Transport of Air Toxics

III Taller sobre implicaciones en política pública de nuevos hallazgos científicos sobre contaminación atmosférica: Contaminantes Tóxicos en Aire

Monterrey, Nuevo León, 20 August 2009

Benjamin de Foy, Saint Louis University

Source Identification:

- Challenges
- Data analysis
- Modeling tools

Challenge of Identifying Sources

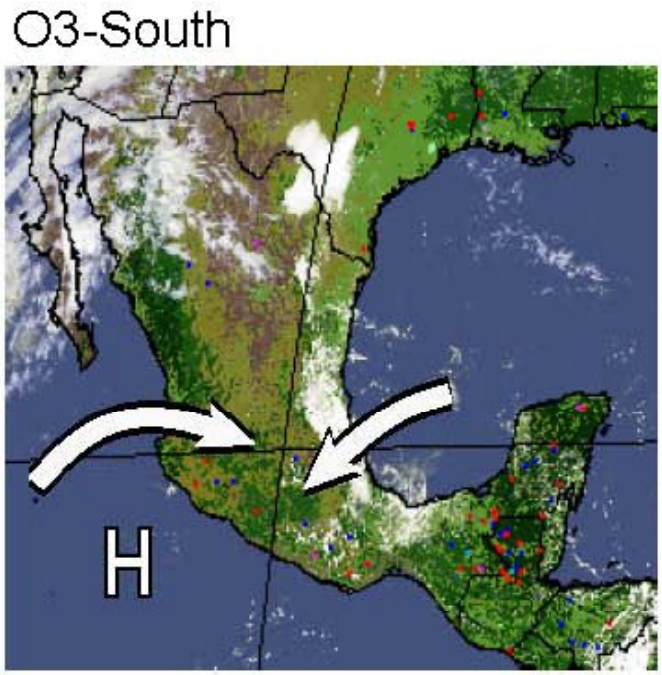
- Many different types – point, area, fugitive, …
- Emissions not continuous in time
- Urban areas often have complex winds
- Numerical simulations have large uncertainties

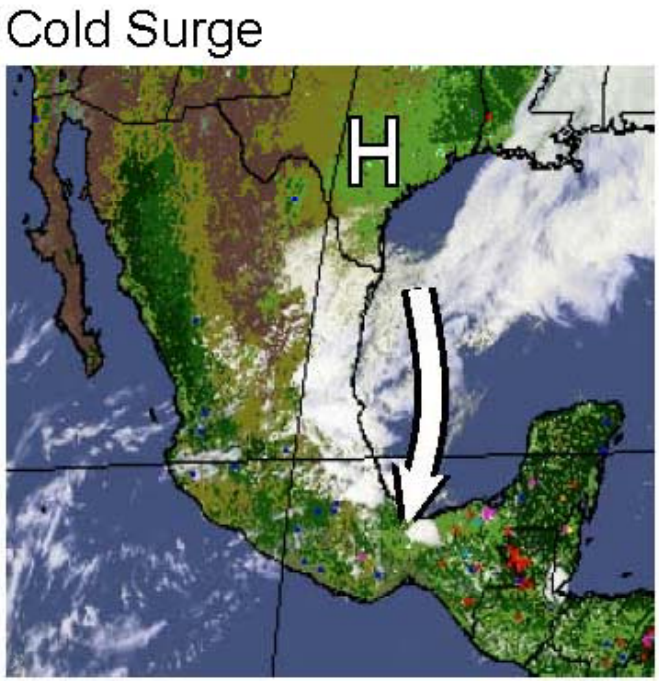
But, chemical signature can make them individually identifiable.

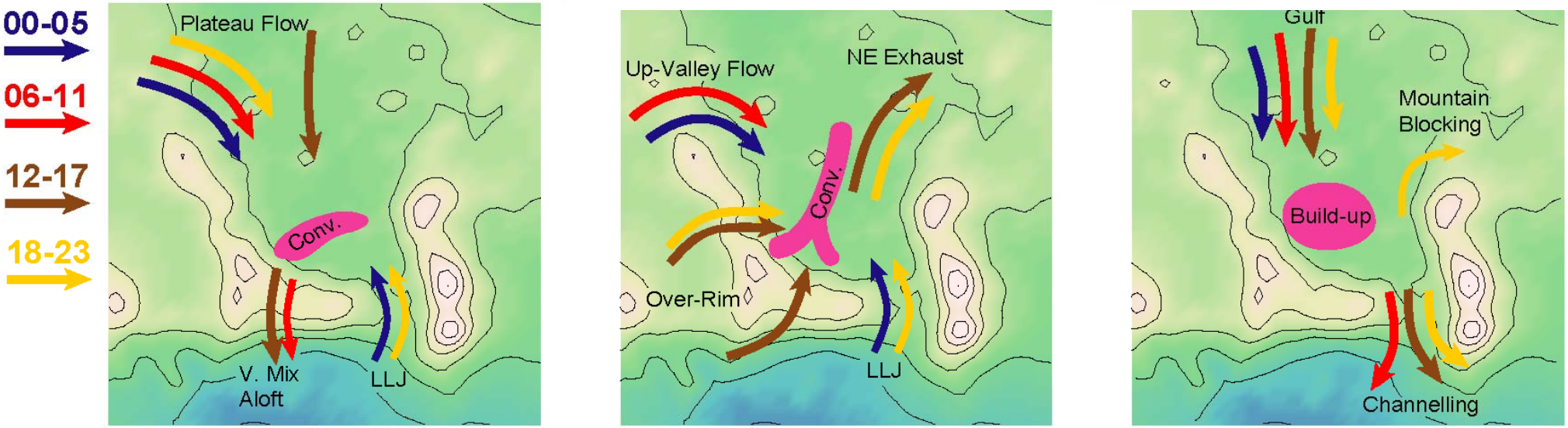
Need multi-prong analysis approach:

- Wind vector analysis:
  - Surface winds
  - Radar wind profilers
  - Wind and pollution roses
- Particle trajectory modeling (Lagrangian)
  - Back-trajectories
  - Concentration Field Analysis
  - Forward trajectories
- Grid modeling (Eulerian)

