ACCORD

ATMOSPHERIC CIRCULATION CLASSIFICATION AND REGIONAL DOWNSCALING

ENV-4-CT97-0530

Minutes of the start-up meeting

27-28 February 1998

University of East Anglia, Norwich, UK

Summary of agreed action points

All ACCORD participants were asked to let the co-ordinator (UEA) know about:

- any problems with financial payments,
- relevant meetings in which ACCORD partners should participate (see Appendix 3),
- presentations made at meetings / published papers and abstracts,
- data available for use in ACCORD (including details of access/restrictions on use),
- links to Web pages which should be included on the ACCORD Web site at UEA, and
- working papers for rapid dissemination of results within the ACCORD group.

All ACCORD participants were asked to provide (as appropriate) additional information, comments, and amendments on:

- the list of ACCORD participants (Appendix 4),
- the list of NCEP reanalysis variables to be extracted (Appendix 5),
- the list of standard diagnostics to be used for validation (Appendix 7), and
- the list of data available for use in ACCORD (Appendix 9).

Finally, all ACCORD participants were asked to provide answers to the list of questions which need to be answered in order to provide a methodological overview (Appendix 8).
[*This information will be collated and circulated to ACCORD participants prior to the next progress meeting.*]

It was agreed that the co-ordinator (UEA) will:

- set up an email-box for communication/discussion of ACCORD issues [*This has been done. The address is accord@uea.ac.uk.)*],
- extract NCEP reanalysis data for an agreed window/set of variables and put these data on a ftp-server for access by ACCORD participants [*This is being done.*],
- develop the ACCORD Web site at UEA (http://www.uea.ac.uk/cru/projects/accord/), and
- send the agreed minutes to the three external experts and invite them to the next two progress meetings.

The following dates and locations were agreed for future ACCORD meetings:

- first progress meeting, 16-17 October 1998, Stuttgart [*confirmed*],
- second progress meeting, 26-27 March 1999, Bologna [*confirmed*], and
- final meeting, October 1999, Copenhagen [*to be confirmed*].

The start date for ACCORD is 1 December 1997. Thus the first annual report is due 30 November 1998, and the final report a year later.

The following people at UEA can be contacted on specific ACCORD issues:
- Data: Phil Jones (p.jones@uea.ac.uk)
- Financial matters: Janice Darch (j.darch@uea.ac.uk) (cc Clare Goodess)
- General non-data/non-financial matters: Clare Goodess (c.goodess@uea.ac.uk)

MINUTES OF THE ACCORD START-UP MEETING

UEA, NORWICH, 27-28 FEBRUARY 1998

LIST OF PARTICIPANTS (see Appendix 1)

AGENDA (see Appendix 2)

WORK PROGRAMME (see Appendix 10)

These Minutes are more detailed than those envisaged for future ACCORD meetings because this was the first meeting and there were no reports from the groups.

ADMINISTRATIVE ISSUES (Phil Jones)

ACCORD finances

The official start-date for ACCORD is 1 December 1997. The first financial payment should have been sent from UEA to Partners about two weeks ago. Partners should let CRU know if there have been any delays with this payment.

ACCORD meetings and reports

ACCORD is formally committed to produce the first annual report at the end of November 1998 and we should adhere to this. The final report is due at the end of November 1999 but, in view of the late notification of the start date, it is likely that a three-month no-funds extension will be sought at an appropriate later date.

It is proposed to hold the next progress meetings in October 1998 (Stuttgart) and March/April 1999 (Bologna). The final meeting will be held in Copenhagen towards the end of 1999, possibly in October. (The dates for these meetings were discussed further in the final General Discussion). Progress reports (the 6-monthly reports listed in the work programme) will be required for each of these meetings.

Publications, working papers and conferences

Please let CRU know about any relevant meetings in which ACCORD partners should participate. A list of meetings will be maintained centrally (see draft circulated at the meeting, Appendix 3). Please also let CRU know about presentations you make at meetings and let us have copies of papers/abstracts.

Communications

A draft list of all ACCORD participants was circulated for correction (Appendix 4). Any additional corrections or amendments should be sent to Clare Goodess after the meeting. This list should include all staff working on ACCORD, with email addresses wherever possible.

An ACCORD email-box will be set up at UEA as soon as possible and will include all the email addresses from the list of participants. [*This became operational on 13 March 1998. The address is accord@uea.ac.uk.*]

DATA (Phil Jones)

Reanalysis data

The CRU is involved in a number of other EC-funded projects (e.g. WRINCLE, REFLECT) which require similar reanalysis data. These projects are using the NCEP reanalysis data because they are available now and will eventually provide longer series than ECMWF. Data for 1964-1996 are available now and will be extended back to 1958 (some variables are already available for the full period). The Washington group is running the same model for the present-day so the reanalysis data set is “model-consistent”, although there are differences in data input over time.

The list of variables considered for use in the WRINCLE project was described (see Appendix 5). These fall into three categories: pressure-level data; U/V components; and vertical velocity. Vertical velocity is probably not very useful for downscaling (see forthcoming paper based on work in North America).

The CRU proposes to extract a large data window appropriate for ACCORD and other EC-projects. These data will then be made available on an ftp-server at UEA. The proposed European window is 60W to 70E and 80N to 30N. Data will be interpolated to a 2.5° by 2.5° grid. Some ACCORD groups may also require hemispheric data, but for a smaller number of variables.

In discussion, it was noted that this resolution is coarse for some ACCORD regional studies. It is probably not appropriate to interpolate the original spectral model data to a finer-scale and the 2.5° by 2.5° scale is comparable with the GCM scale for future development of the ACCORD work.

The NCEP reanalysis data are available every 6 hours. It was agreed that daily values were not sufficient for all the ACCORD needs (e.g. cyclone analysis) and that data for 0z and 12z hours should be extracted.

The relative merits of the NCEP/ECMWF data sets were discussed. Currently only 15 years of ECMWF data are available and an extension of the reanalysis project has not been funded. A third, minor reanalysis project (DAO) also exists. It was agreed that the NCEP data seem best for the purposes of ACCORD, although some use of the ECMWF reanalysis will be undertaken (see U.BERN later). Some ACCORD tasks will also use the 5° by 10° surface pressure grid set, which extends back to the 1880s, for looking at decadal-scale variability.

Potential inhomogeneity problems in the reanalysis data are likely to vary from variable to variable. A considerable amount of documentation is available for the NCEP data set. The 1996 Kalnay et al. paper published in the Bulletin of the American Meteorological Society (volume 77, p.437-471) is available over the Web (http://wesley.wwb.noaa.gov/bams96.html). Documentation is also available from the NCEP web site (http://www.cdc.noaa.gov/cdc/reanalysis/reanalysis.shtml). Evi Schuepbach has the proceedings from a conference on reanalysis held in the USA last year. It was noted that, as part of the Euro-CLIVAR programme, it is hoped that the post-1979 data will be reanalysed without the satellite data to determine the effect of using this additional data source. The results of this study will not, however, be available during the ACCORD project.

The list of reanalysis variables, including potential vorticity, which it is proposed to extract will be circulated to ACCORD participants (Appendix 5). These data will be extracted by the CRU and put on an ftp-server as soon as possible. [*Inspection of the NCEP Web site indicates that potential vorticity is absent, but can be calculated from spectral coefficients or from pressure-level data.*]

Surface data sets

Scandinavia: Povl Frich described the data available from various EC/Nordic Council-funded programmes. The NACD monthly data set was published in 1996 as a DMI Report (Frich et al., North Atlantic Climatological Dataset (NACD Version 1) Final Report. DMI Scientific Report 96-1). The extension to the NACD project was the WASA project. The final report (Schmith et al., North Atlantic-European Pressure Observations 1868-1995 (WASA dataset version 1.0), DMI Technical Report 97-3) includes a CD-ROM containing daily quality-controlled MSLP data for 22 stations, 1868-1995. Copies of this report were circulated at the meeting and additional copies are available from Povl Frich. The national meteorological institutes in the Nordic countries are currently involved in the REWARD project. This involves, amongst other things, the publication of a Nordic Atlas of Extremes for 1890-1996. An updated version of monthly time series from the Nordic countries will be published later this year. From this and previous work, DMI will select a number of homogeneous time series of precipitation. These daily series need to be digitised (2-5 series from Denmark). The access to five series of daily precipitation from Norway and similar series from Sweden will have to be negotiated with DNMI and SMHI.

Italy: Carlo Cacciamani reported that daily data from about 1962 onwards are available from the national meteorological service and the hydrographic service. He will check what data are available for use in ACCORD and give UEA the name and address of the person to approach to ask for access on behalf of ACCORD participants. [*Information concerning the National Hydrographic Service in Rome was provided following the meeting. Phil Jones has written requesting daily temperature and precipitation data on behalf of ACCORD.*]

Alpine region: Christoph Frei described the Alpine data set developed at ETH. This data set of gridded daily precipitation is based on a very high-resolution rain gauge network of 6800 stations for 1966-1996 (Figure 1). The gauges are unheated. Heated and unheated gauges share common problems, particularly with snow, due to wind blowing across the gauge top. Correction procedures have been developed by Boris Sevruk for Swiss stations. They would like to extend these correction procedures to the whole Alpine region but this will require huge amounts of metadata. At the moment, no corrected values are included in the data set.

The original daily time series, collected as part of the Mesoscale Alpine Programme, cannot be made available to ACCORD participants but the gridded data set can be released free of charge to registered users (information on access is available at http://www.map.ethz.ch). A spatial aggregation technique has been used to produce gridded data at a mesoscale resolution of 25 km (Figure 2). Potential sources of error are: measurement bias, altitudinal clustering of stations, and sampling error.

SE Europe: Panagiotis Maheras reported that daily precipitation and Tmax/Tmin data are available at the present time for about 25 Greek stations for the period 1950-1992, and possible for the period 1950-1997 in the future.

Iberian Peninsula: Clare Goodess said that daily data were available for SE Spain for the period 1958-1987 from the MEDALUS project. She will check whether it is possible to use these data in ACCORD. Ideally, the series need to be updated.

ECSN: Phil Jones noted that ECSN had been involved in developing the ACCORD proposal and we have the potential of asking them for data for other parts of Europe.

France: Robert Vautard reported that scattered daily data are available for France. Guy Plaut reported that daily precipitation and Tmax/Tmin data are available for about 30 stations for the period 1949-1996. Access is currently restricted by MeteoFrance but UEA could formally ask for access for ACCORD participants. Guy and Robert will provide the name and address of the best person to approach.

CRU data sets (Phil Jones)

The CRU web site (http://www.cru.uea.ac.uk) has recently been extensively updated and redesigned. It now includes information about many open access data sets. A number of these may be useful for ACCORD participants:

1. Global (land and marine) gridded (5° by 5°) monthly temperature anomalies from 1856-1997.
2. Monthly station data and indices for the SO (Tahiti and Darwin station data) and NAO (Gibraltar/Ponta Delgada/Iceland station data from 1821).
3. Long monthly precipitation series from Europe for about 150 stations, mainly in NW Europe. Some series extend back to the 1700s.
4. Daily precipitation and Tmax/Tmin series (1951-1980) for some of the above stations, mainly in C/N Europe. (N.B. it may be possible to update some of these series from the ECMWF archives for 1979 onwards.)
5. Daily time series for ~130 UK stations, 1961-1997. Variables include precipitation, Tmax/Tmin, cloud cover. Phil Jones will check whether these data can be used in ACCORD. The same data may be available from the British Atmospheric Data Centre.
6. Two data sets developed for the carbon-sink project:
   a) Spatial climatology. Global (land only excluding Antarctica) gridded (0.5° resolution) mean values for a range of variables including precipitation, Tmax/Tmin, cloud, vapour pressure and wind-speed. Available for use now.
   b) Monthly time series (anomalies, from 1961-1990 normals) for 1901-1995. Should be available for use in 4/5 months time.
7. Gridded precipitation (5° by 5° resolution) interpolated from about 8000 station series with good coverage over Europe for 1900-1996.
8. The monthly 5° latitude by 10° longitude monthly-mean MSLP dataset for the NH north of 15°N for 1873-1995 (discussed briefly in the Reanalysis section).

