INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

How climate change impact our weather ?

Report Data processing and data analysis for Big Data - 5 ISS

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Introduction

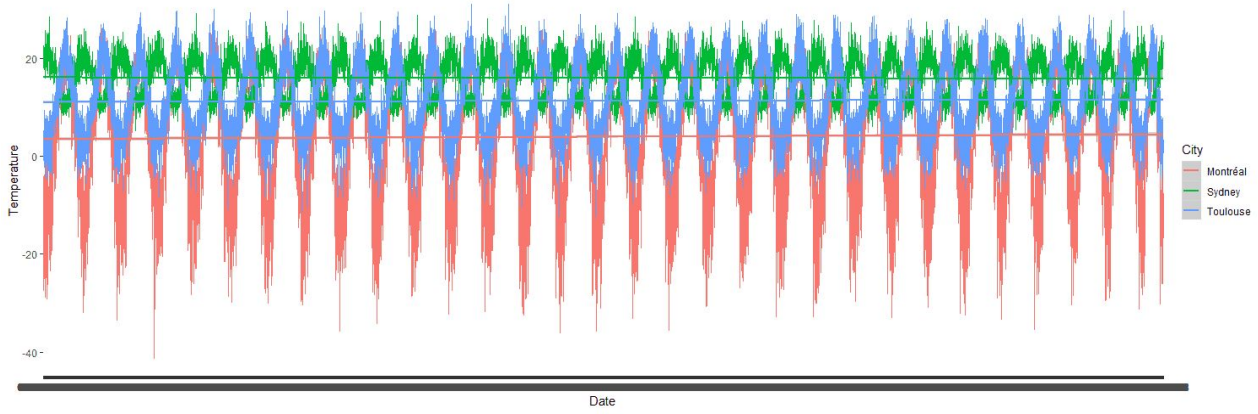
Nowadays, climate change seems to be a reality. We ask ourselves how it impacts our daily weather. In order to that, we choose 3 different cities : Toulouse, Montréal & Sydney covering 3 different continents to see if there is any weather abnormality since 1980.

With the help of the NASA database accessible through the MERRA program [1], we chose to study the three cities from the 1st dec 1980 to the 1st dec 2019 with a point every day at midnight. We gathered that way around 14'500 entries for each city with every entry being composed of Temperature , Relative Humidity, Pressure , Wind speed and direction , Rainfall, Snowfall and Snow depth and Irradiation.

Temperature

Global rise

The main point discussed these times around climate change is the overall heating of the planet. We wanted to observe how much the temperature has changed for the last decades so we plotted the temperature in the three cities in the following chart.



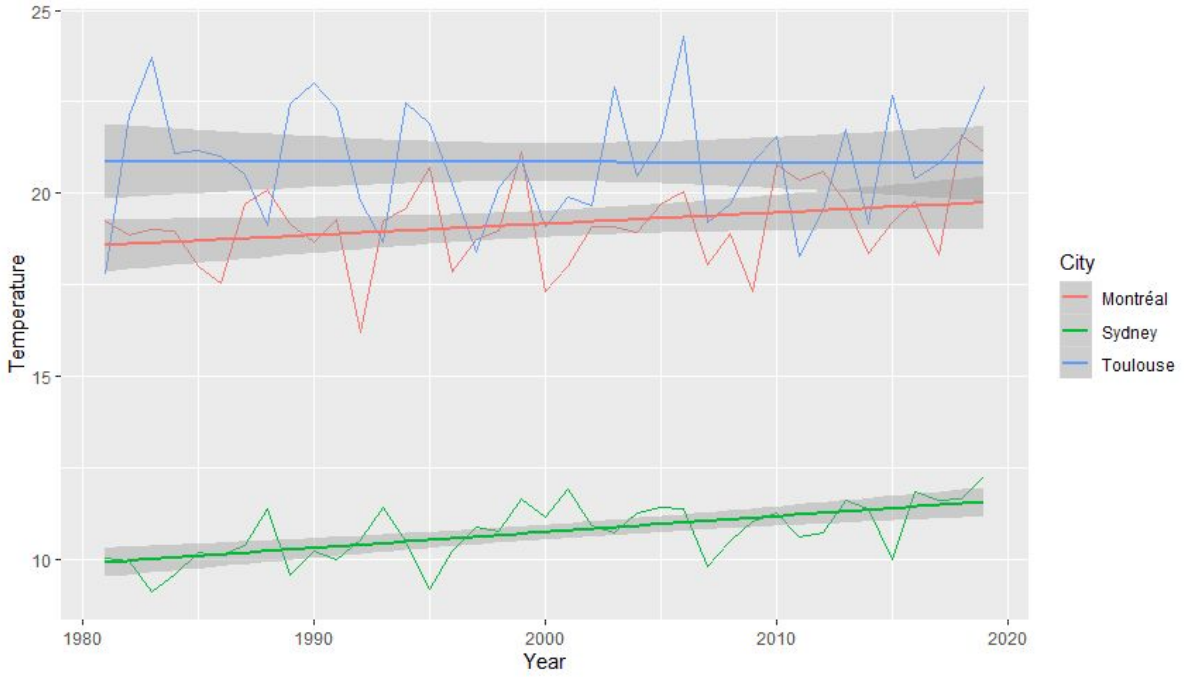
Unfortunately the temperature changes far too often to observe something concrete with our eyes, however we can find a fitting linear model and see if it has good results.
We found an augmentation of `1.55e-04 K` in Montréal per day since 1980. This regression has a p-value of `1.85e-09` making it factually true. The overall temperature has increased of `2.21 K ± 0.36 K` as the error weights `2.58e-05 K` for a day.

