Questions & Answers Session 1

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Sean McCartney (sean.mccartney@nasa.gov) or Amita Mehta (amita.v.mehta@nasa.gov).

Question 1: Can global warming cause extreme cold waves (as we recently saw in America)?
Answer 1: [Alex:] Global warming can shift large-scale conditions that could lead to extreme cold events; however, observational records show that the frequency and severity of cold waves are decreasing as global warming occurs. Warmer average conditions do not preclude the possibility of extreme cold waves, so ongoing research looks at interactions between large-scale weather patterns, sea ice coverage, and ocean circulation as potential drivers of cold extreme distributions and impacts-relevant conditions like frosts.

Question 2: Can you please repeat what kind of aerosols have a warming vs cooling effect?
Answer 2: Aerosols, dust, and smoke come from both human and natural sources and have various effects on climate. **Sulfate aerosols** , which result from burning coal, biomass, and volcanic eruptions, tend to cool the Earth. Other kinds of particles such as **black carbon** have a warming effect.

Question 3: Can this broadening of the land temperature anomaly (animation shown in slide 16) be also due to the disagreement among the CMIP models?
Answer 3: The distributions are calculated from the Goddard Institute of Space Studies GISTEMP surface temperature analysis, and are thus based on station observations rather than CMIP models. Distributions are determined for each year using a kernel density estimator. The data was morphed between those distributions in the animation.

Question 4: If solar irradiance is decreasing and considering the negative radiative effect of continuously increasing aerosol concentration, can we experience any dip in the increasing global air temperature curve during the upcoming few decades? If yes,

then when may it have an impact? Can it nullify the impact of global warming that we are experiencing currently?
Answer 4: [Alex:] Decreasing solar irradiance and high aerosol concentrations have partially countered the warming effects of greenhouse gases in recent decades. The negative health effects of air pollution motivates aerosol emissions reductions that will likely improve air quality in the coming decades but could also more completely reveal the warming effects of greenhouse gases.

Question 5: How does the seafloor accumulation of marine sediments reduce carbon from the atmosphere?
Answer 5: At the ocean's surface, carbon dioxide from the atmosphere dissolves into the water. Phytoplankton in turn use this carbon dioxide for photosynthesis. Phytoplankton are the base of the marine food web. After animals eat the plants, they breathe out the carbon or pass it up the food chain. Phytoplankton can also sink to the bottom of the ocean, where they become buried in marine sediment. Over long time scales, this process has made the ocean floor the largest reservoir of carbon on the planet.

Question 6: What should be the adequate CO_2 concentration?
Answer 6: [Alex:] Different greenhouse gas concentrations are associated with different levels of global warming. Each level of global warming has associated hazards and risks for human and natural systems, and thus policies related to greenhouse gas emissions, concentration targets, and global warming levels are weighing societal pathways against the resulting challenges for adaptation, mitigation, and risk management.

Question 7: Is the data collected by constellations such as Aura and CALIPSO available to the general public? If so, how does one access it?
Answer 7: Yes, **all NASA data** are freely available to the public and can be accessed via EarthDataSearch, a NASA portal for data acquisition. Below is the link to access the website:
https://search.earthdata.nasa.gov/search

Question 8: Which of these datasets can be accessed in Google Earth Engine?

Answer 8: To search for datasets from NASA missions in today's webinar on GEE, use the link below. Many of the datasets can be accessed through GEE but I'm not sure how comprehensive the list is.
https://developers.google.com/earth-engine/datasets

Question 9: Is there a difference in the concentration of carbon over the daily range--night and day?
Answer 9: During the day or in spring and summer, plants take up more carbon dioxide through photosynthesis than they release through respiration, and so concentrations of carbon dioxide in the air decrease. Then at night or during autumn and winter, plants reduce or even stop photosynthesising, releasing carbon dioxide back into the air.

Question 10: Has the Carbon Observatory Mission (i.e., OCO-2) launched and has data already been collected?
Answer 10: Yes, OCO-2 launched in July 2014 and has been operational since that time. OCO-3 is attached to the International Space Station (ISS) and is also currently operational. ARSET is planning trainings in 2022 on using OCO-2 &-3 data so stay tuned.

