European and North Atlantic daily to MULTidecadal climate variability

EMULATE

EVK2-CT-2001-00161

Second annual report: November 2003 to October 2004

Co-ordinator: Prof Phil Jones (p.jones@uea.ac.uk)
Climatic Research Unit, University of East Anglia,
Norwich, NR4 7TJ, UK

EMULATE home page: http://www.cru.uea.ac.uk/projects/emulate/

SECTION 1: MANAGEMENT AND RESOURCE USAGE SUMMARY, RELATED TO THE REPORTING PERIOD NOVEMBER 2003 TO OCTOBER 2004

1.1 Objectives of the reporting period

The reporting period main objectives relate to the (below listed) measurable EMULATE 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.
(iv) Define leading atmospheric circulation patterns for two-month and three-month seasons.
(v) 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.
(vi) Gridded database of drought severity across Europe.
(vii) Determination of a selection of extreme climate indices for Europe and assessment of changes in these indices since 1850.

The completion of the gridded MSLP dataset (i-iii above) was a prerequisite to the completion of several aspects (objectives) of EMULATE. There is a direct connection to objectives (iv) and (v); and other objectives (not listed above) which have to be addressed during the final year of the Project.

1.2 Scientific/technical progress made in different work packages according to the planned time schedule

The schedule of work is shown in Figure 1, while planned/used staff effort is shown in Table 1. Progress on each of the five workpackages (WPs) is outlined below. The work for WPs 2-4 was scheduled to begin at the start of year 2 and thus on completion of the production of the daily-MSLP dataset (EMSLP3 – (iii) above). The late completion of the final version of the EMSLP product (see ***WP1*** below and the report of work for WP1 in Section 3) did not prevent other Partners from undertaking their preparatory work towards the optimization of techniques for the aims of WPs 2 and 3. In addition, WP4 work went ahead as planned. More complete descriptions of progress are given under each WP in Section 3 and in the individual partner reports.

WP1: Create daily gridded MSLP fields from 1850

Objectives (from 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.

Progress: The final gridded product (EMSLP3) was completed and made available to EMULATE Partners (along with diagnostics and other material) during the first week of July, 2004. Additional time had been taken to further optimize all of the component processes (see Section 3.1 below). During this time, the opportunity was taken to digitize more land-station records and thus increase station density for the gridding processes. Work on this WP is now complete – short of the final stages of the production of a peer reviewed paper which describes the production of EMSLP3.

WP2: Derive a set of characteristic atmospheric circulation patterns, and study their variations and trends for each season

Objectives (from 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.

Progress: Much work has gone into defining leading atmospheric circulation patterns, using clustering techniques, for the different seasons. A novel approach has been introduced to an array of sophisticated techniques, to ensure that only patterns showing significant occurrence within EMSLP3 have been chosen. Final decisions relating to the exact procedures to be used were made at the recent ME3 Project meeting in Tarragona. Leading atmospheric circulation patterns (to match the requirements of Deliverable D5) have now been calculated for each 2-month and 3-month seasons of the year. For more detail, see Section 3.2 and the Partner-2 Report. The output data (D5) have been made available to Project members and the wider community *via* EMULATE web pages.

WP3: Relate variations and trends in atmospheric circlation and associated surface climate variability over Europe to sea surface temperature patterns, particularly over the North Atlantic

Objectives (from 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.

Progress: Progress has been made with the atmospheric model simulation exercises. Some slippage has occurred here (with respect to the previous estimated timetable). It is now expected that all simulations will be completed by March 2005. A web site (www.hadc20c.org -limited access) has been set up to enable Partners to make use of model output. The website is being continually updated as model simulations are completed.

Climate model output has been 'verified' by a variety of approaches. When seasonal weather patterns were compared to those seen in the observed pressure dataset (EMSLP3), using the jointly developed (Partners 2 and 3) clustering methodology, strong similarities were apparent. Further verification exercises have looked at the model's ability to capture observed trends in time-series of land-surface temperature anomalies, normalized Southern Oscillation Index anomalies, and winter/summer behaviour of the North Atlantic Oscillation Index.

Progress has been made on the identification of links between sea surface temperatures (SSTs) and atmospheric variability. Connections between SSTs and European temperature and precipitation anomalies have been identified during the 20th Century. Insights into the complex *inter*-relationships between SSTs and atmospheric behaviour have been gained. This work continues. See Section 3.3, below and the D7 Report (http://www.cru.uea.ac.uk/projects/emulate/**)** for more detail.

WP4: Relate variations and trends in atmospheric circulation patterns to prominent extremes in temperature and precipitation

Objectives (from 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.

Progress: The principal work undertaken in year-2 has been the development of indices for climatic extremes, based on a dataset of daily station temperature and precipitation records for more than 200 European stations with records starting between 1850 and 1901. The work has included data collection from external partners, digitising of original data within the project, quality control and homogeneity tests of station data series, development of index definitions and programming of index calculation routines. The dataset of extremes indices has been made available on the public website (http://www.cru.uea.ac.uk/projects/emulate). Analyses of trends in the index time series, as well as analyses of their relationships with atmospheric circulation patterns, have started and will continue in year-3.

WP5: Dissemination and Exploitation of Results

Objectives (from 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.

Progress: The EMULATE project web site has been further developed at the co-ordinator's location (http://www.cru.uea.ac.uk/projects/emulate). There are two sections. A Project only section is password protected. The public domain section of the web site contains some background to the Project, useful links and Project output that is scheduled for open access. The "internal" section is used for the dissemination of data between members, with the emphasis being on draft versions of products, and information that has to remain confidential. In addition, the full minutes and electronic presentation material from all annual meetings are linked. Project output, in the form of Deliverables (datasets and/or reports), is being linked to the public web pages at an increasing rate.

1.3 Milestones and deliverables obtained

Eight of the sixteen EMULATE milestones fall within the reporting period:

- ***Milestone 4 (M4)*** (13 months into the project): First annual meeting held.
- ***Milestone 5 (M5)*** (13 months into the project): Methods for WPs 2-4 defined and WP1 completed (D3).
- ***Milestone 6 (M6)*** (13 months into the project): First annual report produced.
- ***Milestone 7 (M7)*** (24 months into the project): Second annual meeting to discuss the provisional atmospheric circulation patterns held.
- ***Milestone 8 (M8)*** (24 months into the project): Daily pattern amplitude time-series produced (D6).
- ***Milestone 9 (M9)*** (24 months into the project): Preliminary gridded drought index and characteristic patterns of variability produced (D8).
- ***Milestone 10 (M10)*** (24 months into the project): Extreme index series from daily meteorological data produced (D9).
- ***Milestone 11 (M11)*** (24 months into the project): Second annual report produced.

ME3 was held at the URV, Tarragona, 20-22 September, 2004. Minutes of this meeting and electronic presentations are available on the internal web page.

The late completion of the final version of the EMSLP database ((D3); see Section 3.1) meant that the requirements of Deliverable D3 were not fully met until the middle of the current reporting year. Otherwise, six of the 17 EMULATE deliverables are due within the reporting period:

Deliverable No	Deliverable title (brief)	Delivery date	Nature	Dissemination level
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

D4: The daily fields of MSLP are complete and available to EMULATE members *via* the internal web page. Their availability to the wider community (public domain) awaits the successful publication of a multi-author paper, which describes the production of the daily database of MSLP.

D5: The data file for the two- and three-month seasons has been completed. It is now linked to the public domain web page.

D6: The database of daily pattern amplitudes has also been finished and it is now linked to the public domain web page.

D7: The report relating for D7 is complete and is now linked to the public domain web page.

D8: The gridded database of drought, based on a self calibrating version of the Palmer Drought Severity Index (PDSI), awaits a few final checks before it is linked to the public domain web page.

D9: A data base with time series for extremes indices, based on daily temperature and precipitation records from about 200 European stations, have been established and made available on the public website (http://www.cru.uea.ac.uk/projects/emulate). The index series start in various years between 1850 and 1901. In total, 64 different indices have been created (see Table 1 in section 3.4.2 below), all of which have been calculated for both 3-month and 2-month seasons. Along with the index time series, the web site also provides detailed descriptions of each of the indices as a guide to both external and internal users.

1.4 Deviations from the work plan and/or time schedule and their impact

The additional time taken to complete WP1 (and thus produce the gridded daily database of MSLP for the EMULATE region) has been documented elsewhere (see *WP1* above and Section 3.1 below). The impact on other aspects of the Project has been minimal due to the intensity of activities towards optimizing the methodology for other WPs and the fact that a preliminary product (EMSLP1) had been available for testing purposes, since the beginning of the reporting period.

There has been a similar delay in the completion of all climate model simulations under WP3 (see Section 3.3). This has not prevented the model validation exercises being undertaken. In addition, a lot of work has gone into the development of clustering methodologies towards the typing of atmospheric circulation patterns for both observed and modelled pressure fields. This has not been adversely affected by the delay in model output.

1.5 Co-ordination of the information between partners and communication activities

Co-ordination of information has been achieved *via* discussions at project meetings and on an ongoing basis *via* electronic means (i.e., the project web sites and email). The co-ordinator and WP leaders have a major role in ensuring that this is effective.

The UK Department for Environment, Food and Rural Affairs (DEFRA) made a formal request for access to outputs from EMULATE in order to strengthen the basis for policy/regulatory decisions, particularly with respect to the Climate Convention (UNFCCC) and the UK's Climate Change Programme. All EMULATE partners agreed to this request.

Details of the project have been presented to a number of scientific meetings (see details in Section 2).

1.6 Difficulties encountered at management and co-ordination level and solutions

No difficulties have been encountered at the management and co-ordination level. The fourth and final EMULATE progress meeting will be held in France, during the first half of October 2005.

