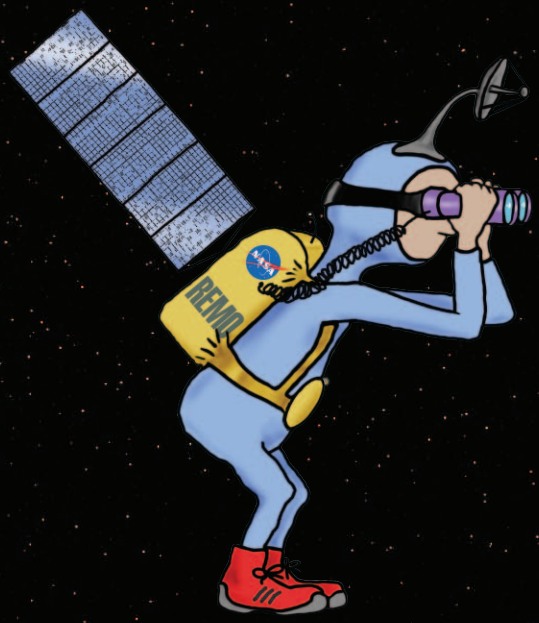
National Aeronautics and Space Administration

Looking at Earth

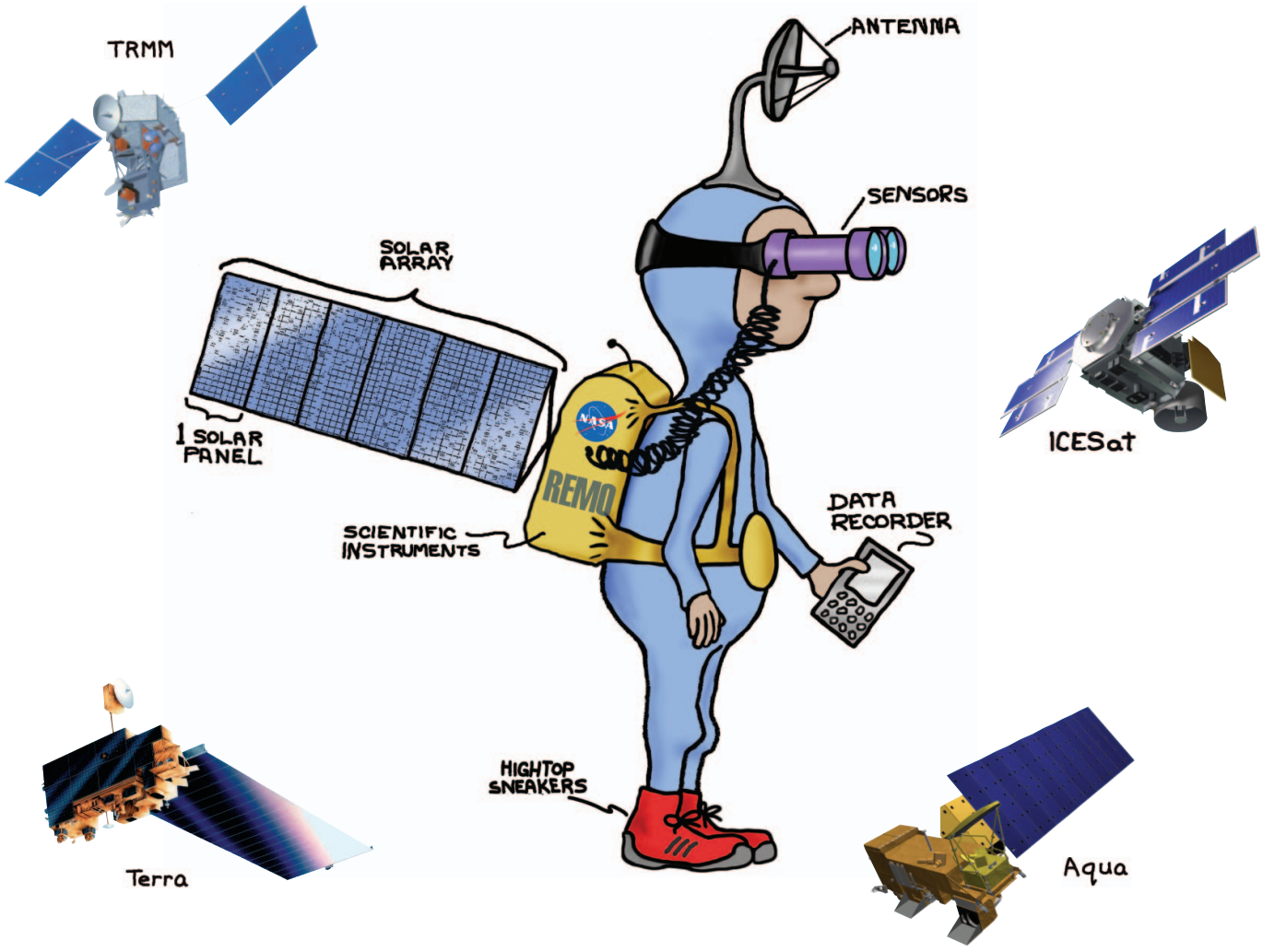
A Family Activity Book



Looking at Earth with REMO

This is REMO. REMO is a Remote Earth-Monitoring Observer. He uses *remote sensing*, which is studying something from a distance, to look at Earth.

Together with his satellite friends, he orbits Earth, always recording things that he finds out. And then he tells us all about them.



With the help of NASA satellites, we can understand how Earth's climate works and changes over time.

Let's see what REMO has found out so far...

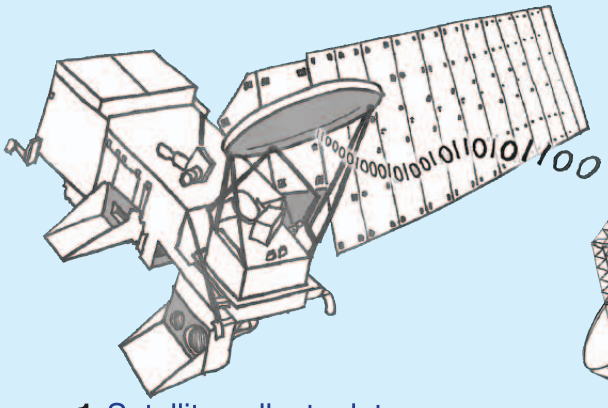
Why There's No Place Like Home

REMO has learned that Earth is a special place. He gets together with other spacecraft to talk about their journeys to other planets. They tell him Venus is like an oven and Mars is like a freezer. REMO tells them, "Earth isn't too hot or too cold; it's just right for life!"

