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Technical Note

A posteriori Filtering of Sea Ice Concentration Analyses[†].

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1 Abstract

A simple basis for filtering sea ice concentration analyses is described here. It requires no information about current sea surface temperature, avoiding the possibility of feedback between the sea ice and sea surface temperature analysis. It uses a fixed reference field – historical minimum observed sea surface temperatures – making it suitable for use in historical ice analysis.

2 Introduction

For quality control of the sea ice concentration analysis, it is desirable to ensure that ice does not appear in areas which are known to always be ice free. Different centers take different approaches. The NSIDC has a set of masks derived from sea ice history [Meier, 2009]. NASA relies on a sea surface temperature climatology [Cavalieri, 2009].

For NCEP use, what we have done since the product was operational was use the current day's operational sea surface temperature (SST) analysis as the filter. Any surface warmer than 275.3 K is deemed incapable of having a sea ice cover. This was used in developing ice covers for the NCEP/NCAR Reanalysis [Kalnay, et al., 1996], the North American Regional Reanalysis [Mesinger et al, 2006]. In the Climate Forecast System Reanalysis and Reforecast (CFSRR), it was discovered that this method failed at times. In particular it fails, when there was a feedback between the ice analysis (looking at the SST analysis) and the SST analysis (looking at the ice analysis and treating ice cover as a cold temperature [Thiebaux et al., 2003]). This happened in the summer of 2006.

To break the feedback possibilities, and to limit their scope for reanalyses, I developed an *a posteriori* filter. It is distinct from the satellite algorithm's weather filter that is run using only the satellite observations themselves [Grumbine 1996]. This new *a posteriori* filter is, again, based on SST. But, rather than use the concurrent analysis, it uses a climatological SST. The SST used is the minimum observed in the AVHRR-only quarter degree OIv2 [Reynolds et al., 2007] from 4 January 1985 (the start of that record) through 3 January 2008. The methods used here are amenable to adding years before or after those start or end dates without requiring a full re-run.

It is also advisable to apply these methods in the operational analysis. Areas of perennially warm water are not normally ice covered, and are normally correctly seen in the satellite as not being ice covered. But land can provide a false signal that ice is present, so coastal areas for which the satellite is viewing both land and sea can show up as ice. The summer 2006 feedback involved coastal points.

3 Maps of the Flags and Temperature Minima

Water surfaces are in two classes – ocean and inland. Inland water may not be fresh, though it generally is. Consequently, in determining flags for surfaces, the two types are treated separately. Most inland water bodies are not treated in the OIv2 analysis [Reynolds, et al., 2007], being treated as land. The only inland water bodies which are treated are the Great Lakes and the Caspian Sea. For all other inland waters (Great Bear Lake, Great Slave Lake, Lake Baikal, and on), we must still rely on the contemporary operational SST analysis.

In keeping with the land mask and other flagging already done with and for the operational sea ice concentration analysis [Grumbine, 1996], the minima are translated to 1 byte values. The code table is

Flag	Number of grid points	Area (10^6 km^2)	case
157	316069	132.488	Land
158	15545	11.953	Ocean > 26 C
159	67683	51.472	Ocean > 24 C
160	64600	48.428	Ocean > 22 C
161	61178	44.545	Ocean > 19 C
162	64645	44.585	Ocean > 15 C
163	79836	49.738	Ocean > 9 C
164	90248	46.746	Ocean > 2.15 C
165	272519	77.481	Ocean > -3 C
170	132	0.081	Inland > 7 C
171	133	0.079	Inland > 4 C
172	72	0.042	Inland > 2.15 C
173	99	0.055	Inland > 0 C
174	391	0.208	Inland > -3 C
224	3650	2.197	Undefined

Points that are 'undefined' are those for which the geographically faithful land mask [Grumbine, 2009] says are water, but for which there is no valid SST in the OIv2, nor can one be diffused inward. 'Land' points are those for which both OIv2 and the land mask agree are land. The geographically faithful mask includes a label 'coast', which for our purposes here is treated as water, hence the mere 26% of earth which is considered 'land'. The flags are non-cumulative. A flag of 159 means waters warmer than 24 C that are not warmer than 26 C.

The 'diffusion' process is an iterative sweep over the points which are coast or water in the geographic land mask. Starting with a range of 1, and increasing to 5, a check is made for valid OIv2 temperatures. If any are found, the coldest is used. Since this is iterative, and the temperature grids are updated at each

