Science AMA Series: We are Earth and solar scientists working with NASA's TSIS-1 mission to measure how much sunlight reaches Earth and its unexpected impacts on our climate. We live on a solar-powered planet, AMA!

NASAEarthRightNow [1] and r/Science AMAs[1]

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Abstract

Hello r/science! From space, NASA has been keeping an eye on Earth's energy supply from the Sun for more than 40 years. For a long time, scientists assumed the Sun's energy output was unwavering, they called it the 'solar constant.' But, by the 1980s, we learned that solar energy reaching Earth was not constant, and fluctuates with solar activity on a roughly 11-year cycle. This change in the total solar irradiance is just one of the Sun's influences on Earth's atmosphere, weather, and climate. We are here to talk all things TSIS-1 and Sun-Earth interactions. Joining you today will be: Peter Pilewskie, professor of ocean and atmospheric science, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder Dong Wu, Earth scientist NASA Goddard Space Flight Center Doug Rabin, solar physicist at NASA Goddard Space Flight Center Jae Lee, Earth Scientists at NASA Goddard Space Flight Center Candace Carlisle, Project Manager TSIS-1 at NASA Goddard Space Flight Center Charles Ichoku, NASA Earth Scientist We'll be back to answer your questions at 3 pm ET (12 PT), Ask Us Anything!

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NASAEARTHRIGHTNOW R/SCIENCE

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Thank you for doing this AMA.

What will TSIS-1 be able to detect that couldn't be observed before? Do you have specific target in mind?

Also, is the 11-year cycle tied in with the sunspot cycle, or are they two different things?

helm

TSIS will be able to measure smaller changes in the Sun's output than any previous instruments used to measure the Sun's light energy. Our target is 0.01% for the measurement of all of the Sun's light energy and 0.2% in specific wavelength bands. This will allow us to monitor the Sun's impact on climate better than ever before. (Peter)

Thank you for doing this AMA.

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"Also, is the 11-year cycle tied in with the sunspot cycle, or are they two different things?"

Yes, the total power from the Sun received at Earth varies up and down in phase with the sunspot cycle. When sunspots are most numerous (about every 11 years), the power is about 0.1% higher. (Doug)

Do we understand the heliophysics well enough to know the cause / pacing of the 11-year cycle?

Does the amplitude of the 11-year cycle vary much from cycle to cycle?

What's a typical amplitude (converted to Watts per meter squared on Earth for us climate folk)?

aClimateScientist

We don't know enough to predict more than a couple of years ahead with any confidence. The solar cycle is driven by the dynamo action of magnetic fields inside the Sun. Although we understand the physical principles of magnetic dynamos, we don't yet have enough computational power, or knowledge about magnetic fields inside the Sun, to predict future cycles from first principles. (Doug)

There isn't a single amplitude to the solar cycle. The peak number of sunspots has varied by about a factor of 3 from cycle to cycle since 1700. We have only accurately measured total solar irradiance (Watts per square meter) for 37 years. At solar maximum, the irradiance is 1-2 Watts per square meter (out of about 1360 Watts per square meter total) greater than at solar minimum. (Doug)

Not all wavelengths of solar light fluctuate the same during the solar cycle. For example, X-rays vary much more than visible light. (Doug)

Why is measuring the sun important for climate?

past_is_future

Several reasons.

The Sun provides almost all of the energy to Earth. This energy is offset by sunlight that is reflected by the Earth and its atmosphere and infrared radiation the Earth emits to space. If there is an imbalance between incoming and outgoing energy over time, climate will change. We need to measure that incoming light energy very accurately to understand Earth's energy budget. (Peter)

How are your instruments different from those flown on the Earth Radiation Budget Explorer 30 years ago? If I recall correctly ERBE's instruments only worked while looking at the atmospheric limb of the planet -e.g. staring at the atmosphere illuminated by the just over the horizon sun. Will your instruments be able to determine in inbound solar energy from measurements viewed from nadir or near nadir perspective? Will a manufacturer of home canning jars make your spacecraft?

shiningPate

TSIS measures the incoming light from the Sun. It does not point in the nadir direction to view the Earth. ERBE also made solar measurements. The measurements from TSIS will be more accurate than those from ERBE. (Peter)

How are your instruments different from those flown on the Earth Radiation Budget Explorer 30 years ago? If I recall correctly ERBE's instruments only worked while looking at the atmospheric limb of the planet -e.g. staring at the atmosphere illuminated by the just over the horizon sun. Will your instruments be able to determine in inbound solar energy from measurements viewed from nadir or near nadir perspective? Will a manufacturer of home canning jars make your spacecraft?

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The Earth Radiation Budget Experiment included instruments to measure the longwave (thermal) and shortwave (reflected solar) radiation from the Earth, in addition to an instrument to measure solar irradiance. Today, we rely on the NASA CERES (Clouds and the Earth's Radiant Energy System) instruments to measure emitted and reflected radiation from the Earth, while TSIS will measure total and spectral solar irradiance. The design of the ERBE solar instrument was similar to the TSIS instrument, but was less sophisticated. (David Considine)

For the Sun's influence on Earth's climate, is it as simple as more solar irradiance --> warmer Earth? Or are there other more complex phenomena at play?

moimitou

That's part of it. However, it is not a straightforward equation. Various Earth's constituents on land, ocean, and the atmosphere interact with the solar irradiance in complex ways, and the resulting Earth's temperature will depend on these processes, many of which are wavelength dependent. This is why TSIS-1 will measure both the total solar irradiance (TSI) and spectral solar irradiance (SSI), to facilitate the precise simulation of these processes. (Charles Ichoku)

When light interacts with water, it refracts (it is refraction, right?) and slows down, does the light fully stop, and when it stops does it dissipate or sit there?

