# *Global Instability Index: Product Guide*

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EUMETSAT
Eumetsat-Allee 1, D-64295 Darmstadt, Germany
Tel: +49 6151 807-7
Fax: +49 6151 807 555
http://www.eumetsat.int

## *Document Change Record*

| *Issue / Revision* | *Date* | *DCN. No* | *Summary of Changes* |
|---|---|---|---|
| 1 | 06/10/2010 | | Initial document started as Factsheet |
| v1A | 08/10/2014 | | Document converted to Product Guide format |
| v1B | 10/12/2014 | | Added initial components for Product Guide and graphics |
| v1C | 02/09/2015 | | Review/corrections by subject matter expert. |

## *Table of Contents*

# 1 PRODUCT DESCRIPTION

Convective systems can develop in a thermodynamically unstable atmosphere. Such systems may quickly reach high altitudes and can cause severe storms. Meteorologists are thus especially interested in identifying such storm potentials while the system is still in a pre-convective state. A number of instability indices have been defined to describe such situations. Traditionally, these indices are taken from temperature and humidity soundings by radiosondes. As a sounding is effectively only a point measurement done only a few times a day, indices derived from satellite data offer a superior temporal and spatial resolution.

The GII product consists of a set of indices which describe the stability of the atmosphere. Note that these indices are highly empirical in nature and might even be only relevant in certain geographic regions or under certain circumstances. Usually, each of these indices is defined such that it describes a potentially unstable layering if it exceeds a certain threshold. The GII product comprises four common instability indices together with information about the precipitable water content:

- K-Index
- KO Index
- Lifted Index
- Maximum Buoyancy
- Layer precipitable water content as an air mass parameter
  - layer precipitable water values for low level—surface to 850 hPa
  - layer precipitable water values for mid level—850 hPa to 500 hPa
  - layer precipitable water values for high level— above 500 hPa
- Total precipitable water

Illustrations of all of these indices outputs are in Section 3.

# 2 PRODUCT SPECIFICATIONS

| *Category* | *Specification* |
|---|---|
| **Type** | Meteorological Product |
| **Applications and users** | Nowcasting, severe weather |
| **Product Distribution** | • EUMETCast<br>• EUMETSAT Data Centre |
| **Product Area** | FES Area |
| **Product Resolution** | FES: 3 × 3 pixels |
| | • EUMETCast: every 15 minutes for these products: 00:00, 00:15, 00:30, …23:45 UTC<br>• EUMETSAT Data Centre: every 15 minutes for these products: 00:00, 00:15, 00:30, …23:45 UTC |
| **Product Format** | BUFR |
| **Product Size** | about 9.0 MB (variable) |

## 2.1 Product history and gaps in coverage:

| | | |
|---|---|---|
| Initial development and baseline: | 27 Nov 2000 | |
| Substantial Revision | 16 Sep 2001 | |
| Substantial Revision | 01 July 2005 | Major change in algorithm implementation. |
| Substantial Revision | 29 Oct 2009 | Layer Precipitable water content parameters added to the product |
| Substantial Revision | 17 Feb 2011 | Resolution for GII product for 0° service increased from 15 × 15 to 3 × 3 pixels |
| Substantial gaps in coverage | None | |

# 3 PRODUCT ILLUSTRATION

## 3.1 Precipitable water

Figure 1 presents the total precipitable water content retrieved over the full disk. Co-located radiosonde observations of the same parameter are shown in the white boxes. The black areas delineate clouds, where no retrieval is possible, or the region outside the processing area.

