Operational Hurricane/Typhoon Prediction with Global Models

EMC/MMM/DTC Joint Hurricane Science Workshop

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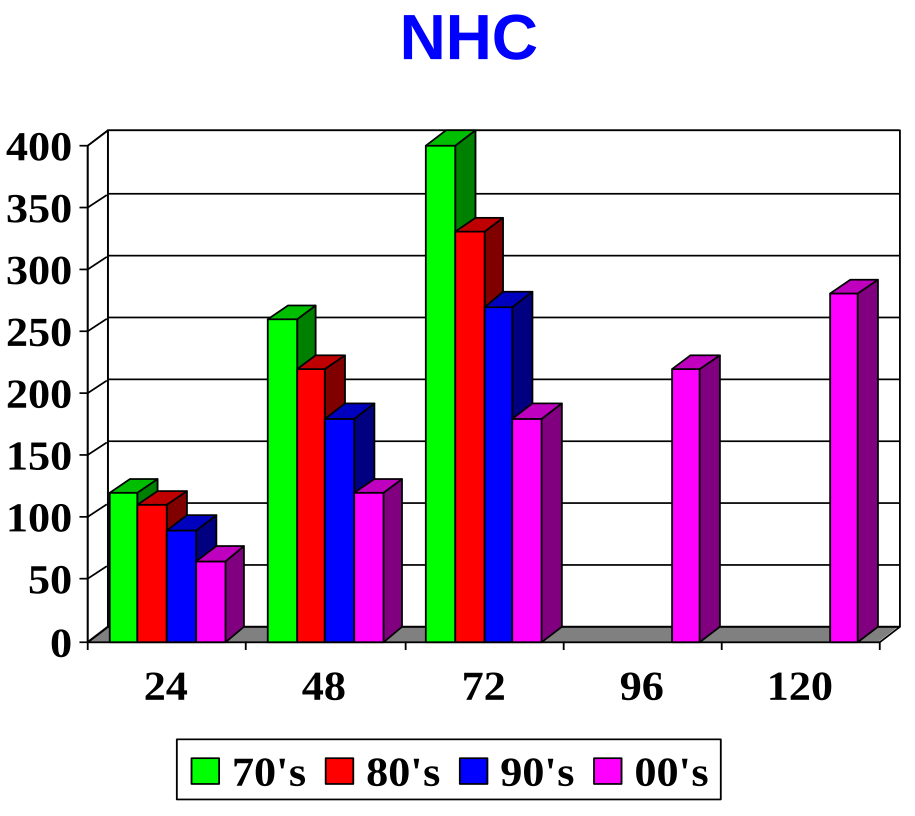
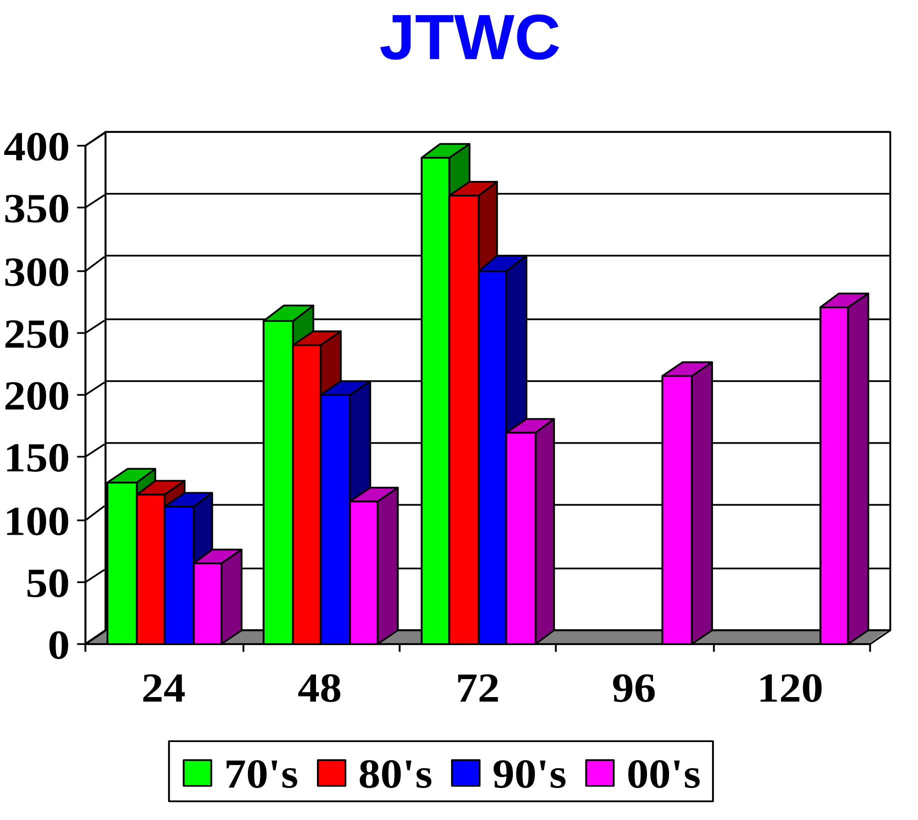
February 22, 2010

Evolution of TC Track Forecast Error (nm) at NHC and JTWC





Historical Background

Bengtsson et al (1982) noted intense hurricane-type vortices in the ECMWF global model (~200 km resolution) in 1980 and pointed out the potential tropical cyclone (TC) forecast skill of global models for the future.

Reed et al (1988) evaluated ECMWF global model (~ 125 km resolution) analyses and forecasts of easterly wave disturbances over Africa and the eastern Atlantic for August-September 1985 and found the forecast performance encouraging.

Hall (1987) found that the UK Met Office global model (~ 200 km resolution), using a small set of synthetic observations, displayed considerable skill in analyzing and forecasting TCs.

Krishnamurti et al (1989) concluded that a high-resolution global model could produce useful track forecasts and found that forecasts improved with increased resolution (~ 625 km to ~ 125 km), improved physics, and improved initial analyses.

Lord (1991) described the synthetic observation assimilation for the NCEP global model.

Historical Background

Goerss and Jeffries (1994) described the synthetic observation assimilation implemented for NOGAPS (~ 165 km resolution) in 1990. They evaluated the NOGAPS TC track forecast performance for 1991 and found it superior to JTWC's exceptionally good performance for that year.

Heming et al (1995) described the improved synthetic observation assimilation scheme implemented for the UK Met Office global model in 1994.

Kuma (1996) discussed the Japanese global spectral model and its application to TC track prediction.

Liu et al (2000) described the vortex relocation procedure used by the NCEP GFS.

Goerss (2000) illustrated the superior TC track forecasting performance that could be gained from a consensus of operational models for the Atlantic (1995-1996) and western North Pacific (1997).

Timeline for Operational Use of Global Models for TC Track Prediction

1992 – NOGAPS and UK Met Office global model at JTWC

1996 – Japanese global spectral model at JTWC

1998 – NOGAPS and UK Met Office global model at NHC; first consensus guidance at JTWC

2000 – NCEP GFS and first consensus guidance at NHC

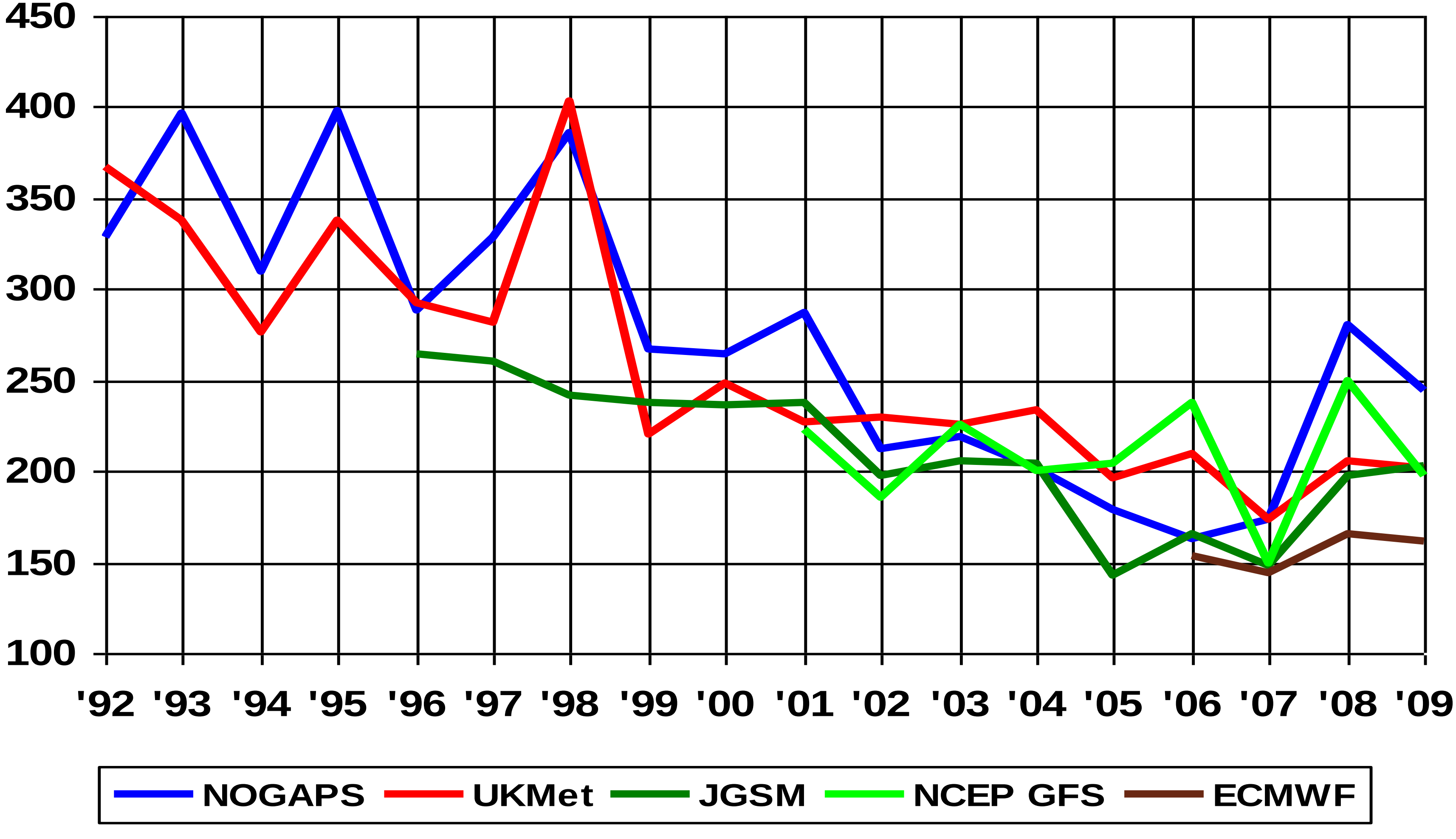
2001 – NCEP GFS at JTWC (JTWC begins official 5-day forecasts)

