

MIRAGE C-130

summary of operations



The MIRAGE airborne division
The C-130 crew and support team
The MILAGRO project

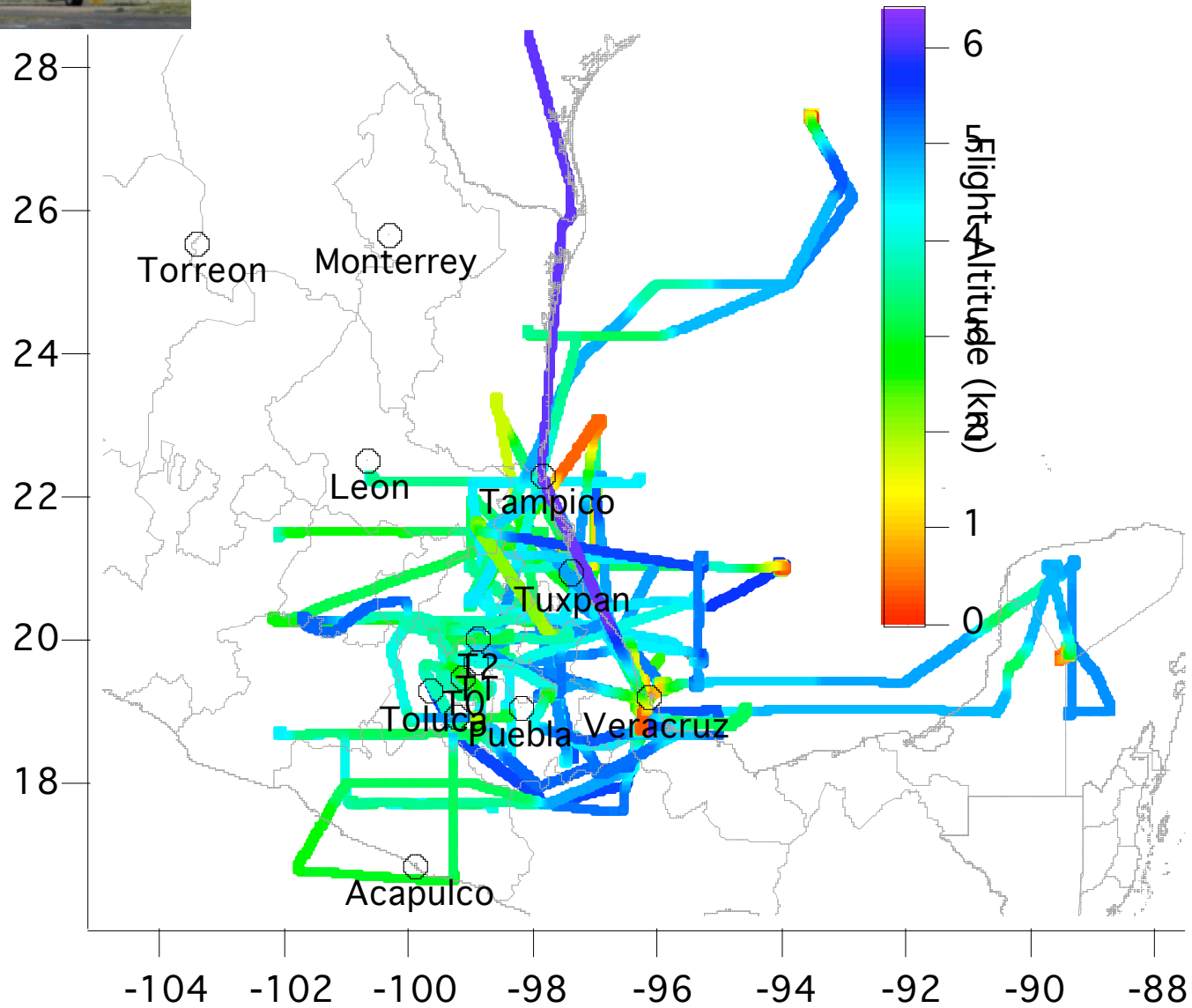


Photo: DC-8





C-130 Flights – overview





C-130 Flights – overview

MILAGRO

Megacity Initiative - Local and Global Research Observations

MIRAGE-Mex

MAX-Mex

MCMA

INTEX-B





C-130 Research Flight summary

- **successful campaign**
- **12 flights while on station (+ two transits)**
- **5400 minutes**
 - 1000 min < 100 km of MEX
 - 2000 min 100-250 km
 - 1600 min 250-500 km
 - 600 min > 500 km



C-130 Research Flight summary

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- **5400 minutes**
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 - 600 min > 500 km
- **already have 5 science highlights**



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- **already have 5 science highlights**
- **23,200 C-130 frequent flyer miles**
INTEX miles don't count and
MIRAGE miles expire 12/31/2006



C-130 Measurements

- Gas phase:

- » CO, CO₂
- » O₃, NO, NO₂, NO_y
- » PANs
- » SO₂
- » OH, H₂SO₄, MSA
- » HO₂, RO₂
- » HNO₃
- » CH₂O
- » H₂O₂, CH₃OOH, HOCH₂OOH, HCN, SO₂, HNO₃, ...
- » VOC, tracers (TOGA)
- » VOC, aromatics, tracers (PTR-MS)
- » NMHC, tracers (WAS)



C-130 Measurements

- Particle phase:

- » Soot Sampler

- » Aerosol Phys. + Optical Properties

- » Aerosol Hygroscopicity + Volatility

- » AMS

- » SP2

- » CNC, Filters (functional grps)

- » PILS liquid sampler

- » SABL (remote aerosol)

Buseck / AZ State U

Clarke / UHI

Collins / Tex A&M

Jimenez / U of C

Kok / Droplet Meas.

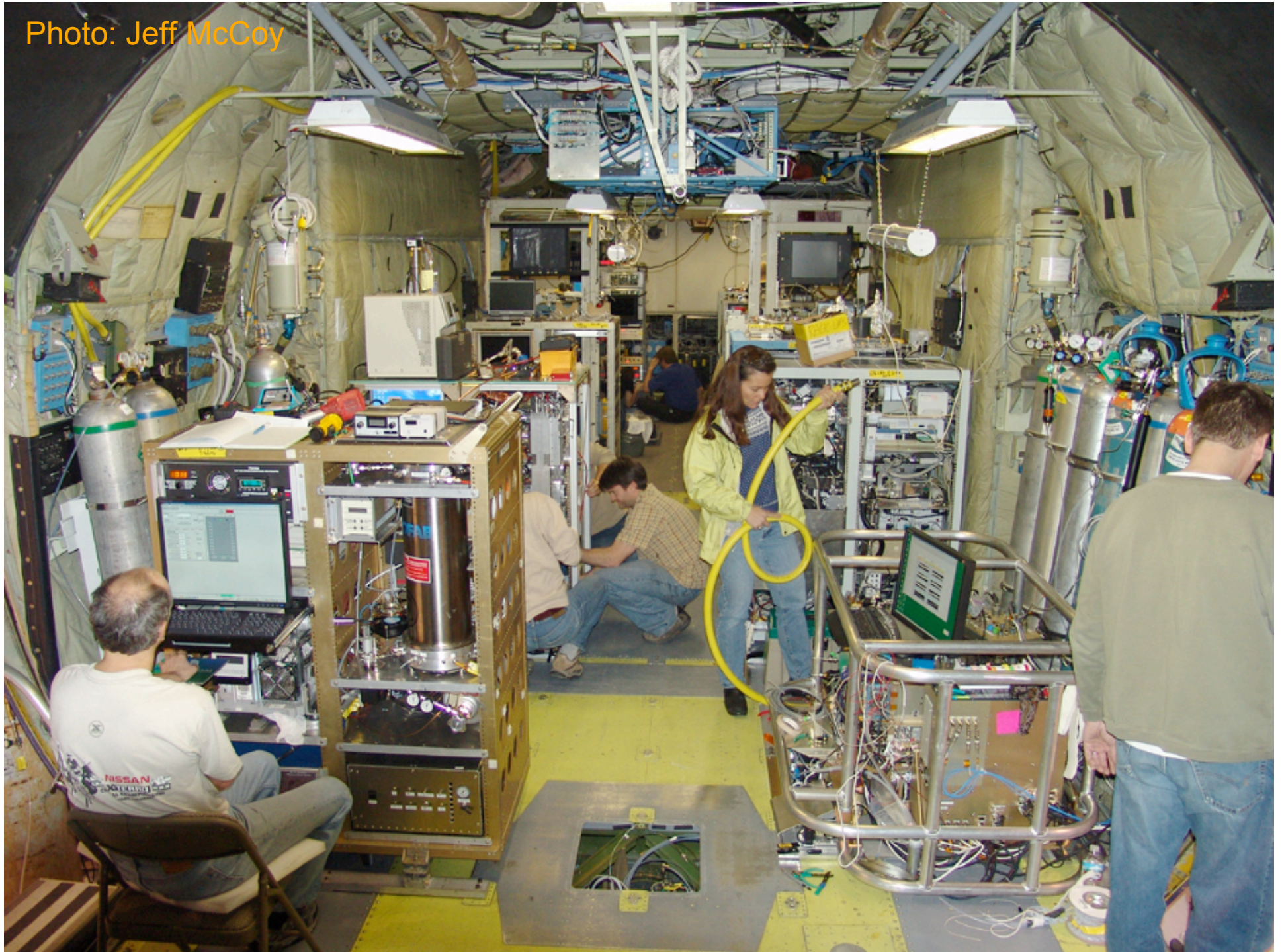
Baumgardner / UNAM

Russell / UCSD

Weber / GaTech

Morley

Photo: Jeff McCoy





C-130 Measurements

- large data set
- lots of exciting results
- touching all science objectives

- controversies

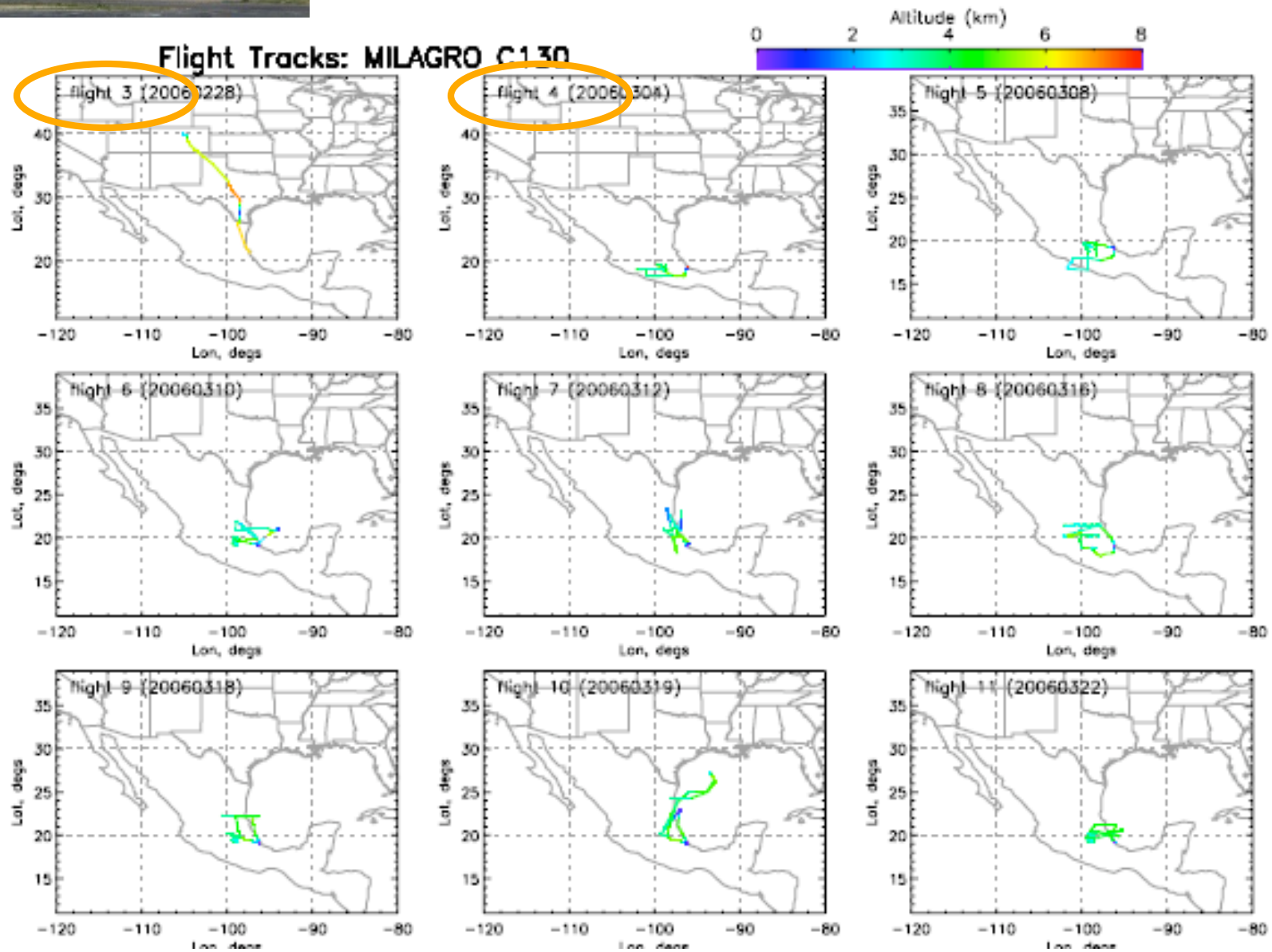


C-130 Measurements

Flight Numbering



C-130 Flight Numbering "System"





C-130 Flight Numbering “System”

NCAR/EOL Mirage Flight Tracks

Browse 2D Flight Tracks : [Google Map Flight Tracks](#)

For Windows XP users who have downloaded GoogleEarth from <http://www.earth.google.com>

Google Earth 3D Flight Tracks ("Save Link Target As..." and then open with GoogleEarth):

[Mirage Ferry 1](#)

[Mirage Ferry 2](#)

[Mirage Flight 1](#)

[Mirage Flight 2](#)

[Mirage Flight 3](#)

[Mirage Flight 4](#)

[Mirage Flight 5](#)

[Mirage Flight 6](#)

[Mirage Flight 7](#)

[Mirage Flight 8](#)

[Mirage Flight 9](#)

[Mirage Flight 10](#)

[Mirage Flight 11](#)

[Mirage Flight 12](#)



C-130 Flight Numbering “System”

NCAR/EOL Mirage Flight Tracks

Browse 2D Flight Tracks : [Google Map Flight Tracks](#)

For Windows XP users who have downloaded GoogleEarth from <http://www.earth.google.com>

Google Earth 3D Flight Tracks ("Save Link Target As..." and then open with GoogleEarth):

Mirage Ferry 1	1	2/28
Mirage Ferry 2	14	3/31
Mirage Flight 1	2	3/4
Mirage Flight 2	3	3/8
Mirage Flight 3	4	3/10
Mirage Flight 4	5	3/12
Mirage Flight 5	6	3/16
Mirage Flight 6	7	3/18
Mirage Flight 7	8	3/19
Mirage Flight 8	9	3/22
Mirage Flight 9	10	3/23
Mirage Flight 10	11	3/26
Mirage Flight 11	12	3/28
Mirage Flight 12	13	3/29



C-130 Flight Numbering “System”

**Please refer to flights with their
respective flight dates**

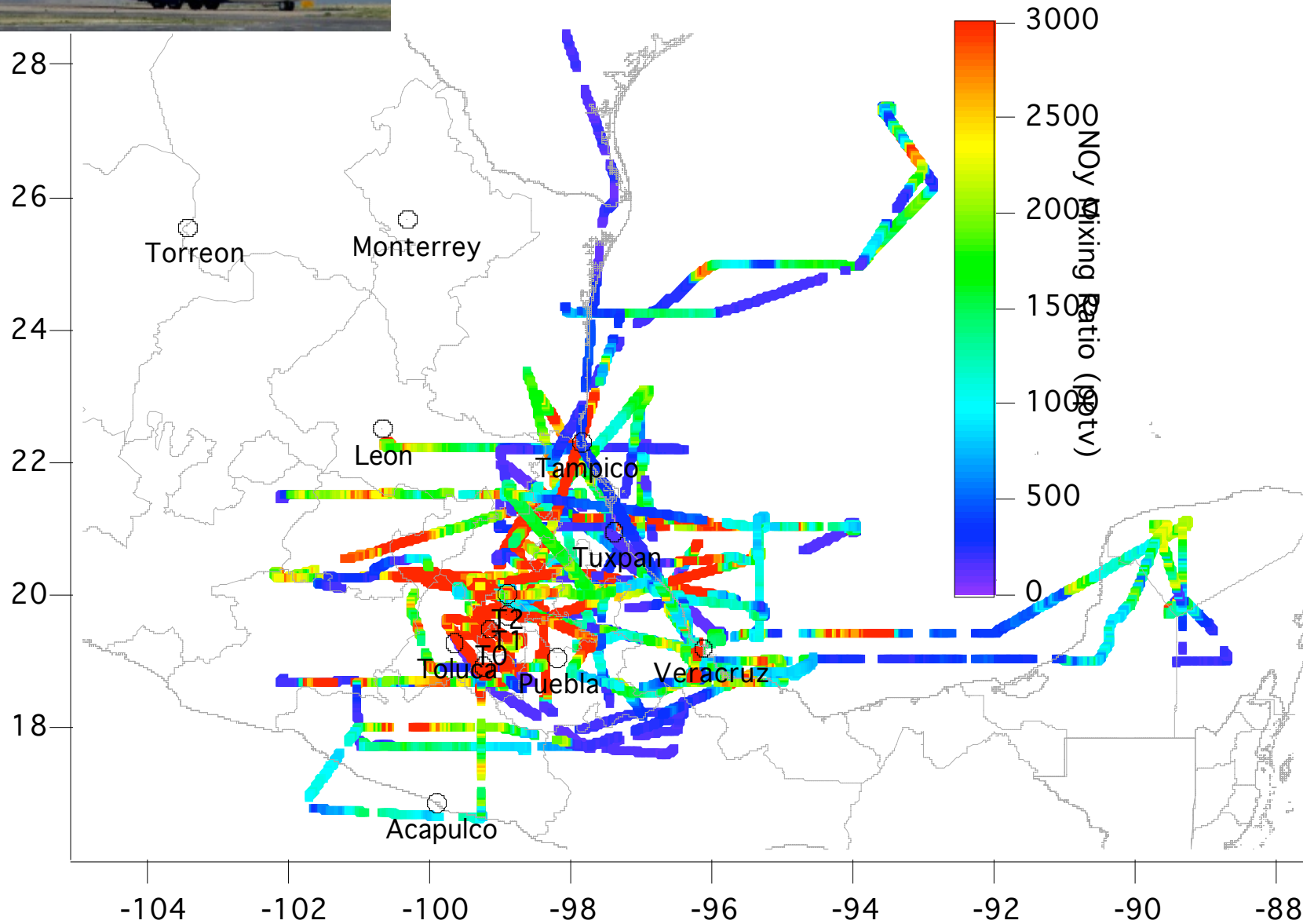
“20060319 flight”

“3/19 flight”

....



