IMPACTS OF CLIMATE CHANGE ON CANADIAN AIRPORT PAVEMENTS

9/11/2019

Presented by **Edward Abreu, BEng**

MASc Candidate

Supervisor: Prof. Susan Tighe

OUTLINE

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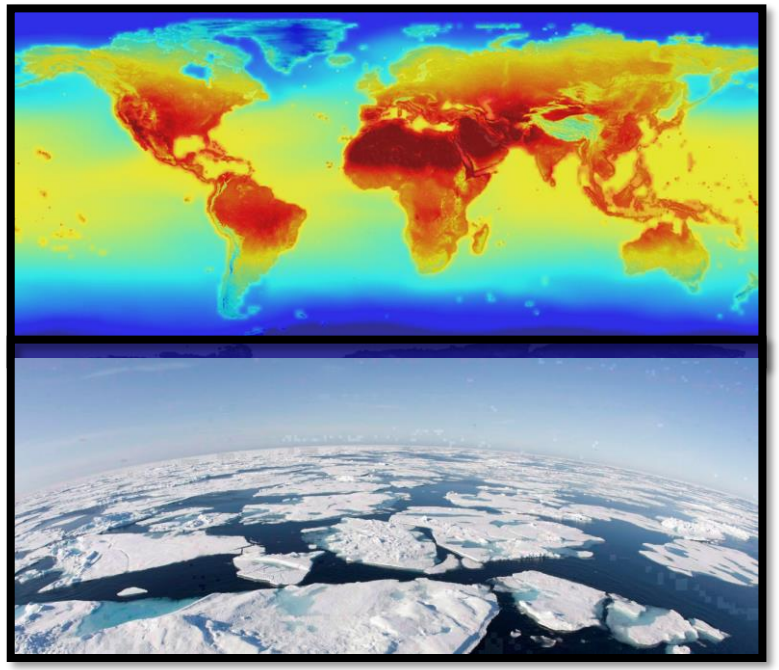

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1

WHAT IS CLIMATE CHANGE?

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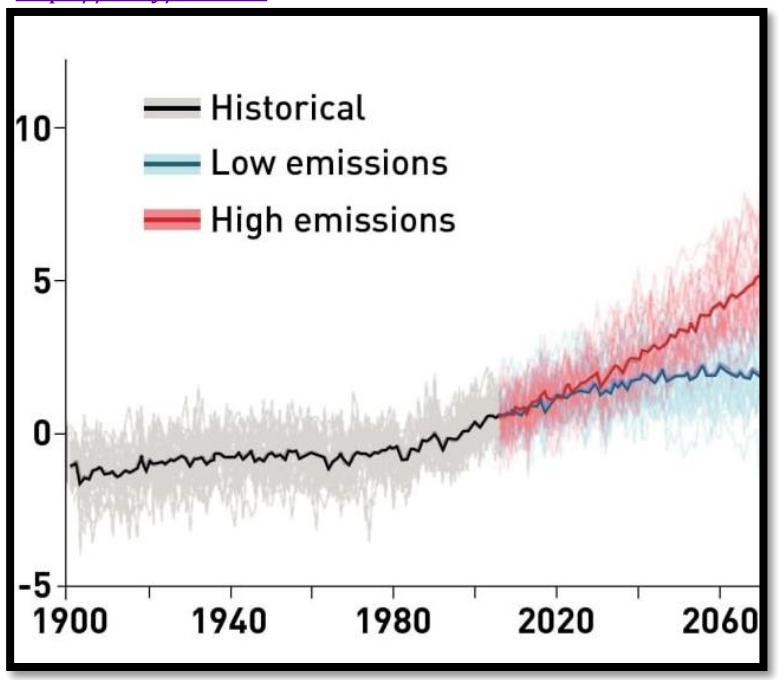
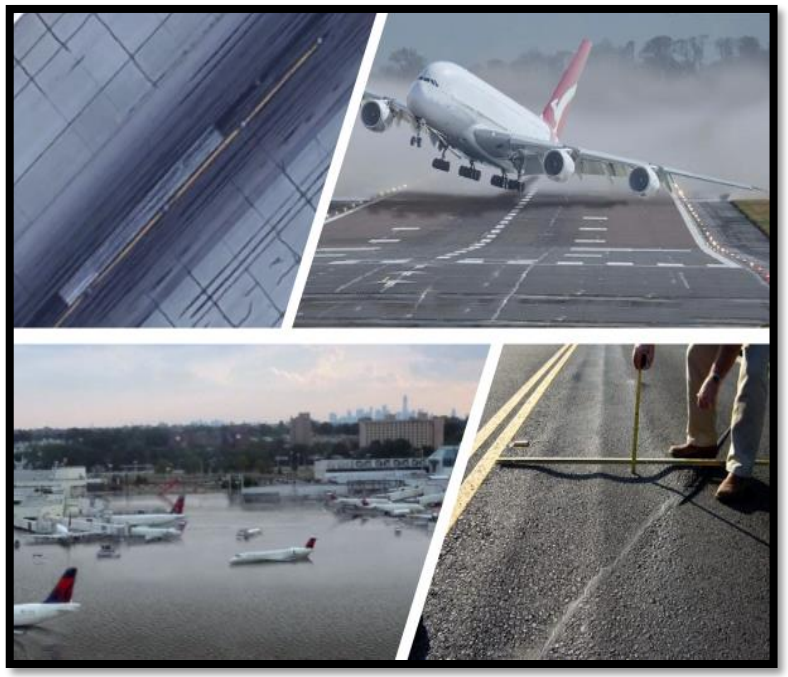


2

HOW IS THE CLIMATE CHANGING IN THE DIFFERENT PROVINCES AND/OR TERRITORIES IN CANADA



3

HOW MUCH DO THOSE CHANGES ARE IMPACTING THE CANADIAN AIRPORT PAVEMENT INFRASTRUCTURE?

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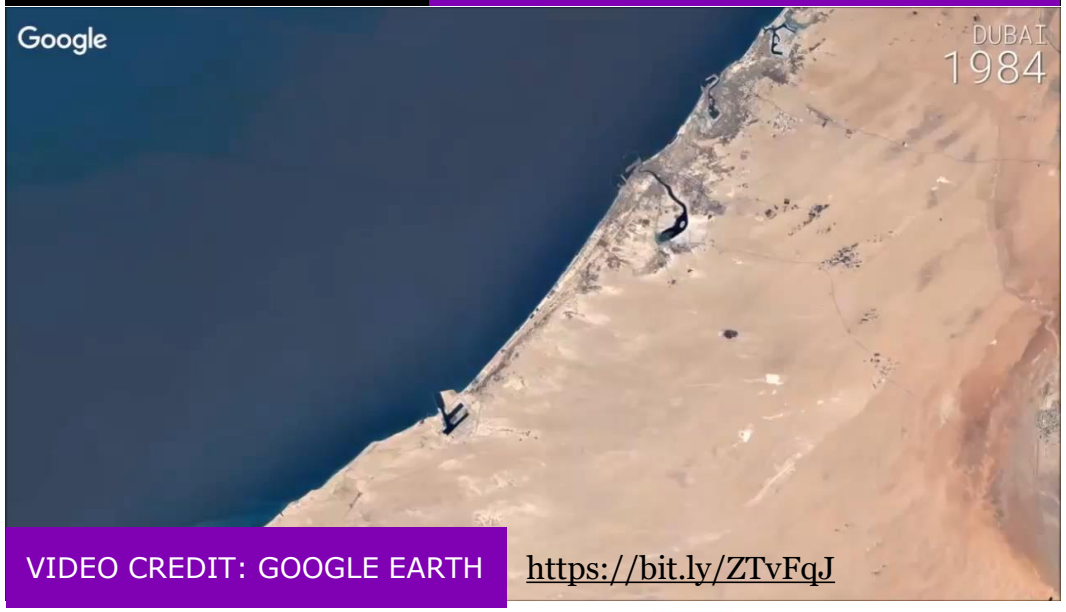
CLIMATE CHANGE

Explanation

Weather versus Climate

Weather, is a description of a short-term variation of the state of the atmosphere while climate, is a long-term average of the weather. Since the beginning of times, the weather is being drastically varying; nonetheless, it created a pattern of statistical distribution.

Hence, climate change refers to a variation of the statistical distribution of the weather patterns.



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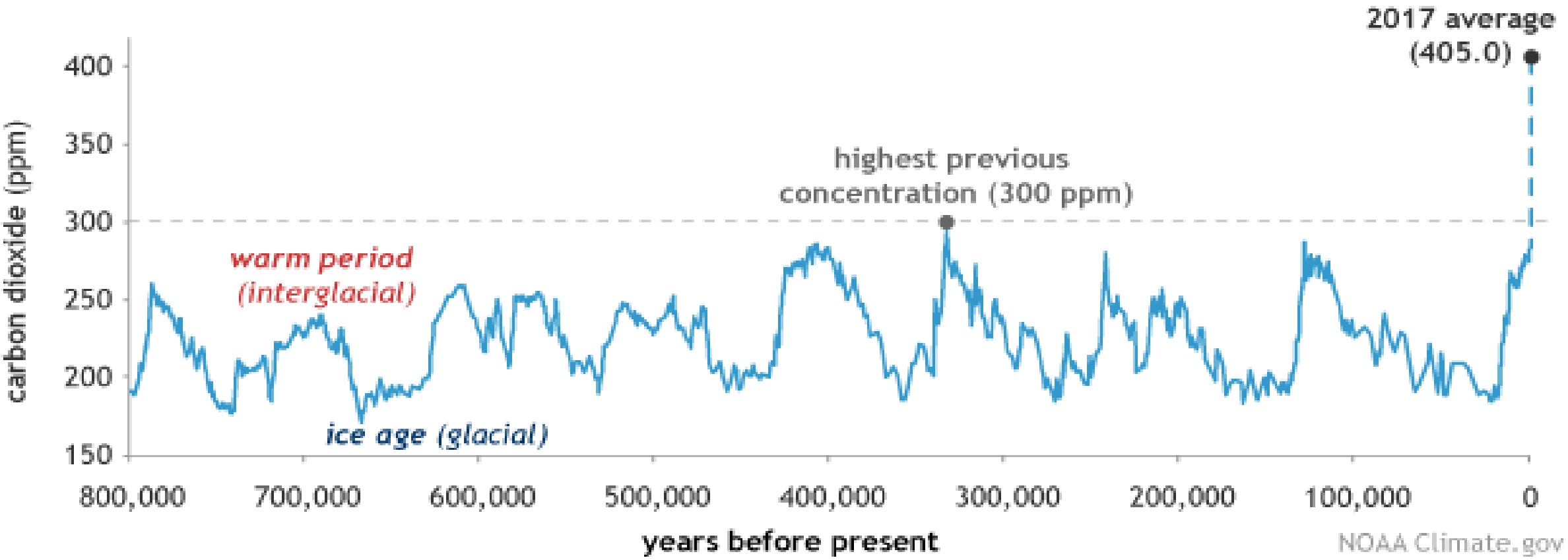

Carbon Dioxide Eq. Concentration for the Past 800,00 years
(National Oceanic and Atmospheric Administration, 2018)

