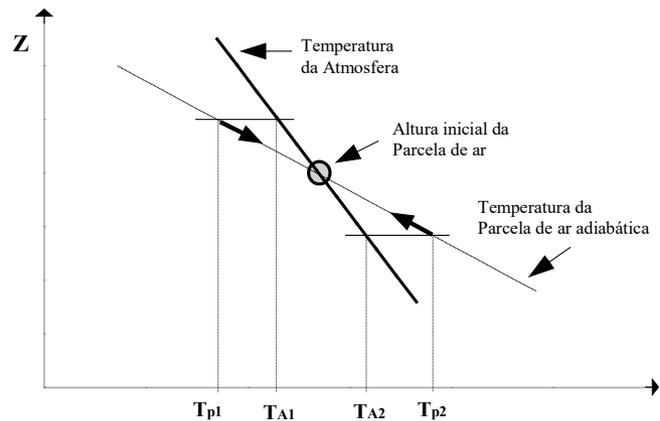


Estabilidade Atmosférica/ Modelos de Dispersão de Poluentes

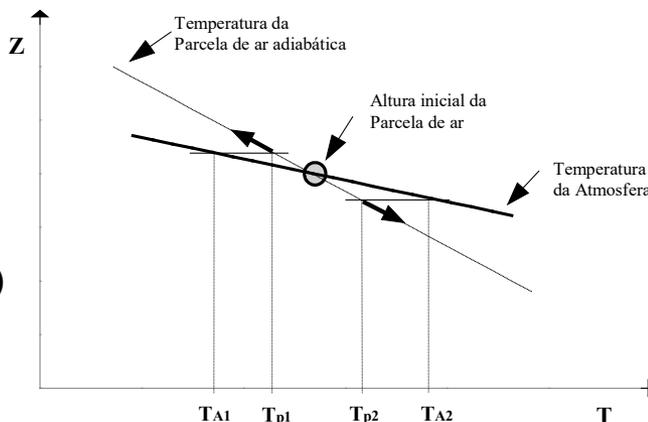


$$\frac{1}{\theta} \frac{d\theta}{dz} = \frac{1}{T} \left[\frac{dT}{dz} - \left(\frac{dT}{dz} \right)_{adiabatico} \right]$$

Estável

$$\left[\frac{d\theta}{dz} > 0 \right]$$

(caso particular: inversão térmica)