C-130 Flights – overview



MCMA Plume persistence

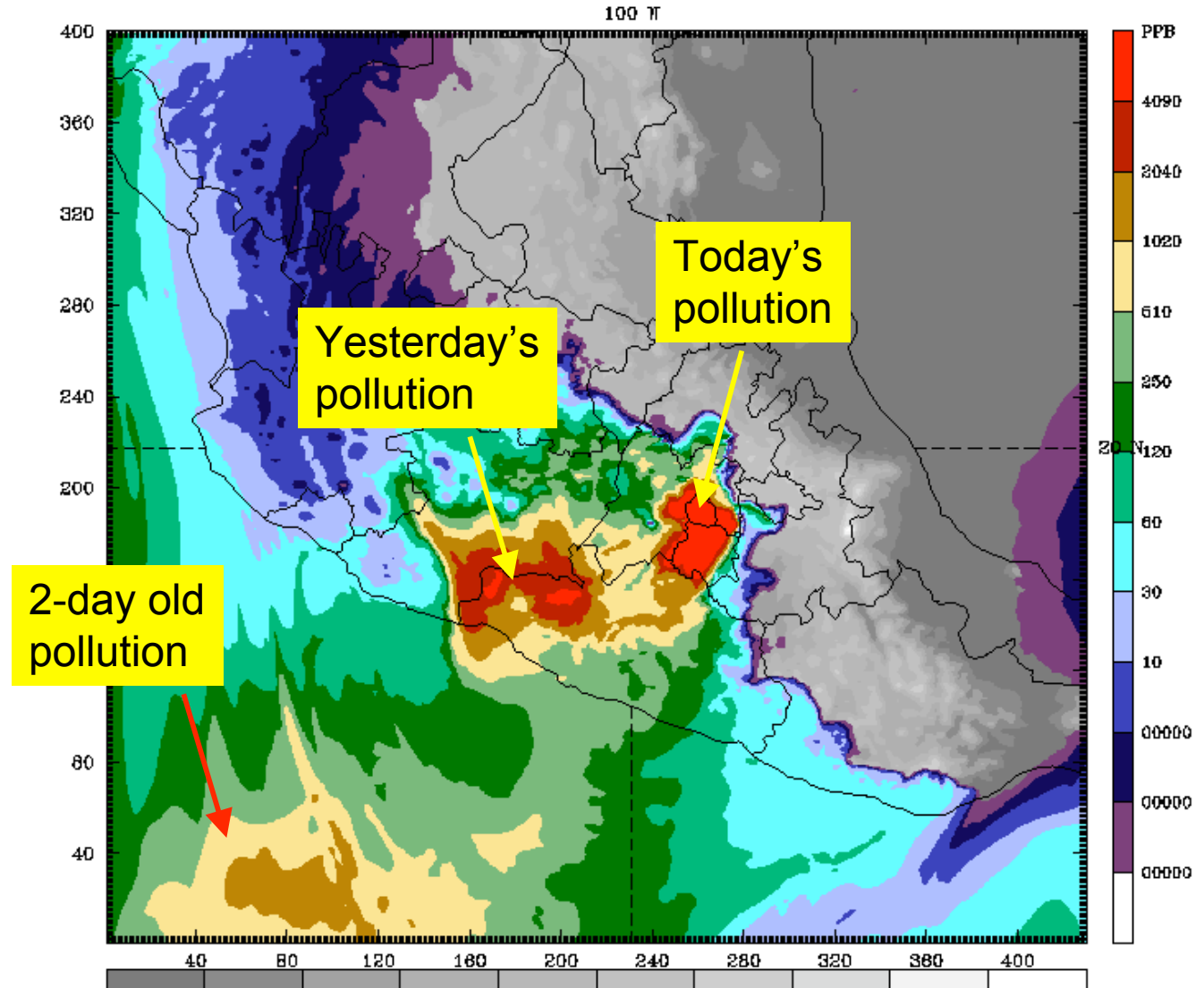
- DC-8: on average unlikely encounter
- BB plumes may dominate Gulf area
- C-130: when “hunted” certainly easy to find even 2 days downwind
- very persistent under stagnant conditions
- visible plume even 2 days downwind



C-130 Flights – 3/4/06

Dataset: dom2 RIP: dom2
Fest: 45.00 h
Terrain height AMSL
Mass weighted c5 integral

Init: 0000 UTC Fri 03 Mar 06
Valid: 2100 UTC Sat 04 Mar 06 (1400 MST Sat 04 Mar 06)





C-130 Flights – 3/4/06

Dataset: 20060304 RIP: 20060304

Init: 0000 UTC Sat 04 Mar 06

Fest: 21.00 h

Valid: 2100 UTC Sat 04 Mar 06 (1400 MST Sat 04 Mar 06)

Terrain height AMSL

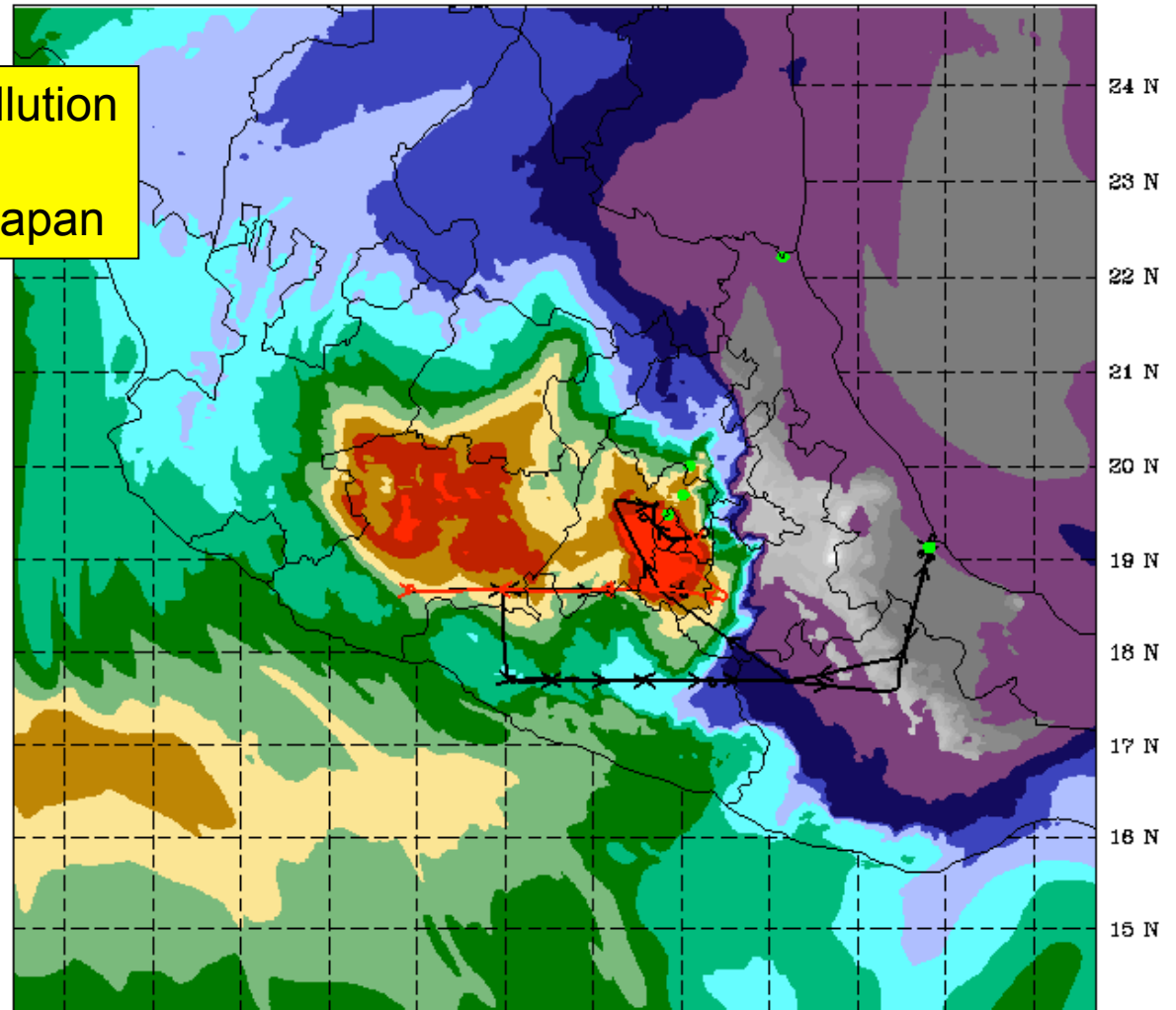
Mass weighted c5 integral

Trajectories from hour 18.333 to 25.833

Trajectories from hour 20.500 to 21.500

106 W 105 W 104 W 103 W 102 W 101 W 100 W 99 W 98 W 97 W 96 W 95 W

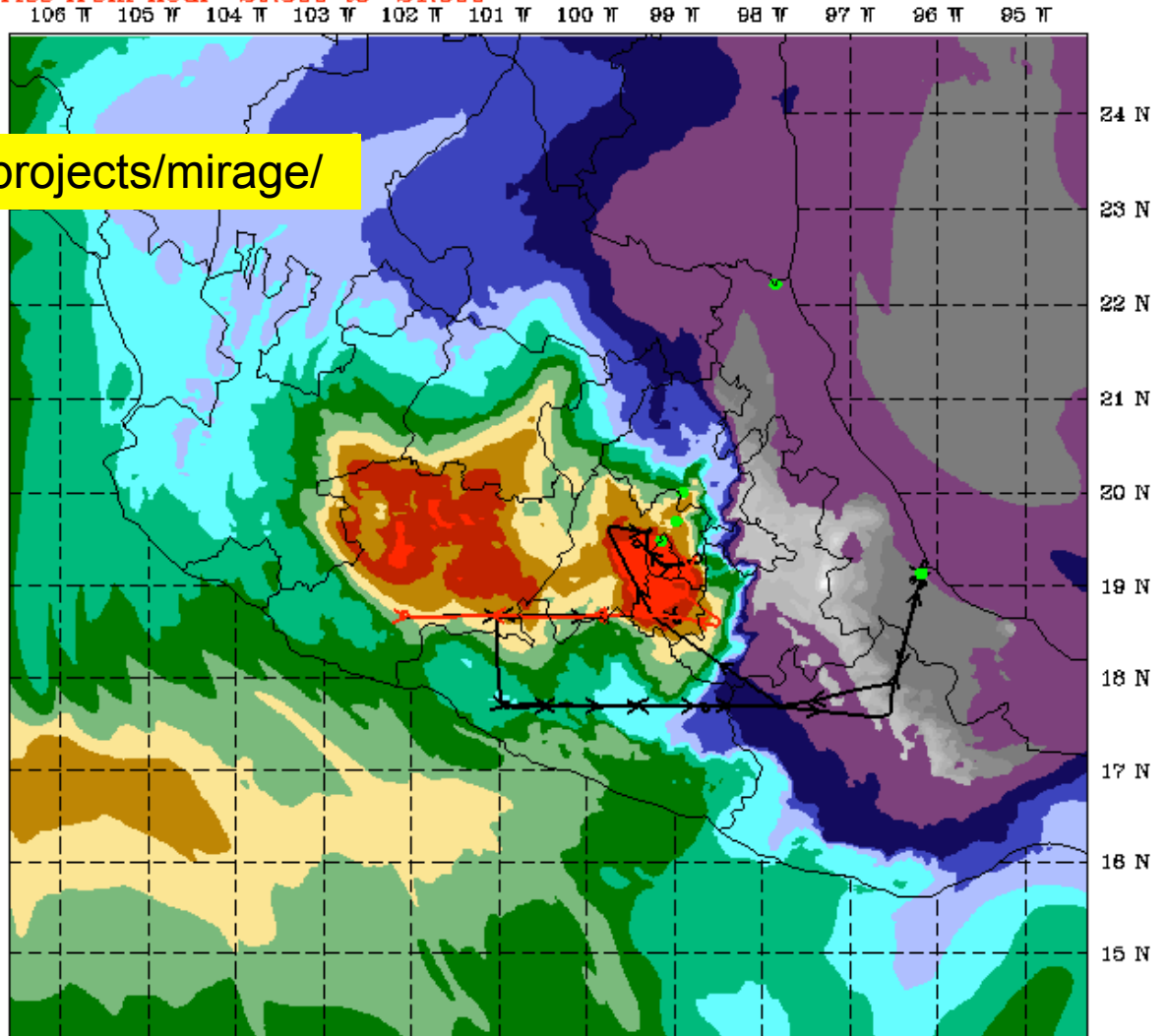
- observed previous day's pollution
- did our first city run
- including low pass over Atizapan





C-130 Flights – 3/4/06

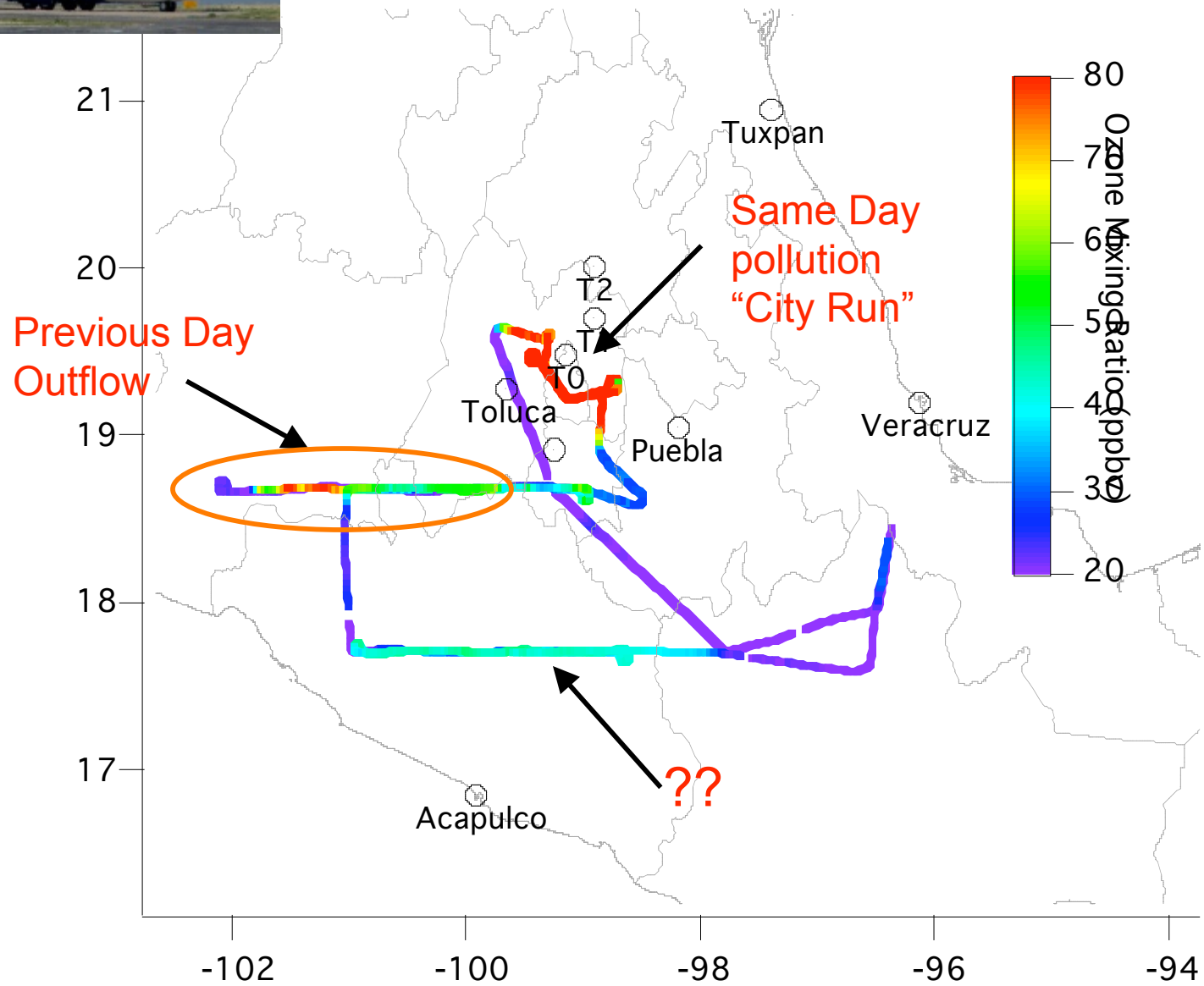
Dataset: 20060304 RIP: 20060304 Init: 0000 UTC Sat 04 Mar 06
Fest: 21.00 h Valid: 2100 UTC Sat 04 Mar 06 (1400 MST Sat 04 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 18.333 to 25.833
Trajectories from hour 20.500 to 21.500



