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# PRECIPITATION, A PRESENT-DAY MODELLING FACTOR IN THE ORĂŞTIE CORRIDOR

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**ABSTRACT. Precipitation, a present-day modelling factor in the Oră tie Corridor.** This Corridor, which extends between the confluence of the Mureş River and its tributaries Sebeş and the Strei, is subjected to vast modelling processes (rain-induced weathering, surface erosion, gullying, torrential activity and landsliding), triggered largely by precipitation. Annual mean values are over 500 mm; however, maximum precipitation/24 hrs of up to 75 mm have the greatest impact. Slope processes are enhanced with precipitation of over 10 mm / day, more frequently occurring from June through to September. The analysis of the Fournier Index (an indicator of rain-induced erosion) has revealed that maximum values were recorded by the Sebeş and Deva weather station in June and July. Large quantities of torrential and lasting precipitation are a frequent occurrence also during transitional seasons, having the same detrimental effects, mostly in spring when harvested soils are already moist from snowmelt. Whenever heavy rains fall after long periods of dryness, the soil is severely impaired by rain-induced denudation, especially on slopes cultivated with hoeing plants.

**Keywords:** precipitation, morphodynamic potential, present-day modelling processes, gravitational processes, Oră tie Corridor.

## 1. Introduction

The Orăştie Corridor (1 150 km$^2$) which stretches out between the confluence of the Mureş River with its tributaries – Sebeş River in the east, and the Strei River in the west –, it lies at the contact with the Vințului Mountains and Metaliferi Mountains, in the north, and the Şureanului Montains, in the south.

Among the factors significantly involved in the manifestation of present-day processes, the precipitation regime is particularly important, high quantities being likely to dynamise their evolution. The present paper analyses this aspect on the basis of daily data registered over 1961-2005 at the Sebeş and Deva weather stations situated in the east and west of the Orăştie Corridor. The aim is to highlight the sequence of significant precipitation which has relevance for a wide variety of present-day geomorphological processes in the area.

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## 2. Materials and methods

The study illustrates the specific features of the region - lies between the two orographic fences in the Apuseni and Meridional Mountains, area recognized for maritime air advection from the west and also Föehn effects - by analysing the characteristics of a 45-year interval of precipitation recorded at Sebeş and Deva stations. The paper deals with the daily amounts of precipitation as registered at these weather stations. Further, were selected the significant precipitation which has relevance for a wide variety of present-day geomorphological processes in the area, which have been described in detail and synthetised in a map.

## 3. Precipitation

The multi-annual precipitation means are relatively low, 510-580 mm (513.1 mm at Sebeş and 577.4 mm at Deva). However, there are some years, e.g. 2001 and 2005 in which several factors cumulating resulting in a maximum value of 659.0 mm at Sebeş and 750 mm at Deva , respectively was recorded (Fig. 1).

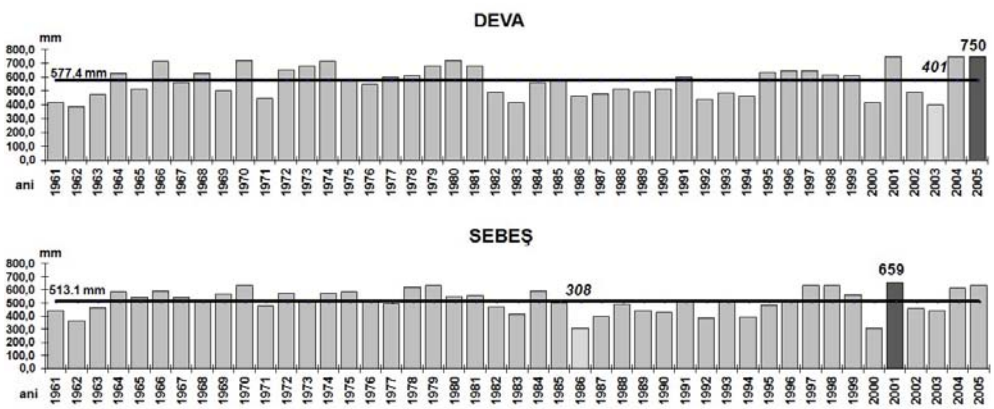


**Figure 1**. Variation of the anuual quantity of precipitation, compared to the annual average.

The lowest annual quantities of precipitations over the observation period common to the two stations were 401.0 mm in 2003 (Deva) and 308 mm in 1986 (Sebeş). The highest negative deviation from the annual means was -177.4 mm in 2003 (Deva). In 1986, Sebeş values of -205.1 mm came close to the deviation of -204.7 mm in 2000, quantities that year totalling nearly half the multi-annual mean characteristic at that station.

