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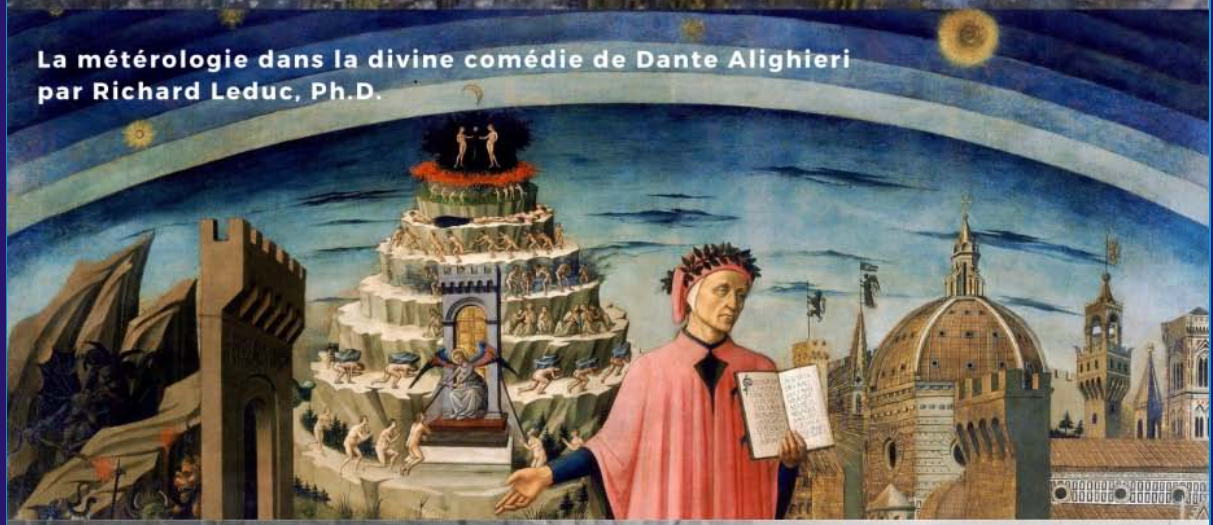

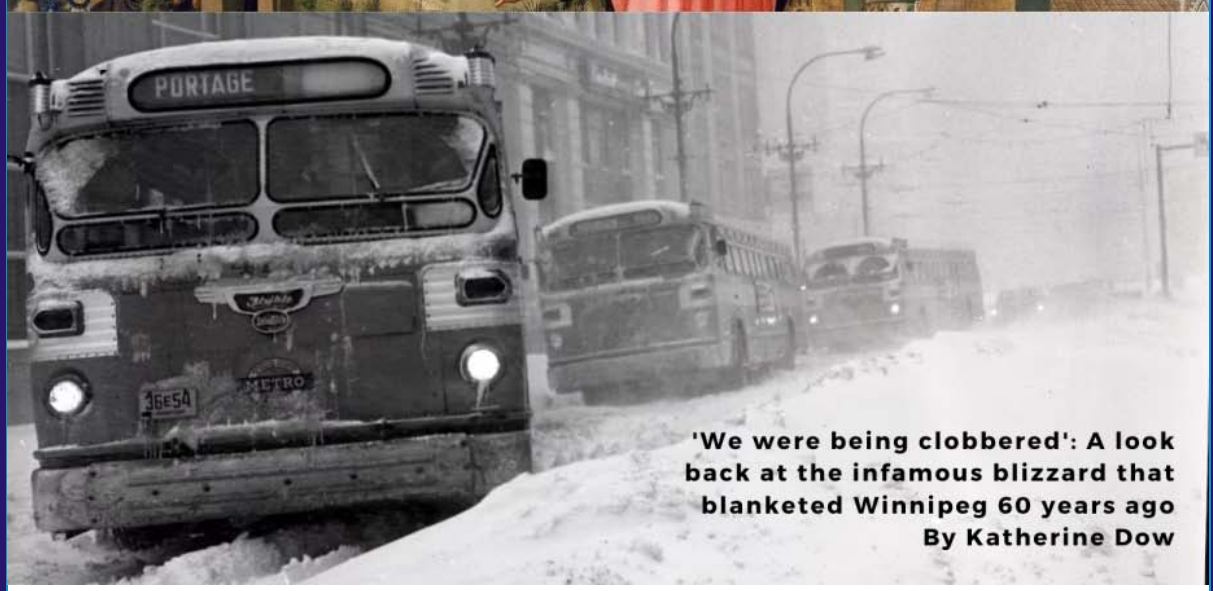

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CMOS Bulletin SCMO

"at the service of its members "

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Words from the President

Our New CMOS Bulletin SCMO

Dear CMOS friends and colleagues,

It is my pleasure to announce the first edition of our revitalized *CMOS Bulletin SCMO.* The *Bulletin* has been part of CMOS, in various formats, since 1963. Our new *Bulletin* will continue to publish short articles by members and others in the fields of interest to Society members. We are making these improvements as part of our 2025-2030 Strategic plan to implement an effective communication strategy. Last year, we introduced *The New Wave* newsletter which provides Society information to members, such as Center news, upcoming events, Congress updates, Council and Executive matters, etc. Our highly regarded and effectively run *Atmosphere-Ocean* journal remains as our flagship publication to share your peer-reviewed science with the world.

Our publications are created to bring our community closer together by sharing knowledge, celebrating achievements, and highlighting the people and ideas that shape our work. Through

these pages, we hope to inform, inspire, and spark conversations that extend well beyond the magazine itself. Your curiosity, dedication, and passion are what make CMOS strong. I encourage you to share your feedback and consider contributing your own experiences and insights in future issues. **Send all feedback and contributions to bulletin@cmos.ca .**

I would like to extend my thanks to the editorial team, contributors, and volunteers whose hard work and vision brought these improvements to life.

I thank you for being part of CMOS and for helping us continue to connect and grow.

Patrick McCarthy
President, CMOS

Notre nouveau CMOS Bulletin SCMO

Chers amis et collègues de la SCMO,

J'ai le plaisir d'annoncer la première édition de notre *CMOS Bulletin SCMO* remanié. Le *Bulletin* fait partie intégrante de la SCMO, sous diverses formes, depuis 1963. Notre nouveau *Bulletin* continuera à publier de courts articles rédigés par des membres et d'autres contributeurs dans les domaines qui intéressent les membres de la Société. Nous apportons ces améliorations dans le cadre de notre plan stratégique 2025-2030 visant à mettre en œuvre une stratégie de communication efficace. L'année dernière, nous avons lancé l'Onde d'infolettre, qui fournit aux membres des informations sur la Société, telles que les actualités des Centres, les événements à venir, les mises à jour sur le congrès, les questions relatives au Conseil et à la direction, etc. Notre revue *Atmosphere-Ocean*, très appréciée et gérée avec efficacité, reste notre publication phare pour partager avec le monde entier vos travaux scientifiques évalués par des pairs.

Nos publications ont pour objectif de renforcer les liens au sein de notre communauté en partageant des connaissances, en célébrant les réussites et en mettant en avant les personnes et les idées qui façonnent notre travail. À travers ces pages, nous espérons informer, inspirer et susciter des échanges qui dépassent largement le cadre du magazine lui-même. C'est votre curiosité, votre dévouement et votre passion qui font la force de la SCMO. Je vous encourage à nous faire part de vos commentaires et à envisager de partager vos propres expériences et réflexions dans les prochains numéros. **Veuillez envoyer vos commentaires et contributions à bulletin@scmo.ca.**

Je tiens à remercier l'équipe éditoriale, les contributeurs et les bénévoles dont le travail acharné et la vision ont permis de concrétiser ces améliorations.

Je vous remercie de faire partie de la SCMO et de nous aider à rester en contact et à nous développer.

Patrick McCarthy
Président de la SCMO

Articles & Reports

Uncertainties in Carbon Emissions from 2023 Canadian Wildfires

By: GS Strong
This paper is endorsed by the Canadian Association of the Club of Rome (CACOR), where Strong sits on the Board.

Abstract

It is well established that carbon dioxide (CO_2) emissions from burning fossil fuels are the primary cause of global warming. Wildfires increase those emissions, and published research on the devastating 2023 Canadian wildfires (Figure 1) suggests that CO_2 emissions can exceed those of fossil fuels from all sources, in this case, by a factor of 3-4 times.

The consequence of these wildfire estimates, if correct, could render all current climate model predictions for future global temperatures to be under-estimated. The purpose of this paper is to investigate several factors in the published results that suggest their calculations for carbon emissions from wildfires may be over-estimated. Such estimates are of crucial importance because carbon emissions from wildfires are mostly excluded from greenhouse gas reporting. That makes it imperative to resolve the problem so that governments can act accordingly.

Figure 1: Active 2023 wildfires in Canada only to July 23. Quebec and Atlantic provinces had similar fires during August. (Reproduced from https://www.aljazeera.com/news .)

Introduction

Climate warming has caused drought conditions across much of Canada, so that historical forest fire conditions are being supplanted by more frequent and more devastating *wildfires* ; that is, uncontrolled fires in a forest or grassland. These have become most prevalent in the last two decades, and can be linked to climate warming. Wildfires destroy or force evacuations

from many towns and cities. More recent ones include Slave Lake AB (May 2011); Richardson AB (Summer 2011); Timmins ON (May-Nov 2011); NWT (Summer 2014); Ft McMurray AB (May-July 2016); Central and South Interior, BC (2017); Parry Sound ON (2018); BC (2018); NW and central AB (2019); Lytton BC (June 2021); Nova Scotia (2023); Alberta and BC (2023 and 2024); Flin Flon MN and Denare Beach SK (May-June 2025); and Newfoundland (August 2025). Wildfires will continue in the future and may even worsen until humans learn to live without burning fossil fuels.

The wildfires shown in Figure 1 (up to July 23) were not limited to western Canada. Many fires broke out later in eastern Ontario and throughout Quebec and the Atlantic provinces. Wildfires were not confined to Canada during 2023; they were also prevalent in Europe and across Asia.

