Simulation of rapid intensification of Hurricane Kenna (1992) using WRF model

-Preliminary results

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1. Introduction
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3. Simulations from WRF model – Preliminary results
4. Summary

1. Introduction

- TC track forecasts (models or official) are much skillful than TC intensity forecasts (Kaplan et al 2003, Gross 2001), the intensity forecast errors mainly from intense hurricane such as category 4 and 5.

- The category 4 and 5 hurricane at least underwent once rapid intensification (maximum surface wind increased 30knots with 24h(Kaplan et al 2003) at least once during their life cycle.

- The rapid intensification has been challenging such as Opal(1995) (Bosart et al 2000, Hong et al 2000,Persing et al 2002, Shay et al 2000)

- Factors effecting the RI forecasts

  > Limited understanding on the mechanism of RI (under-laying ocean, inner-core processes, environmental interaction)

  > Model resolution

  > Physical parameterization

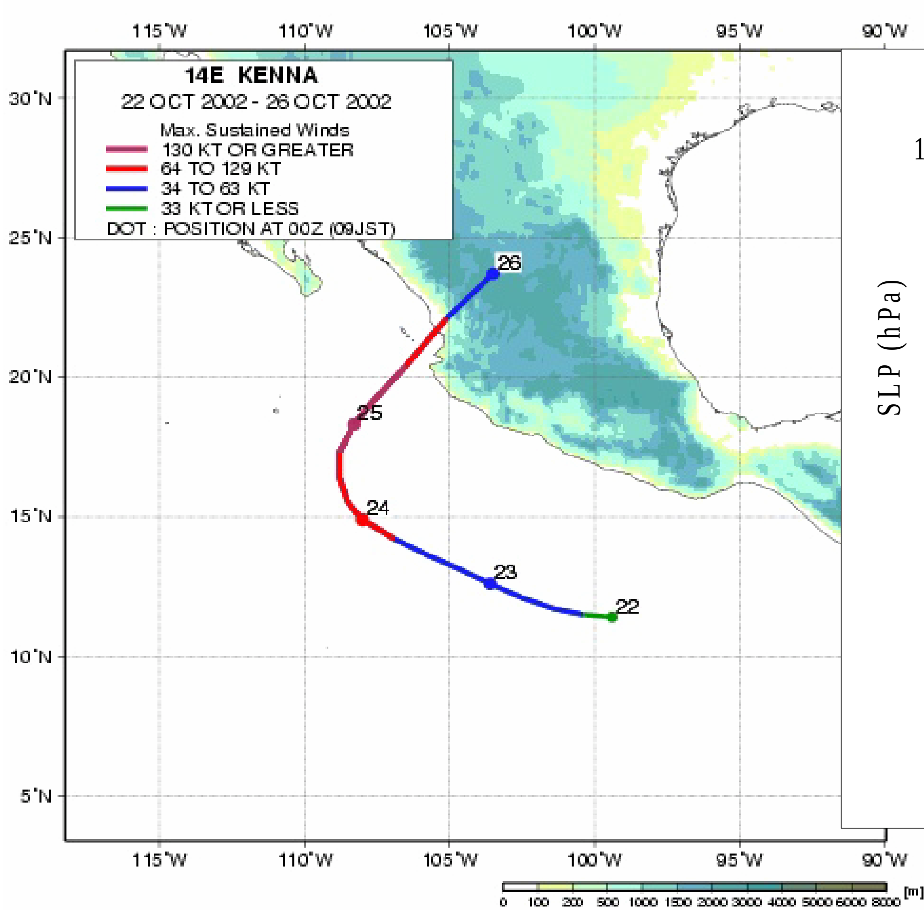
  > initial condition

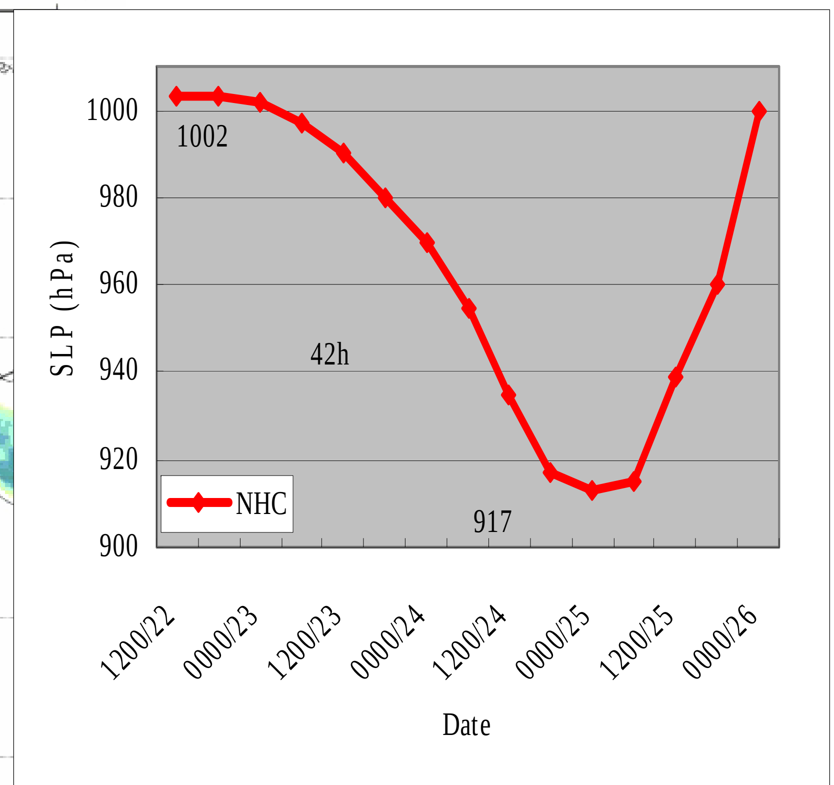
➢ Objective of this study

> The performance of WRF on the simulation of RI of Hurricane Kenna

> If WRF model has a good performance , Some sensitive studies and budget analysis concerning the RI of Hurricane Kenna will be carried out

