# Using NDGPS to Improve Severe Weather Forecasts

Prepared by
Seth I. Gutman
NOAA Earth System Research Laboratory Boulder, Colorado  80305

CGSIC Regional Subcommittee Meeting
New Orleans, Louisiana
July 8, 2008

# Introduction

- Every successful weather forecast starts with atmospheric observations.
- While having good observations does not guarantee an accurate weather prediction…
- …not having them virtually guarantees a poor forecast.
- Nowhere in the U.S. is this more true than along the Gulf of Mexico.
- In this presentation, we will describe how the Nationwide/Maritime Differential GPS Service (N/MDGPS) is helping NOAA to improve its severe weather forecasts.

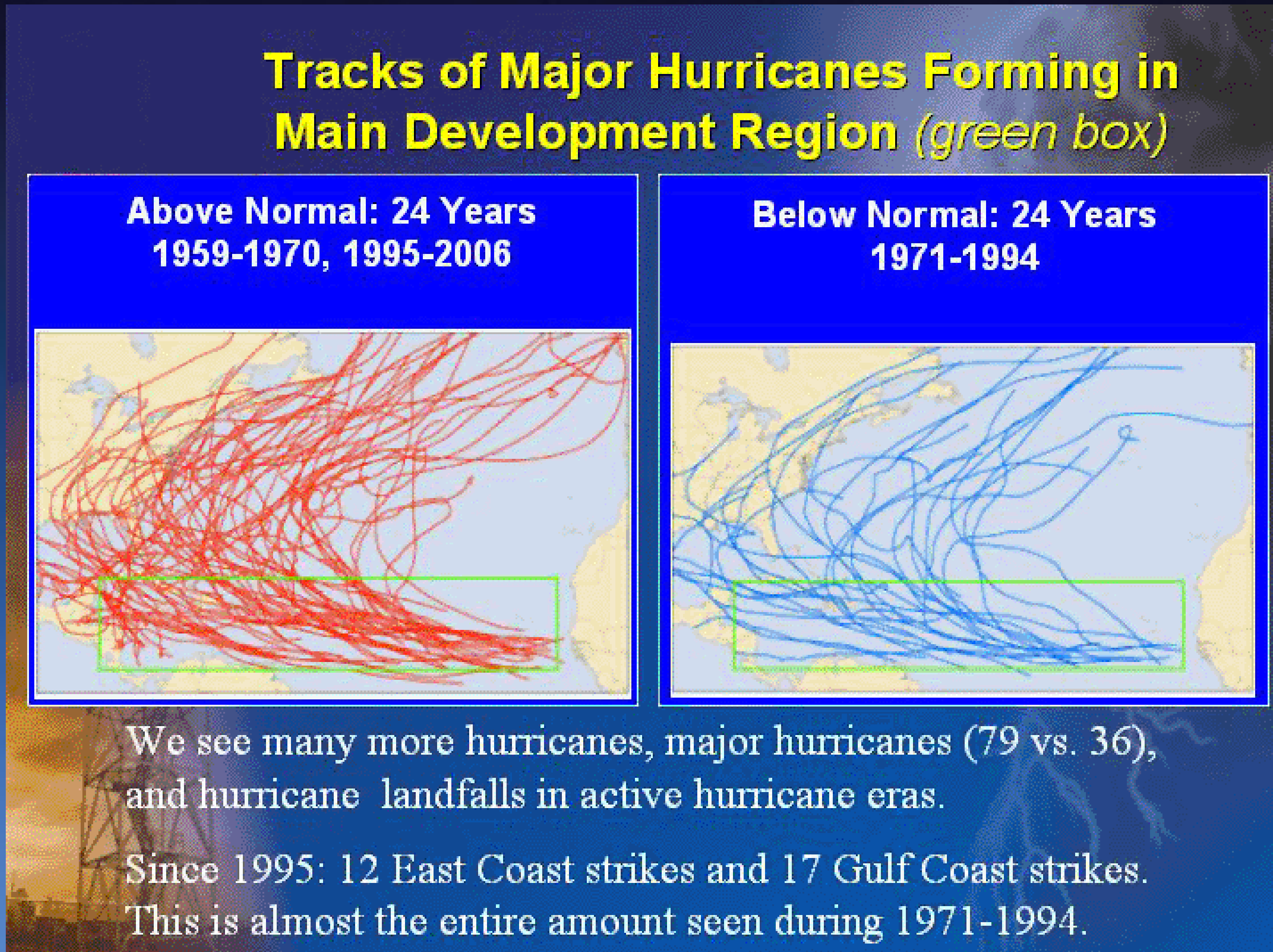
# Why the Gulf of Mexico?

- Most of the atmospheric moisture for the Eastern 2/3 of the U.S. comes from the Gulf of Mexico.
- Moisture flow off the Gulf is responsible for the generation of severe weather (thunderstorms, lightning, tornados) along the coast and farther inland.
- Water vapor derived from the evaporation of sea water is the “fuel” that drives tropical storms including hurricanes.
- One of the biggest gaps in current tropical storm  forecasting is lack of knowledge about the water vapor flux over the open ocean.