Table 1: Comparison between planned and used funded staff effort by Work Packages and partners

Package	Partner	Proposed input				Actual input			
		Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Overall Total
WP1	UEA	11	0	0	11	9	3	-	12
	MetO	10	0	0	10	7.3	6.5	-	13.8
	UA	2	0	0	2	0.5	0	-	0.5
	CEA	2	0	0	2	0.5	0	-	0.5
	URV	1.5	0	0	1.5	1.5	0	-	1.5
	UBERN	1	0	0	1	1	0	-	1
	SU	0	0	0	0	0	0	-	0
	UGOT	0	0	0	0	0	0	-	0
	TOTAL	27.5	0	0	27.5	19.8	9.5	-	29.3
WP2	UEA	0	6	0	6	0	1	-	1
	MetO	2	10	0	12	0.7	6.8	-	7.5
	UA	6.33	8.67	0	15	5	8	-	13
	CEA	0	4	4	8	0.5	0	-	0.5
	URV	0	0	0	0	0	0	-	0
	UBERN	0	7	0	7	4	2.6	-	6.6
	SU	0	1	1	2	0	0	-	0
	UGOT	0	0	0	0	0	0	-	0
	TOTAL	8.33	36.67	5	50	10.2	18.4	-	28.6
WP3	UEA	0	5	0	5	0	3	-	3
	MetO	3	6	12	21	4	4.2	-	8.2
	UA	0	0	3	3	0	0	-	0
	CEA	0	4	3.4	7.4	0.5	0	-	0.5
	URV	0	6	7	13	0	6	-	6
	UBERN	0	0	7	7	1	4.3	-	5.3
	SU	0	0	2	2	0	0	-	0
	UGOT	0	0	0	0	0	0	-	0
	TOTAL	3	21	34.4	58.4	5.5	17.5	-	20
WP4	UEA	0	0	6	6	0	2	-	2
	MetO	0	0	3	3	0	0	-	0
	UA	0	4.67	9.33	14	3.2	3	-	6.2
	CEA	0	2	2	4	0.5	2.2	-	2.7
	URV	0	6.5	5.5	12	0	6.5	-	6.5
	UBERN	0	0	4.5	4.5	0	2.1	-	2.1
	SU	0	6.8	4.7	11.5	0	7.4	-	7.4
	UGOT	0	9	0	9	0	8	-	8
	TOTAL	0	29	35	64	3.7	31.2	-	34.9

		Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Overall Total
WP5	UEA	1	1	6	8	1	2	-	3
	MetO	0	0	1	1	0	0	-	0
	UA	0	1	2	3	0	0	-	0
	CEA	0	1	1	2	0	0	-	0
	URV	0	0	0	0	0	0	-	0
	UBERN	0	0	1	1	0	0	-	0
	SU	0.7	0.6	0.7	2	0	1	-	1.1
	UGOT	0	0	1	1	0	0	-	0
	TOTAL	1.7	3.6	12.7	18	1	3	-	5.4
PROJECT	UEA	12	12	12	36	10	11	-	21
TOTALS	MetO	15	16	16	47	12	17.5	-	29.5
	UA	8.33	14.33	14.33	37	8.7	11	-	19.7
	CEA	2	11	10.4	23.4	2	2.2	-	4.2
	URV	1.5	12.5	12.5	26.5	1.5	12.5	-	14
	UBERN	1	7	12.5	20.5	6	9	-	15
	SU	0.7	8.4	8.4	17.5	0	8.4	-	8.4
	UGOT	0	9	1	10	0	8	-	8
	TOTAL	40.53	90.23	87.13	217.9	40.2	79.6	-	119.8

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	01 → 06
1b: Combine land and marine data to create daily gridded MSLP fields	01 → 12
2a: Assess the statistical techniques for defining circulation patterns	07 → 18
2b: Create the patterns for each two- and three-month season of the year	13 → 24
2c: Create and analyse database of changes in pattern amplitudes since 1850	13 → 36
3a: Document relationships between SST and climate patterns	13 → 24
3b: Assess influence of external forcings on the relationships	13 → 36
3c: Quantify the fraction of the variability that can be explained	13 → 36
3d: Develop a gridded drought index data base	13 → 24
3e: Make estimates of potential predictability on various time scales	13 → 36
4a: Create a set of extremes indices based on temperature and rainfall data	13 → 24
4b: Calculate time series of these extremes at selected stations back to 1850	13 → 36
4c: Relate variations and trends in extremes to circulation patterns	13 → 36
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)

No modifications have been made to the scheduling of the five WPs or the Milestones. The original deliverable dates are shown here. All deliverables, due by the end of month 24, are/will be linked to relevant web-pages before the end of 2004. The only possible exception to this is for D8 which may have a slight delay before the final version is completed.

SECTION 2: Executive publishable summary, related to reporting period

Contract n°	EVK2-CT-2001-00161	Reporting period:	November 2003 to October 2004
Title	European and North Atlantic daily to multidecadal climate variability EMULATE		

Objectives:

The reporting period objectives relate to the first seven measurable EMULATE objectives (the first three of which were carried over from the first year):

1. Digitize additional daily land station pressure data back to 1850.
2. Integrate daily land station data with the I-COADS Data Set.
3. Produce the daily gridded MSLP dataset (1850 to present) using the best method.
4. Define leading atmospheric circulation patterns for two-month and three-month seasons.
5. 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.
6. Gridded database of drought severity across Europe.
7. Determination of a selection of extreme climate indices for Europe and assessment of changes in these indices since 1850.

Scientific achievements:

The final version of the daily gridded MSLP database is complete. This high quality resource has now replaced the earlier draft versions, for use within other components of the EMULATE work. It will soon be available to the wider scientific community. A complex methodology has been developed and used to identify atmospheric circulation patterns, both within observed and modelled pressure data sets. Atmospheric model simulations have been verified for use towards the identification of links between SSTs and extreme climate/weather patterns in Europe. A suite of extreme (weather) index series has been formulated and used towards the production of extreme time-series for land-stations in Europe. A gridded database of drought has been produced for Europe for the 20th Century. Work to draw together the database of patterns of atmospheric circulation, the time-series of extreme index series and the climate model output has now begun.

Socio-economic relevance and policy implications:

The extreme index time series (in WP4) are focused on extreme weather/climate phenomena, which are likely to be of interest to stakeholders and policy makers. Through the identification of relationships between SSTs, atmospheric circulation patterns and extreme weather/climate, there will be great benefit to both short and longer-term forecasts of climatic conditions. This type of advancement would assist the optimisation of resource use, especially, in the face of climate change.

Conclusions:

The project is running largely to the planned schedule. More and more information is becoming available to project participants and the wider scientific community through the web pages (http://www.cru.uea.ac.uk/cru/projects/EMULATE/).

Keywords:
Pressure, North Atlantic, daily variability, temperature, precipitation, extremes, circulation typing

Peer Reviewed Articles - published or in press

Authors	Date	Title	Journal/Book	Reference
ANSELL, T. *et al.*		Daily mean sea level pressure reconstructions for the European-North Atlantic region for the period 1850-2003.	Will be submitted to *J. Climate*	To be submitted for review early 2005
BRUNET, M., BAÑÓN, M., GARCÍA, F., AGUILAR, E., SALADIÉ, O., SIGRÓ, J., ASÍN, J., LÓPEZ, D.	2004	An experimental approach to the evalutation and minimisation of the "screen bias", througout dual temperature observations	*La meteorología y el clima atlánticos*, Publicaciones de la Asociación Española de Meteorología, Badajoz, 93-103	ISBN 84-8320-261-1
JACOBEIT, J., A. DÜNKELOH & E. HERTIG	2004	*Die Niederschlagsentwicklung im mediterranen Raum und ihre Ursachen*	In: Lozán, J., H. Graßl, P. Hupfer, L. Menzel & C.-D. Schönwiese (Hrsg.): Warnsignal Klima: Genug Wasser für alle? Hamburg,192-196	
JACOBEIT, J., A. DÜNKELOH & E. HERTIG	2004	Recent and possible future changes in Mediterranean precipitation	*Geophysical Research Abstracts*, **6**, No. EGU04-A-04027	
JACOBEIT, J., R. GLASER, M. NONNENMACHER & H. STANGL	2004	Hochwasserentwicklung in Mitteleuropa und Schwankungen der atmosphärischen Zirkulation	*Geographische Rundschau*, **56**, 26-34	
MOBERG, A., JONES, P.D.	2004	Trends in indices for moderate extremes in observed daily temperature and precipitation in Europe 1901-1999	*Int. J. Climatol.*	conditionally accepted
PHILIPP, A. & J. JACOBEIT	2003	Circulation Dynamics of Mediterranean Precipitation Variability 1948-98	*Int. J. Climatol.*, **23**, 2003, 1843-1866	
PHILIPP, A. & J. JACOBEIT	2003	Das Hochwasserereignis in Mitteleuropa im August 2002 aus klimatologischer Perspektive.	*Petermanns Geographische Mitteilungen*, **147**, 2003/6, 50-52	
SALADIÉ, O., BRUNET, M., AGUILAR, E., SIGRÓ, J., LÓPEZ, D	2004	Variations and secular trends of precipitation in the Sistema Mediterráneo Catalán (1901-2000)	*El clima entre el mar y la montaña*, Asociación Española de Climatología, Santander	in print
WANNER, H., C. BECK, R. BRAZDIL, C. CASTY, M. DEUTSCH, R. GLASER, J. JACOBEIT, J. LUTERBACHER, C. PFISTER, S. POHL, K. STURM, P.C. WERNER & E. XOPLAKI	2004	Dynamic and socioeconomic aspects of historical floods in Central Europe	*Erdkunde*, **58**, 1-16	
YIOU, P. & NOGAJ, M.	2004	Climatic extremes and weather extremes: Where and when?	*Geophys. Res. Lett.*, **31,** L07202, doi:10.1029/2003-GL019119	

YIOU, P., NOGAJ, M., KAGEYAMA, M., BRACONNAT, P., LE CLAINCHE, Y. AND MARTI, O.	2004	Impact of the thermohaline circulationon on North American Climate Variability	*J. Clim.*	Submitted

Non refereed literature

Author/Editors	Date	Title	Event	Reference	Type
Ansell, T.	2003	Development of a daily gridded MSLP data set over the North Atlantic region using I-COADS	CLIMAR 2 (November) Workshop in Brussels		O
Ansell, T.	2004	Development of a daily gridded MSLP data set over the North Atlantic European region from 1850-2002	C20C (April) Workshop in Trieste		O
BRUNET, M., BAÑÓN, M., GARCÍA, F., AGUILAR, E., SALADIÉ, O., SIGRÓ, J., ASÍN, J., LÓPEZ, D.	2004	An experimental approach to the evalutation and minimisation of the "screen bias", througout dual temperature observations	La Meteorología y el clima atlánticos, 5º Encuentro Hispano-Luso de Meteorología: La Meteorología y Climatología en los sectores público y privado, Badajoz 11 al 13 de febrero 2004, Seville	XXVIII Jornadas Científicas., pp. 35-36.	O/P
DELLA-MARTA, P.M., HAYLOCK, M., XOPLAKI, E., LUTERBACHER, J. AND WANNER, H.	2004	Relationships between the statistical dynamics of cyclones and indices of extreme events over Europe.	EGU, Nice	Extended Abstract	O
WALTHER, A.	2004	The development in time and the spatial distribution of precipitation- and temperature-extremes over Europe since 1850	Diploma thesis (1st degree)	University of Wuerzburg - Institute of Geography, Wuerzburg, Germany, 117 pp	D

D = Dissertation, O = Oral presentation, P = Proceedings

3.1 Workpackage 1: Create daily gridded MSLP fields from 1850
WP leader: Phil Jones (UEA)

3.1.1. Objectives
The objectives of WP1 are:

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

3.1.2. Methodology and scientific achievements related to the Work Package including contribution from partners

Summary of work done in year-2

The EMULATE dataset (EMSLP1) released in November 2003, and described in the first annual report, was a preliminary product. Over this last year, considerable improvements have been made, resulting in two additional versions of the dataset (EMSLP2 and EMSLP3) being released. The improvements made have included:

- increasing the number of land stations from 41 to 86,
- applying a diurnal and semi-diurnal cycle correction,
- improved homogenisation,
- correcting daily means to represent the same 24 hour period,
- gridding the marine and station data from 1850-2003,
- correcting the marine observations for a low MSLP bias, and
- improving error estimates for RSOI.

EMSLP3 was released to the EMULATE group in June (2004) – completing Deliverable D3. All land station data (both ‘uncorrected’ and quality controlled station data series) used in the project were also made available on the EMULATE web site (part of Deliverable D4). A diagnostics report and a draft paper have also been produced; the former is also available from the web-site.

Description of modifications

EMSLP3 was developed with essentially the same methodology as that used for EMSLP1, described in the first annual report. The reader is referred to this first report for details on the quality control and gridding of the marine observations (Section 1.2), the blending of the land and marine fields (Section 1.4) and the interpolation procedure (Section 1.5). In the section below we describe the main improvements and modifications made to this existing methodology.

