UiO : Department of Geosciences
University of Oslo

Olga Silantyeva*, Ola Skavhaug, Lena M. Tallaksen, John F. Burkhart, Sigbjørn Helset

Analysis on the added value of accounting for slope/aspect in hydrologic simulations

5th Conference on Modelling Hydrology, Climate and Surface Processes
September 17 – 19, 2019, Lillehammer, Norway

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

Do hillslopes matter for operational hydrology?[1]

- Terrain topography controls insolation variations, as the local solar angle is different
- Snow on sunny slopes melt earlier compared to shady ones
- Station networks in mountainous regions are too sparse and re-analysis grids are too coarse to correctly capture hillslopes impact

How should we deal with all this for operational cases?

[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)

SHyFT + RaspuTIN

The toolbox for hydrologic simulations on triangular irregular networks (TINs)[2]

- SHyFT is an enterprise software for operational hydrology
- Rasputin creates mesh with land cover (Corine or GlobCov)
- Together: Framework for better rainfall-runoff simulations

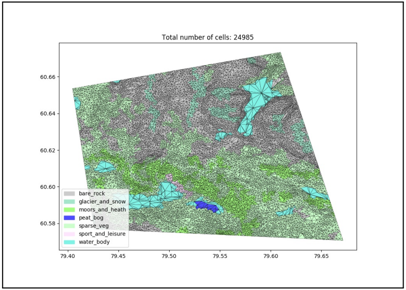


Figure: Area around Finse Research station with Corine landcover applied

[2] Marsh, C. B., Spiteri, R. J., Pomeroy, J. W., Wheater, H. S. (2018). Multi-objective unstructured triangular mesh generation for use in hydrological and land surface models. Computers and Geosciences, 119.

Study area

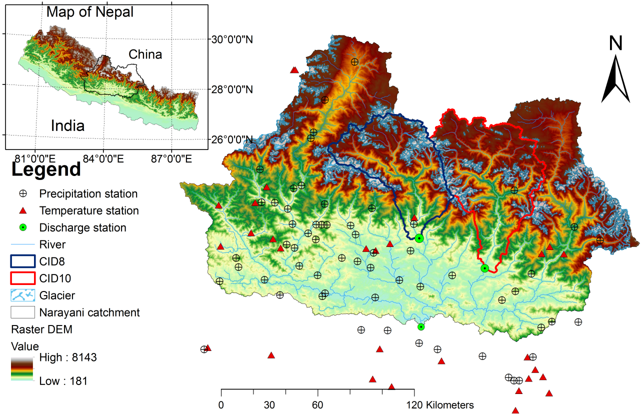
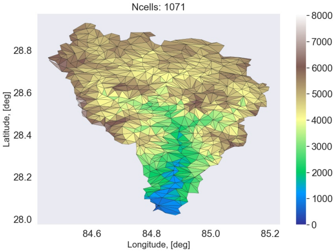
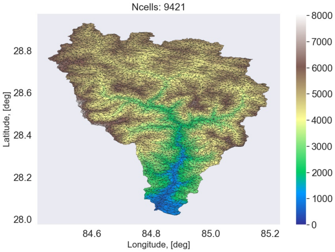


Figure: Narayani river catchment with subcatchments 8 (Marsyangti-2) and 10 (Burkhi-Gandaki)

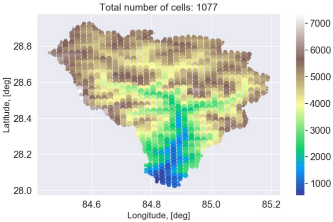
Burkhi-Gandaki (10) Mesh



(a) Coarse mesh



(b) High resolution mesh



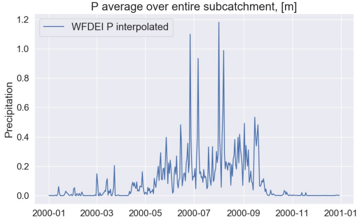
(c) Old grid scatter

Experiments

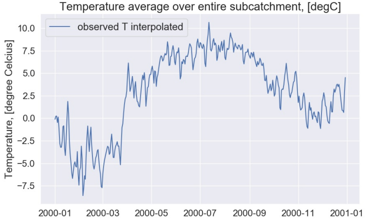
- Experiments set A: preliminary study to define mesh resolution:
  - A.1 Observed Precipitation
  - A.2 WFDEI Precipitation[3]
- Experiments set B: year 2000 with 100 days of spin-up period; 24-h time step
  - B.1 All TINs looking North: slope is coming from mesh, aspect set to 0.0
  - B.2 All TINs looking South: slope coming from mesh, aspect set to 180.0
  - B.3 Slope is fixed to 31^0 (mean value), aspect comes from mesh
  - B.4 Real slope and aspect compared to old regular grid
- All experiments are performed for coarse and fine TIN meshes.

