IWAIS2015 16TH INTERNATIONAL WORKSHOP ON ATMOSPHERIC ICING OF STRUCTURES

Expansion of the ice deposition monitoring network in Germany

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Wetter und Klima aus einer Hand

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Long-term ice deposition measurements were carried out at up to 35 stations in the east part of Germany during 1965-1990.

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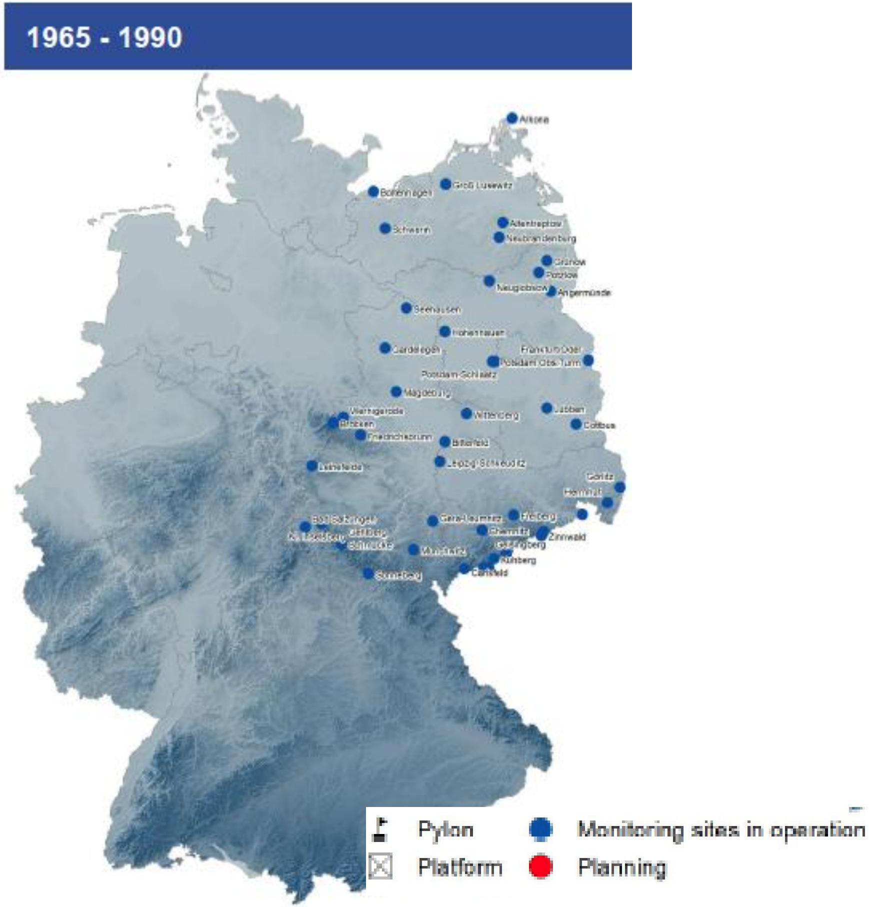
In 1991 the number of locations with ice deposition measurements was reduced to a total number of five. Since 2005 additional ice deposition measurements have been available from a meteorological mast (three heights 10 m, 50 m and 90 m above ground) at Falkenberg, near the Meteorological Observatory Lindenberg of German Meteorological Service (DWD).

The severe wet snow incident in November 2005 in the northwest part of Germany (Münsterland area) …

as well as the results of the European COST-Action 727 “Measuring and forecasting atmospheric icing on structures” gave convincing reasons for an expansion of the ice deposition monitoring network in Germany. Therefore, DWD started a project to implement the expansion of the network.

Fig. 1 – 3: *Timeline of the ice deposition monitoring network in Germany. Background color varies with altitude. See [1] for more information regarding Fig. 1 and 2, respectively.*



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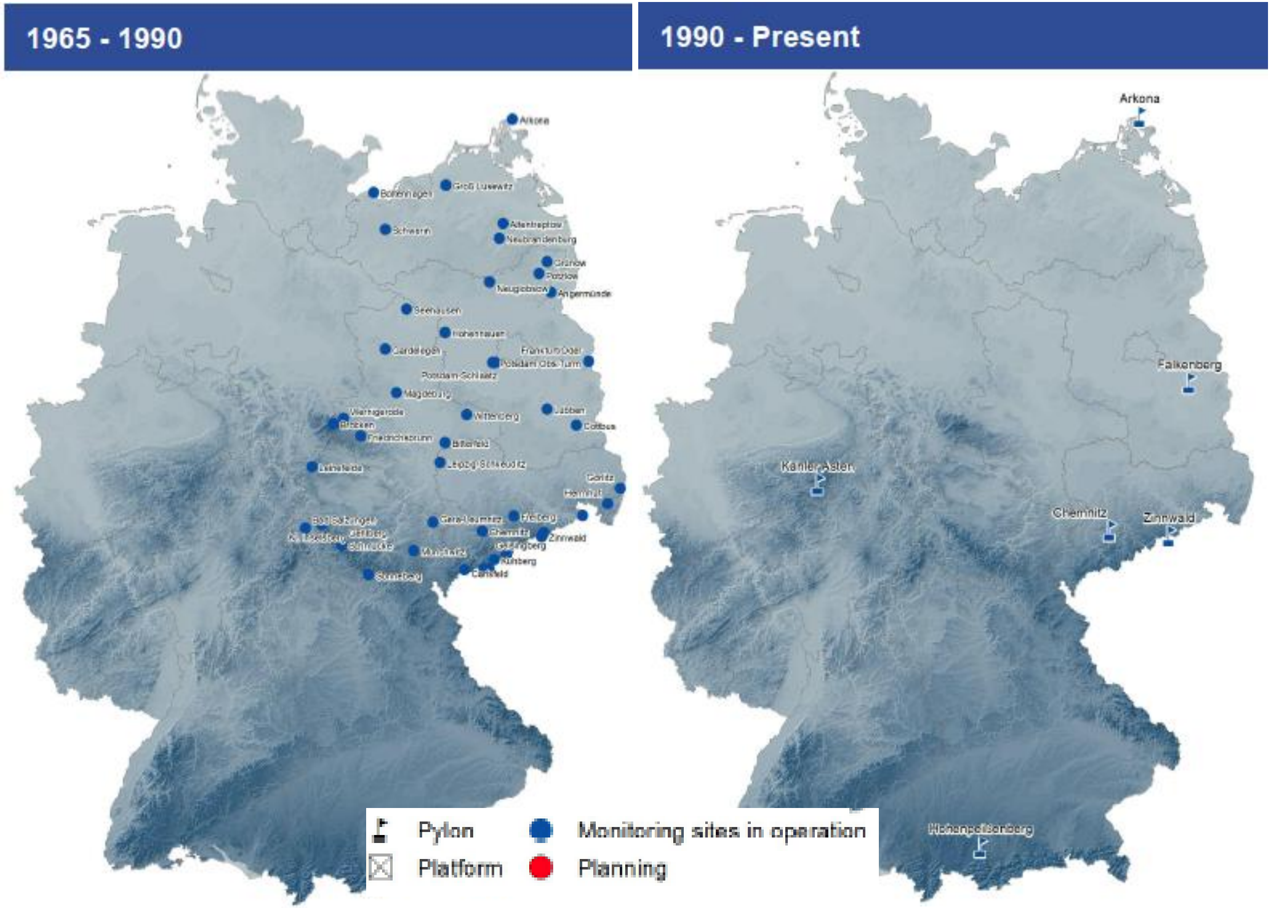

