**Discussing errors in forecast models**

There are various ways that a model might not provide an accurate prediction. Ask the students to think about their model and what might explain the difference between the model forecast and where the buoy actually drifted.

Below are examples of particular types of errors in modeling. In considering each error it is important to consider if the model, with it’s known uncertainties is fit for the purpose it is designed for. In this case that purpose is estimating where a buoy will drift so it can be revisited in a day. We can quantify the ability of the model to predict ice drift, in terms of a model skill score. The art of modeling is to reduce errors to acceptable levels and/or to understand how model behavior responds to variance that is similar to the known error. In the case of a sea ice trajectory we have a tolerance of an acceptable search radius to find the buoy in a day, this might be as large as 10km (for example for a helicopter search and rescue operation).

*Types of Error* we encounter in these lessons

Calculation Error: Were your calculations accurate? Check yourself by comparing to others or redoing your calculation.

In a model which has equations solved by computation (numerical methods) there is an inherent error introduced by rounding because a computer can only hold numbers to limited precision. This introduces a roundoff error in calculations. It is typically small, but some systems of equations can amplify numerical error. We study variability in the climate system by allowing model runs to be initialized with numbers describing the atmospheric state that are within numerical tolerance of each other. The natural variability in the climate system these experiments show is commonly known as the butterfly effect. A small beat of wings here will change the weather elsewhere.

While we can not control the chaotic behavior of our model, we can work to ensure the sensitivity of the model to variability in forcing (sunlight for example) is realistic. Such a model will describe the long-term response of the system well.

Measurement Error: GPS is accurate to about 25m for typical handheld devices. This error propagates through your calculations, and so will introduce a minimum drift speed that is detectable. Essentially you cannot dissociate two points less than 50m apart, so the ice needs to drift more than 50m for a speed to be detectable.

Speed = distance travelled / time

If positions are recorded one hour apart, the buoy must drift at least 50m in that hour. So the minimum speed detectable is 50 m / 1 hr = 50 / 3600 sec = 0.01 m/s

Ice on average moves at about 2 m/s, so this error is not significant in our calculations.

Discretisation Error: This is the error introduced by the assumptions you make to calculate a solution by approximating the function you are solving. In the case of finding the distance a buoy has drifted, the piecewise linear approximation will introduce a discretization error.

Representation Error: The earth is not perfectly spherical, it is an oblique ellipsoid, and radius varies with location on the planet. You estimate of drift speed is based on assuming the earth is locally flat, this introduces a representation error into your calculations. You can quantify this error. It is important to consider such representation errors when choosing a map projection to work in for calculations of distance, bearing or area on the Earth.

Model Error: The persistence model does not account for information related to the force balance on the ice, it does not obey Newton’s laws. Would a physically realistic model, that solves the momentum balance according to Newton’s laws do a better job?