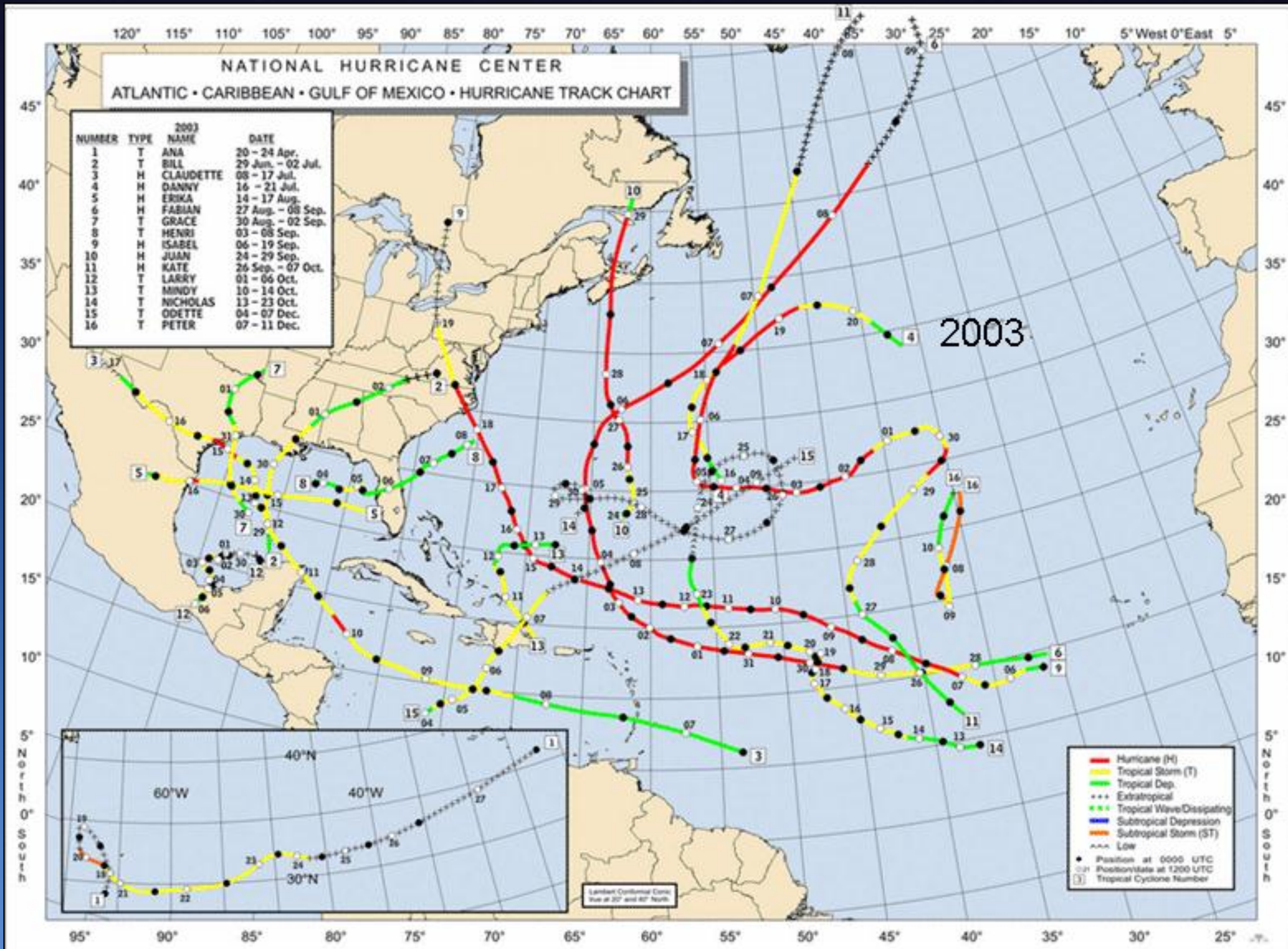
# Severe Storm Variability

- As the next few slides illustrate, there is lots of natural variability in severe weather originating from or coming in-to and out-of the Gulf.
- Few years were as memorable as 2005, but by any account 2007 was a <u>very strange year</u>.
- 2007 started off with ST Andria on May 9 and ended with TS Olga on December 12. Hurricane season officially starts on June 1 and ends on November 30.
- In between, two Category 5 hurricanes made landfall in the same year for the first time in recorded history, and Hurricane Humberto formed and intensified faster than any other tropical cyclone on record – 18 hours.

