EVALUATION OF A BIN CLOUD MODEL USING DATA FROM CHUVA PROJECT FOR FORTALEZA, CEARA

MOTIVATION

- This work is a result of the current effort to produce a brazilian mixed phase bin cloud model.
- During the attemps to implement the mixed phase, it was realized that the old version of the model described at Almeida et al. (1998) and Costa et al. (2000) could not simulate situations of very large number of grid points.
- Also, it was needed to evaluated modifications on some microphysical process not well represented
- The mixed phase bin cloud model can be used to calculate the charge transfer between hidrometeors

OBJECTIVES

- Find dynamical situations where mixed phase is very probable to occur.

A MODEL DESCRIPTION

- Wet, deep and free convection (subroutine of convection was modified).
- Linear momentum conservation.
- Mass Conservation
- Energy conservation, and
- Water conservation
- Almeida et al. (2008), Costa et al. (2008) Almeida and Santos (2007), Almeida (2010)

MODEL DESCRIPTION

- The cloud microphysical processes on the model:

  Nucleation (modified)

  Condensation and Evaporation

  Colission and coalescence.

  Collision and break up (Modified).

  Spontaneous break up.

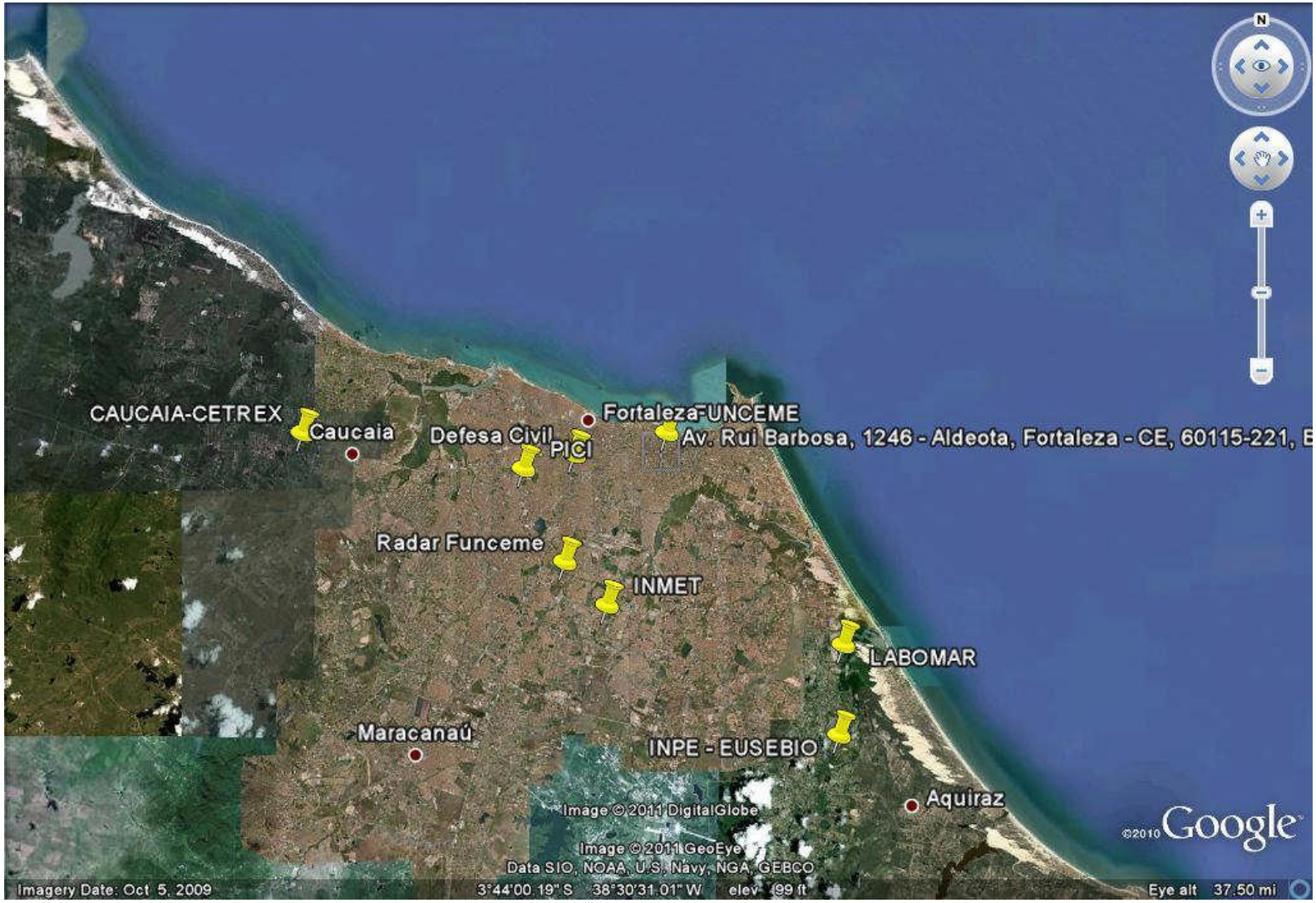
$$\frac{\partial f_i}{\partial t} = -(w - V_r)\frac{\partial f_i}{\partial z} + \frac{2\alpha^2}{a}|w|(f_{ia} - f_i) + \frac{2}{a}\mu_c(f_i - f_{ic}) +$$

