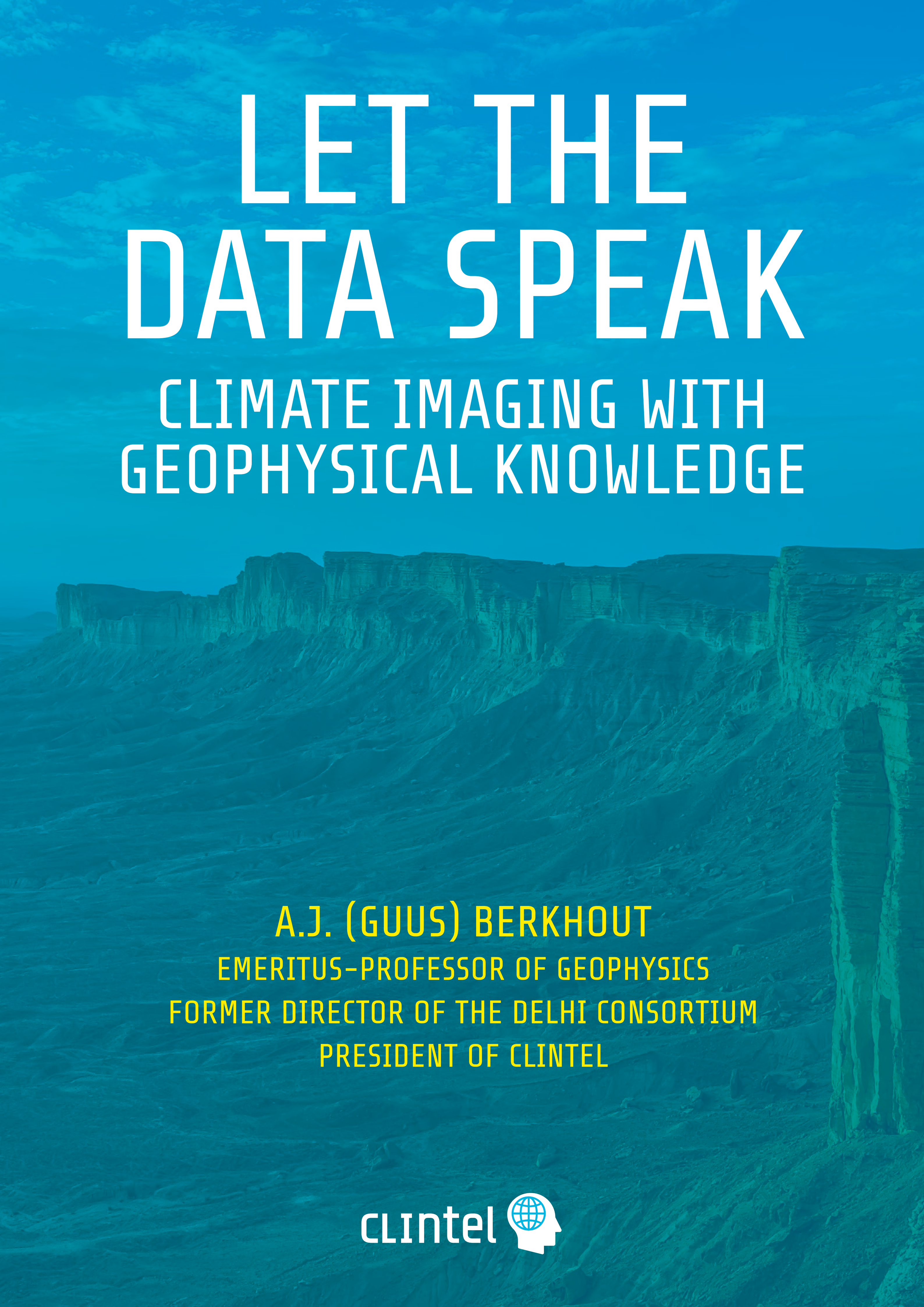

LET THE DATA SPEAK

CLIMATE IMAGING WITH GEOPHYSICAL KNOWLEDGE

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CLINTEL

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Contents

Introduction:
The urgent need for objective system science

Scientific research into complex systems cannot be properly done by segmented scientific organizations. In addition, the output of scientific research should never be driven by political wish lists.

If we look at today's big issues, we unfortunately see that governments have failed to come up with proper solutions. Think, particularly, about the issues of climate change and energy transition. One of the causes of this failure is that the mainstream science in these areas is not fit for purpose. For sure, we need to carry on with further improvements in the many specialized scientific disciplines. However, using my over 60-years of experience in scientific research, I have learned that big progress must come from bringing the knowledge of all these specialized disciplines together. Not only from within one scientific area, but also by crossing scientific areas. This conclusion should not come as a surprise because the world around us is complex, meaning that thousands of different subsystems are interconnected with each other. This means that the real world cannot be described by a collection of independent disciplinary constituents. Or, in other words, the real-world functions as one massive integrated system and scientific research should be organized accordingly.