All the above series are documented on the CRU web site including details of data formats and how to download them (http://www.cru.uea.ac.uk/cru/data/).

In addition, there are some CRU data sets which have constraints on access so cannot be made available over the Web. These include the daily versions of the 5° by 10° gridded MSLP, 500hPa and 1000 hPa data sets. The monthly data sets are available freely from the CRU web site, but the daily sets are only available to ACCORD participants from a ftp-server by contacting Phil Jones.

The ACCORD web site will include information and links relating to the various data sets. All the CRU data accessible to ACCORD participants will be available either from the CRU web site or from a ftp-server. In addition to the accessible data sets there will be other data sets which ACCORD partners may need/want to keep within their own group.

Discussion

Vanina Cesari showed a list of gridded data which will be used by ARPA-SMR and ADGB in ACCORD (Figure 3). This includes data originating from NMC, ECMWF and ETH.

Some partners may want to do some comparisons of different data sets. The different climatologies for the Alpine region could be compared, for example, although the resolution of the data sets varies. It may also be possible to compare parts of the ECMWF and NCEP reanalysis data sets.

The most appropriate data set to use will depend on the particular analysis being undertaken and the spatial/time scales being studied. For supra-regional studies, 2.5°/5° gridded data sets are appropriate. Station data are most appropriate for sub-regional studies. Ideally, the regional studies should be based on 1° resolution data, but this is not available and is incompatible with the GCM scale. One of the aims of ACCORD is to determine how much regional detail can be extracted from the GCM scale, remembering that the ultimate aim of this work is downscaling. It was noted that an acceptable Mediterranean cyclone climatology has been constructed in the CRU using a 2.5° by 2.5° grid. It was also noted that 5 years of data are available from the unified model at a spatial resolution of about 50 km for the Limited Area Model (LAM) and about 100 km (i.e. 1°) for the global model.

The ACCORD web site

An ACCORD web site has been set up at UEA. This currently consists of a one-page summary of the project but additional information will be added in the near future. Links to ACCORD partners will be included: please let CRU have the addresses of any relevant pages.

The address of the ACCORD home page is: http://www.cru.uea.ac.uk/cru/projects/accord/

TECHNICAL PRESENTATIONS

Attention was drawn to the list of tasks requiring collaboration (Appendix 6).

UEA (Phil Jones)

Phil Jones outlined the three main areas in which UEA will be working initially:

- hemispheric scale: can the Dzerdeevski scheme be automated, and what does it tell us?
- NAO index: identification of links with regional classifications.
- Grosswetterlagen (GWL): can it be automated in a similar way to the Lamb Weather Type (LWT) catalogue using Jenkinson's method?

Steve Dorling reported that he and Gavin Cawley have used a neural net approach to develop an automated-LWT classification scheme. Results are slightly better than for the Jenkinson automated method. About 50% of days are classified correctly (as one of 29 possible types) and most of the incorrectly classified days are close to the observed type. The method needs to take better account of the continuity and development of circulation patterns. At present the NCAR data set is used. It will be another step-up in complexity to apply this approach to the GWL catalogue. It is likely that techniques will be developed using the existing pressure data sets and then applied to the reanalysis data.

In discussion, it was noted that appropriate validation methods depend on the application. For ACCORD, we need to consider whether it is more important to get the classification right or the downscaled surface weather. Hans Caspary and Andras Bardossy are particularly interested in discussing these issues with UEA.

UEA also plans to analyse the European pressure data using PCA and/or cluster analysis. This will allow the data itself to determine the circulation patterns rather than using subjectively pre-determined classifications (such as LWT or GWL). Neural nets may work better in reproducing the former (i.e. not pre-determined) classifications. UEA may also pursue the method of self-organising maps.

It is not certain how far the hemispheric analyses will be taken. Some objective work has already been done at this scale and regular updates are available on the NCEP web pages.

UEA will work with DMI, VI and UD to investigate links between NAO indices and regional climate particularly over Scandinavia and the British Isles. UEA and other groups will also be looking at circulation classifications at the smaller regional scale for: the British Isles, the Iberian Peninsula, southern Scandinavia, central Mediterranean and eastern Mediterranean (Task 1.4). There are a number of common issues which need to addressed by all partners:

- should we use reanalysis or "real" data?
- should we use upper-air (e.g. 500/700 hPa) data as well as MSLP?
- should we classify directly from the circulation?
- and/or should we classify from surface climate fields (particularly for extremes) using compositing techniques?

- are circulation/climate relationships stationary?
- should variations in humidity and/or temperature variables be considered together with the synoptic circulation changes?
- are the techniques developed suitable for downscaling, i.e. can they be applied to GCMs in the longer-term?

Groups working together on joint tasks should be encouraged to use the same data sets, but should also have the freedom to use their own data sets where appropriate. It is hoped that good working links will develop between sub-groups (which are likely to consist of 2/3 partners working on the same task). The importance of talking to each other was stressed.

In discussion, Hans Caspary noted that a strong relationship was observed between the frequency of westerly circulation types and flood damage in central Europe. Christoph Frei considered that it was important to consider temperature forcing, particularly in relation to precipitation intensity. The use of LAMs was discussed. It was agreed that several years of further development is required and that the resolution of these models is such that downscaling will still be needed for some applications.

DMI and VI (Povl Frich and Torben Schmith)

Povl Frich described the observed changes in precipitation which DMI and VI hope to explain as part of the ACCORD project. He started by presenting a digital map showing precipitation normals for 1961-1990 for 2900 stations in the Nordic countries (Tveito et al., 1997. Nordic Precipitation Maps. DNMI Report No. 22/97 KLIMA), and then showed the ratios of precipitation for two normal periods, 1961-1990 vs 1931-1960. Increased precipitation is seen in the second period in a coastal strip extending from Belgium to northern Norway. Why is a larger area not affected? If the cause is some change in circulation it must be confined to coastal areas, which is hard to explain.

A similar pattern of change is seen at Danish stations if the two periods 1874-1905 vs 1961-1990 are compared. At Vestervig, there is a 20% increase in annual precipitation over the period 1874-1994. This mostly occurs in the winter half year, with little change in summer. There is a 50% increase in the number of days with ≥10 mm precipitation (R10), i.e. the change is mainly due to an increase in the frequency of heavy precipitation events.

A more detailed study of these precipitation changes is available (Frich et al., Observed Precipitation in Denmark, 1961-1990, DMI Technical Report 97-8) on the DMI web site (http://www.dmi.dk/Welcome-uk.html).

The occurrence of R10 precipitation events at six Danish stations, 1961-1997, has been studied. These events mainly occur in autumn. The frequency of "showers" (R10 at 1 out of 6 stations) has decreased. The frequency of "soakers" (R10 at 6 out of 6 stations) has increased slightly. The typical synoptic condition on R10 days is a front over Denmark, with large vorticity values, and a deep low to the north of the British Isles. Povl Frich concluded by advocating the use of long daily data series (~100 years) in order to see precipitation trends properly.

Torben Schmith described how DMI and VI propose to investigate the potential causes of the precipitation changes described by Povl Frich. First, he showed Table 11 from Hurrell and van Loon (1997, Climatic Change, vol. 36, p.301-326) which indicates regions where there are: (i) strong positive, or (ii) strong negative, or (iii) "zero" correlations between winter precipitation and the NAO index. He then showed results of canonical correlation analyses completed at DMI using NCEP reanalysis data. In winter (January, February, March), MSLP and precipitation are strongly correlated over two regions (northern Scandinavia and southern Europe). In the middle region (centred over Denmark) there are no/only weak correlations.

For each of these regions, a multiple linear regression technique has been used to hindcast winter total precipitation and to identify the corresponding pressure anomaly pattern, the so-called optimal predictor map (OPM). For the northern region, the OPM resembles the NAO pattern but is shifted eastwards. The correlation coefficient between hindcast and observed precipitation is in the northern region 0.76, compared with 0.58 for the NAO index. This indicates that better circulation indices exist than the NAO index. A similar pattern is seen in the middle region (UK/Denmark/N France) where correlation coefficients are 0.68 and -0.44 for the OPM and NAO indices respectively. In the southern region (Iberian Peninsula, western Mediterranean) the correlation coefficients are 0.66 and -0.66 respectively.

Precipitation for stations in the middle region has been hindcast using the same technique. For example, the correlation coefficient for Fanø in S Denmark is 0.47. A trend in the residual is evident over the 100-year data period, indicating that the OPM/precipitation relationship is not stationary and that some factor other than circulation must be changing. Similar results are obtained for De Bilt (correlation coefficient = 0.59).

Further analyses will focus on the identification of statistical links between the supra-regional circulation and local precipitation (for the winter half-year, October-March, 1900-1995) and on the explanation of non-stationarity in these relationships. In particular, DMI will:

1. calculate a daily local vorticity and flow index from the WASA station data set, 1875-1995,
2. identify links between local vorticity/flow statistics and the supra-regional circulation,
3. identify links between local vorticity/flow and local precipitation.

Non-stationarity problems may occur in the second and third steps. It is important to identify which of these two potential problems might be responsible for the observed increase in extreme precipitation events.

In the ensuing discussion, it was asked whether data collection problems could be completely discounted as a cause of the apparent increase in extreme precipitation events. DMI thought that data inhomogeneity could not be a satisfactory explanation of the observed changes. In reply to another question, DMI said that long humidity records are available in digitised form but have not been analysed yet.

A general comment was made that you don't necessarily expect changes to be seen in vorticity. It is possible that subtle changes could occur in weather type frequency, for example, without being seen in pressure/vorticity data. It would be possible, however, to analyse the variability of vorticity by using a technique such as Fourier analysis.

Other possible causes of the observed precipitation changes might be changes in atmospheric aerosol concentration or vegetation changes.

It was suggested that the observed precipitation changes might be associated with changes in the extent of the westerlies. Phil Jones noted that the decrease in westerly days in the subjective LWT catalogue is not evident in the automated (Jenkinson) LWT catalogue. Steve Dorling and Gavin Cawley thought that it was probably not evident in the neural net version of the LWT catalogue.

Hans Caspary noted that Schonwiese had also found evidence of a trend towards more intense winter precipitation in some regions of Germany (supporting DMI's findings for Denmark).

UD (Rob Wilby)
Rob Wilby stated that non-stationarity issues were a major focus of the proposed work by UD because this is the main underlying assumption for downscaling from GCMs.

The problems were illustrated using rainfall statistics (probability of a wet day, and mean wet day rainfall amount) for Durham and Kempsford in the British Isles calculated using data for the last 100 years. The rainfall occurrence parameters are more closely correlated than the rainfall amount parameters, 0.59 and 0.22 respectively for the stations considered here. These two parameters are fundamental to many weather generators and downscaling techniques.