Carbon Emissions from Forest Fires

The stage of a fire significantly impacts carbon monoxide (CO) levels. Smoldering fires, characterized by low heat and restricted oxygen flow, are especially prone to generating high concentrations of CO. Intense hot fires that burn with more visible flames and greater oxygen availability, tend to produce more CO_2 and less CO. That aside, when CO is produced along with CO_2 from the burning of fossil fuels and from forest fires, the CO eventually oxidizes by combining with oxygen (O2) in the atmosphere to produce additional CO_2 through the reaction:

$2CO + O2 \rightarrow 2CO2$.

This reaction is often a slow process, but it is still a major concern with forest fires, since additional CO_2 represents a positive feedback to climate warming.

Climatology of Forest Fires in Canada

There were 6690 individual fires in Canada during 2023 so that with the number appears like an average or below average year in Figure 2, showing total burn areas from 1983-2023.

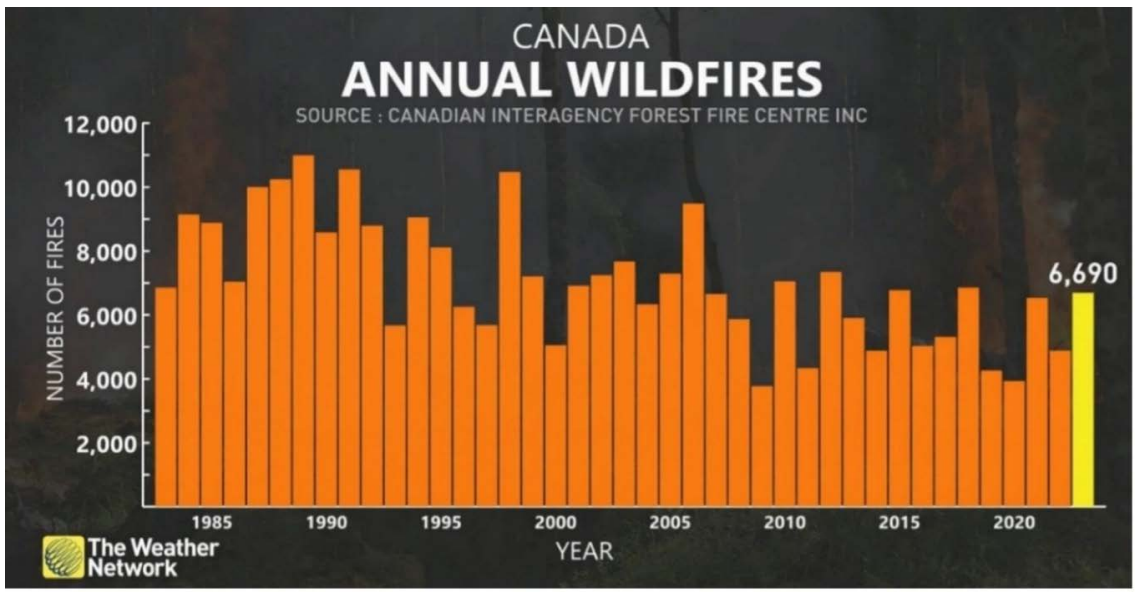

Figure 2: Annual number of forest fires, 1983-2023 (from The Weather Network).

However, when the total area burned during the 2023 wildfires is compared with those of 1983-2023, there is no contest as 2023 burned a record of almost 15 million hectares versus the climatological average of 2-3 million hectares (Figure 3).

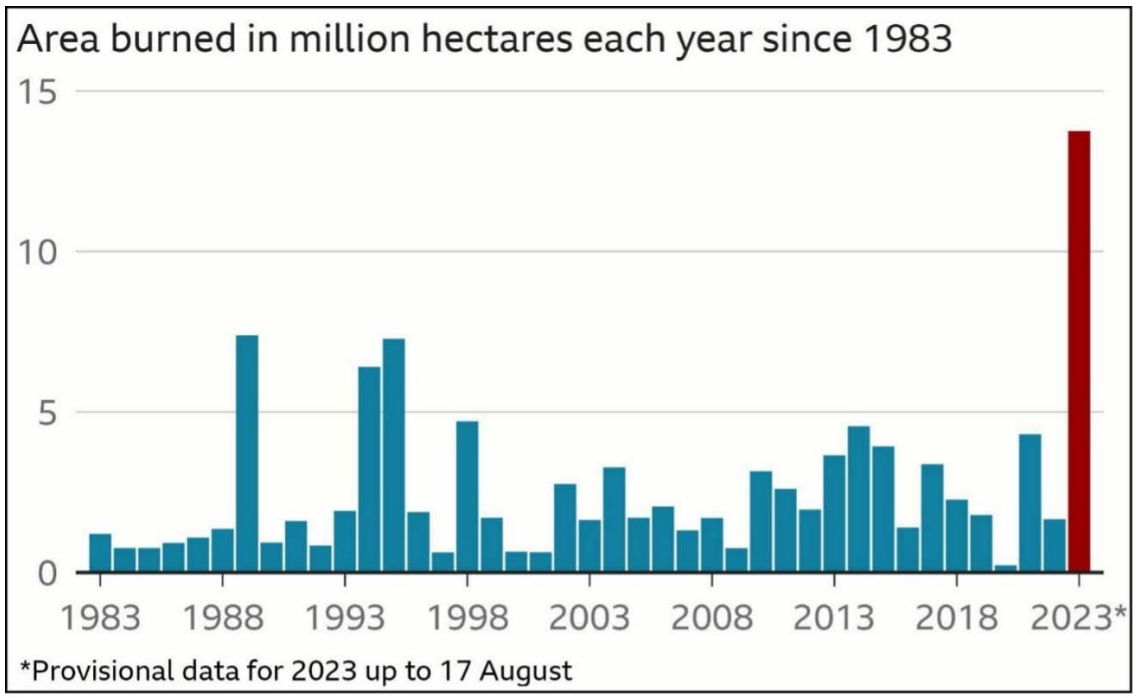

Figure 3: Annual total areas of forest fire burn and intensity, 1982-2023. (Source: Canadian Interagency Forest Fire Centre.)

Research on 2023 Canadian Wildfires

We focus on two papers investigating Canada's 2023 wildfires that were published in 2024. MacCarthy et al. (June 27, 2024) estimated that "*2023 Canadian wildfires burned nearly 7.8 million hectares of forest . . . and emitted nearly 3 billion tons of CO_2*". Byrne et al. (Aug. 28, 2024) pegged the *cumulative burn area as 15 million hectares*, almost double that of MacCarthy et al., which agreed with estimates by the Canadian Interagency Forest Fire Centre. The differences in total burn areas in the two studies alone should have triggered a more thorough examination.

The MacCarthy group estimate of CO_2 (3 billion tons = 2.72 billion metric tonnes) is more than 4 times the 2023 CO_2 emissions from fossil fuel combustion and industrial processes in Canada, which totaled 694 Mt (million tonnes) according to ECCC data.

The Byrne group stated: "*The 2023 Canadian forest fires have been extreme in scale and intensity . . . and the magnitude of the carbon* (i.e., $C = CO + CO_2$) *emissions is 647 TgC* (carbon)" Media had misinterpreted this number as 647 MT of CO_2. But 647 Tg of Carbon (=3.664 X 647 MT CO_2) = 2370 MT CO_2. Combined with CO_2 from fossil fuels, it amounts to a total output of 3064 MT, 4.4 times that of fossil fuels alone, agreeing with the MacCarthy group. The Byrne group added that fire, insects, and droughts were driving Canadian forests into a carbon source rather than sink. While they admitted that "*The CO_2/CO emission ratios can be highly variable, adding uncertainty to our analysis*," the magnitude of their results are extremely important and **should be a shocking revelation to the climate science community and to the Canadian government**.

Early hints of these results were reported a year earlier (presumably leaked) in the middle of the 2023 wildfire catastrophe. A few examples of media editorials included: "*Wildfires are set to double Canada's climate emissions this year*" (Financial Post, July 26, 2023); "*Canadian wildfire emissions double previous record as flames rage on*" (CTV News, Aug. 3, 2023); and "*Our forests have reached a tipping point*" (National Observer, Aug. 21, 2023), among others. It was these

stark media reports that prompted this paper to check whether the research results missed something important.

Meanwhile, the fossil fuel industry played up these alarming results because it automatically took some heat off them (fires emitting 4 times more CO_2 than fossil fuels), and it may have been a factor in the Canadian government delaying any significant moves to curtail carbon emissions from fossil fuels throughout 2025. It may also have been a factor in BC government easing forestry rules to allow more harvesting of trees, perhaps to curtail forest fires? If true, these would be big mistakes, for governments at all levels need to take notice of science results in making or changing policies affecting the environment.

Before considering potential errors in the MacCarthy and Byrne papers, it is necessary to first examine how much CO_2 trees sequester from the atmosphere in order to estimate the carbon emission potential of wildfires.

Carbon Sequestration by Trees

Strong and Barge (2022) applied data and analysis techniques from several forestry research centres in North America to compute carbon sequestration rates for Douglas Firs (common to British Columbia), and for eastern Sugar Maples. Table 1 summarizes those results for 10-year increments of growth for Douglas Firs up to 100 years.

Various sources suggest that tree mass is distributed as 1% in the leaves, 11% in branches, 62% in the main trunk, and 26% in the roots. Of course, it's the first two numbers, leaves and branches (12% of the tree's mass), that take the first brunt of burning in a forest fire, which effectively kills most trees, while any remaining upright tree trunks and unburned roots contain the bulk of carbon by far, as much as 88% for large trees.