Positive deviations were used to single out excessively humid years. The years with highest annual quantities of precipitation registered at the two stations do not coincide, despite both lying rather close to each other (ca. 70 km): 750 mm in 2005 at Deva, 659.0 mm in 2001 at Sebeş. In general, positive deviations from the normal are lower than negative ones, e.g. : 145.9 mm in 2001 at Sebeş and 172.6 mm in 2005 at Deva.

Looking at the variation of the annual quantities of precipitations and deviation from the annual mean it emerges that at Sebeş occur the highest positive deviations and the lowest negative deviations, in the conditions of a rather low multi-annual mean, due to the influence of the Föehn in the eastern half of the Orăştie Corridor and the distance to oceanic advections.

According to the diagrams of the multi-annual monthly mean quantities of precipitation, falls in the warm season are significantly higher (65-70% of the annual mean), with a maximum in June (79.5 mm at Deva and 73.1 mm at Sebeş) (Fig. 2).

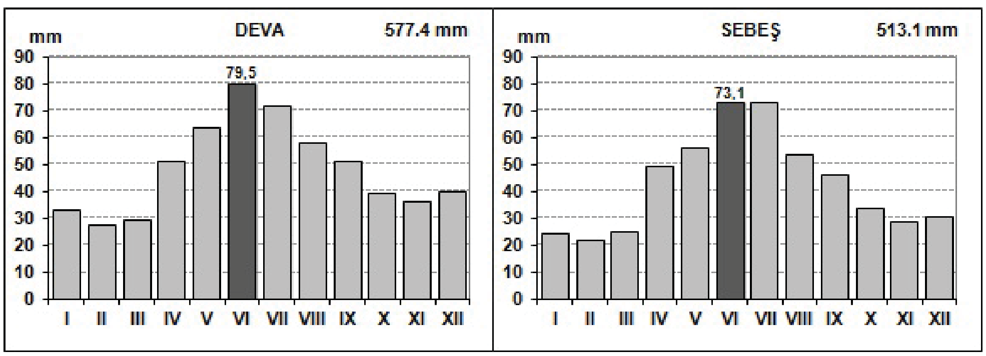


**Figure 2**. Variation of the multiannual monthly precipitation mean.

The same regime specific to the warm semester is illustrated also by the annual distribution of precipitation maxima / 24 hrs, highest monthly differing at the two stations: Deva, 262.0 mm in July and Sebeş, 75.6 mm in August (Fig. 3).

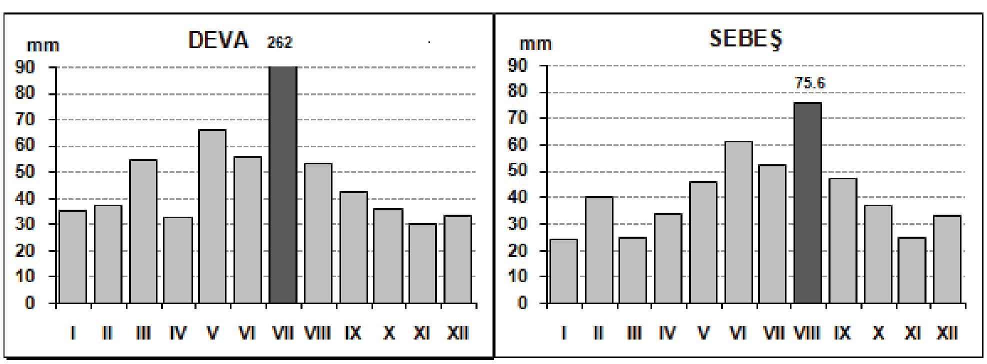


**Figure 3**. Annual distribution of precipitation maxima/24 hrs.

The distribution of the number of precipitation days over the year shows spring values to rise swiftly, with a maximum in May at Sebeş and in June at Deva, subsequently falling steadily until October; again a sudden rise occurring until a secondary maximum in December, when a secondary maximum was being registered (Fig. 4).