Terrestrial data sources
In all, 86 continental and island stations over the North-Atlantic European region (see Figure 2 for land station distribution) were selected for EMSLP3. A detailed list of the individual station lengths is provided in Table 2.

Station	first year	end year	lat.	long.	Station	first year	last year	lat.	long.
Aberdeen	1861	1995	57.16	-2.10	Alexandria	1876	1881	31.20	29.95
Algiers	1872	1881	36.76	3.10	Ammasalik	1894	1995	65.60	-37.63
Angra (de Heroismo)	1871	1878	38.66	-27.22	Archangel	1866	2000	64.55	40.53
Armagh	1850	2001	54.35	-6.65	Astrakhan	1850	2000	46.35	48.03
Athens	1850	1880	37.90	23.73	Baghdad	1869	1876	33.23	44.23
Barcelona	1850	2002	41.50	2.01	Beirut	1869	1876	33.82	35.48
Bergen	1868	2002	60.38	5.33	Bermuda	1852	1880	32.28	-64.50
Biarritz	1860	1880	43.46	-1.53	Biskra	1878	1881	34.80	5.73
Bodo	1868	1994	67.26	14.43	Brest	1861	1881	48.45	-4.16
Cadiz	1786	2002	37.46	-6.28	Corfu	1852	1880	39.61	19.91
De Bilt	1850	2001	52.10	5.18	Diyarbakir	1869	1876	37.88	40.18
Durham	1850	1881	54.76	-1.58	Fao (near Al Basrah)	1869	1876	29.98	48.50
Funchal	1871	1881	32.63	-16.90	Galway	1850	1880	53.28	-9.02
Gibraltar	1850	2002	36.10	-5.35	Godthaab	1850	1880	64.16	-51.75
Gothenburg	1860	2002	55.70	11.98	Halifax	1850	1875	44.63	-63.50
Hammerodde	1874	1995	55.30	14.78	Haparanda	1860	2002	65.82	24.13
Harnosand	1860	1995	62.61	17.93	Helsinki	1844	2001	60.17	24.95
Hohenpeissenberg	1850	2002	47.80	11.02	Jena	1850	2000	50.93	11.58
Kazan	1850	2000	55.78	49.13	Kem	1866	1880	64.95	34.65
Kiev	1850	1990	50.40	30.45	Kostroma	1850	1880	57.73	40.78
La Coruna	1865	2002	43.16	-8.50	Lesina (Split)	1869	1881	43.53	16.30
Lisbon	1869	1881	38.77	-9.13	London	1850	1881	51.46	0
Lugansk	1850	1880	48.60	39.30	Lund	1864	2001	55.70	13.20
Lyon	1869	1881	45.72	4.95	Madrid	1853	1880	40.45	-3.71
Malta	1852	1880	35.83	14.00	Milan	1763	1998	45.61	8.73
Montreal	1850	1873	45.53	-73.60	Moscow	1850	2000	55.76	37.66
Nikolayev	1850	1880	46.58	31.95	Nordby	1874	2002	55.43	8.40
Oksoyfyr	1870	2002	58.07	8.05	Orenburg	1850	1876	51.75	55.10
Padua	1766	1997	45.40	11.85	Palermo	1851	1880	38.13	13.33
Paris	1851	1880	48.81	2.33	Plymouth	1861	1881	50.35	-4.15
Potsdam	1893	1993	52.38	13.06	Prague	1850	1880	50.08	14.42
Providence	1850	1860	41.68	-71.25	Reykjavik	1820	2001	64.13	-21.90
Riga	1850	1990	56.81	23.89	Rochefort	1862	1881	45.93	-0.93
Rome	1869	1881	41.95	12.50	Scutari	1866	1880	41.00	29.05
Sevastopol	1850	1990	44.61	33.55	Sibiu	1878	1881	45.80	24.15
St Johns	1852	1876	47.56	-52.70	Stockholm	1850	1998	59.33	18.05
Stornoway	1872	1881	58.22	-6.32	St Petersburg	1850	2000	59.93	27.96
Stykkisholmur	1874	2003	65.08	-22.73	Tenerife	1901	2001	28.47	-16.32
Tbilisi	1850	1990	41.68	44.95	Tørshavn	1874	2002	62.02	-6.77
Toulon	1868	1881	43.10	5.93	Uppsala	1722	1998	59.86	17.63
Valentia	1861	1995	51.93	-10.25	Vardo	1861	2003	70.36	31.10
Vestervig	1874	1995	56.77	8.32	Visby	1860	2002	57.63	18.28
Wilna	1850	1990	54.68	25.30	Zagreb	1862	2000	45.82	15.98

Table 2: *List of 86 pressure sites used in EMULATE. The start and end year of the record is given, as well as the lat. and long. in decimal degrees (negative longitudes are degrees west).*

Over this last year considerable material was digitised from individual hard copy records from Russian, United Kingdom (UK), French and Spanish daily weather records (DWRs), held in the UK National Meteorological Archives and Library. These were supplemented by scanned Algerian, French and US observations available from the NOAA library web site (http://docs.lib.noaa.gov/rescue/data_rescue_home.html). Old American 'Bulletin of International Meteorological observations' volumes also provided valuable records for Godthaab in Greenland and helped fill gaps in existing records. Data were also digitised from compilations made under the auspices of the UK Board of Trade, Royal Engineers and Army medical departments and from Ottoman Empire records also held in the UK National Meteorological Archives.

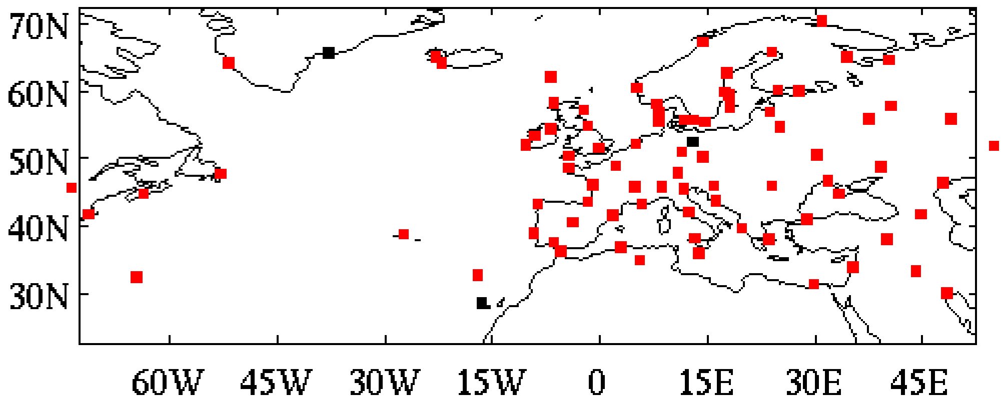

Figure 2: *Distribution of the 86 continental and island station in EMSLP3. Red squares indicate stations whose records begin between 1850-1880. Black squares are for those stations whose record begins post 1880. 1850-1880 corresponds to the period when we have no Superfile (Jackson, 1986) data available.*

Diurnal corrections
Atmospheric pressure has a marked semi-diurnal and diurnal variation. This arises from internal gravity waves in the atmosphere, generated by atmospheric solar heating, due to the absorption of solar radiation, and upward eddy conduction of heat from the ground (Chapman & Lindzen, 1970). Over the EMULATE region, the amplitude of both the diurnal and semi-diurnal oscillation is generally < 1.0 hPa (Dai & Wang, 1999). In order for the daily fields to better approximate the 'true' daily mean, a correction is required.

Due to a lack of sufficient sub-daily data, we were unable to calculate the diurnal and semidiurnal cycle at each station directly. Instead, we used the phase and amplitude fields (seasonal) calculated by Dai and Wang (1999) and interpolated from the nearest grid point to each station. Observation hours for each day of the station series were collated and used to determine the appropriate adjustment required. No diurnal correction was applied in EMSLP1.

Homogenisation of land-station data.
As described in the first annual report, to address homogenisation issues we applied broad adjustment factors. Specifically, the monthly means were calculated for each daily series and compared to a reference value [the corresponding ADVICE (Jones et al, 1999) monthly station series or obtained by interpolating from the nearest ADVICE or HadSLP (Basenett & Parker, 1997) grid point]. The difference in monthly means was then used to adjust the daily SLP values. To avoid jumps in adjustments at the end of each month, a binomial filter was applied. Preference was given to the ADVICE station series where possible [for EMSLP1 only the gridded product was used, resulting in some coarse adjustments (e.g. St. Petersburg)].

For the Canadian stations and those in the far east of the EMULATE region a final adjustment was required so that their daily average represented the same 24 hour period as the other series. The Canadian stations are five hours behind central Europe, some of the Russian are four hours ahead. As only daily averages were available for these stations, we were forced to interpolate between the preceding (following) day and the actual day for the Canadian (far Russian) stations.

Blending land and marine fields
The marine fields were QC-ed and gridded following the procedure outlined in Section 1.2 of the first annual report. For EMSLP3 the US Maury observations were additionally corrected

for a low MSLP bias (described in the Appendix of the report from Partner 2). The QC-ed land station data were blended with these gridded marine fields from 1850-2003, using a procedure similar to that employed with the marine observations. A climatological monthly average of 1871-1900 from HadSLP was used as the QC background field for the period 1850-1870.

The Superfiles (1881-2003) were then combined with these blended 1850-2003 fields by solving the Laplacian (Reynolds, 1988). Using the observations as the ground truth, the Laplacian (second derivative) of the Superfile anomalies was used to interpolate between the observations.

Correcting for the low MSLP bias in US Maury Observations
The 1850s decade in the I-COADS data is dominated by anomalously low MSLP over much of the globe. This signal is strongest in midlatitude regions. Such a large and coherent signal was not seen during any other decade. It was first reported by Todd Mitchell in 2002 at a workshop in Boulder, USA, on the use of Historical Marine Climate Data (Diaz et al., 2002), and remains an unresolved problem within the I-COADS pressure community.

During 1850-1855 the only data source was deck 701 (the US Maury collection). After 1855, observations from the Netherlands deck 193 begin and the low bias is less prominent. Given the EMULATE project requires fields to start in 1850, it was not possible to simply ignore the US Maury observations and start the gridded product from 1855.

The marine gridding procedure works with residuals, by removing a reference monthly background field value from each observation. The deck 701 observations are anomalously low when compared to this background field, however if we created residuals by removing a background based on just the biased deck 701 observations, the residuals would be smaller. After gridding the residuals and forming the median value, the `normal' and unbiased monthly background field would then be added back, resulting in hopefully a reduction of the low pressure bias.

Adopting this methodology, a deck 701 monthly background climatology was created by averaging deck 701 gridded fields only from 1850-1860. The gridding and quality control procedure was re-run, using now two reference monthly background fields (the `normal' monthly 1850-2003 background and the deck 701 monthly climatology). If an observation was from deck 701, the 701 climatology was removed; the monthly background field was removed from all other observations. Note again that after the daily median residual was formed on the 1x1 degree grid, the monthly background value was added back.

By incorporating this procedure, a marked reduction in the low MSLP bias was observed. When comparing the 1850-1860 decade to a 1961-1990 climatology, the North Atlantic region remained anomalously low, though this signal was weaker than was observed in version 1 of the EMSLP dataset. Much of the tropics and southern midlatitudes anomalies were near normal.

