Report on PhD research

Cloud Computing to Simulate the Movement of Pollutants in the Atmosphere

Mykola Skrypskyj
Seminar "Formal Methods II"
Hagenberg, Austria
March 13, 2013

Overview

- Relevance
- Methods for Simulation
- Some Modern Modeling Systems
- Simulation the Movement Pollutants using Cloud
- Novelty
- Future Plans
- Recent Publications

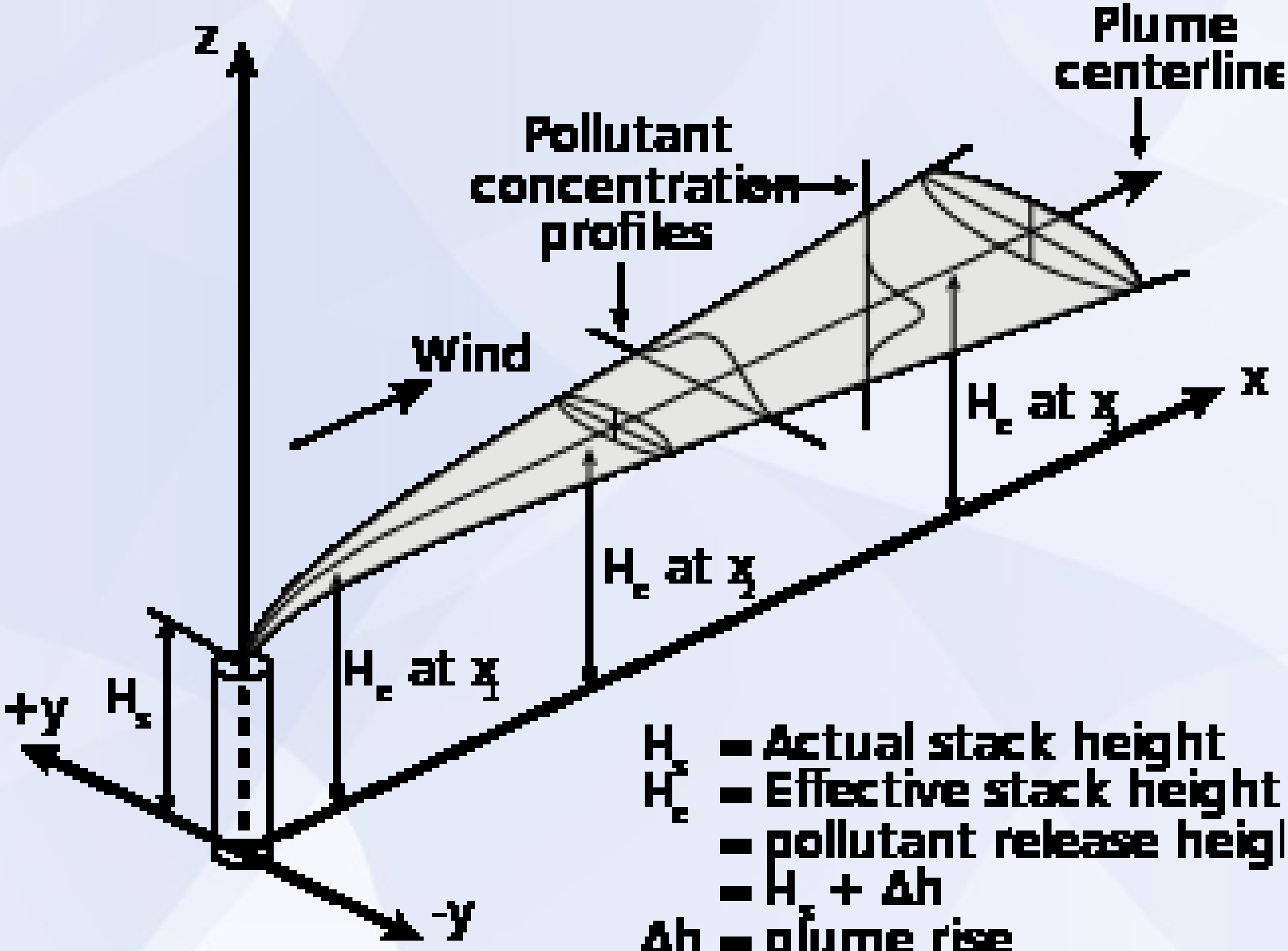
Relevance

- There are many models for modeling of air pollutants.
- Simulation for air pollution tasks are consuming CPU time.
- Usually software for simulation are not cross-platform and need big computers resources.

