Weather and Climate

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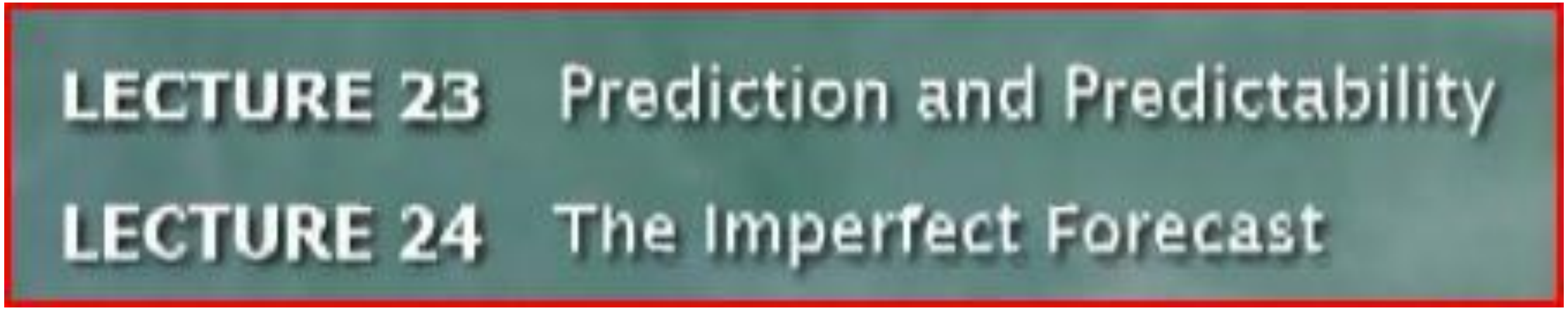
Week 8 March: 5th , 2019

PART A

- LECTURE 23: PREDICTION AND PREDICABILITY
- LECTURE 24: THE IMPERFECT FORECAST
- CLIMATE CHANGE – PART B



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METEOROLOGY

An Introduction to the Wonders of the Weather

Lecture 23

Prediction and Predictability

Models

Will discuss how models work

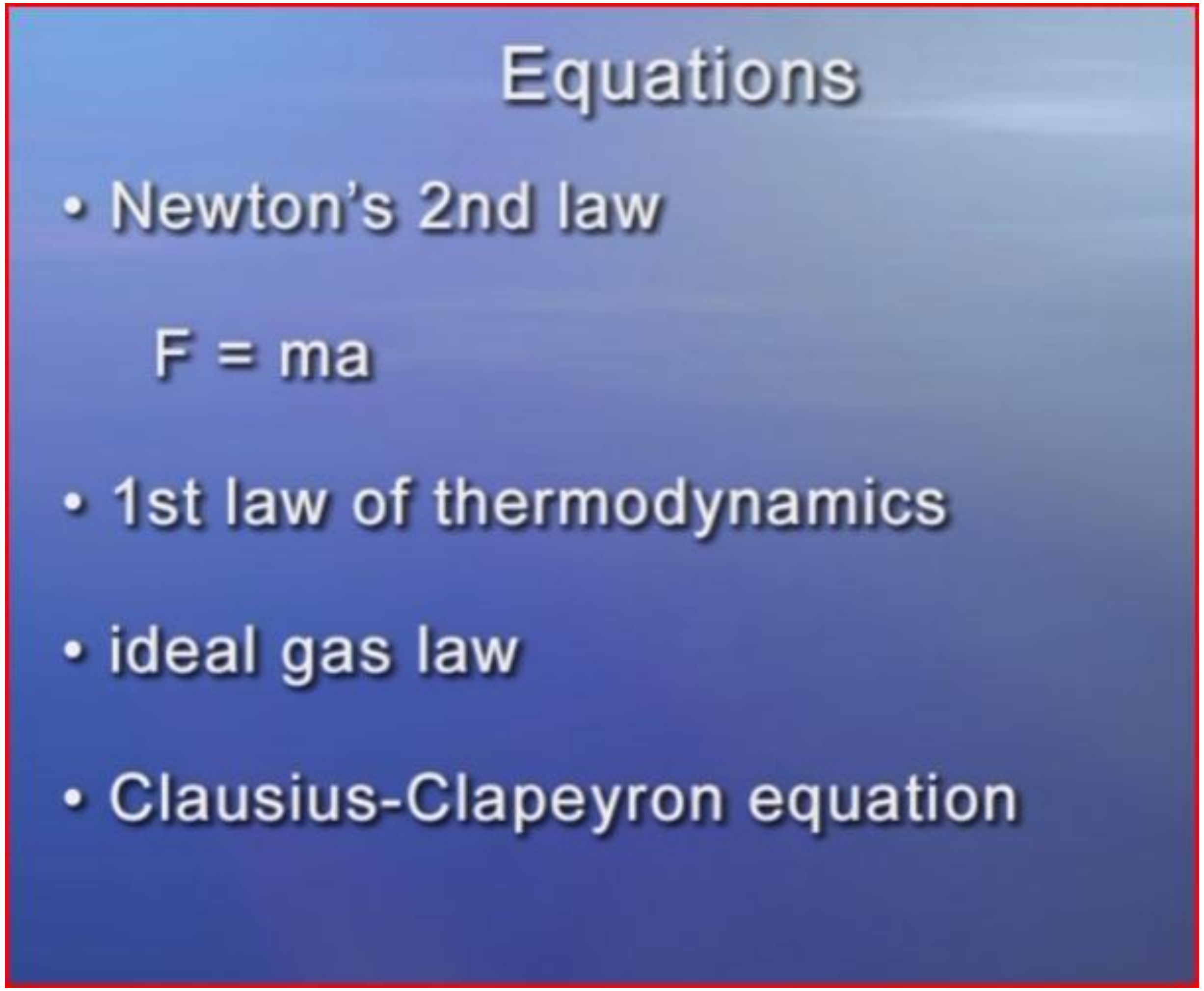
- Observations blended with modeling and how predictions are made
- The difference between weather and climate

Models

Start with equations:

- F = ma (mass times acceleration)
  - Governs winds and flows
  - Combinations of these forces occur

- 1st law of thermodynamics – how T changes in response to heating
- Ideal gas law – relates P, T and density
- Clausius-Clapeyron equation – T and saturation pressure



Models and Model strategies

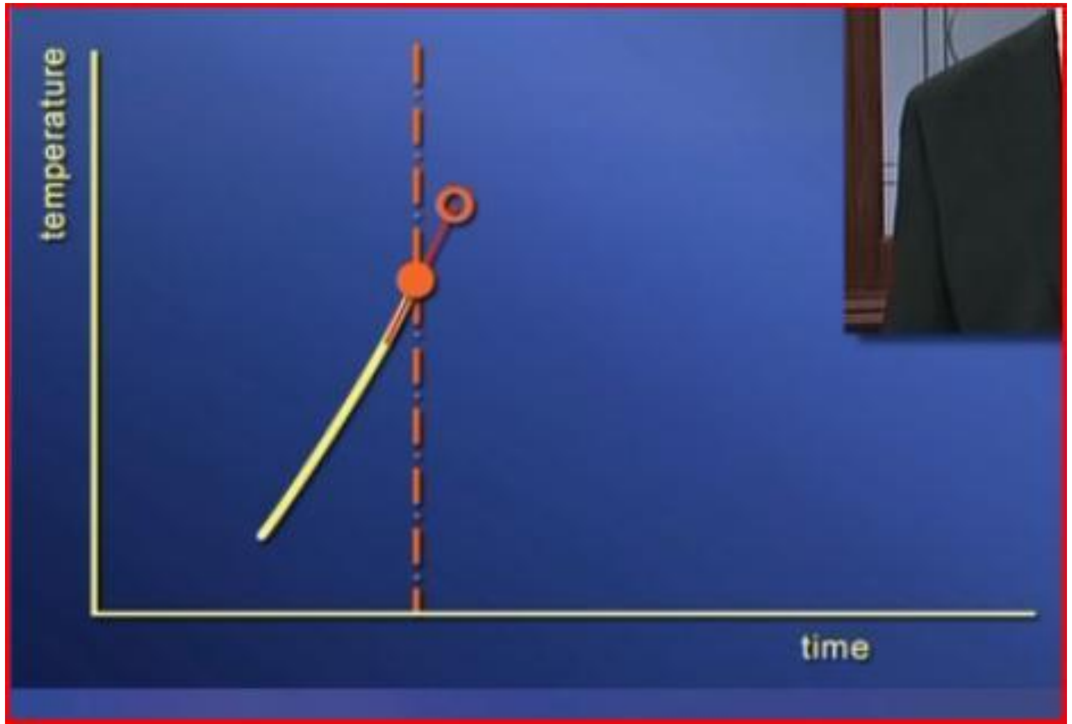
- Involves partitioning using a three dimensional grid
- Grid points
- The smaller the partitioning the better the forecast but the more computer horsepower needed

