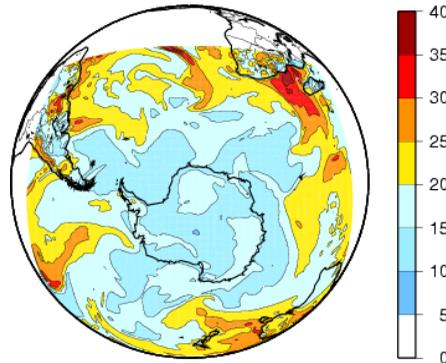


chimere

version 2016

<http://www.lmd.polytechnique.fr/chimere>



Surface ozone concentrations

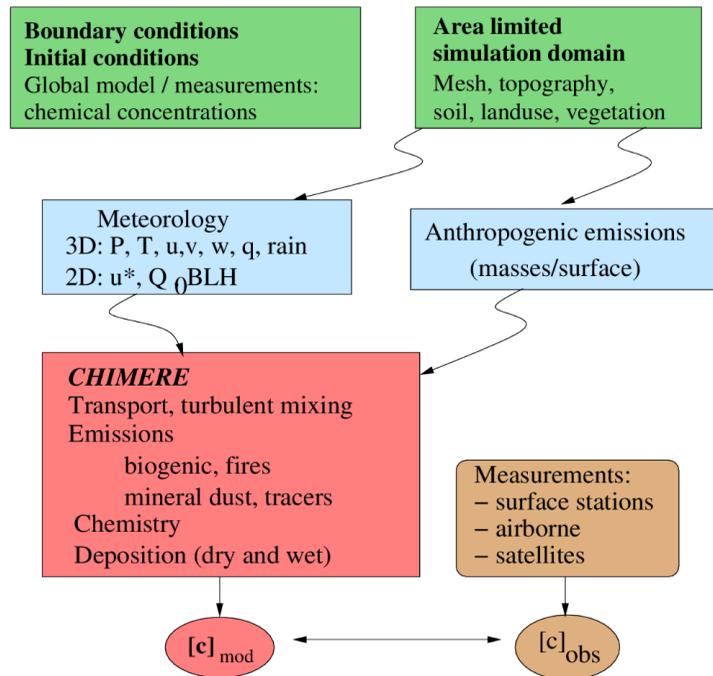
Laurent MENUT
Laboratoire de Météorologie Dynamique

A chemistry-transport model for research on processes, scenarios and forecast

CHIMERE

off-line three-dimensionnal model

- CHIMERE calculates and provides atmospheric concentrations of tens of gas-phase and aerosol species
- External forcings are required to run a simulation: meteorological fields, primary pollutant emissions, chemical boundary conditions
- CHIMERE is distributed under the General Public License and is a National Tool of the French Institut des Sciences de l'Univers
- The code is completely written in Fortran90, and running scripts are written in shell (using gnu-awk for input datafiles processing)



A chemistry-transport model for research on processes, scenarios and forecast

CHIMERE is used for:

Physical and chemical processes research

- Transport and mixing, turbulence
- Gas and aerosol chemistry
- Anthropogenic, biogenic, mineral dust, vegetation fires and volcanos emissions
- gas and aerosol dry and wet deposition

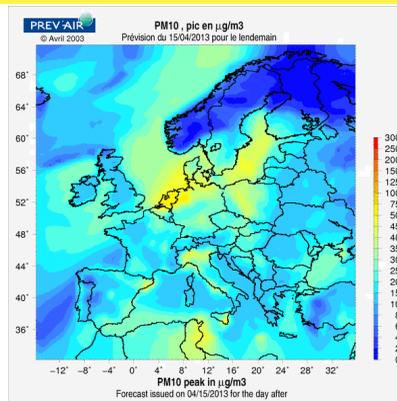
Scenarios and climatologies

- Past and future emissions impacts
- Ensemble analysis

Forecast

- Experimental forecast at LMD during specific field experiments
- Operational forecasts:
 - In Europe: MACC
 - In France: PREVAIR
 - Over many regions: Regional air quality networks