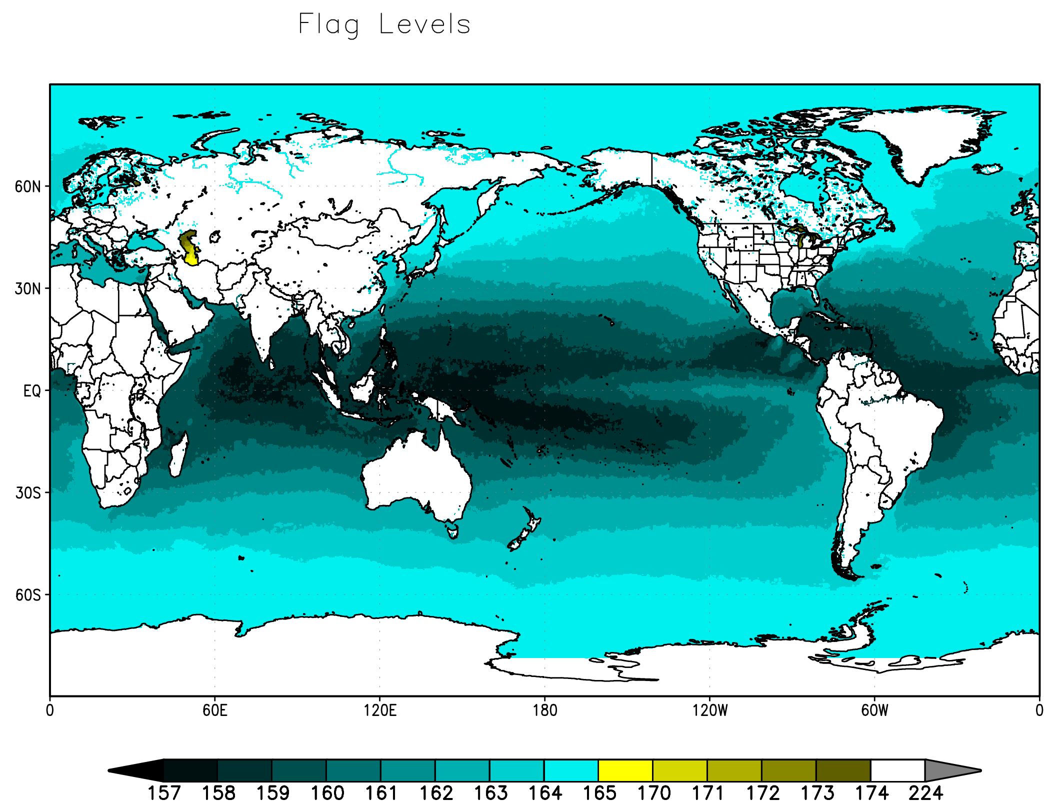

Fig. 3.1 : Map of Flag Values

step, water temperatures as far as 15 grid points away can diffuse inwards from the ocean and up embayments. This is most obvious in the Gulf of Ob' and the Yenisey river in figure 2.1. Figure 2.2 shows the temperatures themselves.

26 C was selected as a special value – one of significance to hurricane formation. The other cutoff temperatures are largely selected on the basis of having an approximately even division by area of the world's oceans.

4 Application to Historical Analyst's Grids

The sea ice 'analyst grids' are those grids (polar stereographic, per hemisphere) which are constructed using only that day's satellite observations, which have not been filtered by SST, and which have had no space or time gap filling performed. As such, they provide a good test area to see whether the *a posteriori* filter performs well. I'll take 'well' to mean that the *a posteriori* filter removes a large fraction of the area that filtering with that day's SST analysis would remove. It will be too conservative at all times of year, with the discrepancy being largest in boreal summer when the ocean is warmest and the most ocean is above any

