

Composite atlas of SPM in the southern North Sea 2007

MoS²: Model-supported monitoring of SPM in the Dutch coastal zone



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Summary

This document presents a composite atlas of suspended particular matter (SPM) in the southern North Sea for the year 2007. It summarizes part of the results of the MoS² project carried out for the Port of Rotterdam by VU-IVM and Deltares between 2009 and 2011.

References

This atlas is to be read in conjunction with the technical reports published from the MoS² project:

Blaas, M., Cronin, K., El Serafy, G.Y., Gaytan Aguilar, S., Friocourt, Y.F., Keetels, G.H., 2011, Model setup, data assimilation and skill assessment. MoS²: Model-supported monitoring of SPM in the Dutch coastal zone. Deltares report 1002611, September 2011, Delft.

Eleveld, M.A., De Reus, N.O., 2010, Hydropt for SPM data assimilation: Optics and accuracies. Model-Supported Monitoring of SPM: MoS². WP 2 Remote Sensing. Report accompanying the delivery of the 2007 and 2008 SPM products derived from remote sensing data. VU-IVM report R10/02A, December 2010

Van der Woerd, H.J., De Reus, N.O., 2010, MoS²: WP4 In situ data. Report accompanying the delivery of 2007 SPM products derived from in situ data. VU-IVM report R10/08, November 2010.

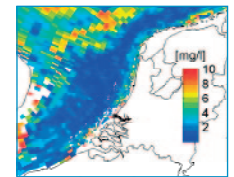
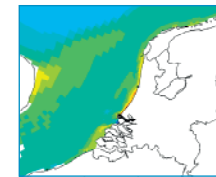
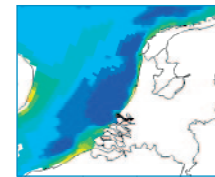
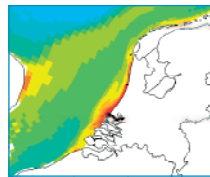


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About this atlas



About this atlas

This document presents a composite atlas of suspended particular matter (SPM) in the southern North Sea for the year 2007. This atlas summarizes part of the results of the MoS² project carried out for the Port of Rotterdam by VU-IVM and Deltares between 2009 and 2011. It is to be regarded as an addendum to the report of the MoS² project delivered in 2011 on the modeling, data-assimilation, and skill assessment of the assimilated results (Blaas et al. 2011). Together with the reports delivered in 2010 on the preparation of the MERIS remote sensing data (Eleveld and De Reus 2010) and analysis of various in situ data sets (Dankers and Van Tongeren 2008, Van der Woerd and De Reus 2010), this constitutes the documentation of the MoS² project covering the year 2007.

In addition to these reports and atlas, all remote sensing and model results have been provided to the Port of Rotterdam as digital files. Please note that these files contain much more extended and higher time and spatial resolution data than

presented here in print. The atlas shows the surface and bottom results of SPM on the grid of the Delft3D transport model, averaged over about a one-week period, whereas the digital files contain the following:

- Instantaneous remote sensing data on 1x1 km resolution with nominal daily overpass of the MERIS sensor (concentrations of SPM and standard error by VU-IVM's HYDROPT algorithm, accompanied by additional meta-parameters on accuracy).
- Instantaneous Delft3D model results of the SPM transport model at each of the 12 layers in the water column and in the two bed layers at hourly time resolution.
- Instantaneous hydrodynamic model results: such as resuspending wave stresses, salinity and water temperature and water levels and current velocities.

This composite atlas is a graphical summary on a weekly timescale of what has been produced in the MoS² project. The reports mentioned above provide the necessary background on the production and interpretation of the data. The full data sets are available as Delft3D output files and NetCDF files via the Port of Rotterdam and can be viewed with software such as Delft3D Quickplot or publicly available tools such as ncBrowse.

In 2012, this version of the atlas will be replaced by an upgraded version based on anticipated results of the follow-up project MoS²-II. This follow-up project will upgrade the model and data assimilation and produce data for the years 2005-2008.



The MoS² project



The MoS² project

The MoS² project (Model-Supported Monitoring of SPM) aims to provide the Port of Rotterdam with novel and improved means to monitor SPM in the Dutch coastal zone in relation to the construction of Maasvlakte-2. Model-supported monitoring combines remote sensing and numerical modelling as a complement to in situ monitoring.

The remote sensing data, originating from the MERIS sensor on ESA's Envisat spacecraft, have been processed by VU-IVM to yield quantitative information on SPM concentrations. To meet the needs of the Port of Rotterdam and to enable the data-assimilation in the MoS² project, also uncertainty information has been derived from the HYDROPT retrieval algorithm. The MERIS data have been aggregated onto the grid of the newly developed Delft3D transport model ZUNO-DD and applied in an Ensemble Kalman Filter to improve

the model description of SPM in the southern North Sea.

Next to tailoring the MERIS data, the MoS² project focused on the redesign and improvement of Delft3D transport model of the southern North Sea. The transport model (ZUNO-DD) has been set up to yield an increased horizontal resolution in the Dutch coastal waters compared to its predecessor (ZUNO Coarse). With domain decomposition techniques, a high-resolution grid (about 40 km wide) has been introduced covering the entire coastal area from Oostende to Schiermonnikoog. More inshore, another grid refinement (about 10-15 km wide, ranging from Voorne to Petten) has been applied to particularly focus on the Rhine outflow region, in order to better resolve the variability in time and space in this dynamic area.

Finally, an Ensemble Kalman Filter has been developed to assimilate the MERIS surface concentrations of SPM into the transport model in order to improve the description of the variability of the model reconstruction of the 2007 SPM concentrations (hindcasts).

In the project, the un-assimilated and assimilated model results and the MERIS data for the year 2007 have been compared to each other and to time series and profiles of in situ data. The year 2007 is one of the years for which Port of Rotterdam wishes to determine the baseline conditions for the southern North Sea, in particular the Dutch coastal waters. Follow-up activities are foreseen to extend the baseline conditions to other years and to improve the accuracy of the model hindcasts.



What is shown in this atlas



What is shown in this atlas

The composite atlas shows per page a set of panels for a zoom-in of the Delft3D transport model domain (details discussed further below). At the bottom, time series of tidal water level and significant wave height are shown.

Each page refers to data averaged over an interval of about 7.5 days. These intervals are based on harmonic analysis of tidal water level fluctuations off Noordwijk. Two important time scales of fluctuation of SPM in the southern North Sea relate to the semidiurnal and spring-neap tidal current variations (see e.g. De Ruijter et al. 1997, Pietrzak et al. 2010). To average out short-term semidiurnal variations and to obtain sufficient samples in the satellite data, but to resolve the spring-neap variations, the averaging intervals have been chosen to center around spring and neap tide consecutively. The interval is indicated in the time series by a pink bar.

Another important source of variability in SPM concentrations is resuspension and vertical mixing by wind waves (see also Eleveld et al. 2008, Fettweis and Nechad 2011). Therefore, the significant wave height at the Euro platform offshore of the Maasvlakte is also plotted. This provides a view of the 'marine weather' conditions preceding and during the interval shown.

The temporal averages over the intervals indicated are geometric means, because the SPM concentrations values are approximately log-normally distributed (see also Eleveld et al. 2008).

The upper row shows the concentrations at the surface layer of the model grid (4% of the total water depth). On the left, the 1x1 km HYDROPT MERIS SPM pixel data have been gridded, weighted according to standard error, and subsequently temporally averaged. The MERIS data are recorded during overpass of the Envisat satellite which occurs nominally once per day between 9:00 and 12:00 AM UTC. These recordings refer to the visible, upper part of the water column. SPM pixels rejected for technical or quality reasons (cloudiness, land, unreliable retrieval) have been removed and may show up as white spots. Note that the number of successful pixels per grid cell shown in a composite may vary between zero to tens of values (for large grid cells and favorable observation conditions). Based on the 7.5 day interval, sufficient MERIS data are collected to provide an area filling image, except during prolonged cloudy periods. Note that all SPM pixels in lakes, the Wadden Sea and the water bodies of the Zeeland and South-Holland delta have been removed because the retrieval model HYDROPT in this case has not been set for these areas with

different optical properties of SPM and other substances.

The middle and right panel show the model results, time-averaged, based on hourly model output data for the model without ('deterministic') and with data assimilation, respectively. For both panels, only the model output at moments where MERIS data were available has been applied. Moreover, only the results of the update by the Kalman filter have been selected in the assimilated output.

The lower middle and right panels show the concentrations at the lowest level in the water column (bottom 4% of the total water depth). These illustrate the model response to the Kalman Filter over the vertical.

On the lower left the Root Mean Square of the difference between the assimilated SPM and the gridded MERIS SPM for the surface layer is plotted for each sample of gridded MERIS pixels and matching model result over the 7.5 day interval. This RMS difference provides insight in the behaviour of the assimilated solution with respect to the satellite data.

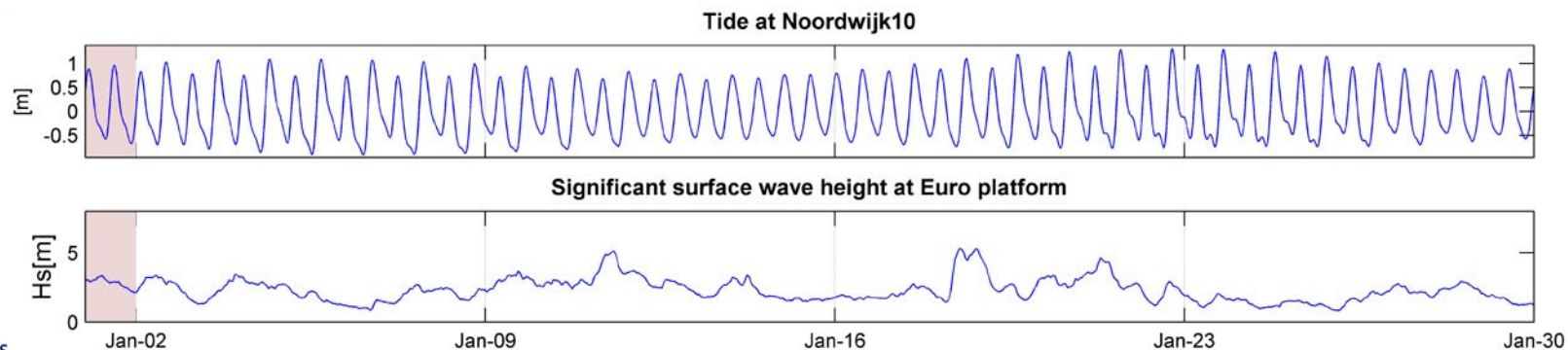
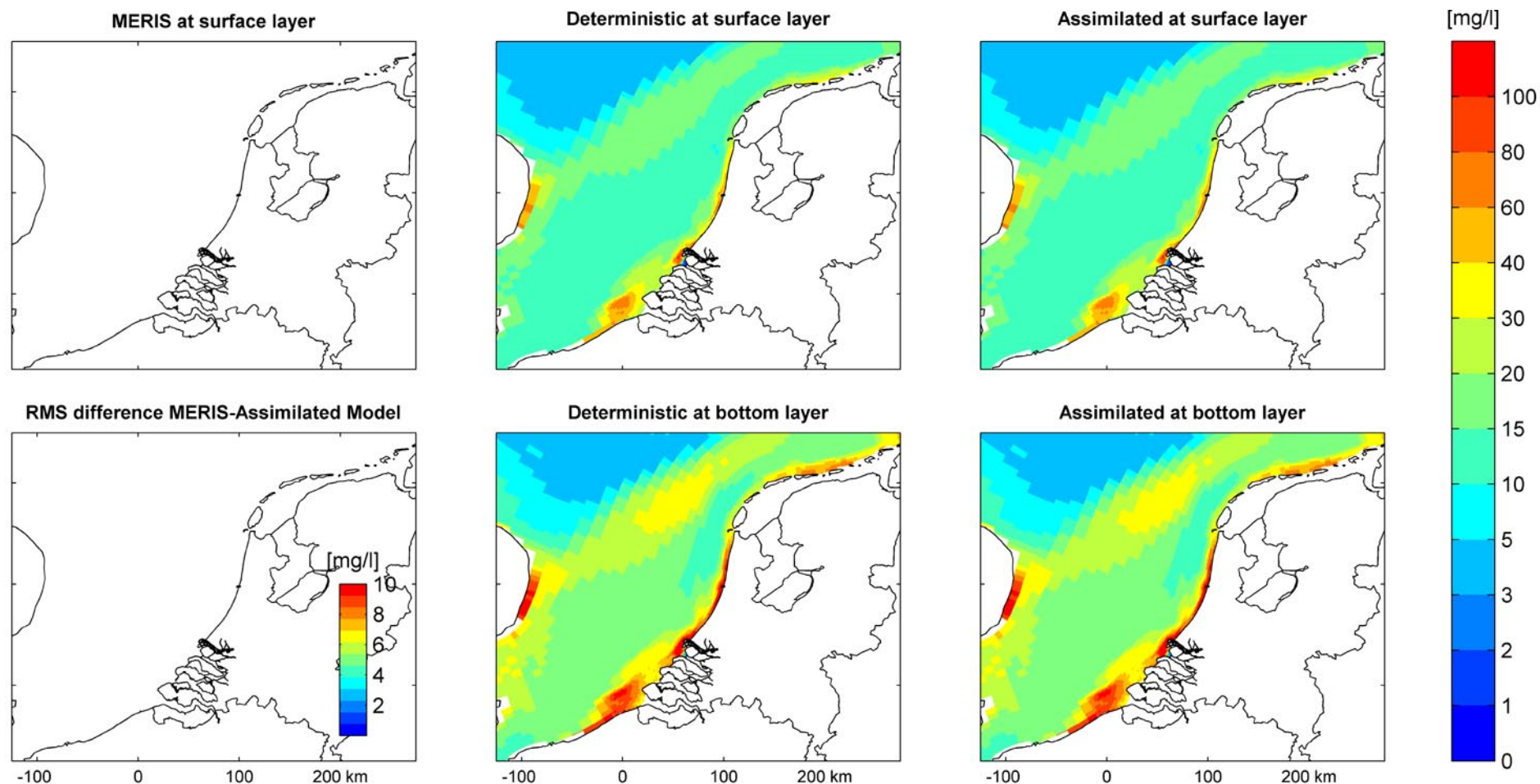


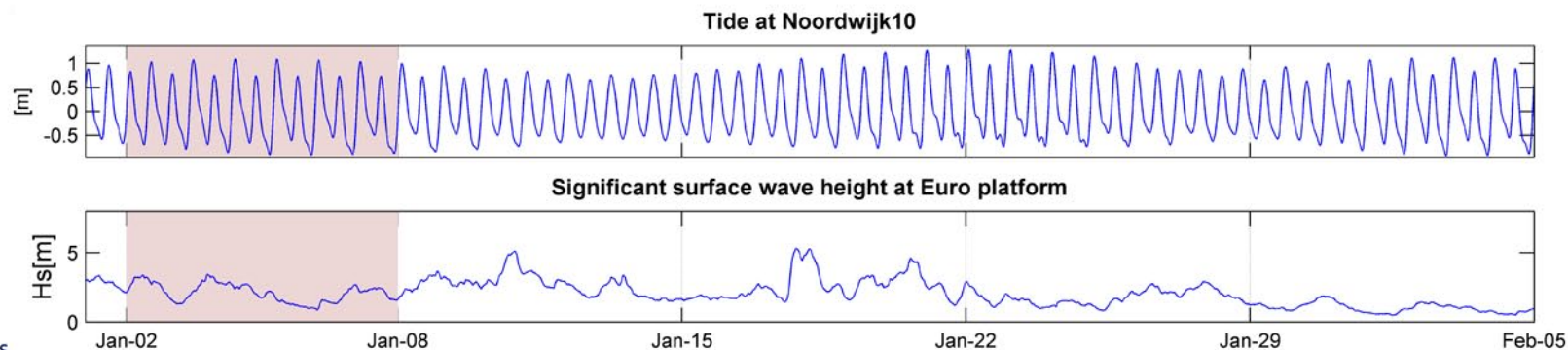
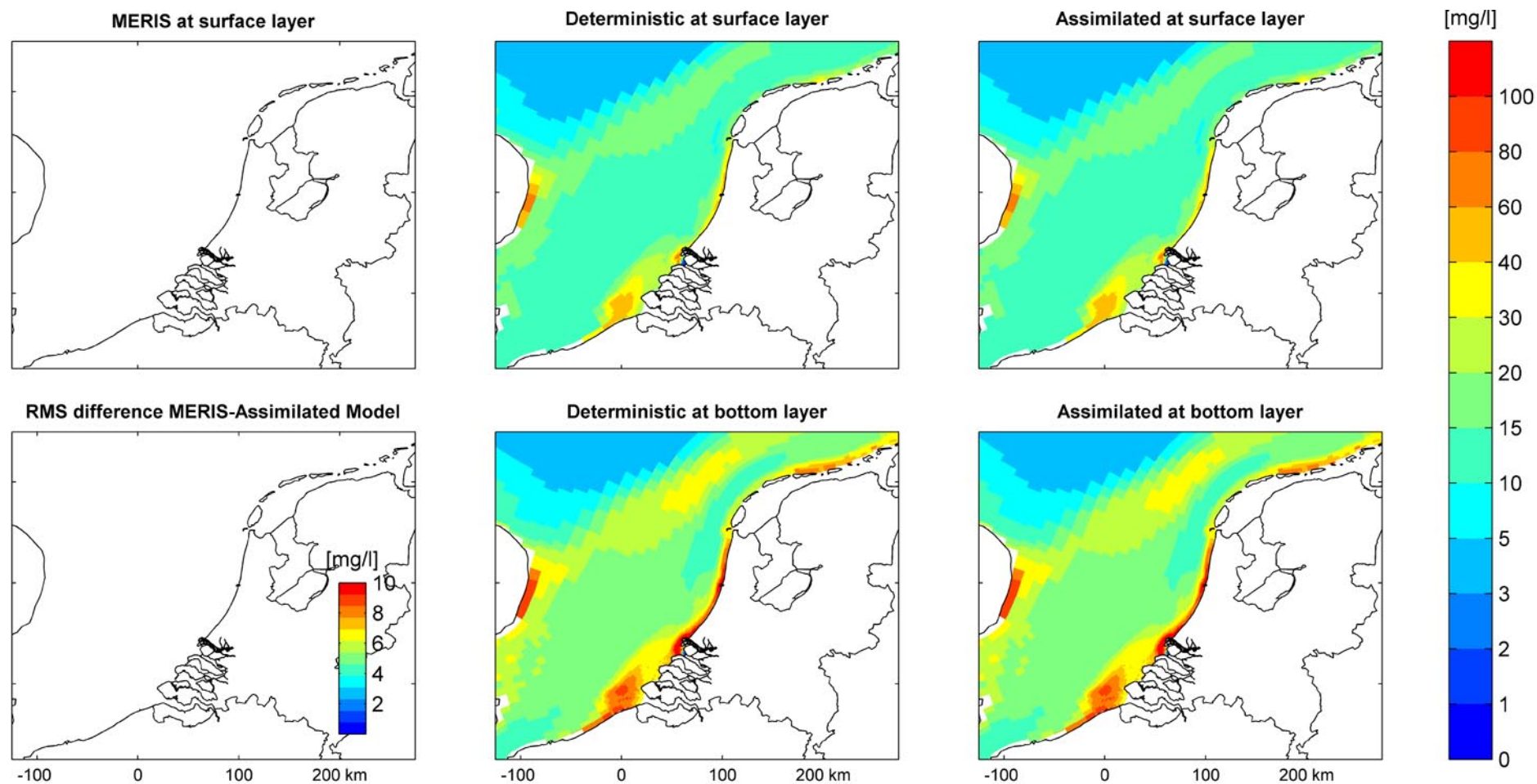
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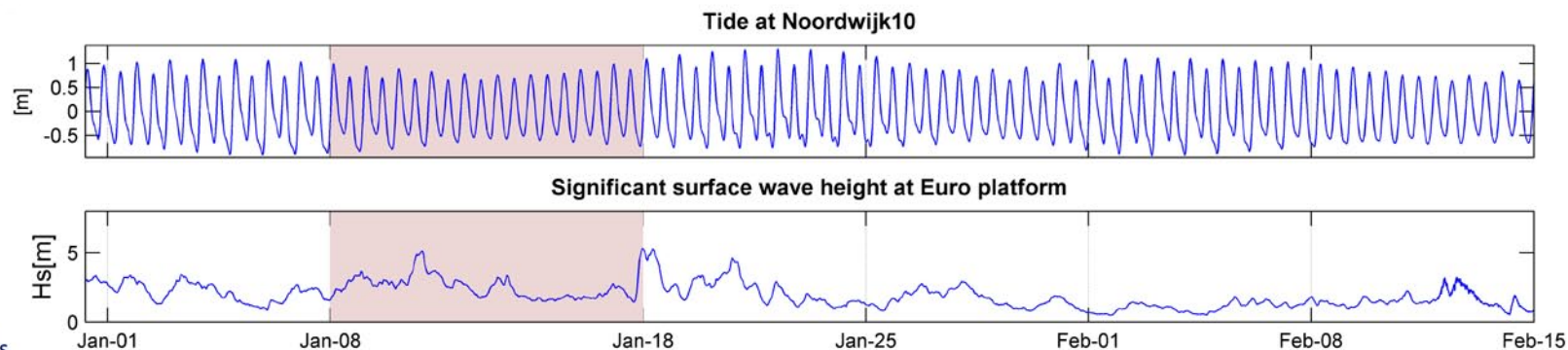
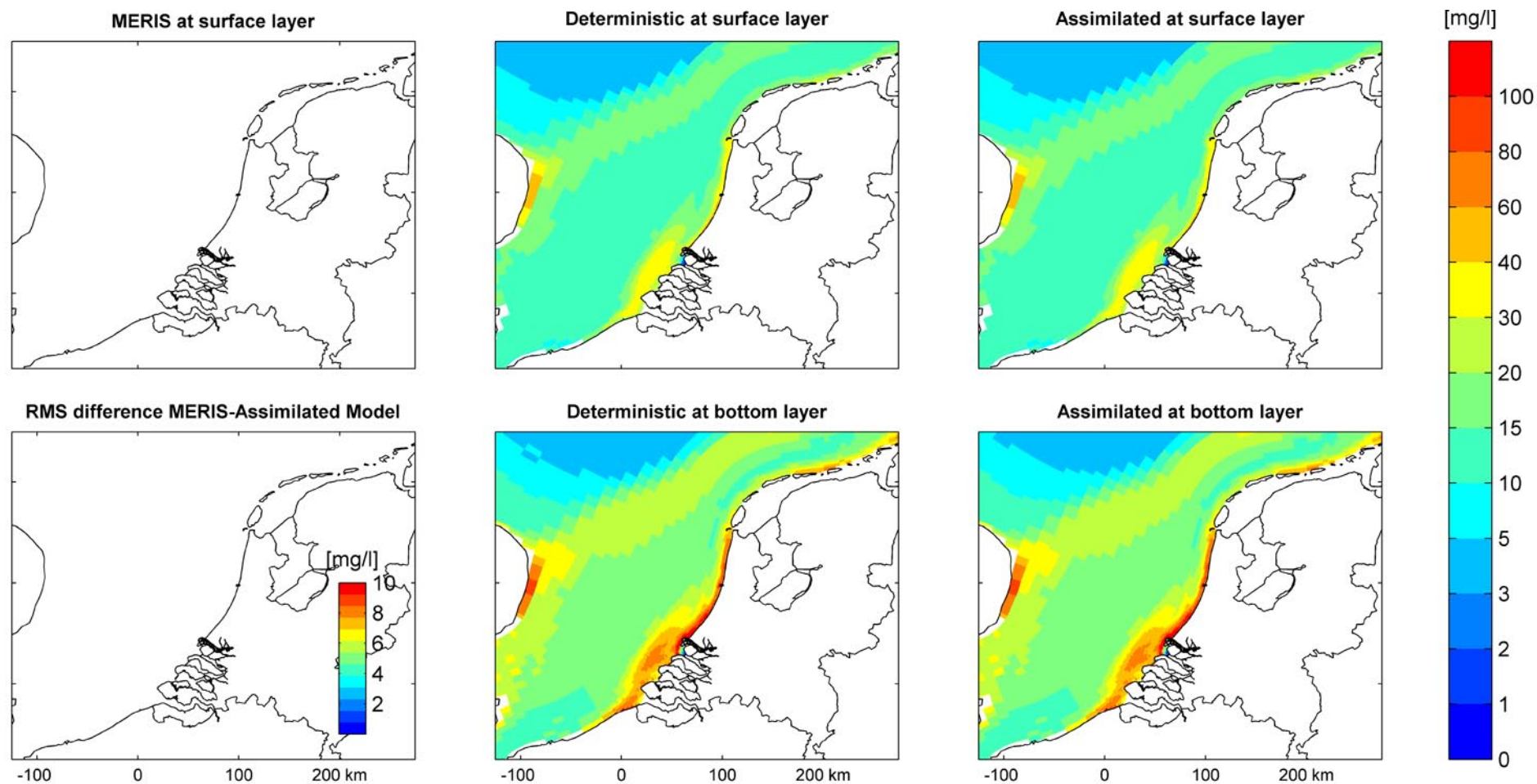


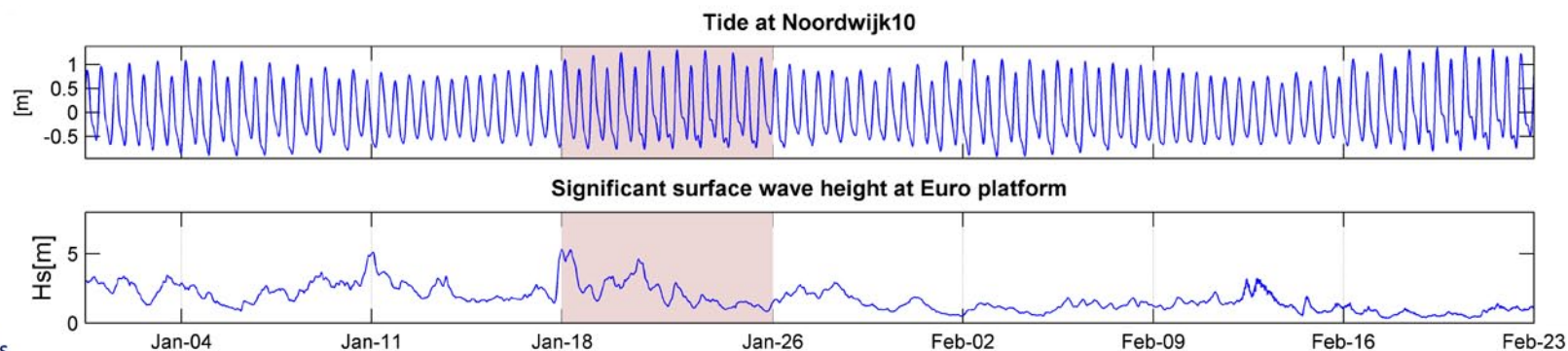
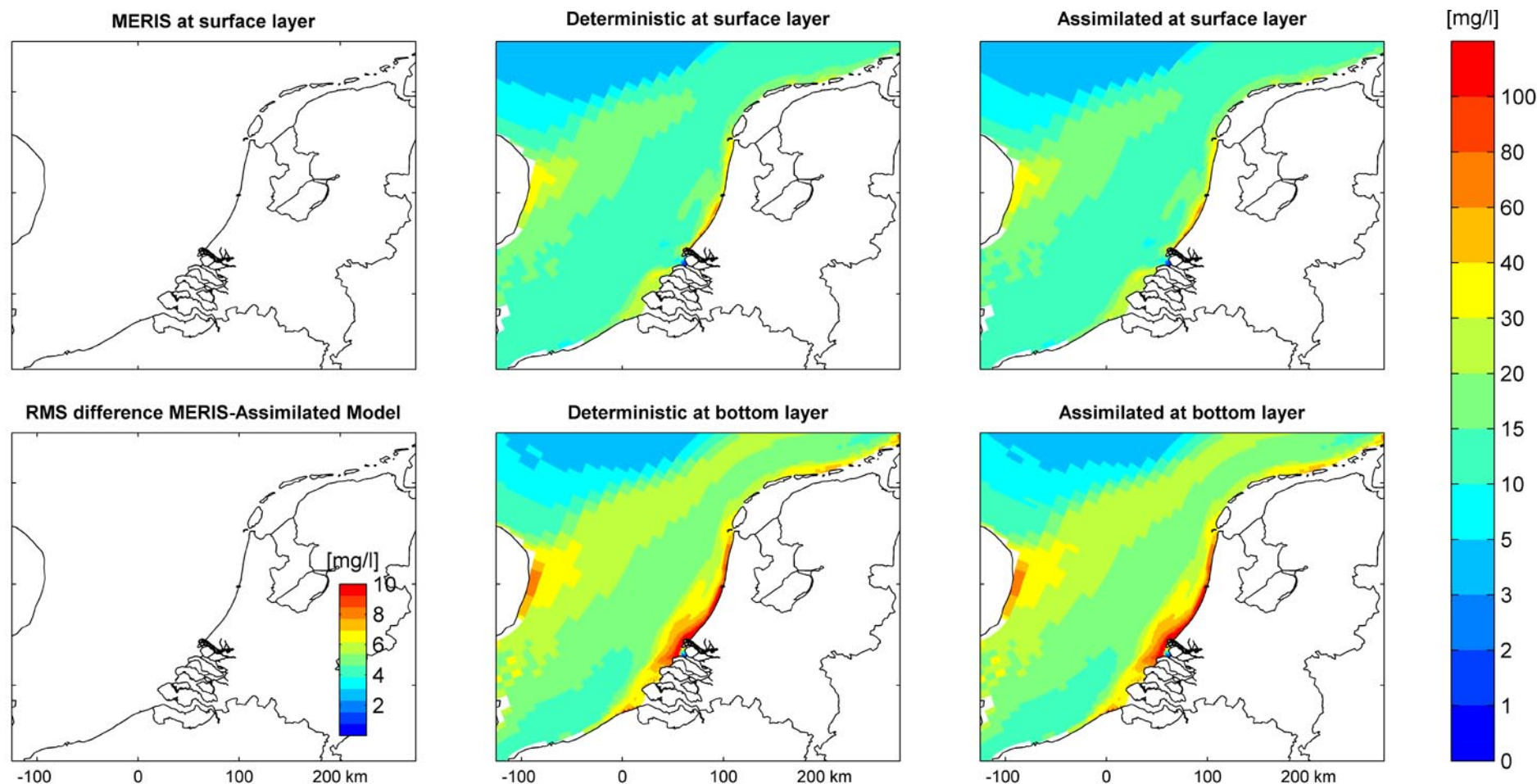
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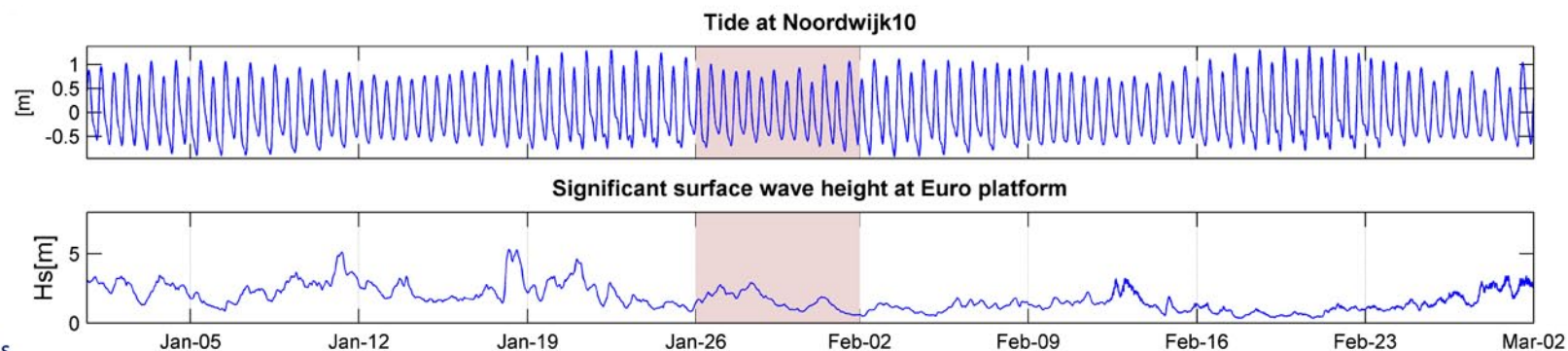
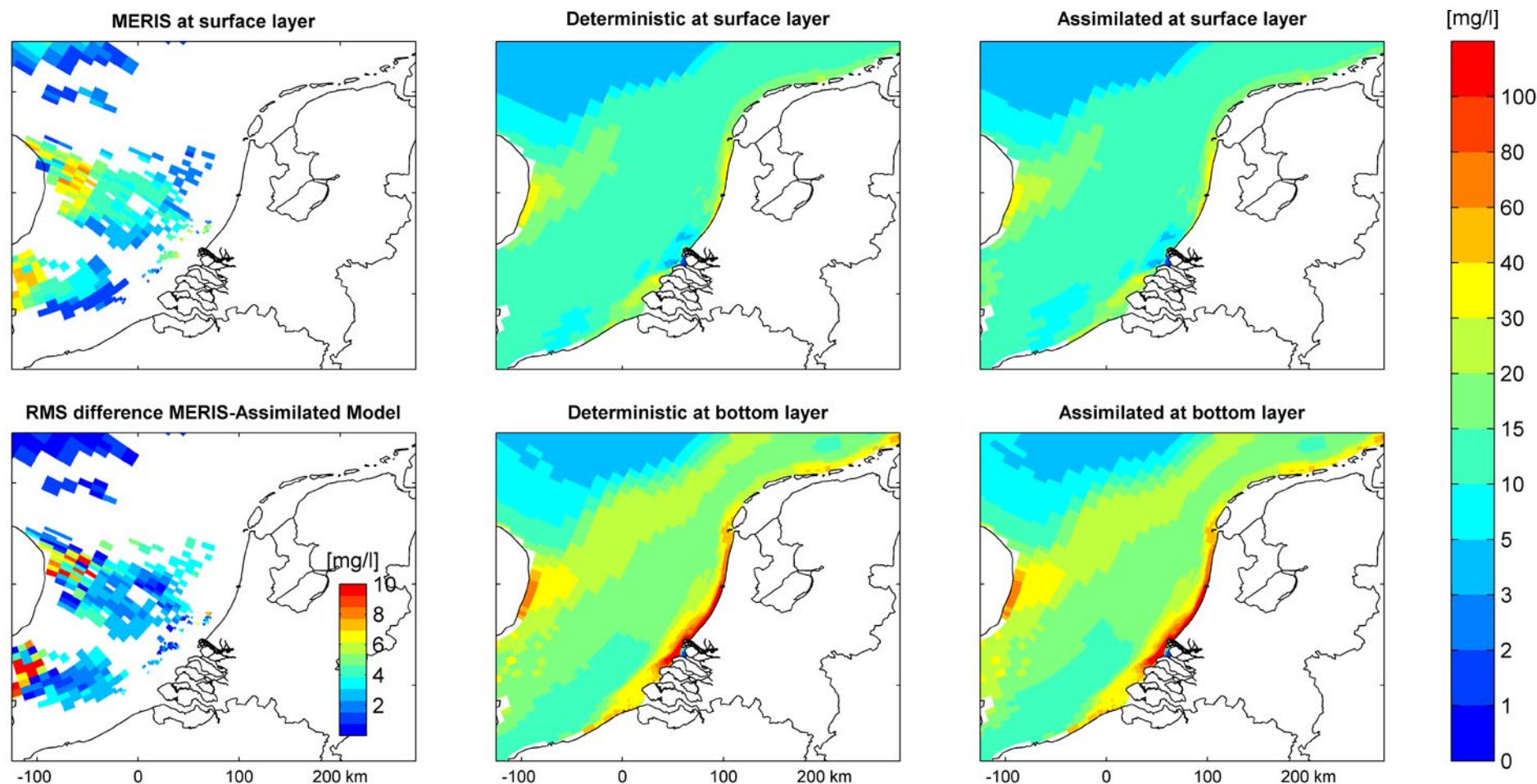
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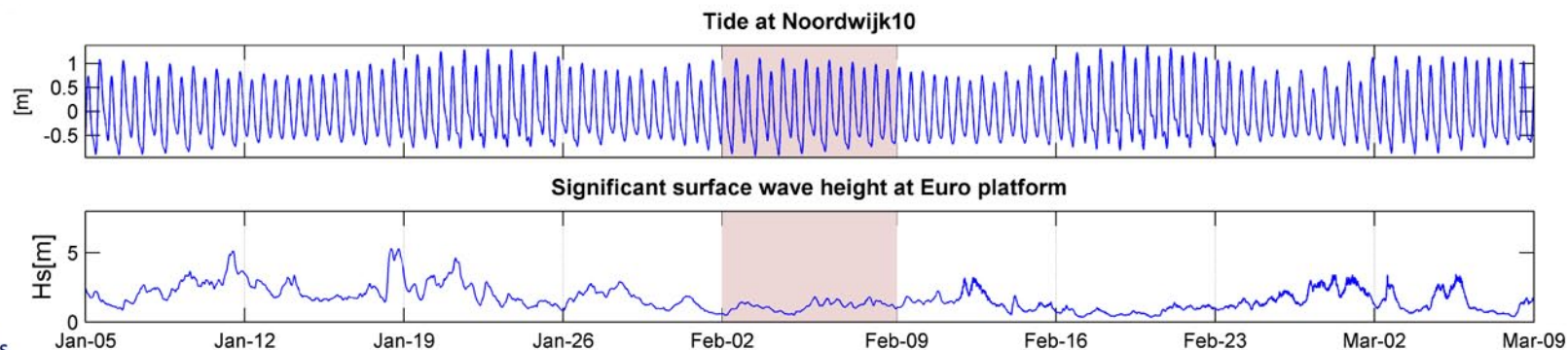
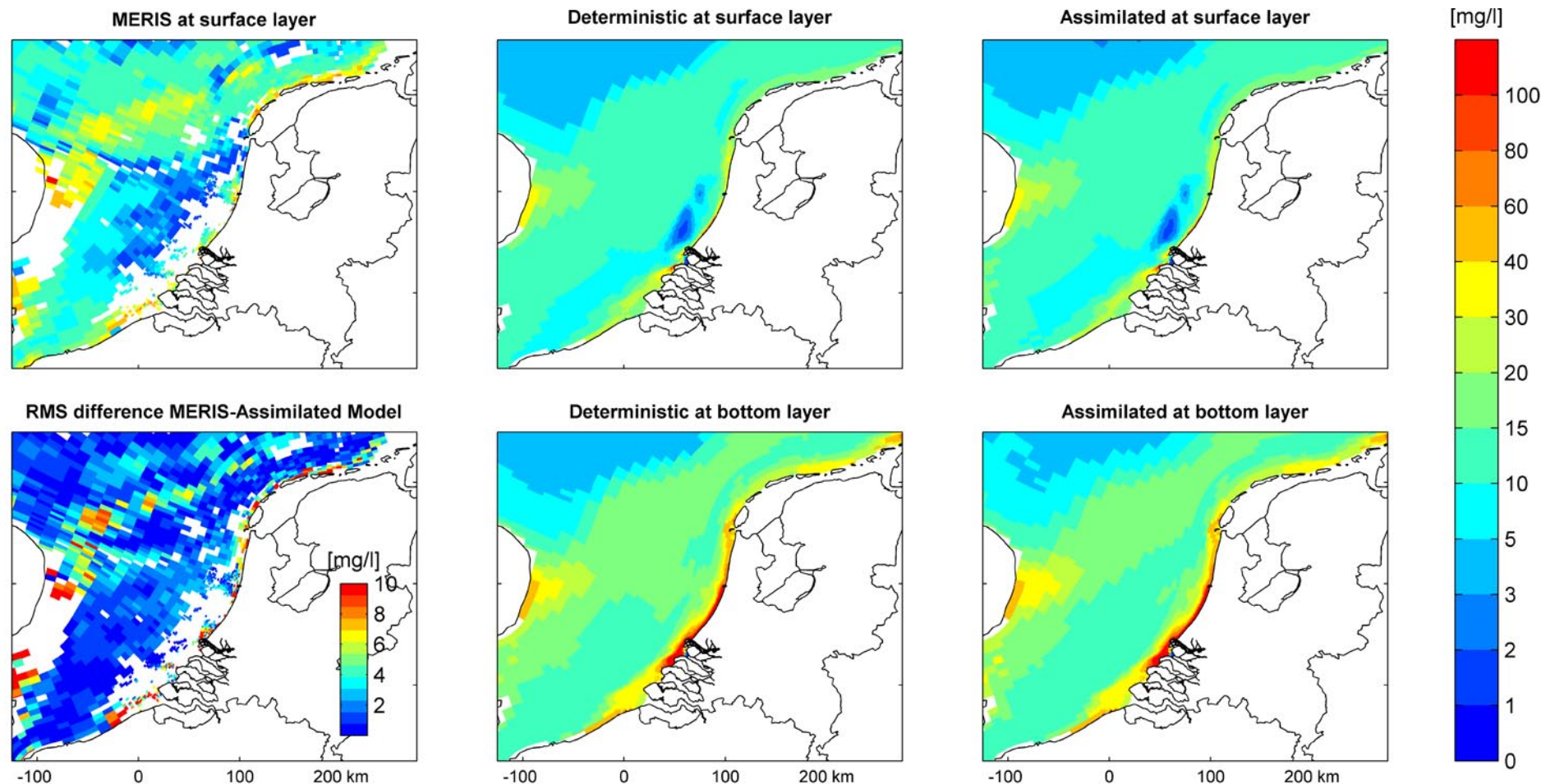


