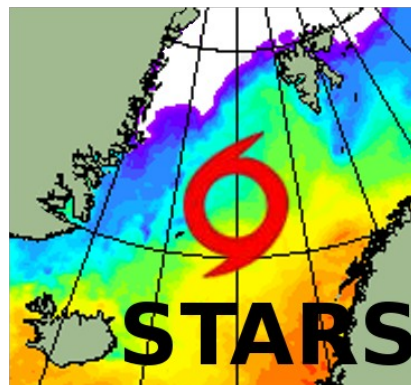# STARS-DAT v2

# User Manual

Version 2.1

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*Steinar Eastwood and Magnus Drivdal*
*Norwegian Meteorological Institute*

## Documentation Change Record

| Document version | Date | Description |
|---|---|---|
| v 0.1 | 25-05-2010 | First draft version 1 |
| v 1.0 | 18-09-2010 | Final version 1 delivered to ESA |
| v 2.0 | 18-01-2011 | Draft version 2 |
| v 2.1 | 24-03-2011 | Added ice concentration product |

# CONTENTS

# 1. Introduction

## 1.1 Purpose of this document

This document is the User Manual for the version 2 of the STARS (Combination of Sea Surface Temperature and AltimeteR Synergy) project data set (STARS-DAT v2) and the corresponding data base (STARS-DAT-DB). The purpose of this document is to provide the user with all necessary information to be able to explore and use the STARS-DAT and STARS-DAT-DB.

## 1.2 Background

The STARS project is an activity funded by the ESA Support To Science Element (STSE) that aims to reinforce the scientific component of the ESA Living Planet programme. The aim of this project is to investigate the use of satellite data (particularly, but not limited to, SST and altimeter data) together with in situ data and coupled ocean-atmosphere models to improve forecasting of polar lows in the Nordic Seas and, based on data assimilation and ocean/atmosphere modeling, investigate the impact of polar lows on the general ocean circulation of the Nordic Seas.

## 1.3 Structure of this documentation

● Chapter 1 is this chapter with the purpose and structure of the document.
● Chapter 2 describes the format and content of the STARS-DAT data set.
● Chapter 3 describes the format and content of the STARS-DAT meta data database, also called STARS-DAT-DB.
● Chapter 4 gives an identification of all the polar low events within the STARS-DAT data set.
● Chapter 5 describes all the different data sources included in the STARS-DAT data set.
● Chapter 6 gives an example of how to query and access the STARS-DAT data set using the STARS-DAT-DB for a particular polar low event.
● Chapter 7 gives recommendations for the future development of the STARS-DAT data set.
● Chapter 8 describes how the user can update the STARS-DAT data set by adding new data sources or extending the period covered.

## 1.4 Glossary

| | |
|---|---|
| AATSR | Advanced Along-Track Scanning Radiometer |
| AMSR-E | Advanced Microwave Scanning Radiometer – Earth Observation System |
| AVHRR | Advanced Very High Resolution Radiometer |
| AVISO | Archiving, Validation and Interpretation of Satellite Oceanographic data |
| ASCAT | Advanced Scatterometer |
| ASCII | American Standard Code for Information Interchange |
| CF | Climate and Forecast |
| DUACS | Data Unification and Altimeter Combination System |
| ECMWF | European Center for Medium Weather Forecast |
| EOS | Earth Observation System |

| | |
|---|---|
| ESA | European Space Agency |
| GAC | Global Area Coverage |
| GFO | Geosat Follow-On |
| GHRSST | Group for High Resolution Sea Surface Temperature |
| GTS | Global Telecommunication System |
| HIRLAM | High Resolution Limited Area Model |
| LAC | Local Area Coverage |
| LTSRF | Long Term Stewardship and Reanalysis Facility |
| LWE | Liquid Water Equivalent |
| METOP | Meteorological Operational Satellite |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| NASA | National Space Agency |
| NAVO | National Oceanographic Office |
| NetCDF | Network Common Data Form |
| NOAA | National Oceanic and Atmospheric Administration |
| NWP | Numerical Weather Prediction |
| OSI SAF | Ocean and Sea Ice Satellite Application Facility |
| PO.DAAC | NASA Physical Oceanography Distributed Active Archive Center |
| SAP | Science Application Plan |
| SSALTO | Segment Sol Multi mission Altimetry and Orbitography |
| STARS | Sea Surface Temperature and AltimeterR Synergy |
| RSS | Remote Sensing Systems |
| UTC | Universal Time Coordinate |
| WMO | World Meteorological Organization |

## *1.5  Reference Documents*

[RD-1]  Statement of Work, STSE – Sea Surface Temperature and Altimeter Synergy. ESA project EOP-SM/1900/CD-cd. Issue:1, Revision: 2. 23-02-2009.

[RD-2]  Sætra, Ø (2010): Scientific and technical review of polar lows in the Nordic Seas. STARS REP-1 report.

[RD-3] Sætra, Ø et al. (2010): STARS Scientific Analysis Plan. STARS SAP report.

[RD-4] Donlon, C et al (2005): GHRSST-PP Product User Guide v1.1.

[RD-5] Dibarboure et al. (2010): SSALTO/DUACS User Handbook : (M)SLA and (M)ADT Near-Real Time and Delayed Time Products v2.1.

[RD-6] OSI SAF Wind team (2010): ASCAT Wind Product User Manual, v1.8.

[RD-7] OSI SAF Wind team (2009): SeaWinds Product User Manual, v1.6.

[RD-8] WMO (1995): Manual on codes. International codes. Volume I.1, Part-A. WMO-No.306.

[RD-9] Sætra, Ø and M. Drivdal (2011): Polar Low Indicator Algorithm Theoretical Baseline Document.

[RD-10] Eastwood, S. et al. (2009): Sea Ice Product Manual, v.3.6. Available at http://osisaf.met.no/docs.

[RD-11] Sætra, Ø et al. (2011): Polar Low Indicator (PLI) development, implementation and validation report. STARS deliverable document D-9, REP-3.

# 2. STARS-DAT Data Model

This chapter describes the format, organization and content of the STARS-DAT v2 data set.

## 2.1 Format

The STARS-DAT data set is given in NetCDF format, version 3.6 (except the in situ data and AVHRR imagery files). The CF-1.0 standard is used for the meta data. All data (expect in situ) has been gridded to one common grid and projection, that is a 2km grid in polar stereographic projection on a spherical earth. In Proj4 terminology, this projection is defined as:

```
+proj=stere +lat_0=90 +lon_0=0 +lat_ts=60 +elips=sphere +a=6371000 +e=0 (1)
```

The area covered by this grid is shown in Figure 1.
The in situ data are given in ASCII format and the AVHRR imagery files are given in TIFF format. These data has not been gridded to the common grid.
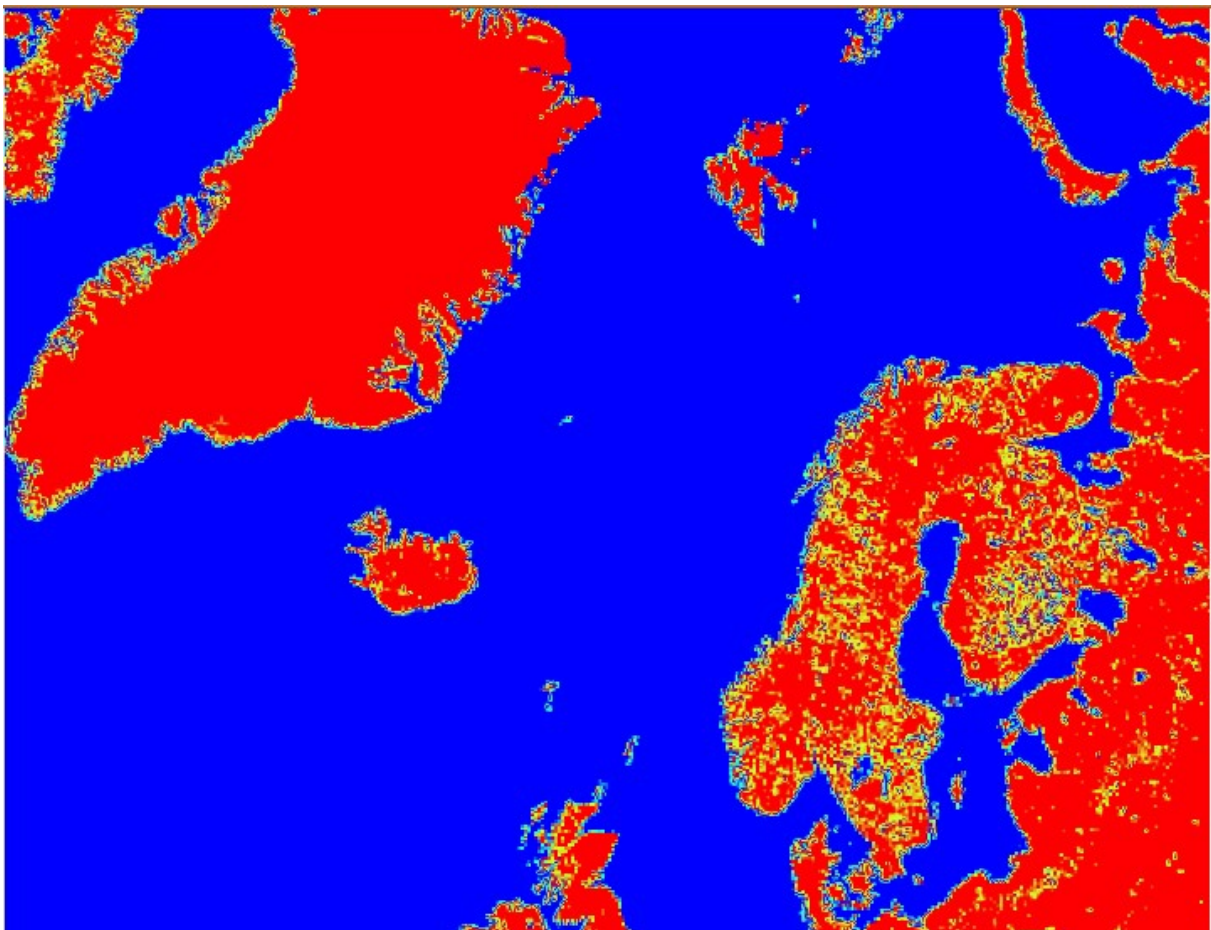


*Figure 1: The area covered by the STARS-DAT data set.*

The version of STARS-DAT that is distributed to users have been compressed using gzip version 1.3.12.