2003 – NHC begins official 5-day forecasts

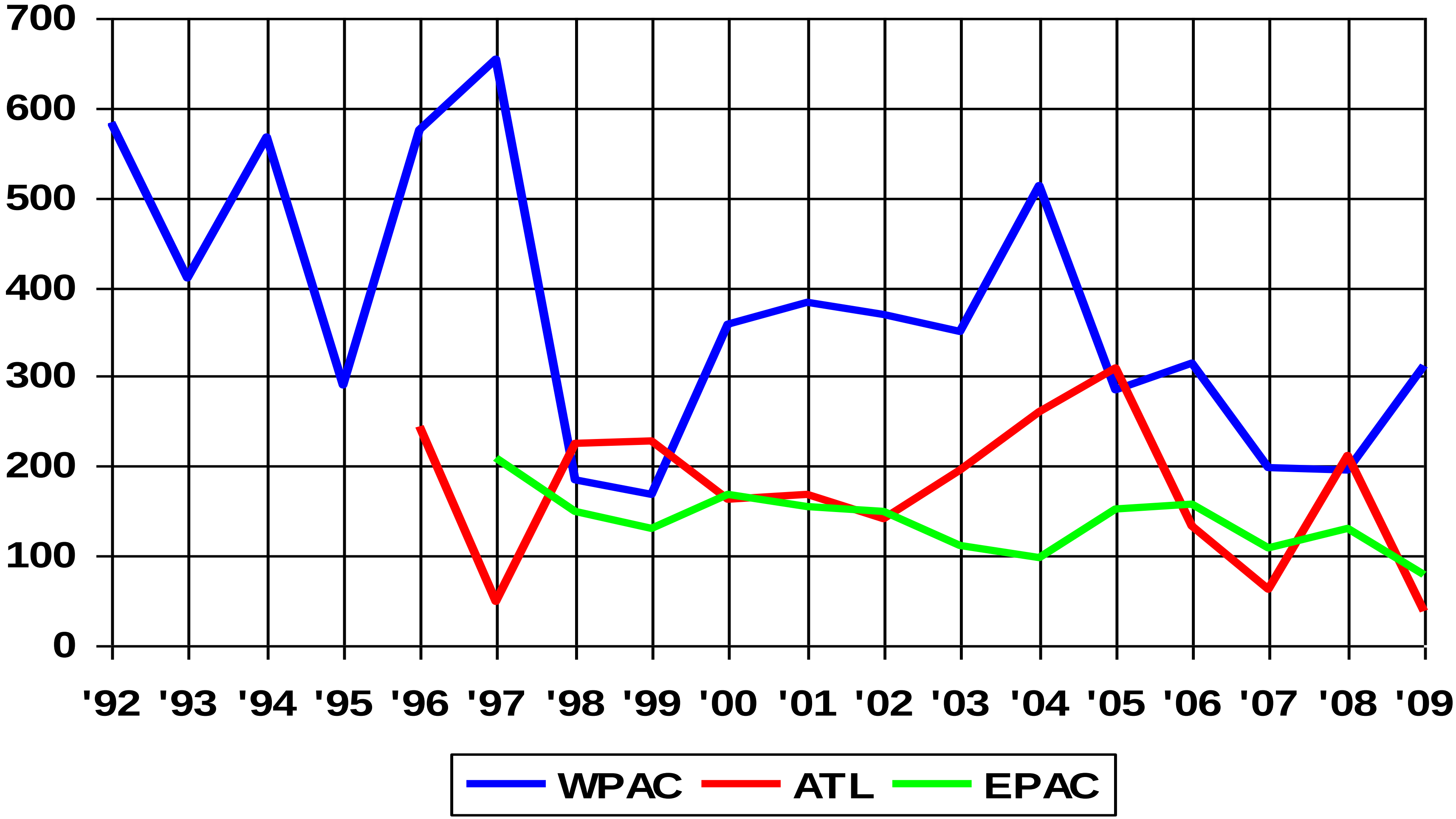
2005 – ECMWF global model at NHC

2006 – ECMWF global model at JTWC

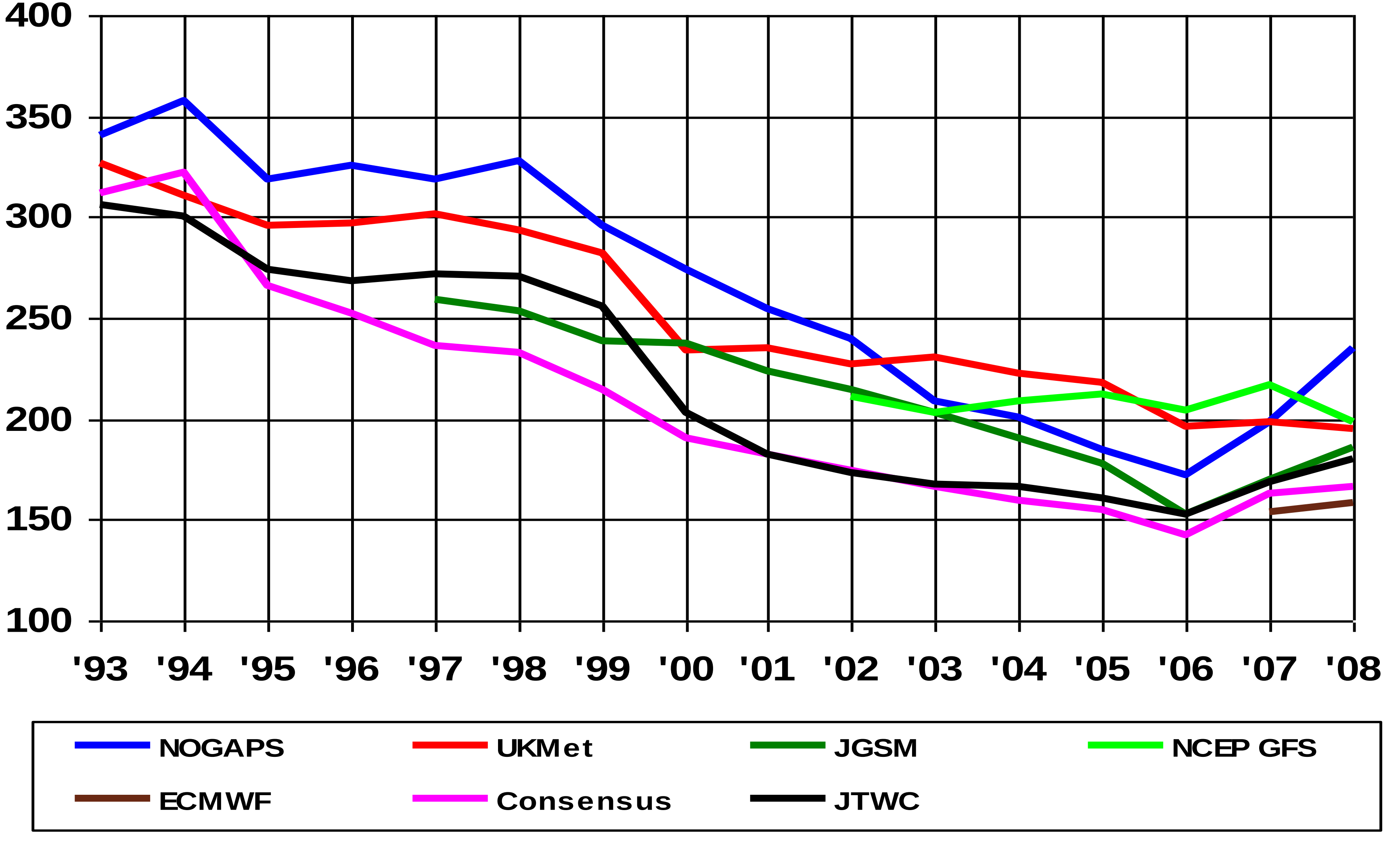
Western North Pacific – Historic Performance
72-h Model Forecast Error (nm)



