Near-Global MSLP Since 1871: A Source for COADS Wind Validation

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Introduction

Recent research emphases on the enhanced greenhouse effect and climatic variability has seen the development of quality controlled global historical data compilations covering land and sea surface temperatures (including integrated sets), precipitation and clouds. However, no such global to near-global coverage is available with regard to parameters indicative of near-surface atmospheric circulation. At present, long-term monthly mean sea level pressure data sets cover 85°N-15°N, 0°E-5°W (1899-1991) (see Bradley et al., 1994) and 15°S-60°S, 0°E-5°W (1911-1989) (Jones, 1991). Shorter global to regional compilations are available (see Jones and Wigley, 1988; Jones, 1991; Barnett and Jones, 1992; Bradley et al., 1994), but they do not have the temporal coverage necessary to resolve the range of decadal-multidecadal fluctuations in climate that are evident in other historical data sets.

Efforts are currently underway to redress the above situation with the construction of a unique near-global monthly sea level pressure (MSLP) compilation using both land and ship observed data and covering the period since 1871 (Allan, 1993). A preliminary version of this MSLP set has been used to examine the long-term nature of relationships indicative of the El Niño Southern Oscillation (ENSO) phenomenon. Results from analyses of the historical instrumental period using the MSLP data have identified decadal-multidecadal global scale fluctuations in ENSO and the climate system. Periods or epochs with different ENSO and MSLP characteristics should also be evident in variables such as surface wind fields that are indicative of atmospheric circulation patterns. In fact, assuming a simple geostrophic relationship with the new near-global MSLP data would allow the calculation of a proxy field for near-surface winds, which could be used as a check on the validity of land or Comprehensive Ocean-Atmosphere Data Set (COADS) ship observed wind fields. In the latter case, this would aid in efforts to develop a quality controlled historical oceanic near-surface wind data compilation.

This paper outlines the current status of the new near-global MSLP compilation, some analyses with a preliminary version of this product, and its potential as a check for historical ship wind reconstruction’s based on experience with studies in the Indian Ocean region.

Data Sources and Methods

Historical station level pressure from land stations and MSLP data from ships across the globe were obtained from World Weather Records (Smithsonian Institute, 1944; WeatherDisc Associates, 1990), Lockyer (1908); Reseau Mondial (1910-34); Berlage, (1957, 1966); Schove and Berlage (1965); Jones (1991); COADS (Woodruff et al., 1987); Allan et al. (1991); Young (1993) and Allan and D'Arrigo (1995) (Fig. 1). Additional records were extracted from numerous manuscripts held by various meteorological services and reports in old meteorological journals. Station level pressure data were reduced to MSLP, and all the resulting MSLP time series were checked and corrected where necessary using a three stage process. In the first stage, each of the individual time series were detrended linearly and the annual cycle removed; the data were then examined for spurious data points, jumps and trends. The second stage of quality control involved cross checking spatially, with the construction of station differences between each time series and neighboring time series used to highlight spurious data points, jumps and trends. Monthly mean gridded data were then derived from the point measurements of MSLP that had undergone the first two stages of quality control, and contoured to form spatial fields of monthly MSLP since 1871. A third and final stage was the subjective checking of each contoured monthly MSLP field against long-term monthly climatologies for obvious spatial inhomogeneities.

Applications

Preliminary MSLP correlation studies of ENSO and the climate system

A preliminary version of the MSLP dataset was the basis for correlation analyses examining the spatial and temporal pattern of ENSO/anti-ENSO teleconnections through relationships between Darwin and global MSLP observations since 1879 (Allan, 1993). Darwin MSLP was used instead of a Southern Oscillation Index (SOI), because a running/sliding correlation (set at 21 years in this case) between the two MSLP stations most often used to form a SOI (Tahiti and Darwin) showed that the correlation structure has changed on multidecadal time frames (Fig. 2). In fact, the strong out of phase relationship between these stations, that is common to more recent epochs and is the basis of persistence forecasts, was not evident over the full period of record (1876-1990). In order to test the wider responses of ENSO during the historical period, and given the indications in Fig. 2, the preliminary M SLP data set was divided initially into five 21- year periods centered around the years 1921-41, when ENSO was apparently weaker than at any other time in the record. The validity of partitioning the data into these five different periods was supported by a number of papers in the literature which have documented the marked weakening and even "breakdown" of correlation's between ENSO and rainfall over the globe during the 1920s-30s period.

