La modellazione delle tempeste di sabbia nell Cina Settentrionale.

M. Pasqui[(1)], L.Bottai[(1)], C.Busillo[(1)], F. Calastrini[(1)], G. Gualtieri[(1)], F.Guarnieri[(1)], A. Taramelli[(2,3)], C. Small[(3)] and A. Barucci[(4)].

(1) IBIMET- CNR Firenze
(2) ICRAM Roma
(3) LDEO – Columbia Univ., NYC
(4) Univ. Firenze

OFFIDA

3 – 5 Giugno 2008

Introduction

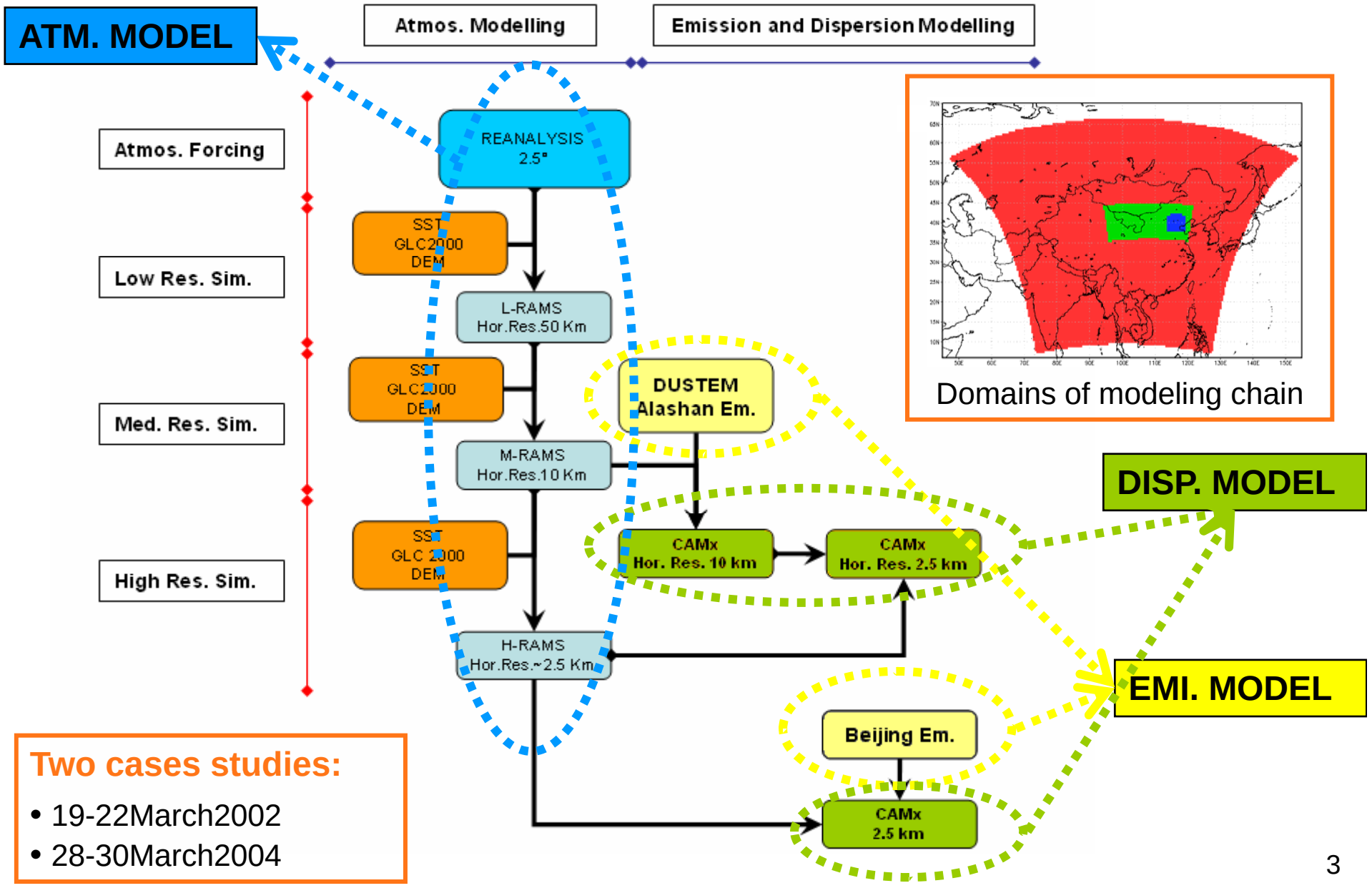
- Studying the dynamics of DSS affecting Beijing: two main dust-sand sources:
  - Northern Chinese deserts (*remote sources*)
  - Abandoned rubble pits in Beijing sourroundings (*local souces*).

- 3D – Modeling architecture:
  - Atmospheric Model: **RAMS**
  - Dust-sand Emission Model: **DustEM** → **4th order data fitting formula**
  - Dispertion Model: **CAMx**

- Analysis of two DSS case studies:
  - 19th – 22th March 2002,
  - 28th – 30th March 2004.

- Analysis of two different intervention scenarios:
  - Reducing remote emission amounts.
  - Reducing local emission amounts.

Introduction



Domains of modeling chain

Two cases studies:

- 19-22March2002
- 28-30March2004

Atmospheric Model - RAMS

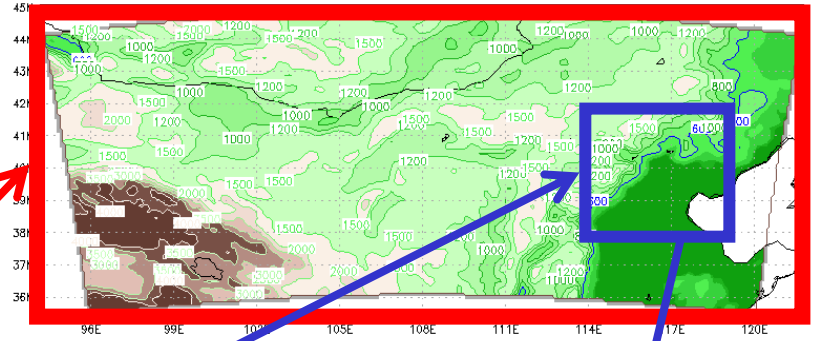
- **Regional Atmospheric Model constructed around the full set of *nonhydrostatic*, *compressible* equations**
  - atmospheric *dynamics* and *thermodynamics*
  - *conservation equations* for scalar quantities
  - a large selection of *parameterizations* for turbulent diffusion, solar and terrestrial radiation, moist processes, cumulus convection, and energy exchange between the atmosphere and the surface through vegetation.
- **Physiographic dataset needed to represent the atmospheric dynamical behavior:**
  - Topography
  - Land cover (Joint Research Centre, GLC2000)
  - Sea surface temperature (NASA-PODAAC SST archive: AVHRR Pathfinder SST & MODIS AQUA/TERRA SST)
- **Atmospheric input providing initial and boundary condition:**
  - Main atmospheric fields from NCEP-NCAR Reanalysis 2.5 degree

Atmospheric Model - RAMS

3 nested grids for each case study:

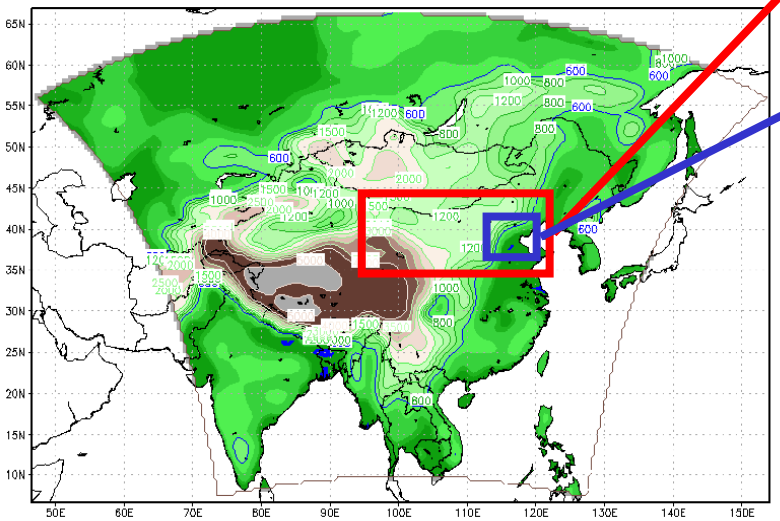
- **Low-resolution** (L-RAMS), 50 km of h.r., 36 vertical levels, 130/130 grid points;
- **Medium-resolution** (M-RAMS),10 km of h.r., 36 vertical levels, 220/100 grid points;
- **High-resolution** (H-RAMS), 2.5 km of h.r., 40 vertical levels, 180/180 grid points.