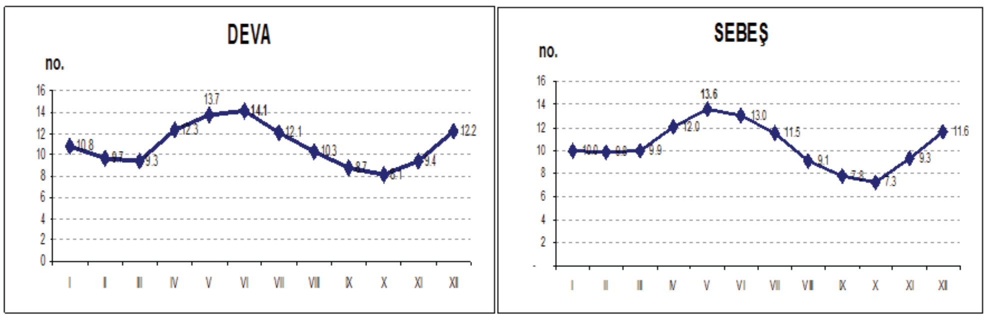


**Figure. 4**. Number of rainny days.

The diagrams of the frequency of days with quantities >10 mm reveal a similar distribution and evolution, that is a gradual value increase in spring, with a maximum in June at Deva and in July at Sebeş followed by a sharp decrease until November (Fig. 5).

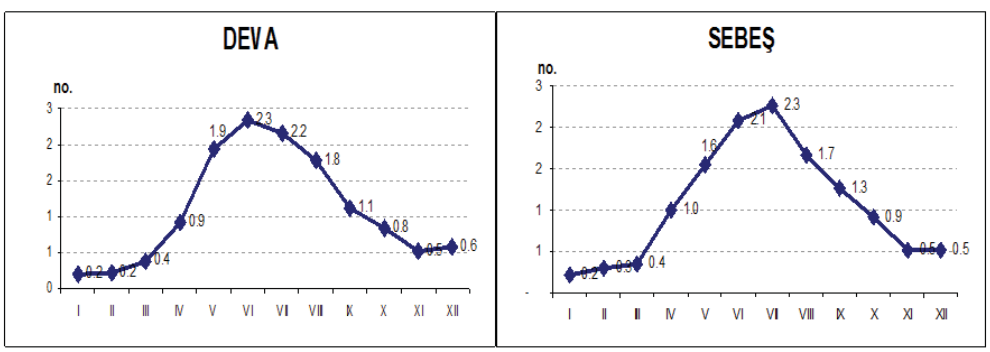


**Figure. 5**. Number of days with precipitation >10 mm.

The Founier Index of uneven precipitation is an indicator of rain-induced erosion during the year, according the formula (Grecu, Palmentola, 1997):

$$\mathbf{K_p = p^2 / P}$$

where:

**p** = total amount of precipitation in the rainiest day of the month
**P** = total mean quantity of rain, fallen in the respective month

The variation of rain splash erosion in the Orăştie Corridor over the year is quite uneven both in time and space (Table 1), with very high July values at Deva (max. 961.4) and June maxima at Sebeş (51.5). These major differences are due to the marked variability of precipitation, of maximum one, in particular (taken into account for index calculation) this variable reflecting the role played by local conditions in generating these extreme phenomena.