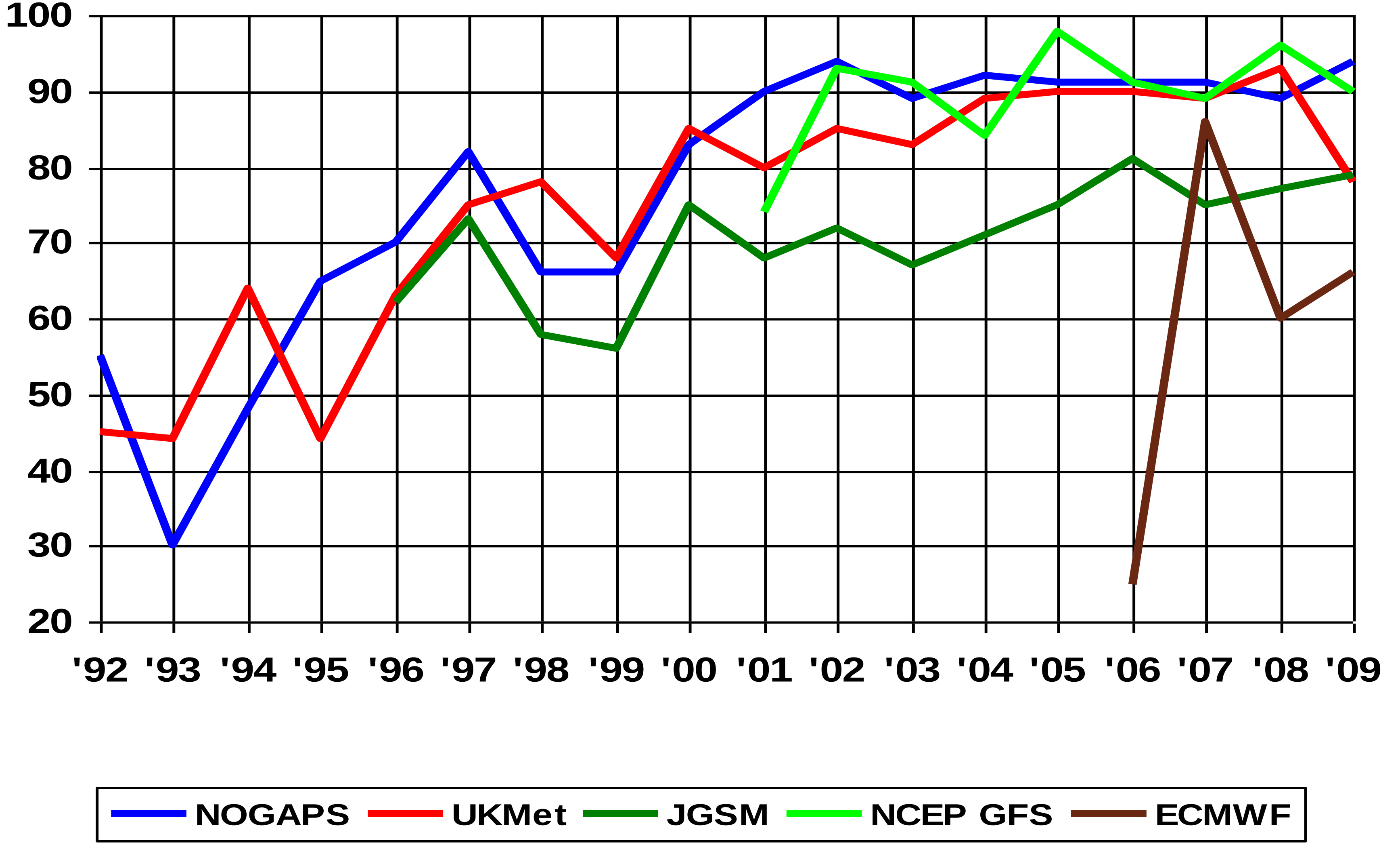
Number of Verifying 72-h Forecasts



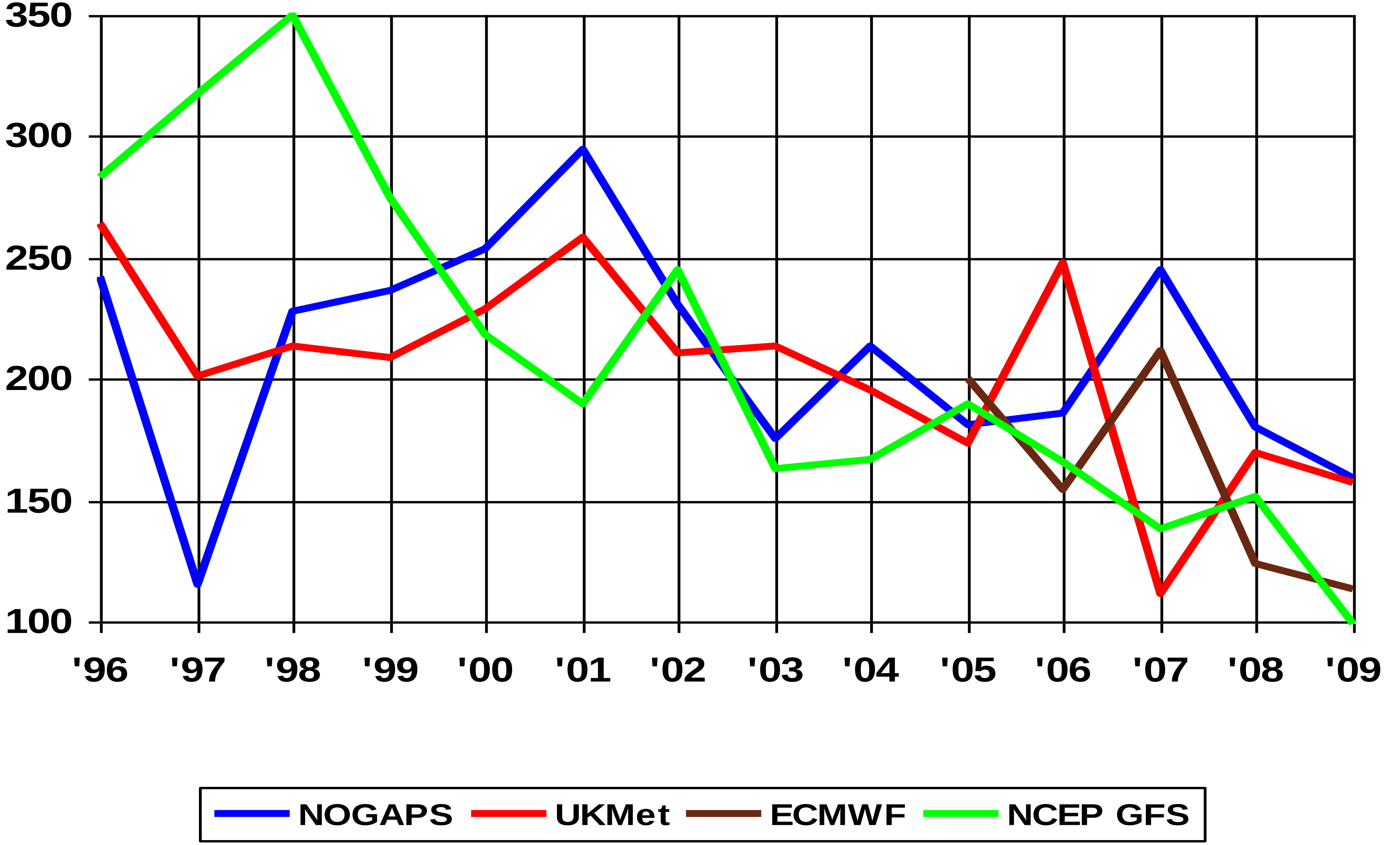
Western North Pacific – Global Models
3-Year Weighted Mean 72-h Forecast Error (nm)



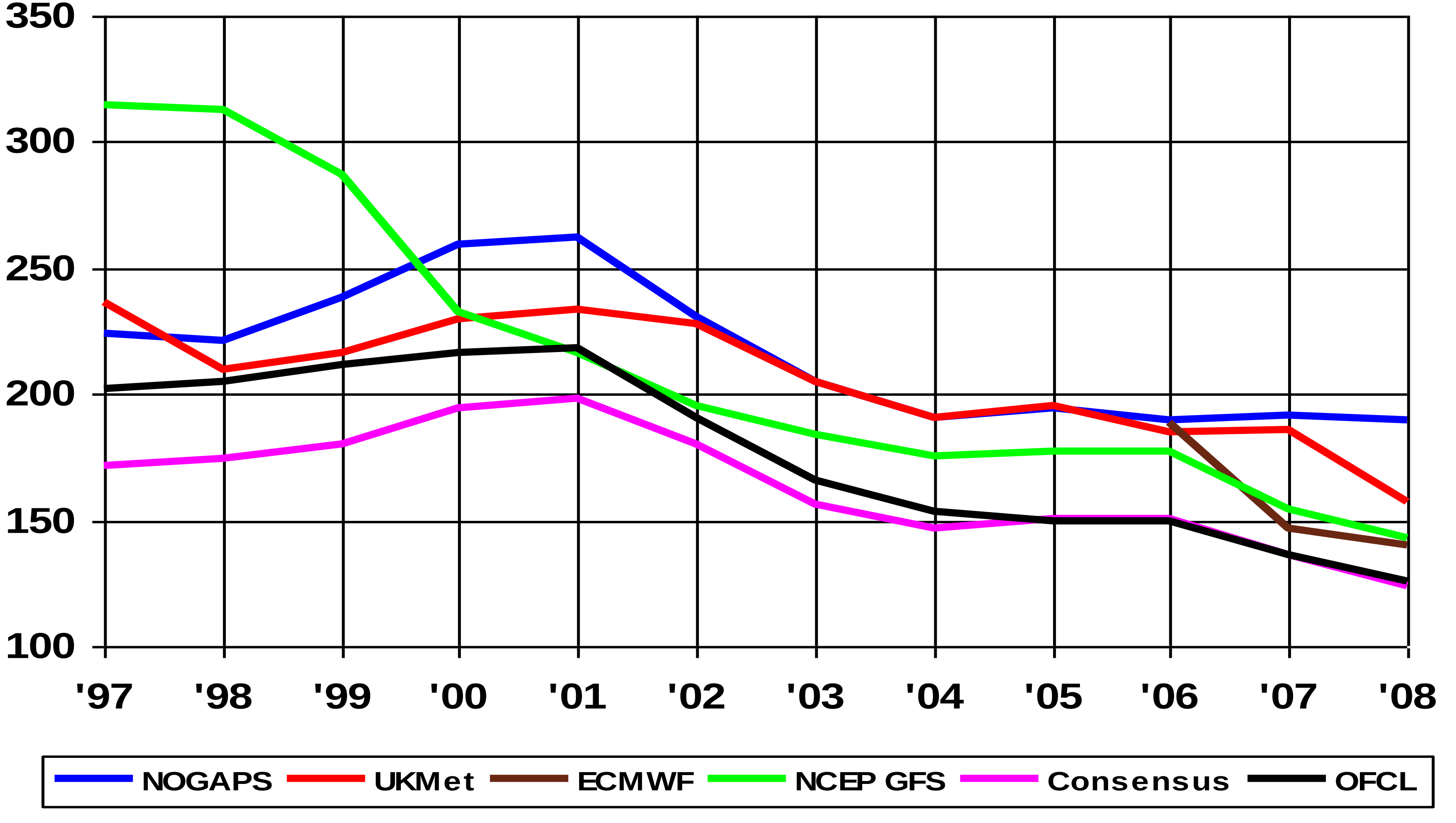
Western North Pacific – Historic Performance
72-h Forecast Availability (Percent)



