# Variability of characteristics and conditions leading to the formation of extreme precipitation events in the south of Western Siberia

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# INTRODUCTION

- Against the background of the socio-technical development of territories there is a growth of the damages in economic and social spheres caused by increasing frequency of hazardous events' occurrence.
- Global warming is happening now, and the changes in the statistics of extreme events are diagnosed in various regions of the Earth.
- Humidification conditions relate to the most essential indicator of both global and regional climate.
- Indicators of humidification regime variability, which also includes hazardous events in the precipitation regime, vary significantly in different regions.

# DATA

**Territory: Tomsk, Kemerovo, Novosibirsk regions and Altai territory**

warm period (April-October)

Precipitation (days with precipitation/no),

The amount of rainfall in 12 hours

→ 68 meteorological stations

**1966-2018**

## WAREP (warning reports)

cases with the hazardous event :

- "**heavy rain**" which defined as rainfall greater than 35 mm in 12 hours
- "**severe rain**" - significant liquid or mixed precipitation, namely rain, rain shower, sleet, wet snow greater than 50 mm in 12 hours

→ 127 meteorological stations

**2015-2018**

## Satellite remote sensing data

**MOD(MYD)21KM** и **ATML2**

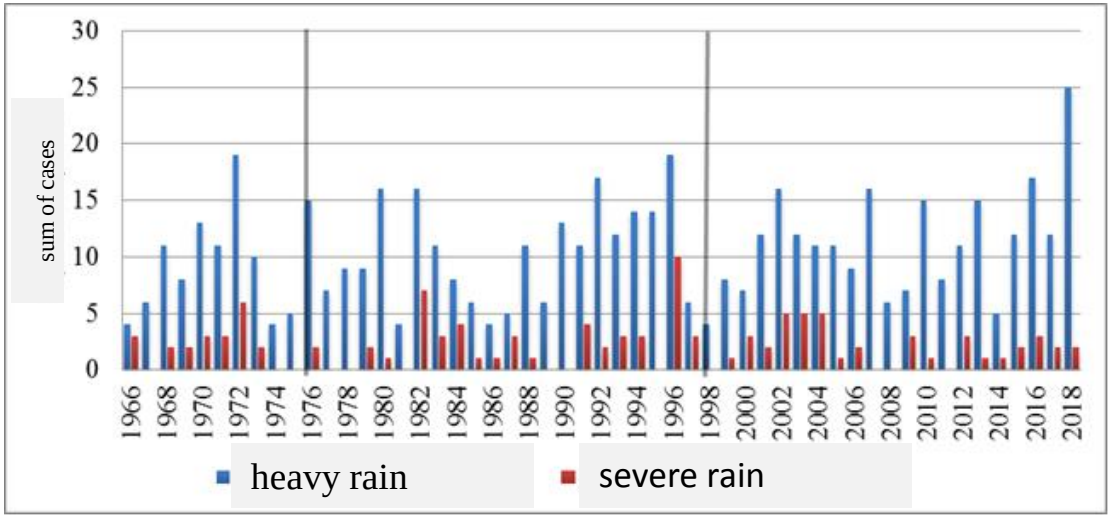
**https://modis-atmos.gsfc.nasa.gov/.**

→ 30 cases were considered (15 – severe rain and 15 – heavy rain)

