IAU

OAE Mini-Review

Earth as a Planet

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Earth as a Planet

Session organiser: Dario del Moro,
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Session overview

Apart from being the cradle of humankind, Earth is also the third planet of our Solar system. This allows us to apply the astronomer point of view to it, and this point of view is the leading topic of the "Earth as Planet" session. This point of view has at least two different declinations, which were both explored in the session: the source of the awareness that we are all "under the same sky", and the consciousness that the physical laws that apply here are the same as elsewhere, and therefore we can learn about our world by comparing it to the others planets.

To represent the first point of view, we had two talks by Mike Simmons and George Miley. They presented ideas and methods to convey this ‘cosmic awareness’ to inspire fraternity and motivate the young.

For the second point of view, strongly related to the climate change issue, we had two talks by Jeff Bennet and William Waller. They introduced ways to advance the public understanding of global warming, with a positive approach, leveraging on our inspirational role as scientists.

On October 13, 2021, actor William Shatner – Captain Kirk of the Enterprise – had his first real orbital flight experience. His first words after exiting the capsule? **"Everybody in the world needs to do this. Everybody in the world needs to see this."** Once again, we went into space and came back with the awareness that this world is fragile and we should take care of it, together. To solve the problems, together.

Astronomy and the Overview Effect

Speaker: Mike Simmons, Affiliate Research Scientist, Blue Marble Space Institute of Science, USA

Upon seeing Earth from space, astronauts often experience the overview effect, a profound shift in their understanding of Earth as a fragile oasis of interwoven and inseparable systems in the vastness of space. But fewer than 1000 of the Earth's billions of inhabitants have had the opportunity to observe Earth as a planet among the stars first-hand. Astronomy gives us a way to bring the overview effect down to Earth, providing a sense of our traveling through space together. This planetary identity is essential if we are to solve the many problems of Spaceship Earth such as climate change, pandemics, and profound inequity. The overview effect, however it is experienced, is the key to advancing from "us and them" to "we."

Talk link: https://youtu.be/KEbgV_HFtuo

Humanity must rise above the earth, to the top of the atmosphere and beyond. For only then will we understand the world in which we live. – Socrates

The overview effect, coined by author Frank White in his book of the same name, is the cognitive shift experienced by many astronauts who see Earth from space. We all understand the planetary nature of Earth intellectually. Images from spacecraft, like Earthrise from Apollo 8 and the Pale Blue Dot from Voyager 1, have shown it to us. But we do not really internalize it as part of our existence. Like the Copernican perspective of the Solar System, it is something we know to be true, something we can prove and understand, but that we do not experience directly by seeing it for ourselves from outside. Astronauts on the International Space Station spend much of their spare time Earthgazing. The view of Earth changes constantly, and astronauts describe it as giving the impression of a dynamic, living organism. They describe Earth's atmosphere as "paper-thin", the Earth as appearing fragile, and the dynamic systems of the planet as clearly interconnected. They often return with a new appreciation for the Earth as a planet, and for the connection between humanity and nature. While the lack of visible borders is often quoted as being an important aspect of the Overview Effect, there is much more to it. Astronauts also see Earth surrounded by stars, as a planet embedded in the immensity of the Universe. When asked about this, astronaut and astrophysicist Jeff Hoffman replied, "You do, from that perspective, see the Earth as a planet. You see the Sun as a star. We see the Sun in a blue sky, but up there, you see the Sun in a black sky. So, yeah, you are seeing it from the cosmic perspective."

The nature of our dependence on each other is not new. R. Buckminster Fuller wrote, "We are all astronauts on a little spaceship called Earth." Marshall McLuhan added, "There are

no passengers on Spaceship Earth, we are all crew." Observing Spaceship Earth from outside, experiencing the overview effect, the intellectual concept becomes reality. It is clear, tangible, palpable, even obvious. But fewer than 600 people have seen the Earth from space. Private flights and virtual reality will help bring the experience to a few more. What about the rest of humanity?

