ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

Global Climate Change:

Was it impacted upon by the COVID-19 industry 'lock-downs'?

Dr Harvey Stern

Disaster & Emergency Management Conference,

Gold Coast, QLD, Australia, Sep 2-3, 2021

*https://climate.nasa.gov/news/2948/milankovitch-orbital-cycles-and-their-role-in-earths-climate/
**https://data.giss.nasa.gov/gistemp ***https://gml.noaa.gov/ccgg/trends/data.html
****http://www.bom.gov.au/climate/enso/soi/ *****http://www.sidc.be/silso/datafile

*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

INTRODUCTORY REMARKS

Aside from what is the main driver of very long-term changes in the earth's climate, the Milankovitch orbital cycles*, we have the key driver of the well-known century-scale observed upward (and accelerating) trend in Global Mean Temperature** (GMT), namely, increasing Carbon Dioxide*** (CO2). There are also numerous drivers of short-term fluctuations in a range of parameters defining the earth's climate. These drivers include the El Niño Southern Oscillation**** (ENSO) phenomenon, volcanic eruptions, the sunspot cycle***** (these are referred to in the paper) and many more.

Evidence is now emerging that the policies adopted by the world's nations to deal with the coronavirus disease of 2019 (COVID-19) pandemic may also have had an impact – an unanticipated consequence – in relation to the Earth's climate. Discussing this matter is the primary raison d'être for what follows. To explain, for much of 2020, and continuing into 2021, many nations have seen the imposing of industry 'lock-downs' as the strategy of choice to bring the COVID-19 under control. In so doing, an involuntary experiment, which provides insight as to how a future transitioning away from a carbon-based economy might address global climate change, may have been conducted.

*https://climate.nasa.gov/news/2948/milankovitch-orbital-cycles-and-their-role-in-earths-climate/
**https://data.giss.nasa.gov/gistemp ***https://gml.noaa.gov/ccgg/trends/data.html
****http://www.bom.gov.au/climate/enso/soi/ *****http://www.sidc.be/silso/datafile

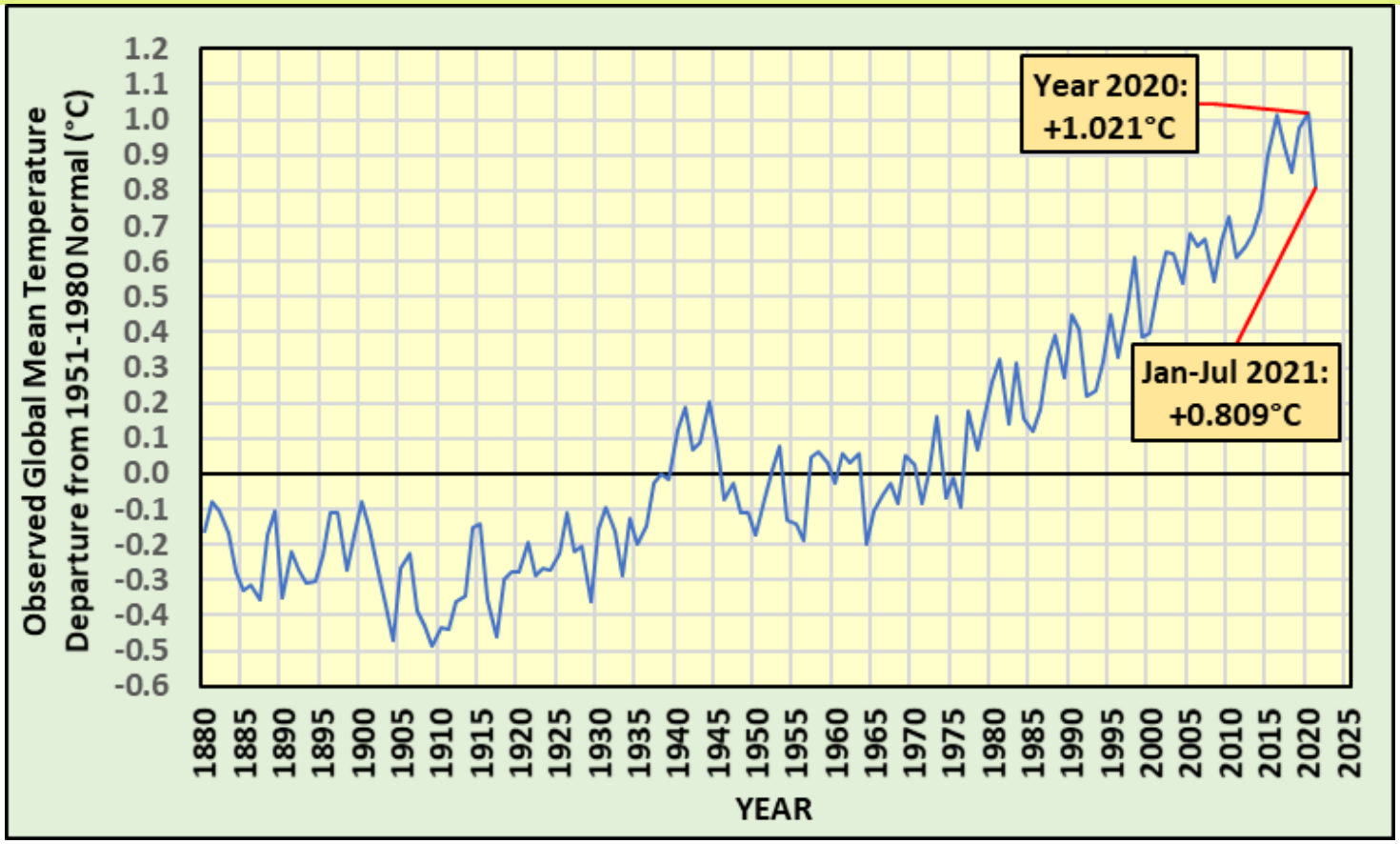
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

A DROP IN GLOBAL MEAN TEMPERATURE

Fig 1 highlights a significant drop in Global Mean Temperature for the first seven months of 2021 following the earth's warmest year on record in 2020.

Fig 1: Observed Year-on-Year Changes in Global Mean Temperature



*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

THE MOUNT PINATUBO ERUPTION

The 1991 Mount Pinatubo eruption (shown below) led to a temporary cooling of the earth's atmosphere. This paper poses the question: Has more than a year of industry 'lock-downs' to address the COVID-19 pandemic resulted in a similar outcome to this, and other, volcanic eruptions?

The Cataclysmic (June) 1991 Eruption of Mount Pinatubo, Philippines, Fact Sheet 113-97 (usgs.gov)
https://pubs.usgs.gov/fs/1997/fs113-97/

*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

COVID-19 & VOLCANIC ERUPTIONS

Fig 2 suggests that changes in the Global Mean Temperature, following the emergence of COVID-19, display similar characteristics to Global Mean Temperature changes in the wake of some of our most significant recent volcanic eruptions.