Interpolation
In order to create spatially complete fields, Reduced Space Optimal Interpolation (RSOI) was used [see Kaplan et al. (1997) and references therein]; the method was described in detail in the first annual report (Section 1.5).

For EMSLP3 an estimate of the sampling error was created by using an average (1961-1990) of the combined marine, land and Superfile sampling error. For the marine observations the sampling error for each month (after Parker, 1984) was calculated, as part of the marine gridding procedure. This was multiplied by the square-root of the number of days. In addition some account of the errors inherent in the ship observations was taken. A value of 0.25 hPa for geographically random one sigma bias was estimated from the differences between synoptic charts and operational model analyses.

Over land, errors were based on the altitude of the station. An estimate of *h/1500* as the bias associated with the reduction to mean sea level, where *h* is the altitude of the station was identified by comparing the pressure reduced to sea level and model analyses at a number of high altitude grid points. Again 0.25 hPa was added (vectorially) to the elevation-related bias, to reflect the random bias error. For grid boxes where the Superfile data were employed, we based the error on the intra-box variability divided by the number of observations in that grid box. Historical synoptic charts were used to estimate the number of observations in each grid box. In regions of zero observations (central Greenland and the far North East) the error was set to the intra-box variability at that grid box.

Following Kaplan et al (1997), EOFs were calculated for each calendar day over just the EMULATE region using a covariance matrix calculated from daily NCEP/NCAR (Kalnay et al, 1996) anomalous fields and applying a fourth-order Shapiro filter (Shapiro, 1971). Kaplan et al (2000) found that in order to obtain a more realistic estimate of the signal covariance and, by association, more realistic theoretical error estimates, it was necessary to re-estimate the signal covariance. After applying a test of consistency, outlined in the Appendix of Kaplan et al 2000, it was found that no correction was required, due, we believe, to the smooth NCEP/NCAR fields from which the covariance matrix was estimated.

Incomplete MSLP fields were then reconstructed using the leading 20 EOFs and the error field. Following Rayner et al (2003), we then blended the 'observations' with the reconstruction. This procedure was described in detail in Section 1.5 of the first annual report.

Summary of results

Comparisons with historical products, such as ADVICE and modern reanalysis products (ERA-40, NCEP/NCAR), indicate that EMSLP3 is able to reproduce climatological features and extreme events well. Three main issues however have been highlighted. Firstly, smoothing applied during the gridding and quality control procedure has 'flattened' the daily fields. The NAO index calculated from EMSLP3 however appears to have the correct magnitude (Figure 3) and there is some indication that at times the flattening cancels out in a monthly analysis of extreme events (not shown).

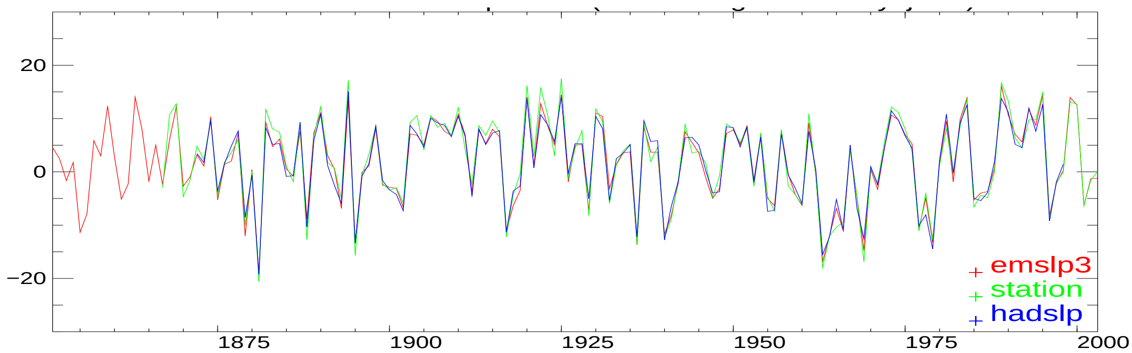

Figure 3: *The winter (DJF) North Atlantic Oscillation from 1850-2003 from EMSLP3 (red), and HadSLP (blue) gridded products. The winter NAO is calculated by taking the difference between the grid point closest to Ponta Delgada and that closest to Reykjavik. The 1961-1990 mean series value is then removed from each value. Also plotted is a station based index (green), using data from Reykjavik and Ponta Delgada (Jones, Rodwell (denoted here 'station'). Differences between the two station series are formed and the 1961-1990 average is also removed; units are in hPa.*

Secondly, during the data sparse period of 1850-1881, the variance to the far east and far west of the EMULATE region is notably lower than in the post 1881 period. This is a consequence of the RSOI procedure and data sparseness. Thirdly, again during this data sparse period, the pressures over Greenland appear to be too high in winter. While it is difficult to correct these problems, error estimates produced with the OI solution can be employed to add error bars. This result also highlights the need to digitise the millions of observations that are still available in ship log books held in the UK National Archives at Kew, London.

Despite these issues, we believe EMSLP3 will be suitable to characterise circulation patterns over the region. We were able to examine the anomalous conditions during the recent 2003 heat wave in Europe and recent flooding events (not shown) in the context of historical events.

3.1.3. Socio-economic relevance and policy implications

The main focus of WP1 in the second year of the project has been on producing the best possible MSLP gridded dataset as required for use by the EMULATE partners. Contacts have also been established between the co-ordinator and the UK Department of Environment, Food and Rural Affairs, who have requested to be informed of annual reports.

3.1.4 Discussion and conclusion

The existence of the preliminary version of the MSLP daily database, at the end of year one, allowed other partners to experiment with techniques in its use, for other aspects of the Project. At the same time, a degree of experimentation and testing was required to optimise the different stages (described above) of production of the final version of the MSLP product. Thus, given a window of opportunity, additional effort was applied to digitise and quality control more station data. The end result was the best possible outcome with regard to the quality of the final version (Deliverable D3) which appeared much later than originally envisaged but this did not inconvenience any other project members.

A paper which gives a comprehensive account of the production and testing/validation of the MSLP daily database is at an advanced stage. This paper will soon be submitted to the *Journal of Climate*. On completion of the review and publication process, the paper, along with the MSLP database will be made available to the climate research community (Deliverable D4) *via* the (public) pages of the EMULATE web site (http://www.cru.uea.ac.uk/cru/projects/emulate/). The MSLP archive is currently available to EMULATE members only, through the "internal" section of the web site. In addition to the MSLP daily database which is a gridded product, individual land-station atmospheric daily pressure series have been made available to all interested parties through EMULATE web pages.

The internal web site and email have provided essential electronic tools (together with progress reports and the three project meetings), for project management over the second year of the project. The co-ordinator has been assisted by the WP leaders. At all meetings, additional scientists were present. Dr Adam Monahan from the University of Victoria, Canada attended the recent ME3 meeting in Tarragona to advise on the use of advanced statistical tools and analyses.

3.1.5 Plan and objectives for the next period

All efforts will be made towards a rapid completion of the publication process for the paper relating to the MSLP daily database. At this point, the MSLP daily database will be made available to all potential users. This will fulfil the requirements of Deliverable D4. Other papers are planned.

References

Basnett, T. and Parker, D. E.,1997: 'Development of the Global Mean Sea Level Pressure Data Set GMSLP2', *CRTN* 79, Hadley Centre, Met Office, Exeter, UK,16pp.

Chapman, S. and Lindzen, R. S., 1970: *Atmospheric Tides*. D. Reidel, 200 pp

Dai, A. and Wang, J. 1999: 'Diurnal and semidiurnal tides in global surface pressure fields' *J. Atmos. Sci.*, **56**, 3874-3891

Diaz, H., Folland, C.K., Manabe, T., Parker, D.E., Reynolds, R., Woodruff, S. (2002) 'Workshop on Advances in the Use of Historical Marine Climate Data'. *CLIVAR exchanges*, **25**, 71-73.

Kalnay et al (1996) `The NCEP/NCAR 40-year reanalysis project', *Bulletin of the American Met Societ*y, **77**, 437-471

Kaplan, A., Kushnir, Y., Cane, M. A. (2000) `Reduced space optimal interpolation of historical marine sea level pressure: 1854-1992', *J. Climate*, **13**, 2987-3002.

Jackson, M., 1986: 'Operational Superfiles', *Met O 13 Technical Note* 25.

Jones, P. D. et al, 1999: 'Monthly mean pressure reconstructions for Europe for the 1780-1995 period', *Int. J. Climatol*., **19**: 347-364.

Parker, D. E., 1984: 'The statistical effects of incomplete sampling of coherent data series', *J. Climatol*., **4**, 445-449

Rayner, N. A., Parker, D. E., Horton, E. B., Folland, C. K., Alexander, L. V., Rowell, D. P., Kent, E. C., Kaplan, A., 2003: 'Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century' , *J. Geophys. Res*. 108, No. D14, 4407**.**

Reynolds, R. W., 1988: 'A real-time global sea surface temperature analysis', *J. Climate*, **1**, 75-86

Shapiro, R., 1971: 'The use of linear filtering as a parameterization of atmospheric diffusion', *J. Atmos. Sci.*, **28**, 523-531

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

WP leader: Jucundus Jacobeit (UWUERZ/UA)

3.2.1. Objectives

The objectives of WP2 are:

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

3.2.2. Methodology and scientific achievements related to Work Packages including contribution from partners

Appropriate methods for defining leading atmospheric circulation patterns have been developed and intensively tested, including the objective determination of reasonable numbers of these patterns for the different seasons. For the latter purpose, particular dominance criteria for the extraction of t-mode PCA patterns have been developed in cooperation between UWUERZ/UA and UBERN ensuring that only patterns with a significant realisation in the original dataset will be retained. This gives the most reliable indication on the number of distinctly different patterns that fit into the dataset.

The determination of these patterns themselves was based on various clustering techniques optimising the assignment of objects to different clusters. The major drawback of common techniques – persistence in local optima of the optimization function with no further approach to the global optimum – was overcome by a number of advanced techniques: repeated runs with differing randomized orders of checks and reassignments, simulated annealing – adopted in cooperation with the Hadley Centre – allowing any random reassignment with a slowly reducing probability, and repeated runs of this kind with different series of random numbers. The latter novel technique proved to yield the best results with a very close approximation to the global optimum.

Based on this technique, the leading atmospheric circulation patterns according to deliverable D5 were calculated for each 2-month and 3-month season of the year. Table 3 specifies the varying number of patterns during these seasons, and Fig. 4 gives a selected example for the January/February season showing the centroid pattern of cluster 3. The corresponding time coefficients – calculated in terms of correlation coefficients between the cluster centroid and each daily pressure pattern – are plotted in Fig. 5 together with low-pass filtered values and normalized cumulative anomalies. These data represent the daily pattern amplitudes since 1850 according to deliverable D6.

