Nowcasting RGB products of severe weather operational used in Ukrainian MetService

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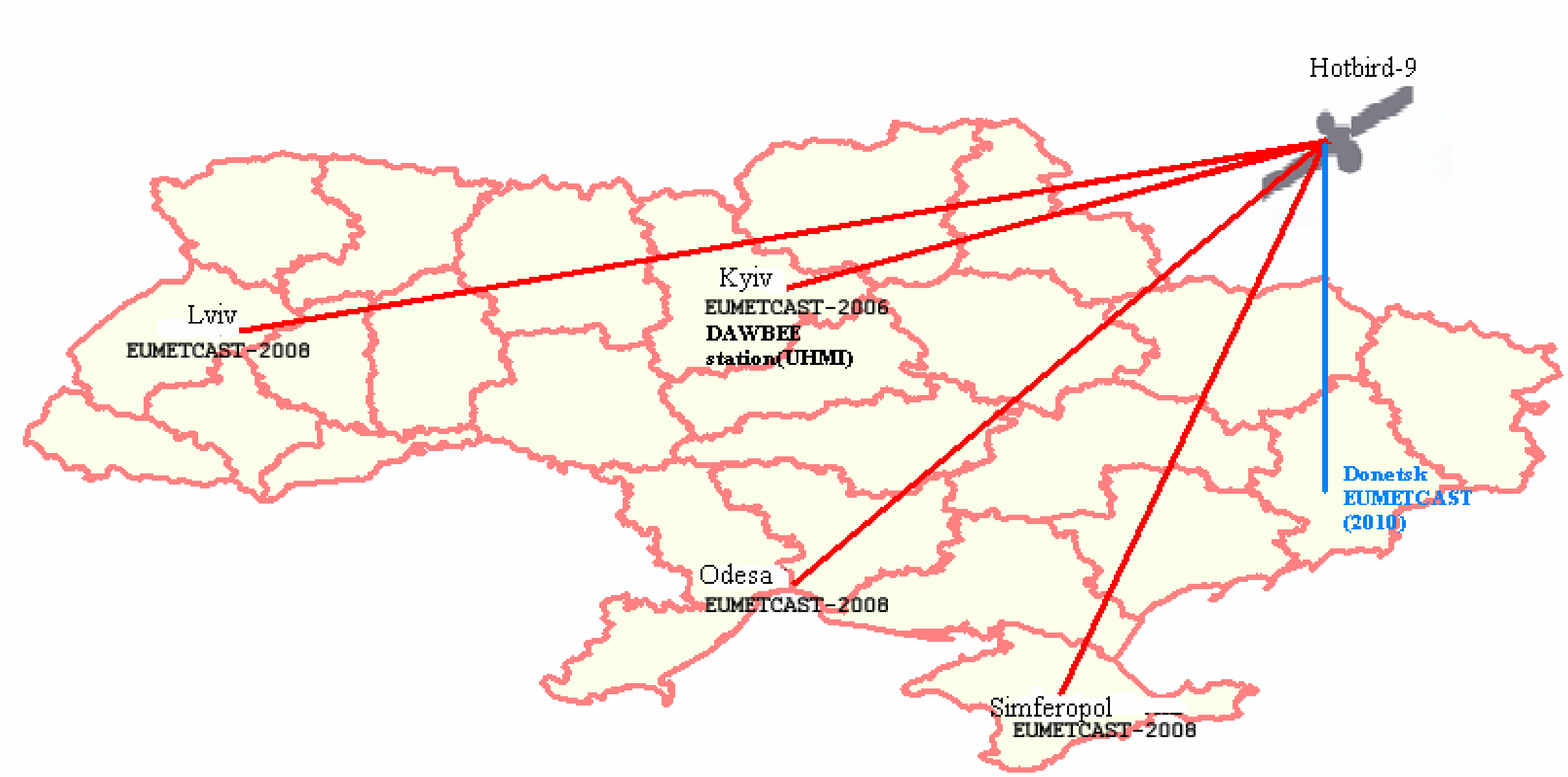
Satellite data reception in the Hydrometeorological Service of Ukraine



EUMETCast reception -Ukrainian Hydrometeorological Institute (Kyiv), Ukrainian Hydrometeorological Centre (Kyiv) , Centre of Hydrometeorology of Azov and Black seas (Odesa), Crimea Centre of Hydrometeorology (Simferopol), L'viv Centre of Hydrometeorology (L'viv) and Donetck Centre of Hydrometeorology

FTP access to operational RGB images and products (GeoTiff and JPG). Data update every 15 (basic) and 5 (only on demand) minutes

Strategy of presenting satellite products within the forecasting environment

1. **Forecasters have a huge amount of information available to them, they have to be selective in what they choose.**
2. **Forecasters cannot spend time trying to extract the signal from the noise. A well tuned product is important.**

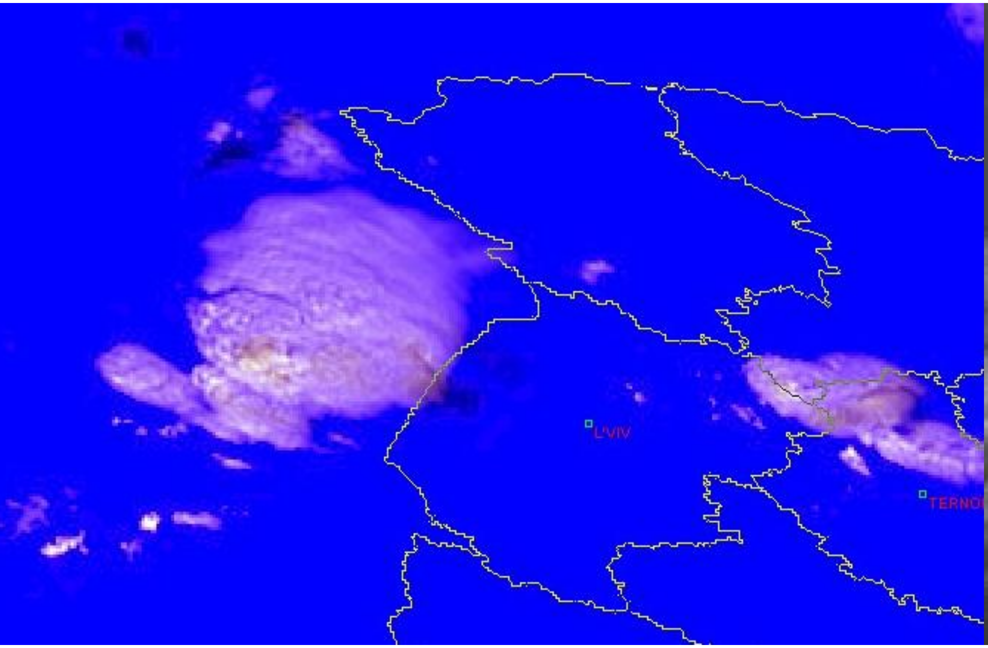
3. **Easy and appropriate presentation of the product.**

SEVERE CLOUD DETECTION ON MSG

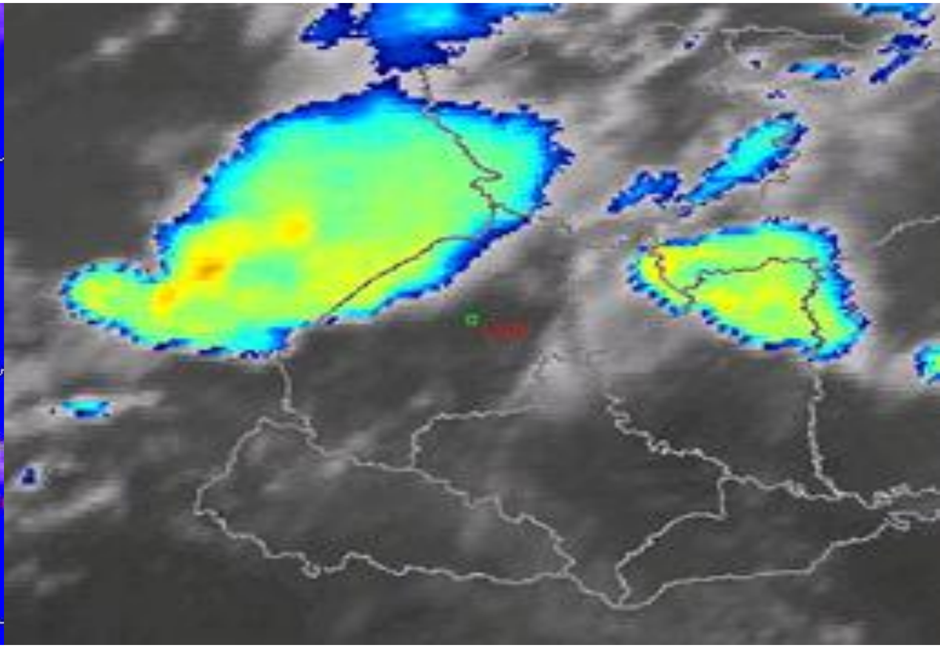
Some standard RGB composites were used for detection of severe cloud (convection) (Final Report RGB Composite Sattelite Imagery Workshop. BOULDER, CO, U.S.A. 5-6 June 2007) . The physical features for detection of convection on the RGB composites are the following: low cloud top temperature; appearance of small ice crystals on the top of clouds; high content of water vapour in the mid level of the atmosphere; significant values of cloud optical thickness. RGB composites with HRV channel gives an additional spatial characteristic – image texture (for example, detection of storm anvils). We used MSG IR10.8 image in order to find so called *cold-ring* and *cold U/V* shape storm and trend (every 15min).

