Circulation weather types that have caused heavy precipitation in Estonia in period 1961-2005.

Olga Mätlik[1], Piia Post [2]
[1] Estonian Meteorological and Hydrological Institute, olgamatlik@hotmail.com
[2]University of Tartu Institute of Environmental Physics, piia.post@ut.ee

Introduction

The subjects of this study are heavy rainfalls and the weather types that have caused them in Estonia in period 1961-2005. The work was concentrated on the analyses and classification of synoptic situations that bring heavy rainfall in the Baltic Sea area.

Data and method

- Precipitation data originate from 28 Estonian meteorological and 93 climatological stations, only 40 of them have measured without skips during 1961-2005.
- Rainfall event is defined as a heavy one if the accumulated sum of precipitation from 18 UTC of the previous day to 18 UTC of the measurement day exceeds 50 mm.
- A day during which at least in one of the stations this amount of precipitation was registered was considered to be a day with heavy rainfall.
- Extreme rainfall – if the 24 h accumulated sum exceeds 100 mm.
- The weather charts of surface analysis and of 500 hPa from the Estonian Meteorological and Hydrological Institute archive and NCEP/NCAR Reanalysis have been used for investigation of the synoptic situations leading to heavy rains.
- Features of the atmospheric circulation are described by trajectories of cyclones, fronts and troughs, that affect a character of the weather in Estonia (Prilipko, 1982).

Heavy rainfall statistics

- 659 heavy rainfall events were registered in Estonia during the period 1961-2005, they occurred during 199 days.
- 50 mm precipitation threshold was exceeded in all climatological stations (where the whole 45 years period has been measured) and in all meteorological stations, except two – Pärnu and Kihnu.
- 12 days with extreme rainfalls

FIG. 1. Location of all Estonian precipitation measuring station in 2007. The red line is a borderline with Russia (east) and Latvia (south), in the north and the west Estonia is surrounded by the Baltic Sea. **x**-locations of stations that recorded extreme rainfall .

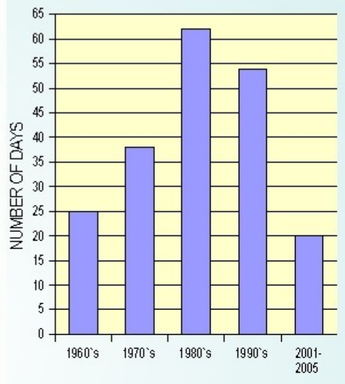


FIG 2. Temporal variability of the heavy precipitation in Estonia per decade. There is a rising trend of the number of days with heavy rainfall until 1990`s.

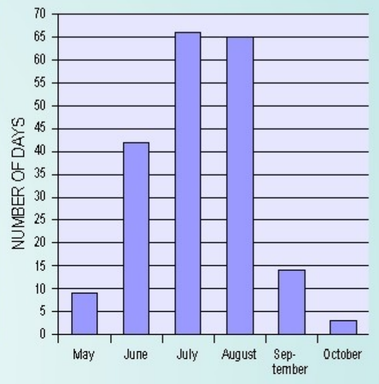


FIG. 3. Monthly distribution of the heavy precipitation in Estonia in 1961-2005. All events occurred in the warm season from May to October, whereby 87% of these days were in the summer months.

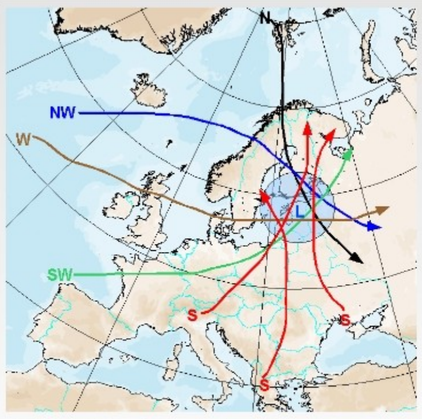


FIG. 4. Main trajectories of cyclones, that caused heavy precipitation in Estonia during the period from 1961 to 2005.

In order to find out the main features of the atmospheric circulation in the Baltic Sea area for all days with extreme rainfalls, origin and moving trajectories of all baric systems have been taken into account. By using trajectories of all cyclones, that affect the character of weather in Estonia (Prilipko, 1982), six main trajectories were highlighted.

N→ northern or „diving„ trajectory.
NW→north-western trajectory. The cyclones travel from near Iceland eastwards.
W→ western trajectory. The lows move from the west to the east over the Northern Great Britain, the Southern Scandinavia to the Baltic States.
SW→ south-western cyclones. Often they form near Bay of Biscay and move north-eastwards.
S→ southern cyclones. They may originate in the area of the Black Sea, the Balkans or near Italy and move along the meridian to the north direction.
L - the area of the local cyclone formation (within the radius of 500 km from Estonian geographical centre).

