

Numerical simulation of space-time distribution of gases and particles emitted during 1998 Roraima fires

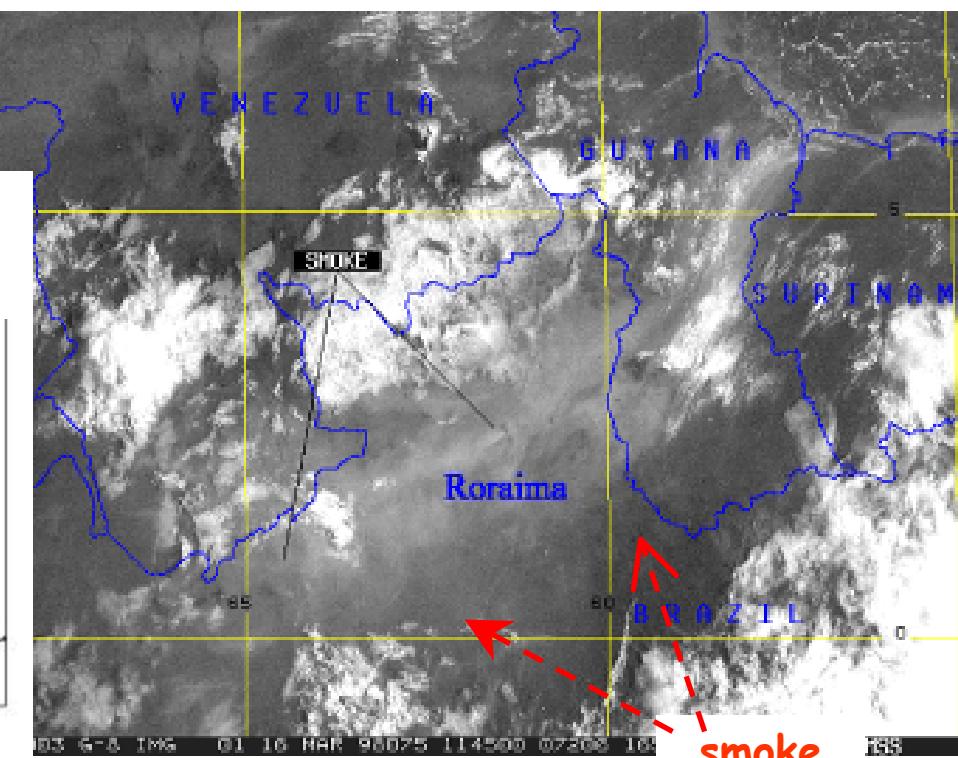
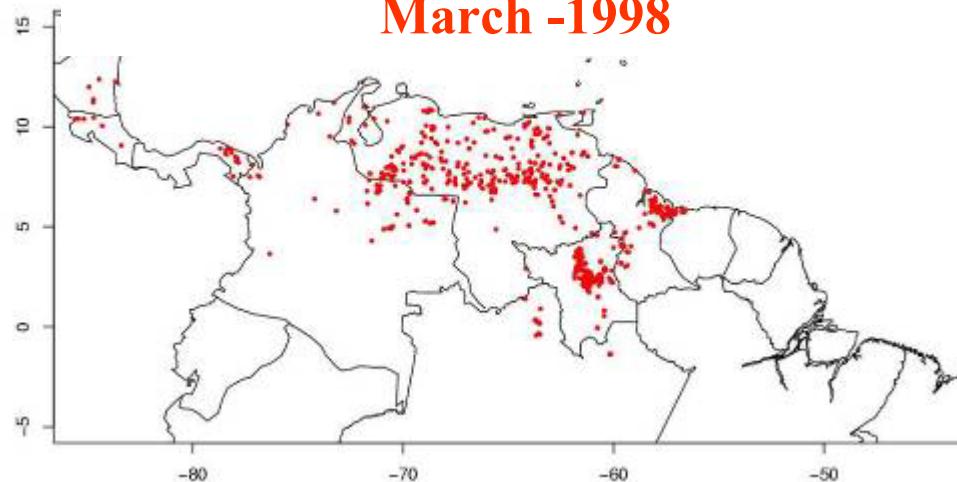
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Vegetation fires in Roraima during 1998

ATSR and TRMM fire counts
March -1998

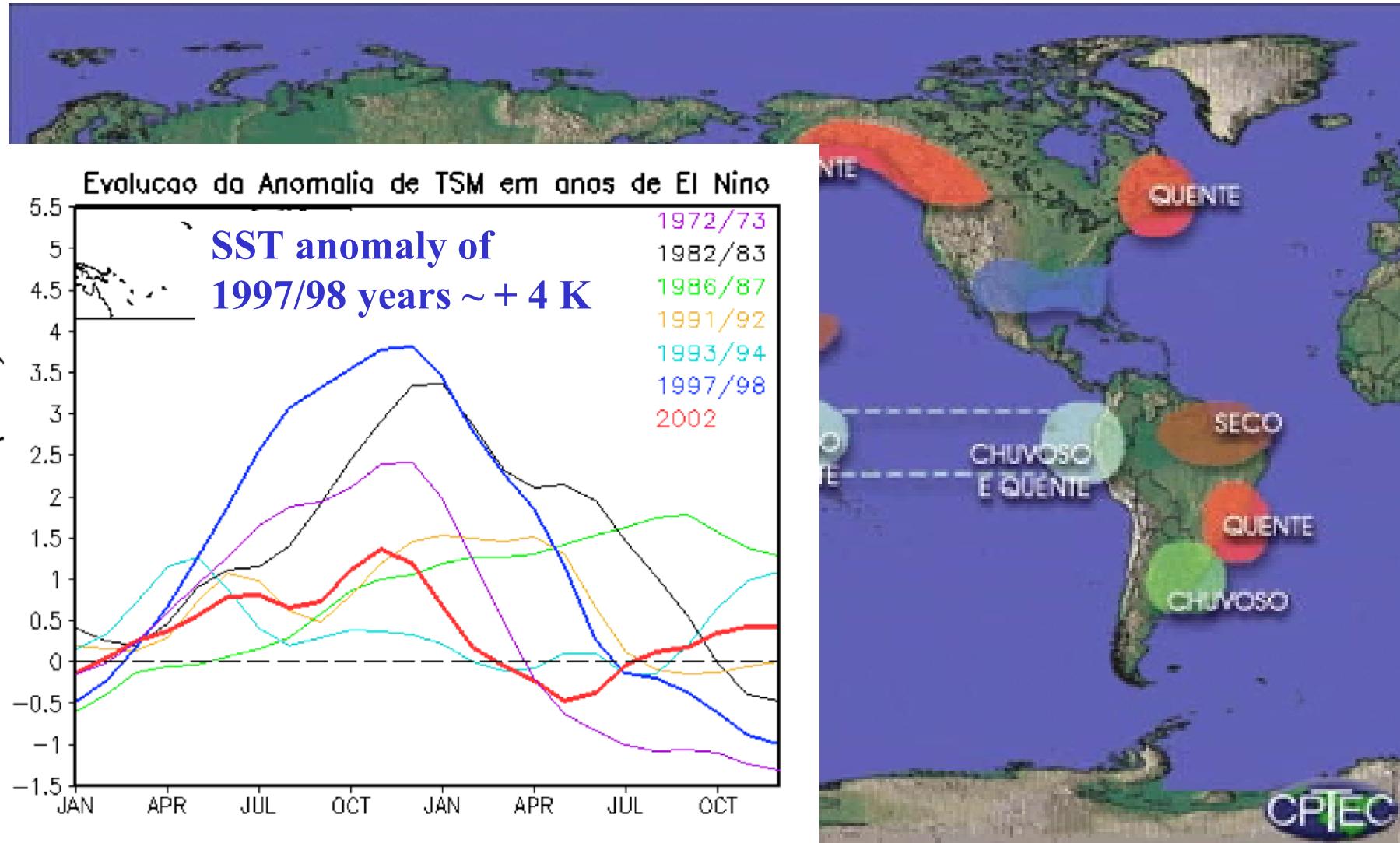


Burned areas by biome (km^2)
Barbosa e Fearnside (2000)

	Área total do sistema	Área efetivamente queimada	Porcentual queimado
Floresta densa	104.810	2.657 a 3.247	2,5 a 3,1
Floresta não-densa	49.817	8.737 a 10.681	17,5 a 21,4
Savanas, campinas e campinaranas	62.659	23.970	38,2
Rural	5.776	2.780	48,1
Urbano	251	-	-
Cursos de água	1.803	-	-
Total	225.116	38.144 a 40.678	16,9 a 18,1

El Niño

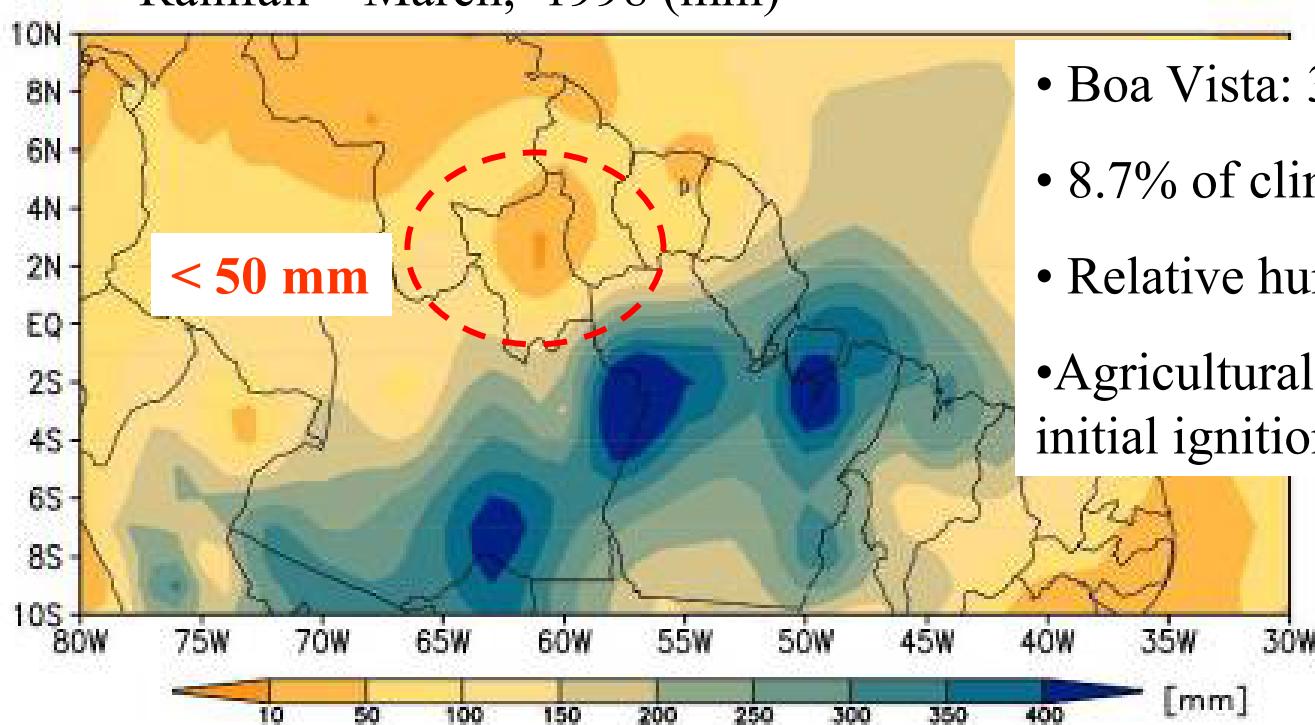
- SST anomaly at Equatorial Pacific: + 3°C.
- Weak convective activity on north of Brazil.
- Positive Anomalies of temperature and negative of relative humidity on Roraima.