Fig 2: The impact of COVID-19 industry 'lock-downs' on global mean temperature vs that of recent major volcanic eruptions

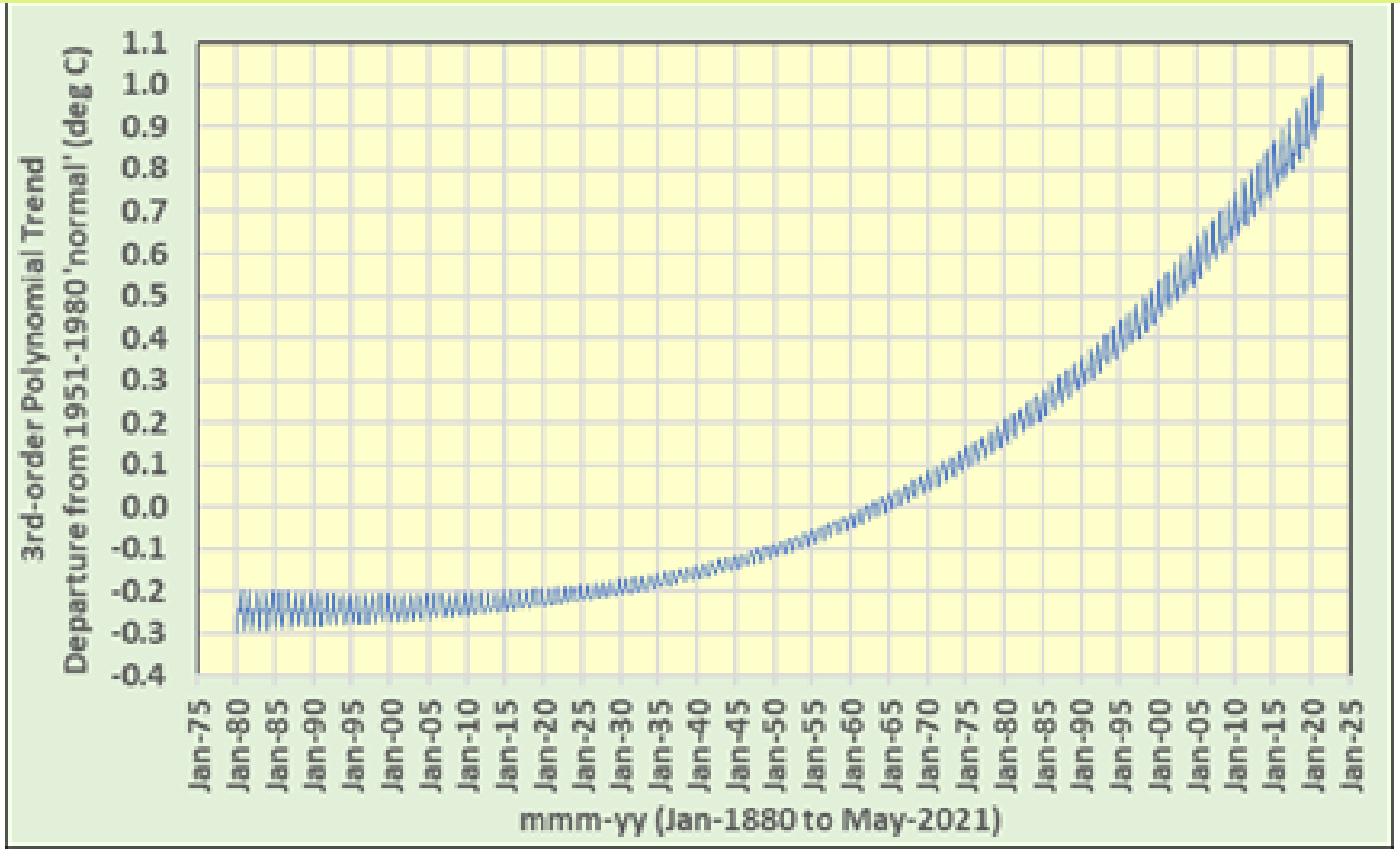
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au *website:* http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

TREND IN THE GLOBAL MEAN TEMPERATURE

An analysis of trends in the Global Mean Temperature data has been undertaken, that analysis revealing an accelerating upward rise in the Global Mean Temperature (**Fig 3**).

Fig 3 Trend in Global Mean Temperature



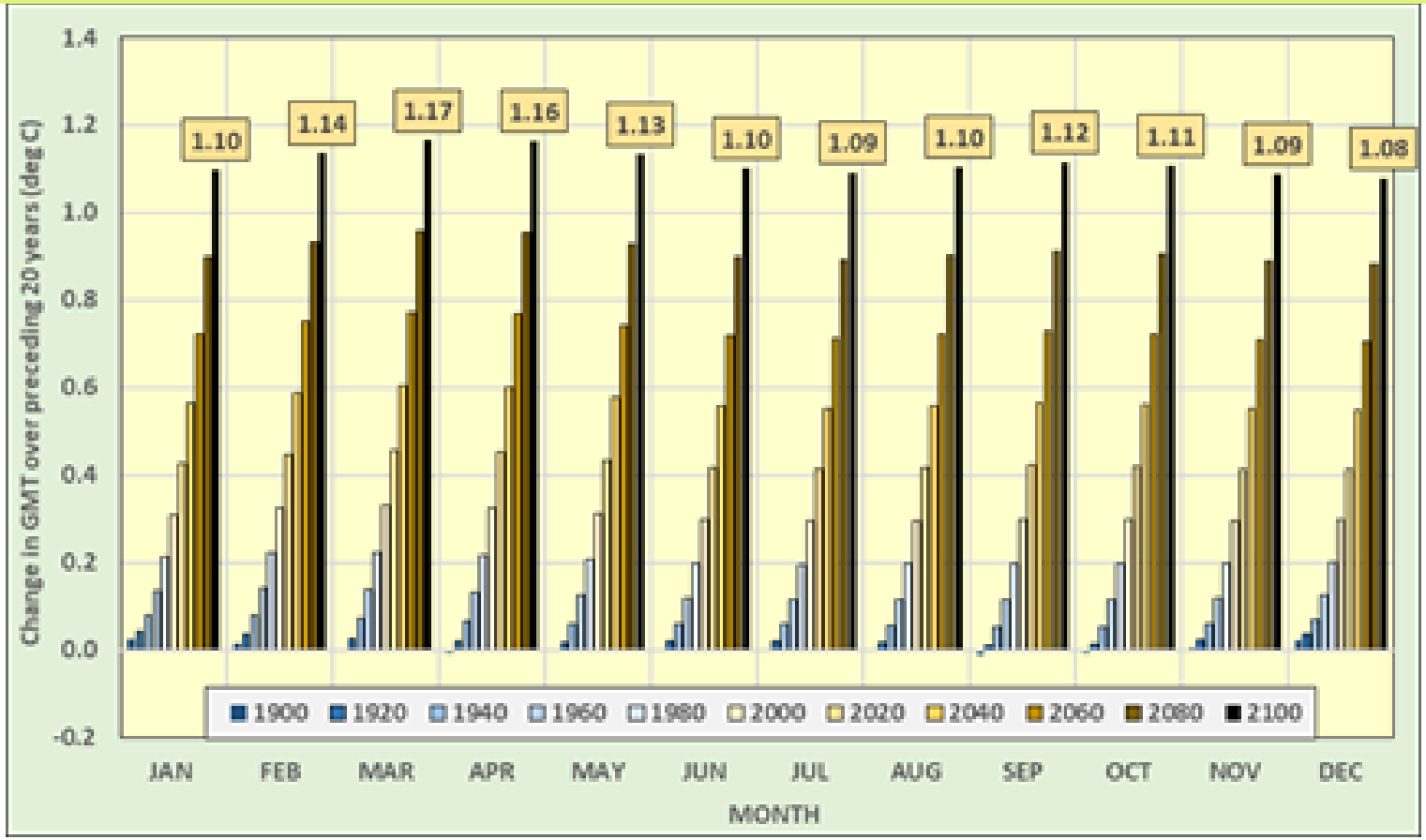
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au *website:* http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

SEASONAL TREND IN GLOBAL MEAN TEMPERATURE

Fig 4 shows that the upward trend in Global Mean Temperature is stronger during the northern hemisphere's late winter/early spring, than it is during other seasons.

