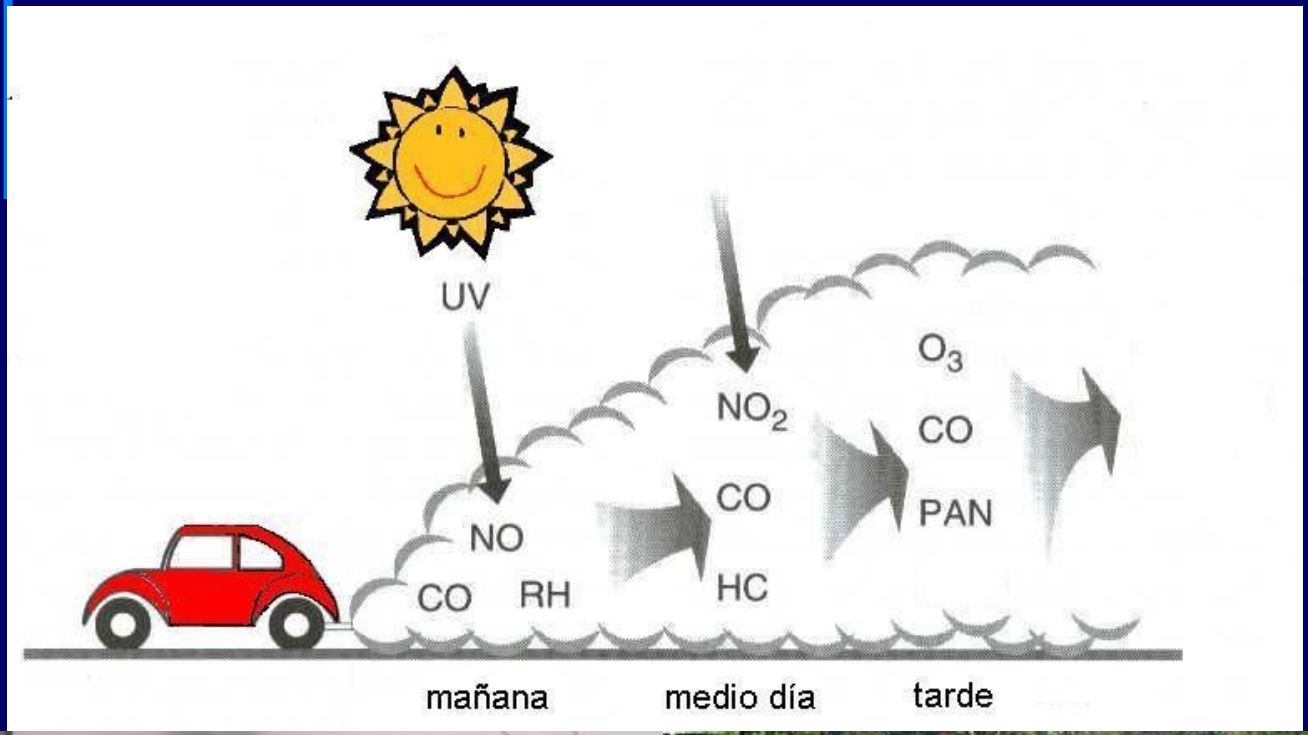

AIR QUALITY and METEOROLOGY
México Valley Case

General: ! This is the phenomenon that we want to study **!**

The Photochemistry has received more attention than the Meteorology
How much of the contamination is explained by the Meteorology?

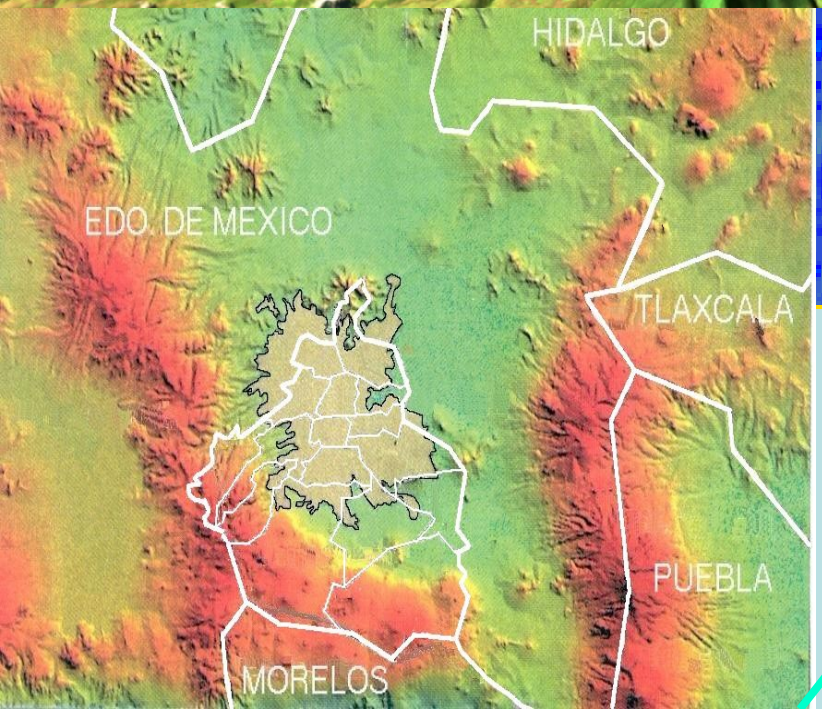


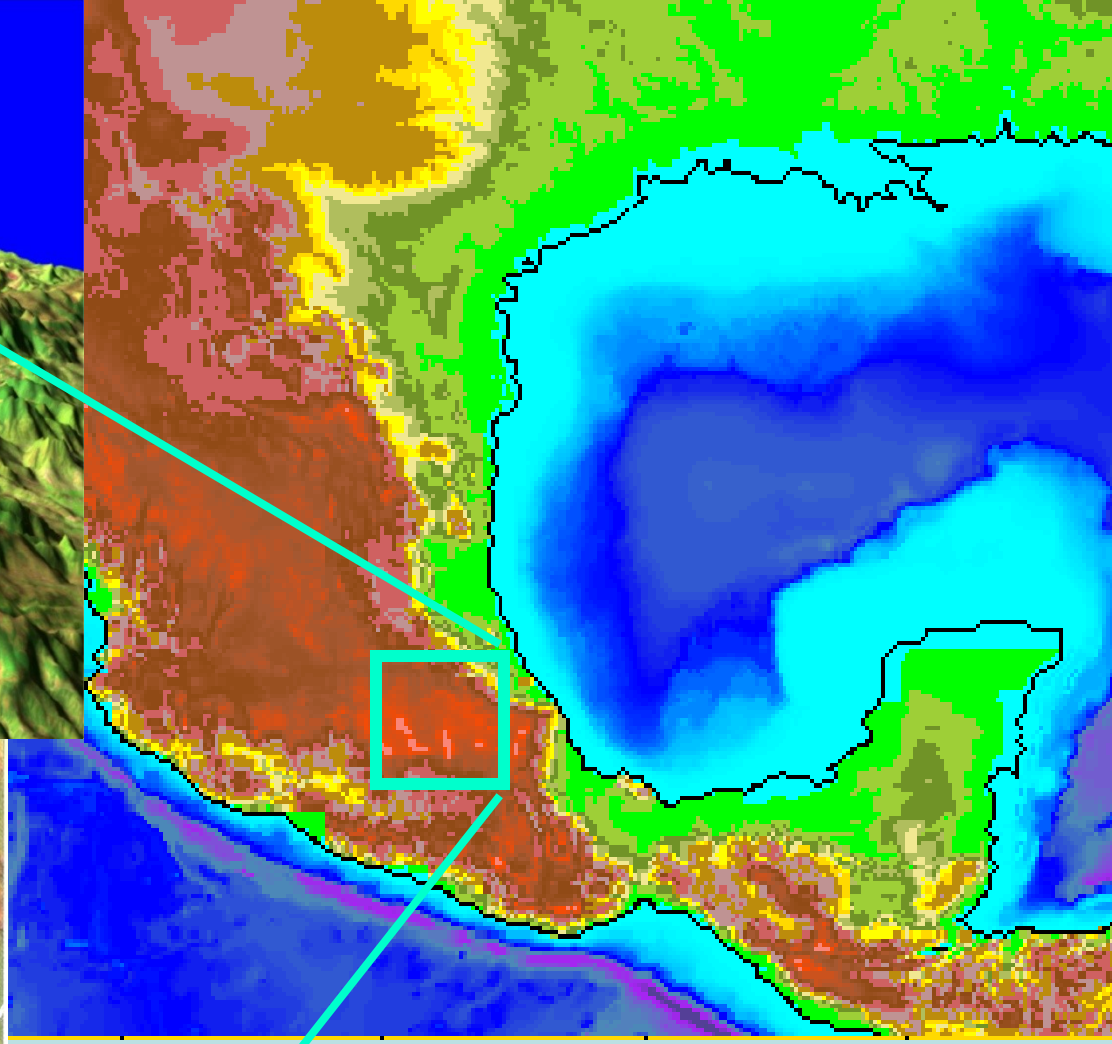
Objectives

Identify the characteristics of the winter atmospheric circulation that are relevant to the air quality modeling in the Mexico basin.

Evaluation of WRF,MM5 models, to simulate parameters of importance for the pollutants dispersal, especially during campaigns (CAM-MIT 2002-2003, Milagro 2006)

Analysis of dynamic processes related to boundary layer changes in the Mesoscale circulation in the Mexico basin





The geographic location and the complex topography play an important roll in terms of dominant meteorological conditions

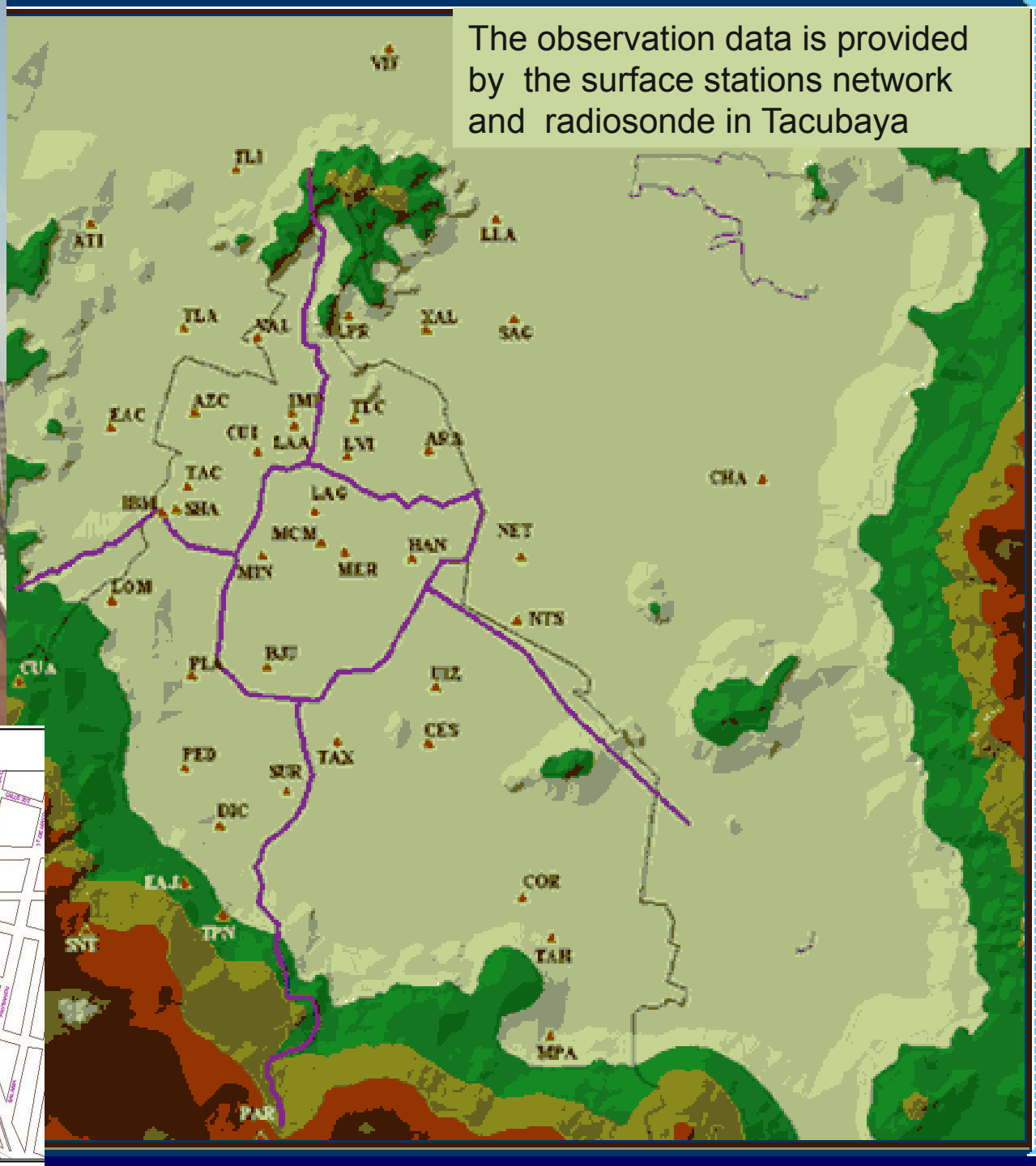
< 08 °C
08 a 10 °C
10 a 12 °C
12 a 14 °C
14 a 16 °C
> 16 °C

< 600 mm
600a 700 mm
700 a 800 mm
800 a 1 000 mm
1 000 a 1 200 mm
1 200 a 1 500 mm
> 1 500 mm

Temperatura

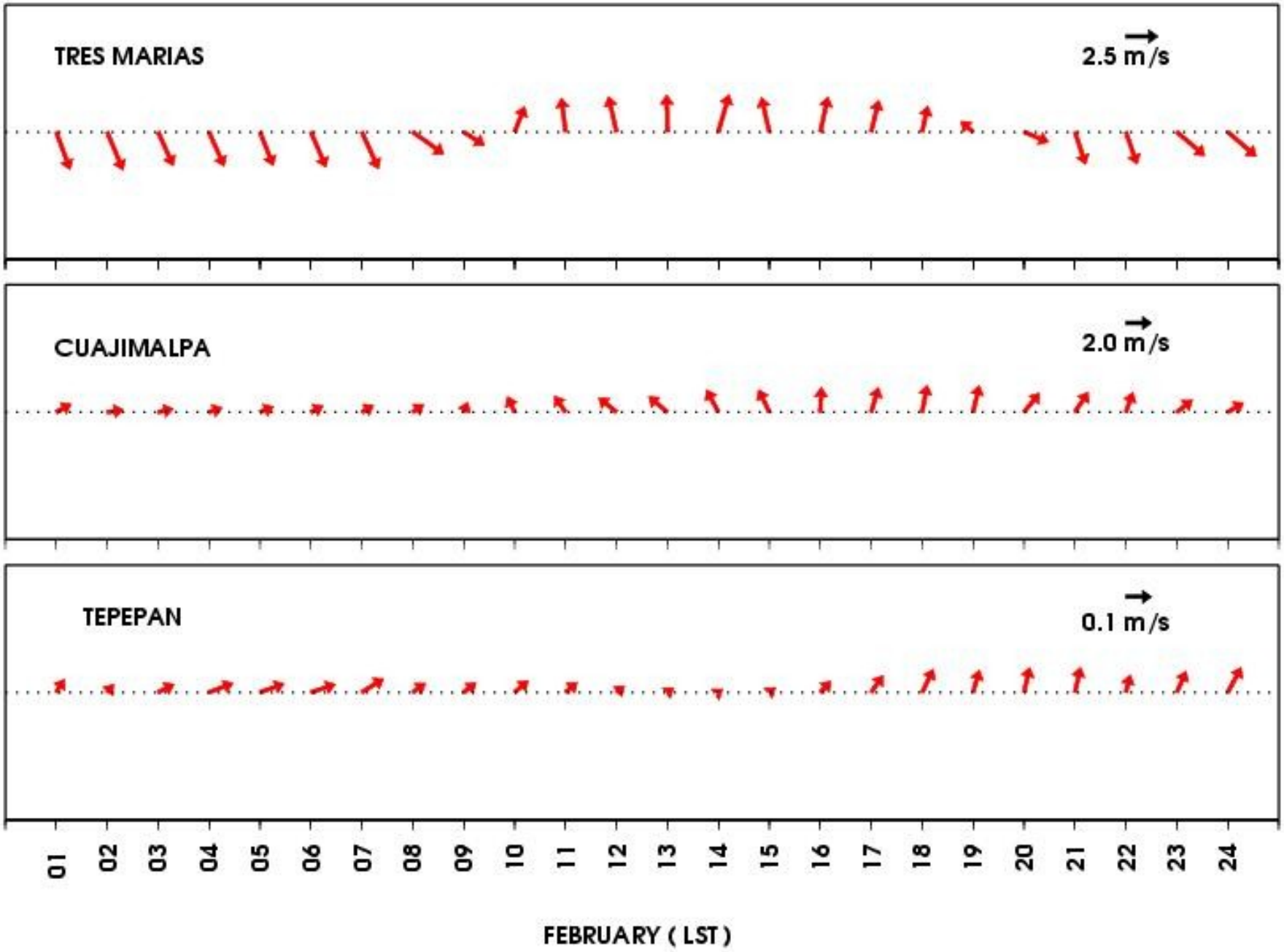
PCP Anual

The observation data is provided by the surface stations network and radiosonde in Tacubaya



During the CAM-MIT and Milagro campaigns had additional observations :

1. Four daily radiosondes (Tacubaya and Veracruz)
2. Tethered and pilot baloons, lidar
3. Expansion of surface met stations
4. Supersites meteorology and chemistry
5. Flux towers


TRES MARIAS
2.5 m/s
CUAJIMALPA
2.0 m/s
TEPEPAN
0.1 m/s
01
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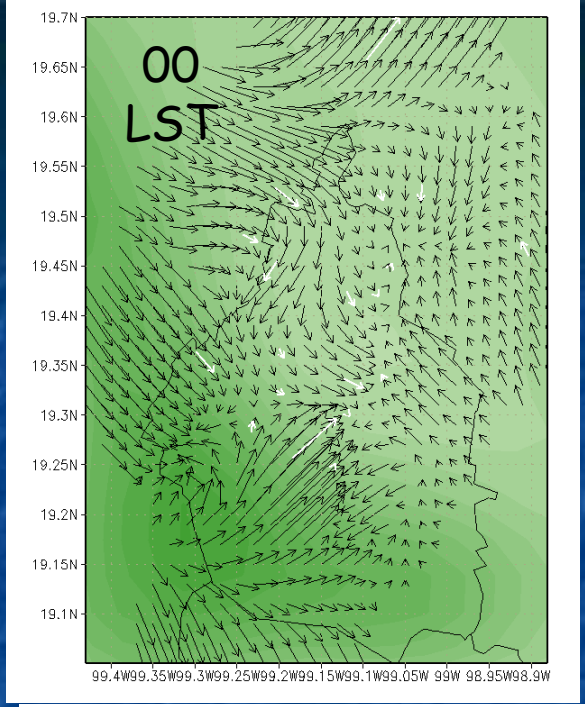
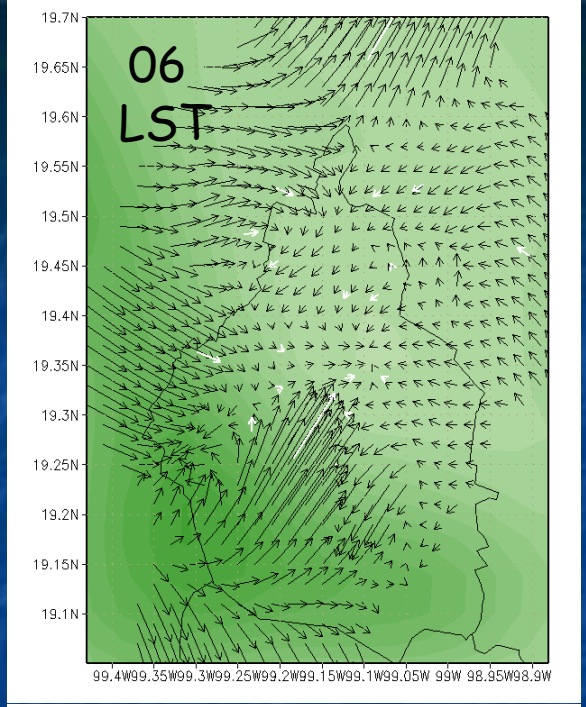
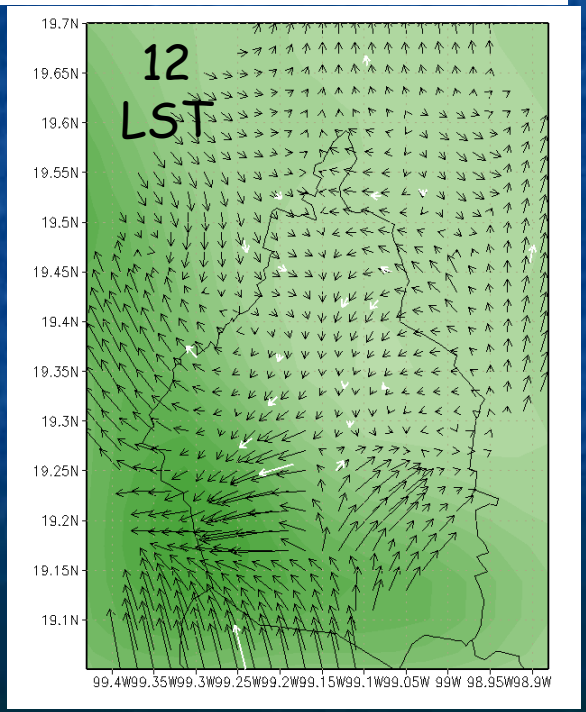
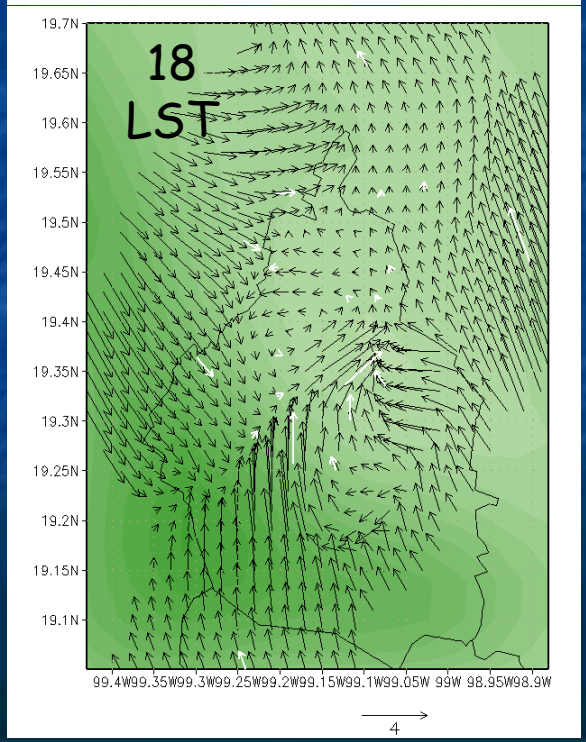
FEBRUARY (LST)

