National Aeronautics and Space Administration

# Hurricane Forecasts with the NASA Global Mesoscale Model and Supercomputers


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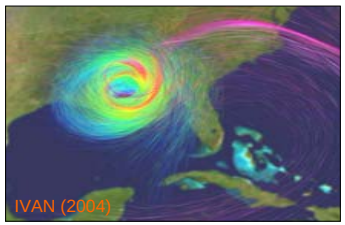
## 1. INTRODUCTION

It is known that General Circulation Models (GCMs) have insufficient resolution to accurately simulate hurricane near-eye structure and intensity. The increasing capabilities of high-end computers have changed this. In 2004, the NASA GCM at a 0.25º resolution, doubling the resolution used by most of operational numerical weather prediction (NWP) centers at that time, was implemented and run on the NASA Columbia Supercomputer to obtain promising landfall predictions for major hurricanes. In 2005, we successfully implemented the 0.125º version, and demonstrated its performance on intensity forecasts with hurricane Katrina (2005). It is found that the 0.125º model is capable of simulating the radius of maximum wind and near-eye wind structure, and thereby promising intensity forecasts. In this study, we further evaluate the model's performance on intensity forecasts of intense hurricanes Ivan, Karl (2004), Dennis, Emily, Katrina, Rita (2005) and Daniel (2006).

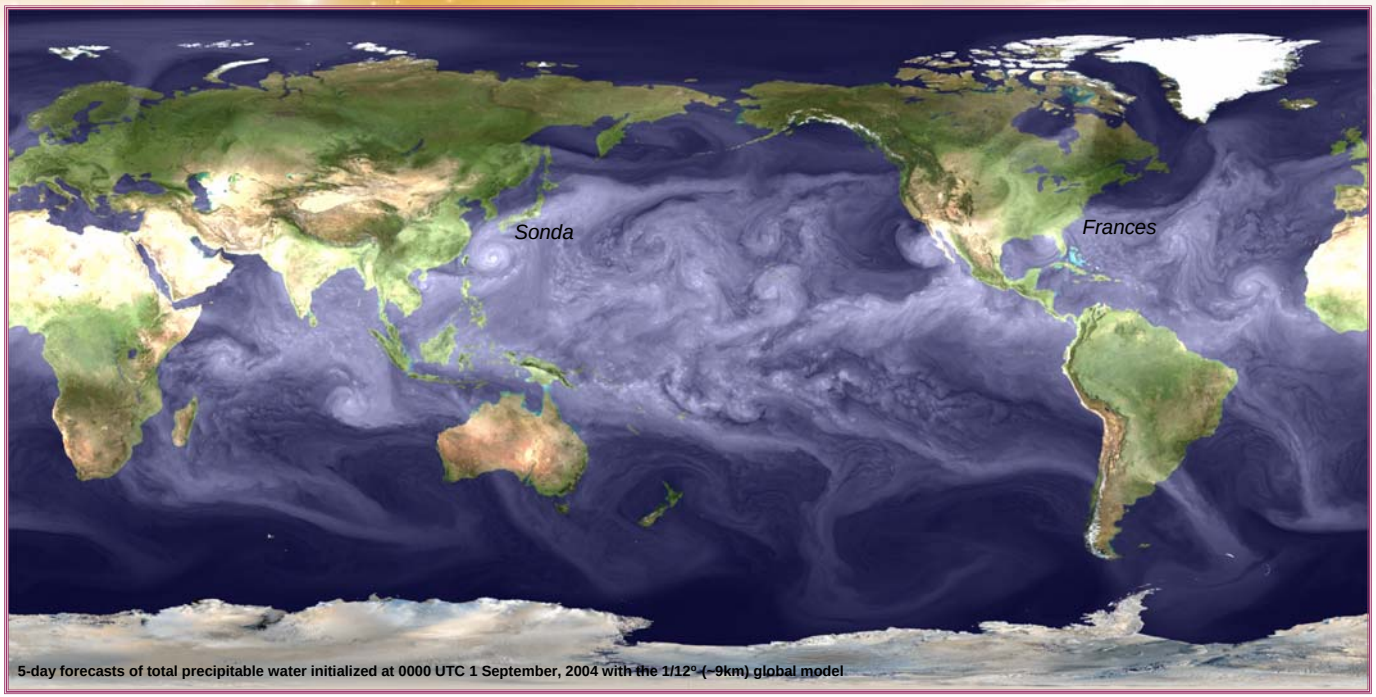
## 2. THE GLOBAL MODEL & SUPERCOMPUTERS

The NASA high-resolution global model (a.k.a. global mesoscale model, GMM) has three major components: (1) finite-volume dynamics (e.g., Lin, 2004, *MWR*), (2) NCAR CCM3 physics, and (3) NCAR Community Land model. Facilitated by Columbia supercomputer, the ultra-high resolution (e.g., 0.125º and 0.08º) model has been deployed to study the impacts of increasing resolutions and disabling cumulus parameterizations on hurricane forecasts. The model performance has been verified with (1) simulations of mesoscale eddies (e.g., the Catalina Eddy, the Hawaii Wake, Shen et al., 2006a); (2) forecasts of hurricanes Gustav, Isidore (2002), Bonnie, Charley, Frances (2004), Emily and Katrina (2005) (Atlas et al., 2005; Shen et al., 2006a,b); and (3) simulations of Tropical Cyclogenesis associated with Madden-Julian Oscillations and equatorial trough (Shen et. al., 2007,2008,2009)