The answer is in the stars. Astronomers look into space from Earth, watching our motion among the planets and our place among the stars. When we see the Moon rising, we know others half a world away are watching it set. When we explore the cosmos with telescopes, we look out at our cosmic environment. We see that we are in space, orbiting the center of mass of the Milky Way galaxy along with billions of other stars. We see the immensity of the Universe and we understand that we are a part of it. Astronomers have a unique perspective, a cosmic perspective. While we do not leave Earth in body, we travel through our local and distant neighborhoods. We are familiar with planets and can see how the Earth is one. We experience what others do not. The passion to share that perspective with others – bringing our telescopes to the streets for people to see the Moon, planets, and more up close for themselves – is not just about sharing a hobby. It is sharing the cosmic perspective that reveals our planetary existence. Those first views of the cosmos through a telescope can be life-changing. Astronomy is the overview effect for those of us who will not make it into space. And it is available to everyone on Earth.

Astronomy is more than a modern-day hobby. It has been a part of all cultures throughout time. There are astronomy enthusiasts everywhere, and sharing the special perspective they have gained is a passion unique to astronomy. The Blue Marble image taken from the Moon by Apollo 8 astronaut Bill Anders started a global movement of environmental awareness, including Earth Day. Anders said, "We came all this way to explore the Moon, and the most important thing is that we discovered the Earth." The Pale Blue Dot image taken by Voyager 1 while six billion kilometers from the Sun shows us the Earth as, in Carl Sagan's words, "a very small stage in a vast cosmic arena." From space, Earth is not "down there." It is "out there", like any other planet. This is a critical part of the overview effect experienced by astronauts. Astronomers understand it as well.

I have found a special connectedness between astronomers around the world based on our common experiences. Our cultures may be different, but the practice of astronomy is the same. We share the same sky. We share that sky with our ancestors as well. We may have different myths about the sky and make different constellations, but even those are created for the same reasons. We feel connected with the stars. We always have. The community of astronomers is truly global, connected by something universal. We can – we must – share what we have with others. We hear "We are all in this together" all the time but even those who say it fail to act like it. The Overview Effect is a paradigm shift that engenders a true sense of interconnectedness and interdependence in the few who have experienced it. Astronomy is the overview effect for the rest of us. More on the overview effect at the Overview Institute website: www.overviewinstitute.org. Watch Overview, a short film on the overview effect by Planetary Collective: https://vimeo.com/55073825. More details on the Center for Planetary Identity: https://www.planetaryidentity.com/.

The "Pale Blue Dot - Universe Awareness" Programme for Very Young Children

Speaker: George Miley, Leiden Observatory, The Netherlands

This talk will demonstrate how exposing children to the wonders of the Universe at an early age can inspire them and contribute uniquely to advancing several of the United Nations Sustainable Development Goals. I shall discuss the rationale for reaching out to children aged 5 to 10 and describe the use of such an approach in the Pale Blue Dot - Universe Awareness project. UNAWE was initiated in 2005 with a main goal of stimulating a sense of global citizenship from a young age. It has since been implemented in more than 60 countries. Pale Blue Dot is building on Universe Awareness and will in addition focus on advancing each of the SDGs, with a set of appropriate materials and modules.

Talk link: https://youtu.be/Xwub8vHU4Bg

Exposing children to the wonders of the Universe at an early age can excite and inspire them and contribute uniquely to advancing several of the United Nations Sustainable Development Goals, particularly SDG4.7 – stimulating a sense of global citizenship.

The survival of our planet is threatened by many global dangers that can only be tackled by cultivating globalism and adopting a global approach. These dangers include human-induced climate change, pandemics, the risk of nuclear war, clashes between rival ethnic groups, increasing political polarization, and extreme nationalism. There is therefore a need to cultivate a sense of global citizenship, tolerance and solidarity throughout the world. Promoting a world view in young children at an age when their value systems are beginning to form is one of the most effective tools for doing this.

