

## **European Severe Storms Laboratory**

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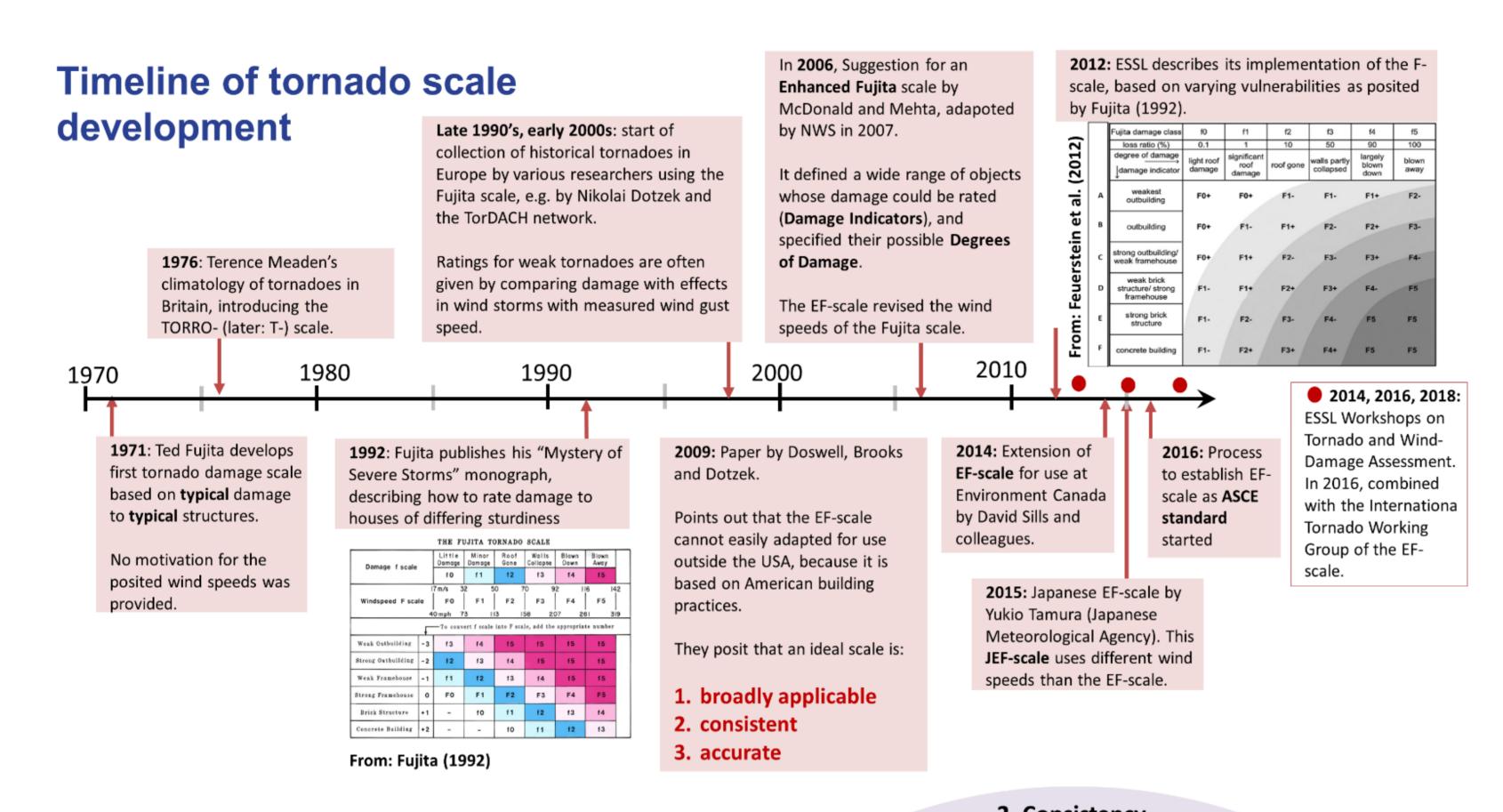


