Predicting Hurricanes Using Regional Dynamic Models

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Limitations of Numerical Models

- Global model:

  a) insufficient resolution;

  b) huge demand on computational power and storage space;

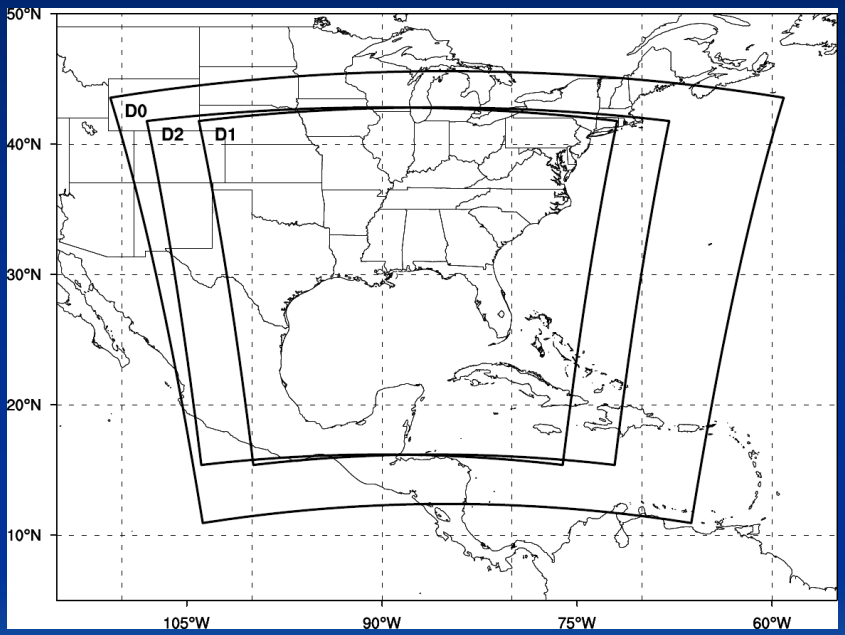
  c) not practical for real-time weather prediction at the present and in the near future.

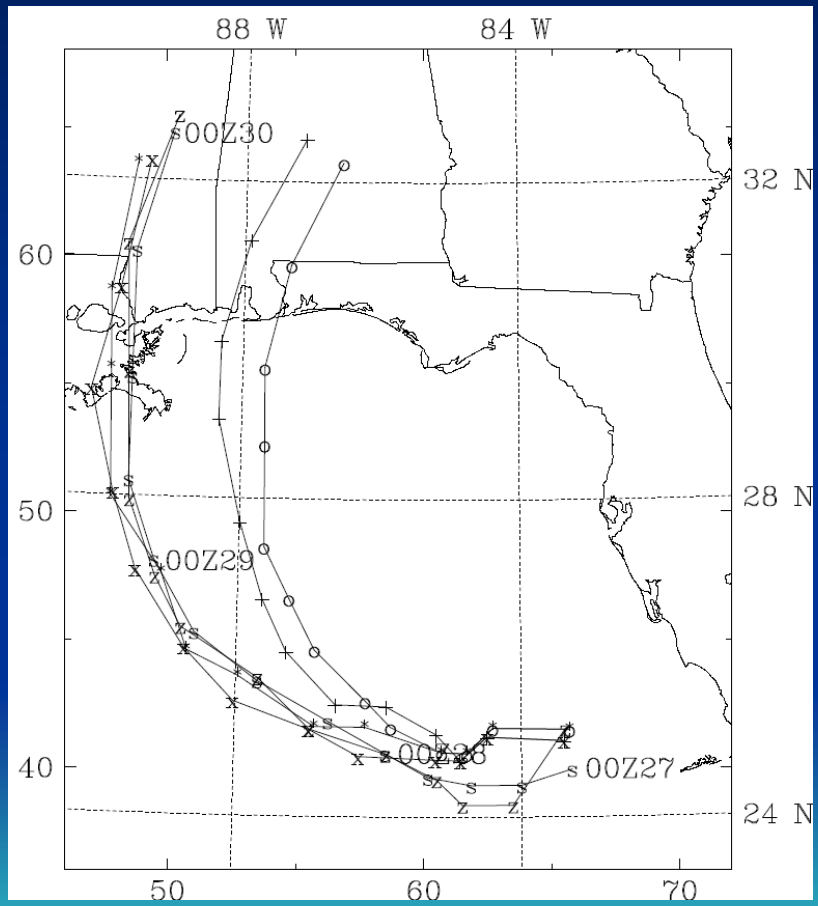
- Regional (limited area) model:

  a) insufficient coverage of forcing outside model domain;

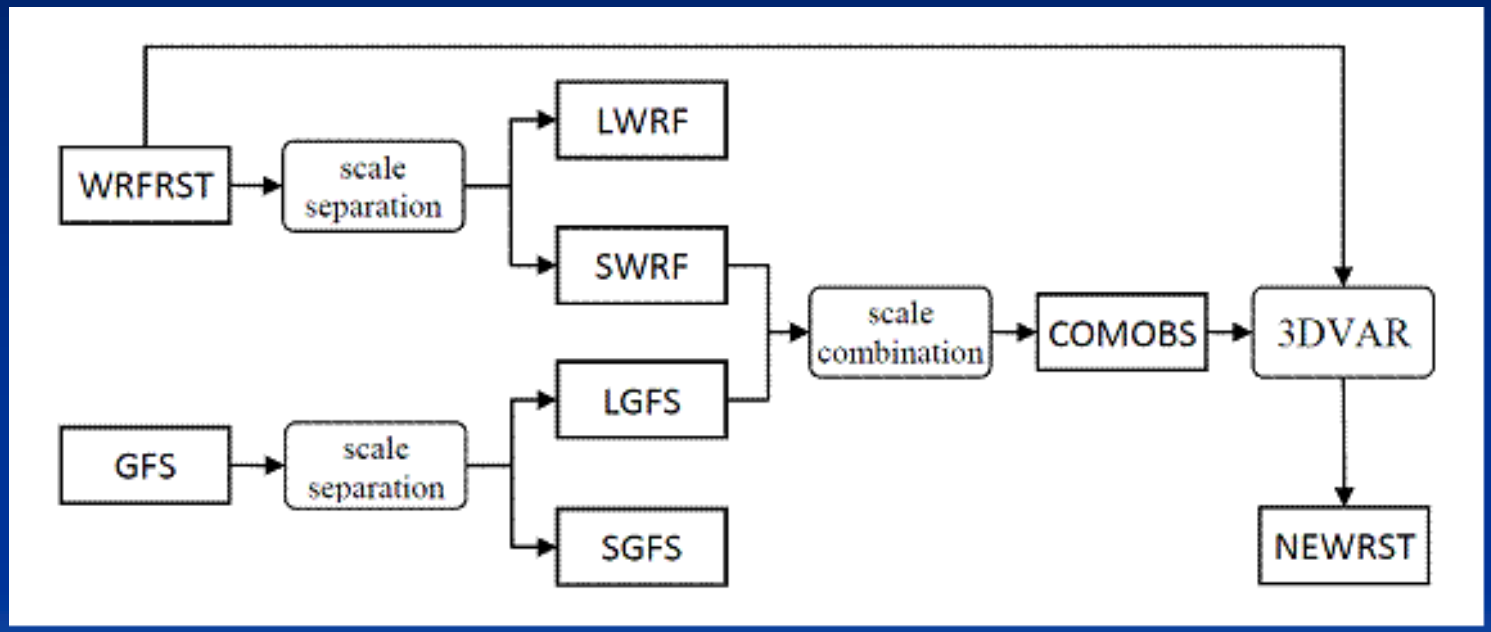
  b) ill-defined open boundary condition.