Complex Flows in Mexico City during MCMA-2003

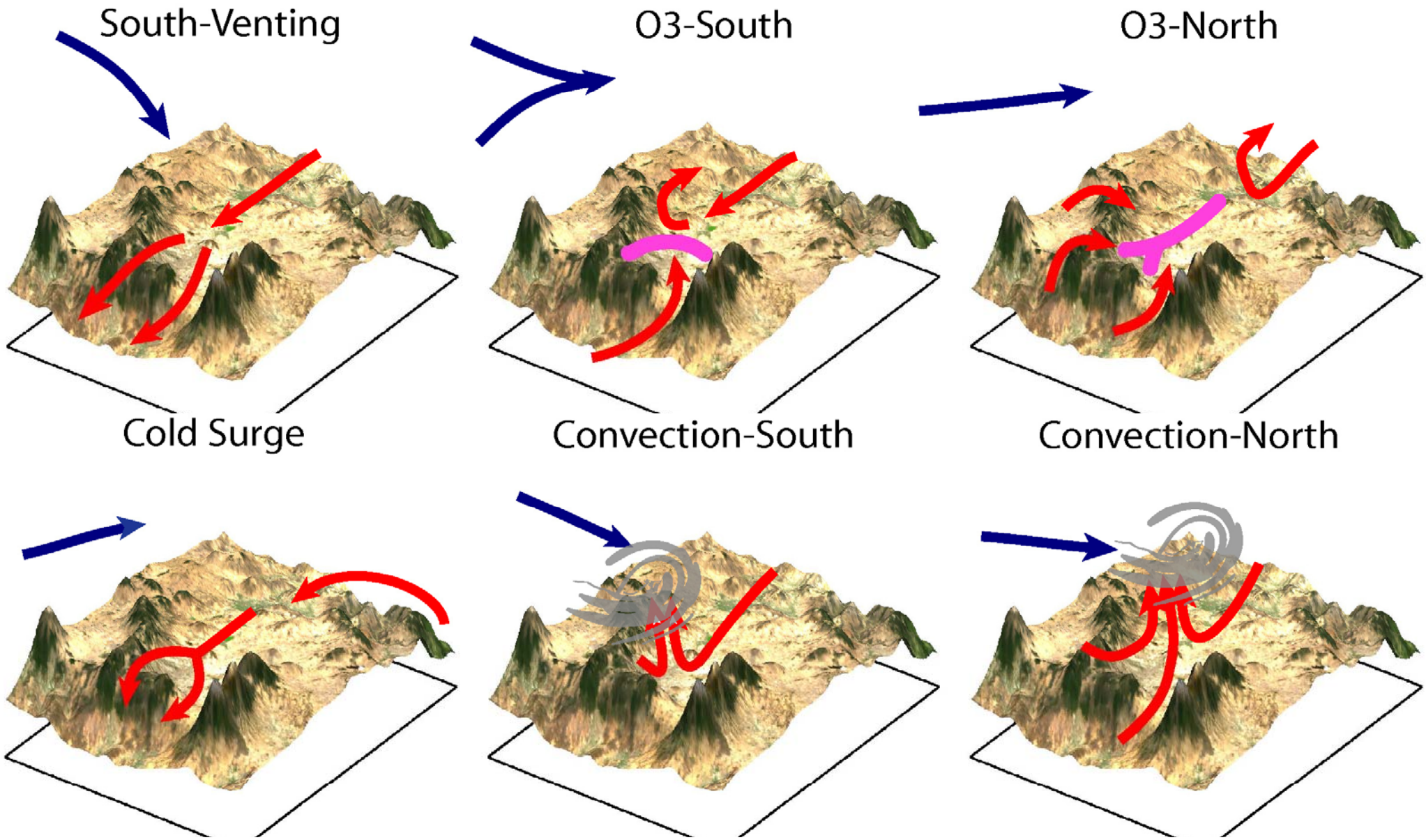






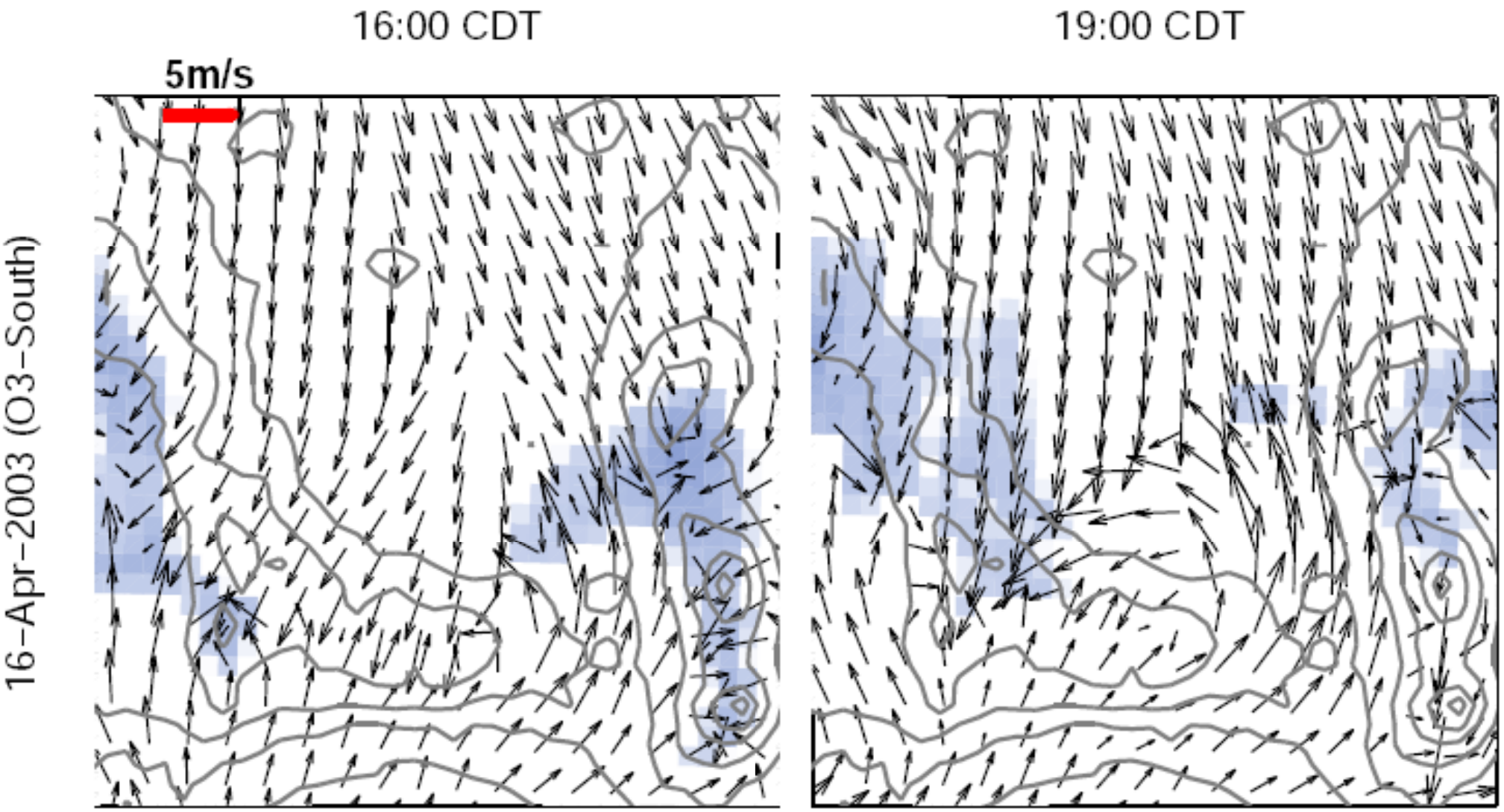
B. de Foy et al. “Mexico City basin wind circulation during the MCMA-2003 field campaign” *Atmospheric Chemistry & Physics*

Complex Basin flows during MILAGRO

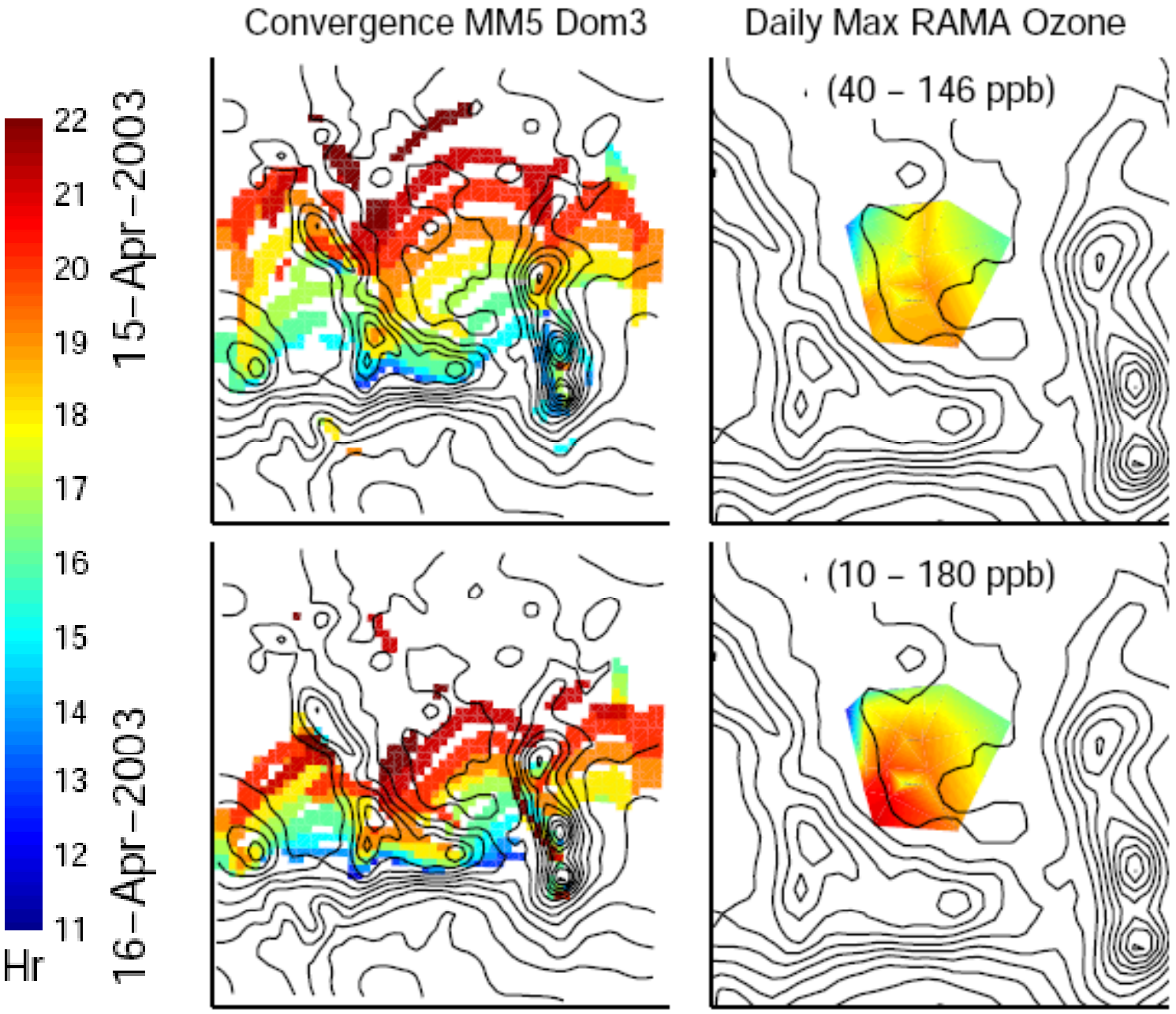


de Foy et al., Basin-scale wind transport during the MILAGRO field campaign and comparison to climatology using cluster analysis, *Atmospheric Chemistry and Physics*.

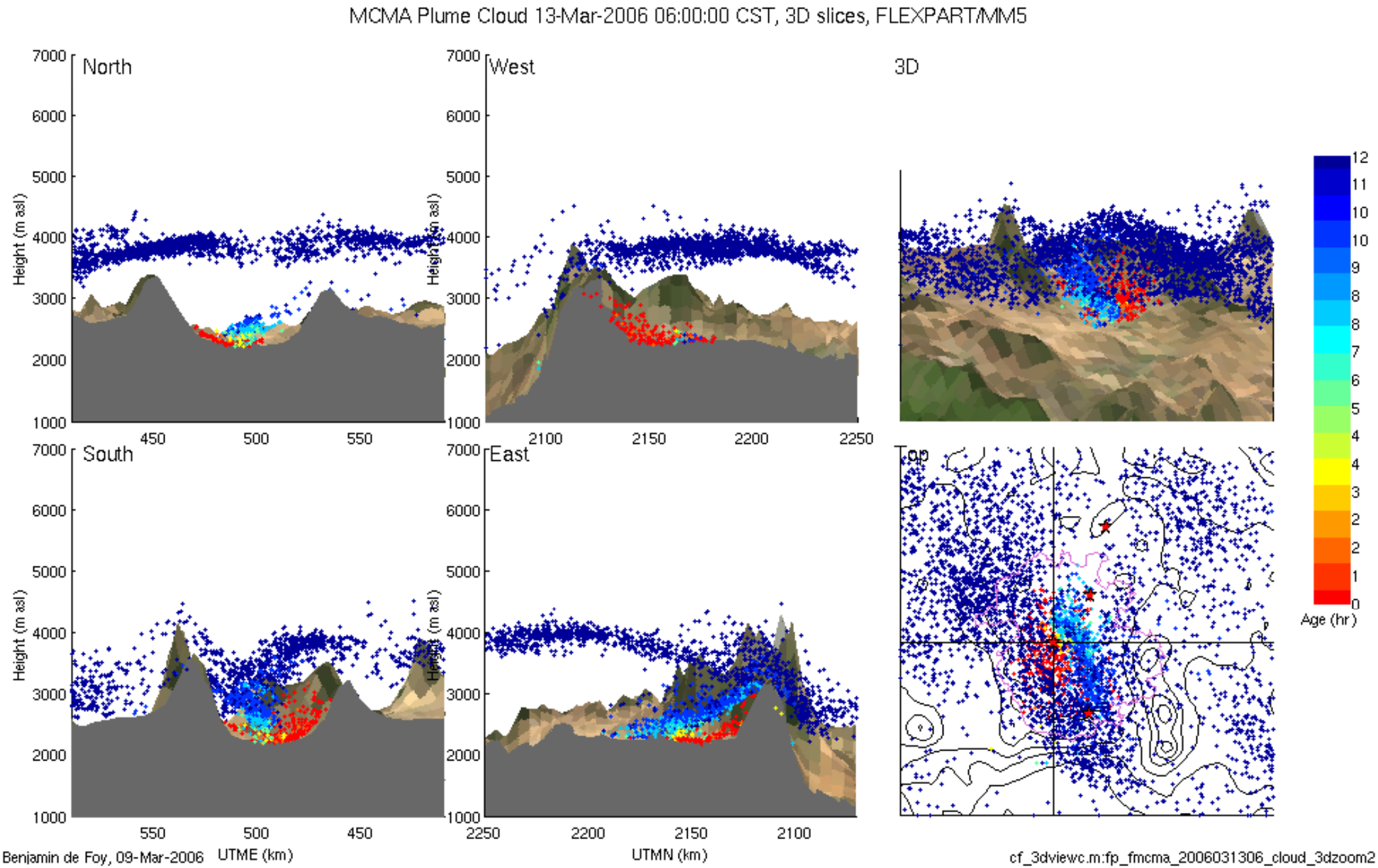
Convergence Line in the Mexico City Basin