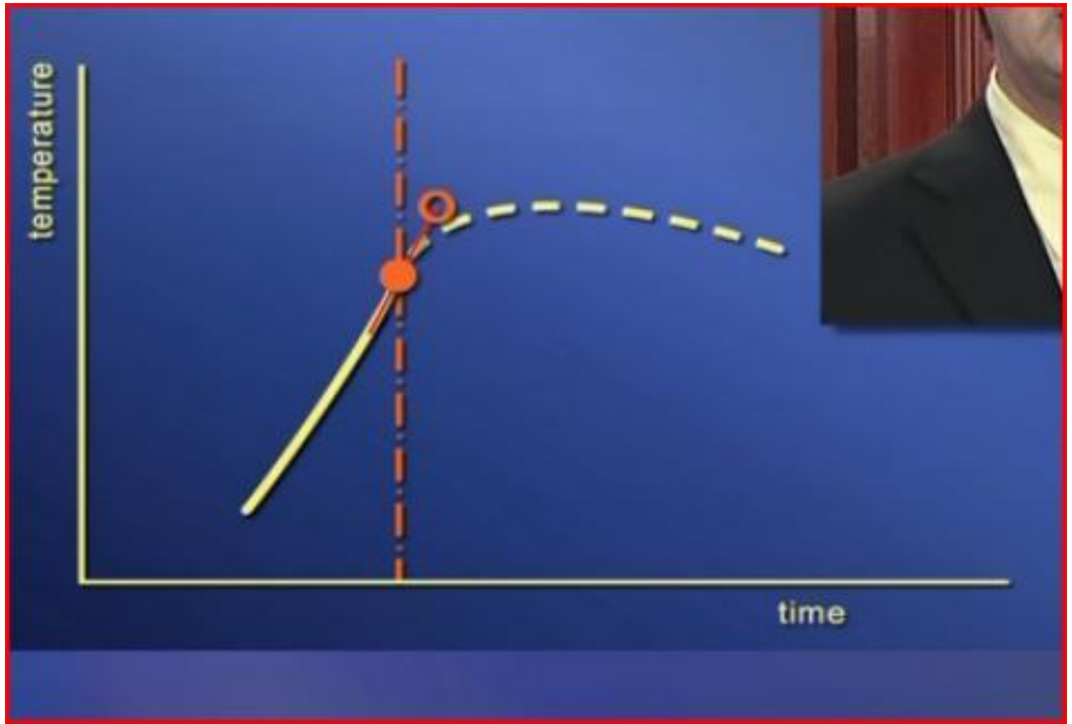
Forecasting is extrapolation using mathematical models

- Based on observations and previous forecasts
- Using judicious assumptions, where necessary

Lecturer runs through example for a model forecast

- Observation and prediction beyond
- Assumptions and predictions (projections)
- Forecast concept can’t be extended too far – things change



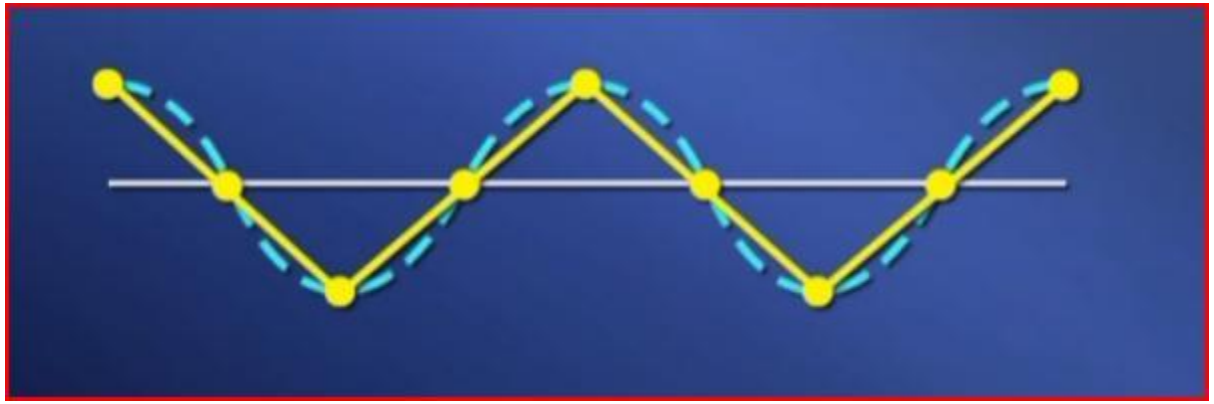


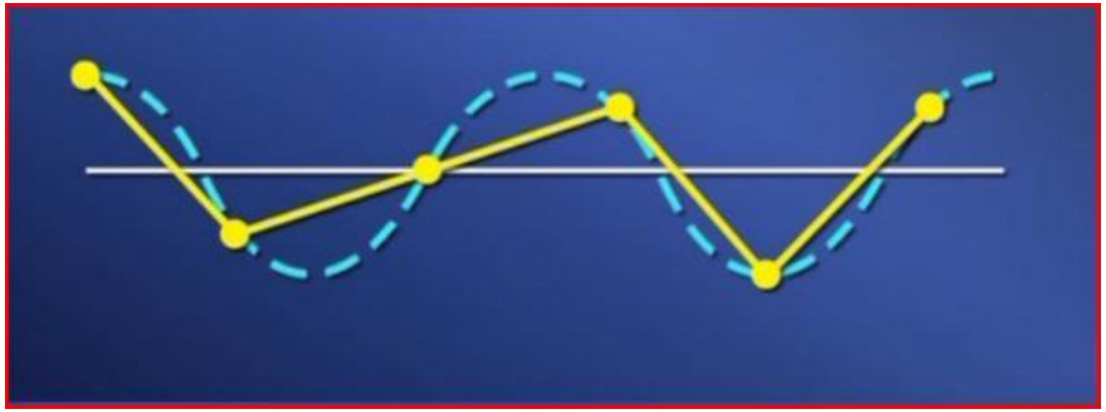
NWP – Numerical Weather Prediction

- Models have been refined over the years based on history
- Increased computation power has vastly improved predictions

Grid – small cells are better but costly in computer time

- Resolution – small cells and more data required
- Left hand model of sign wave is much closer because more data

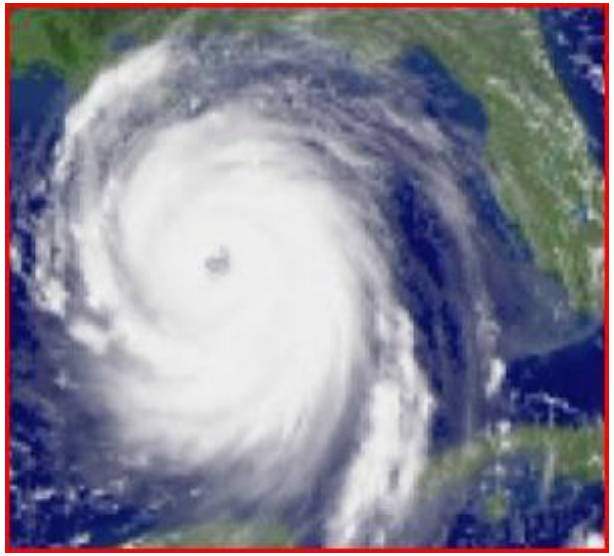


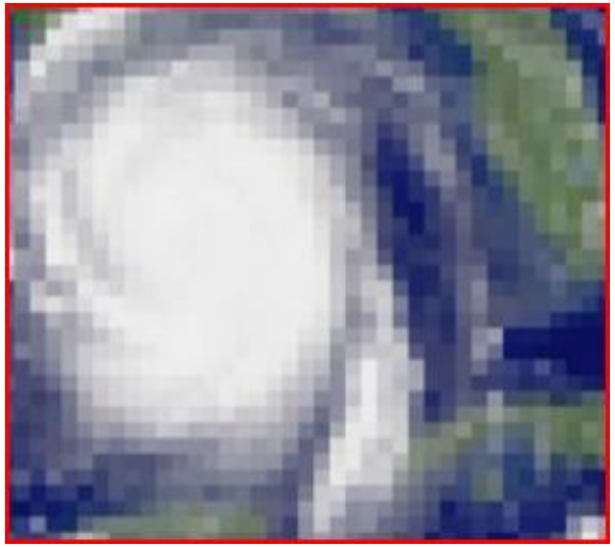


Resolution variations

COMPROMISES IN RESOLUTION:

