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The Pacific Tradewinds Quarterly

The official newsletter of the Schools of the Pacific Rainfall Climate Experiment

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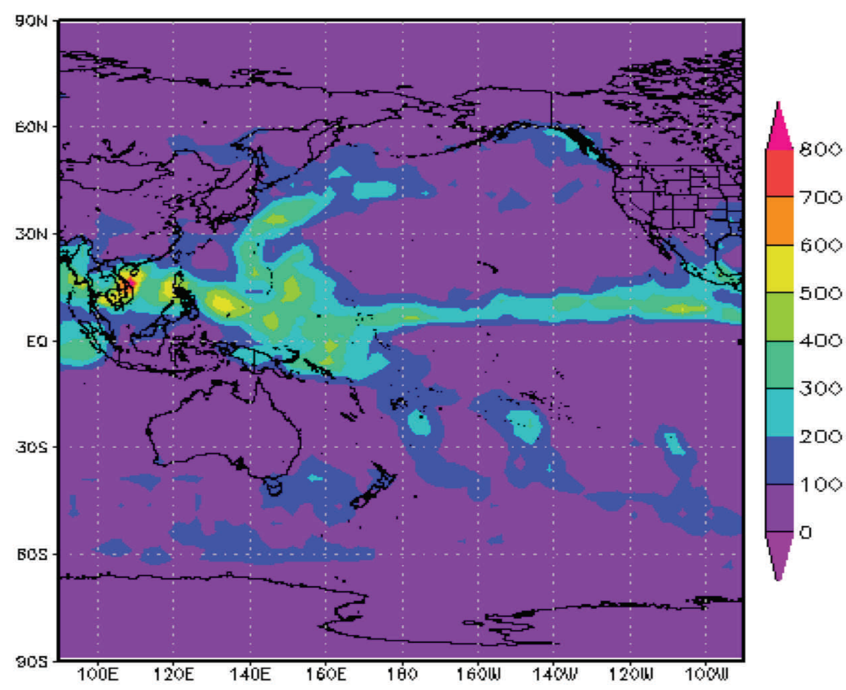
Global Precipitation at Your Fingertips, Part I: Data

By George J. Huffman

NASA Goddard Space Flight Center, Laboratory for Atmospheres and Science Systems and Applications, Inc.

How much precipitation fell last month around the entire globe, or even in your area? What's the long-term average? What are the important year-to-year fluctuations? It is no surprise to this newsletter's readers that these are hard questions because most of you live on small islands and know first-hand that the ocean has a nearly total lack of surface data. It has been clear from the dawn of the Space Age that satellites provide an excellent platform to address this problem, but it was not until the late 1970's that the first generation of sensors was continuously available in space to start the precipitation record. It took another 15 years and a second generation of satellite-based sensors for scientists to develop the first long-term global precipitation data set that took advantage of these then-new satellite data. At the same time, research showed that rain-gauge data continued to be very important, both for use with the satellite data and for independent comparisons to the final precipitation products. This article will describe a few widely available precipitation data sets, while a companion article in the next newsletter will introduce you to a freely accessible World Wide Web site that allows simple interactive display and analysis of these and other data.

