STARS-DAT v3

User Manual

Version 3.1

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v 3.1	20-12-2012	Added wave height product

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1. Introduction

1.1 Purpose of this document

This document is the User Manual for the version 3 of the STARS (Combination of Sea Surface Temperature and AltimeteR Synergy) project data set (STARS-DAT v3) and the corresponding data base (STARS-DAT-DB v3). 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 program. When the SoW was written, the aim of this project was 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.
However, due to the installation of a new super computer facility in Norway in 2011/2012, expert resources on the atmosphere model was tied up. The original plan for STARS was therefore altered to not implement and use the coupled STARS-MODEL. Instead we are assessing the impact of polar lows on the observed surface signals (SST and SLA) and the sub-surface ocean dynamics that re-stratify the water column after PL events. An ocean hindcast simulation of a subregion of the Nordic Seas with a resolution of ~800m, will be analyzed for its response to the passage of one or more polar lows over the winter season. Also, the STARS-DAT data set will be extended with ASAR data and cover a period of 10 years, as documented in this report.

1.3 Structure of this documentation

- Chapter 1 is the 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
SAR	Synthetic Aperture Radar
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 v3 data set.

2.1 Format

The STARS-DAT data set is given in NetCDF format, version 4.0 (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 and SAR data) 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.

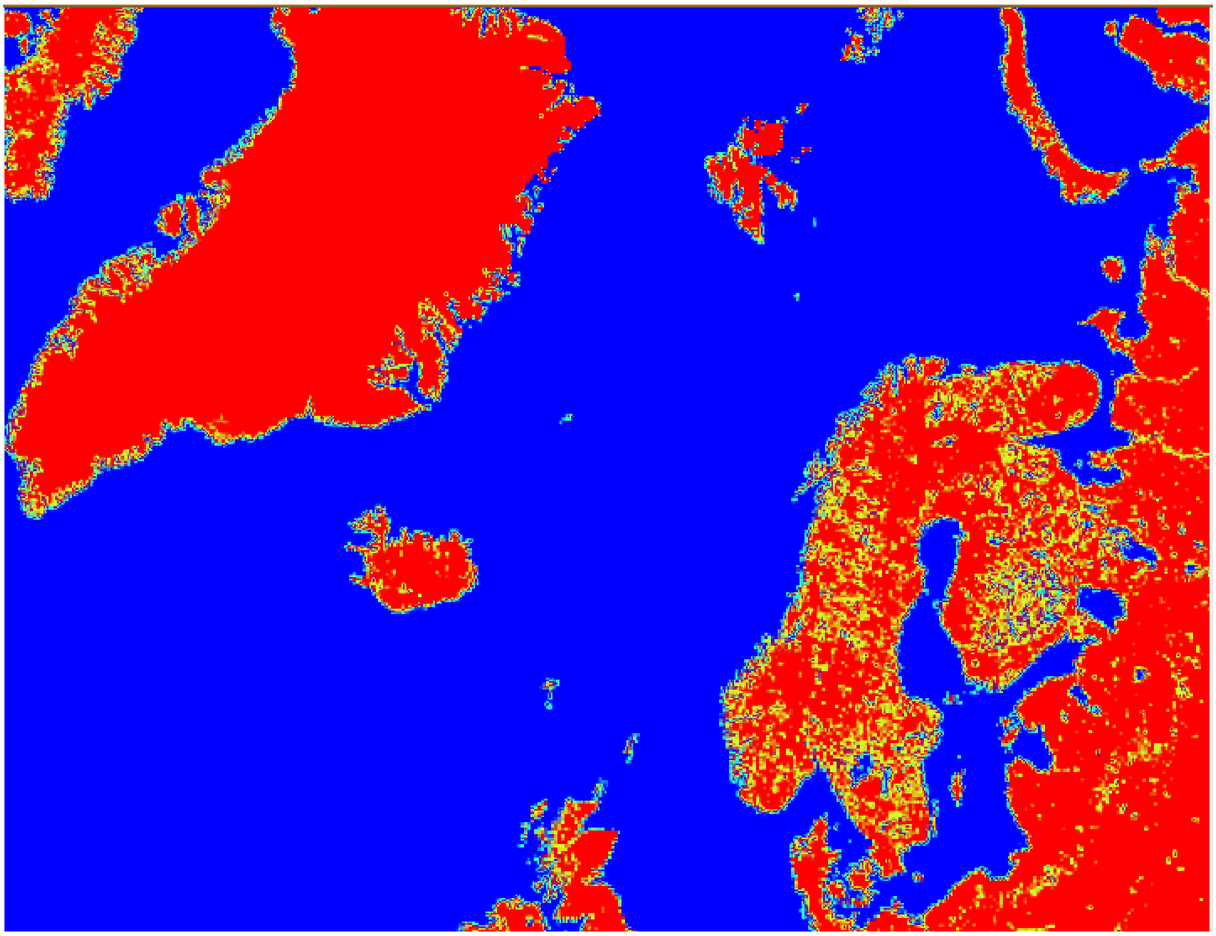

Figure 1: The area covered by the STARS-DAT data set.

2.2 Organization

STARS-DAT contains data for the winter months during 10 years from 2002 - 2011. The data are organized in year and day directories, so that each year in the data set is in one directory, with one directory for each day within that year. The range of days for each year is 1-120 and 274-366, covering the months of January-April and October to December. This directory structure is illustrated in Figure 2. Each of these day directory contains all the data set for this day (defined by UTC), defining daily sub data sets.
At the top level of the data set, a file list is given. The list contains information of all the files in the STARS-DAT data set. This file is named `STARS-DAT_filelist.txt` and the content is described in the header of the file. The polar low lists with tracks (as described in Chapter 4) is also given at the top level of the data set, and is named `PolarLow_tracks_North_2002_2011` and `PolarLow_tracks_South_2006_2009`.

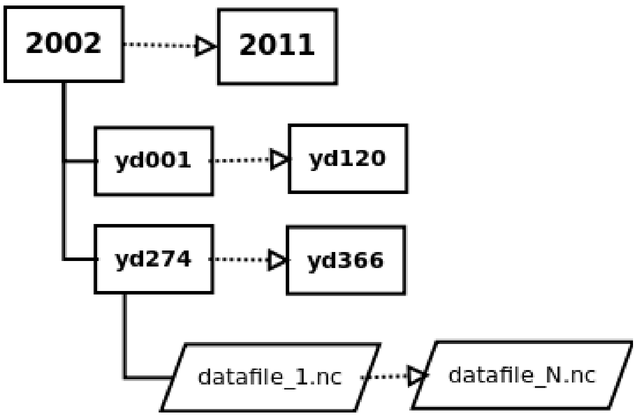

Figure 2: Directory structure of STARS-DAT data set.

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
  - Wave height
  - sea ice concentration
  - imagery
- NWP
  - geopotential height at different pressure levels
  - relative humidity at different pressure levels
  - sea surface temperature
  - precipitation
  - surface wind
  - mean sea level pressure (MSLP)
  - air potential temperature at different pressure levels
- In situ
  - SST
  - surface wind
  - +++++

The STARS-DAT coverage 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. The PLI is based on the principle that when the atmospheric heat potential is sufficiently large, i.e. when the temperature difference between the cloud top level and the sea-surface exceeds a certain threshold level, the potential for polar low development is large. These PLI fields are derived using a combination of the satellite SST fields and NWP fields.

Parameter	Data source	STARS-DAT
Satellite SST	Aqua EOS AMSR-E SST	01.10.2002 - 30.04.2011
	METOP AVHRR SST	28.11.2007 - 31.12.2009
	Aqua/Terra EOS MODIS SST	01.10.2006 - 31.12.2009
	NOAA-17/18 AVHRR LAC/GAC SST	26.01.2006 - 30.12.2009
Satellite SLA	Envisat along-track SLA	10.10.2002 - 21.10.2010
	GFO along-track SLA	01.01.2002 - 30.04.2008
Satellite Wind	METOP ASCAT wind vector	28.03.2007 - 30.04.2011
	QuikSCAT Seawinds wind vector	01.01.2002 - 31.12.2009
	Aqua EOS AMSR-E wind speed	01.10.2002 - 30.04.2011
	Envisat ASAR	For each Polar Low case when ASAR images is available
Satellite Sea Ice	DMSP SSM/I	01.01.2002 - 30.04.2011
Satellite Significant Wave Height	GlobWave ENVISAT	01.10.2002 - 30.04.2011
	GlobWave GFO	01.01.2002 - 30.04.2008
Satellite radiometer imagery	NOAA AVHRR VIS/IR images	01.01.2002 - 30.04.2011
In situ data	GTS synop, buoy and ship	01.01.2003 - 30.04.2011
PLI	Atmospheric Heat Potential (AMSR-E SST - NWP air temperature 500hPa)	19.03.2003 - 30.04.2011
NWP temperature, humidity, precipitation, SST, wind, MSLP, geop.height	HIRLAM 20km	19.03.2003 - 12.02.2008
	HIRLAM 12km	13.02.2008 - 30.04.2011

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 to easily get an overview of the polar low events and the 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://polarlow.met.no/STARS-DAT/browser/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.
AVHRR Image	AVHRR IR image of polar low event at one selected time.
SLA 1 day before	SLA 1 day before polar low event start
SLA 1 day after	SLA 1 day after polar low event end
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.
Surf Pressure day 1	Sea surface pressure from Hirlam analysis
SAR data location	The location of ASAR data during polar low event
SAR backscatter	ASAR backscatter of polar low event
SAR wind speed	ASAR wind speed using HIRLAM wind directions as input

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. A detailed list, identifying each polar low, are given in Appendix A. Since there are different interpretation of a polar low, there might be situations where a polar low case is missed and not documented in the polar low list.