Table 3: *Number of SLP cluster patterns for the different 2-month and 3-month seasons 1850-2003*

JF	FM	MA	AM	MJ	JJ	JA	AS	SO	ON	ND	DJ	DJF	MAM	JJA	SON
7	9	11	10	8	5	6	8	10	7	7	7	9	11	6	8

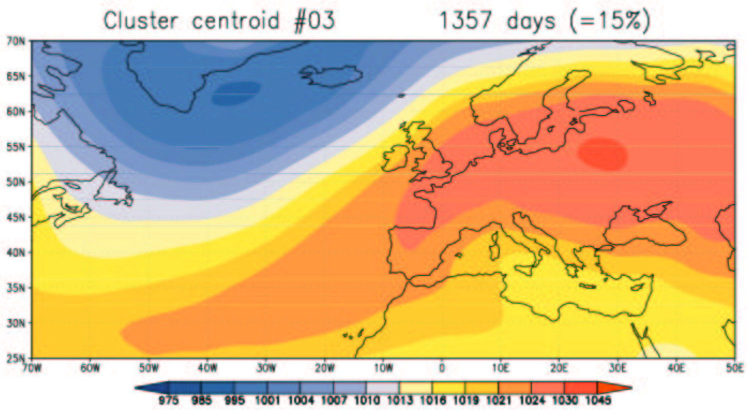

Fig. 4: *Selection from Deliverable D5: Cluster centroid 3 (out of 7) for the January/February season 1850-2003. Values in hPa (without area and error weights).*

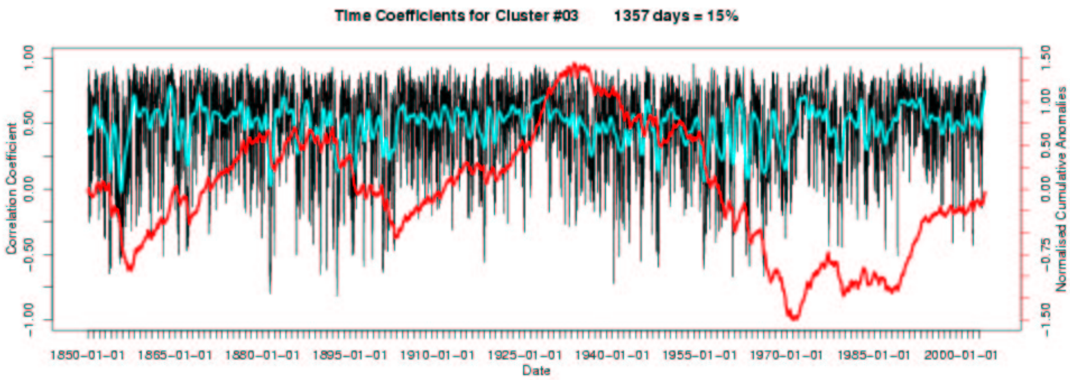

Fig. 5: *Selection from Deliverable D6: Time coefficients for the January/February cluster centroid pattern 3 of Fig. 1. Black bars: correlation coefficients between the cluster centroid pattern and the daily MSLP patterns. Blue line: low-pass filtered time coefficients. Red line: normalized cumulative anomalies of the time coefficients.*

In a further step, cluster centroids resulting from daily and from pentad data (DJF example) were compared by root mean squared error statistics (contribution from UBERN). In most cases the centroids were similar with highly correlated seasonal cluster frequencies; some differences might be due to different numbers of clusters for daily and for pentad data or to the smoothed nature of pentad data.

Finally, additional analyses beyond the scope of defined deliverables were carried out:

- UBERN worked with an extended version of principal component analysis (EPCA). It extracts orthogonal modes in space and the extended dimension, time (extended by 4 days to each day in the present context). Using the number of extracted modes according to the dominance criteria as the prescribed number of extended clusters, ECA (extended cluster analysis) was performed in the simulated annealing mode. Extended clusters give an indication of major transitions between synoptic types, but their usefulness in classification itself has still to be further investigated.

- According to suggestions of Ian Jolliffe (formerly of the University of Aberdeen), a time constrained clustering has been worked out at UWUERZ/UA using the distance in time between each pair of daily pressure patterns for weighting its distance in similarity. Thus, an increased persistence in cluster sequences can be achieved. However, appropriate rules for adjusting the degree of constraining have still to be derived.

- An objective cyclone tracking system was applied by UBERN to the EMULATE and to the NCEP/NCAR datasets (1948–2003). Good agreement was found on a seasonal basis for the average number of cyclone-hours per grid box, but average velocities, cyclone genesis and decay statistics implied less agreement. Poor data in the early part of the EMULATE dataset caused some problems in tracking cyclones.

3.2.3. Socio-economic relevance and policy implications

The classification of daily SLP fields into atmospheric circulation types will be used for studying circulation dynamics of climatic extreme events, and this is of major importance for society including risk assessments and mitigation strategies to be developed.

3.2.4 Discussion and conclusion

There has been extensive testing and discussion of the various methods and approaches for an objective classification of the reconstructed daily SLP grids. Contributions from the WP leader (UWUERZ/UA), the Hadley Centre (MET OFFICE), UBERN and from Ian Jolliffe (formerly of the University of Aberdeen) were put together and finally evaluated during the third EMULATE meeting in Tarragona (September 2004). It has been agreed to use area and error weighted data with daily resolution, to determine the appropriate number of circulation patterns by a t-mode principal component analysis according to an extended dominance criteria, to perform cluster analyses of the absolute (not the anomaly) data, and to apply an extended version of the simulated annealing technique during all 2-month and 3-month seasons of the year. This ensures the best approximation of the global optimum within the clustering procedure and yields resulting circulation patterns appropriate for further analyses in workpackage 4 related to extremes in temperature and precipitation.

3.2.5 Plan and objectives for the next period

There will be further studies to derive objective rules for adjusting the degree of constraining within the novel approach of time constrained clustering. The trends in circulation pattern amplitudes and in the incidence of their extremes will also be investigated during the third year of EMULATE. Particular efforts will be spent on the study of climatic and dynamic variability occurring within the different circulation patterns (so-called within-pattern variability).

3.3 Workpackage 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.

WP leader: Chris Folland (MetO)

3.3.1. Objectives

- 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.
- Gridded database of drought severity across Europe.
- 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.

3.3.2. Methodology and scientific achievements including contribution from partners

i) Numerical model simulations and data dissemination.

Using the third Hadley Centre atmospheric model (HadAM3) bounded by historical, prescribed SSTs and sea-ice extents, we have now completed an ensemble of 6 integrations from 1949-2002 with all available (anthropogenic and natural) climate forcings including land surface changes. We also have an ensemble of 6 parallel simulations with natural climate forcings only (solar and volcanic) and a further ensemble of 6 extended integrations including all forcings for the full period of the Hadley Centre SST dataset (1870-2002) through collaboration with our colleagues at the National Institute of Water and Atmospheric Research, Wellington, New Zealand. The situation is summarized in Table 1 which shows completed and still outstanding simulations. We recently ported the model to our new NEC supercomputer and corrected an ozone error which affected the latter part of the simulations and the model is now ready for further integrations. Remaining simulations will be completed by Mar 2005.

	Natural + Anthropogenic forcing	Natural forcing
1949-2002	6 (4)	6 (4)
1870-2002	6 (0)	2 (4)

Table 4: Completed (black) and planned (red) model simulations.

A web site, www.hadc20c.org, has been established for the dissemination of data to the EMULATE partners. This permits access to diagnostic data and a series of annual and seasonal plots of standard diagnostics to accompany the data from HadAM3 simulations. Access is currently restricted to the project participants by password protection. Passwords are obtained from the Hadley Centre by signing a license agreement. Monthly mean data for 15 key climate variables from the 1950-2002 all forcing and natural forcing runs are available now, with daily data and results from the longer runs to be added next.

ii) Basic analysis of integrations

A member of the Hadley Centre group visited the University of Wuerzburg to liaise with colleagues on the cluster analysis of atmospheric weather patterns and suggested the “simulated annealing” method now adopted in the method used to generate clusters. This method is in principle more robust and tends to avoid non optimal cluster centres. We have used the clustering algorithm in consultation with the other EMULATE groups to validate the model against the surface pressure dataset developed under work package 2. Clusters based on 2 month ‘seasons’ were generated for both model and observed data and the centroids of the clusters show a striking similarity between model and observations (Fig.6 for the Jan./Feb. season). This shows that the cluster analysis is reasonably robust to the choice of dataset (model or observations) and that the model is performing surprisingly well in generating observed surface pressure patterns over such a restricted region of the globe.

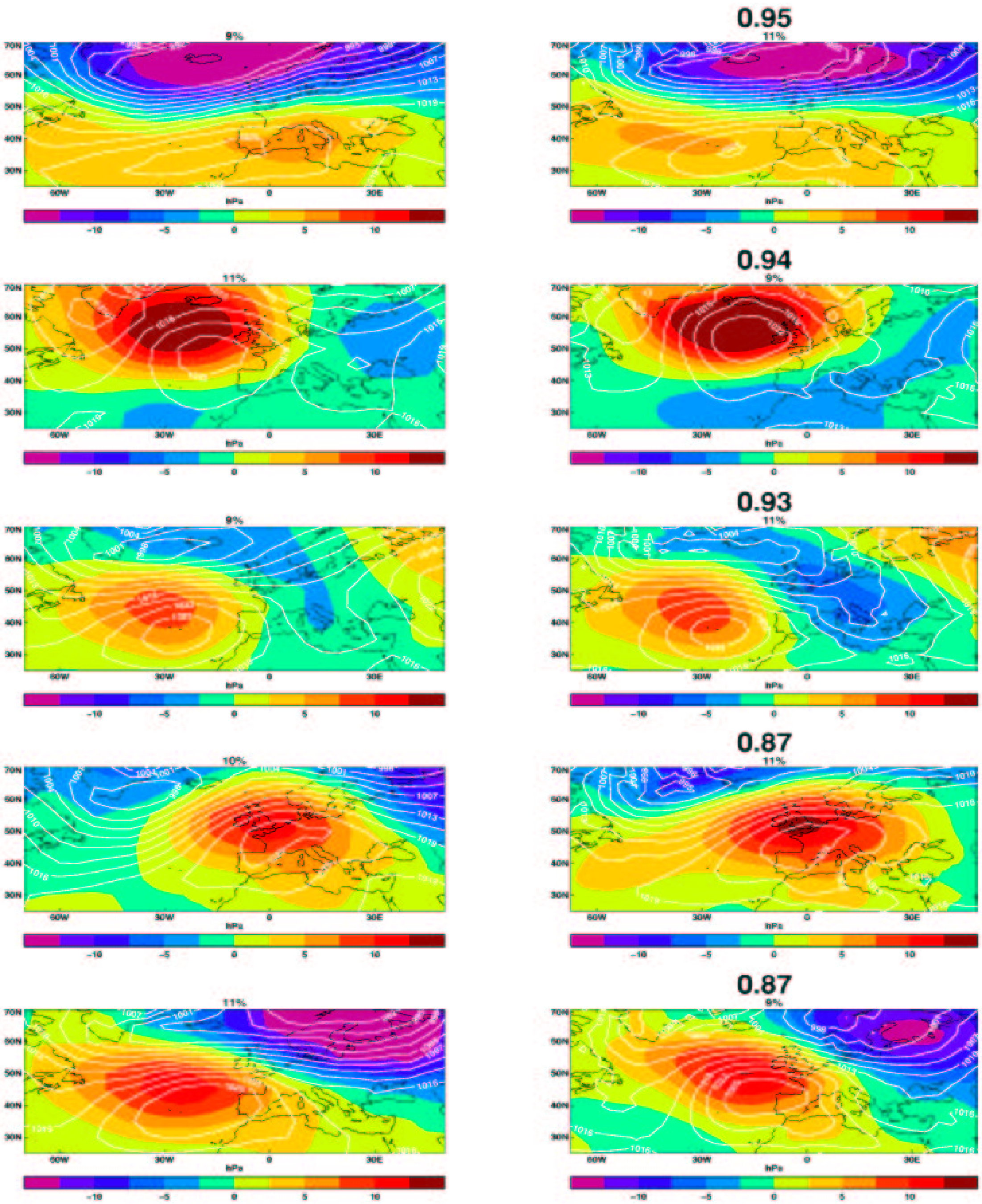

Fig. 6 **Best match observed and modelled clusters for the JF season shown side by side. 10 clusters were formed from both the model and observational data. Colours indicate pressure anomalies from a 1961-1990 climatology that varies through the JF season, while the overlaid white contours show the full pressure fields. Clusters are generated from 5 day mean pressure fields. Observed cluster centroids (left) and modelled cluster centroids (right) are matched by maximum pattern correlation (coefficient shown in bold). Note that not all of the model clusters are shown since one of the model clusters provides the best match to two different observed clusters and thus appears twice.**