Analysis of tornado in L'viv on 23.06.08 at 10:30 UTC

MSG RGB 12,12,4-9



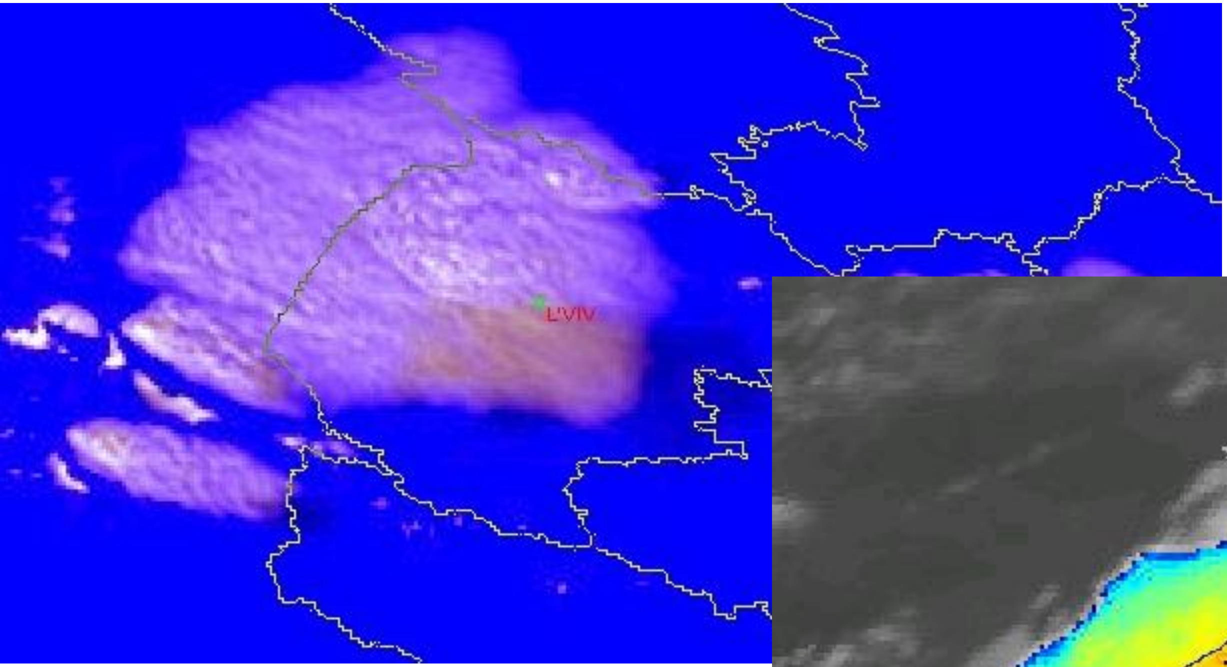
MSG IR10.8

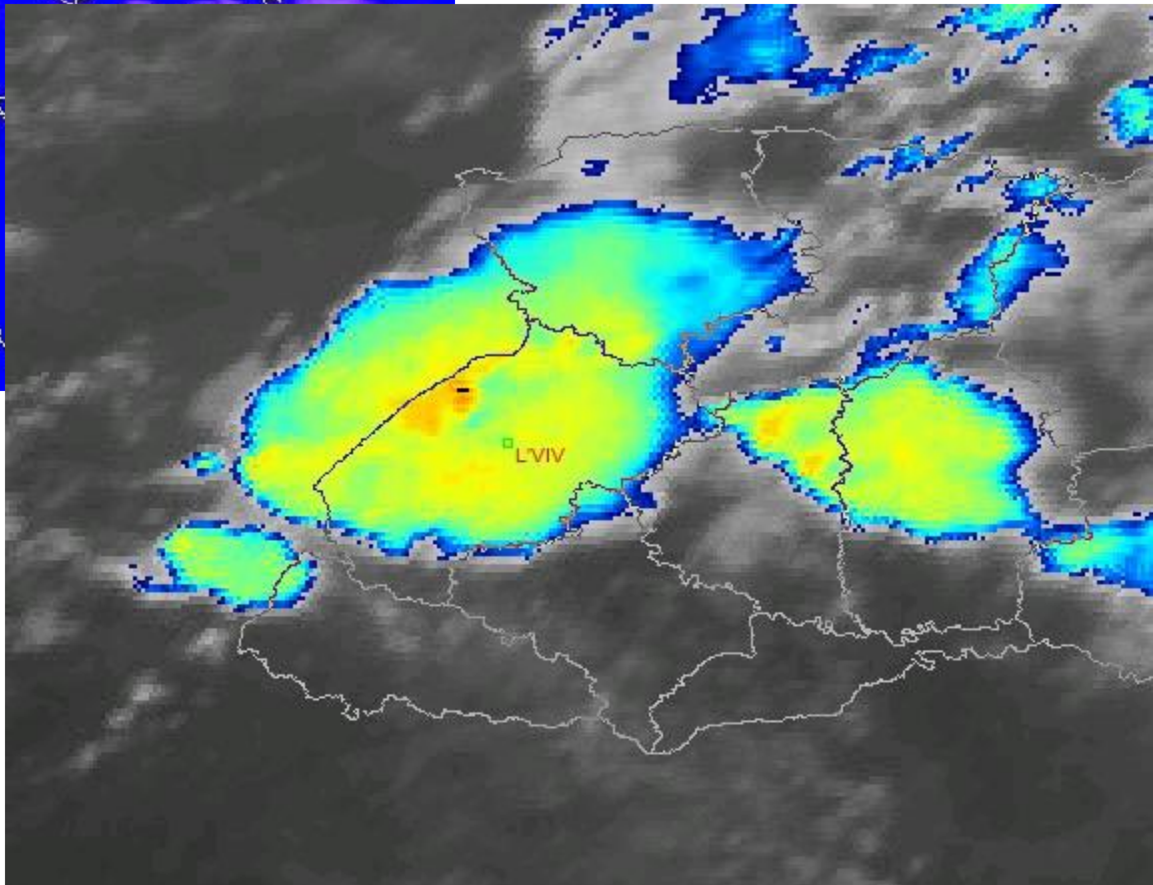


Analysis of tornado in L'viv on 23.06.08 at 11:30 UTC

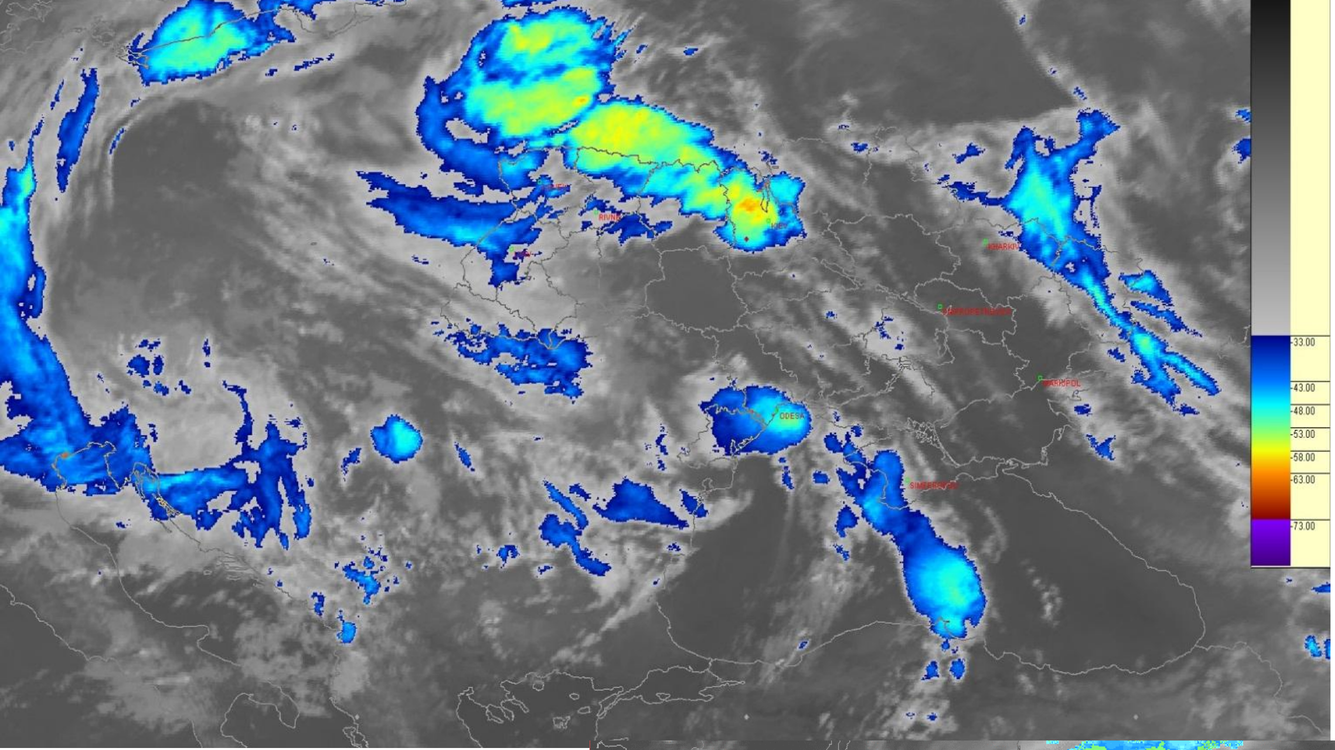
MSG RGB 12,12,4-9

MSG IR10.8

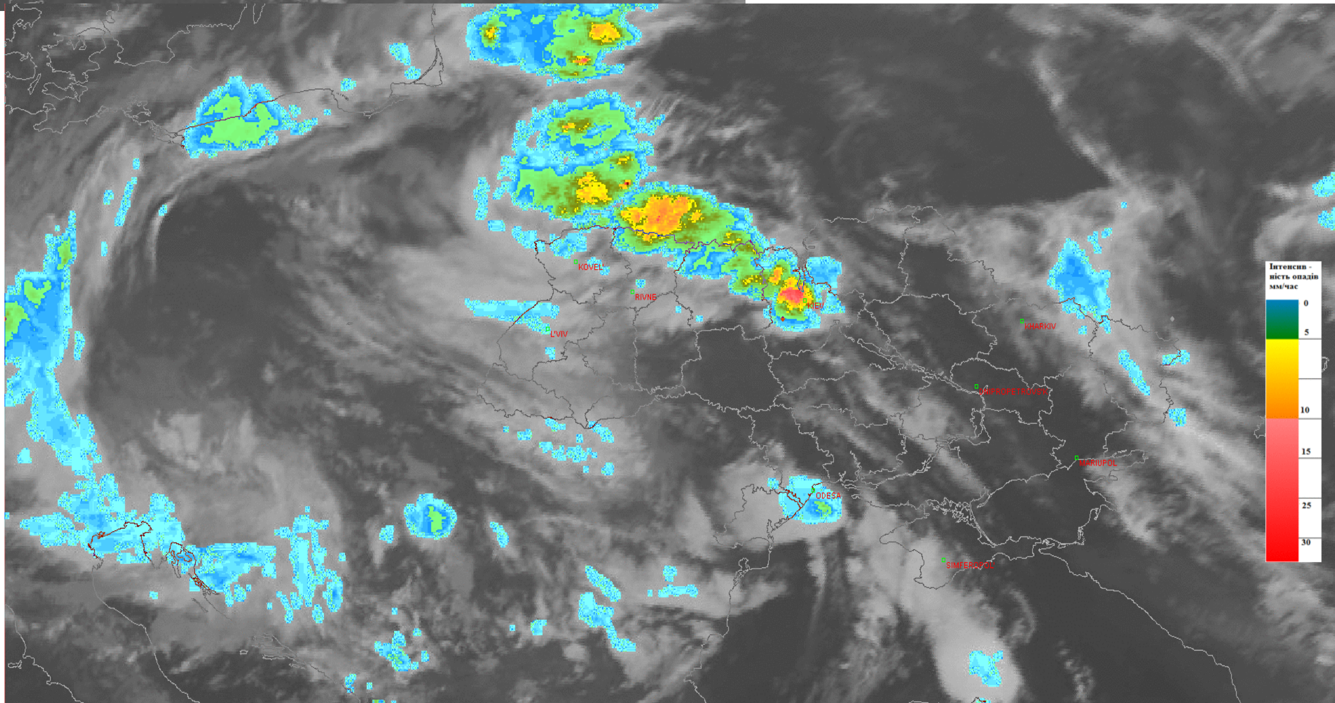




MSG IR10.8



MPEF MPE



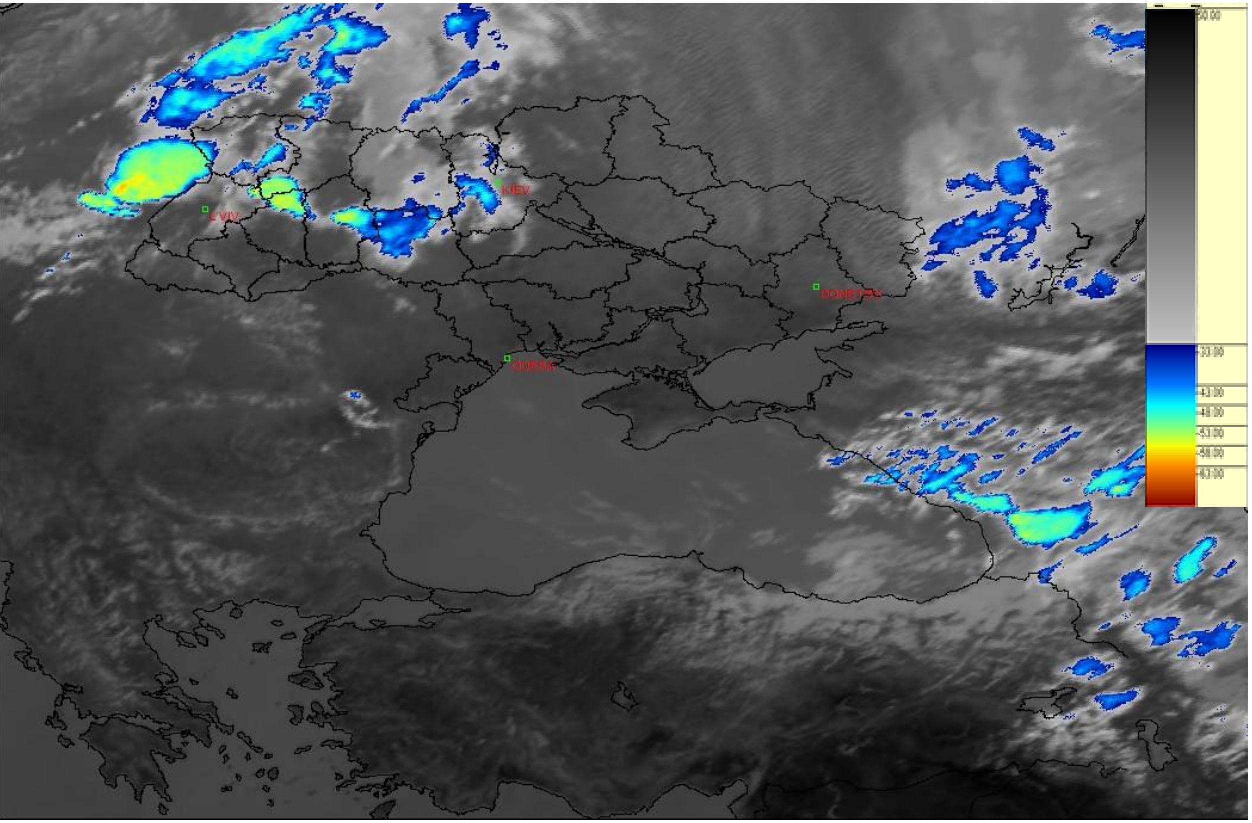
$$POD = \frac{a}{a + c}$$

$$FAR = \frac{b}{a + b}$$