**Table 1.** Rain erosion over the year according to the Fournier Index.

| Station/Month | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deva | 37.3 | 51.8 | 102.1 | 20.6 | 68.9 | 38.7 | **961.4** | 49.2 | 34.9 | 33.5 | 25.0 | 27.6 |
| Sebeş | 15.8 | 42.9 | 25.2 | 24.3 | 37.7 | ***51.5*** | 38.3 | 33.1 | 49.8 | 40.1 | 18.5 | 23.2 |

The daily amounts of precipitation registered at Sebeş and Deva weather stations, studied with the aim to highlight the sequence of rainfall days in a row and their significant thresholds (1.0mm; 5.0mm; 10.0mm; 20.0mm and 30mm), have revealed that current geomorphological processes in the area are triggered by falls of ≥5mm, modelling being the outcome of heavy rains (≥10mm). The intensity of these processes depends on the quantities of water accumulated in the substrate, and these are remarkably big especially in the case of a succession of 4-5 days with precipitation of over 5mm, or of 2-3 days with over 30mm (Mărculeț, Dragotă, Mărculeț, 2008).

## 4. Favouring factors

The influence of precipitation in triggering and amplifying present-day geomorphological processes is related to several factors: the geological substrate, the relief, natural vegetation and land use and the soils.

***a. The geological substrate*** consists only of sedimentary deposits, represented by an alternation of Badennian deposits (sandstones, marls, tuffs, gypsum, sands, gravels), Sarmatian deposits (marls, clays, sandstones, etc.) and Quaternary deposits (sands, gravels), placed on the Sebeş – Pianu – Beriu Syncline (located in the south, parallel to the Mureş River) and on the Jeledinți Antisyncline (in the west). The southern slope of the syncline led to the formation of a network of consequent valleys and the development of cuestas (L. Badea şi colab., 2001).

***b. The relief*** plays a two-fold role: on the one hand, it is a support factor, also-conditioning the modelling processes and on the other hand it is the outcome of their actions. The density of fragmentation (0.5 – 4.5 km/ km$^2$) and the altitude (50-250 m) indicate a fairly advanced stage in landform evolution. Slopes, mostly convex-shaped and over 7° steep, are underlain by brittle, monoclinal sedimentary formations. Extensive present-day modelling is favoured by over 15° (sometimes over 24°) slopes. The terraces of the Mureş River – as mapped by L. Badea and I.

Mărculeț (2008) – are arranged in 9-10 levels: the highest at ca. 150-160 m (360-370 m absolute altitude). The Mureş Floodplain is large (1.5-3 km wide), more developed on the lefthandside of the Mureş River. Its higher level is 2-4 m above the River, being easily flooded.

***c. Natural vegetation and land use*** show local differences to the extent to which the surface is protected or vulnerable to present-day modelling processes. What has been left of the deciduous forests (Quercus, Beech, mixed etc.) which once covered most of the region, are only very small patches of woods, forest land having been gradually replaced by pastures, hay-fields and farm land. These changes have created favourable conditions for landsliding, also enhancing torrential activity. Some species of wild plants from across pastures and hay-fields, the gramineae and leguminous plants (*Andropogon ischaemum, Poa pratensis, Agropyron crestatum, Festuca sulcata, Stipa stenophylla, Medicago lupulina* etc.), gives resistance against erosion triggered by the precipitation. On arable lands some cultivated plants, like the alfalfa, the clover, the sainfoin, the wheat, the barley, the oats etc., protect against erosion.

***d.*** On the slopes and interfluves of the study area, soil factors have generated several types of ***soil***: argillic brown soils, haplic luvisols, eu-mesobasic brown soils, phaeozems marl/luvic, erodisols, cambic chernozems etc. (Parichi, Vartolomei, Stănilă, 2007). Their texture varies from loamy-sand to clay, dominated by loamy-clay. The clay content in the soil texture – usually 40-50% clay under 0.002 mm – makes them little pervious, hence surface erosion is very active on slopes cultivated with hoeing plants. Bulk density with most soils is fairly high ca. 13-1.6 g/m$^2$, effective soil porosity being insufficient (ca. 12%) (Hinescu, Luduşan, Țâra, 2004). However, argillic brown soils, phaeozems marl/luvic, have a much lower infiltration coefficient than the others types of soils, favouring run-off on slopes.

## 5. Precipitation-induced present-day modeling processes

Weathering (fluvial-torrential and mass movement of slope material) in the study-area largely due to precipitation, is quite significant both in terms of frequency and coverage (Fig. 6 A, B).