Figures 3, 4 and 5 show the three most differing epochs in terms of ENSO characteristics during the historical record, Both the earliest (1879-99) and the most recent (1963-83) epochs display the type of coherent and robust patterns indicative of the distribution and extent of ENSO impacts. However, the 1921-41 period (Fig. 4) shows a more fragmented pattern, with the major regions in both Indo-Australasia and the southeastern Pacific being very much weaker and contracted in spatial extent. Thus it would seem that regions of ENSO influence over the globe wax and wane on decadal-multidecadal time scales. The correlation patterns derived from the MSLP set should also reflect changes in other oceanic and atmospheric variables such as broad scale wind patterns. This could be assessed if a global near-surface wind compilation covering the historical period was produced.

Potential as a check for historical ship wind reconstructions: Indian Ocean experience

Significant research has been conducted on historical data observations over the Indian Ocean-Australian region during the austral summer (JFM) (Allan and Lindesay, 1991, 1993; Lindesay and Allan, 1992, 1993; Allan et al., 1995). These studies show different spatial responses in atmospheric circulation/wind, MSLP, sea surface temperature (SST) and cloudiness on inter-annual to multidecadal time scales. Confidence in the observed surface wind data analyzed in the above studies was increased by a comparison of observed winds and those derived from MSLP gradients under a geostrophic assumption (Ward, 1991, 1992). Despite potential biases in ship winds due to changing observer practices, the studies of Ward (1991, 1992) have indicated that data problems relating to observed ship winds tend to be least over the Indian Ocean basin when compared to other ocean regions. However, wind reconstructions using existing MSLP data gradients also need to be examined with care due to potential problems with the MSLP observations in some ocean basins. Preliminary analyses in Allan et al. (1995) suggest that, apart from periods of sparse observations, MSLP data problems in the Indian Ocean region are most acute at high latitudes along the far southern historical ship tracks. Some of these problems are easily identified, as they show up as distinct outliers in MSLP time series. Others are less obvious, and require careful quality control efforts to identify them.

Conclusions

Studies with a preliminary version of a new global MSLP data set have revealed fluctuations in ENSO and the climate system that should also be detectable in surface wind fields. In addition, efforts to produce high quality surface wind field data from sources such as COADS ship observations would benefit substantially from comparisons with geostrophically derived surface wind fields calculated from a high quality MSLP compilation. As noted in Allan (1993) and this study, examinations of historical global MSLP data and the development of a more comprehensive global MSLP compilation are in progress. The ultimate aim is to produce an MSLP data set comparable in quality to the Global sea-Ice and Sea Surface Temperature (GISST) compilation produced by the United Kingdom Meteorological Office (UKMO).

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Figure 1: Maximum distribution of land and ship observations of MSLP used in the new global monthly MSLP data compilation.

