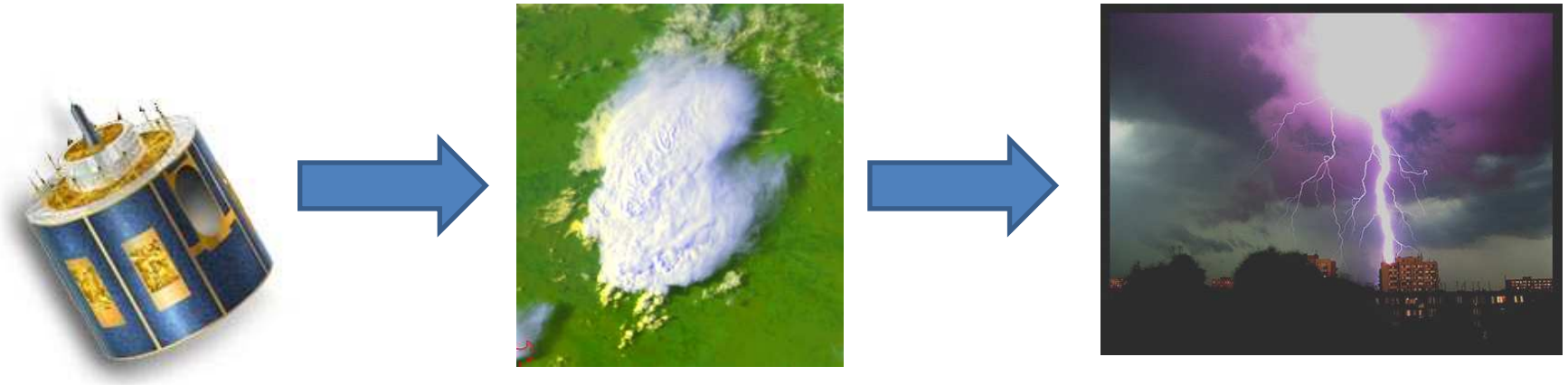
"Experiences with use of EUMETSAT MPEF GII product for convection/storm nowcasting"

Marianne König[1], Monika Pajek[2], Piotr Struzik[2]

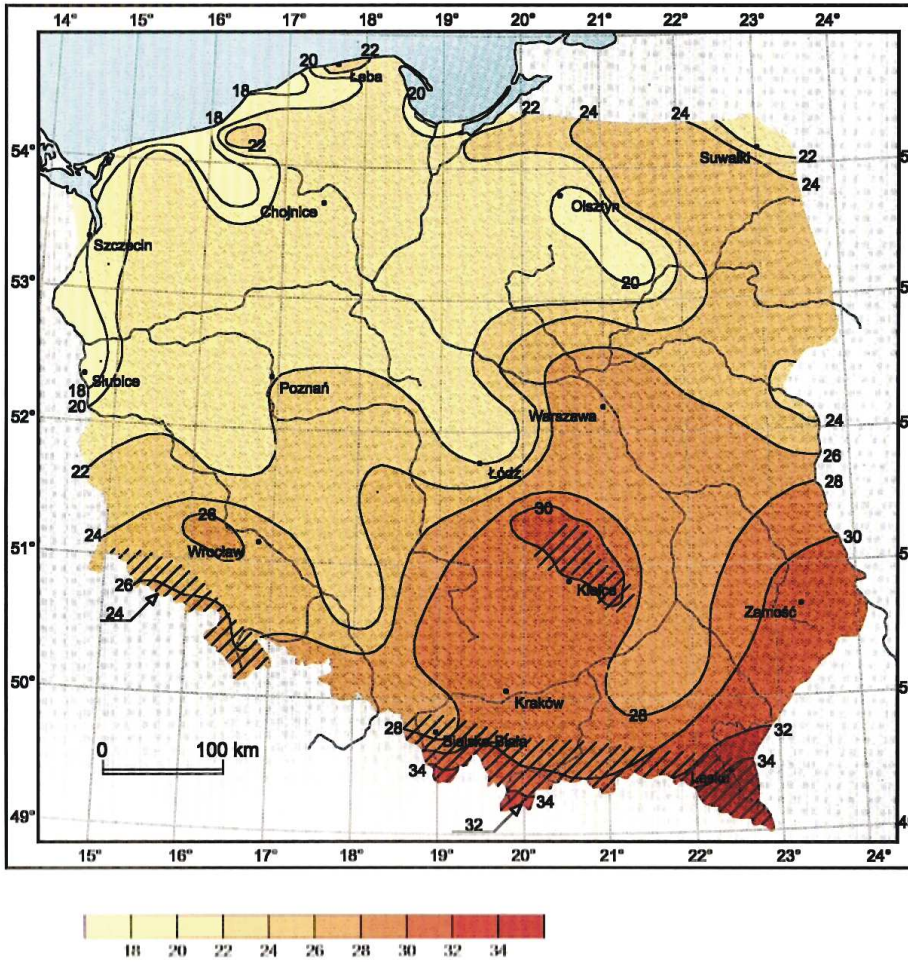
1) *EUMETSAT*
2) *Institute of Meteorology and Water Management, Kraków, Poland*



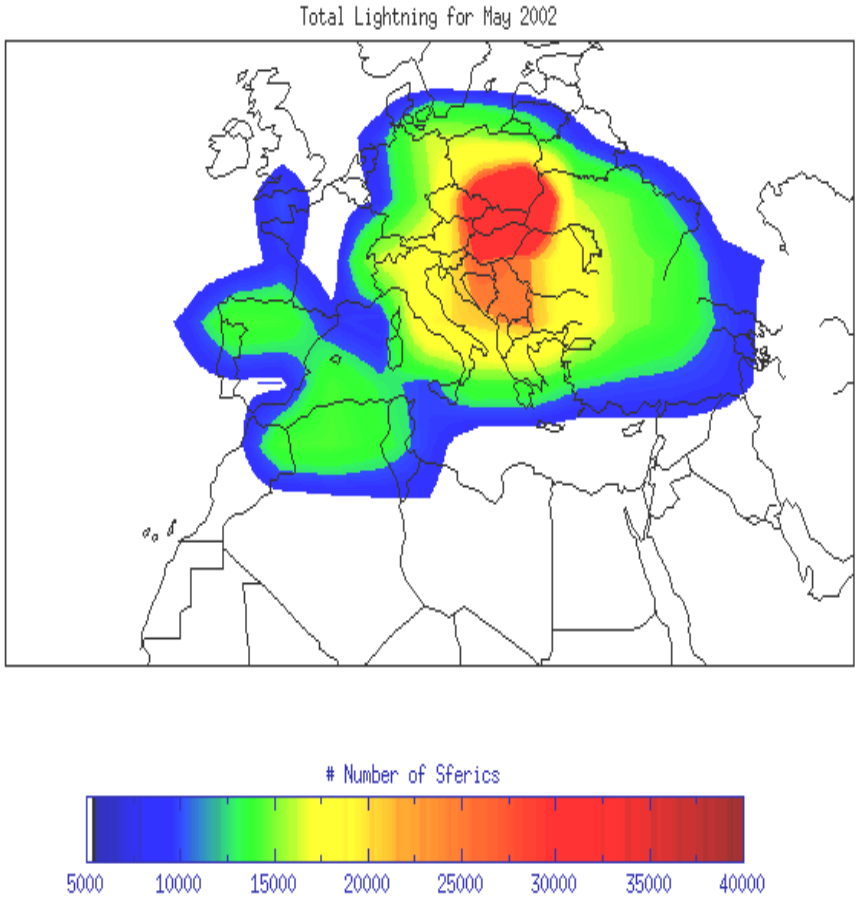
Presentation layout

1. Challenges of storm prediction in Poland (very shortly).
2. Satellite derived Air Stability Indices – possibilities.
3. Convection (storm) nowcasting with use of GII products – selected examples.
4. GII validation studies.
5. Conclusions.

Why we are doing that ?



Annual mean of days with storms in Poland
(”Atlas Klimatu Polski”, H. Lorenc, 2005)



Total number of lightnings
May 2002

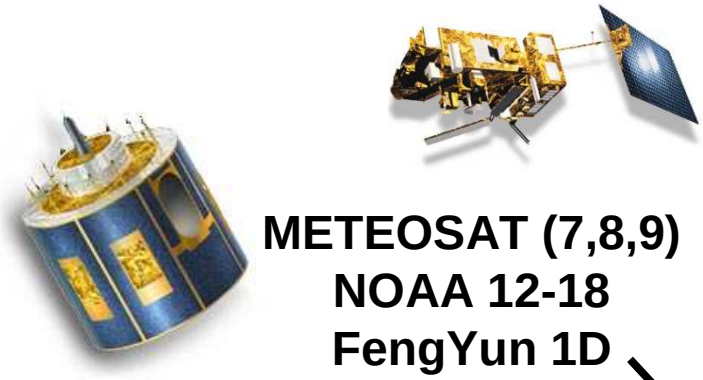

Miasteczko Studenckie AGH, godz. 17:34
fot. A.Mysliwiec


Sukiennice, godz. 18:40
fot. M.Mysliwiec

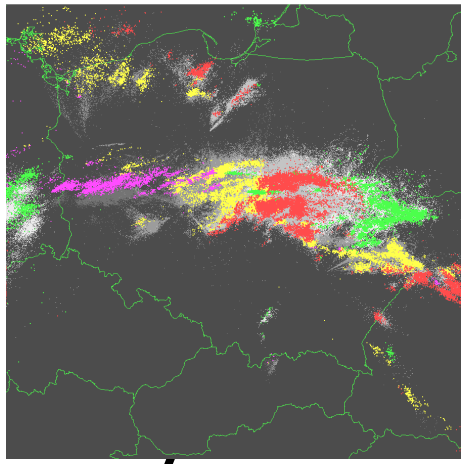
EUMETSAT H-SAF – Satellite Application Facility in Support to Operational Hydrology and Water Management

Flash floods as a result of storm precipitation

Well informed people do not panic even in extreme situations



METEOSAT (7,8,9)
NOAA 12-18
FengYun 1D
Metop (in test)



Lightning detection system PERUN

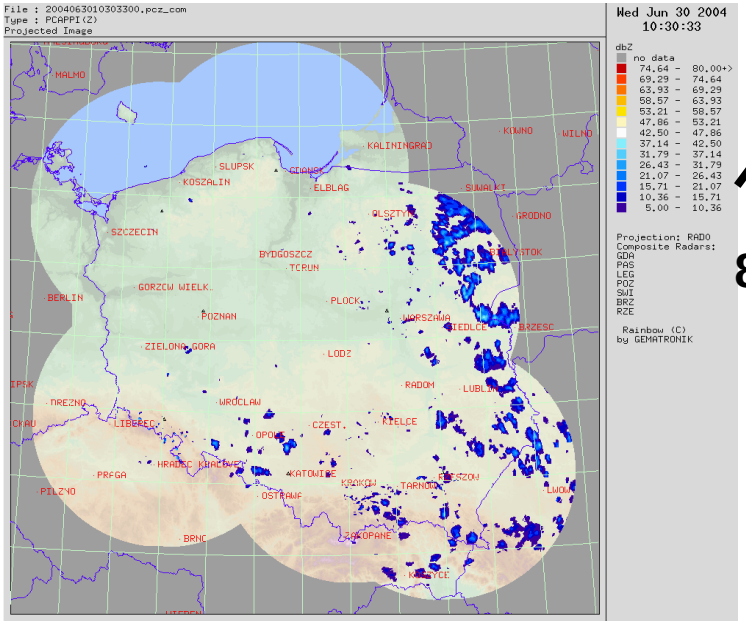
60 Synop
152 Climate
978 Raingauges

Numerical wether prediction models:

COSMO, ALADIN

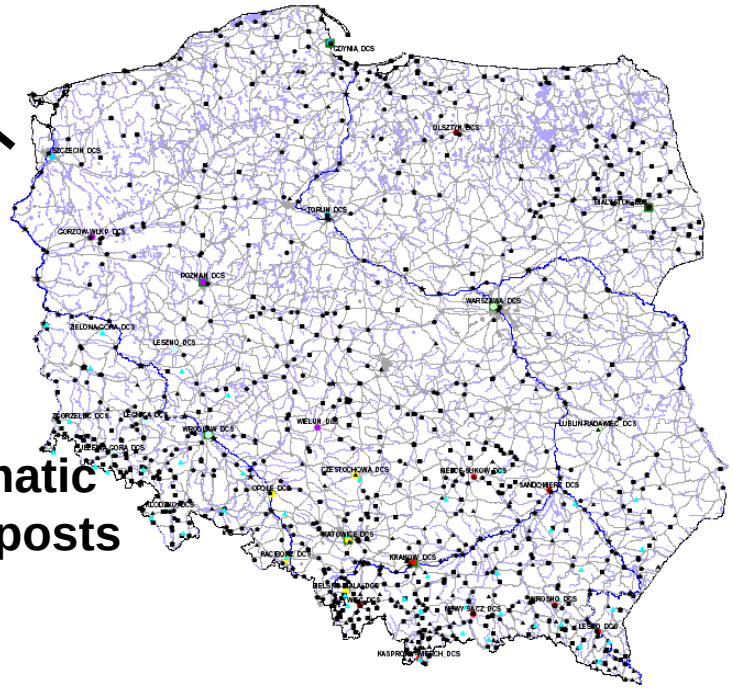
IMWM

Nowcasting model INCA



Composite image from all Polish radars.