<http://box.mmm.ucar.edu/projects/mirage/>

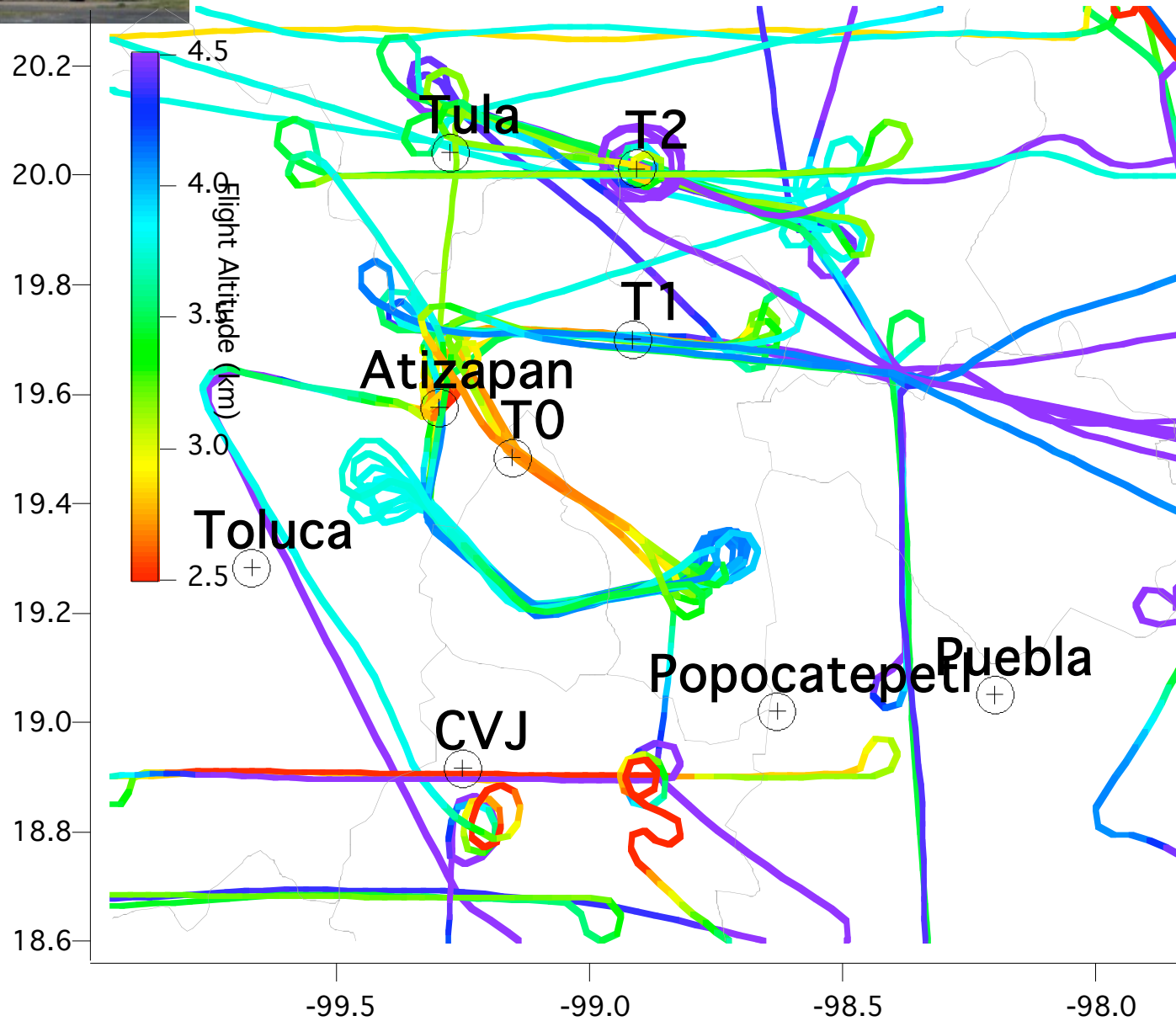


C-130 Flights – 3/4/06





C-130 Flights – MCMA





C-130 Flights – MCMA

Flights including a “city run”:

20060304

20060308 (T0,T1)

20060310 (T0,1,2)

20060318 (T0,1,2)

20060322 (T0,1,2)

20060329 (T0,1,2)

each flight listed above included a missed approach on Atizapan airport

T 1 or T2 overflights only:

20060319 (T2)

20060326 (T-2 spiral)

For ATC reasons, altitudes for overflights were restricted to

- 9000 feet for T-0 (only approved altitude),
- 10500 feet (minimum) for T1,2



Photo: Sasha M.



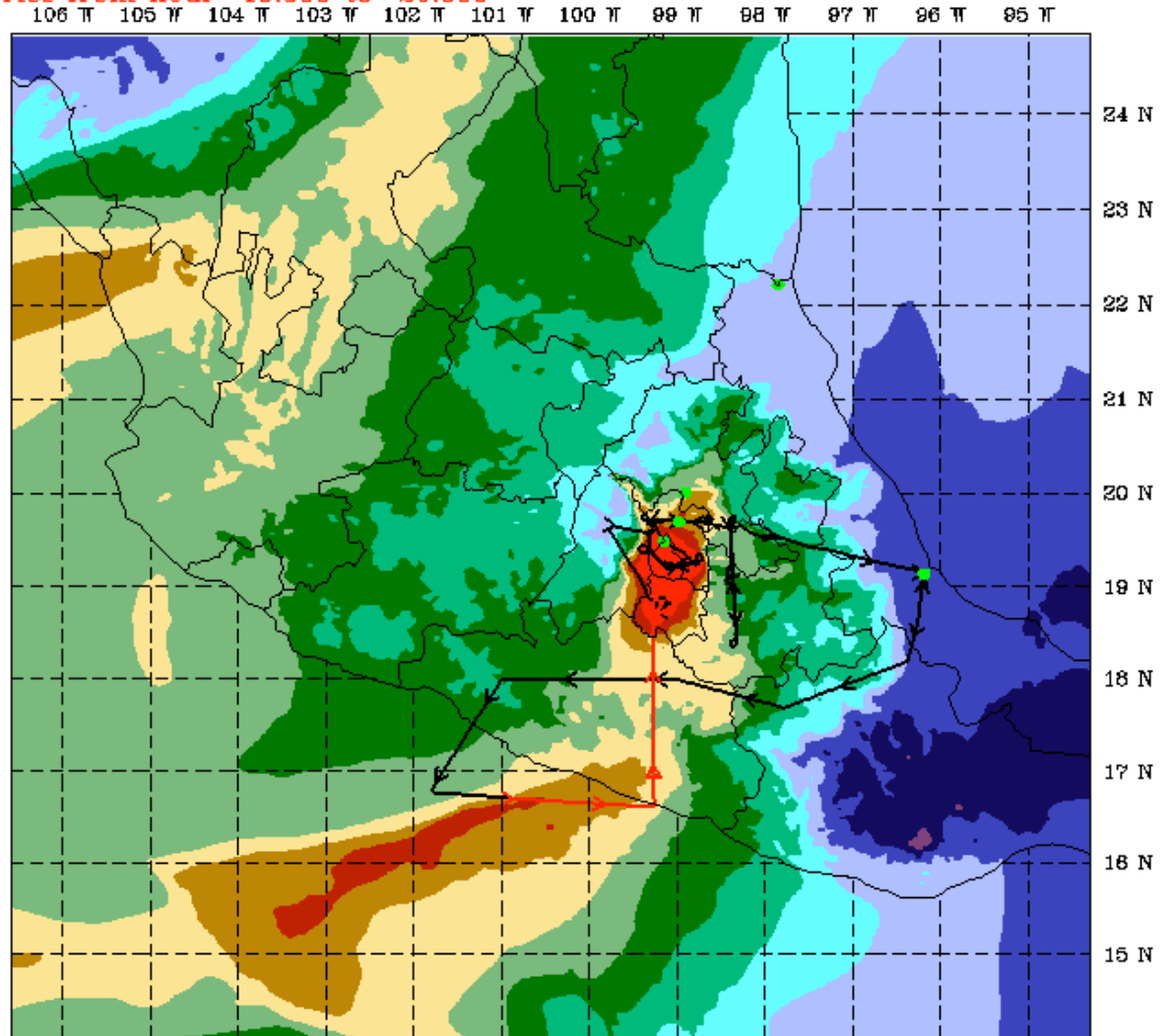
The BB contribution to MCMA pollution

- Crouse et al: large fraction
- Apel et al: small fraction
- Vay et al (DC-8) large fraction?
- PILS data: small fraction?
- PAN data: small fraction?
- Pico de los Padres: large fraction...
- Junkermann: large fraction in SE



C-130 Flights – 3/8/06

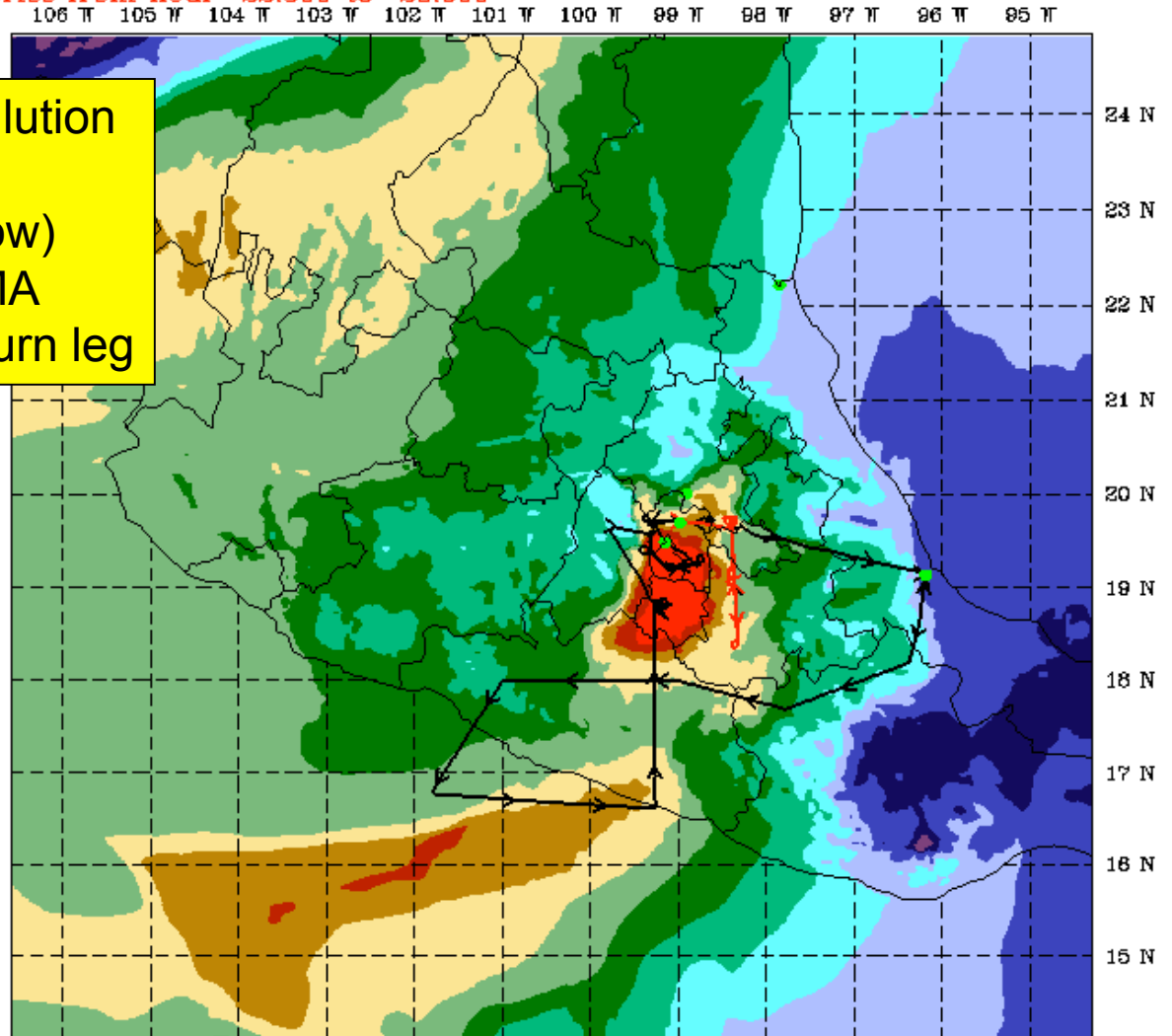
Dataset: 20060308 RIP: 20060308 Init: 0000 UTC Wed 08 Mar 06
Fest: 20.00 h Valid: 2000 UTC Wed 08 Mar 06 (1300 MST Wed 08 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 17.500 to 24.400
Trajectories from hour 19.500 to 20.500





C-130 Flights – 3/8/06

Dataset: 20060308 RIP: 20060308 Init: 0000 UTC Wed 08 Mar 06
Fest: 23.00 h Valid: 2300 UTC Wed 08 Mar 06 (1600 MST Wed 08 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 17.500 to 24.400
Trajectories from hour 22.500 to 23.500



- observed previous day's pollution
- city run with T-0 overpass
- spiral over CVJ ("gap" outflow)
- same day outflow E of MCMA
- elevated background on return leg



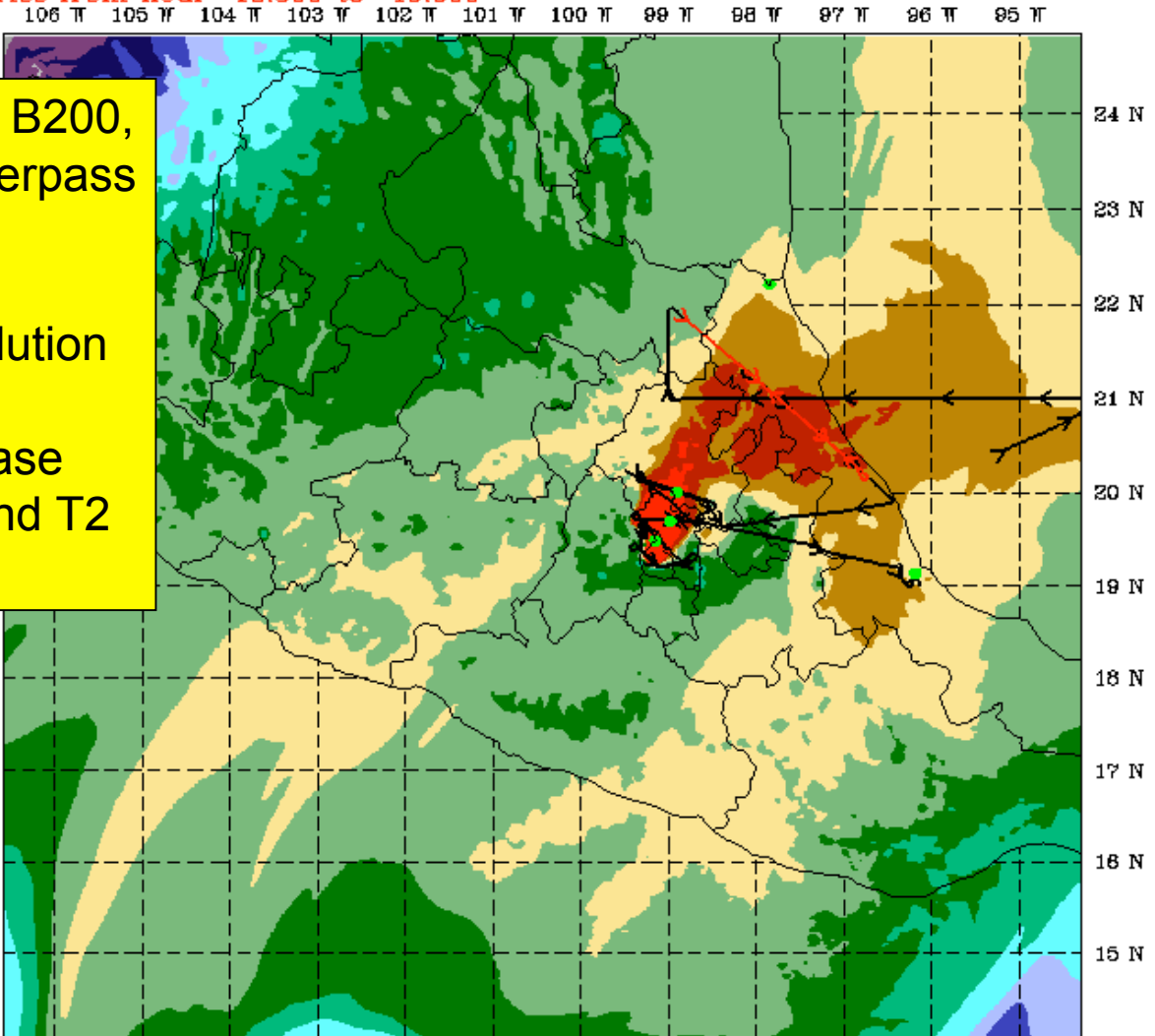
Aerosols

- large particle numbers in MCMA
- persistent large numbers 1-2 days downwind
- particles grow, change optical properties
- particles seem to accumulate organics?
- particles become more hygroscopic



