

SIMULTATION OF TROPICAL DEPRESSIONS and Weather Forecasts

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Many thanks to J. Dudhia, B. Thomas, H. Kruglyak, R. Yablonsky

Goals:

- a) To test the ability of microphysical schemes to describe evolution of TD (the most difficult topic);**
- b) To evaluate a potential of spectral bin microphysics (SBM) in improvement of forecasts and in particular, in TC intensity prediction**

Helene 2006

Daniel P. Brown
National Hurricane Center
15 November 2006

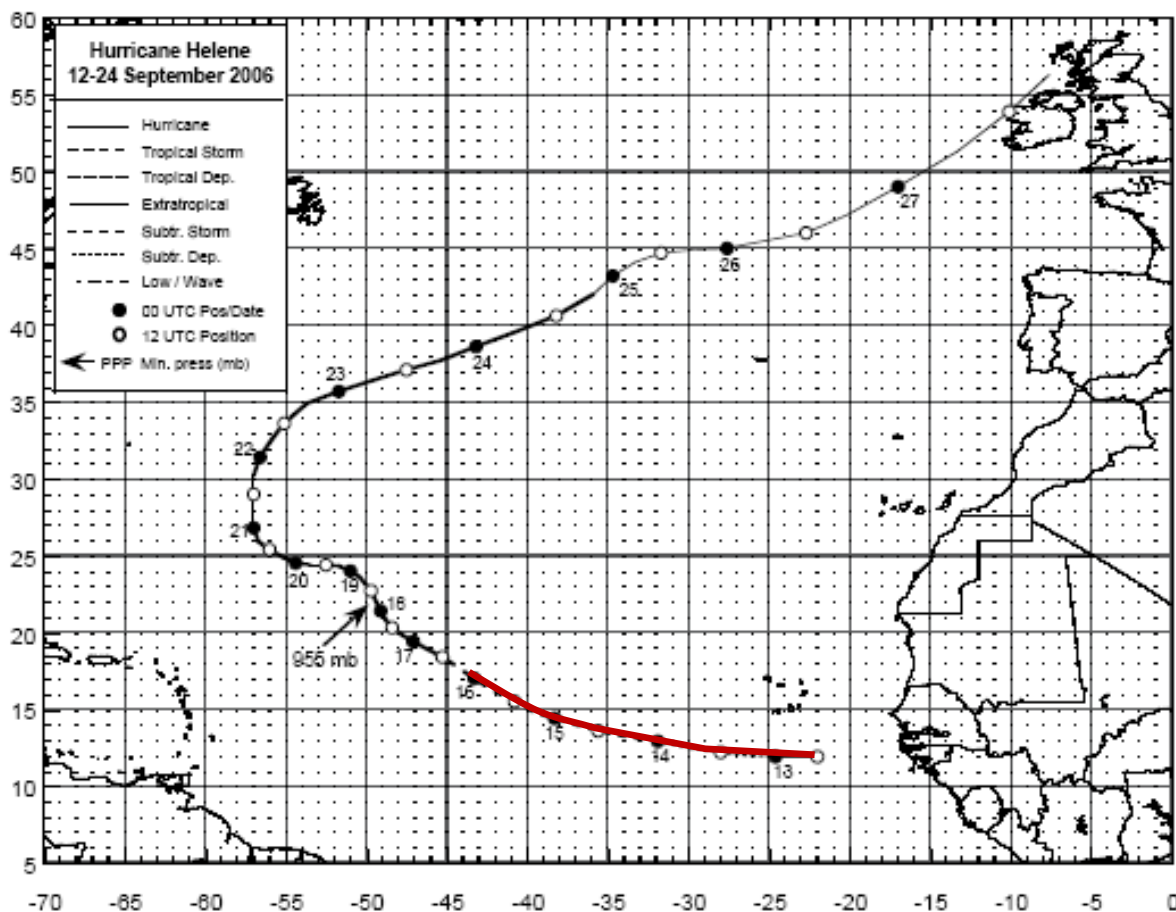


Figure 1. Best track positions for Hurricane Helene, 12-24 September 2006. Track during the extratropical stage is partially based on analyses from the NOAA Ocean Prediction Center.

Helene 2006

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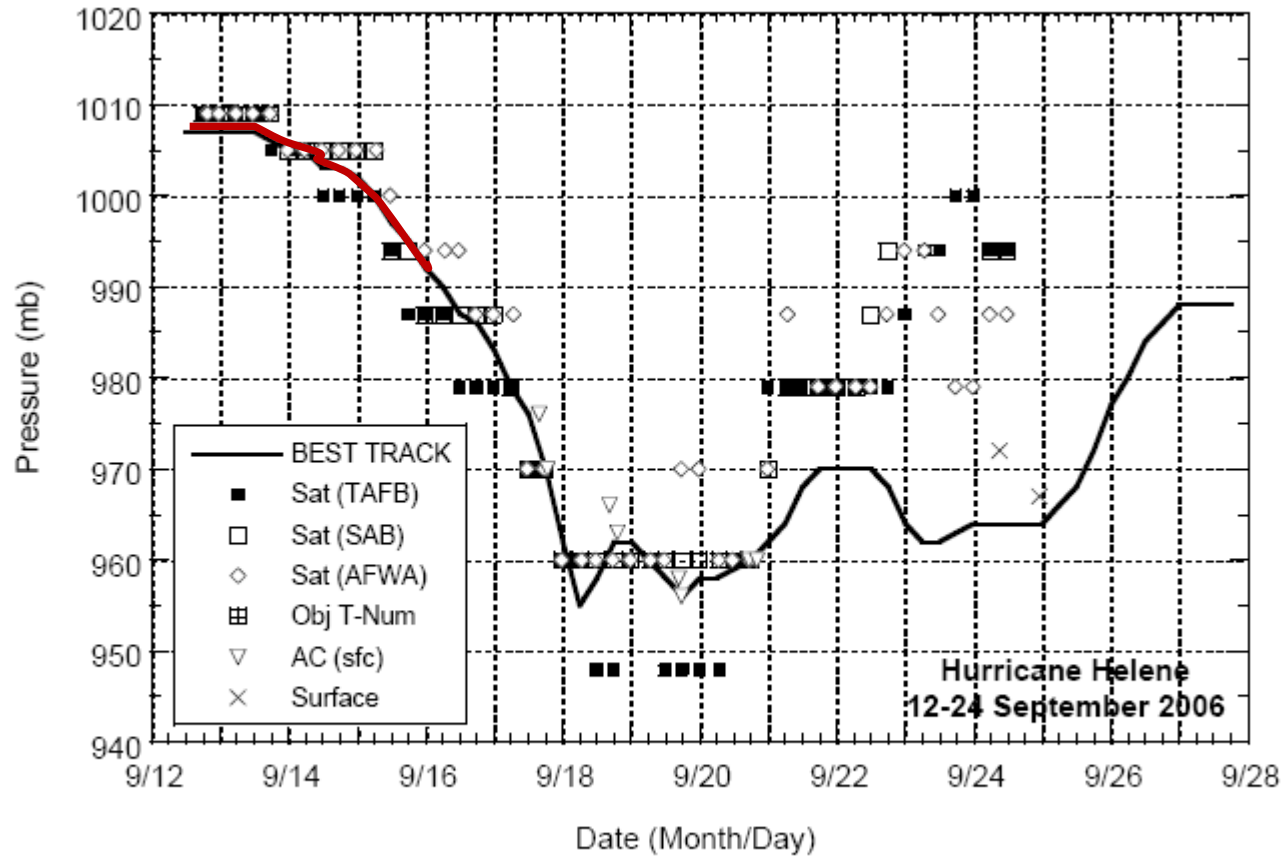


Figure 3. Selected pressure observations and best track minimum central pressure curve for Hurricane Helene, 12-24 September 2006. Estimates during the extratropical stage are based on analyses from the NOAA Ocean Prediction Center.

Design of simulations:

Simulations were performed using WRF movable nested grid:
the 1-st grid: (4050 km x 2700 km) with resolution 9 km ,
the second grid: 1800 x 1200 km with 3 km resolution.

Initial data: reanalysis.

Simulations were performed using WRF-SBM (Khain and Lynn) and 5 bulk-parameterization schemes.

In case the microphysical schemes are sensitive to aerosols, simulations were performed for clean and polluted air

SBM-mar CCN concentration was assumed equal to 100 cm⁻³

SBM -con CCN concentration was assumed equal to 3000 cm⁻³

The Thompson scheme. Thompson- mar -drop concentration 100 cm⁻³

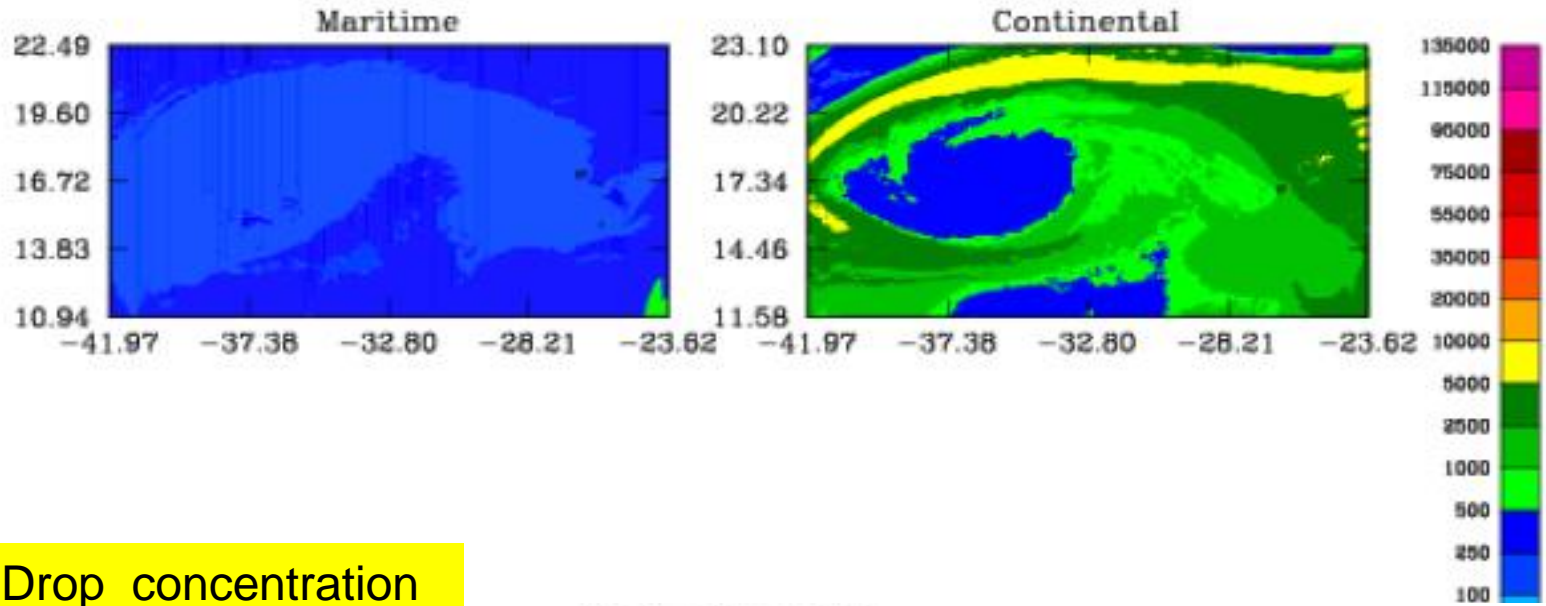
Thompson-con -drop concentration 300 cm⁻³