Sensitivity of simulated TC tracks to model domain selection

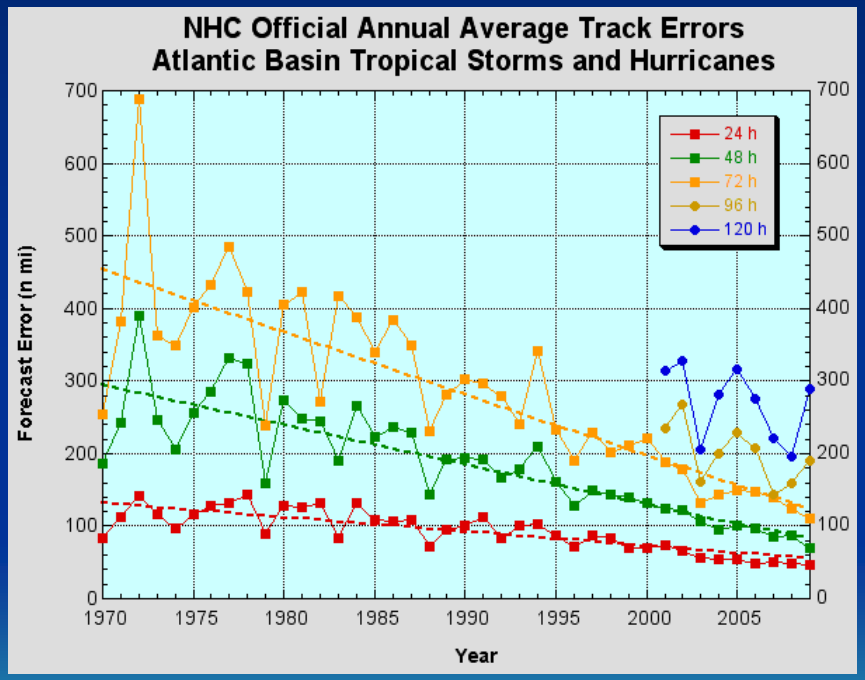


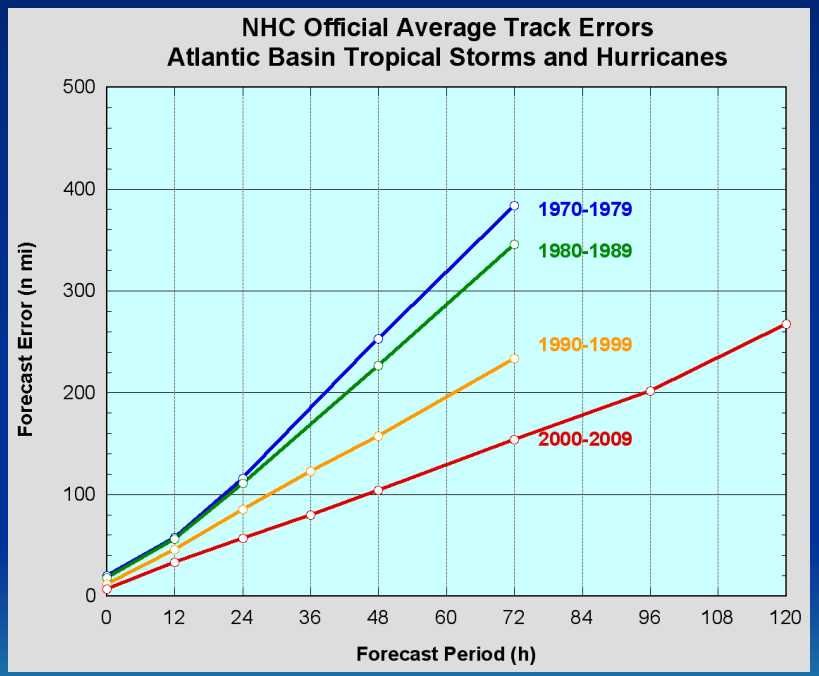


Improved model physics and resolution, better observations and data assimilation techniques can track forecasts, but ill-posed lateral boundary conditions for limited area models remain a major issue for track forecasting.
Scale-Selective Data Assimilation provides a way to improve model nesting.



