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The Earth's Decadal Rotation and Climate Dynamics

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Abstract

Several oscillating atmospheric/oceanic systems (e.g., the El Niño/Southern Oscillation, Quasi-Biennial Oscillation, Pacific Decadal Oscillation, and North Atlantic Oscillation) are largely responsible for the Earth's weather and climate. Two fluid structures (the oceans and atmosphere) envelope the solid Earth. A rotating fluid generates waves (inertial waves) that flow inside the fluid, not on the surface. The inertial (Rossby and Kelvin) waves in the atmosphere and oceans are largely responsible for the formation, intensity, and duration of the main atmospheric/oceanic oscillating systems. The Earth's rotation has a dominant role in climate dynamics because it causes the inertial waves. The Earth rotation rate is typically 86,400 seconds per day: the Length of Day (LoD). There are three well-established findings about the Earth's rotation:

- Every ten years or so the Earth's rotation rate increases or decreases significantly by between three and five milliseconds.
- When, on a decadal basis, the Earth's rotation rate increases, the Earth warms globally; when the rate decreases, the Earth cools globally.
- The cycles of global warming and cooling episodes repeat about every 60 years.

Overlaying these cycles are the impact of the

- Sun via radiation, matter, electromagnetic and gravitational fields, and their interaction effects;
- atmospheric/oceanic systems' interaction effects; and
- interaction effects of all processes.

The decadal rotational variations likely arise from gravitationally driven electromagnetic coupling between inner and outer cores and the mantle. Global temperature changes some eight years after the Earth's rotation rate changes. The Earth's rotation rate changes some eight years after the inner core's rotation rate changes. Recently, scientists found that the inner core's rotation rate began to slow around 2009. Global cooling is likely to set in around 2025. The Intergovernmental Panel on Climate Change does not mention any of the vast body of research published over the last 50 years on this subject. US and OECD scientific authorities consider that the deliberate omission of scientific results constitutes the falsification of science and is scientific misconduct.

Keywords: Greenhouse effect; radiative forcing; Earth rotation; Rossby wave; Kelvin wave; Lunar Nodal Cycle; complex systems; global warming; global cooling; core-mantle coupling; geodynamo; geomagnetic field; electromagnetic coupling; climate dynamics; Hurst-Kolmogorov dynamics; sensitive dependence; Liouville-Euler equations; Barents Sea ice-edge; Earth core; inner core; magnetopause; solar wind; solar system; falsification of science; scientific misconduct.

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Bertrand Russell

The concept of "truth" as something dependent upon facts largely outside human control has been one of the ways in which philosophy hitherto has inculcated the necessary element of humility. When this check upon pride is removed, a further step is taken on the road towards a certain kind of madness--the intoxication of power which invaded philosophy with Fichte, and to which modern men, whether philosophers or not, are prone. I

*am persuaded that this intoxication is the greatest danger of our time, and that any philosophy which, however unintentionally, contributes to it is increasing the danger of vast social disaster.*¹

1. Introduction *

A key finding of Geophysics is that every ten years or so the rate at which the Earth rotates increases or decreases significantly. The Earth typically spins at the rate of 86,400 seconds per day: this rate is known as the Length of Day (LoD). Every ten years or so, the rate of rotation speeds up or slows down more than the usual variations that occur in periods less than ten years. These decadal variations result in the LoD increasing or decreasing by between three and five milliseconds. Historically, the Earth's rotation was the absolute standard for time keeping in the 17th, 18th and 19th centuries. As a result, astronomers used the presumed fixed constant of the Earth's rotation to determine all astronomical attributes of the Sun and the solar system. The world's leading astronomers initially rejected the evidence emerging in the later part of the 19th Century that the Earth's rotation might be variable. An overview of the history of the recognition that the Earth's rotation was variable and not constant is at Attachment A.

Another key finding of Geophysics is that when, on a decadal basis, the rate of rotation of the Earth increases by the number of milliseconds mentioned above, the Earth warms globally²; when the rate decreases by a similar amount, the Earth cools globally. There is a time lag of about 8 years between LoD changes and global temperature changes. The most recent estimates of the temperature changes are $\pm 0.8^{\circ}\text{C}$.

In this paper Figure 1 (page 125) and Figure 7 (page 140), the two diagrams reproduced in Attachment B (Figures B1 and B2) and the discussion of them, shows the well-established relationship between the decadal changes in the Earth's rate of rotation and climate. The finding is not simply a correlation, but a detailed explanation of how changes in the Earth's rotation bring about changes in global temperatures.

These findings have been established by multiple teams of leading scientists working independently over the last half-century and published in the world's leading scientific journals.

The result was first reported in 1976 by Australia's distinguished Geophysicist, Emeritus Professor Kurt Lambeck AC, FRS, FAA, FRSN, Professor of Geophysics at the Australian National University, jointly with Dr Anny Cazenave of France.³ Dr Cazenave has published additional results jointly with two distinguished French Geophysicists, Professor Vincent Courtillot, and Professor Jean-Louise Le Mouel.

Professor Nikolay S. Sidorenkov, the head of the Global Atmospheric Circulation Laboratory of the Russian Hydrometeorological Center, has published extensively on this topic (Sidorenkov (2009)).

Other teams include the distinguished American Physicist, the late Dr Jean O. Dickey (1945 - 2018);⁴ Dr Leonid Zotov, Associate Professor at the Sternberg Astronomical Institute, Lomonosov Moscow State University; Dr Christian Bizouard, Director of the International Earth Rotation and Reference System Service (IERS) Earth Orientation Center and Director of the Earth Rotation and Space Geodesy team at Time-space Reference System (SYRTE) Observatoire de Paris; and Dr C.K. Shum, Professor and Distinguished University Scholar, Division of Geodetic Science, School of Earth Sciences, at The Ohio State University.⁵

In 1990, Professor Jean Pierre Rozelot published evidence of a strong relationship between the Earth's decadal changes in rotation and global temperatures.⁶

*Footnotes are placed at the end (pages 169-172)

Between 1984 and 2009, Professor Horst Jochmann and Dr Hans Greiner-Mai of the GeoForschungsZentrum (GFZ) (German Research Center for Geosciences at the Helmholtz Center Potsdam) published over a two dozen papers that examined aspects of core-mantle coupling, Earth rotation and climate dynamics. The National Report of the Federal Republic of Germany about geodetic activities in the years 1995 to 1999 summarised much of their published research concluding that their work showed that the Earth's climate cycles are related more to core dynamics than to atmospheric circulation.

The following scientific journals published the findings referred to in the three preceding paragraphs:

- *Geophysical Journal of the Royal Astronomical Society*
- *Philosophic Transactions of the Royal Society of London*
- *Journal of Climate*
- *Nature*
- *Geophysical and Astrophysical Fluid Dynamics*
- *Astronomical Notes (Astronomische Nachrichten)*
- *Advances in Space Research*
- *Surveys in Geophysics*
- *Earth Interactions*
- *Physics of the Earth and Planetary Interiors*
- *Geodesy and Geodynamics*
- *Journal of Geodynamics*

as well as three significant monographs, namely Lambeck (1980), Sidorenkov (2009) and Kilian (2020).

These findings, stretching over almost fifty years, have not been contested by any scientist or scientific authority.

In two recently published, richly empirical papers, a team of scientists from Norway and Sweden showed that the Earth's rotation is an agent for forcing the Barents Sea ice-edge (BIE) (at least after 1800) to alternate between a southern and a northern position (Mörner, Solheim, Humlum, and Falk-Petersen (2020) and Solheim, Falk-Petersen, Humlum and Mörner (2021)). In order to understand how the BIE varied over time, the team analysed a 442-yearlong dataset of BIE variations. The data was collected from ship-logs, polar expeditions, and hunters in addition to airplanes and satellites in recent times. The authors explain that the database is the Arctic Climate System Study (ACSYS) Historical Ice Chart Archive, 1553-2002 compiled by Torgny Vinje (1929 – 2015)⁷ of the Norwegian Polar Institute (NPI) over a period of some 50 years (Vinje 2001). The earliest chart on the database dates from 1553. The database is maintained and kept up-to-date; it is considered one of the NPI's significant scientific assets (Issaksson et al. 2016). The team found that the BIE position alternates between a southern and a northern position followed by Gulf Stream Beats (GSBs) at the occurrence of deep solar minima.

The team consisted of Jan-Erik Solheim, Professor Emeritus of The Arctic University, Ole Humlum, Professor Emeritus of Physical Geography at the University of Oslo, Department of Geosciences and adjunct Professor of Physical Geography at the University Centre in Svalbard, Stig Falk-Petersen, Senior Scientist at the Fram Centre, the High North Research Centre for Climate and the Environment, and the late Nils-Axel Mörner (1938 – 2020) formerly the Head of the Paleogeophysics and Geodynamics unit at Stockholm University until his retirement in 2005.

The authors report that the evidence indicates that the BIE is moving south this century, indicating Arctic cooling to come. If so, the effects of the BIE expanding south for the North Atlantic region, will be noticeable consequences for the ocean bio-production from about 2040, and presumably also for planned ocean transport across the Arctic Ocean.

Mazzarella and Scafetta (2018) examined links amongst the time series of LoD (1623–2016), the

zonal index (ZI, 1873–2003), the NAO index 1659–2000) and the global sea surface temperature (SST, 1850–2016) to hindcast the severity of the global climate cooling during the Little Ice Age (LIA) of the seventeenth–eighteenth century. The authors' found that it was most likely that during the coolest period of the Little Ice Age (LIA), SST could have been about 1.0–1.5 °C cooler than the 1950–1980 period. According to the authors, this estimated LIA cooling is greater than what some multiproxy global climate reconstructions suggested, but it is in good agreement with other more recent climate reconstructions including those based on borehole temperature data.

2. Oscillating atmospheric/oceanic systems regulate climate

The Earth's atmosphere contains several major oscillating atmospheric/oceanic systems that are largely responsible for the regulation of the Earth's weather and climate. These oscillating systems include the El Niño/Southern Oscillation (ENSO); Quasi-Biennial Oscillation (QBO); the Pacific Decadal Oscillation (PDO); the Interdecadal Pacific Oscillation (IPO); the North Atlantic Oscillation (NAO); the Atlantic Multidecadal Oscillation (AMO); the Indian Ocean Dipole (IOD); Southern Annular Mode (SAM); the Madden–Julian Oscillation (MJO). the Arctic Oscillation (AO); the northern and southern polar vortices, which are two permanent cyclones at the poles; and Atmospheric Rivers. There are, as well, local systems specific for particular geographic areas of the world. For example, in Australia the Subtropical Ridge and the East-Coast Low Pressure System sometimes have a significant role in the regulation of Australia's weather and climate.

Two fluid structures envelope the solid Earth – the oceans and the atmosphere. A rotating fluid generates waves that flow through the interior of the fluid, not on the surface like the waves on the oceans. These waves are called inertial waves. They are caused by a restoring force, a force that acts to bring a body to its equilibrium position. This force is the Coriolis force which arises (along with the centrifugal force) in a rotating frame because the frame is always accelerating. The Coriolis force acts at a 90° angle to the direction of motion: its strength depends on the rotation rate of the fluid.

Inertial waves are perpendicular to the direction of wave travel, just like light waves. The phase velocity of inertial waves is the movement of the crests and troughs of the wave. It is perpendicular to their group velocity, a measure of the propagation of energy.

The inertial waves in the atmospheres and oceans of planets are known as Rossby waves. They are a key feature of large-scale ocean and atmospheric circulation.

Atmospheric Rossby waves are giant meanders in high-altitude winds that have a major influence on weather and climate. These waves are associated with pressure systems and the jet stream. Oceanic Rossby waves are huge, undulating movements of the ocean that stretch horizontally across the planet for hundreds of kilometres in a westward direction. They are so large and massive that they can change Earth's climate conditions. They move along the thermocline: the boundary between the warm upper layer and the cold deeper part of the ocean. They can be thousands of kilometres long, have amplitudes smaller than 10 cm and travel slowly, requiring years to decades to cross the Pacific Ocean. They do not show up clearly in ocean views provided by conventional measurements.

Since the rotation of the Earth causes Rossby waves, the rotation of the Earth has a dominant role in the dynamics of the atmosphere and oceans on time scales of a day or more.

If an inertial wave is trapped by a boundary, the fluid piles up and flows along the boundary. This phenomenon in planets' atmospheres and oceans of is known as Kelvin waves.

Atmospheric Kelvin waves play an important role in the adjustment of the tropical atmosphere to convective latent heat release, in the stratospheric quasibiennial oscillation, and in the generation and maintenance of the Madden–Julian Oscillation. The atmospheric equatorial Kelvin wave is

one of the critical wave motions in the response of the tropical atmospheric circulation to a heat source.

Oceanic Kelvin waves play a critical role in tidal motion, in the adjustment of the tropical ocean to wind stress forcing, and in generating, sustaining, and terminating ENSO. Kelvin waves in the far-western Pacific initiate ENSO; whereas Kelvin waves from the western Pacific erode the thermocline structure in the central Pacific preventing further development of ENSO and ultimately terminating it.

In the atmosphere and the oceans, the Coriolis force vanishes at the equator. A consequence of this is that the equator forms a boundary against which the fluid piles up forming an equatorial Kelvin wave that flows eastward.

Rossby and Kelvin waves in the Atmosphere and the Oceans are largely responsible for the formation, intensity and duration of the seven atmospheric/oceanic oscillations – ENSO, QBO, PDO, IPO, IOD, SAM, and MJO that regulate global and regional climate.

Since the rotation of the Earth is responsible for the Rossby and Kelvin waves in the Atmosphere and the Oceans, the Earth's rotation has a dominant role in the dynamics of the Earth's atmosphere and oceans on time scales of a day or more. Therefore, changes in the Earth rotation rate are likely to affect the behaviour of Rossby and Kelvin waves. For example, in Australia there will be consequential effects of changes in the Earth's rotation on the atmospheric/oceanic oscillations, and therefore, on Australia's weather and climate and the risks of natural disasters.

According to Zotov et al. (2022), the Earth's rotation started to accelerate again after the strong El Nino in 2016 and in 2021 reached the maximal velocity observed almost since 1930s. Recently published evidence shows that the Earth's rotation would begin to slow down in 2024 and continue slowing down until at least 2032. As a result, the global warming observed from the beginning of the 20th century will most likely transition to a global cooling from the middle of the next decade.

3. Origin of decadal LoD variations

The development of knowledge about, and reasons for, the decadal variations in the Earth's rotation and the global warming/cooling that accompanies rotation variations is an active area of scientific inquiry. The major working hypothesis is about some form of coupling between inner core, the outer core, and the mantle. The preferred type of coupling is electromagnetic, but the precise form is the subject of intense investigation, as are the reasons for variations of LoD of between three and five milliseconds.

Strong evidence points to gravitational forces driving the electromagnetic coupling. There is also significant work-in-progress to explain the:

- global warming/cooling connected to Earth rotation variations;
- time lag of about eight years between changes in the Earth's rotational speed and surface temperature; and
- time lag of about eight years between the electromagnetic event that results in Earth rotation variations and the rotation variations happening.

It is to be noted that the Intergovernmental Panel on Climate Change (IPCC) does not mention in any of its many reports the vast body of research published over the last 50 years on this subject.

On 23 January 2023 Professor Xiaodong Song at the School of Earth and Space Sciences (SESS), Peking University, and Dr Yi Yang, an Associate Research Scientist in Professor Song's group reported substantial observational findings that inner-core rotation varies over multidecadal time-scales and has slowed in recent years, probably from 2009 onwards (Yang, Y and Song, X D (2023)). This temporal variation in inner-core rotation is coupled to processes observed at the

Earth's surface, including the LoD and magnetic field variation. The authors used seismic observations to study the inner core. They analysed the difference in the waveform and travel time of seismic waves from near-identical earthquakes that have passed through the Earth's inner core along similar paths since the 1960s.

The analysis shows that the Earth's inner core oscillates with a period of approximately seven decades. See also Hawkins, Louise (2023).

Planet Earth, the diameter of which is 12,742 kms, consists of five major structures. The first is the crust –up to 70 kms thick – an oblate spheroid shell on which civilisation dwells. The second, the oblate spheroid shell immediately below the crust, is the mantle. It is solid and about 2,900 kms thick. The third oblate spheroid shell, which the mantle envelopes, is the super-heated outer core. It is a 2,300 kilometres wide roiling river of about 178 million cubic kilometres of super-heated liquid metal (mostly a mix of Iron and Nickel), the temperature of which is around 5,000° Centigrade. The viscosity of the liquid is like that of water; it sloshes about generating electromagnetic fields, which constitute the Earth's dynamo. The outer core envelopes the fourth structure, the inner core, a super-heated tangled bundle of structures, some solid, probably crystalline, some elastic, that sit within gooey Iron-Nickel mush, about 70% of the size of the Moon. The mush is known as a superionic fluid, a state more fluid than a solid, but not quite as fluid as a liquid. At the centre of the mosaic-like, malleable inner core is the fifth structure, a solid ball of metal 650 km in diameter. The pressure within the inner core is intense, about 3.6 million atmospheres. The irregular-shaped surface of the inner core is about 5,300 kms below the Earth's surface.

The gravitational and electromagnetic fields of the rest of planet Earth have countervailing impacts on the rate of rotation of the inner core, which floats in the low viscosity fluid of the outer core. This fluid does not restrain the inner core's motion; however, the gravitational and electromagnetic fields in which it is embedded and with which it interacts, do. In addition, since the inner core is pliable the impact of the countervailing forces can change the shape and orientation of the inner core not only its motion.

The magnitude and impact of the gravitational and electromagnetic fields interacting with the inner core, the nature of the interaction is a very active area of science, but at the time of writing this paper, there were not unambiguous findings. Mohazzabi and Skalbeck (2015) is a good example of work-in-progress.

In 1936 the Danish seismologist and geophysicist, Inge Lehmann (1888 – 1993) reported her discovery of the Earth's solid inner core inside the molten outer core. Prior to that, the scientific community believed Earth's core to be a single molten sphere. She discovered the inner core by a careful, rigorous examination of time travel curves generated by earthquakes.⁸ Her discovery was corroborated by other scientists in the 1940s and 50s. In 1971, Dziewonski & Gilbert (1971) confirmed the hypothesis that the inner core was solid. According to Anderson (Anderson (2007)), *the inner core is isolated from the rest of the Earth by the low viscosity fluid outer core and it can rotate, nod, wobble, precess, oscillate, and even flip over, only loosely constrained by the surrounding shells. Among its anomalous characteristics are low rigidity and viscosity (compared to other solids), bulk attenuation, extreme anisotropy and super-rotation (or deformation).*⁹

In 2013 Professor Hrvoje Tkalčić and his team at the ANU College of Physical and Mathematical Sciences (Tkalčić et al. 2013) were the first to provide experimental evidence that the Earth's inner core has rotated at a variety of different speeds and at a different rate than the mantle. He found that the inner core's pattern of rotation over time is best described a pattern of *shuffling* rotation. The ANU team found that the inner core has a non-steady rotation with respect to the mantle on which are superimposed decadal fluctuations.

Professor Tkalčić and his team have corroborated findings of others that the inner core is distinctly heterogeneous consisting of a tangled mix of liquid, soft, elastic, hard and crystalline structures,

field changes and the LoD variations, respectively. Thus, the Earth seems to behave as a resonating system that involves all the major layers of the solid Earth, from the surface to the inner core.

This study shows that inner-core rotation varies over multidecadal timescales and has slowed in recent years. This temporal variation in inner-core rotation appears to be coupled to processes we observe at the Earth's surface, including the length of day and magnetic field variation.

Difficulties in measuring accurately the variable rate of rotation of the inner core in the 21st Century are analogous to the difficulties in measuring the variable rate of rotation of the Earth in the 19th Century (see Attachment A).

Hofmeister (Hofmeister et al. 2022), pointed out that basic principles of motion, discovered by Newton, require that lateral forces cause lateral motions. Their analysis, using Newtonian celestial mechanics, shows that the Moon is essential to Earth's long-lasting dynamics and unique tectonics, because its presence induces spatial and temporal variations in the positions of the barycenter and geocenter.

Their analysis shows that the unique dynamic geometry of the Earth-Moon-Sun system produces imbalanced forces and torques that drive Earth's tectonic plates and influences the activity of the other oblate spheroid shell structures of which the Earth is composed. The imbalance arises from the:

- shape of the Earth and its internal structures being oblate spheroids that are dynamic, not static;
- oscillating, off-center barycentre of the Earth-Moon system;
- imbalance between the Earth's tangential orbital acceleration and the Sun's gravitational field;
- cyclical stresses arising from this imbalance creates fractures in the Earth's structures, especially the cold, rigid and brittle lithosphere thereby adding further asymmetry to plate motions; and
- frictional heat created by the stress associated with the off-centre, shifting barycentre.

4. The 1970s findings of Lambeck and Cazenave

During the 1970s, Kurt Lambeck and Anny Cazenave published a series of papers reporting ground-breaking scientific observation and analysis showing that variations in the long-period (about 10 years) rotation of the Earth resulted in episodes of global warming and global cooling.¹⁰ In these papers, Kurt Lambeck and Anny Cazenave drew on findings from Dr Cazenave's 1975 PhD thesis and prior work of Professor Lambeck and others about the Earth's rotation. They also reported considerable original work they undertook jointly during the 1970s.

