Geophysical Fluid Dynamics

"… study of naturally occuring,

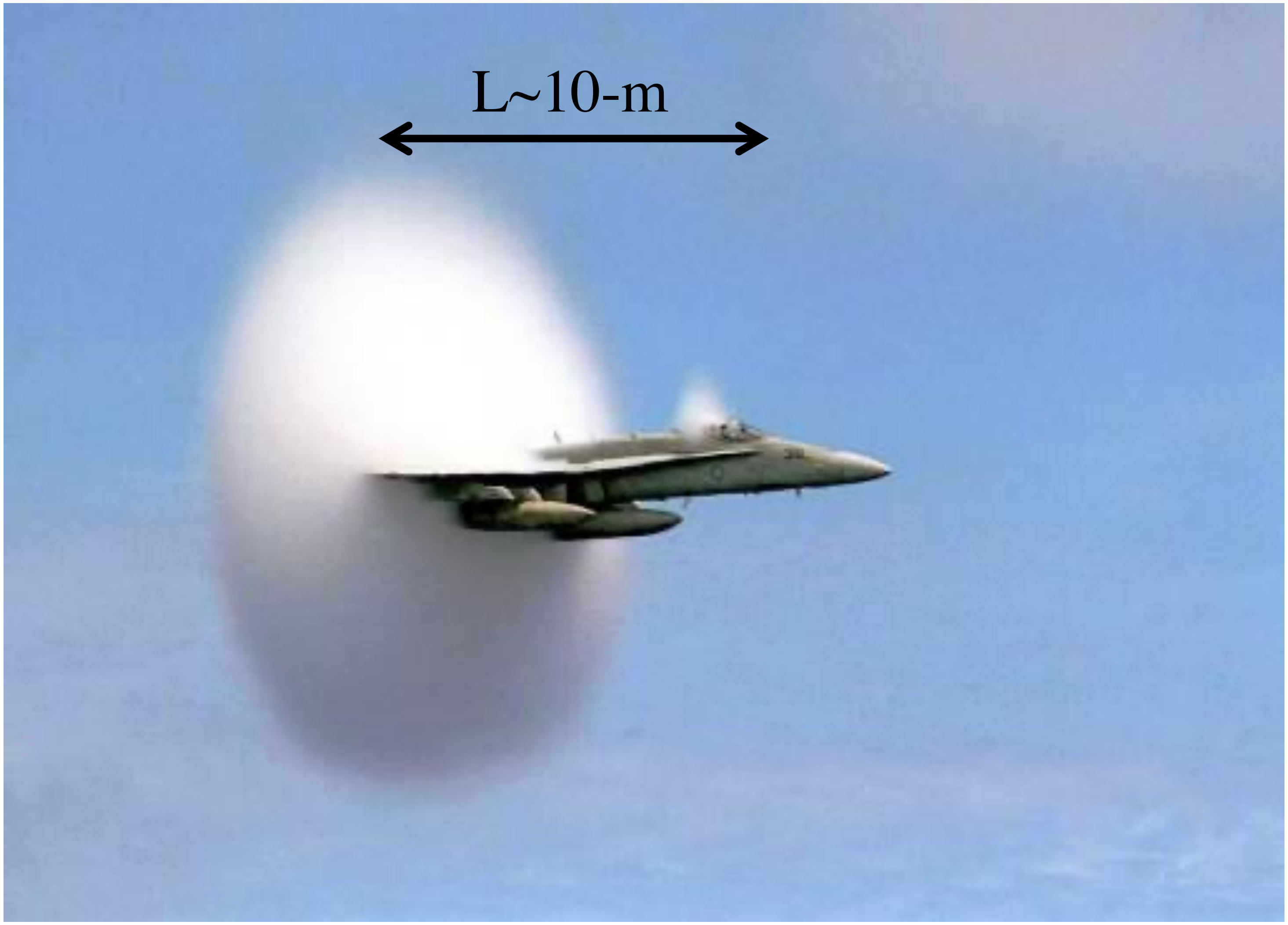
large-scale flows on earth and

elsewhere …"

Definition ***large-scale***:

Time Scale of Rotation $1/\Omega$ (about a day on Earth)
small relative to
Time Scale of Motion L/U