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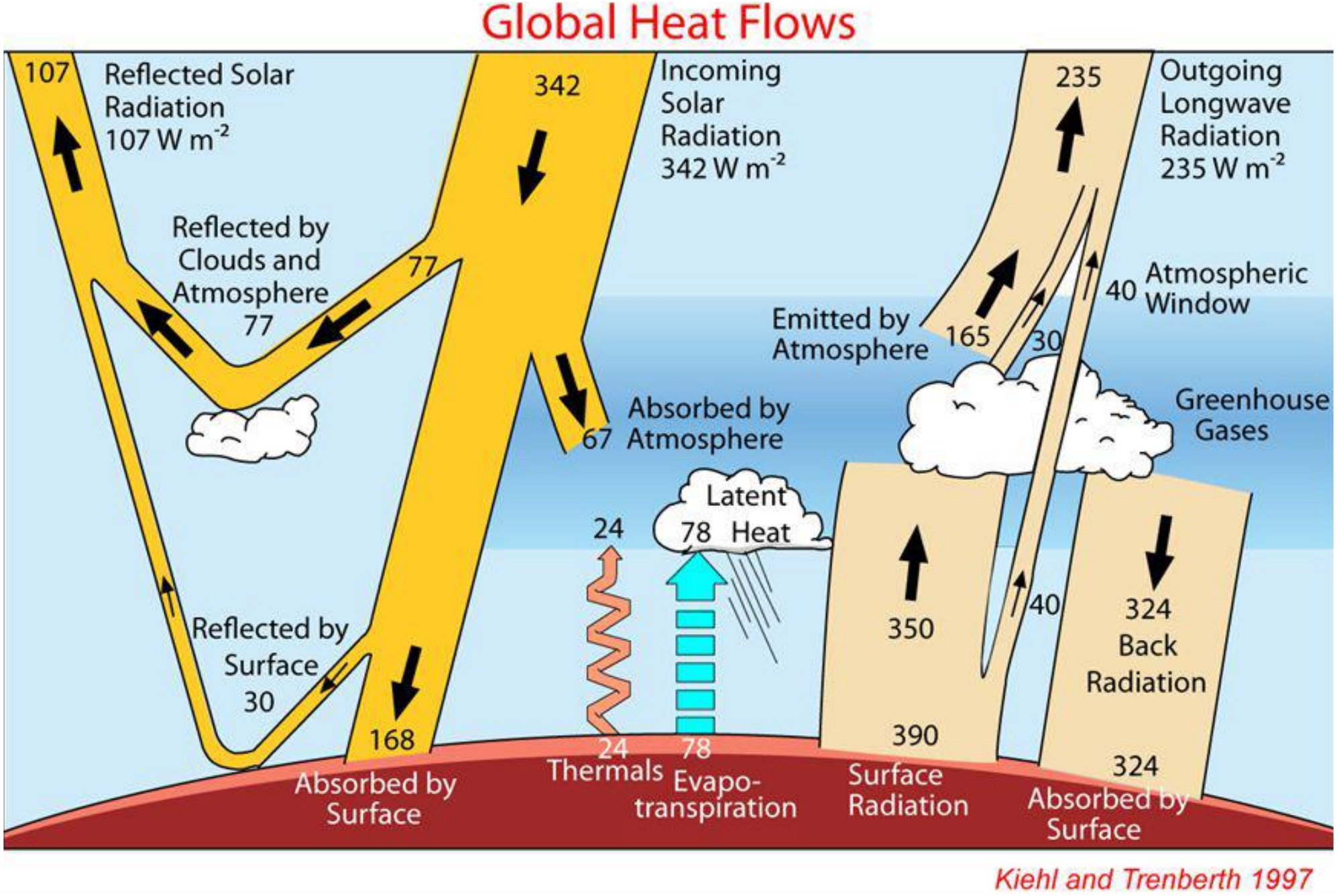
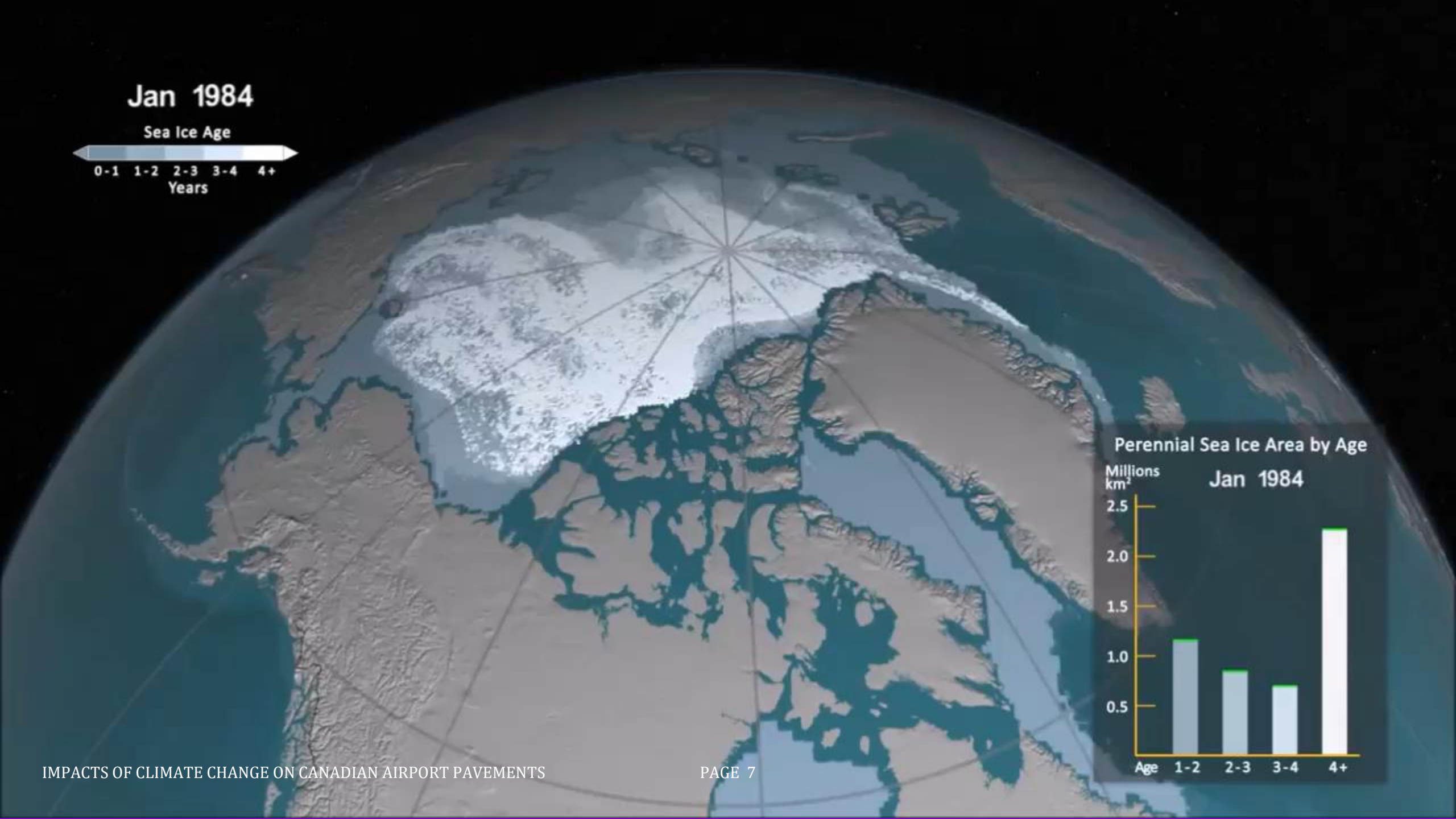
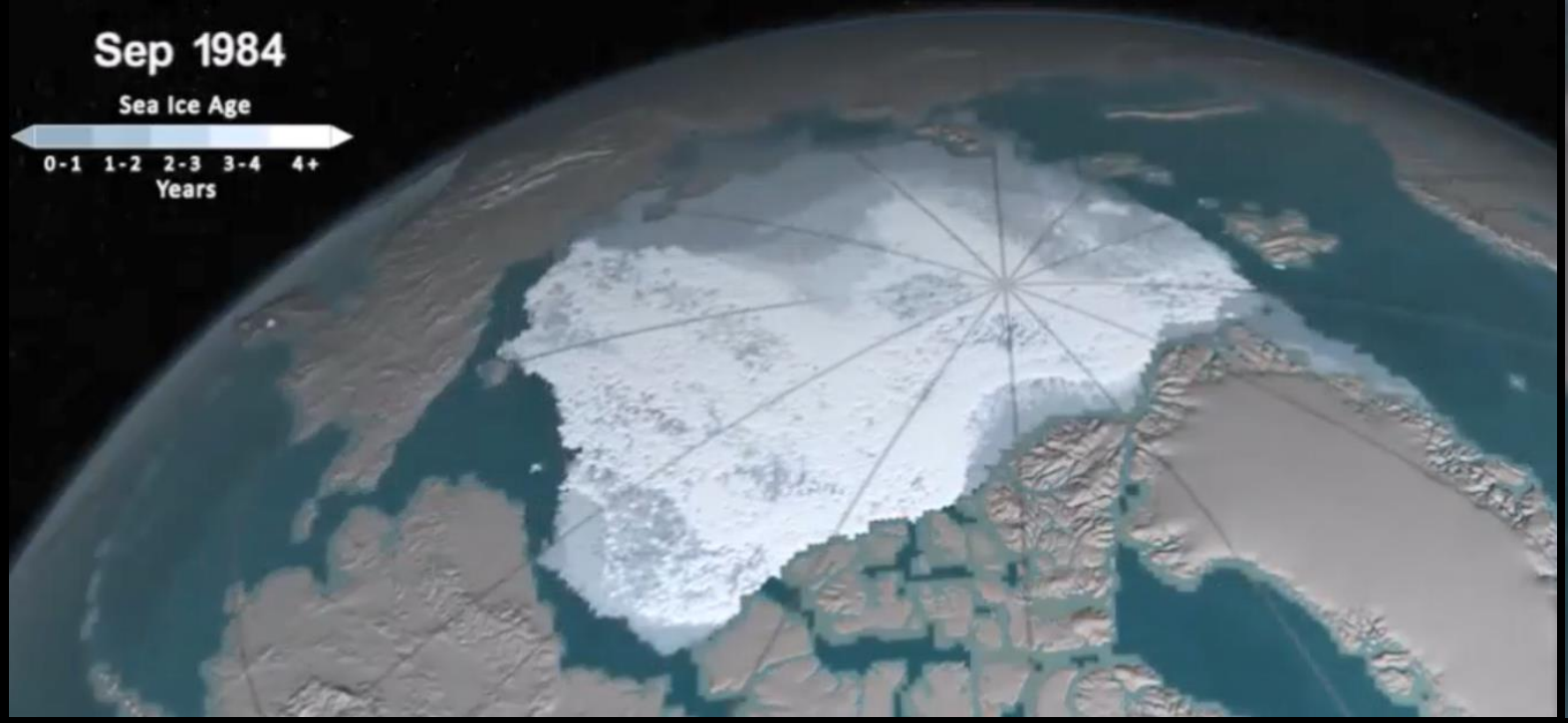
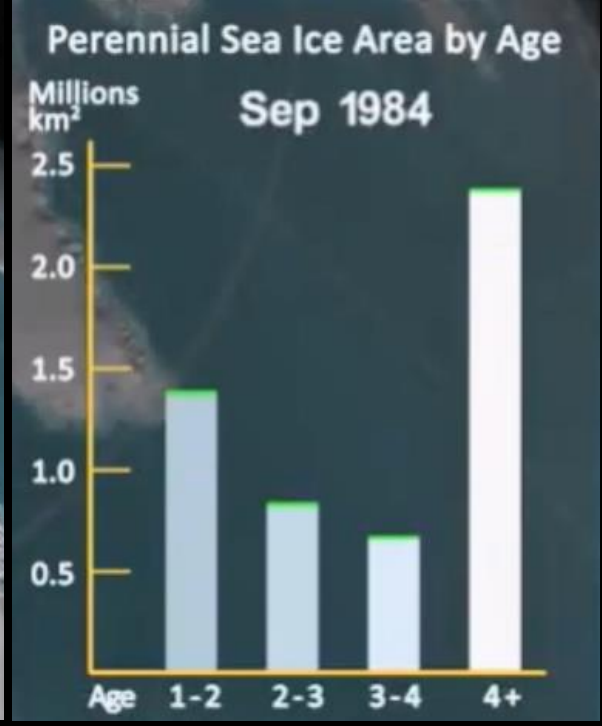
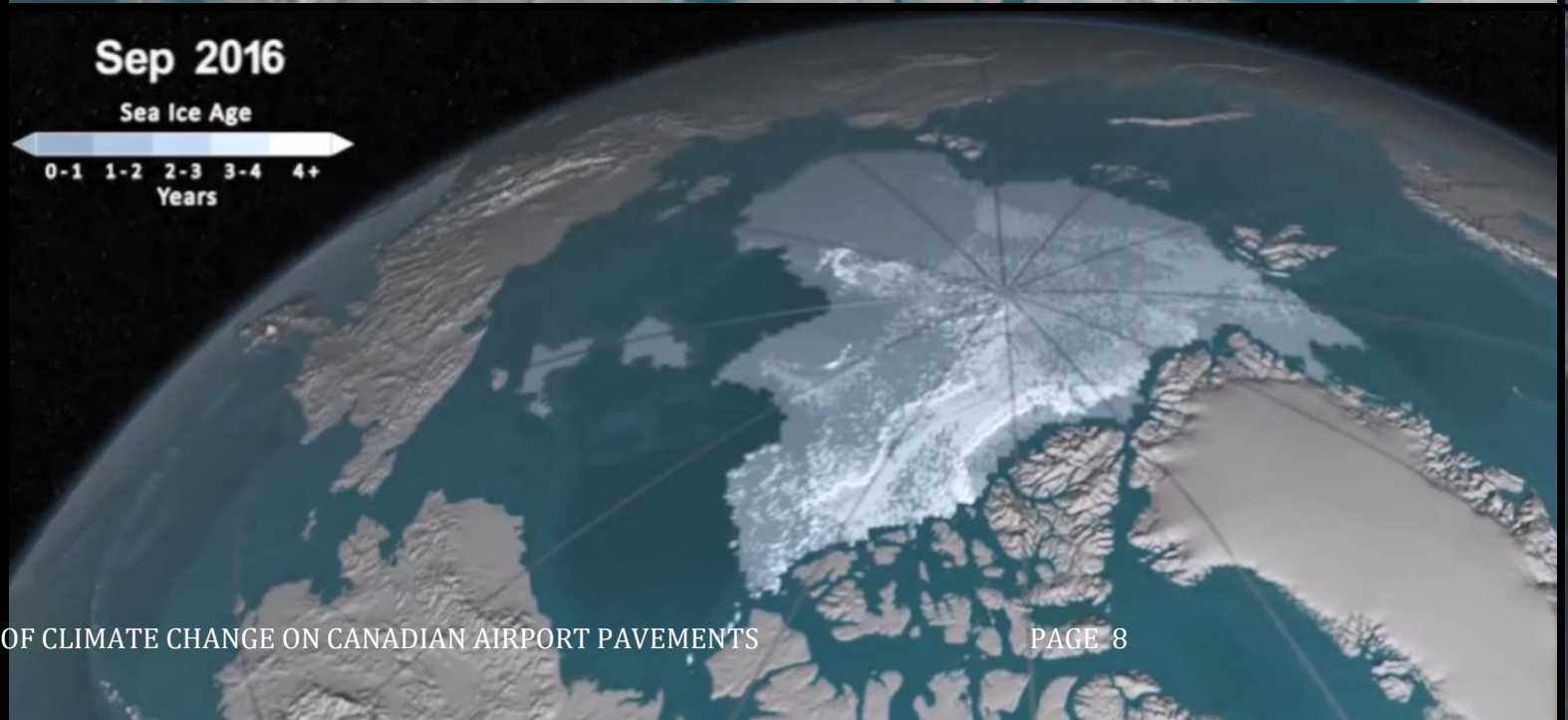
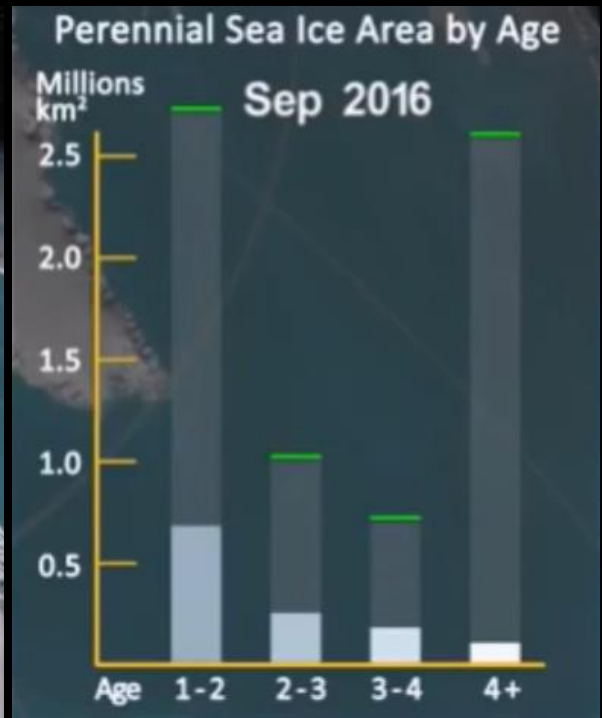

