ENERGY FLOWS

Many reports and climate models use a simple diagram to illustrate the major energy flows associated with determining the earth's temperature. Recall that at the top of the atmosphere, there is an average equivalent perpendicular incoming solar radiation density of 341.3 Watts per square metre (W/m^2). An Energy Flow diagram attempts to map how this insolation flows through the earth's atmosphere, and how much of it is eventually radiated into space either as infrared or visible energy. By its very nature, these diagrams have to use average values for all coefficients, and an example is shown in Figure 36.

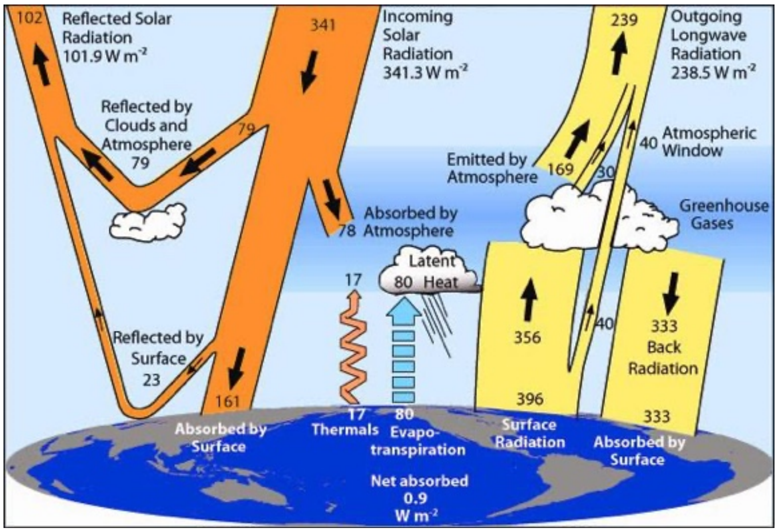

FIGURE 36 – Energy Flow Diagram

Looking at Figure 36, there is a net energy density flow of 0.9 W/m^2 that is absorbed by the earth, which will cause long-term heating, but don't forget that the numbers in this diagram are all estimates, and have significant error bands, so the result should not be taken as certain. In particular, the absorption by the earth is stated as an average value, which has to include all the surfaces (water, land, ice, trees, sand, etc), so this is a questionable value. Also note the large effect that clouds have: again, this is an average value over the whole earth.

For the moment, as a thought experiment, imagine that the earth's reflectivity (it's "Albedo") is constant across its entire surface. Although we know the average incoming solar radiation density (it's "Insolation") is 341.2 W/m^2, it should be obvious that the value will be higher near the equator than it is near the poles. This is illustrated in Figure 37.

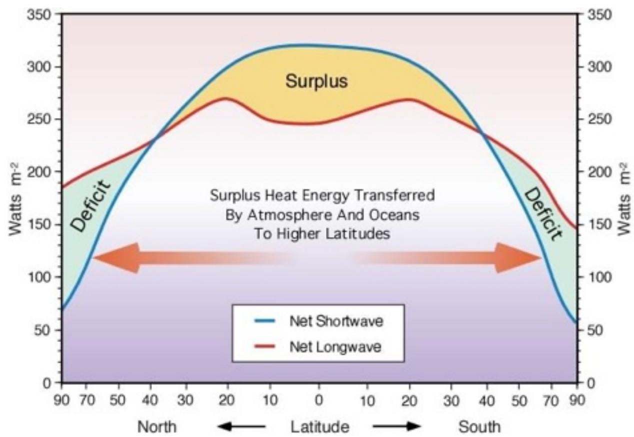

FIGURE 37 – Energy Distribution as a Function of Latitude

Looking at Figure 37, the horizontal axis represents the latitude from the North Pole to the South Pole. The blue line represents the incoming solar energy density, and it is highest at the equator. The red line represents the outgoing energy moving upward from the surface of the earth. The areas under both curves must be roughly equal, so we can say that there is an energy "deficit" near the poles, and a "surplus" near the equator. In order to maintain equilibrium, energy must flow to higher latitudes. This is achieved by the previously-discussed ocean currents, or by winds.

AIR CURRENTS

Most of earth's weather occurs in the Troposphere, which is the bottom layer of the atmosphere. The top of this layer occurs at the "Tropopause", which is a thermodynamic gradient-stratification layer that is approximately 17-18 Km high at the equator and 8Km or lower at the poles. Immediately above the tropopause is the TIL (Tropopause Inversion Layer). Clouds are normally formed underneath the tropopause. Figure 38 is a cross section of the atmosphere, using the same horizontal axis configuration as Figure 37.

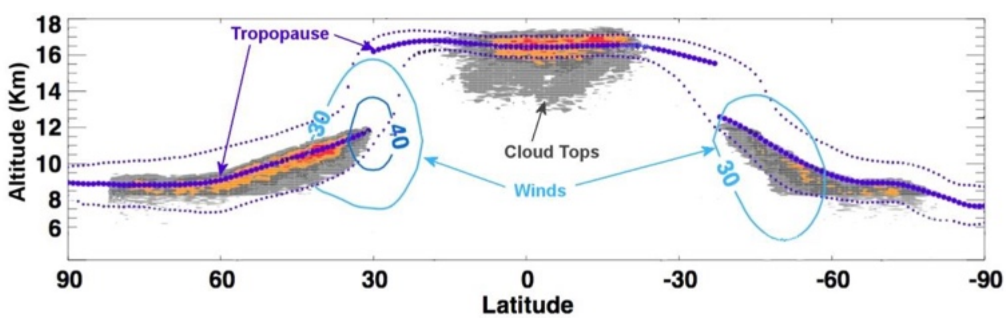

FIGURE 38 – Tropopause As a Function of Latitude

Looking at Figure 38, the small purple dots show 10th and 90th percentile range of the tropopause height. The cloud top fraction density is shown as a colour-coded distribution (grey to red). The light blue lines outline areas of strong winds at the "break" in the tropopause at about 30 degrees North and South latitude, and the numbers represent velocities in metres per second. The tropopause at approximately 60 degrees latitude gets broken again when a front forms as cold polar air forces underneath warmer tropical air .These tropopause breaks are areas where two jet streams form in each hemisphere: the Polar Jet Stream, and the Subtropical Jet stream. A cross section of just the Northern Hemisphere is shown in Figure 39.

