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Assessments of the reliability of NCEP circulation data and relationships with surface climate by direct comparisons with station based data

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ABSTRACT: An assessment is made of the climate simulations from the NCEP (National Centers for Environmental Prediction) Reanalyses over Europe. This assessment was initiated as part of the European Commission funded study on Atmospheric Circulation Classification and Regional Downscaling (ACCORD) and was designed to test the suitability of the Reanalyses for this type of application. Here NCEP Reanalyses (pressure, temperature and precipitation) from 1958 through 1997 are compared to station data of precipitation and temperature and composites of mean sea level pressure (MSLP) data. The comparison is made over a European window using monthly data with a focus on 3 land areas: Central and Eastern England and Italy, where daily timescale data are employed. MSLP data are generally well simulated; however, an input problem in the NCEP data prior to 1967 results in unrealistically low surface pressure. NCEP surface pressure over Greenland is also shown to be unrealistically high during the winter months. Spatially NCEP MSLP is shown to correlate quite well with UK Meteorological Office (UKMO) MSLP over the ocean and much of northeast Europe, while they correlate less well over high orographical regions. It is shown that, while daily temperature is well simulated, daily precipitation is less so, particularly during the summer months when convective precipitation is dominant. Total precipitation over the 2 UK areas is lower than observed, by as much as 22% over Central England. The number of rain day events is underestimated over the 3 regions, although the anomaly of rain per rain day is shown to vary between the regions, being overestimated in NCEP in Eastern England and Italy. Mean daily temperature is shown to be much better simulated compared with precipitation, with a slight warm bias in all 3 grid boxes.

KEY WORDS: NCEP · Reanalyses · Europe · Pressure · Temperature · Precipitation · ACCORD

1. INTRODUCTION

Global atmospheric reanalyses of assimilated data are a valuable tool in obtaining information about potential climate change, atmospheric conditions and general circulation patterns. There is a need, however, to establish the limitations of the data for particular applications. For example, atmospheric analyses can produce biases over time due to variations in input data, or human error, or seasonal variations due to limitations in the ability of the model to simulate physical or dynamical processes. While the model process in the NCEP (National Centers for Environmental Prediction) Reanalyses may not vary, the output over time may, due principally to changes in the amount or quality of input data.

Three categories of model output variables are defined for the purpose of this study: outputs which are strongly influenced by observational input data (for example, geopotential height and mean sea level pressure [MSLP]), outputs which are influenced by observational data but are also influenced by the assimilation processes and the model (for example, surface

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temperature), and outputs that are solely derived from the model (for example, precipitation which is forecast) (see Kalnay et al. 1996, Appendix A).

This study sought to establish the suitability of the NCEP Reanalyses for the period 1958 through 1997 for use in the Atmospheric Circulation Classification and Regional Downscaling (ACCORD) project (Jones et al. 2000). To accomplish this we examined each of these 3 categories of variables: MSLP, temperature and precipitation. These variables were used extensively in ACCORD.

The ability of the NCEP and ECMWF Reanalyses to simulate observed climatic conditions has been assessed in a number of previous studies. Stendel & Arpe (1997) suggest that the ECMWF Reanalyses (Gibson et al. 1996) are superior to the NCEP Reanalyses for simulation of precipitation in the extratropics. However, the ECMWF Reanalyses produce a 10° southward shift in the Intertropical Convergence Zone (ITCZ) over Africa at around 1987; therefore there are some applications for which the NCEP Reanalyses may be better. Furthermore, the ECMWF Reanalyses are currently available only over a limited time scale (1979–1993), generally a very short period for the downscaling studies envisaged in ACCORD.

Janowiak et al. (1998) compared the NCEP Reanalyses with data from the Global Precipitation Climatology Project (GPCP) rain gauge-satellite combined data set. They found that the large-scale variability of precipitation in the model is generally well simulated, although there are low correlations with the GPCP data over oceans, equatorial land regions and the regions encompassing the Pacific ITCZ.

Zonal mean cross sections of precipitation over land suggest that the NCEP Reanalyses tend to forecast too much precipitation between 50 and 60° N, with NCEP producing a higher rate of precipitation over Russia than observed (see White & da Silva 1999). White & da Silva (1999) find that globally the NCEP Reanalyses provide a high anomaly correlation with observed precipitation over Europe, east Asia, North America, Australia, southern Africa and eastern South America; regions where radiosonde data for input into the reanalyses are readily available and of good quality. Correlations have been found to be lower over areas with high convective rainfall and steep orography (White & da Silva 1998).

Basist & Chelliah (1997) compared tropospheric temperatures derived from the NCEP Reanalyses with those from the NCEP operational analyses and the Microwave Sounding Unit for the period 1979–1995. By comparing brightness temperatures (T_b) they found that the Reanalyses T_b tended to become too cool during 1992 before stabilizing again in 1995. While it is not clearly established why this bias occurred, Basist & Chelliah suggest that changes in satellite retrievals (which feed into the Reanalyses) and the eruption of Mt. Pinatubo, the Philippines, may have had some influence on this.

Within this study we compare NCEP Reanalyses with long-term databases of observed temperature, precipitation and MSLP data over Europe in order to provide an indication of how well the analyses represent local atmospheric conditions and general circulation patterns for each of the 3 data categories. NCEP data were used extensively in this study and in ACCORD as they provide a potential 40 yr of near-consistent data (1958–1997). In Section 3.3 we combine an analysis of NCEP and observed MSLP with surface values of precipitation and temperature. This analysis is undertaken over Europe, where the quality of data input into the model Reanalyses is generally high. Because of this, the conclusions of the study are unlikely to apply to regions where input quality is poorer.

2. DATA AND METHOD

The NCEP Reanalyses are output from an assimilation/forecast model based on a synthesis of all available weather and satellite information (Kalnay et al. 1996). The model is run with a triangular 62 (T62) wave truncated horizontal resolution (approximately 2° × 2° with 28 vertical levels). Data are generally available either on a 2.5° × 2.5° grid (MSLP) or at T62 resolution on a Gaussian grid (precipitation and temperature). As opposed to the operational NCEP analyses, the Reanalyses are the result of a fixed analysis through time, providing a near-consistent simulation of climatic conditions over the reanalysis period (1958–1997). The only variable through time is the input data. Assimilation of observational data takes place every 6 h, with the model forecast providing a first guess for the assimilation process. Interestingly, because there are no precipitation estimates of sufficient spatial resolution or length, no station precipitation data are assimilated directly into the model (Janowiak et al. 1998).

Below we compare the NCEP Reanalyses data with observational data sets of MSLP, temperature and precipitation. The area of coverage for this project was 80–30° N, 60° W–70° E, this providing 71 × 28 grid points on the Gaussian grid for temperature and precipitation.

Several sources of observational data were used in comparison to the NCEP Reanalyses. For this purpose, daily and monthly observed surface temperature, precipitation and pressure data archived at the Climatic Research Unit (CRU) were used. The daily observational data consist of about 350 station records