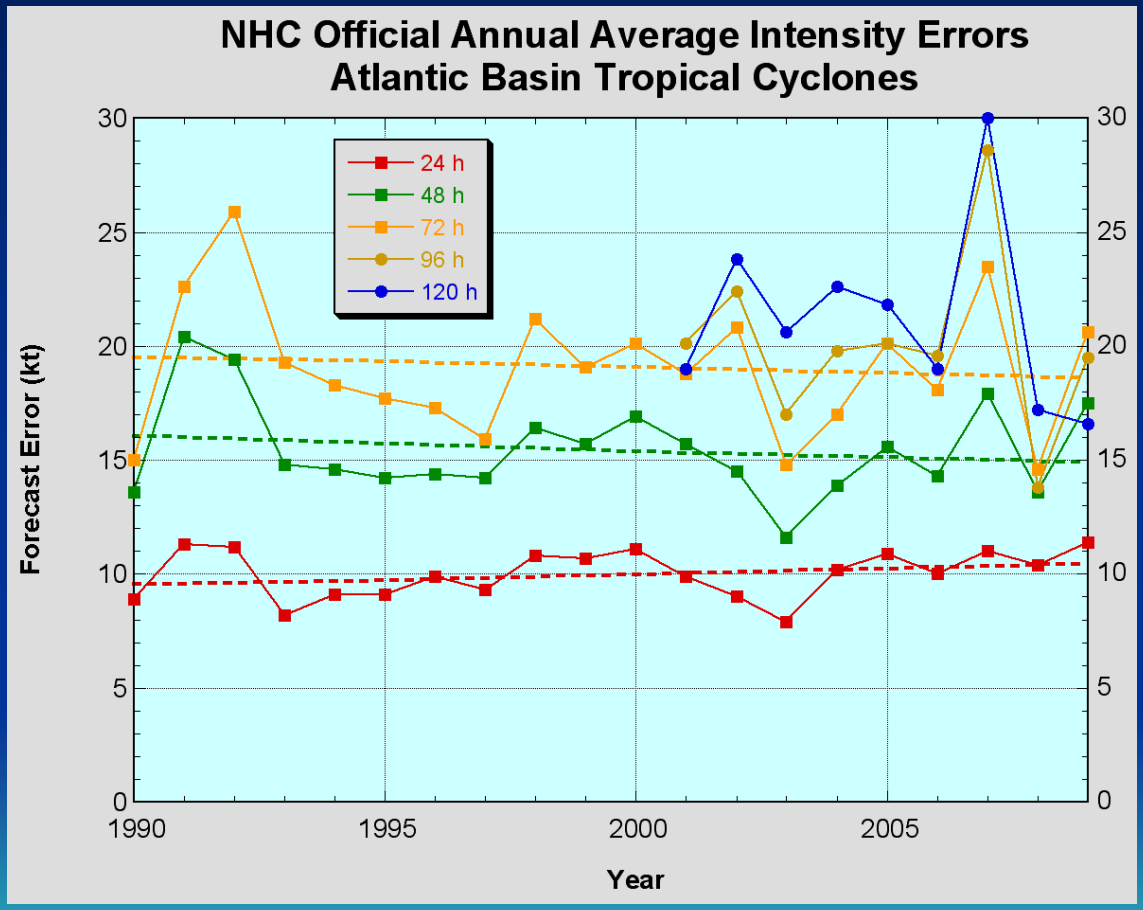
Hurricane track forecasts have shown steady improvement but mean error remains approximately 200 km at 48 h (2 days), 500 km at 120 h (5 days)





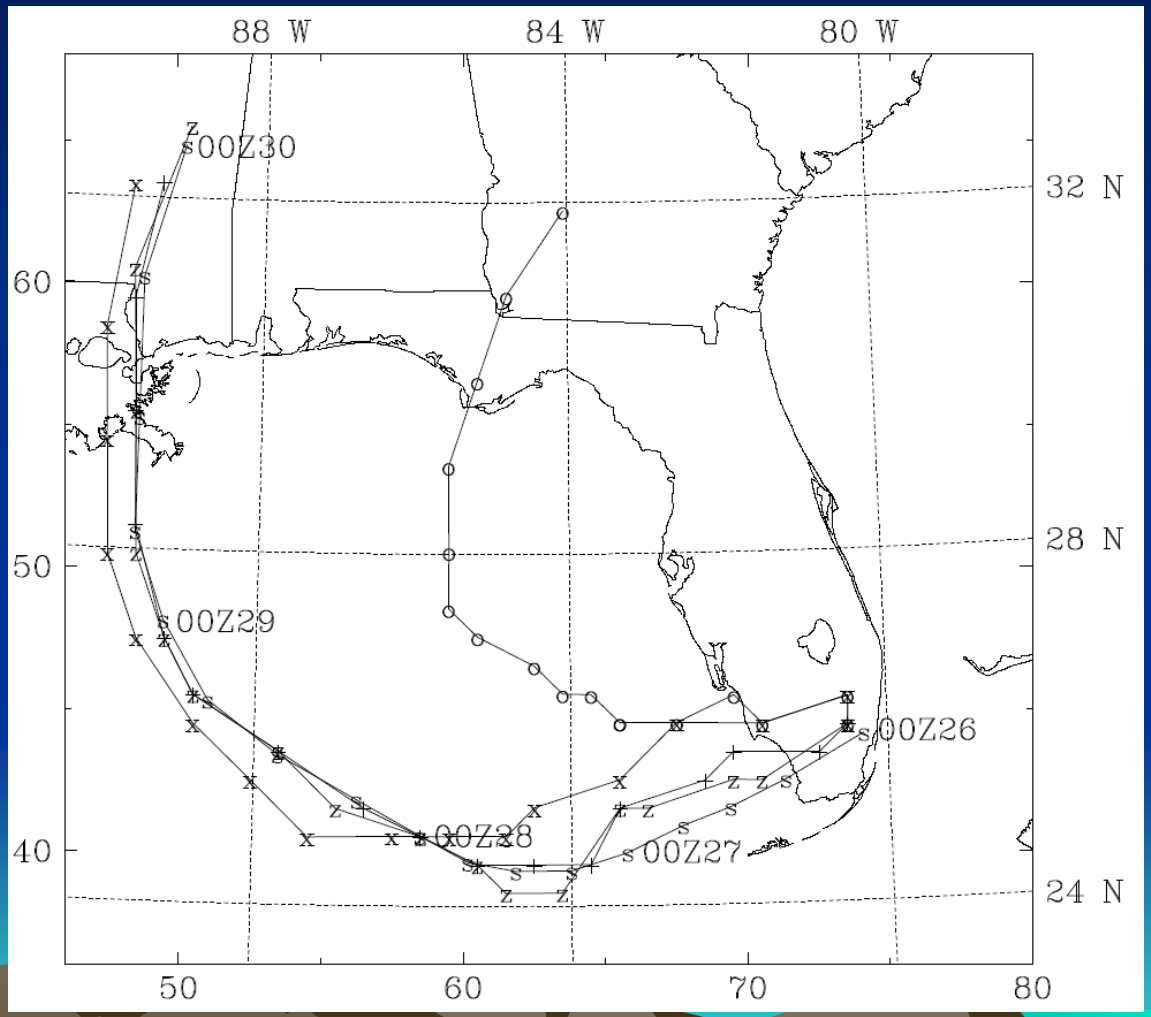
Source: NOAA/NHC: http://www.nhc.noaa.gov/verification/index.shtml

Intensity forecast presents an even bigger challenge. Historical records show little improvements in intensity forecasts despite the introduction of air-sea coupled models and advanced DA techniques in the last decade