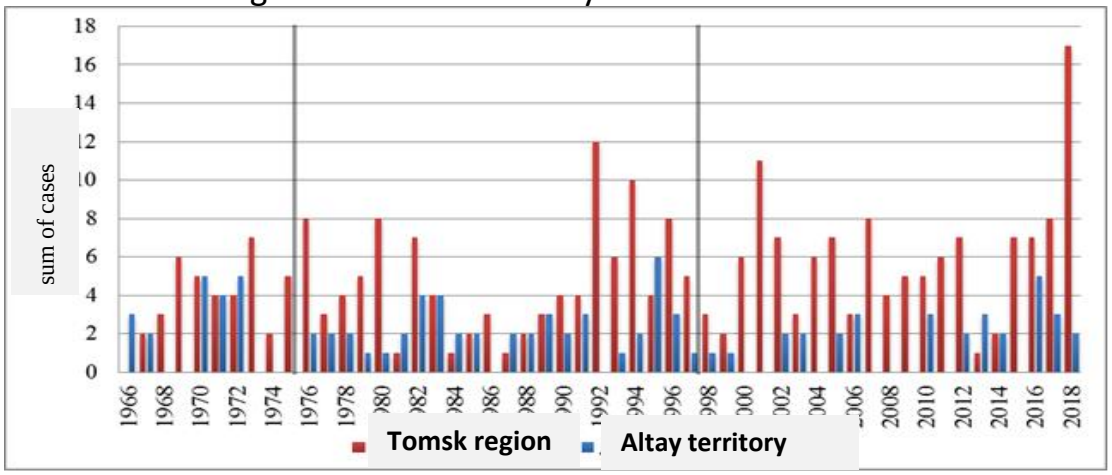
# RESULTS

## Against the background of warming intensifies extreme weather events?

Dynamics of cases with the hazardous event
on average for the south-east of Western Siberia




Dynamics of cases "Heavy rain"
in the Tomsk region and Altai Territory




**1976-1997** period of accelerated global warming
**1998-2018** warming slowdown period

" **Heavy rain**" was observed more often during the warming slowdown, with a maximum (25 cases) in 2018.
"**Severe rain**" was more often observed during the period of of accelerated global warming with a maximum (10 cases) in 1996

If we consider individual regions and areas within the studied territory, the trends are even less unambiguous

# RESULTS

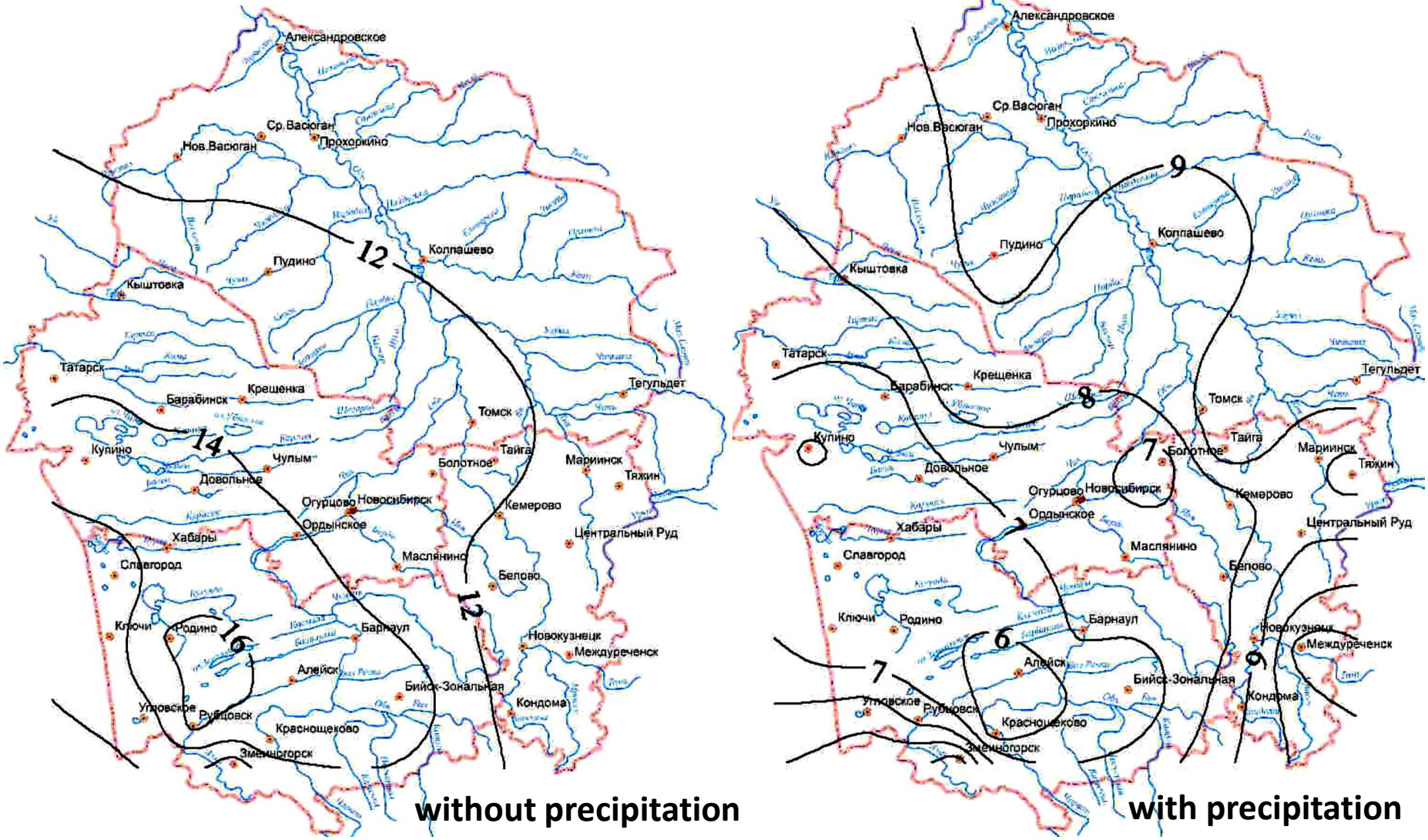
Table 1 - Average number of cases and repeatability of days (%) with "**Heavy rain**" and "**Severe rain** " in the south-east of Western Siberia for 1966-2018.

