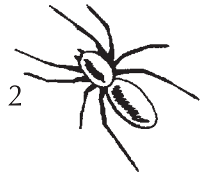


Activity #2

Mauna Lei Mystery

● ● ● Class Period One *Solving the Mystery*

Materials & Setup

- *He Lei Keakea* acetate (master, p. 11)
- Overhead projector and screen

For each group of four to six students

- Student Page "Solving the *Mauna Lei* Mystery" (pp.17-25)

Instructions

1) Show the *He Lei Keakea* acetate to the class and read the Hawaiian chant, or have one or all the students read it. Then read the English translation and ask students whether they have ever noticed this *lei* of clouds around Haleakalā. What do they think causes it?

2) Divide the class into groups of four to six and pass out the Student Page "Solving the *Mauna Lei* Mystery." Allow groups to work together to explain the regular formation of the "cloud lei" around the upper slopes of Haleakalā, using the clues provided.

   Teaching Option
   If you prefer that your students work with graphs instead of data tables, substitute the four graphs and one table in the "Optional Graphs for Solving the *Mauna Lei* Mystery" (master, pp. 12-16) for data tables 1-5 in the Student Page "Solving the *Mauna Lei* Mystery." Have students use these graphs instead of the tables to fill in the Climate Conditions Clues Summary Table (p. 18).

3) If students are having difficulty working through the clues, you may want to prompt them with questions. For the Climate Conditions Clues (pp. 18-21), these questions may be helpful:
   a) Looking at the grid, how would you characterize the climate at each of the five elevations?
   b) Which of the climatic conditions do not change in a linear fashion according to the elevations? What do you think might explain unexpected changes in conditions at the middle elevations?

   For the Global Forces Clues (pp. 22-24), these questions may help:
   a) What happens to moisture in the air as the air cools or is under less pressure?
   b) It's generally true that "hot air rises," but is there any evidence that a warmer air mass may be found on top of cooler air in the atmosphere?
   c) What effect would a layer of warmer air over cooler air have on cloud formation?

● ● ● Class Period Two *Team Presentations*

Instructions

1) Group by group, have students present their findings to the class, explaining how they resolved the *mauna lei* mystery and what evidence and reasoning they used to support their conclusions. Either have each group present its answers to all the questions posed on the student sheet, or ask different groups to cover each question in turn.

2) Culminate the discussion by asking the final question posed on the student page, "What are the main climatic conditions and patterns within the alpine/aeolian zone?" Ask students to consider what living conditions are like for plants and animals that live in the alpine/aeolian zone, and to compare them to likely conditions on other parts of Haleakalā.

Journal Ideas

- There is a weather phenomenon known as a Kona storm that occasionally occurs in the Hawaiian Islands. These spectacular winter storms are associated with strong winds from the south that bring large amounts of rain. When Kona storms hit Haleakalā, maximum rainfall generally falls at the summit, and rainfall decreases with elevation. Where do you find evidence of Kona storms on Table 5 of the Student Page "Solving the *Mauna Lei* Mystery"? Explain your answer and hypothesize about how a strong season of Kona storms might skew other climate data you have been working with in this activity.
- In addition to the *mauna lei*, what other weather phenomena can you think of that seem to have regular daily patterns of change?
- Ancient Hawaiians did not live in the summit area of Haleakalā, which is a sacred place in Hawaiian tradition. What would it have been like for early Hawaiians to visit the summit area? How might they have protected themselves from climate extremes without modern technology?

Assessment Tools

- Student Page "Solving the *Mauna Lei* Mystery" (teacher version, pp. 9-10)
- Cooperation and participation in group work
- Team presentations: Evaluate on the basis of reasoning, clarity, and accuracy of the presentation, and completeness.
- Journal entries

Teacher Version

Solving the *Mauna Lei* Mystery

[This teacher version contains only the portions of the student page that require student responses.]

1) At what time of day and approximate elevation does the *mauna lei* usually appear and disappear?

• On leeward Haleakalā, the *mauna lei* generally appears on the following cycle: 7:00 a.m., clear skies; by 10:00 a.m., cloud begin to form; 3:00 p.m., a band of clouds obscures the view of the summit; by 6:00 p.m., clouds have dissipated, as the intensity of solar radiation decreases and the temperature and pressure gradients shift again. (Students will not be able to figure the exact times based on the information provided in the student page, but they should be able to reason their way to the general pattern.)