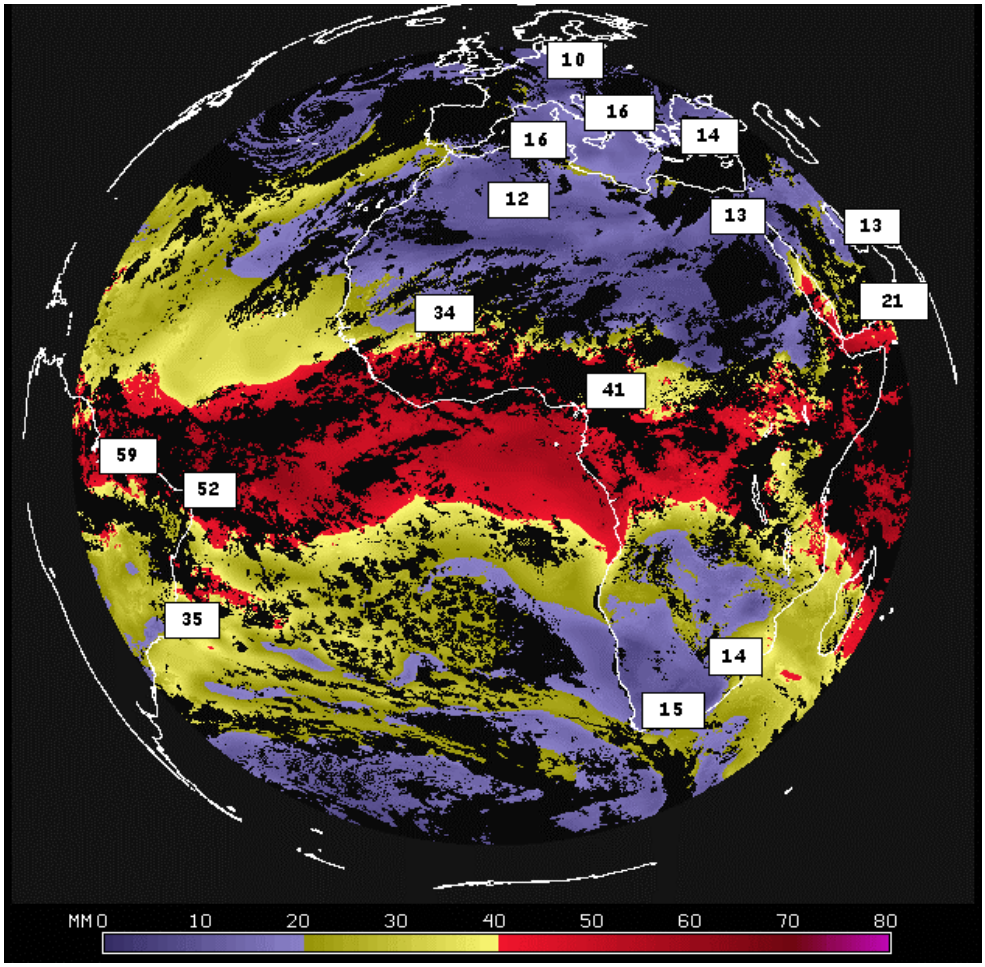


*Figure 1: Total Precipitable Water content.*

## 3.2 Lifted Index

Figure 2 is an example of the Lifted Index retrieved over Central Eastern Europe. With Lifted Index negative values indicate potential instability. On this particular day the air mass over the region was rather unstable, shown in the yellow and red colours on this picture. The collocated radiosonde observations (white boxes) support the satellite retrieval. Again, black areas are clouds or the region outside the processing area.