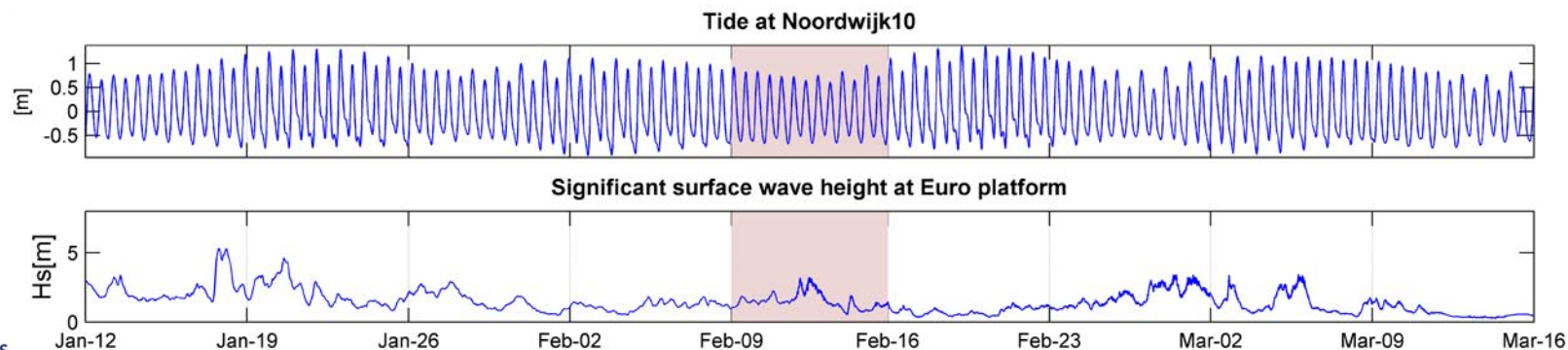
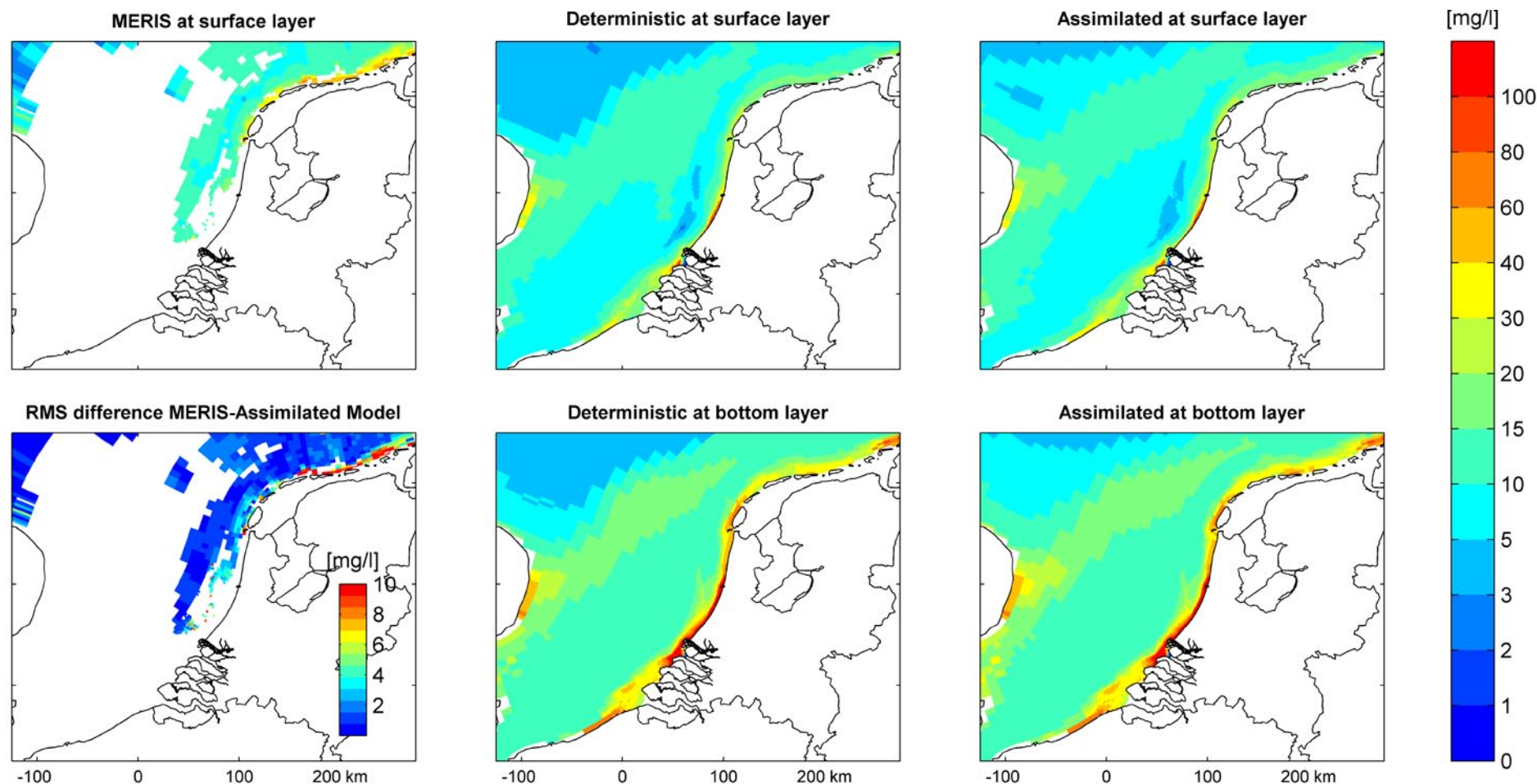


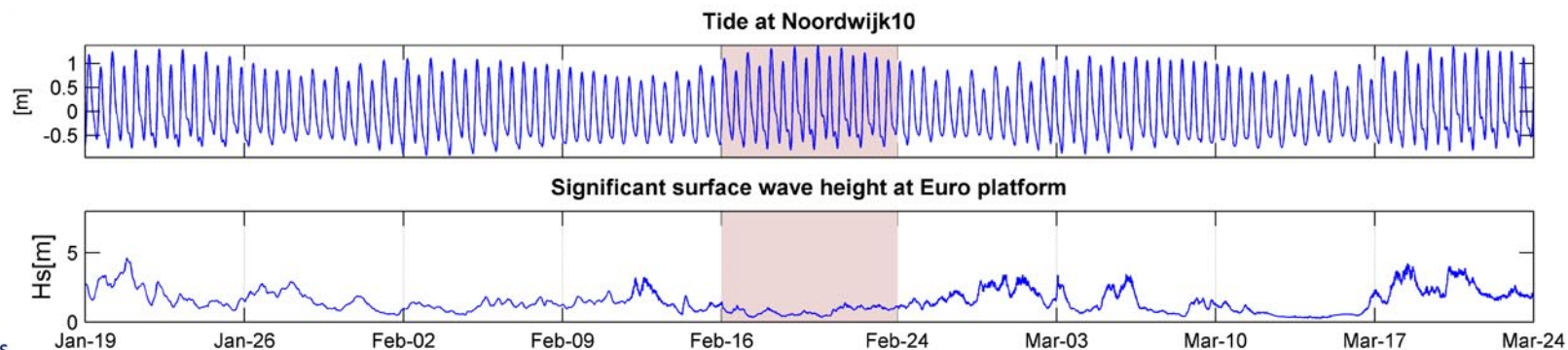
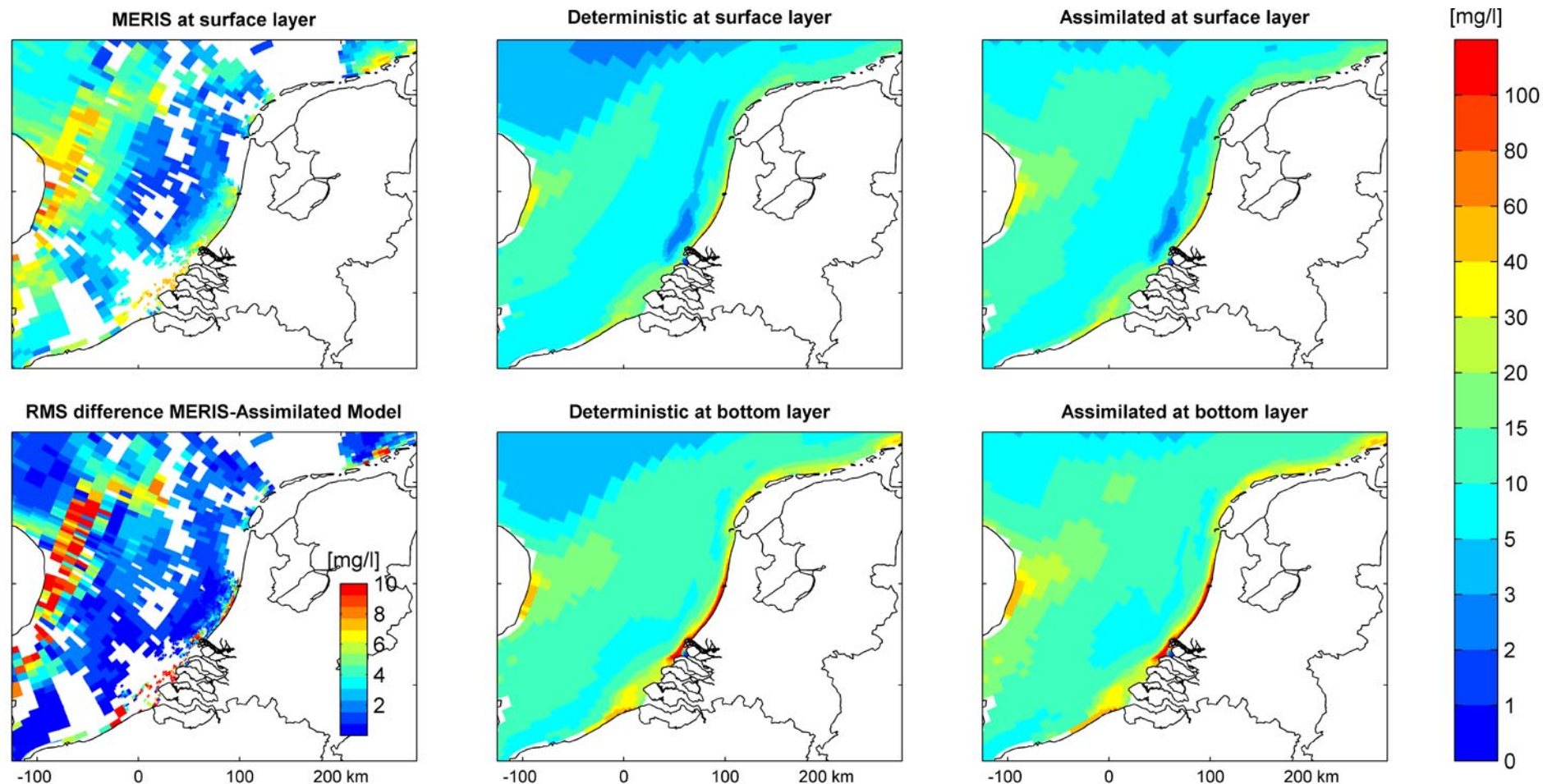


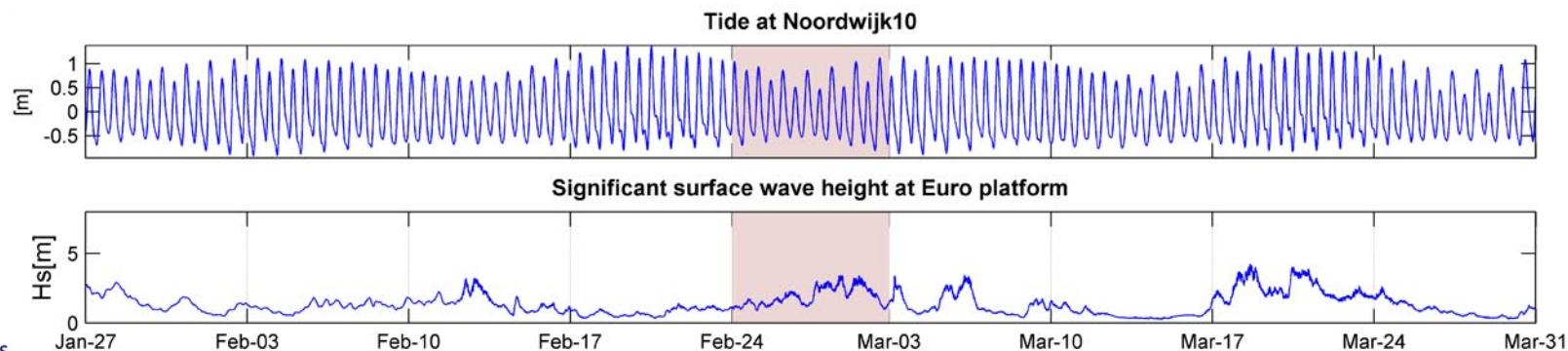
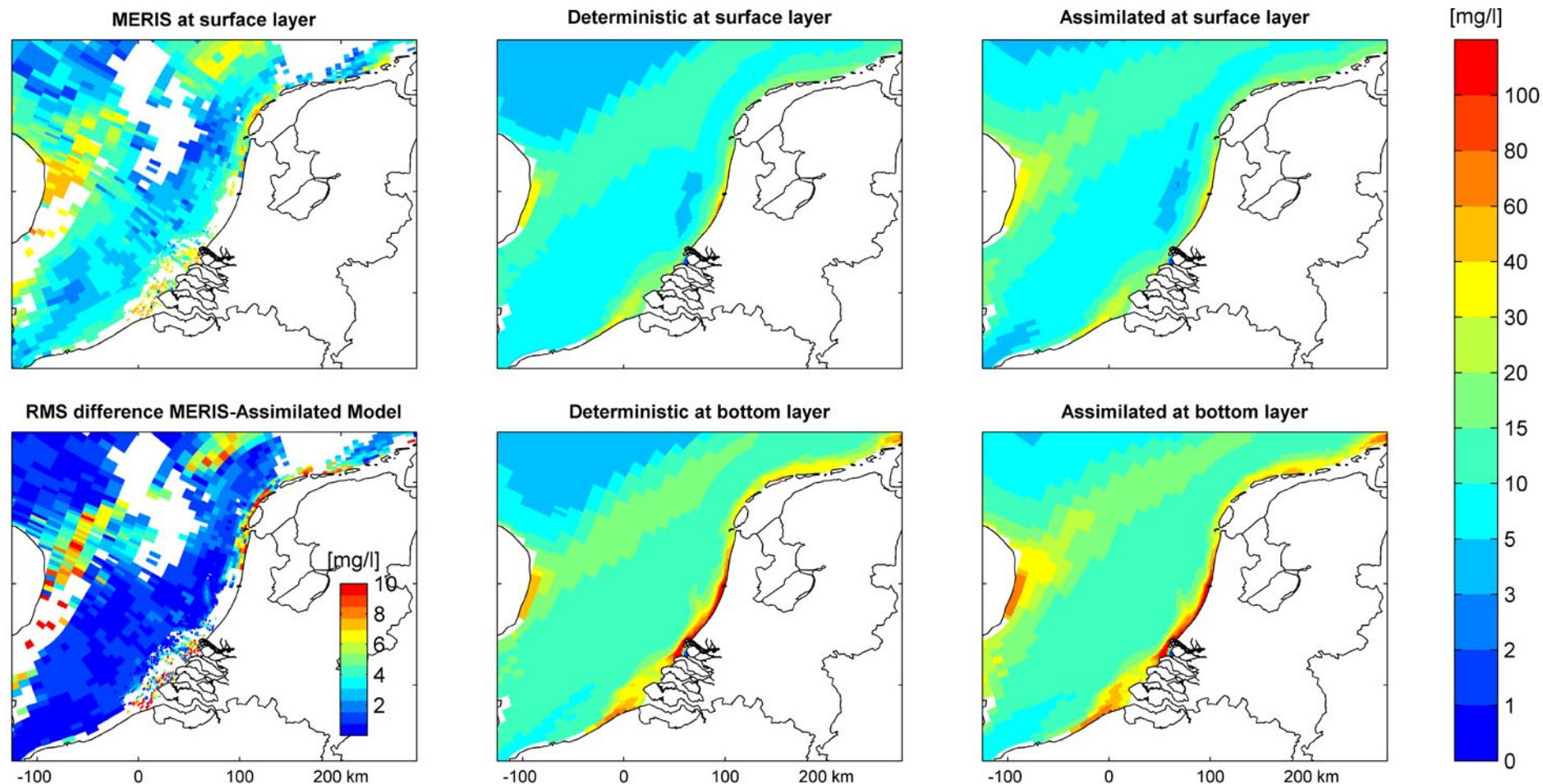


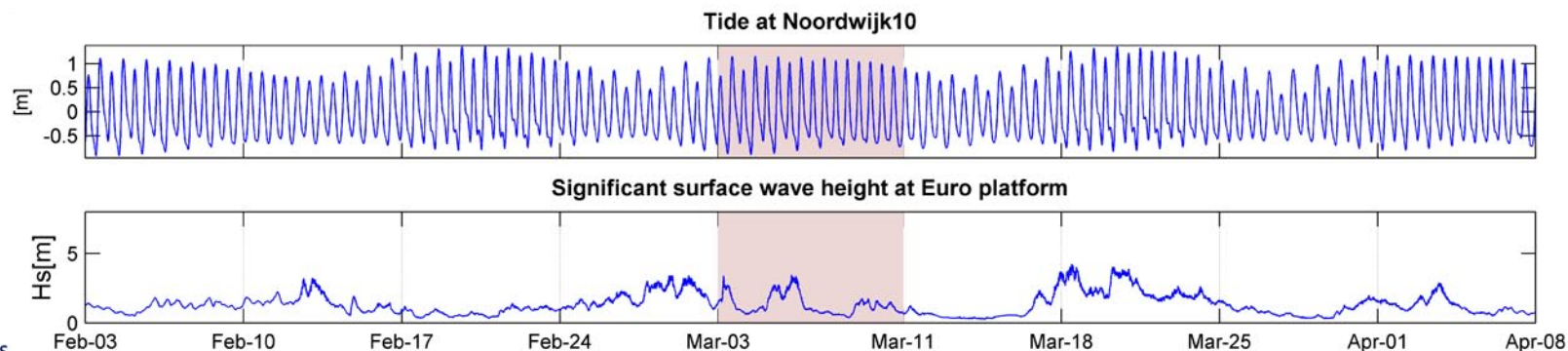
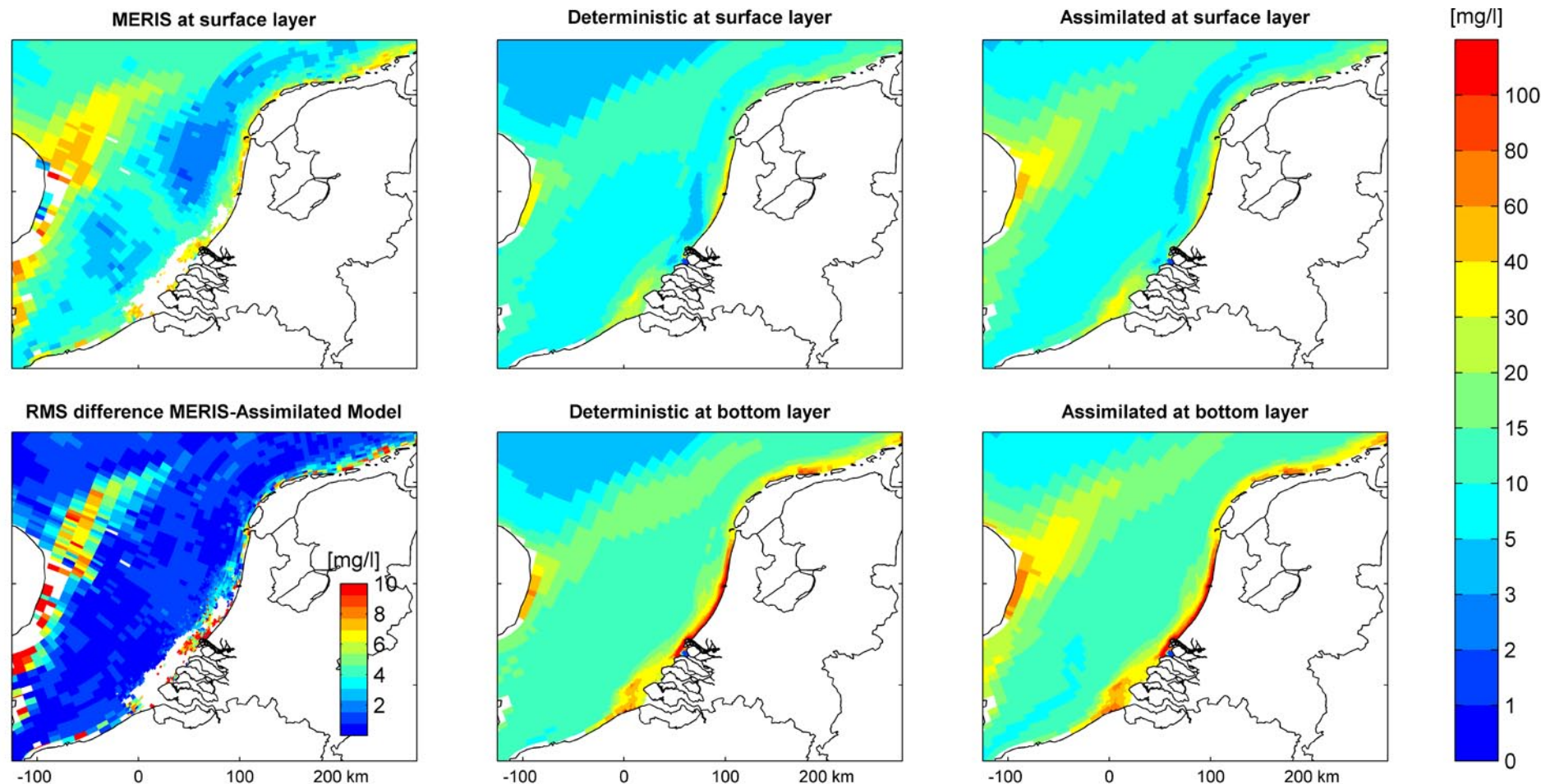


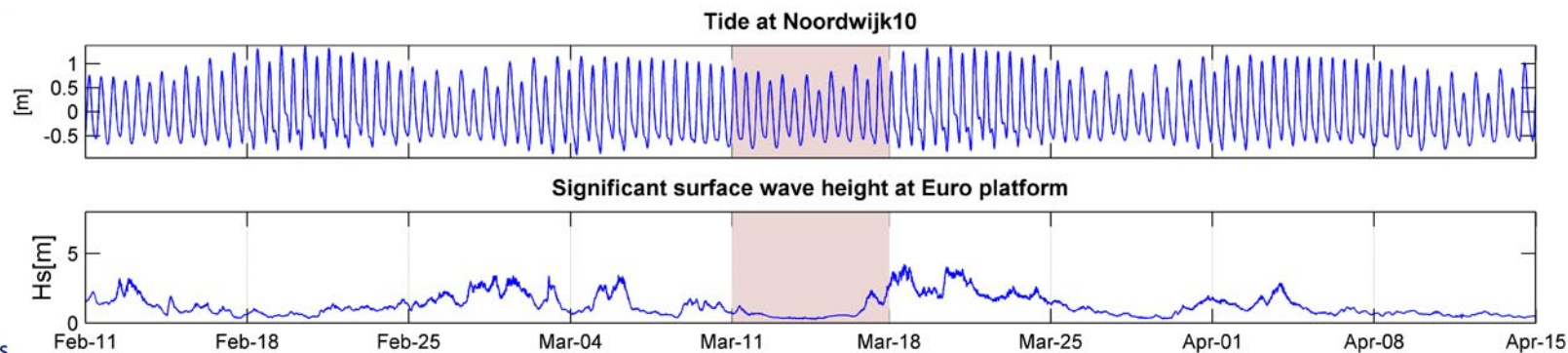
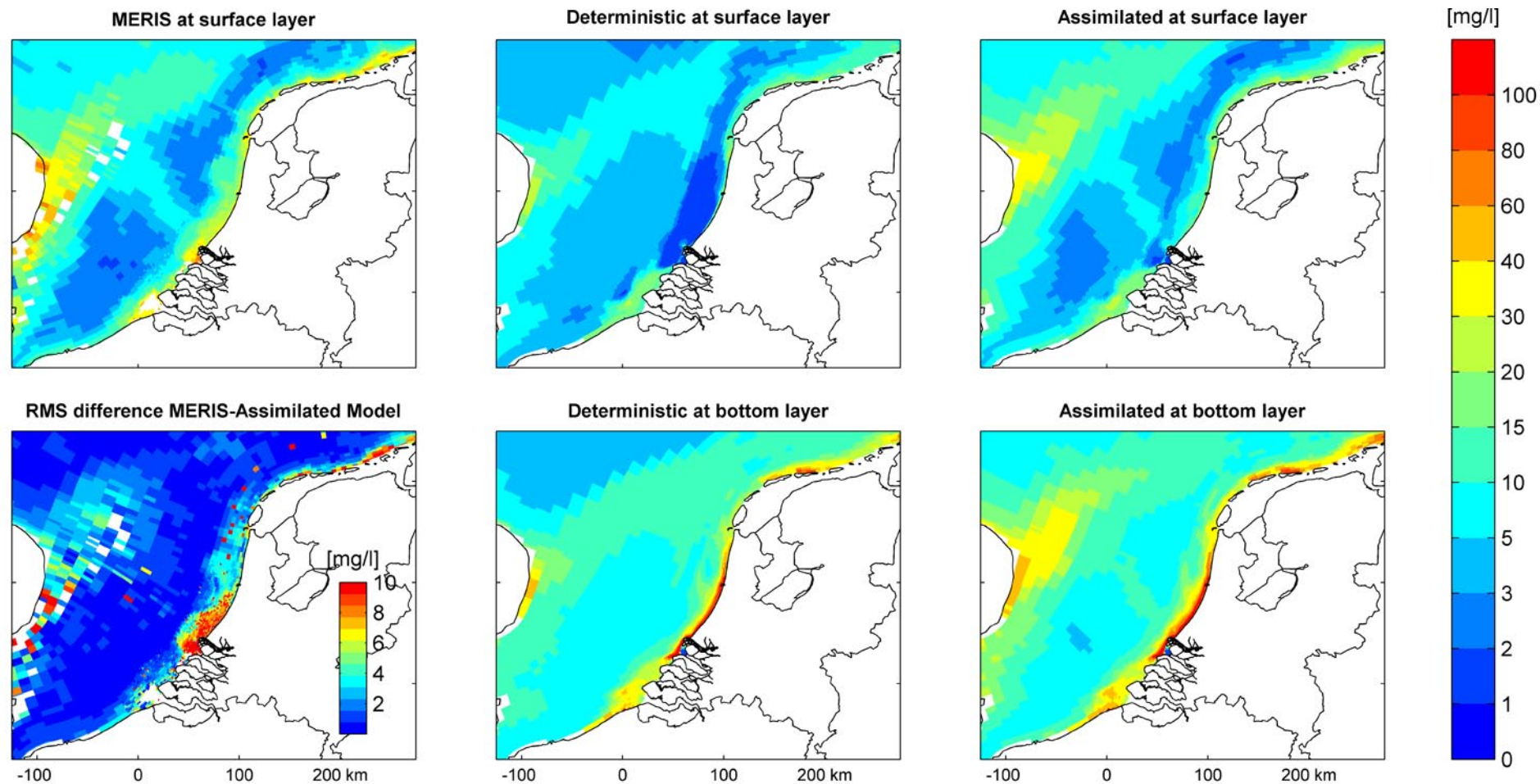