| Region | Heavy rain | | Severe rain | |
|---|---|---|---|---|
| | Number of cases | Repeatability for May-August % | Number of cases | Repeatability for May-August % |
| Tomsk region | 11 | 0,1 | 2 | 0,03 |
| Kemerovo region | 11 | 0,1 | 2 | 0,03 |
| Novosibirsk region | 9 | 0,1 | 2 | 0,02 |
| Altai Krai | 9 | 0,1 | 2 | 0,02 |

Table 2 - Average repeatability (%) of the "Heavy rain" in the south-east of Western Siberia at different time intervals

| time intervals | 1976-1997 | 1997-2018 | 1966-2018 |
|---|---|---|---|
| Tomsk region | 0,2 | 0,2 | 0,1 |
| Kemerovo region | 0,1 | 0,2 | 0,1 |
| Novosibirsk region | 0,1 | 0,1 | 0,1 |
| Altai Krai | 0,1 | 0,1 | 0,1 |

# Maximum duration of periods

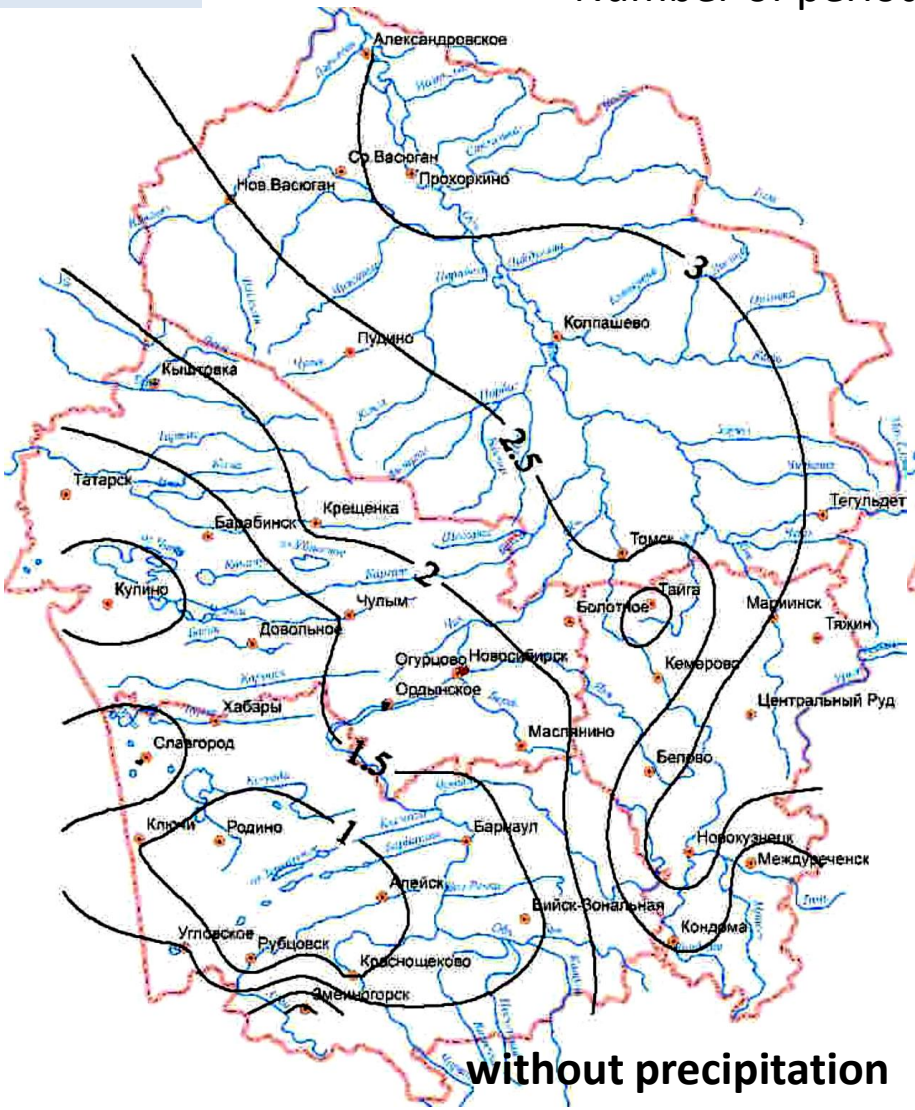



**without precipitation** **with precipitation**

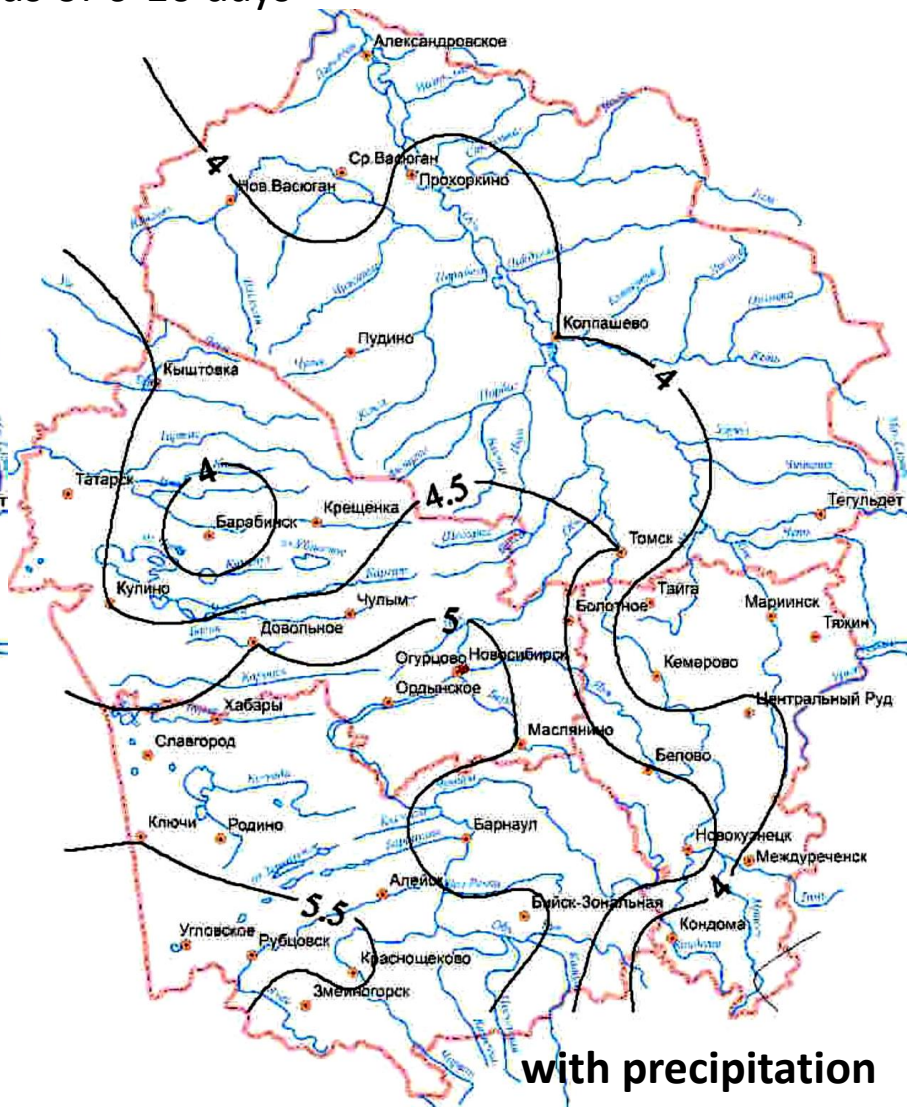
In general, for the 1966-2018 , periods without precipitation are twice exceeded the number of periods with precipitation and predominately more extended.