8 radars



989 automatic telemetric posts

Typical air stability indices retrieved from different satellite data

TOVS/NOAA sounding: more realistic soundings due to instrument (HIRS +AMSU), poor temporal resolution

NWC-SAF SAI product: neural network algorithm questionable in mid latitudes. Full SEVIRI resolution.

MPEF GII product – physical retrieval, poor spatial resolution.

GII- like products generated by local installations (PL, SA), full SEVIRI resolution, different NWP as first guess !

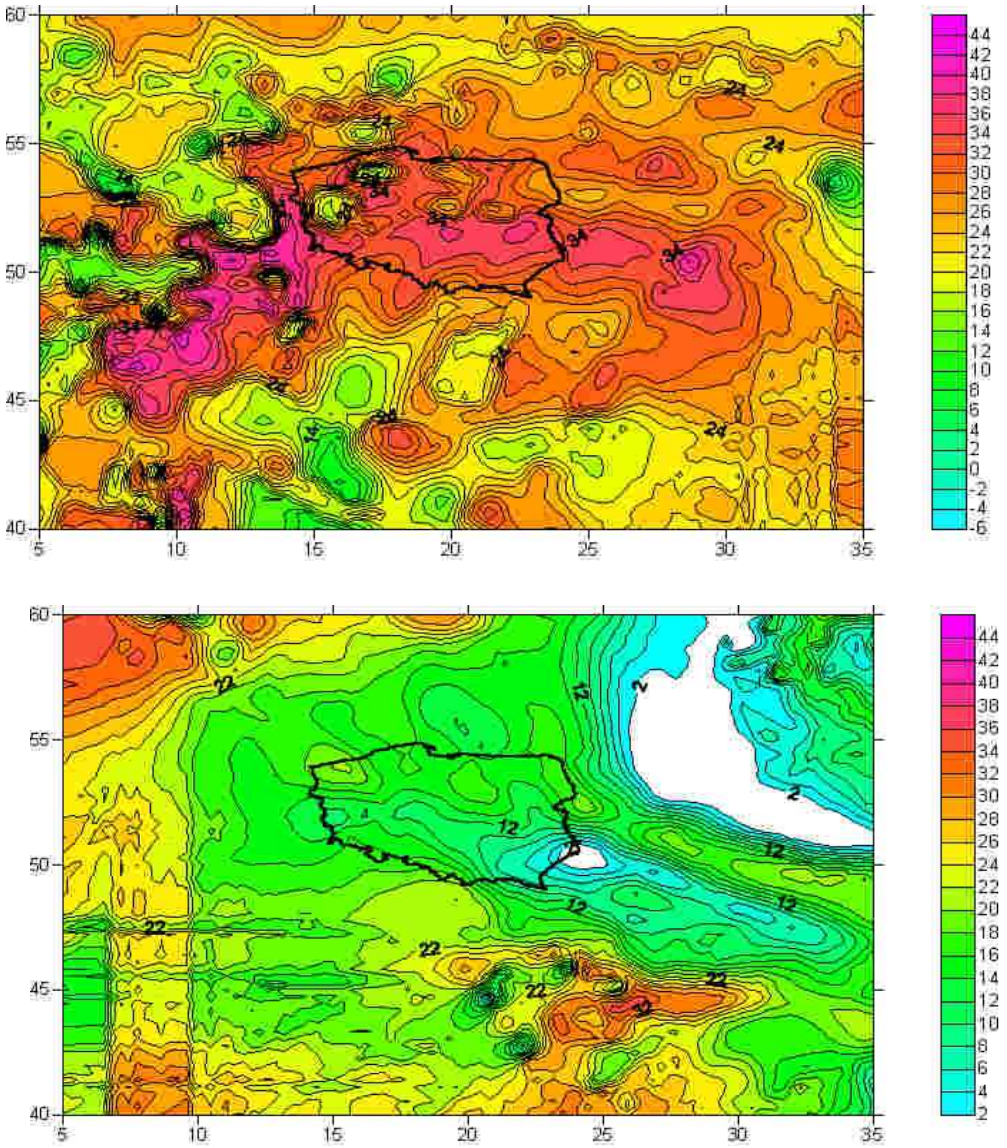
Indices retrieved from TOVS/NOAA sounding instrument

TOVS/NOAA data represents better sounding unit containing both infrared soundings (HIRS) and passive microwave sounding (AMSU).

As a result stability indices are calculated from retrieved temperature and moisture profiles. Infrared sounding is limited to cloud free areas similar like indices based on METEOSAT/SEVIRI data.

Microwaves give opportunity to provide sounding capacity in all weather conditions.

Disadvantage of Indices retrieved from TOVS data is poor temporal sampling comparing to geostationary satellites, resolution in best case comparable to HIRS pixel (17 km in nadir).



Examples of unstable and stable conditions (K Index)

SAI (Stability Analysis Imagery)

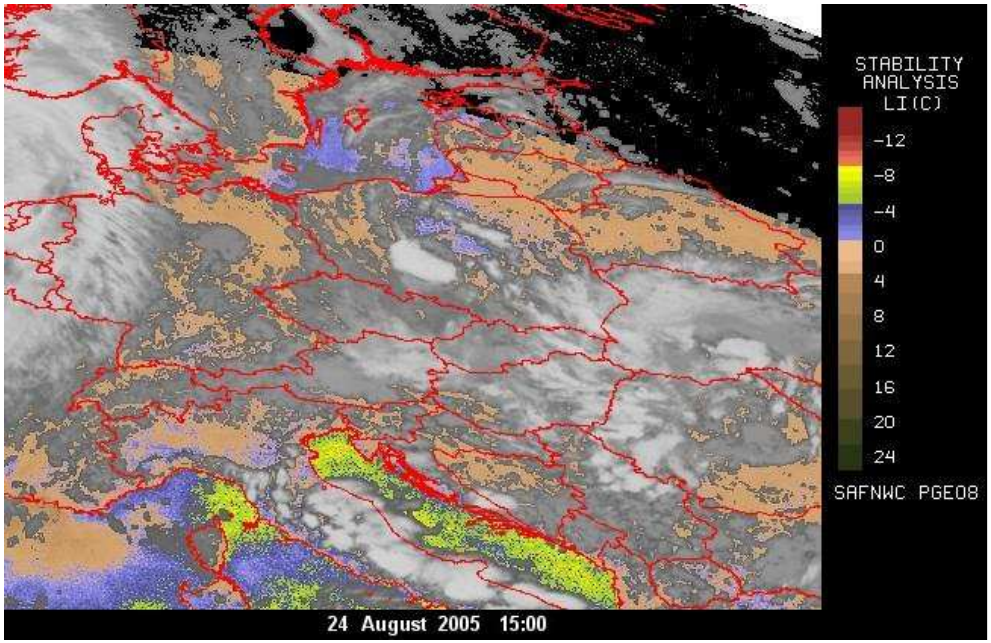
SAI (Stability Analysis Imagery) - one of the EUMETSAT Nowcasting SAF products produced with use of local installation of NWC-SAF software.

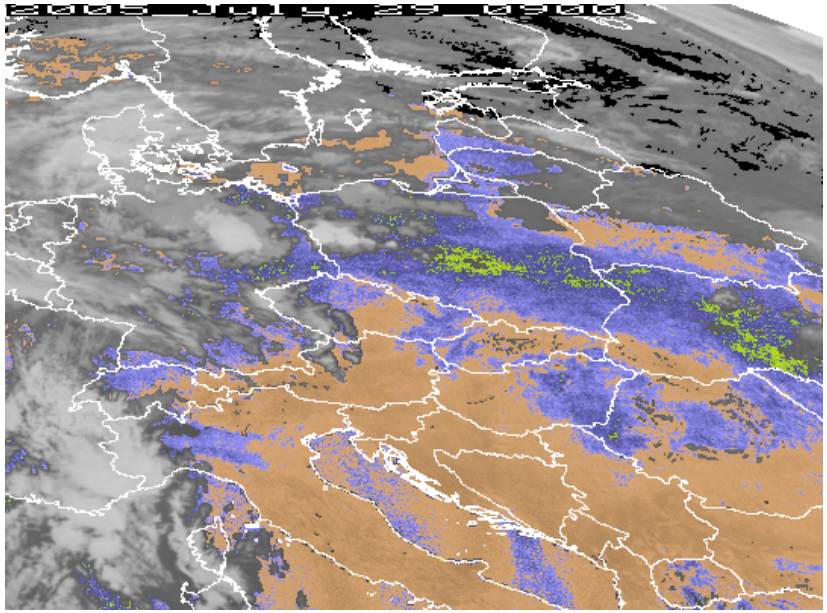
Air stability product represents Lifted Index calculated by Neural Network algorithm.

Advantages of this product are: full SEVIRI pixel resolution, simple processing without use of extended NWP model data.

Limitations detected for the area of Poland (V1.3 software) are:

- generally very stable air detected in most cases,
- only very high unstability is reflected by this product,
- artificial differences between land and sea surfaces.





Instability Indices in MSG GII product disseminated via EUMETCast

EUMETSAT MPEF GII product is generated from MSG satellite data every 15 minutes with resolution 15 x 15 SEVIRI pixels and disseminated via EUMETCast. Physical method is applied with use of ECMWF model as a first guess.

During Rapid Scan cmpaign RII 1x1 SEVIRI disseminated (PL half covered)

.

- Lifted Index

  $LI = T^{obs} - T^{lifted\ from\ surface}$ at 500 hPa

- K-Index

  $KI = (T^{obs(850)} - T^{obs(500)}) + TD^{obs(850)} - (T^{obs(700)} - TD^{obs(700)})$

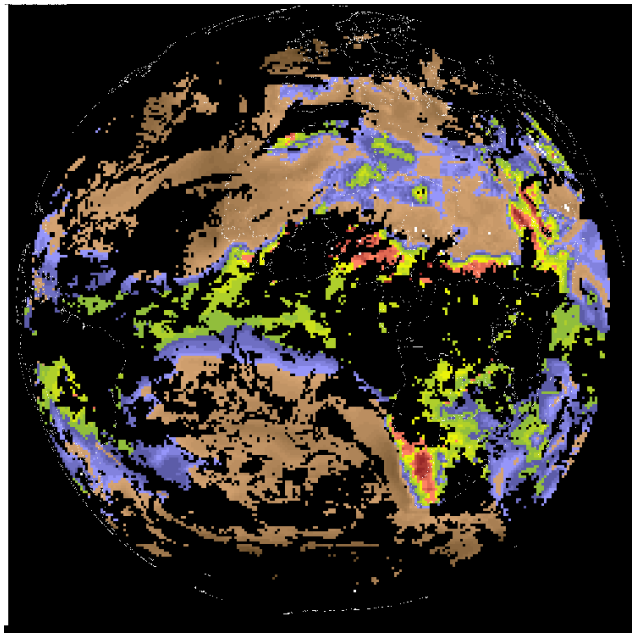
- KO Index

  $KO = 0.5 * (\Theta_e^{obs(500)} + \Theta_e^{obs(700)} - \Theta_e^{obs(850)} - \Theta_e^{obs(1000)})$

- Maximum Buoyancy

  $MB = \Theta_e^{obs(maximum\ between\ surface\ and\ 850)} - \Theta_e^{obs(minimum\ between\ 700\ and\ 300)}$

- Precipitable Water



Global Lifted Index (example)