A UD pilot study used 10 long UK records (the longest is 1881-1992) to look at non-stationarity in a range of 14 precipitation diagnostics or indicator variables (Appendix 7). The frequency of significant correlations between the precipitation diagnostics and the NAO index was calculated (the maximum possible number of possible correlations is 40 per season, and 7 are expected by chance):

Winter = 20; Spring = 24; Summer = 18; Autumn = 19. Total = 81.

The probability of two consecutive dry days (Pdd) is the most frequently correlated of the 14 diagnostic variables and has been used to construct a regression relationship (with a large degree of scatter), e.g. for Wall Grange in Spring, r^2=0.118.

The correlation analyses were repeated using SST rather than the NAO index. The summary of results is:

Winter = 37; Spring = 79; Summer = 37; Autumn = 24. Total = 177.

More significant correlations with the rainfall diagnostics are therefore obtained using SST than the NAO index. The highest correlations again occur in spring and for rainfall occurrence, e.g. for Pdd at Wall Grange, r^2=0.222. At most, only 25% of the variance is explained by any one of these Atlantic indices (SST or NAO).

Under the ACCORD project the UD will:

- investigate spatial/temporal patterns between the daily precipitation diagnostics and circulation indices such as the NAO index,

- derive empirical relationships for daily precipitation occurrence/amount for key sites/homogeneous regions,
- force these relationships using high frequency (e.g. vorticity) and low frequency (e.g. NAO index) predictors, and
- use appropriate diagnostics to compare results with previous (e.g. vorticity only) downscaling models.

Rob Wilby concluded that it is difficult to justify downscaling methods unless the problem of non-stationarity is acknowledged and accounted for.

During the ensuing discussion, it was asked whether the number of significant correlations is a good way of assessing relationships. Rob Wilby responded that it is, but it is more complex than indicated by the summary of results presented here.

It was commented that SST may reflect the longer-term (decadal) variability of the NAO, which is more chaotic on shorter time-scales. This could explain the higher correlations found with SST. Rob Wilby noted that he had looked at the frequency of fronts in the past but this did not help much in explaining circulation/rainfall relationships over the British Isles. It was suggested that the speed of fronts, i.e. the mobility of systems, might be more important. The strength of the steering flow might, therefore, be a more appropriate circulation indicator. Rob replied that, on a decadal basis, there was a relationship between rainfall and a strength of flow parameter (F from the Jenkinson automated LWT scheme) and that this parameter was very useful for investigating non-stationarity.

ARPA-SMR/ADGB (Vanina Cesari)
The presentation by Vanina Cesari was in two parts: work performed and plans for future work.

Work performed
As regards the supra-regional scale, the main activity of ARPA-SMR has been the investigation of blocking and cyclones phenomena. Two objective indices have been used: the Tibaldi-Molteni (1990) blocking index (Figure 4) and the Muraro (1997) cyclones index (Figure 5). The blocking index works in a latitudinal belt and, for each longitude it recognises whether a day is blocked or non-blocked. This allows identification of two main areas of blocking episodes but does not distinguish the type of blocking (purely Atlantic or European for example). This sub-classification is relevant to investigation of links with the regional scale patterns (Grosswetterlagen). Some results of the statistical studies obtained using the Tibaldi-Molteni index are summarised in Figure 6 which shows blocking frequency as a function of longitude (upper panel), and the Hoffmoller diagram (lower panel) where the time dependence (on a monthly base) is represented.

Concerning cyclones, the index developed by Muraro has been improved. It works on a synoptic scale grid (3.75° x 2.5° resolution), and, analysing each grid point, it looks for a minimum in mean sea level pressure. The index allows the cyclone to be followed during its lifetime and its path to be tracked. The algorithm recognises a minimum as a cyclone event following the steps in Figure 5 and takes into account different shapes of pressure minima, either evaluating gradients or through the direct comparison between the central point and the two crowns. Two aspects have been investigated: cyclone occurrence and cyclone genesis (first finding of a particular cyclone). Results of the analysis are shown in Figures 7, 8 and 9.

Moving from the supra-regional scale to the European (regional) scale, attention has focused on the search for links between phenomena on different spatial scales. EOF decomposition of monthly mean precipitation fields has been carried out on a European area and composites of Z500 geopotential height have been calculated based on months in which the first precipitation principal component shows relevant anomalies. At the same time, similar work has been developed starting from an EOF decomposition of the Z500 geopotential height and then calculating precipitation composites with the same selection criteria. The results of this analysis are shown in Figures 10 and 11. It is clear that precipitation patterns (EOF1 of precipitation, Figure 11a) are very similar to the composite precipitation field based on the EOF decomposition of the geopotential field (Figure 10b). The same conclusion is reached for Z500 geopotential height patterns.

Plans for Future Work

Future work by ARPA-SMR will start from the supra-regional scale (Task 1.2) and will be initially addressed at the investigation of possible links (Task 2.2) between blocking phenomena catalogued by the Tibaldi-Molteni index and, for example, the cut-off-lows phenomena which will be catalogued by the U.BERN group (Partner 7).

Moving to the regional-scale (Task 1.3) which is the kernel of their work, ARPA-SMR will try to define “weather types” on a European scale by using a completely automatic technique based, first, on a EOF decomposition of the Z500 geopotential field, and then, on a cluster analysis applied to the principal components of the previously defined EOF patterns.

If clusters can be defined, then (step 1) it will be possible (Task 3.7) to make composites of the precipitation fields available on a sub-regional scale (the Alpine precipitation analyses developed at ETH by Christoph Frei) and to verify (step 2) if precipitation regimes are visible. At the same time, ARPA-SMR will start from an EOF decomposition of precipitation field available on a sub-regional scale (step 3) and then go back to make composites of the Z500 geopotential fields to verify (step 4) if circulation regimes are visible.

During the ensuing discussion, it was noted that vorticity might be better than MSLP for defining storms and that small-scale storms may be the strongest. Vanina Cesari considered that MSLP was adequate for defining large-scale storms. She clarified that time series of cyclone occurrence/genesis are available for each grid box and that it is possible to track cyclones, although their intensity is not calculated. It was remarked that some high-resolution pressure data was available from 1991 onwards and could be used to assess the intensity of cyclones.

ETH (Christoph Frei)

Christoph Frei presented some results from the Alpine region precipitation data set which he had described earlier in the day (Figures 1 and 2).

First, he showed long-term mean precipitation for 1971-1990 (Frei and Schär, 1997, Precipitation climate of the European Alps as deduced from high-resolution rain-gauge observations, International Journal of Climatology, in press), including a N-S cross-section across the Alps and the relationship with topography. The main features are moist anomalies along the Alpine rim and an inner “dry” region.

The spatial distribution of wet days is quasi-asymmetric, with higher occurrences to the north and lower occurrences to the south. A quasi-asymmetry is also seen in intensity statistics, with local spots of high frequency R20 and R50 events along the southern rim of the Alps. Statistics comparing the frequency of rare events and their total contribution to mean precipitation were also shown (e.g. one type of event occurred on 3.7% of days, but contributed 40% of total rainfall). This indicates the importance of extreme circulation types.

The synoptic weather situation underlying heavy precipitation events shows an annual cycle. In summer these events are convective with highest precipitation along the northern and southern Alpine rims. The distribution of precipitation is very different in autumn, with an asymmetric pattern over the Alps and high precipitation over much of southern Europe. Seasonal differences in the correlation between stations are also evident. For example, for three Alpine locations, correlations are much higher in autumn (0.89 to 0.94) than summer (0.2 to 0.6). Large-scale synoptic events dominate in autumn, while small-scale convective events dominate in summer.

Winter-time Alpine precipitation has been correlated with the NAO index. Positive correlations are found in the north/central rim while negative correlations are found to the south. The Alpine region is in the transition zone between high positive correlations to the north and weaker correlations to the south. All the correlations in the Alpine region are, however, relatively weak.

The Alpine data set is rather short for investigating interannual variability. A reconstruction project at ETH and U.BERN is using ~20 long-term series to reconstruct seasonal mean precipitation for Switzerland based on PCA. Long-term Alpine analyses are not yet available.

PC trend filtering has been conducted for centennial-length records from the Swiss territory only. The PC filtered trends for winter, 1901-1990, show a statistically significant linear increase (Widmann and Schär, 1997, A principal component and long-term trend analysis of daily precipitation in Switzerland, International Journal of Climatology, 17, 1333-1356). A PhD student has analysed this trend using formal decomposition techniques and the Schüepp weather type classification (which consists of 8 types). It was concluded that the increasing precipitation trend can not be explained by changes in the weather types (which indicate decreasing precipitation). A different mechanism is therefore needed to explain the trend.

Centennial trends in the frequency of events exceeding the long-term 3% quantile have been calculated. Over 80% of Swiss stations have a positive trend and the increase is statistically significant at about a third of the 114 stations. Hence the positive trend in winter-time mean precipitation is primarily the result of more frequent intense events. Similar trends in the occurrence of intense precipitation were noted for autumn, but not spring or summer.

In conclusion, the Alpine precipitation climate:

- is highly spatially variable,
- rare intense events make a significant contribution to total precipitation,
- topography affects precipitation and circulation,

- various circulation phenomena are associated with distinct topographic feedbacks and surface climate responses,
- links to NAO variations appear relatively weak,
- it is an interesting study area (http://www.umnw.ethz.ch/LAPETH/doc/model.html#03)

A more detailed description of the Alpine precipitation climatology can be found on http://www.map.ethz.ch/rr_clim.

Christoph Frei was asked how good are the Schüepp weather types at discriminating precipitation. He replied that ETH will look at the contribution to precipitation change from changes in the large-scale circulation and atmospheric humidity. Another questioner asked what would be the impact of a relatively small change in the relative proportions of rain and snow. Christoph Frei said that a colleague had looked at this and that it may explain part, but not all, of the observed precipitation trend.

U.BERN (Evi Schuepbach)

Evi Schuepbach identified the people collaborating on the ACCORD project at the Swiss Meteorological Institute (SMI) (Dr D. Cattani, Dr J. Ambuehl and Dr P. Eckert). Jacques Ambuehl is an expert on neural nets and will give a presentation at the next ACCORD meeting.

The U.BERN data requirements are:

- ECMWF reanalysis data (T106) for the neural network scheme developed by the SMI
- surface variables from ANETZ* and ENET stations* (available from SMI)
- gridded upper-air and surface variables (NCEP reanalysis data)
- CRU gridded surface pressure data set back to 1881

* ANETZ is the Swiss Automated Network (meteorology) operated by the Swiss Met. Service with around 72 stations in Switzerland. ANETZ data are available every 10 minutes since around 1980. There are also 43 ENET stations in Switzerland measuring precipitation (10 minute data) since autumn 1994. In addition, there exist a number of long precipitation records (starting in 1900) at different heights.

U.BERN will be working with Partner 1 in Tasks 1.2, 2.1 and 2.2, and with Partner 3 in Tasks 1.4, 2.1, 2.2, 3.1 and 3.7. Over the next six months (March-August 1998) U.BERN will work on Tasks 1.2, 1.4, 2.1, 2.2 and 3.1, focusing on Task 1.4.