## *2.2 Organization*

The STARS-DAT data set contains data from the winter months during 5 years from 2006-2010. The data are organized in year and year day directories, so that each year in the data set is in one directory, with one directory for each year day within that year. The range of year days for each year is 1-120 and 274-366, so covering the months of January-April and October to December. This directory structure is illustrated in Figure 2. For 2010 only January-April is present. Each of these year day directory contains all the data set for this day (defined by UTC), defining daily sub data sets. In total, the data set contains about 137.000 files.

At top level of the data set is also given a file list which contains a list of all files in the STARS-DAT data set. This file is named "`STARS-DAT_filelist.txt`" and the content of this file is described in the header of the file.
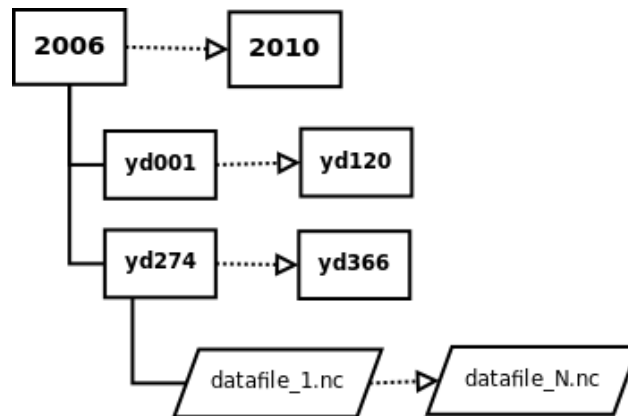


*Figure 2: Directory structure of STARS-DAT data set.*

## *2.3 Content*

Each of the daily sub data sets contains satellite, NWP and in situ data covering the following parameters:

- Satellite
  - SST
  - SLA
  - surface wind
  - sea ice concentration
  - imagery
- NWP
  - air potential temperature at different pressure levels
- In situ
  - SST
  - surface wind
  - ++

The sources for the different data sources are listed in Table 1.

In addition the STARS-DAT contains the estimated Polar Low Indicator (PLI) fields in separate files. These PLI fields are derived using a combination of the satellite SST fields and NWP fields.

| Parameter | Data source | Data provider |
|---|---|---|
| Satellite SST | Aqua EOS AMSR-E SST | RSS/GHRSST |
| | METOP AVHRR SST | OSI SAF |
| | AATSR SST | ESA/GHRSST |
| | Aqua/Terra EOS MODIS SST | NASA/GHRSST |
| | NOAA-17/18 AVHRR LAC/GAC SST | NAVO/GHRSST |
| Satellite SLA | Envisat along-track SLA | AVISO |
| | GFO along-track SLA | AVISO |
| Satellite Wind | METOP ASCAT wind vector | OSI SAF |
| | QuikSCAT Seawinds wind vector | OSI SAF |
| | Aqua EOS AMSR-E wind speed | RSS/GHRSST |
| Satellite Sea Ice | DMSP SSM/I | EUMETSAT OSI SAF |
| Satellite radiometer imagery | NOAA AVHRR VIS/IR images | met.no |
| In situ data | GTS synop, buoy and ship | met.no |
| NWP model layer temperature | HIRLAM | met.no |

*Table 1: Sources of data for the STARS-DAT data set.*

# 3.   STARS-DAT meta data database

This chapter describes the format, organization and content of the STARS-DAT meta data database, also called STARS-DAT-DB. The intention of STARS-DAT-DB is to ease the exploration of STARS-DAT and easily get an overview of the polar low events and essential geospatial metadata for these events. For the STARS project this data base has been built by selecting a set of key variables in STARS-DAT and present them as an image data base with one set of images for each polar low event within the data set. This image data base is available through an on-line PHP interface at this address:

http://projects.met.no/stars/view_stars-dat.php

The set of key variables are listed in Table 2 and examples images of all these key variables are shown in Chapter 6.

| Key variable short name | Key variable description |
|---|---|
| Polar Low Track | Track of polar low event from observed start to end. |
| Polar Low Image | AVHRR IR image of polar low event at one selected time. |
| SLA Track | Tracks of all available SLA data within polar low event period. |
| SST 2 days before | Daily AMSR-E SST mean 2 days before polar low event start. |
| SST 1 day before | Daily AMSR-E SST mean 1 day before polar low event start. |
| SST 1 day after | Daily AMSR-E SST mean 1 day after polar low event end. |
| SST 2 days after | Daily AMSR-E SST mean 2 days after polar low event end. |
| SST difference | Change in daily mean AMSR-E SST between SST fields one day before event start and one day after polar low event end. |
| SST along PL track | Plot of AMSR-E SST along polar low track, one day before and one day after. |
| SST-SLA synergy | Plot of AMSR-E SST and SLA along SLA track, one day before and one day after, for selected SLA tracks. |
| SST-SLA correlation | Correlation between matching daily mean AMSR-E SST and SLA observations, one day before and one day after. |
| Atm Heat Potential | Atmospheric Heat Potential (SST-T500hPa) at start of polar low event. This potential is used as polar low indicator. |

*Table 2: List of STARS-DAT-DB key variables with description.*

# 4. Polar low events

This chapter gives an identification of all the polar low events within the STARS-DAT data set. This chapter will be completed in version 2 of this User Manual.

## 4.1 Tracks of polar low events

The STARS-DAT AVHRR image data set has been used to track polar low events in the North Atlantic for the period covered by the STARS-DAT data set, 2006.01-2010.04. The method used for tracking polar low events is described in the Science Analysis Plan (SAP) [RD-3]. The polar lows that were tracked, have been split in two subsets (as described in the SAP). The first subset contains polar lows in the Norwegian Sea and Barents Sea. The second subset contains polar lows in the area between South-Greenland and United Kingdom. Plots of the tracks for each of these two subsets are shown in Figure 1 and Figure 2. A more detailed list identifying each polar low is in Appendix A.
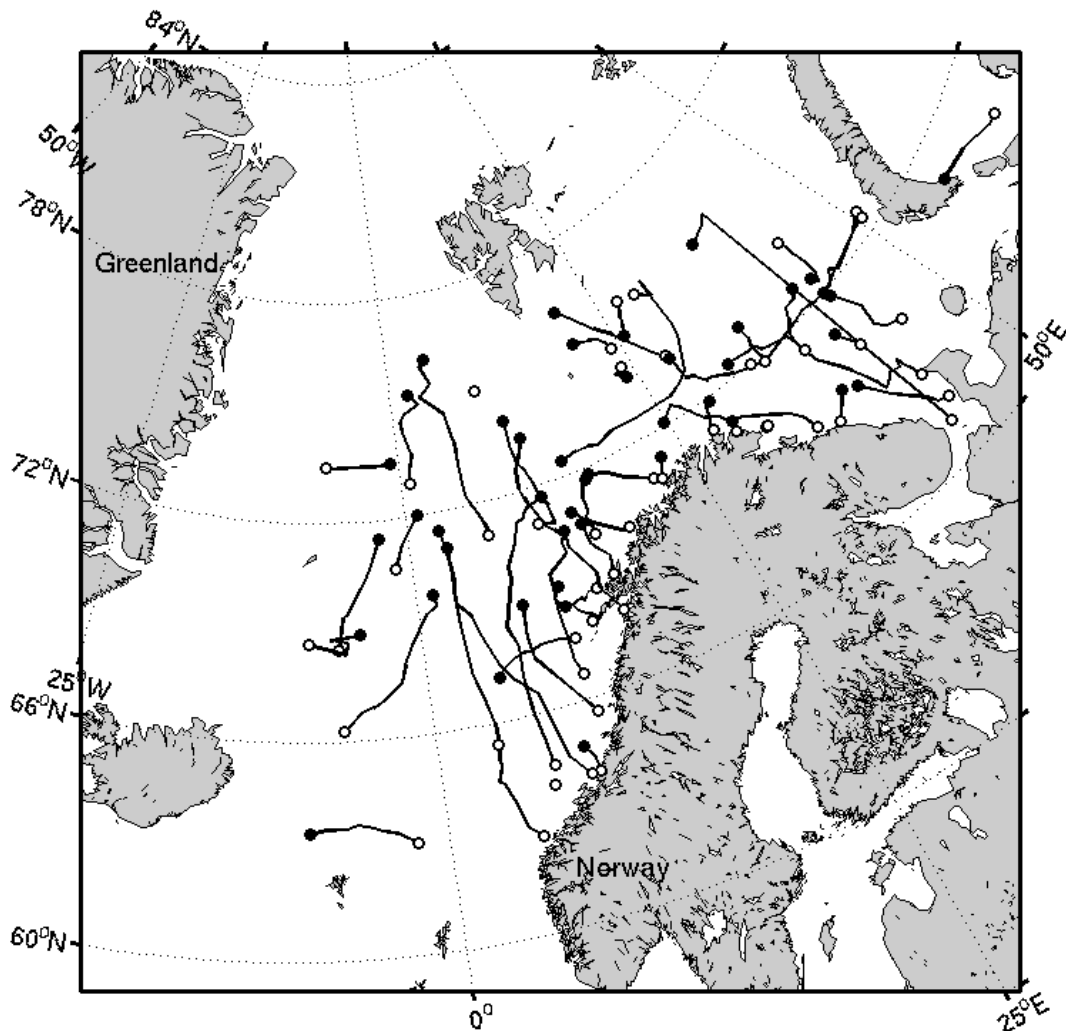


