Duplicate and distribute to students.

Student Materials

Overview

Scientists classify many features in our environment such as species of life, forest types, or rock types. These classifications, or categories, help us to organize and understand the natural world. In order for these classifications to be useful for scientists, we need to know how accurate they are. A difference/error matrix is the basic tool used to measure the accuracy of a classification procedure. This difference/error matrix also shows us where there was confusion, or difficulty classifying certain classes.

In this activity, images of clouds will be classified into 3 clearly defined categories according to given criteria. Results of this classification will be compared with validation (reference) data by entry onto a chart. The accuracy of charted results will be tallied in a difference/error matrix.

When you have completed this activity, you will be able to:

- classify a set of items (images of clouds) into a well-defined classification scheme
- compare the classifications to a set of validation data to generate a difference/error matrix
- gain an understanding of the meaning of measurement accuracy and precision
- gain insight into some sources of error in scientific measurements.

Materials and Tools

A set of 20 cloud pictures
Copy of procedure with cloud type sketches and Difference/Error Matrix
Cloud Classification Work Sheet

What To Do and How To Do It

1. Carefully spread out the numbered cloud photos as provided and directed by your teacher. Twenty (20) will be classified in this exercise.
2. Using a Cloud Classification Work Sheet, classify all of the clouds in the dataset into three categories: cumulus, stratus, and cirrus.

   Note: Cloud types do not always fit exactly into in these three basic categories. For the purpose of this exercise, use only this simplified classification scheme. Some confusion may occur in the classification process. Accept this 'fuzziness' as part of the uncertainty in the activity. This uncertainty is part of the nature of science, any particular classification scheme never exactly matches the perceived state of the natural world.

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The criteria for the classes are as follows:

cumulus: detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes or towers, of which the upper bulging part often resembles a cauliflower;

stratus: generally gray cloud layer with a fairly uniform base;

cirrus: detached clouds in the form of white, delicate filaments or white or mostly white patches or narrow bands. These clouds may look like horsetails.

3. Sort the clouds into three piles or columns (cumulus, stratus, and cirrus), leaving photos which are difficult to classify between the piles or columns. After classifying all the photos, return to the photos which were difficult to classify. Make a final determination of the appropriate class for each of these. If there is more than one type of cloud in a photo, you must select one dominant cloud type to classify the photo. The decision criteria for the dominant cloud type is whichever cloud type covers the greatest percentage of the sky in the photo. Check your classifications for each one of the twenty photos and record these in the Student Classification column on the Cloud Classification Work Sheet.
4. Your teacher will provide the validation cloud types to the class. You must record the validation cloud type for each photo in the Validation Data column on the Cloud Classification Work Sheet. A record of all the validation cloud types will be *necessary* to complete the exercise!
5. For each photo in which the Student Classification cloud type matches the Validation Data cloud type, put a check (÷) in the (X or ÷) column. For each photo which does not match, put an X in the (X or ÷) column.

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6. Tally the results from the match (X or ÷) column in the matrix using the following directions and the example:
   A. Using the Cloud Classification Work Sheet, count how many times your group matched a student classification of cumulus with a validation answer of cumulus. Place that number here ___________. Now place the same answer in cell A1 in the Difference/Error Matrix below.
   B. Now count how many times your group matched a student classification of cumulus with a validation answer of stratus. Place that number here ________. Now place the answer in cell B1 below.
   C. Check with your teacher before going further!
   D. Fill in the rest of the Difference/Error Matrix following the same procedure.
   E. Double-check that every sample from the Cloud Classification Work Sheet has been tallied in the Difference/Error Matrix. Now, calculate the overall accuracy of your classification according to the formula at the bottom of this page.

Table LAND-L-8: Cloud Classification - Difference/Error Matrix Work Sheet

Validation Data

Student Data	Cumulus	Stratus	Cirrus	Row Total
Cumulus	A1:	B1:	C1:	D2:
Stratus	A2:	B2:	C2:	D2:
Cirrus	A3:	B3:	C3:	D3:
Column Total	A4:	B4:	C4:	D4:

D4 = A4 + B4 + C4 = D1 + D2 + D3

(column total) = (row total)

$$\text{Overall accuracy} = \frac{A1 + B2 + C3}{D4} \times 100$$

Overall accuracy = ____________________ x 100 =__________

Table LAND-L-9: Cloud Classification Work Sheet

Sample Number	Photo Number	Student Classification	Validation Data	✔	X
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Table LAND-L-10: Cloud Classification - Validation Data Sheet

