UiO : Department of Geosciences
University of Oslo

Olga Silantyeva, John F. Burkhart, Bikas C. Bhattarai, Ola Skavhaug, Sigbjorn Helset

Operational hydrology in highly steep areas:

evaluation of tin-based toolchain

EGU Meeting 2020
May 4, 2020

LATICE — Land-ATmosphere Interactions in Cold Emvironments
LATICE is a strategic research area by the Faculty of Mathematics and Natural Sciences at the University of Oslo

What it is all about?

- **Triangular irregular network** is a simplified triangular mesh, which is highly flexible, so allows capturing more details from the terrain topography with less computational effort [1].
- The hydropower production companies need **highly efficient and secure software** to simulate inflows, which ultimately leads to more reliable and competitive prices prediction.
- How to proper simulate discharge in **remote areas**, where gauges network is sparse and re-analysis data might be unreliable?
- Do **hillslopes** matter for operational hydrology?[1] Terrain topography controls insolation variations, as the local solar angle is different. Snow on sunny slopes melts earlier compared to shady ones. Is it important for hydropower production?

---

[1] Fan, Y., Clark, M., Lawrence, D. M.,, . . . Yamazaki, D. (2019). Hillslope hydrology in global change research and earth system modeling. Water Resources Research, 55(2)

We present:

- **Rasputin** software https://github.com/expertanalytics/rasputin converts raster digital elevation models (dems) into simplified triangular meshes (TINs) with land cover representation coming either from GlobCov 2009 or Corine (Europe) datasets with resolutions 300m and 80m respectively. The tool is freely available under GNU GPLv.3 lisence.
- An enterprise framework **Shyft** (https://gitlab.com/shyft-os/shyft) contains tools for highly-efficient distributed hydrologic modeling. The current version of the Shyft model is available from the project website: https://gitlab.com/shyft-os/shyft under the GPLv.3 license [2].
- **Shyft + Rasputin** is a toolchain which allows the researcher to study areas with high terrain and land-use variability. With an introduction of a new routine to account for insolation variations [3] the toolchain becomes a **unique software** to study impact of radiation on hydrologic processes. An example of usage of our toolchain in subcatchments of Central Nepal shows great potential of tins for operational

The Question:

Does operational hydrology gain any profit by more detailed terrain representation and accounting for hillslopes?

Study Area: Catchment in central Nepal

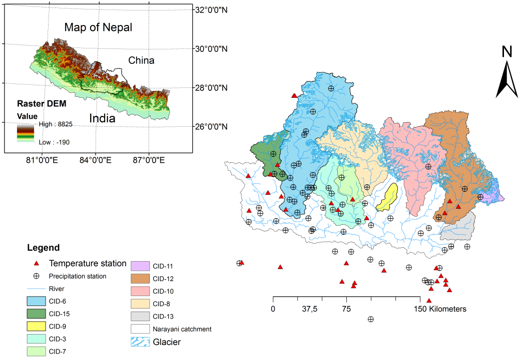


Figure: Narayani river catchment with subcatchments 3, 6, 7, 8, 9, 10, 11, 12, 13, 15

The study area is highly steep with stations located mainly in low-land areas and the re-analysis data for the subcatchments is rather coarse and prone to biases [4].

Result: Insolation Variations, SWE

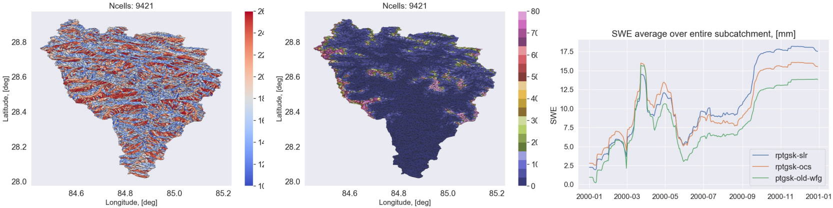


Figure: a) Insolation variation, cid-10: slope and aspect from TIN, b) SWE variation, c) SWE avergaed over basin for old-grid (ptgsk-old-wfg) and 2 cases of tin-grids (ocs –low resolution, slr – high resolution)

With the new radiation routine we can see, that south-facing slopes are actually getting higher shortwave-radiation. This leads to changes in resultant SWE compared to previous grid-based solution with no variations in radiation.

