Global model physics

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FY09 Tasks per 23 March 09 email

EMC

- Develop improved surface flux, shallow convection, radiation and cloud microphysics parameterizations for global model

- Tune global and regional physics packages for optimum performance

Goal--mitigate GFS biases in the tropics

New PBL scheme

- Include stratocumulus-top driven turbulence mixing.

- Enhance stratocumulus top driven diffusion when the condition for cloud top entrainment instability is met.

- Use local diffusion for the nighttime stable PBL.

- Background diffusion in inversion layers below 2.5km over ocean is reduced by 70% to decrease the erosion of stratocumulus along the costal area. (Moorthi)

Updated new mass flux shallow convection scheme

- Detrain cloud water from every updraft layer
- Convection starting level is defined as the level of maximum moist static energy within PBL
- Cloud top is limited to 700 hPa.
- Entrainment rate inversely proportional to height and detrainment rate is set to be a constant as entrainment rate at the cloud base.
- Mass flux at cloud base is made a function of convective boundary layer velocity scale.

Updated deep convection scheme

- Random cloud top is not used any more, and cloud water is detrained from every cloud layer of the single cloud.
- Finite entrainment and detrainment rates for heat, moisture, and momentum are specified.
- Similar to shallow convection scheme, entrainment rate is given to be inversely proportional to height in sub-cloud layers and detrainment rate is set to be a constant as entrainment rate at the cloud base.
- Above cloud base, an organized entrainment is added, which is a function of environmental relative humidity.

Planned Radiation Configurations in Future NCEP Models

- GFS 2009:

Radiation:	LW & SW: RRTM (v2.3)
Cloud Overlapping:	LW & SW: Max-rand
Aerosols:	LW & SW: Climatology (5˚x5˚)

- GFS 2010*:

Radiation:	LW & SW: RRTM with McICA sub-grid approx
Cloud Overlapping:	LW & SW: Max-rand or Hybird
Aerosols:	LW & SW: GOCART interactive scheme

- NAM: similar radiation package to GFS

FY09 Tasks per 23 March 09 email

ESRL

Expand physics options for FIM

Tune FIM physics package for 10 km resolution

Activities

ESRL

Implementation of current operational GFS physics into FIM completed and cleaned up, including random generation of cloud-top height in SAS deep convection.

GFS physics ran stably in G8 (30km horizontal resolution), G9 (15km) and G9.5 (10km) versions of FIM and on both the ESRL Jet and NSF TACC computers.

Grell-Devenyi convection and Lin et al microphysics (2-moment cloud and rain) introduced into NEMS-compatible version of FIM and tested.

ESRL Activities, Cont.

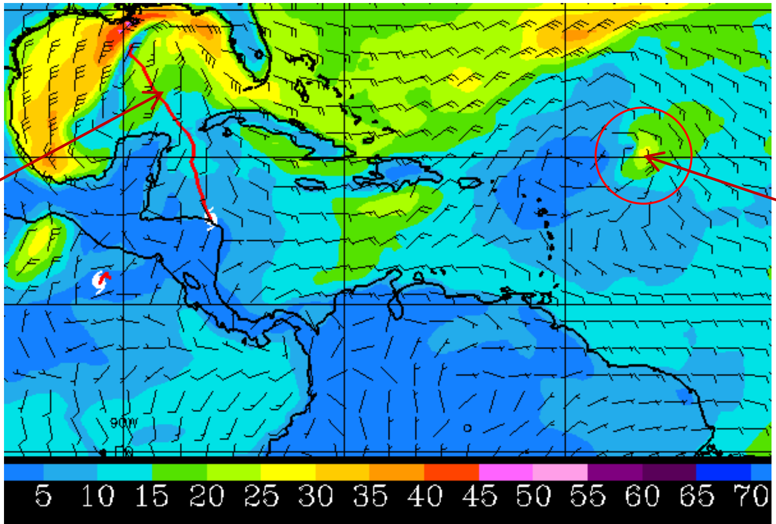
FIM develops more closed cyclonic circulations in Tropical Cyclone genesis regions than the operational global models (except maybe for CMC).

The West Pac and East Pac basins are most prone to these developments.

Preliminary investigation: too large a fraction of model pcpn produced on the grid scale, rather than by the SAS convective scheme (related to GFS pcpn bullseyes problem).