$$\frac{f_i w}{\rho_a}\frac{d\rho_a}{dz} + \left.\frac{\partial f_i}{\partial t}\right|_{nuc} + \left.\frac{\partial f_i}{\partial t}\right|_{CE} + \left.\frac{\partial f_i}{\partial t}\right|_{coa} + \left.\frac{\partial f_i}{\partial t}\right|_{Q} \qquad i = 1, 2, 3, \ldots, M$$

MODEL SIMULATION

- The model uses 100 bin classes to represent cloud drops, with diameters ranging from 2 μm a 10 mm.
- The model also uses 168 bin classes to represent CCN with chemical, with critical supersaturation ranging from 0.00 to 3.00%
- The cloud domain was modified from 80x80 grid points (6400 m x 6400 m) to 230x230 grid points (18400 m x 18400m) 80 m resolution.

Figure 1: measurements sites during CHUVA at Fortaleza, from 29/March/2011 to 29/April/2011.

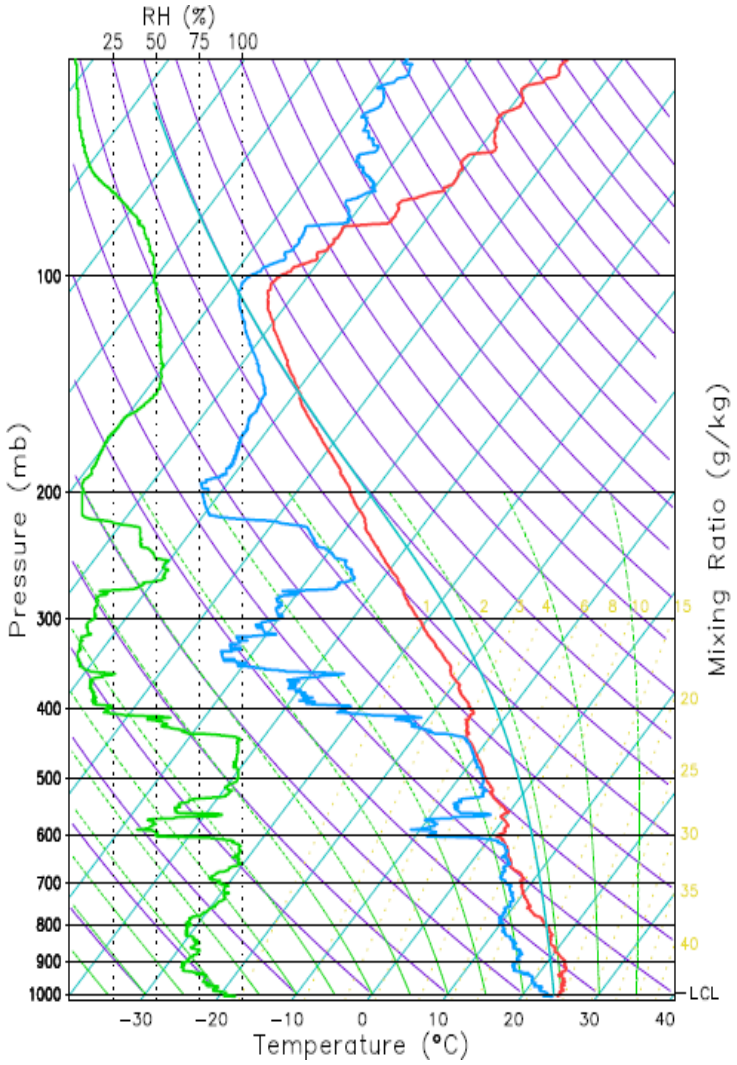


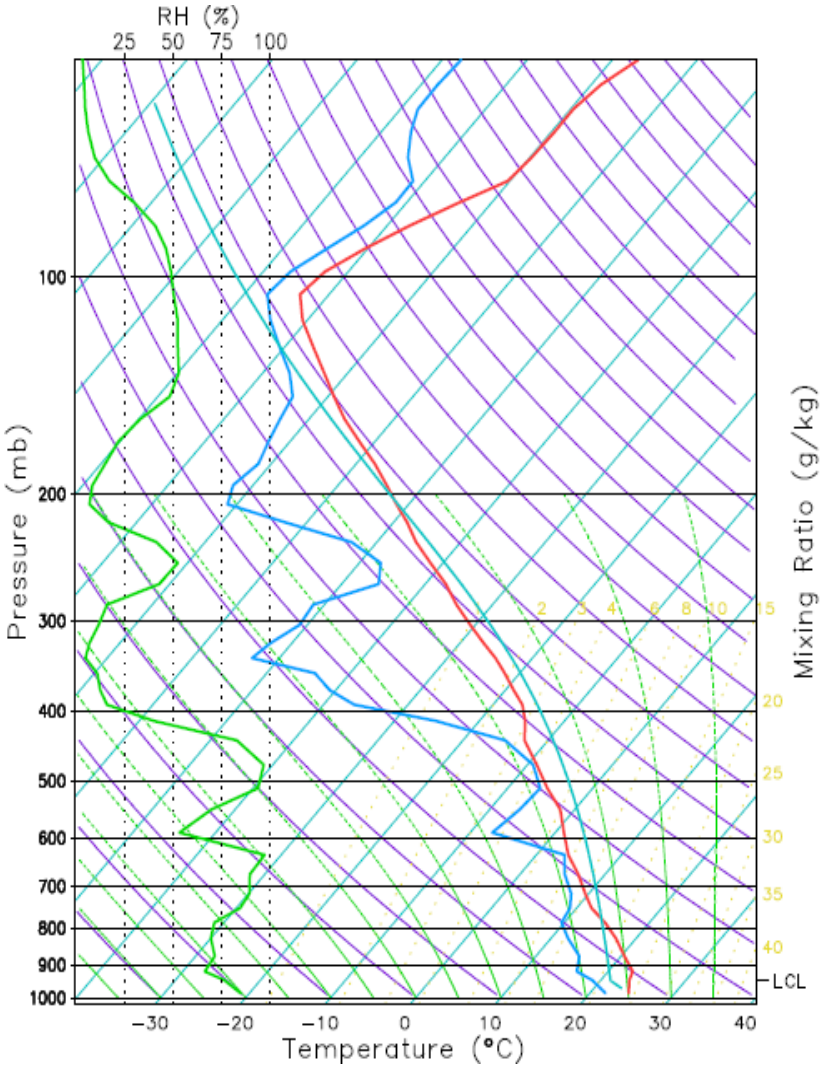
MODEL SIMULATIONS

- Initial condition were obtained from radio-soundings, microwave radiometers.

- Only data from Fortaleza were used

MODEL SIMULATION





MODEL SIMULATION

- Time step of 5 s for dynamics, 0.2 s for microphysics and 1 hour for total simulation.

- Cloud Condensation Nuclei (CCN) are considered for 3 regimes: maritime, pollluted and intermediate, following relationships of the kind $N = C \cdot S^k$ where N is the concentration in cm^{-3}, C e k are constants, and S is the supersaturation in $\%$.