Small Rossby Number: $Ro = (1/\Omega) / (L/U) < 1$



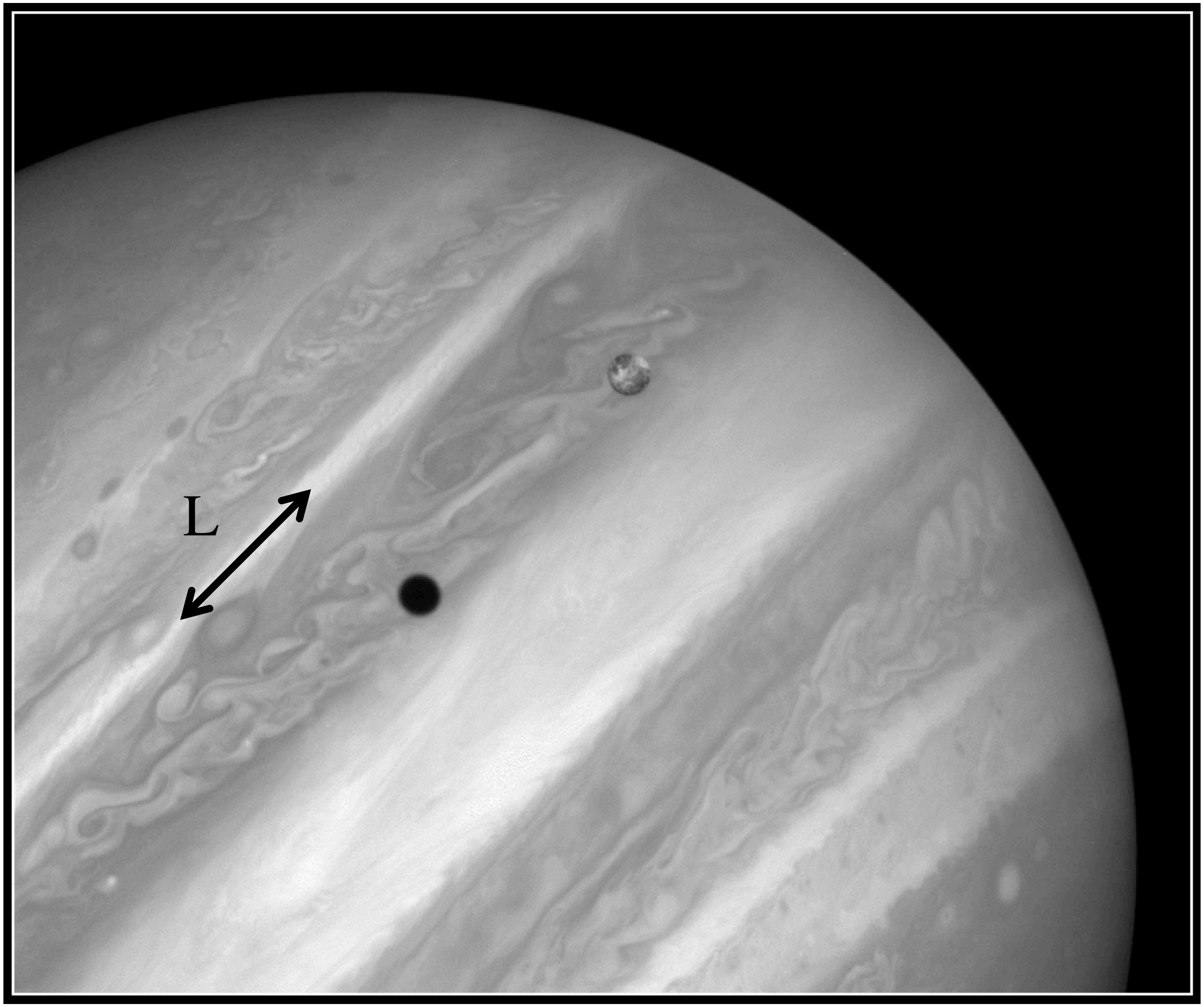
$L \sim 10$ m
$U \sim 300$ m/s
$L/U \sim 33$ ms
$1/\Omega \sim 24$ hrs / 2π