The maximum duration of dry periods is generally higher than the duration of wet periods.

Number of periods of 6-10 days




without precipitation




with precipitation

For the period under consideration, the number of periods without precipitation lasting 6-10 days is much less than the number of long periods with precipitation

# RESULTS

- ✓ There is a decrease in short-term periods (1–5 days in duration) and an increase in longer ones (6–10 days), both for cases with/without precipitation. Trends range from 0.1 to 0.6 periods / 10 years, and in most cases are not statistically significant

- ✓ The series of maximum duration of periods without precipitation / with precipitation for a given time period do not have a pronounced trend of long-term change, most of the trends are not statistically significant

Table 3 - Satellite-based sensing data for cases "**Heavy rain**"

| Station | Date | Time of a extreme precipitation events | Time of the satellite pass | Amount of precipitation, mm | Cloud type | Optical Thickness | Top height , m | Water Patch , g/m^2 |
|---|---|---|---|---|---|---|---|---|
| Ordynskoe | 12.08.2015 | 9:34 | 6:35 | 35 | MCSs | 150 | 15600 | 4047 |
| Talmenka | 22.09.2015 | 1:08 | 4:50 | 37 | cold front | 150 | 10250 | 3617 |
| Gornyak | 21.06.2016 | 2:18 | 5:35 | 45 | MCSs | 150 | 10650 | 4204 |
| Volciha | 23.07.2016 | 11:47 | 7:20 | 39 | MCSs | 150 | 14800 | 3154 |
| Kuzedeevo | 24.07.2016 | 4:40 | 6:25 | 36 | MCSs | 150 | 12300 | 2101 |
| Ust-Kabyrza | 08.08.2016 | 6:40 | 7:20 | 41 | cold front | 150 | 12600 | 5140 |
| Baturino | 26.06.2017 | 2:44 | 5:20 | 44 | cold front | 150 | 17000 | 4434 |
| Iskitim | 18.07.2017 | 4:20 | 4:45 | 39 | MCSs | 150 | 10600 | 3142 |
| Severnoye | 25.07.2017 | 4:13 | 4:50 | 45 | mesovortex | 150 | 10700 | 3861 |
| Ust-Tarka | 28.07.2017 | 10:25 | 7:10 | 42 | mesovortex | 150 | 10700 | 3309 |
| Shelabolikha | 10.06.2018 | 9:35 | 8:15 | 37 | cold front | 150 | 12050 | 2498 |
| Staritsa | 26.06.2018 | 5:00 | 4:50 | 38 | mesovortex | 150 | 12150 | 2664 |
| Bakchar | 01.07.2018 | 7:29 | 6:45 | 37 | MCSs | 150 | 12150 | 4541 |
| Troitskoe | 01.07.2018 | 9:38 | 6:45 | 35 | MCSs | 150 | 16900 | 4659 |
| Novokuznetsk | 01.07.2018 | 10:40 | 6:45 | 43 | MCSs | 150 | 16900 | 4659 |

***MCSs - mesoscale convective systems***

Heavy rain in 8 out of 15 cases relate to mesoscale convective systems (MCSs); in four cases, the hazard was associated with the passage of cold fronts, and in three cases – with mesovortices.

Optical thickness, cloud top height and water content correspond to cumulonimbus clouds with high moisture content

