

# Model: KLIWAS Climatology of Sea Surface Temperature and Ocean Colour Fronts in the North Sea

Author fact-sheet: Holger Klein, Grit Kirches

| <b>1. General Information</b>   |  |
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| Model name  | KLIWAS Climatology of Sea Surface Temperature and Ocean Colour Fronts in the North Sea   |
| Version   | 1.0  |
| Author(s) / First publication   | <p>Kirches G., Paperin M., Klein H., Brockmann C. and Stelzer K. (2013). Detection and Analysis of Fronts in the North Sea. in Proceedings of the Sentinel-3 OLCI/SLSTR and MERIS/(A)ATSR Workshop - 15–19.10.2012 Frascati, Italy, SP-711, Jan. 2013, ISBN 978-92-9092-275-9</p> <p>Kirches G., Paperin M., Klein H., Brockmann C. and Stelzer K. (2013). Ozeanische Fronten aus Fernerkundungsdaten (Seite: 273-283) in Geoinformation für die Küstenzone Band 4: Beiträge des 4. Hamburger Symposiums zur Küstenzone und Beiträge des 9. Workshops zur Nutzung der Fernerkundung im Bereich der Bundesanstalt für Gewässerkunde/ Wasser- und Schifffahrtsverwaltung des Bundes, Sokrates &amp; Freunde GmbH; 1. Auflage (1. Juli 2013), ISBN-13: 978-3981423402, 312 Seiten</p> |
| Contact person (name, email)  | Holger Klein - holger.klein@bsh.de,<br>Grit Kirches - grit.kirches@brockmann-consult.de  |
| Institute   | Federal Maritime and Hydrographic Agency (BSH),<br>Brockmann Consult GmbH (BC)   |
| Web site  | -  |
| General modelling objectives  | Regional climatology of oceanic fronts   |
| Domain of applicability   | North Sea and adjacent parts of the North Atlantic   |
| KLIWAS contact (authority, name, email)                                 | BSH, Holger Klein, holger.klein@bsh.de   |
| Model adaption in KLIWAS  | -  |
| Model coupling in KLIWAS<br>In our case: input data for front detection | <p>Input data from remote sensing observations</p> <ul style="list-style-type: none"> <li>• Advanced Along-Track Scanning Radiometer (AATSR) on ENVISAT</li> <li>• Advanced Very High Resolution Radiometer (AVHRR) on NOAA or MetOp</li> <li>• Medium Resolution Imaging Spectrometer (MERIS) on ENVISAT</li> <li>• Moderate Resolution Imaging Spectroradiometer (MODIS) on AQUA</li> </ul>  |
| <b>2. Model description</b>   |  |
| Model type  | <p>Regional climatology of Sea Surface Temperature and Ocean Colour Fronts</p> <p>There is no numerical model applied, the climatology bases</p>   |

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|  | upon satellite based earth observation data!  |
| Temporal discretization                                      | -   |
| Temporal resolution  | multi-annual, multi-seasonal, and multi-monthly means   |
| Spatial discretization                                       | gridded   |
| Spatial resolution   | <p>Standard-Grid AATSR, MERIS and MODIS</p> <ul style="list-style-type: none"> <li>• horizontal: 1273 pixel;</li> <li>• vertical: 1337 pixel;</li> <li>• size: 1273 x 1337;</li> <li>• scale: 1 km/pixel;</li> <li>• projection: UTM Zone 31 WGS 1984</li> </ul> <p>Standard-Grid AVHRR</p> <ul style="list-style-type: none"> <li>• horizontal: 1100 pixel;</li> <li>• vertical: 1000 pixel;</li> <li>• size: 1100 x 1000;</li> <li>• scale: 1 km/pixel;</li> <li>• projection: Mercator</li> </ul>  |
| Dimension  | -   |
| Short description of model structure detailing main function | <p>This is the first version (1.0) of a climatology for Sea Surface Temperature and Ocean Colour Fronts for the region:</p> <ul style="list-style-type: none"> <li>• 47 to 63 °N, 16 °W to 15 °E (Standard-Grid AATSR, MERIS and MODIS)</li> <li>• 48 to 63 °N, 11 °W to 17 °E (Standard-Grid AVHRR)</li> </ul> <p>It contains the multi-annual, multi-seasonal, and multi-monthly means of the gradient magnitude and of the gradient vector (magnitude and direction) for a frontal zone as well as the number of observations, the number of observations of frontal zone over a defined time interval and the probability of a front observation.</p> <p>The development of an algorithm which automatically detects frontal positions and gradients from satellite data was driven by the need to establish a climatology for oceanographic fronts in the North.</p> <p>GRADHIST is a new algorithm for the detection and mapping of oceanic fronts, which is based on a combination and refinement of the gradient algorithm of Canny (1986) and the histogram algorithm of Cayula and Cornillon (1992). GRADHIST preserves the main principles of both algorithms, improves the quality of front detection and can be applied to various ocean parameters as well as to different sensors.</p> <p>GRADHIST has been validated using both synthetic and real data and applied to sea surface temperature and ocean colour parameters retrieved from satellite data.</p> <p>After the algorithm has been validated and tested the satellite data have been processed to compute the gradient magnitude and gradient direction. Based on these two parameters the temporal statistic has been derived which include the calculation of a set of statistical measures for SST and Ocean Colour front products.</p> |
| Scheme of model structure                                    | -   |

| <p>Procedure of model parameter estimation</p>     | <p>Measurement and automatic algorithm</p>  |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
|--|---|------------------|---------------|------------------|--------------------|--------------|-------------------------|-------|---------|-------------|---|-------------------------|-------|------|-------------|---|-------------------------|-------|--------------|------------|---|-------------|-------|---------|-------------|-------------------|------------------------|-------|---------|-------------|------------------|-----------------------------|-------|---------|-------------|-----|-----------|-------|---------|-------------|-----|
| <p><b>3. Model inputs / Model outputs</b></p>      |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| <p>List and characteristics of input variables</p> | <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><b>Parameter</b></th> </tr> <tr> <th style="text-align: center;"><b>Sensor</b></th> </tr> <tr> <th style="text-align: center;"><b>Satellite</b></th> </tr> <tr> <th style="text-align: center;"><b>Time Period</b></th> </tr> <tr> <th style="text-align: center;"><b>Units</b></th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Sea Surface Temperature</td> </tr> <tr> <td style="text-align: center;">AATSR</td> </tr> <tr> <td style="text-align: center;">ENVISAT</td> </tr> <tr> <td style="text-align: center;">2002 - 2011</td> </tr> <tr> <td style="text-align: center;">K</td> </tr> <tr> <td style="text-align: center;">Sea Surface Temperature</td> </tr> <tr> <td style="text-align: center;">MODIS</td> </tr> <tr> <td style="text-align: center;">AQUA</td> </tr> <tr> <td style="text-align: center;">2003 - 2011</td> </tr> <tr> <td style="text-align: center;">K</td> </tr> <tr> <td style="text-align: center;">Sea Surface Temperature</td> </tr> <tr> <td style="text-align: center;">AVHRR</td> </tr> <tr> <td style="text-align: center;">NOAA &amp; METOP</td> </tr> <tr> <td style="text-align: center;">1990 -2011</td> </tr> <tr> <td style="text-align: center;">K</td> </tr> <tr> <td style="text-align: center;">Chlorophyll</td> </tr> <tr> <td style="text-align: center;">MERIS</td> </tr> <tr> <td style="text-align: center;">ENVISAT</td> </tr> <tr> <td style="text-align: center;">2002 - 2010</td> </tr> <tr> <td style="text-align: center;">mg/m<sup>3</sup></td> </tr> <tr> <td style="text-align: center;">Total Suspended Matter</td> </tr> <tr> <td style="text-align: center;">MERIS</td> </tr> <tr> <td style="text-align: center;">ENVISAT</td> </tr> <tr> <td style="text-align: center;">2002 - 2010</td> </tr> <tr> <td style="text-align: center;">g/m<sup>3</sup></td> </tr> <tr> <td style="text-align: center;">Yellow Substance Absorption</td> </tr> <tr> <td style="text-align: center;">MERIS</td> </tr> <tr> <td style="text-align: center;">ENVISAT</td> </tr> <tr> <td style="text-align: center;">2002 - 2010</td> </tr> <tr> <td style="text-align: center;">1/m</td> </tr> <tr> <td style="text-align: center;">Turbidity</td> </tr> <tr> <td style="text-align: center;">MERIS</td> </tr> <tr> <td style="text-align: center;">ENVISAT</td> </tr> <tr> <td style="text-align: center;">2002 - 2010</td> </tr> <tr> <td style="text-align: center;">1/m</td> </tr> </tbody> </table> | <b>Parameter</b> | <b>Sensor</b> | <b>Satellite</b> | <b>Time Period</b> | <b>Units</b> | Sea Surface Temperature | AATSR | ENVISAT | 2002 - 2011 | K | Sea Surface Temperature | MODIS | AQUA | 2003 - 2011 | K | Sea Surface Temperature | AVHRR | NOAA & METOP | 1990 -2011 | K | Chlorophyll | MERIS | ENVISAT | 2002 - 2010 | mg/m <sup>3</sup> | Total Suspended Matter | MERIS | ENVISAT | 2002 - 2010 | g/m <sup>3</sup> | Yellow Substance Absorption | MERIS | ENVISAT | 2002 - 2010 | 1/m | Turbidity | MERIS | ENVISAT | 2002 - 2010 | 1/m |
| <b>Parameter</b>                                   |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| <b>Sensor</b>                                      |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| <b>Satellite</b>                                   |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| <b>Time Period</b>                                 |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| <b>Units</b>                                       |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Sea Surface Temperature                            |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| AATSR  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| ENVISAT  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 2002 - 2011  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| K  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Sea Surface Temperature                            |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| MODIS  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| AQUA   |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 2003 - 2011  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| K  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Sea Surface Temperature                            |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| AVHRR  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| NOAA & METOP                                       |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 1990 -2011   |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| K  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Chlorophyll  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| MERIS  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| ENVISAT  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 2002 - 2010  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| mg/m <sup>3</sup>                                  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Total Suspended Matter                             |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| MERIS  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| ENVISAT  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 2002 - 2010  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| g/m <sup>3</sup>                                   |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Yellow Substance Absorption                        |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| MERIS  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| ENVISAT  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 2002 - 2010  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 1/m  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| Turbidity  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| MERIS  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| ENVISAT  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 2002 - 2010  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |
| 1/m  |   |                  |               |                  |                    |              |                         |       |         |             |   |                         |       |      |             |   |                         |       |              |            |   |             |       |         |             |                   |                        |       |         |             |                  |                             |       |         |             |     |           |       |         |             |     |

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| <p>List and characteristics of output variables</p>      | <p><b>No.</b><br/><b>Value</b><br/><b>Description</b></p> <p>1<br/>LandWater<br/>Land water mask</p> <p>2<br/>depth_ETOPO1_ice<br/>Land topography and ocean bathymetry</p> <p>3<br/>parameter_count<br/>Number of observations</p> <p>4<br/>frontzone_count<br/>Number of observations of frontal zone over a defined time interval</p> <p>5<br/>frontzone_propability<br/>Probability of a front observation</p> <p>6<br/>frontzone_magnitude_total<br/>Mean gradient magnitude for frontal zone</p> <p>7<br/>frontzone_vector_magnitude<br/>Magnitude of mean gradient vector for frontal zone</p> <p>8<br/>frontzone_vector_direction<br/>Direction of gradient vector for frontal zone</p> |
| <p><b>4. Examples of model applications</b></p>          |   |
| <p>Catchments, objectives etc.</p>                       | <p>Reference data base for climatology of Sea Surface Temperature and Ocean Colour Fronts</p>   |
| <p>Results of existing comparisons with other models</p> | <p>-</p>  |
| <p>Application in the framework of KLIWAS</p>            | <p>Reference data base for climatology of Sea Surface Temperature and Ocean Colour Fronts</p>   |
| <p><b>5. List of 5 selected references</b></p>           |   |

- Belkin et al., 2009 I.M. Belkin, P.C. Cornillon and K. Sherman, Fronts in Large Marine Ecosystems, Progress in Oceanography, 81 (1-4)(2009), p.:223-236
- Miller, 2009 P.I. Miller, Composite front maps for improved visibility of dynamic sea-surface features on cloudy SeaWiFS and AVHRR data, Journal of Marine Systems 78(3) (2009), pp. 327–336
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- Cayula J.-F. and Cornillon P. (1992). Edge detection algorithm for SST images. Journal of Atmospheric and Oceanic Technology 9(1), 67–80