Global Heat Flows
107
Reflected Solar Radiation 107 W m-2
342
Incoming Solar Radiation 342 W m-2
235
Outgoing Longwave Radiation 235 W m-2
Reflected by Clouds and Atmosphere 77
77
40 Atmospheric Window
Emitted by Atmosphere
165
30
Absorbed by Atmosphere
67
Greenhouse Gases
Latent Heat
78
24
Reflected by Surface 30
168
350
40
324 Back Radiation
390
24
78
Thermals
Evapo-transpiration
Surface Radiation
324
Absorbed by Surface
Absorbed by Surface
Kiehl and Trenberth 1997


Jan 1984
Sea Ice Age
0-1 1-2 2-3 3-4 4+
Years
Perennial Sea Ice Area by Age
Jan 1984
Millions km²
2.5
2.0
1.5
1.0
0.5
Age 1-2 2-3 3-4 4+


Sep 1984
Sea Ice Age
0-1 1-2 2-3 3-4 4+
Years


Perennial Sea Ice Area by Age
Millions km²
Sep 1984
2.5
2.0
1.5
1.0
0.5
Age 1-2 2-3 3-4 4+

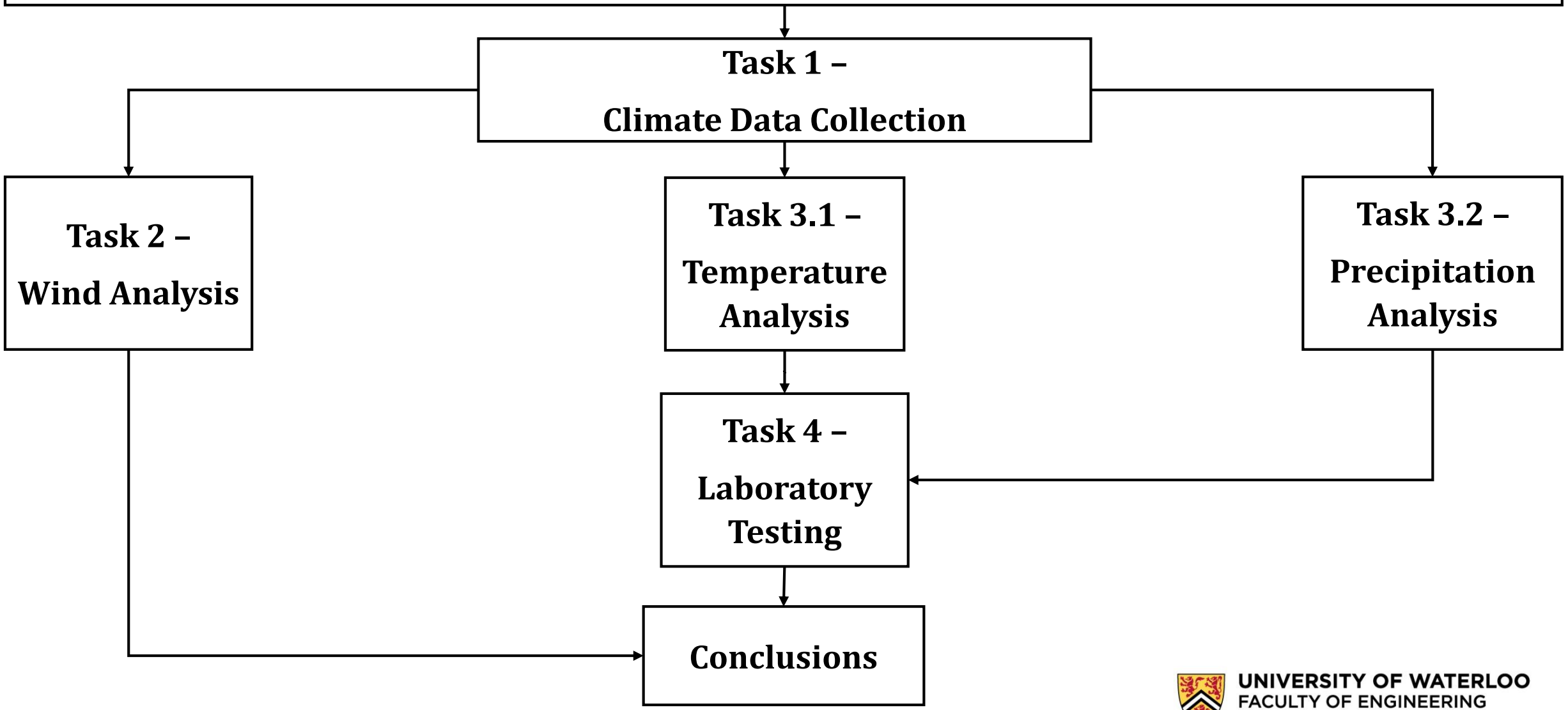

Sep 2016
Sea Ice Age
0-1 1-2 2-3 3-4 4+
Years


Perennial Sea Ice Area by Age
Millions km²
Sep 2016
2.5
2.0
1.5
1.0
0.5
Age 1-2 2-3 3-4 4+

CLIMATE CHANGE

In Canada

Impacts of Climate Change on Canadian Airport Pavements



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Impacts of Climate Change on Canadian Airport Pavements

Task 1 –

Climate Data Collection

Environment Canada

Canada

TEMPERATURE, PRECIPITATION, AND FREEZE-THAW CYCLES ANALYSIS

meteoblue

WIND ANALYSIS

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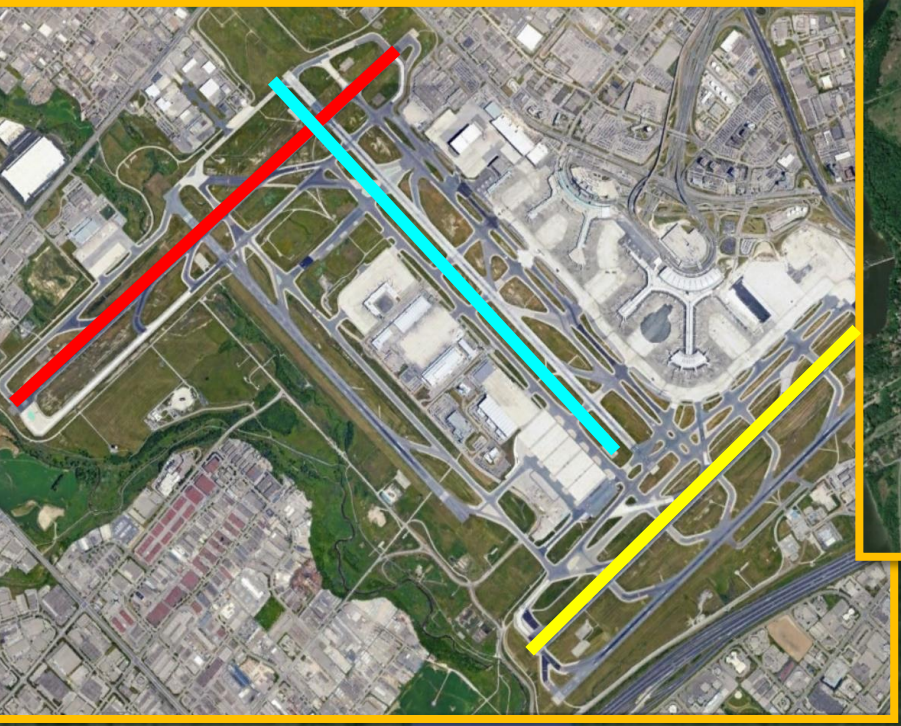
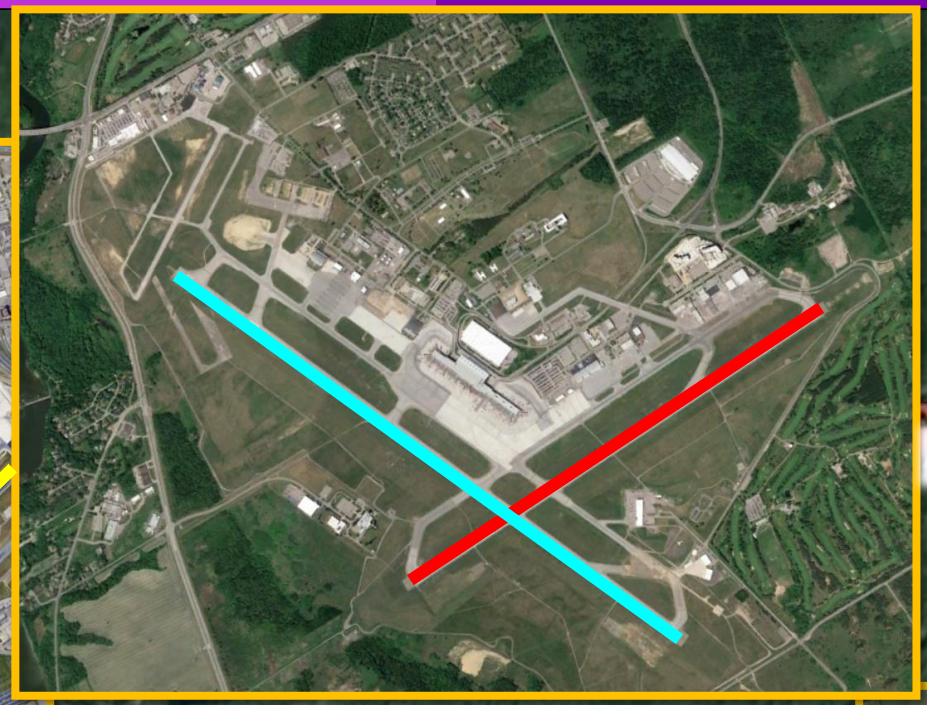
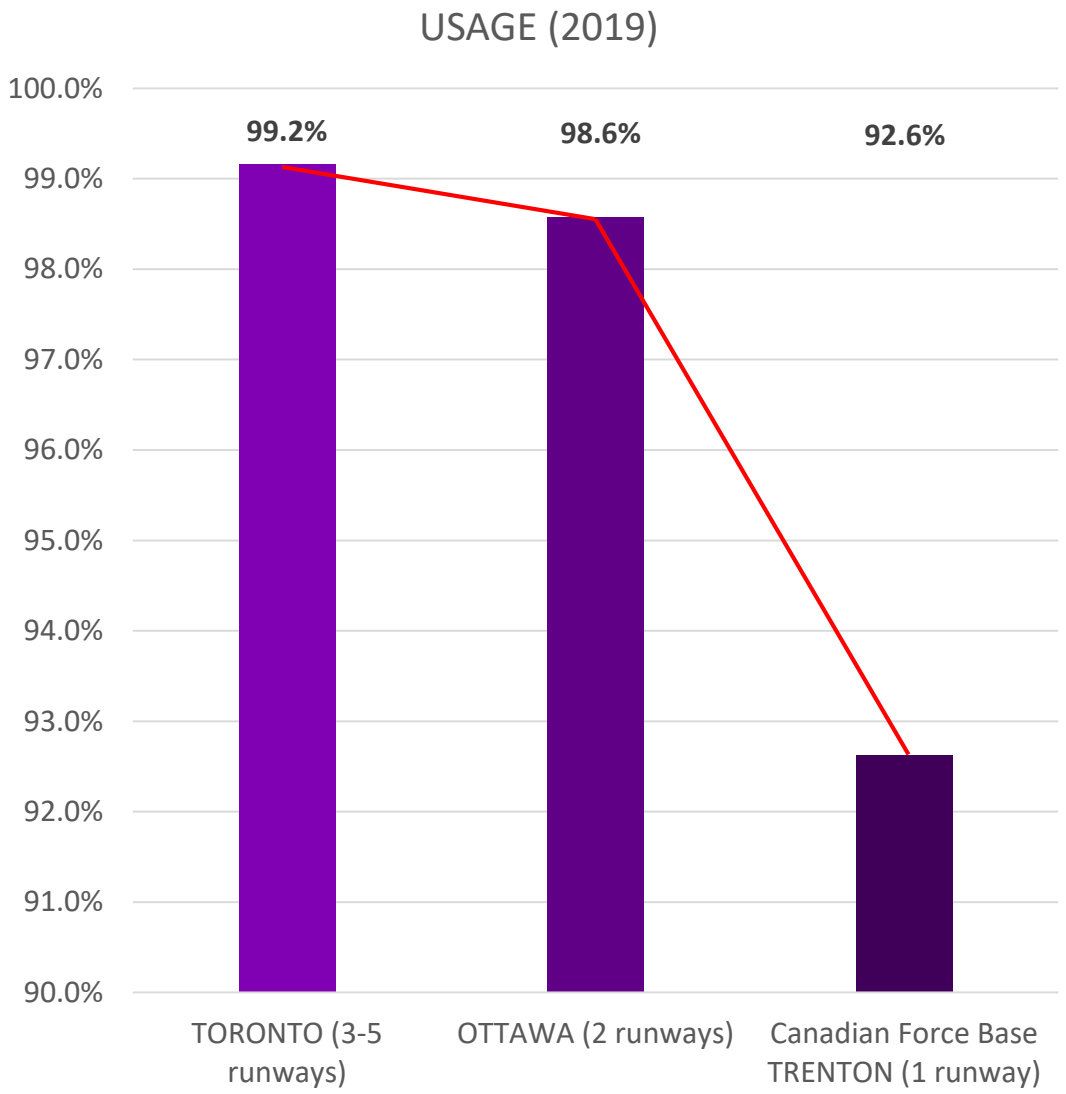


