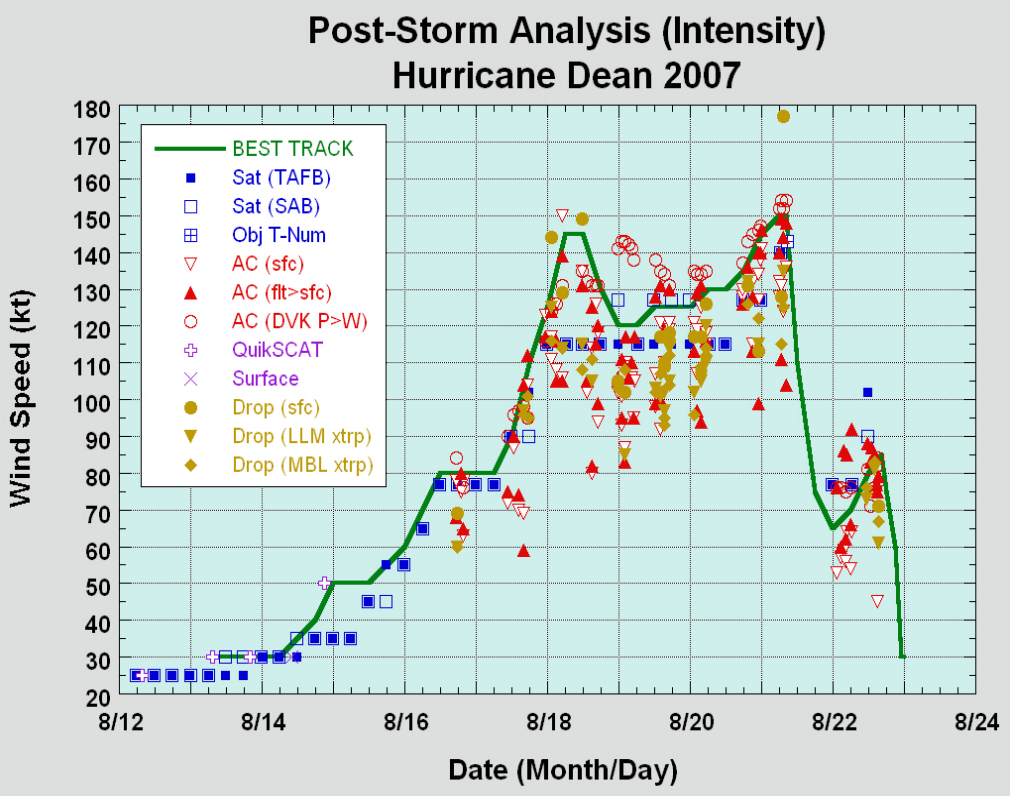
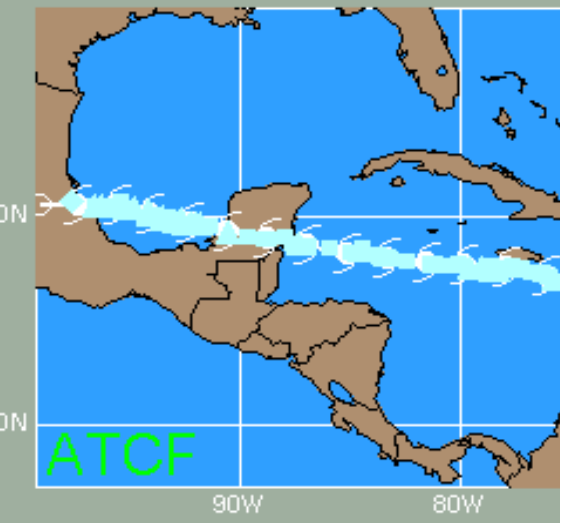
# How Good are the "Best Tracks"? Estimating Uncertainty in the Atlantic Hurricane Database

Chris Landsea
National Hurricane Center

13 March, 2013
HFIP Bi-monthly Meeting

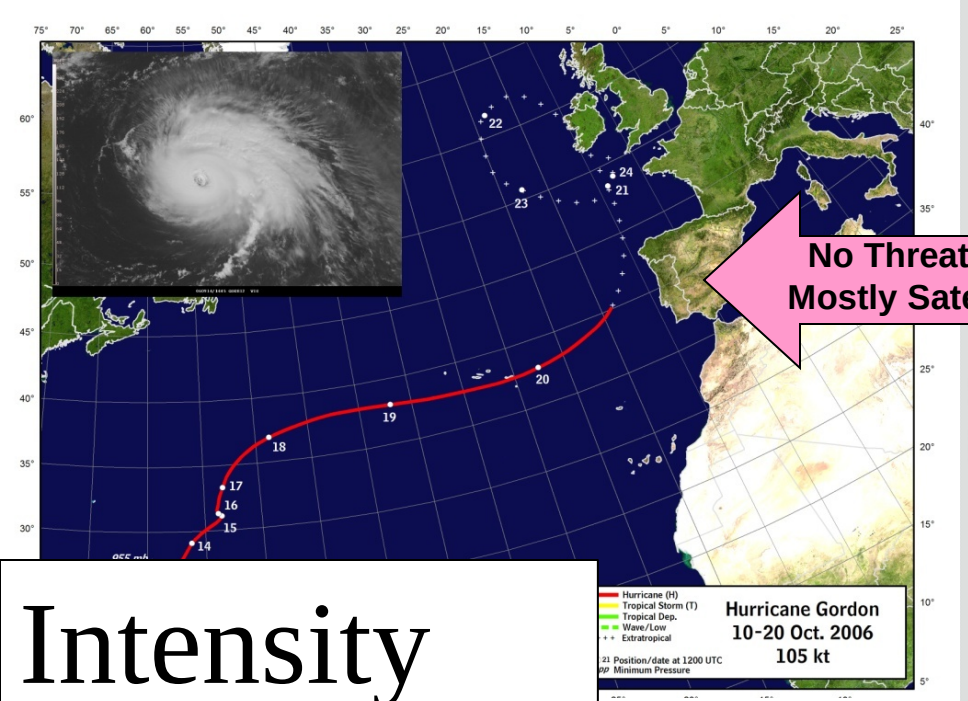


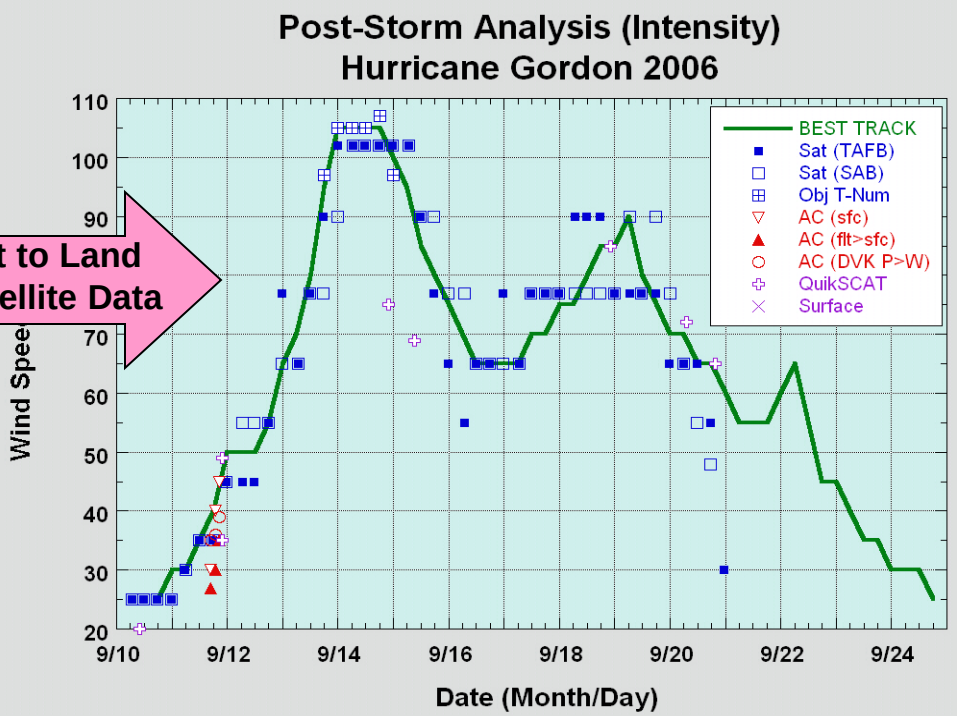

NHC **"best tracks"** (conducts a post-season analysis) all TCs for the following:

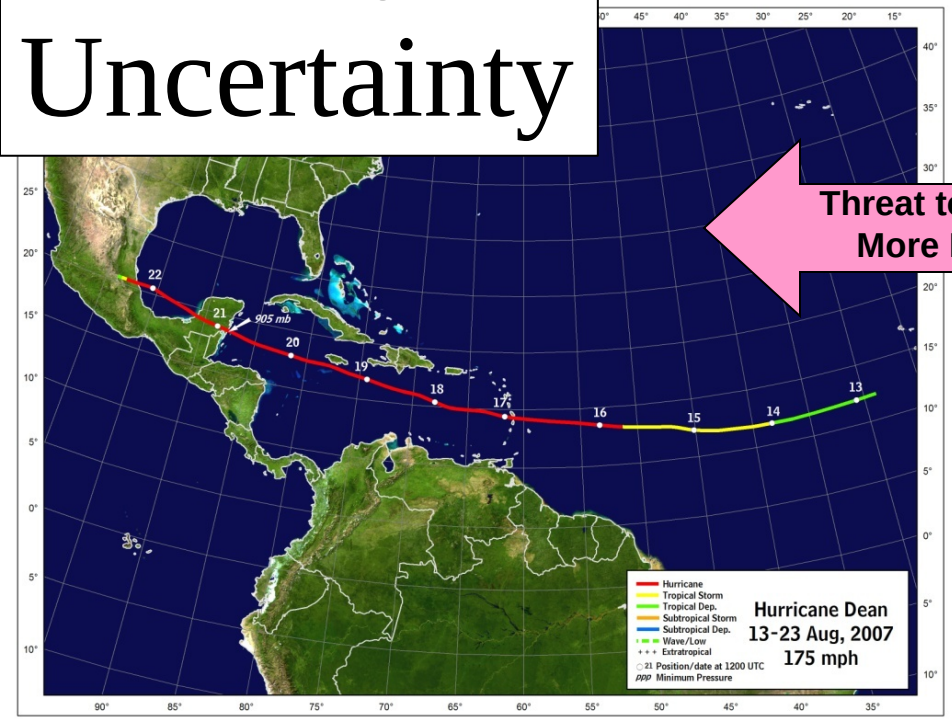
a) **Intensity** (max 1 min 10 m winds – to nearest 5 kt)
b) **Central Pressure** (1 mb)
c) **Position** (6 nm)
d) **Maximum Gale (34 kt) Radii** (since 2004, 5 nm)
e) **Maximum Storm (50 kt) Radii** (since 2004, 5 nm)
f) **Maximum Hurricane (64 kt) Radii** (since 2004, 5 nm)

