

WHAT IS SPACE WEATHER?!

MANGA: HAYANON+SCIENCE MANGA STUDIO

SUPERVISORS: KAZUO SHIOKAWA,

YOSHIZUMI MIYOSHI,

AND RYUHO KATAOKA



NAGOYA UNIVERSITY



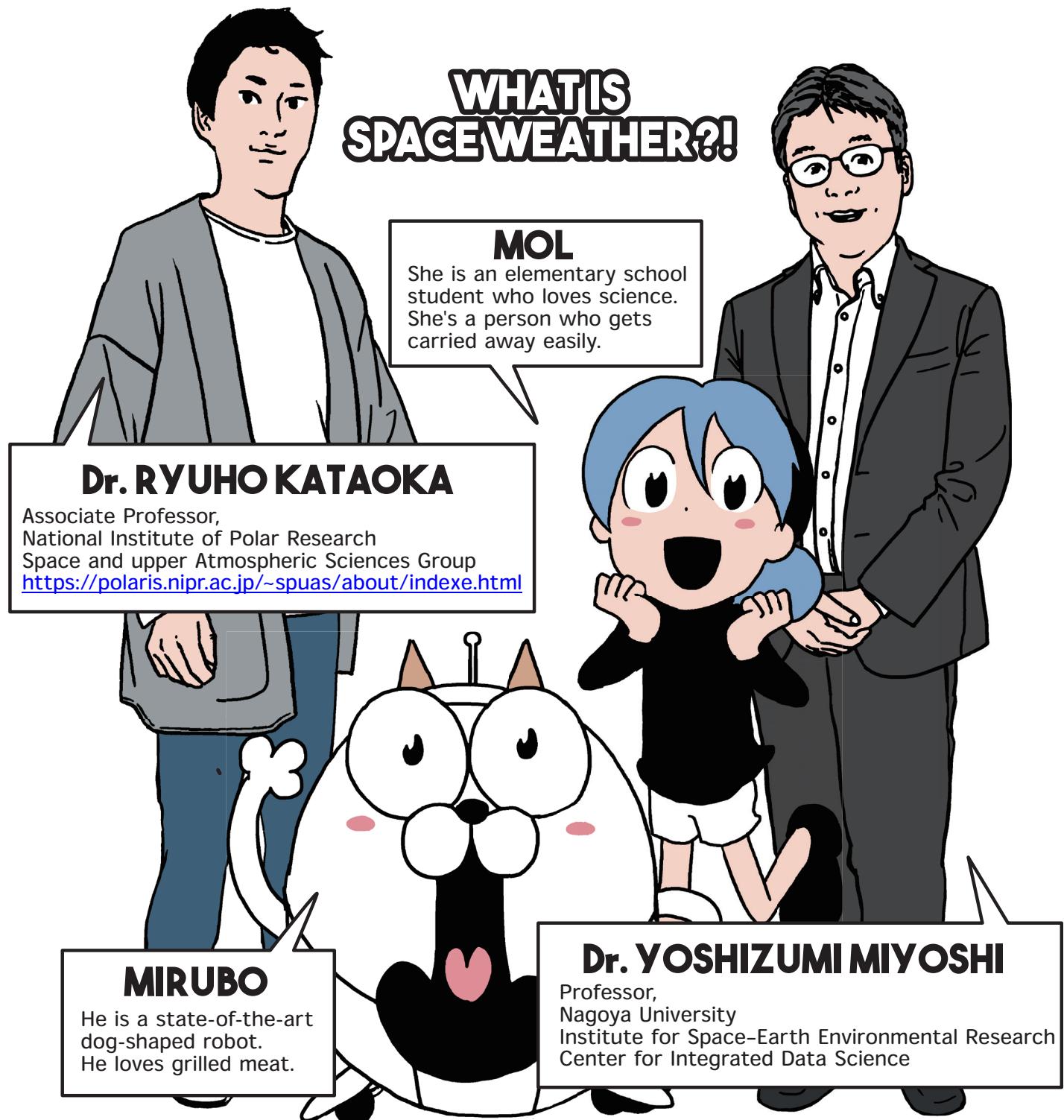
Institute for
Space-Earth
Environmental
Research



Scientific Committee on Solar-Terrestrial Physics



Is it true that space has weather? the Sun, which we thought was always the same, is actually changing at a dizzying pace, sometimes going quiet and other times exploding. When the "solar wind," which is made of plasma emitted from the Sun, causes a "magnetic storm" on the Earth, electrical facilities on the ground may break down or suffer serious damage. In order to know this in advance and prevent damage, research and efforts in "space weather forecasting," in which solar activity is observed to predict upcoming phenomena, are spreading around the world. Let's learn about "space weather" with MIRUBO, MOL, and the researchers (SENSEI) in this MANGA!



I'M MIRUBO.
A ROBOT
WITH THE
TECHNOLOGY
OF THE FUTURE.