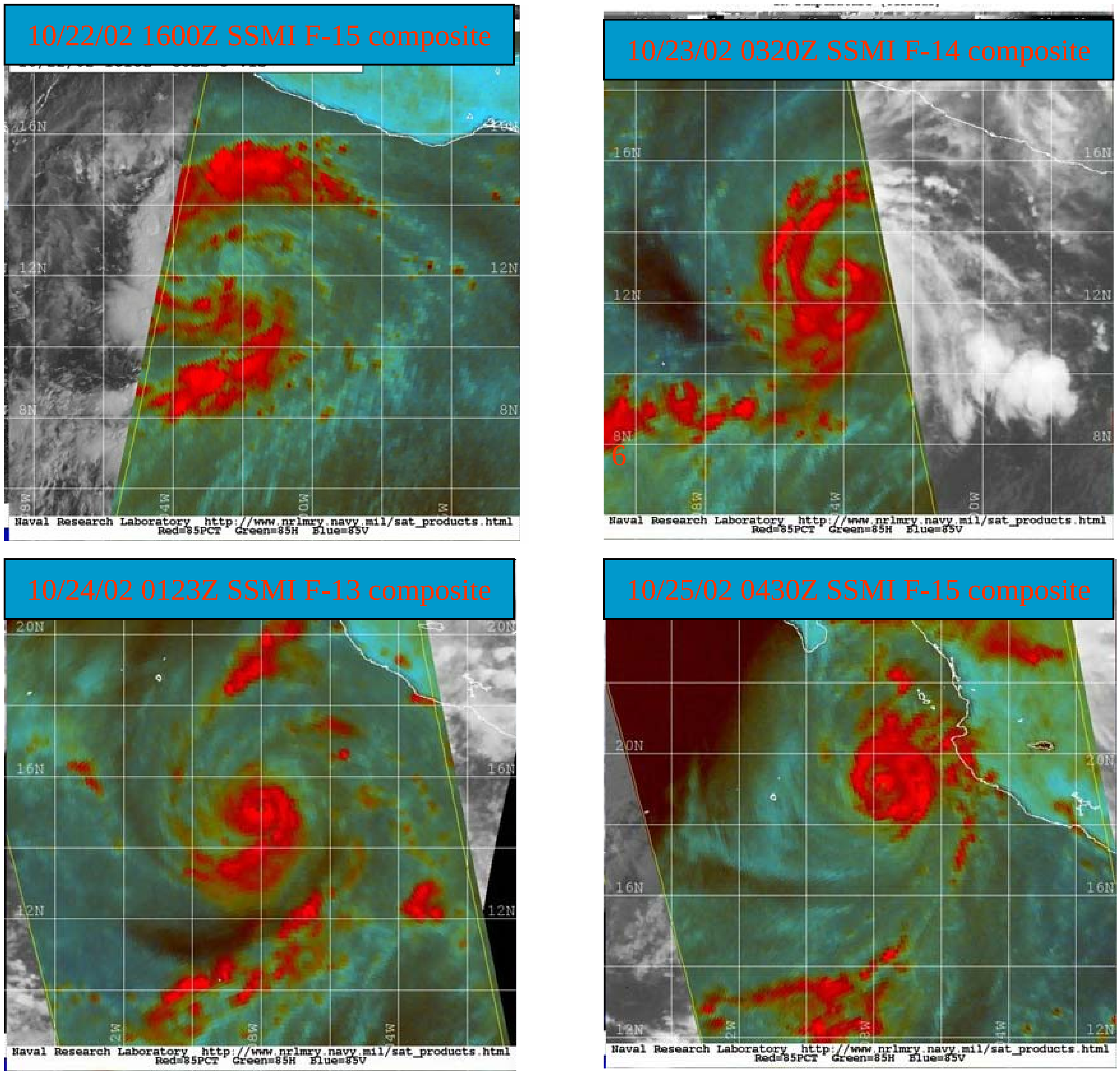
2. Overview of Hurricane Kenna





Hurricane Kenna, the sixteenth tropical disturbance of the 2002 eastern Pacific hurricane season, explosively intensified from a tropical storm to a Category 5 hurricane within 42 hours. The central SLP decreased from 1002hPa to 917hPa and maximum wind speed increased from 40knots to 145knots. On Friday, October 25, Hurricane Kenna made landfall over the western Mexican coast as a Category 4 storm (maximum wind 120knots). Kenna was born in the warm tropical waters of the eastern Pacific south of Mexico on October 22 to become the strongest storm to threaten the Americas in 2002

Hurricane Kenna underwent big structure changes during RI, Images from SSM/I.



3.Simulations from WRF model

3.1 Discription of the WRF simulation

* Twice nested (27km/9km), fixed domains
* Vertical level 31
* Initial condition and lateral boundary condition from NCEP reanalysis dataset (1^{o}* 1^{o})
* No Bogus vortex added

3.2 Configuration of simulations (6)

Date	Cumulus convection	Boundary layer
2002-10-22:1200UTC	Kain-Fritsch	Mellor-Yamada-Janjic
	Kain-Fritsch	YSU
	Betts-Miller-Janjic	Mellor-Yamada-Janjic
	Betts-Miller-Janjic	YSU
	Grell-Devenyi	Mellor-Yamada-Janjic
	Grell-Devenyi	YSU