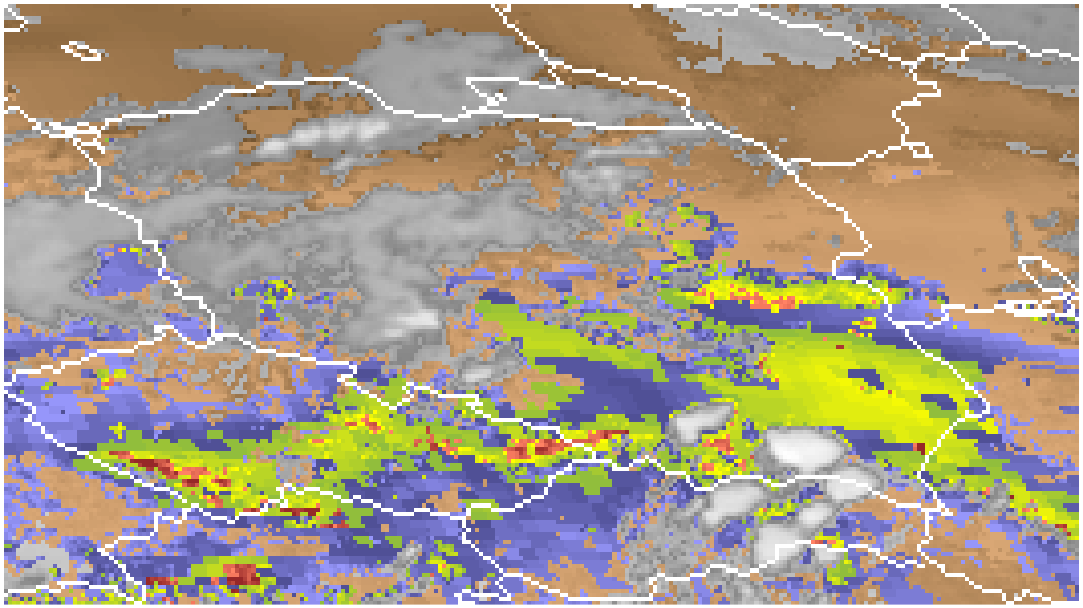
Regional studies (Poland)

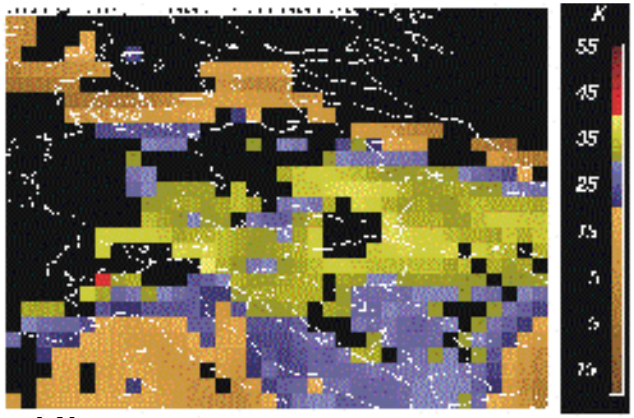
Operational use of GII indices for Central Europe

In IMWM operational product at IMWM since Apr. 2007

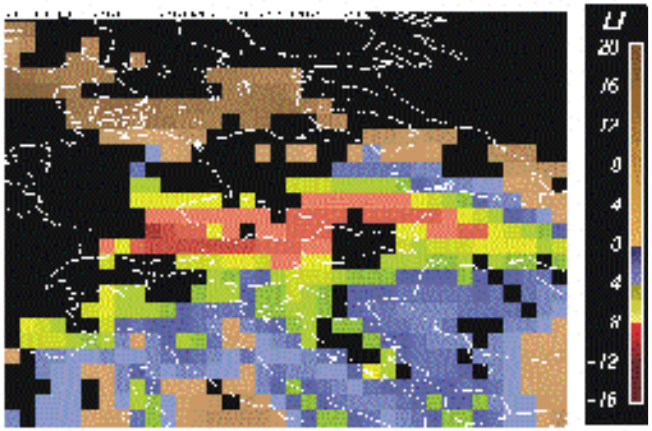
Local installation of GII software – ALADIN Model as a first guess.

Resolution 5x5, 3x3 or 1x1 SEVIRI pixel available.

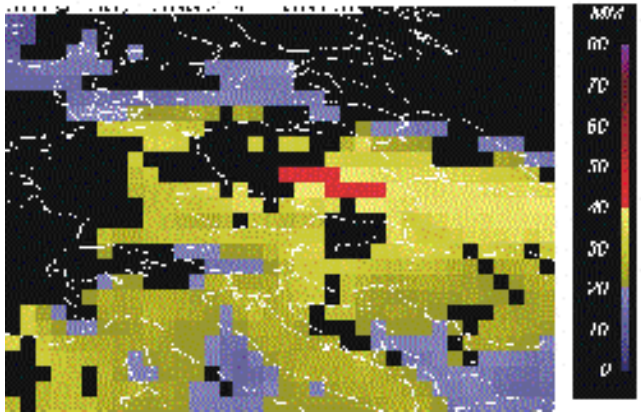




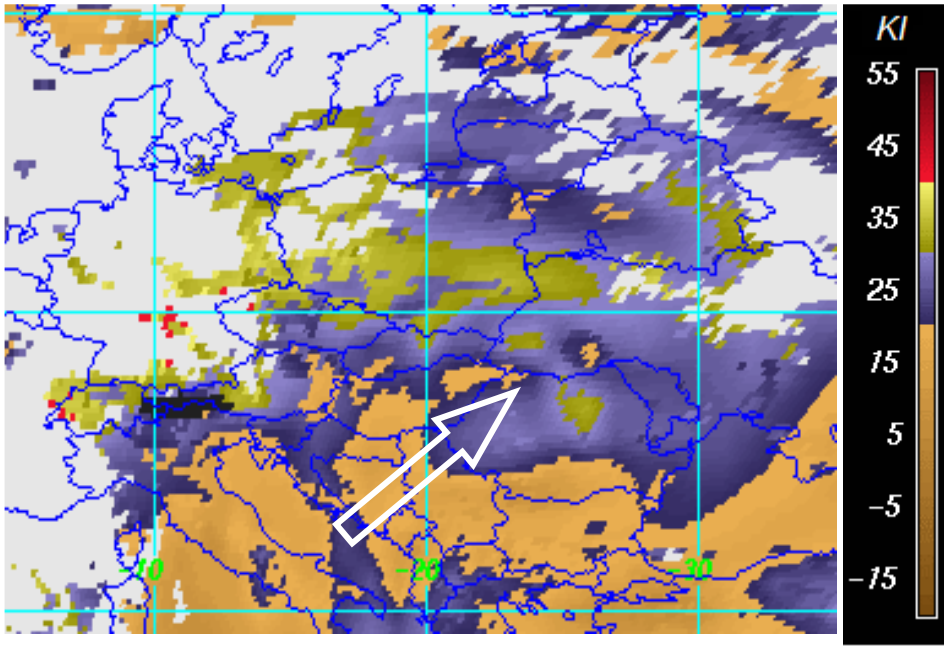
KI



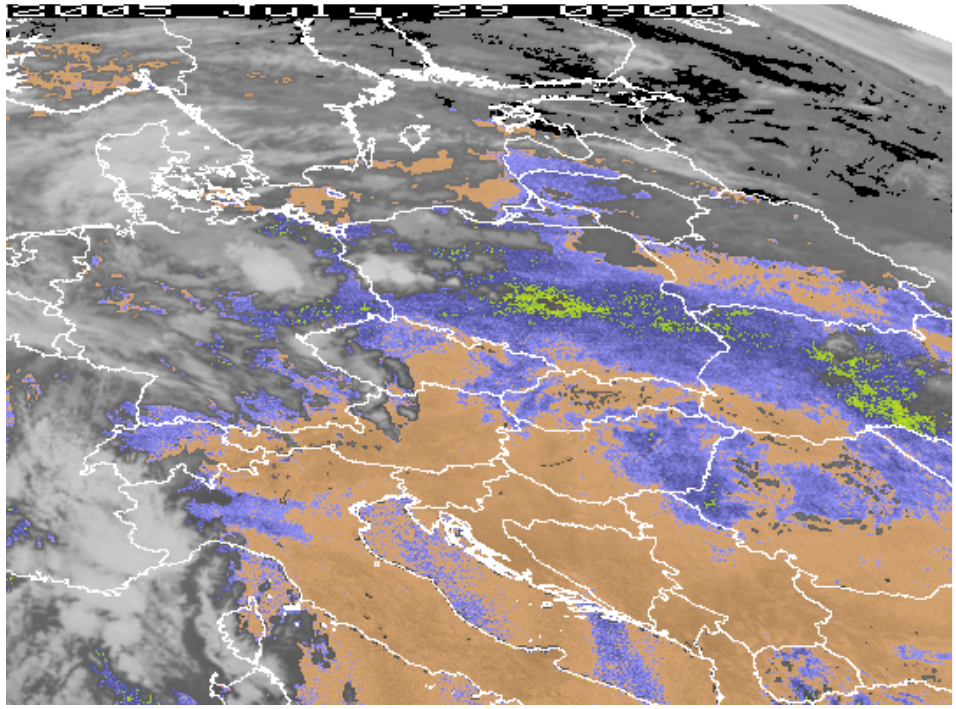
LI



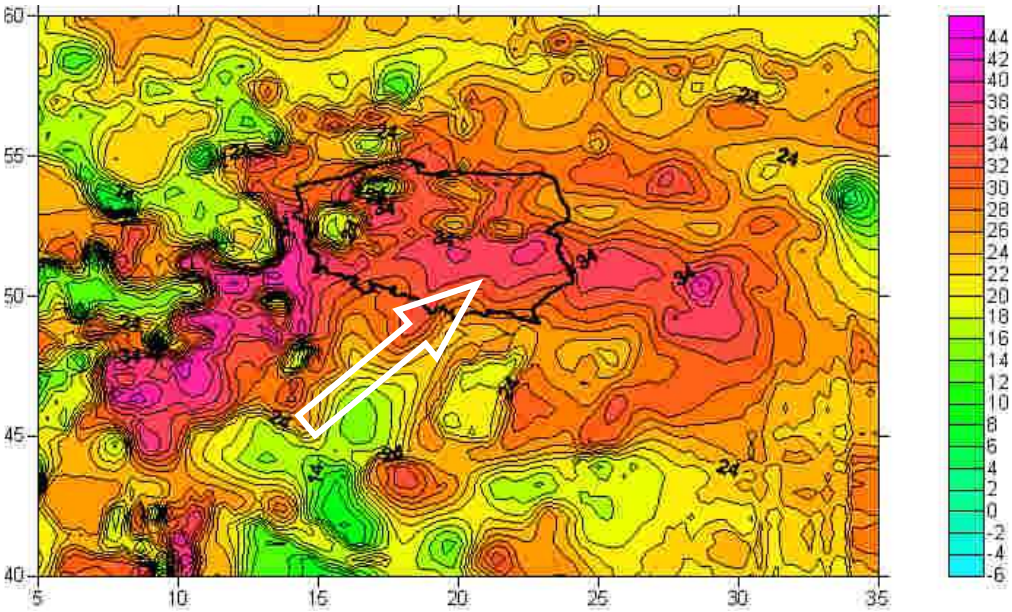
TPW



K-Index GII



NWC-SAF/MSG SAI (Lifted Index)