I'M MOL,
AN ELEMENTARY
SCHOOL STUDENT
WHO LOVES
SCIENCE.

THIS IS
AN INSTITUTE!
I'M HERE TODAY
TO FIND
AN INTERESTING
STORY.

HMM?
UGH!

WHAT'S WRONG
WITH YOU?
MIRUBO?

HE SUDDENLY
STOPPED
MOVING!

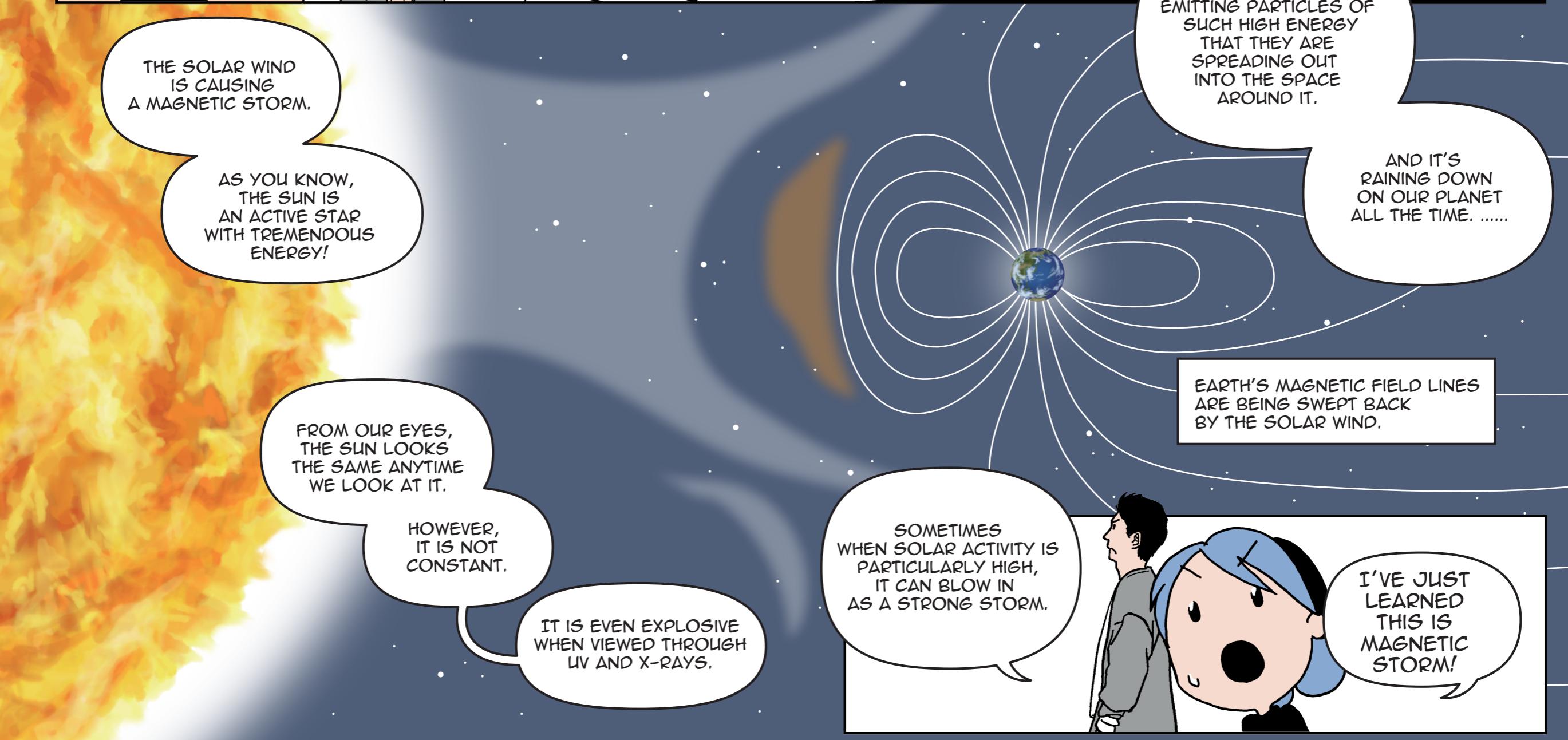
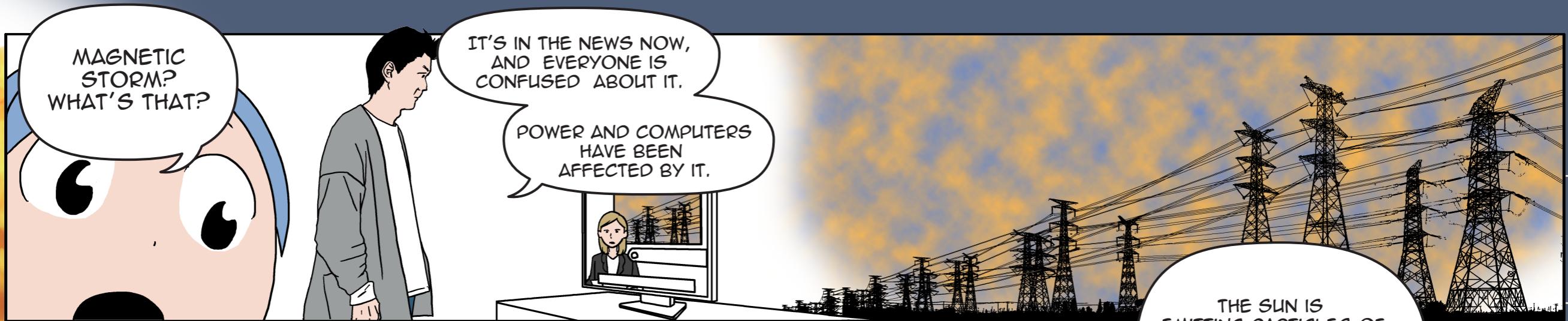
MIRUBO!!