Question 11: Is El Nino responsible for global warming? And are human beings responsible for El Nino?
Answer 11: El Niño is a complex and naturally occurring weather pattern that results when ocean temperatures in the Pacific Ocean near the equator vary from the norm. Humans are not responsible for El Nino. Normally-—that is, in years when El Niño does not occur—strong trade winds blow from east to west across the Pacific Ocean around the equator. The winds push warm surface ocean water from South America west towards Asia and Australia, and cold water wells up from below in t he east to take its place along South America. In an El Niño year, the trade winds weaken or break down. The warm water that is normally pushed towards the western Pacific washes back across, piling up on the east side of the Pacific from California to Chi le, causing rain and storms.

Question 12: How exactly is the temperature of the ocean rising?
Answer 12: Data from the US National Oceanic and Atmospheric Administration (NOAA) shows that the average global sea surface temperature – the temperature of

the upper few metres of the ocean – has increased by approximately 0.13°C per decade over the past 100 years.

Question 13: Where can we obtain local sea level rise data especially for southeast-asian countries?
Answer 13: A full list of data tools from the NASA sea level portal can be found at the link: https://sealevel.nasa.gov/data/tools

Question 14: Which is the better NASA mission to provide a precise water level and volume in the lakes?
Answer 14: Jason-2 & Jason-3 and IceSAT-2 are current NASA missions providing surface height of lakes. ARSET held an entire training on this topic " *Mapping and Monitoring Lakes and Reservoirs with Satellite Observations"* which you can explore at the link below:
https://appliedsciences.nasa.gov/join-mission/training/english/arset-mapping-and-monitoring-lakes-and-reservoirs-satellite

Question 15: MODIS provides data for up to 20 years. But more than 30 years of data is required for climate change studies. Is 20 years of data sufficient for climate change studies?
Answer 15: Fortunately we have data from meteorological stations, buoys, ships, planes, and other geostationary satellites that extend the record back over a century. You are correct, 30 years (or more) of data is optimal for climate change studies, and MODIS helps to build that record over the past 20+ years.

Question 16: Regarding regional sea level change, what are the main reasons why the Earth doesn't behave like a "bathtub" (i.e., sea level rise on the opposite side of where the ice/glaciers melts)?
Answer 16: The ice sheets on Greenland and Antarctica are immense, and it turns out they exert enough gravitational pull to draw a substantial amount of ocean water toward them. So if you imagine the whole Greenland ice sheet melting, for instance, something quite bizarre will happen nearby: sea level will fall across an area stretching more than a thousand miles from the ice sheet, as discussed in today's presentation. Another factor that can alter sea levels is a shift in wind patterns. The prevailing winds can cause water to pile up in some locations, as happens today off the eastern coast

of Asia. The complexities do not stop there. As water is added to the ocean basins, the basins themselves adjust to the extra weight, behaving less like a bathtub and more like a kid's pool made of flexible plastic. The ocean floor can actually sink. The deformation is slow, but it changes the distribution of ocean water over time. There are a number of other factors such as ocean currents and circulation and fluctuations in land rise and subsidence due to tectonic activity and groundwater pumping.

Question 17: How is NASA connected to IPCC, IPBES, UNFCCC, UNEP and other international policy think-tanks on climate change and impact on society?
Answer 17: NASA has a team of expert scientists who contribute their time collaborating with these international institutions. One of the presenters in Part 2 of this training, Alex Ruane, is one of the scientists contributing to the IPCC AR6 report.

Question 18: Could you mention some examples of successful measures for mitigation and adaptation to climate change around the world?
Answer 18: [Alex:] Mitigation includes efforts to reduce greenhouse gas emissions, including a reduction in energy demand, the use of fuels with lower greenhouse gas emissions (e.g., natural gas vs. coal), and protection of natural forests. Adaptation can vary strongly across regions and impact sectors, including building sea walls, selecting heat-tolerant seeds for crops, reducing exposure to wildfire, and creating larger risk pools to prepare for severe storms or river flooding.

Question 19: How are the spaceborne climate datasets validated?
Answer 19: In most cases with ground-based and/or aircraft-based measurements.

Question 20: What type of analysis is performed in studying the effects of sea-level rise to coastal vegetations such as mangroves or seagrass?
Answer 20: [Alex:] Scientists use a combination of models, field observations, and controlled environment experiments to understand the biophysical impacts of sea level rise on mangroves, seagrass, and the ecosystems that depend on these resources.

Question 21: I think most of the EO datasets have a spatial resolution of 5 km - 20 km. Do you think that variability and magnitude of various meteorological variables in EO datasets is correctly quantified in mountainous regions such as in South Asia as compared to hilly areas and flat lands?