# The International Fujita Scale\*:

A Globally Applicable Scale for Tornado and Wind Damage Classification

Pieter Groenemeijer, Alois M. Holzer, Martin Hubrig, Thilo Kühne, Rainer Kaltenberger

and the IF-scale Steering Group\*\*



#### **Properties of the IF-scale**

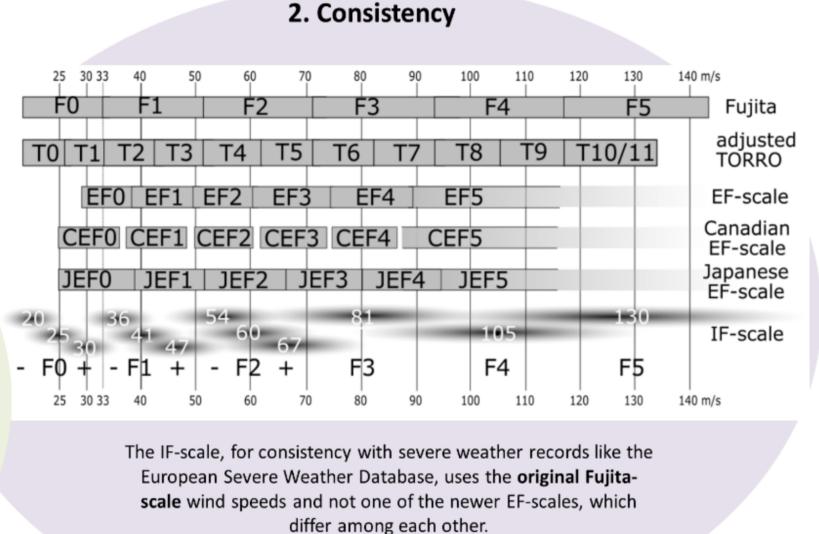
1. Broad applicability IF scale defines Damage Indicators using the sturdiness rather than the function of a building EF-scale has damage indicators defined by their function, e.g. elementary school. But elementary school buildings vary widely. Simply adding Damage Indicators to the EF-scale will therefore not work. NAME AND ADDRESS OF THE OWNER, OF Elementary schools in three locations in three different countries.

The IF-scale includes all wind speeds originally covered by the Fujita scale (135 m/s), which have been confirmed to occur in tornadoes by by Doppler radar measurements.

> The IF-scale can also be applied to non-tornadic damage.

\*\* IF-scale Steering Group includes representatives from ESSL and national weather services from Germany, Spain and Austria. The group is seeking more international collaborators, especially from the engineering community.

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#### 3. Accuracy

The IF-scale will use scientific measurements, where avaiable, to underpin wind speed estimates. We are just at the beginning of this, but have taken into account available literature.

In order not to convey an unrealistic accuracy, a step on the scale is not to be expressed as a range of wind speeds, but as a best estimate value and an error, e.g. IF1+ = 47 +/- 14 m/s.

The steps of the scale were chosen to be so wide that no accuracy will be lost when expressing damage on the scale. Each of the steps IFO, IF1 and IF2 may be followed by a - or + suffix to indicate a 1/3 higher or lower value, e.g. F1equals "F¾" and F2+ equals "F2¾".