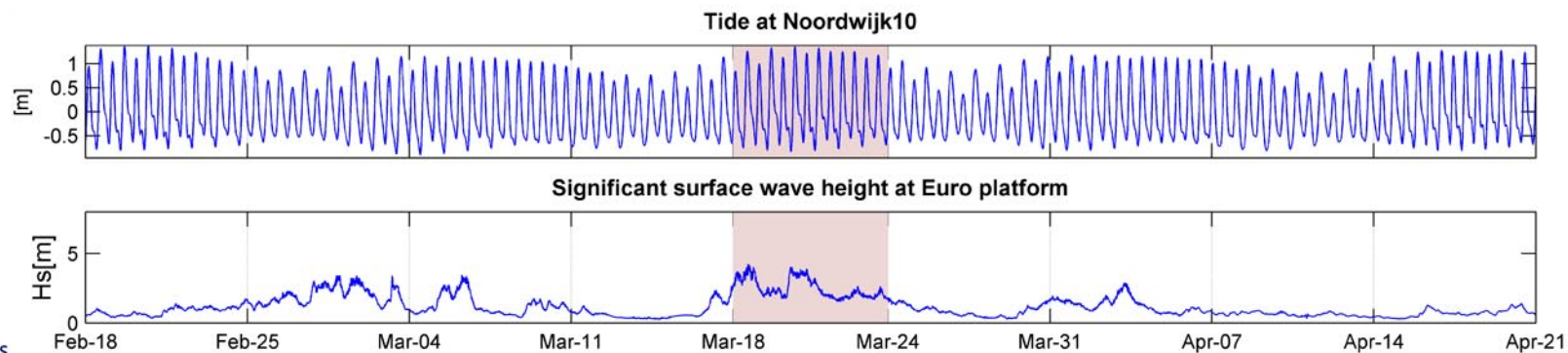
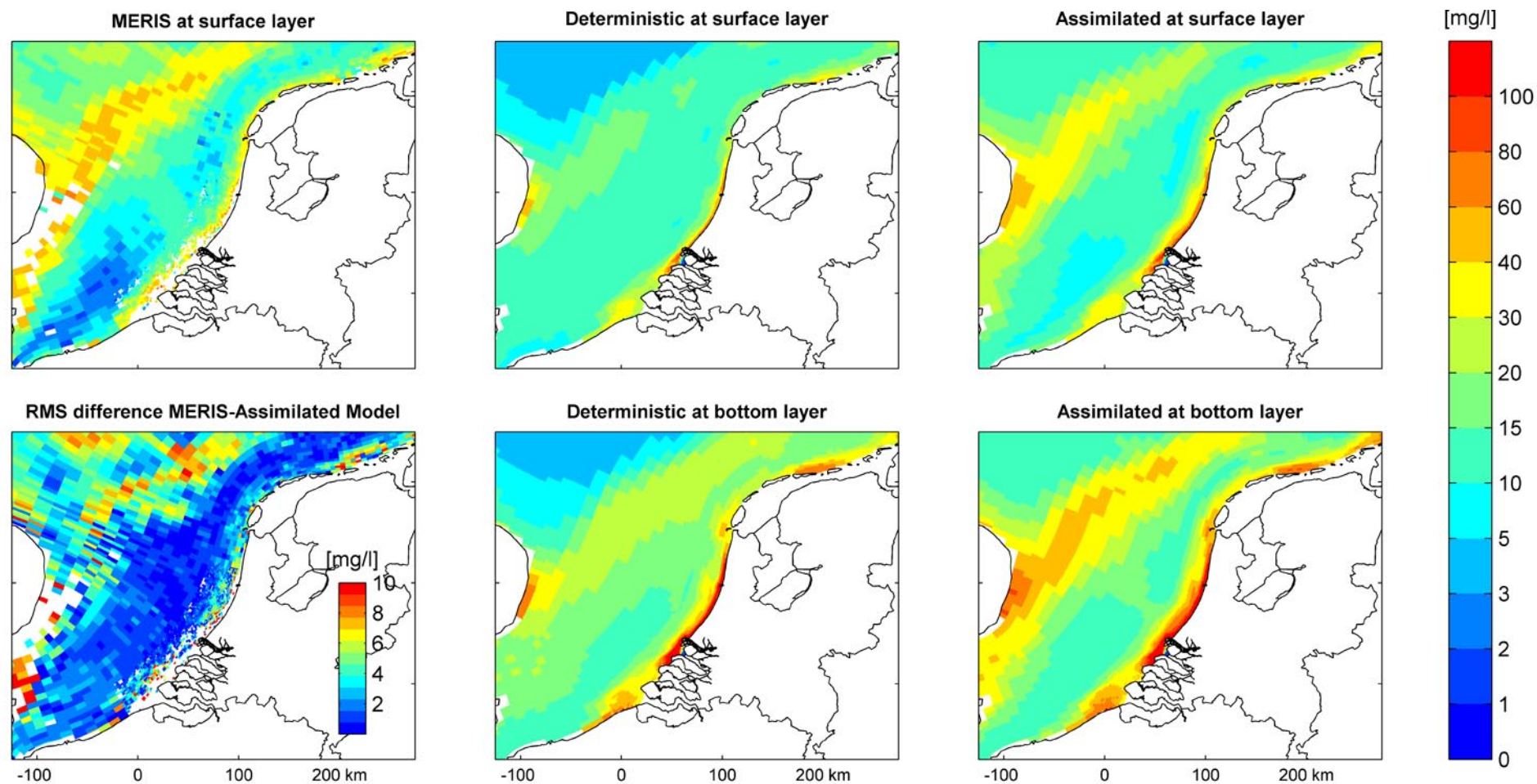


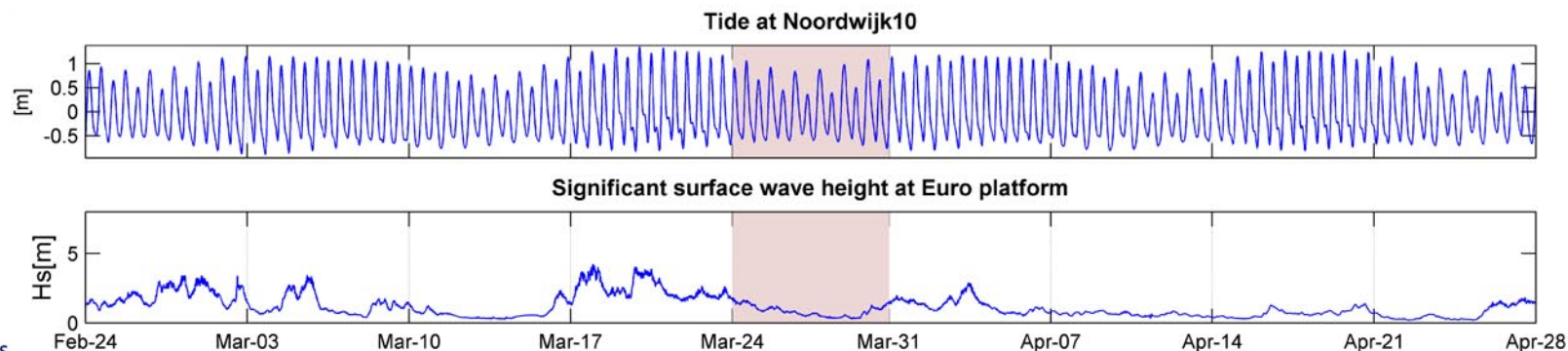
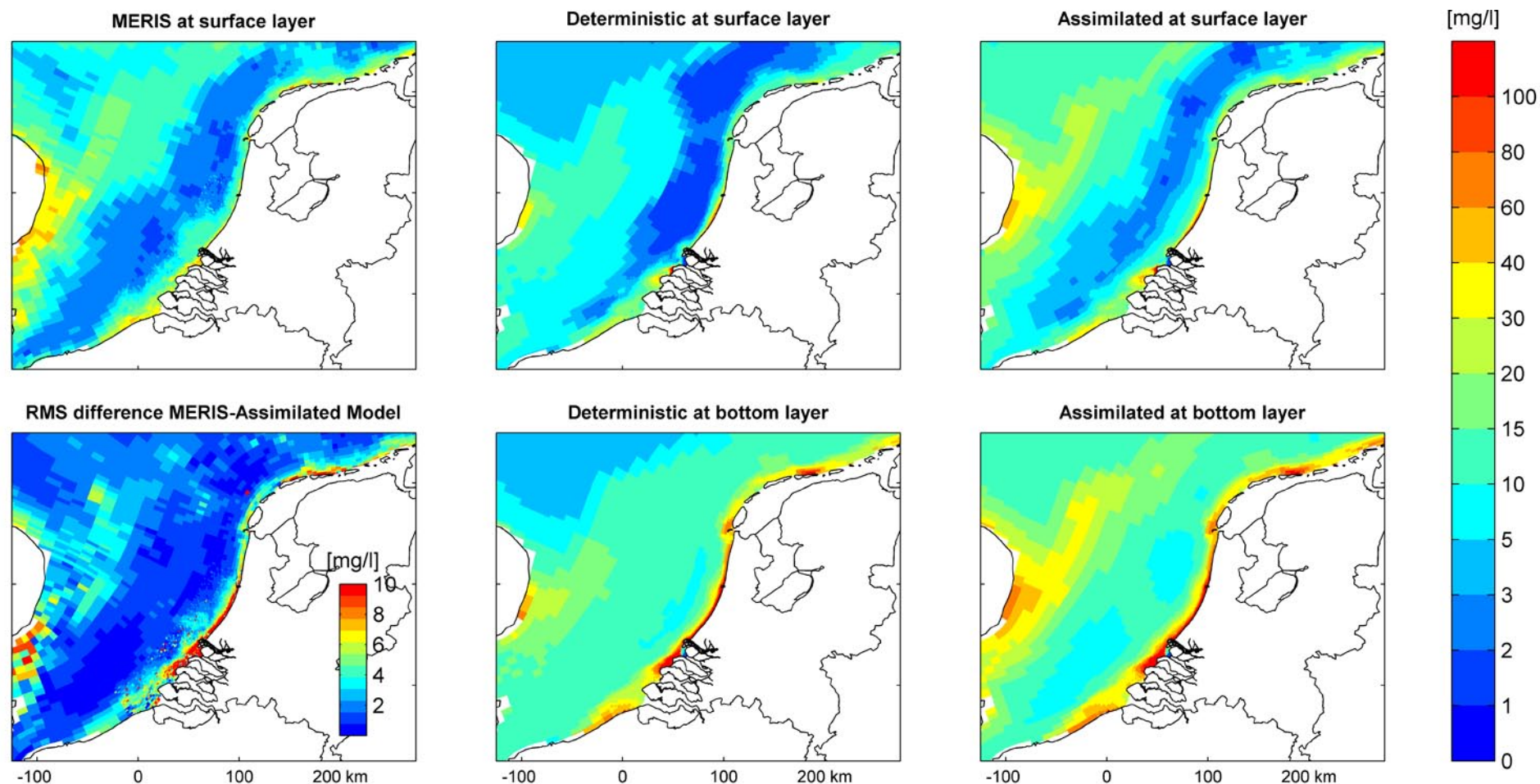


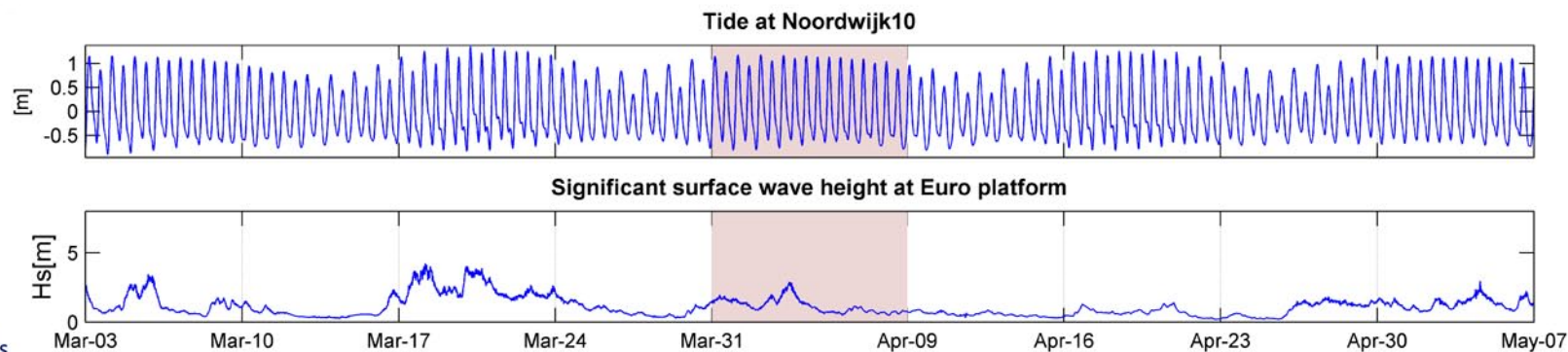
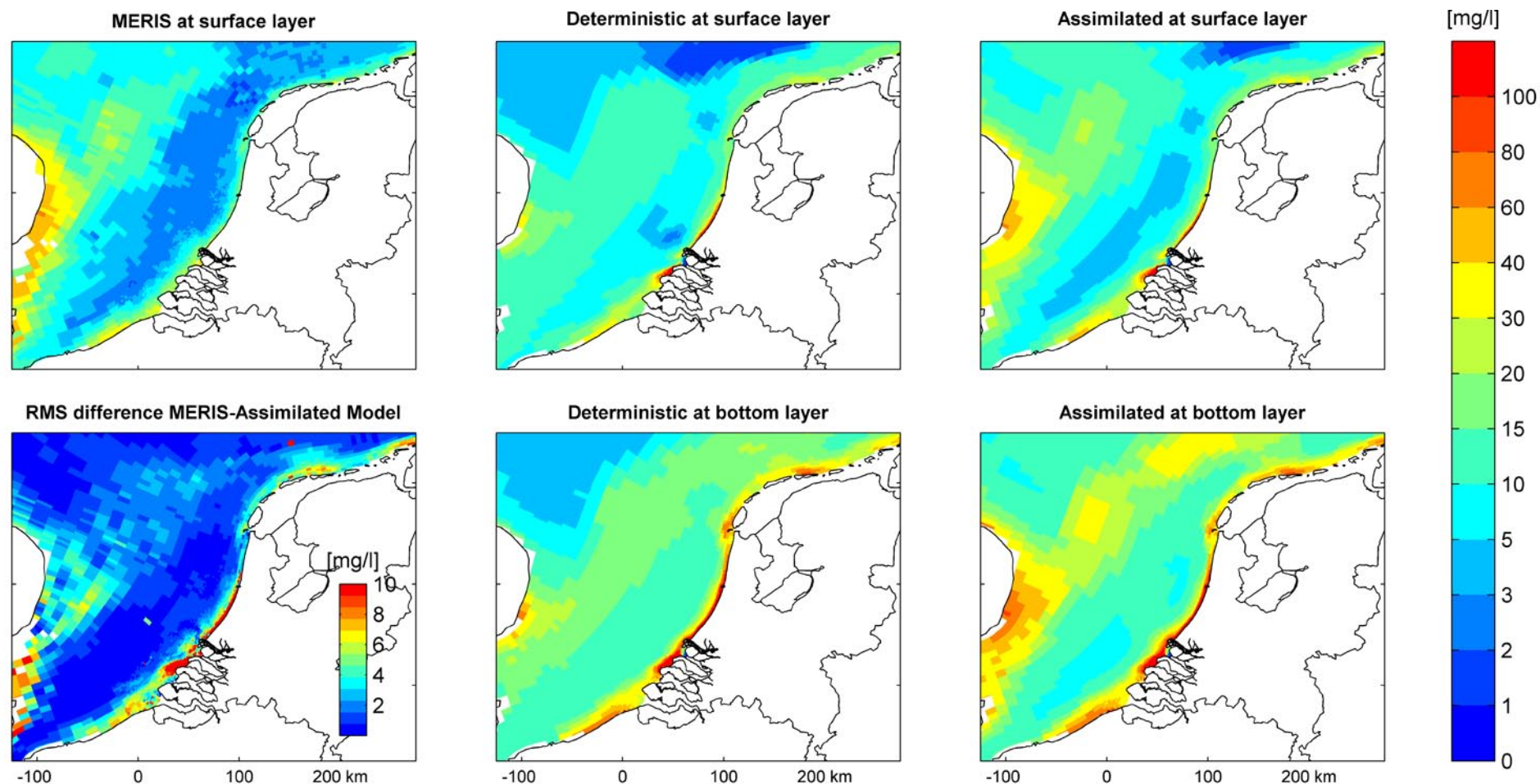


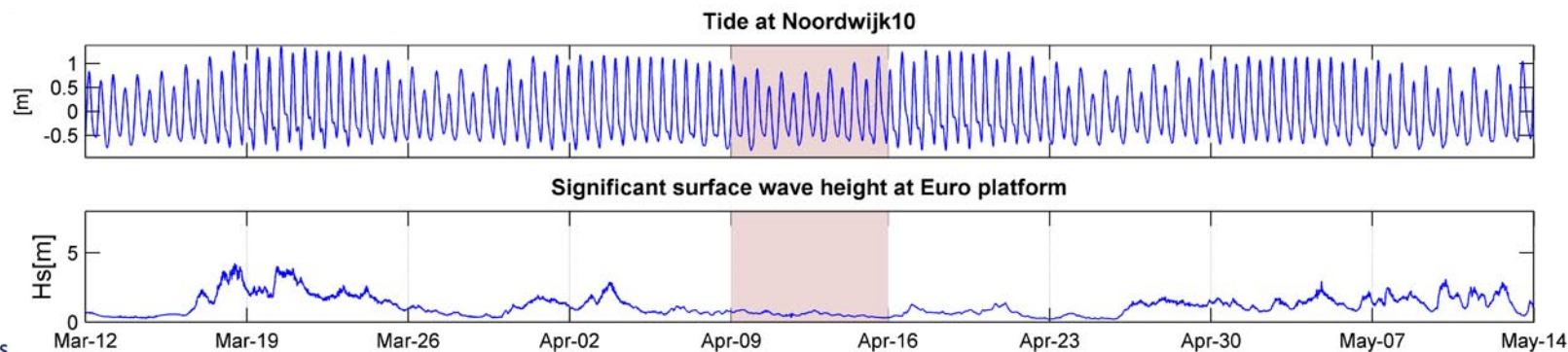
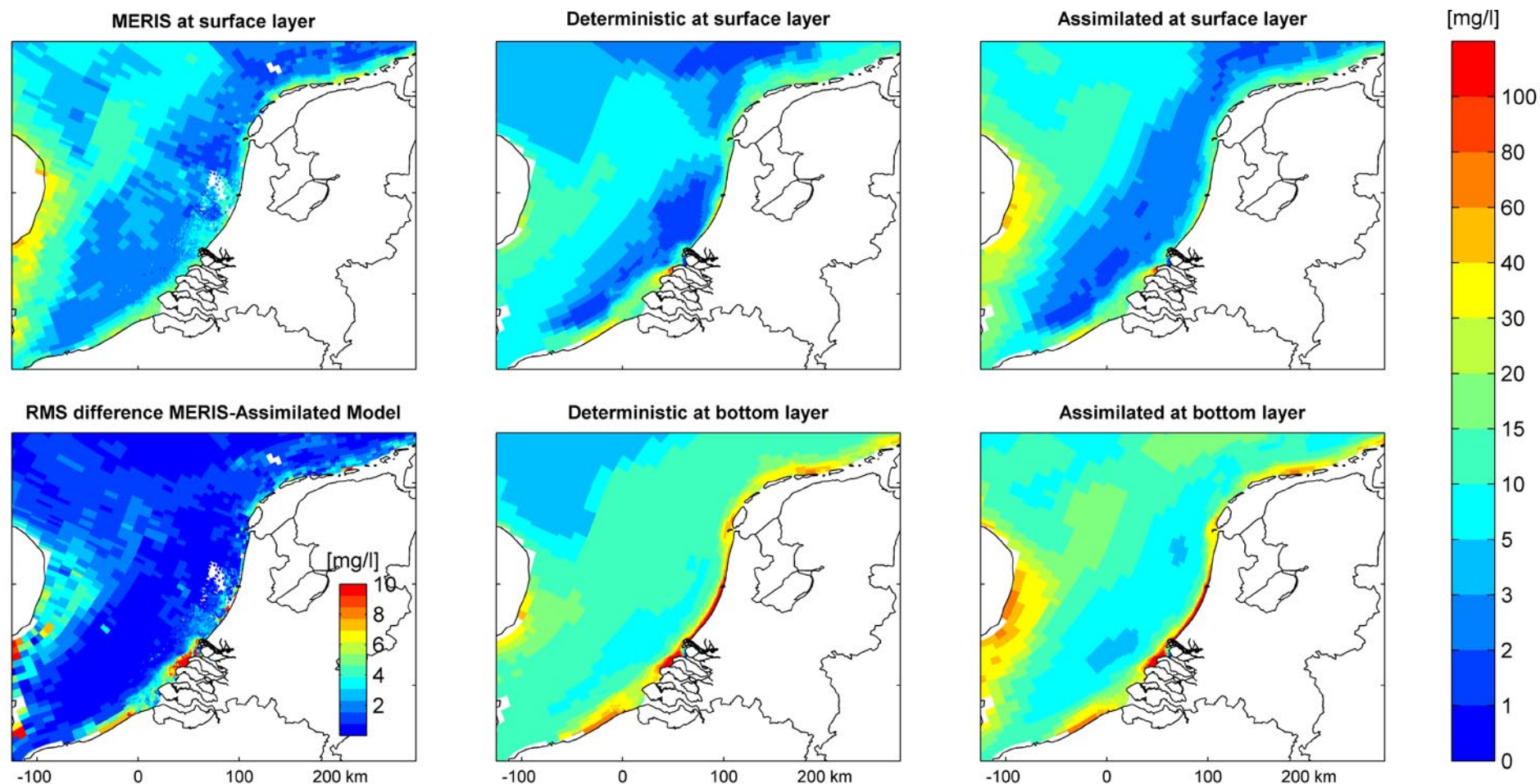


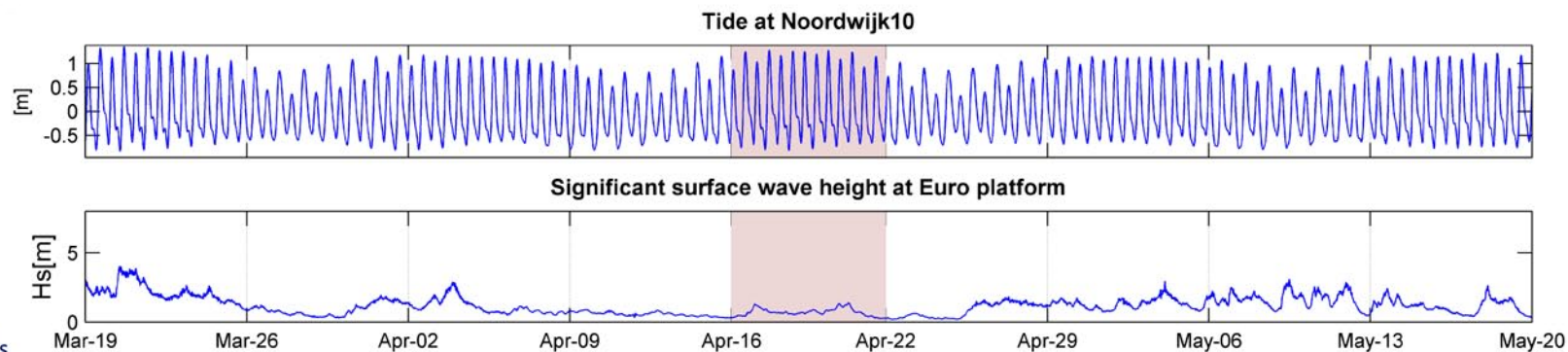
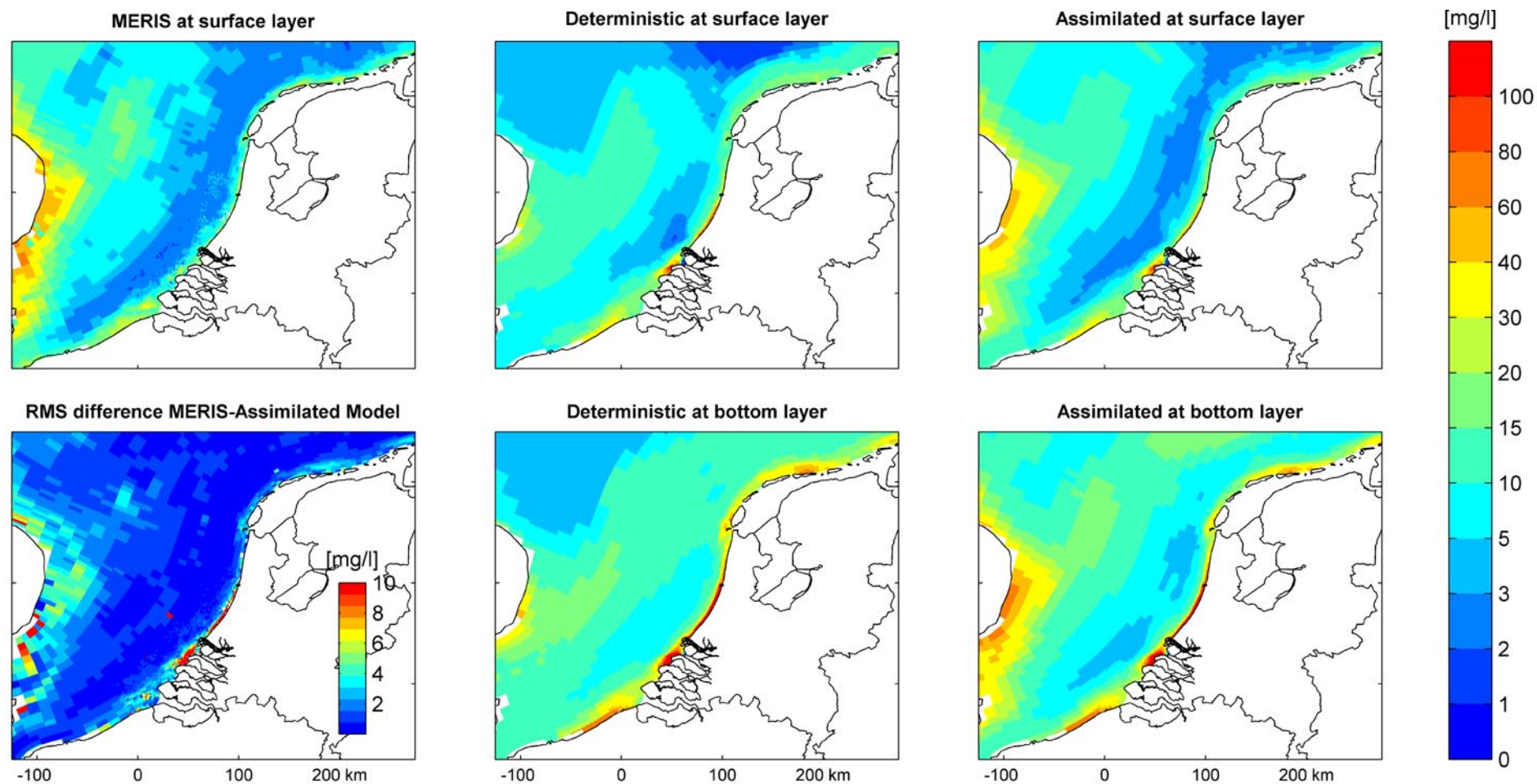


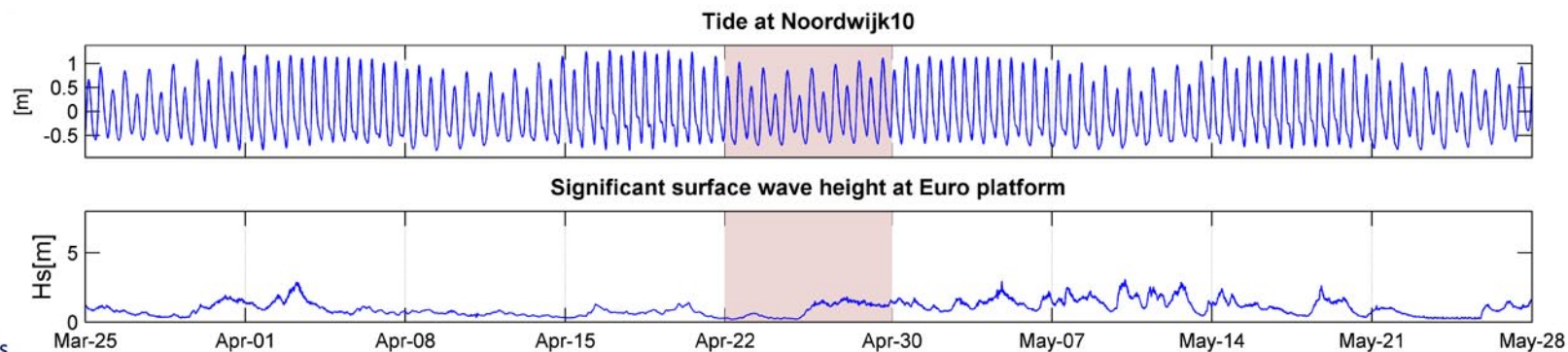
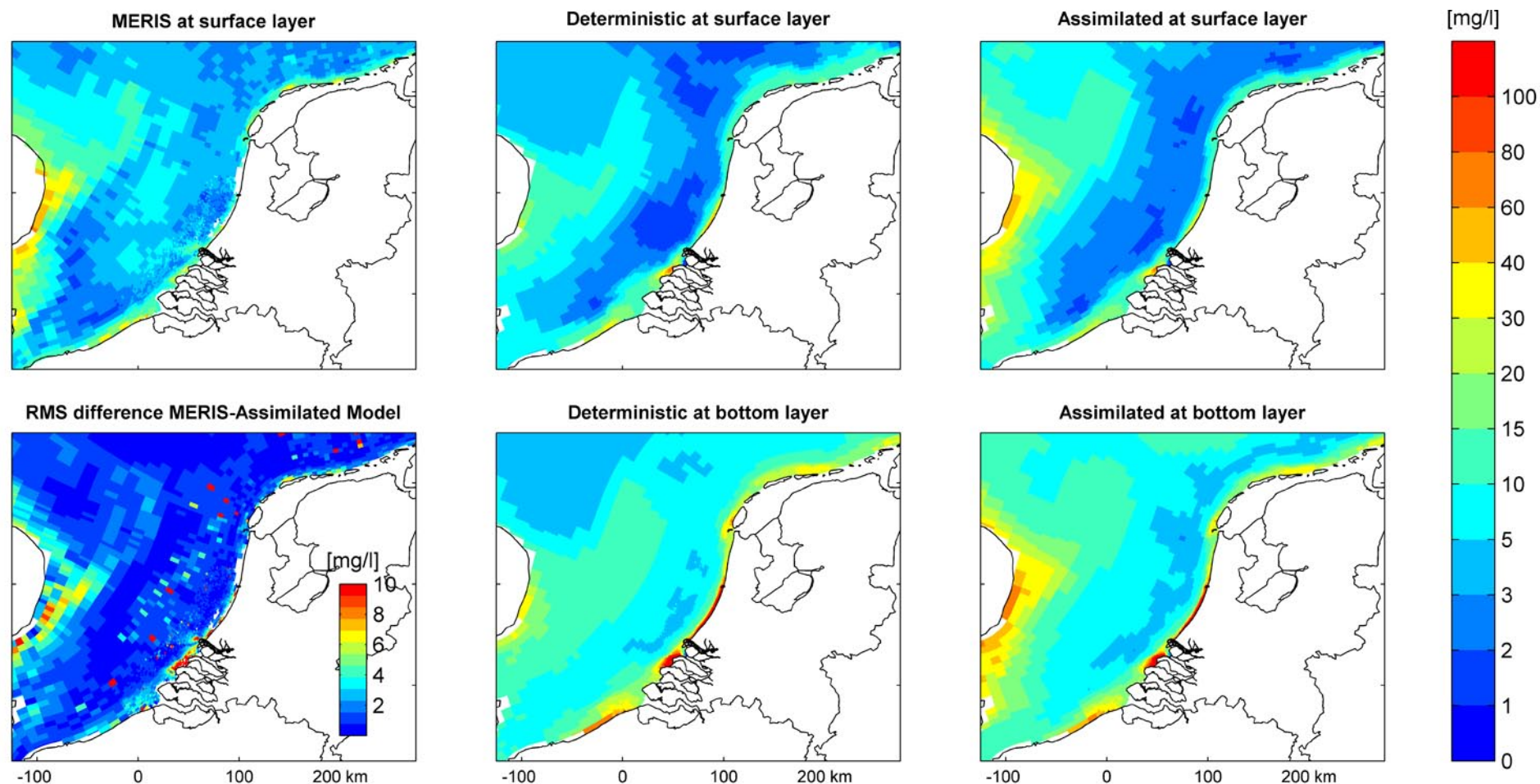


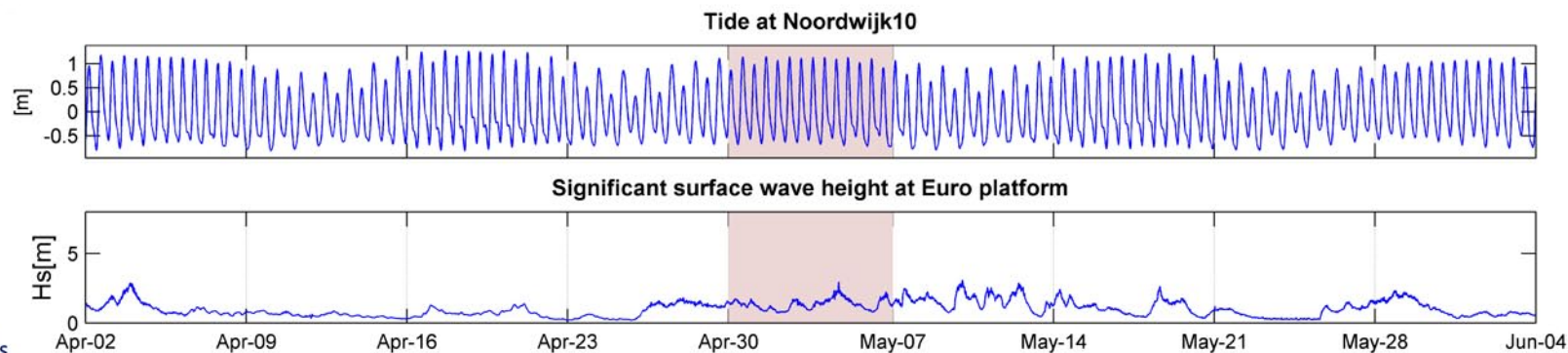
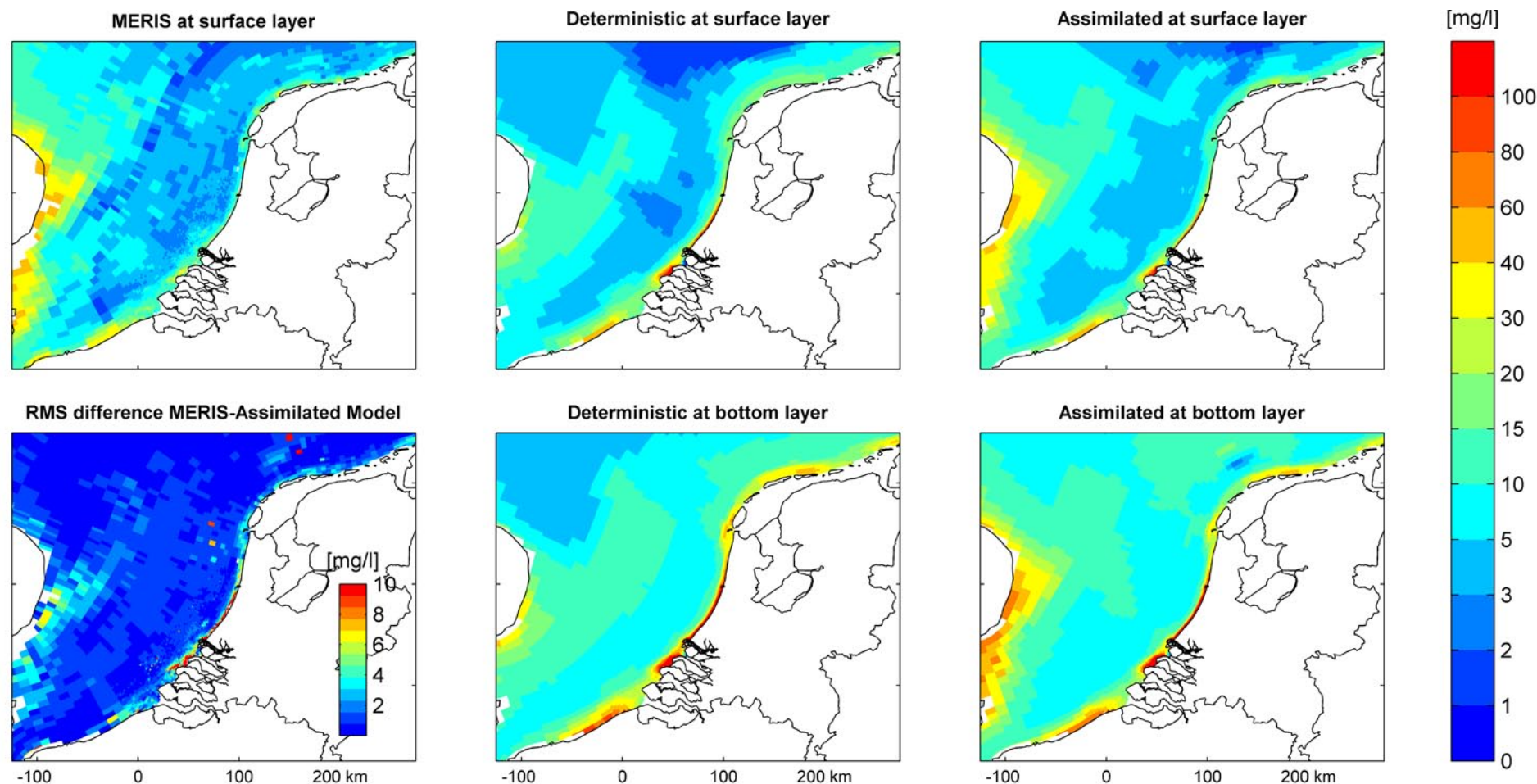


