Building the STARS data set

Implementation:

Technical and scientific requirement:

Data description:

Table 1: Data to be collected for STARS-DAT, covering the winter seasons from 2005 to 2009.

Dataset	Where to access	Restriction on access/use
SST L2P	GHRSST LTSRF (http://ghrsst.nodc.noaa.gov)	Freely available
SLA from Envisat and GFO, gridded and along-track data	AVISO http://www.aviso.oceanobs.com	Freely available
SLA from ERS-2, Gridded and along-track data	ESA, availability to be confirmed by ESA	met.no is Cat-1 user
Wind vector from QuikScat and ASCAT	OSI SAF	Freely available, met.no is partner in OSI SAF
Wind speed and water vapor from AMSR-E	RSS http://www.remss.com	Freely available
AVHRR VIS/IR images	Locally received data, available in local archive	No restrictions
In situ meteorological data (synop,buoy,ship)	Locally received data through GTS, available in local archive	No restrictions
In situ sub surface data (XBT, ARGO gliders etc)	Coriolis (http://www.coriolis.eu.org); Institute of Marine Research (http://www.imr.no)	Coriolis: Freely available IMR: Available through cooperation agreement
NWP model runs	ECMWF: MARS archive HIRLAM: local archive	ECMWF: met.no is national member, has free access.
Observational data from IPY campaigns	IPY database is hosted by met.no	Freely available

SST L2P : Strength: Common format, several satellites

SLA: Weakness: limited coverage

Wind scatterometer: Strength: Good cooperation with data provider

Strength ASCAT: collocated in time with Metop SST. Weakness ASCAT: no nadir coverage

AVHRR VIS/IR: Strength: In-house availability.

HIRLAM NWP: Strength: Locally produced.

In situ meteorological data: Strength: In-house availability. Weakness: Few observations over ocean areas.

In situ sub-surface data: Strength: Strength: Provide daily temperature analyses for the Nordic Seas. Weakness: mainly based on ARGO boys with relatively few observations for the North Atlantic

Observational data from IPY campaigns: Very good coverage for the particular cases observed. Weakness: Limited number of cases.

Identify and catalogue polar lows in the STARS data set

This activity is carried out under Task 4 according to the STARS Technical proposal.

Implementation:

In this activity, polar lows will be catalogued whenever the observed phenomena fulfills the requirements of the following definition:

"A polar low is a small, but fairly intense maritime cyclone that forms poleward of the main baroclinic zone (the polar front or other major baroclinic zone). The horizontal scale of the polar low is approximately between 200 and 1000 kilometers and surface winds near or above gale force".

This work will be carried out in three phases. First, infrared satellite images will be inspected manually and all events with cloud structure that looks like meso-scale cyclone activity during the full STARS data period will be noted down. The list will be reinspected by and discussed by the scientists in the STARS project and also with forecasters to sort out events that are considered too weak or other meso-scale activities that do not fall within the definition of polar lows given above. A reviewed list where short list where only polar lows according to the definition is listed is produced. In the second phase, tracks of the polar lows are listed with latitudes and longitudes of each polar low in the list. In the third phase, the polar lows are characterized according to:

- Cloud structure (comma cloud, marry go round etc.).
- Max wind speed observed by satellite scatterometer. In cases where scaterometer is not available, the intensity will be estimated by synoptic wind observations from coastal stations and form meteorological analyses.

During each polar low event listed in the STAR catalogue, the SSH response will be will be correlated to any possible responses in microwave satellite observations

Technical and scientific requirement:

The requirement of this task is scatterometer, infrared and in-situ meteorological observations in the STARS

Data description:

All data used in this task is described under Task 3, STARS data set

Creating a Polar-Low Indicator (PLI)

This activity is carried out under Task 5 according to the STARS Technical proposal.