In relation to decadal variations in the Earth's rotation, Lambeck and Cazenave found that as the Earth rotates faster, (i.e. LoD shortens) the planet warms; in contrast, as the Earth rotates slower (i.e. LoD lengthens,) the planet cools. They found that not only did global temperature vary with these changes in the Earth's rotation, but other major climatic indices varied as well. These climatic indices included: changes in the atmospheric mass and pressure distribution; changes in the patterns of global wind circulation and velocity; variations in sea level; variations in the volumes of Arctic sea ice and snow accumulation at the South Pole; and variations of ice movements in the Weddell Sea. Lambeck and Cazenave found that there is a time lag of between six and fifteen years between changes in the Earth's rotation and changes in the global temperature.

Lambeck and Cazenave (1976) found that:

The long-period (greater than about 10 yr) variations in the length-of-day (LoD) observed since 1820 show a marked similarity with variations observed in various climatic

*indices; periods of acceleration of the Earth corresponding to years of increasing intensity of the zonal circulation and to global-surface warming; periods of deceleration corresponding to years of decreasing zonal-circulation intensity and to a global decrease in surface temperatures. The long-period atmospheric excitation functions for near-surface geostrophic winds, for changes in the atmospheric mass distribution and for eustatic variations in sea level have been evaluated and correlate well with the observed changes in the LoD.*¹¹

Lambeck and Cazenave (1976) argued that the cooling of the planet experienced in the 1960s and 1970s¹² arose from a slowing of the Earth's rotation in the 1950s. They wrote:

*if the hypothesis [that decadal rotation decrease (increase) results in planetary cooling (warming)] is accepted, then the continuing deceleration of [the rotating Earth] for the last 10 yr suggests that the present period of decreasing average global temperature will continue for at least another 5-10 yr.*¹³ They added, *Perhaps a slight comfort in this gloomy trend is that in 1972 the LOD showed a sharp positive acceleration that has persisted until the present.....*¹⁴

meaning that a period of global warming would begin around 1982/87.

A period of global warming began in the 1980s after a lengthy period of global cooling.

Lambeck and Cazenave (1976) comment further that:

*Whatever mechanism is finally proposed it will have to explain the apparently significant lag that is found between the LoD and the various climatic indices, temperature and excitations. The interest of this lag suggests that the LoD observations can be used as an indicator of future climatic trends, in particular of the surface warmings.*¹⁵

Lambeck and Cazenave (1976) provided a broad overview of how decadal rotation variations over the period 1800 to 1950 changed ocean/atmospheric oscillations and thereby global and regional climates using results reported by Horace Lamb in his 1972 treatise, *Climate, present, past and future* (Lamb 1972). Lamb reported this pattern based on detailed observations of 150 years of climate data.

Lambeck and Cazenave (1976) summarised the patterns of global atmospheric circulation as follows:

*Observations of climatic fluctuations during the last two centuries show two principal types of atmospheric circulation alternating typically every 20 - 40 years. The first type (type I) is characterized by an increasing intensity of the zonal circulation at all latitudes and with a poleward migration of the belts of maximum wind intensities. The circulation is accompanied by a decrease in the overall range of surface-air temperatures between the equator and the poles, and by an overall increase in the mean global surface-air temperatures. Ocean-surface temperatures also tend to increase at high latitudes. The type II circulation is characterized by a weakening of the zonal circulation, by a migration of the main streams to lower latitudes and by an overall decrease in temperature. For both types of circulation, the migration in latitude and the changing intensities are global phenomena, occurring at all longitudes and in the northern and southern hemispheres although the trends in different regions are not always in phase. Both easterly and westerly winds increase with the type I circulation, and both decrease during the type II circulation.*¹⁶

Lambeck and Cazenave (1976) explain how the decadal changes in the Earth's rotation (going faster/going slower) alter the Type I and II patterns of atmospheric circulation, resulting in periods of global warming and cooling. A central finding of Lambeck and Cazenave (1976) is that over a span of 150 years, when, on a decadal basis, the rotation of the Earth increased, then some 10 to 15 years later the planet warms; conversely, also on a decadal basis, when the rotation of the Earth decreased, some 10 to 15 years later the planet cools. They identify an interval of around

60 to 80 years between episodes of climate warming and cooling. That would suggest that the next episode of global cooling should begin around 2040/60.

In 1980, Cambridge University Press published Professor Lambeck's definitive treatise on the rotation of the Earth, *The Earth's Variable Rotation – Geophysical causes and consequences* (Lambeck 1980). This treatise is the standard text on this subject. On pages 275 to 285, Professor Lambeck summarises the findings and conclusions of his joint papers with Dr Cazenave. He included graphs of these findings, which are reproduced in Attachment B as Figures B1 and B2.

In relation to the central finding of Lambeck and Cazenave (1976), Professor Lambeck reported:

Cause and effect cannot be distinguished from this observation alone and three alternative hypotheses are possible:

a) the atmospheric circulation causes long-period changes in LoD, as it does for periods of less than 2-3 year;

b) the fluctuations in LoD and climatic change are both consequences of a third phenomenon;

c) or the fluctuation in LoD causes the observed variations in the circulation.¹⁷

Professor Lambeck examined the likelihood of these three alternatives and concluded:

If the correlations of the indices and of the atmospheric-oceanic excitation functions with m_3 ¹⁸ are real, the second hypothesis (b) is the most convincing even if little quantitative information appears to be available to substantiate it.¹⁹

Having concluded that variations in climate and LoD are the consequences of a third phenomenon, Professor Lambeck reviewed likely candidates and concluded:

electromagnetic coupling of the mantle to fluid motions in the core appears to be the most plausible explanation of the decade variations in the LoD.²⁰

In 1982, Dr Cazenave, jointly with three French scientists²¹, (Courtillot, Le Mouel, Ducruix and Cazenave (1982), (1983)), published a paper in the journal *Nature* that reported a correlation between variations in the Earth's magnetic field, the Earth's rotation rate and some climatic indicators, thus suggesting a long-term influence of motions of the Earth's core on the Earth's climate dynamics. Dr Cazenave and her colleagues reported that a high correlation had been demonstrated between variations in the LoD with periods of about 10 years and trends in several climatic indices over the past 150 year. Dr Cazenave and colleagues reported that scientists had found a high (and significant) correlation between geomagnetic secular variations and decadal LoD fluctuations in the records of European observatories where the longest records are available: 1865-1975. The correlation coefficient was found to be about 0.8, with the geomagnetic variations leading LoD fluctuations by about 10 yr.

Courtillot, Le Mouel, Ducruix and Cazenave (1982), (1983) reported that

The clearly established 1970 secular acceleration, which has now been maintained for a decade, suggests a correlated positive acceleration in the immediate future and the beginning of a period of steady increase in average global temperature around 1990 (+ or - yr).

The IPCC ignored this well-established explanation for the global warming that the IPCC attributed erroneously to Carbon Dioxide.

De Michelis, Tozzi, and Meloni, (2005) repeated this finding in a review article published in the *Memorie della Società Astronomica Italiana*. The IPCC ignored this, as well.

Mouel et al. (1981) in a paper published in *Nature* reported a good correlation between secular

variations of the Earth's magnetic field and variations in the Earth's rate of rotation. They measured secular variations of the Earth's magnetic field using variations in the declination of the Earth's magnetic field.²²

Given the high correlation between geomagnetic variations and decadal LoD variations on the one hand, and the high correlation between decadal LoD fluctuations and several climatic indices on the other, the authors point out that there is, most likely, a long-term influence of core motions on climate.

The authors report that there was a sudden and sharp acceleration of global extent in the geomagnetic field around 1970. This acceleration had been maintained (at the time of the publication of the authors' paper, 1982) for a decade. Since there is lead-time of about 10 years between geomagnetic variations and decadal LoD variations and about 8 years between LoD variations and climatic variations²³, the authors suggest that a period of global warming would begin in the 1990s and continue beyond. Dr Cazenave and her colleagues suggest that geomagnetic secular variation can be used to forecast a climatic change.

5. Corroboration of Lambeck and Cazenave's findings

Since the publication of Lambeck and Cazenave (1976), Lambeck (1980) and Cazenave et al. (1982) a substantial volume of peer reviewed scientific studies about the relationship between decadal changes in the Earth's rotation and climate dynamics has been published. The challenge of identifying the 'third phenomenon' has also been the subject of substantial investigation, which is summarised in below.

Dr Nikolay Sidorenkov of the Hydrometcentre of Russian Federation summarised a good portion of published research about the relationship between decadal changes in the Earth's rotation and climate dynamics in his recently published book *The Interaction Between Earth's Rotation and Geophysical Processes* (Sidorenkov 2009).

Amongst other things, he concludes:²⁴

We have shown that there are strong correlations between the decadal variations in the length of day, variations in the rate of westward drift of the geomagnetic eccentric dipole, and variations in certain climate characteristics (the increments of the Antarctic and Greenland ice sheets, anomalies of the atmospheric circulation regimes, the hemisphere-averaged air temperature, the Pacific Decadal Oscillation, etc).

Sidorenkov (2009) concluded that because long-term variations in LoD can now be determined with great accuracy, the many-year findings he and others have documented show that the long-term variations in LoD present a unique, nature-born integral index of global climate changes.

In 1990, Professor Rozelot (Rozelot and Spaute (1990)) found a high and significant correlation between the LoD time series maintained by the Bureau International de l'Heure in Paris and 13 sets of climatological data from around the world containing measures of air temperature. These sets included three sets (Mexico, Lisbon and England) of 100 years length; one from Paris of 200 years length; one from Central England of 300 years length; and one from Shanghai of 500 years length.

Jochmann and Greiner-Mai (1996) (1997) found that

the variation of the geomagnetic field indicates the temporal behaviour of the core process which influences the Earth's rotation via core-mantle coupling and independently those processes which possibly cause climate variations. A direct influence of the magnetic field on climate could not be proved until now.

And

Since the variation of the geomagnetic parameters precede that of the climate parameters, it may be supposed that geomagnetic variations could serve as indicators of natural climate change.

And

So it can be concluded that the variation of the geomagnetic field indicates the temporal behaviour of the core process which influences the Earth's rotation via core-mantle coupling and independently those processes which possibly cause climate variations. A direct influence of the magnetic field on climate could not be proved until now.

In 1999, the National Report of the Federal Republic of Germany about geodetic activities in the years 1995 to 1999 summarised much of the work of Professor Jochmann and Dr Greiner-Mai. The Report concluded that Jochmann and Greiner-Mai showed that the Earth's climate cycles are related more to core dynamics than to atmospheric circulation.²⁵

In 2007, Professor Paul Roberts,²⁶ and colleagues (Roberts, et al. (2007)) established that there is 60-year period in the LoD, strong evidence for a very similar periodicity in the geomagnetic signal. They found that the geomagnetic change comes before the LoD variation by about 8 years.

In 2011, Dr Jean O Dickey²⁷ and colleagues published a paper in the *Journal of Climate* issued by the American Meteorological Society (Dickey et al. 2011) that confirmed the findings of Lambeck and Cazenave, Sidorenkov and Roberts. Dickey et al. (2011) analysed better quality global temperature time series and better-quality time series of the Earth rotation measures than those available to Lambeck and Cazenave in the 1970s.

The global surface temperature time series covered the period from 1850 to 2005; the Earth rotation time series covered the period from 1832 to 2004. Dickey et al. (2011) found that the global surface temperature increased following an increase in the rotational speed of the Earth; the global temperature decreased following a decrease in the speed of the Earth's rotation. Dickey et al. (2011) found that the time lag between changes in the Earth's rotational speed and surface temperature was 8 years rather than the 10 to 15 years reported by Lambeck and Cazenave or the 5 years reported by Dr Cazenave and her colleagues in 1982.

Dickey et al. (2011) reported extensive evidence that there is a period in the 60 to 80 year range between episodes of climate warming and cooling, corroborating the finding of Lambeck and Cazenave.

In 2016, three scientists (Zotov et al. (2016))²⁸ published a paper corroborating the findings of Dickey et al. (2011), Sidorenkov, Lambeck and Cazenave: that, on a decadal basis, as the Earth rotates faster, (i.e. LoD shortens) the planet warms; in contrast, as the Earth rotates slower (i.e. LoD lengthens,) the planet cools. The three scientists also confirmed the 60-year range between episodes of climate warming and cooling, but did not estimate the time lag between changes in the speed of rotation and changes in global temperature.

In 2016, Dr Steven Marcus, one of the co-authors of Dickey et al. (2011) repeated the analysis in Dickey et al. (2011) using more extensive data bases published by IPCC scientists and the UK Met Office Hadley Centre (Marcus 2016). Marcus (2016) found more evidence corroborating the theory of an Earth core-to-climate, one-way chain of causality. According to this theory - for which there is substantial evidence and analysis - multidecadal episodes of global warming and cooling arise from an internally generated, core-to-climate process imprinted on both the climate and Earth's rotational rate.

6. Earth's Decadal Rotation Variations driven by electromagnetic coupling of the mantle to fluid motions in the core

In his treatise, Lambeck (1980), Professor Lambeck concluded that the most plausible explanation of the decade variations in the Earth's rotation is electromagnetic coupling of the mantle to fluid motions in the core.²⁹

Dickey et al. (2011) concluded that the same core processes that are known to affect Earth's rotation and magnetic field are likely to contribute to the excitation of the multidecadal climatic modes of global warming and cooling they document. Dickey et al. (2011) suggested that this could happen through geomagnetic modulation of near-Earth charged-particle fluxes that may influence cloud nucleation processes, and hence the planetary albedo, on regional as well as global scales.

Cazenave et al. (1982) noted that Professor Lambeck considered that the role of the Earth's core is central to a satisfactory explanation of the Earth's decadal rotation because it is the only sufficiently mobile part of the Earth with sufficient mass to modify the Earth's rotation by the observed amounts on that time scale. Furthermore, the authors explain, out of the range of mechanisms by which the required core-mantle coupling could occur, only electromagnetic core-mantle coupling survives the screening process despite severe uncertainties regarding the conductivity of the lower mantle and the core motions.

There is significant evidence that electromagnetic core-mantle coupling is the result of irregular magnetohydrodynamic³⁰ flow in the Earth's liquid metallic core. This irregular flow is a result of mechanical processes (such as tidal processes) and/or electromagnetic induction. As the electrically conducting metallic fluid core sloshes about, as it were, it interacts with the ambient magnetic field, generating additional electric currents and magnetic fields that in turn reinforce the ambient magnetic field.

Figure 2 is a cutaway diagram showing the layers of Earth from the crust to the inner core. The torsional waves (TW) in the core are shown in red.

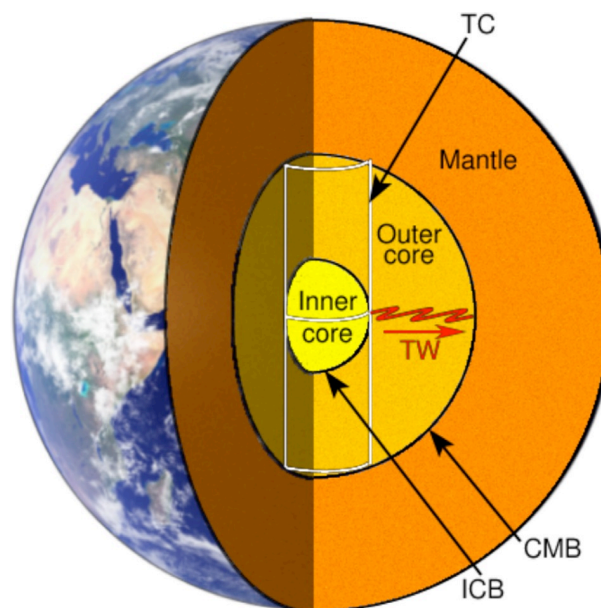


Figure 2. Schematic of torsional waves in the core. A cutaway diagram showing the layers of Earth from the crust to the inner core. Solid white lines show the location of the imaginary 'tangent cylinder' (TC), running vertically from pole-to-pole in the outer core and circumscribing the inner core. The red line indicates the possible trajectory of a torsional wave (TW) in the outer core from the inner core boundary (ICB) to the core-mantle boundary (CMB). The transverse torsional wave propagates radially from the TC to the CMB with its oscillations in the azimuthal direction. From Teed, et al. (2019)

In 1976, Professor Vincent Courtillot and Professor Jean-Louis Le Mouél, reported (Courtillot and Le Mouél 1976) that in 1969 there had been a sudden worldwide change in the dynamics of the Earth's magnetic field. These sudden changes are now referred to as geodynamic jerks. Geophysicists have established that these sudden changes occur roughly every ten years. There is considerable evidence that Alfvén torsional waves³¹ are responsible for the geomagnetic jerks and the decade variations in the LoD (Jault 2003). There is also evidence (Lopes et al. 2021) that the

aggregate joint gravitational forces of the Sun, Moon and planets regulate the Alfvén torsional waves, and, as a result, decadal variations in the LoD and the resultant episodes of global warming/global cooling. There are time lags between the principal events: some 8 years after the abrupt change to the Alfvén torsional waves, the Earth’s decadal rotation changes – speeding up or slowing down; some 8 years after the change in LoD, the global temperature changes – if the Earth speeds up, the planet warms up, if the Earth slows down, the planet cools down. The cycles of global warming and cooling repeat every sixty years.

In 2019 Aleksander Tolstikov, Head of the measurement of time, frequency and determination of Earth rotation parameters, Federal State Unitary Enterprise All-Russian Research Institute of Metrology, and colleagues (Tolstikov et al. 2019) reported that in 2024 the Earth’s rotation would go into a deceleration phase until 2032. As a result, the global climate warming observed from the beginning of the 20th century will most likely transition to a global climate cooling from the middle of the next decade.

In 2020 Leonid Zotov, Christian Bizouard, Nikolay Sidorenkov (Zotov et al. 2020) reported the same finding. In the near future, the Earth’s rate of rotation will slow down and the LoD will lengthen. This means that the Earth will enter a period of global cooling.

The development of knowledge about reasons for the decadal variations in the Earth’s rotation and the global warming/cooling that accompanies rotation variations is an active area of scientific inquiry. The major working hypothesis is about some form of coupling between inner core, the outer core and the mantle.

The preferred type of coupling is electromagnetic, but the precise form is the subject of intense investigation, as are the reasons for variations of LoD of between three and five milliseconds. Strong evidence points to gravitational forces driving the electromagnetic coupling.

5. Earth decadal rotation and seismic activity

Bostrom (2000)) points out that Sir George Darwin (1845 – 1912) in 1879, Professor Alfred Wegener (1880 – 1930) in 1915 and Professor John Joly (1857 – 1933) in 1925 had all proposed a connection between the Earth’s rotation and displacements in the Earth’s crust. However, Sir Harold Jeffreys (1881 – 1989) opposed it, just as he strongly and stubbornly opposed the theory of continental drift. Sir Harold Jeffreys’ forceful opposition to a relationship between the Earth’s rotation and crustal displacements dominated Geophysics throughout the first half of the 20th Century. According to Bostrom:

Perhaps more than most fields, research as to the relation between the Earth’s deformation and its rotation has been characterised by dominant personalities. This may be because it is hard to explore such disparate areas as Astronomy and Geology.³²

In 1969, Dr. Nicolas Stoyko (1894 -1976) Chief Administrator, International Time Bureau, Paris Observatory (1942 -1969) and his wife Anna, also employed at the Bureau, reported a significant correlation between LoD variations and seismic activity (Stoyko, A and Stoyka, N (1969).

In 1974, the distinguished American Geologist, Professor Don Anderson (1933 – 2014) reported a striking correlation between the decadal variations in the Earth’s rotation and global seismic and volcanic activity (Anderson 1974). Professor Anderson explained that since the Earth’s crust and upper mantle stored a large amount of elastic energy because of rotational processes, a small perturbation in the rotational parameters is a probable trigger of global seismic activity.

Since Professor Anderson’s finding, many scientists have reported the correlation, with more detailed explanations published in recent years. For example, in 1995, Da-Wei Zheng & Yong-Hong Zhou of the Shanghai Observatory, Chinese Academy of Sciences (Zheng and Zhou 1995) reported a correlation between decadal rotation variations and global seismic activity similar to

that found by Professor Anderson. They explained the causative role of the decadal rotation variations in inducing seismic events that is similar to that of Professor Anderson. Gokhberga et al. (2016) reported findings that corroborate Zheng and Zhou (1995).

Scafetta and Mazzarella (2015) found that large earthquakes are highly likely to be triggered by crust deformations induced by, and/or linked to climatic and oceanic oscillations induced by astronomical forcings, which also regulate the LoD.

In 2017, Roger Bendick and Rebecca Bilham (Bendick and Bilham 2017) report that large earthquakes synchronize globally in the manner of integrate-and-fire oscillators most likely through a self-organizing process. They use the relatively new method of quantitative analysis known as topological data analysis to reveal the pattern of synchronisation. The elastic properties of the crust, asthenosphere and mantle provide the underlying mechanical coupling required for synchronization. Bilham and Bendick (2017) outline a way that decadal rotational fluctuations trigger the earthquakes that is similar to that suggested by Anderson in 1974. In particular, large earthquakes synchronize globally, and occur in groups in response to very low stress interactions such as that provided by abrupt changes in the Earth's decadal rotation. They found that earthquake activity clusters into peak activity approximately every 32 years. This peak happens five years after the Earth's decadal rotation variation reaches its slowest rate.