After I retired as scientific director from the geophysical Delphi Consortium in 2016, I continued my research on the Earth's *climate* system. As an experienced scientist I was astonished to find out that the mainstream climate models were not describing the real world but were instead promoting a political narrative. In early 2019 I co-founded the Clintel Foundation with science writer Marcel Crok. In the past 6 years Clintel truthfully informed people about climate science and climate policies from a science-based perspective that most people had not heard before. Clintel's **World Climate Declaration** – summarizing the key points of this perspective and concluding that there is no climate emergency – has now been signed by almost 2000 scientists, engineers and economists worldwide, including two Nobel Prize laureates.

In this article I show how to combine the geophysical knowledge – describing the world *below* the Earth's surface – with the climate knowledge, describing the world *above* the Earth's surface. In Figure 1 it is visualized that at the Earth's surface the solar-driven natural processes in the Earth's atmosphere meet the tectonic-driven natural processes in the Earth's lithosphere. Together they determine the natural living conditions at the Earth's surface.

Today's mainstream climate science is in deep crisis. It is concerned too much with models and too little with data. The result is that mainstream scientists try to understand reality before they know what the reality is. Even worse, the mainstream climate community looks through a narrow

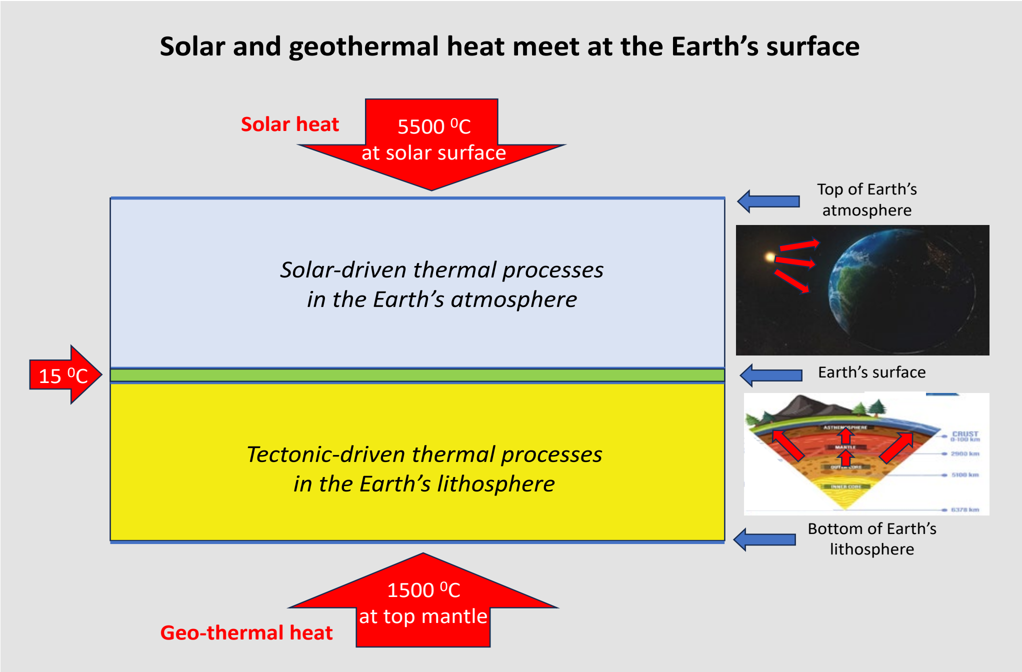

Figure 1: The solar-driven natural processes in the Earth's **atmosphere** meet the tectonic-driven natural processes in the Earth's **lithosphere** at the Earth's surface Together they determine the natural living conditions at the Earth's surface.

keyhole at the climate system. As a result, current climate models are too simplistic, the discussion is too one-dimensional, and the driving force is too political. Keep in mind that politicians love theoretical models. With these models they can easily abuse science by steering the model outcome to what they have in mind. No surprise that their models invariably predict apocalyptic warming in the future. Unfortunate consequences are the Net Zero climate policies and the green energy projects. If these policies and projects continue, they will bring the Western world into bankruptcy. China and Russia would love it!

I argue that when we are dealing with very complex systems, such as the Earth's 4D geological system and the Earth's 4D climate system, research should be largely data driven. Not relying on theoretical models but letting real measurements tell the full story! And not just looking through a keyhole to the present but opening the door to include massive historical data. Bear in mind that historical climate data from millions of years back can be found in the *geological* archive.

From Figure 2 you see that the Earth's climate has consisted of many warm and cold periods over the past 570 million years. On this long-time scale, we can also see that today's CO_2-level has reached a historical low. Please realize that below 150 ppm, most life on Earth cannot survive, because plants will die. Spending huge sums of money on storing CO_2 in empty gas fields is scientifically foolish and economically utterly wasteful.

An interesting *geophysical* example is the evidence that the phenomena El Niño and La Niña may not have an atmospheric origin but may be caused by the earlier mentioned tectonic-driven natural processes in the Earth's crust. A better image of the ocean floor is urgently needed.

My message is that the rich scientific knowledge and the no-nonsense approach of geophysicists could provide a major contribution to solving the current crisis in mainstream climate science. This unique combination will be a great help to correct for some of the fundamental errors in the mainstream climate models. We may expect that a better understanding of the Earth's climate will have a huge impact on today's climate change and energy transition policies. And bear also in mind, a sound physics and economics based energy transition policy is indispensable to retain a prosperous Western world.

