European and North Atlantic daily to MULTidecadal climATE variability

EMULATE

Description of Work

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LIST OF PARTNERS

1	UEA	University of East Anglia, UK
2	MetO	Meteorological Office, UK
3	UA	üUniversitaet of Augsburg, Germany
4	CEA	CEA/DSM’s Laboratoire des Sciences du Climat et de l'Environnement,
5	URV	University Rovira i Virgili, Tarragona, Spain
6	UBERN	University of Bern, Switzerland
7	SU	Stockholm University, Sweden
8	UGOT	University of Gothenburg, Sweden

1. Project Summary

Studies of the influence of atmospheric circulation on surface climate variables are limited by data availability. The instrumental database is short and it is often difficult to discern if relationships are stationary or whether subtle changes are occurring. Europe has the longest of all instrumental climate records as the first instruments were developed here in the late 17th century. Although earlier projects have highlighted some of these records, others wait to be digitised and homogenised. EMULATE seeks to extend continent-wide analyses back to the mid-19th century, providing 150 years of gridded daily pressure data to analyse. Homogeneity issues and digital availability, both of which we will address, are the principal constraints on analyses of European/North Atlantic circulation patterns and their influence on surface climate variations. Many analyses begin in the mid-20th century when with some effort and care, they could begin in the mid-19th century.

EMULATE proposes to create daily gridded fields of mean-sea-level pressure (MSLP) over the extratropical North Atlantic and Europe (25ºN to 70ºN; 70ºW to 50ºE on a 5º by 5º grid spacing), 1850 to date. The data will be used to develop time series of characteristic atmospheric circulation patterns for each season, sampled on sub-monthly time scales. The database will be assessed for quality and the standard errors quantified for each time step and grid-point location. Variations and trends in these patterns, and associated temperature and precipitation patterns, will be related to those evident in large-scale sea surface temperatures (SSTs) and other possible oceanic fluctuations. This includes fluctuations of the thermohaline circulation. The work will be done with the aid of atmosphere only and coupled atmosphere and ocean models. Variations in the incidence of extremes of temperature and precipitation (including drought) across Europe will be related to fluctuations and trends in the atmospheric circulation patterns on daily to multi-decadal timescales and, for temperature, to SST and possible anthropogenic factors. With the new datasets and patterns, relationships can be investigated for much longer periods than currently available.

The longer daily MSLP record will enable the assessment of the relative importance of anthropogenic factors to be more reliably determined. Relationships found (and their variability) will be compared with results from the Hadley Centre atmosphere-only and coupled climate models. The project will define an array of extreme events over the last 150 years across Europe and determine the importance of atmospheric circulation changes, SST and external forcing factors. This will enable the probable impacts of anthropogenic factors on extreme events to be determined over Europe.

2. Scientific/technical Objectives and Innovation

2.1 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 recently enhanced International Comprehensive Ocean Atmosphere Data Set (newly named I-COADS) and recently digitized marine data from Norway and other sources. The marine pressure data is 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 Data Set.
(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 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.
(iii) Ascertain whether extremes of climate had different characteristics in the late 20th century from those evident in the late 19th and early 20th centuries and determine the likely magnitude of human influences.

2.2 Innovation

The creation of daily mean-sea-level pressure (MSLP) fields back to 1850 will provide a new resource for research into the historical characteristics of European climate on sub-monthly and longer timescales. The availability of the fields will allow extensive analyses of characteristic weather patterns over Europe and the North Atlantic. This will enable an improved understanding of changes in extreme events over the last 150 years, and particularly how recent extreme events relate to long-term climate variability. Daily MSLP fields already exist since 1880 for part of the study region, but the project will have access to a large number of new marine pressure data, mainly before 1950 and extending back to 1850. These should greatly improve data quality as well as extend the analyses over the North Atlantic. An innovative aspect of the work will be the assessment of the uncertainties in the daily MSLP fields themselves. The extension of the fields over the mid-latitudes of the North Atlantic Ocean will allow improved interpretation of European climate events in terms of atmospheric conditions upstream.

Climate data are more widely used if they are available in some gridded form, so that they are both temporally and spatially complete and also easy to analyse in map/time series form. Gridding and interpolation, however, involve some form of data interpretation. Several techniques are available, the impacts of some well understood, some less so, but there have been few intercomparisons of all their benefits and failings. EMULATE will intercompare all the well-used techniques to determine the ‘best' one for daily MSLP data. Daily MSLP fields will then be constructed incorporating information from newly completed monthly analyses using the best technique.

A thorough exploration of the most appropriate techniques for defining the major pressure patterns will be examined. Non-linear techniques of principal components analysis (NLPCA) have recently been developed and these should be especially important as analyses will no longer be restricted by linearity constraints. It is well known that the positive and negative modes of leading circulation indices like the NAO are not exact opposites of one another, as shown by their characteristic jet stream configurations. We will also be able to study long-term changes in typical atmospheric circulation patterns and determine how these might change the frequency and severity of temperature and precipitation extremes across Europe. In addition we will investigate drought severity across Europe and changes in storminess in European coastal waters all using a longer-term context than is possible at present.

Existing studies of European climate variations are often nationally based and some do not consider data collected before the development of national meteorological services (NMSs). However, a number of recent developments in data archaeology and computing mean that much of the monthly temperature, precipitation and pressure data collected in the 19th century are now fully available for study. EMULATE will extend the work to the daily timescale necessary for studying all aspects of extremes. Important attributes of extremes such as intensity and duration cannot be assessed with monthly data. Europe alone has this wealth of climatic data and European scientists need to analyse it. In this way we can better determine the levels of natural climatic variability, because the 19th century data can only have negligible anthropogenic influence. We will also assess the natural variability of the influence of atmospheric circulation on surface climate. Many studies in different parts of the world (even some European ones) have concluded that climate and its variability have changed and/or recent events are unusual. EMULATE aims to make improved versions of the longest European series available for all to see whether interrelationships between climate variables, including atmospheric circulation, as measured through pressure data, and daily timescale extremes are changing in unusual ways in a 150 year context.

EMULATE will build on the substantial research experience of the investigators in relating atmospheric circulation to large-scale sea surface temperature patterns. It is expected that, in addition to studies of this topic for EMULATE, substantial leverage will be gained from a number of related on-going projects. The work will particularly involve the use of results from the most realistic atmospheric and coupled climate models currently available. EMULATE will involve a number of European groups who have considerable experience in analysis techniques, dataset development and in the sources of early daily instrumental climate (pressure, temperature and precipitation) data. Furthermore, very few studies have been undertaken linking ocean surface forcing to atmospheric phenomena on intrinsically sub-monthly (i.e., daily through weekly to half-monthly) timescales. This influence is expected to be shown on seasonal and longer timescales in the form of changes in the probability distributions of the sub-monthly atmospheric patterns.

Finally, EMULATE will also take advantage of the recent creation of an International Surface Pressure Working Group set up under the auspices of the Atmospheric and Oceanic Observation Panels (AOPC/OOPC) of the Global Climate Observation System/World Meteorological Organization (GCOS/WMO). This group aims to promote the development of long-term high-quality analyses of atmospheric surface pressure. Its terms of reference include:

- promoting the recovery of atmospheric pressure data, including issues associated with data access, archiving and maintenance,

- promoting the analysis of global surface pressure from both real-time and historical sources using both daily and monthly data,

- recording and evaluation of differences among surface pressure analyses through comparison of basic products, and recommending consequent actions to ensure the quality and consistency of the analyses.

3. Project Workplan

3.1 Introduction

This proposal has four main objectives, each associated with a Workpackage (WP):

i) Create daily gridded MSLP fields from 1850;

ii) Derive a set of characteristic atmospheric circulation patterns, and study their variations and trends for each season;

iii) Relate variations and trends in atmospheric circulation and associated surface climate variability over Europe to sea surface temperature patterns, particularly from the North Atlantic;

iv) Relate variations and trends in atmospheric circulation patterns to prominent extremes in temperature and precipitation.

The scientific work in EMULATE will be carried out in four work packages (WP1 to WP4). WP1 creates a dataset which will be extensively analysed in the remaining three major WPs. An additional work package (WP5) is included to ensure that EMULATE is effectively managed, all project objectives met and the climate data, analysis results and the specific deliverables disseminated to the wider community as soon as possible.

3.2 Project planning and timetable

Introduction
The EMULATE project will run for 36 months. Sixteen milestones can be identified over the project period (see below). The first of 17 project deliverables will be produced in Month 1, with the final deliverables due in Month 36 (see Table 1). A timetable showing the schedule for the WPs, milestones, deliverables and reporting is shown in Figure 1. The links between the WPs are illustrated in Figure 2.

UEA has experience of successfully managing large consortia in Frameworks 3,4 and 5. The web site, email and ftp will provide the principal electronic tools (together with progress reports and meetings) for project management, ensuring that all partners work efficiently and consistently towards the EMULATE objectives. The co-ordinator will be assisted by the WP leaders.

Milestones

EMULATE has sixteen milestones which reflect the measurable objectives given in Section 2.1.

- ***Milestone 1 (M1)*** (1 month into the project): Start-up meeting, web site developed and partners provide databases.
- ***Milestone 2 (M2)*** (6 months into the project): Techniques for blending and interpolation of data tested and agreed (Measurable Objectives (i) and (ii) of Objective 1).
- ***Milestone 3 (M3)*** (12 months into the project): Completion of compilation and gridded pressure data made available to partners (Measurable Objective (iii) of Objective 1).
- ***Milestones 4/5/6 (M4/5/6)*** (13 months into the project): First annual meeting which will define methods to be used for WPs 2,3 and 4 ***(M4/5)*** and complete WP1. First annual report produced ***(M6)***.
- ***Milestones 7/8/9/10/11 (M7/8/9/10/11)*** (24 months into the project): Second annual meeting which will discuss the provisional atmospheric circulation patterns ***(M7)***, daily pattern amplitude time series ***(M8)***, preliminary gridded drought index and characterise patterns of variability ***(M9)***,

and development of extreme indices from daily data ***(M10)***. Second annual report produced ***(M11)***. (Measurable Objectives (i) and (ii) of Objective 2, (i) and (ii) of Objective 3 and (i) of Objective 4).