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, 2002.01-2011.04.
For each polar low event, the movement has been catalogued by identifying the centre of the storm for each AVHRR images available. The hourly positions of the polar lows is then found by interpolation. To classify the size of the different polar lows, the radius of the storms has been estimated and catalogued. Both the tracking and the estimation of the radius is a subjective process, and the polar low list is therefore prone to human error.
The polar lows that have been 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. For the second subset, the STARS-DAT data set, only covers the polar low seasons 2006.01-2010.04. Plots of the tracks for each of these two subsets are shown in Figure 4 and Figure 5. In some cases with dual systems, both polar lows has been tracked, for other cases, only the strongest polar low of a dual system has been tracked, witch depend on the situation. Figure 3 illustrates how the Polar Low List for each track look likes. In this Figure, case number 49 (from the original polar low list) is used as an example.

N	year	month	day	hour	min	lat	lon	Q	R(km)
49	2009	04	05	00	59	71.8	43.3	0	200
49	2009	04	05	01	56	71.0	44.3	0	200
49	2009	04	05	02	34	70.4	43.8	0	200
49	2009	04	05	04	15	70.4	43.8	0	200
49	2009	04	05	05	03	70.1	44.4	0	200
49	2009	04	05	05	54	69.9	45.6	0	200
49	2009	04	05	06	43	69.9	45.6	0	200
49	2009	04	05	07	36	69.9	45.6	0	200
49	2009	04	05	08	51	69.9	45.6	0	200
49	2009	04	05	09	17	69.9	45.6	0	200

Figure 3: An example to show how the Polar Low List with tracks look likes. The following gives information about case number 49 (from the original Polar Low list)

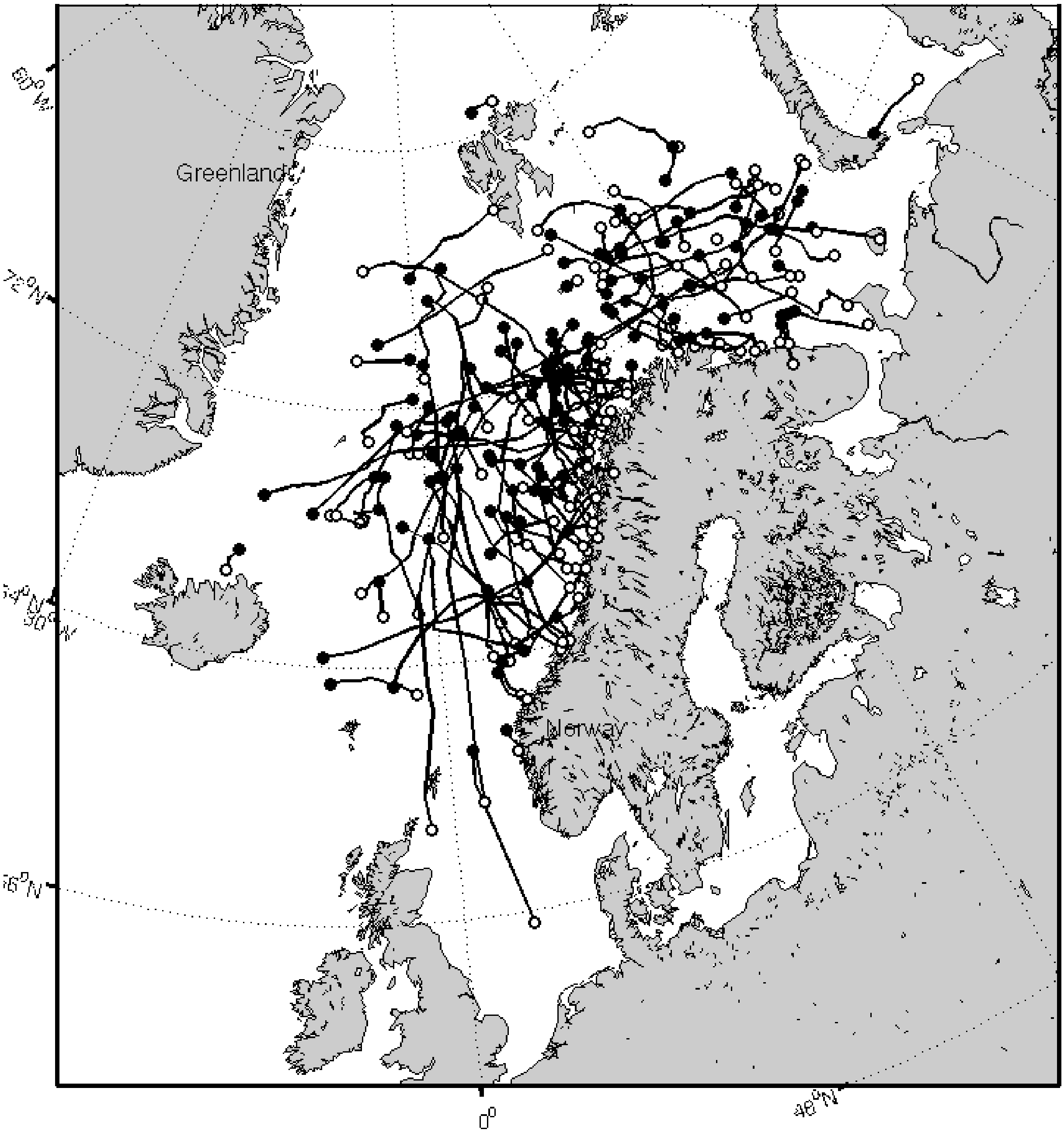

Figure 4: Tracks of polar low events in the period 2002.01-2011.04 in the Norwegian Sea and Barents Sea. Filled circle indicates first observation and open circle indicates last observation of polar low.

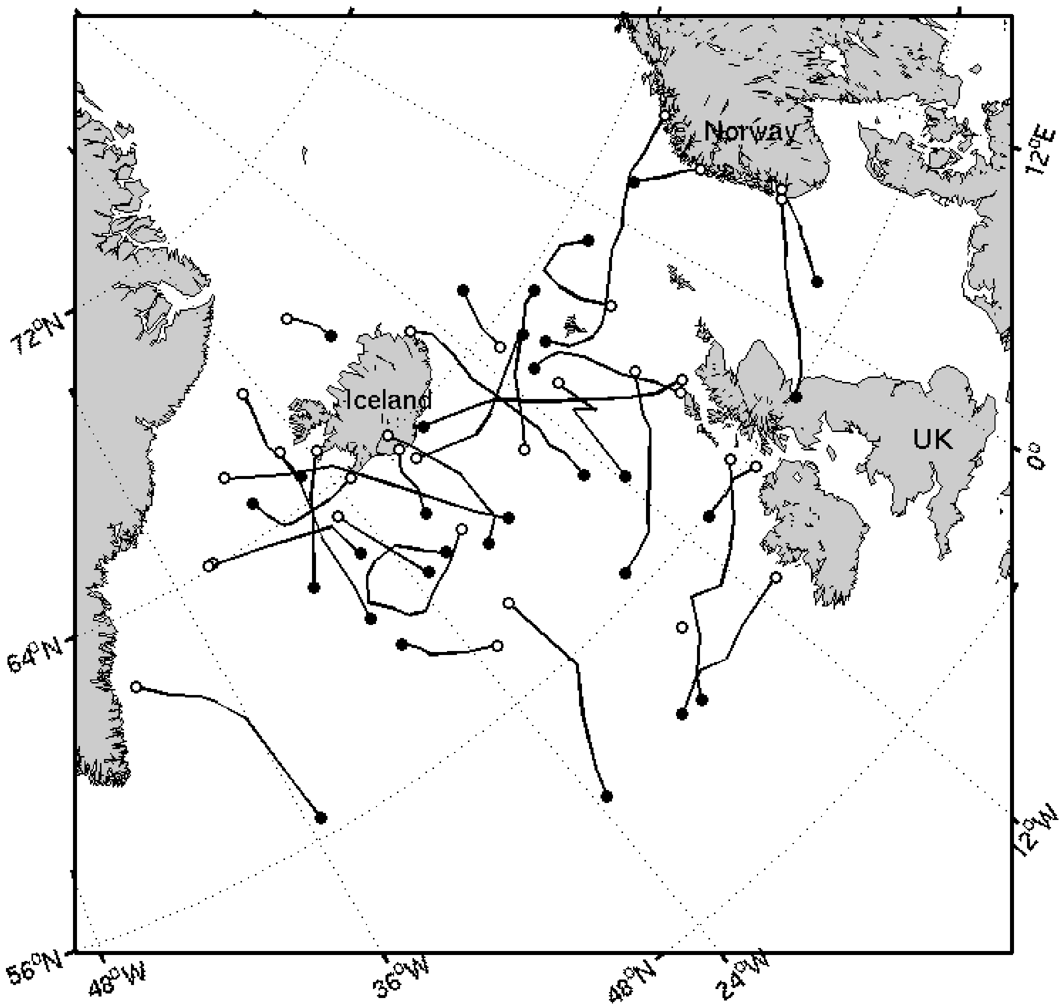

Figure 5: Tracks of polar low events in the period 2006.01-2010.04 in the area between South-Greenland and United Kingdom. Filled circle indicates first observation and open circle indicates last observation of polar low.

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 re-gridded to the STARS-DAT grid described in Chapter 2. Most of the parameters in the original files have been kept on the re-gridded 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, AATSRand 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 (delayed time mode data). However, Envisat was moved to a lower orbit on October 22, so SLA satellite data is not included in STARS-DAT for the period 2010-10-22 to 2011-04-30.

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 6.