Mean wind fields for February 2002





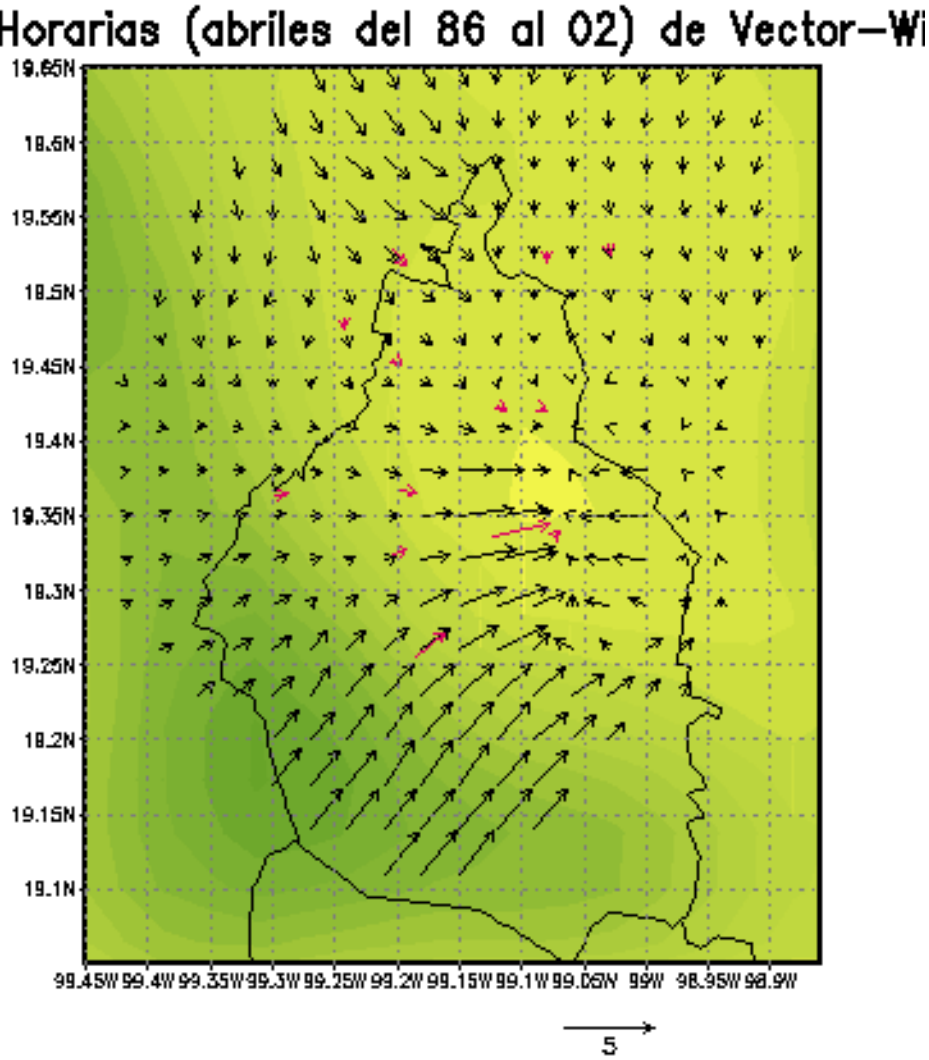


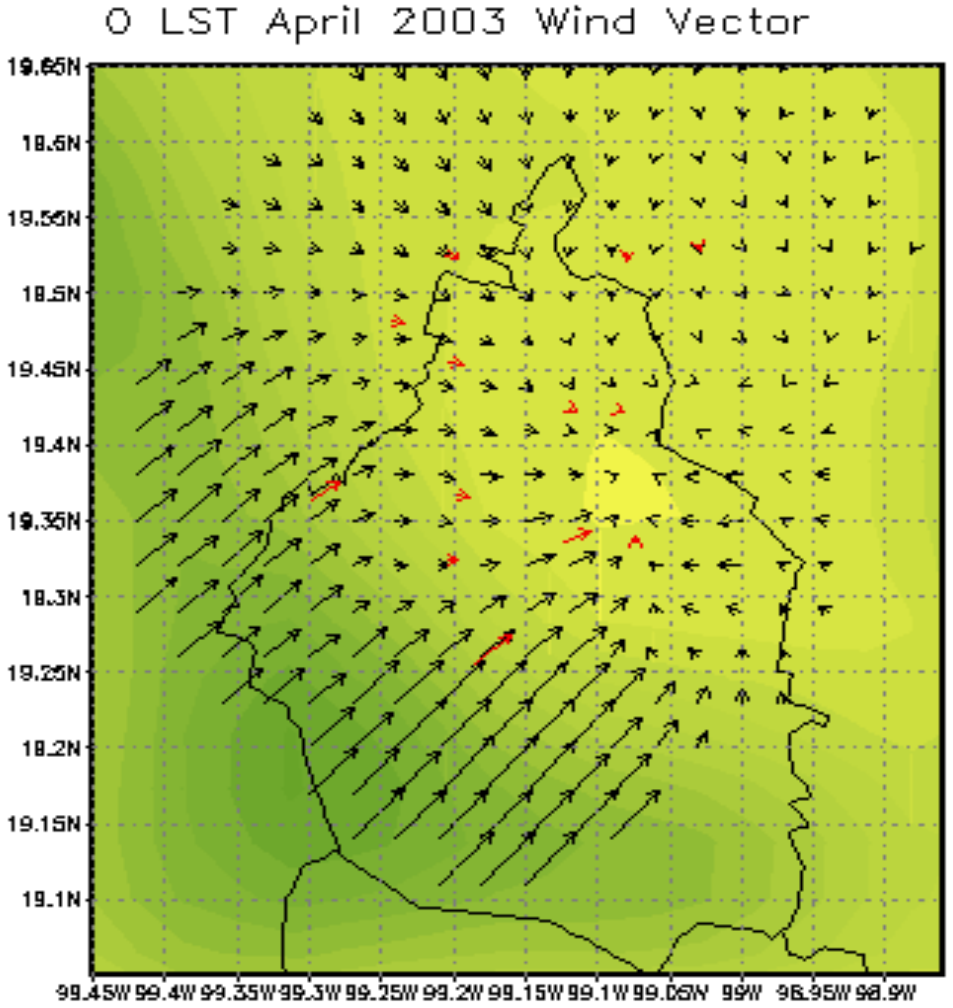


April circulation

Climatology

00:00 LST

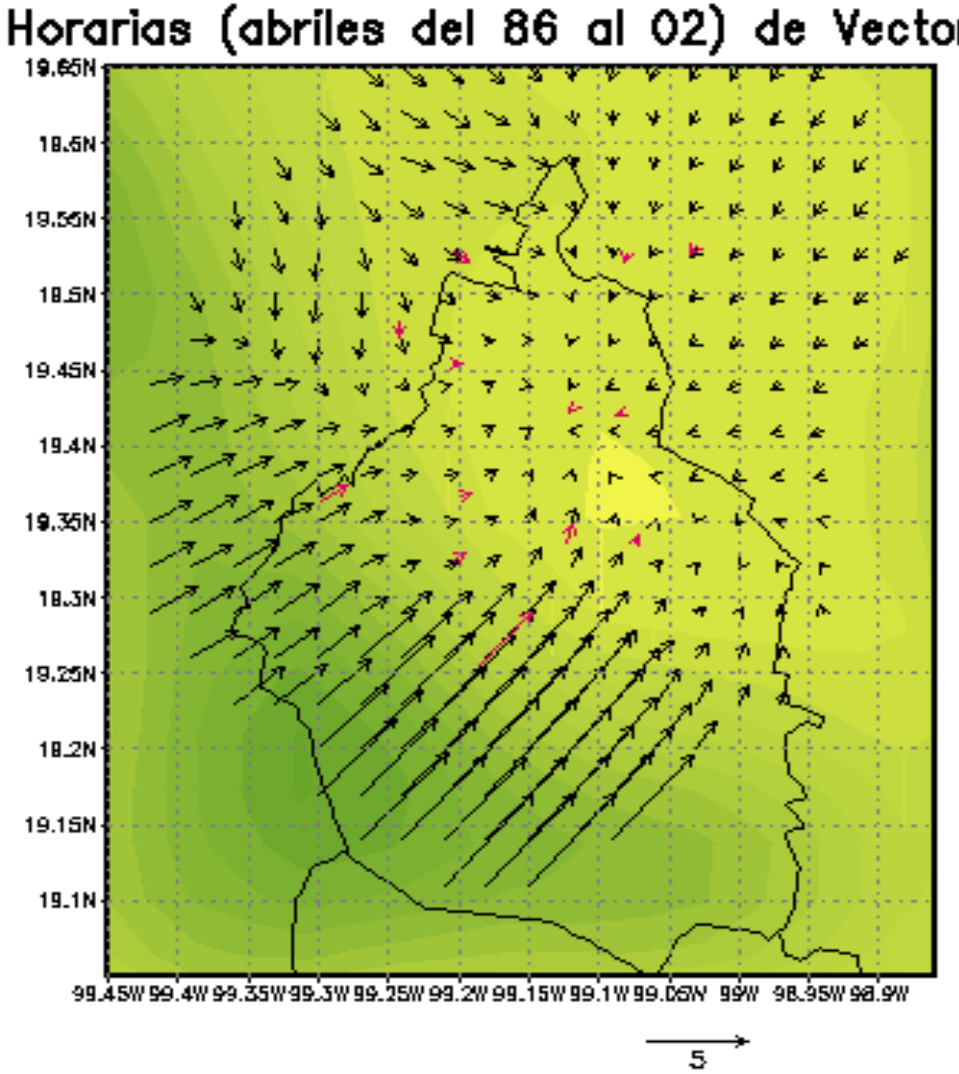


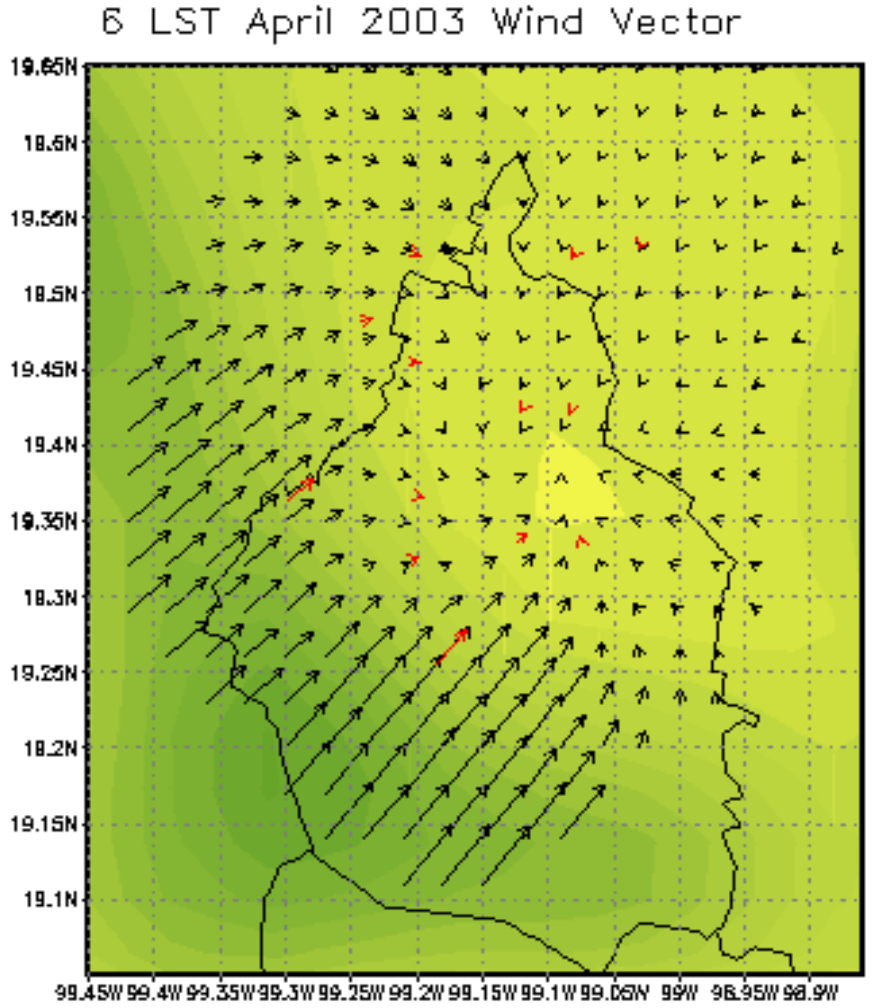


April circulation

06:00 LST

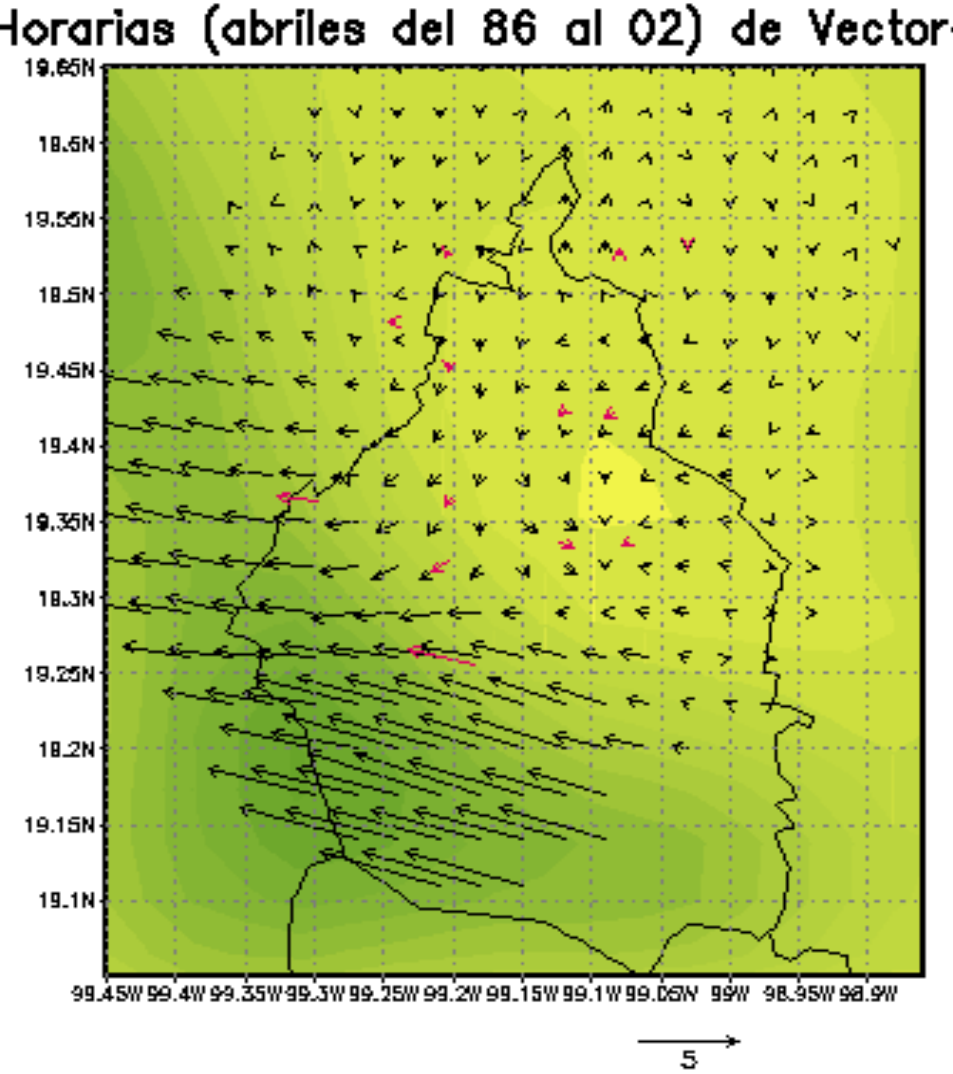
Climatology

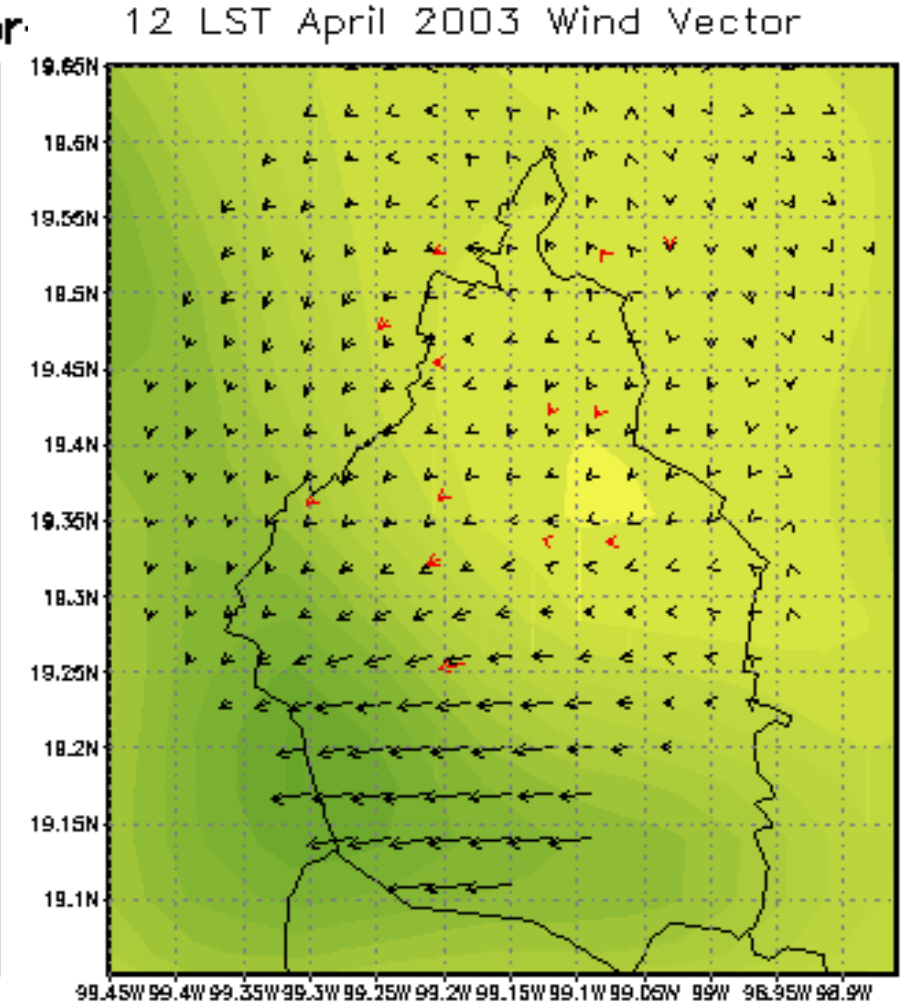




April circulation
12:00 LST

Climatology

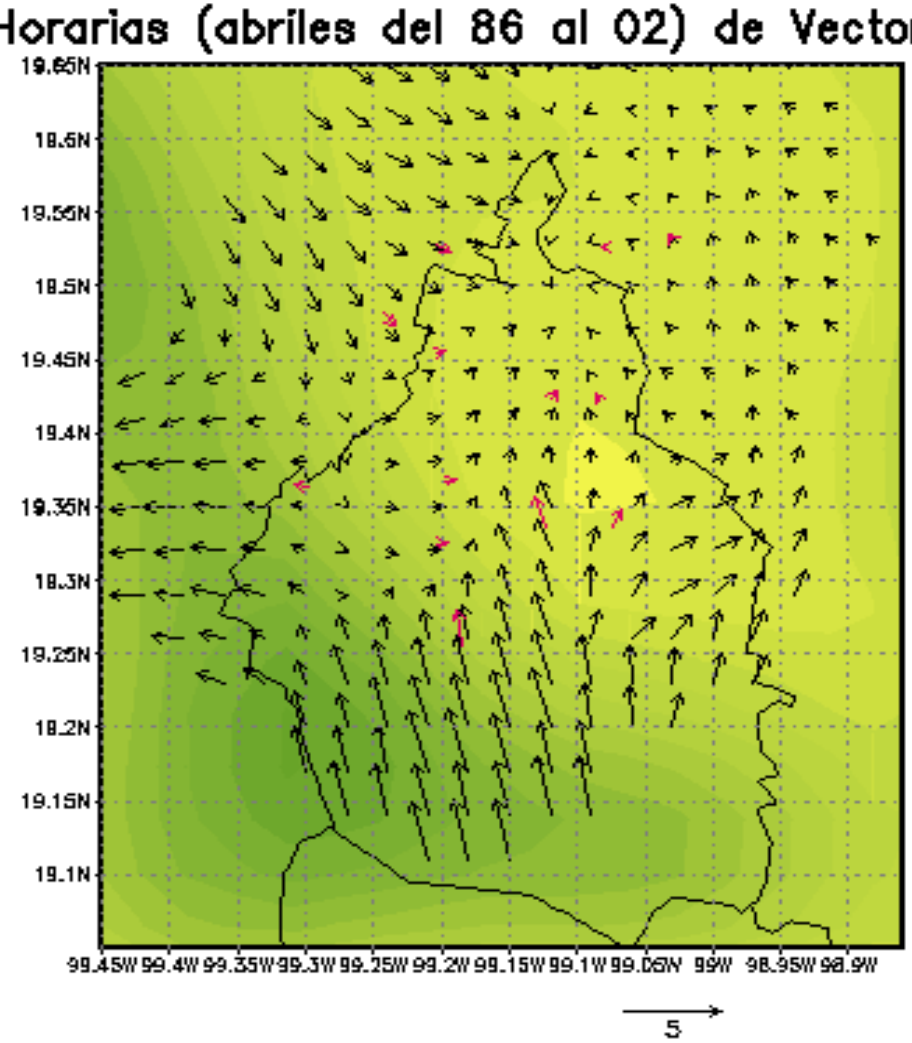


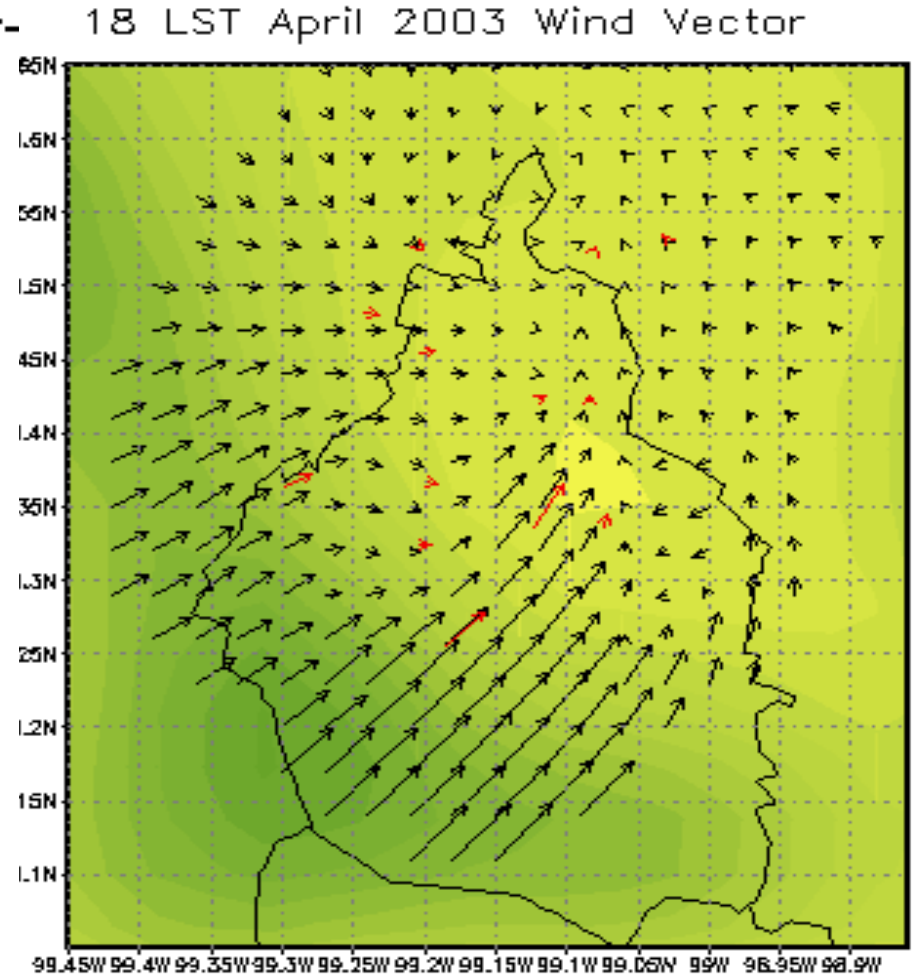


April circulation

Climatology

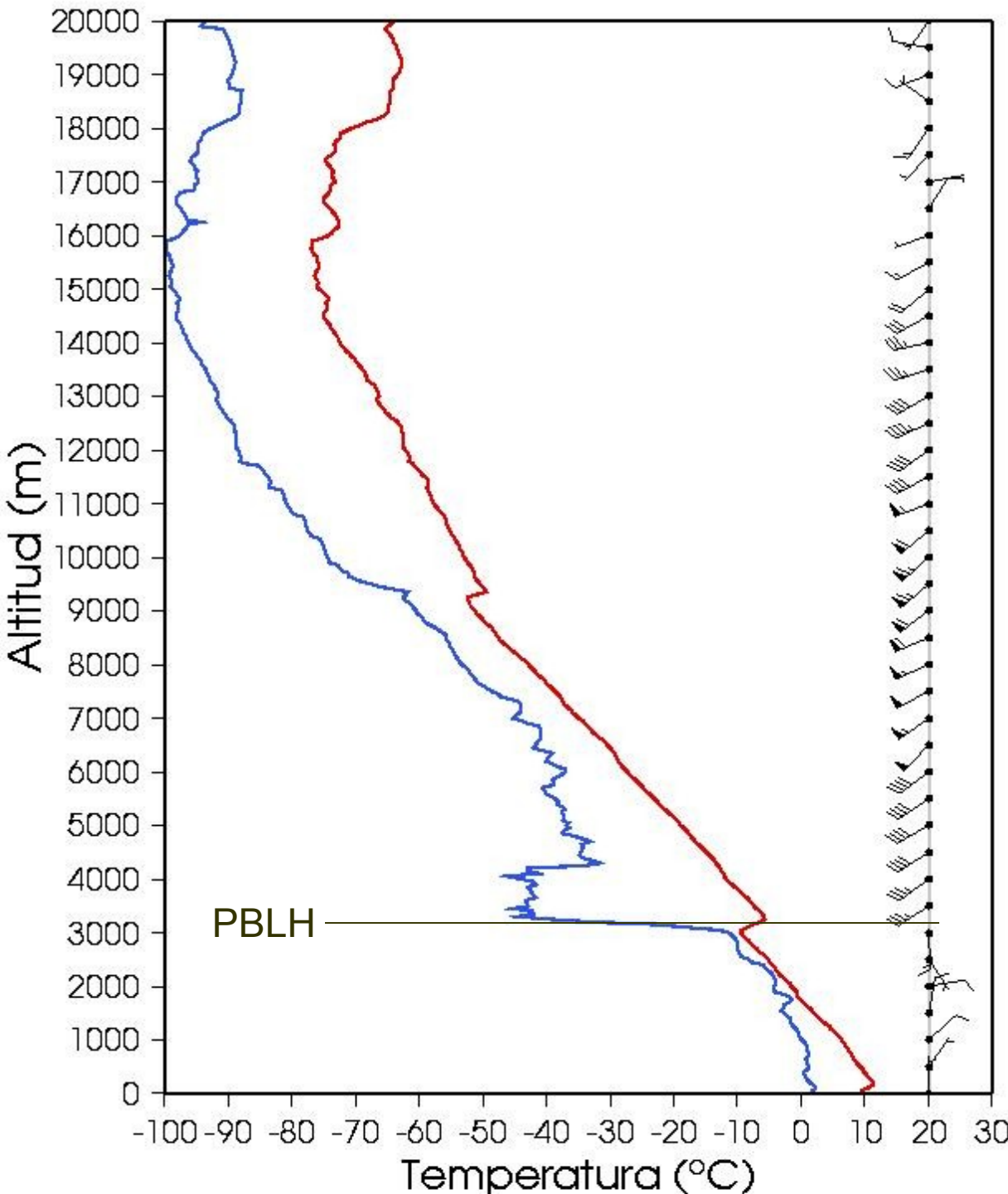
18:00 LST

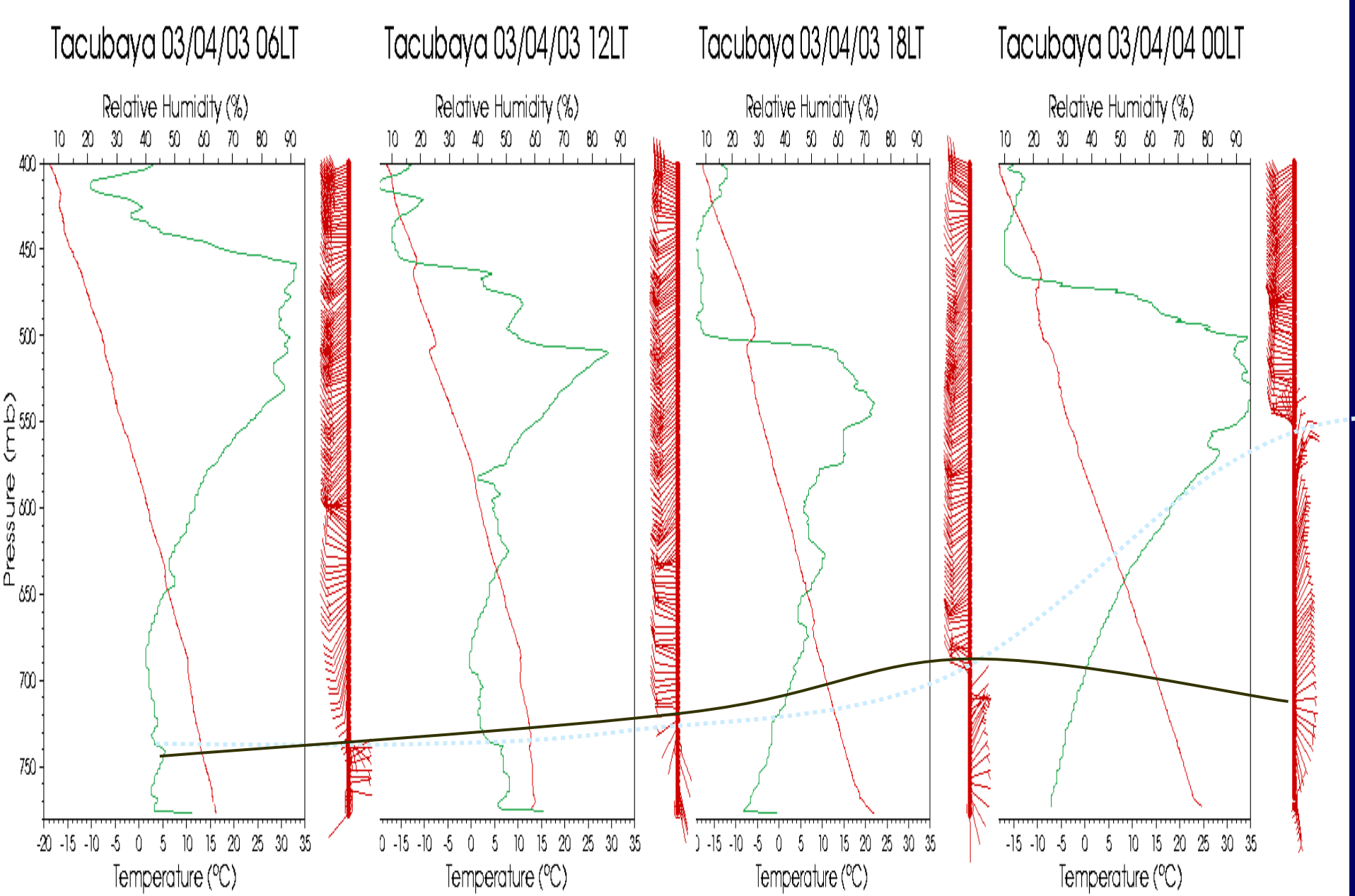




Cuatitlán
Sonde

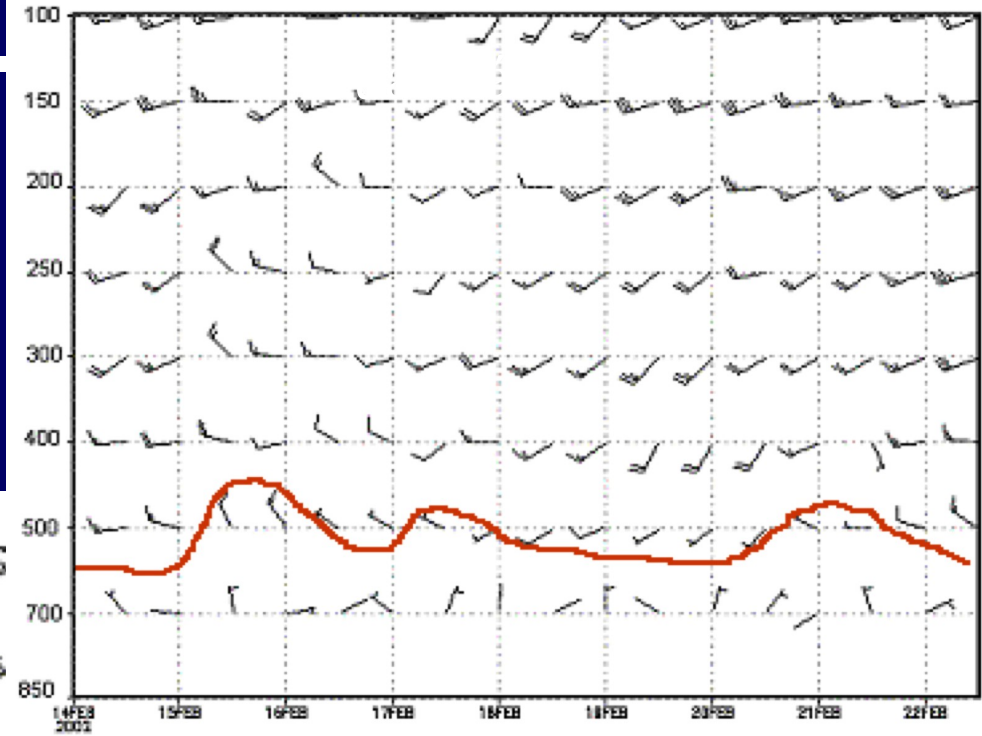
10-02-2002

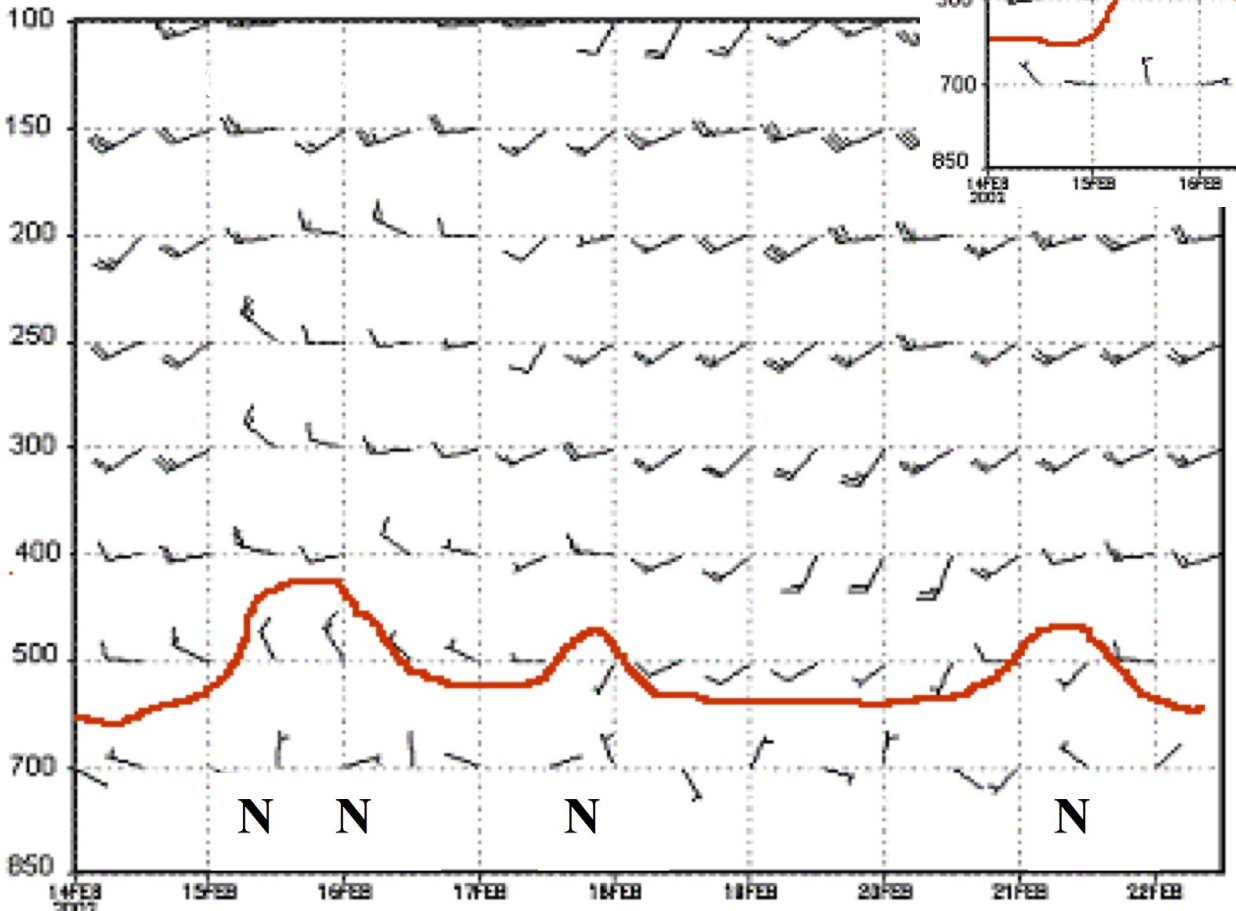




Temporal evolution of the mixed layer can be derived from changes in the direction and intensity of the wind