- ***Milestone 12 (M12)*** (34 months into the project): Final meeting of all the partners and the scientific steering group.
- ***Milestones 13/14/15/16 (M13/14/15/16)*** (36 months into the project): Final reports on WPs 2, 3 and 4 complete. This includes the assessment of trends in pattern amplitudes and incidence of amplitude extremes ***(M13)***, final drought index and model/observational comparisons ***(M14)*** and completion of work on extremes and assessment of factors which influence their changes ***(M15)***. Final report sent to the EU and planning of papers for peer-review journals ***(M16)***. (Measurable Objectives (iii) and (iv) of Objective 2, (iii) of Objective 3 and (ii) and (iii) of Objective 4).

Table 1: List of deliverables.

DL	Deliverables list

Deliverable No	Deliverable title (brief)	Delivery date	Nature	Dissemination level
D1	Project web site	1	O*	PU
D2	Daily pressure data for additional 40 stations for 1850-1880	6	Da	PU
D3	Daily gridded fields of MSLP over the extratropical North Atlantic and Europe	12	Da	CO
D4	Daily fields of MSLP made available to wider community via the web site	24	Da	PU
D5	Fields defining leading atmospheric circulation patterns for 2-month and 3-month seasons	24	Da	PU
D6	Database of daily pattern amplitudes since 1850	24	Da	PU
D7	Assessment of the variability of the observed North Atlantic and European atmospheric circulation for the last 150 years in relation to SST patterns	24	Re	PU
D8	Gridded database of drought index for Europe	24	Da	PU
D9	Time series of selected 'extremes' indices, based on temperature and precipitation, of value to society at a set of homogeneous daily stations covering Europe	24	Da	PU
D10	Assessments of trends in pattern amplitudes and in the incidence of amplitude extremes	36	Re	PU
D11	Assessment of the time-varying influence of SST and atmospheric circulation on European surface temperature and precipitation patterns	36	Re	PU
D12	Results of model experiments to determine if the observed relationships in D7 and D11 are reproduced or can be better resolved using the longer time scales of the coupled model experiments, and an initial study of mechanisms and potential predictability.	36	Re	PU
D13	Assessment of the relative influence of external forcing factors (natural and human) and internal variability and their seasonal differences	36	Re	PU
D14	Assessments of changes in such extremes since the late nineteenth century	36	Re	PU
D15	Assessments of the influence of atmospheric circulation variations on the incidence of extremes	36	Re	PU
D16	Assessment of the likelihood of any anthropogenic influence on extremes	36	Re	PU
D17	Final technical report to EU	36	Re	PU

O* Web site

***Table 2: Schedule of workpackages and links between the workpackages and deliverables*.**

WPL	**Workpackage list**

Work-package No	**Workpackage title**	**Lead contractor No**	**Person-months (EU)** **(Months for Permanent staff)**	**Start month**	**End month**	**Deliverable No**
1	Create daily gridded MSLP fields from 1850	1	27.5 (2.5)	0	12	D2, D3
2	Derive a set of characteristic atmospheric circulation patterns, and study their variations and trends for each season	3	50 (3.5)	7	36	D5, D6, D10
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	2	58.4 (7.5)	13	36	D7, D8, D11, D12, D13
4	Relate variations and trends in atmospheric circulation patterns to prominent extremes in temperature and precipitation	7	64 (10.5)	13	36	D9, D14, D15, D16
5	Dissemination and Exploitation of Results	1	18 (5)	0	36	D1, D4, D17
	TOTAL		217.9 (29)			

Figure 1: Schedule of work.

Work package objectives (brief titles)	**01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36**
1a: Digitise daily land station pressure data for about 40 stations	
1b: Combine land and marine data to create daily gridded MSLP fields	
2a: Assess the statistical techniques for defining circulation patterns	
2b: Create the patterns for each two- and three-month season of the year	
2c: Create and analyse database of changes in pattern amplitudes since 1850	
3a: Document relationships between SST and climate patterns	
3b: Assess influence of external forcings on the relationships	
3c: Quantify the fraction of the variability that can be explained	
3d: Develop a gridded drought index data base	
3e: Make estimates of potential predictability on various time scales	
4a: Create a set of extremes indices based on temperature and rainfall data	
4b: Calculate time series of these extremes at selected stations back to 1850	
4c: Relate variations and trends in extremes to circulation patterns	
WP5: Dissemination and exploitation of results	
D1: project web site	X (01)
D4: daily fields of MSLP to wider community via the web site	X (24)
D17: final technical report to EU	X (36)
Start-up meeting	X (01)
Progress meetings and preparation of annual progress reports	X (11) X (23)
Final meeting	X (35)
WP leaders meeting: to finalise deliverables	X (35)
Technological Implementation Plan	Draft (10) Final (35–36)

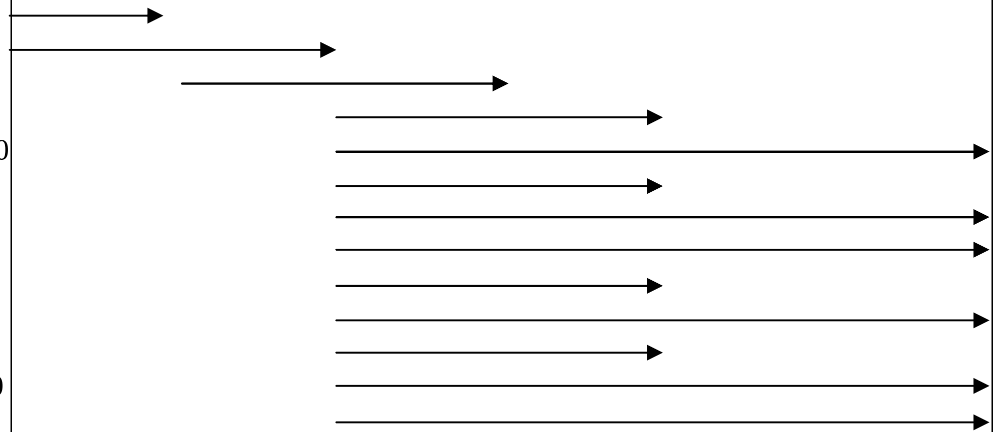
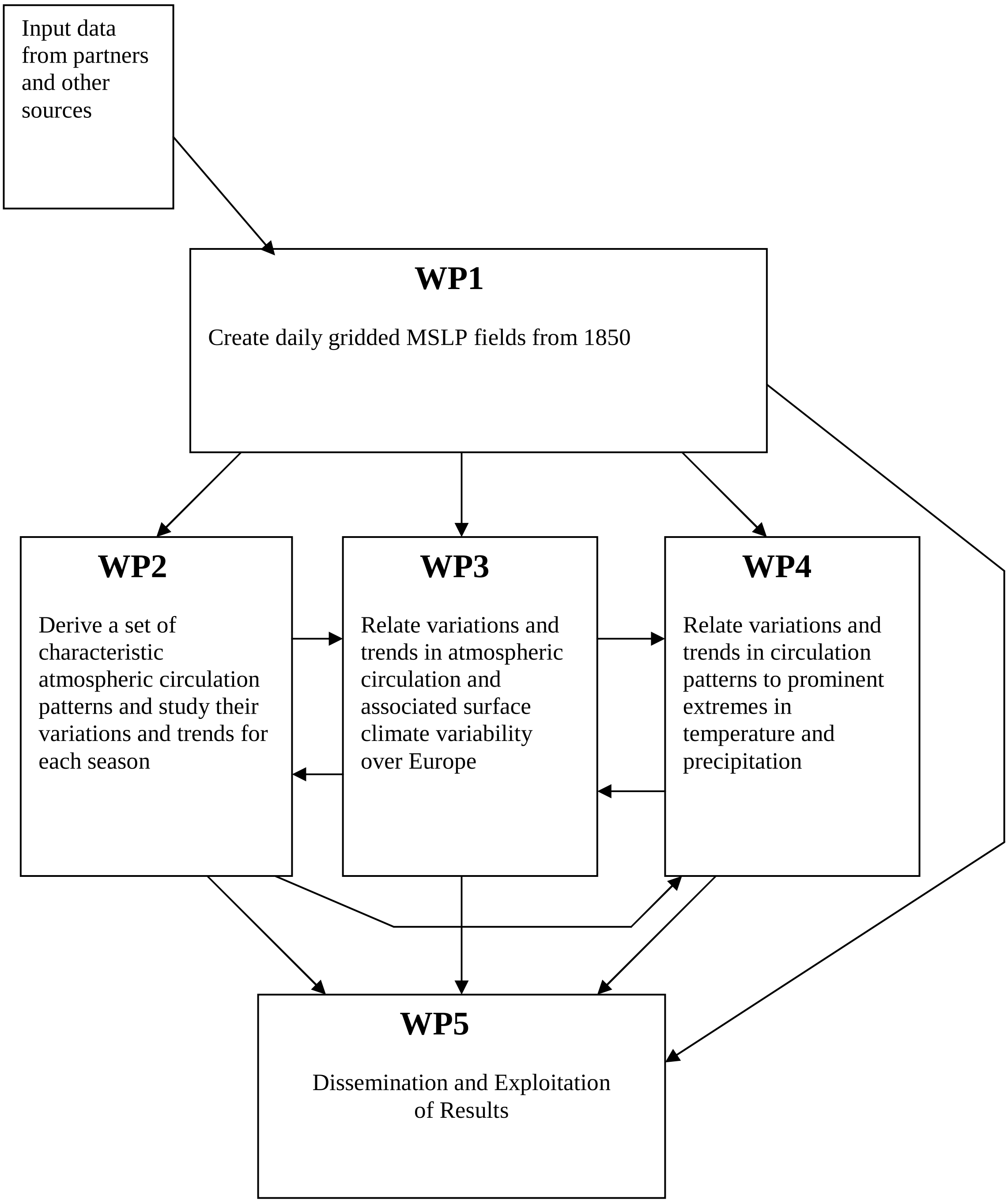


Figure 2: Graphical presentation of the project's components.