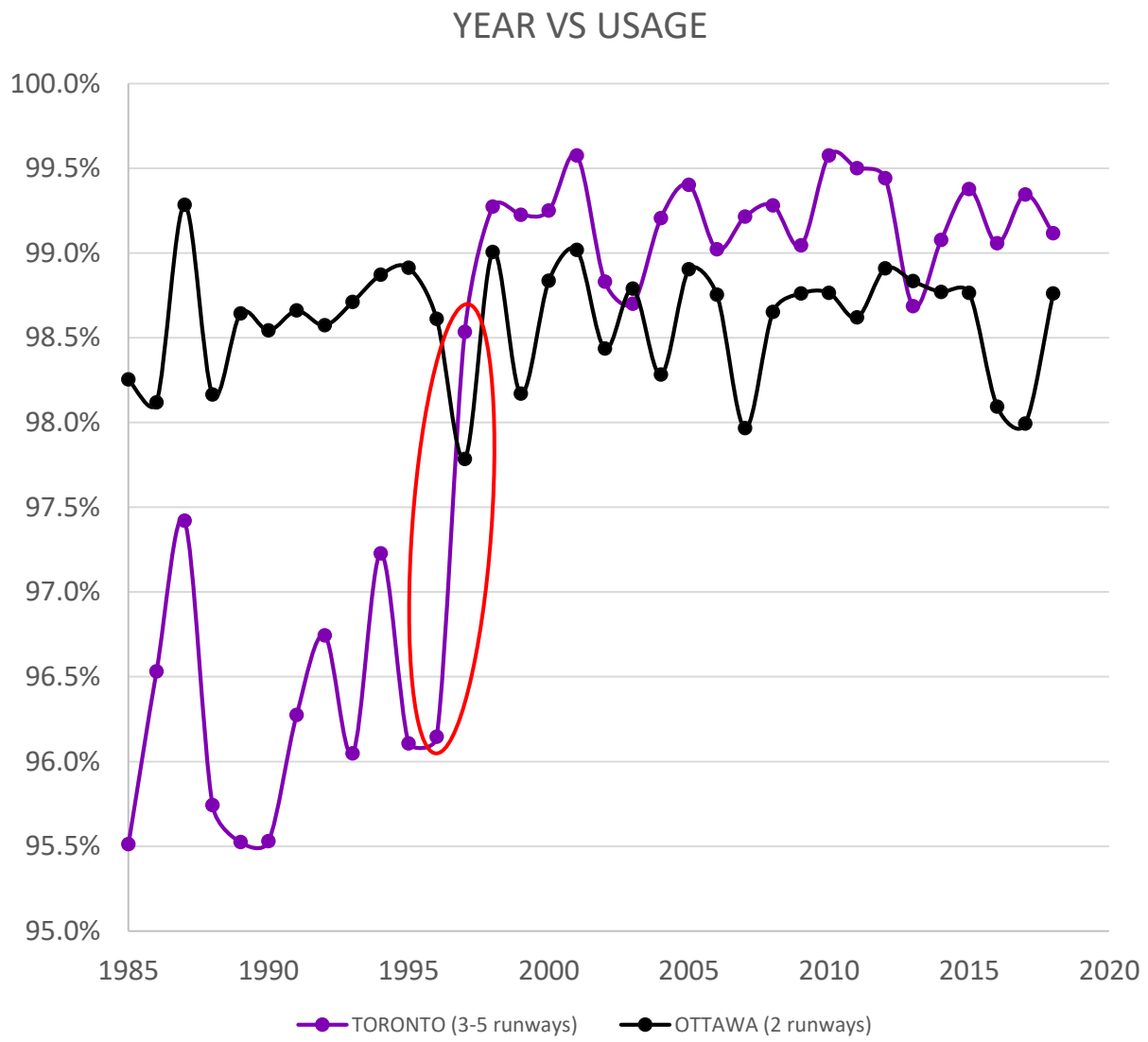
Toronto Pearson International Airport



Ottawa International Airport

Canadian Force Base, Trenton





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Impacts of Climate Change on Canadian Airport Pavements

Task 1 – Climate Data Collection

Task 2 – Wind Analysis

Task 3.1 – Temperature Analysis

Task 3.2 – Precipitation Analysis

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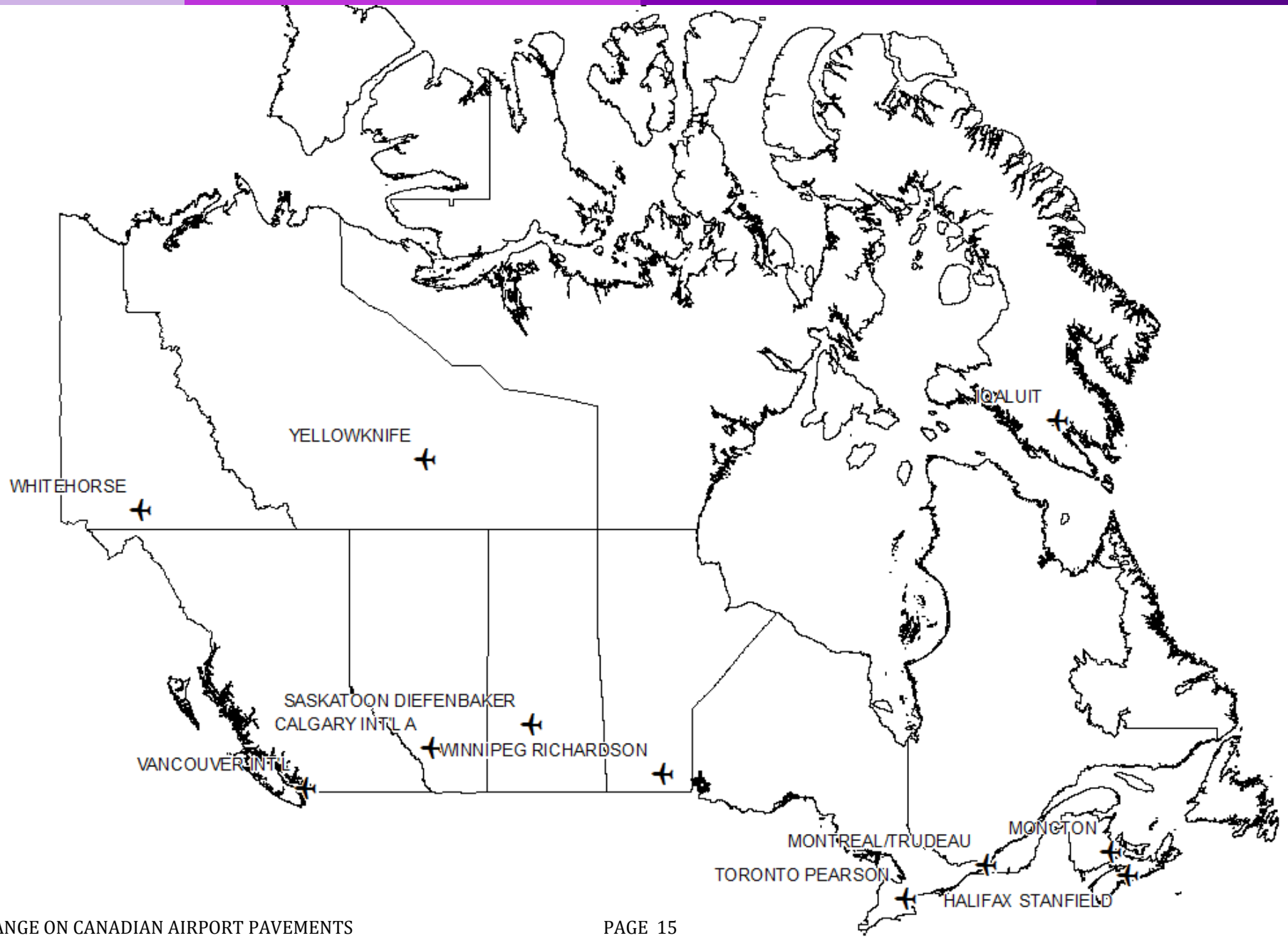
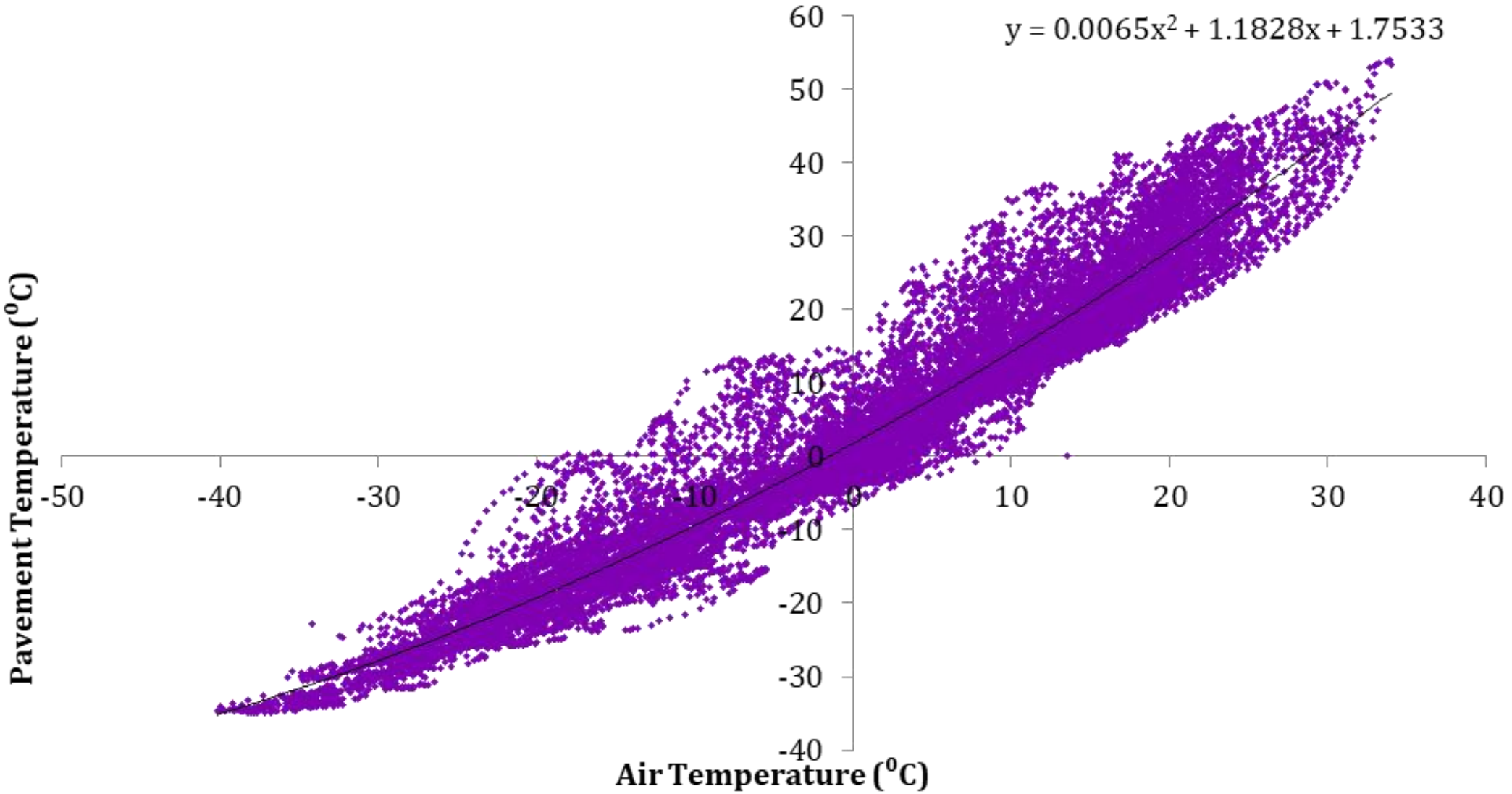

IQALUIT
YELLOWKNIFE
WHITEHORSE
SASKATOON DIEFENBAKER
CALGARY INTL A
WINNIPEG RICHARDSON
VANCOUVER INTL
MONTREAL/TRUDEAU
MONCTON
TORONTO PEARSON
HALIFAX STANFIELD