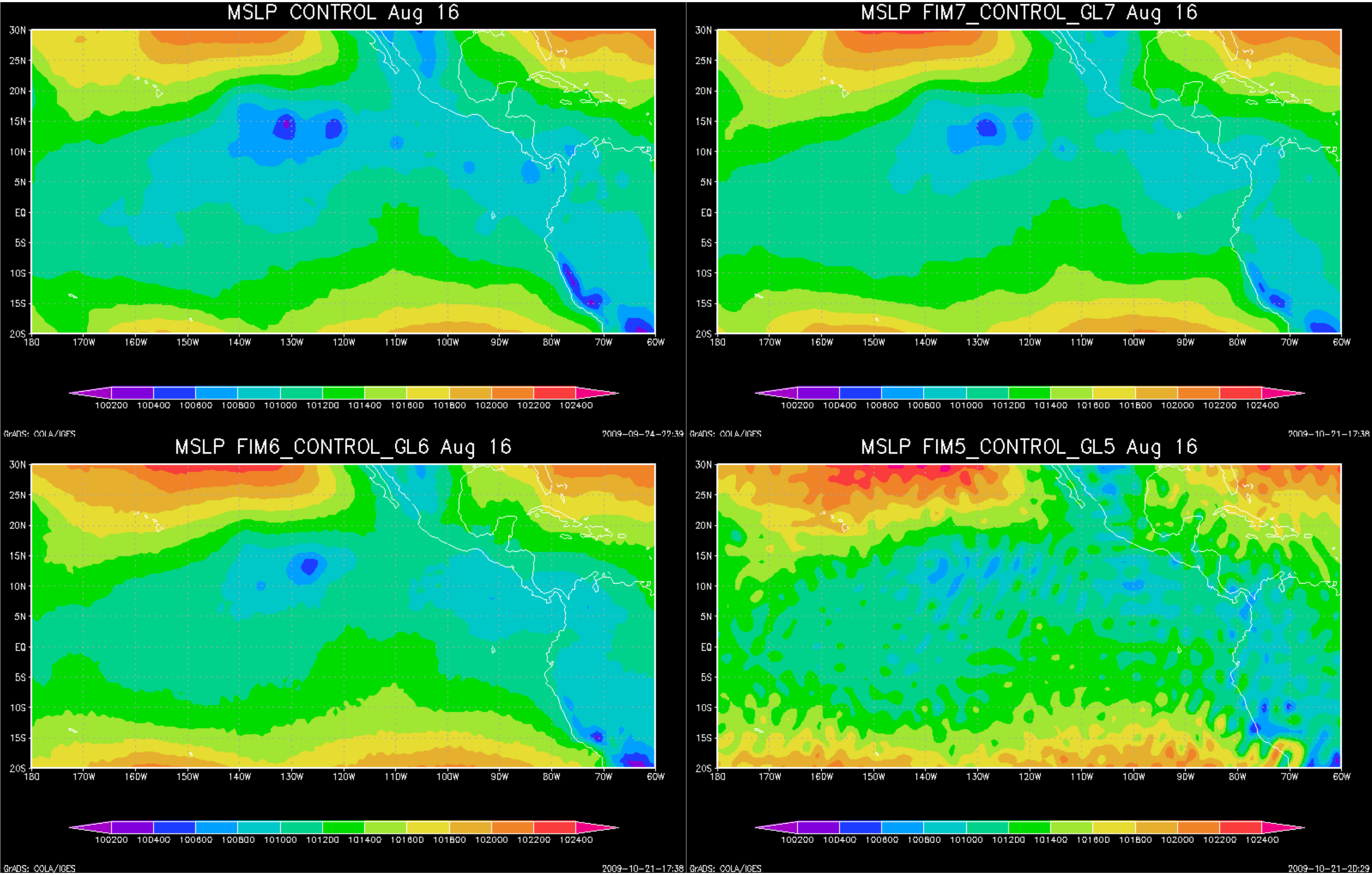
FIM 10m wind 84h fcst from 00z 7 Nov 09

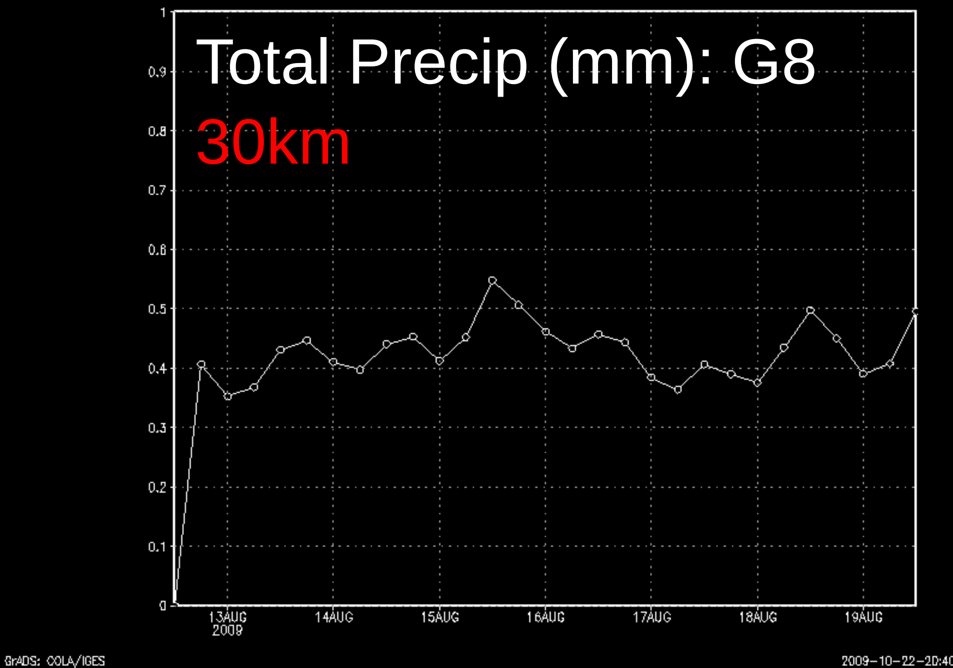
Track of Ida



Spurious circulation?