The strategy of targeting young children to promote the message of global citizenship derives from evidence that:

1. Ages 5 – 8 are crucial in brain development and is a crucial period in the development of our value systems (Brierley & Barlow, 1994),

2. Early childhood education contributes to global development (Samuelsson and Kaga, 2007, Shonkoff, et al. 2007),

3. The social effectiveness of education is greatest for the youngest children (multi-decadal study by Nobel Prize-winning economist James Heckman and colleagues (Heckman et al, 2009).

This evidence was the rationale for initiating the Universe Awareness programme (UNAWE) and its follow-up project Pale Blue Dot-Universe Awareness (PBD-UNAWE). UNAWE was started by

Leiden University in 2005 with the main goal of stimulating a sense of global citizenship from a young age. It has since been implemented in more than 60 countries, and was the basis for two projects funded by the European Research Council (e.g. EU-UNAWE Team, 2015). "Pale Blue Dot" (PBD-UNAWE), founded in 2018, builds on Universe Awareness and also focuses on advancing several of the UN Sustainable Development Goals, in addition to SDG 4.7 on globalism.

The philosophy of PBD-UNAWE is encapsulated in three quotations by Carl Sagan:

1. "Fanatical ethnic or national chauvinisme are difficult to maintain when we see our planet as a fragile blue crescent fading to become an inconspicuous point of light against the bastion and citadel of the stars." (SDG 6 – Peace).

2. "Look again at that dot. That is here. That is home. That is us. It makes clear our responsibility to deal kindly with one another, and preserve and appreciate the pale blue dot" (SDG 13 – Climate).

3. "I wanted to be a scientist since my earliest school days. The crystallizing moment came when I first caught on, that stars are mighty suns, and how staggeringly far away they must be to appear to us as mere bright spots." (SDG 4 - Education).

A set of new materials and teaching modules for PBD-UNAWE is being developed by Cecilia Scorza at Munich, who is organizing a pilot project in 5 countries, together with local educators and astronomers. Pale Blue Dot has been adopted as a "flagship" project by the IAU OAD in Cape Town and is being managed by the IAU European Office of Astronomy for Development in Leiden. It is planned to translate the materials into several languages and cultures and to develop and distribute accompanying training tools for teachers.

In September 2020, during the 75th anniversary of the founding of the United Nations, the IAU European Regional Office of Astronomy for Development held a virtual UN GA75 Dialogue on "Astronomy for Global Citizenship" (https://astro4dev.eu/images/main/Dialogue_summary.pdf). The speakers included South African Minister of International Relations and Cooperation, Grace Naledi Pandor. All participants, including Minister Pandor, strongly supported the concluding statement of the Dialogue that was subsequently communicated to the UN Secretary General: **"Before they are 10 years old, every child should be introduced to pictures of our tiny earth from space and the inspiring notion that we all together inhabit a tiny planet in a vast wonderful universe. This will help foster their sense of belonging to a common humanity (SDG 4.7), encourage them to respect and protect the environment (SDG 13) and advance the cause of peace (SDG 16)"**

In summary, stimulating a sense of globalism among all people is crucially important for the survival of our planet and targeting young children with programmes such as PBD-UNAWE is one of the most effective methods of doing this. There is a great need to support such efforts. We hope to build up PBD-UNAWE gradually – first with the 5-country pilot project and gradually increase the scope of the project until the above UN Dialogue resolution can be implemented.

I am deeply grateful to the many gifted people who contributed enormously to this project over the years. They include but are not limited to: Mahbobah Ahmadi, Kevin Govender, Carolina Ödman, Premana Premadi, Rosa Ros, Teresa Riera, Pedro Russo, Cecilia Scorza, and Michelle

Willebrands (in alphabetical order).

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Astronomers' Role in Climate Education

Speaker: Jeffrey Bennett, Big Kid Science / U. Colorado (Boulder), USA

You may think of climate science as distinct from astronomy, but the differences are not so important to the public. Both disciplines use the same basic physics, and many aspects of climate science come from astronomy (e.g., Venus). In this presentation, I will focus on why the public popularity of astronomy gives us a unique platform for advancing public understanding of global warming. I will emphasize the importance of approaching the topic 'with inspiration, not fear', providing concrete examples of strategies for audiences ranging from school kids to the general public. Note: Many of the examples will be drawn from my book A Global Warming Primer, posted free online at globalwarmingprimer.com, and my free middle school climate curriculum (bigkidscience.com/climatechange).