- 1 km vs. 10 km VS. 30 km

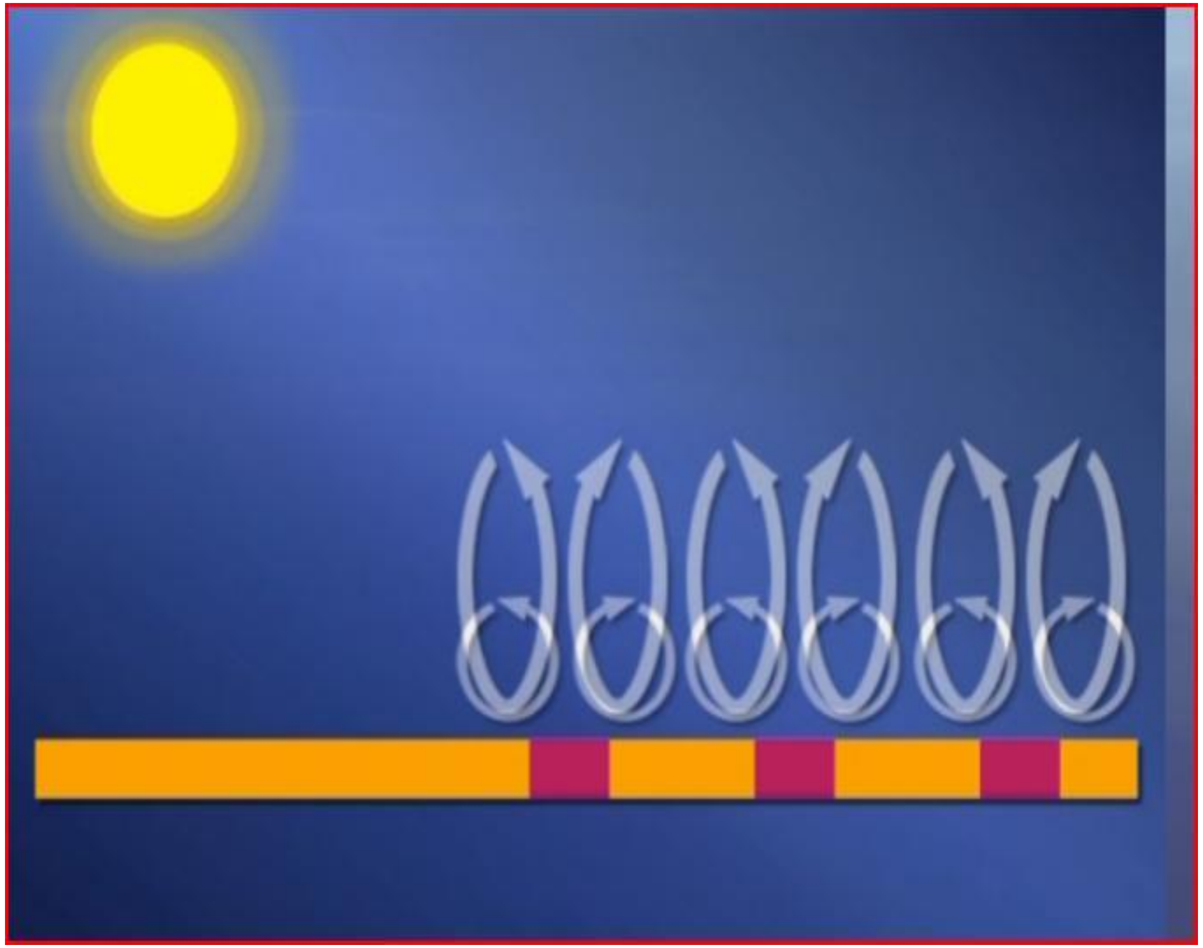


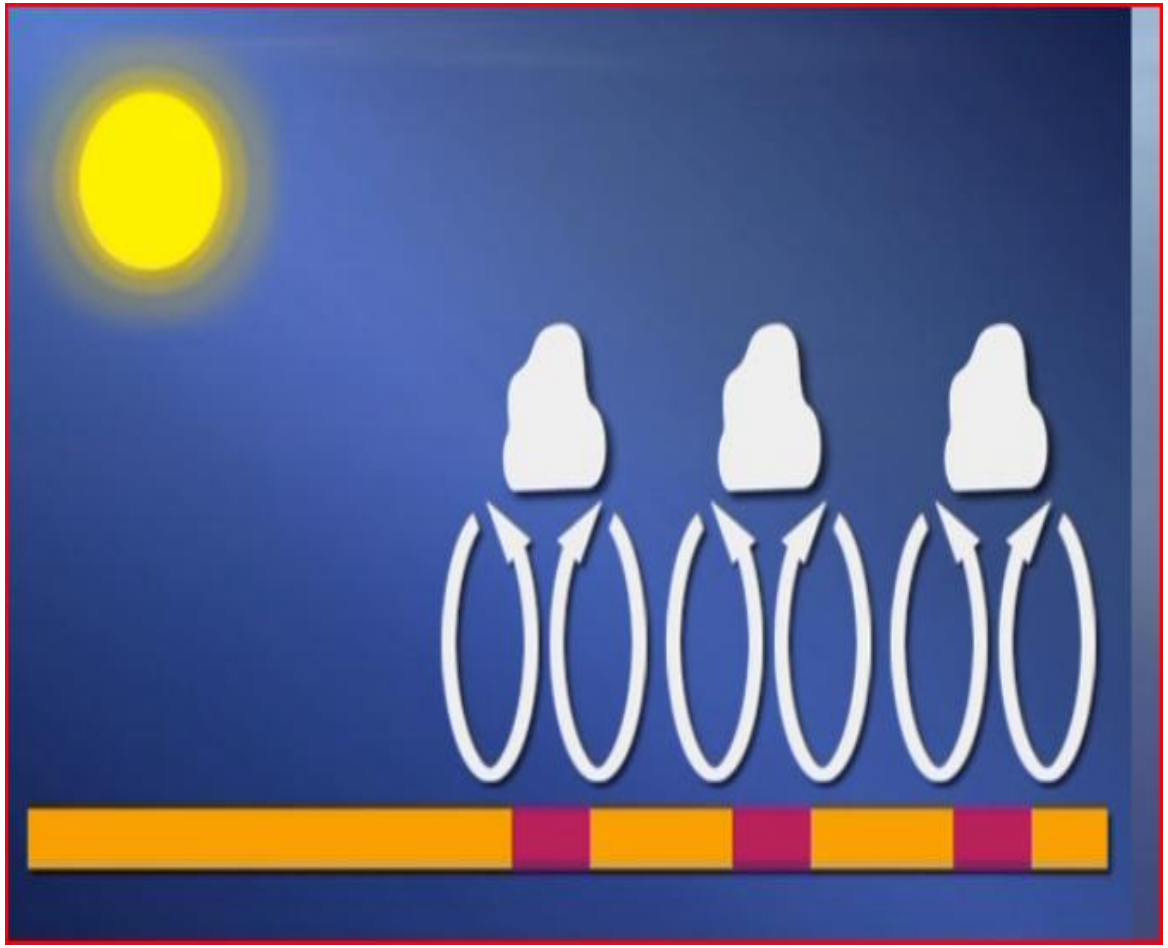


Parameterization

- boundary layer processes
- cloud microphysics
- convective parameterizations
- surface processes
- subsurface processes
- radiative transfer

Advection and roll Clouds



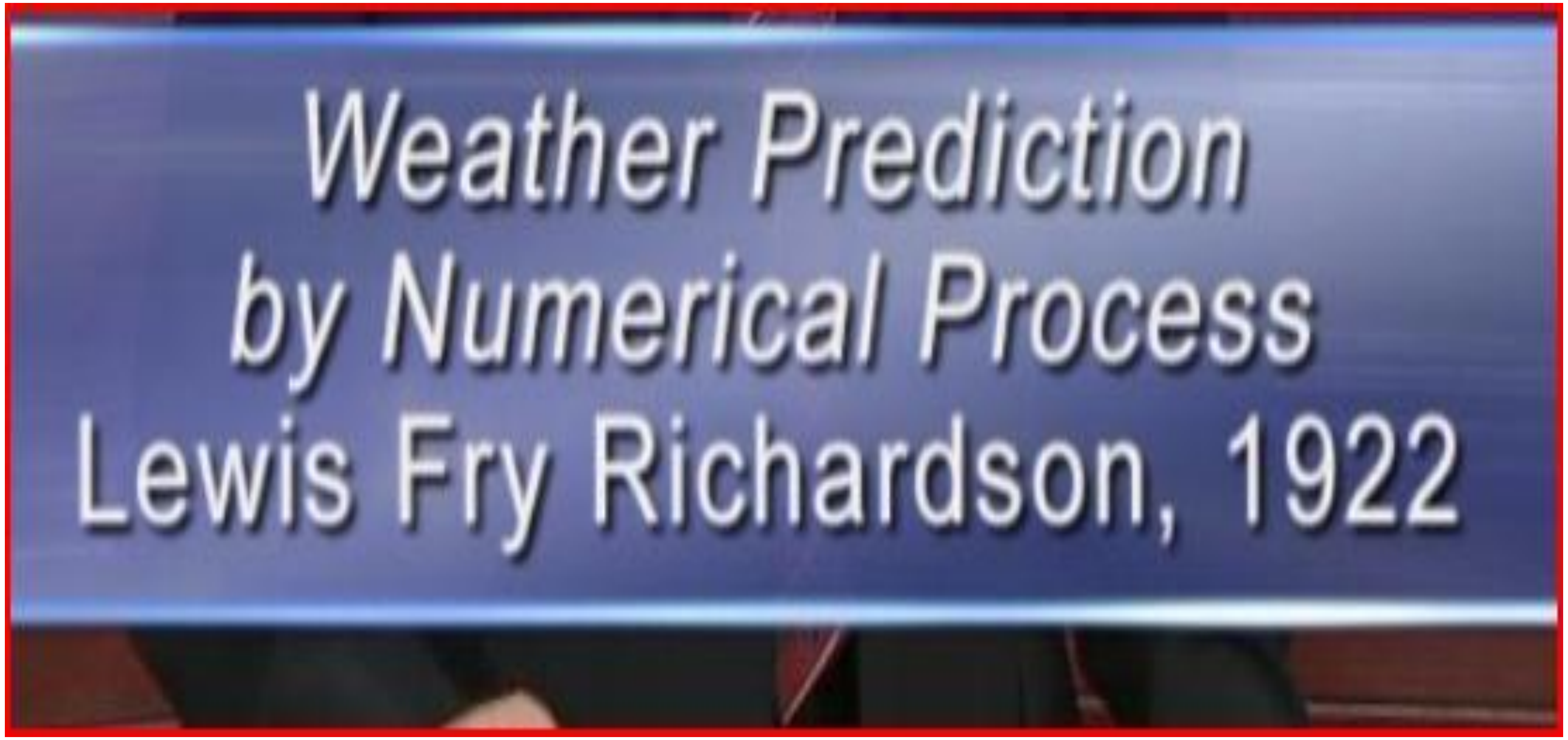


7 Fundamental Variables

- temperature
- pressure
- density
- humidity
- three wind directions

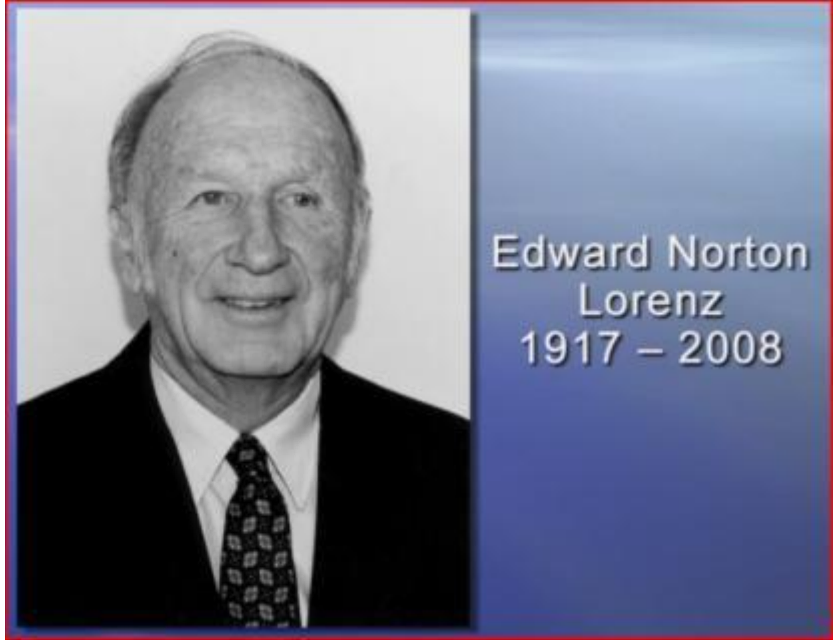
Modelling and over-extrapolation, but a start