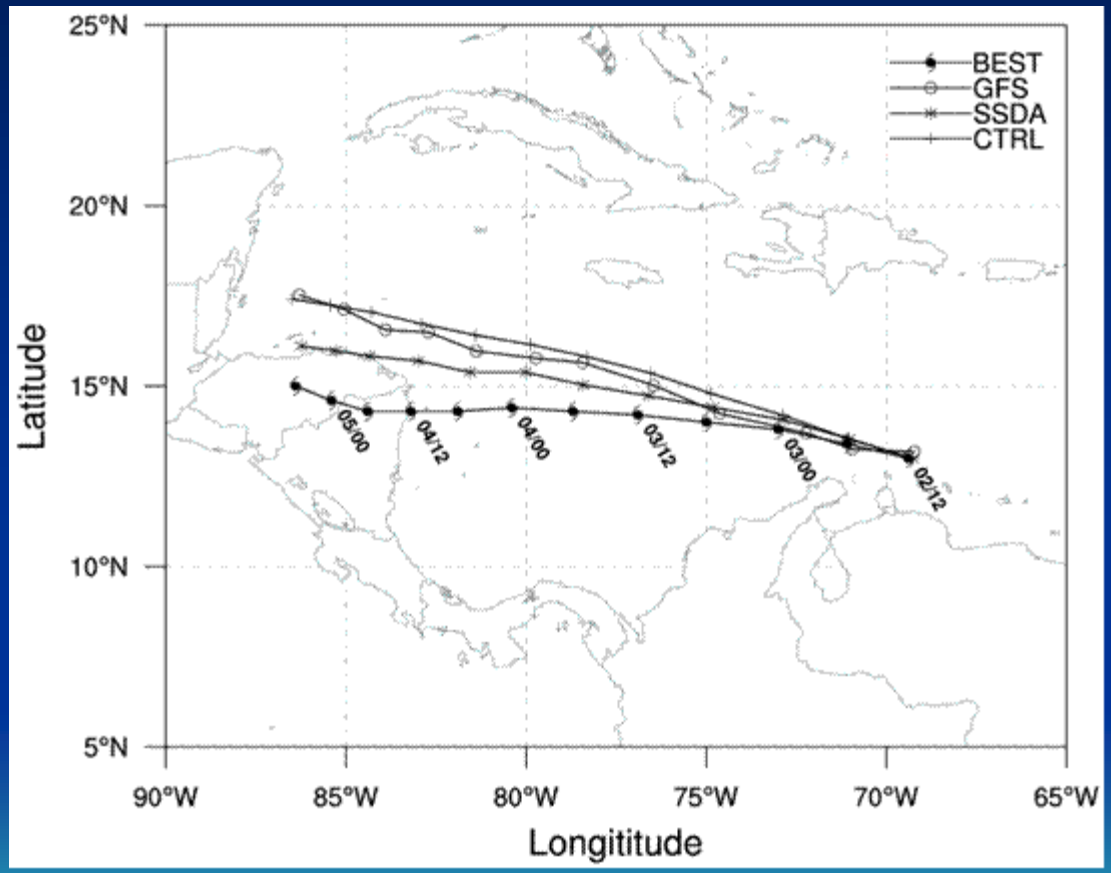


Source: NOAA/NHC: http://www.nhc.noaa.gov/verification/index.shtml

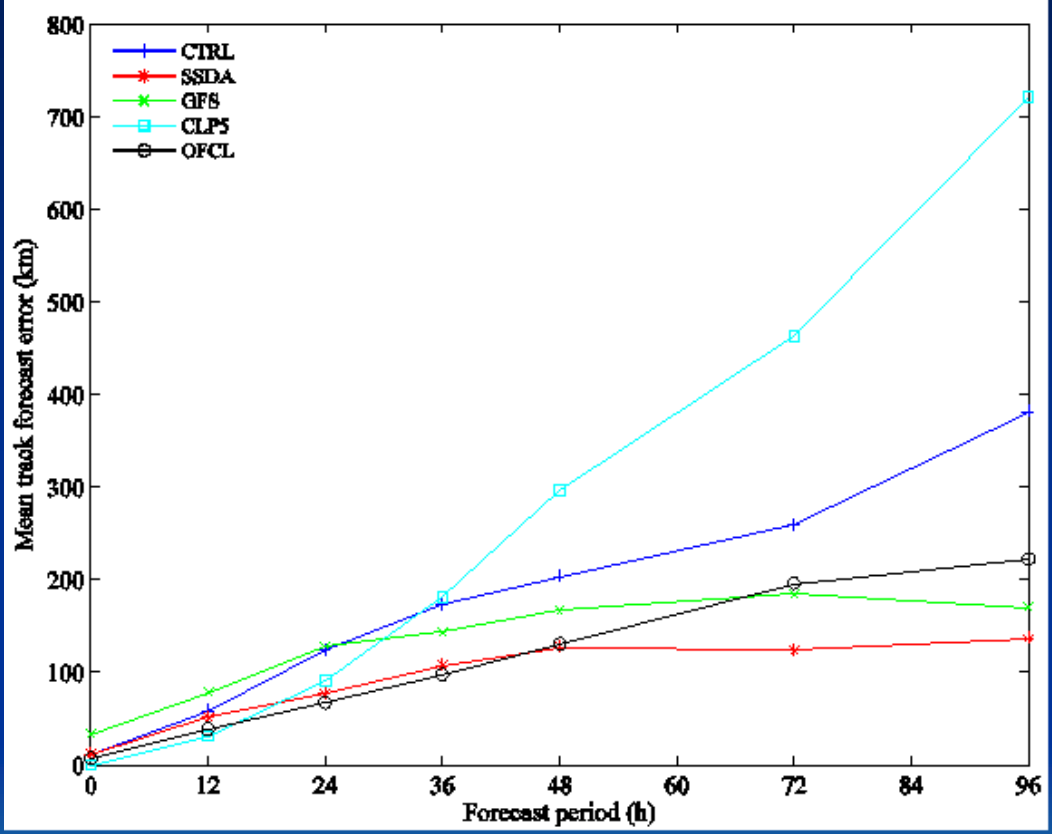
SSDA corrects the simulated track of Hurricane Katrina initialized at 00Z August 26



SSDA cuts the track forecast error for Hurricane Felix of 2007 by 30-50% comparing with GFS or WRF