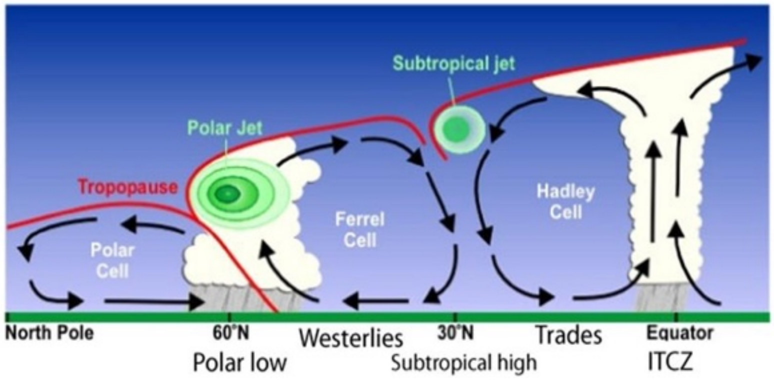

FIGURE 39 – Jet Streams and the Tropopause in the Northern Hemisphere

Figure 39 shows the breaks in the tropopause, and the location of the two jet streams in each hemisphere. There are three rotary vertical air circulations, known as the Polar, Ferrel, and Hadley cells which are important energy transport mechanisms for the earth. The Intertropical Convergence Zone (ITCZ) is the starting point for these mechanisms, and its position moves with the seasons, as shown in Figure 40. Moist, warm air gets drawn in on both sides of the ITCZ, where it then rises into the edge of the Hadley Cells. The rising moist air creates many thunderstorms in this area. Recent findings have supported an unproven theory that there are actually two parallel ITC regions.

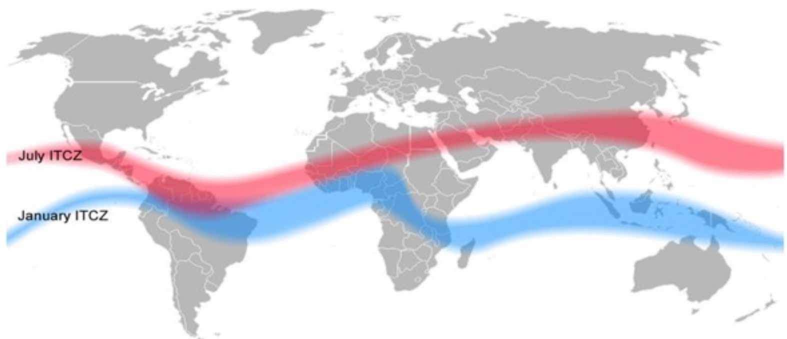

FIGURE 40 – Average ITCZ Locations For July (Red) and January (Blue)

Tropical storms commonly start their lives in the ITCZ. Figure 41 is a composite of the tracks of hurricanes and typhoons over the past 150 years, and it will be noted that the ITCZ is the birth place of most of them.

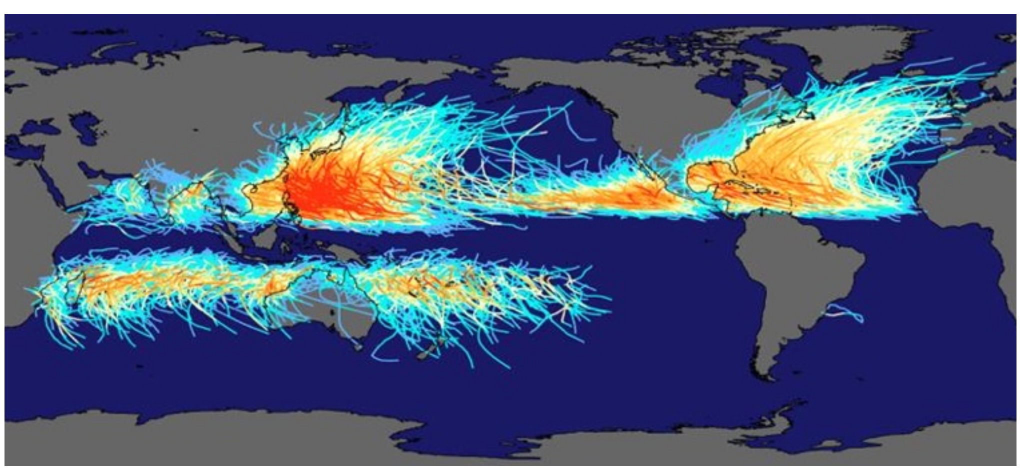

FIGURE 41 – 150 Years of Typhoons and Hurricanes

The jet streams (two in each hemisphere) also move throughout the year. Figure 42 shows the average positions of these jets.

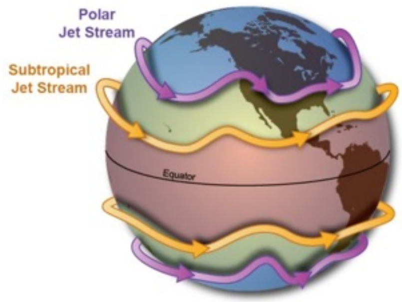

FIGURE 42 – Average Location of the Jet Streams

As discussed in the previous section, there is a general energy surplus in the equatorial regions, and a deficit nearer to the poles. This imbalance drives the flow of energy from the equator toward the poles by both the ocean currents, and the air currents that we have just reviewed.

ATMOSPHERIC LAYERS

As discussed earlier, all of earth's weather occurs in the troposphere, which is a well-mixed layer closest to the earth The troposphere is bounded to the top by the tropopause. The many atmospheric layers above the tropopause are primarily stratified, and are identified as shown in Figure 43.