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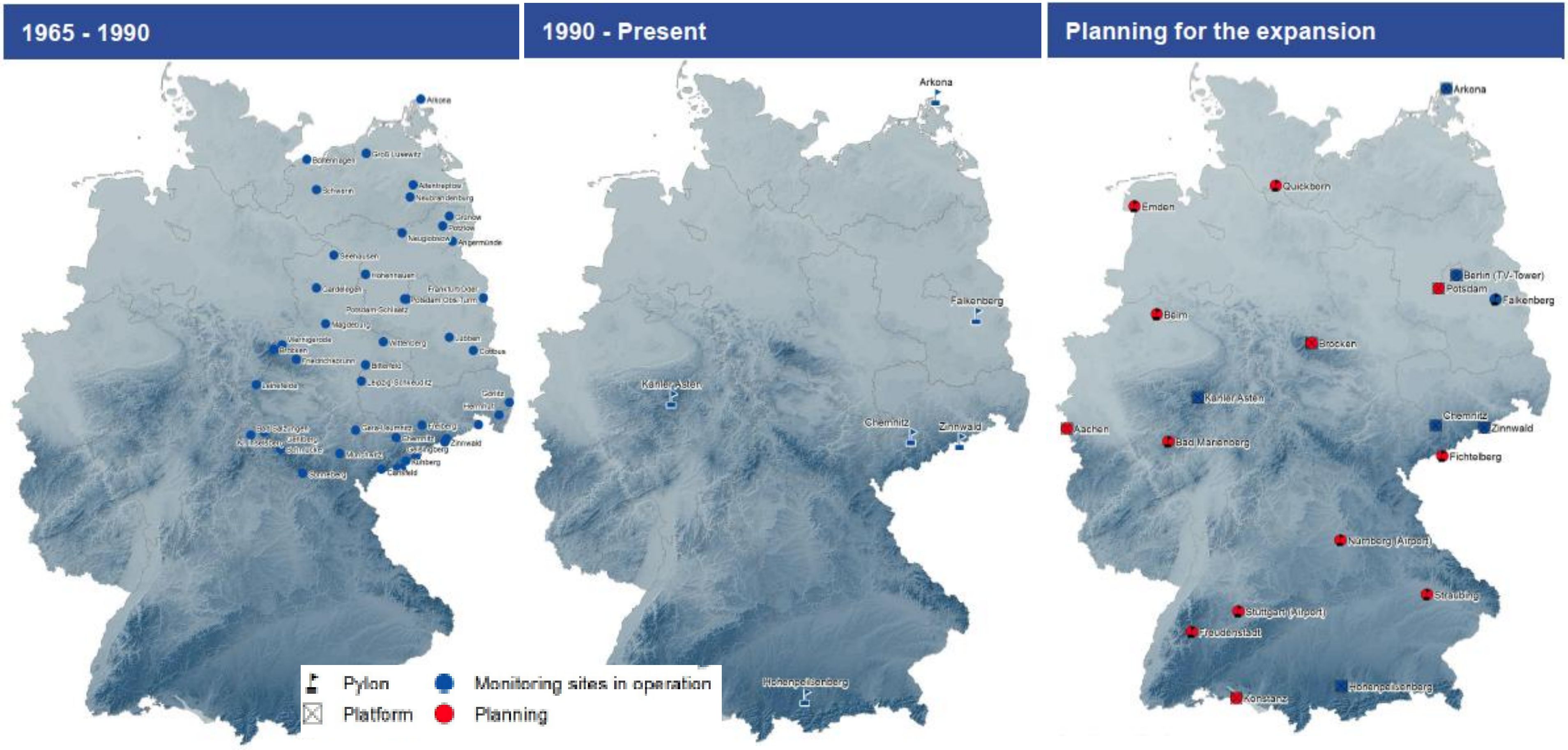

Trigger Event: Severe wet snow incident in November 2005 in the northwest part of Germany (Münsterland area).

- more than 80 power line towers were damaged as a result of wet snow accretion on power line cables (see Fig. 3, [2], [3]),
- due to the enormous economical impact of such damage the question arises as to how frequently similar climatic conditions may occur; such information forms the basis of structural design of power lines in areas prone to icing events,
- statistics on ice loads are scarce since they are seldom measured routinely.

Fig. 3: Damaged power line poles in Münsterland area on 26.11.2005 (Photo © DPA, 2005; see [2] and [3] for more information)

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Trigger Event: Results of the European COST-Action 727 “Measuring and forecasting atmospheric icing on structures”

- a comparison of icing measurement devices was carried out at weather station Zinnwald during winter seasons 2007/2008 and 2008/2009 (see Fig. 4, for an example of results; [4], [5]),
- the comparison campaigns were part of the COST-Action 727,
- results of COST-Action 727 showed clearly the need of ice deposition measurements in order to monitor icing conditions for several applications [6].