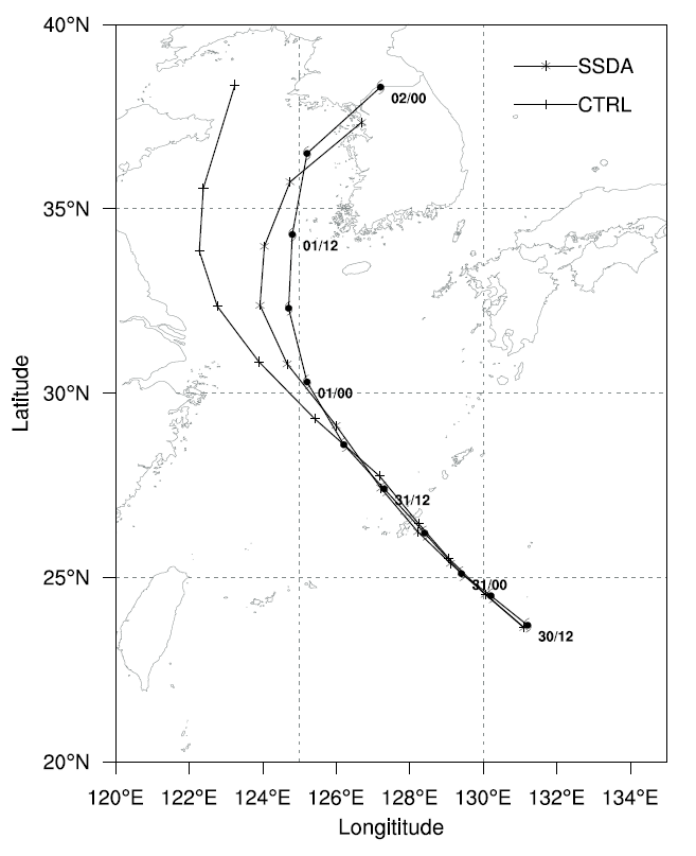


Improvements in track forecasts by using SSDA are more evident beyond 48 h



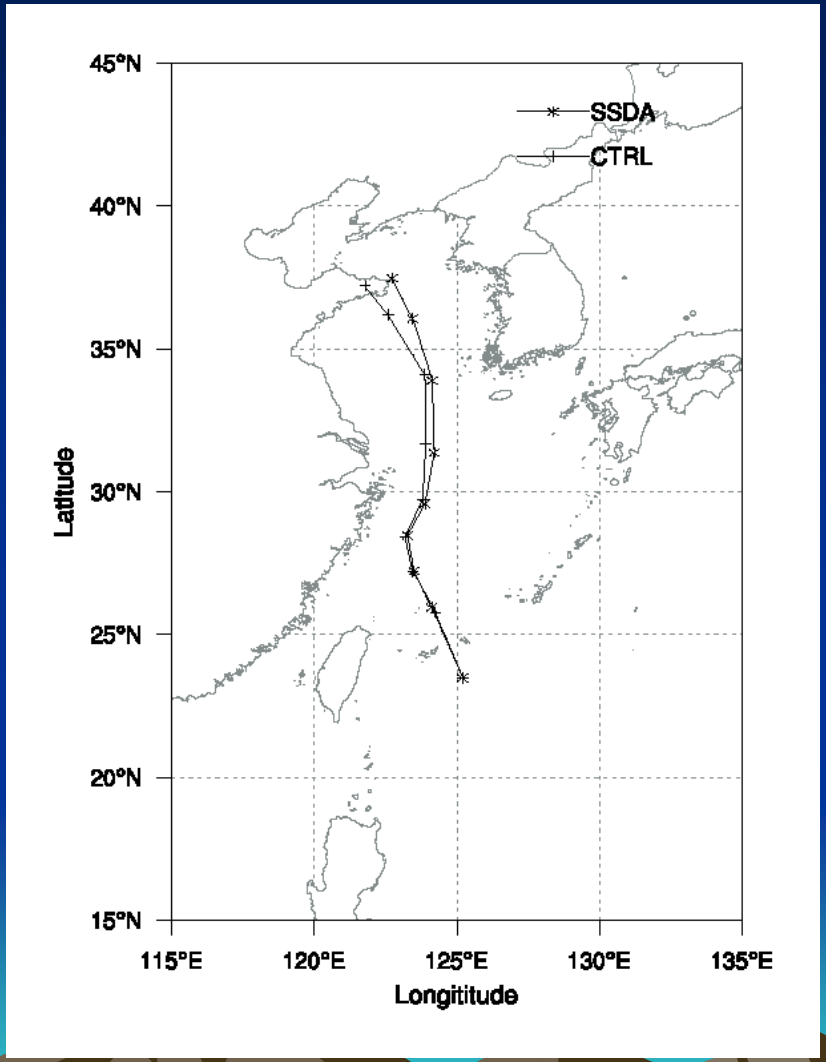
$$e = 111.11\cos^{-1}\left[\sin\varphi_o \sin\varphi_f + \cos\varphi_o \cos\varphi_f \cos(\lambda_o - \lambda_f)\right]$$

For over 100 simulations, using SSDA led to track forecast improvement in all of the cases



Typhoon Kompasu (2010) presented a major forecast challenge for forecasters. Using SSDA would have avoided the false warning in Shanghai that led to unnecessary school, store and office closures.

Typhoon MEARI（1105号）

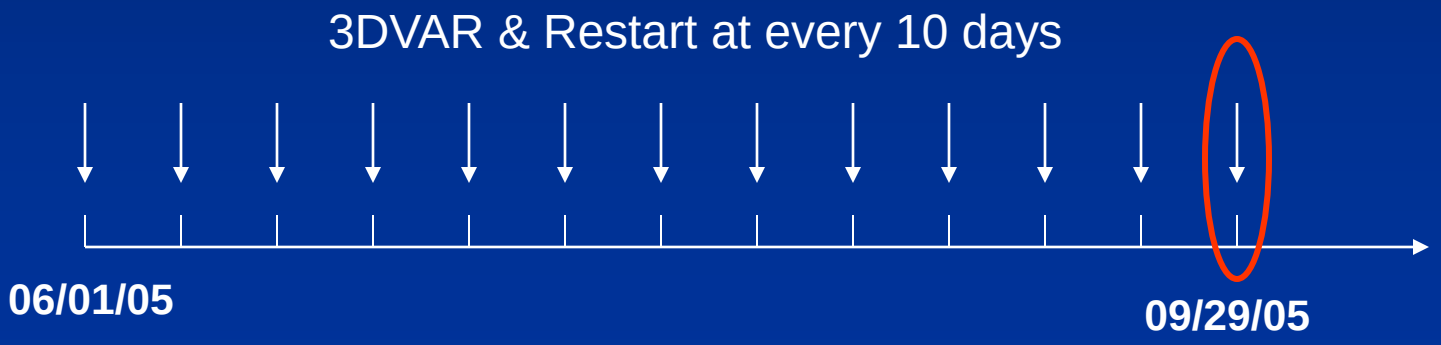


Time (UTC)	Lat	Lon	MinSLP (hPa)	MaxWind (m/s)	
2011-06-24_12:00:00	23.49	125.20	983.3	25.9	**30**
2011-06-24_18:00:00	25.95	124.12	977.9	27.8	**30**
2011-06-25_00:00:00	27.23	123.50	977.6	25.1	**30**
2011-06-25_06:00:00	28.47	123.28	978.2	23.9	**30**
2011-06-25_12:00:00	29.58	123.89	979.1	24.0	**28**
2011-06-25_18:00:00	31.37	124.21	979.1	24.4	**28**
2011-06-26_00:00:00	33.89	124.14	980.1	25.8	**25**
2011-06-26_06:00:00	36.06	123.45	980.1	25.0	**23**
2011-06-26_12:00:00	37.47	122.74	980.7	22.8	**23**