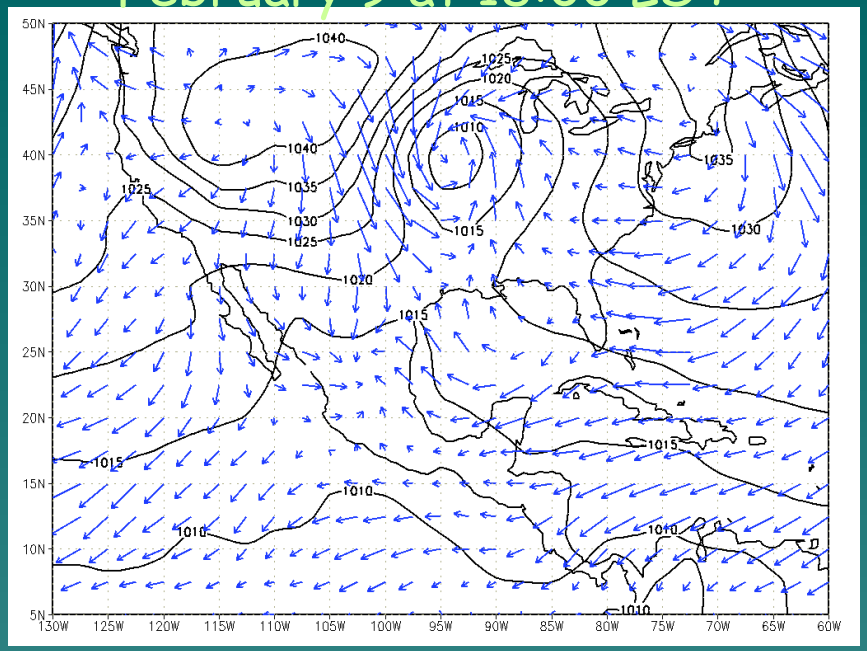
Tacubaya sondes feb. 2002



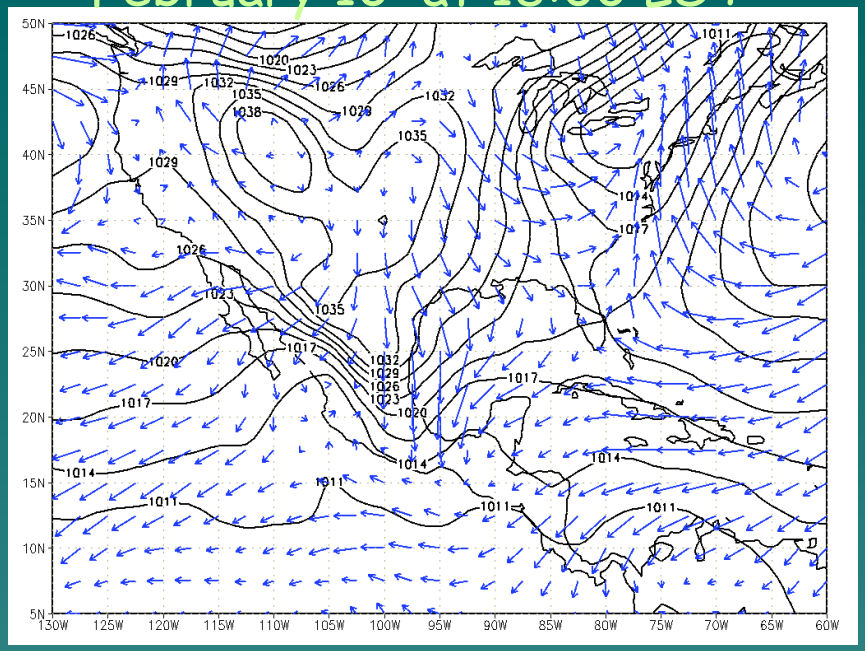


Planetary Boundary Layer

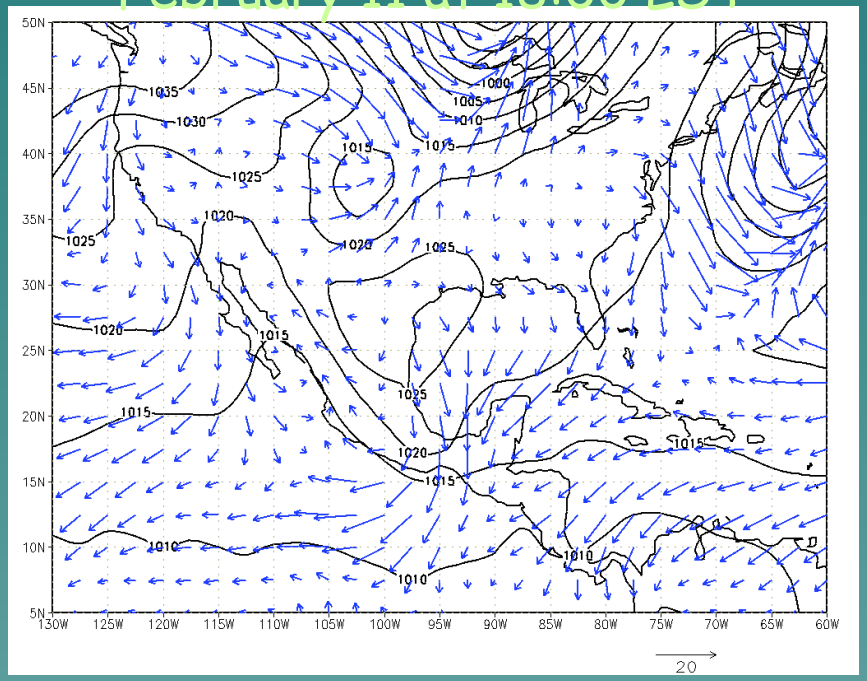
February 9 at 18:00 LST



February 10 at 18:00 LST



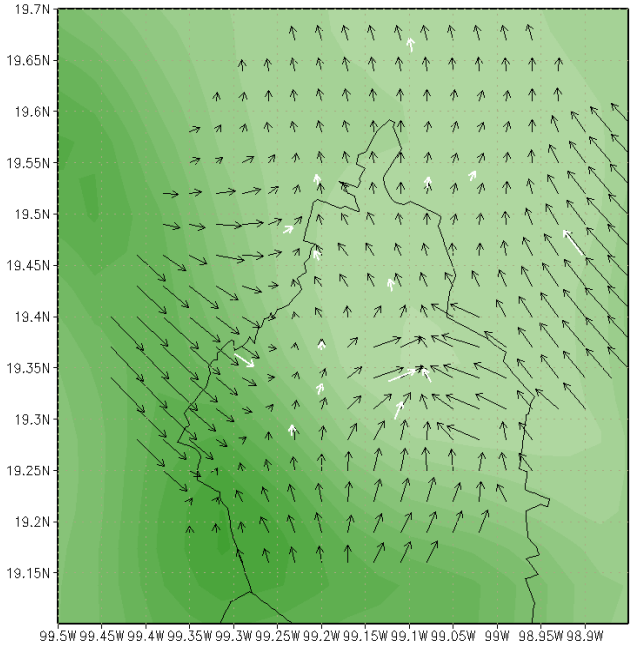
February 11 at 18:00 LST



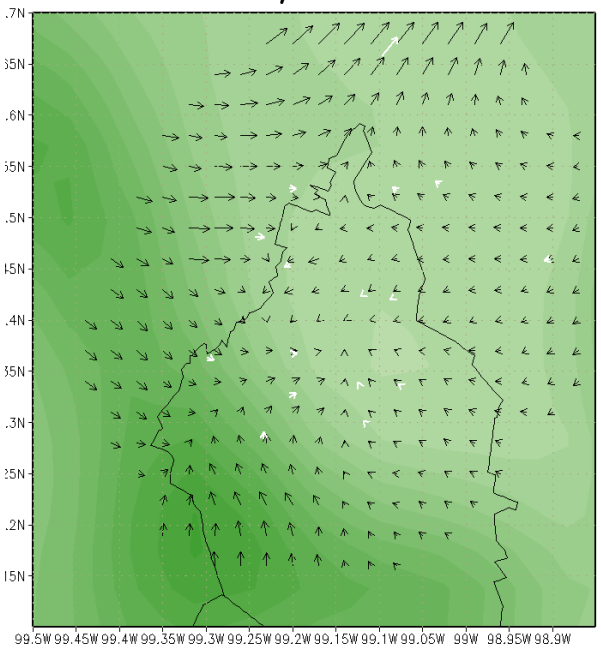
Surface pressure and wind for cold surges (*Norte*) events

good for ventilation

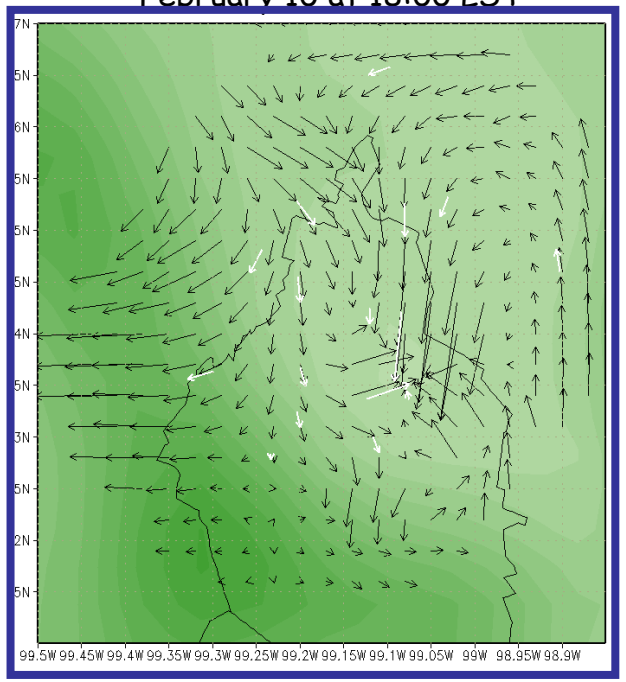
February 9 at 18:00 LST

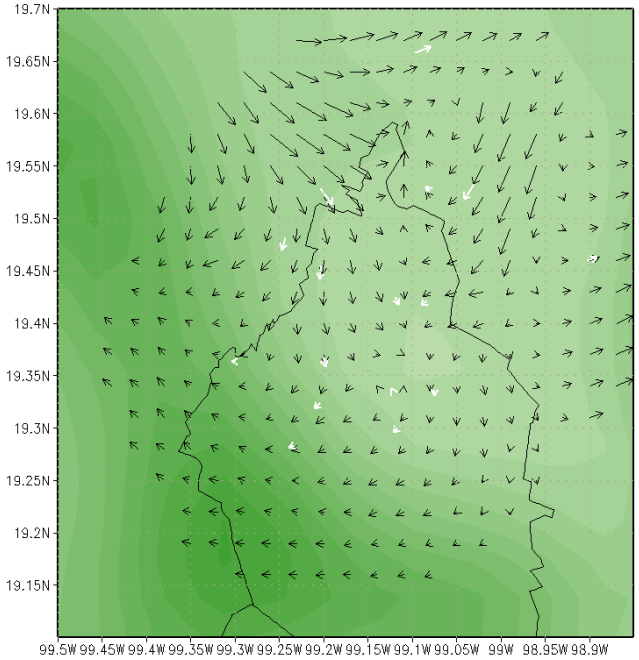


February 10 at 6:00 LST



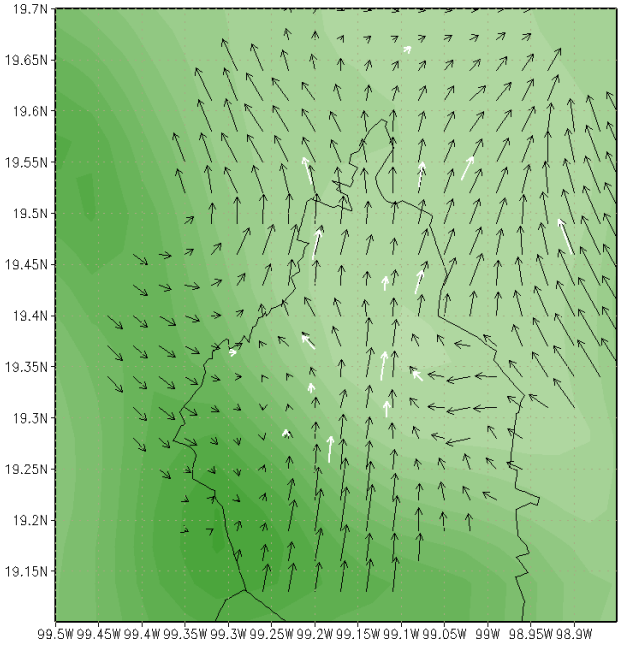
February 10 at 18:00 LST





February 11 at 6:00 LST

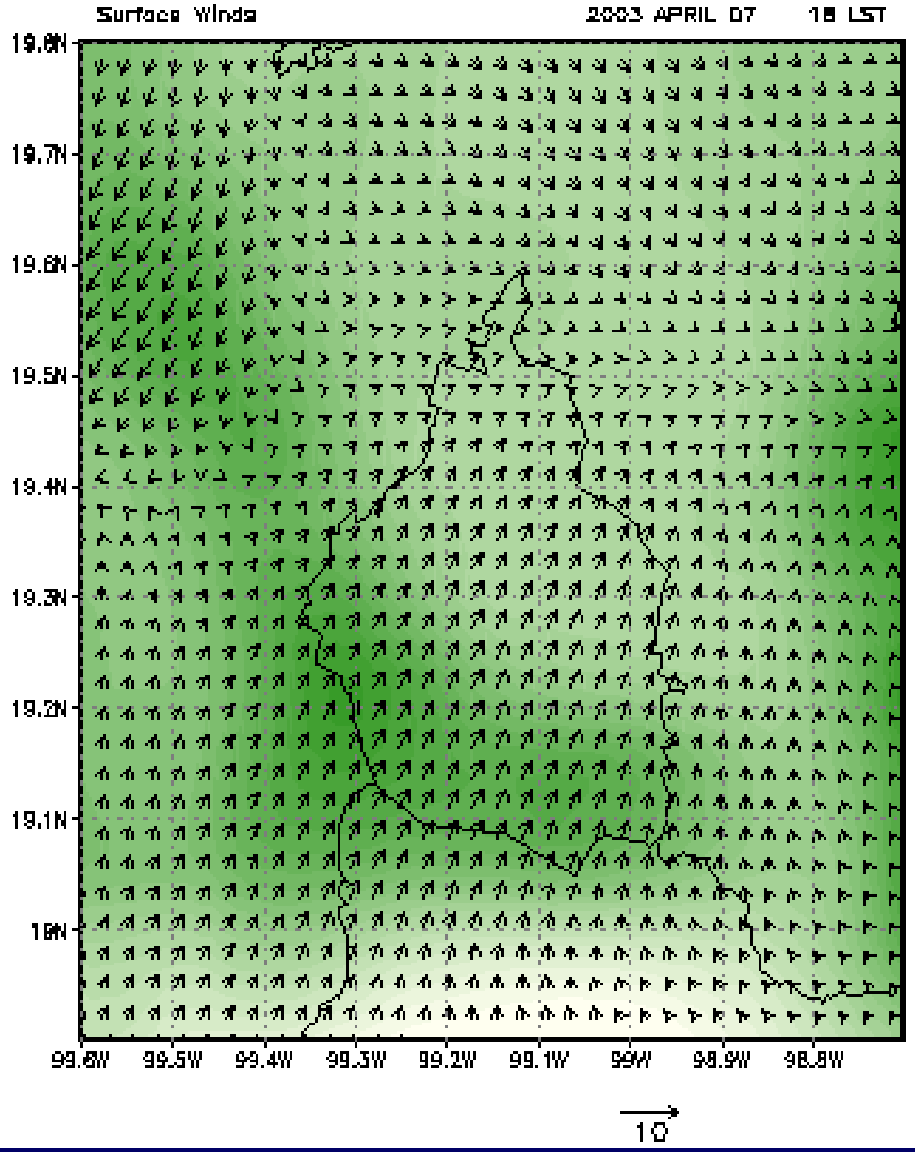
Wind objective analysis
Análisis (m/s) during the
Norte event



February 11 at 18:00 LST

MM5

Simulation



Meteorological Modelling

1. 36 hours weather forecasting for Mexico Valley routinely prepared with the high resolution (8 km horizontal grid space) MM5 model.

2. The initial conditions were prepared every morning with the assimilation of surface and upper air data obtained by the operational network and the stations instrumented for the Field Campaign.

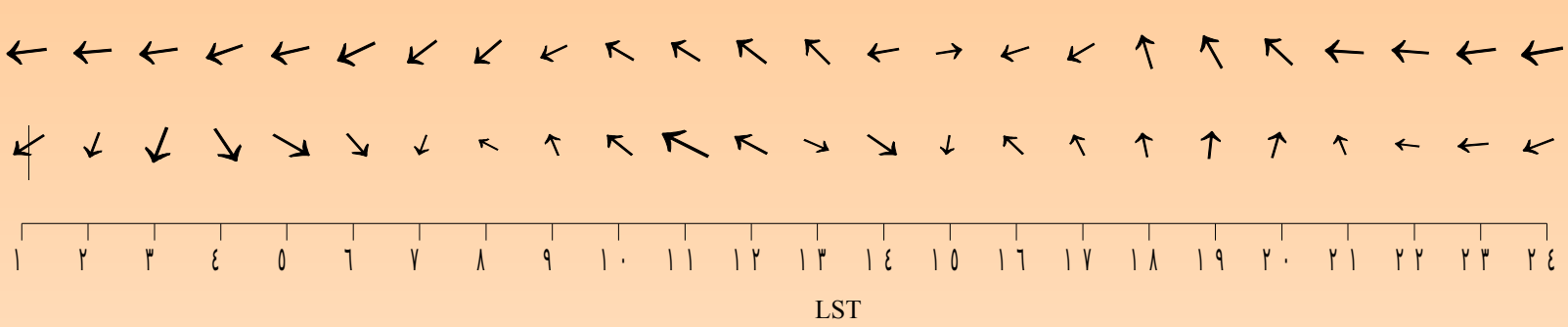
3. Evaluation of the MM5 prediction (surface winds, radiation, temperature profile etc.).

4. April 2003 three-dimensional hourly mesoscale analyses for meteorological fields were prepared by assimilation of all meteorological data available during field campaign period, into MM5 forecasting .

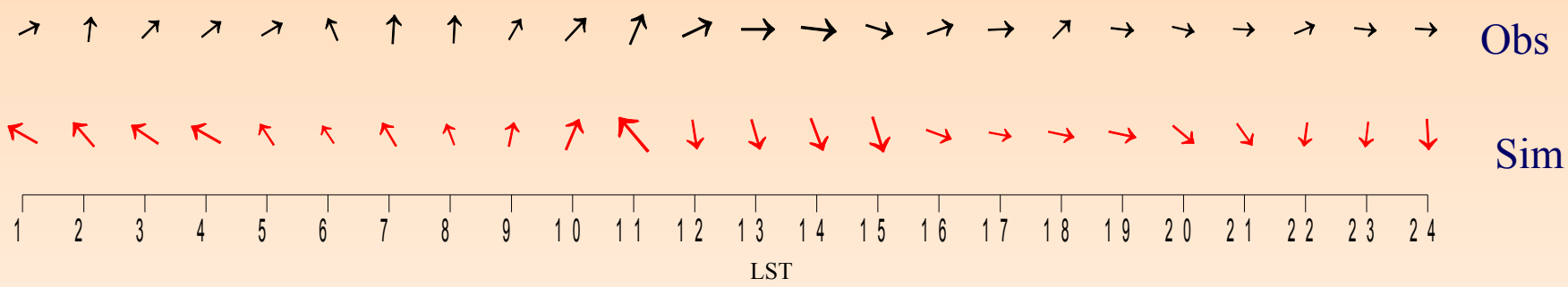
5. Continuous asimilation of observations (nudging) for the data collected during the campaigns

Cerro Catedral

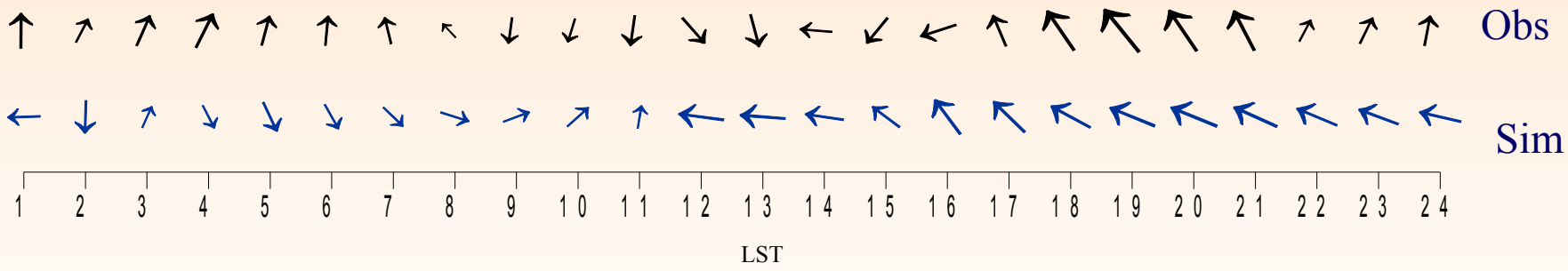
April 3 2003



ININ

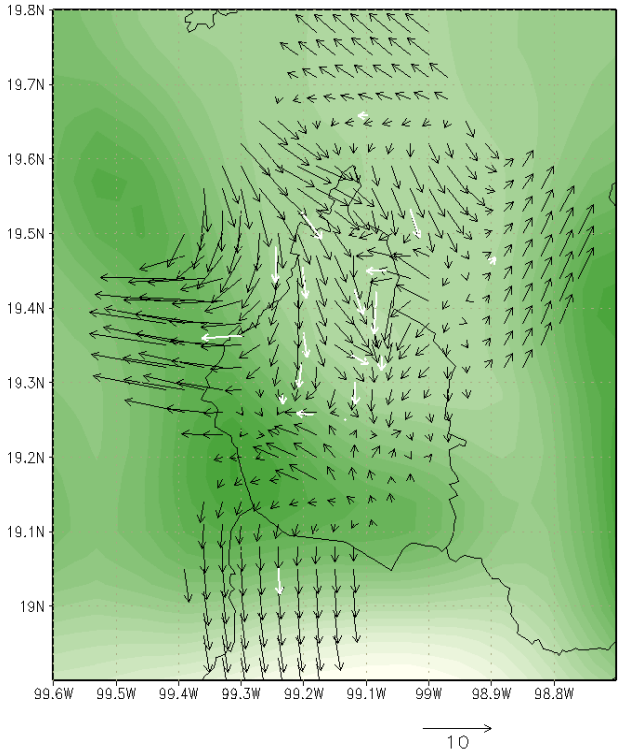


Santa Ana

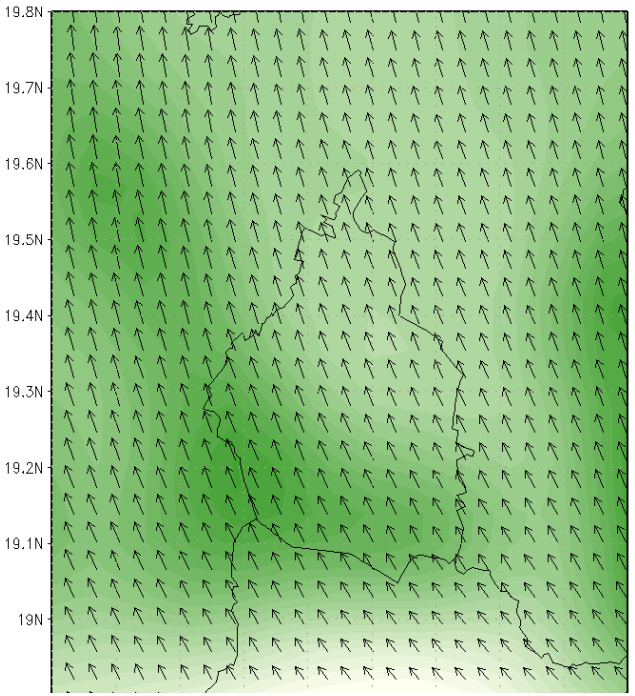


First step is to analyze the quality of wind surface simulations

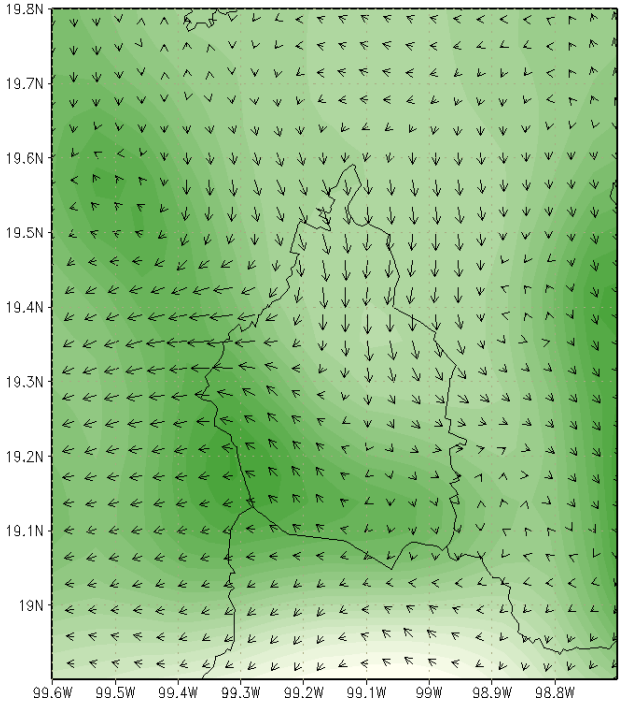
Objective analysis



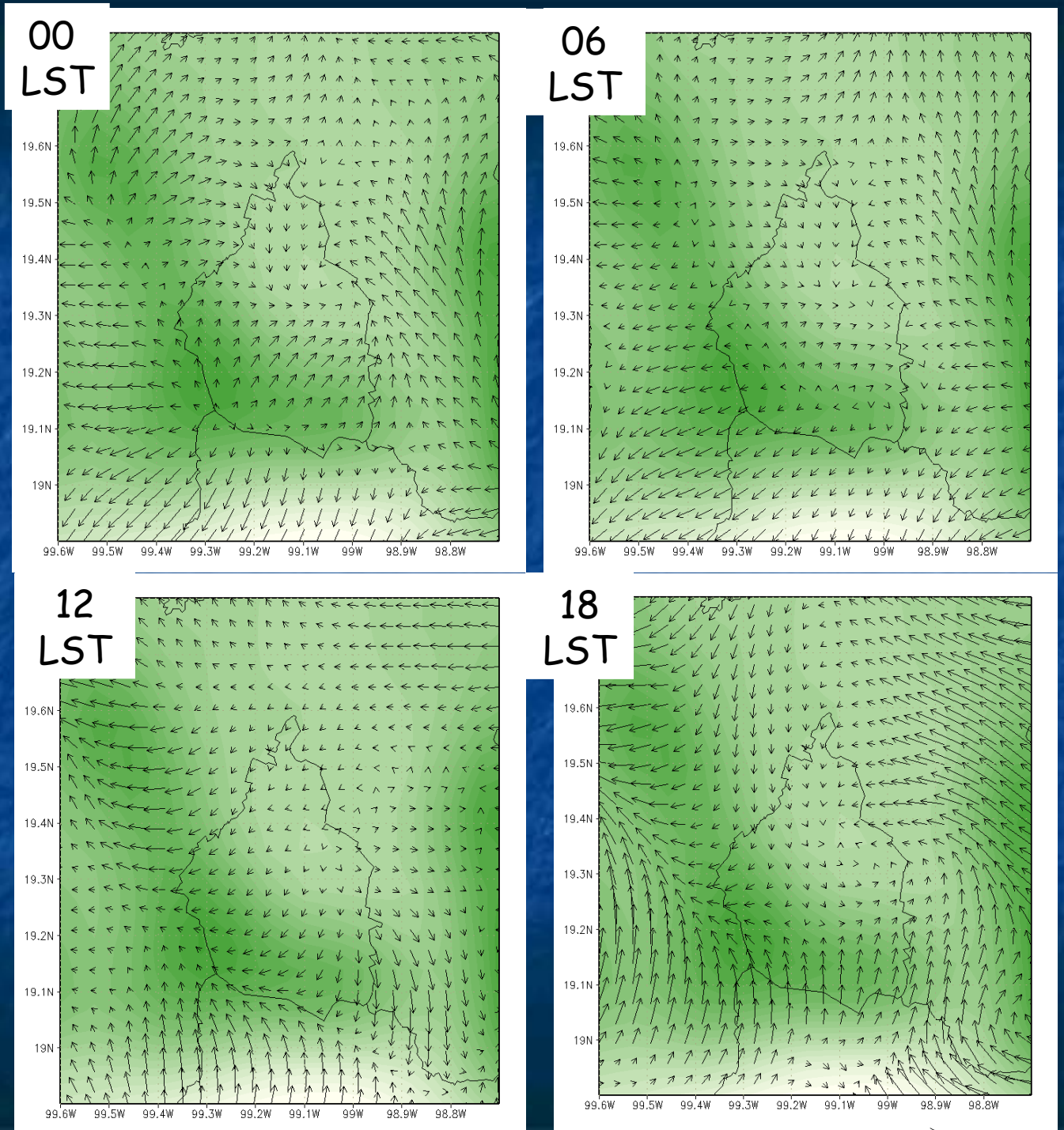
MM5 Initial conditions



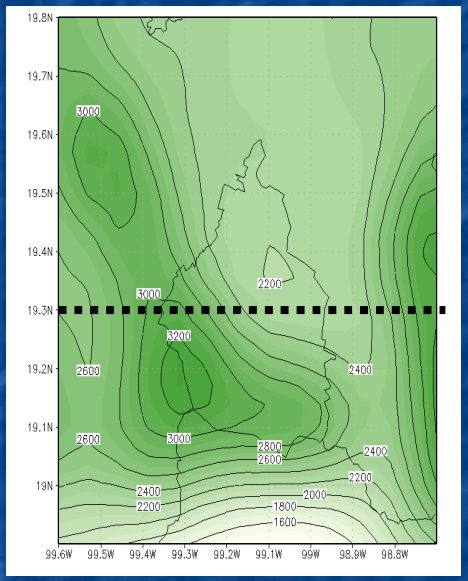
"asimilation Data" Initial condition

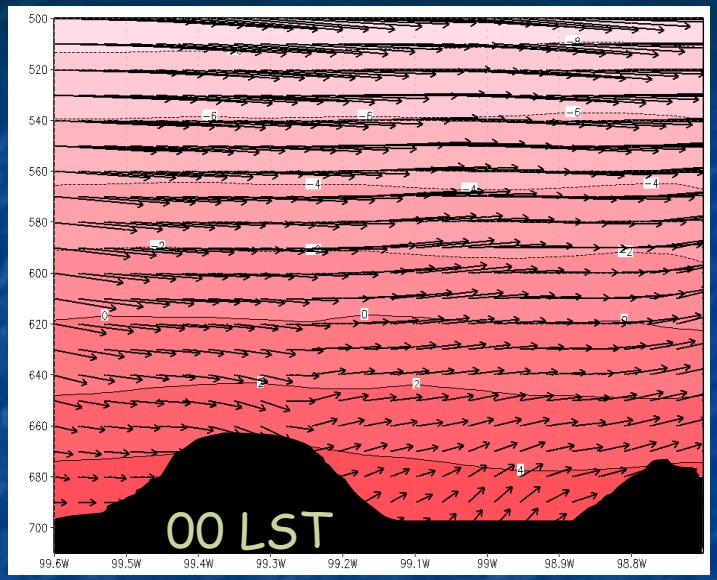


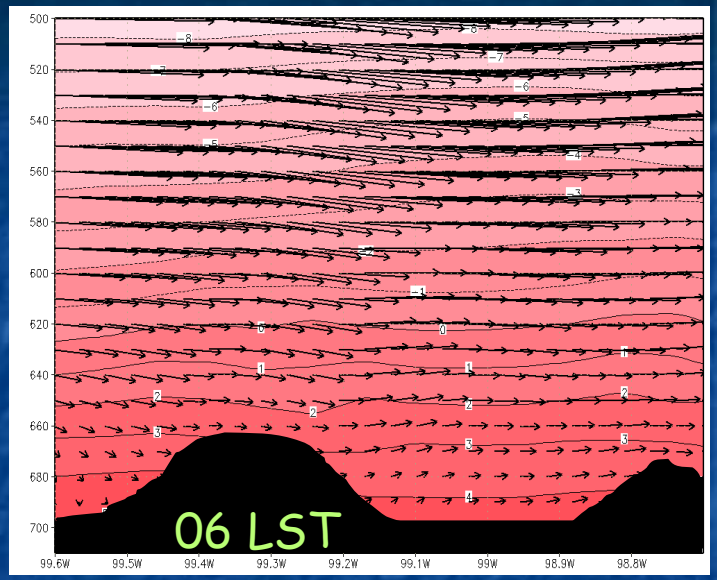
Average hourly of "assimilated" surface wind fields (m / s) February 2002

