Back-calculation of the 2021 Chamoli event with r.avaflow: manual

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Datasets

Name	Type	Description
chamoli	Folder	GRASS GIS location, containing all spatial data in GRASS GIS raster format at a cell size of 2 m: • ch_elev: DEM (derived from Bhushan and Shean, 2021) • ch_hrelease: Release height (derived from Bhushan and Shean, 2021 and Shean et al., 2021) • ch_hentrmax: maximum height of entrainment This folder should not be manipulated manually, but only through the GRASS GIS interface.
r.avaflow2.3Enhanced	Folder	Model code of r.avaflow. The content of this folder should not be manipulated manually. Note that this is an enhanced version of r.avaflow 2.3 which is available at https://www.avaflow.org, including a manual. The enhanced version contains some functionalities not available with the official version.
ch.avaflow.start.sh	Shell script	Start script for executing the r.avaflow simulation for the Chamoli event.
PostprocessData	Folder	Tiffs and shapefiles needed for post-processing of the simulation results • ch_profile.shp: Longitudinal profile (modified from data provided by Wolfgang Schwanghart) • ch_trimlines.shp: Mapped trimlines (prepared by Dan H. Shugar) • ch_velocitysections.shp: Parts of the profile which were used for velocity estimates (modified from data provided by Wolfgang Schwanghart and Adam Emmer)
ch.postprocess.py	Python script	Script for post-processing of the simulation results with arcpy

Software requirements

- Simulation: Linux installation, preferably Ubuntu 20.04LTS, sudo rights
- Post-processing: ArcGIS with Spatial Analyst and 3D analyst

Simulation work flow

1. Install the software prerequisites by running the script *grass7.install.sh* in the r.avaflow folder in sudo mode.
2. Install r.avaflow by running the shell script r.avaflow.install.sh in sudo mode.
3. Start grass with the *chamoli* location.
4. Execute the script *ch.avaflow.start.sh*.
5. Wait until the execution of the script has finished. Depending on the capacity of your system, this may take several hours. The simulation results are stored in the folders *ch_exp1a_results* and *ch_exp1b_results* (see https://www.avaflow.org/manual.php for further information).

Post-processing work flow

6. Transfer the result folders *ch_exp1a_results* and *ch_exp1b_results* to the system on which you have ArcGIS available.
7. Save the results folders in the same directory as the script *ch.postprocess.py* and the folder *PostprocessData*. In the same directory, create a folder named *PostprocessResults*.

8. Execute the script *ch.postprocess.py*. Make sure to use the Python version associated to your ArcGIS installation.
9. Wait until the execution of the script has completed. This should not take much longer than a minute on most systems. The results are stored in the folder *PostprocessResults*:
   - *ch_hflow_max.tif*: maximum flow height, combined from the first part and the second part of the simulation, cell size: 20 m
   - *ch_profile_r1front.shp*: 3D shapefile representing the rock fraction at the flow front along the longitudinal profile
   - *ch_profile_r1max.shp*: 3D shapefile representing the rock fraction at the maximum flow momentum along the longitudinal profile
   - *ch_profile_r3front.shp*: 3D shapefile representing the rock fraction at the flow front along the longitudinal profile
   - *ch_profile_r3max.shp*: 3D shapefile representing the fluid fraction at the maximum flow momentum along the longitudinal profile
   - *ch_profile_vfront.shp*: 3D shapefile representing the velocity at the flow front along the longitudinal profile
   - *ch_profile_vhmax.shp*: 3D shapefile representing the velocity at the maximum flow momentum along the longitudinal profile

   Each of the 3D profile shapefiles is automatically derived from a corresponding tif raster. These rasters are also available in the same folder.

10. The 3D profile shapefiles can be used to produce profile graphs with ArcGIS (or possibly another suitable software), whereas the maximum flow height raster can be displayed and compared with the trimlines. Note that there is a lot of fine-scale variation in both the profiles and the rasters, so that interpretation will benefit from some smoothing (e.g. moving averages).

Further notes

- The parameterization of the simulations is optimized for a good correspondence with the observed characteristics of the 2021 Chamoli event. The simulation results may respond to changes of parameter values in a very sensitive way. The parameter sets used are not necessarily useful for the back-calculation of other events and may not be used for predictive simulations without prior careful evaluation.
- The output hydrograph OH3 of the first part of the simulation (*ch_exp1a*) and the input hydrograph IH1 of the second part (*ch_exp1b*) are identical. A difference between the two layouts occurs for the reason that input of material through the hydrograph occurs at the beginning of each time step, whereas the graph is written at the end.
- Basic information on the parameters is provided as comments in the *ch.avaflow.start.sh* script. More information is provided at https://www.avaflow.org/manual.php. There are three main differences between the official release of r.avaflow 2.3 and the enhanced version provided here:
  - Stopping is also governed by the option *stoptime*: a raster map representing for each pixel the time in seconds from which on stopping is enabled (positive values) or at which stopping is enforced (negative values).
  - Additional output raster maps of velocities and phase fractions at the front and at the time of maximum momentum are provided (used for step 9 of the work flow).
  - Output hydrograph files are additionally provided in the format necessary to directly use them as input hydrograph files for follow-up simulations.

  These and other features will be officially available with the upcoming release of r.avaflow 2.4. It is strictly not recommended to use the version provided here for other purposes than for reproducing the back-calculation of the 2021 Chamoli event, as it did not undergo a thorough bug fixing procedure.

References

Bhushan, S., Shean, D. (2021). Chamoli Disaster Pre-event 2-m DEM Composite: September 2015 (Version 1.0) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.4554647 License: CC-BY-NC.

Shean, D., Bhushan, S., Berthier, E., Deschamps-Berger, C., Gascoin, S., Knuth, F. (2021). Chamoli Disaster Post-event 2-m DEM Composite (February 10-11, 2021) and Difference Map (Version 1.0) [Data set]. Zenodo. http://doi.org/10.5281/zenodo.4558692 License: CC-BY-NC.