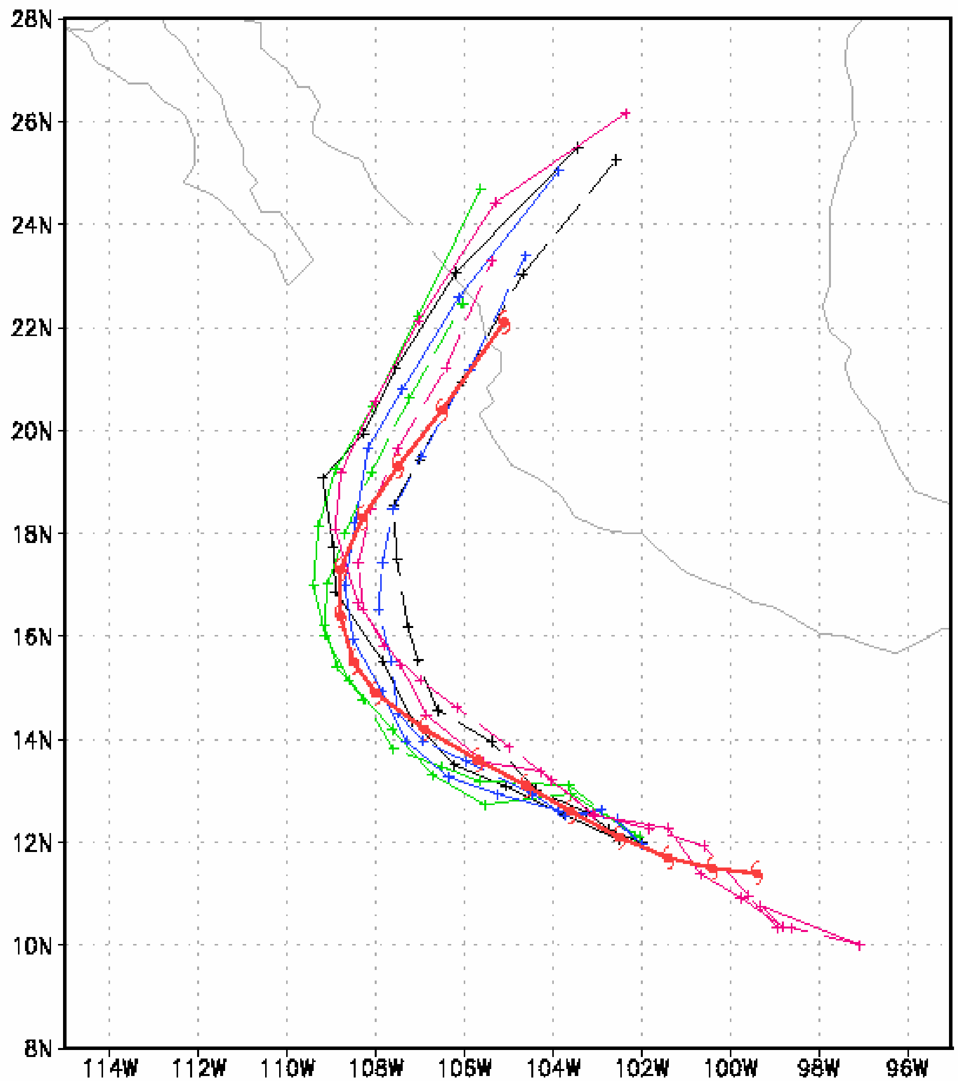
The other physics:

Microphysics :Ferrier(new Eta);

Radiation : RRTM, Dudhia

3.3 Results

Tracks from WRF simulation

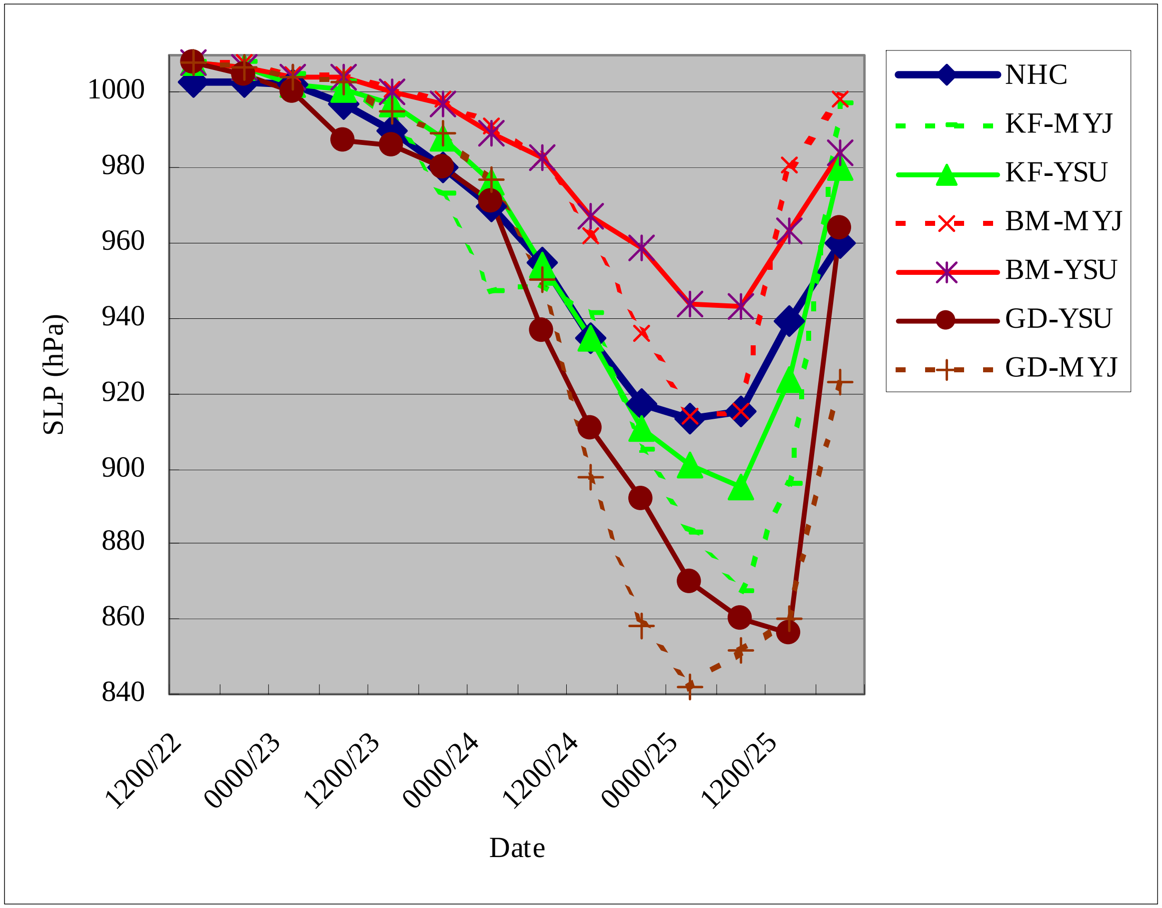


Dashed-lines :MY

Solid-lines : YSU

Different color : different cumulus

Central sea level pressure (hPa)

