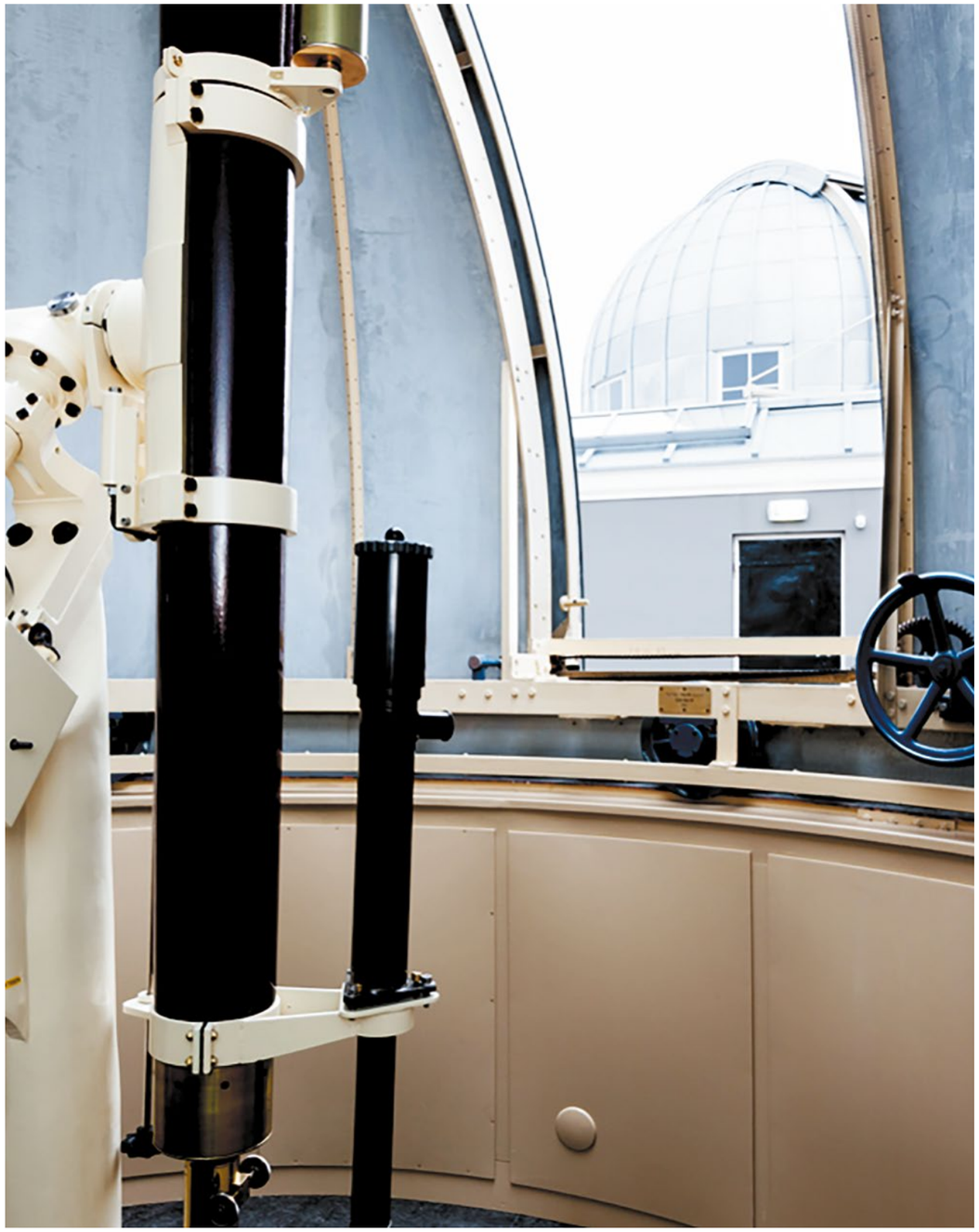
ASTRONOMY AND THE CLIMATE CRISIS



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When I last boarded a plane, in December 2018, for a scientific conference in Chile, my "flygskam" was enormous and I vowed not to take another flight unless it was absolutely necessary. For the entire year 2019 it turned out that I didn't have to: A mix of videoconferences, long day trips on trains and occasional night trains, in combination with the geographic distribution of my main collaborators as well as my existing network and position, made it possible to avoid flying for the entire year of 2019. It did require quite some organisation within my family since e.g. a train trip to ESO Garching obviously takes longer than the corresponding flight. It did not, however, feel like a sacrifice. I was able to spend the time on the train quite well for working, reading, relaxing, much more so than on a plane.

