EMULATE Scientific objectives

Introduction

EMULATE will create daily gridded fields of mean-sea-level pressure (MSLP) over the extratropical North Atlantic and Europe (25˚N to 70˚N; 70˚W to 50˚E on a 5º by 5º grid spacing), 1850 to date. The data will be used to develop daily and longer time-scale characteristic atmospheric circulation patterns over the region for each two-month and three-month season of the year. The variations and trends in these patterns will be related to those evident in large-scale sea surface temperature patterns, with the aid of both surface temperature and precipitation data and coupled atmospheric and oceanic model simulations. Variations in the incidence of extremes of temperature and precipitation across Europe will be related to the atmospheric circulation patterns on daily to multidecadal time-scales.

Objective 1: Create daily gridded MSLP fields from 1850

EMULATE will use already available gridded daily fields for Europe after 1881 adjusted to be consistent with recently produced homogeneous monthly pressure fields. The gridded fields are available to the two UK partners. We will augment these data by digitising daily station pressure data for the 1850-1880 period particularly over Eastern Europe and the Eastern Mediterranean region. Exploratory study indicates that no more than about 40 additional daily MSLP series for 1850-80 will be needed as many long daily series are available from earlier EU and national studies. Over the open ocean, we will use the new blend of the Met Office marine data bank with the International Comprehensive Ocean Atmosphere Data Set (I-COADS) and recently digitized marine data from Norway. The marine pressure data are a considerable enhancement over data previously available. In addition, daily station data for several eastern North American locations (from Canadian and US colleagues) are required to complete the Atlantic analysis.

Analyses of climatic variability tend to be more effective if they have used data interpolated to a regular grid. This is because interpolation/extrapolation enables both spatially and temporally complete, and more internally consistent, datasets, to be produced which are more amenable to many of the complex multivariate analysis techniques now available. All presently available interpolation methods are based on correlation and covariance matrices and least-squares theory. Most produce similar results, particularly when the relationships between the predictors and predictands are strong. We will intercompare several methods (e.g., simple linear interpolation and more complex optimal interpolation methods which involve principal components of the basic data) to determine the best method and the impacts of any method on resulting analyses. Errors of estimation will be produced for the best method.

Measurable objectives:

(i) Digitize additional daily land station pressure data back to 1850.
(ii) Integrate daily land station data with the I-COADS.
(iii) Produce the daily gridded MSLP dataset (1850 to present) using the best method.

Objective 2: Derive a set of characteristic atmospheric circulation patterns, and study their variations and trends for each season

We will consider several techniques, including cluster analysis, principal component analysis (PCA) and non-linear PCA (NLPCA), to derive characteristic atmospheric circulation patterns. The surface climate of Europe is strongly influenced by many circulation factors. Of these, the North Atlantic Oscillation (NAO) is best known, but other patterns are often equally important. For example, the recent heavy precipitation and resultant flooding in northwestern Europe (April 2000-April 2001 and especially the autumn months in 2000) was unrelated to the NAO and resulted from persistent blocking over western and northern Europe. NLPCA, in particular, is a novel technique that should assist in pattern recognition.

Measurable objectives

(i) Define leading atmospheric circulation patterns for two-month and three-month seasons.
(ii) Create a database of quantitative changes in pattern amplitudes since 1850.
(iii) Assessments of trends in pattern amplitudes and in the incidence of their extremes.
(iv) Characterise within-pattern variability.

Objective 3: Relate variations and trends in atmospheric circulation and associated surface climate variability over Europe to sea surface temperature patterns, particularly from the North Atlantic

Winter temperatures and precipitation amounts in Europe are known to be quite strongly influenced by the NAO and may also be affected by other circulation and sea surface temperature (SST) patterns. Summer precipitation totals in Europe are less influenced by the NAO but show marked multidecadal variability and are related to global-scale SST and atmospheric circulation variability. The nature and importance of multidecadal relationships between both SST and the atmospheric circulation and precipitation and temperature will be investigated with the help of the extended data sets being created by this project. The long instrumental records, together with climate model data, will also be used to assess the importance of external climate forcing factors (including anthropogenic) to determine whether influences are changing.

Relationships also exist between regional-scale SST and atmospheric circulation patterns for the North Atlantic and the spatial and temporal scale of drought patterns in Europe. The temporal behaviour of such relationships will be investigated, with special emphasis on studying possible anthropogenic influences. The Mediterranean region is particularly sensitive to droughts and any increased ability to predict future droughts would be of great benefit to these countries.

Measurable objectives:

(i) Assessment of the relationship between both SST and North Atlantic and European atmospheric circulation patterns and surface temperature and precipitation variability, through the seasonal cycle.
(ii) Gridded database of drought severity across Europe.
(iii) Assessment of the relative influence of external forcing factors (natural and anthropogenic) and internal climate variability and their seasonal differences, mainly through the use of climate models.

Objective 4: Relate variations and trends in atmospheric circulation patterns to prominent extremes in temperature and precipitation

There is increasing concern that extreme climate (including the weather timescale) events, which have major impacts on society and ecosystems, may be changing in frequency and character as a result of human influences on climate. This project will define these extreme events based on long daily temperature and precipitation series across Europe and determine the importance of atmospheric circulation changes. We will also assess the part human influences (directly or indirectly) may have played in changes in the frequency and severity of extreme events, additionally involving the use of climate model results.

Measurable objectives:

(i) Determination of a selection of extreme climate indices for Europe and assessment of changes in these indices since 1850.
(ii) Determine the significance of atmospheric circulation for the extreme indices.