Satellite \Observations	Yes	No
Yes	a	b
No	c	d

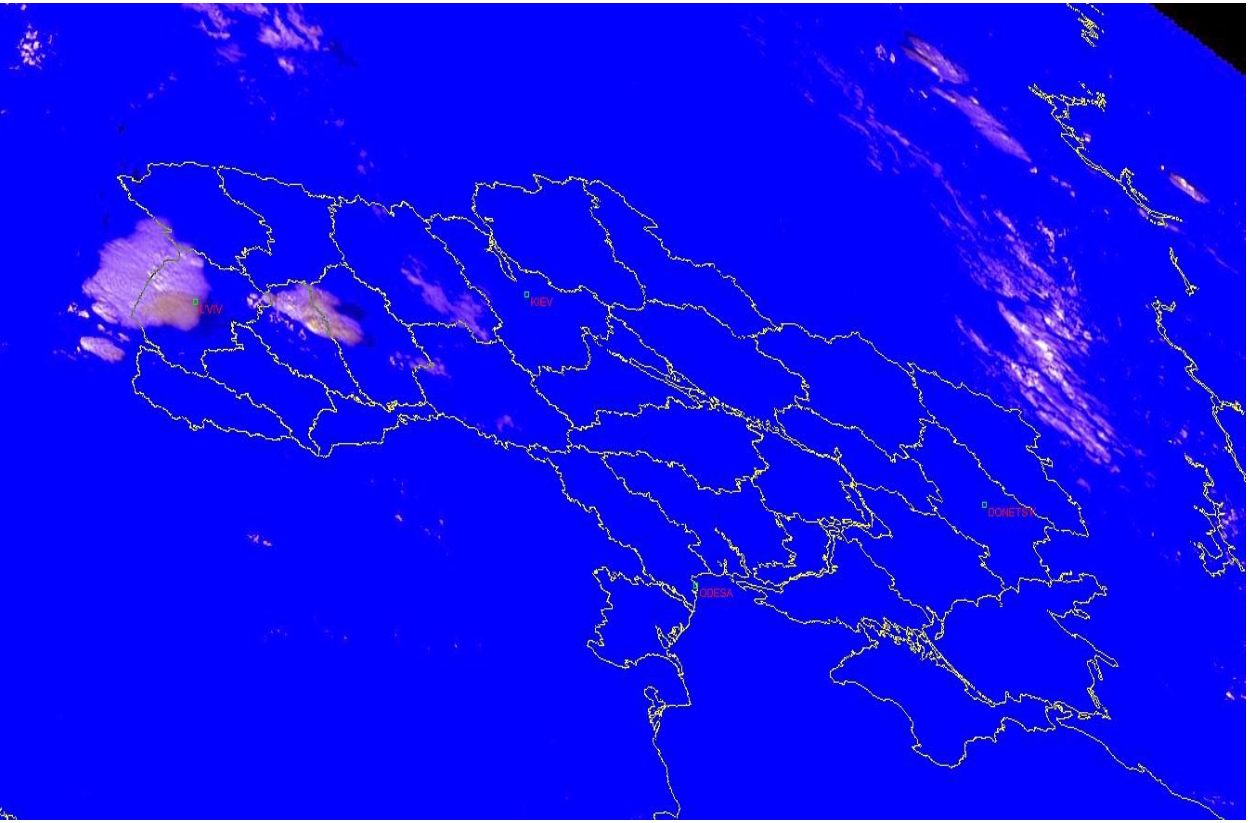
The convective environment on days with severe thunderstorms in Ukraine was investigated. Satellite derived Parameters (RGB and Products) were verified against subsequent thunderstorm observations derived from SYNOP station data, radar data, and damage reports of a building insurance company. The skill of satellite derived parameters to nowcast thunderstorms was evaluated by POD and FAR.

MSG IR 10.8



