Sea ice prediction environment: Documentation

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1 Abstract

An operational sea ice model requires significant support codes in the form of boundary conditions, initial conditions, forcing fields, model analysis, as well as the model itself. This document describes the sea ice prediction environment developed for NCEP use, for the ice prediction model to be run in an off-line mode with information provided by the weather model. This form of the model should also be useful for research purposes.

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2 Introduction

A number of programs have been developed at NCEP to support sea ice modelling. The guiding principle in developing these programs has been to design an efficient environment to conduct studies on sea ice modelling, and to generate sea ice forecast products on a routine basis. In order to meet those goals, the different elements have been developed on the concept of 'plug compatibility'. The classical elements for a forecast model are: derivation of boundary conditions, derivation of initial conditions, construction of model forcing, model analysis, and the model itself. These have been implemented as separate programs in such a way that each element may be improved without requiring modification in the others. Further, the design is such that the model domain and resolutions may be changed without searching through the several thousand lines of code for the relevant parameters. The mechanism for implementing that ability are "include" files. While not standard Fortran-77, they are part of the Fortran-90 standard, and are quite common in Fortran-77 compilers. A further note is that certain parts of the environment have been written in C, though most is in Fortran.

The environment descriptions are written separately. There is a final section which describes working within the environment as a whole (i.e., doing some real work). Along the way, storage, execution memory, and cpu requirements are discussed.

3 General Comments

All grids are assumed to be polar stereographic, true at 60 degrees (north or south), with 80 W at the bottom of the page in the Northern Hemisphere, and the top in the Southern Hemisphere, in accordance with the NCEP standards. Grids are written out with the convention that 1,1 is the lower left corner. The current working resolution is 127 km (at 60 degrees). The model is written so that the resolution can be change easily to any multiple of 25.4 km (1/15 Bedient), so that future resolutions will be 101.6, 76.2, 50.8, and 25.4 km. Different grids may be developed by more extensive modification of the icegrid include files. The minimum resolution is set by the SSMI sensor, for which the highest resolution from the NASA Team algorithm is approximately 25 km. The model domains are shown in figures 1a and 1b.

The grid specifications are given in table 1:

Variable	North	South
L	77*127	59*127
M	93*127	61*127
dx	127 km	127 km
dy	127 km	127 km
Pole - I	38 * 127 km	30 * 127 km
Pole - J	46 * 127 km	36 * 127 km
Standard Latitude	60 N	60 S
Standard Longitude	80 W	+100 E

where L and M specify the width of the domain in the x and y directions, respectively, and pole-i, pole-j specify the location of the pole (it need not be on the map), and the standard longitude is referenced to having 90 W at the bottom of the page.

4 Boundary Conditions

The boundary conditions to the sea ice model are the ocean mixed layer temperature and salinity, the temperature and salinity at a depth below the seasonal thermocline, the land mask, and the depth of the ocean. The present version of the model includes the oceanic fields in the restart file, so they are only taken from the boundary condition file for a cold start.

4.1 Land Mask

The land mask is derived first. The required information is the location of the pole, nominal grid spacing, size of the grid, and rotation of the grid (if any) with respect to 90 W. These parameters are declared in include files icegrid.north and icegrid.south. Other domains, for example the Great Lakes, may be studied by creating icegrid.glk, say. The original land mask is currently the zmask 1x1 grid from Joe Sela. As this is a one degree gridded field, the resolution is not sufficient for high resolution regional modelling. Parameter values for the northern and southern hemisphere grid are given in table 1.

The program which creates the land mask is 'masker' which calls terp, w3ft01, mapxy, and mclean. Terp produces the first guess interpolation field. The values are real numbers due to the interpolation, rather than the integers which are needed by the models. Mapxy and w3ft01 are called by terp. Mapxy converts i,j coordinates to latitude and longitude on a polar stereographic grid. W3ft01 is an NCEP library routine which does fairly general interpolations. Mclean first rounds these numbers to 0 or 1, whichever is closer. Then Mclean cleans up the grid by removing water points which are surrounded by land at points (i+1,j) (i-1,j), (i,j+1), (i,j-1) – the cardinal directions in grid space. The ice model uses a staggered grid. For the inner grid, if two or more of the four nearest neighbors are ocean points, the inner grid value is set to ocean. The land masks are given in figures 2a and 2b.

4.2 Ocean Temperature and Salinity

The ocean boundary conditions are derived from the Levitus [1982] ocean atlas of climatological values for temperature and salinity at the surface and at a depth below the seasonal thermocline in the region. The mechanism is to interpolate from the latitude-longitude grid of those data (1 by 1 degree, with values at the half-integer locations) to the model grid. Since the land mask used in the atlas may not (in fact, does not) correspond to the land mask derived in the sea ice environment, a scheme is necessary to obtain values for T, S at those points where the ice model has ocean and the atlas has land. The mechanism used is to construct a weighted average of all points in the atlas within 220 km of the ice model point. The weight is proportional to $\exp(-4\ x^2 / R^2)$, where x is the distance between the ice point and the atlas point, and R is the radius of 220 km. If there are no data points within that radius, the temperature is set to -1.66 (slightly above the freezing point of sea water), and the salinity is set to 34.7 psu (mean ocean salinity). This is unsatisfactory for the Great Lakes and Caspian Sea. For that reason, these areas are not considered part of the operational grid, though they do appear on the map.