Small changes in the Convergence lines leads to big changes in pollution levels



Example of Vertical Stratification



Analysis Approach

- Wind vector analysis:
  - Surface winds
  - Radar wind profilers
  - Wind and pollution roses
- Particle trajectory modeling (Lagrangian)
  - Back-trajectories
  - Concentration Field Analysis
  - Forward trajectories
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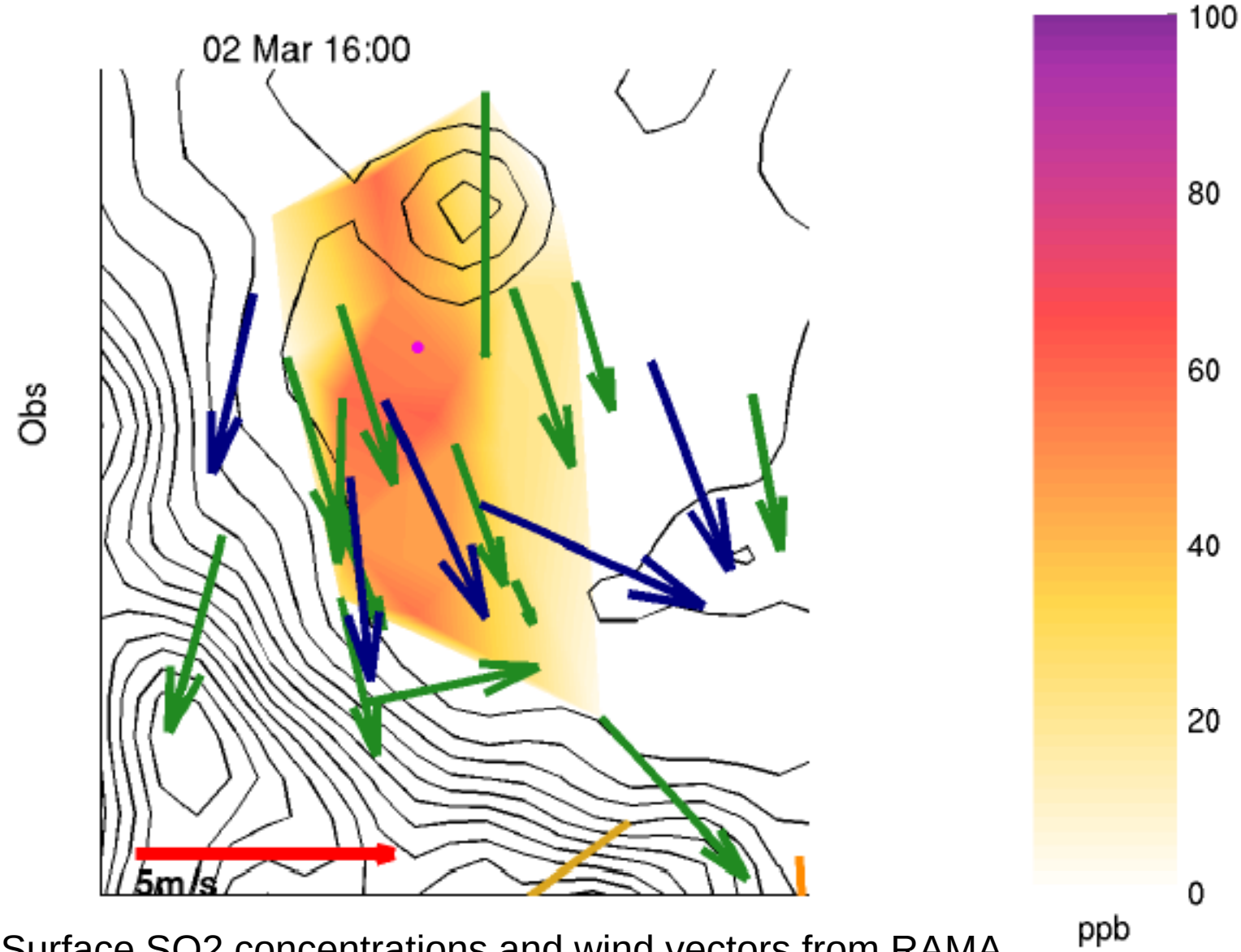
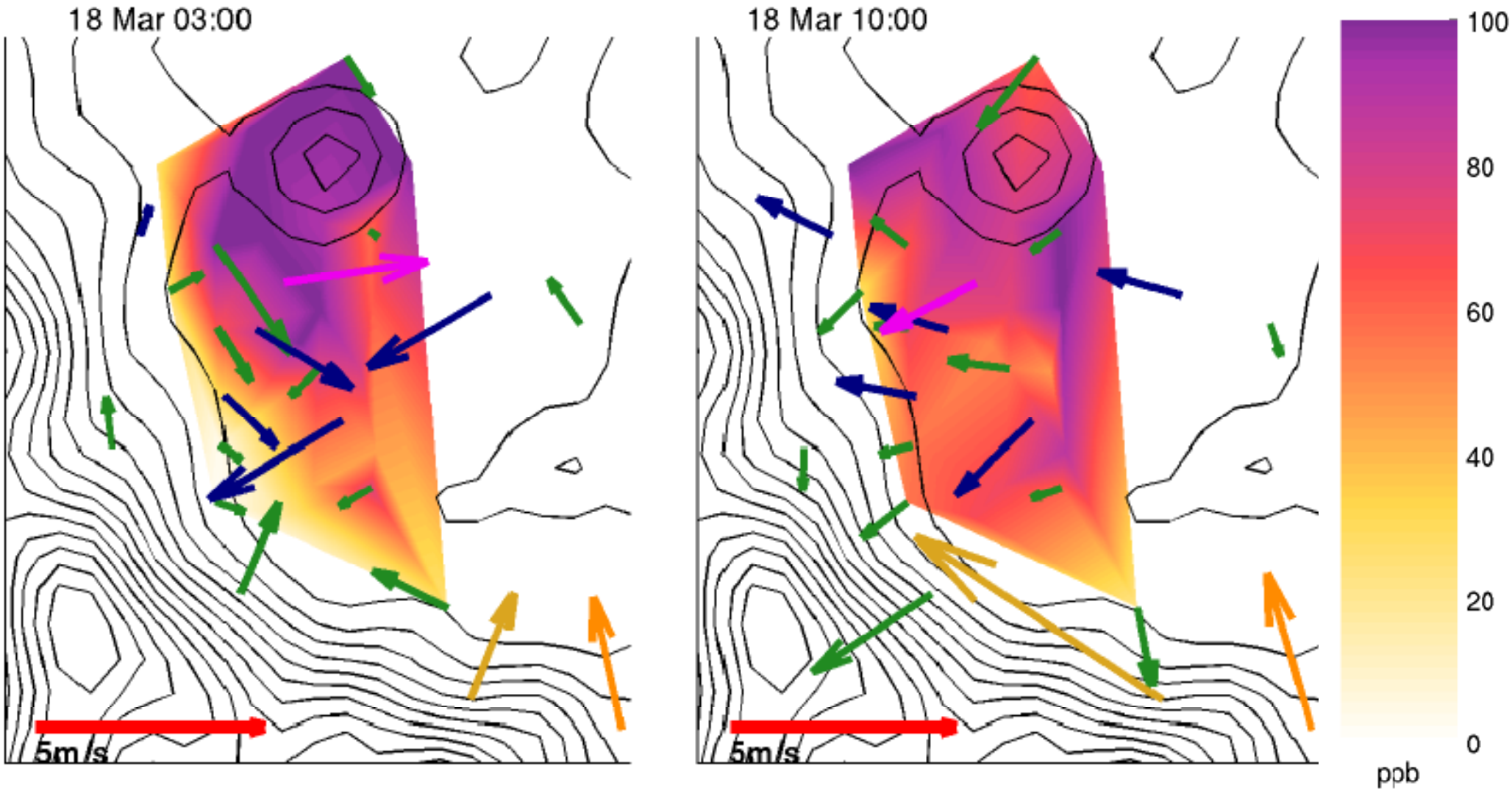
Plume Transport Inferred from Surface Wind Vectors



Surface SO2 concentrations and wind vectors from RAMA

B. de Foy et al. “Hit from both sides: tracking industrial and volcanic plumes in Mexico City” *Atm. Chem. & Phys. Discuss.*