AS I PREDICTED,
HE HAD
A BREAKDOWN.

OH
YOU COME
TO US!
SENSEI!!

THIS IS PROBABLY
DUE TO
MAGNETIC STORM.

Dr. RYUHO KATAOKA SENSEI



ROUGH GEOMAGNETIC FIELD
CAUSES ABNORMAL
ELECTRIC CURRENTS
ON THE GROUND.
AND THAT CAN DESTROY
POWER GRID
AND CAUSE MACHINERY
TO MALFUNCTION.

IN 1989,
AN ACCIDENT OCCURRED
IN CANADA
THAT SHUT DOWN
THE POWER GRID.
IT WAS PRETTY BIG,
AND IT WAS GOING TO
AFFECT THE WHOLE SOCIETY.

THAT'S WHAT
GOT ME TOO.

SO,
THE GREAT EXPLOSION
OF THE SUN
HAS COME TO
CAUSE GREAT DAMAGE
TO OUR SOCIETY.

THIS KIND OF DAMAGE
DID NOT HAPPEN
50 OR 100 YEARS AGO.

OH?
WHY?

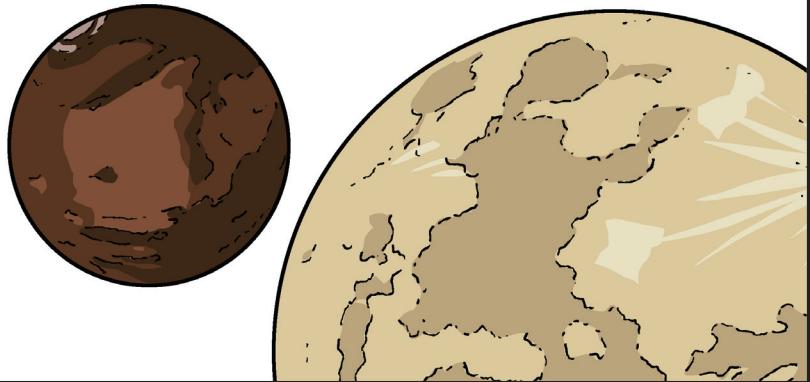
AH, YES!

I SEE!
I WASN'T
EVEN BORN YET
AT THAT TIME.

THIS IS BECAUSE
THE POWER GRID
AND COMPUTER EQUIPMENT
DID NOT EXIST
IN THAT PERIOD
AS IT DOES TODAY.

IN PARTICULAR,
THE EVENT OF "DAMAGE TO SATELLITES" IS
A "SPACE DISASTER" THAT HAS OCCURRED
OVER THE PAST FEW YEARS TO DECADES
AS HUMANS HAVE EXPANDED
INTO SPACE!

AS HUMANS TRAVEL
TO THE MOON AND MARS
IN THE COMING YEARS,
IT WILL BECOME
INCREASINGLY IMPORTANT
TO PREVENT DAMAGE
FROM SUCH DISASTERS!



IN SOME SITUATIONS,
SUCH AS TRANSPORTATION
AND MEDICAL CARE,
DISASTERS CAN
IMMEDIATELY AFFECT
HUMAN LIVES.

IF WE COULD USE THE
"SPACE WEATHER FORECAST"
TO KNOW THAT
A PARTICULARLY STRONG
MAGNETIC STORM IS COMING,

JUST AS WE KNOW
FROM THE WEATHER FORECAST
THAT A WINDSTORM
OR STORM IS COMING.

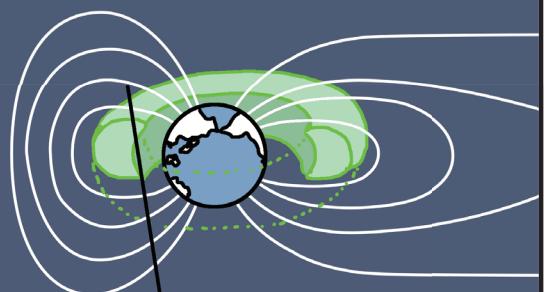
IT MAY
LESSEN THE DAMAGE,
AS IN,
"IT'S DANGEROUS,
SO LET'S NOT
GO OUTSIDE FOR A WHILE."

