European and North Atlantic daily to MULtidecadal climATE variability

EMULATE

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Third management report: November 2004 to February 2006

Section 1: Management and resource usage summary

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SECTION 1: MANAGEMENT AND RESOURCE USAGE SUMMARY, RELATED TO THE REPORTING PERIOD NOVEMBER 2004 TO FEBRUARY 2006

1.1 Objectives of the reporting period

The reporting period objectives relate primarily to the (below listed) measurable EMULATE 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.

(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) 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.

(viii) Determination of a selection of extreme climate indices for Europe and assessment of changes in these indices since 1850.

(ix) Determine the significance of atmospheric circulation for the extreme indices.

(x) Ascertain whether extremes of climate had different characteristics in the late 20^{th} century from those evident in the late 19^{th} and early 20^{th} centuries and determine the likely magnitude of human influences.

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

For an updated Gantt chart (to illustrate the deterministic schedule of work), and the table showing the comparison between planned and used manpower/financial resources (by Work Packages and partner), see Figure 1 and Table 1 at the end of this section. The list of partners on page 9 complements Figure 1 and Table 1.

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 principal objectives of WP1 had already been largely achieved at the start of the present reporting period. The remaining aspects of this work involved the review process for the paper which describes the production of the daily gridded MSLP database 1850-present (EMSLP). The journal publication of this paper is a prerequisite to the granting of public access to the database (Deliverable D4). The paper has been accepted by *Journal of Climate* and will appear during 2006. The database has been linked to the EMULATE public web pages.

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 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.
Based on the most suitable technique, leading atmospheric circulation patterns and their daily amplitudes since 1850 will be created and analysed for each 2-month and 3-month season of the year.

Progress:

An improved version of daily MSLP amplitudes has been calculated based on Euclidean distances instead of correlation coefficients. It will be submitted as a supplement to D6. Major effort in this period was spent on calculating trend matrices for D10: on the one hand related to the daily MSLP amplitudes for each 2-month and 3-month season, and on the other hand related to extremes indices of the pattern amplitudes based on particular percentiles (2nd, 5th, 10th, 90th, 95th, 98th). By this means a comprehensive overview of all possible trends for periods greater or equal than 20 years within the whole EMULATE period 1850-2003 could be achieved including assessments of statistical significance based on the non-parametric Mann-Kendall trend test. Further work has focussed on within-pattern variability, assessing by moving time series of particular parameters which approximate vorticity, intensity, and regional temperature and precipitation for each of the seasonal MSLP patterns. It could be demonstrated that climate variability is linked not only to frequency changes but also to within-pattern changes of major circulation types. Finally, progress has been achieved by some additional analyses: e.g. tuning the MSLP clustering with respect to climate variability by introducing temperature or precipitation covariates into the simulated annealing algorithms; improving the representation of MSLP clusters beyond the standard centroid patterns by adding a particular set of ’fringe patterns’; considering selected regional conditions within clustering techniques by applying an extended approach of clustering objects on regional subsets of attributes.

WP3: Relate variations and trends in atmospheric circulation and associated surface climate variability over Europe to sea surface temperature patterns, particularly from 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: All items in the work plan have been addressed. Significant resources have been used to provide the full contracted set of model data for ”all forcing conditions” and ”natural forcing conditions” from the EMULATE website and the Hadley Centre webserver. A final version of the drought index has been made available from the EMULATE website. A range of techniques have been used to analyse possible relationships between SST variability and atmospheric circulation regimes as illustrated in the deliverable reports and journal papers itemised below. In particular, a detailed cluster analysis of the model data has been completed for all seasons of the year and investigations have been made on the links with SST. Prominent links with SST are highlighted in the deliverables. Various perturbation experiments and coupled ocean-atmosphere model investigations were done in parallel with the main ensembles of simulations to investigate particular links with SST as described in the deliverables. Several further journal papers are now also planned and being written, including a paper on modelled extremes which links with WP4 and a paper on changes in the frequency of circulation patterns over the 20th century. The web based data store has a growing number of users and should prove useful long after EMULATE has formally completed.

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 indices 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 (from Workpackage 3) to help determine if any anthropogenic influence exists on a European scale, particularly for temperature.

Progress: All items in the work plan have been addressed. Much work in months 24-40 has been based on indices for temperature and precipitation extremes that were developed as deliverable D9 in year 2. An assessment has been made of trends over the period 1901-2000 in a selection of nineteen indices for stations spread across Europe. Analyses for selected stations, selected sub-regions and selected indices (e.g. the length of summer heat waves) have also been made back to 1850 or 1880 or other starting years. Results from these studies contribute to D14. Further analyses, contributing to D15, have dealt with determining statistical relationships between the leading atmospheric circulation patterns over the North Atlantic and Europe and various indices for temperature and precipitation extremes in Europe during the entire 20th century or back into the late 19th century. Output from simulations with an atmospheric model have also been analysed with the purpose of identifying the likely anthropogenic influence on the occurrence of temperature extremes. The latter analysis was based on the ensemble-mean difference between ensmble simulations with natural-plus-anthropogenic forcings and natural-only forcings. The time-period in focus for the model analyses, contributing to D16, was the second half of the 20th century.