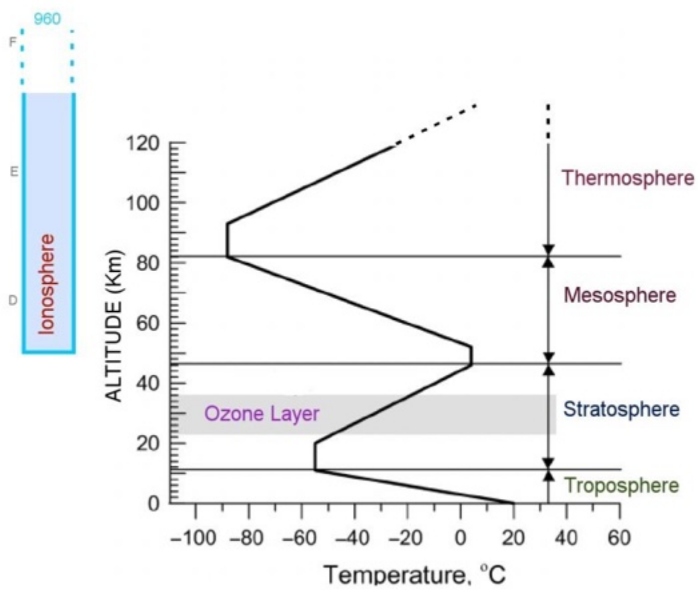

FIGURE 43 – Layers Of The Atmosphere

Looking at Figure 43, the temperature decreases linearly with altitude in the troposphere, with an average lapse rate of about -9.8 °C/Km. Just above the tropopause is an inversion layer, and then the temperature increases with altitude to the top of the stratosphere, where there is another inversion as the mesosphere is entered. Temperature again decreases with altitude through the mesosphere until another inversion layer is encountered at the start of the thermosphere, which extends up to about 690 Km. Beyond the Thermosphere is a region known as the exosphere.

As a side note, the term "Space" is defined as any altitude above 100 Km. The various companies offering brave (and rich) adventurers a ride into Space, all carry their passengers to an altitude of at least 100 Km before returning them to earth.

The ionosphere (shown on the left of Figure 43) is a region that contains ionized atoms and molecules. Energy from extreme ultraviolet solar radiation (wavelength of less than 121 nm) causes electrons to be "stripped off" the air's atoms and molecules, and the resulting electrically charged particles have properties that strongly affect long distance radio communication. There are several defined layers of ionization: D-layer (48 to 90 km), E-layer (90 to 150 Km), and F-layer (150 to 500 Km or more). These layers change significantly as the earth rotates through a solar day, and are also strongly affected by the 11 year solar sunspot cycle.

There is an ozone layer immediately above the tropopause inversion layer (TIL). In this region, solar extreme ultraviolet radiation dissociates atmospheric oxygen (O_2) into ozone (O_3). As noted earlier, ozone is a powerful greenhouse gas. The concentration of atmospheric ozone decreased by about 3 percent between 1979 and 2014, as the result of increased use of chlorofluorocarbons (CFCs). An agreement known as the "Montreal Protocol" in 1987 placed limits on the production and use of CFCs, and the atmospheric ozone concentration is slowly building back up. Ozone has no effect on UV-A (315 to 400 nm), but it mostly absorbs UV-B (280 to 315 nm), and completely absorbs UV-C (100-280 nm).

The tropopause inversion layer (TIL) is a direct result of the ozone layer absorbing UV solar energy. The TIL creates a "cap" to the normal adiabatic heat loss in the lower atmosphere. Ozone changes have had little effect on global warming, but they have affected global circulation, and it is believed that the polar vortex conditions have strengthened as a result.

As described earlier, although the total energy output of the sun has only minor variations over the 11 year sunspot cycle, the spectral distribution does change, and the ultraviolet component has significant variations. While the UV-A, B, and C components might vary by up to +/- 15%, the extreme UV wavelengths of less than 65 nm can vary by up to a factor of 7 through a complete sunspot cycle.

CLOUDS

Clouds are visible accumulations of small water droplets or ice crystals that are suspended in the atmosphere. They are categorized by their appearance and altitude, as shown in Figure 44.

FIGURE 44 – Cloud Types

Cumulonimbus clouds are easily spotted, because they have a great deal of vertical development, and can extend upwards right to the tropopause. They are associated with strong vertical air currents, turbulence, and precipitation.

Clouds are important, because climate is affected by “shading” due to the albedo changes of their top surface, and absorption of infrared energy being transmitted upward from the earth’s surface. Both of these parameters are difficult to predict. As an example, the range of albedo estimates for cirrus clouds is 0.1 to 0.3, for altostratus it is 0.2 to 0.5, for cumulonimbus it is 0.7 to 0.9, and for stratus it is 0.3 to 0.6. Unfortunately, no reliable proxies exist to study cloud cover’s influence on historical climate.

Clouds form when water vapour condenses because the air is saturated, and cannot hold any more moisture in gaseous form. The water vapour condenses on “condensation nuclei”[22], which can be dust particles, soot, aerosols, bacteria, or even phytoplankton. These nuclei are very small particles, usually 0.2 microns in diameter or less. The actual condensed water or ice droplet is about 100 times larger in diameter. Studies at CERN have shown that the rate of condensation about certain nuclei is strongly affected by cosmic rays coming from outer space. The incoming cosmic flux density is affected by changes to the protective heliosphere caused by sun’s changing magnetic field. It has been found that there is an inverse relationship between the cosmic ray flux and solar activity. Studies have shown that there might be an increase of 3 to 4 percent in cloud cover between solar maximum and solar minimum. This field is subject to ongoing research, and the actual mechanisms involved are not well understood.

High altitude bacteria have also been found to act as condensation nuclei. A number of factors can affect the population density of these bacteria, and hence the formation of clouds, and their subsequent effect on global temperature.