	Venus	Earth	Mars
Average surface pressure (relative to Earth's atmosphere)	93.0	1.0	0.007
Carbon dioxide (CO_2) (percent of planet's atmosphere)	96.5%	0.04%	95.3%
Oxygen (O_2) (percent of planet's atmosphere)	0	20.9%	0.13%
Average Surface Temperatures	465°C (870°F)	15°C (59°F)	-65°C (-85°F)

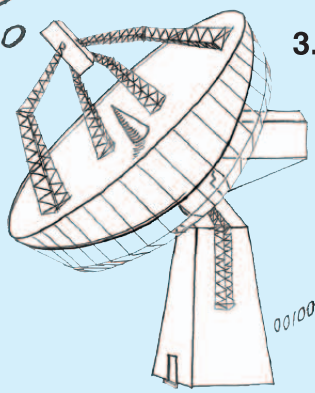
How Do REMO's Satellite Friends Work?

Many NASA satellites use their sensors to collect information about Earth. Some sensors measure the amount of light reflected from Earth and record that information as numbers. The satellite transmits the numbers down to Earth in the form of binary code—zeroes and ones—where computers store the data until people analyze it.



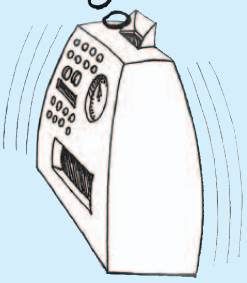
1. Satellite collects data

2. Satellite sends data to ground station



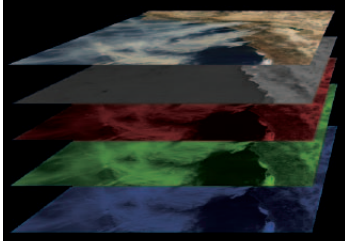
3. Ground station collects data and sends to processing facility

4. Data processing



5. Image generated and ready for study

A natural-color image of wildfires in southern California and the northern Baja California Peninsula on October 26, 2003. It is made by combining separate images from different parts of the visible color spectrum and overlaying hot fires from an infrared channel.



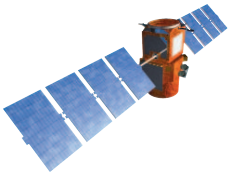
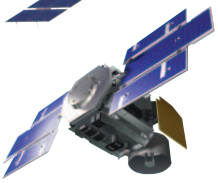
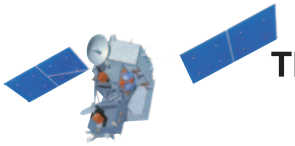
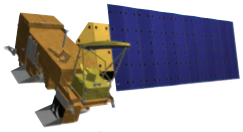
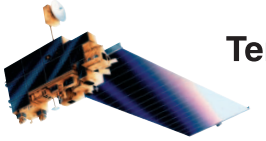
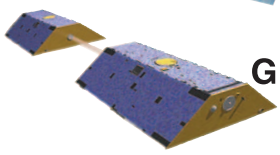
Natural color
Infrared
Red
Green
Blue

In addition to visible light, some satellite sensors can detect other forms of light that the human eye cannot see. This non-visible light data give scientists important information about the Earth's atmosphere, land, ocean, and cryosphere (sea ice and land snow/ice) and make satellite instruments indispensable tools for understanding our climate.

Images generated from satellite data are often made to highlight features of interest to scientists. "False-color" composite images are not true to real-life color, but provide contrast to features that are not readily seen with the human eye. They are made with a combination of visible and/or non-visible light data.

What's in a Name?

REMO's satellite friends below are members of NASA's Earth Observing System (EOS) fleet. Each satellite name tells a story about what part of Earth it studies. Using the name's meaning as your guide, draw a line to the satellite's favorite subject.

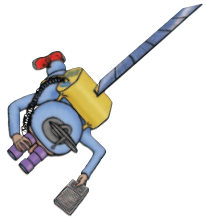
REMO's Friend	Meaning	Subject
 **CALIPSO**	**C**loud-**A**erosol **L**idar and **I**nfrared **P**athfinder **S**atellite **O**bservation	Earth's continents and land surfaces (2 possible answers)
 **OSTM**	**O**cean **S**urface **T**opography **M**ission	A flagship satellite of the Earth Observing System
 **ICESat**	**I**ce, **C**loud, and land **E**levation **S**atellite	Precipitation from hurricanes and other storms
 **TRMM**	**T**ropical **R**ainfall **M**easuring **M**ission	How clouds and aerosols affect climate
 **Aqua**	Latin word for "water"	Air quality, ozone, composition of Earth's atmosphere
 **Terra**	Latin word for "earth"	Earth's gravitational field
 **Landsat-7**	The seventh **L**and **S**atellite	Ocean wave heights, current speeds, and circulation
 **GRACE**	**G**ravity **R**ecovery and **C**limate **E**xperiment	Ice sheet mass, clouds over polar regions, land features
 **Aura**	Latin word for "breeze, wind, or air"	All forms of water: ice, water vapor, rain, snow

Answers are below.

CALIPSO - How clouds and aerosols affect climate
OSTM - Ocean wave heights, current speeds, and circulation
ICESat - Ice sheet mass, clouds over polar regions, land features
TRMM - Precipitation from hurricanes and other storms
Aqua - Ice, water vapor, rain, snow

Terra - A flagship satellite of the Earth-Observing System; also, Earth's continents and land surfaces
Landsat-7 - Earth's continents and land surfaces
GRACE - Earth's gravitational field
Aura - Air quality, ozone, composition of Earth's atmosphere

Aerosol Word Jumble

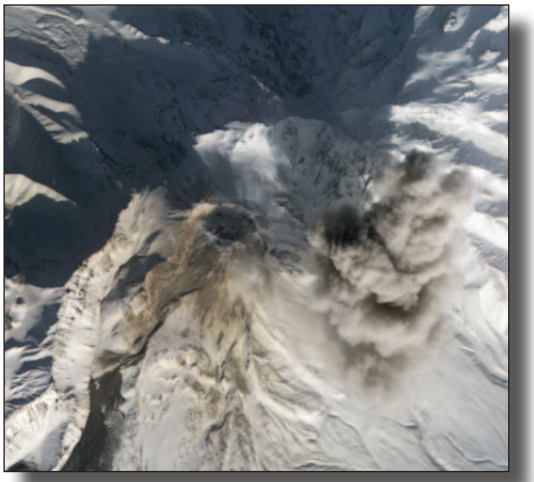


Unscramble the letters in some of the words below.