Seasonal Prediction

- **Control run**: **4-month integration of WRF from 00UTC 01 June to 00UTC 29 Sept. 2005**

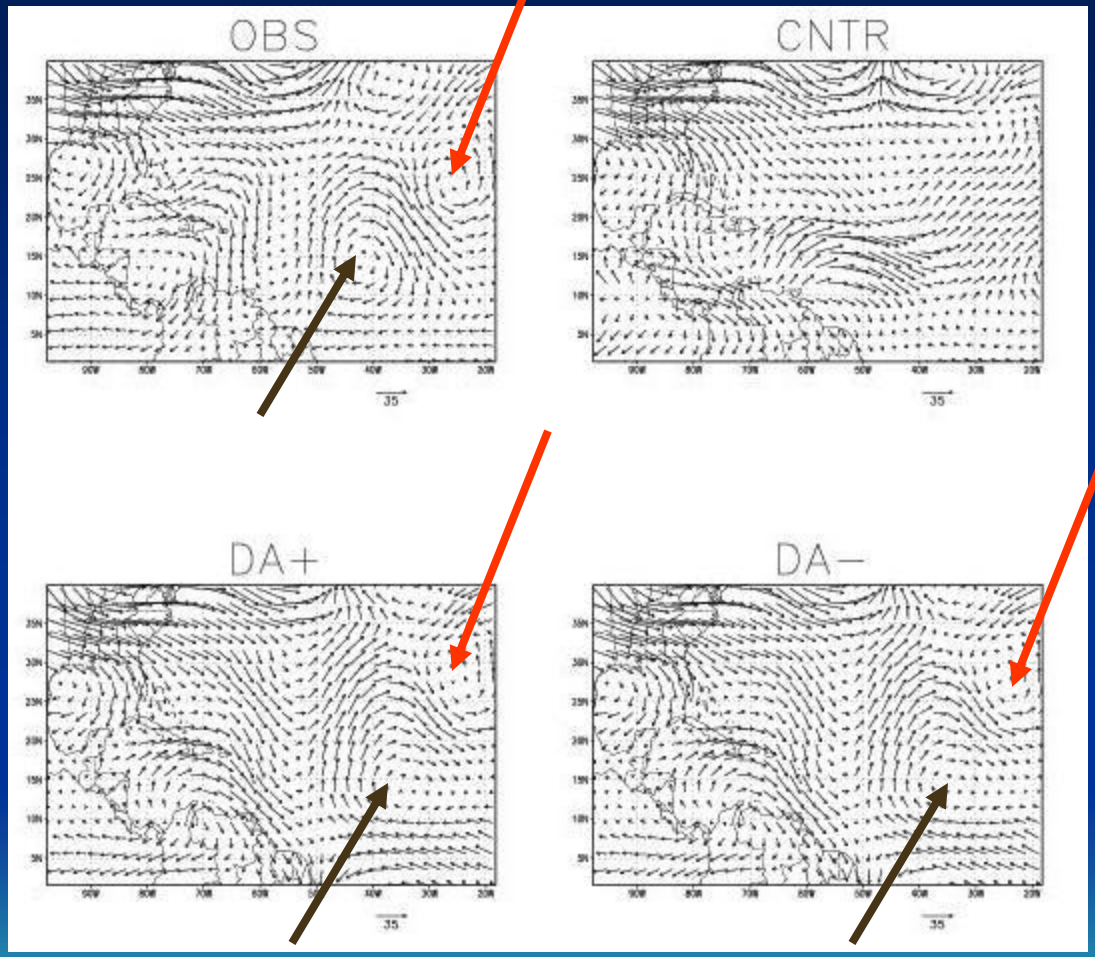
- **3DVAR expts:**



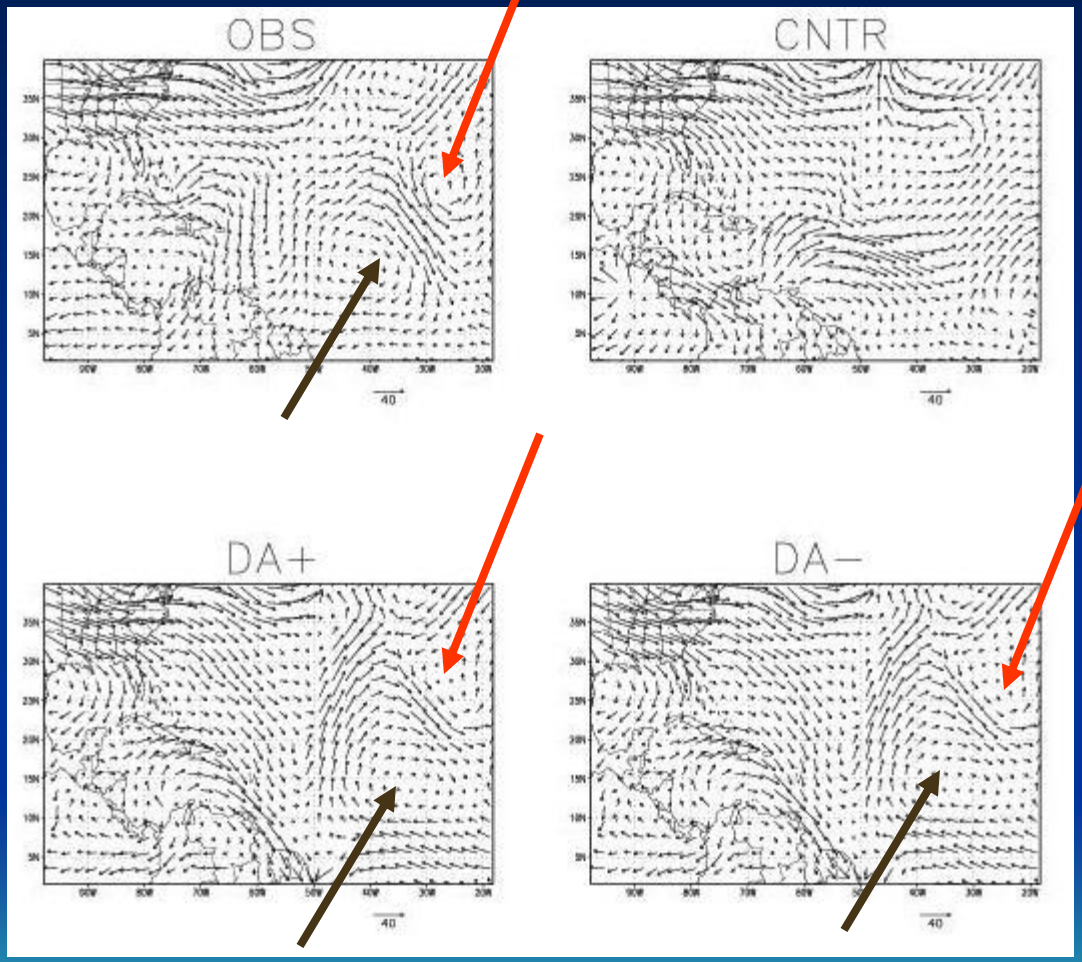
DA - : before performing the last cycle of 3DVAR at 00UTC 29 Sept. 2005