The most accurate satellite estimates come

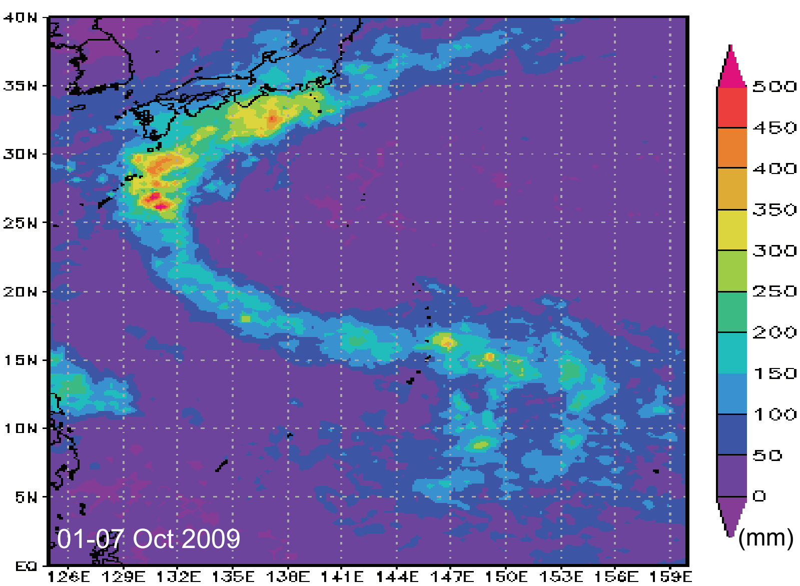


Example of GPCP precipitation accumulation (in mm) for the Pacific Ocean sector in September 2009. The Intertropical Convergence Zone runs east-to-west just north of the Equator. The South Pacific Convergence Zone extends southeastward from the Equator east of Australia, while mid-latitude storm tracks are located south of Australia and east of Japan. The heavy precipitation in Southeast Asia is part of the Asian Monsoon.

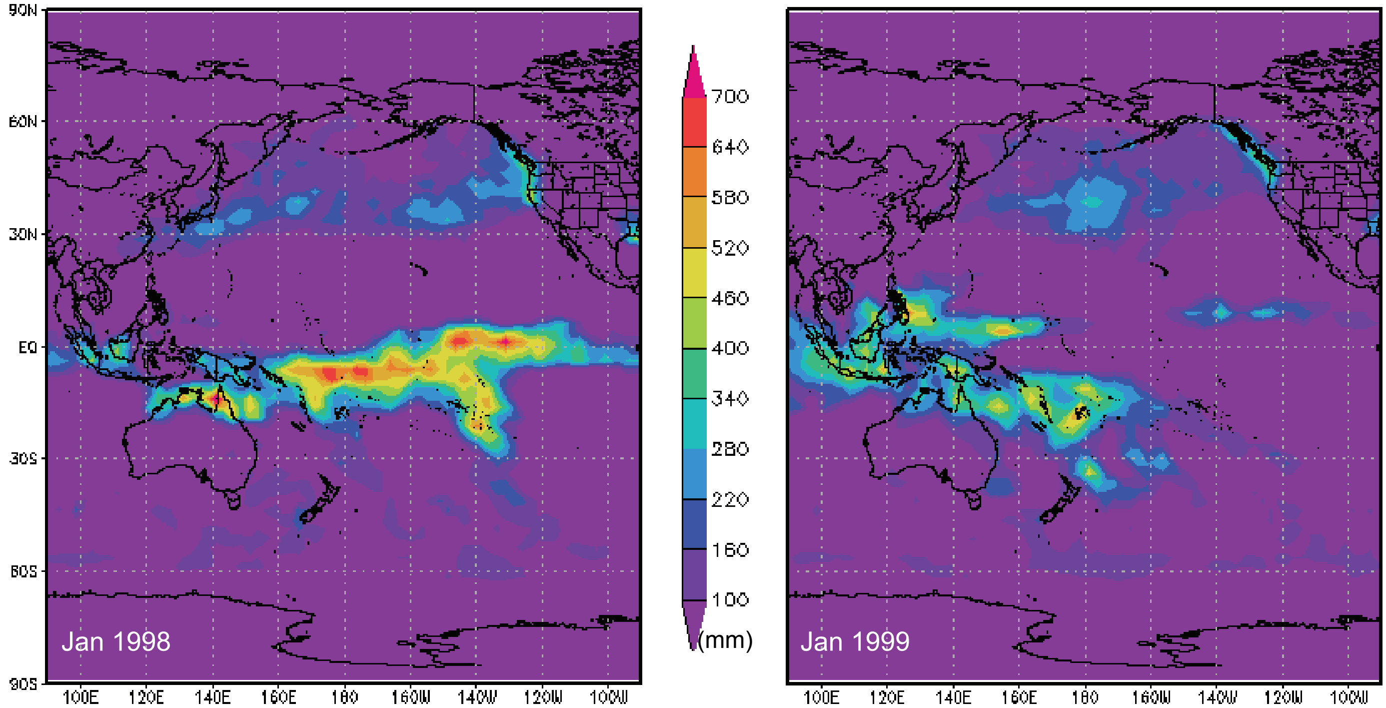
from the first precipitation radar (PR) to fly in space, aboard the Tropical Rainfall Measuring Mission (TRMM) satellite. Although important for research, the PR's coverage is too limited to give routine monitoring of global precipitation. Rather, we depend on observations of the Earth system's natural emission of microwave energy. Even these data are not available at all times since the satellites on which the microwave sensors fly are in "low Earth orbit", or LEO, some 400-800 km above the surface. Such LEO satellites pass over any given spot on Earth twice a day. In contrast, "geosynchronous Earth orbit", or GEO, satellites at an altitude of about 35,000 km orbit at the same speed that the Earth revolves and therefore always view the same part of the surface. The trade-off is that GEO sensors provide less-precise estimates computed from the Earth system's natural emissions of infrared (IR) energy. Other satellite datasets are used to provide estimates in regions where both microwave and IR have difficulty, such as polar regions or times before mid-1987 when microwave data became available. Finally, rain gauge data where available, have proved to be valuable for helping to reduce biases in the satellite data, which are persistent differences between the satellite estimate and the precipitation that actually occurred. The datasets discussed below take slightly different approaches to mixing and matching the various kinds of input data to create global estimates of precipitation that answer different needs and/or take advantage of different input data. Each is produced at the NASA Goddard Space Flight Center, in Greenbelt, Maryland, USA. [Other combination datasets are produced at other data centers.]

