MODEL COMPARISON EXERCISE DESIGN

COST Action ES1306 Connecteur, Working Group 3

Last adjusted 06/04/2017

Objectives of the modelling exercise – analyse connectivity using models:

- Key message 1: model ensembles can be used to understand the impact of landscape scenarios on connectivity
- Key message 2: simulated connectivity is linked with model structure

Exercise design – "semi-virtual catchment approach":

Several different models will be applied to the Giser catchment (Belgium). They will simulate a number of individual rainfall events, using scenarios with different spatial complexities and connectivity features. Model results will evaluate the impacts of these scenarios on overland flow and sediment connectivity, assuming subsurface connectivity is constant.

2 rainfall scenarios will be simulated, with constant rainfall during 1 hour: 38.7 and 29.9 mm, with return periods of 50 and 10 years. The translation into kinetic energy will use a function provided for Belgium. Initial soil moisture will be at field capacity. Seasonality will not be considered as soil moisture is relatively constant in space and time, and only vegetation cover changes. Models will be run for 2 hours (1 hour after rainfall stops).

A baseline scenario will be "virtual", consisting of the Giser catchment devoid of any connectivity features. For this, a third rainfall scenario will be simulated: constant 17.4 mm rainfall during one hour, with a return period of 1 year. 73 connectivity scenarios will be simulated, including:

- Baseline (no features)
- 3x field size: 20, 10 and 5 ha
- 5x land-use patterns, with tillage orientation following the axis of the fields
- For the mid-sized field, each connectivity feature will be tested (for 5x land-use patterns):
    - conservation tillage orientation (contour)
    - grass strips (location by expert judgement, 12 m width and grassed waterway)

Each connectivity scenario has been designed in detail by an expert team from Univ. Louvain.

Models:

Selected models should be able to produce spatial patterns of hydrological variables, and should have been already evaluated against data in publications. The main models to be used in the exercise are listed in Table 1. Others can be invited later.

All models will be applied with the same DEM and spatial resolution (1 m), with temporal resolution left to each model. For each scenario there will be a map of connectivity features and land use, designed by the expert team. All spatial data will be supplied in ArcGIS ASCII files. Parameters or ranges of parameters will be provided by the expert team from Louvain for those listed in Table 1, including parameters for each land use type and for the grass strips. Based on this, each modeller decides the actual parameter value to use in his/her model.

Model calibration will not represent the actual landscape, as it is too complex and might erroneously rank models accordingly to accuracy. This will be replaced by a model assessment to ensure that all provide results in a similar range: all models will be run for the 3 events in the reference scenario, and results for runoff amount, time to peak and sediment amount will be compared between models to see the spread. Each modeller will then adjust his results if they believe them to be unrealistic or too far from those from other models. The criteria for realism will include runoff and sediment yield within credible bounds, and the existence of a model process justifying model disparity (e.g. a model which simulates gully development would have higher sediment yield than one which doesn't).

Table 1. Models to be used in the exercise and contact persons

Model	Person	Email	Institution	Country
Data provisioning	Charles Bielders	charles.bielders@uclouvain.be	Louvain Catholic University	Belgium
Data analysis	Rens Masselink	rens.masselink@wur.nl	Wageningen University	Netherlands
Calendarization	João Pedro Nunes	jpcnunes@fc.ul.pt	University of Lisbon	Portugal
EROSION3D	Marcus Schindewolf	MGA450@ku.de	Technical University Freiberg	Germany
FullSWOF*	Frédéric Darboux	Frederic.Darboux@orleans.inra.fr	INRA	France
LANDSOIL	Aurore Degre	aurore.degre@ulg.ac.be	University of Liège	Belgium
LANDSOIL	Vincent Cantreul	vincent.cantreul@ulg.ac.be	University of Liège	Belgium
LISEM	Jantiene Baartman	jantiene.baartman@wur.nl	Wageningen University	Netherlands
MAHLERAN	Laura Turnbull	laura.turnbull@durham.ac.uk	Durham University	UK
MAHLERAN	John Wainwright	John.Wainwright@durham.ac.uk	Durham University	UK
MCST	Peter Fiener	peter.fiener@geo.uni-augsburg.de	Augsburg University	Germany
MCST	Florian Wilken	florian.wilken@geo.uni-augsburg.de	Augsburg University	Germany
SMODERP*	Petr Kavka	petr.kavka@fsv.cvut.cz	Czech Technical University	Czechia
WATERSED	Olivier Cerdan	o.cerdan@brgm.fr	BRGM	France
WATERSED	Thomas Grangeon	t.grangeon@brgm.fr	BRGM	France

* Runoff only

Model output analysis:

Functional connectivity will be calculated from model outputs, with these maps (per scenario):

- flux of water and sediment passing through each cell
- connectivity: a pixel is "connected" to the outlet above a threshold of runoff or sediment (using the flow direction algorithm of the model when possible)
- a different connectivity threshold will be calculated for each model, as a percentile of model results for the baseline scenario (after a connectivity analysis)