• Using the Climate Clues Summary Table, students should reason that the *mauna lei* occurs in the middle elevations above 1650 meters (5412 feet), more likely higher up around 2130 meters (6986 feet) or even higher. In the "Solar Radiation" and "Rainfall" columns, students see that the relationship between these variables and elevation is not linear, suggesting the presence of cloud cover. The drop in solar radiation at the 1650-meter (5412 feet) level suggests shading by cloud cover, and increased rainfall at the 2130-meter (6986 feet) station suggests that this station may be just below the usual lower limit of the *mauna lei*. The width of the cloud formation is not apparent from the clues that students have been provided.

2) What are the climate conditions above and below the *mauna lei*?

• Above the *mauna lei*: coldest, driest air, greatest wind speed, greatest solar radiation, low rainfall

• Below the *mauna lei*: warm temperatures, high relative humidity, low solar radiation, rainier than above the *mauna lei*

3) Why doesn't the *mauna lei* form higher on the mountain, around the summit?

• Cloud formation is capped by the trade wind inversion. When rising and cooling clouds meet warm descending air in the Hadley Cell, the inversion layer forms. Warm air overlying the cooler air is a barrier to clouds—clouds forced through the inversion layer rapidly evaporate in the dry air above it. From the Climate Clues Summary Table, students should surmise that this inversion layer typically occurs between 2130 meters (6986 feet) and 2600 meters (8528 feet). (The trade wind temperature inversion occurs at altitudes between 1525 meters (5000 feet) and 3050 meters (10,000 feet). Students are not given enough information to determine this range.)

4) What global factors are involved in the formation of the *mauna lei*? Explain.

• Global air circulation patterns including the Hadley Cell cause the inversion layer, and in combination with the Coriolis effect give rise to the trade winds themselves. (See the Student Page "Solving the *Mauna Lei* Mystery" for more details.)

5) What are the different causes of the *mauna lei* on the leeward vs. the windward side of Haleakalā? Explain the effects of temperature and pressure on the formation of the *mauna lei* on windward and leeward Haleakalā.

• On the windward side, the *mauna lei* is formed when moist trade winds are blown up the slopes of Haleakalā. As the air rises, temperature and air pressure drop, and the moisture in the air condenses to form clouds.

• On the leeward side, the sun heats the slopes of Haleakalā and the surrounding air. This creates a zone of warmer air at higher elevations where solar radiation is more intense. As air over the heating slopes rises, this creates a pressure differential that draws air from over the ocean up the mountain's slopes. This moister air cools as it is forced upward, forming a layer of clouds.

6) What are the main climatic conditions and patterns within the alpine/aeolian zone?

• Dry air and little rain, hot during the day, clear skies, sunny, windy.

Climate Conditions Clues Summary Table

Elevation	Air Temperature	Relative Humidity	Wind Speed	Solar Radiation	Rainfall
950 m (3116 ft)	5	5	1	2	4
1650 m (5412 ft)	4	4	2	1	3
2130 m (6986 ft)	3	3	3	3	5
2600 m (8528 ft)	2	2	4	4	2
3000 m (9840 ft)	1	1	5	5	1

Photo: Ann Fielding

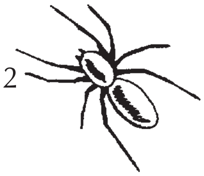
He Lei Keakea

He lei keakea noho mai la i ka mauna
Ka mauna ki‘eki‘e i luna kū kilakila
Kilakila nō luna
Nō luna i ke ao
Ke ao ua malu nā kumu la‘au
La‘au ho‘ohu‘ohu
‘Ohu‘ohu ho‘ohiehie
Ho‘ohiehie launa ‘ole!
‘A‘okle lua na‘e ke ‘ike aku
He‘ike aku nā moku ‘o Hawai‘i
Hawai‘i ke kuine ‘o ka Pākipika
Ka Pākipika ua la‘i i ka lā
Ka lā ho‘olewa i ka nalu
Ka nalu kohu lei ana
Lei ana i ke aloha
Pumehana me ke aloha
Aloha e!

— *From Winona Desha Beamer,* Talking Story With Nona Beamer, *The Bess Press, Honolulu, 1984.*

The White Lei

The soft white lei encircles the crest of the mountain
The mountain high above standing in great majesty
Majestic on high,
Bedded in clouds.
The clouds cast a shadow on the trees
The trees so haughty;
So haughty and proud,
This is splendor beyond compare!
There is no beauty to equal this sight
The sight of the islands of Hawai‘i
Hawai‘i, the Queen of the Pacific.
The Pacific lies calm in the sun
The sun, moving on the waves
The waves bedeck, as a lei
A lei of love,
Warm is this love,
It is love, indeed!