Mean Sea-Level Pressure (Pa): Valid at 96 H

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GrADS: COLA/IGES
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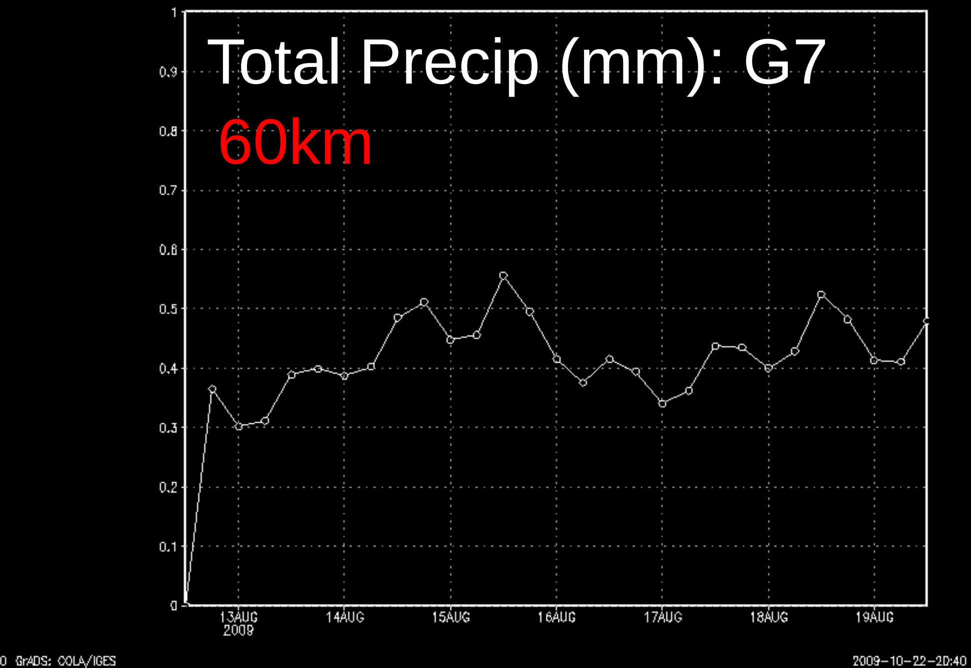
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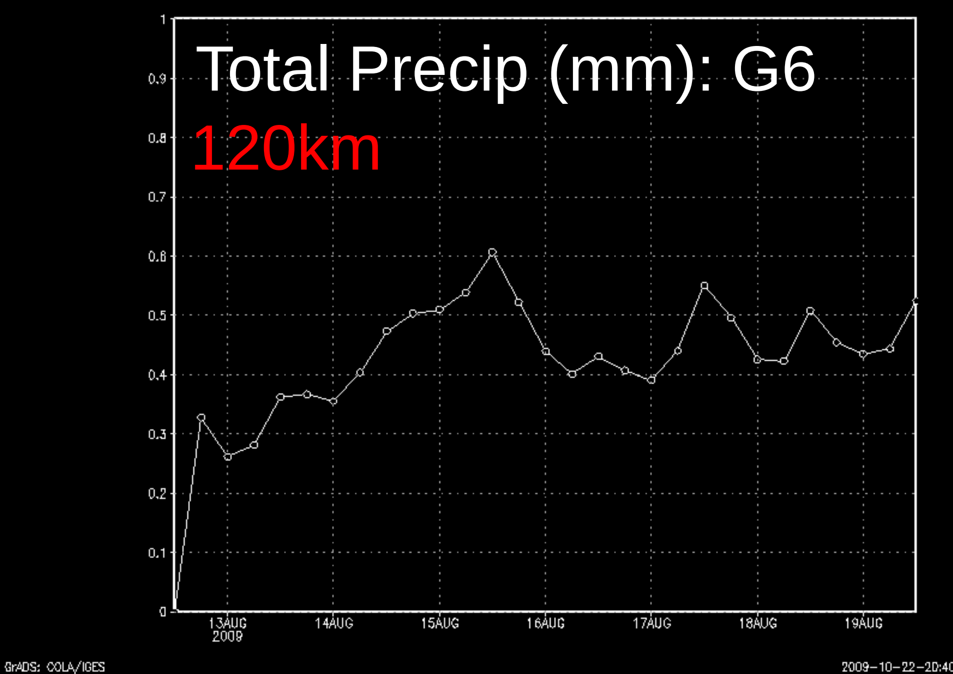
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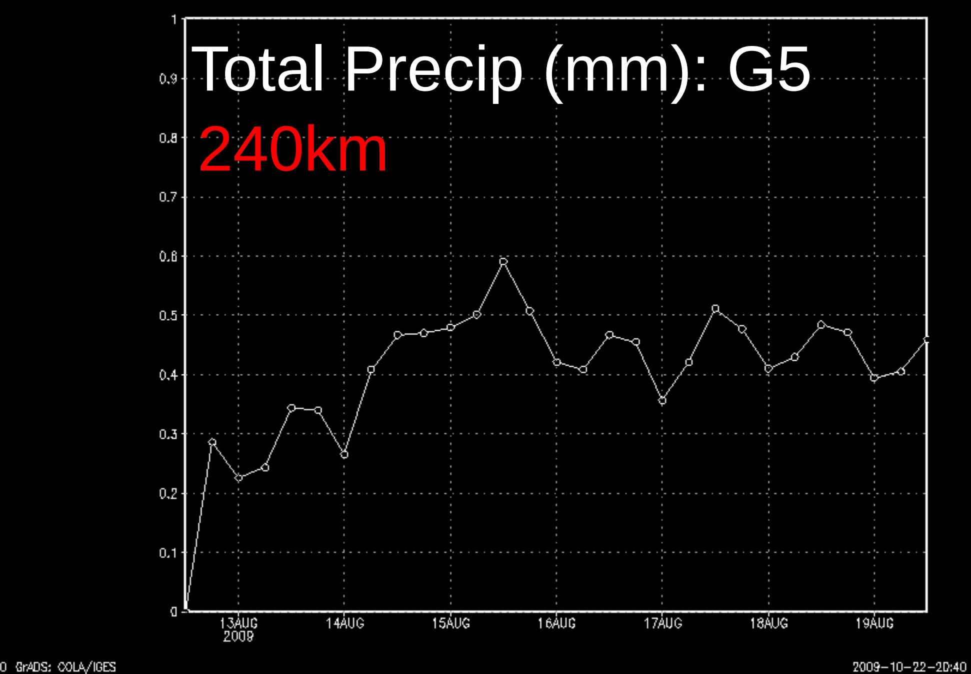