[3] Bhattarai, B. C., Burkhart, J. F., Tallaksen, L. M., Xu, C.-Y., and Matt, F. N. (2019). Evaluation of forcing datasets for hydropower inflow simulation in Nepal. In Review. Hydrology research

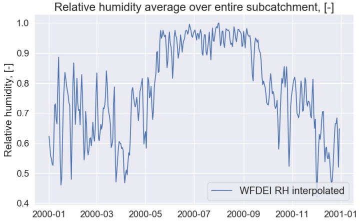
Forcings



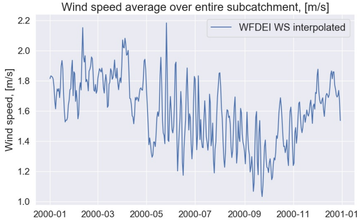
(a) WFDEI Precipitation



(b) Observed Temperature



(c) WFDEI Relative Humidity



(d) WFDEI Wind Speed

Forcings

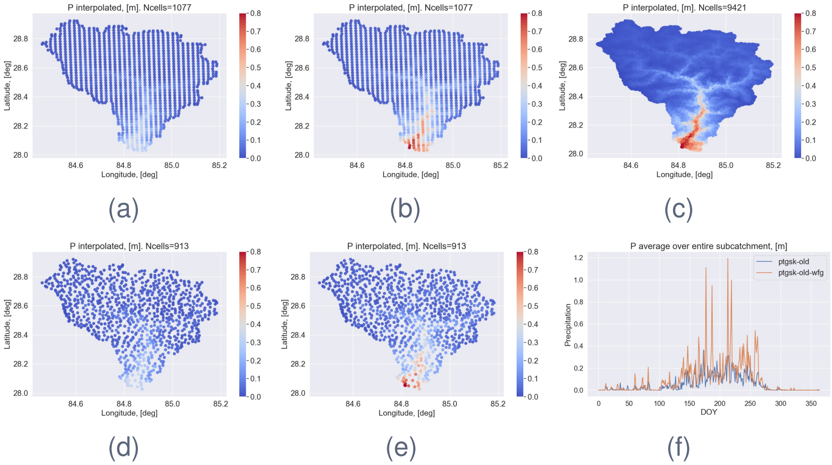
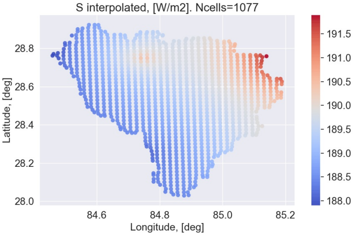
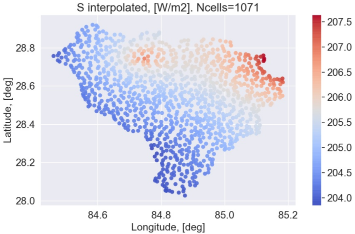
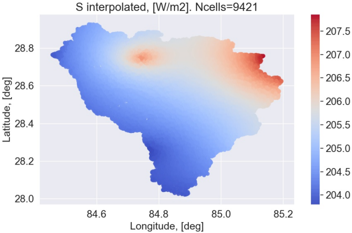


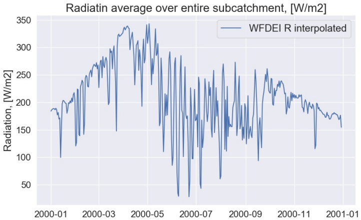
Figure: Precipitation input interpolated onto mesh: a) old mesh, observed P, b) old mesh, WFDEI P c) tin-ocs, observed P d) tin-ocs, WFDEI P, e) tin-slr WFDEI, f) Averaged across entire basin

Forcings









(a) WFDEI Radiation

Results. Experiments A.