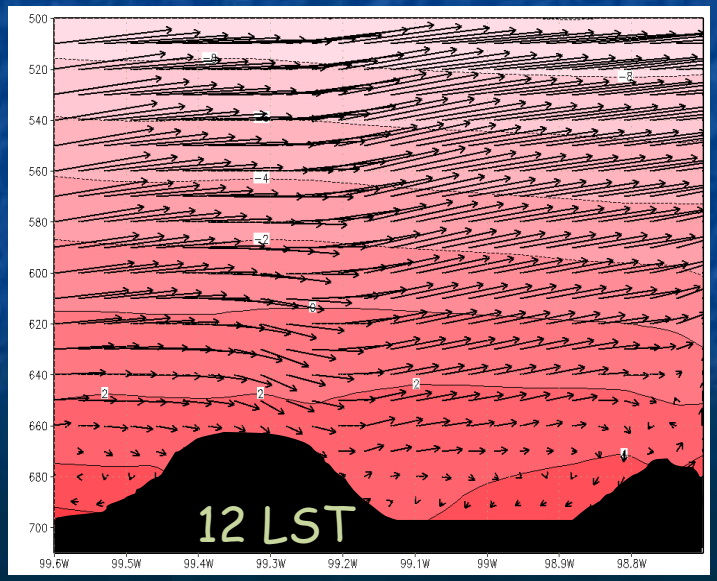


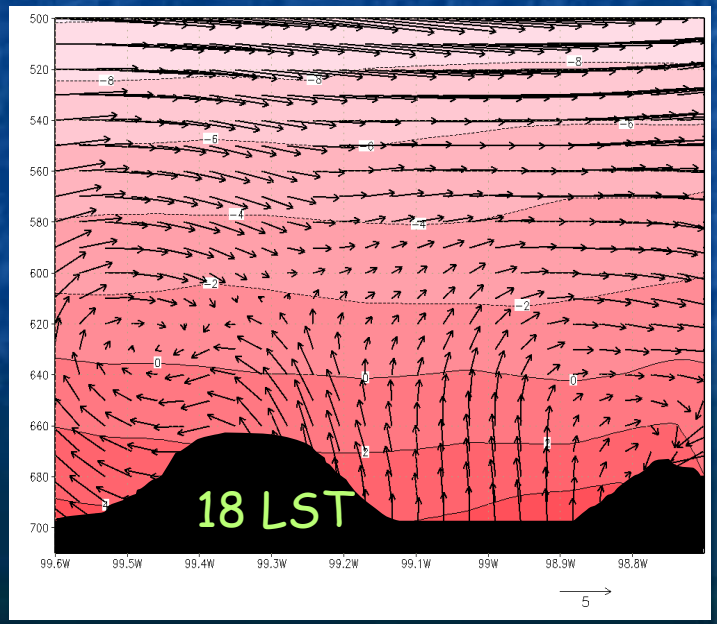
zonal cross section of mean hourly wind (m/s) simulated by the MM5 for February 2002



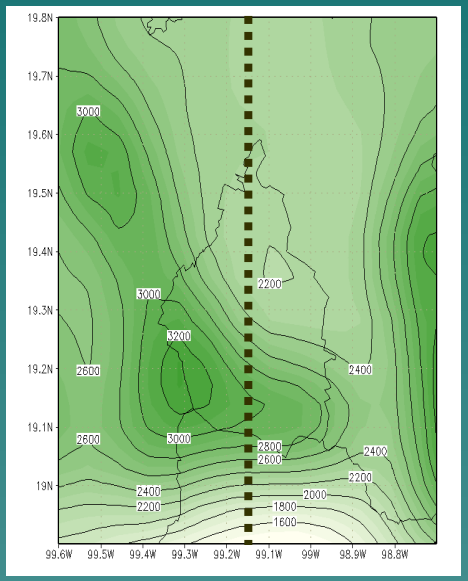


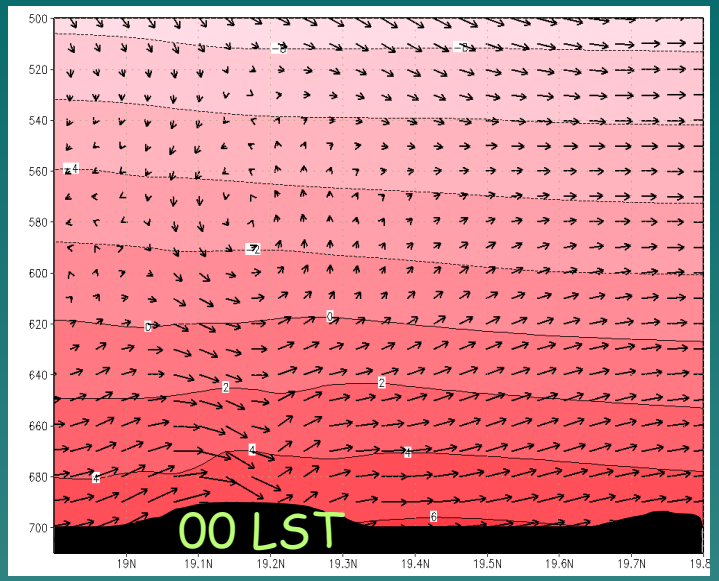


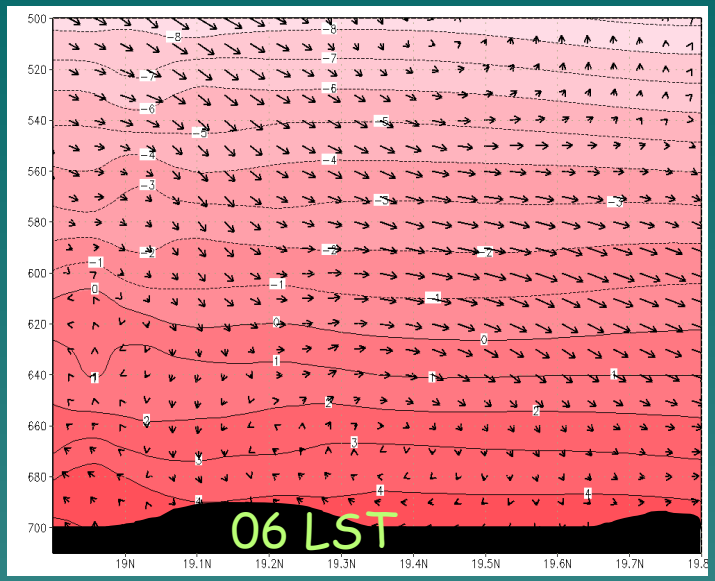


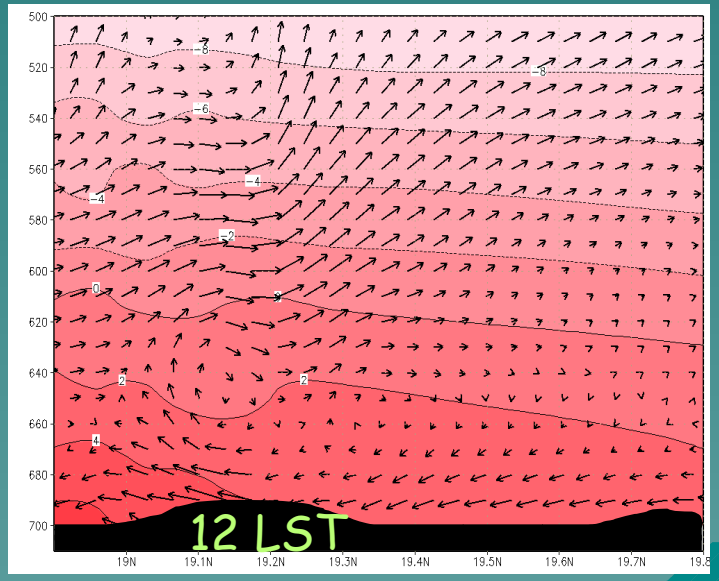


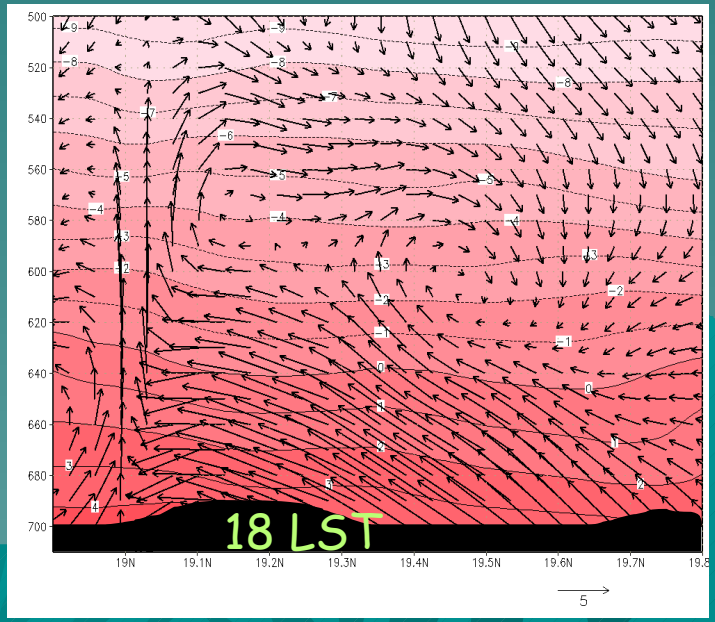
Meridional cross section of mean hourly wind (m/s) simulated by the MM5 for February 2002



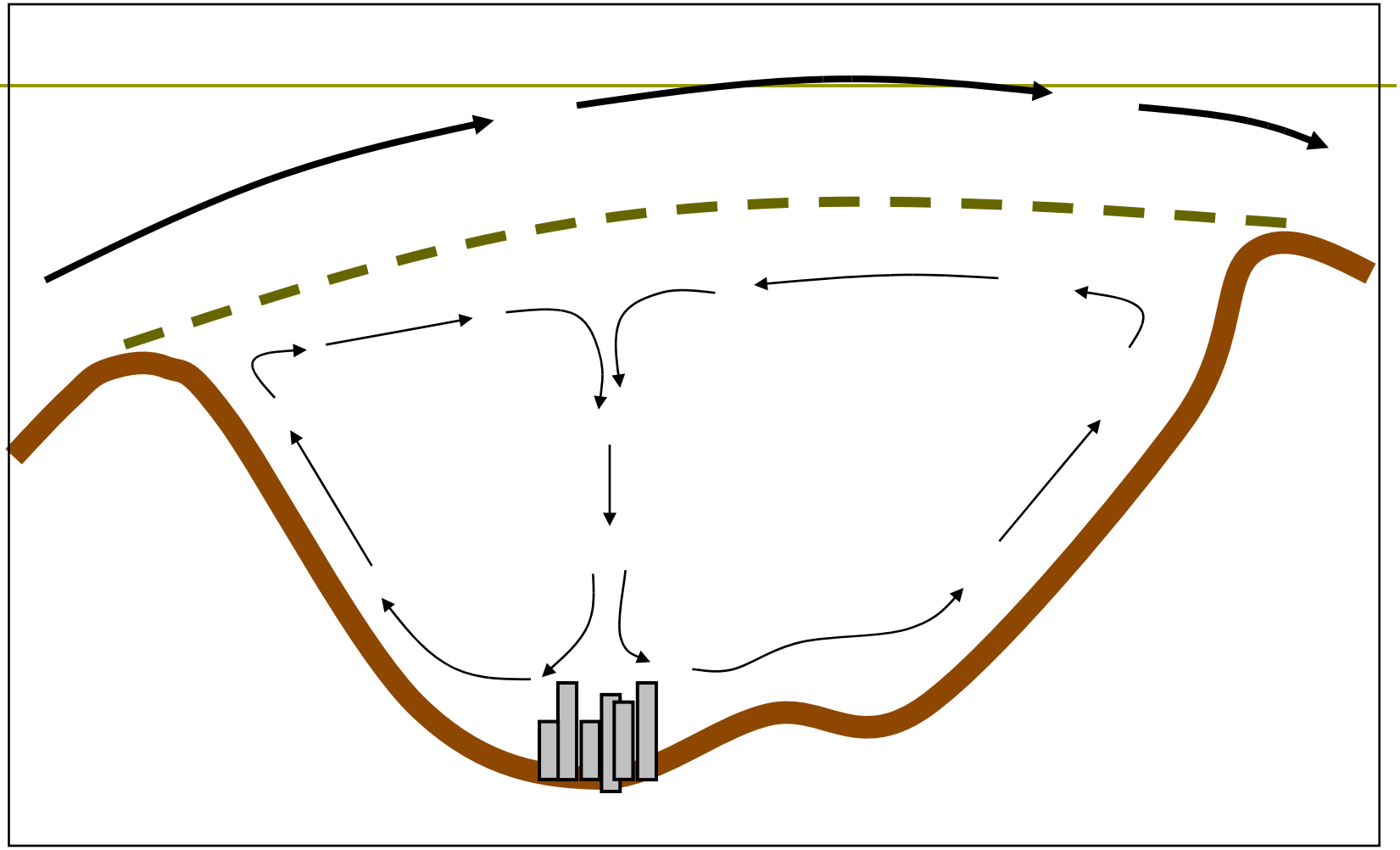


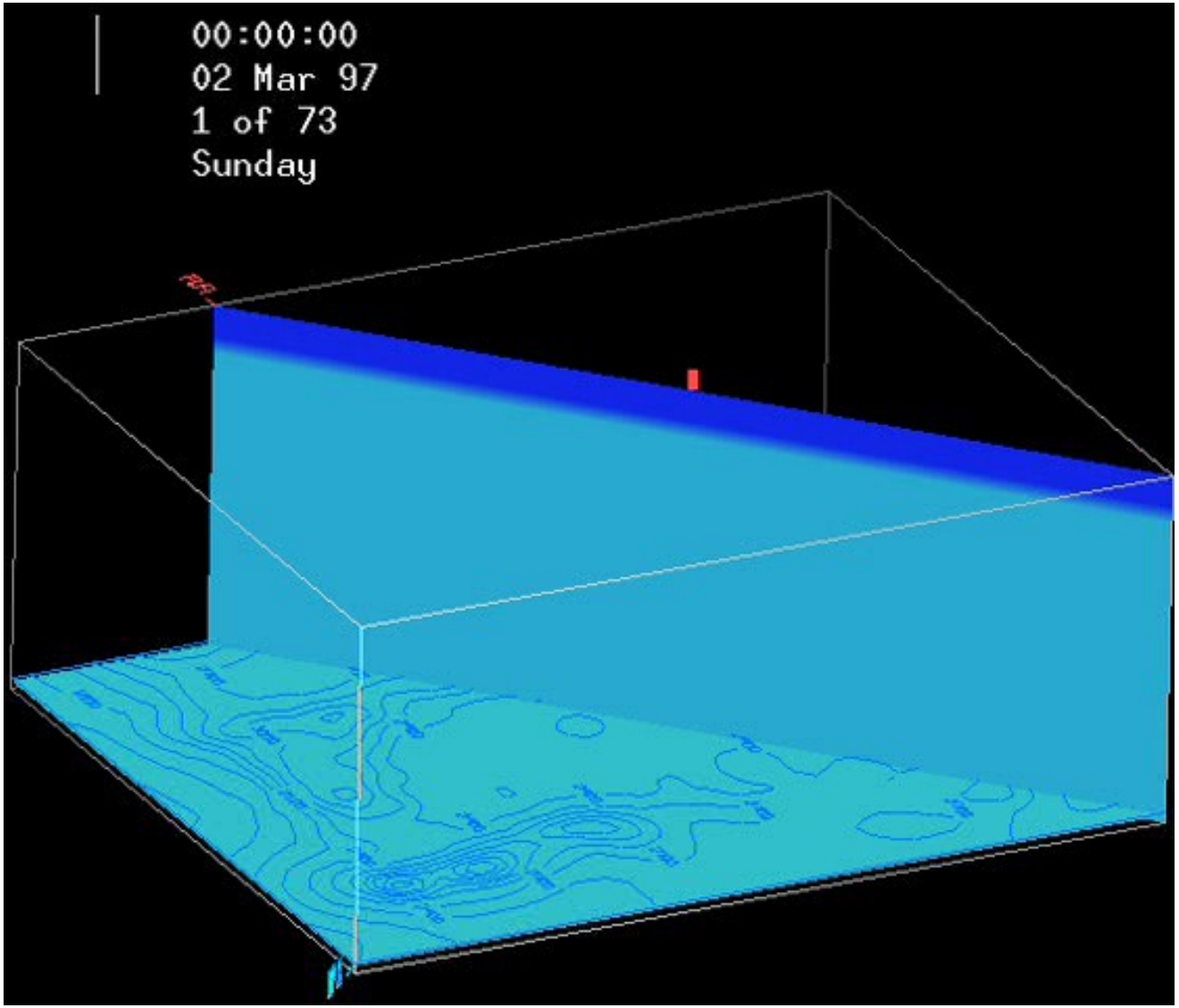






DIRECT LOCAL CIRCULATION



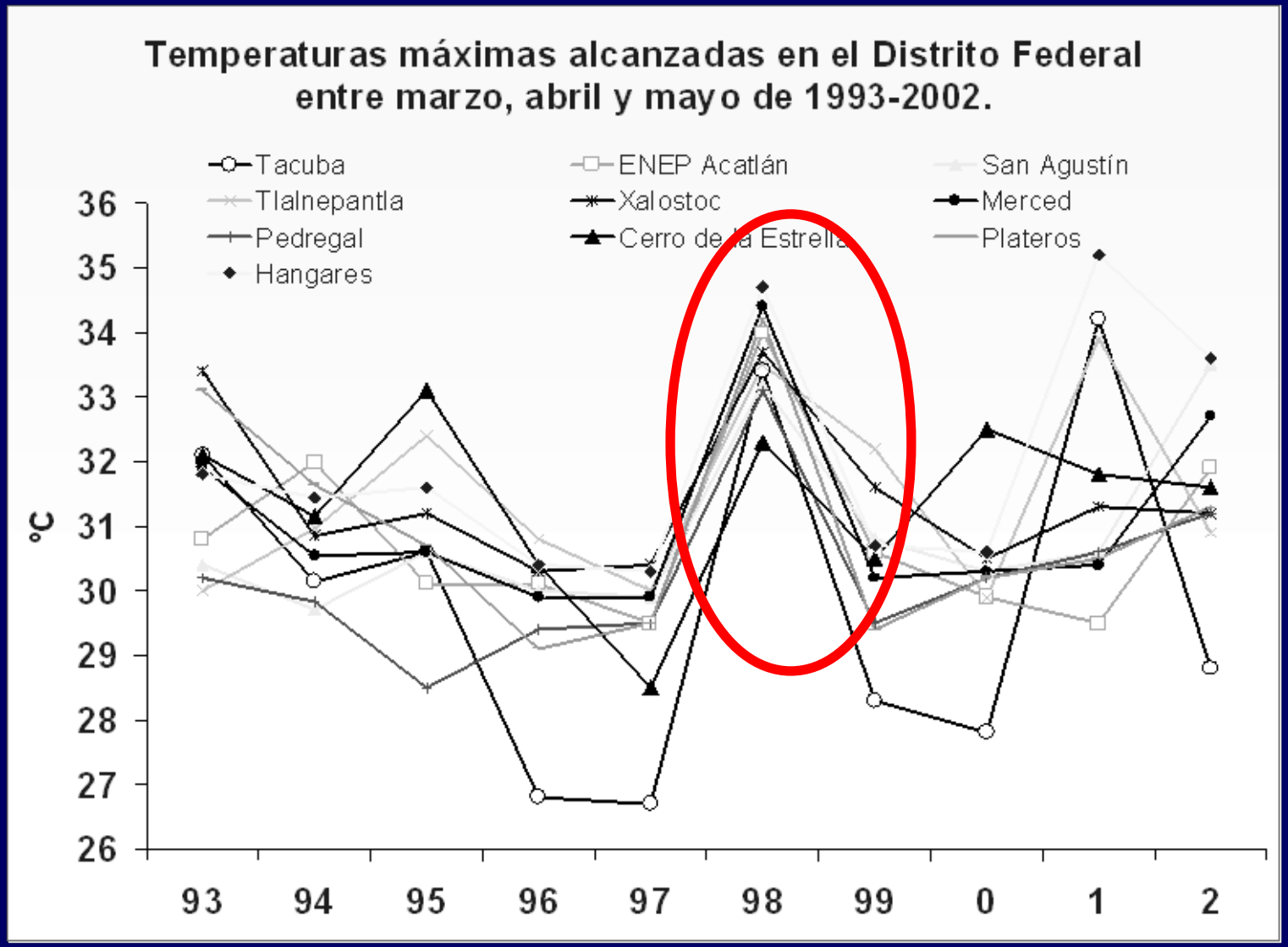

00:00:00
02 Mar 97
1 of 73
Sunday

Landuse Change and air quality

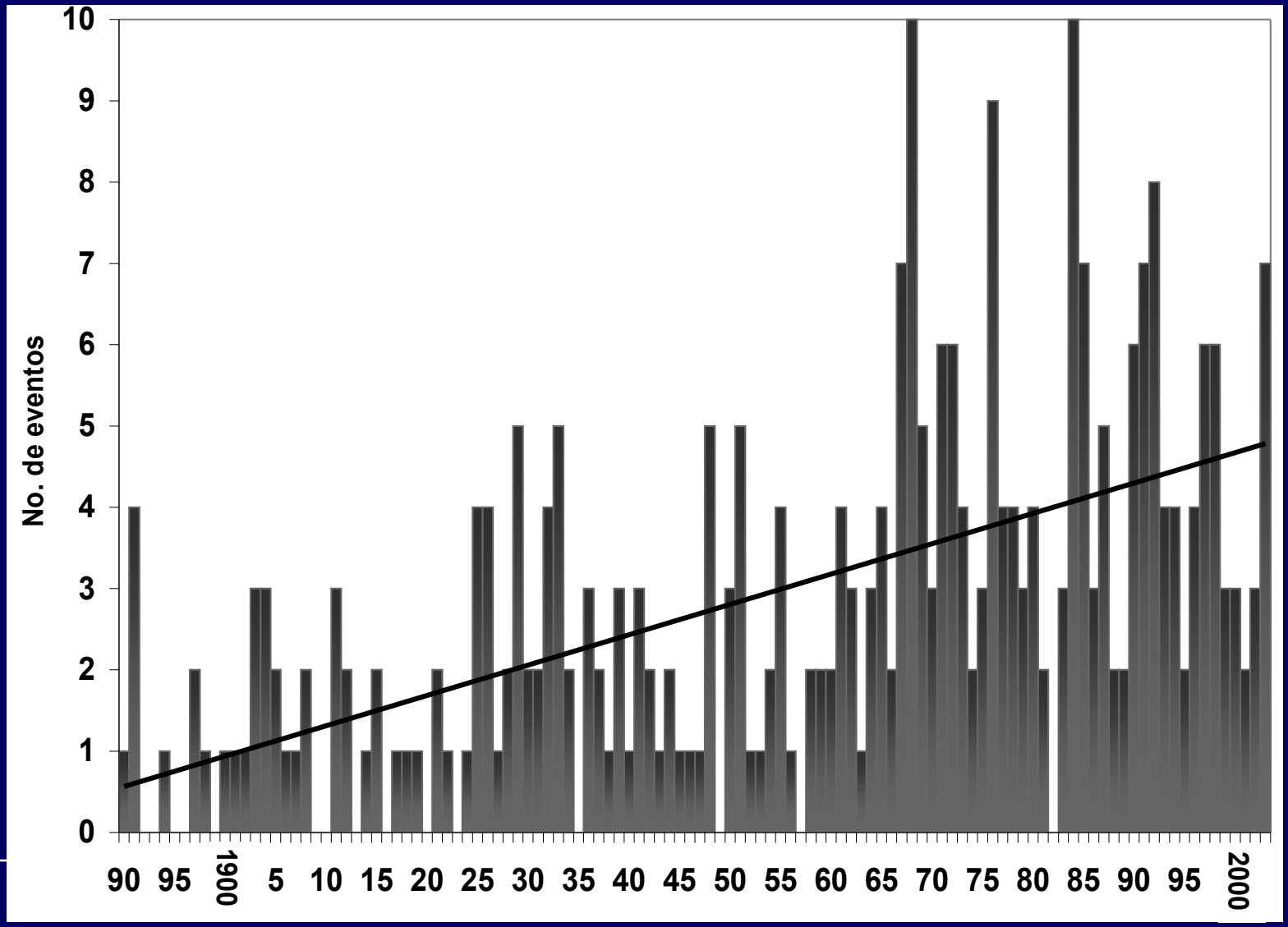
The process of urbanization has led to changes in local climate as the heat island

To what extent the changes in landuse lead to changes in local circulation of the winds?