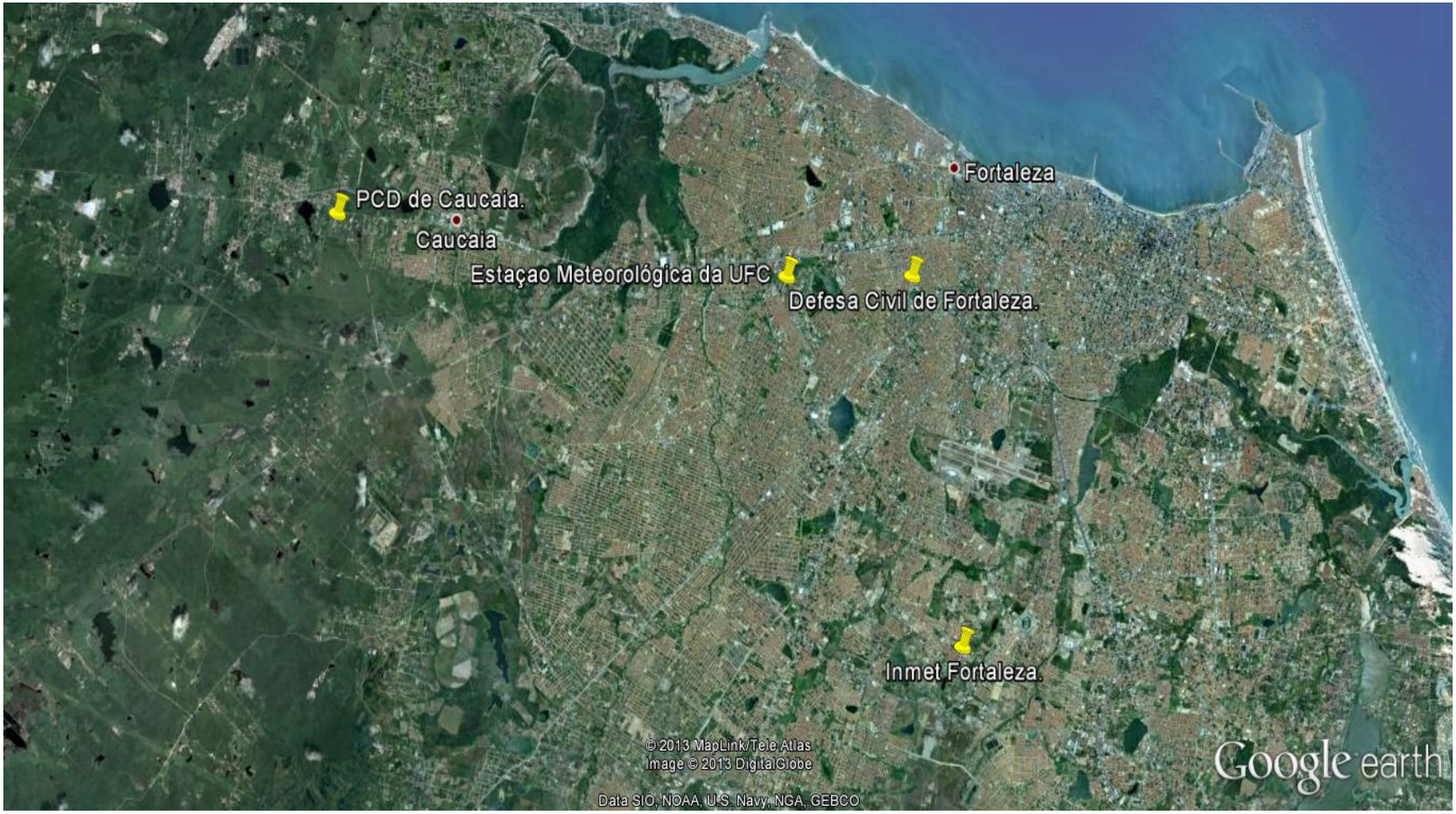
- The values for C and k are: 245 and 0,33 (maritime); 1275 and 0,72 (intermidiate); and 2450 and 0,9569 (polluted).

MATERIAIS E MÉTODOS

- Através de radiossondagens realizadas no INMET em Fortaleza, obtêm-se as condições iniciais do modelo de nuvem, que será simulado gerando arquivos contém informações especificas sobre o comportamento da nuvem como, por exemplo; altura da base e topo da nuvem, sua extensão, a razão de mistura de água de nuvem e a razão de mistura de água chuva e a precipitação pluviométrica.

- Através das informações geradas pelo modelo de nuvem será analisado os valores de precipitação pluviométricas em comparação com as informações obtidas na PCD de Caucaia, na Estação pluviométrica da UFC, no INMET e na Defesa Civil de Fortaleza.

