Activity #1

Exploring the Importance of the Summit

● ● ● Class Period One *Exploring the Importance of the Summit*

Materials & Setup

- Acetate of *Nani Ke Ao i Haleakalā* chant (master, p. 9)
- Overhead projector and screen

Instructions

1) Display the chant and read it aloud, or have a student read it. Ask students to focus on the feelings the chant invokes.

2) After the chant has finished, ask students to write down the feelings the chant brought out, or what it made them think about. Then ask several students to share what they wrote.

3) Display the acetate on the overhead and read aloud the English version of the chant. Ask students to write down whether they have different thoughts and feelings now that they know what the chant means. Ask a few students to share their reactions.

4) Ask the class to brainstorm answers to this question: Why is the summit area of Haleakalā important to people? Encourage students to think about people in the past, present, and future. Write student responses on the board or overhead. Try to generate as complete a list as possible, making sure that something related to the research and other work done at the observatories gets on the list, as well as the location of television and radio transmitters.

5) Lead a lecture and discussion of the characteristics of the summit area that make it suitable for observatories. See the teacher background (pp. 6-8) for details.

Journal Ideas

- Think of a situation in which you felt very differently about something than another person did. Were you able to work out your differences? If so, how? If not, why not?
- Write a poem, short story, or Hawaiian *mele,* or draw pictures that illustrate what Haleakalā means to you.
- Think about all the reasons that the summit of Haleakalā is important to people. Which do you think are the most important?
- If a company or government agency wanted to build a new observatory at the summit, do you think they should be allowed to do so? Why or why not?

Assessment Tools

- Participation in class discussion
- In-class writing
- Journal entries

Teacher Background

What Makes the Summit Area of Haleakalā Suited to Observatories?

Near the summit of Haleakalā, which rises 3056 meters (10,023 feet) from sea level, the Haleakalā Observatories occupy a site that is considered to be among the top five percent in the world for locating ground-based astronomy research and monitoring facilities.

Since 1961, several facilities have been built on this site to study and track a variety of things having to do with the sun and moon, the earth's atmosphere, satellites, and other objects traveling through space. These facilities include:

The Air Force Maui Space Surveillance Complex (MSSC)

Space surveillance activities are conducted here for the U.S. Department of Defense. Find more information at <ulua.mhpcc.af.mil/>.

Cosmic Ray Neutron Monitor Station

A neutron monitor detects incoming energy from cosmic rays emanating from sources including solar flares. Find more information at <ulysses.sr.unh.edu/NeutronMonitor/neutron_mon.html>.

Lunar and Satellite Ranging (LURE) Observatory

Laser equipment is used to track satellites. Until 1990, this equipment was also used to track the distance between the earth and the moon, helping scientists measure phenomena such as tectonic plate shifts. Find more information at <koa.ifa.hawaii.edu.>.

Mees Solar Observatory

The main instrument used here is the imaging vector magnetograph, which enables researchers to measure the electric currents passing through selected regions of the sun's surface. Research topics include solar flares, magnetic fields on the sun, and solar oscillations. Find more information at <koa.ifa.hawaii.edu> and <www.ifa.hawaii.edu/research>.

For a listing of related websites, see Bonus Activity "What Goes On at the Observatories?" Student Page "Surf the Net to Research the Haleakalā Observatories" (pp. 36-38).

Summit Advantages

Why is the Haleakalā High Altitude Observatory Site such a good place for these types of research and other work?

- Astronomers prefer to work on high mountain tops in order to have the clearest view possible of objects in space. In general, high mountain tops are above most of the dust, clouds, and water vapor found in the lower atmosphere.

- The summit area of Haleakalā is above the trade wind inversion much of the time. (See Alpine/Aeolian Unit 2 "*Mauna Lei* Mystery" for background information about the tradewind inversion.) Because of this, there is a good proportion of days suitable for viewing. The trade wind inversion restricts the influx of air pollution, clouds, and water vapor from lower elevations.

- At night, a usual downslope flow of air enhances clarity by keeping moisture and particulates from reaching the summit or accumulating there.

- Because Haleakalā is in the middle of the ocean, the air is even cleaner and clearer than

it is at many landlocked sites. In addition, the fact that air currents travel over the ocean, rather than large land masses, before they reach Haleakalā means that there is less air turbulence. Air turbulence is caused by differences in air density caused by differential heating. Air flows traveling across land masses can pick up heat, causing turbulence when they mix with the cooler air at higher elevations. This causes blurriness in the image, reducing the quality of what astronomers call "seeing," or visibility through the atmosphere. The air flows coming directly from the ocean rather than over land are called "free atmosphere." They generally contain less turbulence and make for clearer viewing.

