Specification of additional idealized test cases
Milestone M2.1

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Specification of additional idealized test cases

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This document presents a proposal for additional idealized test cases to be simulated with large-eddy simulations (LES) in work package WP 2.14.

Additional numerical experiments with a large-eddy simulation (LES) model offer the possibility to obtain spatially and temporally highly resolved data under controlled environmental conditions. One main objective of WP 2.14 is to generate additional LES data sets for less complex test cases than the experimental ones that can be used for the verification of meso- and microscale models further developed in WP 3.

To complement the „Northern Europe combined Meso-scale Experiment“, the development of internal boundary layers (IBL) in cases of land-sea or sea-land transitions shall be simulated with LES, where the complexity of the real coastline and processes in the atmospheric boundary layer is reduced by prescribing a straight-line boundary between land and sea. The land-sea transition will be prescribed as a step change in roughness and surface temperature.

Three test cases are proposed:

1) Land-sea transition with homogeneous land surface

This is the most idealized and basic case which allows to investigate the sensitivity of the IBL development towards basic surface properties and meteorological conditions. Both atmospheric and surface parameters will be varied: inflow stability (neutral, convective, stable), roughness difference between land and sea, temperature or surface heat flux difference between land and sea.

2) Land-sea transition with heterogeneous land surface

The second test case is based upon the first case but adds one step in complexity: a heterogeneous land surface. In a previous study by Dörenkämper et al. (2015, *Boundary-Layer Meteorol.*, **155 (3)**, 459-482) meso-scale simulations with the WRF model showed that roughness heterogeneities at the coast and further onshore lead to the development of strong horizontal wind speed gradients. Such streaks have shown to occur for stable and neutral conditions over sea and to depend on the PBL scheme. With the proposed test case it can be checked if these streaks are realistic or just a feature in WRF (which would prove the need for improved diffusion parameterization in meso- and microscale models). The heterogeneities will still be very idealized, i.e. rectangular stripes of different surface

properties (roughness and/or temperature/heat flux). The sensitivity of the results towards the magnitude and layout (length, width) of the surface heterogeneities will be tested.

3) Land-sea transition for realistic conditions, validation of the RUNE experiment

The third case is actually not an idealized case any more but a validation of data from the RUNE experimental campaign which was running from November 2015 until April 2016 at the western coast of Denmark. As it, however, bridges the gap between the idealized test cases 1 and 2 and real experimental data, it will be included here as well. The experiment was designed to measure the land-sea transition e.g. in a transect perpendicular to the coastline in several heights by using several LIDAR devices at the coastline and offshore. One or two test cases will be selected from the available data from the experiment and simulated with LES. The inflow conditions of the LES shall match the measured conditions. In addition, information from meso-scale simulations will be used to generate realistic inflow conditions.

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Outline of WP 2.14

- **Overall goal of WP 2.14:** Obtain spatially and temporally highly resolved LES data under controlled environmental conditions

- **Objectives:**
  1) Generate additional LES data sets for less complex test cases than the experimental ones that can be used for the verification of meso- and microscale models further developed in WP 3

     → virtual experiments to complement the real experiments
  2) Apply LES to assist the planning of the experiments and for validation and verification purposes

- **Milestone M2.1:** Specification of additional idealized test cases → web release
- **Deliverable D2.6:** Data base and report for LES of additional idealized test cases → M18
- **Deliverable D2.8:** Data base and report for LES for planning of the Perdigao experiment → M21
- **Deliverable D2.13:** Data base and report for LES for the Kassel experiment → M30
- **Deliverable D2.17:** Data base and report for LES for the Perdigao experiment → M36

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Milestone M2.1: Specification of additional idealized test cases

- **General topic:** Investigate land-sea transition with highly resolved LES (to complement WP 2.9 – Northern Europe Meso-scale Experiment)

- **Three test cases:**

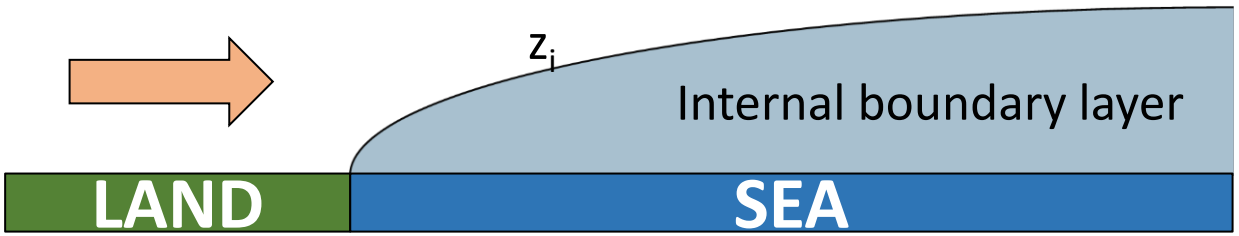
  1) Land-sea transition with homogeneous land surface

  2) Land-sea transition with homogeneous land surface

  3) Land-sea transition for realistic conditions (land surface and atmospheric conditions) → validation of the RUNE experiment*