Methods for Simulation

- Gaussian model
- The Fick's law of diffusion

A buoyant Gaussian air pollutant dispersion plume



The Fick's law of diffusion

Fick's first law relates the diffusive flux to the concentration under the assumption of steady state. In one (spatial) dimension, the law is

$$J = -D\frac{\partial \phi}{\partial x}$$

In two or more dimensions we must use ∇, the del or gradient operator, which generalises the first derivative, obtaining

$$J = -D\nabla\phi$$

Some Modern Modeling Systems (1/2)

- AERMOD Modeling System (North America)
- ADMS (UK)
- OND-86 (ОНД-86) (ex-USSR)

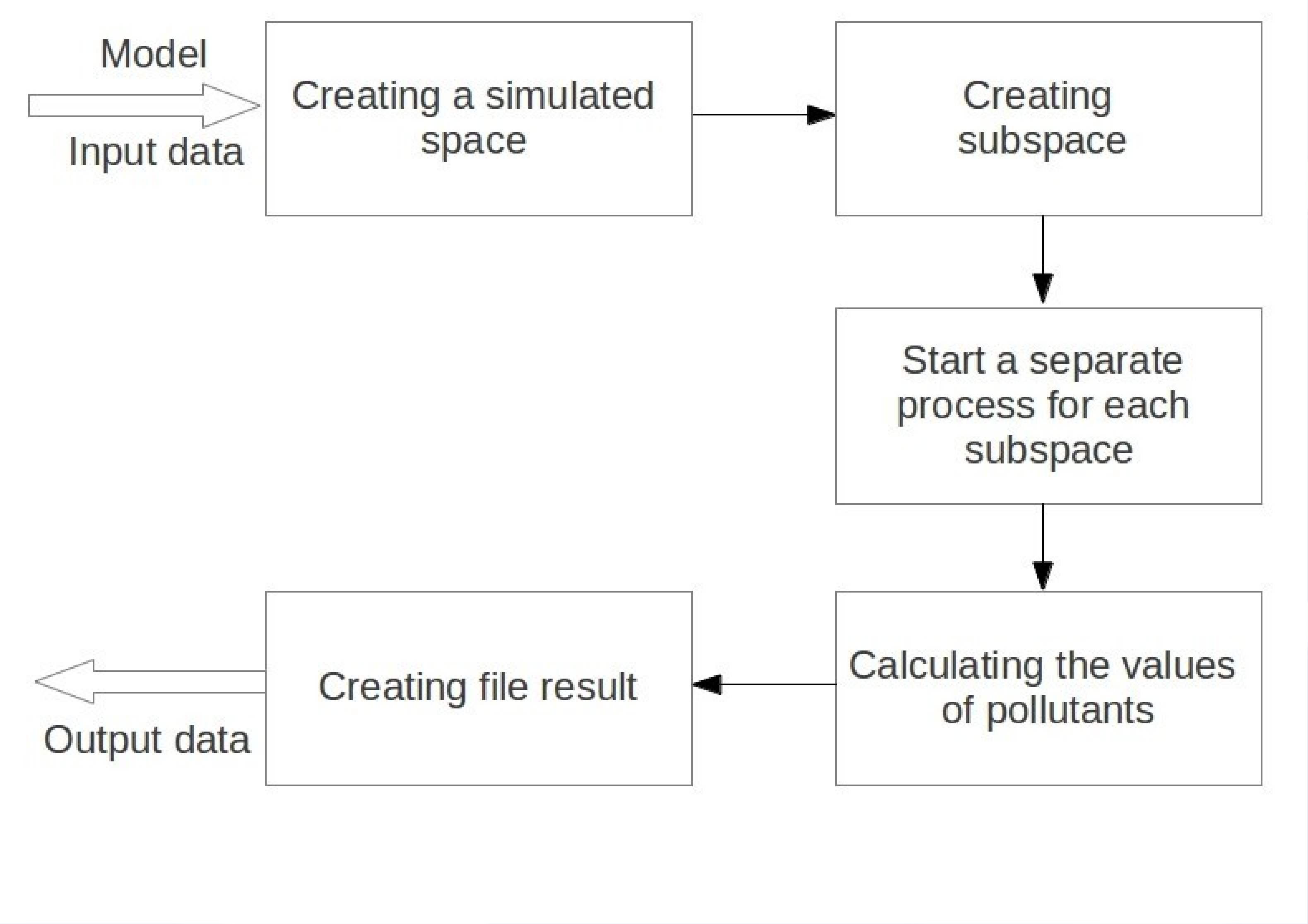
Some Modern Modeling Systems (2/2)