Plume Transport Inferred from Surface Wind Vectors



Surface SO2 concentrations and wind vectors from RAMA

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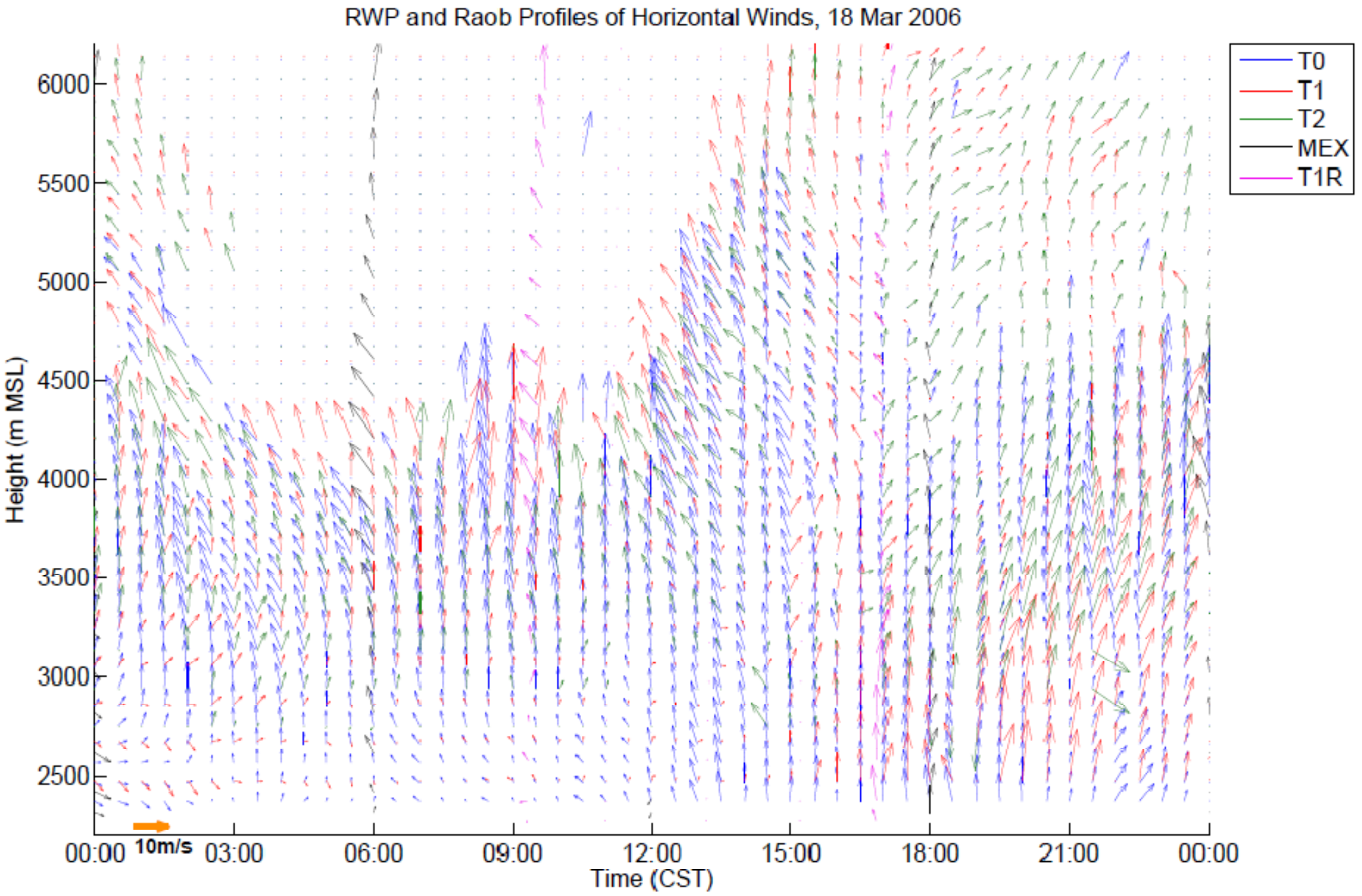
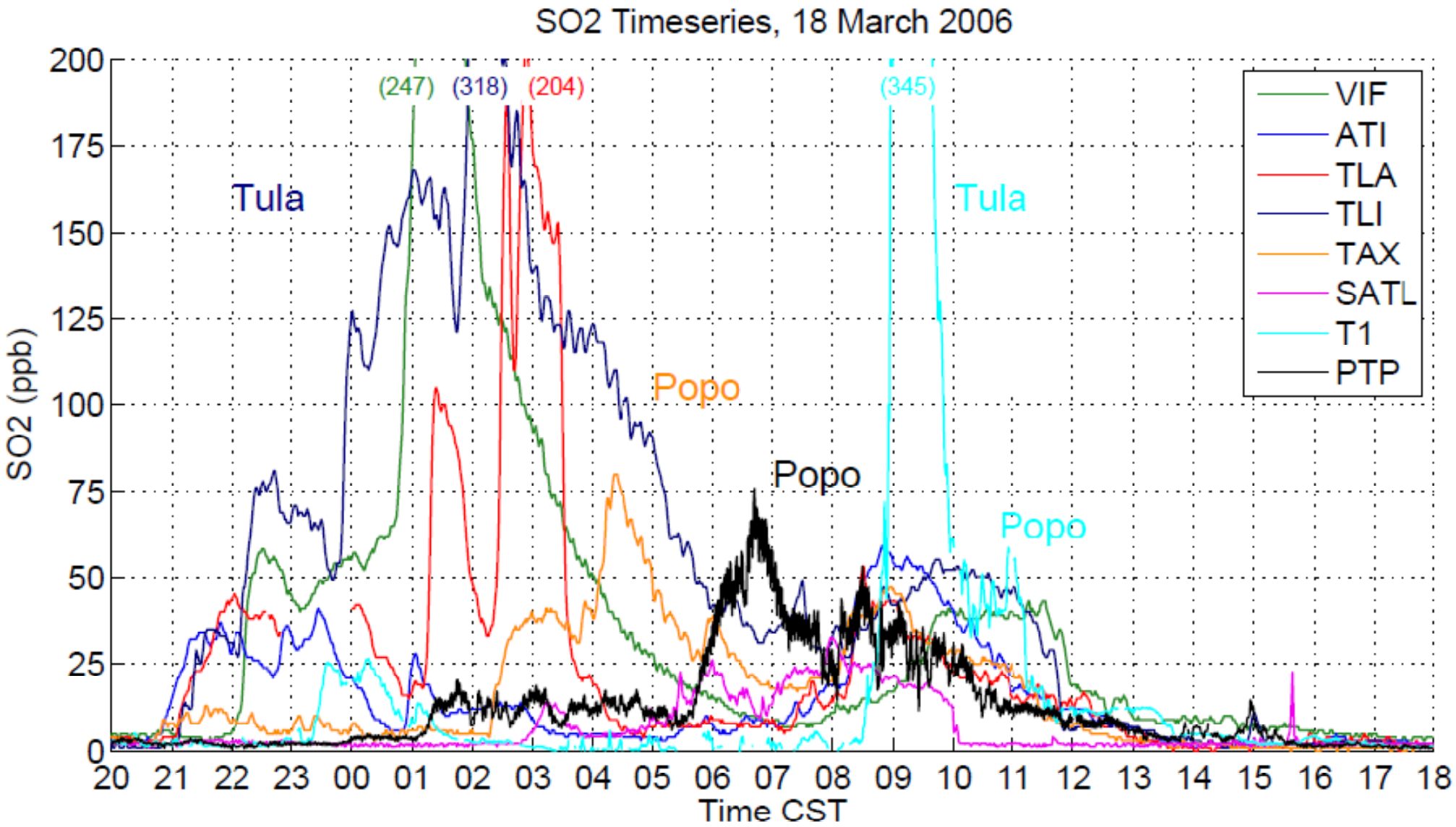
Wind Transport Changes with Height: Radar Wind Profilers