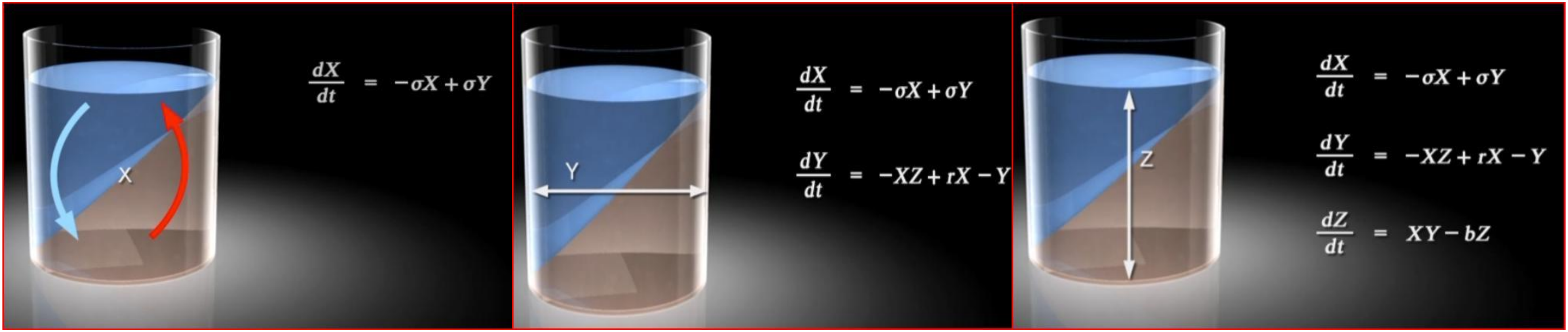
- By pencil and slide rule (the rotary telephone of computation).



1962 Lorenz model

- **Equations vs. grid:**
- **X**
- **Y**
- **Z**





Limits to Predictability

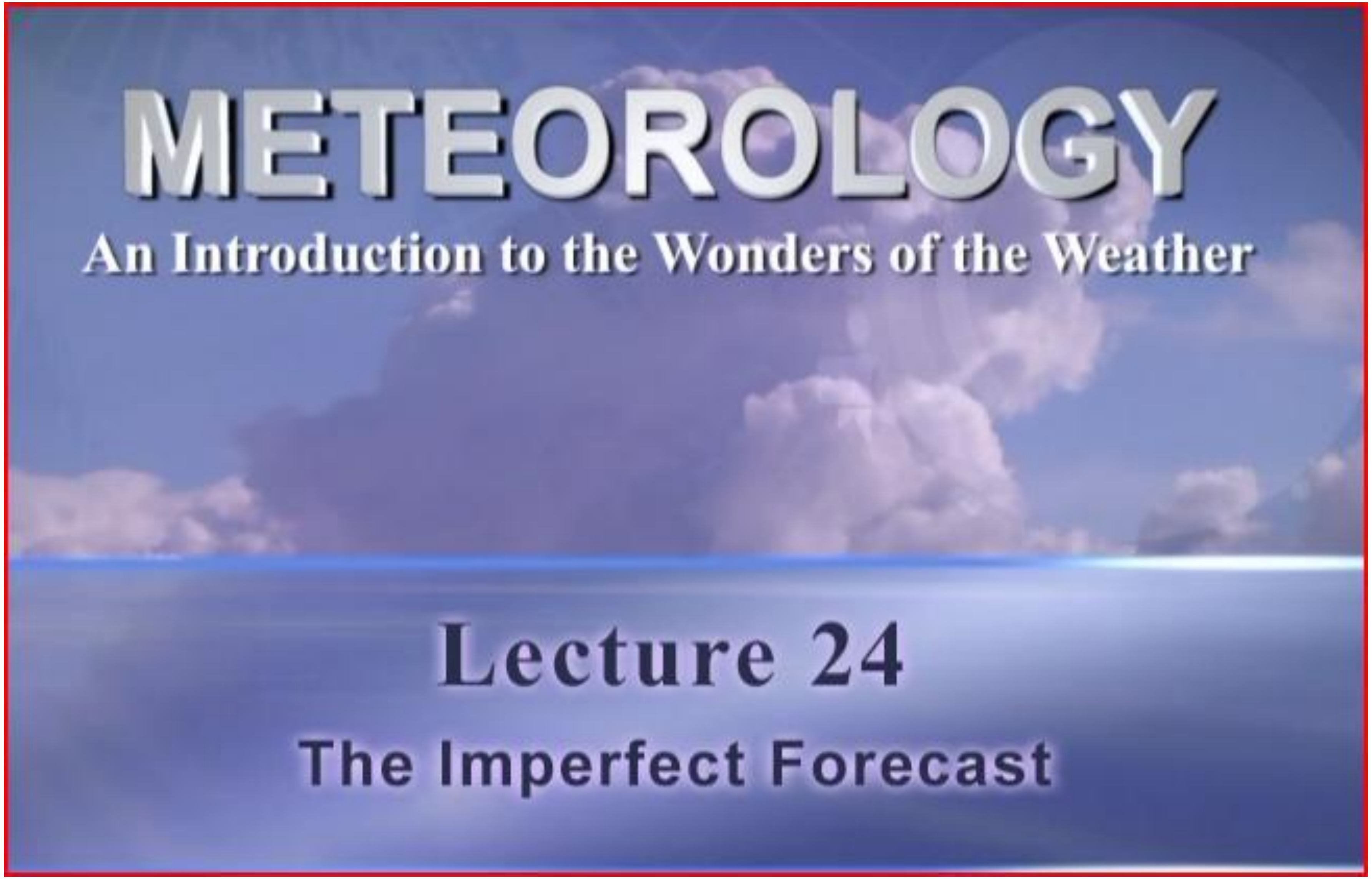
Sensitive dependence on initial conditions:

- Chaos theory, aka Butterfly effect
- Actually deterministic

How can we predict climate projection if we can’t predict next week’s weather

- Weather is not climate
- Climate is the statistics of weather and whether the statistics of weather will change in the future
- Limits of what can be resolved vs. what cannot be resolved
- Need to parameterize those that cannot be resolved - process of providing different input values through external parameters is called **parameterization**.