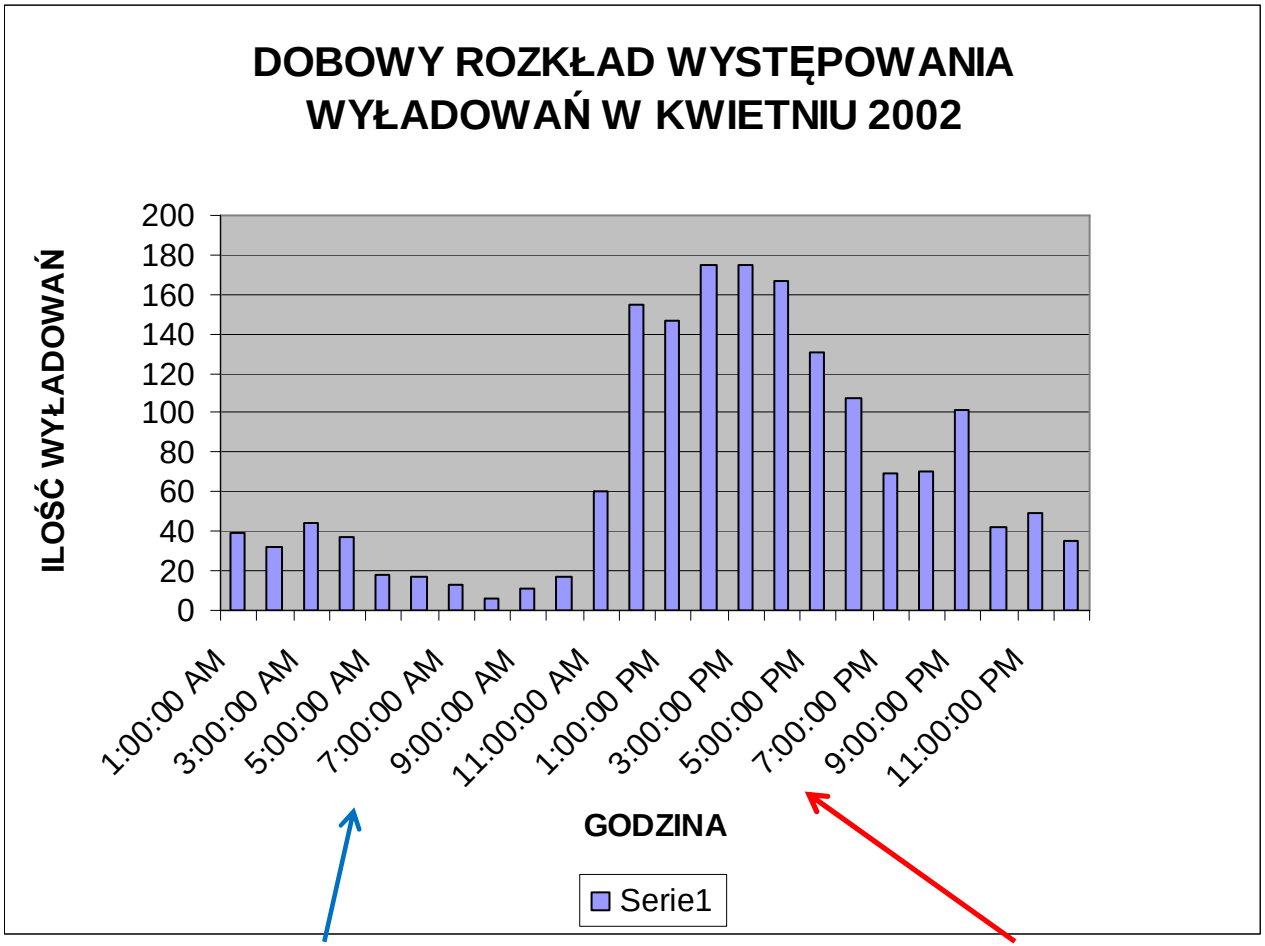


K-Index NOAA-14

29 July 2005 0830 UTC

Unusual agreement !!!

PERUN - System for detection and localisation of lightnings



Prediction

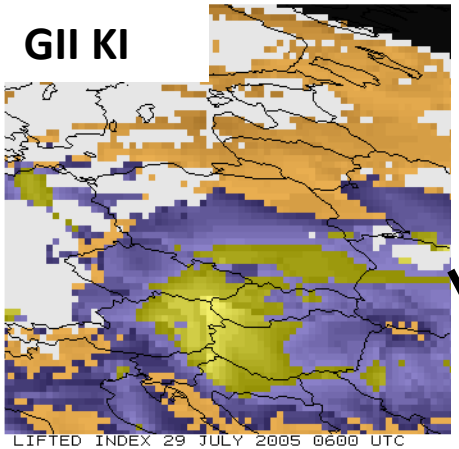
Forecasted phenomena

- system works operationally since January 2002
- Durnal distribution of lightnings (example)

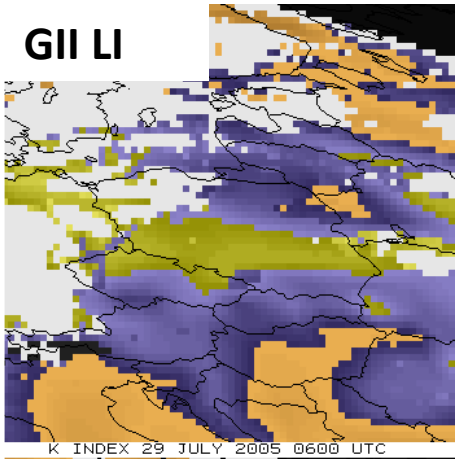
Validation methodology

Satellite air stability products for storms' nowcasting

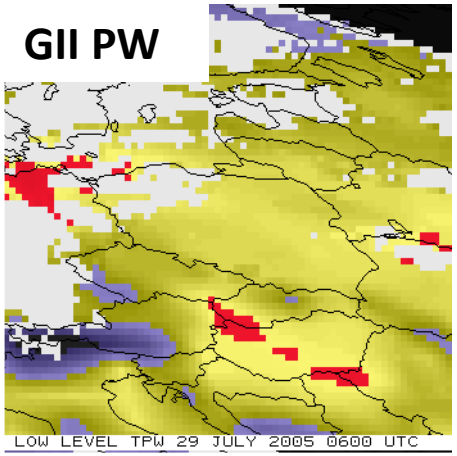
GII KI



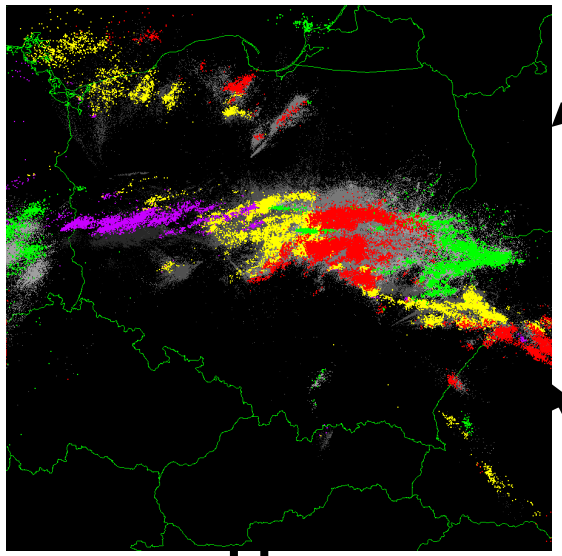
GII LI

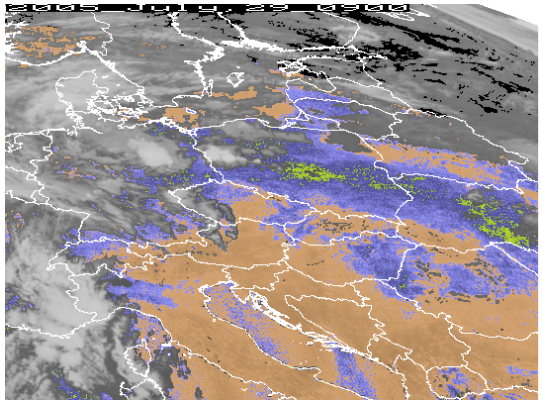


GII PW

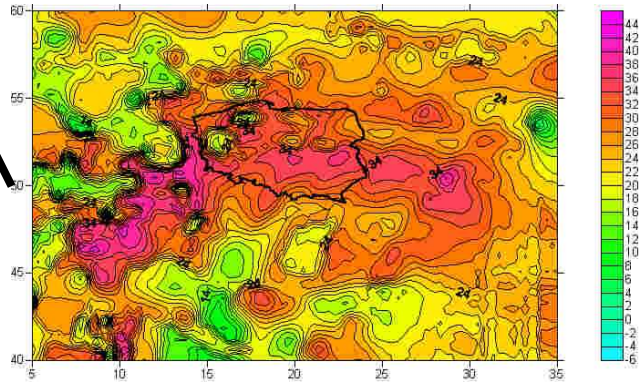


Lightnings





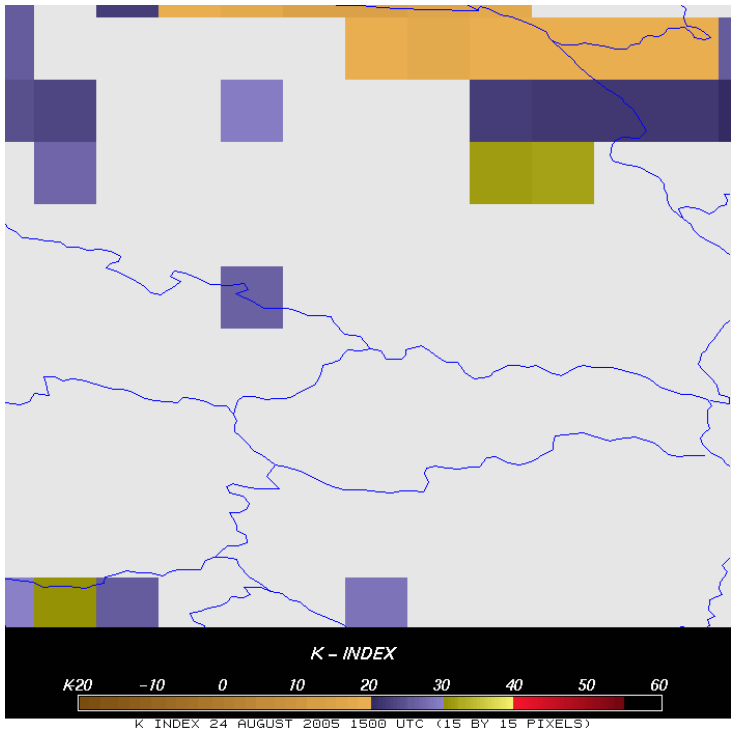
NWC-SAF/MSG SAI



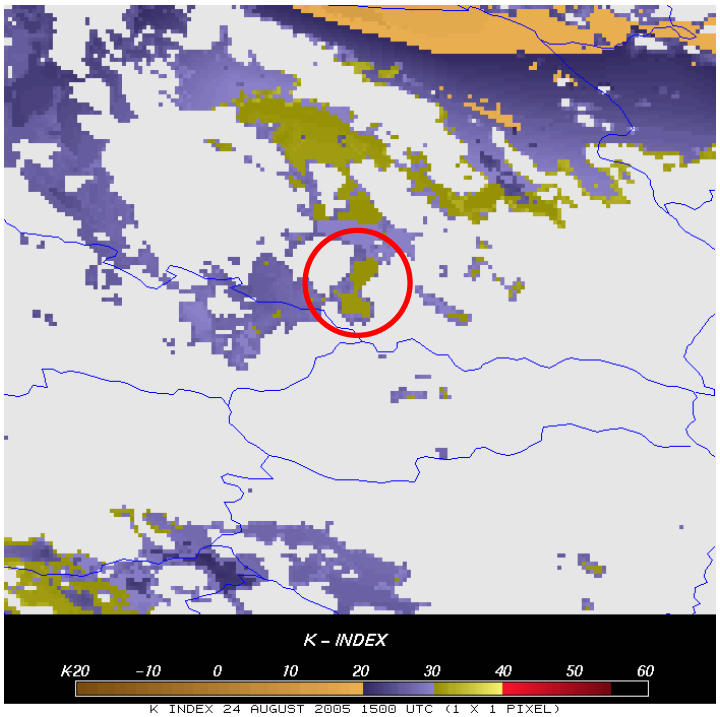
TOVS/NOAA KI

Problem of spatial resolution of instability indices

Operationally available MPEF GII indices are generated with 15x15 SEVIRI pixel resolution.
- Limited amount of completely cloud free pixels, for which indices may be calculated.
- In case of fractional cloudiness, indices frequently cannot be retrieved for whole area of Poland.



Operatinal 15x15 resolution



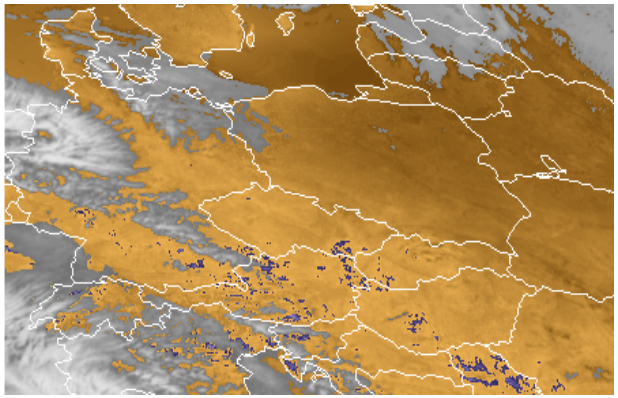
1 x 1 SEVIRI pixel resolution

Problem of NWP model data used as a first guess for retrieval of stability indices from satellite data

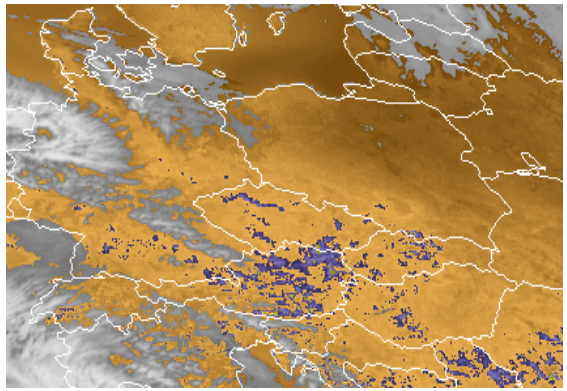
Physical method of stability indices retrieval from MSG satellite data uses data from NWP model as a first guess.