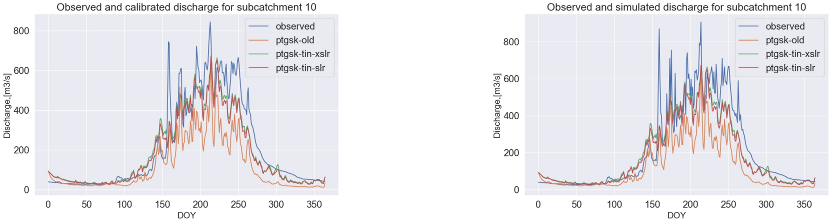


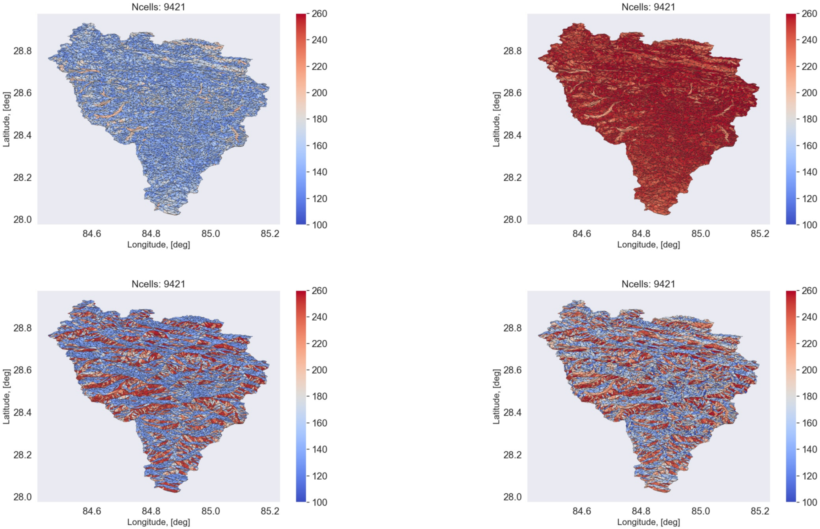
Figure: Exp. A.1 discharge: a) calibration result, b) simulation result

	Calibration			Simulation		
	Old	TIN-ocs	TIN-slr	Old	TIN-ocs	TIN-slr
NSE	0.554	0.862	0.85	0.5538	0.848	0.838
KGE	0.38	0.782	0.741	0.376	0.773	0.733
NS-SQ	0.631	0.902	0.895	0.631	0.894	0.889

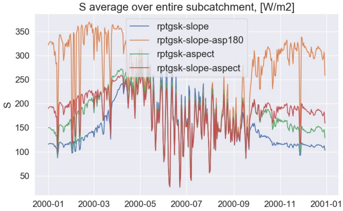
Table: Experiment A.1 Efficiency

Results. Experiments B.

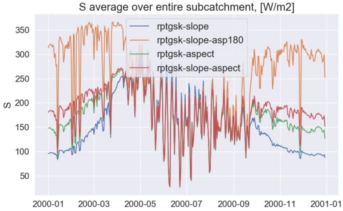
Irradiance, year average



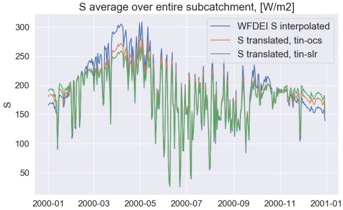
Area-averaged radiation



(a) Fine mesh



(b) Coarse mesh

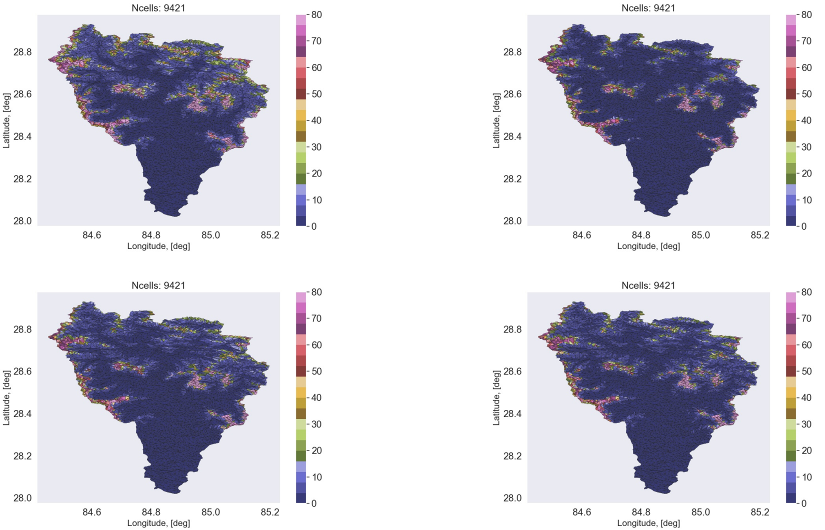


(c) B.4 comparison

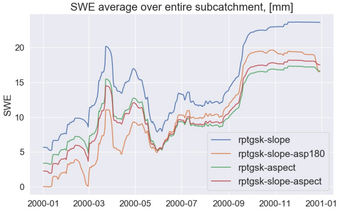
	B.1	B.2	B.3	B.4
min	122.4	202.8	123.5	74.2
max	209.0	263.2	258.6	263.7
median	151.0	255.3	150.56	177.6