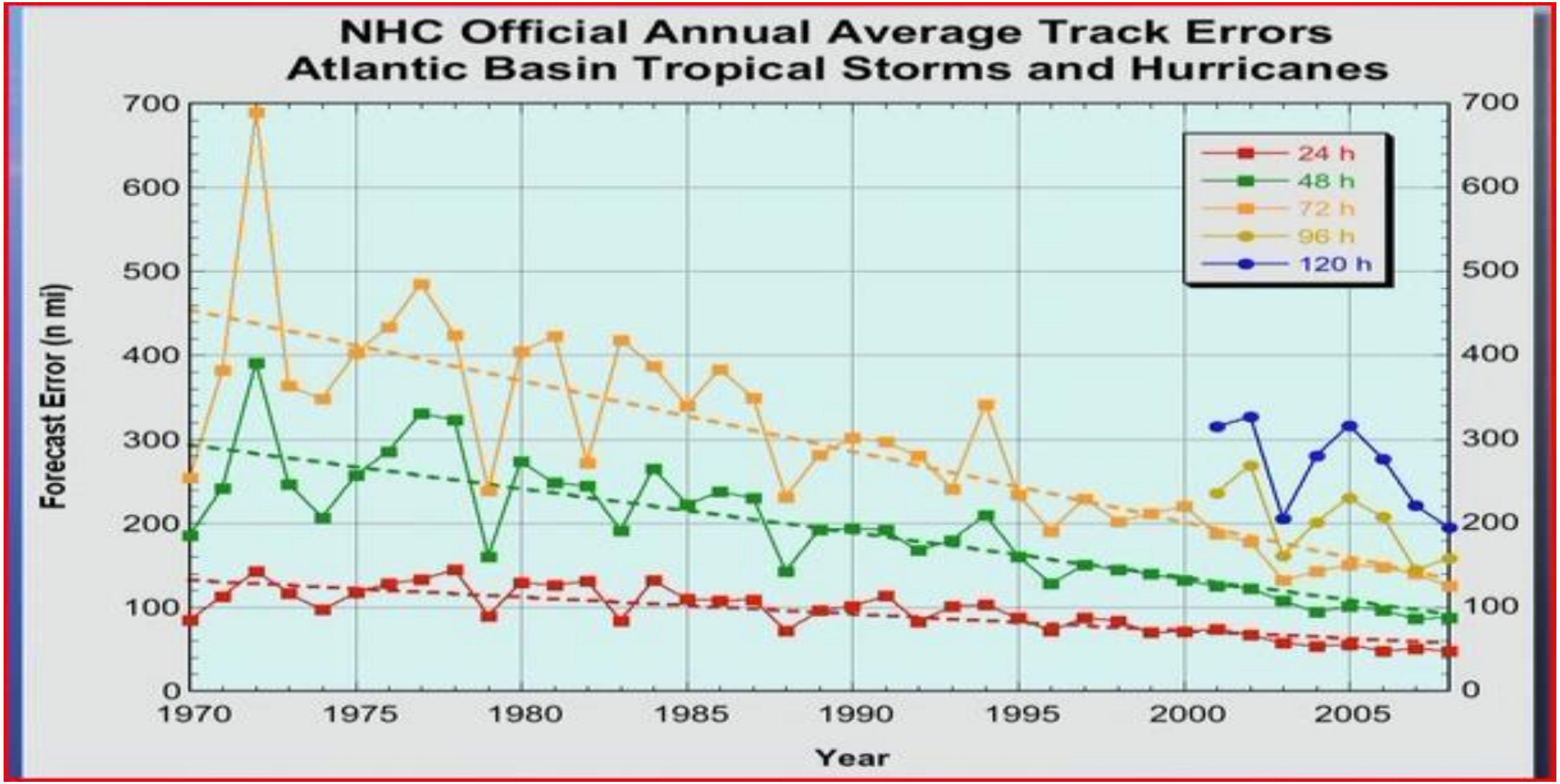
…and thus the Imperfect forecast



NHC – National Hurricane Center

- Hurricane forecasting
- Tropical cyclogenesis
- Track forecasting

Shows improvement of forecasting

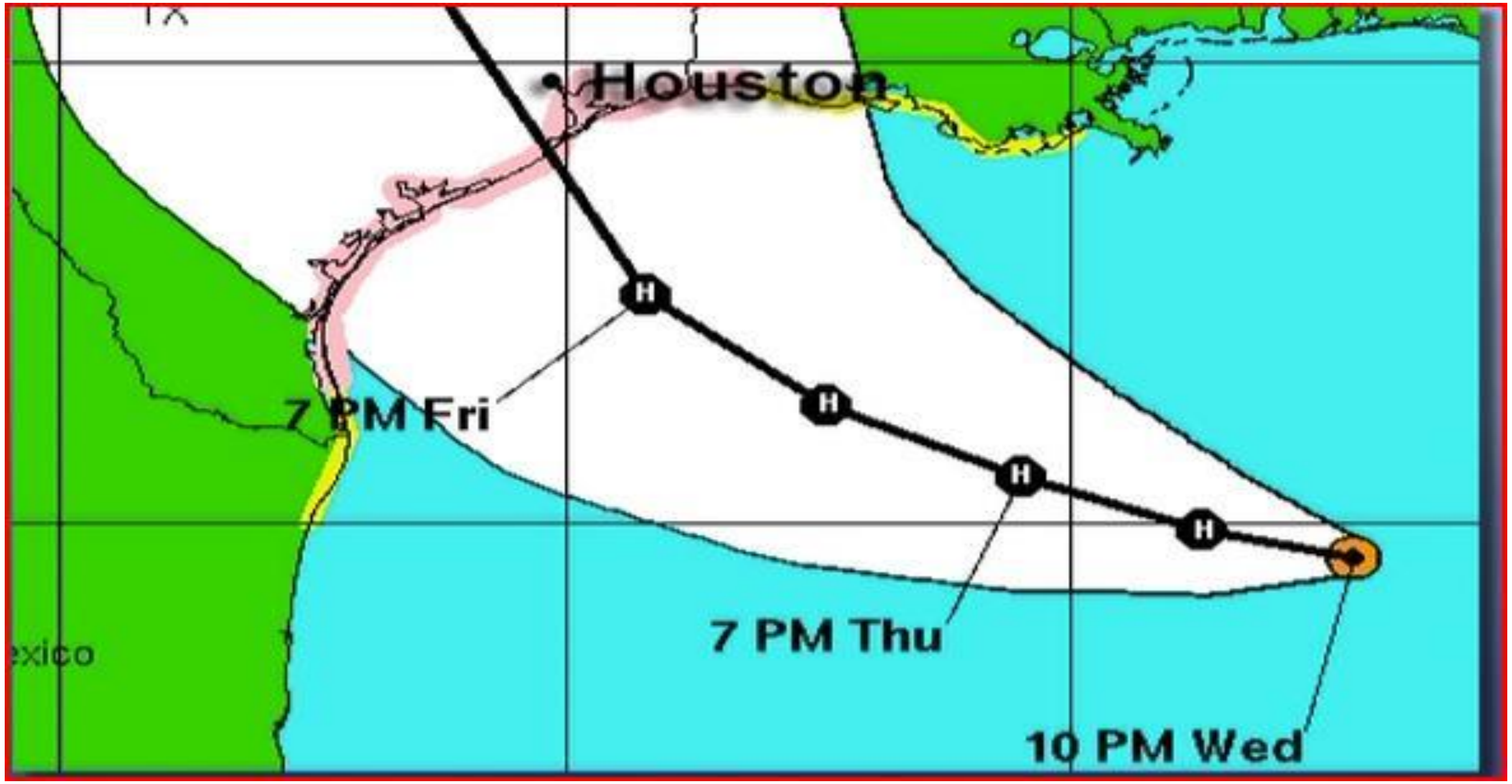


Katrina landfall 8/25/05 Florida and 8/29 in LA; Rita landfall 9/21-222/2005

https://en.wikipedia.org/wiki/Hurricane_Katrina https://en.wikipedia.org/wiki/Hurricane_Rita

Rita landfall in Louisiana 9/21-222/2005

- A pressure ridge caused deviation to the east and landed in less populated Louisiana



https://en.wikipedia.org/wiki/Hurricane_Rita

Most intense Atlantic hurricanes

Rank	Hurricane	Season	Pressure	
			hPa	inHg
1	Wilma	2005	882	26.05
2	Gilbert	1988	888	26.23
3	"Labor Day"	1935	892	26.34
4	Rita	2005	895	26.43
5	Allen	1980	899	26.55
6	Camille	1969	900	26.58
7	Katrina	2005	902	26.64
8	Mitch	1998	905	26.73
	Dean	2007		
10	Maria	2017	908	26.81

Source: HURDAT[1]

Most intense landfalling Atlantic hurricanes

Intensity is measured solely by central pressure

Rank	Hurricane	Season	Landfall pressure
1	"Labor Day"	1935	892 mbar (hPa)
2	Camille	1969	900 mbar (hPa)
	Gilbert	1988	
4	Dean	2007	905 mbar (hPa)
5	"Cuba"	1924	910 mbar (hPa)
6	Janet	1955	914 mbar (hPa)
	Irma	2017	
8	"Cuba"	1932	918 mbar (hPa)
9	Michael	2018	919 mbar (hPa)
10	Katrina	2005	920 mbar (hPa)
	Maria	2017	

Sources: Atlantic Hurricane Best Track Data
Documentation of Atlantic Tropical Cyclones
National Hurricane Center

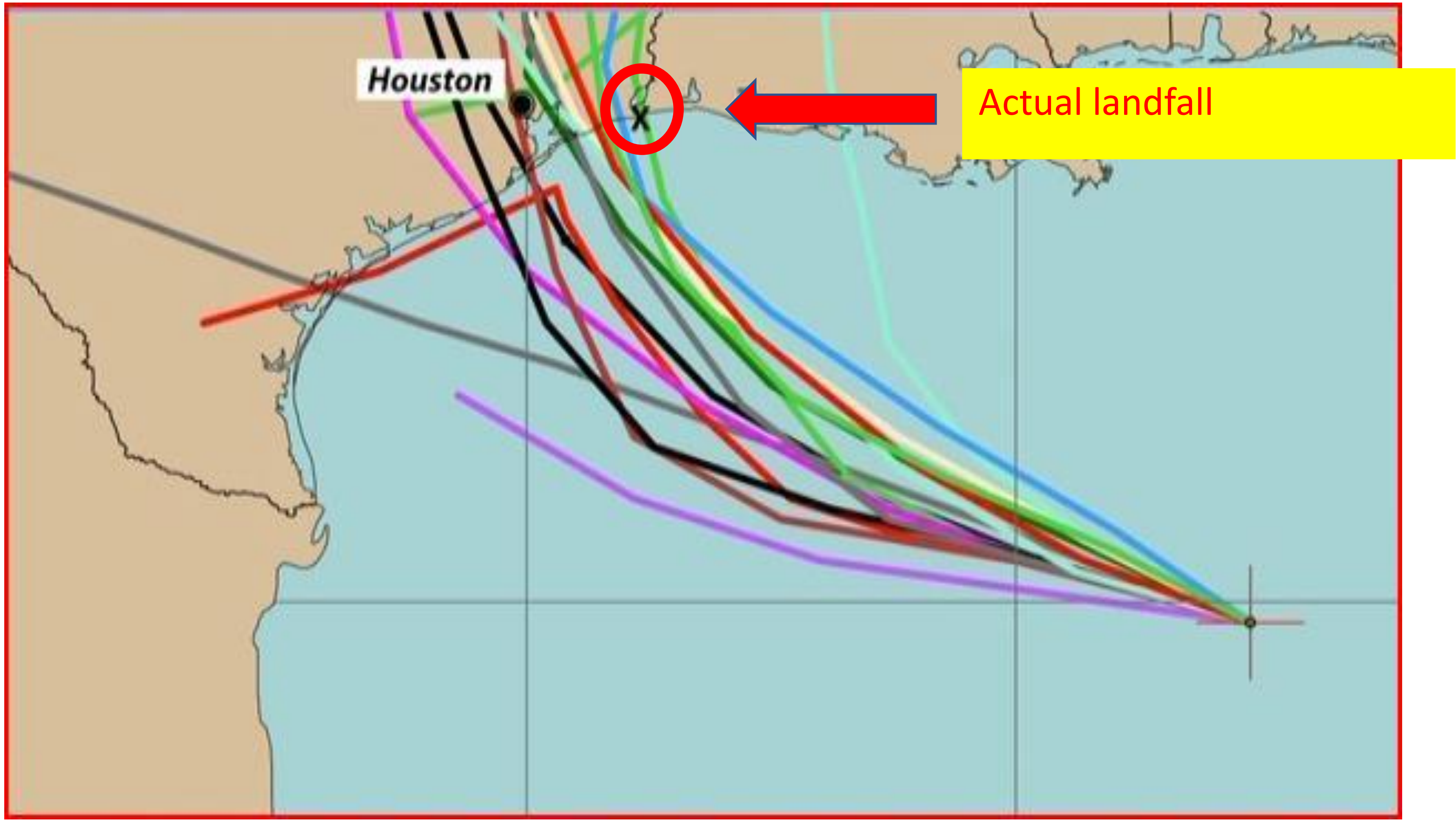
https://en.wikipedia.org/wiki/List_of_Atlantic_hurricane_records