3.3 Critical path and risk of failure

The flow of information and data (i.e., the flow of deliverables) between WPs and the inter-linkages between WPs are shown in Figure 2. The scheduling of the work (Figure 1) is timed to reflect this flow, but with sufficient overlap in time to minimise any problems due to delays in any particular area of work.

The start-up meeting will focus on ensuring that appropriate data sets are available to all partners at an early stage in the project. The locations and sources of these data are known to the co-ordinator and some of the partners. Much data are contained in meteorological archives throughout western Europe (see Table 3). The methodology for constructing the daily gridded series from 1850 has been applied in other areas of climatology. The success of the project is dependent upon the production of the dataset in WP1. WP2 can begin before WP1 is finished using 20th century data sources and completed when the final version (back to 1850) is available at the end of the first year.

All of the HadAM3 and HadCM3 integrations to be used in WP3 have either already been completed or will be during the first year of the project as a result of other funding initiatives. New integrations using the atmospheric component (HadGAM) of the new Hadley Centre couple model HadGEM may become available during the project and will be used where appropriate. WP4 will use widely available datasets of daily surface climate observations. Since submission availability has been significantly enhanced by efforts of the European Climate Assessment at the Dutch Met. Service (KNMI) and through the Global Climate Observing System's surface network (GSN). These data and others can be freely used by the consortium. No major problems with any of the WPs are foreseen because the group has access to the basic data and is aware of where additional data resides should it be needed.

3.4 Detailed project description broken down into workpackages

WP 1: Create daily gridded MSLP fields from 1850

Daily gridded mean-sea-level pressure (MSLP) fields are already available since 1881 but are only reliable over western and central Europe. These fields will therefore be improved and extended where necessary to provide complete reliable daily estimates of MSLP over the region 25ºN to 70ºN, 70ºW to 50ºE back to 1850. To achieve this, long station-based European pressure series from earlier EU and several nationally funded projects (e.g. IMPROVE, ADVICE, WASA, NACD, and ALOCLIM) will be incorporated. ADVICE developed a monthly MSLP dataset for 1780-1995 for the region 35-70ºN by 30ºW-40ºE. IMPROVE homogenized daily temperature and pressure records for seven European locations (Camuffo and Jones, 2002). NACD and ALOCLIM developed monthly climate series for Fennoscandia and Austria respectively. WASA assessed changes in storm frequency and intensity over Northern Europe. EMULATE will use some of the daily MSLP series from WASA and all the IMPROVE and the ADVICE monthly data from 1850 onwards. Daily MSLP data for about 40 additional stations for 1850 to 1880 will be digitised, to fill gaps in daily data availability particularly over Eastern Europe, the Eastern Mediterranean, and coastal sites in eastern North America. Eastern European data will be digitised from the St. Petersburg yearbooks of the former Russian Empire (copies available with the two UK partners). Other European sources, noted but not used at the daily timescale during the ADVICE project, will also be digitised. The daily North American data (for the eastern seaboard) will be obtained through contacts at the Climate Research Branch of Environment Canada and with the USA's National Climatic Data Center. A list of example sites is given in Table 3.

Over the open ocean, we will use pressure measurements from the new International COADS (I-COADS) Data Set (a combination of the Met Office Marine Data Bank with the latest release of USA's Comprehensive Ocean Atmosphere Data Set, COADS), which includes the USA's Maury collection (Diaz et al., 2002). This collection has significantly improved pressure data availability over the North Atlantic in the 1850s and 1860s. We will remove biases arising from the lack of corrections to ships' barometric pressures for the variation of gravity with latitude. Wind direction data from the augmented marine database will also be used in the pressure analysis, if these data are of adequate quality.

Table 3: Daily MSLP sites (1850-1880)

Region	**Selected specific locations**	**Digital (Yes/No)**
Eastern North America (Labrador and E. Canada)	Labrador sites, Halifax, St. Johns	No
Eastern North America (USA)	Boston, Washington, New York Cape Hatteras and Key West	No
Mid Atlantic	Reykjavik (Iceland)/Bermuda	Yes/No
Europe	IMPROVE (Cadiz, Milan, Padua, Uppsala, Stockholm)	Yes
Southwestern Europe	Madrid, Barcelona, La Coruña	No
Central/Northern Europe	Sites in France, Germany, UK and Scandinavia	No
Eastern Europe	Russian Empire stations (Kiev, Archangel, Moscow, Lvov, Odessa, Helsinki, Warsaw)	No
Mediterranean	Gibraltar, Malta, Athens and Scutari (Izmir)	No

To interpolate sparsely sampled regions, we will compare several techniques, some of which are listed below. We will select that approach which reconstructs sub-sampled recent data with greatest skill. Fields of errors of estimation will be calculated. Over the ocean in particular, the analyses will also be guided and verified using homogeneous MSLP fields created monthly, using an optimum interpolation technique to improve on the analyses of Basnett and Parker (1997). A provisional version is already available from 1871 onwards. Where daily data are sparse, the monthly averages of the daily fields will be constrained to equal these homogeneous monthly fields where available. Uncertainties in the daily analyses will be confirmed by analysing daily MSLP fields for 1961-1990 from the NCEP Reanalyses sub-sampled using historical coverage, and comparing it with the reliably known fields for 1961-1990.

The three basic types of interpolation techniques to be used are:

- Simple methods that encompass the use of linear interpolation. All are best performed in anomaly space (i.e. with the average for a common base period, e.g. 1961-90, removed).
- Principal Component (PC) based techniques (e.g., Canonical Correlation, PC regression) fill the network spatially and, to a lesser extent, temporally by using patterns defined from the covariance characteristics of the data. Setting some data aside enables the regression based estimates to be assessed with independent data, thus allowing errors of estimation to be calculated (Jones *et al*., 1999, Luterbacher *et al*., 2000).
- Reduced-space optimal interpolation techniques are further extensions of PC based techniques, and use smoothed covariance matrices to undertake more extensive filling of gridded data sets. They assume constancy of PC patterns through time, though not of the relative importance of the various patterns. The results include fields of theoretical errors of estimate (Kaplan *et al*., 2000), which can also be combined with other independent errors (e.g. uncertainties in biases or their correction, Folland *et al*., 2001).

Although it is difficult to judge before the work begins, it is expected that reduced-space optimal interpolation techniques will likely be the best technique.

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

The aims of this WP are to define characteristic atmospheric circulation patterns for each two-month and three-month season of the year for the area 25ºN to 70ºN, 70ºW to 50ºE; and to create and analyse a database of quantitative changes in pattern amplitudes since 1850. This will be undertaken using the daily gridded fields of MSLP over the extratropical North Atlantic and Europe from 1850 to date, from WP1.

We will assess the skill of several traditional classification techniques, including k-means cluster analysis (e.g. Maryon and Storey, 1985), linear principal components analysis (PCA) and a new technique known as nonlinear PCA (NLPCA, Monahan, 2001), to define characteristic atmospheric circulation patterns. NLPCA will enable the positive and negative phases of major atmospheric circulation patterns, such as the North Atlantic Oscillation (NAO), not to be exact opposites. NLPCA has yet to be tested in the North Atlantic/European region. The chosen technique will be applied separately to the daily gridded MSLP fields for both traditional three-months seasons as well as each two-month season (January-February, etc.), because the NAO and other leading atmospheric circulation modes have seasonally-varying characteristics (Hurrell, 1995). Two-month seasons relate better to the basic climatological state of the atmosphere through the annual cycle. A modern training period, such as 1961-1990, for which adequate gridded data are already available, will be used to define the patterns, but we will assess the sensitivity of the results to the choice of training period. The projection of each daily field onto each chosen pattern for the appropriate season will be used to create a database of daily pattern amplitudes from 1850 to date.

We will also assess techniques for time-domain analysis, such as wavelet analysis, multichannel and extended singular spectrum analysis (MCSSA) and multi-taper methods involving singular value decomposition (MTM-SVD). The time-domain techniques will be applied to the pattern amplitudes and other indices. Maximum-likelihood statistical tests will be used to assess trends in pattern amplitudes, and a range of non-parametric tests used to study changes in the incidence of extreme pattern amplitudes. Changes in mean amplitudes and their variability, persistence and transitions of regimes (Corti *et al*., 1999), and extremes will be compared, and related to changes in the position and strength of the North Atlantic storm track. The aim will be to determine if there is any long timescale structure to the NAO and its influence on climate. Is its influence stationary on some timescales, but more chaotic on others? We will investigate, similarly, other leading modes, such as the Eurasian index (pressure difference between Britain and the Balkans, Luterbacher *et al*., 1999), the strength of the central European High, a measure of Siberian High incursions during wintertime and the Mediterranean Oscillation (Conte *et al.*, 1989). We will also assess influences from further afield such as the Southern Oscillation Index (SOI). In addition, a Rossby wave-like response over Europe has been demonstrated in observations and models from SST variations in the Gulf Stream-Labrador current boundary near Newfoundland, particularly in winter (Ratcliffe and Murray, 1970, Palmer and Sun, 1985). If the NAO weakens its influence, does one of the other factors become more important? Do any of these other indices co-vary with the NAO?

WP 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

WP3 will consider the influence of sea surface temperature (SST) variability on European climate through the atmospheric circulation at all times of the year. Winter is the time when the NAO and blocking over central and northern Europe influence European weather most. Sometimes the NAO weakens allowing the Siberian High to penetrate west causing extreme cold outbreaks. In summer, there are long term fluctuations in cyclonicity and anticyclonicity over northern Europe, which influence precipitation totals and therefore summer drought, and also temperature. In addition there has been renewed interest in autumn because of the exceptional rain and floods in northwestern Europe in 2000. Key questions will include responses to SST variations, including any related to natural thermohaline circulation variations (Delworth and Mann, 2000) on decadal to multidecadal timescales, other external (both natural and anthropogenic) forcings, and a preliminary estimate of any potential predictability.

