Characteristics of the linearly organized convective systems over Croatia

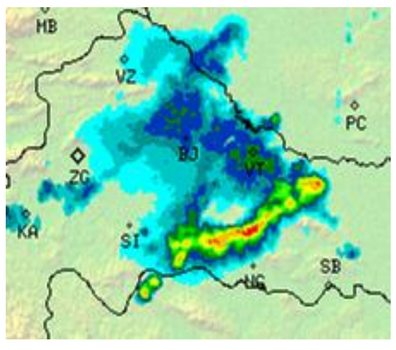
Nataša Strelec Mahović (1), Petra Mikuš Jurković (1), Branimir Lovrić, Vinko Šoljan (2) and Tanja Renko (1)

(1) Meteorological and Hydrological service, Zagreb, Croatia, (2) Croatia Control Ltd., Zagreb, Croatia

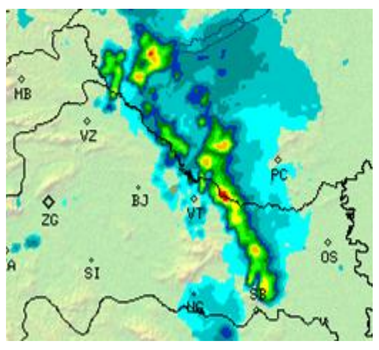
Photo: Bruno Fantulin

INTRODUCTION

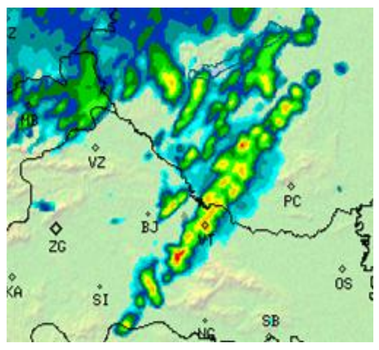
Linearly organized convective systems frequently cause heavy rain, strong winds, intense lightning, hail and consequently flash flooding. In the Pannonian basin squall lines are a frequent cause of severe weather events and can result in large material damages. We investigated squall lines above continental part of Croatia, focusing on their appearance and the synoptic and thermodynamic environment in which they form. Using archive radar and lightning data, we isolated 50 linearly organized convective systems during 8 years (2010-2017) and grouped them into types, according to the appearance in radar images. To assess the thermodynamic conditions prevailing at the time of squall-line formation we calculated CAPE by lifting three different air parcels: a surface based, a mixed layer parcel and the most unstable parcel, as well as bulk shear 0-1, 0-3, 0-6 km and bulk Richardson number from the radiosounding data measured at Zagreb-Maksimir station.