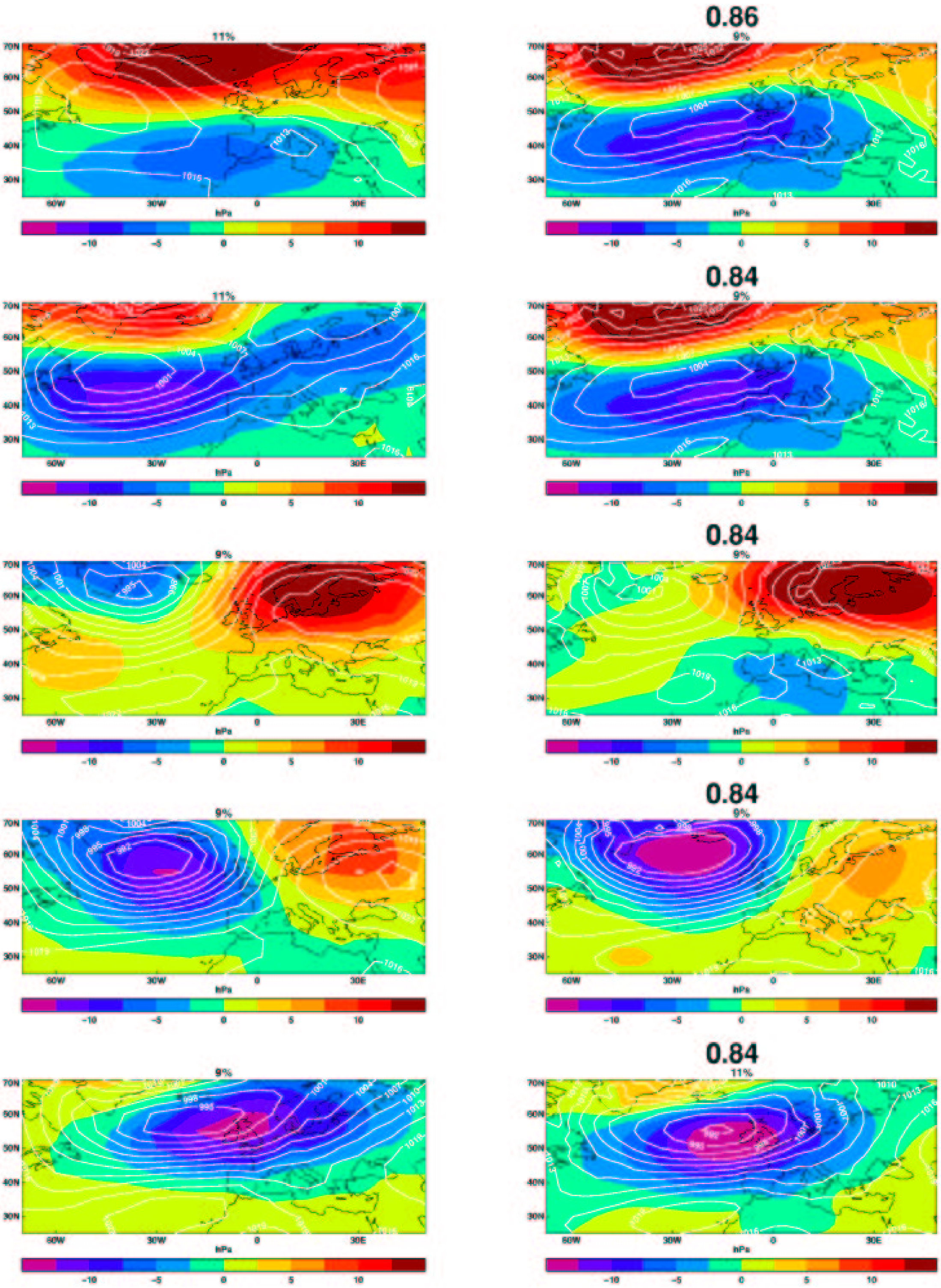

Fig. 6 continued.

Further model validation has been done to compare the EMULATE simulations against observed standard climate indices and seven other model simulations of the 20th Century taken from a parallel CLIVAR project which we co-lead called The Climate of the Twentieth Century (C20C). Fig. 7 shows the ensemble mean of our full forcings integrations compared to standard indices of Land Surface Temperature and the Southern Oscillation since around 1950.

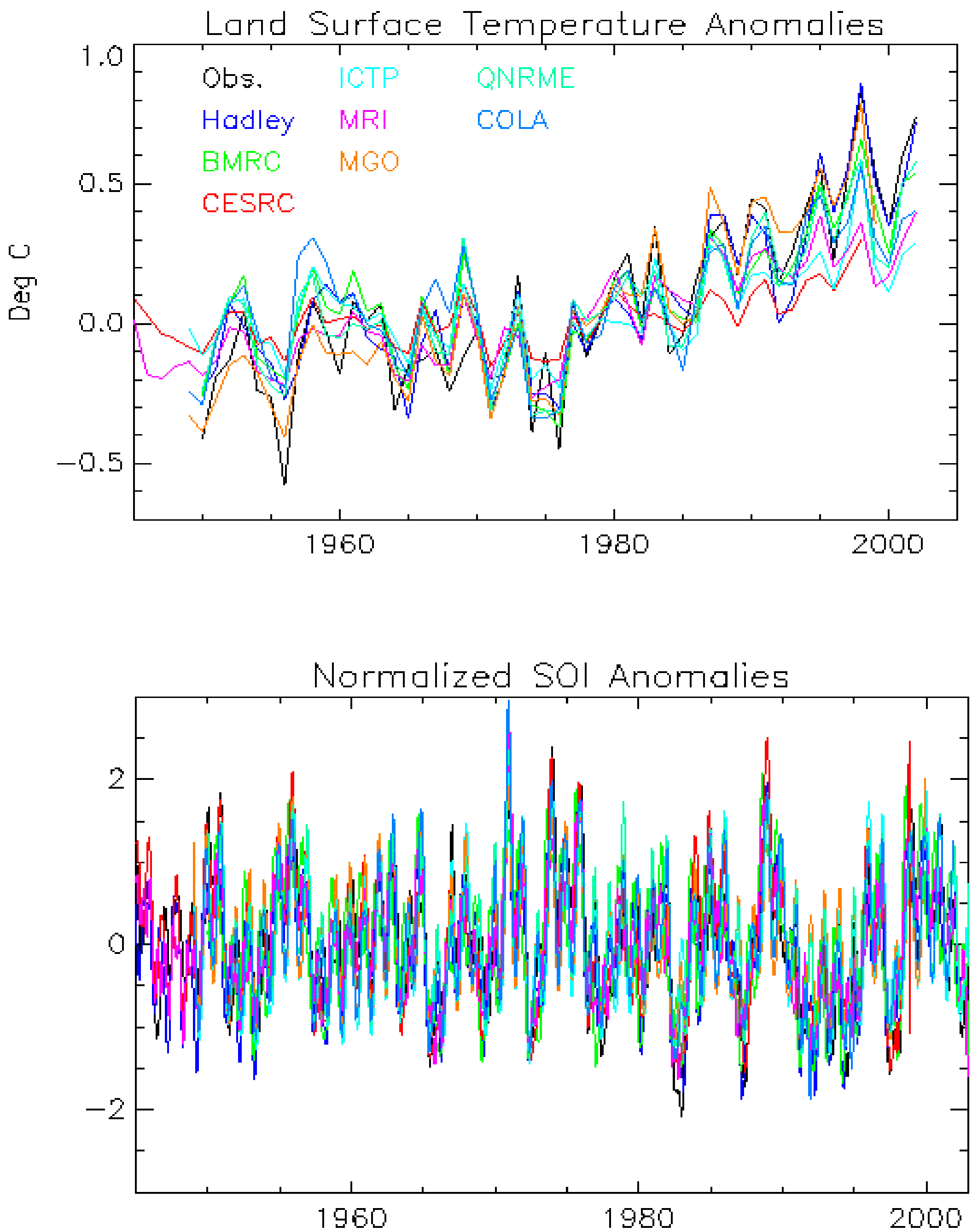

Fig. 7 (top) Land surface air temperature anomalies (upper) from the 1961-1990 mean and (bottom) the Southern Oscillation index (lower) from the EMULATE all forcings simulations and 7 other C20C models; observations are shown in black. Hadley Centre data are shown in dark blue.

The integrations of the Hadley Centre model with all forcings show excellent agreement with the observed land surface temperature record and the observed Southern Oscillation index. This strengthens our confidence that the integrations are a useful tool for studying variations in the climate of the last century.

A large range of standard diagnostics have been calculated and validated against observations and are being made available through our website at www.hadC20C.org.

iii) Major modes of summer and winter climate variability in the European region

Winter NAO

The winter North Atlantic Oscillation (NAO) has been analysed in the ensembles from 1948-2002 and shows interannual variability in agreement with observations. The minimum winter NAO in the 1960s is weakly forced by specifying SST in our model which also shows a weak positive trend in subsequent decades. However, low frequency variability, and in particular the strong positive trend from the 1960s onwards is not nearly reproduced by the correct magnitude in our ensemble of simulations. This is true of most models, though an earlier Hadley Centre model, HadAM2b, simulated nearly half the low frequency changes since 1950. Accordingly, a set of parallel, additional integrations were performed to test the possibility that the surface trend could be linked to upper level (lower stratospheric) wind speed and associated circulation changes. By introducing an upper level trend in the winds based on observations,

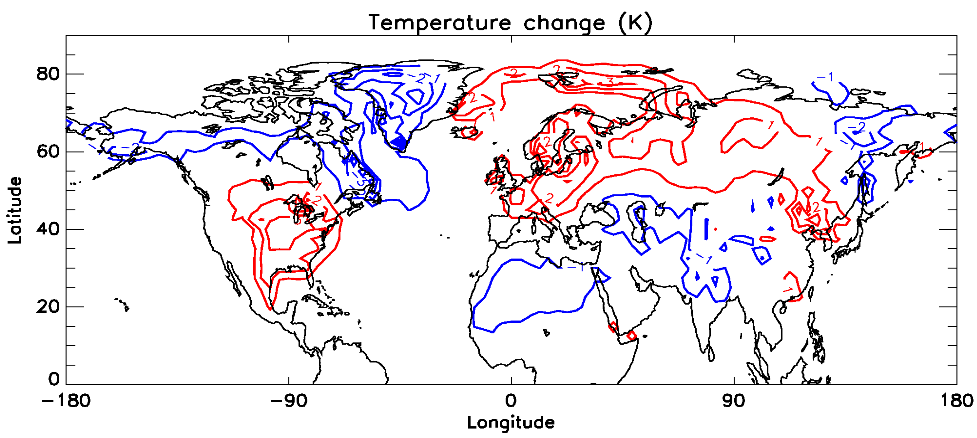

Fig. 8 Surface winter temperature change over 1965-1995 resulting from an imposed stratospheric circulation trend derived from observations. The temperature change shows the characteristic quadrupole pattern associated with the North Atlantic Oscillation with warming over Eurasia and America and cooling over the Middle East/North Africa and Canada/Greenland. The contour interval is 1K.

we were able to successfully reproduce the full observed increase in the winter NAO and European and North American surface temperature trends over the latter half of the 20th Century (see figure 8). A paper has been submitted to *Science* on the strength of these results.