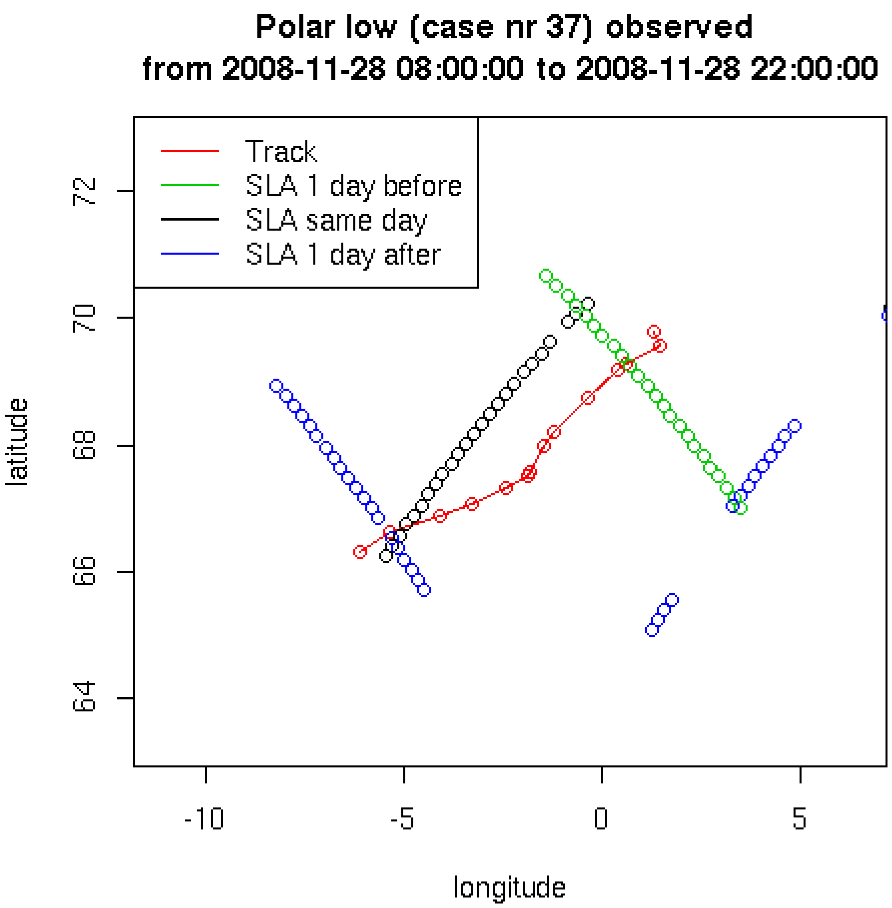

Figure 6: Coverage of SLA data in the vicinity of a polar low event. All SLA data from Envisat +/- 1 day from the duration of the polar low event is shown.

5.3 Satellite Wave data

The satellite wave data have all been collected from the GlobWave L2P data archive. The L2P data consists of Level-2 data of wave measurements from multiple SAR and altimetry sensors given in the common netCDF-3 format. In STARS-DAT, the delayed mode (GDR) data from Envisat and GFO have been used. More information about the data products are available at the GlobWave web portal:
http://www.globwave.org/Products/GlobWave-Satellite-Data.

The along-track data have been re-gridded to the 2km STARS-DAT grid. Each wave observation has been placed in the nearest neighbor grid cell (where the center of the grid cell has to be less than 2km from the observation). No filling has been applied. The following parameters are provided in the re-gridded GlobWave files:

- Significant wave height
- Significant wave height quality

The file name convention for the wave height files are described in Table 4.

5.4 Satellite Wind data

Four 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 "the NASA Scatterometer Project"
- AMSR-E passive microwave wind speed from RSS.
- Wind speed from ASAR using HIRLAM wind directions as input to CMOD5

The original OSI SAF ASCAT NetCDF and Seawinds swath Hdf4 files were downloaded from http://podaac-ftp.jpl.nasa.gov/allData and have all been re-gridded to the STARS-DAT grid, implying a oversampling from the original 25km field-of-view. The filename convention is listed in Table 4. The main parameters in the ASCAT and Seawinds files are wind speed and wind direction. More details about the content on the ASCAT and Seawinds files are given in the respective docs catalogues on the podaac ftp site.

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 re-gridded 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 ASAR scenes are calibrated using NEST (http://nest.array.ca/web/nest). Wind speed is retrieved using CMOD5 and wind directions from the atmospheric meso.-scale model HIRLAM. The files contain normalized radar backscatter and wind speed from SAR, wind speed and wind direction from HIRLAM and normalized backscatter from HIRLAM assuming SAR geometry. The file name convention for these files are listed in Table 4.

5.5 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 re-gridded 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]. The file name convention for these files are listed in Table 4.

5.6 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.

5.7 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.

5.8 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 re-gridded to the 2km STARS-DAT grid. For the regridding of the HIRLAM files the Fimex software has been used, using bilinear 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 the air potential temperature, relative humidity and geopotential height are collected for the pressure levels at 1000, 925, 850, 700 and 500 hPa. At sea level, the surface pressure, precipitation, wind, sea surface temperature (SST) and surface roughness are collected for STARS-DAT. The data is collected every third hour at 00, 03, 06, 09, 12, 15, 18, 21 and 24 UTC, except SST which are collected at 00 and 12 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.

5.9 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.

5.10 File name conventions

In Table 4, the file name convention is given for all data types in STARS-DAT.

Data source	File name convention
Aqua EOS AMSR-E SST	<YYYYMMDD>-AMSRE-REMSS-L2P-amsr_l2b_v05_rXXXXX.dat-v01.nc 20070410-AMSRE-REMSS-L2P-amsr_l2b_v05_r26239.dat-v01.nc
METOP AVHRR SST	<YYYYMMDD>-EUR-L2P_GHRSST-SSTsubskin-AVHRR_METOP_A-eumetsat_sstmgr_metop02_<YYYYMMDD>_<HHMISS>-v01.7-fv01.0.nc 20090410-EUR-L2P_GHRSST-SSTsubskin-AVHRR_METOP_A-eumetsat_sstmgr_metop02_20090410_100103-v01.7-fv01.0.nc
AATSR SST	<YYYYMMDD>-ATS_NR_2P-EUR-L2P-ATS_NR__2PNPDE<YYYYMMDD>_<HHMISS>_XXXXXXXXXXXX_XXXXX_XXXXX_XXXX.N1-v01.nc 20070410-ATS_NR_2P-EUR-L2P-ATS_NR__2PNPDE20070410_204758_000066812057_00114_26721_6738.N1-v01.nc

Aqua/Terra EOS MODIS SST	<YYYYMMDD>-MODIS_A-JPL-L2P-A<YYYYMMDDHHMI>.L2_LAC_GHRSST-v01.nc 20070410-MODIS_A-JPL-L2P-A2007100010000.L2_LAC_GHRSST-v01.nc
NOAA-17/18 AVHRR LAC/GAC SST	<YYYYMMDD>-AVHRR17_G-NAVO-L2P-SST_s<HHMI1>_e<HHMI2>-v01.nc eg. 20070410-AVHRR17_G-NAVO-L2P-SST_s0838_e1033-v01.nc
GLOBWAVE ENVISAT wave height	GW_L2P_ALT_ENVI_GDR_<YYYYMMDD_HHMI1SS_YYYYMMDD_HHMI2SS_cycle_orbit>.nc eg. GW_L2P_ALT_ENVI_GDR_20071001_065908_20071001_074925_062_092.nc
GLOBWAVE GFO wave height	GW_L2P_ALT_GFO_GDR_<YYYYMMDD_HHMI1SS_YYYYMMDD_HHMI2SS_cycle_orbit>.nc eg. GW_L2P_ALT_GFO_GDR_20071001_065908_20071001_074925_062_092.nc
ENVISAT along-track SLA	gridded_dt_upd_global_en_sla_vfec_<YYYYMMDDHHMI1>-<YYYYMMDDHHMI2>.nc eg. gridded_dt_upd_global_en_sla_vfec_200704100000-200704102359.nc
GFO along-track SLA	gridded_dt_upd_global_g2_sla_vfec_<YYYYMMDDHHMI1>-<YYYYMMDDHHMI2>.nc eg. gridded_dt_upd_global_g2_sla_vfec_200704100000-200704102359.nc
METOP ASCAT wind vector	ascat_<YYYYMMDD>_<HHMISS>_metopa_XXXXX_eps_t_250_0100_ovw.l2.nc eg. ascat_20070410_063602_metopa_02452_eps_t_250_0100_ovw.l2.nc
QuikSCAT Seawinds wind vector	QS025_D<YYJJJ>_S<HHMI1>_E<HHMI2>_BXXXXXXX.nc eg. QS025_D09087_S0032_E0210_B5107475.nc
Aqua EOS AMSR-E wind speed	<YYYYMMDD>-AMSRE-REMSS-L2P-amsr_l2b_v05_rXXXXX.dat-v01.nc 20070410-AMSRE-REMSS-L2P-amsr_l2b_v05_r26239.dat-v01.
ASAR	SAR_wind_gridded_<YYYYMMDD>_<HHMI>.nc e.g. SAR_wind_gridded_20100215_2038.nc
OSI SAF Sea Ice Concentration	ice_conc_nh_polstere-020_multi_<YYYYMMDDHHMI>.nc eg. ice_conc_nh_polstere-020_multi_200912301200.nc
NOAA AVHRR VIS/IR images	noaa<YYYYMMDDHHMI>mne.mitiff eg. noaa200611051546mne.mitiff
GTS synop, buoy and ship	syno_<YYYYMMDDHHMI>.txt drau_<YYYYMMDDHHMI>.txt eg. syno_200910281200.txt, drau_200910281200.txt

HIRLAM	h20pl00_<YYYYMMDD>.nc for 00UTC forecast 00-12UTC. h20pl12_<YYYYMMDD>.nc for 12UTC forecast 12-24UTC. h12pl00_<YYYYMMDD>.nc for 00UTC forecast 00-12UTC. h12pl12_<YYYYMMDD>.nc for 12UTC forecast 12-24UTC. h12sf00_<YYYYMMDD>.nc for 00UTC forecast 00-12UTC. h20 is the 20km HIRLAM model, h12 the 12km model.
Polar Low Indicator	pli_h20pl00_<YYYYMMDD>.nc pli_h12pl00_<YYYYMMDD>.nc 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 7. Figure 8 and Figure 9 show the SAR backscatter and wind speed for case 25. The track of the polar low event is shown in Figure 10. 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 11. Different SST plots are shown in Figure 12 to Figure 15, and illustrates how the SST in this case was reduced along most of the polar low track as it passed. In Figure 16 to Figure 18, 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 19 the difference between SST and air temperature at 500hPa, also called atmospheric heat content, is calculated to be used as 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.