C-130 Flights – 3/10/06

Dataset: 20060310 RIP: 20060310 Init: 0000 UTC Fri 10 Mar 06
Fest: 19.00 h Valid: 1900 UTC Fri 10 Mar 06 (1200 MST Fri 10 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 16.333 to 23.878
Trajectories from hour 18.500 to 19.500



- coordinated spiral with J-31, B200, MISR overpass
- radiation closure attempt
- observed previous day's pollution
- city run with T-0 overpass
- first "classic" NE transport case
- same day outflow over T1 and T2
- PBL at 16 kft N of MCMA

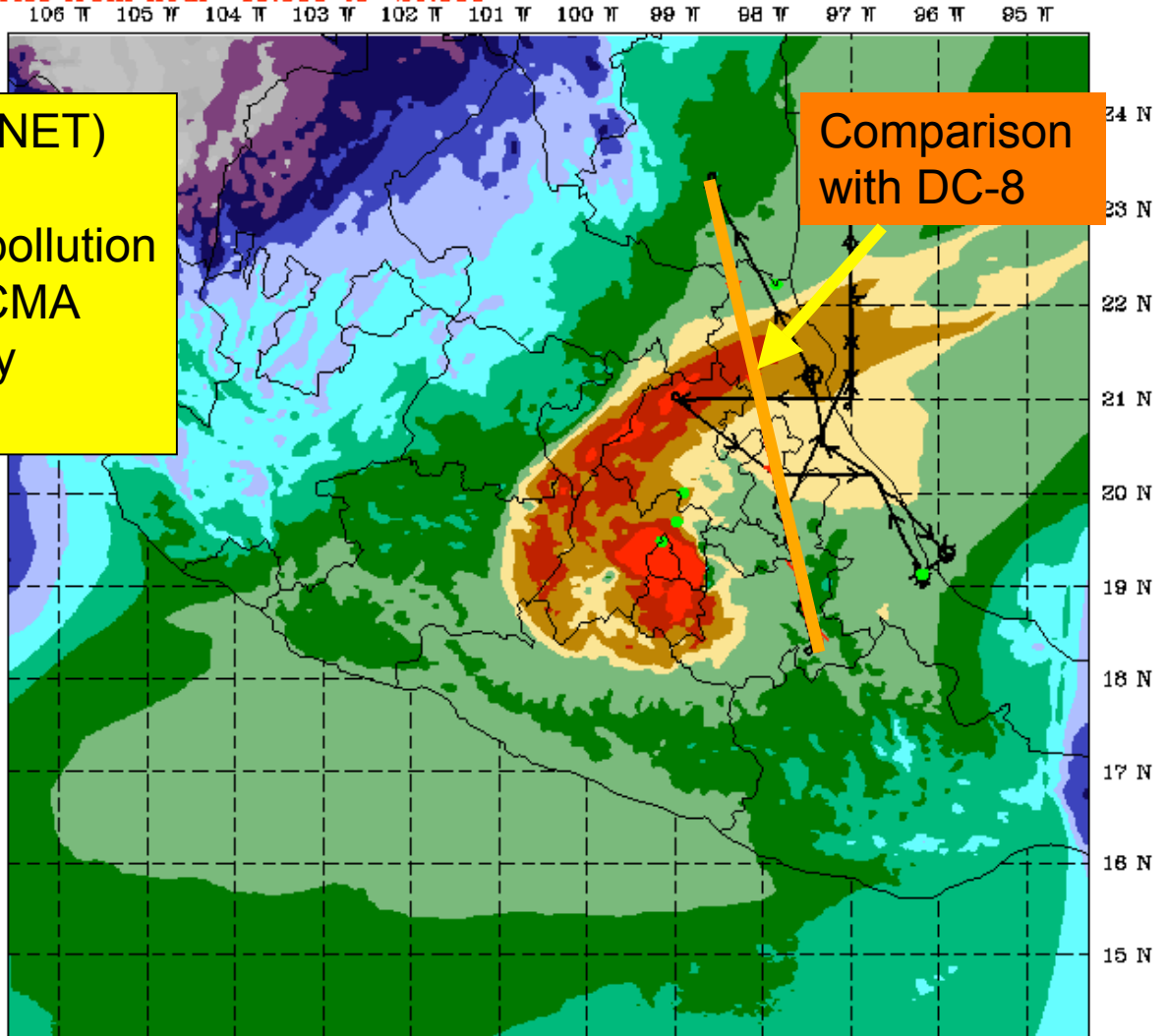






C-130 Flights – 3/12/06

Dataset: 20060312 RIP: 20060312 Init: 0000 UTC Sun 12 Mar 06
Fest: 20.00 h Valid: 2000 UTC Sun 12 Mar 06 (1300 MST Sun 12 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 17.433 to 25.600
Trajectories from hour 19.500 to 20.500



- spiral over Tamihua (AERONET)
- first comparison with DC-8
 - some gradients but weak pollution
- prev day's pollution N of MCMA
- strong dust(?) layer E of City
- spiral off coast near VER

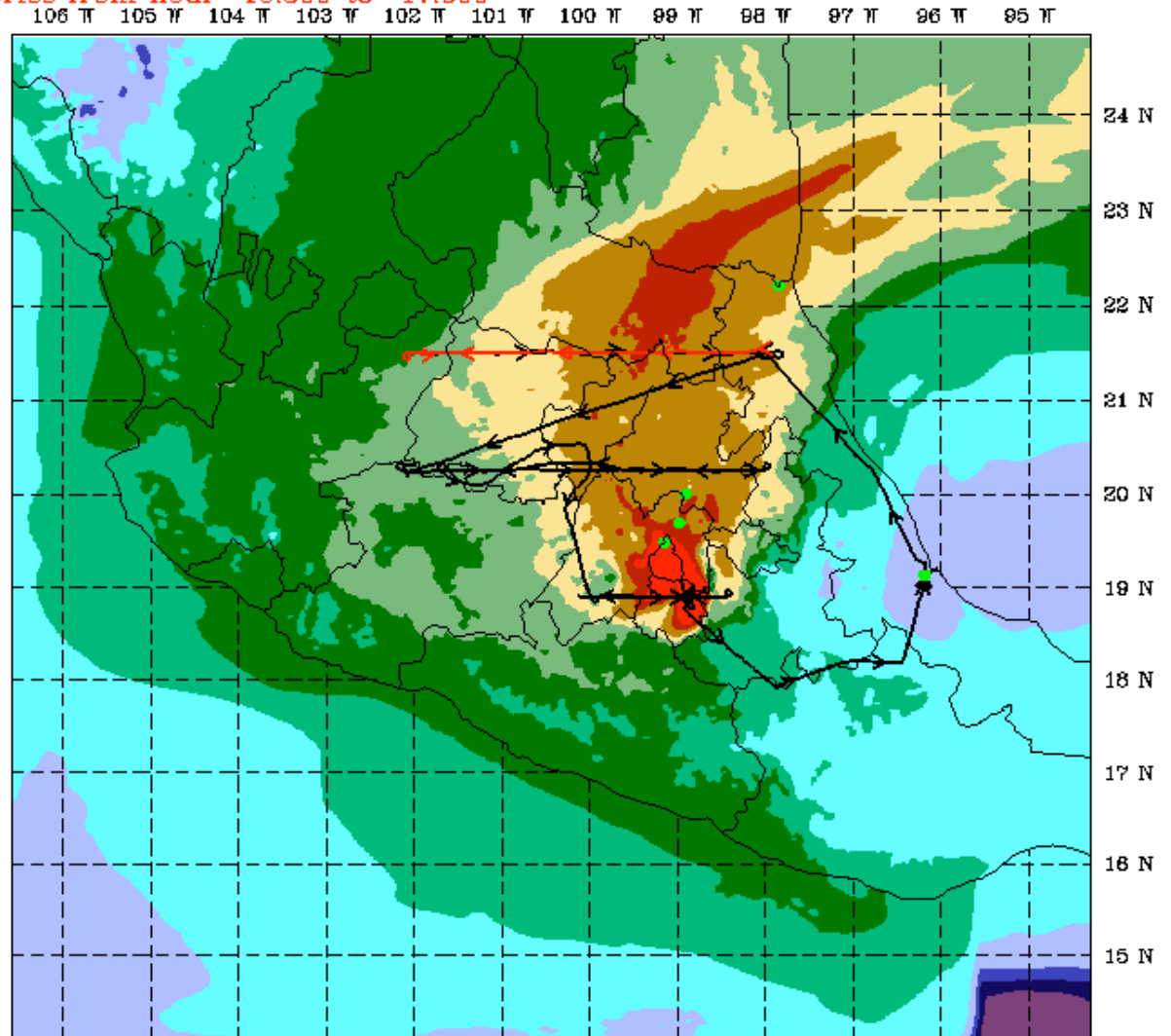
Comparison with DC-8





C-130 Flights – 3/16/06

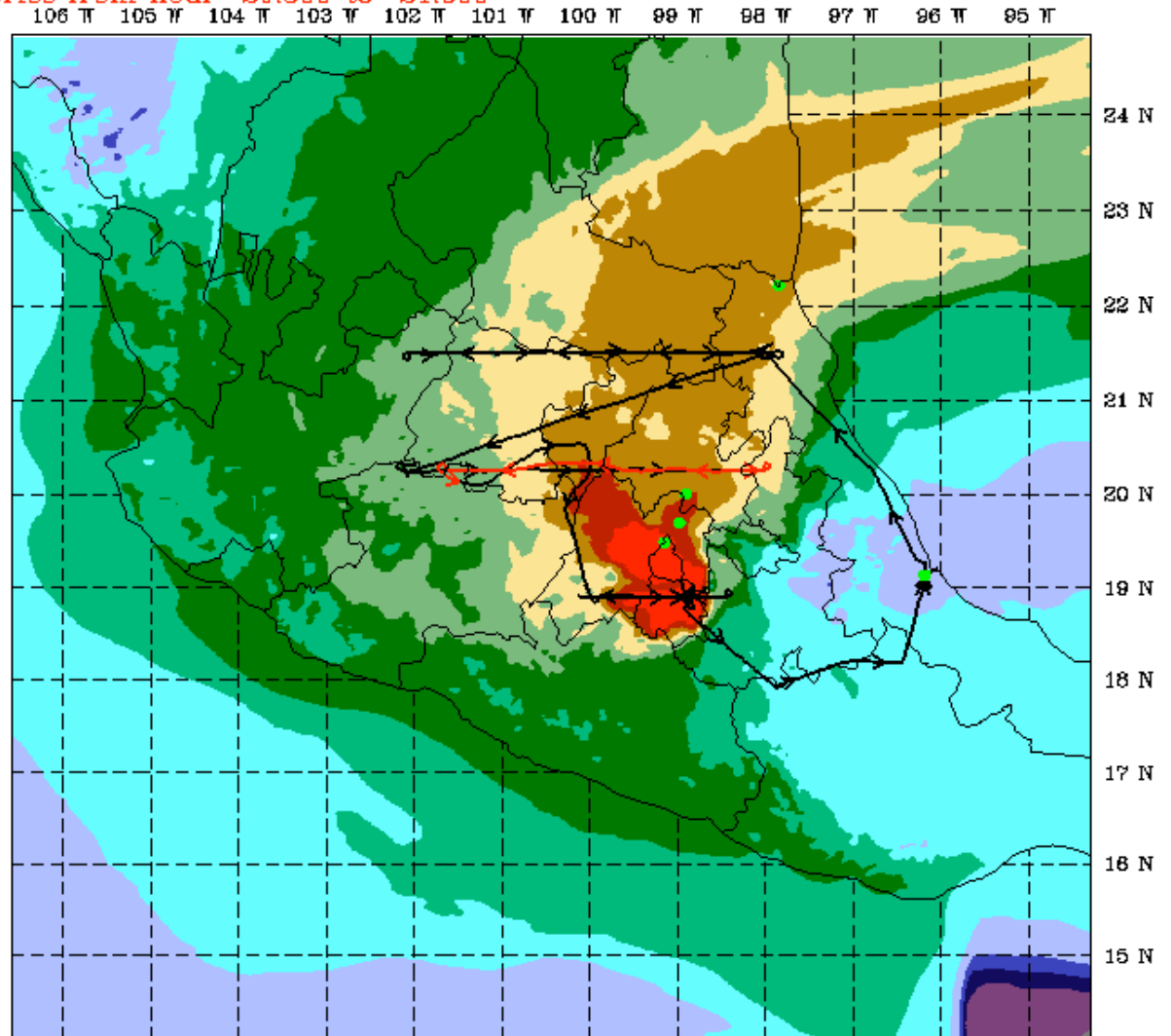
Dataset: 20060316 RIP: 20060316 Init: 0000 UTC Thu 16 Mar 06
Fest: 17.00 h Valid: 1700 UTC Thu 16 Mar 06 (1000 MST Thu 16 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 15.700 to 24.561
Trajectories from hour 16.500 to 17.500





C-130 Flights – 3/16/06

Dataset: 20060316 RIP: 20060316 Init: 0000 UTC Thu 16 Mar 06
Fest: 21.00 h Valid: 2100 UTC Thu 16 Mar 06 (1400 MST Thu 16 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 15.700 to 24.561
Trajectories from hour 20.500 to 21.500



