WET-SNOW ACTIVITY REASERCH IN ITALY

Matteo Lacavalla[1], Pietro Marcacci[1], Andrea Freddo[2]

[1] RSE SpA, Research on the Energy System, via R. Rubattino 54, 20134 Milan, Italy

[2] TERNA SpA, - Via Egidio Galbani, 70 - 00156 Rome - Italy

matteo.lacavalla@rse-web.it

Abstract: **The power grid infrastructure is vulnerable to some extreme meteorological phenomena and this could create some difficulties in the safe management of the power system. The wet-snow accretion on overhead lines is well-known to the Transmission and Distribution System Operators. The problem affects much of Europe, with an annual number of wet-snow type steadily increasing over the total number of snowfalls. The problem imposes a greater attention to this phenomenon, either through a focused weather forecast both through active and passive mitigation strategies. RSE has developed WOLF (Wet snow Overload aLert and Forecasting) for overhead lines warning on the transmission power grid. The weather forecast system is already being tested at the Italian TSO. WOLF, together with wet-snow load, provides an estimation of the ant-icing current necessary to keep OHL free of wet-snow sleeve formations, supporting operators in adopting mitigation active strategies. In synergy with WOLF, an automatic station named WILD (Wet Snow Ice Laboratory Detection) has been installed in the municipality of Vinadio in the west Alps, at an altitude of 950 m asl, for the verification of the forecasts system. Through WILD measurements, it is possible to analyse in detail the weather conditions most critical for the wet-snow sleeve formation and, at the same time, to make the "tuning" of the parameters in the models of accretion and anti-icing. A prototype of an active anti-icing circuit is able to maintain snow-free the surface of a typical cable in any condition of wet-snowfall and a rotating system allows to measure and compare the sleeve accretion on different type of conductors. In the terms of the passive mitigation, a qualitative test is being carried out at WILD station on innovative conductors materials provided by Italian TSO, characterized by different surface hydrophobic and ice-phobic treatments. The wet-snow accretions on new cables are compared, although qualitatively, in the same weather conditions with those on conventional conductors. This experimentation may be an important test to get a selection of materials to be used in the areas most exposed at wet-snow risk.**

Keywords: wet snowfall, overhead lines, winter blackouts, weather forecast, wet snow sleeve accretion monitoring.

LEGEND AND ABBREVIATIONS

OHL	*Overhead Lines*
HV	*High Voltage*
MV	*Medium Voltage*
TSO	*Transmission System Operator*
DSO	*Distribution System Operator*
WOLF	*Wet-snow Overload aLert and Forecasting*
WILD	*Wet-Snow Ice Laboratory Detection*
NWP	*Numerical Weather Prediction*
RAMS	*Regional Atmospheric Modeling System*
WRF	*Weather Research and Forecasting*
AI	*Anti-Icing current*
ACSR	*Aluminium Conductor Steel Reinforced*
ACSR-Z	*ACSR with Trapezoidal Wire*
ACCC	*Aluminium Composite Core Conductor*
TACIR	*Aluminium Conductor Invar Steel Reinforced*
MAE	*Mean Absolute Error*
RMSE	*Root Mean Square Error*
R^2	*Coefficient of determination*

INTRODUCTION

The heavy wet snowfall events are responsible for several and harmful winter blackouts on Italian electrical networks of HV and MV power lines due to the formations of ice and snow on OHL conductors [1]. It is estimated that every year, in Italy, the cost of damages from these particular snowstorms is greater than 200 million euros. For this reason, it is important to develop and define different strategies to limit the risk on overhead power lines. Efforts are made to establish and improve standards and methodologies for handling the impact of wet snow accretion in the most economical and rational manner. Over the past 30-50 years, such knowledge was built up from field observations and measurements, laboratory studies and model development [2,3]. However, despite this better understanding, actual severe weather conditions at a remote location are always a critical question for overhead power lines [4,5].

Figure 1: broken MV conductor on ground due to strong wet-snowfall event in central part of Italy.

In order to approach the problem, RSE and the Italian TSO TERNA, have developed two primary strategies:

- **Predictive system**. WOLF [5] is the forecast system based on the output of different NWP models (RAMS,WRF) in combination with:

i. the wet-snow accretion model proposed by Makkonen [6,7] for the estimation of snow load and sleeve thickness on cylindrical conductor;

ii. the mathematical thermal model proposed by Shurig and Frick [8,9] for the estimation of AI current to prevent from ice formations on OHL.

- **Wet-snow test site**. WILD is the first outdoor remote station in Italy, entirely developed by RSE, in which it is possible to:

i. monitor the wet-snow accretion on different types of conductors by using a special rotating test-span weighted by two load cells;
ii. test innovative super-hydrophobic and icephobic coatings of ACSR and ACCC conductors;
iii. verify the weather and accretion forecast by using instruments able to operate in extreme weather conditions;
iv. test the effect of AI current on ACSR conductors.

I. WET-SNOW TEST SITE

The IEC 61774 rules [10] and the activity of CIGRE WG B2.28 advise a strategy for collecting different data sources in order to obtain the best possible information basis to evaluate the maximum design load. The experimental research in Iceland has been also considered in this work [11,12,13]. WILD has been developed taking into account these recommendations. The wet-snow test site has been installed in the west part of the Alps in the municipality of Vinadio, at an altitude of 950 m asl. This area is particularly subjected to strong wet-snowfall events due to intense humid fronts coming from the Ligurian sea.