# RESULTS

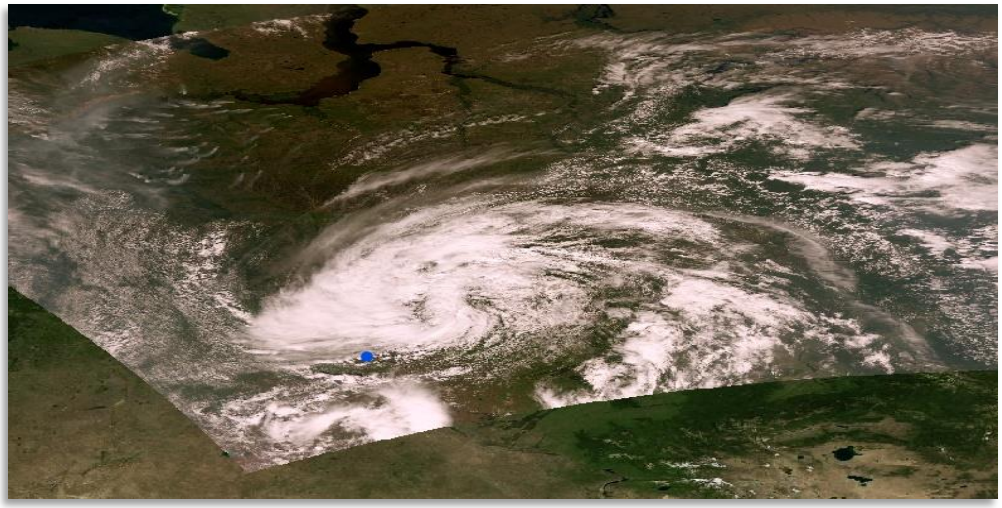
**Case: Heavy rain**

**Ust-Tarka** 28.07. 2017

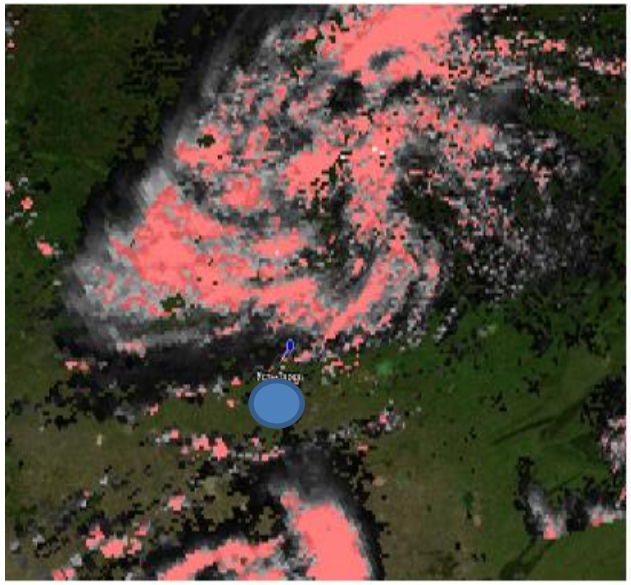
42 mm (10:25 UTC)

According to RGB composite images, a mesovortex was observed over the Novosibirsk region.

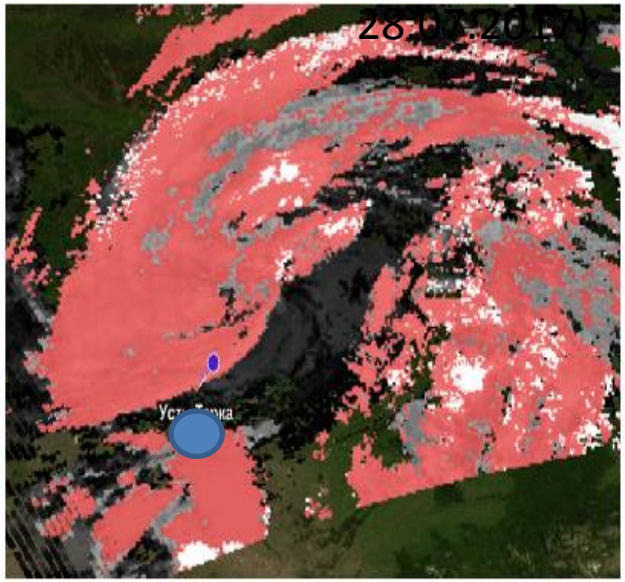
| |
|---|
| **Water Patch = 3309 g/m^2** |
| **Optical Thickness = 150** |
| **Top height = 10700 m** |