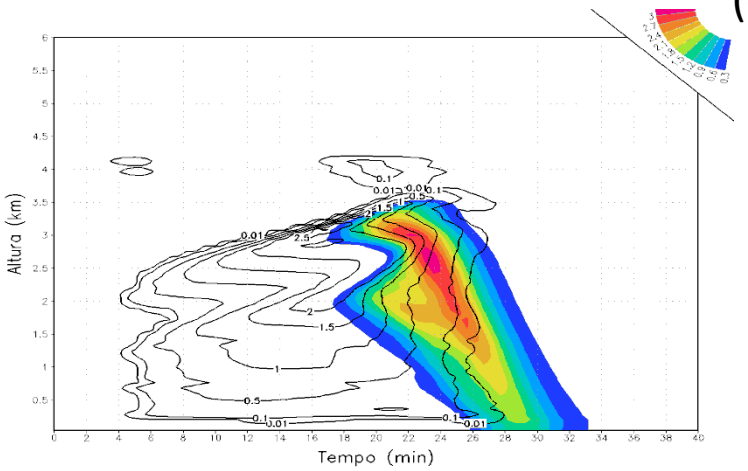
Figure 2 – Sites with precipitation measurements.



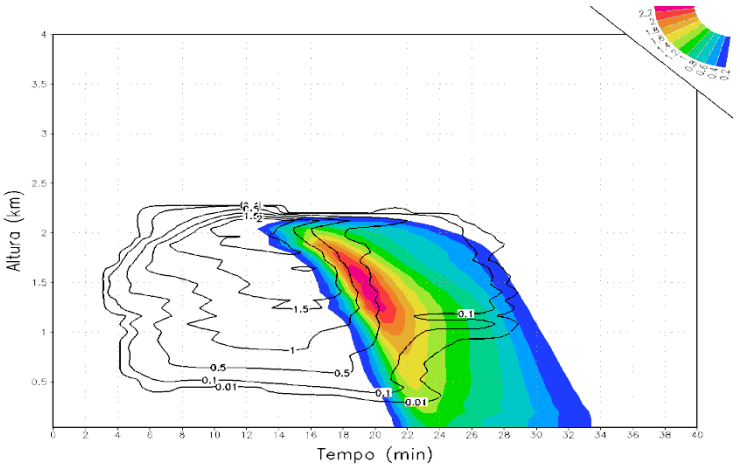
RESULTS

FIGURE 3 – Temporal evolution of cloud water mixing ratio (g/kg) and rain (in colors g/kg) for control simulations (a) 09/Apr/2011 05:37 UTC, (b) 09/Apr/2011 at 12:01 UTC, (c) 09/Apr/2011 at 18:01 UTC and (d) 10/Apr/2011 at 17:56 UTC.

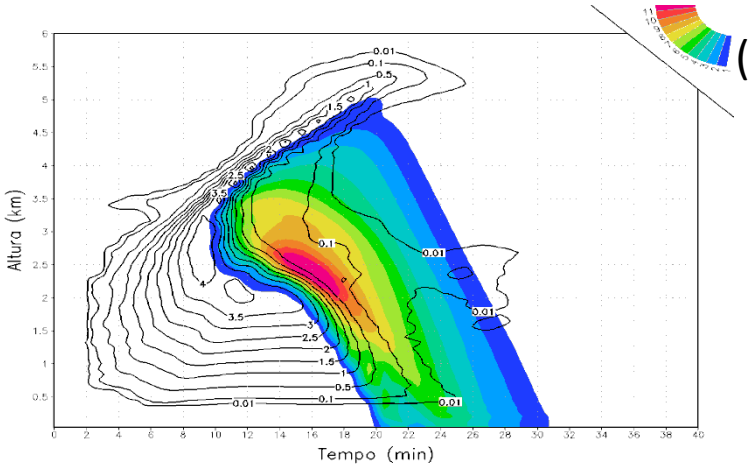
(a)



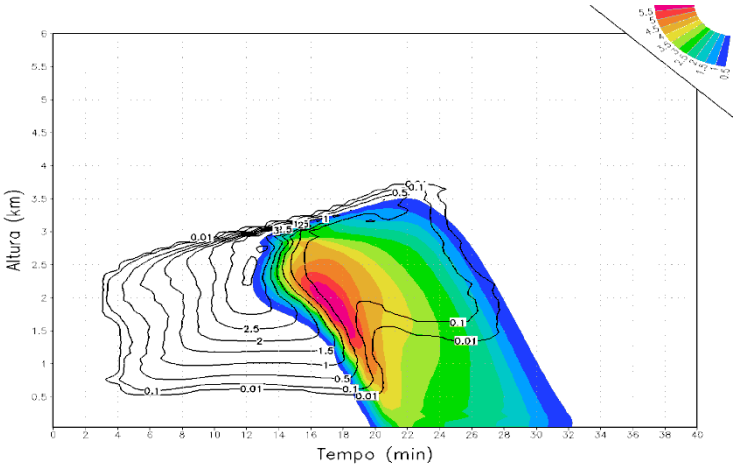
(c)