In Sydney, the temperature averagely rises `8.15e-05 K` per day, making an augmentation of `1.16 K ± 0.11 K` over the last 4 decades with a p-value below `2e-16`.
For Toulouse, the temperature has increased of `0.91 K ± 0.21 K` with a p-value of `1.93e-05`.

These p-values being below `5%`-all of them are below `0.002%`-making undeniable that the temperature has risen these four last decades all over the world.

Summer and winter rises

To understand better the new phenomenons making fires in the West-Canada's and Australia's forests as well as heat waves all over Europe, we made a chart displaying the summer in the previously chosen cities.

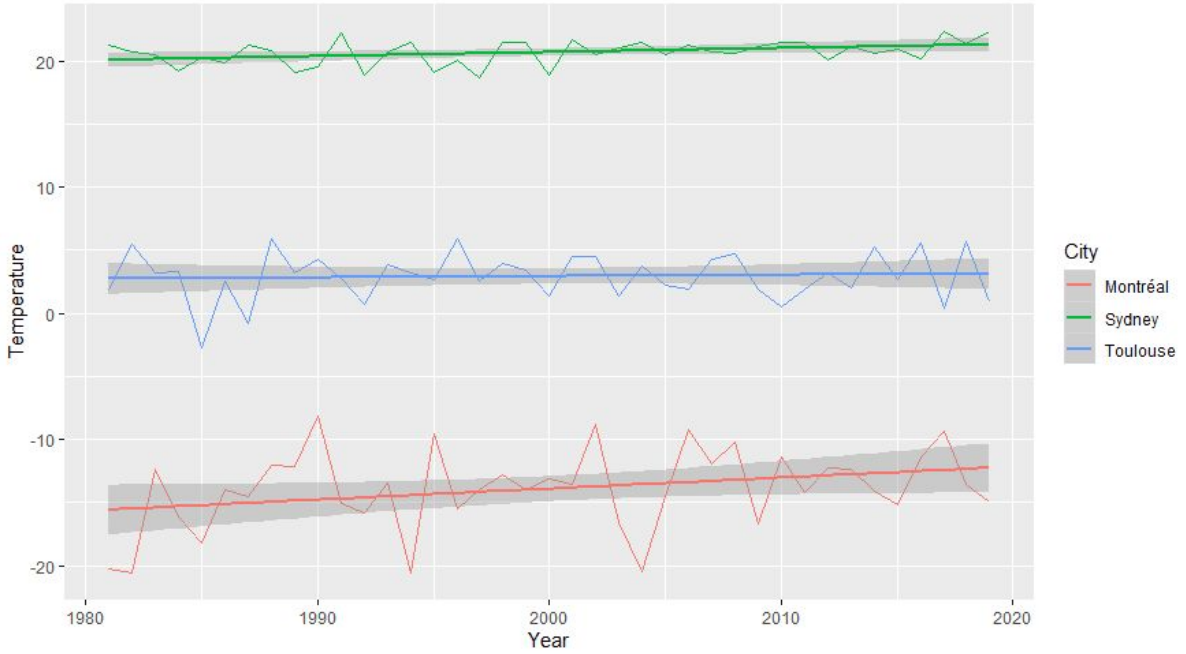


Above is shown the month of July over the years. As far as our eyes can tell, the model seems to indicate an increase of temperature for Montréal and Sydney but no concrete augmentation for Toulouse.