The detailed work plan for Task 1.4 (circulation classification at the sub-European scale) was described. This task involves classification of atmospheric circulation using a self-organised neural network developed by the SMI (Cattani, Ambuehl, Eckert). The following steps are required:

1. Understand the methodology → C, C++ source code
2. Implement / recompile / set up source code (C, C++)
3. Improvements on methodology (replace RMS)
4. Retrieve ECMWF fields (ERA T106) for self-organised learning
    - two sets of fields (1982-96), one for frontal rainfall and one for convective rainfall

- total precipitation/large-scale precipitation, Q-vectors at 700 hPa
- convective precipitation, humidity, potential vorticity

5. Pre-processing, Self-organised learning.

The proposed work plan for Task 2.2 (characterising time-trends, variability and linkages between circulations) was also outlined:

- The interests of U.BERN focus on upper-level troughs and cut-off lows which are likely to cause severe weather (heavy rainfall) in the Alps.
- These are also important in instigating (and maintaining) lee cyclones which are capable of producing severe weather over the northern Italy/Alps region.
- Time-trends and variability of UTs/COLs in the Atlantic-European region will be investigated using thickness (300 hPa/850 hPa) over the North Atlantic/Europe region on a seasonal scale (based on NCEP reanalysis data).
- Thickness anomalies will be calculated back to the 1940s.
- These anomalies and distributions will be linked to surface pressure back to 1881 in order to isolate the pre-1949 surface pressure patterns indicating **past** UT/COL behaviour in the North Atlantic/European region.
- Are certain NH modes more frequent with UTs/COLs? The starting point for this analysis on the links between UTs/COLs and hemispheric circulation modes will be the Dzerdzeevskii classification scheme (with Partner 1).
- The possibility of extending the European-Atlantic blocking catalogue developed under Theme 1 back to 1881 using the GWL classification will be considered with Partner 1.

The main task over the next six months will be development of the neural network. The SMI network will produce 144 weather types and the approach is similar to that of self-organising maps (Kohonen). U.BERN are interested in foehn cases and heavy precipitation events. It will be possible to look at the probability of precipitation for particular weather types/cases. The neural net-based classifications could also be compared with other classifications, such as the Schüepp weather types. The neural network scheme has been used in post-processing at ECMWF since about 1994 for classifying ensemble forecasts and for assessing the performance of the ECMWF ensemble forecasts, based on entropy.

In the following discussion, concerns about statistical significance/degrees of freedom associated with the large number of weather types (144) were raised. A 20-year training set may not be sufficient with so many classes. It would be difficult to use so many classes in downscaling procedures (which require the calculation of statistics for each type/class). However, it is not certain whether the real problem is a sampling or a classification problem. This raises the question of how many weather types exist in reality, and even whether or not weather types exist at all in the real-world continuum. It might be possible to use PCA to determine the optimal number of weather types and to maximise the variance explained by these weather types. Some of these arguments provide support for classifying by surface weather variables rather than by circulation type.

Another area of general discussion concerned the pattern of sequences and the development of systems. Subjective classifications such as LWT and GWL consider sequences over 2-3 days. It may be possible to consider similar length sequences in neural network schemes. Tests to reproduce the GWL scheme with the SMI neural network scheme have not been successful so far (this may partly be due to the smaller domain used in the SMI neural network scheme).

The general issue of sensitivity to domain size was also discussed. If the domain is increased then one might expect the number of weather types to increase. However, Robert Vautard reported some work done on hemispheric-scale classification which indicates that there are only 4-6 robust circulation regimes at this scale. With more regimes, the results are non-robust (i.e. different results are obtained if the analysis is repeated using data for a different 40-year period). These results are supported by work with a simple geostrophic model. Finally, it was noted that the timescale (monthly vs. daily) also has a bearing on the optimal number of circulation types.

IWS (Andras Bardossy)

Andras Bardossy described the fuzzy classification approach which will be used by IWS and FTS in ACCORD. It involves three main stages:

- verbal description of the classification patterns,
- translation into fuzzy rules, and
- classification of observed time series.

The method is a descriptive tool and is not precise. It can be used to identify, for example, the location of low/high pressure anomalies or the location of no low/high pressure anomalies. The classifications can be used to model local variations in precipitation and temperature on different time scales (month/daily/hourly). For example, the circulation pattern (CP) dependent probability of a wet hour can be calculated in order to get some idea about precipitation intensity.

The concept of objective persistence is important, i.e. the sequence of precipitation which can be defined as the spatial covariance between precipitation on two consecutive days. This series, r(t), has been calculated for Europe at a 5° resolution. Correlations between days are generally relatively high (~0.8-0.9), but there are days when the correlations suddenly drop. So the time series can be sub-divided into more-or-less homogeneous periods and these sub-periods, rather than single days, can be classified (this should make the method more comparable with subjective classification methods). Time series of spatial variance can also be analysed in the same way.

The three stages in the classification procedure are:

- identification of homogeneous time periods (persistence),
- classification using fuzzy rules (not for individual days), and
- improvement using local climate variations, with verification (split sampling).

The quality of the classification needs to be assessed using a good measure:

- precipitation (station and areal)
  - probability of precipitation
  - mean precipitation amount
  - variance and extremes
- temperature
  - anomalies

- objective measure

The classification can be improved using:

- local information,
- qualitative measures, and
- optimising the classification quality by modifying the fuzzy rules.

(e.g. SA or discrete combinatorial optimization)

The advantages of the method are that it is:

- knowledge based,
- can be optimized,
- “white”, i.e. not black box,
- can be applied at global and local scales, and
- is “objective”.

The disadvantages are that:

- it requires prior knowledge, and
- is partly subjective.

The method will be applied to two areas during the ACCORD project:

- C. Europe - two catchments in Germany, and
- S. Europe - Greece (how can the “Maheras” classification be modified?).

In response to a question, Andras Bardossy said that the homogeneous periods were typically 5 days long (based on 30 years data and a very large European window). In response to a further question, he acknowledged that evolution does occur through the “homogeneous” blocks but that problems can be avoided by using lags (e.g. 1-5 days) to calculate the correlations. It was suggested that the correlations could be calculated using the first day in the block (a threshold approach). Andras Bardossy has not looked at interannual variability in the correlation time series. In response to a comment that the fuzzy rules are tuned from the data, he said that they also come from the initial meteorologists’ verbal description and so the classifications should be repeatable.

FTS (Hans Caspary)

Hans Caspary described in further detail how the fuzzy rule method will be applied in ACCORD. First, the available data were described:

- NMC grid point NH data set
  - surface pressure (since 1963)
  - 500 hPa (since 1947)
  - 700 hPa (1963-1993)

- catchment data
  - Aller River basin (15 003 km^2)

    30 stations (daily time series 1963-1993 for precipitation and temperature)

    Digital Relief Model (DRM)
  - Ruhr catchment (4 488 km^2)

The model concept is shown in Figure 12. Work in ACCORD will focus on the middle section of the diagram.

6. Calibration and validation of the downscaling model “CP-P&T” for the Aller catchment
   - Calibration (IWS and FTS)
   - Validation (FTS)
     - Validation parameters:
       - annual cycle of monthly means of precipitation and temperature

- areal distribution of precipitation/temperature (means/stand. dev.)
- probability of precipitation exceeding a certain threshold
- maximum daily precipitation per month
- duration of long (> 10 days) dry periods during the vegetation period

7. Calibration and validation of the downscaling model “CP-P&T” for the Greece catchment

   - Calibration (IWS and UT)
   - Validation (IWS, UT and FTS)
     Validation parameters as listed in 6.

In response to a question, Hans Caspary explained that the probability of precipitation for each CP was calculated for every day, i.e. conditional precipitation probabilities are calculated from the annual cycle and the CPs.

The discussion then focused on problems associated with the validation of probabilistic forecasts where what is observed is only one possible realisation. It was noted that ECMWF have some experience of this with their ensemble prediction forecasts. Andras Bardossy explained that the aim was to minimise the following expression:

$\sum (Pi(t) - I(t))^2$, where the first term is the probability, and the second is the outcome.

In response to a question about spatial dependence, Hans Caspary said that this depends on the CP. The correlation length for precipitation varies widely between CPs. In the Ruhr, for example, it varies from 4 km for the anticyclonic CP to 61 km for the southerly/easterly CP.

During a discussion of suitable validation parameters it was noted that the software developed at UD during a previous project is available for use/adaptation in ACCORD. Rob Wilby reported that this is available as QBASIC or FORTRAN code. The Wilby et al. paper submitted to Water Resources Research will be circulated to ACCORD participants with the minutes. [*Copies were circulated with the draft minutes. Additional copies can be obtained from Clare Goodess.*] It reports the results of a study which compared the application of six different downscaling methods in six regions of North America. It was agreed that some standard methods of comparison are needed in the ACCORD project and that an agreed list of common validation parameters is needed. (This issue was discussed further during the final General Discussion session.)

UT (Panagiotis Maheras)

Panagiotis Maheras outlined the research which UT envisage doing in the ACCORD project:

- Provision of data: daily temperature and precipitation from about 20 stations uniformly distributed in the Greek territory, for the period 1950 (1955) to 1992 and possibly later to 1997.

- Application of fuzzy-rule technique, developed by Partners 5 and 6 and application of other methodologies for an objective classification for circulation types in Greece.

- In collaboration with Partners 1, 3 and 4, the links with supra-regional and regional circulations will be determined, connection of circulation in Western Europe with circulation in Western and Eastern Mediterranean.

- In collaboration with Partners 5 and 6, a version of the multivariate stochastic model will be developed for use in selected episodes of extreme weather events occurring in several selected stations in Greece and not on the catchment scale.

Panagiotis Maheras then outlined work on the objective classification of circulation types in Greece according to the empirical classification by Maheras (1982). This classification, based on MSLP and 500 hPa data, consists of 16 types: 5 anticyclonic types, 6 cyclonic types, 2 mixed types and 3 characteristic types. Maps showing the location of anticyclone centres and the main cyclone trajectories were shown. Panagiotis Maheras then showed 500 hPA pressure composite maps (1950-1990) for each season and each of the subjectively-classified 16 circulation types.

Over the last three months, UT have tried to construct some special software for an automated classification of the “Maheras” circulation types, using almost all the criteria of the empirical classification. Up to now, they have achieved an automated classification of the anticyclonic circulation types. Composite MSLP and 500 hPa maps have been constructed for these objectively-classified types and Panagiotis Maheras demonstrated that, for each anticylonic type, these maps generally agree well with those for the original subjective classifications. The correspondence of frequencies between the two classifications, empirical and objective, varies between 85-90% depending on season. There is a higher percentage of correspondence in winter.

The criteria set in order to objectively classify the circulation types are:

1. The pressure values (hPa) over Greece for each month:

January	1017.9
February	1017.3
March	1016.4
April	1014.9
May	1015.2
June	1014.2
July	1012.9
August	1013.1
September	1015.2
October	1017.0
November	1018.1
December	1018.3

2. The position of the anticyclone centre in Europe (according to the map shown earlier).

The methodology is first to examine whether the mean daily pressure over Greece (for 9 grid points, 2.5° x 2.5°) is anticyclonic or cyclonic according to the monthly MSLP thresholds listed above. The second step is to look for the centre of the high or low, as it was determined in the first step. The centre is determined by the absolute highest value in the grid field 30-65 N and 20W-40E. The next step is to look for other regional or local centres. The smaller distance from Greece determines the final centre of the pressure system. The circulation type is determined according to the location of the anticyclonic centre.

At the moment, UT are trying to classify the “characteristic” circulation type 14 which is most frequent in summer and is defined by the extension of the SE Asia thermal low towards the Eastern Mediterranean. It is a key-type of the circulation over the Eastern Mediterranean in summer.

