

Polyphemus Training Day

Introduction to Polyphemus (translated from French)

Vivien Mallet, for the development team

27 March 2007

Outline

Polyphemus
Training Day

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Goals

Structure,
development
guidelines

Current
Content

Next...

- 1 Goals
- 2 Structure, development guidelines
- 3 Current Content
- 4 Next...

Polyphemus Images

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Greek Mythology

- Polyphemus, cyclops in Odyssey

Why this name ?

- « Poly » : multiple
- « phemus » : speech



Multiple Goals

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Multiple Models

- Scales : from local scale to continental scale
- Formulations : Gaussian, Eulerian, . . .

Multiple Pollutants

- Passive, radionuclides
- Photochemistry
- Aerosols
- Persistent organic pollutants, heavy metals, . . .

Multiple Inputs

- From meteorological models
- Ground data

Multiple Methods

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Data Assimilation

- Sequential
- Variational
- Inverse modeling (parameter estimation)

Ensemble Forecast

- Multimodels
- Monte Carlo
- Models combinations (« superensembles », ...)

Models Coupling

- Feedbacks
- Impact

Constraints

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Perennial Code

- System maintenance
- Scalable, integration of new developments

Open

- Availability, distribution
- Development or contributions from other teams

Field Context

- From research to operational use

Overall structure

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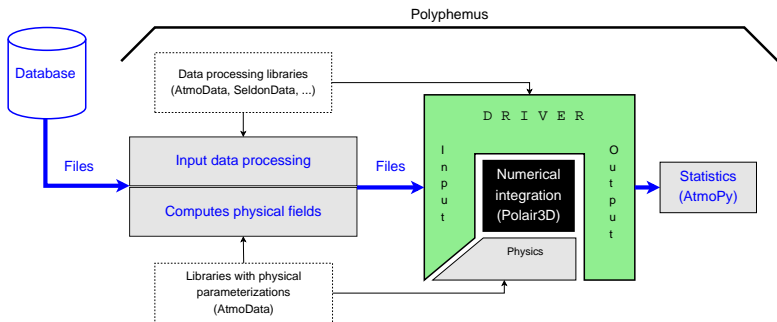
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Programming Choices

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Main language : C++

- Efficient for scientific computing
- Advanced object design
 - Inheritance, genericity
 - Management of complex objects
 - Exceptions
- Widely used and perennial

Example : Data Manipulation

```
LinearInterpolationRegular(SoilWater, SoilWater_out);  
SoilWater_out.Threshold(0., 1.);
```

Example : Model Manipulation

```
Model.Forward();  
OutputSaver.Save(Model);
```


Programming Choices

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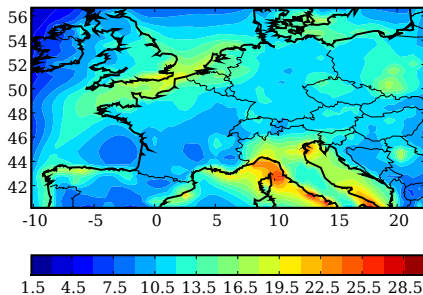
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Complementary Language : Python

- Dynamic, interactive
- Visualization
- Scripts
- Increasingly used in scientific computing



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Historical Language : Fortran 77

- Automatic differentiation
- Continuity
- Calls from C++

Policy

- To avoid dealing with too many languages
- To use primarily languages with strong potential and productivity

Overall Structure

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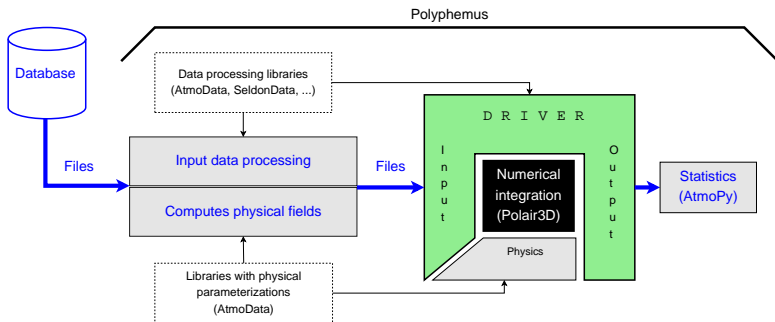
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Libraries

AtmoData, SeldonData, AtmoPy, Talos

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Preprocessing, Data Management

- SeldonData (C++)
 - Interpolations, input/output operations, ...
- AtmoData (C++)
 - Extension of SeldonData to atmospheric sciences

Physics

- AtmoData (C++, Fortran 77)
 - Meteorology, emissions, ...

Visualization, Postprocessing, Statistics

- AtmoPy (Python)

Miscellaneous

- Talos (C++) : configuration files

Models

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Gaussian Models

- Stationary Gaussian model and puff Gaussian model
- Gas and aerosols
- Several parameterizations to compute the dispersion

Eulerian Models

- Castor (clone of the gas version of Chimere)
 - Passive and chemical versions
- Polair3D
 - Passive, chemical, aerosol and adjoint (for gas) versions
- Modules for transport, chemistry and aerosols

Modules

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Transport

- Advection (DST3, PPM), diffusion (ROS2)

Chemistry

- RADM, RACM, Melchior
- Radioactive or biological decay

Aerosols

- SIREAM (semi-Lagrangian)

Output Savers

- Whole domain, list of points
- Boundary conditions (for nesting)
- Deposition fluxes, ...