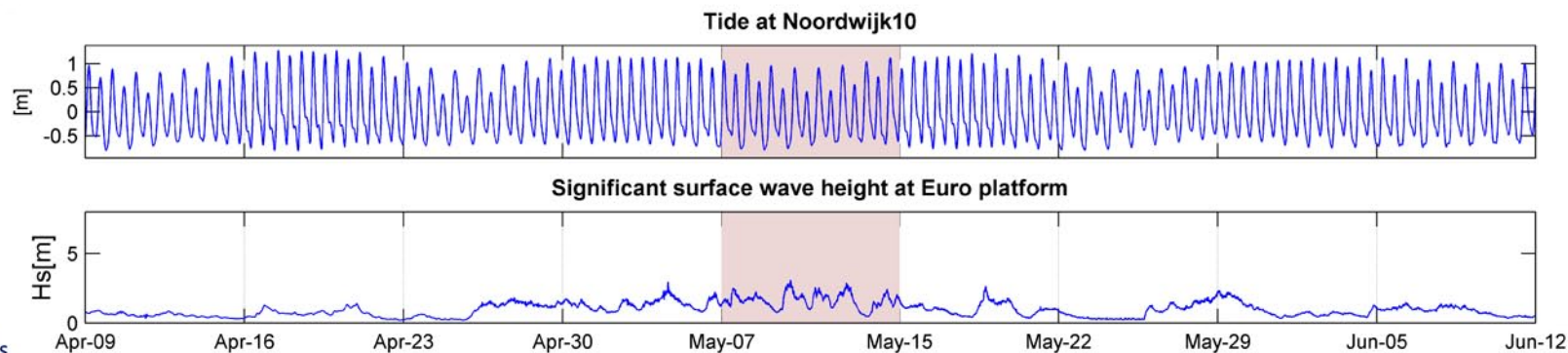
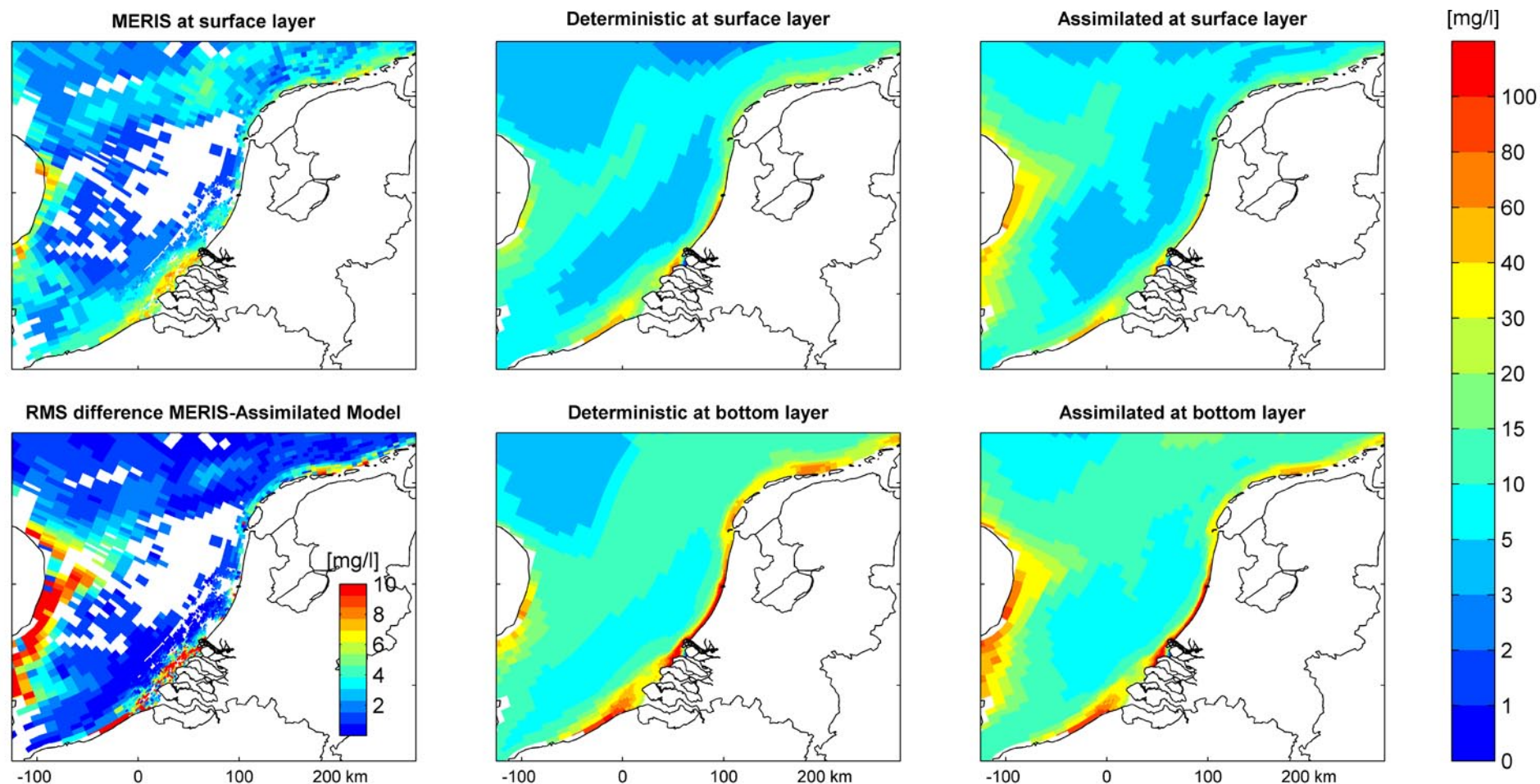


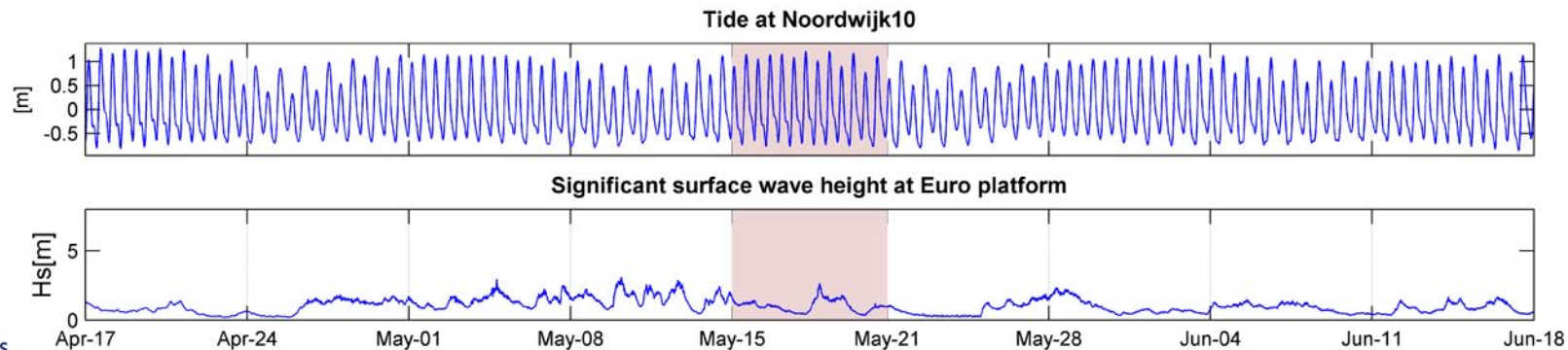
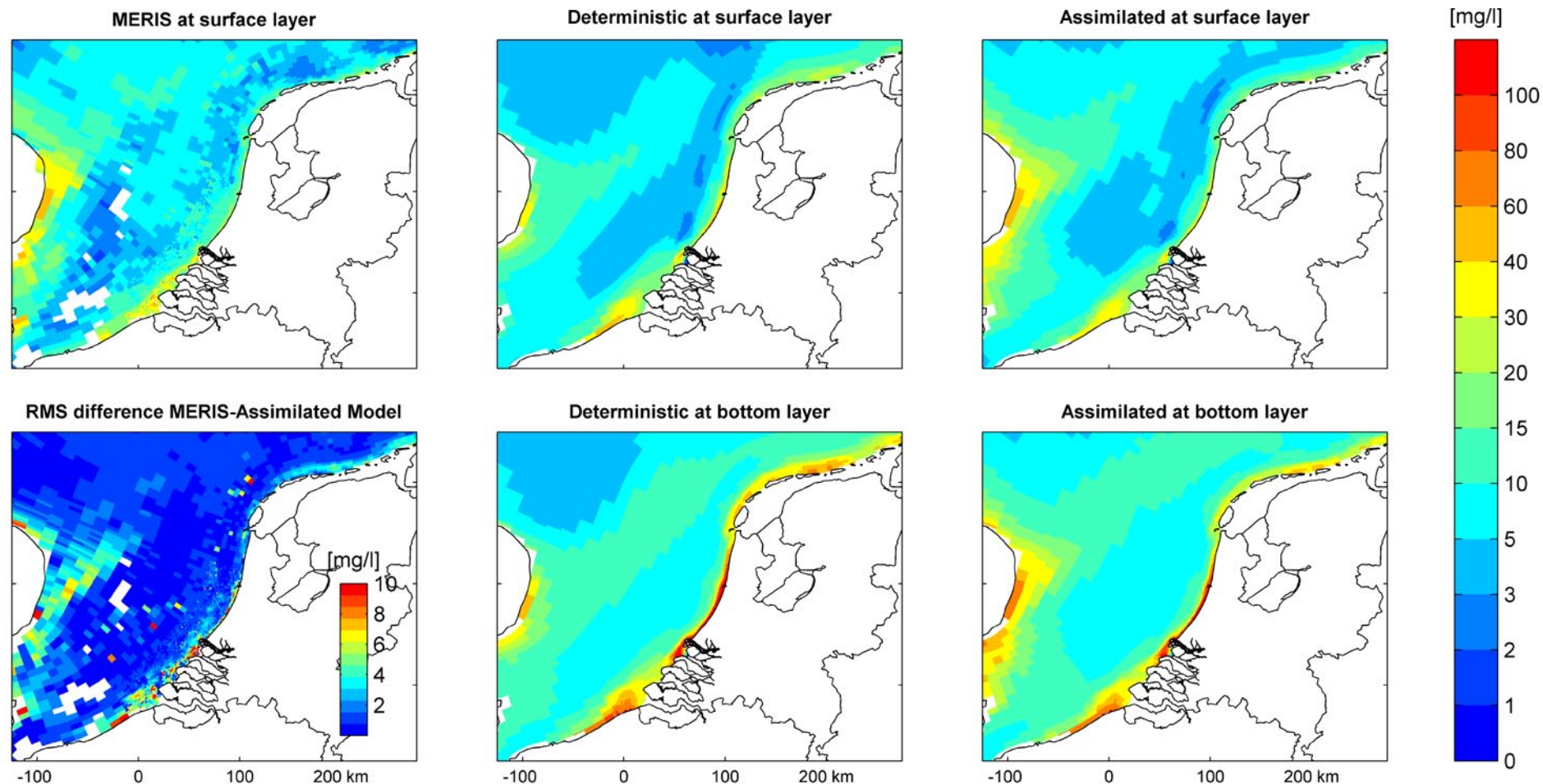


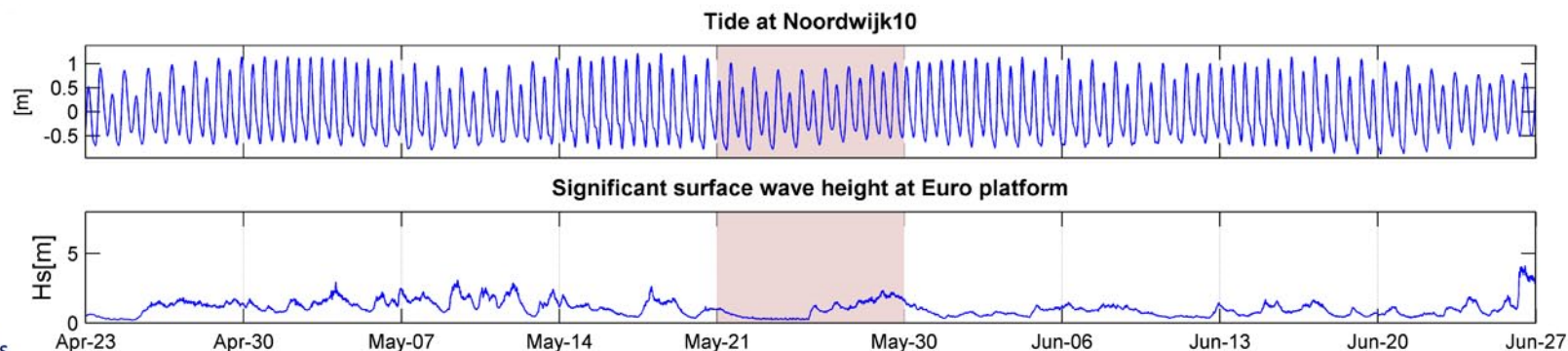
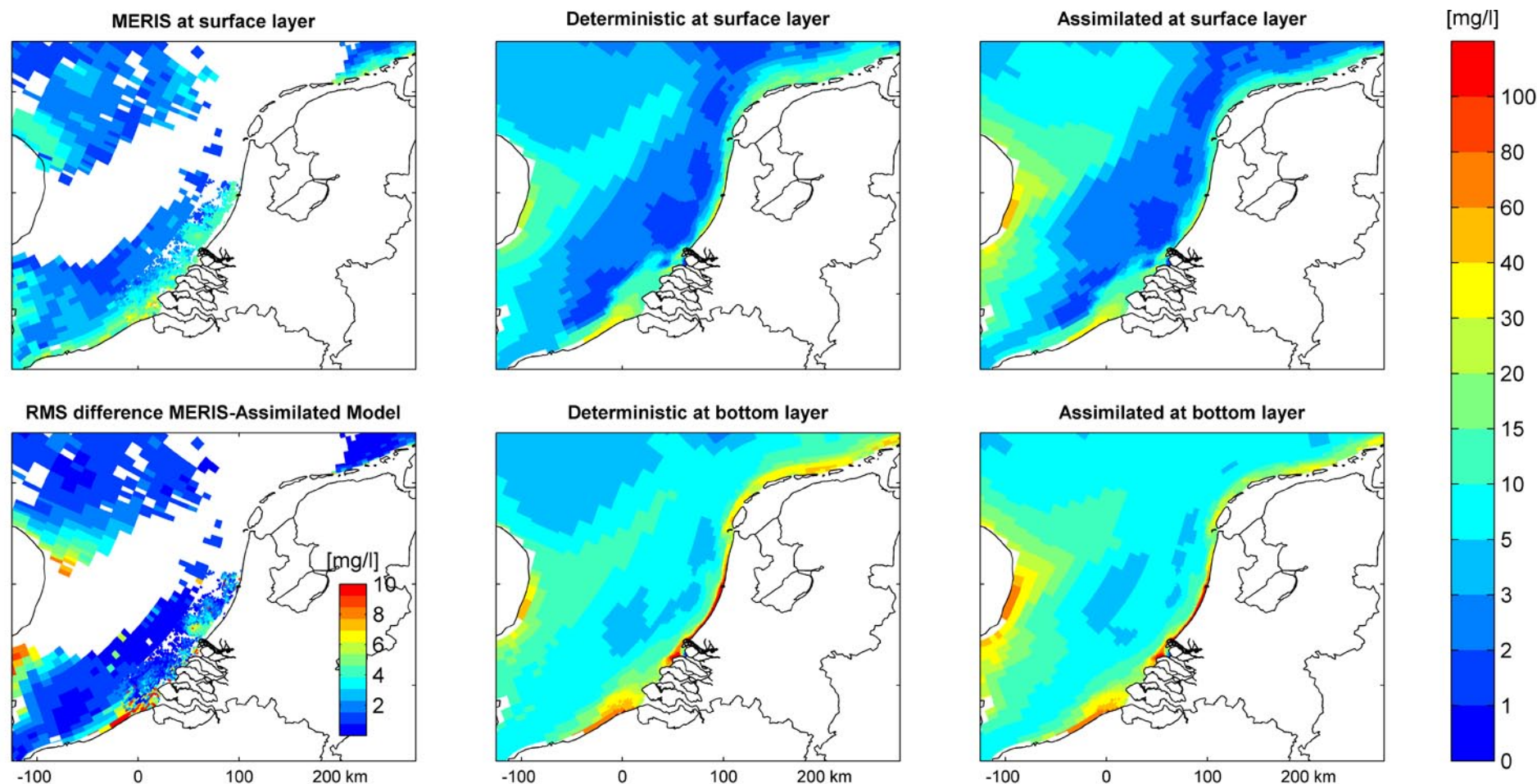


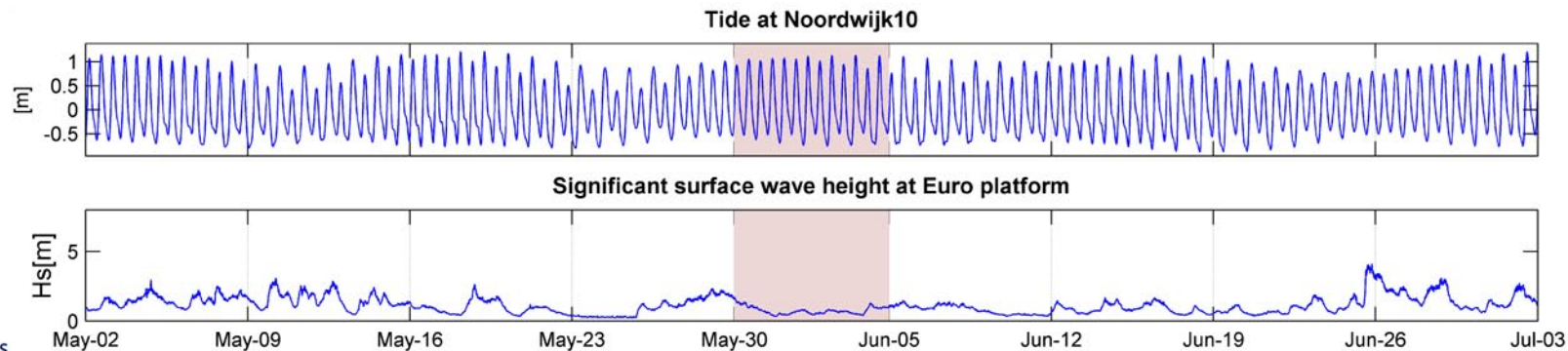
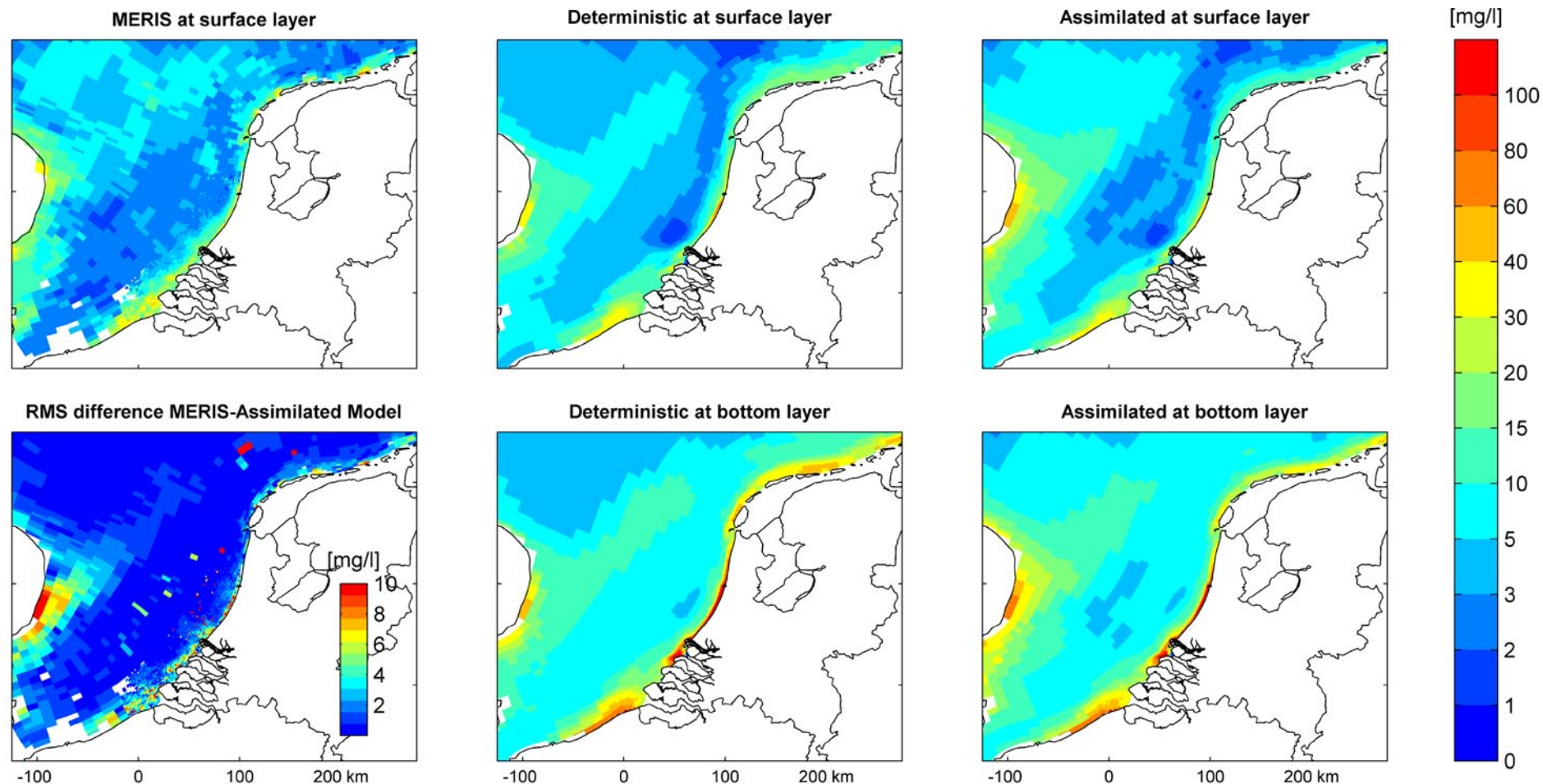


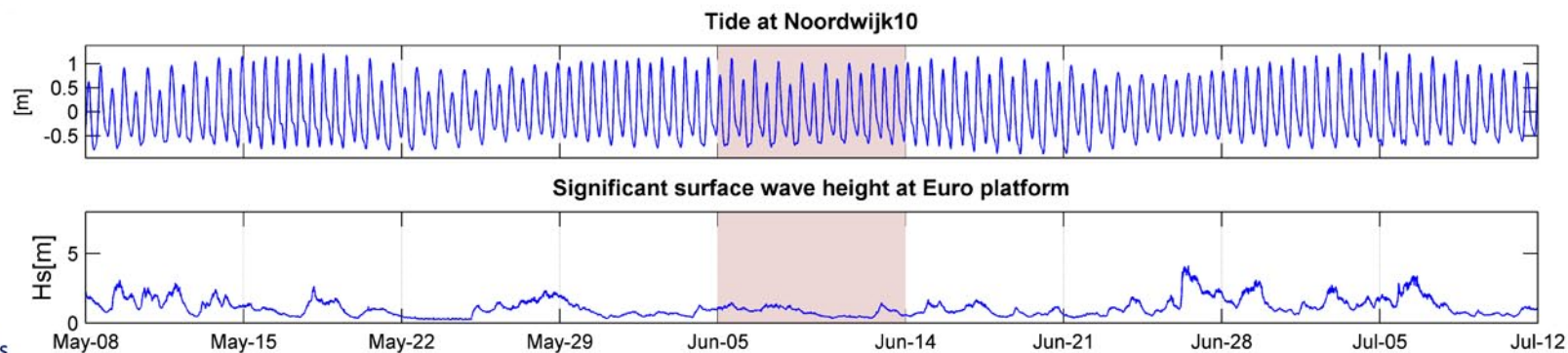
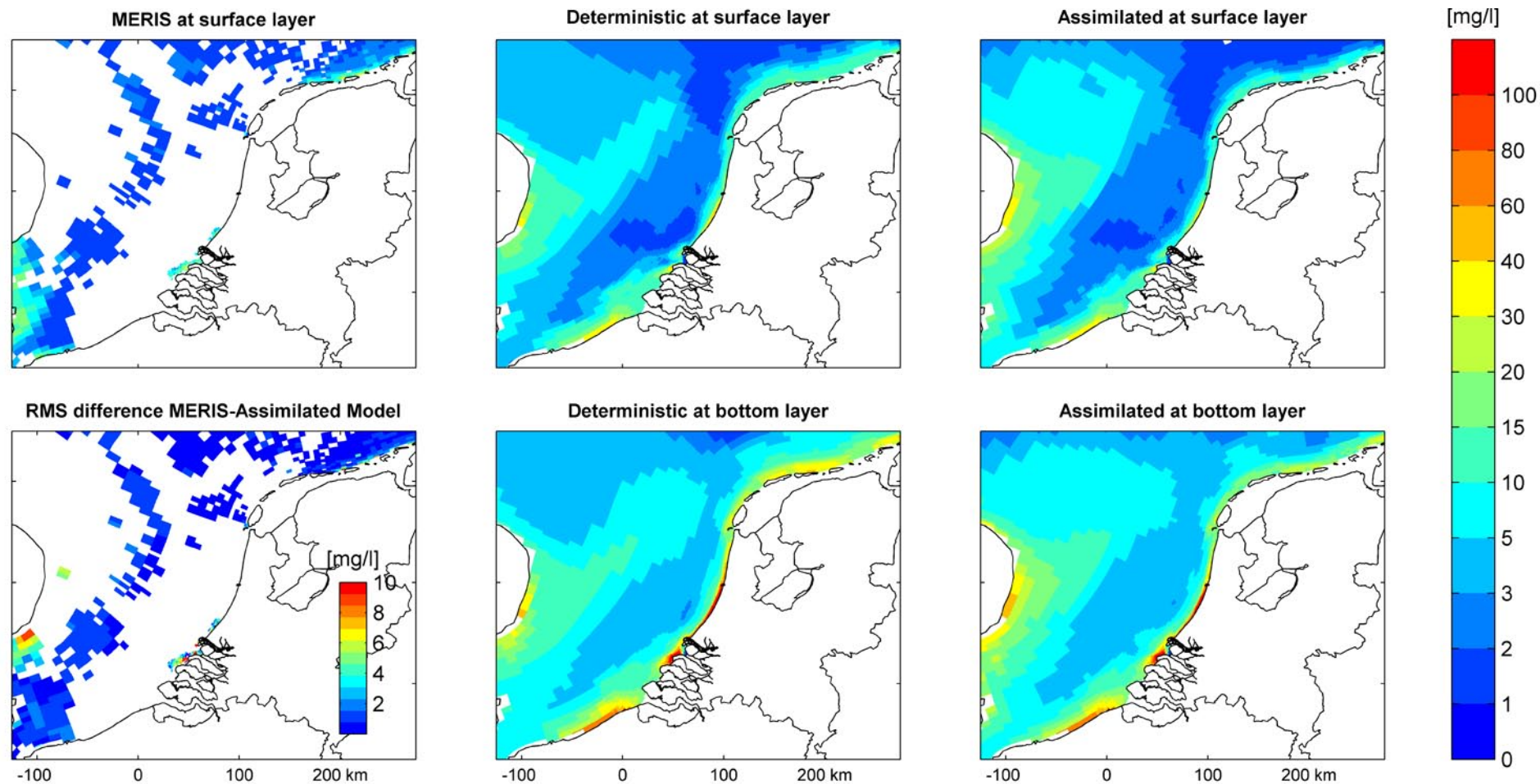


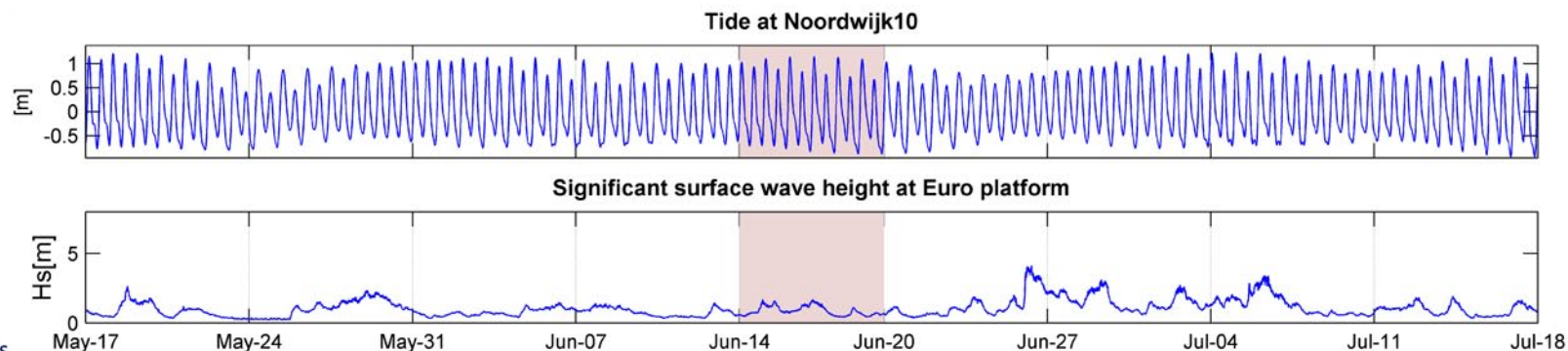
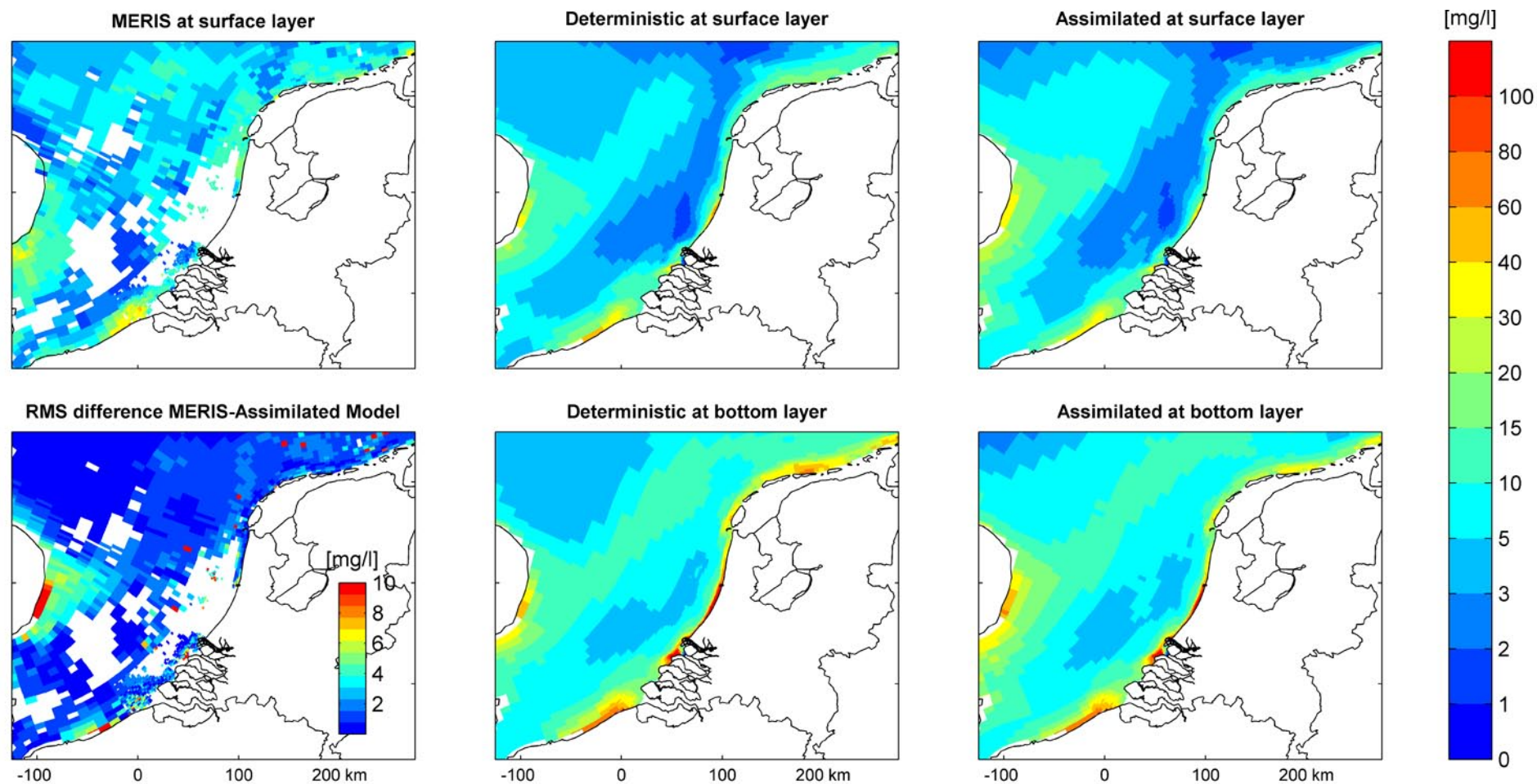