(d) S [W/m2] statistics

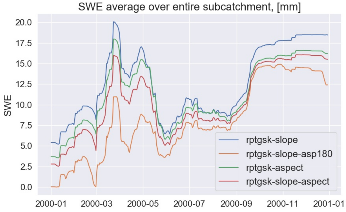
SWE, year average



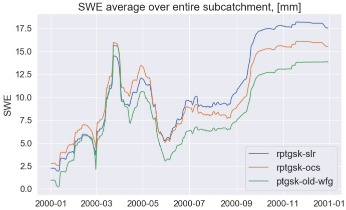
Area-averaged SWE



(a) Fine mesh



(b) Coarse mesh

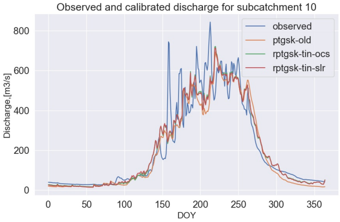


(c) B.4 comparison

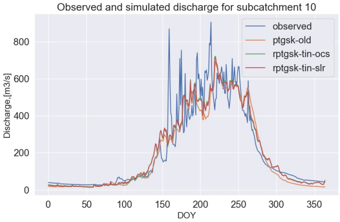
	B.1	B.2	B.3	B.4
min	0.0	0.0	0.0	0.0
max	169.3	122.5	146.7	156.8
mean	15.1	10.42	10.91	10.88
median	4.6	2.27	3.69	3.69

(d) SWE [mm] statistics

Discharge simulation



(a) calibration result



(b) simulation result

	Calibration			Simulation		
	Old	TIN-ocs	TIN-slr	Old	TIN-ocs	TIN-slr
NSE	0.849	0.874	0.872	0.832	0.853	0.852
KGE	0.879	0.92	0.917	0.869	0.906	0.902
NS-SQ	0.892	0.923	0.92	0.885	0.914	0.911

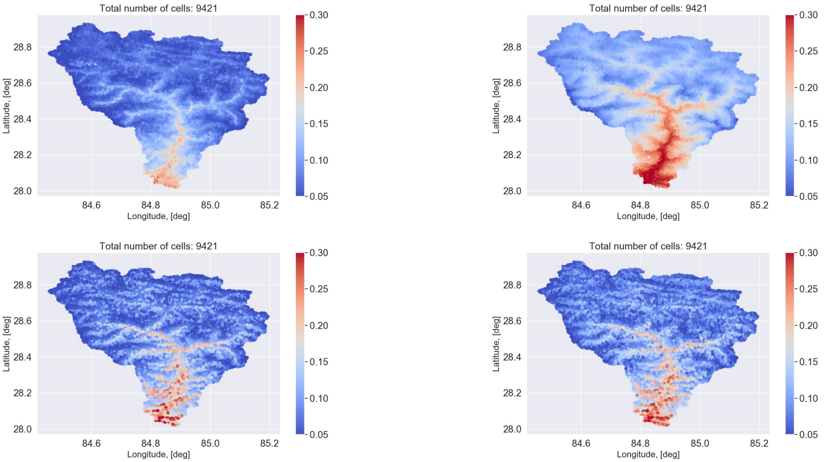
Table: Experiment B.4 Efficiency

Conclusion

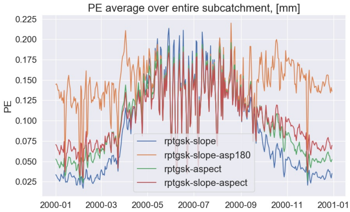
- From Experiments set A:
  - Use TINs, especially with low-quality meteorological data $\longrightarrow$ increase in efficiency with no extra computational costs
- From Experiments set B:
  - There is a clear difference between south-facing and north-facing experiments: the higher the radiation, the lower the SWE for the subcatchment
  - Clear difference between coarse and fine meshes. For snow simulation fine-mesh performs better, though there is a slight decrease in efficiency of discharge simulations
  - Benefits for operational hydrology: better prediction of snow cover $\longrightarrow$ better snowmelt prediction
- Shadows impact still to be assessed
- Correct snow cover still to be evaluated based on MODIS

Thank you!

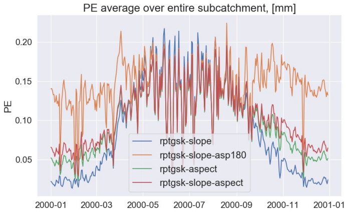
PE, year average



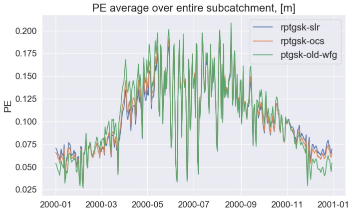
Area-averaged PE



(a) Fine mesh



(b) Coarse mesh



(c) B.4 comparison

Snow cover over cid-8