# Intensity Uncertainty

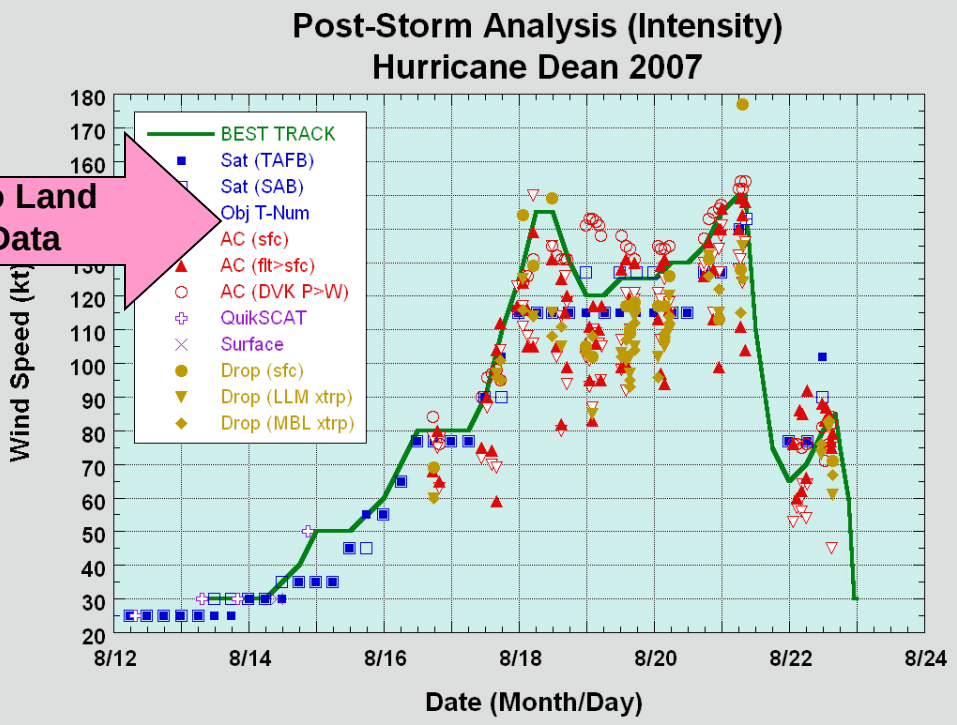



No Threat to Land
Mostly Satellite Data

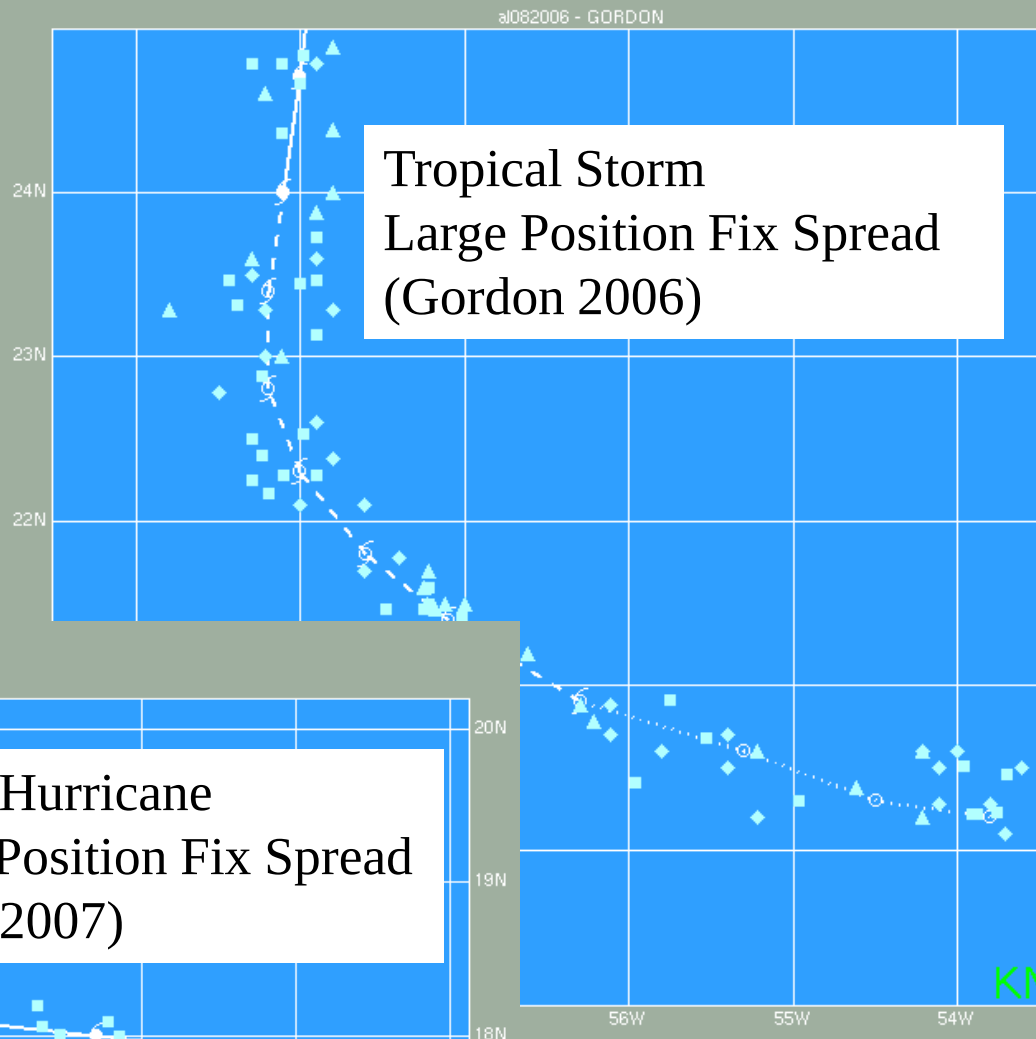


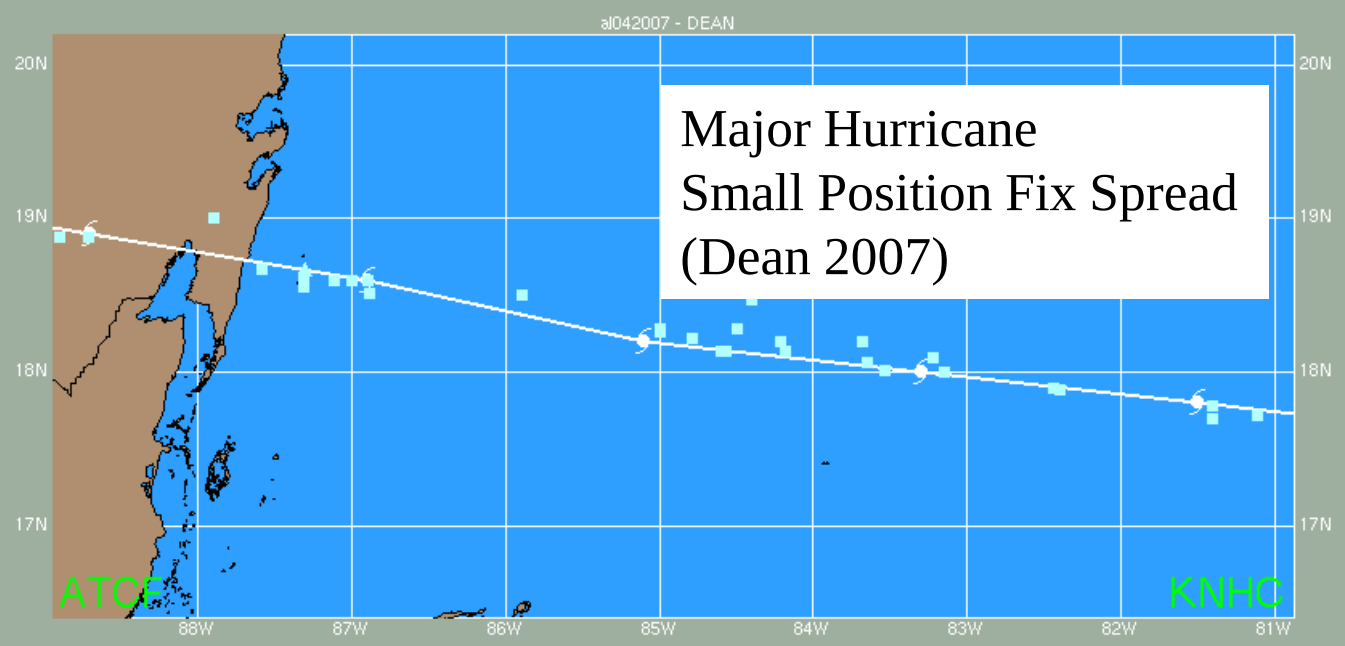

Threat to Land
More Data



# Position Uncertainty




Tropical Storm
Large Position Fix Spread
(Gordon 2006)




Major Hurricane
Small Position Fix Spread
(Dean 2007)

A survey of the NHC Hurricane Specialists was conducted in **2010** for their estimates of the average errors (uncertainties) inherent in the best tracks that they create.

Best Track average error estimates are stratified both by:

**Tropical Storm** **Category 1&2 Hurricanes** **Major Hurricanes**

and by:

**Satellite Only** **Aircraft and Satellite Data** **U.S. Landfalling**

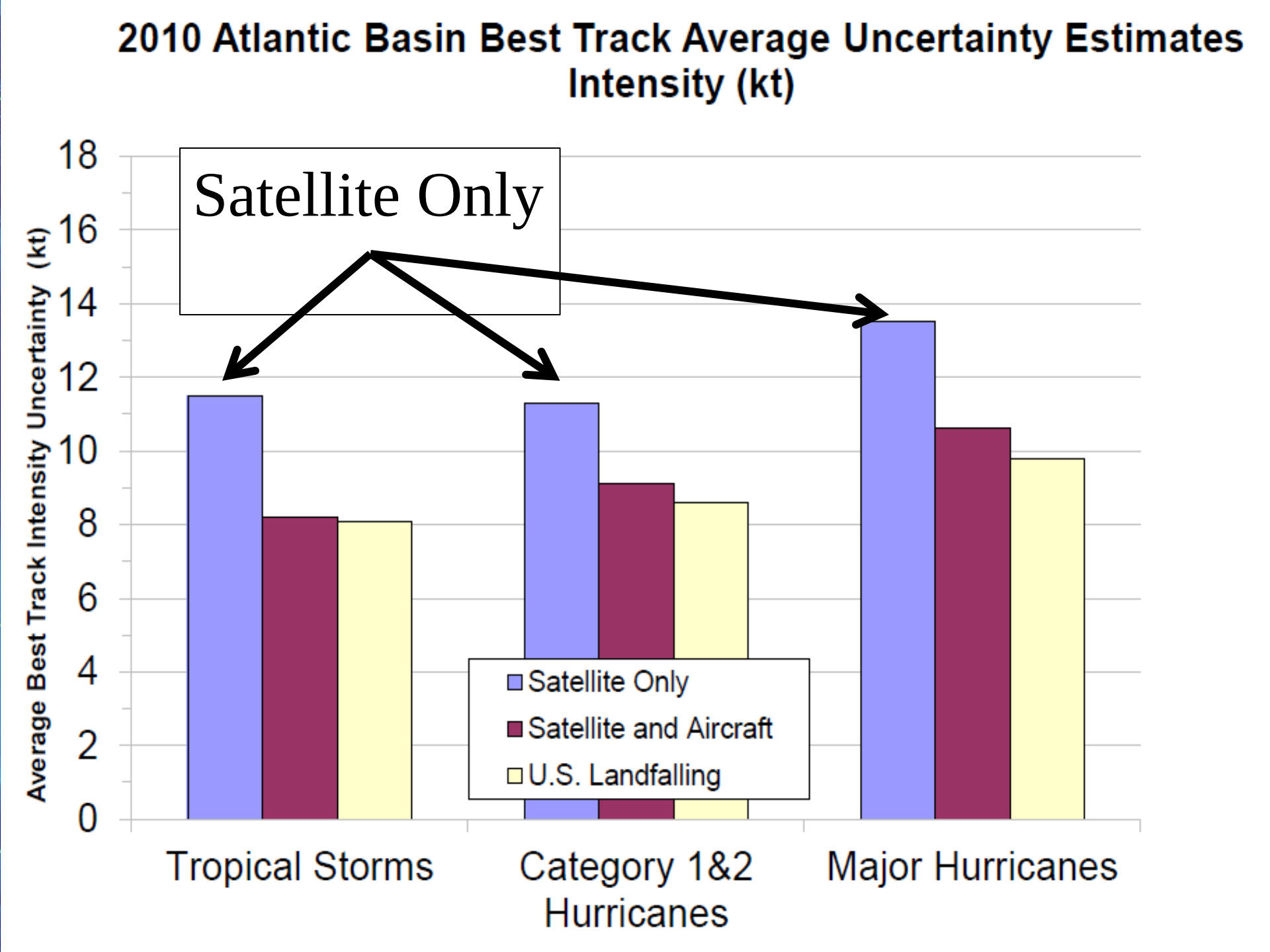
# 2010 Atlantic Basin Best Track Average Error Estimates
## Satellite Imagery Only (Dvorak, Microwave, & QuikSCAT)
### (Average errors for: intensity, central pressure, position, gale-50 kt-hurricane force radii)

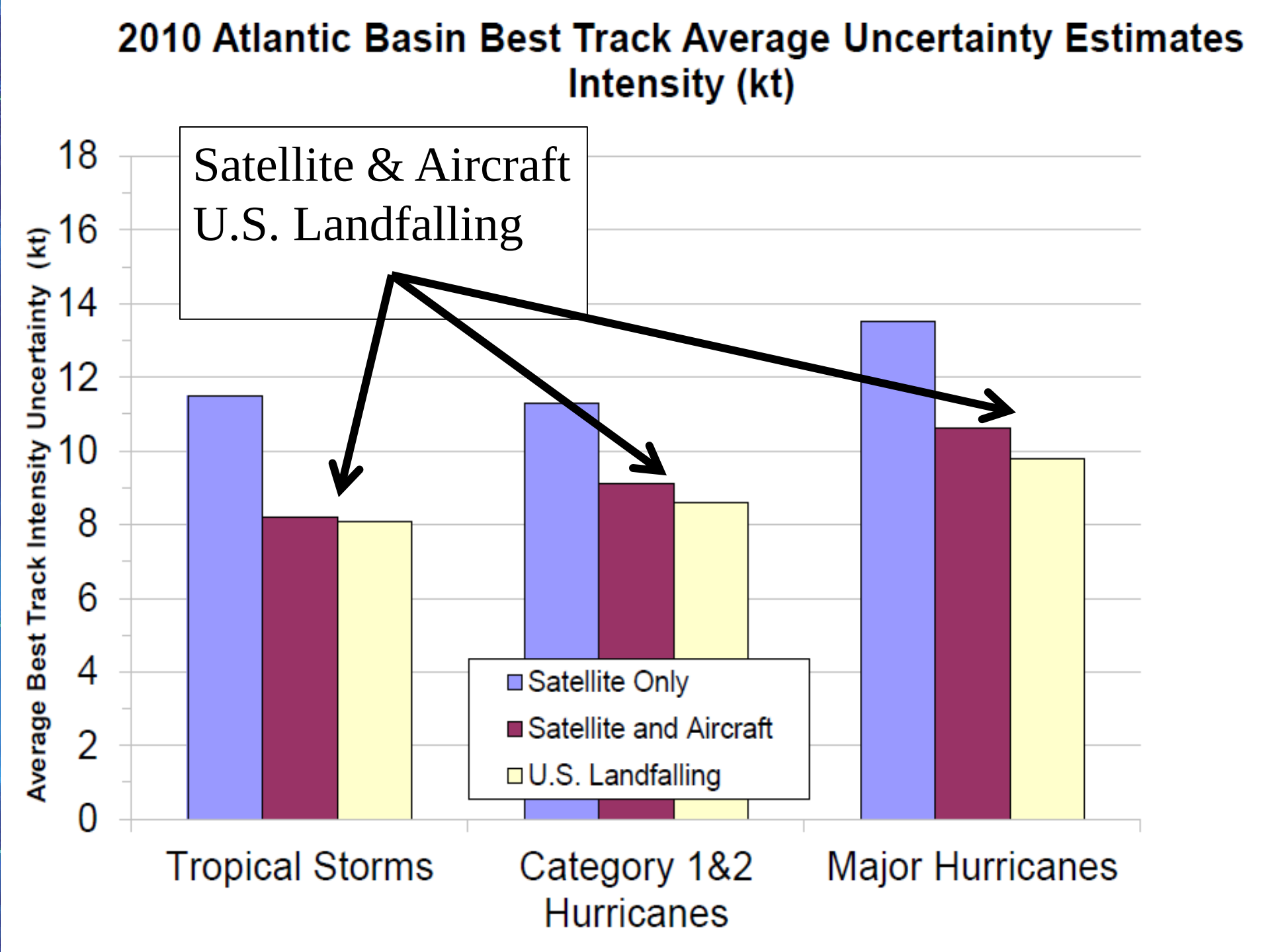
| Hurricane Specialist | Tropical Storm | Category 1 & 2 Hurricanes | Major Hurricanes |
|---|---|---|---|
| L. Avila | 15kt / 5mb / 40nm/ 50-50nm | 15kt / 5mb / 40nm/ 50-50-50nm | 15kt / 5mb / 20nm/ 50-50-50nm |
| R. Berg | 15 kt / 10 mb / 45 nm / 60-30 nm | 10 kt / 10 mb / 30 nm / 60-30-15 nm | 10 kt / 10 mb / 10 nm / 60-30-15 nm |
| J. Beven | 10 kt/3 mb/40 nm/ 40-20 nm | 10 kt/5 mb/20 nm/40-20-10 nm | 10 kt/7 mb/5 nm/40-20-20 nm |
| E. Blake | 10 kt/ 5 mb/ 25 nm/ 45-25 nm | 10 kt/ 8 mb/ 20 nm/ 35-25-20 | 10-15 kt/ 10 mb/ 10-15 nm/ 30-25-20 |
| M. Brennan | 10 kt/5mb/30 nm/20-15 nm | 10 kt/8 mb/15 nm/30-20-20 | 15 kt/15 mb/10 nm/30-30-20 |
| D. Brown | 7-12 kt/5 mb/30 nm/25-35 15-20 nm | 8-15kt/7-12mb/20nm/25-40 20-30 10-20nm | 14-22kt/8-14mb/10-15nm/25-40 20-30 10-20nm |
| J. Cangialosi | 10 kt/5 mb/30 nm/40-20 nm | 10 kt/8 mb/15 nm/40-30-20 nm | 15 kt/12 mb/10 nm/40-30-20 nm |
| J. Franklin | 10-15 kt/5-7 mb/ 25 nm/ 40-30 nm | 10-15 kt/7-10 mb/20 nm/40-30-20 nm | 15 kt/7-10 mb/15 nm/40-30-20 nm |
| T. Kimberlain | 10 kt/6-8 mb/30 nm/25-25 nm | 10 kt/7-9 mb/20 nm/25 25 5-10 nm | 5-10 kt/5-8 mb/5 nm/25 25 5-10 nm |
| R. Pasch | 15 kt/5 mb/40 nm/50-50 nm | 15 kt/5 mb/25 nm/50-50-40 nm | 15 kt/5 mb/15 nm/50-50-40 nm |
| S. Stewart | 10 kt/8 mb/45 nm/20-20 nm | 10 kt/10 mb/30 nm/30-30-30 nm | 15 kt/15 mb/20 nm/40-40-40 nm |
| Consensus (Range) | 11.5 kt/5.8 mb/34.5 nm/38.0 & 27.7nm (7-15 kt/3-10 mb/25-45 nm/20-60 & 15-50 nm) | 11.3 kt/7.7 mb/23.2 nm/39.4 & 30.5 & 22.5 nm (8-15 kt/5-12 mb/15-40 nm/25-60 & 20-50 & 5-50 nm) | 13.5 kt/9.5 mb/12.3 nm/39.8 & 32.3 & 24.4 nm (5-22 kt/5-15 mb/5-20 nm/25-60 & 20-50 & 5-50 nm) |