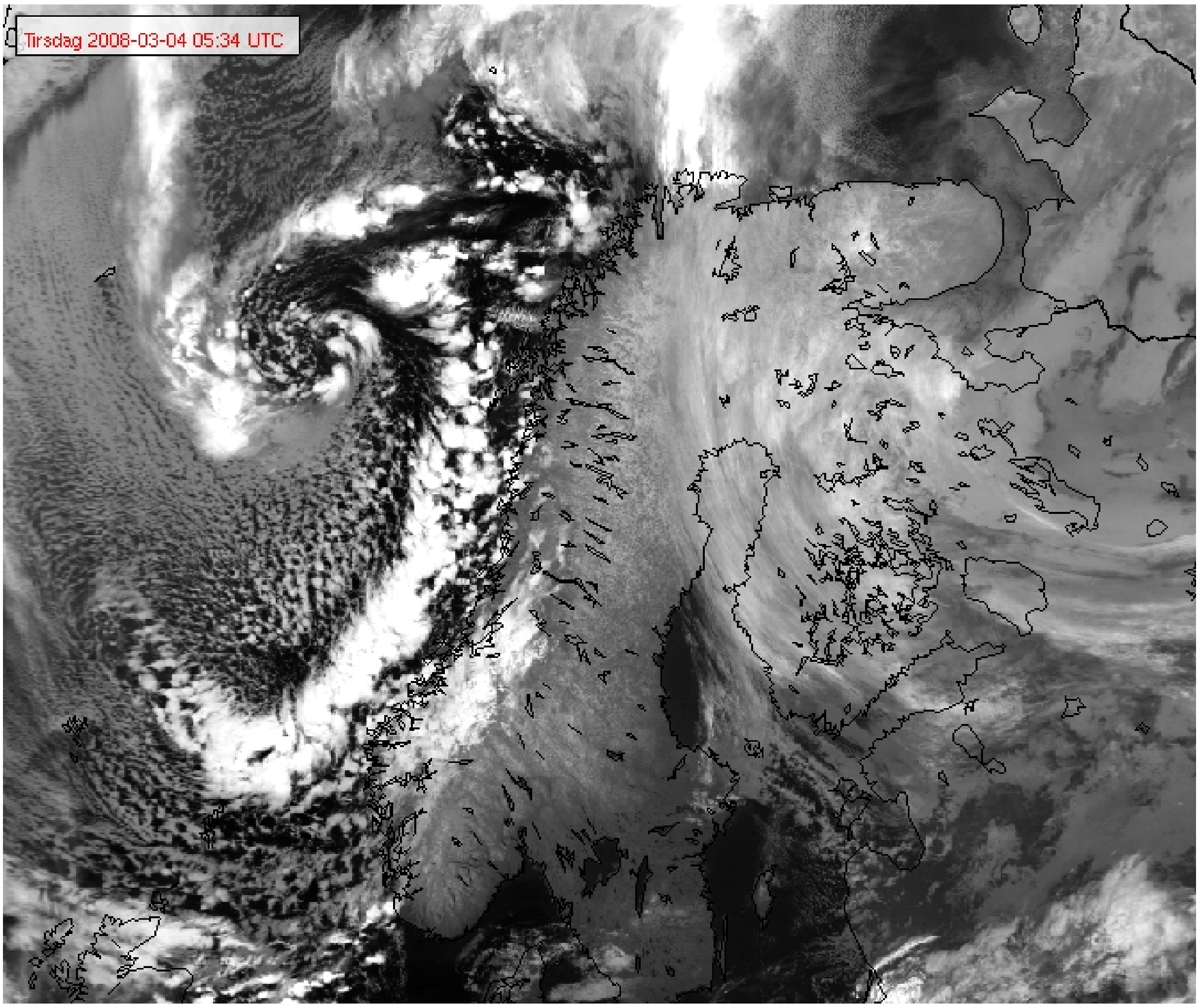

Figure 7: AVHRR IR image of polar low event 25, from 2008 -03-04 05:34 UTC.

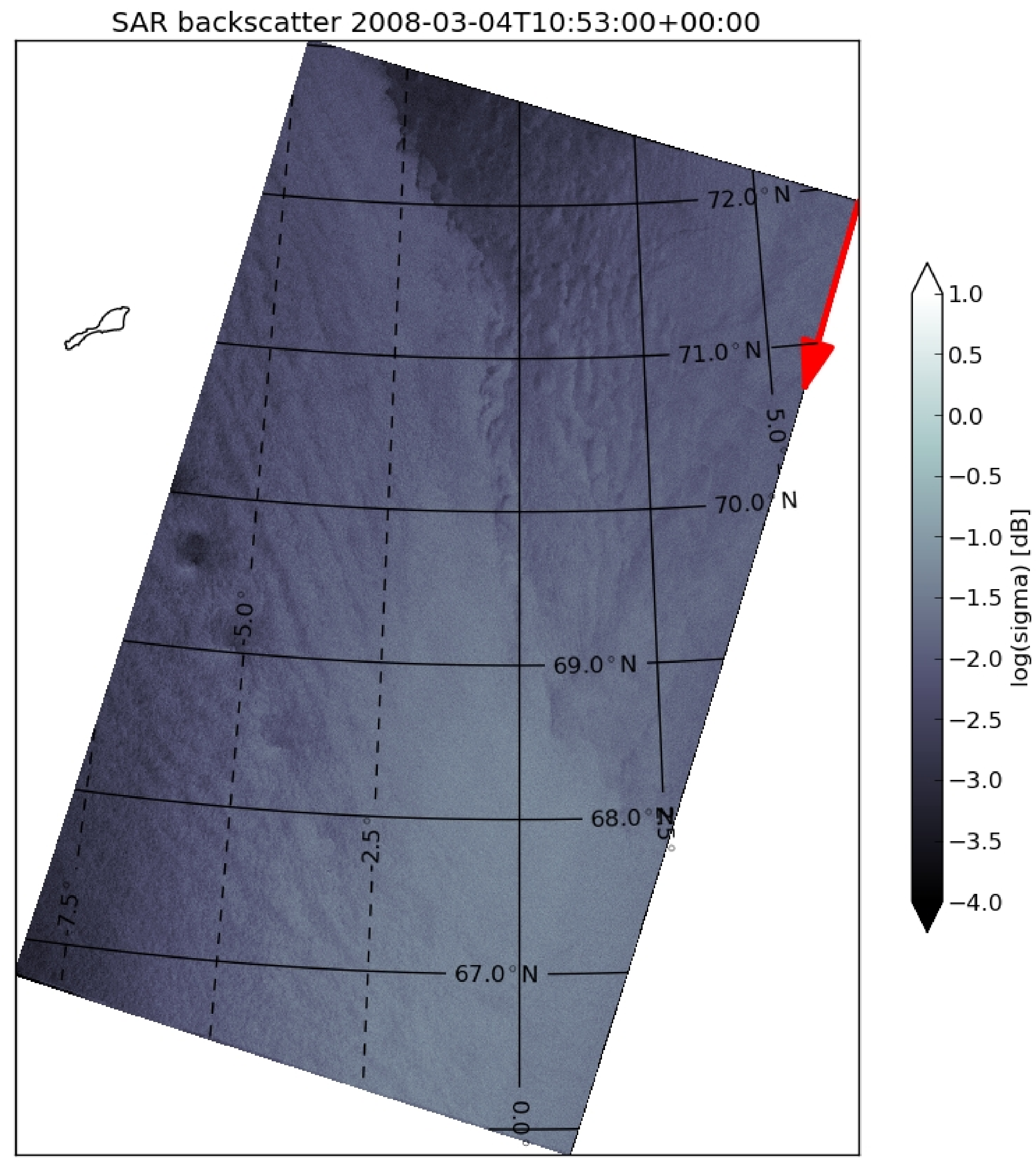

Figure 8: SAR backscatter for polar low case 25.