InterstellarCow

The light "fully stops" only if it is absorbed by the water, the light energy converted to another type of energy, for example, thermal energy that raises the temperature of the water.

Visible light that you can see will travel many meters (several tens of feet) before it is absorbed. This is why you can easily see through a glass of water.

(Peter)

Thank you for this AMA! You guys are awesome here's my question:

*Why did it fluctuates? Was it before reaching Earth or after?

bronxyle

The total light from the Sun fluctuates for at least two reasons: sunspots, which are dark and cool (if you call 6500 F cool!), and regions called "faculae", which are brighter and hotter. When there are

many sunspots, there are also many faculae. The faculae win out, and the Sun is slightly brighter at solar maximum. (Doug)

Thank you for this AMA! You guys are awesome here's my question:

*Why did it fluctuates? Was it before reaching Earth or after?

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We are interested in how the Sun's light fluctuates before it reaches the Earth because that is the input to the climate system. (Peter)

Has TSIS-1 launched yet or was it part of the delayed missions this month? You must be very excited about having a new tool on the space station.

As I understand it, the TSIS-1 instruments are quite superior to the SORCE mission tools. What can you do with this new technology that you couldn't accomplish before?

adenovato

No it has not launched yet. TSIS is currently scheduled to launch no earlier than December 8, 2017. And, yes, we are very excited! (Peter)

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adenovato

From the NASA News Room. TSIS-1 is riding a SpaceX rocket to the space station.

NASA and our commercial cargo provider SpaceX are targeting the 13th commercial resupply services mission to the International Space Station for no earlier than 1:20 p.m. EST Friday, Dec. 8. This new launch date will allow SpaceX to finalize pad readiness, and provide an additional launch opportunity Saturday, Dec. 9, if needed. Carrying about 4,800 pounds of cargo including critical science and research, the Dragon spacecraft will spend a month attached to the space station.

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adenovato

The TSIS instruments will be able to monitor smaller changes in the Sun's light energy than ever before, improving our ability to quantify the sources - both "natural" and anthropogenic - of climate change. Nevertheless, credit must be given to SORCE (SOlar Radiation and Climate Experiment). The total solar irradiance measurements from SORCE are by far the most accurate and stable of any

measurements that make up the 40-year record of satellite measurements. And the SORCE spectral irradiance (sunlight in individual wavelength bands) measurements represent the first daily measurements of the full spectrum of sunlight from space. So SORCE was truly groundbreaking. Incidentally, SORCE is now nearing the end of its 15th year of operation, 10-years beyond its nominal mission lifetime! (Peter)

How do you build a sensor that captures all the different wavelengths of light? How does the sensor trap all the high energy light and all the low energy light at the same time?

StarkillerX42

The total irradiance monitor, or TIM, captures light of all wavelengths by using a highly absorptive material that absorbs virtually all light that falls on it. The absorbed light energy is balanced by an equivalent amount of electrical energy from which we can determine the total power that entered the instrument.

The spectral irradiance monitor, or SIM, uses a prism to disperse light of different wavelengths that are measured by a detector one wavelength band at a time. (Peter)

Is there anything new that y'all are specifically looking for?

Spider-Man-2099

Although TSIS falls into the category of a continuity mission - in this case, continuity of the 40-year record of solar irradiance from space - rather than a discovery mission, every measurement of the Sun will be “new”. We are unable to predict the future behavior of the Sun with a high level accuracy, making the TSIS measurements crucial for understanding the amount of energy that is supplied to Earth, and for deciphering how the atmosphere responds to seemingly small changes in the Sun’s output. (Peter)

The sun's gravity keeps Earth in orbit around it, and light from the sun takes 8 minutes to reach Earth. Now if the sun disappeared entirely, would Earth immediately drift off in a straight line or would we continue to orbit where the sun had been for 8 minutes until the Earth noticed the sun's gravity had stopped acting upon it?

misteil

It is quite a hypothetical question to postulate the Sun would disappear without any other forces. Gravity acts at the speed of light in a vacuum. If the sun were to suddenly disappear, the effect of the sun's gravity on the earth would be experienced at the same time as the lack of sunlight... approximately 8 minutes after the sun's disappearance. Assuming no other gravitational forces, the Earth would continue to travel in a tangential line to its current orbit. However, there are other gravitational forces that would influence the Earth's travel. (Candace)

Do solar neutrinos create pressure like photons create EM radiation pressure?

aliensexdrive

Like photons, neutrinos do create pressure, but the pressure of solar neutrinos is unmeasurably small. In a supernova, it's a different story! As the neutron star that will be left behind is forming, an amazingly

intense flux of neutrinos interacts strongly with neutrons and protons. (Doug)