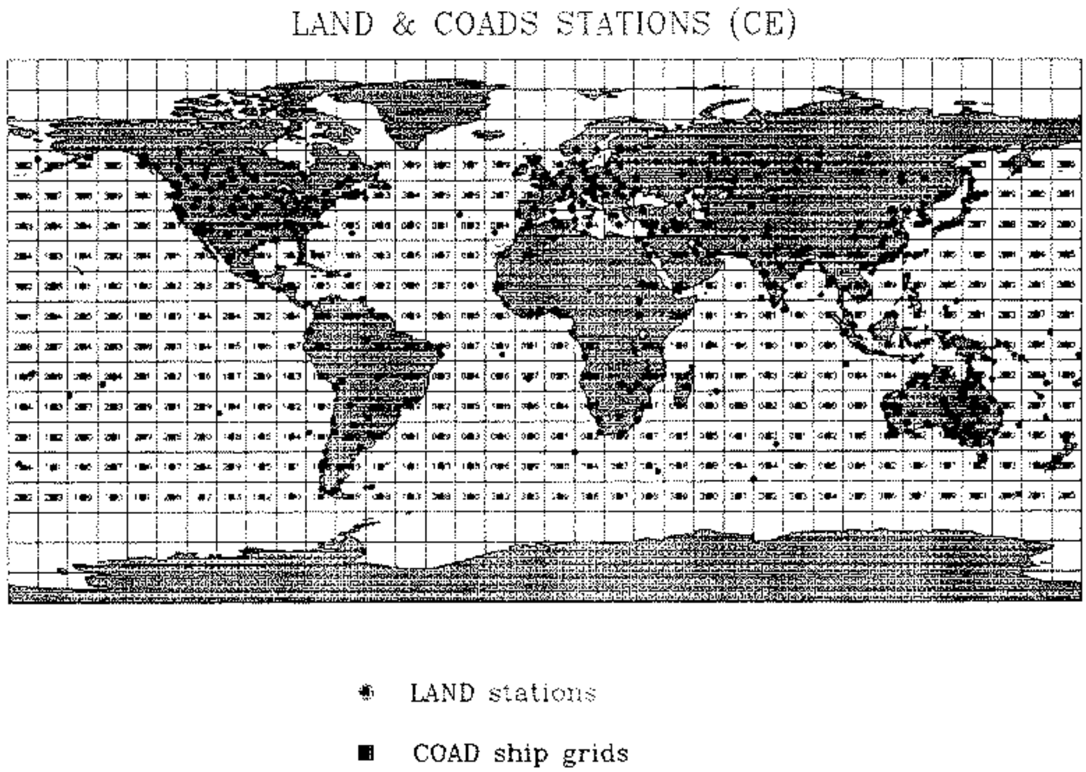

Figure 2: 21 year running/sliding monthly correlations between Darwin and Tahiti MSLP since 1876. Areas of negative correlation significant at the 95% level are shaded.