### Wind speeds

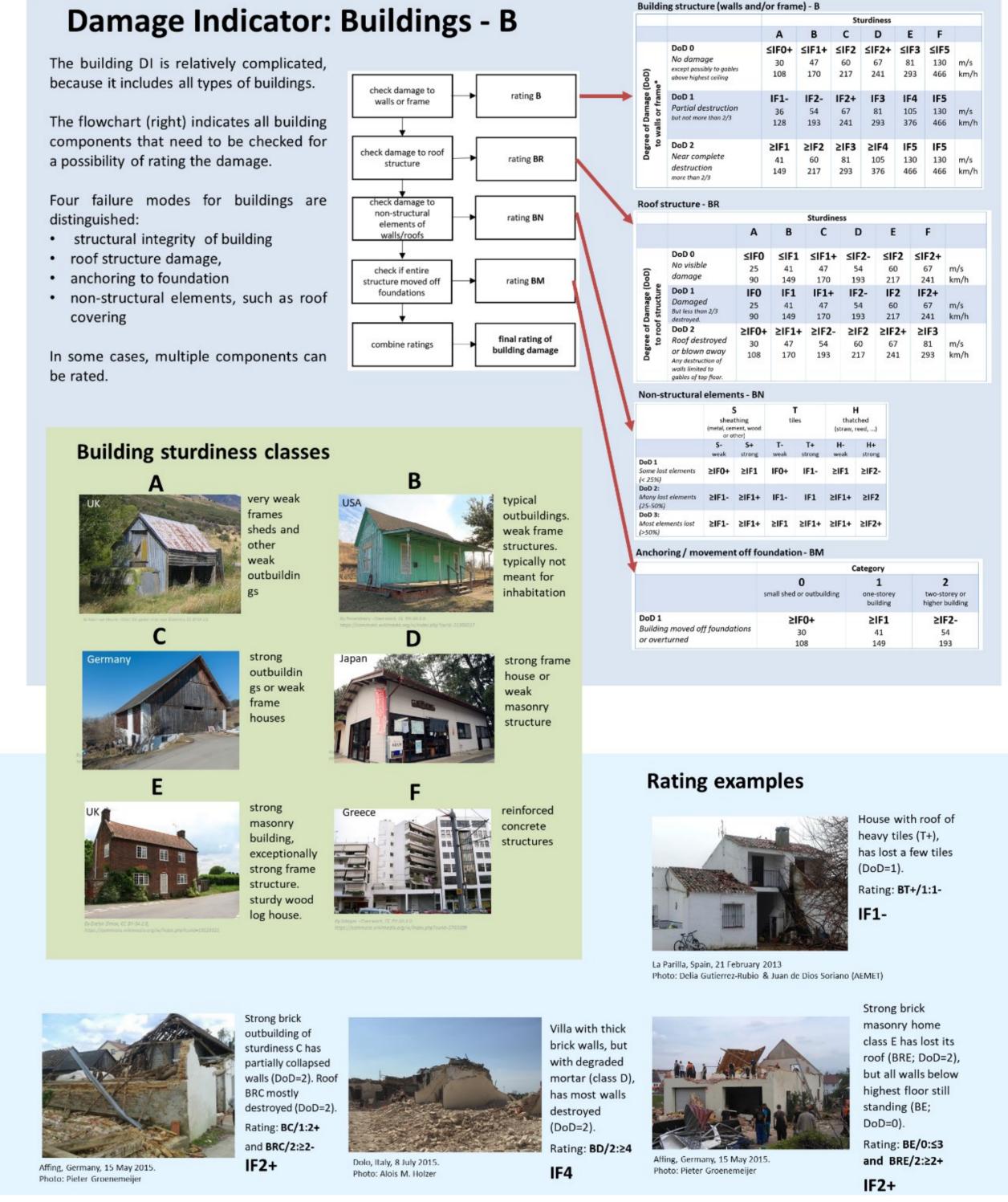
Class	speed m/s	error m/s	speea km/h	error km/h	speed mph	error mph	speed knots	error knots
IFO-	20	± 6	72	± 22	45	± 14	39	± 12
IF0	25	± 7	90	± 27	56	± 17	48	± 15
IFO+	30	± 9	108	± 32	67	± 20	58	± 18
IF1-	36	± 11	128	± 38	70	± 24	69	± 21
IF1	41	± 12	149	± 45	92	± 28	80	± 24
IF1+	47	± 14	170	± 51	106	± 32	92	± 28
IF2-	54	± 16	193	± 58	120	± 36	104	± 31
IF2	60	± 18	217	± 65	135	± 40	117	± 35
IF2+	67	± 20	241	± 72	150	± 45	130	± 39
IF3	81	± 24	293	± 88	182	± 55	158	± 47
IF4	105	± 31	376	± 113	234	± 70	203	± 61
IF5	130	± 39	466	± 140	290	± 87	252	± 76
		ot	hers were	newly into	e selected roduced, v or based	vere devel	oped from	n ESSL rati

