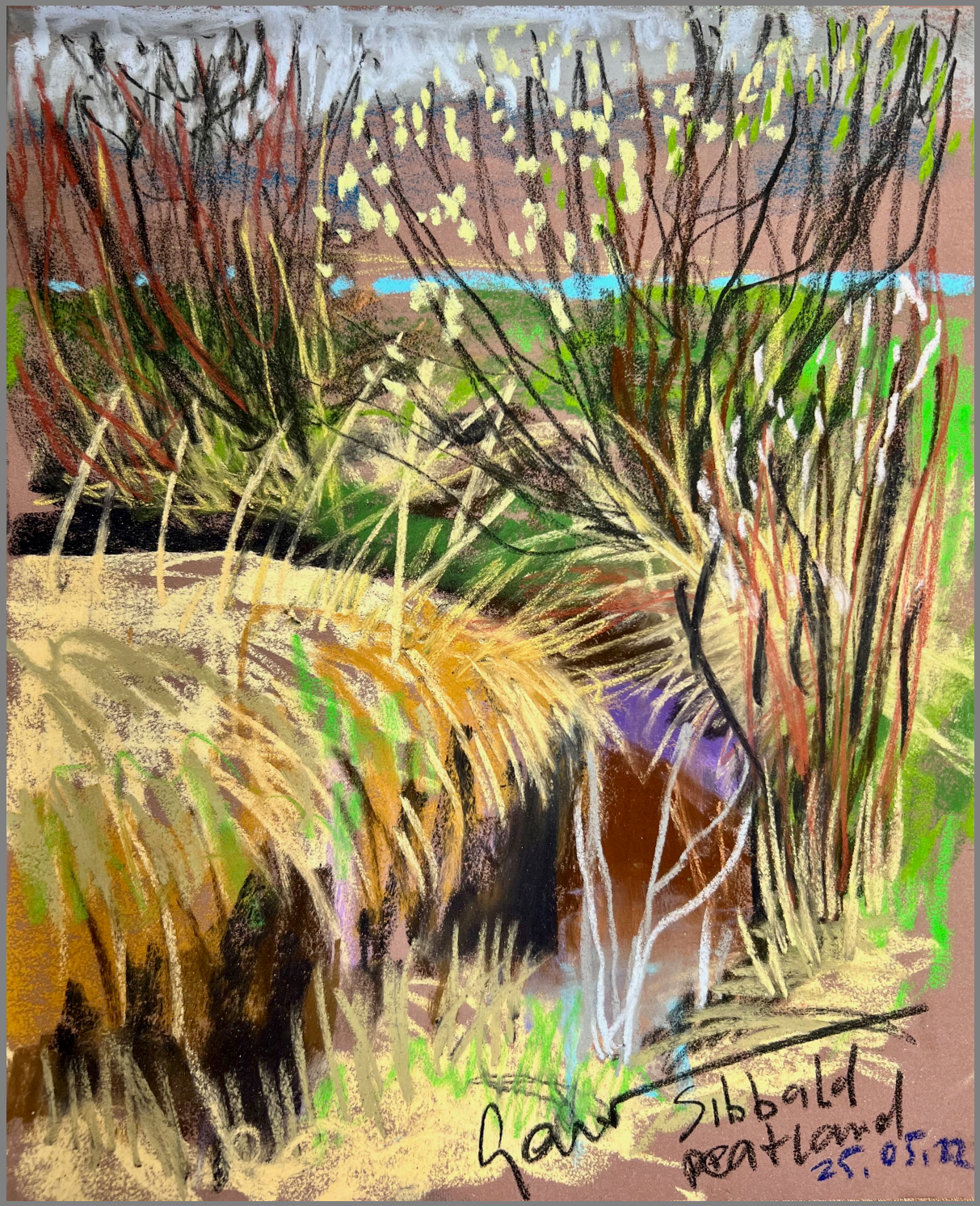
Upper Kananaskis Lake
Pastel on paper, 33 x 45 cm, 2022

COUGAR CREEK DEBRIS NET
Field drawing pastel on paper, 33 x 45 cm, 2019

On June 20 2013, the town of Canmore, Alberta and much of the surrounding region experienced a devastating flood that was part of the most expensive natural disaster in Canadian history at that time. The torrent formed a debris flow that tore down Cougar Creek destroying homes, railways and roads, causing substantial damage and isolating the region for several days. The flood was caused by three days of heavy rainfall forming runoff over still frozen alpine soils and enhanced by melt of a late lying alpine snowpack. It was exceptional event in modern Canmore, but similar events were noted in the late 19th and early 20th C. In anticipation of the increased frequency and magnitude that is likely for future extreme rainfalls, a temporary debris net was constructed above the town after the 2013 flood to retain boulders and trees within the torrent. A retaining dam is now being built to replace this. The University of Saskatchewan's Coldwater Laboratory is based in Canmore, researching climate and hydrological regime changes and has developed predictive models for events such as this.