WDM6-mar: CCN concentration was assumed equal to 100 cm⁻³

WDM6-con CCN concentration was assumed equal to 3000 cm⁻³

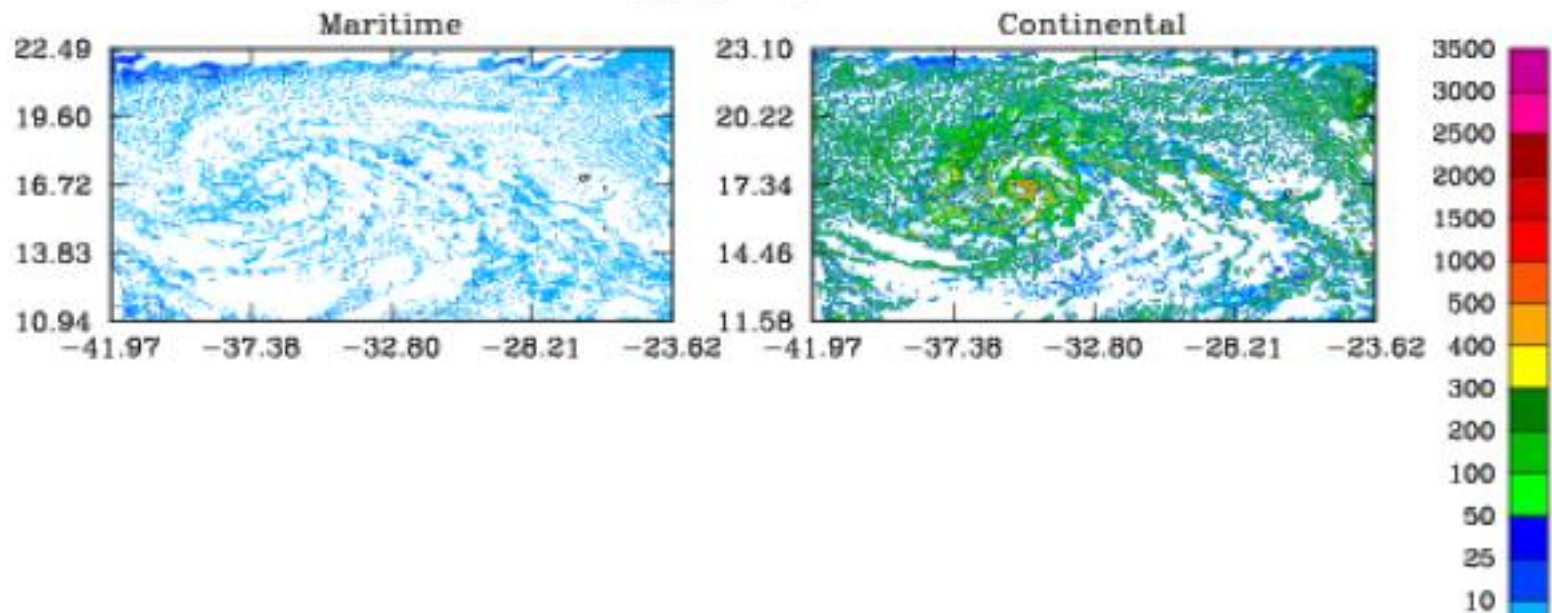
Aerosol concentration

September 15
Hour =12



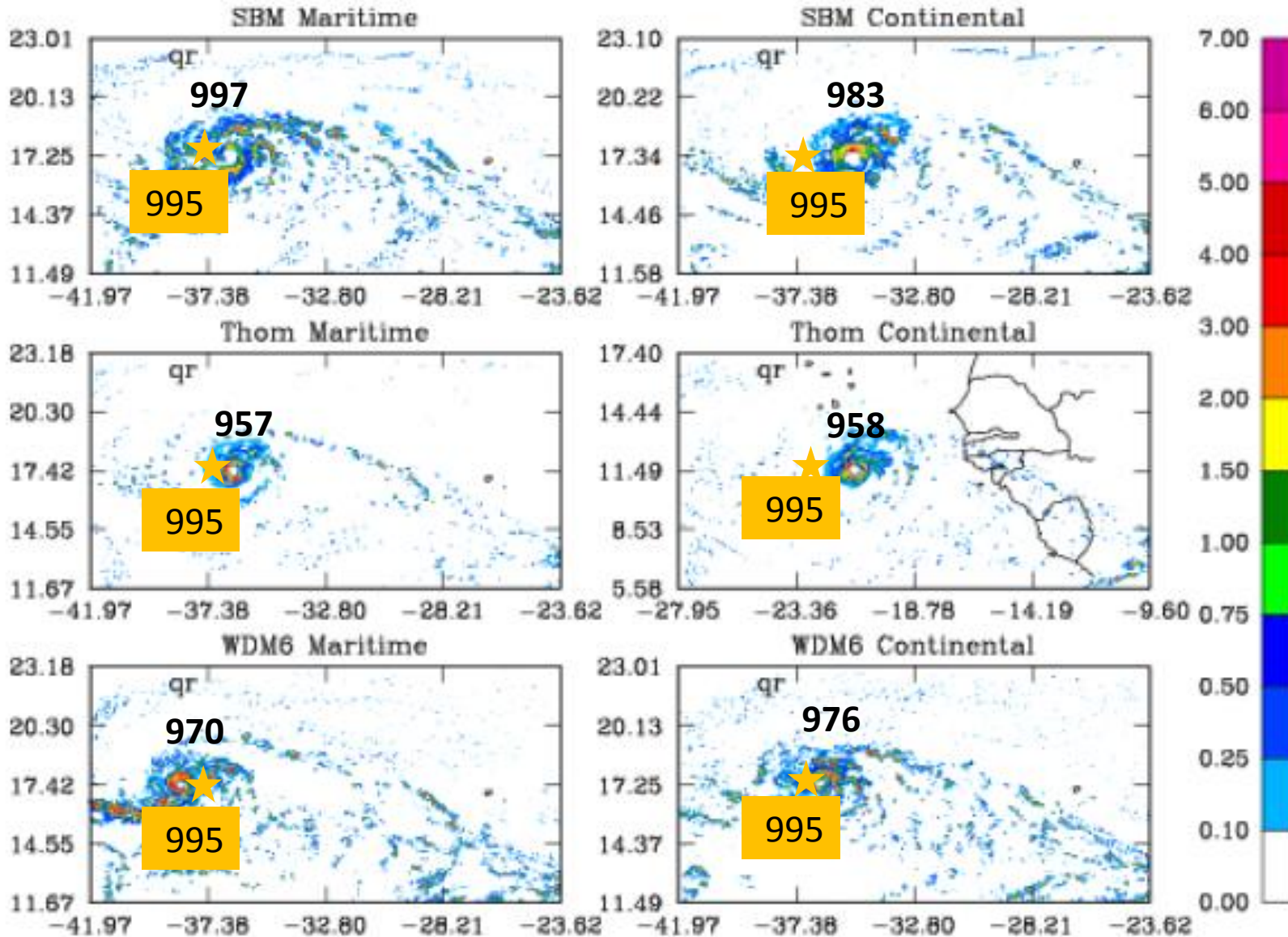
Drop concentration

September 15
Hour =12



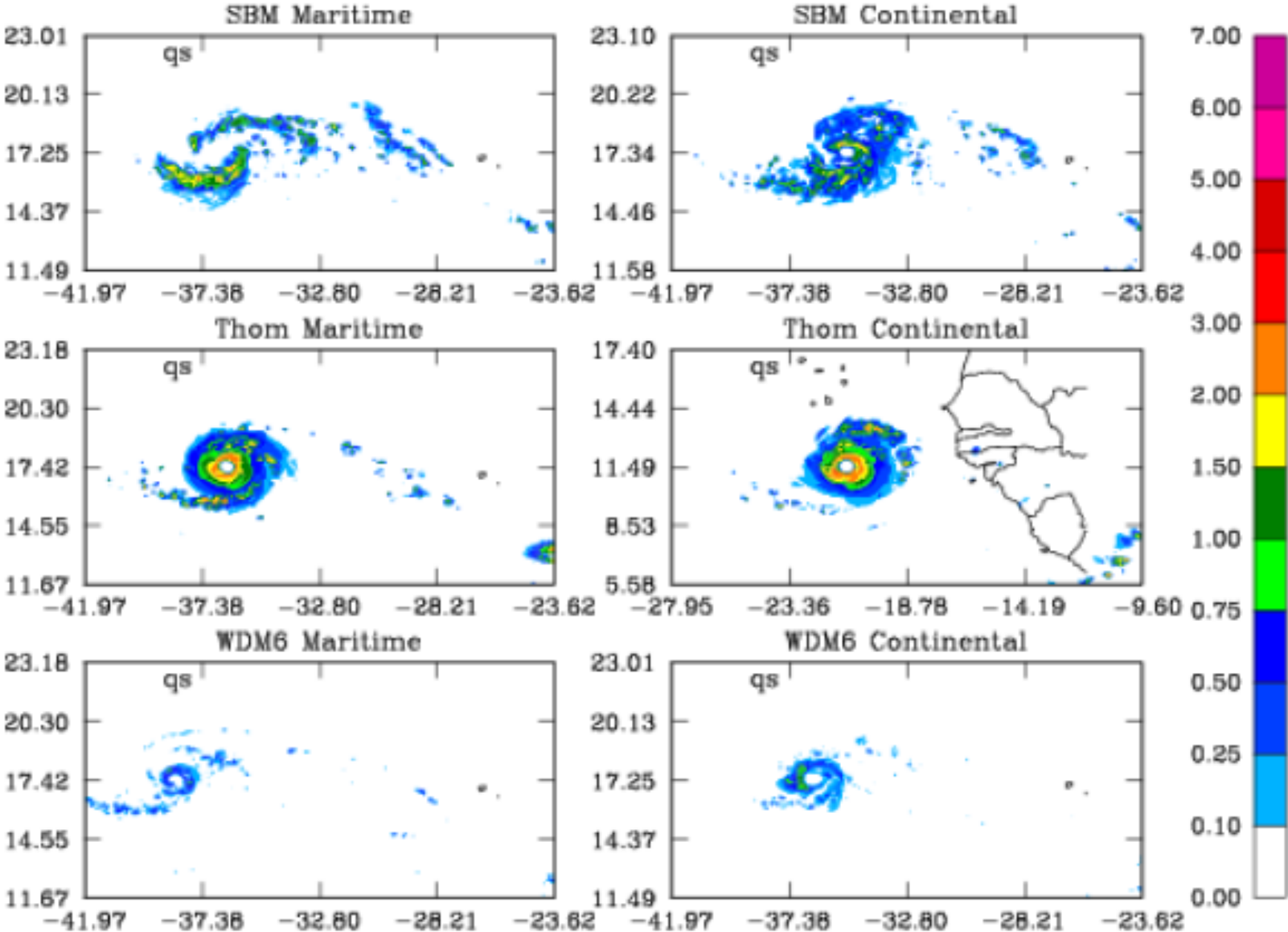
Rain water content

September 15
Hour =12



Snow content

September 15
Hour =12

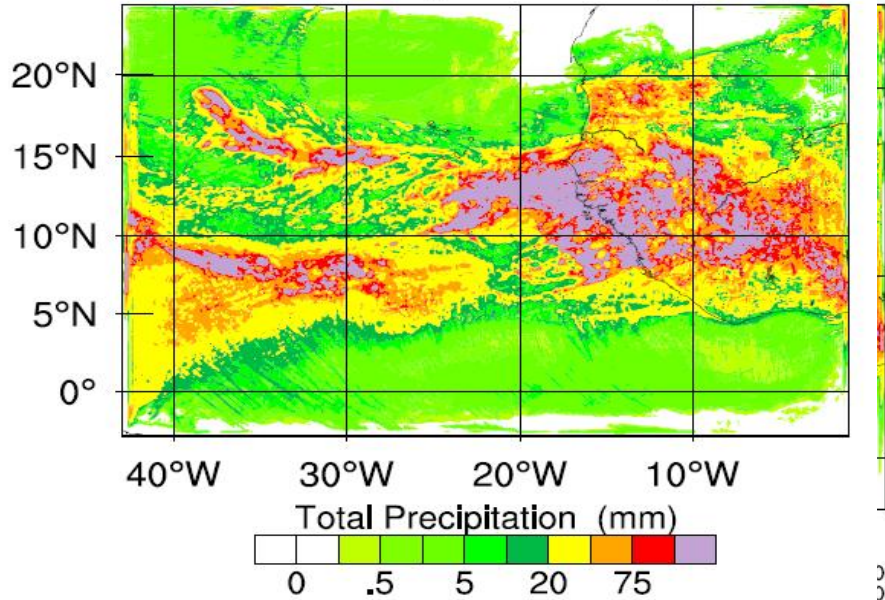


REAL-TIME WRF

WDM6-con

Init: 2006-09-11_00:00:00
Valld: 2006-09-16_00:00:00

Total Precipitation from 2006-09-15_18:00:00 to 2006-09-15_21:00:00 (mm)

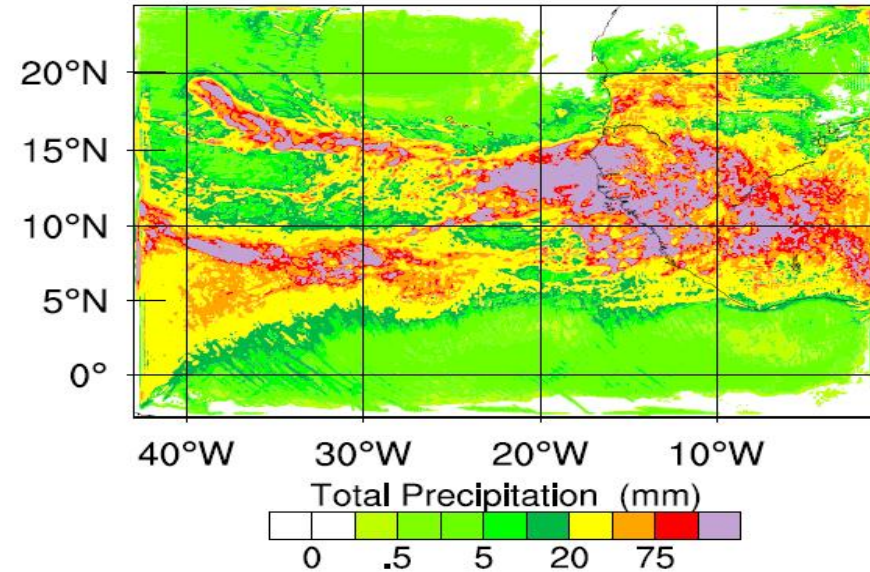


REAL-TIME WRF

WDM6-mar

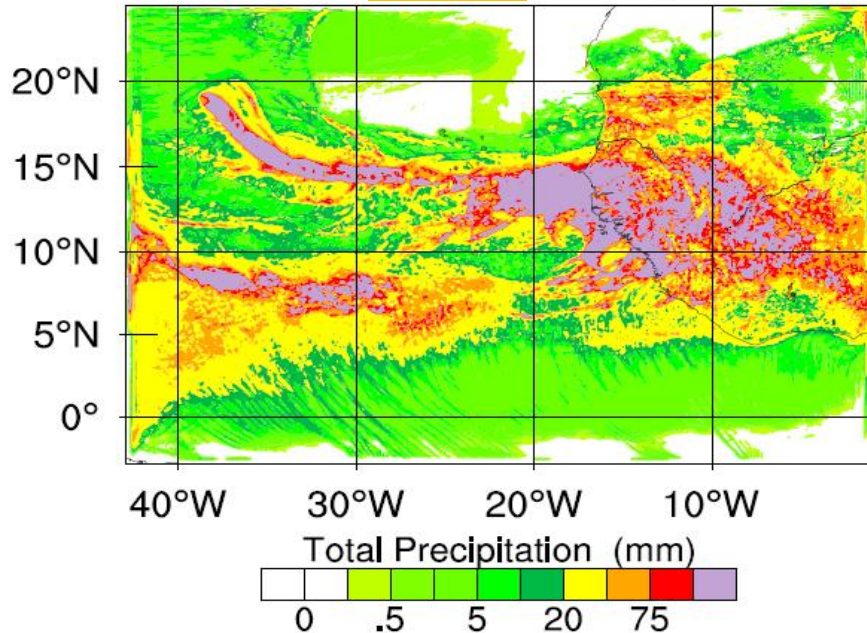
Init: 2006-09-11_00:00:00
Valld: 2006-09-16_00:00:00

Total Precipitation from 2006-09-15_18:00:00 to 2006-09-15_21:00:00 (mm)



GCE

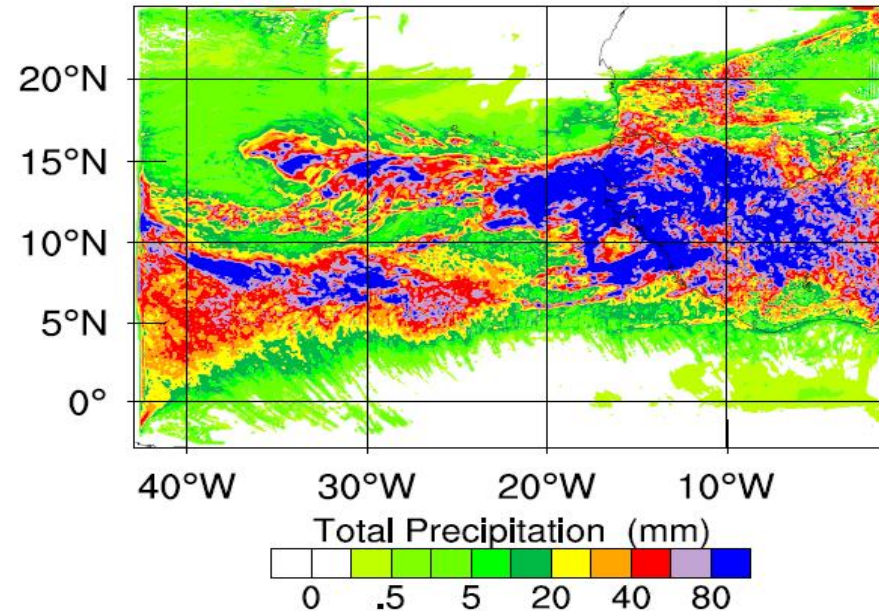
Total Precipitation from 2006-09-15_18:00:00 to 2006-09-15_21:00:00 (mm)



SBM: Khain-Lynn

Init: 2006-09-14_21:00:00
Valld: 2006-09-15_06:00:00

Total Precipitation from 2006-09-15_00:00:00 to 2006-09-15_03:00:00 (mm)