Haze over the Hudson River, New York City

Aerosols are **itny** particles in the atmosphere. You see them as the **ezha** that is sometimes **gginahn** around cities.

Desert **stdu** and eruptions from volcanoes are **ssoorela** that occur in **enautr**.

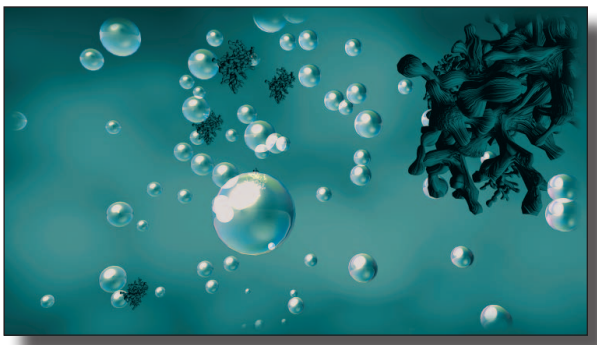


Terra satellite image of the Shiveluch volcano erupting in Russia, February 2008

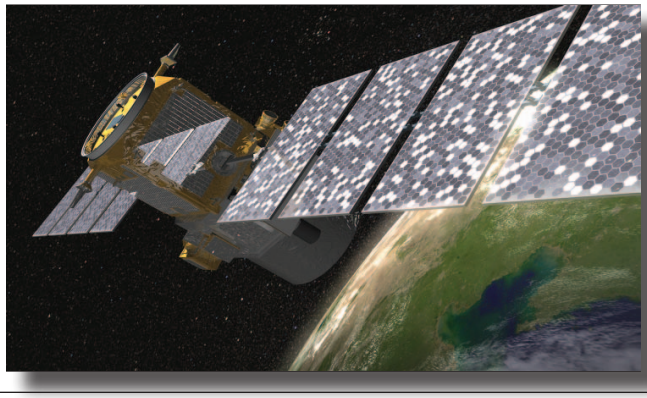
Coal-fired power plant

Pollutants from industrial activity and from vehicles create man-made aerosols, like those generated from **tsauehx**.

Aerosols can affect climate by reflecting and absorbing solar radiation. Some **cta** as "seeds" around which a **cudol** of droplets forms, in a process called *nucleation*. **giHh** aerosol concentrations in clouds can potentially change precipitation by limiting the size and number of **spordniar**.



Water molecules stick to aerosol particles, eventually forming cloud droplets.



One of REMO's friends is CALIPSO. CALIPSO's **ojb** is to study how aerosols and clouds affect climate.

Answers are below.

tiny haze hanging dust aerosols nature exhaust
act cloud High raindrops job

Aerosol Word Find

The 21 words from the word list below are related to aerosols. Circle them in the Word Find box. They can run horizontally, vertically, and diagonally.

WORD LIST

DUST	NUCLEATION	RAINFALL
ERUPTION	DROPLET	HAZE
SOLAR	WIND	CONCENTRATION
POLLUTANT	DESERTIFICATION	CLOUDS
AEROSOL	PRECIPITATION	ATMOSPHERE
PARTICLE	VOLCANO	CONTRAIL
TROPOSPHERE	EXHAUST	INDUSTRIAL

D U S T G W S G C N N B E X Y J V U X W
R U U W P I N O Z L U U K R K D D Z Y W
A P U N D M Q U L B O P C V U T O E A S
P O L L U T A N T A L U L L V P S M N F
Y V Q T T Q J N O P R B D F E N T U E E
P R E C I P I T A T I O N S T A G I R Z
W Z Y W N R D O U Y K W S R U H T E O L
C D E S E R T I F I C A T I O N H I L N
D O D N E O H V E H E H V Q D P M A O R
R F N N D N W L V S A A S O S R F X I N
O N M C F K C I L H L Z J O L N I F U I
P D T P E I A I N A Z E P U I C V J Y B
L B A I T N A G I D O O L A Q V A R U N
E N S R R R T R G N R Q R J B R M N C H
T A A S T V T R D T A E R O S O L O O X
A P H N F S W V A A T M O S P H E R E H
E M O O U K J Q D T E X H A U S T T F O
E C P D T V B A R U I G O B T A L C W I
W A N Y Y O J U X Q R O O Z R Z L T A D
V I S K S E N R X S V B N Z C C H M H R

Solution can be found on page 18.

Facts About Ozone True or False

Mark these statements about ozone true (T) or false (F):

1. Ozone (O_3) is a molecule made up of three oxygen atoms. _____
2. The ozone layer shields us from the sun's ultraviolet radiation. _____
3. The cause of the ozone hole is related to ozone reacting with carbon dioxide. _____
4. Each year, the ozone hole over Antarctica is largest during September-October. _____
5. The ozone "hole" is an actual hole in the stratosphere. _____
6. Polar clouds in the stratosphere help shield ozone from chlorine. _____
7. Ozone in the troposphere, the lower part of the atmosphere, can be found in smog. _____
8. The concentration of ozone is highest in Earth's stratosphere. _____

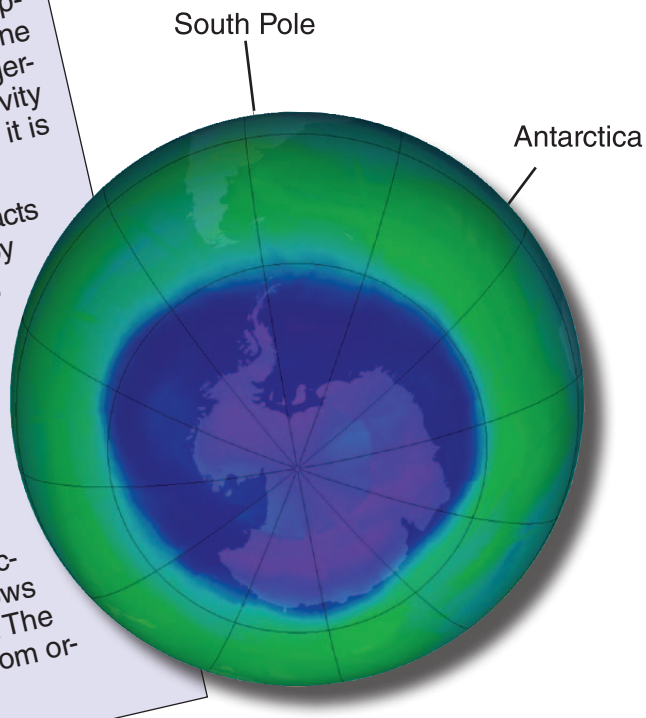
Answers are below.