Vegetation fires in Roraima during 1998

Meteorological condition - (El Niño)

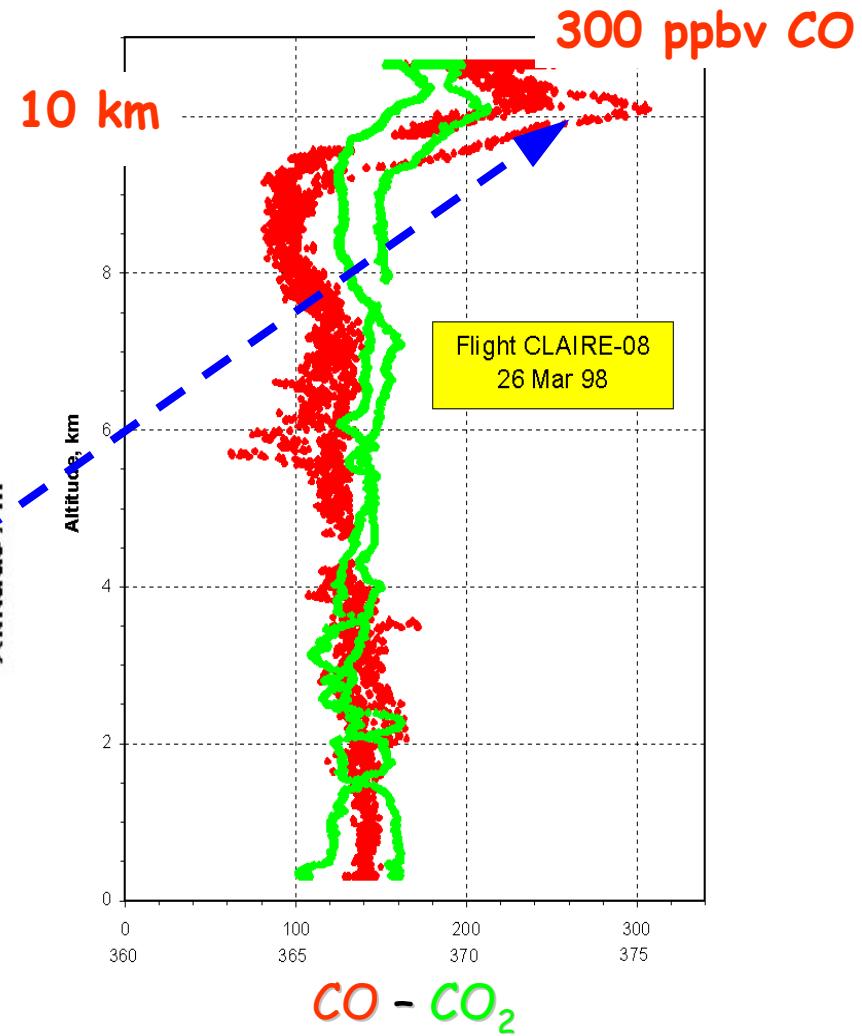
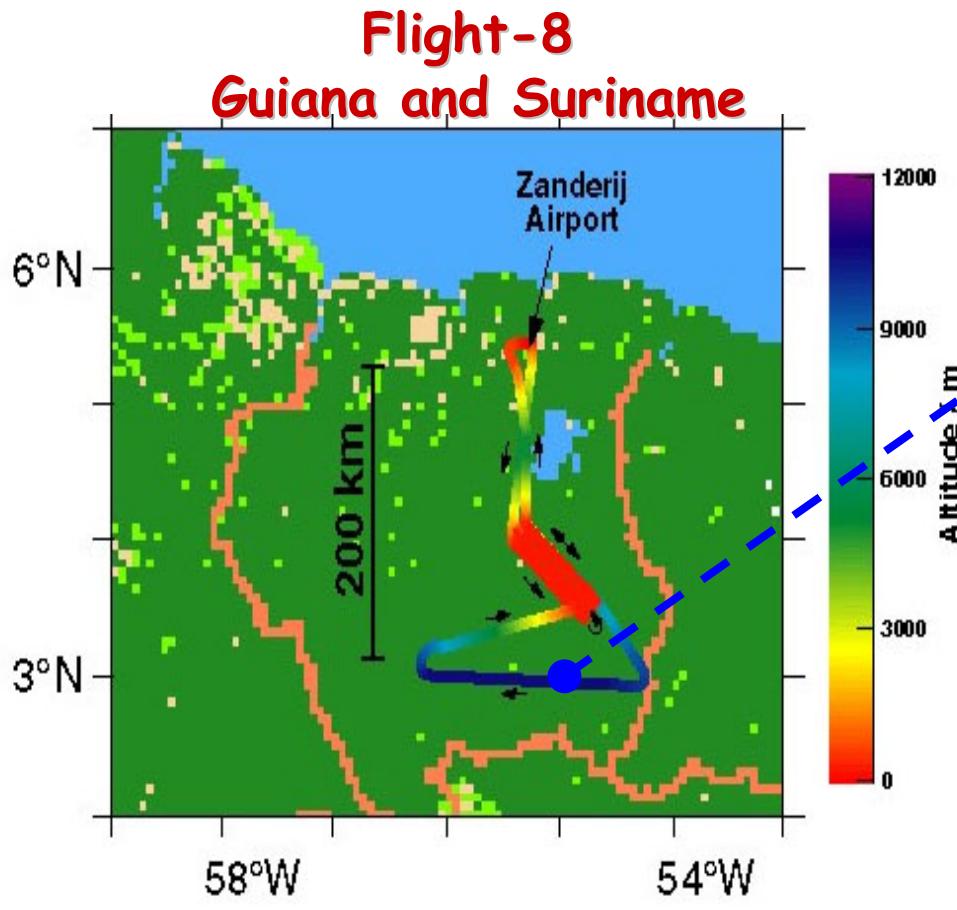
Rainfall – March, 1998 (mm)



- Boa Vista: 30,6 mm set/97-mar/98
- 8.7% of climatological mean 352mm
- Relative humidity < 60 %
- Agricultural burning was the cause of initial ignition

LBA-CLAIRe 1998 Experiment: Flight-8, March, 26 1998

Measurement of CO and CO_2 at high troposphere with biomass burning "signature"



Origin of air mass on Suriname on March, 26 1998

NOAA HYSPLIT MODEL
Backward trajectories ending at 20 UTC 26 Mar 98
FNL Meteorological Data

- Planetary Boundary Layer (1km)

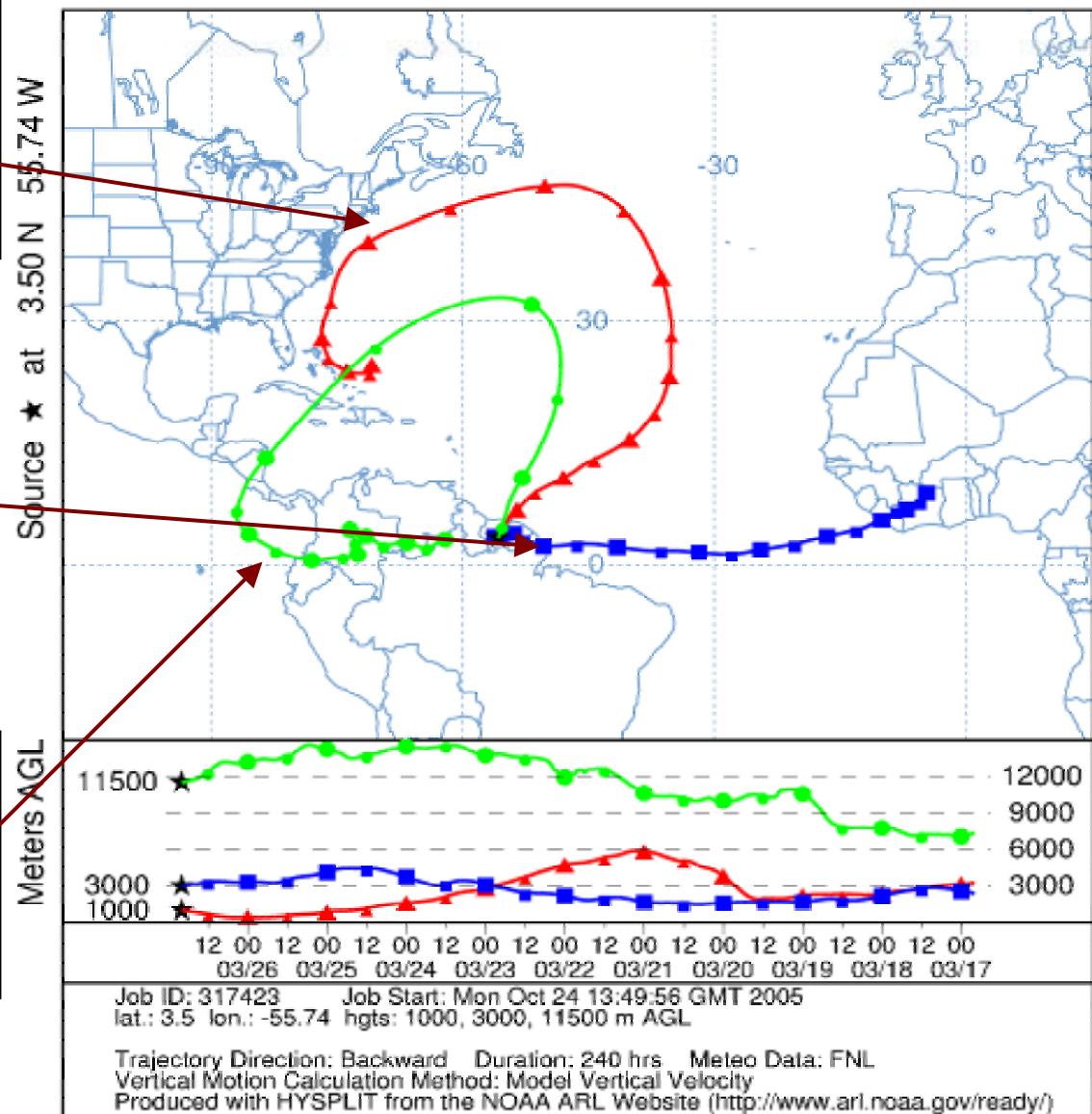
→ East cost of EUA
(Krejci et al., 2004)

- Low troposphere ~ 3 km:

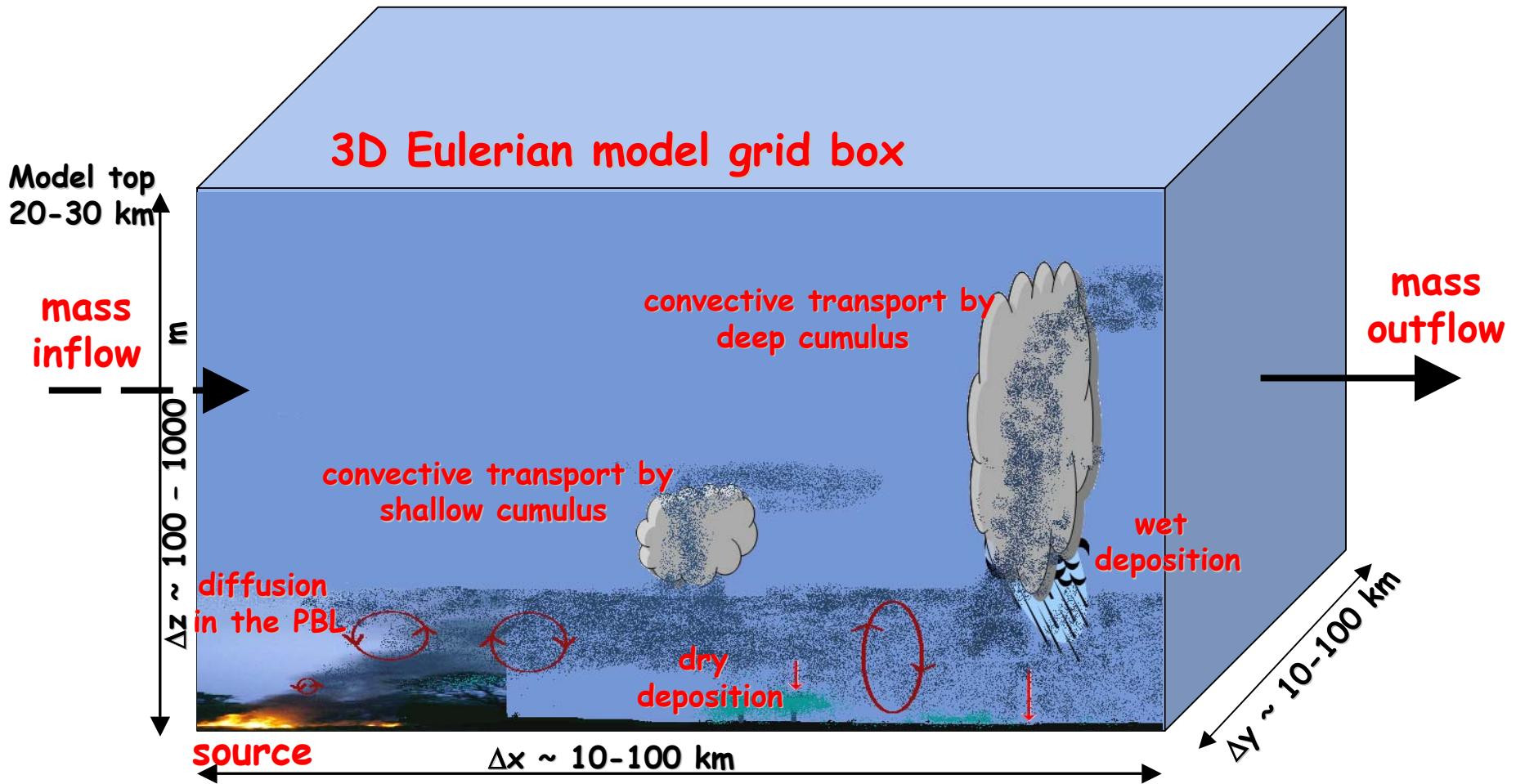
→ Africa
(Formenti et al., 2001)