Simulation of genesis of TD-TS Debby 2007

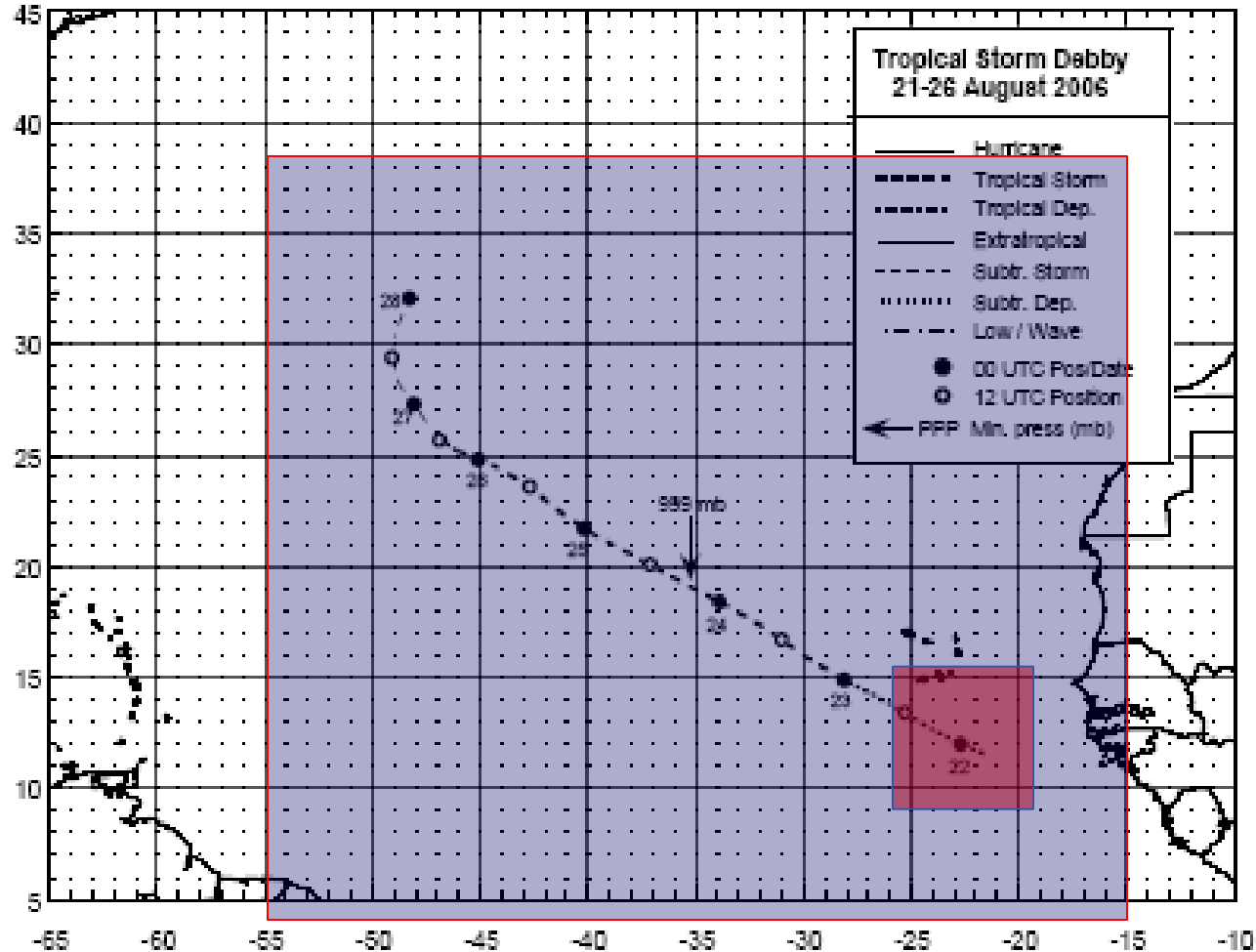


Figure 1. Best track positions for Tropical Storm Debby, 21-26 August 2006.

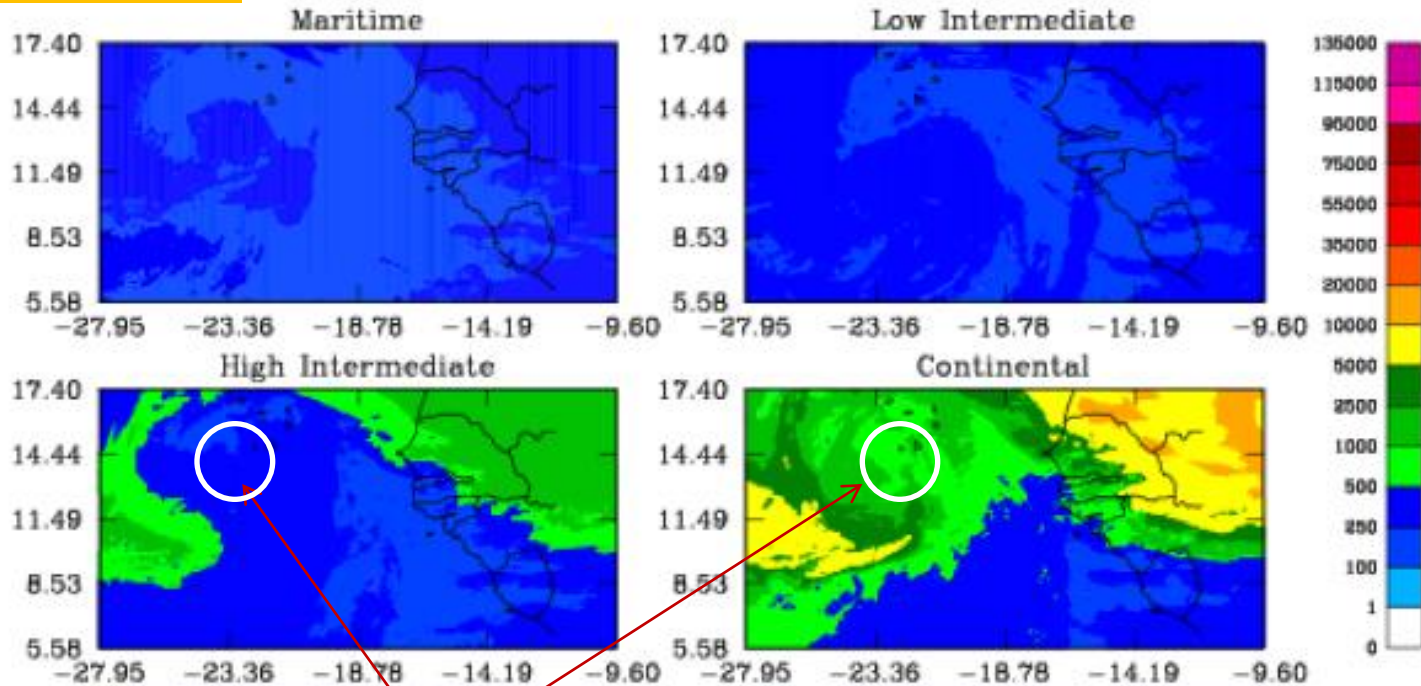
TD Debby was simulated using WRF model with different bulk parameterization schemes within the same dynamical and thermodynamical framework