Answer 21: [Alex:] We use an array of methodological approaches to address scale challenges in climate data and applications. These include the use of dynamical and empirical downscaling models as well as bias-adjustment that uses finer resolution climate datasets to fill in the gaps and provide finer detail in coarser climate datasets. These processes need to recognize the statistical ramifications of scale adjustments, for example in identifying the relative level of extreme values within the tails of distributions (for example, heavy precipitation over a broad area will appear lower than the heaviest downpour captured on fine scales).

Question 22: Which service is most used to observe pluvial flooding? Are there known and agreed upon standards?
Answer 22: [Alex:] The Global Precipitation Measurement Mission (e.g., its IMERG product) has advanced our ability to observe heavy precipitation events. The local flooding levels depend also on local vulnerability and exposure, for example the engineered tolerance levels of local stormwater drainage systems.

Question 23: A lot of countries are in a race in developing, it is clear that more developed countries mean more emissions. How is NASA taking into account this social variable for the forecasting or estimation of the impact of it in climate change?
Answer 23: [Alex:] Simulations of future climate are driven by scenarios of socioeconomic development and associated emissions from different regions of the world. These scenarios reflect different levels of technological advance, fossil fuel usage, and international cooperation, and the set of scenarios therefore allows us to explore the ramifications of these policy choices.

Question 24: What are new instruments that were added on Landsat 9 related to climate change?
Answer 24: Landsat 9 launched two days ago on Sept 27, 2021. The satellite carries the same instruments (OLI 2 and TIRS 2) as Landsat 8. Land processes are observed via Landsat which contributes to long-term records of global change (1972 - present). The Thermal Infrared Sensor-2 (TIRS-2) instrument helps us characterize land surface temperature across the planet, to better understand urban heat islands and changes in regional and global surface temperature.

Question 25: In the graph on slide 36, is it known what happened between about 1935 and 1945 to raise CO_2/global temperature? The time frame makes me wonder if that was an effect of WWII.
Answer 25: [Alex:] There are many factors that affected the temperature trends in this period. The period around World War II is noted for high aerosol concentrations as well as a rebound from land degradation challenges in the 1930s (e.g., the US Dust Bowl).

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Question 1: What are the most effective human activities which cause a negative impact on climate?
Answer 1: CO_2 contributions from human activities cause the largest negative impact on climate. Causes for human emissions include burning fossil fuels (coal, oil, gas), cutting down forests, increasing livestock farming, and using fluorinated gases.

Question 2: Is there a method to calculate the carbon sequestration of restoration or revegetation?
Answer 2: Methods do exist but they vary across biomes. Below are a couple links to learn more about methods to calculate carbon sequestration:
Zhu et al. (2010) *A method for assessing carbon stocks, carbon sequestration, and greenhouse-gas fluxes in ecosystems of the United States under present conditions and future scenarios*: U.S. Geological Survey Scientific Investigations Report 2010–5233, 188p

Pearson, Timothy R.H.; Brown, Sandra L.; Birdsey, Richard A. 2007. Measurement guidelines for the sequestration of forest carbon. Gen. Tech. Rep. NRS-18. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 42 p.

Question 3: If climate change is a fact and we accept that changes have already started to occur, what is the point of using a long time series of climate data (temperature, rainfall, NDVI...) to calculate their anomalies for, say, agricultural use? Would it be appropriate to use shorter time series? Could you please indicate an appropriate time period of analysis in the current context of change?
Answer 3: [Alex:] Agricultural planners may use a diverse set of information to understand current and future challenges. Long time series can shed light on changing conditions that may motivate departures from traditional management practices, and projections into the future informs planning for longer-term investments such as seasonal management decisions, market futures or the purchase of new equipment, irrigation facilities, agricultural land, or value chain components such as processing and packaging plants and import/export partners.

Question 4: How can heat pass through greenhouse gases but cannot leave?
Answer 4: [Alex:] The size and molecular structure of greenhouse gases makes them transparent to “shortwave” radiation (sunlight) but opaque to the thermal radiation emitted by the earth. This difference means greenhouse gases do not stop energy coming into the climate system, but prevents a portion of the earth’s energy from escaping to space and thus disrupts the energy balance of the climate system and results in warming.