REMO says...

Ozone (O_3) is a gas found in tiny amounts in our upper atmosphere, the stratosphere. This "good" ozone forms a layer that protects us by absorbing dangerous ultraviolet radiation from the sun. Human activity creates "bad" ozone closer to the ground, where it is a harmful pollutant.

"Good" ozone can be destroyed when it reacts with chlorine, introduced into the atmosphere by human activity. During August through October, the amount of ozone in the stratosphere over Antarctica drops. Additionally, polar stratospheric clouds that form during this time help chlorine deplete ozone. This region of low ozone amount is called the ozone "hole", though it's not an actual hole in the stratosphere.

This map of the world (right) shows Antarctica in false colors. The purple area shows the ozone hole on September 12, 2008. The map was made from data sent down from orbit by NASA's Aura satellite.



1. **True.**
2. **True.**
3. **False.** The ozone hole is caused by molecules of ozone reacting with chlorine in the stratosphere.
4. **True.**
5. **False.** The "hole" is an area where ozone is less than in surrounding regions, but it isn't an actual hole.
6. **False.** Polar clouds interact with chlorine to deplete ozone.
7. **True.** Smog is a type of air pollution in the troposphere, the lower layer of the atmosphere. Smog can contain many chemical ingredients, including ground-level ozone.
8. **True.** 90% of ozone is in the stratosphere, the layer between the troposphere and mesosphere.

Ozone Hole Double Puzzle

Twelve words from Ozone Facts are scrambled below. Unscramble them and copy the letters in their numbered boxes to the boxes at bottom of this page to find a message about ozone.

1. NAACCATRIT

									A
				13					

hint: a continent

2. SRSEHATOTREP

	T										E
					4		14				

hint: about 90% of atmospheric ozone is located here

3. RUTOILEATVL

						I				T
	2									

hint: shortwave

4. DAITIANOR

		D						
							1	

hint: #3 is a type

5. HINROELC

19			6				

hint: ozone-depleting

6. OMLEUCEL

					22	9	12

hint: ozone is one

7. SEPMERTOHA

					P				
10	17			23				15	

hint: Earth's life support

8. NOXYGE

		11		18	7

9. NOEZO

	5			

10. CONREITAONNTC

C											N
				8		20					

hint: ozone's highest in the stratosphere

11. PORAL

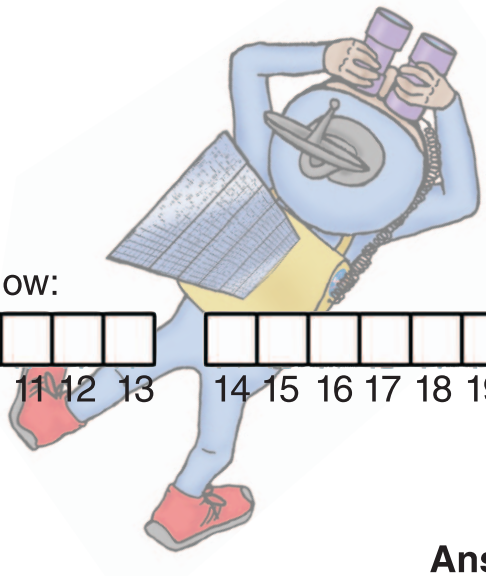
				3

12. SMGO

21		16	

Something important we all should know:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

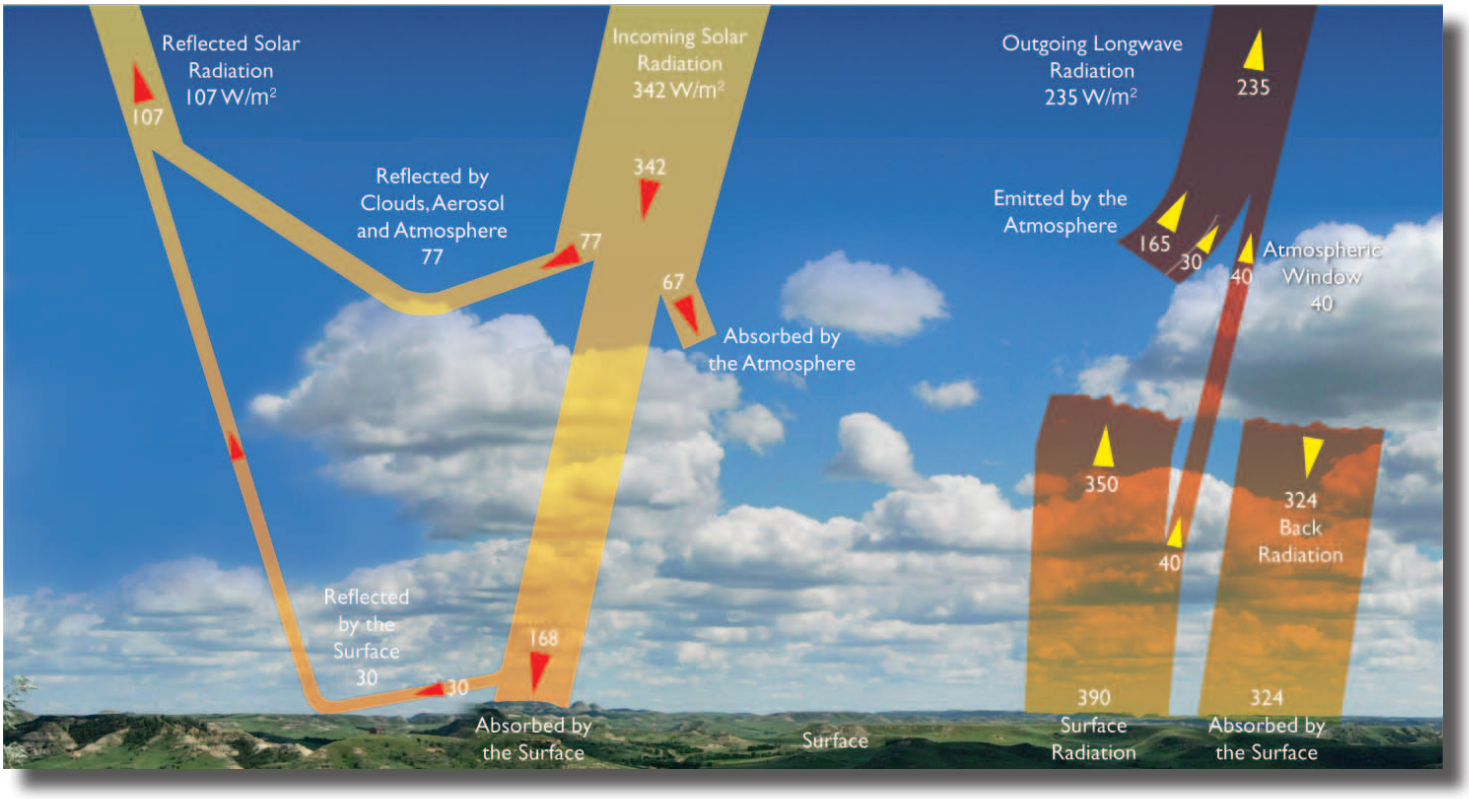


Answers are below.