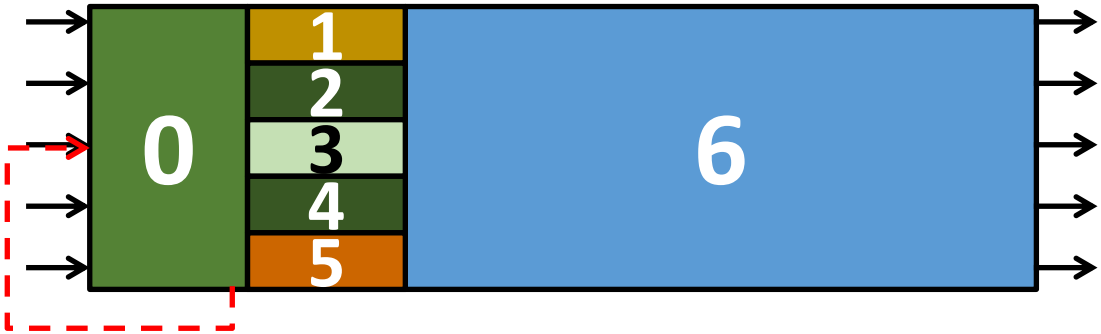
* Case 3 is not really idealized any more but bridging the gap between the idealized cases 1 and 2 and the RUNE experimental campaign. Thus, it will be included here as well.

Test case 1: Land-sea transition with homogeneous land surface



- Flow from land to sea with step change of surface roughness and/or surface temperature/heat flux → most idealized and simple case
- Development of a shallow internal boundary layer (IBL) over the sea
- High spatial resolution required to resolve the shallow IBL
- Variation of following parameters:
  - inflow stability (neutral, convective, stable)
  - roughness difference between land and sea
  - temperature or surface heat flux difference between land and sea

Test case 2: Land-sea transition with heterogeneous land surface



- **Motivation:** Mesoscale simulations (WRF) showed that roughness heterogeneities at the coast and further onshore lead to development of strong offshore horizontal wind speed gradients (Dörenkämper et al., 2015, *Boundary-Layer Meteorol.*, **155 (3)**, 459-482); streaks occur for stable and neutral conditions (over sea) and depend on PBL scheme

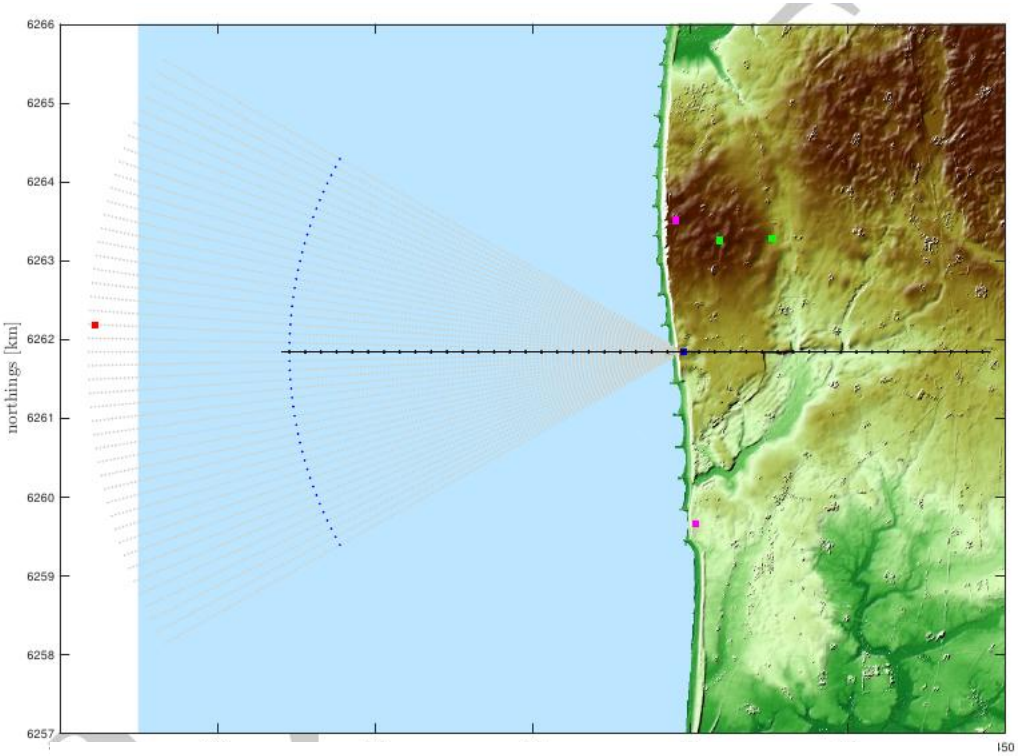
  → Are these streaks realistic or just a feature in WRF (→ need to improve diffusion parametrization in meso- and microscale models)?

- Basic setup of test case 1 – add surface heterogeneities (roughness and/or surface temperature/heat flux)

- Change magnitude and layout of the heterogeneities (length, width)

Test case 3: Land-sea transition for realistic conditions (RUNE)

- RUNE campaign from November 2015 – April 2016 at the Danish west coast
- Measuring the land-sea (and sea-land) transition
- 3 scanning lidars at the coastline, 1 floating lidar, 4 vertical profiling lidars on the coast, 1 wave buoy
- To be compared with meso-scale modelling, met mast, satellite wind data and LES
- Select 1 or 2 test cases from available data
- LES runs with realistic inflow conditions (derived from meso-scale simulations)



From: „RUNE – short guideline of the offshore experiment“ by Alfredo Peña (DTU)

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Acknowledgements

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