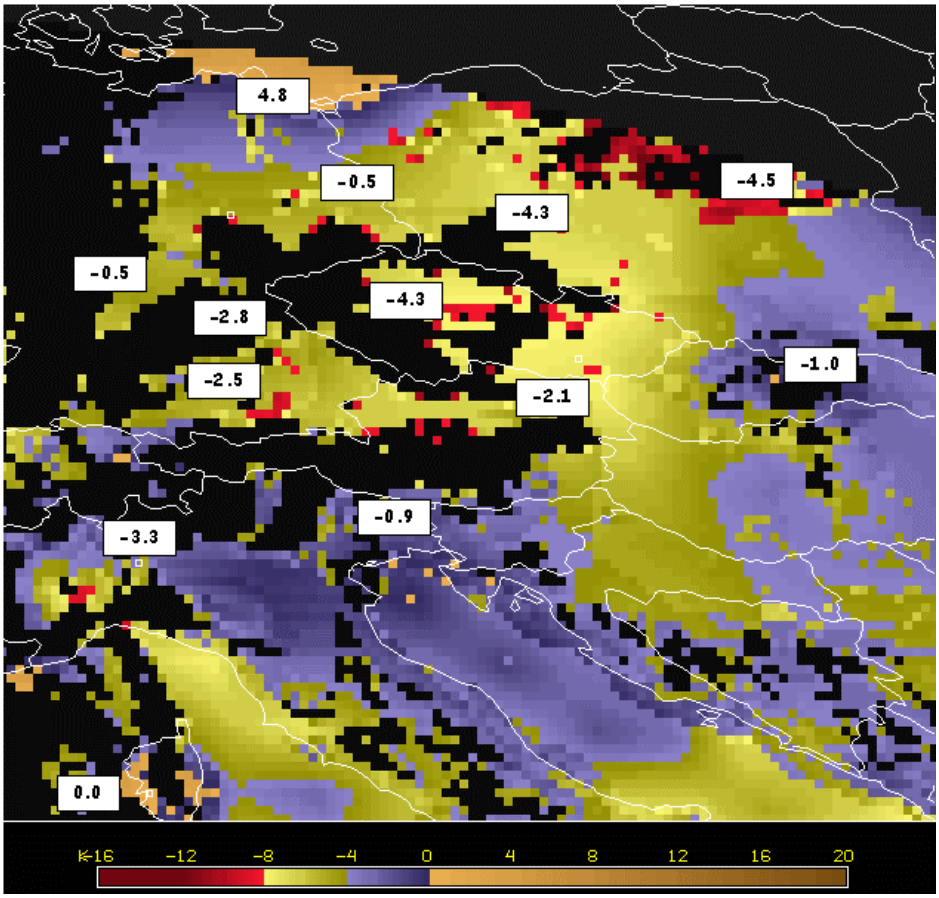


*Figure 2: Lifted Index 5 June 2003 at 09:00 UTC.*

The skill of the Lifted Index in Nowcasting is clearly shown in the two maps in Figure 3. The left panel shows the Lifted Index on 5 June 2003 at 09:00 UTC, where an unstable air mass (yellow to red) is identified over eastern Germany and Poland under cloud-free conditions. The right panel shows the IR10.8 image taken some hours later, at 14:30 UTC, which shows the large convective cells that have formed in this unstable air mass. The image in the right panel is taken from the animation sequence available on the EUMETSAT web page. See Section 5 for links and references to this web page.