TABLE 1: CO_2 Sequestration Rates by Age for Douglas Firs (From Strong and Barge, 2022)

Age (years)	Diameter (cm)	Height (m)	Total Wt green (kg)	Dry Wt (kg)	Wt of Carbon (kg)	Sequestered Wt of CO2 (kg/yr)	Cumulative Wt of CO2 (tonnes)	No. Trees to Sequester 1 MT per year
5	4.0	3.9	3.6	2.6	1.3	1.0	0.0020	1,040,245,000
10	**6.6**	**6.3**	**16.2**	**11.7**	**5.9**	**2.2**	**0.0127**	**464,705,000**
20	11.3	10.7	79.2	57.4	28.7	5.3	0.0571	189,574,000
30	15.6	14.5	203.3	147.4	73.7	9.0	0.1377	119,808,000
40	19.6	17.7	392.9	284.9	142.4	13.1	0.2583	76,435,000
50	**23.3**	**20.6**	**646.9**	**469.0**	**234.5**	**17.2**	**0.4202**	**58,035,000**
60	26.9	23.1	960.6	696.4	348.2	21.3	0.6233	46,901,000
70	30.1	25.3	1,327.7	962.6	481.3	25.3	0.8662	39,589,000
80	33.2	27.3	1,741.2	1,262.4	631.2	29.0	1.1469	34,499,000
90	36.1	29.1	2,194.2	1,590.8	795.4	32.5	1.4630	30,798,000
100	**38.9**	**30.7**	**2,680.1**	**1,943.1**	**971.6**	**35.7**	**1.8121**	**28,016,000**

A 50-year-old Douglas Fir on average weighs 647 kg ; its dry weight is 469 kg; sequestered carbon (50% of dry weight) is 235 kg. The cumulative weight of sequestered CO_2 per tree is 0.42 tonne over its 50-year growth. The comparative value for 50-year Sugar Maples was 0.41 tonne, so one can infer that other native boreal trees such as spruce would be approximately the same over a 50-year period. From these data, one can estimate:

a. The number of trees to sequester 647 MT of CO_2 over the tree's lifetime is approximately 647,000,000 ÷ 0.42 = 1.54 billion trees growing over a 50-year period.
b. The number of trees to sequester Byrne et al.'s 2370 MT = 2,370,000,000 ÷ 0.42 = 5.6 billion trees. Canada has approximately 277 billion trees (Betkowski, 2025), which means that the 2023 wildfires would have destroyed about 2% of that total, ***if*** all trees

were completely consumed (which seems rather unlikely considering Figures 5 and 6 coming up).

Possible Sources of Error in the MacCarthy and Byrne Results

The total global CO_2 emissions from burning fossil fuels in 2023 was 36.8 billion tonnes, meaning that Canada's total CO_2 output (3.064 billion tonnes) was a significant 8.3% of global emissions. The burns across Europe and Asia could conceivably double the Canadian numbers.

During the Covid epidemic in early 2020, most industries across the globe shut down for 1-3 months. The drop in atmospheric CO_2 was noticeable in the short-term measurements of CO_2 from the NOAA observatory at Mauna Loa [1]. For such dramatic increases in atmospheric CO_2 from the 2023 wildfires across Canada, Europe, and Asia, one might expect to see a slight upward trend or pause in the monthly data from Mauna Loa, against the seasonal decline that typically starts in late-May, but such is not the case with the orange (2023) curve shown in Figure 4 [2]. This also raises slight doubt about the validity of the Byrne group estimates. However, it is noteworthy that NASA adopted the Byrne results in a press release on August 28, 2024. We summarize possible sources of error in the MacCarthy and Byrne results in what follows:

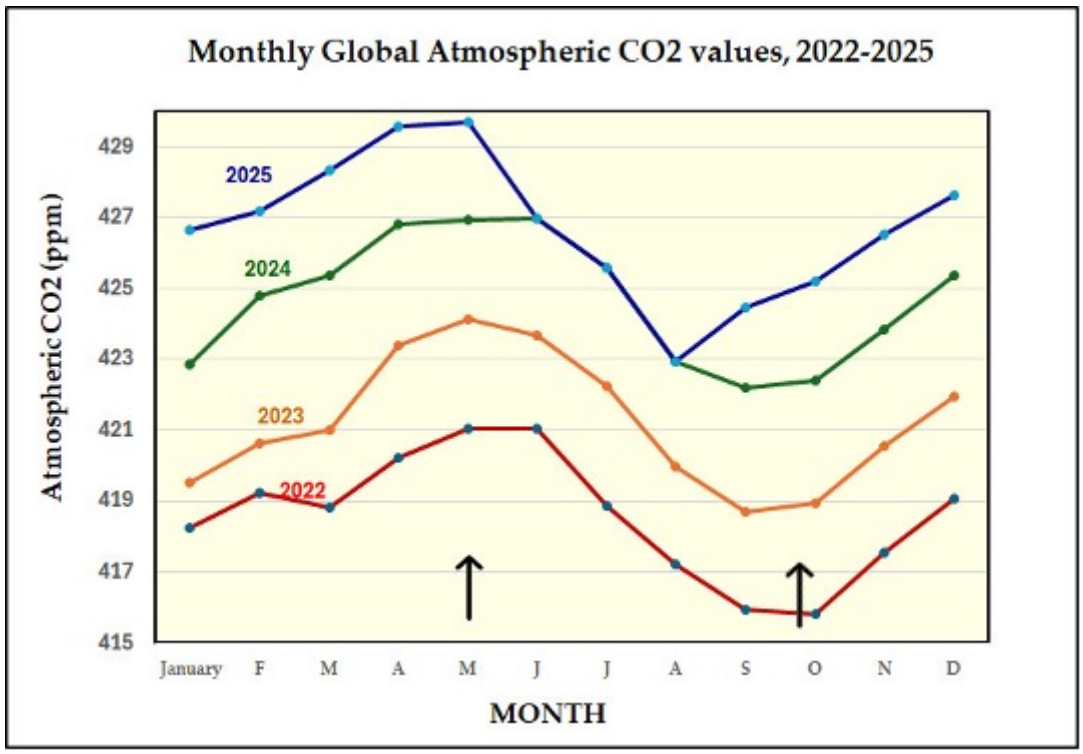

Figure 4: Monthly average atmospheric CO_2 measurements from Mauna Loa data for 2022 to 2025. (Data from NOAA Mauna Loa Observatory.)

1. Total areas Burned - MacCarthy et al. estimated the total burn areas across Canada to be 7.8 million hectares (78,000 km^2), while Byrne et al. pegged the total burn areas as 15 million hectares, almost twice that of MacCarthy et al. Obviously, it is essential to more accurately quantify the total area of 'burn', but data are not available at this time to determine which was more correct. However, we refer to a recent paper by van der Werf et al. (2025), in which they show that a new version of the Global Fire Emissions Database (GFED5) incorporates new information, particularly on 'area of burns', and "new improved modeling of fuel loadings, and new emission factors." We note that the Byrne group used an older version, GFED4 [3].

2. Sporadic burn areas - Operational estimates of 'burn areas' do not account for the fact that forest fires usually burn forested regions sporadically, such as the photos in Figure 5 from the Alberta Jasper Park wildfire of July 2024, and 2025 fires over Manitoba and Ontario demonstrate. The latter included 4 separate fires within the red ellipse. Similar intermittent unburned areas were not noted in either paper addressed here, and may be a source of over-estimates of CO_2.

Figure 5: (a) A Portion of the Jasper Park fire of July 2024, showing gaps of green forest (photo from Parks Canada). (b) Fires that broke out in southeast Manitoba and western Ontario on May 15, 2025. (Photo from NASA Earth Observatory.)

3. Post-Fire Forest - Once a forest fire is out, the burn area often looks much like the photos in Figure 6, (with graveyards of the largest unconsumed upright tree trunks, but which, with the roots still contain more than 80% of the carbon sequestered during growth.

Figure 6: (a) Burn area just south of the 2021 Lytton fire (Photo: G.Strong, Oct. 2023); (b) an area from 2024 Jasper Park wildfire (Photo: Atco Electricity). Most of the tree trunks in both photos remain standing.

The Byrne group did not specifically state the resolution of satellite data that they used, but various other data used ranged from 0.5° X 0.625° to 2° X 2.5°. If we assume the minimum value here, that is, 0.5° X 0.5 °, it suggests data resolution coarser than 50 km. That resolution could not resolve any of the unburned areas in Figure 5. Confidence in their 'areas of burn' therefore have to be questioned. Moreover, van der Werf et al. (2025) evaluated the much-improved Global Fire Emissions Database (GFED5, over the GFED4 used by the Byrne group), and indicate that initial estimates of small-fire burned area boosted the global burned area by 35%. They also suggested that studies using satellite measurements of column CO indicated that emissions from regional fire complexes often exceed estimates from global inventories. This demands a more thorough analysis, including a comparison of Byrne group's estimate of emissions from a reasonable size forest fire with ground-based and possible aircraft measurements. Our estimates of carbon sequestration based on Table 1, also suggest that their carbon emissions from the 2023 wildfires may have been highly overestimated.

4. Fire-Scorched Tree Trunks - The remaining upright tree trunks and underground roots are still mostly intact following a fire, and still contain most of their sequestered carbon. This is apparent in Figure 7 with a pile of logs claimed from the 2021 Lytton fire that reveal only scorching on the bark of larger trees. It is assumed (as yet unconfirmed) that Byrne et al. included this 88% of carbon as having been consumed in their analysis.

Trees and roots of burned-over forest contain most of the carbon sequestered during their growing period. Granted, as dead tree trunks start to decompose following a wildfire, much of that sequestered carbon slowly reunites with oxygen to emit CO_2 back into the atmosphere, but that decomposition is spread out over one or two decades, not over the short period of the wildfire. Some other facts:

- If a fire is smoldering, it produces mostly CO.
- A hot fire releases mostly CO_2.
- CO released to the atmosphere during burning eventually combines with oxygen and/or water to produce additional CO_2.
- Carbon from decomposing roots is mostly absorbed by the soils over a longer period.
- Younger trees, brush, and the needles (or leaves) and branches are quickly consumed in a wildfire, releasing the carbon, approximately 11% of a tree's total carbon. For example, a 5-year old fir tree weighs less than 4 kg and will have sequestered only 0.002 tonne (= 2 kg) of CO_2 (from Table 1).

- The remaining upright tree trunks and underground roots (minus branches and leaves) are still mostly intact and still hold most (at least 80%) of its sequestered carbon. This appears as a possible major source of error in the Byrne et al. estimates of CO_2 from the 2023 wildfires, except they insist that carbon emissions were estimated directly from the satellite data.