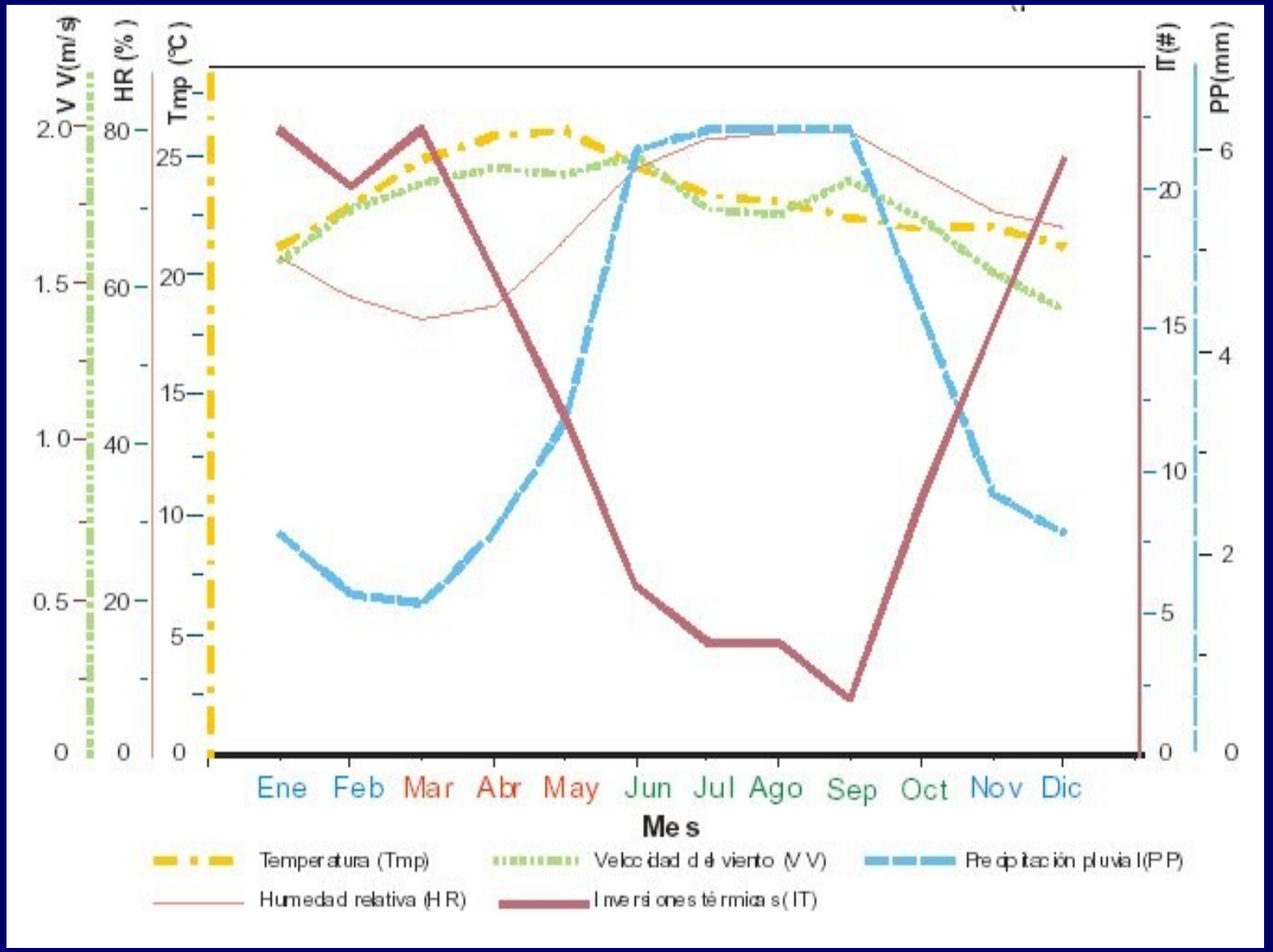
Maxima Temperatures for March, April and May 1993-2002

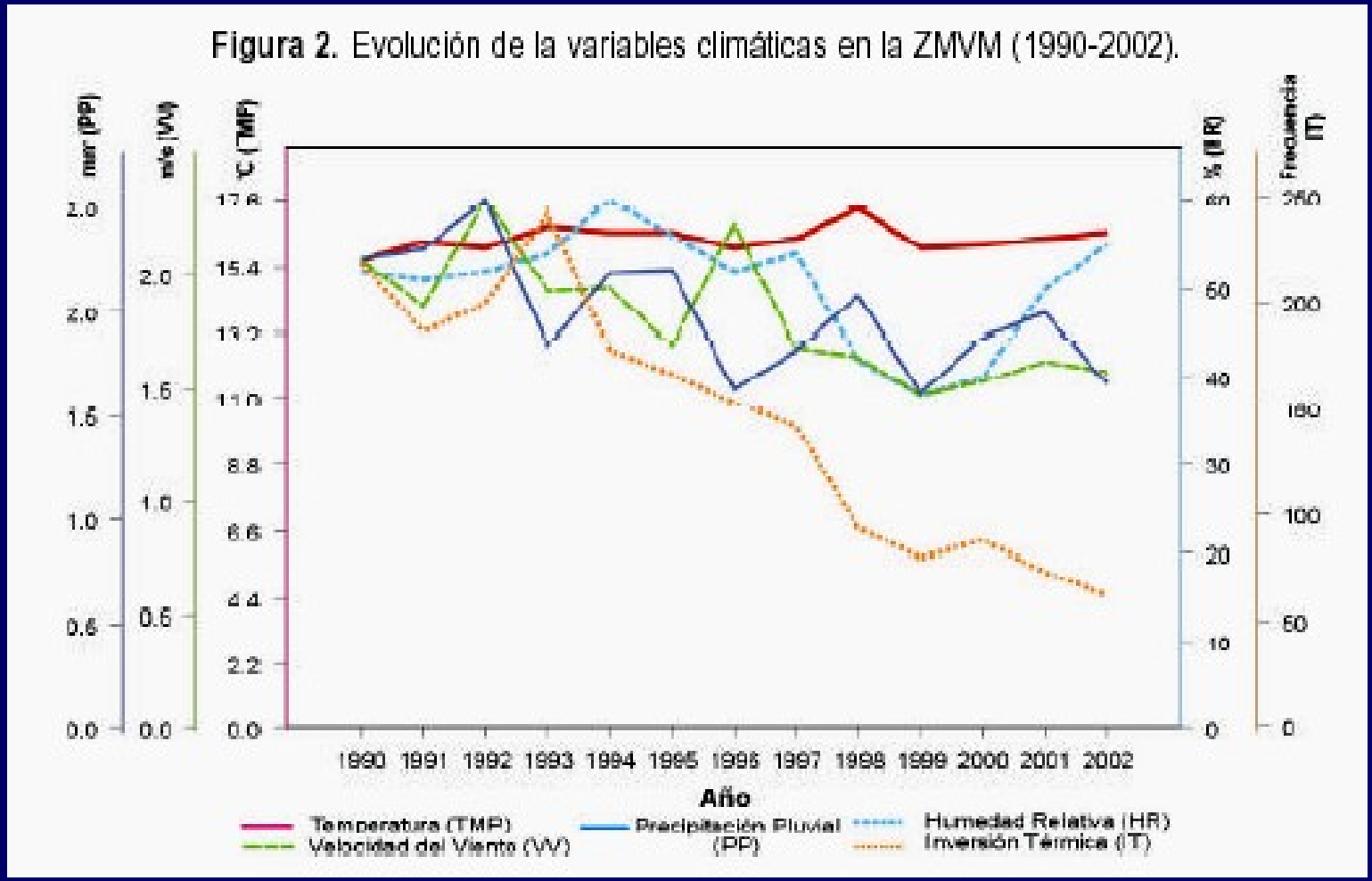


Number of extreme precipitation events (> 30 mm / day) Tacubaya station between 1890 and 2003



Annual Cycle





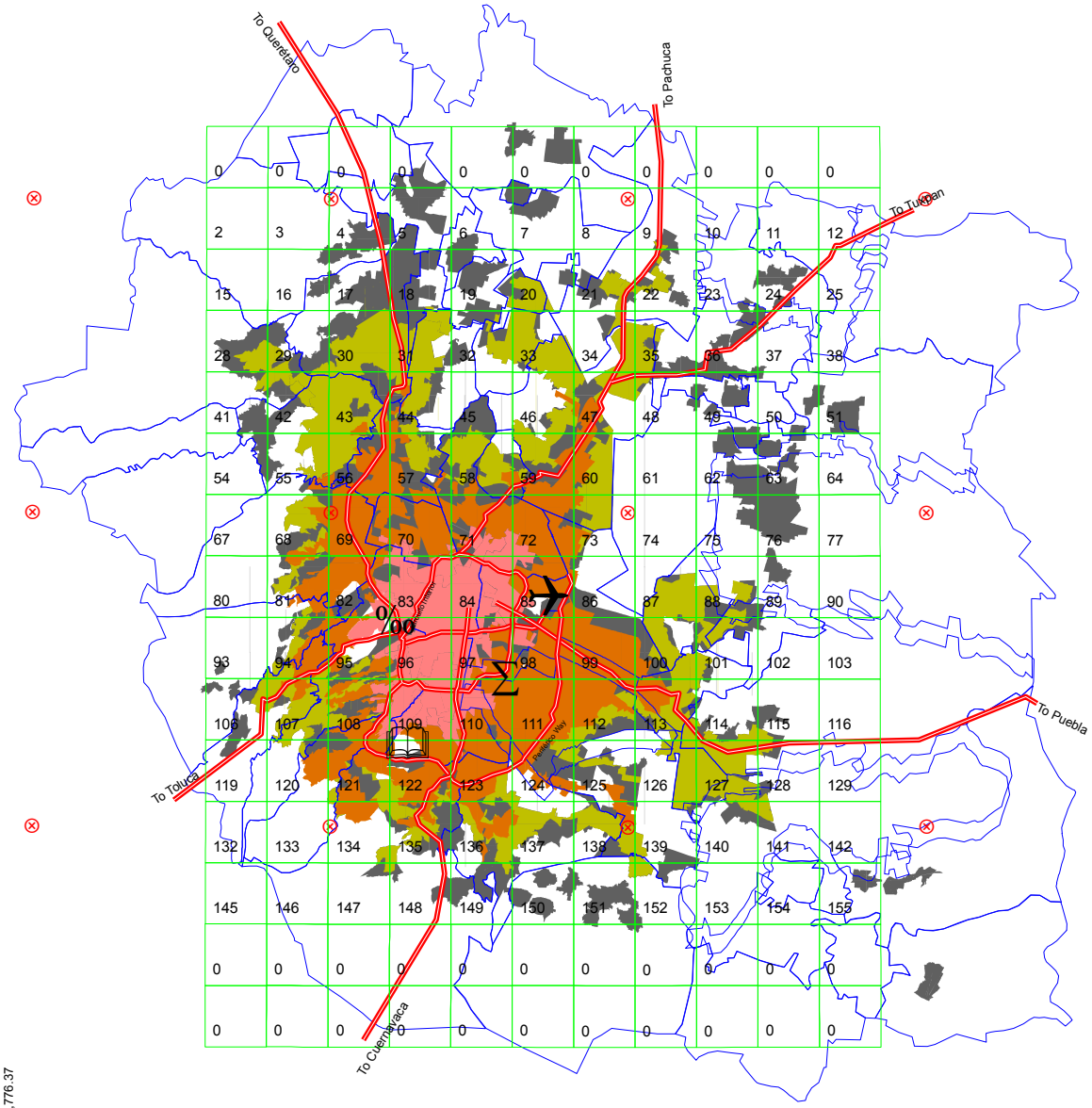
GDF Report : the thermal inversion is reducing

447,696.07 500,000 552,303.93

2,211,427.83

2,100,776.37

Urban growth



México City Metropolitan Area

1953 - 1995

1953

1973

1993

1995

General symbology:

Guía Roji Plane

X= Number of plane

UTM Reference Point

Main avenue or regional way

Airport

Chapultepec Park

Central market

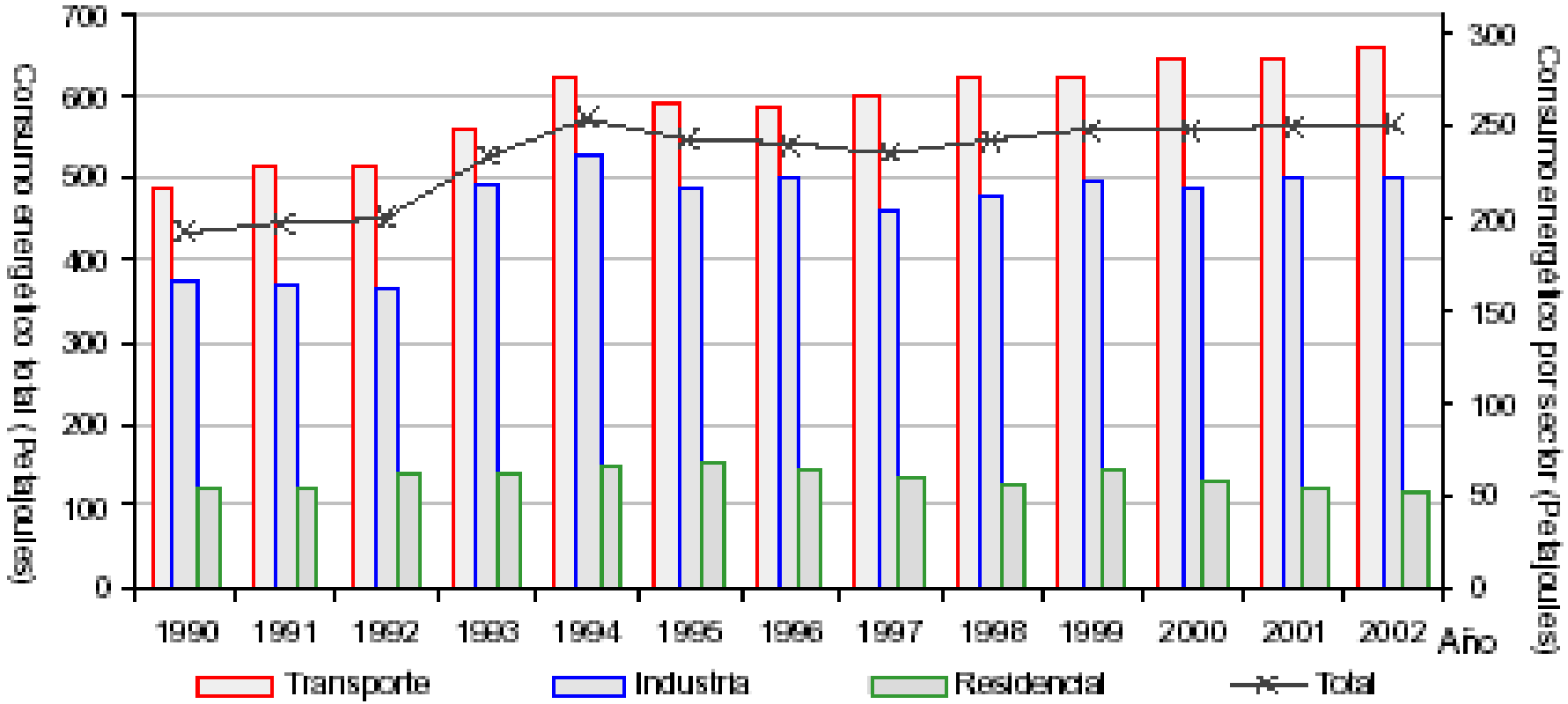
University

0 Kilometers 15 30

2,211,427.83

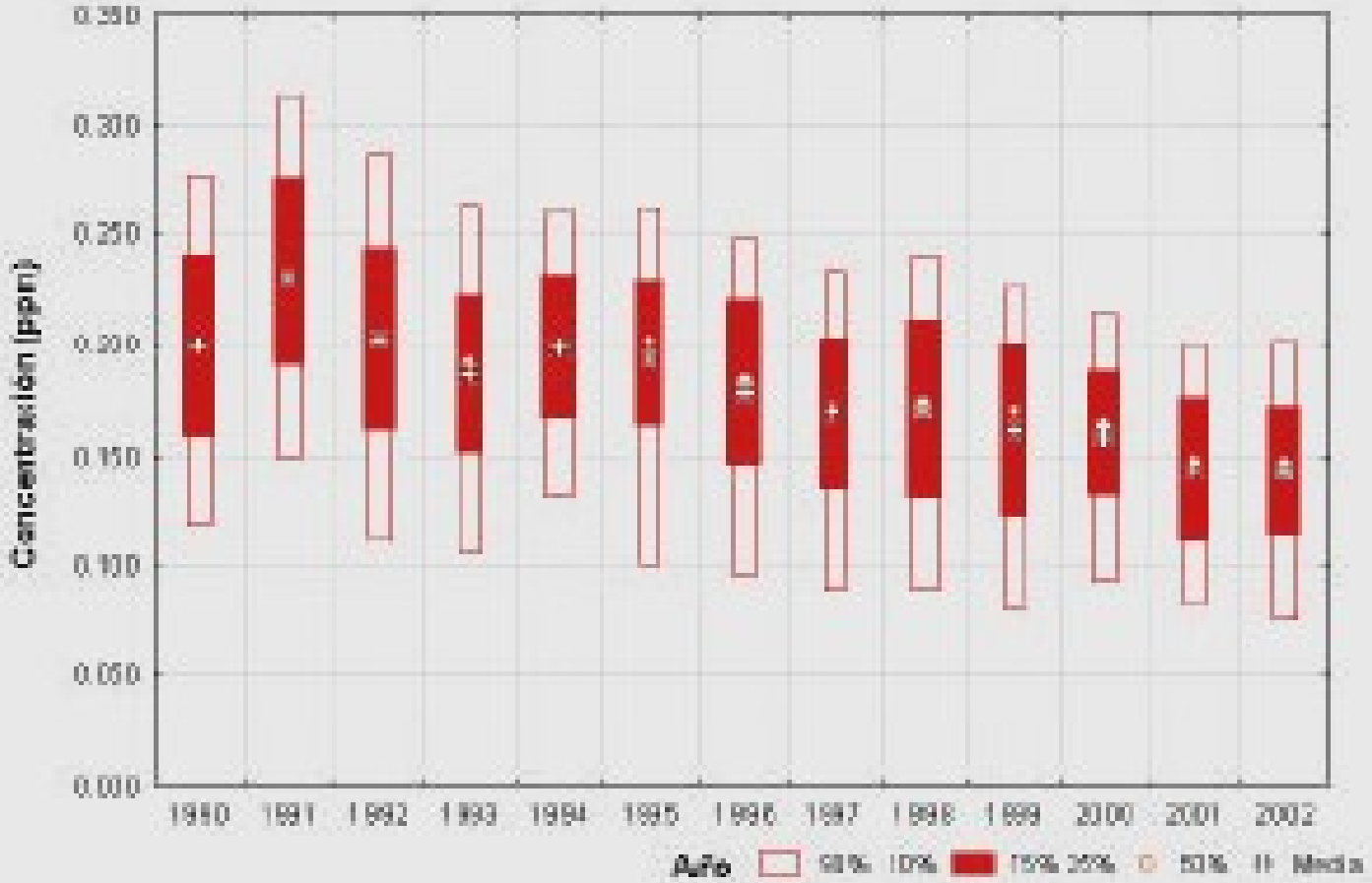
Information Sources:
INEGI, 1990, 1995,
Delgado 2000 .
Map maker: Tonatiuh Suárez Meaney. GeoEstrategias

Figura 1. Distribución por tipo de combustible en la ZMVM (1990–2001).



Fuente: Datos proporcionados por PEMEX GAS Y PETROQUIMICA BÁSICA, PEMEX REFINACIÓN.
Conversión a Petajoules: Dirección de Inventario y Modelación de Emisiones DGGAA-SMA-GDF

Figura 4. Comportamiento de O_3 en la ZMVM, 1990–2002.

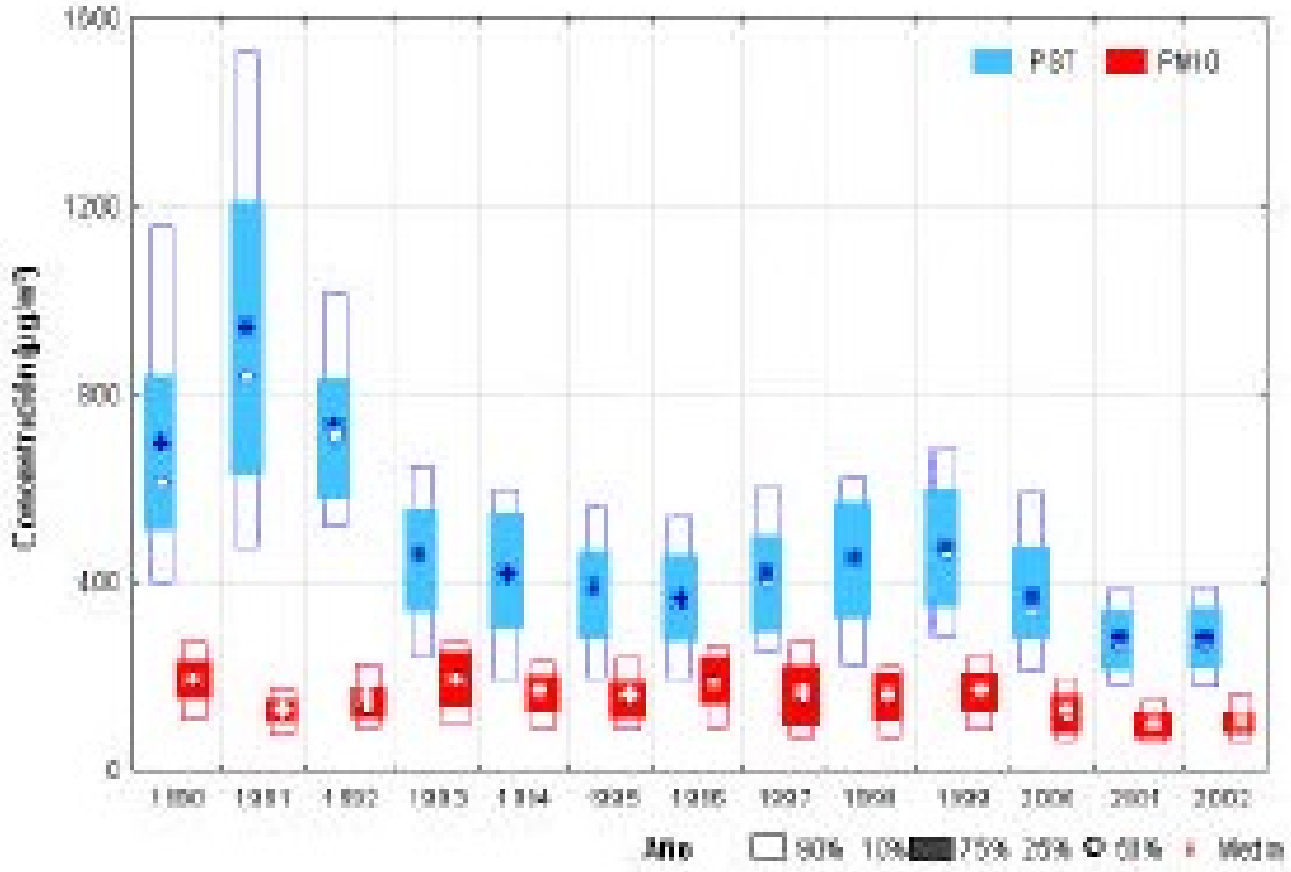


The same is true of some other pollutants

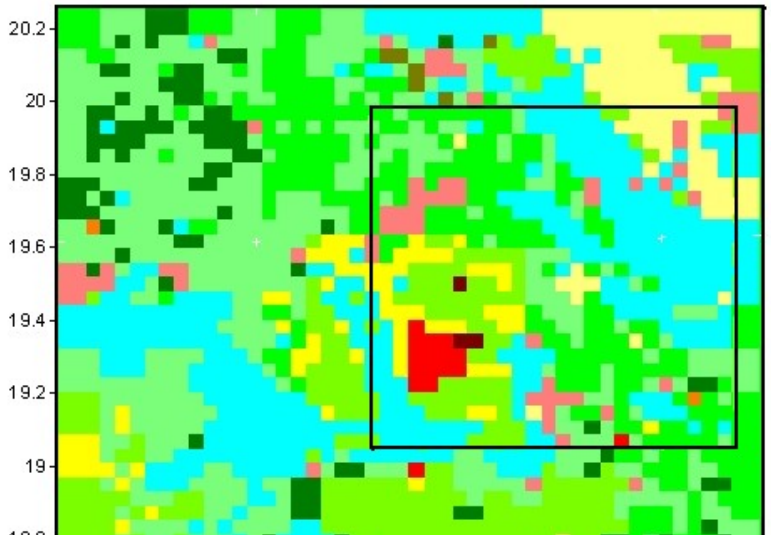
….. As with the suspended particles. The question is then:

How much of that pollution is reduced by the measurements and how is reduced by the meteorology? Has changed the last? Why?

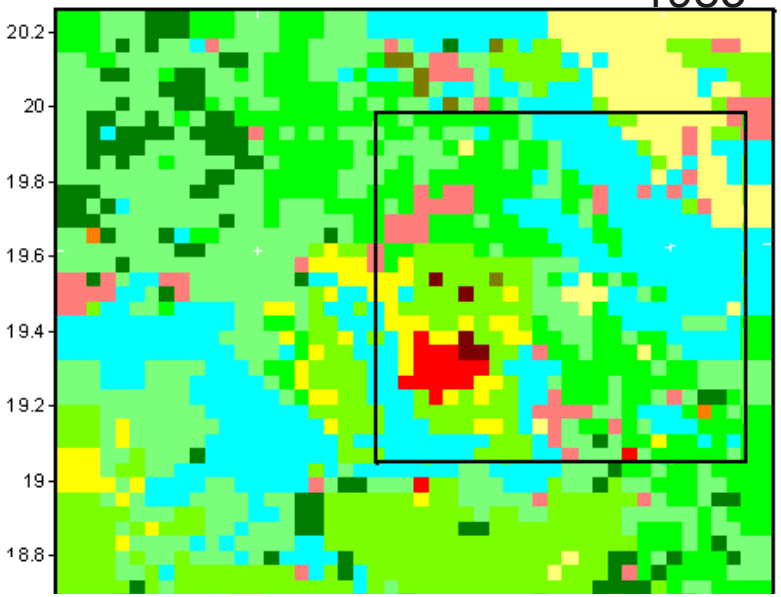
Figura 6. Comportamiento de PST y PM10 en la ZMVM, 1990-2002.