MPEF GII - ECMWF global model as first guess
Local installation of EUMETSAT software in IMWM - ALADIN mezoscale model as a first guess.
Two used models differ in spatial scale both horizontal and vertical ! Results ?!

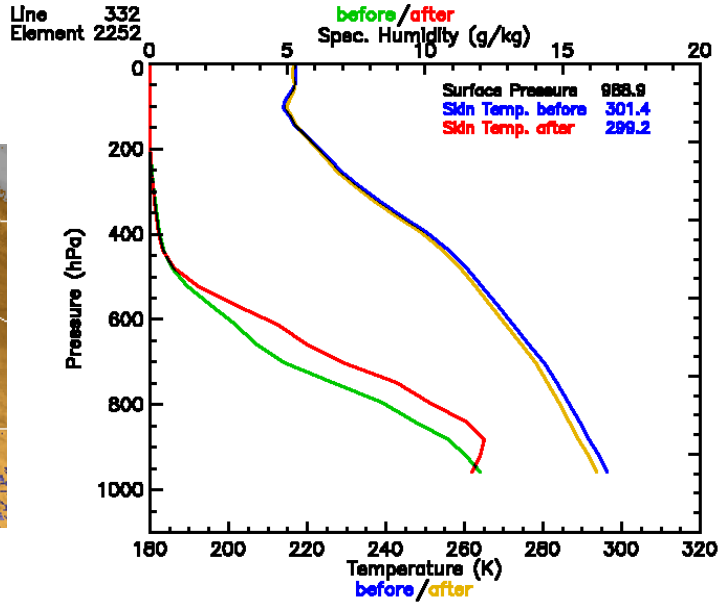
How first guess is propagating through GII retrieval scheme ?
What added value is provided by satellite data ?



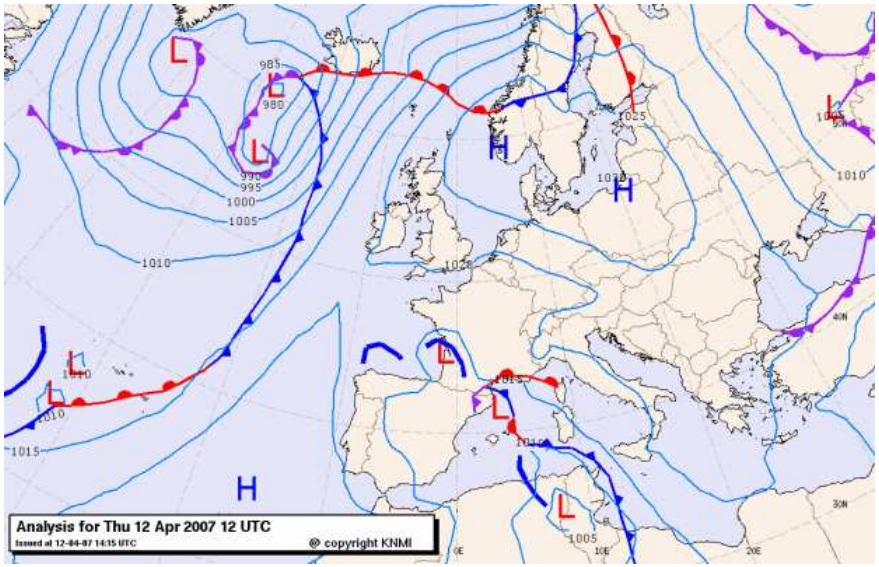
First guess ECMWF

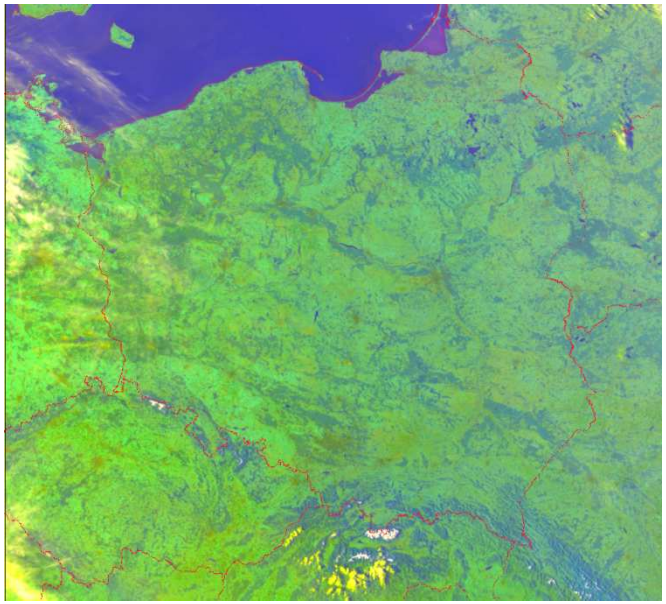


First guess ALADIN

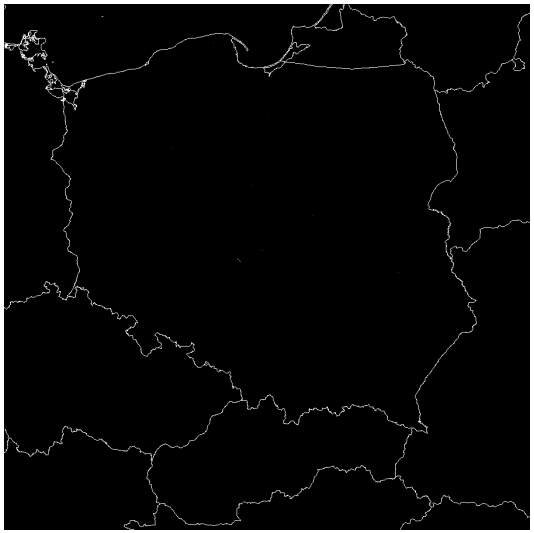


Case Study – stable situation - 20070413





AVHRR/NOAA RGB composition of channels 1/2/3 at 15/;15 UTC



Perun – no lightnings

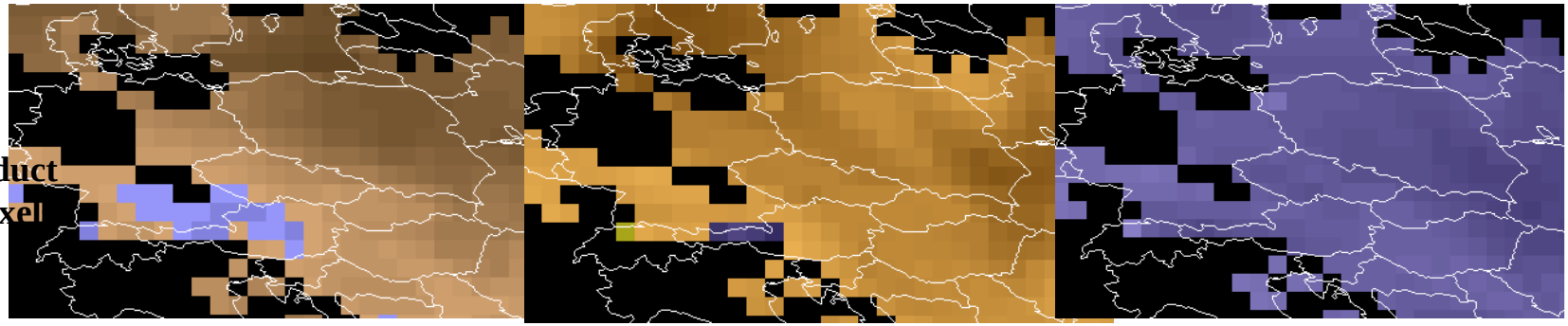
Example presented below show comparison between operational GII products and the same products calculated on local installation with full SEVIRI resolution, using two NWP models.

LI 11:00 UTC

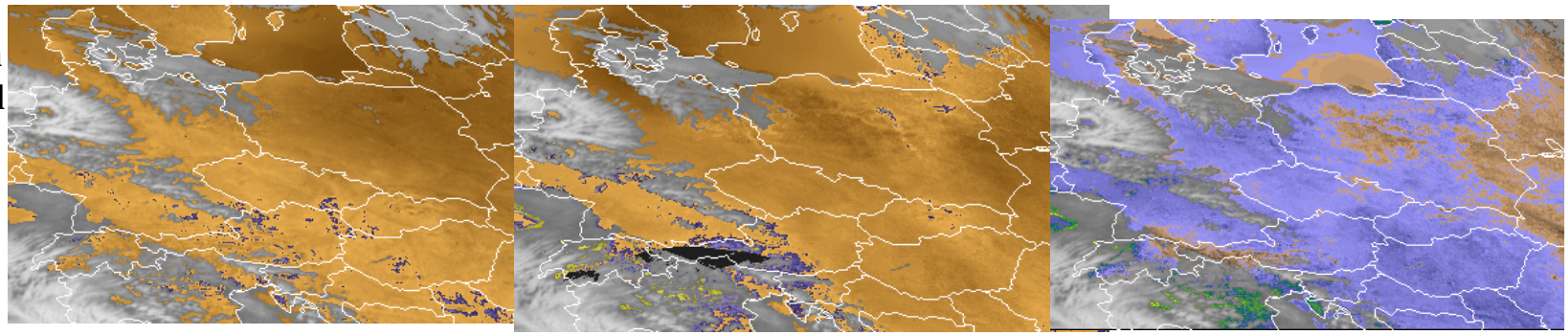
K-Index 11:00 UTC

PW 11:00 UTC

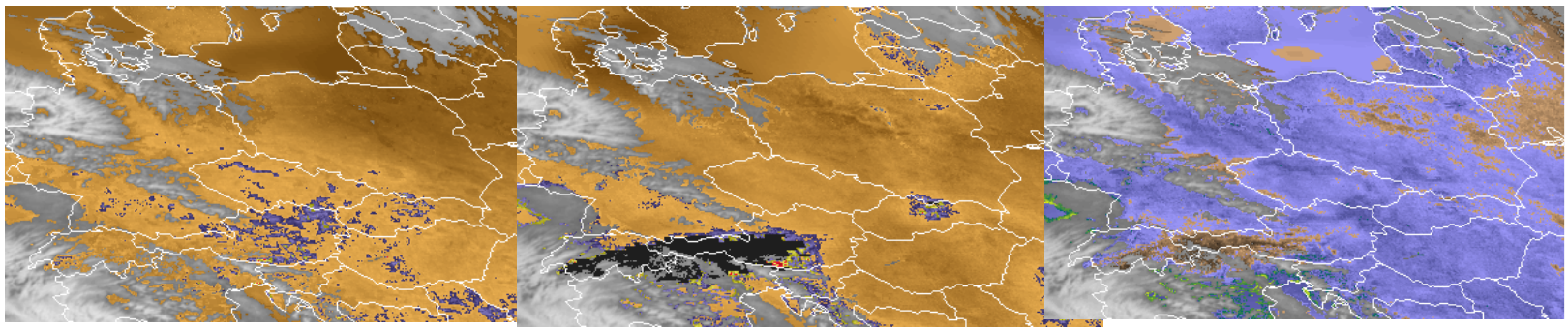
Original
MPEF GII product
15X15 Seviri pixel
First guess
ECMWF