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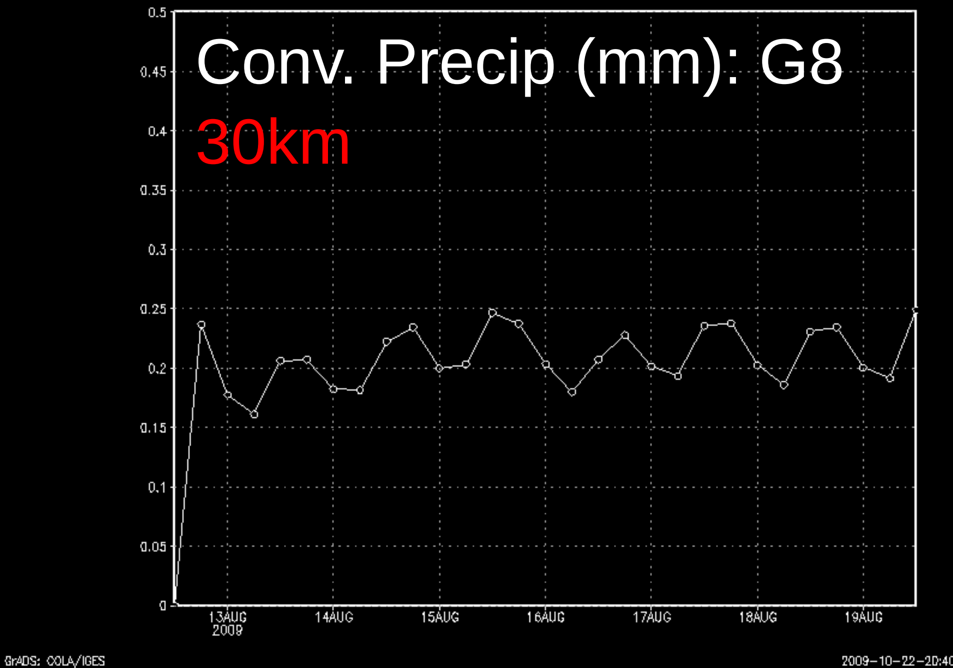
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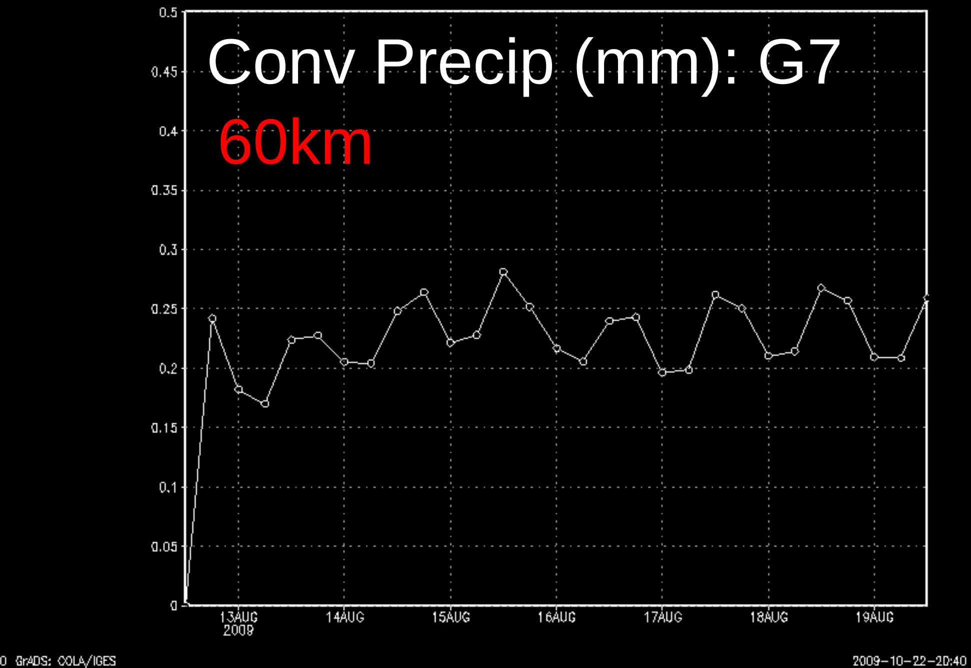
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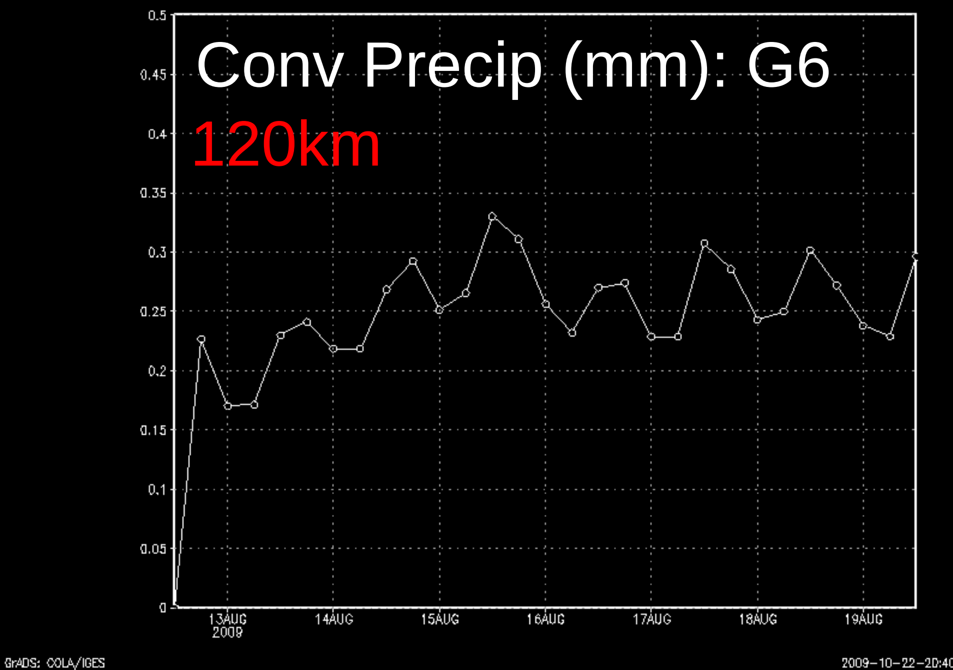
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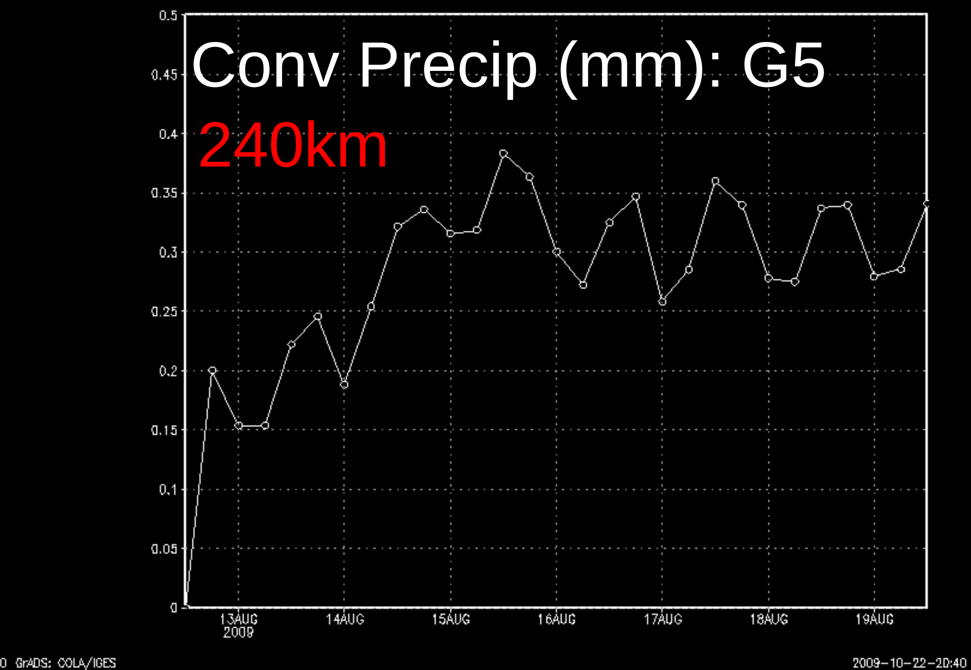
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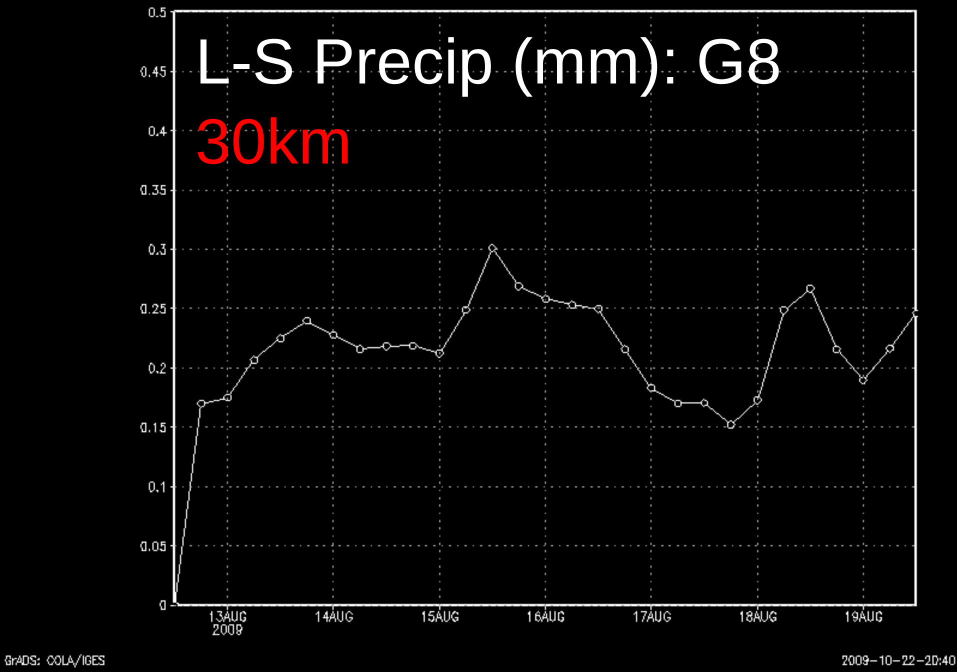
