Towards a Quantitative Prediction of Ice Forming at the Surface of Airport Runways

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Introduction: Airport runway winter security is a domain where errors are not allowed. Precipitations of different kind can be responsible of the security degradation, but nowadays efficient de-icing salts are spread preventively. To minimize their use and their impact on the environment, a better prediction of the runway temperature is required. This is where simulation intervenes (1).

Figure 1. Airplane on a runway

Model description: The runway and its foundation are modelled with the different corresponding layers (see Figure 2).

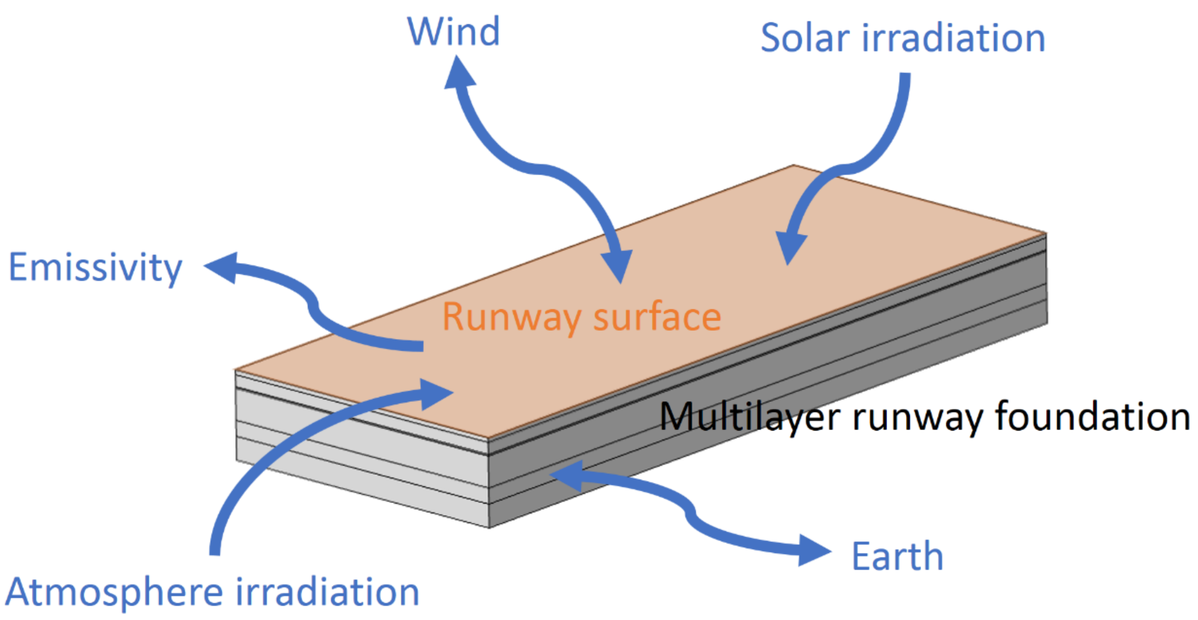

Figure 2. Runway surface and foundation

The heat equation is solved on all the domains:

$$\rho C_p \frac{\partial T}{\partial t} - \nabla.(\lambda \nabla T) = 0$$

At the runway surface, the meteorological contributions to the temperature variations are applied as boundary conditions (see Figure 2). Wind: convection heat transfer (2), Solar irradiation: meteorological prediction data, emissivity: black body theory, atmosphere irradiation: Brutsaert (3) expression. At the other boundaries: heat exchanges with the earth.

Results: Thanks to this model, the temperature at the runway surface can be predicted and compared to the dew point (see Figure 3) to predict frost forming for instance. Moreover the dominant heat fluxes can be identified precisely (see Figure 4).

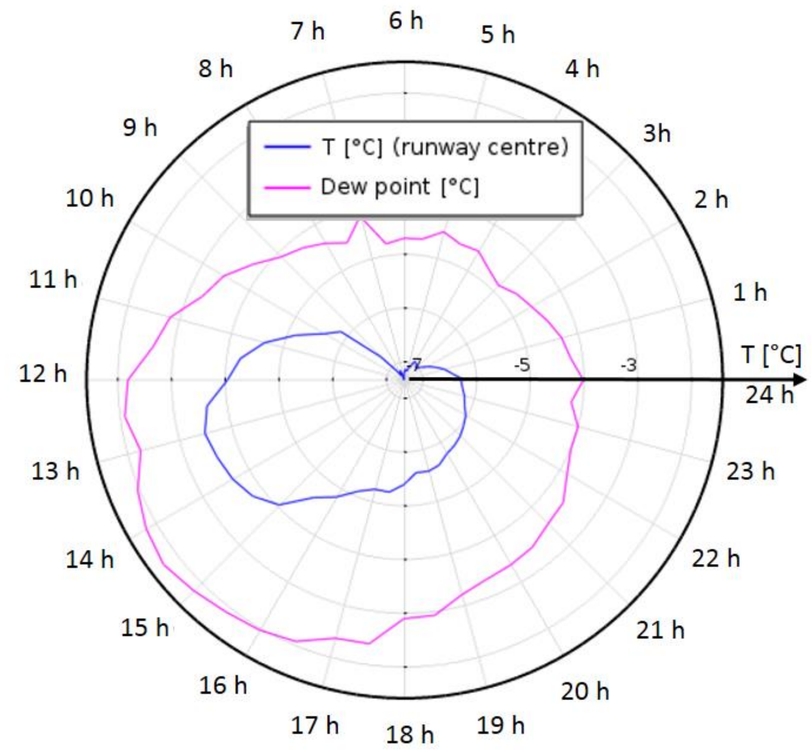

Figure 3. Frost risk prediction

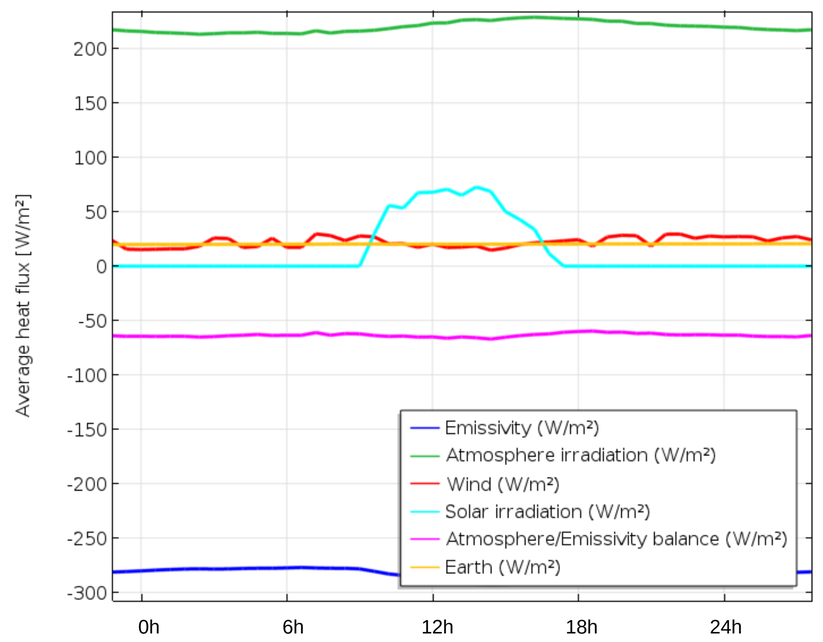

Figure 4. Heat exchanges

Conclusions: The numerical model presented enables temperature predictions very locally, at the runway surface, from regional meteorological data. Comparing this temperature with dew point provides local predictions on the risk of condensation and on water freezing.
Possible model improvements:

- replace Brutsaert (3) expression with a more accurate expression
- take into account fusion latent heat
- experimental campaign to assess the model

References:

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