In addition to observational data analyses, we will use a two-pronged modelling approach to investigate the influence of SST and other forcings on these various variability modes:

1. Long integrations of the Hadley Centre atmosphere-only model HadAM3 forced with observed SST and sea ice extents from 1870 are already available. Ensembles of runs forced with the same SST data with added solar and volcanic forcings and a variety of added anthropogenic focings, including direct and indirect tropospheric aerosol effects, will also be used. Furthermore, we will also analyse ensembles of runs with a higher resolution atmospheric model. This will be based on the atmospheric version of the new Hadley Centre Global Environmental Model (HadGEM) that should better capture winter jet stream behaviour over Europe, given planned higher atmospheric resolution. SST influences will be diagnosed using both analysis of variance approaches (Rowell, 1998) and the new pattern-based method proposed by Venzke *et al*. (1999) for analysing the influence of SST on circulation patterns. Where slowly varying anthropogenic forcings are important, a technique based on a general linear statistical model will be used to quantify any effects additional to those of SST and sea ice extent in the atmospheric model (Sexton, 2000).

2. Available control integrations of the Hadley Centre coupled model (HadCM3) will be used to gain a longer perspective and particularly to explore thermohaline circulation related variations in atmospheric circulation such as those likely influencing the “Atlantic Multidecadal Mode” (e.g. Enfield and Mestas-Nunez, 1999). HadCM3 contains natural variations of the thermohaline circulation and the most highly resolved model of the ocean (1.25º by 1.25º) for which such very long control integrations are available. Anthropogenically-forced ensembles are also available since about 1850. Later a more highly resolved atmospheric model (HadGEM) should become available.

WP3 will undertake the following analyses :

- Using both gridded data fields of pressure, temperature and precipitation, characterize the spatial patterns across Europe of climatic changes and variability, as well as the relationships between the variables, over the last 150 years in all seasons, and the relationships between the seasons. Are the relationships the same in the 19th and the 20th centuries? Analysis techniques will be similar as those proposed in WP2, with greatest emphasis placed on low-frequency and possible regime changes and transistions between regimes. Observatonal results will then be compared with those obtained from the climate model integrations.
- The improved SST database for the North Atlantic, and globally, since 1850 together with sea ice variations, will be used to investigate any oceanic feedback to the atmosphere using the two modelling approaches described above with particular emphasis on summer/winter differences and relationships with the pattern of SST variation that influenced the autumn 2000 floods.
- The possible external effects of solar output variations and volcanic aerosol loadings, on the pressure, temperature and precipitation fields in all seasons, will be investigated using (a) correlation and superposed epoch analyses and (b) using the long atmospheric model integrations. Are the spatial patterns of variability in pressure, temperature and precipitation fields affected by external forcings on one or another timescale? Do the relationships between the fields of different climate variables change as anthropogenic forcing increases during the 20th century?
- Using a combination of multivariate techniques for data decomposition of the suite of atmospheric model runs (in ensemble mode) with a variety of imposed forcings, including observed SST, determine how well the European climate can be explained as a result of internal

stochastic variability and to what extent it is forced by external factors. In particular, can the variability and changes over the 20th century be explained entirely by internal variability? How strong are the SST influences and what are they? Has anthropogenic forcing been strong enough to have already been detected above the level of natural variability in its influence on (a) temperature, (b) patterns of atmospheric ciculation and (c) patterns of precipitation?

- Develop a database of drought for Europe extending back to the mid-19th century and relate it as far as possible to the atmospheric circulation variations in all seasons. Different seasons have greater importance with respect to drought in different parts of Europe.

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

Changes in extremes are one of the most societally-important impacts of climate variability and change. Their analysis depends on the availability of daily data. Recently it has been shown that statistically significant changes in some temperature and precipitation-related extremes have occurred, e.g. over the USA (Karl *et al*., 1995) and over much of the Northern Hemisphere and some parts of the Southern Hemisphere (IPCC, 2001; Frich *et al*., 2002). The definition of an 'extreme' will be set so that events have societal importance, but are not so rare (e.g. the 95th or 98th percentile) that there are too few events that trends cannot be estimated. Wide ranging discussions of the issues and many other regional results appear in Karl *et al*. (1999). Existing analyses are limited to the twentieth century or even just its second half. However, over Europe sufficient daily temperature and precipitation data are available since 1850 to allow many more extensive analyses to be performed, enabling long-term changes in variability to be considered. Many long European daily data sources are now available from previous EU and nationally funded projects (IMPROVE and data available through the European Climate Assessment).

A wide range of extremes indices can be calculated from daily temperature and precipitation data (see e.g. Folland *et al*., 1999, Nicholls and Murray, 1999). Examples are the number of very warm and cold days for the time of year, the number of heavy rainfall days, and number of frost days (Frich *et al*., 2002). Some extremes are determined by natural thresholds (e.g. 0ºC), while the majority are determined by the data's own distribution, making them simple to calculate for all available daily data. The majority of indices relate to counts of individual daily extremes, but a few are determined by spells of exceptionally warm/cold temperatures or wet/dry periods. Spells of extreme weather generally have greater societal impacts (both directly and through their importance to insurance companies) and may be related to changes in regimes or in the position of the storm tracks. We will be able to address questions such as whether the frequency of certain types of spells is changing and whether apparent clusters of spells/extremes are significant changes or just random occurrences (e.g. using Sherman's ω statistic, Craddock, 1968).

A set of about 30 'extremes' indices will be defined for the long daily stations and trends for each location will be calculated using regression and non-parametric methods. Methods of combining specific extremes at each station will be explored to create a set of northern and southern Europe-wide indices. Only relevant extremes will be combined (i.e. only temperature extremes in Southern Europe in summer) and other divisions such as eastern and western Europe will be considered. The results will show whether a wide variety of extremes in the second half of the nineteenth century differ significantly from those in the late twentieth, information not hitherto available.

Variations of some extremes will be related to atmospheric circulation indices such as the clear link between the winter North Atlantic Oscillation and heavy winter precipitation or winter drought (e.g. Rodwell *et al*., 1999). This will be assessed using running correlation and correlation-based (e.g. running regression and canonical correlation analysis, CCA) methods with appropriate time windows. Is there any potential for predictability using these circulation influences concerning extremes that have clear societal impacts?

Assessment of changes to extremes due to anthropogenic effects will be made by comparing the observed extremes data with co-located gridded daily model data from the atmospheric model (HadAM3 or HadGAM) experiments in WP3. Both sets of extremes (observational and model) will be similarly averaged over northern and southern Europe, other European divisions, or Europe as a whole, to enable comparisons to be undertaken. These approaches will also be applied to daily coupled model output (e.g. HadCM3), especially for temperature. There are a number of methodological and statistical issues relating to assessing model extremes, from an ensemble of model experiments, which will be addressed to ensure meaningful comparisons with observations.

WP 5: Dissemination and Exploitation of Results

WP5 has two aims. First, to ensure that EMULATE is managed effectively and efficiently, so that all the project objectives are met. Second, to disseminate all the databases developed and the analysis results as quickly as possible to the wider community. While the co-ordinator will have overall responsibility for ensuring both aims, the WP leaders will assist with the flow of both expertise and data between the WPs and ensure the individual WP objectives are met. A project brochure will be produced early in the project to publicise the work.

All partners will be involved in the publication of scientific papers arising from the work. In addition, the gridded daily MSLP fields (Deliverable D3) will be made available to the rest of the project within 12 months of the start and to the wider community after the second year (D4, using the EMULATE web site and by ftp links). Other 'dataset' deliverables (D2, D5-6, D8-9) will be made available via the web site. The EMULATE web site (Deliverable D1) will be set up by the co-ordinator and all partners will contribute to the promotion of the site by seeking announcements/links through national climate change commissions and relevant interdisciplinary bodies at the interface of science/the public/politics. This WP will also develop a draft Technological Implementation Plan at the end of the first year and finalise this as the final meeting.

Table 4: Summary of WP1.

DWP Workpackage description

Workpackage number : 1	**Create daily gridded MSLP fields from 1850**					
Start date or starting event:	Month 0					
Partner No. (Lead in bold):	**1**	2	3	4	5	6
Person-months per partner:	11	10	2	2	1.5	1
Permanent Staff months:	2	0	0	0	0.5	0

Objectives

1a: Digitise daily land station pressure data for about 40 stations

1b: Combine land and marine data to create daily gridded MSLP fields over Europe, the North Atlantic and the eastern seaboard of North America since 1850

Inputs

- Daily pressure fields over Europe since 1881, already available
- Homogeneous monthly pressure fields for the Northern Hemisphere since 1871, already available
- Daily station-based European pressure series from earlier EU and several nationally funded projects, and available daily pressure series from the east coast of N America
- Augmented marine database already created by blending data banks from the UK and USA with newly-digitised observations from the Maury collection, Norway and elsewhere

Description of work

Daily gridded MSLP fields, which are already available since 1881 but only reliable over western and central Europe, will be improved and extended to cover 25ºN to 70ºN, 70ºW to 50ºE on a 5º by 5º grid with daily estimates of MSLP back to 1850. To achieve this, daily land station pressure data developed during previous EU and national projects will be incorporated. Additional daily data for about 40 stations for 1850 to 1880 will also be acquired and digitised to fill gaps over Eastern Europe, the Eastern Mediterranean, and coastal sites in eastern North America. Over the open ocean, we will use pressures and, if reliable, winds from the new International Marine Climate Data Set. We will remove biases arising from the lack of corrections to ships' barometric pressures for the variation of gravity with latitude. To interpolate sparsely sampled regions, we will compare several techniques, including optimal interpolation methods which use the covariance statistics of the data, and select the technique which best reconstructs sub-sampled recent data. Errors of estimation will be calculated. The analyses will also be guided and verified using homogeneous monthly pressure fields already available from 1871 onwards.

Deliverables and input to next workpackage

D2: Daily pressure data for additional 40 stations for 1850-1880.

D3: Daily gridded fields of MSLP over the extratropical North Atlantic and Europe (25ºN to 70ºN, 70ºW to 50ºE on 5º by 5º grid spacing), 1850 to date.