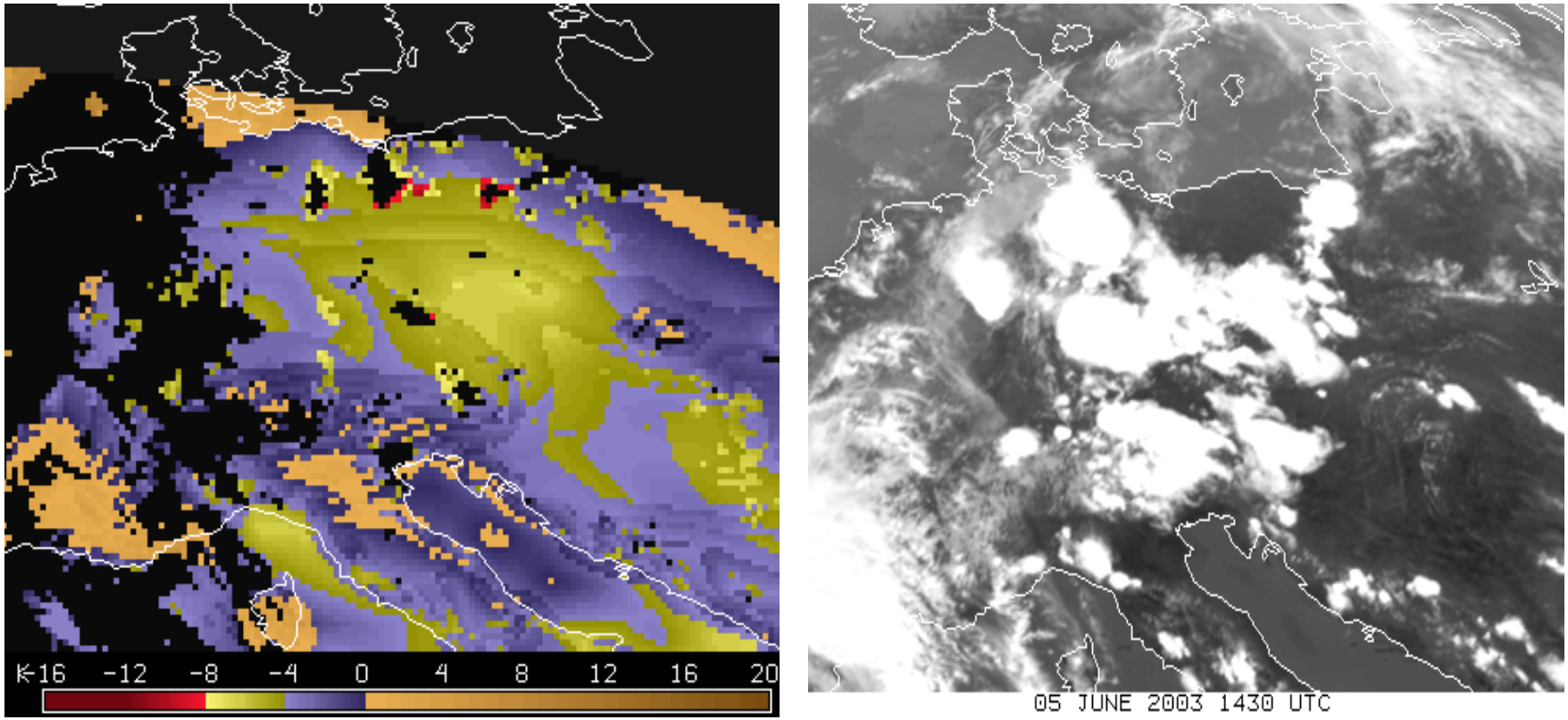


*Figure 3: Left, Lifted Index 5 June 2003 at 09:00 UTC. Right, IR10.8 image at 14:30 UTC.*

## 3.3 Lifted Index and Precipitable Water combined

In Figure 4, the Lifted Index and the Total Precipitable Water content products on 6 January 2005 at 06:00 UTC over South Aftrica are presented. The north-eastern part of the region shows a zone of moist and potentially unstable air, while the south-western part of South Africa is much drier and, hence, indicates much more stable atmospheric conditions.