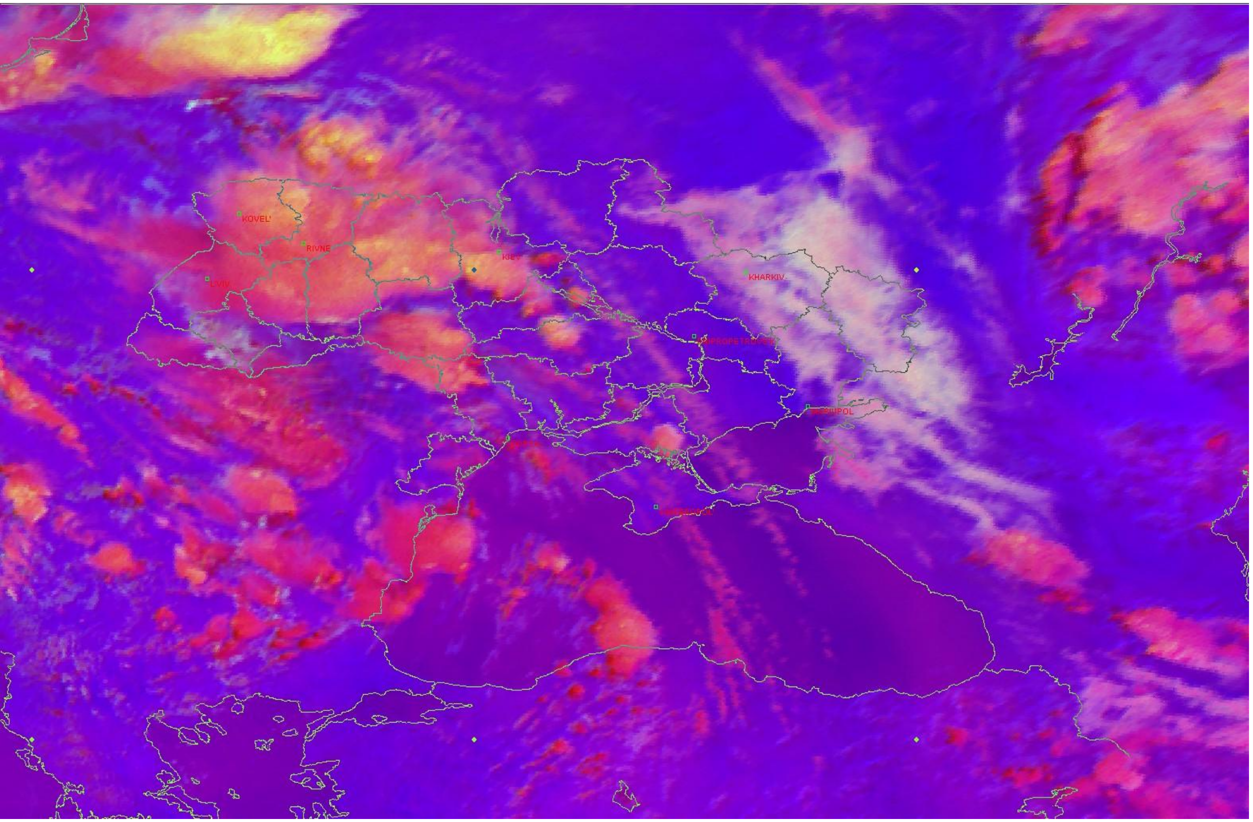
In general with additional information of cloud type and cloud top cooling rate information POD=0.67 and FAR=0.36. We cannot find robust relation between intensity of thunderstorm and “Cold ring” and U, V shape.

HRV SEVERE STORM **RGB 12,12,9-4**



Few cases were studied POD=0.44 and FAR=0.30, disadvantage more false alarms when the sun is low

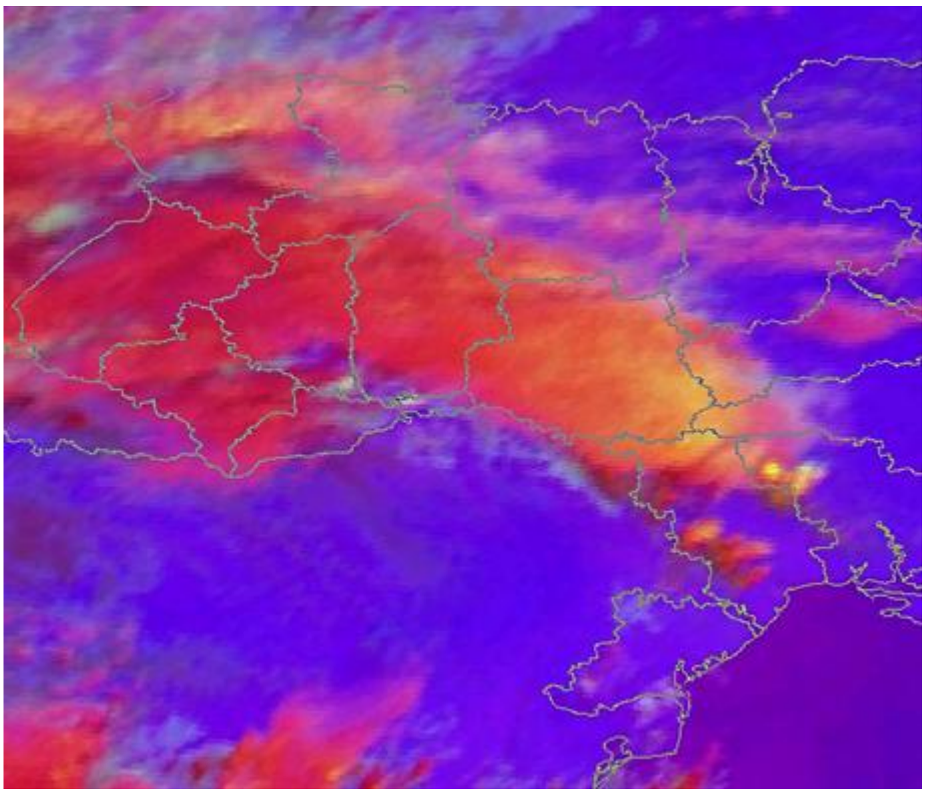
Day Severe Convection **RGB 5-6,4-9,3-1**