The longest-running dataset, beginning with 1979, is the monthly satellite-gauge combined dataset produced as part of the Global Precipitation Climatology Project (GPCP). The GPCP is an international project whose ultimate reporting authority is the World Meteorological Organization. The gridbox size is relatively coarse, 2.5° x 2.5° of latitude/longitude. In the SPaRCE region, the data are mostly created by calibrating the IR data to the microwave satellite closest to the 6 a.m. / 6 p.m. overpass time. Another way of saying this is that we try to develop equations that make the average behavior of IR-based precipitation estimates as much like the microwave-based estimates at 6 a.m. / 6 p.m. as possible. Then we apply those equations to all of the IR data for the entire day. As a last step, these microwave-calibrated IR estimates are added up for the month and combined with raingauge data over continental regions to compute the final satellite-gauge product.

Three combination data sets are produced as part of the highly successful TRMM, which is a joint NASA – Japanese Aerospace Exploration Agency satellite mission. These data sets are created at much finer time and space scales than the GPCP data, but for a shorter period and only the tropical and subtropical regions. The general algorithm name is TRMM Multi-satellite Precipitation Analysis, and the various datasets are given different product numbers to help keep straight which one is being used. The first is 3B42, which is computed on a 3-hourly, 0.25° x 0.25° latitude/longitude grid for the period 1998 to the present. Unlike the GPCP product all available microwave data are used, first to calibrate the IR and second to directly make the estimates. Gridboxes that lack microwave data for a given 3-hour period are given an IR estimate. All 3-hourly data in a month are added up and combined with monthly raingauge data, similar to the GPCP procedure, to create the TMPA monthly product, 3B43. Then we go back and the 3B42 3-hourly estimates are all slightly inflated or deflated so that they add up to the



Precipitation (in mm) accumulated for the period 01-07 October 2009 in the northwestern Pacific as estimated by the TRMM 3B42RT. During this time Typhoon Melor tracked from the area east of the Marinas Islands to the coastal waters south of Japan. Melor attained supertyphoon strength in the middle of its lifetime. However, the heaviest accumulations occurred at the beginning and end of the period, when Melor was not a supertyphoon.

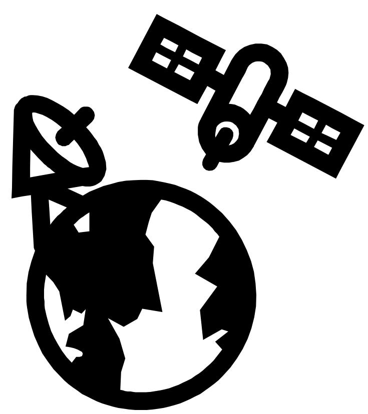


Back-to-back strong El Niño and La Niña events in 1998 and 1999 created dramatically different precipitation patterns over the tropical Pacific Ocean (shown here for Januaries from the GPCP monthly estimates). The El Niño focuses precipitation along the Equator, while the La Niña shifts precipitation reinforces dry conditions along the Equator and heavy precipitation to the west, north, and south.