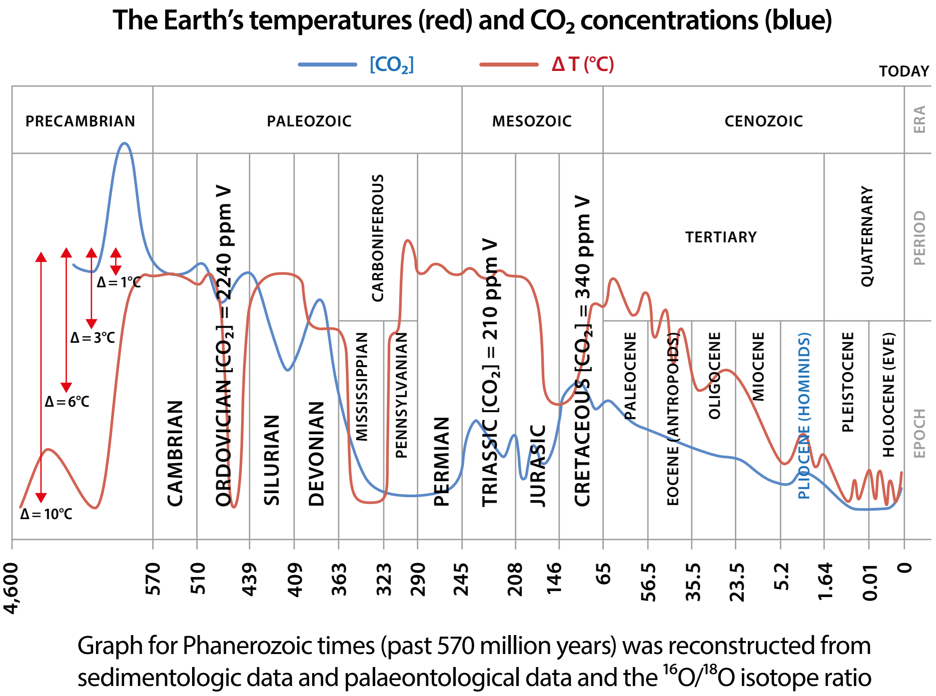

Figure 2: The geological archive reveals that the Earth's climate consists of many warm and cold periods (long-time presentation). As can be seen as well, today's CO_2-level has reached a historical low.

Imaging is the transformation of multidimensional measurements into a 3D picture of the system under investigation. Think of healthcare were medical imaging techniques, such as CT-scanning and MRI-scanning, provide information about the condition of the internal human body. By repeating imaging at different moments of time a 4D picture is obtained.

We often hear from climate modelers that we must rely on their models "because we only have one planet Earth, and models are the only way to study changes in the Earth system". That is a false statement. For instance, 4D geophysical imaging is a proven noninvasive technique to obtain information of the Earth's geological system in space and time. 4D climate imaging can do the same for studying the Earth's climate through space and time.

Bear also in mind that imaging can be done without understanding the complex mechanisms of the system under investigation. Therefore, acquiring information from 4D images is invaluable in urgent decision-making processes, where decision makers don't have time to wait for the availability of reliable scientific models. Or in other words, in complex real worlds we generally cannot wait for truthful scientific explanations before starting to act. In real-life situations it is wise to base decisions on high-quality images instead of immature theoretical models. Therefore, images with their certainties and uncertainties describe the typical working environment of engineers and economists. I expect that climate imaging will cause a revolution in climate policymaking. No need to tell that such a revolution is badly needed!

In the following, I will review the fundamental properties of climate modeling and climate imaging in terms of what is daily practice in exploration geophysics.

Climate Modeling:
Let the theory speak

The climate system is extremely complex. Mainstream models are too simplistic and, therefore, current modeling results do not represent the real world. It has resulted in climate policies that have no effect on the climate and that are very harmful to the Western economies.

In climate modeling we start with a set of coupled theoretical relationships, and we generate pseudo-measurements by discretizing and solving the involved coupled differential equations. This process is generally referred to as 'numerical simulation'. So, with modeling we try to reconstruct with theoretical relationships what we observe in the real world. For complex systems, such as the Earth's climate, modeling is a huge scientific challenge.

Figure 3 schematically shows that in this modeling process the incoming solar radiation from space is propagated downward through the atmosphere towards the spherical Earth's surface. The result of this numerical radiation process shows how the Earth's surface is illuminated by the Sun. Note that during propagation both reflection and absorption take place due to the presence of aerosols and clouds in the atmosphere. Given the heat capacity properties of the Earth's surface, absorption of the net incoming solar energy leads to a *warmer* surface.

Next, each grid point of the warmed surface acts as an infrared source. The infrared energy of all these secondary sources is propagated upward through the atmosphere back into space. This upgoing net infrared radiation leads to a *cooler* Earth's surface. Again, during upward propagation both reflection and absorption may occur due to the presence of aerosols and clouds. In upward infrared propagation, however, absorption also occurs by greenhouse gases such as carbon dioxide (CO_2) and especially water vapor (H_2O).

In the situation of global warming the net incoming solar radiation is larger than the net outgoing infrared radiation. Note that the properties of aerosols and clouds are key in regulating the incoming solar energy and the outgoing infrared energy.