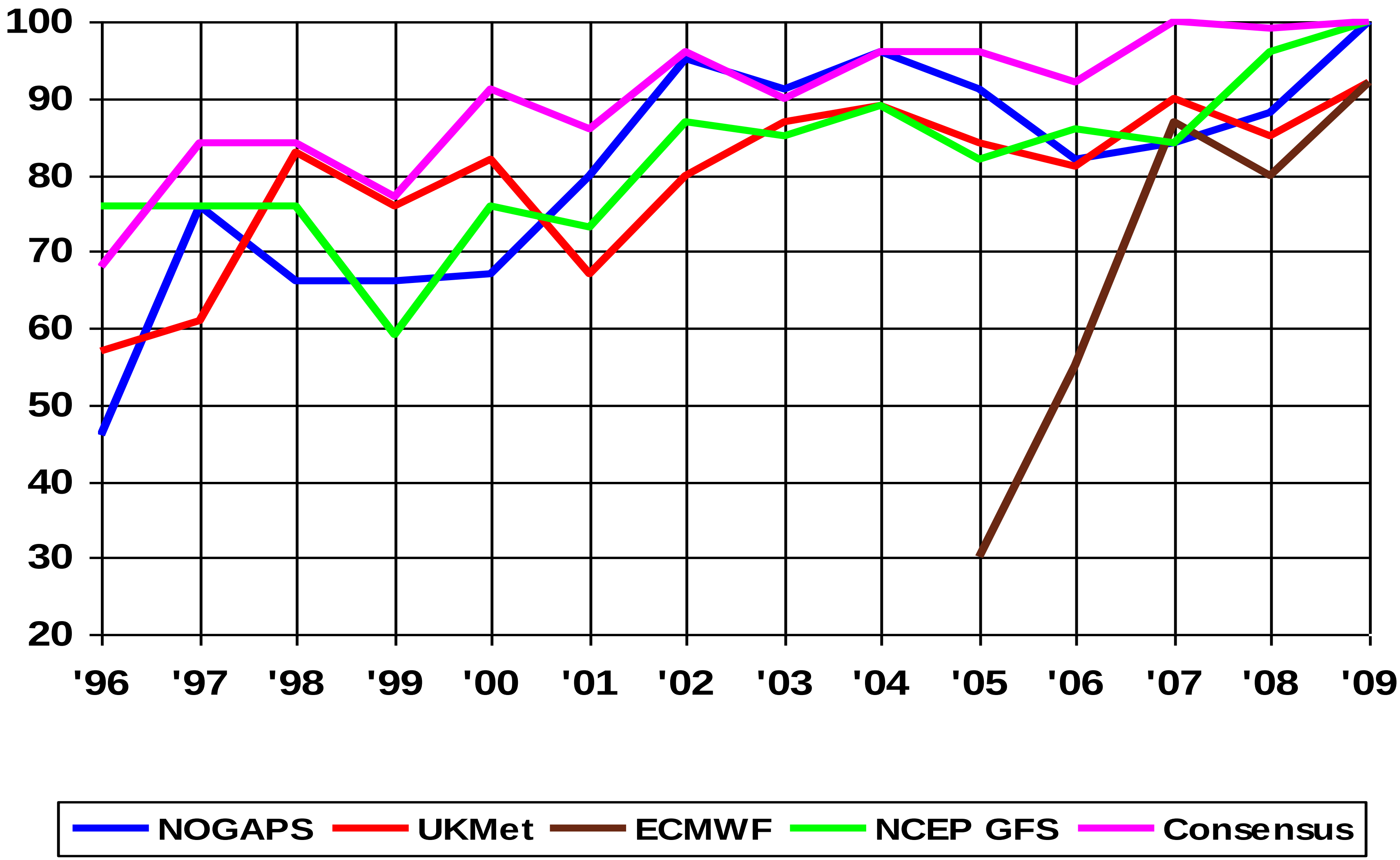
Atlantic – Historic Performance
72-h Model Forecast Error (nm)



Atlantic – Global Models
3-Year Weighted Mean 72-h Forecast Error (nm)

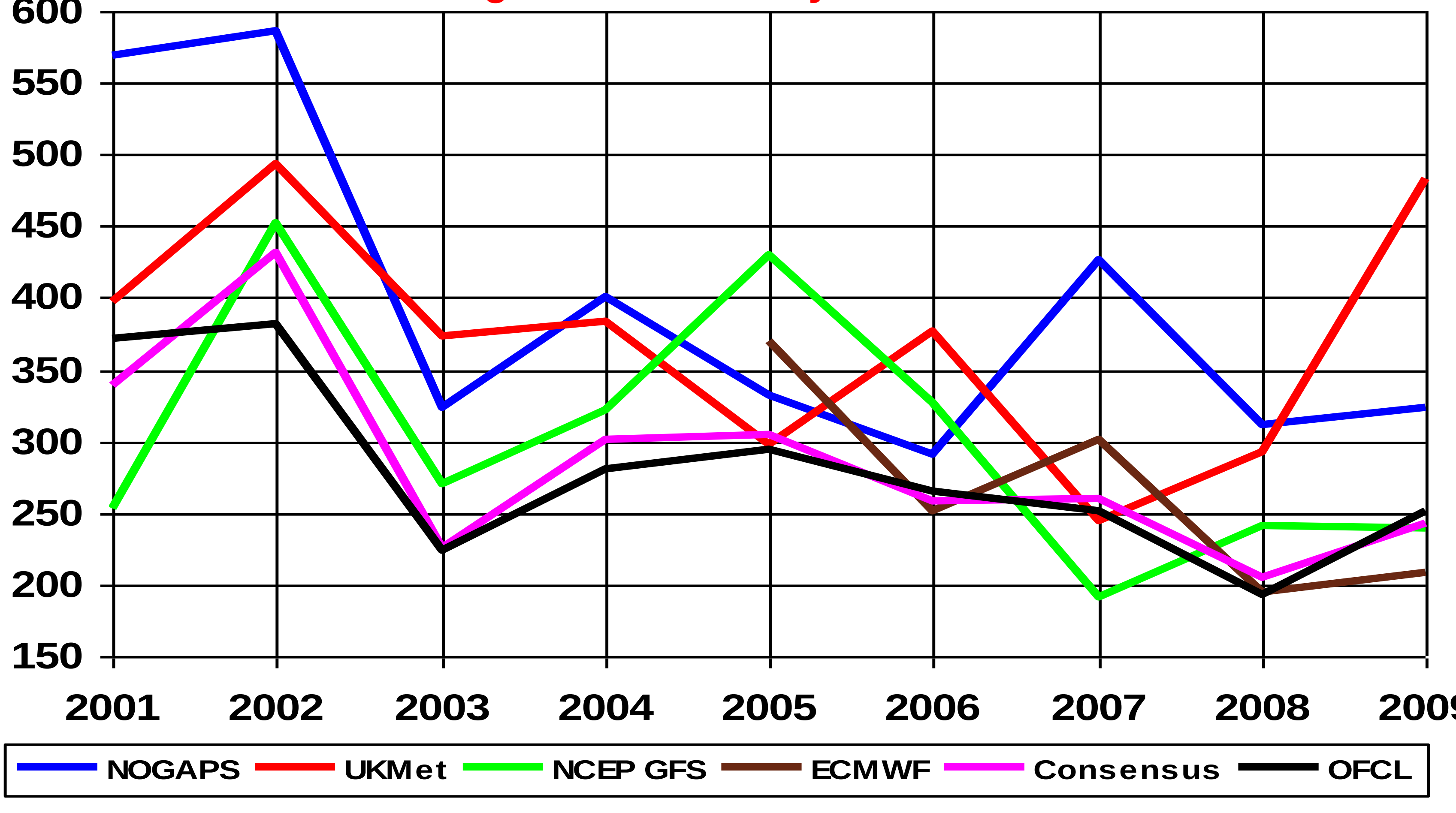


Atlantic – Historic Performance
72-h Forecast Availability (Percent)