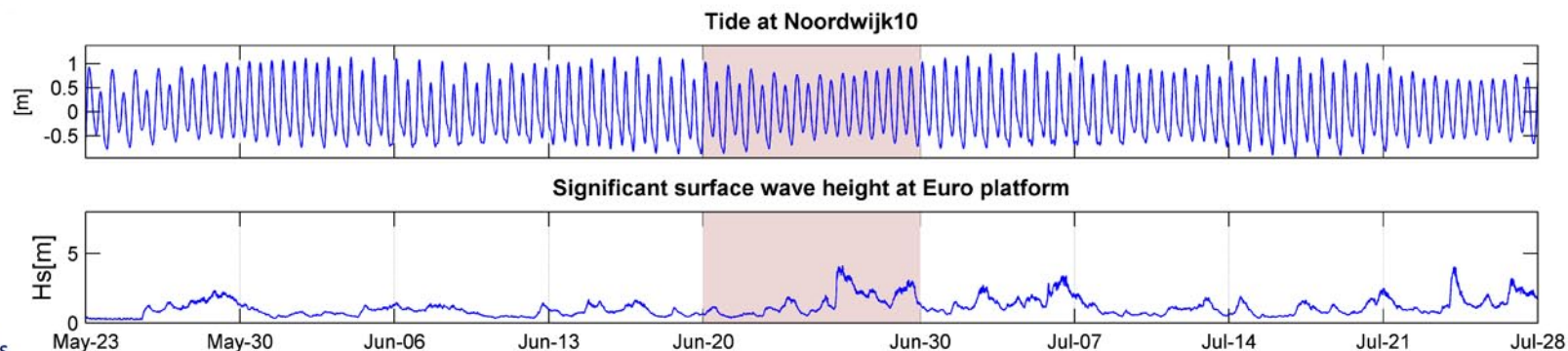
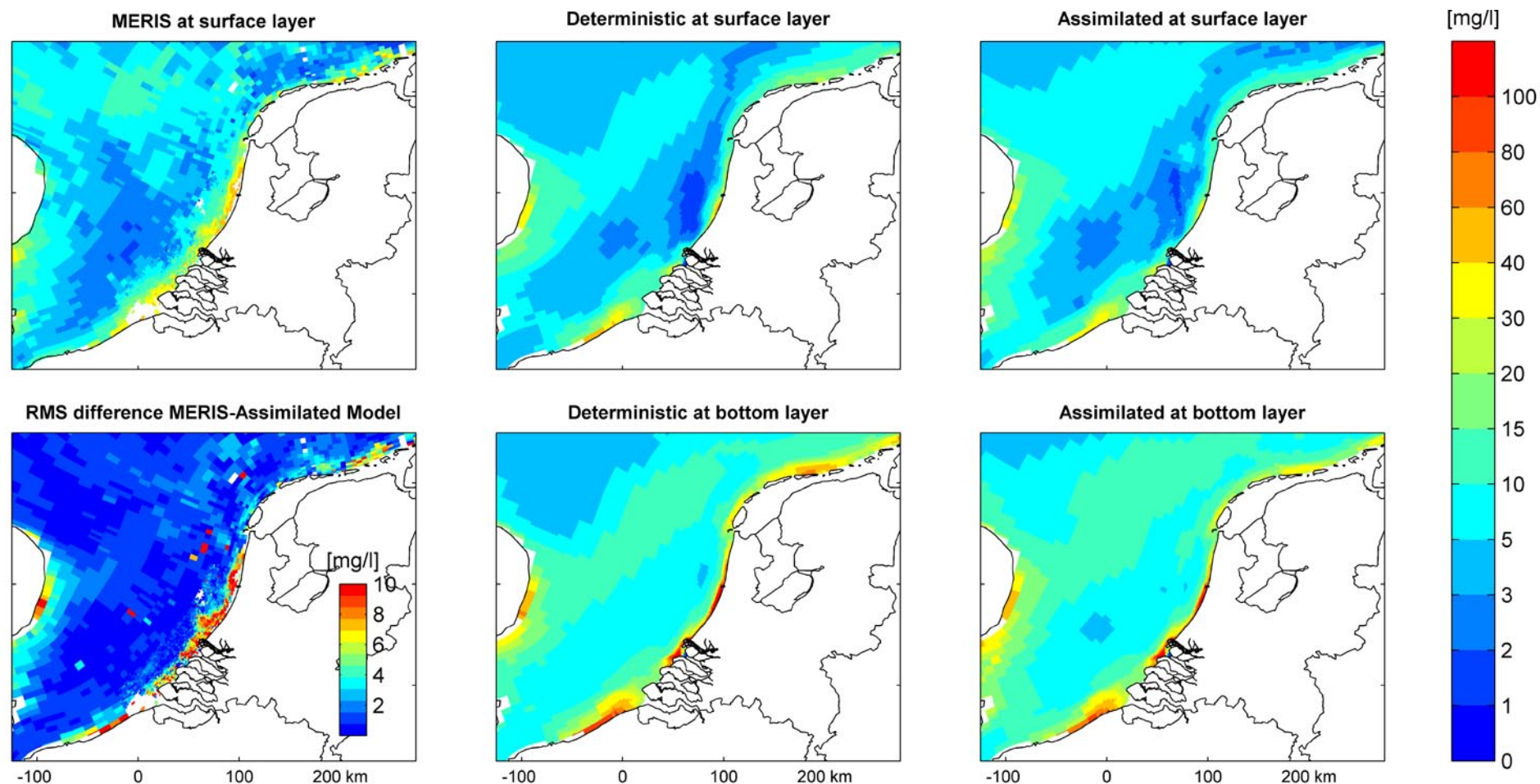


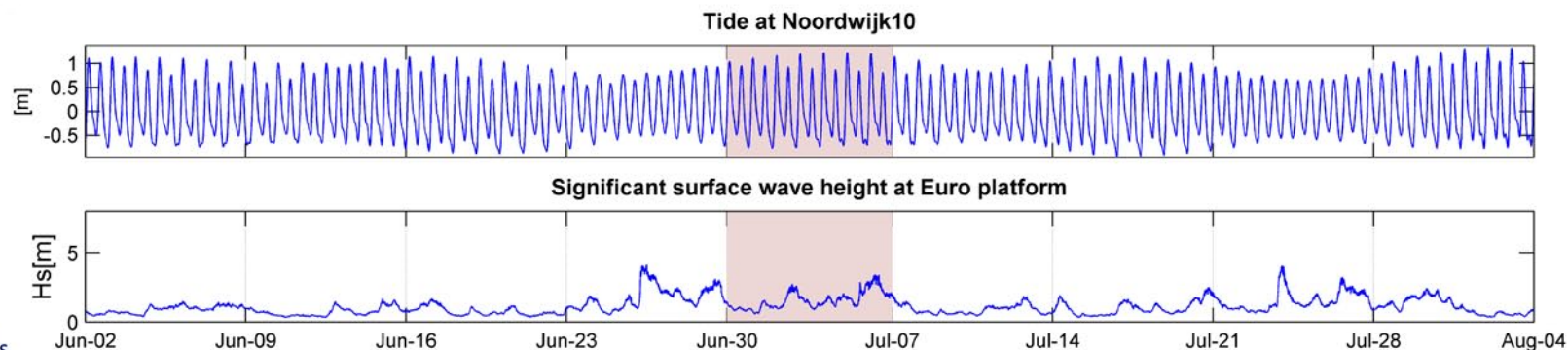
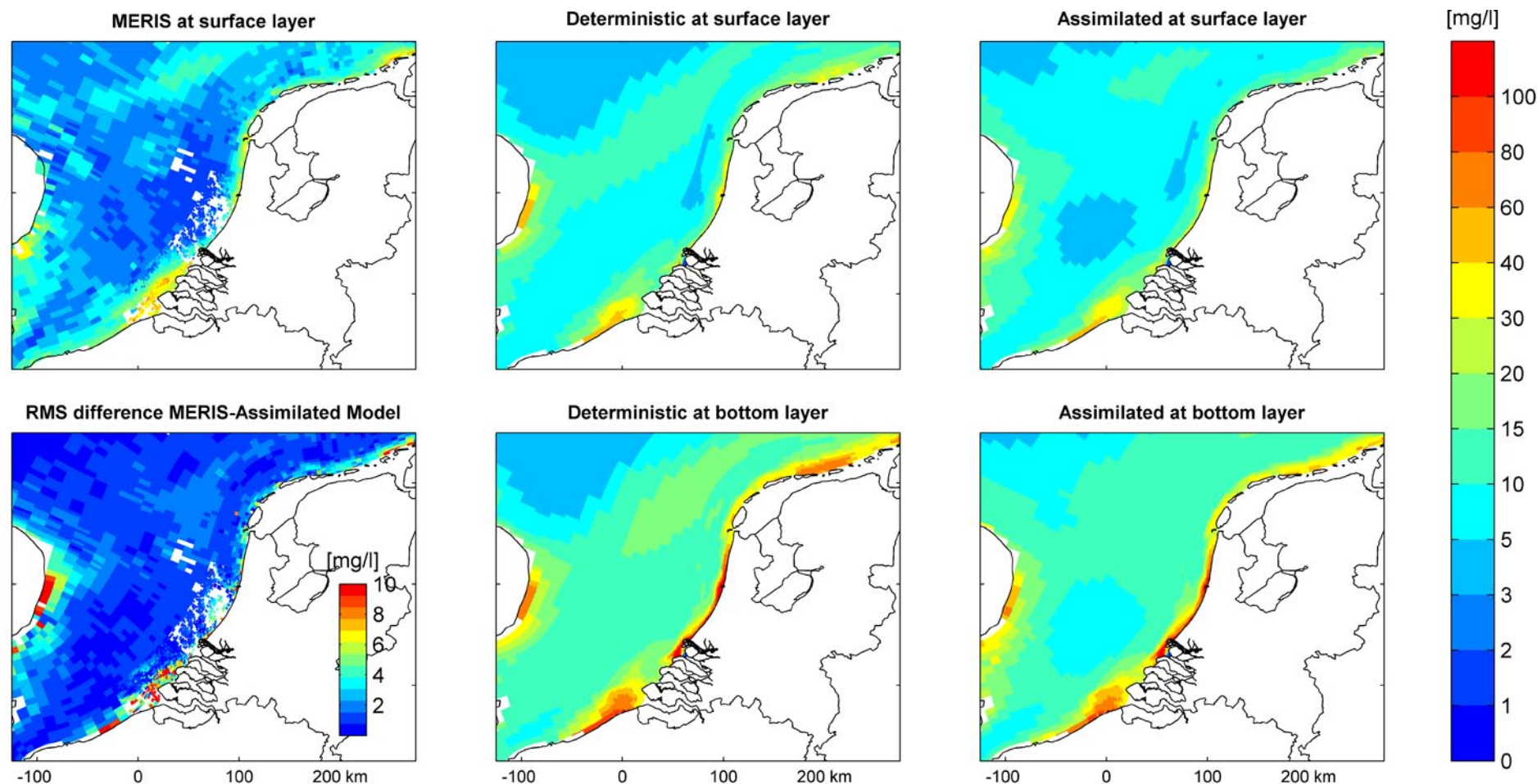


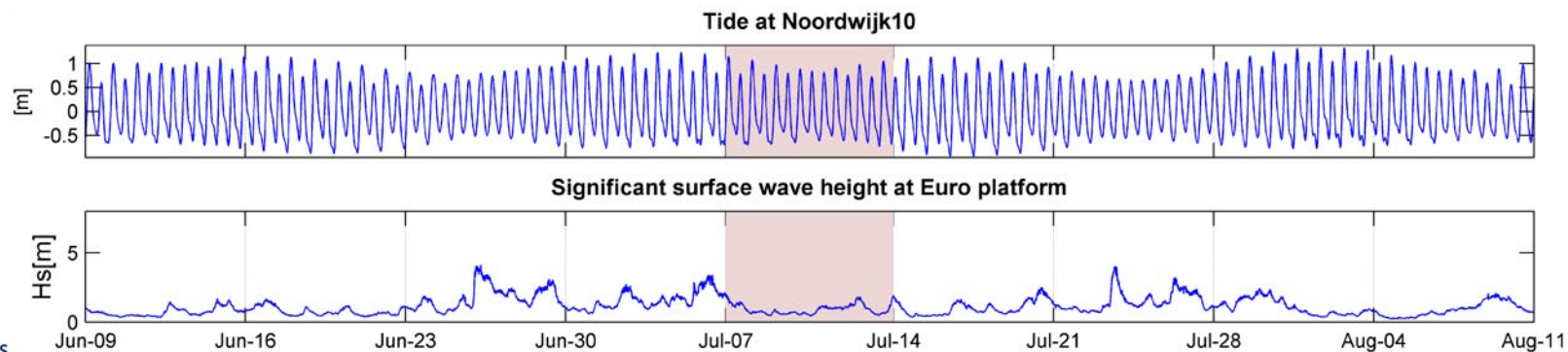
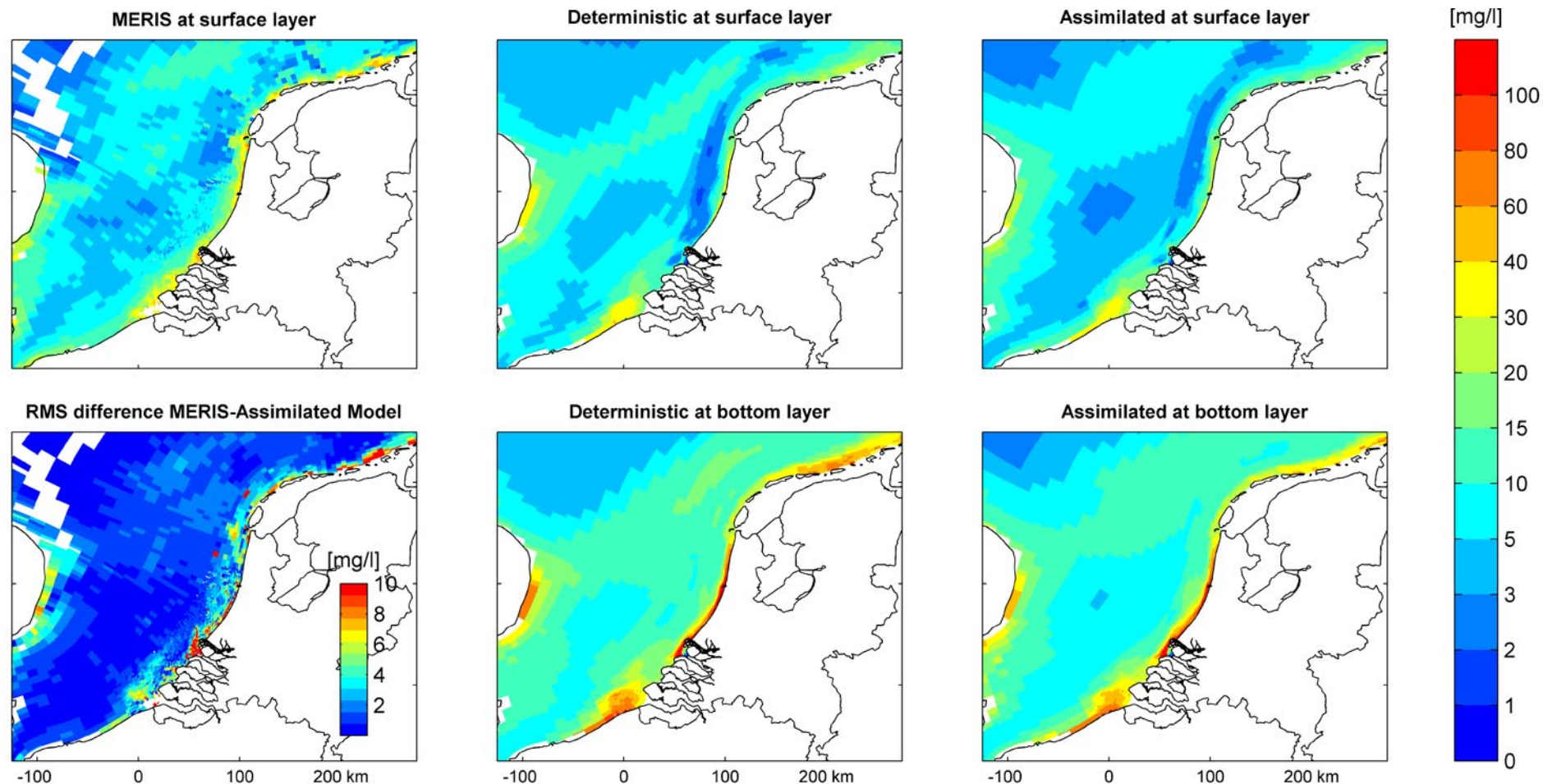


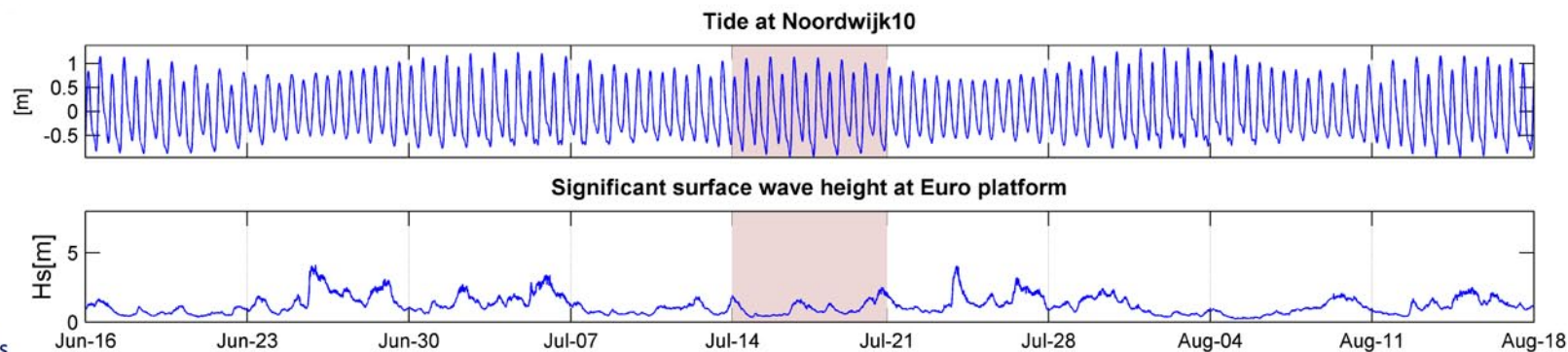
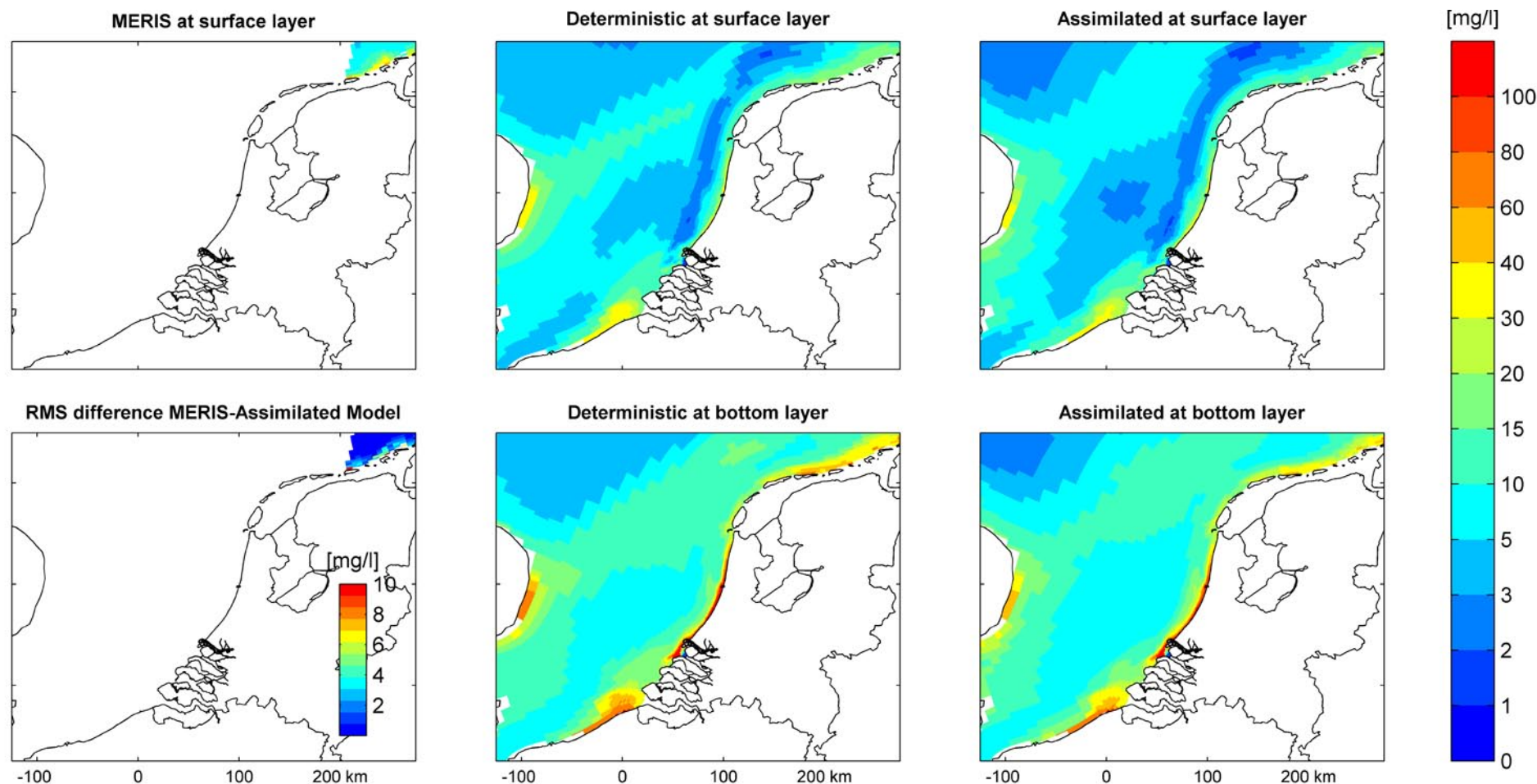


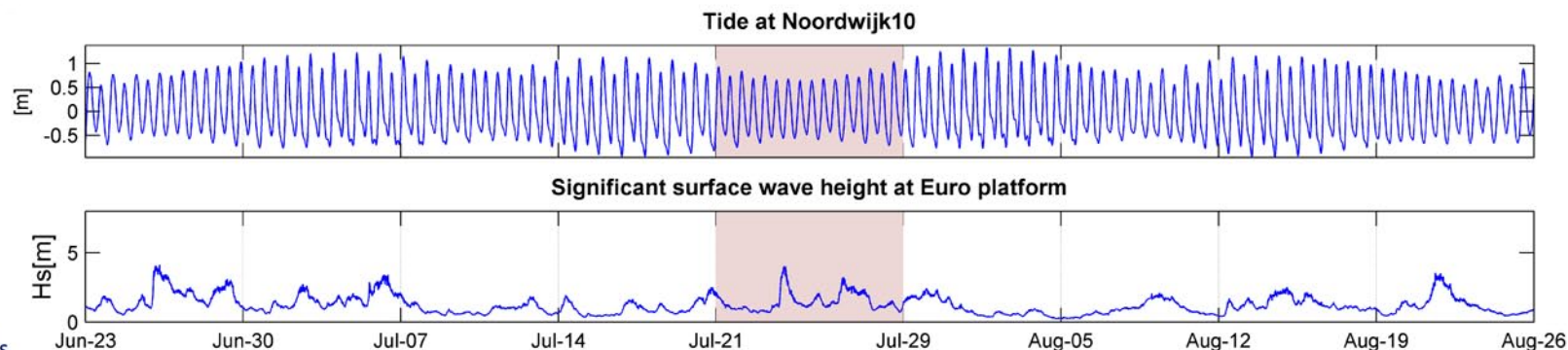
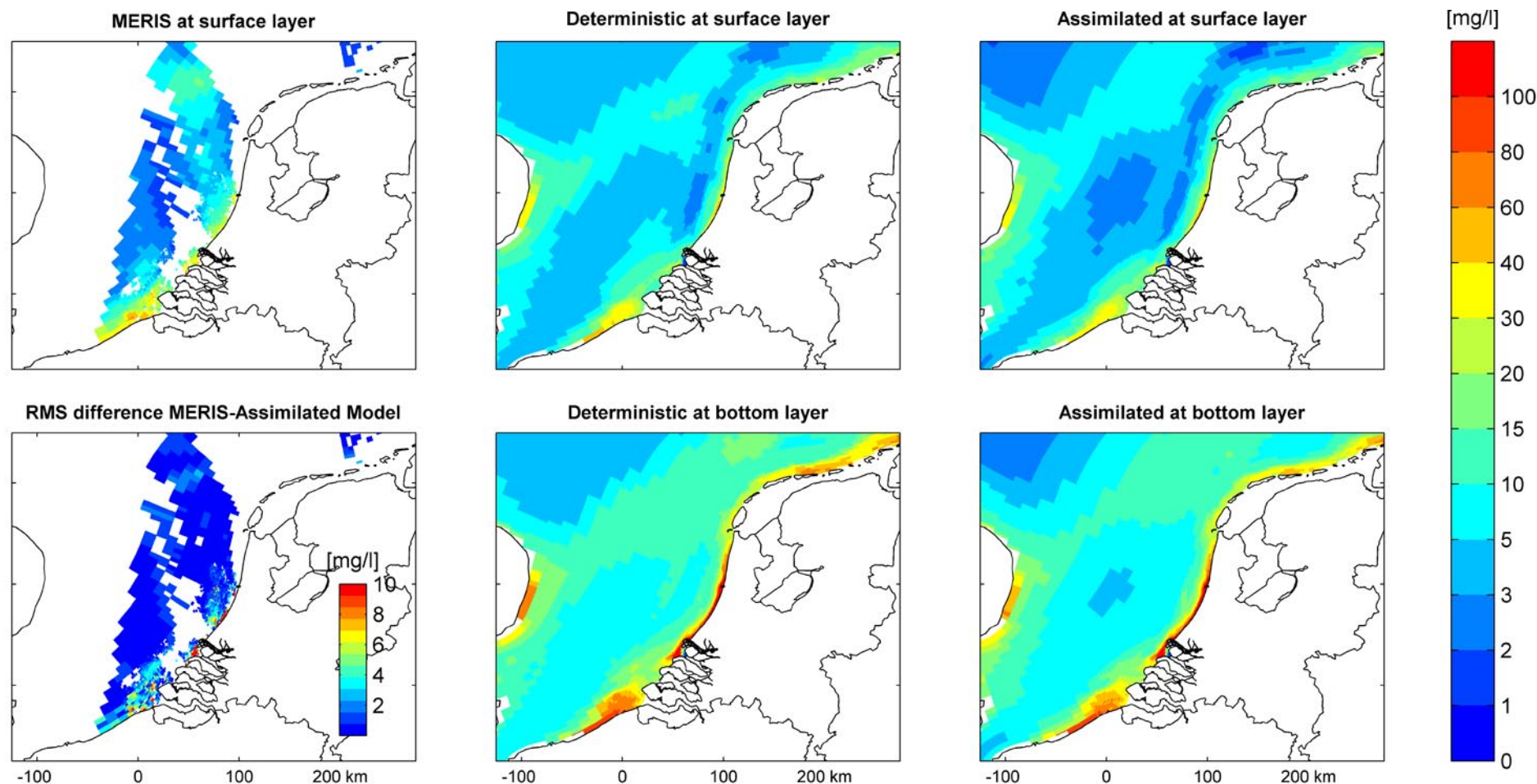


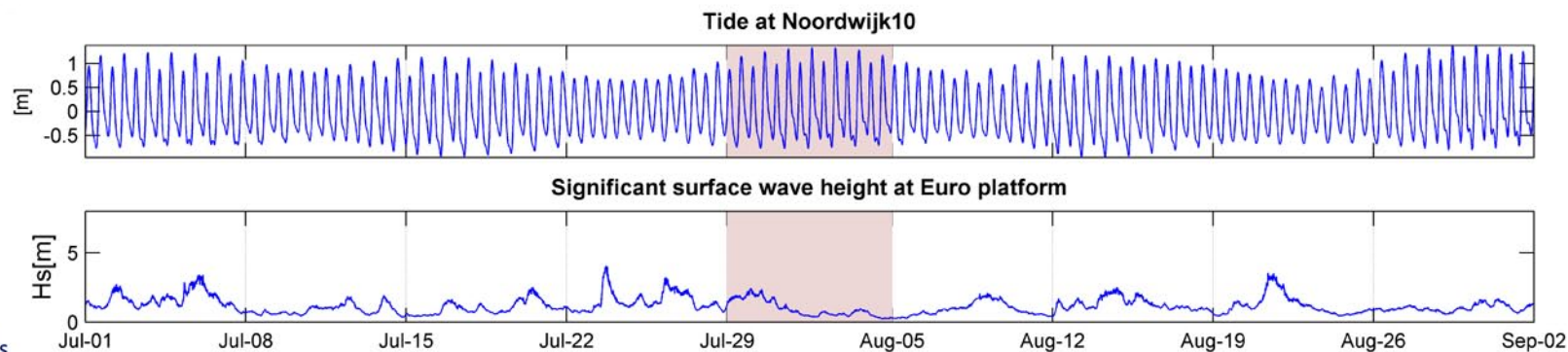
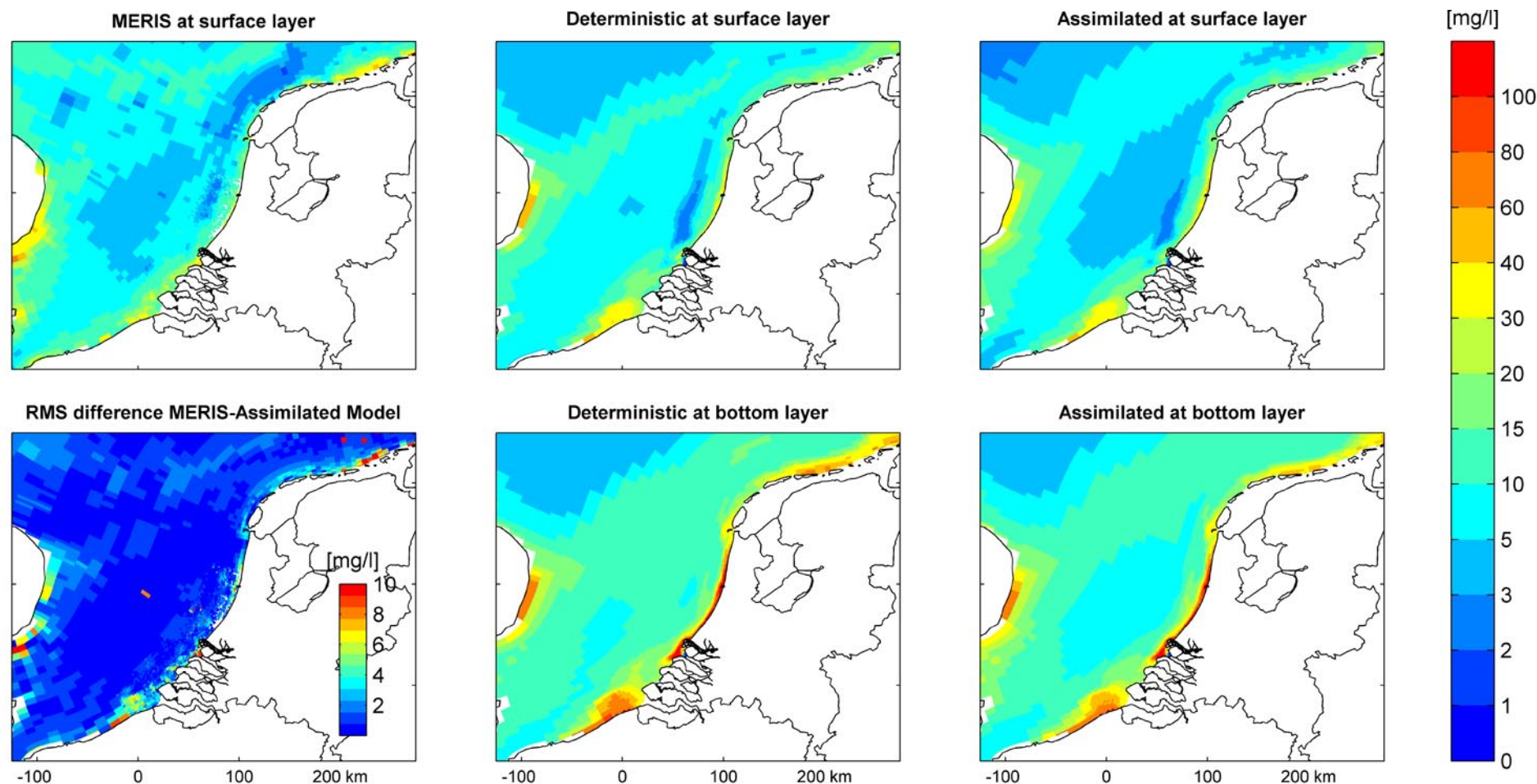


