Comparative study of the surface energy and mass balance of Kersten Glacier on Mt. Kilimanjaro: COSIPY vs. previous modeling

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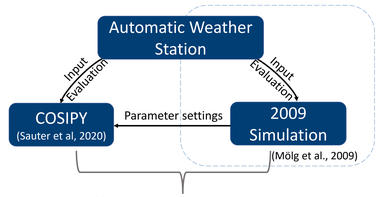
Background on Kersten Glacier

- Mt. Kilimanjaro, 3° S, East Africa
- Altitude ca. 5000-6000 MSL
- Freely exposed to midtropospheric flow
  ⇒ important climate indicator (Mölg et al., 2009)
- Daily temperature cycle exceeds intra-annual variation

Methods

Investigation period: 2005-02-09 to 2008-01-03



T_s	surface temperature
E_{Net}	net energy flux at surface
E_R	net radiation flux
E_H	net sensible heat flux
E_E	net latent heat flux
E_C	conductive ground flux
E_{PS}	penetrating radiation
ρ_{sfl}	surface layer density
d_{sfl}	surface layer thickness
c_i	spec. heat capacity of ice

Key difference: T_s calculation

$$E_{Net}(T_s) = E_R(T_s) + E_H(T_s) + E_E(T_s) + E_C(T_s) + E_{PS}$$

T_s for infinitesimal thin surface layer

$$E_{Net}(T_s) \equiv 0 \Rightarrow T_s$$

T_s for surface layer of height $d_{sfl} = 0.5\text{m}$

$$T_s(t + \Delta t) = T_s(t) + E_{Net}(t)\frac{\Delta t}{\rho_{sfl} d_{sfl} c_i}$$

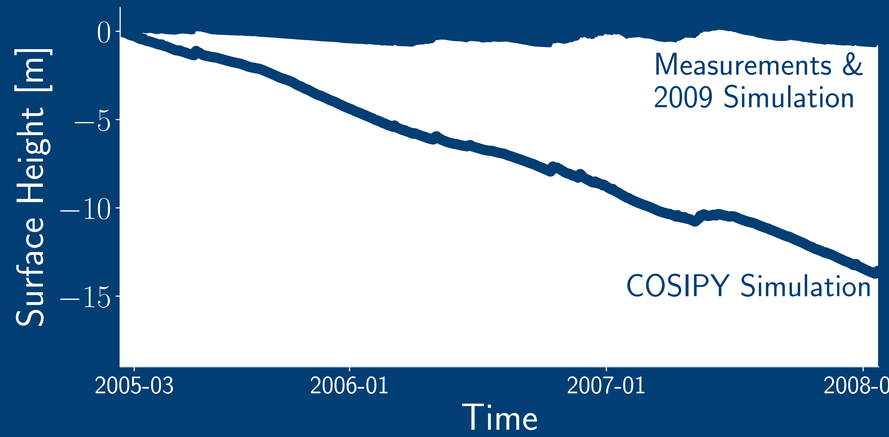
Results & Conclusion

- COSIPY overestimated melt; other mass fluxes similar

	COSIPY	AWS	2009 Sim.
Hours T_s at melting point	25%	5 %	4 %
Mass balance $[t/m^2]$	−13.58	−0.65	−0.65
Melt $[t/m^2]$	−14.10	/	−0.97
Refreezing $[t/m^2]$	0.50	/	0.30
Turbulent water vapor flux $[t/m^2]$	−1.39	/	−1.72

- Albedo feedback due to low snow depths on Kersten
- Future work: vary parameters in COSIPY
- Implementing a second T_s scheme In COSIPY might help to better accommodate tropical glaciers.

In our setting, **COSIPY** v1.4 severely **overestimated melting** on **tropical glacier** Kersten.



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Additional Information

Fig. 1 Diurnal Cycle of the Surface Temperature:

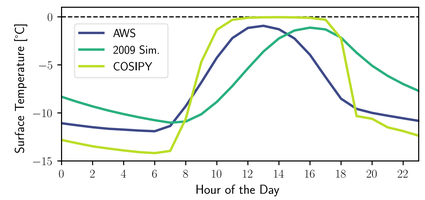


Fig. 2 Daily Mean Snow Depth and Albedo:

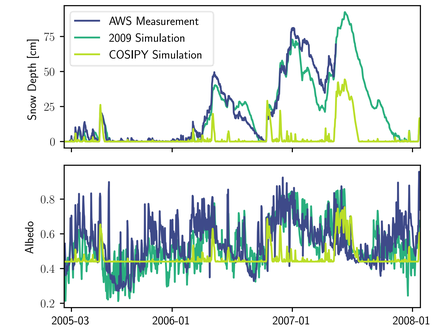
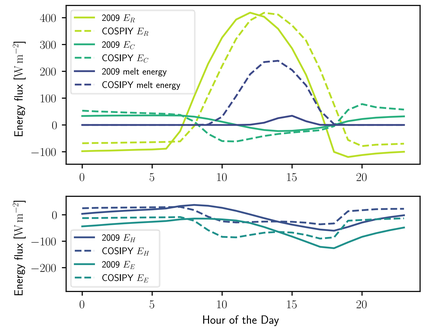


Fig. 3 Diurnal Cycle of the simulated Energy Fluxes:



AWS: Automatic Weather Station
COSIPY: COupled Snowpack and Ice surface energy and mass balance model in PYthon

References

- Mölg et al. (2009): Quantifying climate change in the tropical midtroposphere over East Africa from glacier shrinkage on Kilimanjaro, J. Climate, 22, 4162–4181
- Sauter et al. (2020): COSIPY v1.3 – an open-source coupled snowpack and ice surface energy and mass balance model, Geosci. Model Dev., 13, 5645–5662

- For this poster, the ‘betterposter’ poster design template by Fabio Crameri based on Mike Morrison’s initiative (https://osf.io/ef53g/) was used. It is available from the s-Ink.org collection.

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