A similar survey was conducted in **1999** with the current Hurricane Specialists

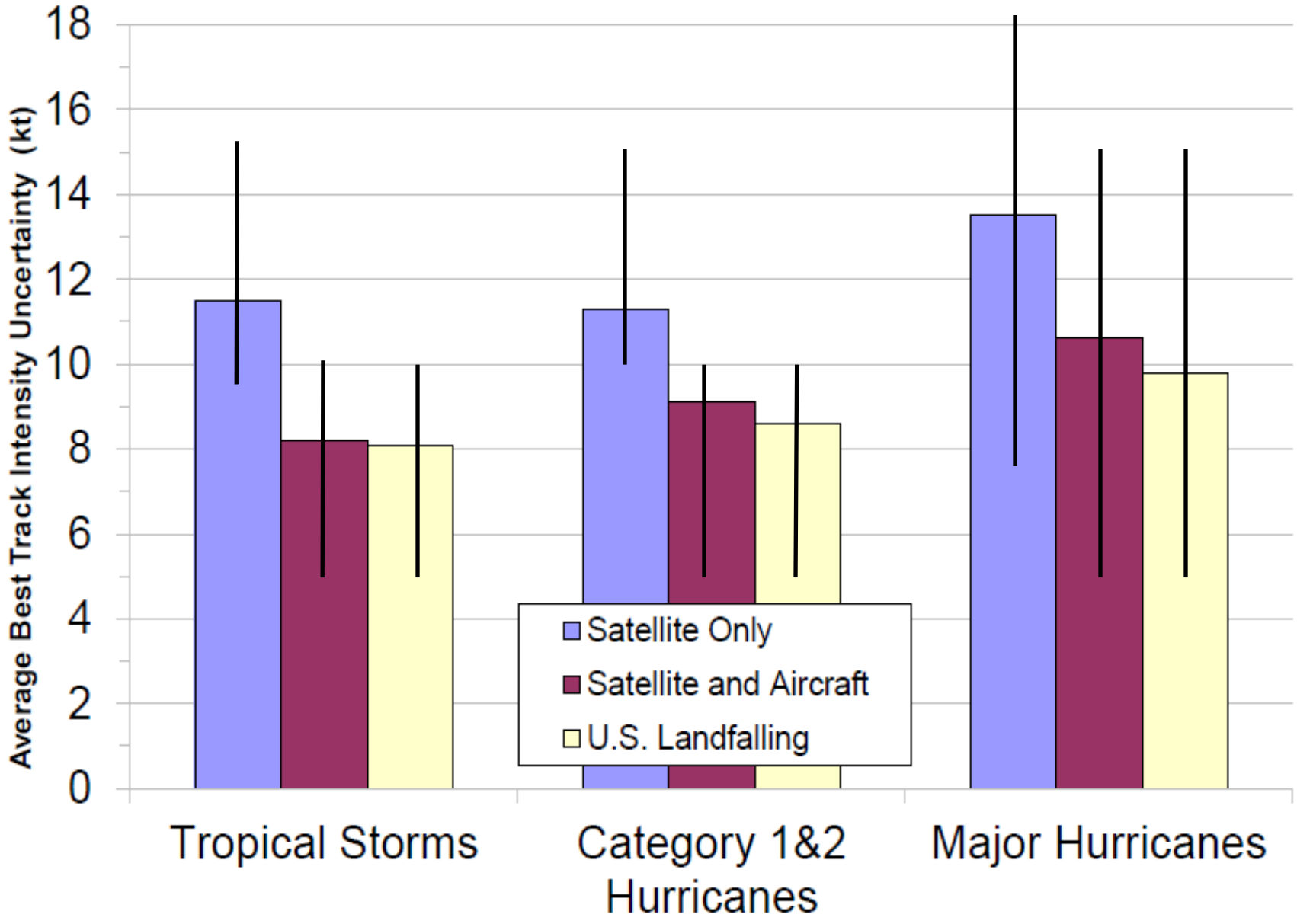
# 1999 Atlantic Basin Best Track Error Estimates
## Satellite Imagery Only

| Hurricane Specialist | Tropical Storm | Category 1 & 2 Hurricanes | Major Hurricanes |
|---|---|---|---|
| **L. Avila** | 15 kt / 40-50 nm | (No Eye) 15 kt / 40-50 nm<br>(Eye) 15 kt / 20 nm | 25 kt / 20 nm |
| **J. Beven** | 10 kt / 30 nm | (No Eye) 15 kt / 30 nm<br>(Eye) 10 kt / 10 nm | 5-10 kt / 6-12 nm |
| **J. Jarrell** | 10 kt / 20 nm | 10 kt / 15 nm | 20 kt / 10 nm |
| **M. Lawrence** | 20 kt / 30 nm | 20-25 kt / 25 nm | 25 kt / 20 nm |
| **M. Mayfield** | 5-10 kt / 30 nm | 10-13 kt / 18-24 nm | 12-15 kt / 18 nm |
| **R. Pasch** | 10 kt / 30 nm | 10 kt / 20-25 nm | 15-20 kt / 10-15 nm |
| **E. Rappaport** | 7-13 kt / 15 nm | 10-14 kt / 10-15 nm | 10-22 kt / 10 nm |
| **Consensus (Range)** | **11.8 kt/ 28.6 nm (5-20 kt/15-50 nm)** | **13.4 kt/21.2 nm (10-25 kt/10-50 nm)** | **17.8 kt/14.2 nm (5-25 kt/6-20 nm)** |

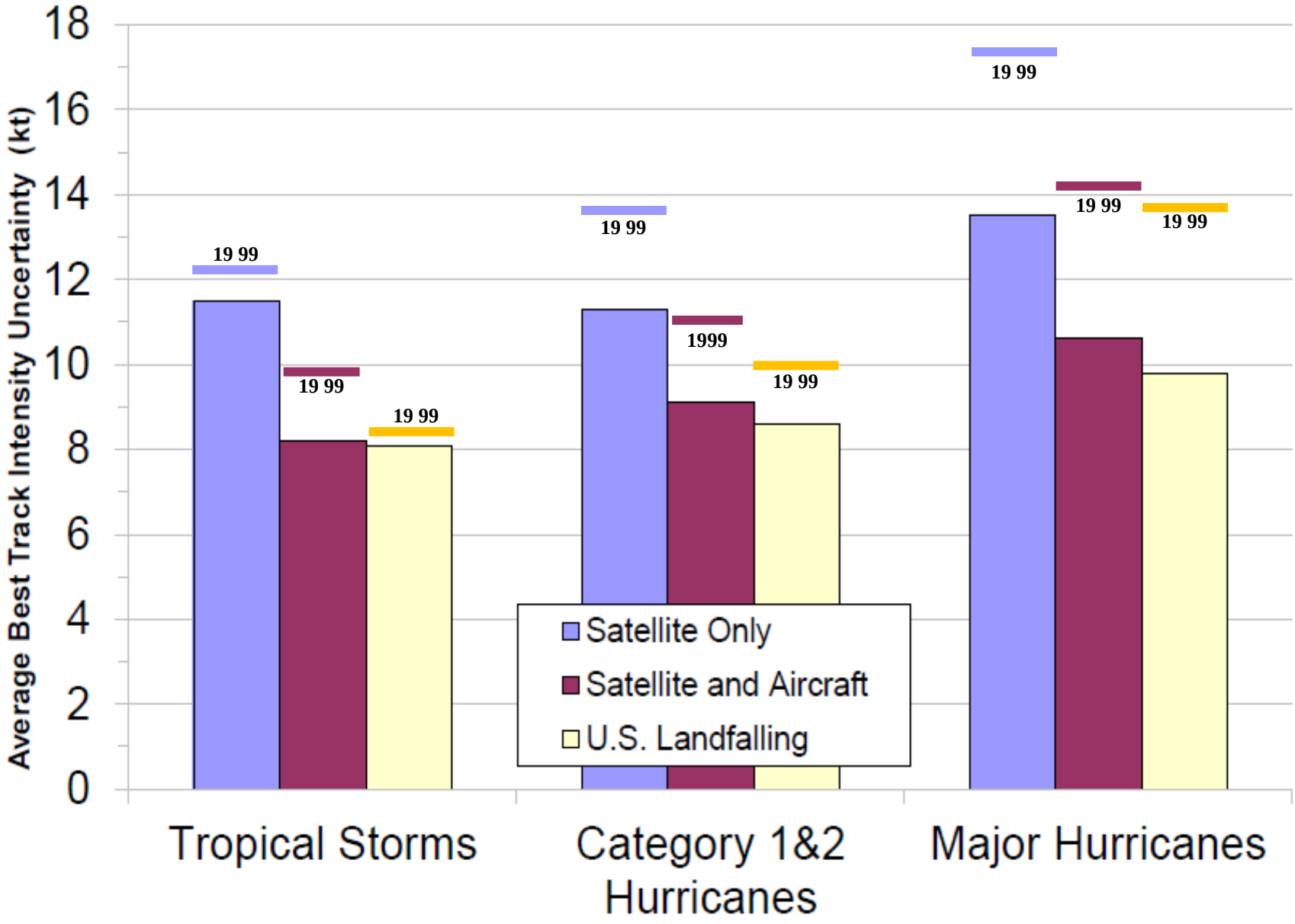

2010 Atlantic Basin Best Track Average Uncertainty Estimates
Intensity (kt)
Satellite Only
Average Best Track Intensity Uncertainty (kt)
18
16
14
12
10
8
6
4
2
0
Satellite Only
Satellite and Aircraft
U.S. Landfalling
Tropical Storms
Category 1&2 Hurricanes
Major Hurricanes

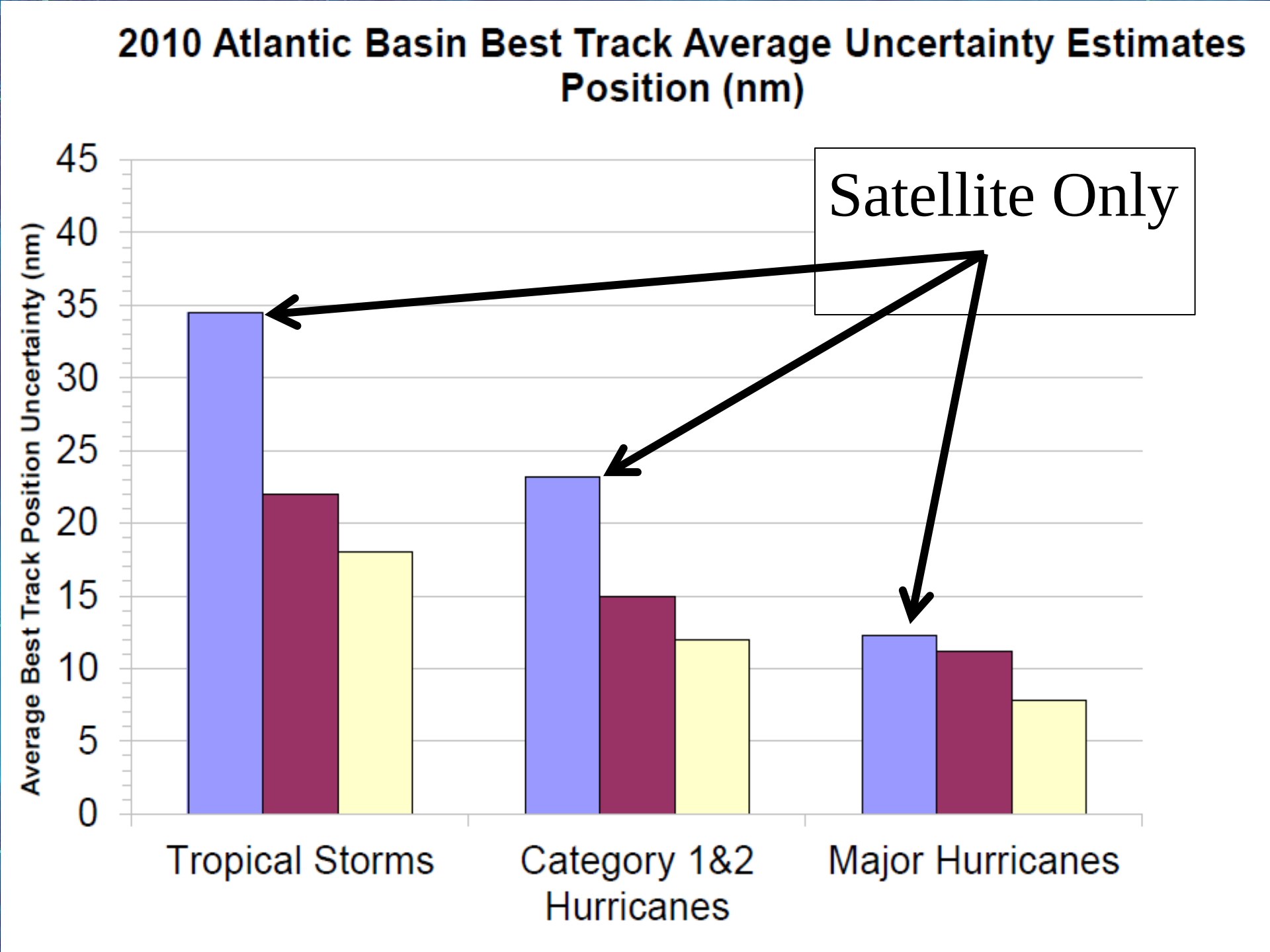

2010 Atlantic Basin Best Track Average Uncertainty Estimates
Intensity (kt)
Satellite & Aircraft
U.S. Landfalling
Average Best Track Intensity Uncertainty (kt)
18
16
14
12
10
8
6
4
2
0
Satellite Only
Satellite and Aircraft
U.S. Landfalling
Tropical Storms
Category 1&2
Hurricanes
Major Hurricanes