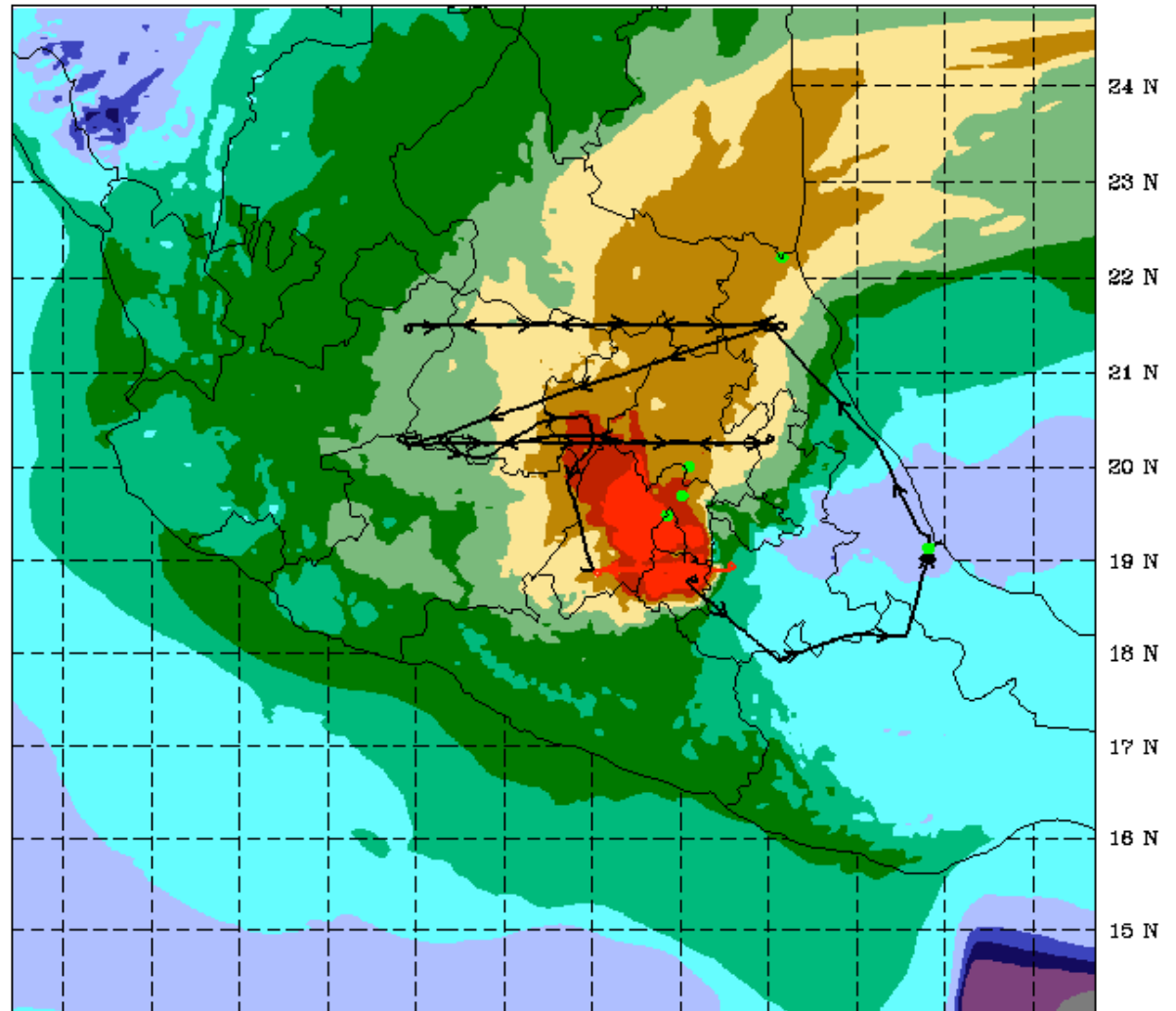


C-130 Flights – 3/16/06

Dataset: 20060316 RIP: 20060316 Init: 0000 UTC Thu 16 Mar 06
Fest: 23.00 h Valid: 2300 UTC Thu 16 Mar 06 (1600 MST Thu 16 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 15.700 to 24.561
Trajectories from hour 22.500 to 23.500

106 W 105 W 104 W 103 W 102 W 101 W 100 W 99 W 98 W 97 W 96 W 95 W

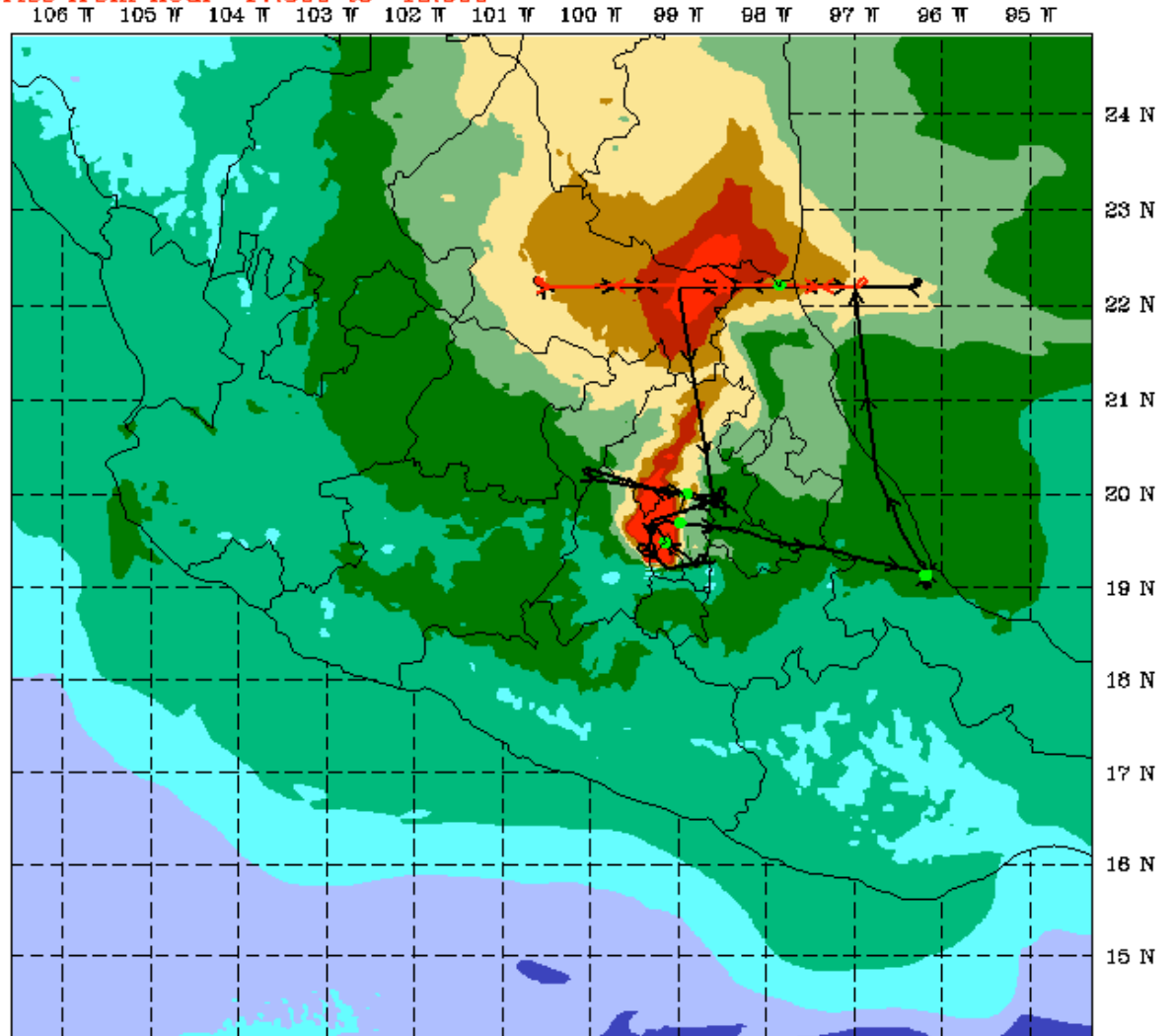
- prev day's pollution far N
- same day N of T-2
- flow reversal
- same day S of city
- profile over CVA





C-130 Flights – 3/18/06

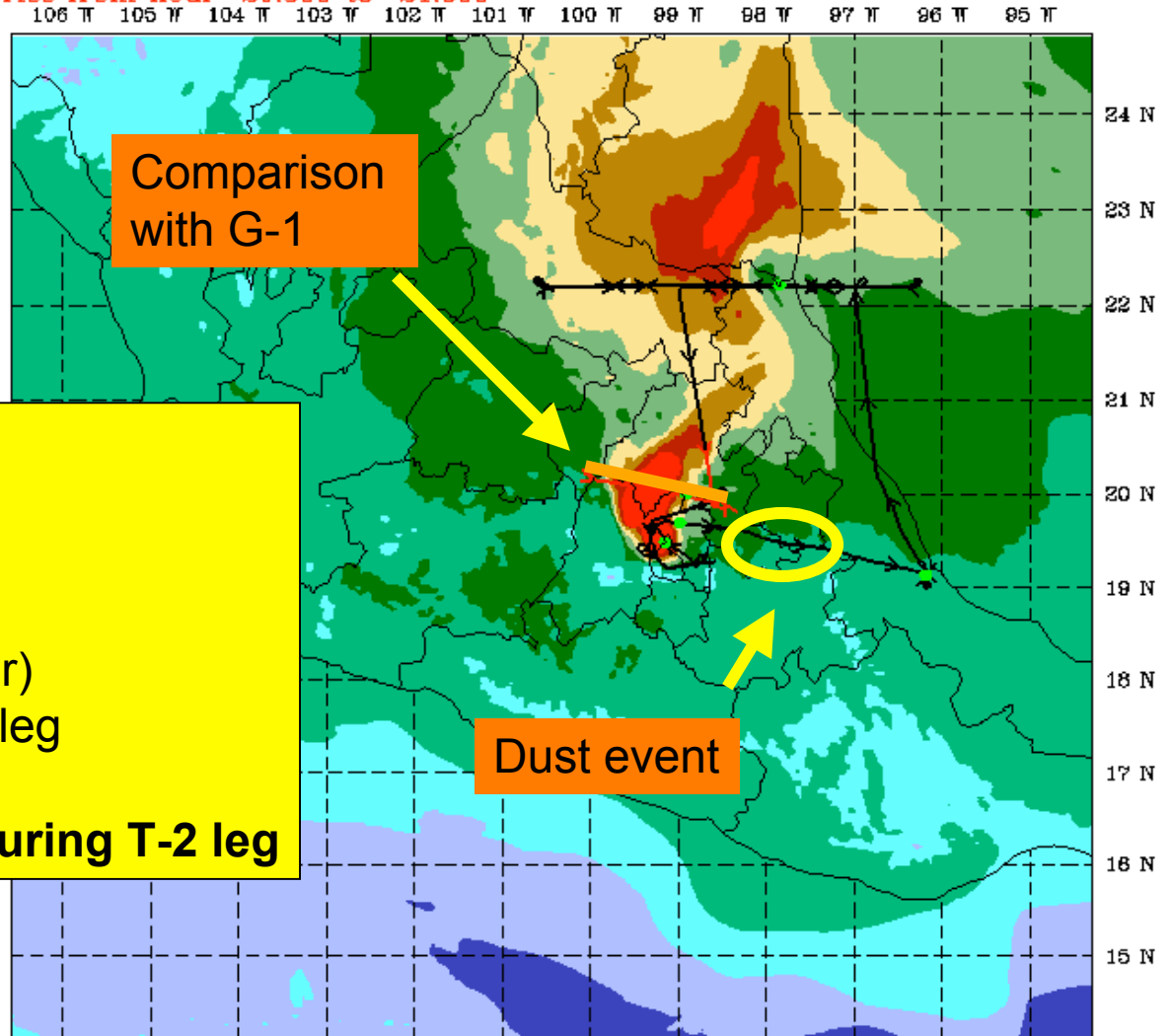
Dataset: 20060318 RIP: 20060318 Init: 0000 UTC Sat 18 Mar 06
Fest: 18.00 h Valid: 1800 UTC Sat 18 Mar 06 (1100 MST Sat 18 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 15.167 to 23.717
Trajectories from hour 17.500 to 18.500





C-130 Flights – 3/18/06

Dataset: 20060318 RIP: 20060318 Init: 0000 UTC Sat 18 Mar 06
Fest: 21.00 h Valid: 2100 UTC Sat 18 Mar 06 (1400 MST Sat 18 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 15.167 to 23.717
Trajectories from hour 20.500 to 21.500



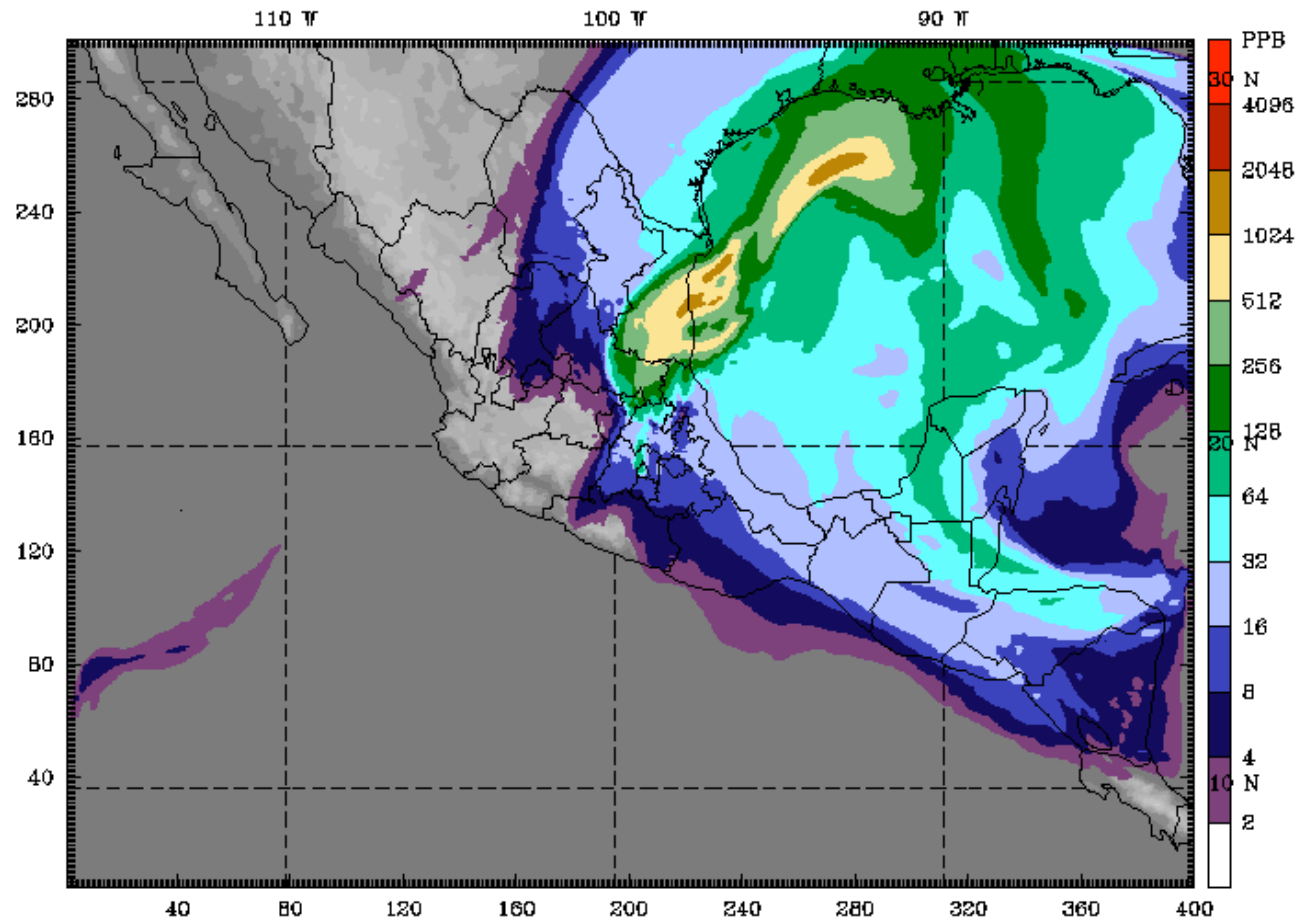
- prev day's pollution far N
- same day over T-2
- comparison with G-1
- city run
- forest fire (overflow Tw.Otter)
- strong dust event on return leg
- **CMET balloons released during T-2 leg**



C-130 Flights – 3/19/06

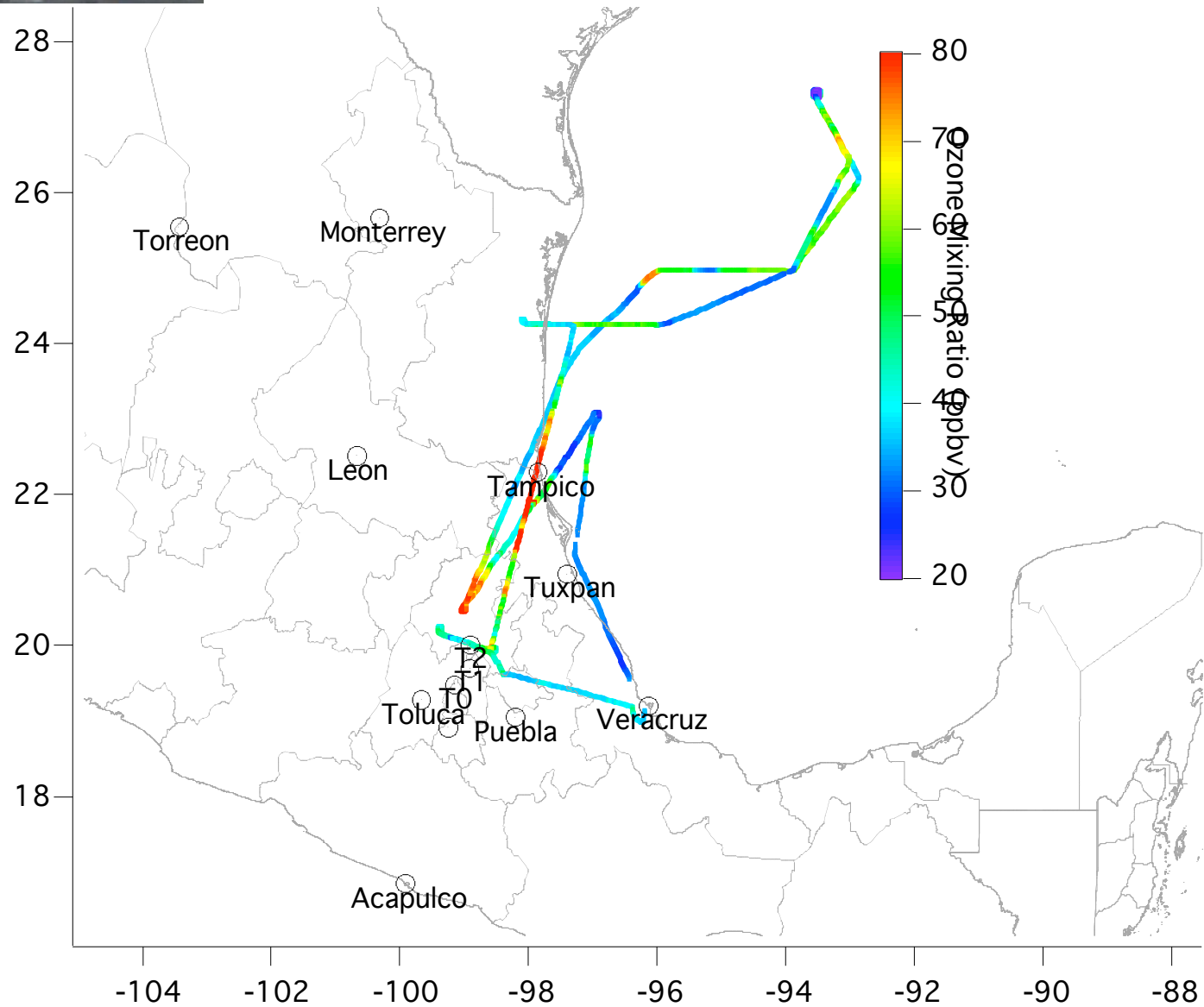
Dataset: dom1 RIP: dom1
Fest: 36.00 h
Terrain height AMSL
Mass weighted c5 integral