They wrote

On five occasions in the past century, a 25-30% increase in annual numbers of $M_w \geq 7$ earthquakes has coincided with a slowing in the mean rotation velocity of the Earth, with a corresponding decrease at times when the length-of-day (LoD) is short. The correlation between Earth's angular deceleration ($d[\text{LoD}]/dt$) and global seismic productivity is yet more striking and can be shown to precede seismicity by 5-6 years, permitting societies at risk from earthquakes an unexpected glimpse of future seismic hazard.

The cause of Earth's variable rotation is the exchange of angular momentum between the solid and fluid Earth (atmospheres, oceans and outer core). Maximum LoD is preceded by an angular deceleration of the Earth by 6-8 years. We show delayed (increase in) global seismic productivity is most pronounced at equatorial latitudes 10°N - 30°S .

The observed relationship is unable to indicate precisely when and where these future earthquakes will occur, although we note that most of the additional $M_w > 7$ earthquakes have historically occurred near the equator in the West and East Indies. A striking example is that since 1900 more than 80% of all $M \geq 7$ earthquakes on the eastern Caribbean plate boundary have occurred 5 years following a maximum deceleration (including the 2010 Haiti earthquake).

The 5-6 year advanced warning of increased seismic hazards afforded by the first derivative of the LoD is fortuitous and has utility in disaster planning. The year 2017 marks six years following a deceleration episode that commenced in 2011, suggesting that the world has now entered a period of enhanced global seismic productivity with a duration of at least five years.

Figure 3 below is Figure 4 in Bendick and Bilham (2017). It shows the relationship between changes in the Earth's rotation rate and the occurrence of large ($M_w \geq 7$) earthquakes.

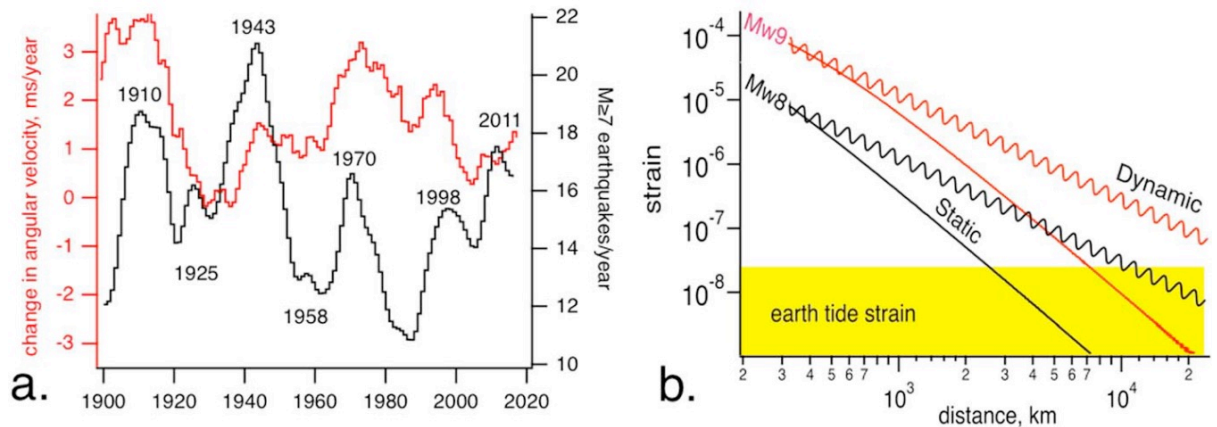


Figure 3. (a) Changes in the LoD (Gross et al., (2004)) correlate with decadal fluctuations in annual $M \geq 7$ earthquakes (Anderson 1974; Shanker et al. 2001) (smoothed with 10 year running mean). Peak seismic activity and rotational acceleration occur at 15, 33, 60, and 88 years intervals. (b) Static (Press 1965) and dynamic (Agnew and Wyatt 2014) strain from distant $M_w = 8$ and $M_w = 9$ earthquakes exceed earth tide strain amplitudes at distances of 2500–30,000 km. Distances between plate boundaries are typically 1000–12,000 km; hence, the largest of Earth's earthquakes provides the weak force required for hemispheric synchronization. Source: Bendick and Bilham (2017).

In 2020, Alexey Lyubushin of the Institute of Physics of the Earth, Russian Academy of Sciences, Moscow, Russia, outlined a statistical methodology to construct 50 clusters of the world's seismic stations (Lyubushin 2020). He reported that a pattern is emerging that suggests that there will be in the near future, a small number of very large earthquakes, rather than a large number of small earthquakes. His analysis indicates that the next big earthquake will have a magnitude of 10 and occur in Nankai Trough south of Tokyo. He found that the decadal variations in the Earth rotation to be the determinant of this pattern and that an abrupt change in the rotation rate will induce the Earthquake.³³ According to conventional seismology, there is a 70-80% chance that a Nankai Trough megathrust earthquake will occur in the next 30 years.³⁴

6. Measurement of global temperature

There are differences in the validity and reliability of the measures of temperature used in the three papers that establish the relationship between the changes in the Earth's decadal rate of rotation and climate dynamics. The examination of these differences will help establish the validity of the relationship.

Lambeck and Cazenave (1976) used actual measures of global temperature compiled by the National Center for Atmospheric Research (NCAR), Boulder, Colorado together with global temperature time series compiled by the American climatologist, J Murray Mitchell (1928 to 1990) (Mitchell 1970, 1961, 1953).

In the papers cited, Mitchell records the many shortcomings in the validity and reliability of the measures of temperature taken over the period he studied, 1860 to 1969. These included the use of different measuring instruments; instruments lacking standardised calibration; the encroachment of cities and airports; changes in the types of thermometers used; changes in the use and design of thermometer shelters; the accumulation of dirt on thermometers and their shelters; changes in methods of calibration; changes in the method of computing means; major changes in sites. Mitchell (and others) have pointed out that until the establishment of the Intergovernmental Panel for Climate Change (IPCC) all temperature-measuring methodologies were designed to measure temperature in relation to changes in the weather - not changes in the climate.

Lambeck and Cazenave (1976) were aware of the shortcomings of the temperature time-series. Nevertheless, the data they used was the best available. Even with its shortcomings, the analysis

reported by Lambeck and Cazenave revealed a strong relationship between variations in the Earth's rate of rotation – on a decadal basis – and variations in global temperature over the period 1820 to 1970. They also predicted correctly that a period of global warming would begin in the early 1980s. Scientists who have examined this relationship independently of Lambeck and Cazenave have found the same relationship.

In contrast, Dickey et al. (2011) used the yearly mean values of the global average surface temperature, available from the Goddard Institute for Space Studies (GISS) temperature series since 1880 (known as GISTEMP) and from the Meteorological Office Hadley Centre–University of East Anglia Climatic Research Unit temperature series since 1850 (known as HadCRUT3).

The shortcomings of both sets of data (GISTEMP and HadCRUT3) have been documented extensively. For example, in 2010 Ross McKittrick, Professor of Economics, University of Guelph, Guelph Ontario Canada, published a critical review of global surface temperature data products on the Social Science Research Network (SSRN) (McKittrick 2010).

Professor McKittrick reported that

There are three main global temperature histories: the combined CRU-Hadley record (HADCRU), the NASA-GISS (GISTEMP) record, and the NOAA record. All three global averages depend on the same underlying land data archive, the Global Historical Climatology Network (GHCN). CRU and GISS supplement it with a small amount of additional data. Because of this reliance on GHCN, its quality deficiencies will constrain the quality of all derived products. The number of weather stations providing data to GHCN plunged in 1990 and again in 2005. The sample size has fallen by over 75% from its peak in the early 1970s and is now smaller than at any time since 1919. The collapse in sample size has not been spatially uniform. It has increased the relative fraction of data coming from airports to about 50 percent (up from about 30 percent in the 1970s). It has also reduced the average latitude of source data and removed relatively more high-altitude monitoring sites. GHCN applies adjustments to try and correct for sampling discontinuities. These have tended to increase the warming trend over the 20th century. After 1990, the magnitude of the adjustments (positive and negative) gets implausibly large. CRU has stated that about 98 percent of its input data are from GHCN. GISS also relies on GHCN with some additional US data from the USHCN network, and some additional Antarctic data sources. NOAA relies entirely on the GHCN network. The quality of data over land, namely the raw temperature data in GHCN, depends on the validity of adjustments for known problems due to urbanization and land-use change. The adequacy of these adjustments has been tested in three different ways, with two of the three finding evidence that they do not suffice to remove warming biases. The overall conclusion of this report is that there are serious quality problems in the surface temperature data sets that call into question whether the global temperature history, especially over land, can be considered both continuous and precise. Users should be aware of these limitations, especially in policy sensitive applications.

Professor McKittrick found that

All three global products rely on sea surface temperature (SST) series derived from the archive of the International Comprehensive Ocean-Atmosphere Data Set (ICOADS, <http://icoads.noaa.gov>), though the Hadley Centre switched to a real time network source after 1998, which may have caused a jump in that series. Oceanic data are based on SST rather than marine air temperature (MAT). ICOADS observations were primarily obtained from ships that voluntarily monitored SST. Prior to the post-war era, coverage of the southern oceans and polar regions was very thin. Coverage has improved partly due to deployment of buoys, as well as use of satellites to support extrapolation. Ship-based readings changed over the 20th century from bucket-and-thermometer to engine-intake methods, leading to a warm bias as the new readings displaced the old. Until recently, it was assumed that bucket methods disappeared after 1941, but this is now believed not

to be the case, which may necessitate a major revision to the 20th century ocean record. Adjustments for equipment changes, trends in ship height, etc., have been large and are subject to continuing uncertainties. Relatively few studies have compared SST and MAT in places where both are available. There is evidence that SST trends overstate nearby MAT trends. ICOADS draws upon a massive collection of input data, but it should be noted that there are serious problems arising from changes in spatial coverage, observational instruments and measurement times, ship size and speed, and so forth. ICOADS is, in effect, a very large collection of problematic data.

As part of his PhD thesis at James Cook University, John McLean (2017) documented widespread shortcomings in HadCRUT4 (and HadCRUT3). McLean (2017) conducted the first publicly reported audit of the HadCRUT databases. He concluded, amongst other things, that

Data prior to 1950 suffers from poor coverage and very likely multiple incorrect adjustments of station data. Data since that year has better coverage but still has the problem of data adjustments and a host of other issues mentioned in the audit. The primary conclusion of the audit is however that the dataset shows exaggerated warming and that global averages are far less certain than have been claimed. Another implication is that the proposal that the Paris Climate Agreement adopt 1850-1899 averages as “indicative” of pre-industrial temperatures is fatally flawed. During that period global coverage is low – it averages 30% across that time – and many land-based temperatures are very likely to be excessively adjusted and therefore incorrect. A third implication is that even if the IPCC’s claim that mankind has caused the majority of warming since 1950 is correct then the amount of such warming over what is almost 70 years could well be negligible. Ultimately it is the opinion of this author that the HadCRUT4 data, and any reports or claims based on it, do not form a credible basis for government policy on climate or for international agreements about supposed causes of climate change.

McKittrick (2010) and McLean (2017) found a greater variety of data quality shortcomings, including more significant shortcomings, than those documented by Mitchell (1953) and Mitchell (1961). These findings mean that the shortcomings reported by Mitchell from 1953 onwards and by Willett (1950) had not been addressed by the relevant authorities.³⁵ McKittrick (2010) and McLean (2017) find that, amongst other things, the shortcomings in the HadCRUT and GISTEMP data result in both sets of data exaggerating any global warming. The IPCC’s second, third, fourth and fifth assessment reports, published in 1995, 2001, 2007 and 2014 respectively, projected global temperature increases that greatly exceeded those that occurred from 1995 onwards.

Since the start of routine satellite temperature observations in 1979, there has been conflict between the temperature records compiled in HADCRUT and GISTEMP records on the one hand and the temperature record derived from the Microwave Sounding Units on satellites, on the other. Thorne et al. (2010) reviewed these controversies and produced a ‘best estimate’ of temperature trends from 1979 to 2009. Professor Peter Thorne is one of the lead authors of the IPCC’s *Fifth Assessment Report*, published in 2014.

Figure 4 below shows the best estimate of temperature trends from 1979 to 2008 derived by Thorne et al. (2010):

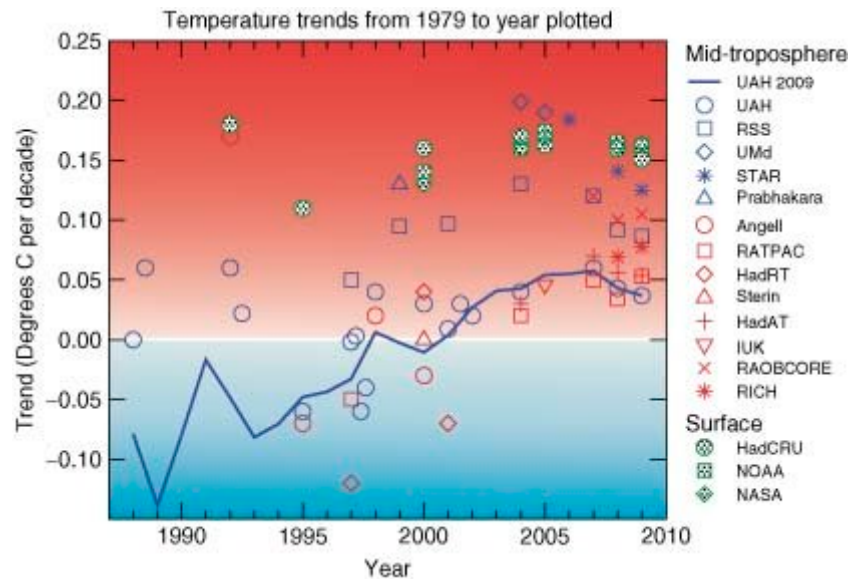


Figure 4. Evolution of estimates of observed trends in global-mean mid-troposphere and surface temperatures during the satellite era (since 1979), based on satellite (blue), radiosonde (red) and land/SST (green) observations. Symbols show trends for 1979 to the year plotted, as reported in the literature, except for 1979–2008 trends, which were calculated for Thorne et al. (2010). The acronyms listed on the right hand side are defined in Attachment C (page 156). Source: Thorne et al. (2010).

The blue line shows trends from the September 2009 version of University of Alabama in Huntsville (UAH) data for each year. Differences between this line and the UAH published estimates (blue circles) illustrate the degree of change in the different versions of this dataset.

Thorne et al. (2010) concluded that the satellite-based temperature published by University of Alabama in Huntsville has greater reliability and validity than the HADCRUT and GISTEMP records. That is to say, the blue line in the graph above is the most accurate record of global warming from 1990 to 2008. The most recent UAH Global Temperature Report April 2023 is:

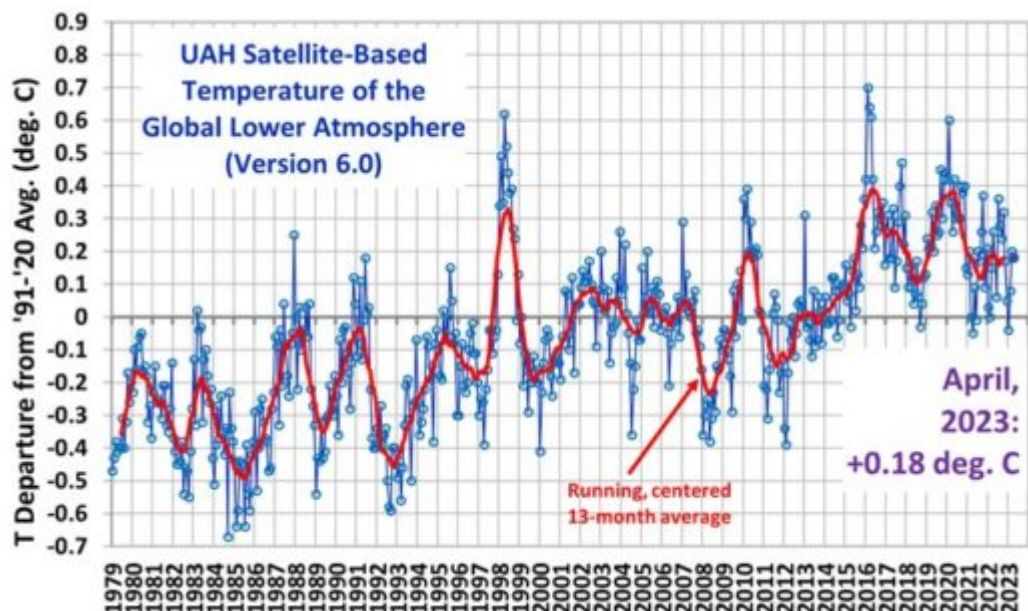


Figure 5. The linear warming trend since January 1979 remains at +0.13 C/decade (+0.11 C/decade over the global-averaged oceans, and +0.18 C/decade over global-averaged land). Source: UAH Global Temperature Report available here - [UAH Global Temperature Update for April, 2023: +0.18 deg. C](https://climate.uaahuntsville.edu/global-temperature-report/) - Roy Spencer, PhD. (drroyspencer.com)

The following is drawn from Dr Spencer's website:

The global atmospheric temperature in April was very close to that of March, being only -0.02°C cooler at $+0.18^{\circ}\text{C}$ ($+0.32^{\circ}\text{F}$) above the 30-year average. The La Niña that has influenced global temperatures for almost three years has ended as the tropical atmospheric temperature shows a near zero departure from average (-0.03°C). Compared with March, the April NH temperatures cooled a bit and the SH temperatures warmed by almost the same amount, leaving the total global change, as noted, to be near zero. The atmosphere takes about 2 to 5 months to reflect major changes in the tropical sea water temperatures, so we can expect generally rising air temperature anomalies from now through the boreal winter in 2024 since the tropical Pacific sea water temperatures are warming rapidly. The sea is expected to warm as NOAA has declared an El Niño Watch, indicating high confidence that a warm phase tropical Pacific event is in the near future.

The planet's warmest spot in April occurred over western East Antarctica near the Princess Martha Coast with a departure from average of $+4.4^{\circ}\text{C}$ ($+7.9^{\circ}\text{F}$). Warmer than average temperatures were felt from the North Pacific northwestward through eastern Russia, as well as a band from Quebec to Greenland to the Svalbard Islands then south through western Russia. Spain was warmer than average as was East Antarctica to New Zealand. With a reading of -3.2°C (-5.7°F) the coolest departure from average could be found over western Alaska near Kaltag. Another region of very cool air resided over central Russia, lying between warm areas to the east and west. North Africa eastward to India was cool as was the North Atlantic and central Europe. Much of the conterminous US was slightly below average giving a 48-state average of -0.38°C (-0.68°F). Alaska was even cooler than that, so with Alaska, the 49-state average fell to -0.66°C (-1.19°F).
[Microsoft Word - GTR_202304APR_1.docx \(uah.edu\)](#)

Attachment D is Dr Spencer's analysis of Australia's surface temperatures as recorded by Australia's Bureau of Meteorology (BoM) and compared to UAH Satellite data over the last 40 Years.

In contrast, the latest GISTEMP global average surface temperature graphs are:

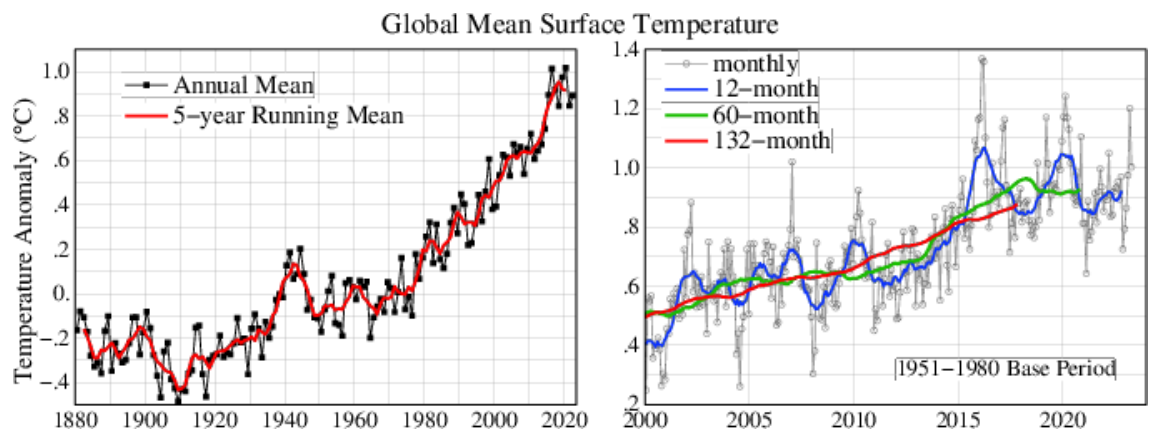


Figure 6. The latest GISTEMP global average surface temp graphs [Global Temperature \(columbia.edu\)](#)

Please note that there are crucial differences in the ordinate and abscissa scales used within Figure 6 and between Figures 5 and 4.

