AN ILLUSTRATED VERBAL DESCRIPTION OF THE TORRO- AND FUJITA-SCALES ADAPTED FOR CENTRAL EUROPE CONSIDERING BUILDING STRUCTURE AND VEGETATION CHARACTERISTICS

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Determination of tornado or downburst intensity is a difficult task, as it is mostly done using the damage occurring with a storm. Only in very rare cases are there reliable measurements of wind speed. A grading of intensity is done either using the Fujita-scale (F- or EF-scale) or the TORRO-scale (T-scale), or using both classifications. In order to determine which typical property-, building-, and vegetation damage occurs with the different classes of the F-/T-scales or the newly developed E-scale (Dotzek, 2009) one needs a verbal description of that damage. A simple adoption of the description valid in the USA (EF-scale) is not very helpful in Europe since the construction of homes differs significantly. A verbal description of the TORRO- and Fujita-scales adapted for Central Europe considering building structure and vegetation characteristics (Hubrig, 2004) was developed by ESSL, Skywarn Germany and Munich Re members in 2004 (Dotzek et al., 2000; 2004), but so far was only available in German.

In a joint effort within the BMBF project RegioExAKT, ESSL and Skywarn Germany supplemented the verbal T-scale damage description by photos of typical damage. The updated text is now available in English and considers wind impact to light and strong buildings as well as vegetation.

	Unterkritisch (Sub–critical)				Schwach (Weak)			
Fujita	F-2		F-1		F0		F1	
TORRO	T-4	T-3	T-2	T-1	T0	T1	T2	T3
Beaufort	B0, B1	B2, B3	B4, B5	B6, B7	B8, B9	B10, B11	B12, B13	B14, B15
v in $\mathrm{m\,s^{-1}}$	0 – 3	3 – 7	7 – 12	12 – 18	18 – 25	25 – 33	33 – 42	42 – 51
v in $\mathrm{km\,h^{-1}}$	0 – 11	11 – 25	25 – 43	43 – 65	65 – 90	90 – 119	119 – 151	151 – 184
Δv in $\mathrm{m\,s^{-1}}$	3	4	5	6	7	8	9	9
$\bar{S}_-$ in %	0.0	0.0	0.0	0.01	0.05	0.10	0.25	0.80
$\bar{S}_+$ in %	0.0	0.0	0.0	0.0	0.01	0.05	0.10	0.25

	Signifikant (Significant)							
	Stark (Strong)				Verheerend (Violent)			
Fujita	F2		F3		F4		F5	
TORRO	T4	T5	T6	T7	T8	T9	T10	T11
Beaufort	B16, B17	B18, B19	B20, B21	B22, B23	B24, B25	B26, B27	B28, B29	B30, B31
v in $\mathrm{m\,s^{-1}}$	51 – 61	61 – 71	71 – 82	82 – 93	93 – 105	105 – 117	117 – 130	130 – 143
v in $\mathrm{km\,h^{-1}}$	184 – 220	220 – 256	256 – 295	295 – 335	335 – 378	378 – 421	421 – 468	468 – 515
Δv in $\mathrm{m\,s^{-1}}$	10	10	11	11	12	12	13	13
$\bar{S}_-$ in %	3.0	10.0	30.0	90.0	100	100	100	100
$\bar{S}_+$ in %	0.80	3.0	10.0	30.0	60.0	80.0	90.0	95.0

FIG. 1: Overview of the F- and T-scale, the related wind speeds, and typical loss ratios S for light (S–) and strong (S+) buildings in Central Europe.

FIG. 1 gives an overview of the F- and T-scale, the related wind speeds, and typical loss ratios S for light (S–) and strong (S+) buildings in Central Europe. The quantity "loss ratio" is often applied in the insurance industry and denotes the ratio of property damage to reinstatement value in percent. These values adapted for Central Europe were determined in cooperation with Munich Reinsurance (Dotzek et al., 2000).

The scales reach from –2 to 6 (F-scale) and –4 to 13 (T-scale), respectively. But only the grades F0 to F5 or T0 to T11 are really being applied. The tornadoes with negative scale values are so weak that they do not cause any damage. For the existence of F6 tornadoes (T12, T13), there is currently only little evidence. And besides, there is an

FIG. 2: Weak tornado damage (T3/F1 – 151-183 km/h); upper part: 29.05.2007 - Borler / German (Photo: Erik Dirksen), lower part: 01.03.2008 - Uttershausen / Hessen (Foto: Eyk Neidert)

estimate of maximum tornado windspeeds close to the F5 to F6 threshold, which comes from energy budget calculations. The terms to coarsely classify tornado intensity in the table are also important: Weak (F0, F1), strong (F2, F3), and violent (F4, F5). FIG. 2 to 4 show typical damage to buildings as well as to vegetation out of these three classes. Tornadoes with an intensity of F2 or greater are called significant, while tornadoes with negative F- or T-scale are named subcritical. The verbal damage description contains typical values for the loss ratios. This readily enables us to include building structure representative for Central Europe when determining tornado or downburst intensity.

Forest damage was recently investigated (Hubrig, 2004). As the stability of e.g. trees is certainly much more uniform worldwide as that of buildings, a scientific overview of vegetation damage analysis is very important and desirable. In Europe since the 19th century, there has been a tradition to put emphasis on the assessment of forest damage occurring with winter cyclones or severe local storms like tornadoes and downbursts.

FIG. 3: Strong tornado damage (T5/F2 – 220-254 km/h); upper part: 29.06.1997 - Bissendorf / Germany (Photo: Martin Hubrig), lower part: 18.07.2004 - Tönisvorst / Germany (Photo: Thomas Sävert).

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FIG. 4: Violent tornado damage (T8/F4 – 335-377 km/h); upper part: 01.06.1927 - Auen / Germany (Photo: Heinz Brinkmann), lower part: 03.08.2008 - Hautmont / France (Photo: Bjoern Stumpf).

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