L-S Precip (mm): G8
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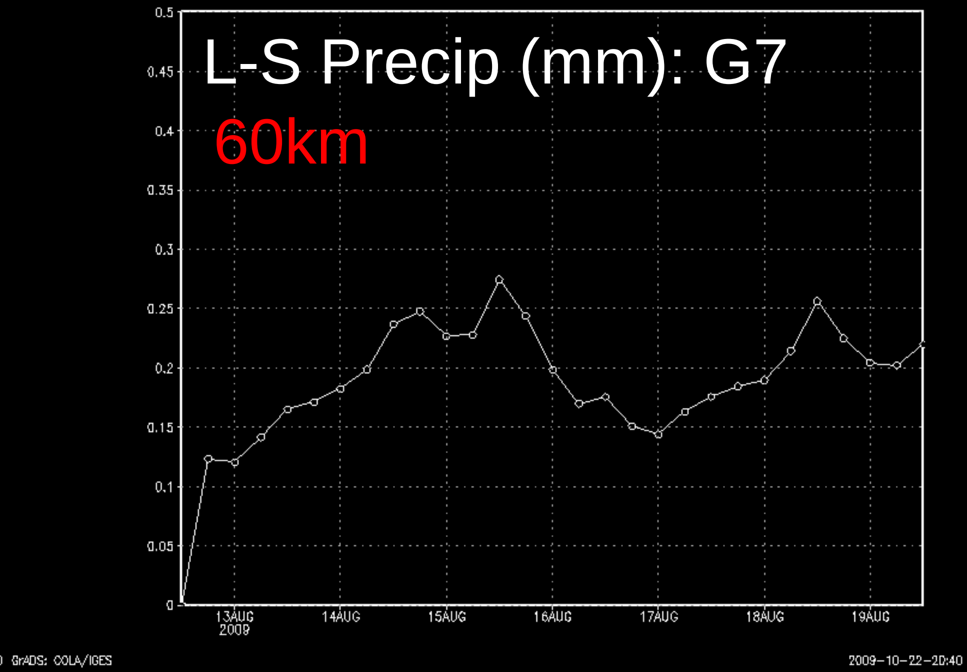
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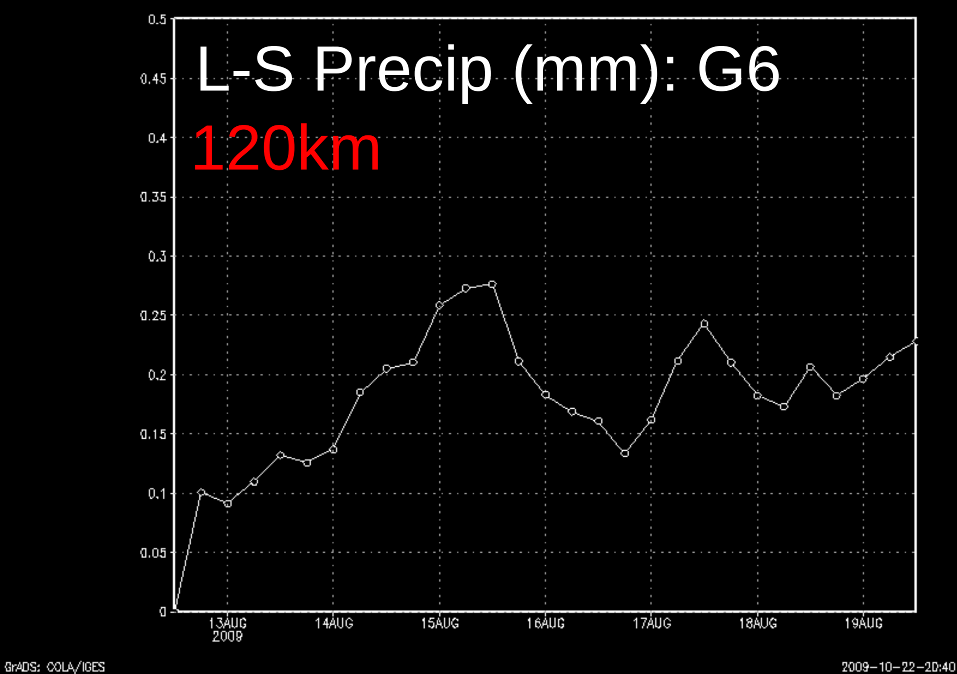
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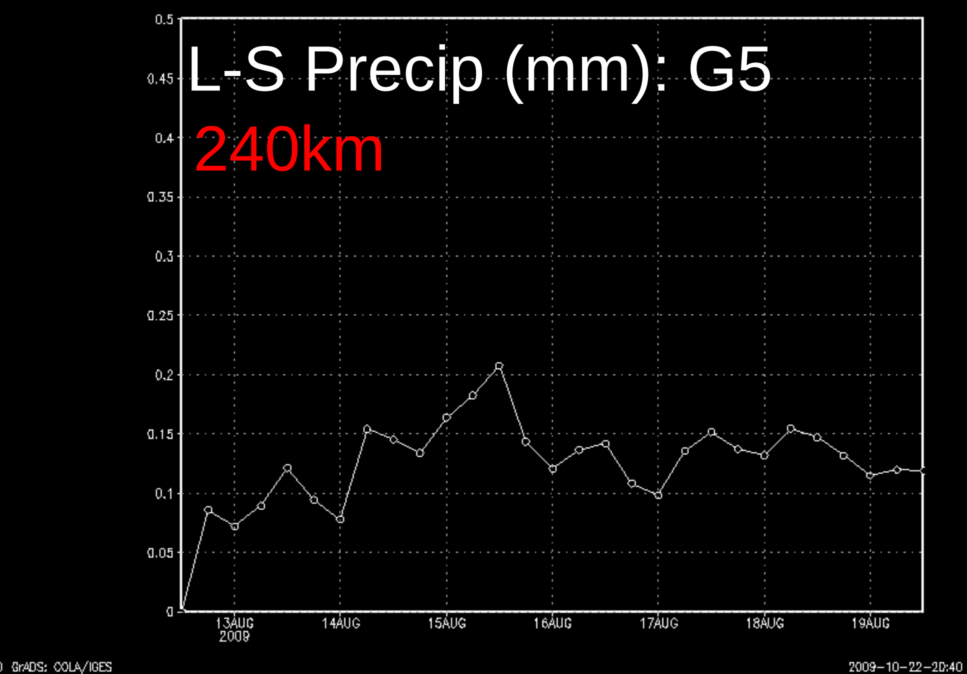
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FY09 Tasks per 23 March 09 email