Fig 4 Seasonal Observed & Projected Trend in GMT

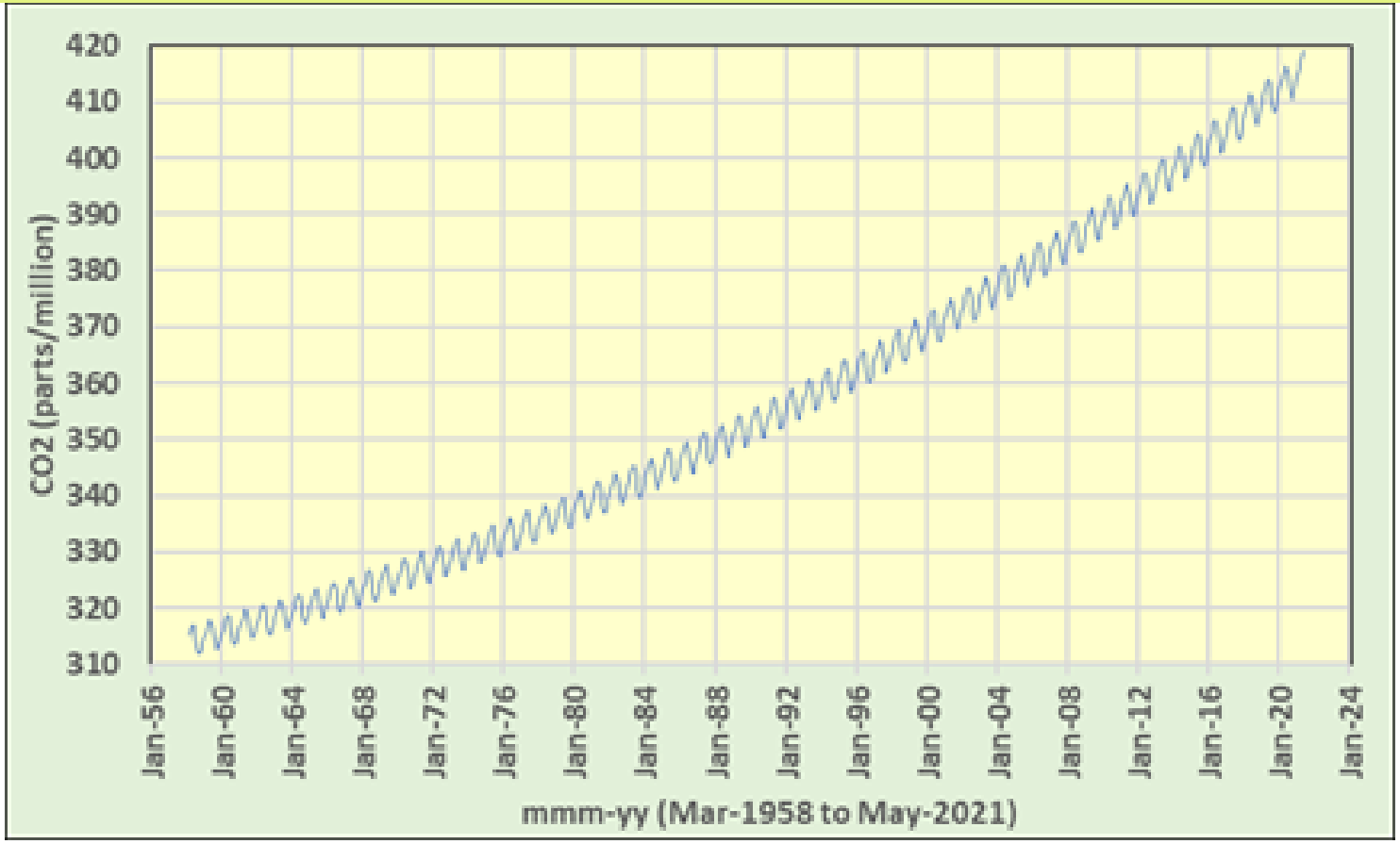


*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au *website:* http://www.weather-climate.com

TREND IN CO2

Fig 5 depicts the trend in what is the main century-scale driver of that upward trend in Global Mean Temperature, namely, increasing CO2 over the past six decades from 310 to 420 parts per million.

Fig 5 Trend in CO2



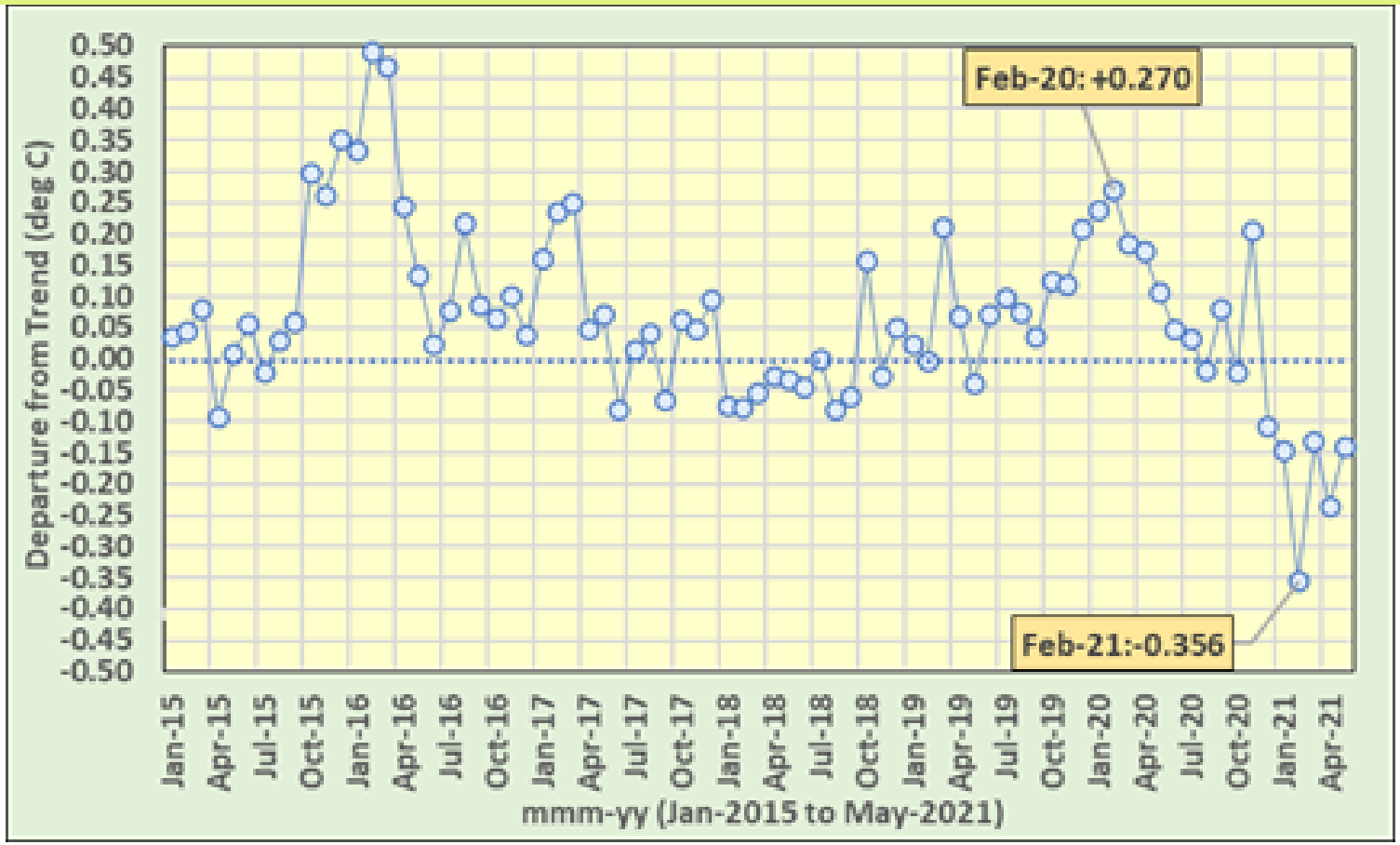
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

RECENT *DEPARTURE FROM TREND* OF GLOBAL MEAN TEMPERATURE

Fig 6 shows that, in the year from Feb-2020 to Feb-2021, the *Departure from Trend* of the Global Mean Temperature fell from +0.270°C to -0.356°C (a net fall of 0.626°C).

