Warning system for temperature and salinity

1. Summary

A so-called warning system could draw the partner's attention to possible problems with their model by giving information to a modeler, when his forecast product starts to drift away from the multi-model ensemble (MME) on the current day. Other MME statistics and figures from the MME NOOS website may be consulted (e.g. "MME differences") to further investigate a problem. The warning system is based on the temporally and spatially averaged difference between each forecast product and the MME median for a certain region (Figure 1). For each parameter a separate warning system is created: temperature and salinity at the surface (SST, SSS) and at the bottom (SBT, SBS). The system is separated into two parts, whereas for each part different thresholds are defined. For the calculation of these thresholds it is assumed, that the data of the forecast products are normally distributed and that approximately 95% of the data are within the range of **mean or median ± 2*standard deviation** (depending on the test). If a forecast is outside of this range (remaining ~5%), a warning is issued.

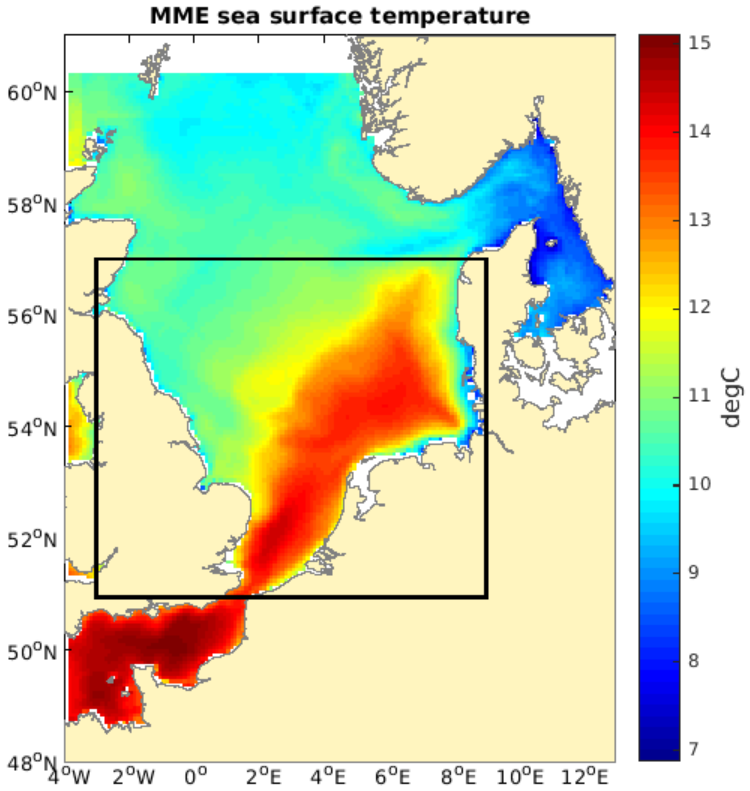

Figure 1: The area for the warning system is marked by the black box.

In the first test it is investigated, if a forecast product exceeds a threshold which is calculated from the data for the current day. This threshold is defined as the median of differences plus 2*standard deviation of the differences (see calculation in 2.). This calculation includes all forecasts available on that day. In the second test it is examined, if a forecast product exceeds an individual threshold, which is based on the forecasts of the last 30 days. Therefore the standard deviation of differences is calculated for each forecast product over the last 30 days, whereas only those days are included on which all forecasts are available (!). Consequently the individual thresholds for each forecast product are defined as the mean difference of the

forecast over the last 30 days plus 2*mean of all standard deviations, which is the ensemble deviation (see calculation in 2.).

2. Calculation steps

a) ***Absolute difference*** of each forecast product from the MME median at each grid point at each time step (1h – 48h) of the current forecast date.

b) ***Area mean*** (2.5°W-9.5°E, 50.9°N-57°N) of this ***absolute difference*** at each time step (1h – 48h).

c) ***Temporal mean*** of ***area mean*** of the absolute difference of each ensemble member:
$\vec{X} = (X_1, X_2, \dots, X_n)$ with n: number of ensemble members

d) Median (MD) and standard deviation (SD) of $\vec{X}$:

I. $MD = median(\vec{X})$

II. $SD = std(\vec{X})$

III. $Threshold_1$= MD + 2*SD

> ➢ **1st warning "Daily-median-test":** Check for each ensemble member (X_i):
> If $X_i > Threshold_1$ then 1st warning

a) Mean ($\vec{M}_{30}$) and standard deviation ($\vec{\sigma}_{30} = (\sigma_1, \sigma_2, \dots, \sigma_n)$) of differences of the last 30 days for each ensemble member ($\vec{X}_{30}$):

I. $\vec{M}_{30} = mean(\vec{X}_{30})$

II. $\vec{\sigma}_{30} = std(\vec{X}_{30})$

e) Mean of all standard deviations:

I. $SD_{all} = mean(\vec{\sigma}_{30})$

II. $\overrightarrow{Threshold_2}$= $\vec{M}_{30}$ + 2* SD_{all}

> ➢ **2nd warning "30days-threshold-test":** Check for each ensemble member (X_i with i=1:n):
> If $X_i > Threshold_{2,i}$ then 2nd warning

3. Figures

There are two figures of each variable which are updated daily on the NOOS website, showing results for the current day and for the last 30 days.
The first figure should give an overview of the model behaviour as well as a better estimate for a warning occuring. It shows the daily spatially averaged data of each model that contributed to the MME, as well as the MME median and the member median for the last 30 days of the same area used to calculate the warning.
The gray-shaded area can be considered as an "uncertainty range". This part shows the range between the 2.3rd and 97.7th percentiles around the member median, i.e. the median of the averaged models (without MME median). This percentile is analogous to two standard deviations. This is to provide a more accurate assessment of the behavior of the MME as well as the individual models.

With this figure, it is possible to discover unexpected behaviour, but also to detect a false warning. A false warning could occur if a model is missing, because this could change the MME median, increasing the difference between the model and the median and triggering a warning. The second figure shows the averaged difference between each model member and the MME median. If the **1st warning** occurs for one of the forecast products on the current day, the **threshold** is marked by a **vertical line**, similar to an error bar. The product, which exceeds the threshold on that day, is additionally marked by a **filled circle**. If the **2nd warning** occurs for one forecast product on the current day, the **threshold** for the corresponding forecast is marked by a **horizontal dashed line** with the same color as the time series. Further, a **thick black line** (at the top of the plot) marks those days, on which **all forecast** products are **available**.
In addition, all warnings over the last 3 months are summarized for each forecast product and displayed in a plot.