Aerosol concentration in Debbie

100 cm⁻³

August 22
Hour = 6

500 cm⁻³



1500 cm⁻³

Debbie formation

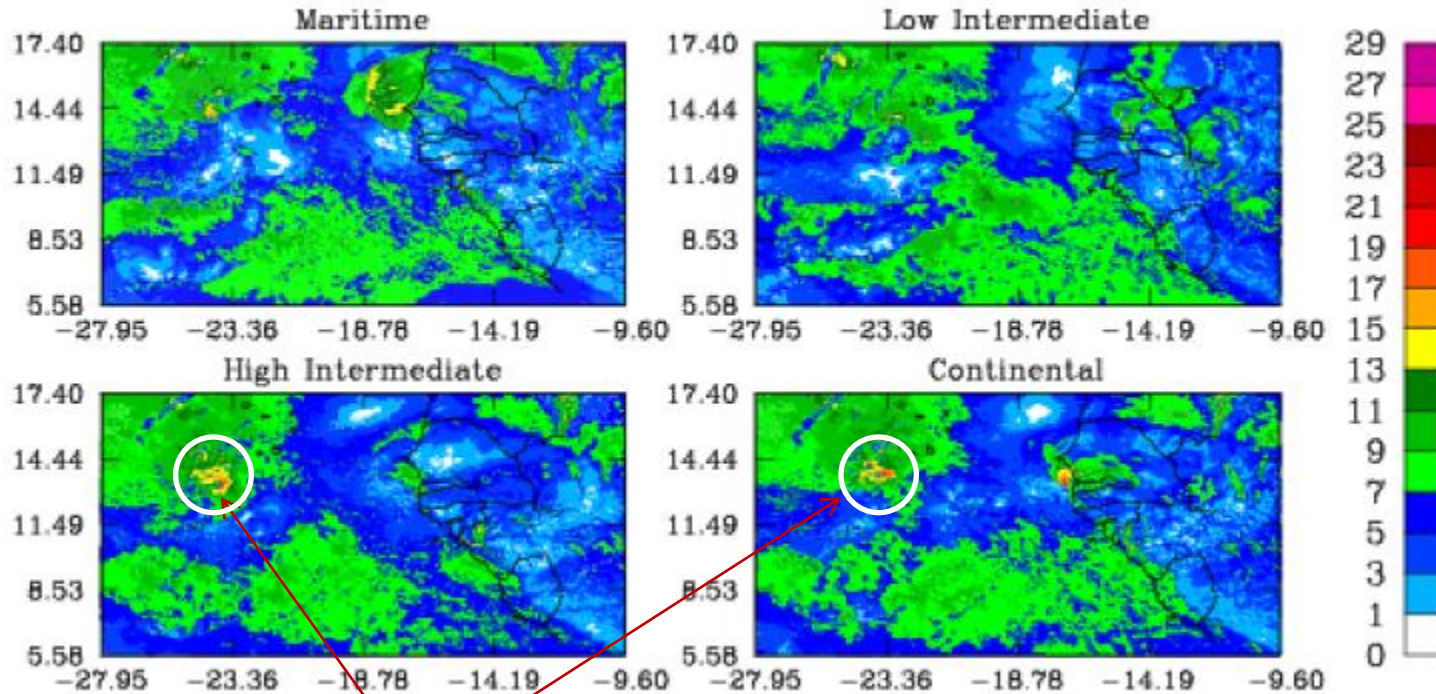
3000 cm⁻³

SBM: Debbie wind speed: effect of aerosols

100 cm⁻³

August 22
Hour = 9

500 cm⁻³

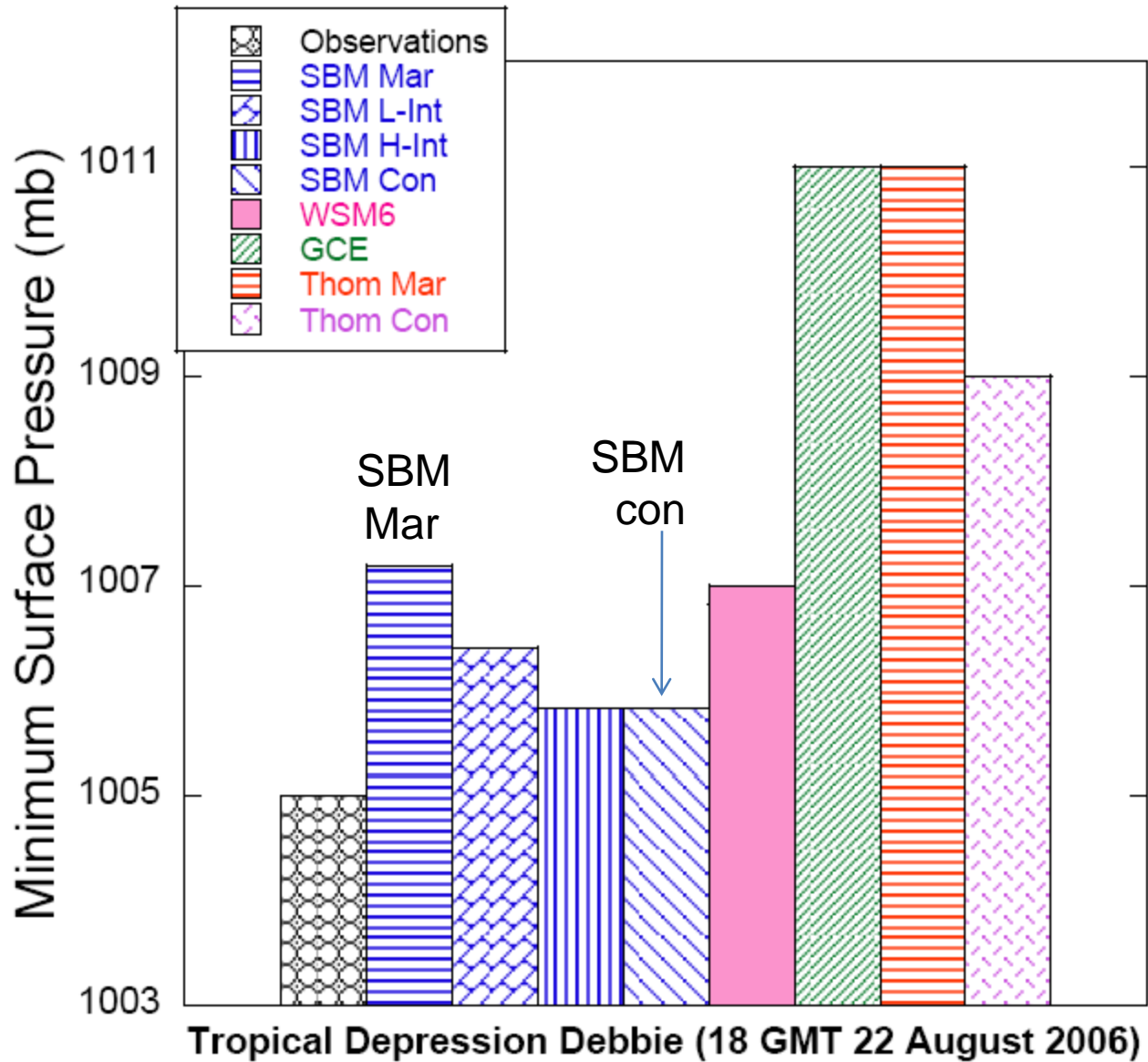


1500 cm⁻³

3000 cm⁻³

Debbie formation

Aerosols intensify convection and foster TD development

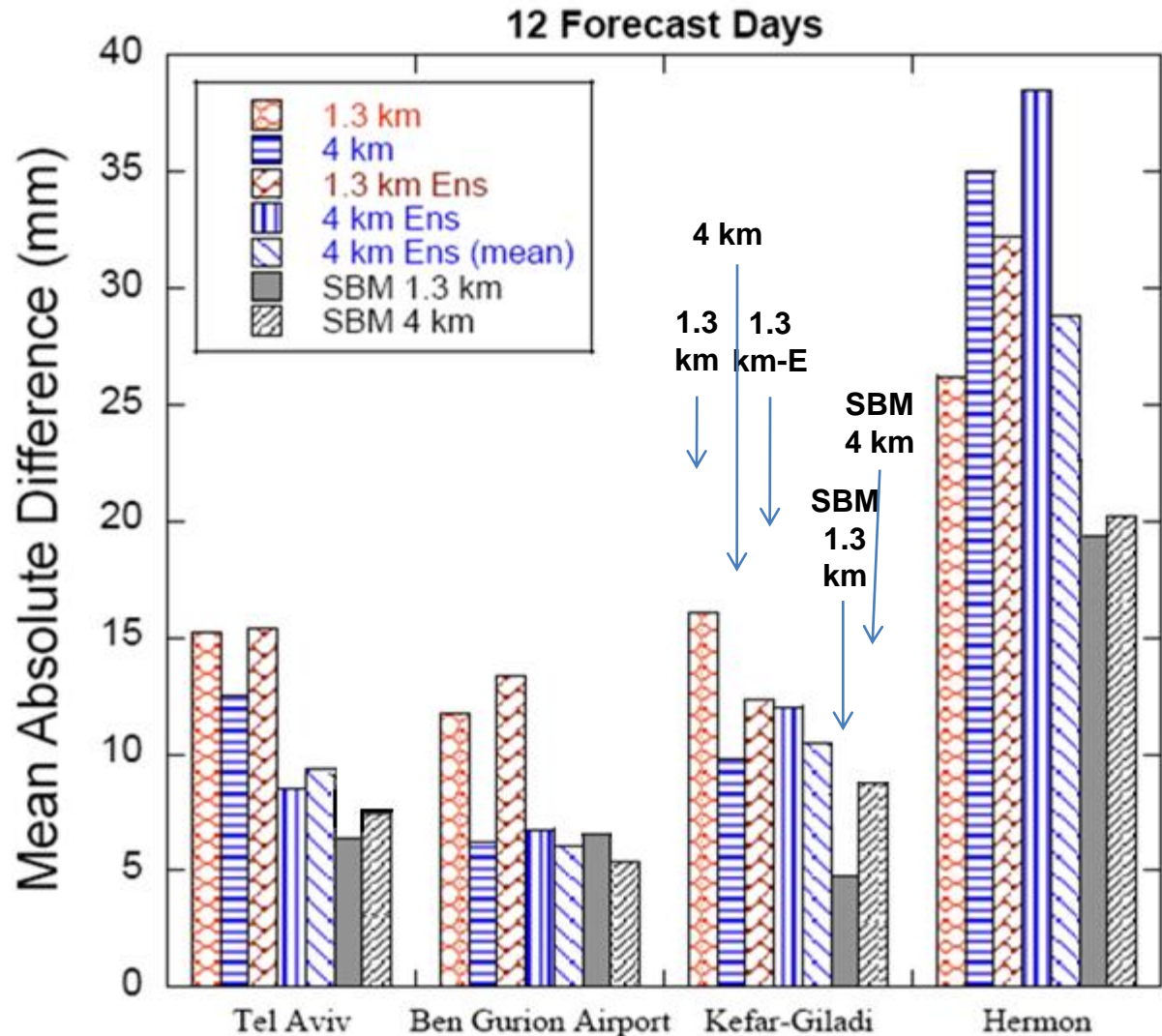


Rain FORECASTS with WRF-SBM and one moment bulk scheme WSM6 (preliminary results)

L-Y. Leung (PNNL) , B. Lynn (HUJI) (in preparation)

Aerosol production
in industrial zones
was taken into
account

Ensembles -9 cases



SUGGESTIONS (For discussion)

1. To use WRF/SBM for investigation of factors affecting TC intensity, TC genesis;
2. To use WRF/SBM for investigation of spray effects of cloud convection and TC intensity
3. To use WRF/SBM to calibrate bulk microphysics schemes

Thank you!

Scheme of droplet size spectrum formation in deep cumulus clouds (Pinsky and Khain 2002; Khain et al 2011; Prabha et al 2011)

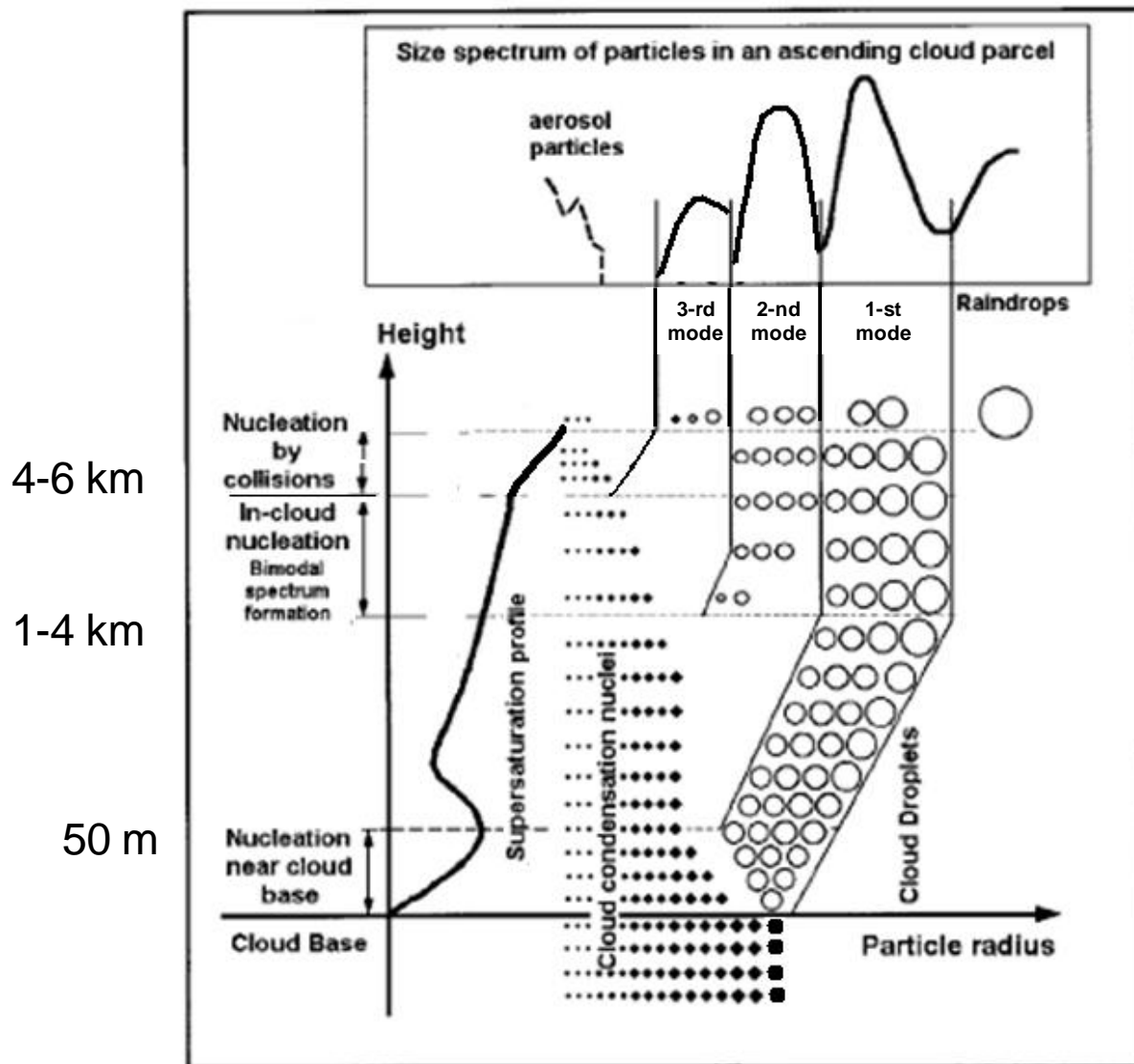
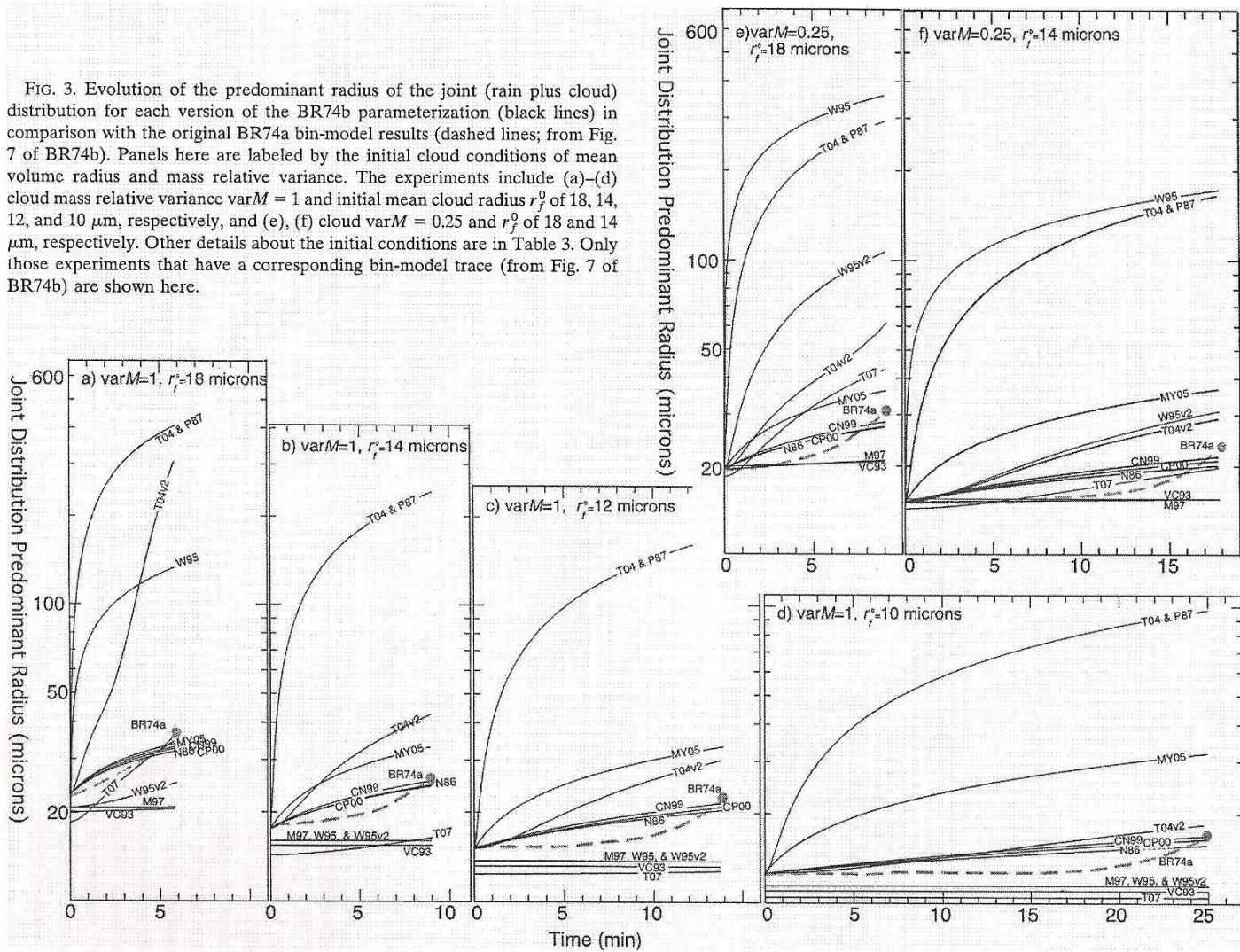
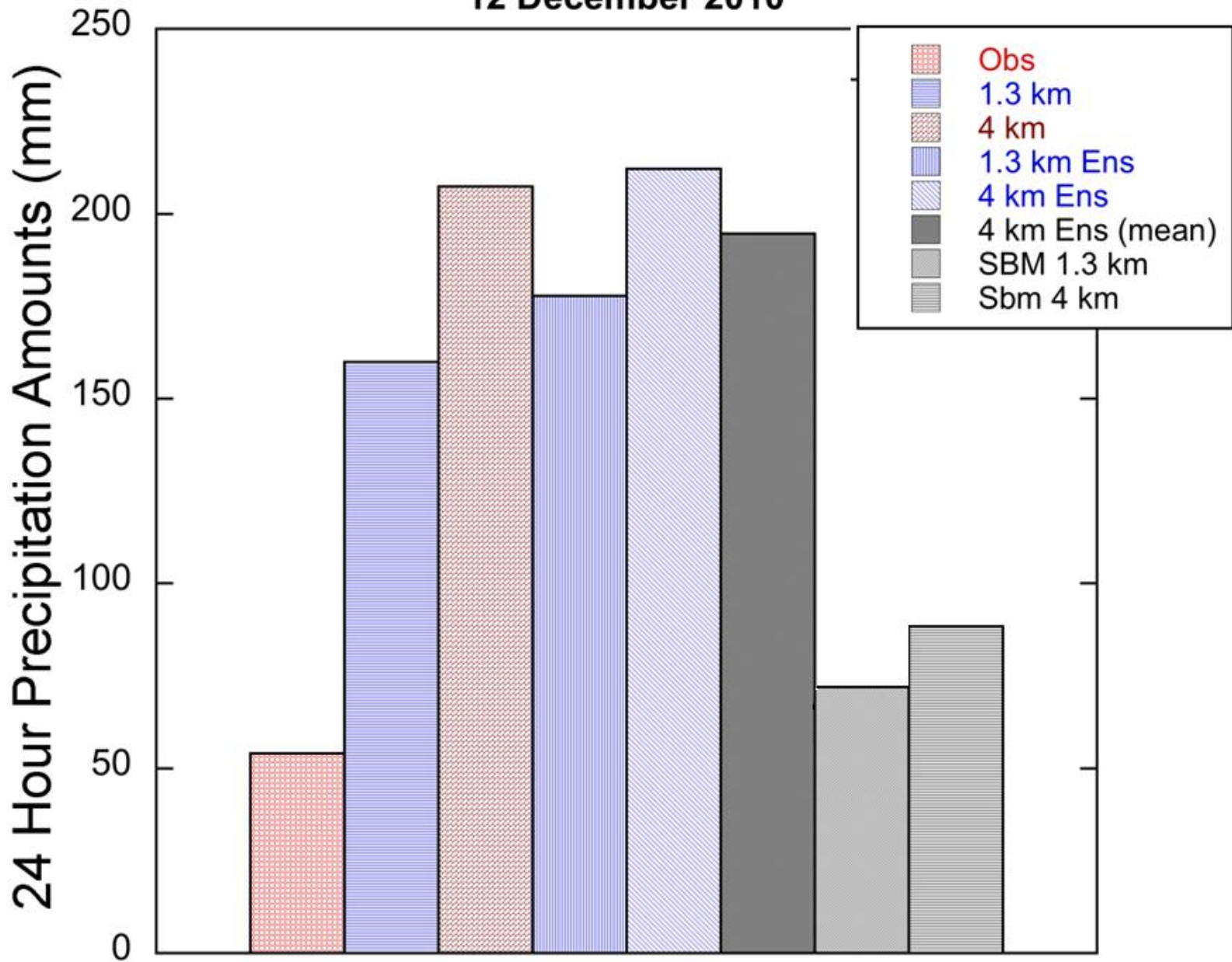


FIG. 3. Evolution of the predominant radius of the joint (rain plus cloud) distribution for each version of the BR74b parameterization (black lines) in comparison with the original BR74a bin-model results (dashed lines; from Fig. 7 of BR74b). Panels here are labeled by the initial conditions of mean volume radius and mass relative variance. The experiments include (a)–(d) cloud mass relative variance $\text{var}M = 1$ and initial mean cloud radius r_f^0 of 18, 14, 12, and 10 μm , respectively, and (e), (f) cloud $\text{var}M = 0.25$ and r_f^0 of 18 and 14 μm , respectively. Other details about the initial conditions are in Table 3. Only those experiments that have a corresponding bin-model trace (from Fig. 7 of BR74b) are shown here.

