Agenda

• Motivation

• Test case and emission data sets

• Modeling systems

• Implementation of new scheme in WRF

• Air quality modeling
Methodology

• Air quality modeling systems:
  – EMEP
  – WRF – CAMx
  – Future works: WRF Chem, WRF – CMAQ

• Emission data sets
  – EMEP
  – TNO-MACC

• NCEP Final GFS reanalysis

• Simulation period:
Test case
Unified EMEP model

• **PARLAM-PS** meteorology data
  
  **HIRLAM** (High Resolution Limited Area Model) NWP model
  
  $dt = 3h$; vertical levels $= 20$ levels

• **EMISSIONS**
  
  – Anthropogenic (aircraft, shipping, VOC, SO2, NOx, CO, PM)
  – Biogenic (calculated from landuse) – NMVOC, DMS, Lightning, Volcanoes

• **Initial/boundary conditions** GEOS/ANTHRO
Unified EMEP model
WRF model
ABL modeling

- Turbulent/laminar

- Turbulent kinetic energy

\[ \text{Re} = \frac{UL}{v} \]
\[ \text{TKE} = \frac{1}{2} \left( u'^2 + v'^2 + w'^2 \right) \]

\[ -w'u' = K_M \frac{\partial \bar{u}}{\partial \bar{z}} \]
\[ -w'v' = K_M \frac{\partial \bar{v}}{\partial \bar{z}} \]
\[ -w'\theta_v' = K_H \frac{\partial \bar{\theta_v}}{\partial \bar{z}} \]

- Mellor–Yamada–Janjic scheme:
  - Kinematic difusivity
    \[ K_M = -lqS_M \]
  - Thermal conductivity
    \[ K_H = -lqS_H \]

- Mixing length (Blackadarova eq.)

\[ l = \sqrt{\zeta'^2} \]
\[ l = \frac{kz}{1 + \frac{kz}{l_o}} \]
\[ l_o = \alpha \frac{\int (|z|\sqrt{TKE} \, dz)}{\int \sqrt{TKE} \, dz} \]
New mixing length

- Grisogono and Belušić, 2008; Grisogono, 2010;
- Valid in whole atmosphere in neutral and stable conditions

\[ \Lambda = \text{const} \Lambda_0 f(R_i, P_r) \]

\[ \Lambda_0 = \frac{\sqrt{TKE}}{|S|} \quad \text{const} = \sqrt{\frac{b}{a}} \]

where:

\[ f(R_i, P_r) = 1 + \frac{R_i}{2P_r} \]

Coefficients of turbulent diffusivity:

\[ K_M = a\Lambda \sqrt{TKE} \quad K_H = a\Lambda \frac{\sqrt{TKE}}{P_r} \]

Gašparac, Jeričević: Workshop on Meso and Micrometeorology, 03-04.11.2014.
WRF comparison

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WRF comparison
WRF comparison

Difference between surface fields for
- 10m wind speed
- temperature at 2m
WRF comparison

Difference between surface fields for:
- 10m wind speed
- temperature at 2m
CAMx model

$O_3$ example
Difference between surface fields, WRF – Modified WRF

\[ SO_2 \text{ concentration} \quad \text{Temperature at 2m} \quad \text{Wind speed at 10m [m/s]} \]
Summary

The WRF model performance is evaluated for 7 different parameterisation schemes.

Problems:
- model parameterization
- point representativity
- reproducing stable atmospheric boundary layer conditions

New mixing length scheme
- depend on location and time period
- no substantial differences between different parameterisation schemes
- noticeable improvement: reducing model systematic errors

EMEP: very good agreement with measurements

CAMx
- Dependence on area
- Small differences (WRF – WRF modified) in time series, but larger in surface fields
- Point representativity problem
- Insufficient emission data set
Thank you for your attention 😊