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Along-valley winds in the Himalayas as simulated by the WRF-model

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Along-valley winds in four major valleys in the southern slope of Nepal Himalayas are studied by means of a 5-day long high-resolution Weather Research and Forecasting model simulation. Model evaluation against observations from three automatic weather stations in the Khumbu valley showed a good agreement in the simulated diurnal cycle of wind direction and strength. The characteristics of the daytime up-valley winds are identified in the four valleys and compared to each other. Since all four valleys are under similar large-scale forcing, the differences in the along-valley winds are assumed to be mainly due to differences in the valley topographies. These valleys are separated by their topographic characteristics in two groups: the valleys in the west have a continuous inclination (2–5 degrees) in the valley floor and there is an 1-km high perpendicular mountain barrier between the valleys and the plain. The two valleys in the east have a 40 km portion with a nearly flat valley floor (<1 degree inclination) from the open valley entrance into the valley.

Daytime up-valley winds develop in all of the four valleys and they vary between the valleys and their parts in strength (2–10 m/s) and flow depth (600–1500 m). The night-time along-valley winds are weak and flow mostly in the up-valley direction. During large-scale northerlies, the daily cycle of the along-valley winds is interrupted more compared to the days with large-scale westerlies especially in the heads of the valleys that reach up to 4000 masl. The night-time down-valley winds are found more during the large-scale northerlies, which is most likely due to channelling of above-valley winds into the valley atmosphere.

The daytime up-valley winds are shallower and weaker in the parts of the valleys where the floor inclination exceeds 2 degrees compared to the parts where the valley floor is almost flat. The depth of the surface-based heated layer within the valleys is correlated with the flow depth and is lower in the steeply inclined parts of the valleys. The steep inclination of the valley floor and ridges in along-valley direction may shift the dominant driving mechanism of the along-valley winds from the valley volume effect to the buoyancy mechanism which would explain the shallower and weaker along-valley winds.

The winds at the valley entrances are weaker in the two valleys with the 1-km high barrier between the valleys and the plain, compared to the valleys with open valley entrances. A shallow layer with strong along-valley winds is found on the lee-side slope of the barrier and 20 km after this (i.e. towards the head of the valley), weaker winds are evident. This spatial distribution of the along-valley wind speed resembles the typical structure of a hydraulic jump related to down-slope windstorms.