SO,
HOW DO YOU
FIGURE OUT
HOW AND WHEN
MAGNETIC STORMS
OCCUR?

THE JAPANESE SATELLITE
"ARASE"
WAS LAUNCHED IN 2016
TO UNDERSTAND
HIGH-ENERGY PARTICLES
FLOWING TO EARTH FROM SPACE.

IT CONTINUES
TO OBSERVE
IN THE "VAN ALLEN BELT,"
A REGION THAT
ENCIRCLES THE EARTH.

IT LOOKS LIKE A DONUT!



Dr. YOSHIZUMI MIYOSHI SENSEI

THE AREA IS FULL OF RADIATION,
WHICH IS NORMALLY
A VERY HARSH ENVIRONMENT
FOR OBSERVATION EQUIPMENT,
BUT IT IS WORKING VERY HARD
AND SENDING US DATA!

GEOSPACE SATELLITE "ARASE"

THE SUN IS KNOWN
TO INCREASE
AND DECREASE
IN ACTIVITY
IN AN 11-YEAR CYCLE

IT WILL REACH
ITS MAXIMUM
IN 2024-2025,
SO THIS IS
A VERY ACTIVE PERIOD.

WE CAN OBSERVE THE MAGNETIC STORMS THAT ARE HAPPENING RIGHT NOW.

WHAT MAGNETIC STORMS HAVE OCCURRED IN EARTH'S HISTORY UP TO THE PRESENT?

IT IS VERY DIFFICULT TO KNOW THIS

IN THE TIME OF OUR ANCESTORS, THERE WAS NO EQUIPMENT TO MAKE OBSERVATIONS.

OH

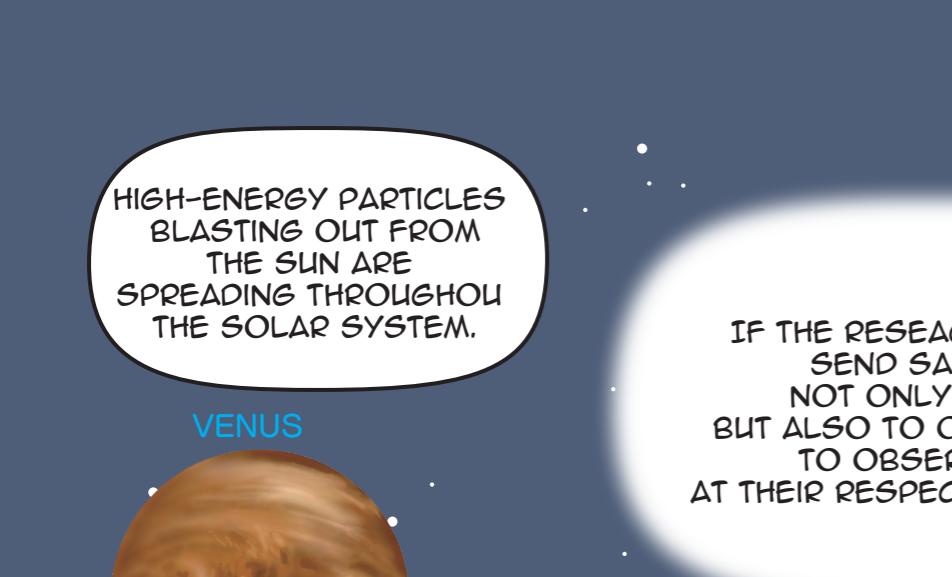
THAT'S TRUE

HOWEVER, IT WAS SAID. PEOPLE SAW AURORAS IN PLACES WHERE THEY WOULD NOT NORMALLY SEE THEM WHEN GEOMAGNETIC ANOMALIES OCCURRED.

SUCH RECORDS HAVE BEEN FOUND IN ANCIENT DOCUMENTS.

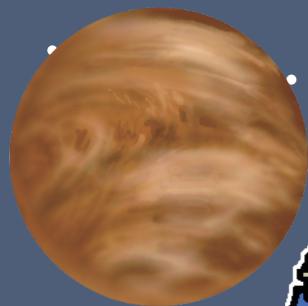
PEOPLE TEND TO THINK THAT RESEARCH ON AURORAS AND OTHER PHENOMENA IS SOMETHING THAT ONLY SCIENCE AND ENGINEERING PEOPLE DO, BUT WE ARE ALSO COLLABORATING WITH RESEARCHERS IN THE FIELD OF HISTORICAL RECORD TO FIND OUT WHAT HAPPENED AND WHEN!

IN THE OLD DAYS, WHEN PEOPLE SAW THE MOUNTAINS TURNING RED, THEY MIGHT HAVE BEEN SCARED THINKING IT MUST BE A FIRE...