Fig 6 Observed *Departure from Trend* of Global Mean Temperature

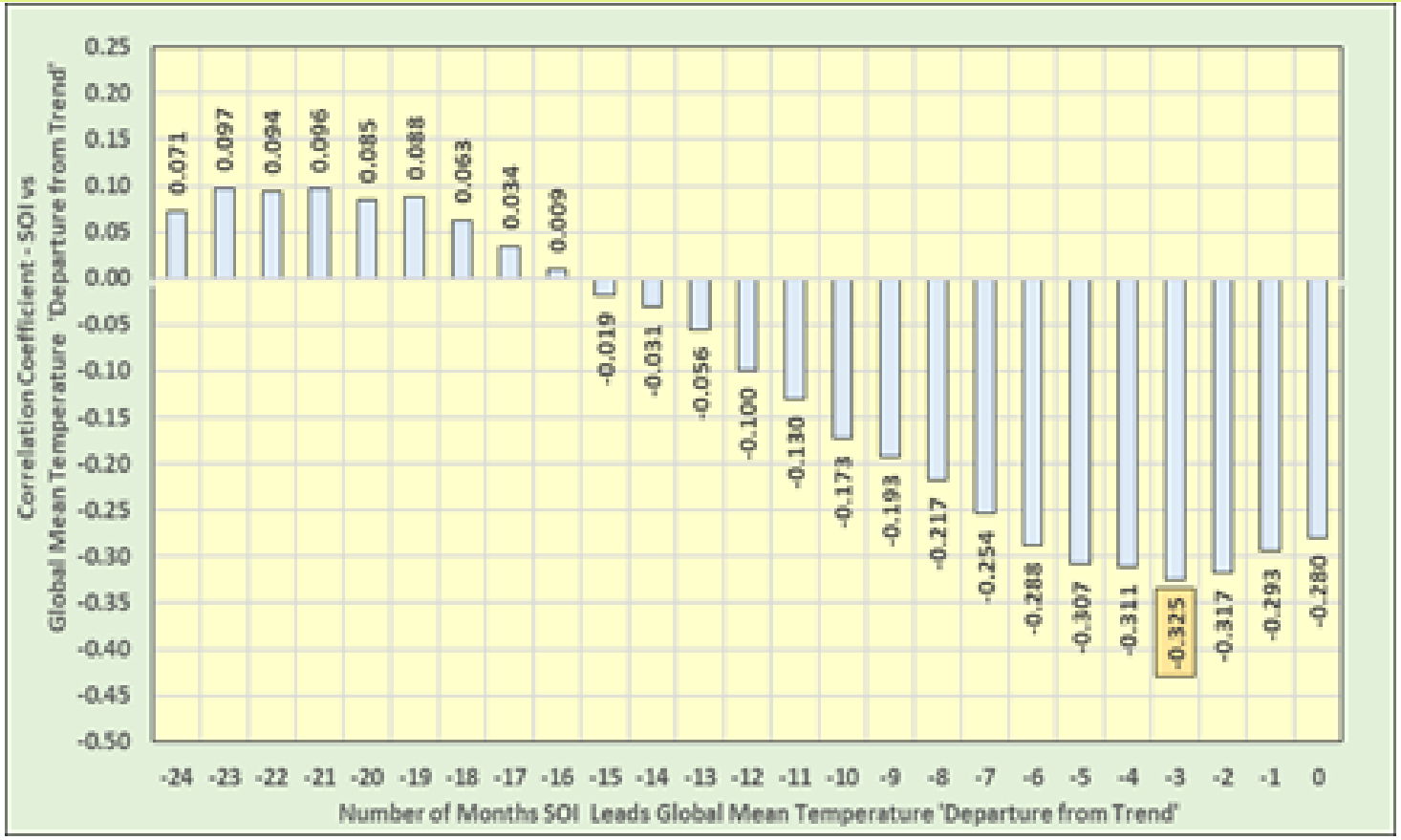


*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au *website:* http://www.weather-climate.com

HOW ENSO 'DRIVES' GLOBAL MEAN TEMPERATURE

Fig 7 demonstrates that short-term fluctuations in the Global Mean Temperature are driven (with a lag of three months) by ENSO.

Fig 7 How the Southern Oscillation Index (SOI) Leads the Global Mean Temperature



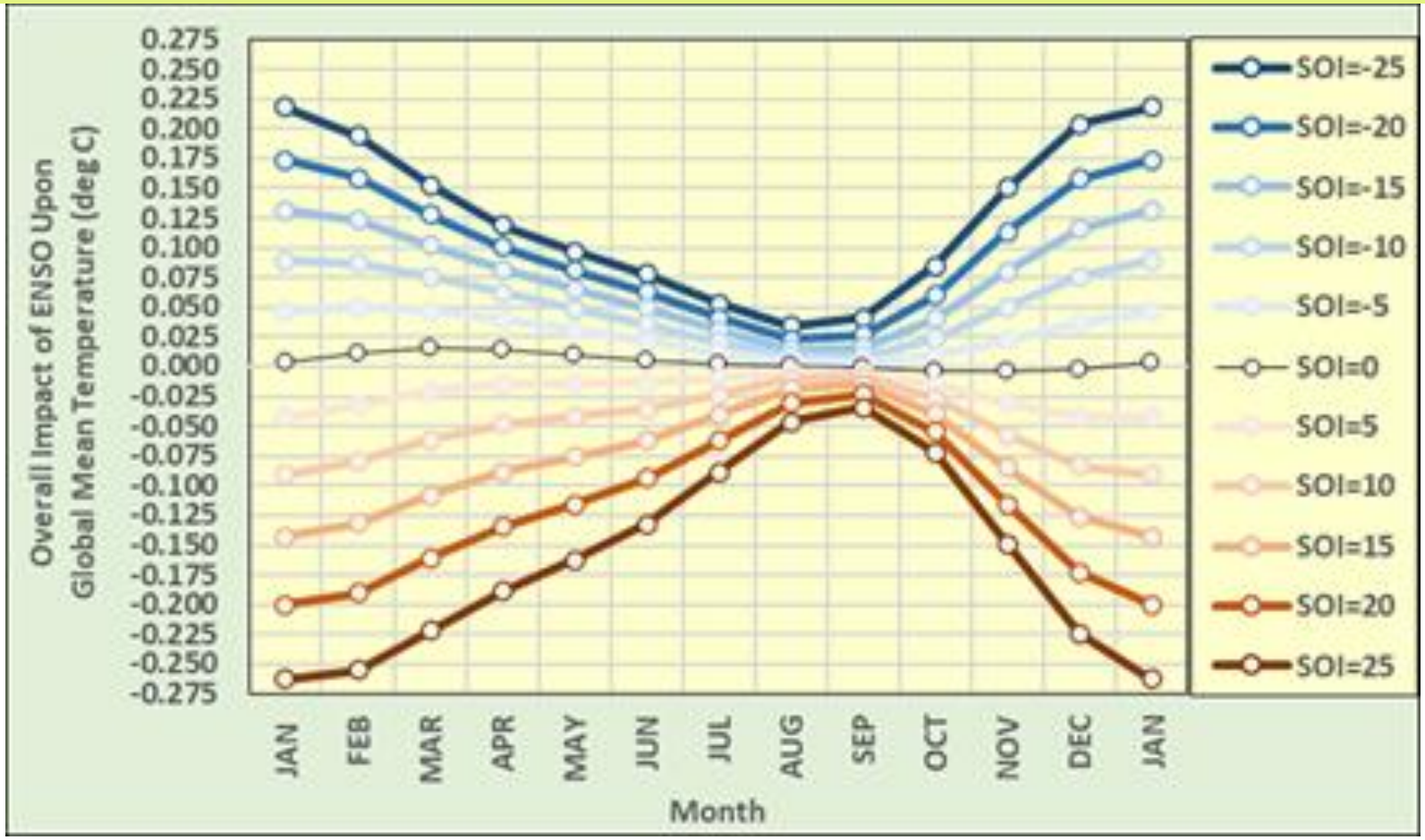
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