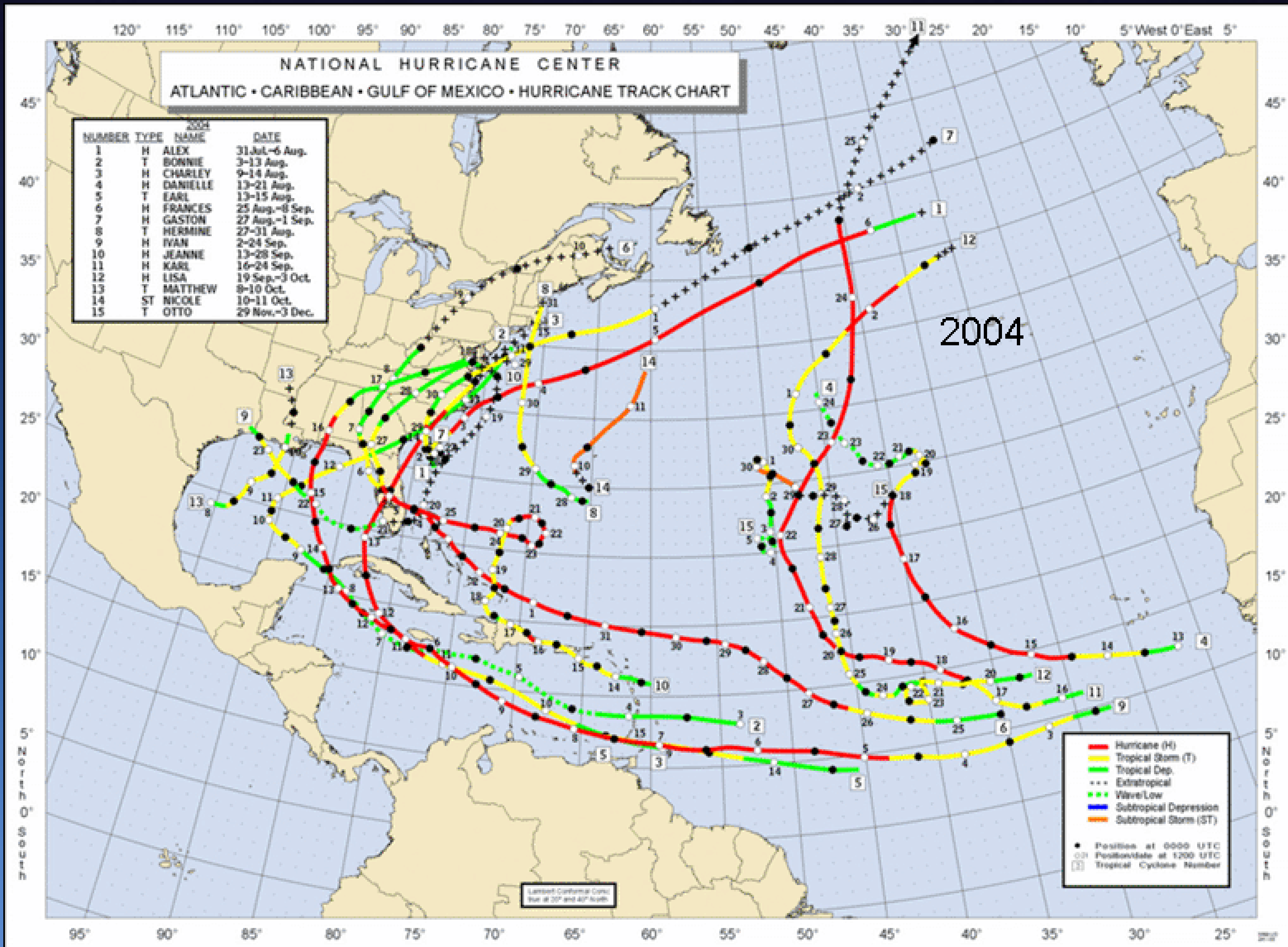
# Recent Atlantic/IAS Tropical Storms



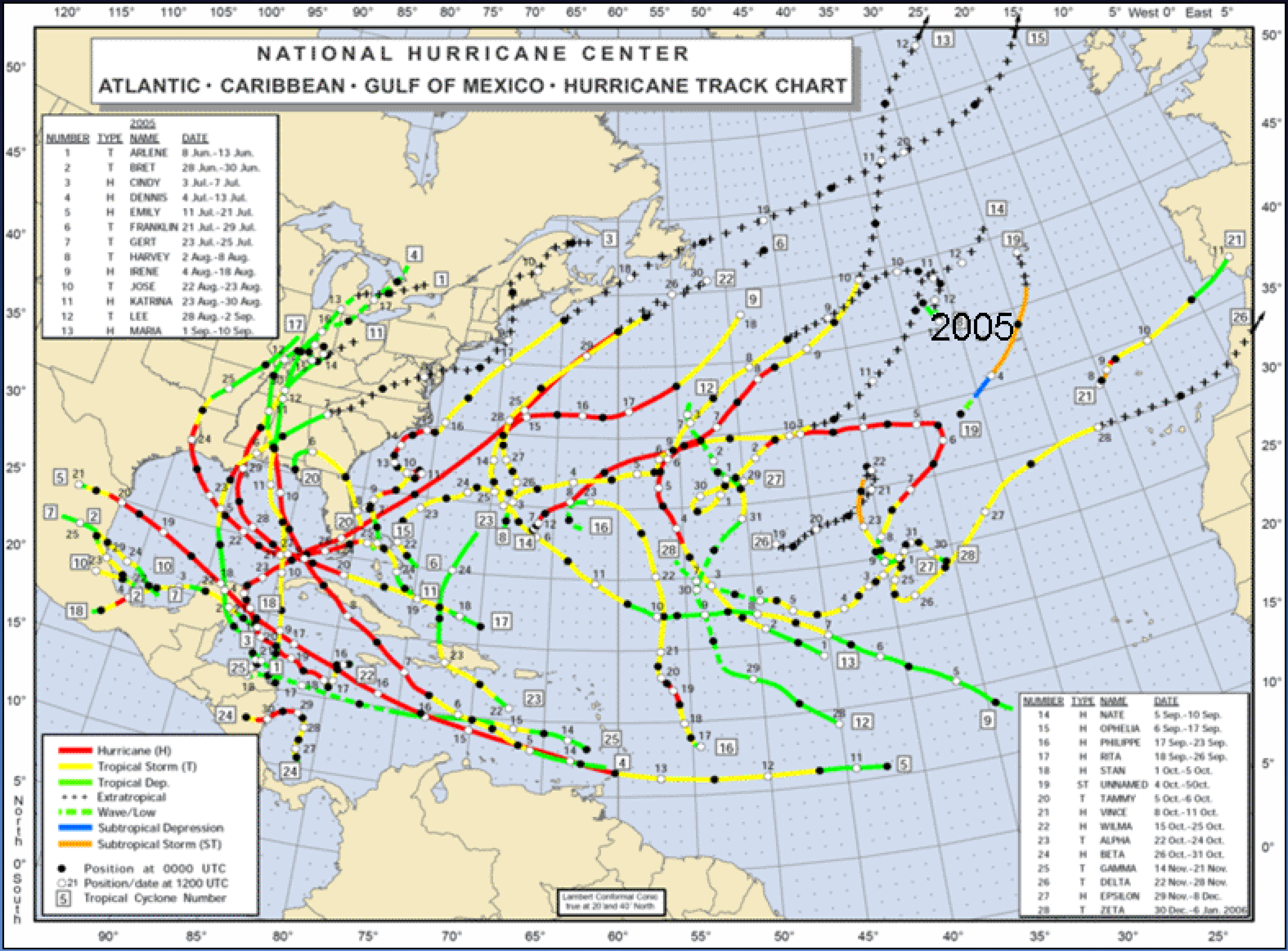
# 2003 Atlantic/IAS Tropical Storms



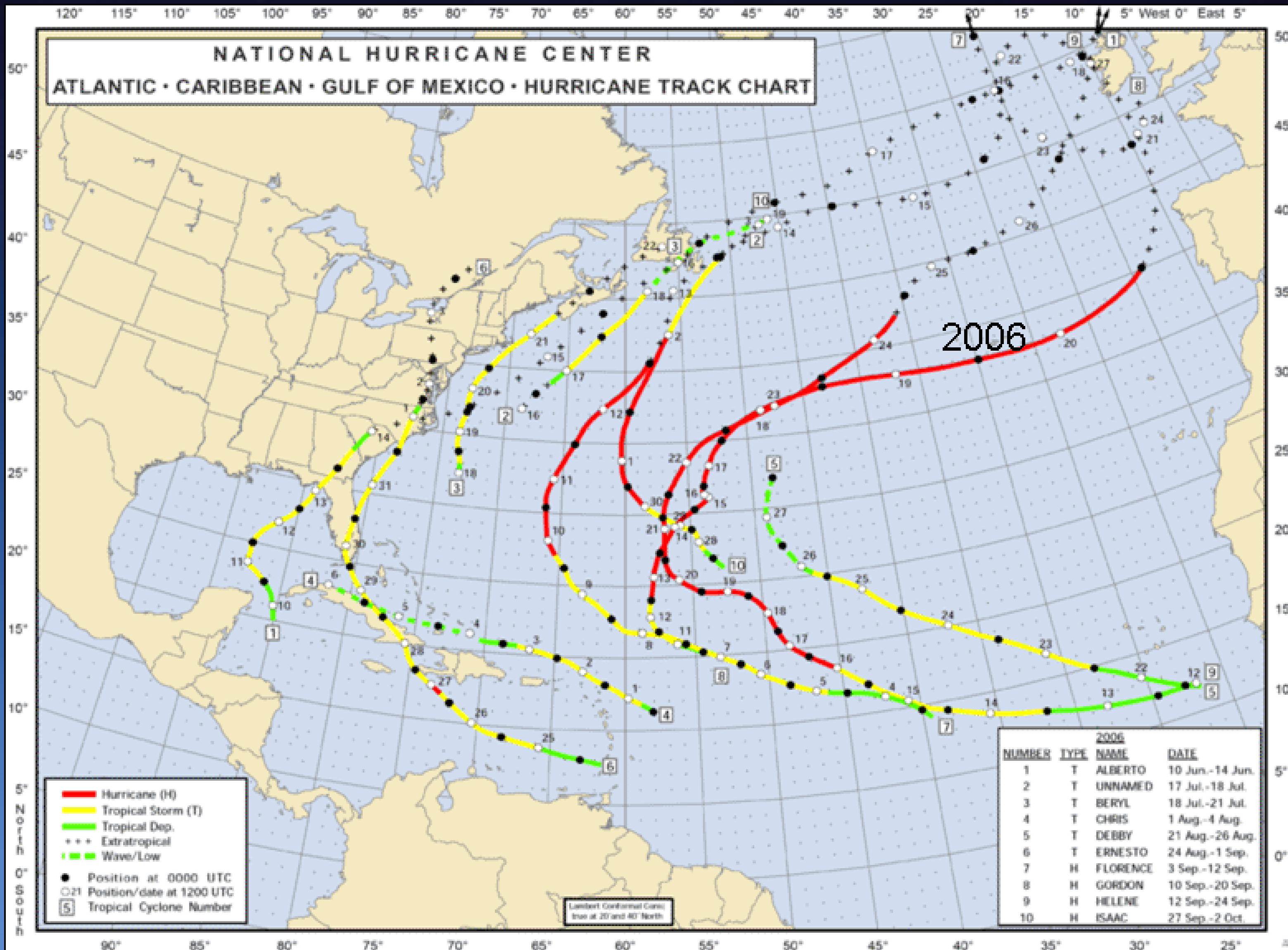
# 2004 Atlantic/IAS Tropical Storms



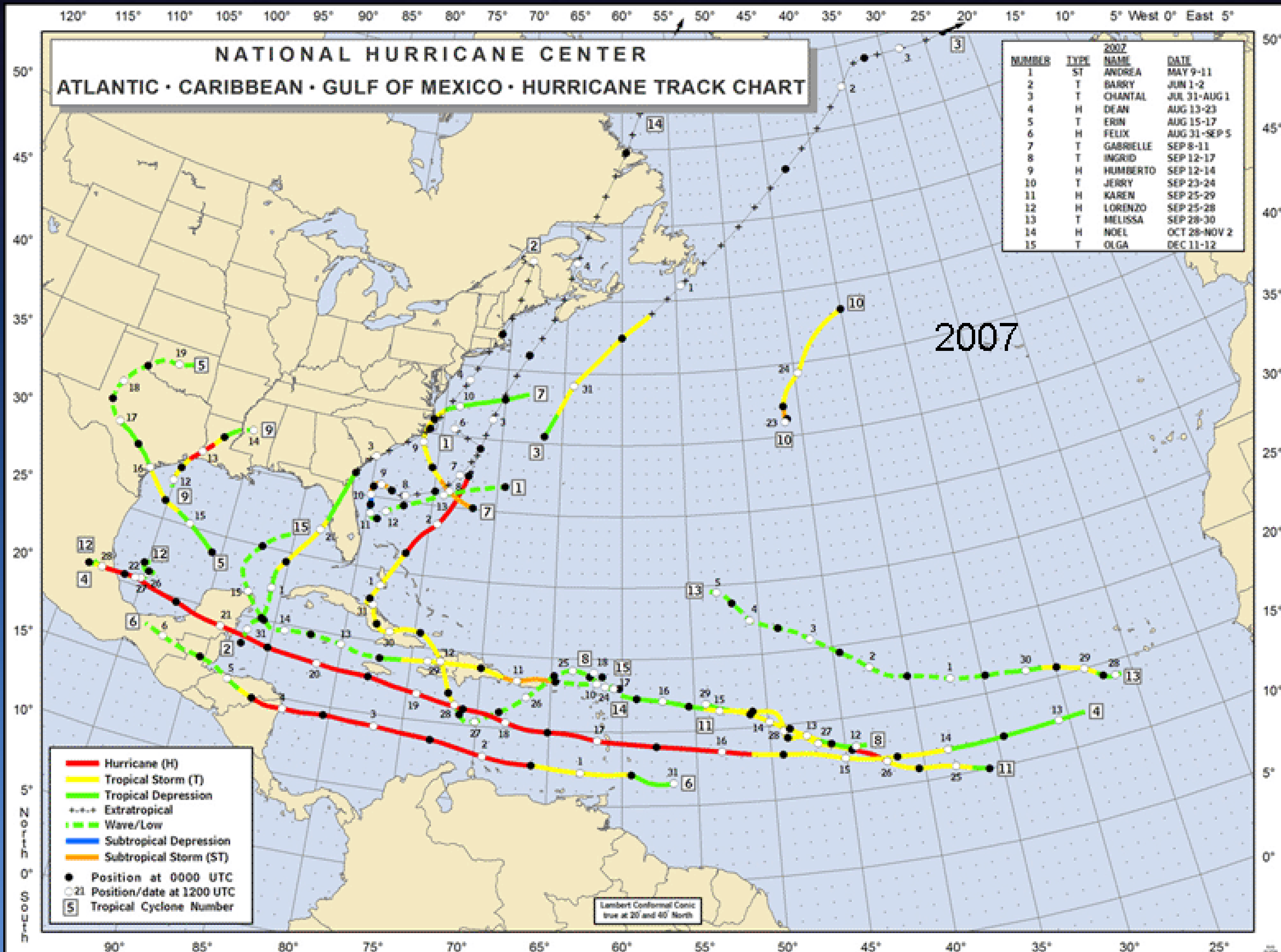
# 2005 Atlantic/IAS Tropical Storms



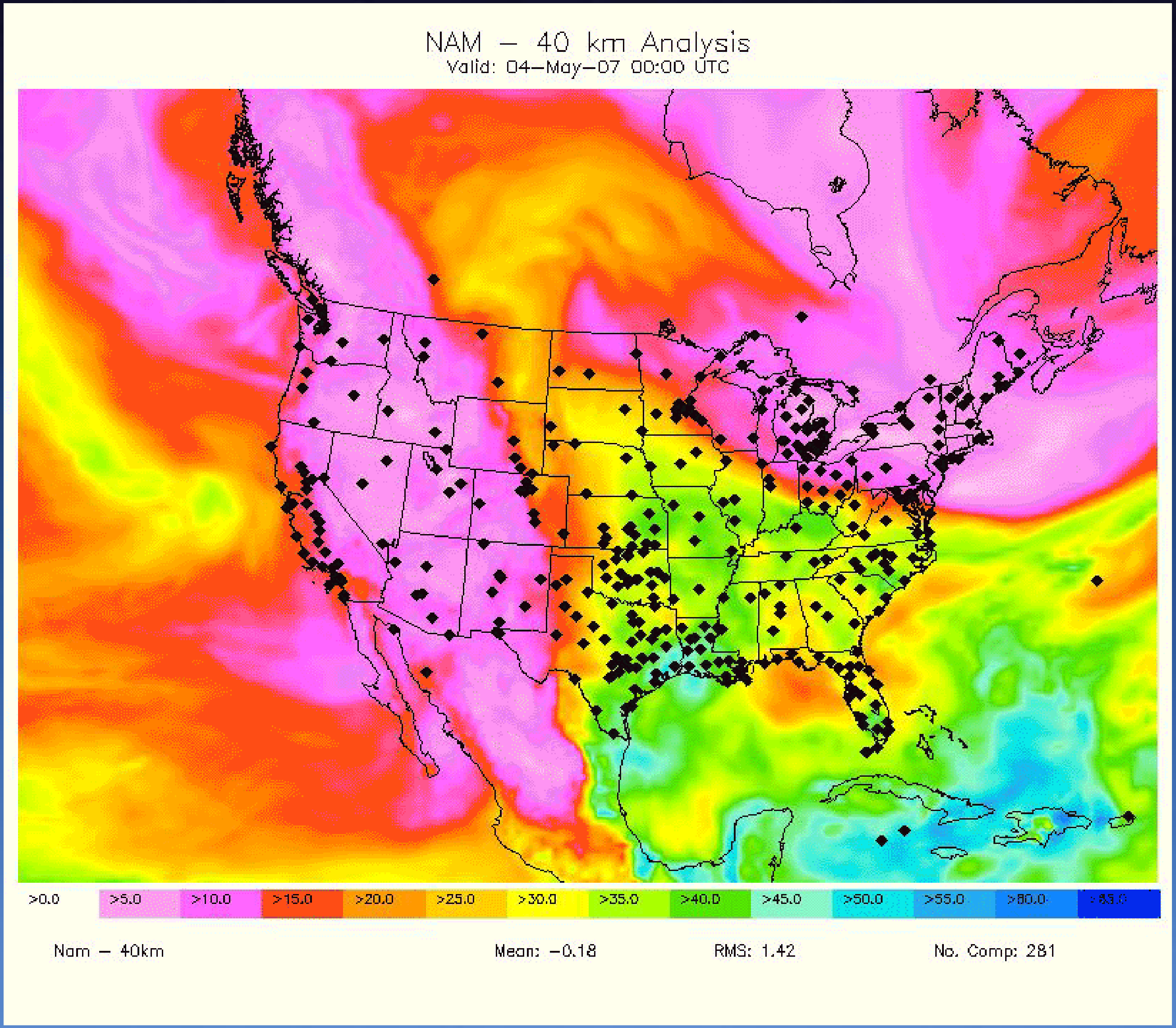