The measurements acquired from the WILD station are of different types and can be grouped as follows:

- principal meteorological parameters as air temperature, wind speed and its direction, snow accumulation, snow water equivalent of precipitation;
- physical measurements and characterization of the snowfall: droplet size, snowflakes velocity, number of particles;
- mechanical measurements on conductors exposed to snowfall: weight, size, diameters of ice sleeve;
- electronic measurements related to the control of the anti-icing current;
- pictures of the wet-snow event by using two web-cameras.

A scheme of wet-snow test site is shown in Figure 2. The weather and accretion measurements converge in a central acquisition system. The acquisition system allows the sending of data to RSE server, through a scheduling by internet connection.

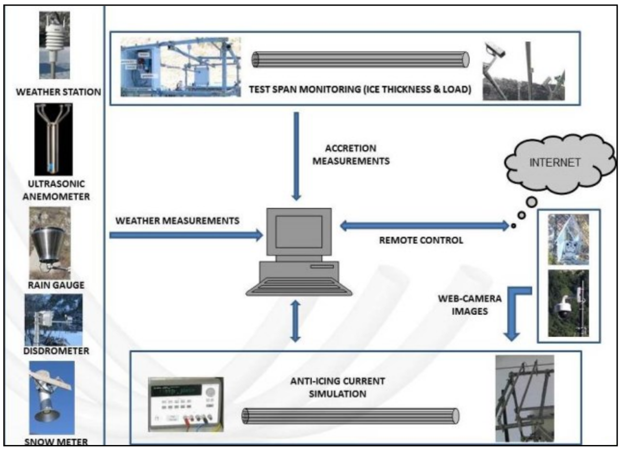

Figure 2: scheme of all measurements collected at the experimental station.

A. *The monitoring system of test spans*

WILD, in the current configuration, allows the installation up to seven test spans of about 14 meters in length to carry out qualitative comparative test of different type of conductors exposed to the same environmental condition. Figure 3 shows the set-up of test span installed at WILD station. Starting from the left of the image, the first two conductors have been treated with black varnish, the first one is a conductor ACSR-Z Ø19.04mm, the second one is the *low-sag* type TACIR Ø18.99mm. At the center of image, the two not treated conductors are respectively ACCC Ø24mm and ACSR Ø22mm. The last two conductors are ACSR-Z Ø19.04mm with two different of hydrophobic coatings.

Figure 3: test span installed at the experimental station.

B. *The accretion monitoring system*

Two other pieces of ACSR conductors with a length of 3 meters have been mounted on a system that allows them a slow rotation, according to ISO12494. The rotation is necessary for two reasons: principally because the rotation system is able to efficiently capture the total flow of snowfall and in this way it is more correct the comparison with the simulated values obtained by the accretion model which assumes a conservative growth on conductor. The second reason is because especially at the center of a span of overhead power line, the load of snow sleeve causes a little torsion/rotation of conductor. One of these two pieces of ACSR conductor has been treated on the surface with an hydrophobic coating. The not treated ACSR conductor is weighted through two load cells placed under them and two ultrasonic sensors measure the thickness of snow-sleeve during the wet-snowfall event.

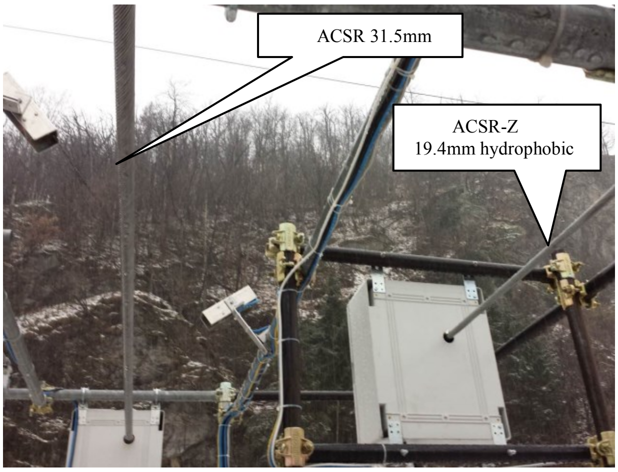

Figure 4: ACSR conductors subjected to slow rotation. The left conductor of the image is weighted and ultrasonic sensors measure the thickness of snow sleeve.

C. The AI current system

Two ACSR Ø31.5mm conductors of 1.5m in length are devoted to the simulation of the AI current. A previous experimental campaign has already shown that a skin temperature set to 2°C is sufficient to prevent from ice formation in all snowfall conditions. For this reason, in order to minimize the AI current for the power line, the surface temperatures of two conductors have been reduced respectively to 1°C and 1.5°C through a specific circuit. The simulation of AI current is allowed by a resistance wire inside each conductor, able to produce a Joule-effect up to 40 W/m as shown in Figure 5. To maintain the skin temperature at the set points in all environmental conditions, a PC acquires every minute the surface temperature measured by thermal sensors and regulates the power sent to the conductors by a programmable power supply.