Figure 7: Stacked logs from the wildfire east of Lytton with only the bark scorched. (Photos: G. Strong)

5. Salvageable Tree Trunks - The bark of the logs shown from largest tree trunks were somewhat scorched, but the trunks are suitable to salvage for lumber. Remaining smaller trees could be used for wood chip and pulp industries. Salvage has a number of advantages:

- Depending on accessible roads, it is economical to harvest these burned trees within the first year or two following a burn. With most undergrowth consumed it allows easier access.
- After salvaging burned tree trunks, the job of replanting the area later is also easier.
- The salvage process repairs the fire wound in the forest and allows vegetation and animals to flourish.
- Salvaging these scorched trees for lumber and wood chips stops most of the sequestered carbon from later reentering the atmosphere as CO_2, by stopping the decomposition of the tree trunks.
- It allows nearby unburned forest that might otherwise be cut, to continue sequestering atmospheric carbon – a double win.

6. Forest Density of Trees - Google-Earth imagery prior to the 2021 Lytton wildfire (Figure 8a) suggests high variability in the tree density east of the town (centre-left), an area of approximately 5 km^2, with a large part of it just open ground, probably from earlier clear-cutting. The burned area (Figure 8b) does not really indicate this, so that carbon emissions from the area would have been minimal. It is unknown how the Byrne group evaluated such areas.

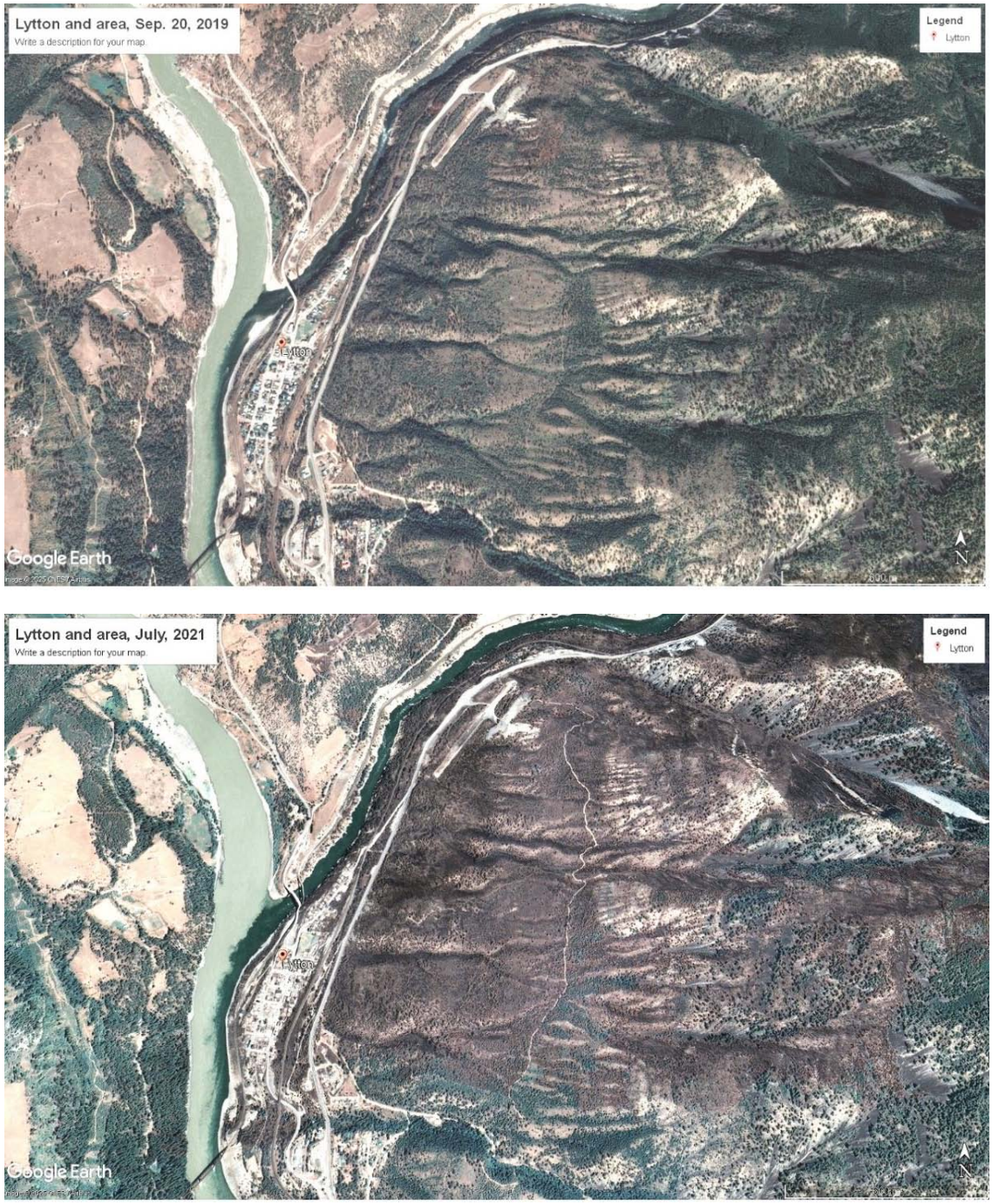

Figure 8: (a) GE image of Lytton BC and area prior to wildfire, Sep. 20, 2019. (b) Same location following the wildfire, July 15, 2021. (Google Earth images.)

CONCLUSIONS

Both the MacCarthy and Byrne groups investigated the 2023 wildfire season across Canada. These studies draw attention to the often-ignored amount of CO_2 released during wildfires. Regardless of any errors or over-estimates in their results, they highlight the importance of improving techniques to evaluate carbon emissions from every major wildfire, including total burned area less unburned gaps, the average or modal size of trees, and more accurate estimates of carbon released during the fire. Main conclusions here are:

1. Byrne et al., in considering the whole land mass of Canada (10 million km^2), could not account for all unscathed parts of burn areas. This could be a major source of error and needs further study.

2. It is difficult to accurately determine the amount of tree trunks left standing and containing most of the trees' carbon. These may be the main source of error in their analysis.
3. Immediate carbon emissions from forest fires result primarily from leaves and branches (12% of the trees), plus smaller trees and brush containing negligible carbon, while larger tree trunks and their roots (88% of a tree's carbon) are killed but are often left unscathed during the fire. These slowly release CO_2 both to the atmosphere and soils during subsequent decomposition (over 1-2 decades), unless harvested by the forestry industry for lumber.
4. The value of 2370 Mt CO_2 approximated for the 2023 wildfire season by the Byrne group was likely over-estimated. Based on amounts of carbon sequestered by trees, the actual CO_2 emissions in 2023 were likely considerably less, but are still a major concern, considering that the only means at present to curb climate warming is to suppress carbon emissions.
5. It is important that federal/provincial governments require the forestry industry to harvest scorched but intact tree trunks to: a) avoid further carbon release as burnt trees decompose; b) allow cleared areas for new growth and wildlife to flourish; c) make the task of later replanting tree seedlings easier; and d) conserve nearby unburnt forest that can continue sequestering CO_2. All of this is done to some extent (e.g., Yunker (2024); British Columbia Ministry of Forests (2025)), but without a clear ruling and very little field supervision, profits become the primary driver.
6. Strong and Barge (2022) showed that the 2 billion new tree seedlings provided for in the GOC budget could not possibly offset annual carbon emissions of ~700 MT. Tree seedlings sequester very little carbon in the first 10 years of growth, but are still needed to help draw down atmospheric CO_2 over the next century or more once 'carbon emission' problems are rectified.
7. While the focus of this paper is on carbon emissions, it should be mentioned that wildfire smoke is a significant source of fine particulate matter, $PM_{2.5}$ pollution, which makes up approximately 90% of total wildfire smoke mass. $PM_{2.5}$ can penetrate deep into the lungs, posing serious health risks and death, and should be included in studies quantifying emissions from wildfires.

Most important here is that carbon emissions from wildfires cannot be ignored, should be quantified in the federal government's annual inventory of carbon emissions, and all governments need to be aware of the catastrophic impacts on our future climate exacerbated by wildfires.

[1] See https://www.co2.earth/daily-co2 for daily/weekly/monthly values of atmospheric CO_2.

[2] The more rapid decrease in CO_2 after May 2025 (blue curve in Fig. 4), normally attributed to re-growth of vegetation in the northern hemisphere, is likely due to a drop in China emissions as they brought extensive renewable energy systems online during 2025, while stopping coal-fired generation stations.

[3] 1 ton = 0. 907 tonne; 1 Tg carbon = 1 Mt C = 3.664 MT CO2.

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La métérologie dans la divine comédie de Dante Alighieri

Richard Leduc, Ph.D.

1 INTRODUCTION

La Divine Comédie de Dante Alighieri est considérée comme un chef d'œuvre de la littérature européenne, sinon mondiale.

En 2021, on rendit hommage à Dante dans la presse en soulignant le 700e anniversaire de sa mort, motif pour en entreprendre la lecture. L'édition qui sert ici est celle de Risset (2010).

On a abordé l'oeuvre de Dante selon un point de vue météorologique. L'intention est de savoir comment la météorologie se retrouve dans l'œuvre de Dante et comment il utilise les phénomènes météorologiques pour décrire son voyage ou pour renforcer son propos. La quantification des phénomènes météorologiques permet de voir leur importance et un classement selon des catégories plus générales permet de mieux comprendre de quelle

manière ils s'insèrent dans le récit. On présente ici un bref résumé d'un texte plus complet (Leduc, 2025) disponible sur demande.

Dante Alighieri's Divine Comedy is considered a masterpiece of European, if not world, literature.

In 2021, the press paid tribute to Dante on the 700th anniversary of his death, providing an opportunity to reread his work. The edition used here is Risset's (2010).

Dante's work has been approached from a meteorological perspective. The aim is to understand how meteorology appears in Dante's work and how he uses meteorological phenomena to describe his journey or to reinforce his arguments. Quantifying meteorological phenomena reveals their significance, and classifying them into broader categories helps to better understand how they fit into the narrative. A brief summary of a more complete text (Leduc, 2025), available upon request, is presented here.

2 BREF APERÇU DE LA DIVINE COMÉDIE

On trouve sur internet une grande quantité d'informations sur cet ouvrage.