Bear in mind that this is the radiation story only. At the same time heat transfer by thermal convection occurs as well. In addition, phase changes of H_2O may take place from ice to water to water vapor and vice versa, having a cooling and warming effect respectively. Note that all these different physical processes are interconnected. Also note that on top of all these atmospheric processes, geothermal warming from the hot mantle occurs.

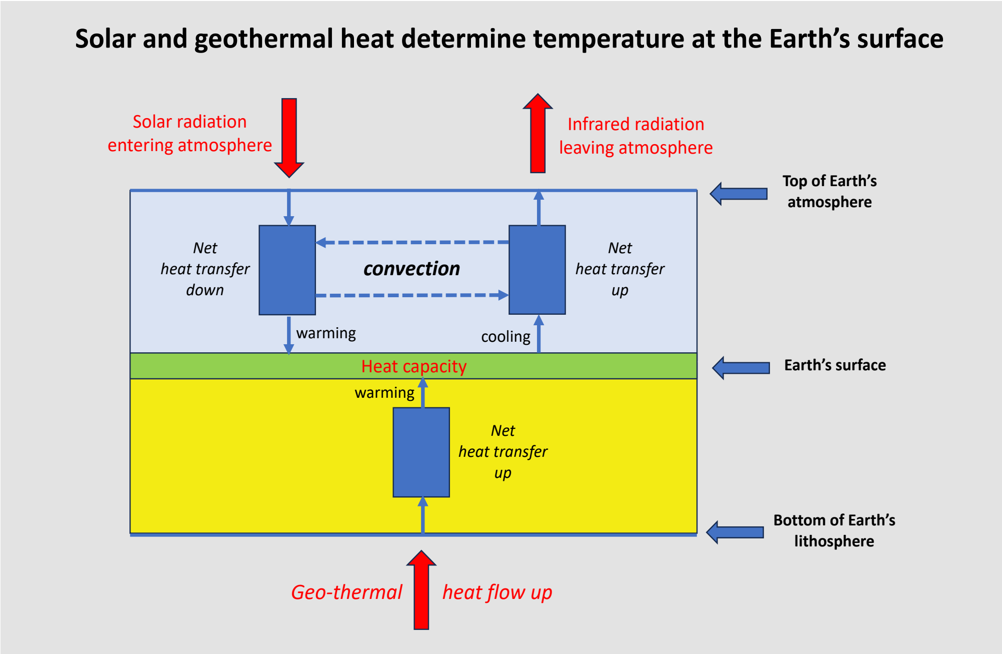

Figure 3: In climate modeling the incoming solar radiation from space is numerically propagated downward through the atmosphere towards the spherical Earth's surface. Absorption of the net incoming solar energy leads to a warmer surface. Next, the warmed surface acts as an infrared heat source and radiates energy back into space. This infrared radiation leads to a cooler surface. On top of these atmospheric processes, geothermal warming from the hot mantle occurs.

In summary, I hope I have made clear that the 4D climate modeling process is a formidable scientific challenge. Claiming 'the science is settled' is a political fiction that scientifically does not make any sense. Why do universities keep quiet?

Given a specific choice of hypotheses and algorithms, the complex *simulation* process is followed by a critical *validation* process. In validation the model parameters are optimized such that the difference between the simulated measurements and the real measurements are reduced to a minimum, often referred to as residuals. The optimized model parameters must have a physical meaning and the residuals must be small. No surprise that in climate modeling both simulation and validation are far from settled processes.

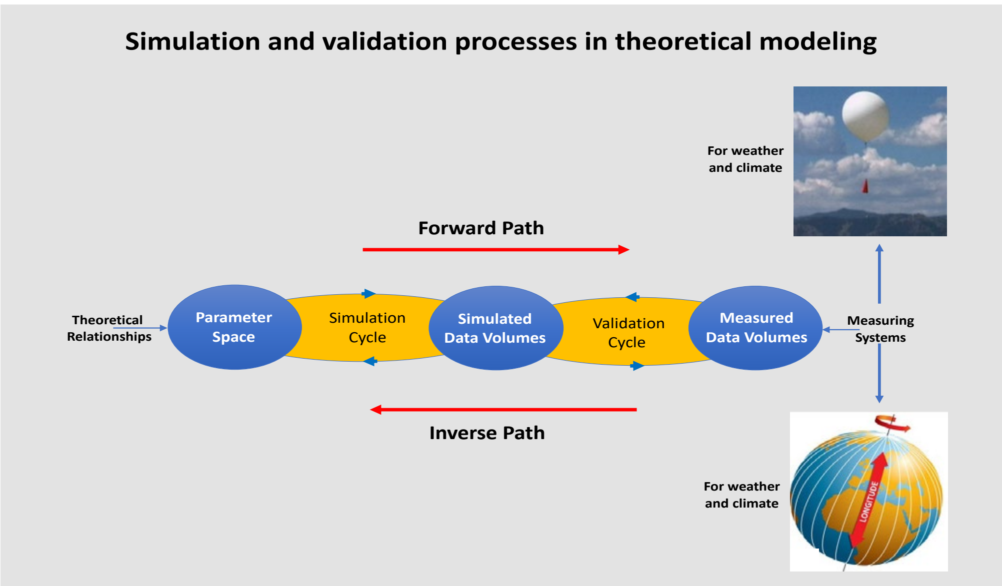

Figure 4: Climate modeling involves iterative processes through two coupled cycles. Going from left to right in the simulation cycle, measurements are numerically generated. In the validation cycle the system parameters are optimized such that the modeled world ressembles the real world.