HIGH-ENERGY PARTICLES BLASTING OUT FROM THE SUN ARE SPREADING THROUGHOUT THE SOLAR SYSTEM.

VENUS



IF THE RESEARCHERS COULD SEND SATELLITES NOT ONLY TO EARTH BUT ALSO TO OTHER PLANETS TO OBSERVE THEM AT THEIR RESPECTIVE LOCATIONS



RESEARCH TEAMS FROM AROUND THE WORLD ARE EMBARKING ON A SERIES OF INVESTIGATIONS!



JUICE

DEIMOS

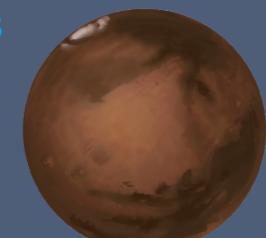


JUPITER



EUROPA

PHOBOS



NAVIC



QZSS



GOES



PSP



DSCOVR



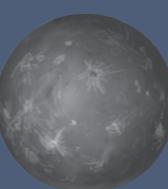
HINODE



GPS



MERCURY



MIO



THE EARTH



METEOROLOGICAL SATELLITES, POSITIONING SATELLITES, ETC HAVE WORKED AN IMPORTANT ROLE FOR THE SPACE WEATHER.

THE MOON

ARTEMIS



THE MOON

MMS



MMS

ARASE



GLONASS



GALILEO



BEIDOU



IF THEY CAN DO THIS, WE WILL BE ABLE TO UNDERSTAND MORE ABOUT THE ACTIVITY OF THE SUN AND THE FLOW OF PARTICLES, AND THEY WILL BE ABLE TO PREDICT WHAT KIND OF WINDS AND STORMS WILL BLOW IN THIS SPACE.

IN THE FUTURE,
OUR SOCIETY WILL BE
MORE AND MORE VULNERABLE
TO DISASTERS FROM SPACE,
AS WE WILL HAVE
EVEN MORE ELECTRIC POWER
AND INFORMATION DEVICES!

"SPACE WEATHER FORECASTING"
MUST ENABLE
"SPACE DISASTER PREVENTION"
AND "DISASTER MITIGATION."



MORE AND MORE
COUNTRIES ARE
TACKLING
THIS PROBLEM!

DISCUSSIONS ON
SPACE WEATHER ARE
UNDERWAY AT
THE UNITED NATIONS.