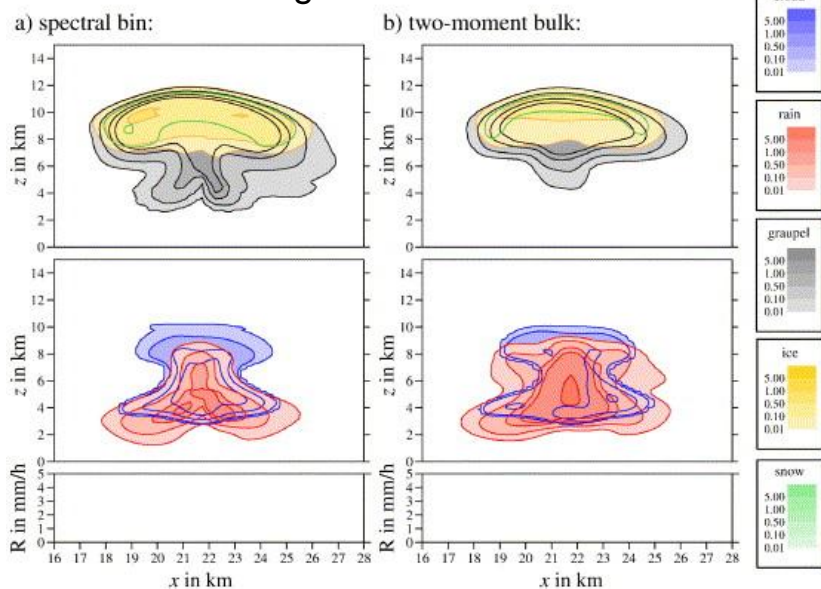


12 December 2010

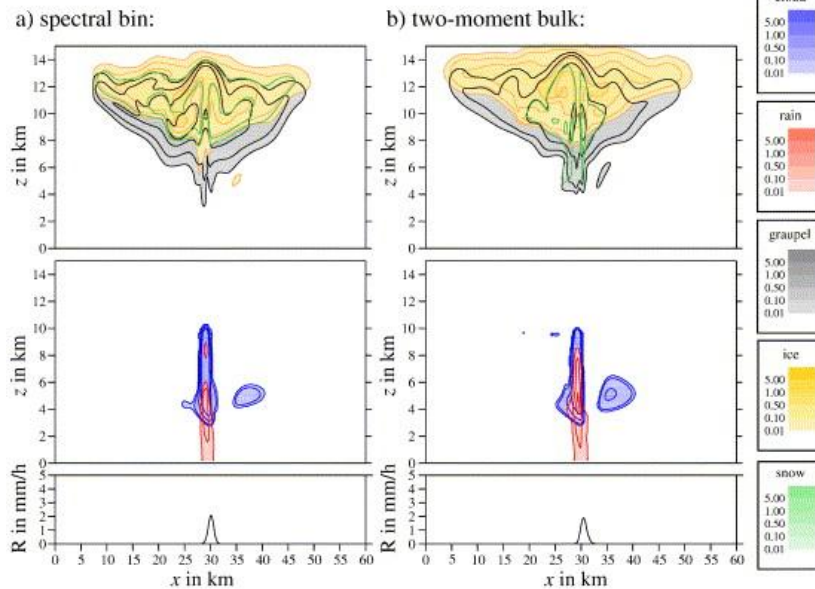


To use spectral bin microphysics for calibration of existent bulk-parameterization schemes for improvement of the TC intensity forecast: *Seifert et al 2006*

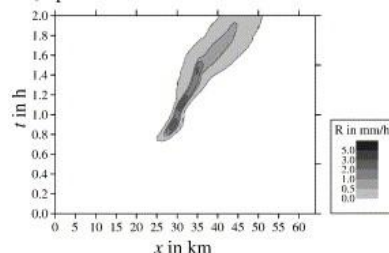
High AP concentration



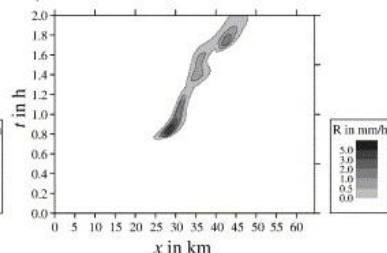
Low AP concentration



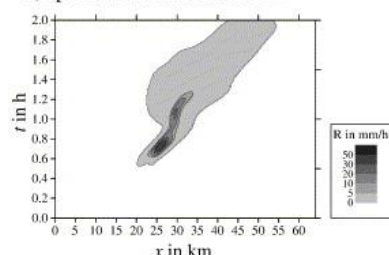
a) spectral bin: continental CCN



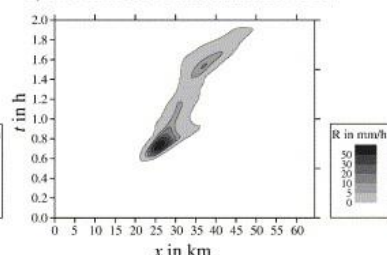
b) two-moment bulk: continental CCN



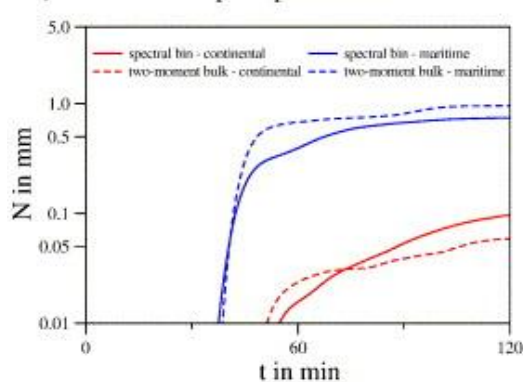
c) spectral bin: maritime CCN



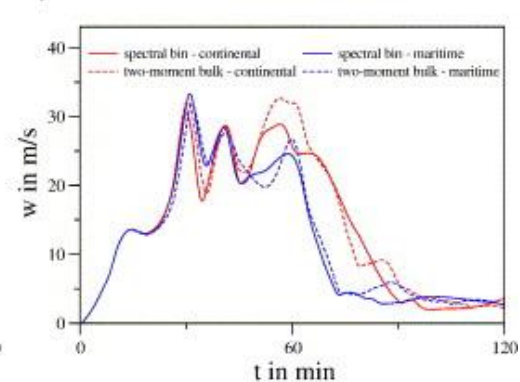
d) two-moment bulk: maritime CCN

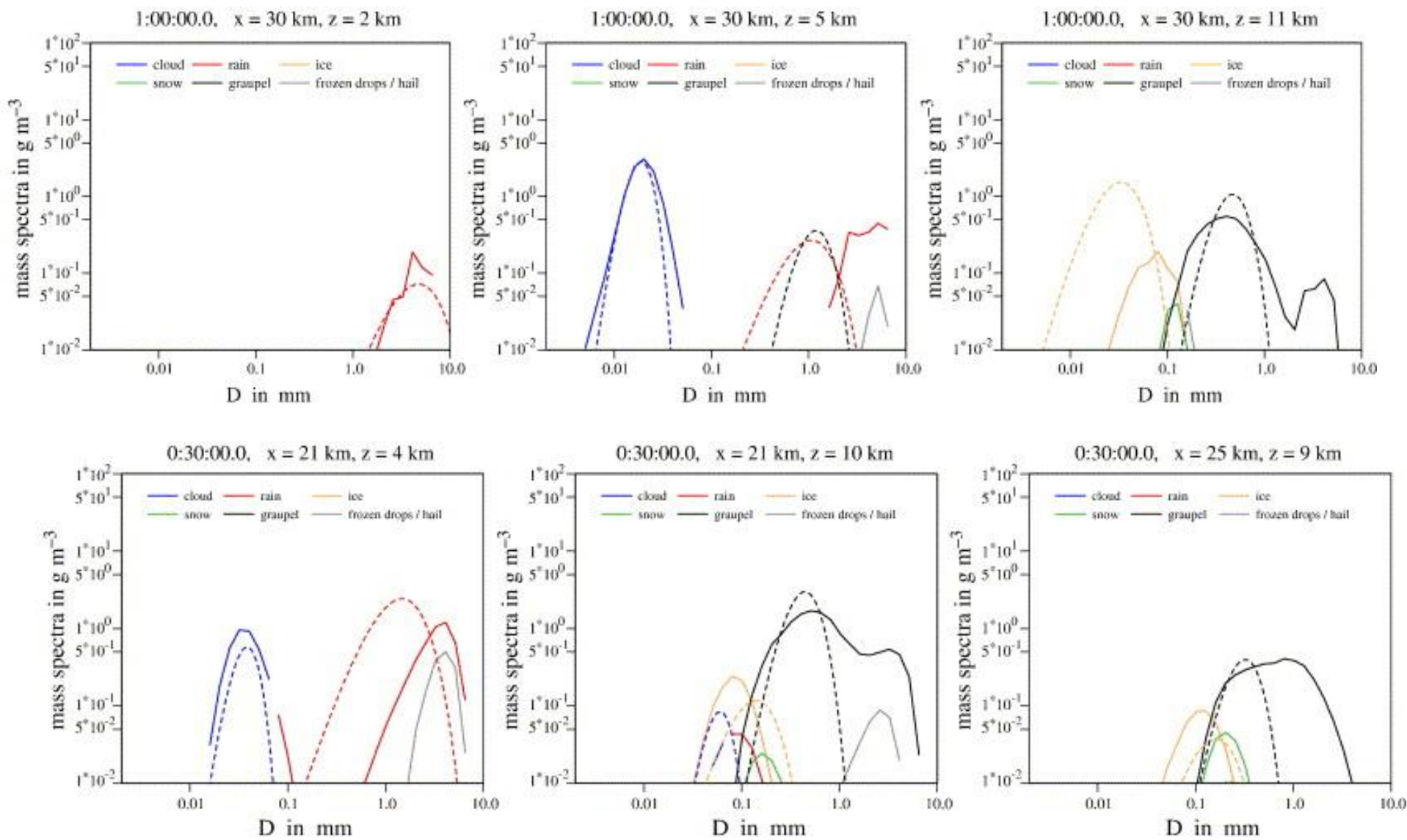


a) accumulated precipitation



b) maximum vertical velocities

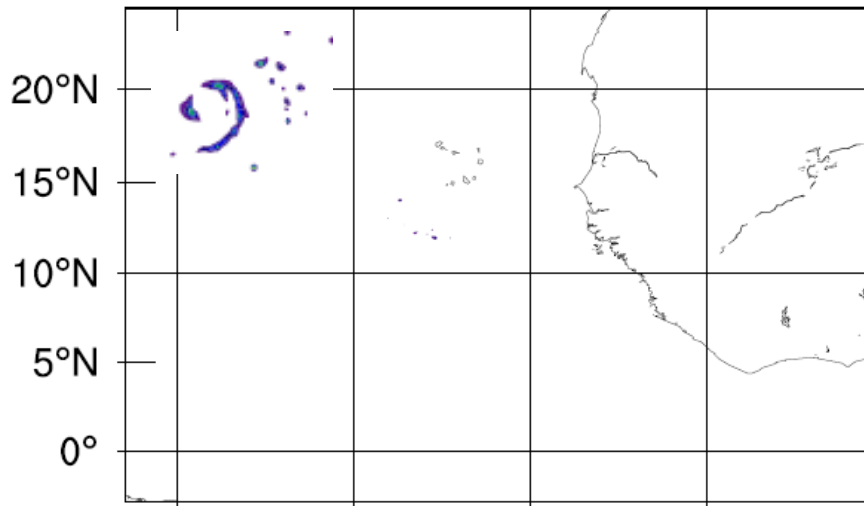




REAL-TIME WRF

Init: 2006-09-11_00:00:00
Valid: 2006-09-16_00:00:00

Max Graupel Mixing Ratio (g/kg)



40°W 30°W 20°W 10°W

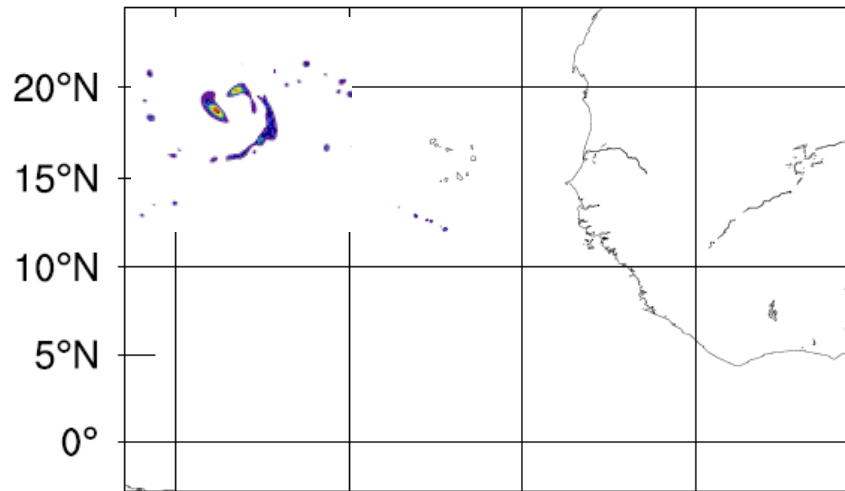
Max Graupel Mixing Ratio (g/kg)



REAL-TIME WRF

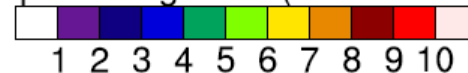
Init: 2006-09-11_00:00:00
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Max Graupel Mixing Ratio (Above 3.5 km) (g/kg)



40°W 30°W 20°W 10°W

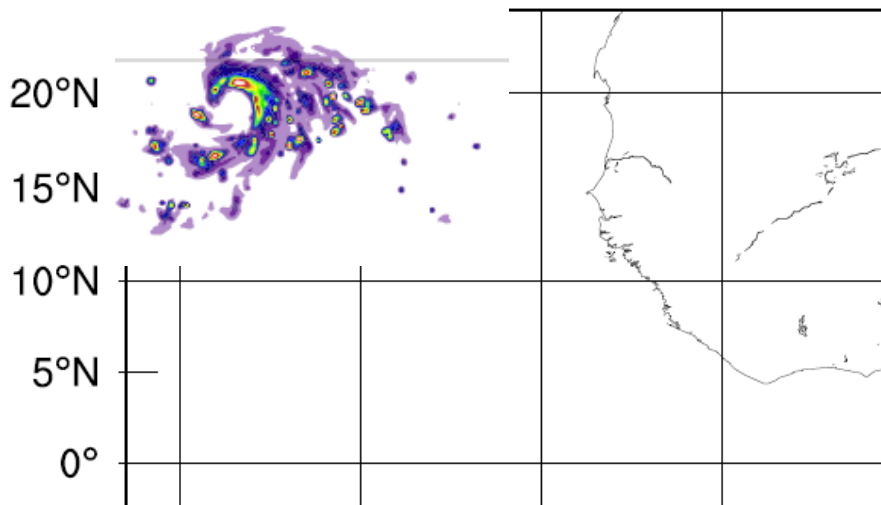
Max Graupel Mixing Ratio (Above 3.5 km) (g/kg)