DA + : after performing the last cycle of 3DVAR at 00UTC 29 Sept. 2005

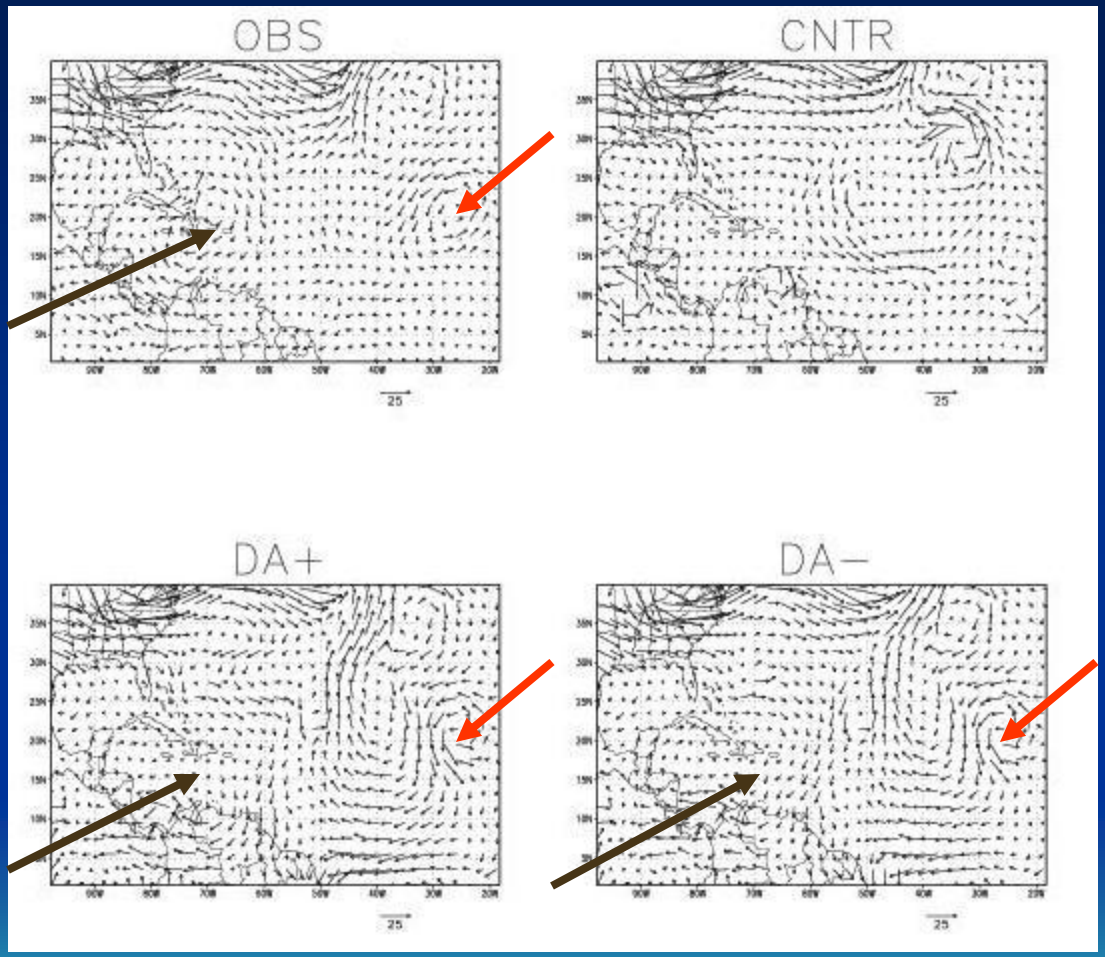
Wind field (large scale at ~ 200mb)