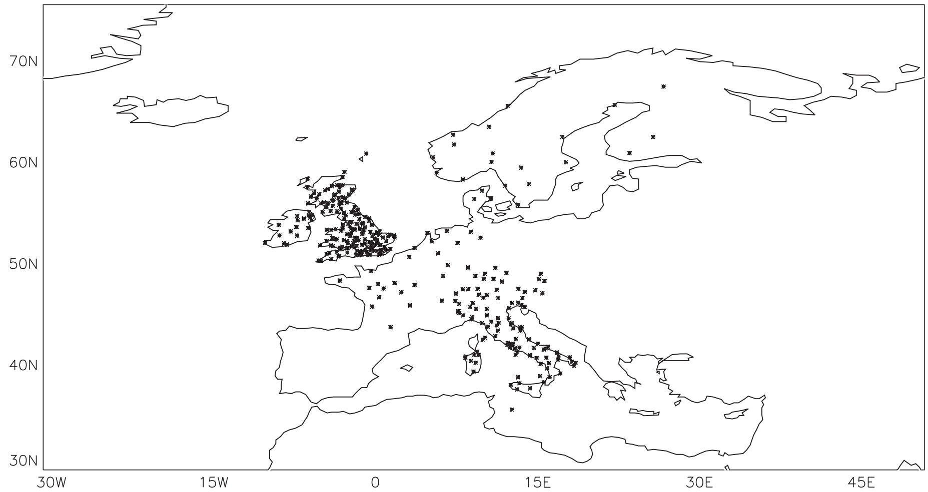

Fig. 1. Location of stations with daily temperature and precipitation records available at the Climatic Research Unit

over Europe, mostly over the UK and Italy, with less spatial density over some other parts of western and northern Europe. Detailed comparisons are discussed for 2 UK grid boxes: a Central England box (51.45–53.35° N, 2.82–0.94° W) and an Eastern England box (51.45–53.35° N, 0.94° W–0.94° E), and central Italy (40.02–41.57° N, 14.30–15.80° E). Observed grid box values were obtained by averaging values for all stations in each grid box for which daily time series were available (see Fig. 1). The maximum number of stations available for the analysis period, 1961–1995, was 22 for Central England, 17 for Eastern England and 7 for Italy. This period was chosen because the time series of station data are nearly complete for this epoch and these stations. None of these daily temperature records are assimilated into the Reanalyses. Instead Reanalyses, and Operational Analyses for that matter, use 6 h measurements from primary stations (~10 to 12 stations over both the UK and Italy).

Further analyses are also made using monthly mean observed temperature (Jones et al. 1999) and precipitation (Hulme 1994), each on a grid-box (5° × 5°) basis. Where necessary the NCEP Reanalyses were interpolated onto the 5° × 5° grid for comparison with the observational gridded data using an inverse distance (with spherical adjustment) angular weighted interpolation scheme.

NCEP Reanalysis MSLP were compared with an observed database over the common data period 1958–1995. The observed pressure data set (referred to as UKMO and held at the CRU) covers the Northern Hemisphere north of 15° N from 1881–1995 and is available on a 5° latitude × 10° longitude grid (Jones [1987] details the source used in this data set). It should be noted that station MSLP data are included as input into the NCEP Reanalysis as well as forming the input data for the UKMO gridded MSLP data. As a result a high correlation between UKMO gridded observations and reanalyses can be expected.

3. RESULTS

3.1. Comparison between the NCEP Reanalyses and UKMO gridded (observed) pressure data

Simple difference maps between NCEP and UKMO grid-point MSLP were produced for the year as a whole and for January and July, for single years at 5 yr intervals. The difference maps for 1990 are shown in Fig. 2. Other years between 1970 and 1995 are similar.

Over much of Europe, differences between the NCEP and UKMO series are generally small (<1 to 2 hPa) in all years. Large differences, however, occur over Greenland and over the Barents Sea, where annual NCEP values are up to 6–8 hPa higher than UKMO values. The annual and winter patterns are very similar. In summer, however, NCEP values over Greenland are up to 1–2 hPa lower than UKMO values. Thus the annual pattern reflects the large, positive differences in the winter half of the year. Examination of the maps through time indicates that the annual MSLP differences over Greenland have increased over time from about 2–4 hPa in 1960 to over 6 hPa by 1985. Annual time series plots for individual NCEP grid points (not shown) confirm this. It is not immediately clear which data set is correct, although UKMO is probably closer to reality than NCEP as time series of its grid points over Greenland show little long-term change since 1958.

Away from Greenland and, more importantly, the annual time series plots (not shown) indicate that before the mid-1960s NCEP annual MSLP tends to be lower than UKMO at many grid points, particularly those located south of 55° N. This is attributed to a major NCEP data input error over much of Europe. Before 1967, MSLP values below 1000 hPa were incorrectly adjusted for their offset and were then rejected by the quality control checks on data input (see http://lnx21.wwb.noaa.gov/images/psfc/psfc.html for details). Prior to 1967, therefore, the majority of low pressure centres in the NCEP data set are entirely model derived. It is to be hoped that this problem is corrected in any subsequent version of the NCEP Reanalyses and will not be a factor in longer ECMWF Reanalyses. Both these major problems support con-

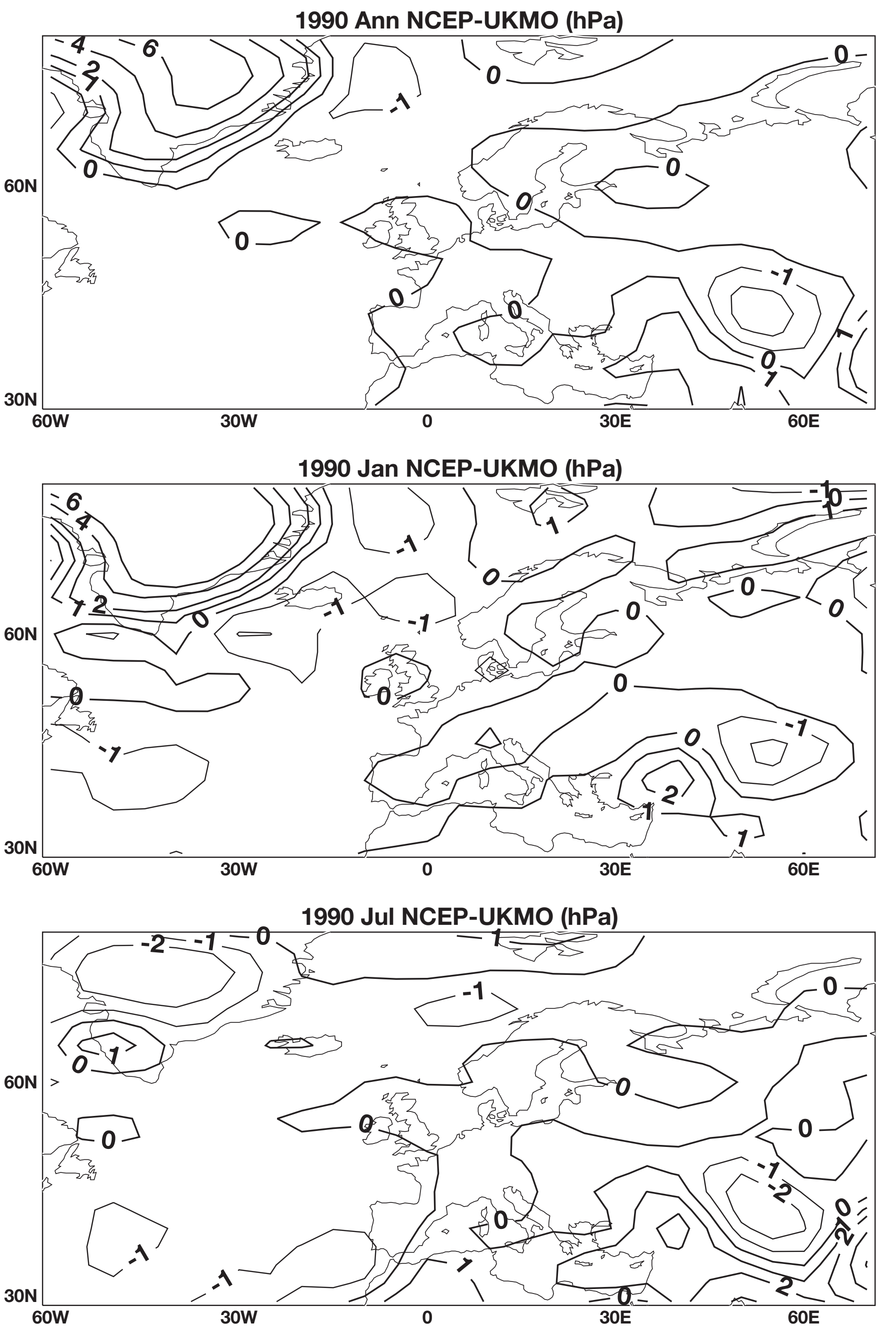

Fig. 2. Differences (hPa) in NCEP minus UKMO MSLP (mean sea level pressure) in 1990: annual (top panel), January (middle panel) and July (bottom panel)