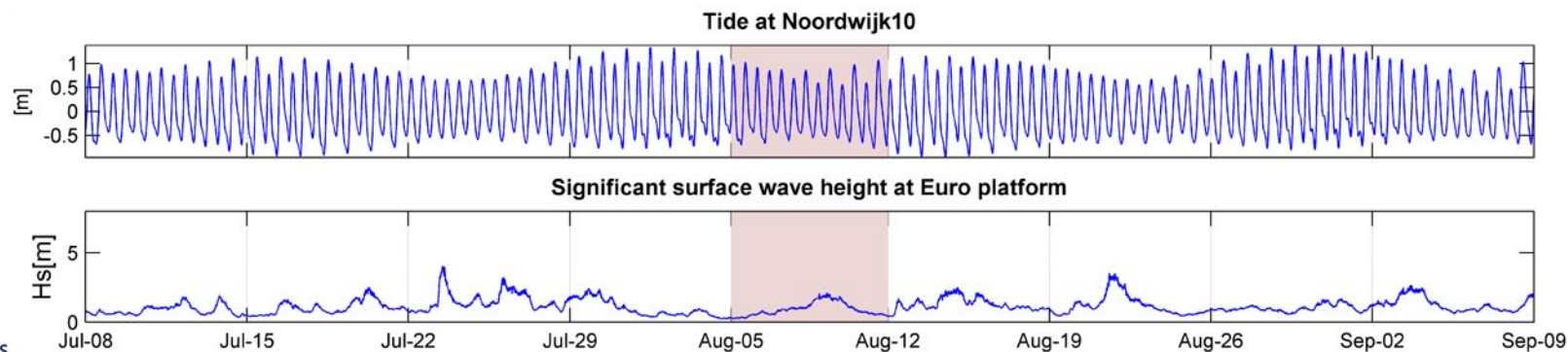
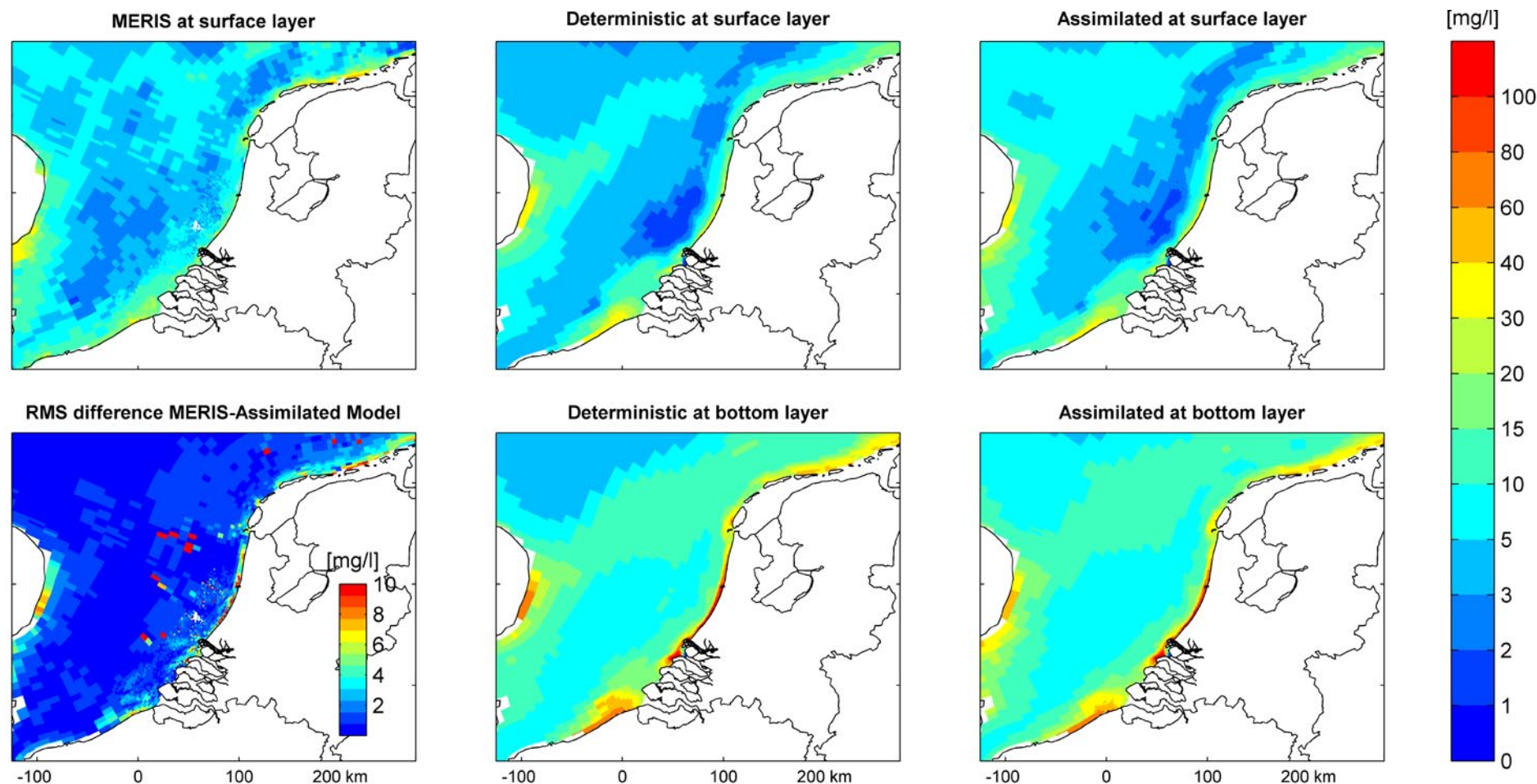


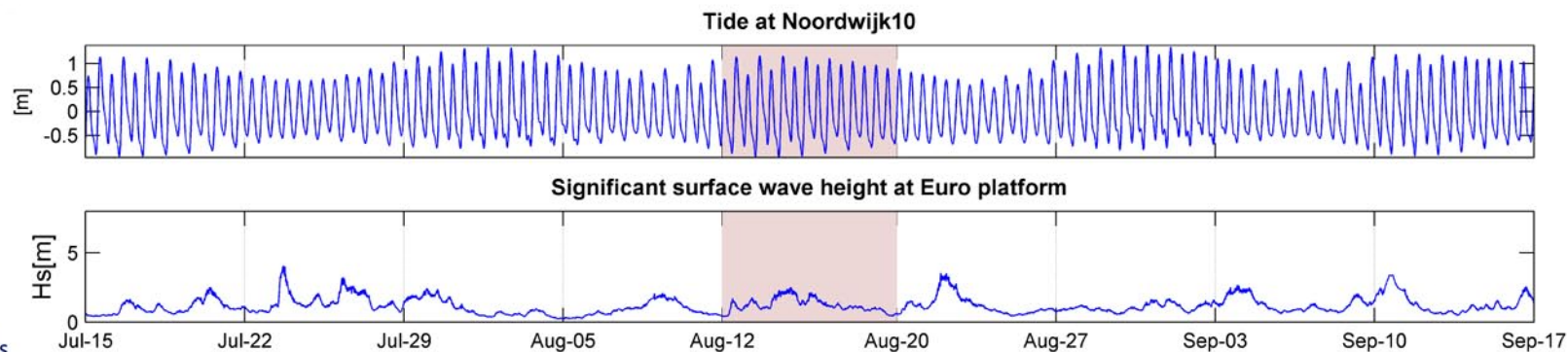
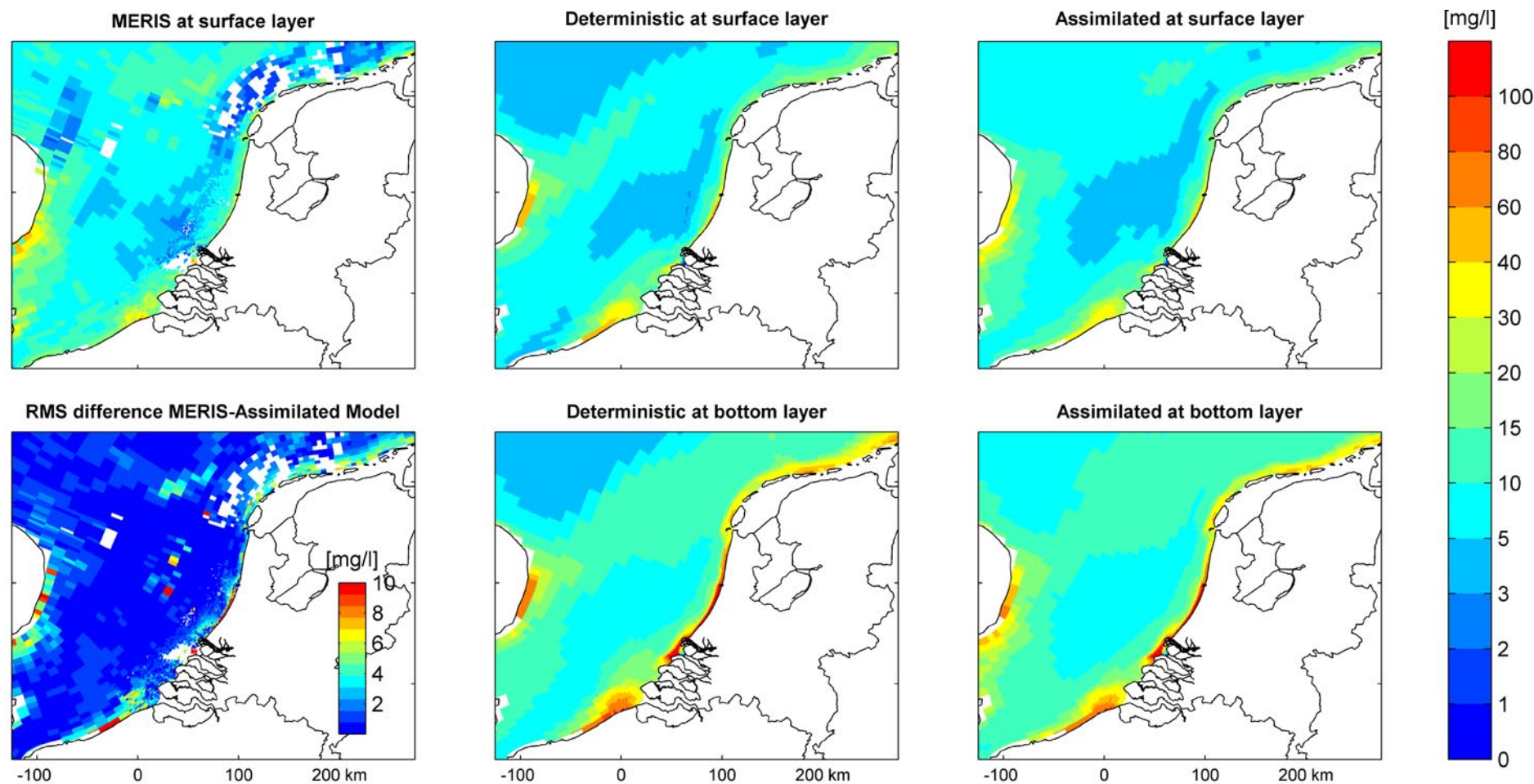


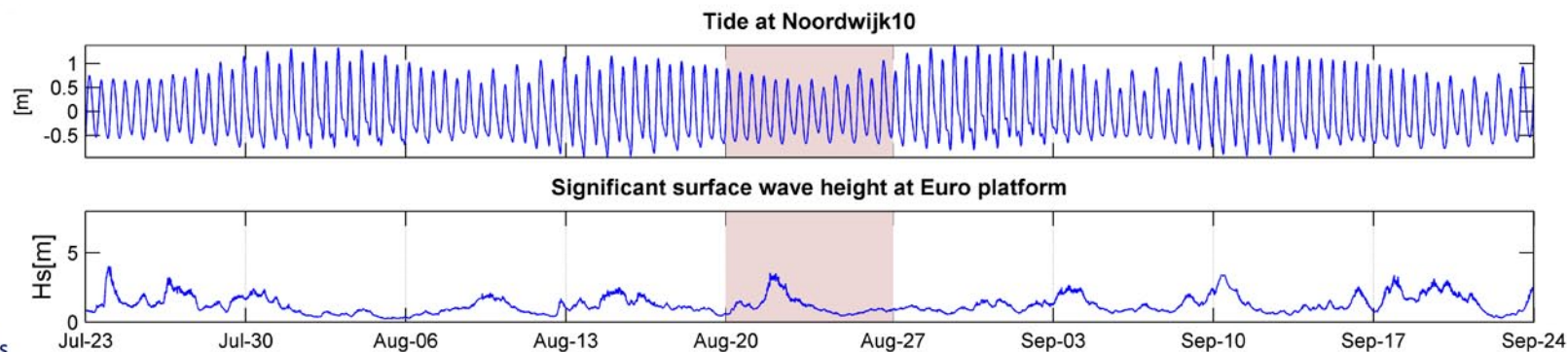
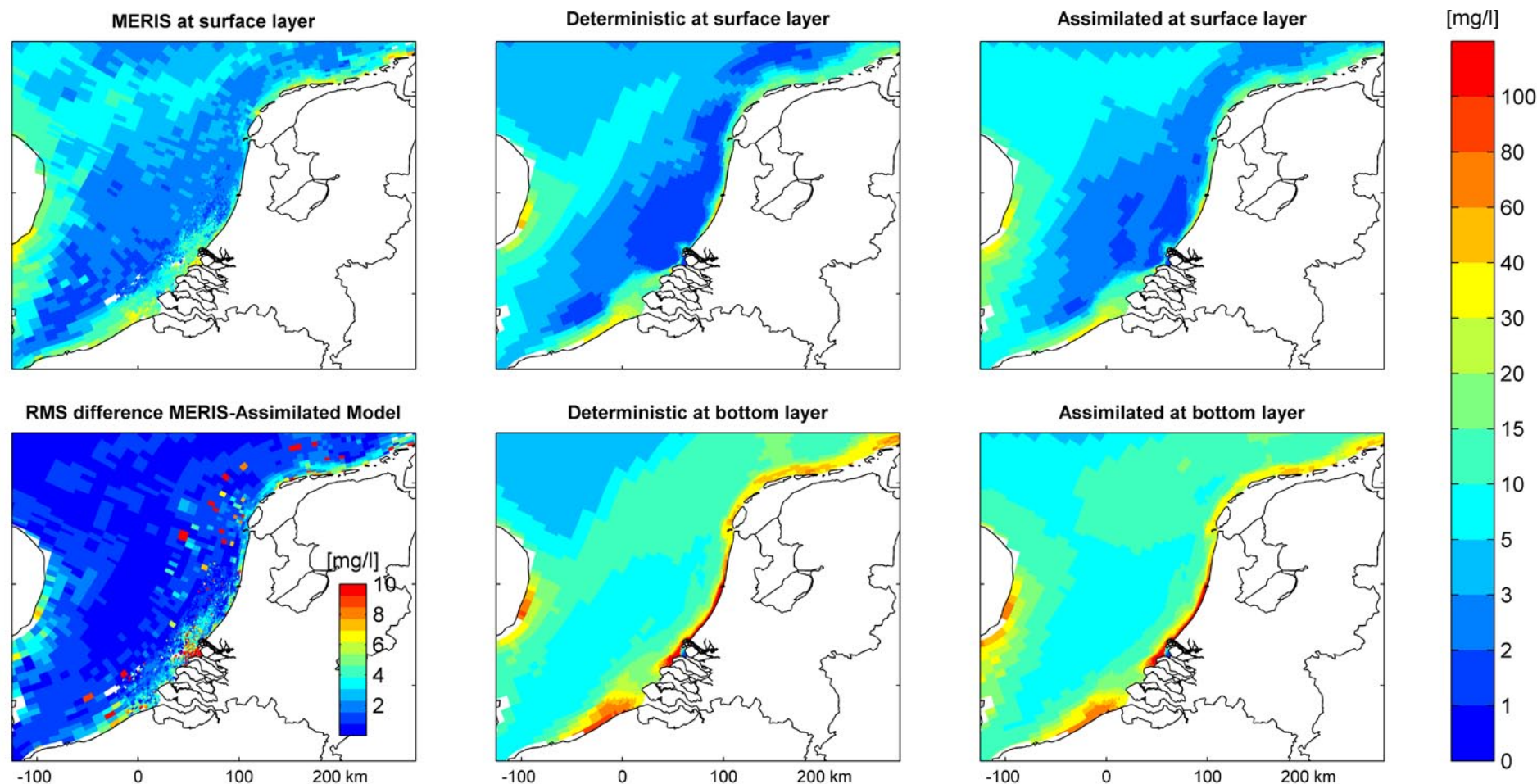


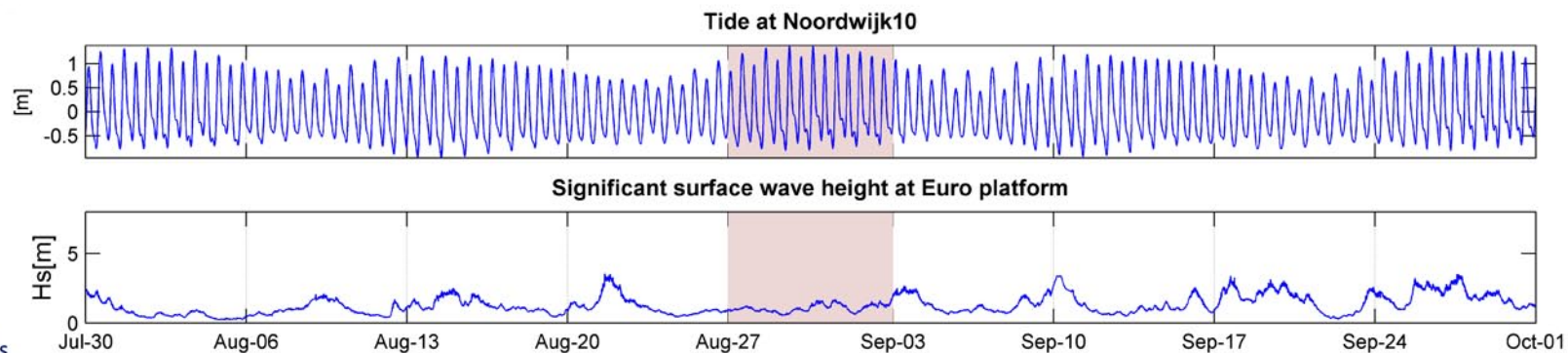
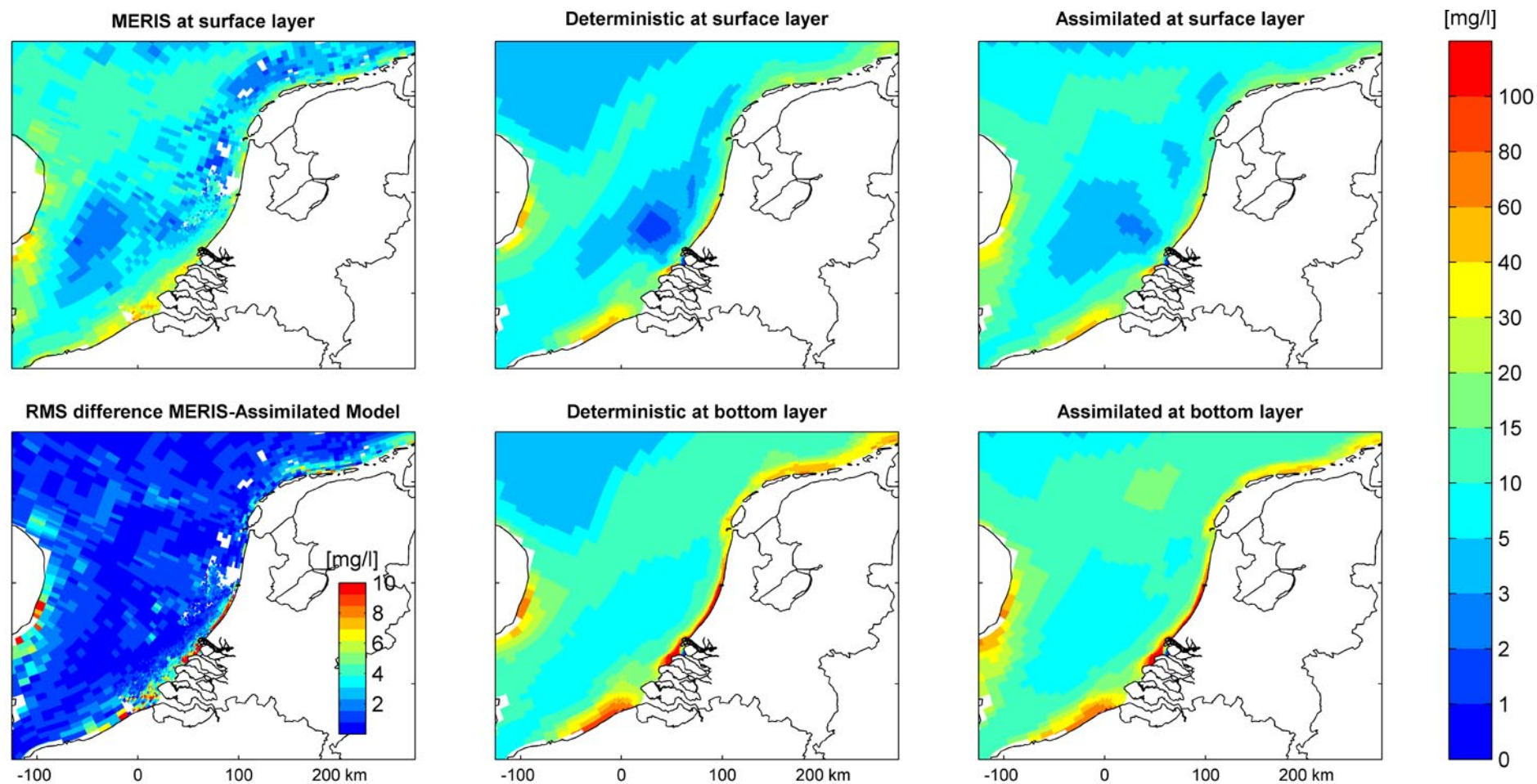


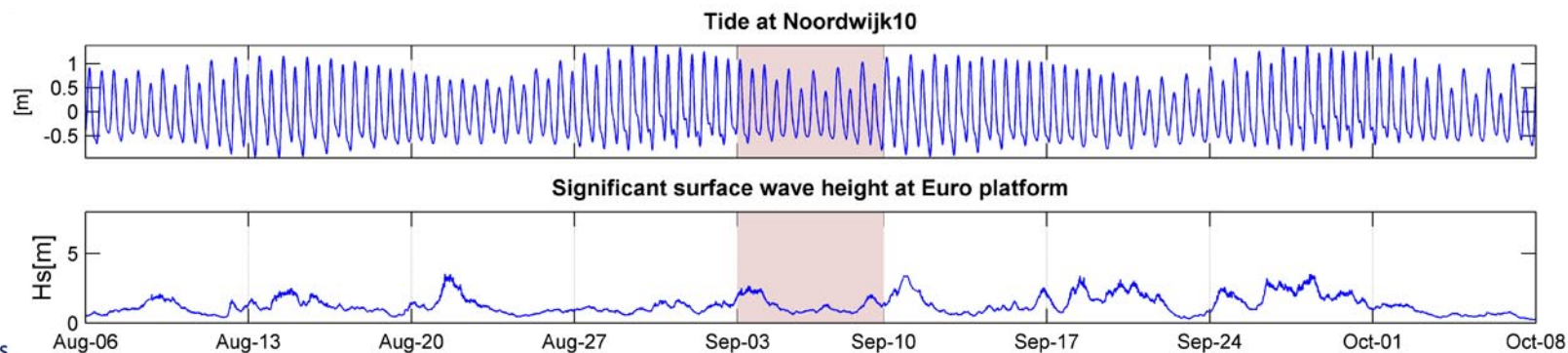
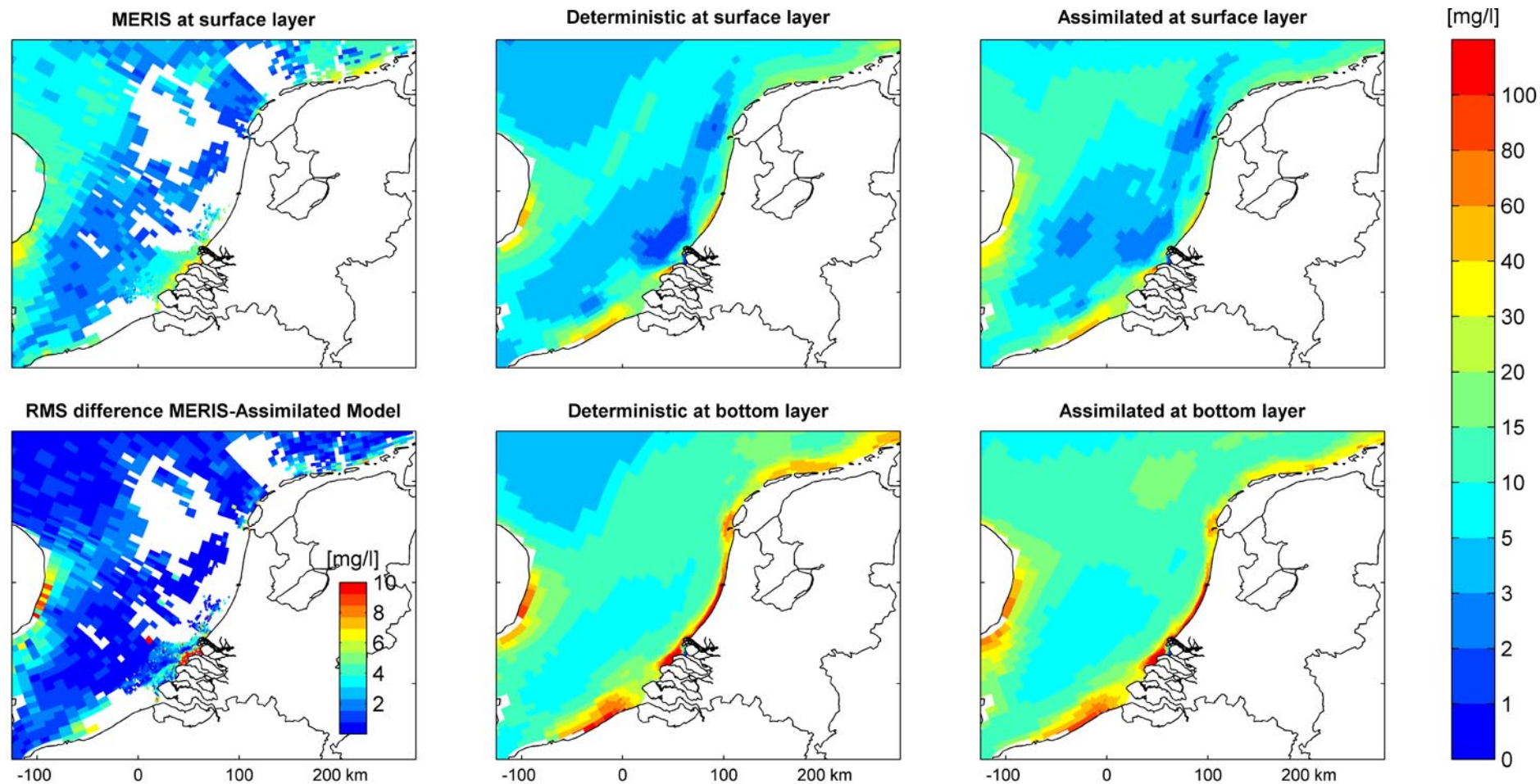


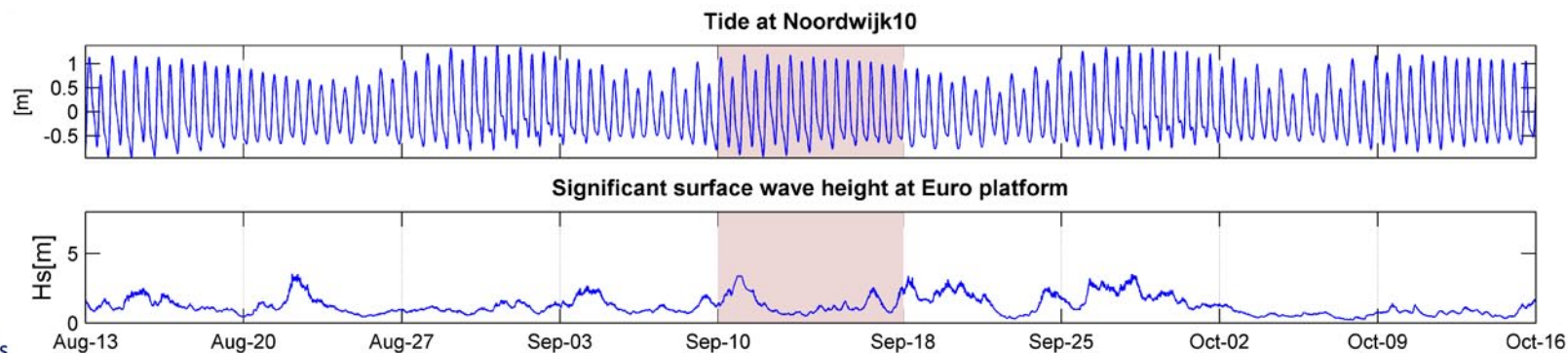
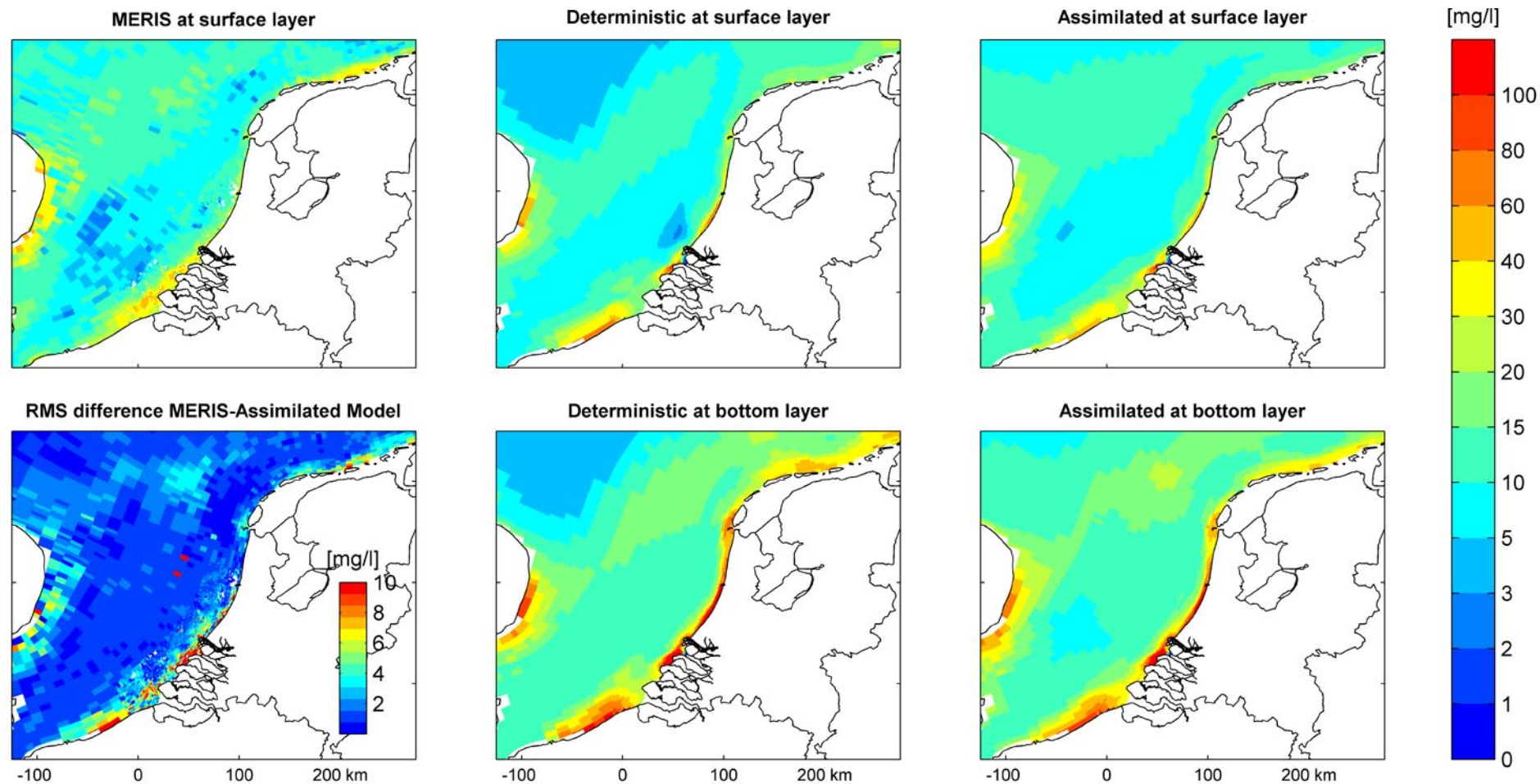


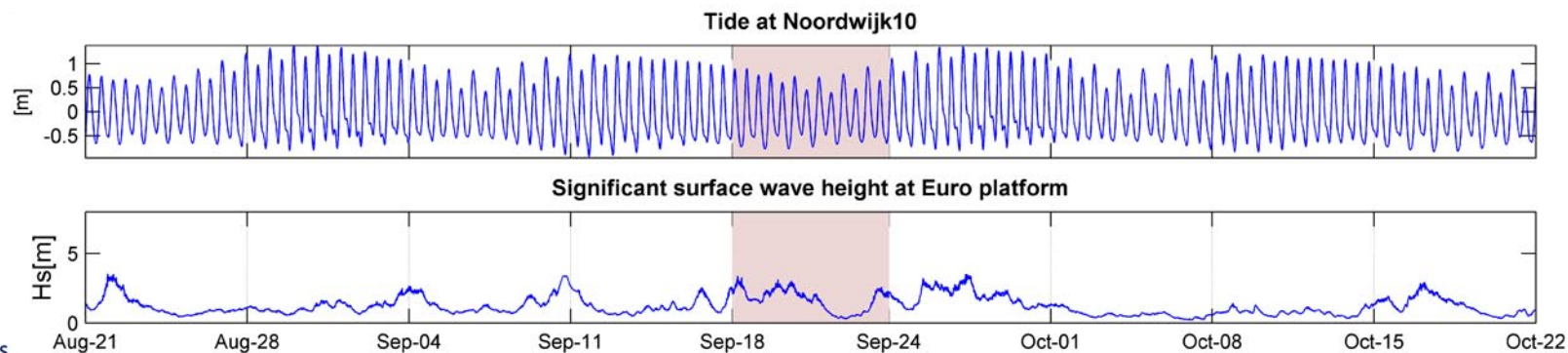
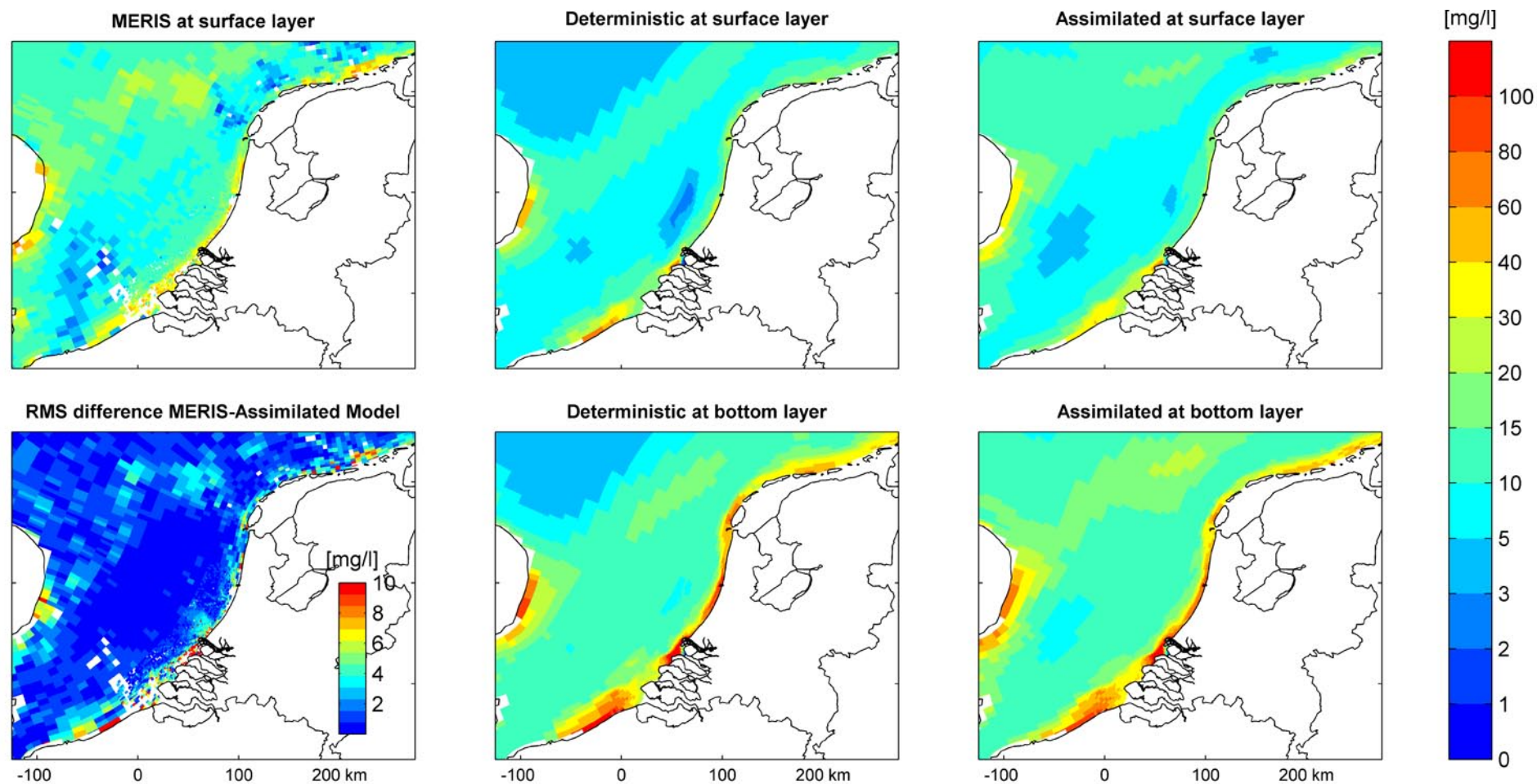