Model	Meteorological pre-processor	Concentration distribution	Plume rise	Price	Time profiler
ADMS 5	Yes	Advanced Gaussian	Advanced integral model	<1600 EURO	Yes
AERMOD	Yes	Advanced Gaussian	Briggs empirical expressions	Free (Basic) $ 1495 (Pro)	Yes
OND-86	No	Basic Gaussian	Briggs empirical expressions	free	No

Idea

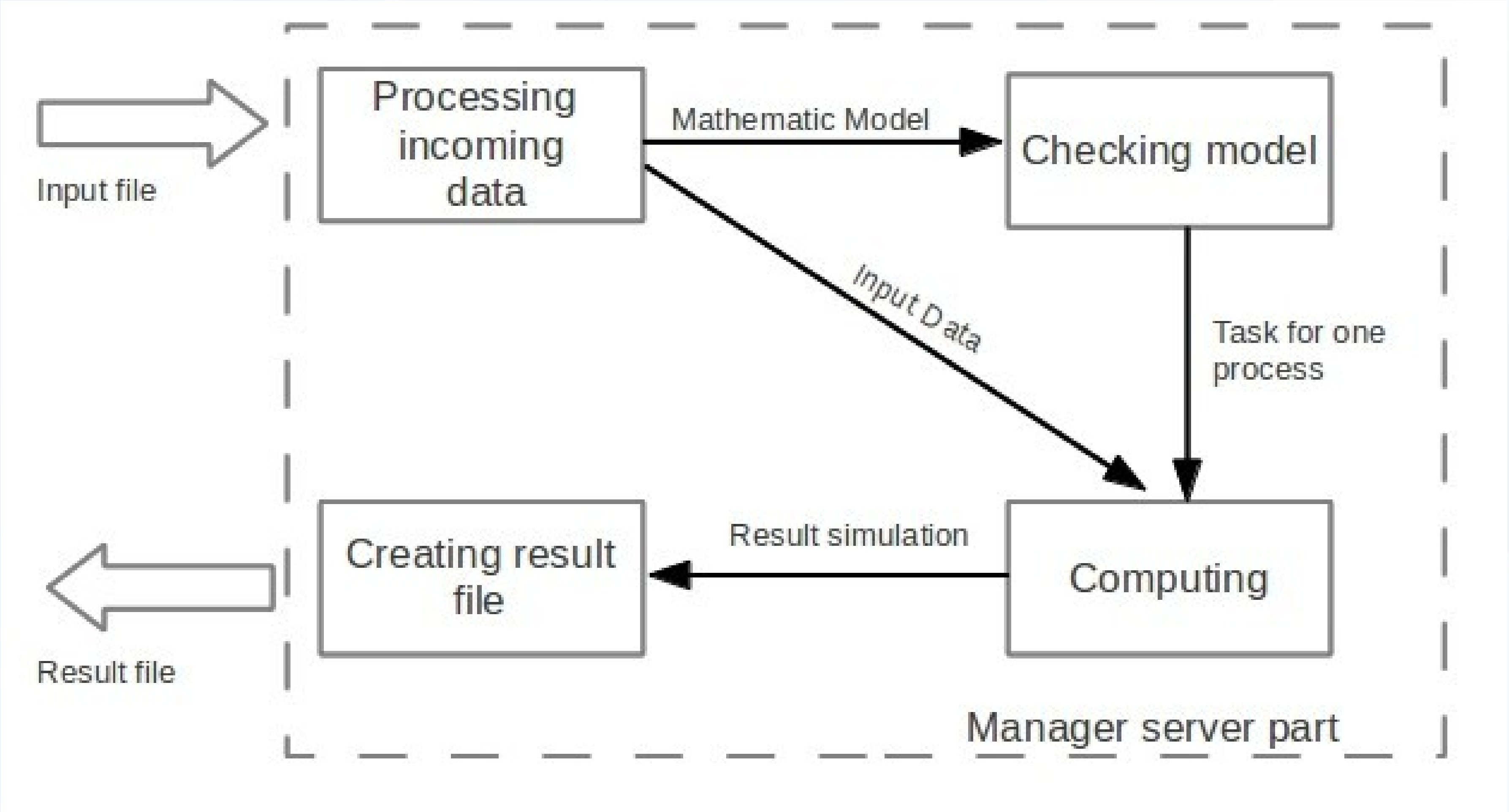
- Separating the space that is simulated on the small subspaces
- Handling the track changes over time in the initial conditions
- Separate process to calculate values for each subspace