*Figure 3: Tracks of polar low events in the period 2006.01-2010.04 in the Norwegian Sea and Barents Sea. Filled circle indicates first observation and open circle indicates last observation of polar low.*
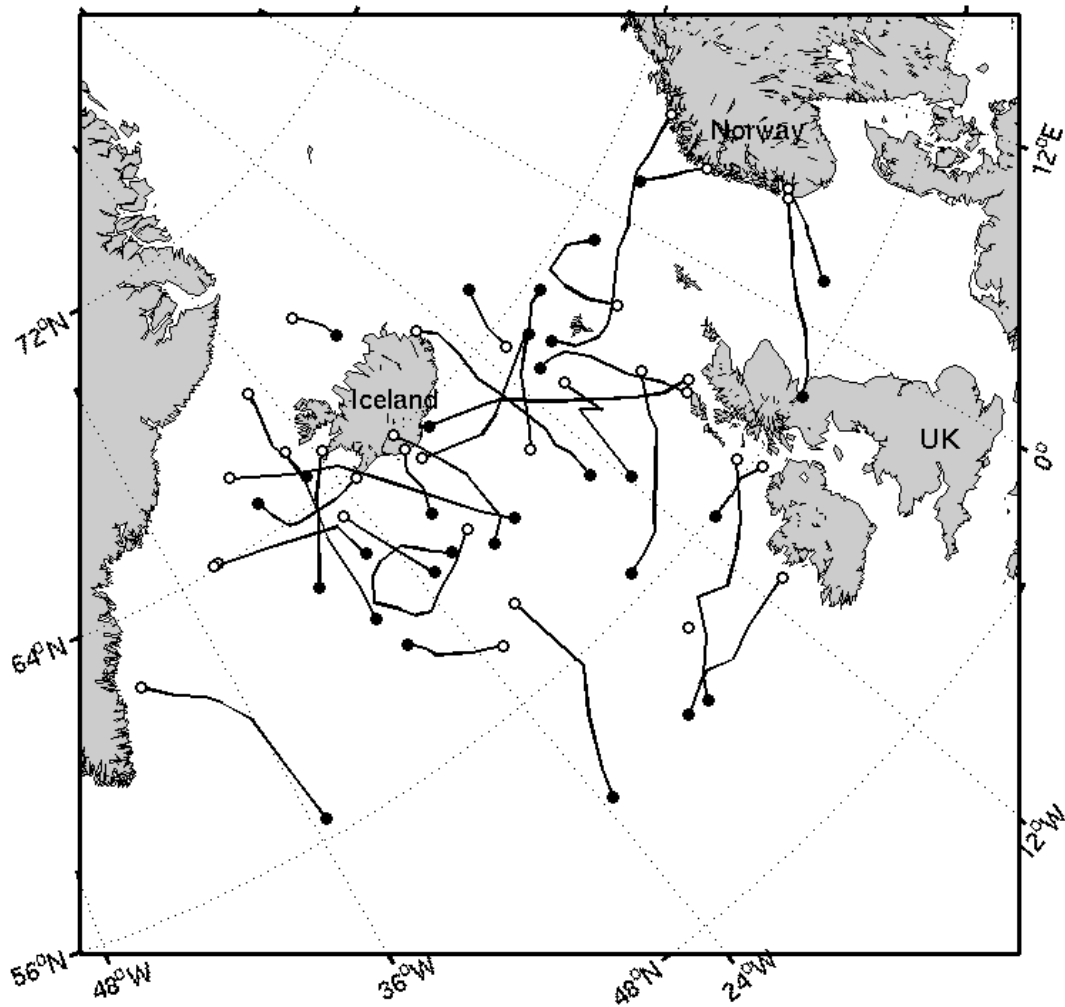
*Figure 4: Tracks of polar low events in the period 2006.01-2010.04 in the area between South-Greenland and United Kingdom. Filled circle indicates first observation and open circle indicates last observation of polar low.*

# 5.  Data set description

This chapter describes all the different data sources included in STARS-DAT. Most of the needed details of the data file parameters and contents are available within the NetCDF files, and by using the program ncdump these details can be listed. This chapter therefore gives a more overall description of the data set.

## 5.1  Satellite SST data

All the satellite SST data have been collected from the GHRSST LTSRF archive at http://ghrsst.nodc.noaa.gov. All these files are provided in the same NetCDF format and structure, thanks to the efforts of GHRSST. The original format of the files are described in the GHRSST product user guide [RD-4]. The fields in the original SST files have been regridded to the STARS-DAT grid described in Chapter 2. Most of the parameters in the original files have been kept on the regridded files, such as:

- sea surface temperature
- SSES bias
- proximity confidence level

The regridding implies that the resolution of some of the products has been degraded with respect to the original resolution. This is the case for the METOP AVHRR, NOAA AVHRR LAC, AATSR and MODIS products. The other products have been oversampled and are presented in a higher resolution with respect to the original resolution. This is the case for the AMSR-E and NOAA AVHRR GAC SST products.

The original file name convention for each data type has been kept, as described in Table 4. More details on the content of the GHRSST SST data set are given in the GHRSST product user guide [RD-4], and more details are therefore not given here.

## 5.2  Satellite SLA data

The satellite SLA data have all been collected from the AVISO SSALTO/DUACS archive at AVISO (http://www.aviso.oceanobs.com), in NetCDF format. AVISO provides along-track and gridded SLA data from all available altimeter missions, in real-time, near real-time and delayed time mode. In STARS-DAT the along-track data from Envisat and GFO have been used. The delayed time mode data have been used for the period 2006-01-01 to 2009-10-28. For the period 2009-10-29 the near real-time data have been used. This is because the delayed time data were not available for the last period when STARS-DAT was built. The files that have been collected are validated, filtered, sub-sampled and LWE-corrected (see [RD-5] chapter 5.3.1), which is indicated by "vfec" in the file names.

The along-track data have been re-gridded to the 2km STARS-DAT grid. Each SLA observation has been placed in the nearest neighbor grid cell, and no filling has been applied. The following parameters are provided in the re-gridded SLA files:

- SLA
- reference time (for each file)
- dtime, time difference between reference time and observation time, in seconds (for each observation)
- latitude and longitude
- grid x and y-coordinates
- land mask

The file name convention for the SLA files is described in Table 4. This file name convention is very similar to the original file names. There is one SLA file for each day, with all SLA

observation within that day, one for GFO and one for Envisat. The original SLA along-track files which contain observations from 7-days periods, have been split in daily files. More details on the SLA parameter are given in the AVISO user handbook [RD-5], and more details are therefore not given here.

An example of coverage of SLA data in the vicinity of a polar low track is shown in Figure 5.
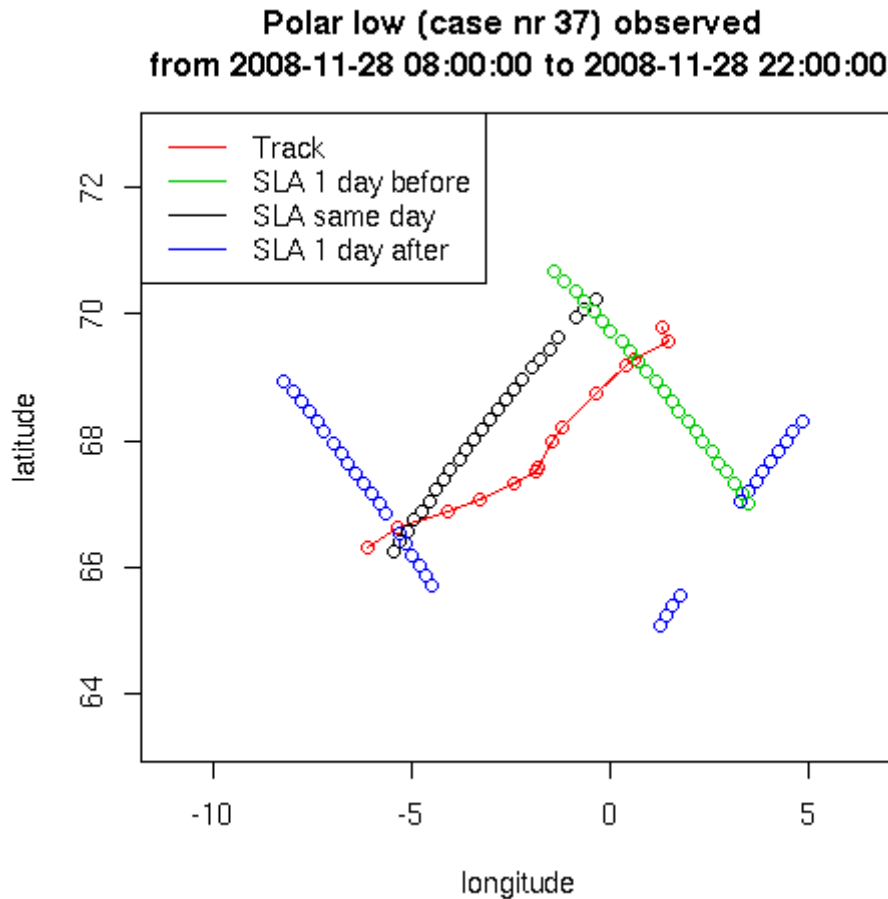


*Figure 5: Coverage of SLA data in the vicinity of a polar low event. All SLA data from Envisat +/- 1 day from the duration of the polar low event is shown.*

## 5.3 Satellite Wind data

Three sets of satellite derived wind products are included in STARS-DAT:
- ASCAT scatterometer wind speed and direction from OSI SAF.
- Seawinds scatterometer wind speed and direction from OSI SAF.
- AMSR-E passive microwave wind speed from RSS.

The original OSI SAF ASCAT and Seawinds swath NetCDF files have all been regridded to the STARS-DAT grid, implying a oversampling from the original 25km field-of-view. The original filename convention have been kept and is listed in Table 4. The main parameters in the ASCAT and Seawinds files are wind speed and wind direction. All the other parameters from the original files have been regridded. More details about the content on the ASCAT and Seawinds files are given in the OSI SAF Product Manuals [RD-6] and [RD-7].

The AMSR-E passive microwave derived wind speed data are provided in the AMSR-E SST files as an auxiliary parameter. This parameter has been regridded as part of the SST regridding procedures. These AMSR-E wind speed data are also provided on swath format, and the regridding implies that the data are oversampled. The file name convention for these files are listed in Table 4.

## 5.4 Satellite Sea Ice

Satellite sea ice concentration from the EUMETSAT OSI SAF are included in STARS-DAT. The OSI SAF provides daily sea ice concentration products on a 10km grid (sensor resolution around 25km). These daily sea ice concentration fields have been regridded to the STARS-DAT grid. Only the sea ice concentration field from the OSI SAF product is included in the sea ice files. More details about the sea ice concentration product are given in the OSI SAF Sea Ice Product Manual [RD-10].