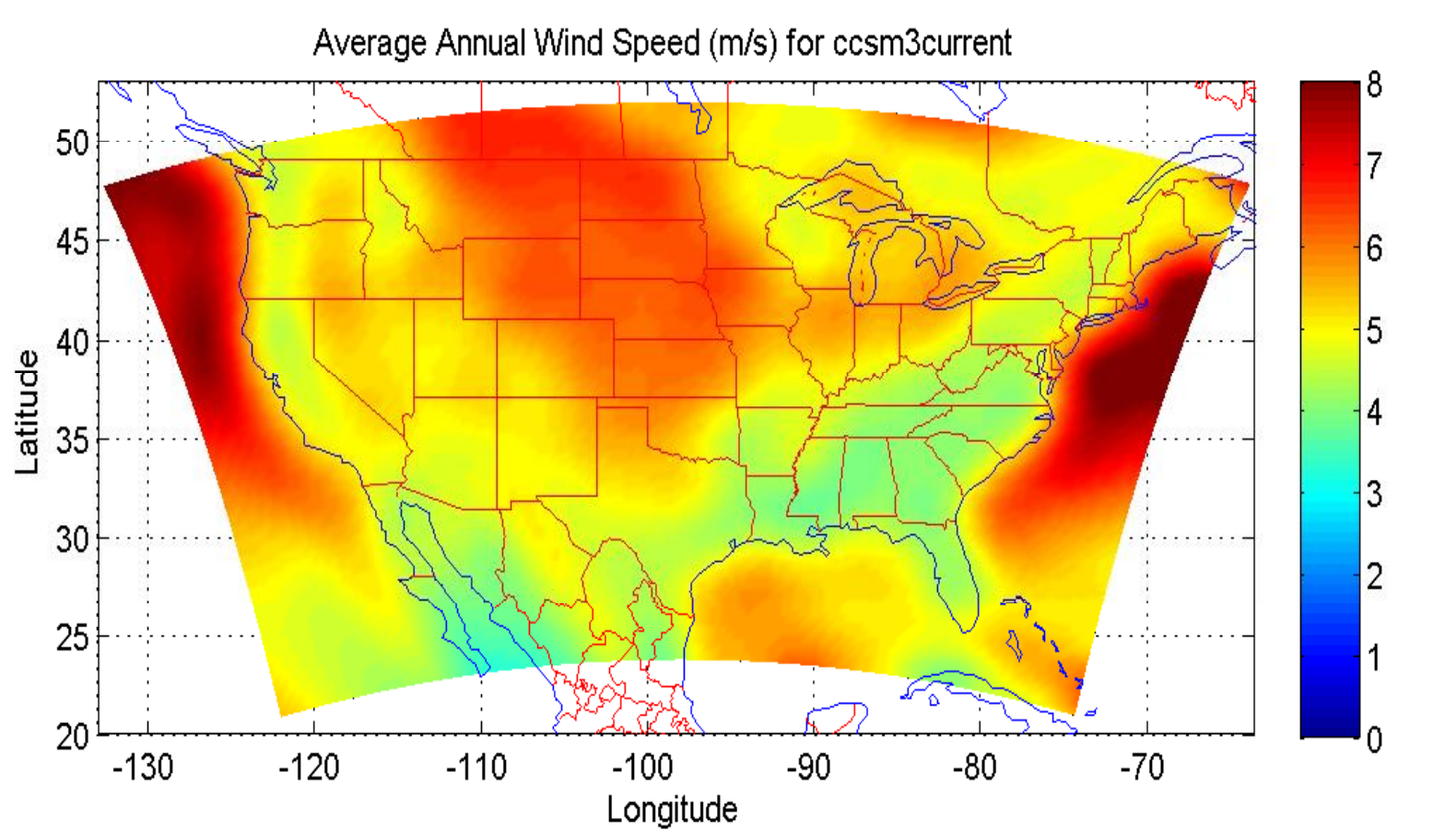
Wind field (combined at ~ 200mb)

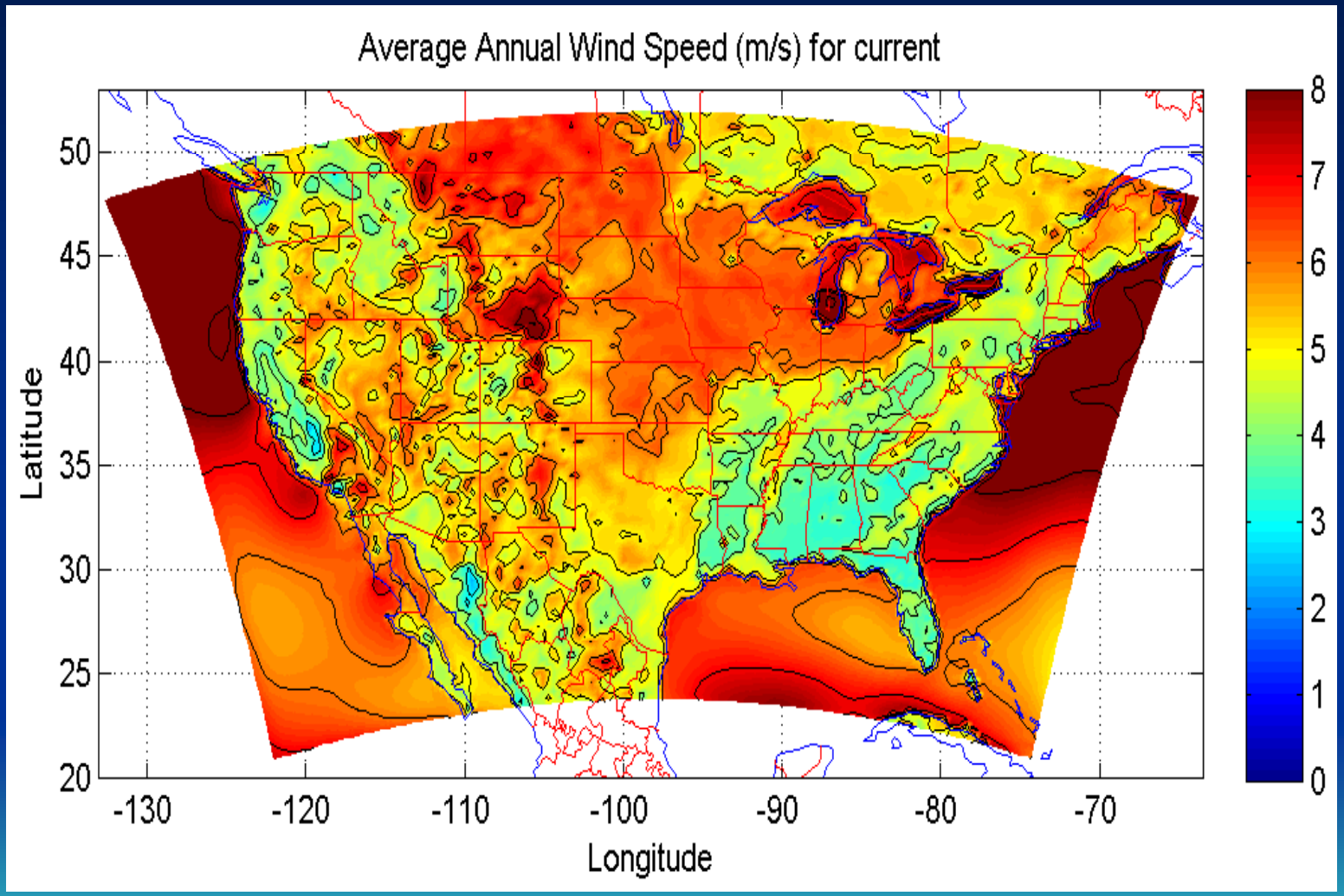


Wind field (combined at ~ 500mb)



1990 – 1999 CCSM3 Annual mean wind speed




Average Annual Wind Speed (m/s) for current
Latitude
50
45
40
35
30
25
20
-130
-120
-110
-100
-90
-80
-70
Longitude
8
7
6
5
4
3
2
1
0

Mean Absolution Error (MAE)
Comparing with 30 Surface Wind Observations:
25%-30% MAE reduction

	CCSM4	SSDA	NARR
MAE	1.43	1.27	1.40
MAE for wind speeds >6 m/s	1.78	1.35	1.88

Conclusion

SSDA with WRF 3DVAR is a cost-effective alternative to high-resolution global models for regional weather and climate prediction and downscaling.

For more information visit: http://cfdl.meas.ncsu.edu/