A local version of the GII in South Africa – comparisons to verify the value of this product as an operational nowcasting tool

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1. Introduction

A local version of the EUMETSAT MPEF GII product was installed in South Africa in September 2007. This Regional Instability Indices (RII) product is based on the same MSG channels as the MPEF products, but relies on the South African version of the Unified Model (UM) instead of ECMWF. This implies that the RII's horizontal resolution has improved from 1 degree to 0.1 degrees and the local product – running on local servers – can do the calculations in 3X3 pixels instead of 15X15 pixels. The computation of the Lifted Index has also been adjusted to local conditions and thus differs in magnitude from the GII's Lifted Index.

Specific case studies have been selected in order to demonstrate the usefulness of the RII product as an operational nowcasting tool in South Africa. Experimental results from statistical comparisons between RII and sounding data over South Africa, as well as RII and lightning activity during convection, will be shown. It will also be shown how the additional benefits of the RII product adds value to the UM's instability indices.

2. Evaluation of GII and RII products against sounding data in South Africa

The K Index (KI), Lifted Index (LI) as well as Precipitable Water (PW) were evaluated against soundings done twice daily at nine places across South Africa over five of the summer months. For the KI the correlation coefficient was above 0.7 for GII and between 0.5 and 0.7 for RII. The LI correlation coefficients were almost the same for GII and RII and varied between 0.6 and 0.71. Correlation coefficients for PW were the highest – all above 0.7, up to 0.9. The GII's correlation coefficients were almost always higher than the RII's. It would, however, not be fair to conclude that the RII is performing worse than GII, since so many things vary between the two methods:

- Two different models with different parameterization schemes
- Model resolutions differ (0.1° for Unified Model and 1° for ECMWF)
- For GII the output is the average value in a 15x15 pixel block, whereas the RII is the exact value at the latitude and longitude of the upper-air sounding station.

3. Evaluation of GII against lightning data for a few case studies

A more quantitative evaluation method was developed to show the accuracy of these parameters when compared to the occurrence of lightning over South Africa. In this method a contingency table approach was used to calculate the Probability of Detection (POD), False Alarm Ratio (FARatio) and Accuracy (ACC) of KI and LI of the GII product. Extreme values of LI and KI were used for the 15X15 block – i.e. the maximum K index and the minimum Lifted Index between 04:00 and 08:00 and compared against the occurrence of lightning between 11:00 and 18:00 GMT. The occurrence of lighting was seen as confirmation of convective activity. If the LI was less than -5° and more than 5 lightning strokes occurred in a 0.4°X0.4° block (~15X15 pixels) later in the day, the forecast was considered to be correct. Similarly if the KI was more than 35° and more than 5 strokes occurred in this block, it was considered a hit. For 8 case studies of 2007 and 2008, the average POD for the KI was 78%, the FARatio 27% and the ACC 74%. Based on these few cases it thus proved to be a valuable tool for short range forecasting of thunderstorms.

Due to the various differences mentioned in the previous paragraph, it was not worthwhile to do a similar evaluation of the RII indices and compare the values.

4. Another index added to the RII suite of indices

Various forecasters and other users of the GII products expressed the need to have a GII index which not only says something about the probability of thunderstorms, but also something about the possible severity. In this vein the Total Totals index was added to the list of RII parameters, defined as:

$$TT = T850 + Td850 - 2\,T500$$

where:

T850 is Temperature at 850 hPa,

Td850 is Dew point temperature at 850 hPa and

T500 is Temperature at 500 hPa.

