Evaluating different methods for monthly glacier mass balance interpolation at the example of a tropical glacier

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wgms

CATCOS
Capacity Building and Twinning for Climate Observing Systems - Phase 2

Setting

Conejeras glacier is located in the Andes of Colombia, in the Cordillera Central, ca. 140 km west of Bogotà. It is on the western side of Nevado Santa Isabel, the middle one of three glacierized volcanoes.

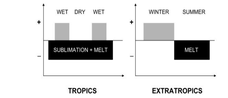
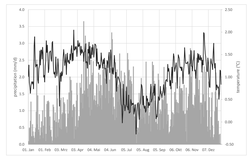


Figure 5: Accumulation (gray) and ablation (black; with dominant components) on mountain glaciers due to atmospheric forcing in the tropics (succession of wet and dry seasons) and extratropics (succession of temperature seasons); modified from Kaser et al. (1996);

Mölg, T. (2009)

The figures show the basic climatic difference between tropics and extratropics.



The second figure shows that there is no dry period on Conejeras and the seasonal temperature cycle is ~1.5°.

Interpolation Methods

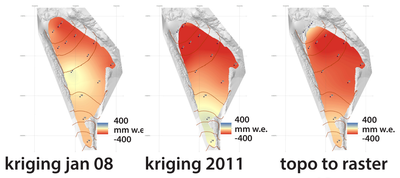
Pre-Conditions:
- High stake density
- Even distribution
- Good coverage

Potential for use of different methods

"Manual" Methods:
- Profile Method
  - Original
  - Stake Averaged
- Contour Line Method
- Index Method

Van Beusekom et al. 2010

GIS Methods:
- Kriging
- Topo to Raster



kriging jan 08 | kriging 2011 | topo to raster nov 13

Programme

A mass balance programme was started in 2006. Because a clear separation in accumulation and ablation season is not possible in the Inner Tropics, a monthly measurement interval was chosen, to better understand the relations of mass balance and tropical climate.

Mass Balance Programme:
- 14 stakes
- February 2006
- Monthly measurements

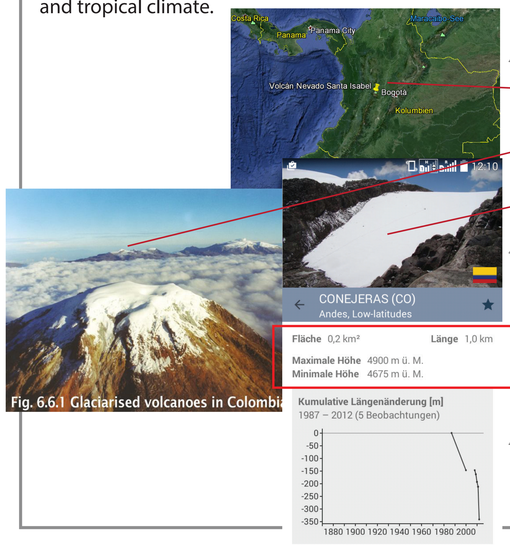
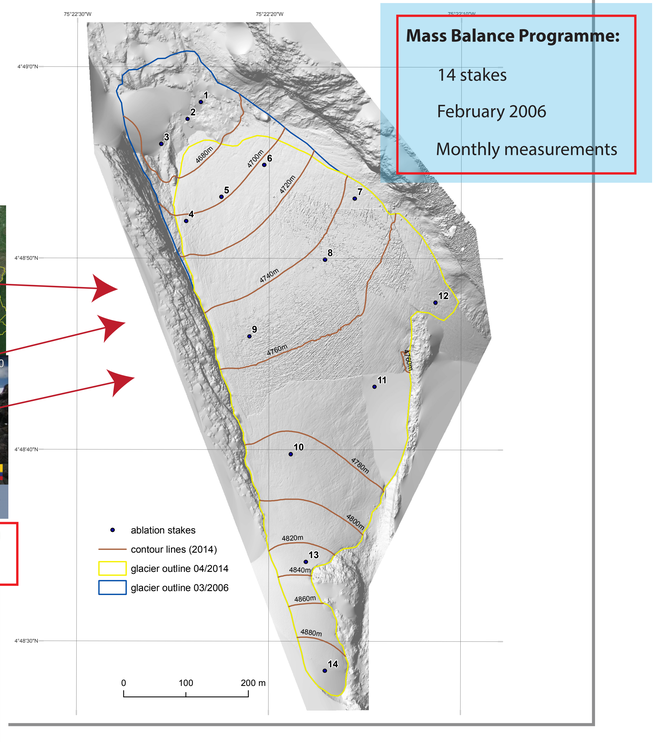


Fig. 6.6.1 Glaciarised volcanoes in Colombia



Aim

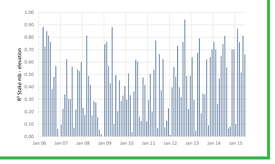
Ten years of measurements - reported balances partly inconsistent - high quality DEM available

For these reasons a reanalysis of the whole time series has been done.