Ensemble forecasting

- Make a series of slight adjustments to assumptions of conditions to make a resultant series of simulations. Small adjustments can result in large changes of hurricane tracks and even the strengths of hurricanes. The ensemble of simulations then depicts the various futures of the different simulated hurricanes. One of them will probably be a correct depiction of the actual hurricane. But which one is it?

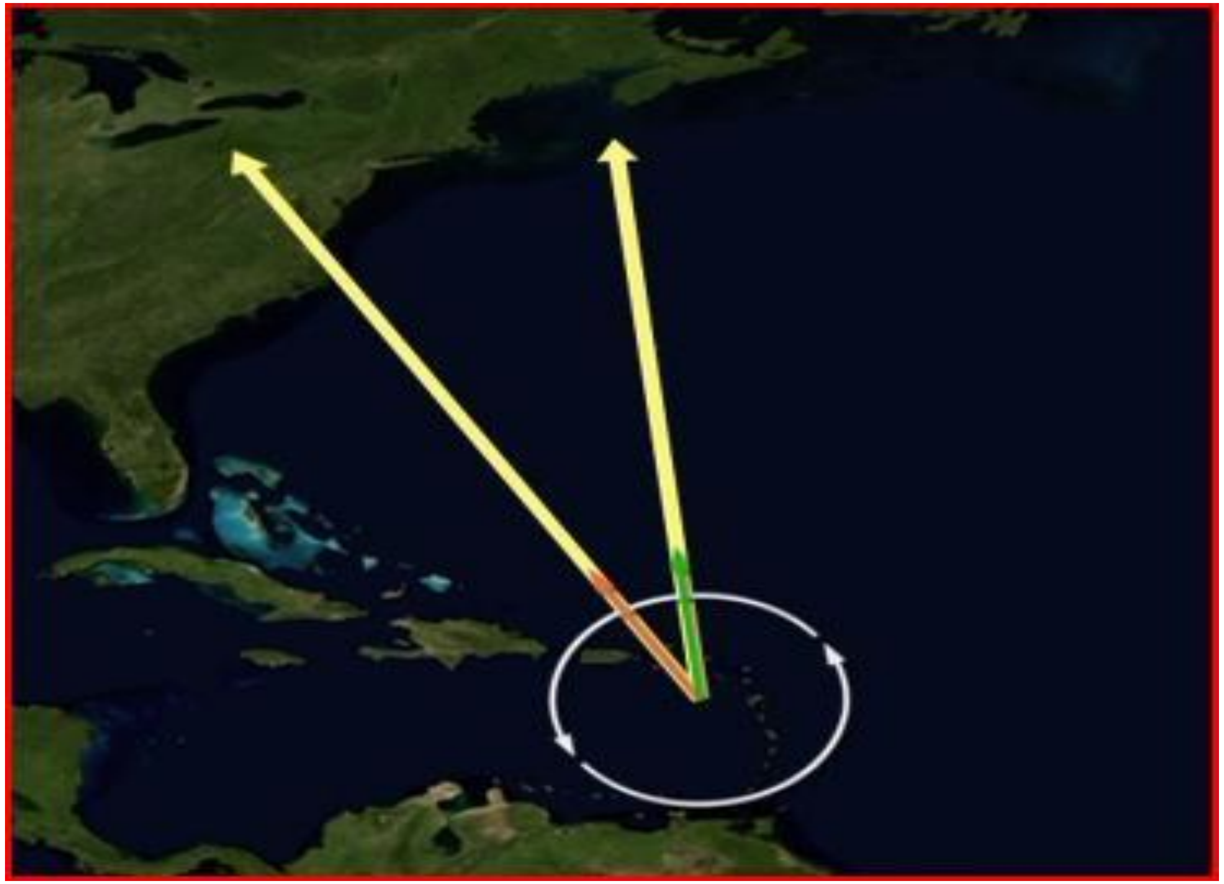
https://en.wikipedia.org/wiki/Ensemble_forecasting

Ensemble forecasting:
16 forecast models for Hurricane Rita



https://en.wikipedia.org/wiki/Ensemble_forecasting

Bermuda High – different projections for paths around the high. This illustration shows an example hurricane. The high would have clockwise rotation and is not depicted.

