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# Organization and evolution of mesoscale convective systems using radar data: objective description. The “dominating thunderstorm” conception and its application to MCS climatology

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## 1. **The goals** of present study are:

- Demonstration of *practical method* leading to objective description of *organization* of meso-convective systems (MCS);
- Construction of MCS *climatology* and their using *as evaluating tool* in severe weather forecasting and numerical modelling.

# 2. What problems are associated with goals ?

- Typically MCS develop in meso-$\alpha$ domain ~300km during ~7 -8 hours changing their organization including shape, size, intensity of precipitation, storm type, associated severe weather and etc.
- We cannot use any MCS climatology in practice as severe weather forecasting guidance or use some of derived climatological properties to evaluate numerical modeling results.
- The basic difficulty is *the absence of rigid definition of MCS stages*, in other words, we need to determine the *representative instance (es) of MCS life cycle* when morphology of all observed and/or modeled systems can be adequately compared.

# 3. How the concept of “dominating thunderstorms” resolves the problem of representative instance?

*3.1 Concept*

- Both squall lines and MCS with more complex morphology demonstrate auto-organization.
- It means the quasi-periodically striking of intense dominating thunderstorms occurred with ~1 hour one after other, and 2-3 large meso-$\beta$ ensembles, compounded by 2-4 dominant and subdominant thunderstorms, that define entire convective activity of order 8-10 hours