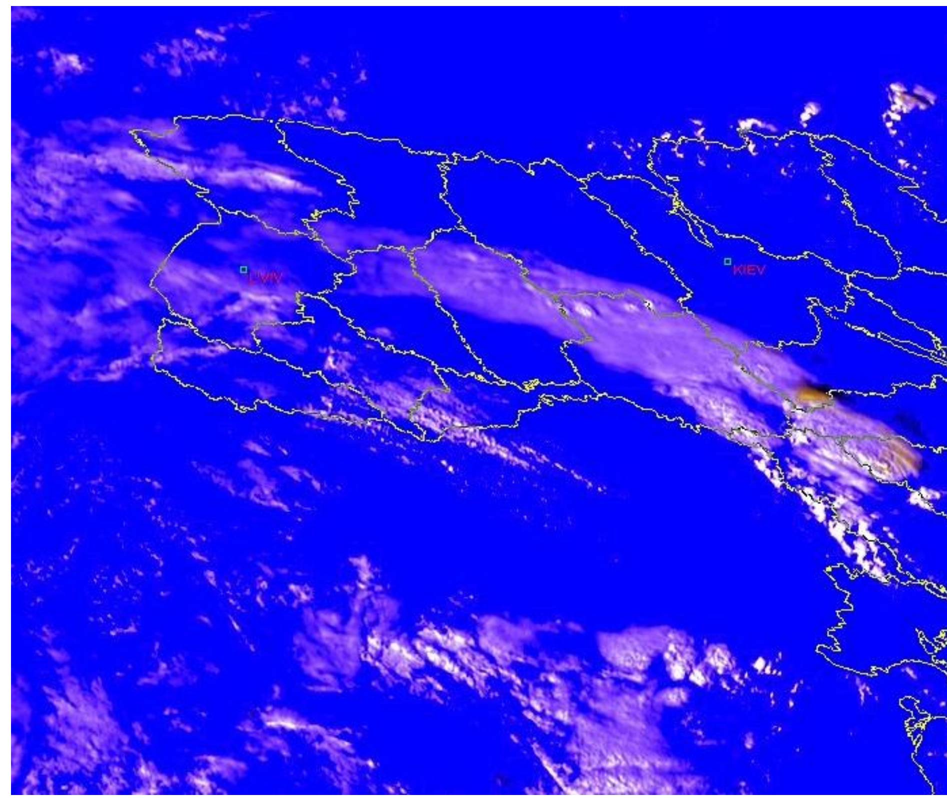
POD=0.53 and FAR=0.51. Overestimated the area of real thunderstorm activity (dependence of sun angle).