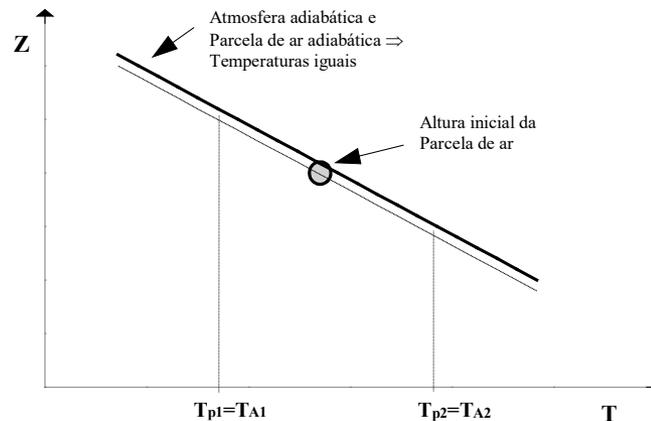


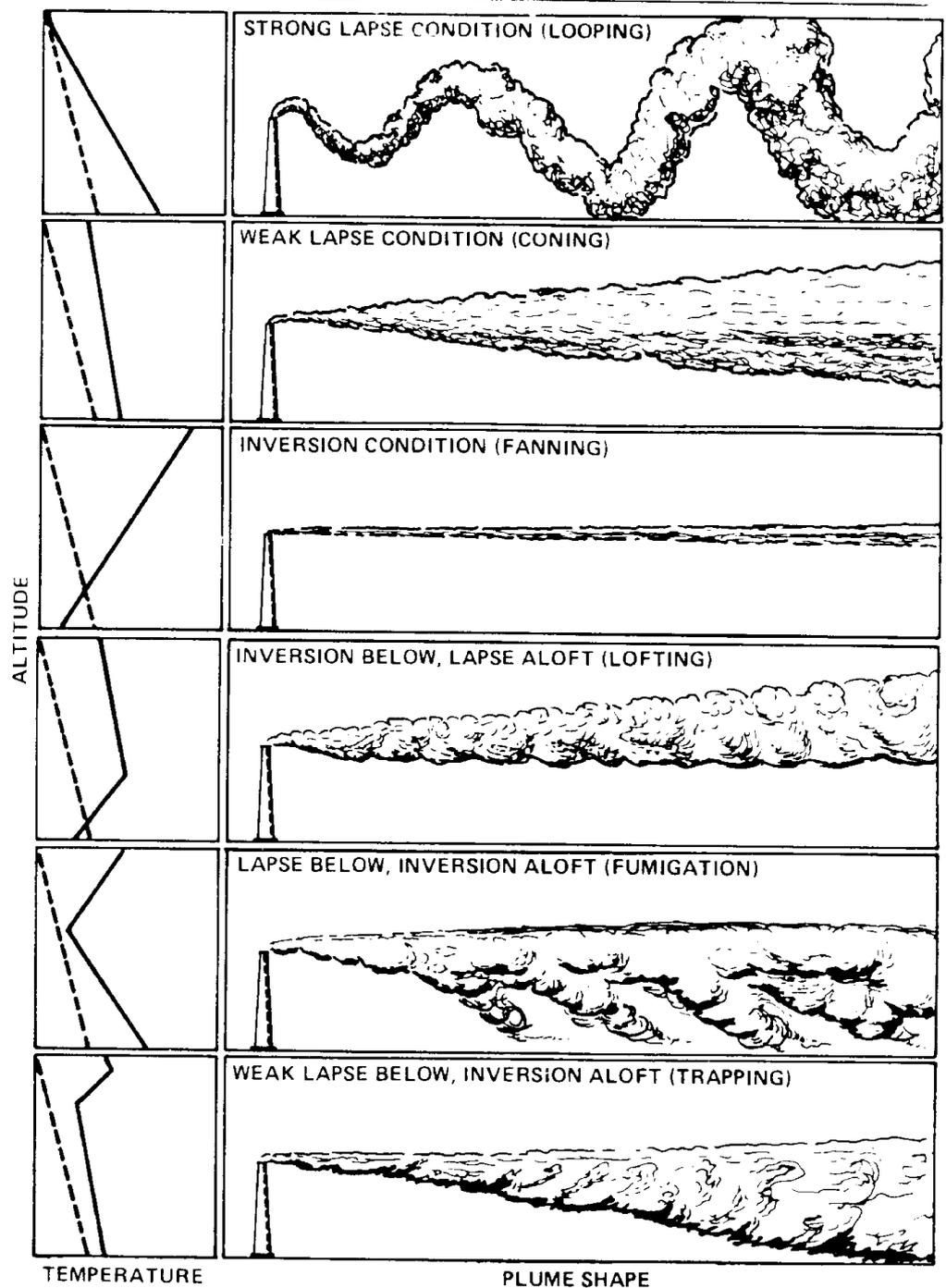
Instável

$$\left[\frac{d\theta}{dz} < 0 \right]$$

Neutro

$$\left[\frac{d\theta}{dz} = 0 \right]$$

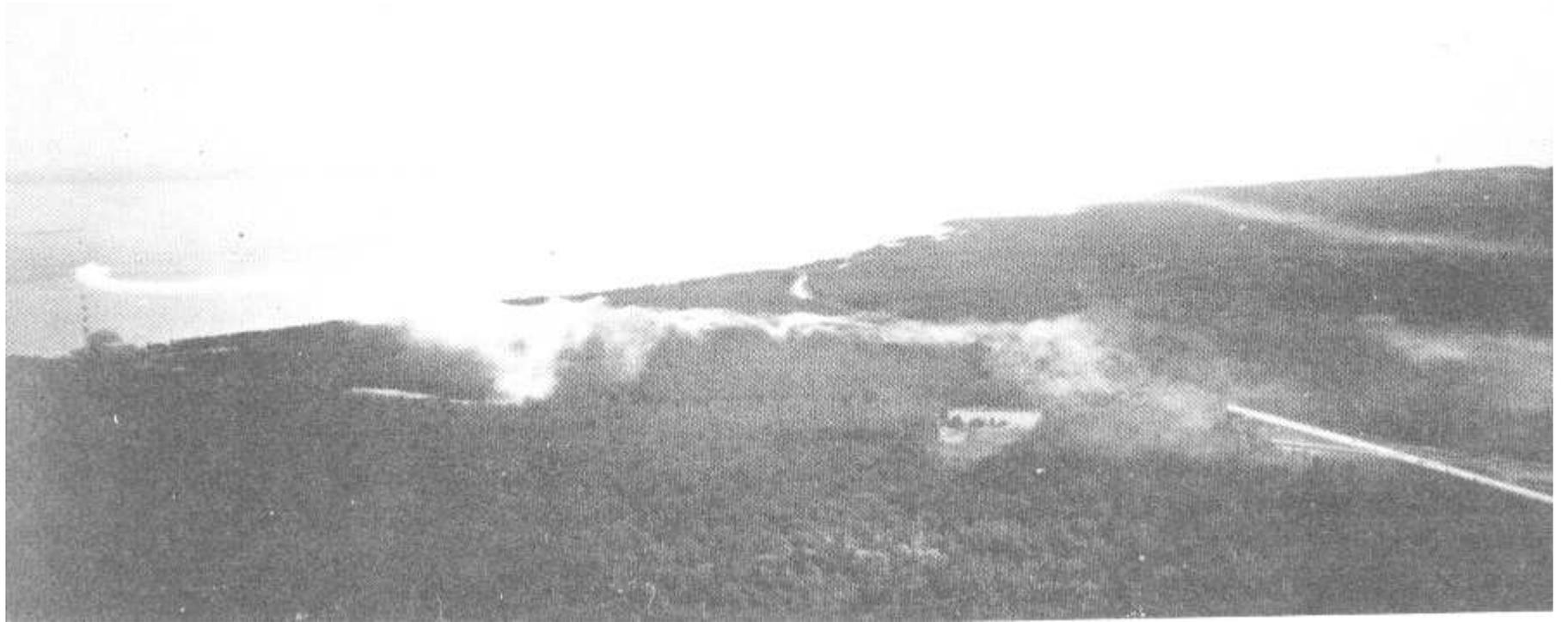




ALTITUDE

TEMPERATURE

PLUME SHAPE



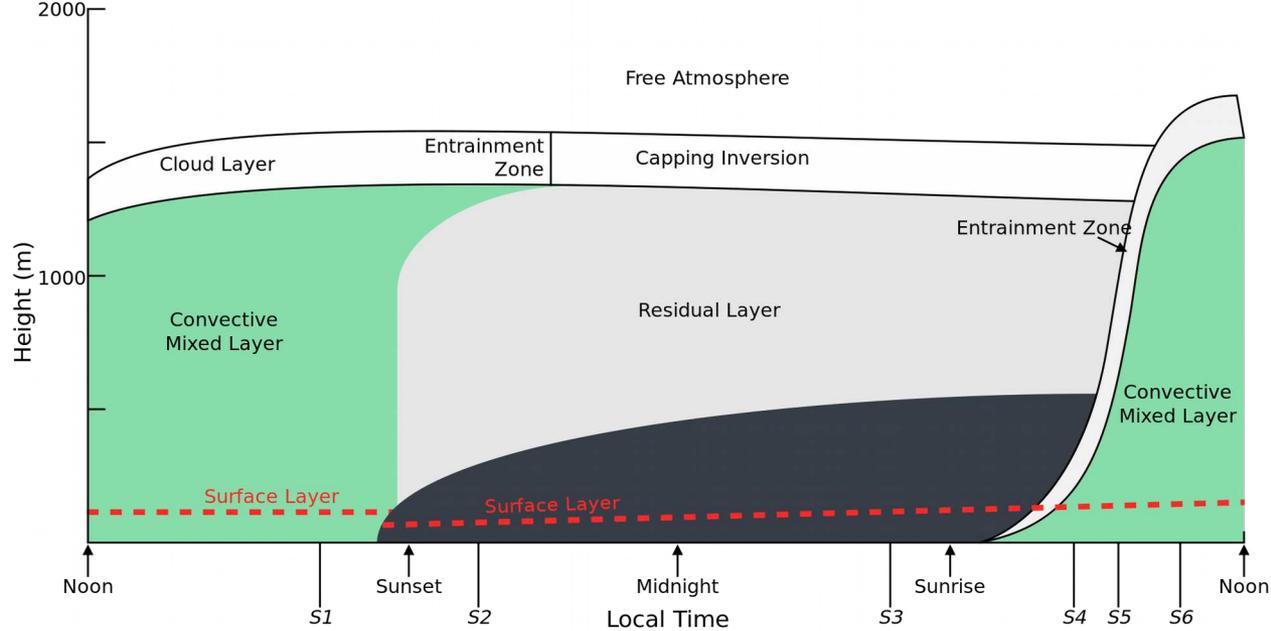
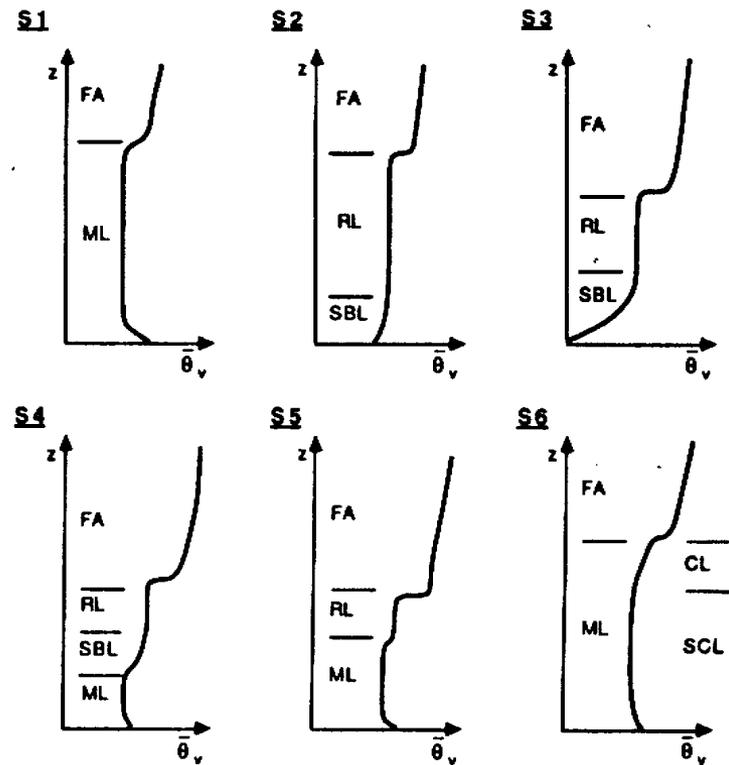
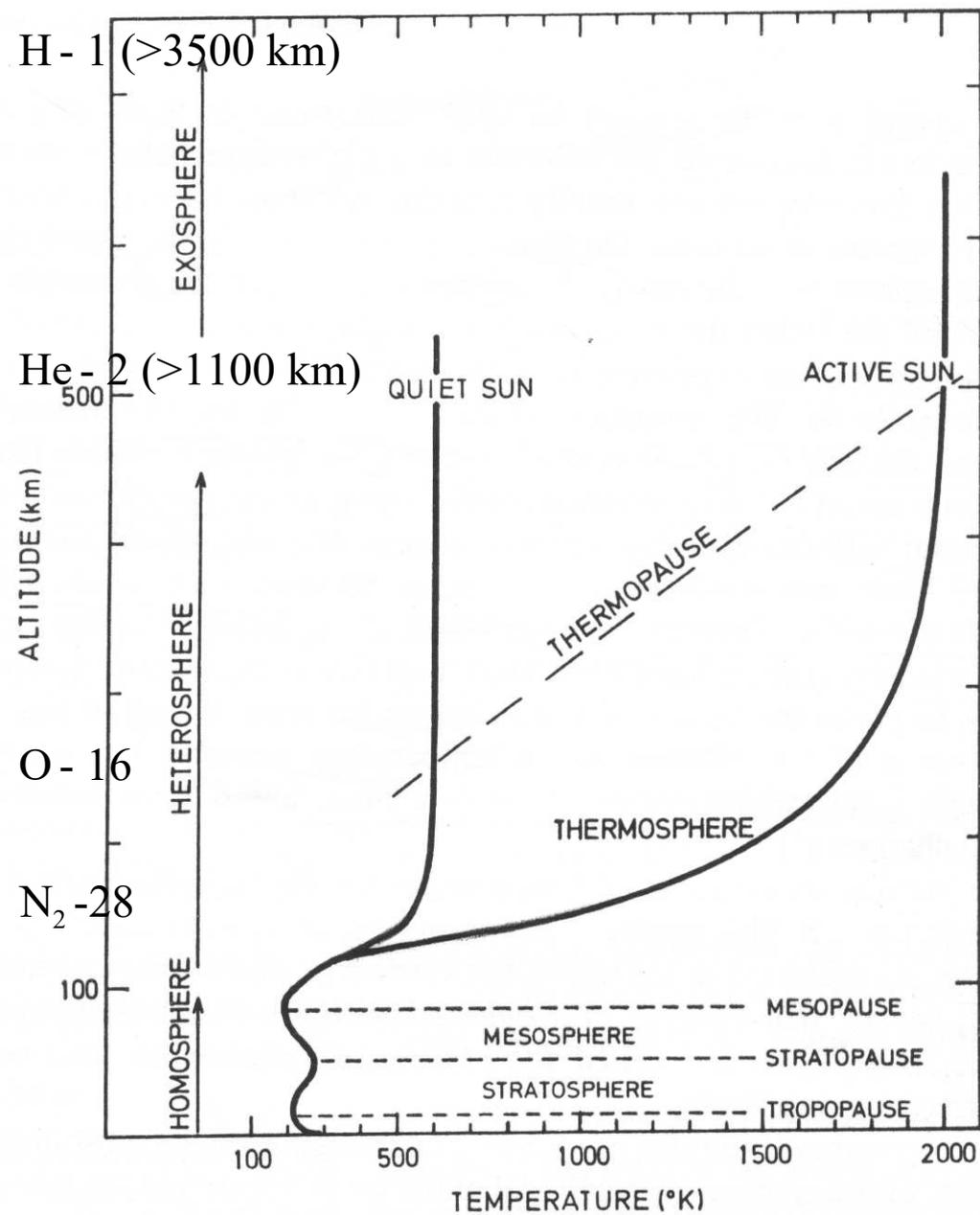


Fig. 1.12
 Profiles of mean virtual potential temperature, $\bar{\theta}_v$, showing the boundary-layer evolution during a diurnal cycle starting at about 1600 local time. S1-S6 identify each sounding with an associated launch time indicated in Fig. 1.7.