1. antarctica, 2. stratosphere, 3. ultraviolet, 4. radiation, 5. chlorine, 6. molecule, 7. atmosphere, 8. oxygen, 9. ozone, 10. concentration, 11. polar, 12. smog. The message is: Our ozone layer protects us.

Earth's 'Radiation Budget' - Fill in the Blanks

Earth is a welcome place for life because radiative energy from the sun is distributed "just right." REMO can speak in terms of watts per square meter (W/m^2), or power per unit of area, to tell us how the sun's energy interacts with Earth. Fill in the blanks below using this picture as your guide.



The average daily amount of solar radiation reaching the top of Earth's atmosphere is __ __ __ watts per square meter (W/m^2).

The atmosphere absorbs __ __% of the sun's radiation.

The amount of solar radiation absorbed by Earth's surface is __ __%.

Thirty percent (30%) of solar radiation is reflected back into space by clouds, aerosols, the atmosphere, and Earth's __ __ __ __ __ __ __.

The amount of average radiation **emitted** by Earth's surface is __ __ __ W/m^2, but only __ __ W/m^2 actually escapes all the way back into space.

This kind of radiation is called __ __ __ __ __ __ __ __ radiation and is, relative to visible light, from the "long" wavelength part of the spectrum. It can sometimes be perceived as heat.

Answers are below.

On the next page, see how some greenhouse gases can affect the sun's radiation.

The average daily amount of solar radiation reaching the top of Earth's atmosphere is **342** watts per square meter (W/m^2).
The atmosphere absorbs **20**% of the sun's radiation.
The amount of solar radiation absorbed by Earth's surface is **49**%.
Thirty percent (30%) of solar radiation is reflected back into space by clouds, aerosols, the atmosphere, and Earth's **surface**.
The amount of average radiation emitted by Earth's surface is **390** W/m^2, but only **40** W/m^2 actually escapes all the way back into space.
This kind of radiation is called **infrared** radiation and is, relative to visible light, from the "long" wavelength part of the spectrum. It can sometimes be perceived as heat.

Greenhouse Gas Match Up

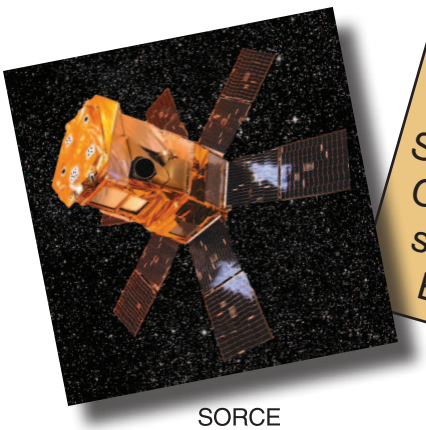
Earth's 'radiation budget' can change when the amount of greenhouse gases in the atmosphere goes up. Greenhouse gases absorb heat from the sun and trap it in the atmosphere.

Draw a line connecting each source of greenhouse gas in the column on the left with its "fun fact" in the middle. Then write in the blank if the source is natural or man-made.

Source	Fun Fact	Natural or Man-made?
Cars	These insects are the second biggest source of methane after wetlands.	_____
Cows	It's estimated there are 600 million of these carbon dioxide emitters on the road.	_____
Termites	These were kept cold with ozone-depleting CFCs, but now use HFCs, which are a potent greenhouse gas.*	_____
Refrigerators	The digestion of food in these creatures' four stomachs produces methane.	_____

* *CFCs* stand for chlorofluorocarbons and *HFCs* stand for hydrofluorocarbons

Answers are below.



SORCE

REMO says...

SORCE, the SOlar Radiation and Climate Experiment, studies the sun's energy and how it affects Earth's climate.

Cars: 600 million; man-made source
Cows: Four stomachs; natural source
Termites: Insects; natural source
Refrigerators: These were kept cold with ozone-depleting CFCs, but now use HFCs, which are a potent greenhouse gas.

How We Change Earth

Fill in the blanks with words from the word bank to discover some ways in which climate can be affected by humans changing Earth's surface.

Word Bank: carbon dioxide, coral, cut down, water, cities, temperatures, acidification, carbonic, ocean, hydrochloric, denitrification, clouds

_____ grow.

Sometimes trees are _____ _____ .

Then, there are less trees to absorb _____ _____ .

The _____ also absorbs carbon dioxide.

Ocean _____ occurs because

carbon dioxide + _____ = _____ acid.

Wildlife is impacted. For example, _____ growth may slow.

Answers are below.

1. cities 2. cut down 3. carbon dioxide 4. ocean 5. acidification 6. water 7. carbonic 8. coral

Letter Tiles About Land Use

Below are four facts about growth of cities, population, land use. Unscramble each set of tiles to reveal a fun message about how humans change Earth.

for example:

ABO	UT 2	ER .	PAP	N OF	EES
IT T	4 TR	TO M	AKES	AKE	A TO

IT T	AKES	ABO	UT 2	4 TR	EES
TO M	AKE	A TO	N OF	PAP	ER.

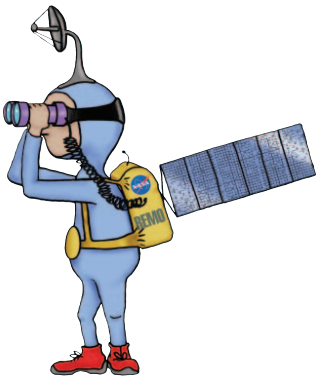
*

* Paper used for printing and writing, not newspaper.

1.