### 3.2 How the concept of “dominating thunderstorms” resolves the problem of representative instance?

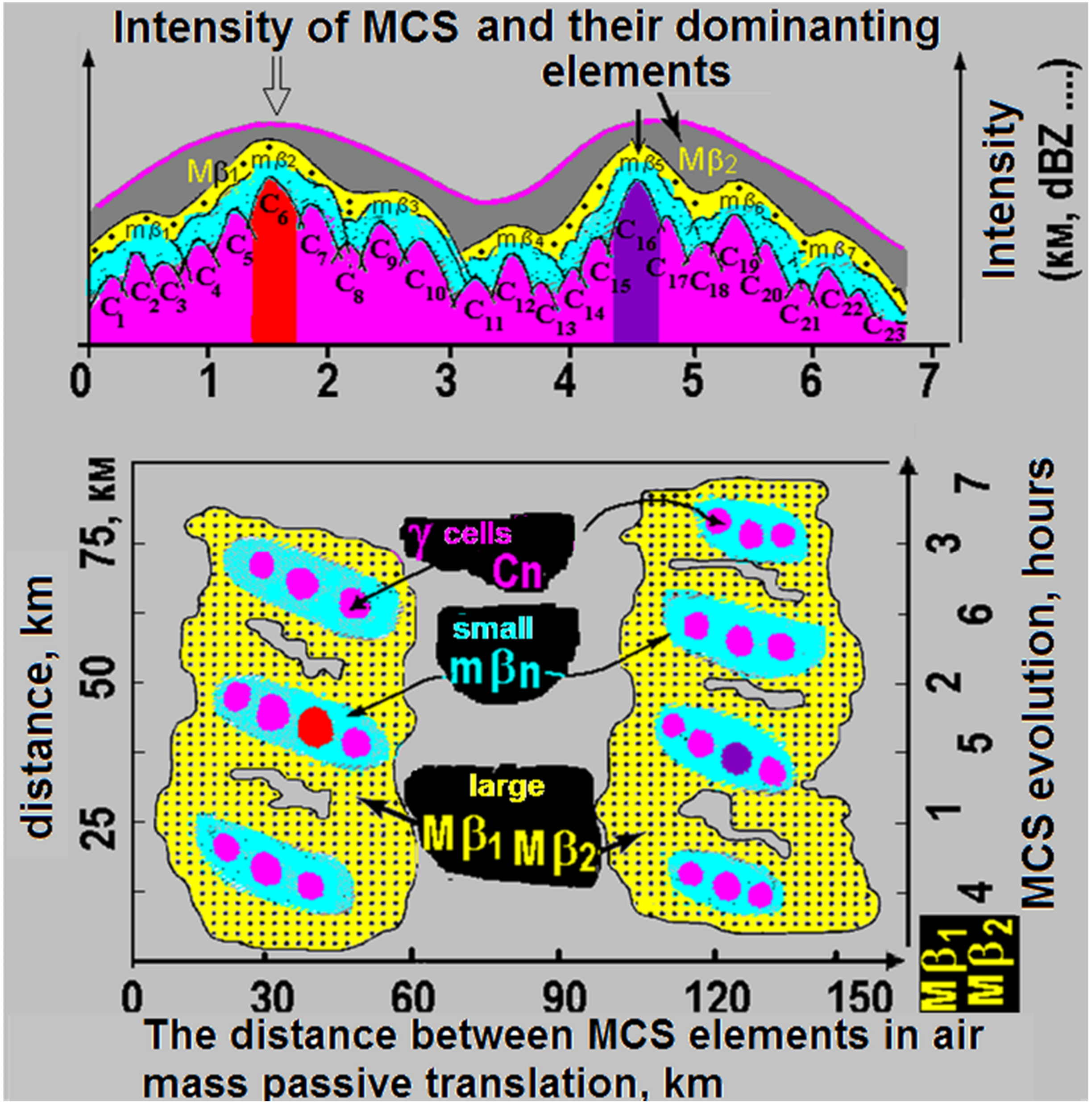



Figure 1. Life-cycle of MCS described in terms of their dominating elements. Some intense cells (pink) combine dominating multi-supercell thunderstorms (blue) – the storms with cells of major intensity in respect to other subdominant thunderstorms. Groups of dominating severe thunderstorms compose large meso-β ensembles dominating (yellow). The oscillating nature of convective activity is associated with quasi-periodic occurrence of dominating elements. Occurrence of cells, storms and ensembles lead to ~0, 25, 1-hour and 3-hour oscllillation of MCS intensity

*3.2 Conceptual model*

**3.3 How the concept of “dominating thunderstorms” resolves the problem of representative instance?**

Representative instance ?

- We can determine some interval around of the moment when <u>dominating thunderstorm of maximal intensity</u> is observed (e.g. red on Fig.1)
- So-called maximal intensity stage can be found in the life cycle of any mesoscale system independently its origin, scale and severity.

Classification design and MCS climatology

# 4. Objective classification and it’s using as object oriented forecasting tool

Design of semi- automated classification procedure for radar derived MCS climatology consists of 5 main phases:

4.1 Expert estimation of sample representativeness

4.2 Identifying of individual systems life cycle maxima

4.3 Describing individual MCS morphology and combine pattern categories

4.4 Deriving MCS properties and construction of their climatological CDF quantiles

4.5 Membership determination of observed and modeled MCS

# 4.1 Expert estimation of sample representativeness

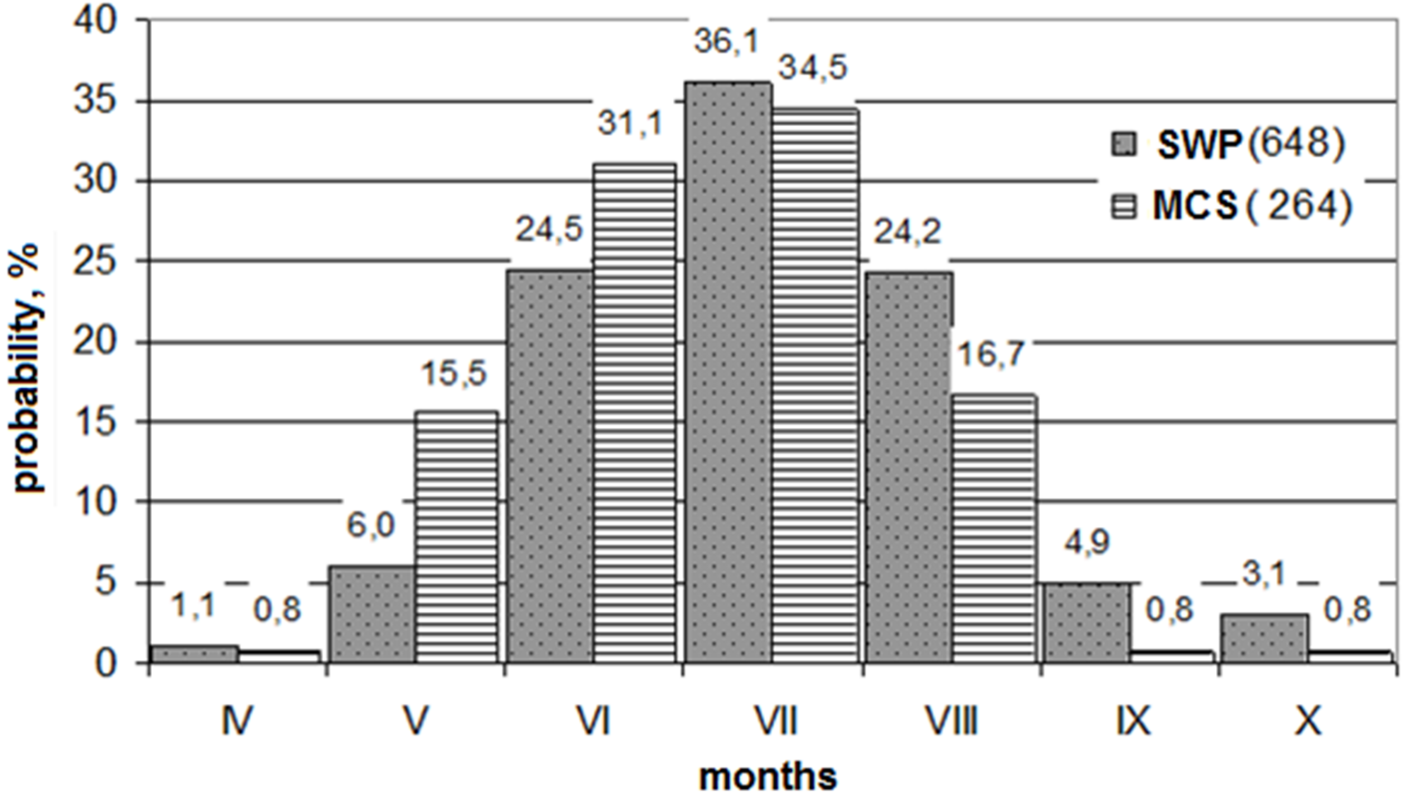



**Figure 2**

**Severe weather phenomena and MCS