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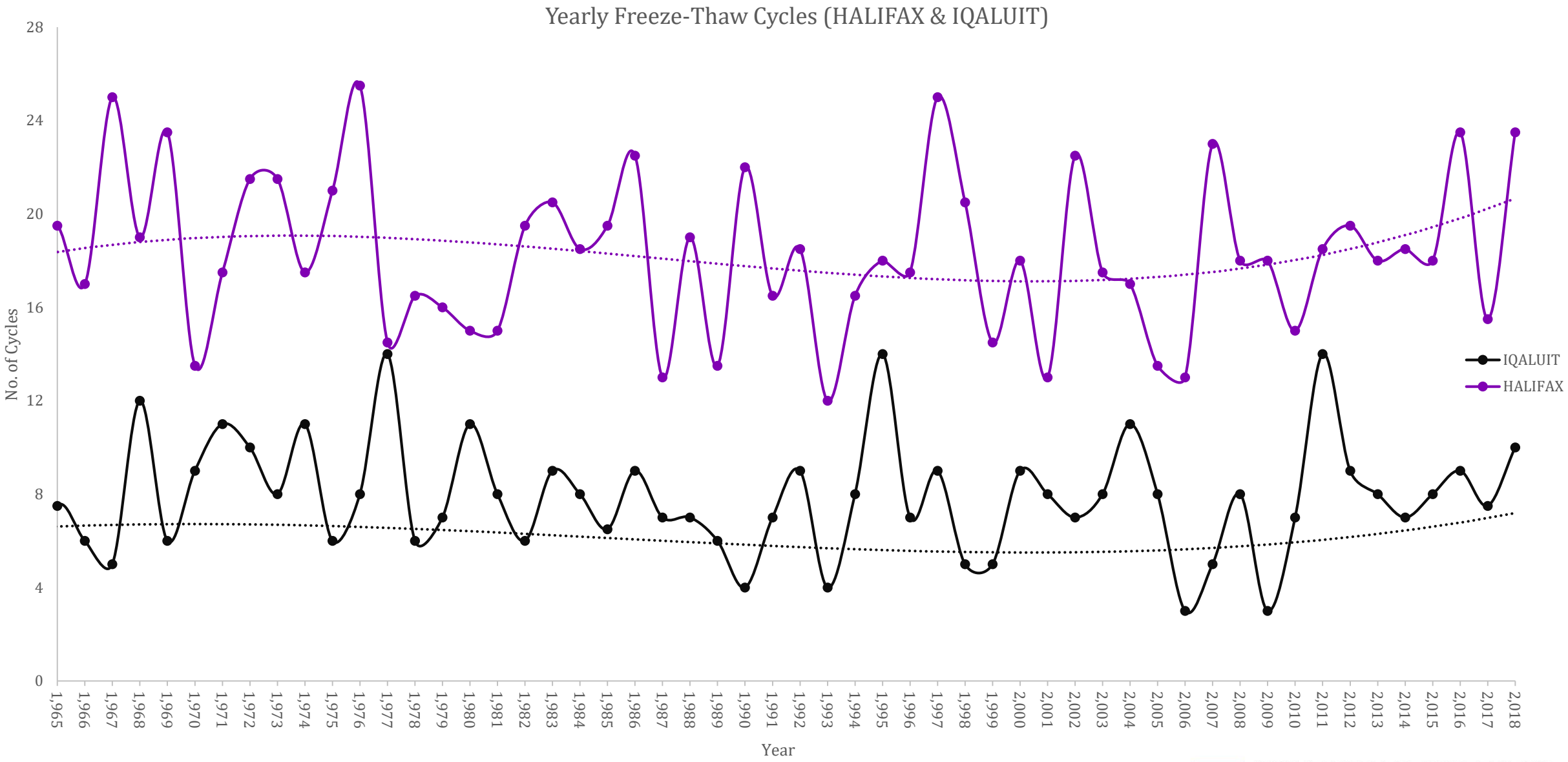

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Climate Change Consequences

Temperature Rise

- Permafrost melting
- Sea-level rise (significant concern for coastal zones)
- Change of location of weather events
- Wind speed and direction intensification
- Freeze-Thaw Cycles variation
- Infrastructure damage

Increment in Precipitation

- Extreme snow events
- Higher frequency of floods
- Infrastructure damage

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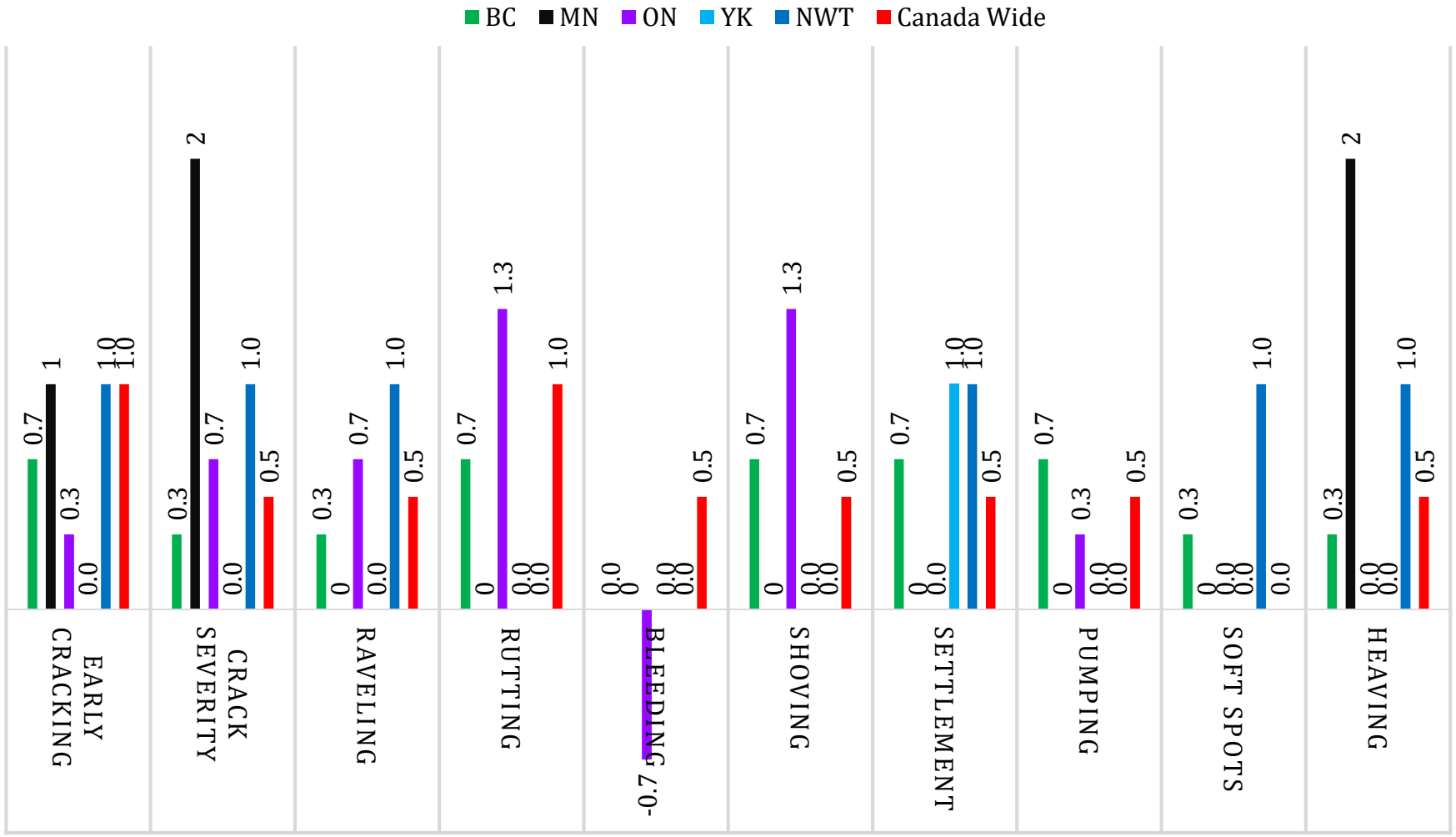
Canadian Airport Authorities Perspective under climate change consequences on airfield pavement structures



Extend of Opinion	Quantification
Strongly Agree	2
Agree	1
Neutral	0
Disagree	-1
Strongly Disagree	-2

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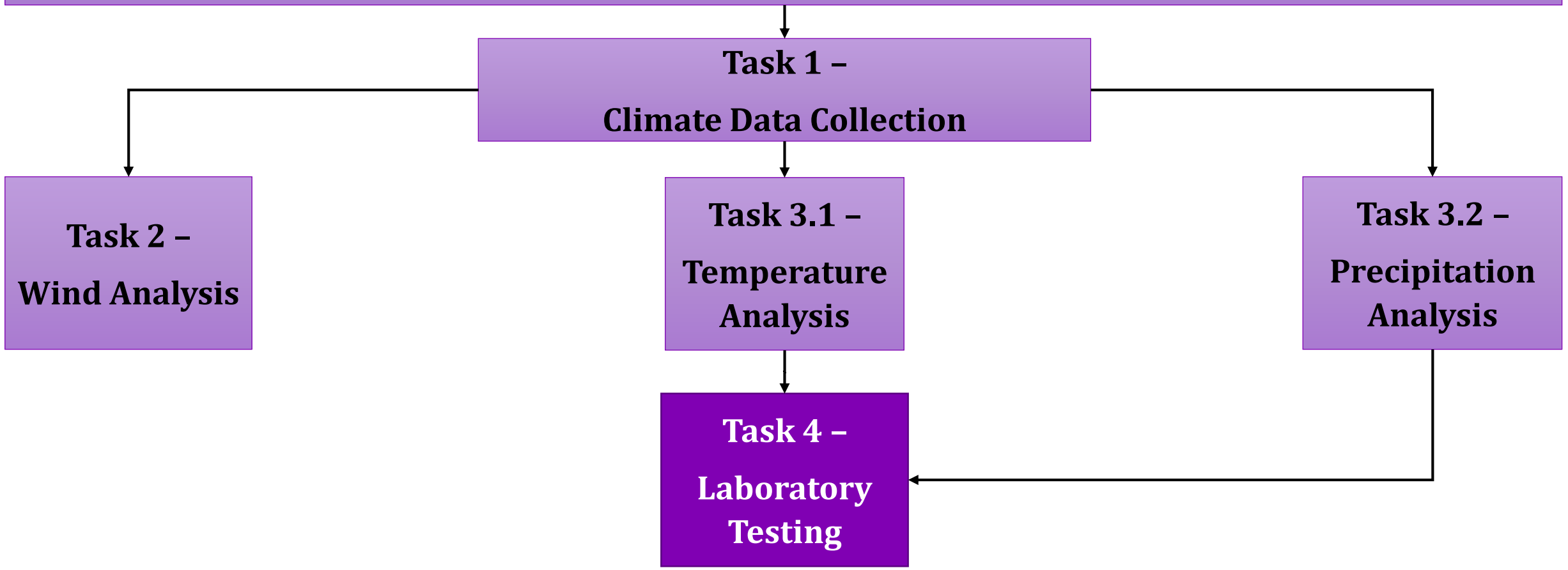
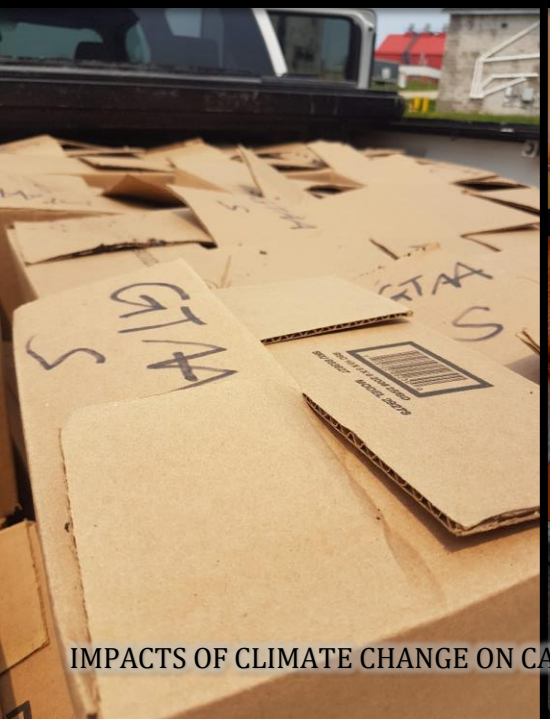
CLIMATE CHANGE