There are many theories about possible causes of global temperature change. One of the more interesting theories focuses on the fact that the earth's magnetic poles are moving, and the magnetic field strength is weakening prior to an expected "flip" in the earth's magnetism within the next century. These changes have happened many times before, at a rate of about once every 100,000 to 1,000,000 years. The last "flip" of the poles occurred about 780,000 years ago.[23] The decreasing magnetic field strength of the earth reduces the effectiveness of the earth's magnetosphere, thereby offering lesser protection to the incoming solar wind, and this will definitely affect the earth's atmosphere. Cosmic particles that reach the atmosphere have a part to play in the "seeding" of clouds, and cloud cover has a strong effect on the amount of the sun's solar radiation that actually reaches the earth's surface.[24]

VOLCANOES & FOREST FIRES

Volcanoes have the ability to affect the earth’s climate. Not only do they emit large amounts of greenhouse gases, but the fine particulate matter that is emitted into the atmosphere can cause “shading”, and SO_2 discharges can combine with water vapour to form sulphuric acid (H_2SO_4) that condenses into sulphate aerosols that can reflect incoming solar radiation. The emissions from volcanoes can reach all the way up into the stratosphere. Even underwater volcanoes can affect climate to some degree. It is estimated that about 75% of active volcanoes occur under water.

Wildfires and forest fires are often in the news. These fires not only create particulate matter, but they also release CO_2 which was previously stored (in a solid form) in the biomass. Vegetation is just one state in the Carbon Cycle that was discussed earlier, but its combustion often creates newsworthy events, and the media looks to “Climate Change” as being the culprit.

FEEDBACKS

The earth's climate system contains many feedback mechanisms – some are positive, increasing the temperature effect of small perturbations, and some are negative.

As a simple example of a positive feedback, consider what would happen if the global temperature increase by one or two degrees. Over a long period of time, this temperature increase would cause some of the ice caps to melt on Greenland and Antarctica, and the exposed ground which was previously covered with highly reflective ice (high albedo) would lower the average albedo of the surface, thereby absorbing more solar energy and causing more heating. Conversely, if the earth were to cool, the increased ice cover would increase the average surface albedo, and less solar energy would be absorbed, thereby causing additional cooling.

As an example of a negative feedback path, consider what might happen if the global temperature were to increase. This would result in the atmosphere containing more water vapour, which would ultimately result in an increase in cloud cover. The "shading" effect of the increased cloud cover would then reduce the solar energy arriving at the earth's surface, and there would be a net cooling effect.

As an example of a negative feedback mechanism, consider that an increase in atmospheric CO_2 will result in enhanced growth in trees and similar vegetation. This will then lead to an increased rate of removal of CO_2 from the atmosphere due to photosynthesis, thereby reducing the effect of the initial perturbation.

If positive feedback paths dominate and become excessive, it is possible that an initial perturbation will get magnified into a much larger change that continues to grow unabated. This form of excessive positive feedback is similar to that produced by a PA sound system when the system's gain is set too high, and the system breaks into a loud "howling" oscillation. In looking at the very long term temperature record, it is probable that this condition was encountered many times before over the millennia, and resulted in both high and low temperature extremes.

There are many different climate feedback loops in operation. Negative feedback tends to stabilize the climate, and reduce temperature excursions. Positive feedback can magnify the oscillations of global temperature caused by other effects. This is somewhat analogous to electronic amplifier design – negative feedback is commonly used to decrease distortion, while positive feedback can cause a non-linear response, and ultimately (if there is too much) result in oscillations.

There is controversy over the magnitude and effectiveness of the multiple feedback paths (positive and negative) which affect the earth's climate, and whether any of them might ultimately lead to a "tipping point", whereby the temperature starts to climb or descend in an uncontrollable fashion. The oceans have a major effect on all of this, and are the subject of a great deal of ongoing research.

CLIMATE MODELS

A number of attempts have been made to develop a scientific "model" of the various processes that can affect the earth's climate, so that predictions can be made for the future climate on the basis of known information. The IPCC has encouraged the development of many different models over the years, but they keep changing them as new information or theories are unearthed. Back in the 1970's, climate models were actually predicting a global cooling period, and concerns were expressed about the "coming ice age"!

In order to truly believe a computer climate model, it must be possible to put historical data into it, and then examine predictions to see if they match what actually occurred. It must also be possible to "run the model backwards" (in other words, we need "backsight" as well as "foresight"), and see if it can predict the historical ice ages and warm periods. So far, there is no model that can do this!

A climate change model needs to include the effects of the various complex interactions between the atmosphere, biosphere, and hydrosphere. Looking very simplistically at just the flow of energy from the sun to the earth, the model needs to account for the various absorption and reflection mechanisms (all at different wavelengths) that are applicable, and then come up with a net "energy budget" that can be used to predict the earth's surface temperature. Although numerical estimates exist for most of these mechanisms, there are non-trivial uncertainties in all of these numbers. When the entire budget is summed up, the resultant total cumulative uncertainties mask much of the residual effect that the model is trying to quantify! Further complicating all this is the presence of many different "feedback mechanisms" (some positive, some negative) that can exacerbate or diminish the effect of certain parameter changes.

Many climate models have been developed, as researchers strive to include all the possible factors affecting climate. Figure 45 charts the global temperature predictions for the tropical mid-troposphere made by 102 different climate models, and also plots actual observed temperature observations.