GFDL

- Improve global physics parameterizations (work with ESRL)

- Test new physics components in Global model. Tune to 10km resolution

GFDL High-Resolution Atmosphere Model Physics

- Developed for 1-100 km resolution
- Shares most physics codes with the GFDL AM2/AM3

****** EXCEPTING ******

- *6-category single-moment bulk cloud microphysics* computational efficiency significantly improved with time-implicit treatment of microphysics processes and vertically Lagrangian terminal fall of all condensate (rain, snow, ice, and graupel). Subgrid cloud formation accounted for using both vertical & horizontal subgrid distributions (with a PDF approach).

(Continued next slide)

GFDL High-Resolution Atmosphere Model Physics (cont.)

- Deep convective parameterization scheme replaced by an essentially *non-precipitating* *shallow* convection scheme (Zhao *et al*. 2009)

- *Surface flux calculation over ocean modified for high winds* (*Moon et al*. 2007)

Global cloud-resolving prototype model
Resolution: C720 (~13-km)
5-day forecast of Wilma (00Z 18 Oct 2005)

FY09 Tasks per 23 March 09 email

NRL

Test new physics components in Global model. Tune to 10km resolution.

NRL NOGAPS Physics Experiments

T. Hogan

- Impact of amount of convective momentum transport on TC track and intensity
- Preliminary results with Semi-Lagrangian formulation of NOGAPS.

In a study Hogan and Pauley (2007) showed the sensitivity the TC track forecasts in the NOGAPS/T239L30 with 3-d variational analysis (NAVDAS) to the amount of convective momentum transport (CMT) in the Emanuel cumulus parameterization. In the current scheme the CMT is based on the work of Gregory, et al. (1997) with an adjustable parameter Cu, and is given by

$$\left(\frac{\partial \overline{\vec{u}}}{\partial t}\right)^{CMT} = Cu\left\{ g\frac{\partial\left(\sum M^u[\vec{u}^u - \overline{\vec{u}}]\right)}{\partial p} + g\frac{\partial\left(\sum M^d[\vec{u}^d - \overline{\vec{u}}]\right)}{\partial p}\right\}$$

where $\overline{\vec{u}}$ = mean vector wind

M^u = upward mass flux

M^d = downward mass flux

$\vec{u}^u$ = upward sub-grid updraft given by entrainment calculation

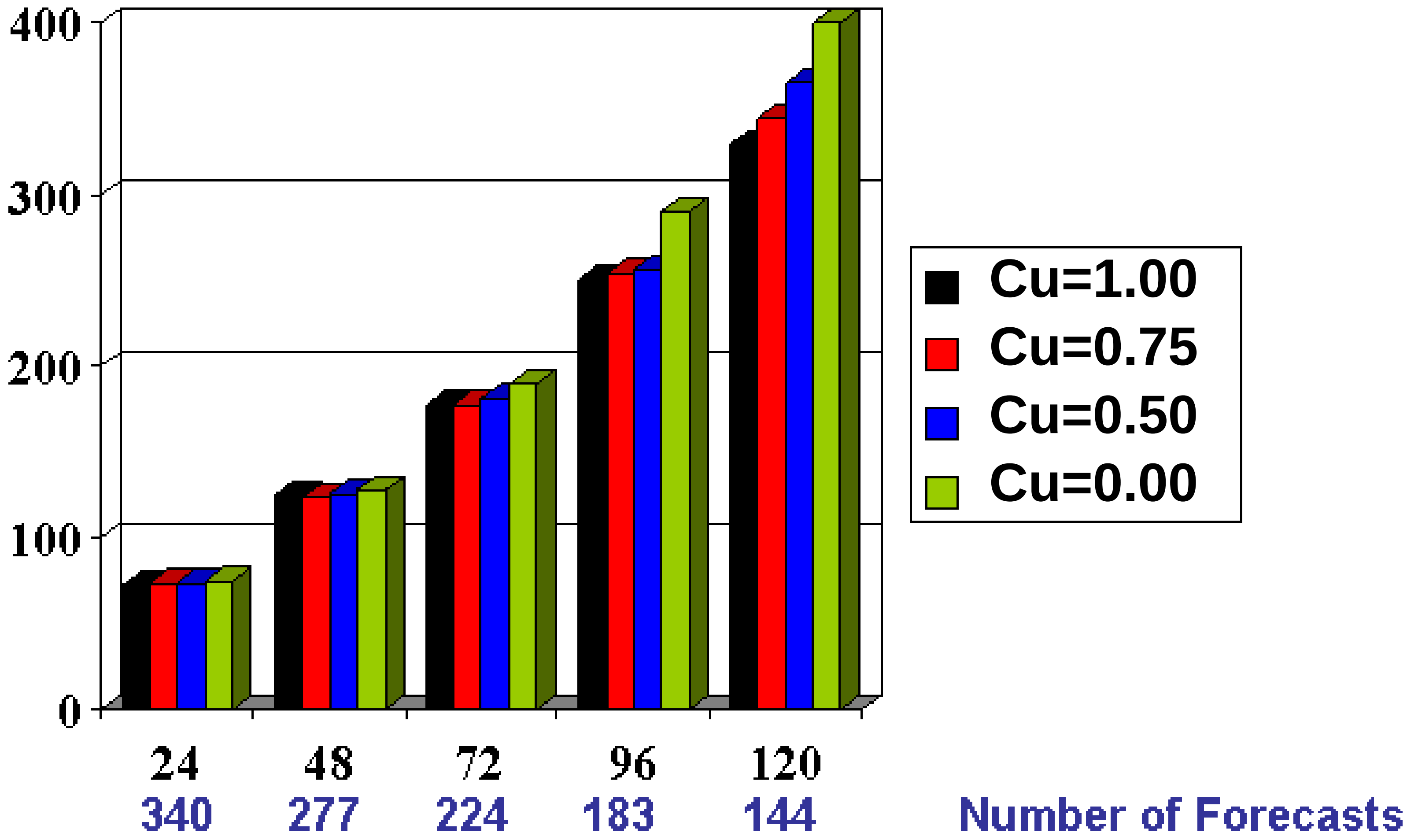
$\vec{u}^d$ = downward sub-grid updraft given by momentum conservation

Gregory, D., R. Kershaw, and P. M. Inness, 1997: Parameterization of momentum transport by convection: II Tests in single-column and general circulation models. *Q. J. R. Meteor. Soc.,* **123**, 1153-1183.