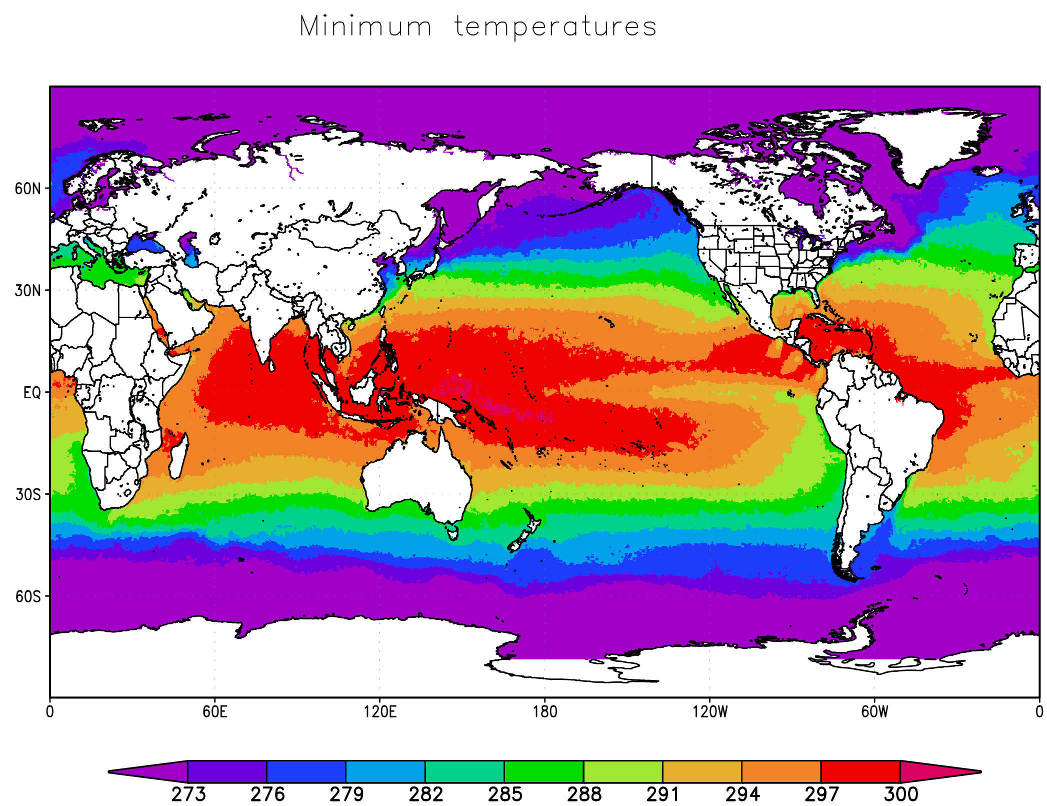

Fig. 3.2 : Map of Minimum Sea Surface Temperatures

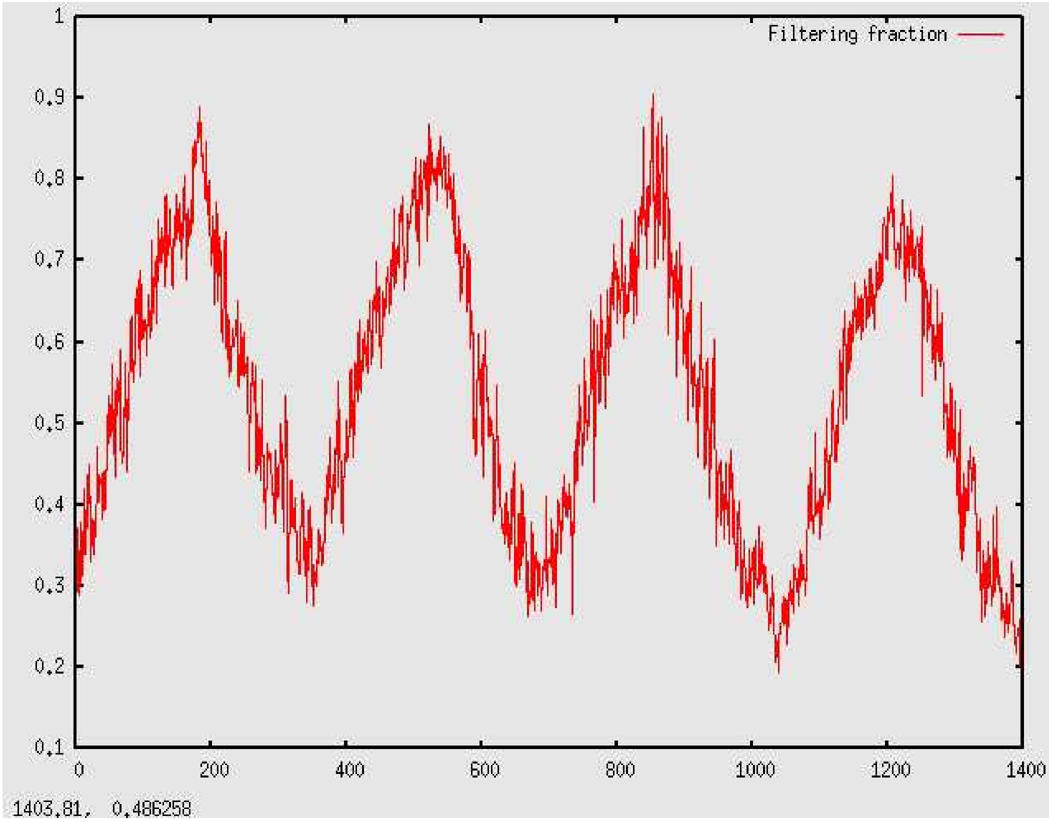

Fig. 4.1 : Filtering Fraction – A posteriori vs. Concurrent Analysis

given cutoff temperature. (The Southern Ocean has a large area of water which is perennially below 2.15 C and which does not get and ice cover. This sort of filter is least useful there.) On the other hand, filtering a significant fraction of the area also means that this is a large area which will not be able to engage in an ice-sst analysis feedback.

Figure 3.1 shows the ratio between the area filtered by this method and the area filtered by the given day's SST analysis. Time is days from September 1, 2004, and skips 20 July 2006. We see that the maximum is reassuringly high – about 90% – the minimum is still about 30%, and the median is about 50%. These fit our desire for a filter.

5 Conclusions

This *a posteriori* filter performed as needed in constructing the 2008 version of sea ice (covering October 1978 through October 2008) for the CFSRR. It has not been used in NCEP operations, but should be for the same reasons that prompted its application to the CFSRR data set. Further, had it been present in summer

2006, some problems which occurred in the sea ice analysis and the RTG SST analysis would have been impossible – the feeback could not have occurred.

It is still desirable to get knowledge of whether all other lakes freeze. Probably not Lake Victoria and other large African rift valley lakes. Unfortunately, all or almost all large Canadian lakes do freeze, and none are addressed by this filter.

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