Surface SO2 in Mexico City from Different Sources



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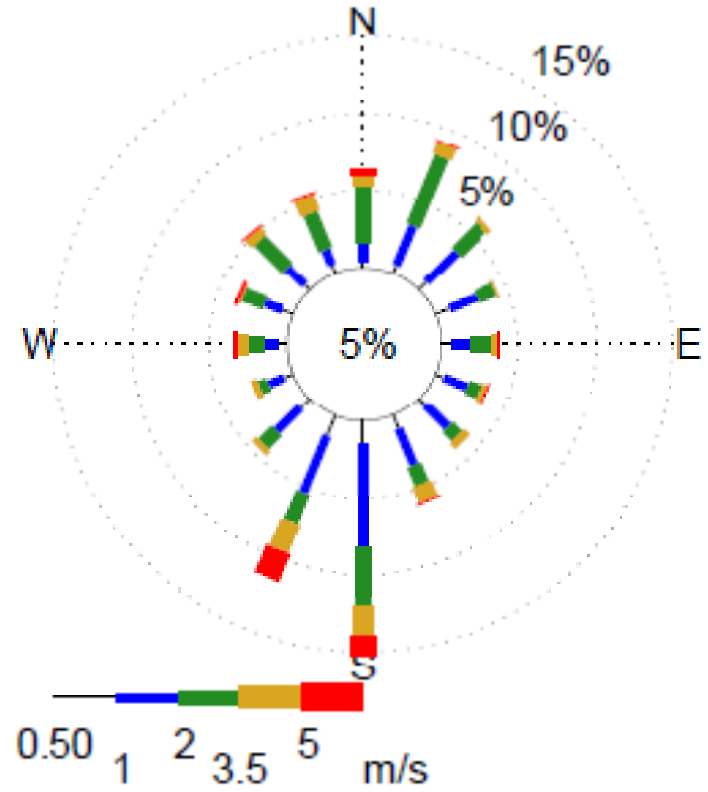
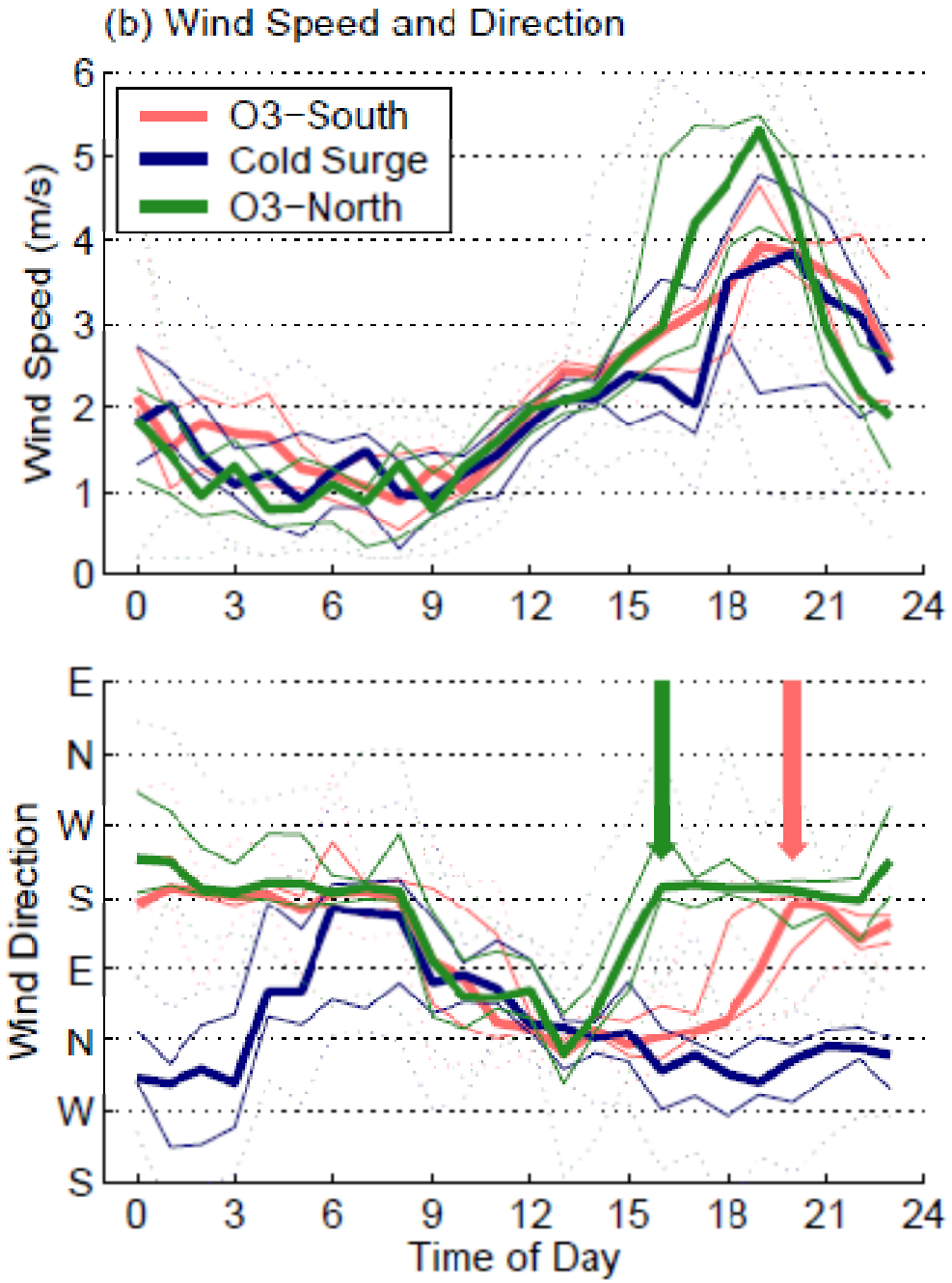
Wind Roses: CENICA during MCMA-2003





de Foy, B., Caetano, E., Magaña, V., Zitácuaro, A., Cárdenas, B., Retama, A., Ramos, R., Molina, L. T., and Molina, M. J.: Mexico City basin wind circulation during the MCMA-2003 field campaign, Atmos. Chem. Phys., 5, 2267-2288, 2005.

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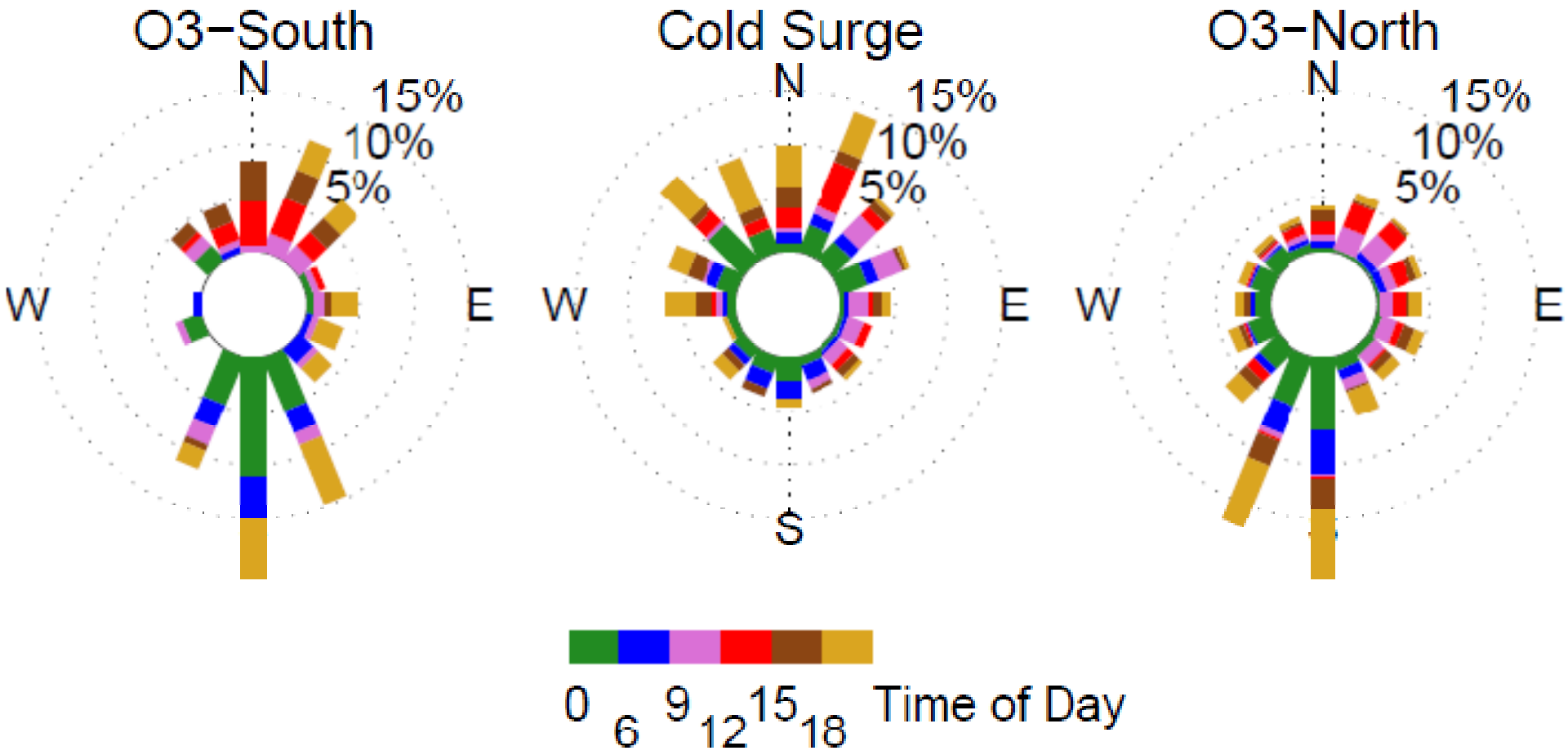