During the ensuing discussion, the need for care in the use of terminology was noted. The scheme developed at UT, for example, is an automated subjective scheme rather than an objective scheme, i.e. it uses the same subjective rules as the original “Maheras” scheme.

Problems which arise in comparing different classification schemes were then discussed. It would be interesting to do some more comparisons. For example, the automated “Maheras” scheme could be compared with the automated LWT scheme over Greece. It is not just a matter of knowing whether individual days are “correctly” classified, we also need to know how close the classification is on “incorrectly” classified days. The agreement between different schemes is expected to vary for different circulation types (see for example, Steve Dorling’s “confusion” matrix of results for LWTs).

Robert Vautard noted that there are some objective ways of quantifying closeness such as LEPS scores (Potts et al., 1996, Revised LEPS scores for assessing climate model simulations and long-range forecasts. Journal of Climate, 9, 34-53.). A single number can be used to measure closeness to the diagonal of a contingency table. In the continuing discussion it was noted that there are two ways of assessing performance: first, how close are the classifications, and second, how close are the downscaled surface variables? Further complications may arise when trying to compare classification schemes with a different number of types.

LMD (Robert Vautard)

Robert Vautard outlined the development of cluster analysis techniques at LMD using 500 and 700 hPa data and the dynamical cluster method of Michelangeli et al., 1995 (Weather regimes: recurrence and quasi-stationarity. Journal of the Atmospheric Sciences, 52, 1237-1256). An algorithm has been developed to find the optimal number of clusters (which is four weather regimes for the North Atlantic sector). The investigation of ultra low-frequency variability is discussed in Michelangeli’s PhD thesis.

The concept of weather regimes is based on dynamical principles and they can be investigated using non-linear equilibration:

$$\underset{\text{(large-scale)}}{\underline{X}} \quad = \quad \underset{\text{(small-scale)}}{f(x, \underline{y}),}$$

so need to search for $< f(x,y)>y=0$, i.e. the large-scale flows with stationary equilibrium.

The development and application of Multi-channel Single Spectral Analysis (MSSA) and SSA is described in a series of papers:

- Plaut and Vautard, 1994 (Spells of low-frequency oscillations and weather regimes in the Northern Hemisphere. Journal of the Atmospheric Sciences, 51, 210-236.) 35 and 70-day oscillations are identified.

- Plaut et al., 1995 (Interannual and interdecadal variability in 335 years of Central England Temperature. Science, 268, 710-713.) Copies of this paper were circulated at the meeting.

- Moron et al., 1998. Application of the methods to global and basin SSTs (identification of 14-year oscillation).

These methods can be used for prediction (on a monthly and seasonal time scale) because they allow the identification of slow, high-variance, predictable mechanisms (e.g. Vautard et al., 1996. Long-range atmospheric predictability using space-time principal components. Monthly Weather Review, 124, 289-307. Vautard et al., 1998. Journal of Climate). These results compare well with those based on CCA.

The following work is planned in ACCORD:

- application of cluster analysis and MSSA at the regional scale using circulation fields (Z700 and MSLP) and physical fields (temperature and precipitation),

- investigation of links between Western Mediterranean/Western Europe/France and supra-regional circulation patterns using cross-composites.

- investigation of trends in regional circulation using MSSA on different timescales: synoptic or intraseasonal (from daily data); interannual (from monthly data) and interdecadal.

- in order to develop downscaling methods, the links between circulation patterns and cold spells/droughts/floods will be studied using composites, correlation (CCA) and mutual information.

- probabilistic downscaling methods will be developed for various time scales using:
  - kernel models,
  - linear CCA downscaling, and
  - analogues.

INLN (Guy Plaut)
Guy Plaut described work carried out using a dynamical cluster algorithm (implemented using the ANAXV software package) and 700 hPa data.

First, the phase space must be chosen. Here it is supra-regional and typically the first 10 PCs are retained. Random seeds are selected from the sample to be classified. The gravity centres are taken as the new seeds and the procedure repeated until no improvement occurs. The whole process is repeated 50 times in order to obtain 50 classifications each consisting of four clusters.

The next step is to decide which of the 50 classifications is best. This is done by calculating the anomaly correlation coefficient (ACC) between two classification sets. The best classification is the one with the best $\overline{\mathrm{ACC}}$ with the 49 other classifications. Thus $\overline{\mathrm{ACC}}$ is the classification index. Two issues need to be considered: reproducibility and significance (i.e. what is the optimal number of classes?).

Significance is tested using a Gaussian Markov process with a time lag. Thus, 100 samples are generated and each sample is classified. $\overline{ACC}$ is calculated for each sample. These are ranked in order to find the 5% and 95% confidence limits. These limits are then compared with the real data classifications. The whole process is repeated for each cluster. The results can be plotted and used to determine the optimal number of clusters or classes. Reproducibility is tested using different data sets and confirms the level of confidence in the classification.

Four weather regimes are obtained for the North Atlantic region: (i) Zonal, (ii) Blocking, (iii) Greenland Anticyclone, and (iv) Atlantic Ridge. The same regimes are obtained whatever seeds are used, i.e. they are robust.

When asked why they do not like the classification behaving like a stochastic process, Robert Vautard and Guy Plaut explained that it was because weather regimes and phase-space regimes can be in the same state with different forcing. Many meteorological processes are Gaussian and the choice of a Markov model was arbitrary. In response to a question about sensitivity to the choice of phase space, Robert Vautard said that they got stable results after using the first 5 PCs.

Guy Plaut then described the application of MSSA. The first step is to compute a correlation matrix. The technique is similar to PCA but is based on more lags. Guy Plaut outlined some of the good features of MSSA as an analytical tool.

MSSA has been used to investigate lags and spectra in the CET record (Plaut et al., 1995 - see previous contribution by Robert Vautard). The robustness of the 15-year spectral peaks identified in this record was tested by varying the window length (using a sliding window Fourier transform). This technique has been used for forecasting CET to 2010 and to forecast global temperature based on the CRU data set. It has also been applied to grid-point data (space-time data), i.e. z700 over the Atlantic. A 70-day peak is detected in the eigenvectors. Four phases of this oscillation can be defined and pressure composites have been produced for each phase in order to look at the development of the oscillation through time (e.g. during each winter 1958-1962).

GENERAL DISCUSSION

The need for consistency/common approaches

Discussions during the meeting have highlighted the need for some consistency of approach in comparing the different techniques which it is proposed to use in ACCORD. Hans Caspary showed an overhead summarising the problems and the need for an overview (Appendix 8).

It was agreed that the list of questions concerning each method should be circulated with the minutes and groups asked to reply to these questions as soon as possible. The questions (also listed in Appendix 8) which need to be answered are:

- what input data are needed? (parameters/resolution in time and space)
- what area is covered?
- what time series are used?
- what kind of circulation pattern classification model is used?
- what kind of downscaling model is used?
- what are the outputs? (what parameters are downscaled?)
- what kind of validation parameters are used?

It was also agreed to circulate the list of precipitation diagnostics (Appendix 7) developed by Rob Wilby and colleagues as part of the ACACIA programme (see Wilby et al., 1998, Statistical downscaling of general circulation model output: a comparison of methods, Water Resources Research, submitted). This list can be used as a basis for drawing up a list of validation parameters appropriate for use by all ACCORD partners (N.B. parameters for temperature and other surface variables will have to be added.)

Communication/Publications

The ACCORD email-box will be used as a forum for discussion between meetings. It will be set up as soon as possible. [*This became operational on 13 March 1998. The address is accord@uea.ac.uk.*]

The ACCORD working paper series is intended to provide an opportunity for rapid dissemination of results within the ACCORD group. These papers will be circulated by the CRU (as electronic or hard copy as appropriate) with a suitable wording to make it clear that these are unpublished results and should not be quoted without permission from the authors.

Janice Darch at UEA is the person to contact concerning financial issues and her address will be added to the list of participants (Appendix 4). It would be a good idea for partners to copy correspondence on financial issues to Clare Goodess in case of problems with email etc. Partners were asked to let Janice know if the first payment has not arrived when they return to their institutions.

Participants were reminded of the need to acknowledge ACCORD in publications and to send the CRU details of conference abstracts/papers etc. for inclusion in the annual reports.

Data

Participants were reminded that the CRU aimed to make the extracted NCEP reanalysis data available as soon as possible.

It was agreed that a summary table of available data should be produced and included in the minutes (Appendix 9). This table can then be added to during the course of the project.

Phil Jones is the CRU person to contact on data issues. Clare Goodess is the contact person for general administrative (non-data/non-financial) issues. (Janice Darch is the contact for all financial matters, copying email/fax to Clare Goodess.)

Meetings

Phil Jones will give a ~15 minute presentation on the ACCORD project at the EC meeting in Vienna, 19-23 October 1998.

The six-monthly reports listed in the work programme will be the meeting reports. The first formal report to the EC is the annual report due at the end of November 1998 (this can be largely based on the progress reports prepared for the Stuttgart meeting). The CRU will inform partners if a particular format for this report is required by Brussels.

The date for the next progress meeting was provisionally agreed as Friday 16 - Saturday 17 October. [*This date was confirmed by Andras Bardossy following the meeting.*]

The second progress meeting will be in Bologna in late March/early April 1999. Carlo Cacciamani and Vanina Cesari will check possible dates, taking account of Easter and the different dates for Easter in Greece. Possible weekend dates are 4/5 April or 26/27 March. [*Following the meeting, 26-27 March was confirmed as the date of this meeting.*]

The final meeting will be in Copenhagen, probably in October 1999. This final meeting may need to be a little longer (possibly Thursday to Saturday).

UEA will write to the three external experts (Machenhauer, Navarra and von Storch) inviting them to the meetings in Stuttgart and Bologna. These meetings will therefore need to be a little more formal than the start-up meeting and allow time for the experts to respond to the presentations. They will also be sent copies of the minutes of the start-up meeting once they have been agreed, but will not be included in the ACCORD email-box.

