# Fold and Forecast: Teacher's Guide

## Overview

In this activity, students will learn about climate models and their role in making forecasts of future weather and climate. Additionally, students will learn how to convey information when it isn't certain that an outcome will happen. Throwing paper airplanes allows the students to create their own forecasts about a weather or climate event of the instructor's choice.

The provided materials give 2 examples: "Will it rain tomorrow?" from weather forecasting, and "Will there be an El Niño or a La Niña event?" from climate forecasting. By throwing paper airplanes, the students will build a probabilistic forecast and discuss why statements of probability help convey the forecast information. The accompanying video in this unit has step-by-step instructions about how to create a forecast, and how to make a viable paper airplane.

## Glossary

Climate Model- Climate models use mathematical equations to characterize how energy and matter interact in different parts of the ocean, atmosphere, and land. (Source: NOAA)

Forecast- Forecasts are the calculation or prediction of some future event or condition, usually as a result of study and analysis of available data (Source: Merriam-Webster)

El Niño- El Niño is a joint atmospheric and oceanic condition that occurs in the Pacific Ocean with such great strength that it affects weather all over the world. In El Niño years, ocean waters along the South American and Californian coasts warm above normal temperatures. (Source: NASA)

La Niña- La Niña is a joint atmospheric and oceanic condition that occurs in the Pacific Ocean with such great strength that it affects weather all over the world. In La Niña years, ocean waters along South America and California cool below normal temperatures. (Source: NASA)

## Lesson Information

Subject: Science
Grade Level:
Adaptable for grades 6-12
NGSS:
MS-ESS3-2 Earth and Human Activity
HS-ESS3-5 Earth and Human Activity

## Additional Resources

Full Lesson Recording (12 min)

How to Create a Paper Airplane

Explaining Forecasting to Kids

What is an Ensemble Forecast?

Introduction to Ensemble Forecasts

ENSO Forecasting

## Materials Needed

- Paper (3 pieces per student)
- Template Examples
- Place marker (tape, towel, etc)

## Learning Objectives

- Students will apply fractions and probability to communicate uncertainty in a precipitation forecast
- Students will be able to explain that weather is hard to predict
- Students will explain why a precipitation forecast should be a fraction or percentage
- Students will become familiar with the scientific processes of climate models

# Background Information

## Initial Discussion Questions

How do you use weather forecasts in your everyday life?

Why are forecasts important?

Why do they help in disaster situations like a tornado or a hurricane?

What does a forecast that says "50% chance of rain" mean?

## Models and Forecasts

Forecasting weather is important in making decisions such as picking what to wear for the day, or deciding to bring an umbrella or not. Forecasting climate is important because it can help predict more severe weather and climate events like hurricanes, droughts, or El Niño.

Climate models are computer programs that use the physics of Earth to visualize future climate. When the models are started with the current weather conditions, they can be used to predict the weather in the coming days and climate in future months.

This activity uses paper airplanes as a metaphor for running a weather or climate model multiple times to get a sense of the uncertainty in weather/climate predictions. Because scientists don't have every piece of information about the state of the Earth's atmosphere, it is impossible to know exactly what is going to happen. The phrase we commonly hear of "23 percent chance of rain" is used to communicate this uncertainty.

To make sure a forecast is as accurate as possible, scientists sometimes run ensemble forecasts. Ensemble forecasts are the result of running multiple models with slightly different input information, to help understand all of the possible outcomes. If scientists run a model 4 times and its shows rain in 1, that translates to a 25% chance of rain. The reason students are throwing the airplanes more than once is to simulate running more than one model.

# Background Information

## Butterfly Effect

In a 1972 presentation, meteorologist Edward Lorenz hypothesized that large events could be caused by the smallest of disturbances, such as a tornado being caused by a butterfly flapping its wings miles away, which is now called the butterfly effect. In the context of climate science, the butterfly effect means that tiny changes in the starting state of a climate or weather model can lead to big changes in the model results.

In this activity, the instructor should encourage the students to think about what large or very tiny things could influence the student's airplane toss (e.g., gusts of wind, students bumping into each other, sore wrist, etc.) and how that could make the path of their airplane uncertain. To try to reduce uncertainty, the instructor should suggest that the students throw each airplane exactly the same for every toss. This will keep the experiment as controlled as possible and will attempt to reduce small errors that could send the airplane far off course.