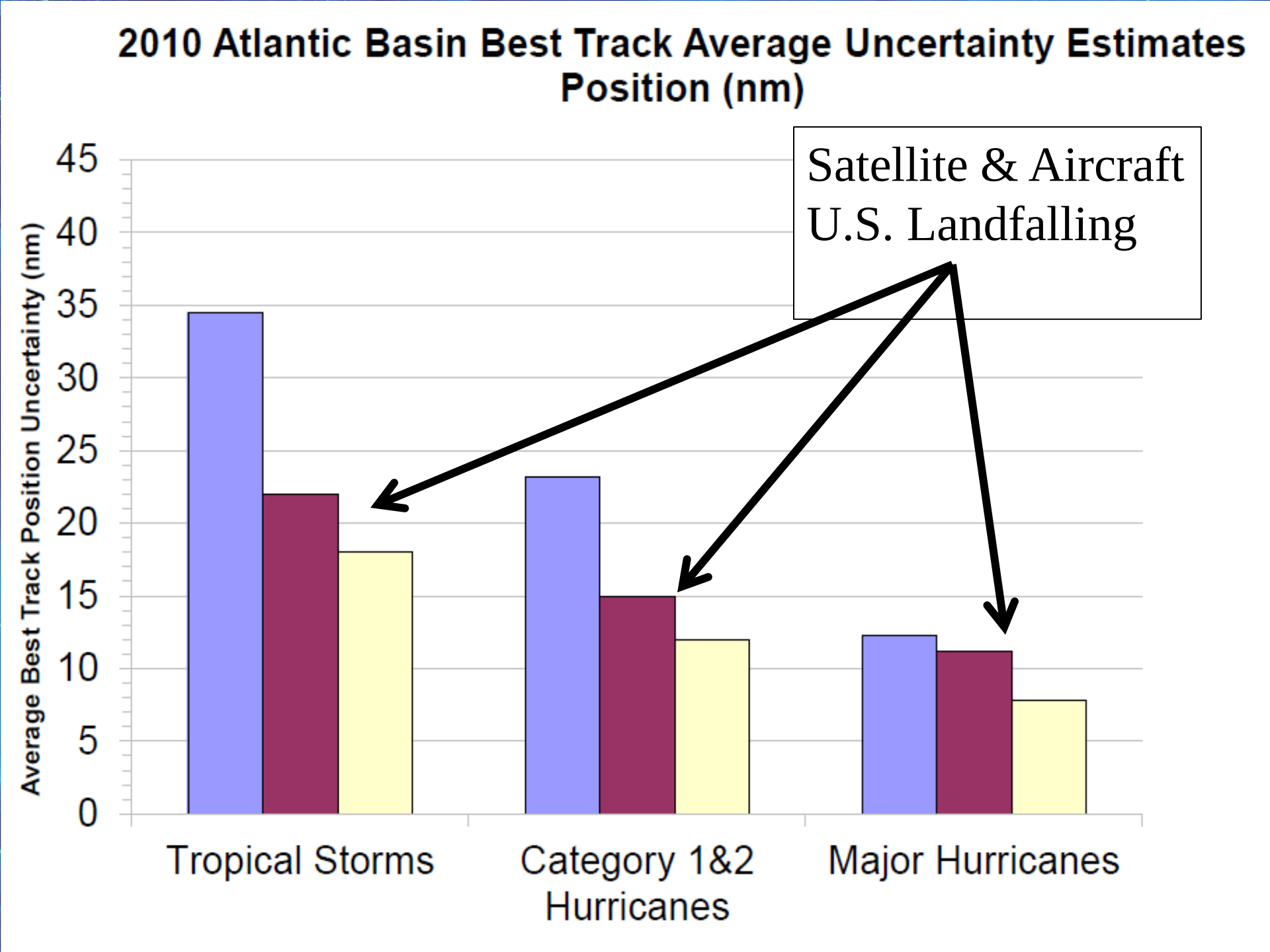
# 2010 Atlantic Basin Best Track Average Uncertainty Estimates Intensity (kt)



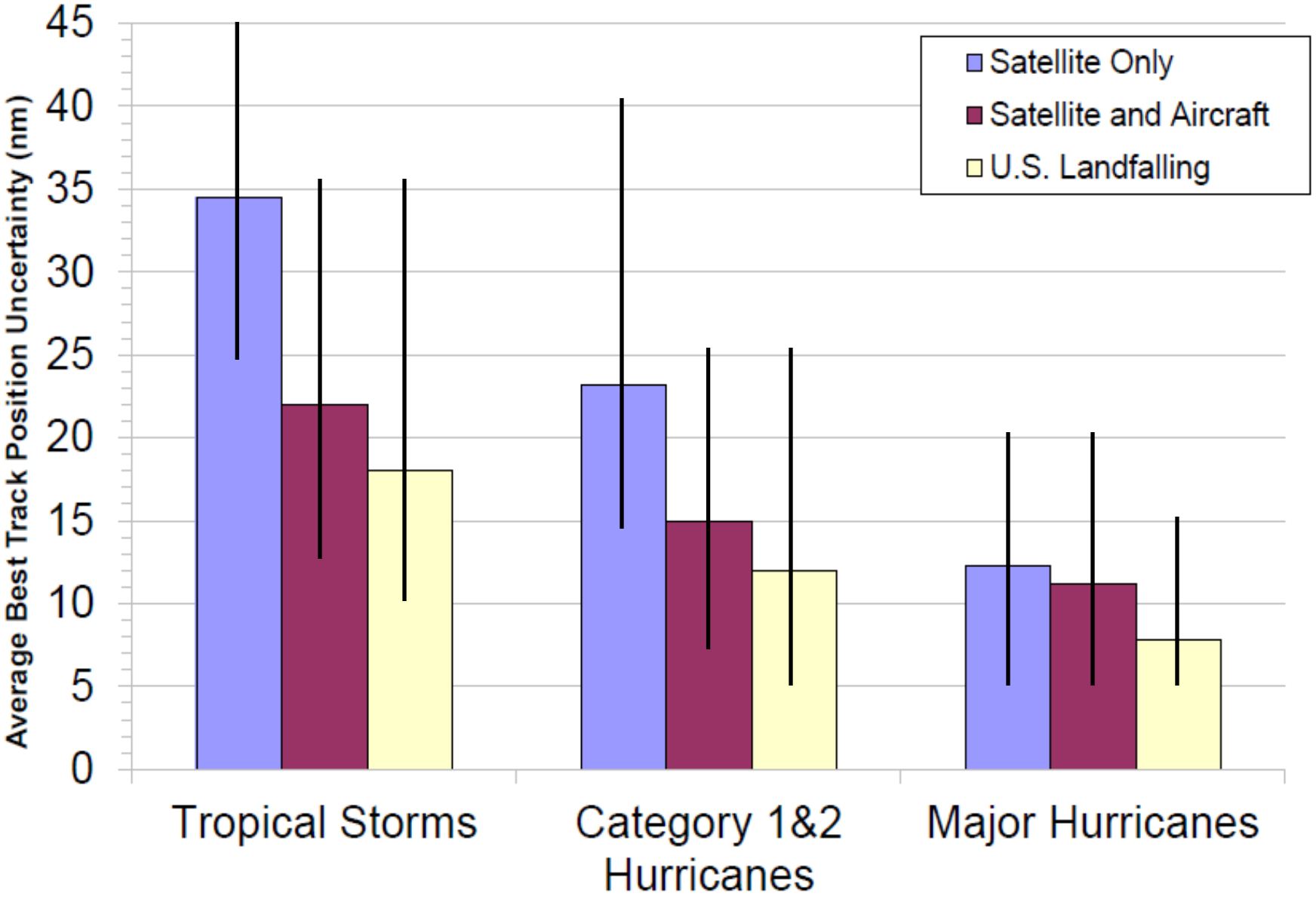
# 2010 Atlantic Basin Best Track Average Uncertainty Estimates Intensity (kt)



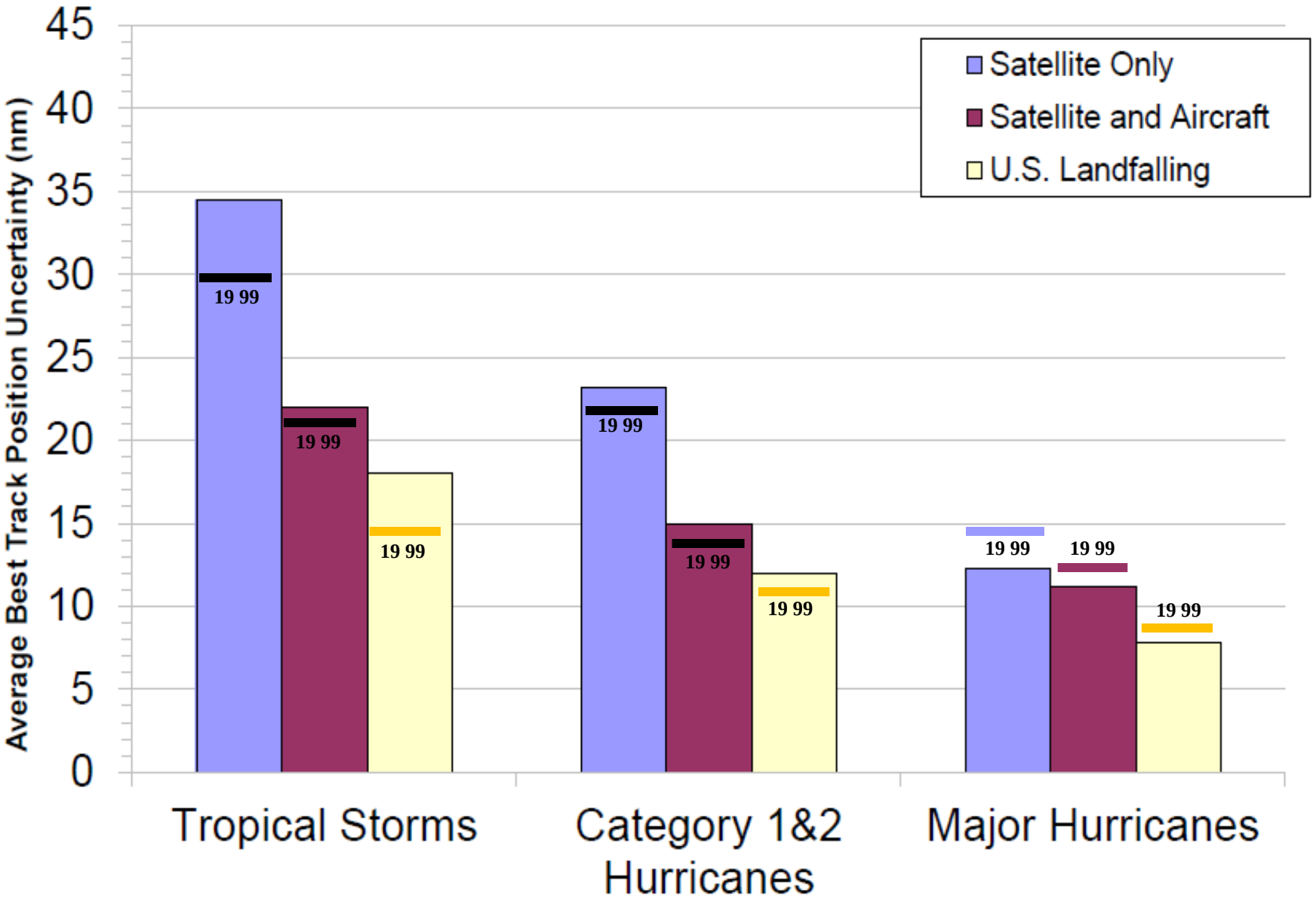

2010 Atlantic Basin Best Track Average Uncertainty Estimates
Position (nm)
Average Best Track Position Uncertainty (nm)
45
40
35
30
25
20
15
10
5
0
Satellite Only
Tropical Storms
Category 1&2 Hurricanes
Major Hurricanes


2010 Atlantic Basin Best Track Average Uncertainty Estimates
Position (nm)
Satellite & Aircraft
U.S. Landfalling
Average Best Track Position Uncertainty (nm)
45
40
35
30
25
20
15
10
5
0
Tropical Storms
Category 1&2
Hurricanes
Major Hurricanes

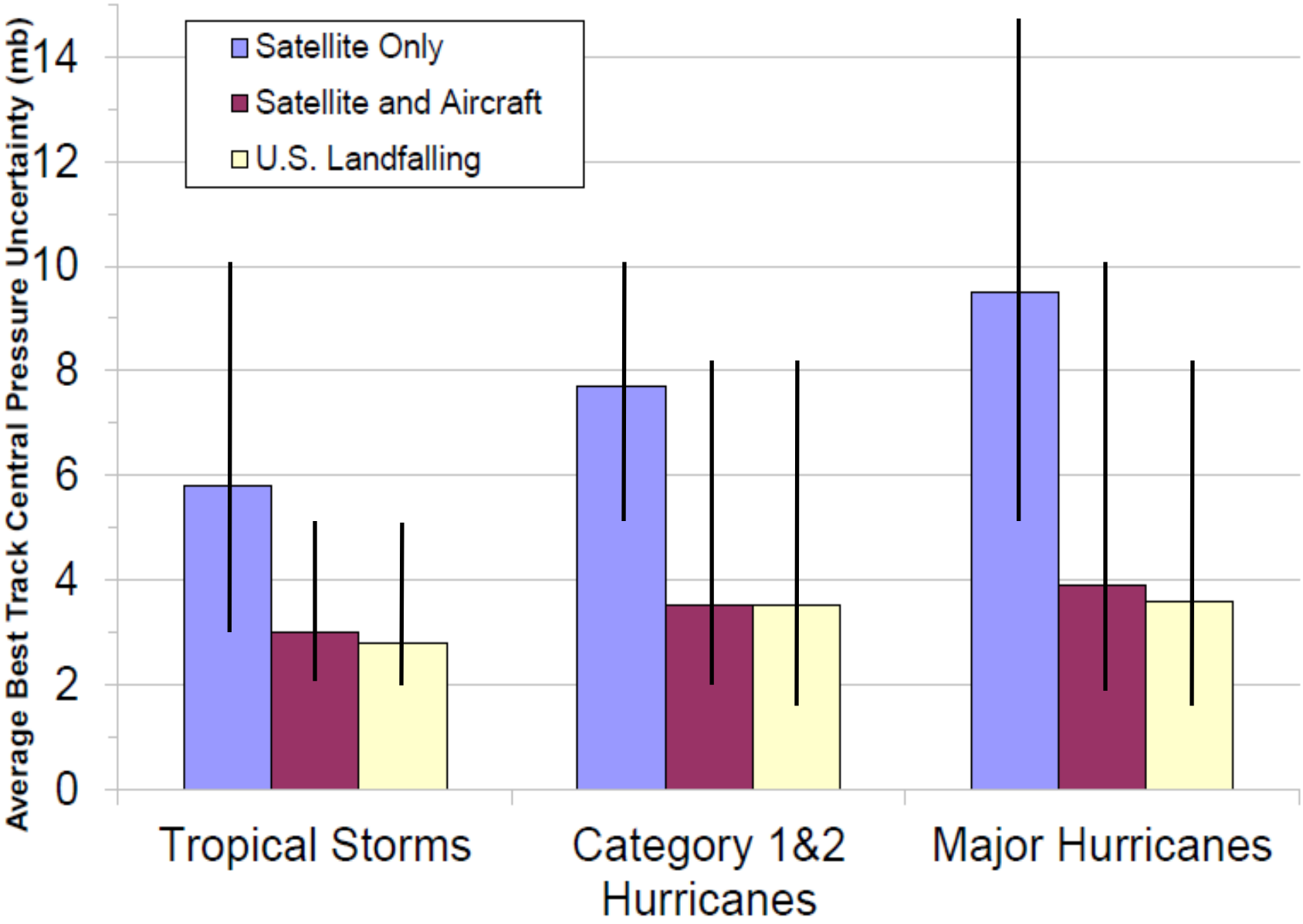
# 2010 Atlantic Basin Best Track Average Uncertainty Estimates Position (nm)