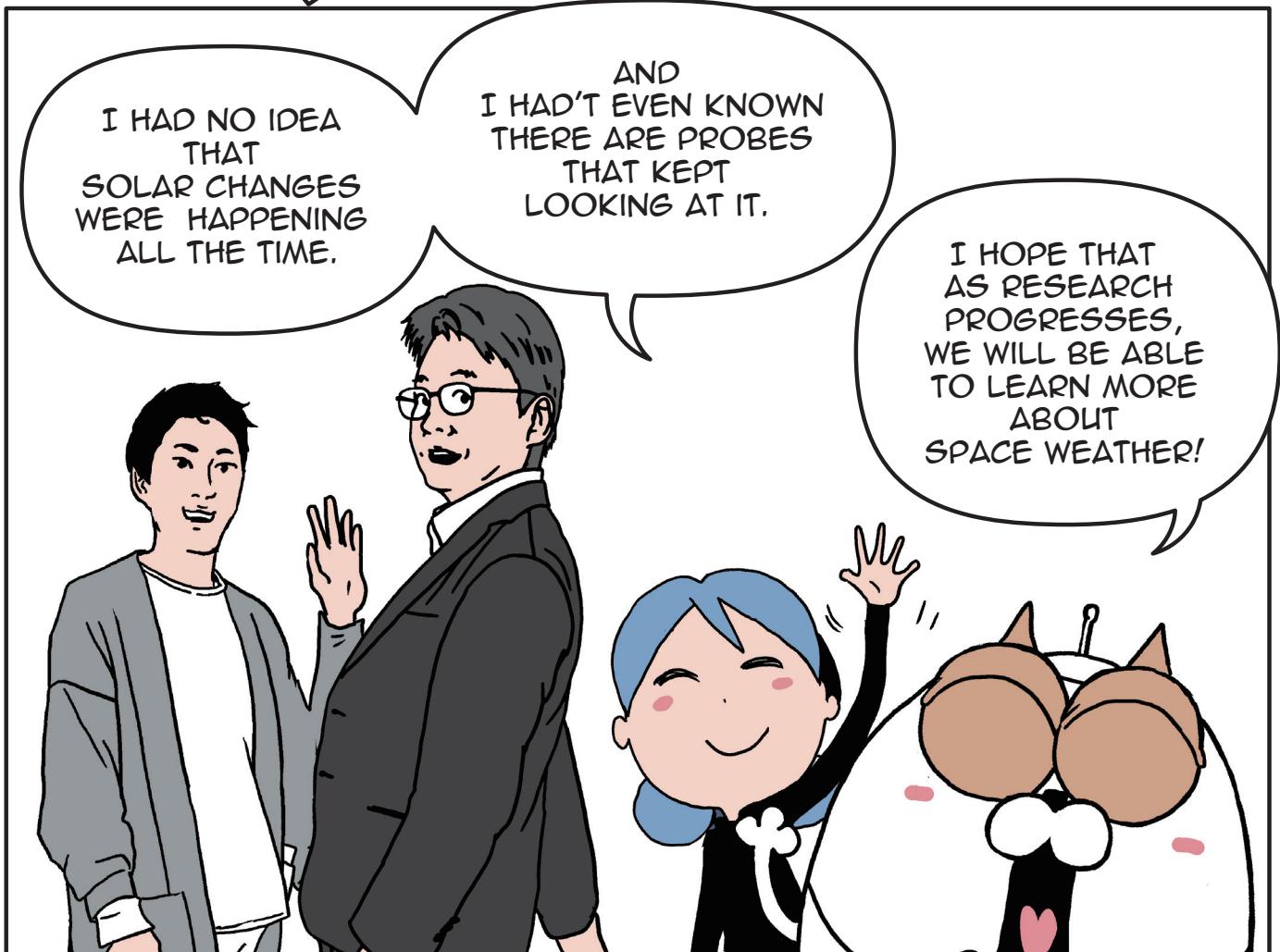
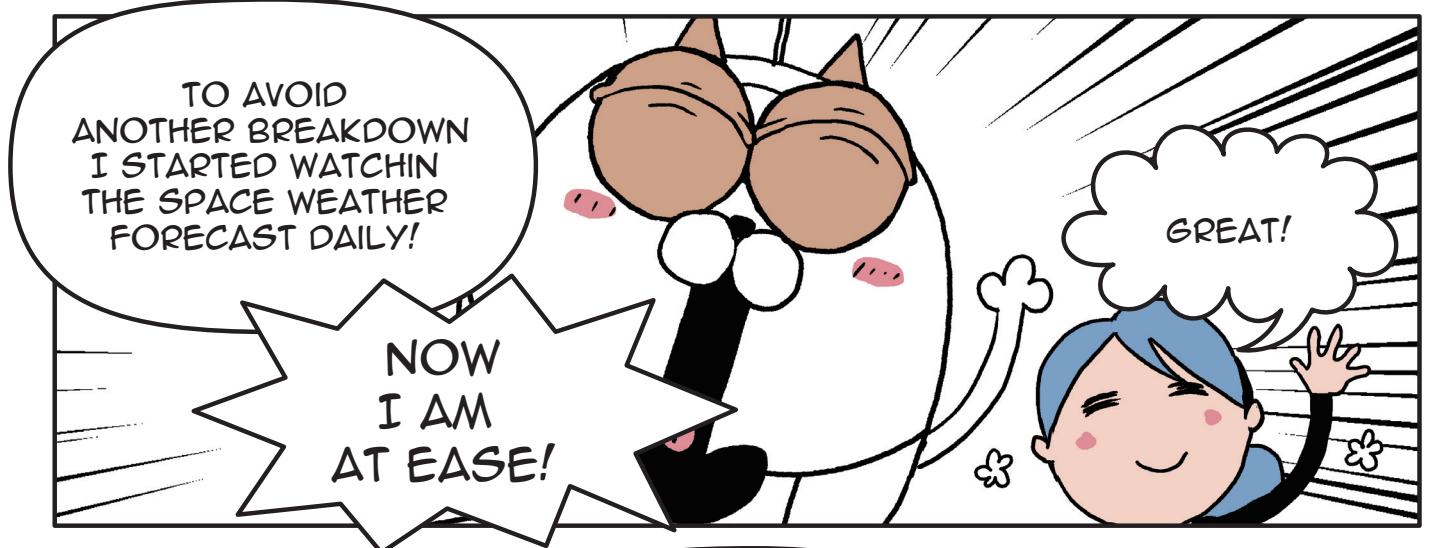
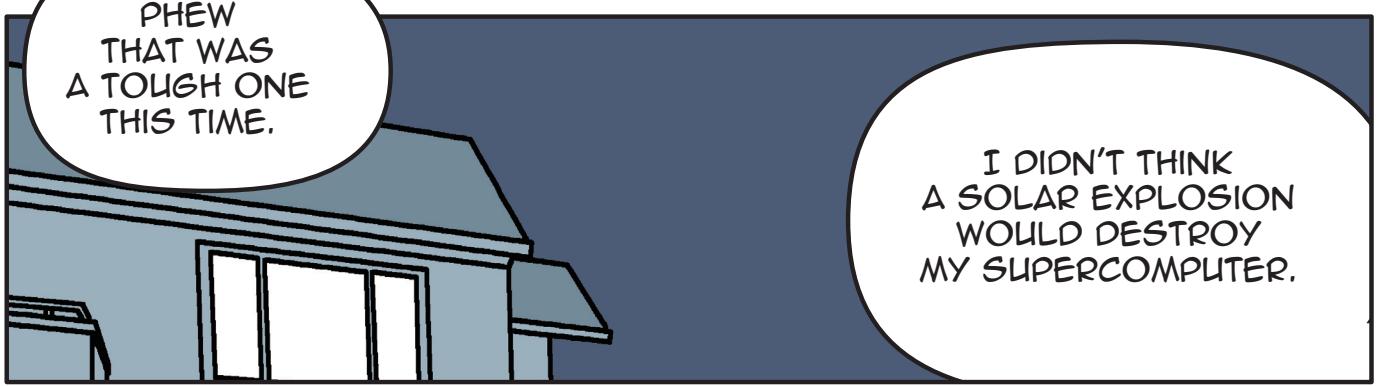
Link to UNITED NATIONS Office for Outer Space Affairs
<https://www.unoosa.org/oosa/en/ourwork/topics/space-weather.html>