In Figure 4 simulation and validation are represented as iterative processes through two coupled cycles, together forming a lemniscate. Going from left to right, the simulation cycle does not only provide simulated measurements, it should also come up with information on the sensitivity of the involved hypotheses and algorithms. Next, the validation cycle does not only minimize the difference between simulated and real measurements, it should also supply optimized model parameters and the statistical significance of those parameters.

Highly-specialized measurement systems are often required in the validation of theoretical models. For instance, think of the famous Large Hadron Collider that confirmed the existence of the Higgs boson. Already Albert Einstein said: *"No amount of experimentation can ever prove me right; a single experiment can prove me wrong."*

Bear in mind that modeling results are always dependent on the theoretical assumptions and the computational simplifications that the modelmakers have brought in. Modeling scientists should evaluate the sensitivity of their hypotheses as well as quantify the influence of their numerical simplifications on the results. Without explicitly showing this information, modeling has little scientific value and the modeling results are of little practical use. Unfortunately, this scientific information is missing in the mainstream climate narrative.

Figure 5: Climate activists like António Guterres and teenager Greta Thunberg have made bold, predictions of disasters that never materialized.

An example of a very influential hypothesis in mainstream climate models is positive feedback in the modeling process. For example, CO_2 leads to warming, which then leads to more water vapor, which itself will cause even more warming. The result of this assumption is that CO_2 has a major effect on global warming. It may explain why mainstream climate models produce alarmingly high temperature predictions due to increasing atmospheric CO_2-concentrations.

The climate-is doomed-narrative also explains why influential climate activists like António Guterres, Al Gore, John Kerry and teenager Greta Thunberg have made bold, headline-grabbing predictions of disasters that never materialized. Figure 5 gives an example of such fearmongering statements. There exists an embarrishingly long list of apocalyptic deadlines that have come and gone without the promised catastrophes.

As I already mentioned, the biggest threat for scientific progress arises when scientific research and policymaking are too much intertwined. This can be understood by realizing that there exists a fundamental difference between the motivation of scientists and policymakers. Scientists do welcome differences between simulated measurements and real measurements, as those differences allow them to improve their theoretical knowledge. Policymakers, however, detest these differences because they can't make use of their favorite model. Here a temptation may occur to correct inconvenient measurements instead of updating the model or, even worse, to leave those measurements out altogether.

In the following, I will explain that climate imaging gives scientists and policymakers the opportunity to make use of information that is not based on theory, but that is based on measurements. Particularly in the situation of complex systems, experience shows that it is better for policymaking to rely on rich images than on poor models. This is the experience of exploration geophysicists indeed!

Climate Imaging:
Let the data speak

Climate imaging is not fed by theoretical relationships, but by the output of measurement instruments. Measurements automatically include that the Earth is spherical, has a complex atmosphere above its surface and a complex geology below its surface, rotates around a tilted axis and orbits around the Sun. Measurements may also include properties of planet Earth we are not yet aware of.

Imaging is the counterpart of modeling. In imaging we don't start with theoretical relationships and simulate measurements in the computer, but we start with acquiring real measurements – often referred to as remote sensing – and use the computer to transform those measurements into a structured picture. This means that in climate imaging we do not simulate but we measure quantities such as heat transfer. More specific, if we measure the *upgoing* infrared radiating field by water balloons and satellites, temperatures at the Earth's surface can be estimated. In addition, if we also measure the *downgoing* solar radiating field by water balloons and satellites, imaging provides an estimate of the heat capacity of the Earth's surface.

Some of you might already have noticed the functional similarity between climate imaging and seismic imaging. For instance, natural illumination of the Earth's surface by the Sun plays the same role as anthropogenic illumination of top-reservoir by seismic sources. In both situations the response is represented by an upgoing wavefield. This upgoing wavefield obtains information about the target. Balloon measurements *above* the Earth's surface – let us refer to them as Vertical Climate Profiling measurements (VCP-measurements) – play the same functional role as Vertical Seismic Profiling measurements (VSP-measurements) *below* the Earth's surface. Working with arrays of balloons does provide a wealth of data for better images.

In climate imaging, we require high-quality measurement instruments that can accurately measure these thermal transports in both space and time. Imaging scientists are prime customers of instrument developers. Think of the spectacular developments in microscopes and telescopes, such as the recent James Webb Space Telescope for finding the first galaxies that were formed in the early Universe. Think also of the newest Geostationary Operational Environmental Satellite, GOES-T, for weather observing and environmental monitoring.

But think also of the Delphi consortium, where in the Delphi acquisition project the needs in the Delphi imaging project were addressed. One interesting outcome was the blended acquisition concept, also referred to as simultaneous sources.