$Ro = (U/L)/\ \Omega$
~ 120

not GFD

Condensation cloud as an F/A-18 Hornet flies at or near the speed of sound.
Photo by John Gay

Geophysical Fluid Dynamics on Jupiter



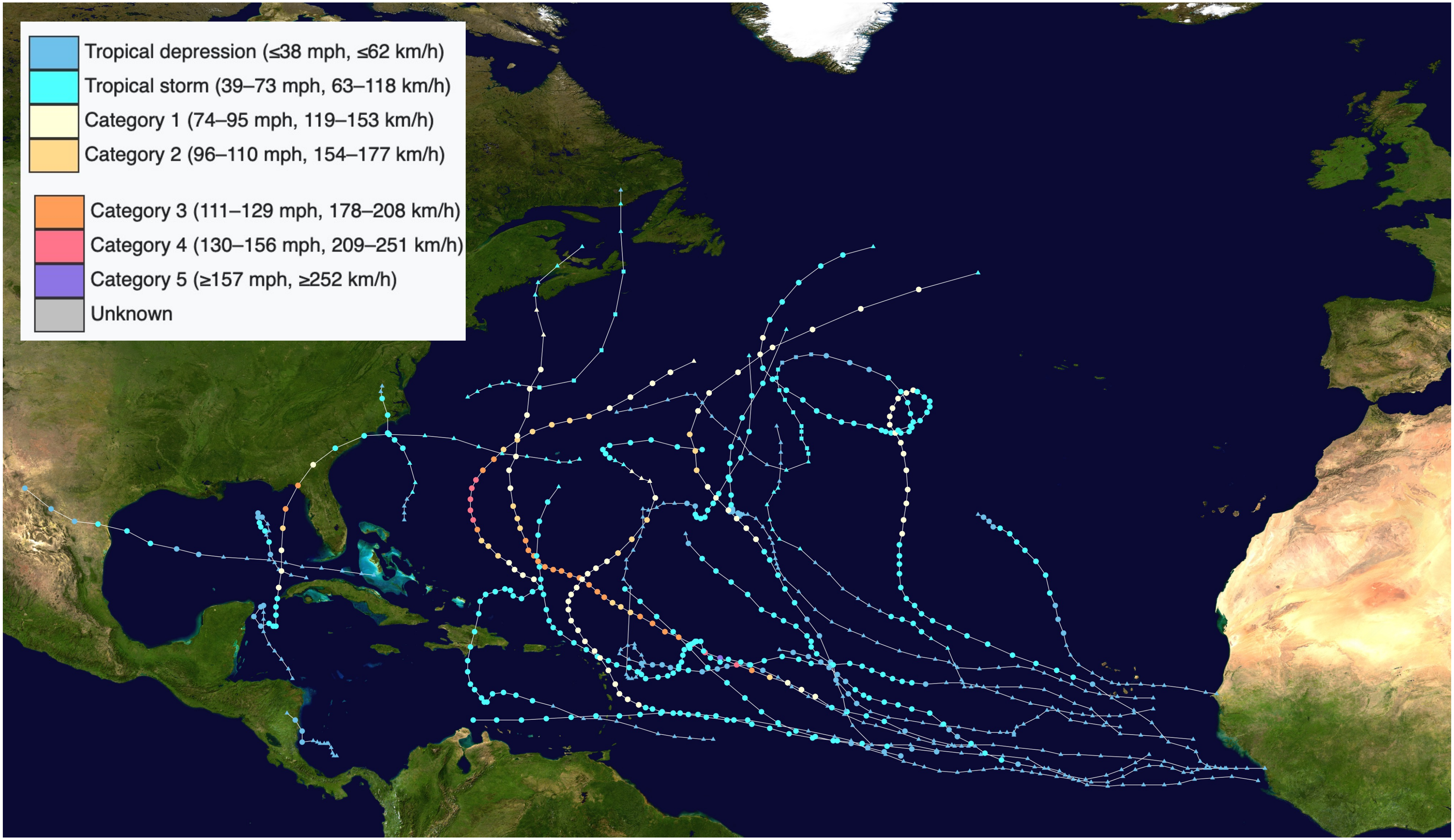
L ~ 10,000 km
U ~ 100 m/s
L/U ~ 27 days
$1/\Omega \sim 10$ hrs / 2π