Question 5: Many of the satellite derived parameters are a measure defined as a column up to top of the atmosphere. In satellite remote sensing for climate applications, the topmost level of which layer of atmosphere (troposphere / stratosphere / mesosphere / thermosphere) is considered as the top of the atmosphere?
Answer 5: Technically, there is no absolute dividing line between the Earth’s atmosphere and space, but for scientists studying the balance of incoming and outgoing energy on the Earth, it is conceptually useful to think of the altitude at about 100 kilometers above the Earth as the “top of the atmosphere.” The top of the atmosphere is the bottom line of Earth’s energy budget, the place where solar energy

(mostly visible light) enters the Earth system and where both reflected light and invisible, thermal radiation from the Sun-warmed Earth exit.

Question 6: What human activity contributes the most with average temperature rise?
Answer 6: The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is very likely due to human activities, primarily from increases in greenhouse gas concentrations resulting from the burning of fossil fuels.

Question 7: Water vapor is the greatest greenhouse gas, however our attention is so much on CO_2 and other anthropogenic GHGs. Why?
Answer 7: Water vapor is the most abundant greenhouse gas in the atmosphere. However, changes in its concentration is also considered to be a result of climate ***feedbacks*** related to the warming of the atmosphere rather than a direct result of industrialization and the burning of fossil fuels. That's not to say climate scientists are not monitoring and modeling changes in water vapor. As stated in today's presentation, NASA has several instruments currently in orbit observing changes in global water vapor concentrations. It is important to monitor changes over time due to warming of the atmosphere.

Question 8: What is the highest resolution of freely available satellite data provided by NASA?
Answer 8: Currently the highest spatial resolution of freely available satellite data provided by NASA is 30 meters. The highest temporal resolution is 1 -2 days but with a much larger spatial resolution (250 meters). There is always a tradeoff between the two (higher spatial resolution versus higher temporal resolution).

Question 9: Could you explain the spatial coverage of GEDI? Is it global?
Answer 9: Since the GEDI instrument is attached to the International Space Station (ISS) it is confined to an orbital inclination of 51.6 degrees to Earth's equator. This means it collects data within 51.6 degrees north and south of the equator. To learn more about the GEDI mission refer to the link below:
https://gedi.umd.edu/

Question 10: How far are the satellites from the earth? "MODIS observes every point on the planet every 1-2 days" what is its speed? Does it achieve this because of the rotation of the earth or is it on its own speed of navigation?
Answer 10: As mentioned in the presentation, different satellites are in varying orbits, some in the “A-train”, some in the “C-train”, etc. To explore more for each specific satellite and instrument use the links provided in each slide referencing that mission. You can also find more on the fundamentals of remote sensing here: https://appliedsciences.nasa.gov/join-mission/training/english/arset-fundamentals-remote-sensing

Question 11: Does NASA produce a summary of all the data in one place?
Answer 11: For summaries of all NASA data please refer to NASA Earth Data Search. This is a one-stop-shop for all NASA Earth observing data, as well as associated information on the data sets, data processing, etc.
https://search.earthdata.nasa.gov/search

Question 12: What products or data from NASA can be used to estimate indicators of retreat, glacial dynamics and impacts on the dynamics of hydrogeological sources in the South American Andes?
Answer 12: There is a NASA team at Goddard Space Flight Center working to monitor the retreat of glaciers in the Andes and worldwide using a combination of satellite data (Landsat) and ice cores.
Below is a link to the literature:
Thompson, L. et al. (2021) The impacts of warming on rapidly retreating high-altitude, low-latitude glaciers and ice core-derived climate records, Global and Planetary Change, Volume 203, 103538, ISSN 0921-8181,
https://doi.org/10.1016/j.gloplacha.2021.103538

Question 13: Considering the fact that climate change impacts are trans-generational, is there any plan or scheme to train the young generation on climate related issues to prepare them adequately for the future?
Answer 13: That is the purpose of this training. ARSET is sharing the best available science with the general public and making all the information available on our website, YouTube, etc. The goal is to get this information into as many hands as possible, irrespective of age, nationality, etc. ARSET will be following up this 2-part training with

a series of Climate trainings over the coming years, and we hope you will share this information with as many people as possible.

Question 14: Do you have products (short papers, presentations, etc) that are targeted towards elected/appointed leaders that planners can use to achieve buy-in for the need for mitigation?
Answer 14: We recommend you share with decision makers the Intergovernmental Panel on Climate Change's Sixth Assessment Report (2021): https://www.ipcc.ch/assessment-report/ar6/

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