10km H.R. 220x100 grid points
36 v. levels



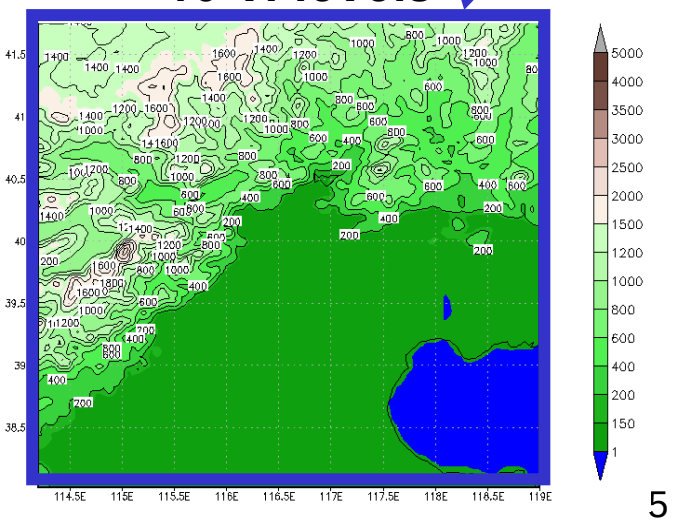
One-way nesting

50km H.R. 130x130 grid points
35 v. levels

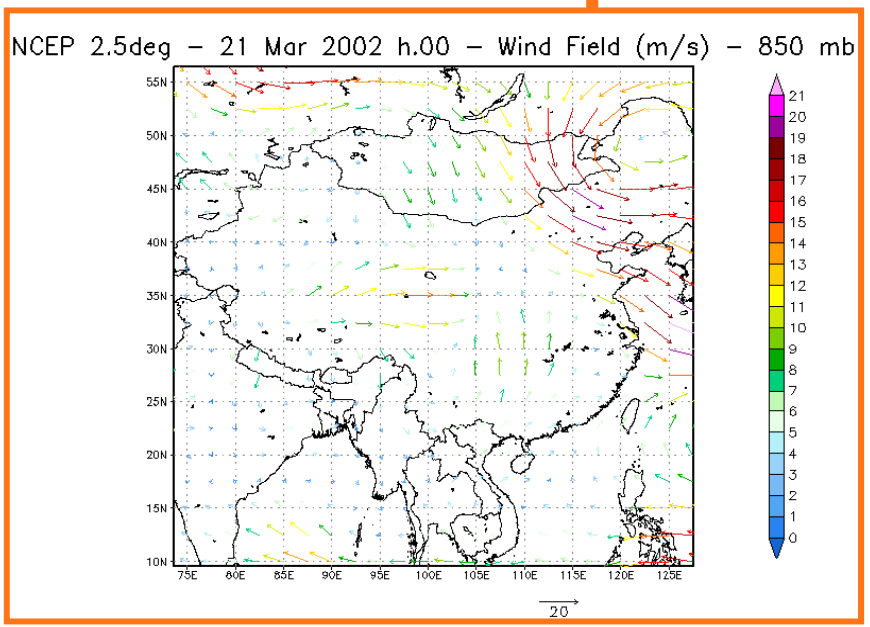


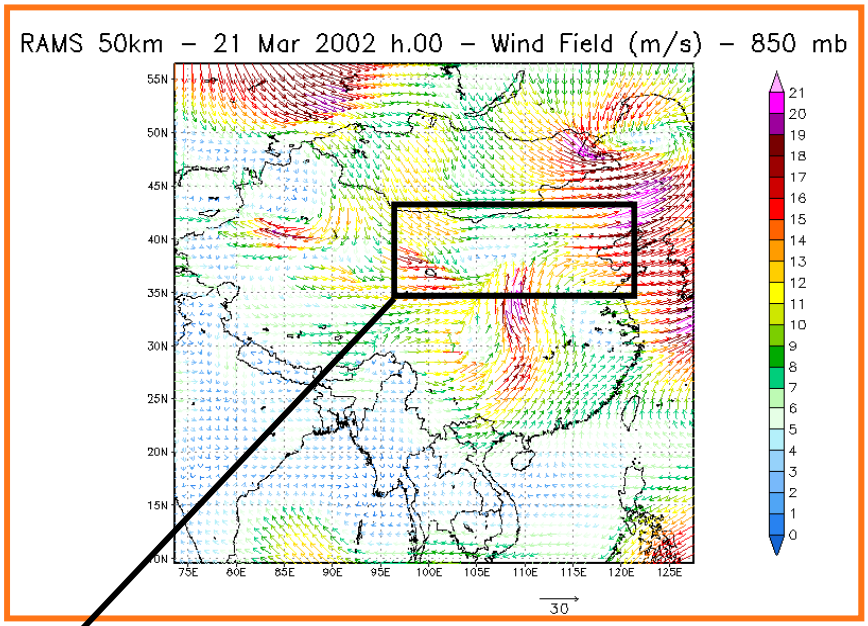
One-way nesting

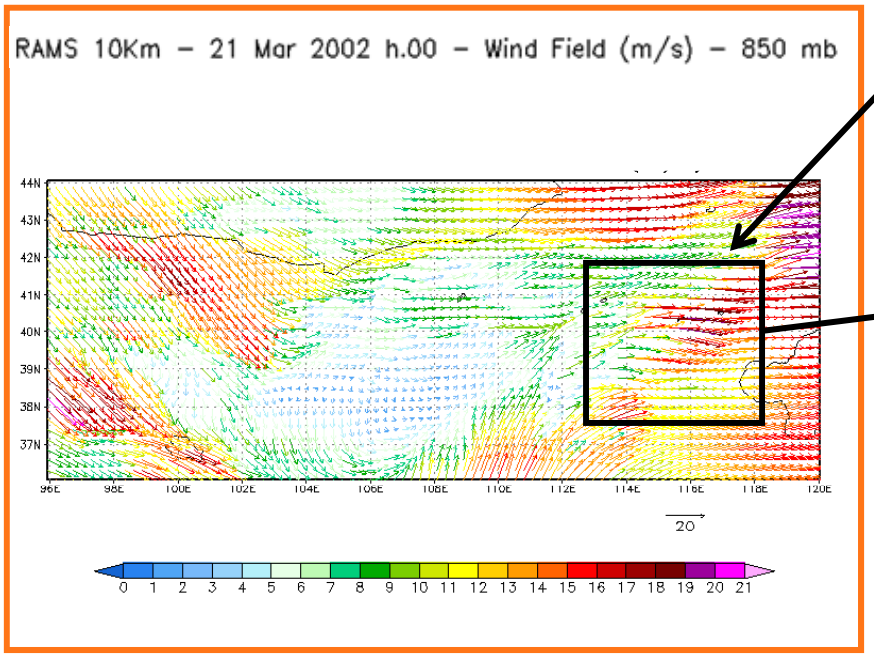
2.5km H.R. 180x180 grid points
40 v. levels