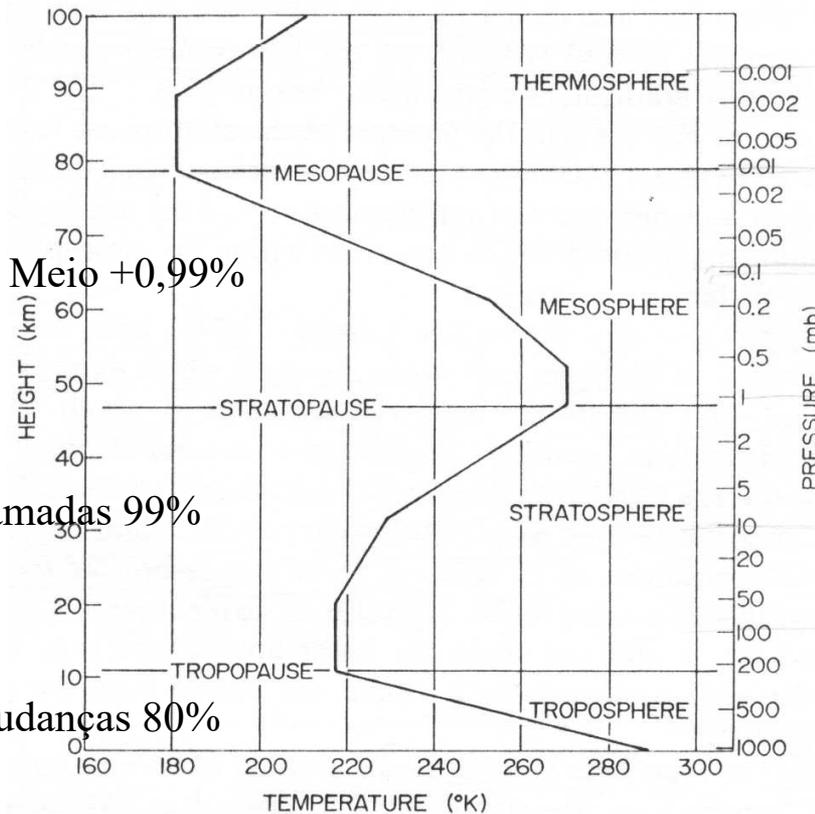


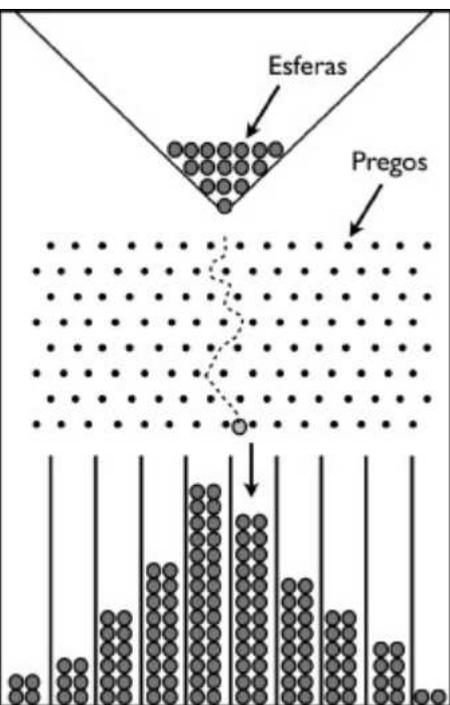
Termosfera +0,01%

do Meio +0,99%

Camadas 99%

Mudanças 80%

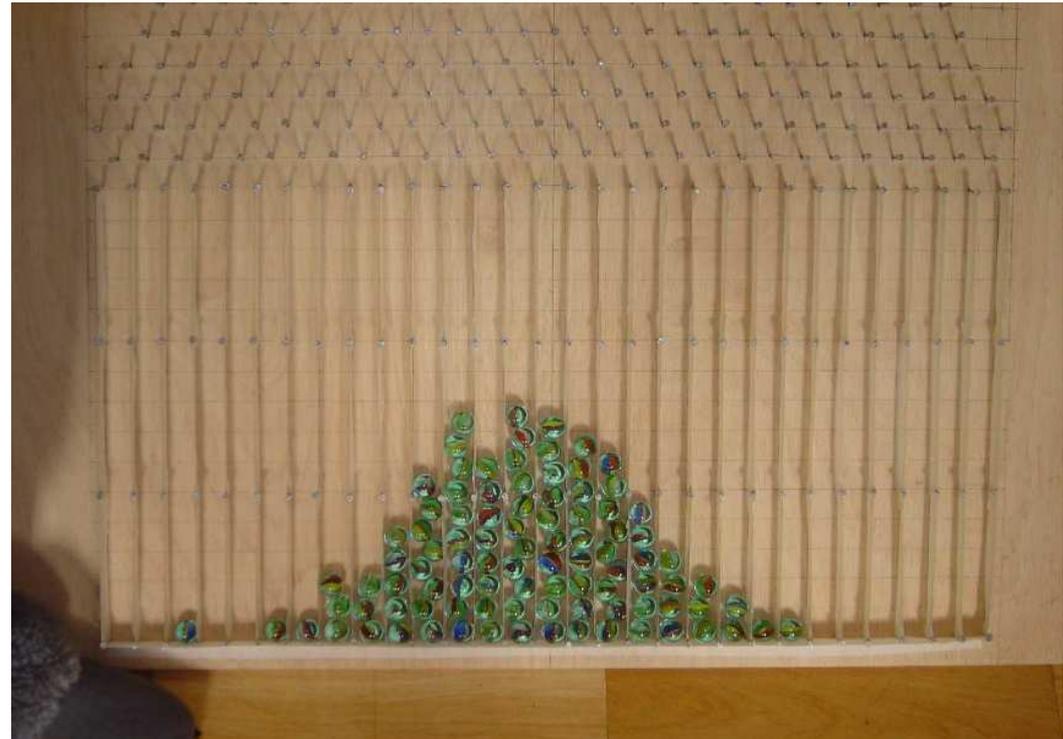




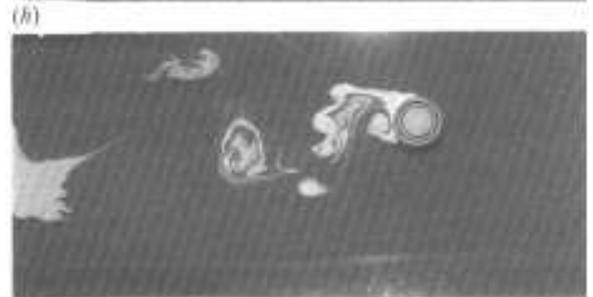
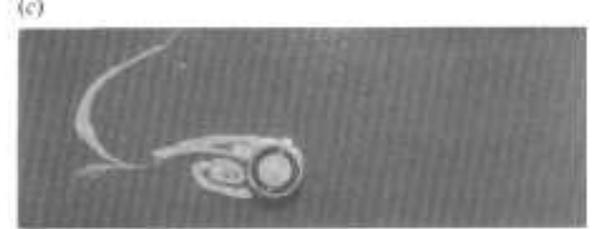
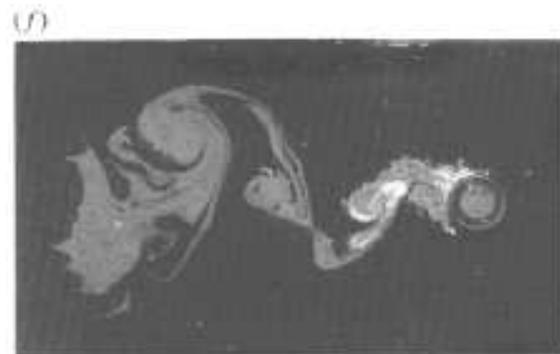
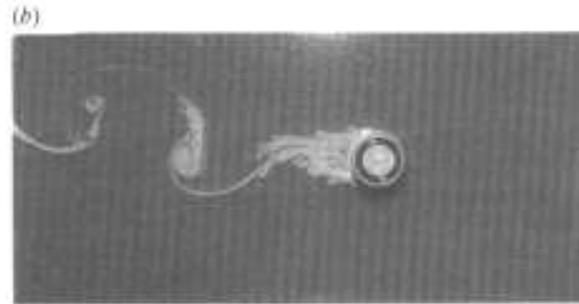
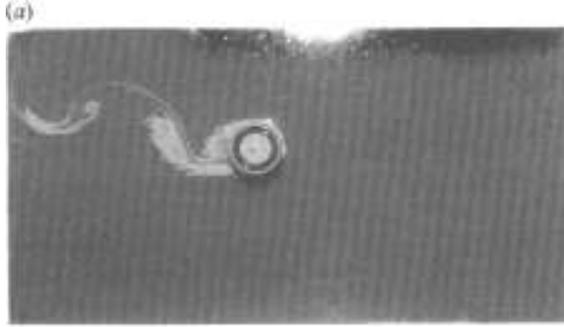
Podemos associar a dispersão de material lançado em uma atmosfera homogênea e estacionária, com a dispersão de esferas em uma Tábua de Galton. Os turbilhões de ar na atmosfera distribuiriam o material de modo análogo aos pregos da tábua, em uma gaussiana.

Tábua de Galton

Um funil colocado sobre uma distribuição de pregos separados por uma distância “ d ”, em uma sucessão de linhas também separadas por distância “ d ”, mas ficando os pregos de cada linha deslocados por “ $d/2$ ”. Um conjunto de bolinhas fluindo pelo funil formarão uma distribuição normal após passarem por esse conjunto de pregos.

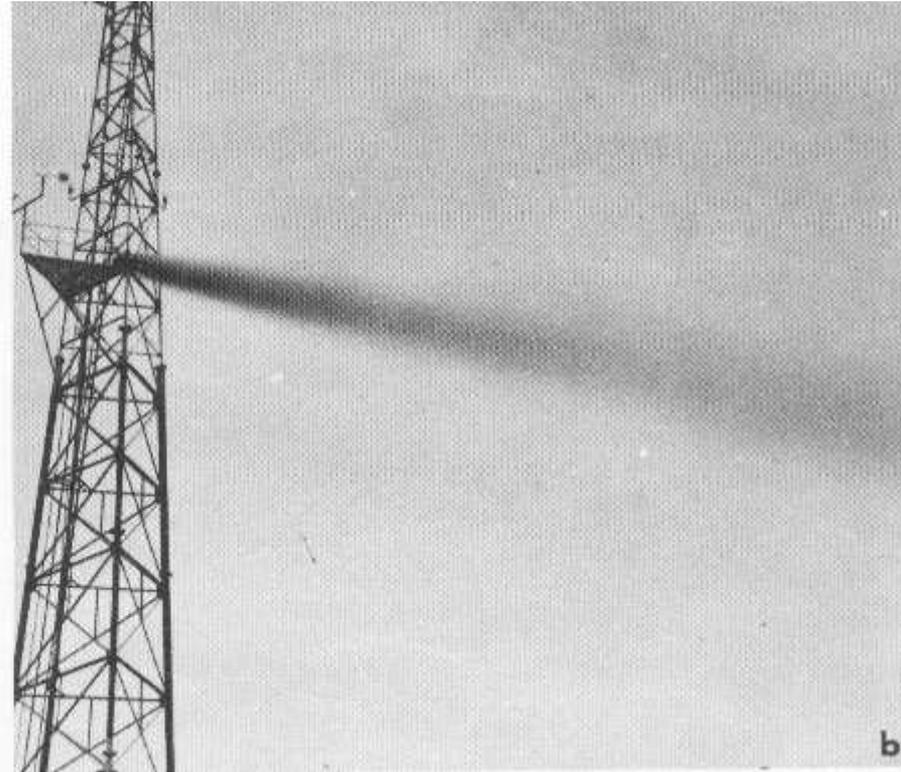
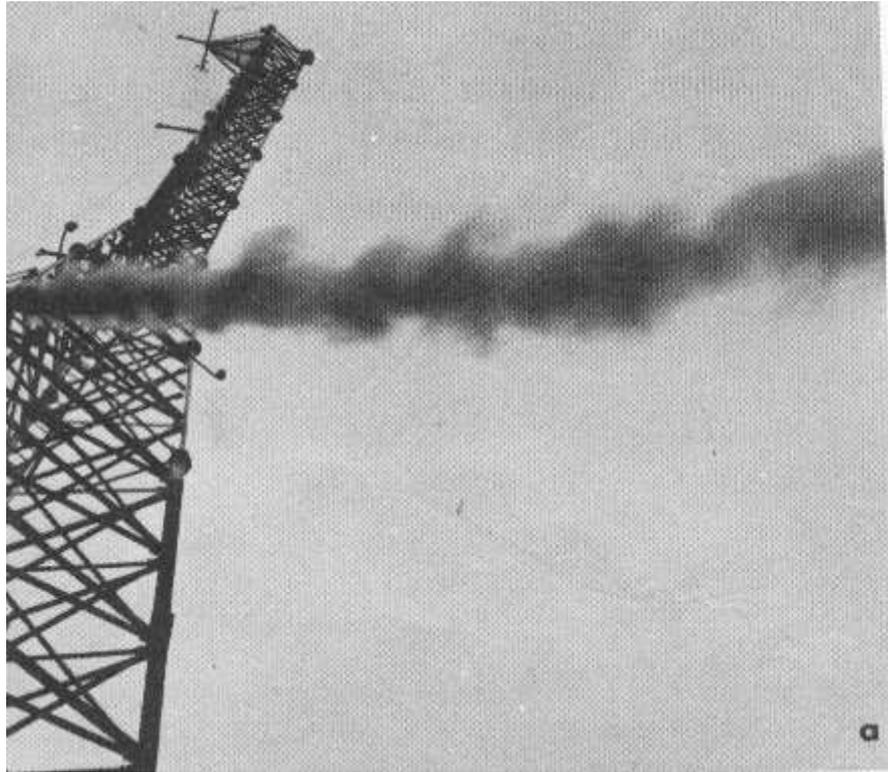


A tinta liberada por um obstáculo mostra os turbilhões formados por um fluido ao passar por ele.



Névoa artificial de óleo negro.

Fostos de curta (a) e longa exposição (b -10 min.)



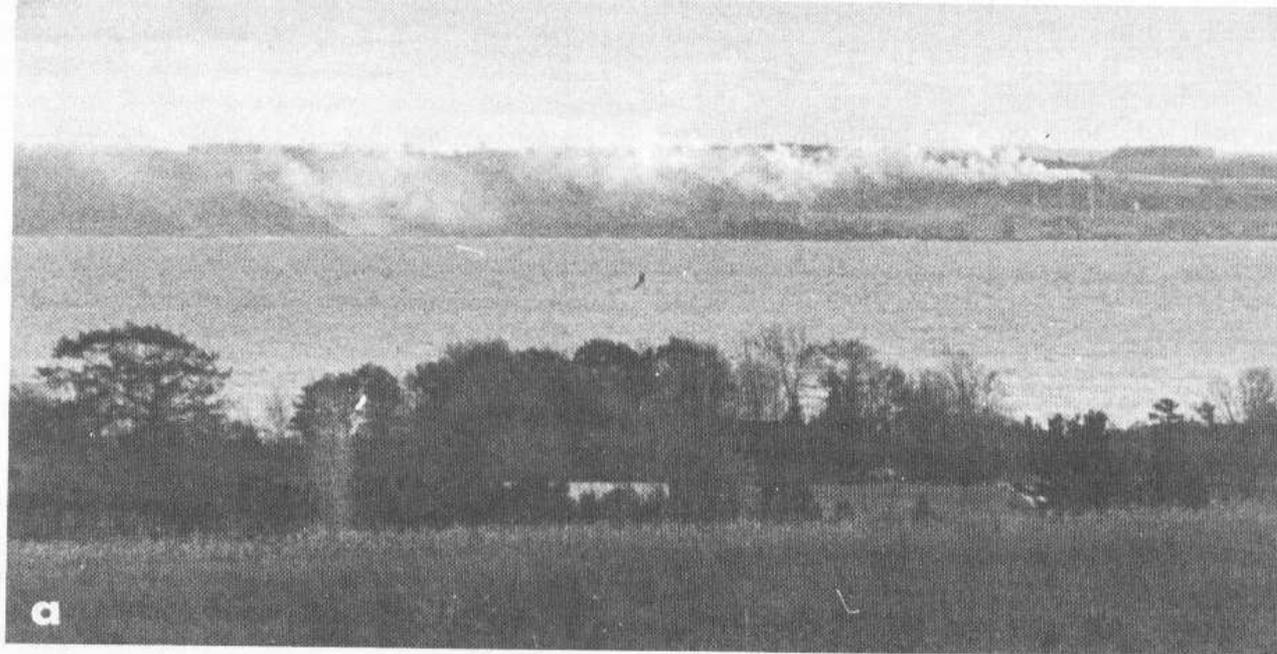


Fig. 3.8 — Plume photographs. (a) Instantaneous ($1/50$ -sec) exposure photograph of a plume. (b) Time exposure (5-min) of same plume. (From Culkowski, 1961.)

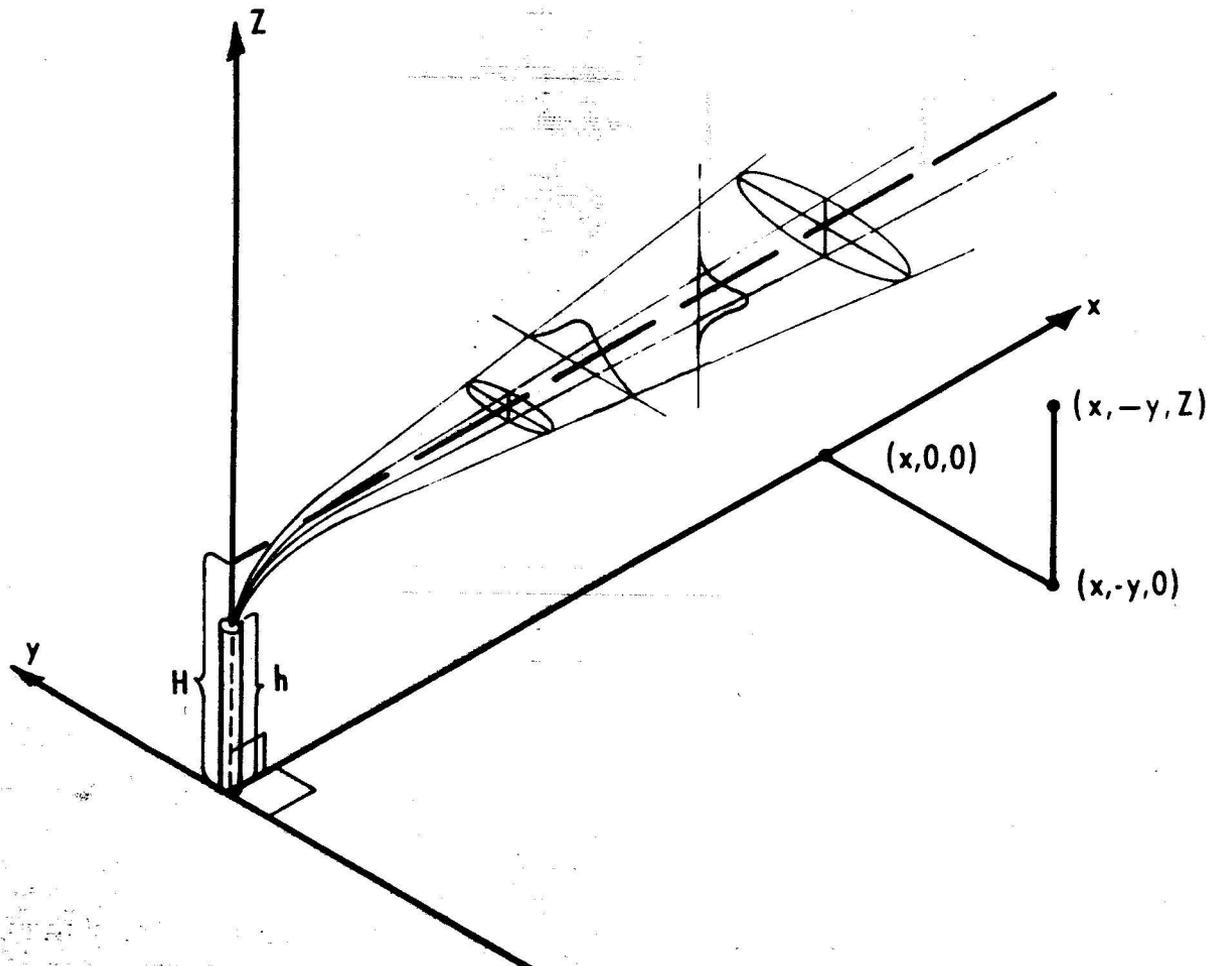


Pluma do Etna

Dispersão de emissões do vulcão Etna na Sicília

Modelo da Pluma Gaussiana

A figura ilustra a forma gaussiana da distribuição espacial de concentrações emitidas por uma chaminé de altura “h” em atmosfera homogênea e estacionária.