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). New data sets and reports (Deliverables) have been linked to public web pages – as and when the material became available. The internal (Project only) web pages have been used for the exchange of information that was not yet ready or was not destined for public access. As with earlier annual Project meetings, all minutes and presentations have been made available to Project participants *via* the internal web pages.

All Final Report material destined for public access, along with outstanding Deliverable material, will soon be linked to the public web pages.

1.3 Milestones and deliverables obtained

The following milestones were achieved during the reporting period:

- ***Milestone 11 (M11)*** (24 months into the project): Second annual Report produced (see public web pages)

• ***Milestone 12 (M12)*** (35 months into the project): Final meeting for all partners and the scientific steering group – (held in Gif-sur-Yvette, France, October 3rd-5th, 2005)

• ***Milestone 13 (M13)*** (40 months into the project): Assessments of trends in pattern amplitudes and in the incidence of amplitude extremes – done (see D10)

• ***Milestone 14 (M14)*** (40 months into the project): Final drought index and model/observational comparisons – done (see D8 and D16)

• ***Milestone 15 (M15)*** (40 months into the project): Completion of work on extremes and assessment of factors which influence their changes – done (see D14 and D11)

• ***Milestone 16 (M16)*** (40 months into the project): Final Report sent to the EU and planning of papers for peer-review journals.

The Deliverables (listed below) have been/will be completed during 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
D10	Assessments of trends in pattern amplitudes and in the incidence of amplitude extremes	40	Da/Re	PU
D11	Assessment of the time-varying influence of SST and atmospheric circulation on European surface temperature and precipitation patterns	40	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.	40	Re	PU
D13	Assessment of the relative influence of external forcing factors (natural and human) and internal variability and their seasonal differences	40	Re	PU
D14	Assessments of changes in such extremes since the late nineteenth century	40	Re	PU
D15	Assessments of the influence of atmospheric circulation variations on the incidence of extremes	40	Re	PU
D16	Assessment of the likelihood of any anthropogenic influence on extremes	40	Re	PU
D17	Final technical report to EU	40	Re	PU

The delays in the linking of (WP1 product) D4 material are explained below (see Section 1.4).

WP2 deliverables are now in place but it should be noted that changes have been made to the presentation of the linked text and data for D5 and D6. The changes reflect the material that has been added here following the use of Euclidian Distance in the production of pattern amplitude datasets (for the Simulated Annealing patterns). A single html structure has been adopted for the presentation of D5 and D6 which will also include the D10 material. It was felt that, due to the very close links between these three Deliverables, a single display structure would be appropriate.

The WP3 Deliverables consist of reports and journal papers based on analyses made by the partners in the consortium. The most important documents are listed below, completed documents are linked to on the public domain web page, others are journal papers that are planned and in preparation as proposed in M16 (drafts are available on request). For more detail also see Section 6 of the EMULATE Final Report.

D11:

- *EMULATE D11: Assessment of the time varying influence of SST and atmospheric circulation on European temperature and precipitation patterns* (Ansell *et al.*)
- *Summer Moisture availability across Europe. (* van der Schrier *et al.)*
- *Contribution from the University of Augsburg to EMULATE D11 (daily cluster stability through time and temperature and precipitation patterns corresponding to daily clusters).* (Jacobeit)
- *Predicting European soil-moisture status (scPDSI) using seasonal circulation indices.* (Lister)
- *EMULATE Report, part of deliverable D11 and D15.* (Mohammad, Moberg and Ansell).
- *Grainger causality of temperature and North Atlantic SST.* (Della-Marta)

D12:

- *EMULATE 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 timescales of the coupled model experiments, and an initial study of mechanisms and potential predictability.* (Scaife *et al.*)
- *North Atlantic and European cyclones: Their Variability and Change from 1881-2003* (Bhend 2005)
- *Climate extremes and the North Atlantic Oscillation*. (Scaife *et al*., also part of WP4)
- *Climate impacts of the Atlantic Multidecadal Oscillation* (Knight *et al.*)

D13:

- *EMULATE D13: Assessment of the relative influence of external forcing factors (natural and huuman) and internal variability and their seasonal differences*. (Knight *et al.*)
- *Cluster Analysis of North Atlantic-European weather types* (Fereday *et al.*)
- *The webserver at www.HadC20C.org has now been fully stocked with seasonally varying model simulation data for all forcing and natural forcing model simulations of the 20th century*

The WP4 Deliverables consist of several reports, manuscripts or journal papers based on analyses made by different partners in the consortium. The most important documents are listed below, all of which are linked to on the public domain web page. For more detail also see Section 6 of the EMULATE Final Report.