PREVAIR forecast - www.prevail.org



ECMWF-MACC ensemble forecast

History of the CHIMERE development

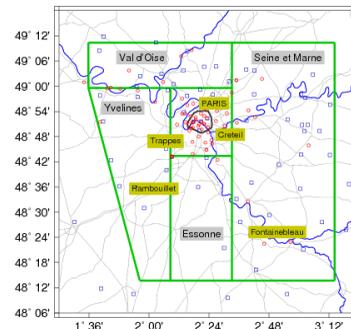
1997 → 2004: urban and regional ozone

- **1997:** Box model version for Paris area for ozone
- **1998:** "Pollux" Esquif experimental forecast
- **1999:** Cartesian grid (over Europe)
- **2000:** Adjoint version and inverse modeling
- **2001:** "Pioneer" experimental forecast
- **2003:** France operational forecast PREVAIR

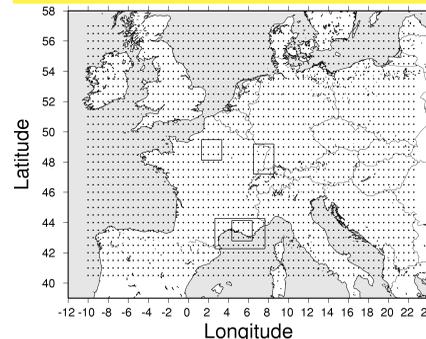
2004 → 2014: aerosols and long-range transport

- **2004:** Add anthropogenic aerosols
- **2005:** Add mineral dust (Africa only)
- **2006:** Parallel version
- **2007:** Deep convection, new deposition scheme
- **2007:** *CHIMERE is a CNRS national tool*
- **2008:** GEMS Experimental forecast
- **2011:** Mineral dust in distributed CHIMERE
- **2012:** MACC Operational forecast
- **2014:** FastJ Radiative transfer and photolysis model, SAPRC chemical mechanism

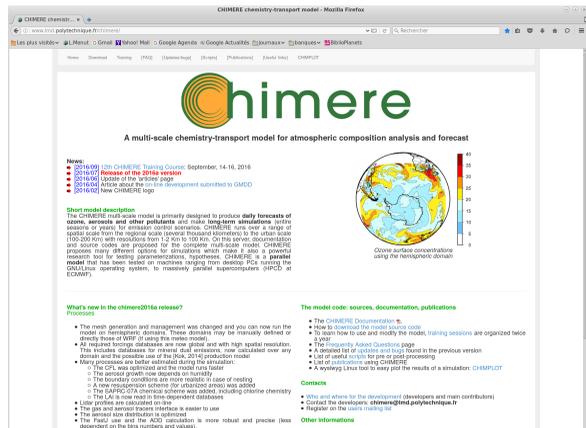
The first domain: Ile de France with 5 boxes (1997)



The first gridded domain (2001)

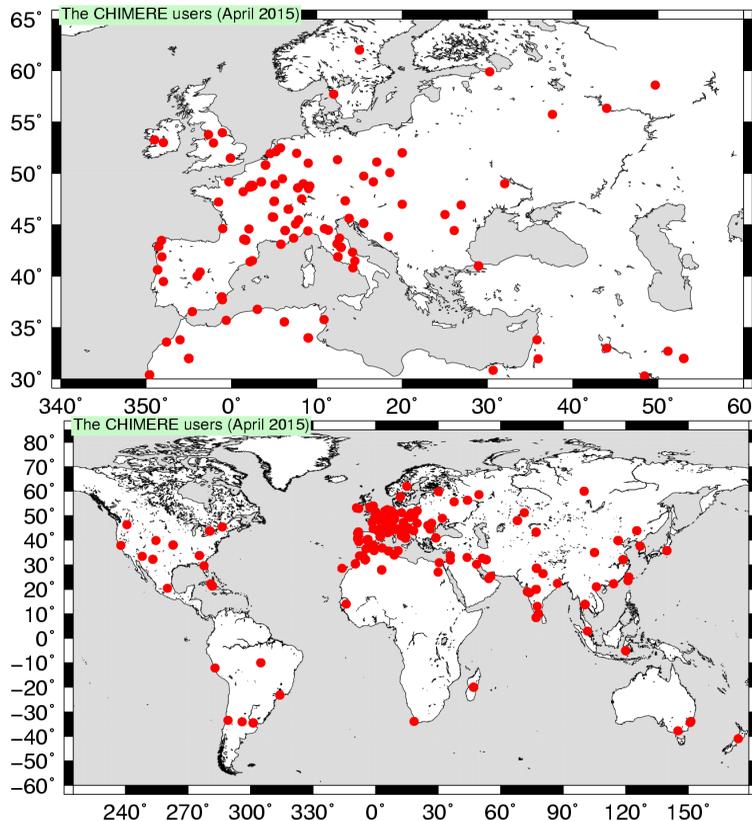


In free access on the model web site:
<http://www.lmd.polytechnique.fr/chimere>



The CHIMERE users

- More than 350 users (registered on the e-mail list),
- In more than 120 research institutes (universities, air quality networks, private companies, etc.)



