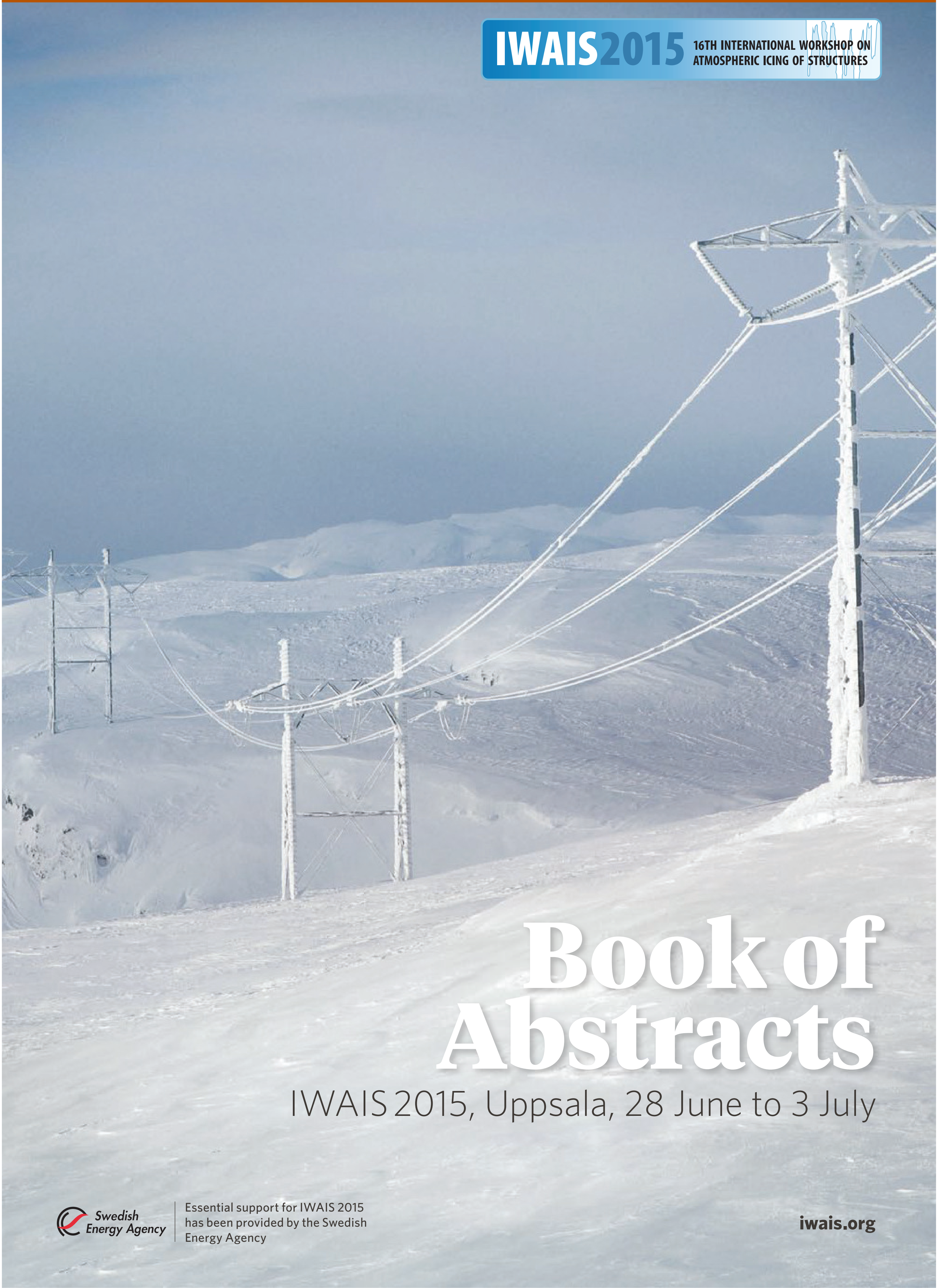

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R&D areas/s: 09. Anti- / de-icing, coatings, 11. Icing in wind energy