REAL-TIME WRF

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Valid: 2006-09-16_00:00:00

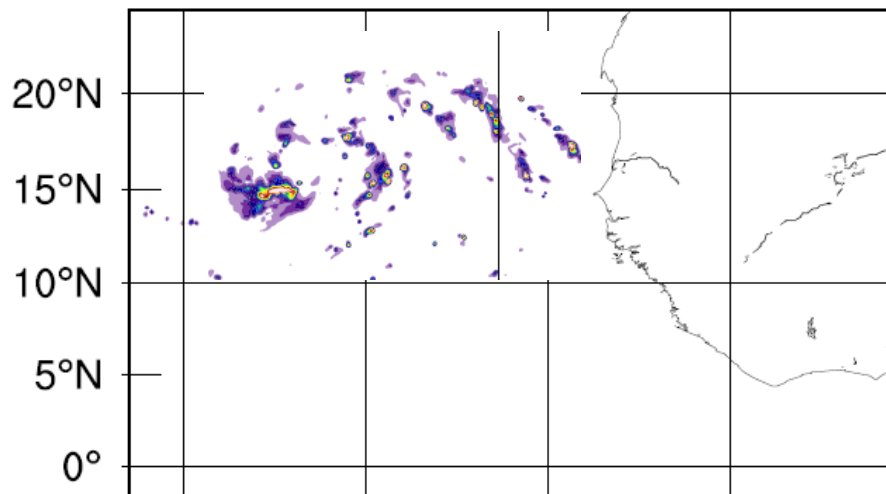
Max Graupel Mixing Ratio (g/kg)



REAL-TIME WRF

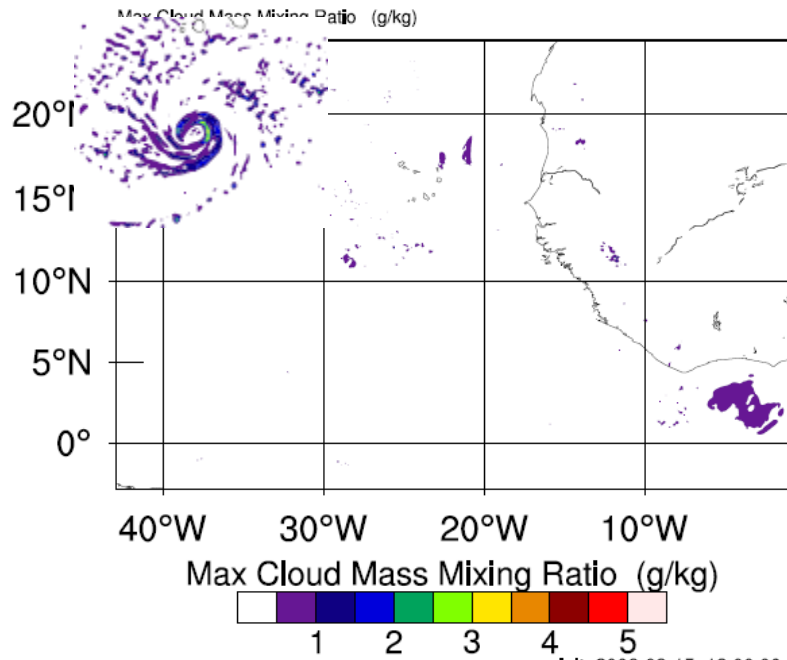
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Valid: 2006-09-15_06:00:00

Max Graupel Mixing Ratio (g/kg)



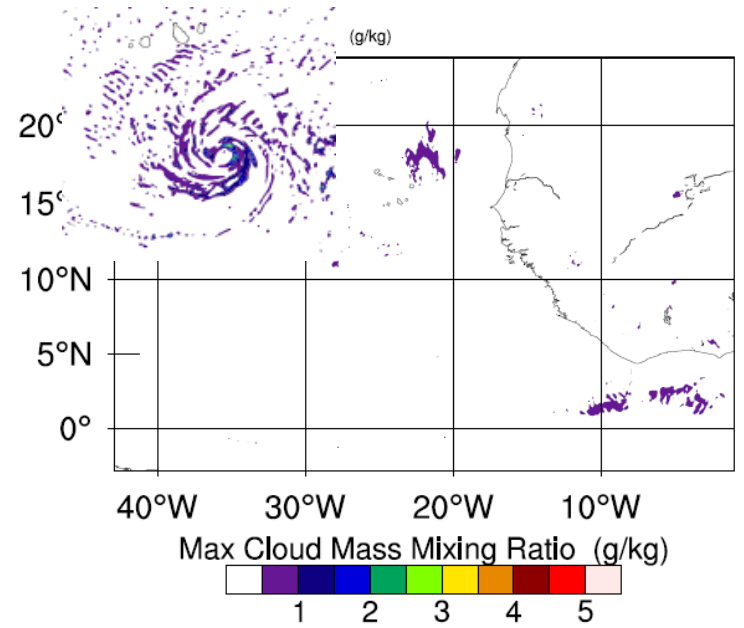
REAL-TIME WRF

Init: 2006-09-11_00:00:00
Valid: 2006-09-15_21:00:00



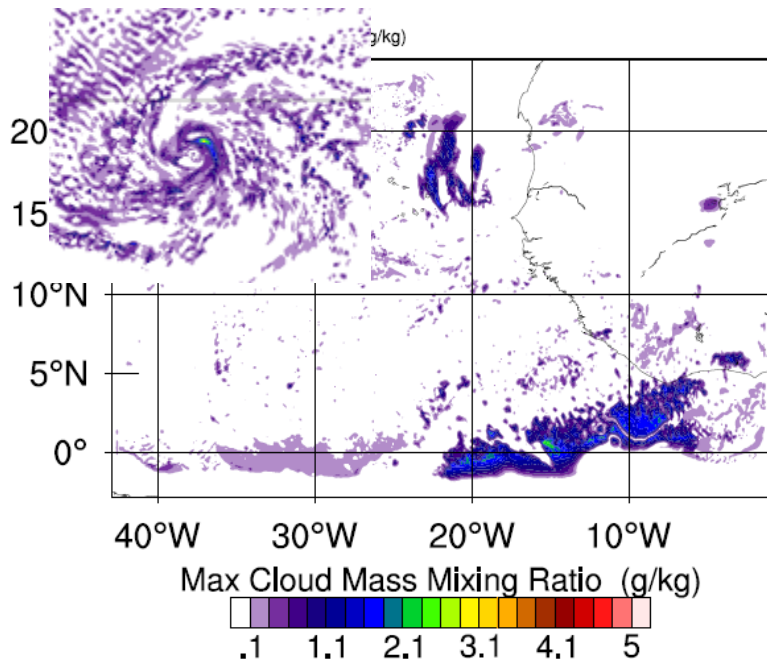
REAL-TIME WRF

Init: 2006-09-11_00:00:00
Valid: 2006-09-16_00:00:00



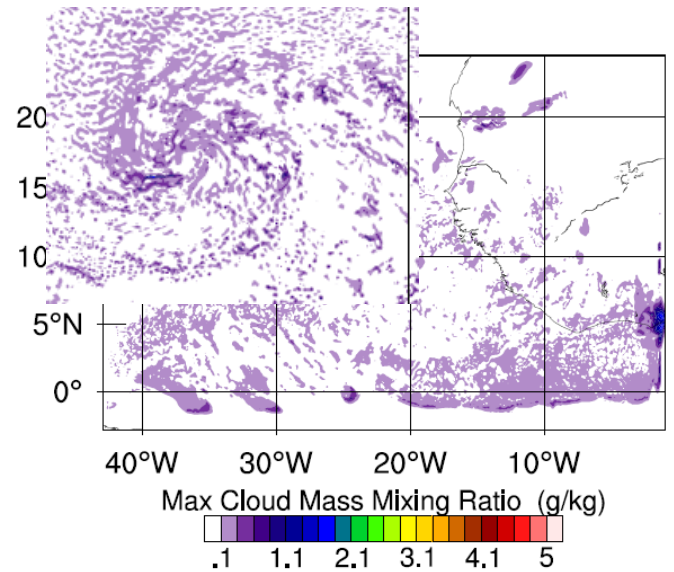
REAL-TIME WRF

Init: 2006-09-15_18:00:00
Valid: 2006-09-16_00:00:00



REAL-TIME WRF

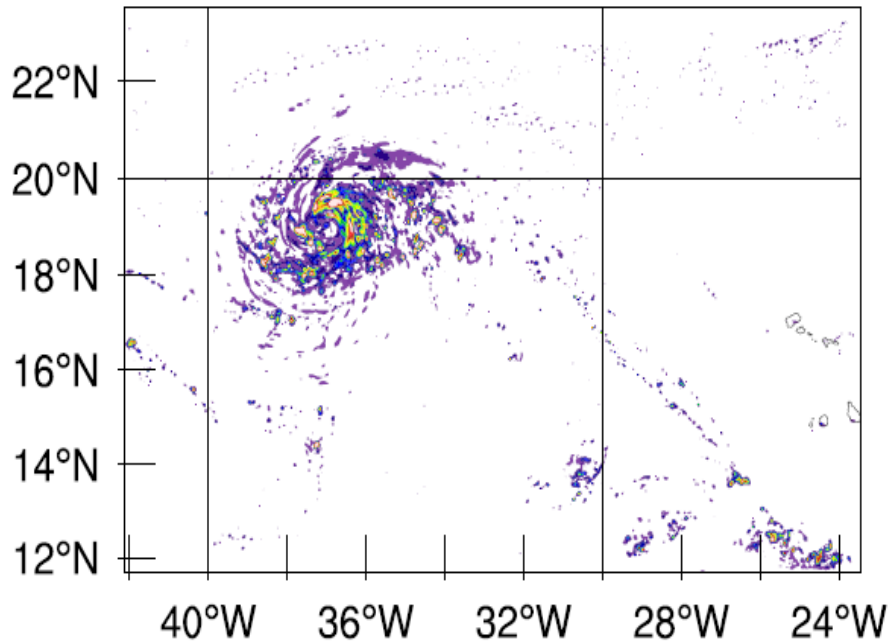
Init: 2006-09-14_21:00:00
Valid: 2006-09-15_06:00:00



Max vertical velocities

REAL-TIME WRF SBM -c on Init: 2006-09-15_18:00:00
Valld: 2006-09-16_00:00:00

Max Vertical Velocity (#/cm**3)

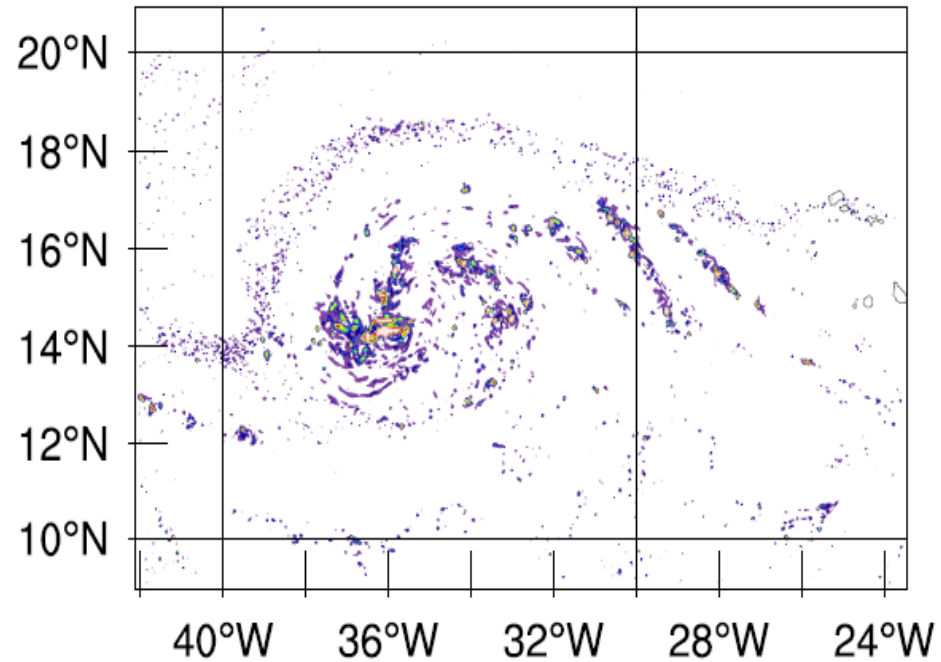


Max Vertical Velocity (#/cm**3)



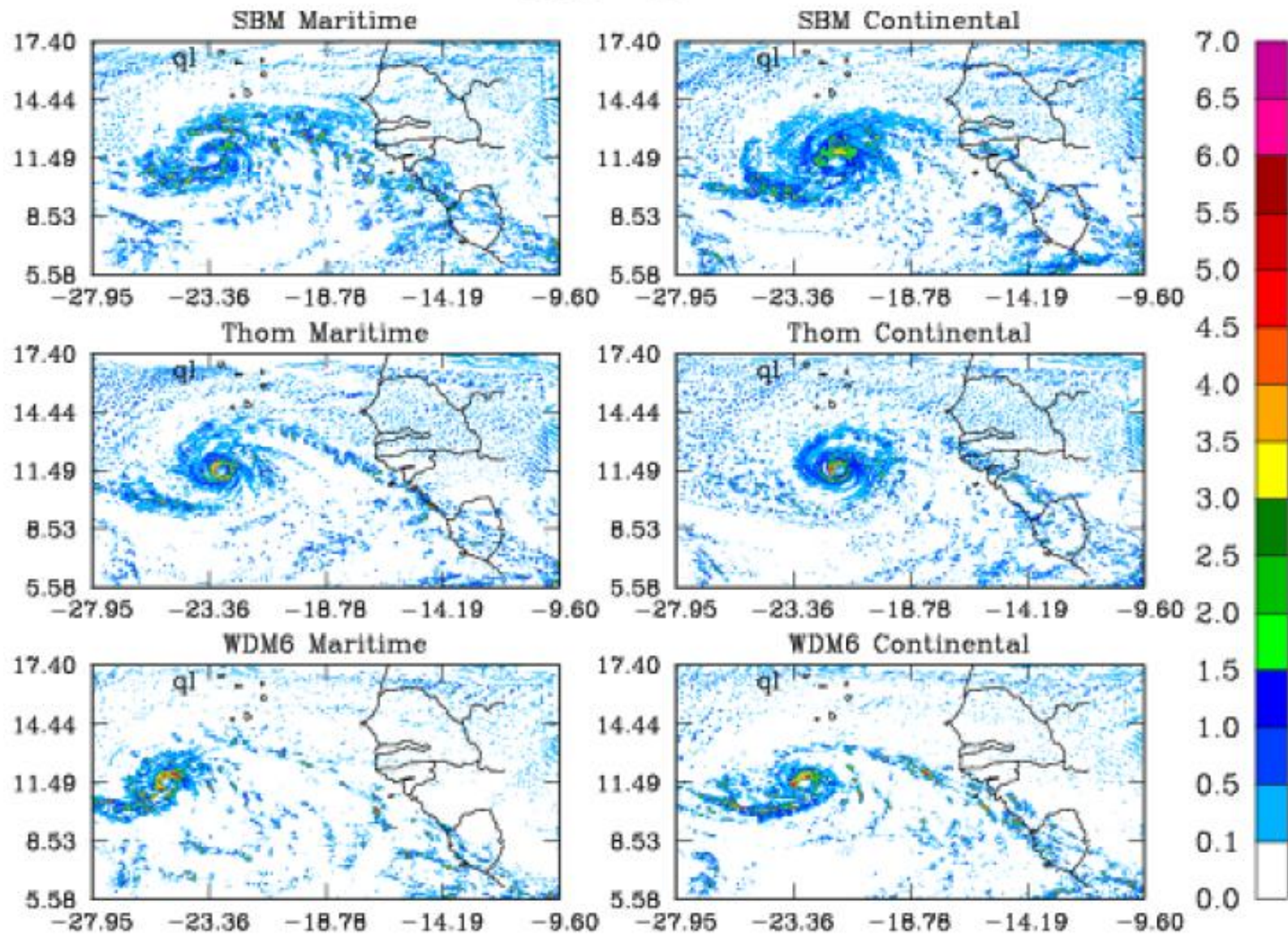
REAL-TIME WRF SBM -mar Init: 2006-09-14_21:00:00
Valld: 2006-09-15_06:00:00