D14:

(a) *Indices for daily temperature and precipitation extremes analysed for the period 1901-2000*. (Moberg *et al.*)
(b) *The length of western European summer heatwaves has doubled since 1880*. (Della-Marta *et al.*)
(c) *Trend atlas of the EMULATE indices: Extreme temperature and precipitation climates over Europe*. (Chen *et al.*)
(d) *Spatial and temporal temperature variability and change over Spain during 1850-2003*. (Brunet *et al.*)
(e) *Trend matrices for regional climatic time series* (Jacobeit *et al.*)
(f) *The development of a new daily adjusted temperature dataset for Spain (1850*-2003). (Brunet *et al.*)
(g) *A method of homogenizing the extremes and mean of daily temperature measurements*. (Della-Marta and Wanner)
(h) *Growing season trends in the greater Baltic area*. (Linderholm *et al.*)

D15:

- *Correlations between indices for temperature and precipitation extremes in Europe and the leading atmospheric circulation mode during 1901-2000*. (Mohammad *et al.*, this is also a part of WP3, D11)
- *Summer heat waves over western Europe 1880-2003, their change and relationships to large scale forcings*. (Della-Marta *et al.*)
- *Daily MSLP classifications and PCA-derived circulation patterns in relation to temperature and precipitation extremes* (Jacobeit *et al.*)
- *Surface temperature anomalies extremes and SLP cluster Association* (Yiou and Fauchereau)
- *Climate extremes and the North Atlantic Oscillation*. (see Scaife et al., part of WP3)

D16:

- *EMULATE D16: Preliminary results of attempts to detect an anthropogenic influence on extreme and mean climate and trends using the HadAM3 GCM*. (Chen *et al.*).

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

The outstanding requirements for the completion of deliverable D4 (under WP1) have been achieved during the reporting period. The lengthy consultation and review process for the multi-author journal paper (which has been accepted by the *Journal of Climate*), delayed the final act of making the database available to the wider scientific community. This delay has not affected the operation of the Project in any way. The EMSLP database files are now linked to the EMULATE (public) web pages.

There have been no deviations from the work plan/time schedules for WP2 and WP3. WP4 has followed the work plan with minor re-distributions of the time input in relation to other WPs. The impacts of this have been negligible. The progress towards WP5 has been regulated by the completion of Deliverables and other material destined for dissemination *via* the EMULATE website. Updates have been completed on receipt of new material.

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

Co-ordination of information and internal communications have been primarily effected *via* the scheduled Project Meetings (ME3 and ME4), which took place in Tarragona, Spain (20^{th}-22^{nd} September, 2004) and Gif-sur-Yvette, France (3^{rd}-5^{th} October, 2005). Decisions taken at these meetings added detail to the existing work schedules for the current reporting period. In addition to the meetings, electronic means (the EMULATE website and e-mails) have enabled regular contact between all or sub-sets of the EMULATE group.

External communications have been primarily through presentations and publications by various members of the EMULATE consortium; at national, European and international meetings, workshops and similar fora. Some publications have also appeared in international journal articles. A full listing of these presentations/publications can be found in Section 2 of the EMULATE Final Report. There will be additional presentations/publications after the formal end of the Project. The Project website has also provided a mechanism for external communication and this will continue to be the case for the forseeable future – with links to relevant material being added as they become available.

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

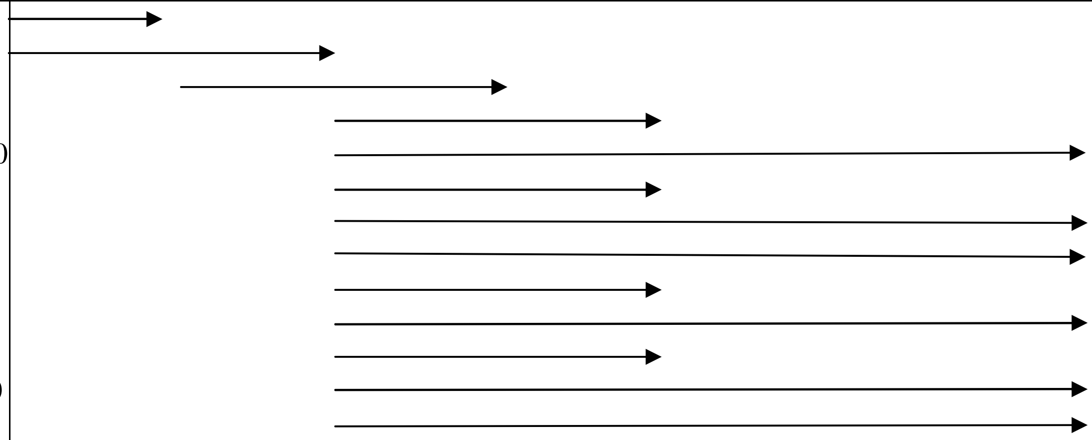
There have been no problems encountered at the management and co-ordination level.

