Sea Ice in the NCEP Climate Forecast System Reanalysis

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ABSTRACT

The recently completed NCEP Climate Forecast System Reanalysis (CFSR) from 1979 to 2009 used the NCEP coupled atmosphere-ocean-land surface-sea ice system. This paper describes the sea ice concentration data used and how sea ice concentration is assimilated in the CFSR. The record minimum of Arctic sea ice in September 2007 is clearly shown in the CFSR output. Because of the realistic sea ice distribution and other improvements in the CFSR, it is expected that the coupled CFS reanalysis will improve in many aspects compared to the previous NCEP/NCAR Reanalysis-1 and NCEP-DOE Reanalysis-2. The improved surface air temperature in the fall is shown in this paper.

KEY WORDS: Reanalysis; sea ice.

INTRODUCTION

Sea ice is known to play a significant role in the global climate system. The accuracy of sea ice coverage is essential for the good performance of atmospheric and oceanic data assimilation models over the polar regions in the CFSR. Global climate model studies showed that sea ice concentration strongly affects the climate in the Antarctic regions (e.g., Simmonds and Budd, 1991; Simmonds and Wu, 1993). However, no sea ice concentration was presented in the previous NCEP reanalysis (NCEP/NCAR Reanalysis-1 (R1) and NCEP-DOE Reanalysis-2 (R2)) although sea ice concentration data from analysis were used to present the sea ice coverage in R1 and R2 with 55% cutoff (i.e. when sea ice concentration is greater than 55% it is considered as 100% sea ice coverage). The NCEP new coupled CFSR (Saha et al. 2010) allows us to add sea ice concentration from analysis into the reanalysis system which would provide a close sea ice-atmosphere link that should provide the main climate patterns and trends that include the polar regions. This paper discusses the sea ice data used in the CFSR and how sea ice concentration is assimilated.

THE SEA ICE CONCENTRATION ANALYSIS

The sea ice analysis produces a global record of sea ice concentration for the CFSR for all points that may freeze anywhere in the globe, on a daily grid of 0.5 degree latitude-longitude resolution throughout the period of the CFSR. When there are discontinuities in the production of the data set, newer data sets and newer methods are used.

From 1979 to 1996, the sea ice concentrations for most of the globe are regridded from Cavalieri et al. (1996, updated 2007) (GSFC Ice), except for (i) possibly ice-covered regions that lie outside that grid, (ii) large Canadian lakes, (iii) the Great Lakes, and (iv) sea surface temperature-based filtering of erroneous ice in the analysis. For the Great Lakes, the data used are Assel et al. (2002) from 1979 through the end of the data set in Spring, 2002, and passive microwave thereafter. Those grids are available 1-3 times per week throughout the period they are available. Concentrations were linearly interpolated between the observation dates, and those interpolated values are used here, averaged on to the target 0.5 degree grid from the native 2.55 km Mercator projection. For large lakes in Canada, the Canadian Ice Service (CIS, personal communication) analyses were used for all lakes which were analyzed from November 1995 through October 29, 2007 (initially 34, in November, 1995, increasing to 137 by October, 2007). From October 30, 2007 onwards, the concentrations are the operational NCEP passive microwave sea ice concentration analyses (Grumbine, 2010).

There are regions which may freeze but lie outside the domain analyzed in GSFC Ice. These large water bodies were analyzed by proxy over 1979-1996, as was done for portions of the North American Regional Reanalysis (Mesinger, et al., 2006). Proxies were generated anew for the CFSR as the domain was much larger, and more data were available. During the period 1 January 1997 - 30 June 2006 when both NCEP ice and GSFC ice were available, the NCEP ice analysis was used to identify points (one by one) which lay inside the GSFC ice domain and which had high correlation to concentrations analyzed for points outside the GSFC ice domain - but still inside the NCEP domain. This includes large lakes such as Lake Ladoga, Lake Onega, and the Caspian Sea. Due to changes in sea surface temperature (SST) sources for filtering sea ice concentration analyses, some regions such as the Aral Sea, Lakes Balkhash, and Hulun Nur could not be consistently analyzed and were assigned zero ice concentration. Some lakes were assigned land flags in the CFSR when they could not be observed strictly by modern passive microwave due to land contamination issues and the lack of available data; these lakes include Lake Athabasca, Lake of the Woods, Lake Nipigon (outside the period of CIS data), Ilimana Lake, and Lake Vanern.

From Jan 1997-Feb 2000, the global ice concentration analysis was the NCEP operational ice analysis (Grumbine, 1996) (outside the Great...