OF T		THER	2.7 MI	ITY	OPLE
ER 1	N PE	E AR	PAN .	E OV	IN T
OKYO	HE C	LLIO	. JA	ING	

	E AR				



2.

N NE	TONS	OF	ARE	GARB	CH D
AGE	RK C	OVER	ITY.	ECTE	W YO
000	D EA	AY I	12,	COLL	

			TONS		

**

** One US ton is 2000 pounds or about 907 kilograms.

3.

I N C	D.	HOT	AUST	ROUN	TEMP
URES	R PE	LIV	ESID	DY.	HE R
OOBE	SO	E UN	A TH	ENTS	RALI
ERAT	DERG	ARE	AT T		

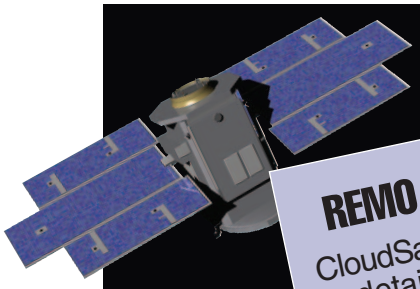
	OOBE				

Answers are below.

1. There are over 12.7 million people living in the city of Tokyo, Japan.
2. Over 12,000 tons of garbage are collected each day in New York City.*
3. Temperatures are so hot in Coober Pedy, Australia that the residents live underground.

*One US ton is 2000 pounds or about 907 kilograms.

Climate Change Crossword (Each answer



REMO says...

CloudSat studies clouds in detail to help us better understand their role in regulating our climate.

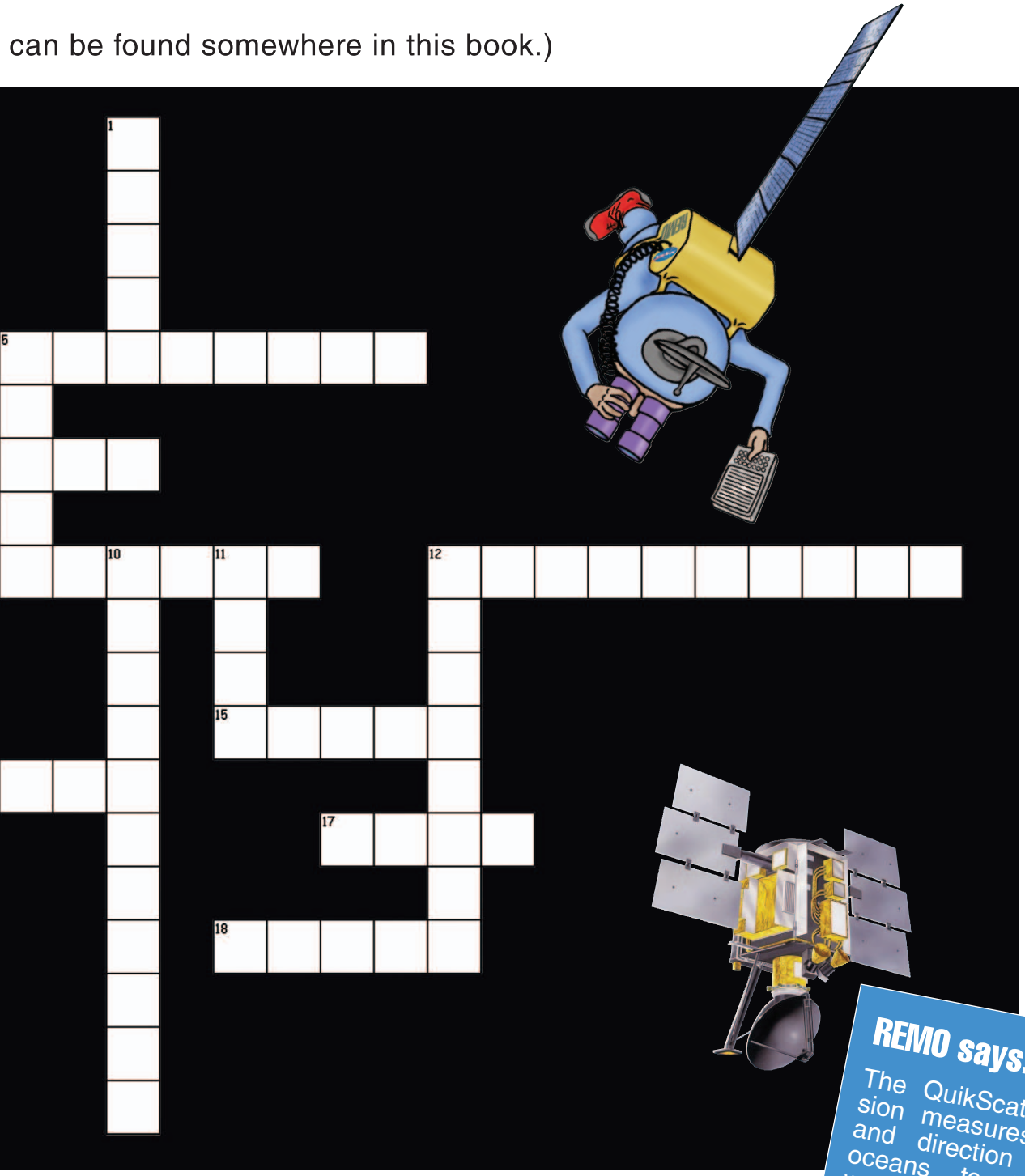
What's this?

Smoke from fire is a type of aerosol. Here is a photo-like image of fires in Los Angeles County, California. But, this picture is not a photograph. It is made from data collected from orbit by NASA's Terra satellite on August 30-31, 2009 and processed on a computer. The red areas show where the fires' hottest spots are located. See the smoke moving from the lower left to upper right?

Across

2. Planet with more oxygen than carbon dioxide
4. Cloud particles resulting from jets in the sky
7. Number of solar panels on the Landsat satellite
8. Greenhouse gas absorbed by trees
9. Super hot town in Australia.
12. Absorbs 20% of the average daily amount of incoming solar radiation
14. Often cut down when cities grow
15. Asian city with HUGE population
16. Studied by the satellite Aqua
17. Ground-level ozone is part of this
18. Planet with no oxygen in its atmosphere

can be found somewhere in this book.)



REMO says...

The QuikScat satellite mission measures wind speed and direction over Earth's oceans to help improve weather forecasting.

Down

1. Measured by satellite sensors
3. REMO's shoes
5. Layer that protects us
6. Distribution of radiative energy from the sun
10. Increases ozone's destruction by chlorine
11. Can be a product of desertification
12. Tiny particles in the atmosphere
13. Trapped by greenhouse gases

Solution can be found on page 18.