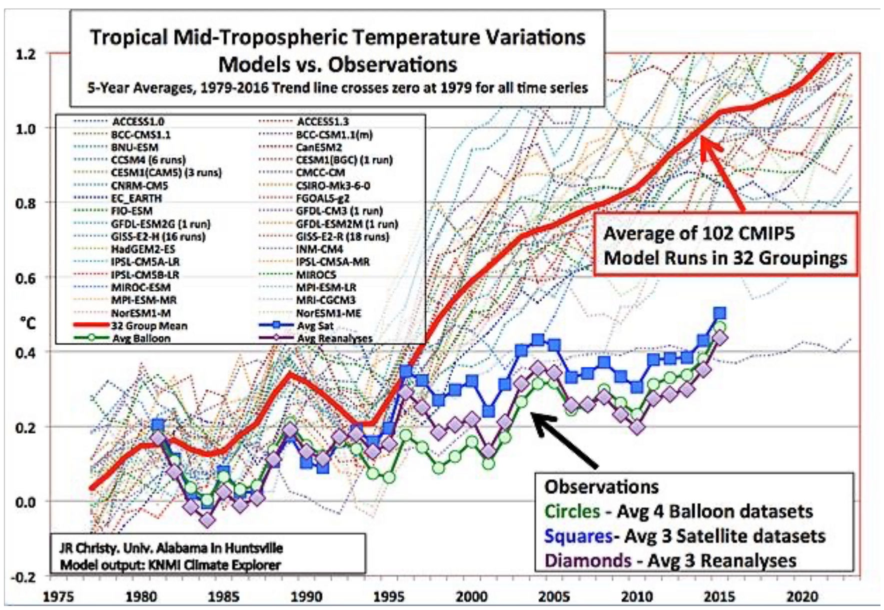

FIGURE 45 – Climate Model Performance

As illustrated by the above chart, the climate models that have been developed all tend to predict an increasing global temperature that is in excess of the observed actual temperature increases. Some of the fundamental problems with existing climate models is that they do a poor job of modelling cloud cover and the effect of the oceans (currents, energy storage, vertical circulation, etc).

The IPCC has emphatically stated: "*In climate research and modelling, we should recognize that we are dealing with a coupled, non-linear, chaotic system, and therefore that the long-term prediction of future climate states is not possible*" [25] (my emphasis). Data from climate models should be treated with a large degree of scepticism!

THE IPCC

The IPCC (Intergovernmental Panel on Climate Change) is a politicized technical organization that reviews and summarizes scientific papers related to climate change.[26] It does not do original research, nor does it conduct climate monitoring.

The IPCC was established in 1988 by the World Meteorological Association (WMO), and the United nations Environment Program (UNEP). It is specifically tasked with assessing published scientific information relevant to human-induced climate change.[27] In other words, the organization already believed that it was human activity that was causing climate change before they even started work!

Member are appointed to the IPCC by individual countries, presumably on the basis for their support of their country's adopted position on the topic. The IPCC generates "Assessment Reports" that are compilations of the technical material that has been reviewed. Six of these assessment reports have been produced so far. Before publication, wording of these assessment reports is reviewed on a line-by-line basis to ensure that the material is consistent with the position of each of the 195 countries that supplied members to the IPCC. Material that does not support the official consensus is often ignored or "de-bunked".

The IPCC relies heavily on computer models to predict future climate changes, and (as illustrated earlier) these always tend to overestimate future temperature rises. Although it has some scientific basis, the IPCC is heavily influenced by politics, and any conclusions or recommendations from the organization tend to have "hidden agendas"!

The IPCC and their political supporters do a good job of ignoring the paleoclimactic record, and focus only on very recent history, in the belief that the current (or recent) climate is ideal, and must somehow be maintained, despite historical records showing the futility of this dream. True to their initial charter, the IPCC continues to preach that climate changes are primarily a result of man's activities, and the associated generation of anthropogenic greenhouse gases. A series of global meetings known as COPs (Committee Of the Parties) have been held where political leaders can tout their countries' programs to reduce the emission of greenhouse gases, thereby supposedly reducing the rate of any future climate change. The politicians are cheered on by various "Green" organizations whose unwritten objective appears to be de-industrialization of the Western world and the destruction of Capitalism. The COP consensus is that any future global temperature rise must be limited to 1.5°C, and that this apparently requires that worldwide CO_2 emissions from anthropogenic activities be reduced to "Net Zero" by 2050.

NET ZERO

As mentioned above, many governments have decided to pursue the goal of becoming "Net Zero" by 2050 (or possibly later). This means that they want all CO_2 emitted by man's activities either to be eliminated or somehow compensated for by 2050 in the belief that this will slow the current rise in global temperatures, and limit the rise to 1.5°C above pre-industrial levels.

As discussed in previous sections, CO_2 concentration is not the primary driver of global temperature, and indeed, rising CO_2 levels might actually be a **result** of warming due to entirely natural factors. Despite the dubious scientific justification, politicians and special-interest groups have embraced the "Net Zero" battle cry, and are falling over themselves with announcements, proclamations, and protests as they attempt to destroy the world's economy.

The concept of Net Zero is that any continuing emissions of CO_2 need to be "offset" by actions to remove the same amount of CO_2 from the atmosphere. These "offsets" could be the planting of trees that absorb CO_2, or they could involve operating actual equipment that removes CO_2 from the atmosphere, and then sequesters it in a safe storage facility (this is called CCS, which stands for Carbon Capture and Sequestration). A marketplace has now developed whereby "carbon credits" are bought and sold, and some rather flimsy schemes have been created.

As an example of how ludicrous this churning process is, consider the example of the DRAX power plant that is located in the U.K. This power plant was built in 1974, and burned coal to generate electricity (in a conventional steam turbine system). Starting in 2013, this power plant was converted to burn compressed wood pellets. The pellets are manufactured in Canada, and shipped to the UK from the port of Prince Rupert, BC. The pellets were originally supposed to use scrap wood left over from existing logging operations, but demand eventually required that trees be specifically grown to feed the process. It was claimed that the entire process (*growing trees, converting the wood to pellets, transporting them between continents, and then burning them in a thermal power plant*) was "sustainable", because new trees were planted to replace those that were cut down!

DIRECT CARBON CAPTURE (DCC)

There are several companies developing technology and equipment for actually extracting ("capturing") CO_2 from the air. The CO_2 is then stored ("sequestered") either as a gas, or converted to some other form. The justification for doing this is that governments and agencies mistakenly believe that CO_2 emissions from human activities is causing the world to warm, and that not only must these emissions stop, but some of the CO_2 must be removed in order to lower the concentration in the atmosphere, thereby supposedly preventing future temperature rises. The processes used for DCC are complex, and require large amounts of energy to operate. It is claimed that the energy will come from "sustainable" sources (hydro, solar, wind, nuclear), so the whole process will help a country reach the goal of "net zero". Funding for these projects effectively comes from selling "carbon credits", because governments have inadvisably placed a dollar value on CO_2.