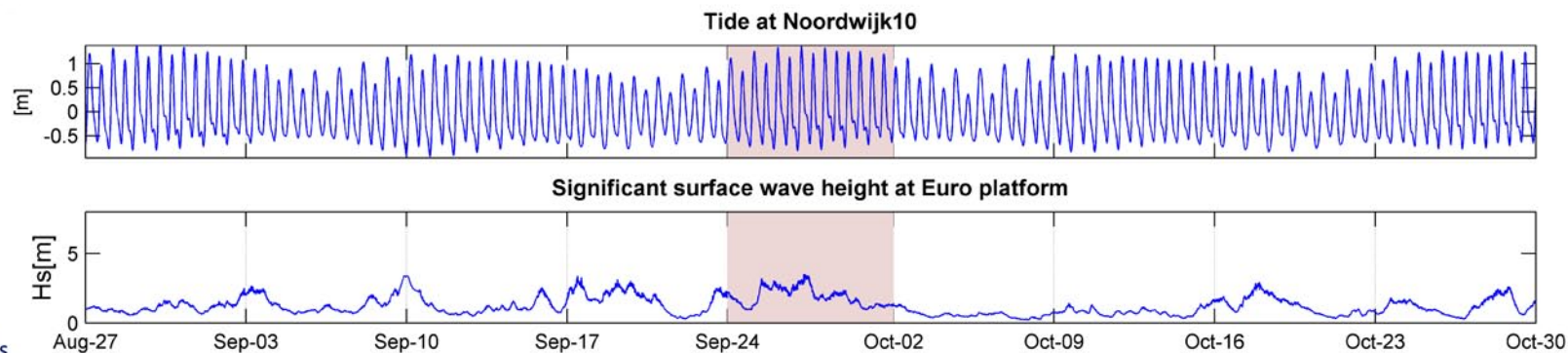
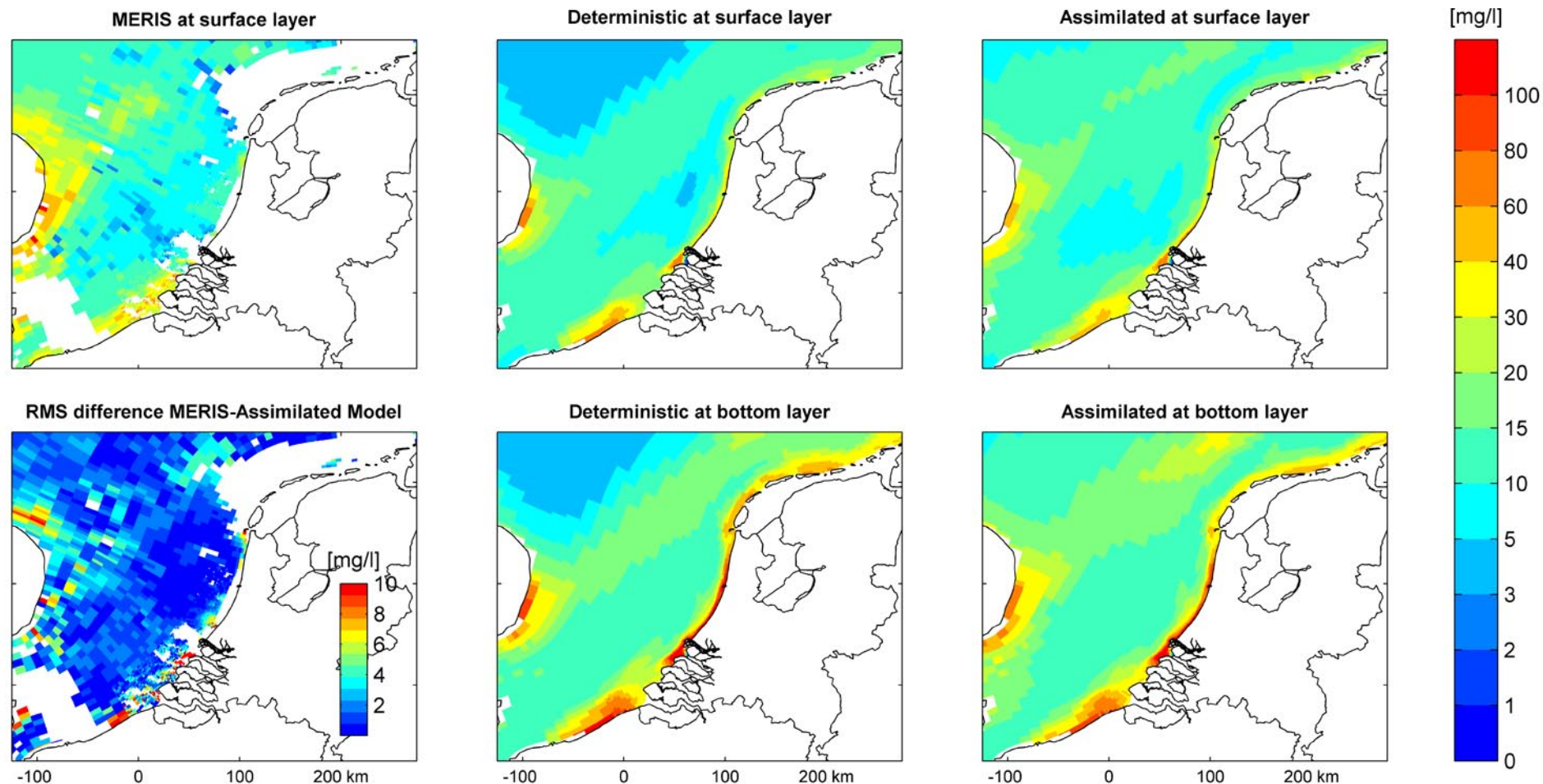


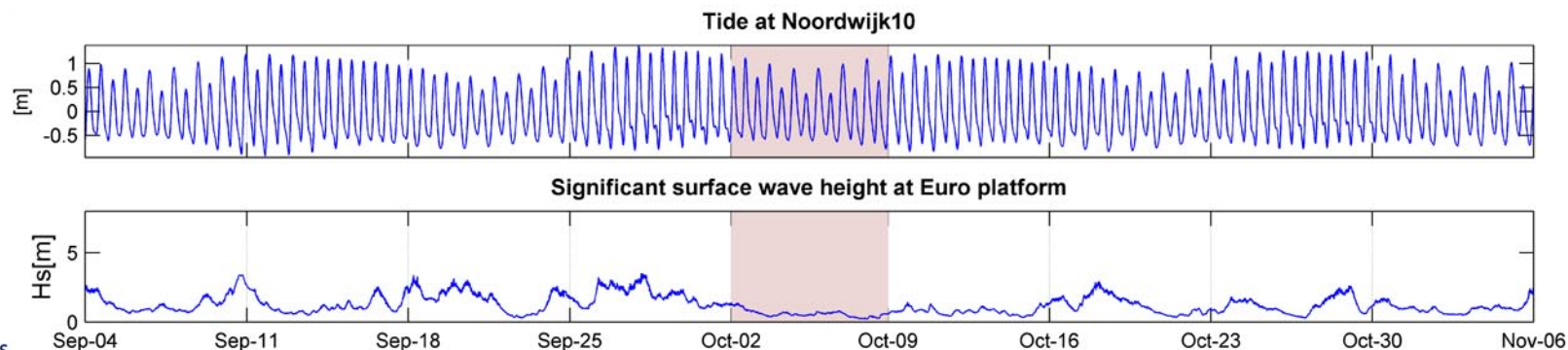
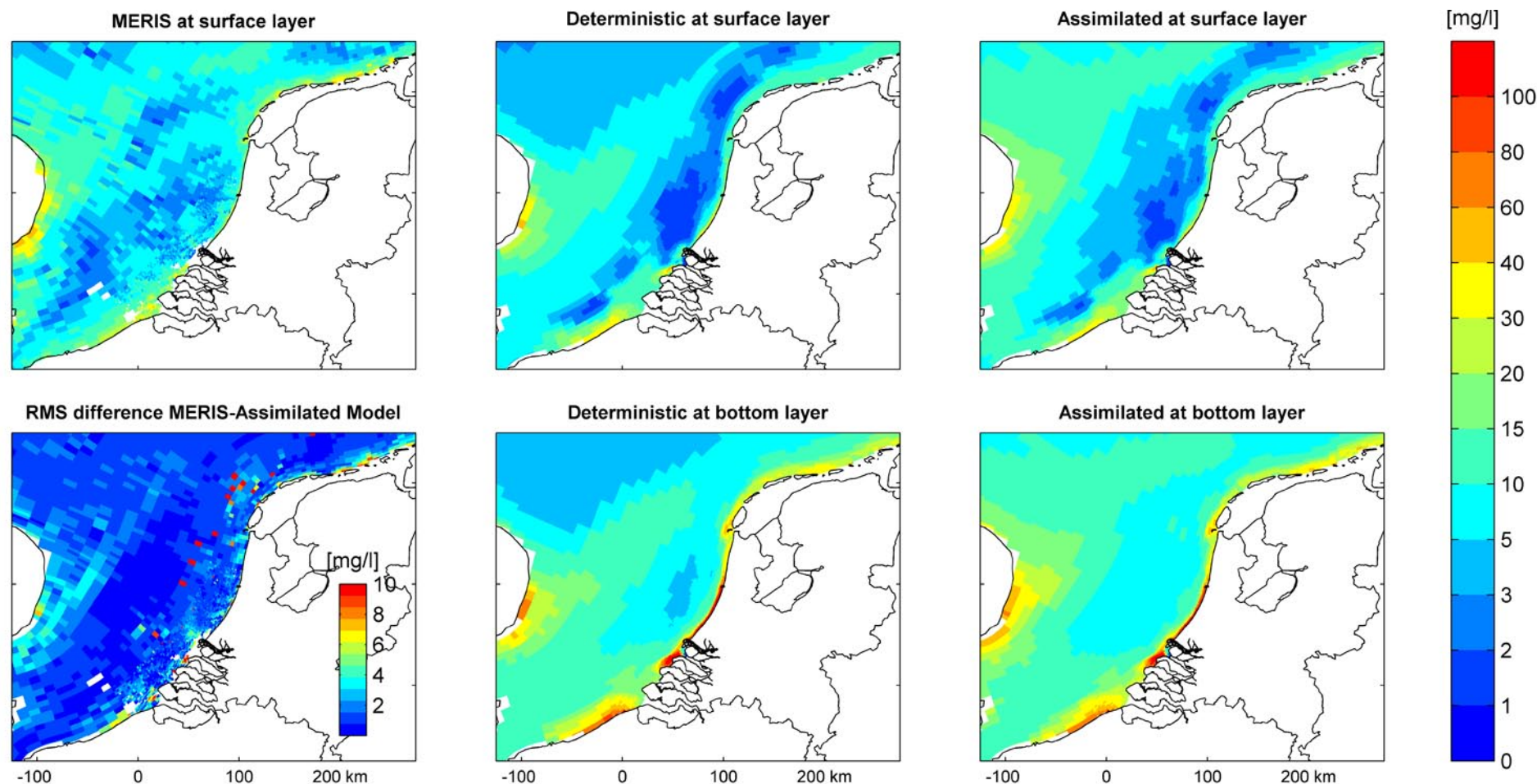


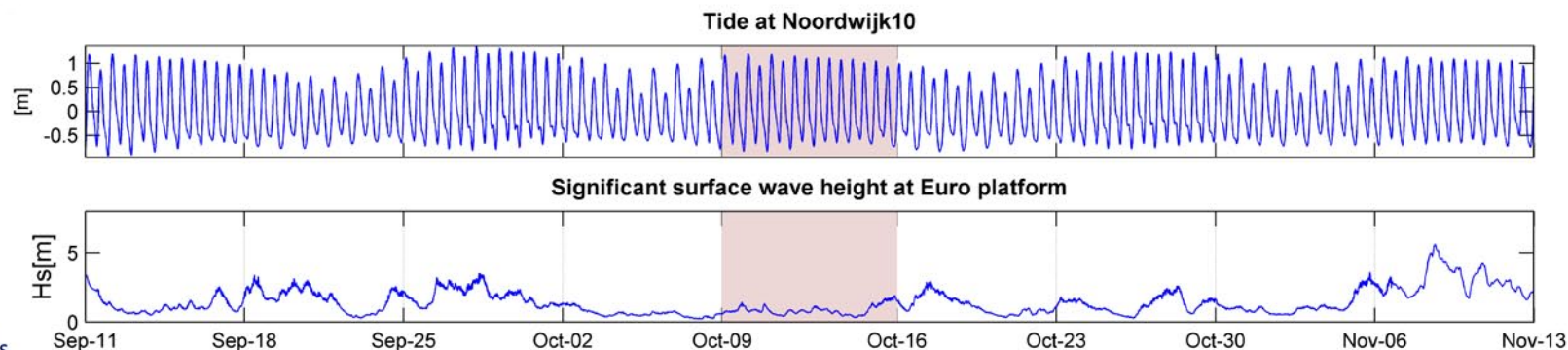
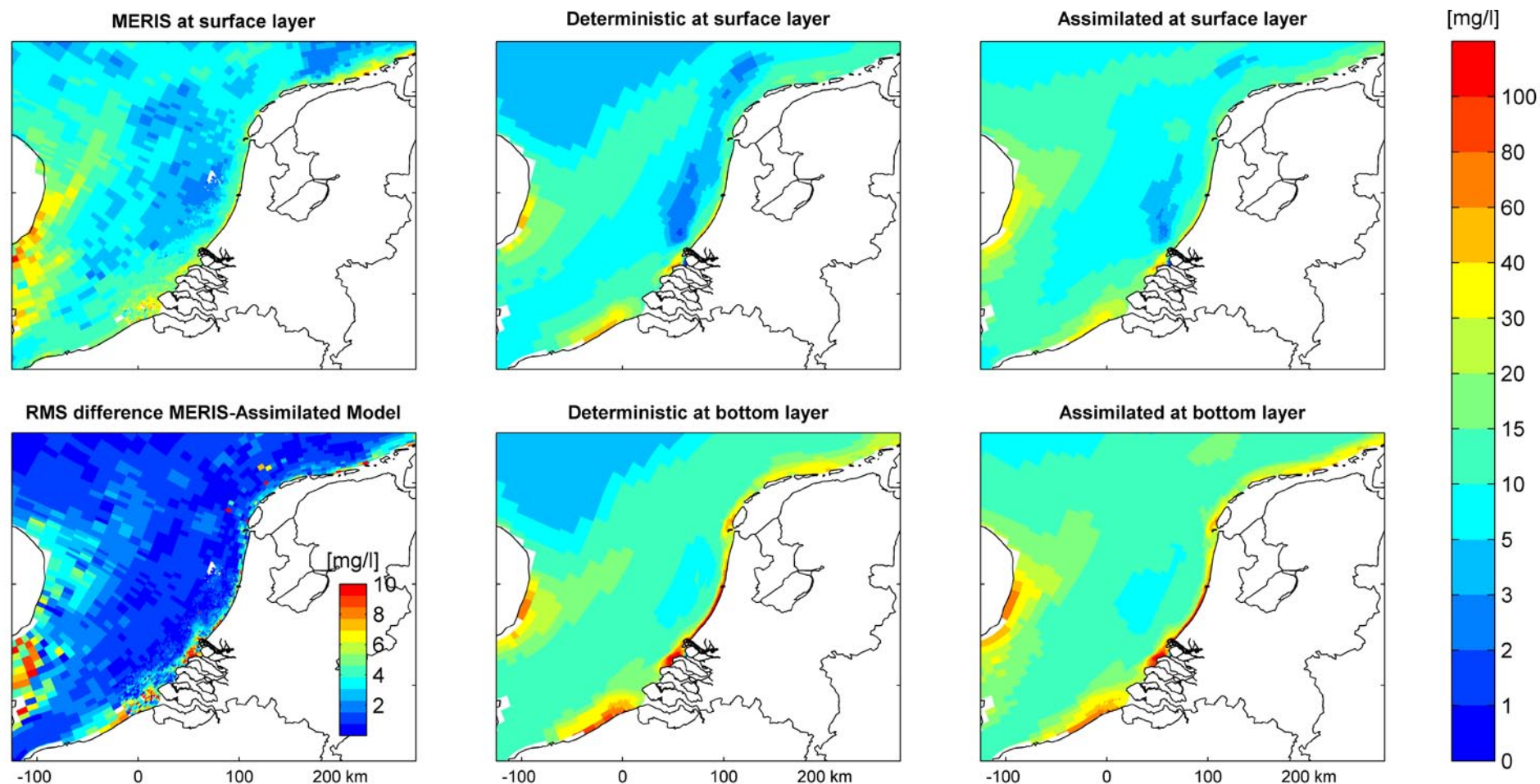


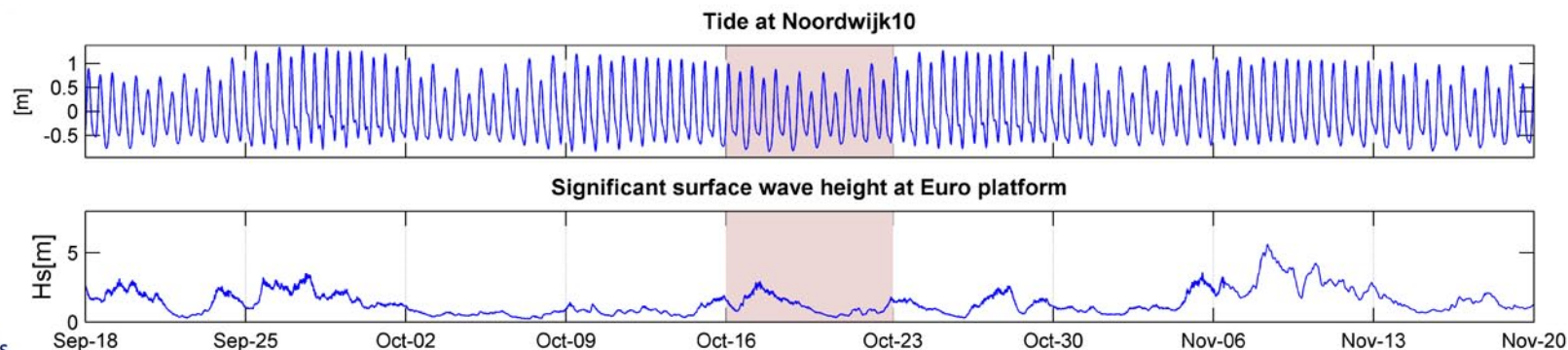
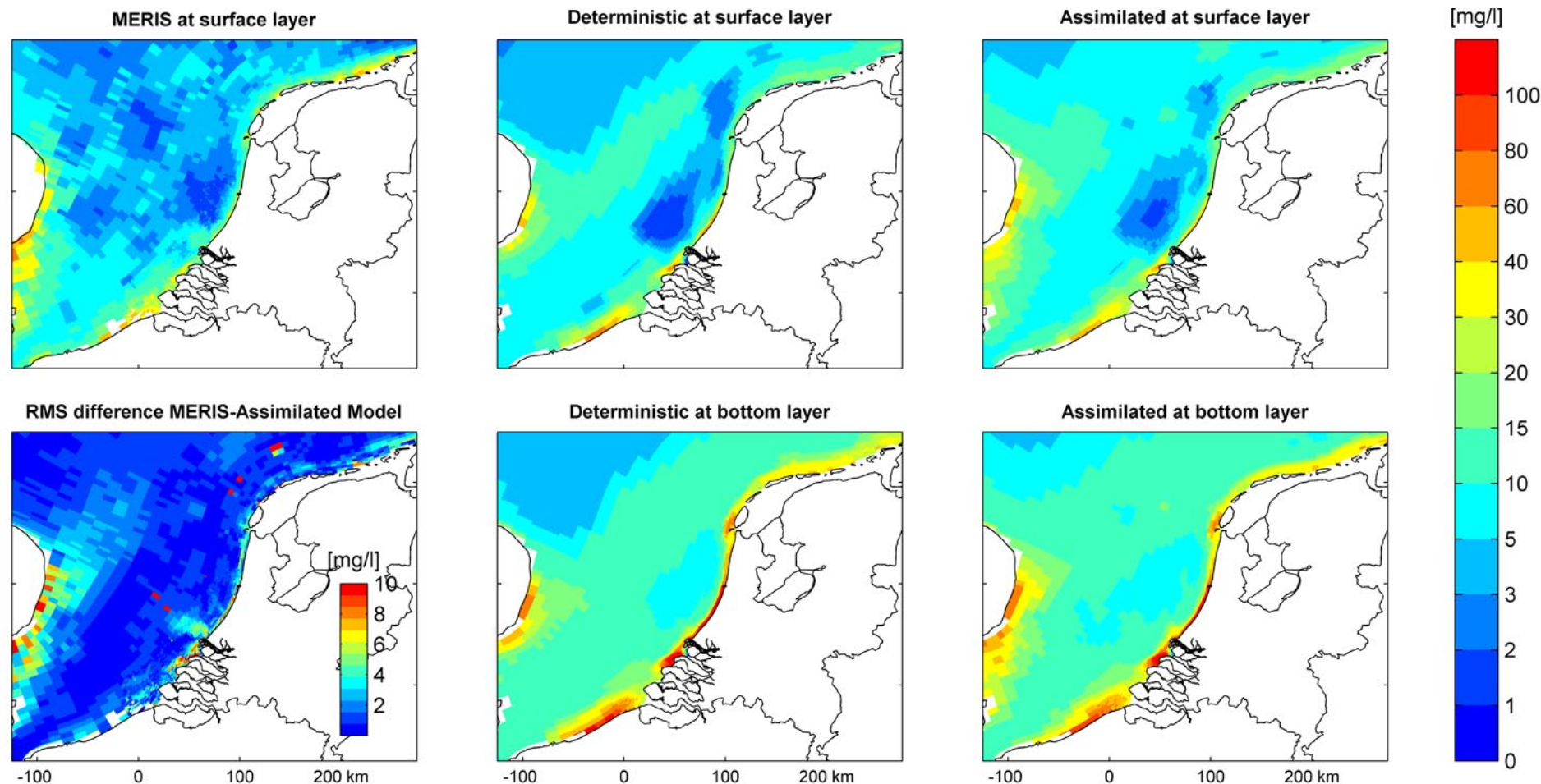


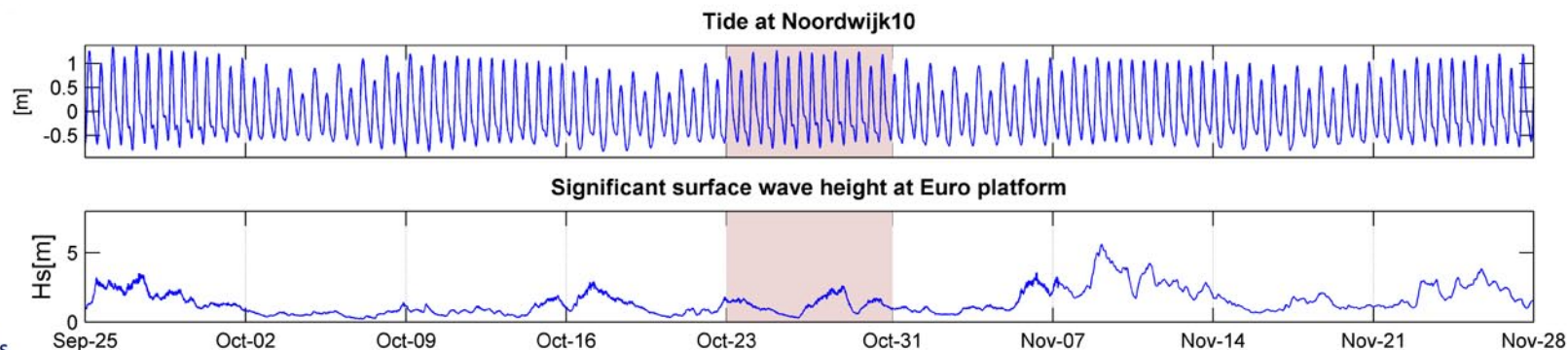
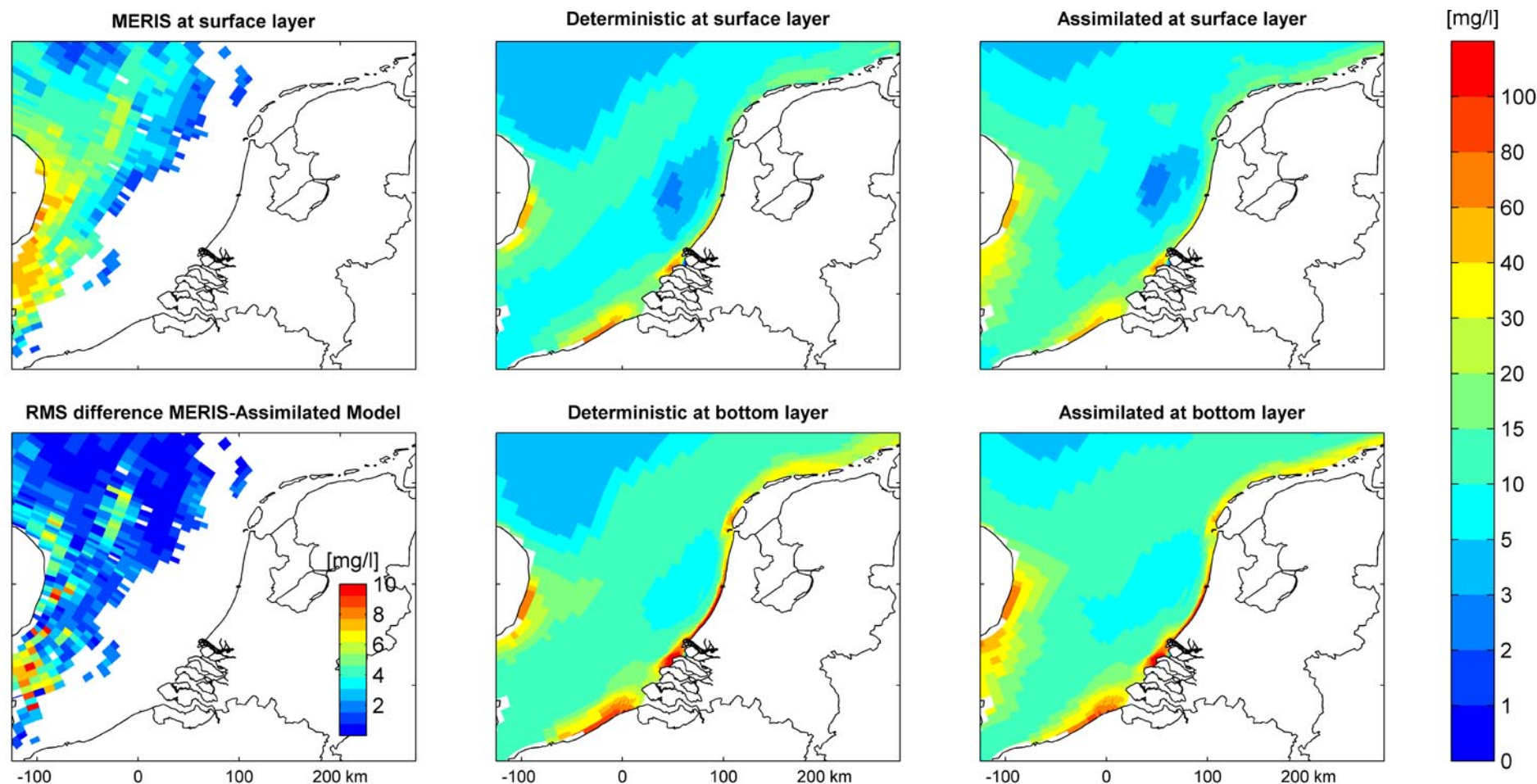


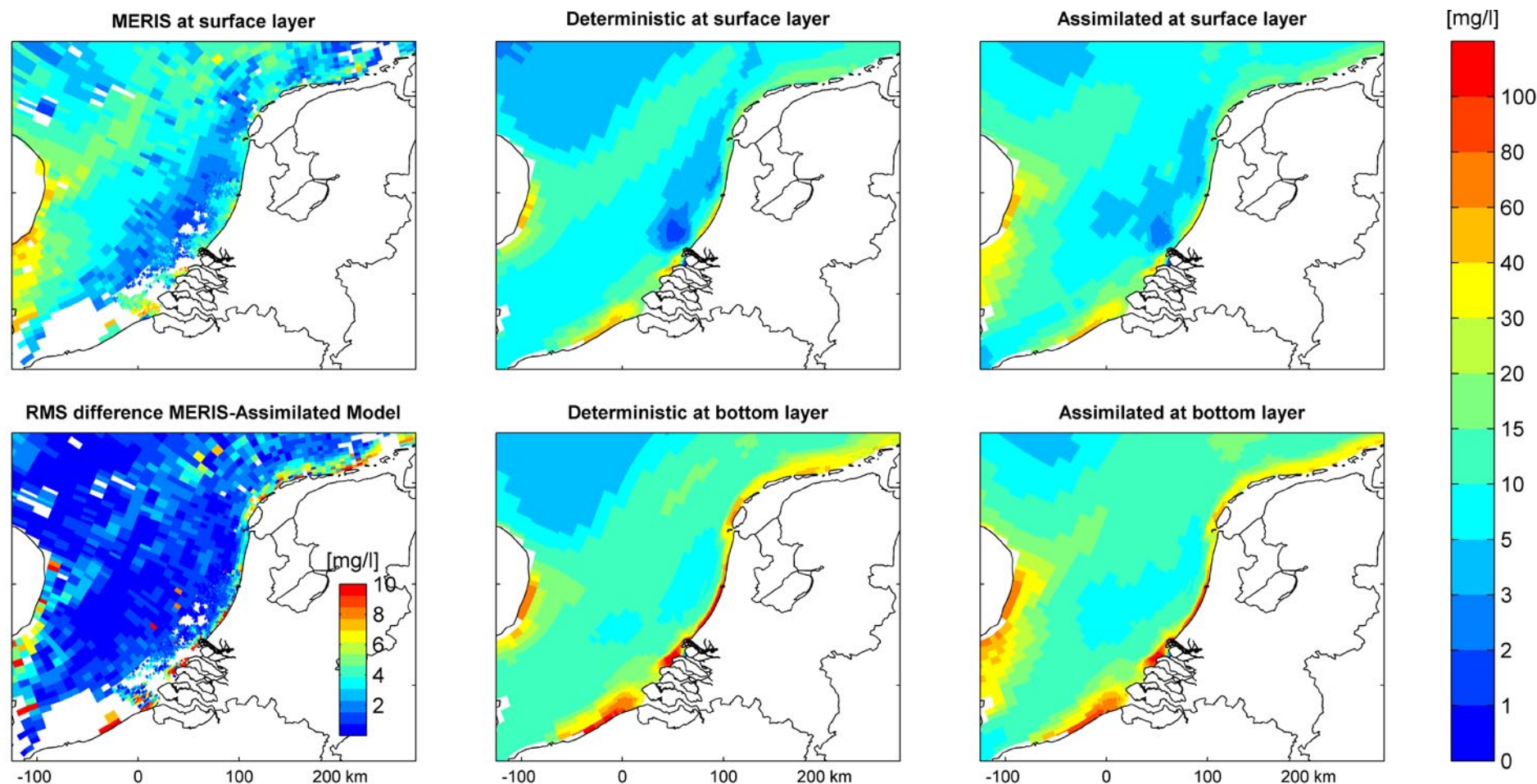


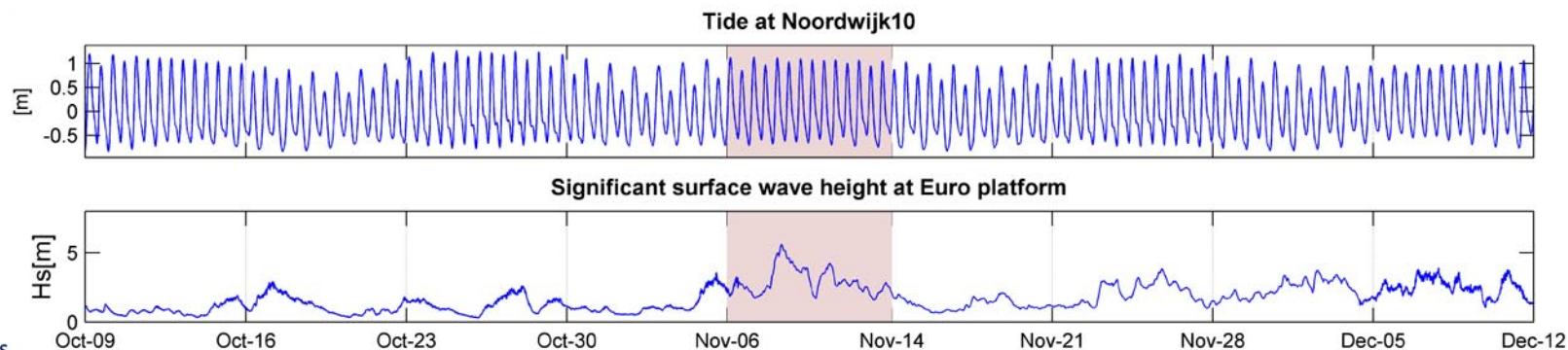
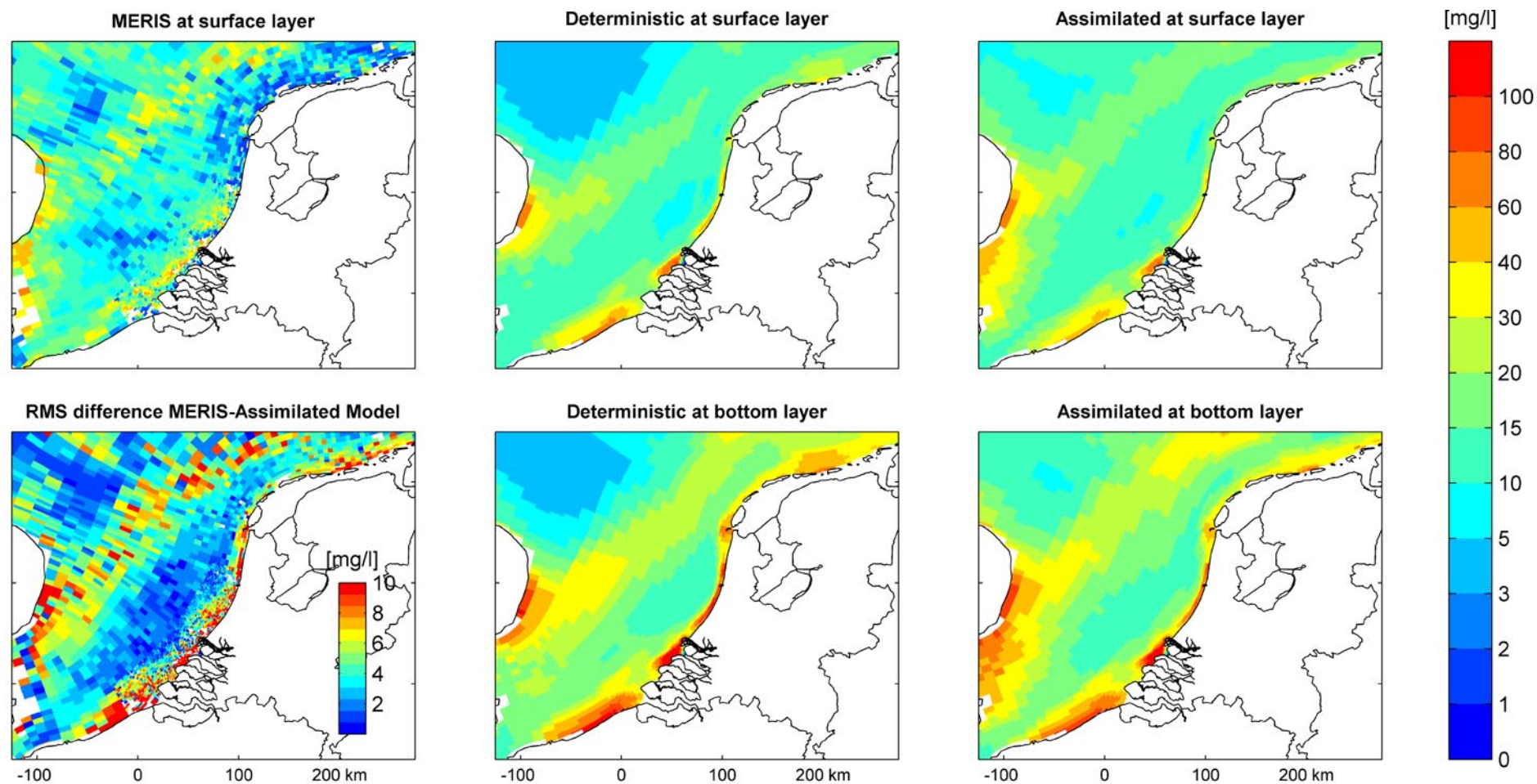