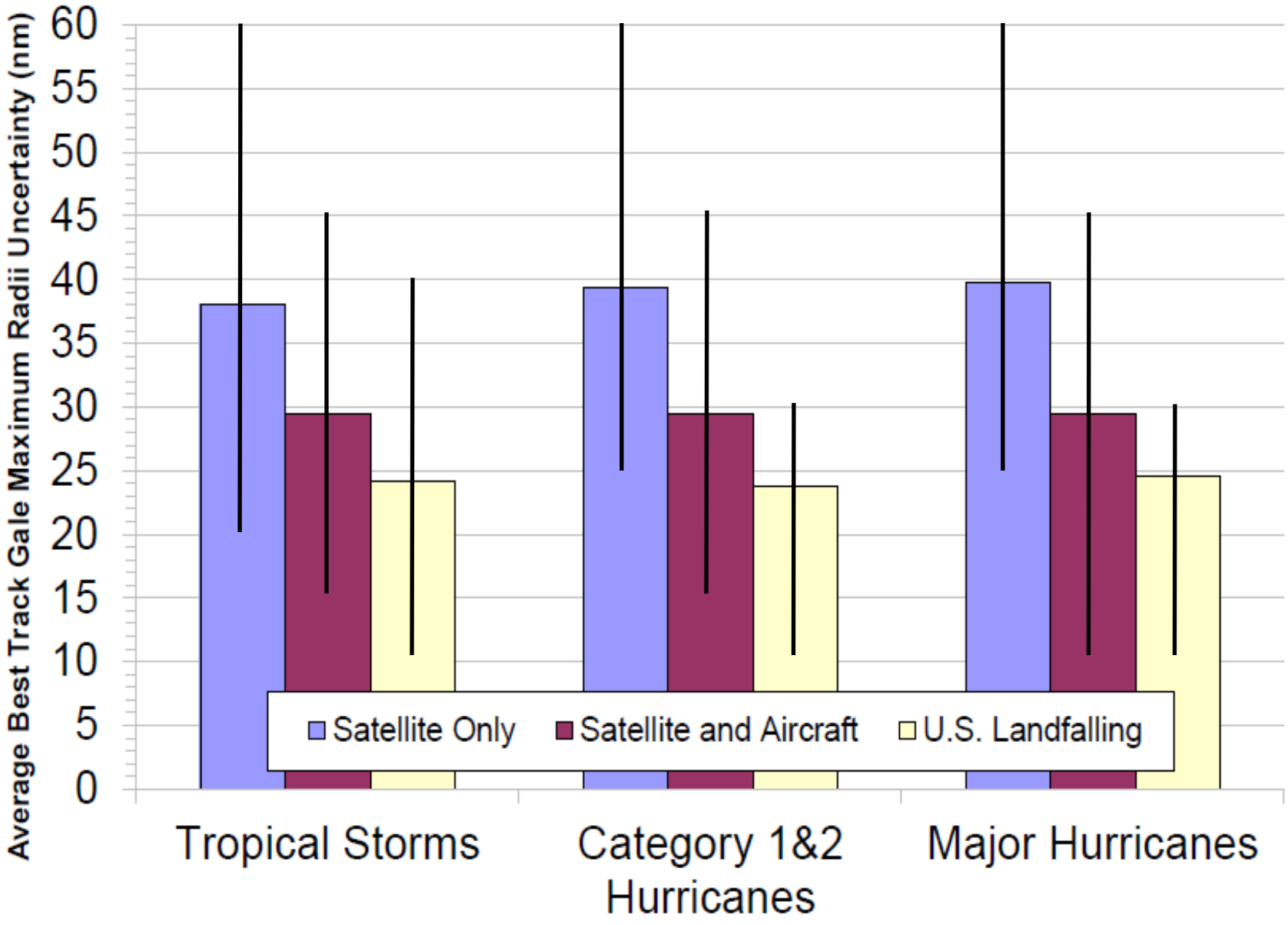
# 2010 Atlantic Basin Best Track Average Uncertainty Estimates Position (nm)

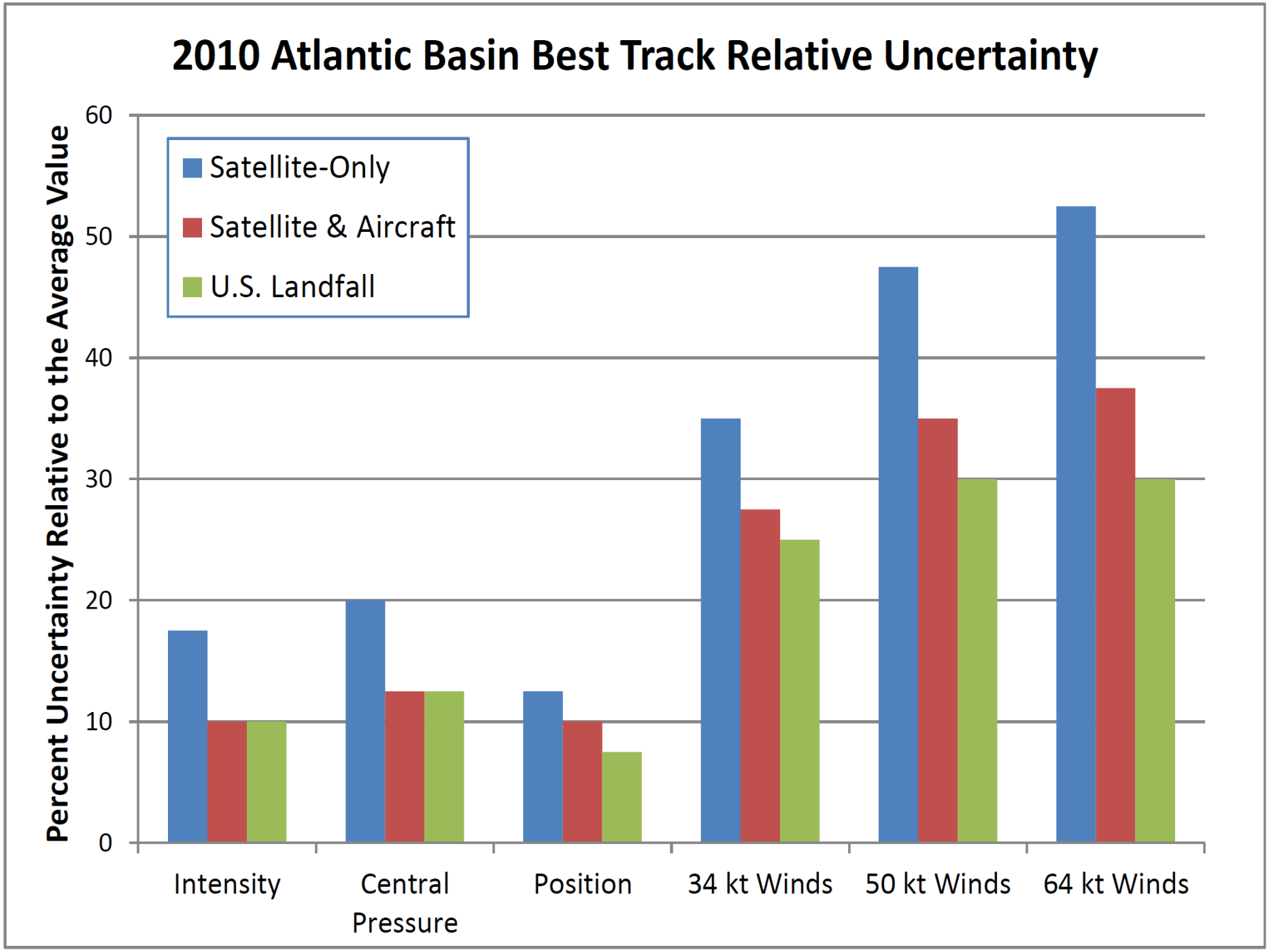


# 2010 Atlantic Basin Best Track Average Uncertainty Estimates
## Central Pressure (mb)



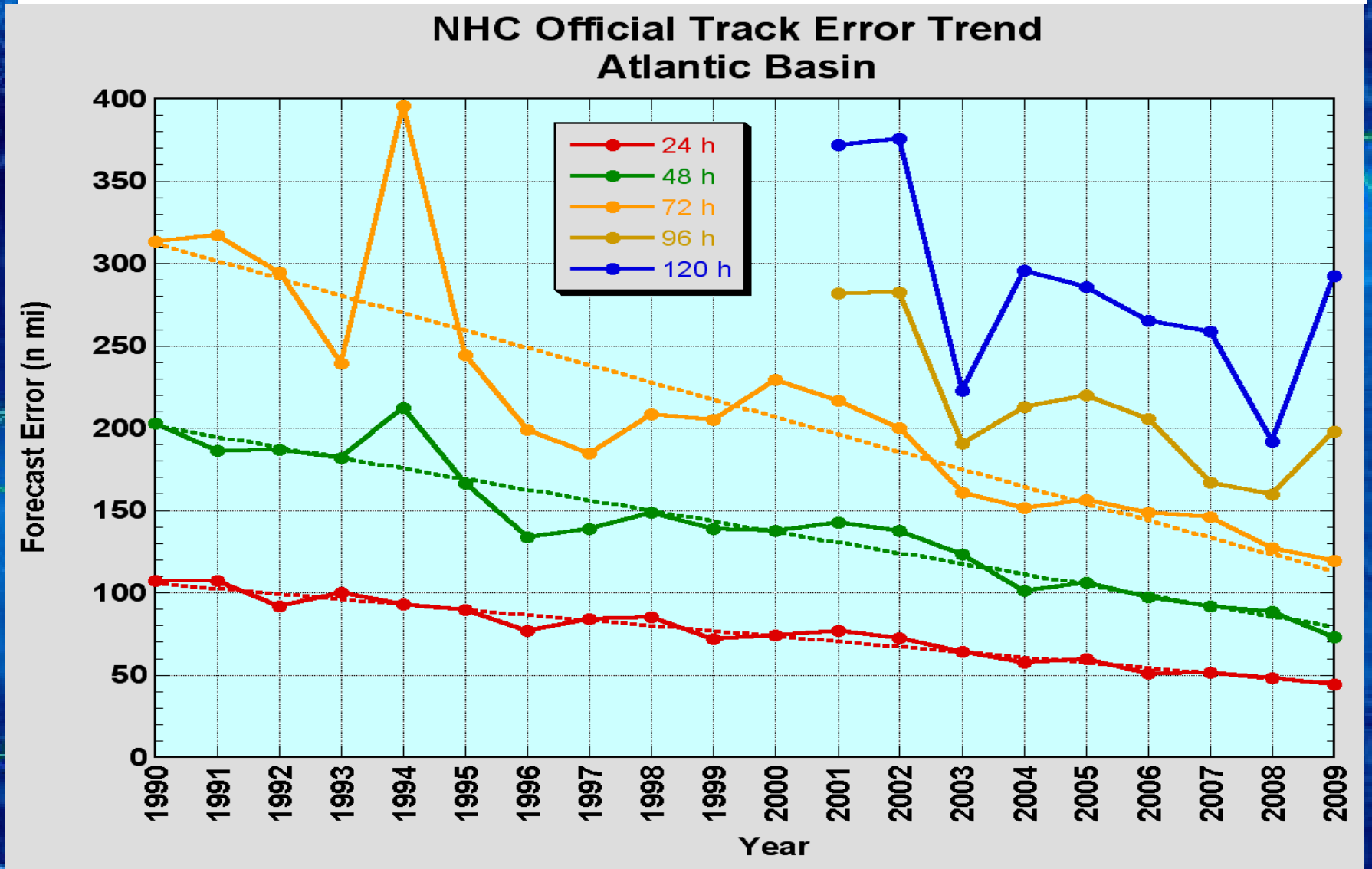
# 2010 Atlantic Basin Best Track Average Uncertainty Estimates
## Gale (34 kt) Maximum Radii (nm)




2010 Atlantic Basin Best Track Relative Uncertainty
Percent Uncertainty Relative to the Average Value
60
50
40
30
20
10
0
Satellite-Only
Satellite & Aircraft
U.S. Landfall
Intensity
Central Pressure
Position
34 kt Winds
50 kt Winds
64 kt Winds

# Implications for Track Forecast Improvement

Goal of Hurricane Forecast Improvement Program (by 2019):
"Reduce average track error by 50% for Days 1 through 5."



