Hydrology

Overview

Hydrologists require reliable estimates and forecasts of precipitation at ground level over selected catchment area. The main advantages of weather radar data are its very high spatial resolution and continuity of the measurements, that make available detailed information about spatial pattern of precipitation field (Fig. 1).

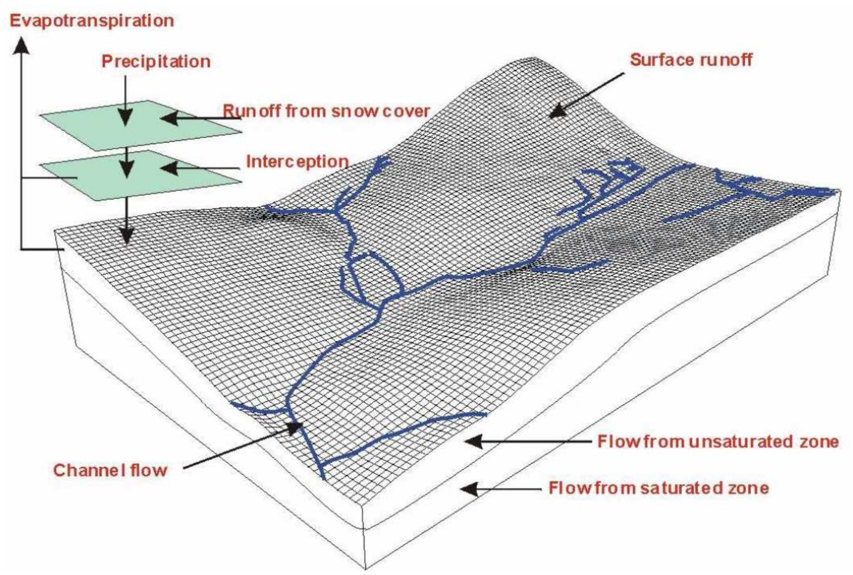


Fig. 1. General structure of a hydrological rainfall-runoff model (Jeníček, 2007).

The operational usage of radar data in hydrological models was investigated in various research programmes, especially in the frame of COST 717 Action (e.g. Szturc et al., 2005). A large European Union programmes (EU Framework Programmes, INTERREG) have been focused on operational using of the data for rainfall-runoff modelling, like CARPE-DIEM, FLOODRELIEF, MANTISSA, MUSIC, VOLTAIRE, BALTRAD etc. One of the main purpose of the projects was to solve practical difficulties in assimilation radar data to hydrological models. However up until now real time usage of radar precipitation is not at the level of their potential.

Data usefulness

Only digital data are expected for hydrological modelling:

- Ground precipitation estimation – estimation of accumulation: 1-hour or longer depending on catchment size (spatial scale) over a strictly determined area, like catchment, subcatchment, hydrological response unit or pixel in case of distributed model. However such data requires advanced correction and processing algorithms. The algorithms need data from other sources, especially from rain gauge network and meteorological satellite.

– Radar-based nowcasting (extrapolation). Since the nowcasting is reliable for relatively short lead-time (about 2-4 hours) the hybrid approaches are developed where data from numerical weather prediction (NWP) models are merged. For lead-times longer than 6 hours practically only NWP data are useful.

Examples of implementations

In general, high-resolution weather radar data are very promising tool in rainfall estimation for distributed hydrological modelling (Delrieu et al., 2009).

Flash floods

Ground precipitation estimation and nowcasting constitute the most important input to hydrological rainfall-runoff modelling. The usefulness of radar data for the modelling can be studied by comparing radar- and rain gauge-derived runoff simulations with observed flow. Promising results are reported (Corral et al., 2001; Yang et al., 2003) for cases in which the raingauge network is sparse, that unfortunately is typical for operational systems (Fig. 2).