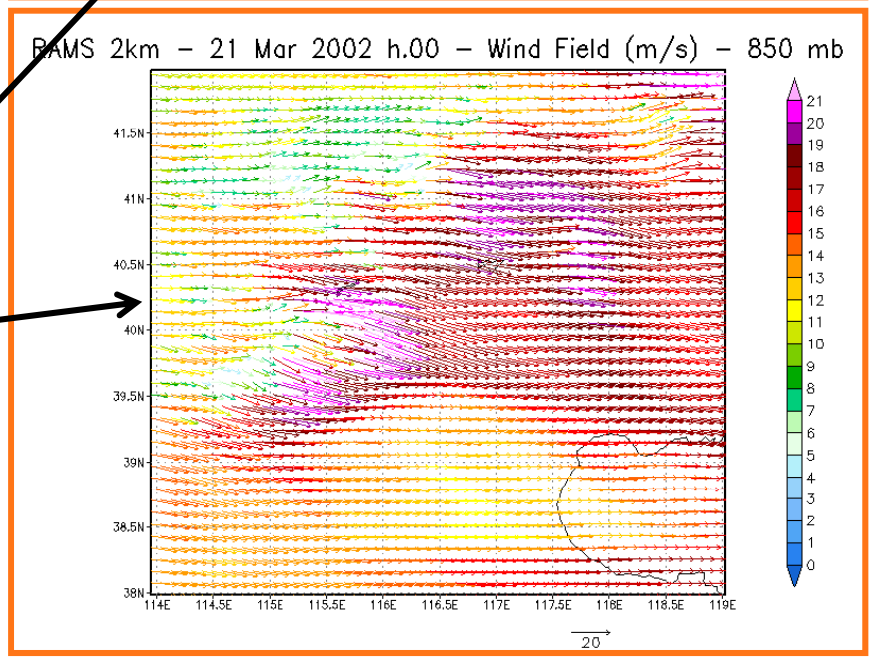


Atmospheric Model - RAMS









Emission Model

- Identify the dust-sand sources and estimate the amount of dust-sand transported by wind.
- Two kinds of sources are been analysed and modeled:
  - Remote sources(i.e. chinese deserts),
  - Local sources (i.e. abandoned rubble pits or drought rivers in Beijing area).
- Dust-sand vertical emission amount dependes, in both cases, from friction velocity:
  - **Remote emissions**:

(Nichovich et al. 2001) →

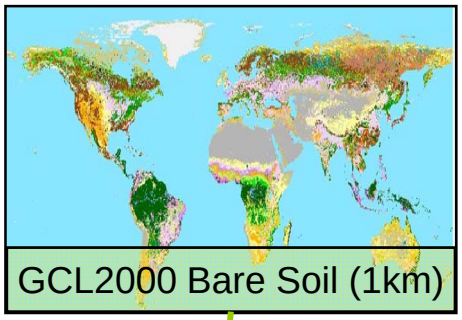
$$F_S^{EFF} = const \times \delta \times u_{*T}^2 \left[1 - \left(\frac{u_{*T}}{u_*} \right)^2 \right] \quad for \quad u_* > u_{*T}$$

  - **Local emissions**:

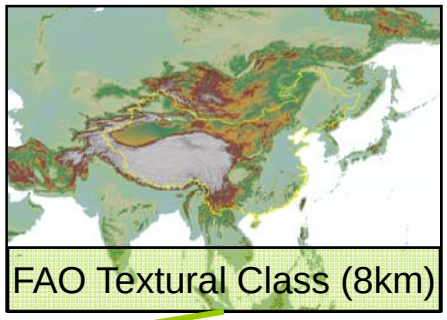
(best polynomial fitting of data collected within WinDust project) →

$$F_S^{EFF} = 69.63\, u_*^4 + 37.8\, u_*^2 + 0.8559$$

Emission Model – remote emissions

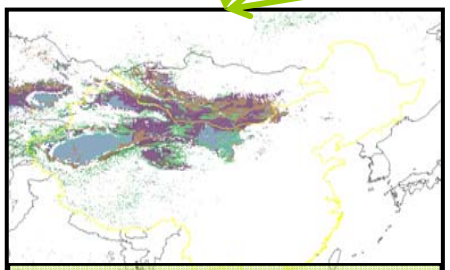


GCL2000 Bare Soil (1km)

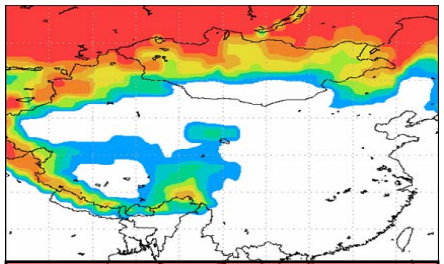


FAO Textural Class (8km)

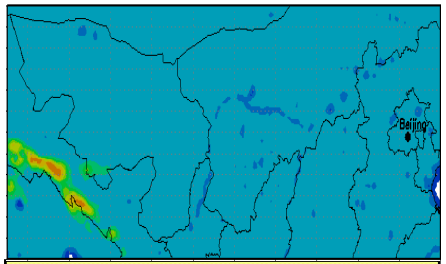
Remote Dust Sources: scheme of inputs for DUSTEM



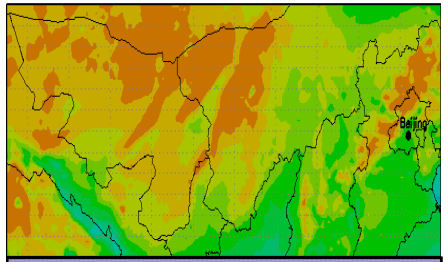
Bare Soil – Textural Map



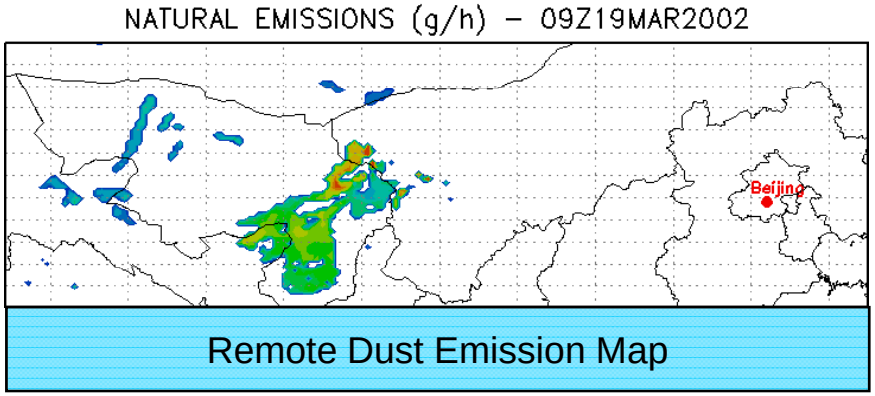
NHE Snow Cover (1deg)