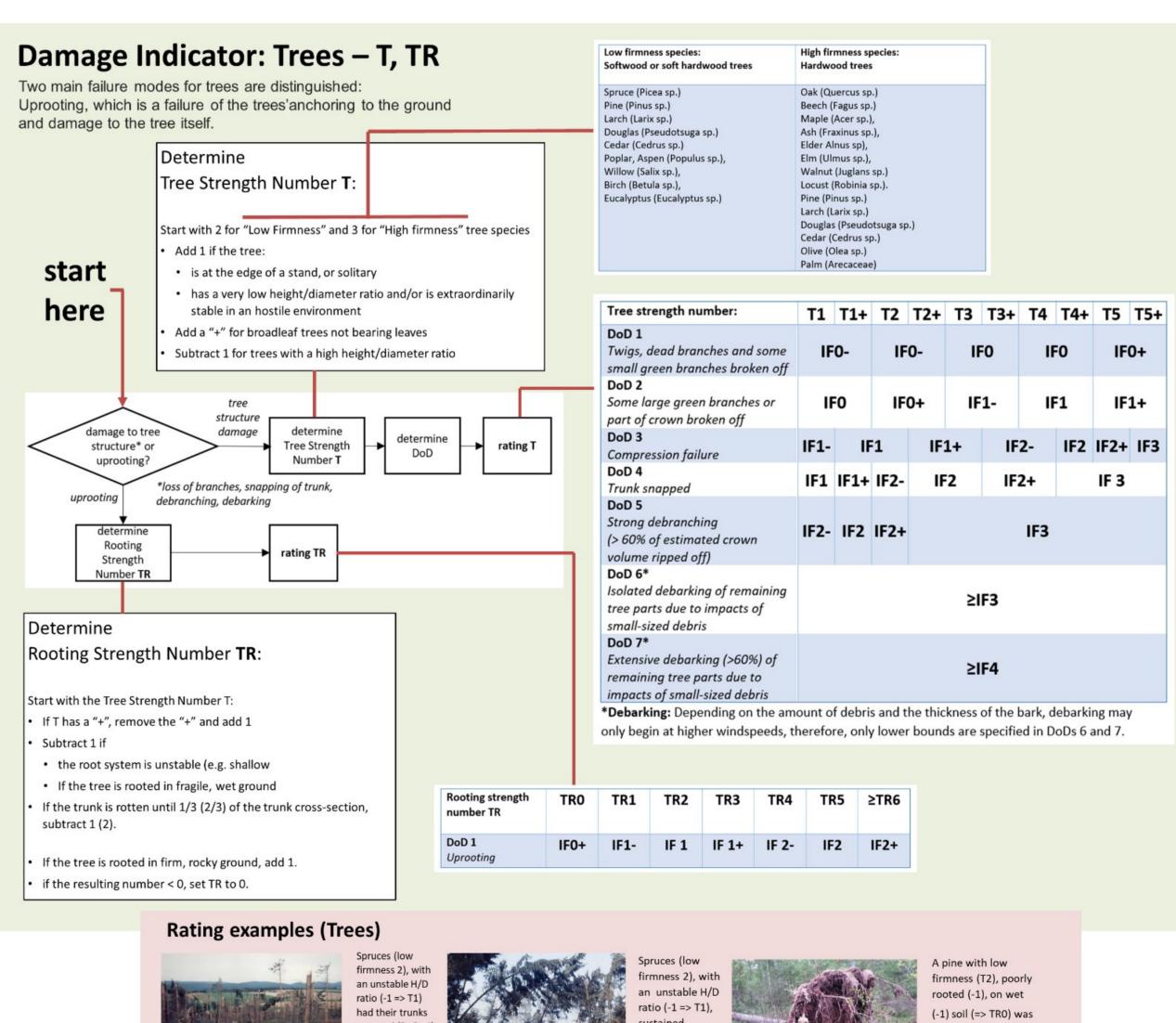
damage (Hubrig, 2015).