**Fragment of RGB image (Aqua), time of flight – 7:10 UTC**



**Water Patch** (ATML2)



**Top height** (ATML2)

## Table 4 - Satellite-based sensing data for cases "**Severe rain**"

| Station | Date | Time of a extreme precipitation events | Time of the satellite pass | Amount of precipitation, mm | Cloud type | Optical Thickness | Top height , m | Water Patch , g/m^2 |
|---|---|---|---|---|---|---|---|---|
| Kupino | 07.06.2015 | 8:11 | 8:35 | 63 | MCSs | 150 | 16450 | 2856 |
| Molchanovo | 02.08.2015 | 12:00 | 7:45 | 69 | cyclonic cloud system with a trail | 150 | 12800 | 3793 |
| Turochak | 19.07.2016 | 8:55 | 7:45 | 53 | MCSs | 150 | 12100 | 4058 |
| Shipunovo | 19.07.2016 | 8:38 | 7:45 | 59 | MCSs | 150 | 12100 | 4058 |
| Krasnoshchekovo | 22.07.2016 | 12:07 | 8:15 | 57 | MCSs | 150 | 12200 | 4580 |
| Soloneshnoe | 22.07.2016 | 12:27 | 8:15 | 59 | MCSs | 150 | 12200 | 4580 |
| Pudino | 25.07.2016 | 11:57 | 7:10 | 50 | cold front | 150 | 17000 | 5158 |
| Rubtsovsk | 06.08.2016 | 1:53 | 5:45 | 67 | MCSs | 150 | 14550 | 3799 |
| Bakchar | 25.06.2017 | 7:40 | 6:25 | 50 | MCSs | 150 | 12200 | 3171 |
| Ust-Kalmanka | 02.07.2017 | 11:54 | 6:30 | 56 | cold front | 150 | 10600 | 3586 |
| Bagan | 26.06.2018 | 0:13 | 4:50 | 96 | mesovortex | 150 | 10650 | 3283 |
| Novostroyka | 27.06.2018 | 17:05 | 5:35 | 92 | cold front | 150 | 16900 | 1751 |
| Khabary | 14.07.2018 | 13:30 | 8:05 | 72 | MCSs | 150 | 10800 | 3181 |
| Tisul | 28.07.2018 | 0:00 | 6:40 | 80 | cyclonic cloud system with a trail | 150 | 10650 | 1724 |
| Kargasok | 26.08.2018 | 15:00 | 7:45 | 64 | cold front | 150 | 10500 | 4478 |

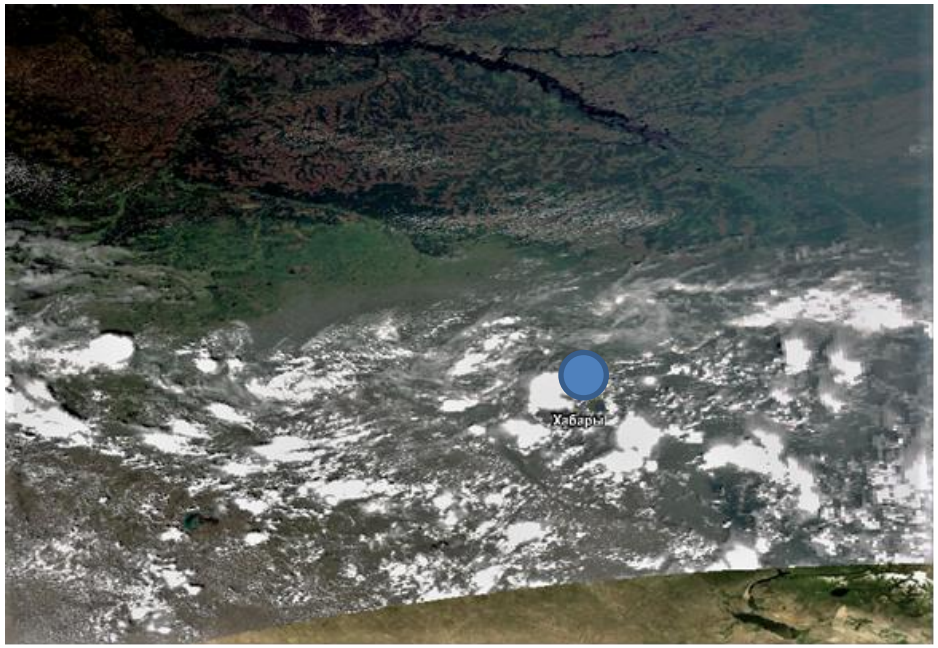
Severe rain mostly observed during MCSs (8) and cold fronts passing (4); in two cases, precipitation was caused by cyclonic cloud system with a trail and one – by **mesovortex clouds/**