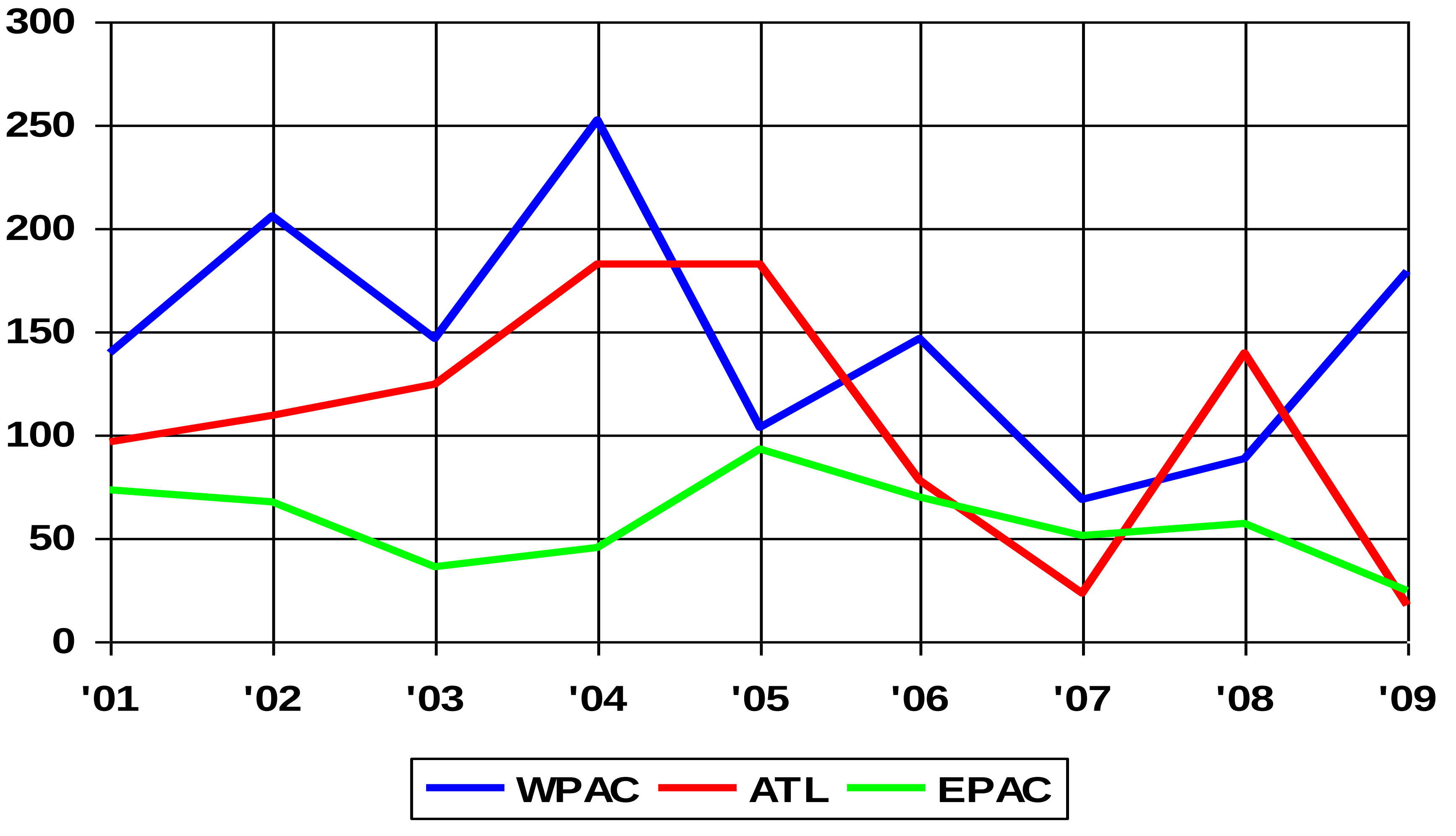


Atlantic – Historic Performance
120-h Model Forecast Error (nm)

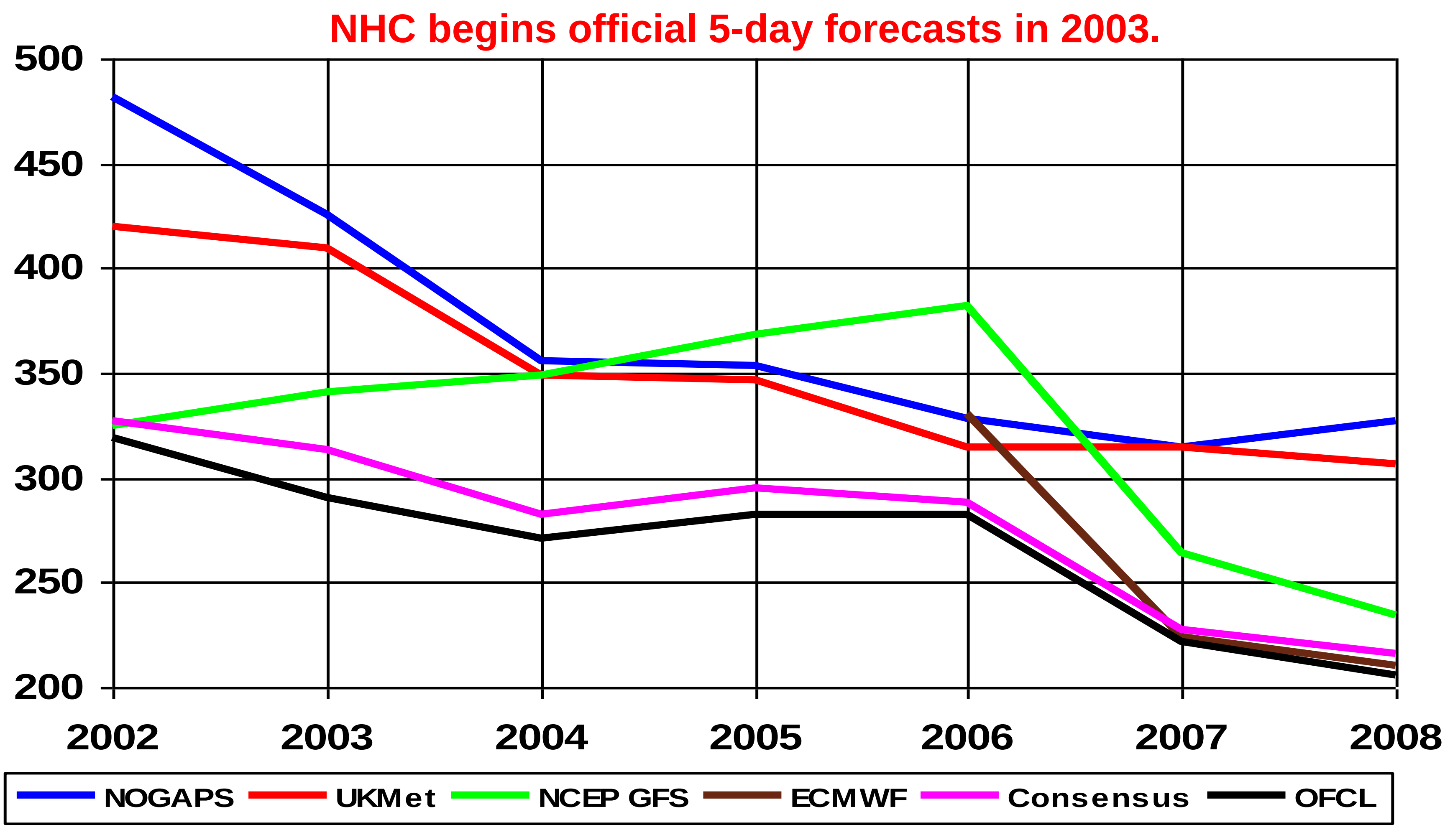
NHC begins official 5-day forecasts in 2003.



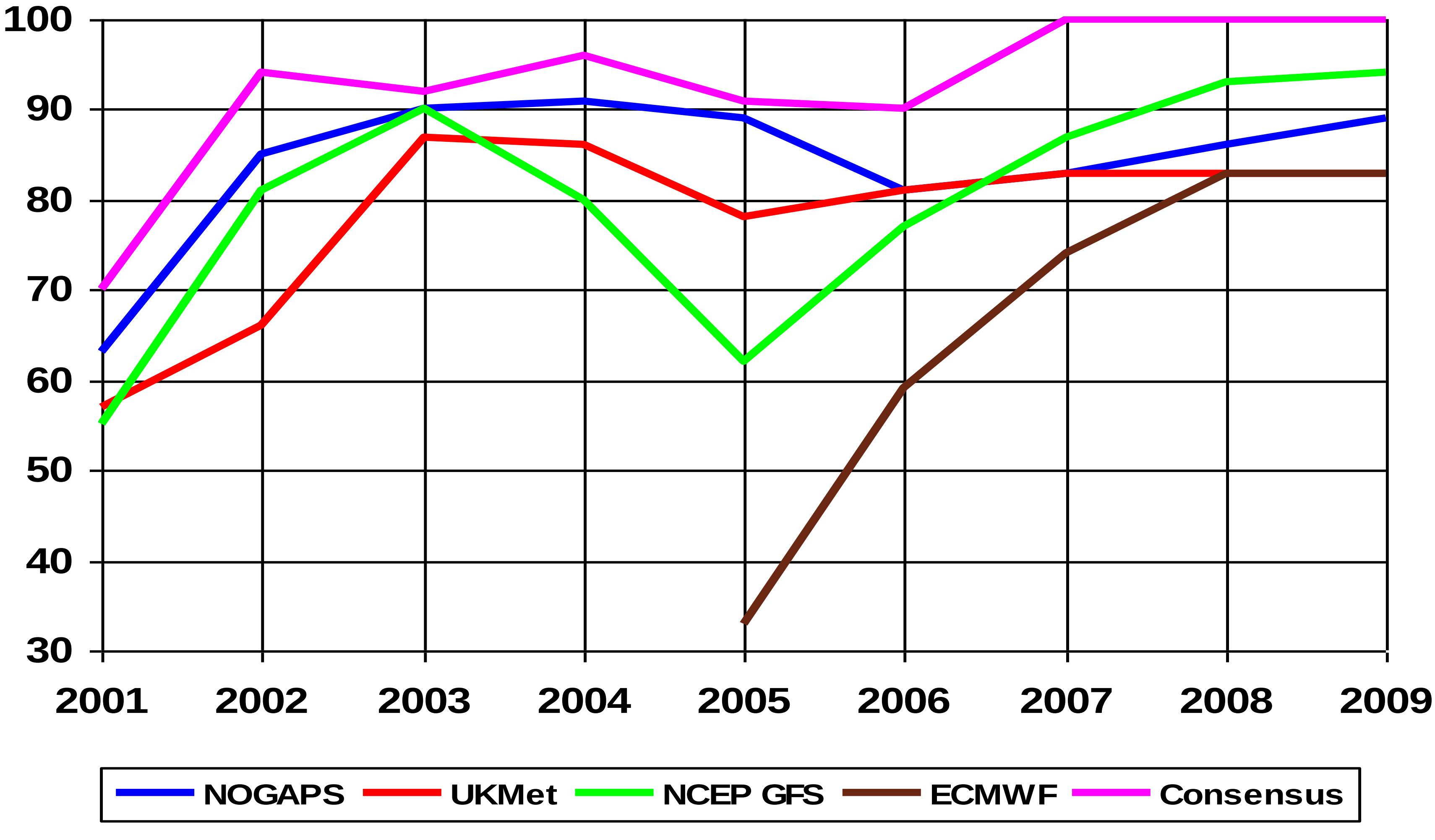
Number of Verifying 120-h Forecasts



Atlantic – Global Models
3-Year Weighted Mean 120-h Forecast Error (nm)



Atlantic – Historic Performance
120-h Model Forecast Availability (Percent)



