A NEW METHODOLOGY FOR THE IDENTIFICATION OF WET-SNOW CONDITIONS FOR SNOW SLEEVES FORECAST ON THE OVERHEAD POWER LINES

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# Outline

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**Case studies:**
- February 27th-28th 2016
- December 1st 2019

| Conclusions |
Introduction

Wet Snow and power networks: effects and costs

Snow Sleeve formation over conductors ➔ Direct impacts

Snow accumulation over trees ➔ Indirect impacts

Damage costs:
up to 33M€/year
Wet Snow and Snow Sleeves formation

-1.0°C < T < +1.5°C

Rain and high temperature break the snow sleeves

T ≥ +2°C

Snow, rotation of conductor and low temperatures generate the snow sleeve

-1.0°C < T < +1.5°C

Wind
Wet Snow Modelling

Current methodology based on Thermal Window TW method

- **Thermal Window TW**
  - -1.0°C – 1.5 °C

- **Makkonen Model** (ISO 12494-2017)
- Cylindrical wet-snow accretion on conductor
- Conservative Model → no shedding
- Different sticking coefficient in wet/dry conditions

Meteorological Variables:
- \( T_{2m} \), Prec, Wind speed

Wet Snow Modelling

Snow Sleeve
- Mass
- Diameter
Wet snow monitoring - WILD

Wet-snow Ice Laboratory Detection

- Weather measurements to validate forecast models
- Measurement of snow sleeve diameter and mass to validate Makkonen model
- Monitoring of slow sleeves with webcams during wet snow events.
Meteorological Input - WRF-ARW

NW Italy Domain

Initial / Boundary Conditions:
1. IFS ECMWF
2. GFS
New methodology for identification of wet-snow conditions

Snow Ratio SR (or Frozen Precipitation Fraction)

\[ SR = \frac{Q_{\text{graup}} + Q_{\text{snow}}}{Q_{\text{graup}} + Q_{\text{snow}} + Q_{\text{rain}}} \]

- \( Q_{\text{graup}} \): graupel mixing ratio (kg kg\(^{-1}\))
- \( Q_{\text{snow}} \): snow mixing ratio (kg kg\(^{-1}\))
- \( Q_{\text{rain}} \): rain mixing ratio (kg kg\(^{-1}\))

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<th>Condition</th>
<th>SR Criteria</th>
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<td>Dry-snow</td>
<td>SR &gt; 0.98</td>
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<td>Wet-snow</td>
<td>0.5 ≤ SR ≤ 0.98</td>
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<td>Maintenance</td>
<td>0.1 ≤ SR &lt; 0.5</td>
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<td>Shedding (Rain)</td>
<td>SR &lt; 0.1</td>
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Sakamoto, «Snow accretion on overhead wires,» 
Case study February 27th-28th 2016

• Classic wet snow event with significant precipitation accumulations
  • Snow Mass of about 8 kg/m and snow sleeve density of about 200 kg/m³
  • About 80 mm of precipitation between Febr. 28th 12UTC and Febr. 29th 12UTC

https://worldview.earthdata.nasa.gov/
24hr Accumulated precipitation
Estimated Snow Mass - Makkonen model

- Strong overestimation TW due to incorrect timing in the beginning of wet snow event (too early)
- Slight underestimation of SR method due to incorrect timing in the beginning of wet snow event (slight delay)
Case study December 1\textsuperscript{st} 2019

- Wet snow event partly \textit{convective}
- Snow Mass of about 3 kg/m and snow sleeve density of about 230 kg/m\textsuperscript{3}
- About 40 mm of precipitation on December 1\textsuperscript{st}

https://worldview.earthdata.nasa.gov
https://www.blitzortung.org

24hr Accumulated precipitation

**WRF ARW – ECMWF – 1 km**

24h Precipitation from 2019-11-30 12:00:00 to 2019-12-02 00:00:00 (mm/24h)
Geopotential (dam) at 500 hPa

**WRF ARW – GFS – 1 km**

24h Precipitation from 2019-11-30 12:00:00 to 2019-12-02 00:00:00 (mm/24h)
Geopotential (dam) at 500 hPa

VINADIO
Estimated Snow Mass - Makkonen model

- Overestimation TW due to lack of dry snow conditions
- Slight underestimation of SR method due to incorrect timing in the beginning of wet snow event
- Dry condition phases correctly seen by SR method
SR spatial distribution

Case study 1 vs. Case study 2

Frozen Precipitation Fraction (%) Valid: 2016-02-29_00:00:00

Frozen Precipitation Fraction (%) Valid: 2019-12-01_11:00:00
SR – Cross Section – WE

Case study 1 vs. Case study 2
Conclusions

Snow ratio SR is an alternative methodology to determine wet/dry snow conditions with respect to traditional TW method.

In the two case studies analyzed in Vinadio monitoring station SR method show a better estimation of snow mass and a better discrimination between wet and dry snow phases.

Wet snow condition may occur with 2m temperature far lower than 0°C as far as dry snow condition may occur also with 2m temperature close to 0°C (microphysics drive better the discrimination between wet and dry snow condition).

Performances of the driver global model for the high-resolution forecasts may vary depending on case studies. Further case study should be analysed to have a more robust statistic of the performances with different driver models.
THANK YOU FOR THE ATTENTION!
Estimated Snow Mass - Makkonen model

1 hr prec. (mm/h)

Snow Mass

Observed Prec. (kg/m)

T2m (°C)

SR

Prec Accum. (mm)
SR vs 1hr Precipitation – WRF IFS
SR – Cross Section – WRF IFS

Frozen Precipitation Ratio (-)
Temperature (C)

Valid: 2016-02-29 00:00:00

Frozen Precipitation Ratio (-)
Temperature (C)

Valid: 2016-02-29 00:00:00

Frozen Precipitation Ratio (-)

Lat: 43.9 - 44.8
Lon: 6.4 - 8.2

VIN
Estimated Snow Mass - Makkonen model

WRF ARW – ECMWF – 1 km

WRF ARW – GFS – 1 km

T2m (°C)

SR

1hr prec (mm/h)

Prec Accum. (mm)

Snow Mass

Observed Prec. (kg/m)
SR vs 1hr Precipitation – WRF GFS