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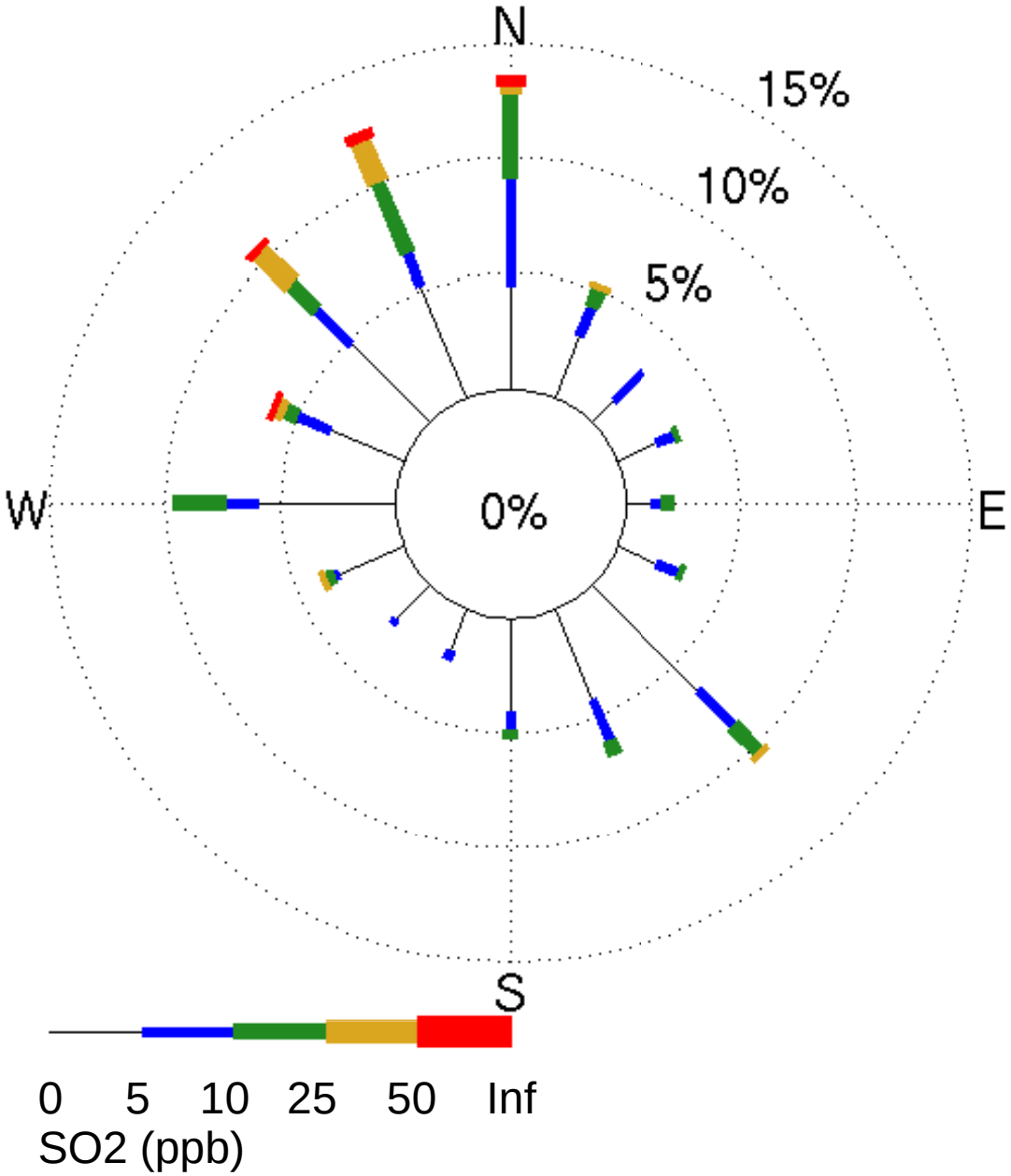
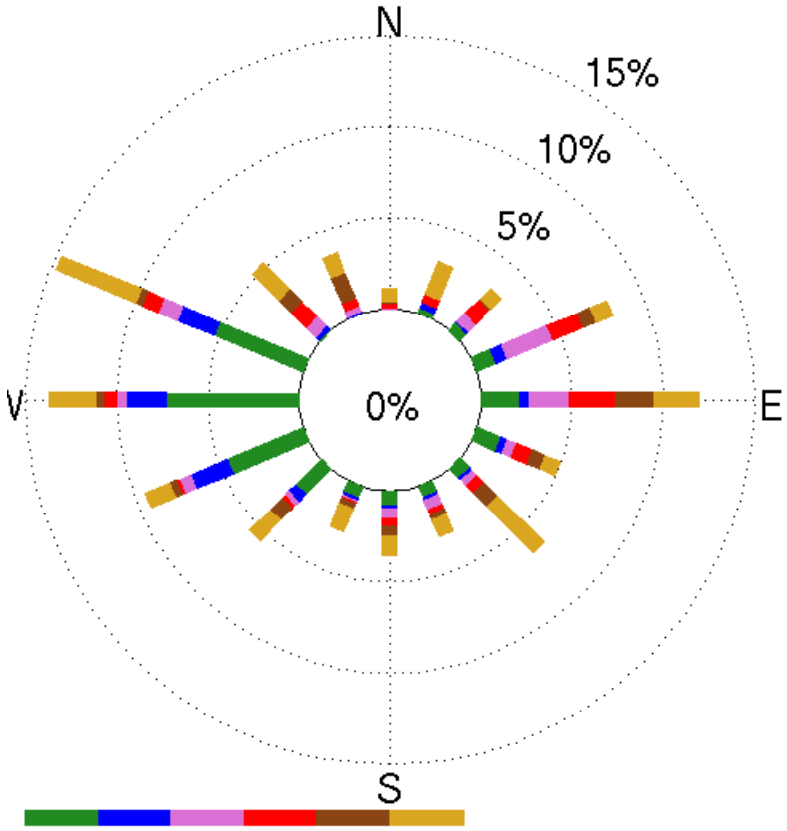
SO2 Rose at Tlanepantla, 10 – 31 March 2006



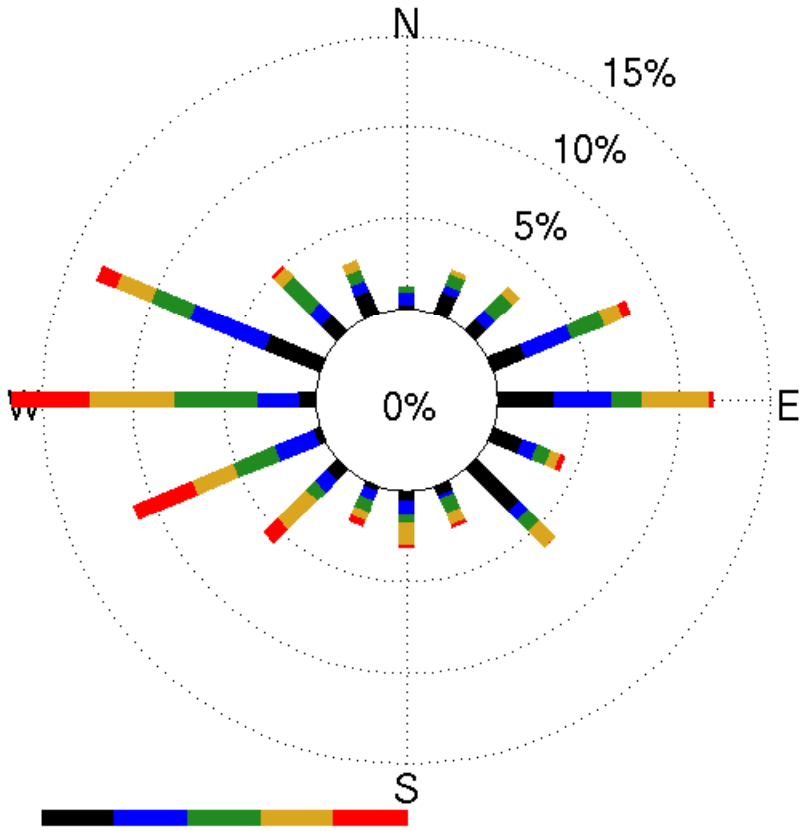
Wind and Pollution Roses

Hr - AMS, Winds: marley t0
10-Mar-2006 11:37:36 - 29-Mar-2006 06:57:44



0 3 9 12 15 18 24
Time of Day

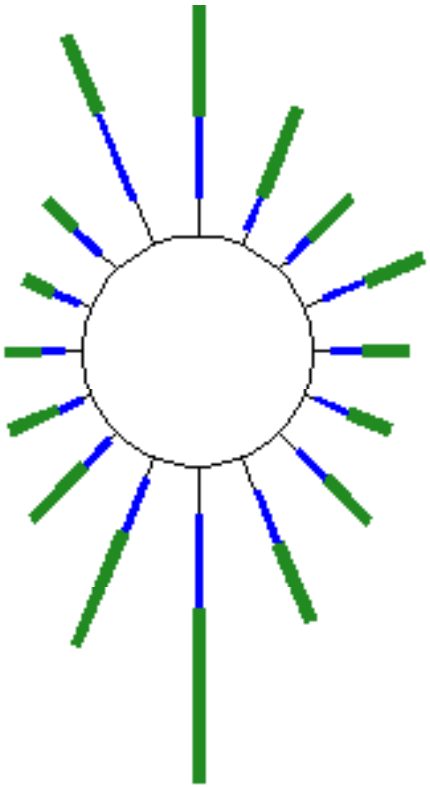
Pb - AMS, Winds: marley t0
10-Mar-2006 10:57:32 - 29-Mar-2006 07:57:36



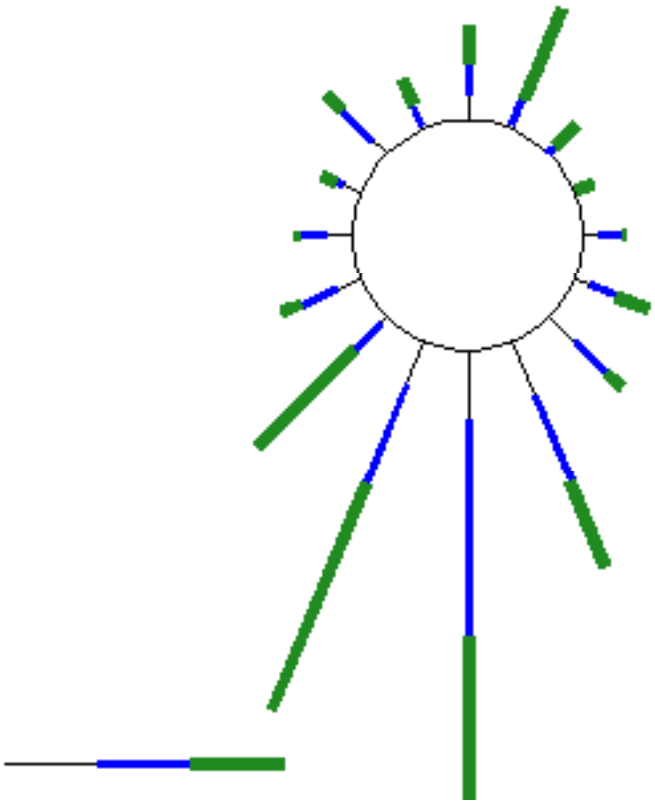
0.08 0.12 0.17 0.33 0.43 Inf
Pb Concentration

AMS Pb Rose with RWP winds by height at T0

Pb 0-0.4



Pb 0.4-2.0



0 – 250 – 500 – 750
M above ground level

Aerosol Mass Spectrometer data at T0, Dara Salcedo, paper in preparation.

Plumas industriales observadas durante MCMA-2003

Análisis de trayectoria en reversa sugieren que la pluma de Vanadio – Nickel – SO_2 se originó del Noroeste.