It was agreed that the minutes will be circulated to all participants for comment and to add in additional information particularly in relation to Appendices 3-5 and 7-9. The aim is to finalise the minutes by the end of March 1998. [*The appendices will be updated on an ongoing basis throughout the ACCORD project. Relevant information should be sent to Clare Goodess.*]

APPENDIX 1

List of participants in the ACCORD start-up meeting

Name	Partner
Bardossy, Andras	IWS
Bowers, David	ECMWF
Burkhard, Reto	U.BERN
Cacciamani, Carlo	ARPA-SMR
Caspary, Hans	FTS
Cawley, Gavin	SYS, UEA
Cesari, Vanina	ARPA-SMR
Davies, Trevor	CRU, UEA
Dorling, Steve	ENV, UEA
Frei, Christoph	ETH
Frich, Povl	DMI
Goodess, Clare	CRU, UEA
Jones, Phil	CRU, UEA
Kolyva-Machera, Fotini	UT
Maheras, Panagiotis	UT
Plaut, Guy	INLN
Schmith, Torben	DMI
Schuepbach, Evi	U.BERN
Vautard, Robert	CNRS
Wilby, Rob	UD

APPENDIX 2

Agenda of the ACCORD start-up meeting

Friday 27 February, Elizabeth Fry Building 0.05, General Business

09.20 - 10.30 Administrative issues:
- ACCORD finances
- ACCORD meetings and reports: dates and locations
- publications, working papers and conferences
- communications

10.30 - 11.00 Coffee
11.00 - 12.00 Data:
- what data do we have?
- what else do we need?
- re-analysis data
- central data catalogue/archive
- transferring data between groups

12.00 - 12.30 The ACCORD Web site
12.30 - 14.00 Lunch in the Private Dining Room, Elizabeth Fry Building

Friday 27 February, Elizabeth Fry Building 0.06, Technical presentations

14.00 - 14.25 UEA
14.25 - 14.50 DMI + VI
14.50 - 15.10 UD
15.10 - 15.30 Discussion
15.30 - 16.00 Tea
16.00 - 16.20 ARPA
16.20 - 16.45 U.BERN + ETH
16.45 - 17.00 Discussion

20.00 - Dinner in the Siam Bangkok Restaurant, Orford Hill, Norwich

Saturday 28 February, Elizabeth Fry Building 0.06, Technical presentations

09.00 - 09.20 IWS
09.20 - 09.40 FTS
09.40 - 10.00 UT
10.00 - 10.20 Discussion
10.20 - 10.50 Coffee
10.21 - 11.15 CNRS + INLN
11.15 - 11.30 Discussion
11.16 - 12.30 General discussion, including finalising data requirements
12.30 - 14.00 Lunch in the Gurney Room, Elizabeth Fry Building

APPENDIX 3

Calendar of meetings

20-24 April 1998	European Geophysical Society XXIII General Assembly Nice, France
7-11 September 1998	Second International Climate and History Conference UEA, Norwich, UK
16-17 October 1998	ACCORD Progress Meeting, Stuttgart Confirmed
19-23 October 1998	European Conference on Applied Climatology Vienna, Austria European Climate Science Conference Vienna, Austria
26-27 March 1999	ACCORD Progress Meeting, Bologna Confirmed
19-23 April 1999	European Geophysical Society XXIV General Assembly Den Haag, Netherlands
October 1999	*ACCORD Final Meeeting in Copenhagen* *To be confirmed*

APPENDIX 4

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APPENDIX 5

List of NCEP reanalysis variables to be extracted by the CRU for ACCORD

Analyses at 0000 and 1200 UTC will be extracted.
Data for the full analysis period 1958-1995 will be extracted.
The spectral model data will be interpolated to a 2.5° by 2.5° grid.

The following list of variables will be extracted:

1. Geopotential heights at MSLP and 1000, 850, 700, 500, 300, 200 hPa

2. Temperature at 850, 500, 200 hPa

3. Relative and specific humidity at 700, 500, 300 hPa
   Relative humidity at 1000 hPa

4. Precipitable water

5. Temperature and precipitation at 2 m

6. Tmin and Tmax

7. U and V components at 10 m

8. Specific humidity at 2m

N.B. During the ACCORD start-up meeting, it was agreed that potential vorticity should be added to the list of variables. [*On checking the NCEP documentation, potential vorticity is not listed as a reanalysis output variable, but can be calculated either from the spectral coefficients or from the pressure-level data. If possible, the CRU will do these calculations to avoid duplication and to ensure a systematic approach.*]

APPENDIX 6

ACCORD tasks requiring colloboration between partners

All the tasks requiring joint work by two or more ACCORD partners are listed here. The project months for which these tasks are time-tabled is also indicated. (Tasks requiring joint work between Partners and sub-contractors (Partner 3 and ETH; Partner 4 and INLN) are not listed.)

Task 1.2: The supra-regional scale - Months 0-12

Partners 1 and 10:	Simple descriptor of the North Atlantic/European circulation.
Partners 1 and 7:	Links to the hemispheric scale using the Dzerdeevskii catalogue.

Task 1.3: Circulation classification at the regional (European) scale - Months 0-12

Partners 1, 3, 4, 5, 6:	One example of each of a number of techniques to be tested - to be specifically allocated between these five partners. 10-15 representative European sites to be identified. All partners to make recommendations on the best methods.

Task 1.4: Circulation classification at the sub-European scale - Months 0-24

Partners 2 and 10:	Southern Scandinavia
Partners 1 and 8:	British Isles
Partners 5, 6 and 9:	Eastern Mediterranean
Partners 3 and 7:	Central Mediterranean (northern Italy/Alps)

Task 2.2: Characterising time-trends, variability and linkages between circulations - Months 6-18

Partners 3, 4, INLN:	"Closely integrated" work on blocking, UTs and COLs etc and their interrelationships, with "related" work by Partner 7.
Partners 1 and 7:	Extension of European-Atlantic blocking catalogue using Grosswetterlagen classifications.
Partners 1, 3, 4, 9:	Links between supra-regional and regional circulations.

Task 3.2: Determining inter-relationships and physical linkages between large-scale variables and surface weather - Months 12-24

Partners 1, 2 and 10:	Links between NAO indices and heavy precipitation events.

Task 3.4: Downscaling methodologies for western Europe: stationarity of circulation-weather relationships - Months 12-24

Partners 1 and 8:	Stationarity of circulation/precipitation relationships over the British Isles.

Task 3.6: Multivariate stochastic modelling using 'fuzzy' rules: central Europe and eastern Mediterranean - Months 6-24

Partners 5 and 6:	Development and testing of multivariate stochastic model in two central European catchments.
Partners 5, 6 and 9:	Development of modified scheme for application in the eastern Mediterranean.

Task 3.7: Links between circulation classifications, blocking, storm-tracks and thunderstorms: northern Italy/Alpine region - Months 12-24

Partners 3, ETH, 7:	Investigation of relationships between surface variables and circulation classifications (blocking, COLs etc.).

APPENDIX 7

List of standard daily rainfall diagnostics used in comparisons (from Wilby et al., paper submitted to Water Resources Research)

Daily rainfall diagnostics

Mean wet-day amount (mm)
Standard deviation of wet-day amount (mm)
Median wet-day amount (mm)
95^{th} percentile of wet-day amount (mm)
p_{00} (probability of a dry-day conditional on the previous day being dry)
p_{11} (probability of a wet-day conditional on the previous day being wet)
π_w (unconditional probability of a wet-day)

Spell statistics

L_w (mean wet-spell length in days, which is directly related to p_{11})
L_d (mean dry-spell length in days, which is directly related to p_{00})
Standard deviation of L_w and L_d (days)
90^{th} percentiles of L_w and L_d (days)

Low frequency diagnostic

Standard deviation of monthly precipitation total (mm)

N.B. A wet day was defined as a day with non-zero precipitation ≥ 0.05 mm.

Additional diagnostics suggested by DMI (Partner 2), based on readily-available monthly time series:

Rx *maximum daily precipitation (mm)*
R10 *number of days with precipitation ‡ 10 mm (days)*

and, to include in the spell statistics:

DRY *number of dry days ‡ 10 consecutive dry days (days)*

APPENDIX 8

The need for an overview (Hans Caspary)

To compare the quality of different circulation pattern classification schemes and downscaling methods we have to use the same:

- consistent dataset → input variables
- calibration period
- validation period
- parameter set for validation
- methods to test the quality of the results that have been obtained for the validation period

Problem

At the moment the groups are working:

- in different regions of Europe
- with different methods for circulation pattern classification and downscaling
- with different input datasets
- with different validation methods

An overview is needed

- what input data are needed? (parameters/resolution in time and space)
- what area is covered?
- what time series are used?
- what kind of circulation pattern classification model is used?
- what kind of downscaling model is used?
- what are the outputs? (what parameters are downscaled?)
- what kind of validation parameters are used?

APPENDIX 9

Data sources for ACCORD (excluding Reanalysis data sources)

Variable(s)	*Domain (Grid/region/station)*	*Time step (Daily/monthly) and period*	*Web site/ ftp address/contact*
Temperature	Global 5° x 5° grid boxes	Monthly 1851→	http://www.cru.uea.ac.uk/cru/ data/temperat.htm
Precipitation	Global land 5° x 5° grid boxes	Monthly 1900→	http://www.cru.uea.ac.uk/ ~mikeh/datasets/global/
MSLP	NH north of 15°N 5° lat. by 10° long.	Monthly 1873-1995	http://www.cru.uea.ac.uk/cru/ data/pressure.htm
MSLP	NH north of 15°N 5° lat. x 10° long.	Daily 1881-1995	Phil Jones
Weather	Stations over Europe (~150 in total)	Daily ~1951-1980	Phil Jones
Weather	~130 UK stations	Daily ~1961-1997	Phil Jones
Precipitation	UK stations (some of above)	Daily (various)	Phil Jones
Many	Global land 0.5° x 0.5°	Climatology for 1961-1990	http://www.cru.uea.ac.uk/ ~markn/carbon/nerc.htm
Many	Global land 0.5° x 0.5°	Monthly infilled 1901-1995	http://www.cru.uea.ac.uk/ ~markn/carbon/nerc.htm
5 NACD T, P, R, N, dsc	North Atlantic – European (388 series)	Monthly 1890-1990	DMI SR 96-1
WASA MSLP	North Atlantic – European (22 series)	3-4 daily observations 1868-1995	DMI TR 97-3
5 REWARD Th, Tx, Tn, Tl, Rx	Nordic (~300 series)	Monthly 1873-1996	DNMI KLIMA Report X/98
Precipitation	Denmark (300 series)	Monthly 1961-1990	DMI TR 97-8

APPENDIX 10

ACCORD Work programme

1.1 Scientific Partners

No.	Acronym	Partner
01	UEA	Climatic Research Unit, University of East Anglia, UK
02	DMI	Danish Meteorological Institute, Denmark
03	ARPA-SMR	Servizio Meteorologico Regionale, ARPA-Emilia Romagna, Italy
04	CNRS	Laboratoire de Météorologie Dynamique, Centre National de la Recherche Scientifique, France
05	IWS	Institut für Wasserbau, Universität Stuttgart, Germany
06	FTS	Fachhochschule für Technik, Stuttgart, Germany
07	U.BERN	Geographisches Institut, University of Berne, Switzerland
08	UD	University of Derby, UK
09	UT	University of Thessaloniki, Greece
10	VI	Verdustofan Islands, Icelandic Meteorological Office, Iceland

1.2 Subcontractors

ETH	Eidgenössische Technische Hochschule, Switzerland
INLN	Institut Non-Lineaire de Nice, France (also a laboratory of CNRS, like the Laboratoire de Météorologie Dynamique; identified as INLN to distinguish it from LMD)

2. WORK CONTENT

2.1 Objectives and Goals

i. To evaluate existing methodologies for classifying atmospheric circulation patterns, to automate them and to develop new automated schemes.

ii. To use these automated schemes to further understanding of climatic variability since the late nineteenth century, and of the physical links between circulation at different space-scales and between circulation modes and synoptic features.

iii. To determine the importance of, in particular, the North Atlantic Oscillation with respect to the variability of surface temperature and precipitation across Europe.

iv. In addition, to determine whether or not circulation changes both at the supra-regional scale and the sub-regional scale (for example, over southern Scandinavia) can explain both the long term and the recent increases in precipitation in many regions of northwest Europe.

v. To improve the potential of the circulation classification approach for downscaling (for example, from the regional scale (European) to the sub-regional scale (for example, Iberian Peninsula, southern Scandinavia), from the sub-regional scale to the catchment scale (for example, in Spain and Germany), and from the catchment scale to the site scale (Greece)) by optimising the discrimination of observed surface weather variables, and assessing stationarity of relationships.

2.2 Project Methodology

The five ACCORD objectives and goals (Section 2.1) will be met through completion of 13 specific tasks which are divided into three thematic groups. The precise contribution of all participants to each task is described below.

Theme One: Circulation Classification Assessment and Development

A comprehensive, co-ordinated and integrated assessment of existing circulation classification methodologies will be conducted, and built on to develop automated schemes. The developmental work will specifically address the issues of appropriate spatial scale, transportability, powers of discrimination and robustness.