Implementation:

For each of the polar low events detected in the STARS data under Task 4, the temperature difference between the upper tropospheric temperature (500 and 700 hPa) and the Sea Surface temperature will be estimated. The upper tropospheric temperature will be estimated from meteorological analyses where radio soundings and satellite data have been assimilated. The SST will be estimated form a combination of infrared and microwave satellite data. In the first part of the analyses a threshold value will be established by determining the minimum observed temperature difference along the tracks in the first half of STARS list of polar low events. The second half of the list will then be used to verify the polar low indicator, correlate the temperature difference with the estimated storm intensity found in Task 4 and to estimate the potential numbers of false alarms.

Technical and scientific requirement:

The polar low list produced under Task4

Meteorological analyses collected in the STARS data set

Infrared, microwave and SLA data in the STARS data set

Data description:

The coupled NS-Model

This activity is carried out under Task 7, 8 and 9 according to the STARS Technical proposal.

Implementation:

The model components to be used in the coupled Nordic Sea Model (NS-MODEL) are the ROMS ocean model (Shchepetkin and McWilliams, 2005), with either existing ice code (Budgell, 2005) or CICE (Hunke and Lipscomb, 2008), and the HIRLAM atmosphere model (Undén et al, 2002). The ROMS with the ice code of Budgell and HIRLAM are currently operational at met.no. The CICE model has been tested but are not operational. The coupling of NS-MODEL will be facilitated with the Model Coupling Toolkit (MCT, Larson et al., 2005; Jacob et al., 2005).

There are several different tools that have been used when building coupled models. In Europe, the OASIS3 and OASIS4 (Redler et al 2010) systems has been widely used, while in the U.S., several institutions work towards the ESMF system. The OASIS4 system is a fairly complete library with grid interpolation, communication, etc, but are still in a beta test phase. The ESMF is more a suite of software tools for building multicomponent earth science applications. Instead of simple library calls as used in OASIS, it requires more of an common ESMF interface between the component models to ensure smooth communication between models. ESMF has been released in version 4. and are still in a development phase. In the span between these two systems, we also find the Model Coupling Toolkit (MCT) library (Larson et al., 2005; Jacob et al., 2005). This is a model communication library, that are capable of handling the complex inter processor communication between the model. This library has been used in many different systems as the NCAR CCSM3 and CCSM4, and for coupling the ocean model ROMS to the wave model SWAN and the atmosphere model WRF. The MCT has proven to be robust, flexible and efficient for building coupled models.

Coupled simulations:

We will primarily evaluate the impact of a dynamic ocean on polar low forecasts, where the ocean model initial state has been made dynamically consistent with OSI-SAF SST via assimilation.

The activity will consist of a set of pairs of (uncoupled and coupled) model integrations, each integration centered on an interesting cold air outbreak (as revealed in Tasks 3 and 4).

For each such event an uncoupled control run will first be done with the atmospheric model feeling static OSI-SAF SSTs (as is done in today's operational forecasts). The integration will be conducted from an initial state given by the existing 3D-VAR assimilation system (which does not include information about SST).

Then the same forecast will be repeated with the coupled NS-MODEL. In the perturbation run(s), the initial state of the atmospheric component will be unchanged from that of the control run. But now the ocean model component will be integrated from an initial state where OSI-SAF SST has been assimilated in as a relatively hard constraint. Variations of this ocean initial state will also include assimilation of hydrographic profiles and SLA as weaker constraints (the ocean model SST field will not be allowed to deviate too much from the OSI-SAF SSTs which the atmospheric model felt during the control run). The surface observations (SST and SLA) will be projected down to depth in a dynamically consistent manner (investigated in Subtask 6.3). Since the assimilation scheme will not be fully multivariate, an adjustment of the entire ocean model field will be done via a nudging period leading up to the analysis time.