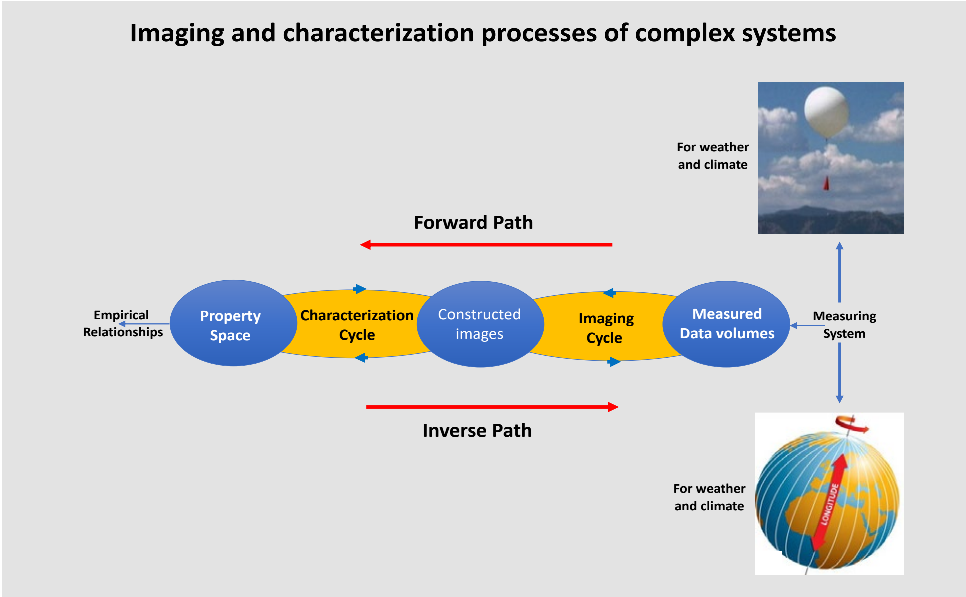

Figure 6: Climate imaging also involves iterative processes through two coupled cycles. Going from right to left, in the imaging cycle measurements are numerically transformed into images. In the characterization cycle properties such as patterns, attributes and emperical relationships are estimated.

Figure 6 shows that climate imaging also involves iterative processes through two coupled cycles. The imaging process begins on the right-hand side of the diagram by selecting the measured up- and downgoing radiating fields. The next step is to construct from these radiating wavefields temperature images in space and time. These 4D images reveal the behavior of the climate system at the Earth's surface. In the characterization cycle the images are searched for properties such as patterns, attributes and empirical relationships.

Figure 7 gives an idea of the climate images we construct. It represents the atmospheric temperatures above the oceans and continents over the period 1980-2020. In Figure 7a the East-West averaged trends – the two curves left and right – show a significant decrease if we move from the Equator to the Poles. This change can be well described by a feedback process with a large negative feedback factor. In Figure 7b the deviations from the trend temperatures are shown, Figure 7c shows the difference between the temperatures in 2020 and 1980, and Figure 7d repeats Figure 7c, visualizing the areas with a total warming over $+1.5^0$ only.

Our 4D climate images reveal that not carbon dioxide but water vapor is by far the leading molecule in weather and climate processes. Humidity, therefore, is a key property in climate change. For a water planet – 71% of the Earth's surface consists of water – this is not a surprise.

The alarmistic discussions on climate warming are primarily based on a time function only, meaning that the complex 4D image is simplified to a simple 1D picture: From T(x,y,z,t) to T(t), see Figure 8. Mainstream scientists explain this simple 1D temperature picture by the single factor CO_2. A simple narrative can be very appealing indeed. Philosopher Ockham already wrote in the 14th century "The simplest explanation is the best." Ockham meant with this statement that if you have the luxury to choose from different models that all can explain the observations well, choose the one with the least assumptions. In the 20th century Einstein formulated it as follows: "Everything should be made as simple as possible, but not simpler." In the past decennia we have seen that a single-factor climate model is too simple to explain the real climate world. Why do academies of sciences keep quiet?