- High Troposphere ~ 10 - 12 km:

→ Roraima
(Freitas et al., 2000)



Some sub-grid process involved at gases/aerosols transportation



Eulerian Transport Model : CATT-BRAMS Atmospheric Model

- in-line Eulerian transport model fully coupled to the atmospheric dynamics
- suitable for feedbacks studies
- tracer mixing ratio tendency equation

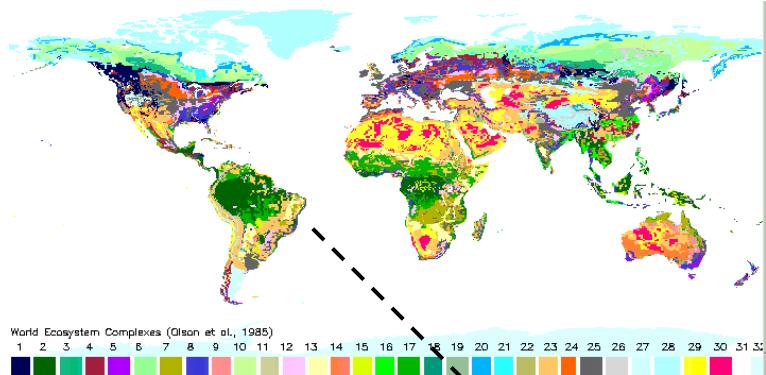
$$\frac{\partial \bar{s}}{\partial t} = \left(\frac{\partial \bar{s}}{\partial t} \right)_{adv} + \left(\frac{\partial \bar{s}}{\partial t} \right)_{PBL\ turb} + \left(\frac{\partial \bar{s}}{\partial t} \right)_{deep\ conv} + \left(\frac{\partial \bar{s}}{\partial t} \right)_{shallow\ conv} + W_{PM\ 2.5} + R + Q,$$

where:

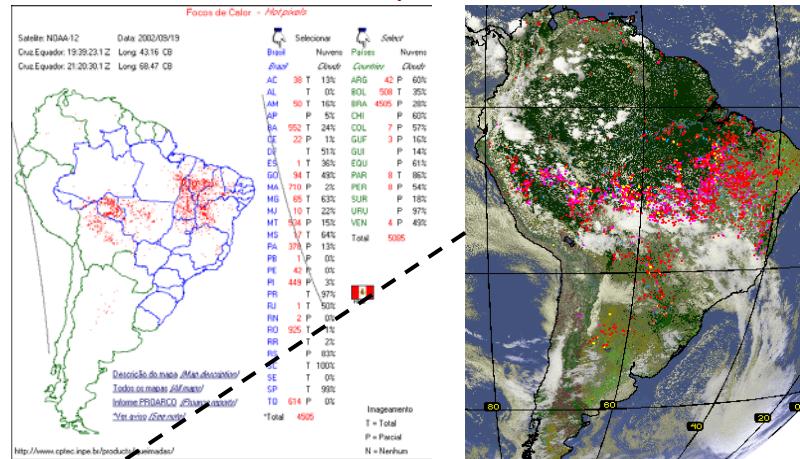
- *adv* grid-scale advection
- *PBL turb* sub-grid transport in the PBL
- *deep conv* sub-grid transport associated to the deep convection including downdraft at cloud scale
- *shallow conv* sub-grid transport associated to the shallow convection
- *W* convective wet removal
- *R* sink term associated with dry deposition or chemical transformation
- *Q* source emission.

Biomass burning emissions estimate

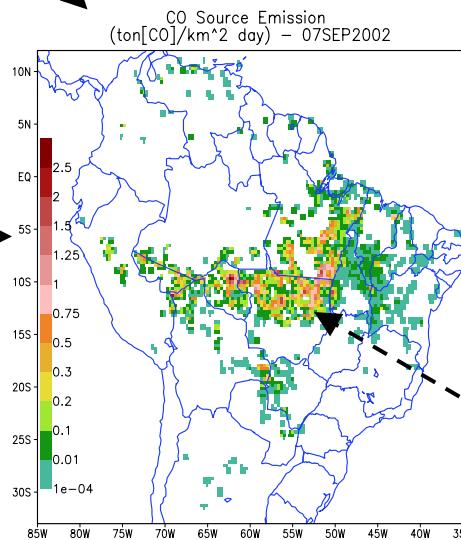
carbon density data



fire product



land use data



CO source emission ($\text{kg m}^{-2}\text{day}^{-1}$)

emission & combustion factors

Biome category	Emission Factor for CO (g/kg)	Emission Factor for PM2.5 (g/kg)	Aboveground biomass density (α , kg/m ²)	Combustion factor (β , fraction)
Tropical forest ¹	110.	8.3	20.7	0.48
South America savanna ²	63.	4.4	0.9	0.78
Pasture ³	49.	2.1	0.7	1.00

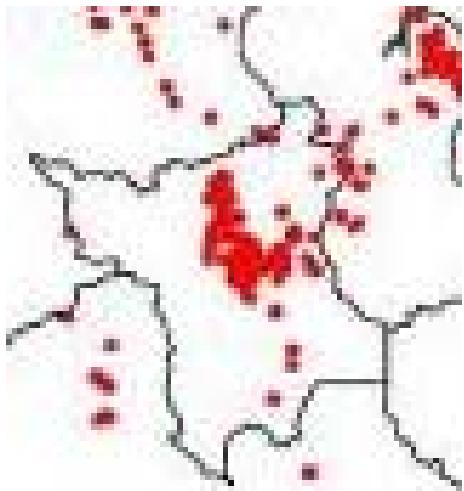
¹ Average values for primary and second-growth tropical forests, ² Average values for campo cerrado (C3) and cerrado sensu stricto (C4), ³ value for campo limpo (C1). All numbers are from Ward et al.,

mass estimation

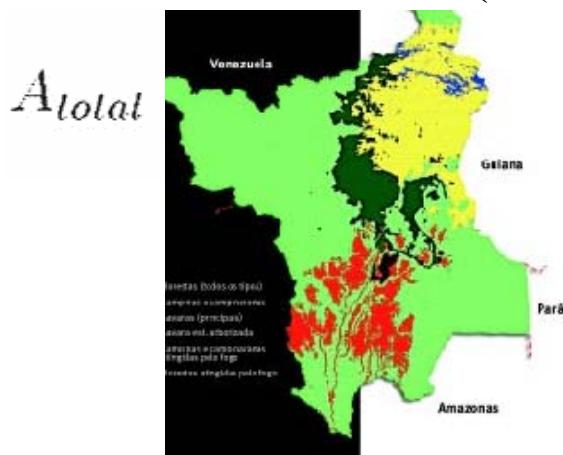
$$M[\eta] = \alpha_{\text{veg}} \cdot \beta_{\text{veg}} \cdot E_{f_{\text{veg}}}^{[\eta]} \cdot a_{\text{fire}},$$

Emission parameterization for this case study

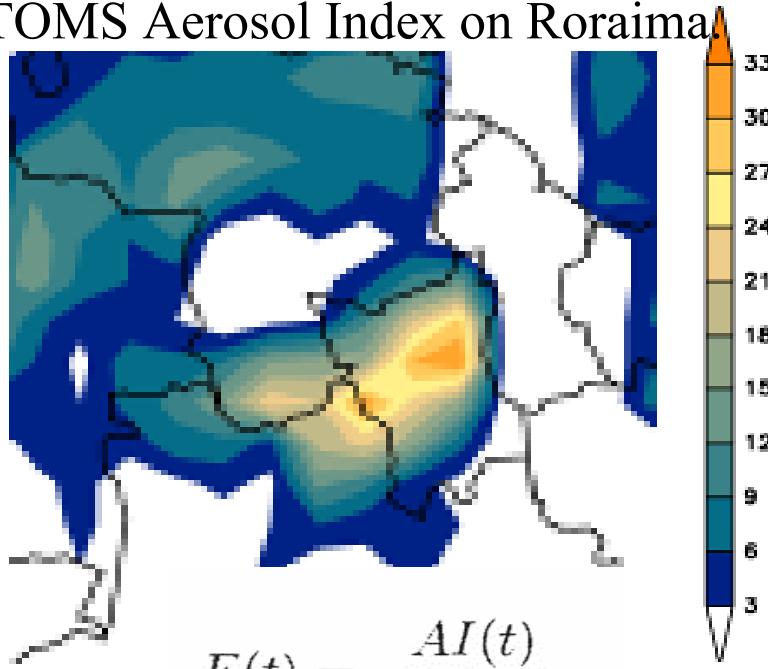
combine fire counts from ATSR
and TRMM to provide fire location



total burned area given by
Barbosa e Fearnside (2000)



diurnal variability of burned area
given by the same time variation of
TOMS Aerosol Index on Roraima



$$F(t) = \frac{AI(t)}{\sum AI(t)}$$

$$A_q(t) = F(t) A_{total}$$

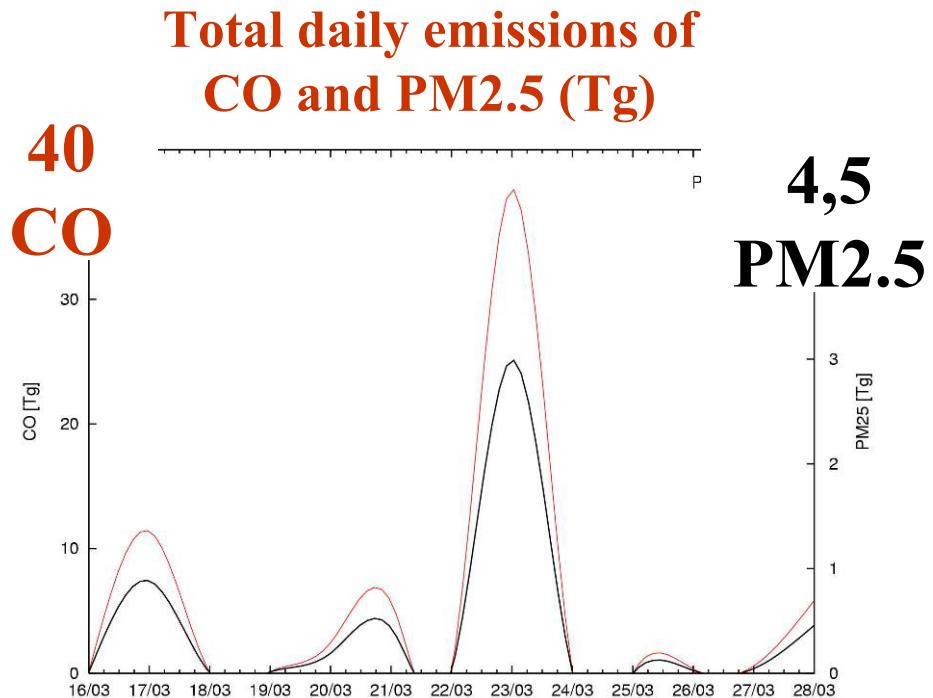
$$A_{fire}(t) = \frac{A_q(t)}{N_{fires\ count}}$$