At Haleakalā, the wind usually blows across the summit basin, coming from the northeast. As it traverses the landscape, the air heats up. It also rises off the lip of the summit basin wall and forms a turbulent eddy, despite the fact that the density differences are minor. Because of this, the quality of "seeing" at Haleakalā is not as good as it is at Mauna Kea. But it is still better than most other observatory locations around the world. (When the winds are light and steady from the southeast, scientists at the Mees Solar Observatory report the best viewing conditions. The winds then are not traversing so much land before reaching the observtory.)

- Because Haleakalā is in the tropics, scientists can view some of the southern sky from there. Observatories on the continental United States are too far north for this.

Adaptive Optics: Advancing Technologies for Even Better "Seeing"

The seeing is already quite good at Haleakalā Observatories, but technological advances are making it even better. "Adaptive optics" are being used in the Advanced Electro-Optics System (AEOS) telescope, which is part of the Maui Space Surveillance Complex.

"Adaptive optics" (or AO) refers to optical equipment that compensates for the effect of turbulence in the lower atmosphere as well as high above the earth's surface. Small temperature variations in the atmosphere cause the light entering different parts of a telescope pupil to travel at slightly different speeds. That's what causes blurriness. The AO system used in the AEOS telescope senses these differences and corrects for them using a flexible mirror. (Modern telescopes use mirrors rather than lenses.) Since the atmosphere is constantly moving, the AO system adjusts rapidly, more than 100 times per second!

The following websites are starting points if you or your students would like to learn more about adaptive optics:

Adaptive Optics at the University of Hawai'i at <www.ifa.hawaii.edu/ao/>. Includes downloadable movies of the Hōkūpa'a ("immovable star") telescope correcting for turbulence.

Herzberg Institute of Astrophysics page on adaptive optics and air turbulence at <www.hia.nrc.ca/moffatt/eng/adaptive/adaptive.html>.

International Society for Optical Engineering overview of adaptive optics at <www.spie.org/web/oer/february/feb98/adapt.html>.

Lawrence Livermore National Laboratory page on adaptive optics at <www.llnl.gov/str>.

- Unlike the weather on high mountains in many other parts of the world, the weather on Haleakalā is only infrequently severe enough to hamper the use of observatory facilities. The weather is more reasonable on Haleakalā than it is even on nearby, but higher, Mauna Kea.

- Temperatures are moderate for the altitude.

- There is more oxygen per volume of air available on Haleakalā than on higher elevation mountains such as Mauna Kea. This makes it easier for researchers and maintenance personnel to work there.

- There is minimal light pollution from nearby urbanized areas.

- Access to the summit is relatively easy. The road is paved all the way to the top, and is seldom closed by bad conditions or weather.

One Significant Disadvantage

Discussing the advantages of Mauna Kea as an observatory site, Saul Price noted that "radio telescopes experience an almost complete absence of electrical interference from urban or other sources." On Mauna Kea, radio and television broadcasting transmitters are not allowed in the Mauna Kea Science Reserve. But on Haleakalā, the observatories are in close proximity to several powerful broadcast facilities, some of which are immediately adjacent to the observatories.

The radio frequency interference (RFI) caused by the proximity of the broadcast facilities to the observatories has a different effect depending upon the device receiving the interfering signals. Some types of equipment are particularly sensitive to the radio frequency signals, which interfere with their ability to amplify, process, and display weak electrical signals associated with astronomical measurements. In some cases, RFI has been so bad that screens that normally display data instead display fuzzy television pictures.

This is one example of a conflict between different uses of the summit area.

Sources

KC Environmental, Inc., *Draft Environmental Assessment and Anticipated Finding of No Significant Impact (FONSI) for a Coordinated Broadcast Facility at Haleakala, Maui, Hawaii,* University of Hawai'i Institute for Astronomy, Honolulu, 1998.

Price, Saul, "Hawai'i as a Site for Research in Astronomy and Climate Change," in *Prevailing Trade Winds: Weather and Climate in Hawai'i*, Marie Sanderson (ed.), University of Hawai'i Press, Honolulu, 1993.

Mickey, Donald. Personal interview, January 2000.

Nani ke Ao i Haleakalā

Nani ke Ao i Haleakalā
ʻOhuʻohu i ka noe o uka
ʻA ʻahu i ke kapa o ka hau
Anu e kai o Kahului
E hului pau mai kaua
I ua mea nei he aloha
E ko a paʻa ka manaʻo
I lua no kuʻu makemeke

Adorned with the mists of the upland
Dressed in a garment of snow
Whose cold reaches down to Kahului
Let us take all to ourselves
This thing that is called love
Grip and hold fast to the thought
That accompanies my desires