National Science and Technology Forum

S.E.T. for socio-economic growth

Message from the NSTF Executive Director

The acclaimed climate scientist, the climate crisis and the crystal ball

We live in dramatic times: a runaway deadly pandemic, intricate remote manoeuvres of equipment on Mars, the Teflon secretary-general of the ruling party in SA finally being suspended, fast melting ice caps, a president of the US calling a climate summit (President Biden Invites 40 World Leaders to Leaders Summit on Climate | The White House) where he pledges to cut fossil fuel emissions by up to 52% of 2005 levels by 2030, etc. The latter is all the more dramatic following on the complete denialism of his predecessor.

President Joe Biden says: "The signs are unmistakable. The science is undeniable. The cost of inaction keeps mounting."

Acclaimed climate scientist

Hardly has the climate summit left the news or people's social media timelines when the dramatic news of the death of a renowned South African climate scientist broke. Now that there is finally acknowledgement by the US and many other countries of the damage wrought by humankind through its incessant pouring of CO_2 into our planet's atmosphere; now that the tide has turned towards scientific advice; Bob Scholes has left us, with our feet firmly on the earth. He died on 28 April 2021 while hiking in Namibia, surrounded by relatively unspoilt natural environment. Tributes abound from around the world.

Bob will be remembered, and hopefully his memory will spur people on to do whatever it takes to bring us back from the brink of destruction. We have lost a great South African, "*a giant in the field of climate science, not only in South Africa, but in the world*," as the University of Witwatersrand (Wits) called him in the statement issued after his death. (2021-05 - Wits Community mourns the loss of one of the world's greatest scientists - Wits University) They pointed out that Scholes was "*among the top one per cent of environmental scientists worldwide, based on citation frequency*."

The tribute from the Intergovernmental Panel on Climate Change (IPCC) shows that they have lost one of their stalwarts (Obituary: Bob Scholes — IPCC). They say the IPCC "*has learned with shock and sadness of the death of long-time IPCC author Bob Scholes, who… was an author of the Third, Fourth and Fifth IPCC Assessment Reports.*"

(The IPCC describes its assessment reports as "a key input into the international negotiations to tackle climate change". The Sixth IPCC Assessment Report is in progress.)

Scholes also led many aspects of the expert work of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), including co-chairing the Land Degradation and Restoration Assessment. Recently, together with the Co-Chair of IPCC Working Group II, Hans-Otto Pörtner, he co-chaired the Scientific Steering Committee of the IPCC-IPBES co-sponsored workshop on climate change and biodiversity that was held in December 2020. [For the rest of this article, italics indicate quotations.]

In tribute, Working Group II Co-Chair Debra Roberts, the IPCC Bureau Member from South Africa, said: ***"We have lost one of our very best. Bob was a pioneer in all that he did. He was a commanding intellect and never allowed anyone to be complacent about science."***

"***There is no doubt in my mind that he lives on through his work – a lasting legacy to this generation and many more to come. Hamba kahle Bob*****,"** she said.

The IPCC further points out that Scholes was a *"Foreign Associate of the US National Academy of Sciences, Fellow of the Royal Society of South Africa, Member of the South African Academy [of Science (ASSAf)] and a winner of South Africa´s National Science and Technology Forum Lifetime Contribution to Science Award."*

When Prof Mary Scholes received the NSTF trophy in 2015 on behalf of her husband, she said that the NSTF Award is particularly meaningful as Bob was underappreciated in his own country, while recognised internationally for making important contributions to science.

Show us the evidence: climate change in southern Africa

Bob Scholes was invited to do a presentation at the November 2017 NSTF annual general meeting (AGM), and delivered an eye-opening presentation with the above title. The focus of the presentation was on the evidence of climate change processes and how to sift the evidence to establish scientific truth.

[I have taken these extracts from the written proceedings produced at the time. I only focus on what he said about temperature changes, and not about rainfall, which is more unpredictable and localised.]