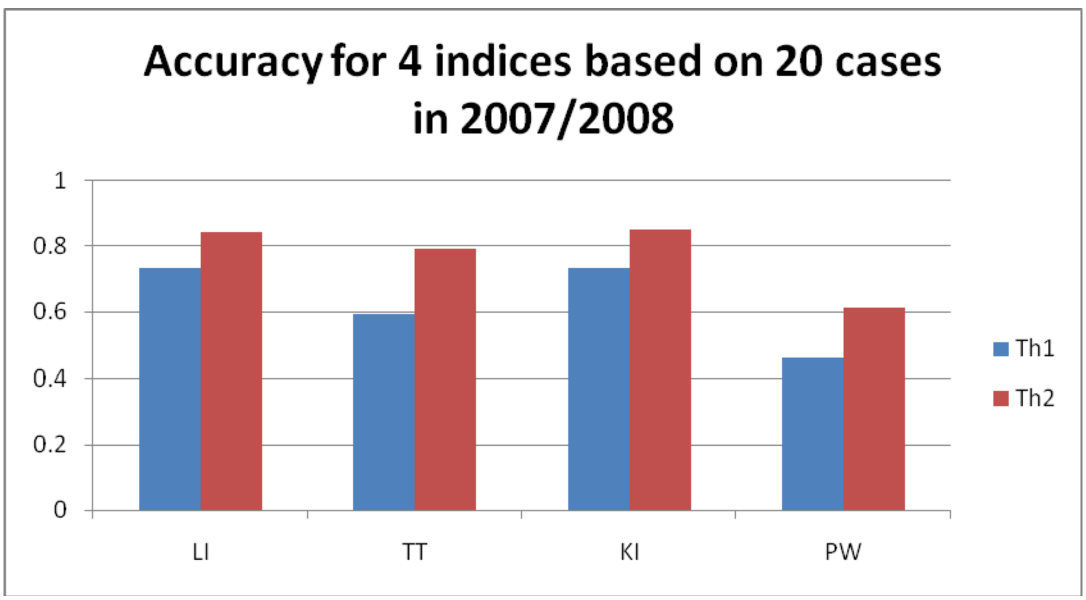
Values of TT which are significant:

<44	Convection not likely
44-50	Likely thunderstorms
51-52	Isolated severe storms
53-56	Widely scattered severe storms
>56	Scattered severe storms

This index was then also evaluated against the occurrence of lightning. A new scheme was used based on a 0.1°X0.1° block , and using the average value for each index (not the extreme values) over the 04:00- 08:00 time period. For each index, two thresholds were chosen and it was compared to the occurrence of one lightning stroke (in this smaller block). Again, the POD, Probability of False Detection (POFD) and Accuracy were calculated based on a contingency table. The chosen thresholds were:

Parameter	Threshold 1	Threshold 2
PW	>20mm	>24mm
KI	>30°	>35°
LI	<-2°	<-4°
TT	>44	>48

Twenty cases over the summer period of 2007/8 were used to do an evaluation against lightning and the accuracy displayed graphically looked like this:



On average the Accuracy was 63% for Threshold1 and 77% for Threshold2.

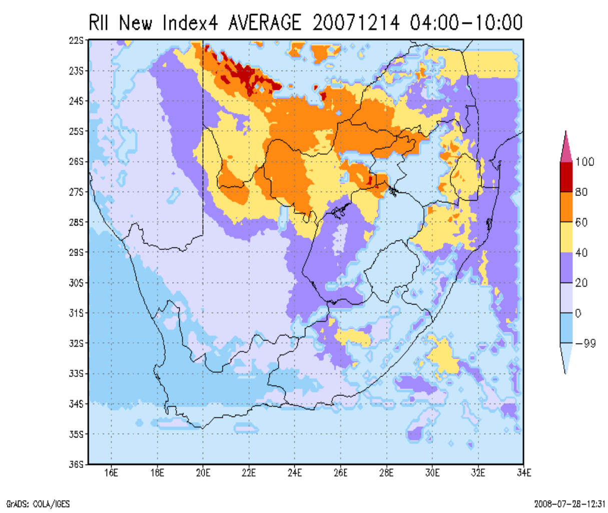
5. A new combined parameter developed based on all four of the above mentioned parameters

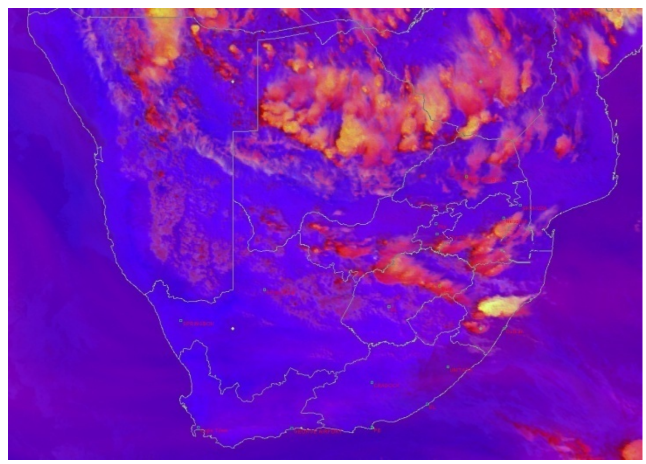
Instead of just adding the TT to the suite of parameters forecasters use every day, it was decided to try to combine these parameters into a single map, given in easy terminology (percentages). For each of the four parameters the following was done based on 20 cases:

- Verify the parameter in the early morning (04:00- 08:00GMT) against the occurrence of lightning later in the day (11:00-18:00)
- Compile a “look-up” table, where a value of the index corresponds to a percentage chance that lightning will occur at that value.