Maps will be calculated for each five minute (for later analysis of temporal evolution) and at the end of the simulation: 60 & 120 mins. "Model ensemble" maps will also be created to show the % of models which connect each pixel to the outlet. The results will be summarized as:

- Hydrograph parameters: runoff coefficient, peak discharge, time to peak
- Sedigraph parameters: total sediment export, sediment delivery ration
- Average soil loss in all cells (excluding re-deposition)
- Sediments entering the channel from the fields (in order to avoid model limitations in simulating channel processes)
- Graph: water and sediment flux vs. distance to the outlet
- Correlation length: mean size of patches unconnected to the outlet
- Graph: cumulative % of watershed connected vs. distance to the outlet

To improve comparability, the results will be given as ratios to the baseline simulation. These outputs will be used to analyse how changes to connectivity features translate into changes to (model-calculated) water and sediment connectivity, including differences between model results.

This is a possible structure for the analysis:

- Baseline analysis
- Scenario analysis: show "magic connectivity number" (no. which shows connectivity for each scenario: e.g. amount of area connected)
- Ensemble maps for all field sizes: use only one rainfall and field pattern
- Ensemble maps for all field patterns: use only one rainfall and field size
- Connectivity time evolution ensemble graph (rainfall & sediment) for 2 rainfalls in selected field size and land use scenarios
- Hydrograph and sedigraph for 2 rainfalls in selected field size and land use scenarios

Exercise steps:

The models will be applied to the scenarios in several steps, in order, to make sure that at least the most important scenarios can be compared. The steps are detailed in Table 2, and include:

1. Baseline: reference model runs, used for model benchmarking
2. Initial field A: mid-sized field and 1st land use, used to test connectivity assessment
3. Field size test A: small and large-sized fields and 1st land use pattern
4. Contour test A: mid-sized contour fields and 1st land use pattern
5. Linear features test A: grass strips and 1st land use pattern
6. Field size, Contour and Linear Features tests B: similar to A but with 2nd land use pattern
7. Field size, Contour and Linear Features tests C: similar to A/B but with 3rd to 5th land use patterns

Model outputs:

The following model outputs are required per scenario:

- Hydrograph and Sedigraph – please provide a single Excel worksheet for all Hydrographs (Q in m3/s, time in minutes) and another for all Sedigraphs (Sediment yield in kg/s, idem)

- Water / Erosion / Sediment map: map with runoff flow / net erosion (including deposition) / flux of sediment passing through each cell at specific timesteps:
  - each 5 minutes, for dynamic models;
  - at the end of the simulation (120 mins), for all models.
- Maps will be provided as GeoTIFF; a script will be made to convert from ASCII to GeoTIFF.

To simplify results processing, maps should be designated as follows (see * Runoff only

for designators):

Output type _ Field map _ Connectivity features map _ Land allocation _ Rainfall _ Model_Time

For example:

- Step 1, Sediment flow map, end of simulation:
  Sediment-map _Baseline_None_None_1yr_LANDSOIL_120min
- Step 3, runoff flow map, 25 mins:
  Water-map_Field_large_None_Rep1_10yr_FULLSWOF_25min
- Step 6, Net erosion map, 50 mins:
  Erosion-map_Field_small_None_Rep3_10yr_EROSION3D_50min

Table 2. Modelling exercise steps

Step	Test	Field map	Connectivity features map	Land allocation	Rainfall	Tests
1	Baseline	-	-	-	1 yr, 10 yr, 50 yr	3
2	Initial field A	Field_med	-	Rep 1	10 yr, 50 yr	2
3	Field size A	Field_small, Field_large	-	Rep 1	10 yr, 50 yr	4
4	Contour A	Field_med_conserv	-	Rep 1	10 yr, 50 yr	2
5	Linear features A	Field_med	Strips	Rep 1	10 yr, 50 yr	2
6	Field size B	Field_small, Field_med, Field_large	-	Rep 2	10 yr, 50 yr	6
7	Contour B	Field_med_conserv	-	Rep 2	10 yr, 50 yr	2
8	Linear features B	Field_med	Strips	Rep 2	10 yr, 50 yr	2
9	Field size C	Field_small, Field_med, Field_large	-	Rep 3, Rep 4, Rep 5	10 yr, 50 yr	18
10	Contour C	Field_med_conserv	-	Rep 3, Rep 4, Rep 5	10 yr, 50 yr	6
11	Linear features C	Field_med	Strips	Rep 3, Rep 4, Rep 5	10 yr, 50 yr	6

Practical issues:

Responsibilities:

- Timeline coordination & metadata structure: João
- DEM preparation: John
- Parameter preparation: Charles
- Land-use pattern preparation & grass strip design: Vincent, Charles
- Evaluation tool to produce indices: Rens

Spatial data will be provided as ASCII.