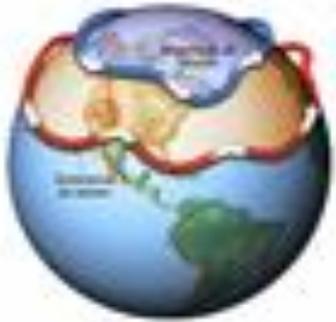


# P1: Vortices in the atmosphere

<http://weatherclimatelab.mit.edu/projects/weather-and-extremes/observation-data>



jet stream



blizzard



hurricane



tornado

# Hurricanes

# Radial force balance for atmospheric vortices

The radial force balance in atmospheric vortices is very similar to the radial force balance in the radial inflow experiment:

$$\frac{v_{\theta}^2}{r} + f v_{\theta} = \frac{1}{\rho} \frac{\partial p}{\partial r}$$

The main difference from the radial inflow experiment is that the Coriolis parameter is given by:

$$f = 2\Omega \sin \phi$$

**Rossby number:** As for the radial inflow experiment, we can use the radial force balance to define a Rossby number

$$Ro = \frac{|v_{\theta}|}{fr}$$

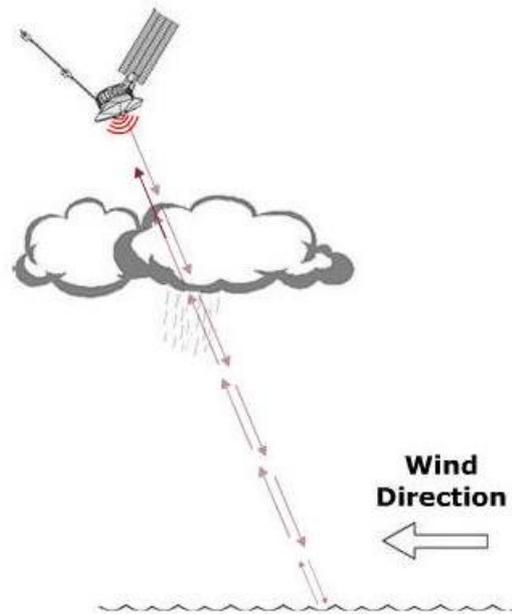
To study the balance of forces in a hurricane we are using  
a special dataset: surface wind data from the  
“**scatterometer**” instrument

See [scatterometer\\_instructions](#)

# Scatterometer data to analyze Hurricanes!

*Scatterometers are remote sensing instruments for deriving wind direction and speed from the roughness of the sea. They are used by low Earth orbiting satellites and act like radars: they transmit electromagnetic pulses and detect the backscattered signals*

- **Satellite sends down pulses of microwave radiation at  $\sim 5$  GHz (European) or  $\sim 13-14$  GHz (US)**
- **Satellite very accurately measures the backscattered energy from the small-scale roughness elements on the ocean surface to determine wind speed and direction**



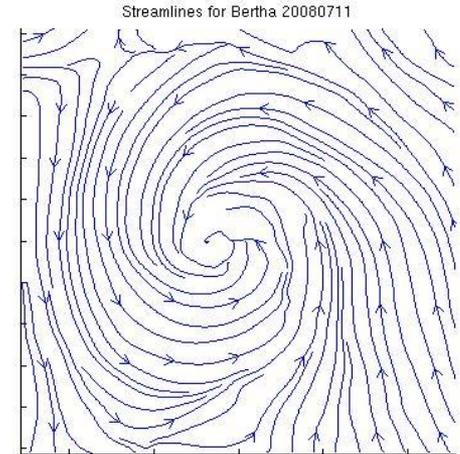
Dr. Michael Freilich



# Streamlines:

Lines which smoothly connect the velocity vectors at an instance in time

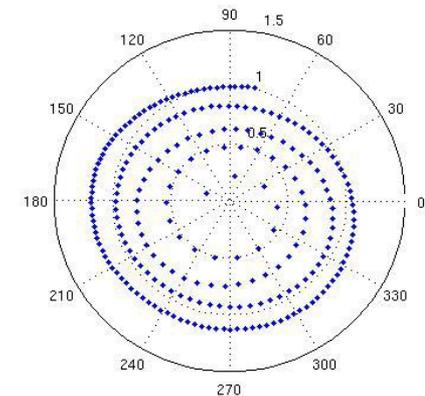
- Shows the direction in which a fluid element will travel in an instantaneous flow
- Can change with time (unless the flow is steady)