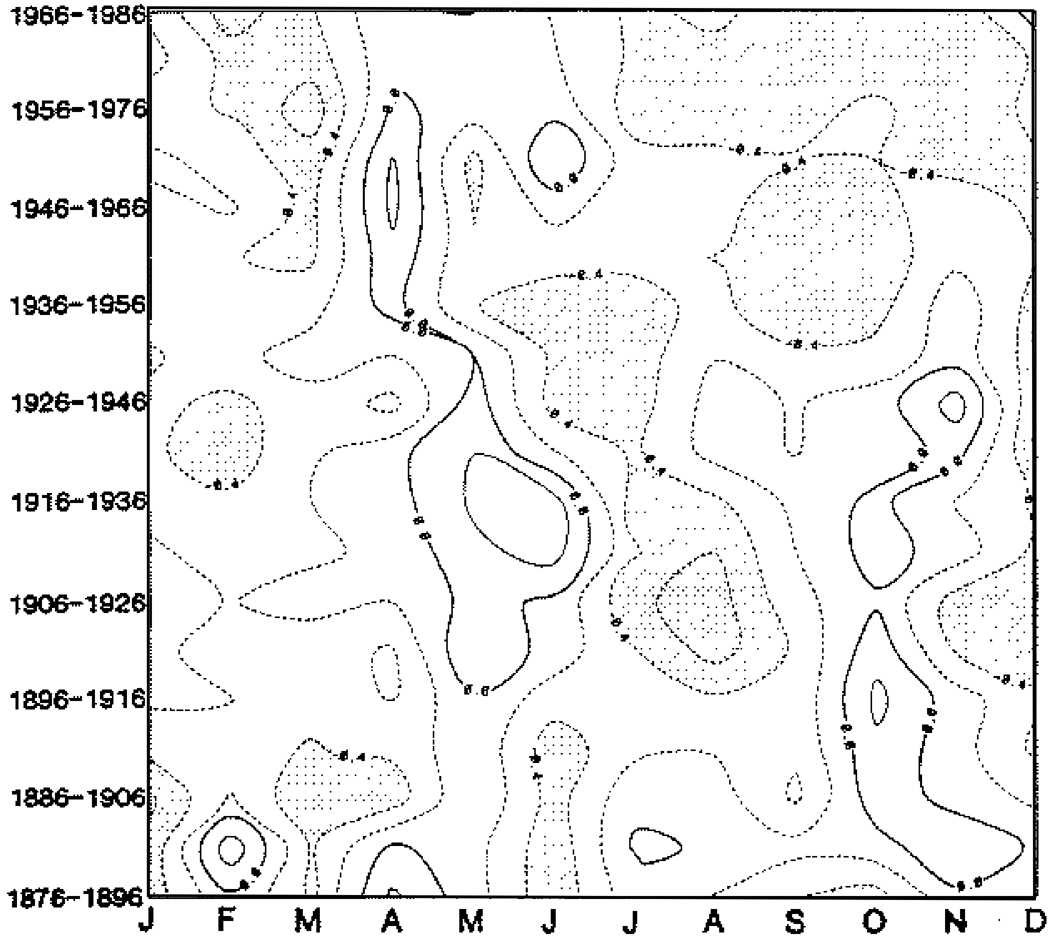

Figure 3: Seasonal analysis of regions of significant (at the 95% level) positive (shaded) and negative (stippled) correlation between mean sea level pressure (MSLP) at Darwin (Australia) and other stations over the globe for the 18791899 epoch. Seasons are defined as the months DJF, MAM, JJA and SON. Contours are shown for correlation coefficients at every 0.2 interval.

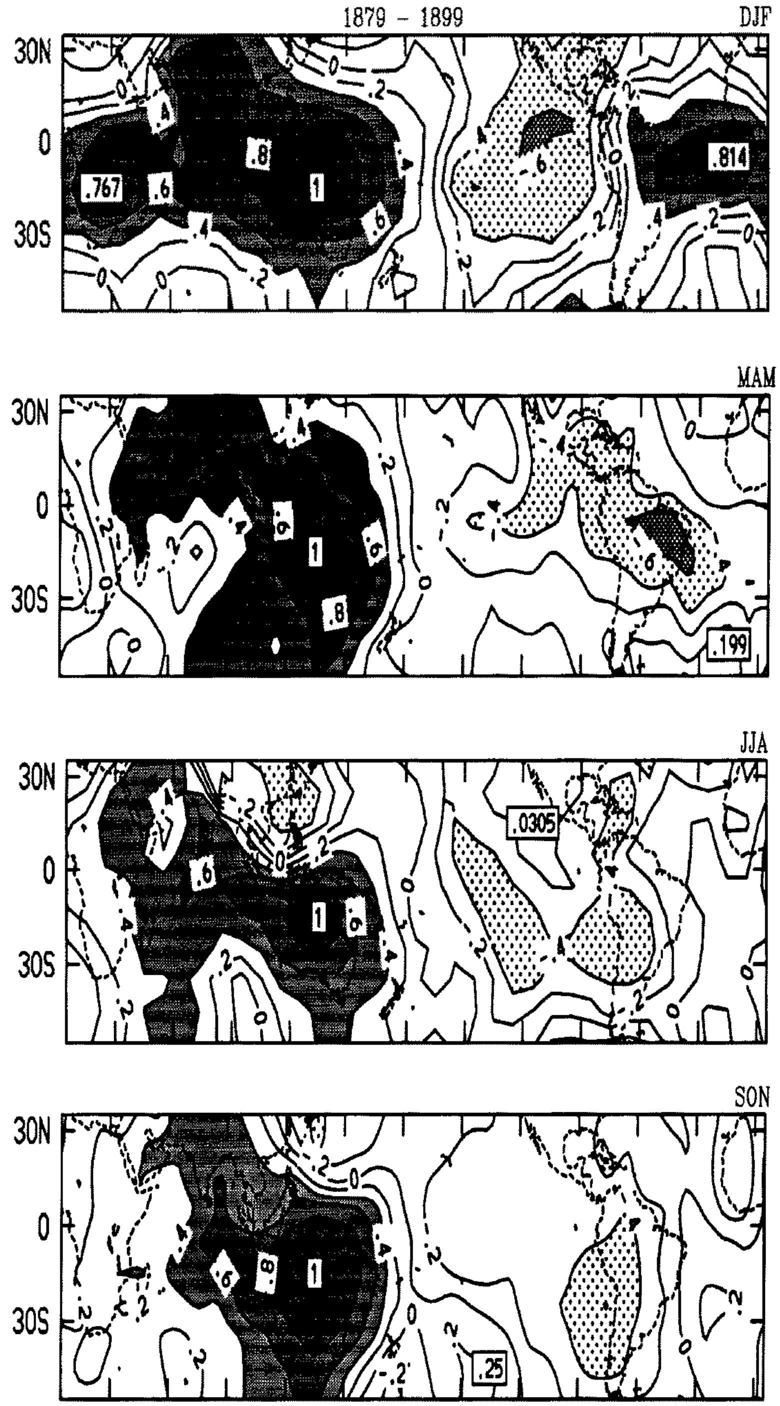

Figure 4: As in Fig. 3, except for the 1921-1941 epoch.