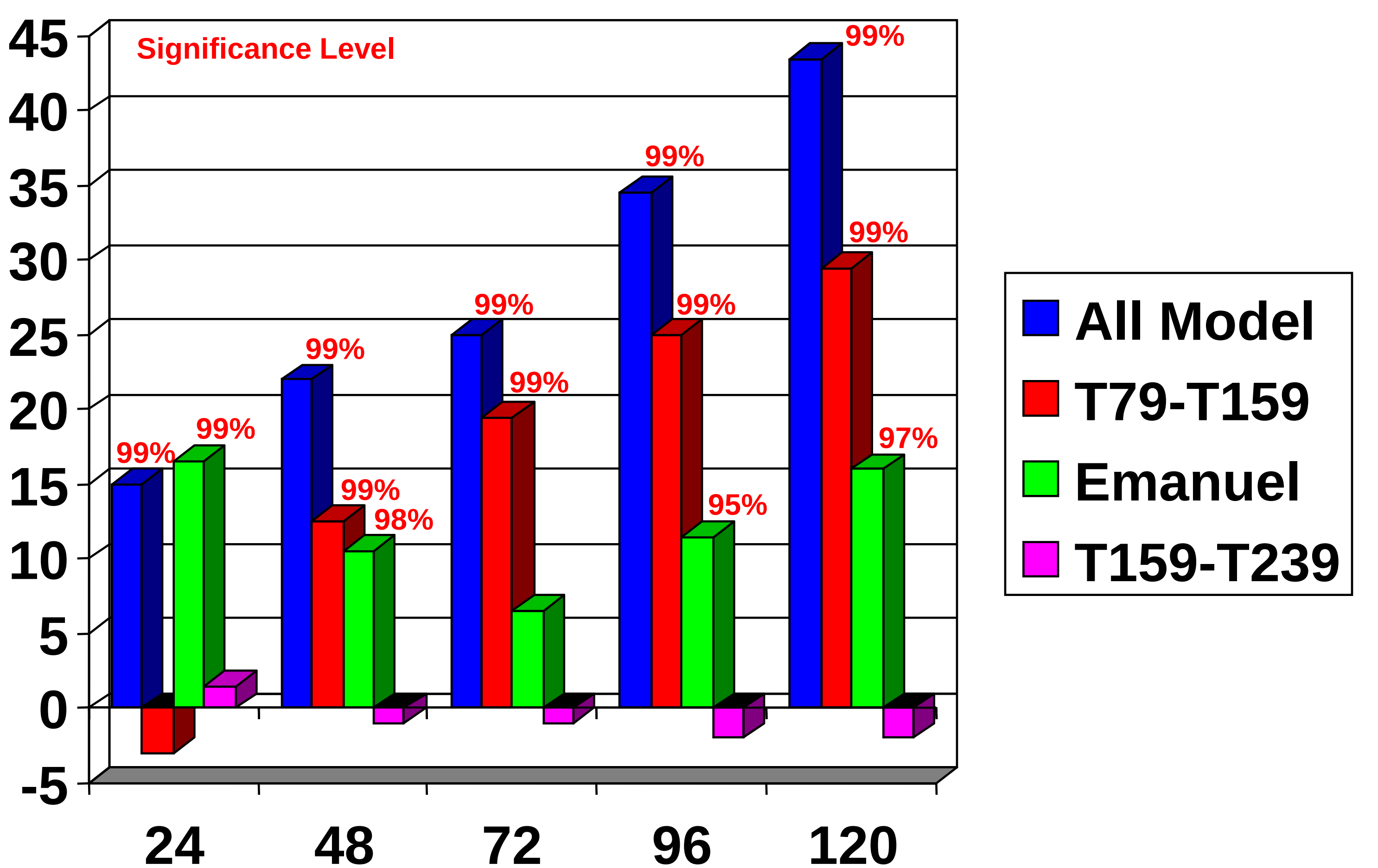
Quantifying Global Model Forecast Improvement

NOGAPS Forecast System Experiments

The operational NOGAPS/NAVDAS data assimilation system was run with different configurations of the NOGAPS global spectral model over the period from August 14-September 30, 2004. The experiments were designed to show the impact of major resolution and physics changes made since the early 1990's (T79 / Arakawa-Schubert to T239 / Emanuel).

This was a particularly active period with 12 hurricanes (including Charley, Frances, Ivan, and Jeanne), 5 typhoons, and 7 tropical storms.

NOGAPS Forecast System Experiments
Percent Improvement

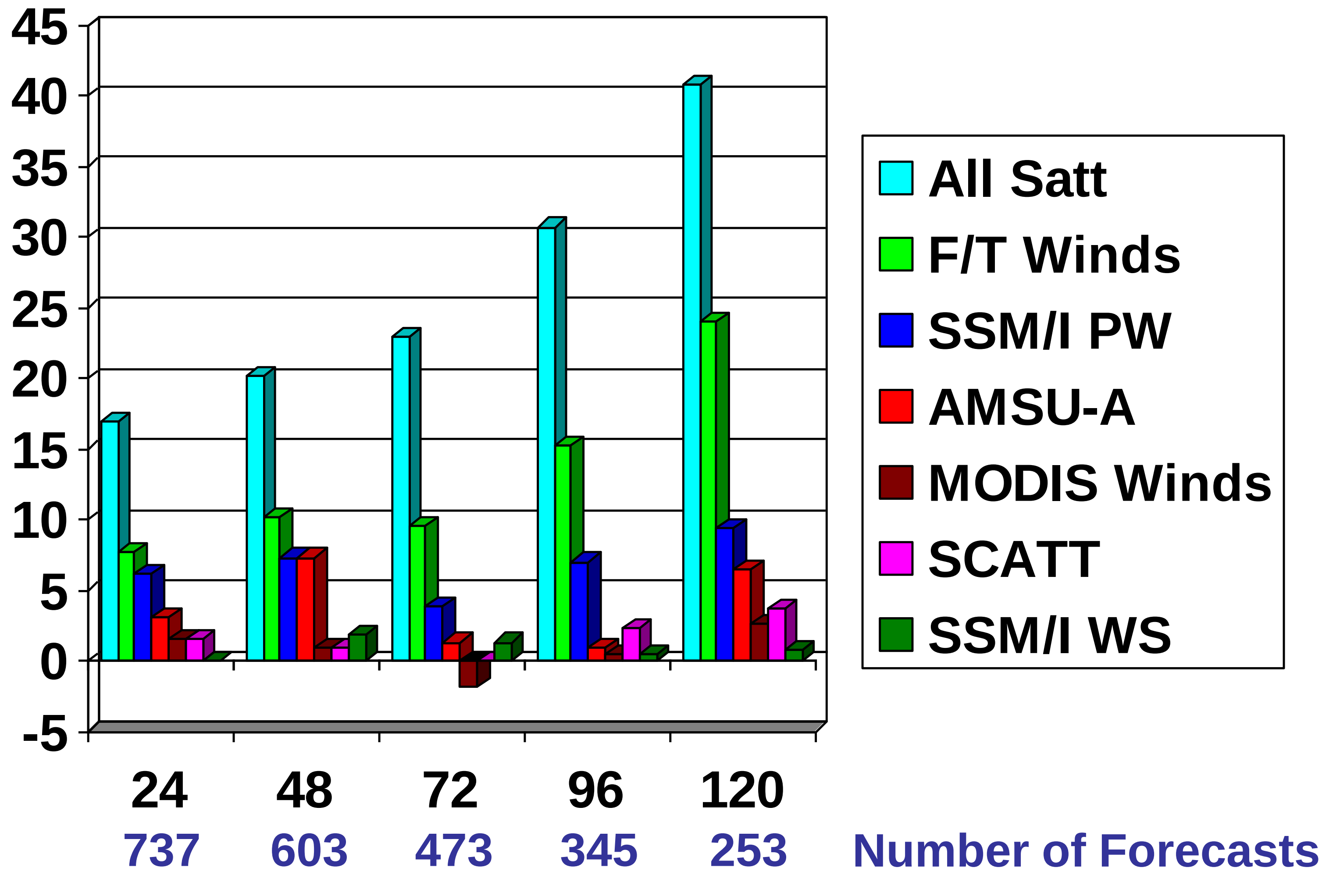


NOGAPS Satellite Observation Impact Experiments

The 2008 NOGAPS/NAVDAS data assimilation system was run with different combinations of observational data over two test periods: July-October 2005 and August-September 2006. The control run used all available conventional and satellite observations. Then, a number of experiments were run in which one type of satellite data was excluded. A final experiment was run excluding all satellite observations.

The first period was an extremely active one covering most of the record-breaking Atlantic season with 18 hurricanes (including Katrina, Rita, and Wilma), 12 typhoons, and 20 tropical storms. The second period was not nearly as active with 9 hurricanes, 7 typhoons, and 10 tropical storms.

Impact of Satellite Data Assimilation
Percent Improvement to NOGAPS TC Forecasts
Atlantic and North Pacific Basins (2005-2006)



Summary

Routine operational use of global model TC track forecasts began in the early 1990's at JTWC and in the late 1990's at NHC.

The number of global models available has increased from 2 in the early 1990's to the 4-5 that are available today, depending on the forecast center.

Typical global model 72-h TC track forecast error has decreased from 300-400 nm in the early 1990's to 150-200 nm today while typical 120-h error has decreased from 400-500 nm in the early 2000's to 250-350 nm today.