If these proposed projects go ahead, the scale and costs involved will be enormous. And remember, lowering the CO_2 concentration in the atmosphere by 1 ppm will only potentially reduce the temperature by between 9 and 15 thousandths of a degree C!

ENERGY & TRANSPORTATION

As part of the charge toward the Holy Grail of "Net Zero", the entire transportation infrastructure is being forced to dispense with the burning of fossil fuels. Governments apply so-called "Carbon Taxes" on the sale of hydrocarbon fuels, and the tax rates are methodically being increased as time goes by, in an effort to get users to switch to another type of energy.

Oil has been a major energy source for over two centuries. It has a high energy density (ie: a small and light weight amount of the substance has the potential to create a large amount of energy). A few decades ago, there was worldwide concern that we were running out of these fuels and only had a limited supply, but new exploration/extraction techniques, combined with more efficient energy use have allayed those concerns.

Fossil fuels are converted to energy by the process of combustion. Almost 40% of the material's potential energy is extracted in modern gasoline or diesel engines, and almost 55% in modern combined-cycle gas-fired power plants. The remaining energy is turned into waste heat. In building heating applications, the fossil fuel is burned to directly create heat: this process can have efficiencies of over 95%. All of these combustion processes generate CO_2, and this is the main focus of politicians, scientists, and environmentalists, despite evidence (as outlined earlier) that climate change is not being primarily driven by increases in CO_2 concentration.

Electricity is a good way of moving energy between terrestrial locations. Thermal power plants convert fossil fuels (usually natural gas or coal) to mechanical energy that drives efficient generators, and the resulting electricity can travel long distances over power lines to operate motors, heaters, lights, and industrial processes in remote locations.

Hydro-electric power plants are an environment-friendly way to generate electricity. After a major capital outlay, the plant produces electricity quietly and efficiently over a long period of time, without emitting greenhouse gases. Unfortunately, suitable sites for new hydro-electric plants are becoming scarce.

Nuclear power plants are pollution-free ways of reliably producing electricity at low cost (other than the very large initial capital outlay), but there are disposal issues with the spent fuel, and certain segments of the public are vehemently "anti-nuclear" based on political views or supposed safety concerns. Despite these concerns, nuclear power plants are widely used in some parts of the world (Over 70% of France's electricity is produced by nuclear power plants). The emerging technology of Small Modular Reactors (SMRs) has the potential to increase the penetration and acceptance of nuclear power, as mass-production techniques reduce the cost and size of efficient power plants designed to be distributed closer to the users.

Photo-voltaic cells ("solar cells") can produce electricity directly from the solar energy incident on the earth. The efficiency of the conversion process can be as high as almost 25%, but it degrades somewhat as the cells age. The biggest problem is that this is an intermittent source: it only produces electricity during the day time, and is affected by local weather conditions (clouds, fog, rain, etc).

Wind turbines produce electricity at any time of day **if** the wind is blowing, but their large, highly-visible profile means that they are usually located in remote areas or offshore. Other so-called "sustainable energy sources" include waves, tidal power, and geothermal.

Wind turbines and solar cells have received most of the publicity in recent years as large arrays of these devices have been installed around the world. The biggest problem is the intermittent nature of their output. To compensate for this, excess generating capacity has to be installed, and very large energy storage devices (batteries, pumped water, etc) have to be included to ensure a reliable source of supply.

If electricity is produced by techniques (such as hydro, solar, wind, or nuclear) that do not emit any greenhouse gases, there is strong political motivation to convert existing consumers of fossil fuels to use electricity as their energy source. Transportation has been a major user of fossil fuels, and the sector is highly visible to the public, so there is considerable pressure to electrify it.

Fossil fuels are an ideal way to power mobile devices (especially road vehicles, aircraft, and ships): the energy density (KW-h per Kg) is very high, and it is easy to quickly refuel as required. There has been much development in electrical technology for road vehicles, but the major problem has been the availability of electrical energy storage devices (primarily batteries) that are small and light enough to fit into the vehicle, and that have sufficient capacity to provide decent range between charges. The energy density (KW-h per Kg) of modern Li-ion batteries is about 2% that of gasoline or diesel fuel. Some electric cars have met with market success, but battery technology needs to develop a major increase in battery energy density before they are considered viable for mainstream applications, and then the problem will be one of installing enough charging infrastructure to allow for unimpeded travel without the drivers suffering from "range anxiety".

Ships, highway trucks and airliners pose their own problems, and are unlikely to be weaned off of fossil fuels for some time to come. These applications need energy storage devices that have much higher density (both by volume and by weight) than batteries – the use of hydrogen (produced by electrolysis of water) and fuel cells is being vigorously pursued. Hydrogen can also be burned directly in modified jet engines or even reciprocating engines, but hydrogen has storage issues that need to be addressed. Hydrogen's energy density (KW-h per Kg) is quite high, but it occupies a large volume, so must be stored at very high pressures if storage tanks are to be kept to a reasonable size. Hydrogen can also be stored in a liquid form, but the extremely low cryogenic temperatures required (-253°C) present significant challenges.

If it were possible to convert all power generation, heating, and transportation applications to non-fossil fuel technology,[28] it would be possible to reduce the total amount of man-made CO_2 emissions by over 50%, but this would have a negligible effect on global temperature. It would of course still be required to extract oil and natural gas from the ground for the manufacture of synthetic materials, plastics, asphalt, lubricants, and pharmaceuticals.

CONSENSUS

In the popular press that reports on climate change, it is common to hear terms such as "The science is settled", or "97% of scientists agree". However, consensus is not a legitimate way to conduct science! If we allowed mere consensus to dictate scientific beliefs, we would still think that the earth was flat and the sun revolved around it, because Pythagorus, Socrates, Aristotle, and Galileo were not part of the "the scientific consensus" at the time.

The "97% of scientists" are often talked about in the media, but there is some doubt about the validity of this number,[29] [30] [31], or their conviction[32] and they fail to mention the numerous other respected scientists who do not believe that CO_2 emissions from man's activities have a meaningful effect on the earth's climate. Organizations such as Clintel [33] are composed of experts from academia (including Nobel laureates) and industry who dispute much of the work that has been done by the IPCC.