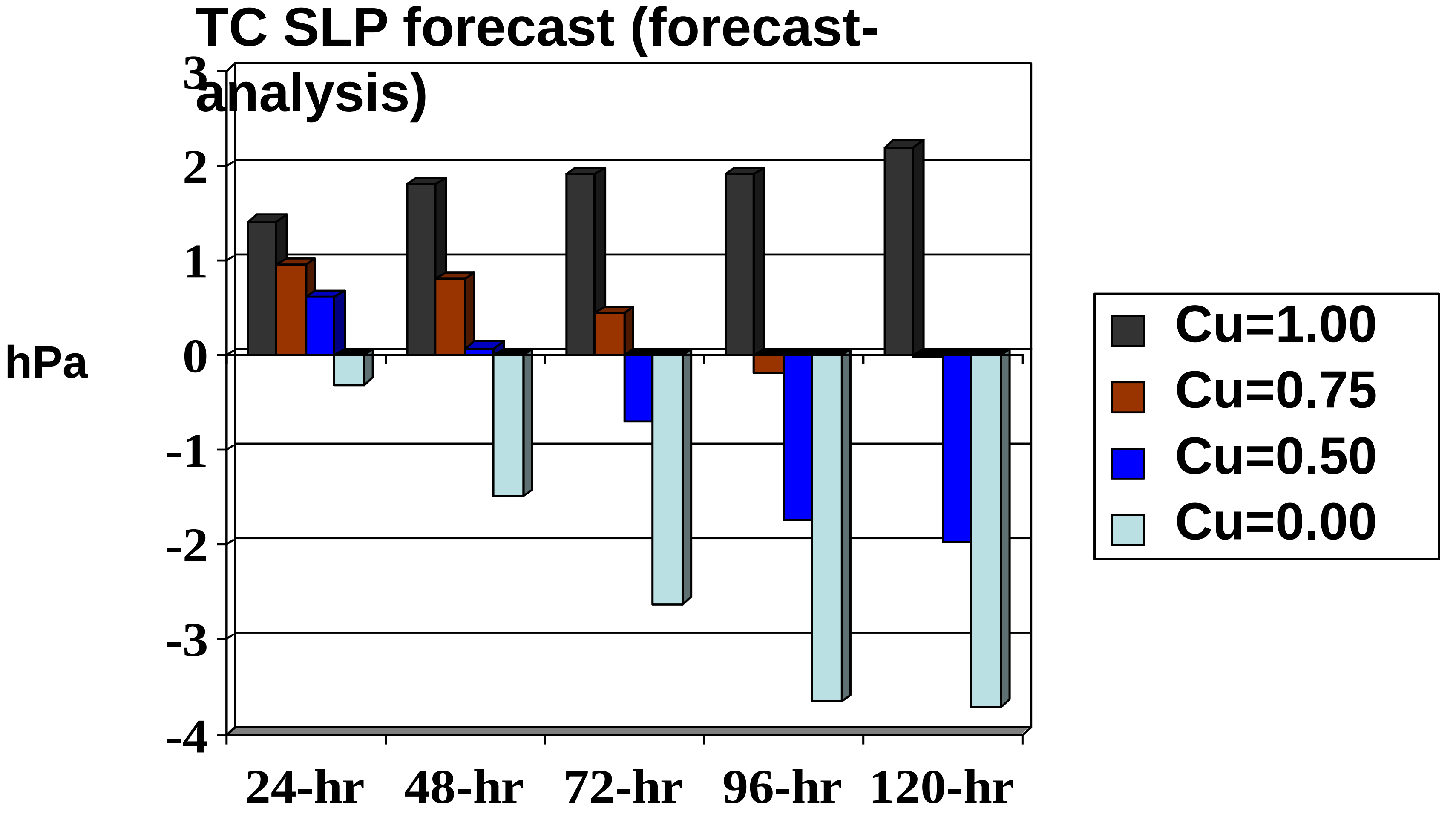
Hogan, T.F. and R.L. Pauley 2007: The impact of convective momentum transport on tropical cyclone track forecasts using the Emanuel cumulus parameterization", *Mon. Wea. Rev*., **135**, 1195-1207.

CMT (Cu) Data Assimilation Experiment Results

TC Forecast Error (nm)
1 August 2004 – 30 September 2004



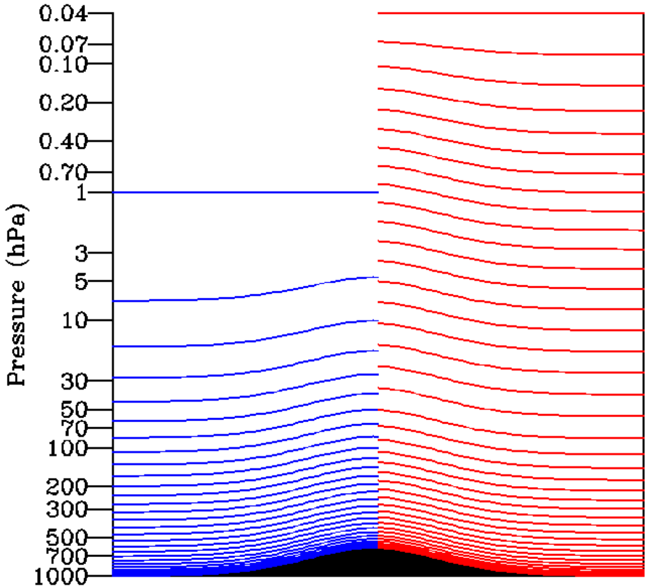
Without CMT the T239L30 NOGAPS over-deepened the forecast central sea level pressure of the TCs relative to the analysis values (fcst-anal < 0), while with CMT the central pressure was under-forecast (fcst-anal > 0).



The mean difference (hPa) of the forecasted TC central sea-level pressure and the analyzed TC central sea-level pressure vs. forecast hour for the four CMT experiments for all TCs between 1 Aug 2004 – 30 Sep 2004.

Since 2004, the operational value for Cu has been 0.75. In September 2009, the global 4-d variational analysis NAVDAS/AR became operational and NOGAPS vertical resolution was increased to 42 levels (T239L42) with a model top increase to 0.04 hPa (71 km).

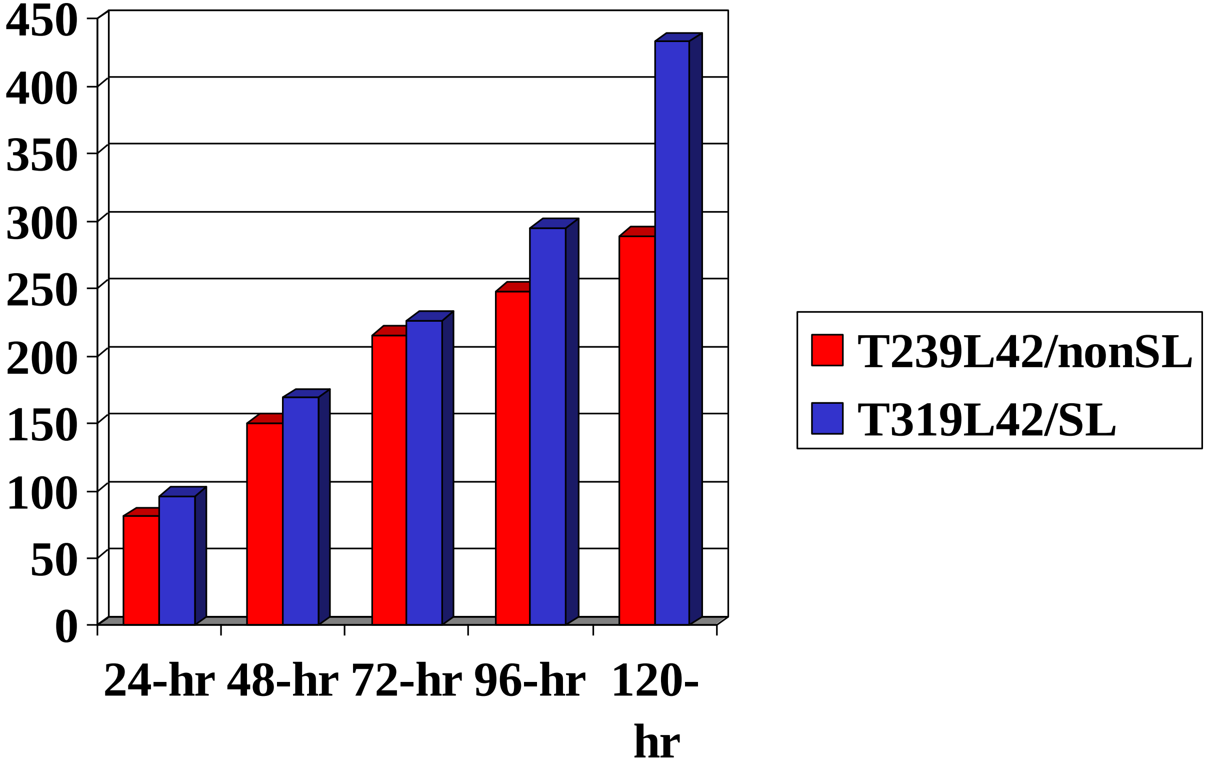
Vertical Structure of the L42 NOGAPS/NAVDAS/AR