$Ro = (U/L)/\ \Omega$
~ 0.06

GFD

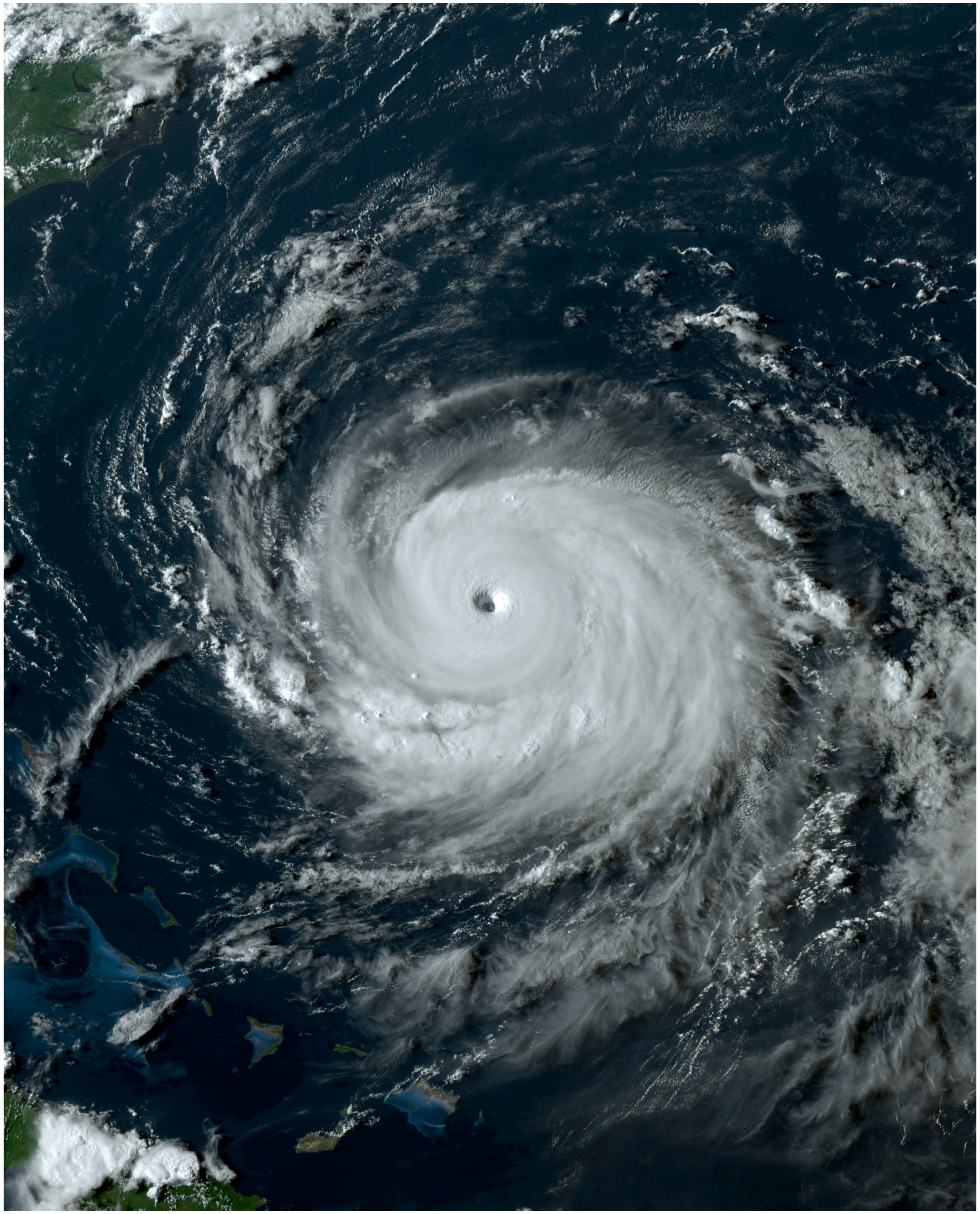
NASA

2023 Atlantic Hurricane Season



This map shows the tracks of all tropical cyclones in the 2023 Atlantic hurricane season. The points show the location of each storm at 6-hour intervals. The colour represents the storm's maximum sustained wind speeds as classified in the Saffir-Simpson Hurricane Scale (see below), and the shape of the data points represent the type of the storm.