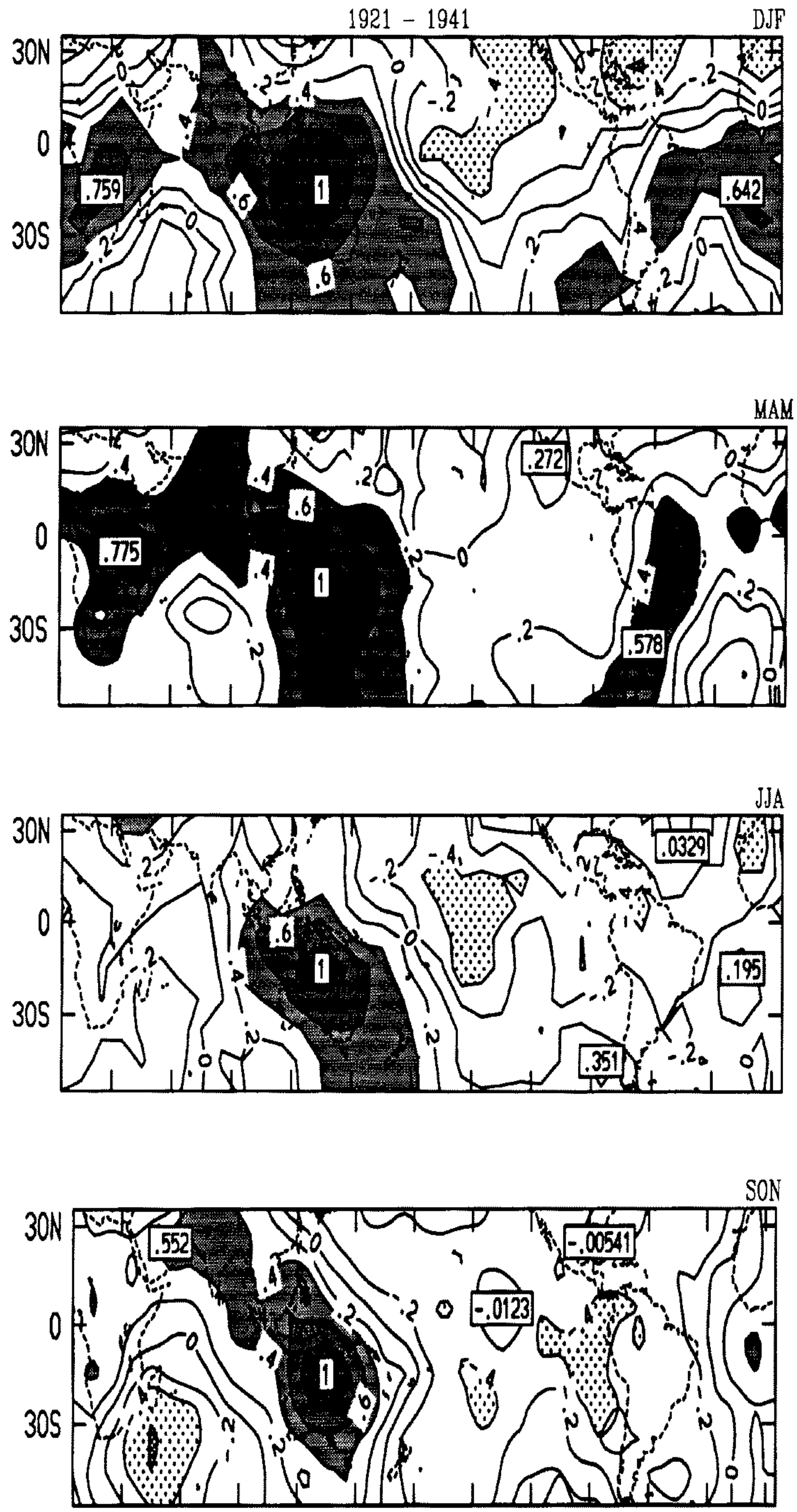

Figure 5: As in Fig. 3, except for the 1963-1983 epoch.