

David Jamieson: The environment of the solar system and the Earth's climate

Dr David Jamieson of the School of Physics, University of Melbourne, took us on a wild ride through the cosmos last Thursday. With humour and practical demonstrations, he began with the Big Bang and ended on an exhortation to care for the only planet we know that exists with conditions suitable for humans.

He described the slow evolution of complex organisms that we call life, and the way in which the human body and all living things maintain equilibrium in the face of the forces of chaos raging all around us. To keep this unique structure - our body - intact requires the dissipation of a lot of heat. If the outside temperature exceeds the temperature of the body, this leads to the dangerous situation of the body overheating. We have the safety valve of sweating – but we are only able to dissipate the extra heat through sweating if the environment can accept the water vapor from the sweat. In situations of high humidity **and** high temperatures this safety valve no longer works.

This led to an analysis of the regulation of temperature in our earthly environment, which is dependent on the composition of the gases in the atmosphere. We are familiar with the fact that the temperature does not change very much when the sun sets at night, showing that we get most of our warmth from our atmosphere, not directly from the sun. This is due mainly due to the water vapour in our atmosphere - evaporated from our massive oceans - keeping us about 30 degrees warmer than if it wasn't there. He demonstrated how the heat coming in via the sun is being balanced by the heat going back out into space, but the heat we get from the atmosphere is increasing due to the increase in greenhouse gases from human activities, principally carbon dioxide. This increase, if not arrested, could be responsible for an increase of between 2 to 4 degrees over the next 80 years. Ice cores from Antarctica clearly reveal how much the concentration of carbon dioxide and the temperature of the planet are correlated, with the record going back 800,000 years.

He likened the speeding up of the climate machine, e.g. the rapid increase of carbon dioxide linked to rising temperature, to pushing hard on the accelerator of a car, in fact, through the floorboards. Even if you don't understand all the details of how the car engine works, you can still measure its performance as you push the accelerator. If the climate machine works the way it has for the 800,000 years, the level of carbon dioxide in the atmosphere today would cause the temperature to jump up by 7 degrees, if there were no natural defences in place to mitigate this.

David went on to discuss other factors that influence temperature on Earth, such as annual variations due to the seasons, which are caused by the tilt of the Earth on its axis relative to the plane of its orbit as it travels around the sun. More subtle influences on climate are caused by long-term shifts in the parameters of the Earth's orbit around the sun. Slow changes in these parameters are gradually causing the tropics to drift across the globe, as well as the timing of the seasons relative to the month of the year.

Although we don't understand all the details, changes in the orientation of the Earth and the shape of the Earth's orbit (Milankovitch cycles) appear to be correlated with the

cycle of ice ages. At some times in the past the Earth appeared to get locked in a global ice age, called Snowball Earth. Once all sunlight gets reflected by the snowball configuration, there is no mechanism for warming up again, unless some unusual event like a giant volcanic eruption or a meteorite triggers the collapse of the snowball.

He debunked theories that the increased temperatures we are now experiencing are due to changes in the sun, such as the 11-year sunspot cycles. These cycles can trigger minor temperature fluctuations, but this only results in about 1% of variation in heat output.

An interesting comparison was made with our neighbouring planets, Venus and Mars. When Earth, Venus and Mars were formed, their atmospheres were more-or-less identical, that is, predominantly carbon dioxide, with smaller amounts of nitrogen and water vapour.

But something unusual happened on Earth – life. Thanks to life, carbon dioxide has drastically reduced in concentration as life consumed the gas and converted it to shells and bones now forming belts of limestone in the crust, along with coal and other deposits of fossil fuels. Once most of the primordial carbon dioxide had been transferred into the Earth's crust by the action of life, the atmosphere remained with the original nitrogen, with now about 21% oxygen left over from work of life consuming the primordial carbon dioxide.

In addition, there are greater than expected variations in temperature between our neighbouring planets than would have been expected if distance from the sun was the only factor influencing temperature. These variations are determined by the different atmospheres for each. The atmosphere on Mars has mostly been blasted away by the Sun, leading to extremely cold temperatures (average surface temperature of -55 degrees), while Venus is shrouded in a thick carbon dioxide greenhouse gas atmosphere, locking the heat in (average surface temperature of +460 degrees). Earth alone maintains a stable average surface temperature of +15 degrees, but it would be -18 degrees if not for the greenhouse effect in its atmosphere.

David concluded with this slide:



It illustrates the immensity of the cosmos, and the extraordinary improbability of us ever being able to find another planet for life. We need to look after this one.