Preprocessing

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Meteorological Fields

- ECMWF, MM5
- Vertical diffusion : Louis and Troen&Mahrt

Ground Data

- Land use cover : USGS, GLCF
- Emissions from EMEP
- Biogenic emissions (Simpson et al., 1999)
- Deposition : Emberson, Wesely and Zhang

Boundary Conditions

- Mozart 2, Inca
- Gocart

Gaussian Models

Forward Simulation (BaseDriver)

- A model is a C++ object

```
/** Initializations */  
  
Model.Init();  
OutputSaver.Init(Model);  
  
/** Time loop */  
  
for (int i = 0; i < Model.GetNt(); i++)  
{  
    Model.InitStep();  
    OutputSaver.InitStep(Model);  
  
    Model.Forward();  
    OutputSaver.Save(Model);  
}
```


Drivers

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Optimal Interpolation

```
for (int i = 0; i < Model.GetNt(); i++)
{
    Model.InitStep();
    OutputSaver.InitStep(Model);

    Model.Forward();

    OutputSaver.SetGroup("forecast");
    OutputSaver.Save(Model);

    // Retrieves observations.
    ObsManager.SetDate(Model.GetCurrentDate());

    if (ObsManager.IsAvailable())
    {
        Model.GetState(state_vector);
        Analyze(state_vector);
        Model.SetState(state_vector);
    }
}
```

Forward Simulation

- `BaseDriver`, `StationaryDriver`
- `PlumeDriver`, `PuffDriver`

Data Assimilation

- Optimal interpolation
- Kalman filters : ensemble version et reduced-rank version
- 4D-Var (and adjoint validation)

Under development

- Plume-in-grid model
- Monte Carlo
- Models coupling : soil model / atmospheric model

Postprocessing

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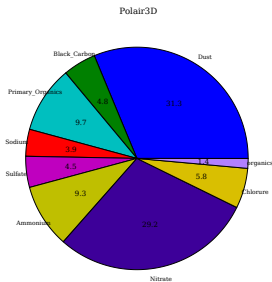
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Programs

- Comparisons to observations (error statistics, visualization)
- Water diagnosis in a plume



AtmoPy Library

- Graphical visualization
- Observations management
- Statistical measures
- Ensembles management (models combinations)

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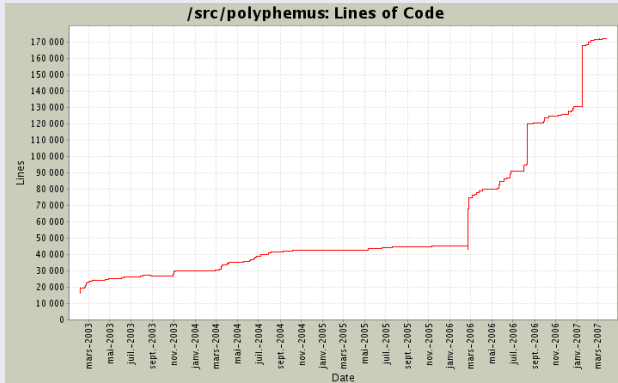
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Code

- 50 000 lines of hand-written code (SLOCcount)
- 50 000 lines automatically generated

Subversion Repository (without SIREAM)



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Current Developers

- | | | |
|----|-------------------------------|--------------|
| 1 | Meryem Ahmed de Biasi (INRIA) | diffusion |
| 2 | Édouard Debry (ENPC) | aerosols |
| 3 | Karine Kata-Sartelet (ENPC) | aerosols |
| 4 | Irène Korsakissok (ENPC) | local |
| 5 | Vivien Mallet (ENPC) | ensemble |
| 6 | Denis Quélo (IRSN) | passive |
| 7 | Yelva Roustan (ENPC) | impact |
| 8 | Bruno Sportisse (ENPC) | aerosols |
| 9 | Marilyne Tombette (ENPC) | aerosols |
| 10 | Lin Wu (INRIA) | assimilation |

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Documentations for users

- User's guide (140 pages)
- Scientific documentation for AtmoData
- Reference documentation for AtmoPy

Documentations for developers

- Guide and reference documentation for SeldonData
- Reference documentation for AtmoData
- Reference documentation for Talos

Examples

- Test cases (Eulerian and Gaussian)
- Practical sessions (primarily for courses at ENSTA and ENPC)

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<http://www.enpc.fr/cerea/polyphemus/>

The screenshot shows a web browser window titled "Polyphemus - Konqueror" displaying the website <http://www.enpc.fr/cerea/polyphemus/applications.html>. The website header features the "POLYPHEMUS Air Quality Modeling System" logo and title. A left-hand navigation menu includes sections for "About Polyphemus" (Introduction, News, Applications, People and Contacts, Positions and Internships), "Resources" (Download, Eulerian Test Case, Gaussian Test Case, Technical FAQ), and "Polyphemus Modules" (AtmoData, AtmoPy). A "Contact" link is located at the bottom of the menu. The main content area is titled "Applications" and features a sub-section "Dispersion of Radionuclides". The text describes the objective of the work: to investigate the validity of Polyphemus for the dispersion of radionuclides, citing model-to-data comparisons for the ETEX campaign, the Chernobyl accident, and the Algeciras release. It mentions preliminary sensitivity analysis and the use of the Polyphemus system for long-range dispersion at IRSN. A timestamp "1986-04-26T00:43:00" is displayed above a map of Europe, which has a red triangle marker labeled "Chernobyl" in the northwestern part of the continent.

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Models (mostly implemented, but not yet included in Polyphemus)

- Secondary organic aerosols
- Modal aerosol module (MAM)
- Heavy metals, mercury
- Passive hemisphere model

Next Steps

- Parallelization
- Lagrangian particle model
- Drivers for assimilation and coupling