The following account is derived from [Data.GISS: GISTEMP HISTORY \(nasa.gov\)](#) and the articles cited therein:

The two ordinates in Figure 6 are different. In the left-hand graph, the ordinate is a temperature anomaly in of 1.4°C ranging from -0.4°C to 1.0°C , each ordinate grid being 0.1°C . The anomaly is calculated by a complicated statistical methodology developed in 1981, revised in 1987 and regularly ever since. The anomaly is a statistical construct formed by combining data from many data points for a designated area and constructing a single derived anomaly by reference to the base year 1880. In the right-hand graph the ordinate is a temperature anomaly in of 1.4°C ranging from 0.2°C to 1.4°C , each ordinate grid being 0.1°C . The anomaly in this graph is a derived

construction similar to the anomaly in the right –hand graph except it is constructed by reference to temperatures constructed for base year period of 1951 to 1980. The derived constructions in the ordinates of Figure 6 are complex constructions which include several untested assumptions and data of questionable quality as revealed elsewhere in this paper. The two abscissae in Figure 6 are also different. In the left-hand graph the abscissa is the years 1880 to 2020, each abscissa grid being 10 years. In the right-hand graph the abscissa is the years 2000 to 2025, each abscissa grid being 5 years. Further detail about these methodologies may be found at [Data.GISS: GISTEMP HISTORY \(nasa.gov\)](https://data.giss.nasa.gov/gistemp/history/).

The following account is derived from [Microsoft Word - GTR_202304APR_1.docx \(uah.edu\)](#).

In Figure 5 the ordinate is a temperature anomaly in of 1.6°C ranging from -0.7°C to +0.9°C each ordinate grid being 0.1°C. The anomaly is a straightforward calculation of the difference between the average temperature of the years 1991 to 2000 and the temperature measured for a particular year from 1979 onwards. In Figure 5 the abscissa is the years 1979 to 2023 each abscissa grid being one year. Further detail about the methodologies may be found at [Microsoft Word - GTR_202304APR_1.docx \(uah.edu\)](#).

Since 2013 several prominent scientists, including several who have been prominent as lead authors of IPCC Assessment Reports, Methodology Reports, Special Reports, Technical Papers, and/or Working Group reports, have published papers reporting that over the period 1995 to 2014 the rate of global mean warming has been lower than the IPCC projected.

In other words, since 1995 the IPCC's climate models projected significantly more warming than has been observed.

For example, in 2013, Otto et al. (2013) reported:

The rate of global mean warming has been lower over the past decade than previously.

Almost all of the 17 authors of this paper are prominent IPCC scientists; for example, 11 are lead authors of IPCC reports. Another co-author, Professor John Church, is a professor with the University of New South Wales' Climate Change Research Centre; was a project leader at CSIRO until 2016. Another co-author is Professor Friederike Otto, who in 2020, became one of 10 international climate scientists to join the core writing team of the IPCC *Synthesis Report of the Sixth Assessment Report* published in April 2022.

In 2014, Schmidt et al. (2014) reported:

Climate models projected stronger warming over the past 15 years than has been seen in observations.

Dr Gavin Schmidt, the principal author, is the Director of the NASA Goddard Institute for Space Studies and a contributing author of the IPCC's *Fourth Assessment Report*. Professor Drew Shindell, one of the joint authors, was a lead author for one of the IPCC's reports.

In 2021, Po-Chedley et al. (2021) reported that climate models have, on average, simulated substantially more tropical tropospheric warming than satellite data, with few simulations matching observations.

Dr Ben Santer, the senior co-author of Po-Chedley et al. (2021), is a climate researcher at Lawrence Livermore National Laboratory and the convening lead author of Chapter 8 (*Detection of Climate Change and Attribution of Causes*) of the 1995 IPCC Working Group I Report *The Physical Science Basis*.

The papers cited above, and the many to which they refer, highlight the inadequacies of the IPCC's quantitative simulations of climate dynamics to portray climate dynamics with sufficient reliability and validity: the simulations exaggerate temperature increases.

The controversies reviewed highlight a central problem: the IPCC's quantitative simulations are not based on a sound theory of climate dynamics.³⁶

A sound theory would examine all independent variables and delineate their relationships and dynamics over time with each other and with the dependent variable, the Earth's climate.

The IPCC's quantitative simulations are designed on the basis that the climate system is in a natural state of energy balance, and that there is no long-term climate change unless humans cause it by the emission of Carbon Dioxide. Climate scientists generally, in their published work, seem unable to explain climate dynamics independently of the IPCC's quantitative simulations.

In Dickey et al. (2011) the authors, using GISTEMP and HadCRUT time series, assumed that *in the last few decades, in particular, a robust global warming has been observed and is attributed to increasing anthropogenic greenhouse gases (Hansen et al. 1999).* and that *anthropogenic effects have significantly altered Earth's climate since the start of the industrial revolution (Solomon et al. 2007)* (i.e. the IPCC report, *Climate Change 2007: The Physical Science Basis*).

As a result, they correct for these by removing estimated and hypothetical anthropogenic temperature change as specified by appropriately forced runs of coupled atmosphere-ocean general circulation models. Marcus (2016) does the same.

Figure 7 shows the graph of Hansen time series (**black line**), now known to be false.

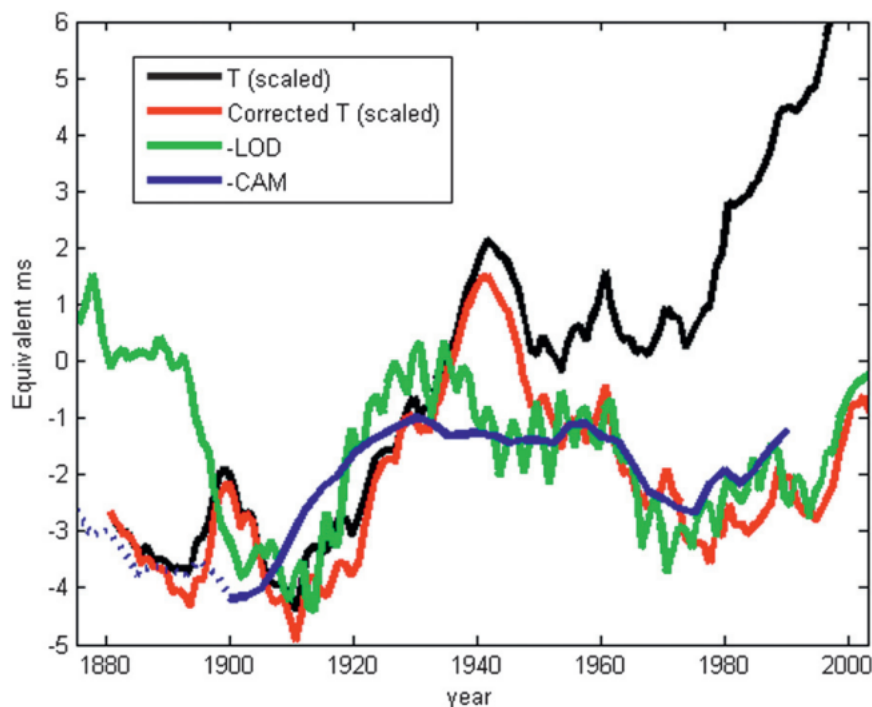


Figure 7. Time series of the surface air temperature, from Dickey et al. (2011). Note the two vertical axis: the left side is time in milliseconds; the right side is temperature; the unit is 0.1 degrees Celsius. Source: Dickey et al. (2011), page 570.

The **black line** is the global temperature estimates calculated by James Hansen in 2007 and used by the IPCC. The estimates are now known to be far too high. The temperature axis is the right-hand side vertical. The red line is the result of removing from the Hansen estimates the component estimated to be hypothetical warming arising from Carbon Dioxide. The red line therefore consists of estimates of the global temperature in the absence of any hypothetical Carbon Dioxide warming effect. The green line is the LoD and therefore a measure of the Earth's rotation. The blue line is the angular momentum of the Earth's core – that is, the rate at which the core spins around - in equivalent milliseconds.

Since it has been established that the global temperatures projected in Hansen et al. (2007) and in

the IPCC reports, including Solomon et al. (2007), have been greatly exaggerated, it is not necessary to do the correction.

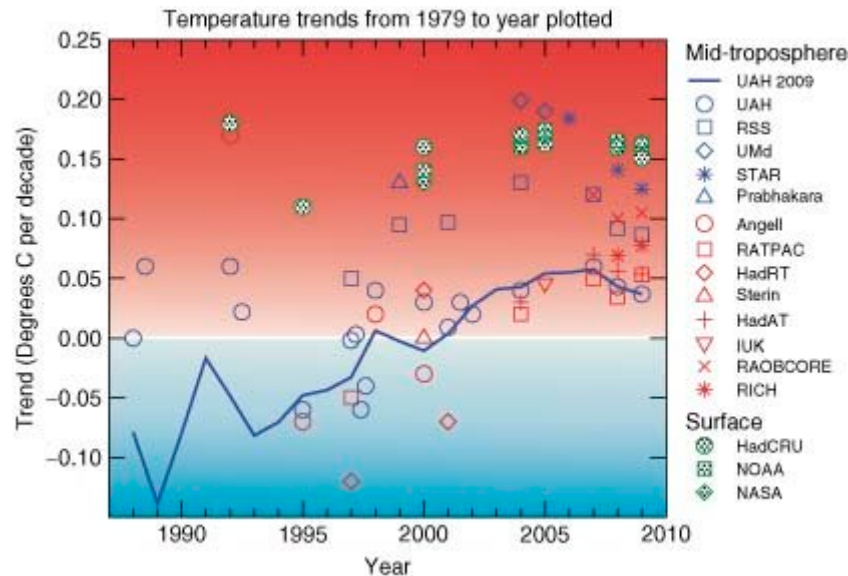


Figure 8. This is the same as Figure 4. It shows the best estimate of temperature trends from 1979 to 2008 derived by Professor Peter Thorne, a lead author of the IPCC's Fifth Assessment Report. The blue line in this Figure (Figure 8) relates to the red line in Figure 7: it is what the red line in Figure 7 should have been. The red line in Figure 7 is the Dickey graph of the 'corrected' Hansen et al. 2007 time series. The acronyms listed on the right hand side are defined in Attachment C (page 156). Source: Thorne et al. (2010).

Had Dickey et al. (2011) used the UAH 2009 time series – the blue line in Figure 8 – they would have concluded that almost all the global warming experienced by the Earth since the mid 1990s was a result of a decadal increase in the speed with which the Earth rotates. As will be explained further, there has been no global warming that could be attributed to Carbon Dioxide, once all other factors are considered.

Zotov et al. (2016) used three sets of data about the Earth's climate: (i) the global Earth temperature time series (land and sea surface) published by the Hadley Centre, HadCRUT4; (ii) A global mean sea level time series constructed by CSIRO for the period 1880 to 2009 (see Church and White (2008)); and (iii) another global mean sea level time series constructed by Jevrejeva et al. (2008) for the period 1700 to 2002. Zotov et al. (2016) refers to the CSIRO sea level time series as GMSL A (Global Mean Sea Level) and the other as GMSL B.

Before applying a statistical methodology to the analysis of these time series to discover if there is evidence of an impact of the Earth's decadal rotation variations on the Earth's climate, Zotov et al. (2016) removed a hypothetical CO₂ warming trend from the HadCRUT4, GMSL A and GMSL B time series. The analysis applied to the use of HadCRUT and GISTEMP data by Dickey et al. (2011) applies, *mutatis mutandis*, to the use of HadCRUT4 data by Zotov et al. (2016). In relation to GMSL A and B, Baart et al. (2012a) and (2012b) found that there is no evidence of a CO₂ warming trend in global sea level time series. In addition, Watson (2020) found that there is no evidence of a CO₂ warming trend in Australia's sea level time series.

Had Zotov et al. (2016) used the UAH 2009 time series – the blue line in Figure 8 – and had they not assumed – incorrectly – a hypothetical Carbon Dioxide warming trend in global sea level time series, they would have concluded that almost all the global warming experienced by the Earth since the mid 1990s was a result of a decadal increase in the speed with which the Earth rotates.

As explained below, there has been no global warming that could be attributed to Carbon Dioxide, once all other factors are considered.

There is also significant work-in-progress to explain the:

- global warming/cooling connected to Earth rotation variations and
- time lag of about eight years between changes in the Earth's rotational speed and surface temperature
- time lag of about eight years between the electromagnetic event that results in Earth rotation variations and the rotation variations happening.

7. Other determinants of climate dynamics

Over the last several decades, scientists from several disciplines have published in many of the world's leading scientific journals abundant evidence about the key determinants of climate dynamics. The most significant determinant is the Sun. The Sun influences climate dynamics in several ways, specifically the:

- Sun's:
 - output of radiation,
 - output of matter,
 - electromagnetic field,
 - gravitational fields,
 - shape; and
- topological structure of the heliosphere.

There are also significant effects from interactions between these.

The climate also depends on a number of subsystems of which the climate system is composed - principally the Earth's:

- atmospheric systems;
- ocean systems;
- coupled atmospheric-oceanic systems;
- clouds;
- Rossby and Kelvin waves;
- atmospheric angular momentum;
- rotation;
- dynamo;
- electromagnetic field;
- global electric circuit; and
- geomagnetic jerks.

Some of foregoing consist of further subsystems, for example:

The Earth's atmosphere and ocean contain several major oscillating atmospheric/oceanic systems that have a key role in the regulation of the Earth's weather and climate. They include the Madden-Julian Oscillation (MJO); the El Niño/Southern Oscillation (ENSO); Quasi-Biennial Oscillation (QBO); the Pacific Decadal Oscillation (PDO); the Interdecadal Pacific Oscillation (IPO); the North Atlantic Oscillation (NAO); the Atlantic Multidecadal Oscillation (AMO); the Indian Ocean Dipole (IOD); the Sub-Tropical Ridge (STR); the Southern Annular Mode (SAM) also known as the Arctic Oscillation (AO); East Coast Lows (ECLs); the Bruckner Cycle; Sudden Stratospheric Warming (SSW); and the Northern and Southern Polar Vortices, which are two permanent cyclones at the poles.³⁷

There are significant interaction effects between these subsystems. Australia's situation illustrates this general point. Australia's climate is largely determined by the following atmos-

pheric/oceanic systems and the interactions between them: Indian Ocean Dipole; El Nino Southern Oscillation; Inter-decadal Pacific Oscillation; The Southern Annular Mode; Madden Julian Oscillation; East Coast Lows; and Sub-Tropical Ridge; Sudden Stratospheric Warming; and the Southern Polar Vortex.

There is a substantial body of science about relationships between the solar wind, the global electric circuit and the Earth's climate dynamics. The solar wind is a stream of charged particles (electrons, protons and alpha particles and traces of heavy ions and atomic nuclei such as C, N, O, Ne, Mg, Si, S, and Fe) released from the Sun's corona (upper atmosphere). The solar wind is not constant; it is usually undulating and has discontinuities. These variations induce changes in the electric current flowing from the atmosphere to ground. This current is referred to as Jz.

Brian Tinsley, recently retired Professor of Physics at the University of Texas Dallas, is one of the world's leading researchers in this field. Professor Tinsley reported that research conducted jointly with Dr. Gary Burns of the Australian Antarctic Division, amongst others, found evidence supporting the theory that the solar wind can make global changes in Jz, which results in global changes in suitable types of clouds, which would result in changes in atmospheric dynamics, including changes in temperature, precipitation, storm invigoration, vorticity, and winter circulation. He found that about half of the global warming over the past century can be accounted for by changes in the Sun and the solar wind.

Professor Tinsley provides an overview of his (and others) research in this area on his website from which this statement is derived.³⁸

7.1 Interaction effects

The interaction effects between all of the determinants listed above are considerable.

For example, it is well known that a sinusoidal force applied to any stable dynamic system induces sinusoidal periodicities in the system.³⁹ Accordingly, the Lunar Nodal Cycle (LNC) induces bi-stable sinusoidal periodicities⁴⁰ in the atmosphere (pressure, temperature and rainfall) and the ocean (temperature and sea level). The sinusoidal, highly stable 18.6 year LNC has a distinctive and significant effect on the Earth's climate dynamics. The LNC's elongated tidal bulge necessarily continues to be aligned with the Moon. The bulge moves to the northern (and southern) latitudes as the Moon moves northwards because of the LNC, being the furthest north it can get to at the 18.6 year point. This last happened on September 16, 2006. Even though the amplitude of the LNC is at most 5 cm, a small tide over a long period has great power.

Mazzarella and Palumbo (1994), in a deeply empirical study, found that in the Western Mediterranean area, the LNC is a significant determinant of a range of climate variable ((atmospheric pressure, rainfall, evaporation, river discharge, air temperature) and oceanic variables (sea surface temperature, mean sea level).

In a thoroughly empirical paper, which also reviews critically a large number of scientific reports published over 10 years, Cervený and Shaffer (2001) report that the LNC is a major determinant of regional climates around the world.

The ocean currents generated by the northward movement of the tidal bulge, in conjunction with the rotation of the Earth through the bulges in the normal manner creating our experience of the tides, brings warmish equatorial water to the Arctic accelerating the warming that had been going on there because of other forms of solar activity and the Earth's variable rotation. The LNC has maximum effect at higher latitudes, resulting in higher sea levels at these latitudes. It creates tidal currents resulting in diapycnal mixing⁴¹, bringing the warmer equatorial waters into the Arctic. The LNC is therefore a major determinant of Arctic climate dynamics, influencing long term fluctuations in Arctic ice. As a result, it is a key driver of European climate.

Professor Emeritus Harald Yndestad of the Norwegian University of Science and Technology has shown in more than one dozen major detailed observational reports enriched by sophisticated

quantitative analysis that the LNC is a significant determinant of the northern hemisphere ecosystem. He demonstrated that the LNC brings cycles of warmth and cold. He showed how the shorter life cycles of biomass adapt to the longer LNC cycles resulting in periods of plenty and periods of scarcity. Professor Yndestad's Climate Clock (<https://www.climateclock.no>) is an excellent guide to his work. Some of his key publications are: Yndestad (1999, 2002), 2003), 2006, 2008) and Yndestad et al. (2008).

He found that the LNC is transitioning to the phase, which results in a period of cooling.

Since the 1980s, a large number of high quality papers have been published, in addition to those already cited, which collectively show that the LNC has a major role in global climate dynamics over many hundreds of years.

For example:

- McKinnell and Crawford (2007) found that the LNC is a significant determinant of the climate dynamics of the entire Pacific Ocean.
- Yasuda (2009) found that the LNC drives the Pacific Decadal Oscillation. In addition, Yasuda (2009) noted that the deterministic role of the LNC means that climate predictability can be improved by use of the time-table from the astronomical tidal cycle.
- Saintilan et al. (2022) found that the LNC regulates the expansion and contraction of mangrove canopy cover over much of the Australian continent.

It is to be noted that the IPCC does not mention in any of its many reports the vast body of research published over the last 40 years about the dominant role of the LNC in the regulation of the Earth's climate.

Lopes et al. (2021) noted that in 1799, LaPlace derived the system of differential equations (now called Liouville-Euler) that fully describes the motions of the rotation axis of any celestial body. Laplace showed that only the gravitational forces and kinetic moments from other celestial bodies influence the rotation of any one of them.

Lopes et al. (2021) construct a 175-year long time series of the variations in the Earth's rotation axis under the influence of both gravitational potentials and kinetic moments. They take into consideration the involvement of the planets, the Sun and the Moon in accordance with Laplace's celestial mechanics, having regard to the Sun carrying more than 99% of the mass and the planets more than 99% of the total angular momentum of the solar system. They use singular spectral analysis to extract components of the time series. Their analysis shows that there are four causal processes that determine changes to the rate and inclination of the Earth's rotation in accordance with LaPlace's equations.

The first process is that of the planets, particularly the Jovian planets, acting on the Earth/Moon system. The second process is that of the Sun acting on the Earth/Moon system (and the rest of the solar system). The third process is that all the planets of the solar system act on the Sun. The fourth is that of the Sun, having been activated by the third process, proceeds to the second process.

The authors' quantitative analysis of solar system data confirms LaPlace's 1799 analysis that the motions of the rotation axis of the Earth is determined fully by both gravitational potentials and kinetic moments.

Mazzarella (2008) outlines a promising approach that has regard to interaction effects. Mazzarella (2008) noted the numerous failures of IPCC sponsored computer simulations of climate dynamics. He pointed out that the reductionist approach on which the simulations are based, blocks the best practice scientific evaluation of them, thereby rendering the simulations unscientific.

Mazzarella (2008) outlines a holistic approach, which complies with the canons of science. His

approach is to analyze the Sun, atmospheric circulation, Earth's rotation and sea temperature as a single unit. He explained that the arrival on the Earth of fronts of hydrodynamic shock waves during epochs of strong ejection of particles from Sun gives rise to a squeezing of the Earth's magnetosphere and to a deceleration of zonal atmospheric circulation, which, like a torque, causes the Earth's rotation to decelerate which, in turn, causes a decrease in sea temperature.

Mazzarella (2008) showed that the integrated whole Earth-atmosphere-Sun system, incorporating the relevant independent variables, including turbulence of solar wind, atmospheric circulation and Earth's rotation, in an integrated way, explains most of global warming that has taken place since the 1980s. He found that the period of warming is about to conclude; it will be followed by a period of global cooling.

IPCC sponsored computer simulations of climate dynamics lack the capacity to portray and simulate successfully ENSO complexity. The simulations are not able to incorporate several important processes involving small scales. These processes have a significant role in the development of ENSO processes in a way analogous the well-known butterfly effect documented in 1963 by Professor Edward Norton Lorenz (1917 – 2008) (Lorenz 1963).⁴² Noting this intrinsic failure of the IPCC sponsored computer simulations and having regard to ENSO's role as the Earth's strongest climate fluctuation, Mazzarella, Giuliacci and Scafetta (2012) adapted the concepts of Mazzarella (2008) to the analysis of ENSO. They confirmed the idea that the major local and global Earth-atmosphere system mechanisms are significantly coupled and synchronized to each other at multiple scales.