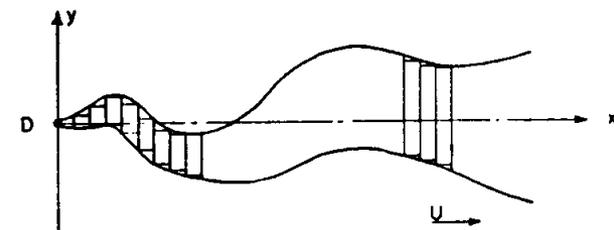
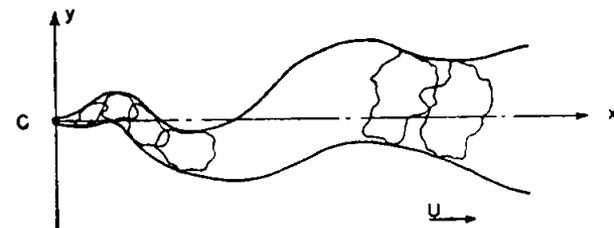
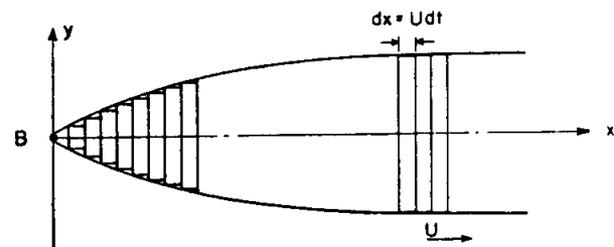
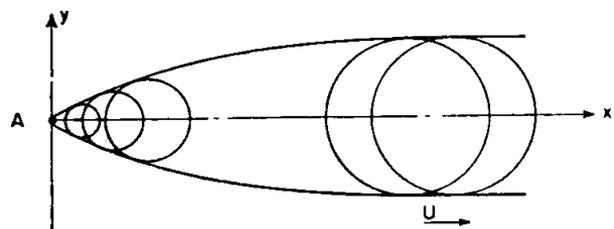
$$P(x, t) = \frac{1}{\sqrt{2\pi}\sigma_x} \exp\left(-\frac{x^2}{2\sigma_x^2}\right)$$

$$\langle C(x, t) \rangle = \frac{dN}{dx} = \frac{Q}{\sqrt{2\pi}\sigma_x} \exp\left(-\frac{x^2}{2\sigma_x^2}\right)$$

$$\langle C(x, y, z, t) \rangle = \frac{Q}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \exp\left\{-\frac{x^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2}\right\}$$

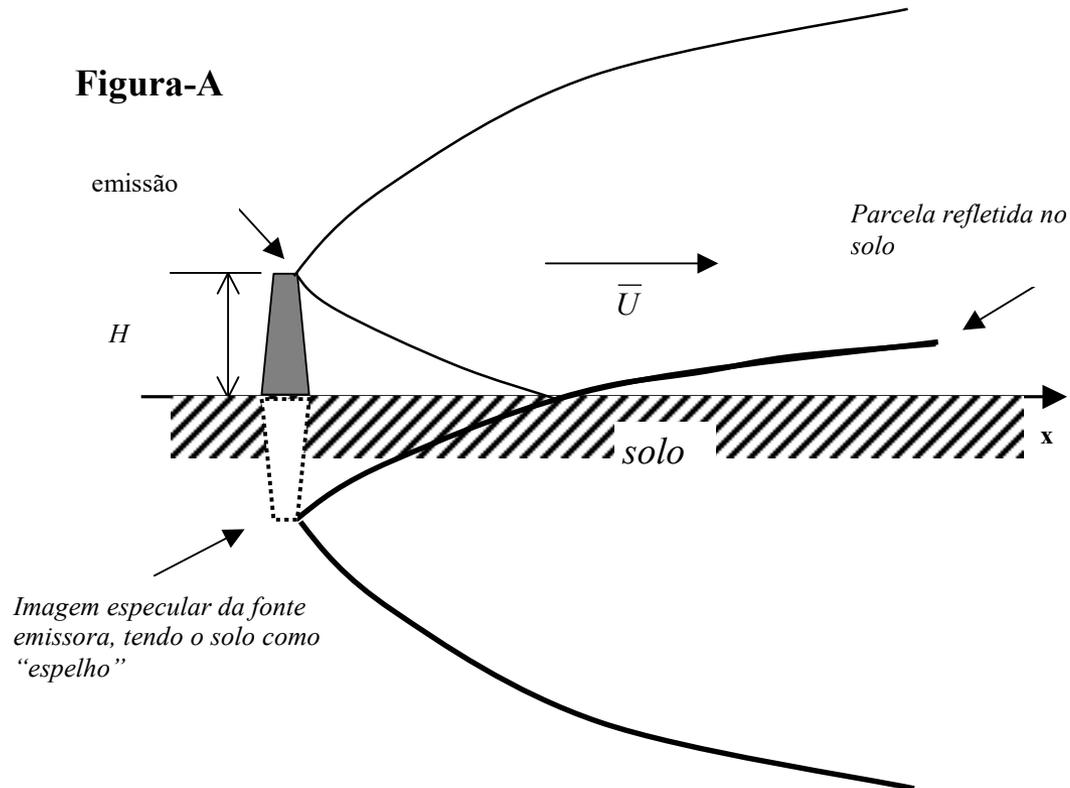
$$\langle C(x, y, z, t) \rangle = \frac{Q}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \exp \left\{ -\frac{(x-Ut)^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2} \right\}$$

$$\langle C(x, y, z) \rangle = \frac{S}{2\pi\sigma_y\sigma_z U} \exp \left[-\frac{y^2}{2\sigma_y^2} - \frac{z^2}{2\sigma_z^2} \right]$$



$$\langle C(x, y, z) \rangle = \frac{S}{2\pi\sigma_y\sigma_zU} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \cdot \left\{ \exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z+H)^2}{2\sigma_z^2}\right] \right\}$$

Figura-A



$$\langle C(x, y, z) \rangle = \frac{S}{2\pi\sigma_y\sigma_z U} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \times \left\{ \exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z+H)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z-2z_o+H)^2}{2\sigma_z^2}\right] \right\}$$

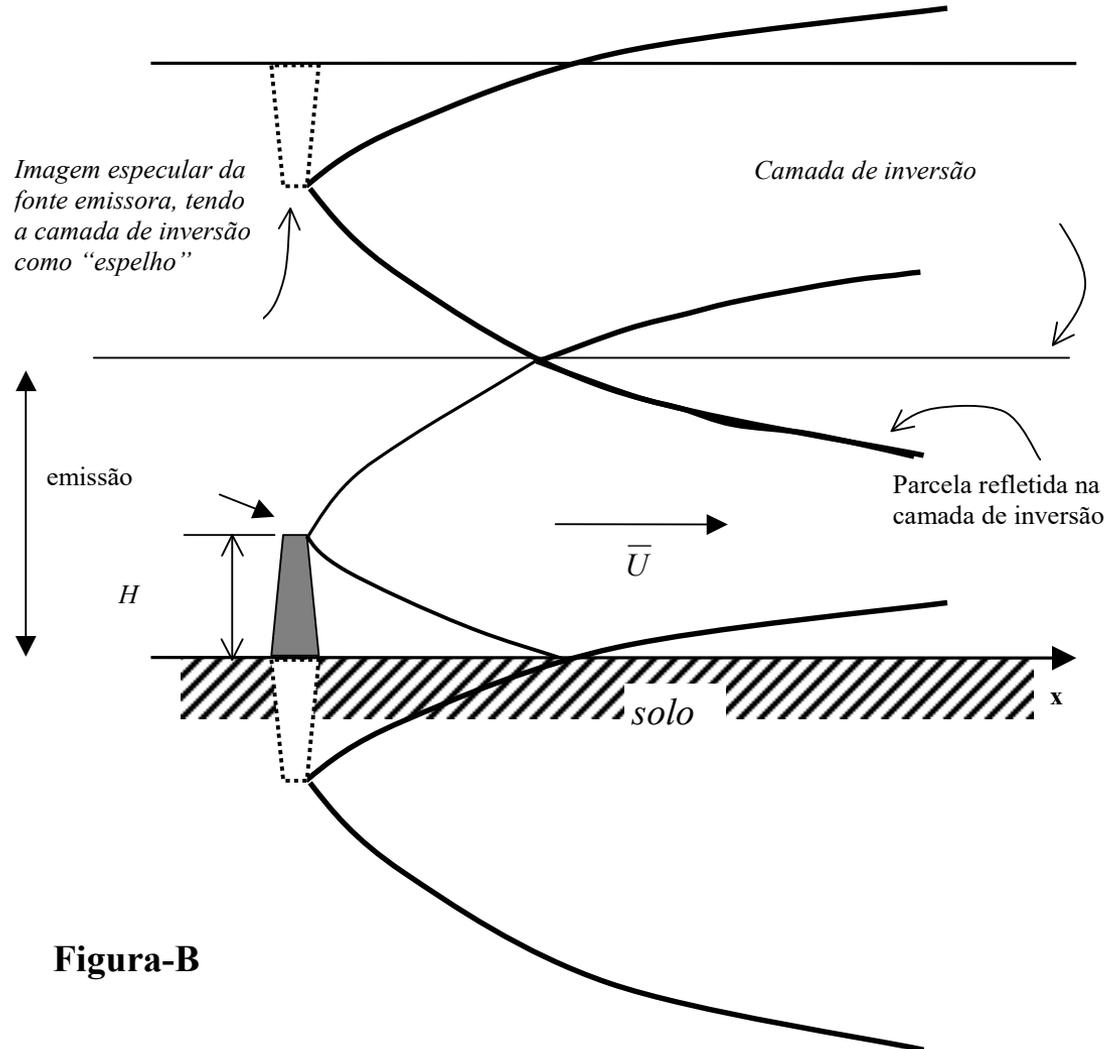


Figura-B

Classe de Estabilidade de P&G			Fórmulas de Briggs		BNL p/ σ_z	
Descrição	Pasquill	σ_θ (Graus)	σ_y (m)	σ_z (m)	c (m)	d
Muito Instável	A	25	$0,22x(1+0,0001x)^{-1/2}$	$0,20x$	0,41	0,91
Moderadamente Instável	B	20	$0,16x(1+0,0001x)^{-1/2}$	$0,12x$	0,33	0,86
Levemente Instável	C	15	$0,11x(1+0,0001x)^{-1/2}$	$0,08x(1+0,0002x)^{-1/2}$		
Neutra	D	10	$0,08x(1+0,0001x)^{-1/2}$	$0,06x(1+0,0015x)^{-1/2}$	0,22	0,78
Moderadamente Estável	E	5	$0,06x(1+0,0001x)^{-1/2}$	$0,03x(1+0,0003x)^{-1}$		
Muito Estável	F	2,5	$0,04x(1+0,0001x)^{-1/2}$	$0,016x(1+0,0003x)^{-1}$	0,06	0,71
Muitíssimo Estável	G	1				

$$\sigma_z = cx^d \quad \text{e} \quad \sigma_y = ax^b$$

Modelos Gerais de Dispersão Atmosférica de Poluentes (abordagens)

A Euleriana obtém o campo de concentrações resolvendo a equação de continuidade de massas na atmosfera.

$$\frac{\partial c}{\partial t} = -u\nabla c + \nabla K\nabla c + S(t)$$

A Lagrangiana. A equação lagrangiana básica usada é:

$$\langle c(\mathbf{r}, t) \rangle = \int_{-\infty}^t \int p(\mathbf{r}, t | \mathbf{r}', t') S(\mathbf{r}', t') d\mathbf{r}' dt'$$

$\langle c(\mathbf{r}, t) \rangle$ - concentração média em \mathbf{r} e no instante t

$S(\mathbf{r}', t')$ - emissão (massa . volume⁻¹ . tempo⁻¹)

$p(\mathbf{r}, t | \mathbf{r}', t')$ - função densidade de probabilidade de que uma parcela de ar mova-se de \mathbf{r}' no instante t' , para \mathbf{r} no instante t

u - velocidade do vento

K - difusibilidade

Na solução numérica Lagrangiana, a posição de cada partícula evolui como segue:

$$X_i(t + \Delta t) = X_i(t) + U_i(t)\Delta t$$

Onde:

$X_i(t)$ são as coordenadas da posição da partícula no instante t e

$U_i(t)$ são as componentes do vetor velocidade no instante t .