Milestones and expected results

Month 1: Start-up meeting. Partners begin to provide databases.

Month 6: Techniques for blending and interpolation of data tested and agreed.

Month 12: Completion of compilation and data made available to partners.

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Table 5: Summary of WP2.

DWP Workpackage description

Workpackage number : 2	**Derive a set of characteristic atmospheric circulation patterns, and study their variations and trends for each season**					
Start date or starting event:	Month 7					
Partner No. (Lead in bold):	**3**	1	2	4	6	7
Person-months per partner:	15	6	12	8	7	2
Permanent Staff months:	1	1	0	0	0.5	1

Objectives

2a: Assess the statistical techniques most suitable for defining regional atmospheric circulation patterns

2b: Create the patterns for each two-month and three-month season of the year for the area 25ºN to 70ºN, 70ºW to 50ºE

2c: Create and analyse a database of quantitative changes in pattern amplitudes since 1850

Inputs

- Daily gridded fields of surface pressure over the extratropical North Atlantic and Europe from 1850 to date, from WP 1

Description of work

We will assess the skill of several classification techniques, including cluster analysis and linear and nonlinear principal component analysis, in defining characteristic atmospheric circulation patterns at the daily timescale. Nonlinear techniques will enable the positive and negative phases of major atmospheric circulation patterns, such as the North Atlantic Oscillation (NAO), not to be constrained to be opposites. The chosen technique will be applied separately to the daily gridded MSLP fields in each two-month (January-February, etc.) and traditional three-month seasons, because all leading atmospheric circulation modes have seasonally-varying characteristics. A modern training period, such as 1961-1990, for which adequate gridded data are already available, will be used to define the patterns, but we will assess the sensitivity of the results to the choice of training period. The projection of each daily field onto each chosen pattern for the appropriate season will be used to create a database of pattern amplitudes from 1850 to date. Maximum-likelihood statistical tests will be used to assess trends in pattern amplitudes, and a range of non-parametric tests will be used to study changes in the incidence of extreme pattern amplitudes.

Deliverables and input to next workpackage

D5: Fields defining leading atmospheric circulation patterns for 2-month and 3-month seasons.

D6: Database of daily pattern amplitudes since 1850.

D10: Assessments of trends in pattern amplitudes and in the incidence of amplitude extremes.

Milestones and expected results

Month 24: Provision of defined leading atmospheric circulation patterns to partners.

Month 24: Provision of daily pattern amplitudes since 1850 to partners.

Month 36: Assessments of trends in pattern amplitudes and in the incidence of amplitude extremes.

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Table 6: Summary of WP3.

DWP	**Workpackage description**

Workpackage number : 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**						
Start date or starting event:	Month 13						
Partner No. (Lead in bold):	**2**	1	3	4	5	6	7
Person-months per partner:	21	5	3	7.4	13	7	2
Permanent Staff months:	0	1	1	0	4	0.5	1

Objectives

3a: Document the spatial and temporal relationships between SST and pressure patterns measured on sub-monthly time scales and associated seasonal European temperature/precipitation patterns.
3b: Assess the influence on the relationship of other external forcings, both natural and anthropogenic, with particular reference to similarities/differences between the seasons.
3c: Quantify the fraction of the total spatial/temporal variability that can be explained by internal stochastic variability and all available external forcings respectively.
3d: Develop a gridded drought index data base, and investigate the existence of any links between North Atlantic SST patterns and European drought patterns.
3e: Make estimates of potential predictability, where feasible, on interannual to decadal time scales.

Inputs

- Observed daily atmospheric circulation data and patterns from WPs 1 and 2.
- Readily available datasets of observed SST and sea ice extent, gridded precipitation and land surface air temperature data.
- Existing atmosphere-only and coupled model (GCM) circulation, SST and selected subsurface ocean data from long integrations with and without anthropogenic forcing.

Description of work

Various statistical techniques will be used to document seasonal relationships between the atmospheric variables (pressure, temperature, precipitation and drought) and SST using both real-world data and GCM simulations. The temporal stability of the relationships will be assessed, with emphasis on whether late-20th century patterns differ from patterns in the 19th century. The influence of external forcing factors will be considered, and the fraction of variability explained by external forcing versus internal stochastic variability will be determined. A drought database will be developed and analysed.

Deliverables and input to final workpackage

D7: Assessment of the variability of the observed North Atlantic and European atmospheric circulation for the last 150 years in relation to SST patterns.
D8: Gridded database of drought index for Europe.
D11: Assessment of the time-varying influence of SST and atmospheric circulation on European surface temperature and precipitation patterns.
D12: Results of model experiments to determine if the observed relationships in **D7** and **D11** are reproduced or can be better resolved using the longer time scales of the coupled model experiments, and an initial study of mechanisms and potential predictability.
D13: Assessment of the relative influence of external forcing factors (natural and human) and internal variability and their seasonal differences.

Milestones and expected result

Month 13*:* Review existing knowledge. Define drought index. Determine techniques for spatial pattern analysis and inter-variable relationships. Agree on existing model simulations to be used.
Month 24: Preliminary gridded drought index dataset completed. Characterisation of spatial patterns of pressure, temperature, precipitation and drought index.
Month 36: Final drought index database made available. Availability on web site of main scientific results and indices. Input to final EMULATE report. Plan papers to peer-reviewed journals collaboratively with other Workpackages.

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Table 7: Summary of WP4.

DWP Workpackage description

Workpackage number : 4	**Relate variations and trends in atmospheric circulation patterns to prominent extremes in temperature and precipitation**							
Start date or starting event:	Month 13							
Partner No. (Lead in bold):	**7**	1	2	3	4	5	6	8
Person-months per partner:	11.5	6	3	14	4	12	4.5	9
Permanent Staff months:	2	1	0	1	0	4	0.5	2

Objectives

4a: Create a set of extremes indices suitable for Europe based on temperature and precipitation and, as far as possible, using existing index definitions

4b: Calculate time series of these extremes at selected stations back to 1850 and estimate variations and trends in the indices based on recently developed methods. Estimate how extremes in the late nineteenth and early twentieth century differ from those in the late twentieth century

4c: Relate these variations and trends to atmospheric circulation pattern variations and trends and to anthropogenic effects, by comparison to existing model-generated data

Inputs

- Databases created in WPs 1 and 2 and series available to partners

Description of work

A set of daily extremes based on temperature and rainfall, of value to society, will be selected after reviewing the existing published literature. Existing analyses of indices of daily extremes in temperature and precipitation for Europe will be extended back to the late 19th century for long homogeneous daily European stations covering the continent. Trends and variations and their statistical significance will be calculated in the indices and related to observed atmospheric circulation changes. The contribution of the more prominent atmospheric patterns derived in Workpackage 2 will be assessed. The results will be compared to data from long simulations of atmospheric models forced with observed SST and sea ice extent, and further integrations with additional anthropogenic forcings to help determine if any anthropogenic influence exists on a European scale, particularly for temperature.

Deliverables and input to next workpackage

D9: Time series of selected 'extremes' indices based on temperature and precipitation, of value to society at a set of homogeneous daily stations covering Europe.

D14: Assessments of changes in such extremes since the late nineteenth century.

D15: Assessments of the influence of atmospheric circulation variations on the incidence of extremes.

D16: Assessment of the likelihood of any anthropogenic influence on extremes.

Milestones and expected result

Month 13: Review existing knowledge and define extreme indices to be used. Decide upon techniques for analysing changes in extremes and links to atmospheric circulation.

Month 24: Provision of time series of extreme indices for daily stations covering Europe.

Month 36: Input to final EMULATE report. Planning of papers to peer-reviewed journals in collaboration with other Workpackages.

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***Table 8: Summary of WP5*.**

DWP Workpackage description

Workpackage number : 5	**Dissemination and Exploitation of Results**							
Start date or starting event:	Month 0							
Partner No. (Lead in bold):	**1**	2	3	4	5	6	7	8
Person-months per partner:	8	1	3	2	0	1	2	1
Permanent Staff months:	1	0	1	0	1	0	1	1

Objectives

5a: To ensure that EMULATE is managed effectively and efficiently so that all project objectives are met

5b: To ensure the effective dissemination and exploitation of the project results and deliverables

Inputs

- Datasets and results/reports from all other WPs

Description of work

The co-ordinator will have overall responsibility for ensuring that all EMULATE objectives are met. A scientific steering group (the WP leaders) will ensure the flow of expertise and data between the WPs and that each individual WP objective is met. In addition to the production of scientific papers, a number of specific deliverables (datasets) are planned. These will be made available to the wider community within 6-12 months of being made available to the partners. Annual reports and a final report will be produced.

Deliverables and input to next workpackage

D1: Project web site

D4: Daily fields of MSLP made available to wider community via the web site

D17: Final Report to the EU

Milestones and expected results

Month 1: Start-up meeting.

Month 13: First annual meeting of all partners and the scientific steering group.

Month 24: Second annual meeting of all partners and the scientific steering group.

Month 34: Final meeting of all partners and the scientific steering group.

Month 36: Final report sent to the EU.

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4. Contribution to Objectives of Programme/Call

This proposal will directly contribute in a number of different ways to RTD priorities 1.1.4-2.4.1 on 'Better exploitation of existing data and adaptation of existing observing systems' and also to 1.1.4-2.1.4 on 'Climate variability and abrupt climate changes' which are both part of Key Action 1.1.4-2 on 'Global Change, Climate and Biodiversity'.

Media reports after many recent climate and weather extremes often link the event(s) to global warming (also the enhanced greenhouse effect) or state that extremes of these types are increasing in frequency. Both statements are generally incorrect or at best a distortion of known facts. To be able to comprehensively answer questions relating to the unprecedentedness of extremes (not only from the media but particularly from governments and stakeholders) requires long digitized records of surface climatic data. Precipitation and temperature are the most important variables from a climate impact point of view, but atmospheric pressure is often the most useful from the perspective of climatic understanding. The development of daily patterns of pressure, for the North Atlantic/European region since 1850, envisaged in this project will provide an unparalleled resource for European climatologists. All the basic data have been collected, but until recently much of it has been hidden away in National Meteorological Service (NMS) and marine archives.