Climate Change

(These “items” can be foun

1. Find the name of the numerical code that just uses zeroes and ones.

2. How many oxygen atoms make up a molecule of

3. What condensed water in the atmosphere emits infrared radiation back to

4. Where does a satellite send its data to? ___ ___ ___ ___ ___ ___

5. When does the ozone hole reach its

6. How many more

7. What type of radiation is from the

9. What’s the biggest natural

10. What volcano erupted in Russia in February 2008?

Scavenger Hunt

d somewhere in this book.)

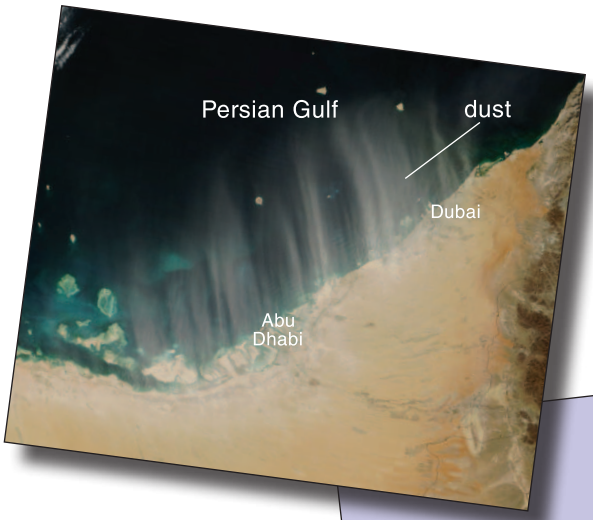
___ ___ ___ ___ ___ ___

ozone? ___ ___ ___ ___ ___

Earth's surface? ___ ___ ___ ___ ___

___ ___ ___ ___ ___ ___ ___

largest size? ___ ___ ___ ___ ___ ___ ___ ___ ___



What's this?

A dust storm blows off the coast of the United Arab Emirates and the Persian Gulf on February 28, 2009. Dust is a type of aerosol. This satellite image was made from data from the Terra satellite. It is not a photograph.

stomachs does a cow have than you do? ___ ___ ___ ___ ___

"long" wavelength part of the spectrum? ___ ___ ___ ___ ___ ___ ___ ___

8. What do REMO's satellite friends look at all the time? ___ ___ ___ ___ ___

source of methane? (hint: it's a type of place) ___ ___ ___ ___ ___ ___ ___ ___

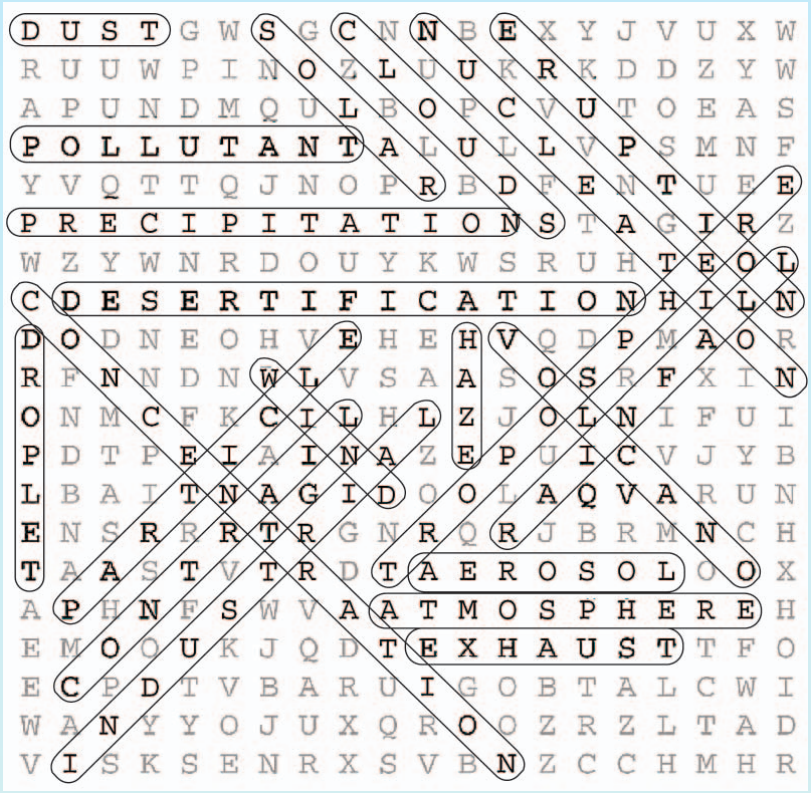
___ ___ ___ ___ ___ ___ ___ ___ ___

Answers are below.