(Answer Key)

Photo #	Validation Data
1	Cirrocumulus
2	Cirrostratus
3	Cumulus
4	Stratus
5	Cirrus
6	Stratocumulus
7	Altocumulus
8	Altostratus
9	Nimbostratus
10	Cumulonimbus
11	Nimbostratus
12	Cumulonimbus
13	Altocumulus
14	Cirrostratus
15	Cirrostratus
16	Altocumulus
17	Nimbostratus
18	Cumulus
19	Altocumulus
20	Nimbostratus

Student accuracy measure:	Level:
0%-50%	Novice
51%75%	Intermediate
76%-100%	Advanced

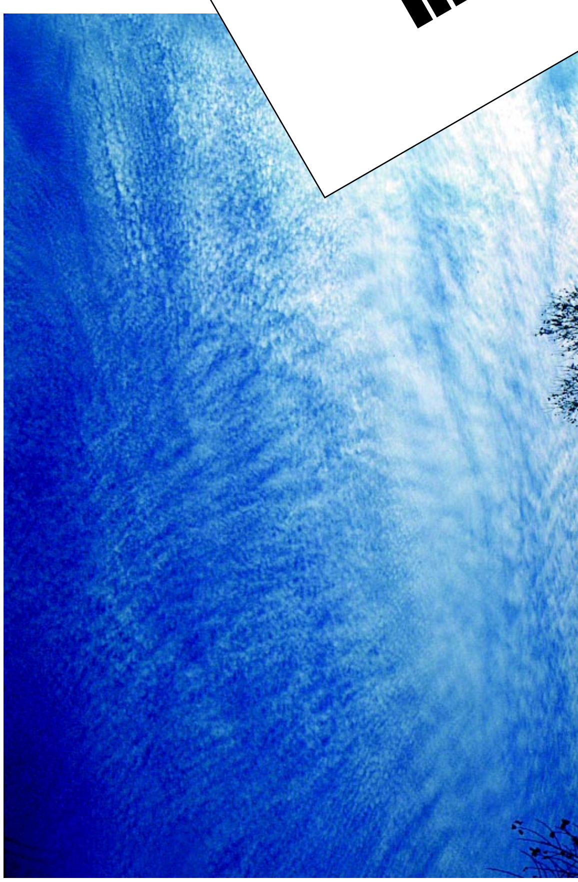

Figure LAND-L-5 (photo 1)

Figure LAND-L-6 (photo 2)

Figure LAND-L-7 (photo 3)

Figure LAND-L-8 (photo 4)

Insert Color Page

Source: Wayne M. Faas and Grant Goodge of the National Climatic Data Center, NOAA

Figure LAND-L-6 (photo 2)

Cirrostratus: *high clouds, light gray or white, often thin with the sun or moon seen through them. Usually covers much of the sky.*

Figure LAND-L-5 (photo 1)

Cirrocumulus: *high clouds with puffy, patchy appearance, with small spaces between clouds. Often form wave-like patterns.*

Figure LAND-L-8 (photo 4)

Stratus: *low clouds, light or dark gray and generally uniform in appearance and cover most of the sky. Fog is a stratus cloud.*

Figure LAND-L-7 (photo 3)

Cumulus: *low clouds. Clouds appear puffy, and look like cotton balls, popcorn or cauliflower.*

Figure LAND-L-9 (photo 5)

Figure LAND-L-10 (photo 6)

Figure LAND-L-11 (photo 7)

hoto 8)

Insert Color Page

Source: Wayne M. Faas and Grant Goodge of the National Climatic Data Center, NOAA

Figure LAND-L-10 (photo 6)

Stratocumulus: *low clouds, with irregular masses of clouds, rolling or puffy in appearance, sometimes with space between the clouds.*

Figure LAND-L-12 (photo 8)

Altostratus: *middle clouds, light gray and uniform in appearance, generally covering most of the sky.*

Figure LAND-L-9 (photo 5)

Cirrus: *high clouds, thin wispy and feathery, composed of ice crystals.*

Figure LAND-L-11 (photo 7)

Altocumulus: *middle clouds with puffy, patchy appearance, usually with spaces between clouds.*