Optional Graphs for Solving the *Mauna Lei* Mystery

You may substitute the four graphs and one table contained in this resource section for the five tables provided in the Student Page "Solving the *Mauna Lei* Mystery." You may put the graphs up on the overhead or allow each student or group to work with its own copies. (Note: Because these graphs may be tricky to read, you could have students trace over the data line for each elevation in a different color pen or pencil. You could do the same on your overhead.)

Graphics and all data in the tables below are taken from Minyard, W. P., T. W. Giambelluca and D. Nullet, *Elevational Patterns of Climate on the Leeward Slope of East Maui, Hawaii,* Cooperative National Park Resources Studies Unit, University of Hawai'i at Manoa, 1994 (used with permission of the Pacific Cooperative Studies Unit).

Table : Rainfall (mm/day)

	Elevation (m)				
	950	1650	2130	2600	3000
January	3.0	5.6	7.4	4.3	5.5
February	2.3	2.1	4.6	1.9	2.9
March	1.5	3.2	10.0	7.2	6.3
April	0.2	0.7	0.6	0.6	0.6
May	0.4	0.8	1.9	0.8	0.2
June	0.4	0.8	2.2	0.9	0.4
July	0.3	1.1	2.0	1.0	0.9
August	0.5	2.1	4.3	3.2	1.6
September	0.6	3.8	3.5	2.2	2.0
October	0.5	2.3	2.6	2.0	2.0
November	4.2	3.2	5.8	9.5	12.5
December	3.7	3.8	5.2	6.3	7.1
Totals	17.6	29.5	50.1	39.9	42.0
Average	1.47	2.46	4.18	3.33	3.50

Figure 1: Monthly Mean Air Temperature (° C)