monthly 3B43 value, gridbox-by-gridbox. The third product is computed separately about 6-9 hours after observation time, rather than waiting for the end of the month. This "real-time" product, 3B42RT, is similar to the first part of 3B42, but then the final adjustment is done using long-term average relations to 3B43 instead of computing a new adjustment each month. The goal for 3B42RT is to give a same-day estimate of the global precipitation for short-term monitoring of floods, droughts, crop development, and other rapid-update issues.

The accuracy of these data sets depends on several factors, including the particular sensor(s) and algorithm(s) used to compute the precipitation, the general type of weather (widespread or spotty showers, deep or shallow clouds, etc.), the underlying surface (land, ocean, coast, or ice, and how flat the land, coast, and ice are), and how large a time/space average is considered. The issue of averaging becomes particularly important when one tries to compare the record at a single gauge against the record for a single gridbox from one of the data sets – individual days will probably show large disagreements, with monthly accumulations agreeing better, seasons even better, and so on.

To get started using these datasets, go to the NASA/Goddard group's Web page, http://precip.gsfc.nasa.gov, for access to the data, technical documentation, pointers to the published papers, and lists of papers that use the data sets. As well, these data sets and others can be displayed and analyzed using the TRMM On-line Visualization and Analysis System (TOVAS) at http://disc2.nascom.nasa.gov/tovas/. The next newsletter will feature an article introducing TOVAS and providing some examples.



Helping Pacific Communities Adapt to Climate Change Impacts

May 13, 2010

The Region is breaking new ground with the Pacific Adaptation to Climate Change Project (PACC) which brings in over 13 million USD to help countries adapt to the impacts of climate change.

The project is the first of its kind in the region that has 13 Pacific Island countries implementing 'on the ground' adaptation projects in any of the three key affected areas: food security, coastal management capacity and water resource management.

In Tonga it is planned that the project will assist stakeholders in the Hihifo district to develop and implement ways to better manage and sustain their water resources. These may include supporting alternative water retention and supply systems to ensure that the people are better able to cope when droughts occur now and into the future.

Coastal management capacity is the key area that Vanuatu is focusing on. The island nation is implementing a very innovative project to involve communities in the design and relocation of road infrastructures in Epi, in the Shefa province which has been devastated by strong storm surges.

Palau will be working with stakeholders and the local communities in Ngatpang State to design methods that improve the resilience of their coastal food production systems to the impacts of climate change in the medium to longer term. One of these methods will include introducing a variety of taro that is salt water tolerant in order to address the issue of salt water inundation in taro patches.

Now one year old the PACC project is commemorating its first year with a review with all key stakeholders to reflect upon the lessons learnt and the successes of year one of a five year project.

"The PACC project cannot fail and we should not. There are ample resources and technical support present at the national and regional level through the Secretariat of the Pacific Regional Environment Programme (SPREP) and other regional organisations to ensure that we do not fail," said SPREP Director David Sheppard at the opening of the PACC multipartite review meeting.

"I know that it is not easy to implement a project like PACC. It is large, it is challenging, and it is ambitious. There are donor requirements that we have to follow in the preparation of reports such as annual work plans, quarterly financial reports and quarterly narratives, audits, monitoring and evaluation. Given that we are breaking new ground with this project there are many eyes looking at this project – from within this region and globally."

During the one week gathering in Apia, Samoa, there are PACC milestones being celebrated which outline the successes in the first year of the regional project funded by the Global Environment Facility and delivered through a partnership of the United Nations Development Programme and SPREP.

There are now 13 signed memoranda of understanding with the Pacific Island countries that outlines how all parties will work together to carry out PACC projects in each of the countries. There are 12 coordinators on board who will oversee the project in these countries and a Project executive committee has been formed.

Representatives from each of the 13 Pacific islands countries and territories, attending the workshop at the SPREP compound, in Apia Samoa.

"The meeting we are having now is a very important one," said Taito Nakalevu the PACC Project Manager.