Reducing our air miles is important in two ways: It shows that we understand the urgency of the climate crisis (see graphic "climate bucket" in Figure 1) and makes us credible actors in demanding change. It also demonstrates that astronomical research and collaboration can continue without (frequent, intercontinental) in-person meetings – an almost trivial statement now that we all have to work and meet remotely due to the global Covid-19 pandemic.

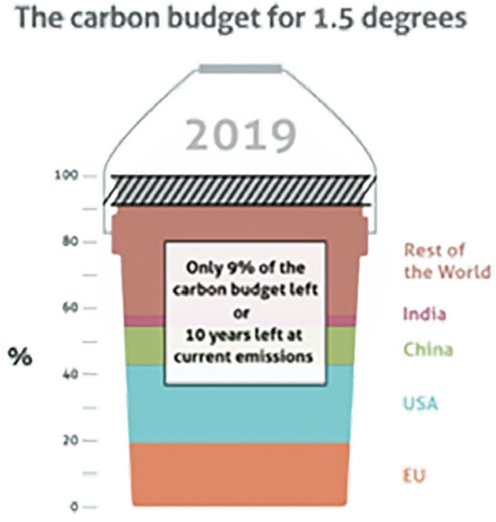

Figure 1: The global carbon budget for anthropogenic CO2 emissions is nearly full. At the 2019 rate of emissions, the bucket will flow over after just 10 more years, making it unlikely to reach the 1.5 degree goal of the Paris agreement and risk severe changes to the Earth's climate. Visualisation and more information, including scientific references: globalcarbonproject.org & University of East Anglia

The Corona crisis also lets us feel the magnitude of the change that is coming. If some of the (travel) restrictions are still in place until the end of the year 2020, the drop in annual CO2 emissions in 2020 will only be 7^{+6}_{-4} % [1]. This is roughly the reduction we need to achieve from now on **every year** to still reach the Paris climate goals.

To understand how we can most effectively reduce our own emissions, it is important to understand our carbon footprint beyond travel, however. Fortunately, two astronomical institutes have recently performed this exercise.

The Max-Planck-Institute for Astronomy in Heidelberg, in many ways comparable to Leiden Observatory, calculated their carbon emissions for the year 2018 [2] and found that 47% of the total output of 2726 t (CO_2 equivalent) comes from flying, mostly long-distance. Other major factors are electricity from both on-site and off-site facilities (e.g. supercomputing centres) that accounted for 29% of the total CO_2 emissions and heating (16%). ESO, who have undergone a full carbon audit [3] and are currently assessing its results, have estimated their total emissions as 28 kt CO_2. Their largest source of emissions is the production of electricity from fossil fuels (41% – more than half of it for Paranal), followed by purchases (30%) and business travel (10%). ALMA was not included in their calculation. Several improvements have already been made inside ESO to reduce their carbon footprint or are underway [4], but power consumption will continue to grow. While the operation of the VLT requires about 10 GWh/year of electrical energy, the ELT will require more than double [5].