## 5.5 Satellite radiometer imagery

The NOAA AVHRR satellite radiometer imagery data files in STARS-DAT are from the local receiving station at met.no. These files are only used for tracking polar low events. There is one file for each satellite passage, and the files are multi-layered TIFF files, one layer for each channel. The AVHRR data have two fixed visible channels (0.6 and 0.9 um) and two fixed infrared channels (10.5 and 11.5um). There is one "flexible" channel that depends from the different missions. This channel is either 1.6um or 3.7um, and for some satellites there is a switch between the two channels so that 1.6um is used at daytime and 3.7um at nighttime.

The file name convention for these files are listed in Table 4.

## 5.6 In situ data

The available in situ synops, drifting and moored buoys and ships observation received at met.no through GTS have been collected from the met.no archive. These files are stored on a local met.no format, and have been converted to ASCII format. The synoptical land stations, ship observation and moored buoy observations are kept in the files called "syno", while the drifting buoy observations are kept in  the files called "drau" (see Table 4). The syno files are hourly files, while the drau files are 3 hourly files.

In Table 3 are listed the parameters given in the in situ data files, organized in columns separated by blanks. More details about the observed parameters are given in WMO documentation [RD-8] or at http://wxp.unisys.com/Appendices/Formats/SYNOP.html .

| Column | Description | Fillvalue |
|--------|-------------|-----------|
| 1 | Station ID, WMO code | Always present |
| 2 | Station type, not used | NA |
| 3 | Latitude in decimal degrees | Always present |
| 4 | Longitude in decimal degrees | Always present |
| 5 | Year | Always present |
| 6 | Month | Always present |
| 7 | Day | Always present |
| 8 | Hour | Always present |
| 9 | Minute | Always present |
| 10 | Air temperature (TTT) | -99.99 |

| 11 | Dew point temperature (TdTdTd) | -99.99 |
|----|--------------------------------|--------|
| 12 | Sea surface temperature (TwTwTw) | -99.99 |
| 13 | Air pressure (PPPP) | -999.9 |
| 14 | Wind speed (ff) | -9 |
| 15 | Wind direction (dd) | -99 |
| 16 | Precipitation (RRR) | -99.9 |
| 17 | State of surface (E) | -9 |
| 18 | Snow depth (sss) | -99 |
| 19 | Cloud cover of all clouds (N) | -9 |
| 20 | Cloud cover of high clouds (Nd) | -9 |
| 21 | Cloud type low layer clouds (Cl) | -9 |
| 22 | Cloud type medium layer clouds (Cm) | -9 |
| 23 | Cloud type high layer clouds (Ch) | -9 |
| 24 | Visibility (VV) | -99 |
| 25 | Weather at observation time (ww) | -99 |
| 26 | Weather since last observation time (W1) | -9 |
| 27 | Weather since last observation time (W2) | -9 |

*Table 3: Content of in situ data files. WMO codes for the observed parameters are given in parentheses.*

## 5.7   NWP data

The NWP model chosen for STAR-DAT is HIRLAM, the operational forecast model run at met.no. More detail about this model is available from http://www.hirlam.org. This model has been run in 20km horizontal resolution until March 2008 and 12km since then. The HIRLAM files have all bin regridded to the 2km STARS-DAT grid. For the regridding of the HIRLAM files the Fimex software has been used, using nearest neighbor interpolation (more details on Fimex is available at https://wiki.met.no/fimex/start), and the resulting files are produced in NetCDF format.

From the HIRLAM forecast products only the air potential temperature in pressure levels and the surface pressure has been collected for STARS-DAT. The air potential temperature are given for pressure levels at 1000, 925, 850, 700 and 500 hPa. The temperature is given for every third hour; at 00, 03, 06, 09, 12, 15, 18, 21 and 24 UTC. There are two files for each day, one with 00-12UTC from the forecast run at 00UTC and one with 12-24UTC from the forecast run at 12UTC. The file name convention for these two files are given in Table 4.

## 5.8   Polar Low Indicator fields

The Polar Low Indicator fields are derived using daily mean AMSR-E SST fields and NWP model layer air temperature at 500hPa, as described in the PLI ATBD [RD-9]. Fields derived using daily mean AMSR-E SST fields and NWP model layer air temperature at 700hPa were also added later, as described in STARS Rep-3 [RD-11]. The estimated PLI fields are provided in separate daily files, and the file name convention for these files are given in Table 4.

## 5.9 File name conventions

In Table 4 is given the file name convention for all the data types in STARS-DAT. In the compressed version of STARS-DAT all files have an additional suffix ".gz".

| Data source | File name convention |
|---|---|
| Aqua EOS AMSR-E SST | &lt;YYYYMMDD&gt;-AMSRE-REMSS-L2P-amsr_l2b_v05_rXXXXX.dat-v01.nc<br><br>20070410-AMSRE-REMSS-L2P-amsr_l2b_v05_r26239.dat-v01.nc |
| METOP AVHRR SST | &lt;YYYYMMDD&gt;-EUR-L2P_GHRSST-SSTsubskin-AVHRR_METOP_A-eumetsat_sstmgr_metop02_&lt;YYYYMMDD&gt;_&lt;HHMISS&gt;-v01.7-fv01.0.nc<br><br>20090410-EUR-L2P_GHRSST-SSTsubskin-AVHRR_METOP_A-eumetsat_sstmgr_metop02_20090410_100103-v01.7-fv01.0.nc |
| AATSR SST | &lt;YYYYMMDD&gt;-ATS_NR_2P-EUR-L2P-ATS_NR__2PNPDE&lt;YYYYMMDD&gt;_&lt;HHMISS&gt;_XXXXXXXXXXXX_XXXXX_XXXXX_XXXX.N1-v01.nc<br><br>20070410-ATS_NR_2P-EUR-L2P-ATS_NR__2PNPDE20070410_204758_000066812057_00114_26721_6738.N1-v01.nc |
| Aqua/Terra EOS MODIS SST | &lt;YYYYMMDD&gt;-MODIS_A-JPL-L2P-A&lt;YYYYMMDDHHMI&gt;.L2_LAC_GHRSST-v01.nc<br><br>20070410-MODIS_A-JPL-L2P-A2007100010000.L2_LAC_GHRSST-v01.nc |
| NOAA-17/18 AVHRR LAC/GAC SST | &lt;YYYYMMDD&gt;-AVHRR17_G-NAVO-L2P-SST_s&lt;HHMI1&gt;_e&lt;HHMI2&gt;-v01.nc<br><br>eg. 20070410-AVHRR17_G-NAVO-L2P-SST_s0838_e1033-v01.nc |
| Envisat along-track SLA | gridded_dt_upd_global_en_sla_vfec_&lt;YYYYMMDDHHMI1&gt;-&lt;YYYYMMDDHHMI2&gt;.nc<br><br>eg. gridded_dt_upd_global_en_sla_vfec_200704100000-200704102359.nc |
| GFO along-track SLA | gridded_dt_upd_global_g2_sla_vfec_&lt;YYYYMMDDHHMI1&gt;-&lt;YYYYMMDDHHMI2&gt;.nc<br><br>eg. gridded_dt_upd_global_g2_sla_vfec_200704100000-200704102359.nc |
| METOP ASCAT wind vector | ascat_&lt;YYYYMMDD&gt;_&lt;HHMISS&gt;_metopa_XXXXX_eps_t_250_0100_ovw.l2.nc<br><br>eg. ascat_20070410_063602_metopa_02452_eps_t_250_0100_ovw.l2.nc |
| QuikSCAT Seawinds wind vector | QS025_D&lt;YYJJJ&gt;_S&lt;HHMI1&gt;_E&lt;HHMI2&gt;_BXXXXXXX.nc<br><br>eg. QS025_D09087_S0032_E0210_B5107475.nc |
| Aqua EOS AMSR-E wind speed | &lt;YYYYMMDD&gt;-AMSRE-REMSS-L2P-amsr_l2b_v05_rXXXXX.dat-v01.nc<br><br>20070410-AMSRE-REMSS-L2P-amsr_l2b_v05_r26239.dat-v01. |

| | |
|---|---|
| OSI SAF Sea Ice Concentration | ice_conc_nh_polstere-020_multi_<YYYYMMDDHHMI>.nc<br><br>eg. ice_conc_nh_polstere-020_multi_200912301200.nc |
| NOAA AVHRR VIS/IR images | noaa<YYYYMMDDHHMI>mne.mitiff<br><br>eg. noaa200611051546mne.mitiff |
| GTS synop, buoy and ship | syno_<YYYYMMDDHHMI>.txt<br>drau_<YYYYMMDDHHMI>.txt<br><br>eg. syno_200910281200.txt, drau_200910281200.txt |
| HIRLAM | h20pl00_<YYYYMMDD>.nc for 00UTC forecast 00-12UTC.<br>h20pl12_<YYYYMMDD>.nc for 12UTC forecast 12-24UTC.<br>h12pl00_<YYYYMMDD>.nc for 00UTC forecast 00-12UTC.<br>h12pl12_<YYYYMMDD>.nc for 12UTC forecast 12-24UTC.<br>h12sf00_<YYYYMMDD>.nc for 00UTC forecast 00-12UTC.<br>h20 is the 20km HIRLAM model, h12 the 12km model. |
| Polar Low Indicator | pli_h20pl00_<YYYYMMDD>.nc<br>pli_h12pl00_<YYYYMMDD>.nc<br>for PLI indicator based on the corresponding NWP and AMSR-E SST files. |

*Table 4: File name convention for the different data types in STARS-DAT. Dates in file names are indicated in <>-brackets, using <YYYYMMDD> for date, <HHMISS> for time, and <JJJ> for day of year. Some file names contains start and end hours, which are indicated by <HHMI1> for start and <HHMI2> for end. Example file names are given in smaller font size.*

# 6. Example of use

This chapter gives an example of how the STARS-DAT DB can be used to explore a particular polar low event.