Le poème est divisé en trois parties soit L'Enfer, Le Purgatoire et Le Paradis, chacune composée de trente-trois chants sauf l'Enfer qui contient un chant préliminaireé L'oeuvre compte un total de 14233 vers selon Portier (2021). Sa représentation imaginaire et allégorique de l'au-delà chrétien est un sommet de la vision médiévale du monde développée par l'Église catholique romaine. Dante parcourt ces lieux afin de retrouver sa bien-aimée Béatrice et d'y avoir la vision de Dieu.

A great deal of information about this work can be found online.

The poem is divided into three parts: Inferno (Hell), Purgatory, and Paradise, each composed of thirty-three cantos, except for Inferno, which contains a preliminary canto. The work comprises a total of 14 233 lines according to Portier (2021). Its imaginative and allegorical representation of the Christian afterlife represents a pinnacle of the medieval worldview developed by the Roman Catholic Church. Dante journeys through these realms in order to find his beloved Beatrice and to have a vision of God.

3 MÉTHODOLOGIE

Les lectures du volume de J. Risset ont permis de repérer tout passage ayant un certain rapport avec la météorologie et les mots (parmi les 10 314 différents au total) ayant un intérêt météorologique sont retenus. Pour chacun des mots on a gardé la partie, le chant, le numéro de page et de vers et un extrait du texte.

Readings of J. Risset's volume allowed us to identify all passages related to meteorology, and the words (out of a total of 10 314) with meteorological significance were selected. For each word, we retained the part, the song, the page and verse number, and an excerpt from the text.

4 DISTRIBUTION DES PHÉNOMÈNES MÉTÉOROLOGIQUES

On a regroupé les 78 mots ayant un lien avec la météorologie en 21 catégories de phénomènes météorologiques (PM) présentés au Tableau 1. Une catégorie peut comprendre divers mots. Par exemple, dans "Précipitations" on distingue un verbe comme neiger, pleuvoir, pleut, pleuvait, etc.; la pluie et la rosée; la neige, les flocons de neige, le givre; et les passages avec plusieurs types de précipitations.

Pour l'ensemble de l'œuvre, on dénombre 337 PM ou référence à un PM parmi ces 21 catégories (Tableau 1). La plus fréquente est celle de l'Air (56 ou 16.6%) laquelle est souvent

associée à l'atmosphère. Le vent est le second plus fréquent avec 48 références soit 14.2%.

The 78 words related to meteorology were grouped into 21 categories of meteorological phenomena (MPs), presented in Table 1. A category can include various words. For example, in "Precipitation," we distinguish a verb such as snowing, rain, is raining, was raining, etc.; rain and dew; snow, snowflakes, frost; and passages with several types of precipitation.

Throughout the work, there are 337 MPs or references to an MP within these 21 categories (Table 1). The most frequent category is Air (56 or 16.6%), which is often associated with the atmosphere. Wind is the second most frequent, with 48 references, or 14.2%.

Tableau 1. Liste des catégories et fréquences

PM	Nombre	Pourcentage	PM	Nombre	Pourcentage
Air	56	16.6	Glace	13	3.9
Arc	4	1.2	Humidité	3	0.9
Brume	11	3.3	Nuages	23	6.8
Chaleur	6	1.8	Précipitations	42	12.5
Climat	2	0.6	Saisons	17	5.0
Éclair	13	3.9	Soleil	8	2.4
Foudre/orage	9	2.7	Souffle	4	1.2
Froid	17	5.0	Tempête	6	1.8
Fumée	19	5.6	Tonnerre	7	2.1
Gel	16	4.8	Vapeur	14	4.2
Glace	12	3.6	Vent	48	14.2
Total				337	100

C'est au Purgatoire qu'il y en a le plus de PM (129, 38.3%), en Enfer il y en a 120 (35.6%) et le Paradis en compte 88 (26.1%).

La Figure 1 illustre les fréquences des PM par rapport au nombre total de la partie. L'Air est à 20% en Enfer, 18.6% au Purgatoire et 9.1% au Paradis. Les Précipitations et le Vent sont à plus de 10% dans les trois parties. Les Nuages sont les plus présents au Paradis à 11.4%. La Fumée a une fréquence de 7.5% en Enfer, plus élevée que dans les deux autres Parties. On note aussi qu'en Enfer, le Froid, le Gel et la Glace, tous trois étant à 6.7%, ont une fréquence plus grande qu'aux deux autres parties. Si on combine ces 3 PM, ils comptent pour 24/120 (20%) en Enfer, 14/129 (10.9%) au Purgatoire et 7/88 (8%) au Paradis. L'enfer est ainsi un endroit froid selon Dante.

Purgatory has the highest number of MPs (129, 38.3%), followed by Hell with 120 (35.6%), and Paradise with 88 (26.1%).

Figure 1 illustrates the frequencies of MPs relative to the total number in each part. Air accounts for 20% of the occurrences in Hell, 18.6% in Purgatory, and 9.1% in Paradise. Precipitation and Wind are present in more than 10% of all three parts. Clouds are most prevalent in Paradise at 11.4%. Smoke has a frequency of 7.5% in Hell, higher than in the other two parts. It is also worth noting that in Hell, Cold, Frost, and Ice, all at 6.7%, have a higher frequency than in the other two parts. If we combine these 3 MPs, they account for 24/120 (20%) in Hell, 14/129 (10.9%) in Purgatory, and 7/88 (8%) in Paradise. Hell is thus a cold place according to Dante.

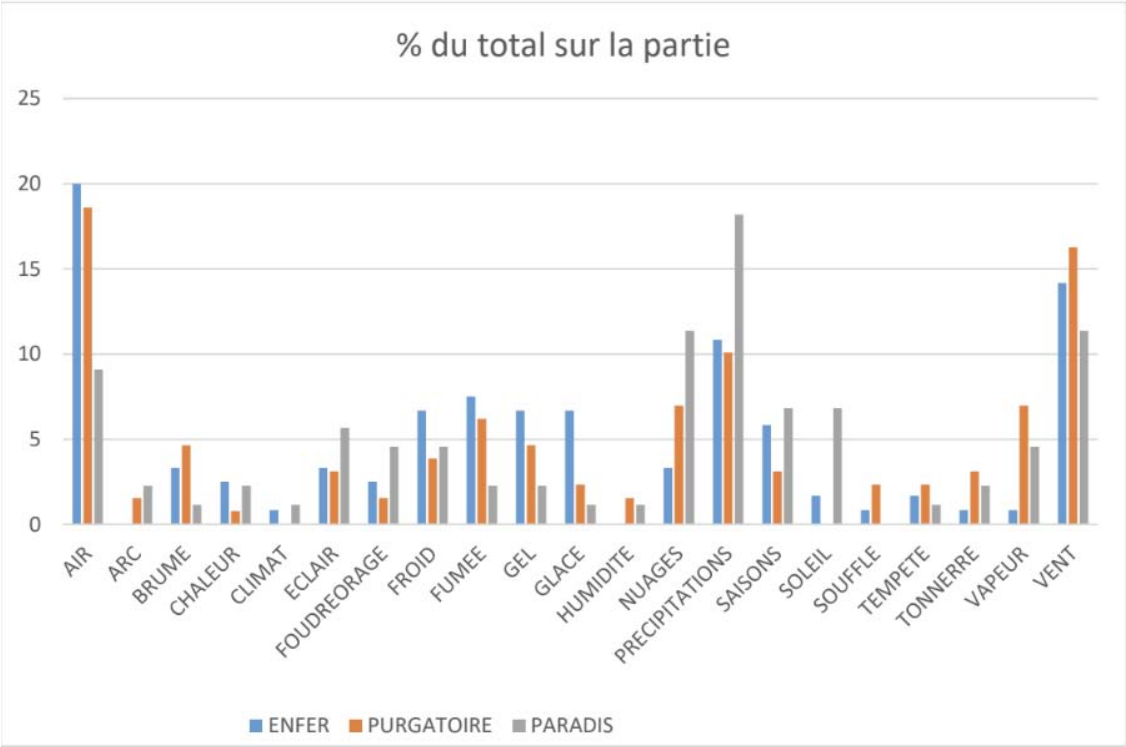


Figure 1. Fréquence (%) des PM par rapport au nombre total de la partie

Les fréquences des PM par rapport au nombre total de chacun sont illustrées à la Figure 2. L'Air est aussi souvent mentionné en Enfer qu'au Purgatoire (42.9%); les Précipitations sont les plus fréquentes au Paradis (38.1%), le Vent au Purgatoire (43.8%) et les Nuages au Paradis (43.5%). Le Froid est le plus souvent mentionné en Enfer soit 47.1% (8 sur 17). La Glace y est aussi la plus présente avec 8 mentions sur 12 (66.7%) de même que le Gel avec 8 fois sur 16 (50%).

The frequencies of MPs relative to the total number of each are illustrated in Figure 2. Air is mentioned as often in Hell as in Purgatory (42.9%); Precipitation is most frequent in Heaven (38.1%), Wind in Purgatory (43.8%), and Clouds in Heaven (43.5%). Cold is most frequently mentioned in Hell at 47.1% (8 out of 17). Ice is also most prevalent there, with 8 out of 12 mentions (66.7%), as is Frost, with 8 out of 16 mentions (50%).