The IPCC scientists have had a number of scandals where it has been alleged that data was falsified in order to support the pre-ordained conclusions that were mandated to be produced. Examples include Mann's famous "Hockey Stick",[34] and the scandal at East Anglia University when leaked e-mails revealed that data was being systematically manipulated.[35] [36] It is claimed that the "East Anglia Data Manipulation" has now been satisfactorily explained, but there is still controversy surrounding the incident. There is considerable controversy and emotion surrounding the topic of "climate change", and both sides of the argument have resorted to less than professional tactics.[37]

Take everything with a grain of salt, and "follow the money". Ever since Al Gore (a former US politician) rejuvenated his career by producing a glossy, sensational, but wildly inaccurate and misleading documentary entitled "An Inconvenient Truth", politicians have been scrambling to climb on the bandwagon and hitch their stars to the climate/environmental movement. Meanwhile, universities, researchers, consultants and NGO's have been given easy access to funds for projects which will support the IPCC's "consensus viewpoint" that Global Warming is caused by man's activities, and that it is bad for humanity. Left-leaning organizations are seizing on "climate change hysteria" as further evidence of capitalism's evil nature.

Unfortunately, Canada's school system has embraced the IPCC's position wholeheartedly, and is indoctrinating our children with their potentially incorrect conclusions, and teaching that "consensus" is now apparently a legitimate way to conduct scientific research. Al Gore's fear-mongering (but inaccurate) documentary is also being widely shown in the schools. throughout the world.

Meanwhile, anyone who offers dissenting points of view is mercilessly hounded and deprived of funding. Climate warming is turning into a religion! [38] Heretics are labelled as "deniers", or "sceptics", and are blacklisted.

Internet resources such as search engines, video repositories, and social media have all been programmed to emphasize the “consensus opinion”, and downplay, black list, or counter-label viewpoints or questions from individuals who question the so-called “science”.

And of course, don't believe anything you read in the popular press as they seek to retain or expand readership by printing more and more sensational headlines such as: "Highest Temperature Ever Recorded", "Global Warming Increasing Hurricane Threat", "The Glaciers Are Melting", "Unprecedented Warming", "Climate Change Is Destroying Fish Stocks", "Global Warming Is Worse Than Predicted", "Polar Bears At Risk", and “The World is Boiling”.

CORRECTIVE ACTION

As discussed above, the predominant factors affecting future climate on the earth are natural; humans can do little about this unless large-scale (and very controversial) geoengineering efforts [39] are made to force climate change artificially (such as by putting reflective particles into orbit around the earth, thereby reducing the incoming solar flux).

However, throughout history, man has shown a remarkable ability to adapt to external events. As an example, the Netherlands has even adapted to having 25% of its surface area being beneath sea level by constructing dykes and flood control dams. London has adapted by building the Thames Barrier to protect the city from abnormally high sea levels under certain conditions.

Note that there is a difference in temperature trends between the Northern and Southern hemispheres. As an example, Figure 44 presents a graphical record of polar sea ice extent [40] over a 30 year period; it can be seen that the Arctic ice is shrinking at the same time that Antarctic ice is slightly expanding:

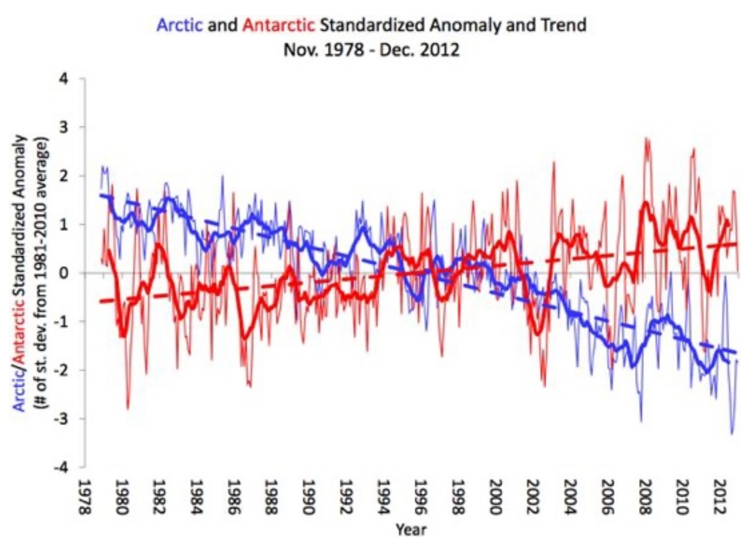

FIGURE 44 – Polar Sea Ice Extent

If the earth warms up, there will be a general shift of the population to cooler regions of the planet. There have been many climate-induced population migrations in the past.

Humans tend to abhor change. A lot of people like things "just the way they are now", and believe that the climate we have been enjoying for the past few decades is "perfect" for them. But it is the height of arrogance and selfishness to believe that present conditions are ideal for <u>us</u>, and that we have the ability to control the climate so that it stays this way! The best recommendation that can be given is that man must learn to <u>adapt</u> to the continually changing climate.

SUMMARY & CONCLUSIONS

The material reviewed so far in this paper confirms that there are a large number of factors that affect the earth's climate. Many of these are poorly understood by man, and there are some factors that probably haven't even been discovered yet.