"It's our first real opportunity to meet with all the PACC coordinators in one setting. So far I am amazed and impressed at the level of progress with these projects at the national level. It's a very excellent start for this project." Nakalevu is also thankful to the Secretariat of the Pacific Community, University of the South Pacific, and the Applied Geosciences Commission for the partnership and assistance provided in the first year of PACC implementation.

"Given the successes and progress the Pacific has achieved together over the first year of the PACC, we will strive to increase project delivery so that communities would see for themselves the benefit of this project."

The workshop took place from 10 to 14 May and has two representatives from each of the 13 Pacific Islands countries and territories; Cook Islands, Federated States of Micronesia, Fiji, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu along with development partners and stakeholders. The PACC multipartite review meeting is held at the SPREP compound, in Apia.

Source: Secretariat of the Pacific Regional Environment Programme Press Release (http://www.sprep.org/climate_change/pacc/pacc_news_detail.asp?id=762)

Pacific Students Tackle Tsunami Building Design

Mix of traditional, western methods considered

July 5, 2010
By Charlina Tone

Pacific Island engineering students studying in New Zealand may be pioneers in creating better building codes to withstand tsunamis.

As part of an EPICS Project (Engineering Project in Community Service) a group from the University of Auckland is in Samoa to identify the building challenges that have resulted from the 2009 disaster.

"The aim is to engage local builders, tradespeople and engineers to identify the major rebuilding challenges with residential areas," said Natalia Palamo, a Samoan fourth-year civil engineering student at the University of Auckland.

Focus is placed on ways to ensure they are rebuilt in a safe way, in order to reduce vulnerability to future hazards she said.

"A major part of this is encouraging local builders, tradespeople and engineers to combine traditional and western methods in rebuilding," she said.

Natalia is part of an ethics project made up of fellow Samoans Nadeen Papalii, Miriam Karalus and Keri Yukich who have developed ideas on reviving traditional building methods.

Fonoti Perelini Perelini, President of the Institute of Professional Engineers in Samoa, said this is a vital step for engineering in the future.

He believes that with the availability of resources at the University of Auckland more research can be conducted into better rebuilding methods after such disasters as the tsunami.

"A possible result would be creating a building code for the future so that infrastructure can withstand tsunamis," said Mr. Perelini.

One of the greatest concerns of the association according to Perelini is the fact that there is a building code but nothing that states anything about tsunamis.

Mr. Perelini hopes that the exchange of the overseas students with the local engineers through the Native Engineering Technology Summit will yield better rebuilding codes for any future disasters.

Reprinted from: ***Pacific Islands Report*** (http://pidp.eastwestcenter.org/pireport/2010/July/07-07-13.htm)
Source: ***Samoa Observer:*** *www.samoaobserver.ws/*

Pacific Species: Few on Land, Many at Sea

By P. Craig
National Park Service

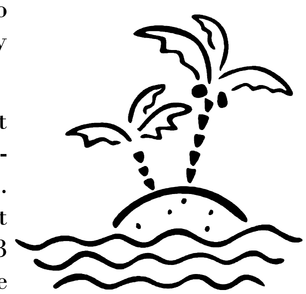
There's a certain mystique about the word "biodiversity" that seems to be associated with images of steamy jungles or wondrous new medicines, but the word more specifically refers to the number of species or "species richness" of an area.

One reason why tropical areas are so fascinating is that they contain the highest numbers of plant and animal species found anywhere on earth.

American Samoa sits squarely in the tropics, so we should have a high biological diversity here, but we do and we don't. There is a sharp contrast between the number of plant and animal species that live on land here (few) versus those that live in our coastal waters (many). Most small islands in the South Pacific share this characteristic.

To start at the beginning, when our islands emerged as fiery volcanoes from the depths of the sea, they were devoid of plants or animals. As time passed and the terrain became more hospitable, life for organisms became possible, but the plants and animals still had to cross vast ocean distances to get here from someplace else.

A quick look at a map will show one reason why few land species got here. We are really quite isolated in the Pacific Ocean, far from potential sources of plants and animals. To reach our shores, organisms would either have to blow in on the wind, drift for hundreds or thousands of miles on some piece of floating debris, or be carried in by another organism like plant seeds in a bird's stomach. The species that were successful probably got here by 'island hopping' across the Pacific, spreading from island to island over the course of many thousands or millions of years.