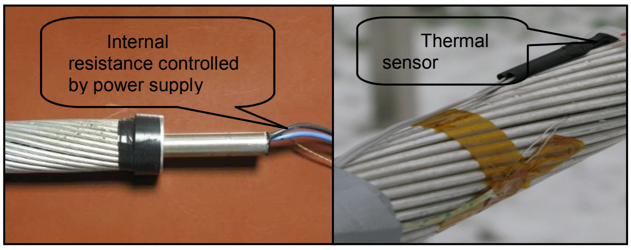

Figure 5: ACSR conductors intended for the simulation of AI current. The internal resistance reproduces the Joule effect and the thermal sensor measures the skin temperature.

II. FUNDAMENTAL OF WET-SNOW MODELS

Unfortunately, there is no specific accretion model that can well simulate all physical and mechanical processes involved in wet-snow accretion. This statement is particularly true for wet snow. There are different models proposed in the literature for wet snow icing accretion [14,15,16,17], but all of them are based on the basic equation (1) for ice accretion described in the ISO standard for icing of structures [7]:

$$\frac{dM}{dt} = \alpha_1 \alpha_2 \alpha_3 * w * A * V \qquad (1)$$

where α_1 is the collision efficiency; α_2 is the sticking efficiency, and α_3 is the accretion efficiency; w is water content (kg/m^3); A is the cross-sectional area (m^2) perpendicular to object; V is the particle impact speed perpendicular to object (m/s).

For the wet-snow precipitation, the atmospheric water content can be considered as the sum of solid (snow and graupel phases) an liquid precipitation. The terminal vertical velocity of snowflakes V_s is assumed to be 1.5 m/s, obtained by three years measurements of a disdrometer during wet-snowfall events. For wet-snow conditions it can be assumed that the collision efficiency and the accretion efficiency is unity (α_1=1 and α_3=1). The sticking efficiency α_2 may be inferred from some field observations. In particular, α_2 depends on the liquid water content of snowflakes and the impact speed. One of α_2 approximation has been proposed by Admirat approach.

Regarding to the density of snow sleeve ρ_s, there is a strong dependence from the wind intensity, because higher snowflake impact speed will tend to produce a more compact snow deposit. For a cylindrical conductor, the sectional area *A* has been approximated to the diameter, considering the mass accreted per unit length.

In general, considering meteorological data given at a temporal resolution Δt, the equation (1) can be integrated forwarding in time [18], assuming that the weather variables are constant for each time step *i*:

$$M_i = M_{i-1} + I_i D_{i-1} \Delta t \qquad (2)$$

where I is the intensity of accretion per unit area and expressed by the following equation (3):

$$I = \alpha_2 I_0 \sqrt{1 + \left(\frac{U \sin\theta}{V_s} \right)^2} \qquad (3)$$

where I_0 may be considered the intensity of precipitation at a given time step; U is the wind intensity (m/s); θ is the angle between the wind direction and the conductor supposed horizontal; V_s is the terminal vertical velocity of snowflakes.

Considering a cylindrical wet-snow accretion on conductor, the corresponding snow sleeve diameter is given by (4):

$$D_i = \left[\frac{4(M_i - M_{i-1})}{\pi \rho_s} + D_{i-1}^2 \right]^{1/2} \qquad (4)$$

The empirical parameters have been deduced from measurements of WILD station collected over the past three winters. Below the methods considered for the algorithm are briefly described.

- Wet-snow condition if air temperature T_{2m} is in the range of -0.5°C to 2°C.
- Precipitation is the sum of solid -snow and graupel- and liquid precipitation.
- Sticking coefficient $\alpha_2 = 1/U^{1/2}$; 0.1 if U>10m/s
- Density of snow sleeve ρ_s = 300 + 30U; ρ_s = 600 kg/m^3 if U>10m/s.
- Vertical velocity of snowflakes V_s = 1.5 m/s.

For dry-snow condition, when the temperature is lower than -0.5°C , the snow accretion is limited by the empirical coefficient α_2 =0.1 and ρ_s=100 kg/m^3.

III. FUNDAMENTAL OF ANTI-INCING MODELS

The literature proposes different thermal models for estimating the temperature of a conductor subject to Joule effect [9]. The thermal model proposed by Shurig and Frick [8] has been used to estimate the AI current necessary to maintain the conductor at a specific skin temperature in order to keep it free from snow accretion. The mathematical model considers the conductor in steady state and the heat balance equation is given by (5):

$$P_j + P_s = P_r + P_c \qquad (5)$$

where P_j and P_s represent the heat gain, P_r and P_c the heat losses. P_j is the Joule heating due to current flow, P_s is the solar radiation heating, P_r is the radiative cooling and P_c is the loss for convective cooling. This equation doesn't consider if the conductor is wetted. But in wet-snow condition, the conductor is affected by a flow of snowfall. For this reason, another loss term P_w must be considered in (1) due to wetted conductor (6).

$$P_j + P_s = P_r + P_c + P_w \qquad (6)$$

Considering the new formulation of heat balance (6), the joule effect produced can be expressed by (7):

$$I^2 * R_T = P_c + P_r + P_w - P_s \qquad (7)$$

where R_T is the resistance at the temperature of conductor. The term P_r depends on the emissivity of conductor, the ambient temperature and the conductor surface temperature. The convective cooling P_c is caused mainly by the wind and the difference temperature of the conductor and the air. Whereas, the term P_s is related to the solar irradiation and to the absorptivity of conductor surface. In wet-snow conditions, P_s can be ignored. Finally, the AI current may be expressed as:

$$AI = 5.6 * \sqrt{\frac{(P_r + P_c + P_w - P_s) * 10^4 * D}{R_T}} \qquad (8)$$

where *D* is the conductor diameter. In order to verify the Joule effect produced by the internal resistance of the ACSR conductor at WILD station, the thermal model proposed by Shurig and Frick has been applied for dry weather condition[1] observed. The conductor surface temperature has been maintained from the electronic circuit around 2°C. The current reproduced by the circuit is in according to the current calculated by the Shurig and Frick thermal model, Figure 6.