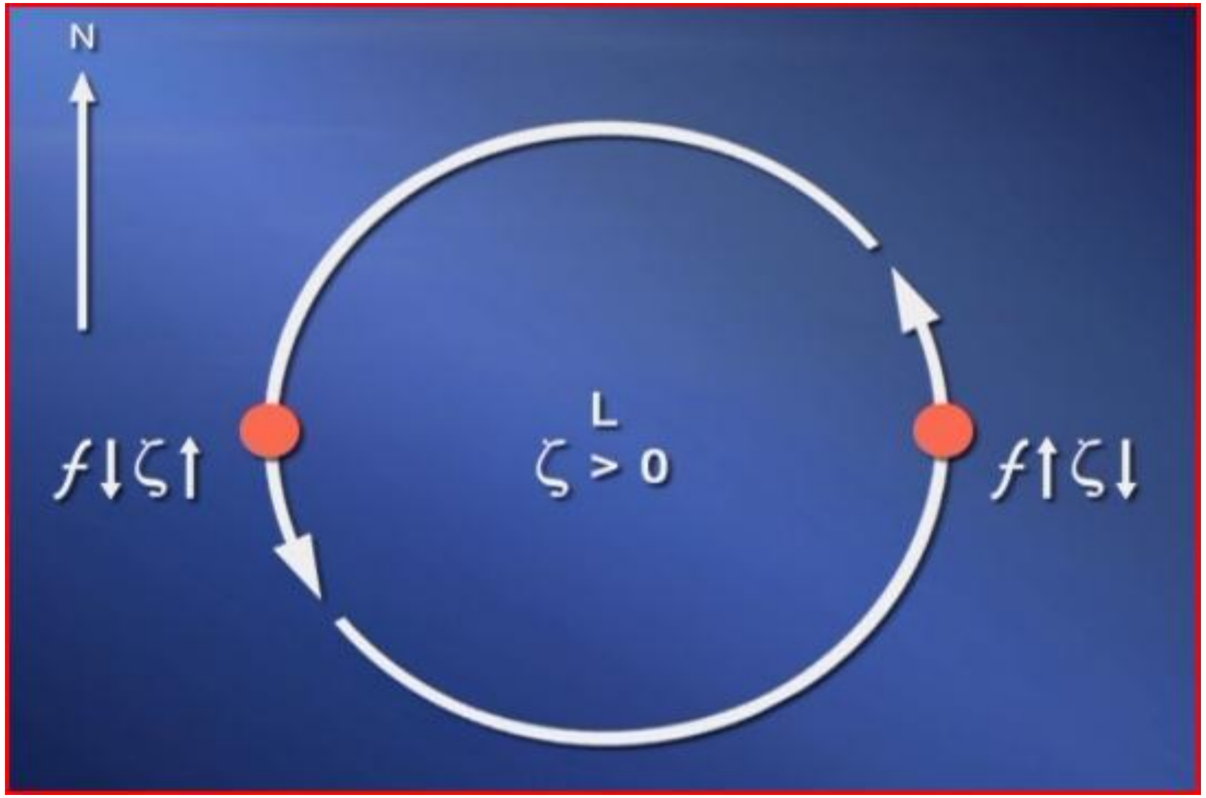


Vorticities

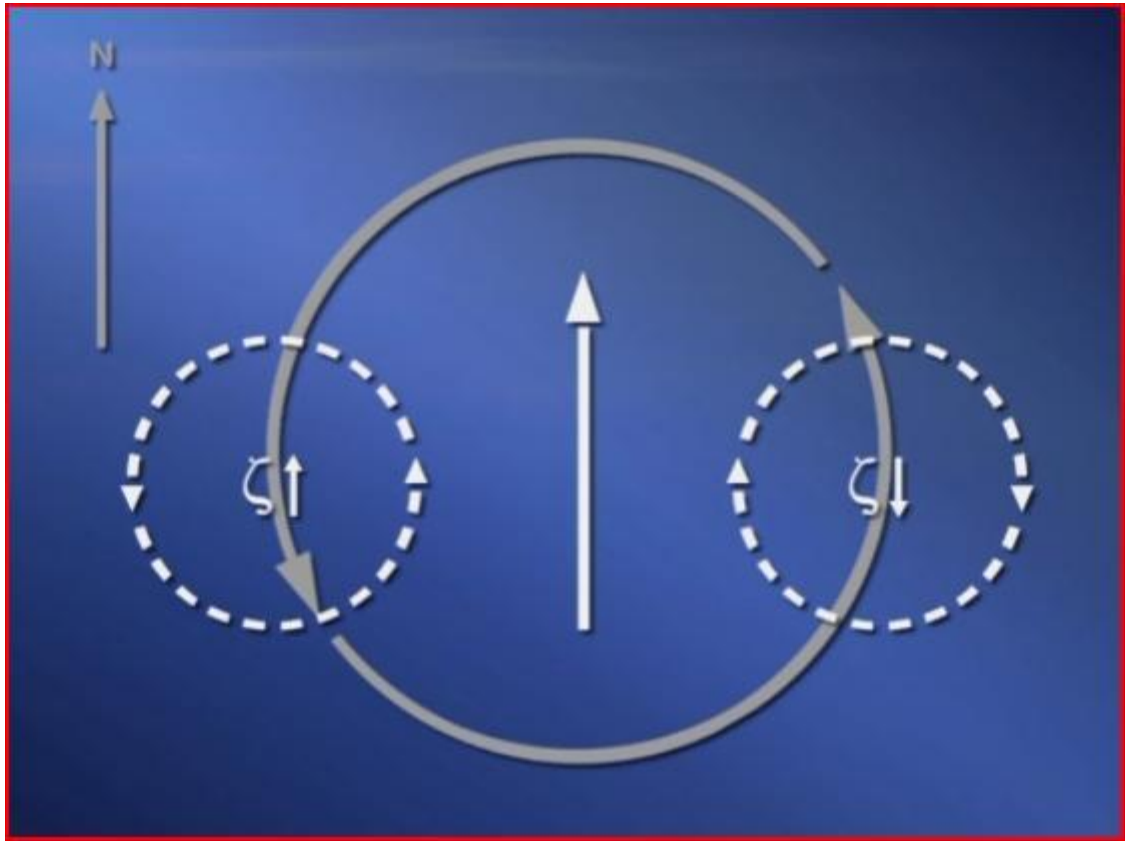
- Planetary vorticity (f) due to rotation of the Earth, Coriolis effect.
- Relative vorticity zeta (ζ) due to rotation of winds
- Total or absolute vorticity is the algebraic sum of f and ζ.

Hurricane = decreasing planetary vorticity when heading south and vice versa when heading north

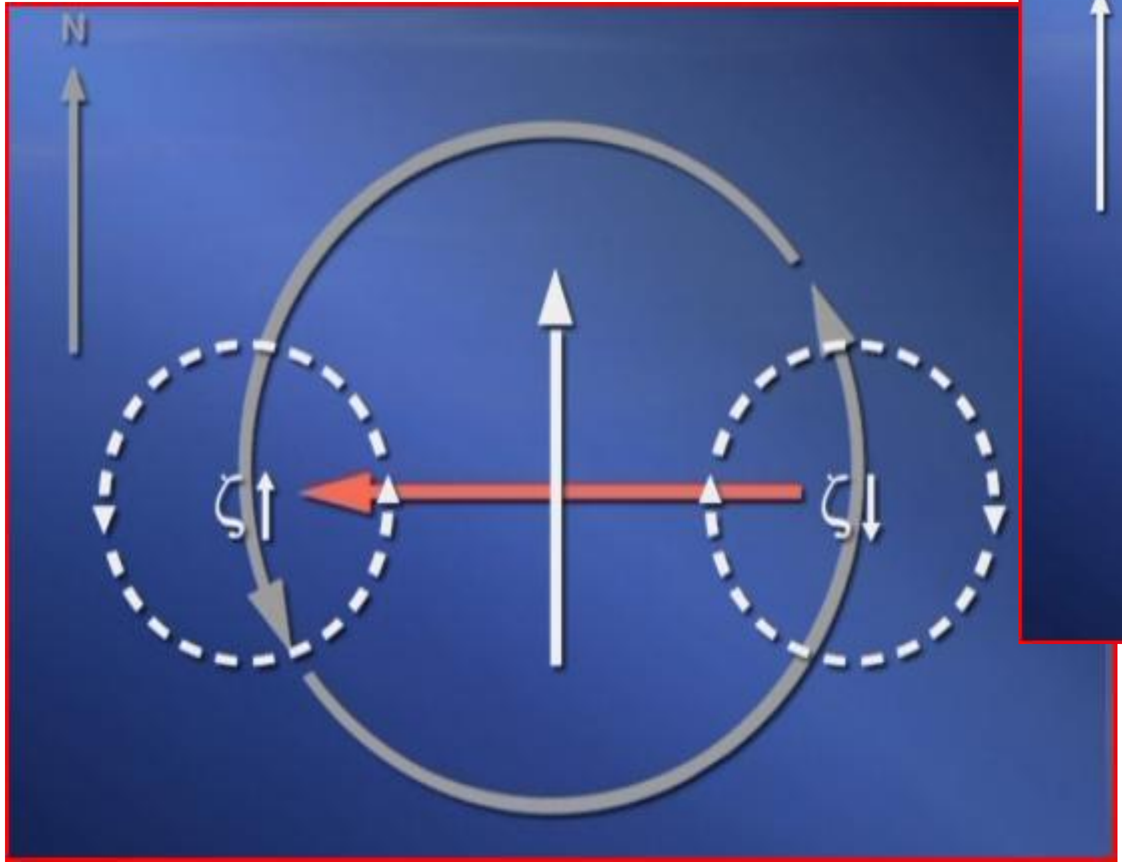
- Hurricane rotation subtracts from or adds to Earth's vorticity when heading south and north respectively.



Subsidiary rotations caused by relative vorticity

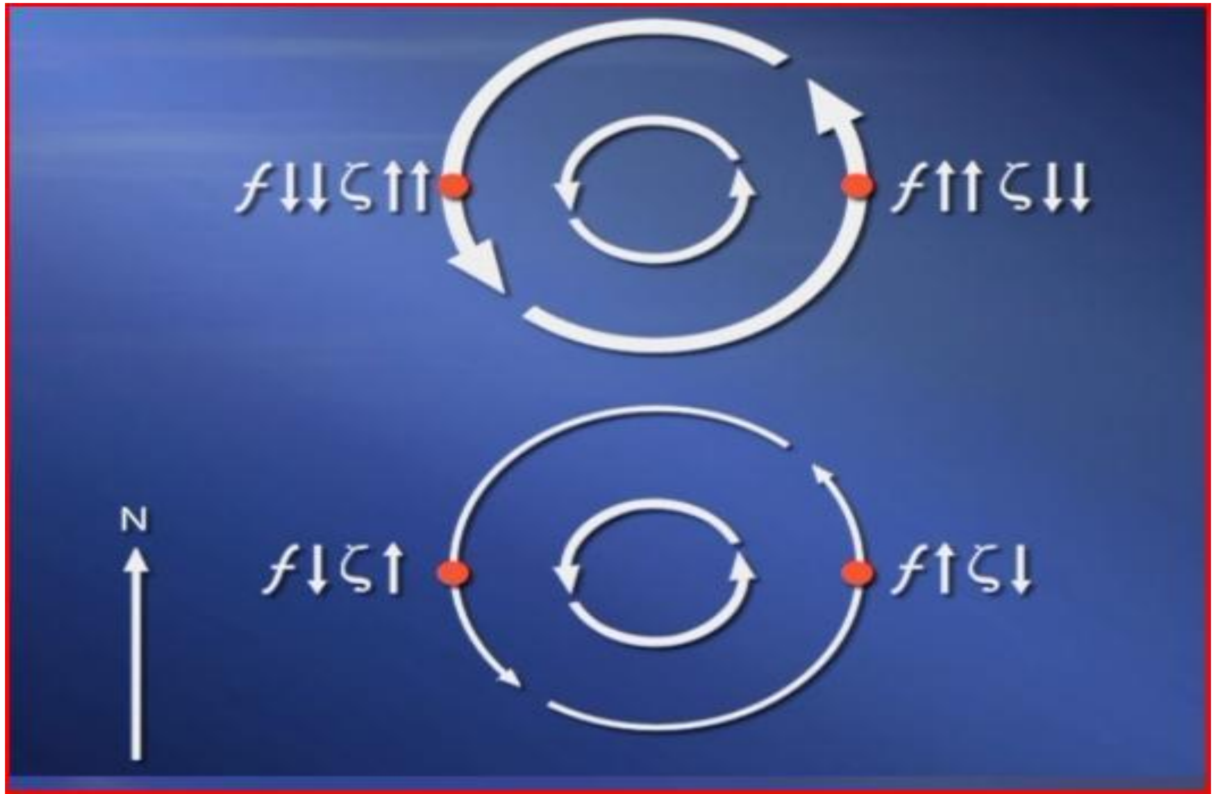


Direction of movement of hurricanes is affected by vorticities. The sum of the vorticity vectors (beta drift) trends northwest from lower latitudes towards the US Mainland. That's why we get all those damn hurricanes, and none of them go to Europe