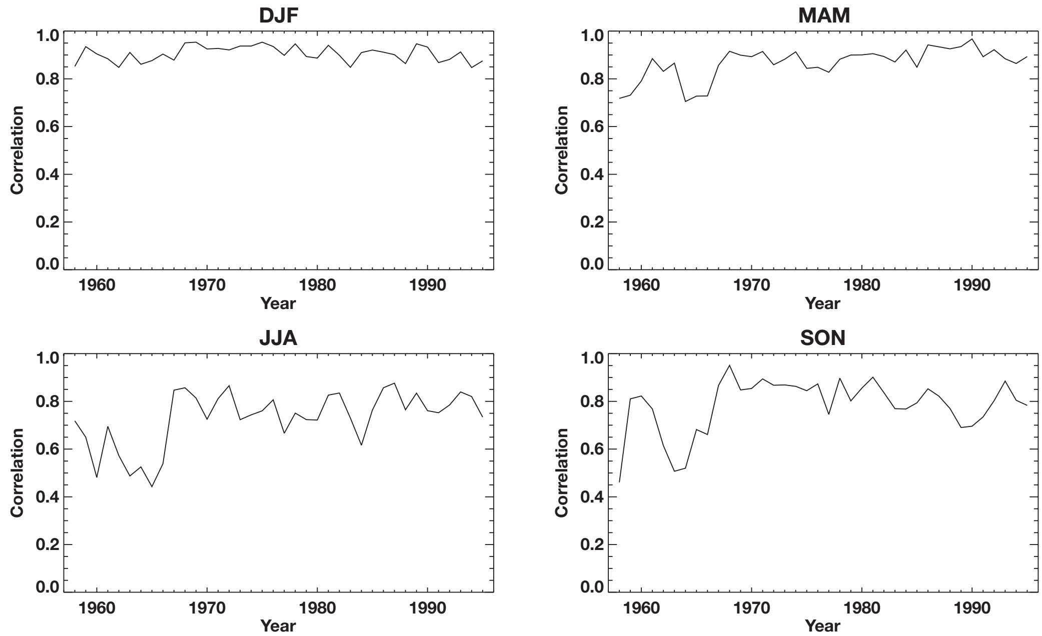

Fig. 3. Spatial averaged correlations (by season) between monthly mean MSLP from the NCEP Reanalyses and UKMO data, over the ACCORD window (80–30°N, 60°W–70°E)

clusions made elsewhere about the NCEP Reanalyses, namely that they are much more reliable for studies looking at interannual variability and are less reliable in many regions for interdecadal-scale studies (Santer et al. 2000, see also Chelliah & Ropelewski 2000). This conclusion is also applicable to the 15 yr ECMWF Reanalyses (Santer et al. 2000).

Seasonal differences between the NCEP and UKMO data are highlighted by a direct correlation comparison between the two for the period 1958–1995 (Fig. 3). Here, monthly averaged grid-point values over the region 80–30°N, 60°W–70°E for the NCEP and UKMO MSLP were correlated against each other after first normalising each grid-point time series using the standard deviation and monthly mean of the data between 1961 through 1990. Clearly the problem with the NCEP Reanalyses prior to 1967 dramatically affects results during June to August (JJA) and September to November (SON), and to a lesser degree in March to May (MAM). Outside of the anomalous early years the correlation between NCEP analyses and observed data are seasonally consistent, although better results are found for December to February (DJF). The spatial pattern of the MSLP correlations over the periods 1958–1995 and 1967–1995 are shown in Fig. 4. High correlations are shown over ocean areas, the UK, Scandinavia and northeast Europe. Lower correlations are found over the higher orographical areas of southern Europe for both epochs, and over Greenland for the 1958–1995 correlation period. This again highlights the problems associated with the data prior to 1967.

As a further comparison, principal components analysis (PCA) was performed on the NCEP and UKMO MSLP (observations) data sets for the 4 seasons for the period 1959–1995. This PCA is based on the correlation matrix, which is dominated by variance on interannual timescales. For each season, the first 4 PCs were compared. Maps of the first 2 PCs for DJF are shown in Fig. 5, along with their time series (or eigenamplitudes). In all seasons except summer, the NCEP and UKMO PCs are essentially the same. In summer, only the first and third PCs are broadly similar. The amount of variance explained by the first 4 NCEP PCs (ranging from 67% in summer and autumn to 83% in winter) is slightly greater than that explained by the UKMO PCs (from 55% in summer to 80% in winter). Some of the differences in variance explained between the 2 sets of PCs may occur because of the different spatial resolution of the data sets (2.5° × 2.5° for NCEP and 5° latitude × 10° longitude for UKMO). Generally, however, the similarities between the 2 sets of results provide further support for the reliability of the NCEP MSLP data over much of the European window after 1967. Down to the fourth PC, the derived variables (time series) of the DJF NCEP and UKMO PCs correlate quite well (0.99, 0.96, 0.83 and 0.78 respectively for PCs 1 to 4). The 2 PC1 time series also correlate well with an NAO series.

This similarity would be expected to be considerably poorer if the correlations were performed at the

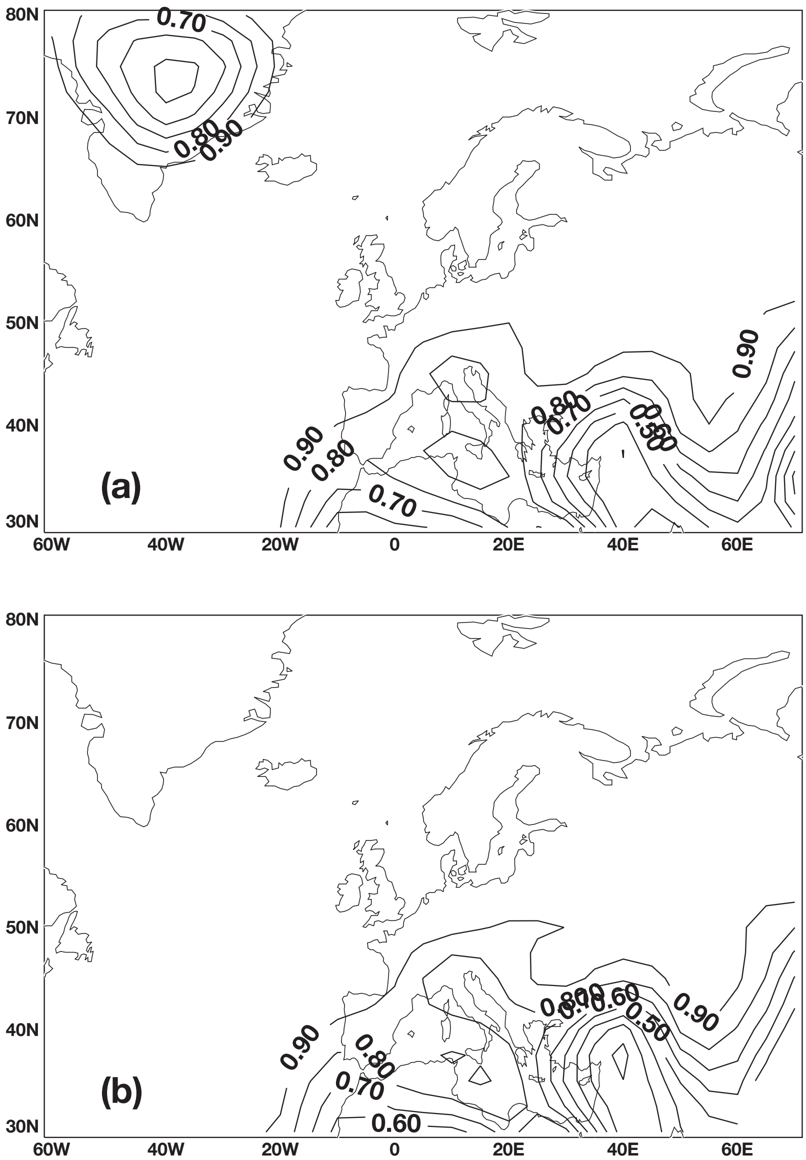

Fig. 4. Spatial correlations between monthly mean MSLP from the NCEP Reanalyses and UKMO data for (a) 1958–1995 and (b) 1967–1995

decadal time scale. The PC time series are used in Section 3.3 to correlate with precipitation and temperature over the regions of interest.