Analysis of heavy rain over western part of Ukraine on 23.07.12 at 11:30 UTC

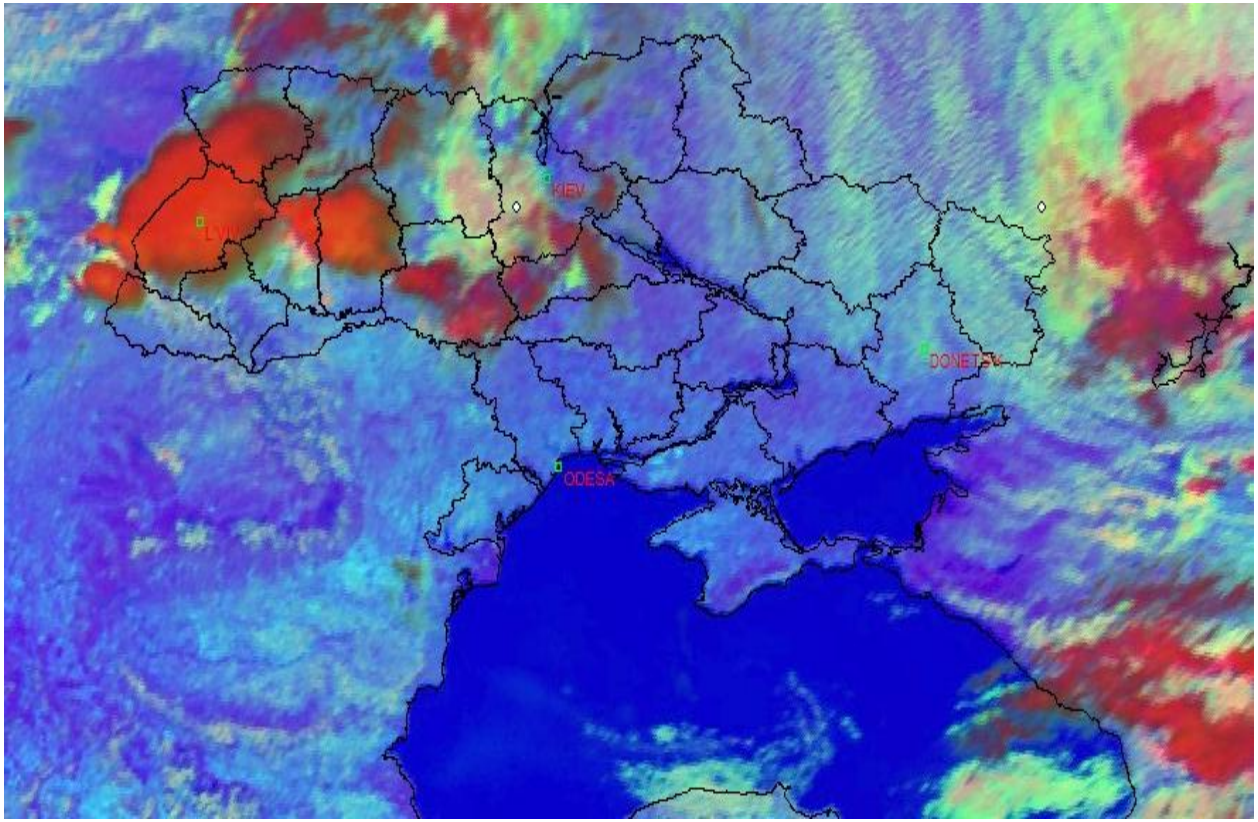
RGB 5-6,4-9,3-1



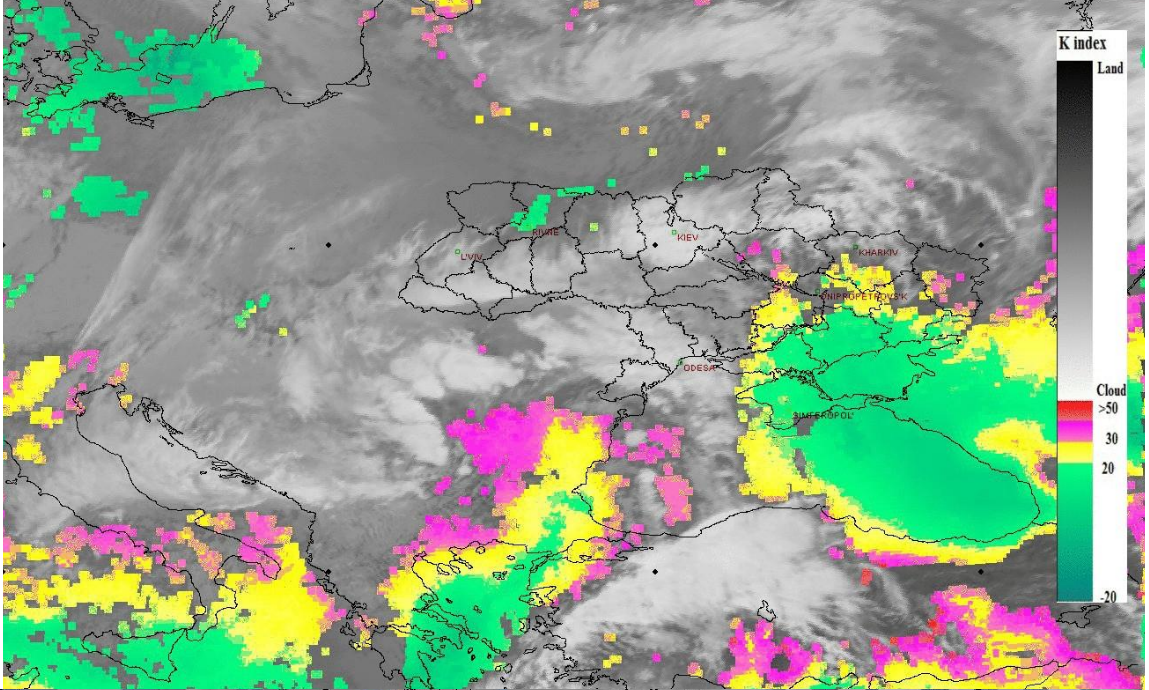
RGB 12,12,9-4

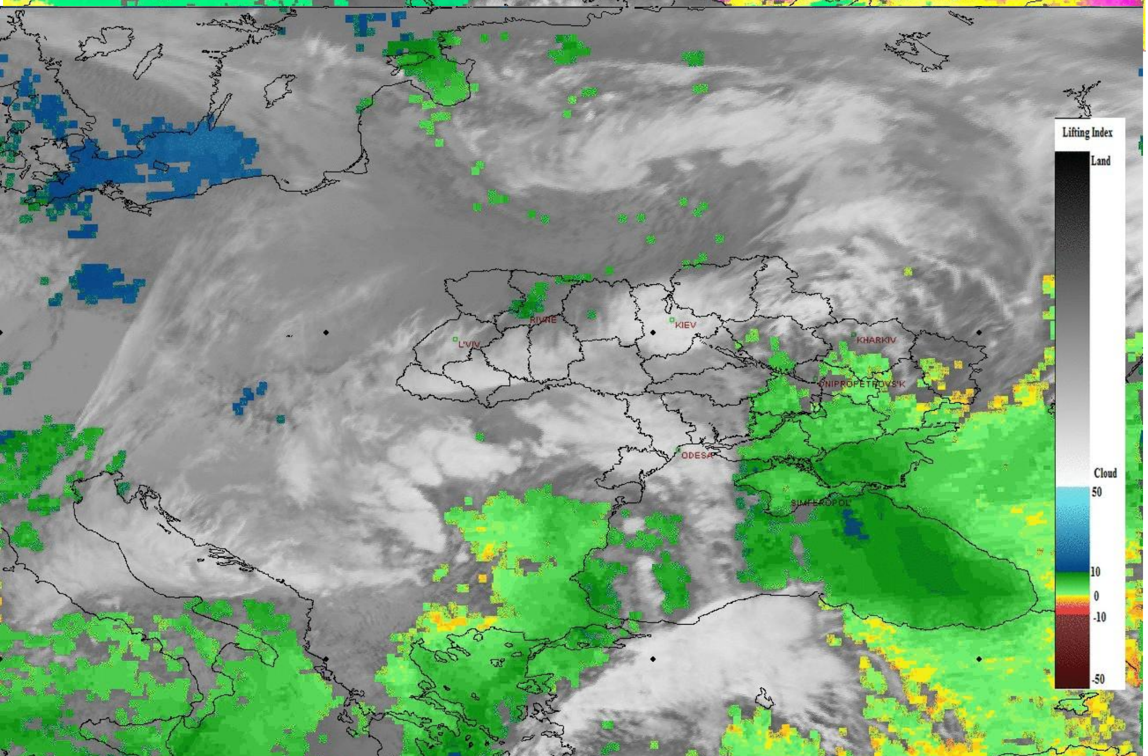


Day microphysics **VIS06 IR3.9 IR10.8**



POD=0.37 and FAR=0.66, overestimates the real thunderstorm activity



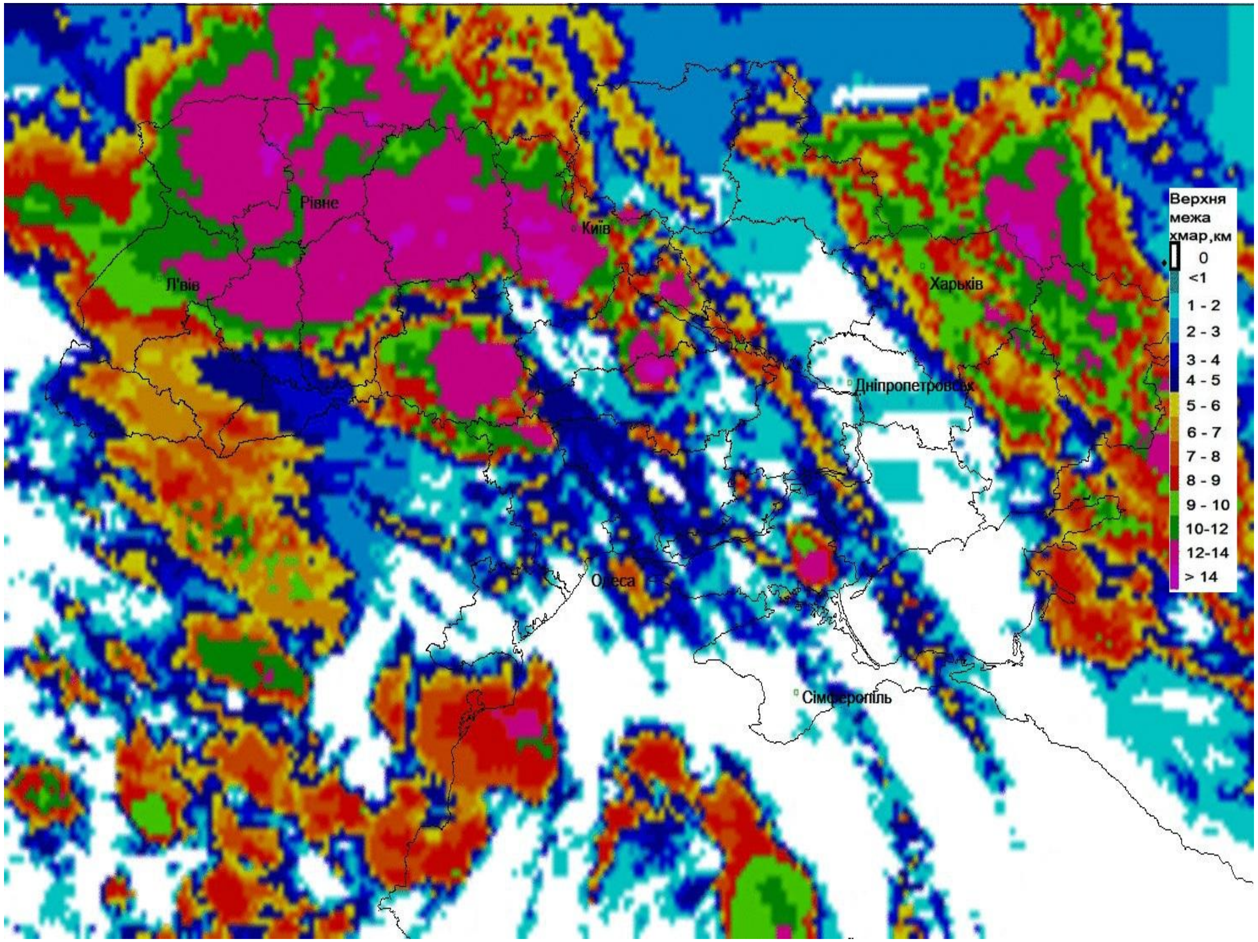


MPEF GII

KI is sensitive to early instability but shows much larger unstable areas then really exist and gives many false alarms.

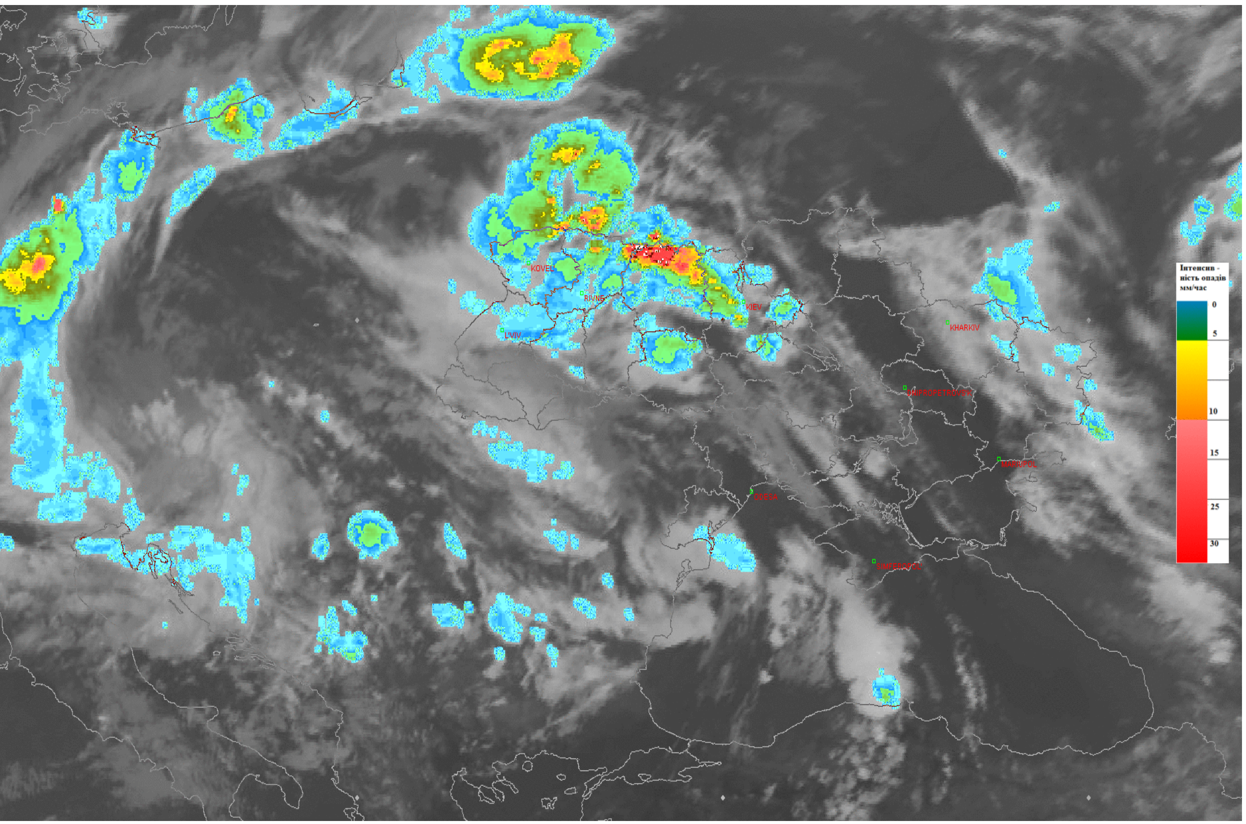
LI gives reasonable information just before convection, but more missed prediction then real.