A number of conclusions can be taken away from the information presented so far in this document:

a) *Climate change is a naturally-occurring, cyclic phenomena, and it has been going on for millions of years.*
b) *Climate change is primarily driven by changes in the energy of the sun that impinges on the earth. The dominant factors driving this are variations in the sun (total output power, spectral distribution, sunspot cycles) Milankovitch Cycles, variations in ocean currents (ENSO, PDO, and AMO). Other factors include the effect of varying cosmic particle influx and high altitude bacteria, causing changes in cloud cover.*
c) *The primary greenhouse gas is water vapour. The effect of atmospheric CO_2 on global temperature change is much less. Because of the non-linear effect of CO_2 concentration, increases beyond the current level will have a decreasing effect on the earth's climate. (it is sometimes stated that CO_2's Greenhouse Effect is becoming "saturated")*
d) *Man-made CO_2 does have a <u>minor</u> effect on global temperature changes, but it is not the dominant factor. A reduction of man-made CO_2 emissions would have a negligible effect on global temperature.*
e) *Man's understanding of the various climate-influencing factors is very limited.*
f) *Climate models are not effective at forecasting future long-term global temperatures.*
g) *There is very little that mankind can do to affect global temperature change. It does not make sense to introduce regulations that will have a negative impact on Western economies in a pointless attempt to change the natural rate of global climate change.*
h) *Mankind will have to learn to **<u>adapt</u>** to future climate changes. If mankind is still around in a few thousand years, they will then have to adapt to global cooling and glaciations!*

Any legislative efforts to limit man-made carbon dioxide emissions at the local, regional, provincial, or federal levels may be well-intended, but are ultimately futile, and potentially dangerous. These efforts will harm the economy, waste resources, and not significantly affect the naturally-occurring cyclic climatic changes.

APPENDIX A

Unit Prefixes and Abbreviations

Prefix	Multiplier	Abbreviation
Exa	10^{18}	E
Peta	10^{15}	P
Tera	10^{12}	T
Giga	10^{9}	G
Mega	10^{6}	M
Kilo	10^{3}	K
Centi	10^{-2}	c
Milli	10^{-3}	m
Micro	10^{-6}	µ
Nano	10^{-9}	n
Pico	10^{-12}	p
Femto	10^{-15}	f

APPENDIX B

USEFUL DATA

Here are some numbers that might prove useful in analyzing proposals related to measuring or attempting to control the earth's climate:

Total mass of atmosphere:	5.1×10^{18} Kg, or 5.1×10^{15} tonnes
Mass of CO_2 in atmosphere:	3.2×10^{12} tonnes (*at 415 ppmv, the concentration in mid-2023*)
Mass of 1 ppmv of atmospheric CO_2:	7.8×10^{9} tonnes, or 7.8 Gigatonnes

Mass (in Gigatonnes) of anthropogenic CO_2 emissions in 2021 by country[41 42]*:*

China	12.4 Gt
USA	4.7 Gt
EU	2.8 Gt
India	2.7 Gt
Russia	1.9 Gt
Japan	1.1 Gt
Iran	0.7 Gt
Germany	0.7 Gt
South Korea	0.6 Gt
Indonesia	0.6 Gt
Saudi Arabia	0.6 Gt
Canada	0.6 Gt
TOTAL WORLD	37.8 Gt

References

[1] http://www.paltec.ca/does_a_global_temperature_exist.pdf

[2] https://en.wikipedia.org/wiki/Albedo

[3] https://tallbloke.wordpress.com/2011/08/05/jackpot-jupiter-and-saturn-solar-cycle-link-confirmed/

[4] https://science.nasa.gov/science-news/science-at-nasa/2013/08jan_sunclimate

[5] https://en.wikipedia.org/wiki/Stefan%E2%80%93Boltzmann_law

[6] https://en.wikipedia.org/wiki/Planck%27s_law

[7] https://en.wikipedia.org/wiki/Wien%27s_displacement_law

[8] https://en.wikipedia.org/wiki/Beer%E2%80%93Lambert_law

[9] https://wattsupwiththat.com/2010/03/08/the-logarithmic-effect-of-carbon-dioxide/

[10] https://wattsupwiththat.com/2013/05/08/the-effectiveness-of-co2-as-a-greenhouse-gas-becomes-ever-more-marginal-with-greater-concentration/

[11] https://wvanwijngaarden.info.yorku.ca/files/2020/12/WThermal-Radiationf.pdf?x45936

[12] www.paltec.ca/Kubicki_2022_paper.pdf

[13] https://par.nsf.gov/servlets/purl/10232685

[14] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[15] https://essd.copernicus.org/articles/14/4811/2022/

[16] https://ourworldindata.org/greenhouse-gas-emissions

[17] https://keelingcurve.ucsd.edu/

[18] https://en.wikipedia.org/wiki/Milankovitch_cycles

[19] https://en.wikipedia.org/wiki/Albedo

[20] https://www.whoi.edu/know-your-ocean/ocean-topics/how-the-ocean-works/ocean-circulation/the-ocean-conveyor/

[21] www.plateclimatology.com

[22] https://en.wikipedia.org/wiki/Cloud_condensation_nuclei

[23] https://en.wikipedia.org/wiki/Geomagnetic_reversal

[24] https://academic.oup.com/astrogeo/article/48/1/1.18/220765

[25] https://archive.ipcc.ch/ipccreports/tar/wg1/index.php?idp=501#:~:text=The%20climate%20system%20is%20a,of%20ensembles%20of%20model%20solutions

[26] https://en.wikipedia.org/wiki/Intergovernmental_Panel_on_Climate_Change

[27] https://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf

[28] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

[29] http://joannenova.com.au/2015/07/less-than-half-of-climate-scientists-agree-with-the-ipcc-95-certainty/

[30] https://wattsupwiththat.files.wordpress.com/2016/04/cookerlrev2.pdf

[31] https://link.springer.com/article/10.1007/s11191-013-9647-9?no-access=true

[32] https://judithcurry.com/2017/11/29/a-veneer-of-certainty-stoking-climate-alarm/

[33] https://clintel.org/

[34] http://www.climatedepot.com/2017/07/05/fatal-courtroom-act-ruins-michael-hockey-stick-mann/

35 https://en.wikipedia.org/wiki/Climatic_Research_Unit_email_controversy

36 https://www.theguardian.com/environment/georgemonbiot/2010/feb/02/climate-change-hacked-emails

37 https://wattsupwiththat.com/climategate/

38 https://www.youtube.com/watch?v=SXxHfb66ZgM

39 https://en.wikipedia.org/wiki/Climate_engineering

40 http://nsidc.org/cryosphere/sotc/sea_ice.html

41 https://edgar.jrc.ec.europa.eu/report_2022

42 https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions