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CLEAN ROADS

A COMBINED ROAD WEATHER FORECAST SYSTEM TO PREVENT ROAD ICE FORMATION IN THE ADIGE VALLEY (ITALY)

Di Napoli Claudia[1]*, Piazza Andrea[1], Antonacci Gianluca[2], Todeschini Ilaria[2], Apolloni Roberto[3], Pretto Ilaria[4]

[1] Meteotrentino Weather Service, Autonomous Province of Trento, Trento, Italy [2] CISMA Srl, Bolzano, Italy [3] Famas System S.P.A., Egna, Italy
[4] Road Management Service, Autonomous Province of Trento, Trento, Italy * email: claudia.dinapoli@provincia.tn.it http://clean-roads.eu

Provincia Autonoma di Trento

CISMA

FAMAS SYSTEM

INTRODUCTION

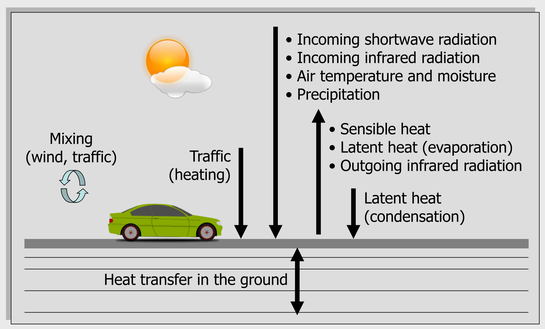
• Ice forms on road pavements in high-humidity conditions when road surface temperatures (RSTs) are below 0°C → Slippery roads increase accident risk and delay travelling times thus posing a serious threat to drivers' safety and the running of economic activities

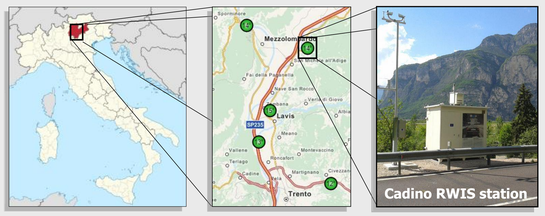
• Spreading de-icers such as sodium chloride to prevent icy roads is nowadays common practice but an excessive, uncontrolled use might be hazardous for the environment and cost-demanding for local road maintenance agencies

A reliable forecast for RSTs is crucial to optimize maintenance costs and reduce the environmental damage from over-salting

FORECAST MODELS

We forecast RSTs for a road location in the Adige Valley complex terrain (Italian Alps) from the combination of two different physical models





1 Reuter
Nocturnal cooling model

Radiation balance at the road surface

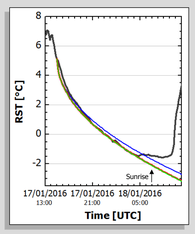
Clear skies, Absence of wind, Low vapour pressure in the atmosphere, Low thermal conductivity, Low specific heat of the ground

Past and present road weather conditions

RSTs at sunrise

$$RST_{sunrise} = RST_{sunset} - K\sqrt{t(sunset, sunrise)}$$

where RST(sunrise) is set to a dynamic RST(t) with t equal to 2, 2.5, 3 … hours after sunset