Passive acoustic signal sensing approach to detection of ice on the rotor blades of wind turbines

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In cold seasons, irregular layers of atmospheric ice (AI) are usually accreted on the rotor blades of wind turbines. These layers can cause unexpected downtimes and increase the maintenance cost reducing the efficiency. AI presents an unpredictable mixture of crystalline and amorphous ices including such forms as dense snow frozen to the surface, soft rime, hard rime, clear ice, and glaze (e.g., [1], [2]). The parameters of the AI-layer e.g., the thickness, mass volumetric density, porosity, elastic moduli, viscosities, and stress-relaxation time) vary significantly, from a half on order to a few orders, depending on the parameter and type of AI (e.g., [1]-[5]).
To solve the icing problem for wind turbines, the ice-detection and de-icing systems are needed. The ice-detection systems (IDSs) should not only detect the AI-layer on the blade skin but also provide the data allowing identification of the AI-layer parameters, which are sufficient for the cost-efficient de-icing. The identification method is, thus, in the focus of the IDS development, which deals with the following main features.
(1) The operational load in a blade creates irregular space-time distributions of acoustic variable (e.g., strain, stress, and displacement) which depend on the acceleration, deceleration, and speed of rotation of the rotor, the blade-pitch angle, the wind, the presence of the AI layer on the skin, and other factors. The corresponding experimental data are well documented (e.g., [6, Figs. 6-9], [7, Fig. 8 and Fig. 10(b)]).
(2) The blade skin is a layer of a complex, curvilinear shape, which, in the course of the turbine operation, varies in space and time. This feature is also well documented (e.g., [6], [7]).
(3) The AI stress-relaxation time can be in an interval of a few orders (e.g., [3]-[5]).

(4) The AI-layer parameters should be identified by means of an appropriate acoustic model from the data of the sensors, which are located on the inner surface of the blade skin and wirelessly controlled in the real-time mode by a computer and gateways.
The present work develops an acoustic model and method for identification of four of the AI-layer parameters: the thickness, mass density, bulk-wave speed, and stress-relaxation time. Due to Point (1), the identification method presumes passive rather than active sensing. The method is based on measurements of the acoustic accelerations at different points on the inner surface of the skin. The challenge in Point (2) is met by the generalizing the thin-planar-disk approximation introduced in [8] from a single solid layer to the system of the blade-skin/AI layers. The features in Points (3) and (4) are allowed for by a generalization of the viscoelastic model developed in [8] and preceded in [9] to the two-layer system. The model is based on a partial integro-differential equation for the non-equilibrium component of the average normal stress. The proposed identification method is computationally efficient and suitable for the use indicated in Point (4). It extends the scope of the structural health monitoring techniques.
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1. R.A. Sommerfeld, Rev. Geophys. & Space Phys., 20(1) (1982) 62-66.
2. H. Gao, J.L. Rose, IEEE Trans. UFFC, 56(2) (2009) 334-344.
3. R.M. Deeley, Proc. Royal Soc. London. Series A 81(547; Sep. 11) (1908) 250-259.
4. P.P. Kobeko et al., J. Tech. Phys., 16(3) (1946) 263-272.
5. P.V. Hobbs, Ice Physics, Clarendon Press, Oxford (1974).
6. K. Schroeder et al., Meas. Sci. Technol. 17 (2006) 1167–1172.
7. J.R. White et al., Proc. of SPIE 7295 (2009) 72952D/1-72952D/12.
8. E. Mamontov, V. Berbyuk, In: VI Int. Conf. Comput. Meth. Marine Engrng, MARINE 2015, 15-17 June 2015, Rome, 12 pp., accepted.
9. E. Mamontov, V. Berbyuk, J. Appl. Math. & Phys 2 (2014) 960-970.

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