**Field experiments and numerical simulations for investigating soil and planetary boundary layer interrelationships in Hungary – WRF case studies**

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**Presented at the 11th Annual Meeting of the European Meteorological Society (EUMS), 10th European Conference on Applications of Meteorology (ECAM), 12th September to 16th September 2011, Berlin, Germany**

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**Abstract**

Partition of surface energy budget components is strongly dependent upon both soil moisture content and the soil hydraulic properties mainly via evapotranspiration. This partition determines the state of near surface air, therefore the turbulent transport of momentum, heat and moisture. The transported energy via turbulent mixing also considerably affects the planetary boundary layer (PBL) height. In this study, two soil datasets were considered, both refer to Hungary. One is called MARTHA (Hungarian Detailed Soil Hydrophysical Database), in which the number of soil samples is 1.5 times higher than in the other, the HUNSODA (Unsaturated Soil Hydraulic Database of Hungary), though the spatial resolution is only five times denser. Because of the amount of soil samples the main hydraulic properties as the wilting point, the field capacity and the saturated soil moisture content significantly differ, which determine both the evapotranspiration and the PBL height. Simulations of the PBL height were conducted over the Carpathian basin on a 3 km horizontal resolution. The calculated PBL heights are compared to wind profiler and radiometric observations on a synoptic station in Hungary. In order to analyze in depth the soil/PBL height relationships on mesoscale, a 160 km x 160 km size net was applied. The resolution of the one-way net is 1 km with the center of the chosen synoptic station. Quantifying the relationships, a significance test which refers to the diurnal course of PBL height and latent heat flux was applied as well.

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**Soil texture**

- **FAO (Food and Agriculture Organization)**: 12 type soil texture.

- **in Hungary**:
  - Spatial interpolation of soil particle size distribution with FAO classification to 30 resolution grid used by the WRF model (Pázer et al., 2010).
  - FAO-STATSGO distribution (5') in surrounding countries.

**Soil database**

  - 476 soil samples.
  - Site sample per soil horizon. soil moisture retention curves in the whole suction range (pF 0, 0.4, 1, 1.5, 2, 2.3, 2.7, 3, 4.2 and 6.1).
  - samples only from plains.

- **MARTHA**: Makó and Tóth (2008)
  - 7500 soil samples; 2300 samples per site.
  - Site sample from the whole country, soil moisture retention curves at least for standard pF values: 0, 2.5, 4.2 and 6.2.

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**Model**

- **WRF-ARW v3.1** (Skamarock et al., 2008)
- **Model features**:
  - resolution: 3 km mother domain, 1 km nest, 50 eta levels;
  - domain size: 233x211; 160x160 gridpoints;
  - simulation time step: 15 s, 5s;
  - strong wave propagation in nest => use of 6th order diffusion;
  - simulation time 18 hours, from 00 UTC;
  - no assimilation of measurements.

**Parameterizations**

- **RTRM** (Mawer et al., 1997);
- **Thompson (2005)**;
- **Bougeault-Lacarrère (1989)**;
- **Noah (Chen & Dudhia, 2001)**;
- No cumulus parameterization.

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**Measurements**

**Measurement site**

Vertical profiling measurements for this study were conducted at the observatory of the Hungarian Meteorological Service in Szeged (46.25720N, 20.09026E). The site is surrounded by agricultural cultivations (corn, barley), outside the city. During the measurement period (August 1-31, 2011), the precipitation was only 1.9 mm, 1/3 of climatic average.

**Instruments**

- **Radiometers MP-3000A**, ground-based microwave radiometer:
  - continuous temperature, humidity, liquid water profiling to 10 km height;
  - 21 calibrated channels in 22-30 GHz (K-band) and 14 in 51-59 GHz (V-band);
  - sensors for surface temperature, relative humidity, and pressure.

**Vlassa LAPP-3000**, low atmospheric wave profiler with radio acoustic sounding system (RASS):
- vertical profiles of horizontal wind speed and direction, and vertical wind velocity up to an altitude of 4 km,
- operating frequency: 915 MHz,
- time steps: every 15 minutes, the average of preceding 30 minutes,
- range resolution: ±220 m.

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**Case studies**

**August 16, 2011:**

- cold front passing the day between anticyclone to the before, high pressure system to northeast and approaching cold front ⇒ stronger southerly winds

**August 26, 2011:**

- high and mid level clouds until on lower levels, no clouds.

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**Diurnal change of PBL height and latent heat flux**

- Diurnal change of PBL height and latent heat flux is an autoregressive stochastical periodic process in a statistical sense and depend mainly on the incoming radiation. In order to separate the effect of soil parameters in the diurnal courses, the natural diurnal course had been alienated from the simulated quantities with Fourier-series analysis. The significances were tested to p<0.01 probability. Errors are found where the simulated PBL height has low daytime change.

- **Latent heat flux**:
  - highly dependent on soil texture and land use;
  - over cities the PBL height doesn’t have a diurnal course ⇒ errors in significance calculations;
  - nest results correspond to mother domain.

- **PBL height**:
  - spatial distribution of change in PBL height show little correlation to latent heat flux change ⇒ differences in surface heat flux is transported;
  - nest show microstructures of flow;
  - daytime PBL height differences vary from 10 – 500 m, in 150 m on average.

**Acknowledgements**

The project is supported by the European Union and co-financed by the European Social Fund (grant no. TÁMOP-4.2.2.A-11/1/KMR-2010-0003) and by the Hungarian Scientific Research Fund (OTKA). The authors also thank the help of Nóra Azánz and the radiometric data. The figures were made with Origin 8 and with Generic Mapping Tools (GMT) software.