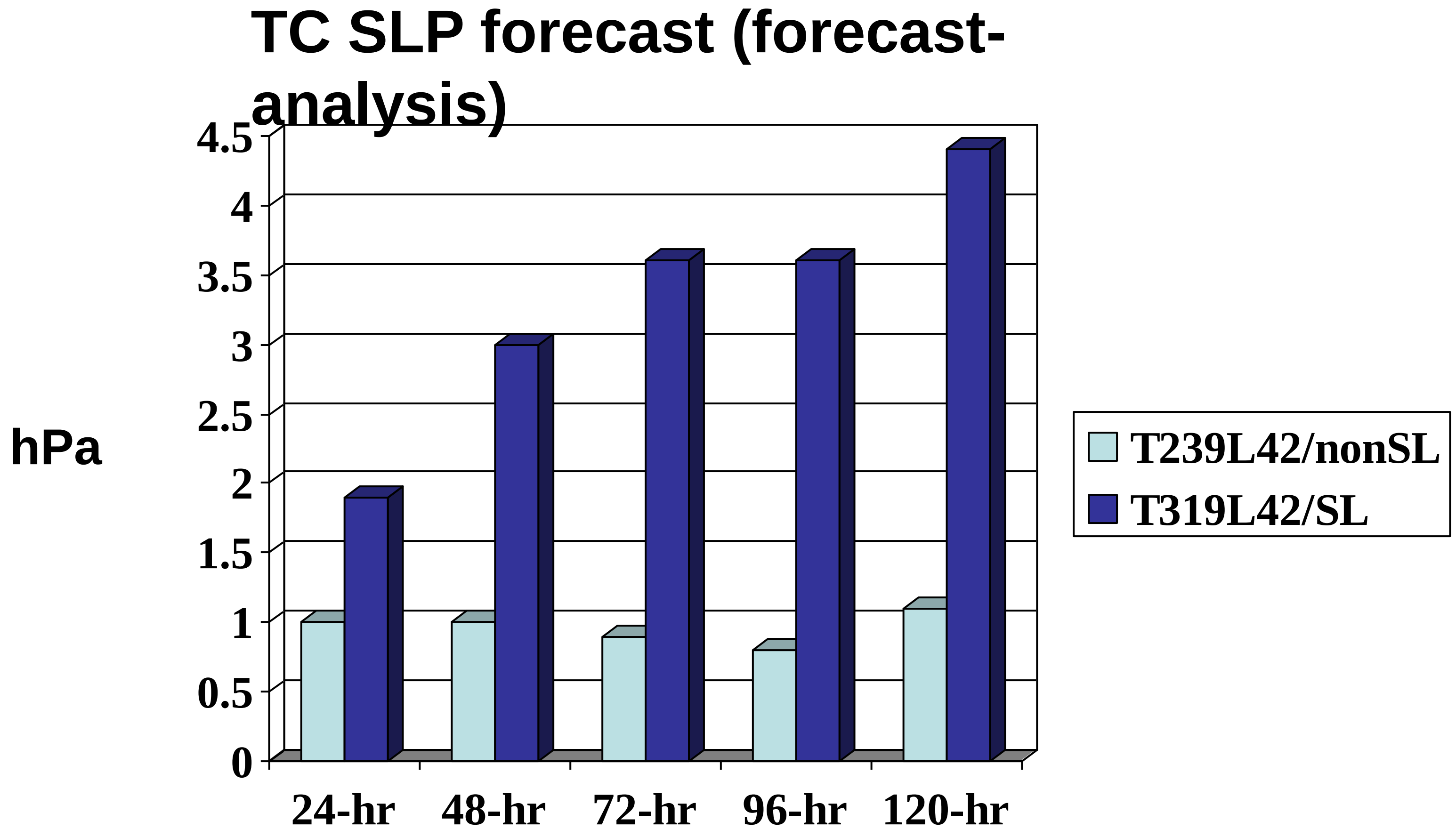
Testing is now underway with the 3-time and 2-time level semi-Lagrangian/semi-implicit (SL) NOGAPS. At T319L42 the 3-time level NOGAPS/SL/SI with a time step of 450 s (vs. 150 for non SL) with the current Emanuel parameterization CMT has a poor TC track performance (next 2 slides). It appears that Emanuel CMT needs either adjustment of the parameters or a new formulation, as the Robe and Emanuel (2001) formulation (J. Atmos. Sci., 58, 1427-1445).

TROPICAL STORM TRACK ERROR

July 1, 2009 – August 22, 2009



No of verifications: 130 96 66 42 22



The mean difference (hPa) of the forecasted TC central sea-level pressure and the analyzed TC central sea-level pressure vs. forecast hour for all TCs between 1 July 2009 – 22 August 2009. The current explicit CMT in the higher resolution, larger time-step NOGAPS SL clearly under forecasts the SLP of TCs.

NRL Summary

- A 3-time and 2-time level with reduced Gaussian grid NOGAPS SL development is near completion,
- Data assimilation testing has just begun with NOGAPS SL with NAVDAS/AR,
- Adjustments in the current physics will be necessary for improved skill,
- Explicit liquid/ice water parameterization studies are planned,
- Transition to higher horizontal and vertical resolution will depend on positive results of data assimilation tests (skill must be better based on FNMOC's score card) and runtime criterion for operations (less than ~5 minutes per forecast day).

Discussion points and Challenges

What are known deficiencies in global model physics?

- Generally recognized difficulties
- Specific to particular physics suites

Strategies for identifying physics problems and distinguishing them from other issues (dynamical core, assimilation)

Coordination between groups for most effective progress