# Trajectories:

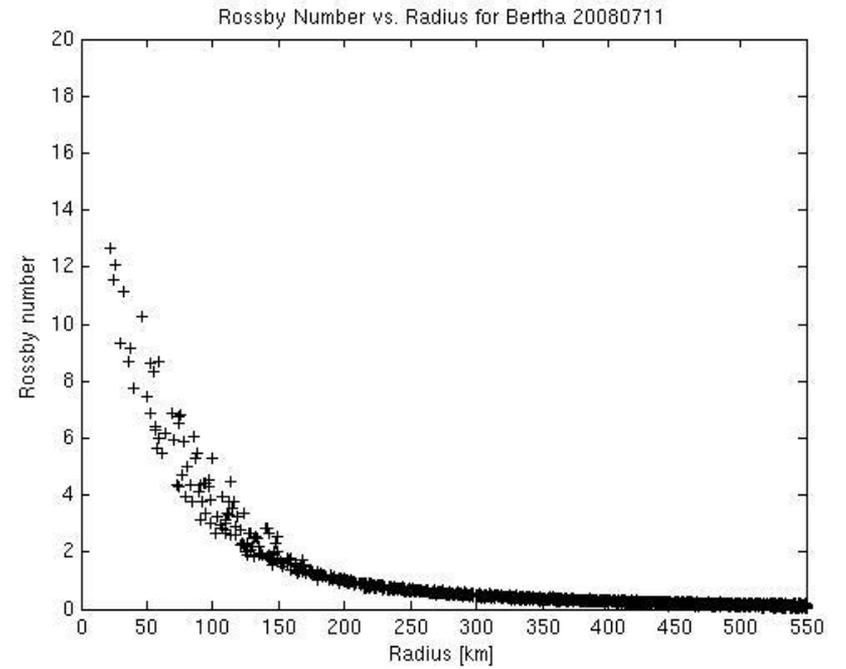
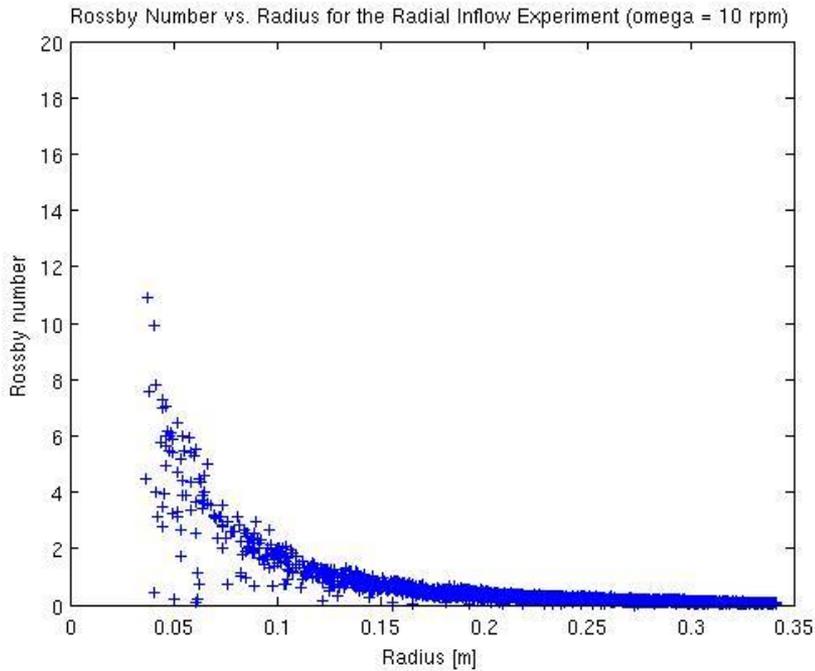
Path of fluid particles in a time dependent flow

- A "recording" of the path of a fluid element in the flow over a certain period.
- The overall path will be determined by the streamlines of the fluid at each moment in time



*Do not confuse them!*

# Balanced Vortex Experiment and the Hurricane flow



How to best combine the two graphs?

# Presentations instructions

- Introduction
- Experimental procedure and relevant theory
- Preliminary results
- Atmospheric data
- Connections
- Future work
- Summary

You can include- challenges/next steps/thoughts...