8. The inner core, the geodynamo, the geomagnetic field and climate dynamics

The turbulent convection of the liquid Iron/Nickle outer core interacting with the inner core sets up a process that converts convective kinetic energy to electrical and magnetic energy. The electrically conducting liquid outer core induces electric currents, which generate magnetic fields. The process creates Alfven waves and is self-sustaining so long as there is an energy source sufficient to maintain convection. Changes in the rate of rotation of the outer core, including any sudden jerks, will induce variations in the accompanying electromagnetic fields.

The Sun's outer atmosphere envelopes planet Earth and extends with diminishing density throughout the solar system. The Sun is more than 99 per cent of the mass of the solar system and more than one million times the size of the Earth. The source of all the Sun's energy is its core, an extremely dense, extremely hot (15 million °Celsius) sphere of continuous boiling thermonuclear fusion. The diameter of this sphere is approximately the distance from the Earth to the Moon. The nuclear fusion core contains about half the mass of the Sun; that is, about 50 per cent of the mass of the solar system. In contrast, the mass of the Earth is about 0.0003 per cent of the mass of the solar system.

The geomagnetic field generated by the outer core protects Earth from the destructive, lethal effects of the Sun, specifically the Sun's output of radiation and matter. The geomagnetic field creates the Earth's magnetosphere, the region of space surrounding the Earth in which charged particles are affected by the geomagnetic field. The magnetopause is the boundary between the magnetosphere and the Sun's extended atmosphere. It is the boundary between the geomagnetic field and the solar wind. The location of the magnetopause depends on the balance between the dynamic pressure of the geomagnetic field and the solar wind. As the solar wind pressure increases and decreases, the magnetopause moves inward and outward in response.

Figure 9 depicts complex, dynamic electromagnetic environment of the Earth.

The Sun-Earth system is electromagnetically, magneto-hydrodynamically, and gravitationally coupled, dominated by significant non-linear, non-stationary interactions, which vary over time and throughout the three-dimensional structure of the Earth, its atmosphere and oceans. The essential elements of the Sun-Earth system are the solar dynamo, the heliosphere, the lunisolar tides,

the Earth's inner and outer cores, mantle, crust, magnetosphere, oceans and atmosphere. The Sun-Earth system is non-ergodic (i.e. characterised by continuous change, complexity, disorder, improbability, spontaneity, connectivity and the unexpected). Climate dynamics, therefore, are non-ergodic, with highly variable climatological features at any one time.

Ruzmaikin (2007) explained that linear and non-linear systems respond differently to external forces. The response of linear system is simply linearly proportional to the applied external force. Non-linear systems respond in a conceptually different way. Non-linear systems have internally defined preferred states known mathematically as attractors.

The response of non-linear systems to an external force is variable residency in the preferred states (i.e. the attractors) and changes in the transitions between them. The issue is not a magnitude of the response to an external force, as with the response of linear systems, but one or more of:

- a change of state;
- a change in the time spent in different states; and/or,
- the rate of oscillation between states.

Ruzmaikin (2007) considered that the impact of solar variability is to change the probability of the duration of particular climate patterns associated with cold conditions in some regions and warm conditions in other regions. These consequences are far more important, he argued, than changes to average global temperatures. Georgieva (2006)) established that the decadal changes in Earth's rotation rate depend on core-mantle coupling processes regulated by solar wind transferring solar magnetic fields and angular momentum modulated by planetary influences, and Kirov et al. (2002) demonstrated that the Earth's rotation rate depends on the magnetic polarity of the Sun. The Earth's rotation is systematically faster with a negative than with a positive polarity of the Sun. Kilfarska (2020) provides a detailed account of the many ways the geomagnetic field influences the Earth's climate.

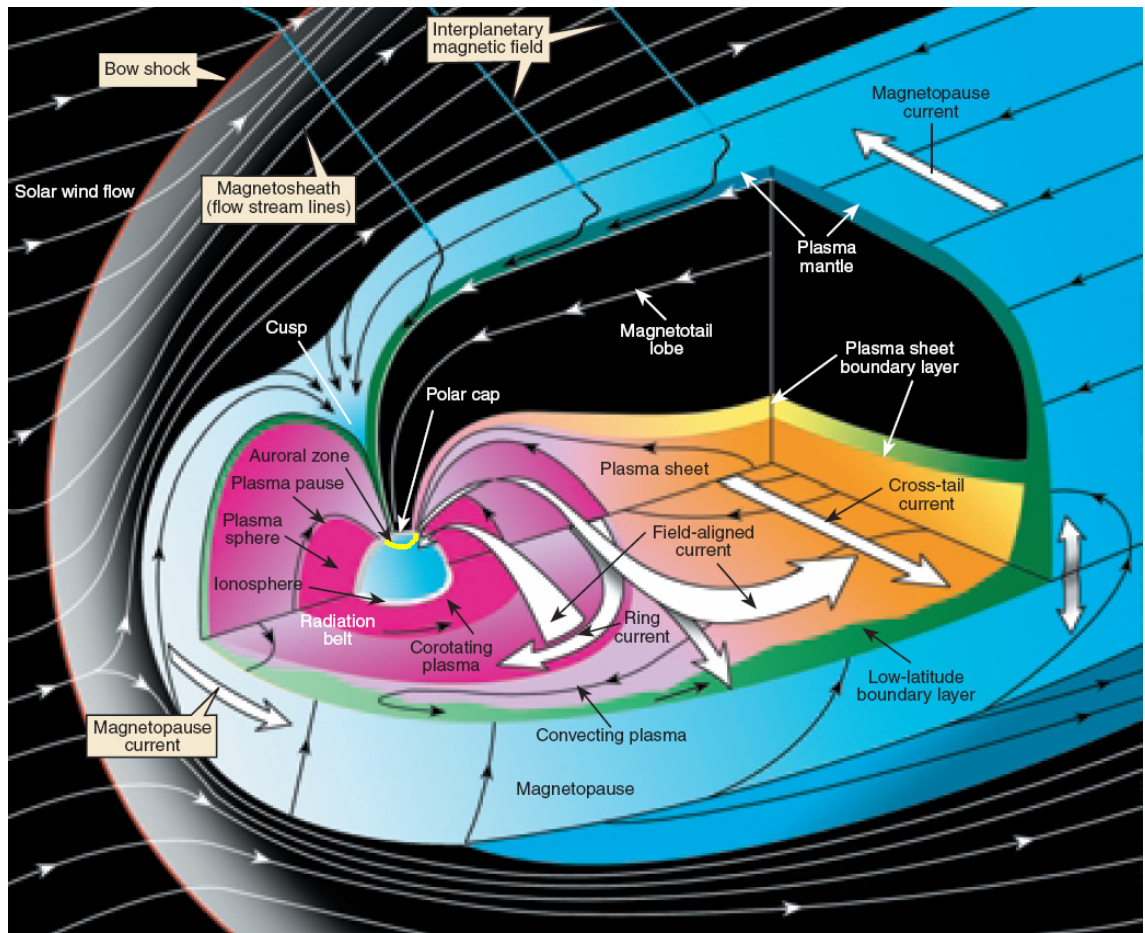


Figure 9. Schematic illustration of Earth's magnetosphere, illustrating major distinct regions and electric current systems. (Source: [Magnetopause & Bow Shock \(sepc.ac.cn\)](http://sepc.ac.cn))

The ring current (Figure 10) is one of the significant structures the Earth's electromagnetic environment. The ring current consists of those particles in the inner magnetosphere, which contribute substantially to the total current density and to the global geomagnetic disturbances on the Earth surface.

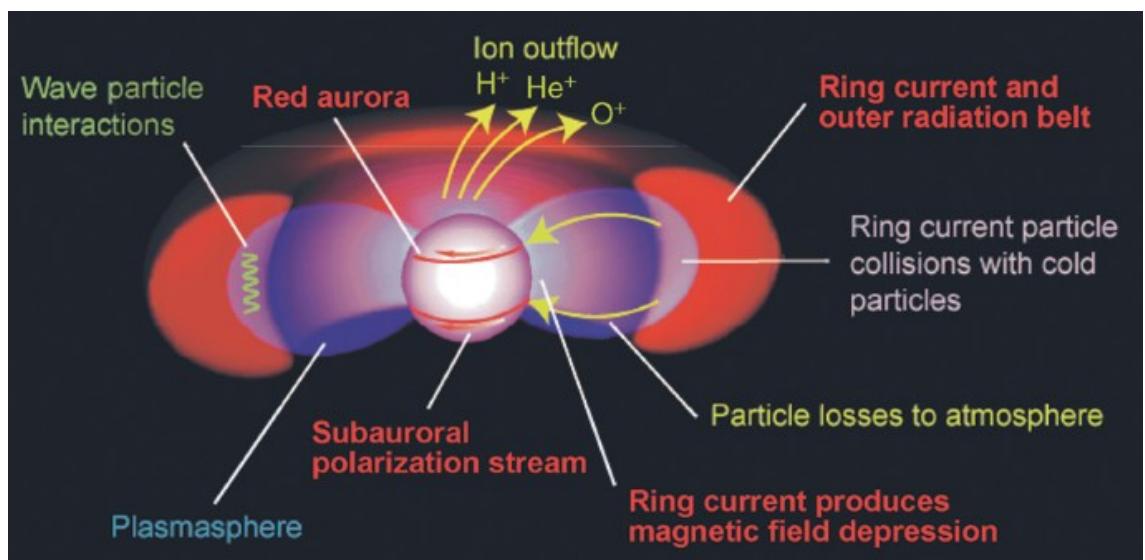


Figure 10 The Earth's ring current is shown as a red torus or donut-shaped region encircling the Earth near the equator at altitudes of 10,000-60,000 km.. Source: Moore (2007).

The ring current is an electric current of millions of Amperes encircling the Earth in space. It is a feature of the interaction between the magnetized conducting solar wind and the Earth, with its geomagnetic field and conducting ionosphere. Changes in the current are responsible for global decreases in the Earth's surface magnetic field. These changes are known as geomagnetic storms. Intense geomagnetic storms have severe effects on technological systems, such as disturbances or even permanent damage to telecommunication and navigation satellites, telecommunication cables, and power grids.

The ring current can be in two states: quiescent or storm.

The quiescent ring current is carried mainly by protons of predominantly solar wind origin

The storm ring current is the prime element of solar storms and is mostly terrestrial in origin. Just how solar storms influence the Earth's atmosphere to build up the high energy ions that characterise the storm ring current is an active area of inquiry.

Duhau and Martinez (1995) provide evidence for the theory that the storm ring current can increase length of day and geomagnetic variations on a decadal time scale via the exchange of angular momentum between the Earth's core and mantle. They found that there would be a 94 year lag between the sharp depression of the magnetic field that happens during a solar storm and the change in the LoD induced by that sharp depression.

Duhau and de Jager (2012) report that there are robust evidences that the semi-secular oscillations in LoD are the result of torsional oscillations in the liquid core that are excited 94 year before at the bottom of this layer by planetary motions. To fulfil the free fall motion principle (Shirley 2006), the total angular momentum of the Earth must be preserved. Therefore, as the motions in the liquid core are first excited at its boundary with the solid core, this last must undergoes a change of impulse of the opposite sign. The inner core motion is most likely to be activated first, because the differential action of the planetary system on the Earth's layers cause the periodic observed relative displacements and the relative turns between the inner core and the mantle (Bakin and Vilke 2004 and references therein).

Significant interactions could also be expected between the processes of the Earth-Moon-Sun geometry described earlier, the processes outlined by Lopes et al. (2021), the processes arising from the role of the Sun summarised above, the interactions between the oscillating atmospheric/oceanic systems outlined above and the Earth's dynamic electromagnetic environment.

For example, Wilson (2013) found that the LoD regulates the NAO and the PDO and that there is a remarkable correlation between the years where the phase of the PDO is most positive and the years where the deviation of the Earth's LoD from its long-term trend is greatest. Furthermore, he found a strong correlation between the times of maximum deviation of the Earth's LoD from its long-term trend and the times where there are abrupt asymmetries in the motion of the Sun about the Solar System barycentre. He claimed that significant synchronization between the orbital period of Jupiter and the rate of precession of the LNC is the reason for the strong correlation.

Scafetta and Willson (2013) report findings that support the hypothesis that the Sun, the heliosphere and the terrestrial magnetosphere are partially modulated by planetary gravitational and magnetic forces synchronized to planetary oscillations, as also found in other recent publications.

9. Scientific Misconduct

The IPCC does not mention in any of its many reports the vast body of research published over the last 50 years about the regulation of the Earth's climate by variations in decadal rotation of the Earth or the dominant role of the LNC in the regulation of the Earth's climate. The IPCC has deliberately omitted reporting these scientific results for over thirty years, since the publication of its *First Assessment Report* in 1990.

According to the U.S. Office of Science and Technology Policy (National Academy of Sciences (US), National Academy of Engineering (US) and Institute of Medicine (US) Committee on Science, Engineering, and Public Policy (2009)), and endorsed by the Organisation for Economic Co-operation and Development Global Science Forum,⁴³ not accurately representing in the research record by the deliberate omission of scientific results constitutes the falsification of science and is scientific misconduct.

Accordingly, the US and OECD scientific authorities would find the IPCC guilty of egregious scientific misconduct.

10. Elegant simplicity

This paper outlines a theory of elegant simplicity (in the sense of William of Occam) that explains the planet's climate dynamics in terms of variables that would apply to any planet of the solar system; indeed, to all planets of any solar system in the universe.

The key variables, the independent variables, are:

- The oblate, spheroid shells of which the planet is composed;
- The Earth-Moon-Sun system;
- The Sun;
- The solar system.

The planet's climate dynamics is the dependent variable.

11. Conclusion

- a) In relation to the Earth's climate dynamics, there are six well-established findings from Geophysics:
 1. When, on a decadal basis, the rate of rotation of the Earth increases by between three and five milliseconds, the Earth warms globally⁴⁴; when the rate decreases by a similar amount, the Earth cools globally.
 2. The behaviour of the Earth's core, particularly the inner core, is the key determinant of the Earth's decadal rotation variations.
 3. Although the dynamics of the core (the outer and inner cores) are not yet fully understood, it is clear that gravitational and electromagnetic couplings of the inner and outer cores to the mantle and crust have a dominant role.
 4. Quantitative analysis of solar system data confirms LaPlace's 1799 analysis that the motion of the rotation axis of the Earth is determined fully by both gravitational potentials and kinetic moments.
 5. There is time lag of about eight years between the electromagnetic event in the core that results in Earth rotation variations and the rotation variations happening.
 6. There is a time lag of about eight years between changes in the Earth's rotational speed and surface temperature.
 - 7.
- b) On 23 January 2023 *Nature Geoscience* published findings of Professor Xiaodong Song at the School of Earth and Space Sciences (SESS), Peking University and Dr Yi Yang, an Associate Research Scientist in Professor Song's group, that the rotation of the Earth's inner core began to slow down from around 2009 onwards. According to the above-mentioned time lags, the Earth's global temperature should begin to decline from 2025 onwards, *ceteris paribus*.
- c) Over the last several decades, scientists from several disciplines have published in many of the world's leading scientific journals abundant evidence about the key determinants of climate dynamics. The most significant determinant is the Sun. The Sun influences climate dynamics in several ways, including electromagnetic radiation, matter, gravitation, and interactions between these variables. The evidence is accumulating that if solar activity influences the Earth's climate dynamics, the climate will cool.
- d) The Earth's climate dynamics also depends on a number of subsystems of which the climate system is composed. There are indications that the likely impact of these subsystems over the next few years will be mixed: some warming; some cooling.
- e) There are, as well, significant interaction effects between all the variables that contribute to the Earth's climate dynamics, but these processes are not well understood.
- f) The IPCC continues to ignore abundant evidence about the role of the Earth's rotation, the LNC, and most of the independent variables discussed in this paper, including interaction effects between the independent variables. The US and OECD scientific authorities would find the IPCC guilty of egregious scientific misconduct. Whereas observation has dominated the science of the Earth's and the inner core's variable rotation, the IPCC's approach to science is to make observation subordinate to computer simulations. This attitude is absent in every other branch of science, including those in which computer simulations have a significant role, such as Solar Physics.
- g) As Bertrand Russell anticipated over 75 years ago, this has resulted in an intoxication contributing to a vast social disaster.

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Conflicts of Interest

The Author declares he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Attachment A

Historical overview- the Earth's variable rotation

Prior to the recognition that the Earth's rotation was variable, the Earth's rotation was assumed constant and therefore the standard for time, thereby placing the rotation of the Earth as the standard clock in the same category as the physical standards for length and weight. As a result, astronomers used the presumed fixed constant of the Earth's rotation to determine all astronomical attributes of the Sun and the solar system.

When in 1870 in the distinguished American Astronomer, Professor Simon Newcomb (1835 - 1909), Director of the Nautical Almanac Office as well as Professor of mathematics and astronomy at Johns Hopkins University in Baltimore, found indications that the Earth's rotation was not constant, but he was reluctant accept this. Part of his concern was the inaccuracies in the relevant measures. The deviations were so small, he found it difficult to different between errors of observation and the real behaviour of the celestial objects (Newcomb 1874). He devoted considerable time and resources to trying to prove that the Earth's rotation was constant. In 1895, he was awarded the Astronomical Journal prize of \$400 "For the most thorough discussion of the theory of the rotation of the Earth, with reference to the recently discovered variation of latitude."

In 1914, Dr A W Brown (1866 - 1938), Professor of Mathematics at Yale University, gave an address - as Vice-president of the British Association for the Advancement of Science - to the Association's Australasian meeting. His address, *Address on Cosmical Physics*, included a discussion of some irregularities in the Moon's motion (Brown 1914). At the time, Dr Brown was the world's expert about the behaviour of the Moon, having devoted his entire professional life to the study of the orbit of the Moon. In his address, he did not consider the idea that the Earth's variable rotation might be the cause of the Moon's irregularities.

In 1915, Sir Joseph Larmor (1857 – 1942), who held the Lucasian Chair of Mathematics at Cambridge University, wrote "The circumstance that there remains an outstanding irregularity in the orbital motion [of the Moon] ... has been felt to create an intolerable discrepancy, which demands every effort of the gravitational astronomer to resolve"(Larmor 1915). He considered that the "outstanding irregularity" would most likely be attributed to irregular changes in the Earth's velocity of rotation on its axis. A change in the Earth's rotation rate causes a corresponding change in the unit of time. This shows up as an error in the position of any celestial body moving fast enough to show the effect. Graphs of the position of the celestial body in which one graph is of the body's theoretical position (assuming the Earth's rotation rate is constant) and the other the actual position will show the error. Sir Joseph Larmor argued that if the discrepancies cannot be explained by attributes of the celestial body or by errors of measurement, then the discrepancies provide convincing evidence for the only other factor, the Earth's variable rotation.

In the same year (1915) a 23 year post graduate student at Cambridge University working under the supervision of Sir Arthur Eddington (Plumian Professor of Astronomy and Experimental Philosophy and Director of the Cambridge Observatory), Hermann Glauert (1892 – 1934), who had a Isaac Newton Studentship in Astronomy and Physical Optics, reported his findings from his examination of the problem (Glauert 1915a, 1915b). He concluded, “...that the errors in longitude of the Moon and the three bodies considered in this paper [Sun, Venus and Mercury] may be accounted for by a rather irregular variation in the rate of rotation of the Earth, the change of momentum being partially or entirely compensated for by a corresponding change in the mean motion of the Moon”. His papers include the detailed calculations and graphs of the results.

Sir Harold Spencer Jones (1890 – 1960), Astronomer Royal, confirmed that the Earth’s rotation was variable, reporting his findings in 1926 and 1939 in the *Monthly Notices of the Royal Astronomical Society* (Spencer Jones 1926, 1939). Following this, various astrometric indices of the Sun and the planets of the solar system had to be recalibrated.

In 1928, the Canadian Astrophysicist, Joseph Pearce (1893 – 1988) reported that “during the last few years much evidence has been advanced which proves conclusively that the rotation of the Earth is variable; that sudden changes in the rate take place; and that these variations are of surprisingly large amounts, the Earth gaining or losing as much as 30 seconds in a period of 40 years” (Pearce 1928).

The next two challenges were (i) to explain why the Earth’s rate of rotation was variable and (ii) to describe and explain any impact the Earth’s variable rate of rotation might have on the other layers of the Earth, especially the asthenosphere, the lithosphere and the atmosphere.

As described in this report, several acclaimed scientists have independently of each other established a clear causative relationship between the Earth’s decadal rotation variations and climate dynamics – as the rotation rate slows, the planet cools; as it speeds up, the planet warms. This pattern of slowing down, speeding up/cooling and warming repeats every 60 years. The scientists are Lambeck and Cazenave (1973, 1974, 1976, 1977), Sidorenkov (2009), Rozelot (1990), and Jochmann and Greiner-Mai (1996, 1997), amongst others.

In addition, Currie (1973) found evidence of a 60-year periodicity in the LoD time series; Currie (1980) found a relationship between the Earth’s decadal rotation variations and the Sun’s activity cycles. Mazzarella and Palumba (1988) found the same as Currie (1980). Mazzarella (2007) found that the turbulence of the solar wind, the Earth’s rotation and atmospheric circulation explained a large proportion of global warming. Mazzarella (2007) concluded that changes in geomagnetic activity, and in the Earth’s rotation, could be used as long- and short-term indicators, respectively, of future changes in global air temperature.