# 2006 Atlantic/IAS Tropical Storms



# 2007 Atlantic/IAS Tropical Storms



# Genesis of Tropical Storm Andrea



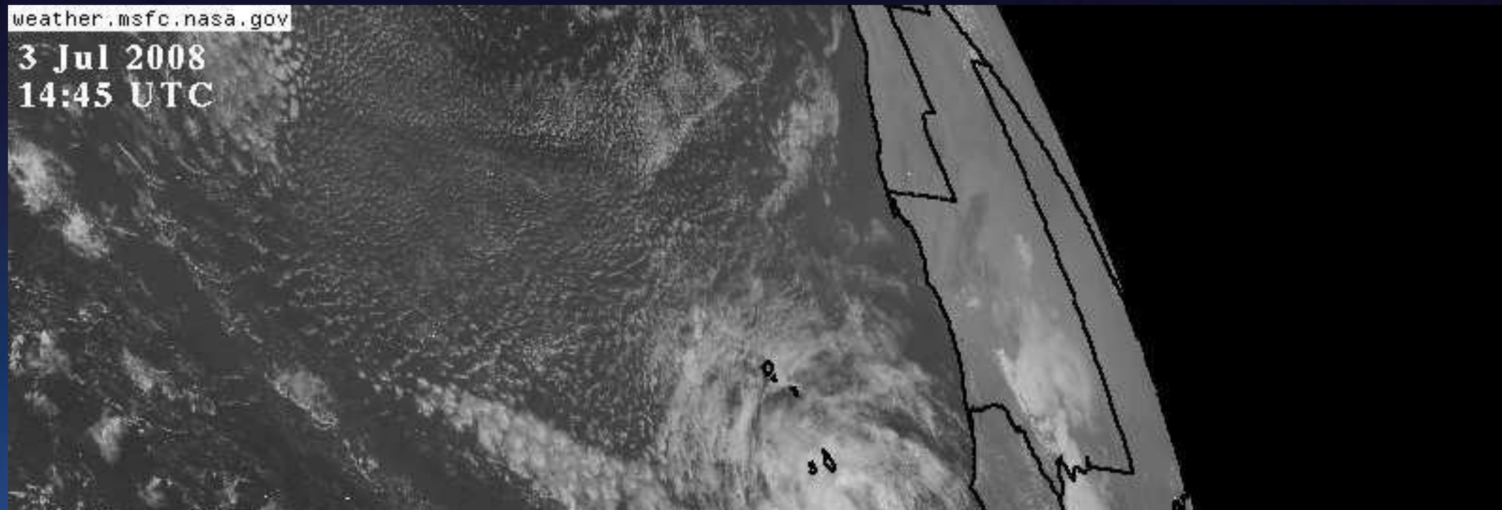

1) flow of moisture from the Gulf of Mexico to the interior of the U.S.

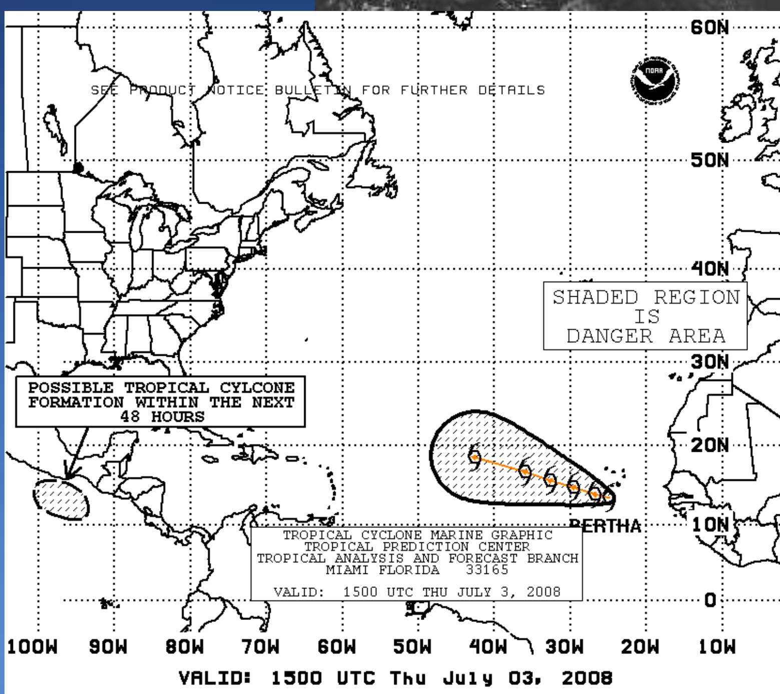
2) triggers strong thunderstorms along the Gulf Coast and inland.

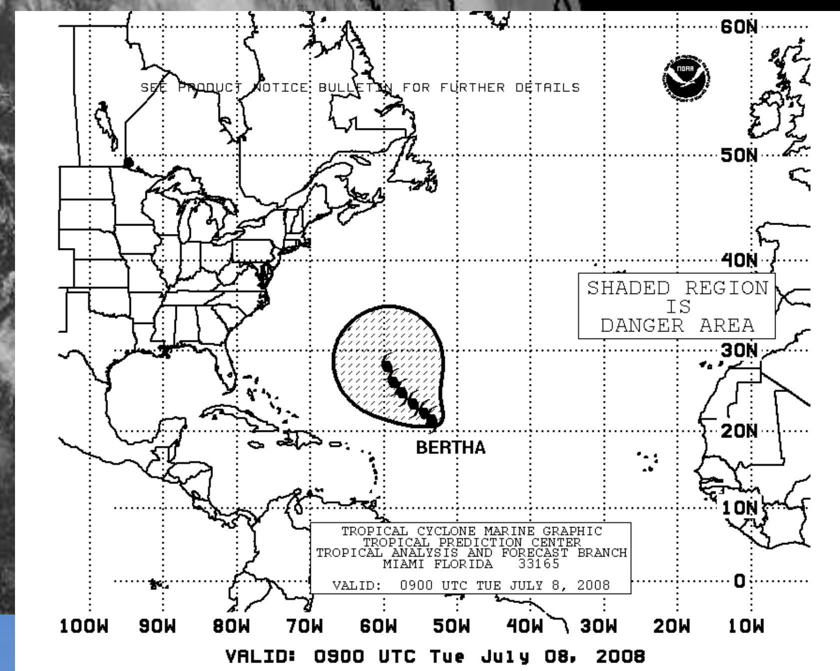
3) Collision between a cold front and warm-moist air off the Carolinas triggers

4) birth of the first named tropical storm of the 2007 Hurricane Season: Andria.

# 2008 Atlantic/IAS Tropical Storms



# Why We Need Improved Observations

- Timely observations provide “situational awareness” to forecasters, decision makers and the general public.
- Observations help define the initial conditions for numerical weather prediction models that provide our long-range weather forecasts.
- Poor or absent observations usually result in erroneous forecasts.
- The need for observations with higher (temporal and spatial) resolution increases as the weather becomes more dynamic.
- GPS observations made under all weather conditions at N/MDGS sites provide critical moisture information when it’s needed most.