RAMS Soil Moisture



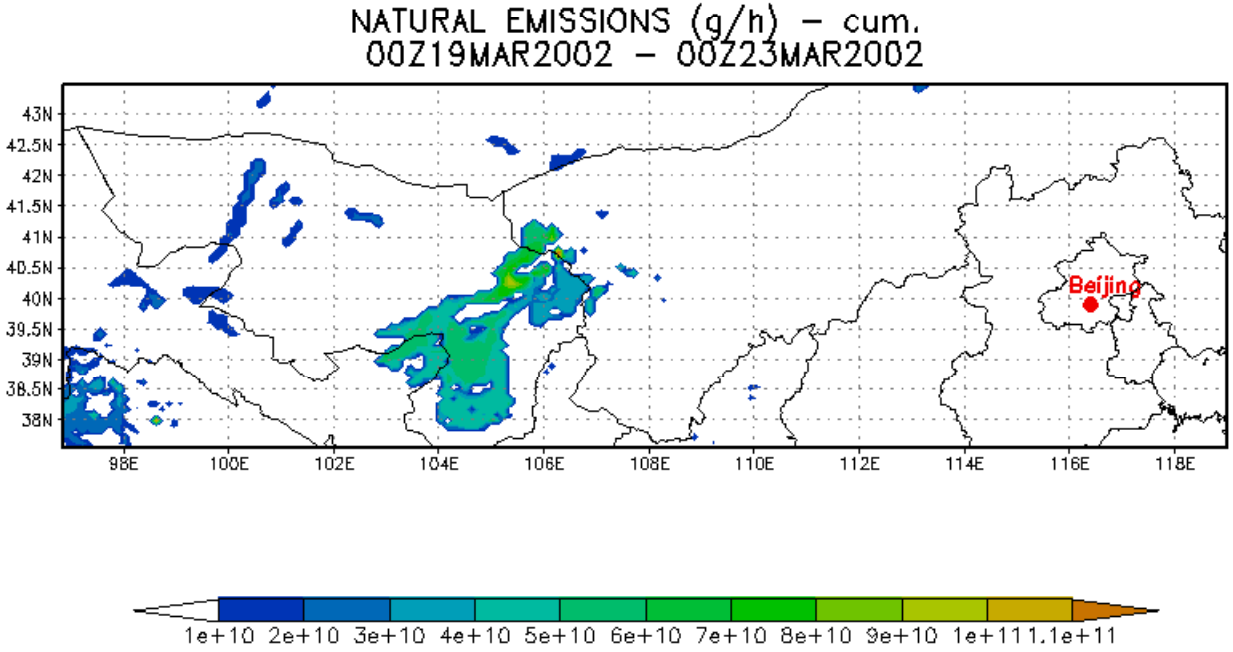
RAMS Friction Velocity



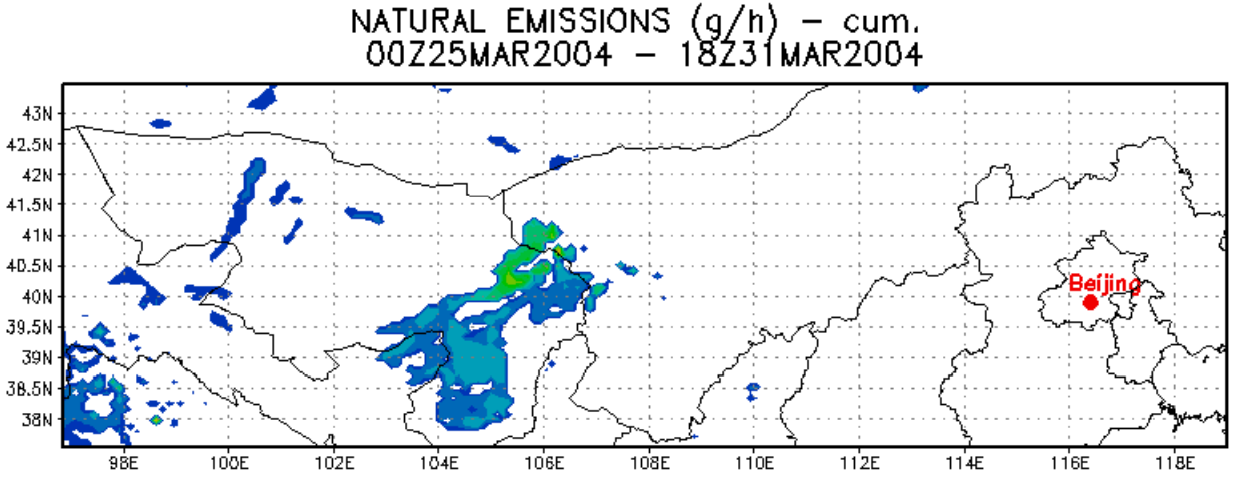
Remote Dust Emission Map

Emission Model – remote emissions

Cumulated Remote Emission amount: case study *19-22 March 2002*



Cumulated Remote Emission amount: case study *28-31 March 2004*

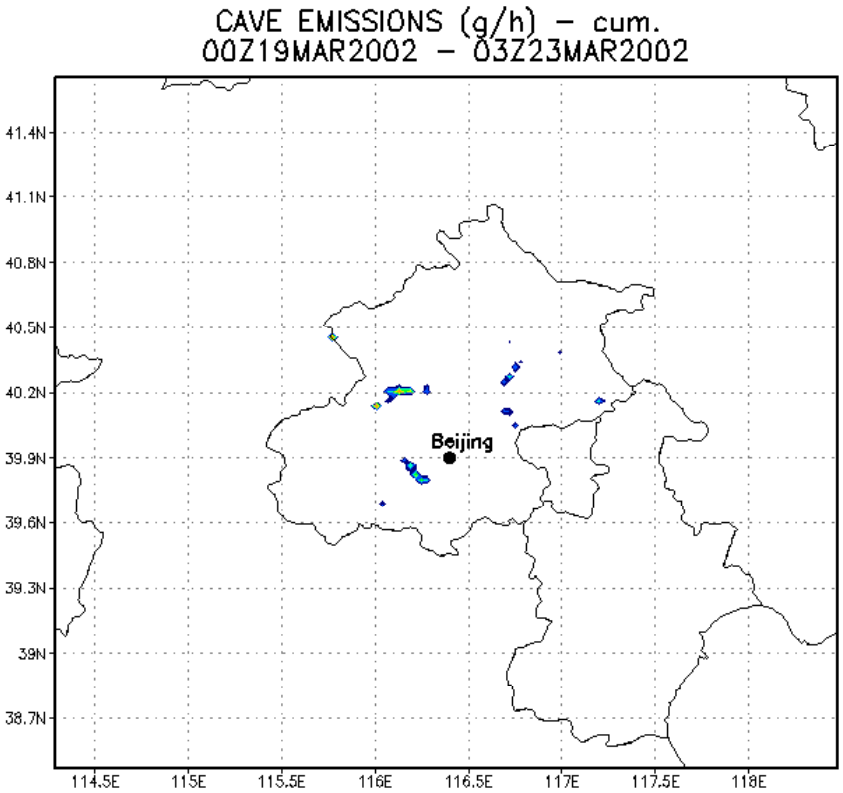


Emission Model – local emissions

Cumulated Local Emission amount:

case study

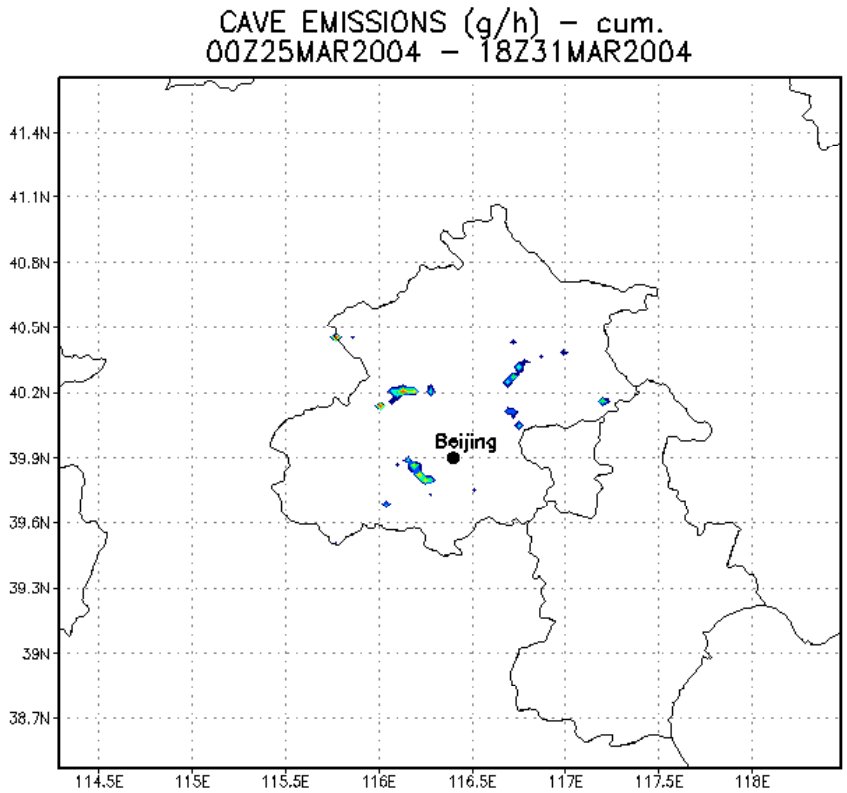
19-22 March 2002



Cumulated Local Emission amount:

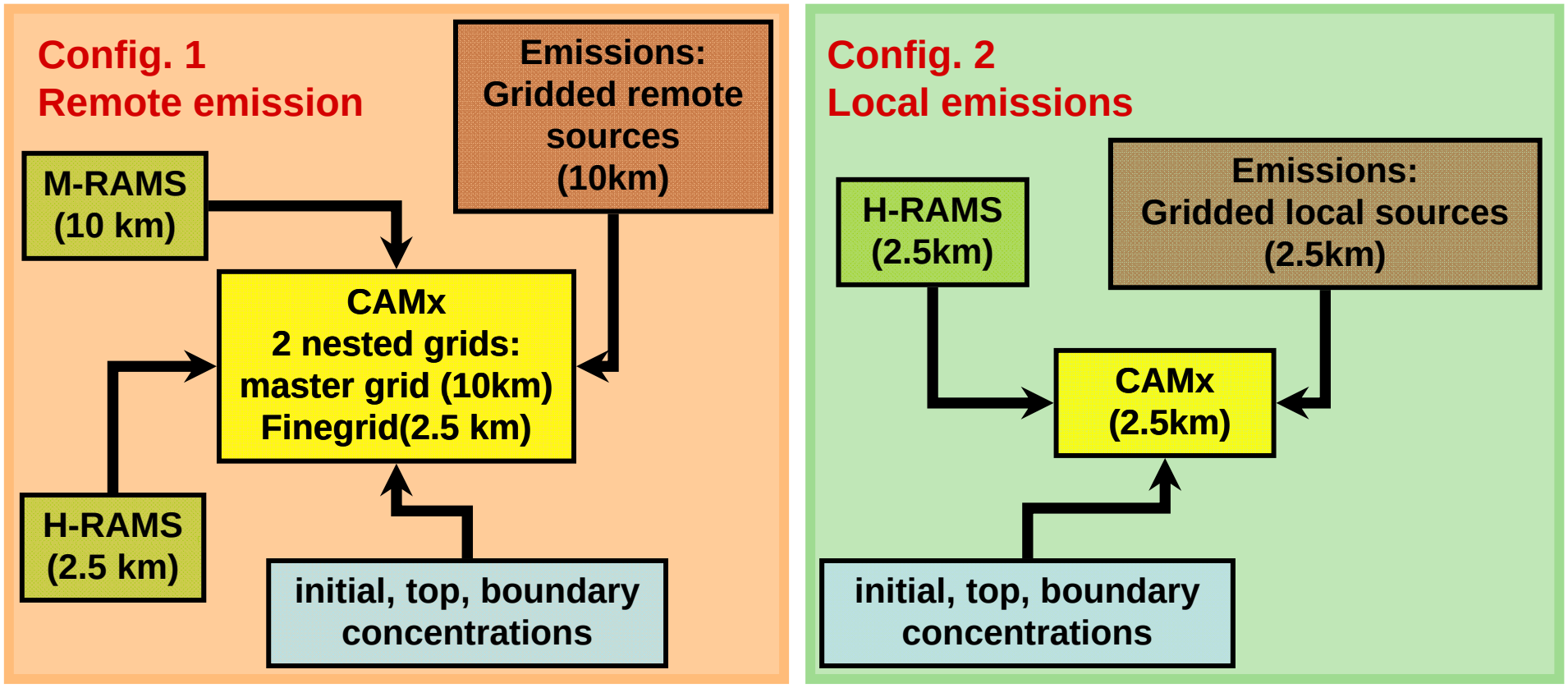
case study

25-31 March 2004



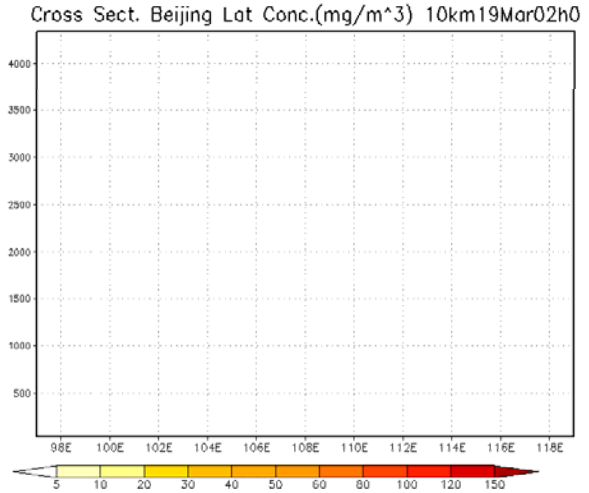
Dispersion Model - CAMx

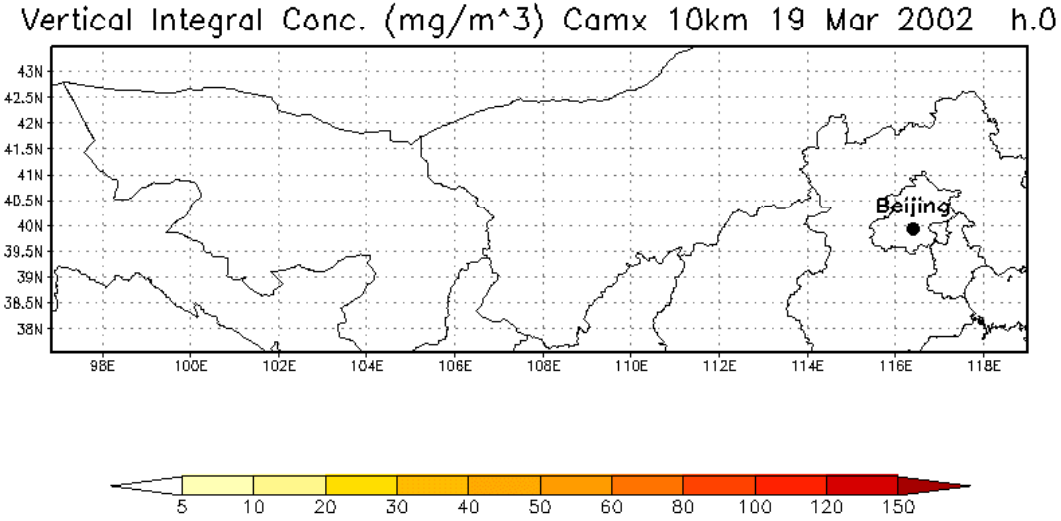
- CAMx (Comprehensive Air Quality Model with extensions), eulerian photechemical dispersion model.
- Input: hourly 3D atmospheric fields (from RAMS) and hourly emission amount (from DUSTEM).
- 2 configurations were set to model DSS dispertion:

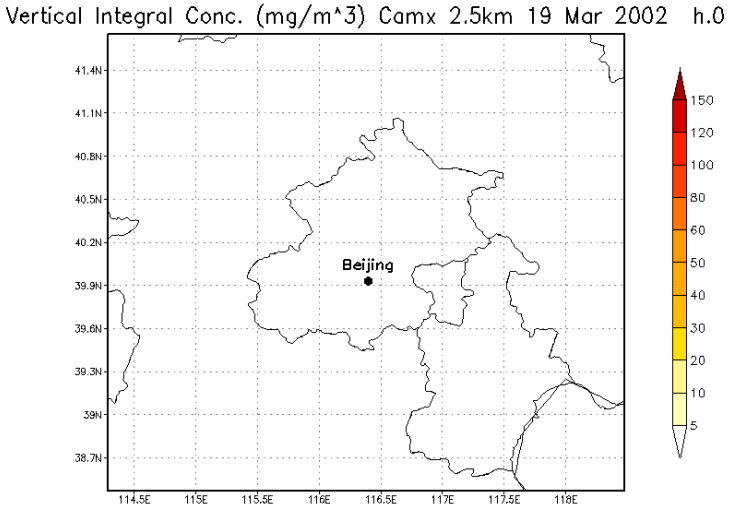


Remote Emission: case study 2002

- Night 19th March – early morning 20th March
- DS concentration vertically spread ranging heights of 3000 m a.g.l.
- Influence of Alashan in dust storm remarkable during the beginning of event.
- Dust concentration peak value in Beijing location of about 9 mg/m3 around midnight of 20th March.

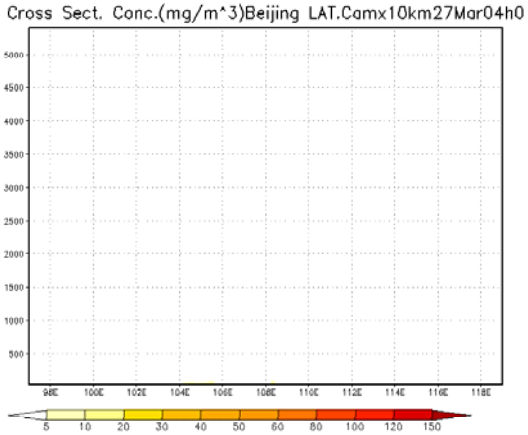


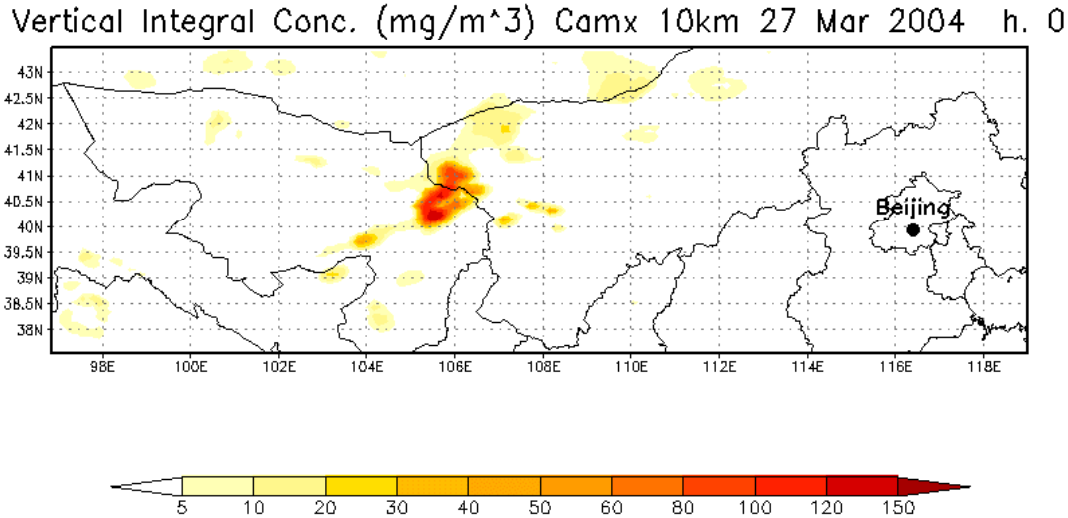


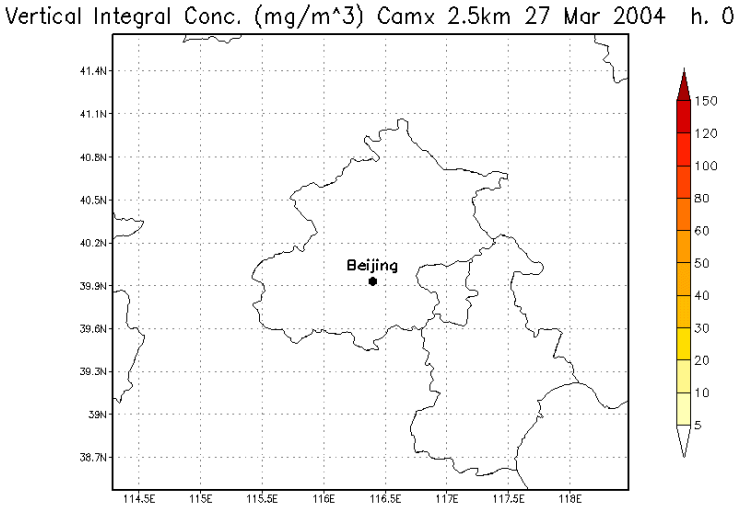


Remote Emission: case study 2004

- First event starting in the early morning of 27th March from the Alashan/Mongolia regions, reaching the Beijing area in the afternoon of the same day.
- Peak concentrations were found over large areas.
- In the morning of 28th March a second DSS event takes place starting from the Mongolia and Alashan, which moves southeast.
- Beijing location shows two different episodes. In the first episode two peaks were found (around 6 and 3 mg/m3 respectively). Two peaks lower than 3 mg/m3 characterize the second episode.



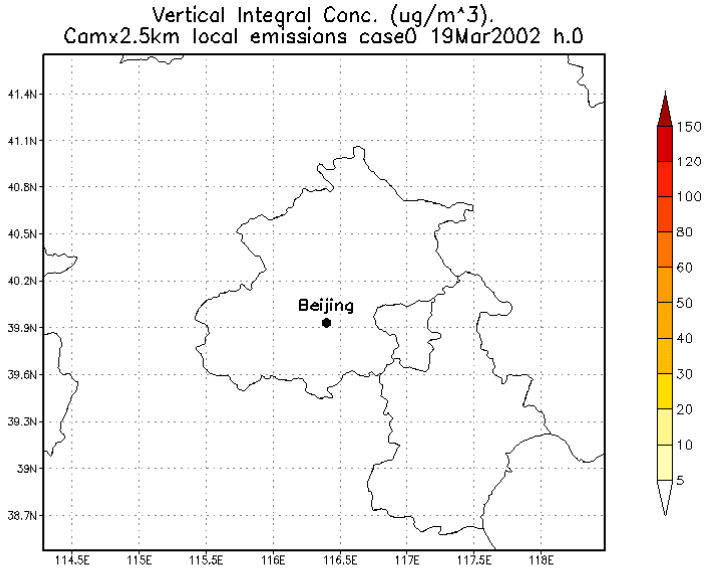




Local Emission: case study 2002 & 2004

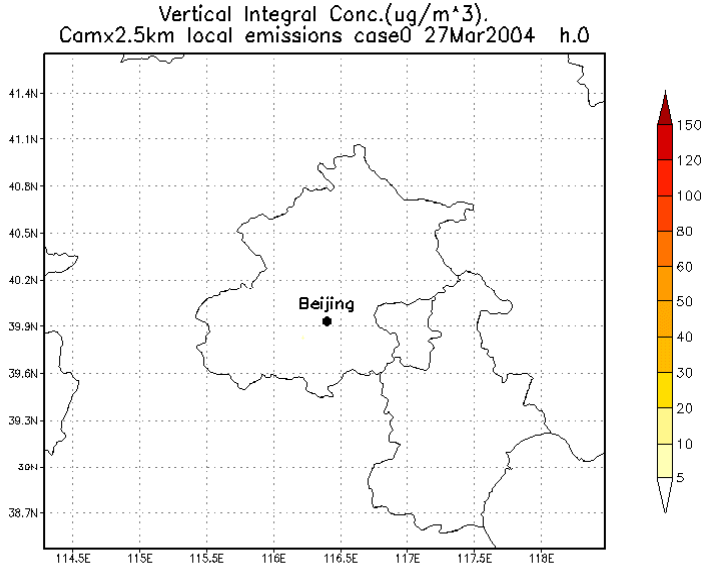
2002.