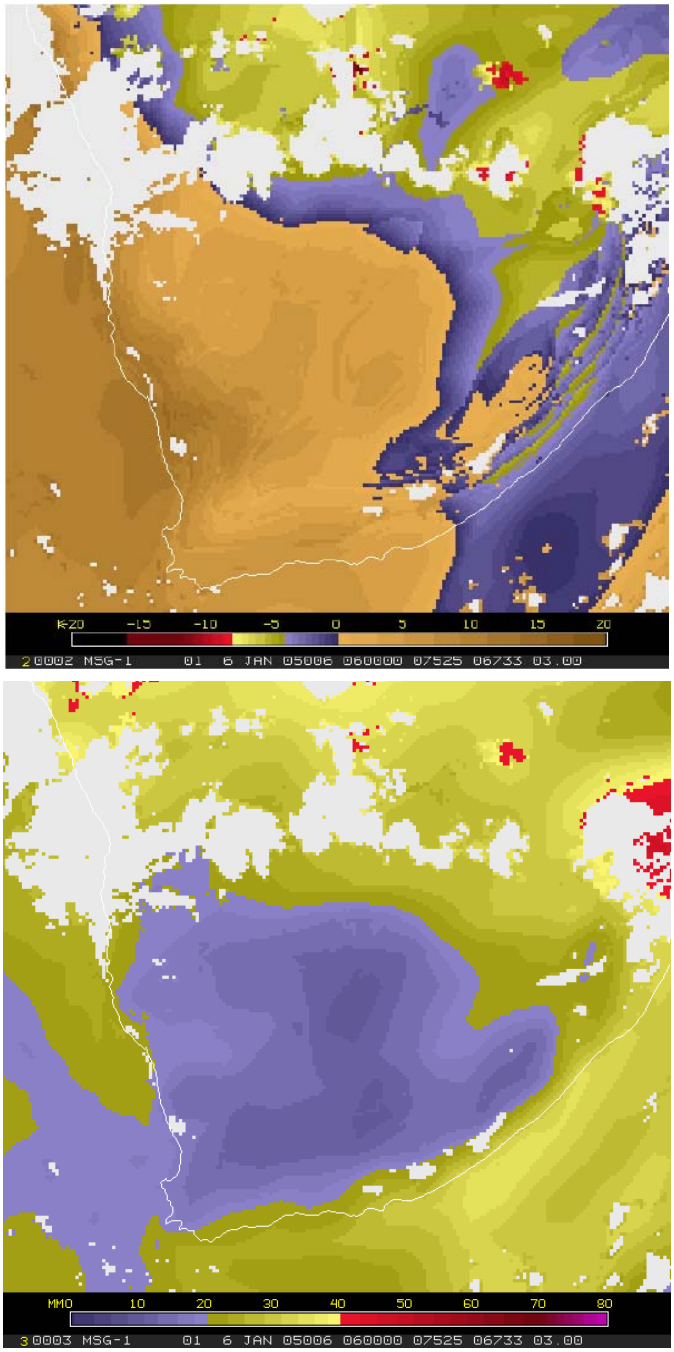


*Figure 4: Lifted index (top) and Total Precipitable Water content (bottom) on 6 January 2005 at 06:00 UTC.*

Figure 5 shows the IR 10.8 image on 6 January at 12:00 UTC. The potentially unstable air mass in the north-eastern region shows the onset of convection, identified 6 hours earlier in Figure 4. Note that the boundary of the convective clouds clearly follows the same curve as the boundary that separates unstable air (brown) and stable air (blue) in Figure 4. There are animated sequences of these maps in the EUMETSAT Image Library.