HOW ENSO 'DRIVES' GLOBAL TEMPERATURE (SEASONAL VARIATIONS)

A clear seasonal variation of that (ENSO) impact, particularly notable during the northern winter, is illustrated by **Fig 8**.

Fig 8 Seasonal Variations in how the Southern Oscillation Index (SOI) Leads Global Mean Temperature



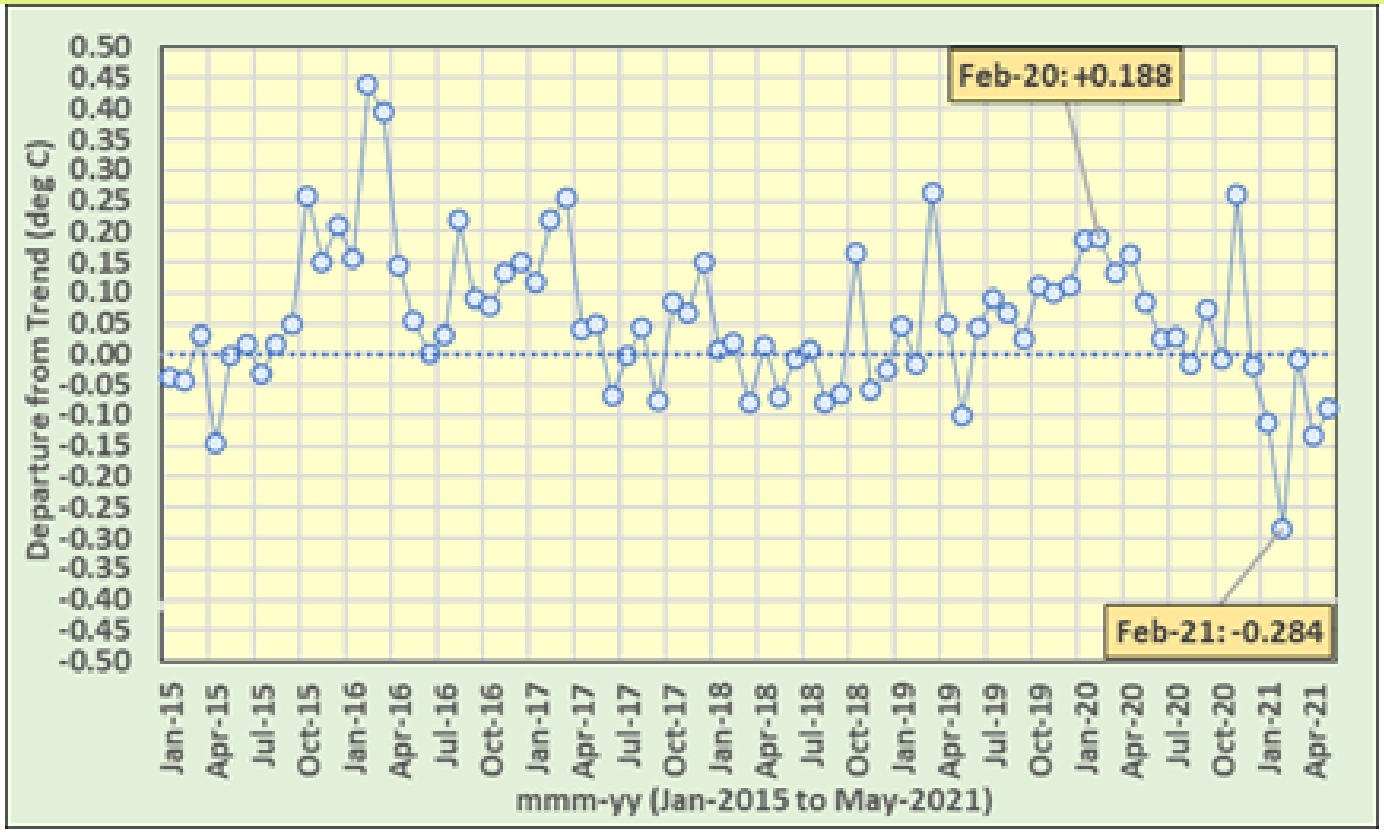
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au *website:* http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

ENSO REDUCES THE 'APPARENT' FALL

Fig 9 suggests that the net 'raw' Feb-2020 to Feb-2021 GMT fall (from +0.270°C to -0.356°C yielding a net change of -0.626°C) is somewhat reduced when the impact of ENSO is considered (now from +0.188°C to -0.284°C yielding a net change of -0.472°C).

Fig 9 *Departure from Trend* of GMT (2015-21): ENSO Adjusted



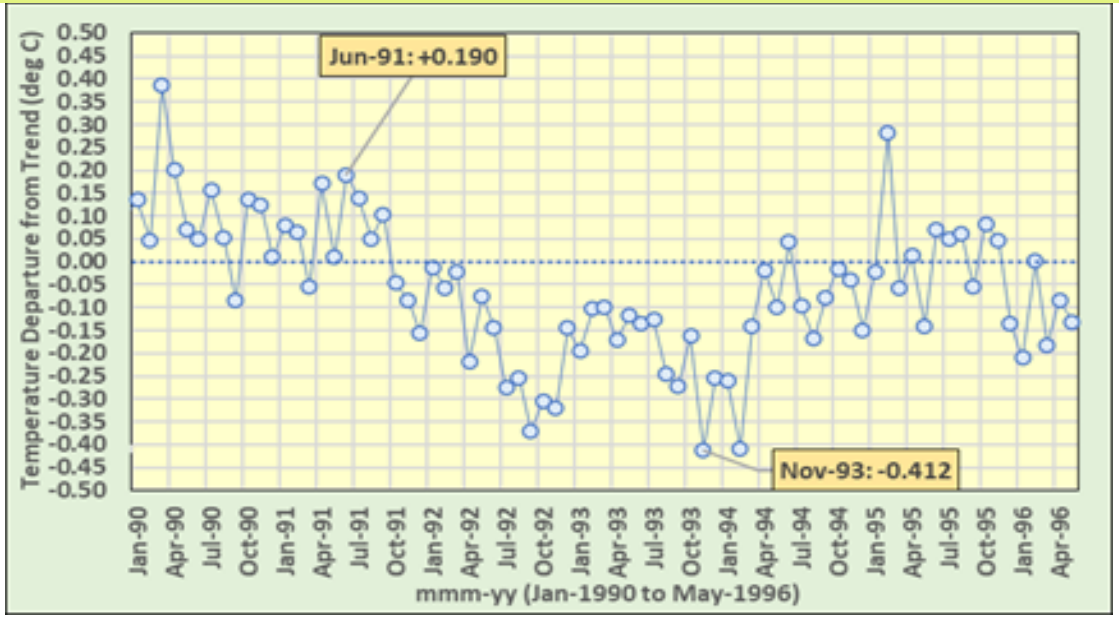
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