seasonal distribution**

At least 5 year sample of MCS+ test to consistence, e.g. Fig. 2

## 4.2 Identifying of individual systems life cycle maxima

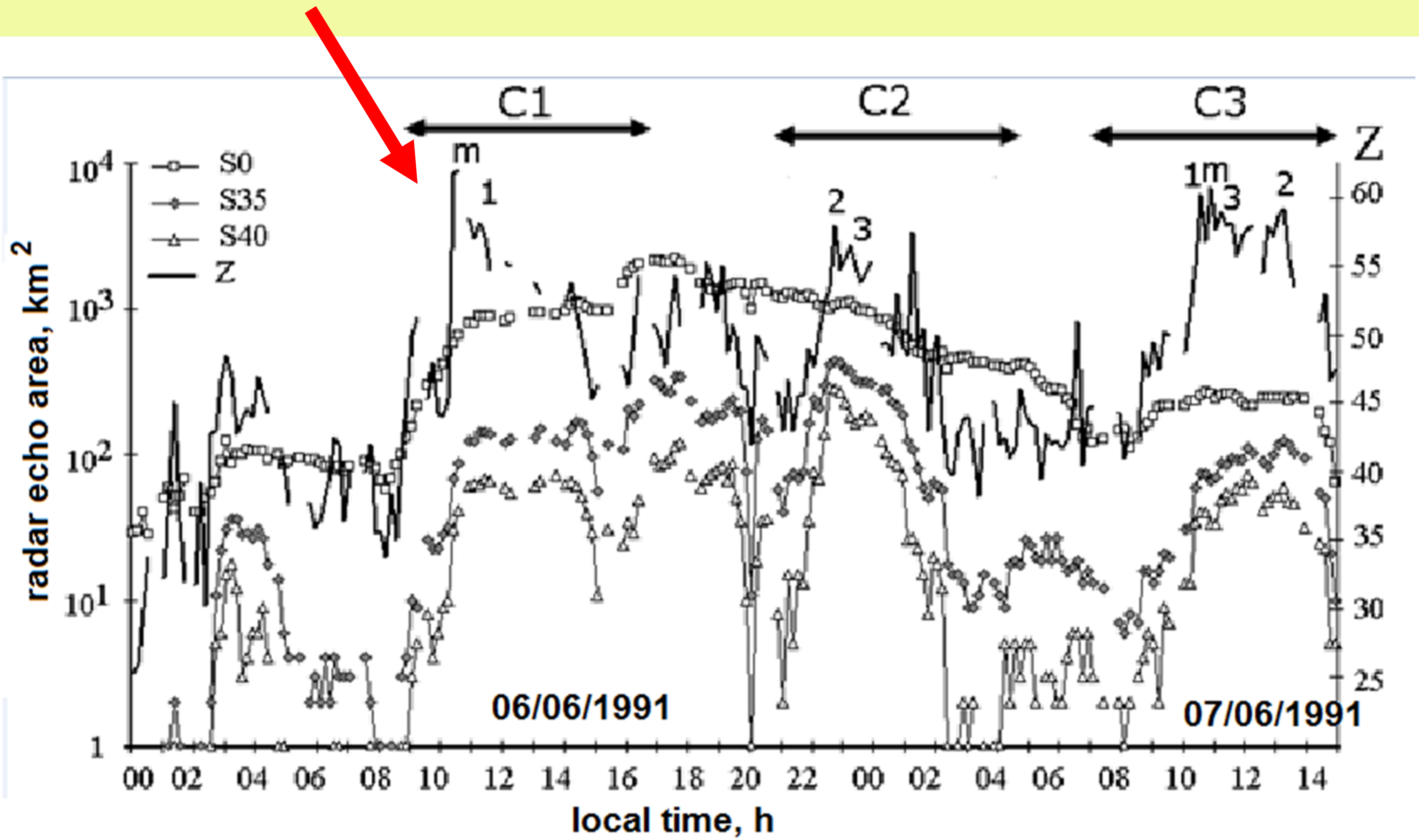
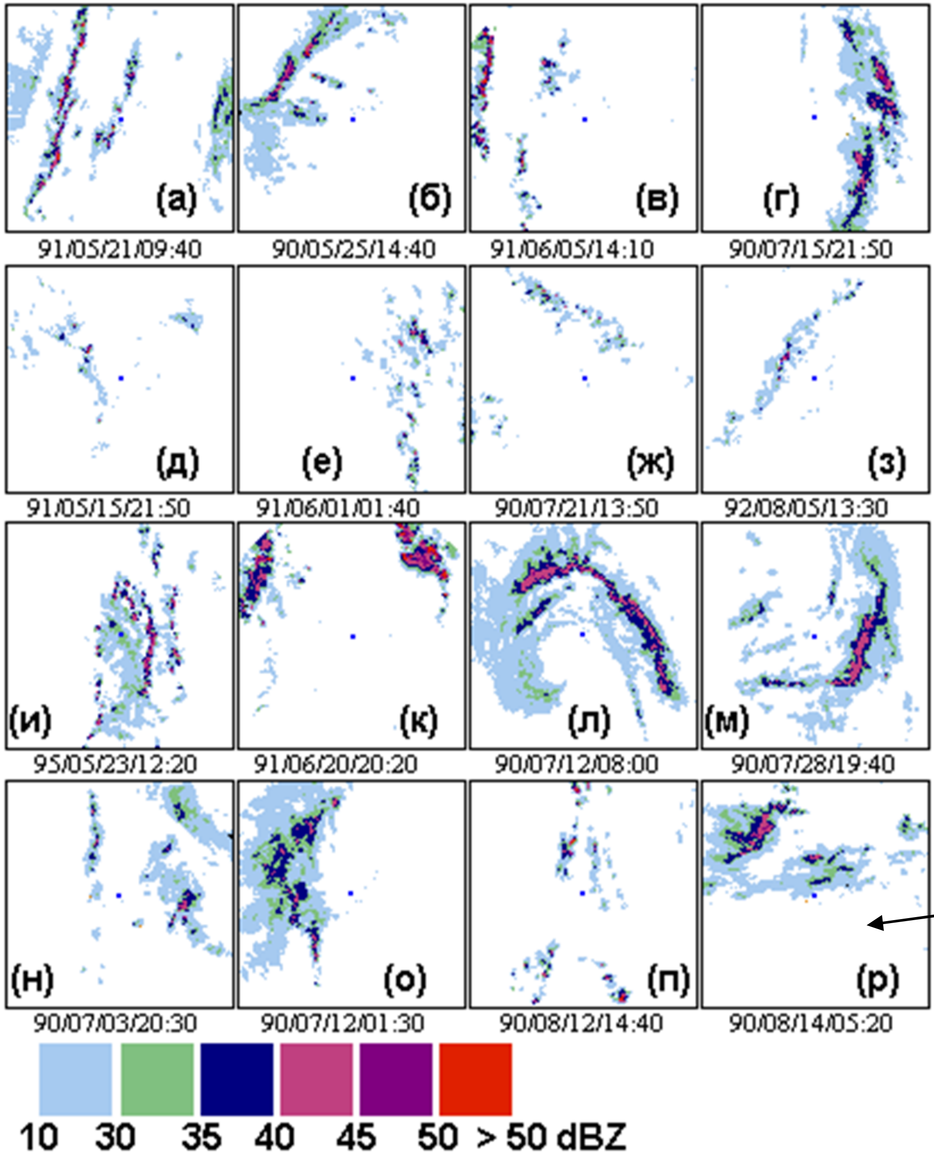