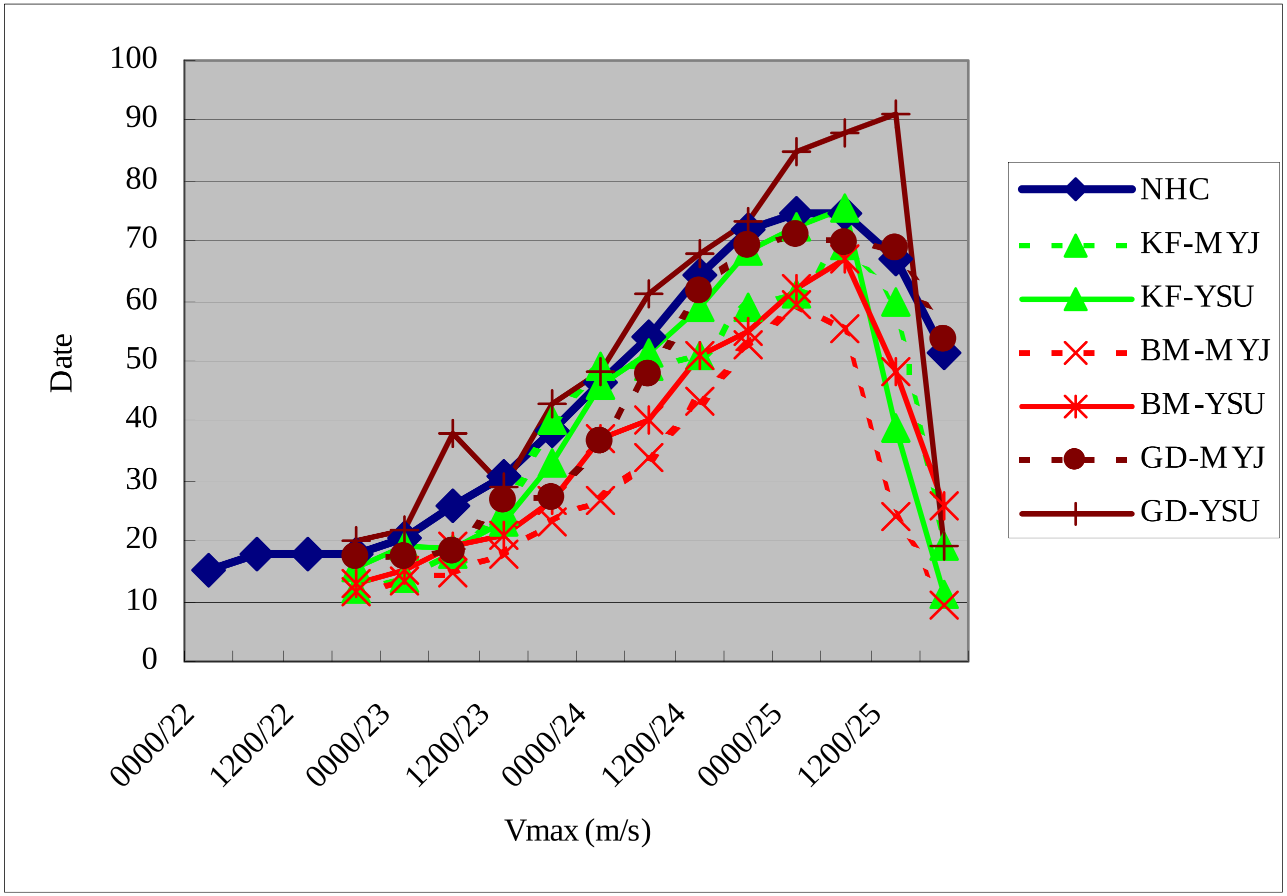


1,same CU, Mellor-Yamada intense hurricane

2, same boundary layer

Grell-Devenyi .Kritsch BM

Maximum surface winds



Summary of the simulations

- All the simulations could simulate the RI of Hurricane Kenna
- All the simulation except the two with BM overestimated the intensity from the point of minimum sea level pressure
- All the simulations with Mellor-Yamada boundary layer scheme tend to simulate a stronger Kenna from the point of the minimum sea level pressure, but weaker from the point of the maximum surface winds compared with those with YSU
- The simulated tracks are reasonably good,the simulations with MYJ tend to produce eastward shift tracks compared those with YSU

What caused the big differences?