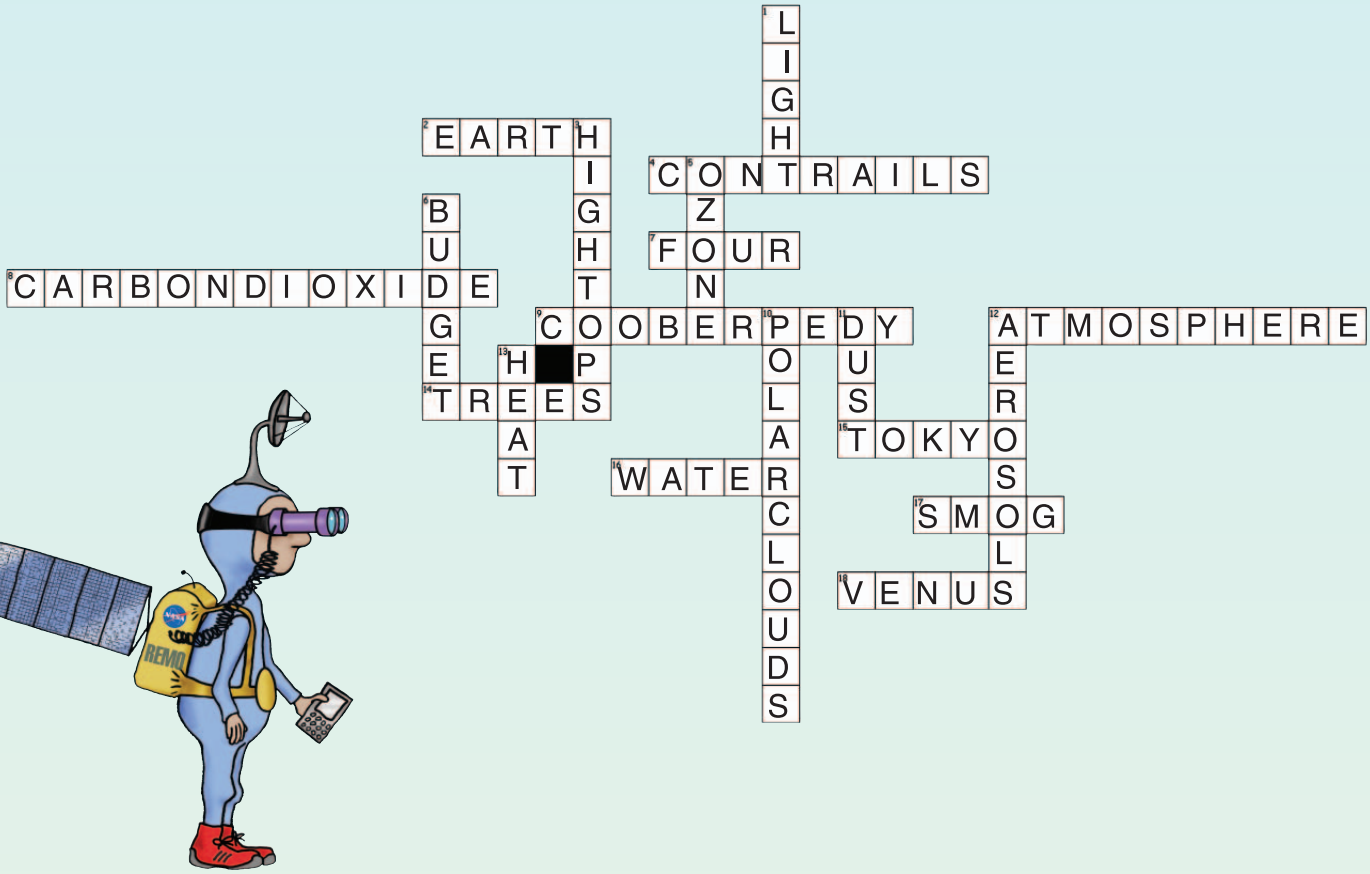
1. Binary . 2. Three. 3. Cloud . 4. Ground station. 5. September. 6. Three. 7. Infrared. 8. Earth . 9. Wetlands. 10. Shivelich.

Answers Page

Aerosol Word Find (page 13)



Crossword Puzzle (pages 14 and 15)



Resources

For more information, go to:

http://climate.nasa.gov/

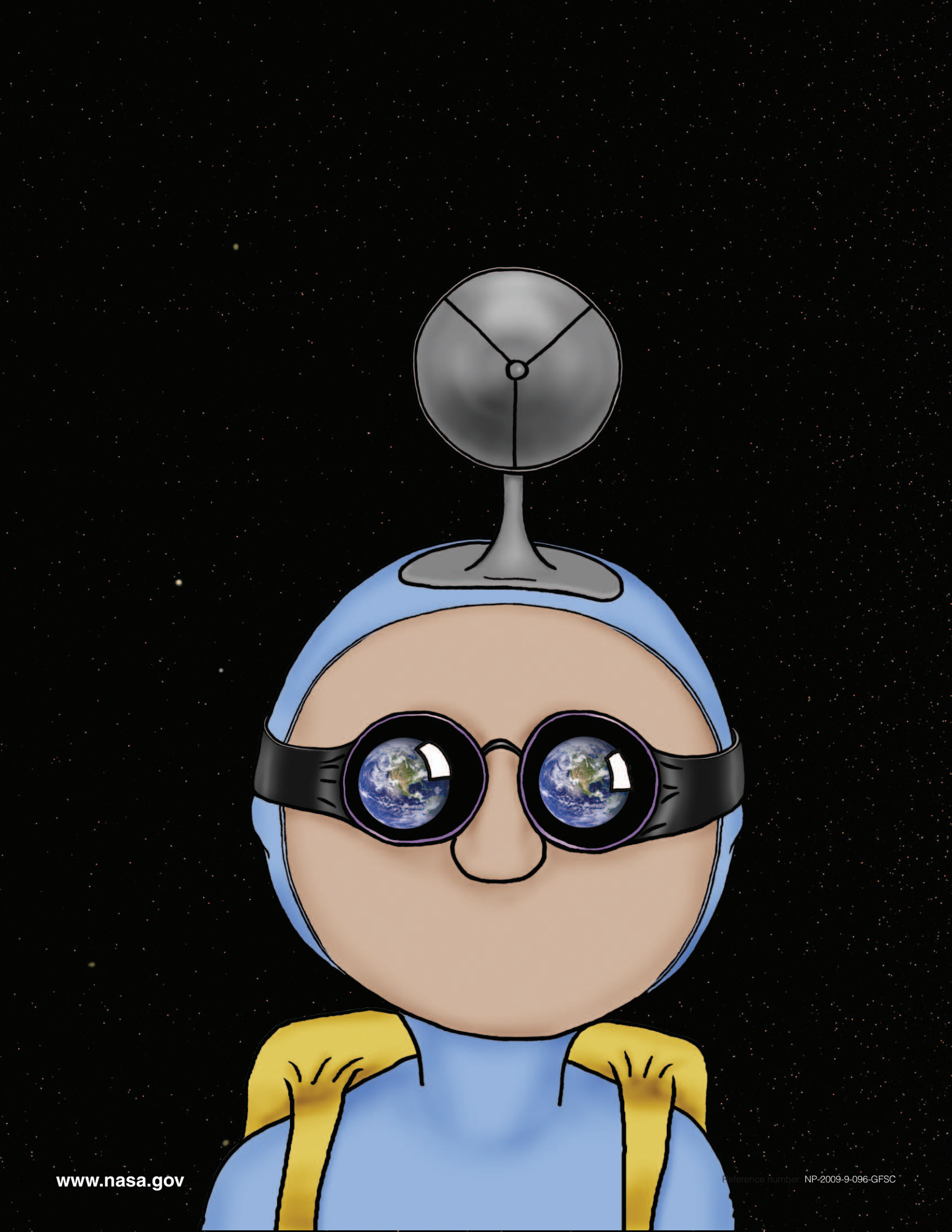
http://eos.nasa.gov

http://earthobservatory.nasa.gov

http://visibleearth.nasa.gov

http://neo.sci.gsfc.nasa.gov

http://svs.gsfc.nasa.gov



www.nasa.gov

Reference number: NP-2009-9-096-GFSC