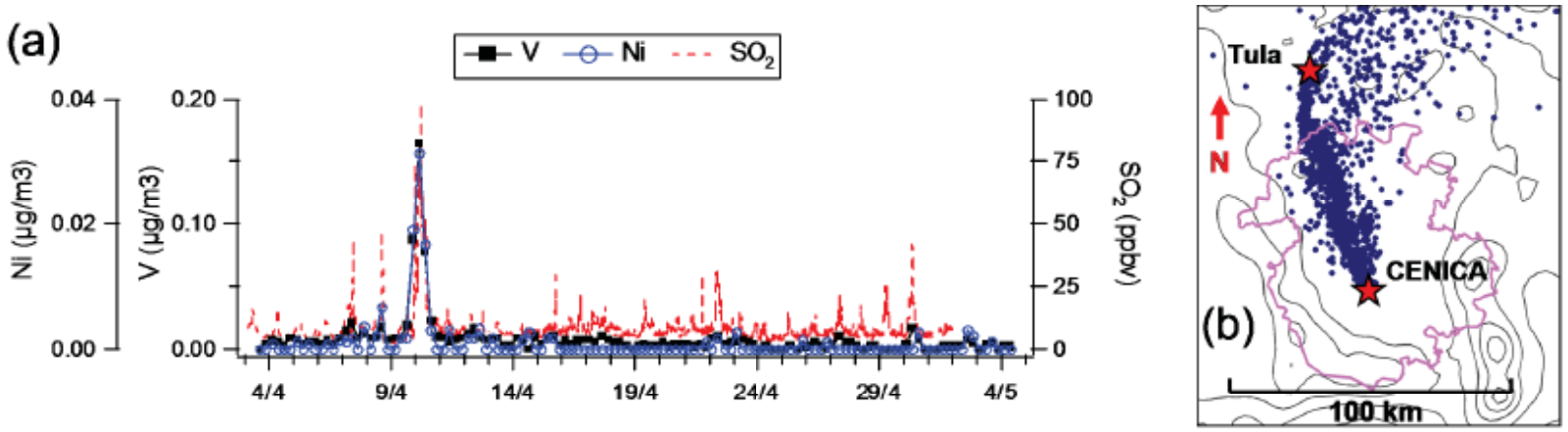


Fig. 3. 10 April emissions: **(a)** time series of fuel oil components V, Ni shown with SO_2 measured at CENICA, and **(b)** particle back trajectory indicating a north/northwest emissions source.

Source: K. S. Johnson et al.: Aerosol composition in MCMA with PIXE/PESA/STIM, ACP 2006

Análisis de campo de concentraciones de SO_2 en VIF y SATL durante MCMA-2003

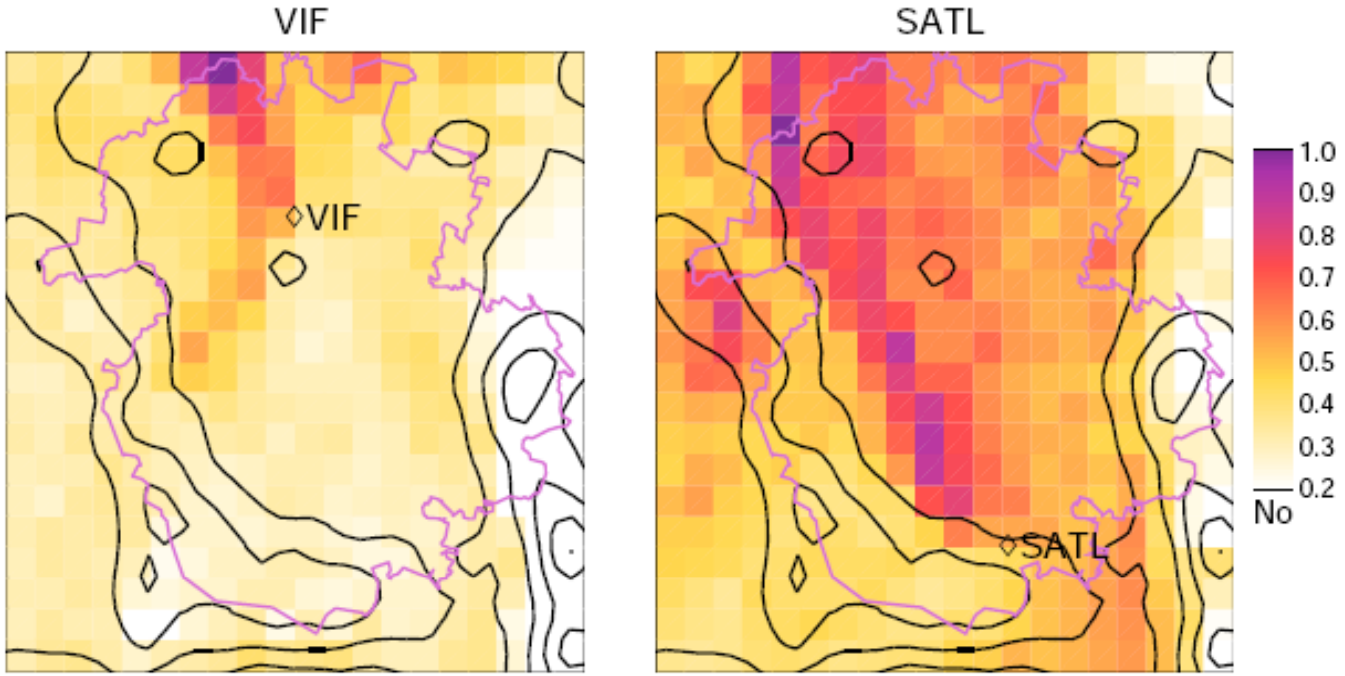
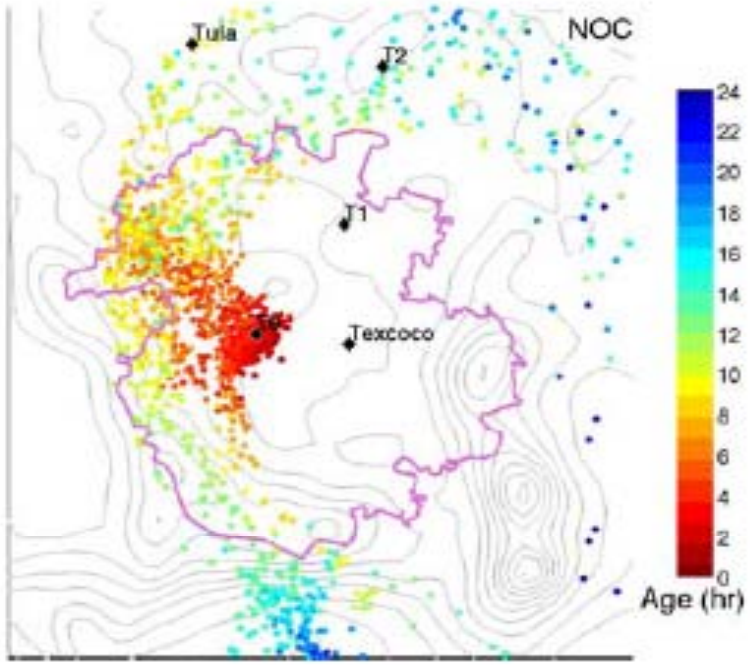


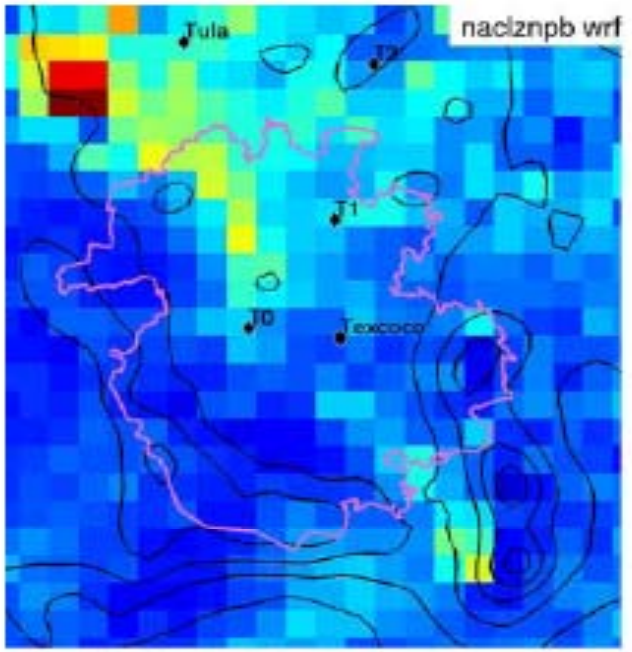
Fig. 14. Concentration Field analysis of SO_2 based on measured concentrations and simulated back-trajectories at VIF (left) and SATL (right) showing possible northwest source region.

Source: B. de Foy et al.: Sources and transport of CO and SO2 in the MCMA, ACP 2007

Mediciones con ATOFMS en T0 durante MILAGRO



Trayectorias en reverso
de pluma NOC



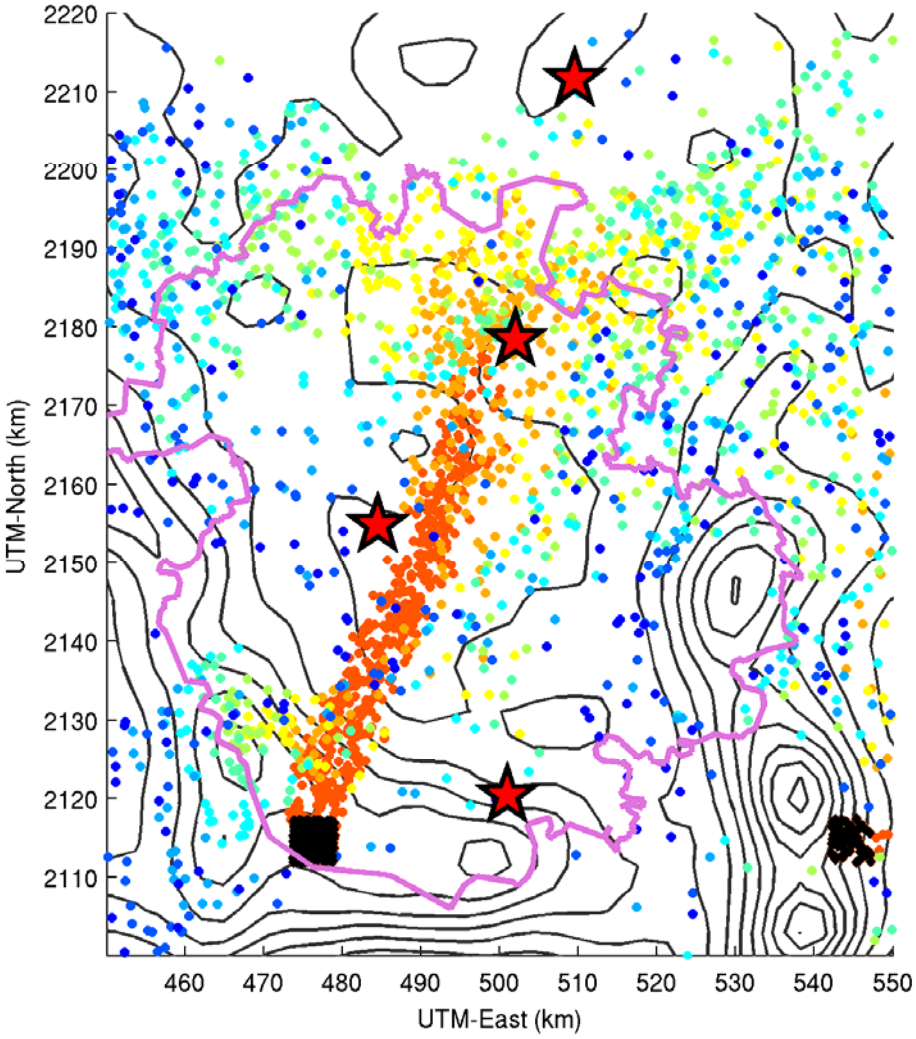
Análisis de Campo de Concentraciones
de partículas PbZn