Result: Discretization

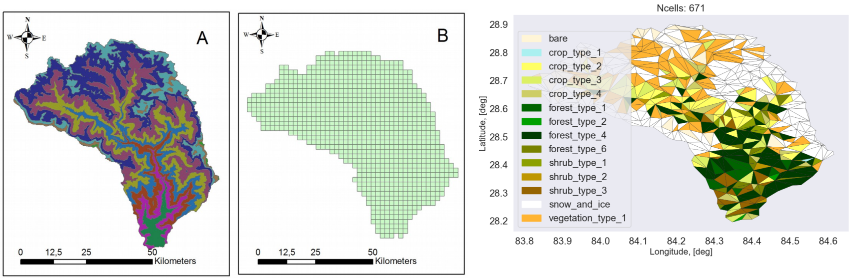
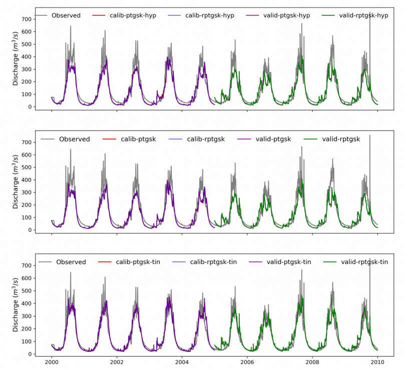


Figure: Cid-8 A: hypsography (HYP), B: square grid (SqGrid), C: Low-resolution TINs

We compare 3 types of terrain representation for discharge simulation with **PTGSK** – no insolation variaiton method and **RPTGSK** – method with variations in insolation (both HYP and SqGrid also get variation for each cell (averaged))

Result: TINs better



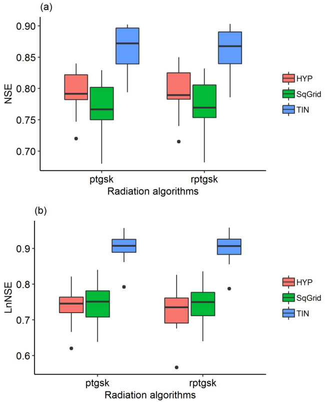


Figure: Left – Discharge simulation, Right – performance

We can clearly see that TINs outperform HYP and SqGrid both in high and low flow simulations. In addition, we see that HYP might be also a good option compared to SqGrid (less cells, but similar efficiency)

Main Outcome

TINs are the first choice for operations

How far should we go with TINs?

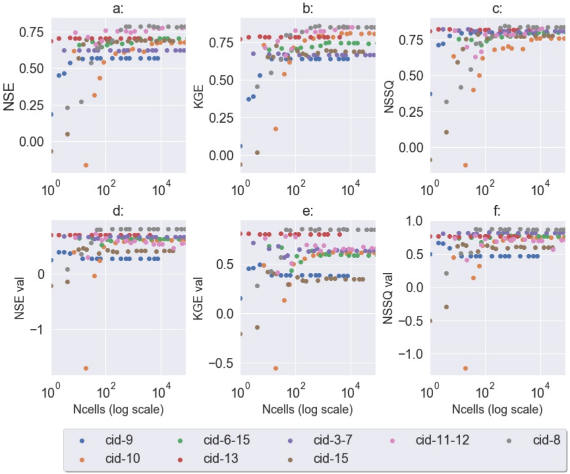


Figure: a), b), c): NSE, KGE and NSSQ for calibration period 2000-2005; d), e), f) NSE, KGE and NSSQ for simulation period 2005-2010

Conclusion

- Radiation variation routine together with TINs give us a tool to study insolation impact on SWE and discharge in highly steep areas.
- We clearly see that TINs solution, even rather course, outperforms regular grid discretization for discharge simulation. So, we recommend it as a first choice for operational use
- The TIN mesh shouldn't be very fine as current state of Shyft is limited by the simplicity of many it's routines.

References

1. Marsh, C. B., Spiteri, R. J., Pomeroy, J. W., and Wheater, H. S.: Multi-objective unstructured triangular mesh generation for use in hydrological and land surface models, Computers and Geosciences, 119, 4967, 2018.
2. Burkhart, J. F., Matt, F., Helset, S., Abdella, Y. S., Skavhaug, O., and Silantyeva, O.: A Framework for Uncertainty Assessment and Distributed Hydrologic Modelling for Operational Hydrology, Geoscientific Model Development Discussions, 2020.
3. Richard G. Allen, Ricardo Trezza, and Masahiro Tasumi. Analytical integrated functions for daily solar radiation on slopes. Agricultural and Forest Meteorology, 139:5573, 2006
4. Bhattarai, B. C., Burkhart, J. F., Tallaksen, L. M., Xu, C.-Y., and Matt, F. N.: Evaluation of forcing datasets for hydropower inflow simulation in Nepal, Hydrology research, 2020

Thank you!