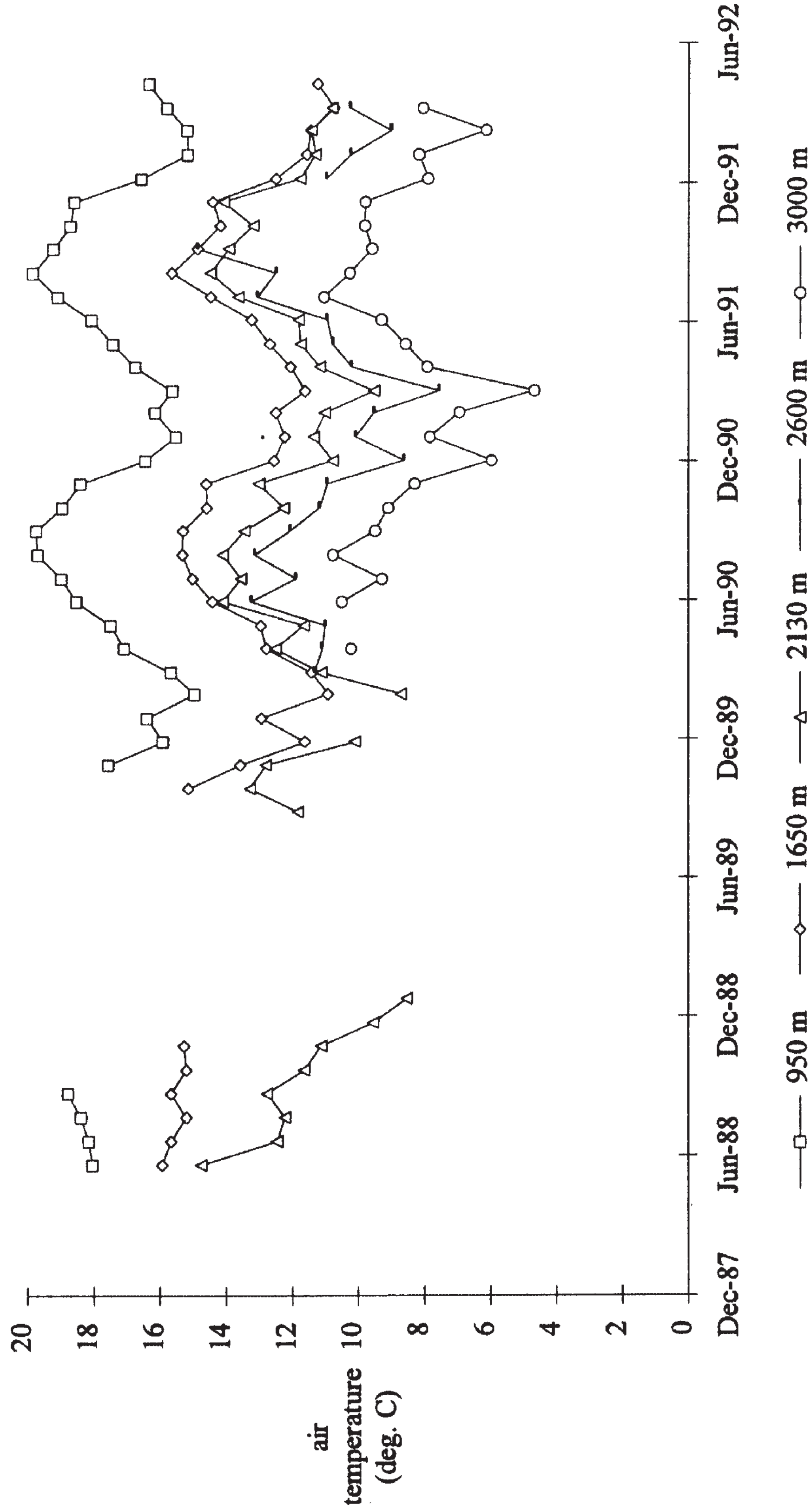
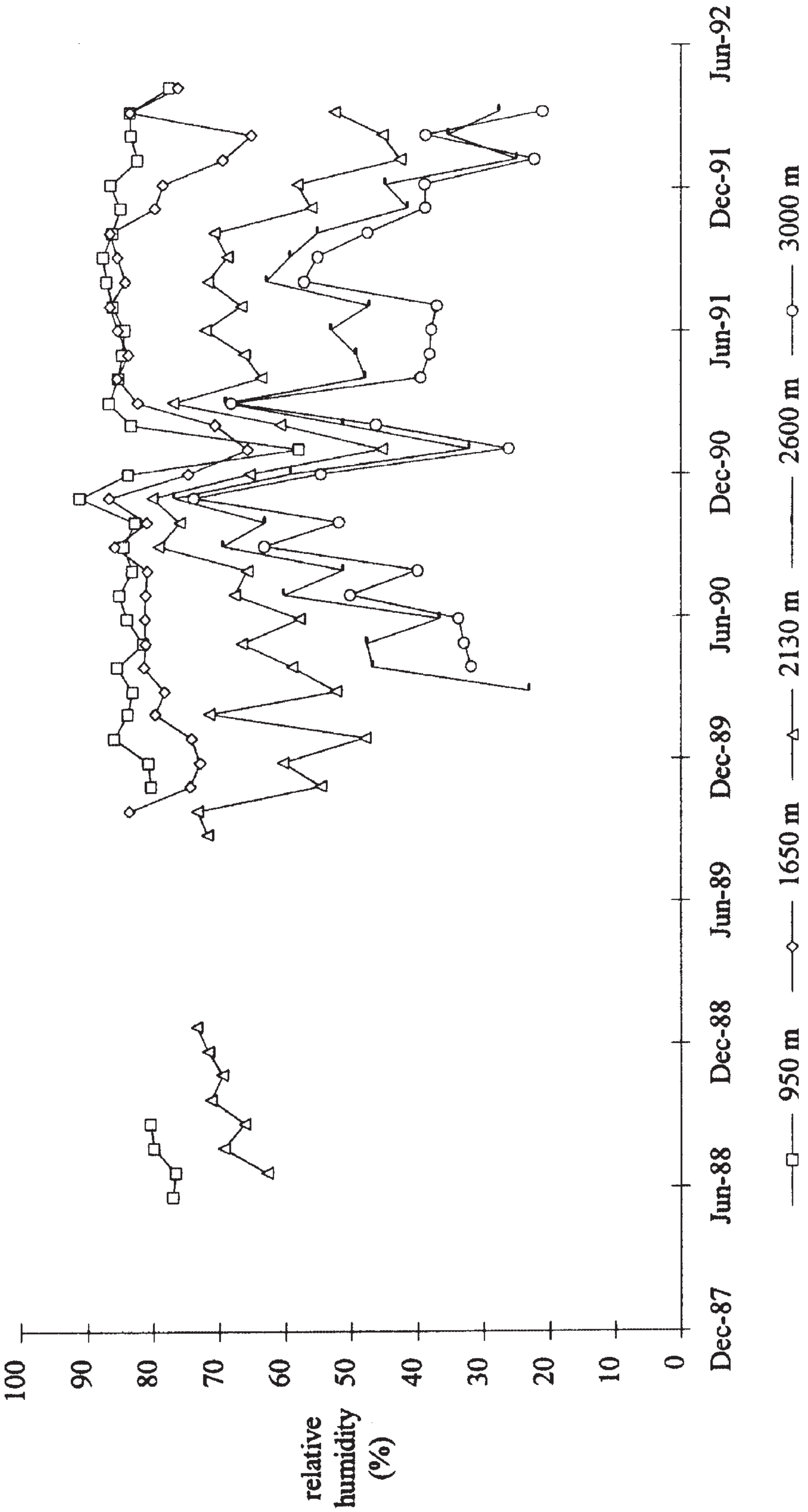