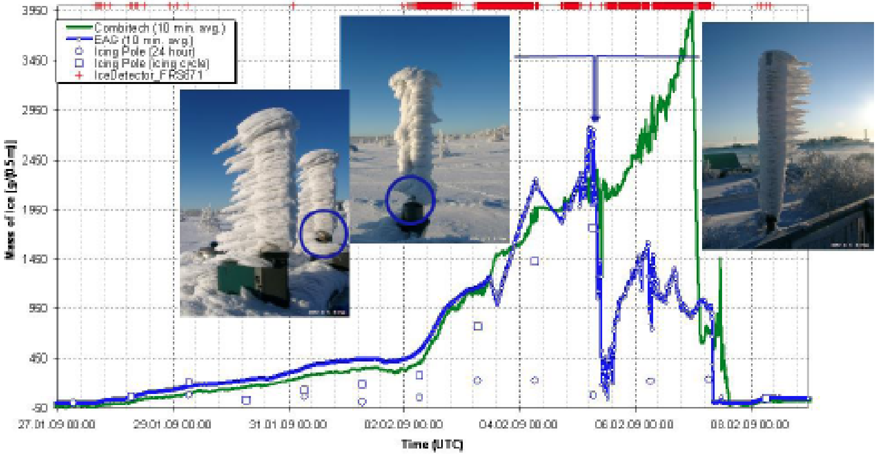

Fig. 4: Time series of icing variables as the result of test measurements with different instruments at weather station Zinnwald during the winter season 2008/2009 (see [4], [5] for more information). The photographs were taken in order to illustrate the result of icing measurements (blue arrows).

Instrumentation: Ice load sensor EAG 200 (as long as an adequate instrument will be available on the market)

- Pole diameter: 0,032 m, Pole length: 0,5 m
- Pole material: PVC
- Electro-mechanical scale
- Measuring range: 0-10 kg
- Resolution: 1 g, Accuracy: ± 50 g
- Standard measurement height: 6 m above terrain*
- On pylons or platforms (if on-site already)
- Measurement interval: 10 minute means
- Installation at weather stations, i.e. the full meteorological measurement program is available as supplementary information

* notwithstanding [7] in order to continue long term measurements at similar heights at many sites in Germany, see [1] for more information)

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References:

[1] Wichura, B., 2007. A survey of icing measurements in Germany, 12th International Workshop on Atmospheric Icing of Structures (IWAIS2007), Yokohama, Japan, pp. 4.

[2] Wichura, B. and Makkonen, L., 2009. Evaluation of a Wet Snow Accretion model for the Münsterland event in November 2005, 13th International Workshop on Atmospheric Icing of Structures (IWAIS 2009), Andermatt, pp. 7.

[3] Makkonen, L. and Wichura, B., 2010. Simulating wet snow loads on power line cables by a simple model. Cold Regions Science and Technology, 61(2-3): 73-81.

[4] Wichura, B., 2009a. Intercomparison of icing measurements at Zinnwald test site, 13th International Workshop on Atmospheric Icing of Structures (IWAIS 2009), Andermatt, Switzerland, pp. 4.

[5] Wichura, B., 2009b. Zinnwald test site for intercomparison of icing measurements, 13th International Workshop on Atmospheric Icing of Structures (IWAIS 2009), Andermatt, Switzerland, pp. 4.

[6] Fikke, S. et al., 2006. COST Action 727: Atmospheric Icing on Structures; Measurements and data collection on Icing : State of the Art. Publication of MeteoSwiss, 75, Zürich, pp. 110.

[7] ISO 12494, 2001. Atmospheric icing of structures, International Organization for Standardization, Geneva.

The Numerical Analysis for Jump Height of Multi-two-spans Ice-shedding at Different Time Intervals of Overhead Transmission Line

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Abstract

According to different parameters of transmission line such as spans, span length, ice thickness, a finite element analysis model of wire-insulator was established, and the simulation of ice-shedding from overhead transmission line was adopted by additional force method. Then, the jump height of multi-two-spans at different time intervals can be got.

I . NUMERICAL SIMULATION METHOD ON ICE-SHEDDING OF OVERHEAD LINE

A. Wires-insulator finite element analysis model

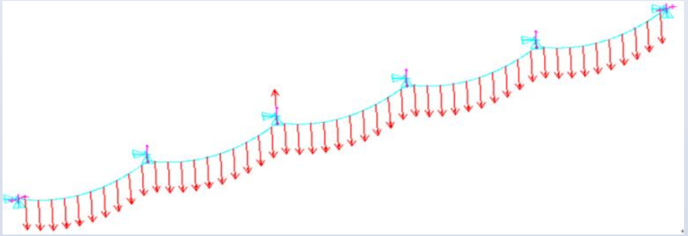


Figure 1: Finite element model of conductor-insulator

B. The FEA process of the ice-shedding process

(1) The transmission line form finding, catenary equilibrium calculation of overhead transmission line in operation under the action of self weight and tension;

(2) The catenary equilibrium calculation overhead line with ice loads;

(3) The ice cover in the overhead line at a certain time is detached in some form, and the process is mainly simulated by the additional concentrated load method, the element birth and death method or the changing density method.;

(4) The response of the tower line after the ice-shedding.