IMPACT OF PINATUBO ERUPTION

Fig 10 suggests that the 1991 Mount Pinatubo eruption led to a temporary cooling of the earth's atmosphere. In Jun-1991, when the Mount Pinatubo eruption took place, the *Departure from Trend* of the Global Mean Temperature was +0.190°C. Seventeen months later, it was -0.412°C. That net drop of 0.602°C may be attributed to the injection of volcanic gases, such as Sulphur Dioxide, into the stratosphere by the eruption. What might we now say about whether more than a year of industry 'lock-downs' to address the COVID-19 pandemic has resulted in a similar outcome to the Mount Pinatubo eruption? Whilst the Global Mean Temperature data provide evidence in support of an affirmative response to that question, there is no support from the recent atmospheric CO2 data. … SEE NEXT SLIDE (**Fig11**)

Fig 10 *Departure from Trend* of GMT (1990-1996): ENSO Adjusted



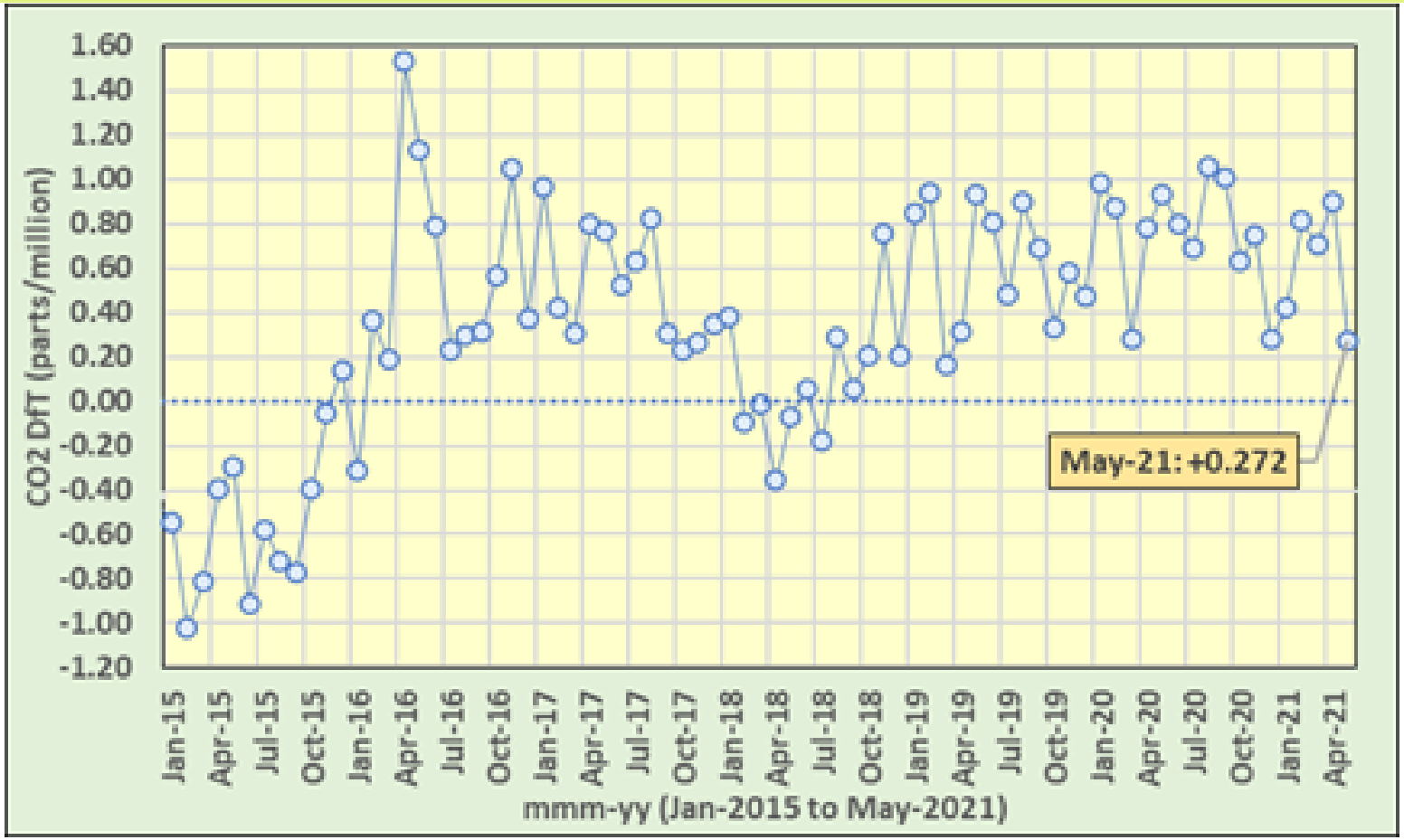
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

CO2 DURING PANDEMIC

After all, **Fig 11** indicates a positive 'Departure from Trend' of CO2 throughout the period of the pandemic.

Fig 11 *Departure from Trend* of CO2 (2015-2021)



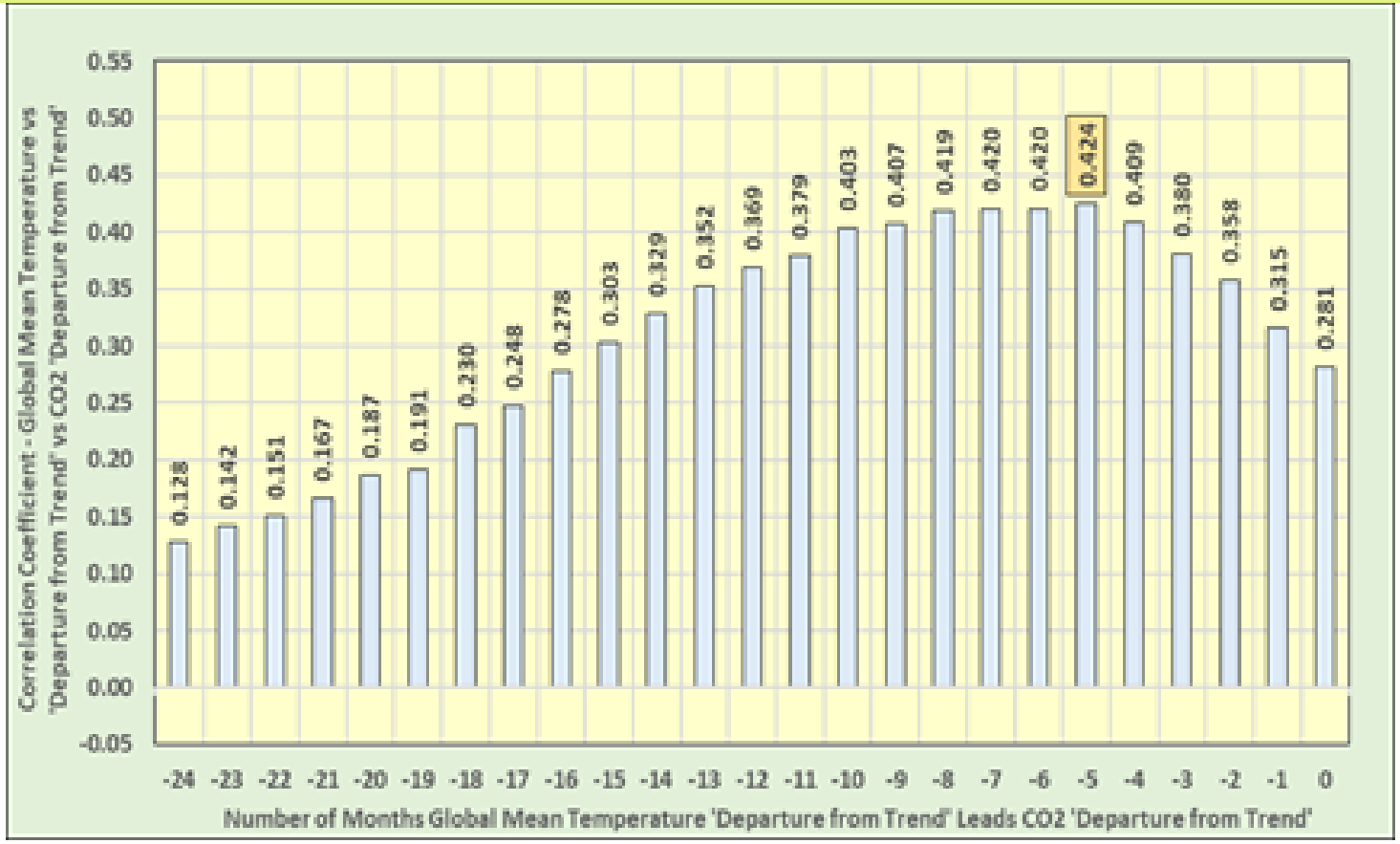
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au *website:* http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