Impacts to Canadian Airport Pavements

Impacts of Climate Change on Canadian Airport Pavements



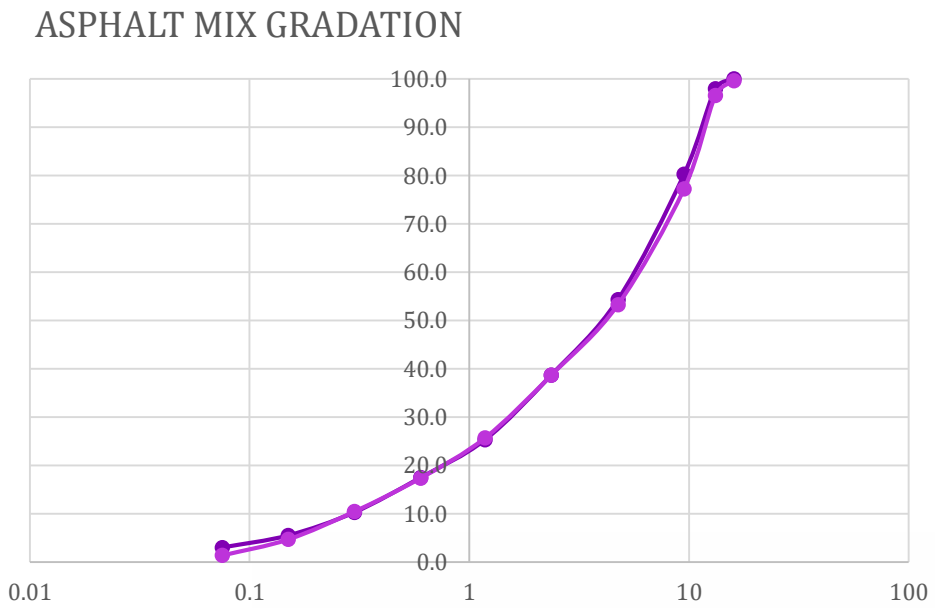


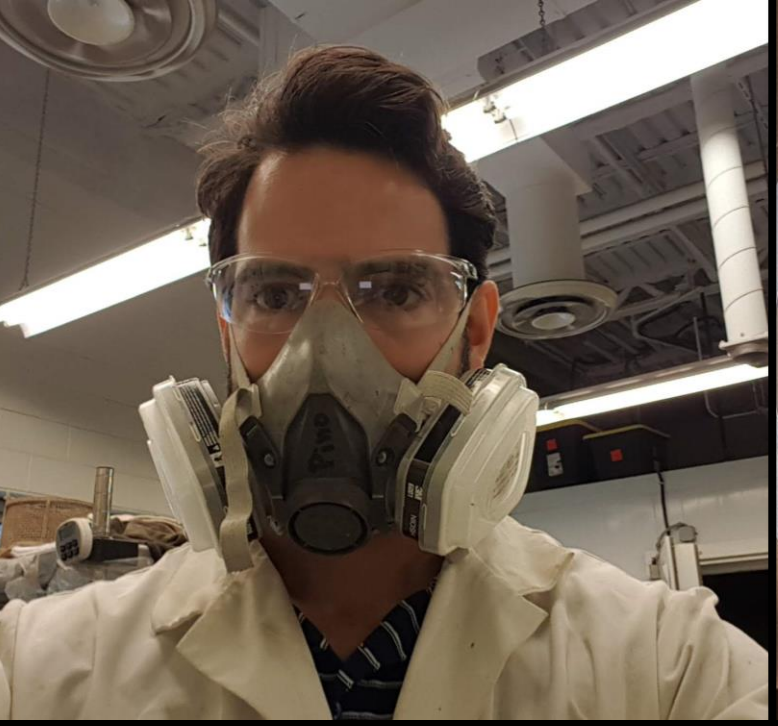
The asphalt samples were to be used on Toronto Pearson Airport's Taxiway.

They were designed by SNC Lavalin and produced by PaveAl.

The samples were picked up at the PaveAl's plant, stored in boxes, and transported to the Centre for Pavement and Transportation Technology's warehouse and laboratory.

ASPHALT CONTENT = 5.2%; PG 70-28J






Rotavapor
BÜCHI 471 Oil Bath


U.S.A. STANDARD TEST SIEVE
ASTM E-11 SPECIFICATION
GILSON
CANADIAN STANDARD SIEVE SERIES
DANGER
HAZARDOUS MATERIAL
CPATT

SAMPLE'S PREPARATION AND CONDITIONING

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HAMBURG WHEEL TRACK TEST

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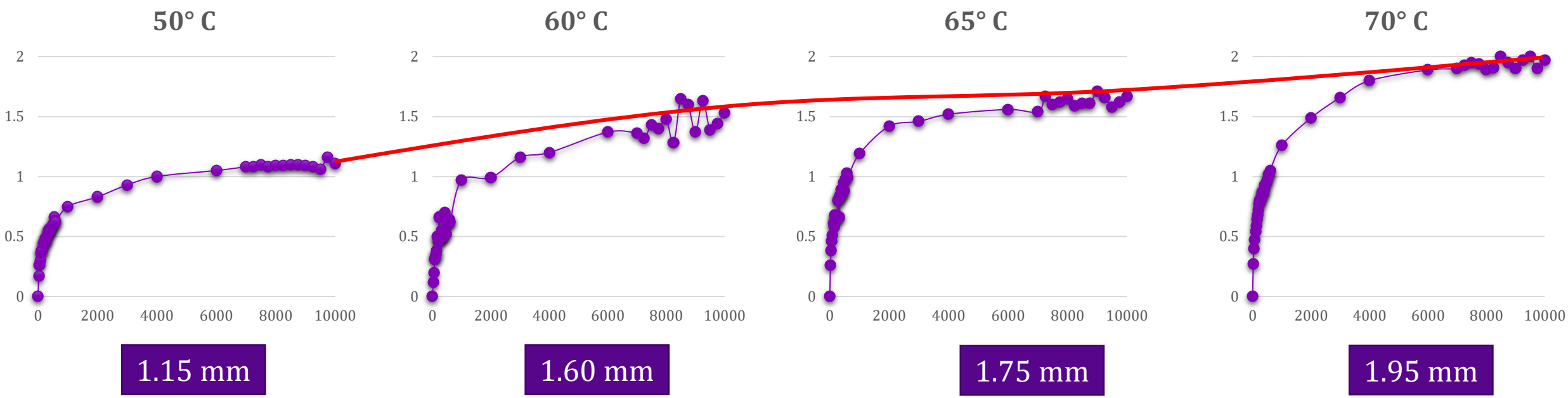
Temperature Variation



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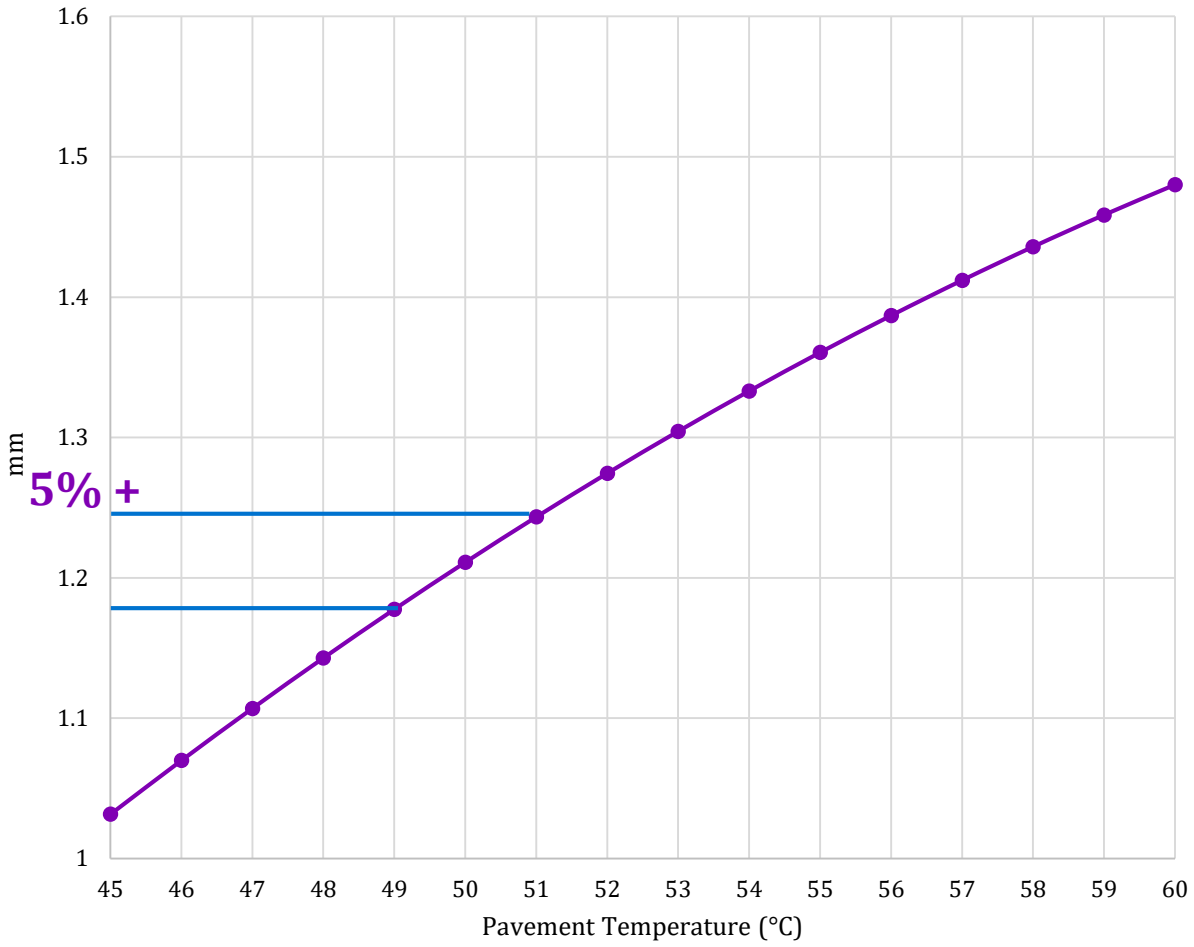
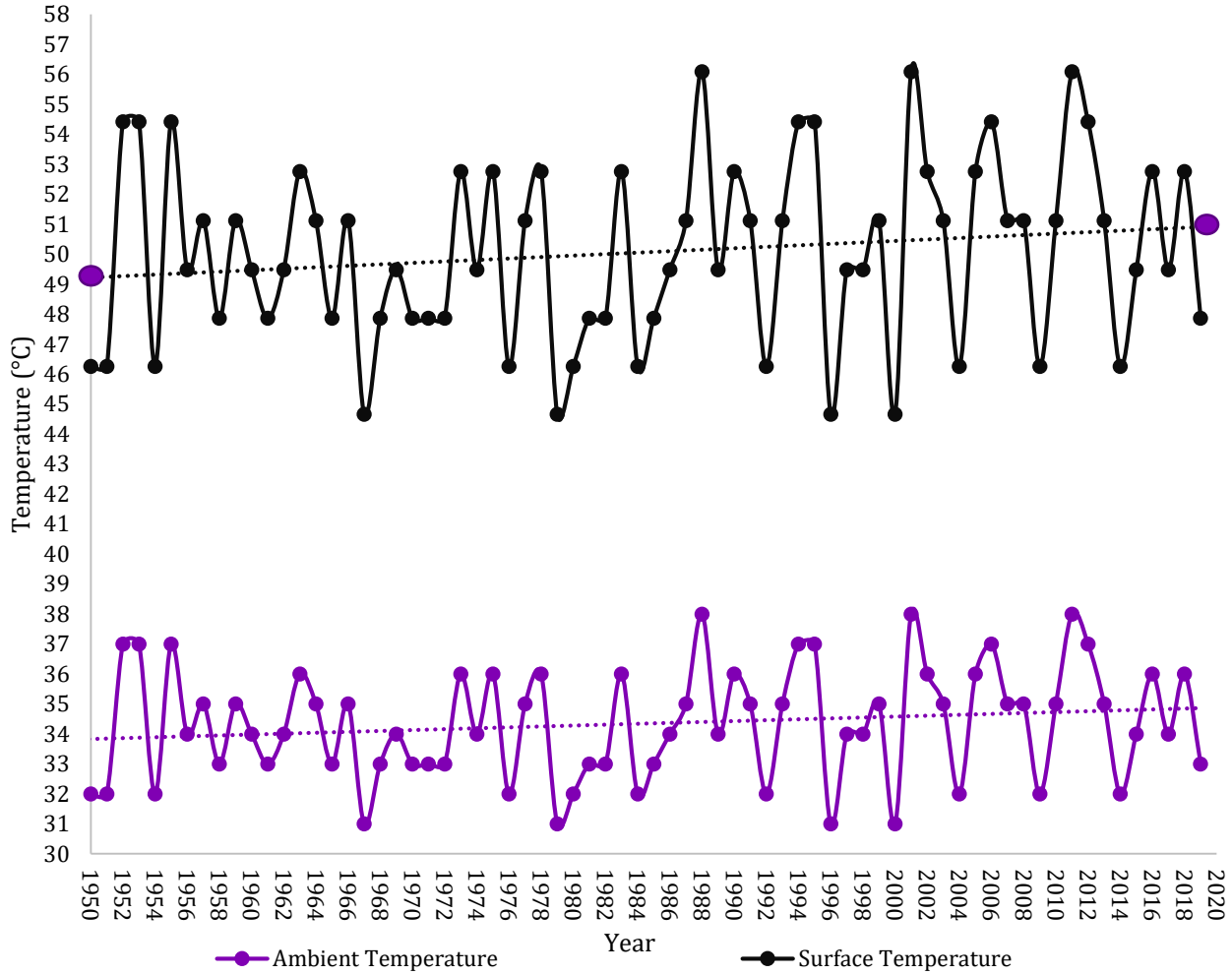
Temperature Variation

Pavement temperature versus Permanent Deformation after 10,000 Cycles



Highest Yearly Temperature at Toronto Pearson International Airport



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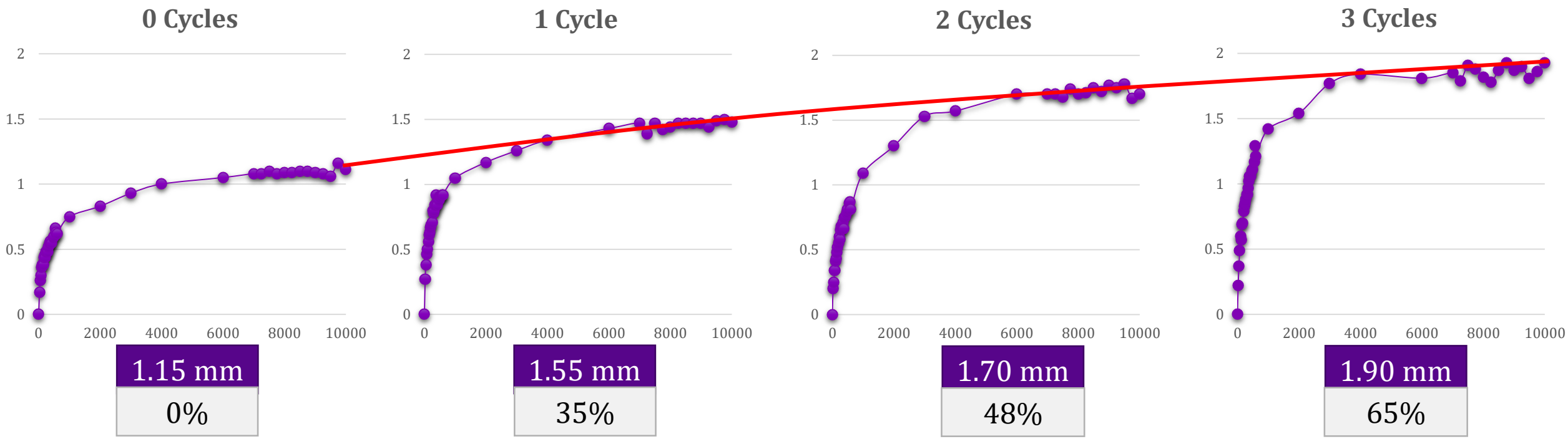
Freeze-Thaw Cycles Variation



As it can be seen, the more freeze-thaw cycles, the higher the susceptibility to rutting.
The results present that after some years of exposure to F-T cycles the pavement surface can be compromised up to a 100% or more.