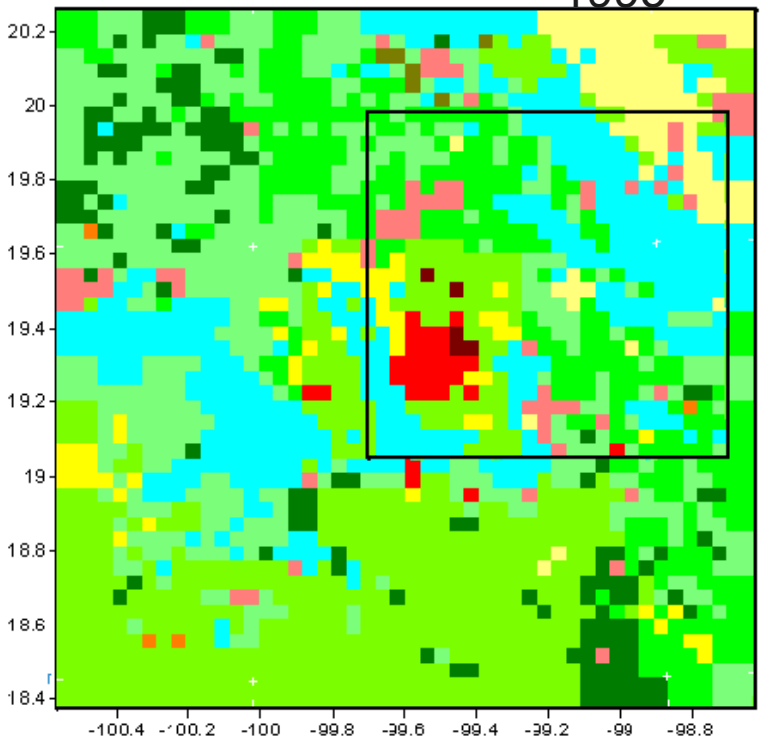
1976



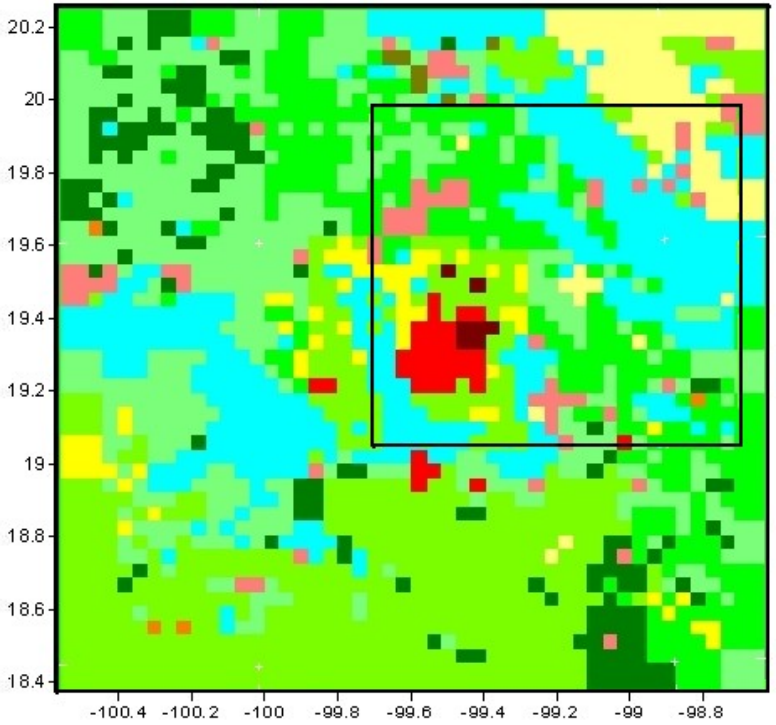
1983

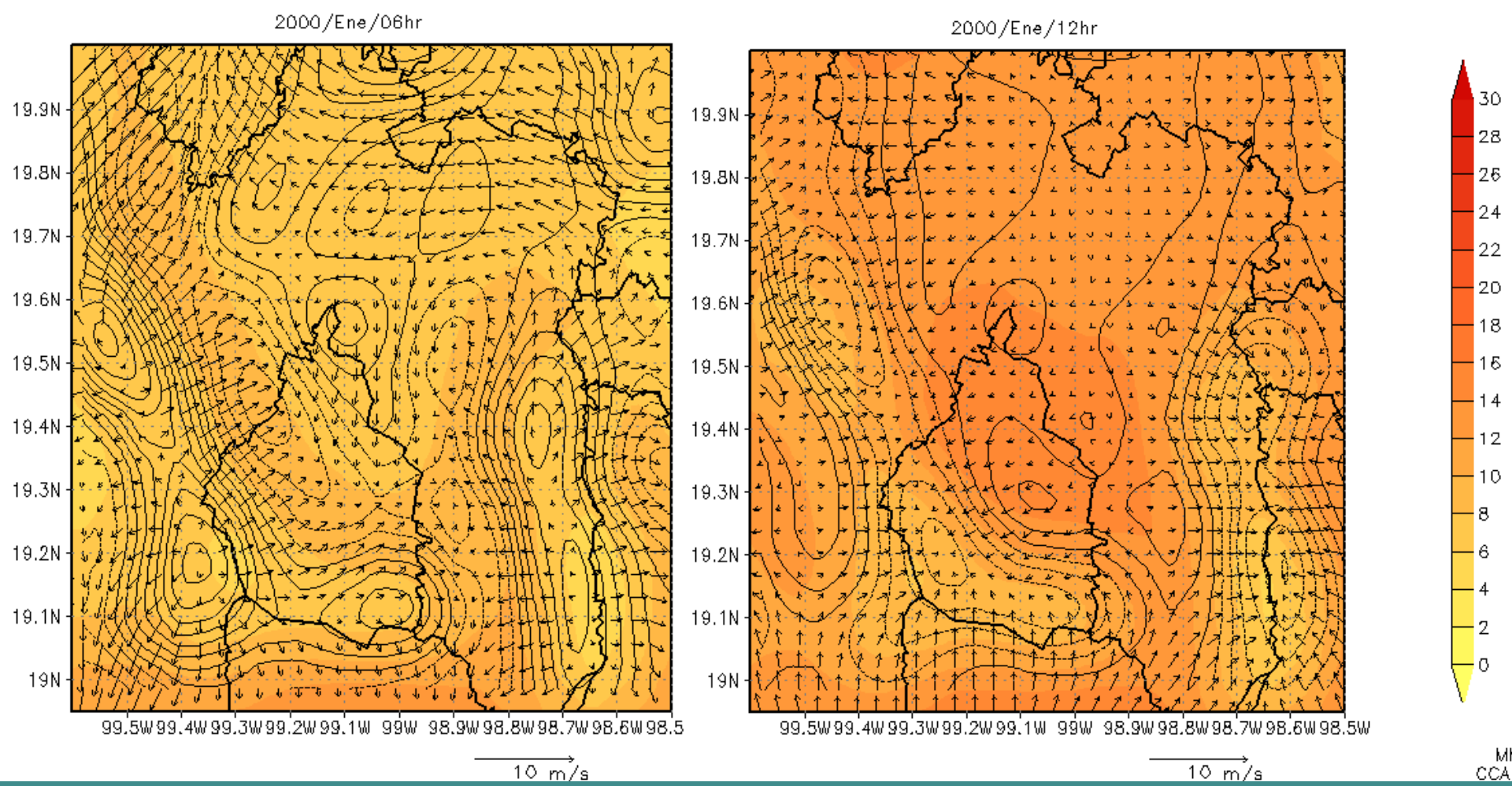


1993

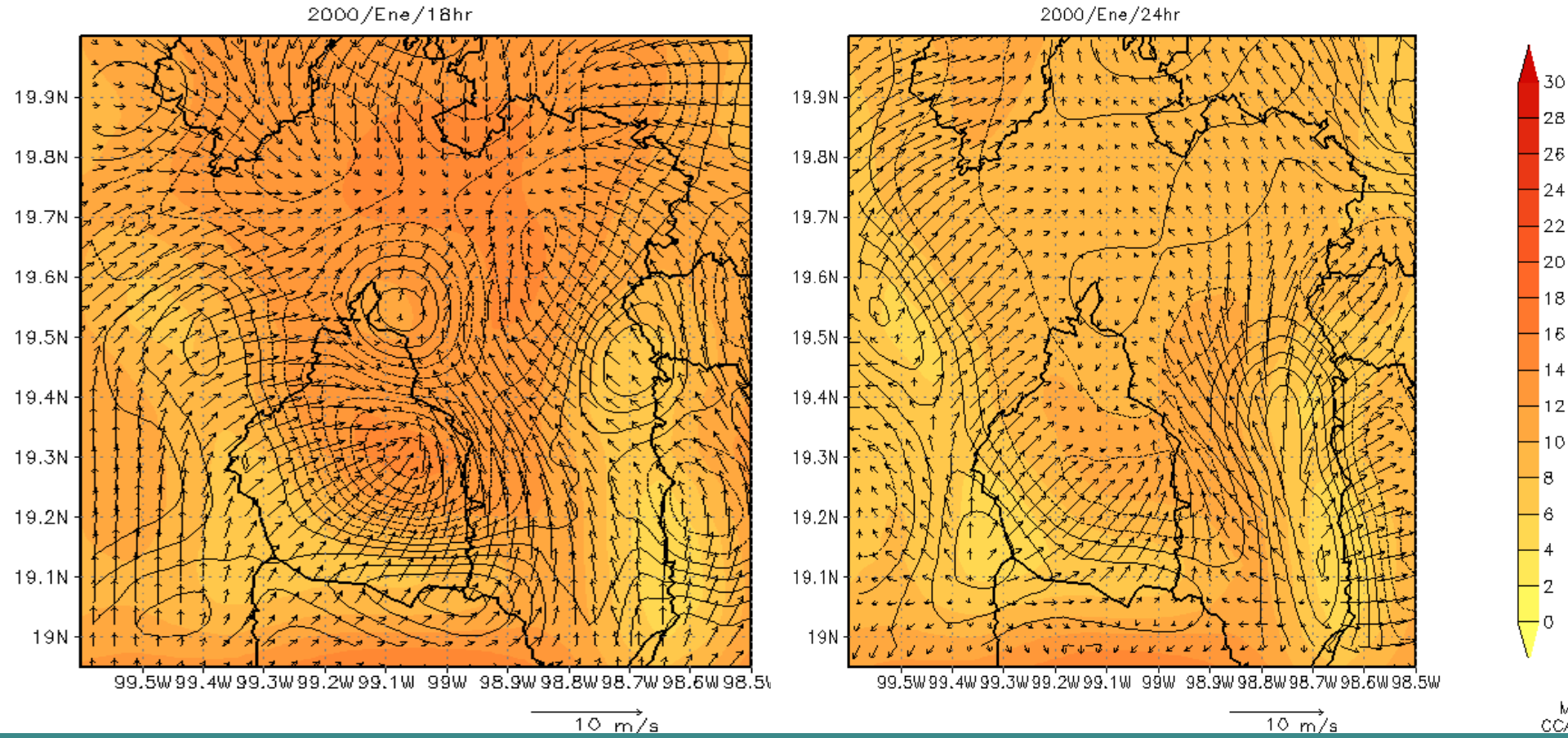


2000

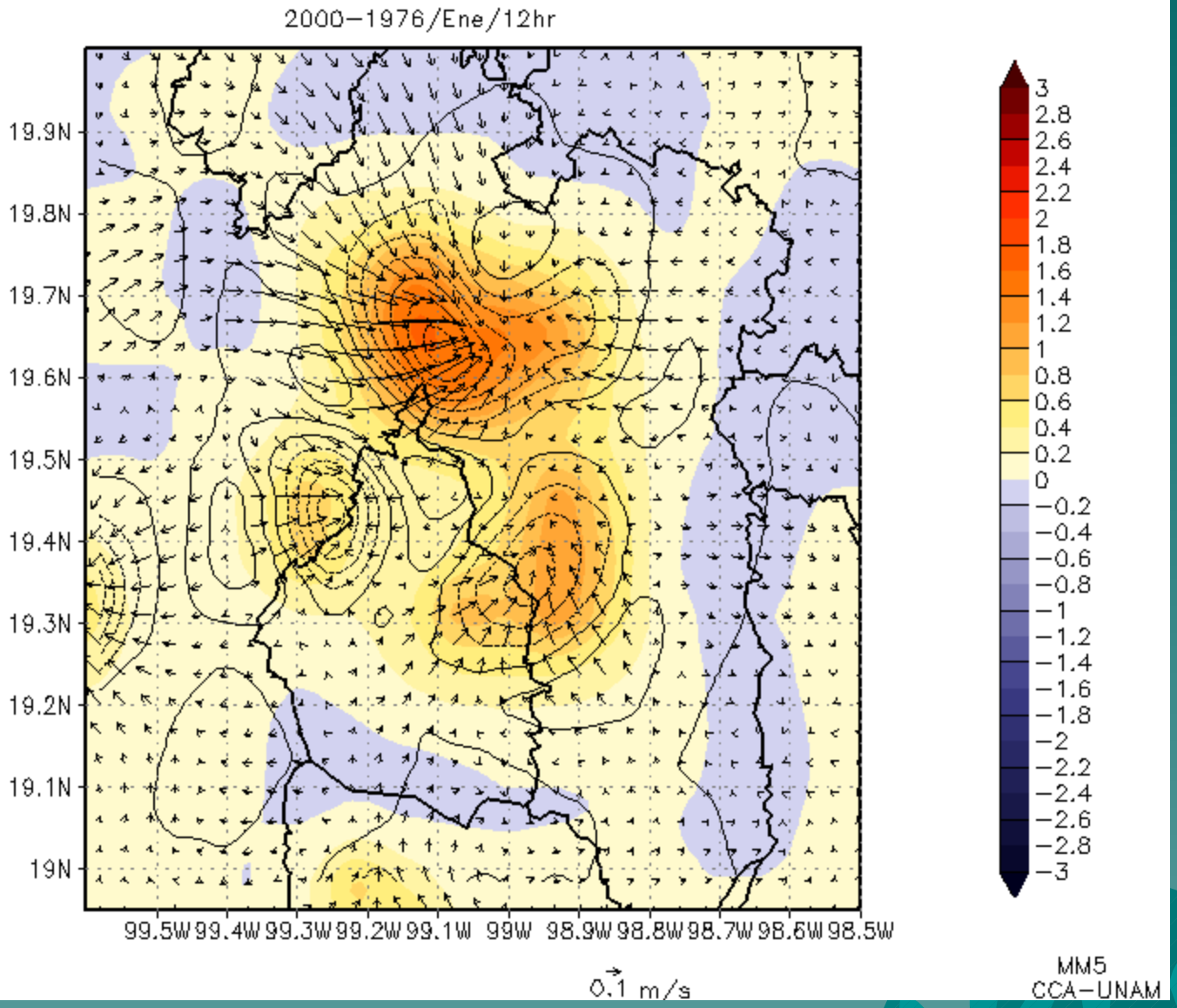


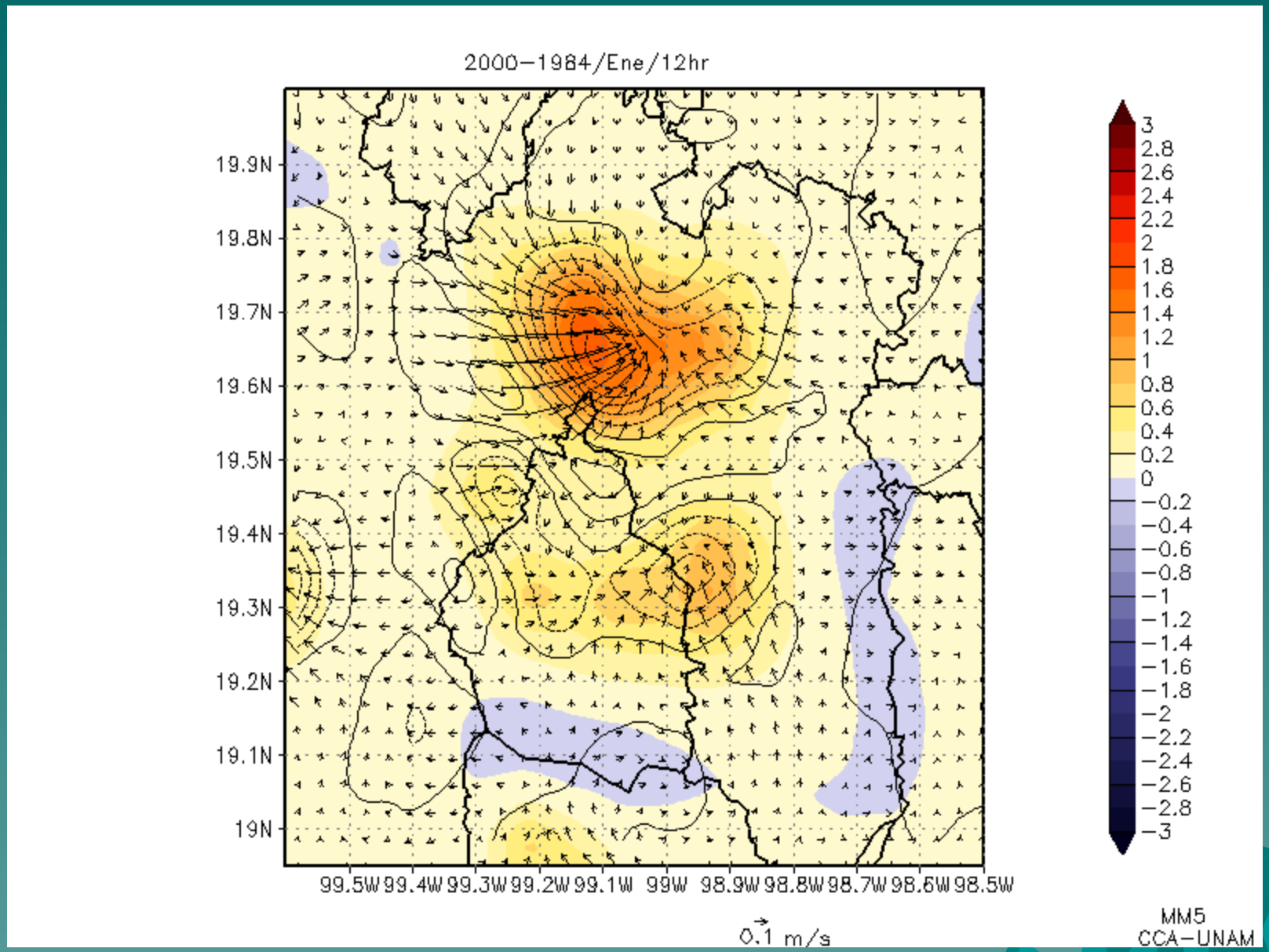


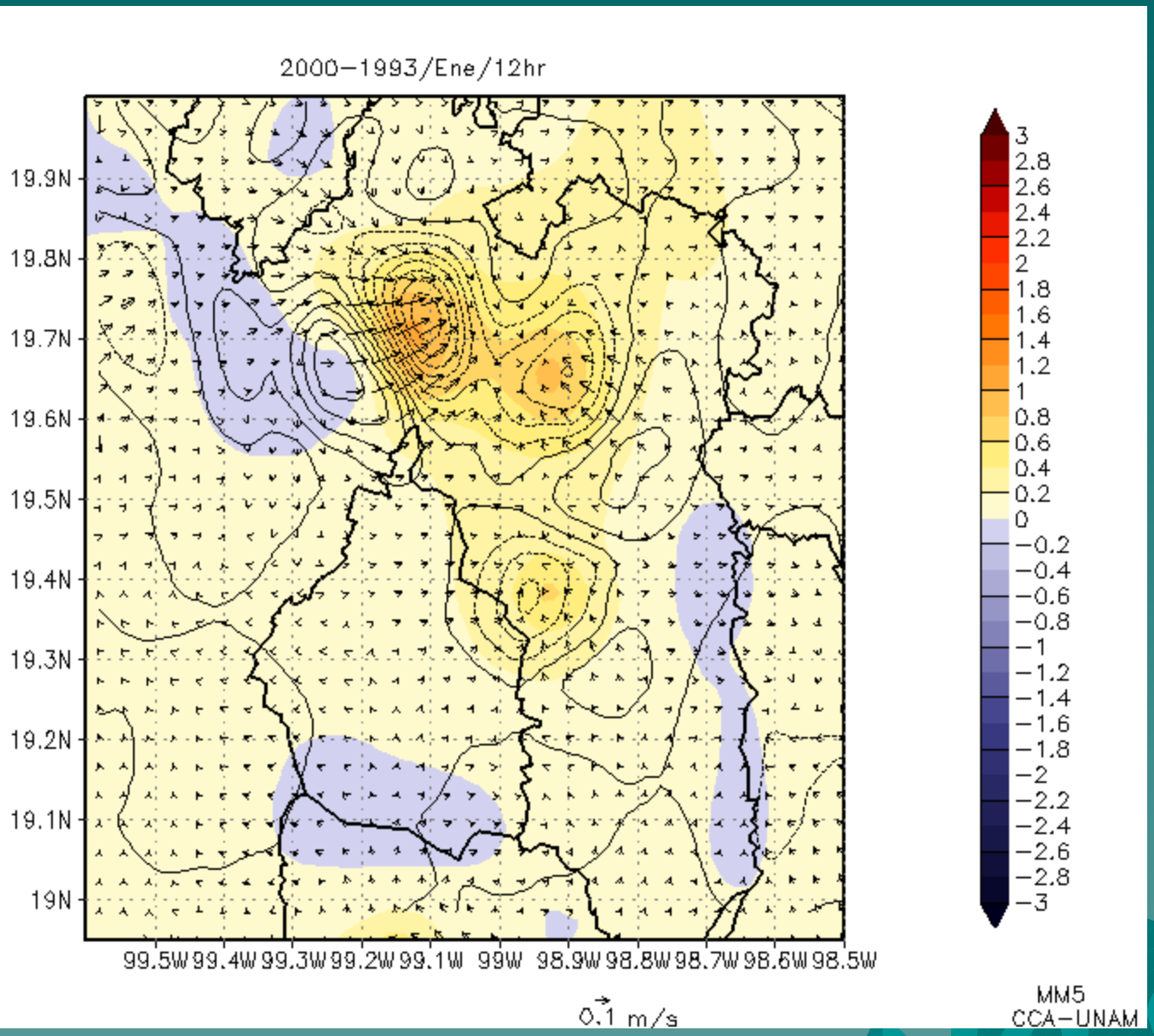
Mean surface wind field for 2000 landuse (06 y 12 LST)



Mean surface wind field for 2000 landuse (18 y 24 LST)


2000−1976/Ene/12hr
19.9N
19.8N
19.7N
19.6N
19.5N
19.4N
19.3N
19.2N
19.1N
19N
99.5W 99.4W 99.3W 99.2W 99.1W 99W 98.9W 98.8W 98.7W 98.6W 98.5W
0.1 m/s
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−1.6
−1.8
−2
−2.2
−2.4
−2.6
−2.8
−3
MM5
CCA−UNAM


2000−1984/Ene/12hr
19.9N
19.8N
19.7N
19.6N
19.5N
19.4N
19.3N
19.2N
19.1N
19N
99.5W 99.4W 99.3W 99.2W 99.1W 99W 98.9W 98.8W 98.7W 98.6W 98.5W
0.1 m/s
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−1.6
−1.8
−2
−2.2
−2.4
−2.6
−2.8
−3
MM5
CCA−UNAM


2000−1993/Ene/12hr
19.9N
19.8N
19.7N
19.6N
19.5N
19.4N
19.3N
19.2N
19.1N
19N
99.5W 99.4W 99.3W 99.2W 99.1W 99W 98.9W 98.8W 98.7W 98.6W 98.5W
0.1 m/s
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.4
−1.6
−1.8
−2
−2.2
−2.4
−2.6
−2.8
−3
MM5
CCA−UNAM

Some conclusions

The *Nortes* acted as ventilation systems in the Mexico basin .

The numerical models (MM5 and WRF) are able to reproduce and predict the local circulations in the Valley of Mexico. It is necessary to use assimilation (nudging) of data in the initial condition.

Direct local circulations can maintain high levels of contamination.

Urbanization may have led to the ventilation in the Valley of Mexico changes the regions of maximum concentration of pollutants

Urbanization may have led to the thermal inversion a less frequent (Heat Island effect)

IDENTIFICATION OF AIRSHED IN MÉXICO

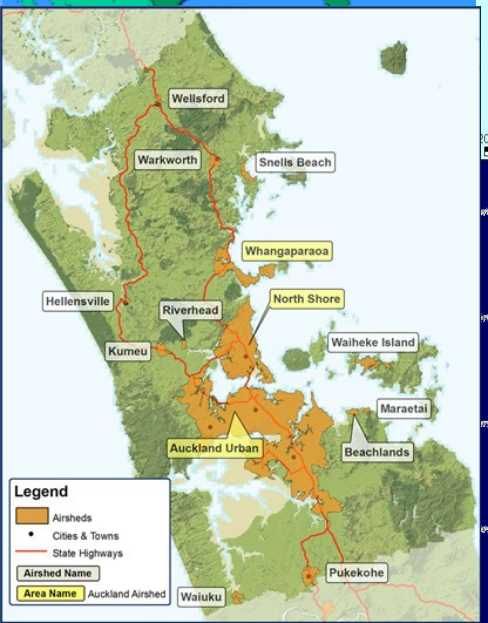
¿Qué es una cuenca atmosférica?

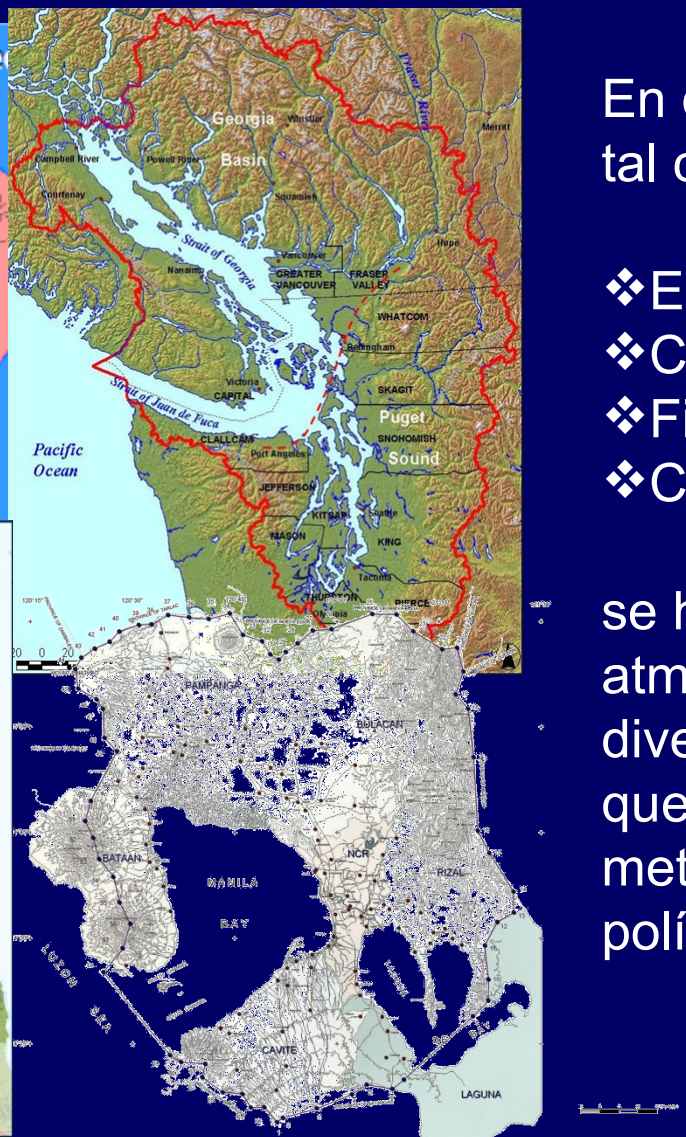
Una cuenca atmosférica es un volumen de aire que está separado de otro por factores geográficos o meteorológicos. Cuando hablamos de una cuenca atmosférica nos referimos a una zona geográfica donde los contaminantes atmosféricos de fuentes "aguas arriba" o dentro del área de flujo están presentes en el aire

Una cuenca atmosférica es afectada por emisiones de origen urbano, suburbano, marino, o agrícola, así como por fuentes naturales, las cuales sufren transformaciones que afectan la calidad del aire

¿Cuál es el objetivo de la gestión por cuenca atmosférica?

La calidad del aire está determinada en gran medida por los patrones de viento, y estos a su vez están influidos por la topografía de la región. El aire se mueve y dispersa sustancias químicas en suspensión que se emiten a partir de una variedad de fuentes humanas y fuentes naturales, tanto de dentro como fuera de la cuenca





En diversas partes del mundo, tal como:

- Estados Unidos
- Canadá
- Filipinas
- Comunidad europea

se han definido cuencas atmosféricas siguiendo diversos criterios, entre los que se incluyen meteorológicos, geográficos y político administrativos.

¿Cuándo es conveniente hacer uso del concepto de cuenca atmosférica?

- Las fuentes de emisión y los impactos asociados están localizados en un área geográfica extendida
- Los problemas de calidad del aire se relacionan a condiciones ecológicas, meteorológicas y topográficas que son comunes a un área
- El transporte atmosférico de los contaminantes hacia adentro y hacia fuera de un área definible ocurre de manera regular
- Se requieren esquemas regionales de gestión, complementarios a los definidos en la normatividad vigente
- Se requiere de la participación de tomadores de decisiones de más de una entidad federativa

Ventajas de la gestión por cuenca atmosférica

- Carácter preventivo
- Aseguramiento de una buena calidad del aire en el largo plazo (25 años)
- Basado en la dinámica atmosférica y no en fronteras políticas
- Contempla a todos los contaminantes al mismo tiempo
- Propicia el desarrollo de agendas ambientales conjuntas en varias entidades
- Permite el establecimiento de un mercado de emisiones

OBJETIVO

Proyecto INE-CCA

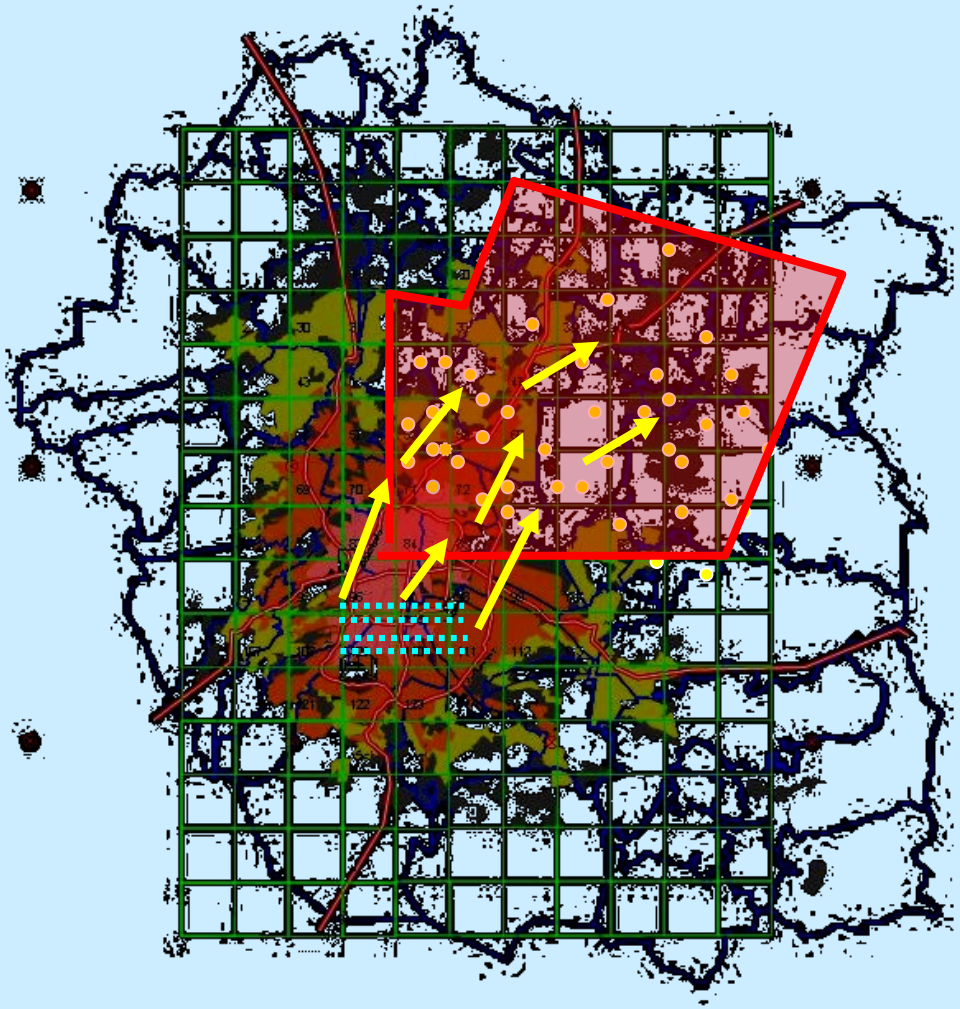
- Desarrollar una propuesta metodológica para la determinación de cuencas atmosféricas en México

- Identificar de manera preliminar cuencas atmosféricas en México a través de la aplicación de la metodología propuesta

Propuesta metodológica para definir cuencas atmosféricas

- Uso de trayectorias hacia adelante (*forward*) de parcelas atmosféricas cerca de la superficie en zonas urbanas
- Las parcelas están arregladas simétricamente en una malla a distancias de 5km de separación
- La integración de las trayectorias se hace por 24 horas, tiempo en que se espera viajen una distancia de alrededor de 430 km suponiendo vientos promedio de 5 m/s
- La dispersión de las trayectorias define el grado de concentración de éstas en el tiempo y el espacio
- La definición de cuenca atmosférica mediante el criterio de concentración de parcelas