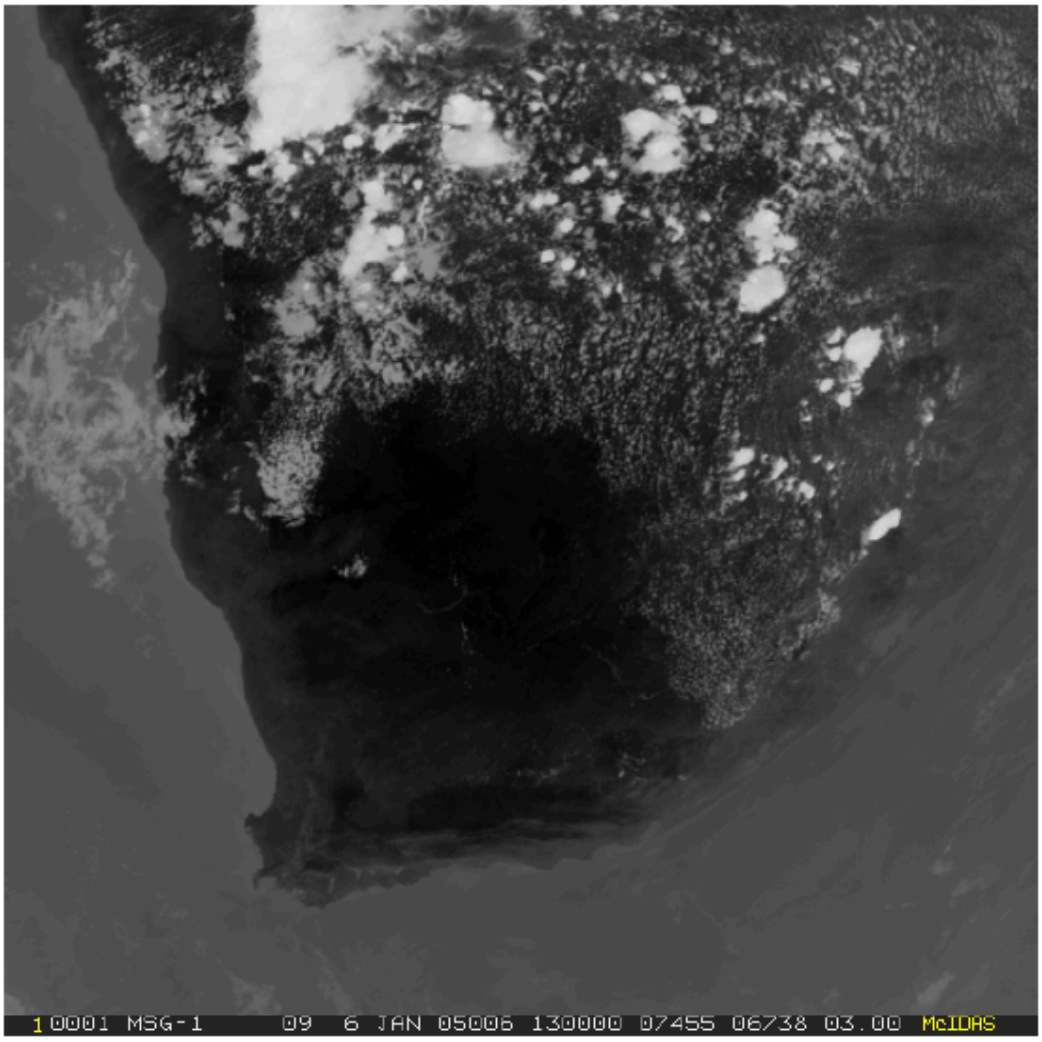


*Figure 5: Image taken from animation sequence for IR 10.8 on 6 January 2005, 06:00 UTC.*

## 3.4 Case Study over Central Eastern Europe

The images in Figure 6 illustrate a case of strong convection over Poland, Austria, the Czech Republic, and the Baltic region on 30 July 2005. This convective activity was not associated with any frontal systems. There are cloud-free midday conditions on the 12:00 UTC IR 10.8 image, but heavy late afternoon storm activity occurs later in the evening. The convective storms are circled in red on the 18:00 UTC image on the right.