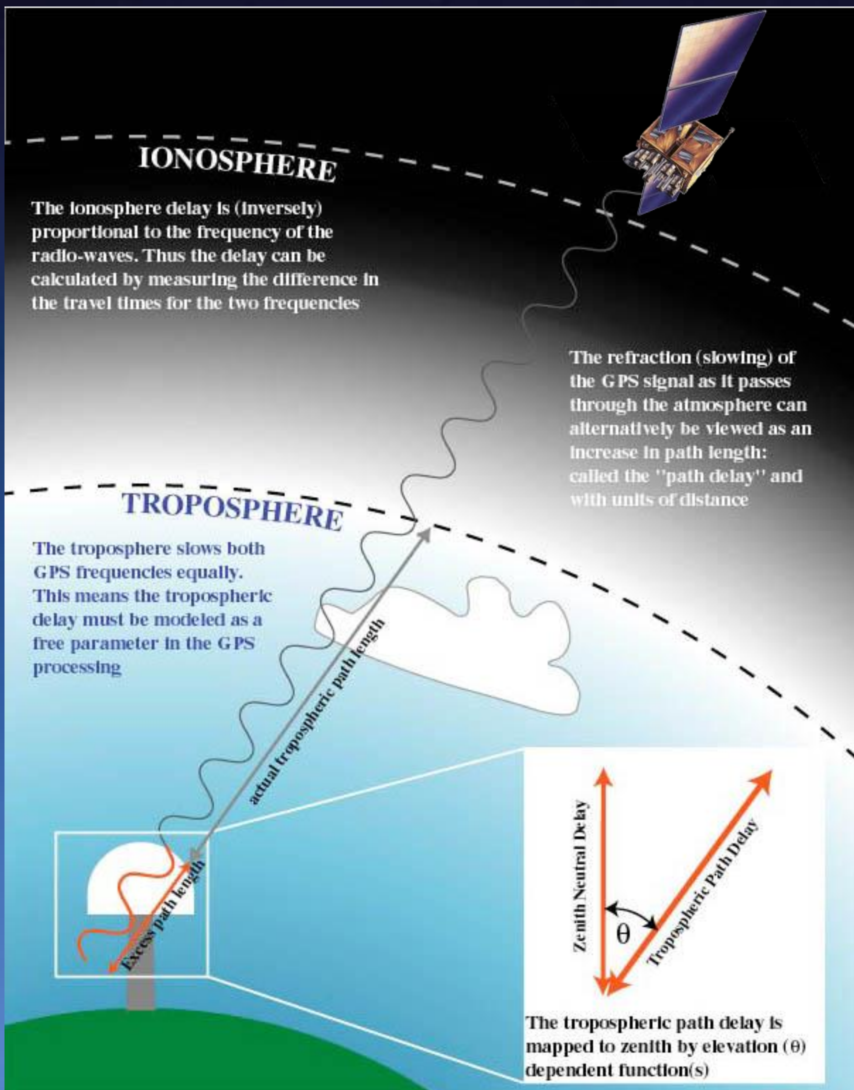
# Background


- The satellite Global Positioning System (GPS) was developed by the U.S. Military to provide high accuracy positioning, navigation & time transfer information anywhere on Earth under all weather conditions.

- The radio signals transmitted by the GPS satellites are refracted (i.e. slowed and bent) by the constituents of the upper and lower atmosphere.

- This causes apparent delays in the arrival of the GPS signals that result in errors in the computed position of a GPS receiver at the surface of the Earth.

# Background




- Geodesists developed techniques to model tropospheric signal delays as “noise” and remove them to improve survey accuracy.
- In 1992, Mike Bevis (then at NCSU) and others proposed that this noise was actually a “signal” that could be used to measure water vapor in the lower atmosphere.
- Understanding the implications of this for weather forecasting and other meteorological applications, NOAA collaborated with several universities to develop operational techniques to monitor water vapor using COTS GPS receivers.

# Overview of GPS Meteorology

**GPS Signal in Ionosphere**

- Refractivity associated with changes in electron plasma density or TEC between 50 and 400 km AGL.
- Signal delays in dispersive media are inversely proportional to frequency.
- Ionospheric delays are estimated (or removed) using dual frequency receivers.

