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Supplement of

Quantification of different flow components in a high-altitude glacierized catchment (Dudh Koshi, Himalaya): some cryospheric-related issues

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Quantification of different flow components in a high-altitude glacierized catchment (Dudh Koshi, Nepalese Himalaya). Supplementary material

Computation of the flow components from contributive areas (Definition 2)

This section describes the method used for the computation of the hydrological contributions (definition 2) from the simulated outputs (Fig. 1).

Five types of contributions are considered in definition 2:

- direct glacier contribution: direct runoff from glacierized areas $\mathrm{Gl}_{\mathrm{direct}}$,
- delayed glacier contribution: resurging melt water stored inside glaciers $\mathrm{Gl}_{\mathrm{delayed}}$,
- direct snow contribution: direct outflow from snow covered non-glacierized areas $\mathrm{Sn}_{\mathrm{direct}}$,
- direct runoff: direct runoff from areas without snow and glaciers $\mathrm{Rn}_{\mathrm{direct}}$,
- subsurface and groundwater contribution: resurging water from the soil in non-glacierized areas resulting from infiltrated rainfall, snow melt, as well as upstream lateral subsurface flows $\mathrm{Soil}_{\mathrm{delayed}}$.

The following model outputs (in mm/hour) were used:

- water input (i.e. liquid water reaching the surface) from glacierized ares (mix of ice melt, snow melt and net rainfall) $\mathrm{Input}_{\mathrm{gl}}$,
- water input from snow covered non-glacierized areas (mix of snow melt and net rainfall) $\mathrm{Input}_{\mathrm{snow}}$,
- water input from areas without snow or glaciers (net rainfall) $\mathrm{Input}_{\mathrm{rain}}$,
- soil water content in non-glacierized areas $\mathrm{Soil}_{\mathrm{water}}$,
- soil water content in glacierized areas (considered as glacier liquid water content) $\mathrm{Gl}_{\mathrm{water}}$,
- soil evaporation E_{Soil},
- actual evaporation E_{Act}.

Contributions are computed at an hourly time step and then aggregated to daily, monthly and annual time steps.

Contributions from glacierized areas

The variation of the glacier liquid water content $\Delta\mathrm{Gl}_{\mathrm{water}}$ during the time step with no water inputs (mostly during the night when there is no melt and few rainfall) shows that the release of liquid water stored inside glaciers is constant at daily scale.

Therefore, $\mathrm{Gl}_{\mathrm{delayed}}$ is derived as the daily mean of negative $\Delta\mathrm{Gl}_{\mathrm{water}}$ (i.e. release of englacial water)

Direct runoff from glacierized areas $\mathrm{Gl}_{\mathrm{direct}}$ is computed according the following equations:

$$\mathrm{Gl}_{\mathrm{direct}} = \mathrm{Input}_{\mathrm{gl}} - \mathrm{Gl}_{\mathrm{inf}} \tag{1}$$

Where $\mathrm{Gl}_{\mathrm{inf}}$ is the infiltration of water in glaciers:

$$\Delta\mathrm{Gl}_{\mathrm{water}} = \mathrm{Gl}_{\mathrm{delayed}} - \mathrm{Gl}_{\mathrm{inf}} \tag{2}$$