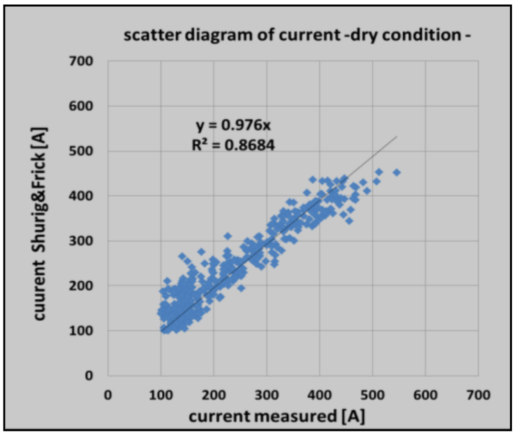

Figure 6: correlation between AI current calculated by using the thermal model and AI measured on ACSR conductor.

The same simulation has been conducted in wet-snow condition, where the surface conductor was wetted. By using the (5), it is notable the underestimation ($BIAS_{model}$=-130A) of the current given by thermal model respect to measured current (Figure 7). The energy debt is mainly due to the cooling of wetted conductor and can be expressed by the P_w term.

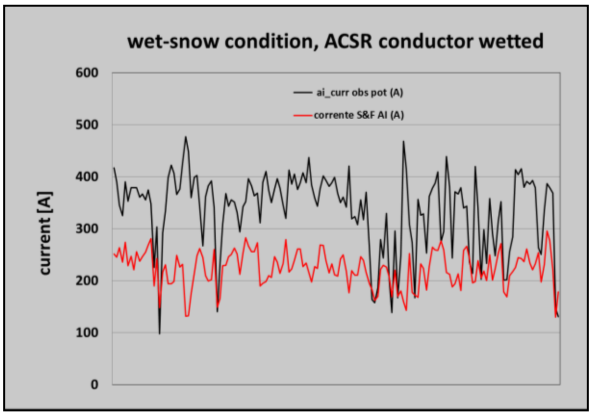

Figure 7: underestimation of current calculated through the model in wet snow condition (red line) respect to observed data (black line).

The P_w term, that represents the cooling for surface unit, can be calculated by (9):

$$P_w = P_j + P_s - (P_r + P_c) \qquad (9)$$

The wet cooling effect is mainly related to the intensity of snow precipitation, as shown in Figure 8.

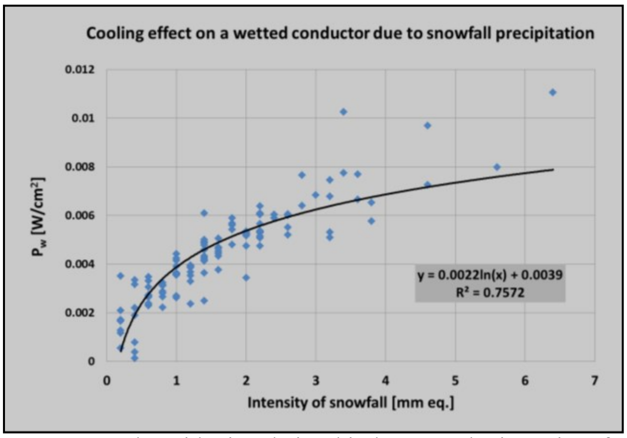

Figure 8: logarithmic relationship between the intensity of snowfall and the term P_w.

The loss due to snowfall precipitation can be expressed by the following empirical equation:

$$P_w = 0.0022 * \ln(prec) + 0.0039 \qquad (10)$$

where *prec* is the observed water equivalent of snowfall. Using the empirical P_w term into (8) for the calculation of AI current, it is possible to obtain a new AI current very close to experimental data as shown in Figure 9 ($BIAS_{model}$=4A).

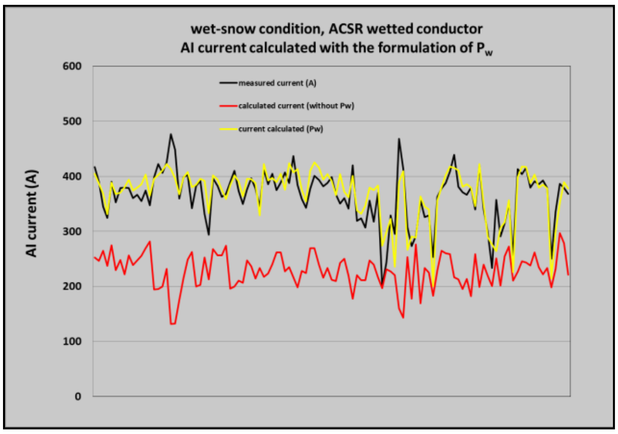

Figure 9: AI current calculated in wet-snow condition with the empirical term P_w deduced by experimental data (yellow line).