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Goal of Hurricane Forecast Improvement Program (by 2019):
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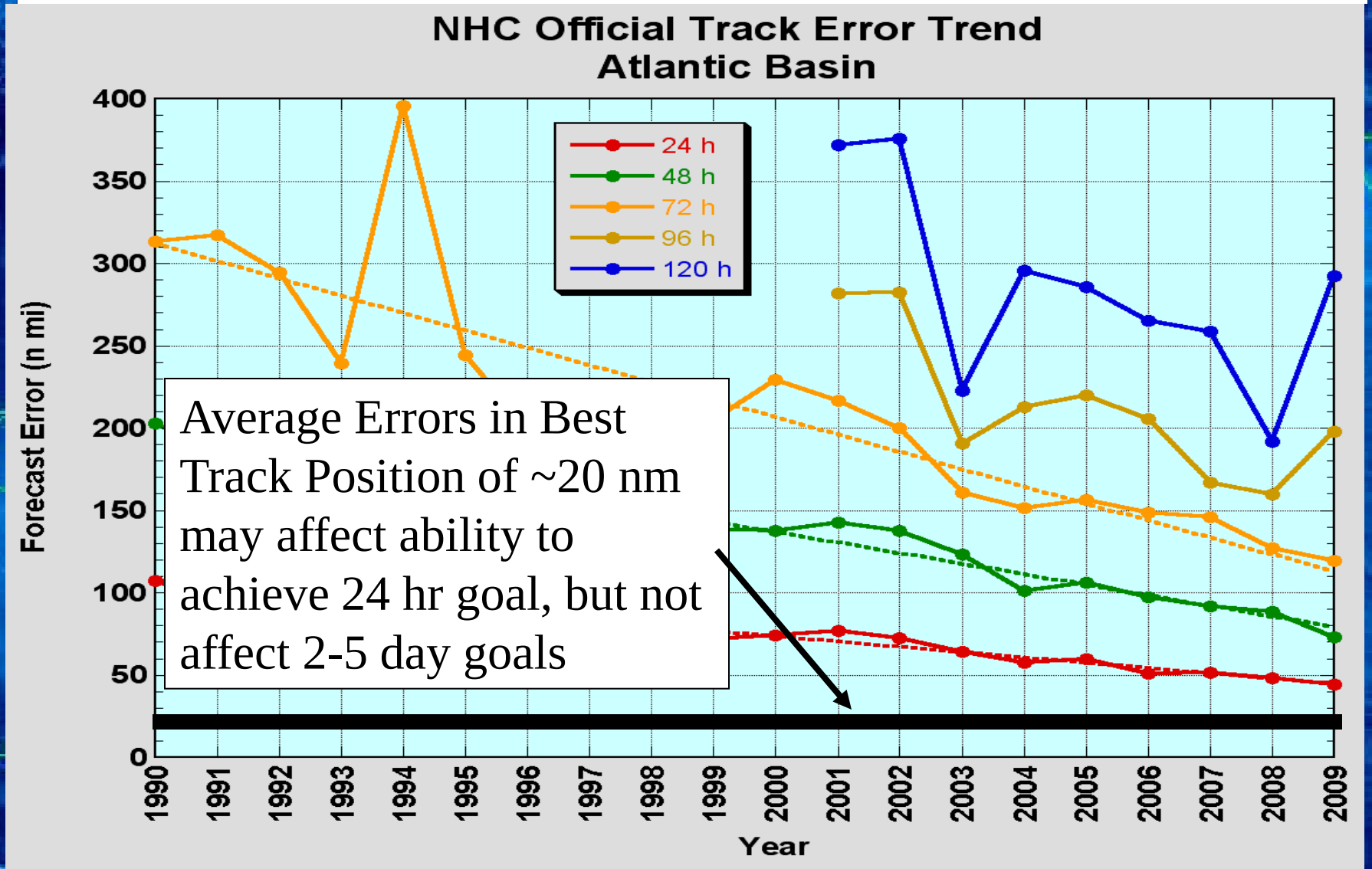
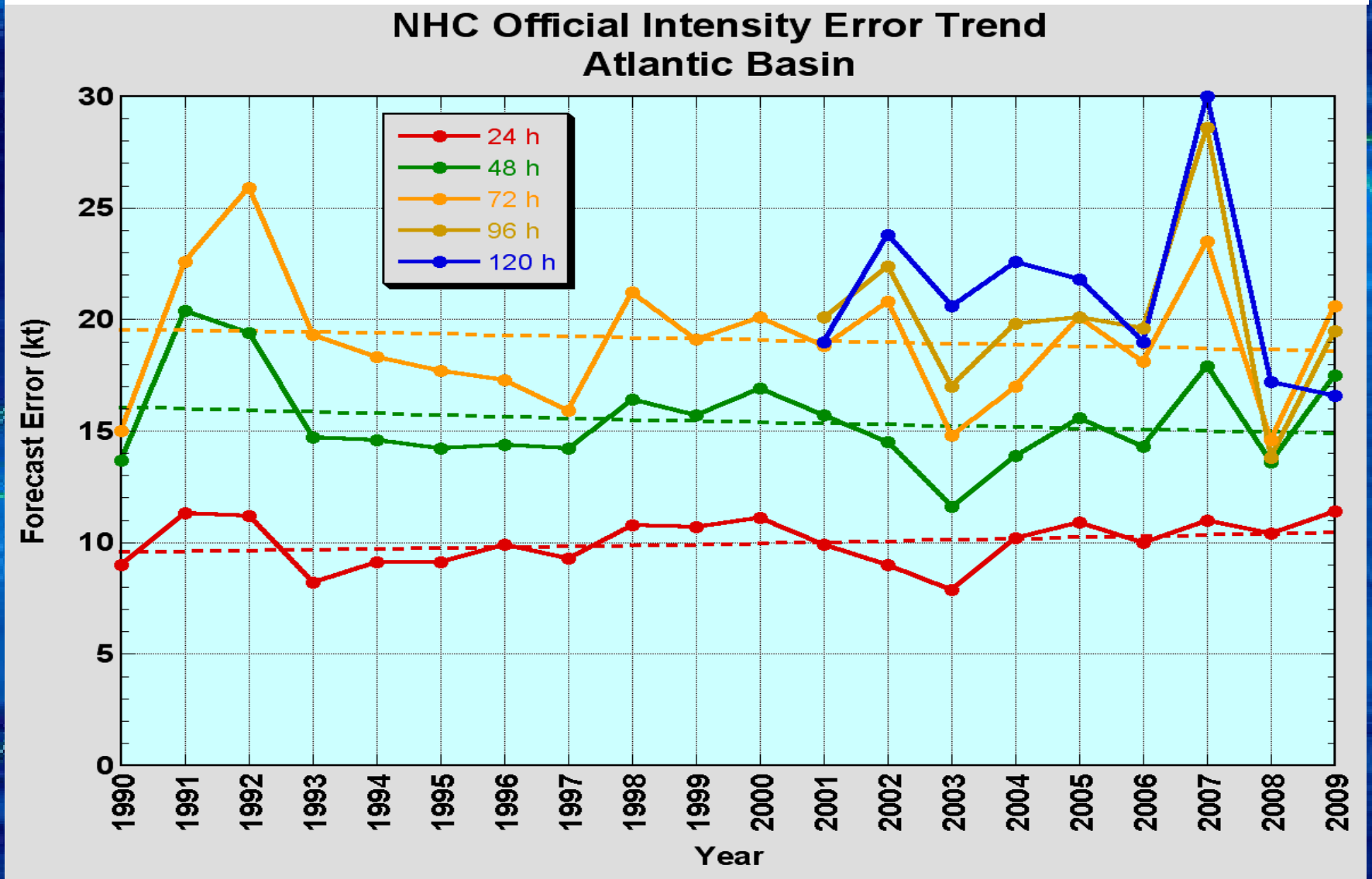


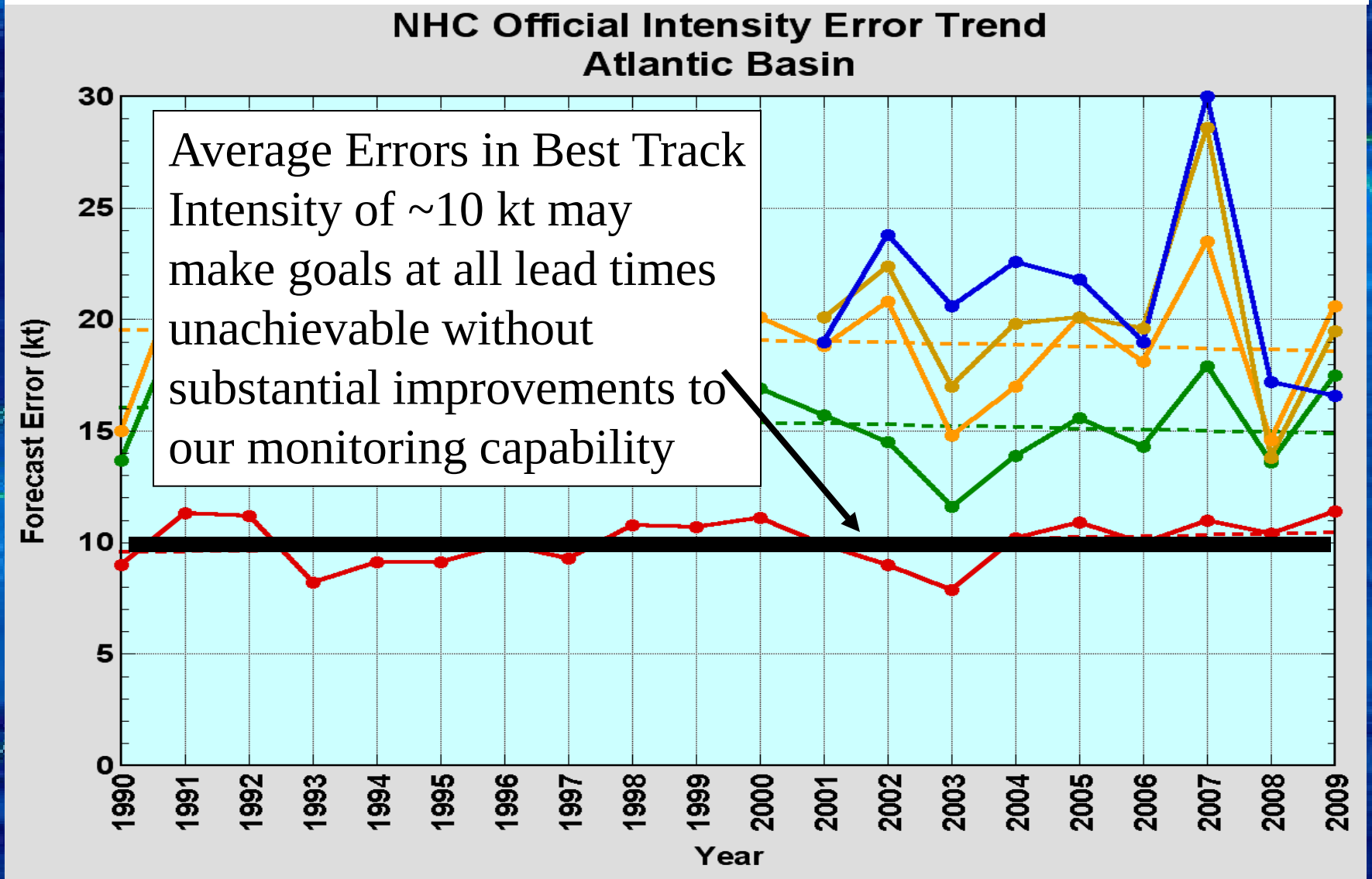
# Implications for Intensity Forecast Improvement

Goal of Hurricane Forecast Improvement Program (by 2019):
"Reduce average intensity error by 50% for Days 1 through 5."



# Implications for Intensity Forecast Improvement

Goal of Hurricane Forecast Improvement Program (by 2019):
"Reduce average intensity error by 50% for Days 1 through 5."



# Best Track Uncertainties

**Best Track Intensity** – Average Errors:

Increase Moderately with Intensity
Decrease Substantially with Aircraft Data
(Substantial Improvement in 2010 compared to 1999)

**Best Track Central Pressure** – Average Errors:

Increase Moderately with Intensity
Decrease to Near Insignificant Values with Aircraft Data

**Best Track Position** – Average Errors:

Decrease Substantially with Intensity
Decrease Substantially with Aircraft Data
(Little Change in 2010 compared to 1999)

**Best Track Size** – Average Errors:

Change Little with Intensity
Decrease Moderately with Aircraft Data

**Implications for HFIP Goals:**

Best track position uncertainty may not substantial hinder track goals
Best track intensity uncertainty may make intensity goals unachievable