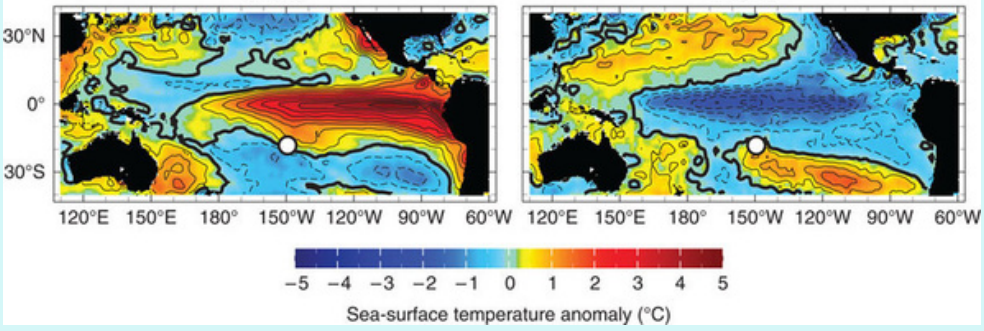
However, even with an identical toss of the paper airplane every time, students will see that the airplanes do not land in the same spot. This is because no throw can ever be exactly the same due to the small things that change over time, such as the flap of a butterfly wing. Similarly, in climate science, even with a perfect understanding of the initial state of the climate system, the outcome of model runs is uncertain, and that uncertainty grows over time creating different, but equally possible forecasts of the future.

## ENSO

ENSO stands for El Niño Southern Oscillation, which is the interaction between the ocean and atmosphere of the tropical Pacific Ocean, which impacts the temperature of the waters in the central and eastern Pacific.

ENSO is important because of its ability to influence temperature and precipitation around the world. These ENSO changes can impact food security, agricultural decision-making, and drought and flood patterns from extreme weather events like tropical cyclone activity.

It is possible to predict ENSO through observational data and seasonal forecast models. One model is run multiple times through a supercomputer and tiny adjustments are made to see the impacts on the atmosphere. Models are run multiple times to get an accurate prediction, which is simulated in the activity by throwing the paper airplane several times.




El Niño La Niña

# Activity 1: Making a Forecast

Time Required:
25 minutes - 30 minutes

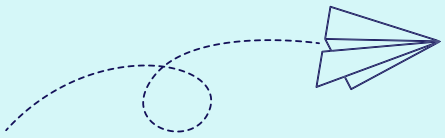
## Making Paper Airplanes

Each student will throw an airplane at least three times to replicate a forecast. It will be beneficial to the instructor to have each student keep track of their throws either on a worksheet, whiteboard, or chalkboard.

The students will need to construct their own paper airplanes. The steps for creating a paper airplane are to first fold the paper in half vertically also known as hotdog style. Then the students should open the paper up with the crease down, fold the top corners of the paper down to meet the middle crease into a point, and repeat folding the folded corners in again to create a sharper point.

Next, the students should fold the airplane in half along the original fold line and press the airplane so the edges are smooth. Following, the students need to take each wing and fold them out and way from the body of the airplane. Lastly, lift the wings up a bit more so that the paper airplane is ready to fly. For a step-by-step visual tutorial on how to make a paper airplane, instructors can go to 1:40 of the instruction video.

## Issuing Forecasts



The instructor should put a sign on the floor that is divided in half, with the top half indicating one weather event like rainfall and the bottom half indicating the opposite, so no rainfall. Instructors can also place tape or some form of marker across the floor of the room, to make it easier for students to visualize.

Each student should throw the airplane from a place on the floor that is marked by the instructor. The instructor should emphasize the importance of trying to have the same type of throw each time so that the student is properly replicating their experiment.

If the student's airplane is past the half of the piece of paper that states which weather event is occurring then the student should mark that as one throw for the weather event happening and if the paper airplane does not reach the half of the paper, it is counted as a throw for the weather event not occurring.

Using rainfall as an example, after each student throws at least three paper airplanes they can determine the forecast of rainfall occurring using fractions. For example, if a student threw 4 paper airplanes and three went past the sign indicating rainfall and one did not, then there is a ¾ chance that it rains or a forecast stating there is a 75 percent chance of rain.

# Activity 1: Making a Forecast

Time Required:
25 minutes - 30 minutes

## Discussion/Wrap Up

Now that you've done the activity, what do you think a forecast that says "50% chance of rain" means?

Teachers can guide the discussion by highlighting how many times the students threw the paper airplanes versus how many times they landed in the "rain" category. If the paper airplane landed in "rain" two out of four tries, or when a scientist runs a model four times and it shows rain twice, that translates to a 50% chance of rain. Scientists use this same strategy by running multiple computer models, to generate ensemble forecasts.

Why do you think climate scientists run models multiple times?

Teachers can guide the discussion by encouraging students to think about how many trials they did with their paper airplanes. If they only threw the planes twice, the fractions would not be very accurate because of the lack of data. But, the more times they throw the airplane, the more data they can collect. Since each model takes different environmental factors and processes into account, the more models that are available to run, the more accurate the forecast will be.

What was the point of throwing the paper airplane the same way every time? What would happen if you hadn't thrown it the same way?

Teachers can facilitate discussion by restating that the not throwing the airplane the same way will create less accurate results. Inaccurate results would create bad forecasts, which in real life could hurt the people relying on the information.

**Subject Connection: MATH**
This activity can help teach fractions. Students will need to find a percentage or fraction of the forecast of the climate event.

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