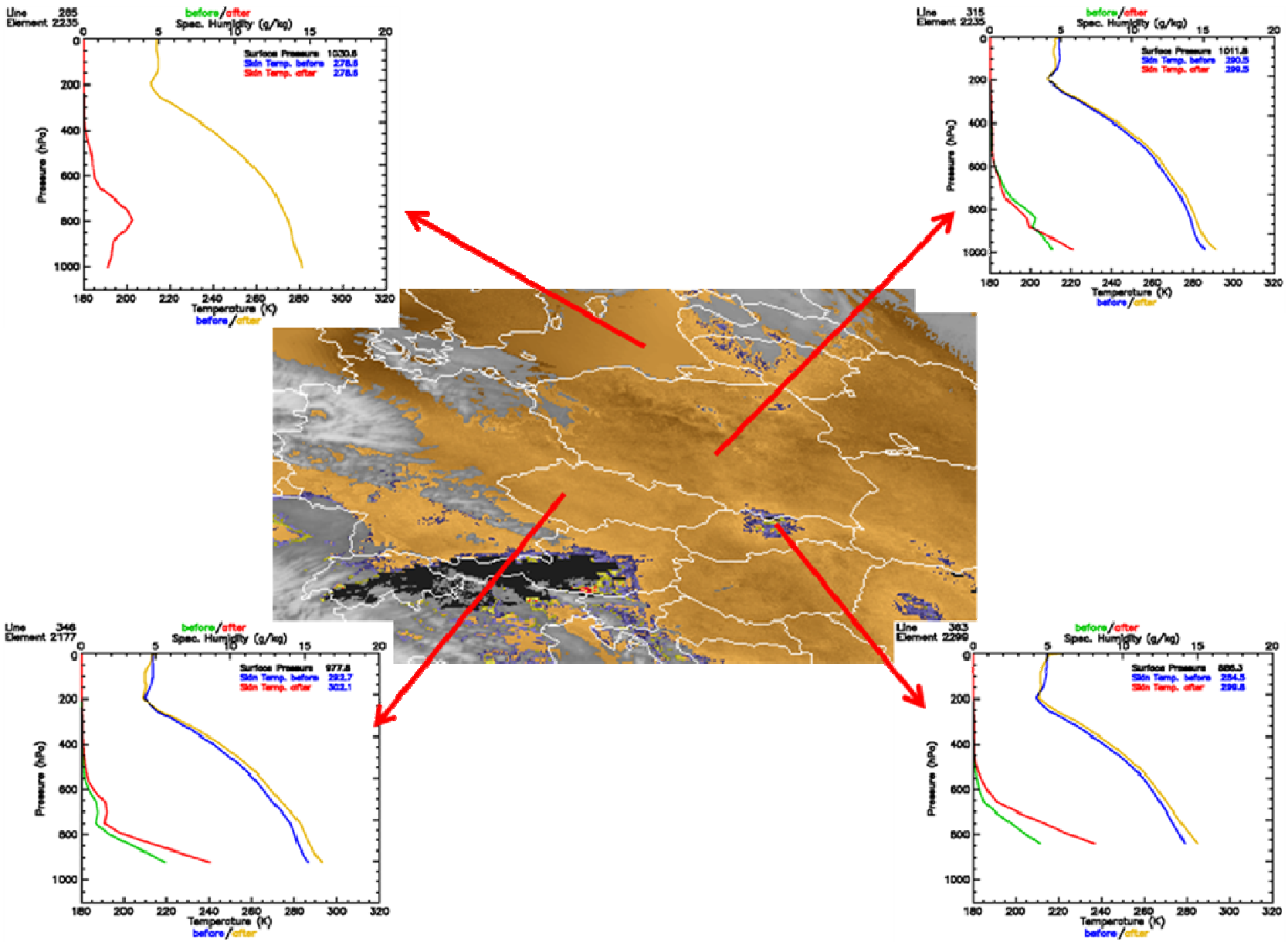


GII product with
1x1 SEVIRI pixel
resolution
First guess
ECMWF



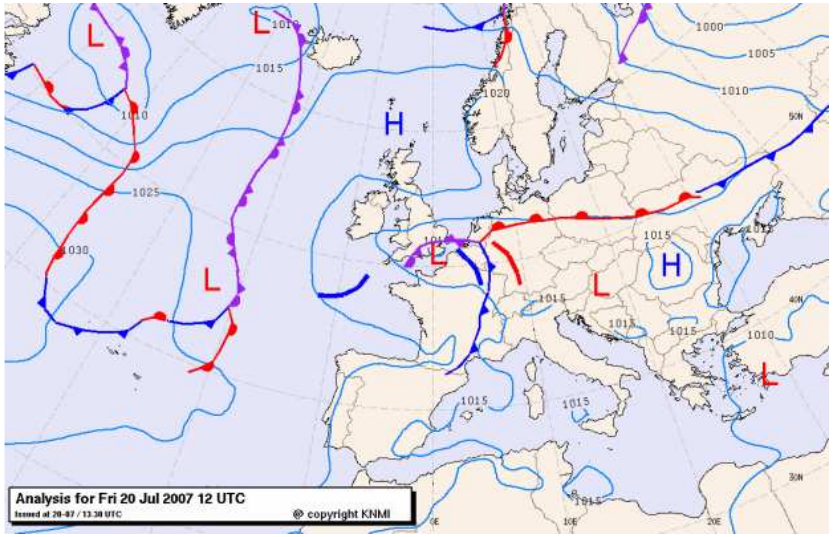
GII product with
1x1 SEVIRI pixel
resolution
First guess
ALADIN

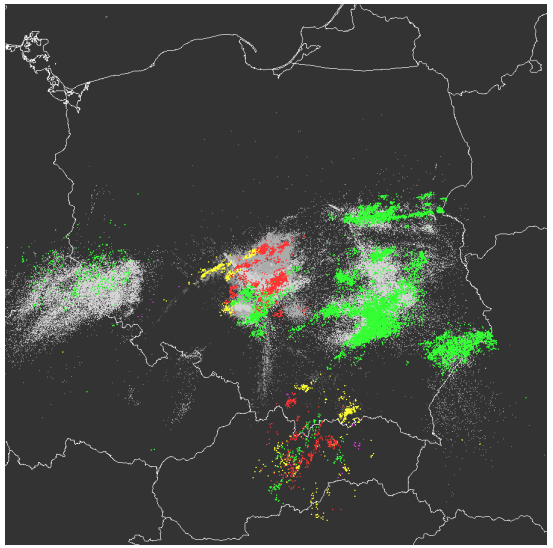




Case Study – stable situation - 20070413 – first gues and retrieved profiles

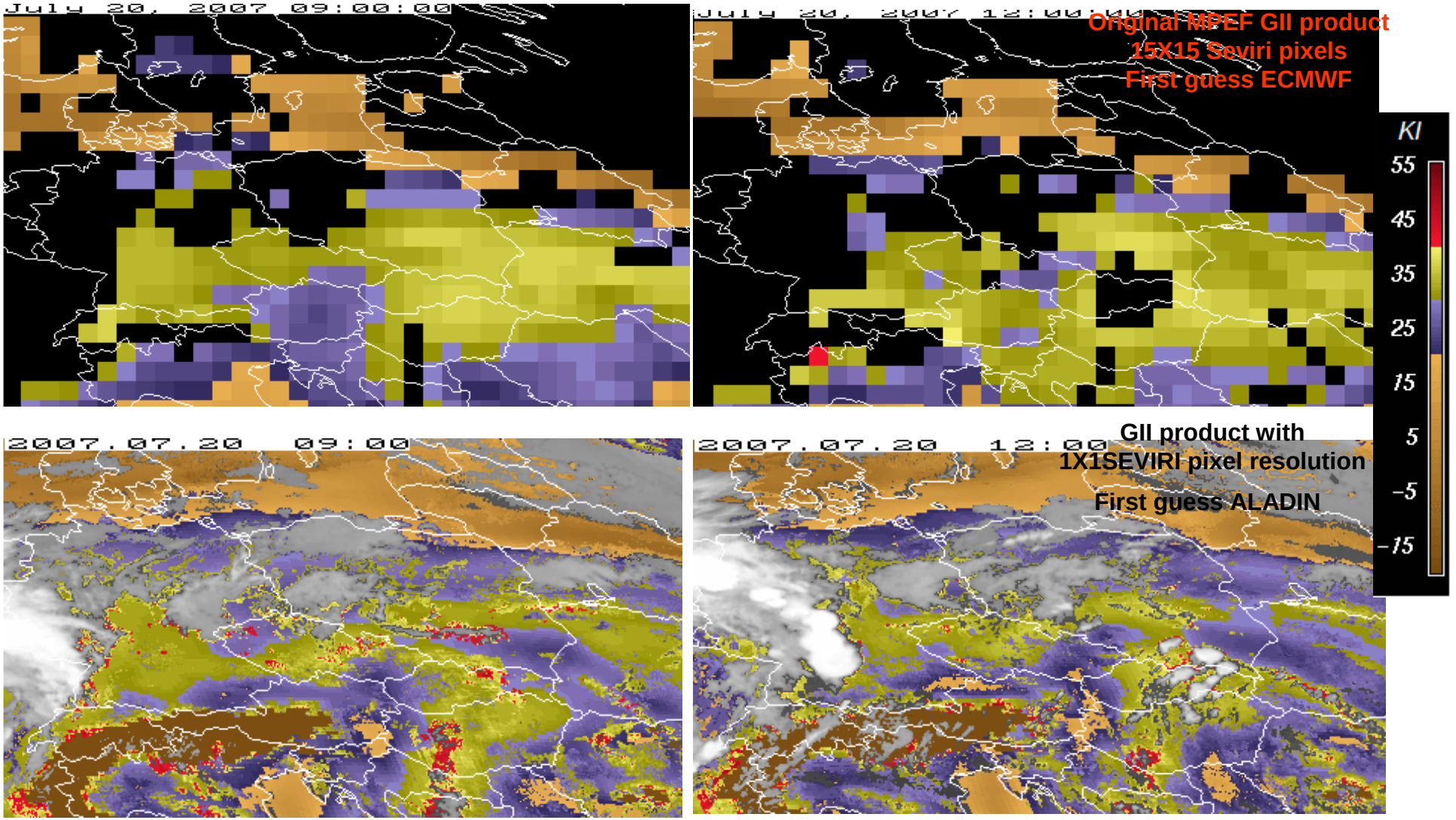
Case Study –unstable situation -20070720





Record high temperatures in South-Eastern Poland in whole history of measurements. Temperature reached 36 deg. C. At the same time in North-Western Poland was only 20 deg. C. High difference of temperatures between two airmasses resulted with rapid development of severe weather conditions.
Storm developing in South and South-Western part of Poland were gradually moving to East and North East direction covering practically half of country area.
Hail storms produced 3 cm hail stones.
In Czestochowa region, tornado causes large damages. Many buildings were destroyed, trees uprooted, electrical networks damaged. One person was killed by falling tree, 7 injured, 2 hit by lightings.

09:00 UTC K-Index 20070720 12:00 UTC



At 09 00 more unstable then at 12:00

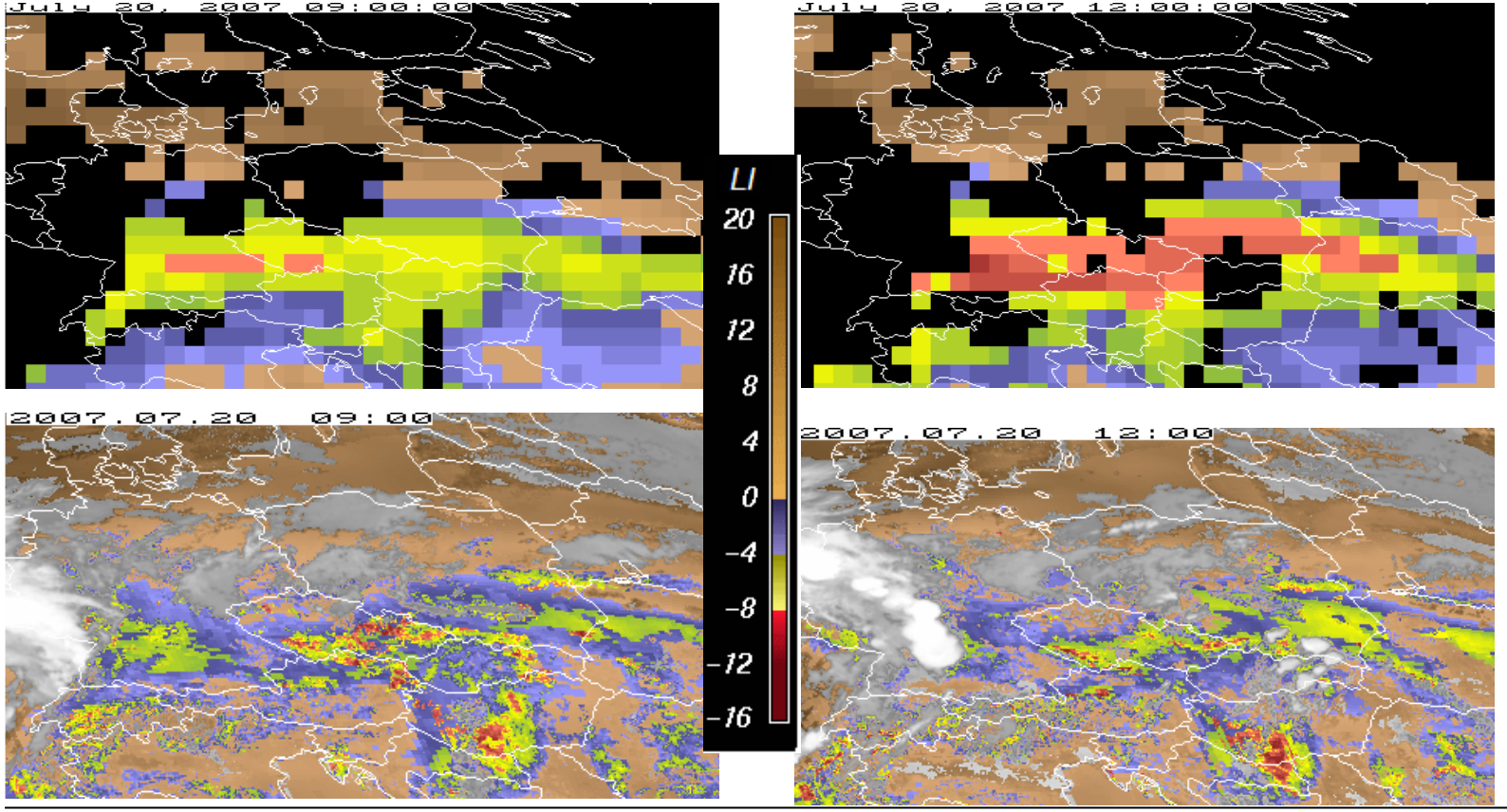
Resolution of 1 pixel - well depicted most unstable area.