**Mean burned area
estimate per fire count**

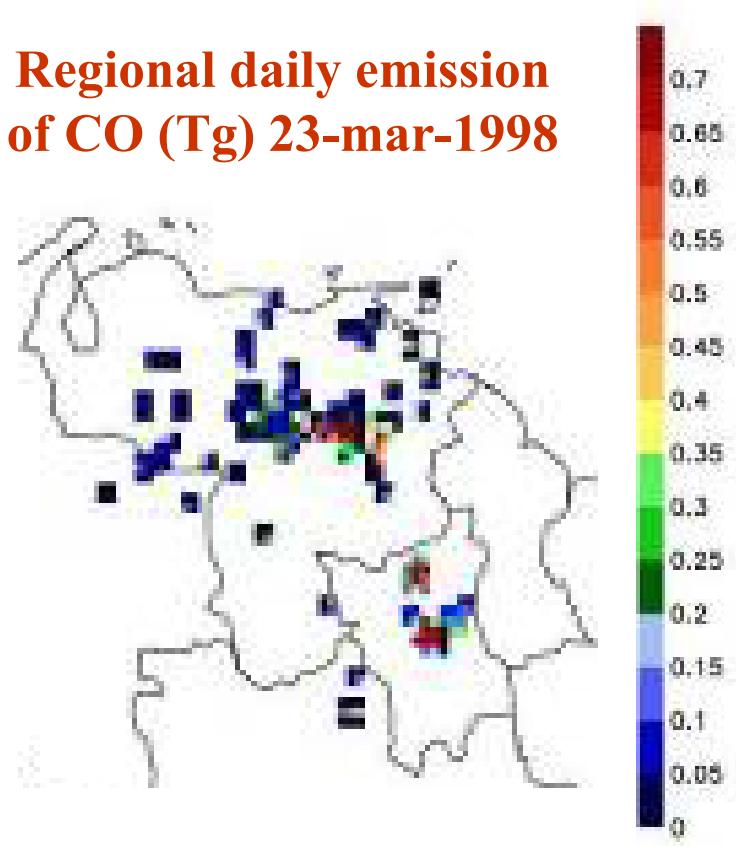
Emission parameterization for this case study

Model grid-box daily emissions estimate:

$$\bar{Q}_{[\eta]}(i, j, t) = \frac{r(t)}{\rho_0 \Delta V} \sum_{\substack{\text{fires} \in \\ \text{Grid_Box}}} \beta B_\alpha E_{[\eta]} A_{\text{fire}},$$



Regional daily emission of CO (Tg) 23-mar-1998



Parameterized Deep Convective Transport

$$\frac{1}{m_u(z_b)} \frac{\partial \overline{w' s'}_{\text{deep conv}}}{\partial z} = \frac{\partial}{\partial z} (\eta_u s_u - \varepsilon \eta_d s_d - \tilde{\eta} \tilde{s}) \text{ or } \left(\frac{\partial \bar{s}}{\partial t} \right)_{\text{deep conv}} = \frac{m_u(z_b)}{\rho_0} \left[\delta_u \eta_u (s_u - \tilde{s}) + \delta_d \varepsilon \eta_d (s_d - \tilde{s}) + \tilde{\eta} \frac{\partial \tilde{s}}{\partial z} \right]$$

updraft detrainment

downdraft detrainment

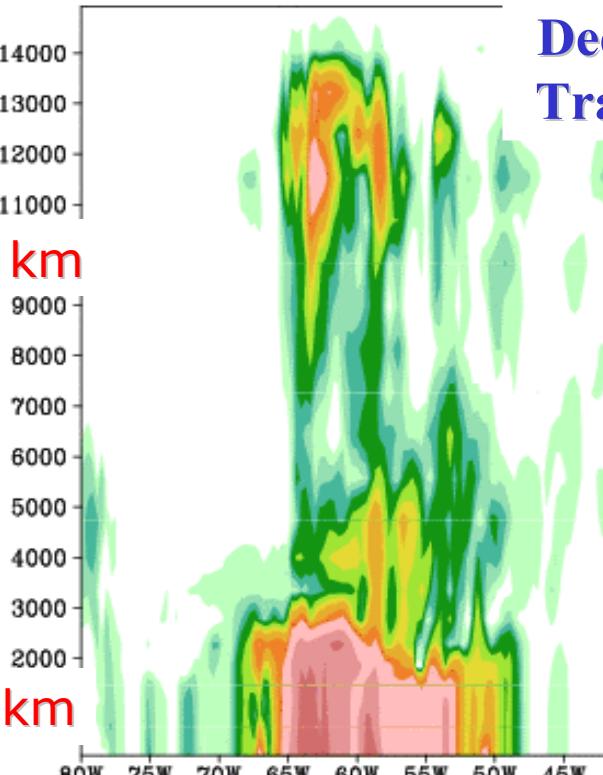
environment subsidence

(a) Carbon Monoxide (ppb)
Lat 10S – 21Z24SEP2002

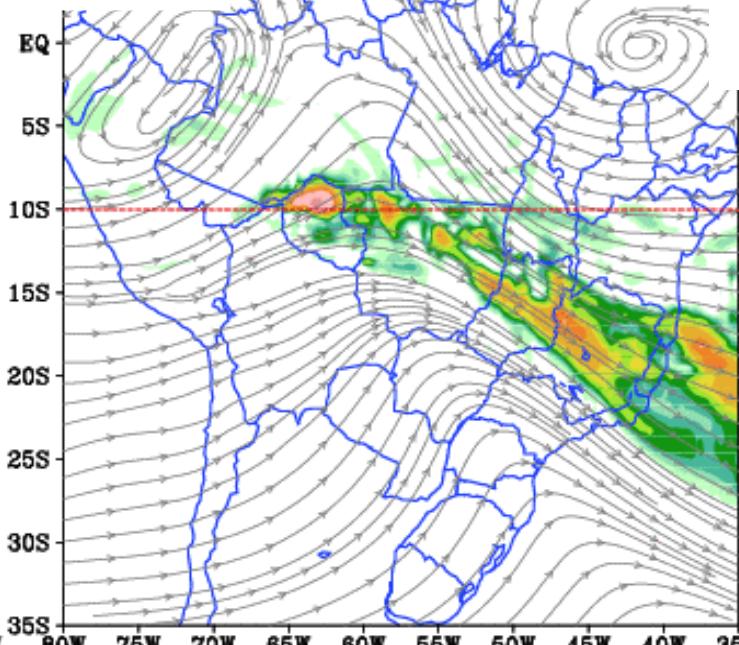
(b) Carbon Monoxide (ppb)
level 11.5 km – 21Z24SEP2002

Deep Convective Transport of CO

Height (m)



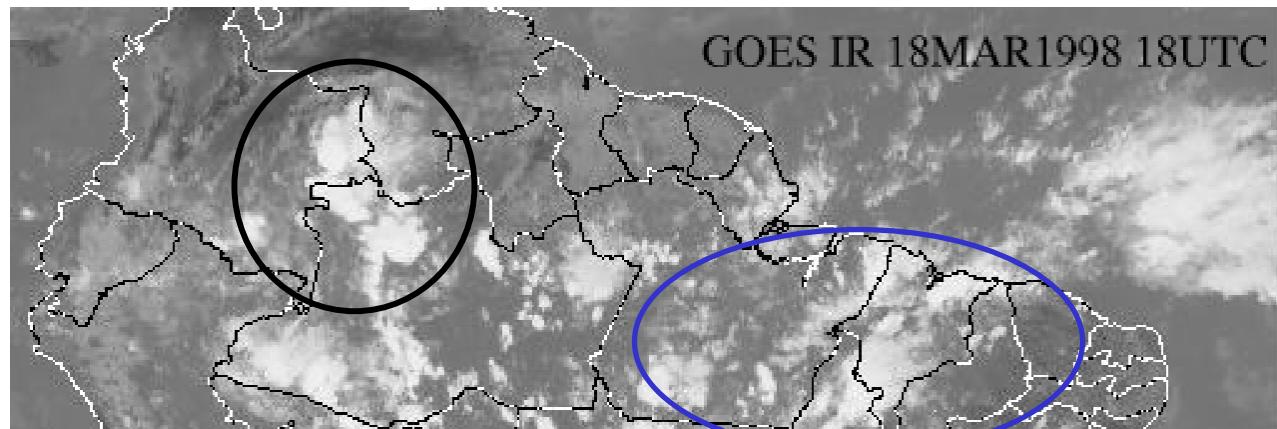
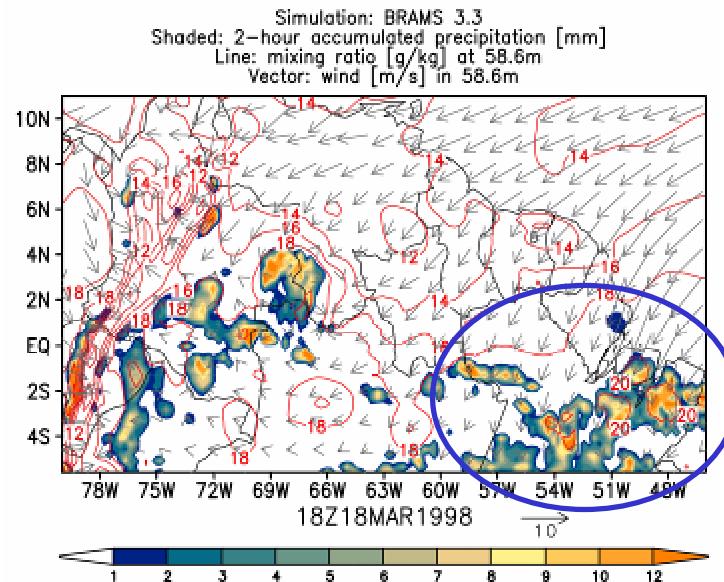
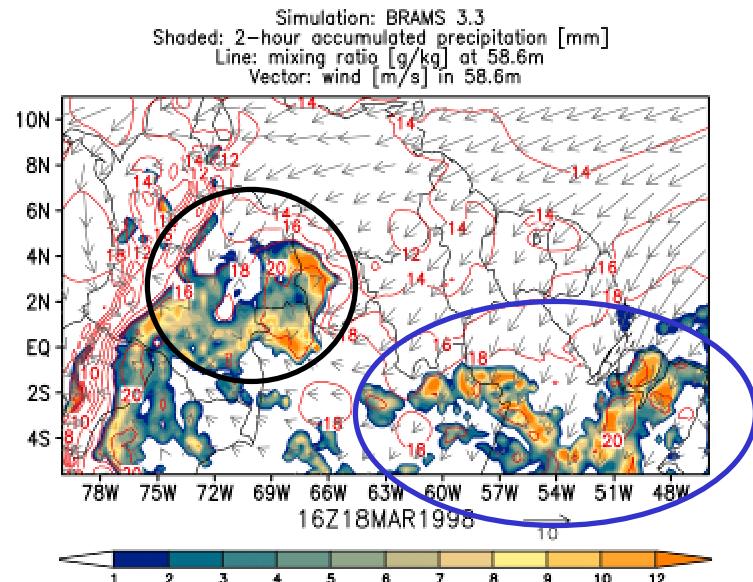
Vertical section at lat 10S



vertical
level
11.5 km

CO (ppbv)