Mörner (1995) found that there is a strong linkage between the Earth’s rate of rotation and the changes in ocean circulation. He established that there is a causal connection between the Earth’s rotation, oceanic circulation (primarily the surface circulation; ocean/atmosphere heating, atmospheric (wind) heat transport and continental paleoclimatic changes.

Scientists discovered that the decadal variations in the Earth’s rotation rate gave rise to variations of the geomagnetic field. Some of the key scientists were Emeritus Professor Takesi Yukutake of the University of Tokyo, the Russian scientist Dr S I Braginsky (Braginsky (1982)) and the French scientists, Professors Vincent Courtillot, Jean-Louis Le Mouél and Dominique Jault and Dr Camille Gire of the Institute of Globe Physics of Paris. Professor Yukutake worked at the Earthquake Research Institute, University of Tokyo, for over thirty years. His first significant paper linking the decadal variations of the Earth’s rotation and the Earth’s geomagnetic field was published in 1973. The French team published relevant papers from 1982 onwards. In 1976 the French team reported that that in 1969 there had been a sudden worldwide change in the dynamics of the Earth’s magnetic field (geomagnetic jerks). They explained that the geomagnetic jerks are most likely to be a key determinant of the Earth’s decadal rotational variations. Other scientists have independently corroborated this finding.

Several scientists have since established that variations in the Earth's geomagnetic field give rise to variations in the Earth's climate dynamics. Relevant findings have been published since 1956. Kilifarska et al. (2020) provides an overview of these findings.

There are other variables that give rise to the Earth's climate dynamics that take place concurrently with the changes to the Earth's climate dynamics arising from the decadal variations in the Earth's rotation. Over the last several decades, scientists from several disciplines have published in many of the world's leading scientific journals an abundance of evidence about the key determinants of climate dynamics.

The most significant determinant is the Sun. The Sun can affect the climate in several ways, specifically the Sun's:

- output of radiation,
- output of matter,
- electromagnetic field,
- gravitational fields,
- shape; and,

as well, the topological structure of the heliosphere.

There are also significant effects from interactions between these.

The main paper (of which this is an Attachment) summarises the findings as well as findings about the impact on the Earth's climate dynamics arising from the complex interactive dynamics of the many subsystems of which the climate system is composed.

Attachment B

On pages 275 to 285 of his treatise, *The Earth's Variable Rotation – Geophysical Causes and Consequences*, (Lambeck (1980)) Professor Lambeck summarises the findings and conclusions of his joint papers with Dr Cazenave. He included graphs of these findings, which are reproduced below.

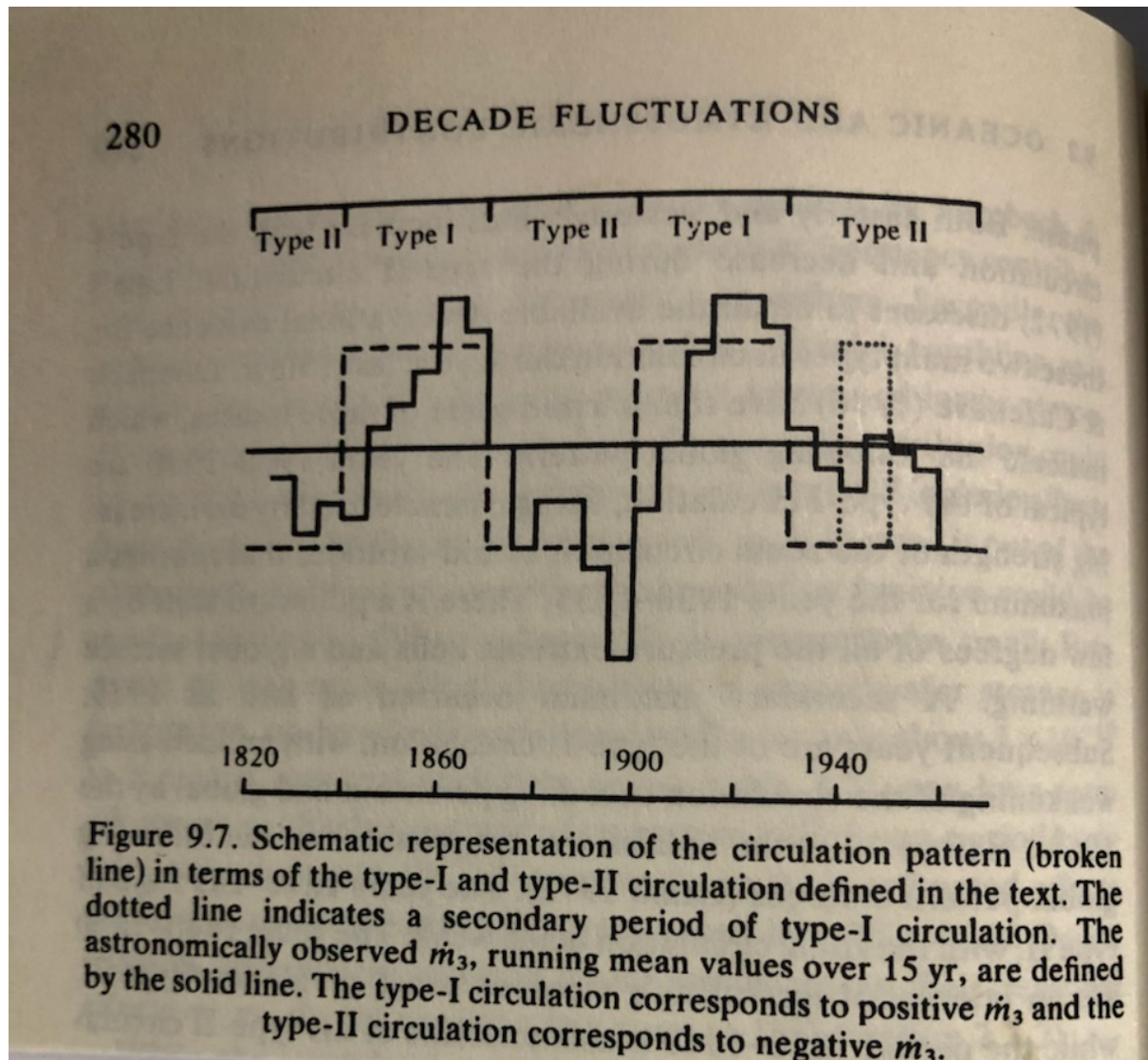


Figure B1. Relationship between variations in oceanic-atmospheric circulation patterns and variations in LoD (from Lambeck 1980).

On page 279 of Lambeck (1980), Professor Lambeck explains that this schematic diagram shows that a rotational acceleration is accompanied by periods of increasing strength of the zonal circulation while a rotational deceleration is accompanied by periods of decreasing circulation.

Note: The Earth's rotation rate, m_3 , is directly proportional to changes in the LoD. \dot{m}_3 denotes the rate of change of the Earth's rotation. Therefore, a positive \dot{m}_3 means the Earth's rotation rate is increasing, whereas a negative \dot{m}_3 means the Earth's rotation rate is decreasing.

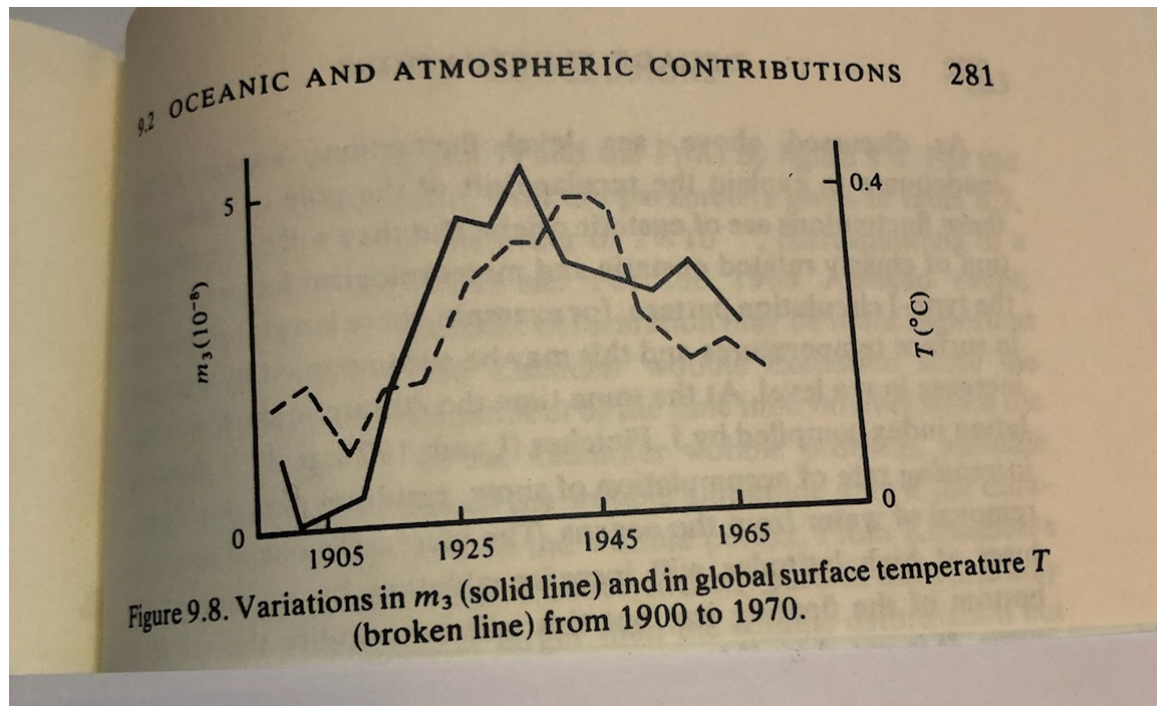


Figure B2. Relationship between variations in Earth rotation rate and variations in global surface temperature 1900 to 1970 (from Lambeck (1980)).

The left-hand side ordinate is the Earth's rotation rate, m_3 , in milliseconds from 0 to 5; whereas the right hand side ordinate is the variation in global surface temperature in $^{\circ}\text{C}$ from no variation at all (0) to a maximum of 0.4°C .

Note: The Earth's rotation rate, m_3 , is directly proportional to changes in the LoD.

Attachment C

Acronyms in Figures 4 and 8

This list explains the acronyms listed on the right-hand side in Figures 4 and 8. The explanations and definitions are from Thorne et al. (2010).

MSU—Microwave Sounding Unit

UAH—University of Alabama in Huntsville, developer of a version of MSU data products

RSS—Remote Sensing Systems, developer of a version of MSU data products

UMd—University of Maryland

STAR—The National Oceanic and Atmospheric Administration Center for Satellite Applications and Research

Prabhakara—Prabhakara (1999); Prabhakara C, Iacovazzi R, Yoo J-M, Dalu G (2000) and Prabhakara C, Iacovazzi R, Yoo J-M, Dalu G (1998)

Angell— Angell (2003)

RATPAC—Radiosonde Atmospheric Temperature Products for Climate, an adjusted radiosonde dataset

Sterin— Sterin AM, Eskridge RE (1997).

HadAT—Hadley Centre Atmospheric Temperatures, an adjusted radiosonde dataset

RAOBCORE—RADiosonde OBServation CORrection using REanalyses, an adjusted radiosonde dataset

RICH—Radiosonde Innovation Composite Homogenization, an adjusted radiosonde dataset

HadCRUT3—Surface temperature dataset jointly prepared by the Hadley Centre and the Climatic Research Unit

NOAA—The National Oceanic and Atmospheric Administration

NASA—The National Aeronautics and Space Administration

Attachment D

Australia Surface Temperatures Compared to UAH Satellite Data Over the Last 40 Years

April 3rd, 2019 by Roy W. Spencer, Ph. D: The monthly anomalies in Australia-average surface versus satellite deep-layer lower-tropospheric temperatures correlate at 0.70 (with a 0.57 deg. C standard deviation of their difference), increasing to 0.80 correlation (with a 0.48 deg. C standard deviation of their difference) after accounting for precipitation effects on the relationship. The 40-year trends (1979-2019) are similar for the raw anomalies (+0.21 C/decade for the observed temperature trend of the surface T_{surface} (T_{sfc}), +0.18 deg. C for satellite), but if the satellite and rainfall data are used to estimate T_{sfc} through a regression relationship, the adjusted satellite data then has a reduced trend of +0.15 C/decade. Thus, those who compare the UAH monthly anomalies to the BoM surface temperature anomalies should expect routine disagreements of 0.5 deg. C or more, due to the inherently different nature of surface versus tropospheric temperature measurements

1. Introduction.

I often receive questions from Australians about the UAH LT (lower troposphere) temperature anomalies over Australia, as they sometimes differ substantially from the surface temperature data compiled by BoM. As a result, I decided to do a quantitative comparison.

While we expect that the tropospheric and surface temperature variations should be somewhat correlated, there are reasons to expect the correlation to not be high. The surface-troposphere system is not regionally isolated over Australia, as the troposphere can be affected by distant processes. For example, subsidence warming over the continent can be caused by vigorous precipitation systems hundreds or thousands of miles away.

I use our monthly UAH LT anomalies for Australia (available [here](#)), and monthly anomalies in average (day+night) surface temperature and rainfall (available from BoM [here](#)). All monthly anomalies from BoM have been recomputed to be relative to the 1981-2010 base period to make them comparable to the UAH LT anomalies. The period analyzed here is January 1979 through March 2019.

2. Results before adjustments

A time series comparison between monthly T_{sfc} and LT anomalies shows warming in both, with a T_{sfc} warming trend of +0.21 C/decade, and a satellite LT trend of +0.18 C/decade:

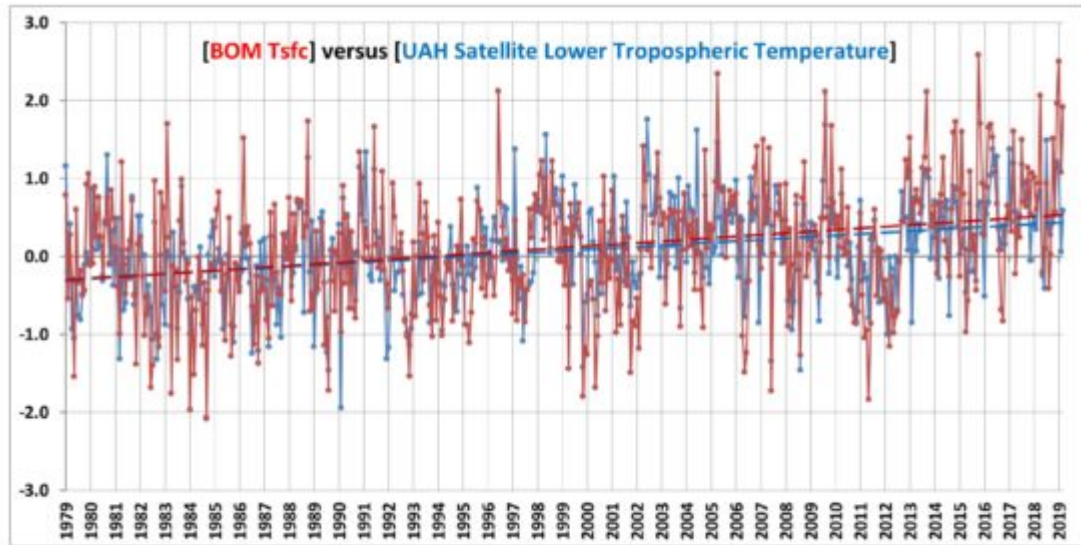


Figure D1. Australia average surface temperature (T_{sfc}) (red) and satellite lower tropospheric temperature (LT, blue) anomalies from January 1979 through March 2019.

The correlation between the two time-series is 0.70, indicating considerable — but not close — agreement between the two measures of temperature. The standard deviation of their difference is 0.57 deg. C, which means that people doing a comparison of UAH and BoM anomalies each month should not be surprised to see 0.6 deg. C differences (or more).

Part of the disagreement comes from rainfall conditions, which can affect the temperature lapse rate in the troposphere.

For reference, the following plot shows Australian precipitation anomalies for the same period:

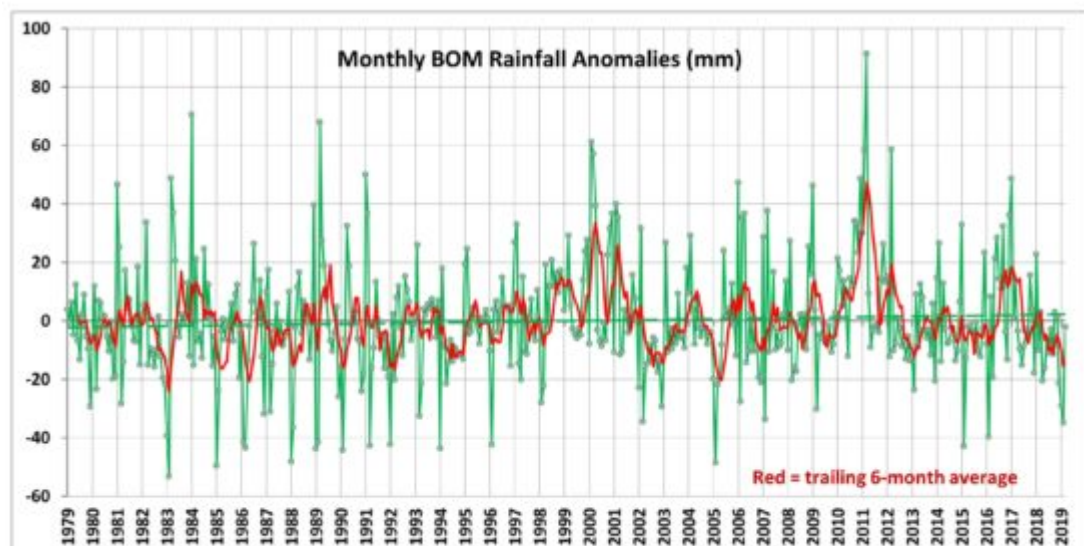


Figure D2. Australia precipitation anomalies from January 1979 through March 2019.

If we take the data in Figure D1 and create a scatter plot, but show the months with the 25% highest precipitation anomalies in green and the lowest 25% precipitation in red, we see that

drought periods tend to have higher surface temperatures compared to tropospheric temperatures, while the wettest periods tend to have lower surface temperatures compared to the troposphere:

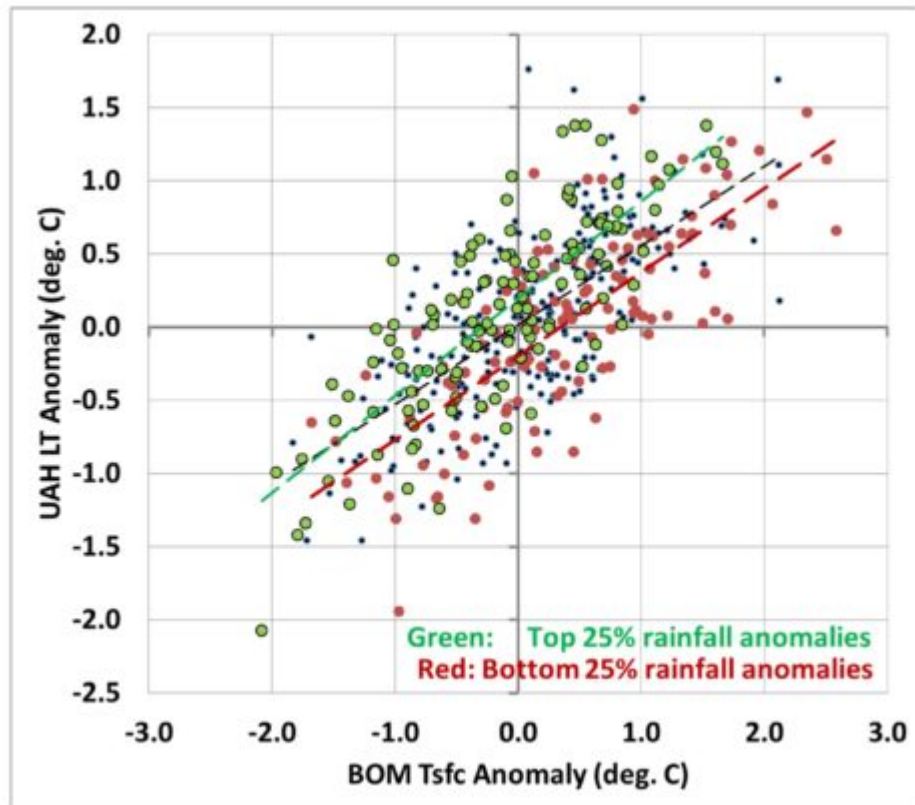


Figure D3. Scatterplot of the data in Figure D1, but with colour coding of those months with the 25% highest (green) and lowest (red) precipitation departures from average.

3. A more apples-to-apples Comparison

Comparing tropospheric and surface temperatures is a little like comparing apples and oranges. But one interesting thing we can do is to regress the surface temperature data against the tropospheric temperatures plus rainfall data to get equations that provide a “best estimate” of the surface temperatures from tropospheric temperatures and rainfall.

I did this for each of the 12 calendar months separately because it turned out that the precipitation relationship evident in Figure D3 was only a warm season phenomenon. During the winter months of June, July, and August, the relationship to precipitation had the opposite sign, with excessive precipitation being associated with warmer surface temperature versus the troposphere, and drought conditions associated with cooler surface temperatures than the troposphere (on average).