As an example, before the exposure, if 10,000 arrivals and departures (A&D) from a A380 were needed to provoke 10 mm of permanent deformation, after 3 years of exposure to F-T, the same 10,000 A&D of the A380 will induce 16.5 mm of deformation.

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Freeze-Thaw Cycles Variation

Temperature Variation

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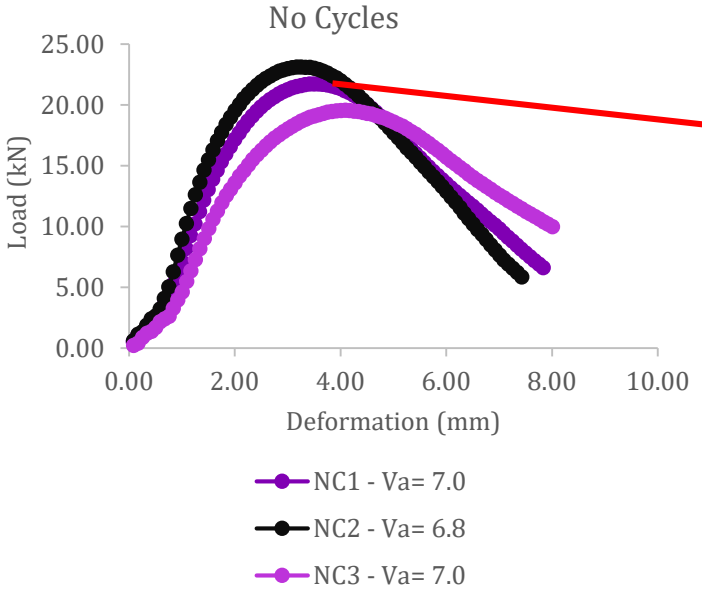
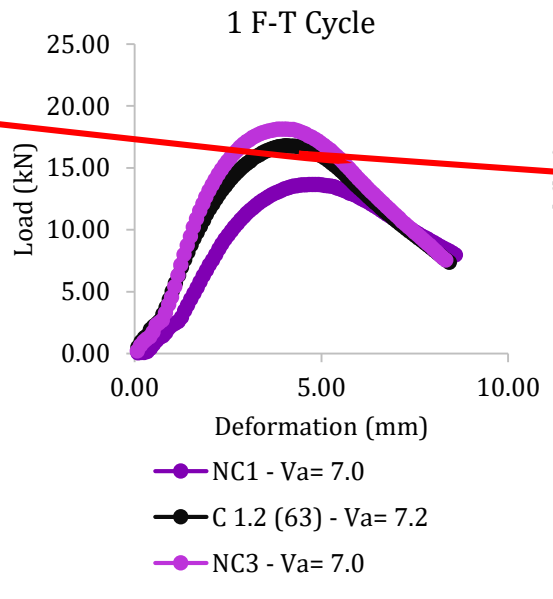
TENSILE STRENGTH RATIO

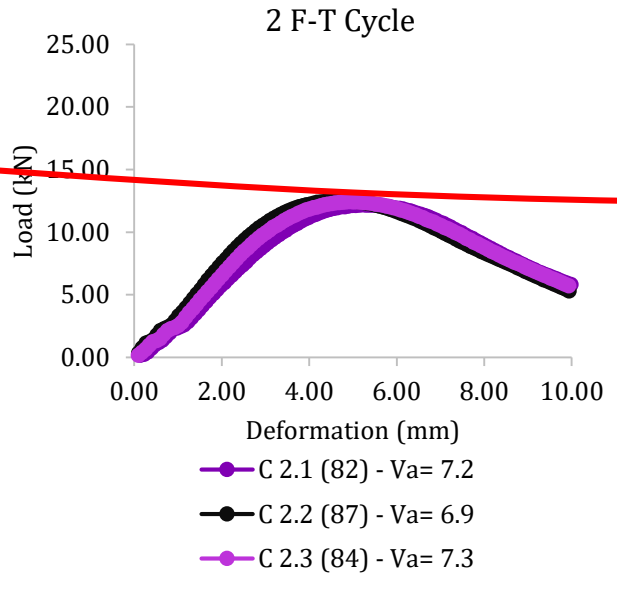
TENSILE STRENGTH RATIO



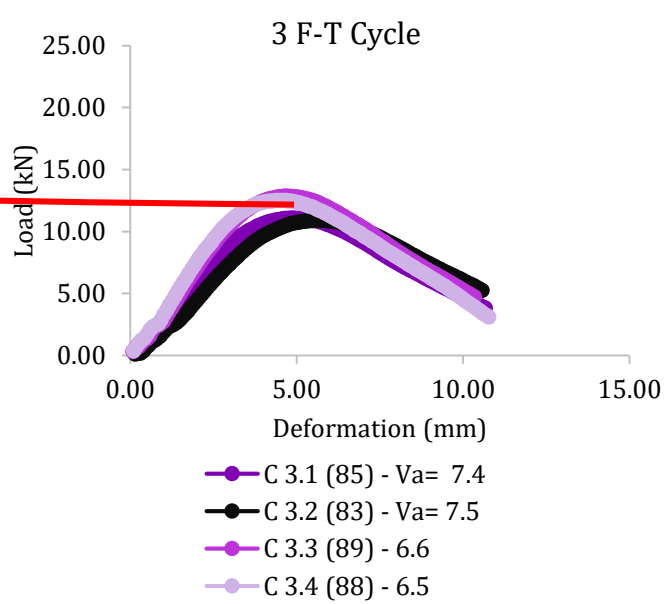
100%



76%

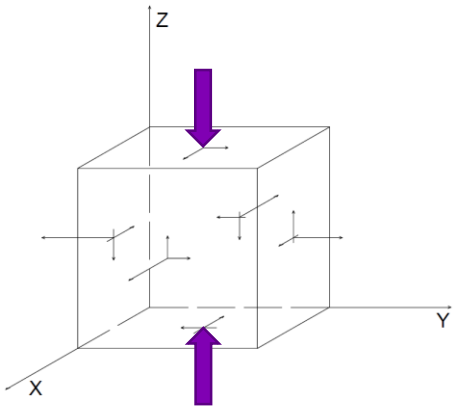


55%



51%

When a vertical load is applied to a mass, it creates vertical but also shear stresses inside the mass.



Similarly as the HWTT presented before, the more F-T cycles, the higher damage the sample will have.

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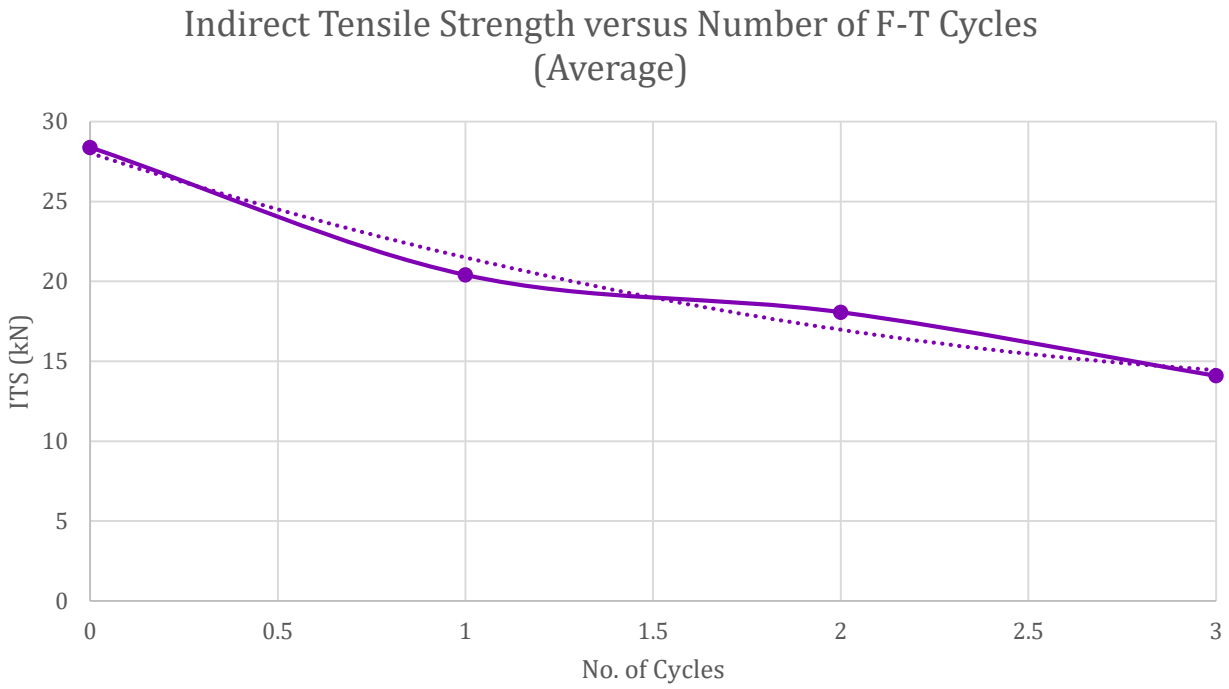
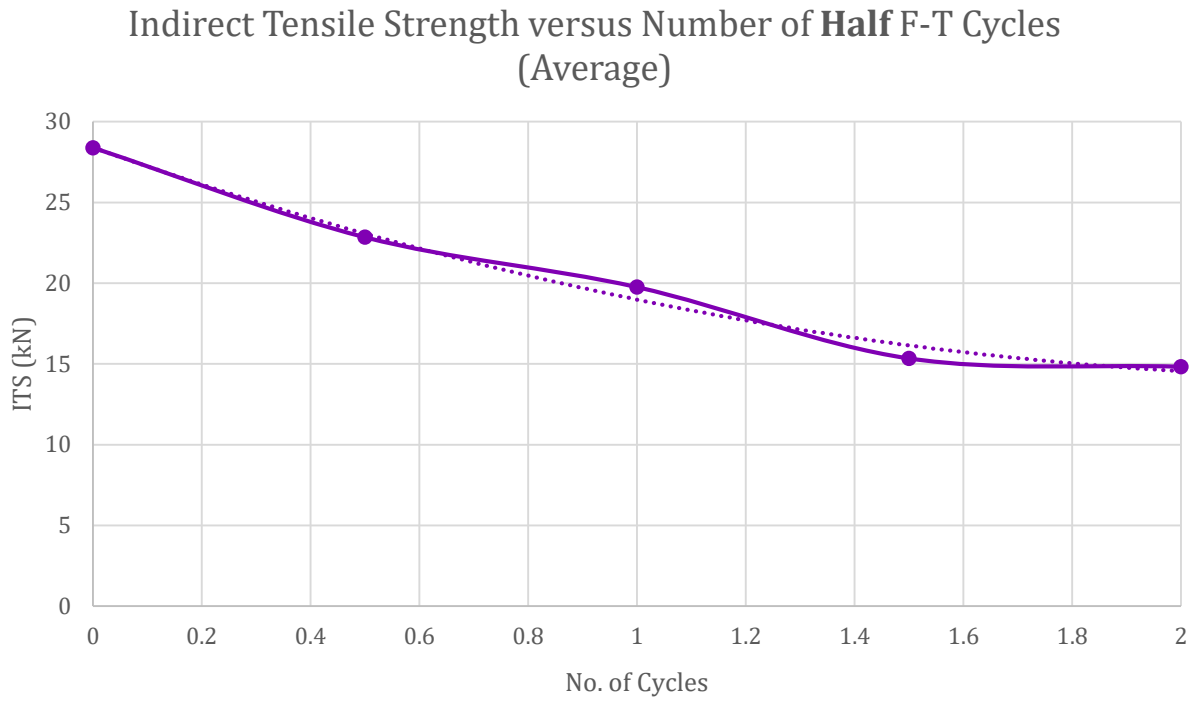
TENSILE STRENGTH RATIO MODIFIED (50 MM/S)





The left figure shows that the higher the impact, the stiffer the asphalt sample becomes and therefore, the higher indirect tensile strength will have.

The results of this right figure explain that the quantity of cycles is more significant that the timing of the cycles. That being said, going back to the F-T cycle's example presented in page 14 on which Halifax and Iqaluit airports were involved, Halifax Airport is being meaningfully more impacted by F-T cycles than Iqaluit Airport.