Cloud Top Height



Useful as additional product for estimation of cloud penetration of the tropopause

MPEF MPE



Useful as additional product for estimation of precipitation, but the the accuracy is still low, bias correction is needed

Conclusions

We still need the robust convective products, based on satellite and NWP data.

Motivation

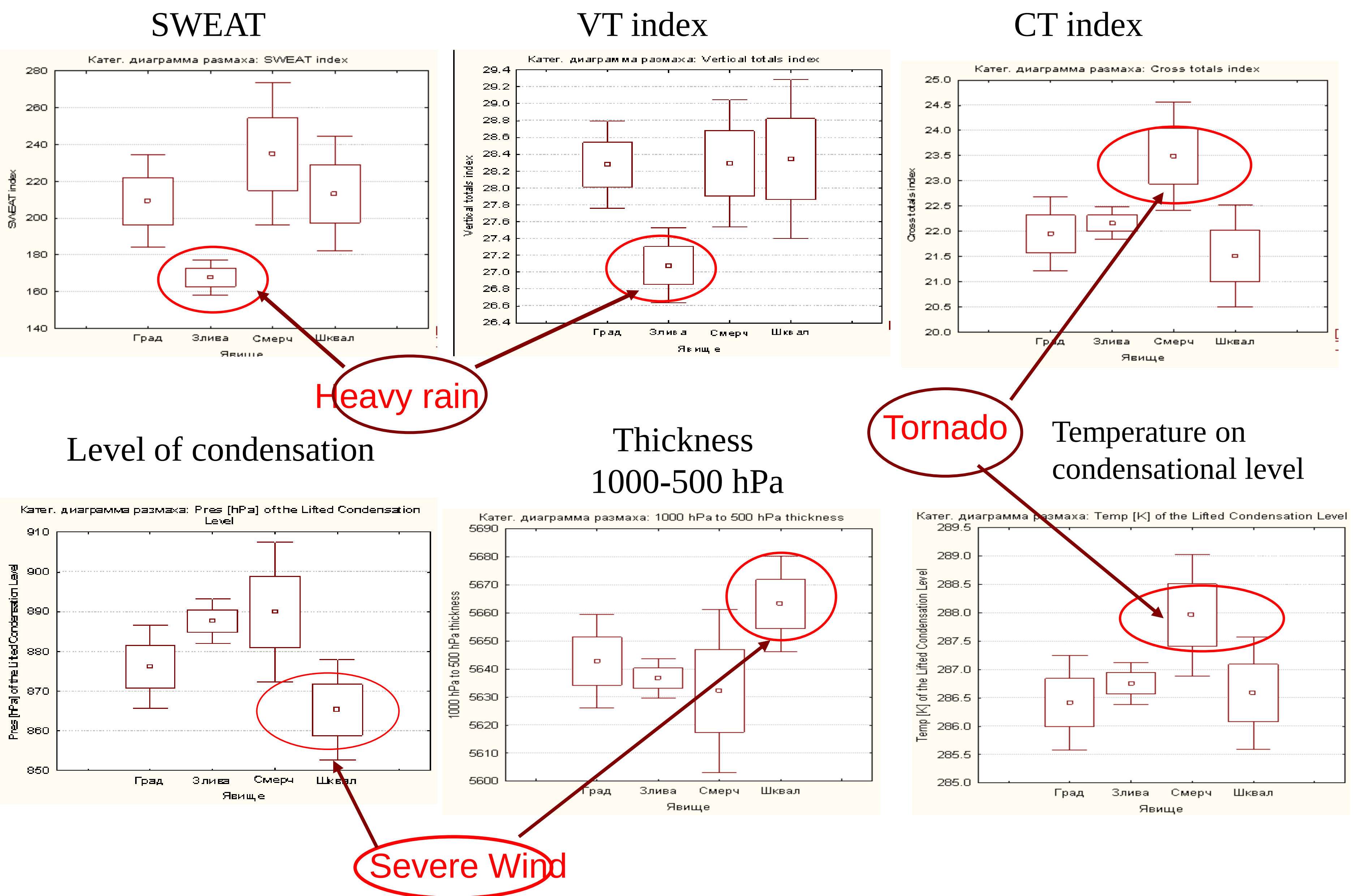
- Strong demand of our operational forecasters to forecast/nowcast the type of severe storm, we call it dangerous meteorological phenomena (DMP), especially in summer time, which is caused by convection (hail, severe wind, tornado, heavy rain).

- To improve our understandings about the spatial and temporal distribution of severe weather over Ukraine and database of DMP.

Index Name	Formula	Reference
Showalter index	$SI = T_{500} - T_{lp(850\ hPa)}$	Showalter (1947)
Lifted index	$LI = T_{lp(fcst\ surface)} - T_{500}$	Galway (1956)
K-index	$K = (T_{850} - T_{500}) + D_{850} - (T_{700} - D_{700})$	George (1960, pp. 407–415)
Convective available potential energy	$CAPE = \int_{LFC}^{EL} (\alpha_{lp} - \alpha) dp$	Glickman (2000, p. 176)
Vertical totals	$VT = T_{850} - T_{500}$	Miller (1972)
Cross totals	$CT = D_{850} - T_{500}$	Miller (1972)
Total totals	$TT = VT + CT$	Miller (1972)
SWEAT index	$SWEAT = 20(TT - 49°C) + 12D_{850} + 2V_{850} + V_{500} + 125 [\sin(\Delta V_{500\text{-}850}) + 0.2]$	Miller (1972)
Bulk Richardson number	$BRN = \frac{CAPE}{\frac{1}{2}(\overline{U} - U_0)^2}$	Weisman and Klemp (1982)
Storm-relative helicity	$SRH = -\int_{z_0}^{z} \mathbf{k} \bullet \left[(\mathbf{V}_h - \mathbf{C}) \times \frac{\partial \mathbf{V}_h}{\partial z} \right] dz$	Davies-Jones et al. (1990)
Energy-helicity index	$EHI = \frac{(CAPE)(SRH)}{160{,}000}$	Hart and Korotky (1991)
Supercell composite parameter	$SCP = \left(\frac{MUCAPE}{1000 J kg^{-1}}\right)\left(\frac{SRH_{0-3km}}{100 m^2 s^{-2}}\right)\left(\frac{\overline{U} - U_0}{40 m s^{-1}}\right)$	Thompson et al. (2003)
Significant tornado parameter	$STP = \left(\frac{MLCAPE}{1000 J kg^{-1}}\right)\left(\frac{SHR_{0-6km}}{20 m s^{-1}}\right)\left(\frac{SHR_{0-1km}}{100 m^2 s^{-2}}\right)\left(\frac{(2000m - MLLCL)}{1500m}\right)$	Thompson et al. (2003)
Enhanced stretching potential	$ESP = \left(\frac{\partial T}{\partial z}\Big\|_{0-2km} - 7°C km^{-1}\right)\left(\frac{MLCAPE_{3km}}{50 J kg^{-1}}\right)$	Davies (2005 – personal communication)

On the Use of Indices and Parameters in Forecasting Severe Storms (C.Doswell)