The difficulty in getting here is best illustrated by the sparse representation of native mammal species. Over the past 1.5 million years that Tutuila Island has existed, only 3 mammal species (all bats) got here and established viable populations. Our native species list also includes about 478 flowering plants and ferns, 18 resident or migratory land and water birds, 20 resident seabirds, 3 skinks, 1 gecko, 2 sea turtles, and occasional other visitors (this list does not include any species presumably introduced by early Polynesians or all the recently introduced non-native species like rats, dogs, pigs, toads, myna birds, and many weeds).

There's a second reason for our low diversity on land -- the small size of our islands. In general, the smaller the island, the fewer the species on it. For example, tiny Rose Atoll (0.4 sq mi) supports only 5 native plant species, 21 birds (virtually all seabirds), 2 geckos, and 2 sea turtles.

So, although American Samoa technically has 'tropical rain-forests' due to our high level of rainfall (200-300 inches per year in some mountainous areas), we lack the high species richness found in the jungle rainforests of Indonesia, Africa or South America that are filled with hooting monkeys, poison dart frogs, pythons, and flesh-eating piranhas.

On the other hand, because of our isolation, some terrestrial species in Samoa have evolved over many thousands of years to such an extent that they have become distinctly different species found nowhere else but here. For example, 30% of our plant species and the Samoan starling (fuia) occur only in the Samoan archipelago (which includes western Samoa); and the Samoan fruit bat occurs only in the Samoan and Fijian islands. So, our rainforests may lack diversity, but they contain some species found nowhere else on earth.

Turning to our marine environment, we find the opposite situation. There is an incredibly diverse ecosystem just beneath the waves. Coral reefs are among the most species-rich ecosystems in the world. We have, for example, 961 nearshore fish species which is an amazingly high number compared to many other coastal areas. To get a sense of this species-rich environment, if you were to dive on our reefs once a week, you could in theory see a new fish species on every dive for 18 years.

Although coral reefs are limited to shallow waters, usually around the fringes of islands, most coral reef species have eggs and larvae that can survive for weeks or months in the open ocean and get dispersed by ocean currents to new locations (see Chapter 11). As a result of this genetic exchange of marine organisms between islands, there are probably few marine species that are unique to the Samoan islands.

Finally, superimposed over the South Pacific region is a large-scale pattern of species distributions. Most of our marine and land species can be traced back to the same or related species inhabiting mainland and insular southeast Asia. From that center of remarkably high diversity, rainforest and coral reef species radiated out, spreading eastward across the South Pacific islands. But like ripples in a pond, the farther away one gets from that 'center', the fewer the species This same pattern applies to corals, fishes, sea turtles, seagrasses, mangroves, land birds, and plants. Very few species reached here from the opposite direction (South America) probably due to the much greater distance and fewer islands in that direction to facilitate 'island hopping'.

Reprinted From: ***Pacific Islands* Report** (http://pidp.eastwestcenter.org/pireport/2010/June/06-08-ft.htm)

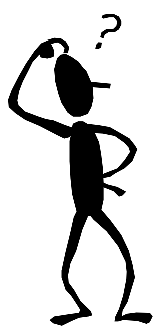
Brain Teasers

Sudoku

Complete the grid such that every row, every column, and the nine 3x3 blocks contain the digits from 1 to 9.

		7	9		3	2		
	5	3				6	8	
1	2			8			3	4
7								3
		4				1		
2								8
6	8			4			1	9
	3	1				8	4	
		9	8		1	3		

Math Quiz



We have been quite lucky with the weather recently, it has got steadily warmer each day, over the last five days. By this, I mean that the temperature rose by the same amount each day. The average temperature was 2 degrees C and I know it froze on two occasions. I also know the product of the temperatures was over 500 degrees but below 2,000 degrees and each temperature was an integer. What were the last 5 temperatures?

Look for answers in the next newsletter!