Elementos para la definición de cuenca atmosférica mediante densidad de parcelas



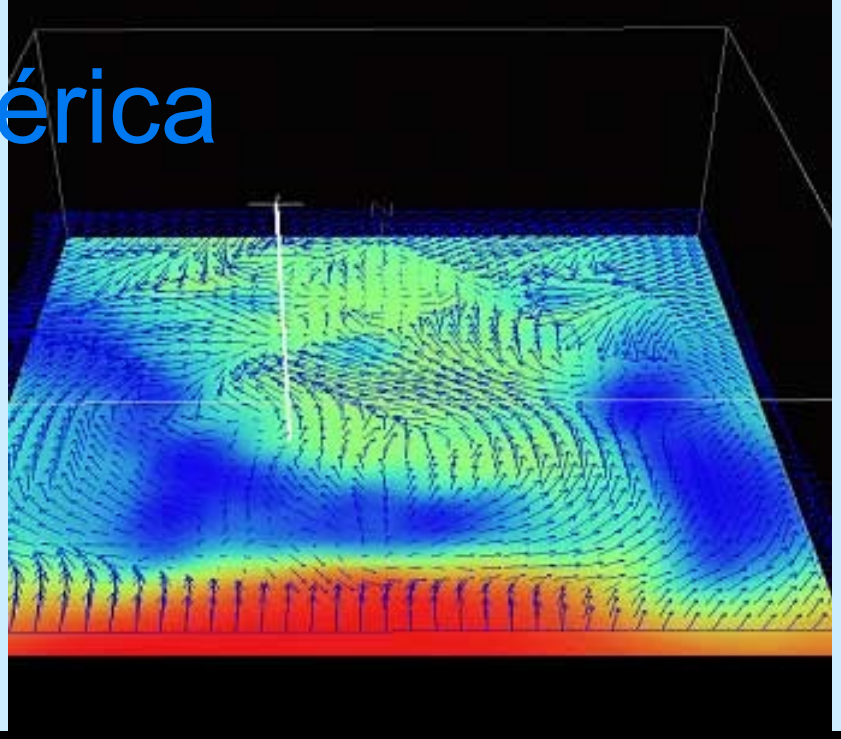
Parcelas
Posición inicial

Parcelas
Posición final

Cuenca Atmosférica

vientos

Modelación atmosférica



MM5 (WRF)

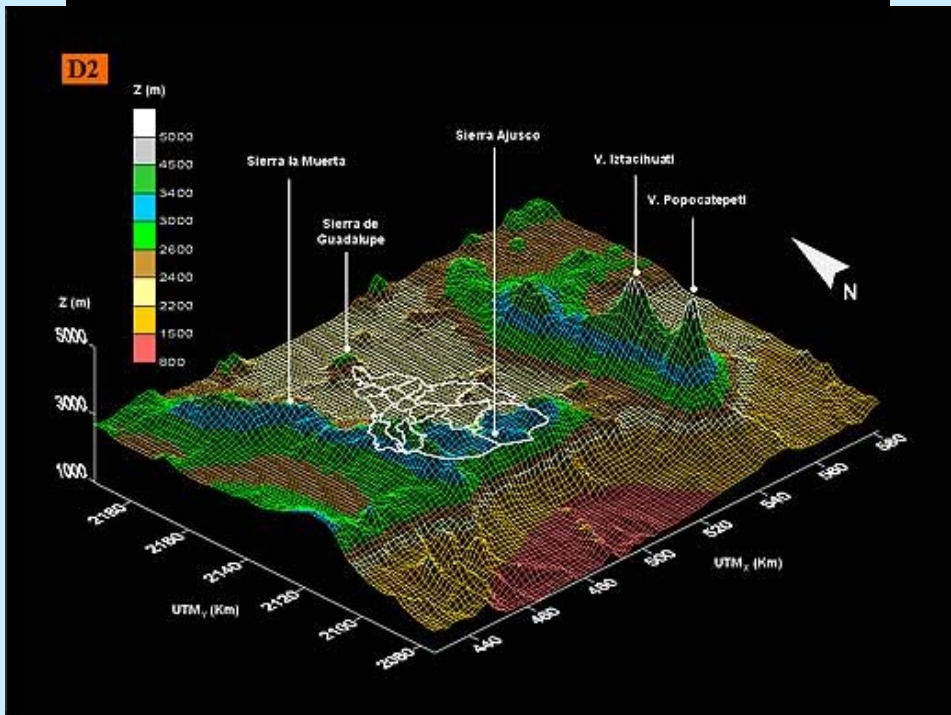
Es un modelo meteorológica de mesoescala que posee las siguientes características:

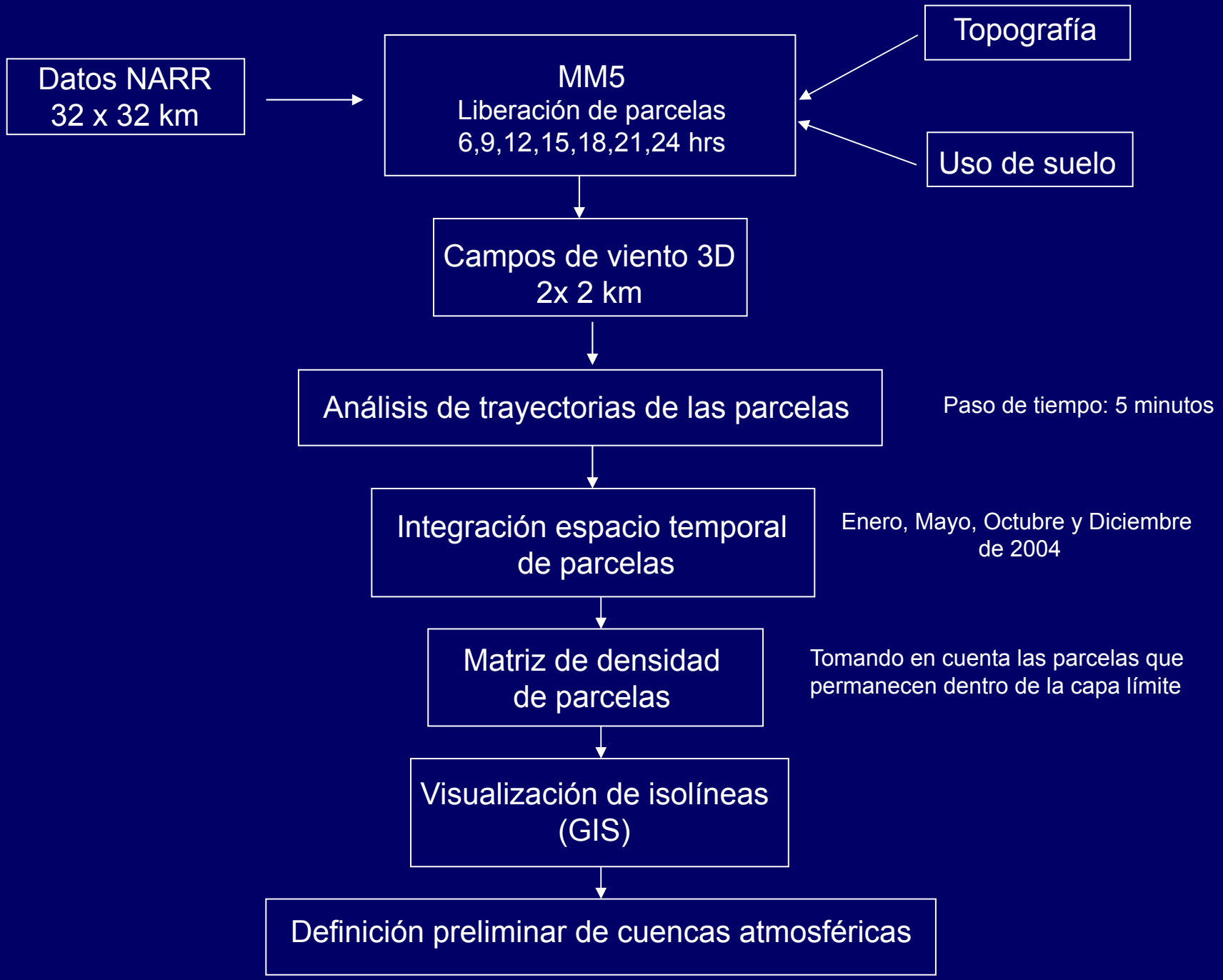
a) Capacidad de anidamiento múltiple

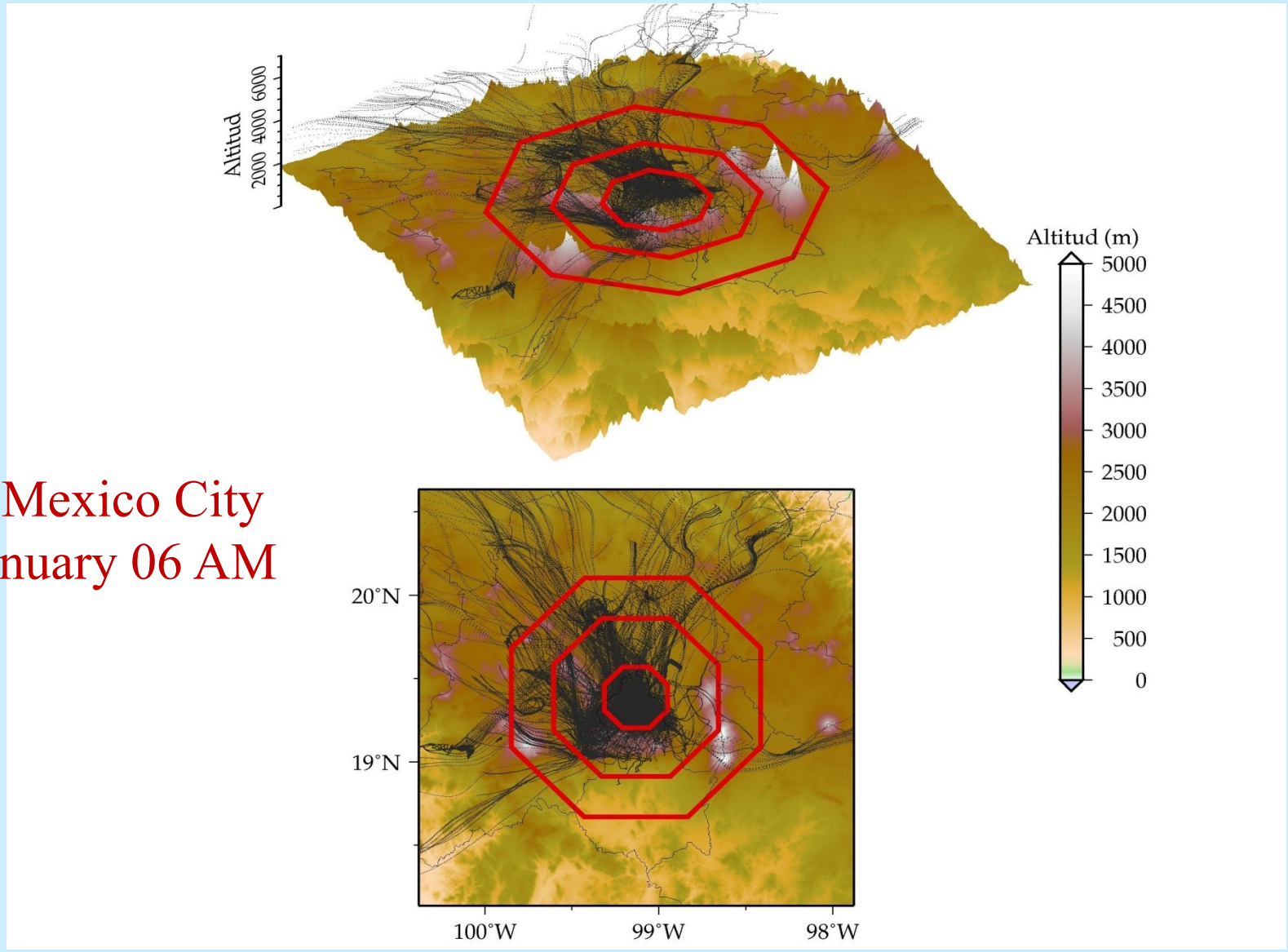
b) Dinámica no hidrostática

c) Asimilación de datos en cuatro dimensiones

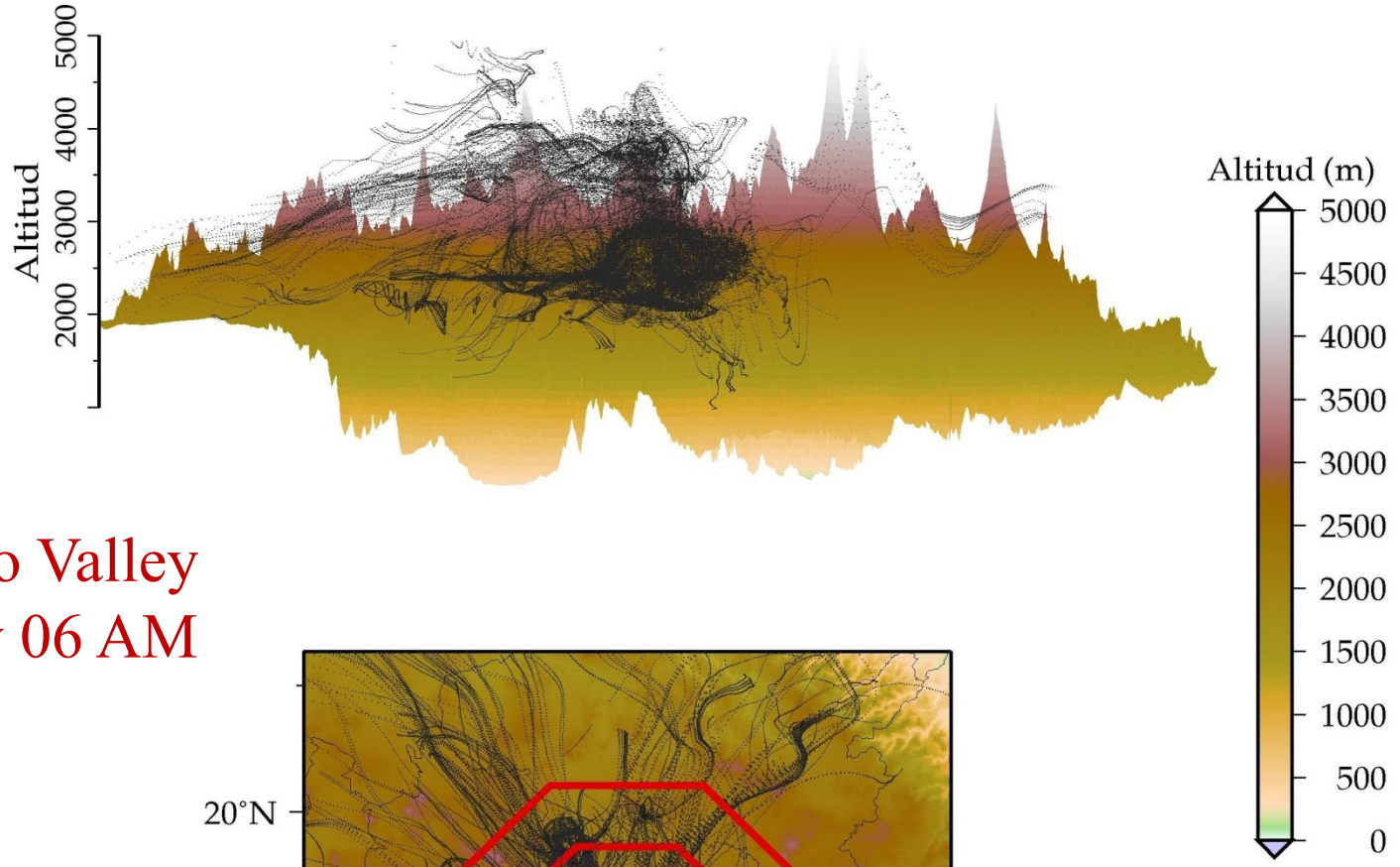
d) Portabilidad en un amplio rango de plataformas de cómputo



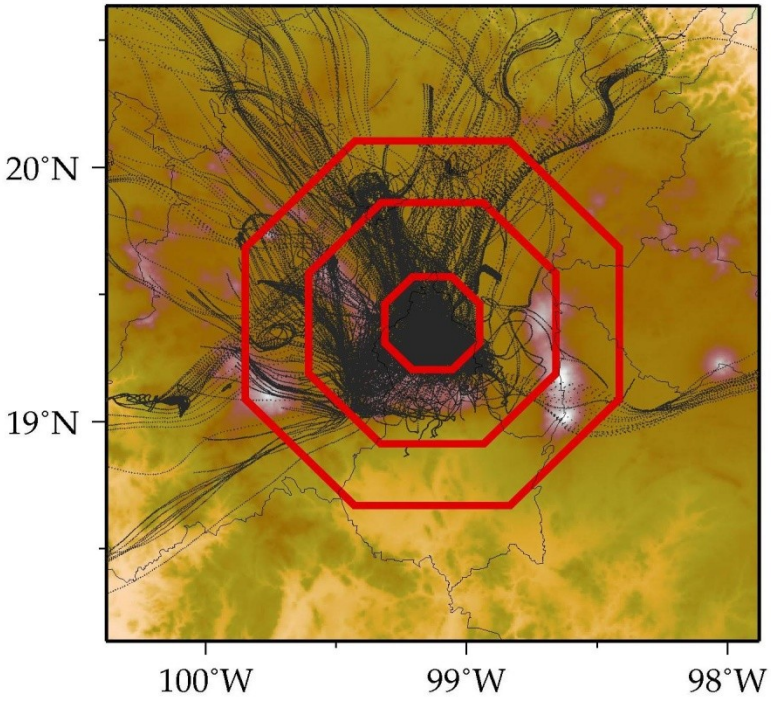

Datos NARR
32 x 32 km
MM5
Liberación de parcelas
6,9,12,15,18,21,24 hrs
Topografía
Uso de suelo
Campos de viento 3D
2x 2 km
Análisis de trayectorias de las parcelas
Paso de tiempo: 5 minutos
Integración espacio temporal
de parcelas
Enero, Mayo, Octubre y Diciembre
de 2004
Matriz de densidad
de parcelas
Tomando en cuenta las parcelas que
permanecen dentro de la capa límite
Visualización de isolíneas
(GIS)
Definición preliminar de cuencas atmosféricas

