# Downscaling Temperature Forecasts along the Coast

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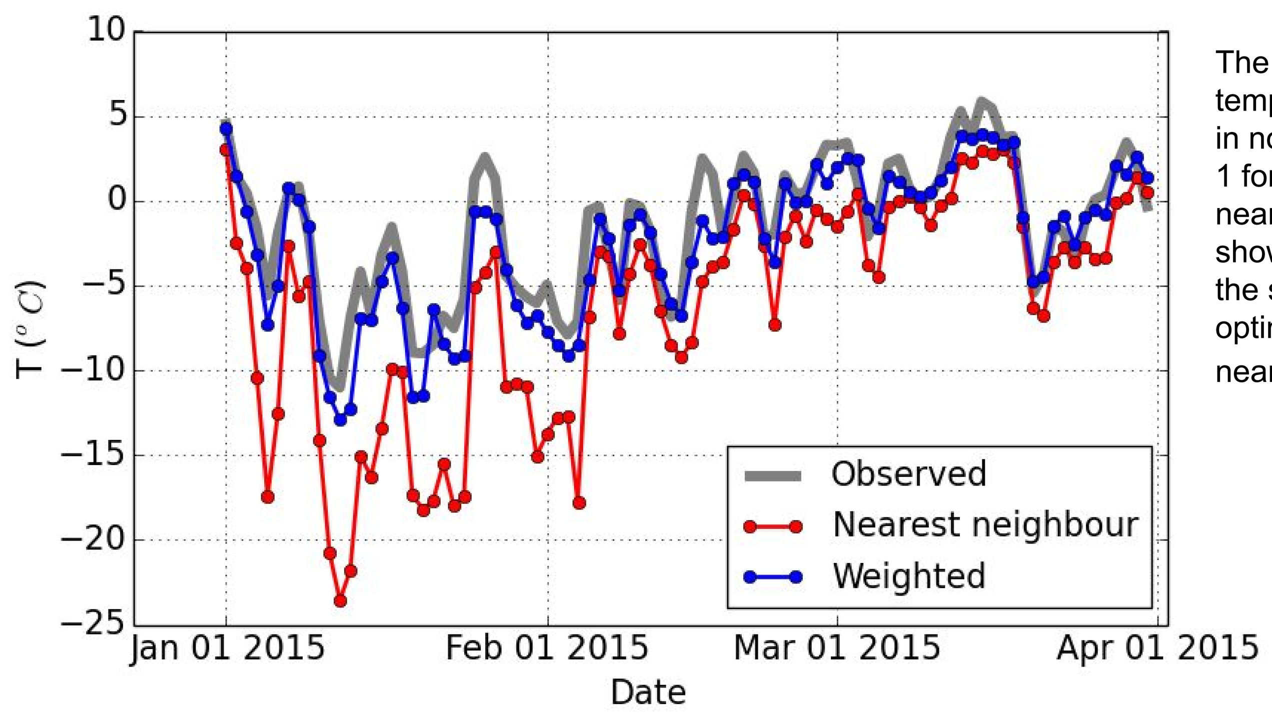
## 1. Introduction