GLOBAL MEAN TEMPERATURE LEADS CO2

Nevertheless, the jury appears to be still out, especially given that short-term fluctuations in CO2 lag fluctuations in Global Mean Temperature (**Fig 12**) by 5 months.

Fig 12 How Global Mean Temperature Leads CO2



*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

HOW SOI LEADS CO2

Short-term fluctuations in CO2 are also driven by the ENSO phenomenon, in this case with a lag of 12 months (**Fig 13**).

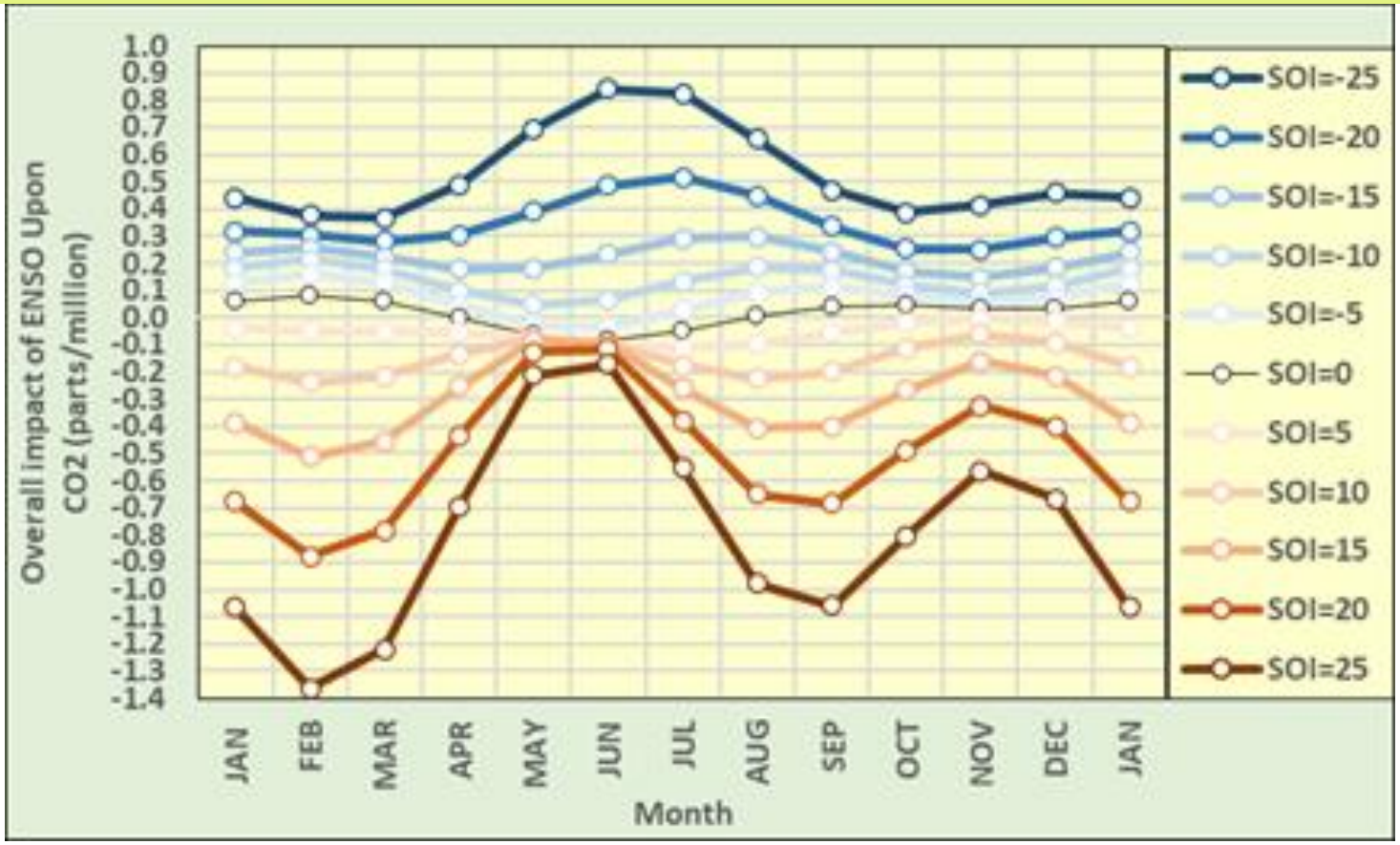
Fig 13 How SOI Leads CO2

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

ENSO'S SEASONAL IMPACT ON CO2

Specifically, increases in CO2 follow El Niño events (indicated by negative SOIs), especially in the late northern winters and late northern summers (**Fig 14**), whilst decreases in CO2 follow La Niña events (indicated by positive SOIs).