IV. WET-SNOW SIMULATION

Two wet-snow events occurred at WILD station last February 2015, are simulated with 2 non-hydrostatic NWP models, RAMS v6.0 developed by ATMET[2] and WRF ARW - V3.4.1. The simulation of both NWP models are done at a resolution of 0.05° with 40x41 grid points in the 2-way nested domains, Figure 10. Both models use terrain-following vertical coordinate with 36 vertical levels. The models are initialized and forced at their boundaries with ECMWF forecast with a

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[1] This condition refers to the absence of precipitation and air temperature lower than 3°C. In this condition, the surface conductor is dry.

[2] Atmospheric, Meteorological and Environmental Technologies.

grid resolution of 0.125°. The structure of the atmospheric water content is given by the Thompson scheme. The predicted phases graupel, snow and rain have been converted to total mass of precipitation.

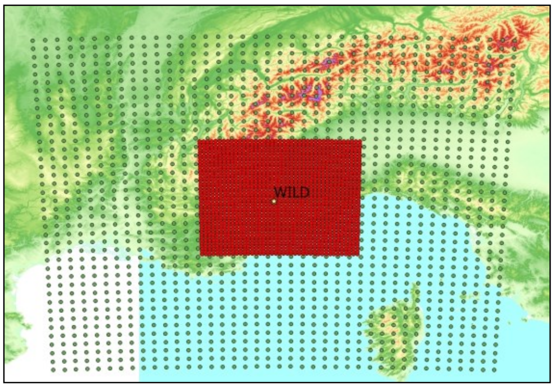
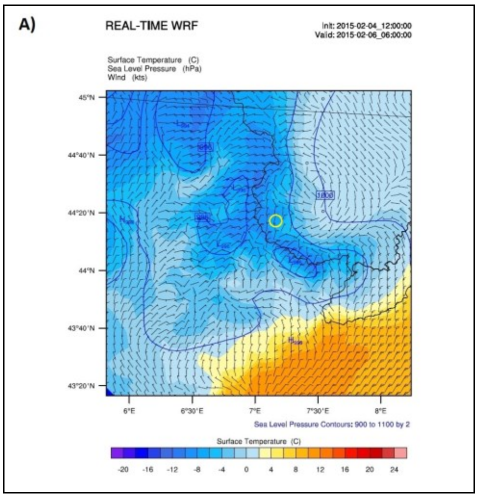


Figure 10: NWP two-way nested domains. WILD station is located at the center of two domains.

The models are run for the whole accretion period as indicated by the wet-snow observation with a forecast horizon of +84h, 1-hour time step. For these simulations, some improvements have been introduced to better represent the complex orography of the domain. The enhancement can be summarized in an improved land-use classification based on the Corine-dataset and in a better representation of orography based on SRTM-dataset with a resolution of 90m. These changes lead to a more accurate surface temperatures and a better representation of the surface winds. The two case studies analysed concern the snowfall events occurred on 5-6 and on 15-16 of February 2015. In the next three paragraph, all simulations of weather forecast, wet-snow accumulation prediction on rotating ACSR conductors and AI current simulation has been described, together with images of webcam installed at the experimental station.

A. Simulation of weather

The simulations of NWP models have been compared with the observation registered at the WILD station. Figure 11 represents very typical conditions favourable for wet-snow accumulation determined by a low pressure in the Rhone-Alps region for both snowfall events. The low pressure is capable of activating high wind speed against Italian west-Alps (*stau effect*), and heavy precipitation near the alpine ridge where the experimental station is located (Figure 12). The air temperature is slightly below 0°C and the typical duration of these events is 24-36 hours with important wet-snow accumulation on OHL.



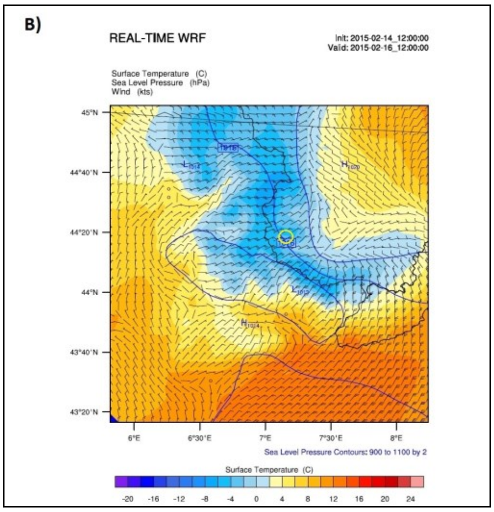
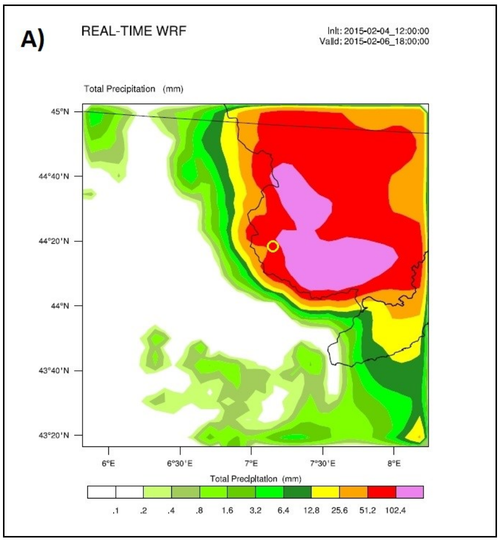