Full SEVIRI resolution - high values at cloud edges – maybe compromise 3x3 SEVIRI pixels is the best ???

Lifted Index 20070720

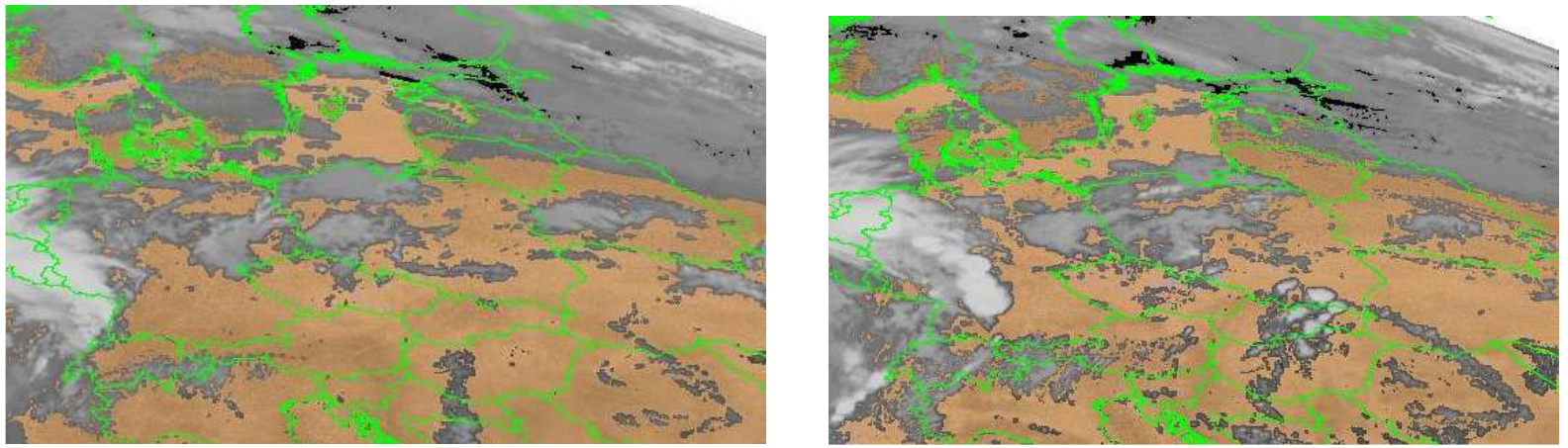
0900 UTC

1200 UTC



MPEF/GII

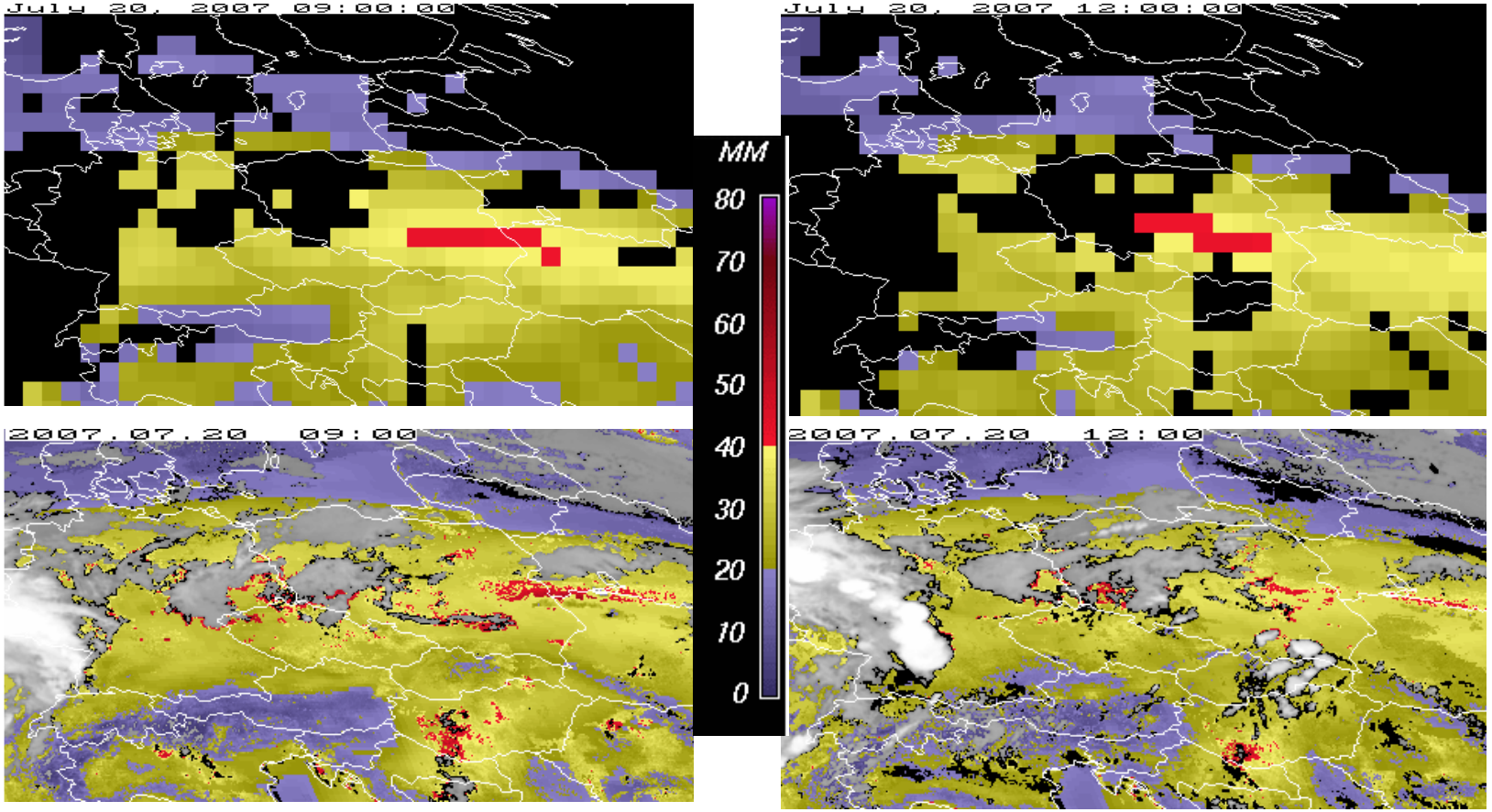
Local GII



NWCSAF_SAI

Perfectly stable

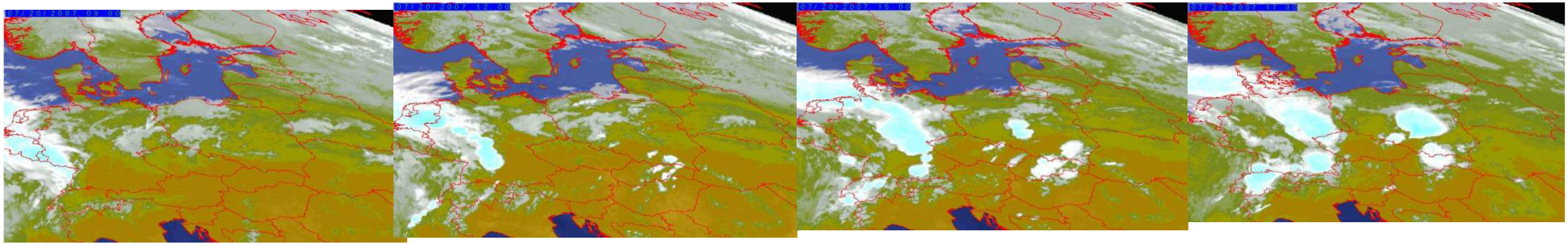
09:00 UTC Total Precipitable Water 20070720 12:00 UTC



MPEF/GII

Local GII

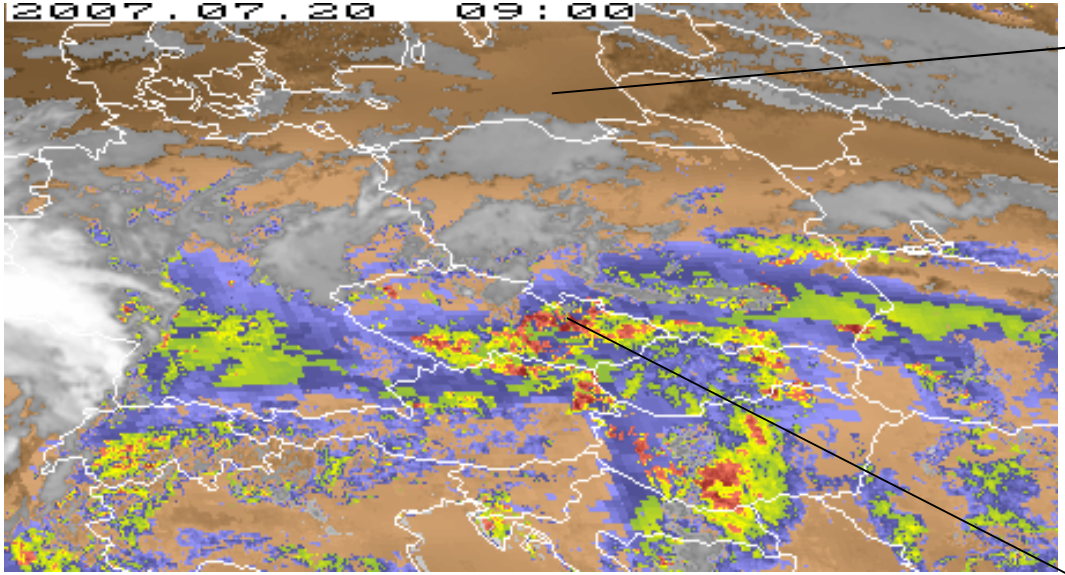
IR_10,8 mask 09:00 UTC 12:00 UTC 15:00 UTC 17:00 UTC

