Skin surface temperature interpolation improvement

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Introduction

At Meteogroup we use ECMWF to initialize WRF. We found a problem with the initialization of the Skin Surface Temperature (TSK) of water points near the coast when we use ECMWF data instead of GFS data. During winter time, when WRF is initialized at 0 UTC (night time in Europe) all water points got a too low temperature.

Since in WRF the TSK of water points remain constant during the entire run, it creates strange behavior during the day near the coast (low temperatures, fog etc.).

In this study the winter case of 2011-01-29 is used to test two different solutions for this problem. The first solution is an additional preprocessing step. This has been used for our operational WRF runs from 2007 till 2010. The second solution has been built in the Metgrid software (part of WPS) and is used from 2010 till present. It has also been implemented in the latest release of WPS (v3.3).

On the day of the case study the night temperature was below freezing and during the day just above.
WRF is run with a 3 km nest covering France, England, The Netherlands and Germany. The main focus will be on the North Sea coast of the Netherlands.
WRF is initialized using ECMWF 0 UTC initialization.

Original TSK initialization

In the Metgrid table there is an interpolation option to tell Metgrid which grid points should be used. In case of the TSK it means that Metgrid ignores grid points with a land mask of 1 when interpolating water points and vice versa.
ECMWF uses a fractional land mask, so grid points near the coast could have, for instance, a land mask with a value of 0.4, but still a TSK that is typical for a land grid point, see figure 1.

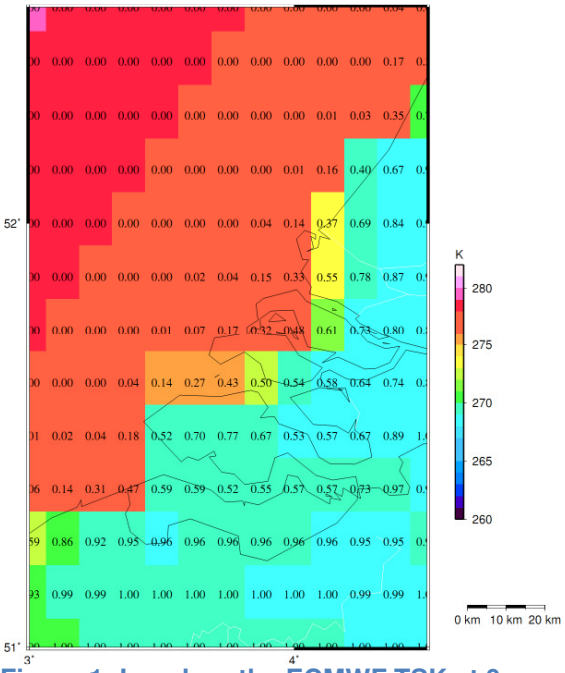

Figure 1: In colors the ECMWF TSK at 0 UTC and the numbers represent the land fraction

After the horizontal interpolation of the TSK in Metgrid the transition from water to land is smoothed. As shown in figure 2.

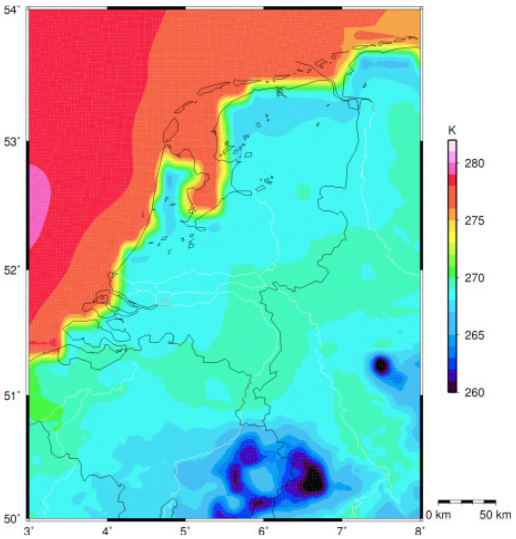

Figure 2: WRF TSK after horizontal interpolation at 0 UTC (FP=0)

The TSK of water points remains constant during the entire WRF run. The wrongly initialized TSK values produce cold spots near the coast, as can be seen in figure 3. The

green and yellow areas near the coast are too cold.

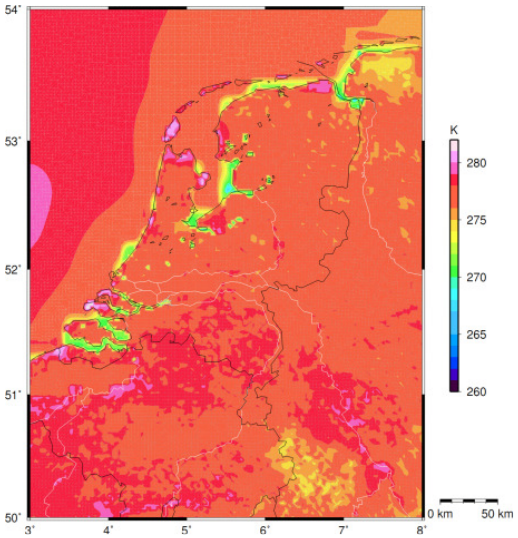

Figure 3: WRF TSK at 13 UTC (FP=13)

Due to these wrong TSK values a wrong 2 meter temperature near the coast is computed. This also results in cloud formation (fog) and small amounts of precipitation. This is not acceptable in a good forecast, therefore the initialization of the TSK had to be improved.

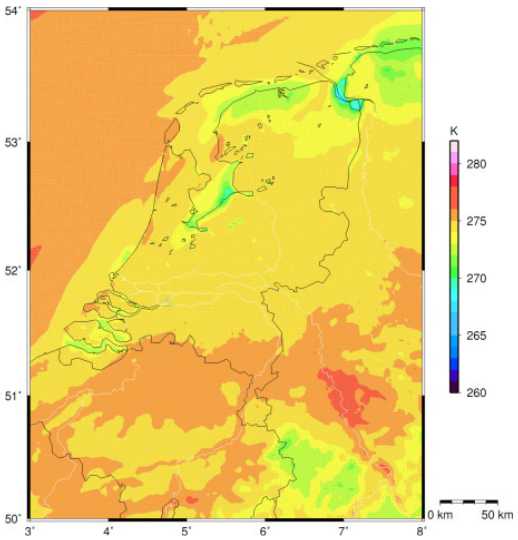

Figure 4: WRF T2m at 13 UTC (FP=13)

Adding an additional data processing method

To solve the problem an additional preprocessing step that would smooth the TSK near the coast was developed. This method has been used from 2007 till 2010 in all MeteoGroup WRF products.
The first step was to look at each coastal grid point in the initial field of WRF. Per coastal grid point the area averaged TSK of the surrounding grid points in WRF was computed.

The first neighboring grid points were ignored, since there is a big chance that they are wrong as well and that they would wrongly influence the area average TSK. Figure 5 shows a schematic representation of the method.

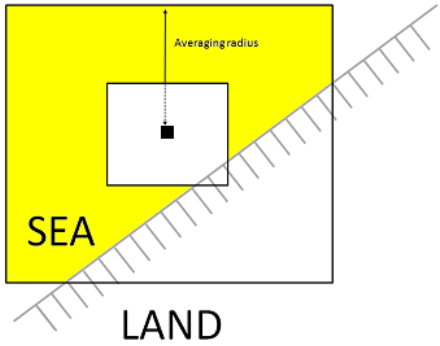

Figure 5: schematic representation of computing an area average TSK value

Next the area average TSK is compared to the actual TSK of the WRF grid point, if the difference is too big the actual value is replaced by the area average TSK. This is an iterative process.
This solved most of the problems, because most of the erroneous low TSK values are removed.

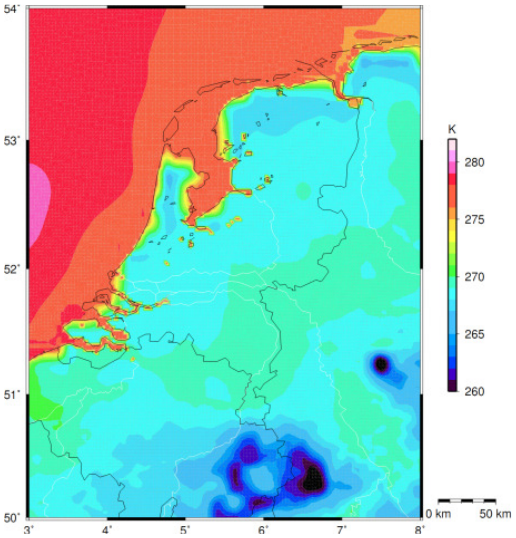

Figure 6: WRF TSK after additional TSK check at 0 UTC (FP=0)

Still some of the water points got a wrong initialization which became clear after a few forecasting hours.