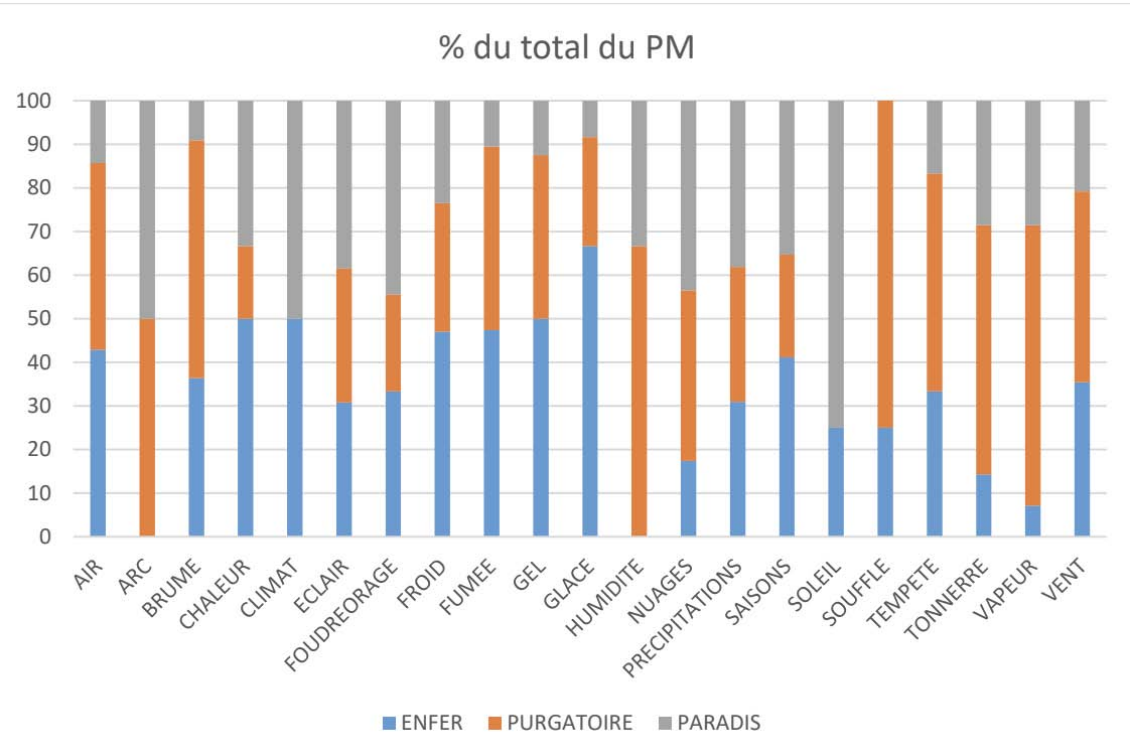


Figure 2. Fréquence (%) des PM par rapport au nombre total de PM

On s'intéresse à savoir comment les PM se répartissent dans les chants; notons qu'en Enfer 4 chants sont sans PM, il y en a 3 au Purgatoire et 4 au Paradis soit 11 chants sur 100; les PM sont ainsi présents dans la presque totalité du récit. La Figure 3 montre la suite du nombre de PM (partie et chant numéroté de 1 à 100). Il y a 7 chants qui ont 10 PM et plus, soit l'Enfer (chants 5 et 31), le Purgatoire (chants 5, 28, 29 et 30) et le Paradis (chant 27).

We are interested in how the MPs are distributed throughout the cantos; note that in Hell there are 4 cantos without MPs, there are 3 in Purgatory and 4 in Paradise, totaling 11 cantos out of 100; MPs are thus present in almost the entire narrative. Figure 3 shows the sequence of MPs (part and canto numbered from 1 to 100). There are 7 cantos that have 10 or more MPs, namely Hell (cantos 5 and 31), Purgatory (cantos 5, 28, 29 and 30) and Paradise (canto 27).

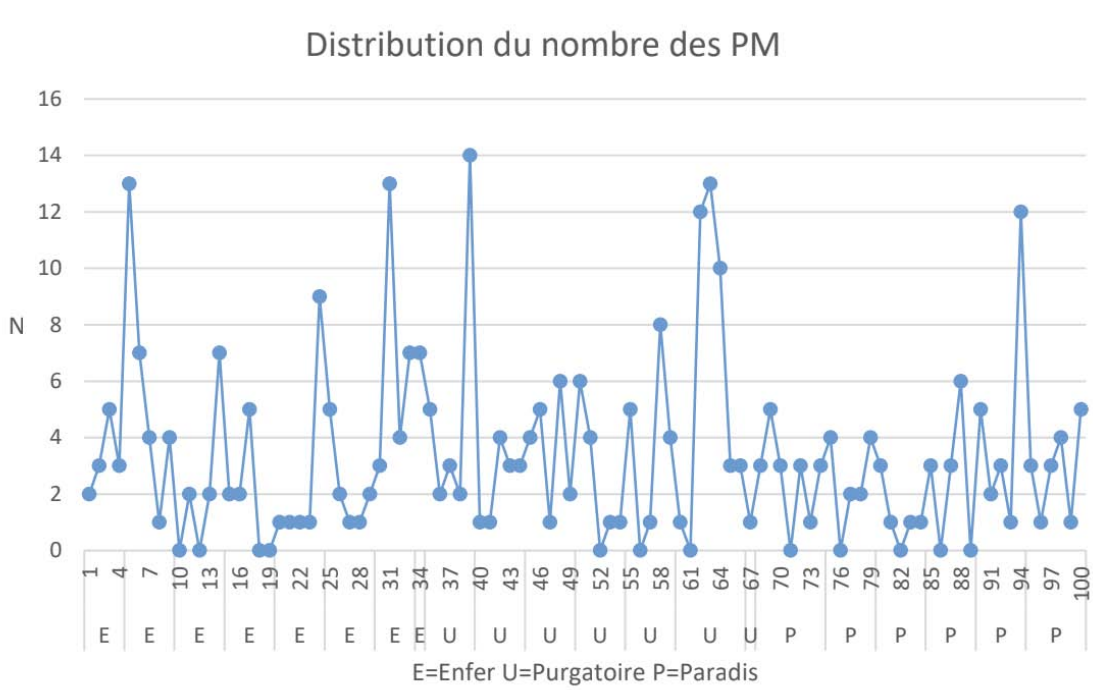


Figure 3. Distribution du nombre (N) des PM

Le chant 5 compte le plus grand nombre de PM soit 30, l'Enfer en ayant 13, le Purgatoire 14 et 3 pour le Paradis. La Figure 4 illustre le pourcentage des PM par chant par rapport au total de la partie. Ainsi, pour l'Enfer et le Purgatoire, 10.8% des PM sont au chant 5. Pour l'Enfer il y en a aussi 10.8% au chant 31. Le chant 24 en compte aussi davantage pour l'Enfer et le Purgatoire, soit 7.5% et 6.2%. Pour le Paradis, le chant 27 est le plus important avec 13.6% (12/88) du total de la partie.

Canto 5 has the highest number of MPs (30), Hell with 13, Purgatory with 14, and Paradise with 3. Figure 4 illustrates the percentage of MPs per canto relative to the total of the part. For Hell and Purgatory, 10.8% of MPs are in Canto 5. For Hell, 10.8% are also in Canto 31. Canto 24 also has a higher percentage of MPs for Hell and Purgatory, at 7.5% and 6.2% respectively. For Paradise, Canto 27 is the most significant, accounting for 13.6% (12/88) of the total of the part.

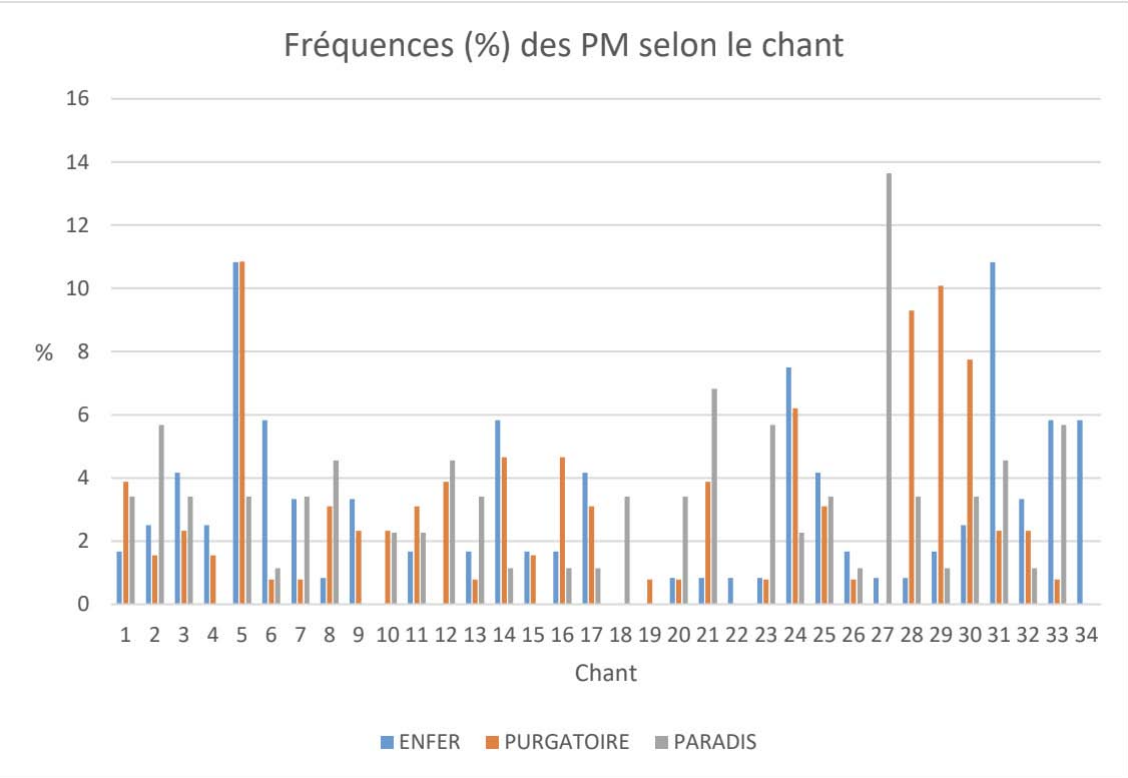


Figure 4. Fréquence (%) des PM selon le chant et par partie

5 CLASSEMENT

Chacune des 337 références à un PM est partagée en 6 classes: Réel, Métaphore, Comparaison, Allégorie, Personnification et Oxymore (Tableau 2). Le cas le plus fréquent à près de 71% est celui de Réel qui comprend les mentions à un PM réel observé ou déduit par Dante. La Métaphore, la Comparaison et l'Allégorie sont presque aussi fréquentes l'une que l'autre et avec un total de près de 29%.

Each of the 337 references to a MP is divided into six categories: Real, Metaphor, Comparative, Allegory, Personification, and Oxymoron (Table 2). The most frequent case, at nearly 71%, is that of Real, which includes references to an actual MP observed or deduced by Dante. Metaphor, Comparative, and Allegory are almost equally frequent, totaling nearly 29%.