Over the past 20 years much of this data has been digitised but EMULATE's aims are to bring these archives together to develop a pressure database of known quality over Europe and the North Atlantic. Gridded daily data already exist for the region for much of the period since 1880 but the data are of variable and sometimes unknown quality. The present project will develop a reproducible dataset, using the latest mathematical and statistical interpolation techniques, with every value associated with an error estimate. The dataset can be used to address numerous questions of major importance in climatology.

Extensive measurements of temperature and precipitation data have been made throughout Europe and eastern North America since the 19th century and in some locations back to the early 18th/late 17th centuries. However, in no country is this full record available at daily timescales. Digitization and homogeneity assessments have been undertaken in a few countries generally at the monthly timescale. Although useful, this timescale limits the types of extreme events that can be studied. Most useful definitions of extremes require daily data. One of the aims of this project is to make these early data (from this, and earlier, EU and national funded projects) more widely known to the climatological community world wide (i.e. we will foster better use of existing data, RTD Priority 1.1.4-2.4.1). The gridded daily pressure fields and long daily instrumental databases produced will be made available to climatologists worldwide.

There is growing evidence that natural influences on the climate system and inter-variable relationships (e.g. the strength of circulation influences on surface climate parameters) are being altered by anthropogenic factors such as increasing concentrations of greenhouse gases and sulphate aerosol emissions. Only in Europe are detailed instrumental records long enough to adequately determine the influences of natural factors for extensive periods before anthropogenic modifications can have had any measurable effect. EMULATE proposes a comprehensive analysis, which, as a by-product, will enable us to determine whether recent climate has behaved unusually (i.e we will extensively assess climate variability, RTD priority 1.1.4-2.1.4). The results of the project will be important to both the climate change detection and the climate prediction communities as well as being of considerable interest to insurance and re-insurance companies and to EU policy on climate change.

5. Community Added Value and Contribution to EU Policies

The EU has played a key role in mobilising international efforts to address the major environmental issues of global climate change due to increasing atmospheric concentrations of greenhouse gases and sulphate aerosol emissions arising from human activity. The EU took the lead in 1992 in Rio de Janeiro by committing to stabilise its CO_2 emissions at 1990 levels by 2000 and should reach this target. It is also an advocate of early action by all developed (Annex 1) countries and it played a major role in negotiations leading up to the Kyoto Protocol which it signed in April 1998. In June 1998, the EU reached an agreement on the contribution of each of its 15 Member States towards the 8% reduction in emissions relative to 1990, to be achieved by 2008-2012 by the Community as a whole in order to meet the provisions of the Protocol.

Domestic action, on a country-by-country basis is essential to meet these targets, but there is also a role for Community-based policies and measures. Three sectors (energy, transport and agriculture) were identified in June 1998 as the first priorities for such measures, which enable environmental issues to be integrated into other policy areas. Domestic action and implementation of community-wide measures will only be effective if the business community and ordinary people are convinced of the need for action. Confidence in climate detection and attribution studies is growing in the scientific community. The 2001 IPCC report has strengthened detection claims first made in the 1995/6 report. Such studies, however, still appear remote and academic to many outside this community. One of the main EUROCLIVAR recommendations was that results of detection and attribution (D&A) studies must be presented in a form intelligible to policy makers. EMULATE will help to achieve this using indices of extremes, assessing whether some are changing at unprecedented rates. It is through extremes that the public perceive most climatic change.

Perhaps the most important aspect of all D&A studies is to better understand the level of natural climate variability. This can be estimated from models, but business and the public are more likely to trust estimates using past instrumental observations. Public, politicians and opinion-formers will often assign more credence to ‘real’ measurements, than what are commonly regarded as esoteric models, often perceived as being divorced from reality. Europe, with its wealth of instrumental records, can consider climate variability in a natural state during the late 19th century and judge whether the late 20th century has seen changes. EMULATE will develop, during its early stages, an unrivalled database of daily MSLP fields for the North Atlantic and Europe. The daily MSLP fields will prove invaluable to many other projects, making much better use of the daily data that has been collected since 1850 and providing better understanding of the courses of change over the last 150 years.

The EMULATE consortium of scientists brings together many of the leading experts in instrumental climate studies within Europe, as well as access to all the datasets needed to begin WP1. Most of the consortium have worked extensively together in previously completed EU-funded projects, ADVICE, IMPROVE and to a lesser extent ACCORD. EMULATE will extend and augment the databases developed within ADVICE, IMPROVE and a number of other EU-funded (e.g. WASA, NACD) and national (e.g. REWARD in the Nordic countries and ALOCLIM in Austria) projects. Marine archives were improved through the first release of COADS (Comprehensive Ocean Atmosphere Data Set) in the late 1980s. The recent improvement (Release 1c or I-COADS) has dramatically improved coverage over the North Atlantic for the period from 1850 to 1900. An aim of EMULATE is to bring all these data sources to a wider community but the main aim is the more extensive diagnosis of European climate variations at a daily timescale since 1850, as measured solely by instrumental observations. It is essential for this type of work to be undertaken in a pan-European context. Future anthropogenic change is a global problem but Europe has both the economic resources and the instrumental climate data to make a very significant contribution to improved understanding in assessments of the levels of natural climate variability.

6. Contribution to Community Social Objectives

Natural and anthropogenic fluctuations of the climate in Europe affect many sectors (environment, energy, insurance, forestry, agriculture, water, transport and health) and the more extreme variations have significant consequences. Improved understanding of the past variability of climate is vital to assess likely future fluctuations, their potential predictability and whether any changes are caused by anthropogenic factors. Quantifying the impacts of this project, however, on the quality of life, health, safety, employment and maintenance of the environment is not possible, although it is clear that the project will make many positive contributions to fostering an informed awareness of climate change amongst members of the civil and governmental communities within the EU. The very fact that EU-funded research in global change is occurring is recognition by the EU that there is a problem, which might increase in coming decades. To meet the requirements of the UNFCCC the EU is funding research into climate change and improving educational opportunities in the subject.

EMULATE will provide a daily MSLP dataset, covering the North Atlantic and the European continent, which will be used to determine the level of natural variability of the climate system through extensive analysis of the wealth of instrumental observations available over the continent. Climate is just one factor the many sectors mentioned above have to take into account when considering the future. It is a factor that cannot be ignored. The database will be made available over the Web and via ftp, enabling anyone with Internet access to download information to make their own assessments.

EMULATE's extensive diagnosis of daily climatic variability will provide EU policy makers and scientists with an unrivalled database and an assessment of what has changed and a measure of the degree to which recent changes might be termed unusual. In the extension, beyond EMULATE, the outcome of the project is expected to serve as important background material in future evaluations of human impacts on climate, and on future projections, or forecasts, of both human-induced and natural climate change. Societal planners, together with policy makers and scientists, need to implement actions to minimise the risk of future hazards or other negative impacts on society caused by undesired climatic changes. In this respect, the outcomes of EMULATE will in the future help society to preserve, and hopefully enhance, the quality of environment and availability of natural resources.

EMULATE will also bring social benefits by building on previous work funded by the EU (the ADVICE and IMPROVE projects, see Section 5) and by further raising skill levels within the European scientific community. The EMULATE consortium will work together to enable the efficient transfer and interchange of information, data and skills between all its members, ensuring that all benefit equally and maintain their state-of-the-art level of expertise. Each EMULATE group will be made up of a mix of experienced researchers and younger post-doctoral researchers (some of whom will be new appointments).

The European Commission has a strategy of equal opportunities in all EU policies. The EMULATE consortium includes a number of women scientists of varying seniority. Opportunities to further increase the participation of women will be pursued wherever possible during the course of the project.

7. Economic Development and Scientific and Technological Prospects

The first deliverable (D1) is a project web site which will be set up by the co-ordinator (UEA). This will provide the main information point about the project for all participants, together with information of relevance to non-participants. It will include links to individual participant web pages, to sites of relevant organisations, projects and individuals, and publicise the work of the group.

Deliverables D2-D16 arise from WP1 to WP4. These deliverables include datasets (D2-6 and D8-9) each of which will be used by the consortium, but will also be made available publicly via the project web site, within 12 months of being completed. The Surface Pressure Working Group (see Section 2.2) of GCOS will be made aware of the availability of D4. The modelling results will be made known to the CLIVAR Climate of the Twentieth Century Project (Chris Folland of MetO is the co-chairman). All the remaining deliverables will be in the form of reports, all for public dissemination. Copies of progress reports prepared for project meetings and the annual reports prepared for the EU will be made available on the project web site. The last deliverable (D17) will be the final report. This will also be made available through the web site after submission. The main datasets produced during the project will be lodged at appropriate international sites. The web and ftp site will be maintained by the co-ordinator for at least two years after the end of the project and will be updated with lists of scientific papers and other publications arising from the project.

In addition to all the specific deliverables, all participants will be encouraged to produce scientific papers for publication in the peer-reviewed literature and to present their EMULATE work at scientific conferences. Possible meetings include the Assemblies of the European Geophysical Society, GCOS and CLIVAR sponsored meetings, the International Union of Geodesy and Geophysics' (IUGG) International Association of Meteorology and Atmospheric Sciences (IAMAS) and the annual meetings of the American Meteorological Society.

Ensuring dissemination of project results to relevant groups (both our scientific colleagues and the media/public) and maximising feedback from potential users (other scientists and politicians/public) is seen as a vital part of the EMULATE work. In part this will be achieved through the involvement of some of the participants (such as UEA, MetO, SU, UBERN and CEA) who have good links with climate modelling centres, the IPCC process, scientific societies and the media. MetO have regular opportunities for presentations directly to UK government ministers and other government policy makers.