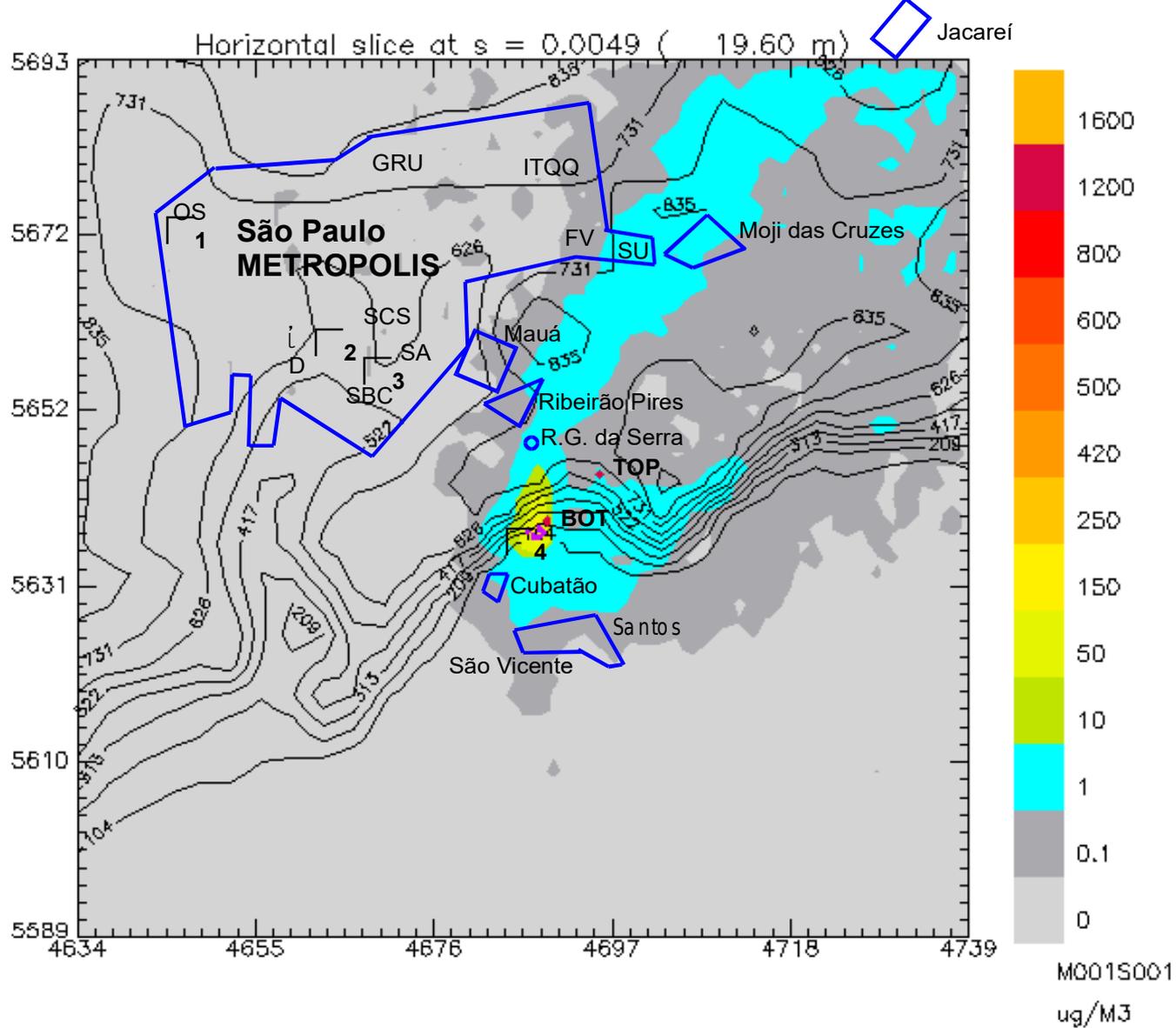
U_i é decomposto em 2 parcelas,

$$U_i(t) = \overline{U_i(X, t)} + U'_i(t)$$

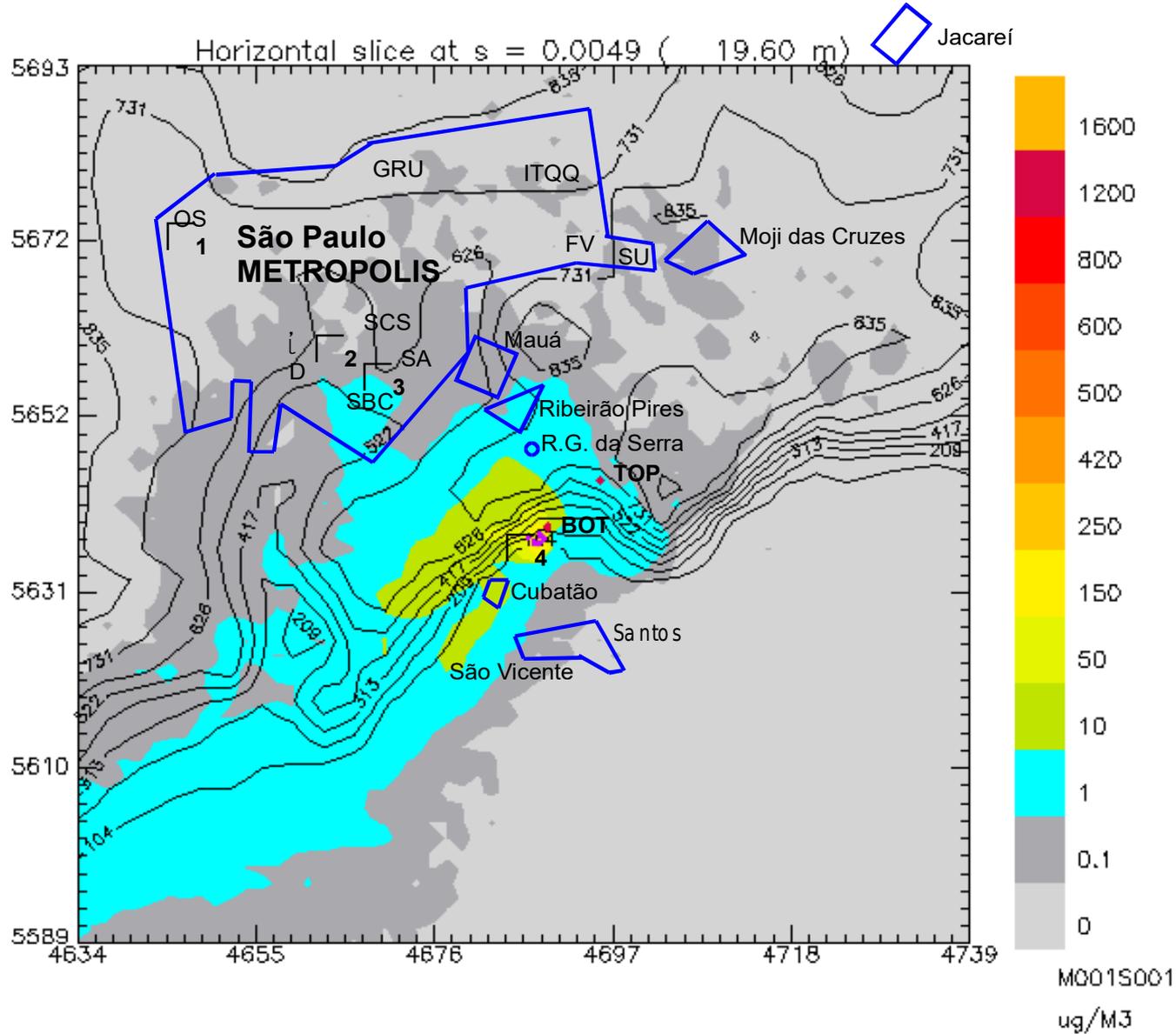
O último termo é a flutuação estatística da velocidade.

Usa-se, por exemplo, uma Gaussiana para a função densidade de probabilidade atmosférica (PDF) na horizontal e uma PDF Gram-Charlier, truncada na quarta ordem, para a vertical.