Fig. 9. Spatial distributions of industrial emissions in Mexico City. **(a)** Particle back-trajectories for a release on 15 March, 08:00–09:00 CST, for a representative nitrogen organic carbon (NOC) peak in the time series. Particle positions are plotted every hour and color indicates age. **(b)** Concentration field analysis for PbZn particles. High non-dimensional number (red) indicates possible source region, low numbers (blue) indicate areas with low or zero emissions.

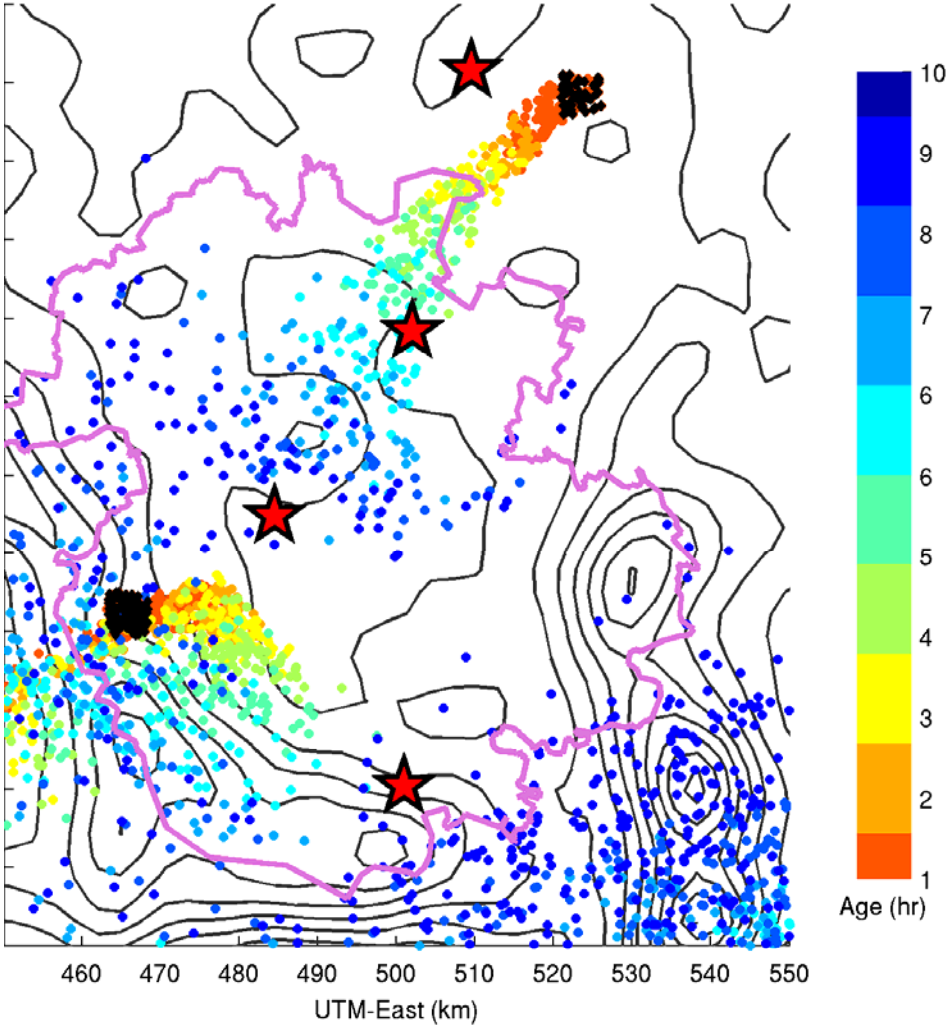
R. C. Moffet et al.: Single particle mass spectrometry on Mexico City aerosols, ACP 2008.

Forward Biomass Burning Trajectories

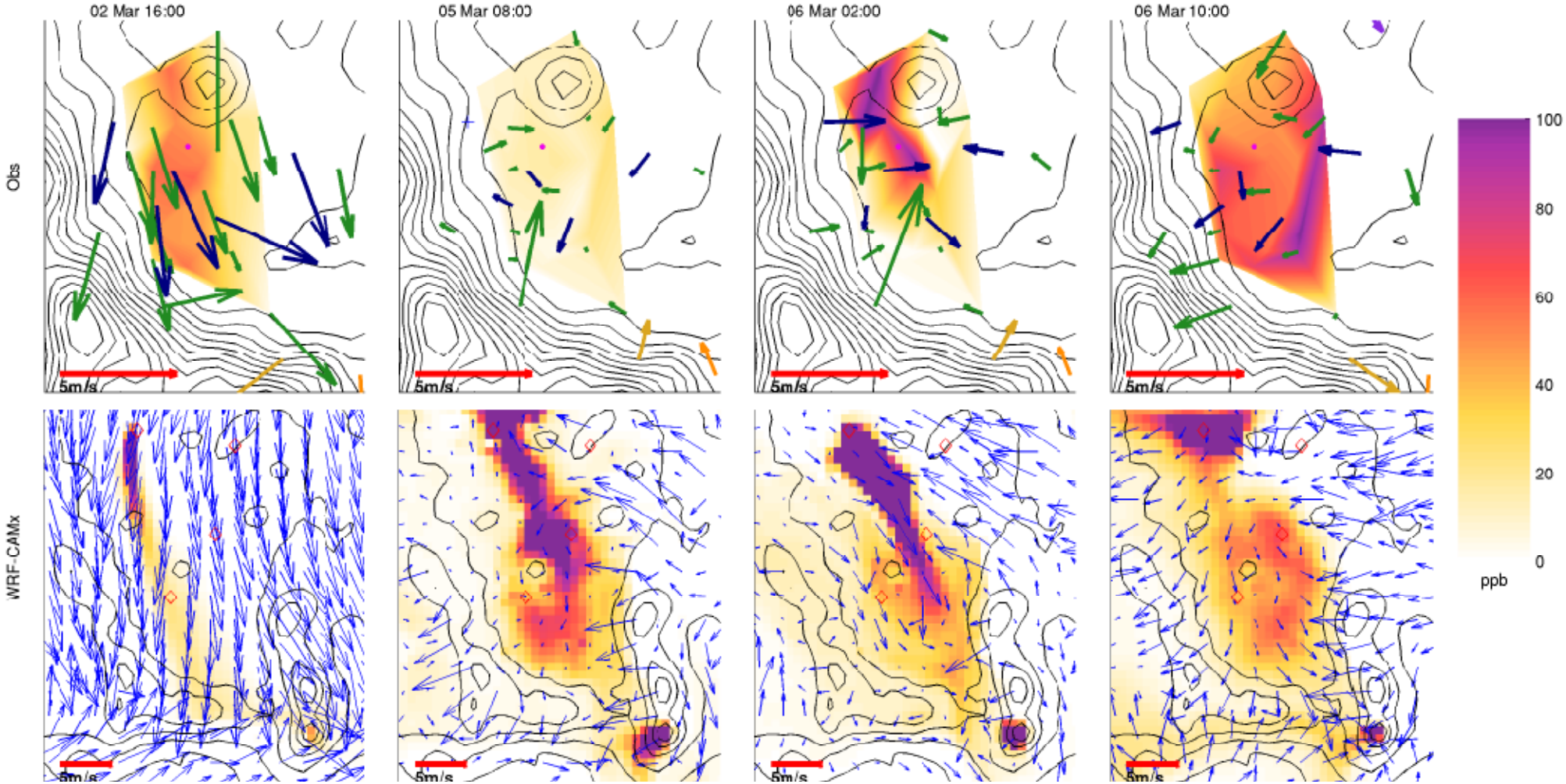
FIRE Forward Traj, 20-Mar-2006 18:00-19:00 CST
144 hr FLEXPART/WRF Simulation, age<=10hr



FIRE Forward Traj, 21-Mar-2006 04:00-05:00 CST
144 hr FLEXPART/WRF Simulation, age<=10hr



Grid Modeling



de Foy, B., Bei, N., Herndon, S. C., Huey, L. G., Martínez, A.-P., Ruiz-Suárez, L. G., Wood, E. C., Zavala, M., and Molina, L. T.: Hit from both sides: tracking industrial and volcanic plumes in Mexico City with surface measurements and OMI SO2 retrievals during the MILAGRO field campaign, Atmos. Chem. Phys. Discuss., 9, 16563-16605, 2009.

Conclusions

There's no proof in this business, so the more evidence the better

There's no short cut to detailed analysis

- Wind vector analysis:
  - Surface winds
  - Radar wind profilers
  - Wind and pollution roses

Models as a tool to help understand measurements

- Particle trajectory modeling (Lagrangian)
  - Back-trajectories
  - Concentration Field Analysis
  - Forward trajectories
- Grid modeling (Eulerian)