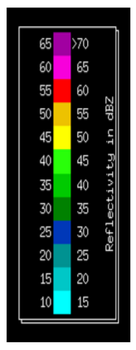
Trailing stratiform (TS) type



Leading stratiform (LS) type



Parallel stratiform (PS) type

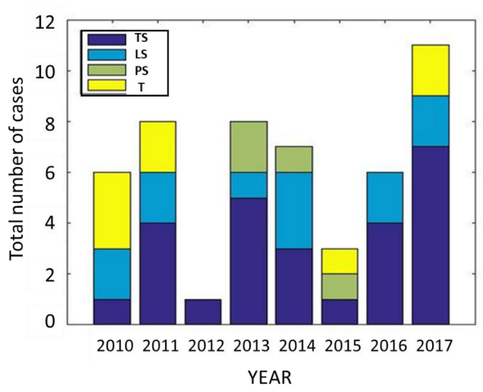


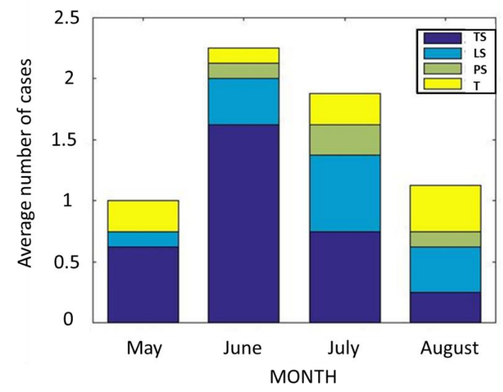
APPEARANCE IN RADAR IMAGES

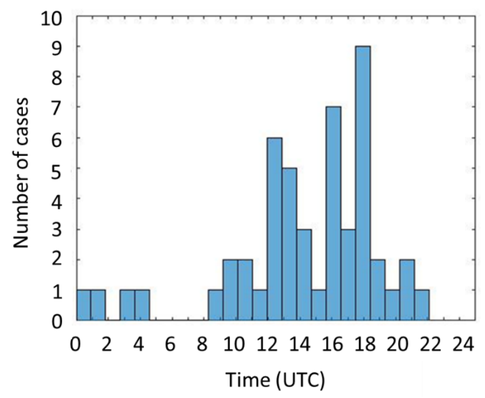
We used radar imagery from radar center Bilogora of the Croatian Meteorological and Hydrological Service, an S-band doppler radar, with 240 km maximum range. The data is available every 15-minutes. In radar images, linear MCSs appear as the line of contiguous or nearly contiguous chain of convective echoes, that share a nearly common leading edge and move approximately in a group. They can be arranged in a nearly straight line or a moderately curved arc. Based on the distribution of the stratiform precipitation in relation to convective line, linearly organized convective systems were classified into three types: trailing stratiform (TS), leading stratiform (LS) and parallel stratiform (PS) (after Parker and Johnson, 2000) – as seen in the examples. Additional type was considered – transitional type (T) – used for the cases when the type of the squall line changed during its lifetime.

PRECIPITATION CHARACTERISTICS

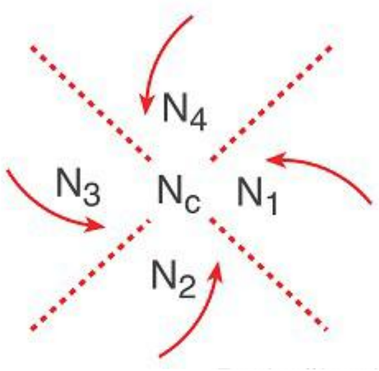
Most of the squall line cases were observed in 2017 and the most active month was June. The most frequent type of was the one with trailing stratiform precipitation (52% of all cases). TS type was present in each convective season and every month, whereas it was the dominant type in May and June. Most of linearly organized systems generally developed in the afternoon and evening in the period between 12 and 19 UTC (14-21 h local time).



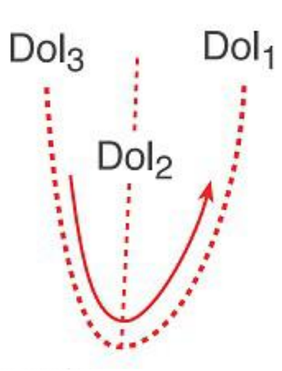




SURFACE LOW



SURFACE TROUGH



SYNOPTIC CONDITIONS

The most common surface synoptic situation, related to linearly organized convection, was the presence of the center of cyclone above Croatia, which was often situated above the Adriatic Sea. From 50 cases, 18 developed in the presence of cyclonic center (36%) and further 12 (24%) in the eastern sector of a cyclone.

Analysis of the 500 hPa pressure level showed that most of the cases developed in the forward flank of a trough, in the presence of south-westerly flow regime.

N1	N2	N3	N4	Nc	Dol1	Dol2	Dol3	tDol	B	*Type*
12	3	6	1	18	0	1	3	1	5	*Number*
24	6	12	2	36	0	2	6	2	10	%