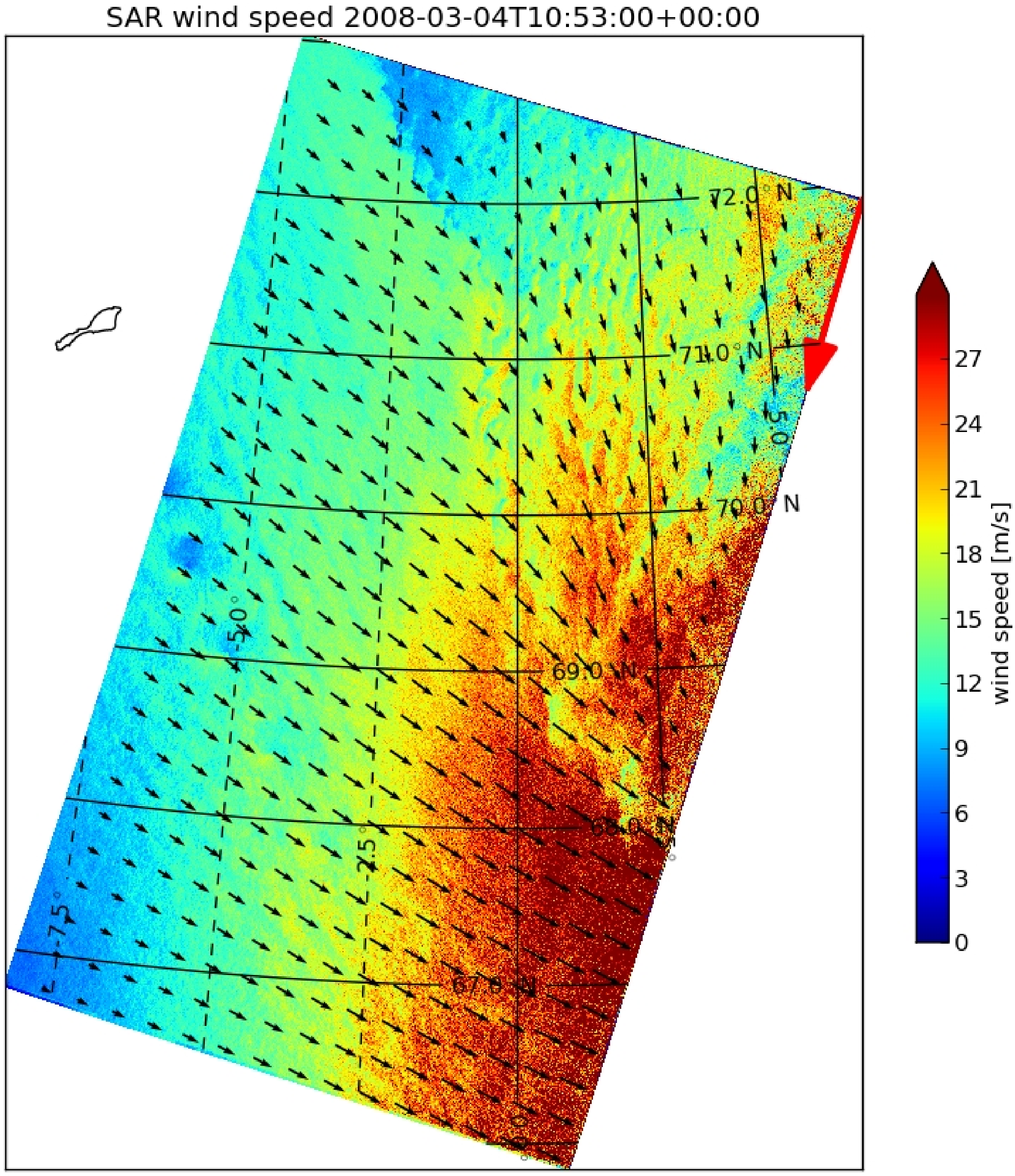

Figure 9: SAR wind speed for polar low case 25.

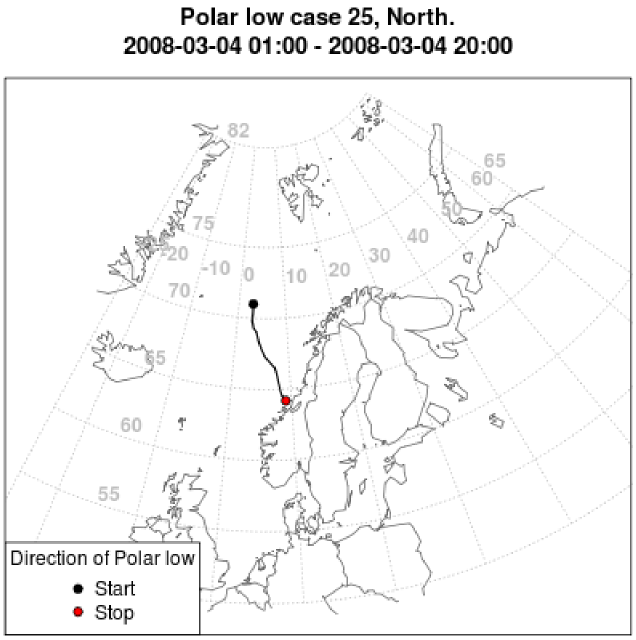

Figure 10: Track of polar low event 25 from start to end (4. March 2008 01 UTC to 4. March 2008 20 UTC).

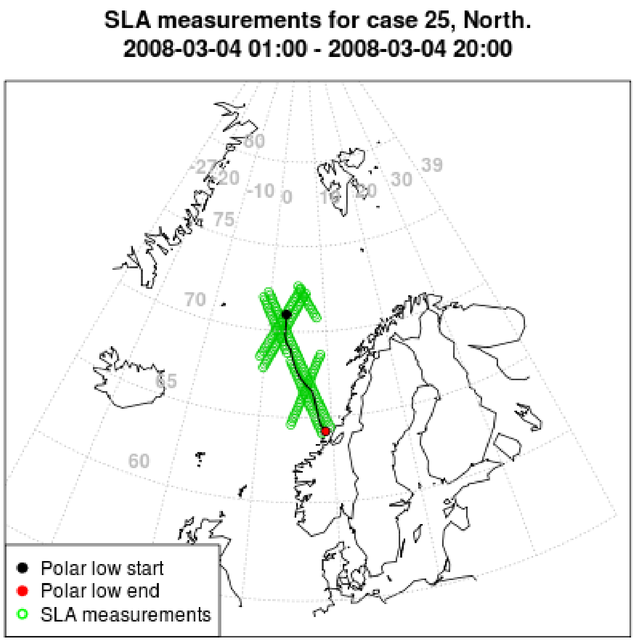

Figure 11: Track of all measurements in vicinity of polar low event 25.

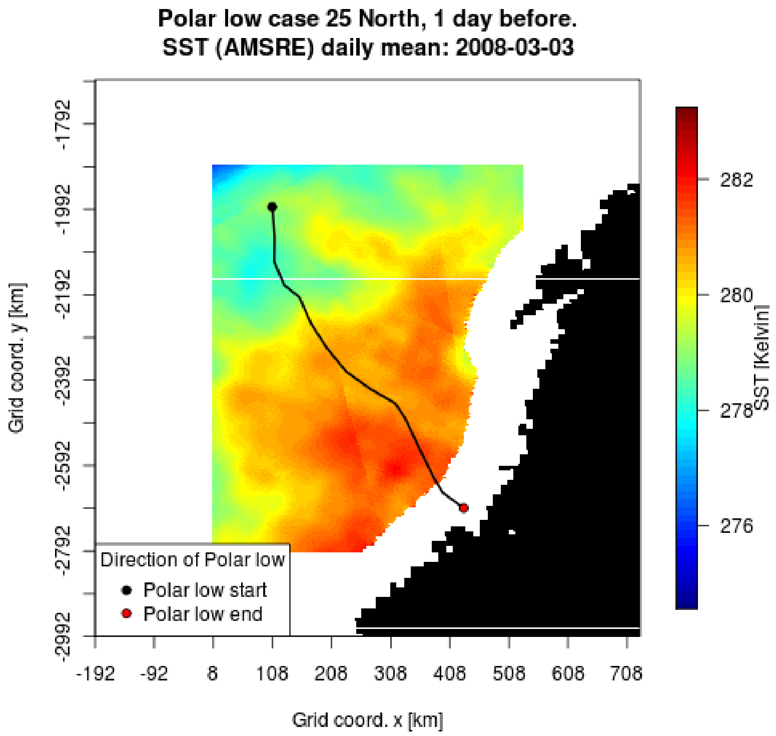

Figure 12: Daily mean AMSR-E SST one day before polar low event 25.

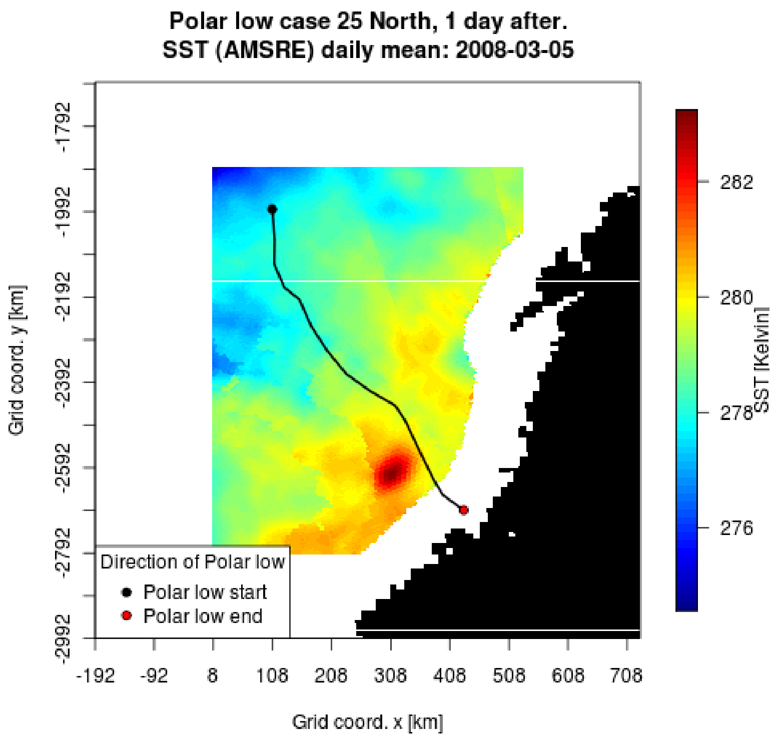

Figure 13: Daily mean AMSR-E SST one day after polar low event 25.