Bob summed up his talk at the end by telling the difference between misinformation and science:

It is important for scientists to navigate the conflicting evidence of climate change and its effects, to distinguish between what we know and what we do not know, and to determine our responsibilities about how to communicate this. Scientists are trained to be sceptical, and climate scientists are no exception. Rules of evidence must be followed, and uncertainties acknowledged. ***'Climate denialists' stick to their message regardless of the strength of evidence provided to refute it. The following questions can be used to separate the legitimate from the misguided, mischievous and malicious:***

- *Do they have qualifications and a track record in the field?*
- *Do they offer verifiable evidence, or just assertions?*
- *Do they publish in peer-reviewed journals?*
- *Do they repeat long-disproven claims and conspiracy theories?*

The beginning of the talk went as follows:

The global climate system is complex, with internal dynamics of variability. Being a complex system means that the system has feedbacks, non-linearities, inertia and time delays that are internal to the system. The global climate system is also subject to various external forces that are natural in origin (e.g. variations due to the Earth's orbit around the sun not being circular but elliptical; the Earth's axis being inclined perpendicular to the plane of orbit but with a small wobble). Because of these factors, the amount of solar radiation that the Earth receives is variable. The Sun has its own internal dynamics (e.g. sunspots). The climate of the Earth thus varies according to various time scales (i.e. between day and night, throughout the year, over several decades, and over periods of tens of thousands of years). Scientists understand these dynamics reasonably well, and have records and proxy records to demonstrate them. In addition, there is the human force. There are directional trends over time, against natural variations. ***The issue is how to distinguish which changes are due to natural variation and which are due to human effects.***

The way in which scientists approach this problem is summed up by a quotation from Sherlock Holmes in The Sign of the Four (A. Conan Doyle, 1890): 'When you have eliminated the impossible, whatever remains, however improbable, must be the truth'. Scientists account for all known climate variation due to natural sources (e.g. orbital variations of the Earth and the effect of volcanoes) and then try to explain residual variation in the most plausible way.

Data are accumulated from sources around the world from throughout the 20th century. The first global climate records date back to the 1850s. One of the oldest international data sources is the South African Astronomical Observatory. … The records are generally too sparse to form a comprehensive picture of the global climate before the 20th century. Data from tens of thousands of weather stations and ships-of-opportunity worldwide are used in the analysis. There are anomalies in using data from ships …

It is not valid to simply take averages from the vast amount of data available. The data are first corrected for spatial, local and instrument biases. ***According to available data, the only place in the world that has been cooling over the last century is just south of Greenland.*** *The reason is that the ocean circulation has been perturbed and there has been increased upwelling of cold water in this location (given that most of the heat in the world's climate system is not in the atmosphere but in the oceans and ice bodies).*

The global compendium of climate data produced by the Intergovernmental Panel on Climate Change (IPCC) has been criticised as fake data. In order to fake the data would require faking the data at thousands of observing stations around the world, which is an unreasonable hypothesis. Most of the criticism has been about the way in which the data are manipulated to produce a homogeneous data set. There is a legitimate discussion about which interpolation processes and homogeneity tests should be used. Some researchers have responded by building different data sets, but they have nevertheless produced similar findings. There is an underlying signal in the data despite small differences as a result of applying different methods.

The impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways

The following year (2018), a special report of the IPCC was published: Global Warming of 1.5 ºC — (ipcc.ch) (See also: Summary for Policymakers — Global Warming of 1.5 ºC (ipcc.ch)

Here follow quotations from the report:

Human-induced warming reached approximately 1°C (likely between 0.8°C and 1.2°C) above pre-industrial levels in 2017, increasing at 0.2°C (likely between 0.1°C and 0.3°C) per decade (high confidence).

Global warming is defined in this report as an increase in combined surface air and sea surface temperatures averaged over the globe and over a 30-year period. Unless otherwise specified, warming is expressed relative to the period 1850–1900, used as an approximation of pre-industrial temperatures in AR5 [Assessment Report 5].

Since 2000, the estimated level of human-induced warming has been equal to the level of observed warming with a likely range of ±20% accounting for uncertainty due to contributions from solar and volcanic activity over the historical period (high confidence).

***Warming greater than the global average has already been experienced in many regions and seasons, with higher average warming over land than over the ocean** (high confidence**).** Most land regions are experiencing greater warming than the global average, while most ocean regions are warming at a slower rate. Depending on the temperature dataset considered, 20–40% of the global human population live in regions that, by the decade 2006–2015, had already experienced warming of more than 1.5°C above pre-industrial in at least one season (medium confidence).*

If all anthropogenic emissions (including aerosol-related) were reduced to zero immediately, any further warming beyond the 1°C already experienced would likely be less than 0.5°C over the next two to three decades (high confidence), and likely less than 0.5°C on a century time scale (medium

confidence), due to the opposing effects of different climate processes and drivers. A warming greater than 1.5°C is therefore not geophysically unavoidable: whether it will occur depends on future rates of emission reductions.