Puzzles devised by © Kevin Stone [www.brainbashers.com]

Previous newsletter puzzle answers:

Across:	Down:
3.Hurricane	1.Temperature
8.Tornado	2.Hail
9.Lightning	4.Rainbow
11.Wind	5.Fog
12.Dew	6.Barometer
13.Precipitation	7.Snow
	8.Thunder
	9.Humidity

Classroom Science Focus

Weather vs. Climate

Weather vs. Climate

How is **climate** related to **weather**? **Climate** helps you understand the **weather** in your own part of the world.

Here's a simple explanation of **weather**: The air, or atmosphere, around us behaves in different ways. It changes when it's hot or cold, and when it's wet or dry. It acts differently when it's calm or stormy, and clear or cloudy. The atmosphere reacts to everything from rain to sunshine. A snow flurry is **weather**. Thunder and lightning are **weather**, too. Sometimes the atmosphere behaves violently, and sometimes it's peaceful and quiet. Either way, it's **weather**.

Meteorologists record the weather every day. The constant recording of weather information helps to determine the **climate** of an area.

Climate is the average **weather** in a location over a long period of time. A place that doesn't get much rain over many years would have a dry **climate**. A place where it stays cold for most of the year would have a cold **climate**. **Climate** is useful for **weather** forecasting. It also helps determine when the best time would be for farmers to plant their crops. In other words, look out your window any day, any time and you see **weather**. Look out your window every day for a month or longer, observe the weather each day, and you can determine the **climate**.

Now that you know about **climate** and how it relates to **weather**, try these **climate** activities. They'll help you watch the **climate** and think about your favorite **weather**. And always talk to your teacher before you start one of these activities. Your teacher may have additional things for you to do.

Climate Watch

Materials: Temperature and precipitation for a month or more (such as data taken for SPaRCE).

Activity: You can follow the climate for your home. Record the temperature and rainfall for your town each day at a certain time. At the end of the month, see if your records match the recorded climate. Use the website http://www.worldclimate.com/ for climate information to compare with your information. (If your school does not have access to the internet please write a letter to SPaRCE and we can get you the climatology records for your location).

Calculate the average minimum and maximum temperatures.

To calculate the average, divide the sum of the records by the number of records taken. The equation for an average is shown below, where N is the number of days and A is the temperature or rainfall of each record during the N number of days. The Σ symbol in the equation below is called sigma, which is the mathematical notation for sum.

$$\frac{1}{N}\sum_{i=1}^{N} A_i$$

For example here we have one week's worth of records:

Date	Time of Reading (LST)	Rainfall (mm)	Min Temp. (°C)	Current Temp. (°C)	Max Temp. (°C)
1	1200	2.0	26	30	30
2	1200	9.0	25	30	30
3	1200	2.0	26	31	31
4	1200	10.0	26	31	31
5	1200	4.8	27	31	31
6	1200	1.0	27	31	31
7	1200	2.0	27	29	30

Since there are 7 days, N = 7 and the total rainfall sums to 30.8 mm, so $\Sigma A = 30.8$ mm

$$\frac{1}{7days}\sum_{i=1}^{7}(2.0+9.0+2.0+10.0+4.8+1.0+2.0)mm \Rightarrow \frac{30.8mm}{7days} = 4.4mm/day$$

Dividing the sum of the rainfall (30.8 mm) by the number of records (7 days) we get an average of **4.4 mm** per day, for this particular week.

To calculate the monthly average, use the same equation as above, the only difference is you will have many more days worth of data. Add up the records from each day of the month and divide by the number of days that data was recorded.

Practice calculating the monthly average rainfall and minimum, current, and maximum temperatures of the data you have recorded with the SPaRCE program. In the next SPaRCE Newsletter mini lesson we will take a closer look different climatologies around the world and how they are different from one another.

Much of this lesson was adapted from: http://weathereye.kgan.com/cadet/climate/climate_vs.html

What's Going on with SPaRCE

Greetings friends! As always, I hope this newsletter finds you safe and well. I hope you enjoyed the cover article from our good friend, George Huffman. He was kind enough to offer to write an article for this issue of the newsletter. In the next newsletter we will have an article which will introduce us to the TRMM Online Visualization and Analysis System (TOVAS).

If you have any questions about the Classroom Science Focus in this issue, please send me an email (or letter through post) and I'll be happy to help you. Be sure to keep collecting your rainfall and temperature data so you and your students can use it in the activities.