Polar low event 25 is used as example and this event lasted from 01UTC to 20 UTC 4. March 2008. The natural starting point for studying polar low events are IR satellite images, and an example from NOAA AVHRR is shown in Figure 6. The track of the polar low event is shown in Figure 7. One goal of the STARS project is to study SLA observations in connection with polar low events, and all available along-track SLA observation in the vicinity of the polar low track is shown in Figure 8. Different SST plots are shown in Figure 9 to Figure 12, and illustrates how the SST in this case was reduced along most of the polar low track as it passed. In Figure 13 to Figure 15 SST and SLA observation are matched to study the possible correlation between these quantities when a polar low is passing over open sea. In Figure 16 the difference between SST and air temperature at 500hPa, also called atmospheric heat content, is calculated to be used at a polar low indicator. For polar low event 25 it is clear that the atmospheric heat potential is higher than the surroundings all along the polar low track at the start of the polar low event.
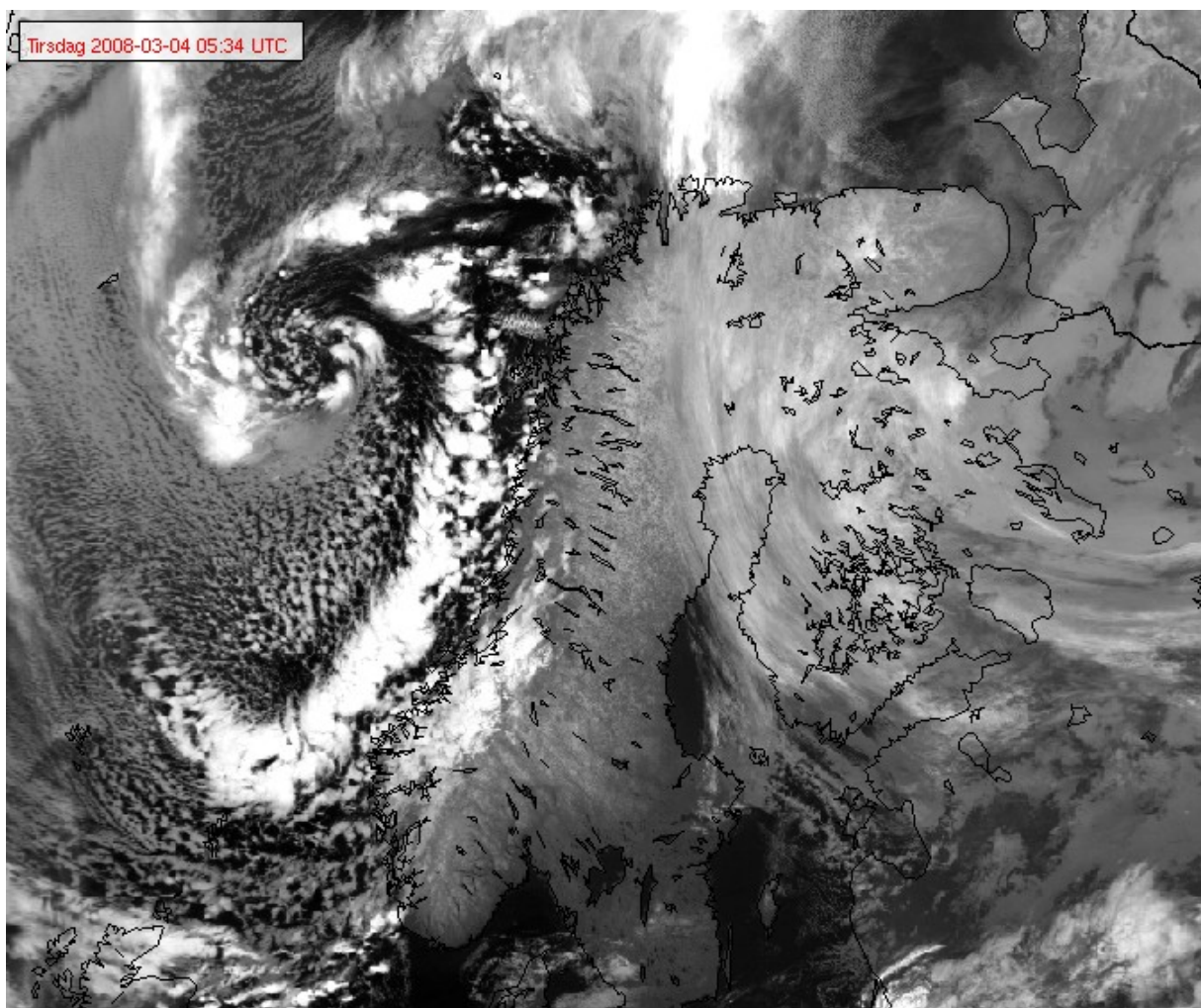


*Figure 6: AVHRR IR image of polar low event 25, from 2008 -03-04 05:34 UTC.*
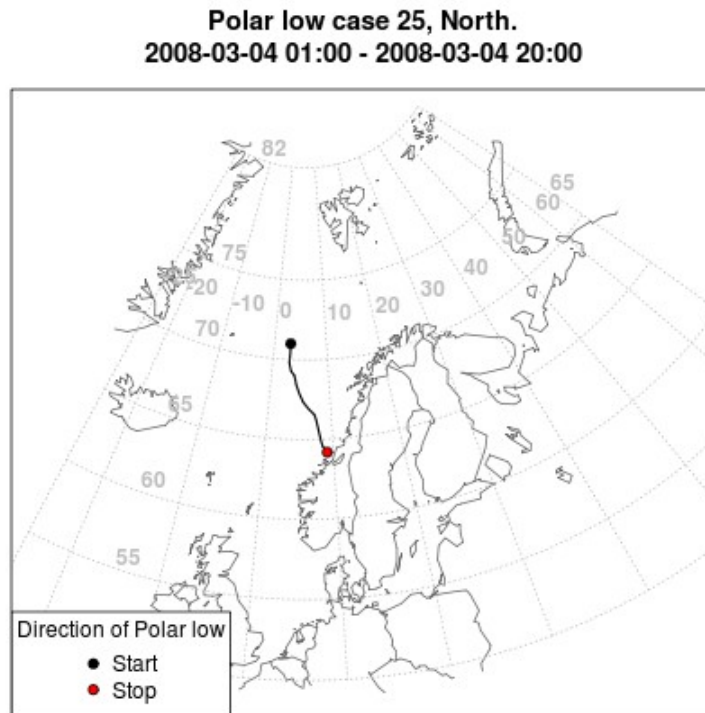
*Figure 7: Track of polar low event 25 from start to end (4. March 2008 01 UTC to 4. March 2008 20 UTC)*
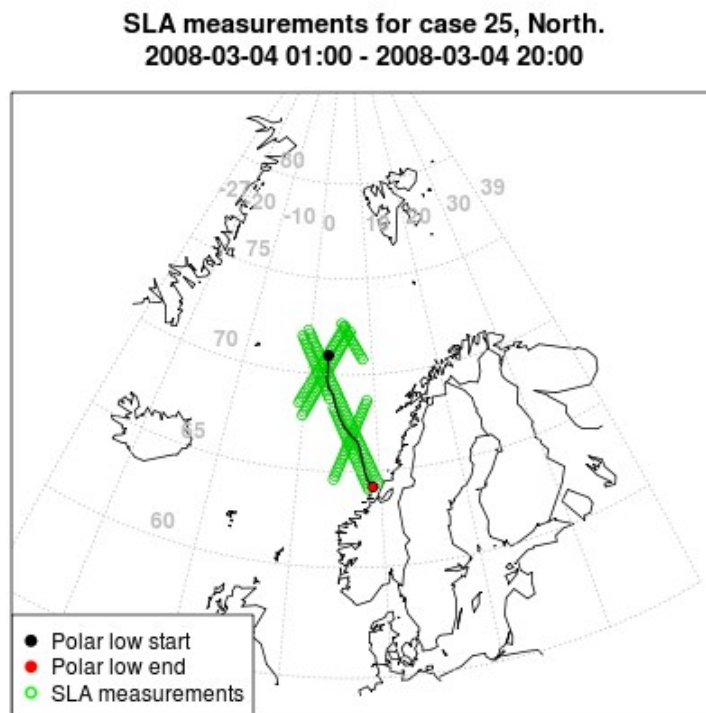


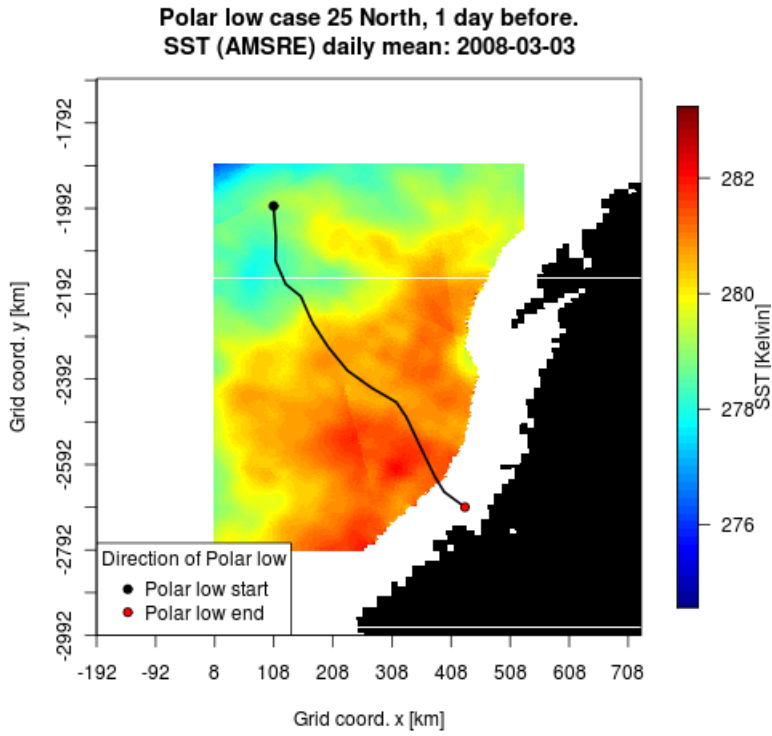*Figure 8: Track of all SLA measurements in vicinity of polar low event 25.*