SHORT SOJOURN ON SOUTH SASKATCHEVAN
Field drawing pastel on paper, 24 x 30 cm, 2019

Hundreds of kilometres to the east, the meltwater from the Bow River flows through the Canadian Prairies in the South Saskatchewan River. The streamflow regimes in the Canadian Prairies are also changing because of climate change and human use for irrigation and hydroelectric power. Pronounced floods and droughts (which are leading to earlier and more frequent vegetation fires) are increasing in frequency and intensity, with implications for agriculture, infrastructure and transport. The worst floods and droughts since colonisation of the region in the late 1800s have occurred in the last two decades. The South Saskatchewan River flows through the city of Saskatoon, the home of the University of Saskatchewan and the headquarters of the Global Water Futures research programme. The slumping banks of the river, and the changing pattern of sand bars, show evidence of shifting patterns of erosion and deposition in response to recent hydrological changes. The best way of seeing this evidence is from a canoe, and this series of pastels illustrates the changing views – very different from the sculpted landscapes of the Rockies – painted on a 12km sojourn on the river, downstream towards Saskatoon, under the paddle power of the scientists!



Sibbald Peatland
Pastel on paper, 30 x 24 cm, 2022

Sibbald Peatland
Pastel on paper, 30 x 24 cm, 2022

Sibbald Wetland Research Basin in Kananaskis was instrumented in 2006 to study how beaver-created wetlands influence hydrology and water supply. In the massive flood of 2013 the beaver dams held and reduced flooding downstream in Calgary. Studies of beaver-influence hydrology show how ecosystem processes can restore hydrological stability even when extreme events due to climate change occur. This is part of the Global Water Futures Observatories network of 76 research basins across Canada.

Challenges and Solutions

THE ICE AND FIRE
Oil on canvas, 116 x 91 cm, 2019

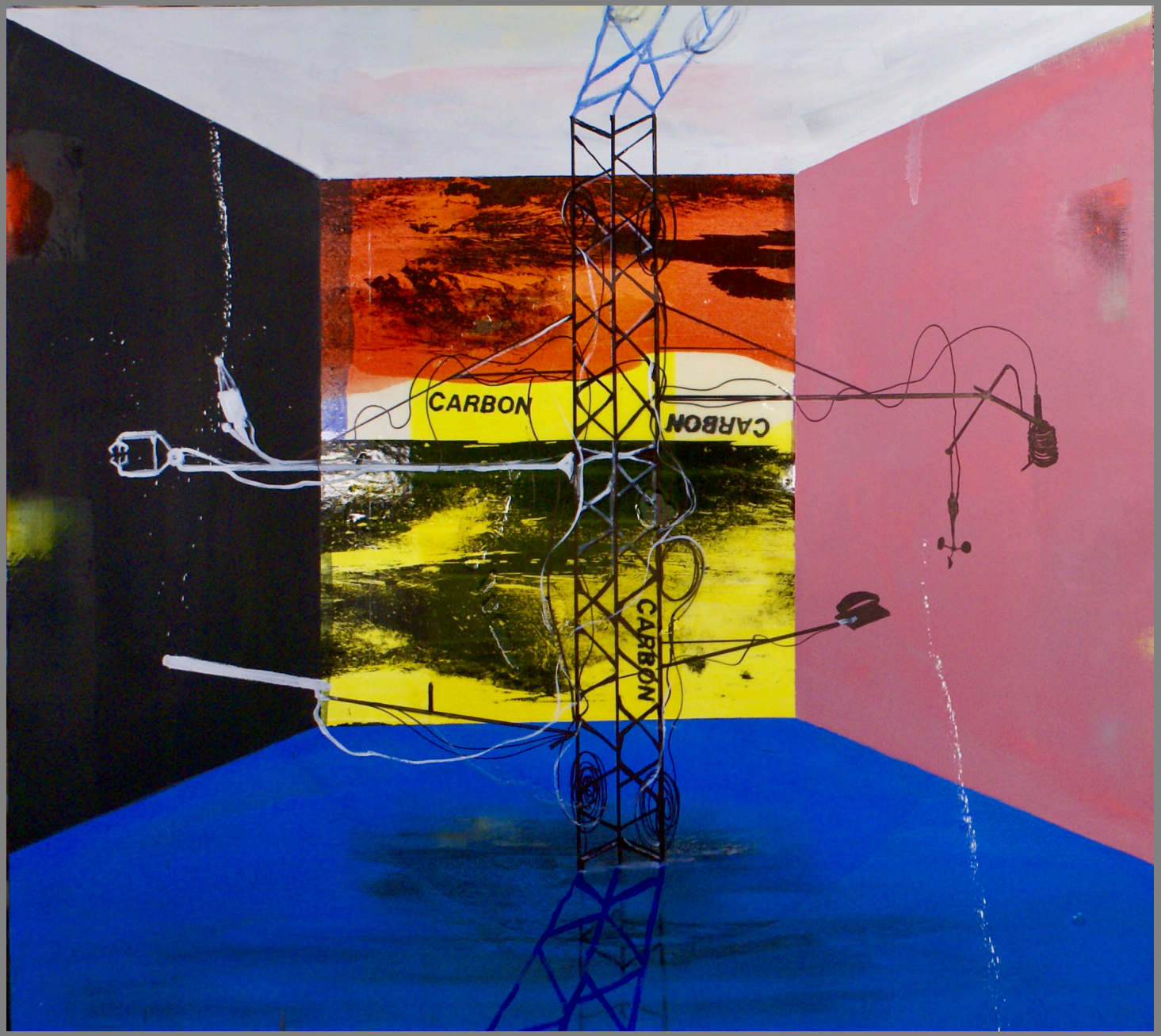
Here the artist expresses some of his memories of the Transitions trip to the Rockies and the Prairies. One is the seemingly endless trains which transport Canadian resources for export and carry manufactured goods from around the globe – a symbol of the nature of human activity which is driving climate change. Also included is a Global Water Futures' observation station which monitors the changing weather due to climate change, and the changing state of glaciers and snow-packs. A scientist reflects on the challenges global society faces in de-coupling our necessary activities from continuing increases in greenhouse gas emissions. We need to open the window to adopting, and identifying, new solutions.