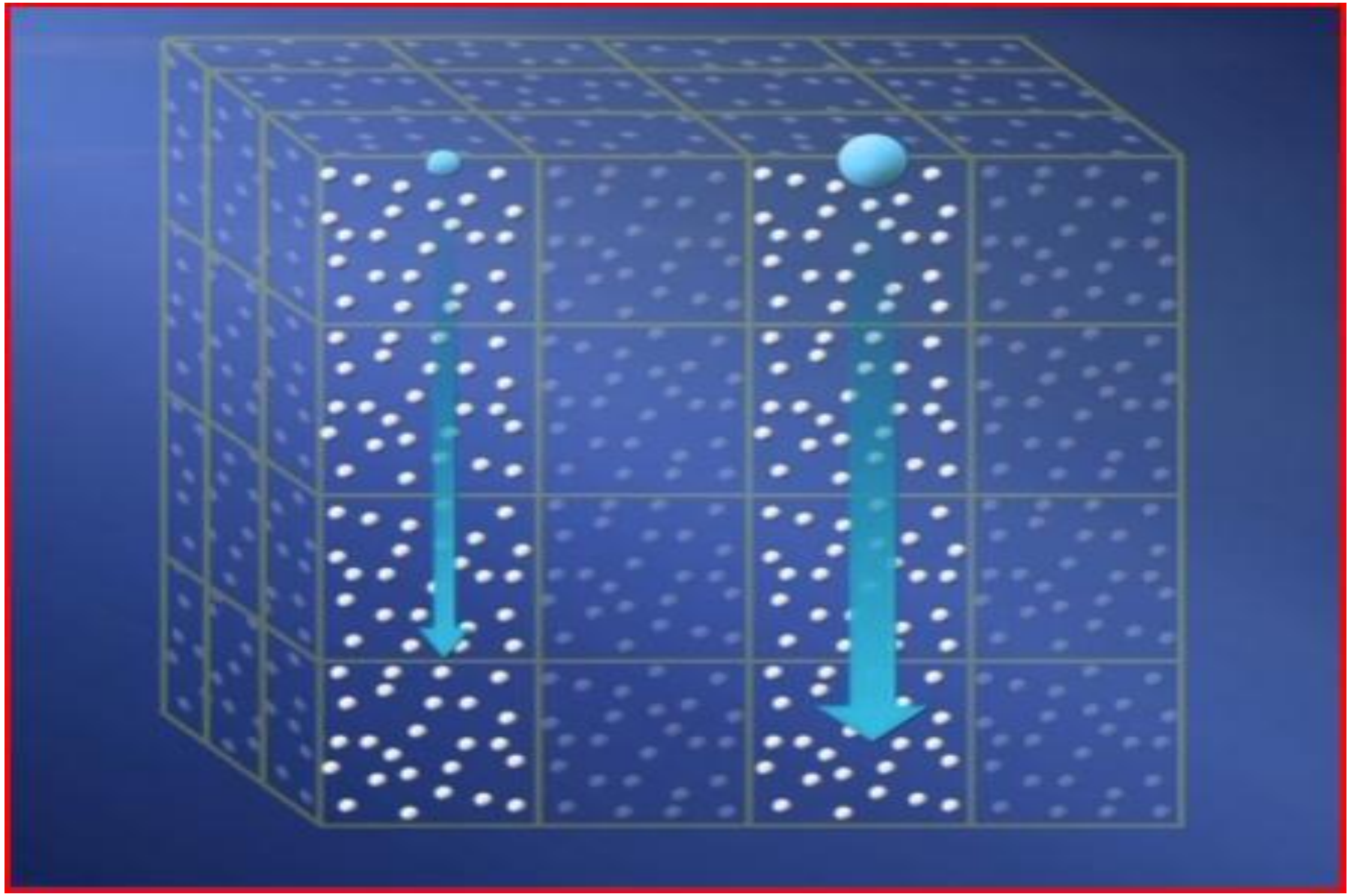


2 Hurricanes of different vorticities.

- Total vorticity (rotation speed/angular momentum) is the sum of f (planetary vorticity) and ζ (relative vorticity - rotation of the hurricane winds). On the west side of a hurricane, f and ζ are in opposition but they act together on the east side. To maintain total positive vorticity on the east, ζ has to increase to cancel out the negative f.

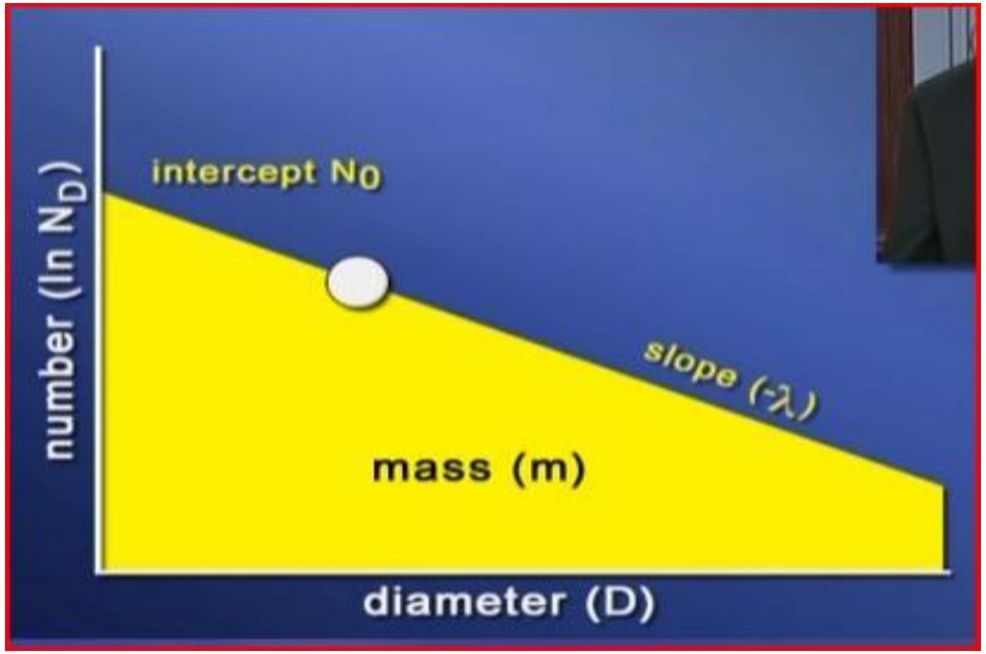


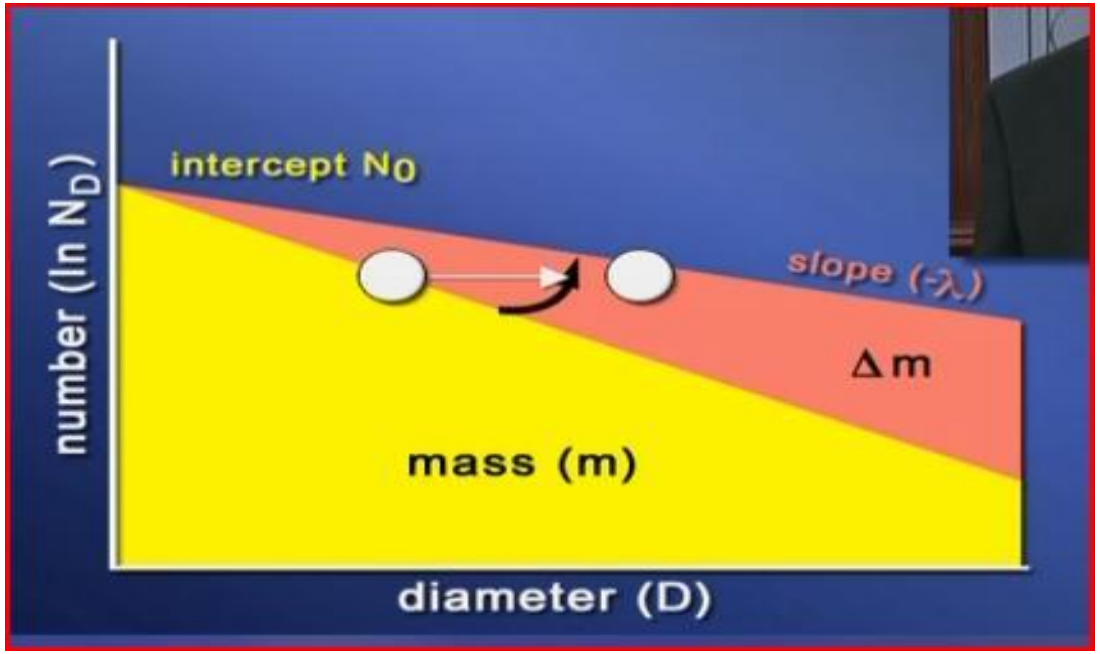
The results from the modelling are even affected by assumptions made about the size of raindrops



Assumptions about number and size of raindrops affect results predicted by models

- Exponentially more small droplets to start with, but larger droplets collect more water as they fall, so mean droplet size increases over time. Large droplets tend to fall as rain affecting the winds and energy of the simulation.





Informed assumptions have to be made about whether droplets will freeze to ice, hail, snow and add latent heat to a modeled system.

- Parameterization assumptions have to be made because data are lacking and models can only handle grids of reasonable size.

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- END OF WEEK 8 videos –
- Check out this website for more info about understanding weather:

  http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/cyc/arms.rxml

The Storm

-
- Distracted by the balmy day
- I paid scant notice
- to the small cloud on the horizon
- Until petulant and crying for attention
- it flashed obscene gestures
  and growled at me
-
- If anything
  as it came closer
- its humor soured
  Its behavior worsened
- Until I had to pay it some regard
- and then the brat
- wet its pants on me
-
- Jim Keller
- July 28, 1996