3 institutes (LMD, INERIS, LISA)
10 developers

At LMD: 3 permanent people for the development:

- CNRS Research Engineer: Dmitry Khvorostyanov (2007)
- Observatory Physician: Myrto Valari (2011)
- CNRS researcher: Laurent Menut (1998), coordination (since 2006)

BESSAGNET Bertrand
INERIS
Research engineer



MELEUX Frederik
INERIS
Research engineer



COLETTE Augustin
INERIS
Research engineer



MENUT Laurent
IPSL/LMD (model coordination)
DR CNRS



COUVIDAT Florian
INERIS
Research engineer



SIOUR Guillaume
IPSL/LISA
IR CNRS



KHVOROSTYANOV Dmitry
IPSL/LMD
IR CNRS



TURQUETY Solene
IPSL/LMD
Assistant Prof. UPMC



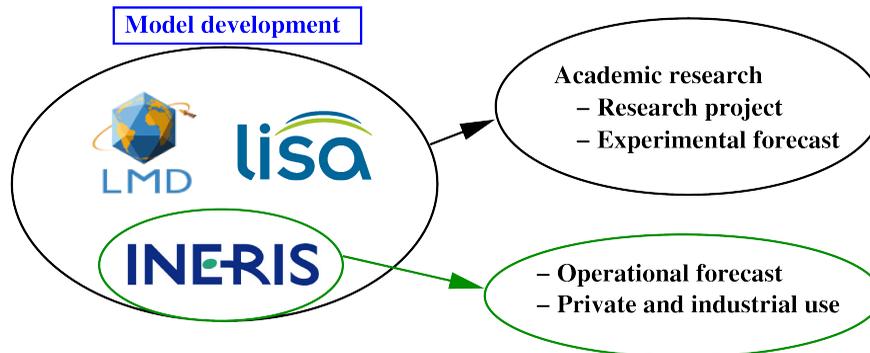
MAILLER Sylvain
IPSL/LMD
IPCE



VALARI Myrto
IPSL/LMD
Assistant Phys. UPMC



How to use the model?



For academic research use:

- 1 Register on the CHIMERE web site to have a password to download the code
- 2 Try the studied case already prepared
- 3 For questions about:
 - The model use: write to the users mailing list **chimere-users@lmd**
 - The model schemes: write to the developers **chimere@lmd**

For private or industrial use, or daily operational forecast:

- 1 Contact the developers of INERIS (already involved in a lot of these studies)

Developments

- 1 The developments priorities are managed by the developers group
- 2 In case of new developments, the user have to send it to the developers
- 3 The development team proposed the code but is not designed to run simulations for users
- 4 Interactions between users and developers are welcome but only under the format of funded projects.

Inclusion of preprocessed calculations

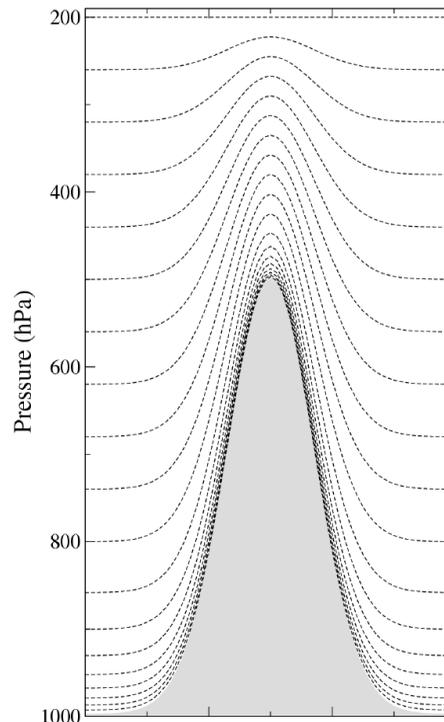
- Reduction of global computation time (done in parallel mode instead of sequential)
- Enables to make interactions between meteo and chemistry (preparation of the on-line coupled model)
- Limitation: only for forcing with the WRF model