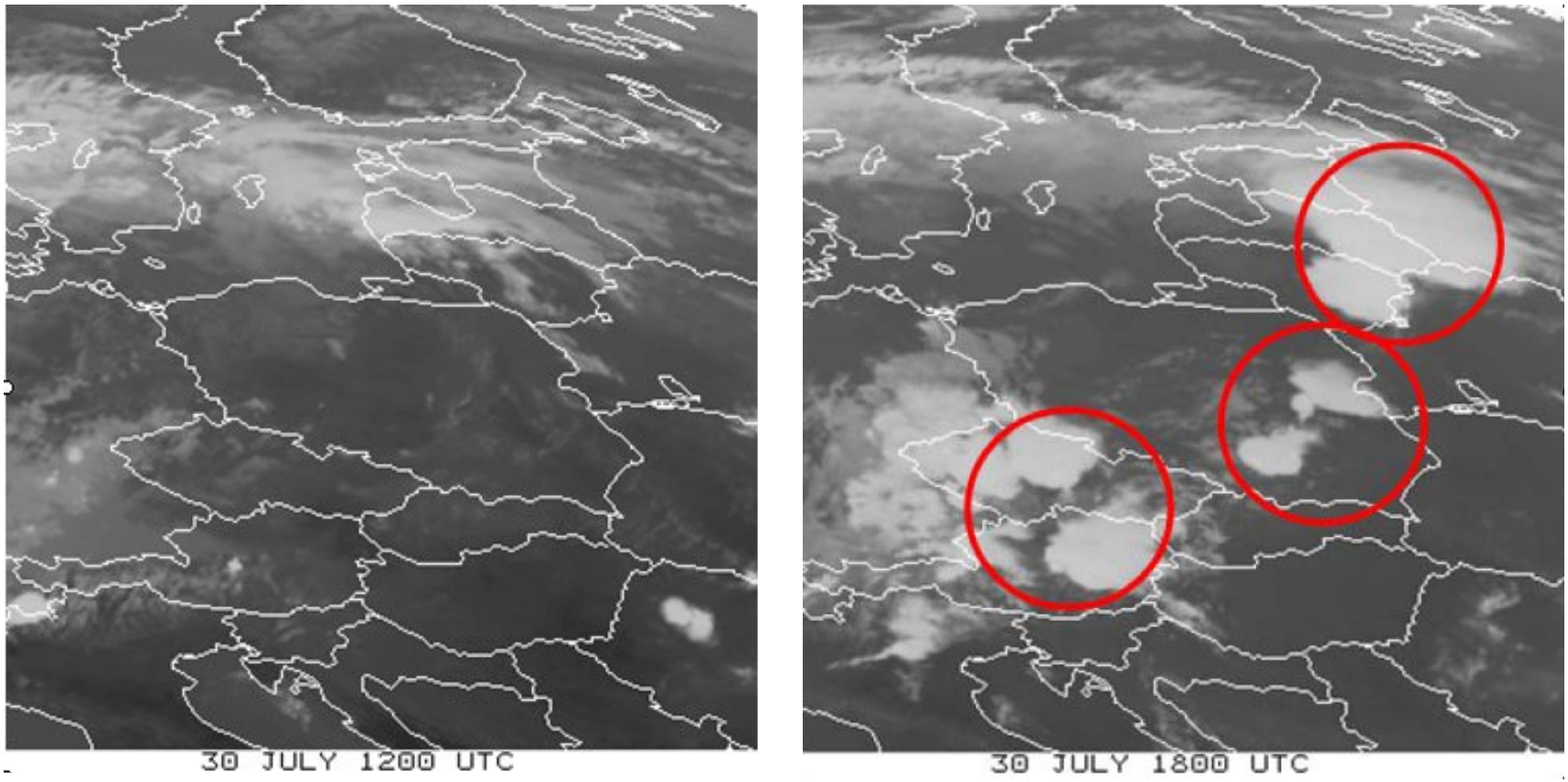


*Figure 6: Images of convective activity for 30 July 2005, 12:00 and 18:00 UTC.*

Figure 7 shows the GII K-Index (top) and Lifted Index (bottom) on 30 July at 12:00 UTC. Increased instability can be identified with both indices: KI greater than 35 degrees (yellow/red), LI less than –8 degrees (red). These areas match well with the convective activity (circled red) in Figure 6. Note that the Baltic region was already covered by lower clouds at 12:00 UTC, so no instability indices could be derived for this area. Therefore, the GII product could not provide information about the potential storm development in this area.

This is another good example of how instability indices derived from the GII product are applied to Nowcasting and short-term weather forecasting.