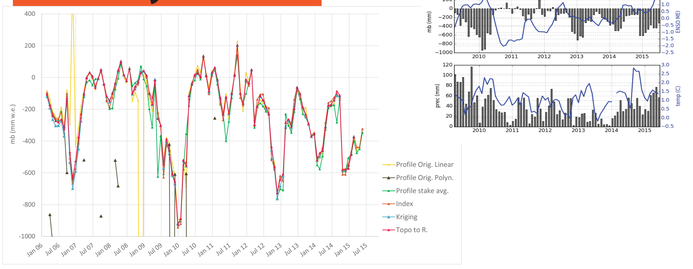
Mass Balance Reanalysis

- **Snow density**
- **Elevation information**
  30 m elevation bins
- **Measurement date correction**
- **Ablation stake outliers**
- **Interpolation method**

Reanalysis shows:
Weak relation mass balance - elevation



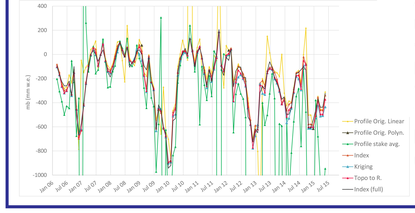
Monthly results



A comparison of the results of the different interpolation methods (graph + table). Index method and GIS methods are most stable and reliable.

	Original stake values				Filtered stake values				
	Profile Orig. Linear	Profile Orig. Polyn.	Profile stake avg.	Index	Profile Orig. Linear	Profile Orig. Polyn.	Profile stake avg.	Index	Kriging	Topo to R.
SUM	-28593		-28834	-25602	-29071		-27500	-25046	-24654	-23710
Mrz 06	-82	#NUM!	-96	-95	-82	#NUM!	-96	-95	-120	-106.6914
Apr 06	-137	-862	-170	-170	-137	-862	-170	-170	-193	-172.7366
Mai 06	-215	-1042	-228	-226	-215	-1042	-228	-226	-264	-241.0346
Jun 06	-248	-1145	-272	-260	-248	-1145	-272	-260	-304	-273.0994
Jul 06	-263	-2165	-272	-263	-263	-2165	-272	-261	-303	-281.3359
Aug 06	-188	#NUM!	-214	-221	-188	#NUM!	-214	-221	-273	-263.2627
Sep 06	-908	-907	-547	-546	-908	-907	-547	-546	-369	-521.9658
Okt 06	-80	-598	-113	-101	-80	-598	-113	-101	-141	-127.7327

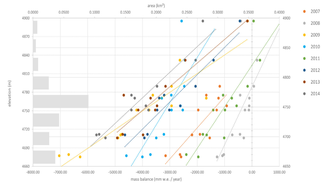
Reduced stake network to 4 stakes (4,6,8,10):



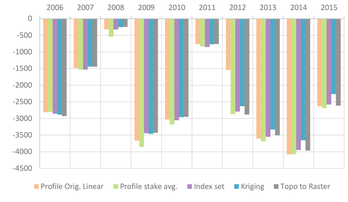
Also with the reduced network the methods performing best are the same.
For comparison see the series "Index (full)".
The stake average profile method loses its robust base and is not useful anymore.

Annual results

Annual stake values correlate much stronger with elevation.



For this reason also the profile methods lead to comparable and stable results.
The profile method using the stake values averaged over the elevation bin tends to more negative numbers.



Conclusions

- **x** If requirements are fulfilled -> a number of interpolation methods is useful
- **x** The profile method(s) do not perform well on monthly data
- **x** The contour line method is too laborious for monthly reanalysis
- **x** The Index method is robust and reliable
- **x** GIS methods are similar and robust and comparable to Index results

advantages vs. disadvantages

Regular measurements and analysis at IDEAM/CO
High work load for responsible person
Changing colleagues of responsible person

} Method should be
- robust
- easy to use
- comprehensible

For ***continuous measurements*** and annual reporting we recommend the **Index method**.

For a ***complete reanalysis*** we recommend using **additionally** the **GIS methods** as a measure of robustness and for estimation of uncertainties.