Figure 11: simulated surface air temperature (°C), 10 meter wind speed (half-barb 5 kts, full-barb 10 kts, flag 50 kts) and direction at a horizontal resolution of 5 km at 06 UTC on 6 February (A) and at 12 UTC on 16 February (B). The yellow circle line in both images indicates the position of WILD station.



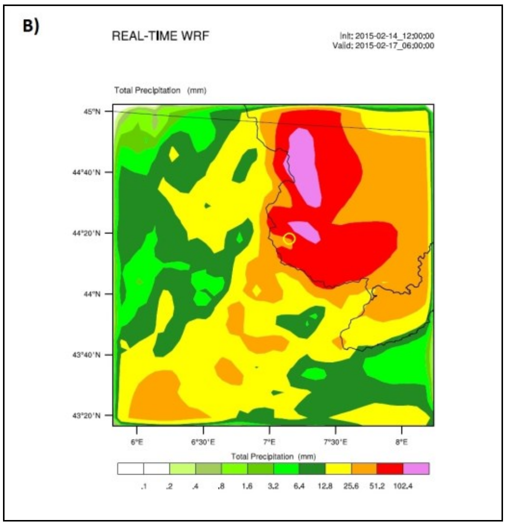


Figure 12: simulated total precipitation (mm) at the end of snowfall forecast period at 18 UTC on 6 February (A) and at 06 UTC on 17 February (B). For both events, WRF simulation indicates heavy snowfall in the west part of the Alps, especially in the area near the WILD station (yellow circle line).

Since the air temperature is a critical parameter to predict in complex orography [12,19], two grid points of WRF models has been considered for the simulation of air temperature. The first one (WRF1) is the nearest point to the station. The air temperature at the altitude of WRF1 (1548 m asl) has been attributed to the elevation of WILD station (944m asl) by using a low vertical lapse rate Γ of 0.3°C/100m, deduced from some observation in wet-snow condition in the Alps. The second grid point (WRF2) is located in the same valley at an altitude of grid point of 1082 m asl very close to the elevation of the station. Whereas, only one grid point of RAMS has been chosen at an altitude of 1559 m asl, because the resolution of topography does not allow to find a grid point with an elevation close to the station. Figure 13 details the simulated air temperature and precipitation for WILD location. The best prediction of the air temperature has been obtained by using WRF2 for both events (Table 1). For these cases, the models tend to underestimate temperature (-1°C WRF2, -2.2°C RAMS -2°C WRF1). The bias of 1°C is within the typical uncertainty of a prediction model, the other values can be affected by an error due to the use of vertical lapse rate that is very difficult to determine in complex orography. Other tests have been performed using a square box of grid points centered on station, but the performance of the forecast has not changed significantly. The reason is that the points of the box are always at a higher altitude than the elevation of the station and the average air temperature of the box must be recalculated through the vertical lapse rate Γ.

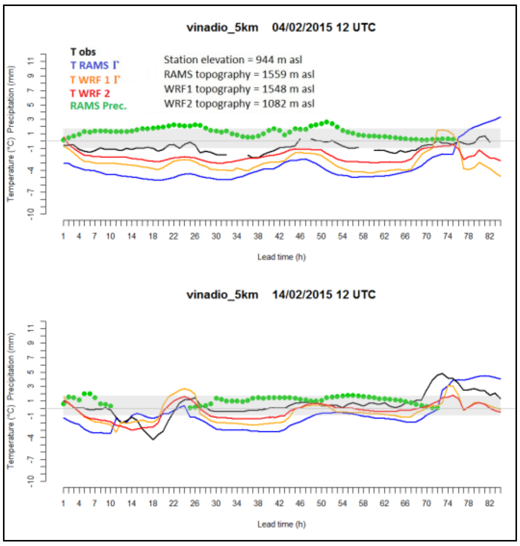


Figure 13: measured (black line) and simulated air temperature for both case studies. Blue curve represents temperature of RAMS, orange and red lines respectively WRF1 and WRF2 simulations. Green dots represents the intensity of precipitation (mm/h) expected from RAMS.

Regarding to the total precipitation, both models tend to overestimate the precipitation observed at the experimental station (Figure 14). For the first event 5-6 February, the observed precipitation was 65 mm, respect to 92 mm predicted by RAMS and 113 mm with WRF. In the second case, the precipitation was 50 mm, 66 mm predicted by RAMS, 61 mm simulated with WRF. It is evident the best prediction both in terms of temperature and precipitation for the second case study. The statistical indices have been summarized in Table 1 and Table 2. The analysis was not performed on the intensity of the wind, because the station is located in an area particularly sheltered from the wind. In the wet-snow conditions observed, the intensity of the wind measured was always less than 2 m/s, instead of wind forecast generally greater than 6-7 m/s.