SOME MAY THINK
THAT THIS IS NONE OF
THEIR BUSINESS...
BUT MANY PARTS OF
SOCIETY ARE AFFECTED
BY SPACE WEATHER!

I HOPE THAT PEOPLE
WHO HAVE NEVER HEARD OF
SPACE WEATHER WILL LEARN
ABOUT IT AND THINK ABOUT
HOW WE ARE LIVING TOGETHER
IN SPACE,
LIVING WITH A STAR
CALLED SUN.

OKAY,
I GOT IT.

I'LL HAVE TO
KEEP AN EYE
ON THE SPACE
WEATHER FORECAST
TOO.



What's a space weather forecast?



MOL: Sensei, what is space weather forecasting? Does it mean rain and wind in space...!?



SENSEI: Space weather forecasting means that we observe solar activity and solar wind conditions to predict what will happen, and thereby predict and inform you of the effects on the electromagnetic environment on the Earth and on communication and power grids....



MOL: Is solar activity relevant?



SENSEI: The energy and materials emitted from the Sun create the weather around the Sun. You may have heard of solar flares or coronal mass ejections.



MIRUBO: I know what they are! (Mmm, that's a tough one! Let's sneak out and search for it on my super smartphone...!)



SENSEI: The electromagnetic environment on the Earth can be affected by "plasma" and "magnetic fields" emitted from the Sun. Especially when solar activity is intense, the effects are often significant.



MOL: By influence, you mean something bad happens, right?



SENSEI: For example, a strong magnetic storm can affect communications equipment and power facilities, and can also interfere with satellite and spacecraft operations.



MIRUBO: That's a big problem! I wish you'd tell me before that happens, man!



MOL: How do you know that a magnetic storm is about to hit? What methods do you use to find out?



SENSEI: Observational instruments are used to observe solar activity such as solar flares and coronal mass ejections, and ground-based instruments and space satellites are used to observe the magnetic field and plasma around the Earth. Based on these observation data, numerical simulations and analyses are conducted to forecast space weather.



MIRUBO: So if we observe and find changes, we can tell that "the Sun has exploded, and a storm is coming...! That's a big help!



SENSEI: We live in an era where humans are increasingly expanding into space. People will need this much more than before. Space weather forecasting is useful in a wide range of applications, such as protecting the infrastructure that is essential to modern society, including satellite communications, GPS, and the power grid, as well as providing safety measures for space navigation and space travel.



SENSEI: Space weather forecasting also makes it possible to predict weather changes caused by solar activity.



MOL: So you can tell from the space weather forecast that a magnetic storm is coming and that there will be a great aurora borealis! This could be good for people who definitely want to see the Northern Lights when they travel. I would hate to go on a trip and not be able to see them...



M I R U B O : I have a state-of-the-art supercomputer in my head, and I don't want it to fail due to a magnetic storm... How can I get access to the space weather forecast?



SENSEI: Even ordinary people can easily check space weather forecasts via the Internet or smartphone apps! In addition, some countries and regions have their own organizations that publish space weather forecasts.



MOL: Wow! Is that so! I thought it was something you had to be an expert to see. And, well... I hate to say this, but are space weather forecasts accurate...?



SENSEI: Well, yes... Current space weather forecasting has limitations in accuracy and prediction period. Also, there are still many unknowns in predicting solar activity. It is hoped that the development of more advanced observation and analysis techniques will enable more accurate space weather forecasting in the future.... That's the way it is at the moment.



MOL: I see..! So space weather forecasting will continue to evolve...?



SENSEI: Space weather on the Moon and Mars will become more and more important as the area of human activity expands in the future.



MIRUBO: I'm rooting for it to get better in the future!

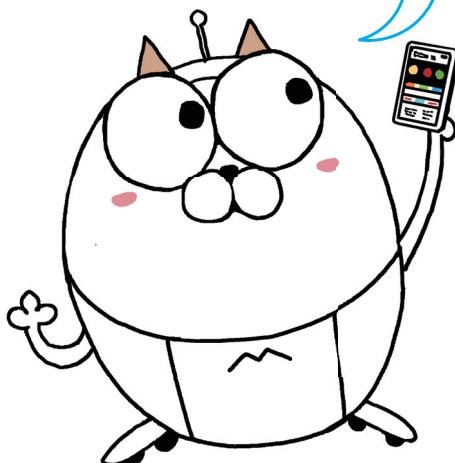


SENSEI: Please take a look at the news about space weather forecast when it is available!