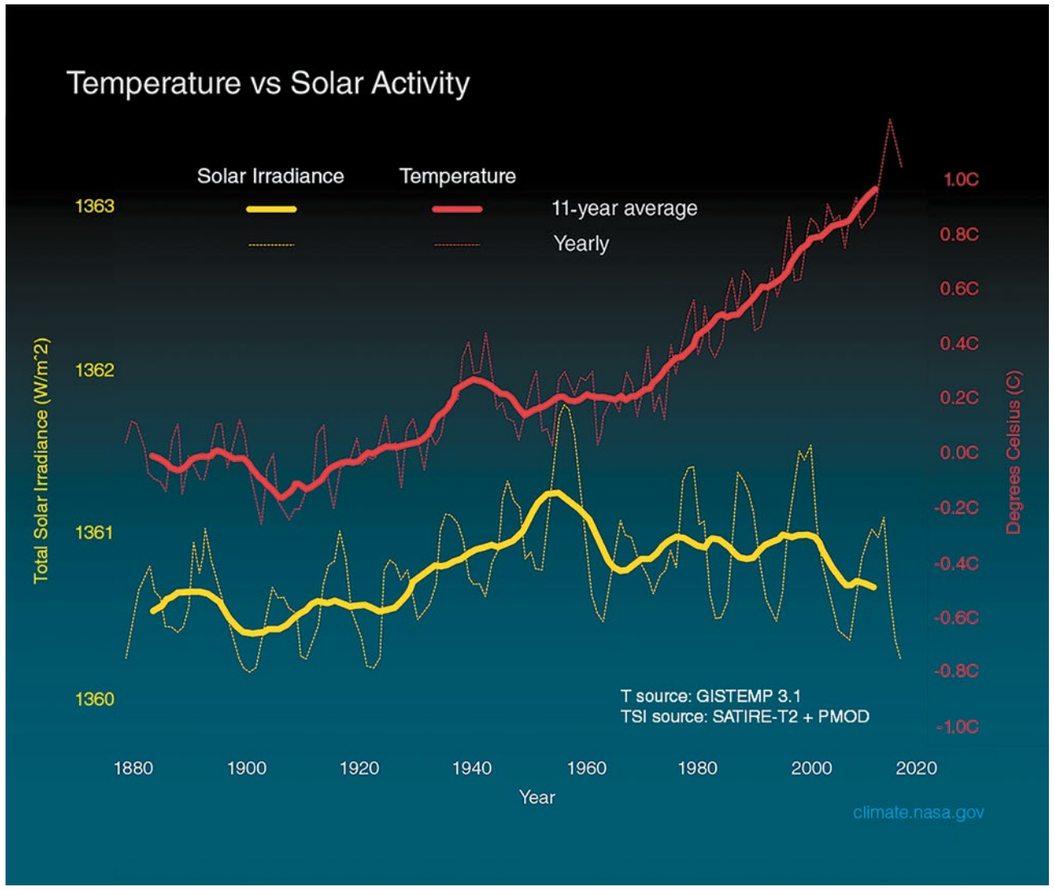

Figure 2: Global mean surface temperature vs. solar activity. (Image: NASA/JPL-Caltech)

I believe we should strive to reduce our own carbon footprint as much as possible, both for moral reasons and as a message in itself that we are taking the climate crisis seriously. We should not, however, stop there, since we can do much more: Many of us are avid science communicators and we can use our abilities and our reach not just to highlight the latest astrophysical results, but also for the better of humanity.

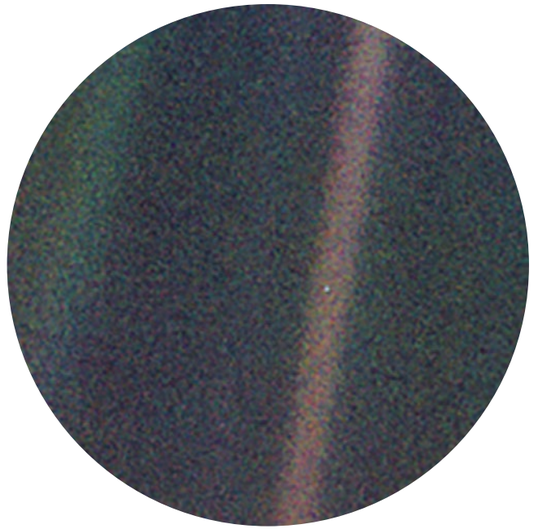

Figure 3: Earth as seen from behind Neptune's orbit: A pale blue dot. (Cropped; Image: NASA)

Astronomical climate communication can be on a number of aspects:

We can convey (astronomical) climate **facts**, such as the (non-)relation between the sun's activity and the recent warming of the Earth (see Figure 2) and explain how both measurements come about. There is generally a lot of interest – and trust – in astronomical discoveries and we can use this neutral standpoint to explain that the scientific method (and technology) telling us about the coming climate crisis is exactly the same as the one that brings us a picture of a super-massive black hole. We can also back the climate protesters' statement "There is no planet B" by embedding statements about the uniqueness of Earth in our talks about exoplanets. Rather than claiming that we search for "Earth 2.0", we should communicate that we have nowhere else to go and need to protect our only home.

Secondly, we can bring perspective. One of the most influential astronomical pictures has been the image of the Earth taken by the Voyager 1 space probe from behind Neptune's orbit (see Figure 3). I have not yet met a person who was not thrilled when shown this image of Earth as a "Pale Blue Dot". The image conveys a sense of uniqueness of our planet, a feeling of global citizenship arises and it becomes clear that we can only protect humankind by working together.

Finally, many of our pictures and movies of the wonders of the universe are breathtakingly beautiful. It is known from psychological research that awe promotes empathy and altruism [6] and may thus help to convince the public of the necessary actions to avoid climate breakdown.

References:

- [1] Le Quéré, Jackson, Jones et al. „Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement", Nat. Clim. Chang. (2020), https://doi.org/10.1038/s41558-020-0797-x
- [2] MPIA Carbon budget, Jahnke et al. (in prep.)
- [3] ESO carbon audit, Arsenault et al. & carbone4.com (in prep.)
- [4] https://www.eso.org/public/about-eso/green/?lang
- [5] Filippi et al. (2016), SPIE
- [6] Piff, Dietze, Feinberg et al. „Awe, the Small Self, and Prosocial Behavior", Jour. of Pers. and Soc. Psych. (2015), 108, 6, 883