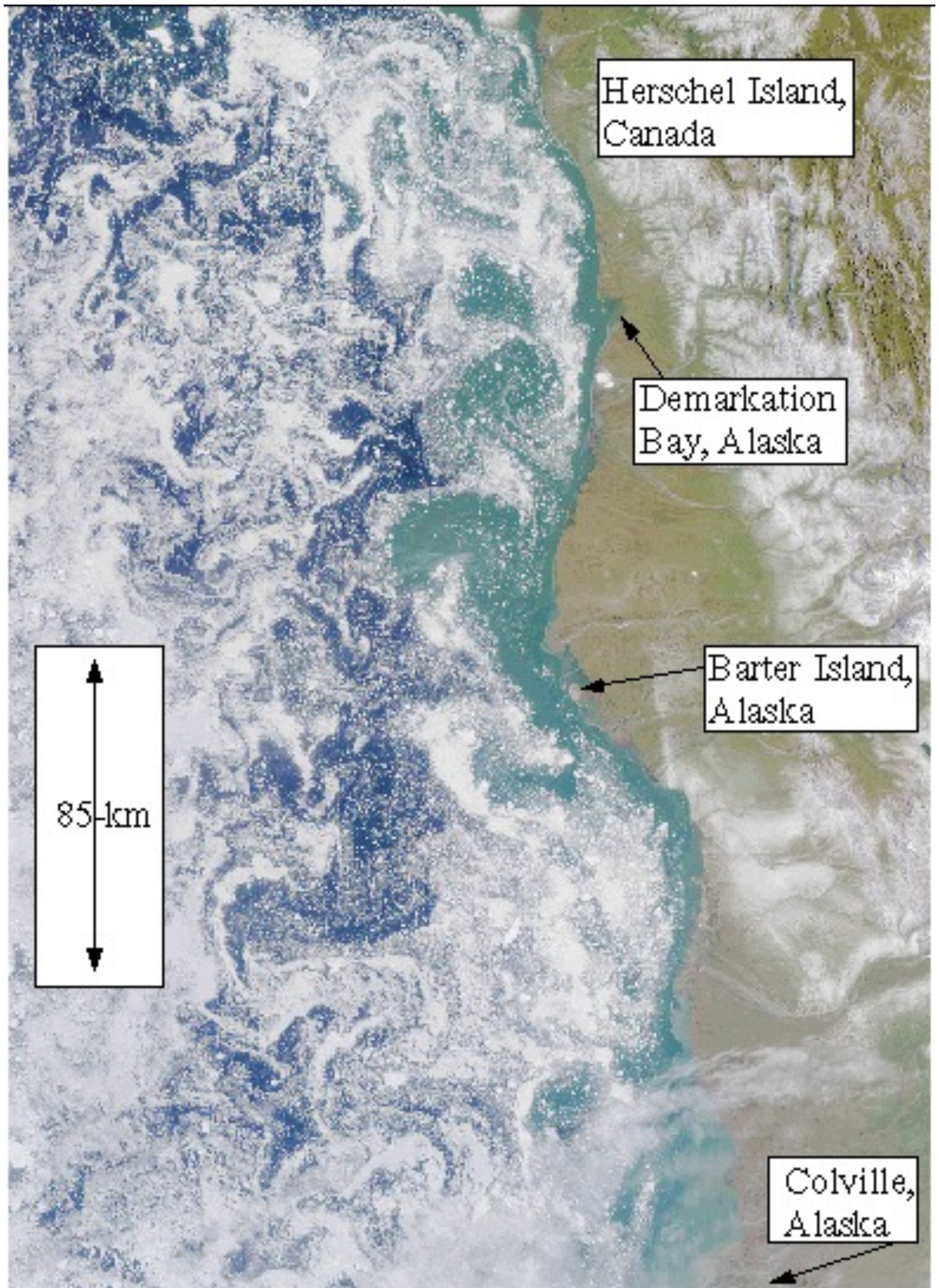
2023 Hurricane “Franklin”