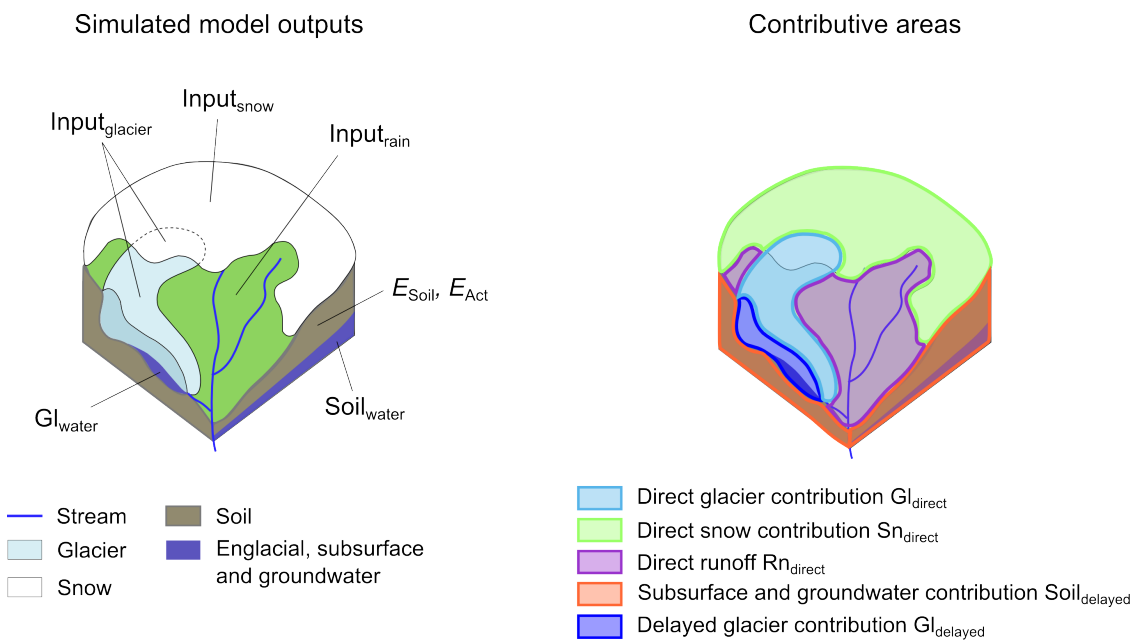

Figure 1: Simulated model outputs used for the computation of the flow components from contributive areas (left panel) and definition of the contributive areas (right panel).

Contributions from non-glacierized areas

The soil contribution $\mathrm{Soil}_{\mathrm{delayed}}$ is computed with the same method used for $\mathrm{Gl}_{\mathrm{delayed}}$ in non-glacierized areas. Infiltration in non glacierized areas $\mathrm{Soil}_{\mathrm{inf}}$ is calculated using the mass balance equation in soils:

$$\Delta\mathrm{Soil}_{\mathrm{water}} = \mathrm{Soil}_{\mathrm{delayed}} - \mathrm{Soil}_{\mathrm{inf}} - (E_{\mathrm{Soil}} + E_{\mathrm{Act}}) \tag{3}$$

Direct contributions $\mathrm{Sn}_{\mathrm{direct}}$ and $\mathrm{Rn}_{\mathrm{direct}}$ are estimated assuming that infiltration in snow covered and non-snow covered areas is proportional to the water input:

$$\mathrm{Sn}_{\mathrm{direct}} = (1 - \frac{\mathrm{Soil}_{\mathrm{inf}}}{\mathrm{Input}_{\mathrm{rain}} + \mathrm{Input}_{\mathrm{snow}}})\ \mathrm{Input}_{\mathrm{snow}} \tag{4}$$

$$\mathrm{Rn}_{\mathrm{direct}} = (1 - \frac{\mathrm{Soil}_{\mathrm{inf}}}{\mathrm{Input}_{\mathrm{rain}} + \mathrm{Input}_{\mathrm{snow}}})\ \mathrm{Input}_{\mathrm{rain}} \tag{5}$$

Lag time

In order to take into account the transfer of runoff through the catchment, a 2 h lag is applied to the direct contribution from glacierized areas $\mathrm{Gl}_{\mathrm{direct}}$ and a 1 h lag is applied to the two other direct contributions $\mathrm{Sn}_{\mathrm{direct}}$ and $\mathrm{Rn}_{\mathrm{direct}}$. These lag times were ajusted so that the sum of the hourly contributions corresponds to the simulated hourly discharges.