The modelling and 'crystal ball' predictions by the scientists have been largely correct (alas):

NASA's video of climate change modelling - Study Confirms Climate Models are Getting Future Warming Projections Right – Climate Change: Vital Signs of the Planet (nasa.gov): 9 January 2020:

An animation of a GISS (Goddard Institute for Space Studies) climate model simulation made for the United Nations' Intergovernmental Panel on Climate Change Fourth Assessment Report, [on which Bob Scholes worked] *showing five-year averaged surface air temperature anomalies in degrees Celsius from 1880 to 2100. The temperature anomaly is a measure of how much warmer or colder it is at a particular place and time than the long-term mean temperature, defined as the average temperature over the 30-year base period from 1951 to 1980. Credit: NASA's Goddard Institute for Space Studies.*

The hallmark of good science is the ability to make testable predictions, and climate models have been making predictions since the 1970s.

Now a new evaluation of global climate models used to project Earth's future global average surface temperatures over the past half-century answers that question: ***most of the models have been quite accurate.***

A research team led by Zeke Hausfather of the University of California, Berkeley, conducted a systematic evaluation of the performance of past climate models. The team compared 17 increasingly sophisticated model projections of global average temperature developed between 1970 and 2007, including some originally developed by NASA, with actual changes in global temperature observed through the end of 2017.

The results: 10 of the model projections closely matched observations. Moreover, after accounting for differences between modelled and actual changes in atmospheric carbon dioxide and other factors that drive climate, the number increased to 14. The authors found no evidence that the climate models evaluated either systematically overestimated or underestimated warming over the period of their projections.

…climate models have come a long way from the simple energy balance and general circulation models of the 1960s and early '70s to today's increasingly high-resolution and comprehensive general circulation models. "The fact that many of the older climate models we reviewed accurately projected subsequent global temperatures is particularly impressive given the limited observational evidence of warming that scientists had in the 1970s, when Earth had been cooling for a few decades," he said.

(See Climate modelling - Bing video for an explanation of how global climate models work).

Is Modelling (computer or mathematical modelling) our crystal ball?

No, explained Prof Sheetal Silal, Director: Modelling and Simulation Hub Africa, University of Cape Town, speaking at the NSTF discussion forum on Preparing for Epidemics in February 2021. She is part of the South African COVID-19 Modelling Consortium, which provides mathematical modelling support to national government during the COVID-19 epidemic. Mathematical modelling is about 'what if' scenarios: "If we make certain assumptions based on available data, this is the likely outcome." **Mathematical models can be understood as tools that create synthetic populations in silico (on computer) that have features similar to the targeted real-world populations.**

Scholes (speaking at the NSTF AGM in 2017) explained it as follows: *The standard for scientific proof is the experiment. Since we have only one world, it is not possible to replicate the conditions for an experiment (i.e. an experimental and a control group). Another approach is thus to run a virtual experiment by creating simulated worlds.* ***Global climate simulation is a remarkable achievement of the 20th century and has achieved high levels of accuracy with respect to general patterns***

of the complex global climate system. *Experiments are applied to the global climate models. There are more than 30 groups around the world involved in experiments of this sort, which means that experiments are never done on a single run, but the mean of the analysis of variance is taken from a large ensemble of simulations. The internal variability does not explain the level of change, which is the basis for the conclusion of the last IPCC Assessment Report that the human influence on the global climate system is clear (although the details may be subject to debate). The patterns are similar for the atmosphere, the oceans and the cryosphere. The analysis can also be applied at regional scale.*

Dr Silal (at the Feb 2021 discussion forum) explained that modelling is about using maths, combining it with computer programming and knowledge about the situation, to create a tool for better decision making.

In another presentation (at SciBono Discovery Centre, 2015 or 2016) for NSTF, Scholes presented an animated climate change model and explained that our region, at the tip of Africa, will be particularly affect by global warming. We need global CO_2 emissions to be kept far below one degree on average. We will also need to adapt to such devastating climate change with dramatic measures to improve our chances of survival.