The different cumulus schemes

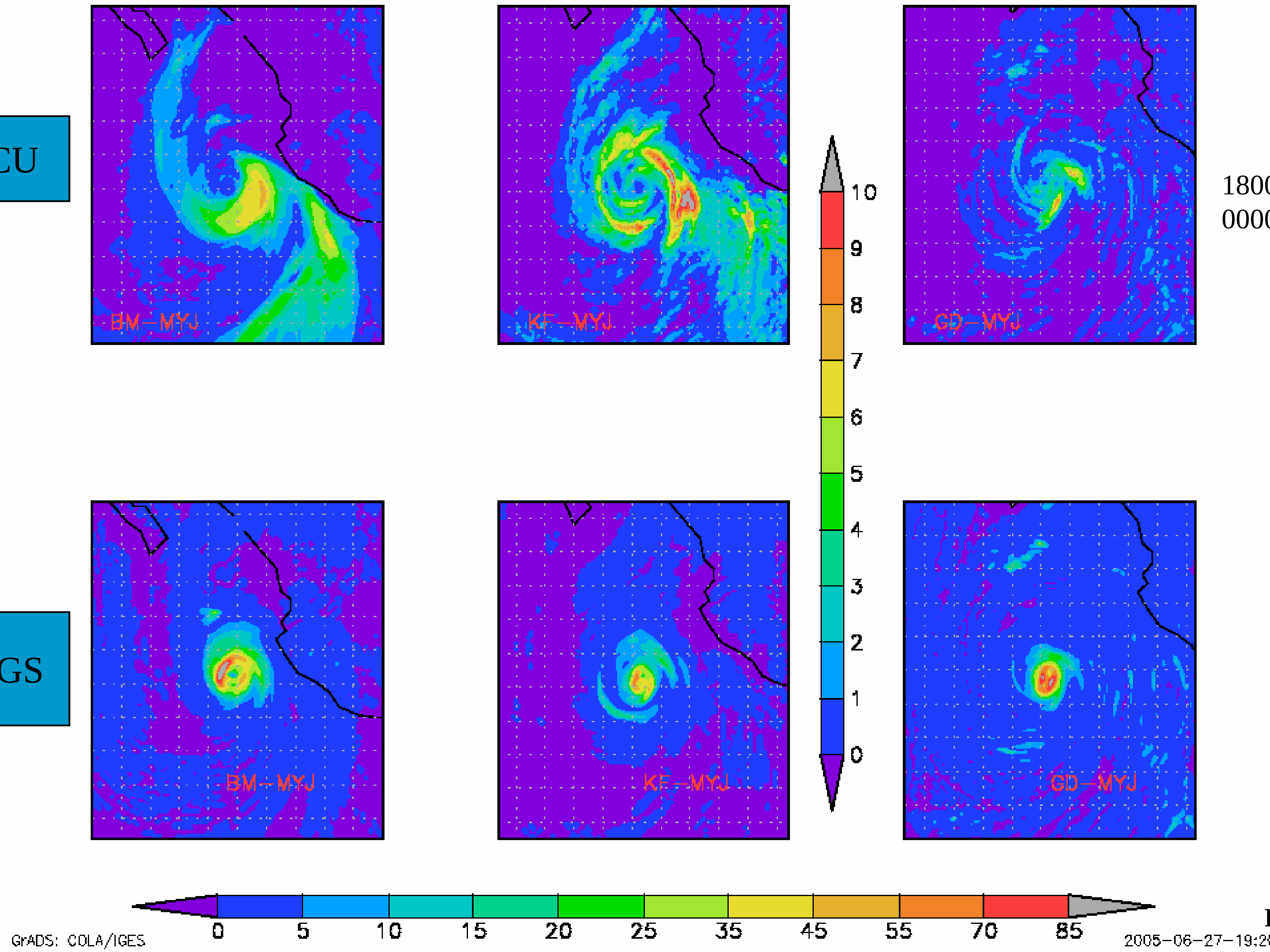
The different boundary layer schemes

The different tracks,Intensity ,structures

Same boundary layer, Different Cumulus (3h average)

CU

GS



1800UTC24-
0000UTC25

mm/h

3h averaged precipitation :top panel is for the cumulus convection precipitation, low panel is for the grad scale precipitation(mm/h)

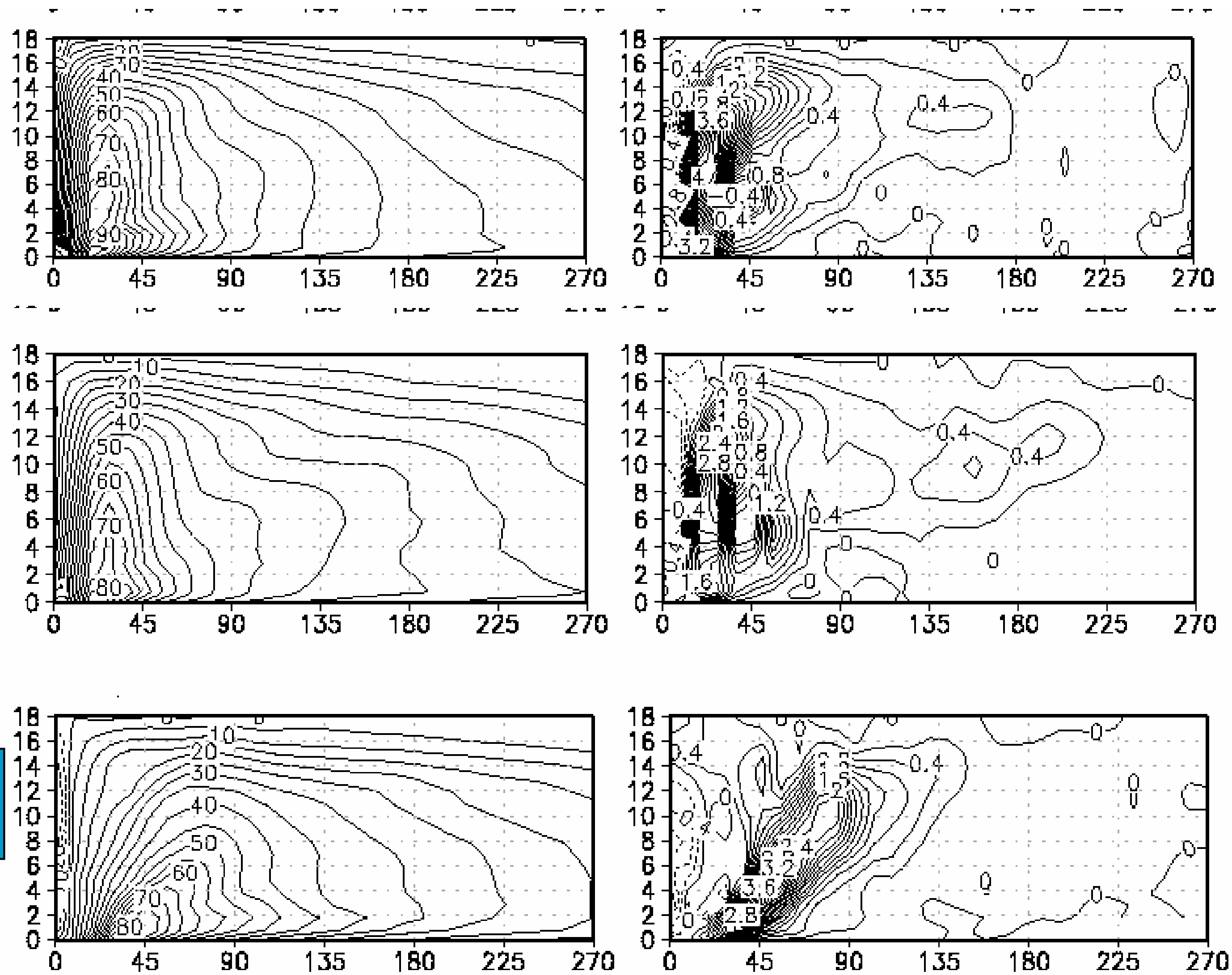
Same boundary layer, different cumulus (000UTC25)