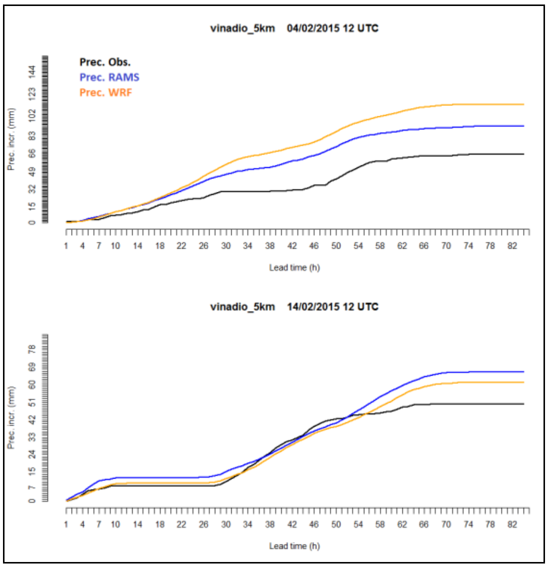


Figure 14: measured (black line) and simulated total precipitation expected from WRF (orange line) and from RAMS (blue curve) for both wet-snowfall events.

Table 1: statistical indices for air temperature.

	4-6 February 2015			14-16 February 2015		
Temp. (°C)	RAMS	WRF1	WRF2	RAMS	WRF1	WRF2
RMSE	3	2.5	**1.4**	2.5	1.7	**1.5**
MAE	3.1	2.2	**1.2**	2	1.4	**1**
BIAS	-2.2	-2	**-1**	-1	-0.8	**-0.7**

Table 2: statistical indices for total precipitation.

	4-6 February 2015		**14-16 February 2015**	
Prec. (mm)	RAMS	WRF	RAMS	WRF
RMSE	**20**	35	10	**5**
MAE	**18**	31	7	**4**
BIAS	**19**	33	6	**3**

B. *Wet-snow accumulation*

Observation and simulation of wet-snow accumulation are presented for the two case studies occurred on 4-6 February and on 15-16 February. The measurements of wet-snow accumulation were obtained from a load cells that were in operation in support of the ACSR Ø31.5mm rotating conductor. Figure 15 shows the most intense phase of snowfall on 5 February, when the sleeves of snow formed on the test spans.

Figure 15: test span during the heavy wet-snowfall event occurred on 05 February 2015.

The next image (Figure 16) reveals a significant wet-snow accretion on the two rotating conductors. It is important to notice that the conductor with hydrophobic coating (on the right part of the image), has a similar sleeve and therefore, the treatment was not appropriate for the wet-snow condition. In the same picture, in the upper left part of the image, the simulation of AI current worked properly and the conductors don't show any wet-snow accretion. Just before the snow shedding, the measured thickness of sleeve was 14 cm and its load 2.7 kg/m, compared to the expected load of 2.4 kg/m (Figure 18).

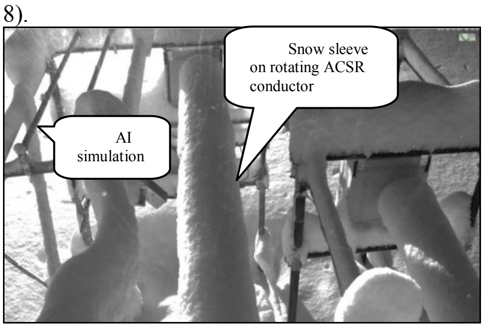


Figure 16: wet-snow accretion on the rotating conductors (photo taken 1-hour before snow shedding, 05-02-2015 06 UTC). In the upper left of image, the two AI conductors are free of snow sleeve.

Figure 17 shows an image captured by the webcam at the end of snowfall occurred on 15-16 February. The snow formation are noticeable for all test spans. The measured load on ACSR conductor was 5kg/m and the thickness of sleeve was 11 cm. The wet-snow load expected on the same conductor was 4.2 kg/m and, also for this event, the two cables with the AI current simulation had no growth of sleeve.

Figure 17: Photo of test spans with snow accretion at the end of the event occurred on 15-16 February 2015.

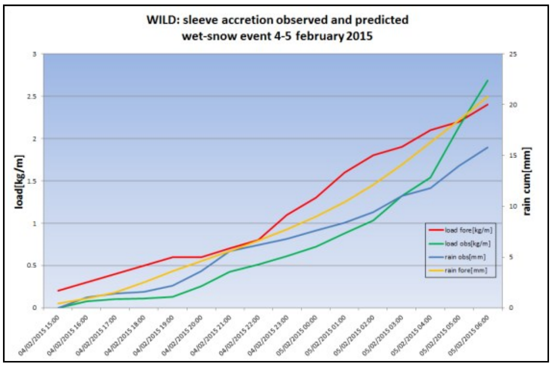


Figure 18: measured (green line) and evaluated wet-snow load (red line) on the ACSR rotating conductor during the event of 4-5 February 2015.