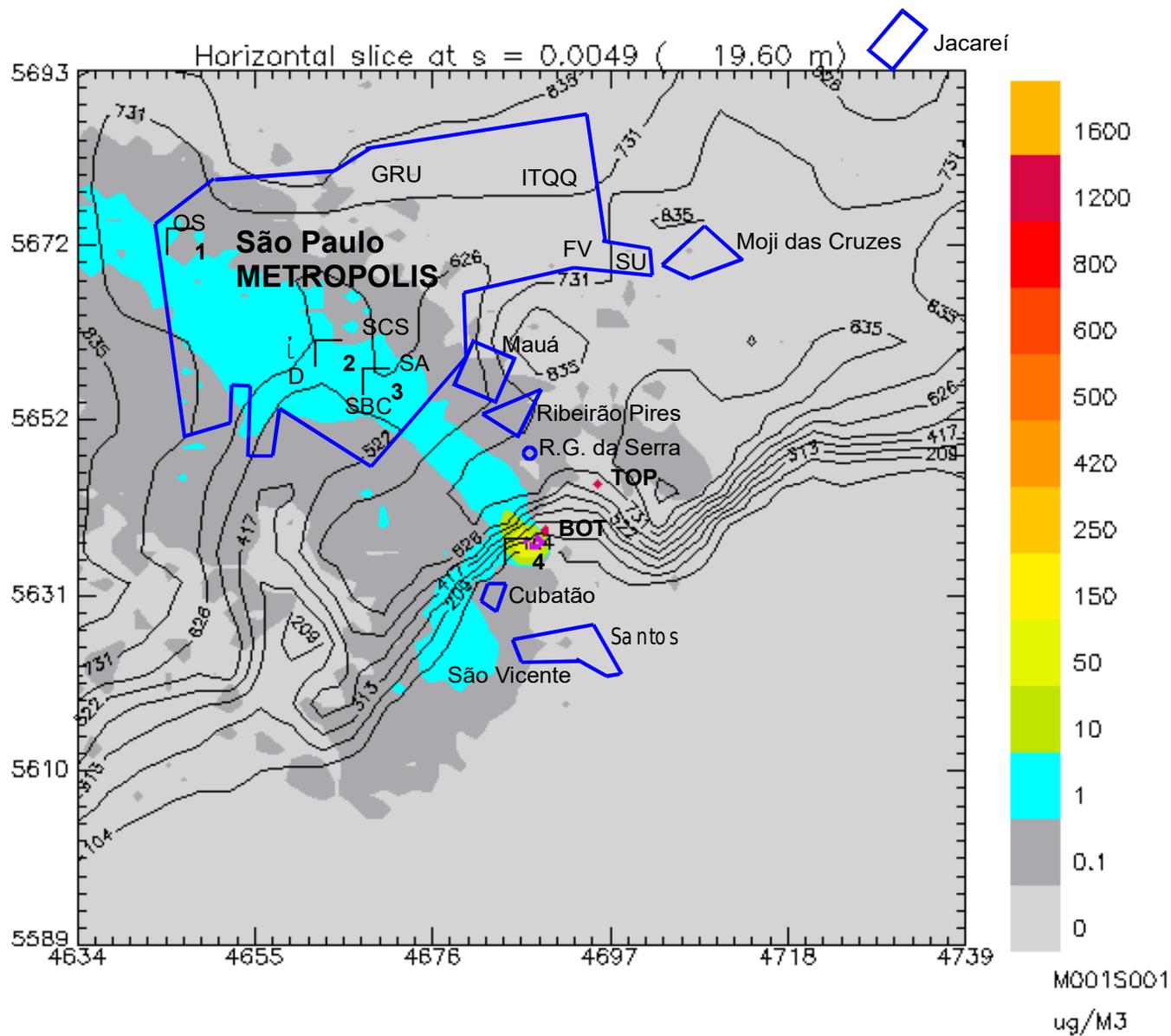




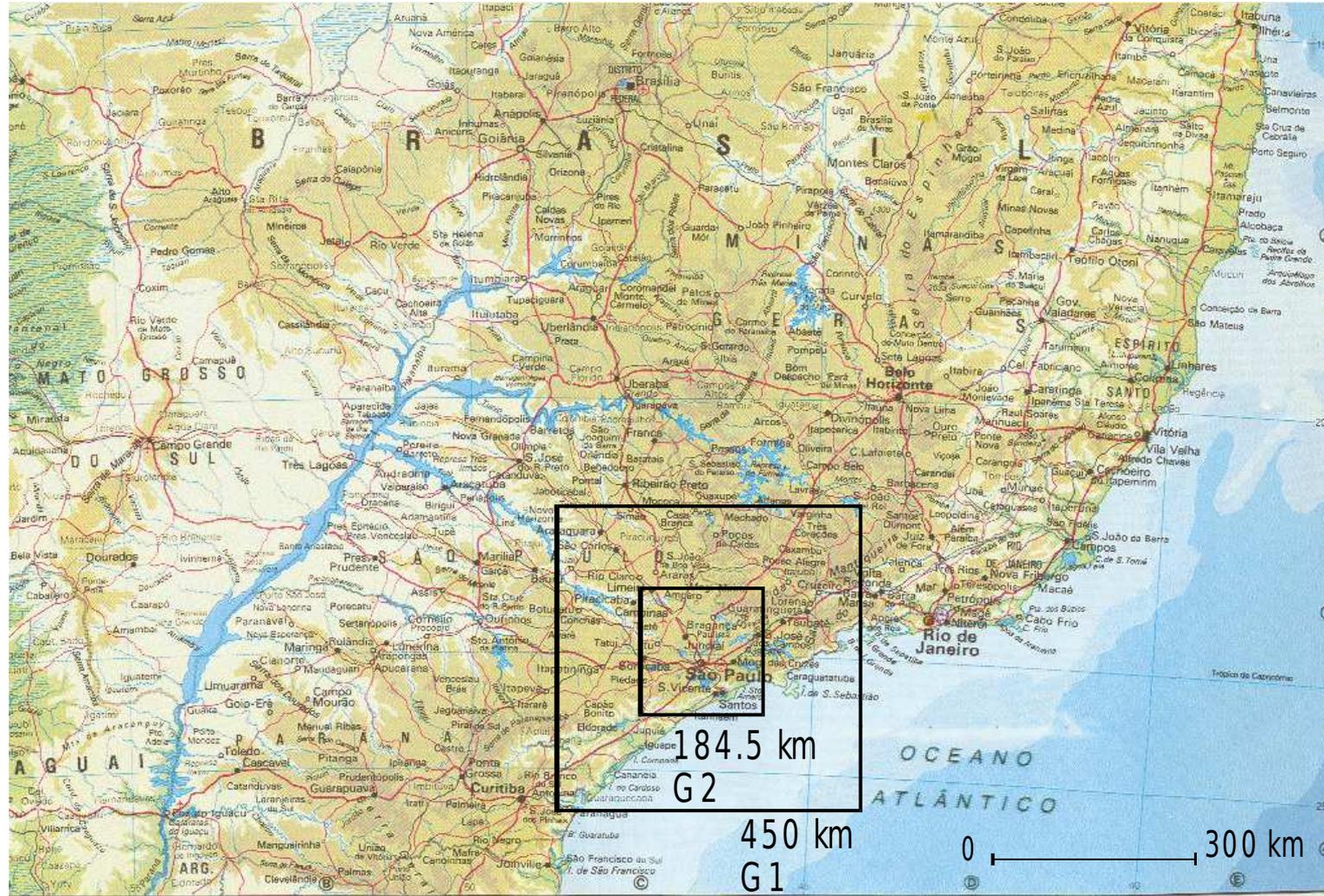
Cubatão, 17/10/91, 22UTC (19LST)



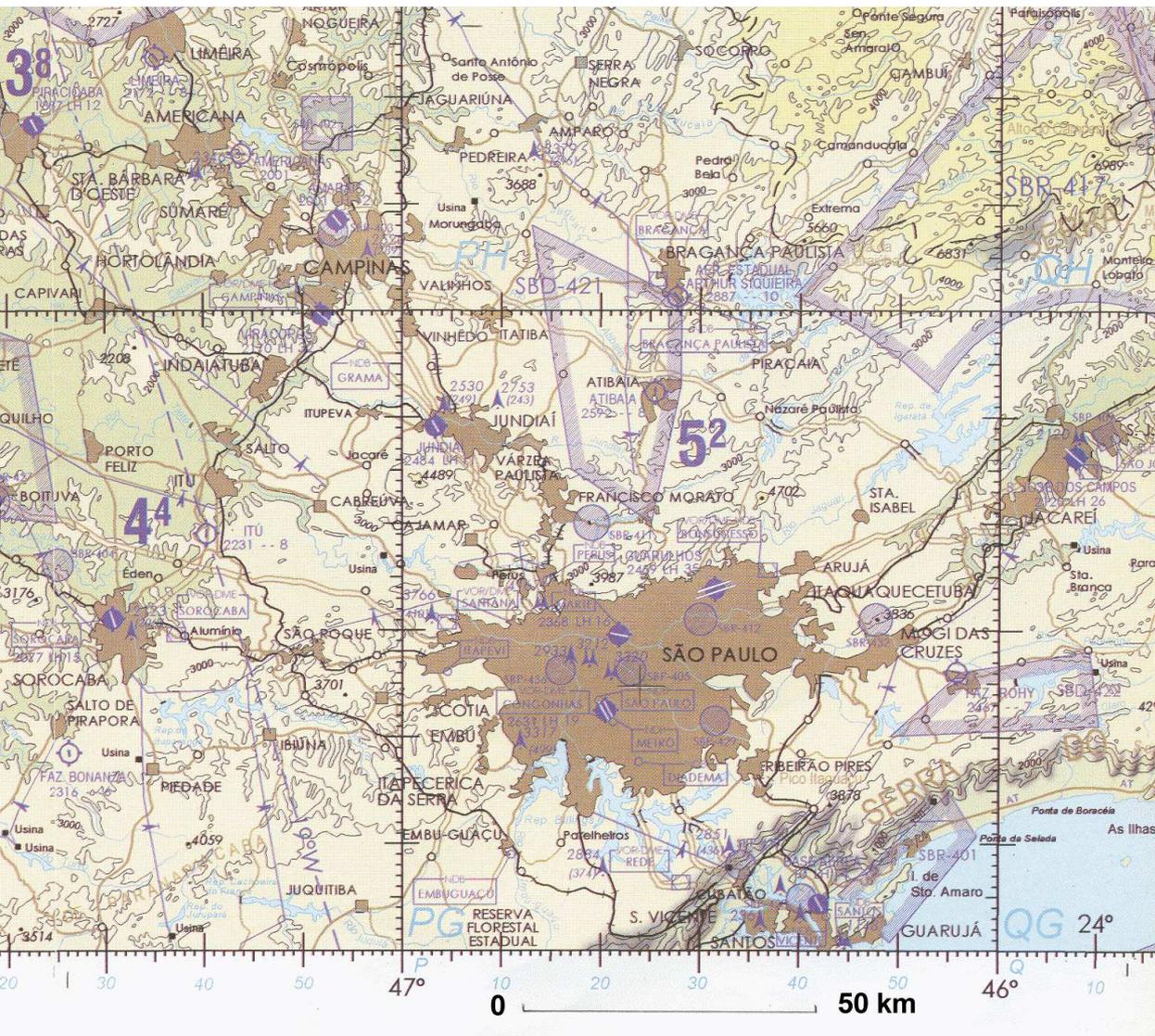
Cubatão, 16/10/91, 22UTC (19LST)



Cubatão, 21/10/91, 14UTC (11LST)



Mapa da área de simulação



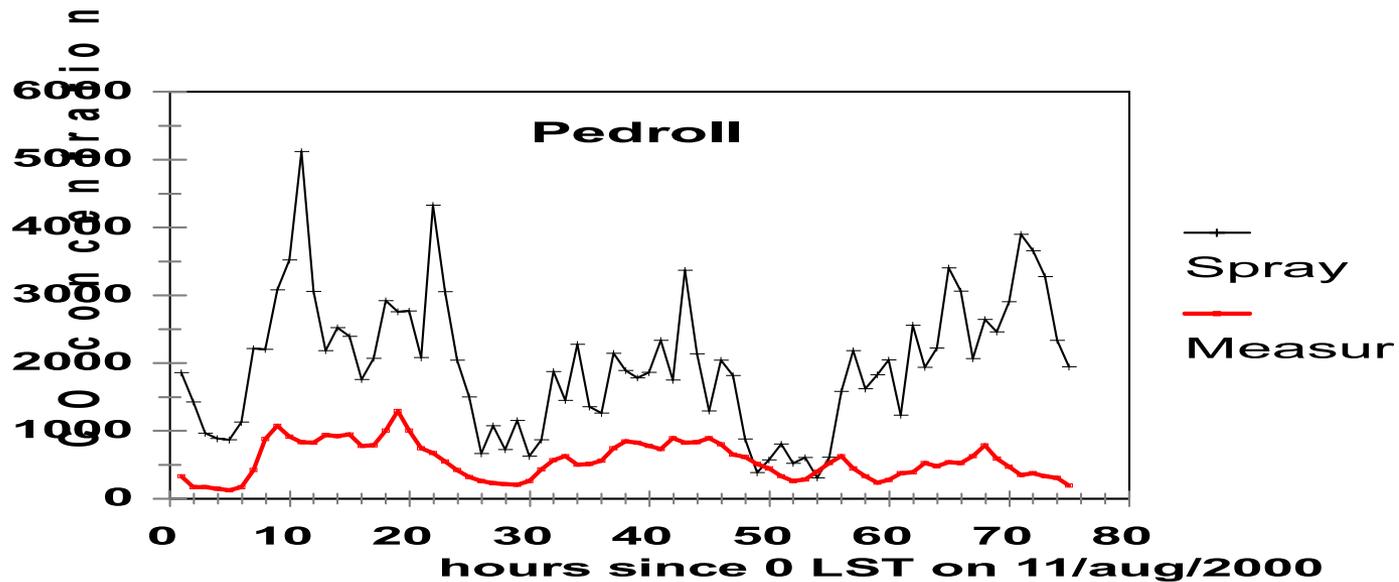
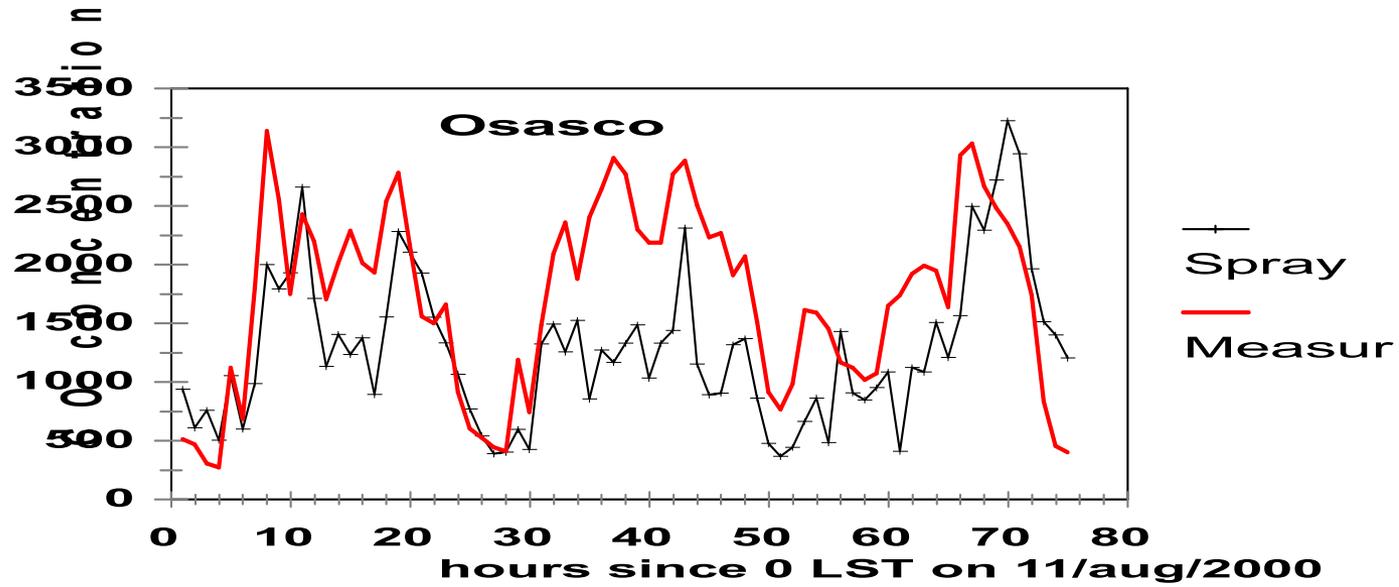
METROPOLES:
São Paulo
8,051 km²
19 x 10⁶ inhabitants