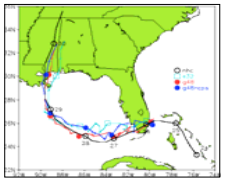

*A 3D simulation of Hurricane Ivan (2004) at landfall. Wind speeds show low-level inward counterclockwise circulation (blue) and upper-level outward clockwise circulation (red).*

*Columbia supercomputer with (in late 2004): (1) 20 SGI Altix superclusters, each with 512 CPUs; (2) 10,240 Intel Itanium II CPUs; (3) 20 TB total memory (Biswas et al., 2007).*

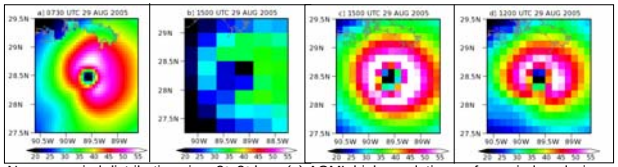



**5-day forecasts of total precipitable water initialized at 0000 UTC 1 September, 2004 with the 1/12º (~9km) global model**

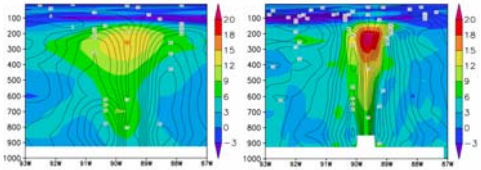
## 3. RESULTS:



5-day track forecasts of Katrina (2005) at different resolutions.

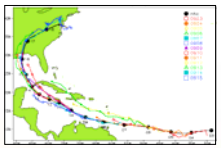



Near-eye wind distributions in a 2ºx2º box. (a) AOML high-resolution surface wind analysis validated at 0730 UTC 29 Aug 2005, (b) 0.25º 99h simulation, (c) 0.125º 99h simulation, (d) 0.125º 96h simulation without convection parameterizations (CPs).

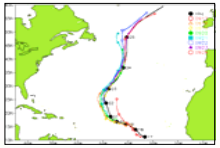



Compared to NCEP T382 (~35km) global analysis at 1200 UTC Aug 29, 2005 (a), high-resolution (0.125º, ~12km) run simulates realistic intensity, radius of max wind and warm core (shaded).

**64 Track and Intensity Forecasts of Intense Hurricanes with no Cumulus Parameterizations**

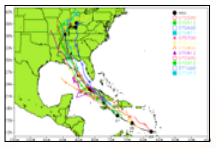


IVAN (CAT-5), 13 runs

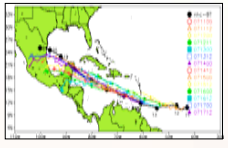


KARL (CAT-4), 8 runs

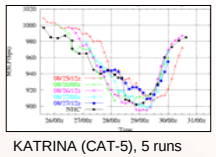
| Res | x | y | # of cells |
|---|---|---|---|
| 0.25º | 1000 | 721 | 721 K |
| 0.125º | 2880 | 1441 | ~4 M |
| 0.08º | 4500 | 2251 | ~10 M |



DENNIS (CAT-4), 12 runs



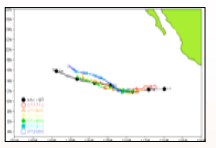
EMILY (CAT-4), 14 runs



RITA (CAT-5), 6 runs



KATRINA (CAT-5), 5 runs



DANIEL (CAT-4), 6 runs

## 4. CONCLUDING REMARKS

The global mesoscale model has been implemented on the NASA Columbia supercomputer and produced promising forecasts for major hurricanes in 2004 and 2005. Our results suggest that realistic intensities and structures of mature hurricanes can be simulated by the 0.125º model without the need for cumulus parameterizations, which are known limiting factors in hurricane simulations with traditional GCMs. More numerical experiments will be conducted on the NASA Pleiades to see if the model can systematically increase the lead time in the prediction of hurricane formation and intensification, which could increase the warning time and as a result save lives and reduce economic damage. Further research will also be conducted with a focus on understanding multi-scale interactions among large-scale flows, mesoscale vortices, surface fluxes, and small-scale convection.

*Selected References and Notes:*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Shen, B.-W., W.-K. Tao, R. Atlas et al., 2009: Hurricane Forecasts with a Global Mesoscale Model on the NASA Columbia Supercomputer, The 2nd SED (Science and Exploration Directorate) Poster Party Blowout, January 21, 2009, Greenbelt, MD. (the second place in the most readable poster category among over 150 posters from Earth sciences to astrophysics).



Acknowledgments:

*We thank Dr. A. Busalacchi of UMCP, and the NSF Science and Technology Center for their support for this study. We would like to thank Dr. C. Henze for visualizations, Drs. J.-D. Chern (GSFC) and Y. Jin (NRL) for valuable discussions. Acknowledgment is also made to Dr. T. Lee at NASA Headquarters, the NASA Advanced Supercomputing (NAS) Division and NASA Center for Computational Sciences for computer time used in this research.*


*Pleiades Supercomputer (ranked 3rd in late 2008) consist of 51,200 cores (with quad-core Xeon 5472 processors) in total, 50+ TB memory, and 500+ TB disk spaces.*