The linear model found gives a constant value of `20.88` with a p-value below `2e-16` but a change of `-0.001 K` over the years that is useless as its p-value shows being equal to `0.95`. Toulouse's summers seems stable over the years.

However, Sydney has an increase of `0.043 K` each year gaining `1.69 K ± 0.34 K` in 39 years with a p-value at `1.8e-05`. Sydney's summers are getting hotter and hotter, even more than the year's average.

Montreal's model estimates an increase of `1.19 K ± 0.62 K` but with a p-value of `0.06`, this increase is not to be taken as fact.



We did the same experiment in January this time to see Sydney's summers as well as the others' winters. The same intuitions are coming from this chart as Montreal's and Sydney's lines are rising and Toulouse's is stable, with uncertainties.

In the model, Toulouse keeps its same logic with a certain constant at `2.71 K` but a very improbable change with `0.70` for p-value. Montreal keeps its problem as well with a high rise of `3.40 K ± 1.71 K` but a p-value of `5,4%` so the statistic can not be considered as true.

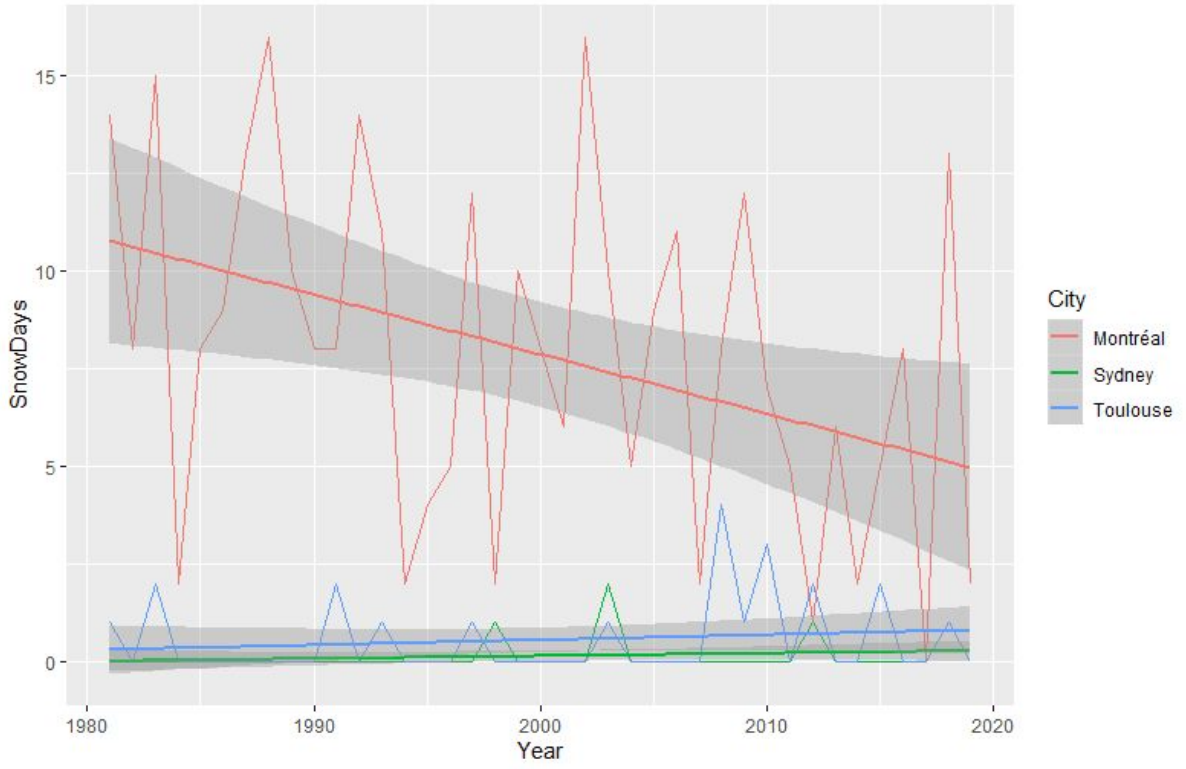
Sydney however is less certain than before-but still more certain than Montréal and Toulouse-with an increase of `1.24 K ± 0.50 K` and a p-value below `2%`.