Tableau 2. Répartition des classes de PM

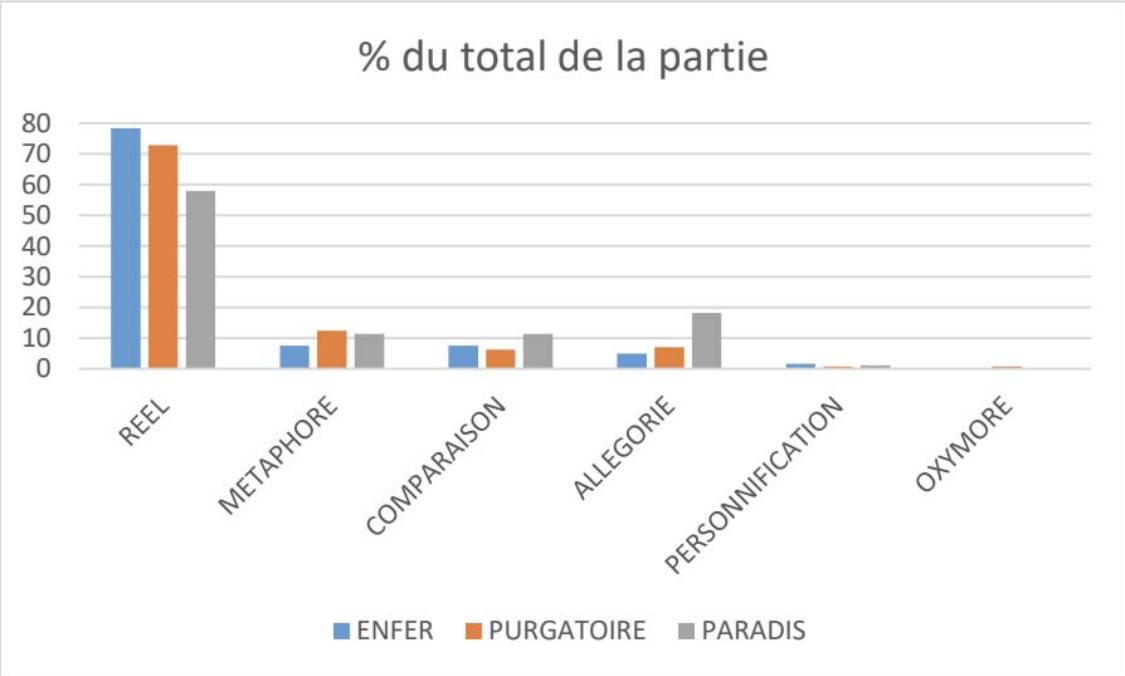
Classe	Nombre	Pourcentage
Réel	239	70.9
Métaphore	35	10.4
Comparaison	27	8.0
Allégorie	31	9.2
Personnification	4	1.2
Oxymore	1	0.3
Total	337	100

La classe Réel (Figure 5) est la plus importante dans chacune des parties avec plus de 70%

dans les deux premières et environ 58% au Paradis. Le Paradis compte le plus grand nombre de référence de classe Allégorie soit 18.2% (16/88).

The Real class (Figure 5) is the most prevalent in each part, accounting for over 70% in the first two and approximately 58% in Paradise. Paradise has the highest number of references to the Allegory class, at 18.2% (16/88).

Figure 5. Fréquence (%) des classes par rapport au nombre total de la partie



6 EXEMPLES DE PHÉNOMÈNES MÉTÉOROLOGIQUES

Dans cette section, on présente au Tableau 3 quelques extraits de La Divine Comédie faisant référence à un phénomène météorologique. Les numéros de vers et de pages sont de J. Risset (2010).

In this section, Table 3 presents some extracts from The Divine Comedy that refer to a meteorological phenomenon. The verse and page numbers are from J. Risset (2010).

Tableau 3. Extraits et commentaires

PARTIE Chant;page;vers	TEXTE	COMMENTAIRES
Enfer 6;36;8	Je suis au troisième cercle, à celui de la pluie éternelle, maudite, froide et lourde ;	Cette pluie est vraiment désagréable; elle vient renforcer l'inhospitalité de l'endroit.
Enfer 6;36;11	Grosse grêle, eau sombre et neige s'y déversent par l'air ténébreux ;	Ces précipitations sont encore vues comme néfastes tout comme l'endroit.
Enfer 31;161;37	Chacune avait la face vers le bas ; la bouche donnait pénible témoignage du froid, les yeux du cœur endolori. Un autre qui avait perdu les deux oreilles à cause du froid, le visage baissé lui aussi, me dit : « Pourquoi te mires-tu en nous ?	Il y fait vraiment froid et ça accentue la douleur. Le vers 71 rapporte aussi mille visages violacés de froid. Ceci renforce la réalité morbide de l'endroit.
Purgatoire 5;199;109	Tu sais comment s'amoncelle dans l'air la vapeur humide qui revient en eau, sitôt quelle monte où le froid la saisit."	Dante connaît bien le phénomène de condensation.
Purgatoire 25;298;93	Et comme l'air, quand il est bien pluvieux, au rayon de soleil qui se reflète en lui, se montre orné de diverses couleurs ;	Dante décrit un arc-en-ciel.
Purgatoire 30;323;85	Comme la neige entre les troncs vivaces se congèle sur l'échine d'Italie, soufflée et serrée par les vents slaves, puis, quand elle a fondu, coule en elle-même, dès que respire la terre où l'ombre se perd, pareille à la flamme qui fond la chandelle ;	Dante connaît bien le lien entre la direction du vent (sa provenance) et la température; les vents slaves de l'est amenaient de l'air froid. Et là où l'ombre a disparue, la neige peut fondre.
Paradis 8;377;22	Des vents descendus d'un froid nuage, visibles ou cachés, et très rapides, auraient paru lents et embarrassés à qui aurait vu venir vers nous ces lumières divines,	Dante avait bien observé la descente d'air froid associé à un cumulonimbus par exemple et au pseudo front froid associé.
Paradis 27;475;124	Le vouloir fleurit bien chez les hommes, mais la pluie continuelle change les bonnes prunes en fruits gâtés.	Allusion à l'effet nuisible de la pluie continuelle.
Paradis 31;492;13	Tous avaient le visage de flamme vive, et les ailes d'or, et le reste si blanc que nulle neige n'arrive à ce terme.	Un comparaison avec la blancheur immaculée de la neige.

Hell

6;36;8 I am in the third circle, that of the eternal rain, cursed, cold, and heavy; This rain is truly unpleasant; it reinforces the inhospitable nature of the place.

Hell

6;36;11 Large hail, dark water, and snow pour down through the gloomy air; These precipitations are still seen as harmful, just like the place itself.

Hell

31;161;37 Each one had her face down; her mouth bore painful witness to the cold, her eyes to a aching heart. Another, who had lost both ears to the cold, his face also bowed, said to me: "Why do you see yourself reflected in us? It is truly cold here, and it accentuates the pain." Verse 71 also reports a thousand faces purpled by the cold. This reinforces the morbid reality of the place.

Purgatory

5;199;109 You know how the moist vapor gathers in the air, only to turn back into water as soon as it rises where the cold grips it." Dante is well acquainted with the phenomenon of condensation.

Purgatory

25;298;93 And as the air, when it is very rainy, appears adorned with various colors in the sunlight reflected upon it; Dante describes a rainbow.

Purgatory

30;323;85 As the snow between the evergreen trunks freezes on the spine of Italy, blown and pressed down by the Slavic winds, and then, when it has melted, flows back into itself as soon as the earth breathes where the shadow is lost, like the flame that melts the candle; Dante is well acquainted with the link between the direction of the wind (its origin) and the temperature; the Slavic winds from the east brought cold air. And where the shadow has

disappeared, the snow can melt.

Paradise

8;377;22 Winds descending from a cold cloud, visible or hidden, and very swift, would have Appearing slow and hesitant to anyone who might have seen these divine lights approaching, Dante had clearly observed the descent of cold air associated with a cumulonimbus cloud, for example, and the associated pseudo-cold front.

Paradise

27;475;124 Willpower flourishes well in men, but continual rain turns good plums into spoiled fruit. Allusion to the harmful effect of continuous rain.

Paradise

31;492;13 All had faces of bright flame, and wings of gold, and the rest so white that no snow ever reaches that degree. A comparison with the immaculate whiteness of snow.

7 CONCLUSION

Les phénomènes météorologiques sont présents tout au long du périple de Dante dans l'Enfer, le Purgatoire et le Paradis.

La Divine Comédie comprend des vers qui révèlent le sens de l'observation de Dante par rapport aux phénomènes météorologiques réels. Il s'en sert souvent pour renforcer la réalité d'une situation ou d'un endroit mais aussi pour illustrer son propos de diverses manières.

Il y a une multitude d'ouvrages consacrés à Dante Alighieri et à son œuvre. Ce travail est une simple contribution voulant rendre hommage à son génie météorologique.

Meteorological phenomena are present throughout Dante's journey through Inferno (Hell), Purgatory, and Paradise.

The Divine Comedy includes verses that reveal Dante's keen observation of real meteorological phenomena. He often uses them to reinforce the reality of a situation or place, but also to illustrate his points in various ways.

There are numerous works devoted to Dante Alighieri and his writings. This work is simply a contribution intended to pay tribute to his meteorological genius.

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'We were being clobbered': A look back at the infamous blizzard that blanketed Winnipeg 60 years ago.

By: Katherine Dow via CTV News

Sixty years ago, a 19-year-old Chuck McCoy clocked in for his overnight radio show on Winnipeg's CKY-FM.

It was his first radio gig.

He was then DJing the coveted midnight to seven a.m. show under the name Merv Clark, playing top 40 hits of the day, be it Petula Clark or Herman's Hermits.

As the night went on, the phone started to ring.

"I was getting phone calls from people saying, 'You know, there's a lot of snow falling out there. Maybe you should update your weather forecast,'" he recalled.

After the calls continued, he walked outside of the Main Street radio station to see for himself what all the fuss was about.