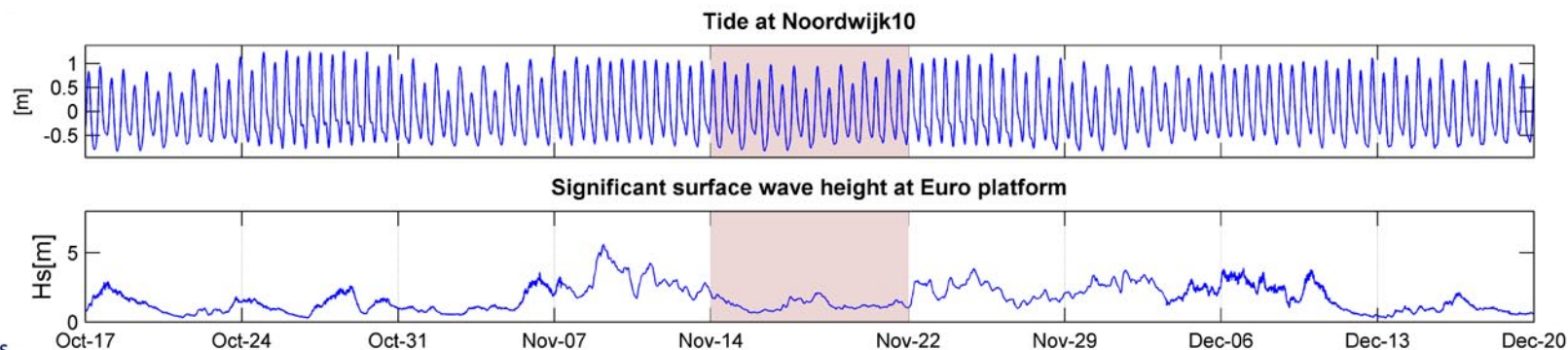
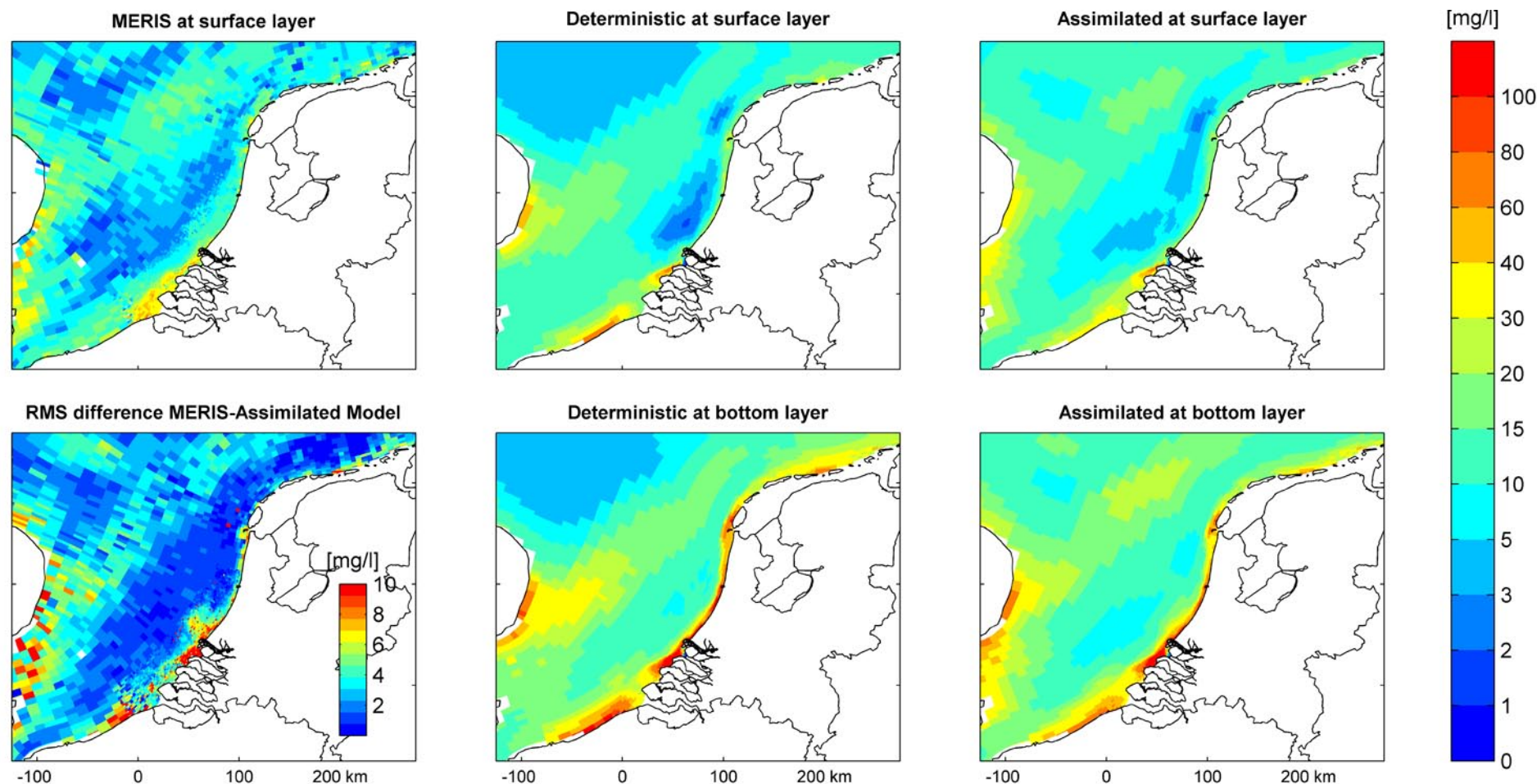


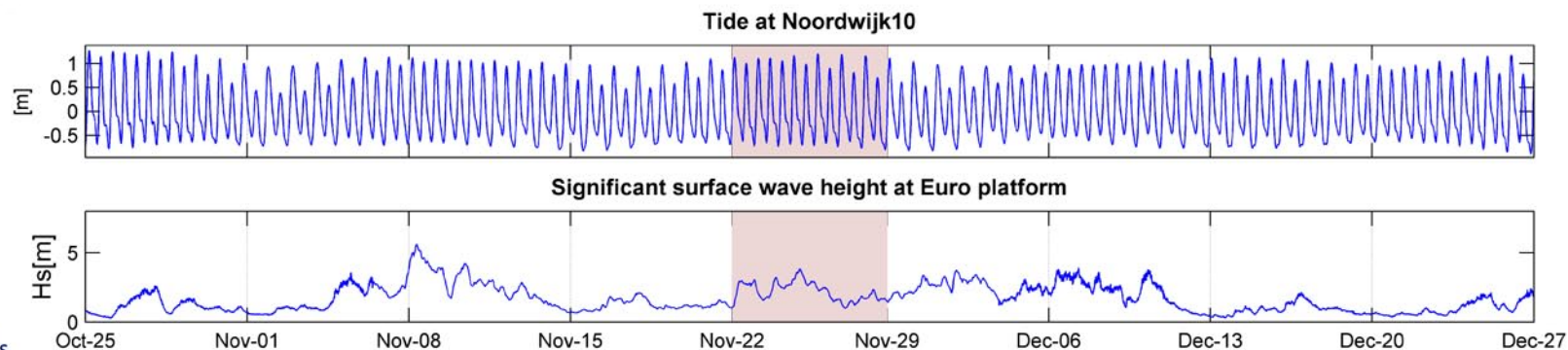
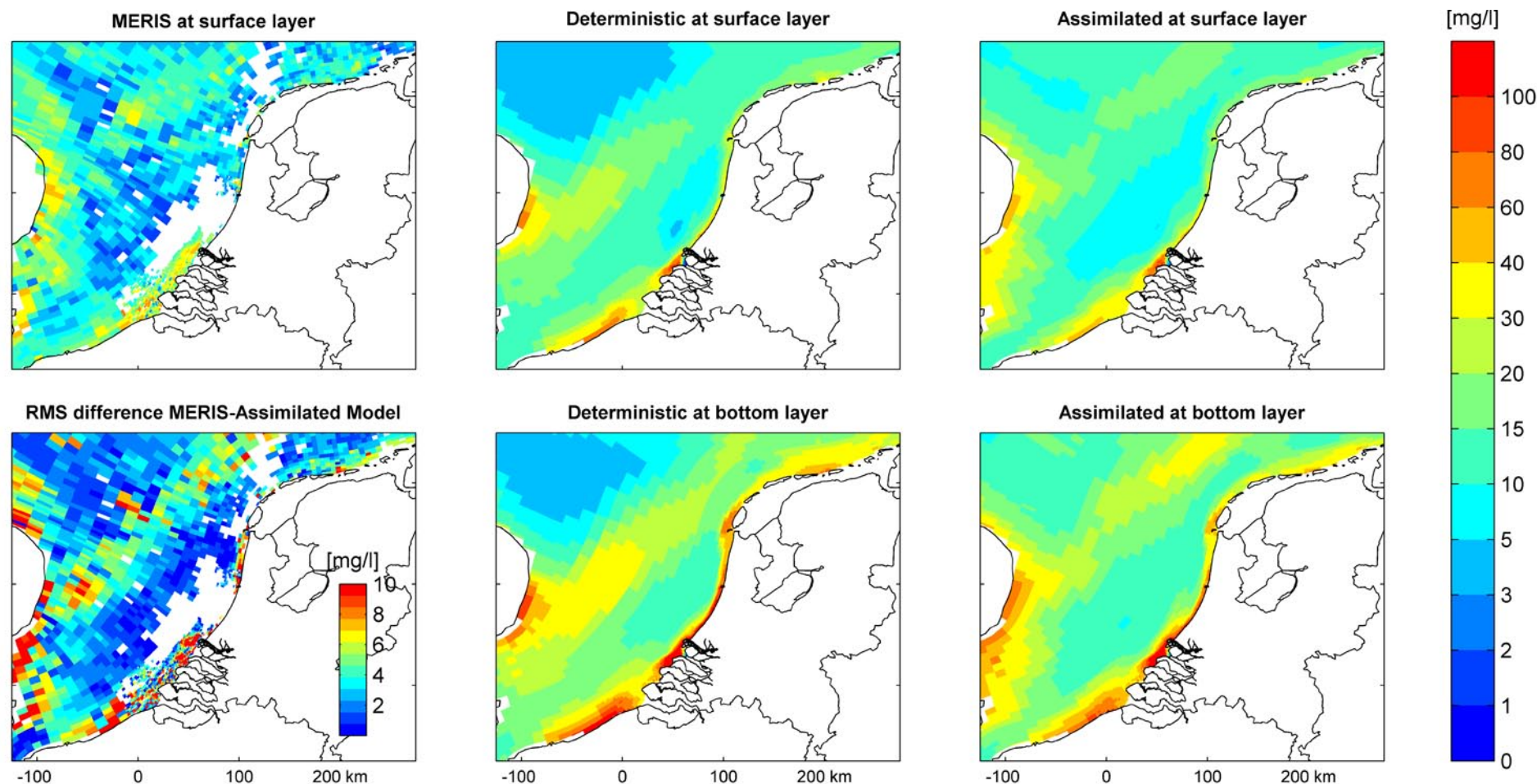


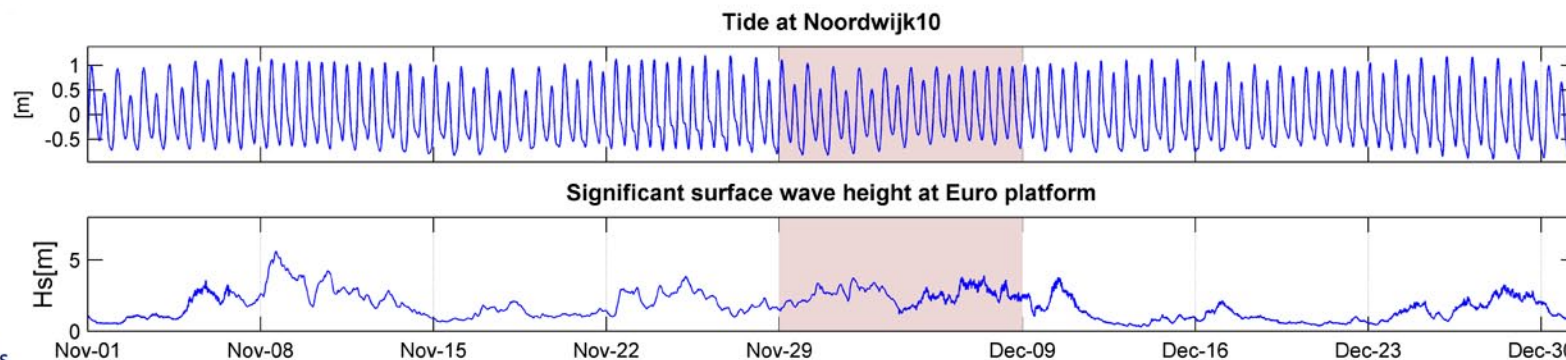
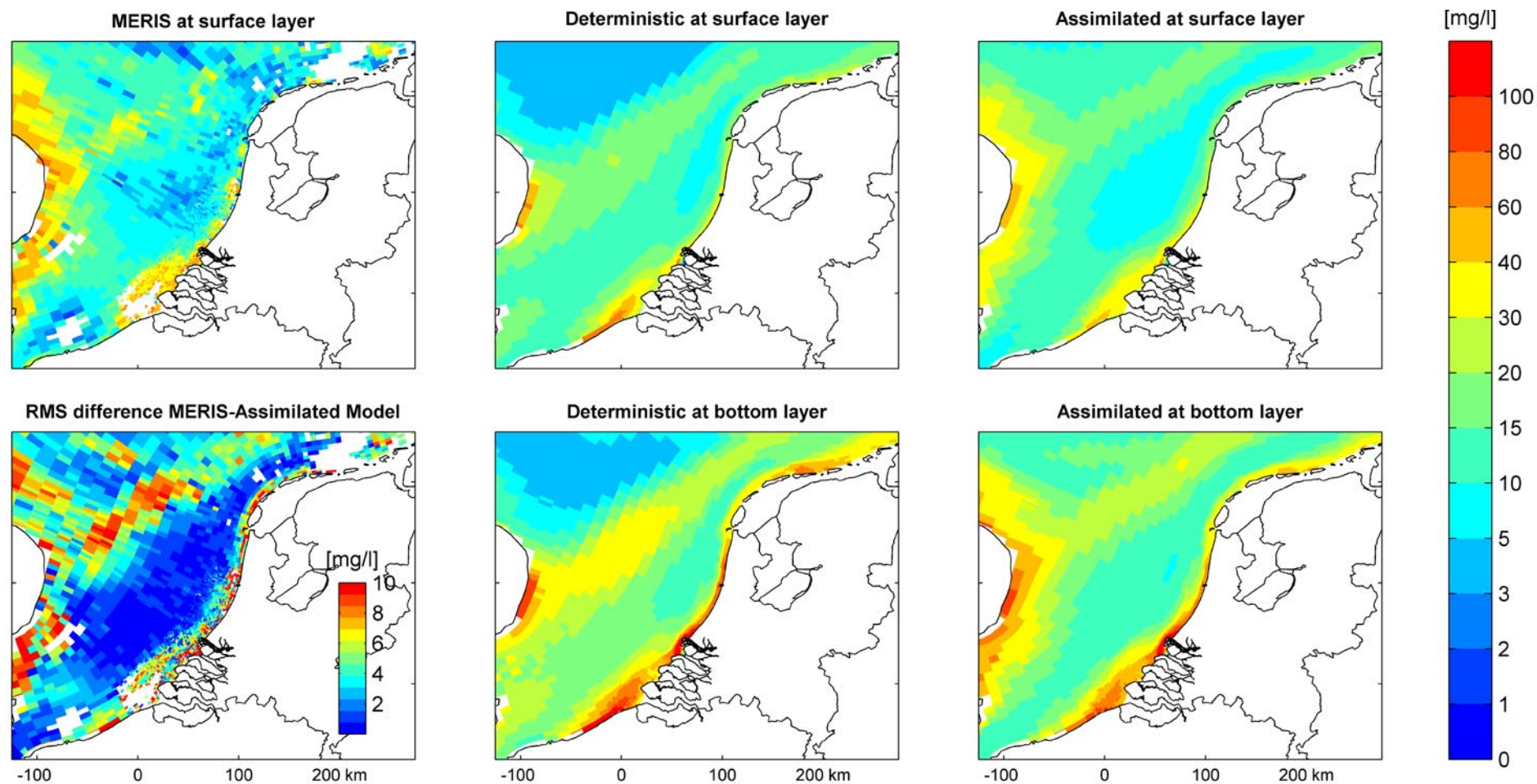


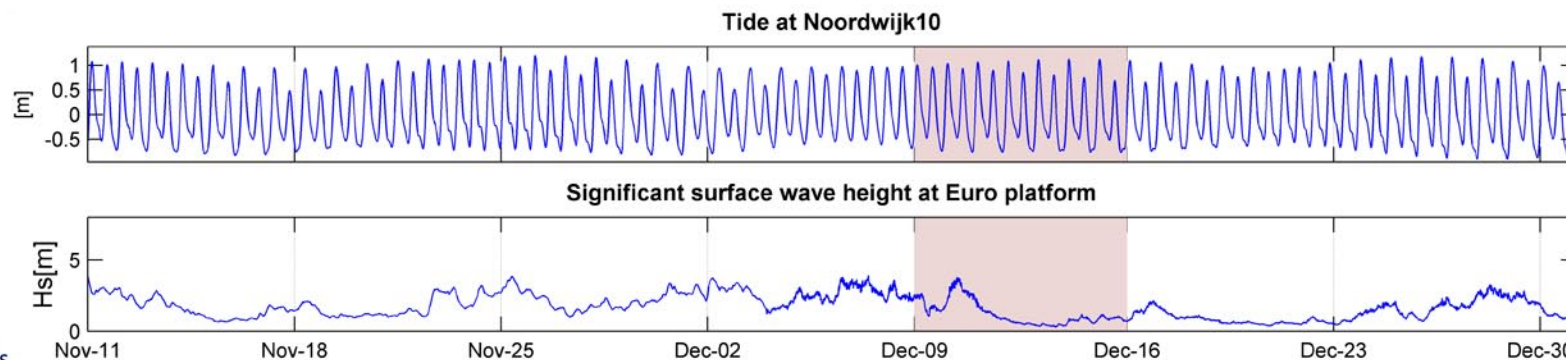
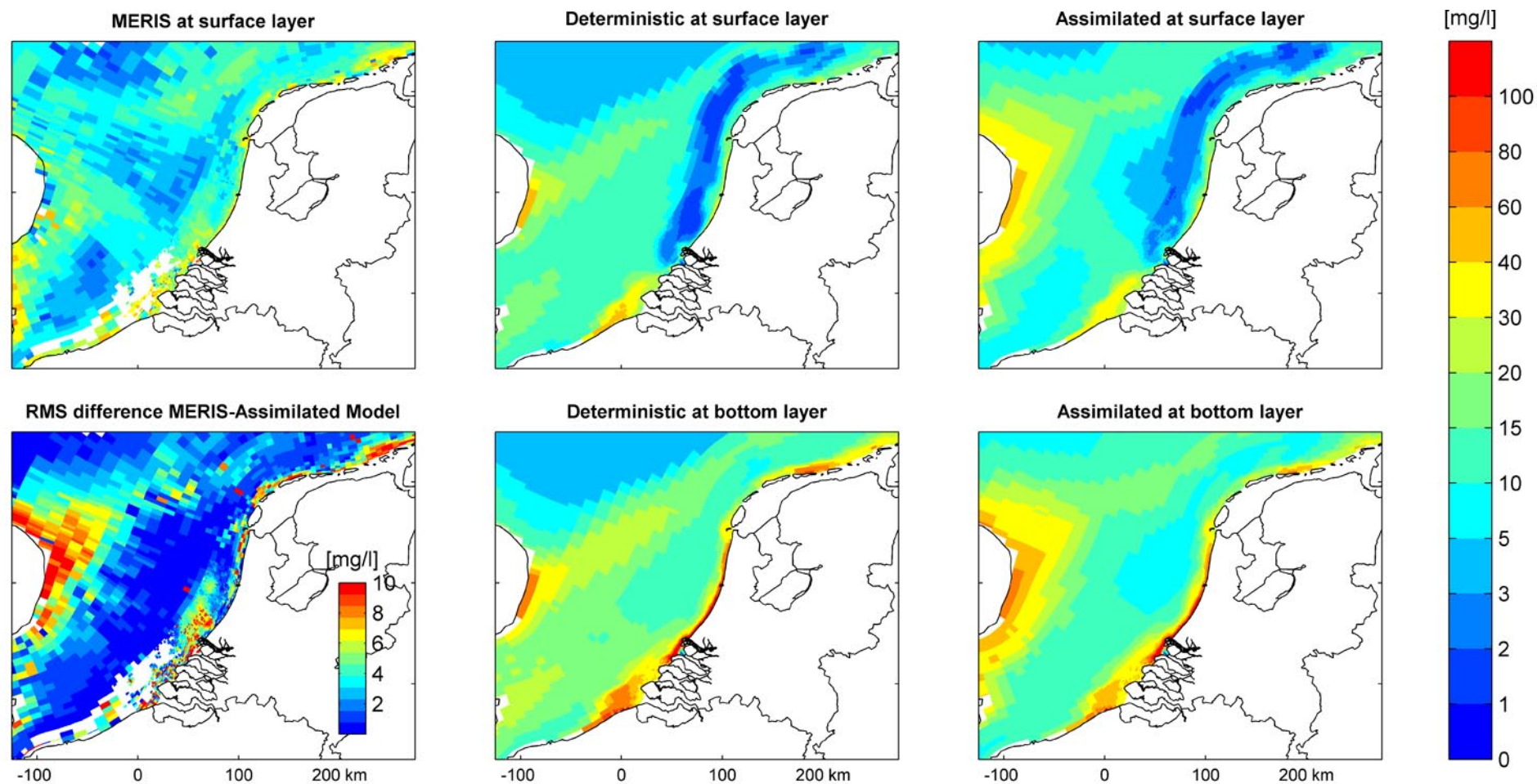


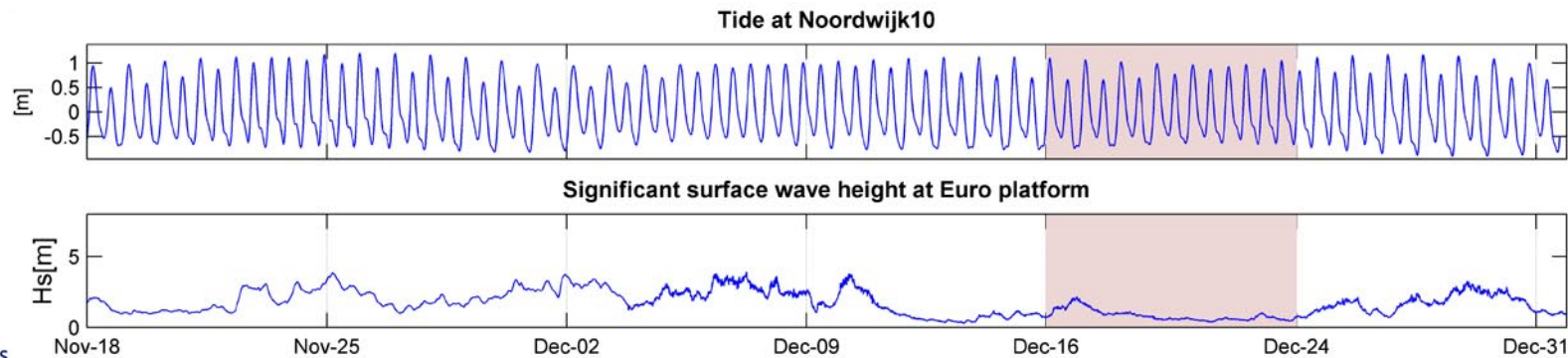
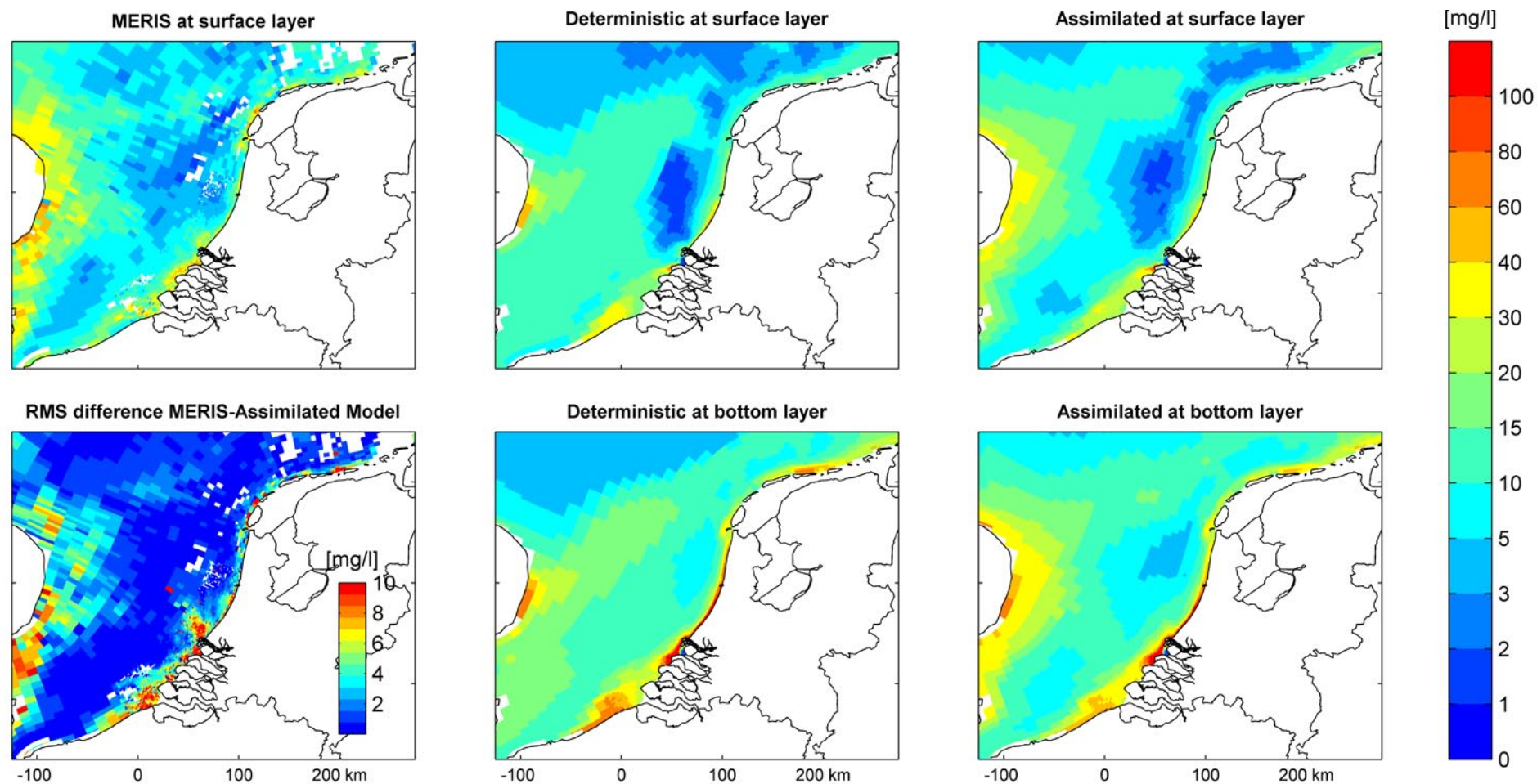


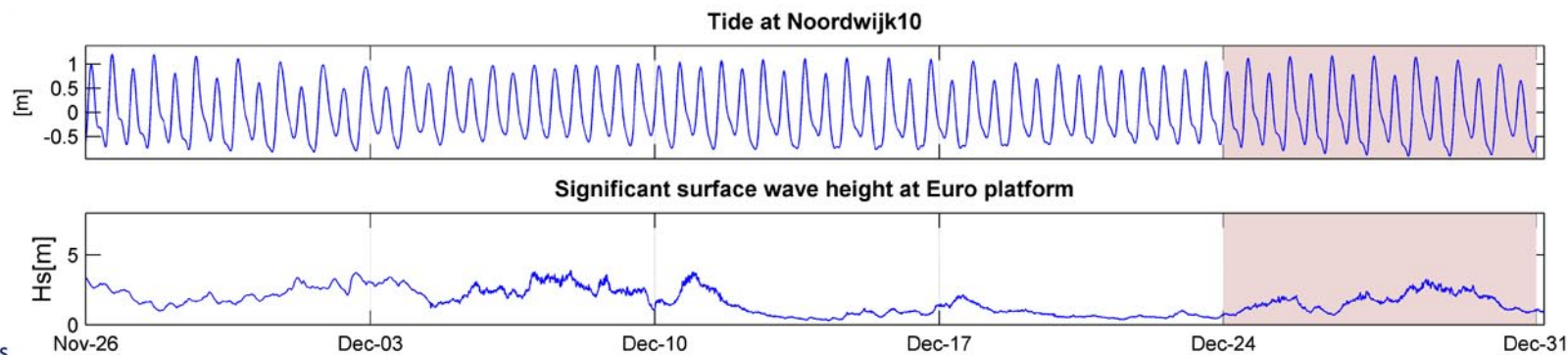
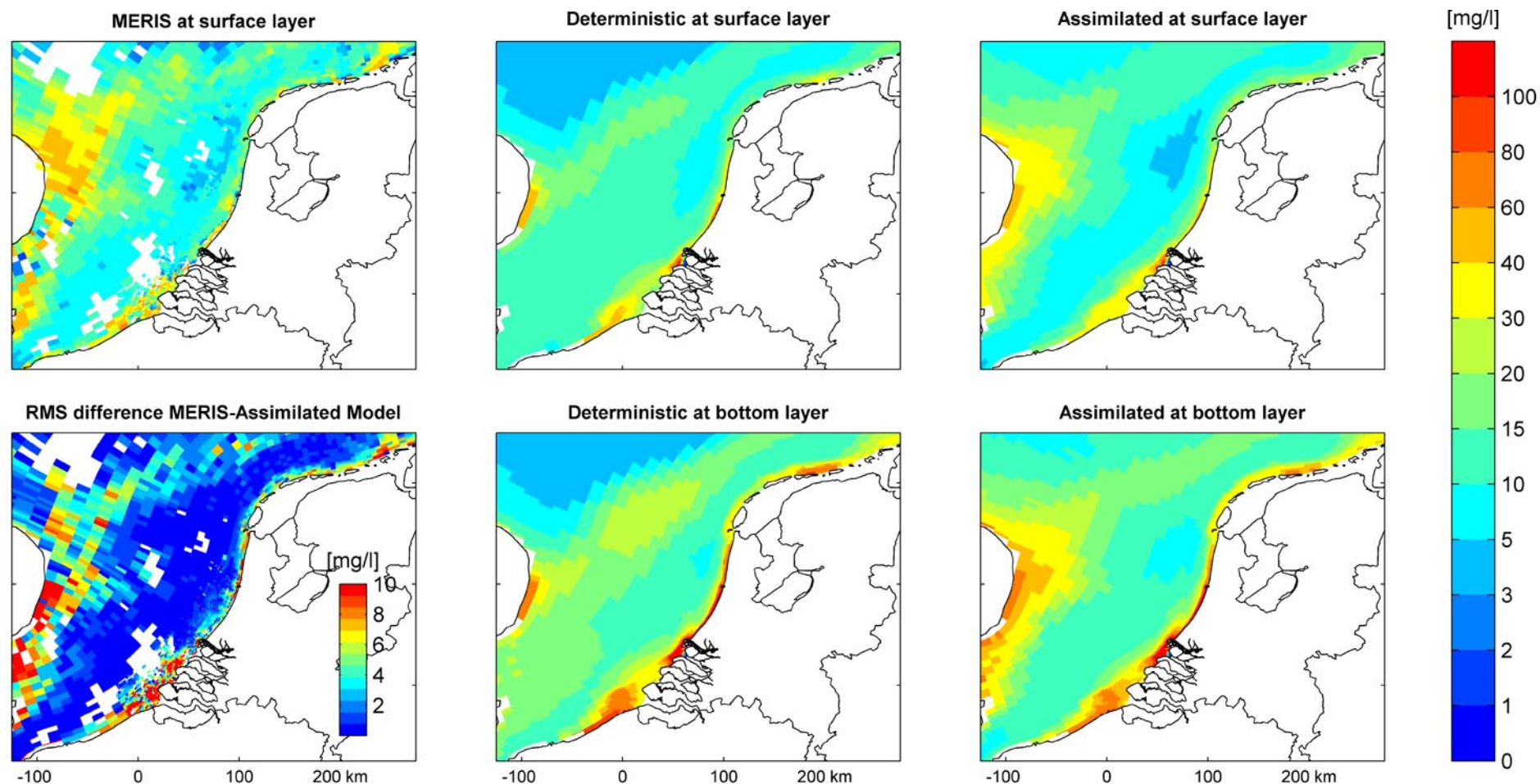












This document presents a composite atlas of suspended particular matter (SPM) in the southern North Sea for the year 2007. It summarizes part of the results of the MoS² project carried out for the Port of Rotterdam by VU-IVM and Deltares between 2009 and 2011. The results are based on MERIS Reduced Resolution imagery and Delf3D model computations. The MERIS data have been integrated into the model by means of Ensemble Kalman Filter data assimilation. All results are presented here on the resolution of the model grid. This atlas is to be read in conjunction with the technical reports from the MoS² project.

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