**Figure 3 Temporal variations of MCS parameters (Z max, convective areas, etc.). C1-C3 are MCS. One day-one MCS**

## 4.3 Describing individual MCS morphology and combine pattern categories

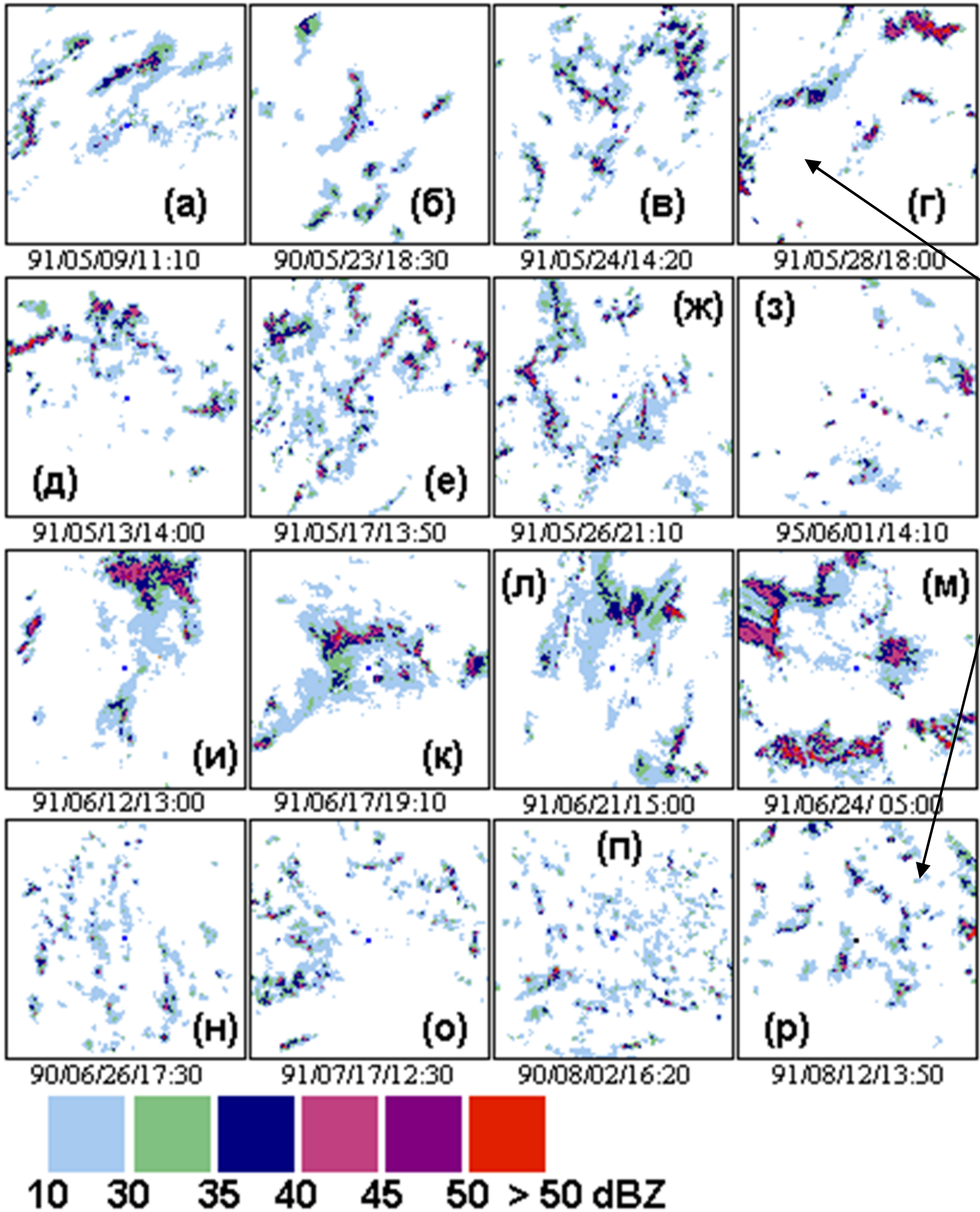



**Linear systems: interrupted lines with solid segments of reflectivity of 40 dBZ about of 100 км long**

**Linear systems: broken lines exhibited mixture of linear and noses-like storms**

**Linear systems: convex or concave bow lines frequently forming families of spirals or occlusions**

**Figure 4.1 Horizontal radar fields corresponding to stage of MCS reflectivity maxima**




**Principal aspects of non-line MCSs is arrangement of individual radar cell into "open meso-β-scale cells" (or small bow segments) ~30 km, but most of this MCSs have "propagation axis" connecting major storms**

**Figure 4.2 Horizontal radar fields corresponding to stage of MCS reflectivity maxima**

**4.3 Describing individual MCS morphology and combine pattern categories**

# 4.4 Deriving MCS properties and construction of their climatological CDF quantiles

| № | Characteristics, MCS | min | Decil, % | | | | | | | | | max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | |
| 1 | Zm, dBZ | 32,25 | 44,00 | 46,50 | 48,00 | 50,00 | 51,00 | 52,50 | 54,25 | 56,00 | 59,00 | 62,50 |
| 2 | Tm, hours, Local Time | 0:10 | 3:50 | 8:00 | 10:10 | 12:50 | 14:00 | 15:10 | 16:50 | 18:30 | 20:30 | 23:30 |
| 3 | S40, км$^2$ | 0 | 32 | 64 | 128 | 208 | 272 | 416 | 672 | 960 | 1424 | 8160 |
| 4 | S35, км$^2$ | 0 | 112 | 272 | 448 | 688 | 864 | 1408 | 2032 | 2736 | 3968 | 16880 |
| 5 | S0, км$^2$ | 246 | 2384 | 4464 | 6640 | 9952 | 12208 | 14994 | 17072 | 21840 | 30064 | 73520 |
| 6 | S35/S40 | 1,00 | 1,76 | 2,01 | 2,25 | 2,51 | 2,83 | 3,32 | 4,02 | 5,31 | 8,33 | 40,03 |
| 7 | S0/S35 | 1,90 | 4,18 | 5,87 | 7,4 | 8,45 | 10,8 | 13,64 | 18,81 | 25,96 | 39,53 | 746 |
| 8 | $V_t = \left(V_x^2 + V_y^2\right)^{1/2}$, м/с | 1,30 | 3,81 | 5,56 | 6,87 | 8,11 | 9,16 | 10,54 | 12,02 | 13,47 | 16,41 | 27,51 |
| 9 | $A_t$. (from) ° | 9 | 135 | 180 | 207 | 219 | 236 | 252 | 270 | 303 | 327 | 360 |
| 10 | Line segment, км | 31,0 | 61,1 | 93,6 | 105,6 | 120,3 | 140,9 | 157,6 | 190,3 | 218,8 | 254,6 | 440 |
| 11 | Orientation | 96,5 | 127 | 137 | 153 | 169 | 186 | 200 | 217 | 233 | 243 | 268 |