LIST OF PARTNERS

1.	UEA	University of East Anglia, UK
2.	MetO	Meteorological Office, UK
3.	UAUGS	Universitaet 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

Figure 1: Schedule of work (updated)

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 37 38 39 40
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 (40)
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)



The only changes (when compared to the original work schedule) to this chart reflect the time extension of the Project from 36 to 40 months. This extension effectively made the final reporting period four months longer (40 months instead of 36 months). The meeting schedule and other completion dates, except for Deliverables *etc*. that were due at the end of the Project, were unaffected by the extension.

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

WP	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	0	12
	MetO	10	0	0	10	7.3	6.5	1.5	15.3
	UAUGS	2	0	0	2	0.5	0	0	0.5
	CEA	2	0	0	2	0.5	0	0	0.5
	URV	1.5	0	0	1.5	1.5	0	0	1.5
	UBERN	1	0	0	1	1	0	0	1
	SU	0	0	0	0	0	0	0	0
	UGOT	0	0	0	0	0	0	0	0
	TOTAL	27.5	0	0	27.5	19.8	9.5	1.5	30.8
WP2	UEA	0	6	0	6	0	1	5	6
	MetO	2	10	0	12	0.7	6.8	0	7.5
	UAUGS	6.33	8.67	0	15	5	8	6	19
	CEA	0	4	4	8	0.5	0	2	2.5
	URV	0	0	0	0	0	0	0	0
	UBERN	0	7	0	7	4	2.6	0.5	7.1
	SU	0	1	1	2	0	0	0.5	0.5
	UGOT	0	0	0	0	0	0	0	0
	TOTAL	8.33	36.67	5	50	10.2	18.4	14	42.6
WP3	UEA	0	5	0	5	0	3	2	5
	MetO	3	6	12	21	4	4.2	22.8	31
	UAUGS	0	0	3	3	0	0	3	3
	CEA	0	4	3.4	7.4	0.5	0	3	3.5
	URV	0	6	7	13	0	6	6.5	12.5
	UBERN	0	0	7	7	1	4.3	2	7.3
	SU	0	0	2	2	0	0	1	1
	UGOT	0	0	0	0	0	0	0	0
	TOTAL	3	21	34.4	58.4	5.5	17.5	40.3	63.3
WP4	UEA	0	0	6	6	0	2	4	6
	MetO	0	0	3	3	0	0	1	1
	UAUGS	0	4.67	9.33	14	3.2	3	6	12.2
	CEA	0	2	2	4	0.5	2.2	4	6.7
	URV	0	6.5	5.5	12	0	6.5	6	12.5
	UBERN	0	0	4.5	4.5	0	2.1	2.5	4.6
	SU	0	6.8	4.7	11.5	0	7.4	6.8	14.2
	UGOT	0	9	0	9	0	8	1	9
	TOTAL	0	29	35	64	3.7	31.2	31.3	66.2

		Year 1	Year 2	Year 3	Total	Year 1	Year 2	Year 3	Overall Total
WP5	UEA	1	1	6	8	1	2	5	8
	MetO	0	0	1	1	0	0	0	0
	UAUGS	0	1	2	3	0	0	2.3	2.3
	CEA	0	1	1	2	0	0	1	1
	URV	0	0	0	0	0	0	0	0
	UBERN	0	0	1	1	0	0	1	1
	SU	0.7	0.6	0.7	2	0	1	1	2
	UGOT	0	0	1	1	0	0	1	1
	TOTAL (WP5)	1.7	3.6	12.7	18	1	3	11.3	15.3
Project totals	UEA	12	12	12	36	10	11	16	37
	MetO	15	16	16	47	12	17.5	25.3	54.8
	UAUGS	8.33	14.33	14.33	37	8.7	11	17.3	37
	CEA	2	11	10.4	23.4	2	2.2	10	14.2
	URV	1.5	12.5	12.5	26.5	1.5	12.5	12.5	26.5
	UBERN	1	7	12.5	20.5	6	9	6	21
	SU	0.7	8.4	8.4	17.5	0	8.4	9.3	17.7
	UGOT	0	9	1	10	0	8	2	10
	TOTAL	40.53	90.23	87.13	217.9	40.2	79.6	98.4	218.2

Table 1. (above) shows that EMULATE proposed work input and the actual output (measured in person.months) are almost identical. However, it should be noted that there was more work done in the final period than originally planned. Some of the work during the second year was delayed by deliberations towards, for example, the optimization of the methods being used in the generation of atmospheric circulation indices.

Participants information

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