Involvement in EMULATE will allow the participants to develop and maintain their pre-eminent positions in the observational climate field and in the symbiotic use of state-of-the-art climate models and observations. The EMULATE work will develop both the most comprehensive daily database of European climate and efficient software for gridding station data to a regular latitude/longitude network. The principal outcome will be an extensive and comprehensive analysis of daily European climate variations since 1850. This will substantially improve our understanding of natural climatic variability, enabling us to quantify human influences on climate particularly with respect to extremes, and also enhance possible predictability with the help of modelling results. The databases and the results will enable the participants and others to exploit other international and national projects in the future.

EMULATE partners will detail their plans for exploiting the project results, which will be described in the Technological Implementation Plan (TIP). A draft TIP will be prepared at the end of the first year of the project and the final version submitted at the end of project (Figure 1).

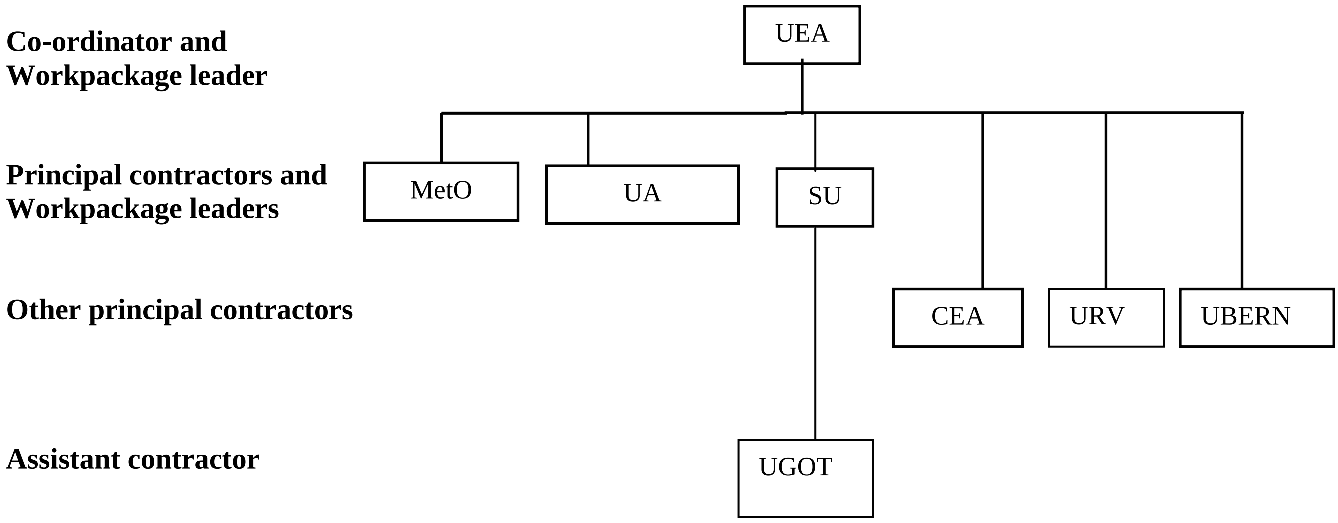
8. The Consortium

The EMULATE consortium consists of seven principal contractors, with one assistant contractor to SU (see later in this section). All these organisations are listed below, together with the key persons at each institute. Most of the partners have experience of working together through either the ADVICE and IMPROVE projects or in earlier joint scientific publications. The final column in the Table lists the Workpackages each group will be involved with.

Table 9: Summary of the Consortium

Principal Contractors	Organisation name	Short name	Key persons involved	Involved in WPs
01	University of East Anglia, UK	UEA	Phil Jones David Lister	WP1, WP2, WP3, WP4, WP5
02	Meteorological Office, UK	MetO	Chris Folland David Parker	WP1, WP2, WP3, WP4, WP5
03	Universitaet Augsburg, Germany	UA	Jucundus Jacobeit Andreas Philipp	WP1, WP2, WP3, WP4, WP5
04	Laboratoire des Sciences du Climat et de l'Environnement, France of CEA/DSM	CEA	Pascal Yiou	WP1,WP2, WP3, WP4, WP5
05	University Rovira i Virgili, Tarragona, Spain	URV	Manuela Brunet-India Diego López Bonillo	WP1, WP3,WP4,WP5
06	University of Bern, Switzerland	UBERN	Jürg Luterbacher Heinz Wanner	WP1, WP2, WP3, WP4, WP5
07	Stockholm University, Sweden	SU	Anders Moberg	WP2, WP3, WP4, WP5
08 (Assistant Contractor)	University of Gothenburg, Sweden	UGOT	Deliang Chen	WP4, WP5

The relationships between the EMULATE groups are summarised below:



The Workpackage leaders (UEA: WP1 and WP5; UA: WP2; MetO: WP3 and SU: WP4) will make up the EMULATE steering group (see Section 9).

All the groups involved in EMULATE have been allocated to Workpackages on the basis of their particular skills and expertise. UA, UBERN and CEA for example, have particular experience in circulation classification techniques (WP2). MetO and UEA have extensive experience in the correction of marine data due to changing instrumentation and developing gridded datasets (WP1). MetO, in particular, and UBERN and CEA have experience in running GCMs and in analysing their results. SU and UEA, through the IMPROVE project, and URV have experience in analysing daily series of temperature and precipitation for the study of changes in extremes. UGOT will work collaboratively with SU in WP4. Each Workpackage has a co-ordinator, however, who will be in overall charge of that aspect of the work. There will be extensive interaction between the Workpackages particularly WP2, WP3 and WP4.

UEA (Partner 1) has extensive experience in the analysis of climate data, in comparisons of climate model results with observations and will co-ordinate the project and will lead WP1 and WP5. The project co-ordinator will undertake a range of tasks related to project management (see above and Section 9) and will also work on the scientific tasks of the project. At the scientific level, UEA will focus on the development of the gridded daily MSLP dataset (WP1), with particular emphasis on the adequacy of the daily data for the 1850-1880 period. UEA will contribute to all the other three scientific WPs. UEA will focus in WP2 on the methods of assessing atmospheric circulation patterns, in WP3 on the development of the drought data base and in WP4 on the development of the set of extreme indices and their analysis. UEA will take the lead in the dissemination of the project results (WP5), through peer-review publications, scientific conferences, the project and its own web site and the TIP forms.

Personnel	1 Permanent Academic	1 Researcher	1 Technician/other for Co-Ordination
Expertise	Project co-ordinator	Data extraction, manipulation and analysis	Data support
Contribution to WPs	WP1-WP5	WP1-WP5	WP1, WP5
Contribution to Milestones and Deliverables	M1-M16 D1-D10, D13-D17	M1-M16 D1-D10, D13-D17	M1, M16 D1, D17

The Met Office (Partner 2), through its Hadley Centre for Climate Prediction and Research, has worked extensively on the creation and analysis of gridded datasets of mean sea level pressure and sea surface temperature, and on atmospheric and coupled model simulations of recent and future climate. In EMULATE, the Met Office will combine land and marine data into gridded fields of mean sea level pressure covering the study area. This will be followed by major contributions to the classification of atmospheric circulation patterns and the analysis of mulitdecadal variations and trends. Work will then focus on specifying relationships between atmospheric circulation and sea surface temperature, and on how these relationships are affected by natural and anthropogenic forcings. We will also assess the potential predictability of selected atmospheric circulation patterns and associated European climate on interannual to decadal time scales. Finally, we will contribute to the analysis of temporal variations in the relationships between atmospheric circulation and European climate, including extremes.

Personnel	1 Scientist (Job Level 1)	1 Scientist (Job Level 2)	1 Scientist (Job Level 3)	1 Scientist (Job Level 4)
Expertise	Principal Investigator	Deputy Principal Investigator	To perform day-to-day work	To perform day-to-day work
Contribution to WPs	WP1-WP5	WP1-WP5	WP1-WP5	WP1 - WP5
Contribution to Milestones and Deliverables	M1-M16 D3, D5-D7, D9-D17	M1-M16 D3, D5-D7, D9-D17	M1-M16 D3, D5-D7, D10-D13, D17	M1-M3, M6, M11, M13-M16 D3, D5-D7, D11, D17

UA (Partner 3) will be involved in all WPs and will lead investigations in WP2. Within WP1 UA will contribute to the acquisition and digitisation of daily land station pressure data stored in German archives. For WP2 UA will test novel techniques for defining atmospheric circulation patterns and promote assessments of the most appropriate techniques with regard to the time-scales of EMULATE analyses. Emphasis is put on the derivation of seasonal circulation patterns and on the analysis of their variabilities in terms of both pattern amplitudes and dynamical properties within each pattern. For WP3 UA will contribute to the study of relationships between atmospheric variables and sea-surface temperatures (SST), in particular with regard to any temporal non-stationarities of relationships. Within WP4 UA will participate in the assessment of possible changes in temperature and precipitation extremes between the end of the 19th and 20th centuries as well as in dynamical studies assessing relationships between changes in atmospheric circulation patterns and incidences of climatic extremes. UA will also be involved in the dissemination of the project results (WP5).

Personnel	1 Scientist (Post-doc)	1 research associate	1 Permanent Academic
Expertise	Programming and statistical analyses	Data acquisition and processing	Principal investigator
Contribution to WPs	WP1-WP5	WP1,WP2,WP4	WP1-WP5
Contribution to Milestones and Deliverables	M1, M4-M8, M11-M16 D1,D2, D5-D7, D9-D11, D13-D17	M6,M11,M13-M16 D2,D6,D9,D17	M1, M4-M8, M11-M16 D1,D2, D5-D7, D9-D11, D13-D17

CEA (Partner 4) has extensive expertise in climate time series analysis and coupled model simulations. CEA is the joint developer of a software package that has become a standard for geophysical data analysis. CEA will use its expertise in data analysis to obtain daily maps of surface conditions (WP1) and focus on data sets in France. CEA will perform multi-channel spectral analyses (M-SSA, M-MTM) and cluster analyses in order to assess the spatial and temporal variability of atmospheric circulation over the North Atlantic (WP2); this will be performed on the data sets obtained from WP1. CEA will perform (nonlinear) lag regression analyses of pressure and surface temperature fields to investigate the atmospheric circulation/climate connection and its stability through time (WP3); these analyses will also be performed in coupled control GCM simulations performed at CEA. Using tools from the statistics of extremes, CEA will investigate the recurrence properties of extreme temperature and precipitation anomalies, especially in France (WP4). CEA will contribute to the dissemination of results by conference communications, article publication, and the distribution of data to the scientific community (WP5).