The main criteria for classification of the synoptic situations were the surface air pressure distribution and the atmospheric fronts. 6 basic synoptic situations appropriate for the 198 days with heavy rains have been distinguished (1 day unclassified).

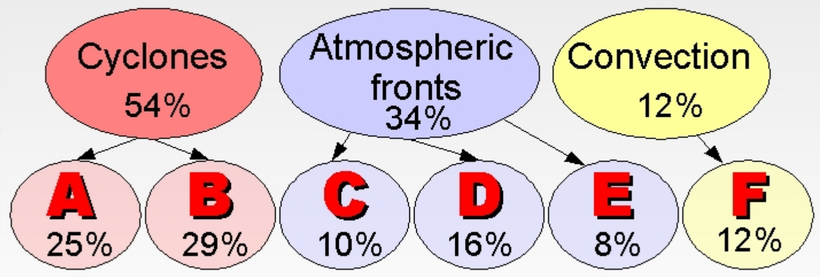
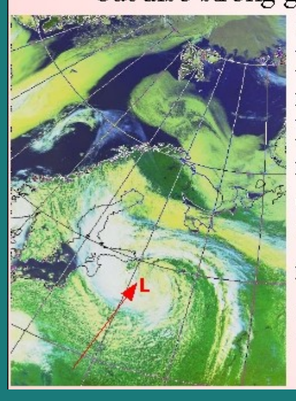


FIG.5. Distribution of the weather types, as the percentage of the total number of days with heavy rains in Estonia in 1961-2005.

A

is associated with the deep depression (visible both at the surface and the upper air pressure field), which centre was passing over or near Estonia. These deep depressions produce not only widespread and continuous precipitation, but also strong gusty wind over large area.

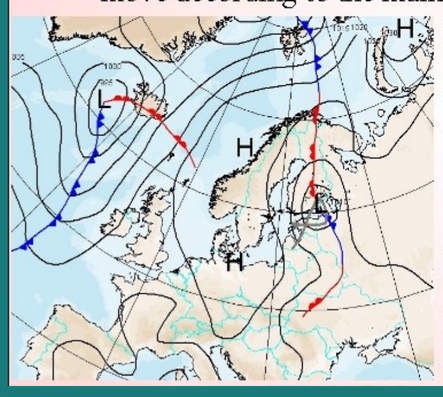


Southern cyclone brought heavy rains in Estonia on August 7 to 8 1987, that were registered in 47 stations. In the South-Eastern Estonia the amount of precipitation rose up to 139-158 mm/48 h. 80% of all crop of the country was damaged, town Võru was flooded. **3 days** with extreme rainfall belong to this type of weather.

FIG. 6. NOAA-9 CH 7 image, 7.VIII 1987 at 12 08 UTC. → **L** – the trajectory and the location of the centre of depression.

B

is associated with the lower level small depression that usually forms near the frontal wave or the point of occlusion, which was crossing over Estonia. These minor lows are invisible in upper pressure field and usually they move according to the main mid-level flow.



5 days with extreme rainfall, including an absolute Estonian record of 24-hour precipitation – 148 mm in Metsküla – are associated with this dominant weather type.

FIG. 7. Surface analysisfor 00 UTC 29.VII 2004. The trajectory of the low is shown by a grey arrow. 148 mm/48 h rained in Tallinn and caused flush flooding.

C

is associated with the frontal wave. The majority of wave disturbance forms on the slow moving cold front and produces widespread and occasional heavy precipitation.

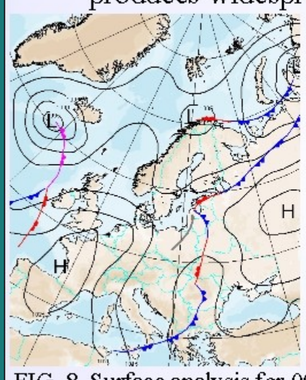


FIG. 8. Surface analysis for 00 UTC on 27.VIII 1985. The trajectory of the wave is shown by a grey arrow.

Southern wave caused heavy rain in Estonia 27.VIII 1985. 87 mm rained in Himmiste, 51.8 in Räpina. 1 day with extreme rainfall belongs to this type.