He was met with massive heaps of snow, the bulk of which had fallen in the two hours since his shift began.

It didn't show signs of letting up, either.

"The snow was just falling and piling up and piling up."

Figure 1. Winnipeg police officers brave the remnants of the March 4, 1966 blizzard in buffalo coats snowshoes. (The University of Manitoba Archives & Special Collections, the Winnipeg Tribune fonds, PC 18)

Not sure what else to do, McCoy went back inside and kept on playing music, telling anyone inquiring about how long the snow would last to request a song instead of a forecast.

'We were being clobbered'

As it turns out, that was the beginning of Winnipeg's now storied 1966 blizzard that buried the city in 13 inches of snow, bringing it to an essential standstill.

Meteorologist Larry Romaniuk (right) was working at Transport Canada at the time.

In the days leading up to the storm, he knew an approaching Colorado low brewing in the southern United States was sure to bring snow to the city, a few inches at least.

Of course, the weather technology at its disposal back in 1966 was a bit more analogous.

“We had no satellites to speak of. The radar we had in those days was the Winnipeg airport's

air traffic control radar, which wasn't really set up too well for weather," he recalled.

"There weren't as many weather-observing stations on the ground."

Figure 3. A lineup of Winnipeg Transit buses stall on Main Street in Winnipeg, Man., after the March 4, 1966 blizzard. (The University of Manitoba Archives & Special Collections, the Winnipeg Tribune funds, PC 18)

As he finished his shift at the airport at midnight, a few inches of snow were already on the ground, and it was only intensifying.

Turns out, the low had stalled over South Dakota, sucking up plenty of moisture from the Gulf of Mexico.

A band of thunderstorms also developed near the US border.

"That was the big kicker," Romaniuk, now 90, recalled.

"That's what caused the heaviest snow because of that stalling, so of course, we were being clobbered."

Figure 4. Winnipeggers pose on a heaping snowbank that nearly reaches the roof of a home on March 4, 1966. (Candice Masters)

A snowy night to remember, 60 years later

Romaniuk was able to make it home before the worst of it set in, though his colleagues got stranded at the airport as the blizzard enveloped the city in the hours to come.

Over at CKY-FM, the hours went on, the snow continued to fall, and McCoy's shift neared its end.

However, the morning show team, led by broadcast legend Jack Wells, didn't show up. The snow had similarly stranded the station's star radio team at home.

McCoy just kept playing the hits for hours and hours on end.

“I'm a teenager. I don't know what I'm supposed to do,” he told CTV News.

“We didn't give any weather information. We didn't do anything that we're supposed to do, because we've never been on the air in the day, never delivered news, so we took the opportunity to play The Beatles and The Rolling Stones while the city was getting buried in snow.”

Figure 5. Towering snowbanks line a Winnipeg, Man., street on March 4, 1966 after a powerful blizzard hit the city. (Gary Robson/CTV News Winnipeg)

A fresh team arrived at 3 pm to relieve McCoy and the rest of the overnight staff, a mere 15 hours into their shift.

But much like the rest of the city, the snow had stranded them, so they were put up in a nearby hotel.

As it turned out, sleep was the last thing on McCoy's mind, as he was still buzzing from his primetime debut.

“It was a big opportunity and a big chance to be on the radio in the daytime. We didn't get tired. We probably stayed up all night the next night,” he said.

Decades later, Romaniuk counts the blizzard of '66 as one of the most notable meteorological events of his decades-long career.

“There have been some memorable times, but most of the time, fortunately, it was a very quiet, day-to-day kind of line of work,” he said.

McCoy's radio career took him off the night shift and to stations across Canada. He received a lifetime achievement award at the Canadian Music Industry Awards in 2009 and was inducted into the Canadian Music Industry Hall of Fame.

Now retired, McCoy will never forget that infamous night that snowed the way for his morning radio debut.

“Memories fade, but that night stays vivid in my memory all these 60 years later.”

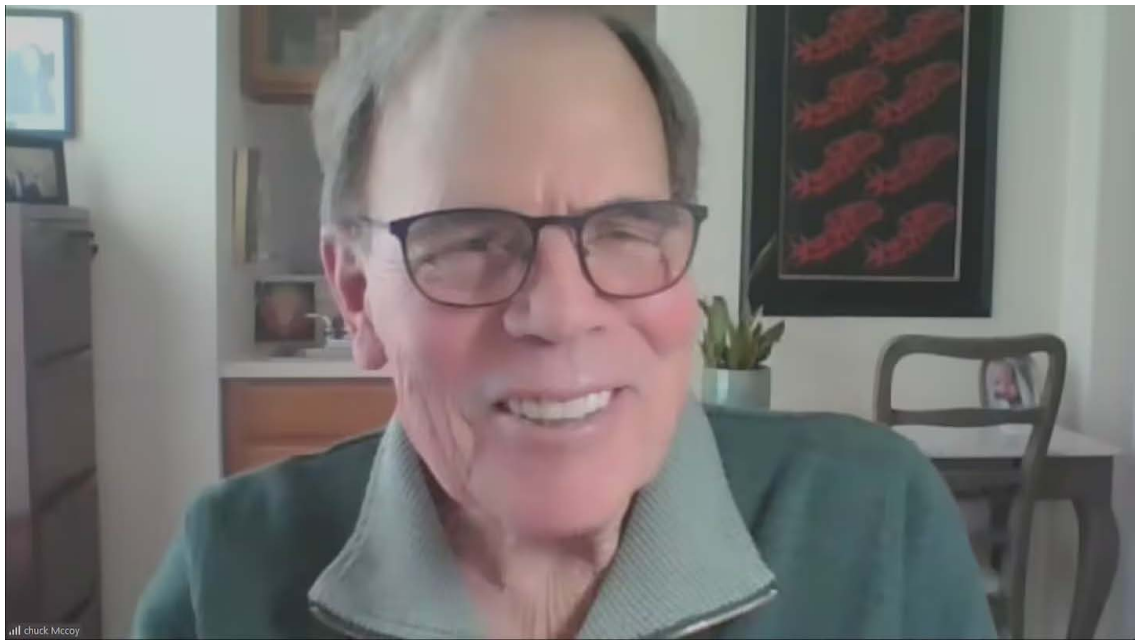

Figure 6. Chuck McCoy is pictured in his New Jersey home during a March 4, 2026 interview with CTV News Winnipeg.

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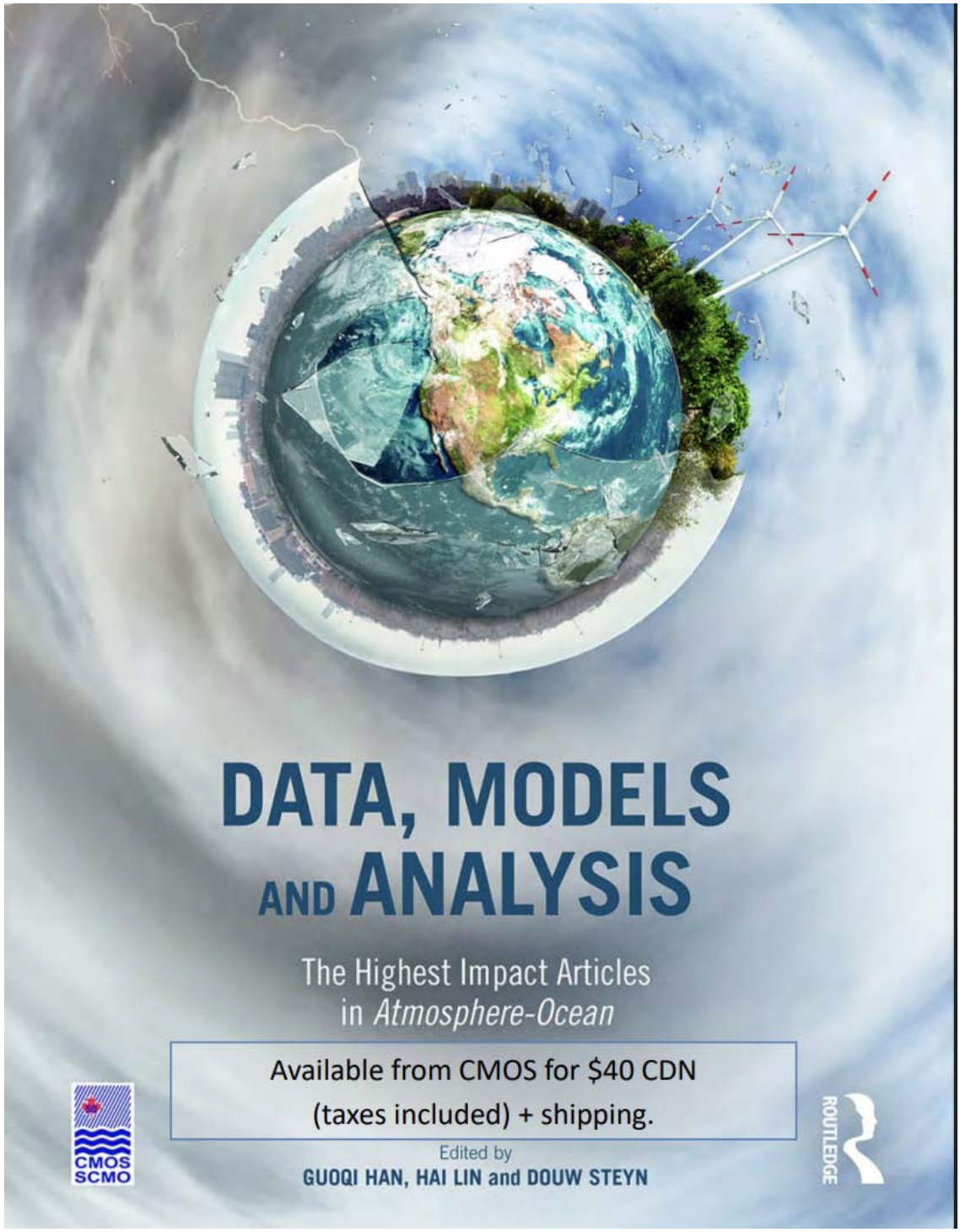
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