3.2. Comparison between NCEP Reanalyses and observed daily temperature and precipitation data

Mean daily temperature (at the 2 m level) and precipitation values from the NCEP Gaussian grid were compared with observed data for the 2 UK grid boxes and the 1 Italian box, as outlined earlier. Time series plots of daily NCEP and observed values and the differences were produced (not shown). The findings are summarised in Table 1, which also summarises the findings of the correlation analysis. NCEP and observed mean daily temperature are found to be highly correlated for each year (0.96–0.98) in each study area. These annual correlations are calculated on anomaly values (i.e. by first removing the 1961–1990 average daily temperature value from both the NCEP and observed series).

NCEP temperature values, however, are consistently higher than observed values. Over the year as a whole, the mean NCEP minus observed differences are 0.38, 0.33 and 1.26°C for the Central and Eastern England and Italian areas respectively. A small part of these differences might be explained by the difference in the average heights of the stations in the grid box and the NCEP 'land height'. There is also a difference between average daily data determined from observations every 6 h (NCEP) and the average maximum and minimum values (observations). Time series plots, however, indicate that the differences are greater in autumn and winter than in the other seasons, suggesting that observation times and height differences are relatively unimportant.

Total precipitation within each of the study areas is underestimated for the 2 UK grid boxes and overestimated for the Italian area, although the overestimation is small (2.4%). Annually, the precipitation correlations on a daily basis vary over each area: 0.37–0.68 and 0.30–0.61 for Central and Eastern England and 0.47–0.81 for Italy. To some degree these correlations are reflected in the mean annual NCEP minus observed precipitation differences: –152 and –68 mm for Central and Eastern England and 17 mm for Italy. They are also influenced by the fact that daily NCEP data are 6 h totals for the 24 h day, while observed daily precipitation is the morning to morning total (09:00 h GMT in the UK and 07:00 h GMT in Italy).

Naturally the number of rain days and rain per rain day within a fixed data set varies depending on what threshold is used to classify a day as a rain day. Often observed trace amounts of precipitation are not defined as rain days. In the comparison here the difference between NCEP and observations varies depend-

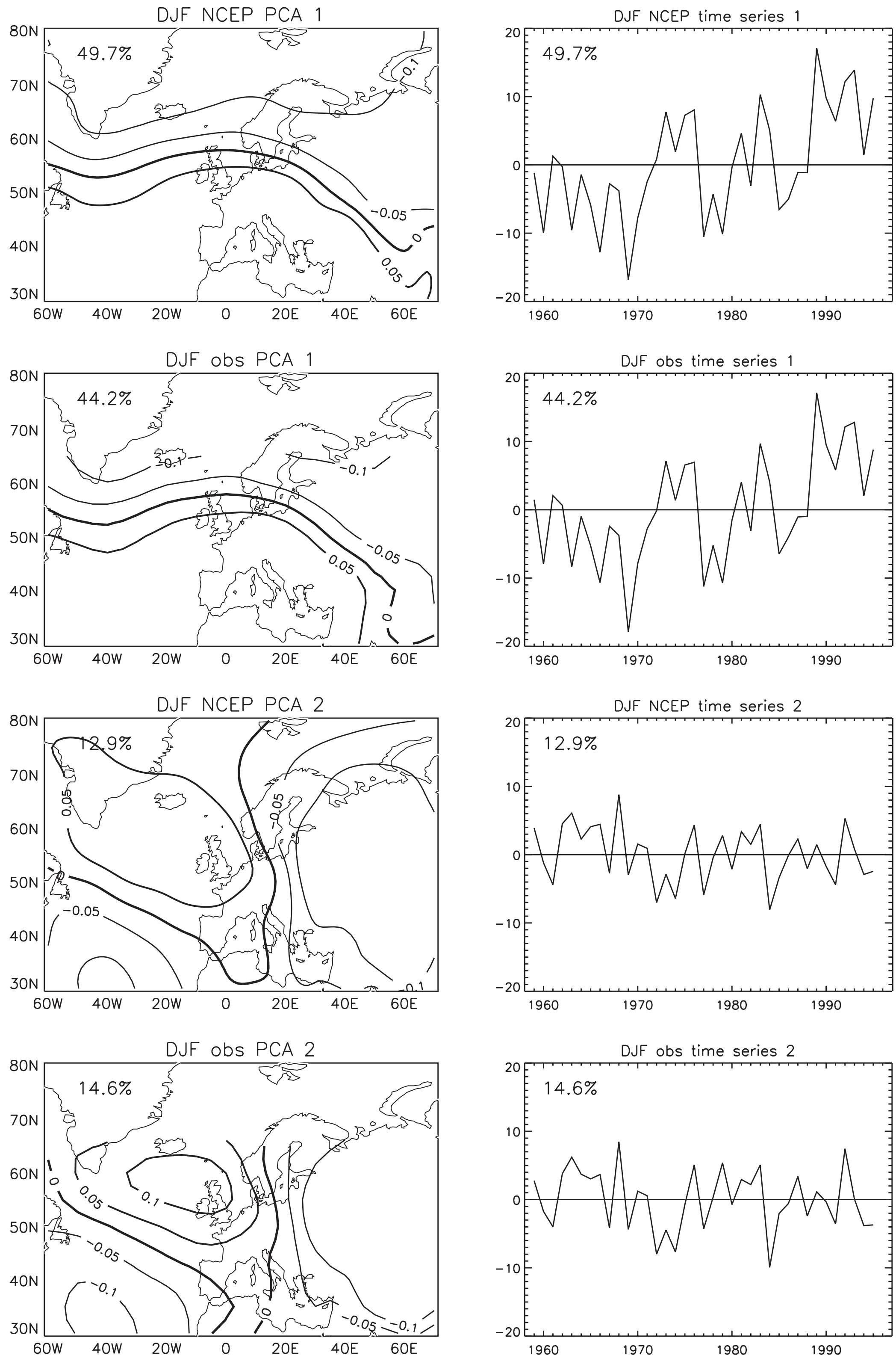

Fig. 5. Comparison between the first 2 PCs of the NCEP and observed DJF MSLP (left panels) and associated time series (eigenamplitudes) (right panels) for 1959–1995. Variance explained by each component is shown in the top left hand corner of each panel

Table 1. Summary of comparison of NCEP and observed daily temperature and precipitation for 2 English grid boxes over the period 1961–1995, and 1 Italian grid box over the period 1961–1992

	Central England (22 stations)	Eastern England (17 stations)	Italy (7 stations)
Mean daily temperature (°C)			
NCEP	9.84	10.00	15.87
Observed	9.46	9.67	14.61
Difference (NCEP – observed)	0.38	0.33	1.26
Annual correlation	0.96–0.98	0.96–0.98	0.96–0.98
Total precipitation (mm)			
NCEP	553	539	735
Observed	705	607	718
Difference (NCEP – observed) (mm/%)	–152/–22	–68/–11	+17/+2.4
Annual correlation	0.37–0.68	0.30–0.61	0.47–0.81
Number of rain days			
NCEP	163	160	128
Observed	177	191	153
Difference (NCEP – observed) (days/%)	–14/–8	–31/–16	–25/–16
Rain per rain day (mm)			
NCEP	3.28	3.25	5.15
Observed	3.87	3.04	4.18
Difference (NCEP – observed) (mm/%)	–0.59/–15	+0.21/+7	+0.97/+23

ing on the threshold used; the difference generally increasing with smaller thresholds. A threshold value of 0.5 mm was used here for both the Reanalyses and the observations, as it allows for the errors associated with averaging station based data into the associated grid boxes.