# HURDAT2

a) Same info as HURDAT

b) Also includes 34, 50, 64 kt radii

c) Also includes non-developing tropical depressions

d) Also includes asynoptic times (landfall, peak intensity, etc.)

```
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National Hurricane Center

13 March, 2013
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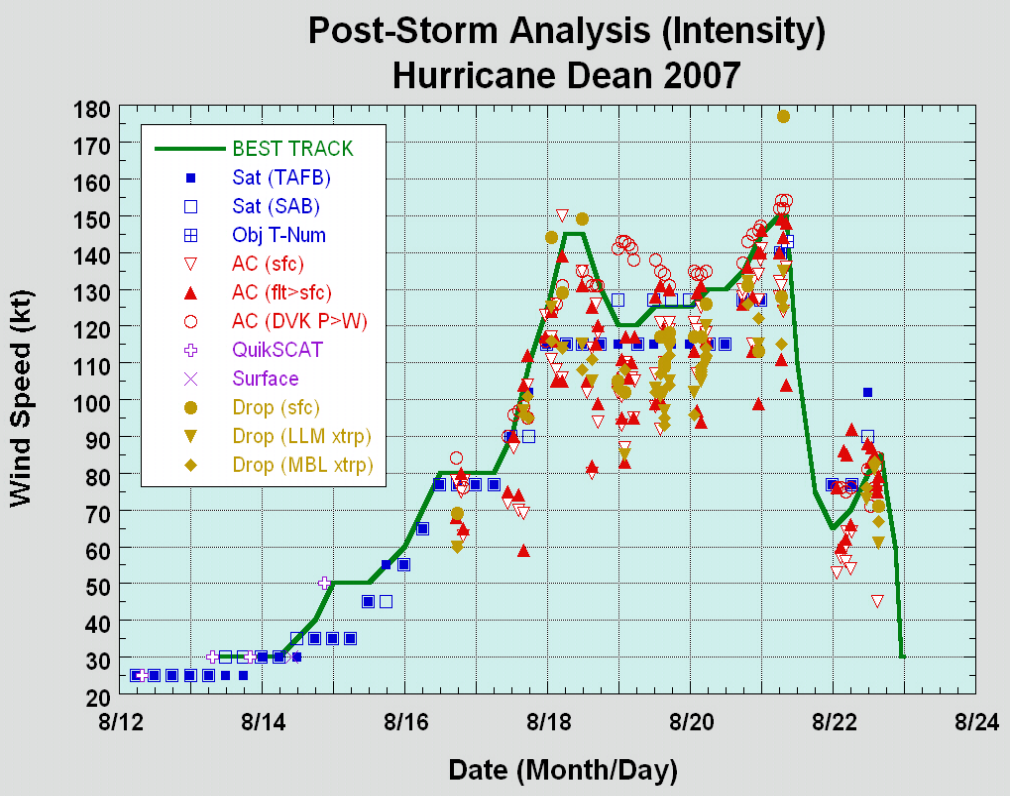


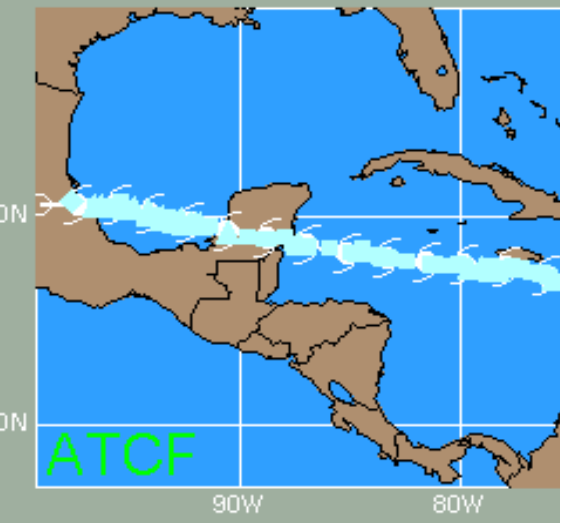


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c) **Position** (6 nm)
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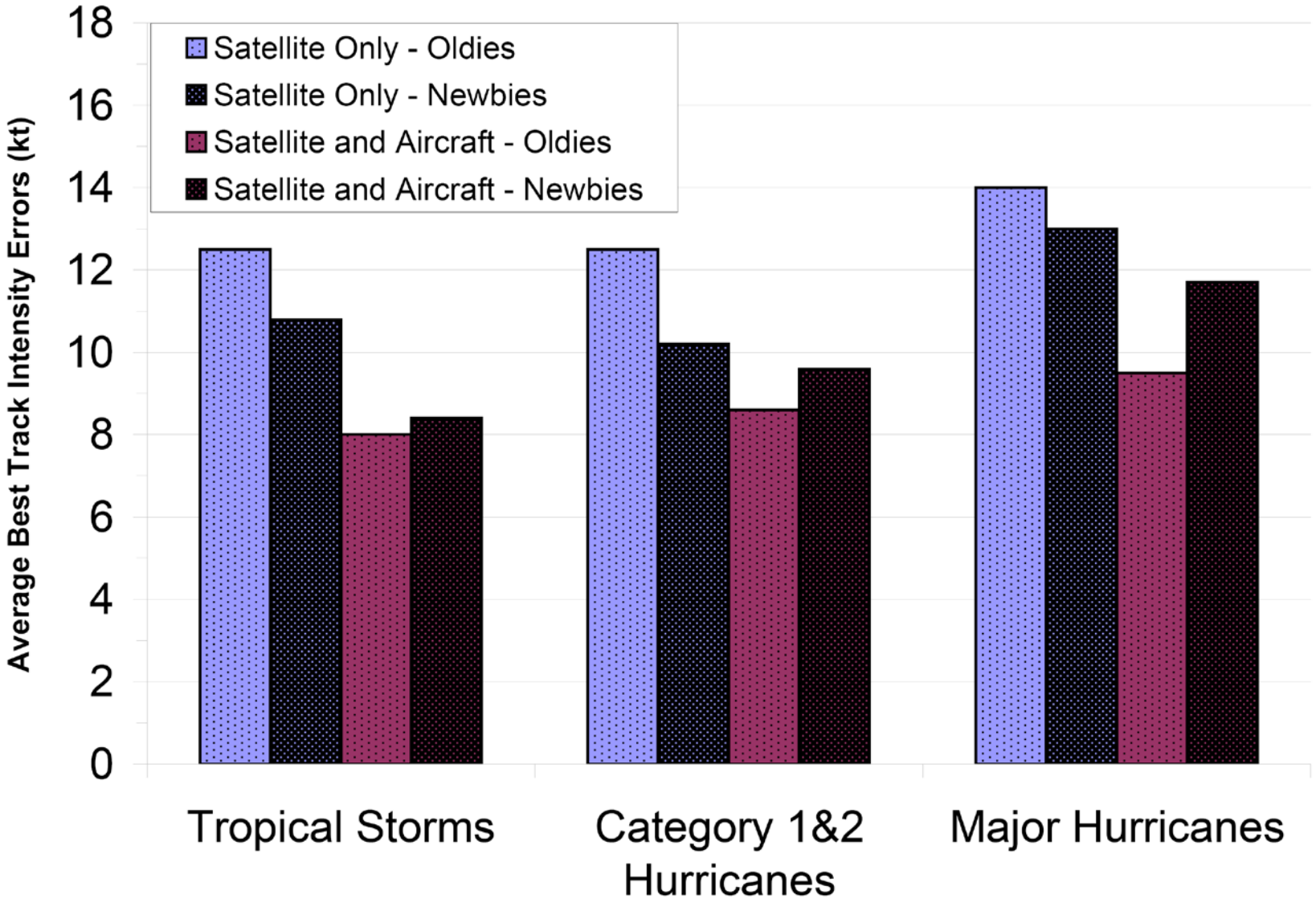
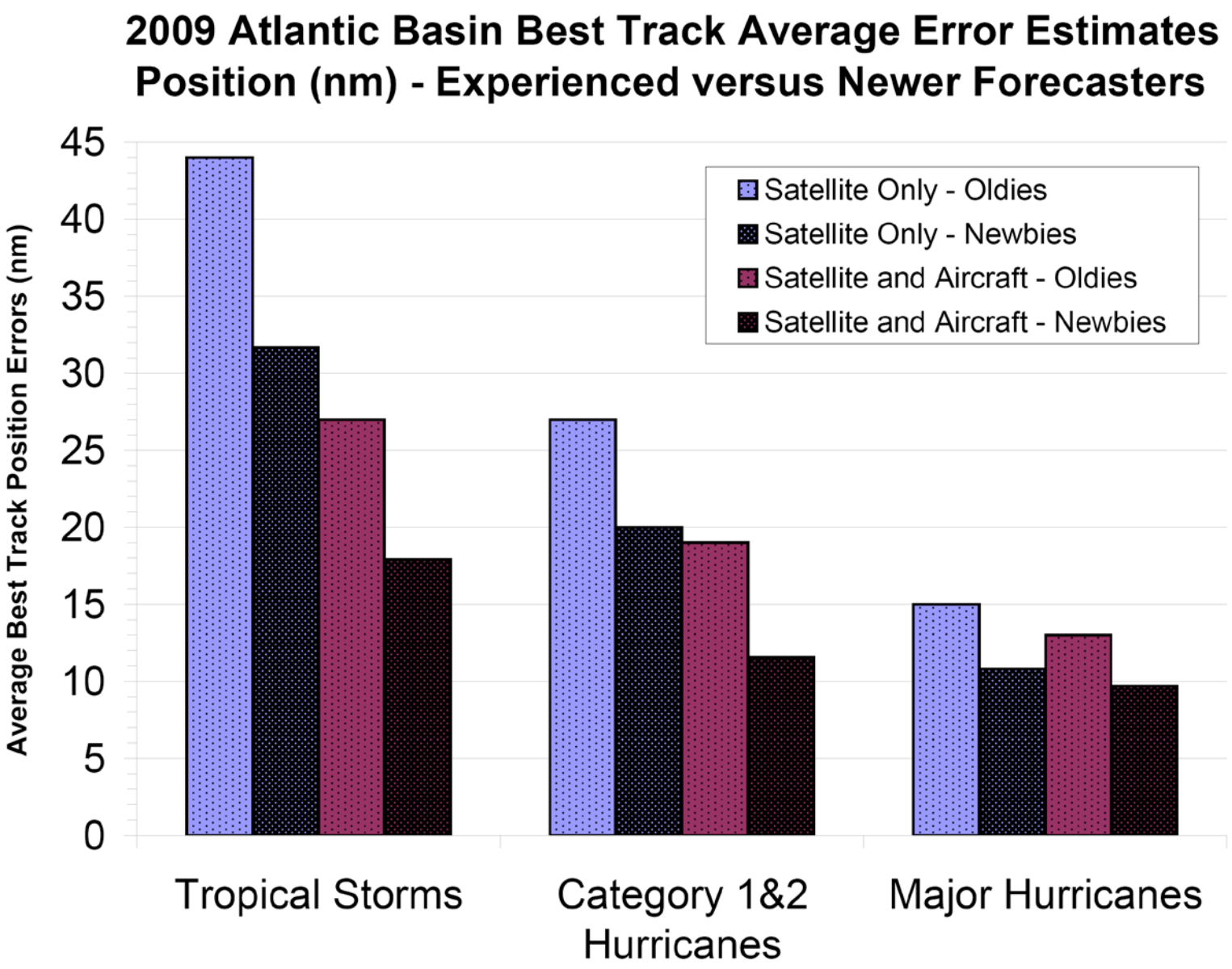
f) **Maximum Hurricane (64 kt) Radii** (since 2004, 5 nm)

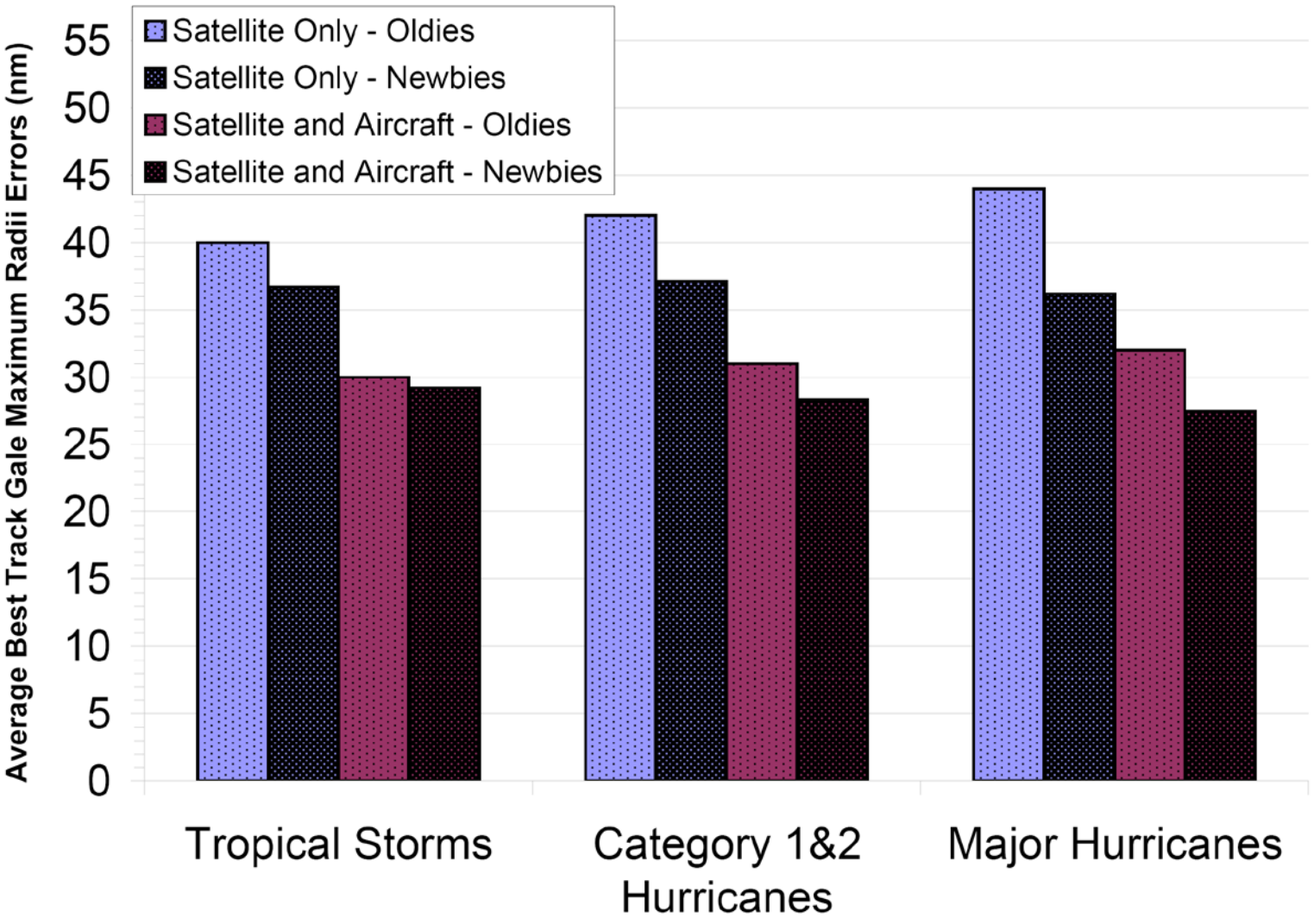
# 2009 Atlantic Basin Best Track Average Error Estimates
# Intensity (kt) - Experienced versus Newer Forecasters




2009 Atlantic Basin Best Track Average Error Estimates
Position (nm) - Experienced versus Newer Forecasters
Average Best Track Position Errors (nm)
45
40
35
30
25
20
15
10
5
0
Satellite Only - Oldies
Satellite Only - Newbies
Satellite and Aircraft - Oldies
Satellite and Aircraft - Newbies