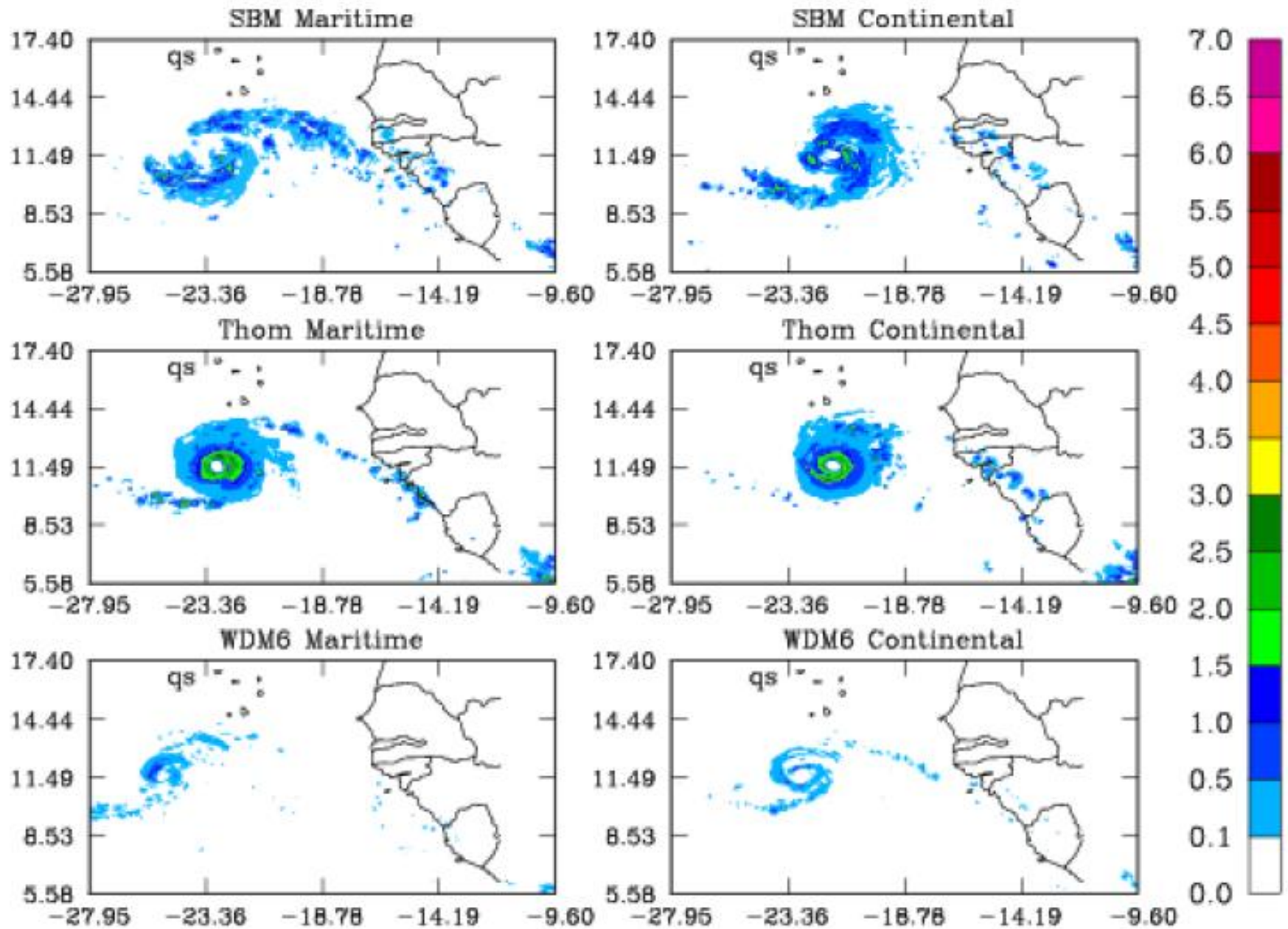
Max Vertical Velocity (#/cm**3)

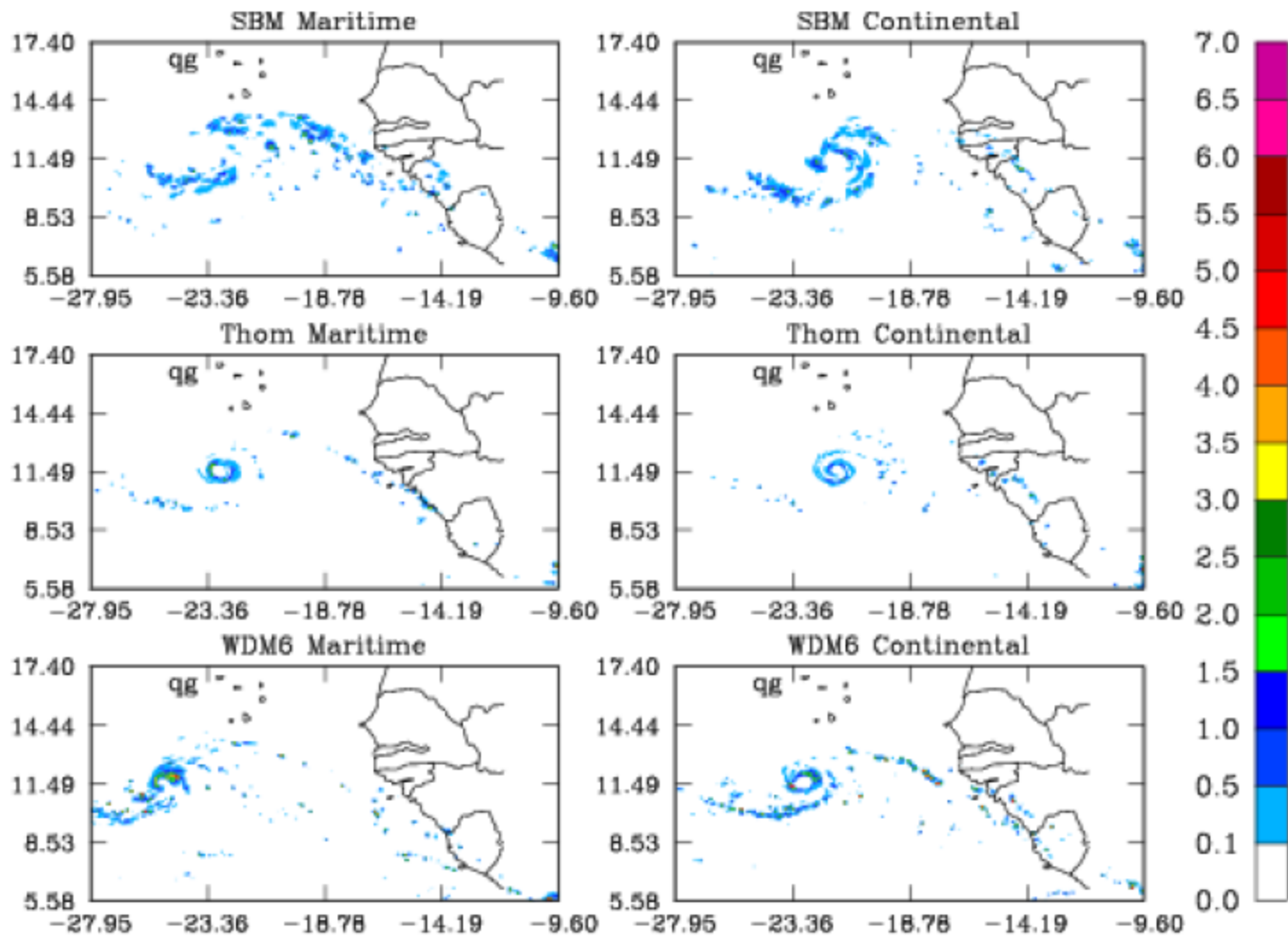


Max Vertical Velocity (#/cm**3)



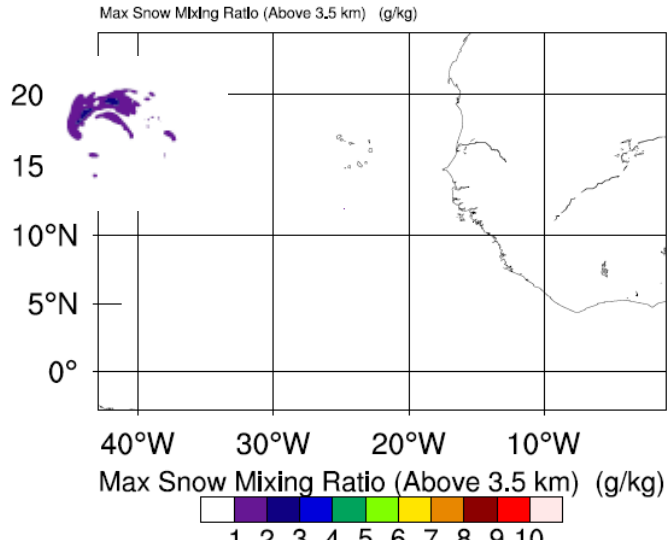






REAL-TIME WRF

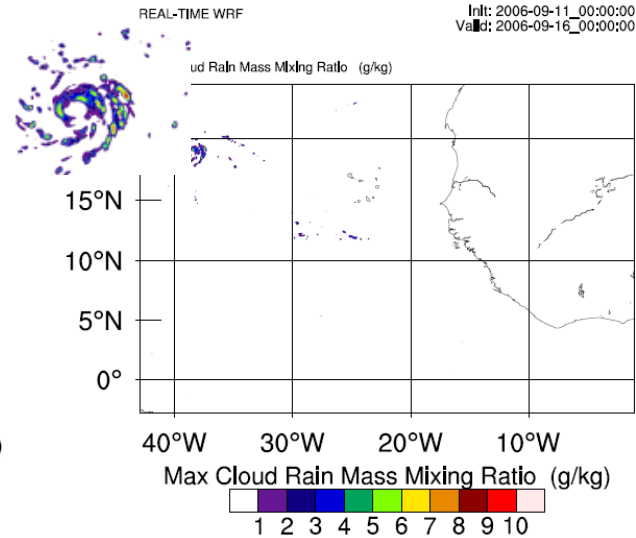
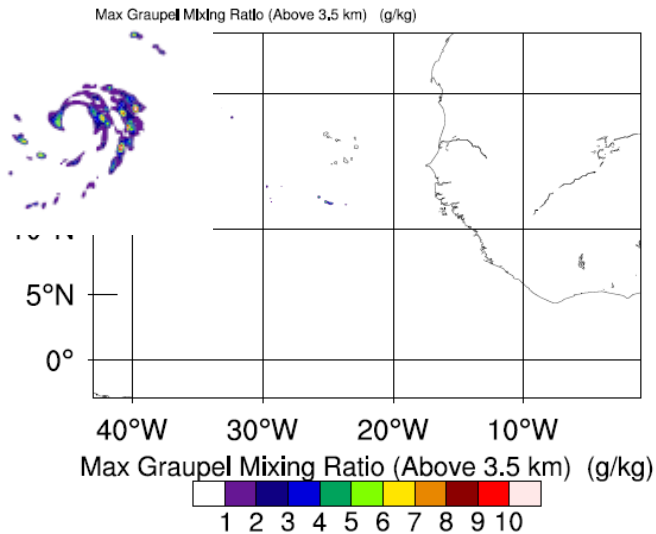
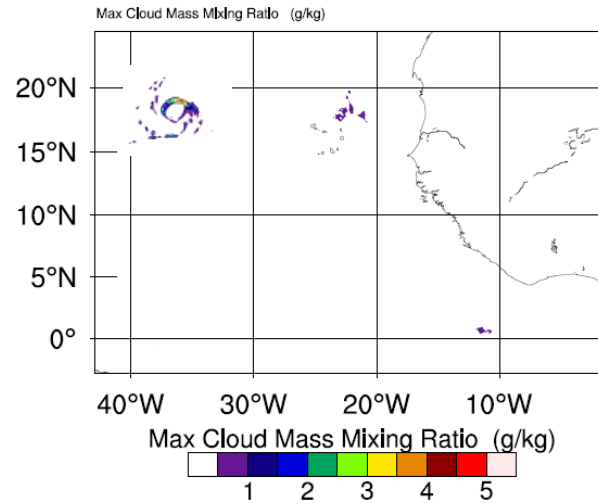
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Valid: 2006-09-16_00:00:00



WDM6-con

REAL-TIME WRF

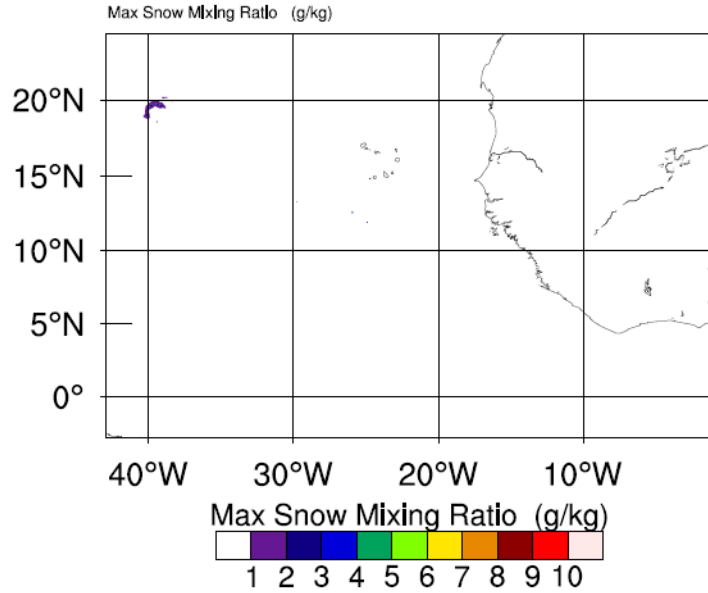
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Valid: 2006-09-16_00:00:00