***a. Rain-induced weathering and sheet erosion*** affect slopes of over 2°-3° whenever the plant cover is missing or it is rare vegetation (including scarps and banks). This happens during both torrential falls and lasting falls, but only when the soil is overmoist.

The effect of rain splash erosion depends on rain drop size, fall speed, quantity and duration of precipitation. Most easily dislodged by rain drops are the fine sand grains rather than the clay ones which have greater cohesion, or the coarse sand grains which are far more heavy.

Because of the multitude of changes on slope and of microforms, large run-off in the Corridor occurs over small areas. It is seen in spring and summer on

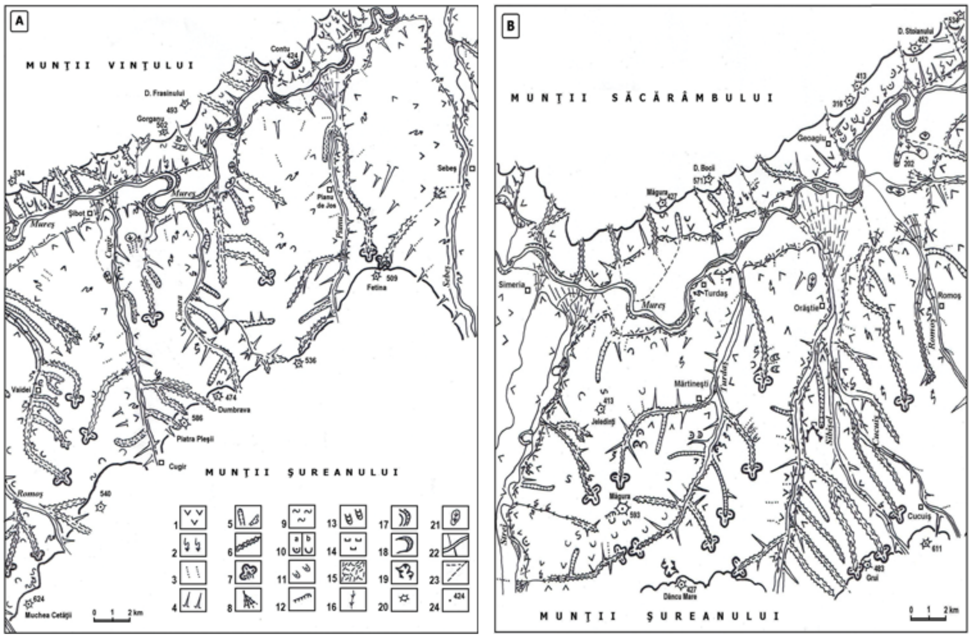


**Figure 6 A and B.** Map of present-day geomorphic processes: 1, raindrop impact; 2, sheet erosion; 3, erosion ditch; 4, groove; 5, ravenes; 6, torrential organism, 7, complex present-day processes; 8, alluvial fan; 9, solifluxion; 10, landslides (a, old, b, recent); 11, earthflow; 12, headscars; 13, mudflows; 14, rock and soil falls; 15, colluvial-proluvial glacis; 16, deepened channel; 17, lateral bank erosion; 18, floodplain meander; 19, scarp; 20, erosion outliers; 21, exces humidity; 22, permanent stream; 23, temporary stream; 24, level.

grounds grown with hoeing plants, when precipitation exceed 10 m / 24 hrs or have peak intensities of 0.5-6.5 mm/minute. The rain aggressiveness index calculated for the study-area lies in the range of 0.3-1.00. Precipitation over 10 mm (Sebeş and Deva stations) have been found to total a maximum of 4-5 days in April and May and 6 at the utmost in June, July and August.

***b. Gullying processes and torrential processes.*** Run-off on some slopes usually gathers in variously-sized channels, lasting or not in time as landforms. The sizes are directly dependent on the precipitation regime, lithology, slope length and declivity, the extent of the vegetation cover and the type of land use. Gullying processes in the Orăştie Corridor take on a multitude of forms in various stages of evolution, from incipient (rills and grooves) to evolved ones (gullies, ravenes, torrents).

Rills are the simplest forms caused by rain-wash, especially on arable land. They are a few inches deep and occur in parallel groups perpendicular to contour levels. In most cases, their existence is ephemeral, disappearing shortly after rains and they are destroyed by creep-moved material or by human activity.