Init: 0000 UTC Sat 18 Mar 06
Valid: 1200 UTC Sun 19 Mar 06 (0500 MST Sun 19 Mar 06)



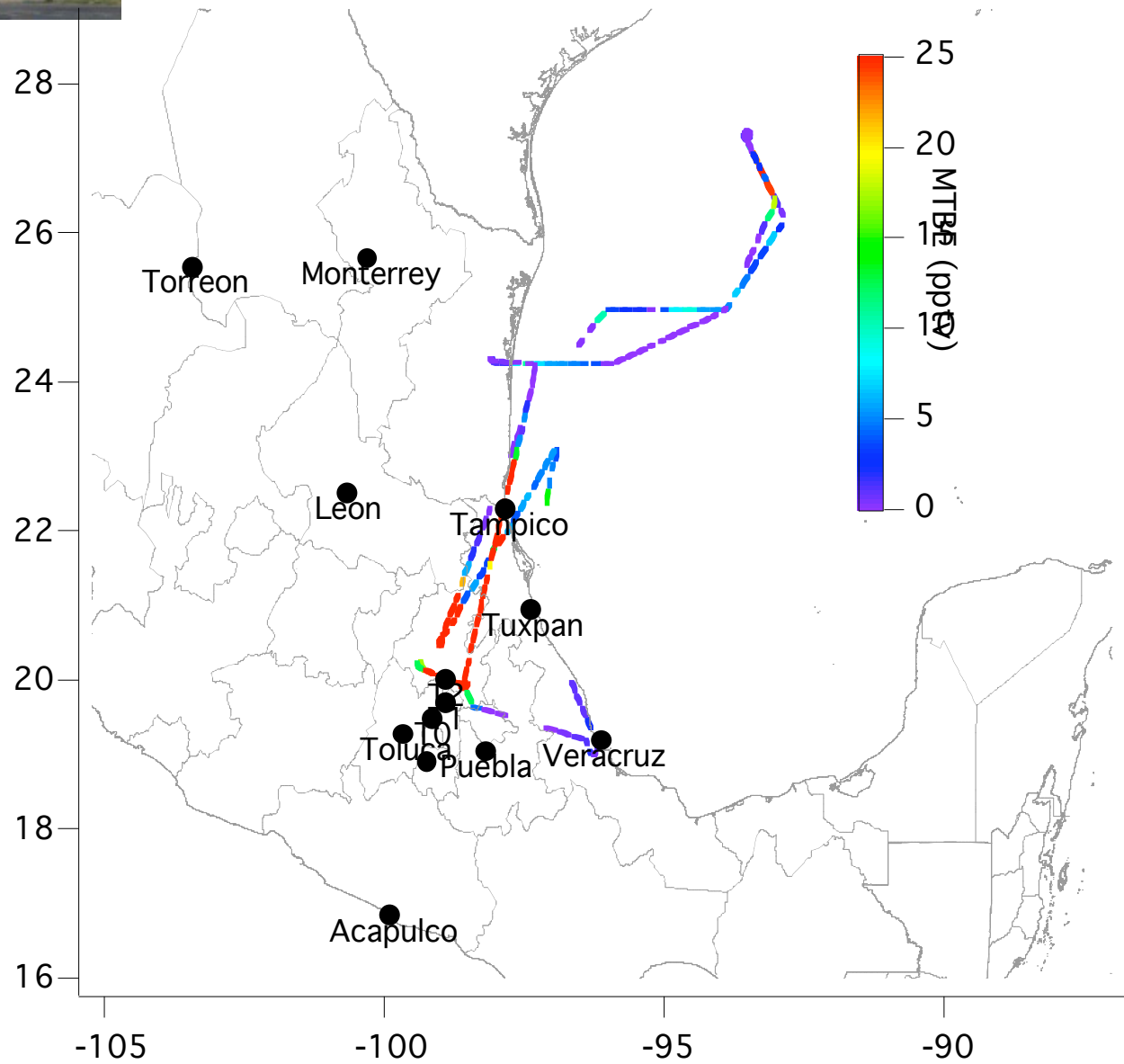


C-130 Flights – 3/19/06





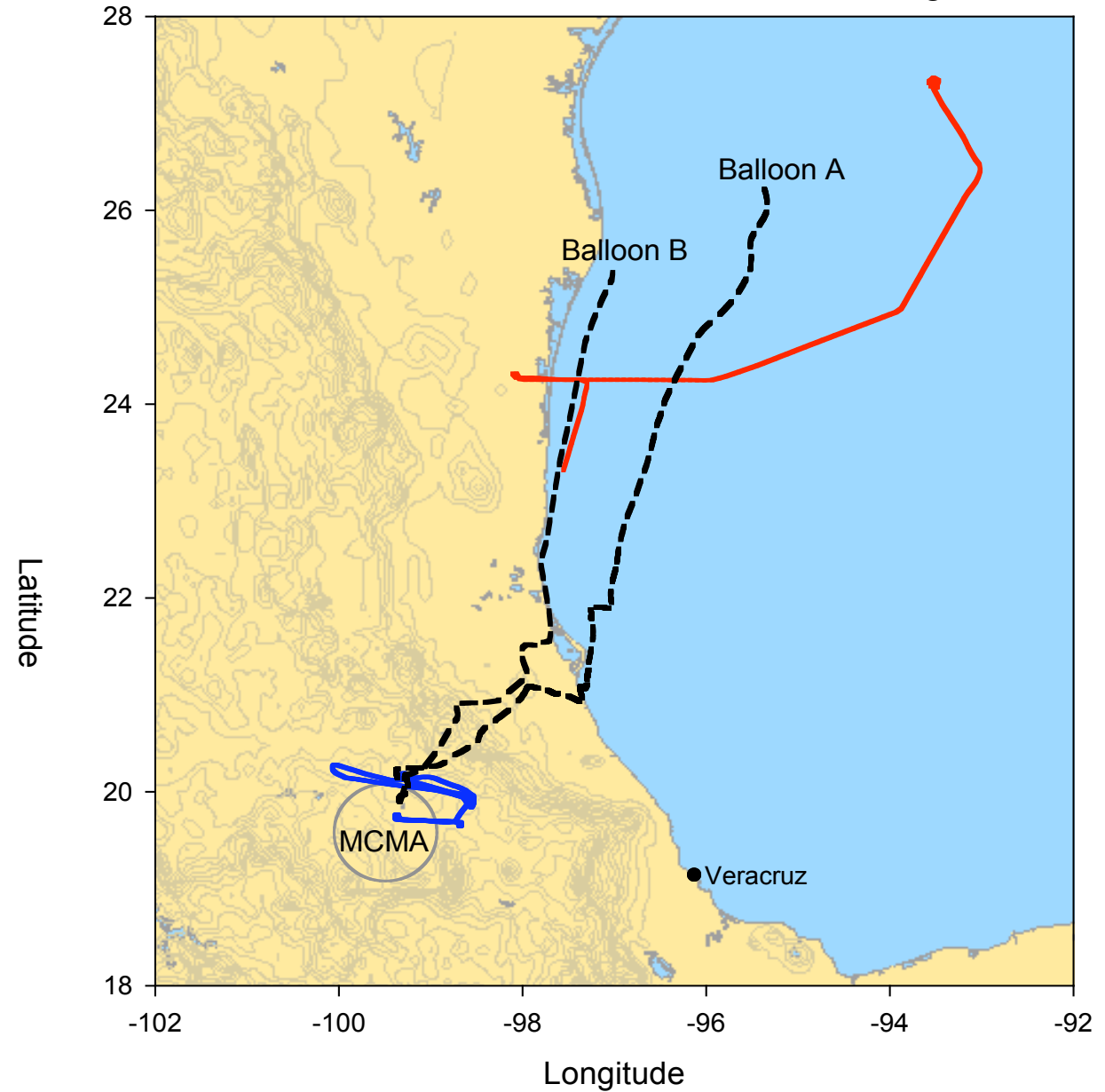
C-130 Flights – 3/19/06





C-130 Flights – 3/19/06

Coordinated G1 - C130 - CMET Balloon Flights





C-130 Flights – 3/19/06

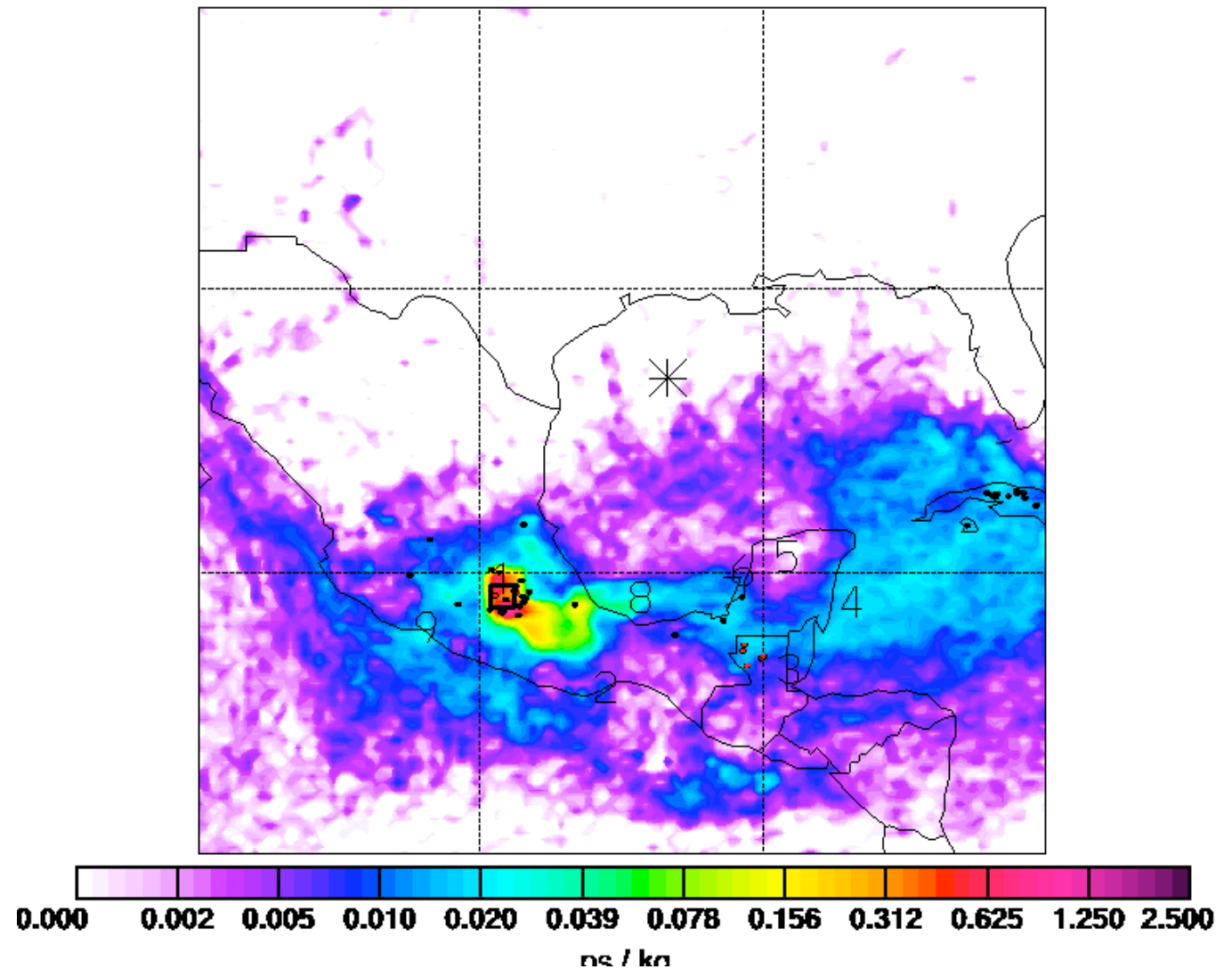
Footprint emission sensitivity in nested domain for c130_060319

Start time of sampling 20060319.212523 End time of sampling 20060319.212812

Lower release height 513 hPa Upper release height 512 hPa

Meteorological data used are from ECMWF

http://zardoz.nilu.no/~andreas/MILAGRO_ETC/





C-130 Flights – 3/19/06

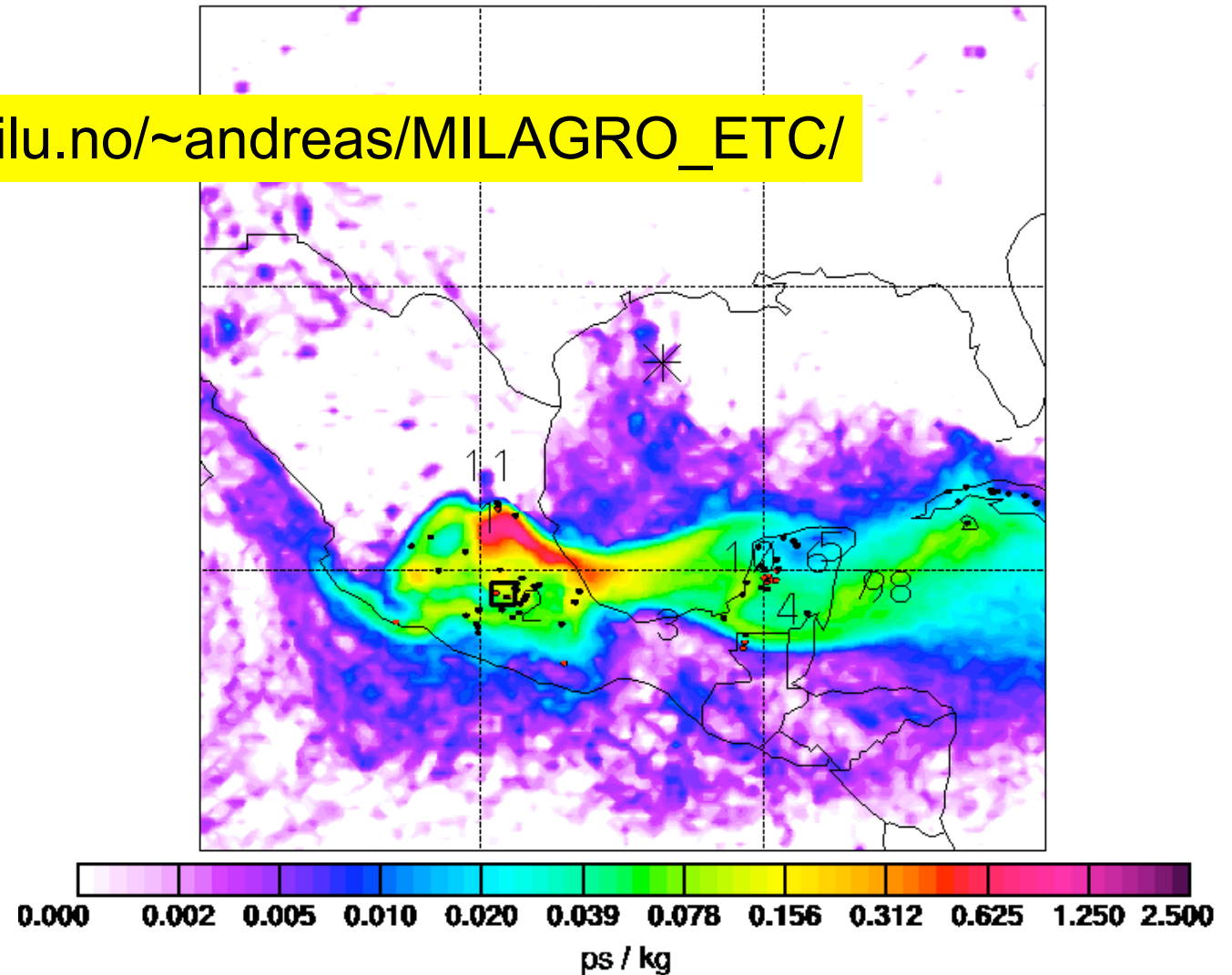
Footprint emission sensitivity in nested domain for c130_060319