WDM6-mar

REAL-TIME WRF

Init: 2006-09-11_00:00:00
Valid: 2006-09-16_00:00:00



REAL-TIME WRF

Init: 2006-09-11_00:00:00
Valid: 2006-09-16_00:00:00

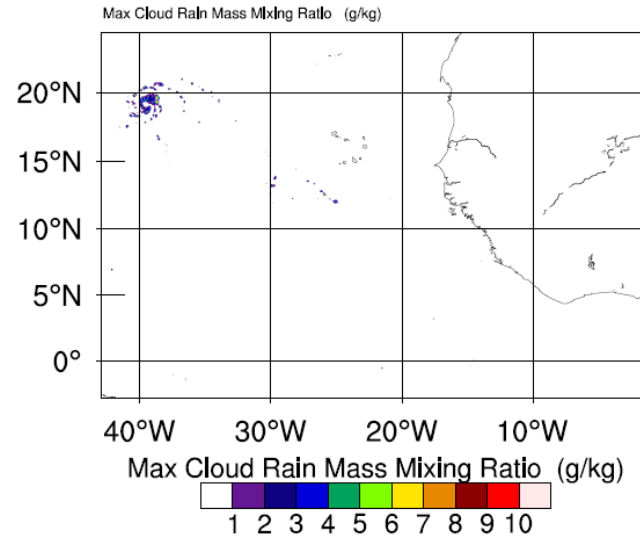
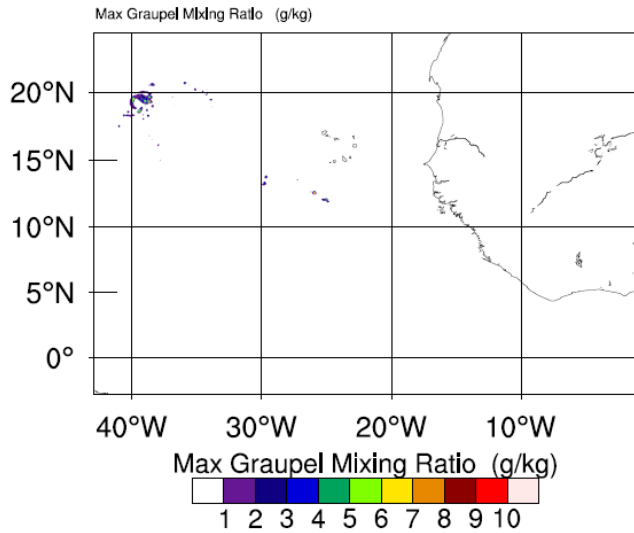
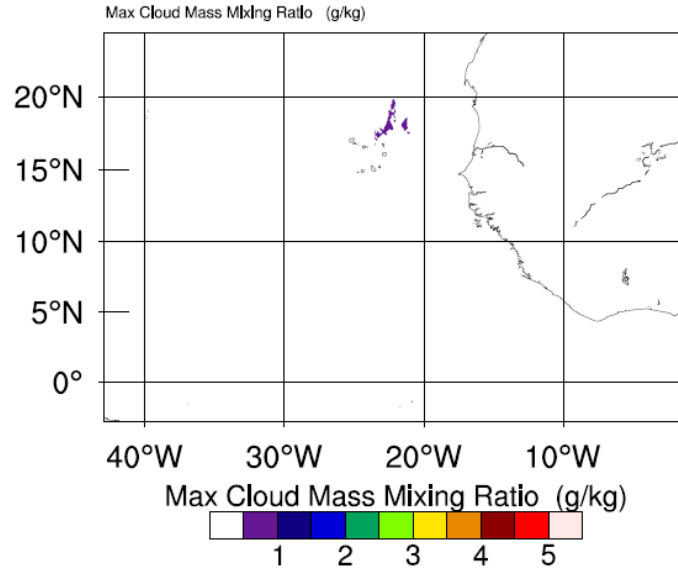


Table 4. Preliminary intensity forecast evaluation (heterogeneous sample) for Hurricane Helene, 12-24 September 2006. Forecast errors (kt) are followed by the number of forecasts in parentheses. Errors smaller than the NHC official forecast are shown in bold-face type. Verification includes the depression stage, but does not include the extratropical stage.

Forecast Technique	Forecast Period (h)						
	12	24	36	48	72	96	120
SHF5	7.3 (47)	9.2 (45)	10.0 (43)	10.6 (41)	10.4 (37)	11.7 (33)	13.8 (29)
GFDI	7.4 (46)	9.4 (44)	8.5 (42)	9.8 (40)	11.3 (36)	12.5 (32)	10.6 (28)
SHIP	8.0 (47)	11.5 (45)	13.8 (43)	15.1 (41)	16.5 (37)	11.9 (33)	6.4 (29)
DSHP	8.0 (47)	11.5 (45)	13.8 (43)	15.1 (41)	16.5 (37)	11.9 (33)	6.4 (29)
FSSE	9.0 (41)	11.2 (39)	12.2 (37)	12.9 (35)	12.6 (31)	7.4 (27)	6.0 (23)
ICON	7.4 (43)	9.0 (41)	9.2 (39)	9.4 (37)	10.7 (33)	9.6 (29)	6.4 (27)
OFCL	7.4 (47)	10.4 (45)	11.6 (43)	11.8 (41)	11.2 (37)	10.6 (33)	9.8 (29)
NHC Official (2001-2005 mean)	6.3 (1930)	9.8 (1743)	12.1 (1569)	14.3 (1410)	18.4 (1138)	19.8 (913)	21.8 (742)

Table 1. Best track for Hurricane Helene, 12-24 September 2006.

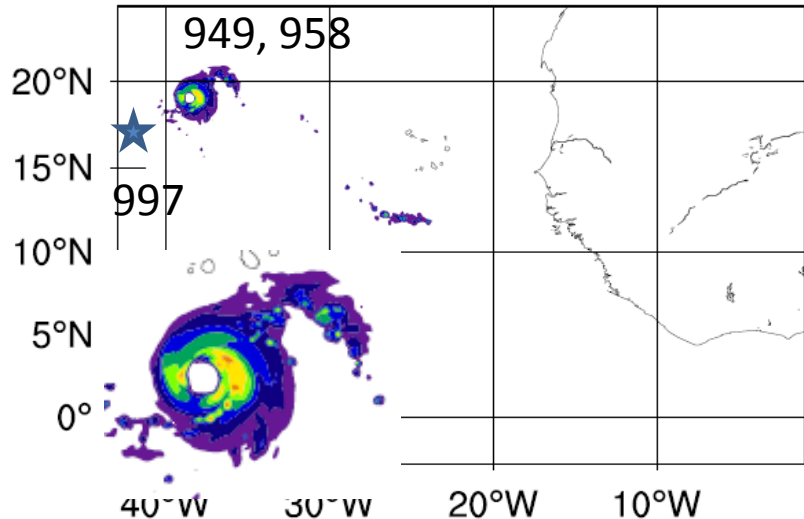
Date/Time (UTC)	Latitude (°N)	Longitude (°W)	Pressure (mb)	Wind Speed (kt)	Stage
12 / 1200	11.9	22.0	1007	25	tropical depression
12 / 1800	11.9	23.2	1007	30	"
13 / 0000	11.9	24.6	1007	30	"
13 / 0600	12.0	26.1	1007	30	"
13 / 1200	12.2	28.0	1007	30	"
13 / 1800	12.5	30.0	1006	30	"
14 / 0000	12.9	31.9	1005	35	tropical storm
14 / 0600	13.2	33.8	1005	35	"
14 / 1200	13.6	35.6	1003	40	"
14 / 1800	14.0	37.0	1003	40	"
15 / 0000	14.4	38.3	1002	40	"
15 / 0600	14.8	39.6	1000	45	"
15 / 1200	15.5	40.8	997	50	"
15 / 1800	16.2	42.1	995	55	"
16 / 0000	17.0	43.3	992	60	"

REAL-TIME WRF

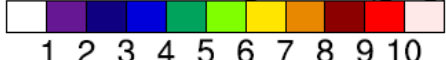
Thompson C

6-09-11_00:00:00
6-09-16_00:00:00

Max Snow Mixing Ratio (g/kg)



Max Snow Mixing Ratio (g/kg)

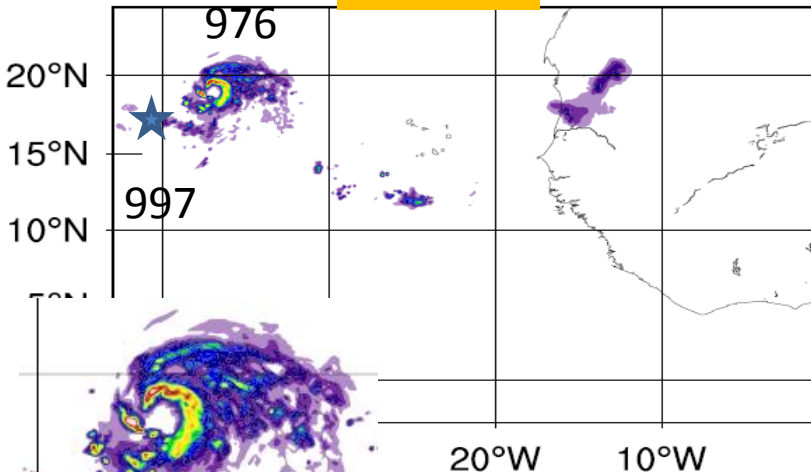


REAL-TIME WRF

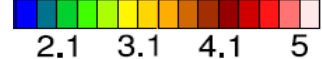
SBM-C

Init: 2006-09-15_18:00:00
Valid: 2006-09-16_00:00:00

Max Snow Mixing Ratio (g/kg)



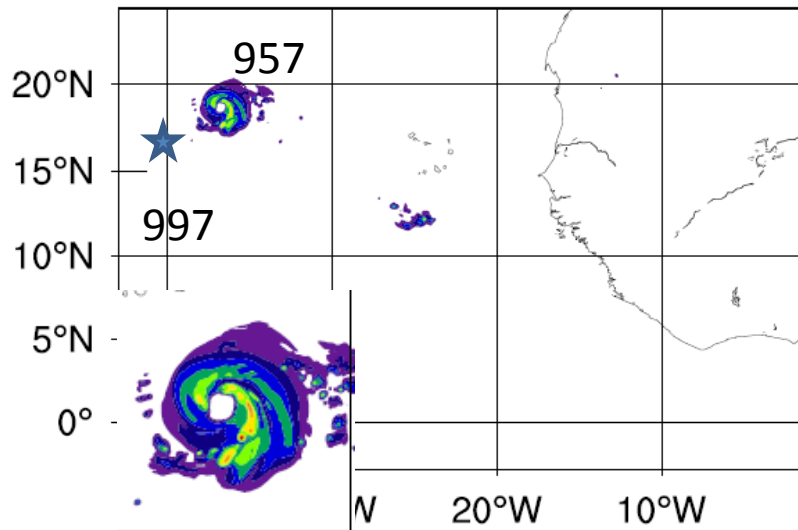
Max Snow Mixing Ratio (g/kg)



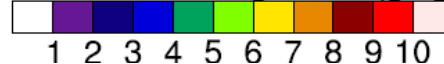
Thompson m

Init: 2006-09-11_00:00:00
lid: 2006-09-16_00:00:00

Max Snow Mixing Ratio (g/kg)



Max Snow Mixing Ratio (g/kg)

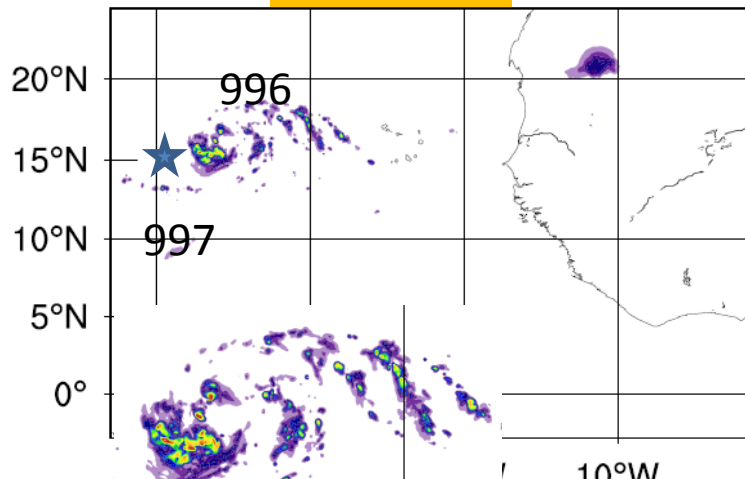


REAL-TIME WRF

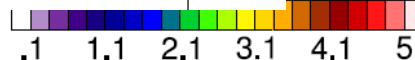
SBM-m

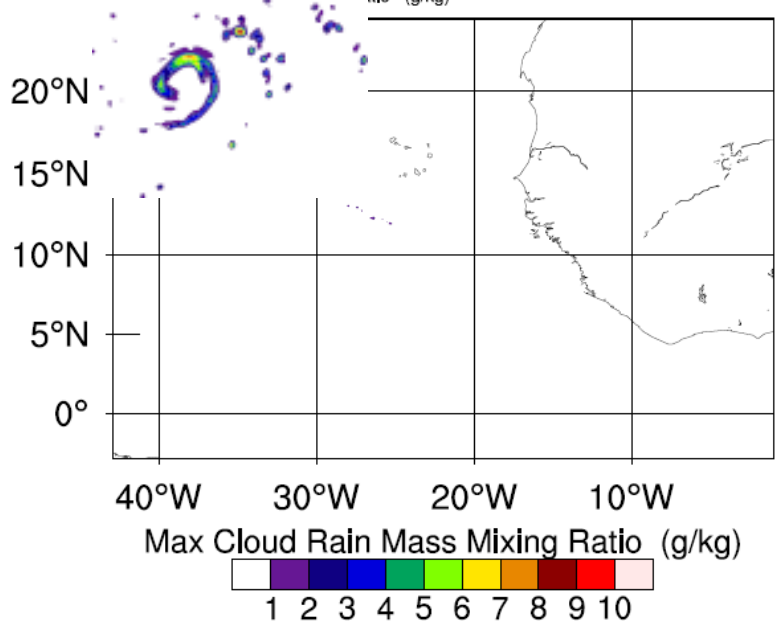
Init: 2006-09-14_21:00:00
Valid: 2006-09-15_06:00:00

Max Snow Mixing Ratio (g/kg)



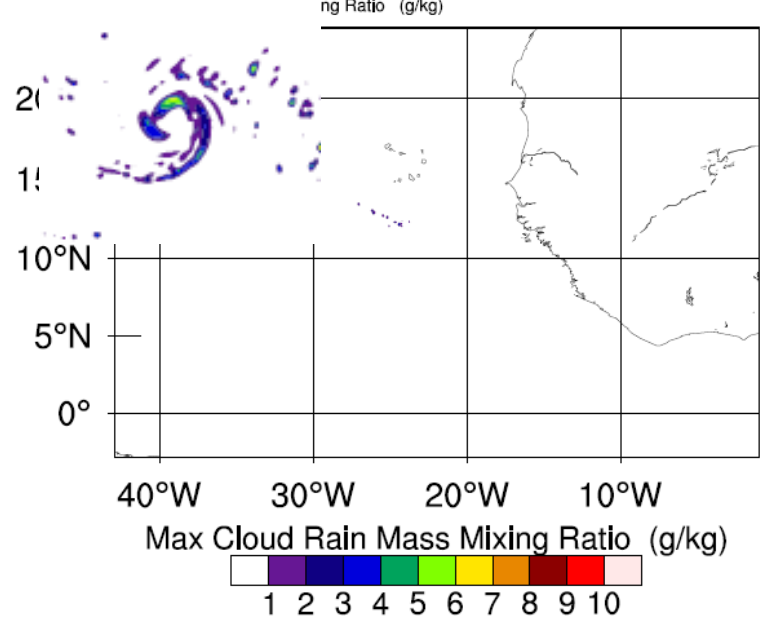
Max Snow Mixing Ratio (g/kg)





REAL-TIME WRF

Init: 2006-09-15_18:00:00
Valid: 2006-09-16_00:00:00



REAL-TIME WRF

SBM-m

Init: 2006-09-14_21:00:00
Valid: 2006-09-15_06:00:00