C. Overhead transmission line finite element form finding(Figure 2)

D. Calculation of additional force (Figure 3)

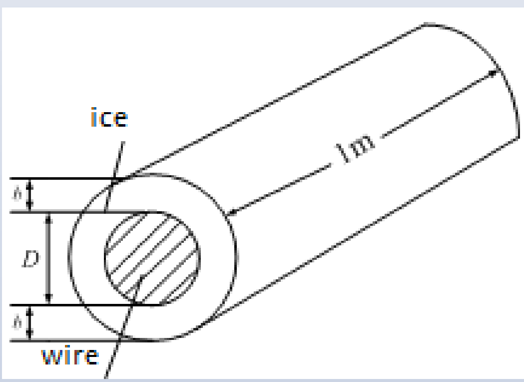


Figure 3: Calculation of ice thickness

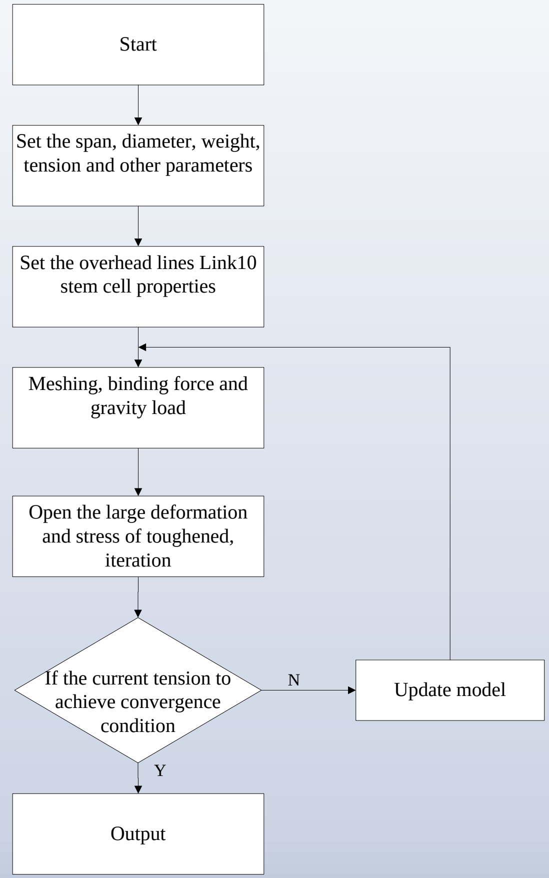
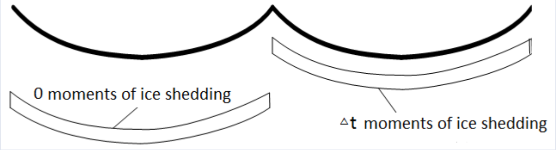
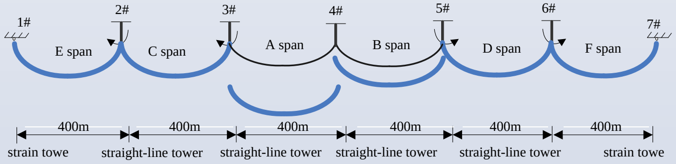


Figure 2: Basic steps of overhead line finite element form finding

II.THE EFFECT OF THE DIFFERENT TIME INTERVALS FOR TWO-SPAN ICE-SHEDDING JUMP HEIGHT





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5 |

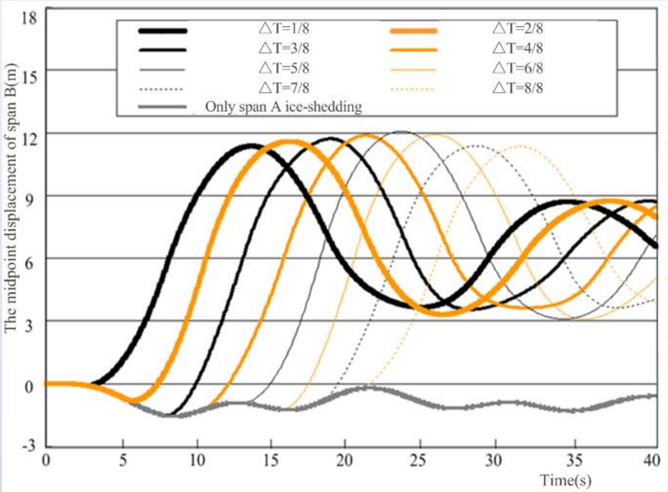


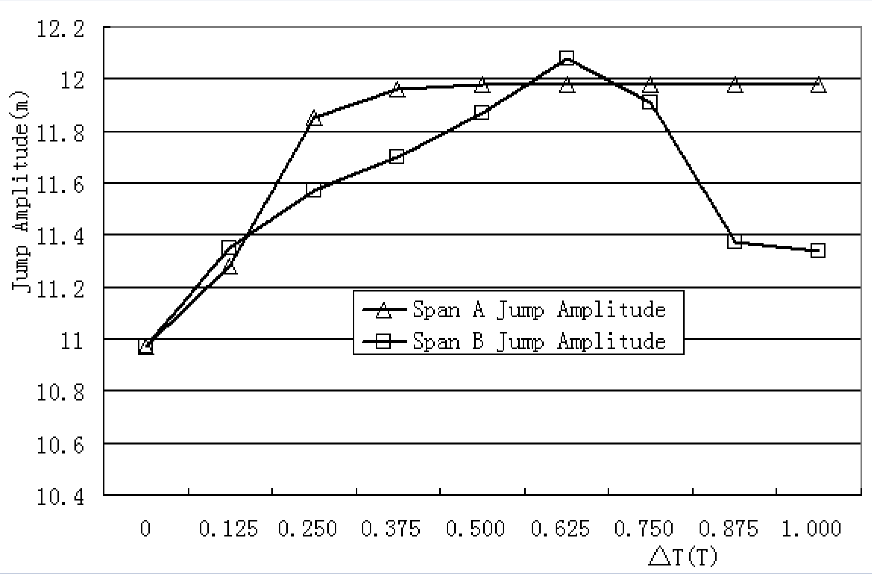
Figure 4: The way at different intervals times for adjacent two-span ice-shedding on overhead line

Figure 5: Transmission line with 7 tower and 6 span

Figure 6: Time history of displacement responses at midpoints of span B for two-span assembling ice-shedding

Table 1: Ice jump amplitude of two-span ice-shedding at different times

ΔT (T)	A jump amplitude (m)	B jump amplitude (m)	B > A
0	10.97	10.97	
1/8	11.28	11.35	
2/8	11.85	11.57	
3/8	11.96	11.70	
4/8	11.98	11.87	
5/8	11.98	12.08	YES
6/8	11.98	11.91	
7/8	11.98	11.37	
8/8	11.98	11.34	



III. Analysis of the influence factors in two-span ice-shedding jump height

A. Impact of ice weight for two-span ice-shedding jump height

ΔT (T)	Icing thickness (mm)	A jump amplitude (m)	B jump amplitude (m)	B > A
0	10	7.4	7.4	
4/8	10	8.35	8.19	
5/8	10	8.35	8.21	
6/8	10	8.35	8.02	
0	15	10.98	10.98	
4/8	15	12.04	11.87	
5/8	15	12.04	12.08	YES
6/8	15	12.04	11.91	
0	20	14.2	14.2	
4/8	20	15.28	15.03	
5/8	20	15.28	15.54	YES
6/8	20	15.28	15.51	YES