Optimization of the parallelization

- Removal of the master/worker architecture
- Use of the parallel input/output NetCDF libraries
- Best performances when using numerous processors

Optimization of the vertical grid calculation

- Selection of the first vertical level, top of domain and top domain pressure
- A more regular spacing in the free troposphere

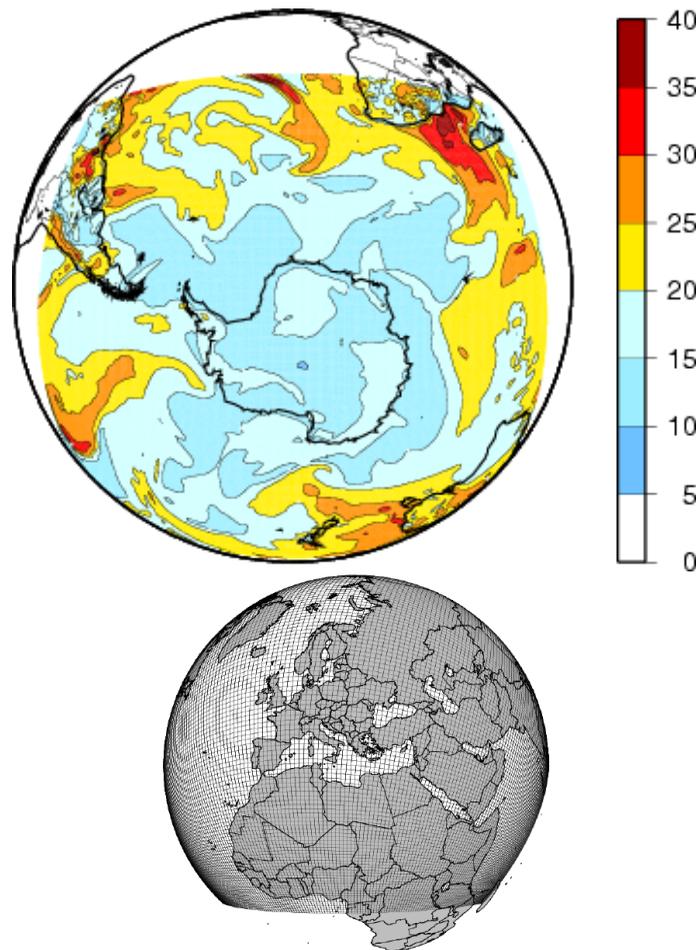


Why an hemispheric version?

- To produce homogeneous boundary conditions for the regional domains (same model, same chemistry etc.)
- To allow long-range transport studies of dust, fires and volcano plumes

A new model architecture with:

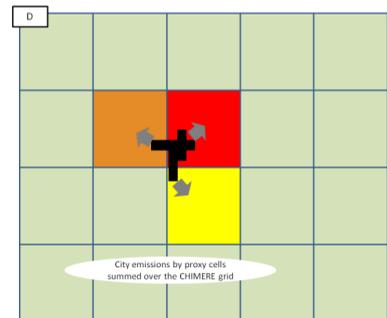
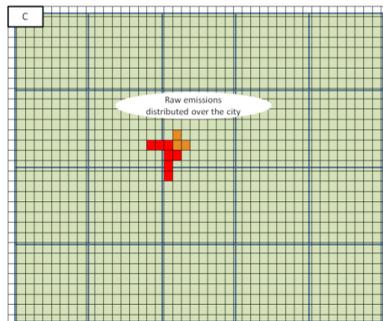
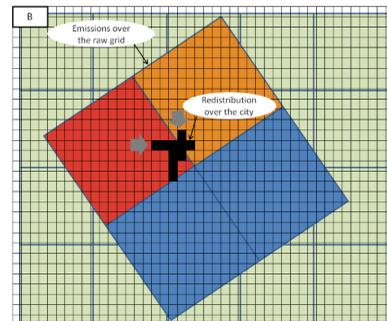
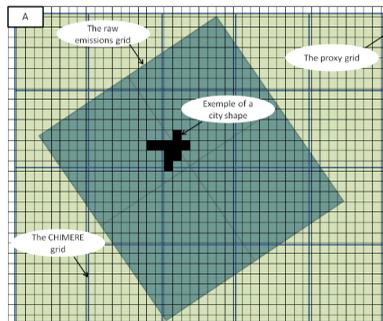
- An updated version of the 'anthropogenic pre-processor program' (emisurf)
- An updated version of the horizontal transport in CHIMERE