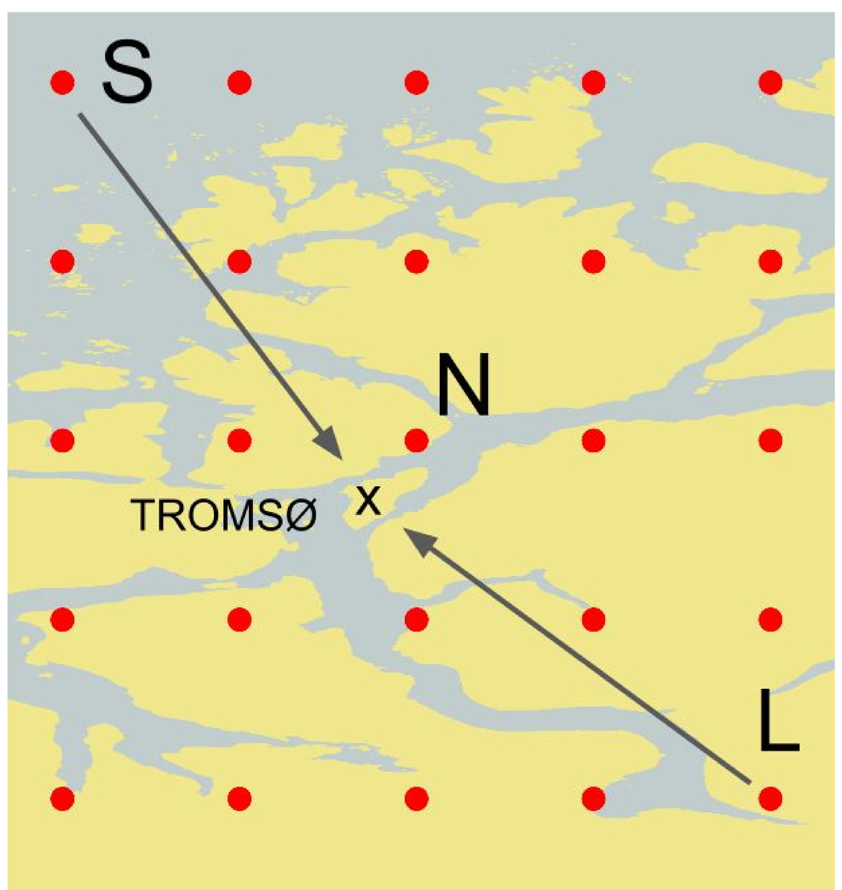



The figure shows observed 2m air temperature for the city of Tromsø in northern Norway (grey line). Day 1 forecast from EC-ENS using the nearest neighbour grid point are shown in red. The blue line shows the same forecasts using an optimal weighting between a nearby sea and land grid point.

Providing accurate location-specific temperature forecasts along coastlines using coarse resolution NWP models is a challenge. Forecast errors in excess of 10 °C are not uncommon and are a result of the model's inability to resolve the intricate coastline. Also, forecast users on the weather site Yr (www.yr.no) expect a smooth transition from the short-range forecasts, which is based on a 2.5 km convection-permitting model, to the medium-range forecast from the ECMWF ensemble (EC-ENS). To achieve this we will show that a simple regression-based calibration method, using a high-resolution NWP model as reference, removes most of the systematic bias and significantly improves the temperature forecasts.

## 2. Method

The method calibrates the coarse model by treating the fine model as the truth. Land and sea temperatures in a neighborhood are used in the regression as they contain additional information that the nearest neighbour by itself does not contain.




$$A \sim S + c(L - S) + b$$

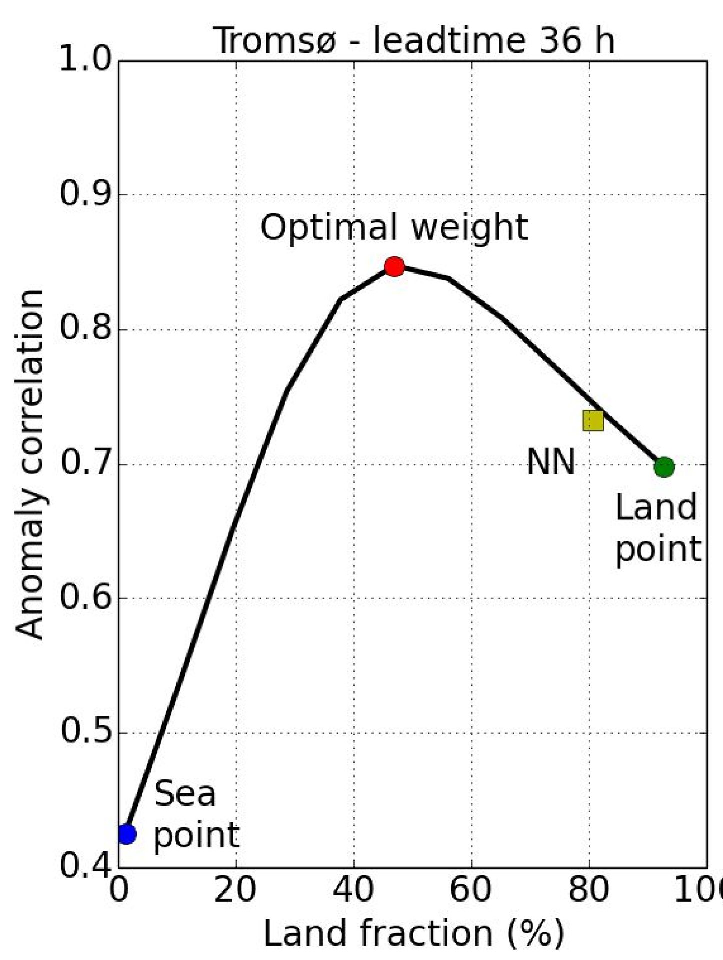
A: 2m air temperature forecast Arome-MetCoOp 2.5 km model

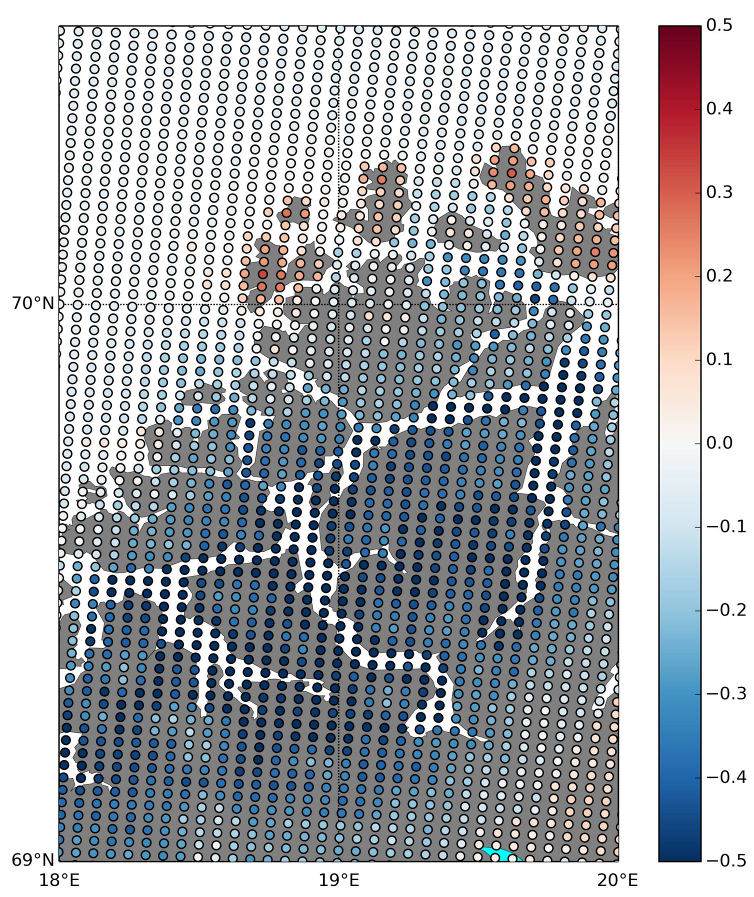
S: 2m air temperature forecast EC-ENS model (approx 18 km) Gridpoint with largest sea fraction in 5x5 neighbourhood

L: 2m air temperature forecast EC-ENS model (approx 18 km) Gridpoint with largest land fraction in 5x5 neighbourhood

c: Regression coefficient

b: Regression coefficient

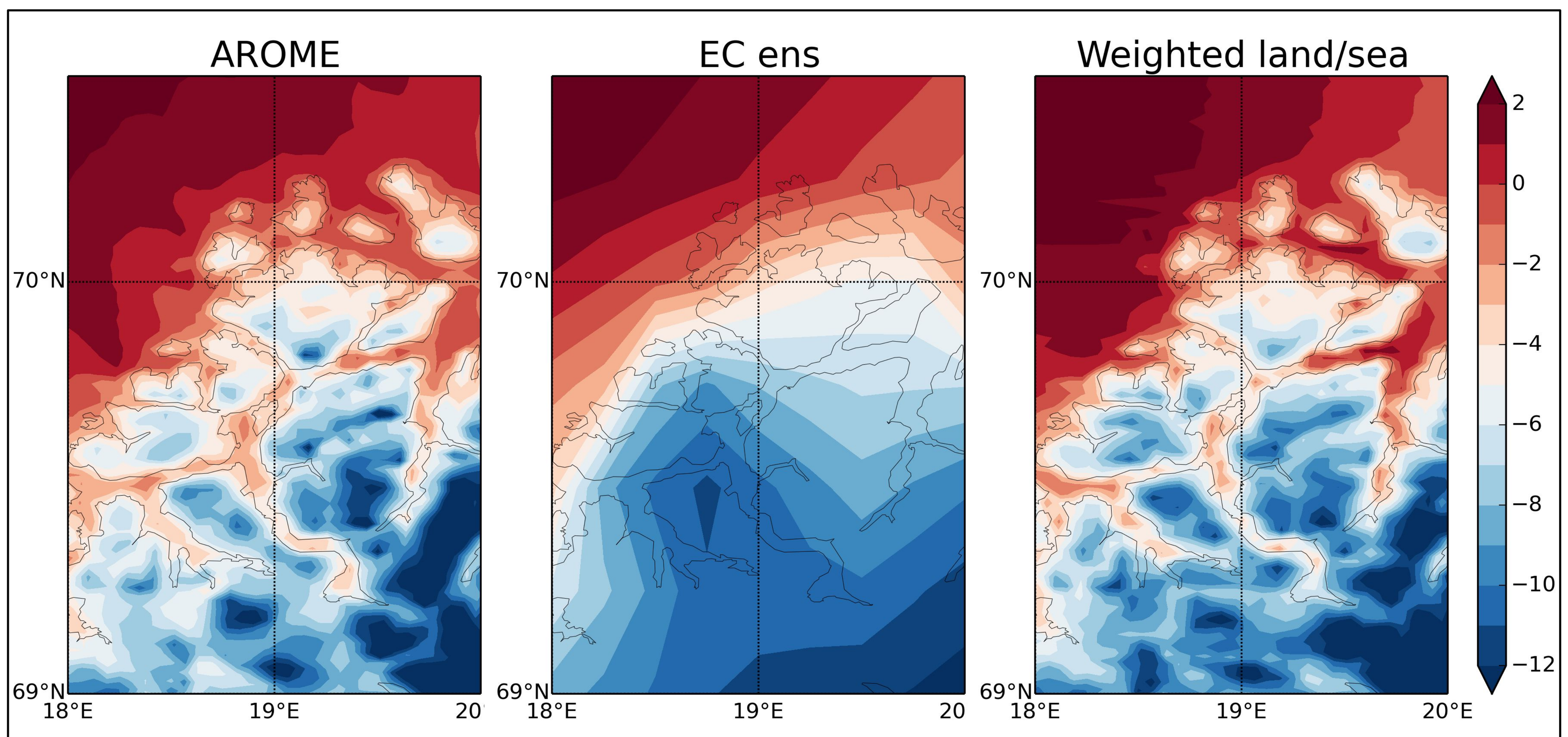


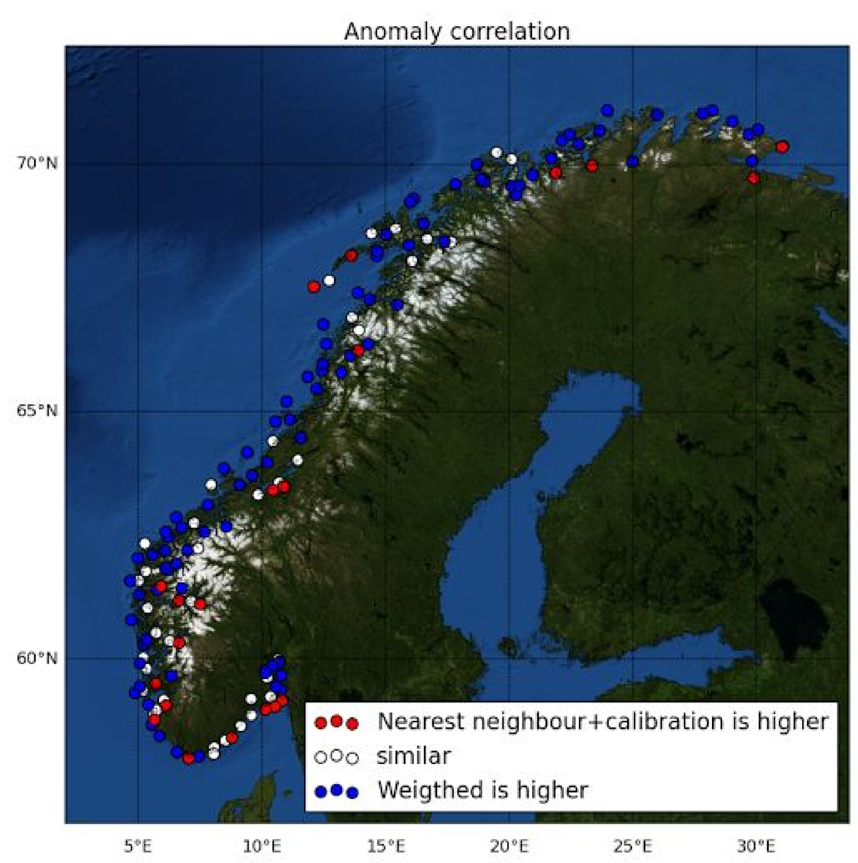
The figure above (left) shows an example of the optimal weight for the city of Tromsø. It shows the anomaly correlation between the Arome-MetCoOp model and EC-ENS. The black line shows the anomaly correlation when the sea and land point are weighted differently. In this case a 50%/50% weighting yields a higher correlation than the nearest neighbor (NN). The higher weighting of the sea point ensures that most of the cold bias during winter is removed.

The figure above (right) shows how the weighting of land and sea points vary spatially. Blue colour indicates where the regression gives more weight to the sea point relative to the nearest neighbour. Red indicates where more weight is given to the land point relative to the nearest grid point. In general, inland fjords have too little ocean influence and islands on the outer coast have too little land influence.