When using a threshold value of 0.5 mm, the number of rain days in the NCEP Reanalyses is conservative, although the error is less than 16% in all 3 areas. A smaller threshold (0.1 mm) produced marginally worse results of less than 22% fewer days of rain in each area (not shown). The rain per rain day is variable, with the largest error being in Italy, where there is a surfeit of 23% in the Reanalyses. NCEP Reanalyses underestimate the rain per rain day in Central England by 15%. These findings are in contrast to those found in general circulation models, where there is a tendency to overestimate precipitation frequency and underestimate precipitation intensity (Chen et al. 1996, Dai et al. 1999).

Long-term (1961–1995) correlations between daily NCEP and observed surface parameters were found to vary seasonally (Figs. 6 & 7). Over each grid box, the correlation of precipitation is higher during winter (DJF) than for the other seasons, particularly summer. This is probably due to precipitation being the result of convective processes during summer months, which are less well represented in the NCEP model. For temperature, the correlations are high throughout the year, although a small bimodal cycle exists: generally higher during April and November and lower during January and August for each of the 3 regions.

Not only do the correlations with surface climate variables vary seasonally, they also vary over time. Over the long term, for both variables, the initial seasonal trends in correlations are generally enhanced. With precipitation, there is a rise in the correlations over winter months and a fall during warmer months. For temperature, there is a slight increase in correlations during equinoctial periods, and a slight decrease during other periods. These findings are summarised in Figs. 6 & 7. Annually, there is a trend showing an increase in precipitation correlations over the English grid boxes and a slight decrease over Italy (Fig. 8), although only the trends for the 2 English grid boxes have significance above 5%.

Temperature correlations over the 3 regions of interest are shown to be generally very high, with lower correlations most often occurring during the warmer months (JJA) (Fig. 6). This is particularly so in Italy, where correlations can drop below 0.5 during that season. Distinct periods of low temperature correlation are found in the early 1960s, 1971–1973 and 1991–1992: all during the warmer season. The latter may be associated with the Mt. Pinatubo eruption in 1991, although Basist & Chelliah (1997) suggest that it may be more complex than that. These periods of low correlation in temperature are not mirrored in the precipitation results (Fig. 7).

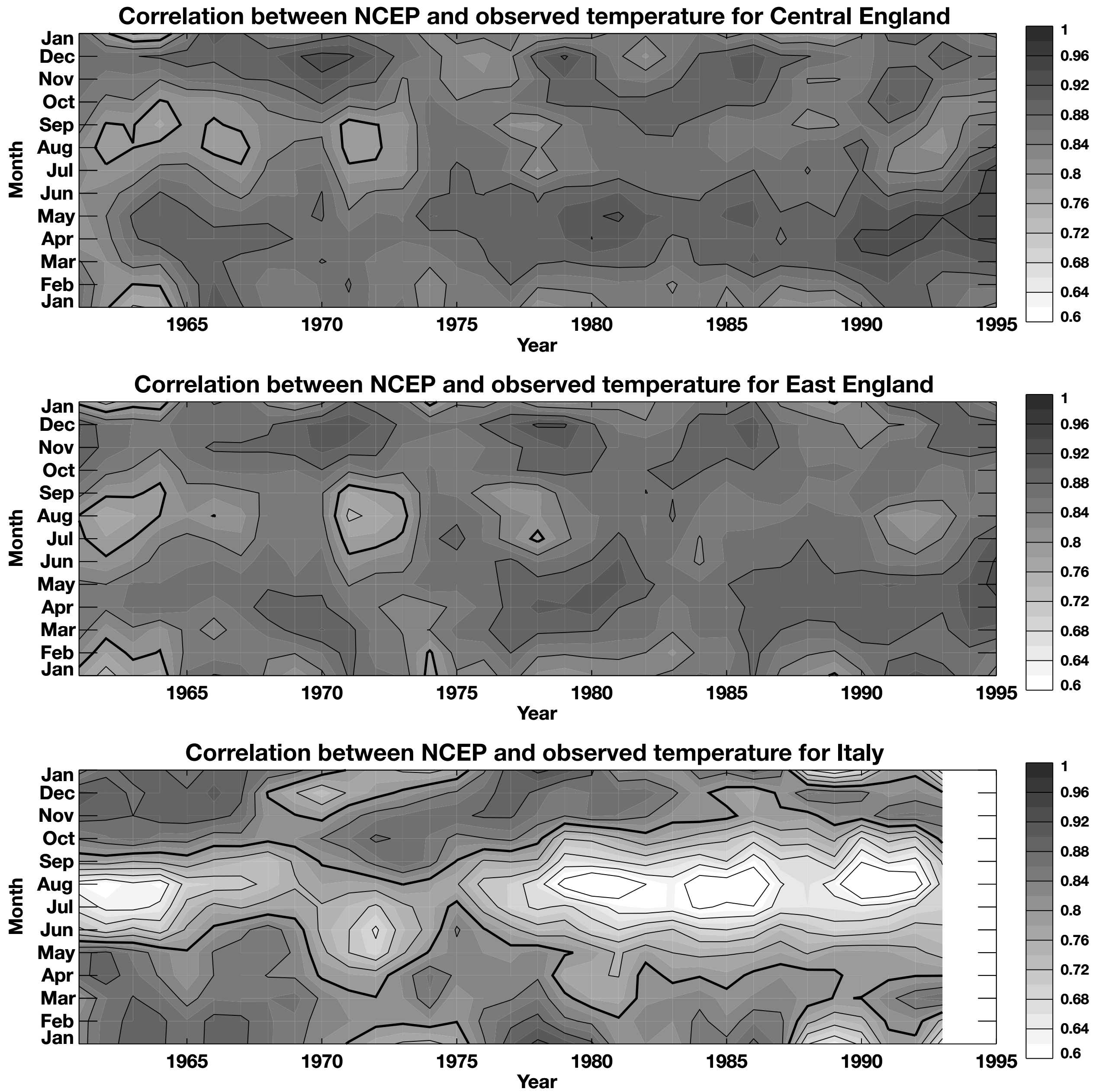

Fig. 6. Time series of correlations (by months) between daily NCEP and observed temperature for Central and East England and for Italy. The 0.8 correlation contour is given in bold

3.3. Comparison between the relationships of MSLP with precipitation and temperature

In the previous 2 sections we have compared Reanalyses with observed data for variables from each of the 3 separate categories. In this section we compare the intervariable relationships in NCEP and those in the real world. We do this by correlating time series of MSLP with those of temperature and precipitation.

PCs and associated time series (eigenamplitudes) of MSLP were produced earlier (Fig. 5) for the NCEP Reanalyses and observed data set. The time series of the first 3 PCs of the NCEP and observed data (1967–1995) are used here to correlate with the $5° \times 5°$ grid-box time series of monthly precipitation and temperature over the whole European window. Here, NCEP correlations are between NCEP MSLP and NCEP surface variables, while observed correlations