Figure 9: Daily mean AMSR-E SST one day before polar low event 25.
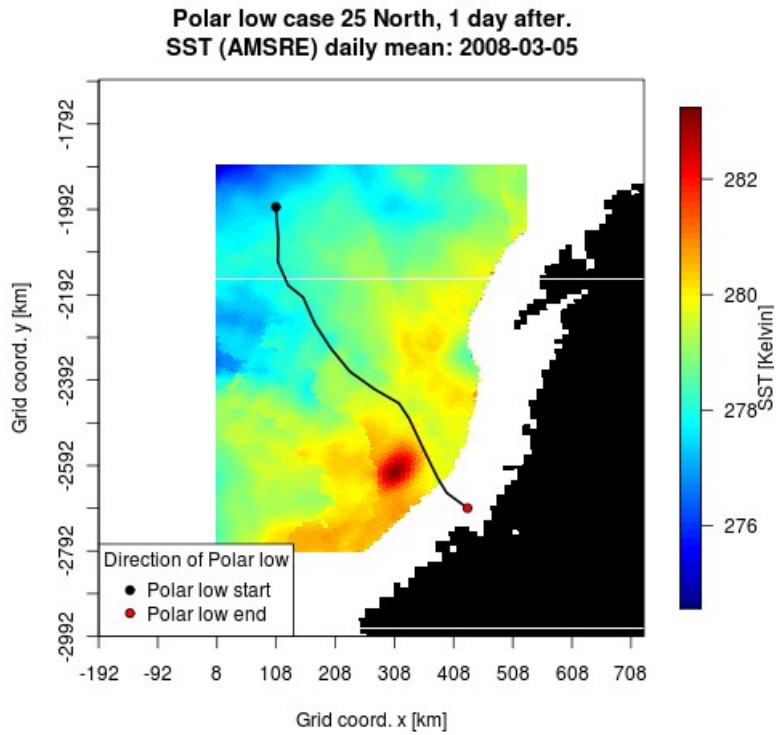


Figure 10: Daily mean AMSR-E SST one day after polar low event 25.
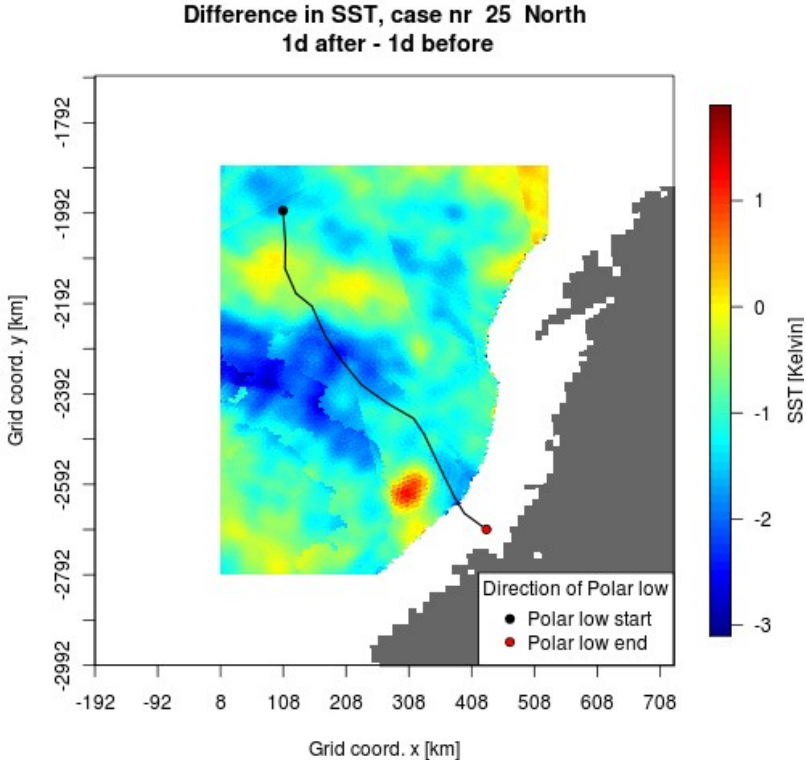
*Figure 11: Difference in daily mean AMSR-E SST (one day after - one day before) for polar low event 25.*
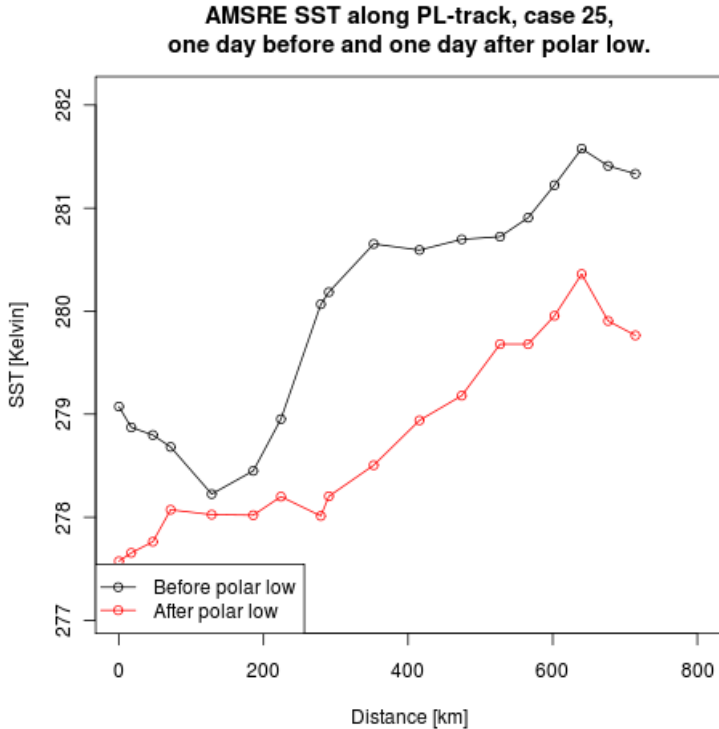


*Figure 12: AMSR-E SST along polar low track for event 25. In black one day before polar low, in red on day after polar low event.*
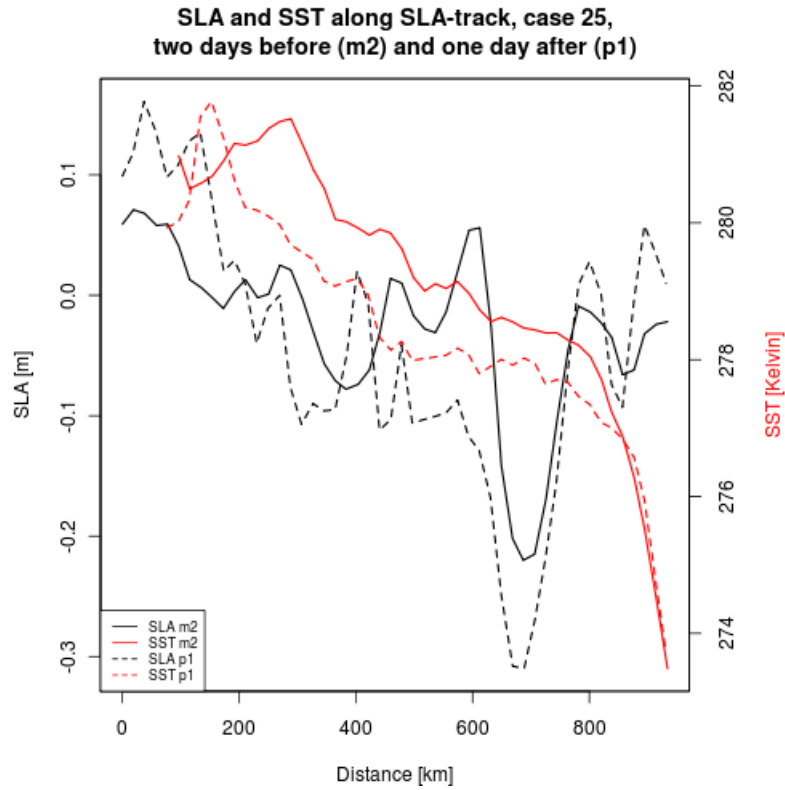
*Figure 13: SLA amd SST along SLA track for polar low event 25. In black is SLA, in red is SST. Solid line 2 days before event, dotted 1 day after.*



*Figure 14: Shows which SLA tracks are plotted in Figure 13.*
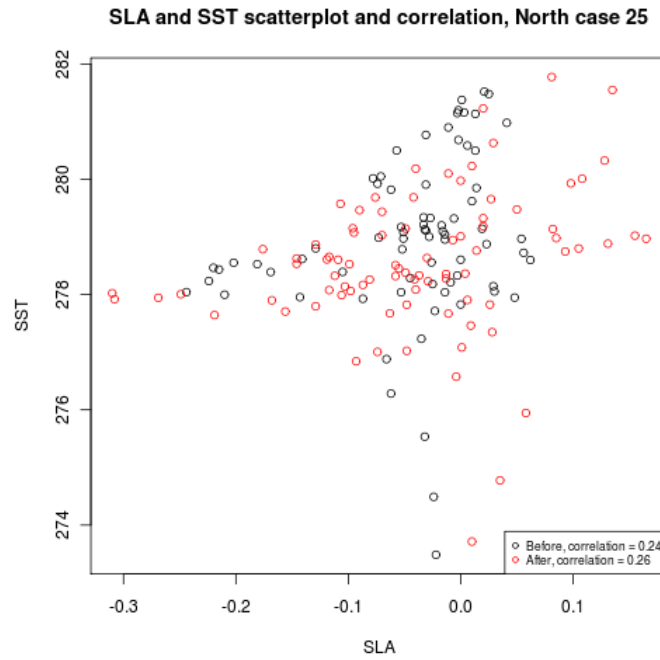
*Figure 15: Correlation between SLA and SST observation for polar low event 25.*
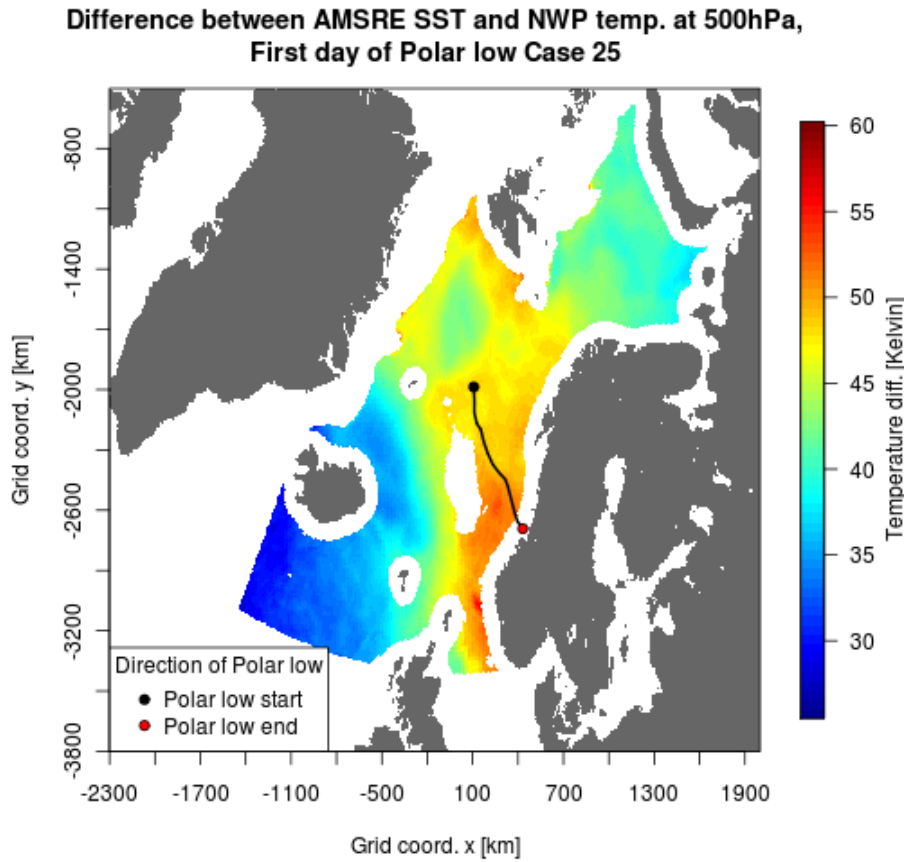