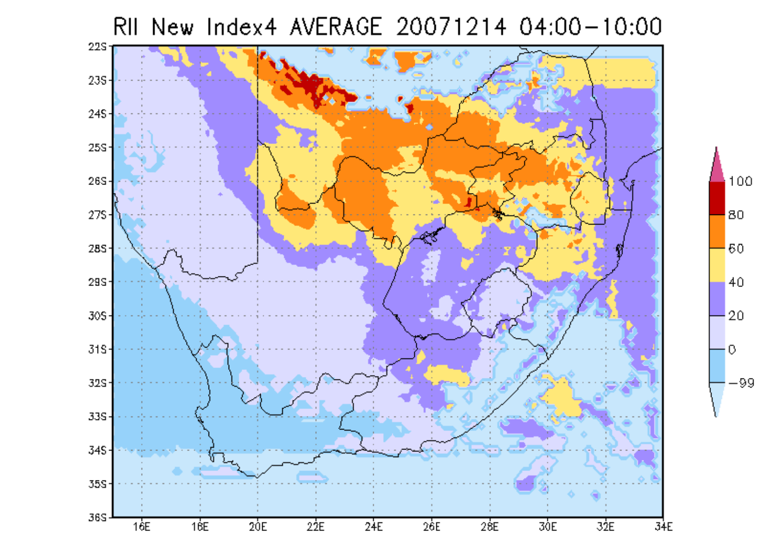
The four parameters’ look-up table values were then averaged to get the New Index in probabilities. Instead of using the new combination in 15 min time steps, it is only calculated as a 6 hour time average. This contributed to better areal coverage and more consistency.

The New Index for 14 Dec 2007 (at 10:00 GMT) is shown below left and the Convection RGB for 15:00 GMT below right:



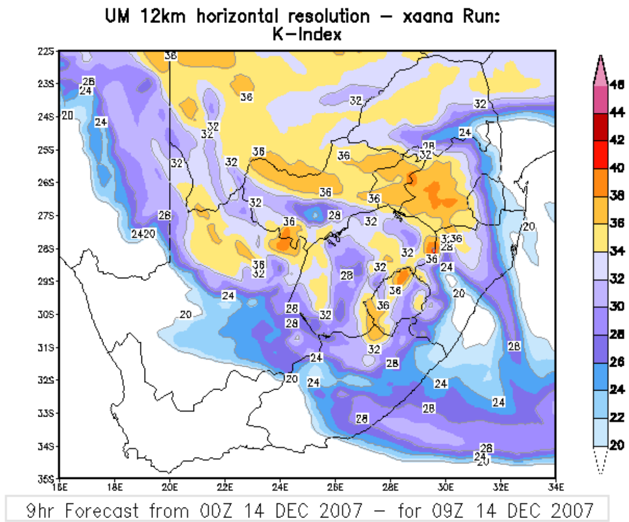


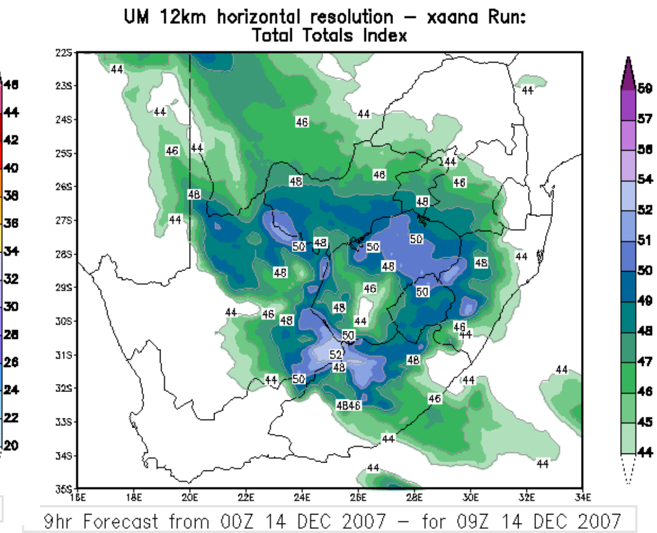
Visually the New Index compared well with the occurrence of convection later in the day. A problem was that the high-lying ground (eastern parts of SA) cannot be covered since both the KI and TT depend on 850 hPa values in the calculations, and since these areas are higher than 850 hPa, the New Index over these areas shows a ‘default’ value of -99 (light blue). A first attempt to solve this, was to use only PW and LI in these areas and then just divide by two instead of four. A better solution might be to use