L ~ 1000 km

L ~ 1000 km
U ~ 50 m/s
L/U ~ 6 hrs
Ro = (U/L)/ Ω
 ~ 0.8

GFD



Multi-angle Imaging SpectroRadiometer's nadir (vertical-viewing) camera on August 16, 2001, during Terra orbit 3532. [http://www-misr.jpl.nasa.gov/gallery/galhistory/2001_aug_22.html]

Arctic Sea Ice off Alaska

Summer 2001

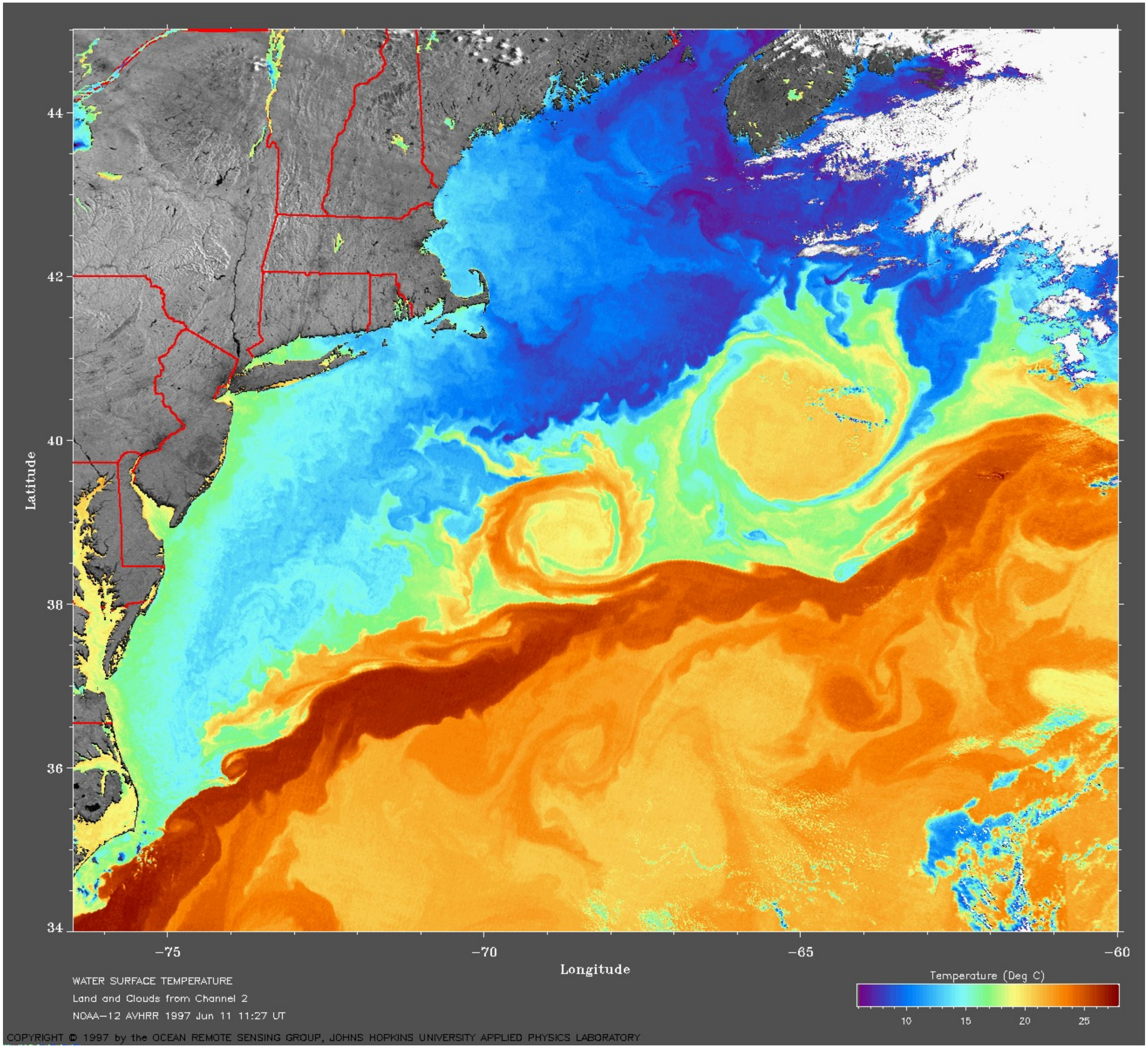
from MODIS

Optical Remote Sensing

L ~ 20 km
U ~ 0.1 m/s
L/U ~ 50 hrs
Ro = (U/L)/ Ω
~ 0.1