Talk link: https://youtu.be/gtq3ERLCaB4

Global Warming Communication — Why Astronomers?: We are scientists. We may think of climate science as distinct from astronomy, but the differences are not so important to the

public. It is "our" topic. Many of the key topics in climate science are also part of astronomy. For example, Venus and planetary science, Radiative transfer and the greenhouse effect, The Sun and its effects on Earth, Relevance to astrobiology, SETI, etc. Public interest in astronomy gives us credibility with the public. For those teaching college courses on introduction to astronomy/astrobiology, your class may be the only place where your students will learn about the science of global warming.

General Principles for Climate Communication: Maintain "radical civility" (as discussed by Travis Rector), which essentially means being respectful to your audience, even to those who may seem unreasonable to us. Be sure you always focus not only on science and consequences, but also on solutions, so that we are showing that there is indeed hope. Going along with that, your focus should be on inspiration not fear. This is a bit subtle, since global warming is scary, but keep focus on the fact that it is also solvable and our goal is therefore to inspire the action that will create the kind of world in which we will all want to live.

What is the "Future"?: Most people tend to think in horizons no more than a few years, and media discussions of climate change rarely go beyond about 2050. But, many or most of today's kids – and your kids/grand kids – are likely to still be living in the year 2100 and beyond. So it is important to focus on that longer time horizon.

Discussing the Science: "Global Warming 1-2-3": The climate *is* complex, but the basic science of global warming is actually as simple as "1-2-3":
1. FACT: Carbon dioxide (and other greenhouse gasses) makes Earth warmer than it would be otherwise (and the more there is, the warmer it becomes).
2. FACT: Use of fossil fuels (coal/oil/gas) is adding carbon dioxide to the atmosphere.
3. CONCLUSION: We expect global warming to occur.
And the data confirm that global warming is happening as the 1-2-3 science predicts.

Discussing the Consequences: There are many consequences, but I find it useful to separate them into five major categories:
1. Regional climate change
2. Increase in storms and extreme weather
3. Melting of Sea Ice
4. Rising Sea Level
5. Ocean acidification

Discussing the Solutions: Two basic steps to creating a "post-global warming world":
1. Stop making the problem worse, which means stop adding greenhouse gas to the atmosphere.
2. Find a way (e.g., future technology) to bring the CO2 level back to something more reasonable, such as 350 ppm.

The first step requires replacing fossil fuels with other energy sources, and we already have three existing technologies that could allow us to still have just as much energy without causing further greenhouse emissions: Energy efficiency, renewables (wind, solar, etc.) and nuclear – must remain on the table as one of the potential solutions for global warming. Future technologies could do far more, including providing the energy needed for active carbon dioxide removal. For example, advanced biofuels, solar energy from space, nuclear fusion. And given a time horizon looking toward the year 2100, it seems almost inevitable that, by then, we will have the

technology needed to provide clean, cheap, and abundant energy to all.

Inspire Your Audience to Action: Think about two possible futures:
1. Status quo, in which we will suffer severe consequences from global warming.
2. Rapid action, leading us to a post-global warming world.

Write a letter to your grandchildren that will be sealed in a time capsule for 50 years. What will they think of the actions you took today?

Resources:
For college students: Sections on global warming in my textbooks on astronomy (The Cosmic Perspective) and astrobiology (Life in the Universe).
For the public: A Global Warming Primer, posted freely at globalwarmingprimer.com
For middle/high school: free Earth/Space Science curriculum posted at grade8science.com; Chapter 7 focuses on climate change.
For kids: The Wizard Who Saved the World, more info at bigkidscience.com/wizard.
Free Totality app for solar eclipses includes section on global warming; more info and download links at bigkidscience.com/eclipse
Scale model solar systems provide a great way to help people obtain a "cosmic perspective" on our planet and also to understand many ideas of global warming. Available now to communities around the world. Information at voyagesolarsystem.org.