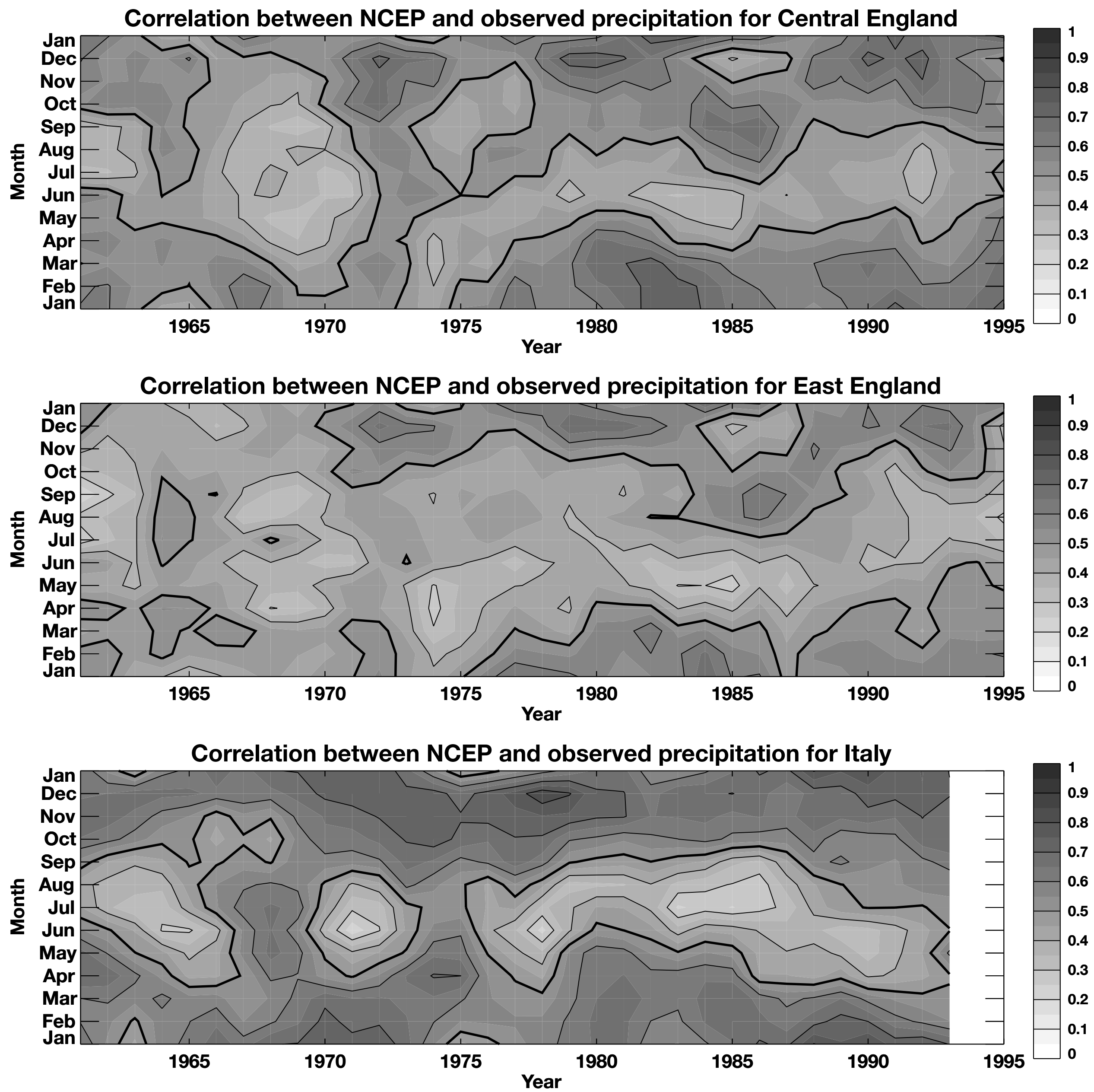

Fig. 7. Time series of correlations (by months) between daily NCEP and observed precipitation for Central and Eastern England and for Italy. The 0.5 correlation contour is given in bold

are between UKMO MSLP and observed 5° × 5° gridbox surface variables (precipitation, Hulme 1994; temperature, Jones et al. 1999; Figs. 9 & 10, respectively). Spatial correlations with observed data are restricted to land areas for precipitation. For temperature the correlations over marine areas incorporate sea surface temperature (SST) anomalies. Good agreement would be expected here, though, as historic monthly SST data are used as the input lower boundary in both NCEP and ECMWF.

The correlation patterns between the PCs and temperature are found to be smoother than for precipitation, reflecting the higher spatial variability of precipitation compared to temperature. For the correlations of both temperature and precipitation, the patterns of the NCEP Reanalyses and observations are shown to be broadly similar over areas of overlap, although this is more so for temperature than precipitation for the second and third PCs. To some degree this reflects the higher correlation between NCEP

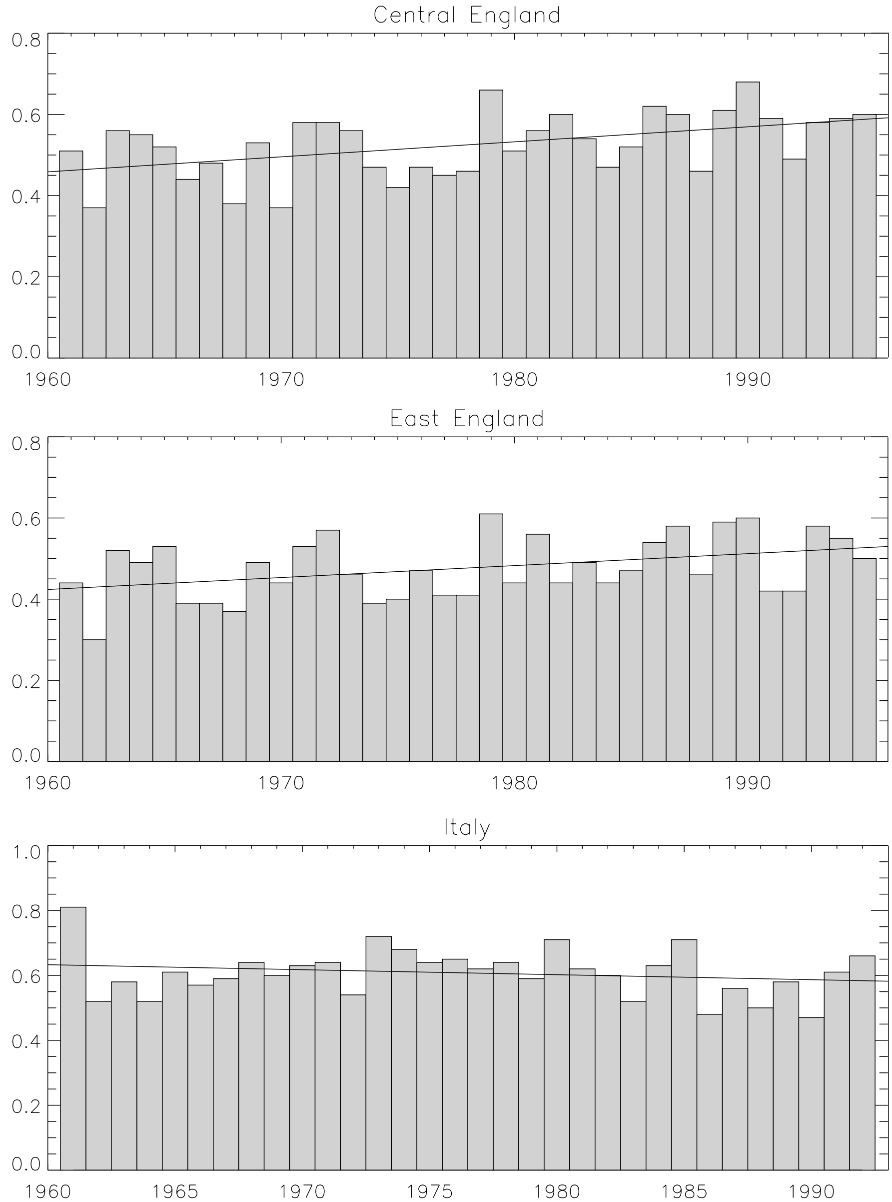

Fig. 8. Long-term variability of correlations between NCEP and observed precipitation rates for Eastern and Central England and for Italy

and observed temperature compared to precipitation (Table 1). The correlations in the NCEP Reanalyses are shown to have more structure than seen in the observations, primarily due to the higher resolution of the data along with greater area coverage (i.e. over the oceans as well as land).

Broad areas of high correlation exist for both precipitation and temperature, with much of the high correlation over the European region existing in the first PC, and each subsequent PC having lower correlations. With precipitation, both NCEP and observations give high correlations over central Europe for the first PC; however, subsequent PCs exhibit little similarity between NCEP and observations. For temperature, high correlations are found over much of northern Europe and Greenland in the first PC, after which the general patterns of correlations are found to be broadly similar in both NCEP and observations. The correlations of the first PCs resembles correlation maps between the North Atlantic Oscillation (NAO) and surface temperature and precipitation (see also Hurrell 1995, Dai et al. 1997 and the next section).