MYJ

GD

KF

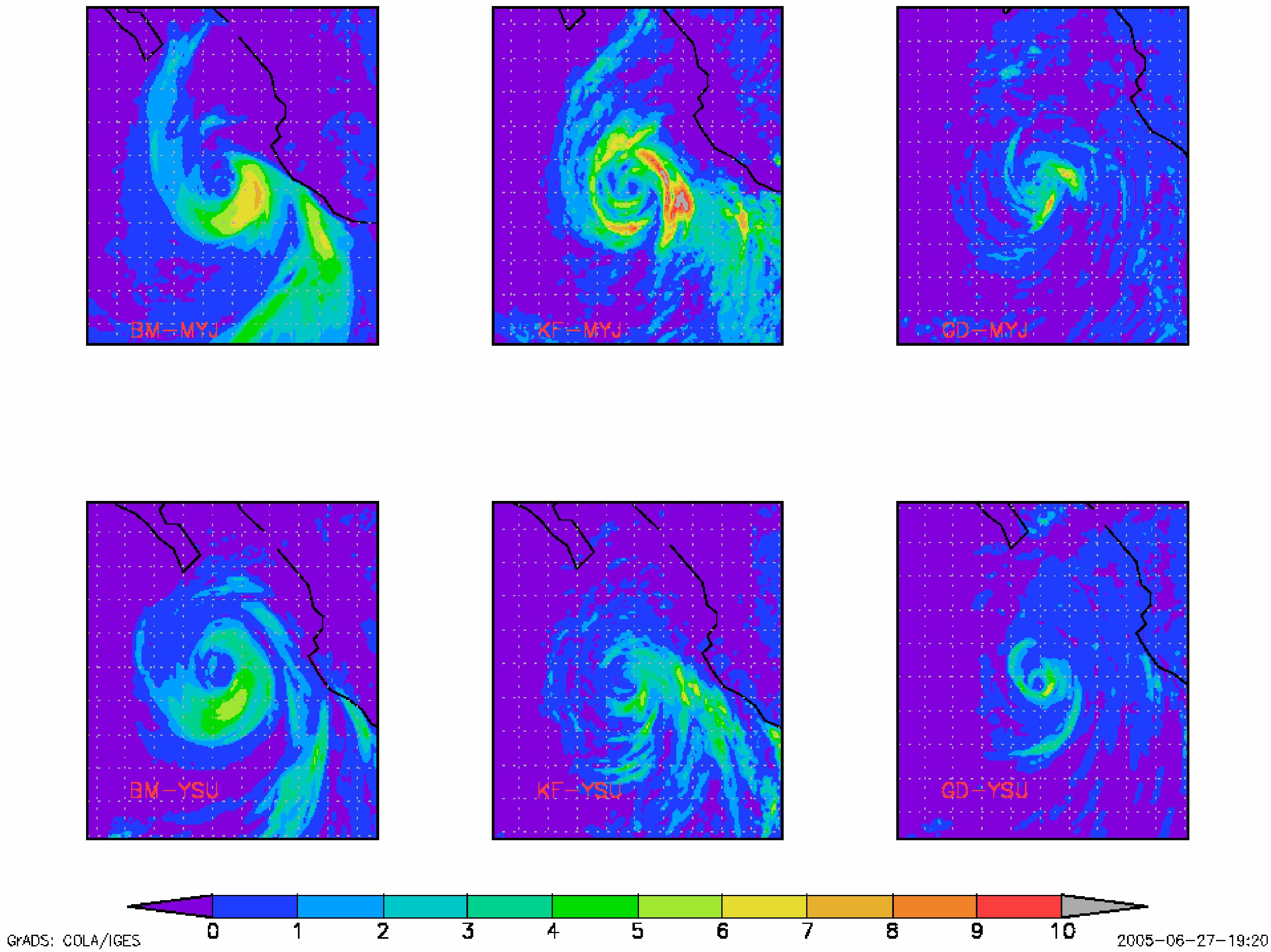
BM



Vertical cross section of azimuthally averaged tangential velocity and vertical velocity , for tangential wind, the interval is 5m/s, for vertical velocity, the interval is 0.2mm/s

Same cumulus, different boundary

(1800UTC24-0000UTC25)



3h averaged cumulus convection precipitation :top panel is for MYJ, low panel is for the YSU(mm/h)