Summer NAO

A study has been carried out on the summer NAO in the EMULATE ensemble of model simulations and in collaboration with Jim Kinter at the Center for Ocean-Land-Atmosphere studies. This circulation mode, which differs from its winter counterpart while having the same general form, has also shown a strong increase over the latter half of the 20th Century and corresponds to increasing anticyclonicity in summer over the UK. The EMULATE ensemble has been shown to capture some of this trend; part of the trend has been shown to be forced by the sea –surface conditions used in our model.

iv) Investigations of links between atmospheric variability and Sea-Surface Temperature

Work has been done by Partner 2 (MetO) and Partner 6 (UBERN) on links between variability in surface climate and sea surface temperature to accompany our model simulations which are forced by the same observed sea surface conditions.

UBERN has conducted a number of exploratory studies looking at the relationship between winter (DJFM) North Atlantic sea surface temperature (SST) and winter European surface temperature and precipitation during the twentieth century. They confirm an association between winter SST patterns in the North Atlantic and surface temperature anomalies over Europe, consistent with a major influence of the winter NAO. They also confirm a relationship between SST, seasonal pressure anomalies and seasonal European precipitation anomalies, again consistent with the NAO.

Using results from WP2, the Hadley Centre (MetO) has related high frequency surface pressure patterns to associated sea surface temperature anomalies using the WP1 surface pressure dataset and the HadISST sea surface dataset. Some SST forcing of the atmosphere is indicated by SST patterns leading the atmospheric anomalies and shows evidence for oceanic forcing of the North Atlantic Oscillation and other atmospheric patterns though often the reverse relationship is stronger. Here atmospheric pressure patterns lead SST variations and indicate that the atmosphere is responsible for a relative large forcing of the sea surface temperature. It is clear that both phenomena are at work. Through the cluster analysis we are also now able to relate high frequency weather patterns to sea-surface temperature variability though it is realized that there is much internal variability so such forcing can only modulate the probabilities of such cluster patterns. This will be investigated in more detail..

We have also identified some of the remote teleconnection responses to ENSO in our model simulations. Interestingly, the standard winter teleconnection of low geopotential height over the extratropical North Pacific shifts eastward with the larger amplitude ENSO events and there is a persistent winter teleconnection of low geopotential height (and lower mean tropospheric temperature) over NW Europe.

A full report on this work is contained in Deliverable D7 (see website).

v) Gridded database for drought severity across Europe

Work has been done by Partner 1 towards the production of a gridded database of drought for Europe (Deliverable D8). The method used is a variant of the Palmer Drought Severity Index (PDSI; Palmer, 1965). The self-calibrating PDSI (as developed by Wells *et al.*, 2004), produces measures of soil moisture status that are comparable across diverse climatological regions, for studies at the continental scale. Soil moisture status is quantified across the full spectrum of conditions from extremely dry to extremely wet. Preliminary output for the

European window (north of 35°N and west of 60°E), for the period 1901-2002, allows the production of time-series and annual snapshots (see figures 9 and 10).

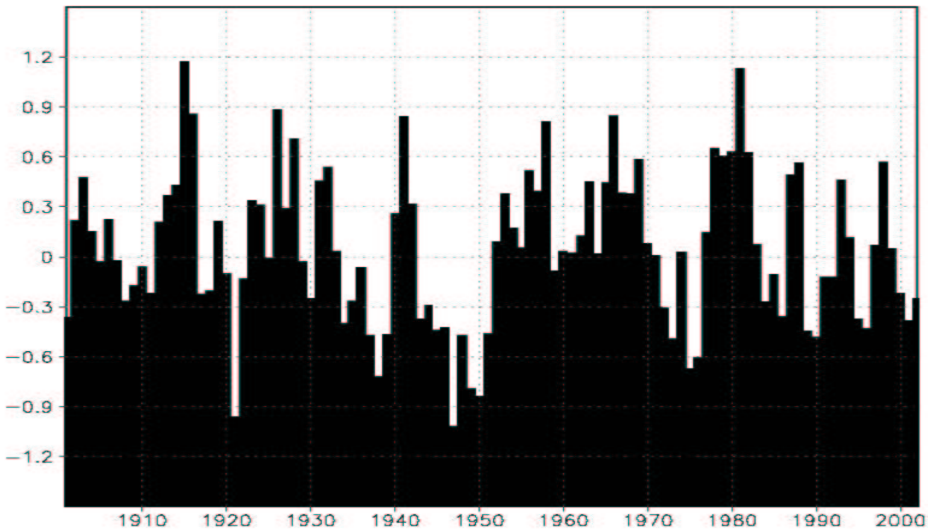

Fig. 9 Mean European summer PDSI. The three driest and wettest years on record are 1947, 1921, 1950 and 1915, 1981, 1926.

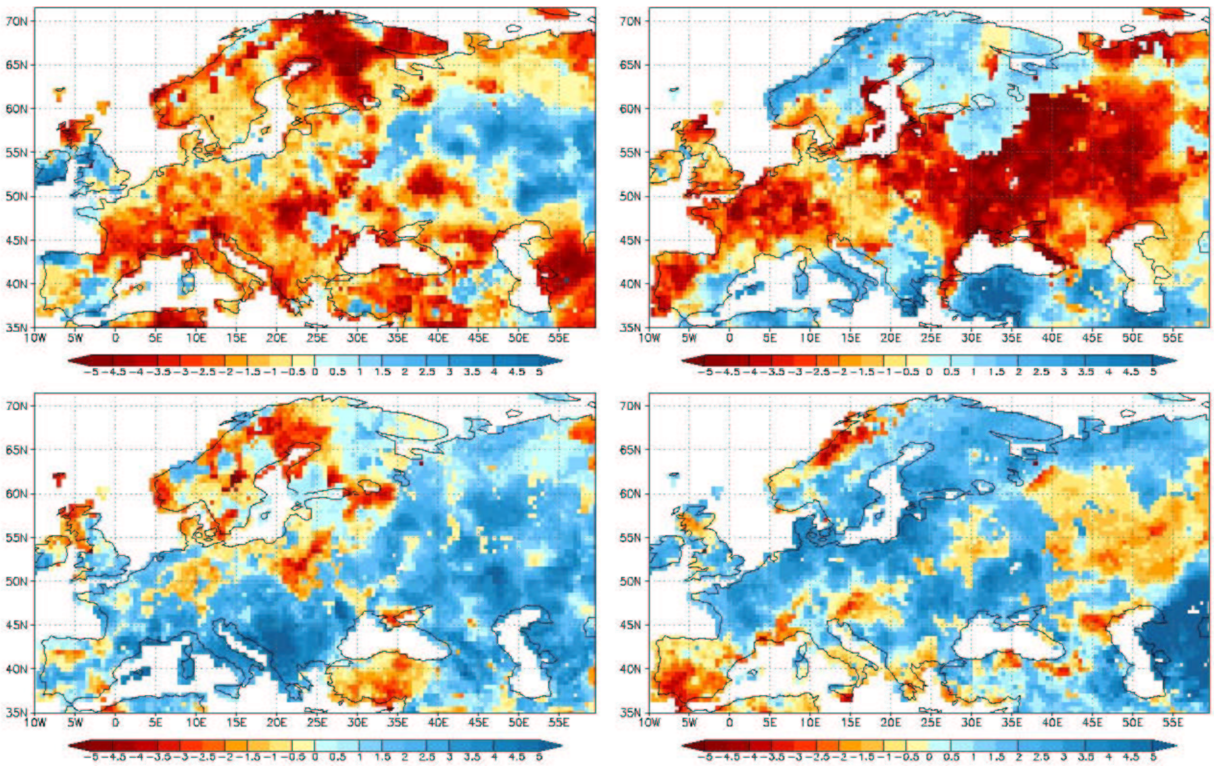

Fig. 10 Maps of self-calibrated PDSI for Europe for the two driest years (1947 and 1921) and the two wettest years on record (1915 and 1981).

A little more work is required (for example, the self-calibrating PDSI component that calculates evapotranspiration needs verification work), before final PDSI values are available. This should be completed during the first few weeks of 2005.

3.3.3. Socio-economic relevance and policy implication

If our preliminary work on the summer North Atlantic Oscillation is confirmed, this would have considerable explanatory potential for summer droughts over North West Europe. This is clearly of considerable societal interest for a European season that hitherto has had little attention.

3.3.4. Discussion and conclusion

A significant proportion of our planned simulations to accompany the surface pressure dataset developed under EMULATE are now complete. This is despite significant obstacles due to the installation and testing of a new supercomputer at the institute of Partner 2. Data from these simulations has been carefully verified against numerous observational datasets and against other models.

A new webserver and website were successfully set up to distribute data to the other partners within EMULATE using a password system. A series of diagnostic data and accompanying figures are available from the site and some of the partners are already using this facility.

We are identifying the major patterns of European circulation variability through the seasonal cycle. We have made progress in identifying new ways in which SST forces such patterns using observational SST analyses and the surface pressure dataset constructed in EMULATE's WP1. The imminent availability of the database of European "drought" (soil moisture status) will complement the work with circulation variability and the connections with SST patterns.

We have started carrying out analysis of our model integrations ahead of the agreed schedule. Studies of summer and winter modes are well underway and clustering techniques developed in WP2 are being tested on the model simulations in all seasons.

3.3.5. Plan and objectives for the next period

Our immediate priority is to complete the remaining simulations (now underway) by March 2005. We also plan to add daily model data to our website at www.HadC20C.org to facilitate the study of extremes under WP4. In particular, this will help to allow estimates to be made of the changes in extreme events due to anthropogenic forcing in Workpackage 4.

In the meantime, we are better determining the SST patterns associated with regimes of surface climate using a variety of statistical techniques (including the cluster analysis developed in WP2 and the other techniques outlined in deliverable D7). This will help to guide model perturbation experiments over the coming year. A significant component is to examine our natural and fully forced simulations for shifts in the probabilities of weather regimes due to the imposed anthropogenic changes.

References

Palmer, W.C., 1965. *Meteorological Drought*. US Weather Bureau Research Paper No 45, US Department of Commerce, Washington, DC, 58pp.

Wells, N., Goddard, S. and Hayes, M.J. 2004. A self-calibrating Palmer Drought Severity Index. *J. Climate*, **17**: 2335-2351.