*Figure 16: Difference between daily mean AMSR-E SST and HIRLAM air temperature at 500hPa, also referred to as atmospheric heat potential, for polar low event 25.*

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# 7. Recommended future developments

This chapter gives recommendations for the future development of the STARS-DAT data set.

## 7.1 Add new polar low events to list
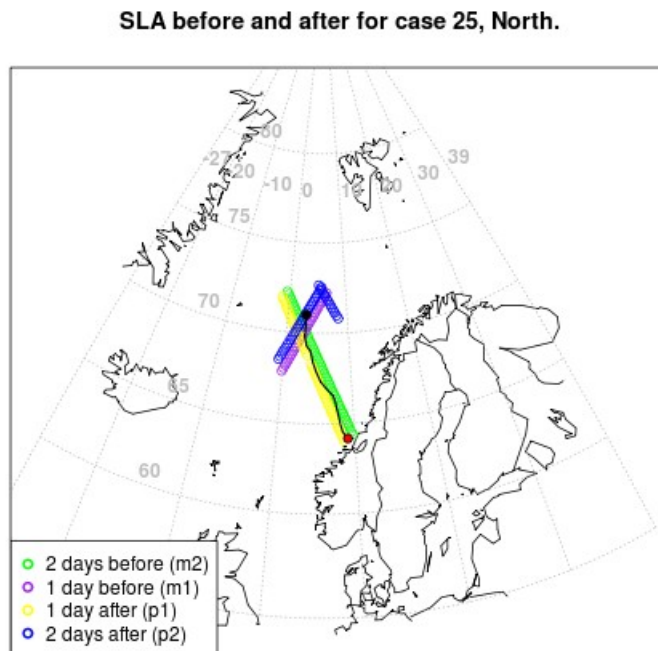
A natural development of the STARS-DAT data set will be to update the list of polar low events with future polar lows. The forecasting section for Arctic weather at met.no are continuously tracking polar lows as a part of the operational weather forecasting service. The list of polar low events in the STARS-DAT area could be updated by contacting the forecasting section for Arctic weather at met.no.

## 7.2 Adding SAR data

SAR data can be used to study the details in the wind patterns of polar lows in fine details, even though there are limitations in wind retrievals based on SAR data. This is not directly useful for the studies in the STARS project, but could be a useful future extention of STARS-DAT to extend the use of STARS-DAT.

# 8. Procedures for updating STARS-DAT

The STARS-DAT and STARS-DAT-DB is designed so that they can be archived and re-located in a manner that can be easily updated and extended if required in the future. The easiest way to extend with future data will of course be to apply the software used in the STARS project, but since this software is plainly performing nearest neighbor interpolation, it could be done with any regridding software. The following sections shortly describes where to get the needed data.

## 8.1 Adding new polar low events

Contact Øyvind Sætra (oyvinds@met.no) or Gunnar Noer (g.noer@met.no) to get an updated list of polar low events.

## 8.2 Adding satellite SST data

Collect the GHRSST L2P SST data from the GHRSST LTSRF at http://ghrsst.nodc.noaa.gov in delayed mode, with open data access.

## 8.3 Adding satellite SLA data

Collect data from the AVISO SLA archive at http://www.aviso.oceanobs.com. User registration is requested for accessing the data archives.

## 8.4 Adding satellite wind data

The OSI SAF ASCAT wind products are available through the EUMETSAT Data Center (http://www.eumetsat.int) or through PO.DAAC (http://podaac.jpl.nasa.gov). User registration is requested for accessing the data archives.
The RSS AMSR-E wind speed data products are available in GHRSST L2P format through the AMSR-E SST files at the GHRSST LTSRF (http://ghrsst.nodc.noaa.gov) in delayed mode, with open data access.

## 8.5 Adding satellite sea ice concentration

The OSI SAF sea ice concentration products are available on FTP at ftp://osisaf.met.no/archive/ice/conc or through the EUMETSAT Data Center (http://www.eumetsat.int), with open data access.

## 8.6 Satellite radiometer imagery

The AVHRR data were only used to track the polar low events. So if an updated list of polar lows is collected as described in Chapter 8.1, there is no need to update the AVHRR radiometer imagery data.

## 8.7 In situ data

The in situ data source used to build STARS-DAT was an internal binary format at met.no archive, which is not accessible outside met.no. A alternative to this archive is the Coriolis in situ data archive available at http://www.coriolis.eu.org.

## 8.8 NWP data

The HIRLAM NWP data used in STARS-DAT are not accessible outside met.no in general. But any NWP model covering the North Atlantic up to the Arctic can be used, either from a national weather service and the ECMWF (http://www.ecmwf.int).

## *8.9  Polar Low Indicator fields*

PLI fields can be estimated and added to the data set if SST and NWP 500hPa air temperature fields are available, as described in the PLI ATBD [RD-9]. So this directly depends on Chapter 8.2 and 8.7.

# 9.   Appendix A

Table of polar low events within the STARS-DAT period 2006.01-2010.04. The first table is for the Norwegian Sea and Barents Sea, and the second table for area between South Greenland and United Kingdom.

| Polar low ID | Start time | End time | Start position | End position |
|---|---|---|---|---|
| 1 | 2006-01-29 15UTC | 2006-01-30 02UTC | 76.11N  20.83E | 73.63N  28.12E |
| 2 | 2006-03-06 14UTC | 2006-03-06 21UTC | 68.60N  11.10E | 68.80N  13.80E |
| 3 | 2006-03-20 14UTC | 2006-03-22 07UTC | 71.36N  02.75E | 62.75N  05.46E |
| 4 | 2006-10-29 11UTC | 2006-10-29 22UTC | 71.70N  16.20E | 70.00N  18.00E |
| 5 | 2006-11-01 19UTC | 2006-11-02 04UTC | 75.18N  20.95E | 74.60N  24.00E |
| 6 | 2006-11-08 14UTC | 2006-11-08 23UTC | 63.53N  08.23W | 63.10N  02.00W |
| 7 | 2006-12-22 12UTC | 2006-12-22 16UTC | 71.80N  16.60E | 70.90N  21.60E |
| 8 | 2006-12-26 03UTC | 2006-12-26-18UTC | 72.40N  14.80E | 75.50N  29.20E |
| 9 | 2007-01-21 05UTC | 2007-01-22 17UTC | 72.70N  41.50E | 68.57N  43.26E |
| 10 | 2007-01-22 14UTC | 2007-01-23 17UTC | 76.20N  04.40E | 71.11N  06.80E |
| 11 | 2007-01-26 04UTC | 2007-01-26 09UTC | 70.60N  14.50E | 69.07N  15.44E |
| 12 | 2007-01-27 01UTC | 2007-01-27 07UTC | 75.54N  38.16E | 75.98N  41.60E |
| 13 | 2007-02-05 01UTC | 2007-02-05 04UTC | 64.75N  09.46E | 64.03N  09.99E |
| 14 | 2007-02-13 06UTC | 2007-02-13 09UTC | 71.25N  22.90E | 70.80N  22.20E |
| 15 | 2007-04-06 00UTC | 2007-04-06 20UTC | 73.40N  12.00E | 68.00N  15.10E |
| 16 | 2007-04-29 01UTC | 2007-04-29 02UTC | 71.10N  29.70E | 70.80N  29.60E |
| 17 | 2007-09-03 04UTC | 2007-09-03 05UTC | 64.00N  06.40E | 64.00N  04.00E |
| 18 | 2007-12-11 18UTC | 2007-12-11 19UTC | 70.40N  31.70E | 70.40N  31.90E |
| 19 | 2008-01-25 13UTC | 2008-01-25 21UTC | 67.28N  05.26E | 67.70N  11.10E |
| 20 | 2008-01-31 04UTC | 2008-01-31 17UTC | 73.92N  10.98E | 71.00N  11.10E |
| 21 | 2008-02-14 23UTC | 2008-02-15 01UTC | 69.80N  38.20E | 69.20N  36.50E |
| 22 | 2008-02-29 11UTC | 2008-02-29 16UTC | 73.70N  23.90E | 73.98N  23.86E |
| 23 | 2008-03-02 21UTC | 2008-03-02 21UTC | 75.00N  09.00E | 75.00N  09.00E |
| 24 | 2008-03-02 21UTC | 2008-03-03 09UTC | 69.20N  11.10E | 68.00N  12.70E |
| 25 | 2008-03-04 01UTC | 2008-03-04 20UTC | 71.00N  03.10E | 64.17N  09.11E |
| 26 | 2008-03-16 09UTC | 2008-03-17 11UTC | 71.75N  12.03E | 64.50N  07.30E |
| 27 | 2008-03-18 15UTC | 2008-03-20 14UTC | 73.50N  28.40E | 72.53N  50.07E |
| 28 | 2008-03-20 07UTC | 2008-03-20 14UTC | 72.00N  43.27E | 72.40N  50.15E |
| 29 | 2008-04-04 01UTC | 2008-04-04 20UTC | 72.00N  01.00E | 70.69N  01.29W |
| 30 | 2008-04-24 12UTC | 2008-04-24 13UTC | 71.00N  41.00E | 70.30N  41.90E |
| 31 | 2008-10-27 20UTC | 2008-10-27 22UTC | 66.70N  04.70W | 65.60N  04.40W |
| 32 | 2008-11-17 07UTC | 2008-11-17 16UTC | 74.70N  25.90E | 75.60N  27.20E |
| 33 | 2008-11-18 02UTC | 2008-11-18 20UTC | 75.30N  02.00E | 73.00N  00.83E |