Fig 14 Seasonal *Departure from Trend* of CO2 vs SOI



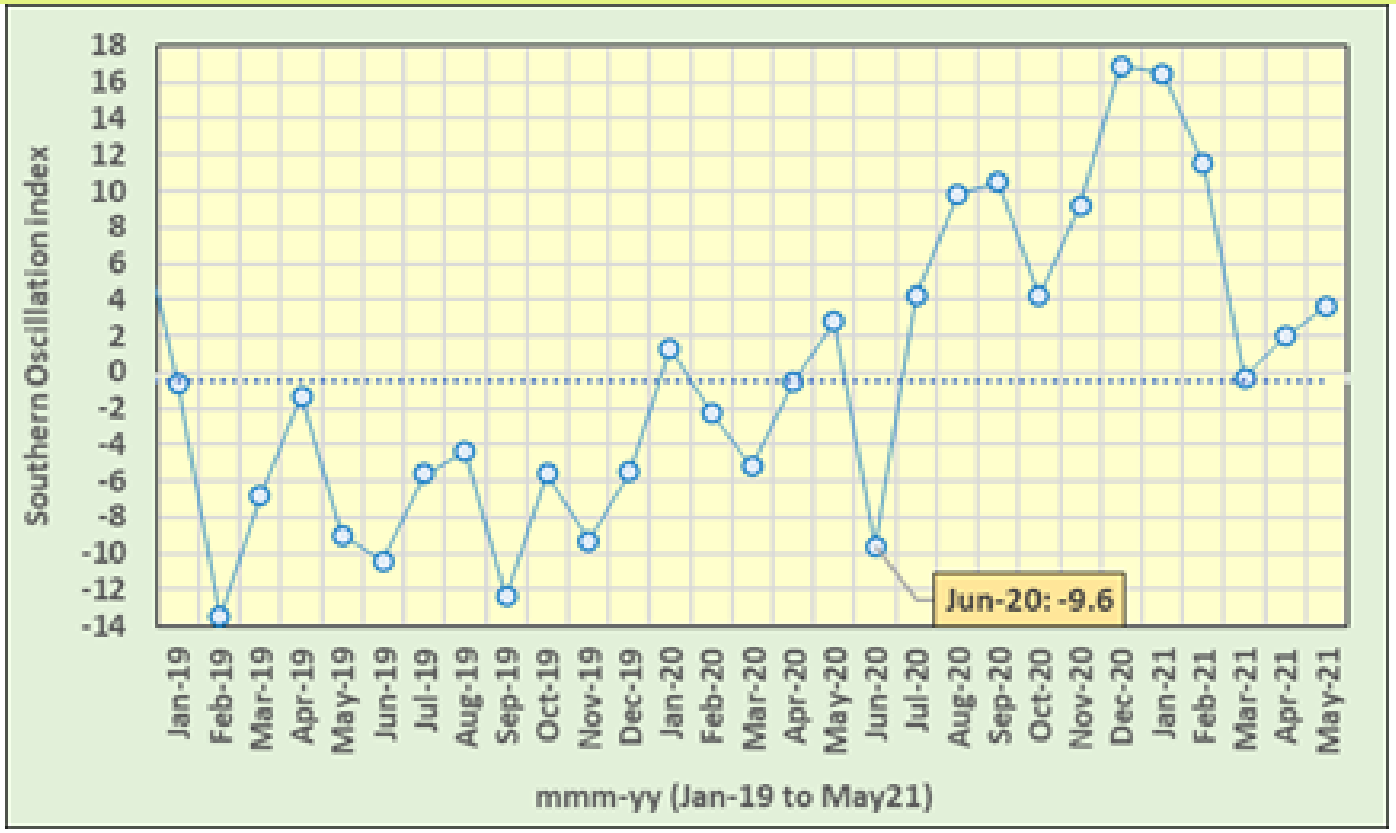
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

RECENT SOI VALUES AND CO2

Furthermore, the positive *Departure from Trend* of CO2 during recent months may be a consequence of the previous 2019-2020 El Niño, bearing in mind that its impact was being felt as recently as Jun-2020, when the Southern Oscillation Index (SOI) was -9.6 (**Fig 15**).

Fig 15 Monthly Southern Oscillation Index (SOI)



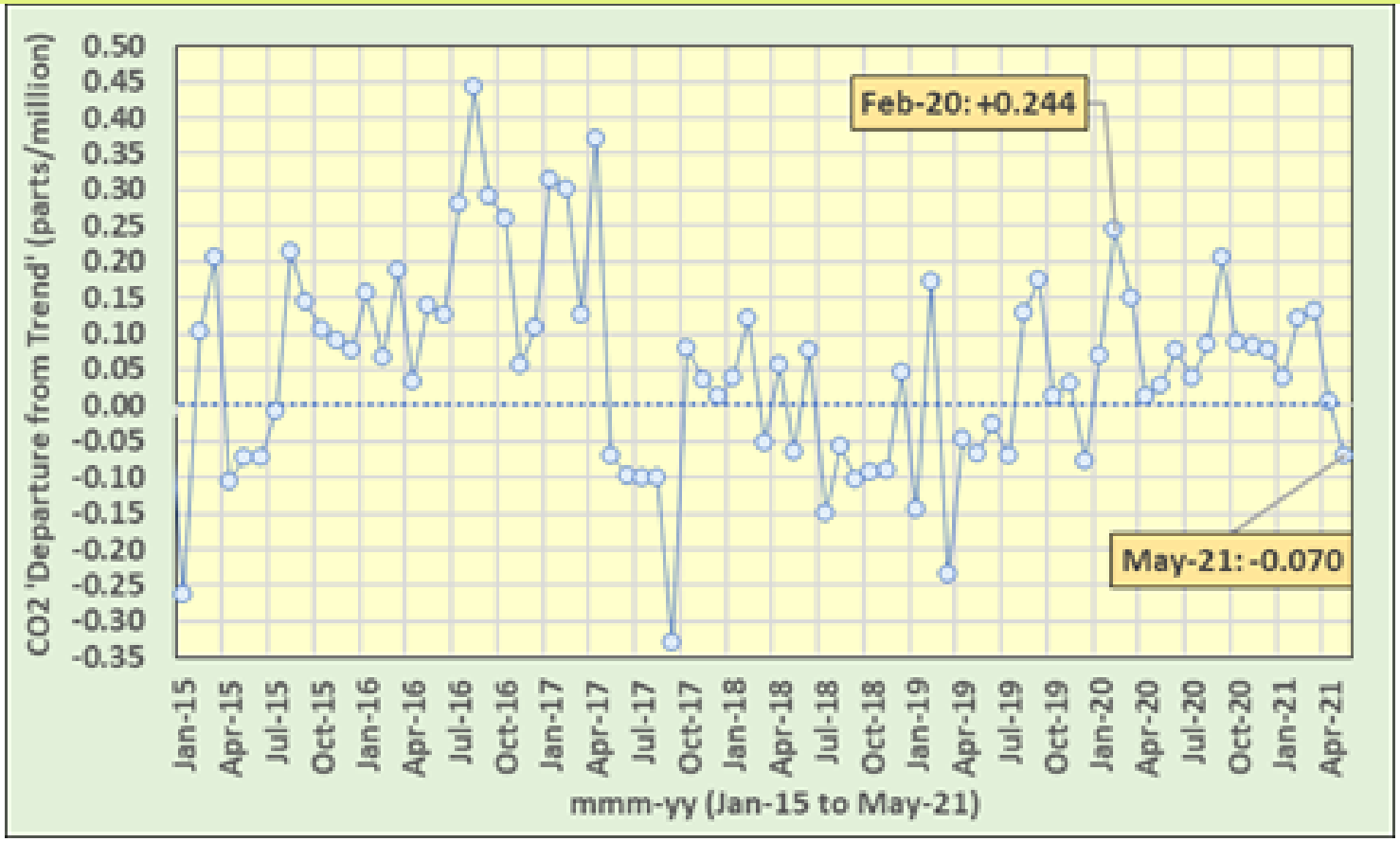
*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

CO2 DURING PANDEMIC: ENSO ADJUSTED

To this end, **Fig 16** provides support for the proposition that, if one considers the impact of the ENSO phenomenon, the *Departure from Trend* of the CO2 was (possibly) turning negative by May-2021.

Fig 16 *Departure from Trend* of CO2 (2015-2021) ENSO Adjusted



*School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com

ACRONYMS: CO2: Carbon Dioxide. COVID-19: coronavirus disease of 2019. GMT: Global Mean Temperature. SOI: Southern Oscillation Index. ENSO: El Niño Southern Oscillation.

CONCLUDING REMARKS

This paper opened asking whether the policies adopted by the world's nations to deal with the COVID-19 pandemic, such as the industry 'lock-downs', have had an impact on the earth's climate.

The paper closes with some data suggesting that the consequence may have been a temporary cooling of the earth's atmosphere, the magnitude of that cooling having been like that which occurred in response to major volcanic eruptions.

On the other hand, however, the minimal response on the part of 'raw' trends in atmospheric CO2 casts doubt on this suggestion, and the best one can say is that the jury is still out on the matter.

As time passes, and new data becomes available for further analysis, one may be able to reach a more confident conclusion.

… THANK YOU

[*]School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Parkville, Vic., Australia.
e-mail: hstern@unimelb.edu.au website: http://www.weather-climate.com