## 3. Evaluation

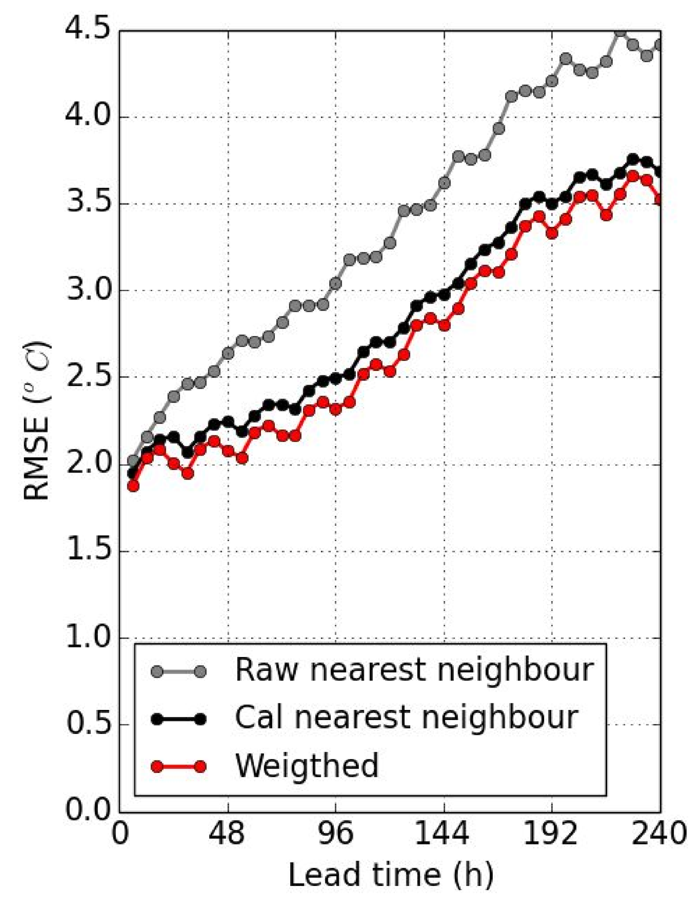


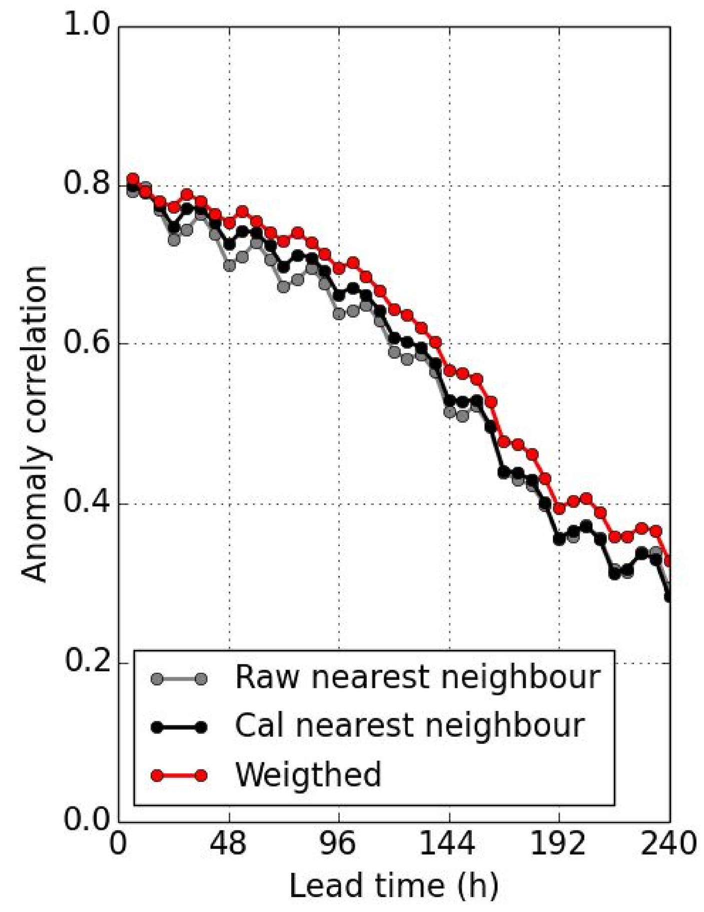

The figures above demonstrate the method for a case with a large cold bias for the city of Tromsø. The figures show: 2m temperature field from the Arome-MetCoOp 2.5 km model (left), the corresponding temperature field from the coarse resolution EC-ENS control run (middle) and the final downscaled field using the optimal land/sea weighting method (right)




The method is evaluated using observations from 159 stations along the coast of Norway. For the verification we used 1.5 years as training data and 1.5 years to evaluate out-of-sample.

The figure (left) shows the anomaly correlation of the weighting method compared to calibration using only the nearest grid point. The weighting method is clearly better for most stations. There are a few stations where the nearest neighbor point is equal or better since the land fraction is already close to optimal in these places.




- Verification shows that calibrating towards the high-resolution model significantly reduces RMSE for all lead times (gray to black line).
- Using the optimal weighting of land and sea further improves the forecasts (black to red line). Most of the systematic bias is also removed (not shown).
- The anomaly correlation (lower figure) also shows that there is a benefit to weighting land and sea points.
- The method under-forecasts the highest temperatures on calm sunny days during summer. For such cases it would be beneficial with more weight towards land. This may be solved using a quantile-quantile mapping as a second step.
- To account for cases where a point behaves differently than its assigned weight, other predictors may also be included such as wind and solar insolation.

### References

Seierstad, I. et.al. Better temperature forecasts along the Norwegian coast. ECMWF Newsletter 148

*Müller, M. et al.* AROME - MetCoOp : A Nordic convective scale operational weather prediction model. Submitted to WAF

Open source post-processing software: https://github.com/metno/gridpp

Open source verification software: https://github.com/WFRT/verif

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