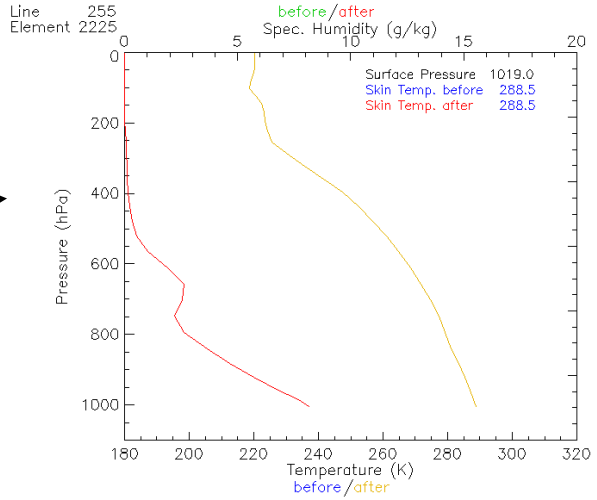


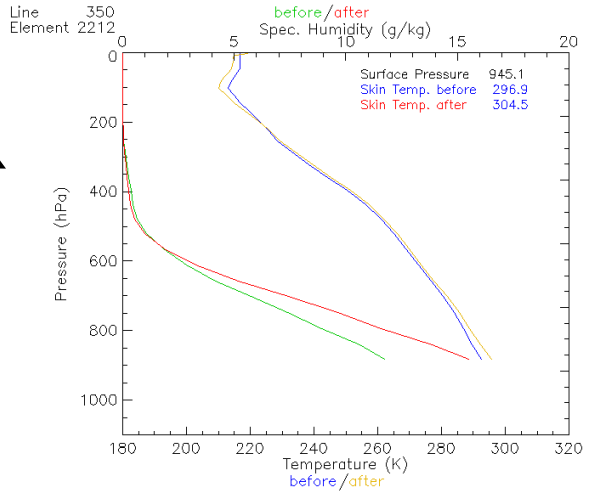
Lifted Index

Local implementation

09:00 UTC

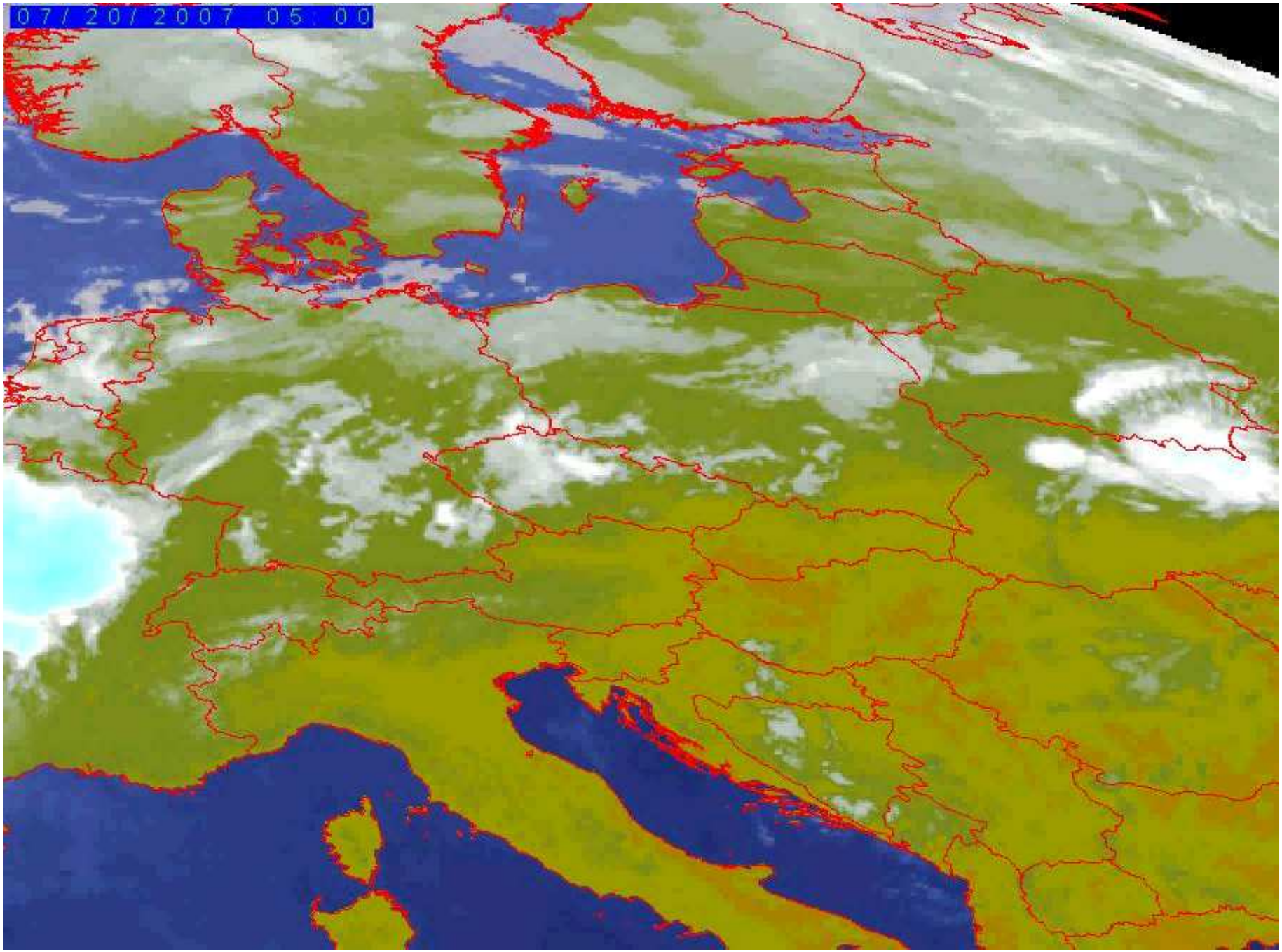






First guess and retrieved profiles of temperature and moisture

In different conditions (stable or unstable)- added value of satellite data.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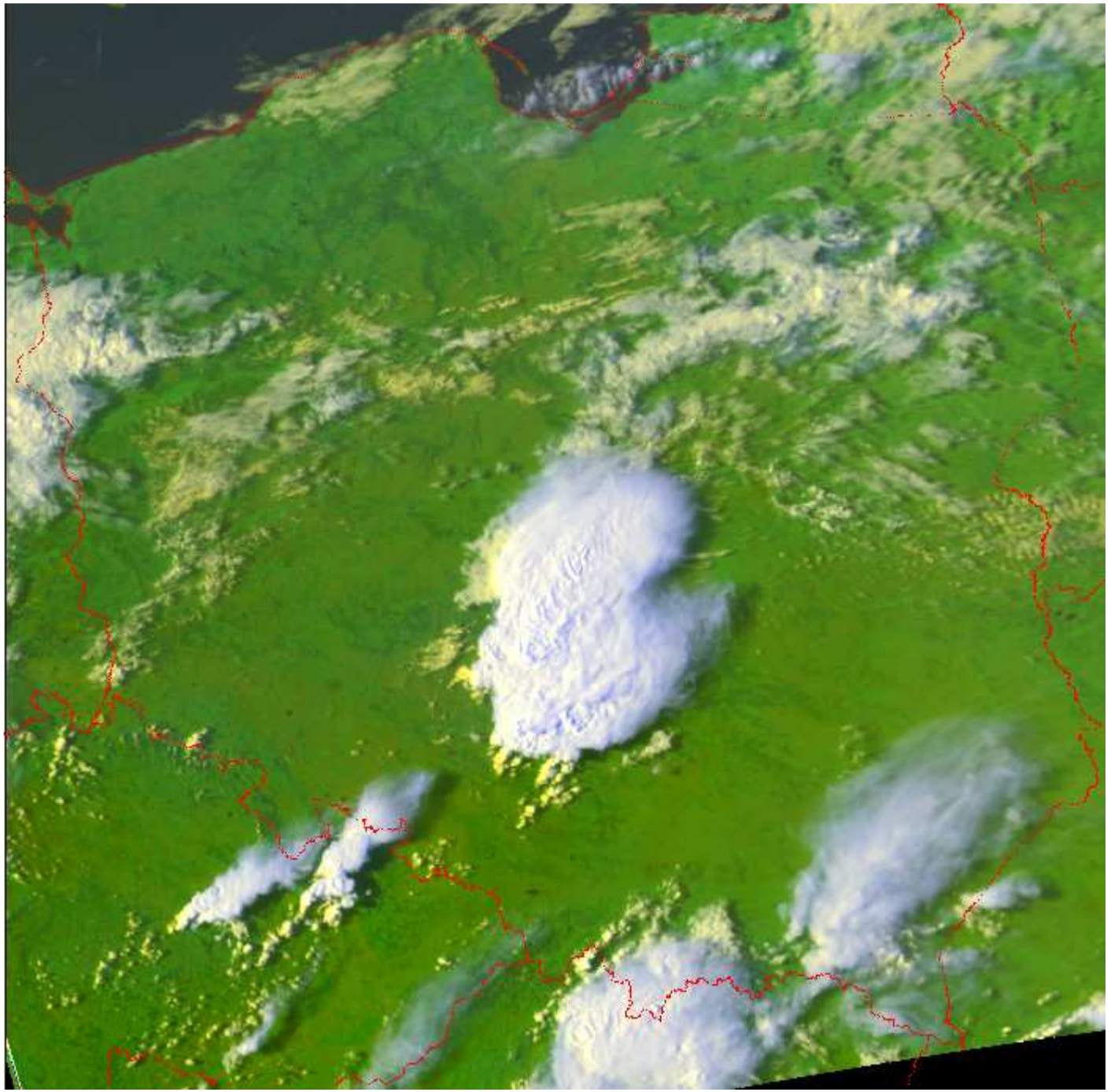

NOAA
RGB Composite
15:33


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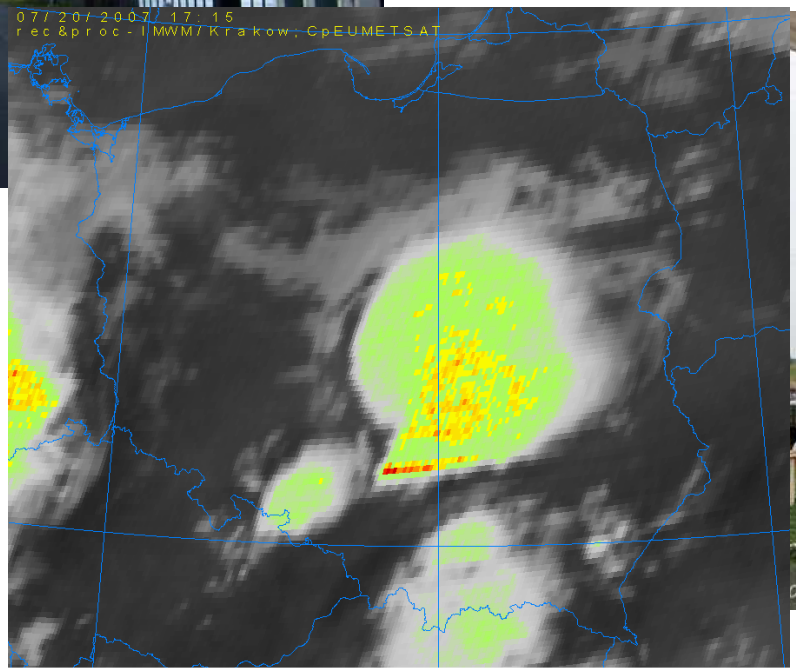
07/20/2007 17:15
rec&proc-IMWM/Krakow, CpEUMETSAT


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Validation of satellite derived stability indices:

- First validation studies – TOVS/NOAA retrieved indices vs. convective clouds presence.

- SAI investigations – much problems (PL completely stable) but conlusions presented to early (lost bet !!!)

- GII validation against lightning presence – very promising results. Problems with cloudiness and resolution.

- Case studies for comparison of first guess problem – continuaton needed.

But:

Convection development (specially storms) are not related only to unstable conditions !!!
More extended studies required.

Problem with cloudiness on the area of Poland:

	Number of cases				
April 2006	6:00	9:00	12:00	**Total**	
Cloudiness <30 %	8	6	1	**15**	16.8%
Cloudiness 30-70%	9	9	6	**24**	43.8%
Cloudiness >70 <100%	11	11	17	**39**	87.6% at least 1 pixel clear
Cloudiness 100%	1	4	6	**11**	
May 2006					
Cloudiness <30 %	7	7	1	**15**	16.3%
Cloudiness 30-70%	11	9	9	**29**	47.8%
Cloudiness >70 <100%	11	11	17	**39**	90.2% at least 1 pixel clear
Cloudiness 100%	3	2	4	**9**	

Results from statistics

2006 storm season

Contingency table K Index

1.04 - 31.08. 2006

	No lightnings	Presence of lightnings
KI <20° (stable)	**40** (correct negatives)	**5** (misses)
KI>20° (unstable)	**17** (false alarms)	**69** (hits)

Contingency table Lifted Index
1.04-31.05 and 7.07-31.08.2006

	No lightnings	Presence of lightnings
LI > 0° (stable)	**29** (correct negatives)	**16** (misses)
LI < 0° (unstable)	**9** (false alarms)	**42** (hits)

Typical categorical statistics indices:

	KI	**LI**
Probability of Detection	POD=0.93	POD=0.72
False Alarm Ratio	FAR=0.20	FAR=0.18
Probability of False Detection	POFD=0.30	POFD=0.24
Accuracy	0.83	0.74

Conclusions

- There is lack of perfect tool for determination of storm initiation area but stability indices are certain solution. Both unstable air presence and its dynamical changes may be used as storm predictors.
- The satellite observations contributed some additional information over the first guess, and these locations coincide well with the potentially unstable regions, which were not so well identified by the first guess.
- Full SEVIRI resolution of GII product is specially important in mid latitudes where cloudiness is part of the game. Number of clear pixels, where is possible to retrieve air stability indices, substantially grows with increased resolution.

- When generating GII with full SEVIRI resolution, use of NWP model with better spatial resolution increases quality of GII product.
- In unstable areas number of iterations during physical retrieval of profiles is larger then in stable places. Influence of satellite data is well seen. This is specially important for dynamic processes like deep convection.
- A few hour before severe weather conditions, GII gives proper warning. KI is more sensitive to early instability but shows much larger unstable areas then LI and gives more false alarms. LI gives reasonable information just before convection. More detailed area of possible convection. More missed prediction then KI.

ACKNOWLEDGMENTS

Presented work was done in cooperation between IMWM Poland and EUMETSAT Organization