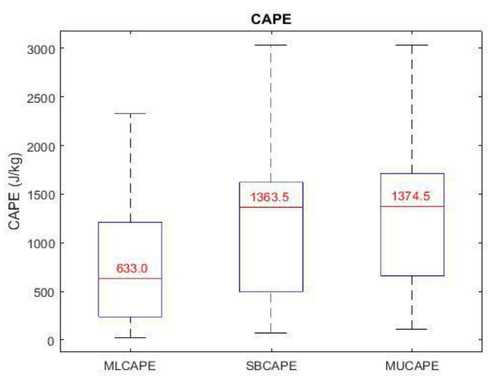
THERMODYNAMIC CHARACTERISTICS

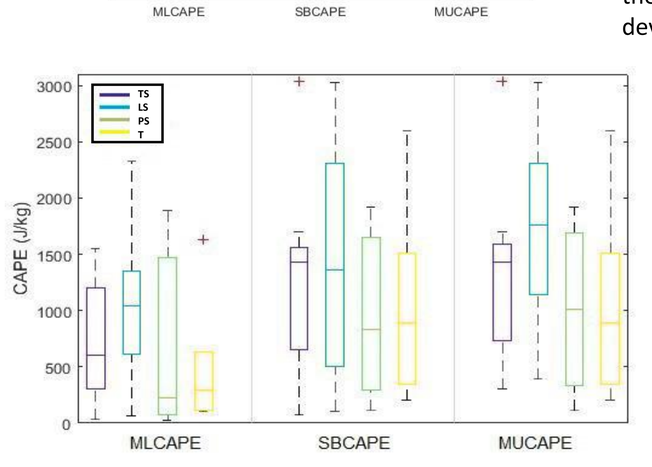
CAPE

For all investigated squall line cases MLCAPE, SBCAPE and MUCAPE were calculated from Zagreb radiosunding data using SHARPpy. Median of MLCAPE was 633 J/kg, whereas SBCAPE and MUCAPE had higher, but also similar values. SBCAPE was in range from 72 to 3031 J/kg, with median 1363 J/kg and MUCAPE values were from 110 to 3031 J/kg with median 1374 J/kg.

LS type of squall-lines had in general the highest MLCAPE (median was 1042 J/kg) and MUCAPE(1756 J/kg). Also, the highest value of SBCAPE occurred in one LS type squall-line, 3031 J/kg. For both LS and TS types, all three CAPE values are much higher than for PS and T types.

If we analyze the values by month, highest CAPE values occur in June, and the lowest in May, while for all three CAPEs maximum values took place in August (not shown). In addition, they were generally higher for squall lines occurring in the eastern sector of a cyclone than for those occurring in the presence of a cyclone center. The reason can be found in the advection of warm and humid air to the area of interest in the eastern sector of a cyclone (not shown).



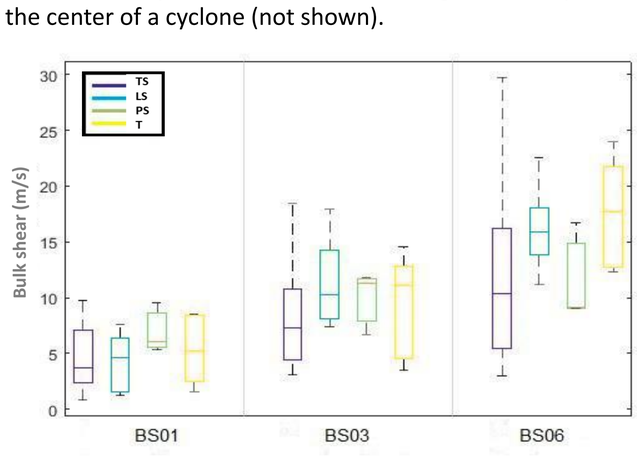


SHEAR

For all types of linerly organized systems median of bulk shear 0-6 km was the highest. The T type had the highest median value, 17.7 m/s, while the PS type had the lowest value of 9.2 m/s.

BS01 and BS03 were highest for PS and lowest for TS type. Transitional type of squall lines generally developed in the environment with highest bulk shear, while for the most frequent type, TS, environment with less shear was sufficient for the development.

BS01 and BS03 were similar in cases related to the center of a cyclone and the eastern sector of a cyclone, but BS06 was higher for squall lines developing in the center of a cyclone (not shown).



SUMMARY and CONCLUSIONS

The study of the linearly organized convective systems was performed during 8 years over Croatian territory. The convective season with the highest number of cases was season 2017, and in general most cases were observed in June. Linearly organized systems with trailing stratiform precipitation (TS) were the most frequent type.

Majority of cases developed at the forward flank of an upper level trough in the presence of south-westerly flow regime, within a surface low or on its eastern side.
Instability indices were calculated from radiosounding data of station Zagreb-Maksimir. CAPE was calculated in three ways, as mixed layer, surface based and most unstable CAPE. The highest median values of CAPE were found in June. Higher values of CAPE seem to be related to TS and LS type of squall lines. On the contrary, bulk shear was found to be lower for TS and LS type whereas the highest bulk shear 0-6 km was connected to transitional (T) type of the linearly organized system.

In short, linearly organized systems with trailing or leading stratiform precipitation seem to develop in high CAPE – low SHEAR environment, while in parallel stratiform and transitional cases more often lower CAPE values and stronger SHEAR were present.

Photo: Bruno Fantulin