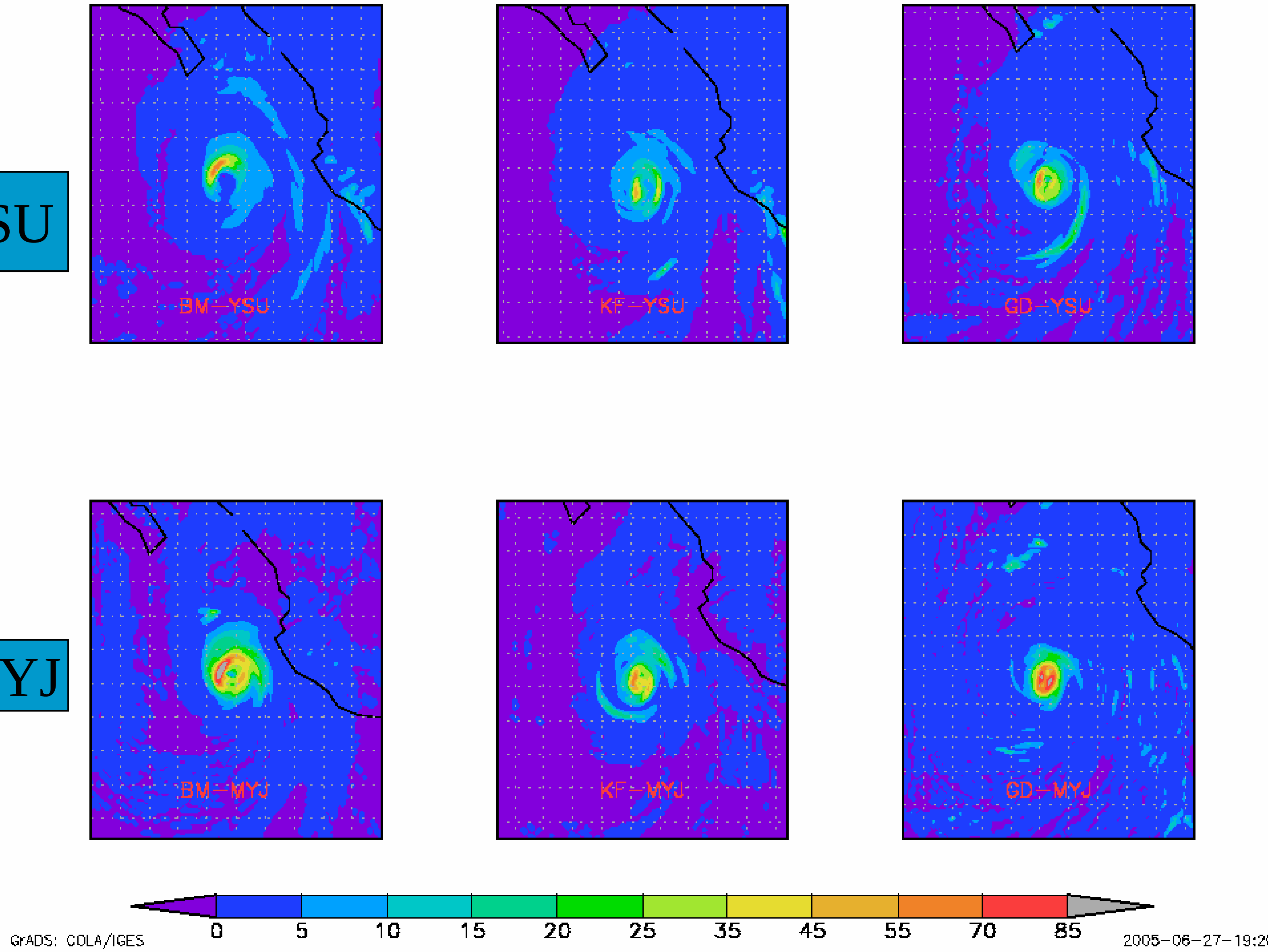
mm/s

Same cumulus, different boundary

(1800UTC24-0000UTC25)

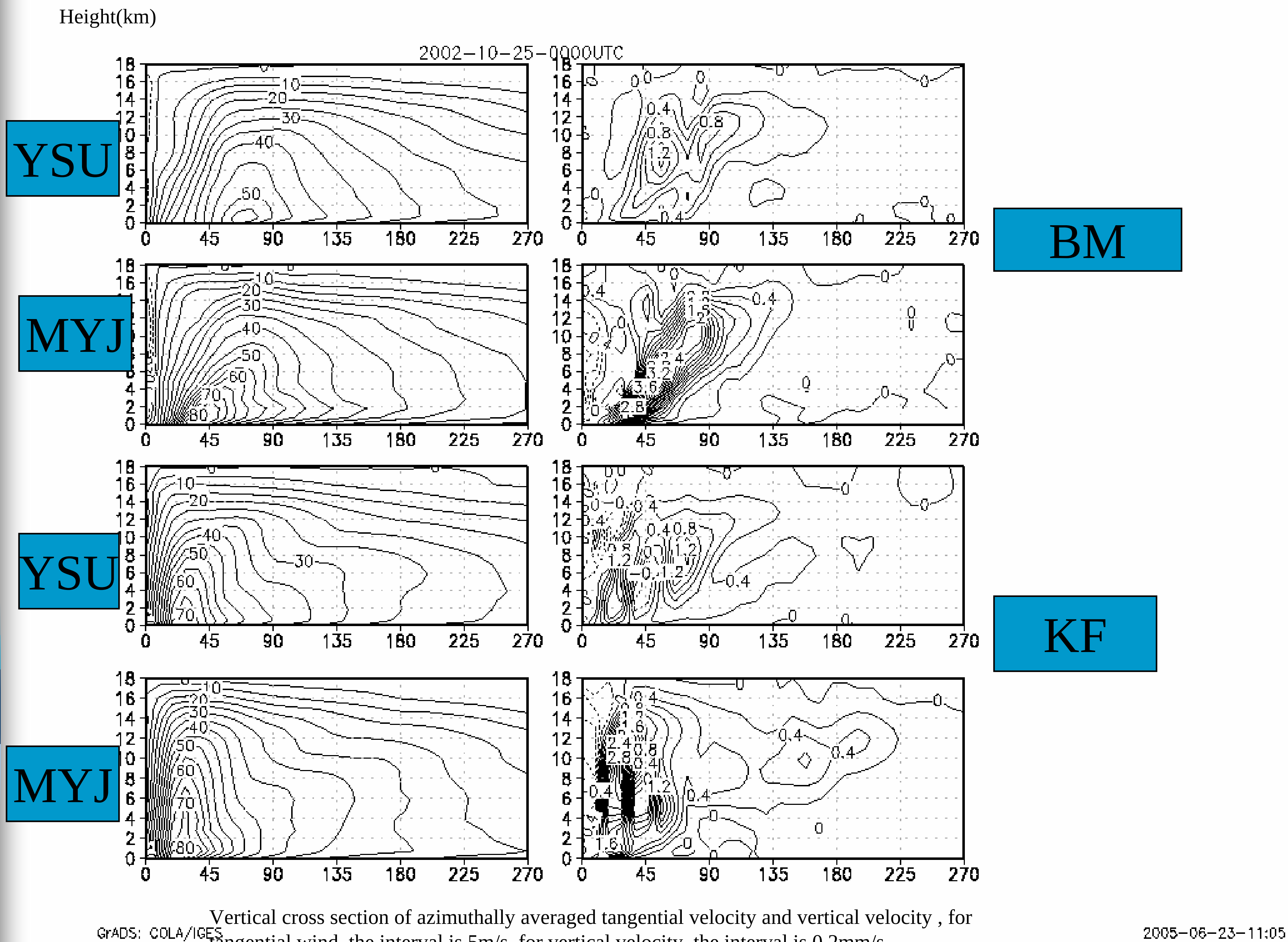
YSU

MYJ



3h averaged grad scale precipitation :top panel is for YSU, low panel is for the MYJ(mm/h)