Campinas
3,673 km²
2.6 x 10⁶ inhabitants

Baixada Santista
2,273 km²
1.6 x 10⁶ habitantes

População destas áreas:
~ 24 x 10⁶ habitantes

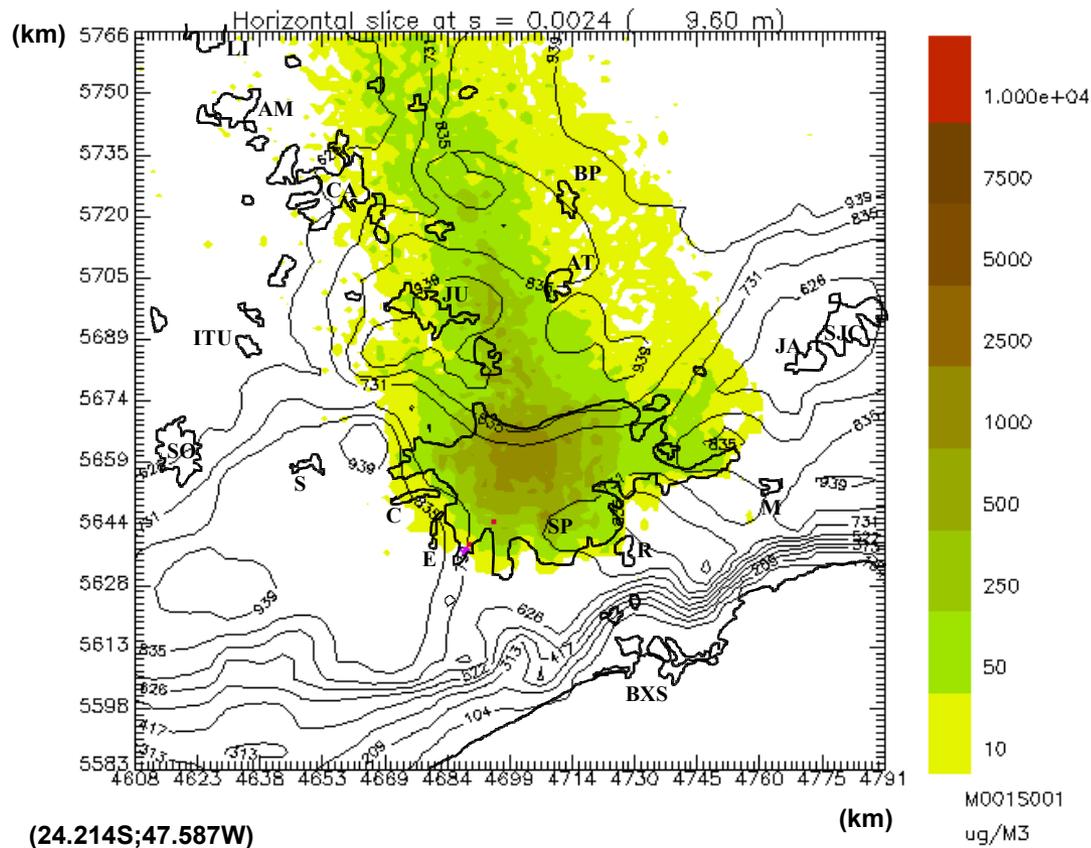
Comparação das concentrações de CO simuladas e medidas



13/Outubro às 12GMT a 14/Outubro às 5GMT

ENEL/GRAM - 02/September/2005 15:21
File name: /home/akerr/SPRAY20/DATA/SP/CONC_05F_G2SP169zo13_B
Model: SPRAY Simulation time: 13.06. 0 12:00:00
Lower corner: [4607.72,5582.72] Upper corner: [4790.72,5765.72] Z Top: 4000
Variable : M001S001
Global Data Min : 0 Max : 3486.94 Local Data Min : 0 Max : 2199.54

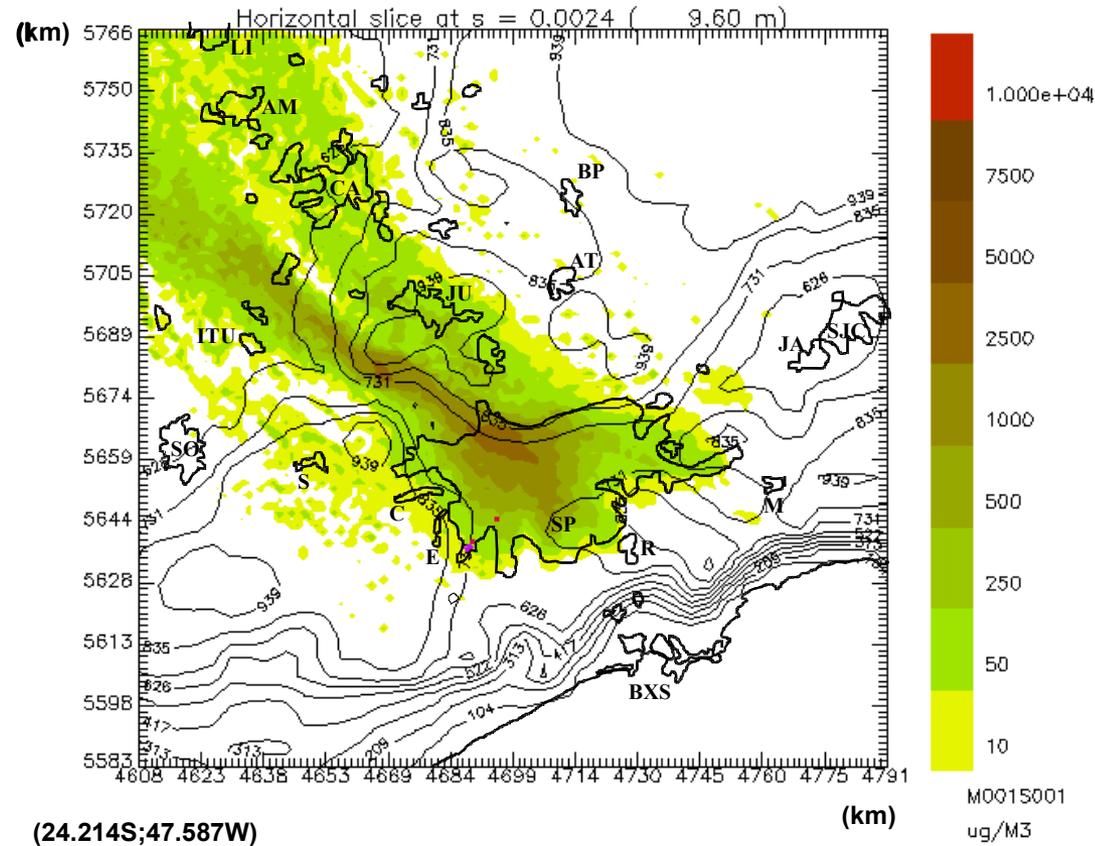
CIN Project



13/Outubro às 12GMT a 14/Outubro às 5GMT

ENEL/CRAM - 01/September/2005 22:14
File name: /home/akerr/SPRAY20/DATA/SP/CONC_05F_G2SP169zo14_B
Model: SPRAY Simulation time: 14.06. 0 05:00:00
Lower corner: [4607.72,5582.72] Upper corner: [4790.72,5765.72] Z Top: 4000
Variable : M001S001
Global Data Min : 0 Max : 5757.74 Local Data Min : 0 Max : 5292.42

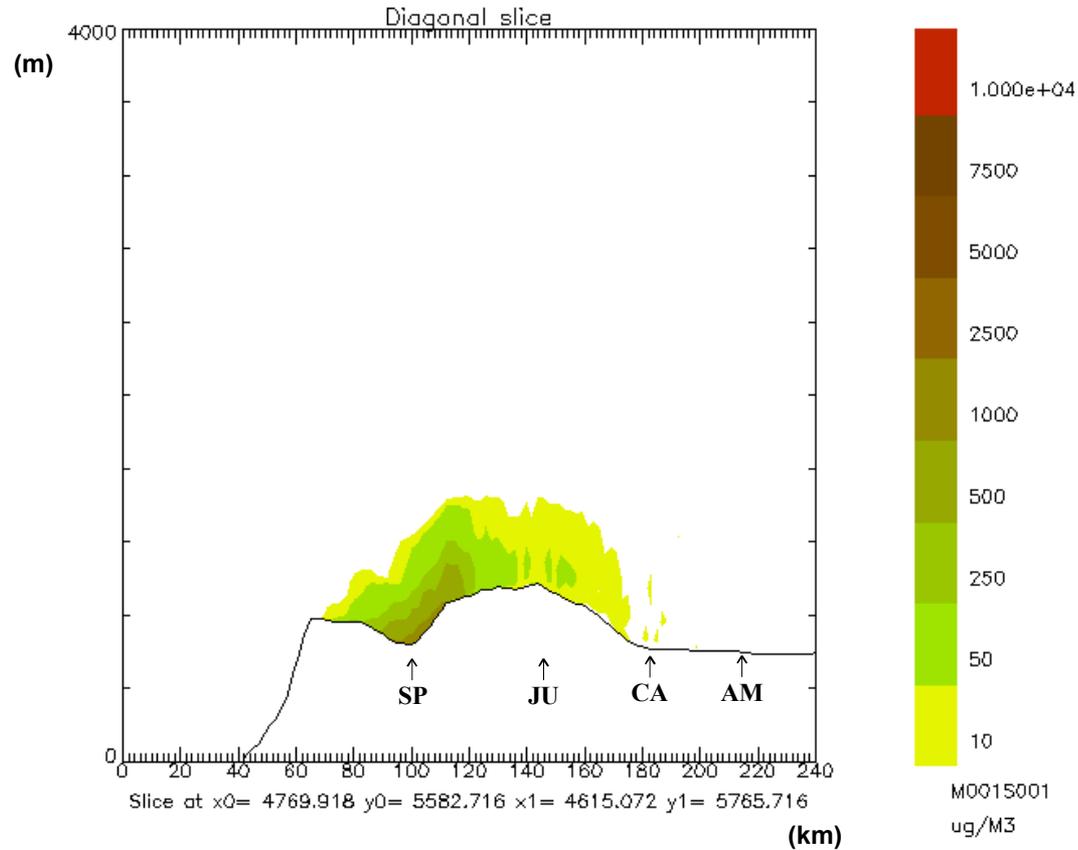
CIN Project



13/Outubro às 12GMT a 14/Outubro às 5GMT

ENEL/CRAM - 02/September/2005 15:19
File name: /home/akerr/SPRAY20/DATA/SP/CQNC_05F_G2SP169zo13_B
Model: SPRAY Simulation time: 13.08.0 12:00:00
Lower corner: [0,0] Upper corner: [239.721,1] Z Top: 4000
Variable : M001S001
Global Data Min : 0 Max : 3486.94 Local Data Min : 0 Max : 3076.53