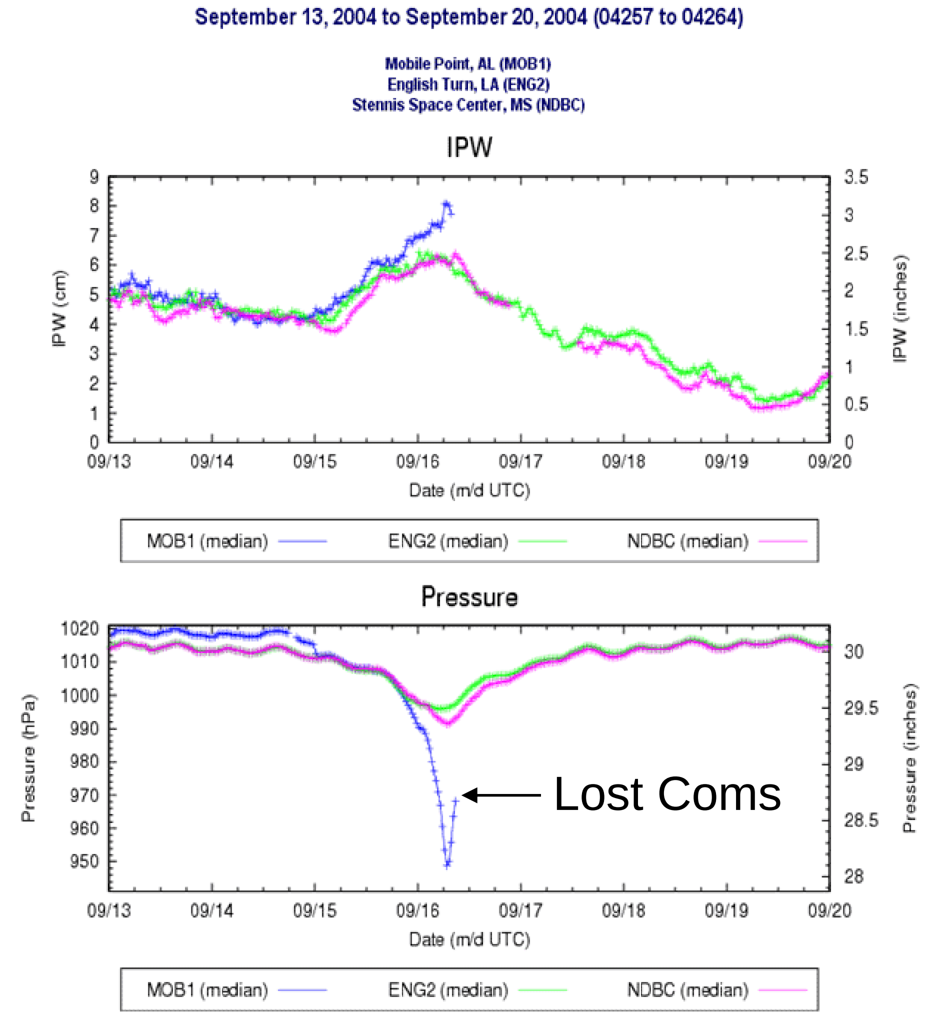
GPS SV

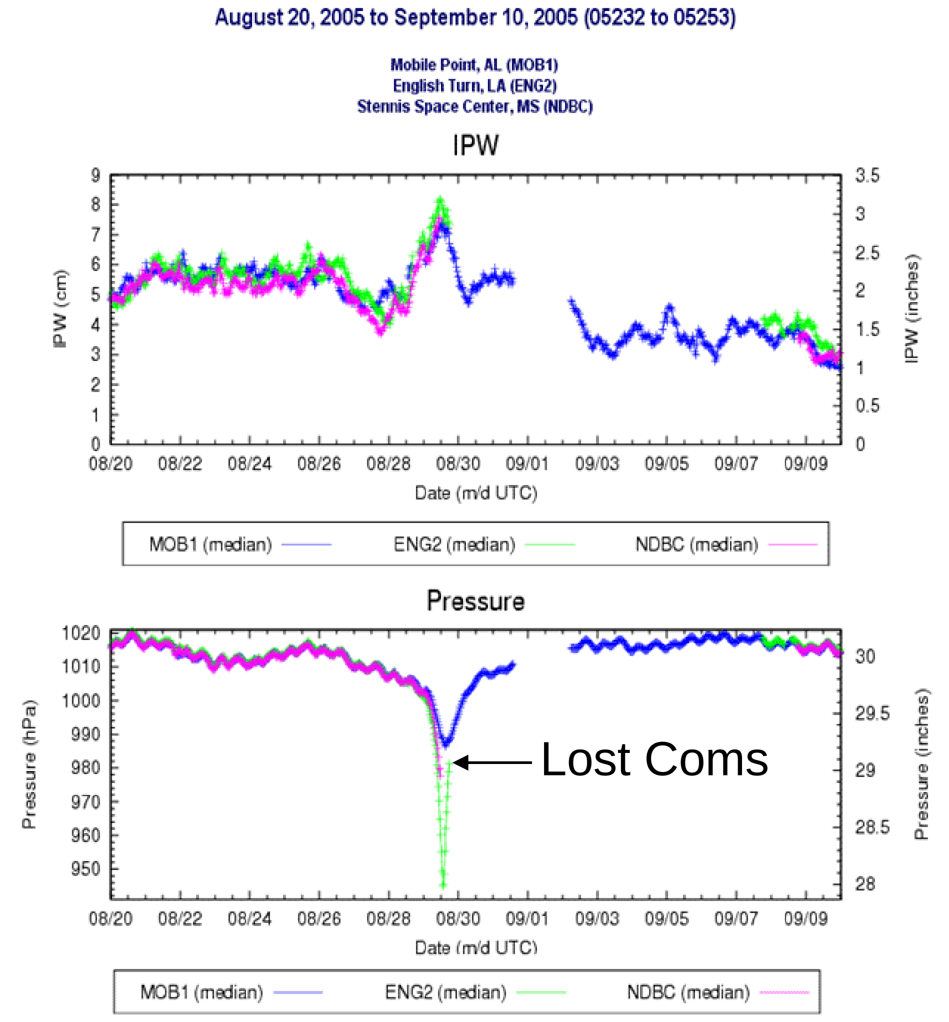
**GPS Signal in Troposphere**

- Refractivity associated with changes in T,P,WV in neutral atmosphere.
- Signal delays are unrelated to frequency below 30 GHz.
- Delays are estimated as a free parameter in the calculation of antenna position.

DGPS Site
English Turn, LA

# GPS Water Vapor Observations During Hurricanes Ivan (2004) & Katrina (2005)




Hurricane Ivan

Hurricane Katrina

# Lessons Learned

- Observing systems need to be more resilient.
  - ✓ Harden sites.
  - ✓ Ability to switch from local power and communications to backups (e.g. batteries and satellite communications).
- Need more surface and upper-air observations.
  - ✓ Complete NDGPS.
  - ✓ Put GPS on offshore drilling platforms.
  - ✓ Put GPS on islands in Western Atlantic and Caribbean.
  - ✓ Expand GPS coverage along the coasts of the U.S., Mexico, and Central America.

Thanks for your attention!

Any questions?

# Contact Information:

Seth I. Gutman, Physical Scientist
NOAA Earth System Research Laboratory (ESRL)
325 Broadway R/GSD7
Boulder, CO 80305-3328

Phone: (303) 497-7031
FAX: (303) 497-6014

Email: Seth.I.Gutman@noaa.gov
Web: http://gpsmet_test.fsl.noaa.gov.