LISTEN TO THE SCIENTISTS
Oil on canvas, 200 x 140 cm, 2020

Prof John Pomeroy explaining some of Global Water Futures research on the Athabasca Glacier to Greta Thunberg in early winter 2019. A message Ms Thunberg often gives is “listen to the scientists”.

AND FIRE IN HIS EYES
Oil on canvas, 100 x 100 cm, 2019

This painting shows John Pomeroy, who is discussing some important detail of the science, with Trevor Davies. Davies is the reflection; standing next to the GWFO automatic weather station on the Athabasca Glacier.
Artist's Note: “One thing which has really struck me about the scientists is how enthusiastic – indeed, passionate – they are about their research. They are fired-up about their work."



DENIERS' STATION
Oil on canvas, 95 x 90 cm, 2019

Ivanov's inspiration for this painting was the cold regions field research stations of the Global Water Future Observatories programme. The instruments record meteorological variables including water vapour flux and carbon dioxide exchange. Ivanov has inverted the instruments since, to him, it represents the way in which climate deniers turn logic upside-down.

THE DINOSAUR'S DAMNATION
Oil on canvas, 120 x 150 cm, 2019

The artist has taken the opportunity to juxtapose a dinosaur, the fossil- and coal-bearing strata, and a modern Alberta oil extraction facility. Many indigenous peoples in North America have a mythology about a horned serpent, with the mystical beast associated with extreme events – rain, water, thunder, lightning. The dinosaur is watching, atop the beds overlaying the fossil-rich strata, as humankind is instigating a global environmental change which may well appear in Earth's future geological record- and is already dubbed the Anthropocene. Artist's Note: "Many of the fabulous fossils in the Tyrell Museum just outside Drumheller evoked a horned serpent in my mind."

SADNESS AT HAPPISBURGH
Oil on canvas, 109 x 81 cm, 2018

Here in Norfolk, England, the impacts of rising sea level due to glacier melt and ocean temperature increases and increasing storms due to a changing atmosphere are apparent in this receding coastline that is destroying ancient villages. Norfolk villages are falling into the sea and defending all of them against this global heating trifecta of melting glaciers, warming oceans and increasing coastal storms is sadly impossible.
Artist's Statement: Since I have been working with scientists, I have started to understand how humans are affecting the whole world, and how impacts in one region have consequences for other regions. My home is in Norfolk, England, and here Canadian glacier melt water can be seen in rising sea levels and coastline erosion."