Besides the classification of circulation, attention will be paid to methods of recognising and characterising circulation behaviour. This research is important because, for example, the North Atlantic-European region is strongly influenced by the North Atlantic Oscillation (NAO), blocking, cut-off lows and lee cyclogenesis. A number of objective indices and diagnostic tools have been developed to synoptically diagnose the occurrence of such phenomena. It has been shown that climate simulations on the regional scale are of limited use without some skill in the prediction of blocking frequency, especially in the Atlantic-Europe-Mediterranean area. It is, therefore, important to be confident of methods of characterising observed variability of such important features with the appropriate space-time variability.

Task 1.1: Provision and utilisation of data sets

Most groups will be using standard gridded pressure data sets, or gridded data sets already in their possession, such as the gridded Northern Hemisphere mean sea level pressure (MSLP) data set. The quality of all data sets will be checked before they are used in ACCORD. The Northern Hemisphere MSLP data set, for example, is considered reliable on the monthly time scale, but there is some uncertainty concerning the reliability and homogeneity of the day-to-day variance of this data set, particularly during the early 1960s. Partner 1 will assess the reliability of this daily data set by comparing the gridded data with long-observed pressure records (available through the current EC project ADVICE). Partner 2 will use the homogenised multi-elemental North Atlantic Climatological Dataset (NACD) and the data set of homogenised daily pressure observations (WASA), in combination with other data sets. Intercomparisons of the various data sets will be a main task.

Surface variables will be required for the sub-regions, where circulation classification will be undertaken based on clustering surface weather conditions and using the clusters to identify circulation modes producing characteristic weather conditions (surface-to-circulation classification). Some of the necessary daily surface data (for example, NACD, WASA, REWARD and gridded data sources) is available to some Partners. Other Partners will compile, collate and quality control data in areas where data availability is currently restricted. Where possible, data will be obtained from national agencies through the European Climate Support Network (ECSN).

Although relatively short in the context of the last 120 years the Reanalysis data set produced by NCEP/NOAA will be particularly important. Current Reanalysis extends back to 1965 but, during the course of the ACCORD project, results for the Northern Hemisphere back to the early 1950s may become available.

Task 1.2: The supra-regional scale

Partner 2 will develop a circulation index on the North Atlantic-European scale using monthly mean pressure. Homogenised station data from the NACD, as well as the gridded MSLP data will be used, presenting an opportunity to compare the two data sets. An index using Gibraltar as the southern node enables the NAO to be extended back to the 1820s. Further work by Partners 1 and 10 will provide a simple (and statistically robust) descriptor of the North Atlantic-European circulation. This will provide a bridge between the (quasi) hemispheric circulation classifications and the regional and sub-regional circulation classifications. Links to the hemispheric scale will be made using the existing Dzerdeevskii hemispheric-scale catalogue (Partners 1 and 7), in order to determine the character of circulation links between spatial scales.

Partner 3 will investigate supra-regional scale circulation behaviour through the calculation and compilation of Atlantic-European and Pacific blocking catalogues from 1949 onwards (the period from which 500 hPa data are available). Similar work will be undertaken in respect of cut-off lows, on the hemispheric scale. In both these respects the Reanalysis data will provide important inputs.

Task 1.3: Circulation classification at the regional (European) scale

At the European scale, one example of each of a number of techniques will be utilised, including those requiring no prior knowledge, such as principal components analysis (PCA), those which can be taught (artificial intelligence methods, also called neural networks) and mixed schemes based on fuzzy rules, to classify the circulation. This work will be specifically allocated between Partners 1, 3, 4, 5 and 6. The existing "manual" scheme of the Grosswetterlagen (GWL) will be utilised initially to implement the learning process for the artificial intelligence schemes (Partner 1). It is recognised that there are likely to be inhomogeneities in parts of the GWL record so only the more reliable recent period will initially be used for the learning process. The artificial intelligence based system will then provide an opportunity for assessing the homogeneity of the whole GWL record. The various schemes will then be applied to different input information, including and excluding upper air data. Adjustments and modifications will then be made to the GWL record so that it can be fully used in ACCORD and by others. Once corrected, the GWL scheme will be compared with PCA-based methods that start with no prior knowledge.

Assessments will be made of the dependency of the schemes on the space-domain. Surface pressure will be the primary input, but 500 hPa data will also be used for some analyses. Assessments will also be made of how well the various classification schemes discriminate the surface climate at a number of representative European locations (say 10-15 sites). All Partners will make recommendations on best methods. The criteria for judgement will be discrimination between classifications (where this can be quantified, as in PCA), robustness of the scheme, number of cases in the “unclassified” category, and discrimination of surface climate.

Developmental work will also be undertaken on the identification and characterisation of circulation classification regularities. Cluster analysis has been applied to the North Atlantic-European sector using geopotential heights. Partner 4 will apply this method to the regional scale by using surface data, and comparing results with the larger scale. Partner 3 will establish quantitative links with blocking events, and with floods on the sub-regional scale, using the detailed synoptic analysis of blocking frequency (and cut-off lows) developed under Task 1.2.

Task 1.4: Circulation classification at the sub-European scale

It is an open question over which spatial domain it is legitimate to apply a particular classification scheme. Research undertaken at the European scale will start to address this question, but it is reasonable to assume that sub-regional classification schemes will provide greater surface climate discrimination. Certainly, sub-regional manual schemes, such as the Lamb classification for the British Isles, have proved useful for a variety of surface environmental variables. It is proposed that five European sub-regions (Iberia, central Mediterranean (northern Italy/Alps), eastern Mediterranean, southern Scandinavia, and British Isles) will be used to develop circulation schemes and to specifically address the issue of spatial scale for optimum discrimination of both circulation classification and for links with surface weather. Three of the sub-regions will be used, additionally, for the development of surface climate-to-circulation classification. Sub-period analysis will be used to validate the effectiveness of the classification schemes. The sub-region based research will be undertaken by groups with particular familiarity with the sub-regions, and with existing sub-region based skills. Partners 2 and 10, for example, will develop circulation indices for southern Scandinavia, based on geostrophic flow and vorticity, calculated on a daily basis.

Work over the British Isles will take circulation classification further than the existing automated scheme to reproduce the Lamb Weather Types (Partner 1, with Partner 8). It is intended to test a spectrum of techniques, such as PCA, cluster analysis and neural networks. An objective will be to see if the Lamb scheme can be improved upon in respect of surface climate discrimination, for example, by using continuous indices rather than discrete weather classes. A further objective will be to test the efficacy of combining surface and upper air circulation observations, and then taking the classification back to the pre-1940s (before upper air observations are available) by employing "learnt" knowledge. The spatial domain will be extended out into the Eastern Atlantic in order to assess whether a more explicit incorporation of the poles of the NAO improves classification. Work will also be undertaken on the development of a classification scheme based on appropriate clustering of point surface variables or on surface variable patterns.

In the western Mediterranean work has been undertaken which is focused on surface variables-to-circulation links and the use of pressure composites. This work will be further developed in the ACCORD project by Partner 1 and will provide a good basis for ensuring that imported automated schemes have physical reality in the Iberian region.

The fuzzy-rule technique developed for central Europe will be transported to the eastern Mediterranean, and assessed and modified as necessary in that sub-region by Partners 5, 6 and 9. An existing manual circulation classification will be used for comparative assessments.

Effort in the central Mediterranean will involve developing a circulation classification centred on the northern Italy/Alps region (Partners 3 and 7). A major focus will also be the calculation and compilation of Gulf of Genoa lee cyclones. As part of this work, it is necessary for gridded pressure data to be available at high resolution for automated classification. Reliable gridded data at a high enough resolution ($< 2^o$) are available only from 1983 onwards, although the Reanalysis products should extend this further back in time. A central Mediterranean cyclone climatology will be constructed. Individual cyclones will be identified as systems which are evident as at least one closed isobar on a chart with 5 hPa interval. Central pressure, an estimate of the pressure gradient, and the distances to each surrounding, closed, isobar will be recorded. This information will be used to develop indices of cyclone intensity and extent, collated onto a $1^o \times 1^o$ grid.

Theme Two: Using Circulation Classifications to (i) Characterise Time-trends and Variability, and (ii) Determine Inter-relationships and Physical Linkages

Task 2.1: Preparation of data sets

Partners involved in Theme Two will contribute towards the quality-controlled data sets a), c) and d) listed under Section 4.1.

Task 2.2: Characterising time-trends, variability and linkages between circulations

Multi-channel Single Spectral Analysis (MSSA) has been used to identify recurrent sequences of circulation evolutions, particularly spells of oscillatory behaviour at the supra-regional scale. Partner 4 and INLN will apply MSSA at the sub-regional scale (western Europe and western Mediterranean), and will use the technique to examine oscillation occurrence and variability over 120 years for a range of time scales (intraseasonal, interseasonal and interdecadal). Monthly mean variance maps for the Mediterranean will be constructed from high-resolution pressure data from the early 1980s to the present. Canonical Correlation Analysis (CCA) or singular value decomposition (SVD) will be performed on the co-variance of Mediterranean cyclone behaviour and the supra-regional scale anomalies. The separation of the long-term inter-annual anomalies from those related to month-to-month non-regular variability will be attempted.

The work by Partner 4 and INLN described above will be closely integrated with that undertaken by Partner 3, who will use Reanalysis data sets to establish relationships between blocking modes, storm tracks, cut-off lows and lee cyclones. Related work will be undertaken by Partner 7, whose interest focuses on upper troughs (UTs) and cut-off lows (COLs), i.e. synoptic features which are likely to cause severe weather (heavy rainfall) in the Alps. UTs and COLs approaching the Alps are also of importance in initiating (and maintaining) lee cyclones, which are capable of producing severe weather over the northern Italy/Alps region.

Partner 7 therefore proposes to characterise the time-trends and variability of UTs and COLs over the North Atlantic/European region on a seasonal basis using Re-Analysis data. Thickness (the geopotential height difference between 1000 hPa and 500 hPa) is a useful tool for characterising UTs and COLs. Thickness anomalies back to 1949 will be derived from the gridded National Meteorological Center data set. These anomalies and distributions will be linked to surface pressure, available back to 1881, in order to isolate the pre-1949 surface pressure patterns indicating past UT/COL behaviour in the North Atlantic/European region.

It is possible that UTs/COLs are more frequent with certain hemispheric circulation modes, and the Dzerdzeevskii classification will be the starting point for this analysis. The relationships between UTs/COLs and blocking situations will also be explored with Partner 3.

The possibility of extending the European-Atlantic blocking catalogue developed under Theme One back to 1881 using the Grosswetterlagen weather classifications will be considered by Partner 1, together with Partner 7. Partner 1 will also liase with Partners 3, 4 and 9 to determine the links with supra-regional and regional circulations. Relationships with the sub-regional circulation will also be assessed, as well as the links between central Mediterranean cyclone behaviour and cut-off-lows and lee cyclones, and the Grosswetterlagen classification. Justification for this work lies in the importance of cut-off lows and lee cyclones in the genesis of Mediterranean cyclones, and their association with extreme events. The Mediterranean work will be extended to examine the eastern Mediterranean circulation over time and the relationships between eastern Mediterranean circulation classifications and the European and supra-regional scale circulation classifications.