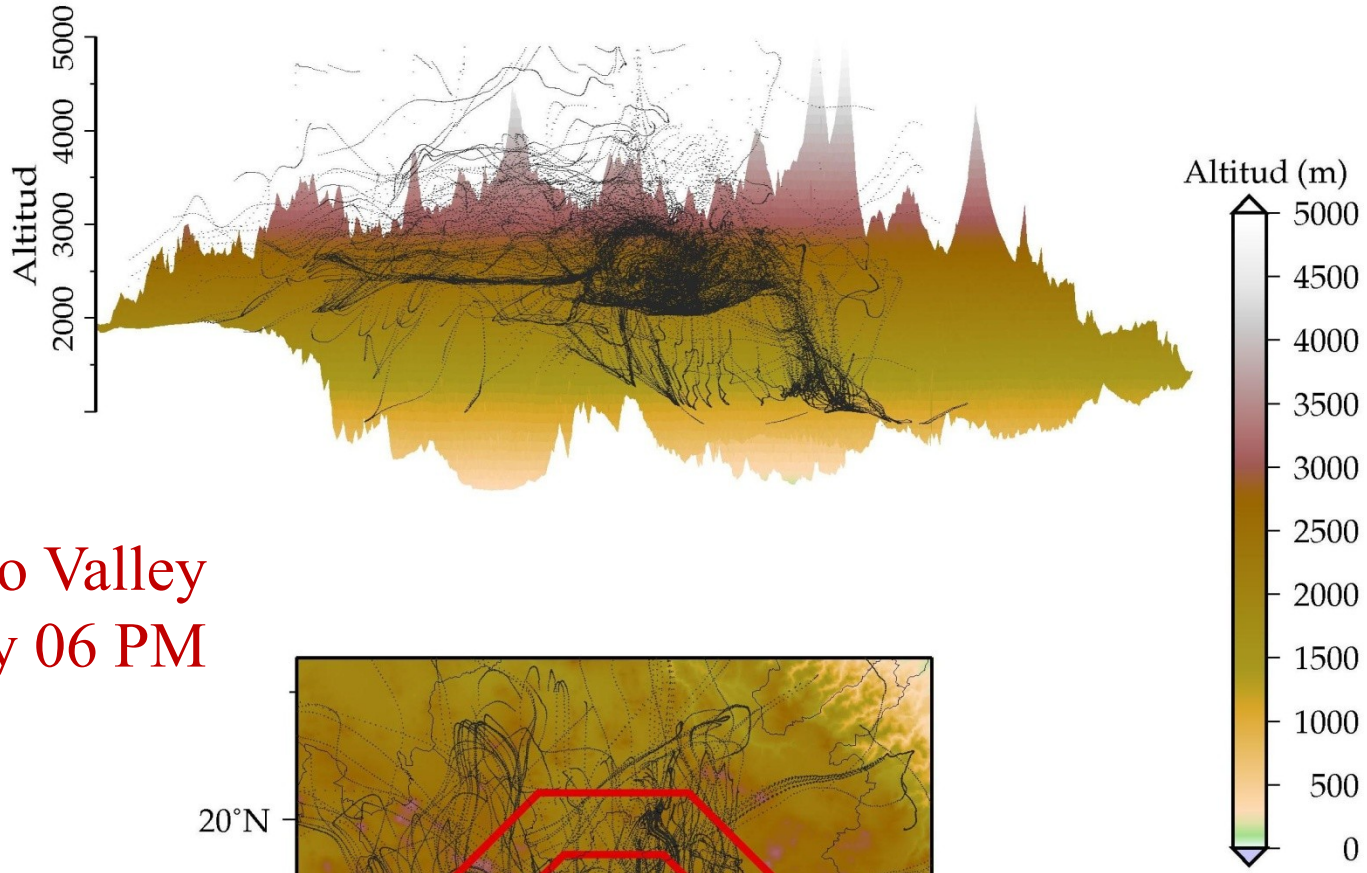


Mexico City
January 06 AM

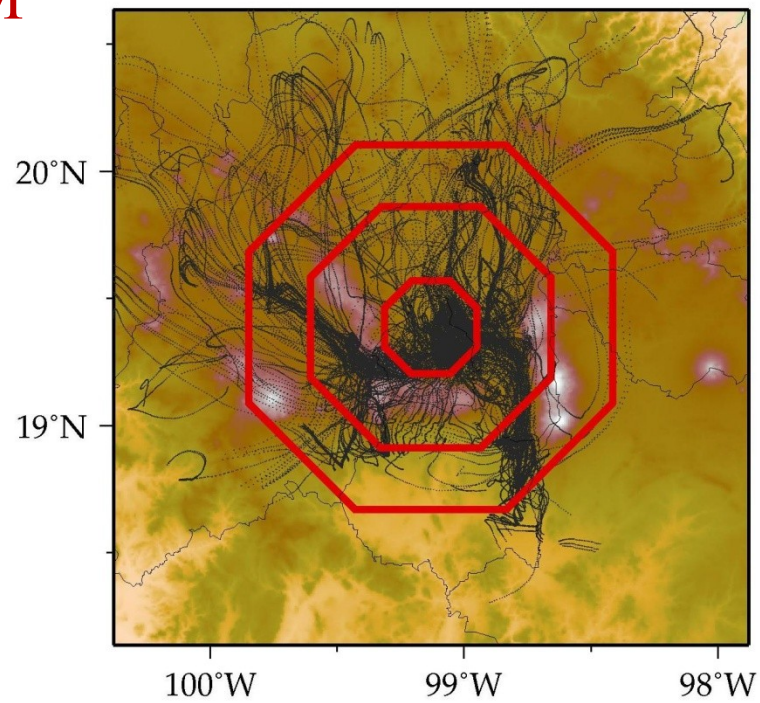


Mexico Valley
January 06 AM

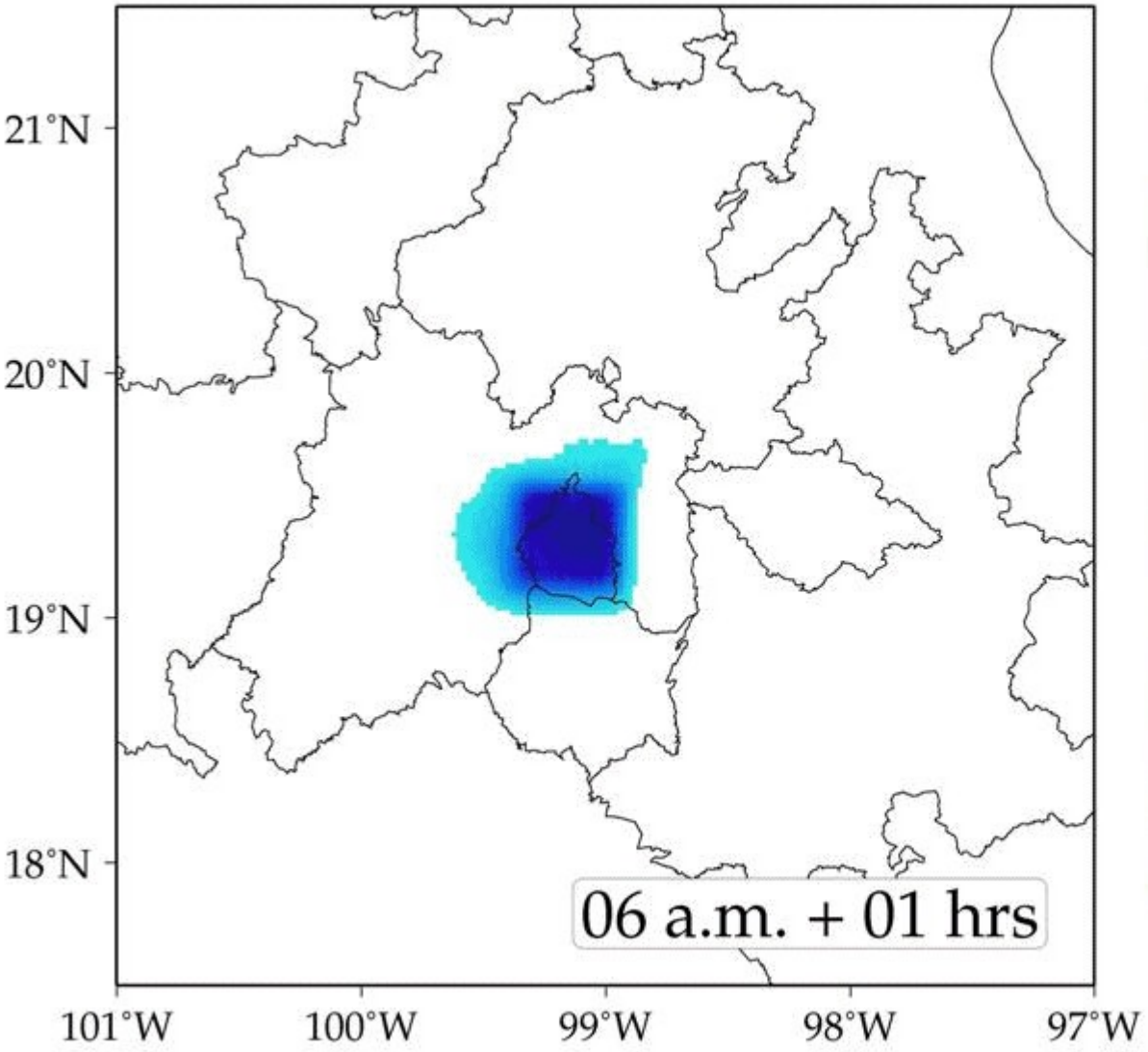


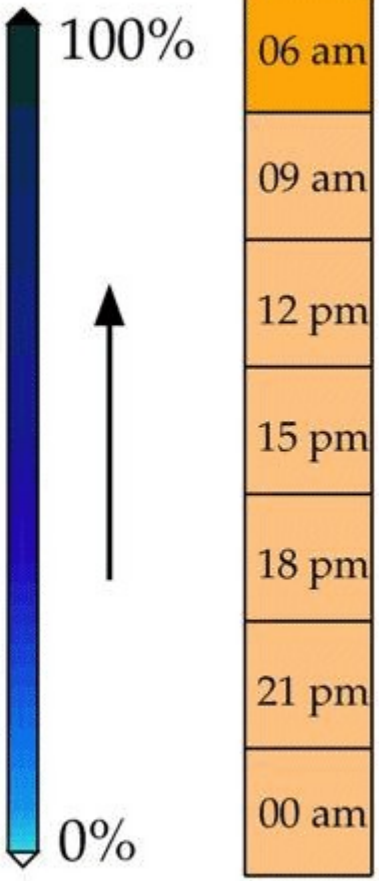


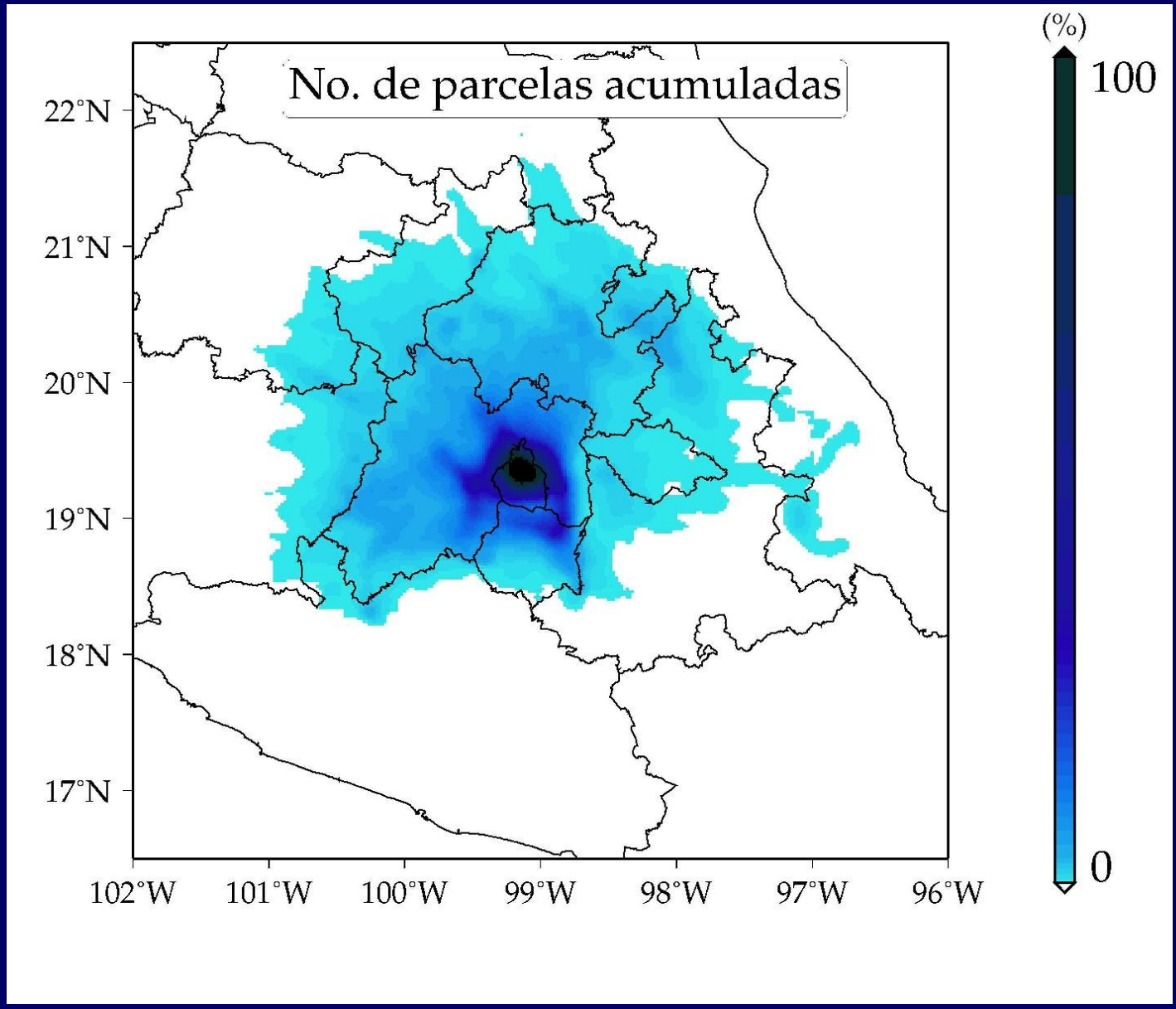
Mexico Valley
January 06 PM



Trayectories Analysis

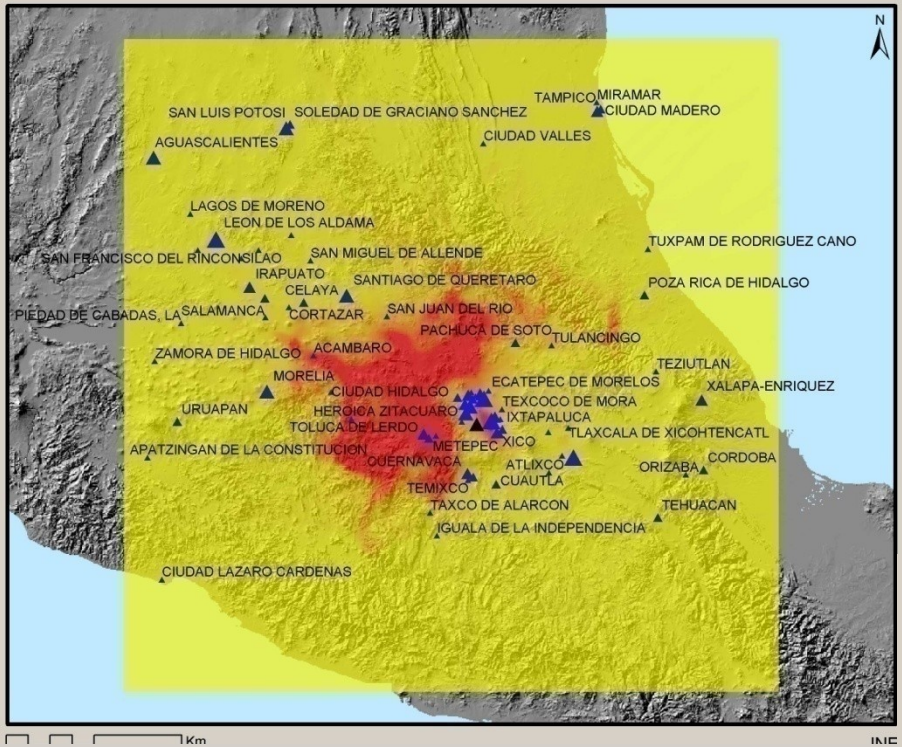


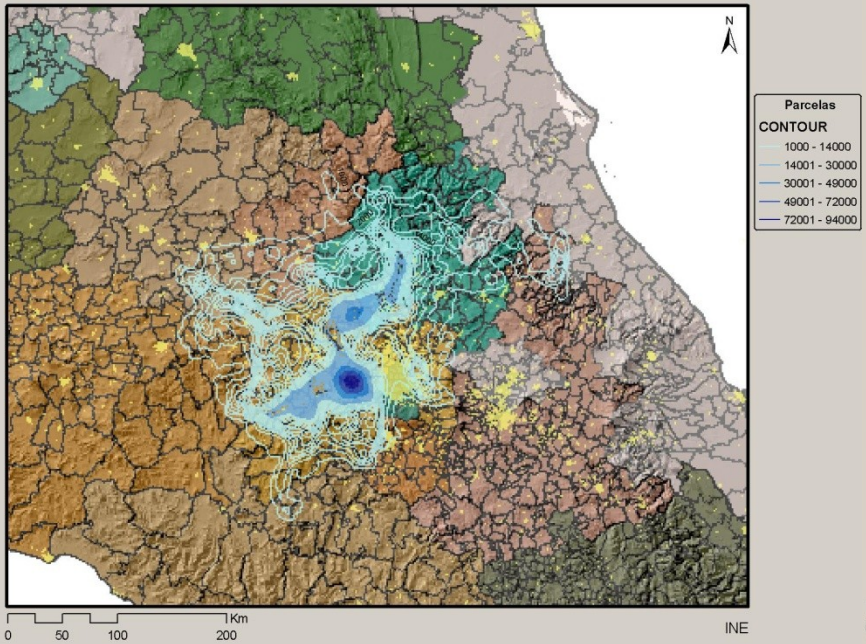


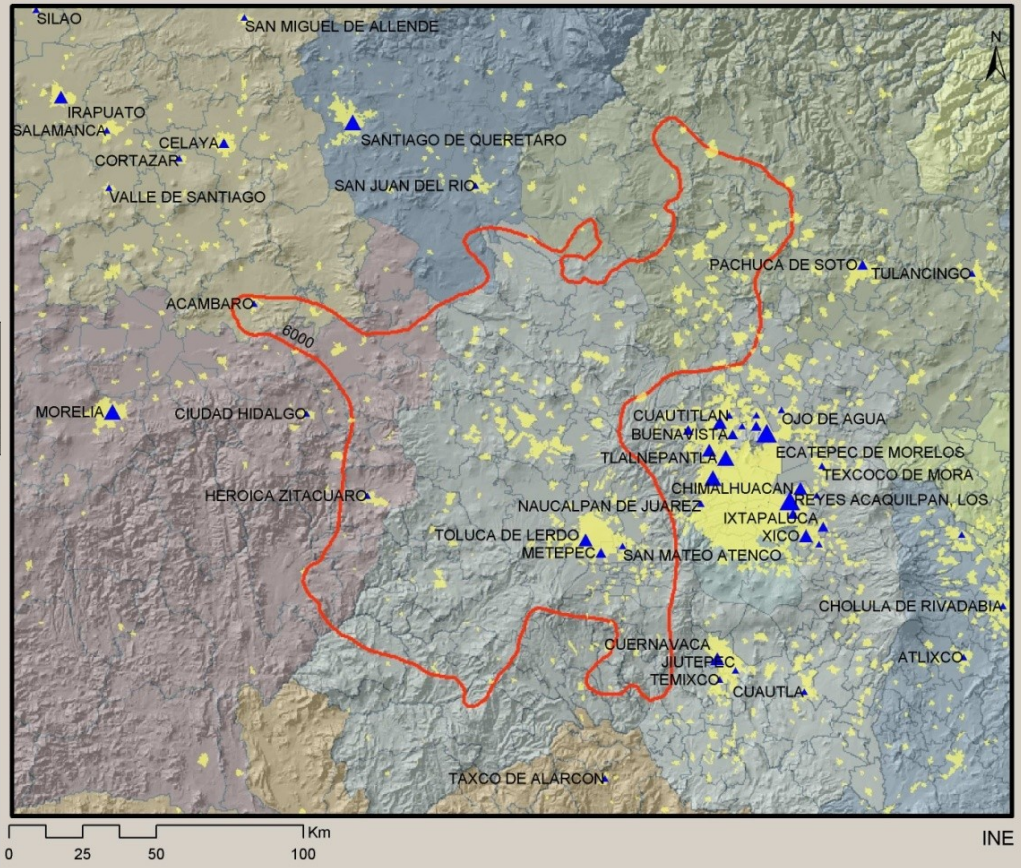


Accumulated parcel

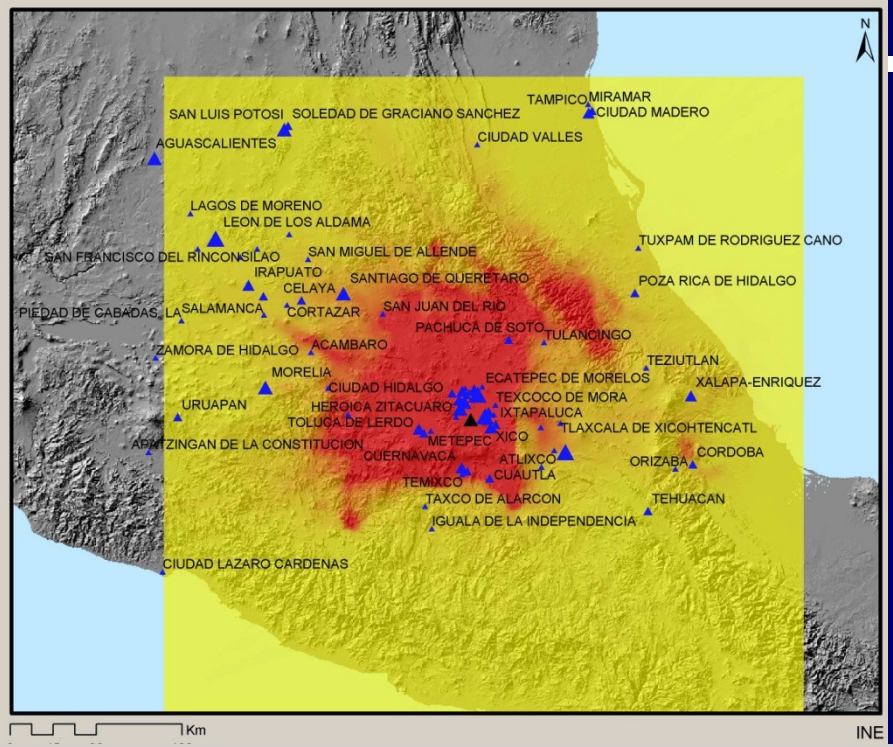
Toluca, Edo. Mex.

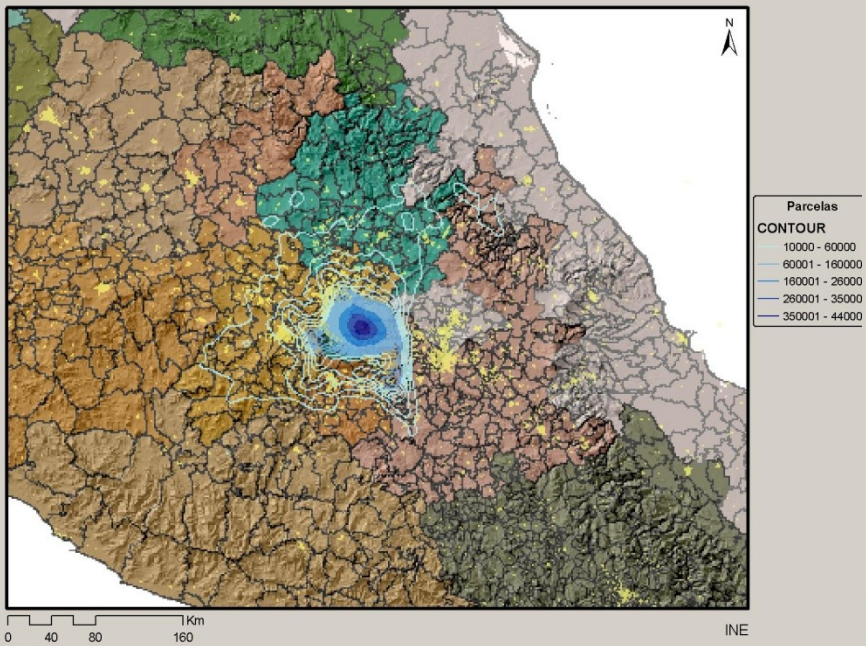


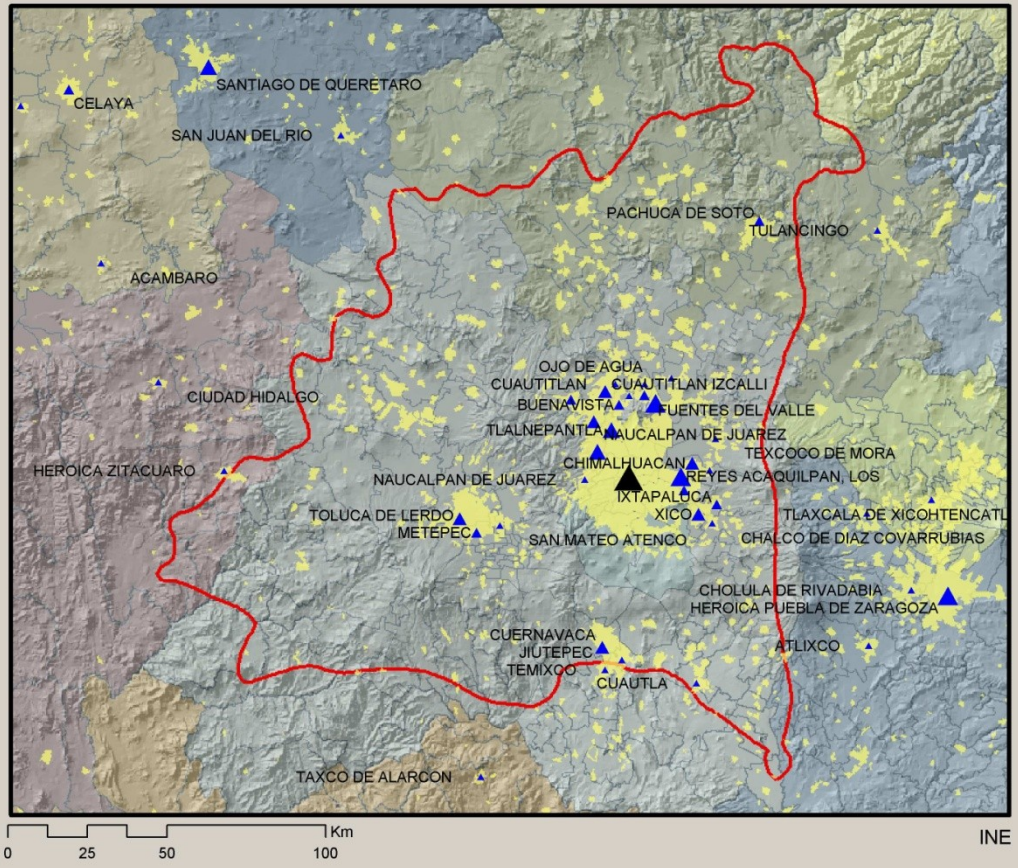




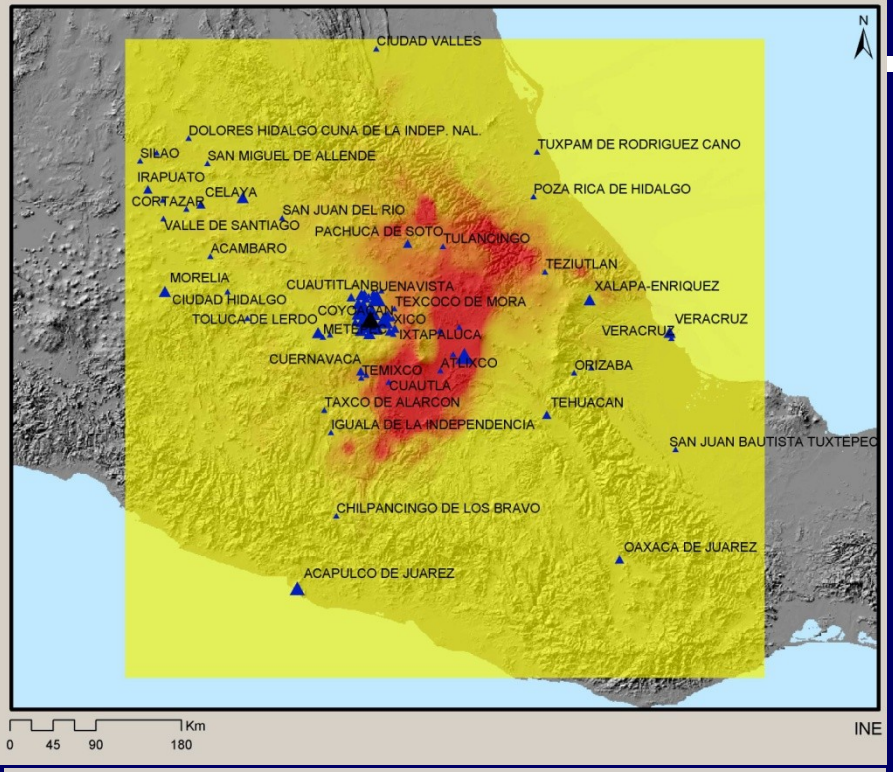
Distrito Federal







Puebla, Pue.


CIUDAD VALLES
DOLORES HIDALGO CUNA DE LA INDEP. NAL.
SILAO
SAN MIGUEL DE ALLENDE
TUXPAM DE RODRIGUEZ CANO
IRAPUATO
CELAYA
POZA RICA DE HIDALGO
CORTAZAR
SAN JUAN DEL RIO
VALLE DE SANTIAGO
PACHUCA DE SOTO
TULANCINGO
ACAMBARO
TEZIUTLAN
MORELIA
CUAUTITLANBUENAVISTA
XALAPA-ENRIQUEZ
CIUDAD HIDALGO
TEXCOCO DE MORA
TOLUCA DE LERDO
VERACRUZ
IXTAPALUCA
CUERNAVACA
ATLIXCO
ORIZABA
TEMIXCO
CUAUTLA
TAXCO DE ALARCON
TEHUACAN
IGUALA DE LA INDEPENDENCIA
SAN JUAN BAUTISTA TUXTEPEC
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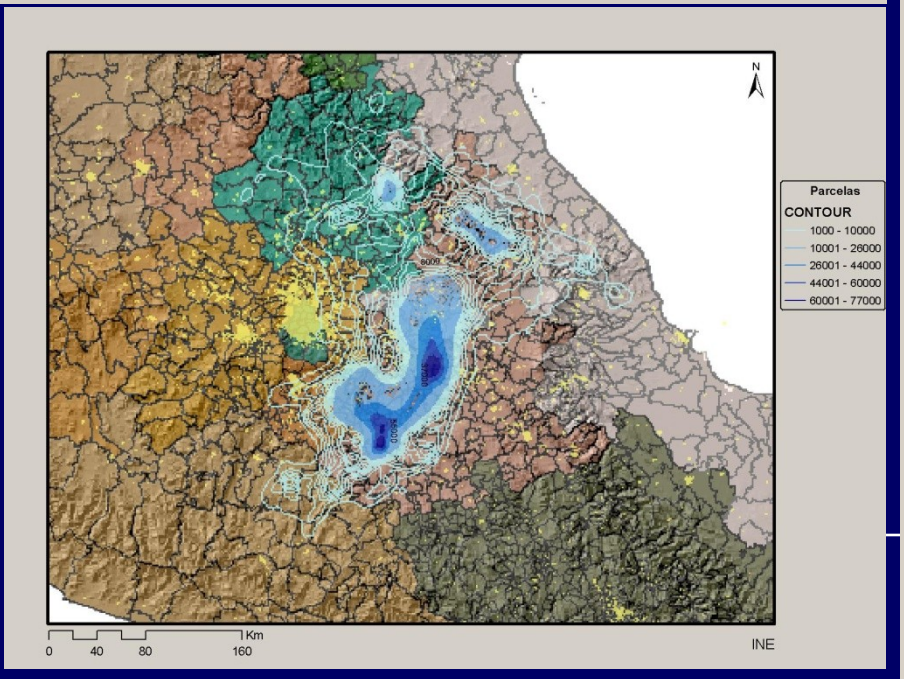
INE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Parcelas
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44001 - 60000
60001 - 77000
Km
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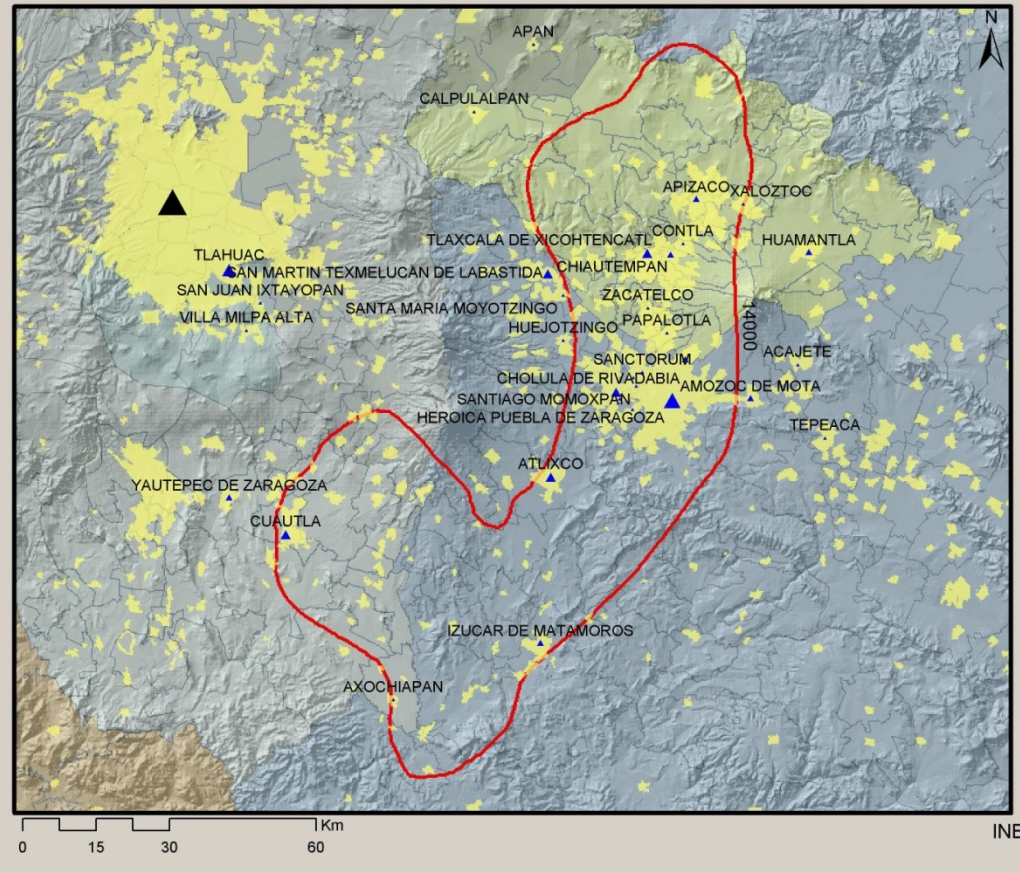
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APIZACO
XALOZTOC
TLAXCALA DE XICOHTENCATL
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TLAHUAC
SAN MARTIN TEXMELUCAN DE LABASTIDA
CHIAUTEMPAN
SAN JUAN IXTAYOPAN
ZACATELCO
VILLA MILPA ALTA
SANTA MARIA MOYOTZINGO
PAPALOTLA
HUEJOTZINGO
ACAJETE
SANCTORUM
CHOLULA DE RIVADABIA
AMOZOC DE MOTA
SANTIAGO MOMOXPAN
HEROICA PUEBLA DE ZARAGOZA
TEPEACA
ATLIXCO
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CUAUTLA
IZUCAR DE MATAMOROS
AXOCHIAPAN
Km
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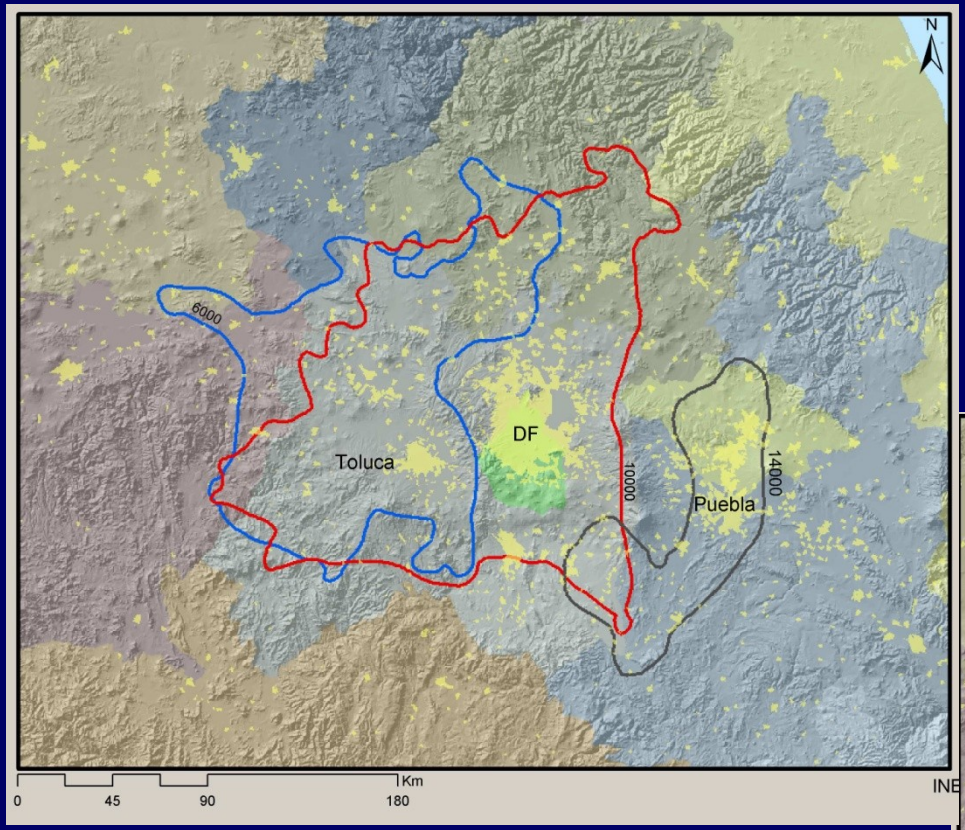
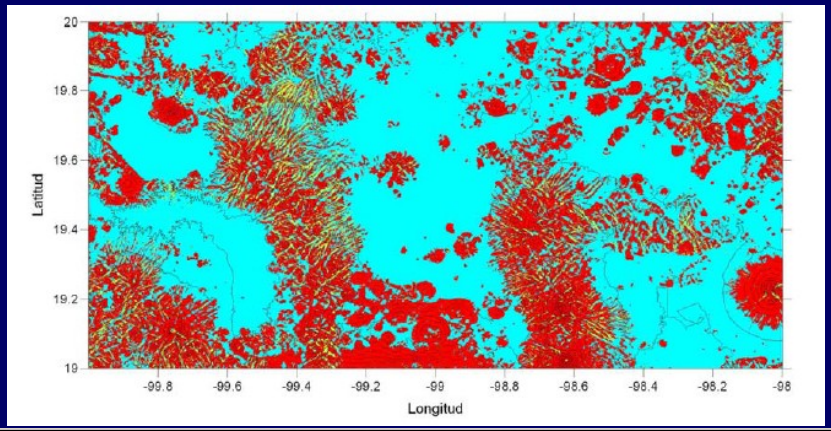
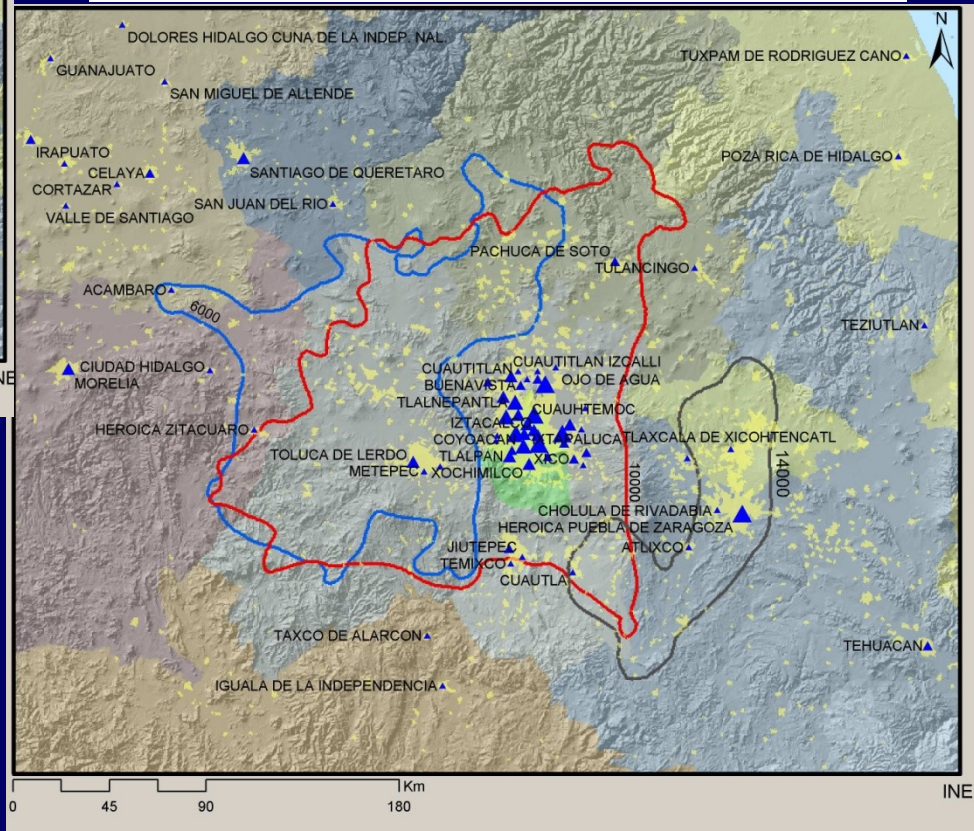
Toluca, D. F. y Puebla







Final Objective
Air Quality Forecast
Warning System