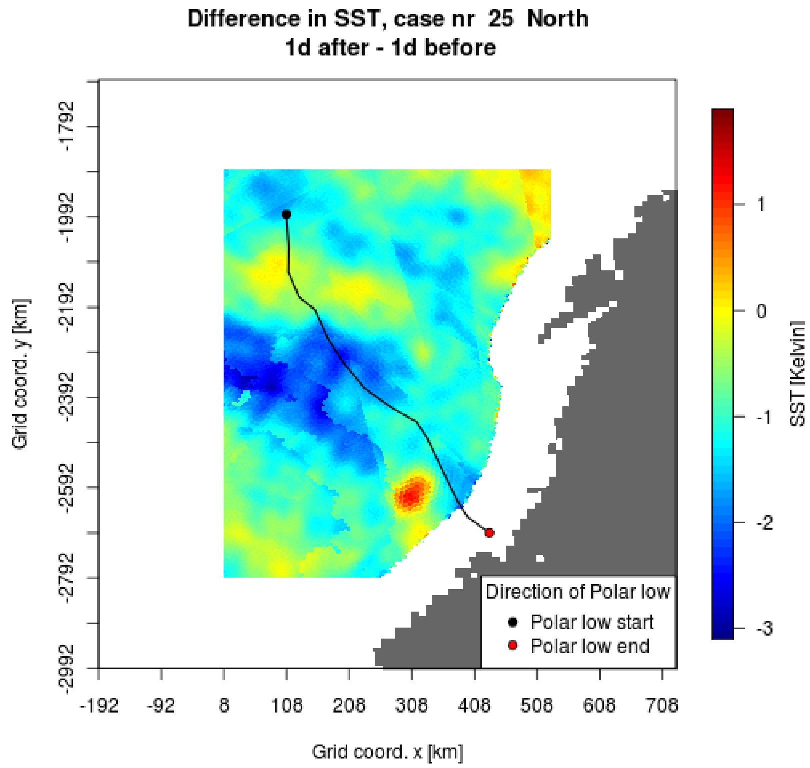

Figure 14: Difference in daily mean AMSR-E SST (one day after – one day before) for polar low event 25.

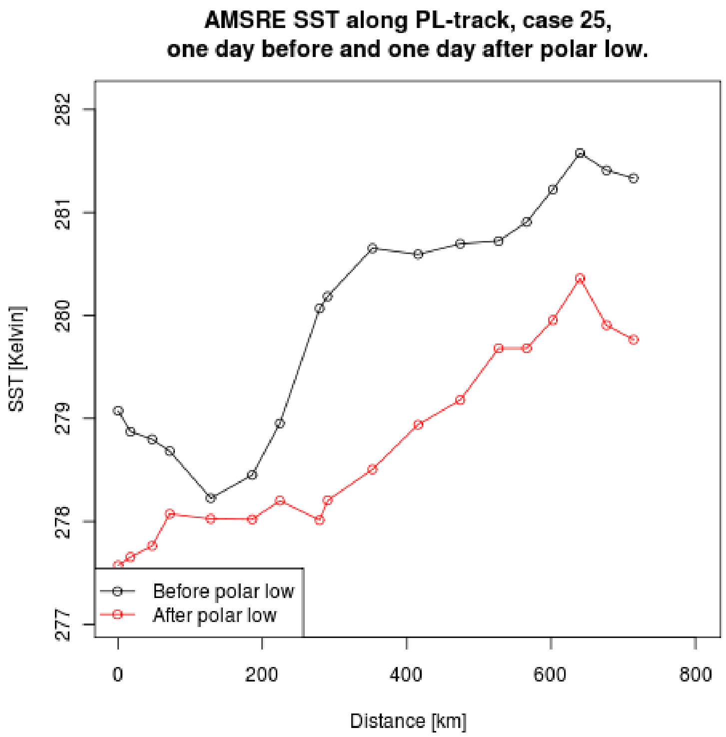

Figure 15: AMSR-E SST along polar low track for event 25. In black one day before polar low, in red one day after polar low event.

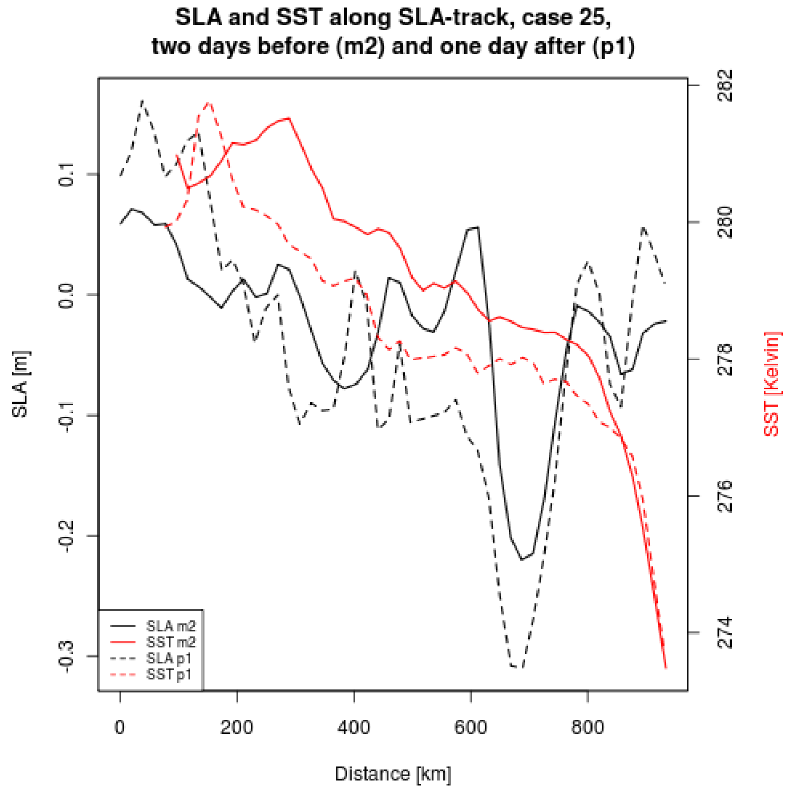

Figure 16: SLA and SST along SLA track for polar low event 25. In black is SLA, in red is SST. Solid line 2 days before event, dotted 1 day after.

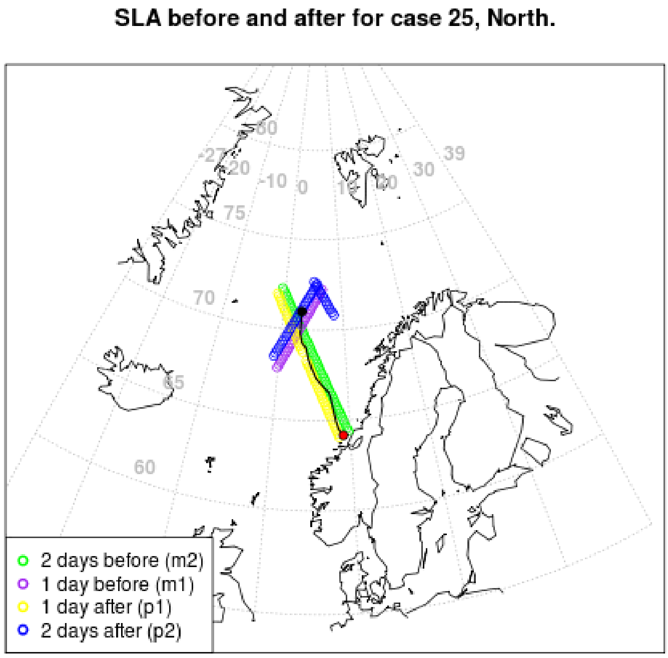

Figure 17: Shows which SLA tracks are plotted.

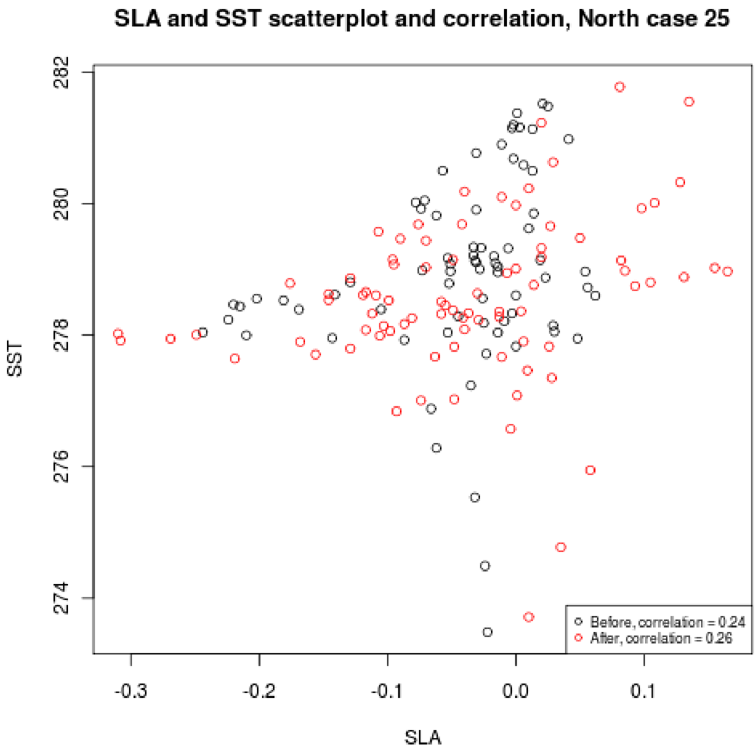

Figure 18: Correlation between SLA and SST observations for polar low event 25.