Same cumulus, different boundary



Vertical cross section of azimuthally averaged tangential velocity and vertical velocity , for tangential wind, the interval is 5m/s, for vertical velocity, the interval is 0.2mm/s

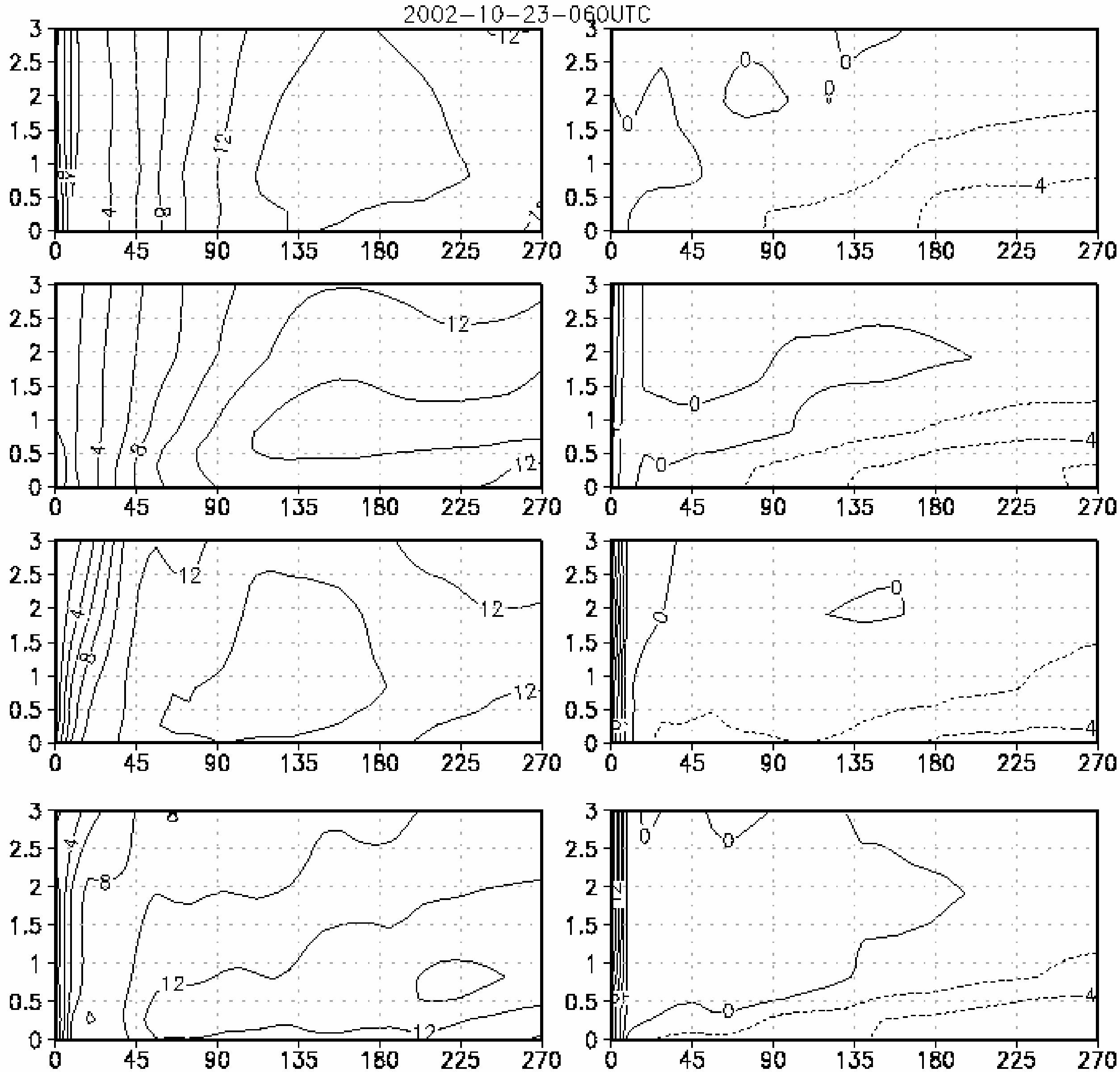
Why MYJ tend to produce a stranger Hurricane compared with YSU but weaker 10m wind)

YSU

MYJ

YSU

MYJ



BM

KF

Tangential velocityVertical gradient much larger than YSU

Raidial flow stronger than YSU

Vertical cross section of azimuthally averaged tangential velocity(left panel) and radial velocity (right panel), for tangential wind, the interval is 2m/s, for radial velocity, the interval is 2m/s

GrADS: COLA/IGES

2005-06-23-15:22

Summary of the preliminary analysis

Under the same boundary layer scheme

➢ Precipitation:BM tend to produce much smoother and stronger cumulus precipitation and grid scale precipitation with a larger size . GD tend to produce the weakest cumulus precipitation with smallest size and there exit some small scale precipitation in both kinds of precipitation, KF between these two

➢The RMW and vertical structure: BM has a largest RMW and the mean updraft tilt outward sharply with height, GD has the smallest RMW and the updraft tilt outward sharply at the lower level and smaller tilt in the middle to upper level, The RMW from KF is between the above two and the updraft much straight and has a outward tilt in the upper level

Summary of the preliminary analysis

Under the same boundary layer scheme

- **The precipitation:** The simulations with MYJ tend to produce stronger precipitation with smaller radius
- **The RMW and vertical structure:** MYJ has a smaller RMW and strong updraft
- **The characteristics in the lower level:** the gradient in the lower several km (3km) is much lager in MYJ and weaker in YSU; and MYJ tends to produce stronger radial inflow