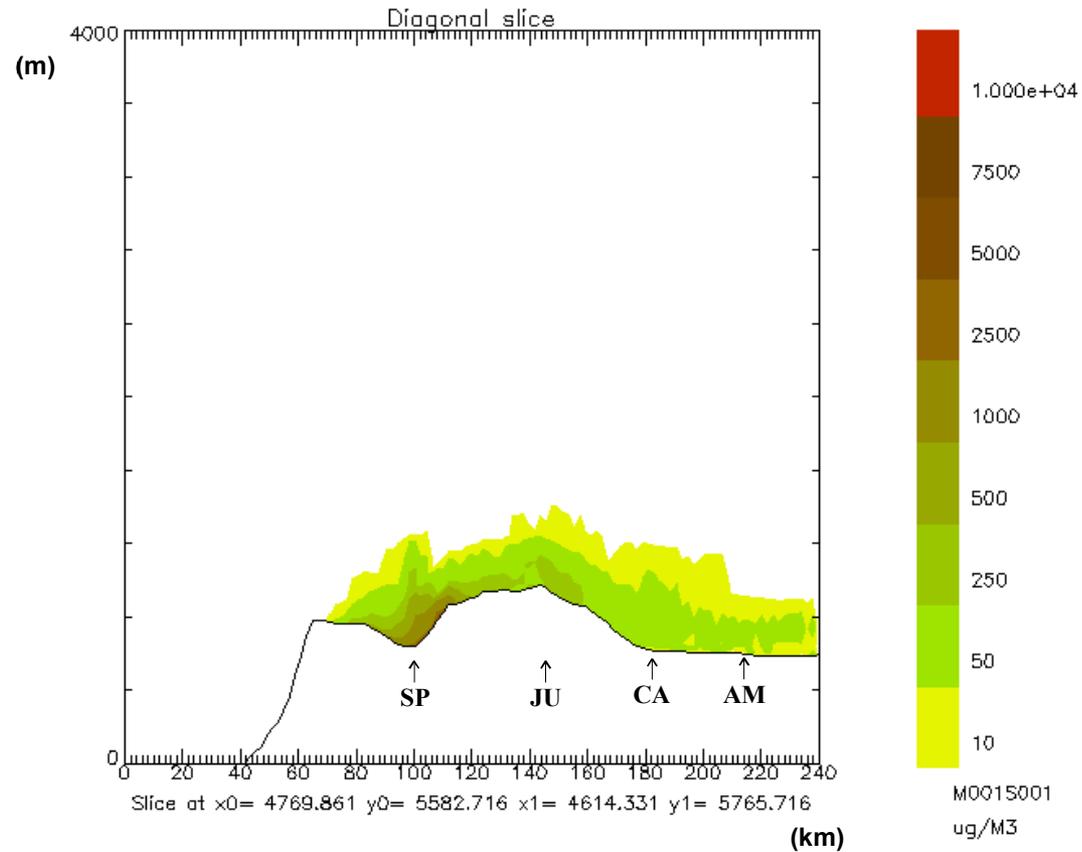
CIN Project



13/Outubro às 12GMT a 14/Outubro às 5GMT

ENEL/CRAM - 01/September/2005 22:16
File name: /home/akerr/SPRAY20/DATA/SP/CQNC_05F_G2SP169zo14_B
Model: SPRAY Simulation time: 14.08.0 05:00:00
Lower corner: [0,0] Upper corner: [240,164,1] Z Top: 4000
Variable : M001S001
Global Data Min : 0 Max : 5757.74 Local Data Min : 0 Max : 3696.44

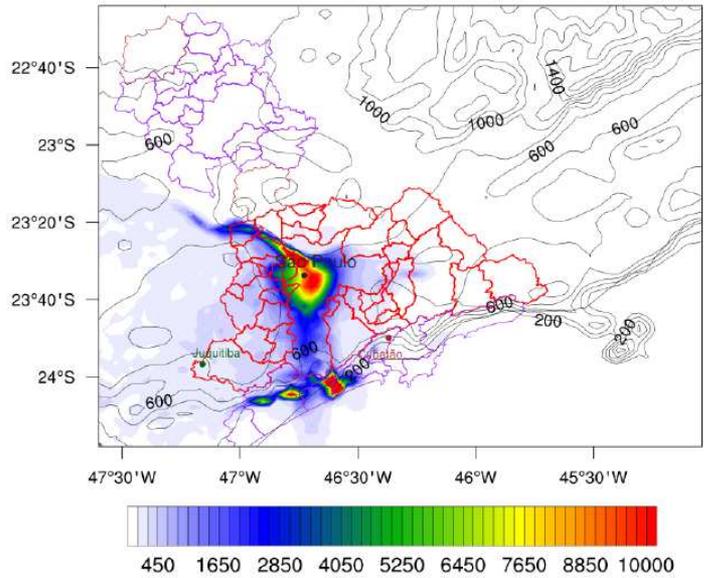
CIN Project



CO Concentration for MASP and Nearby Areas

08/26/2006 6h UTC

ug/M3



AMSU 1.7.1

24/June/2016 17:34

File: E:\Mestrado\ResultadosSpray\cujusP-G2-CongonhasMod2006\resulta\conc-26-08-2006.bin

Model SPRAY Simulation time: 26.08.2006 10:00:00 Variable: M001S001

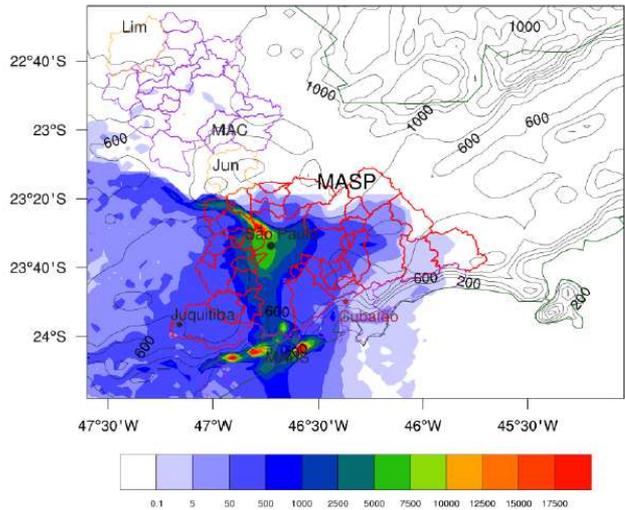
Area range [0,0] [31.4482,3000] Top of domain 3000

Global data range: [0,48020] Actual: [0,36196.1]

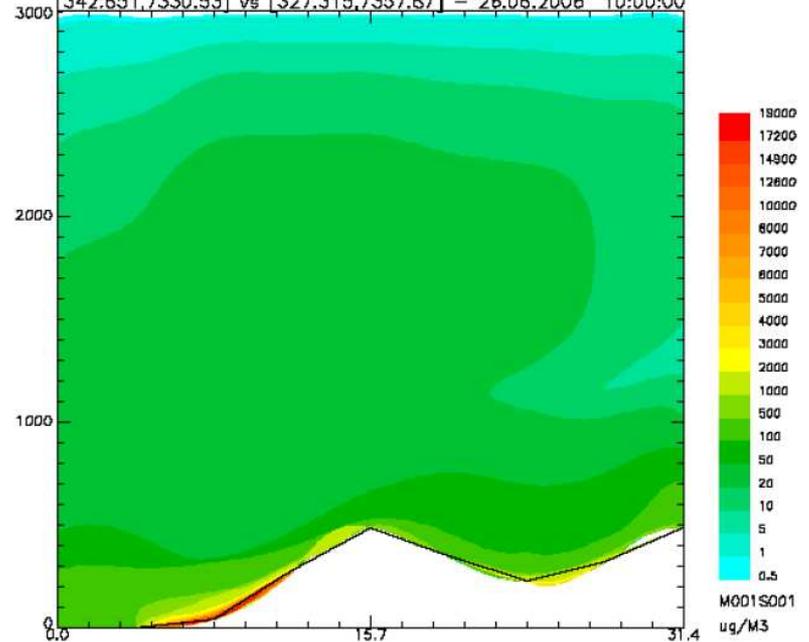
CO Concentration for MASP and Nearby Areas

26/08/2006 9h UTC

ug m⁻³



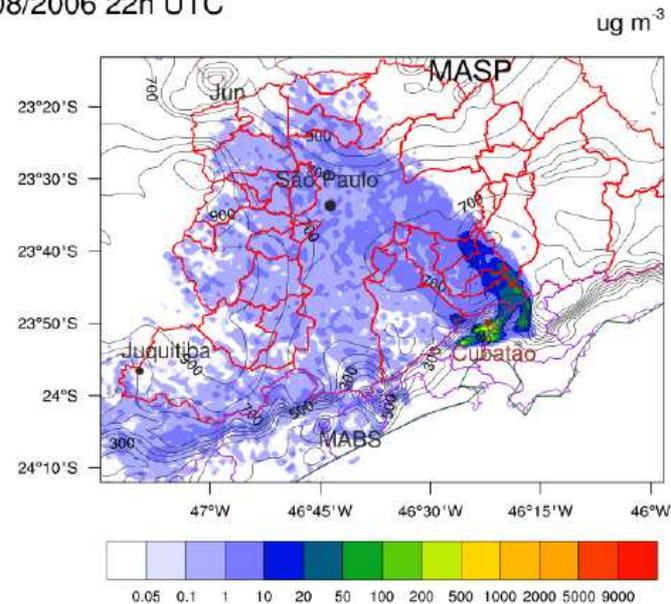
[342.851,7330.53] vs [327.315,7357.67] - 26.08.2006 10:00:00



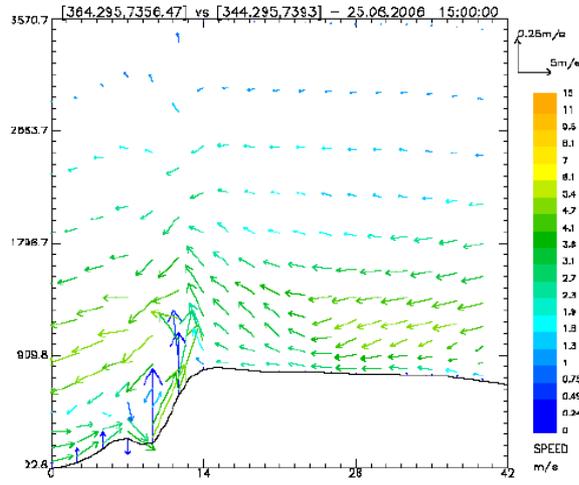
Simulação das Concentrações de Material Particulado geradas pelas respectivas emissões em Cubatão

PM10 Concentration for MASP and Nearby Areas

25/08/2006 22h UTC

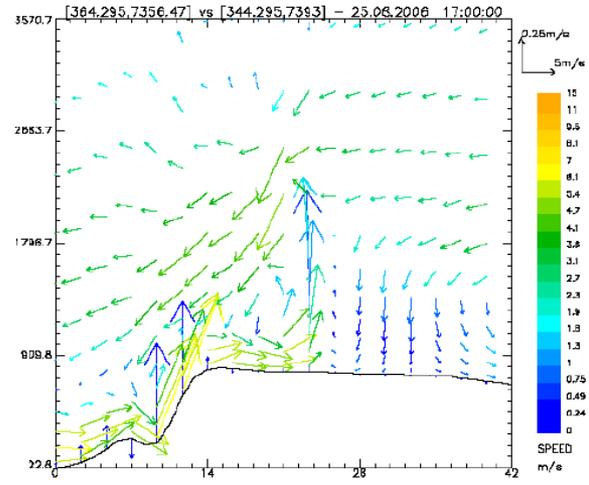


AMSU 1.7.1 24/June/2016 21:17
 File: F:\Nastreda\ResultosSpray\CUJesp-G3Meio\resulta\meteor.turb.hb
 Model SURFPROS Simulation time: 25.06.2008 15:00:00 Wind colored by: SPEED
 Area range [0,22.7707] [41.645,3570.73] Top of domain 17343.7
 Global data range: [0,17.9285] Actual: [0.00893024,4.63611]



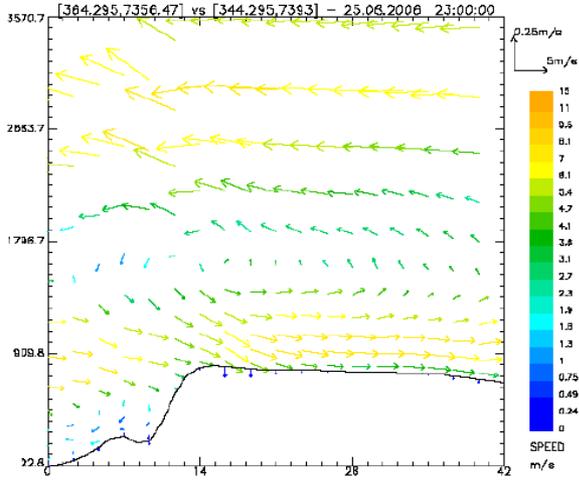
(a) Vento à 15h (UTC)

AMSU 1.7.1 24/June/2016 21:17
 File: F:\Nastreda\ResultosSpray\CUJesp-G3Meio\resulta\meteor.turb.hb
 Model SURFPROS Simulation time: 25.06.2008 17:00:00 Wind colored by: SPEED
 Area range [0,22.7707] [41.645,3570.73] Top of domain 17343.7
 Global data range: [0,18.3066] Actual: [0.0025792,6.18629]



(b) Vento à 17h (UTC)

AMSU 1.7.1 24/June/2016 21:19
 File: F:\Nastreda\ResultosSpray\CUJesp-G3Meio\resulta\meteor.turb.hb
 Model SURFPROS Simulation time: 25.06.2008 23:00:00 Wind colored by: SPEED
 Area range [0,22.7707] [41.645,3570.73] Top of domain 17343.7
 Global data range: [0,20.1696] Actual: [0.00930573,7.61369]



(c) Vento à 23h (UTC)