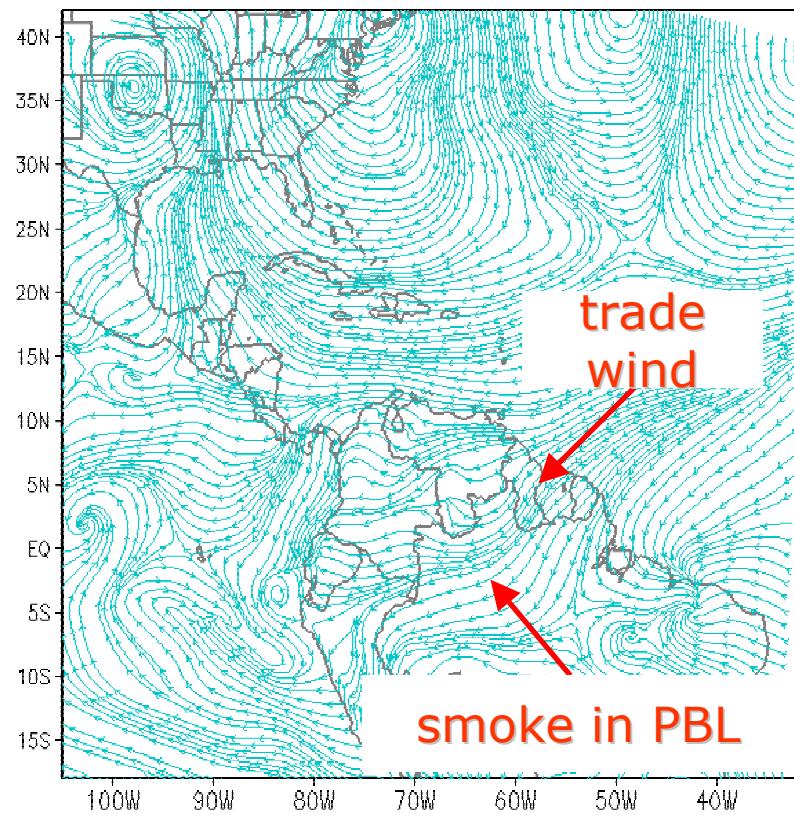
Model simulation of the main convective systems on 18-march-1998



Numerical simulation of transport of CO with CATT-BRAMS during CLAIRE flight 8

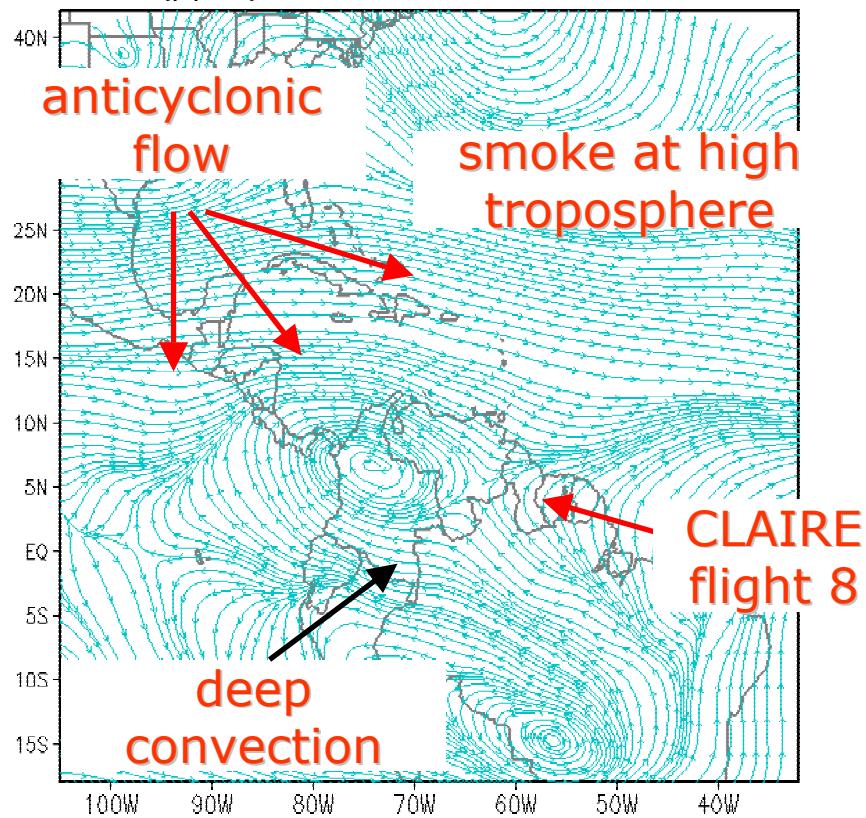
height 1km

CO BB (ppbv) - 12Z17MAR1998 - 1.0296 km



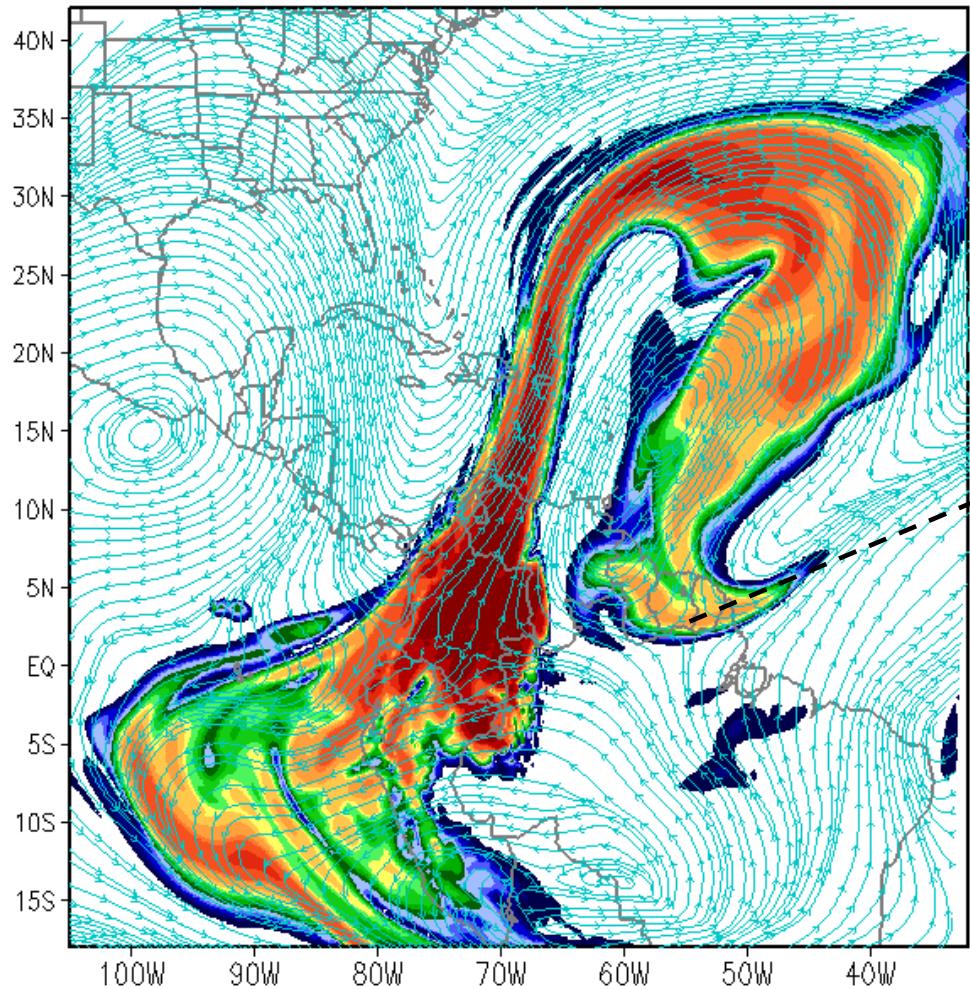
height 11,7 km

CO BB (ppbv) - 12Z17MAR1998 - 11.748 km

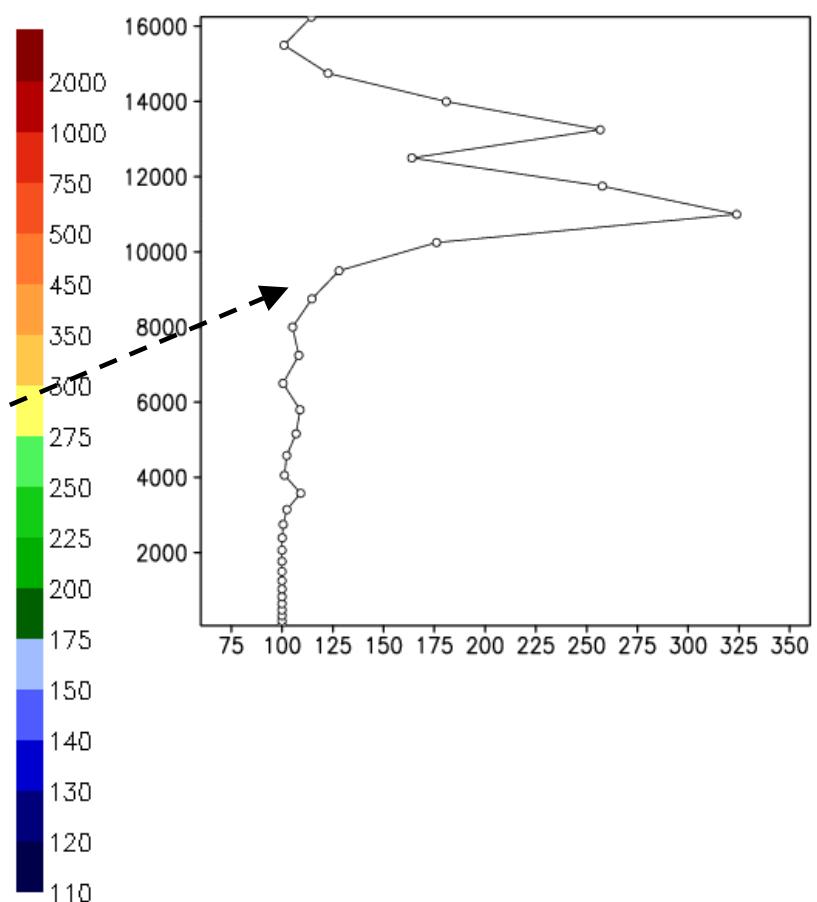


Numerical simulation of transport of CO with CATT-BRAMS during CLAIRE flight 8

CO BB (ppbv) – 18Z26MAR1998 – 11.748 km

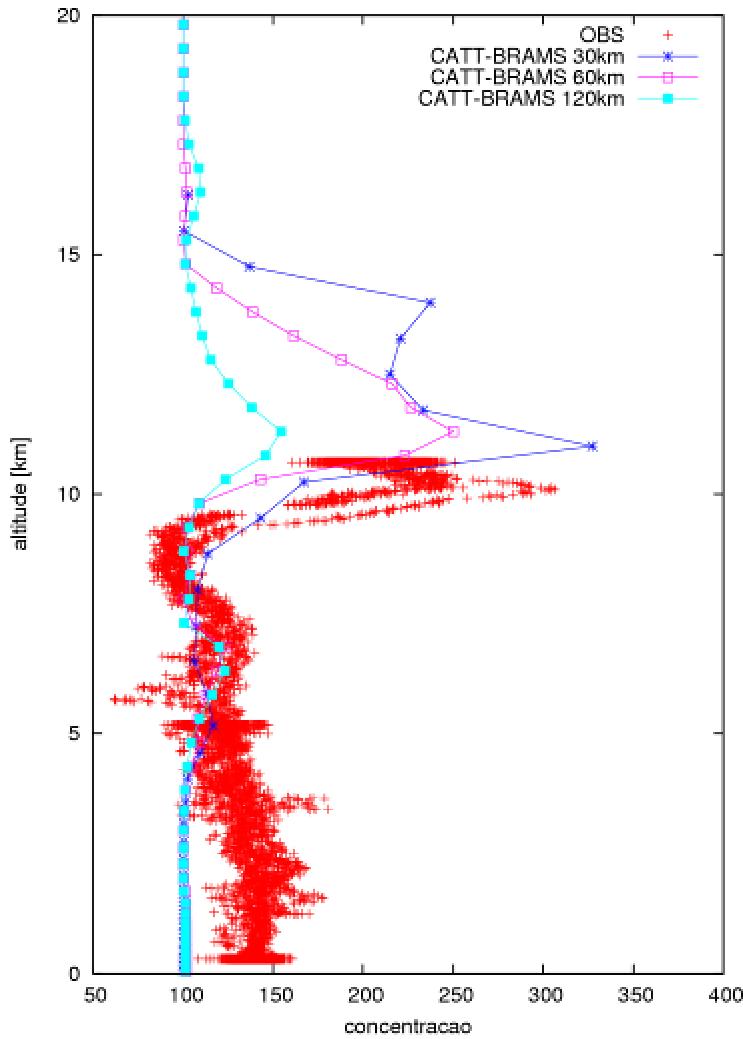


CO – 20UTC26MAR1998 [ppb]