Table 1. Climatological characteristics of MCS in central Russia

# 4.5 Membership determination of observed and modeled MCS

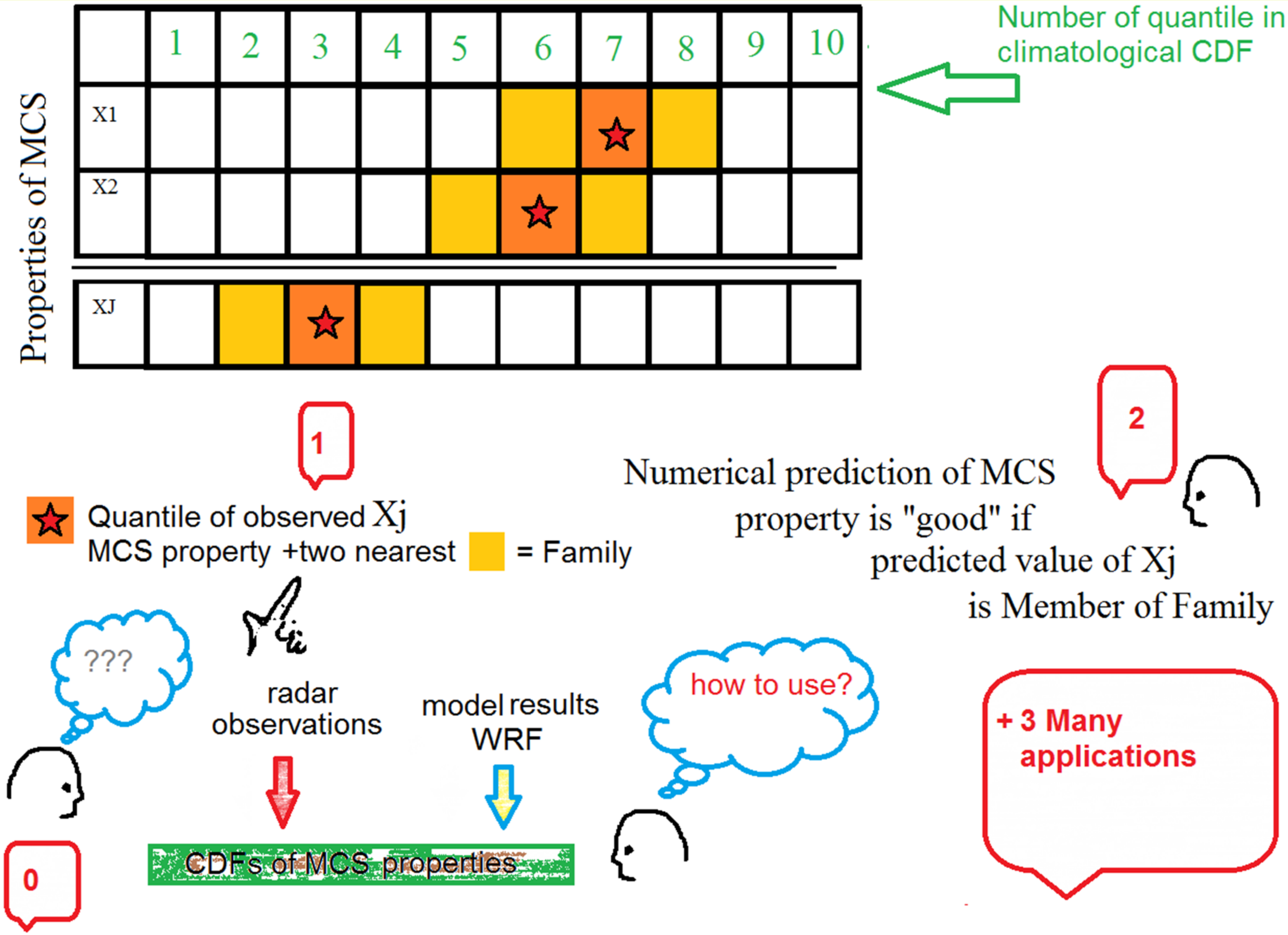



**Figure 5. Climatological CDF and their combinations can be used as a base to describing new MCS observation and modelling. One simplest way is demonstranted in poster section.**

# CONSLUSION

- “Dominating thunderstorms” is simple, but very useful conception to compare MCS observations in objective manner.
- It can be adopted as design platform for various *practical methods* including:

(i) MCS climatological classifications, MCS observations and nowcasting;

(ii) short range severe weather forecasting;

(iii) evoluation of numerical modelling