Tropical Storms
Category 1&2 Hurricanes
Major Hurricanes

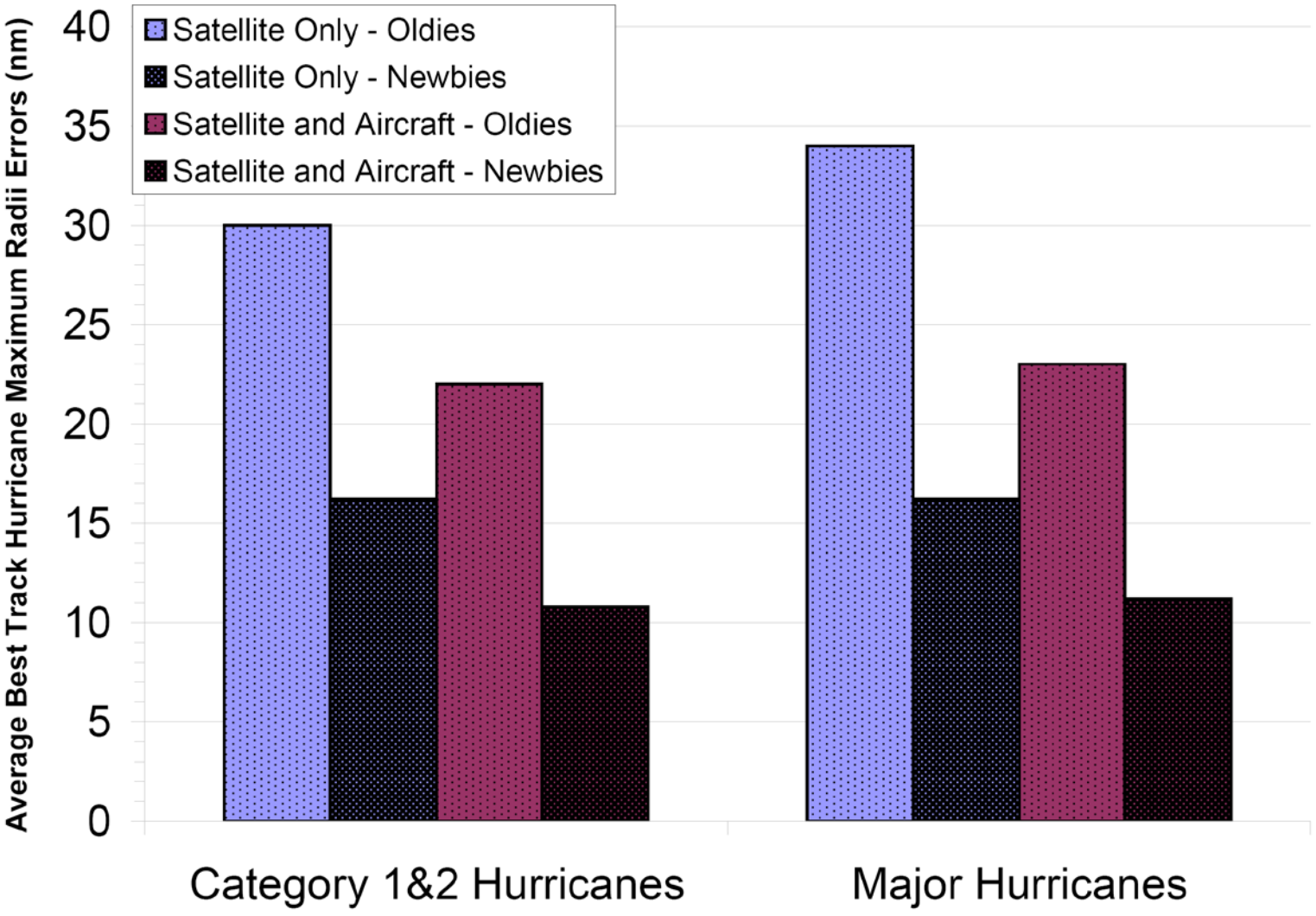
# 2009 Atlantic Basin Best Track Average Error Estimates

## Gale Maximum Radii (nm) - Experienced versus Newer Forecasters

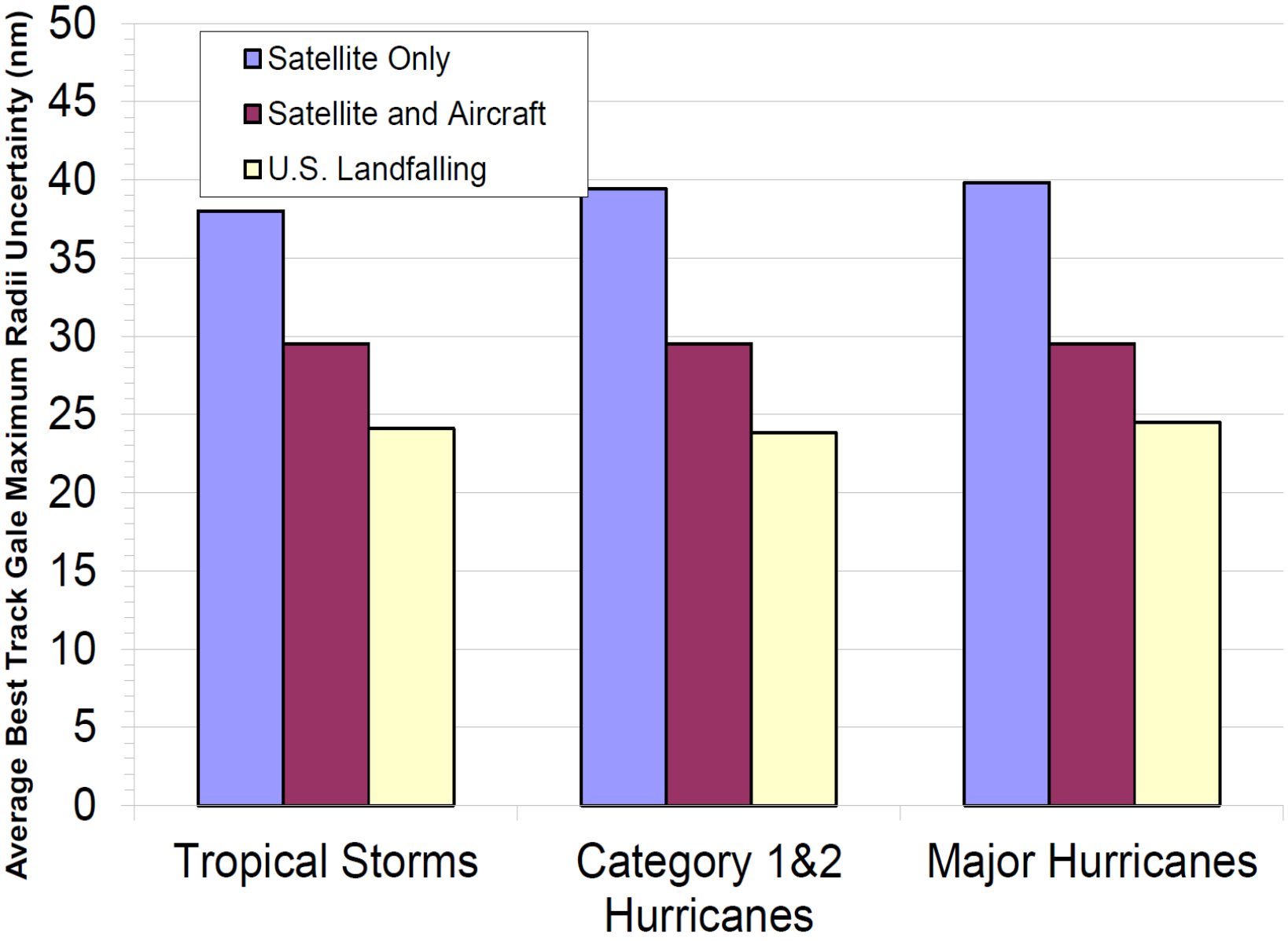


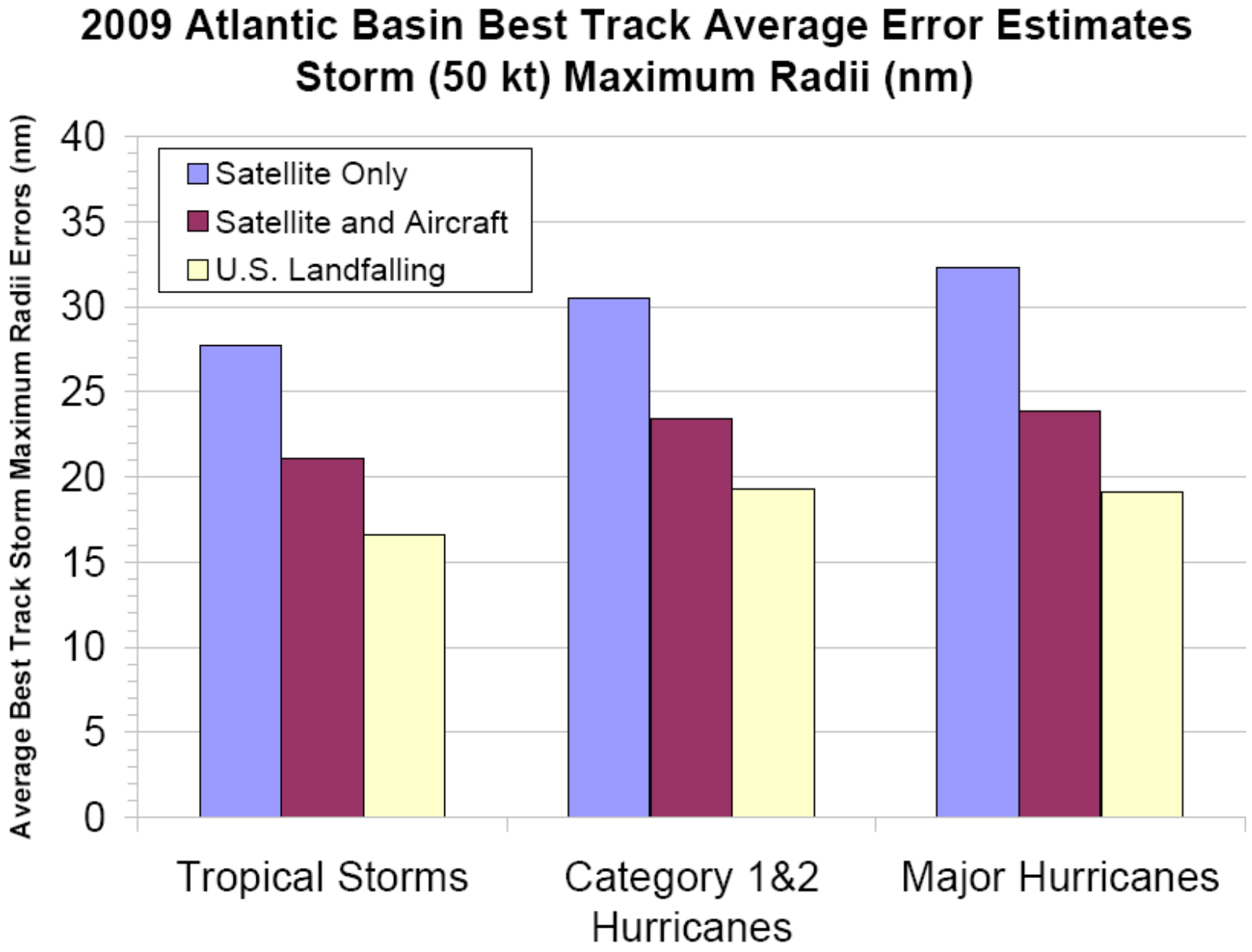
# 2009 Atlantic Basin Best Track Average Error Estimates

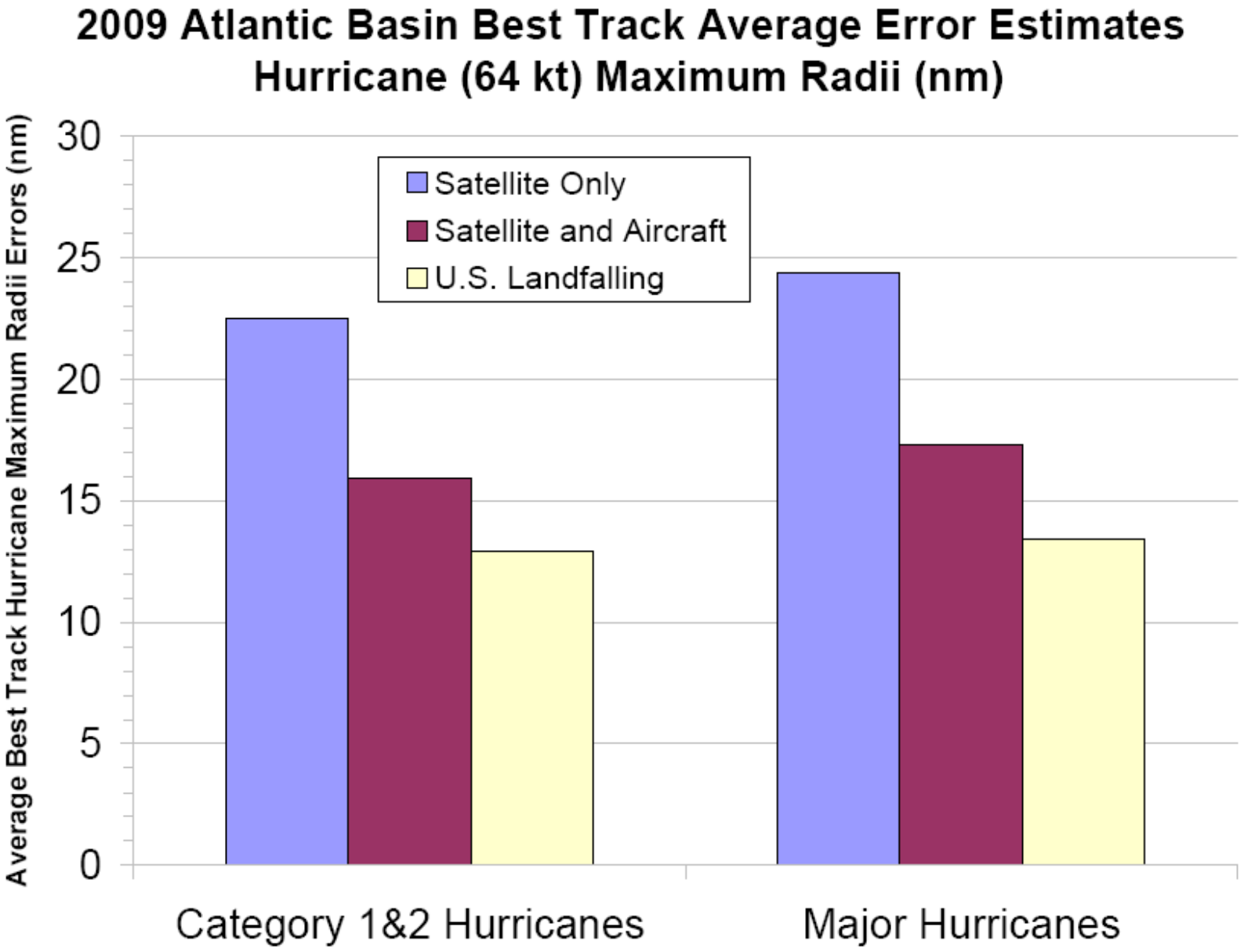
## Hurricane Maximum Radii (nm) - Experienced versus Newer Forecasters



# 2010 Atlantic Basin Best Track Average Uncertainty Estimates
# Gale (34 kt) Maximum Radii (nm)




2009 Atlantic Basin Best Track Average Error Estimates
Storm (50 kt) Maximum Radii (nm)
Average Best Track Storm Maximum Radii Errors (nm)
40
35
30
25
20
15
10
5
0
Satellite Only
Satellite and Aircraft
U.S. Landfalling
Tropical Storms
Category 1&2 Hurricanes
Major Hurricanes


2009 Atlantic Basin Best Track Average Error Estimates
Hurricane (64 kt) Maximum Radii (nm)
Average Best Track Hurricane Maximum Radii Errors (nm)
30
25
20
15
10
5
0
Satellite Only
Satellite and Aircraft
U.S. Landfalling
Category 1&2 Hurricanes
Major Hurricanes