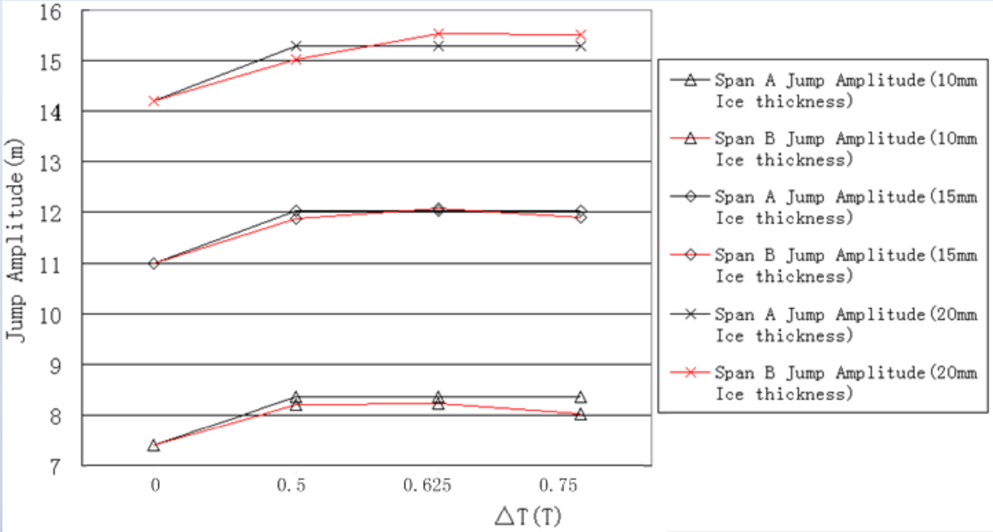


Table 2 Ice jump amplitude of two-span ice-shedding at different ice weight

B. Impact of span length for two-span jump height

ΔT (T)	span length(m)	A jump amplitude(m)	B jump amplitude(m)	B > A
0	300	6.94	6.94	
4/8	300	7.55	7.44	
5/8	300	7.55	7.61	YES
6/8	300	7.55	7.52	
0	400	10.98	10.98	
4/8	400	12.04	11.87	
5/8	400	12.04	12.08	YES
6/8	400	12.04	11.91	
0	500	15.21	15.21	
4/8	500	17.12	16.63	
5/8	500	17.12	16.81	
6/8	500	17.12	16.53	

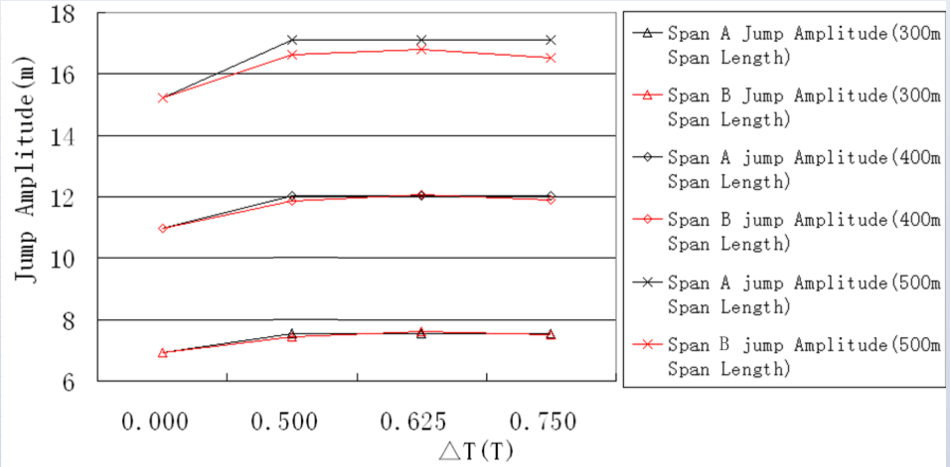


Table 3: Ice jump amplitude of two-span ice-shedding at different span length

C. Impact of spans for two-span ice-shedding jump height

ΔT (T)	spans (m)	A jump amplitude(m)	B jump amplitude(m)	B > A
0	4	10.01	10.01	
4/8	4	11.66	11.29	
5/8	4	11.66	11.48	
6/8	4	11.66	11.15	
0	6	10.98	10.98	
4/8	6	12.04	11.87	
5/8	6	12.04	12.08	YES
6/8	6	12.04	11.91	
0	8	11.33	11.33	
4/8	8	12.2	12.09	
5/8	8	12.2	12.29	YES
6/8	8	12.2	12.14	

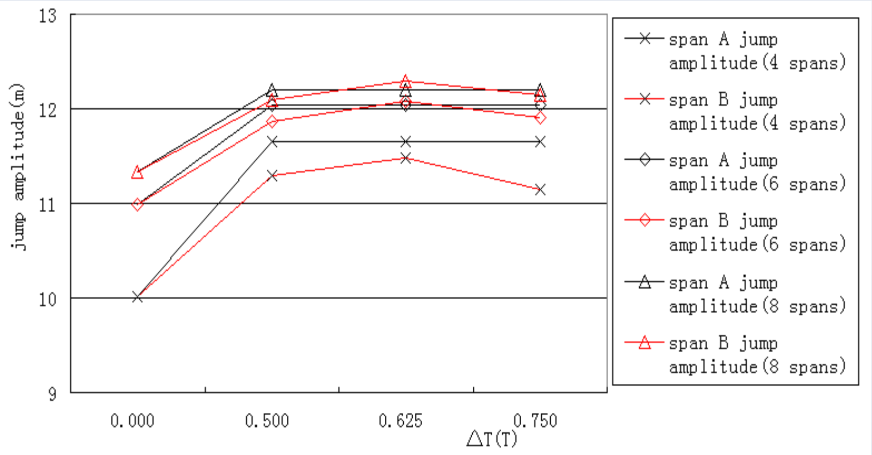


Table 4: Ice jump amplitude of two-span ice-shedding at different spans

D. Impact of height difference for two-span ice-shedding jump height

ΔT (T)	height difference(m)	A jump amplitude(m)	B jump amplitude(m)	B > A
0	0	10.98	10.98	
4/8	0	12.04	11.87	
5/8	0	12.04	12.08	YES
6/8	0	12.04	11.91	
0	40	11.26	11.26	
4/8	40	11.96	11.59	
5/8	40	11.96	11.68	
6/8	40	11.96	11.44	