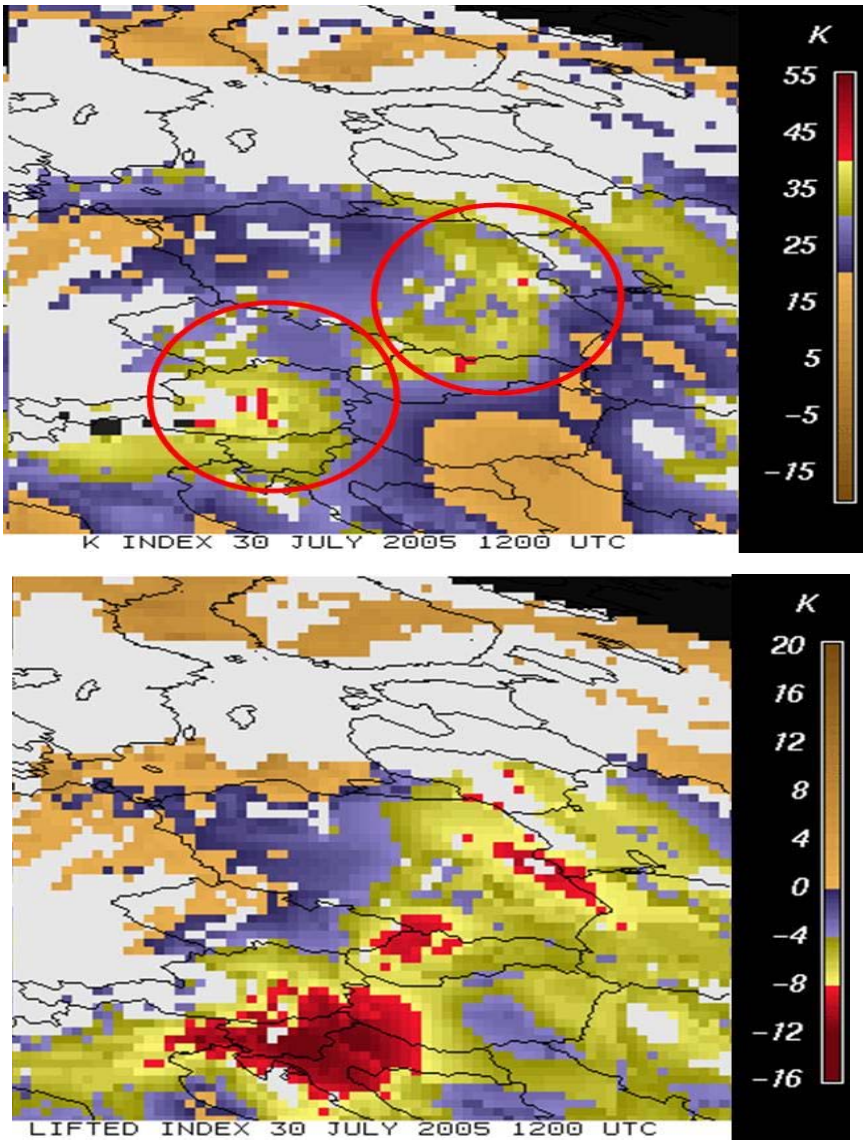


*Figure 7: K Index and Lifted Index for 30 July 2005 at 12:00 UTC.*

# 4 BASICS OF THE ALGORITHM

## Description of the Indices:

The Global Instability Index (GII) and products use MSG-SEVIRI observed brightness temperatures plus some additional data to generate indices of atmospheric instability for Nowcasting of severe weather. We list only the indices calculations here. See Section 5 for document references with complete algorithm descriptions and values tables.

### Lifted Index

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

where:

| | |
|---|---|
| $T^{obs}$ | is the observed temperature |

### K Index

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

where:

| | |
|---|---|
| $T^{obs}(x)$ | is the observed temperature at x hPa height |
| $TD^{obs}(x)$ | is the observed dew point temperature at x hPa height. |

### KO Index

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

where:

| | |
|---|---|
| $\Theta_e^{obs}(x)$ | is the observed equivalent potential temperature at x hPa height. |

### Maximum Buoyancy

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

where:

| | |
|---|---|
| $\Theta_e^{obs}$ | is the observed equivalent potential temperature |

### Precipitable Water

$$W = \frac{1}{g}\int_{surface}^{0} q(p)dp$$

# 5 REFERENCES AND LINKS

## 5.1 Reference Documents

| *Type* | *Document Name* | *Reference* |
|---|---|---|
| Validation Report | MSG-3 System Commissioning Product Validation Test Report | EUM/MSG/REP/12/0190 |
| Detailed Algorithm | The Global Instability Indices Product. Algorithm Theoretical Basis Document | EUM/MET/REP/07/0164 |
| Detailed Algorithm | GII Physical Retrieval Algorithm description | EUM/MET/DOC/04/0155 |

## 5.2 Online Resources and Assistance

All of the reference documents listed above can be found on the EUMETSAT Technical Documents page.

http://www.eumetsat.int > Satellites > Technical Documents > Meteosat Services > 0° Meteosat Meteorological Products

An excellent training presentation for the product can be found on the EUMETSAT Training Library:

http://www.eumetsat.int > Data > Training > TrainingLibrary (use the product filter “Instability”)

There are product animation movies on the image library page on the EUMETSAT web site.

www.eumetsat.int > Images > Image Library (Choose Global Instability Index in the *Product* field of the Product Navigator.

To register for data delivery from this product, go to the Data Registration page on the EUMETSAT web page:

www.eumetsat.int > Data > Data Delivery > Data Registration

To get answers to any of your questions about data delivery, registration or documentation, contact the EUMETSAT User Service Help Desk:

**Telephone**: +49 6151 807 3660/3770
**e-mail**: ops@eumetsat.int