(b)



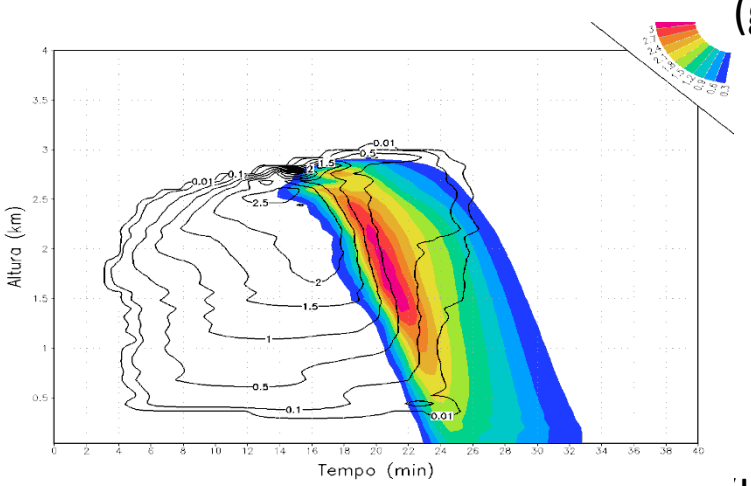
(d)



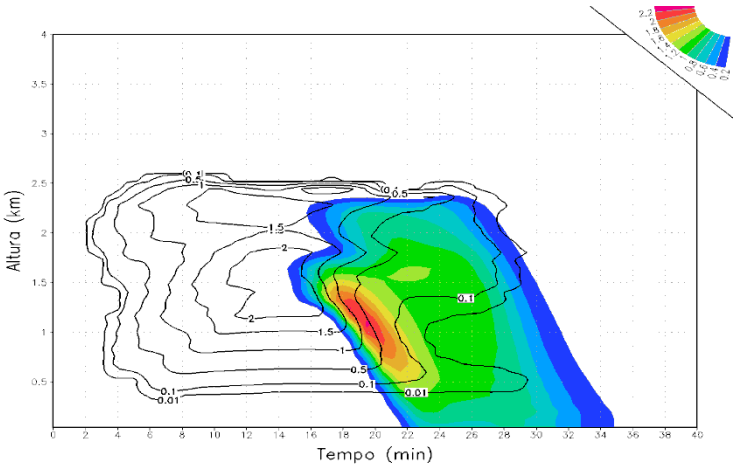
RESULTS

FIGURE 4 – Temporal evolution of cloud water mixing ratio (g/kg) and rain (in colors g/kg) for control simulatios (e) 11/Apr/2011 (11:41 UTC), (f) 11/Apr/2011 (17:36 UTC), (g) 11/April/2011 (23:36 UTC) and (h) 12/Apr/2011 (11:48 UTC).

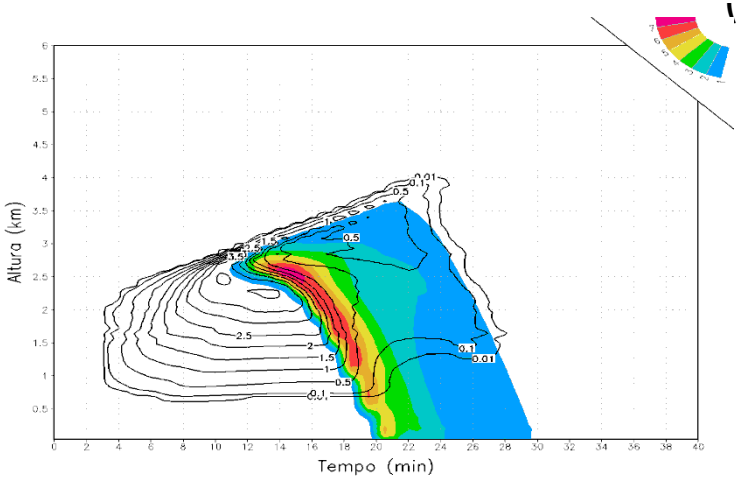
(e)