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

WP leader: Anders Moberg (SU)

3.4.1. Objectives

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

3.4.2. Methodology and scientific achievements including contribution from partners

Based on contacts with scientific colleagues across Europe and national meteorological services a network of over 200 stations with daily temperature (Tmax, Tmin and Tmean) and precipitation data starting between 1850 and 1901 has been developed (some start even before 1850). All daily records have been scanned for outliers (defined as data values that exceed a pre-defined seasonally varying threshold). Printed lists of these outliers have been examined and compared with estimated values derived from well-correlated neighbouring stations (see partner-3 report). Reduced lists with data values that were suspected to be erroneous were then sent out to external data providers with requests to check the original documents and then to provide us with the correct values. All external collaborators have answered our requests and our station data files have been corrected. The files are thus considered to be free of serious errors.

EMULATE has specifically created a new dataset of Spanish daily temperature and precipitation records for 23 stations by collecting and digitising data from original documents (see partner-5 report). This subset of the EMULATE data base of 200 stations has been subject to standard homogeneity tests, in addition to the outlier checks, to estimate adjustment factors on a monthly basis, which have been interpolated to the daily timescale and applied to the data series.

Based on the database of daily temperature and precipitation series, a set of indices for climatic extremes has been developed (Deliverable D9). We have created a set of 64 different indices, which are all calculated at an annual resolution for both 3-month and 2-month seasons. Hence, about 1,000 index time series have been created for each station, which allows for a large number of potential analyses. The definitions of the indices are chosen to agree as far as possible with indices and index calculation software that are already used in other/earlier similiar projects (e.g. the European Climate Assessment, STARDEX, ClimDex). A list of the indices is given in Table 5. Most of the indices involve thresholds based on percentiles, where we chose the 2^{nd}, 5^{th}, 95^{th} and 98^{th} percentiles to represent potentially important extremes along with the 10^{th} and 90^{th} percentiles that represent more moderate low and high values in the distribution of daily data. In addition, seasonal temperature means and precipitation totals have been calculated to allow comparison of changes in means/totals with changes in extremes. All index time series have been made available on the public website (http://www.cru.uea.ac.uk/projects/emulate) along with descriptions and definitions of the indices. (Further details are given in the reports from partners 3 and 7 and in their presentations at the 3rd meeting, in Tarragona, which are available on the Emulate website).

name	unit	TN	TX	TG	PREC	Description	indices
MEANTN, etc	[°C]	x	x	x	-	arithmetic mean of TN, TX, TG	3
PRECTOT	[mm]	-	-	-	x	precipitation total	1
TN10P, etc	[°C]	x	x	x	-	2%, 5%, 10%, 90%, 95%, 98% - percentiles	18
PREC90P, etc	[mm]	-	-	-	x	90%, 95%, 98% - percentiles	3
TN10N, etc	[days]	x	x	x	-	No. of days above (below) the corresponding percentile	18
R90N, etc	[days]	-	-	-	x	No. of days above the corresponding percentile	3
R90T, etc	[%]	-	-	-	x	percentage of total precipitation falling above the corresponding percentile	3
R90AM	[mm]	-	-	-	x	sum of precipitation amount falling above the corresponding percentile	3
SDII	[mm]	-	-	-	x	simple daily intensity (including only raindays ≥ 1mm)	1
SDII90	[mm]	-	-	-	x	simple daily intensity for raindays above the corresponding percentile (including only raindays ≥ 1mm)	3
HWDI	[days]	-	x	-	-	number of consecutive days with more than +5°C above the long-term mean of TX	1
WSDI90	[days]	-	-	x	-	warm spells: at least 6 consecutive days with T_{MAX} exceeding the 90% percentile	1
CSDI10	[days]	-	-	x	-	cold spells: at least 6 consecutive days with T_{MIN} below the 10% percentile	1
GSL	[days]	-	-	x	-	growing season length; days between the first and the last period of 6 consecutive days with T_{MEAN} >= 5°C during one year	1
R5d	[mm]	-	-	-	x	greatest 5-day total rainfall	1
R1d	[mm]	-	-	-	x	greatest 1-day total rainfall	1
CDD	[days]	-	-	-	x	maximum number of consecutive dry days (prec. < 1mm)	1
FD	[days]	x	-	-	-	number of frost days (T_{MIN} < 0°C)	1

Table 5. **Extremes indices computed for the daily temperature and precipitation time series.**

Partners 3, 5 and 7 have undertaken most of the work in WP4 described above, with input also from partner 2 concerning quality controls of the Russian subset of the EMULATE database. In addition, preliminary analyses of relationships between temperature and precipitation extremes and atmospheric circulation indices (from WPs 1-2) have been made by the partners 6 and 8. These show robust and encouraging relationships with sea level pressure patterns, for example relating to trends towards persistent dry spells, hot days and heatwaves in some regions. Extreme value analysis has also been made by partner 4, who found that the behaviour of extremes can be more active than that of mean values. An hypothesis that the probability distribution of a climatic variable can be described as a weighted sum of a number of normal distributions that could be interpreted by distinctively different processes/regimes has also been proposed by partner 8. This approach has a potential to link changes in the occurrence of extremes to the dynamics of the respective processes. Furthermore, partners 1 and 7 have analysed the 20th century trends in a subset of indices for moderate extremes for about 80 European stations. These results show, for example, significant trends over the 20th century in moderately strong winter precipitaion events and also that both the warm and cold tail of the temperature distribution, in winter, warmed over the 20th century as a whole, although there were many stations with insignificant cooling trends in the first half of the century. Analyses of climatic extremes, including the extremes indices, will be performed on the climate model results produced within WP3 in the third year.

3.4.3. Socio-economic relevance and policy implications

The compatibility of the EMULATE extremes index time series with indices developed in other projects guarantees that results from analyses of our index time series will be easily comparable with results from other projects. In particular, we anticipate that results from analyses of the EMULATE indices, and their relationships with changes in atmospheric circulation patterns and indications of any signs of an anthropogenic influence, will be evaluated in the fourth IPCC report. This will guarantee a relevance for society and for policy-making. As an example of a socio-economic relevance there is the need for the insurance industry to better understand how precipitation and temperature extremes have been changing in the recent past and to whether any degree of anthropogenic influence can be seen in these occurrences. WP4 provides essential background knowledge for estimating the expected occurrence of weather-related extreme situations in the near future.

3.4.4. Discussion and conclusion

This WP has strictly followed the work plan during project year-2. The main goal in this year was the establishment of the data base of extremes indices (Deliverable D9), which has been completed successfully. WP 4 is in a very good position and the situation at the start of the third year is optimal for undertaking and completing the work that is scheduled for months 25 to 36.

3.4.5. Plan and objectives for the next period

Three main deliverables are scheduled for month 36: Assessment of changes in temperature and precipitation extremes (D14), assessment of the influence of atmospheric circulation variations on the incidence of extremes (D15) and assessment of the likelihood of any anthropogenic influence on extremes (D16). All partners will be active in this work. Results are expected to be presented in a number of papers to be submitted to peer-reviewed journals and also at scientific meetings.

3.5 Workpackage 5: Dissemination and Exploitation of Results

WP leader: Phil Jones (UEA)

3.5.1. Objectives

- To ensure that EMULATE is managed effectively and efficiently so that all the project objectives are met.
- To ensure the effective dissemination and exploitation of the project results and deliverables.

3.5.2. Methodology and scientific achievements including contribution from partners

The web pages (internal – for project members and associates only; and public domain) are being used as intended and are updated on a regular basis (see below for more detail).

3.5.3. Socio-economic relevance and policy implications

Some of the scheduled deliverables (products) are now in the public domain *via* the web site. Currently, these are Deliverables D2 (mslp land-station daily data) and D9 (extreme weather index series for European land stations). The open availability of other products (deliverables) is imminent. Included here are:

- D4 -daily fields of mslp for the EMULATE region
- D5 -leading atmospheric circulation patterns for 2-month and 3-month seasons
- D6 -database of daily pattern amplitudes since 1850
- 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

The availability of the above products will assist other scientists, working within an array of different disciplines, who may wish to relate climatic events to other phenomena (*e.g.* human health). In addition, the high resolution and quality of the datasets now available will be of use to those working within the more meteorological/climatological fields – including seasonal weather forecasters.

3.5.4. Discussion and conclusion

The release into the public domain of the D4 (see above) product awaits the finalization of the review/publication process of a paper that describes the production of the mslp database. The slight delays with D5, D6 and D7 outputs result from the complex considerations that had to be conducted between the different parties involved. The recent EMULATE (ME3) meeting was the ideal place for the different Partners to discuss how to optimize the different products. Agreement was achieved and the final aspects of the work are now being undertaken. The D8 product is very close to completion. Only the fine tuning of method options remains to be done.

EMULATE (internal) data and other information transfers are greatly facilitated by the restricted access web pages. The minutes of Project meetings, along with all electronic presentations made, are linked to web pages soon after the meetings. In addition, datasets produced/required by different Project Partners are made available through the web pages.

For example, the daily database of land station temperature and precipitation station series; and the extreme index series (D9 - based upon the station series), have been received and used by other Partners.

3.5.5. Plan and objectives for the next period

The outstanding Deliverables (listed above), destined for the public domain, will be made available as soon as they are finalized. The structure and detail of the public web pages will be reviewed to ensure that they are easy to use and hold all required ancillary information.

Participants information

N°	Institution/Organisation	Street name and number	Post Code	Town/City	Country Code	Title	Family Name	First Name	Telephone N°	Fax N°	E-Mail
1	UEA: University of East Anglia	Earlham Road	NR4 7TJ	Norwich	UK	Prof.	Jones	Philip	+44 1603 592090	+44 1603 507784	p.jones@uea.ac.uk
2	MetO: United Kingdom Meteorological Office	Fitzroy Road	EX1 3PB	Exeter	UK	Prof.	Folland	Christopher	+44 1392 886646	+44 1392 885681	chris.folland@metoffice.com
3	UA: University of Augsburg	Universitaetsst-rasse 10	D - 86135	Augsburg	DE	Prof. Dr.	Jacobeit	Jucundus	+49 821/598-2662	+49 821/598-2264	jucundus.jacobeit@geo.uni-augsburg.de
4	CEA: Commissariat à l'Energie Atomique	L'Orme des Misieres	91191	Gif-sur-Yvette	FR	Dr.	Yiou	Pascal	+33 1 69087728	+33 1 69087716	yiou@lsce.saclay.cea.fr
5	URV: Universitat Rovira i Virgili	Pza. Tarraco, n1	43071	Tarragona	ES	Dr.	Brunet-India	Manola	+34 977 559580	+34 977 559597	mbi@fll.urv.es
6	UBERN: Universität Bern	Hallerstrasse 12	CH-3012	Bern	CH	Dr.	Luterbacher	Jürg	+44 31 6318545	+41 31 6318511	juerg@giub.unibe.ch
7	SU: Stockholm University		SE-106 91	Stockholm	SE	Dr.	Moberg	Anders	+46 8 163546	+46 8 157185	anders@misu.su.se
8	UGOT: Göteborg University	Box 460	SE-405 30	Göteborg	SE	Prof. Dr.	Chen	Deliang	+46 31 7734813	+46 31 7731986	deliang@gvc.gu.se