1. Introduction

Land-surface heterogeneity has different scales, and its effect on atmosphere and surface-fluxes is not fully resolved in models. It is specially interesting to understand the interaction of different surface pattern (SP) scales on development of atmosphere boundary layer. However definition of patterns is an open question.

In our study, we first defined SPs by the dominant pattern scale and pattern persistence. Then we replace the surface boundary condition with SPs generated by a multi-fractal spectral approach and let model run with the new surface boundary condition to answer the following questions:

Research Questions:
- If land surface heterogeneity is to be parameterized, which heterogeneity should be considered as the primary parameter?
- For a given run, which land surface pattern is the most important (in terms of producing more/less convective rain and changing rain pattern)?
- Which combination is most critical to boundary layer development?
- Which combination is most important for shallow convection?

2. Model

Model Setup:
To study the interaction between land-surface and atmosphere, we ran the WRF model in its meso-scale mode forced by ERA-INTERIM reanalyses for a time period covered by the HOPE campaign.

WRF (real simulation)
Forcing data: ERA-INTERIM reanalyses
Spatial resolution: 10 km
Temporal resolution: 6 h
One-way nesting:
- d01: 3 km
- d02: 1 km
Baseline run: original geodata from USGS WPS

Duration: 23-27 of April 2013
23rd - Spin-up time
24th - Clear sky
25th - PBL clouds
26th - Frontal clouds, precipitation
27th - Clear sky

Model Evaluation:
To evaluate model baseline run, we compare two model output variables with observations from Hope campaign and reanalysis data from ECMWF at Jülich location.

3. Method

Theory: A multi-fractal approach comes into use because we would like to have many randomly generated SPs with specific properties which are under control. We want to have different scales of fractals in two-dimension (2D) and/or the combination of small and large scale fractals.

\[ P(k) = N \times \left( \frac{k}{k_0} \right)^{s_1} \]

P : spectral density function
k : wave number (k/\(k_0\))
N : normalization factor
s1 & s2: slopes of desired spectral density curve

Design of ensemble runs:
To study more precisely the interaction between land-surface scheme properties and atmosphere, we focus on three surface parameters which categorize as below:
- Hydraulic properties: Soil type, ILSTYP
- Aerodynamic properties: Roughness length, z0
- Thermal/radiative properties: Albedo, ALBBCK

To estimate km0 and slopes for each surface property, we calculate power spectrum of original ILSTYP and z0 fields for the d02 and some other fields which have the same size as d02 and are surrounding d02.

4. Outlook

It is planned to generate an ensemble of a size of the order of 1000 varying the surface pattern parameters. In this ensemble, we will analyze the sensitivity of bulk parameters of the atmosphere to the parameters describing the surface pattern.

Summary of the next steps:
- Random Realization
- Ensemble Runs on Supercomputers
- ANOVA decomposition for the pattern identification and analysis of the model outputs