Algorithm



Model
Input data
Creating a simulated space
Creating subspace
Start a separate process for each subspace
Calculating the values of pollutants
Creating file result
Output data

Server Part


Input file
Processing incoming data
Mathematic Model
Checking model
Input Data
Task for one process
Creating result file
Result simulation
Computing
Result file
Manager server part

Create Subspaces

```
read_data_from_file(filename);
cells = create_environment(size_x, size_y, size_z);
set_source(x,y,z); // it set value for cells[x][y][z];
set_model(model);
tt = 0;
while (t < tt)
 {
   create_process_for_cell(x,y,z, cells);
   tt += dt; // dt is time step
 }
```

Computing New Value in Subspace

```
function create_process_for_cell(int x, int y, int z, int
   ***space )
{
int ***call;
call = get_signal(x,y,z); // get that neiborght havnt process
 for ( int i = x; i < size_of(*call); i++ )
   for ( int j = y; j < size_of(**call); j++ )
    for ( int k = z; k < size_of(*&&call); k++ )
{
          run_model(space[i][j][k]);
}
```

Computing Using Diffusion Model

```
function run_model_diff(double *k, int t)
{
   tmp = (1/(pow((4*pi*t),(3/2))))*
           pow(e, (-((abs(&k)*abs(&k)))/4*t));
   &k = tmp;
}
```

Parallelism

```
MPI_Init(&argc, &argv);
MPI_Comm_size(MPI_COMM_WORLD,&numprocs);
MPI_Comm_rank(MPI_COMM_WORLD,&myid);
MPI_Get_processor_name(processor_name,&namelen);

    if(myid==0)
    {
            n = get_cell_p_count();
            startwtime = MPI_Wtime();
    }
MPI_Bcast(&n, 1, MPI_INT, 0, MPI_COMM_WORLD);
    if(n==0)
            done = 1;
    else
    {
            for(i = myid + 1 ; (i <= n) ; i += numprocs)
            {
                    count_cell_data(data);
            }
            if(myid==0)
            {
                    out_data();
            }
    }
MPI_Finalize();
```

Benefits for the Users

- The software running on Linux
- Users need only a Web browser and intrenet
- The software is free

Cloud Infrastructure

Hardware

- CPU -4x3.0 Ghz
- RAM - 2048MB
- HDD - 30GB

Software

- CentOS
- Apache2
- MySQL

Example Tasks

Area —

l=6 km,

w=10 km,

h=0,5 km

Step = 100 m.

Method — Diffusion model

Time = 9 hours

dT = 1 hour

Weather conditions - Does not change

Source of emissions — Three

Substance — Benzol

Demonstration

Description of the Modeling System

- Using Difussion model and Gaussian plume model
- Running in the cloud
- Amount of emissions of the pollutant may change with time
- Remote access to software

Novelty

- Proposed the method parallel counting for tasks that use the Gaussian model and Diffusion model
- Verification of the proposed method to calculate the diffusion by Fick's law and Gauss plume model

Future Plans

In RISC:

- Visualization of the results with WebGL
- Optimization algorithms for parallel computing
- Ability to create track weather changes over time

In ChNU

- Adding to the cloud custom algorithm
- Dispatching of computation of several tasks simultaneously

Conference / Workshop Proceedings

M. Skrypskyj. G. Vorobets. Cloud Computing for Simulations of Dissemination Pollutants from Industrial Enterprises In: Scientific-Practical Conference “Physical and technological problems of radio engineering devices, telecommunication, nano-and microelectronics”, pp. 153-156, Chernivtsi, Ukraine, November 2011

Thank you!