So, using a different regression relationship for each calendar month (each month having either 40 or 41 years represented), I computed a satellite+rainfall estimate of surface temperature. The resulting “satellite” time series then changes somewhat, and the correlation between them increases from 0.70 to 0.80 as shown in figure D4. Now the “satellite-based” trend is lowered to +0.15 C/decade, compared to the observed T_{sfc} trend of +0.21 C/decade. I will leave it to the reader to decide whether this is a significant difference or not.

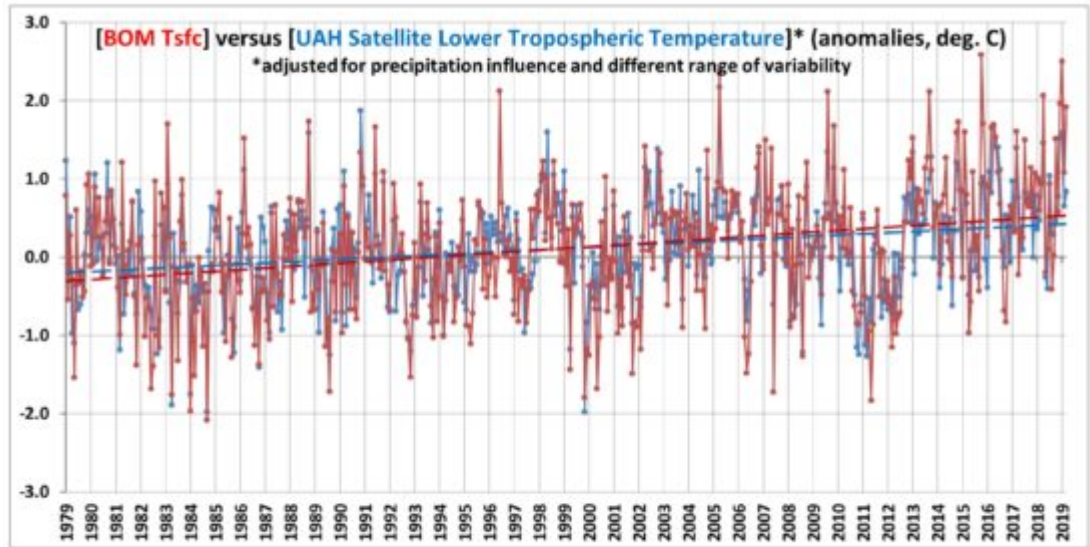


Figure D4. As in Figure D1, but now the satellite data are used along with precipitation data to provide a regression estimate of surface temperature.

To make the differences in Figure D4 a little easier to see, we can plot the difference time series between the two temperature measures as shown in the following Figure D5:

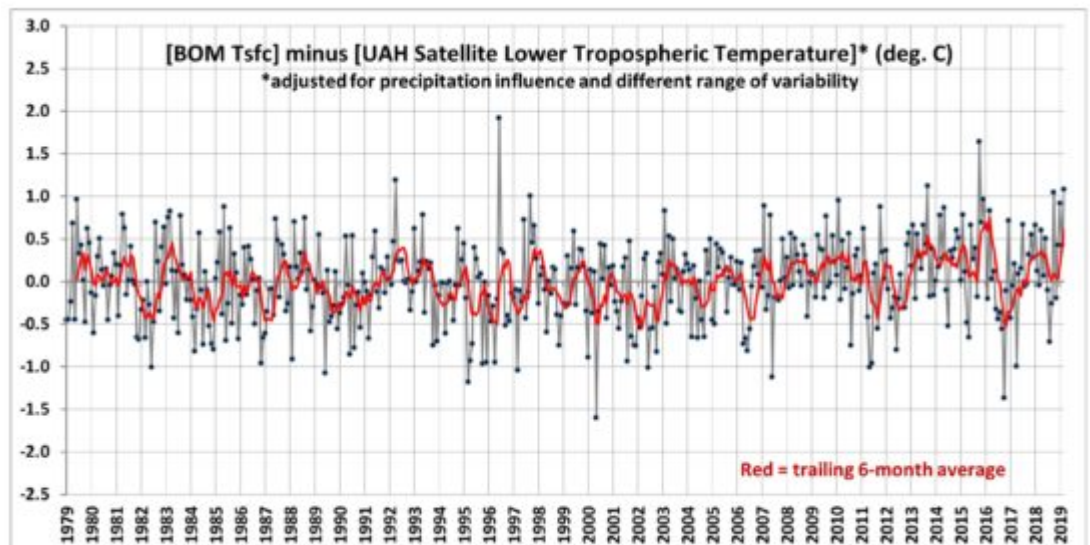


Figure D5. Difference between the two time-series shown in Figure D4.

Now we can see evidence of an enhanced warming trend in the T_{sfc} data versus the satellite over the most recent 20 years, which amounts to 0.40 deg. C during April 1999 – March 2019. I have no opinion on whether this is some natural fluctuation in the relationship between surface and tropospheric temperatures, problems in the surface data, problems in the satellite data, or some combination of all three.

4. Conclusions

The UAH tropospheric temperatures and BoM surface temperatures in Australia are correlated, with similar variability (0.70 correlation). Accounting for anomalous rainfall conditions increases

the correlation to 0.80. The T_{sfc} trends have a slightly greater warming trend than the tropospheric temperatures, but the reasons for this are unclear. Users of the UAH data should expect monthly differences between the UAH and BoM data of 0.6 deg. C or so on a rather routine basis (after correcting for their different 30-year baselines used for anomalies: BoM uses 1961-1990 and UAH uses 1981-2010).

References

Angell J K (2003) *Effect of exclusion of anomalous tropical stations on temperature trends from a 63-station radiosonde network, and comparison with other analyses*. J Climate 2003, 16:2288–2295.

Agnew, D C, and F K Wyatt (2014), *Dynamic strains at regional and teleseismic distances*, the Bulletin of the Seismological Society of America, 104, 41,846–41,859.

Anderson, D L (1974) *Earthquakes and the rotation of the Earth*. Science Vol 186, Issue 4158, pp 49 to 50; 4 October 1974.

Anderson, D L (2007) *The new theory of the Earth* Cambridge University Press

Baart, F., Van Koningsveld, M. and Stive, M. (2012a) *Trends in sea-level trend analysis* (Editorial) Journal of Coastal Research, 28(2), 311–315 West Palm Beach (Florida)

Baart, F., Van Gelder, P. H., De Ronde, J., Van Koningsveld, M. and Wouters, B. (2012b) *The effect of the 18.6-year lunar nodal cycle on regional sea-level rise estimates* Journal of Coastal Research, 28(2), 511–516. West Palm Beach (Florida)

Ball, Tim (2014) *The deliberate corruption of climate science* The Stairway Press Seattle 2014

Bakin Yu V., Vilke V.G. (2004) *Celestial mechanics of planets shells*, Astronomical and Astrophysical Transactions, Vol 23, No 6, pps 533-553

Bendick, Roger and Bilham, Rebecca (2017) *Do weak global stresses synchronize earthquakes?* Geophysics Research Letters, 44, 8320–8327

Bostrom, R.C. (2000) *Tectonic Consequences of the Earth's Rotation* United Kingdom: Oxford University Press

Birch, Francis (1971) *Thirty-third Presentation, William Bowie Medal to Inge Lehmann*; EOS American Geophysical Society Transactions Vol 52 pp 537 – 538

Bolt, Bruce (1997) *Inge Lehmann. 13 May 1888-21 February 1993* Biographical Memoirs of Fellows of the Royal Society, Nov., 1997, Vol. 43 (Nov., 1997), pp. 286-301 Published by: The Royal Society

Brown, E. W. (1914) *Address on Cosmical Physics* - Address of the Vice-president of Section A, British Association for the Advancement of Science, Australasian meeting 1914 published as Cosmical Physics in Science Friday September 1914

Carter, Robert (2010) *Climate – the counter consensus, a Palaeoclimatologist speaks* Stacey International London 2010

Carter, Robert and Spooner, John (2013) *Taxing Air Facts and Fallacies about climate change*

High Horse Books Melbourne Australia 2013

Courtillot, V, Le Mouél, J L, (1976) *On the long-period variations of the Earth's magnetic field from 2 months to 20 years* Journal of Geophysical Research Vol 81 No17 pp 2941–2950 [doi:10.1029/JB081i017p02941](https://doi.org/10.1029/JB081i017p02941) (10 June 1976)

Courtillot, V, Le Mouel, J L, Ducruix, J, and Cazenave, A (1982) *Geomagnetic secular variation as a precursor of climate change* Nature, 297, 386-387

Courtillot, V., Le Mouél, J., Ducruix, J and Cazenave, A (1983) *Corrigendum: Correction to 'Geomagnetic secular variation as a precursor of climatic change'*; Nature 303, 638

Currie, R. G., 1973 *The - 60 year spectral line in length of day fluctuations*, South African Journal of Science, 69, 180-182.

Currie, Robert G, (1980) *Detection of the 11-yr sunspot cycle signal in Earth rotation*, Geophysical Journal International, Volume 61, Issue 1, April 1980, Pages 131–140.

Curry, Judith A and Webster, P J (2011) *Climate Science and the Uncertainty Monster*, Bulletin of the American Meteorological Society, Vol 92, No 12 (December 2011), pp 1667-1682

De Michelis, Paola; Tozzi, Roberta; Meloni, Antonio (2005) *Geomagnetic jerks: observation and theoretical modelling*, Memorie della Società Astronomica Italiana. Vol 76 pp 957–960

Dickey, Jean O, Marcus, Steven L & De Viro, Olivier (2011) *Air Temperature and Anthropogenic Forcing: Insights from the Solid Earth* Notes and Correspondence Journal of Climate Vol 24, 15 January 2011

Duhau S and de Jager C (2012) *On the Origin of the Bi-Decadal and the Semi-Secular Oscillations in the Length of the Day*, in S. Kenyon et al. (eds), *Geodesy for Planet Earth*, International Association of Geodesy Symposia 136, Springer -Verlag Berlin Heidelberg, pp. 507-551.

Duhau S and Martinez EA (1995) *On the Origin of the Length of the Day and the Geomagnetic Field on the Decadal Time Scale*, Geophysical Research Letters Vol 22, pps 3283-3288

Dziewonski, A M and Gilbert, F (1974) *Temporal variation of the seismic moment tensor and the evidence of precursive compression for two deep earthquakes*. Nature, Vol 247 pp 185-8.

Essex, Christopher and McKittrick, Ross (2002) *Taken by Storm The troubled science, policy and politics of global warming* Key Porter Books Ontario Canada 2002

Essex, Christopher (2011) *Climate theory versus a theory for climate* International Journal of Bifurcation and Chaos, Vol 21, No 12 pp 3477–3487 World Scientific Publishing Company

Essex, Christopher (1991) *What Do Climate Models Tell Us About Global Warming?* Pure and Applied Geophysics, January 1991, Volume 135, Issue 1, pp 125 - 133

Fagan, B., (1999) *Floods, Famines and Emperors. El Nino and the Fate of Civilizations* Basic Books.

Fagan, B., (2000) *The Little Ice Age. How Climate Made History 1300-1800*. Basic Books.

Fagan, B., (2004) *The Long Summer. How Climate Changed Civilization*. Basic Books.

Georgieva, K., (2006) *Solar Dynamics and Solar-Terrestrial Influences*. A chapter in Space Science: New Research edited by Nick Maravell (ISBN: 9781600210051) Nova Science Pub Inc.

Glauert, H (1915a) *The rotation of the Earth*, Monthly Notices of the Royal Astronomical Society, 1915, 75, pp 489- 495

Glauert, H (1915b) *The rotation of the Earth, (second paper)* Monthly Notices of the Royal Astronomical Society, 1915, 75, pp 685- 487

Gokhberga, M B, Olshanskayaa, E V, Chkhetianib, O G, Shalimova, S L, and Barsukova O M Presented by Academician E.P. Velikhov (2015) *Correlation between Large-Scale Motions in the Liquid Core of the Earth and Geomagnetic Jerks, Earthquakes, and Variations in the Earth's Length of Day*, Doklady January 24, 2015 Earth Sciences, 2016, Vol. 467, Part 1, pp. 280–283. Pleiades Publishing, Ltd., 2016.

Hawkins, Louise (2023) Associate Editor, Nature Geoscience; *Research briefing Differential rotation of the Earth's inner core changes over decades and has come to near-halt* Nature Geoscience, 23 January 2023

Heck, Bernard, Rummel, Reinhard, Groten, Erwin and Hornik, Helmut (1999) *National Report of the Federal Republic of Germany about geodetic activities in the years 1995 to 1999. A Report to the XXII General Assembly of the International Union for Geodesy and Geophysics (IUGG) 1999 in Birmingham*; Verlag der Bayerischen Akademie der Wissenschaften in Commission at C. H. Beck'schen Verlagsbuchhandlung Munich 1999; available here: [Germany on the Geodetic Activities in the Years 1995 Bb 1999 - DocsLib](#).

Hofmeister, A.M., Criss, R.E., and Criss, E.M., 2022, *Links of planetary energetics to moon size, orbit, and planet spin: A new mechanism for plate tectonics*, in Foulger, G.R., Hamilton, L.C., Jurdy, D.M., Stein, C.A., Howard, K.A., and Stein, S., eds., *In the Footsteps of Warren B. Hamilton: New Ideas in Earth Science*: Geological Society of America Special Paper 553, p. 213–222.

Isaksson, Elisabeth, Gerland, Sebastian & Divine, Dmitry (2016) *In memory of Torgny Vinje—a genuine polar scientist*, Polar Research, 35:1, 32211

Jault, D (2003) *Electromagnetic and Topographic Coupling, and LoD Variations*; a chapter in Jones C A, Soward A M, Zhang K (eds) *Earth's core and lower mantle*. Taylor and Francis, London, pp 46–76.

Jochmann, H and Greiner-Mai, H (1996) *Climate variations and the Earth's rotation* Journal of Geodynamics Vol 21, No. 2, pp 161-176 1996

Jochmann, H and Greiner-Mai, H (1997) *Correction to 'Climate variations and the Earth's rotation'* Journal of Geodynamics Vol 25, No 1, p 14

Kilifarska, N.A., Bakmutov, V.G. and Melnyk, G.V., (2020) *The hidden link between Earth's magnetic field and climate*. Elsevier

Kirov, B.; Georgieva, K.; Javaraiah, J., (2002) *22-year periodicity in solar rotation, solar wind parameters and Earth rotation*. In *Solar variability: from core to outer frontiers. The 10th European Solar Physics Meeting, 9 - 14 September 2002, Prague, Czech Republic*. Ed. A. Wilson. ESA SP-506, Vol. 1. Noordwijk: ESA Publications Division, ISBN 92-9092-816-6, 2002, p. 149 - 152

Koonin, Steven (2021) *Unsettled: What Climate Science Tells Us, What It Doesn't, and Why It Matters* BenBella Books; April 27, 2021

- Koutsoyiannis, D (2011) *Hurst-Kolmogorov dynamics and uncertainty*, Journal of the American Water Resources Association, Vol 47 (3), 481–495
- Lamb, H. H. (1972) *Climate, present, past and future*, Volume 1 Methuen and Co., London. (Note: Volume 2 was published in 1977).
- Lambeck, K. & Cazenave, A., (1973) *The Earth's rotation and atmospheric circulation - I Seasonal variations*, Geophysical Journal of the Royal Astronomical Society 32, 79-93 32, pps 79-93.
- Lambeck, K and Cazenave, A (1974) *The Earth's Rotation and Atmospheric Circulation - II The Continuum* Geophysical Journal of the Royal Astronomical Society 38, pps 49-61.
- Lambeck, K and Cazenave, A (1976), *Long Term Variations in the Length of Day and Climatic Change* Geophysical Journal of the Royal Astronomical Society Vol 26 Issue No 3 pps 555 to 573
- Lambeck, K. and Cazenave, A (1977) *The Earth's variable rate of rotation: a discussion of some meteorological and oceanic causes and consequences*, Philosophic Transactions of the Royal Society of London A284 pps 495-506, 1977
- Lambeck, K (1980) *The Earth's Variable Rotation-Geophysical causes and consequences*, Cambridge University Press.
- Larmor, Joseph Sir (1915) *On Irregularities in the Earth's Rotation, in Relation to the Outstanding Discrepancies in the Orbital Motion of the Moon*; Monthly Notices of the Royal Astronomical Society, Volume 75, Issue 3, January 1915, Pages 211–219
- Lehmann, Inge (1987) *Seismology in the Days of Old Eos*, Vol 68, No 3, January 20, 1987, pp 33-35
- Leroux, Marcel (2005) *Global Warming Myth or Reality The Erring Ways of Climatology*, Springer and Praxis Publishing UK 2005
- Lopes, F, Le Mouel, J L, Courtillot, V and Gilbert, D (2021) *On the shoulders of Laplace*, Physics of the Earth and Planetary Interiors Vol 316, July 2021 106693
- Lorenz, E N (1963) *Deterministic Nonperiodic Flow*, Journal of Atmospheric Science Vol 20, pp 130 – 141
- Lorenz, E. N., (1967). *The Nature and Theory of the General Circulation of the Atmosphere*, World Meteorological Organization, WMO – No. 218. TP. 115; Ibid., pps 135 to 151.
- Lyubushin, A. (2020) *Trends of Global Seismic Noise Properties in Connection to Irregularity of Earth's Rotation*. Pure Appl. Geophys. 177, 621–636.
- McKittrick, Ross (2010) *A Critical Review of Global Surface Temperature Data Products* Social Science Research Network (SSRN) August 5, 2010; Working paper 1653928, (75 pages)
- McLean, John D (2017) *An audit of uncertainties in the HadCRUT4 temperature anomaly dataset plus the investigation of three other contemporary climate issues* PhD thesis, James Cook University

Magnus, K., (1965) *Vibrations* London: Blackie.

Marcus, Steven L (2016) *Does an Intrinsic Source Generate a Shared Low-Frequency Signature in Earth's Climate and Rotation Rate?* Earth Interactions Vol 20 Paper No. 4, 14 pages (Earth Interactions is a joint publication of the American Meteorological Society, American Geophysical Union, and American Association of Geographers).

Mazzarella, Adriano, (2007) The 60-year solar modulation of global air temperature: The Earth's rotation and atmospheric circulation connection, Theoretical and Applied Climatology Vol 88, No. 3) pp 193-1999

Mazzarella, A and Palumbo, A (1994) *The Lunar Nodal Induced-Signal in Climatic and Oceanic Data over the Western Mediterranean Area and on its Bistable Phasing* Theoretical and Applied Climatology Vol 50, pp 93-102

Mazzarella, A and Palumbo, A (1988) *Earth's rotation and solar activity* Geophysical Journal 97, 169-171

Mazzarella A, Giuliacci, A, and Scafetta, N (2012) *Quantifying the Multivariate ENSO Index (MEI) coupling to CO2 concentration and to the length of day variations.* Theoretical Applied Climatology. DOI: 10.1007/s00704-012-0696-9

Mazzarella A and Scafetta N, 2018, *The Little Ice Age was 1.0-1.5 °C cooler than current warm period according to LOD and NAO*, Climate Dynamics November 2018, published online 27 February 2018

Michaels, Patrick (1994) *Shattered Consensus: the True State of Global Warming* Rowman & Littlefield publishers January 1, 1994

Mitchell, J Murray (1953) *On the Causes of Instrumentally Observed Secular Temperature Trends* Journal of Atmospheric Sciences Volume 10: Issue 4 pp 244 to 261.

Mitchell, J Murray, (1961) *Recent Secular Changes in Global Temperatures* Annals of the New York Academy of Sciences, Vol. 95, pp. 235-250.

Mitchell, J Murray (1970) *A Preliminary Evaluation of Atmospheric Pollution as a Cause of the Global Temperature Fluctuations of the Past Century* in Singer, S Fred (1970) *Global Effects of Environmental Pollution* Springer.

Mohazzabi, Pirooz and Skalbeck, John D (2015) *Superrotation of Earth's Inner Core, Extraterrestrial Impacts, and the Effective Viscosity of Outer Core* International Journal of Geophysics Volume 2015 | Article ID 763716

Moore, T.E. (2007). *Ring Current*. In: Gubbins, D., Herrero-Bervera, E. (eds) *Encyclopedia of Geomagnetism and Paleomagnetism*. Springer, Dordrecht.

Mörner, N.A. (1995) *Earth rotation, ocean circulation and paleoclimate*; GeoJournal 37, 419–430

Mörner, N-A, Solheim, J-E, Humlum, O and Falk-Petersen, S (2020) *Changes in Barents Sea ice Edge Positions in the Last 440 years~A Review of Possible Driving Forces*; International Journal of Astronomy and Astrophysics, 10, 97-164

Mouel, J, Madden, T, Ducruix, J, and Courtillot, V (1981) *Decade fluctuations in geomagnetic*

westward drift and Earth rotation Nature Vol 290 30 April 1981 pp 763 to 765

National Academy of Sciences, National Academy of Engineering (US) and Institute of Medicine (US) Committee on Science, Engineering, and Public Policy (2009) *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. Washington (DC): National Academies Press (US); PMID: 25009901

Newcomb, Simon (1874) *On the possible variability of the Earth's axial rotation, as investigated by Mr. Glasenapp*; American Journal of Science (Third Series), September 1874, Vol s3-8, Issue 45, pps 161-169

Otto, Alexander, Otto, Friederike E L, Boucher, Olivier, Church, John , Heger, Gabi, Forster, Piers M, Gillett, Bathan P, Gregory, Johnathan , Gregory, Johnson, C , Knutt, Reto , Lewis, Nicholas, Lohmann, Ulrike, Marotzke, Jochem, Myhre, Gunnar, Shindell, Drew, Stevens, Bjorn and Allen, Myles R (2013) *Energy budget constraints on climate response* Nature Geoscience Vol6 June 2013 pages 415 & 416

Pearce, J A (1928) *The Variability of the Rotation of the Earth*; Journal of the Royal Astronomical Society of Canada, Vol. 22, p.145 April 1928

Pham, Thanh-Son & Tkalcic, Hrvoje (2023) *Up-to-fivefold reverberating waves through the Earth's center and distinctly anisotropic innermost inner core* Nature Communications (2023) 14; 754

Prabhakara C, Iacovazzi R, Yoo J-M, Dalu G (1998) *Global warming deduced from MSU*. Geophys Res Lett 1998, 25:1927–1930.