Start time of sampling 20060319.214146 End time of sampling 20060319.214209

Lower release height 707 hPa Upper release height 695 hPa

Meteorological data used are from ECMWF

http://zardoz.nilu.no/~andreas/MILAGRO_ETC/

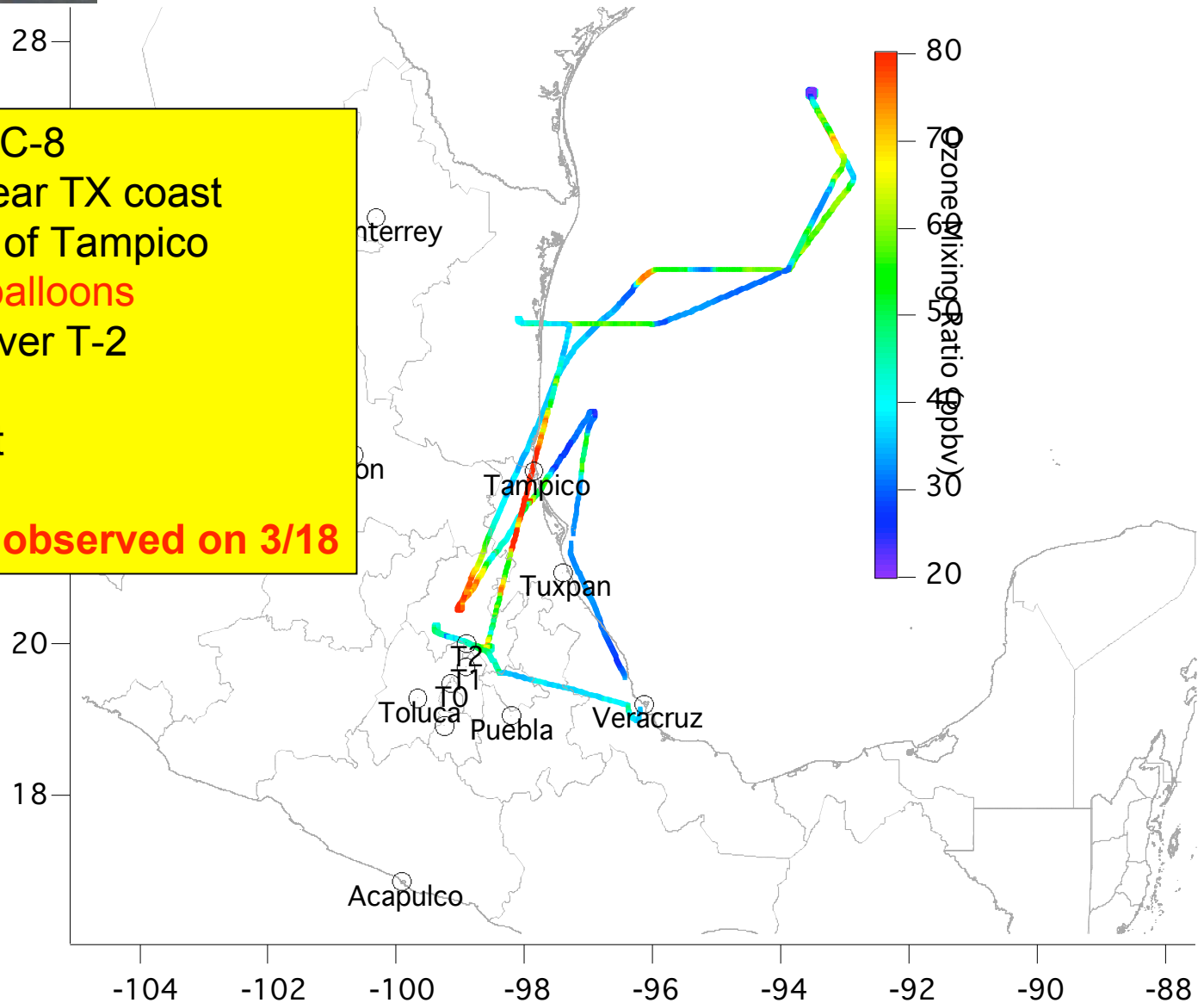




C-130 Flights – 3/19/06

28

- comparison with DC-8
- 2-day old plume near TX coast
- 1 day old plume N of Tampico
- tagged by CMET balloons
- same day plume over T-2
- fireworks near T-2
- 3 days in one flight
- **same air masses observed on 3/18**



MCMA plume processing

- quite large NO_x/NO_y ratio observed even 1000 km (and >2 days) downwind
- slow processing? PAN decomposition?
Other NO_x sources?
- NMHC still high but so are products
- if slow processing - why?
- MCMA outflow characteristics?
- Radical losses?

“Lagrangian” opportunities

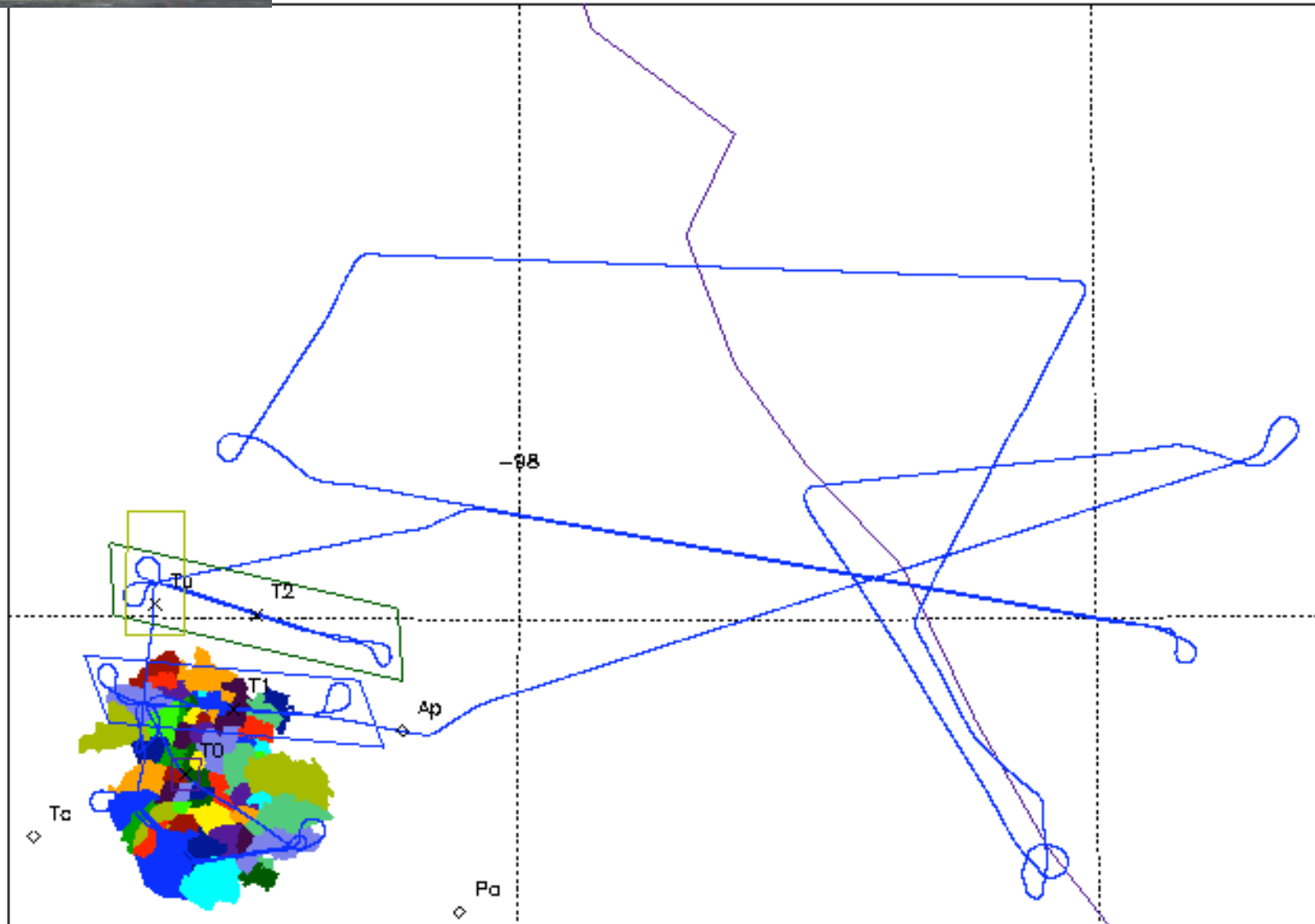
- many cases where one of the other two “in-situ chemistry” aircraft either extend the time base (DC-8, C-130) or provide measurements for the starting conditions for tomorrow’s plume (G-1, DC-8, C-130, ground sites).
- comparisons !
- we tried to plan for this during flight planning



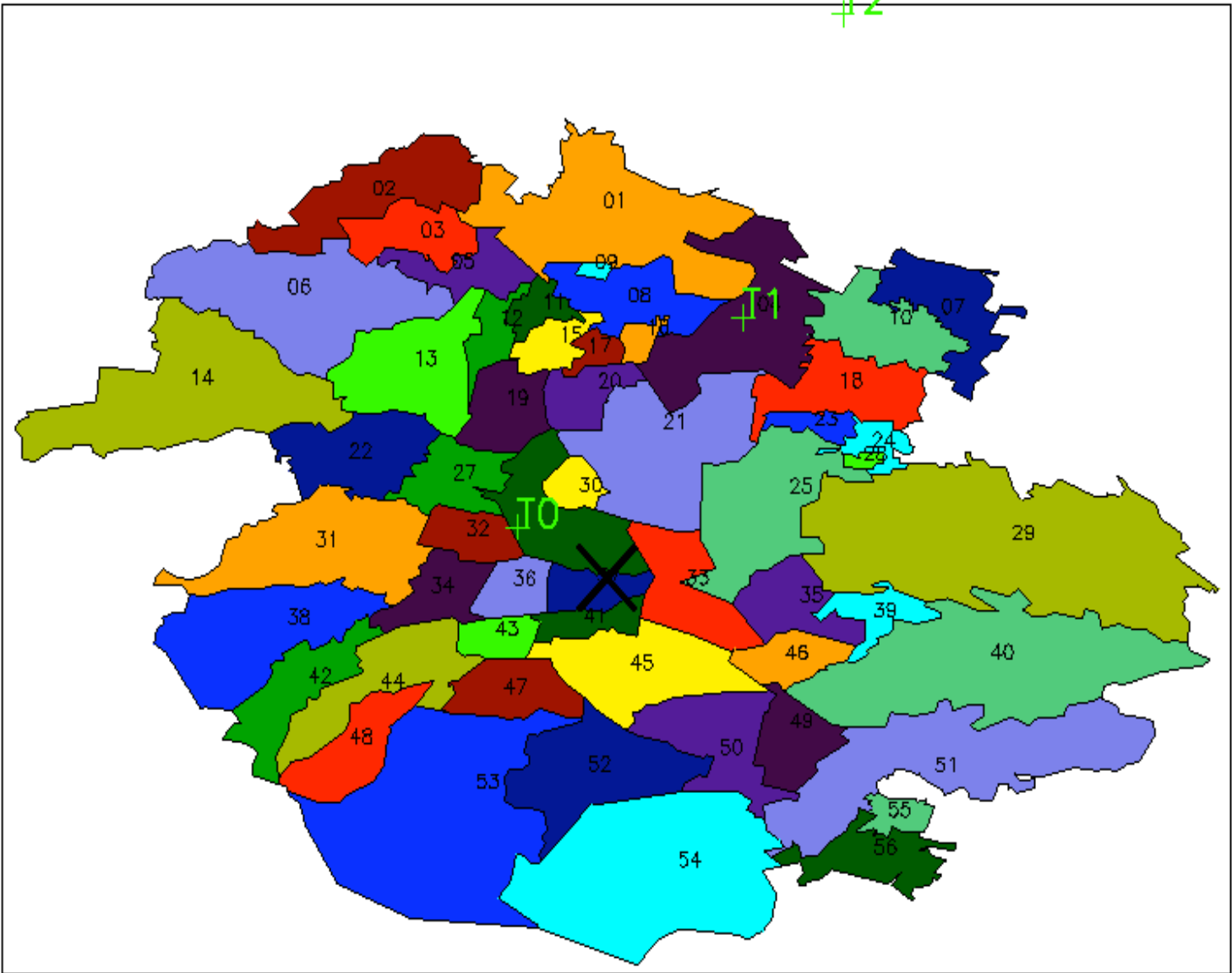
C-130 Flights – 3/22/06

MCR08

2006 03 22



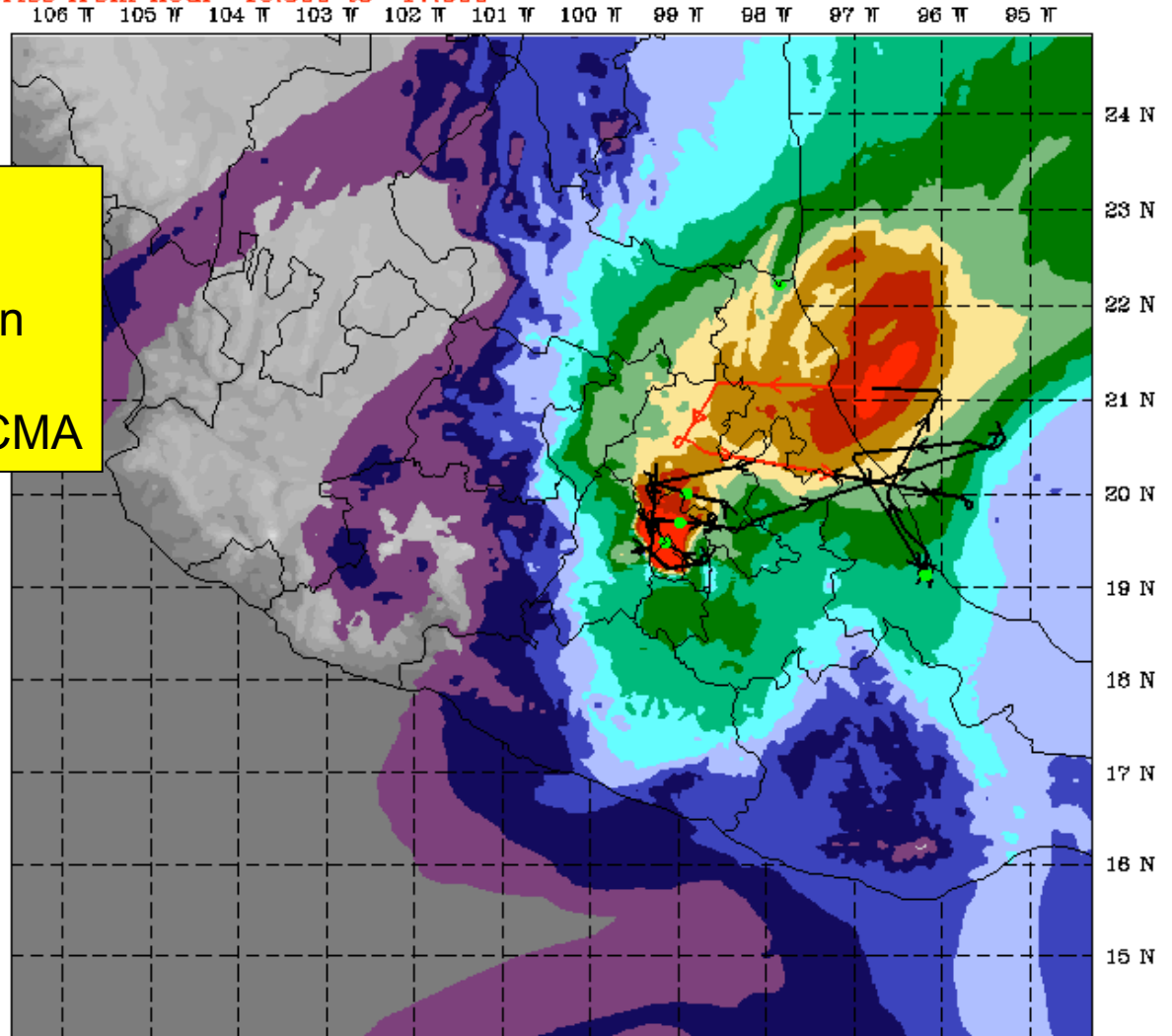
12





C-130 Flights – 3/22/06

Dataset: 20060322 RIP: 20060322 Init: 0000 UTC Wed 22 Mar 06
Fest: 17.00 h Valid: 1700 UTC Wed 22 Mar 06 (1000 MST Wed 22 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 15.683 to 22.683
Trajectories from hour 16.500 to 17.500