Snowfall

To confirm what we observed, we choose to study snowfall in Sydney and Montreal. Unfortunately Toulouse snowfall are almost nonexistent for the period studied.
With a view to have consistent result, we decided to not to consider the amount of snow per day along years, but the number of day with snow. In fact, the amount of snow seems to be stable.
Thus, we use this condition to sort our dataset :

```
data$SnowFall > 0.000001
```

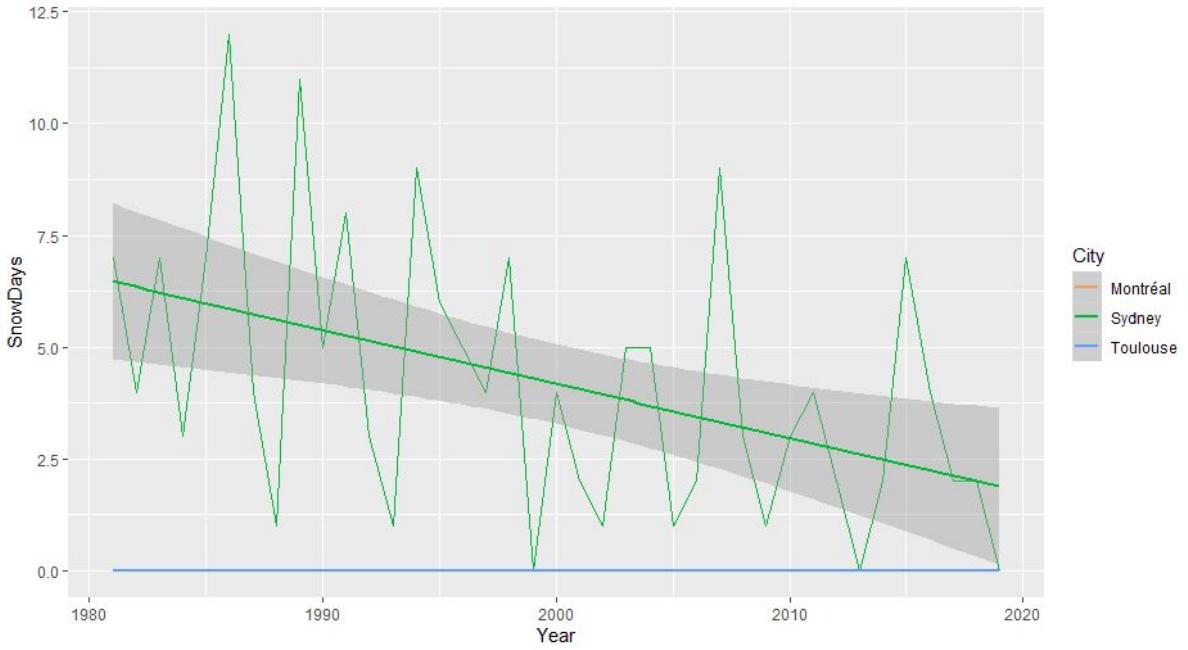
Montréal



Above figure shows days with snow in october. If we focuses on Montreal, the linear model used demonstrate a decrease. Montreal is losing 6 (`-5.95 ± 2.30`) days of snow in october for the period under study.
However, this time p-value is `0.014`, so even if our hypothesis is confirmed, these results are not as significant as previous ones.

Sydney presents no trend of change at all for the period considered according october correspond to spring in southern hemisphere.

Sydney



This time we looked at the city of sydney for the month of july. The same decreasing of days with snow is described by the model. It even appears with the same amplitude as it is in Montreal. Between 1980 and 2020, there are 5 `(-4.71 ± 1.52)` less snowy days in July in Sydney.
The model fits even better with a p-value of `0.0039`.

Conclusion

Our study allowed us to conclude that climate trends to warm, even over a period of 40 years, which is nothing compared to the planet's climate cycle described by Milankovitch, which lasts at least 19,000 years . Over the last 400’000 years, when the earth’s temperature was rising by 2°C, it usually took around 20’000 years. [2]

We found that there is a global rise for the temperature of 1.4 °C in 40 years for the 3 cities.
Montréal’s temperature rose probably more than 2°C in the last 40 years while Toulouse and Sydney have both gained a degree.

It appears also that snowfall are less recurrent and the amount of day with snow per year is decreasing. Since 1980, Sydney and Montreal are losing respectively 5 and 6 days of snow for the considered months.
However, the snow quantity is unchanged between years, we therefore observe that there are fewer snow days and consequently the snowy periods are as in the same way that summers are more pronounced.

In the end, our study demonstrated a certain causality between human activities over the last 40 years and climate change.
However, we can realize the statistical difficulty of the climate study. We have been led to make more or less judicious choices in order to highlight phenomena that are very unpredictable due to their temporality. We can therefore see here the need for transparency on the part of statisticians for subjects of this importance.

Source

[1] : http://www.soda-pro.com/web-services/meteo-data/merra

[2] : https://planet-terre.ens-lyon.fr/article/milankovitch.xml