RST_{sunset}

RST_{Run20} → K_{Run20} $RST_{Run20,\ sunrise}$

RST_{Run22} → K_{Run22} $RST_{Run22,\ sunrise}$

RST_{Run24} → K_{Run24} $RST_{Run24,\ sunrise}$

Conditions

Hypotheses

Input

Output

2 METRo
Model of the Environment and Temperature of Roads

Energy balance at the road surface + heat conduction in the road material

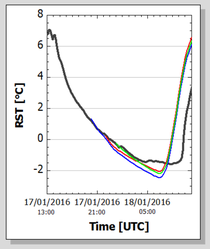
Weather as numerically forecast

Past and present road weather conditions + Future weather predictions

RST minima

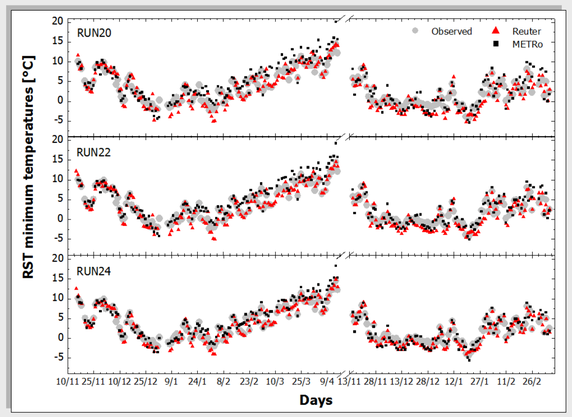
$$RST_{min} = f\left(\begin{matrix} radiation, sensible\ heat \\ latent\ heat, traffic \end{matrix}\right)$$

Coupling with ECMWF T1279 HRES atmospheric model [16 km horizontal resolution; 12UTC run]

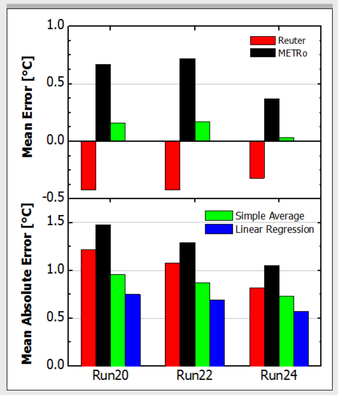


RESULTS

Observed RST minimum values (OBs) have been recorded at Cadino RWIS station every night during winter 2014-2015 and winter 2015-2016. OBs have been compared with corresponding RST forecasts (RSTFs) as obtained by **METRo** and **Reuter**'s model singularly, and by their combinations.



① The correspondence between RSTFs and OBs:
- is better for the Reuter time series in some cases, and for the METRo time series in other cases
- improves with later model runs (closer to sunrise time, longer coupling)

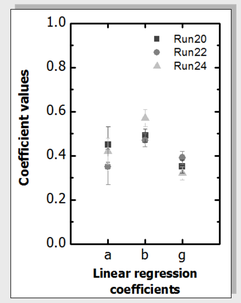


② Single forecasts are biased:
- Reuter forecasts underestimate OBs by 0.4°C on average
- METRo forecasts overestimate OBs by 0.6°C on average

Their accuracy has values between 0.8°C and 1.5°C

③ A simple average forecast has been defined as the arithmetic mean of the i-th Reuter and METRo forecast: $SA_i = 0.5*Reuter_i + 0.5*METRo_i$
- SA forecasts are less biased and more accurate than single forecasts
- SA forecasts represent a 32% (56%) improvement over Reuter (METRo) forecasts on average
- High product-moment correlation coefficients (r >0.97) indicate that the degree of association between SA forecasts and OBs is stronger than that between single forecasts and OBs (0.93 < r < 0.97)

④ A linear regression forecast has been defined in order to *minimise* the sum of squared deviations between the combined forecasts and the corresponding OBs: $LR_i = a + b*Reuter_i + g*METRo_i$
- LR forecasts are unbiased and even more accurate than single forecasts
- LR forecasts represent a 14% improvement over SA forecasts on average



CONCLUSIONS

Combining forecasts can improve forecasting performance for RSTs
- The simple average between Reuter and METRo forecasts outperform the single forecasts.
- Combination via linear regression modelling eliminates unconditional bias, thus increasing overall accuracy and forecasting skill.

This is because the correlation between Reuter and METRo forecasts is less than the respective correlation between these forecasts and the OBs, i.e. Reuter forecasts contain information about OBs not contained in METRo forecasts and *vice versa*.

References
Pretto, I., et al., SIRWEC 2014 conference proceedings, ID:0019 (2014)
Reuter H., Tellus, 3:141 (1951)
Crevier, L.-P. et al., Journal of Applied Meteorology, 40, 2026-2037 (2001)

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