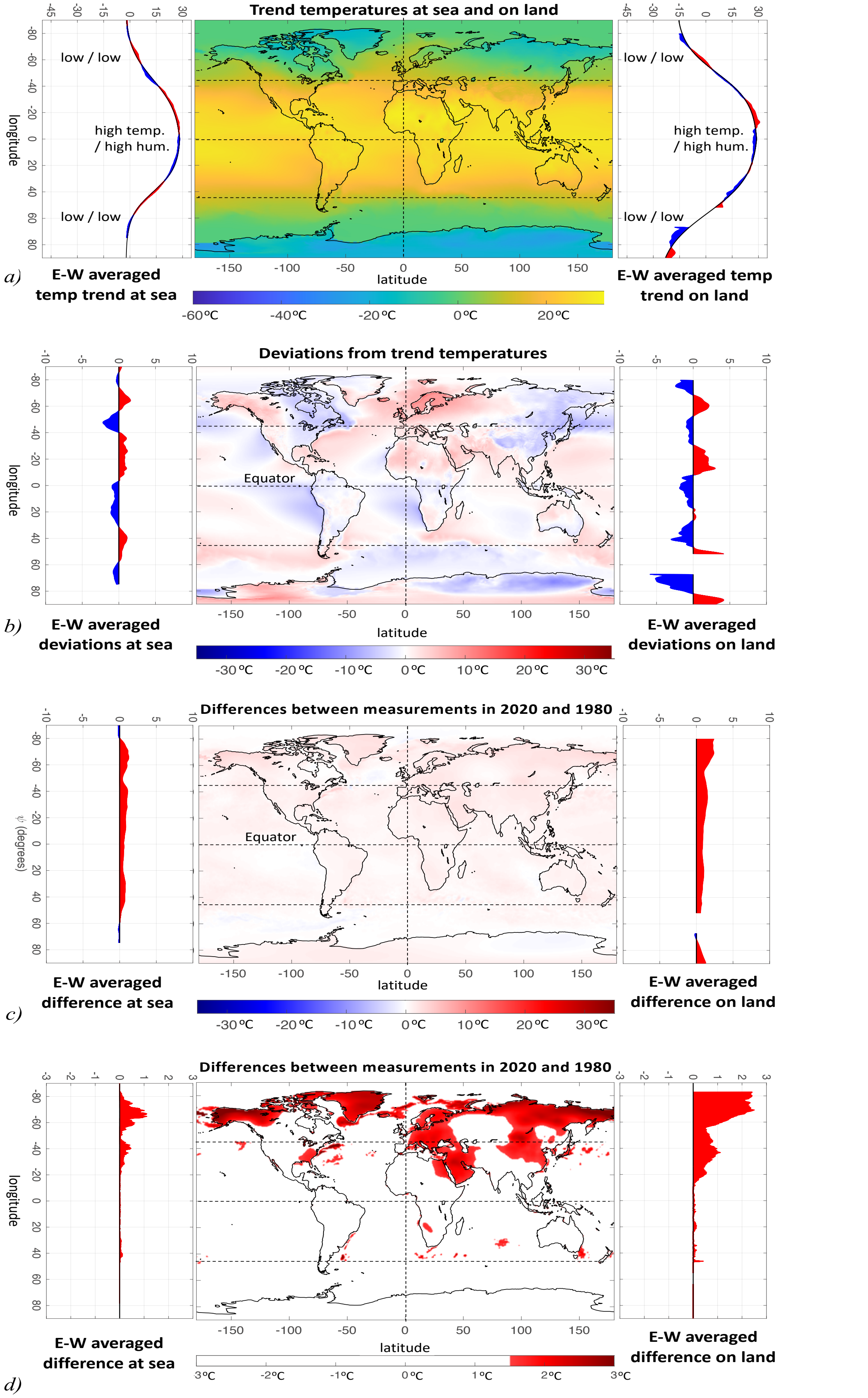

Figure 7: (a) Trend temperatures in the period 1980-2020 flanked by East-West averaged trends at sea (left) and on land (right), (b) deviations from the trend temperatures flanked by East-West averaged deviations at sea (left) and on land (right), and (c) difference between measurements in 2020 and 1980 flanked by East-West averaged differences at sea (left) and on land (right), and (d) a repetition of (c) showing the areas with a warming above 1,5 °C only.

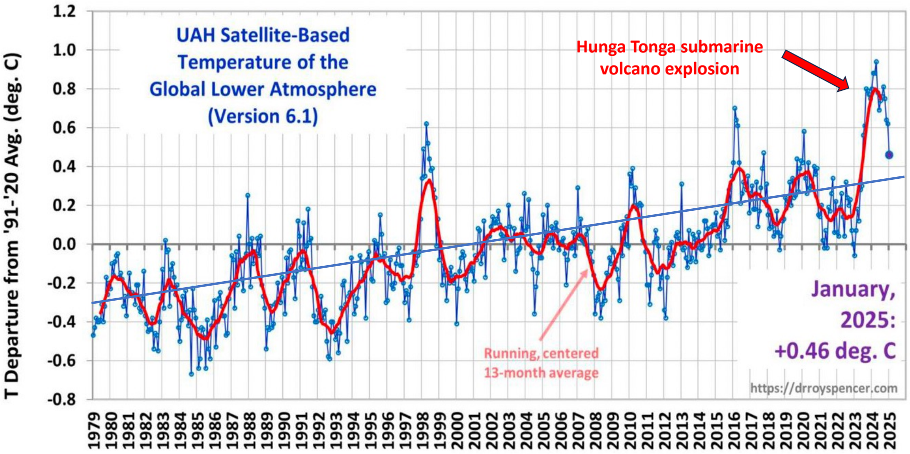

Figure 8: Global Mean Temperature (GMT) in the period 1979-2025. Note that all spatial information has been averaged out (compare with Figure 7).

Conclusion:
Keep politicians away from climate science

4D images below and above the Earth's surface must replace the politics-driven climate models. With image-based information from above and below the Earth's surface, we may expect that climate models can be significantly improved. It will result in sound science-based and economy-based energy policies.

When we compare climate modeling and climate imaging, it is important to realize that a model only contains the knowledge we already have. In contrast, measurements may contain lots of knowledge we don't yet have. In other words, in modeling we apply *existing knowledge* but in imaging we are searching for *new knowledge.* Imaging could be considered as intelligent treasure hunting in a scientific voyage of discovery. In complex situations truthful scientists are aware that what they don't know may be a lot more than what they do know. Therefore, in complex situations truthful scientists are modest and would never make sweeping statements such as 'the science is settled'.