the Elevated Total Totals (using 700 hPa instead of 850 hPa) – this will be addressed at a later stage. The New Index then had a much more continuous and smooth outlook (shown to the right).

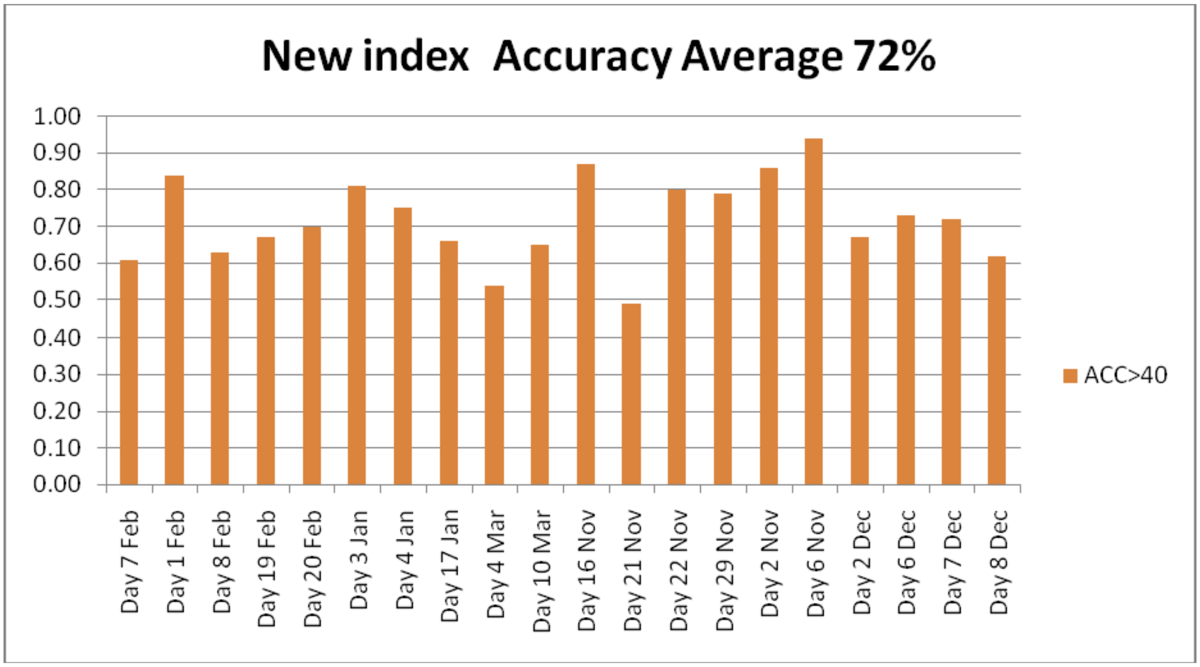
Comparing the New Index with the KI and TT provided by the Unified Model for 09:00 GMT:

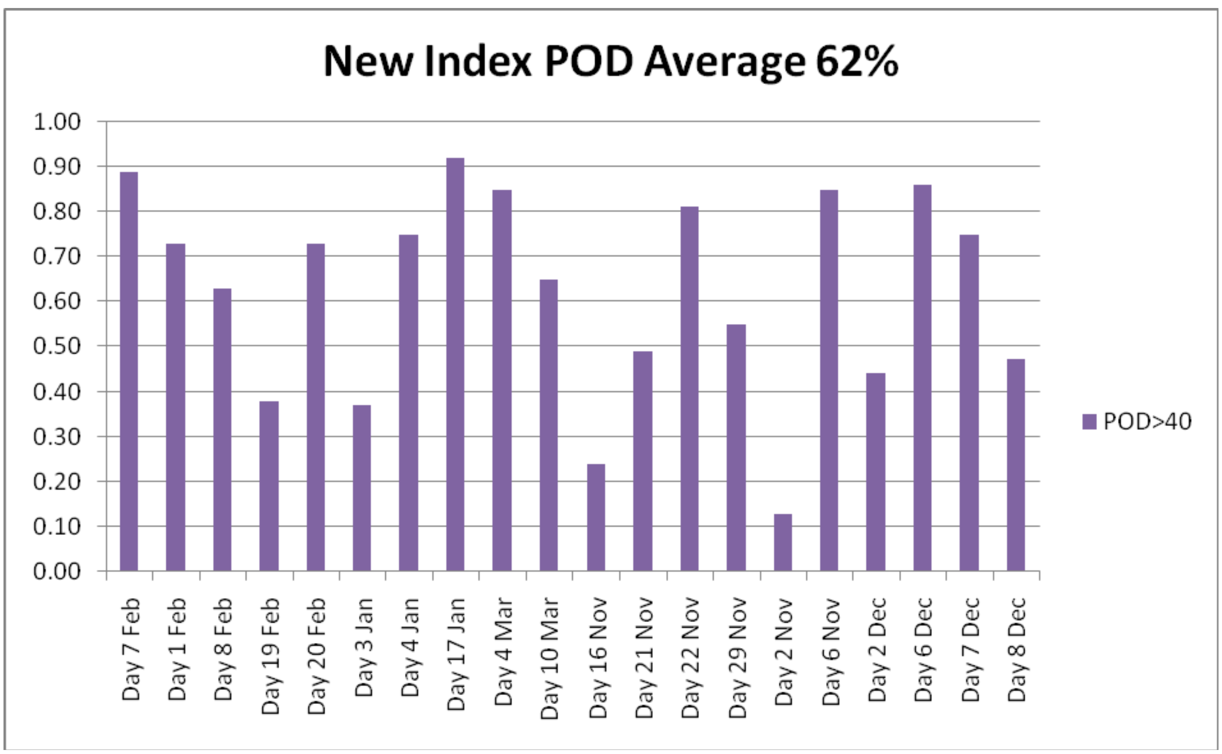


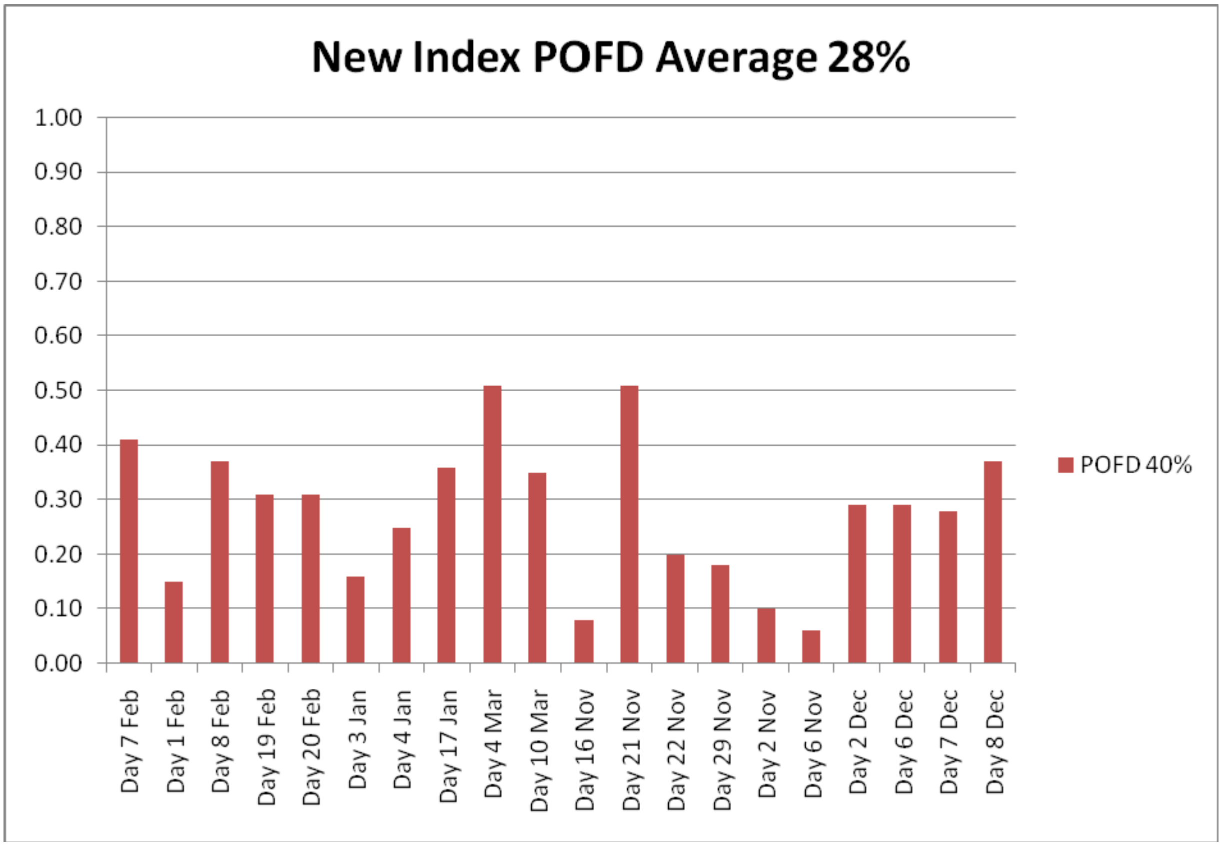


The above mentioned indices seem to have a bigger emphasis over the central parts of the country than the New Index. Although there was some lightning activity and convection over these parts, it seems that the Convection RGB shows more explosive development further north of South Africa. The latter feature was the area with the highest probabilities in the New Index.

The next step was to evaluate the New Index against the occurrence of lightning, in a similar manner to the individual parameters (below). The accuracy for the same twenty cases mentioned before can be seen. On average the accuracy for a threshold of 40% was 72%.


New index Accuracy Average 72%
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Day 7 Feb
Day 1 Feb
Day 8 Feb
Day 19 Feb
Day 20 Feb
Day 3 Jan
Day 4 Jan
Day 17 Jan
Day 4 Mar
Day 10 Mar
Day 16 Nov
Day 21 Nov
Day 22 Nov
Day 29 Nov
Day 2 Nov
Day 6 Nov
Day 2 Dec
Day 6 Dec
Day 7 Dec
Day 8 Dec
ACC>40


New Index POD Average 62%
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Day 7 Feb
Day 1 Feb
Day 8 Feb
Day 19 Feb
Day 20 Feb
Day 3 Jan
Day 4 Jan
Day 17 Jan
Day 4 Mar
Day 10 Mar
Day 16 Nov
Day 21 Nov
Day 22 Nov
Day 29 Nov
Day 2 Nov
Day 6 Nov
Day 2 Dec
Day 6 Dec
Day 7 Dec
Day 8 Dec
POD>40



This is just one way of measuring accuracy, and it is based on the chosen thresholds. This method adds a figure to the idea of how well it correlates with reality, but the methodology has a few limitations:

- Given different thresholds, it will provide different statistics – it is thus very threshold dependant
- The size of the blocks within which the evaluation is done, might influence the statistics

Other methods to evaluate the RII products will still be investigated. The New Index does, however, have some advantages:

- One doesn't have to look at four different parameters, each with their own thresholds
- One map for thunderstorm probability is given – in probabilities (not thresholds) – which is easy to understand and interpret
- Improved areal coverage where KI and TT alone could not provide adequate coverage due to elevation (with the "crude" replacement of 2 instead of 4 indices in those areas)
- Since the map is averaged over time, it is more consistent and also less pixellated

- The development of the New Index was based on the occurrence of lightning (as verification of convection) in a 20-day climatology
- Good correlation with lightning occurrence in nowcasting situations for the tested cases.

6. Conclusions and the way forward

The New Index might go some way to help forecasters to do a very short range forecast of thunderstorm activity. On the tested cases it evaluated well, but it might not be optimal yet. Ways to improve on this first step might include:

- A longer climatology for the "look-up-tables"
- Using elevated TT as a fifth parameter in the equation, and perhaps also an elevated KI
- Using a different (weighted) combination of the parameters, instead of just a simple average
- Another map for severity of thunderstorms, including wind shear parameters and PW in different layers (to include a mid-level dry slot).
- Considering a different evaluation scheme, independent of thresholds of individual parameters.

The current New Index will be available to forecasters in SA in the coming spring and summer. They will use it and give feedback on its performance. Adjustments will then be implemented after the summer. Although it is not a perfect solution for thunderstorm probability forecasting, it should address some of the needs of the forecasters.