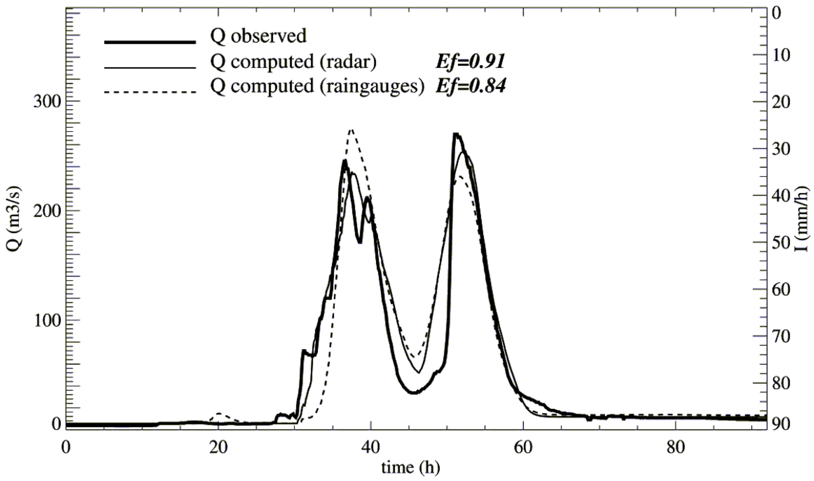
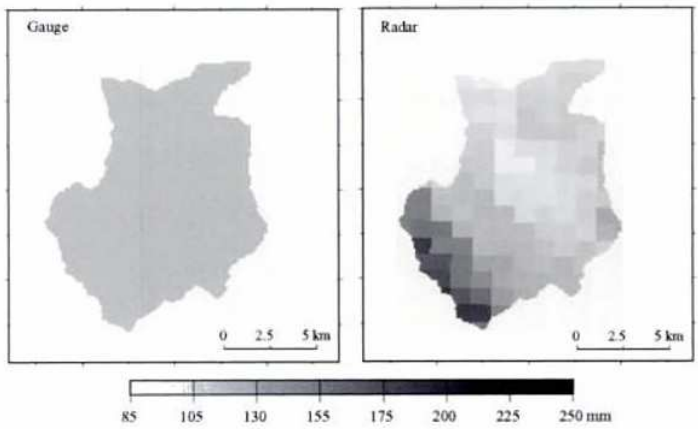


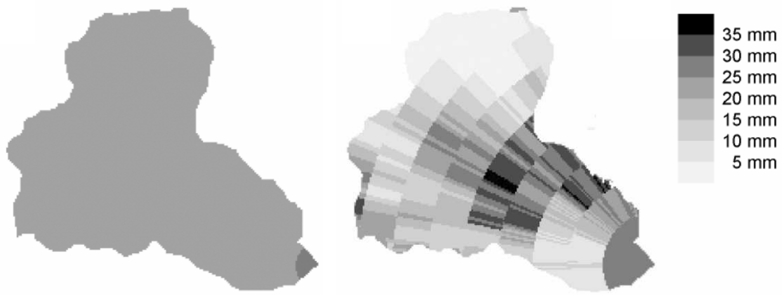
Fig. 2. Comparison of radar- and rain gauge-derived runoff simulations with observed flow (Corral et al., 2001).

Water balance

Heavy precipitation is usually dramatically distributed with space within a basin (Fig. 3). As a result, spatial variability of precipitation causes a significant difference in the shape of the hydrograph (Ishidaira et al., 2003).



(a)



(b)

Fig. 3. Examples of spatial distribution of precipitation field in small catchment during flood event (on the left rain gauge means, on the right radar fields):
(a) the Tone River catchment, Japan, 21-23 August 2001 (Yang et al., 2003); (b) the Brugga River catchment, Germany (area of 40 km^2, 10 rain gauges), 25 May 2002 (Tetzlaff and Uhlenbrook, 2003).

Remarks

Weather radar data are commonly used as precipitation input to rainfall-runoff modelling, especially for small catchment with risk of flash floods. Using distributed hydrological models advantages of the input can be exploited, however other kinds of data should be available with similar spatial and temporal resolution, especially concerning soil, land use, etc. Using the radar input results in more accurate hydrological forecasts.

Literature

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