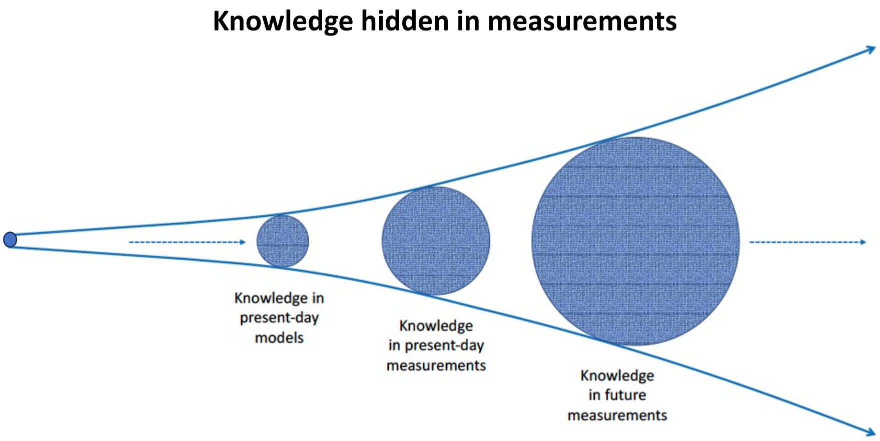

Figure 9: New knowledge must come from new measurements. If we continue with investing in instrument develepment and measurement programs, we may expect an explosion of scientific data.

In Figure 9 it is indicated that the amount of scientific data will increase dramatically in the forthcoming decades. Human beings, however, are weak in searching through terabytes of data and extracting information from these mega data volumes. Here we see that current developments in Artificial Intelligence (AI) technology will be indispensable to assist mankind in the above mentioned scientific journey of discovery. Keep in mind, AI should be the assistant and the scientist should be the leader in this journey. Keep also in mind that the computational effort in the AI-assisted imaging-characterization process requires huge amounts of energy. It again reveals that a prosperous future cannot be built on wind turbines and solar panels. It is the Green (New) Deal that will make us dirt poor.

Today, extreme weather events are big issues as they have a big influence on our daily life. To design effective measures, we must better understand the physics behind the complex processes involved. As I already explained, the climate research programs are too segmented. Even worse, climate science has been hijacked by politicians.

The politics-driven climate models tell us that extreme weather is the result of climate change are therefore caused by us humans. The result is that we are stuck with misinformed citizens and a flawed energy transition. Unfortunately, the Net Zero climate policies and green energy projects have become the big moneymakers for climate alarmists. They will do their utmost to keep the mainstream climate narrative alive.

My message to you is that the Earth's climate system is extremely complex and climate science requires the integration of disciplines from very different knowledge areas: "Innovation by integration." In the years that are still given to me, I will do my utmost to bridge the gap between the science in the natural processes *above* the Earth's surface – driven by the piping hot Sun – and the natural processes *below* the Earth's surface – driven by the piping hot Earth's mantle. In this endeavor imaging is the key technology. If we combine the knowledge and experience in the climate and the geophysical communities, and keep politicians away from our scientific work, we can make a big contribution to humanity.

I hope many of you will join me on this journey. Please read the **Clintel World Climate Declaration** and **sign it** if you agree with its content. Please, **consider to support** the important work of the Clintel Foundation.

Reference

We are finalizing a book which is expected to be available in December of this year:

Guus Berkhout and Gerrit Blacquere,
Imaging the Climate of Planet Earth, let the data speak,
December 2025

Bio-sketch

After a scientific career in the geo-energy industry (Shell, 1964-1976), Professor Guus Berkhout held a chair in geophysical and acoustical imaging at the Delft University of Technology (TU Delft) from 1976-2008.

In 1982 he founded the Delphi consortium to execute a multi-project program on geophysical imaging. He functioned as scientific director of Delphi for 34 years. During 1998-2001 he was member of the Delft University Board, being responsible for scientific research and intellectual property.

In the past decades, Guus Berkhout advised the Dutch government on the environmental problems around Schiphol airport, and the European Commission on innovation matters. In 2019 he co-founded the Climate Intelligence Foundation (Clintel). Clintel's World Climate Declaration (WCD) has now been signed by almost 2000 scientists, including two Nobel Prize laureates.

He has written several hundred peer reviewed scientific articles on sound control in public spaces, and on geophysical imaging of the Earth's upper lithosphere.

Prof. Berkhout is a member of the Royal Netherlands Academy of Arts and Sciences (KNAW), senior member of the Netherlands Academy of Engineering (AcTI), honorary member of the American Society of Exploration Geophysicists (SEG) as well as honorary member of the European Association of Geoscientists and Engineers (EAEG).

He is recipient of the Royal Decoration 'Officier in de Orde van Oranje-Nassau' in recognition of exceptional services to the Dutch society.

About the Clintel Foundation

The Clintel Foundation is an Amsterdam (The Netherlands) based thinktank founded in 2019 by Dutch emeritus professor Guus Berkhout and science writer Marcel Crok.

Clintel operates as a climate science and climate policy watchdog. In its first year it launched the World Climate Declaration, stating "there is no climate emergency". That declaration is now signed by almost 2000 scientists and experts. among them two Nobel Prize winners.

Clintel published a critical book about the latest IPCC report, titled *The Frozen Climate Views of the IPCC*. Clintel is also involved in the promotion and distribution of the 2024 climate documentary *Climate: The Movie*.

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