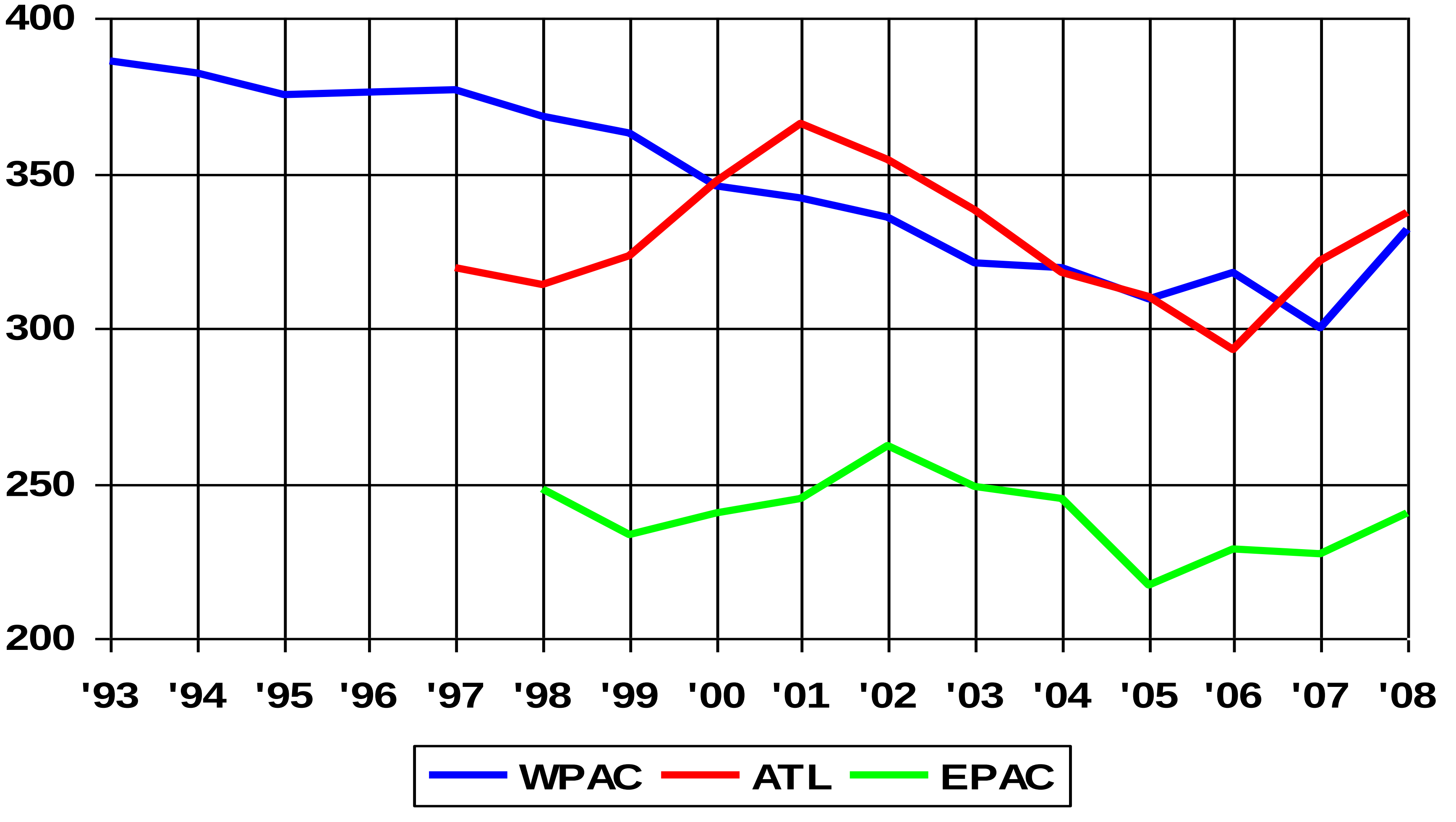
The increased number of models available coupled with model improvement has resulted in the reduction of consensus 72-h TC track forecast error from ~300 nm in the early 1990's to ~150 nm today and the reduction of 120-h error from over 300 nm in the early 2000's to just over 200 nm today.

Based on NOGAPS experiments designed to reflect model improvements made since the early 1990's, increased model resolution resulted in track forecast improvements ranging from over 10 percent at 48 h to nearly 30 percent at 120 h while improved cumulus parameterization resulted in 10-15 percent improvement at all forecast lengths.

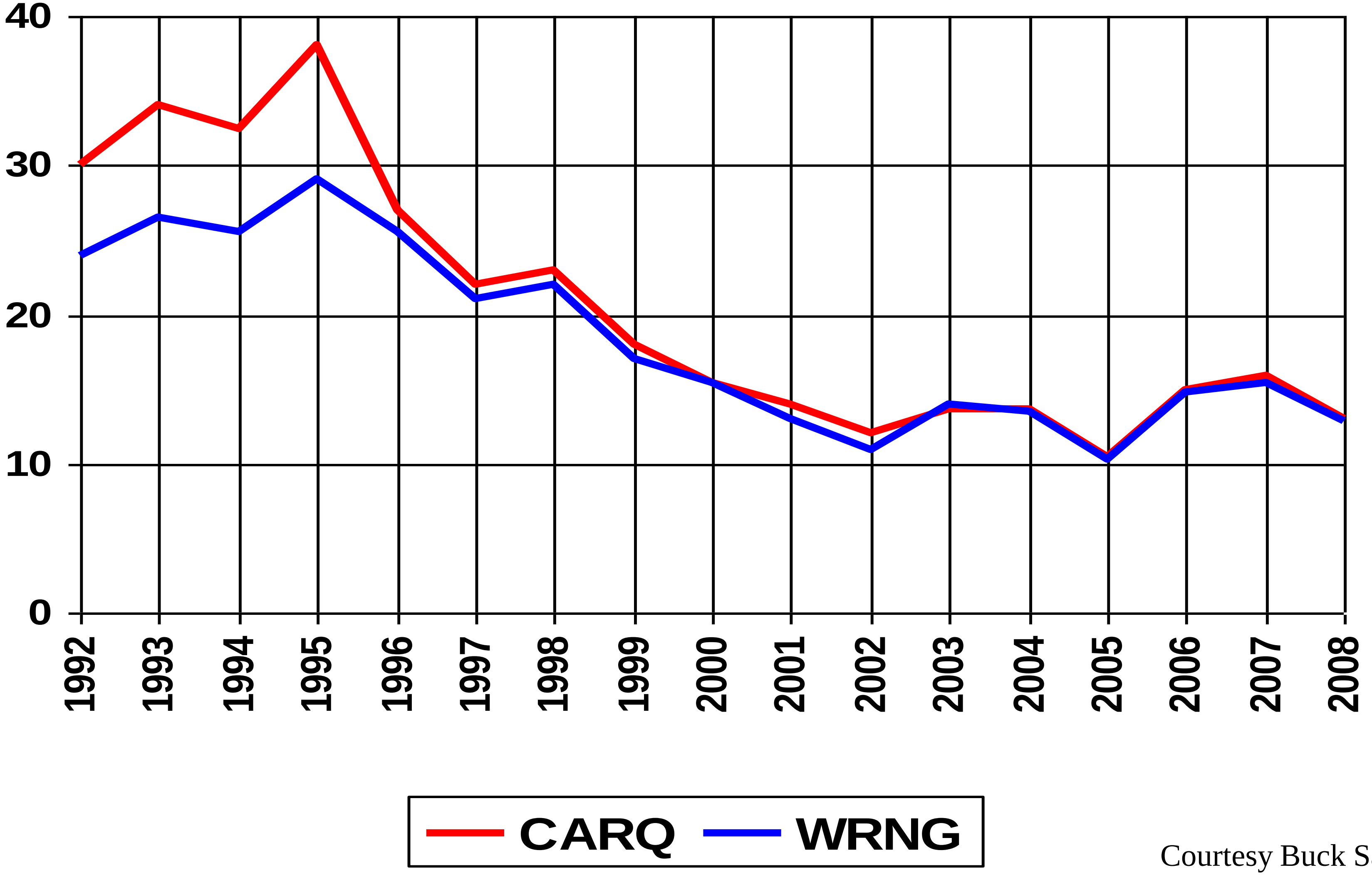
Using the 2008 NOGAPS data assimilation system, the assimilation of all satellite data resulted in further TC track forecast improvement ranging from 15 percent at 24 h to 40 percent at 120 h. The improvement due to the assimilation of feature-track winds from geostationary satellites is the largest ranging from about 7 percent at 24 h to just under 25 percent at 120 h.

Questions?

CLIPER
3-Year Weighted Mean 72-h Forecast Error (nm)