Optical thickness, cloud top height and water content correspond to cumulonimbus clouds with high moisture content

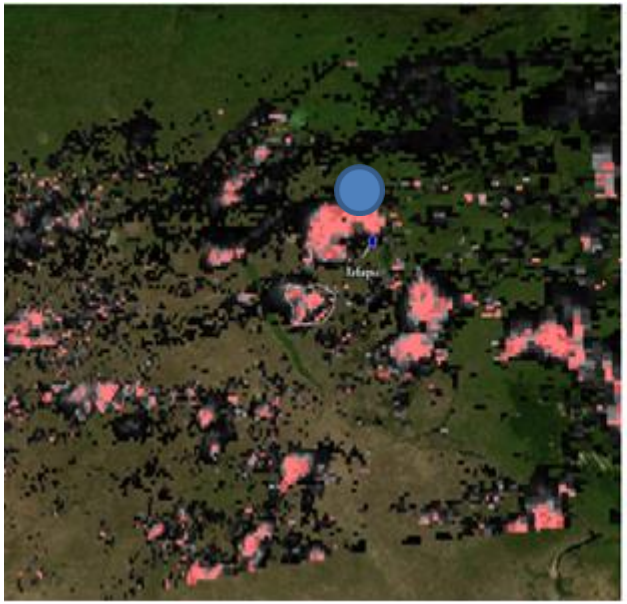
# RESULTS

**Case: Severe rain**
**Khabary** 14.07.2018
**72 mm** (13:30 UTC)
According to RGB composite images , a cloudy meso-vortex was observed over the Altai Territory

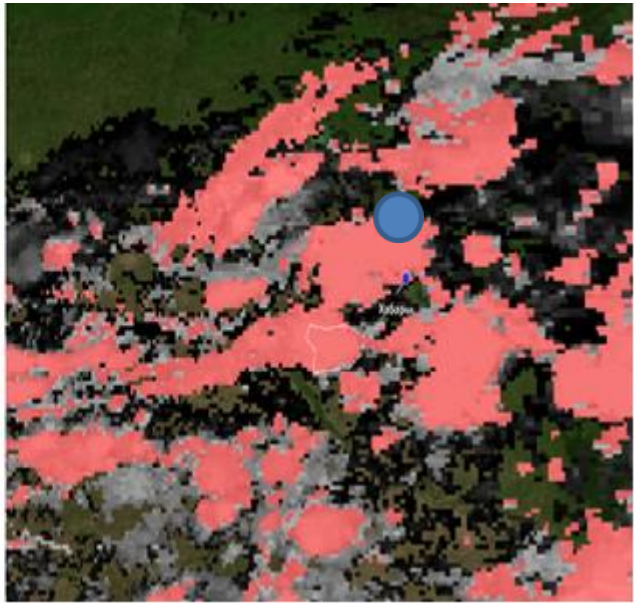
| |
|---|
| **Water Patch = 3181 g/m^2** |
| **Optical Thickness = 150** |
| **Top height = 10800 m** |




**Fragment of RGB image (Aqua), time of flight – 8:05 UTC**



**Water Patch** (ATML2)



**Top height** (ATML2)

# Conclusions

- ✓ Dangerous phenomena caused by heavy precipitation are unevenly distributed throughout the territory
- ✓ At all stations, the repeatability of extreme events in the cage regime does not exceed 0.1% per season
- ✓ It has been found that during the period of accelerated global warming the frequency of extreme precipitation remained almost unchanged within the study area.
- ✓ Periods without precipitation are twice exceeded the number of periods with precipitation and predominately more extended. Withal, there is a decrease in short-term periods (1–5 days in duration) and an increase in longer ones (6–10 days), both for cases with/without precipitation.
- ✓ The maximum continuous dry periods generally lasts longer than the duration of periods with precipitation and in most of the territory of the region goes up by a rate of 0.8 days per decade
- ✓ Extreme events in the precipitation regime in the study area were most often observed during *mesoscale convective systems* ; in all cases of dangerous phenomena, cumulonimbus clouds with a high moisture content were observed.
- ✓ The identified criteria can be used to identify potential hazardous phenomena according to satellite sensing data in areas not covered by meteorological stations.

# Thank you for attention