Validation:

Initial full scale validation tests will be done by running the model for some of the most intense polar low events and compare with independent synoptic observations. The sensitivity to important coupling parameters will be investigated by running the same polar low event with different relevant values spanning the uncertainty in the parameter values. However, because only a limited number of simulations are computational feasible, care should be taken to identify the most sensitive and important parameters. To minimize the risk of missing the important parameters, we will start the screening by looking at the whole parameterizations of the processes that are believed to be important for the coupled response. By altering the whole result from an parameterization, we will have an feeling of how important this process is. For the processes found to be important, we will then investigate the parameterization further. In addition to experimental simulations, the documentation of the different parameterizations has to be studied, to find out how important and sensitive the different parameters that go into the parameterizations are. An uncoupled atmospheric forecast should be used as a reference experiment when the behavior and sensitivity of the coupled system is considered.

Based the co-located model simulations data and In- situ observations of pressure, wind speed and precipitation, standard statistical scores will be calculated. This includes Root-Mean Square Errors (RMSE), Mean error (bias) and standard deviations between model runs and observations.

Technical and scientific requirement:

Running 8 km resolution in both atmosphere and ocean models, requires approximately 170 CPU-hours, and 40 minutes wall clock time per forecast cycle (assimilation/initialization plus a 60 hour prognosis). This is based on using 256 cpus on the present operational super computer running these models.

Data description:

The polar low list produced under Task 4

In situ observations collected in the STARS data set

Impact of polar lows on the ocean circulation

This activity is carried out under Task 8 according to the STARS Technical proposal.

Implementation:

This task will focus on a 4-5 year long uncoupled ocean model run based on an existing ROMS set-up of the Nordic Seas at 4 km horizontal resolution. Forcing will be provided by 25 km ECMWF operational analyses which met.no has in-house access to. The actual integration of this prolonged off-line ROMS simulation has recently started and is conducted in synergy with other projects at met.no.

In such an uncoupled run the total air-sea fluxes will of course be predetermined. An estimate of the relative role of cold air outbreaks and polar lows on the annual net heat and fresh water fluxes through the sea surface can thus be made without concern of the dynamics in the ocean model. And, as part of this subtask, such a “book-keeping” calculation from the analyzed atmospheric fields alone will be conducted. For estimates of the net buoyancy loss and Atlantic Water transformation, we will in addition have to use information about the sea surface given by the ocean model itself (Isachsen et al., 2007). So the estimates of the Atlantic Water buoyancy loss cannot be done without the ocean fields available.

Next, the ocean model itself will be analyzed for its dynamical response to the anomalous momentum and buoyancy fluxes. We will have to skip a close evaluation of the fast processes leading to local mixed-layer deepening since small-scale vertical mixing is parameterized in ROMS. We will instead focus on the subsequent meso-scale and large-scale adjustment to the anomalous densification and wind forcing. Specifically, we will study whether the passage of polar lows sets up particularly unstable density fronts that later produce enhanced levels of baroclinic instability and eddy heat fluxes in the region. Lateral heat fluxes between the warm boundary current and the interior basins will be diagnosed from Reynold's fluxes carried by the model. For the direct wind-driven response, we will check whether the enhanced Ekman suction from the passage of these extreme low pressure systems causes anomalous spin-up of the closed f/H gyres in the region (Isachsen et al., 2003). From a technical point of view this can be done by studying the time evolution of 'gyre indeces' (e.g. the pressure difference between the center and periphery of a gyre) or of the principal components of the EOF that best reflect the coherent gyre variability.

Technical and scientific requirement:

ROMS integrations will be carried out on a Linux cluster at the University of Oslo. A 7-year run (including spin-up) will require approximately 100 000 cpu hours.

Vertical heat, freshwater and density fluxes through the sea surface as well as lateral fluxes between the boundary current and interior basins may be extracted from the stored model fields. Analysis methods are documented in Isachsen et al. (2003) and Isachsen et al. (2007).

Data description:

The polar low list produced under Task 4

EWMWF operational atmospheric analyses for the period 2003-2009.

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