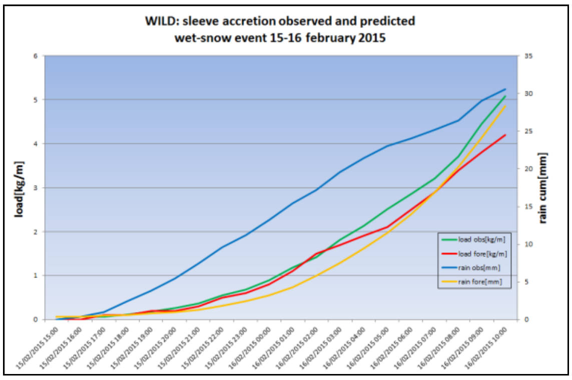


Figure 19: measured and evaluated wet-snow load on the ACSR rotating conductor (15-16 February 2015).

C. *AI current simulation*

During the last winter 2014-2015, 11 snowfall affected the WILD station, but only the two heavy wet-snowfall occurred on February have been considered for the simulation. During these events, the AI circuit described on I.C, worked properly and the accretion of snow has not occurred on both ACSR conductors. In correspondence to these strong wet-snowfall, WOLF has provided an estimation of the AI current necessary to keep OHL free of wet-snow sleeve formations in the expected weather conditions. Thus, it is possible to compare the observed AI current on the ACSR Ø31.5mm used at the WILD site, and the predicted values. The first event has been presented in Figure 20, in which it is possible to notice a variability of the measured AI current, instead of the simulated one. This fact is due to the parameterization of P_w considered in the AI model, while the AI current registered at the station is clearly dependent on the variability of weather conditions. In any case, especially for the second event (Figure 21), there is a good agreement between the predicted and measured data, both in terms of duration of the events, and in the maximum values assumed by the current.

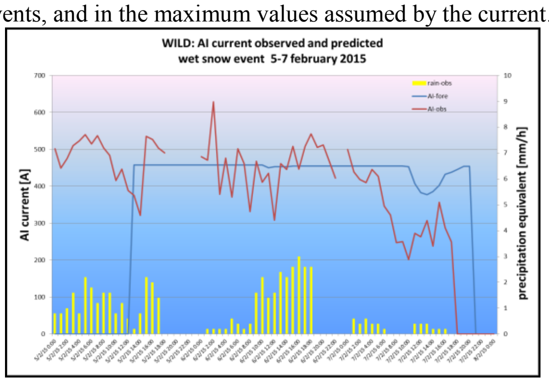


Figure 20: comparison from AI current predicted (blue line) and observed at WILD station (red line) during the wet-snow event on 5-6 February.

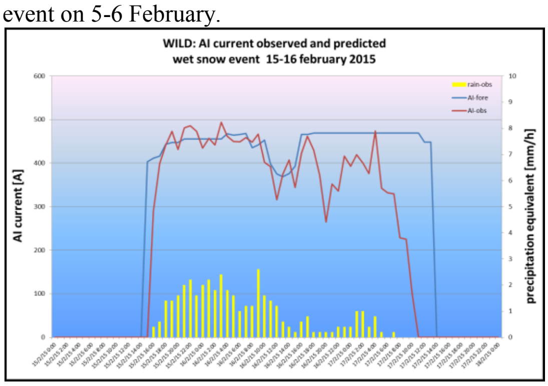


Figure 21: comparison from AI current predicted (blue line) and observed at WILD station (red line) during the wet-snow event on 15-16 February.

V. CONCLUSION

RSE, in collaboration with the Italian TSO TERNA, is carrying out a research activity on issues of prediction, monitoring and mitigation of the wet-snow formations for the overhead power lines. In this paper, two wet-snow events in the west Alps have been described and analyzed using the observation of weather conditions and wet-snow accretion measurement collected at the WILD station. The wet-snow load on the rotating ACSR conductor was respectively of 2.7 kg/m with an equivalent diameters greater than 30 cm for the first event and an accumulation of 5 kg/m with a diameter of 25 cm for the second one. Both the transmission and distribution systems were subject to disruptions close to the WILD station with several blackouts. The new type of conductors, treated on the surface with hydrophobic varnish, were tested with rather poor results.

Two high resolution numerical meteorological models, RAMS and WRF, have been adopted for the atmospheric simulation. The most critical parameter is the air temperature, especially in complex orography. The Γ vertical lapse rate of 0.3°C/100m introduced in the simulations, in some cases revealed to be in a good accordance with the observations, but in other cases is inadequate to represent the vertical profile of the wet-air. The statistical indices for air temperature indicate a better prediction for the WRF model compared to the RAMS simulation with the tendency of both models to underestimate the air temperature. Regarding to the precipitation, the performances of the two models are not so different with a general overestimation of the total amount. It is clear that the successful simulation of wet snow accumulation is critically dependent on detailed and correct atmospheric input data, and detailed and accurate wet-snow model. Considering the experience acquired at the WILD station, the sticking coefficient is too much dependent from the wind. The effect of the wind has been reduced in the estimation of sticking through the square root of its intensity.

The Joule effect simulation on the two ACSR conductors demonstrates that the circuit is able to preserve the cables from snow formation keeping the surface temperature of conductor close to 2°C. The predicted values of AI current obtained through the input of weather forecast in the thermal model [8] correct with the terms P_w, are very close to those simulated. In the next experimental winter season, the set-point will be reduced to 1.5°C in order to limit the simulated AI current.

Other surface treatments of cables will be tested next winter, with the possibility of installing conductors from collaborations with other international research centers.

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