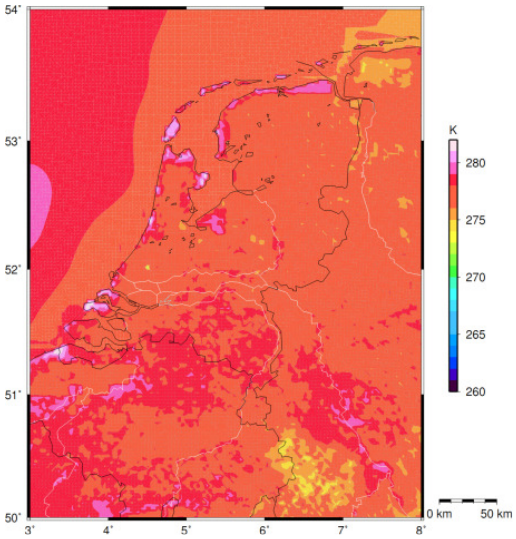

Figure 7: WRF TSK after additional TSK check at 13 UTC (FP=13)

These unrealistic TSK values could still influence the forecast, although the largest part of the errors has been resolved.

Implementation in WPS

The next step was to implement this interpolation option in Metgrid.
An optional relational symbol has been added to the Metgrid table. This way one could tell Metgrid that it should only use grid points where the land mask is smaller than a certain value (e.g. 0.3) to interpolate the TSK of grid points over water. As a result all water grid points in WRF are initialized using real water grid points from the global model as well. This produced a much more realistic initialization of the TSK, see figure 8.

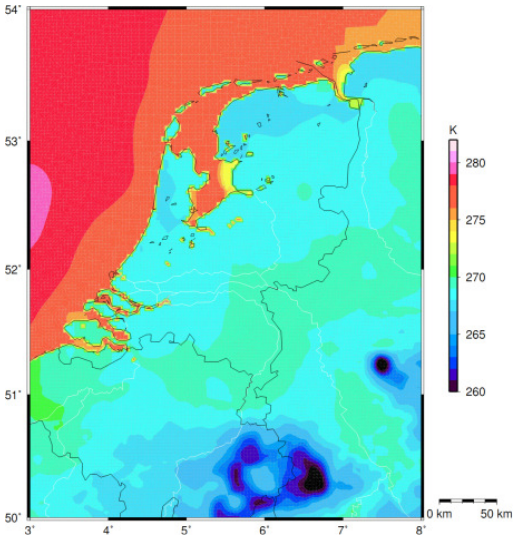

Figure 8: WRF TSK after the new Metgrid interpolation at 0 UTC (FP=0)

After a few forecast hours the TSK still looks much more realistic than when the original Metgrid output was used, see figure 9.

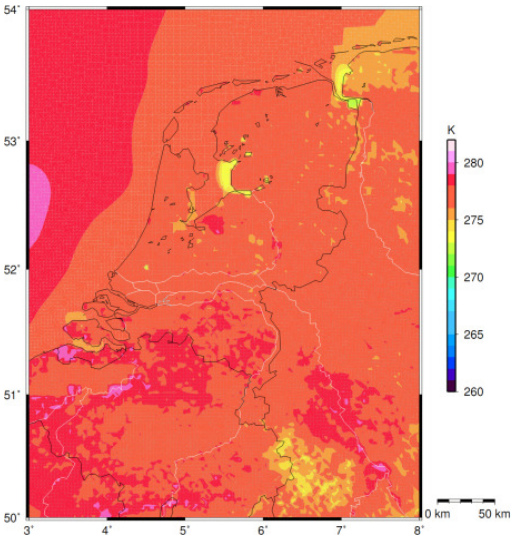

Figure 9: WRF TSK after new Metgrid interpolation at 13 UTC (FP=13)

This new method of the TSK initialization improved the WRF forecast, clearly visible in a much more realistic 2m temperature forecast, see figure 10.

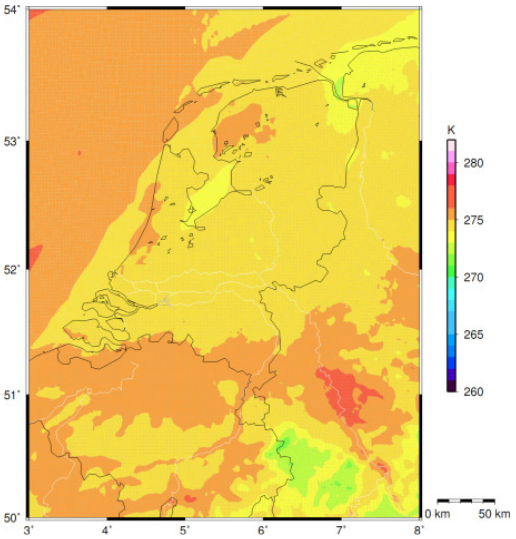

Figure 10: WRF T2m after new Metgrid interpolation at 13 UTC (FP=13)

This option has been implemented for all WRF users in the latest release of Metgrid (WPS v3.3).