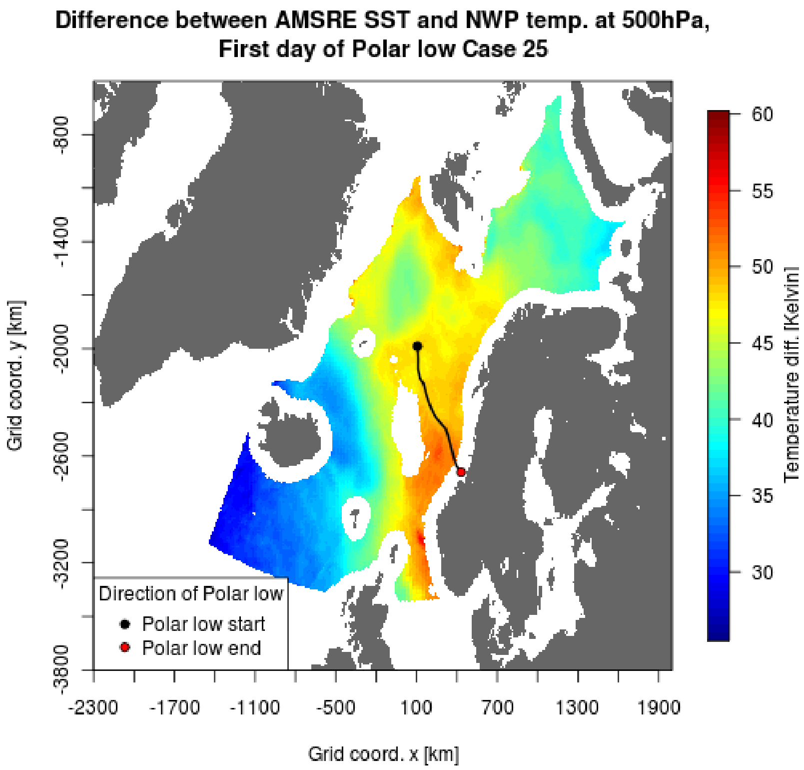

Figure 19: Difference between daily mean AMSR-E SST and HIRLAM air temperature at 500hPa, also referred to as atmospheric heat potential, for polar low event 25.

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.

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 wave height data

The data are made available on the ftp server : ftp://eftp.ifremer.fr/waveuser/globwave/data/ . To obtain login details, send an email to CERSAT help desk: fpaf@ifremer.fr. More information is available at: http://www.globwave.org/Products/GlobWave-Satellite-Data.

8.5 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.
The ASAR data can be added to the data set by ordering ASAR scenes from Eoli-SA. (http://earth.esa.int/EOLIResources/Manual/html/frame.html). User registration is requested for accessing the data. For each polar low, all WSM, GM and IM scenes are ordered. The wide swath images are calibrated using NEST (http://nest.array.ca/web/nest).
Wind speed is retrieved using CMOD5 and wind directions from the atmospheric meso.-scale model HIRLAM.

8.6 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.

8.7 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.

8.8 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.

8.9 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).

8.10 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. The first table is for the Norwegian Sea and Barents Sea and covers the period 2002.02 – 2011.04, the second table covers the area between South Greenland and United Kingdom for the period 2006.01 – 2010..

Polar low ID	***Start time***	***End time***	***Start position***	***End position***
1	2002-01-12 01UTC	2002-01-12 16UTC	74.54N 28.01E	72.74N 46.36E
2	2002-01-19 01UTC	2002-01-19 06UTC	71.00N 46.07E	69.21N 49.22E
3	2002-01-22 10UTC	2002-01-22 12UTC	74.72 N 28.06E	74.77N 25.95E
4	2002-01-23 12UTC	2002-01-23 13UTC	70.23N 16.84E	69.90N 16.04E
5	2002-01-26 03UTC	2002-01-27 08UTC	72.09N 14.99E	76.34N 5.99W
6	2002-02-19 09UTC	2002-02-19 16UTC	74.28N 35.70E	73.50N 34.50E
7	2002-02-22 00UTC	2002-02-22 08UTC	74.04N 32.80E	76.27N 31.26E
8	2002-02-22 00UTC	2002-02-22 08UTC	75.70N 30.50E	76.52N 19.21E
9	2002-02-23 10UTC	2002-02-24 02UTC	68.50N 5.70E	66.10N 11.90E
10	2002-03-01 12UTC	2002-03-02 00UTC	68.80N 10.10E	69.10N 15.06E
11	2002-03-09 11UTC	2002-03-10 09UTC	69.84N 4.08W	65.60 N -1.50W
12	2002-05-20 14UTC	2002-05-20 16UTC	73.25N 16.25E	72.77 N 16.58E
13	2002-12-20 12UTC	2002-12-20 18UTC	68.31N 11.25E	66.52 N 13.18E
14	2002-12-31 11UTC	No tracks	73.00N 38.00E	No tracks
15	2003-01-16 16UTC	2003-01-17 02UTC	71.79N 5.86E	69.70N 5.40E
16	2003-01-17 00UTC	2003-01-17 11UTC	73.20N 25.60E	71.71N 28.49E
17	2003-01-17 12UTC	2003-01-17 18UTC	72.43N 28.91E	71.40N 26.80E
18	2003-01-23 14UTC	2003-01-23 20UTC	73.30N 10.00E	71.50N 17.49E
19	2003-01-29 08UTC	2003-01-30 11UTC	73.17N 0.81E	63.82N 5.20E
20	2003-03-11 00UTC	2003-03-11 07UTC	72.10N 16.70E	71.00N 21.30E
21	2003-03-23 03UTC	2003-03-24 07UTC	68.70N 10.70W	71.60N 20.20E
22	2003-10-24 07UTC	2003-10-24 10UTC	71.15N 18.56E	69.80N 17.60E
23	2003-12-05 12UTC	2003-12-05 18UTC	72.16N 14.40E	69.20N 15.05E
24	2003-12-08 13UTC	2003-12-08 17UTC	70.88N 31.30E	69.80N 33.10E
25	2003-12-17 12UTC	2003-12-17 16UTC	72.40N 39.10E	73.20N 45.40E
26	2003-12-27 09UTC	2003-12-27 15UTC	73.30N 18.90E	72.60N 15.72E
27	2003-12-29 12UTC	2003-12-29 18UTC	69.00N 12.90E	68.00N 12.80E
28	2004-01-27 10UTC	2004-01-28 13UTC	72.00N 12.88E	58.90N 1.60W
29	2004-01-28 02UTC	2004-01-29 02UTC	69.82N 3.08E	55.60N 4.10E
30	2004-01-30 08UTC	2004-01-30 16UTC	69.88N 5.22W	68.70N 9.00W
31	2004-02-06 13UTC	2004-02-06 21UTC	70.76N 12.57E	69.80N 16.38E
32	2004-02-21 11UTC	2004-02-22 04UTC	68.25N 2.01W	64.10N 9.85E
33	2004-03-01 12UTC	2004-03-01 19UTC	70.00N 6.70E	68.70N 10.80E
34	2004-03-27 12UTC	No tracks	65.00N 5.00E	No tracks
35	2004-03-30 18UTC	No tracks	69.00N 9.00E	No tracks
36	2004-11-15 14UTC	2004-11-16 08UTC	69.67N 0.43E	63.81N 9.18E
37	2004-11-16 01UTC	2004-11-16 04UTC	69.10N 15.20E	68.50N 17.40E
38	2004-11-16 16UTC	2004-11-17 01UTC	69.60N 37.70E	68.42N 36.32E
39	2004-11-18 03UTC	2004-11-18 15UTC	74.17N 43.99E	74.30N 25.28E
40	2004-11-23 10UTC	2004-11-23 11UTC	71.90N 47.00E	72.00N 48.10E
41	2004-12-10 17UTC	2004-12-11 12UTC	63.46N 3.65W	65.80N 6.38E
42	2004-12-18 07UTC	2004-12-19 02UTC	70.20N 6.40E	66.70N 12.90E