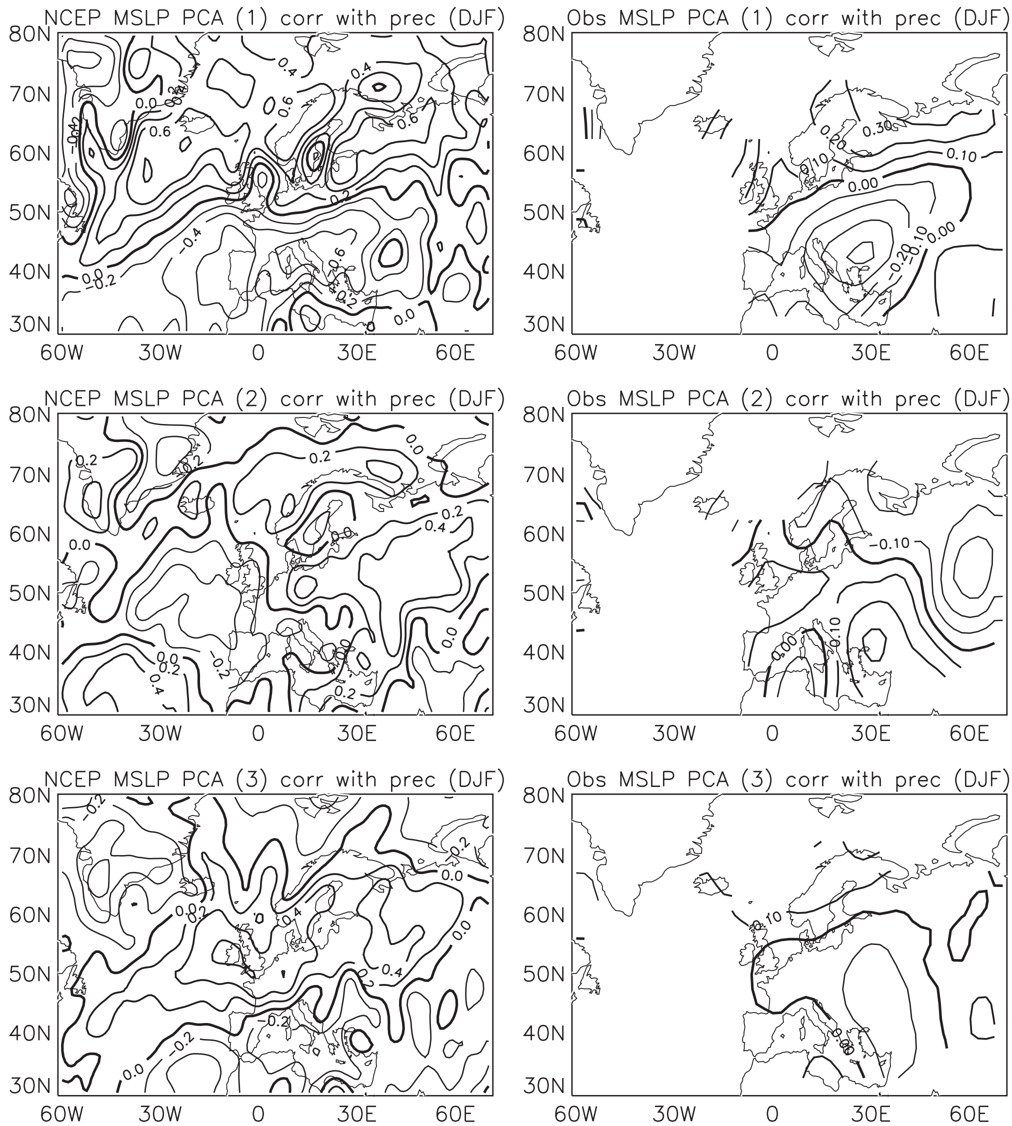

Fig. 9. Correlations between the derived variables (time series) of the PCA of MSLP and precipitation for the NCEP analyses (left panels) and the UKMO data (right panels) for the period 1967–1995

3.4. Comparison between the relationship of NCEP circulation features with precipitation and temperature

Correlations were calculated between NAO indices and surface climate data for each season. The 2 NAO indices used were Gibraltar–Reykjavik and Ponta Delgada–Reykjavik (each station being normalised on a monthly basis based on the 1951–1980 period and then differenced to form the index). For NCEP MSLP values for the 3 stations were interpolated from the 4 surrounding grid points. For NCEP, the correlations were calculated for the period 1958–1997. Two different periods were used for the observed data: 1901–1950 and 1951–1995. Correlation maps for winter temperature and precipitation based on the Gibraltar–Reykjavik NAO index are shown in Fig. 11.

Fig. 11 indicates that in winter NCEP NAO/surface correlations have a similar pattern and strength to the observed 1951–1995 correlations. For temperature, the NCEP and 1951–1995 observed correlations are highest (up to 0.7) over a region extending southwestwards and northeastwards of the Baltic Sea (see also Hurrell 1995). This region is, however, somewhat larger in the NCEP results. As might be expected, the correlations between the NAO and precipitation are somewhat lower than those for temperature. For both temperature and precipitation, the observed correla-

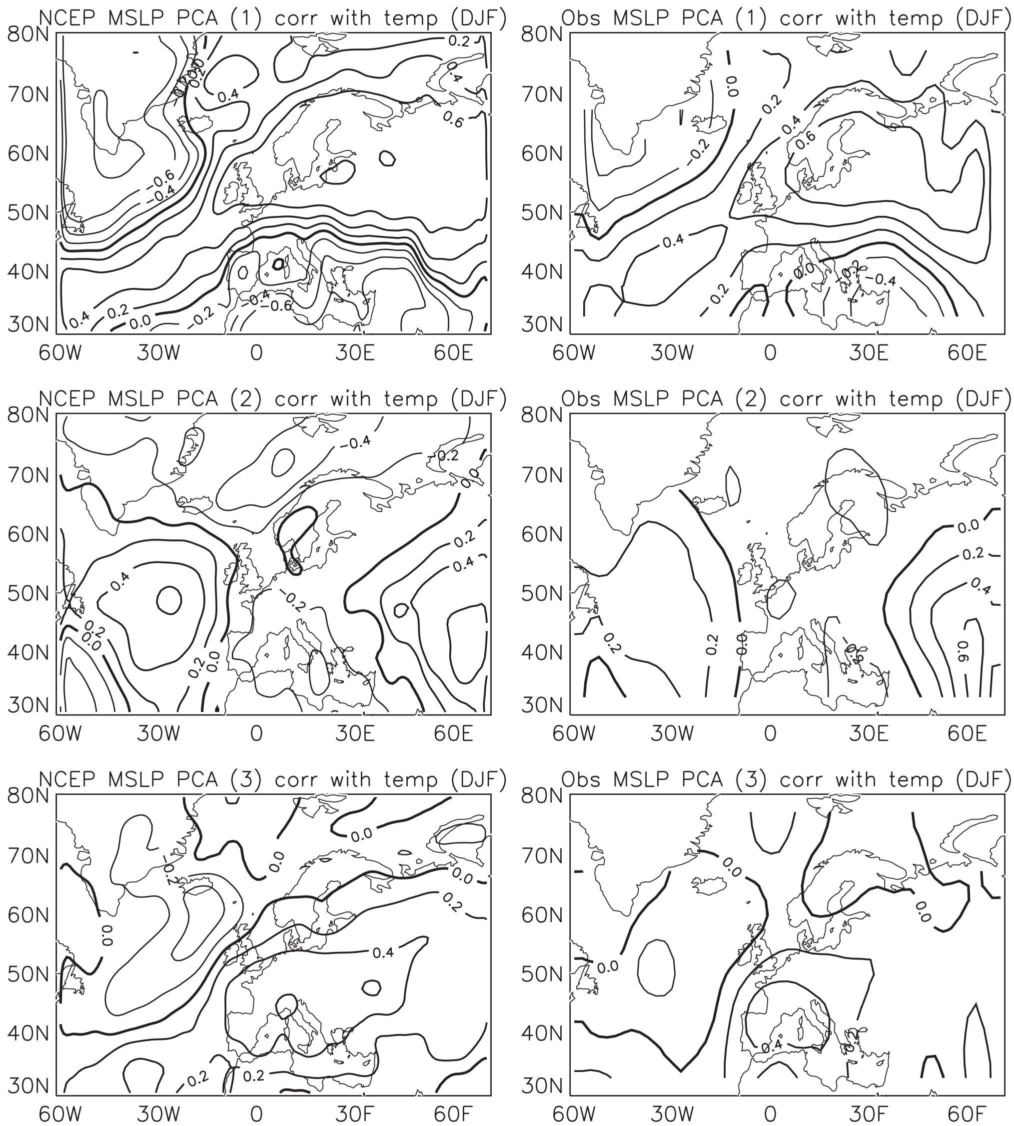

Fig. 10. Correlations between the derived variables (time series) of the PCA of MSLP and temperature for the NCEP analyses (left) and the UKMO data (right) for the period 1967–1995