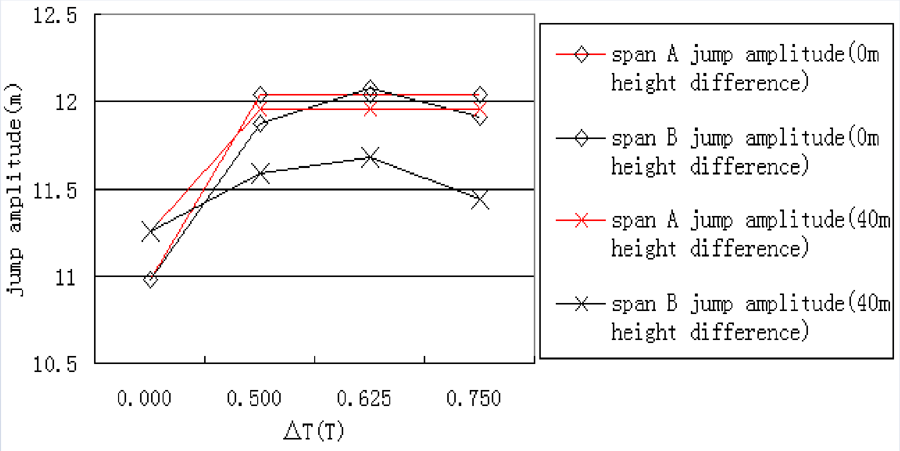


Table 5: Ice jump amplitude of two-span ice-shedding at different height difference

E. Impact of damp coefficient for two-span ice-shedding jump height

ΔT (T)	damp	A jump amplitude(m)	B jump amplitude(m)	B > A
0	0.02	12.61	12.61	
4/8	0.02	13.76	13.88	YES
5/8	0.02	13.76	14.53	YES
6/8	0.02	13.76	14.26	YES
0	0.06	11.74	11.74	
4/8	0.06	12.84	12.806	
5/8	0.06	12.84	13.17	YES
6/8	0.06	12.84	12.95	YES
0	0.1	10.98	10.98	
4/8	0.1	12.04	11.87	
5/8	0.1	12.04	12.08	YES
6/8	0.1	12.04	11.91	

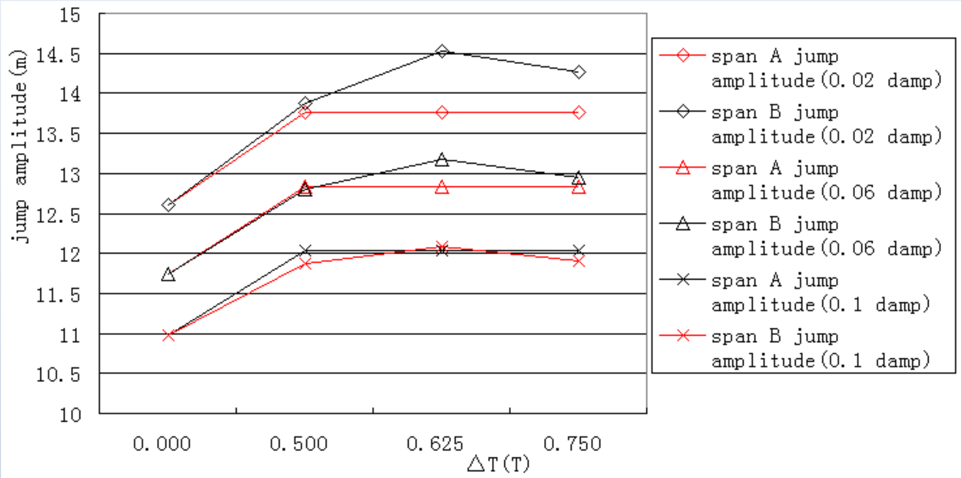


Table 6: Ice jump amplitude of two-span ice-shedding at different damp

CONCLUSION

The result shows that the amplitude of jump height decreased when the same time of ice-shedding on multi-two-spans which effect was equivalent to unilateral strain tower. The amplitude of previous ice-shedding spans is easily exceeded by the later spans when the vibration cycle of multi-two-spans interval was about 5/8. Besides, it was great impact on spans coupling such as the weight of the ice, spans, span length, damp and other factors. When the mass of the ice and spans is larger, the jump height of previous ice-shedding spans can easily passed by the later spans, but the effect of damp, span length is just the opposite.

THANK YOU FOR YOUR ATTENTION!

Development of snow accretion simulation method for electric wires in consideration of snow melting and shedding

Kazuto Ueno, Central Research Institute of Electric Power Industry, Japan (19)

Development of snow accretion simulation method for electric wires in consideration of snow melting and shedding

Civil Engineering Research Laboratory
Central Research Institute of Electric Power Industry

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16th International Workshop on Atmospheric Icing of Structures

July 1, 2015

CRIEPI Central Research Institute of Electric Power Industry

Objectives

(1) CRIEPI have developed SNOVAL(Ver.2) (Snow accretion simulation code for overhead transmission lines) which can simulate the temporal change of three dimensional accreted snow shape under calm to strong wind from any direction, without solving air flow around snow deposit and trajectories of snowflakes before impact. SNOVAL(Ver.2) can estimate the mass of accreted snow with arbitrary shape and electric wire rotation, in contrast to the existing cylindrical-sleeve accretion models.