- The concentration amount due to local emissions is three magnitude orders lower than those due to remote emissions.
- From the afternoon of 19 March to the evening of 22 March and was characterized by a number of low marked peaks.
- Maximum concentrations 2-3µg/m3.
- Local emissions only affect a few hundreds of meters of the atmosphere.



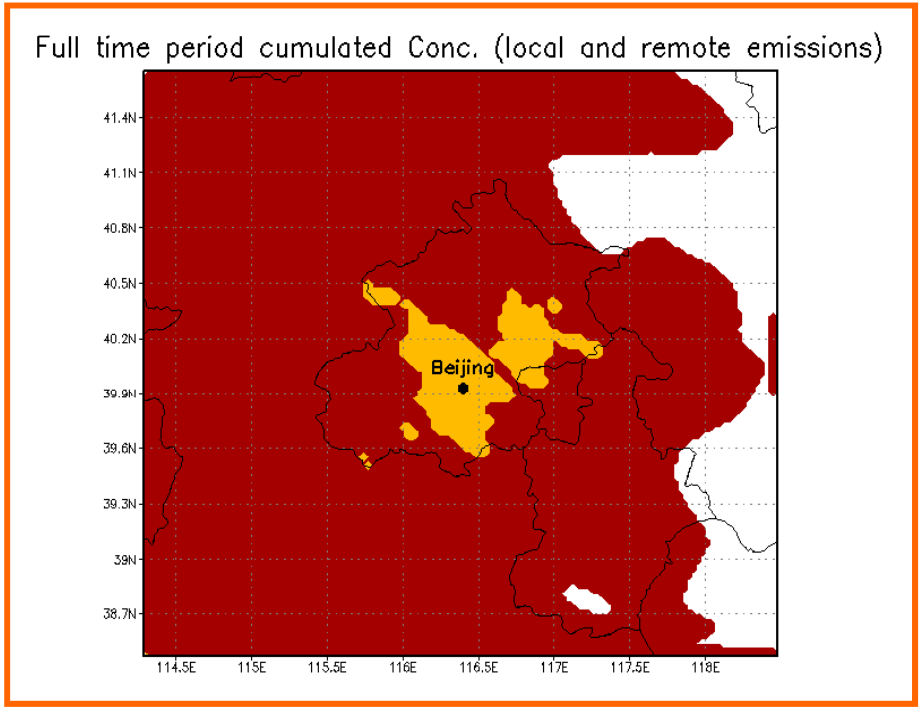
2004.

- DSS event was characterized by a number of marked peaks lower than 4 µg/m3.

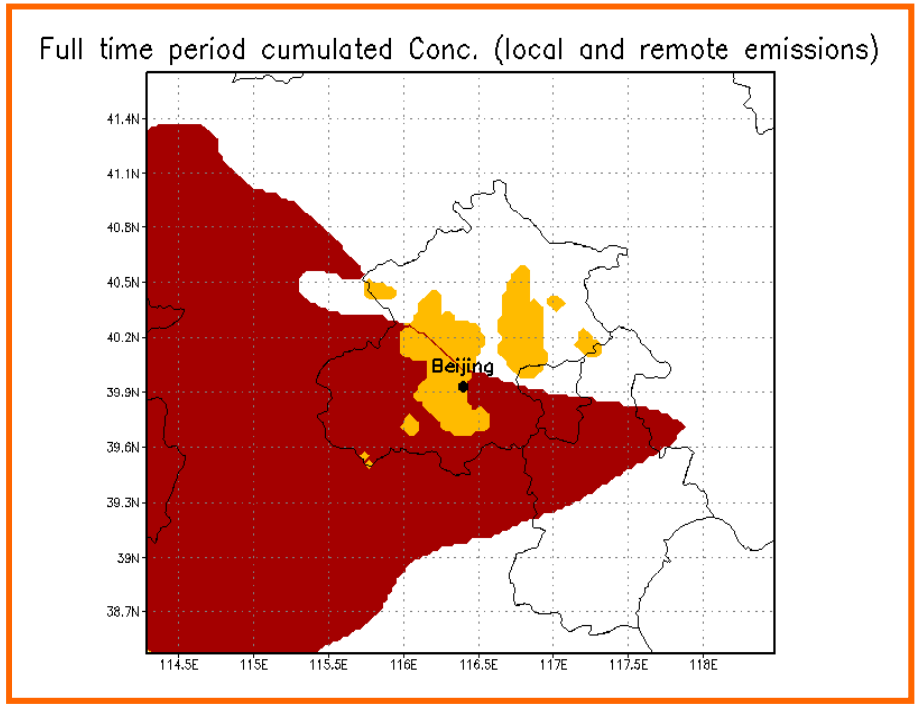


Contibution of remote & local sources

Case study 2002



Case study 2004



- Similar dust distribution on the target area in both case studies for local dust-sand emission *(→ turbulence in low atmosphere)*
- Different dust distribution on the target area in both case studies for remote dust-sand emission *(→ related to particular atmospheric conditions)*

Conclusions

– A complete *coherent* atmospheric/emission/dispersion modelling chain has been *developed* and *optimized* for such target area in order to allow the simulation and analysis of dust/sand storms affecting Beijing.

– Achieving a *good representation of the DSS dynamics* both at regional (Northern China) and local scales (Beijing area), taking into account at the same time remote and local dust sources for a direct comparison and analysis.