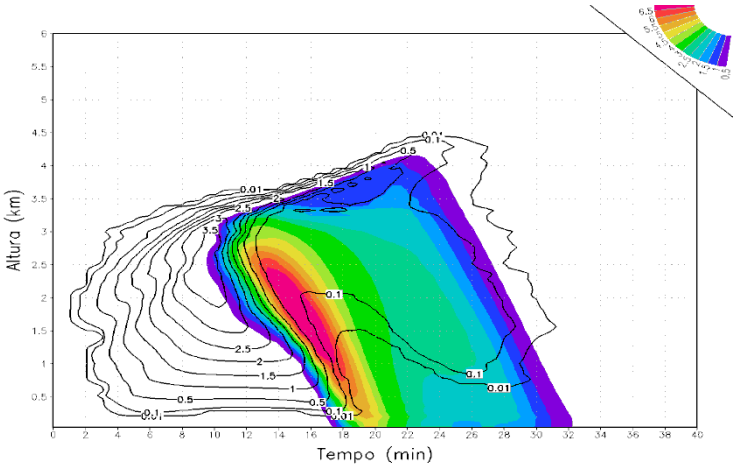
(g)



(f)



(h)



RESULTS

Table 1 – Comparision between simulation control and observation, (underlined observation the model could represents qualitatevely.

Rs	Modeled Precipitation (mm).	Observed Precipitation (mm).			
		PCD de Caucaia.	UFC.	INMET.	Defesa Civil.
09/04/2011 às 05:37 UTC.	0,24	0,00	00,0	0,00	0,00
09/04/2011 às 12:01 UTC.	1,77	0,20	38,6	0,10	0,60
09/04/2011 às 18:01 UTC.	0,25	8,20	0,02	0,00	0,80
10/04/2011 às 17:56 UTC.	1,06	1,60	0,00	12,00	0,00
10/04/2011 às 23:39 UTC.	1,32	0,00	0,00	0,00	0,00
11/04/2011 às 05:38 UTC.	0,00	0,08	0,00	0,00	0,00
11/04/2011 às 11:41 UTC.	0,32	0,70	0,10	0,00	0,10
11/04/2011 às 17:36 UTC.	1,11	0,00	0,00	1,30	0,00
11/04/2011 às 23:36 UTC.	0,22	0,00	0,00	0,00	0,00
12/04/2011 às 11:48 UTC.	1,49	5,70	0,00	0,00	0,00

RESULTADOS

Table 2 – Comparison between simulation control, observation and simulations using smoothed radio-soundings.

Rs.	Precipitação da Simulação de Controle (mm).	Precipitation with Smooths (mm)				Observed Precipitation (mm).			
		5	15	25	50	PCD de Caucaia	UFC	INMET	Defesa Civil
09/04/2011 às 05:37 UTC.	0,24	0,20	0,18	0,13	**0,05**	0,00	0,00	0,00	0,00
09/04/2011 às 12:01 UTC	1,77	1,27	1,93	**2,35**	1,92	0,20	38,6	0,10	0,60
09/04/ 2011 às 18:01 UTC	0,25	**0,27**	0,26	0,22	0,11	8,20	0,02	0,00	0,80
10/04/2011 às 17:56 UTC	**1,06**	1,04	1,05	1,04	0,79	1,60	0,00	12,00	0,00
10/04/2011 às 23:39 UTC	1,32	1,28	1,32	1,31	**0,00**	0,00	0,00	0,00	0,00
11/04/2011 às 05:38 UTC	**0,00**	0,00	0,00	0,00	0,00	0,08	0,00	0,00	0,00
11/04/2011 às 11:41 UTC	0,32	**0,33**	033	0,29	0,00	0,70	0,10	0,00	0,10
11/04/2011 às 17:36 UTC	1,11	1,05	1,16	**1,21**	1,08	0,00	0,00	1,30	0,00
11/04/2011 às 23:36 UTC	0,22	0,19	0,13	0,13	**0,13**	0,00	0,00	0,00	0,00
12/04/2011 às 11:48 UTC	1,49	1,50	1,52	1,57	**1,58**	5,70	0,00	0,00	0,00

Fonte: Própria.

CONCLUSIONS

- The bin cloud model represents observed precipitation on 45% of the cases using the simulation of control.
- When radio-soundings are smoothed the model represents 54% of observations.
- Sometimes observed precipitations is about one order of magnitude of that presented by cloud model. Those cases should be investigated considering the inclusion of mixed phase.