tions tend to be lower during the earlier period (1901–1950) than during the more recent period (1951–1995). Overall, there are considerable differences in the observed correlations between these 2 periods, suggesting considerable variability of the NAO influence on European surface climate. The lower influence over 1901–1950 is in accord with the findings of Osborn et al. (1999).

Results based on the Ponta Delgada–Reykjavik NAO index are not shown here. The correlation patterns are generally similar to those based on the Gibraltar–Reykjavik index but are slightly weaker in winter. Stronger correlations (but still weaker than those in winter) are obtained in spring, summer and autumn using Ponta Delgada in the NAO index rather than Gibraltar, as expected from Jones et al. (1997).

4. DISCUSSION AND CONCLUSIONS

One of the major benefits of the NCEP Reanalysis over observations is the completeness of their spatial and temporal coverage. This makes them potentially ideal for studying broad areas of climate change over global and regional areas. There is, however, a need for an accurate synopsis of climatic conditions for any benefit to be gained. The analysis conducted here is over a European window, where data input into the

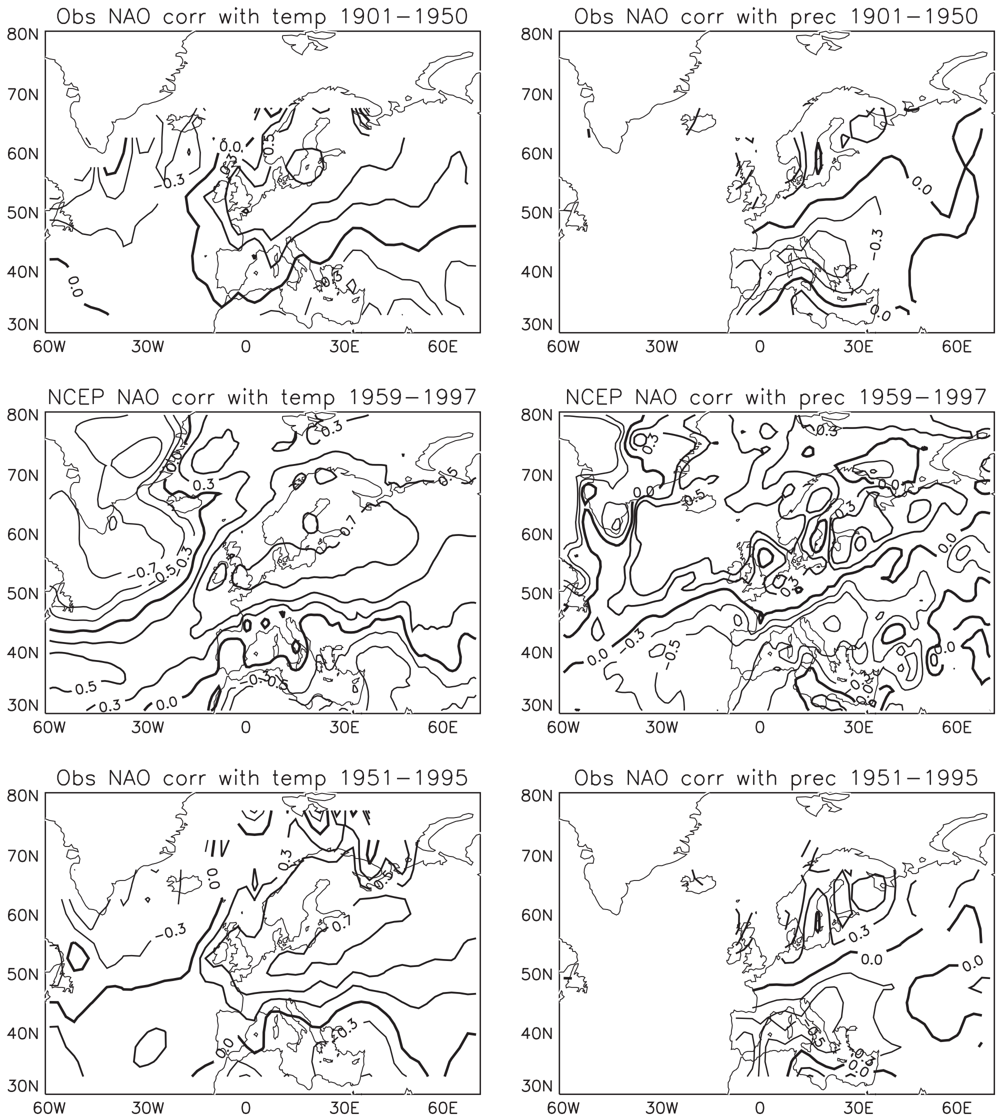

Fig. 11. Correlations for the winter season (DJF) between surface climate (temperature and precipitation) and the NAO (the difference of normalised pressures at Gibraltar and Reykjavik). Correlations are shown for temperature (left panels) and precipitation (right panels) for 2 observed periods and the NCEP-derived pressure and surface variables

assimilation process of the NCEP Reanalyses would have been very thorough in comparison to some other areas. For this reason, the results obtained should be regarded as being specific to this region and should not be generally extrapolated to regions where input data are known to be scarce and where data quality problems are evident.

The results presented here suggest reliance can be placed on the NCEP MSLP data, particularly on the interannual time scale; however, data prior to 1967 should be regarded as being less reliable. Decadal and longer time scale variability in the NCEP Reanalyses is probably more suspect (see also the discussion in Santer et al. 2000 and Chelliah & Ropelewski 2000). Spatially, NCEP and UKMO MSLP are more highly correlated in lower orographic areas and over northeast Europe. MSLP correlations are also shown to be higher during the colder months than during JJA.

Comparisons between daily NCEP and observed temperature and precipitation suggest that, while NCEP temperature is a reliable simulation, precipitation is less reliable, particularly in areas and periods of high convective precipitation. Daily mean temperatures obtained from NCEP over the 3 grid boxes (Central and Eastern England and Italy) are shown to be slightly higher than observed for all 3, while annual mean precipitation is lower over the 2 UK grid boxes and higher over Italy.

Correlations between NCEP and observed daily surface parameters are shown to have a strong seasonal cycle, particularly over Italy, where lower correlations are found in the warmer months for both temperature and precipitation. Correlations are also found to vary over the long term, with the annual correlation increasing over time for both of the English grid boxes. Daily temperature fields are reasonably reliable over this region, while daily precipitation is probably reliable in winter.

The results of the comparison between the PCA of MSLP and surface parameters are to some degree inconclusive, primarily due to the restricted spatial coverage of the observed precipitation data. The results between MSLP and temperature are, however, quite promising, with NCEP simulating the spatial and temporal relationships between the 2 fields quite well.

The NCEP Reanalyses are shown to present a good synopsis of climatic conditions over Europe for MSLP and temperature, with a somewhat poorer result for precipitation. MSLP Reanalyses prior to 1967 can be reliably used within the window of interest for the ACCORD project with the exception of those over Greenland. NCEP surface temperatures can reliably be used, but daily precipitation values are somewhat less reliable.

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