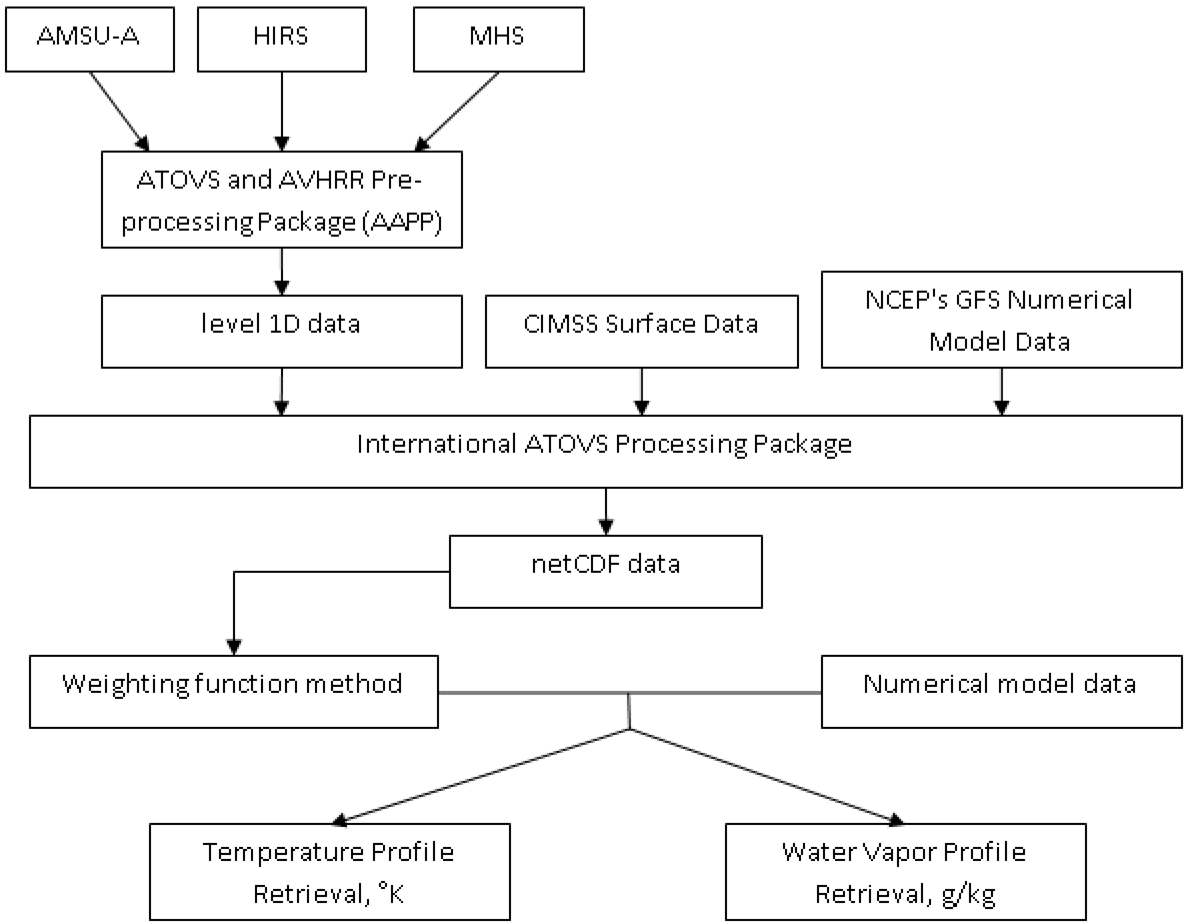
Indicators of severe weather

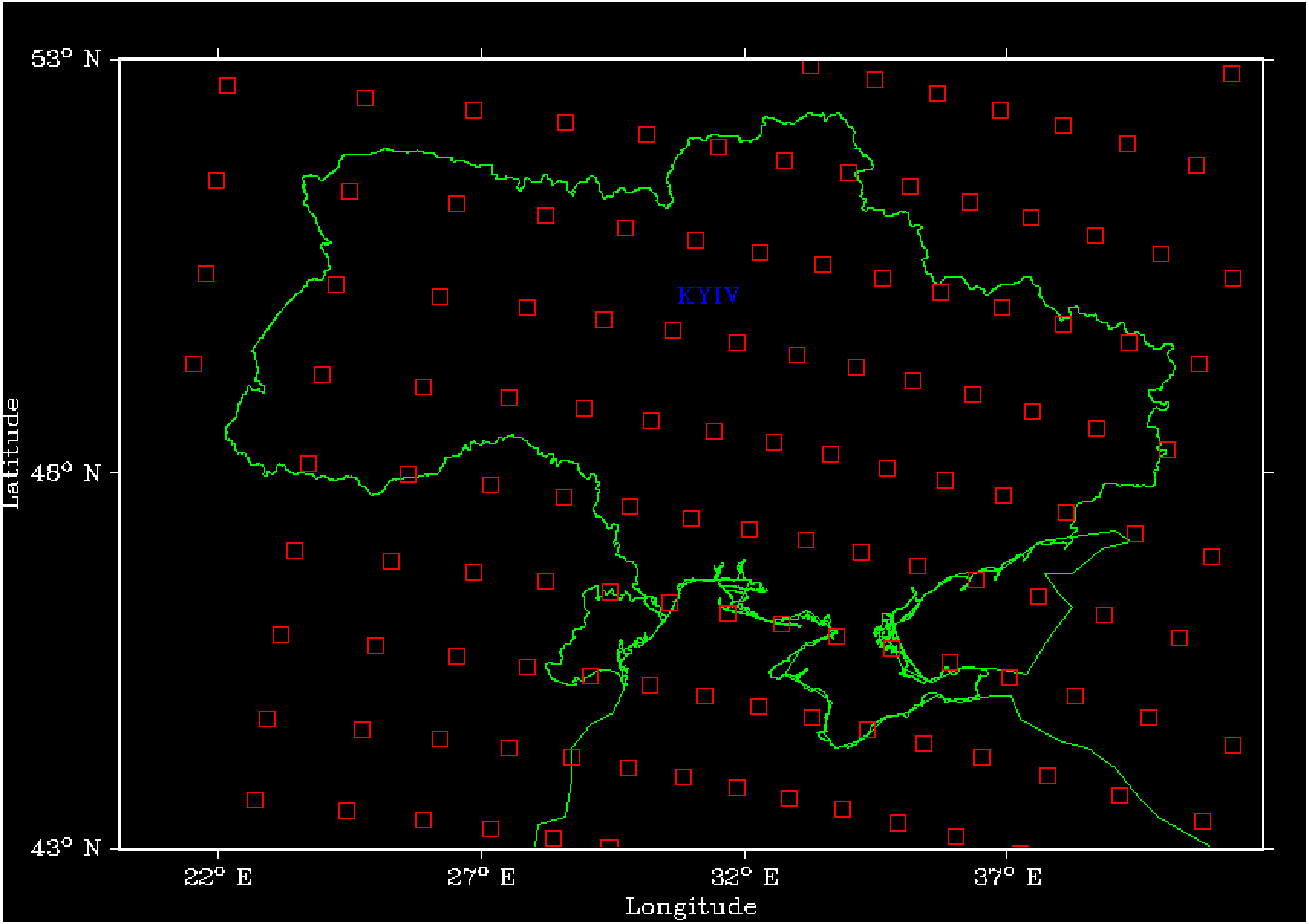


Critical values of severe weather indicators

Heavy rain, 30 mm/hour	**Tornado (Smerch) (F2 according to Fujita scale)**	**Severe wind >25 m/s**
■ CAPE>600 J/кg	■ CAPE>1050 J/kg	Level of condensation <850 hPa
■ SWEAT >168	■ SWEAT >235	■ Thickness of 1000 - 500 гПа >560 гПа
■ VT>27	■ VT>28	
■ TT>50	■ TT>52	
	■ $T_{\text{конд}}$>288 K	
	■ CIL>576 hPa	
	■ Thikness 1000 - 500 hPa >540 hPa	

The scheme for retrieval of temperature and humidity profiles from ATOVS/TOVS




53° N
48° N
43° N
22° E
27° E
32° E
37° E
Latitude
Longitude
KYIV

WRF

Area of calculation - 230 x 180 grids, step - 15 km.

Central point latitude - 48.40, longitude - 31.20 degree, Lambert projection

350 satellite images of 2012-2013 were processed and about 3000 profiles were retrieved :

- time difference between satellite and soundings data was no more than 2 hours;
- soundings from 9 stations were used for verification.

Cloudy situation, σ

Pressure, hPa	850	700	500	400	300	250	200	150	100	50
Satellite	2.01	1.45	1.73	1.64	1.95	2.22	2.03	1.96	2.02	1.42
WRF	1.27	0.96	1.38	1.31	1.81	1.37	1.59	1.61	1.30	1.85
GFS	2.39	1.93	3.13	3.51	3.92	3.34	3.13	2.62	2.31	2.64

Cloudless situation, σ

Pressure, hPa	850	700	500	400	300	250	200	150	100	50
Satellite	1.90	1.67	2.36	1.70	2.54	2.80	2.42	3.19	3.30	2.16
WRF	0.88	0.85	1.42	1.25	2.30	1.58	1.49	2.80	2.58	2.22
GFS	2.07	2.30	3.64	3.95	4.42	3.60	2.31	2.09	2.27	2.79

THANK YOU FOR ATTENTION