Prabhakara C, Iacovazzi R (1999) *Comments on “Analysis of the merging procedure for the MSU daily temperature time series”*. J Climate 1999, 12:3331–3334. 89.

Prabhakara C, Iacovazzi R, Yoo J-M, Dalu G (2000) *Global warming: evidence from satellite observations*. Geophys Res Lett 2000, 27:3517–3520. 90.

Press, F. (1965), *Displacements, strains, and tilts at teleseismic distances*, J. Geophys. Res., 70, 2395–2412.

Po-Chedley, Stephen, Santer, Benjamin D, Fueglistaler, Stephan, Zelinka, Mark D, Cameron-Smith, Philip J, Painter, Jeffrey F, and Qiang Fu (2021) *Natural variability contributes to model–satellite differences in tropical tropospheric warming* Proceedings of the National Academy of Sciences of the United States of America (PNAS) 2021 Vol 118 No 13

Roberts, P H, Yu, Z J and Russell C T (2006) *On the 60-year signal from the core* Geophysical and Astrophysical Fluid Dynamics vol 101 pp11 to 35.

Rozelot, J P and Spaute, D (1990) *Earth Rotation and Climatic Periodicities* in McCarthy, Dennis D and Carter, William E In Variations in Earth Rotation, Geophysical Monograph Series Volume 59 1 January 1990 the American Geophysical Union.

Rousseau, Christine (2013) *How Inge Lehmann Discovered the Inner Core of the Earth* The College Mathematics Journal Vol 44, No 5, November 2013

Russell, Bertrand (1945) *History of Western Philosophy* New York: Simon and Schuster

Ruzmaikin, A., (2007) *Effect of solar variability on the Earth's climate patterns*. Advances in Space Research doi:10.1016/j.asr.2007.01.076; published online 3 March 2007.

- Scafetta N and Mazzarella A (2015) *Spectral coherence between climate oscillations and the $M \geq 7$ earthquake historical worldwide record*, Natural Hazards Vol 76, pps 1807–1829
- Scafetta N and Willson R C (2013) *Planetary Harmonics in the historical Hungarian auroral record (1523-1960)*, Planetary and Space Science Vol78, April 2013, pps 38-44
- Schmidt, Gavin A, Shindell, Drew T and Tsigaridis, Kostas (2014) *Reconciling warming trends* Nature Geoscience Vol 7 March 2014
- Shanker, D., N. Kapur, and V. Singh (2001), *On the spatio temporal distribution of global seismicity and rotation of the earth—A review*, Acta Geodaetica et Geophysica, 36, 175–187
- Shirley J (2006) *Axial rotation, orbital revolution and solar spin-orbit coupling*, Monthly Notices of the Royal Astronomical Society Vol 368, pp 280–282
- Sidorenkov, N. (2009) *The Interaction Between Earth's Rotation and Geophysical Processes* Wiley VCH, p 247
- Solheim, J-E, Falk-Petersen, S, Humlum, O, and Mörner, N-A (2021) *Changes in Barents Sea Ice Edge Positions in the Last 442 Years, Part 2 Sun, Moon and Planets*, International Journal of Astronomy and Astrophysics, 11, 279-341 <https://doi.org/10.4236/ijaa.2021.112015>
- Solomon, S., D. Qin, M. Manning, M. Marquis, K. Averyt, M. M. B. Tignor, H. L. Miller Jr., and Z. Chen, Eds., 2007: *Climate Change 2007: The Physical Science Basis*, Cambridge University Press, 996 pp
- Spencer Jones, H, (1926) *The Rotation of the Earth*, Monthly Notices of the Royal Astronomical Society, Volume 87, Issue 1, November 1926, Pages 4–31
- Spencer-Jones, H, (1939) *The Rotation of the Earth, and the Secular Accelerations of the Sun, Moon and Planets* Monthly Notices of the Royal Astronomical Society, Volume 99, Issue 7, May 1939, Pages 541–55
- Sterin AM, Eskridge RE (1997) Monthly aerological data set: *Some features and comparison of upper-air temperature data to the NCAR/NCEP reanalysis monthly data*. Proceedings of the 22nd Annual Climate Diagnostics and Prediction Workshop: 6–10 October 1997, Berkeley. Silver Spring MD: National Oceanic and Atmospheric Administration; 1998, 210–213.
- Stoyko A, Stoyko N (1969) *Rotation de la terre, phénomènes géophysiques et activité du soleil*. Bulletin Academic Royal Belgique 5: 279-285
- Teed, R J, Jones, C A, and Tobias, S M (2019) *Torsional waves driven by convection and jets in Earth's liquid core*, Geophysical Journal International (2019) 216, 123–129 doi: 10.1093/gji/ggy416, Advance Access publication 2018 October 09 GJI Geomagnetism, rock magnetism and palaeomagnetism EXPRESS LETTER
- Thorne, Peter W, Lanzante, John R, Peterson, Thomas C, Seidel, Dian and Shine, Keith P, (2010) *Tropospheric temperature trends~history of an ongoing controversy* Wiley Interdisciplinary Reviews (WIREs): Climate Change 2010
- Tkalcic, Hrvoje (2015), *Complex inner core of the Earth~The last frontier of global seismology*, Review Geophysics, 53, pp 59–94,
- Tkalci, Hrvoje et al. (2013) *The shuffling rotation of the Earth's inner core revealed by earthquake doublets*; Nature Geoscience Vol 6 June 2013 pp 497 to 502

- Tkalcic, H & Kennett, B L N (2008) *Core structure and heterogeneity: a seismological perspective* Australian Journal of Earth Sciences 55, pp 419 – 431
- Tolstikov, A S, Tissen, Viktor M and Simonova, Galina V (2019) *Long-term climate prediction by means of Earth rotation rate adaptive variations models*, Proc. SPIE 11208, 25th International Symposium on Atmospheric and Ocean Optics: Atmospheric Physics, 1120887 (18 December 2019)
- Vinje, Torgny (2001) *Anomalies and Trends of Sea-Ice Extent and Atmospheric Circulation in the Nordic Seas during the Period 1864–1998* Journal of Climate Vol 14; 1 February 2001; pps 255 – 267
- Watson, P J, (2020) *Updated mean sea-level analysis: Australia* Journal of Coastal Research, 36(5), 915–931 (Florida)
- Wilson I R G (2013) *Are Changes in the Earth's Rotation Rate External Driven and Do They Affect Climate?* The General Science Journal, 3812,1-31
- Yang, Y. and X.D. Song, (2023) *Multidecadal variation of the Earth's inner core rotation*, Nature Geoscience, 23 January 2023
- Zheng, DW and Zhou, YH (1995) *Research on the relationship between Earth's variable rotation and global seismic activity*. Acta Seismologica Sinica 8, 31–37.
- Yndestad, Harald, (1999) *Earth nutation influence on system dynamics of Northeast Arctic cod*, ICES Journal of Marine Science; 56, 652-657. 1999.
- Yndestad H and Stene A, (2002) *Systems Dynamics of Barents Sea Capelin*, ICES Journal of Marine Science. 59: 1155-1166.
- Yndestad, Harald, (2003) *The cause of biomass dynamics in the Barents Sea*, Journal of Marine Systems. 44. 107-124.
- Yndestad, Harald, (2006) *The influence of the lunar nodal cycle on Arctic climate*, International Council for the Exploration of the Sea (ICES) Journal of Marine Science, vol 63, pps 401-420.
- Yndestad, Harald; Turrell, William R; Ozhigin, Vladimir (2008) *Lunar nodal tide effects on variability of sea level, temperature, and salinity in the Faroe-Shetland Channel and the Barents Sea*. Deep Sea Research Part I Oceanographic Research Papers 2008; Volum 55.(10) s.1201-1217
- Yndestad, Harald (2009) *The influence of long tides on ecosystem dynamics in the Barents Sea*. Deep-sea research. Part II, Topical studies in oceanography 2009 ; Volume 56.(21-22) s.2108-2116
- Zotov L, et al., (2016) *A possible interrelation between Earth rotation and climatic variability at decadal time-scale*, Geodesy and Geodynamics (2016), Vol 7, No 3 pp 216 to 222
- Zotov, Leonid, Bizouard, Christian, Sidorenkov, Nikolay, Ustinov, Artem, Ershova, Tatiana (2020) *Multidecadal and 6-year variations of LoD* Journal of Physics Conference Series Vol 1705 Fundamental and applied problems of mechanics (FAPM) 9-12 January 2020, Moscow, Russian Federation. Published under licence by IOP Publishing Ltd.

Footnotes

¹ Russell, Bertrand (1945) *History of Western Philosophy* New York: Simon and Schuster, page 828.

² Global warming and cooling in this context refers to average global atmospheric temperature. The relevant literature does not reference possible changes in the temperatures of the oceans.

³ Dr Cazenave is a Foreign Member of the Royal Society, an Emeritus scientist, Centre National de la Recherche Scientifique of France, and was awarded the 2020 Vetlesen Prize. The Vetlesen Prize was designed to be the Nobel Prize of the Earth sciences.

⁴ [Jean O'Brien Dickey \(1945–2018\) - Eos](#)

⁵ Professor Shum is a Fellow of the American Association for the Advancement of Science and a Fellow of the International Association of Geodesy.

⁶ Professor Rozelot is an eminent, now retired, French astronomer from the Université Nice Sophia Antipolis; Professor at the Université de la Côte d'Azur and formerly the deputy director of the Observatoire de la Côte d'Azur in Nice; a member of Gioenia Academy; formerly President of the National Council of Society of Engineers and Scientists of France (IESF) Côte d'Azur, and member of the National IESF Heritage Committee. He is the author of at least one dozen technical books on Solar Physics and approximately 350 papers published in international scientific journals.

⁷ Torgny Vinje is regarded as one of the most important polar scientists in Norway during the modern polar era (Issaksson et al. (2016)).

⁸ Inge Lehmann was a most impressive and innovative scientist. She stands out as a scientist dedicated to understanding correctly observations of the world. In her case, she showed a single-minded devotion to improving the quality and quantity of seismographic data. By hand, she constructed careful tabulations and graphs of seismic body-wave amplitudes and travel times. As a result of her single minded dedication to observational science, brought to bear her sharp observational insight into the seismic patterns she produced from data in which she had confidence. Her independence of mind and strength of character meant that she was not swayed by the authoritative males who dominated Geophysics at that time.

When presenting the American Geophysical Union's highest honour, the Bowie Medal, to Inge Lehmann in 1971, Professor Francis Birch, who was President of the AGU in 1964, stated *the Lehmann discontinuity was discovered through exacting scrutiny of seismic records by a master of a black art for which no amount of computerization is likely to be a complete substitute.* (Birch, Francis (1971))

Inge Lehmann's approach to the world was most likely shaped by her childhood. Her parents sent Inge, as a child, to an enlightened co-educational school run by Hannah Adler, an aunt of Niels Bohr. She learnt there that boys and girls could be treated alike for work and play. Later, she remarked: 'No difference between the intellect of boys and girls was recognized, a fact that brought some disappointments later in life when I had to recognize that this was not the general attitude.'

After completing her studies and gaining a Master of Science in Geodesy from the University of Copenhagen, in 1928 she was appointed chief of the seismological department of the newly established Royal Danish Geodetic Institute, a post she held until her retirement in 1953. Between 1925 and 1936 she undertook the painstaking, meticulous data gathering, tabulation and graphing that enabled her to perceive the existence of the Earth's inner core. In her biographical notes she wrote:

The most important result arrived at was that the presence of a distinct inner core was required for the interpretation of some phases recorded at great epicentral distances.

Sources: Bolt, Bruce (1997) available here: [Inge Lehmann. 13 May 1888-21 February 1993 \(jstor.org\)](#);

Lehmann (1987); Rousseau, Christine (2013).

⁹ Anderson, D L (2007) page 120.

¹⁰ Lambeck, K. & Cazenave, A., (1973) (1974) (1976), (1977).

¹¹ Lambeck and Cazenave (1976) p555

¹² Peter Weart reported: *Through the 1960s and into the 1970s, the average global temperature remained relatively cool. Western Europe, in particular, suffered some of the coldest winters on record.* <https://history.aip.org/climate/20ctrend.htm>

¹³ Lambeck and Cazenave (1976) p570

¹⁴ Ibid., p570

¹⁵ Ibid., p570

¹⁶ Lambeck and Cazenave (1976), p 559.

¹⁷ Ibid., p279.

¹⁸ Note: m_3 describes variations in the rotation rate (directly proportional to changes in the LoD).

¹⁹ Ibid., p279-280

²⁰ Ibid p283

²¹ Professor Vincent Courtillot is a distinguished Geophysicist, Professor Jean-Louis Le Mouél, is also a distinguished Geophysicist, whose contributions to science have been widely recognized. He is a fellow of the American Geophysical Union (AGU) and the Royal Astronomical Society. He was president of the Geological Society of France, and is a Chevalier of the French Legion of Honor. In 1988, he was elected to the French Academy of Sciences. The AGU and the holders of the John Adam Fleming Medal are very pleased to welcome him as the newest Fleming Medalist. Dr Joel Ducruix (deceased) was a research mathematician in the Département des Sciences de la Terre, Université Paris VII and the Institut de Physique du Globe, Université Paris VI

²² Declination is the angle showing how much magnetic north is different from true north.

²³ The 8 year lag between LoD variations and climatic variations rather than a 10 year lag estimated by Lambeck and Cazenave (1976) has been established by research published in 2006, 2011 and 2016. This research is reviewed in this paper.

²⁴ Sidorenkov, N. (2009) page 247.

²⁵ Professor Horst Jochmann, Doctor of Science (Engineering), is now retired and Dr Hans Greiner-Mai has died.

²⁶ Emeritus Professor of Mathematics and Distinguished Research Professor Mathematics Department, University of California Los Angeles (UCLA) and Emeritus Professor of Geophysical Sciences Institute of Geophysics and Planetary Physics, UCLA

²⁷ Dr Jean O Dickey (1945 -2018)

<https://eos.org/articles/jean-obrien-dickey-1945-2018>

²⁸ The three scientists are: Leonid Zotov, Associate Professor at the Sternberg Astronomical Institute, Lomonosov Moscow State University; Christian Bizouard, Director of the International Earth Rotation and Reference System Service (IERS) Earth Orientation Center and Director of the Earth Rotation and Space Geodesy team at Time-space Reference System (SYRTE) Observatoire de Paris; and C.K. Shum, Professor and Distinguished University Scholar, Division of Geodetic Science, School of Earth Sciences, at The Ohio State University.

²⁹ Lambeck, K (1980) op. cit. p283.

³⁰ The word magnetohydrodynamic (MHD) is derived from *magneto-* meaning magnetic field, *hydro-* meaning liquid, and *-dynamic* meaning movement. Professor Hannes Alfvén initiated the field of MHD in a letter to the journal, *Nature*, published in 1942. In 1970, he received the Nobel Prize in physics for this discovery. The fundamental concept behind MHD is that magnetic fields can induce currents in a moving conductive fluid, which in turn creates forces on the fluid and changes the magnetic field itself.

³¹ An Alfvén wave is a wave that occurs in a conducting fluid as a result of the interaction of the magnetic fields and electric currents within it, causing an oscillation of the charged particles. The conducting fluid supports wave-like variation in the magnetic field. Alfvén waves are like the waves that occur on the stretched string of a guitar, the string representing a magnetic field line. When a small magnetic field disturbance takes place, the field is bent slightly, and the disturbance propagates in the direction of the magnetic field. Since any changing magnetic field creates an electric field, an electromagnetic wave, the Alfvén wave, results. A torsional wave is a twisting wave. An Alfvén torsional wave is an electromagnetic wave that propagates radially from the inner core to the core–mantle boundary with its oscillations in the azimuthal (up and down) direction. See Figure 2.

³² Bostrom (2000) p12.

³³ [Aleksey Lyubushin — speaker of the global conference \(creativesociety.com\)](https://creativesociety.com/speakers/aleksey-lyubushin)

³⁴ [Clarifying the Megathrust Earthquake Mechanism: Can Nankai Trough Earthquakes Be Forecasted? | Research at Kobe \(kobe-u.ac.jp\)](https://www.kobe-u.ac.jp/research/megathrust/)

³⁵ The relevant authorities are: the Hadley Centre of the UK Met Office and the Climatic Research Unit (CRU) of the University of East Anglia for the HadCRUT data and the Goddard Institute for Space Studies for the GISTEMP data.

³⁶ Ball T (2014); Carter, R (2010); Carter, R and Spooner J (2013); Curry, J and Webster, P J (2011); Essex, C (1991), (2011); Essex, C and McKittrick, R (2002); Koonin, S (2021); Leroux, M (2005); Michaels, Patrick (1994).

[Once again IPCC’s math doesn’t check out | Fraser Institute](https://www.fraserinstitute.org/once-again-ipccs-math-doesnt-check-out)

[The Hand of Government in the Intergovernmental Panel on Climate Change \(fraserinstitute.org\)](https://www.fraserinstitute.org/the-hand-of-government-in-the-intergovernmental-panel-on-climate-change)

[Independent summary for policymakers of the IPCC Fourth Assessment Report \(fraserinstitute.org\)](https://www.fraserinstitute.org/independent-summary-for-policymakers-of-the-ipcc-fourth-assessment-report)

<https://www.govinfo.gov/content/pkg/CHRG-115hhrg25098/html/CHRG-115hhrg25098.htm>

<https://judithcurry.com/2021/10/06/ipcc-ar6-breaking-the-hegemony-of-global-climate-models>

[Many climate change scientists do not agree that global warming is happening - PMC \(nih.gov\)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7844441/)

[Climate Intelligence \(CLINTEL\) climate change and climate policy](#)

³⁷ Note that Fagan (1999), (2000) and (2004) has shown how the climate changes rendered by these global atmospheric systems have resulted in major historic changes to cultures and societies throughout the world since the dawn of history.

³⁸ See <http://www.utdallas.edu/physics/faculty/tinsley.html>.

³⁹ Mazzarella and Palumbo (1994) pointed out that bistable modes of oscillation with respect to time are well known in physical and engineering systems and have been extensively studied. They can arise when a system is subjected to external systematic sinusoidal forcing which induces sinusoidal variations in coefficients of the equations of motion. For example, Magnus (1965) showed that „if the input function is sinusoidal, the output function — after the decay of certain transient vibrations — will also be a periodic function with the same frequency ω . In many cases it is, itself, sinusoidal, or at least so closely akin to sinusoidal that we can consider the sine curve to be a very serviceable approximation to it“. See also pages 32 and 33 of *Newtonian Dynamics* by Richard Fitzpatrick, Professor of Physics at the University of Texas at Austin, available here: <http://farside.ph.utexas.edu/teaching/336k/Newton.pdf>. Note, however, if the system is unstable, the impact may be to induce some type of oscillatory behaviour or it may be to induce further instability; if the system is chaotic, the impact may result in a chaotic, oscillatory or stable system.

⁴⁰ ‘Bistable sinusoidal periodicities’ means that system can be in two stable, regular sinusoidal states.

⁴¹ “diapycnal mixing” is the mixing of masses of water of different densities, which would remain in stratified layers except for the mixing.

⁴² Lorenz (1963) showed that the climate system is a complex system characterised by sensitive dependence to initial conditions and perturbations. Such systems show extreme sensitivity to any slight change in the system’s dynamics arising internally or from external impact, or perturbation, however slight. Very small uncertainties in initial conditions or very small disturbances to the processes as they develop will result in a wide spread of uncertainty about the state of the process at future points in time. In a review of the general circulation of the atmosphere, Lorenz (1967) emphasised the need to develop GCMs incorporating this sensitive dependence instead of relying on ad hoc changes to parameters to demonstrate the atmosphere must behave as it does. The computer simulations are only reliable to the extent that they represent correctly the physical processes they purport model, and to the extent that the simulations use correct boundary and initial conditions. The model’s spatial resolution is a further major limitation, especially given the sensitivity of climate systems to initial conditions and perturbations. However, the computer simulations used by the IPCC rely excessively on the use of arbitrarily adjusted parameters. Furthermore, the computer simulations do not use the mathematics of complex systems, such as Hurst-Kolmogorov dynamics (Koutsoyiannis, 2011).

⁴³ [2a \(oecd.org\)](https://www.oecd.org/) (Organisation for Economic Co-operation and Development Global Science Forum - Best Practices for Ensuring Scientific Integrity and Preventing Misconduct).

⁴⁴ Global warming and cooling in this context refers to average global atmospheric temperature. The relevant literature concerning the Earth’s rotation generally does not reference possible changes in the temperatures of the oceans.