Grooves are more advanced forms (1.5-2 m deep) and are more numerous on land with slopes above 15°, on the right hand side of the Mureş River. Simple grooves predominate. Most of them end up in torrents or are lost in the Mureş floodplain.

Gullies (ravenes) over 4-5 m deep are simple or branched out in terms of slope evolution stage and shape. Having 1-4 km lengths, are developed on areas with slopes between 10 and 20°. In the source area, where backward erosion is very active they occur in the form of small scarps. In the convex-shaped slope sectors, gullies have steep sides with saggings, rock- and soil falls and wash. Linear erosion is very active on the gully bottom, the development of some steps indicating landform evolution or rock hardiness.

The formation and evolution of torrential valleys, closely connected with that of the elementary formations, takes place in successive stages in which erosion, transport and accumulation have different values. The morphodynamic action is the result of the impact of precipitation water, geological formations and slope length. They are 5-8 km long and steep which makes reception basins small. Linear and backward erosion dominate the upper half of the valley, while lateral and linear erosion are found in the lower half which comes closer to a balanced profile. Catchment basins are usually small, but have very steep slopes subjected to sheet erosion, deep erosion, rock- and soil falls, etc. On rainy days (20-30 mm) which occur sporadically, mainly in June and July (1-3 cases/month), major changes in basin shape and soil take place due to the tentacular enlargement of existing furrows and the emergence of new ones.

***c. Landslides*** (superficial and deep-seated) are frequently occurring on the slopes of the Orăştie Corridor. These geomorphological processes developed in the Corridor affect fairly large areas especially in the upper part of slopes.

Low-depth or superficial slides (up to 2 m), ripple in aspect, use to dislodge materials on slope: soils, colluvia and deluvia, but seldom the bed-rock. In the study sector are shown mostly on the right side slope. Lasting rainfall (4-5 days in a row) of over 5 mm / 24 hrs and snowmelt in spring, produce surface slides. The data studied have revealed that 4-5 consecutive days with precipitation ≥ 5 mm did occur in March-April, June-August and October-November.

Deep-seated slides**,** occurred over small areas, affect the geological substrate at great depths, usually down to 5 m. They are favoured by the steep slopes, by the destabilization of them by the lateral erosion of the Mureş River, by the torrential and lasting precipitation, by the human activities, etc. Most deep-seated slides are seen in the lower part of slopes, where reactivations and successive overlays lead to the accumulation of thick deluvia which change the initial topography of the place.

The dramatic landscape changes induced by denudation, deep slides, mudflows and gully erosion occur in exceptional situations (like in summer of the year 1998), when a single rainfall reaches absolute maximum values/24hrs (61.3 mm in June 18, at Sebeş), or there is a maximum interval of precipitation days in a row (9 days, from 1 to 15 of May, 1984, at Sebeş), when the quantities fallen (e.g. 79.6 mm) may summate or even exceed the average amounts specific to the rainiest month.

## 6. Conclusions

The findings of the present study have revealed that the main external agent involved in modelling the Orăştie Corridor is precipitation.

The most damaging effects of precipitation-induced land degradation on slope occur in the warm period of the year, largely in the summer months, when torrential falls are most frequent and intense (over 1-10 mm/min/m$^2$ up to 30 minutes) also enhancing erosion and landslide processes. Rains (over 10 mm) very often fall in July and June, augmenting degradation through more run-off on slopes, rilling and gullying.

Large quantities of torrential and lasting precipitation are a frequent occurrence also during transitional seasons, having the same detrimental effects, mostly in spring when harvested soils are already moist from snowmelt.

Whenever heavy rains fall after long periods of dryness, the soil is severely impaired by rain-induced denudation, especially on slopes cultivated with hoeing plants.

Limiting the negative effects of these geomorphological processes requires a set of measures, among which the levelling and consolidation of some slopes, or their stabilisation by planting vine, fruit-trees, or through afforestation, restricting grazing and grass seeding on degraded lands, controlling torrents in the upstream sectors, draining landslides, directing slope water to channels dug into the Mureş floodplain.

## 7. Acknowledgment

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