He said that the older generation will not be affected that much by this heating of our sub-continent, but our children and grandchildren will be. **It was of little comfort when he said, in the long term, the planet will be fine – it will just be without us (humanity)!**

Climate science for a sustainable post-pandemic recovery

The Executive Director of the United Nations Environment Programme (UNEP), Inger Andersen, in her address to the resumed 53rd session of the IPCC (re-scheduled from 2020), on 26 March 2021, said:

*…**it is only solidarity and science that will bring us out of this harrowing pandemic.** To combat the disease, we all have a responsibility on the solidarity front – …And in parallel, science, as well as solidarity on the climate front, will be critical to navigating the planet to a safe harbour for long-term sustainability.*

…we at UNEP, view the three planetary crises — the climate crisis; the biodiversity and nature crisis; and the pollution and waste crisis —as inter-connected. Many of the drivers are common, particularly unsustainable consumption and production. The solutions to one crisis are often solutions or solution elements to the others. This is why it is so important,…that the conventions on climate, biodiversity, land and pollution must work more closely together.

As UNEP's 2020 Emissions Gap Report found, the world is still heading for a temperature rise in excess of 3°C this century. This despite a brief dip in emissions as a result of the pandemic, and despite all commitments made under the Paris Accord made so far.

However, if governments invest in climate action as part of pandemic recovery and turn new net-zero commitments into strengthened pledges at COP26, followed up with swift and time-bound action, they can bring emissions to levels broadly consistent with the 2°C goal and with greater ambition and faster action, we can still stretch for the 1.5°C.

The 6th Assessment Report can help by giving new momentum to coordinated and ambitious action by governments, businesses and people around the world. And it can lend more momentum to the fight to restore nature and biodiversity and contribute to reducing deadly air pollution.

…we at UNEP commit to continue working together with IPCC community to find ways to get climate science to a broader community. We were pleased to do so with the Making Peace with Nature report, launched by the UN Secretary-General. As you may know, this report lays out the gravity of Earth's three planetary crises through a unique synthesis of findings from major global assessments, including those of IPCC.

You are providing a valuable service not just to the governments, businesses and investors who must act on your science, but to every person across the globe impacted by climate change. ***We find ourselves at a pivotal moment in human history. We are investing unprecedented monies to kickstart our economies and protect jobs. These stimulus packages which are essential, us borrowing from future generations, must be guided by climate science. So that we move towards a resilient, just and climate-safe future for all people on this planet.***

Although short-lived, the environmental effects of harsh lockdown measures world-wide were dramatic

Although these were not sustained, it does indicate that we can indeed make a difference. Halting the stream of CO_2 into the atmosphere, even for a month or two, produces immediate results. Imagine what would happen if it could be reduced over a sustained period of time.

A Science Brief by NASA - NASA GISS: Science Brief: COVID-19 Lockdown Effects on Climate Appear Limited and Short-Lived - reveals the evidence for lockdown making an almost instant difference to surface air quality.

These changes had an intriguing effect: it seemed the air was cleaner. In New Delhi, India, an Air Quality Index that was typically an extremely unhealthy 200 or higher fell below 20. Satellites and surface air quality monitors saw distinct reductions in the amounts of particulate matter (PM) — also known as aerosols — and lower-atmospheric ozone pollution in many parts of the world. In some cases, the improvements were strongly influenced by meteorological patterns and longer-term trends, but the COVID lockdowns were also having an effect, often reducing concentrations of pollutants by 10-60%, and emissions of carbon dioxide by about 8%.

Background on the IPCC

The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options.

Through its assessments, the IPCC determines the state of knowledge on climate change. It identifies where there is agreement in the scientific community on topics related to climate change, and where further research is needed. The reports are drafted and reviewed in several stages, thus guaranteeing objectivity and transparency. The IPCC does not conduct its own research. IPCC reports are neutral, policy-relevant but not policy-prescriptive.

The assessment reports are a key input into the international negotiations to tackle climate change. Created by the United Nations Environment Programme (UN Environment) and the World Meteorological Organization (WMO) in 1988, the IPCC has 195 Member countries. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC.

The opinions expressed above are those of the Executive Director, Ms Jansie Niehaus, and do not necessarily reflect the views of the Executive Committee or members of the NSTF.