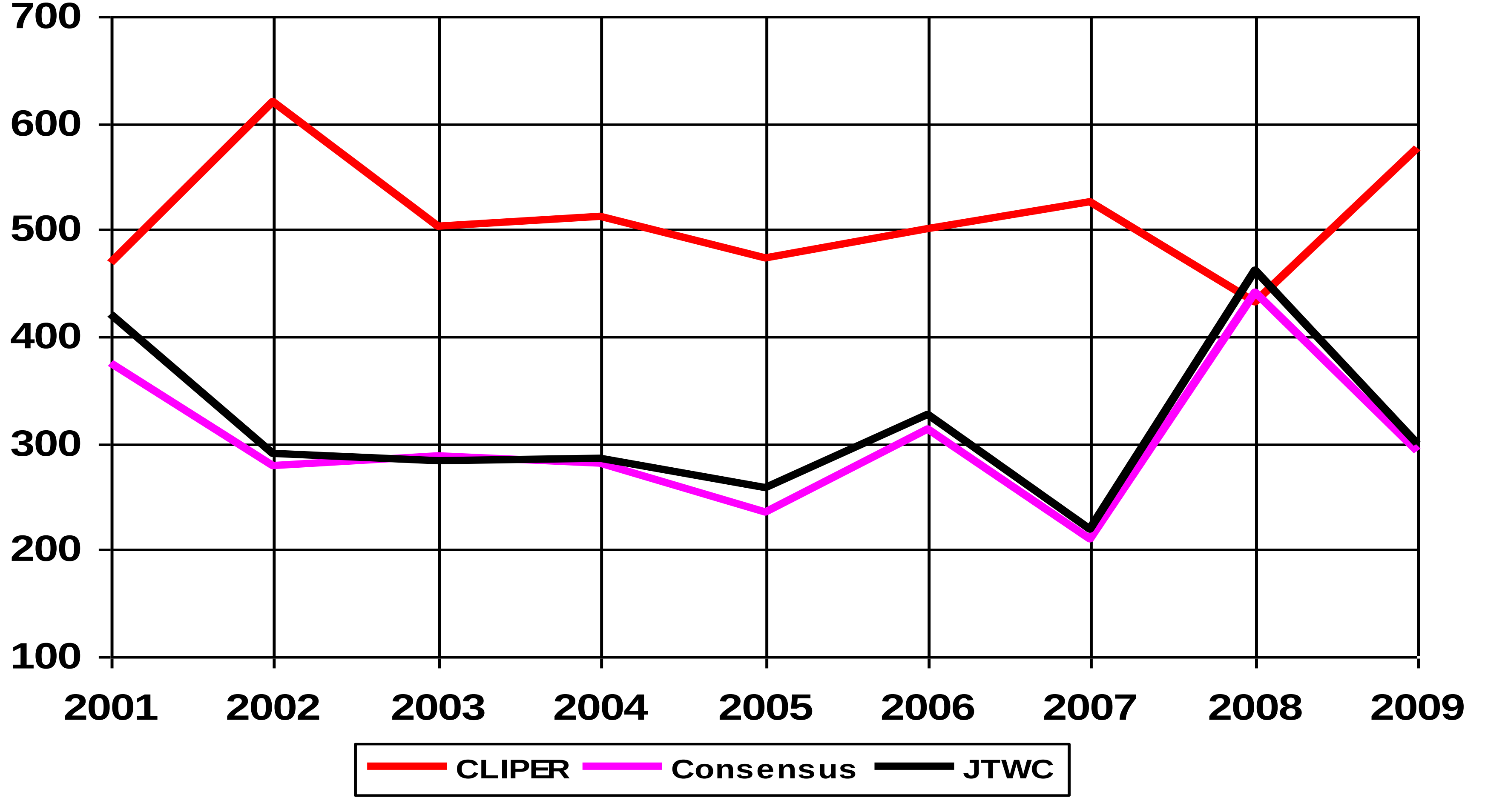


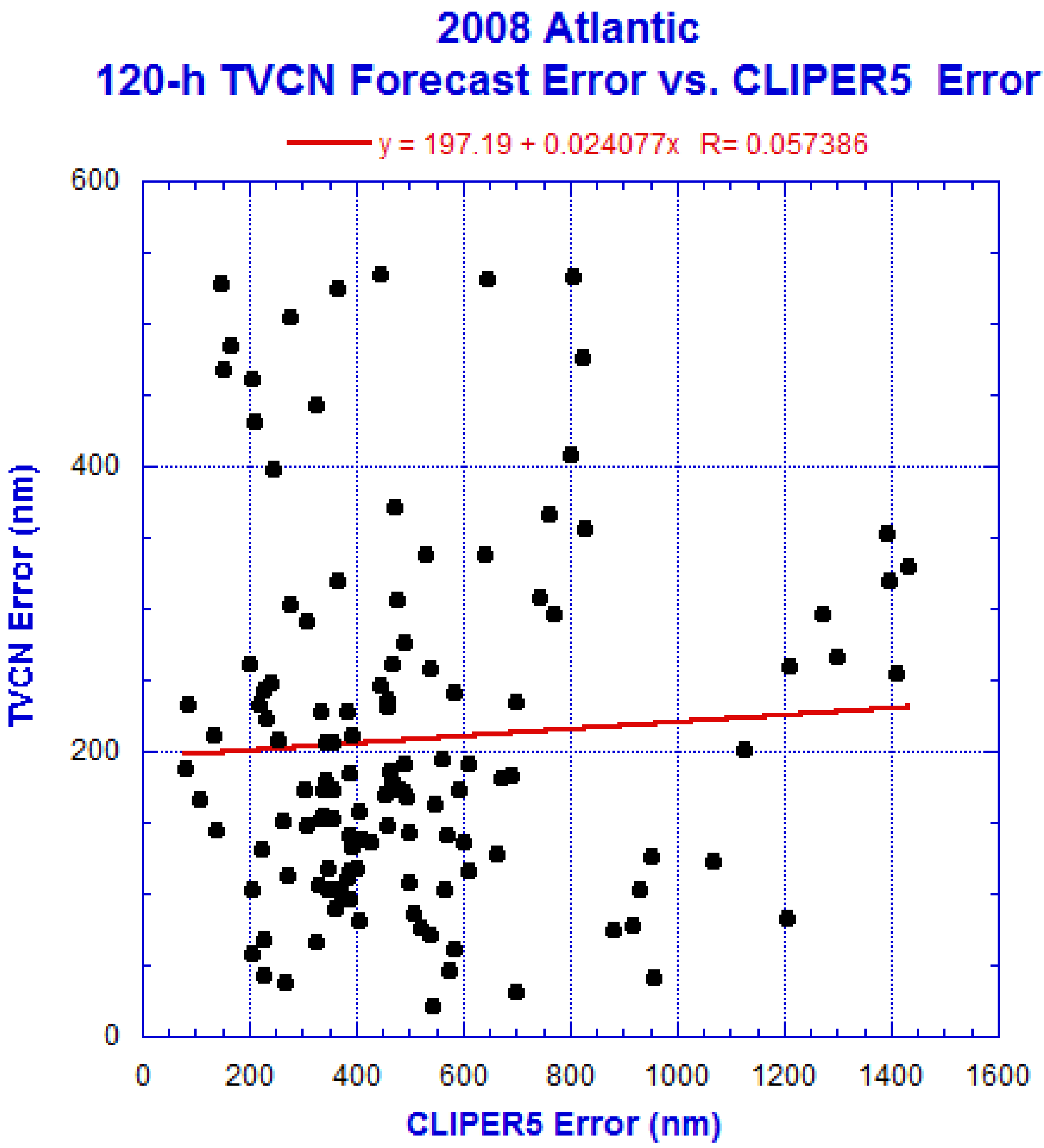
Western North Pacific – Historic Performance
Mean Positioning Error (n mi)

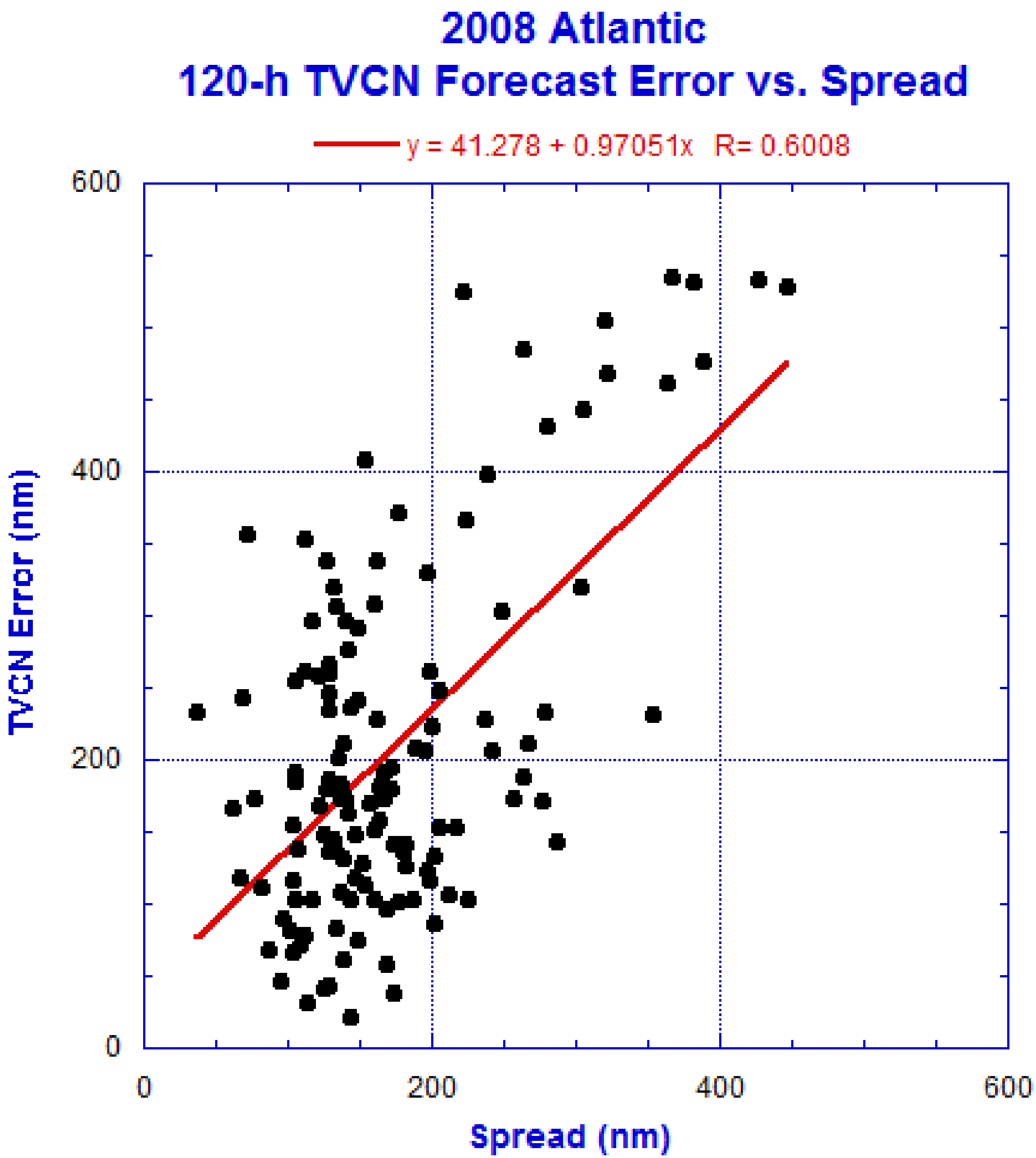


Courtesy Buck Sampson, NRL

Western North Pacific – Historic Performance
120-h Model Forecast Error (nm)




2008 Atlantic
120-h TVCN Forecast Error vs. CLIPER5 Error
y = 197.19 + 0.024077x R= 0.057386
600
400
200
0
0
200
400
600
800
1000
1200
1400
1600
TVCN Error (nm)
CLIPER5 Error (nm)



2008 Atlantic
120-h TVCN Forecast Error vs. Spread
y = 41.278 + 0.97051x R= 0.6008
600
400
200
0
0
200
400
600
TVCN Error (nm)
Spread (nm)