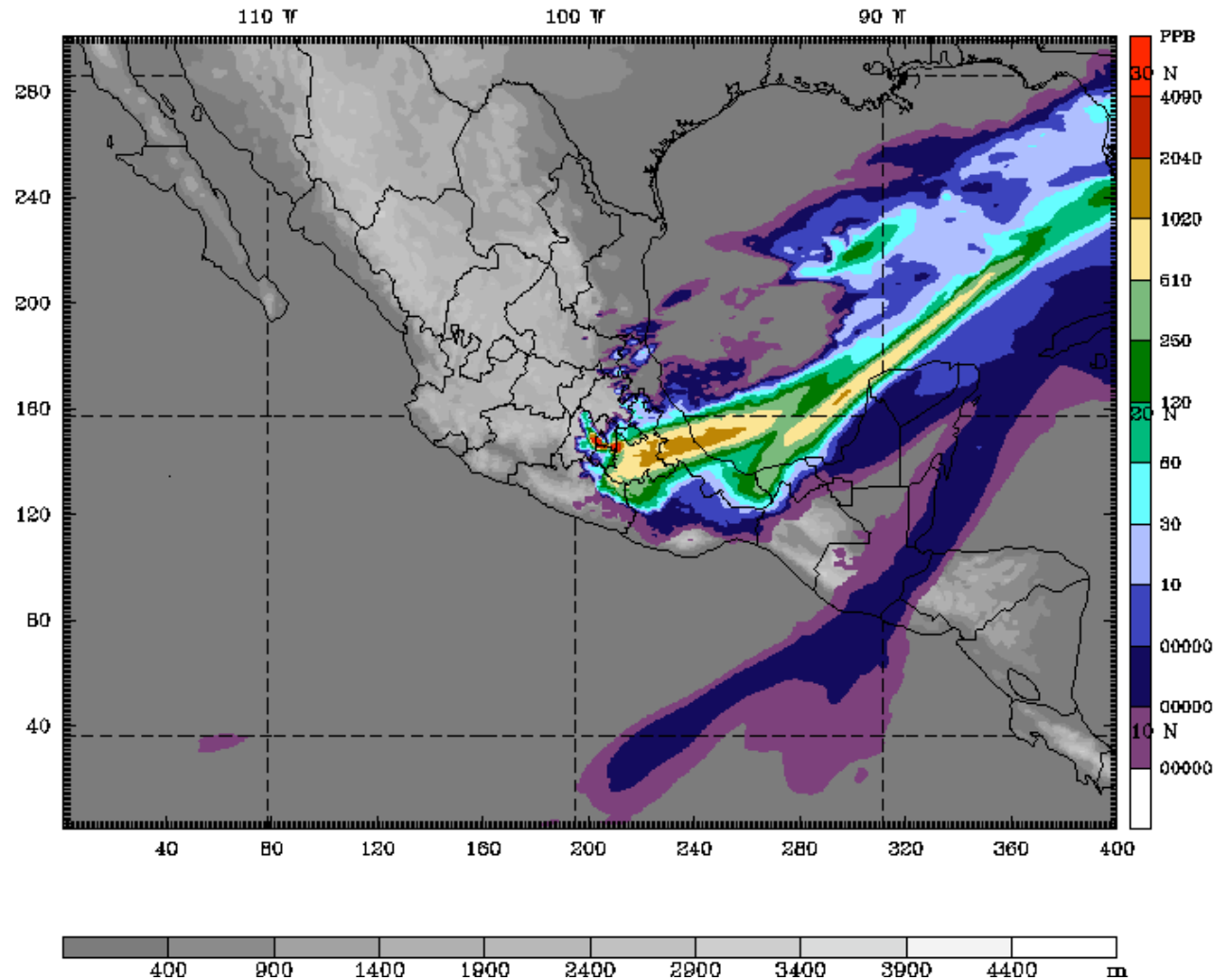
- preparation for next day
- probe 1 day old plume to NE
- probe same-day during city run
- G-1 had sampled morning
- fresh fire plume in the S of MCMA



C-130 Flights – 3/23/06

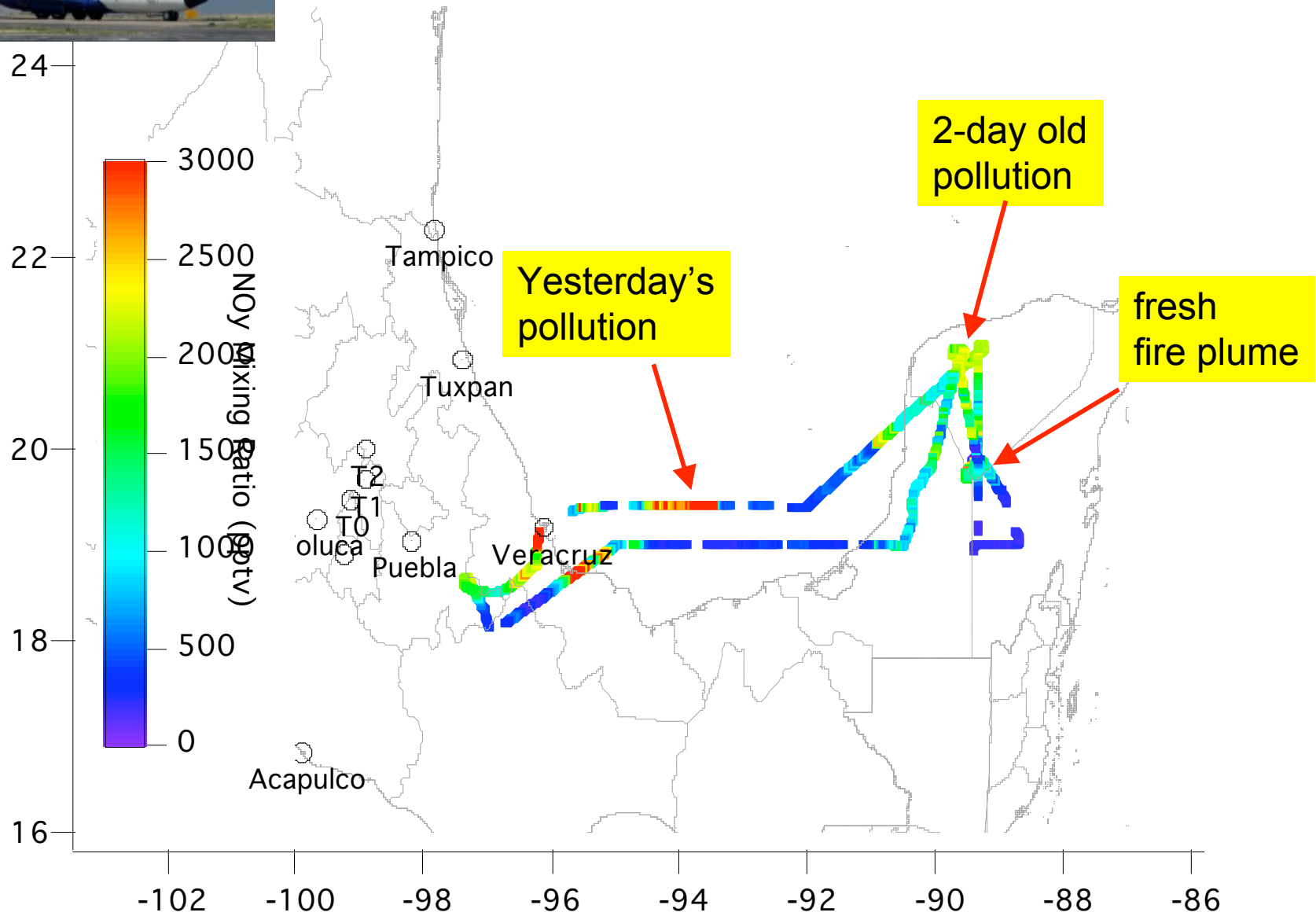
Dataset: dom1 RIP: dom1
Fest: 42.00 h
Terrain height AMSL
Mass weighted c5 integral

Init: 0000 UTC Wed 22 Mar 06
Valid: 1800 UTC Thu 23 Mar 06 (1100 MST Thu 23 Mar 06)





C-130 Flights – 3/23/06





C-130 Flights – 3/28/06

Dataset: 20060328 RIP: 20060328

Init: 0000 UTC Tue 28 Mar 06

Fcst: 12.00 h

Valid: 1200 UTC Tue 28 Mar 06 (0500 MST Tue 28 Mar 06)

Terrain height AMSL

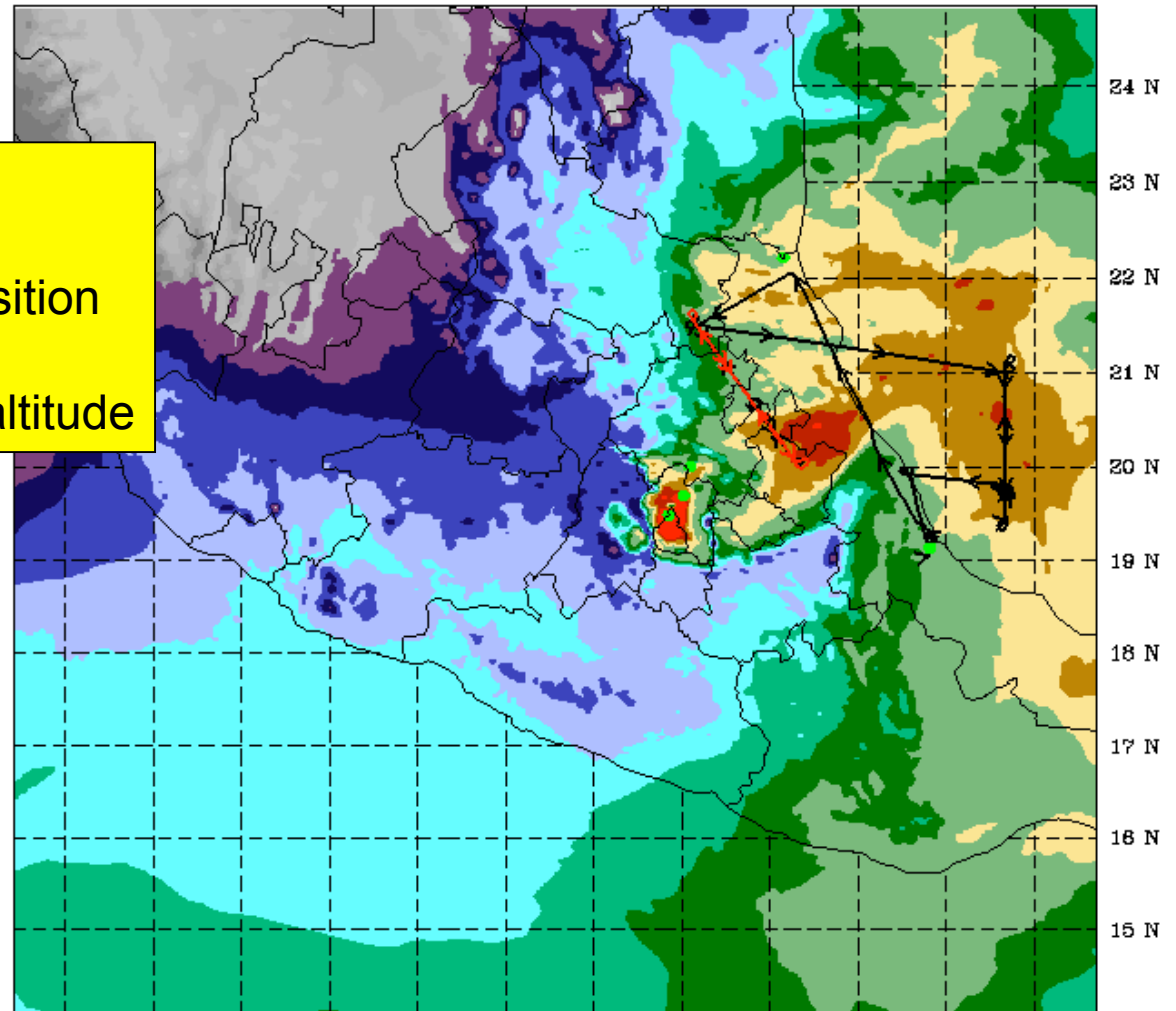
Mass weighted c5 integral

Trajectories from hour 10.117 to 17.483

Trajectories from hour 11.500 to 12.500

106 W 105 W 104 W 103 W 102 W 101 W 100 W 99 W 98 W 97 W 96 W 95 W

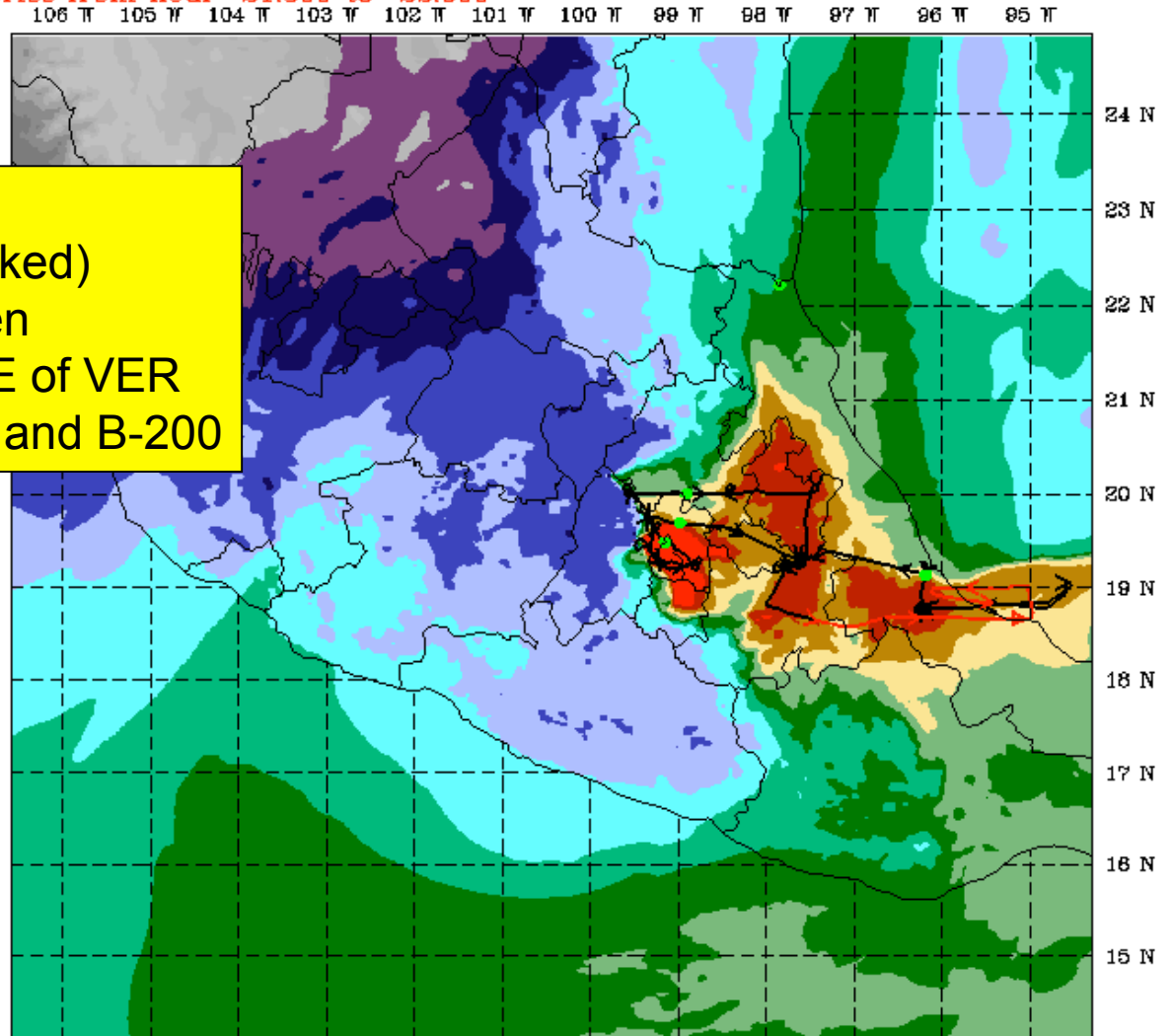
- Sunrise flight
- probe1 day old plume during night-day transition
- probe same air transported further out at higher altitude





C-130 Flights – 3/29/06

Dataset: 20060329 RIP: 20060329 Init: 0000 UTC Wed 29 Mar 06
Fest: 22.00 h Valid: 2200 UTC Wed 29 Mar 06 (1500 MST Wed 29 Mar 06)
Terrain height AMSL
Mass weighted c5 integral
Trajectories from hour 17.067 to 23.900
Trajectories from hour 21.500 to 22.500



- stagnant meteorology
- probe same air 3 times (2 worked)
- city run sandwiched in between
- probe yesterday's air again SE of VER
- coordinated spiral with TERRA and B-200