Also, I would love to hear more from our participants. If you have some spare time feel free to send me an email (nikkiacton@gmail.com) and tell me a bit about yourself, students, and your school. If anyone needs instrument replacements please let me know as soon as possible.

-Nikki Acton, on behalf of the SPaRCE crew.

Send in Your Questions!

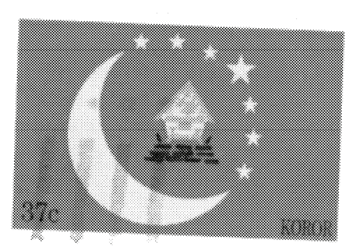
If you or your students have any questions relating to science please send them to us here at SPaRCE. Once we receive a question we will publish the question and an answer in the next newsletter.

Call for Newsletter Contributions

In order to get to know our schools and participants a bit better, please send us items to be published in the SPaRCE newsletter.

Here is a list of ideas:

- ⌧ Accounts of extreme weather events
- ⌧ School history
- ⌧ Pictures of students taking measurements
- ⌧ Activities using SPaRCE data
- ⌧ Songs or poems about weather



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ENSO Discussion

issued by The Climate Prediction Center/NCEP 8 July 2010

Synopsis: **La Niña conditions are likely to develop during July – August 2010.**

During June 2010, sea surface temperature (SST) anomalies continued to decrease across the equatorial Pacific Ocean, with negative anomalies expanding across the central and eastern Pacific. While the rate of decrease slowed during June, all of the Niño indices were cooler compared to the previous month. The subsurface heat content (average temperatures in the upper 300 m of the ocean) also remained below-average during the month. Subsurface temperature anomalies became increasingly negative in the east-central equatorial Pacific and extended to the surface across the eastern half of the basin. Also during June, enhanced convection persisted over Indonesia, while the area of suppressed convection strengthened and expanded westward over the western and central equatorial Pacific. Enhanced low-level easterly trade winds and anomalous upper-level westerly winds prevailed over the western and central equatorial Pacific. Collectively, these oceanic and atmospheric anomalies reflect developing La Niña conditions.

The majority of models now predict La Niña conditions (SST anomalies less than or equal to -0.5°C in the Niño-3.4 region) to develop during June-August and to continue through early 2011. Confidence in this outcome is reinforced by the recent performance of the NCEP Climate Forecast System (CFS), the large reservoir of colder-than-average subsurface water, and signs of coupling with the atmospheric circulation. Therefore, La Niña conditions are likely to develop during July-August 2010.

This discussion is a consolidated effort of the National Oceanic and Atmospheric Administration (NOAA), NOAA's National Weather Service, and their funded institutions. Oceanic and atmospheric conditions are updated weekly on the Climate Prediction Center web site (El Niño/La Niña Current Conditions and Expert Discussions). Forecasts for the evolution of El Niño/La Niña are updated monthly in the Forecast Forum section of CPC's Climate Diagnostics Bulletin. The next ENSO Diagnostics Discussion is scheduled for 5 August 2010. To receive an e-mail notification when the monthly ENSO Diagnostic Discussions are released, please send an e-mail message to: ncep.list.enso-update@noaa.gov.

Get to Know: Ethan Cook

Hello, I'm Ethan Cook. I have the good fortune to do research for the Oklahoma Wind Power Initiative [in the same office as SPaRCE] at EVAC while working toward my graduate degree at the OU School of Meteorology. My work focuses on improving mathematical methods for describing and verifying wind resource climates as well as developing algorithms for estimating long-term variability of wind resources at locations with only short-term weather data.

My research interests include statistical validation techniques and the propagation of uncertainty in the process of numerical weather prediction. Beyond that, I'm also fascinated by a variety of physics topics.

A transplant from rural New England, I feel more like a native of Oklahoma City now, where I live with my wife, Mary. Our pastimes include hiking and exploring, cooking, going out for good local music…and – mainly – entertaining our baby boy, Sam.

Ethan and Sam

SPaRCE would like to thank those who have made this program possible: NOAA's Climate Observations Division, the U.S. GCOS Program at NOAA's National Climatic Data Center, and the PI-GCOS Program based at the Secretariat of the Pacific Region Environment Program (SPREP) in Apia, Samoa.