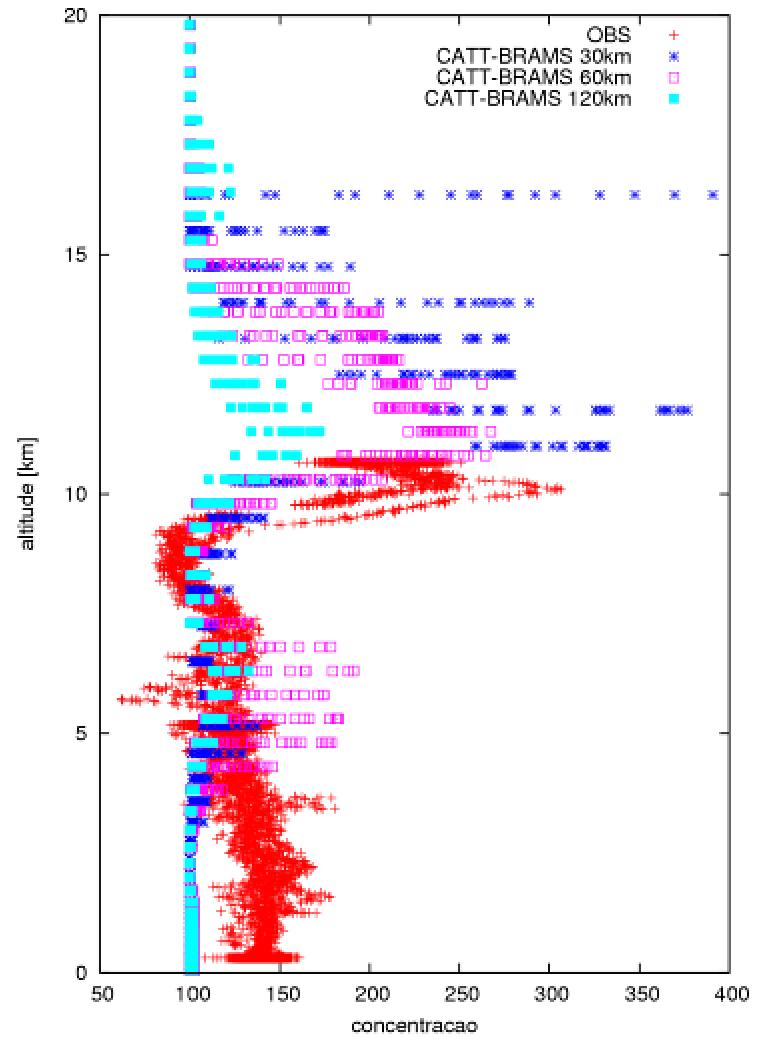


Model validation using flight-8 CO profile

CONCENTRACAO DE MONOXIDO DE CARBONO: VOO 08 LBA-CLAIRE-19

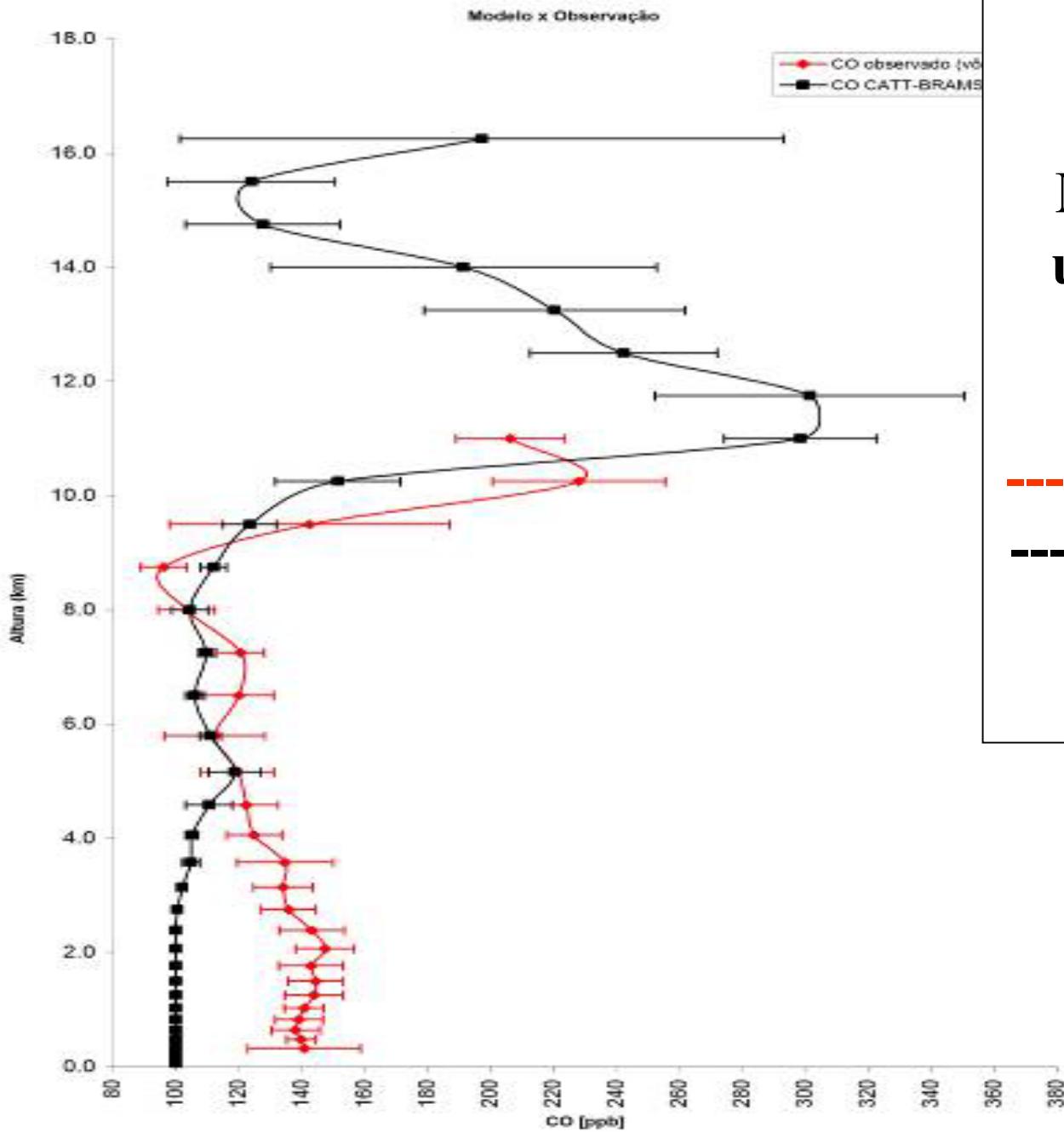


CONCENTRACAO DE MONOXIDO DE CARBONO: VOO 08 LBA-CLAIRE-19



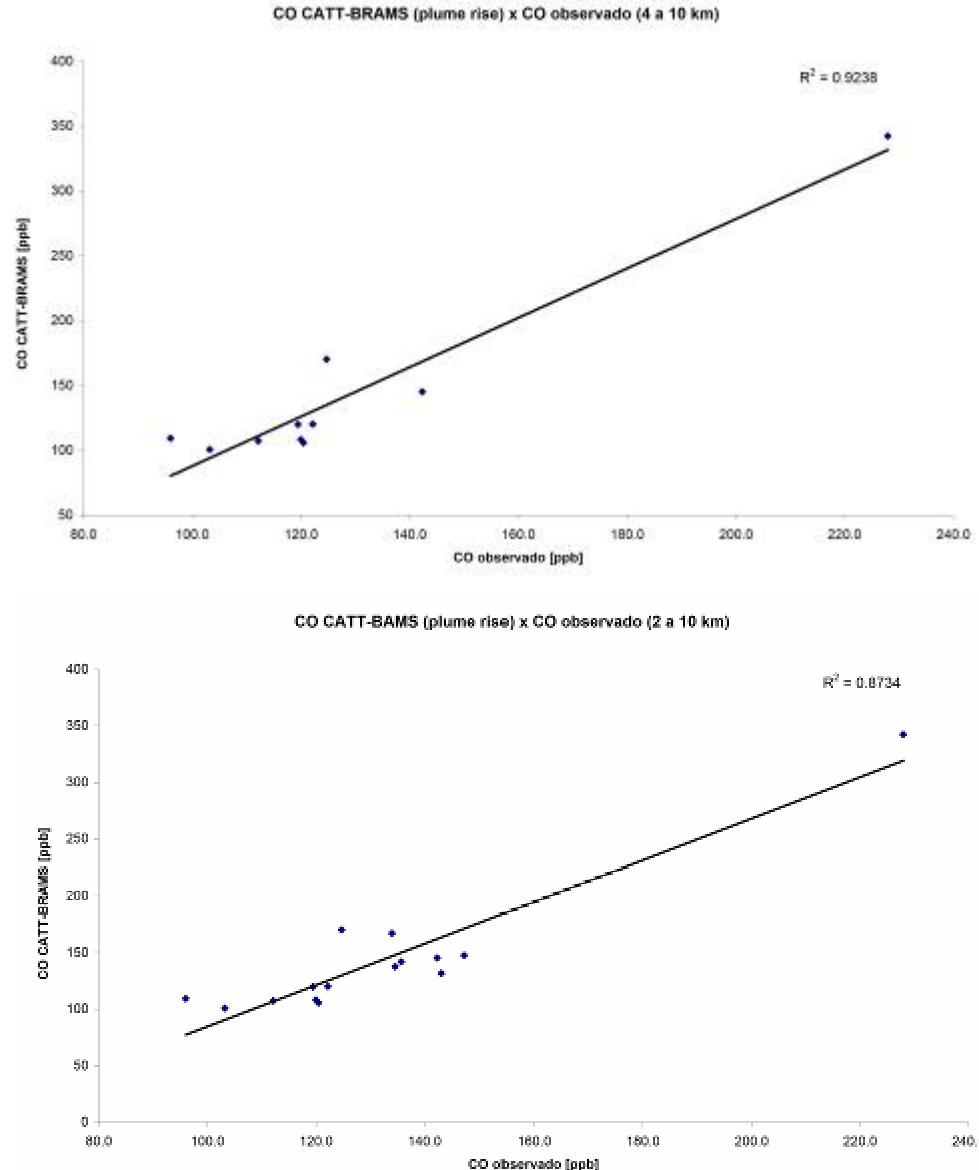
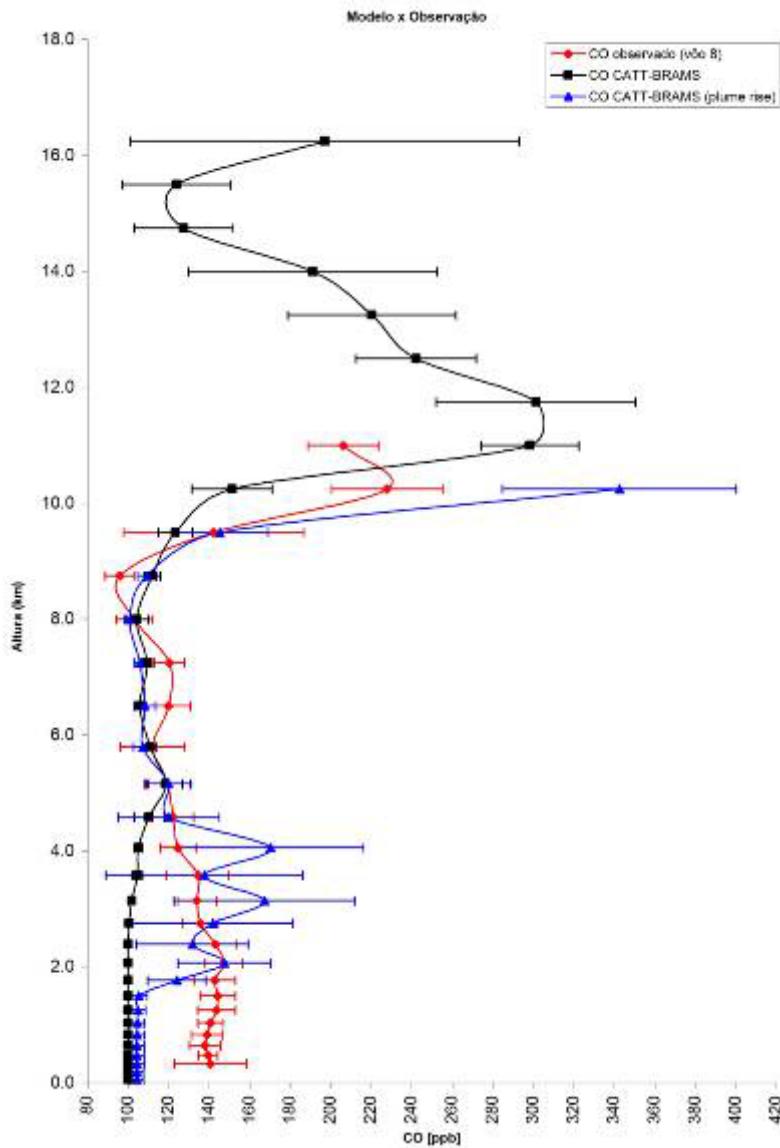
Model validation using flight-8 CO profile