Figure 2: Monthly Mean Relative Humidity



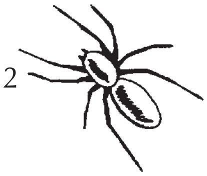


Figure 3: Monthly Mean Wind Speed

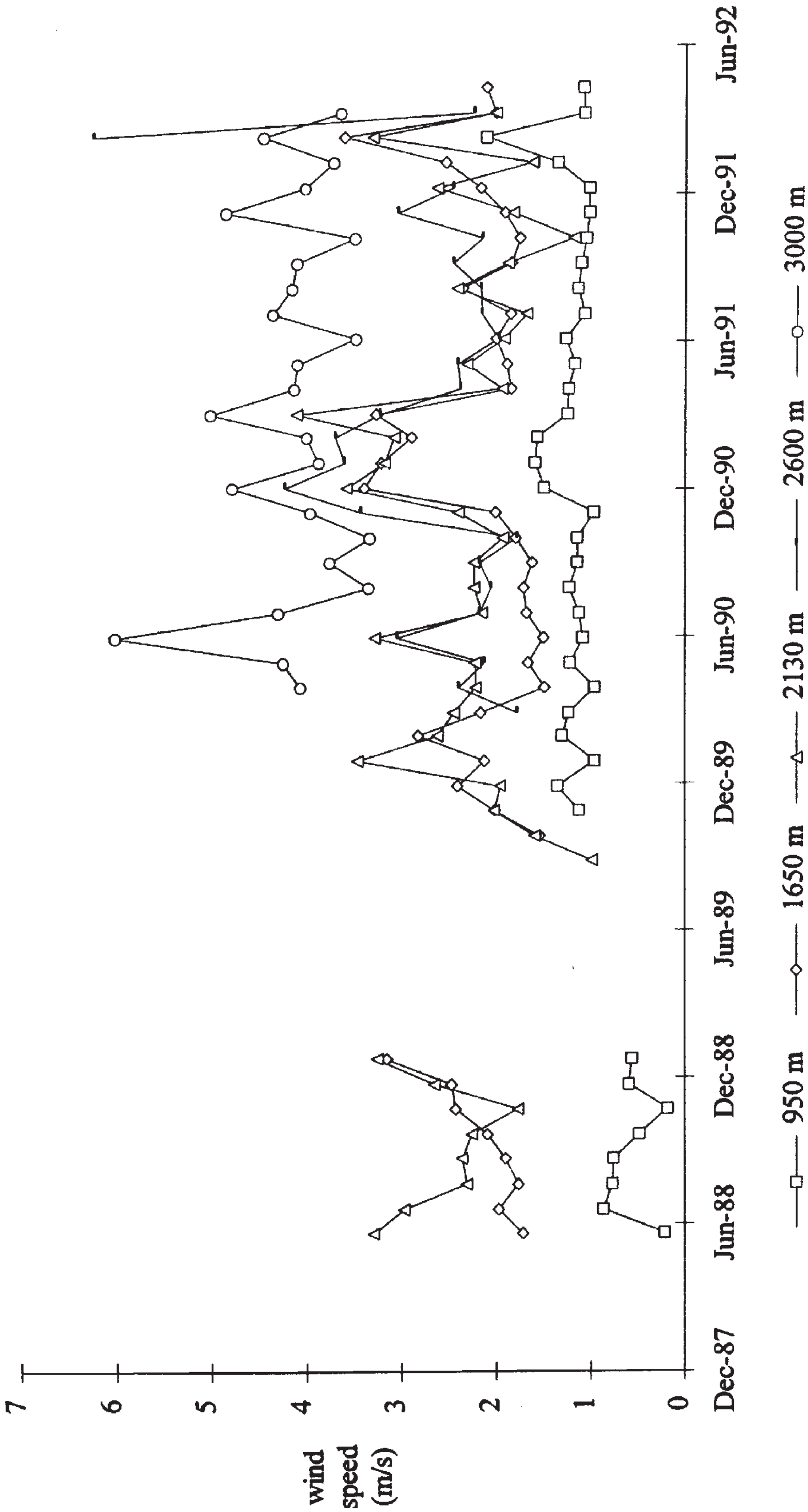


Figure 4: Mean Diurnal Cycle of Global Radiation