GFD

Sea Surface Temperature: Gulf Stream Eddies 1997

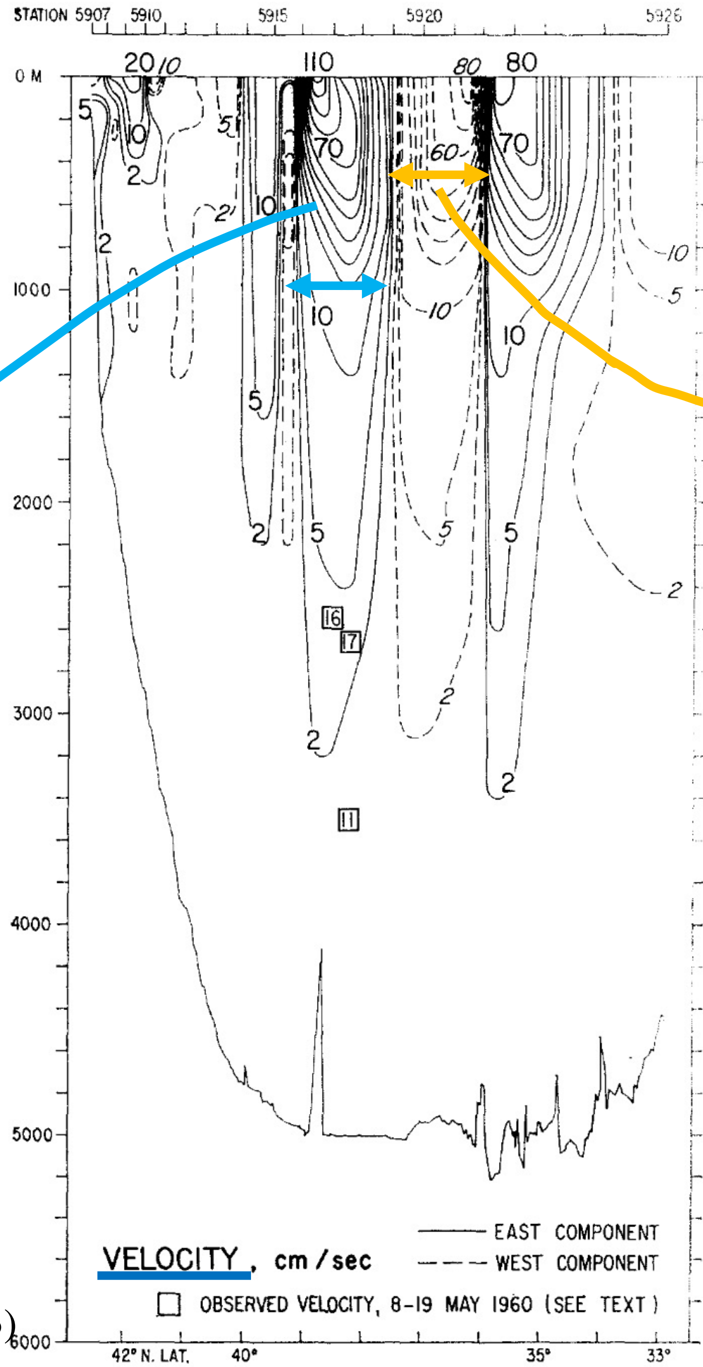


L ~ 200 km

L ~ 200 km
U ~ 1 m/s
L/U ~ 50 hrs
Ro = (U/L)/ Ω
~ 0.1

GFD

L ~ 100 km



D ~ 1 km

Gulf Stream

Cyclonic eddy
or
Gulf Stream meander

Fuglister (1963)

Here L is oceanic mesoscale ~ 100 km

U ~ 0.5 m/s

$\partial U/\partial z \sim U/D \sim 0.5\times10^{-3}\ s^{-1}$

$\partial U/\partial y \sim U/L \sim 0.5\times10^{-5}\ s^{-1}$