----- CO observation
----- CO modeled



Thanks for your attention

Validação do modelo CATT-BRAMS (with *Plume Rise*)



Conclusões

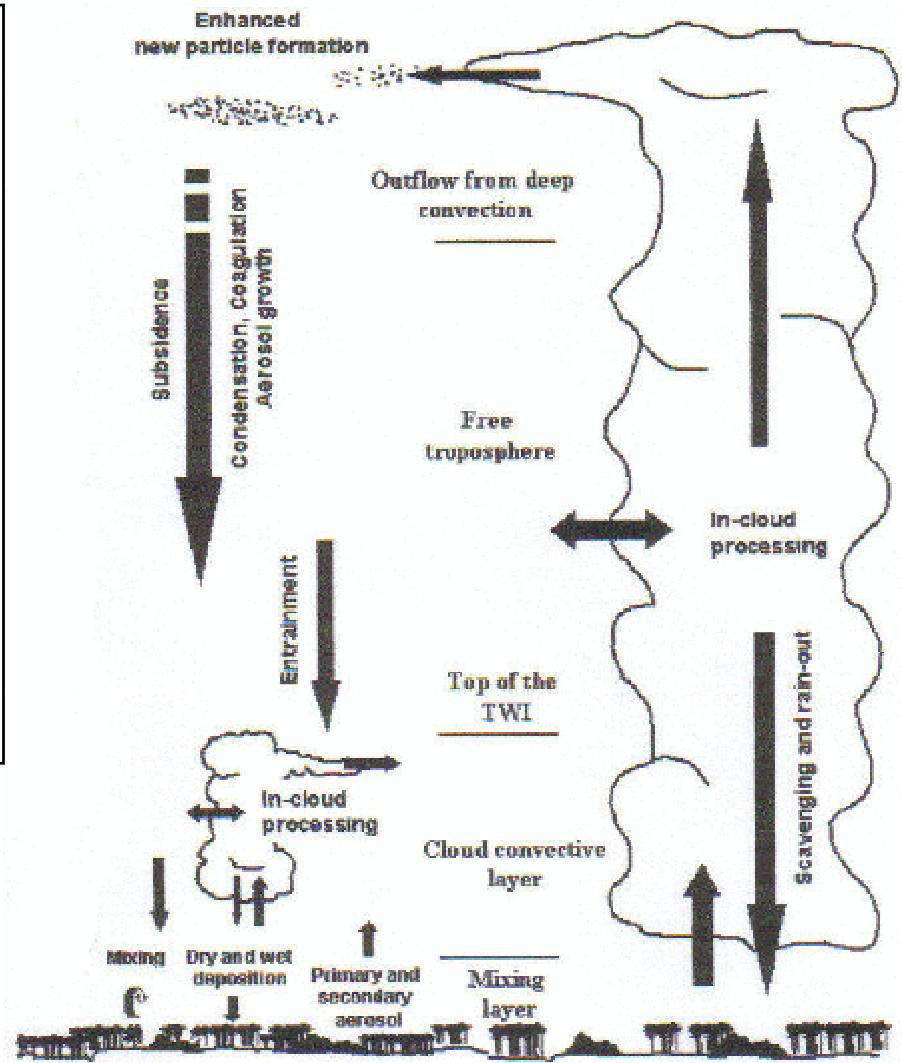
- Validação do modelo de transporte CATT-BRAMS 3.3 e da parametrização de fontes emissoras.
- Utilização de avanços em elementos importantes do modelo atmosférico: parametrização de cúmulos (cúmulos rasos e técnica *training*) e representação de superfície (umidade do solo).
- Importância da queimada de grandes proporções no dia 17/março (pois não houve necessidade de um ambiente previamente poluído) e o sistema convectivo formado na tarde do dia 18/março.
- Testes iniciais da técnica *plume rise*.

Transporte de emissões de queimadas

- advecção em níveis baixos,
- cúmulos rasos,
- cúmulos profundos,
- advecção em níveis altos (jatos),
- formação de novas partículas,
- processos químicos,
- deposição seca,
- remoção úmida, etc.



Transporte em escala continental



Fonte: Krejci et al. (2003)

Plume characteristics Características da pluma de fumaça em altitude ("assinatura")

- elevados valores de $\Delta CO/\Delta CO_2$ acima de 9 km, típicos de eventos extremos de queimadas em savanas,
- ausência de halocarbonetos de origem antropogênica,
- elevada concentração de metilcloratos.

Parâmetro	Fumaça recente	Pluma envelhecida de 2 a 6 dias	Pluma envelhecida acima de 6 dias	CLAIRE 98 em altitude
$\Delta CO/\Delta CO_2$	40 - 80	20 - 90	16 ± 2	55
$\Delta CH_3Cl/\Delta CO$	0.8 - 1.1	1.2 ± 0.12	1.4 ± 0.1	1.1 ± 0.2
$\Delta CH_3CN/\Delta CO$	0.4 - 2.5	-	-	1.2 ± 0.3
$\Delta N_{>0.1}/\Delta CO$	10 - 30	5 ± 3	4.6 ± 2.4	1.2
$\Delta N_{Aitken}/\Delta CO$	-	8 - 18	-	4.9
$\Delta N_{ultrafinas}/\Delta CO$	-	-	-	8.1

Fonte: Andreae et al. (2001)

CATT-BRAMS model simulation setup

- instante inicial: 12UTC 17 março 1998
- instante final: 12UTC 28 março de 1998
- número de pontos: (290,242,43)
- níveis de solo: 7
- resolução horizontal: 30 km
- resolução vertical no primeiro nível: 120 m
- razão de incremento: 1.1
- valor máximo de Δz : 750 m
- passo de tempo: 30 s
- campos atmosféricos: ECMWF
- umidade do solo: Gevaerd e Freitas (2005)
- radiação de onda curta: Harrington (1997)
- radiação de onda longa: Chen e Cotton (1983)
- parametrização de cúmulos: Grell (1993) – *técnica training*

Emissão de poluentes

Destino do carbono queimado em Roraima entre dez/97 e mar/98 (10^6 Ton):

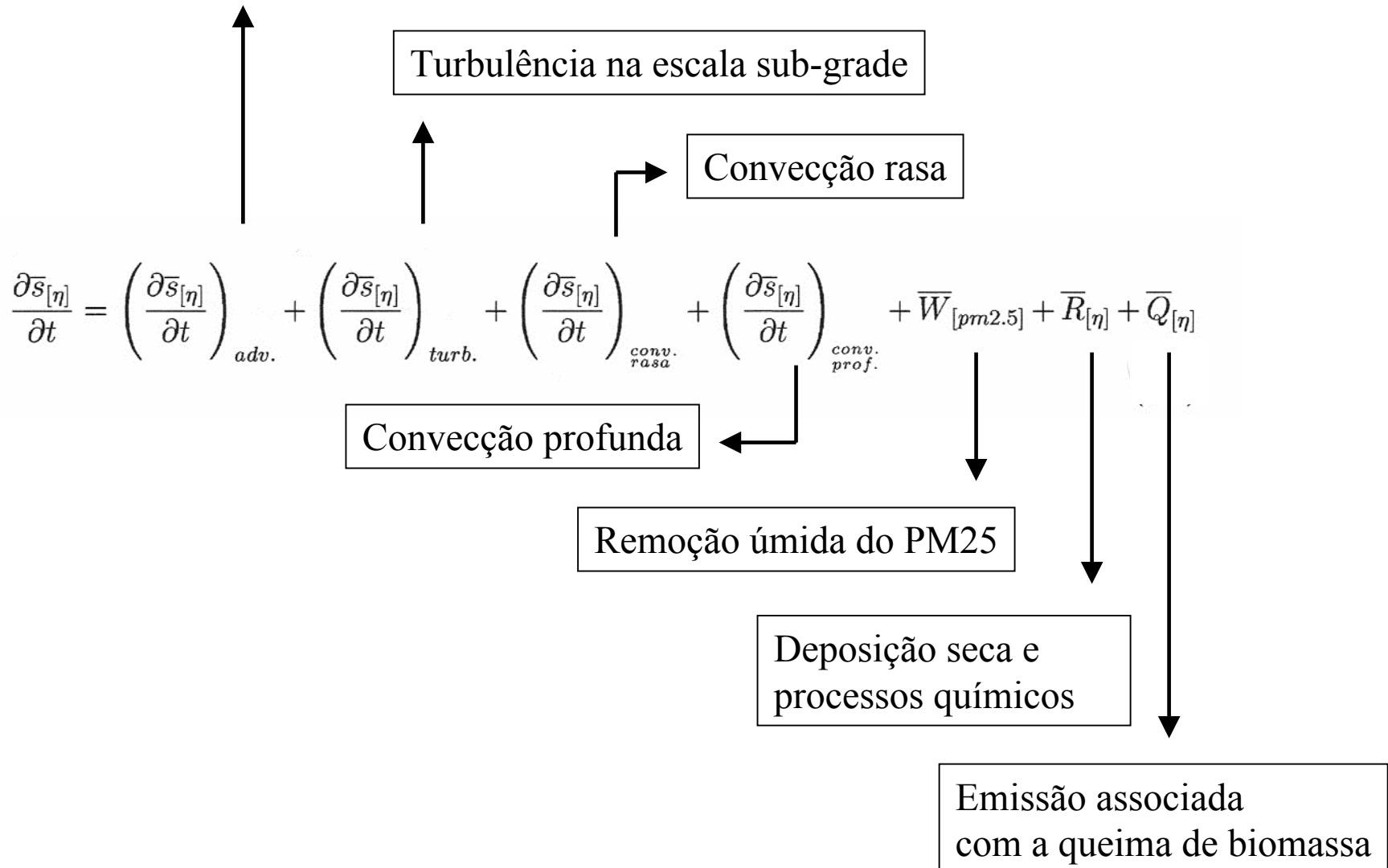
Sistema	Combustão	Carvão	Decomposição	Total
Florestas	12,64	0,18	18,66	31,47
Savanas	3,10	0,0022	2,77	5,87
Outros sistemas não florestais	0,27	0,0008	0,58	0,84
Antrópicos	3,73	0,34	0,33	4,40
Total	19,73	0,52	22,33	42,58