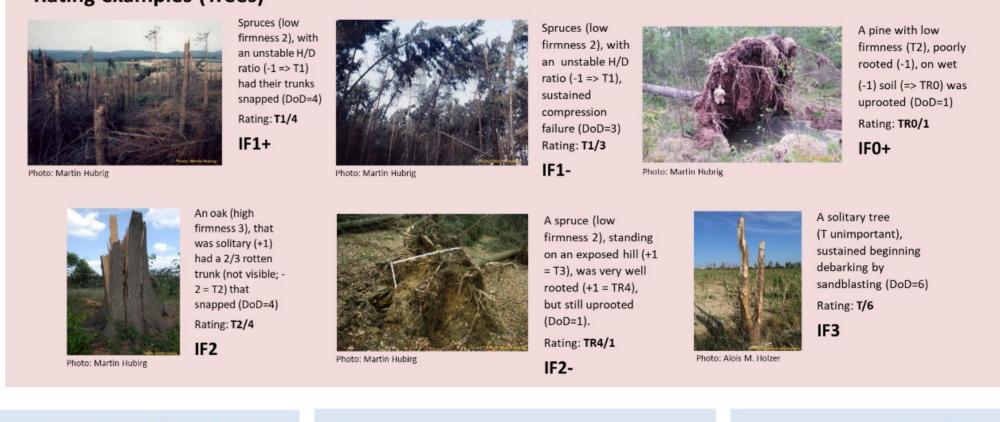
The list of damage indicators will likely be expanded by the steering group.

#### **Damage Indicators**

Dar	Damage Indicator		DI Sub-class		DI Vulnerability class		
В	Buildings		Structure	A - F		1-3	
		R	Roof structure	A-F		0 - 2	
			Non-structural elements	S+/-	sheathing		
				T+/-	roof tiles	1-3	
				H+/-	thatched roof		
		M	Anchoring	1-3		1	
V	Road Vehicles	С	Car				
		E	Empty trucks				
		Н	Large heavy vehicles			1, 2	
		Т	Caravan (towed trailer)				
T	Trees	S	Tree structure damage	0 - 6		1 - 6	
		R	Uprooting	0 - 6			
R	Train cars			S F	stationary/slow operating speed	1	
М	Mobile homes					1-5	
Р	Poles & towers	U	Utility poles				
		L	Light poles			1, 2	
		Т	Power transmission towers				
F	Fences	м				1	
S	Signs	Т	Traffic signs				
	5.8.15	м	Metal frame billboards			1, 2	
D	Scaffolding	-				1	
SS	Service station						
	canopies	anopies				1	
G	Carports / garages					1	
SC	Shipping containers					1	
С	Cranes	C	Container (gantry) crane				
		Т	Tower crane			1, 2	
0	Outdoor furniture	L	Light				
		О	Other			1, 2	







Degree of Domeso				Service Station Canopies - SS			Degrees of Damage	Category			
Degree of Damage	traffic signs*	M metal frame billboards*		Degree of Damage			C cars, vans	E empty trucks/lorries, similar vehicles with large surface area	L large heavy vehicles: buses, loaded trucks/lorries	T towed trailers	
DoD 1	IF1+	IF1+		Degree of Damage			DoD 1	IF1+	IF1	IF1+	IF1-
Inclination or buckling of pillar(s)  DoD 1	47	47	m/s	DoD 1 Collapse	IF2-		Sliding  DoD 2  Overturning	47 170 <b>IF2-</b> 54	41 149 <b>IF1+</b> 47	47 170 ≥ <b>IF2</b> 60	36 128 <b>IF1</b> 41
	170	170	km/h		54 193	m/s					
	IF2-	IF2-				km/h					
Collapse of pillar(s)	*******		,	Note: Estimate based on EF-Scale (McDonald and Mehta, 2006).				193	170	217	149
clination or buckling of pillar(s)  DD 1  Dllapse of pillar(s)	54	54	m/s				DoD 3	≥IF2+	≥IF2	≥IF3	≥IF2
	193	193	km/h				Displacement over	67	60	81	54
Estimates based on JMA(2015).							large distance while overturning and/or	241	217	293	193
							being lofted (> 10 m)				

#### Outlook

- The IF steering group seeks to improve categorization of building sturdiness Continue to use the scale in practice and document examples classes with support of engineering community A final first version of the IF-scale is to be ready by late 2019 or early 2020.
- · New DI's will be added, such as crop fields, shrubs and bushes, noise barrier walls, jersey barriers, wind turbines, free standing masonry and concrete walls.