| 34 | 2008-11-18 20UTC | 2008-11-19 10UTC | 71.00N  14.00E | 70.20N  15.30E |
|---|---|---|---|---|
| 35 | 2008-11-20 06UTC | 2008-11-20 20UTC | 69.00N  08.00E | 65.60N  11.00E |
| 36 | 2008-11-28 08UTC | 2008-11-28 22UTC | 69.80N  01.30E | 66.30N  06.10W |
| 37 | 2008-11-29 19UTC | 2008-11-30 01UTC | 73.50N  00.80W | 73.50N  06.73W |
| 38 | 2008-12-30 11UTC | 2008-12-30 18UTC | 72.50N  32.50E | 70.50N  41.30E |
| 39 | 2009-01-07 03UTC | 2009-01-07 10UTC | 71.90N  29.20E | 71.20N  28.00E |
| 40 | 2009-01-16 12UTC | 2009-01-16 17UTC | 71.00N  57.00E | 70.50N  63.44E |
| 41 | 2009-02-05 03UTC | 2009-02-05 13UTC | 71.44N  02.67W | 68.58N  06.26W |
| 42 | 2009-02-05 18UTC | 2009-02-06 08UTC | 69.60N  39.30E | 67.60N  43.40E |
| 43 | 2009-02-07 17UTC | 2009-02-08 07UTC | 72.50N  43.20E | 73.80N  43.80E |
| 44 | 2009-02-26 18UTC | 2009-02-27 11UTC | 70.60N  12.90E | 66.72N  10.88E |
| 45 | 2009-02-27 18UTC | 2009-02-28 11UTC | 72.40N  32.50E | 71.30N  38.30E |
| 46 | 2009-03-27 22UTC | 2009-03-28 18UTC | 68.90N  04.60W | 68.70N  08.50E |
| 47 | 2009-04-02 09UTC | 2009-04-02 15UTC | 73.00N  35.30E | 71.80N  35.20E |
| 48 | 2009-04-05 01UTC | 2009-04-05 09UTC | 71.79N  43.32E | 69.90N  45.60E |
| 49 | 2009-04-05 07UTC | 2009-04-05 19UTC | 72.10N  24.70E | 69.50N  34.90E |
| 50 | 2010-01-08 11UTC | 2010-01-08 15UTC | 80.70N  15.10E | 80.80N  20.00E |
| 51 | 2010-01-29 17UTC | 2010-01-29 22UTC | 67.95N  08.10E | 67.20N  08.30E |

*Table 5: List of Polar Lows in the north-east part of the North Atlantic for 2006.01-2010.04.*

| Polar low ID | Start time | End time | Start position | End position |
|---|---|---|---|---|
| 1 | 2006-10-25 13UTC | 2006-10-25 17UTC | 62.90N  37.00W | 62.30N  37.70W |
| 2 | 2006-11-29 11UTC | 2006-11-29 23UTC | 69.50N  09.20W | 68.10N  16.10W |
| 3 | 2006-12-14 08UTC | 2006-12-14 16UTC | 62.30N  39.70W | 61.60N  37.90W |
| 4 | 2006-12-29 07UTC | 2006-12-29 15UTC | 67.10N  15.10W | 71.56N  16.61W |
| 5 | 2007-03-03 08UTC | 2007-03-03 21UTC | 61.60N  38.00W | 59.20N  35.20W |
| 6 | 2007-03-06 04UTC | 2007-03-06 17UTC | 56.60N  15.50W | 59.99N  06.92W |
| 7 | 2007-03-07 02UTC | 2007-03-07 12UTC | 52.70N  18.40W | 53.40N  10.86W |
| 8 | 2007-04-15 04UTC | 2007-04-15 22UTC | 64.90N  29.00W | 63.80N  23.00W |
| 9 | 2007-10-03 19UTC | 2007-10-04 07UTC | 64.00N  37.50W | 61.35N  38.01W |
| 10 | 2007-12-02 12UTC | 2007-12-02 20UTC | 59.30N  26.70W | 57.70N  23.17W |
| 11 | 2007-12-06 09UTC | 2007-12-06 21UTC | 58.80N  15.50W | 60.00N  06.00W |
| 12 | 2007-12-06 21UTC | 2007-12-07 05UTC | 55.10N  18.27W | 53.70N  10.60W |
| 13 | 2007-12-06 16UTC | 2007-12-06 16UTC | 54.40N  15.50W | 54.40N  15.50W |
| 14 | 2007-12-06 15UTC | 2007-12-07 13UTC | 64.80N  36.20W | 63.30N  34.10W |
| 15 | 2007-12-09 03UTC | 2007-12-09 03UTC | 64.10N  33.20W | 64.10N  33.20W |
| 16 | 2007-12-09 12UTC | 2007-12-09 20UTC | 61.70N  21.00W | 63.50N  19.60W |
| 17 | 2007-12-12 04UTC | 2007-12-13 04UTC | 56.50N  35.30W | 62.10N  40.89W |
| 18 | 2007-12-13 12UTC | 2007-12-13 22UTC | 60.40N  27.30W | 65.60N  25.60W |
| 19 | 2007-12-21 21UTC | 2007-12-22 08UTC | 64.80N  25.52W | 67.45N  25.12W |
| 20 | 2007-12-21 22UTC | 2007-12-22 12UTC | 62.00N  28.90W | 64.96N  23.69W |
| 21 | 2007-12-29 05UTC | 2007-12-29 08UTC | 55.90N  10.34W | 55.76N  07.43W |
| 22 | 2008-01-06 11UTC | 2008-01-06 21UTC | 51.70N  16.90W | 53.77N  09.96W |
| 23 | 2008-01-07 08UTC | 2008-01-09 08UTC | 60.50N  21.60W | 60.69N  20.15W |
| 24 | 2008-01-08 07UTC | 2008-01-08 22UTC | 52.69N  17.19W | 56.36N  07.78W |
| 25 | 2008-01-17 03UTC | 2008-01-17 08UTC | 66.00N  24.47W | 65.80N  26.00W |
| 26 | 2008-01-17 07UTC | 2008-01-17 10UTC | 67.10N  17.60W | 68.19N  18.84W |
| 27 | 2008-04-13 22UTC | 2008-04-14 21UTC | 63.48N  17.41W | 58.85N  06.02W |
| 28 | 2008-10-04 03UTC | 2008-10-04 07UTC | 65.13N  09.28W | 63.49N  10.57W |
| 29 | 2008-10-04 06UTC | 2008-10-04 21UTC | 63.15N  02.10W | 61.70N  04.68W |
| 30 | 2008-10-22 05UTC | 2008-10-22 22UTC | 63.82N  38.87W | 59.50N  32.30W |
| 31 | 2008-11-15 22UTC | 2008-11-16 05UTC | 62.74N  02.59E | 61.32N  04.86E |
| 32 | 2008-12-01 11UTC | 2008-12-01 22UTC | 62.30N  10.30W | 58.72N  06.45W |
| 33 | 2008-12-15 07UTC | 2008-12-16 15UTC | 63.09N  37.14W | 59.81N  20.17W |
| 34 | 2009-01-12 16UTC | 2009-01-13 20UTC | 62.33N  08.43W | 62.80N  07.00E |
| 35 | 2009-01-16 11UTC | 2009-01-16 22UTC | 60.02N  19.12W | 63.96N  19.46W |
| 36 | 2009-01-28 04UTC | 2009-01-28 20UTC | 59.30N  13.10W | 65.60N  13.60W |
| 37 | 2009-04-04 20UTC | 2009-04-05 04UTC | 60.40N  23.10W | 63.13N  25.06W |
| 38 | 2009-05-09 13UTC | 2009-05-10 01UTC | 55.90N  03.30W | 58.90N  05.30E |

| 39 | 2009-12-23 14UTC | 2009-12-24 02UTC | 57.00N  02.30E | 59.00N  05.80E |
|----|------------------|------------------|----------------|----------------|
| 40 | 2009-12-25 15UTC | 2009-12-26 13UTC | 63.60N  06.56W | 61.00N  14.30W |
| 41 | 2010-01-13 21UTC | 2010-01-14 12UTC | 52.61N  23.37W | 58.29N  20.90W |
| 42 | 2010-01-15 05UTC | 2010-01-16 03UTC | 60.00N  17.70W | 65.85N  29.41W |
| 43 | 2010-02-19 02UTC | 2010-02-19 17UTC | 63.10N  09.10W | 62.95N  18.92W |
| 44 | 2010-03-19 15UTC | 2010-03-20 13UTC | 62.00N  25.50W | 64.09N  33.53W |
| 45 | 2010-03-21 08UTC | 2010-03-21 19UTC | 58.54N  11.64W | 61.47N  10.10W |
| 46 | 2010-03-22 04UTC | 2010-03-22 20UTC | 58.41N  14.29W | 61.91N  17.71W |

*Table 6: List of Polar Lows in the north-west part of the North Atlantic for 2006.01-2010.04.*