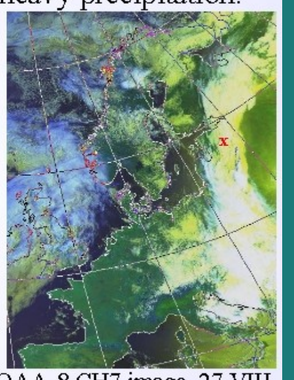
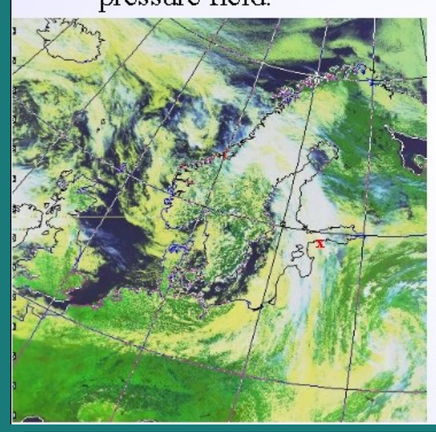


FIG. 9. NOAA-8 CH7 image, 27.VIII 1985 at 07 57 UTC. **x**- location of the area with heavy rains.

D

is associated with the fast running cold or occluded front within well-marked trough. Here are dominant Scandinavian troughs, that are often visible also in upper pressure field.

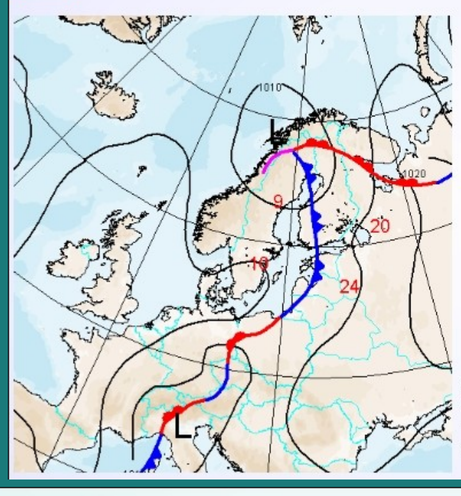


The frontal rains are often complemented by scattered showers in the rear of such troughs. 1 day with extreme rainfall is associated with this type of weather.

FIG. 10. NOAA-9 CH7 image, 21.VIII 1985 at 12 09 UTC. **x**- location of Kloostrimetsa, where 119.9 mm/24h was registered.

E

is associated with slowly moving cold or occluded front within surface slack area of low pressure.



Heavy precipitation, that is related to this type of weather may be characterized as isolated rain showers, but may also be significant. On 23.VII 1976 in Pajusi 71.3 mm, on 25.VI 1991 in Räpina 79.1 mm.

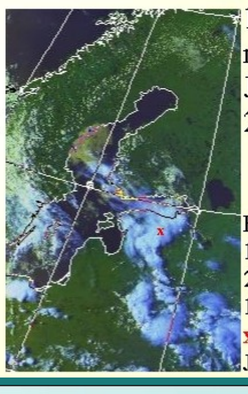
FIG. 11. Surface analysis for 00 00 UTC 16.VII 2001. The red numbers show surface air temperature.

F

is associated with the weak surface pressure field and convective precipitation which is not triggered by the passage of a depression or a front, and the formation of which is largely caused by convection and instability effects.
2 days with extreme rainfall.

Torrential rain and flash flooding in Võru town on 3.VII 1988 130,8 мм/6 h.

FIG. 12. NOAA-9 CH7 image, 3.VII 1988 at 12 43 UTC. **x** - location of Võru



100 mm was registered in Jõgeva on 2.VIII 1994

FIG. 13 NOAA-10 CH7 image, 2.VIII 1994 at 15 44 UTC. **x**- location of Jõgeva

TABLE 1. Occurrences of weather types (the number of days) that have caused heavy precipitation in Estonia in the period 1961-2005.

Trajectory / Weather type	NW	W	SW	S	N	L	Total
A	2	8	9	22	-	8	49
B	5	2	7	25	2	16	57
C	-	-	6	5	-	9	20
D	11	14	4	1	-	2	32
E							16
F							24
Total	18	24	26	53	2	35	1 day unclassified

Results and conclusions

- 88% of all heavy precipitation in Estonia from 1961 to 2005 was produced by the passage of different depressions and frontal systems and 12% were caused by convection and instability effects.
- The dominant heavy rain bringing weather type is B which is associated with lower level small depression - 29% of days with heavy rains.
- From the lows or troughs trajectories, the south is dominant (53 days) heavy rain bringer, also significant contribution has been made by the local formation of low pressure systems - 35 days.
- The most frequent heavy rainfall bringers to Estonia are the south cyclones that are born in the region of the Black Sea or the Mediterranean Sea in 24 % of all cases

References

Prilipko G.I., 1982: The climate of Tallinn, *Gidrometeoizdat, Leningrad*, 267 p.p. (in Russian)

Acknowledgments The authors wish to thank Riina Pärg and Tiina Tammets for extracting heavy rainfall events from database of Estonian Meteorological and Hydrological Institute. We would like to thank Helju Prommik who helped us to find necessary materials in EMHI's historical archive of synoptic maps.