snow cap　　axial growth　　cylindrical growth

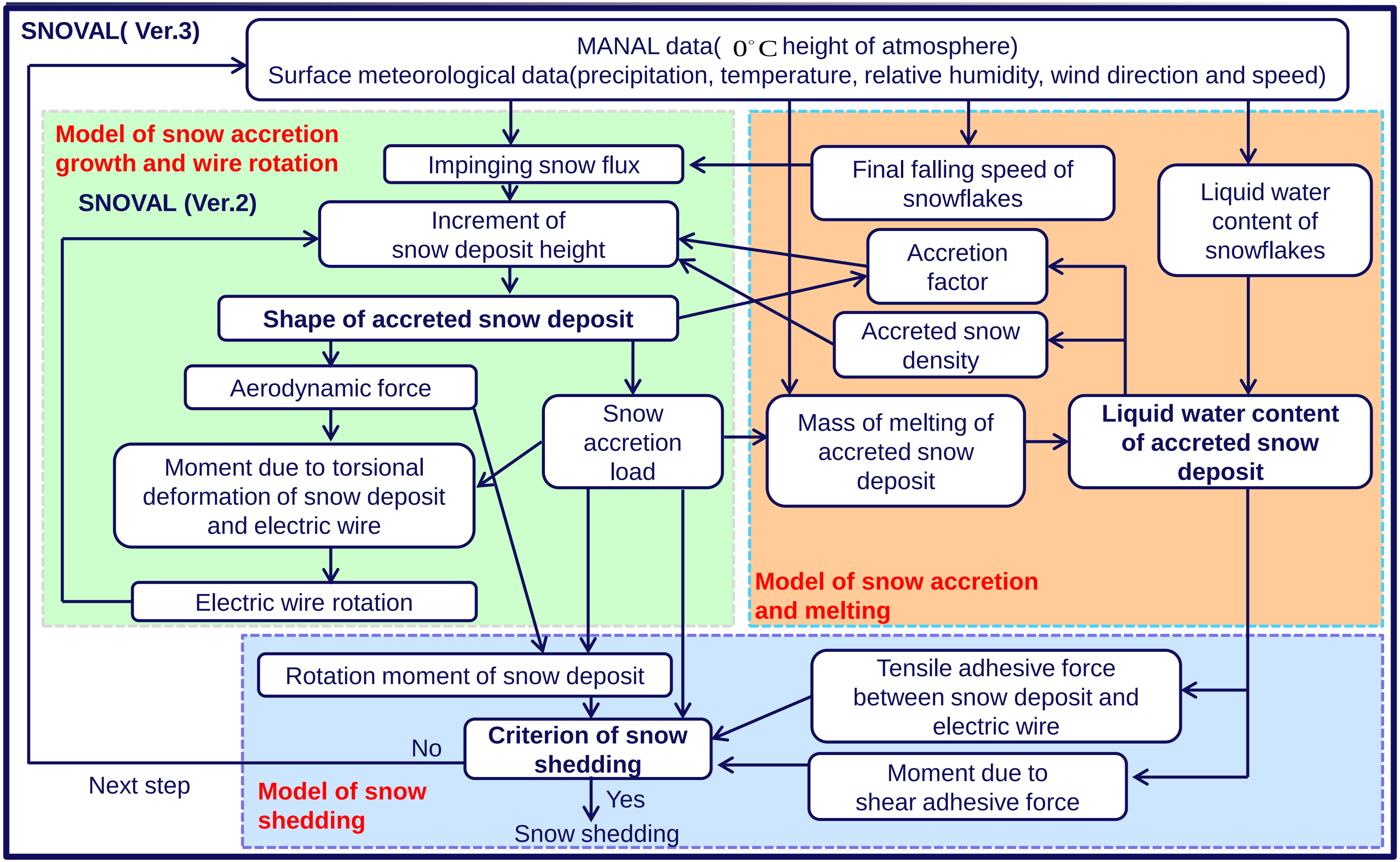
(2) SNOVAL(Ver.2) has been improved to estimate:

- liquid water content (LWC) by considering melting process due to heat exchanges between the air, electric wire and snow deposit and melting of snowflakes below freezing level in the atmosphere,
- density of accreted snow as a function of wind speed and LWC of snow deposit,
- accretion factor as a function of wind speed, LWC of snowflakes before impact and three dimensional snow accretion shape,
- snow shedding based on the balance of forces and its related moments exerted on accreted snow with different shapes.

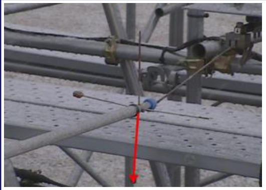
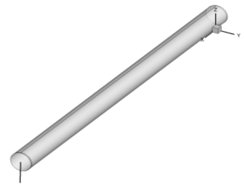
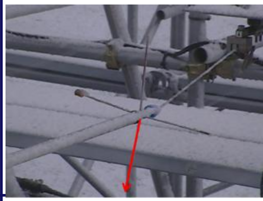
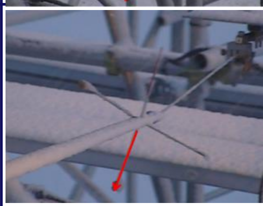
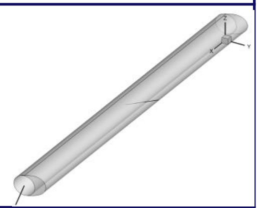
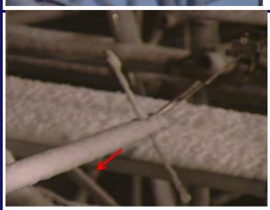
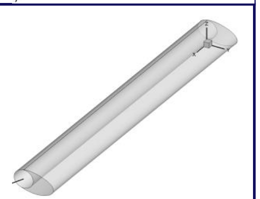
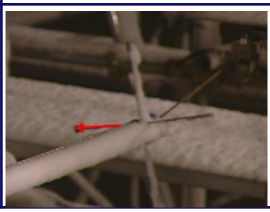
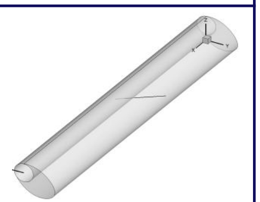
→ SNOVAL (Ver.3)

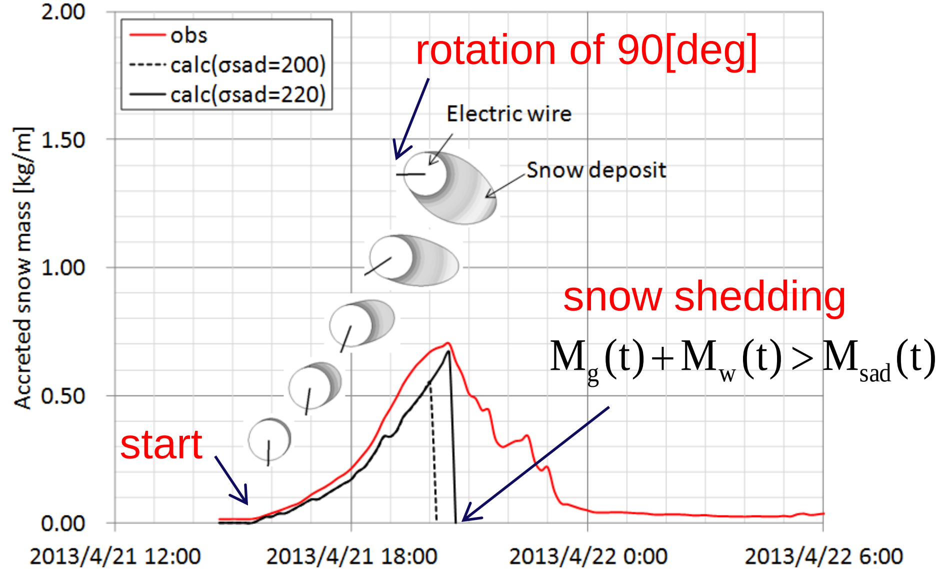
→ Reproduce the process from the start of snow accretion until snow shedding