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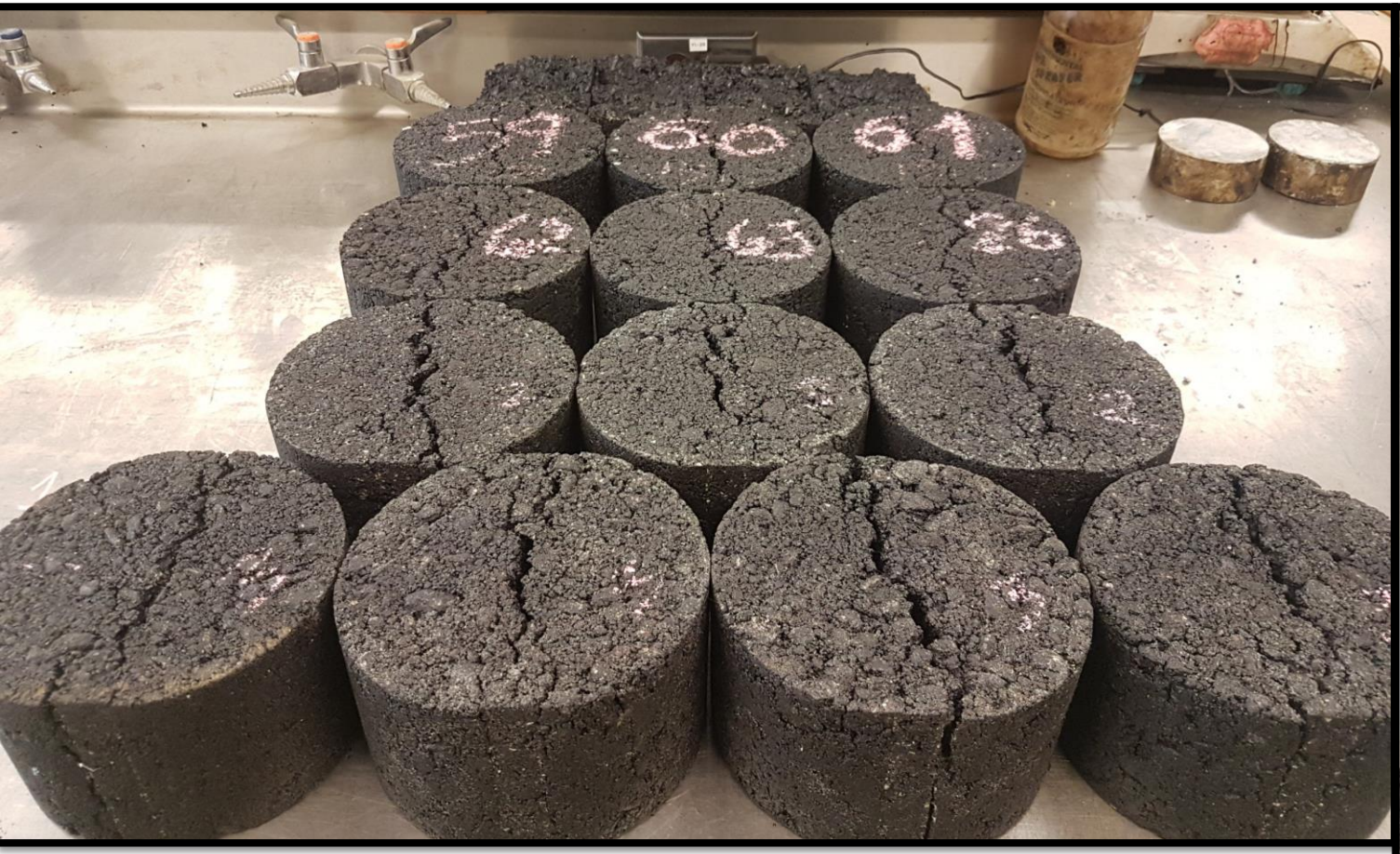

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IDEAL CRACKING TEST

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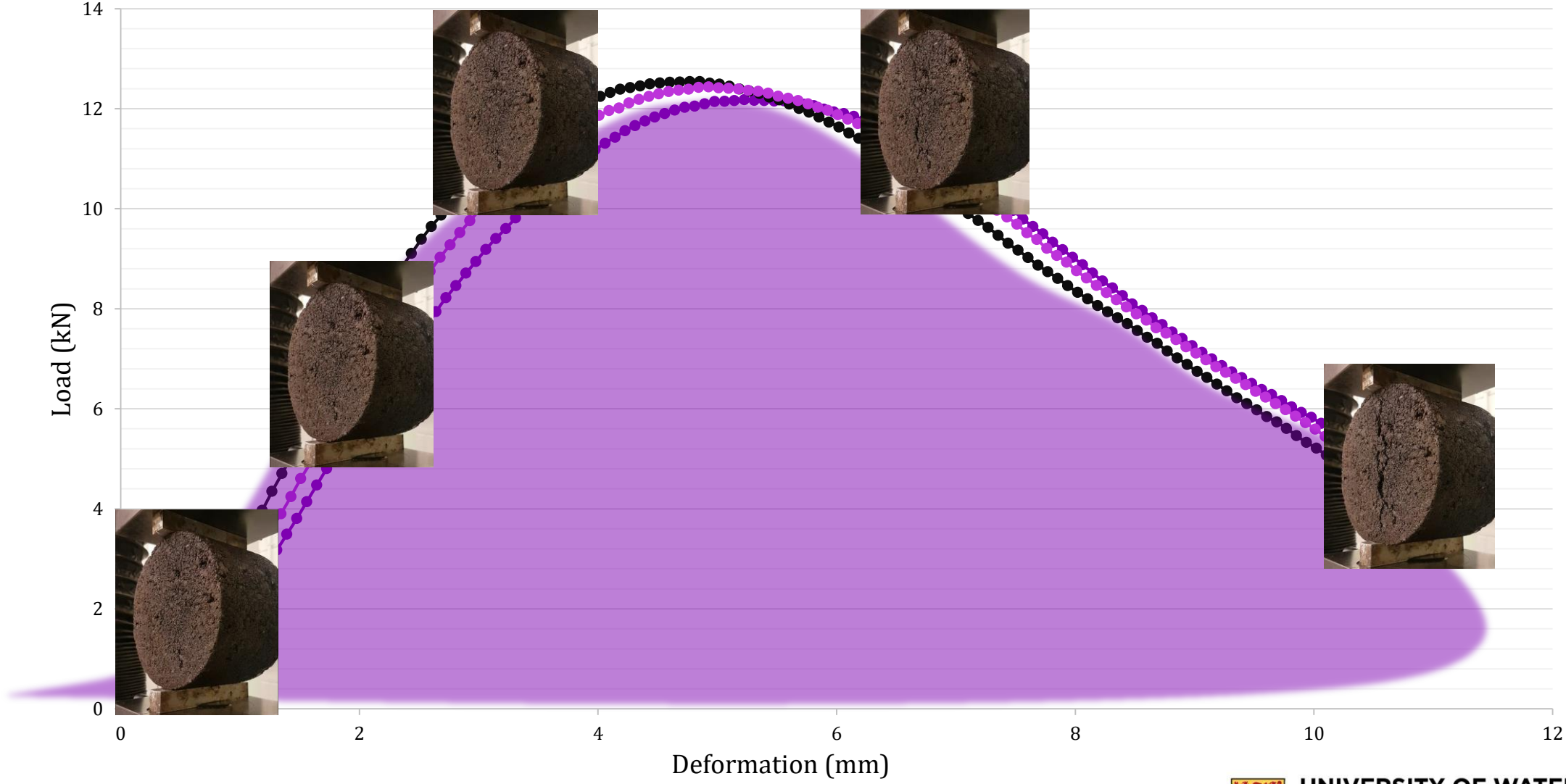
IDEAL CRACKING TEST



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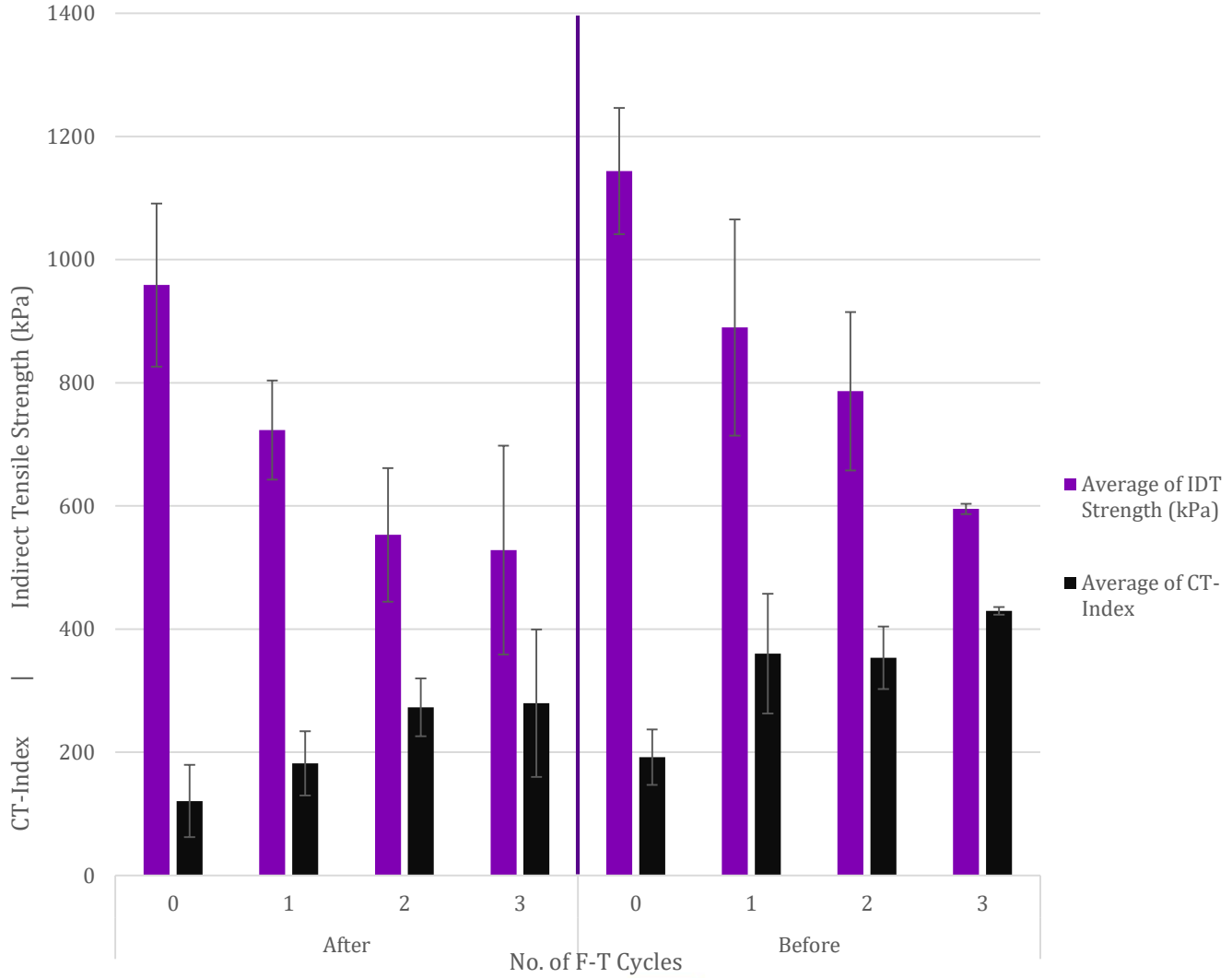
IDEAL CRACKING TEST

- The more FT Cycles, the lower Indirect Tensile Strength; in addition, the higher Cracking Test Index, meaning that every time the asphalt layer freezes and thaws it becomes less strong and more susceptible to cracking.
- In another hand, considering the traffic load, if the impact of loading is higher/faster, the strength of the asphalt, at the moment of impact, is greater, but also the promptness to cracking rises, specially during cold seasons.



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CONCLUSIONS

WHAT IS CLIMATE CHANGE?

- Climate is long-term average of the weather, while climate change is a variation of the statistical distribution of the weather patterns.
- Is being mainly caused by anthropogenic reasons, specifically the burn of fossil fuels, augmenting the concentration of GHGs in the atmosphere, which has also decreased the Albedo, melt a significant amount of sea-ice, among other consequences.

HOW IS THE CLIMATE CHANGING IN THE DIFFERENCE PROVINCES AND/OR TERRITORIES IN CANADA

- Indeed, Canada as part of the world itself, is getting warmer/hotter. Additionally, it is becoming wetter, as the amount of yearly precipitation is being increasing.
- Similar as the sea-ice melting, the permafrost in northern Canada is being reduced which significantly impacts infrastructures and other industries as well.
- The amount of yearly freeze-thaw cycles varies meaningfully, not necessarily increasing nor decreasing (in the long term). It is recommended to make a comparison between provinces to evaluate the necessity to take any further action against this climate challenge.

CONCLUSIONS

HOW MUCH DO THOSE CHANGES ARE IMPACTING THE CANADIAN AIRPORT PAVEMENT INFRASTRUCTURE?

- The more runway directions, the less susceptible the airport will be to crosswinds
- The raise of temperature induces the asphalt mixes to become less elastic making infrastructure more susceptible to rutting/permanent deformation; mostly in southern Canada.
- The increment of precipitation prompts moisture damage to the pavement structure causing stripping, raveling, and lost of indirect tensile strength.
- In northern Canada, the melt of ice on permafrost areas induces settlements and subgrade rutting which directly affects the structural integrity of the pavement structures.

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FUTURE WORK

- This research aims to provide recommendations through the development of mitigation and adaptation strategies for the airside infrastructures to be more resilient against climate change.
- Additionally, the development of GIS Maps to superiorly summarize the environmental results.
- Expected future work is to extend the research to evaluate the impact of climate changes on rigid pavements as well.

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Dr. Sina Varamini, Peng
Michael Esenwa, PEng

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