Comparing the Climates of Earth, Mars, and Venus – Educational Takeaways

Speaker: William H. Waller, IAU/OAE/US-NAEC, Endicott College and The Galactic Inquirer, USA

By comparing the atmospheres and climates of Earth, Venus and Mars, I have found a quantitative warming relation that scales with the 0.3 power of the carbon dioxide mass overlying each square meter of planetary surface. This relation is consistent with the more recent warming experienced on Earth due to human activities. Although the atmospheric photo-chemistry that underlies the observed warming is complex, K-12 students can still progress in their learning Ð from basic observations of rising temperatures and carbon dioxide levels to plotting quantitative relations, interpreting their significance, and deliberating over possible human interventions.

Talk link: https://youtu.be/gq2LjmfrpPg

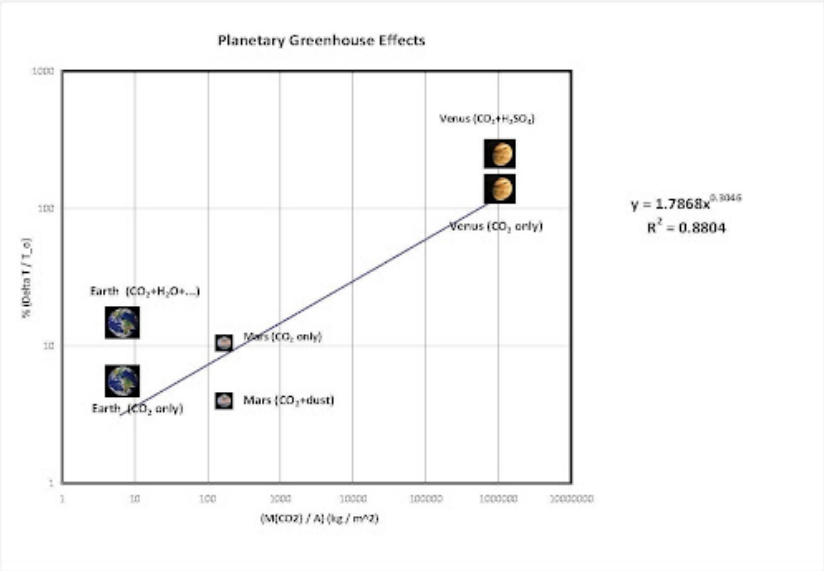

Figure 1: The relationship between percentile warming in Kelvins (relative to an atmosphere-free planet) and the surface density of atmospheric carbon dioxide for Earth, Mars, and Venus. Consideration of the warming produced by CO2 only yields a power-law relation with an exponent of about 0.3.

The signal has grown ever clearer. The Earth's atmosphere, oceans, and land masses have warmed by 1.0° C (1.8° F) since pre-industrial times. Most of this warming has occurred over the past 50 years. The Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities have prompted the bulk of this warming. The burning of fossil fuels, in particular, has increased the concentration of atmospheric carbon dioxide from 280 ppm in pre-industrial times to more than 400 ppm today – an augmentation of this greenhouse gas by more than 44 percent.

By comparing the climates of Earth, Venus, and Mars, I have considered the solar irradiation of these planets, the equilibrium temperatures that they would have without their atmospheres, and the temperatures that currently characterize their surfaces, due to the greenhouse gas warming produced by their atmospheres. Through these planetary comparisons, I conclude that warming by greenhouse gases has played an important role on all three planets. Moreover, the warming scales with the total amount of greenhouse gases in the respective atmospheres. By focusing on the carbon dioxide content, I have found a quantitative warming relation that scales with the 0.3 power of the carbon dioxide mass overlying each square meter of planetary surface (see Figure 1). This relation is consistent with the more recent warming experienced on Earth.