I took a look at NICT's space weather forecast on my smartphone!

On the page, I can see data of sunspots on the surface of the Sun, prominence, and flare (corona) conditions on the Sun's surface.

Other various values and graphs such as the number of sunspots, solar flares, and changes in the geomagnetic field can also be seen.



NICT Space Weather Forecast

This is the site of an information distribution service specializing in space weather forecasts, operated by the Space Environment Research Laboratory, Electromagnetic Wave Research Institute, National Institute of Information and Communications Technology (NICT).
<https://swc.nict.go.jp/en/>

NOAA/SWPC Weather Forecast

This is an information site by the U.S. National Oceanic and Atmospheric Administration's (NOAA) Research Laboratory and the Weather Prediction Center (SWPC).

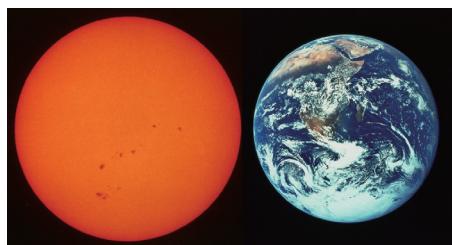
<https://www.swpc.noaa.gov/>



Institute for Space-Earth Environmental Research (ISEE), Nagoya University

The Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan, was launched in October 2015 by merging three institutes of Nagoya University: the Solar Terrestrial Environment Laboratory, the Center for Hydroospheric Atmospheric Research, and the Center for Chronological Research. The mission of the ISEE is to clarify the mechanisms and mutual relationships of the Earth, the Sun, and cosmic space, treating them as a seamless system and to benefit humanity by resolving issues in the global environment and contributing to the advances of space exploration. <https://www.isee.nagoya-u.ac.jp/en/>

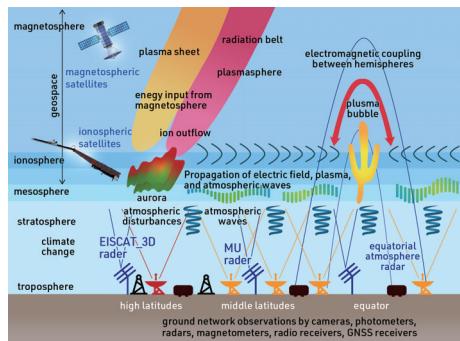
SCOSTEP Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)



Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) is one of the Affiliated Bodies of the International Science Council (ISC) and is a permanent observer at the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). SCOSTEP promotes ISC's mission to strengthen international science for the benefit of society, by running long-term (4-5 years) international interdisciplinary scientific programs of solar terrestrial physics. SCOSTEP promotes capacity building and outreach activities on the Sun-Earth System and how it affects life and society. <https://scostep.org/>

PBASE PBASE Program

The PBASE Program is an international joint research project to contribute to safe and secure space utilization by further internationalizing and upgrading geospace change research and prediction using large-scale observation facilities for geospace (space around the Earth) and upper atmosphere. By involving young researchers and graduate students in this research, the project aims to foster researchers and engineers who will play central roles in future geospace research and development. This booklet is produced with the support of the PBASE program (JSPS Grant-in-Aid for Scientific Research and International Leading Research: 22K21345). <https://www.isee.nagoya-u.ac.jp/dimr/PBASE/en/>



Hayanon

Science manga artist, born in 1975. Graduated from the Department of Physics, Faculty of Science, University of the Ryukyus, with a B.A. (Science). M.A. (Education) in English Education, Graduate School of Education, Chiba University. Her representative works include "GoGo! MIRUBO" (Kodomo no Kagaku), "Fantastic R&D" (Nikkan Kogyo Shimbun), "Lerning Earth Science with MIRUBO" (NASA), "International Science Olympiad Manga" (Japan Science and Technology Agency). She is a representative of "Science Manga Studio," a PR for research business.

Science Manga Studio, Japan

The studio produces manga introducing research in all fields of science and humanities, cover art for academic journals, and provides illustrations explaining the results of research institutions' presentations. Through the production of these works, the studio fosters young science illustrators.

Science illustrators in the production

partly918, Kamito Sumi, Ms.Shell, Milli, and Mochiduki Ami from Science Manga Studio.

What Is…?! Series

This is a research introduction Manga series started in 2002. You can learn about the study of the Sun - Earth with Sensei, Mirubo and Mol.



<https://www.isee.nagoya-u.ac.jp/en/outreach.html>

ISEE MIRUBO

SEARCH

PDFs are distributed free of charge. In addition to the English version, Japanese and other foreign language versions are also available.