43	2005-01-13 17UTC	2005-01-14 02UTC	68.10N 7.17E	66.20N 11.10E
44	2005-01-18 16UTC	2005-01-19 06UTC	72.30N 0.80W	71.00N 5.50W
45	2005-01-23 03UTC	2005-01-23 18UTC	69.50N 10.90E	66.80N 14.40E
46	2005-02-27 03UTC	2005-02-27 07UTC	69.70N 38.70E	69.00N 37.10E
47	2005-03-01 11UTC	2005-03-01 20UTC	74.20N 37.60E	75.20N 31.54E
48	2005-03-07 06UTC	2005-03-07 09UTC	72.60N 19.70E	71.60N 18.80E
49	2005-03-15 09UTC	2005-03-16 02UTC	63.80N 4.60E	66.00N 12.70E
50	2005-03-17 02UTC	2005-03-17 12UTC	72.00N 47.94E	71.40N 41.80E
51	2005-04-02 10UTC	2005-04-03 03UTC	74.74N 25.36E	70.69N 35.33E
52	2005-04-26 17UTC	2005-04-27 09UTC	74.00N 25.10E	72.11N 44.64E
53	2005-10-12 06UTC	2005-10-12 19UTC	76.00N 0.10W	77.56N 13.33E
54	2005-11-23 14UTC	2005-11-24 03UTC	71.60N 14.60E	72.23N 36.20E
55	2005-11-23 18UTC	2005-11-24 03UTC	69.70N 9.30E	70.74N 20.07E
56	2005-11-29 17UTC	2005-11- 29 21UTC	66.04N 4.35E	64.33N 5.87E
57	2005-12-19 03UTC	No Tracks	West Finnmark	No tracks
58	2006-01-29 15UTC	2006-01-30 02UTC	76.11N 20.83E	73.63N 28.12E
59	2006-03-06 14UTC	2006-03-06 21UTC	68.60N 11.10E	68.80N 13.80E
60	2006-03-20 14UTC	2006-03-22 07UTC	71.36N 02.75E	62.75N 05.46E
61	2006-10-29 11UTC	2006-10-29 22UTC	71.70N 16.20E	70.00N 18.00E
62	2006-11-01 19UTC	2006-11-02 04UTC	75.18N 20.95E	74.60N 24.00E
63	2006-11-08 14UTC	2006-11-08 23UTC	63.53N 08.23W	63.10N 02.00W
64	2006-12-22 12UTC	2006-12-22 16UTC	71.80N 16.60E	70.90N 21.60E
65	2006-12-26 03UTC	2006-12-26-18UTC	72.40N 14.80E	75.50N 29.20E
66	2007-01-21 05UTC	2007-01-22 17UTC	72.70N 41.50E	68.57N 43.26E
67	2007-01-22 14UTC	2007-01-23 17UTC	76.20N 04.40E	71.11N 06.80E
68	2007-01-26 04UTC	2007-01-26 09UTC	70.60N 14.50E	69.07N 15.44E
69	2007-01-27 01UTC	2007-01-27 07UTC	75.54N 38.16E	75.98N 41.60E
70	2007-02-05 01UTC	2007-02-05 04UTC	64.75N 09.46E	64.03N 09.99E
71	2007-02-13 06UTC	2007-02-13 09UTC	71.25N 22.90E	70.80N 22.20E
72	2007-04-06 00UTC	2007-04-06 20UTC	73.40N 12.00E	68.00N 15.10E
73	2007-04-29 01UTC	2007-04-29 02UTC	71.10N 29.70E	70.80N 29.60E
74	2007-09-03 04UTC	2007-09-03 05UTC	64.00N 06.40E	64.00N 04.00E
75	2007-12-11 18UTC	2007-12-11 19UTC	70.40N 31.70E	70.40N 31.90E
76	2008-01-25 13UTC	2008-01-25 21UTC	67.28N 05.26E	67.70N 11.10E
77	2008-01-31 04UTC	2008-01-31 17UTC	73.92N 10.98E	71.00N 11.10E
78	2008-02-14 23UTC	2008-02-15 01UTC	69.80N 38.20E	69.20N 36.50E
79	2008-02-29 11UTC	2008-02-29 16UTC	73.70N 23.90E	73.98N 23.86E
80	2008-03-02 21UTC	2008-03-02 21UTC	75.00N 09.00E	75.00N 09.00E
81	2008-03-02 21UTC	2008-03-03 09UTC	69.20N 11.10E	68.00N 12.70E
82	2008-03-04 01UTC	2008-03-04 20UTC	71.00N 03.10E	64.17N 09.11E
83	2008-03-16 09UTC	2008-03-17 11UTC	71.75N 12.03E	64.50N 07.30E
84	2008-03-18 15UTC	2008-03-20 14UTC	73.50N 28.40E	72.53N 50.07E
85	2008-03-20 07UTC	2008-03-20 14UTC	72.00N 43.27E	72.40N 50.15E
86	2008-04-04 01UTC	2008-04-04 20UTC	72.00N 01.00E	70.69N 01.29W

87	2008-04-24 12UTC	2008-04-24 13UTC	71.00N 41.00E	70.30N 41.90E
88	2008-10-27 20UTC	2008-10-27 22UTC	66.70N 04.70W	65.60N 04.40W
89	2008-11-17 07UTC	2008-11-17 16UTC	74.70N 25.90E	75.60N 27.20E
90	2008-11-18 02UTC	2008-11-18 20UTC	75.30N 02.00E	73.00N 00.83E
91	2008-11-18 20UTC	2008-11-19 10UTC	71.00N 14.00E	70.20N 15.30E
92	2008-11-20 06UTC	2008-11-20 20UTC	69.00N 08.00E	65.60N 11.00E
93	2008-11-28 08UTC	2008-11-28 22UTC	69.80N 01.30E	66.30N 06.10W
94	2008-11-29 19UTC	2008-11-30 01UTC	73.50N 00.80W	73.50N 06.73W
95	2008-12-30 11UTC	2008-12-30 18UTC	72.50N 32.50E	70.50N 41.30E
96	2009-01-07 03UTC	2009-01-07 10UTC	71.90N 29.20E	71.20N 28.00E
97	2009-01-16 12UTC	2009-01-16 17UTC	71.00N 57.00E	70.50N 63.44E
98	2009-02-05 03UTC	2009-02-05 13UTC	71.44N 02.67W	68.58N 06.26W
99	2009-02-05 18UTC	2009-02-06 08UTC	69.60N 39.30E	67.60N 43.40E
100	2009-02-07 17UTC	2009-02-08 07UTC	72.50N 43.20E	73.80N 43.80E
101	2009-02-26 18UTC	2009-02-27 11UTC	70.60N 12.90E	66.72N 10.88E
102	2009-02-27 18UTC	2009-02-28 11UTC	72.40N 32.50E	71.30N 38.30E
103	2009-03-27 22UTC	2009-03-28 18UTC	68.90N 04.60W	68.70N 08.50E
104	2009-04-02 09UTC	2009-04-02 15UTC	73.00N 35.30E	71.80N 35.20E
105	2009-04-05 01UTC	2009-04-05 09UTC	71.79N 43.32E	69.90N 45.60E
106	2009-04-05 07UTC	2009-04-05 19UTC	72.10N 24.70E	69.50N 34.90E
107	2010-01-08 11UTC	2010-01-08 15UTC	80.70N 15.10E	80.80N 20.00E
108	2010-01-29 17UTC	2010-01-29 22UTC	67.95N 08.10E	67.20N 08.30E
109	2010-01-30 19UTC	2010-01-30 21UTC	61.69N 4.20E	61.11N 4.80E
110	2010-02-02 16UTC	2010-02-02 21UTC	61.20N 1.60E	59.62N 1.98E
111	2010-02-16 10UTC	2010-02-16 16UTC	71.10N 3.63E	70.60N 0.50W
112	2010-02-23 18UTC	2010-02-23 21UTC	67.30N 16.80W	66.71N 17.50W
113	2010-03-02 09UTC	2010-03-02 14UTC	63.43N 4.25E	62.50N 6.00E
114	2010-03-04 18UTC	2010-03-05 08UTC	73.30N 41.90E	73.55N 46.35E
115	2010-03-10 16UTC	2010-03-11 07UTC	76.10N 41.20E	78.30N 33.00E
116	2010-03-12 12UTC	2010-03-13 08UTC	72.10N 18.90E	69.50N 15.90E
117	2010-03-14 12UTC	2010-03-15 13UTC	72.46N 15.69E	67.10N 14.00E
118	2010-03-19 13UTC	2010-03-19 15UTC	74.50N 20.47E	74.50N 21.40E
119	2010-03-21 03UTC	2010-03-21 06UTC	67.30N 12.10E	67.30N 14.29E
120	2010-03-24 18UTC	2010-03-25 10UTC	72.30N 7.50E	72.40N 21.00E
121	2010-03-27 00UTC	2010-03-27 09UTC	72.70N 20.00E	71.10N 17.30E
122	2010-04-23 08UTC	2010-04-23 19UTC	71.60N 3.20E	71.38N 1.35W
123	2010-05-31 18UTC	No Tracks	70.30N 19.30E	No tracks
124	2010-10-11 12UTC	2010-10-11 17UTC	73.09N 16.10E	70.23N 17.81E
125	2010-10-19 06UTC	2010-10-19 12UTC	73.00N 6.10E	71.80N 10.10E
126	2010-11-07 13UTC	2010-11-08 02UTC	71.89N 15.61E	70.12N 18.46E
127	2010-11-09 09UTC	2010-11-09 17UTC	73.30N 23.30E	73.21N 32.34E
128	2010-11-25 02UTC	2010-11-25 09UTC	71.00N 4.10E	67.92N 1.10E
129	2011-01-13 16UTC	2011-01-15 06UTC	70.50N 0.80E	75.30N 10.10E
130	2011-01-29 03UTC	2011-01-29 21UTC	71.20N 0.09W	69.40N 15.90E

131	2011-01-30 02UTC	2011-01-31 02UTC	74.10N 32.60E	70.88N 45.91E
132	2011-02-06 20UTC	2011-02-08 00 UTC	64.33N 8.67W	68.20N 15.19E
133	2011-02-10 18UTC	2011-02-11 12UTC	71.20N 28.70E	69.50N 34.20E
134	2011-03-11 06UTC	2011-03-12 10UTC	67.90N 0.20W	65.15N 11.39E
135	2011-03-13 10UTC	2011-03-13 18UTC	66.20N 8.15E	68.00N 15.20E
136	2011-03-20 10UTC	2011-03-21 10UTC	74.00N 4.60W	75.80N 19.40E
137	2011-03-22 13UTC	2011-03-22 18UTC	72.86N 23.84E	70.90N 27.90E
138	2011-03-22 03UTC	2011-03-23 14UTC	69.10N 15.30W	70.80N 21.80E
139	2011-03-24 06UTC	2011-03-24 14UTC	70.80N 15.00E	70.60N 21.40E
140	2011-03-31 07UTC	2011-03-31 16UTC	70.89N 33.77E	70.10N 40.27E

Table 5: List of Polar Lows in the north-east part of the North Atlantic for 2002.01-2011.04.

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.