Although the atmospheric photochemistry that underlies the observed warming is complex, K-12 students can still progress in their learning – from basic observations of rising temperatures and carbon dioxide levels to plotting quantitative relations, interpreting their significance, and deliberating over possible human interventions. These remediations include decarbonizing our energy production, industrial processes, and modes of transportation, along with sequestering the excess carbon dioxide by cultivating more trees, kelp beds, and other natural photosynthesizers. A 30-minute video presentation on this subject is available at https://www.youtube.com/watch?v=nUqW8BGbcz0.

Astronomy Education and its Role in Saving the Environment

Presenter: Hassan Baghbani, Iranian Teachers Astronomy Union, Iran

Collaborators: Mahdi Rokni, Fatemeh Hasheminasab, Elham Rajaei, Ayda Rajaei, Mina Someilipour, Ameneh Jamali, Fatemeh Baghbani [1].

The role of astronomy education in helping to preserve the environment Bushehr Teachers' Astronomical Society has changed the way they look at the Earth by holding several astronomy courses for teachers and students in different cities of Bushehr province, so that instead of having a limited view, they can have a long-term view on preserving the environment. These trainings are the formation of the largest environmental protection groups in different cities of Bushehr province, which has been able to make the most successful examples of environmental protection in Iran.The way it works is that after training teachers, they build environmental conservation teams in schools and teach students, and make students' families more sensitive to environmental protection.

Poster link: https://astro4edu.org/siw/p22

ITAU is the first interdisciplinary teacher union of Iran with teachers from elementary, secondary and high school, who work in astronomy and nature fields simultaneously.

After many years of activities there are 20 active local groups of teachers and students in Bushehr and 9 more associations in other provinces of Iran. This association is busy with teaching the teachers and teacher-students, especially in underprivileged areas. Till now more than 2000 teachers have gained education in this field from this union. Also, about 10000 students annually participate in different activities and workshops in motivating the teachers and forming local and international teacher groups are some of the aims in different ways. Teaching astronomy and environment to the teachers of this union.

The result of proper training of teachers and their attention to environmental protection has led to the formation of the most important environmental defense movements in Bushehr province, in all of which it has been led and managed by teachers. For example, in 2016, prevented the establishment of a petrochemical plant in the middle of the abpaksh. Also in 2018 because resistance to the operation of a stone mine that caused the destruction of the Biramy Mountain and the water springs of the region was stopped, the leaders of that protest were teachers.

[1] www.skylian.org

One of the other efforts of teachers to preserve the environment is Resistance against the destruction of Avicenna forest and the rescue of Nayband National Park from a tourist town and hotel construction that is still underway. The result of six years of efforts by these groups. Preventing the establishment of a petrochemical plant in the grove ,Three large mines in environmentally sensitive areas And so on. ITAU tried to correct the views of society as much as possible. In the first step: training in teamwork and holding joint programs will create a close friendship between peoples. Training And preventing excessive consumption, especially of vital elements such as water, has an important role in preventing poverty and migration.

Accompanying the local community and protecting the environment and planting trees and protecting animals are a great help to the environment. Self-knowledge and better understanding of themselves in the form of team projects will improve students' view of future business.

Discussion summary

After the recorded talks, the session hosted a very lively round table with the speakers replying to the audience questions. Let me recap here some of the more interesting: "How can we get governments to act now and cooperatively across the world for long-term solutions?"; "How can we go from awareness to action? In case, what kind of actions would you suggest to citizens?"; "Do we astronomers have to rethink our social role? Do we need to spread more curiosity, inspiration, and motivation?"; "Are we doing enough? How to do more?".

While replying to those questions, the round table participants agreed that we astronomers have a relevant role in spreading the knowledge, in education. We astronomers can help advance the public understanding of global warming. However, we must share that knowledge with a positive attitude. And it is a matter of using the right approach and leveraging on our inspirational role. Also, we should share the same wonder that we felt as kids, pondering on the Universe. Those sensations inspired us, motivated us, and ultimately also defined what we are as grown-ups. Introducing early kids to the cosmic perspective may help have better, more aware persons in the coming years.

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