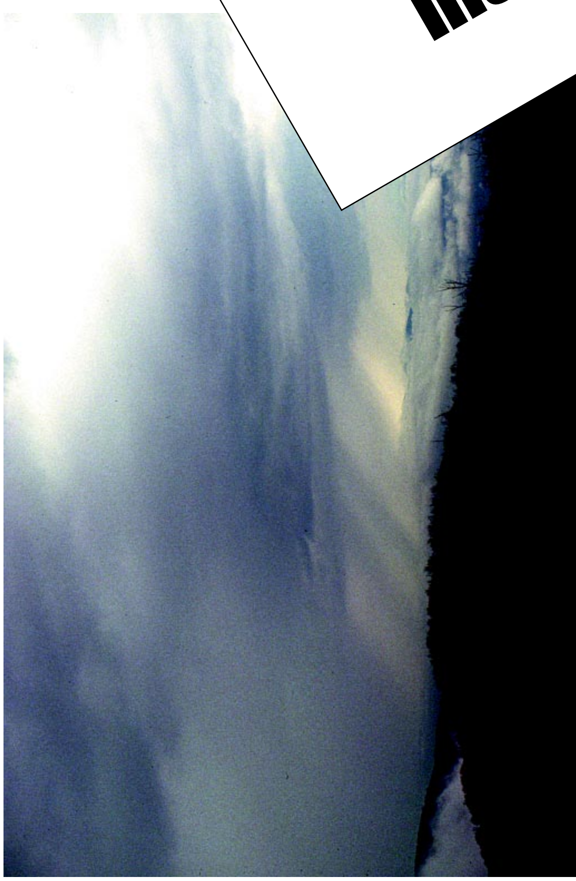

Figure LAND-L-13 (photo 9)

Figure LAND-L-14 (photo 10)

Figure LAND-L-15 (photo 11)

(photo 12)

Insert Color Page

Source: Wayne M. Faas and Grant Goodge of the National Climatic Data Center, NOAA

Figure LAND-L-13 (photo 9)

Nimbostratus: *low and middle dark gray clouds with precipitation falling from them. Bases are diffuse and difficult to determine because of falling precipitation.*

Figure LAND-L-14 (photo 10)

Cumulonimbus: *large clouds with dark bases and tall billowing towers. Can have sharp well defined edges or anvil shape at the top. Precipitation can obscure the base of the clouds. Can be accompanied by thunder.*

Figure LAND-L-15 (photo 11)

Nimbostratus: *low and middle dark gray clouds with precipitation falling from them. Bases are diffuse and difficult to determine because of falling precipitation.*

Figure LAND-L-16 (photo 12)

Cumulonimbus: *large clouds with dark bases and tall billowing towers. Can have sharp well defined edges or anvil shape at the top. Precipitation can obscure the base of the clouds. Can be accompanied by thunder.*

Figure LAND-L-17 (photo 13)

Figure LAND-L-18 (photo 14)

Insert Color Page

Figure LAND-L-19 (photo 15)

…to 16)

Source: Wayne M. Faas and Grant Goodge of the National Climatic Data Center, NOAA

Figure LAND-L-18 (photo 14)

Cirrostratus: *high clouds, light gray or white, often thin with the sun or moon seen through them. Usually covers much of the sky.*

Figure LAND-L-17 (photo 13)

Altocumulus: *middle clouds with puffy, patchy appearance, usually with spaces between clouds.*

Figure LAND-L-20 (photo 16)

Altocumulus: *middle clouds with puffy, patchy appearance, usually with spaces between clouds.*

Figure LAND-L-19 (photo 15)

Cirrostratus: *high clouds, light gray or white, often thin with the sun or moon seen through them. Usually covers much of the sky.*

Figure LAND-L-21 (photo 17)

Figure LAND-L-22 (photo 18)

Figure LAND-L-23 (photo 19)

hoto 20)

Insert Color Page

Source: Wayne M. Faas and Grant Goodge of the National Climatic Data Center, NOAA

Figure LAND-L-21 (photo 17)

***Nimbostratus:** low and middle dark gray clouds with precipitation falling from them. Bases are diffuse and difficult to determine because of falling precipitation.*

Figure LAND-L-22 (photo 18)

***Cumulus:** low clouds. Clouds appear puffy, and look like cotton balls, popcorn or cauli-flower.*

Figure LAND-L-23 (photo 19)

***Altocumulus:** middle clouds with puffy, patchy appearance, usually with spaces between clouds.*

Figure LAND-L-24 (photo 20)

***Nimbostratus:** low and middle dark gray clouds with precipitation falling from them. Bases are diffuse and difficult to determine because of falling precipitation.*