Personnel	1 permanent staff scientist	1 Postdoctoral researcher
Expertise	Principal investigator	Time series analysis of climate variability
Contribution to WPs	WPs 1 to 5	WPs 2 to 4
Contribution to milestones and deliverables	M1, M6, M11, M12, M13, M14, M16 D1, D2, D11, D12, D17	M7, M8, M12, M13, M14, M15 D7, D10, D11, D12, D13, D14, D15

URV (Partner 5) has worked extensively on generating quality controlled and homogenised daily and monthly climate datasets and analysing long-term temperature and precipitation change over Spain and its different sub-regions. URV also has expertise in studying regional climate variability as well as analysing the influence of atmospheric circulation patterns on surface climate. In EMULATE, one of the roles of URV will be contributing to the creation of the daily gridded surface air pressure database, and the development of daily temperature and precipitation series. Another will be assistance with the drought index databases for Europe, as well as analysing relationships among atmospheric circulation, sea surface temperature and climate variability, both at the monthly timescale and for temperature and precipitation extreme events. In WP1, URV will compile and digitise daily surface air pressure for several locations over the Iberian Peninsula. In WP3, URV will participate in documenting the spatial and temporal relationships between SST and air pressure and in analysing the gridded drought index dataset to study relationships between Mediterranean drought patterns and North Atlantic SST patterns. The creation of the extreme climate indices and the estimation of their variations and trends, as well as assessment of the influence of atmospheric circulation variability will be URV's contribution to WP4. Finally, URV in WP5 will collaborate in disseminating project's results via publications and conferences.

Personnel	2 project-funded researchers	1 junior scientist	2 permanent-staff academics
Expertise	Data collection, manipulation and statistical analysis.	Data treatment and statistical analysis. Research duties.	Principal investigator and to lead day-to-day work on the project. Interpretation of results.
Contribution to WPs	WP1, WP3, WP4	WP3, WP4, WP5	WP1, WP3, WP4, WP5
Contribution to Milestones and Deliverables	M1, M3, M9, M5 D2, D3, D7, D8, D9, D11, D14, D15	M9, M5 D7, D8, D9, D11, D14, D15	M1, M4, M5, M6, M11, M12, M14, M16 D7, D11, D14, D15, D17

UBERN (Partner 6) has experience in climate reconstructions, statistical data analysis, climate dynamics, synoptic analysis and future climate scenarios. UBERN also hosts the new Swiss Centre of Competence in Climate Change Studies. In EMULATE, the main role of UBERN will be contributing to WP2, WP3 and WP4. Together with other partners, UBERN will define in WP2 characteristic atmospheric circulation patterns for each season for the eastern Atlantic-European area and analyze changes in pattern amplitudes since 1850. In WP3, UBERN will participate in documenting and analyzing the spatio-temporal connections between SST and European temperature, precipitation and pressure. Further, within WP3 UBERN will be involved in studying the influence of time-varying Atlantic SSTs and atmospheric circulation as well as forcing factors on European climate. Within WP4, UBERN will assess relationships between atmospheric circulation variations and European temperature and precipitation extremes. Finally, UBERN in WP5 will collaborate in disseminating project's results.

Personnel	1 Project-funded Research Assistant	1 Project-funded Post-doctoral Fellow	2 Permanent staff
Expertise	Data treatment and statistical analysis. Research duties	Data treatment and statistical analysis. Research duties	Principal investigator and to lead day-to-day work project. Interpretation of results.
Contribution to WPs	WP1-WP5	WP1-WP5	WP1-WP5
Contribution to Milestones and Deliverables	M4, M7, M9 D5, D7, D11, D15	M1, M4, M5, M7, M8, M9, M15 D2, D5, D6, D7, D9, D11, D13, D14, D15, D17	M1, M4, M7, M9, M15 D5, D7, D11, D13, D17

SU (Partner 7) has extensive experience of analyses of long daily instrumental climate records. SU will lead WP4, which concerns analyses of how variations and trends in atmospheric circulation patterns are related to variability in the frequency of prominent extremes in daily records of temperature and precipitation in Europe. A set of ’extremes’ indices of value to society will be developed and assessments will be made of the likelihood of anthropogenic influence on such extremes. The work includes statistical analyses of the gridded daily pressure data from WP1, the pattern time series derived within WP2, long homogeneous observational daily European records as well as modelled daily data. SU will also contribute to the assessments of trends in atmospheric circulation pattern amplitudes and extremes within WP2 and to assessments of the influence of SST and atmospheric circulation on European surface temperature and precipitation patterns within WP3. Within WP5, SU will contribute to the dissemination of the project results.

Personnel	1 Senior Scientist	1 Permanent Senior Scientist
Expertise	Software development, Statistical analyses	Principal investigator, will lead day-to-day work
Contribution to WPs	WP 2-5	WP 2-5
Contribution to Milestones and Deliverables	M4-6, M7-M8, M10-M11, M13, M15-M16 D1, D7, D9-D11, D14-D17	M1, M6, M11-13, M16 D1, D7, D10-D11, D14-D17

UGOT (Partner 8) is experienced with statistical analyses of climate data and statistical downscaling. UGOT will work under SU who leads WP4. The focus of the work will be on identifying and establishing links between large-scale patterns of atmospheric circulation and SST and variability in the frequency of prominent extremes in daily records of temperature and precipitation in Europe. In addition, UGOT will join the efforts to disseminate the project results (WP5).

Personnel	1 Junior Scientist	1 Permanent Senior Scientist
Expertise	Programming, Statistical analyses	Statistical downscaling
Contribution to WPs	WP 4-5	WP 4-5
Contribution to Milestones and Deliverables	M4-6, M12, M15-M16 D1, D15-17	M1, M4-6, M12, M15-16 D1, D15-17

9. Project Management

The project co-ordinator (UEA) will have overall responsibility for ensuring that EMULATE is managed effectively and efficiently, so that all the project objectives (Section 2.1) are met. The co-ordinator will be assisted by a scientific steering group, which will be composed of the Workpackage (WP) leaders. The main role of this group will be to ensure the flow of expertise and data between WPs takes place, and that all the WP objectives (Tables 4-8) are met. This steering group will meet at the annual meetings and will meet near the end of the project to ensure satisfactory completion of the final report. The steering group will also ensure that the various data products are made available to the whole group and to the wider scientific community later.

The co-ordinator will set up the project web site at the start of EMULATE. This will provide the main information point on the project for all participants, together with information of interest to non-participants. A brochure outlining the project will also be produced to publicise the project. The web site will include links for accessing data and links to individual partner web pages. Access to the web pages will be free to all outside the project. The daily MSLP fields developed during the first year will be made available to the whole climatological community by the end of year 2.

All EMULATE groups will work together on the individual WP objectives and to maximise the free flow of information/data between each other and between the WPs. Electronic means (email, the web site and ftp) will be used wherever possible. The co-ordinator will set up two mailing lists, one for all participants and one for the steering group to facilitate email communication.

Four project meetings are planned: a start-up meeting, two annual progress meetings and a final meeting. One of the major components of each meeting will be thematic plenary sessions focussing on specific aspects of the work. The main aims of the start-up meeting, for example, will be to determine that all the databases necessary for WP1 are fully available for use, to decide which data need to be digitised and to specify the techniques to be used for interpolation. The last meeting will focus on the final report and several joint publications that will arise as a result of the work. The WP leaders will be responsible for co-ordinating the presentations to the plenary sessions of the meetings. The project meetings will also provide an opportunity for solving any problems that may arise during the project. Time for WP groups to meet on an individual basis will be scheduled during each meeting.

Thus the scientific steering group and the rest of the group, through the project meetings, email and the web, all have vital roles in ensuring the successful management of EMULATE. The co-ordinator will have a number of specific tasks and responsibilities to ensure that all aspects operate smoothly:

- Setting up and updating the project web site;
- Placing the daily MSLP fields on the web site;
- Setting up project mailing lists;
- Organising project meetings (including circulation of agendas and minutes on the web site);
- Submission of annual and final reports to the EU and the web site; and,
- Monitoring completion of milestones and deliverables.

All groups will be encouraged to publish in the peer-reviewed literature and to present their work at scientific conferences (Section 7). These will provide an opportunity for the external assessment of the scientific quality of the EMULATE work.

Table 10: The person months for project-specific temporary staff and permanent staff that will be spent on each workpackage.

Project-specific staff:	**Cost basis**	**WP1**	**WP2**	**WP3**	**WP4**	**WP5**	**Total**
UEA	AC	11	6	5	6	5	*33*
Co-ordinator	AC	0	0	0	0	3	*3*
METO	FF	10	12	21	3	1	*47*
UA	AC	2	15	3	14	3	*37*
CEA	FC	2	8	7.4	4	2	*23.4*
URV	AC	1.5	0	13	12	0	*26.5*
UBERN	AC	1	7	7	4.5	1	*20.5*
SU	AC	0	2	2	11.5	2	*17.5*
UGOT	AC	0	0	0	9	1	*10*
Total		*27.5*	*50*	*58.4*	*64*	*18*	*217.9*

Permanent staff:	**Cost basis**	**WP1**	**WP2**	**WP3**	**WP4**	**WP5**	**Total**
UEA	AC	2	1	1	1	1	*6*
Co-ordinator	AC	0	0	0	0	0	*0*
METO	FF	0	0	0	0	0	*0*
UA	AC	0	1	1	1	1	*4*
CEA	FC	0	0	0	0	0	*0*
URV	AC	0.5	0	4	4	1	*9.5*
UBERN	AC	0	0.5	0.5	0.5	0	*1.5*
SU	AC	0	1	1	2	1	*5*
UGOT	AC	0	0	0	2	1	*3*
Total		*2.5*	*3.5*	*7.5*	*10.5*	*5*	*29*

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