Framework of SNOVAL(Ver.3)



Accretion on sampler1 (development on windward side)

	Observation	Simulation
16:00		
17:00		
18:00		
19:00		
20:00		



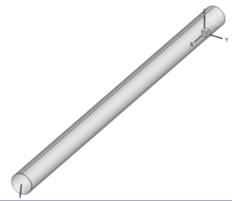
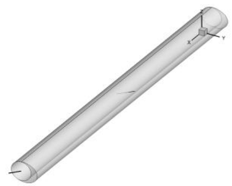
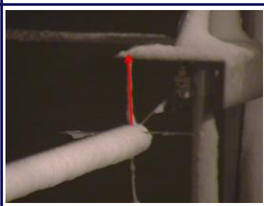
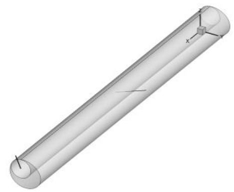
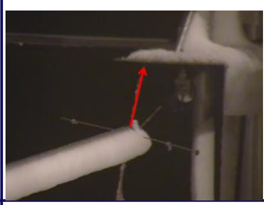
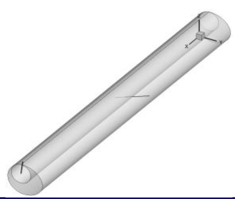
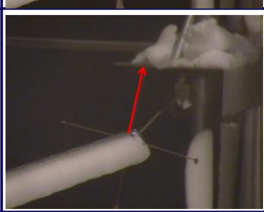
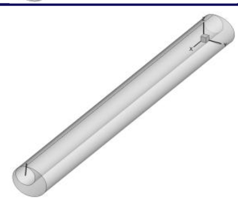
(1) Although the precipitation is observed from 14:50, snow accretion does not occur until 15:40 because LWC of snow deposit is over 0.4 and hence adhesive force is zero.

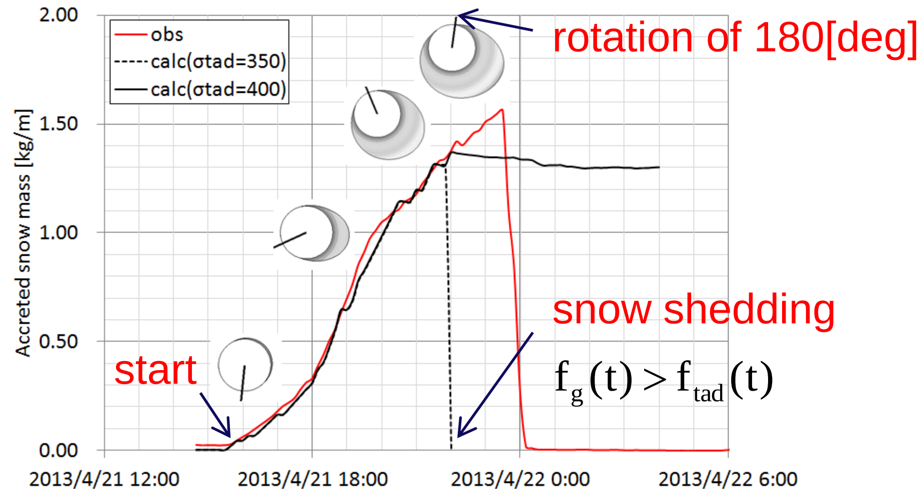
SNOVAL ver.3 can predict the start time of snow accretion.

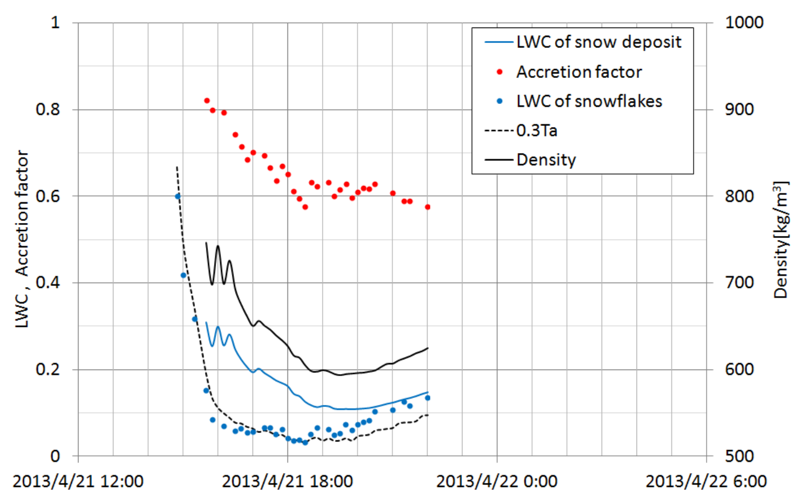
(2) Snow shedding starts at 20:30 and mass of accreted snow gradually decreases due to partial shedding.

Snow shedding model in SNOVAL ver.3 is based on shedding all at once and hence cannot treat partial shedding.

Accretion on sampler2 (close to cylindrical-sleeve shape)

	Observation	Simulation
16:00		
18:00		
20:00		
22:00		
23:20		





LWC of snowflakes and snow deposit is very sensitive to temperature variation. Density is mainly correlated with LWC.

Conclusion and future works

(1) SNOVAL(Ver.3) reproduced the start time of snow accretion and the temporal changes of mass and shape of accreted snow, electric wire rotation consistent with field observations for conductor samplers. An calibration method was employed to find appropriate values of parameters in accretion factor allowing for the best agreement between calculated and observed mass of snow deposit in some Japanese wet snow events.

(2) The time of snow shedding strongly depends on the tensile and shear adhesive strength. It is necessary to estimate these strength experimentally for various LWC and density of snow deposit, different surface roughness of materials and initial compressive stress.

(3) Employing many wet snow events, the versatility of proposed accretion factor and density must be enhanced to improve the accuracy in the estimation of accreted snow load currently used.

(4) Effects of solar radiation and heat generated by electric current on LWC of snow deposit and snow shedding must be incorporated in SNOVAL(Ver.3).

Effect of icephobic coating on ice protection of ultrasonic anemometer with stack-type transducers

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