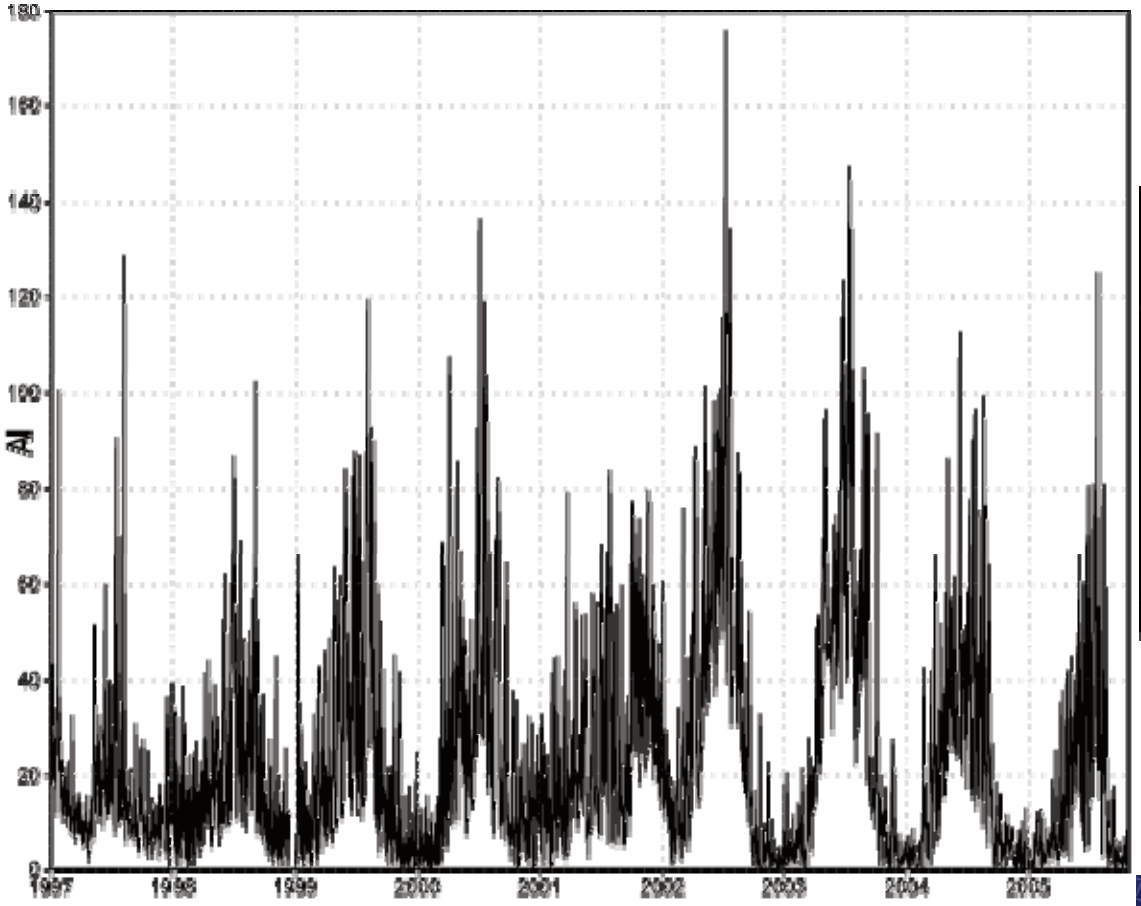
– The RAMS atmospheric model provided a good level of reliability, as derived by comparing the RAMS output to the Reanalysis dataset and to the data measured at the monitoring stations.

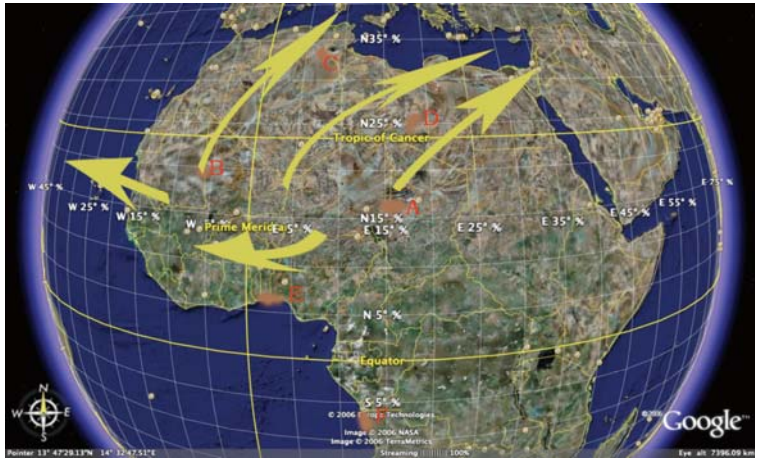
– The CAMx dispersion model provides a good description of the long-range transport phenomenon, as validate with measured data for 2002 event.

– The DUSTEM dust emission model can be improved, but from a synoptical viewpoint, at this scale of study (10km) it provide a quite reasonable emission amounts.

– The whole modelling chain has been developed with an *extreme flexibility*, in order to allow the modification of input data, or some of its parts, and to evaluate the impact of some scenarios.

… e nel Mediterraneo?

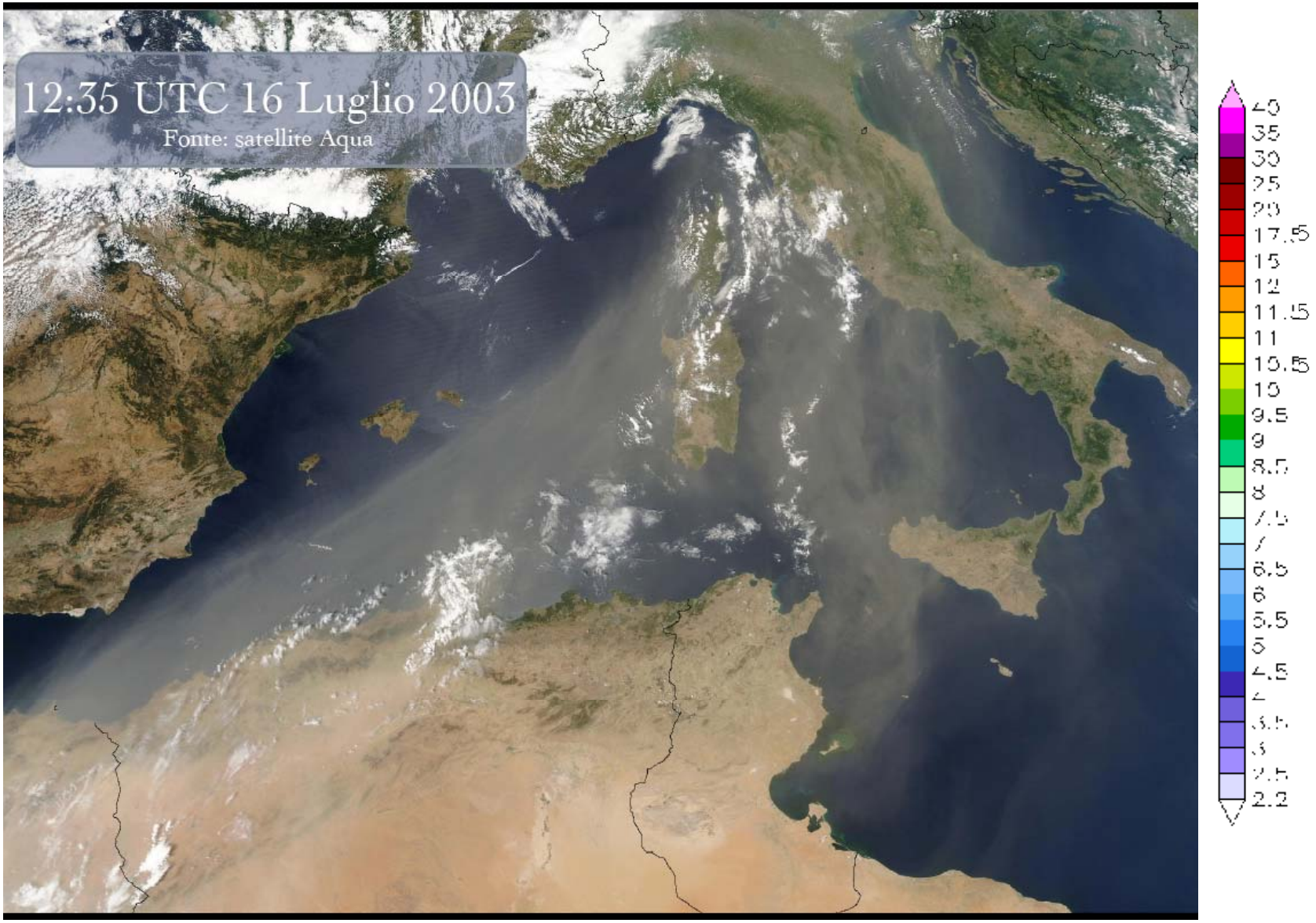




Aerosol INDEX (TOMS – NASA)

1997 - 2006

… e nel Mediterraneo?



Grazie!!!

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