The emisurf preprocessor

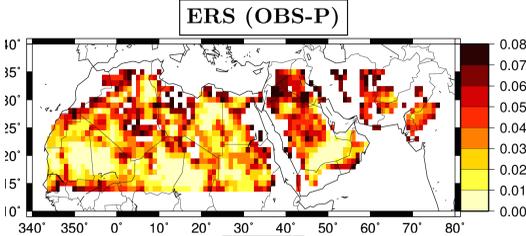
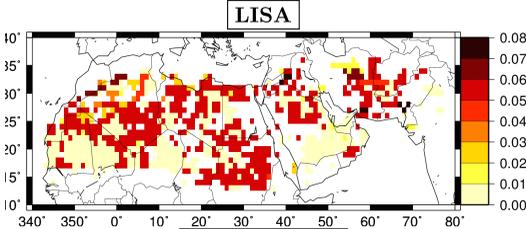
An optional tool for CHIMERE.

- Code optimization
- Residential sector height injections closest to the surface
- Possibility to use proxies to spatially redistribute emissions fluxes, but ONLY over western Europe.
- The current proxies are:
 - 1 CORINE land cover
 - 2 European Pollutant Release and Transfer Register (E-PRTR): industrial sources.
 - 3 European Transport policy Information System (ETIS): roads
 - 4 European population database (Gallego 2010)

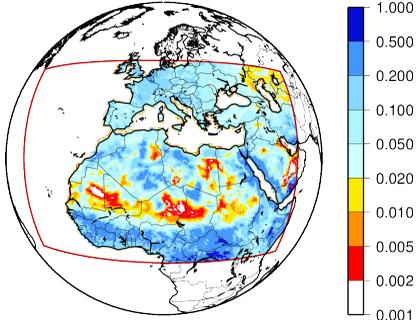


- Updated input databases (soil and surface, z_0 , erodibility)
 - Aeolian roughness length (ASCAT),
 - soil and surface properties (USGS),
 - erodibility (MODIS)
- New emissions scheme, [Kok et al., 2014]
- New processes: soil humidity, precipitations
- Urban resuspension in PPM emissions

Roughness length z_0 (cm)



Example of the domain Africa+Med+Europ



- The SAPRC-07A (Carter, 2010) chemical mechanism
 - 72 species
 - 218 reactions
- Halogen chemistry:
 - Impact on tropospheric ozone concentrations
 - Acts as a nitrogen reservoir
 - Addition of chlorine (+68 reactions with SAPRC only)
- New calculation of aerosol size distribution
 - Prescribe D_{min} and D_{max} , number of bins
 - Respect the cut-off diameters $d=2.5 \mu\text{m}$ and $10 \mu\text{m}$
- Wet diameter and wet density of aerosols
 - Use of the "reverse" mode of ISORROPIA
 - Hygroscopicity for sulphate, nitrate, ammonium and sea salts
 - Density of aqueous phase of particles following [Semmler et al., 2006]
- Improvement of:
 - Absorption
 - Coagulation
 - Wet deposition

- FastJX module
 - New interpolation of bins on fastJ wavelengths
 - Addition of a more realistic stratospheric climatology
 - On-line calculation of water-vapor concentration
- Surface Albedo
 - New data in the near-UV spectral region
 - Taken into account snow
- Lidar profile
 - On-line calculation of lidar profile
 - Zenith or Nadir mode (see [Stromatas et al., 2012])

| | CHIMERE-2013 | CHIMERE-2016 |
|----------------------------|------------------|---|
| SZA | ✓ | ✓ |
| Altitude | ✓ | ✓ |
| Clouds | parameterized | ✓ |
| Tropospheric ozone column | Constant profile | ✓ |
| Stratospheric ozone column | Constant profile | Month- and latitude-dependant climatology |
| Water-vapor concentration | Constant profile | ✓ |
| Aerosol effect | ✗ | ✓ |
| Variable albedo | ✗ | ✓ |