Emissão bruta de gases do efeito estufa em Roraima entre dez/97 e mar/98 (10^6 Ton):

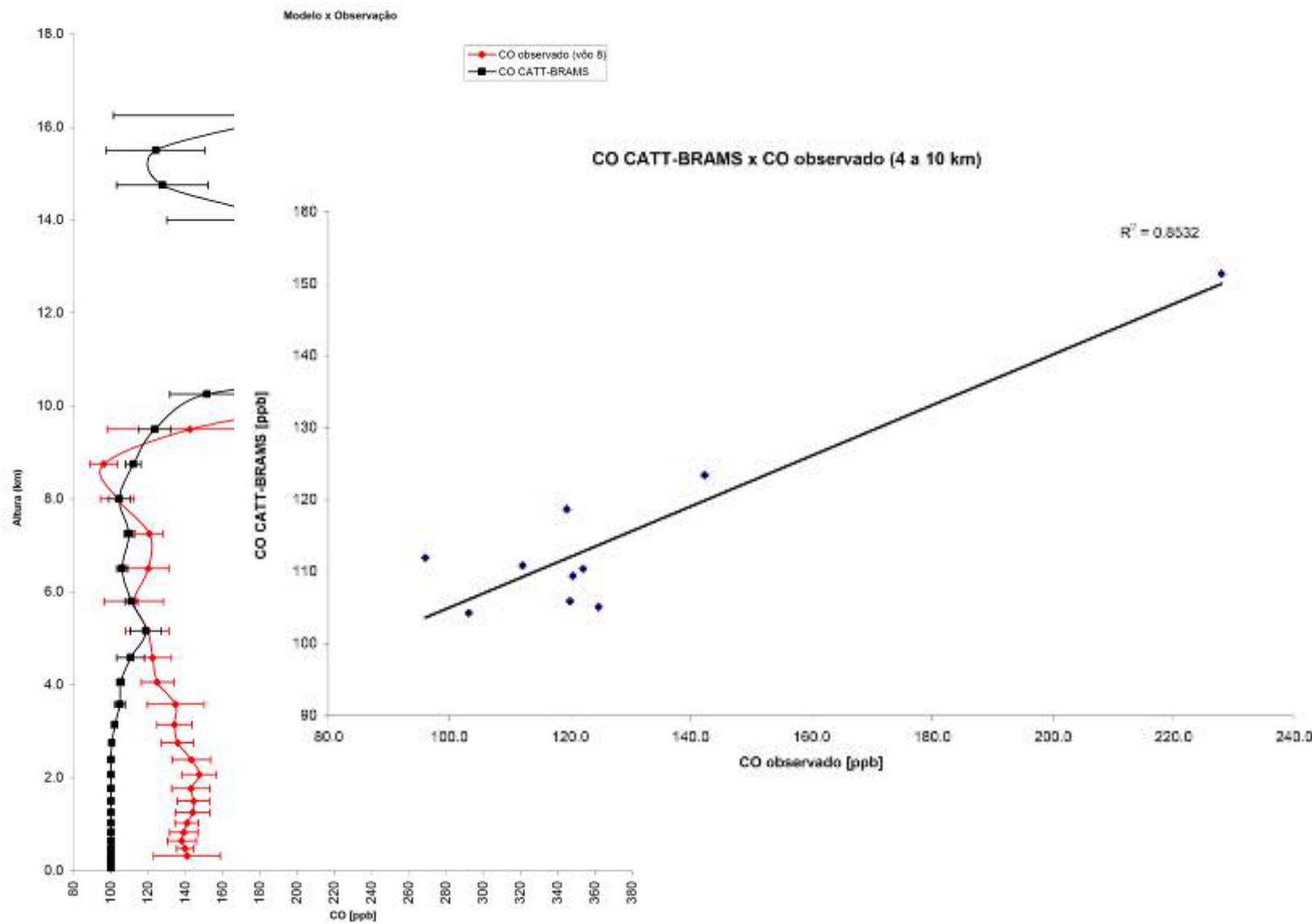
Gás	Emissão
CO_2	17,3
CH_4	0,21 - 0,35
CO	1,99 - 3,68
N_2O	0,001 - 0,003
NO_x	0,06 - 0,09
$HCNM^6$	0,25

Modelo de transporte CATT-BRAMS 3.3

Advecção na escala da grade

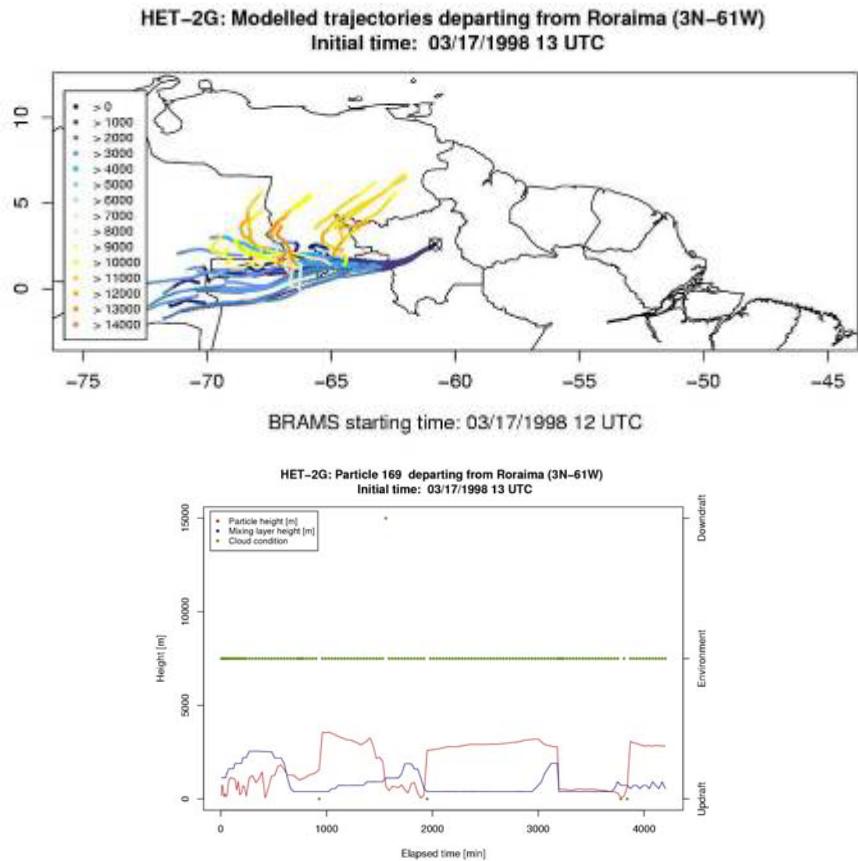


Validação do modelo CATT-BRAMS

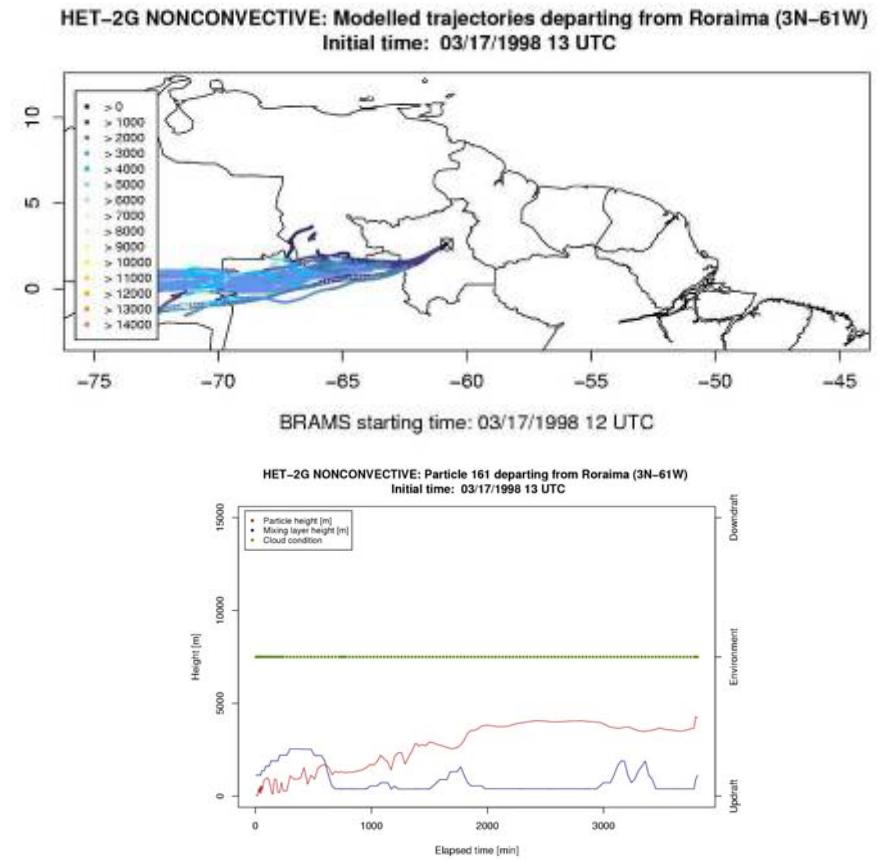


Fatores envolvidos no transporte (STILT)

COM CONVEÇÃO



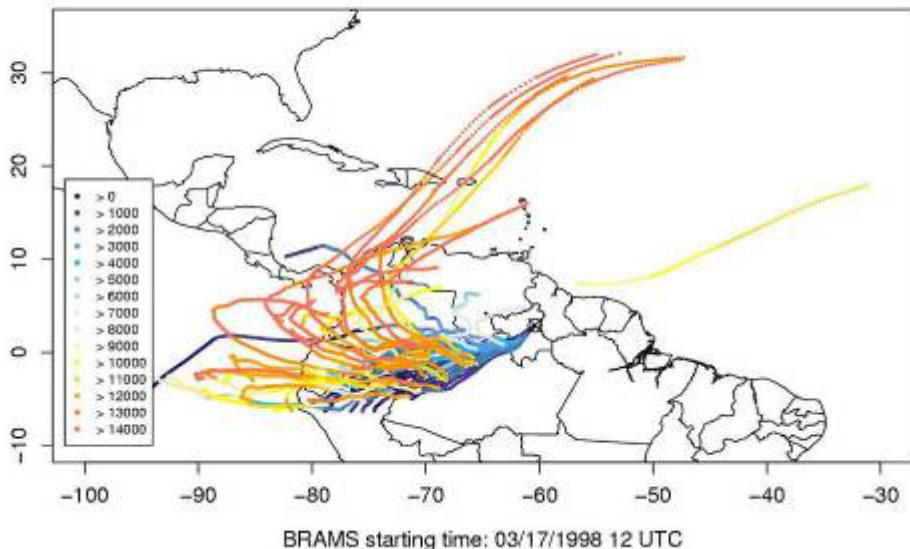
SEM CONVECÇÃO



- (a) Transporte advectivo pelos alísios (baixos níveis),
- (b) Transporte vertical promovido por sistemas convectivos,
- (c) Transporte advectivo seguindo um anticiclone em altos níveis.

Fatores envolvidos no transporte

HET-1G: Modelled trajectories departing from Roraima (3N–61W)
Initial time: 03/17/1998 13 UTC (9-day forward trajectories)



HET-1G: Particle 223 departing from Roraima (3N–61W)
Initial time: 03/17/1998 13 UTC (9-day forward trajectories)