Partner 2 will study the relationship between the supra-regional and the sub-regional scale indices. The hypothesis is that the homogeneous sub-regional scale index, when calculated on a daily basis, can be taken as an index of frontal passages and cyclonic activity. It is therefore supposed that the winter average of this index is controlled by the supra-regional scale indices. This hypothesis will be tested using a multilinear regression technique. The stationarity of the relationships, in particular, will be tested.

Theme Three: Links Between Circulation Classifications and Surface Weather:
(i) European-scale Patterns, (ii) Downscaling

Task 3.1: Preparation of data sets

Many of the surface variables required to complete this group of tasks are held by individual Partners. Additional data will, however, be required and will be obtained, wherever possible, through the ECSN. These data will be used to produce the quality-controlled data set b) listed under Section 4.1.

Task 3.2: Determining inter-relationships and physical linkages between large-scale variables and surface weather

Partners 1, 2 and 10 will use the extended NAO indices developed in ACCORD to examine the strength of the relationships between heavy precipitation events and the NAO. The impact of the decadal-scale fluctuations of the ‘winter’ NAO will be examined through the stationarity of the surface climate/NAO relationships over the last 120 years. For example, do the relationships change during different regimes earlier this century? How does the supra-regional NAO impact the European and sub-regional classification schemes? How much of the longer timescale temperature increase in the region can be explained by decadal-scale changes in the NAO?

Partner 4 will use the circulation regularities identified under Task 1.3 at both the supra-regional scale and the sub-regional scale (western Europe and western Mediterranean) to address the question:- To what extent are there relationships between large-scale circulation and extreme weather events such as cold spells or floods? In particular, the links between blocking spells and cold spells over western Europe will be examined, as will those between regional and sub-regional circulations and repeated heavy rainfalls (likely to lead to flooding) in western Europe. Correlations, CCA and “mutual information” (an extension of correlation analysis to non-linear relationships) will be used. Physical connections will be characterised by the “composite tendency” methodology, which consists of using composite distributions of surface weather variables related to circulation pattern sequences. A particular interest will be to establish the influence of spells of oscillatory behaviour, and to explore the potential for prediction.

Task 3.3: Links between large-scale circulation indices and precipitation in northwestern Europe

There is observational evidence for an increase in winter half-year precipitation during the past 100 years along the northwestern European coast. Preliminary investigations by Partner 2 indicate that these patterns are found in western Norway, southwestern Sweden, western Denmark and the Netherlands. In contrast, there is no trend in the continental parts of Northern Europe. Partner 2 will investigate whether this trend can be explained by circulation changes. The monthly precipitation at a number of homogeneous stations will be downscaled from a large-scale circulation index developed in Task 1.2 and the stationarity of this relationship will be examined.

Preliminary work by Partner 2 indicates that the inter-annual variability, but not the trend, can be explained by circulation changes. This discrepancy will be further investigated. Four explanations will be considered, namely (i) increased water vapour content of the lower troposphere, (ii) increased coastal convergence due to changes in land use, (iii) changes in monsoonal circulation during Spring and Autumn due to changes in CO_2-induced land-ocean temperature contrast, and, (iv) changes in cloud cover and type, possibly related to changes in cloud condensation nuclei. The four hypotheses will be tested in order to isolate the underlying causes.

Daily homogenised precipitation series will be made available for a carefully selected subset of stations. This will make it possible to test whether daily precipitation amounts at the individual stations are controlled by the sub-regional scale index on a daily basis (which again is controlled by the regional-scale index on a monthly basis). Particular attention will be paid to heavy precipitation events. A particular aim of this analysis will be to study the stationarity of circulation-precipitation relationships in the study regions and, in particular, to identify the mechanisms underlying any non-stationarities.

Task 3.4: Downscaling methodologies for western Europe: stationarity of circulation-weather relationships

Long series of circulation classifications (both Lamb classifications and newer variants) will be used to examine the relationships with daily surface variables at a number of locations. These series are likely to be at both the European/NAO and British Isles scales and will be constructed using the recommended methods from Theme One. The British Isles encompass “maritime” and more “continental” climates in the extreme east. This provides the opportunity to test the robustness of relationships over a wide range of temperature and precipitation regimes.

Particular attention will be paid to the stationarity of relationships by Partners 1 and 8. Work undertaken utilising existing circulation classification schemes and using vorticity/precipitation relationships, indicates that the stationarity of circulation/precipitation relationships over the British Isles may not be a reasonable assumption. The extent and causes of any such non-stationarity may be related to the regimes within the NAO series and/or the exponential relationship between temperature and humidity. It is hoped to incorporate the non-linear relationships into the downscaling methodology developed.

Investigation by Partner 1 will also be made of the relationships between the circulation (both over Iberia and in the Atlantic through the NAO) and surface variables on the catchment scale in southern Spain. Special attention will be given to rainfall distributions and extremes (high intensity rainfall events and droughts). The approach will concentrate on developing ways of distinguishing between convective and frontal rainfall, allowing relationships to be established between circulation and the two types of rainfall. Attempts will be made to incorporate these relationships into a stochastic weather generator. The highly seasonal daily rainfall regime, in this the driest part of Europe, may pose particular problems in developing a model. This region has experienced a number of recent extremes of precipitation and the extent to which these may be related to the unusual NAO behaviour needs to be investigated.

Task 3.5: Probabilistic downscaling methods: western Europe and western Mediterranean

Previous work by Partner 4 indicates that a few space-time modes of extratropical circulation variability are predictable on a seasonal time scale. Probabilistic downscaling schemes will be developed by Partner 4 and INLN to estimate the conditional distribution of surface weather in western Europe and the western Mediterranean. Particular attention will be paid to the application of extreme weather prediction using a probabilistic method. A number of downscaling approaches, using different forms of linear and non-linear regressions, will be compared and assessed. Examples will be CCA, radial bias function (non-linear) which builds relationships between variables in the form of local polynomials, and neural networks. Preliminary work, which shows that the character of downscaling is strongly non-linear, provides pointers to the most promising approaches. The surface weather variables (the predictands) will be daily temperature and precipitation at given locations, or surface weather clusters also identified as part of Theme One.

Task 3.6: Multivariate stochastic modelling using 'fuzzy' rules: central Europe and eastern Mediterranean

A multivariate stochastic model will be developed to represent the links between circulation and daily temperature and precipitation. The circulation classification will be the time series defined using a refined fuzzy-rule based automated system developed under Theme One. Classification schemes for two different regions will be used to develop the multivariate stochastic model.

First, a circulation classification scheme based on the (improved in ACCORD) Grosswetterlagen scheme will be used to apply the multivariate stochastic model to Central Europe. The role of topography will be investigated in detail. The model output will be a finely-gridded data set for individual river catchments. Partners 5 and 6 will develop and test this model on two catchments drawn from the following list: the Ruhr, the Aller, the upper Danube and the Neckar. Special emphasis will be given to precipitation extremes over different durations including short-time periods (30 minutes to 24 hours).

A modified form of this circulation classification scheme will be developed for application in the Eastern Mediterranean, in conjunction with Partner 9. This will require the development and validation of a fuzzy-rule based system. This scheme will then be used by Partner 9 to develop a version of the multivariate stochastic model for use in selected episodes of extreme weather events which occurred over the Greek area.

Task 3.7: Links between circulation classifications, blocking, storm-tracks and thunderstorms: northern Italy/Alpine region

Partner 3 will apply results from the study of circulation modes and blocking activity carried out under Themes One and Two to the investigation of surface variables in the Northern Italy/Alpine region. The emphasis will be on extreme events such as heavy rainfall events and cold snaps. Partner 3 has arranged for the transfer of high-resolution precipitation data for the Alps from a subcontractor (ETH) for this work. The relationships between these surface variables and circulation classifications, including cut-off-lows (together with Partner 7) and Genoa lee cyclones, and circulation modes, including blocking and storm track behaviour, will be investigated. If sufficiently long data sets can be identified this work will be extended to investigate relationships between circulation classifications and modes, and thunderstorms.

2.3 Milestones

The ACCORD milestones

The ACCORD milestones are defined as the satisfactory completion of work on each of the 13 tasks. Thus ACCORD has 13 milestones. The ACCORD work programme has been designed so that work on each task will run in parallel as shown in Figure 1. Some of these milestones will be achieved through production of the deliverables summarised in Section 4.1 (and see Table 1).

Project meetings and review

Four major project meetings will be held. The start-up meeting in Norwich will finalise the details of the work programme and the initial data needs. Meetings will then be held at six month intervals in Bologna, Stuttgart and Copenhagen. The aim of these meetings will be to:

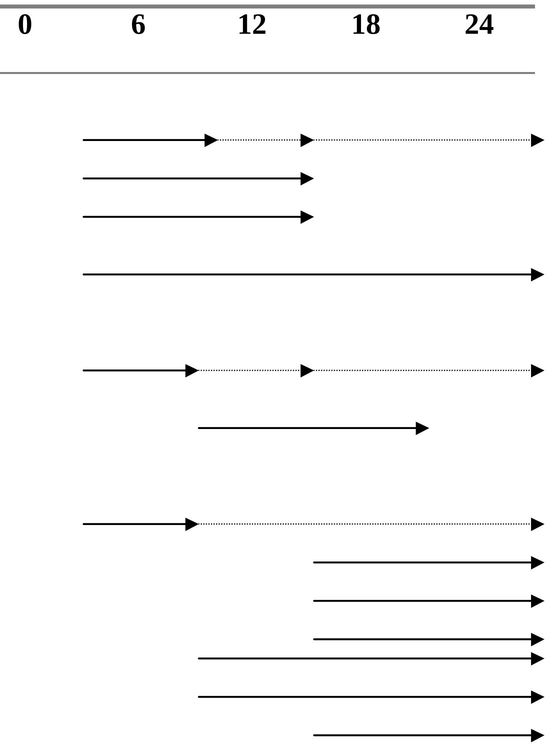
- report and review scientific progress over the previous six months/year;
- exchange data and other information;
- identify and solve any problems particularly those relating to data provision/exchange; and,
- finalise the programme of work for the following six months/year.

All groups will be required to produce progress reports for these meetings according to the schedule shown in Figure 1. The UEA will be responsible for the production and distribution of Agendas and Minutes for all ACCORD meetings.

Three external experts (Prof. Bennert Machenhauer, Dr Antonio Navarra and Dr Hans von Storch) will act as reviewers of the ACCORD project. They will be asked to review the work programme and to attend some of the ACCORD meetings to review scientific progress.

Figure 1: Work programme for completion of the ACCORD tasks (the project milestones).

	Partners involved in Task
1.1	UEA, DMI, ARPA-SMR, CNRS, IWS, FTS, UT, VI
1.2	UEA, DMI, ARPA-SMR, U.BERN,VI
1.3	UEA, ARPA-SMR, CNRS, IWS, FTS
1.4	UEA, DMI, ARPA-SMR, CNRS, IWS, FTS, U.BERN, UD, UT, VI
2.1	UEA, DMI, ARPA-SMR, CNRS, U.BERN, UT, VI
2.2	UEA, DMI, ARPA-SMR, CNRS, U.BERN, UT, VI
3.1	UEA, DMI, ARPA-SMR, CNRS, IWS, FTS, U.BERN, UD, UT, VI
3.2	UEA, DMI, CNRS, VI
3.3	DMI, VI
3.4	UEA, UD
3.5	CNRS
3.6	IWS, FTS, UT
3.7	ARPA-SMR, U.BERN



	0	6	12	18	24
Reports Six-month + Annual * Final **		+	*	+	**

Reports to the European Commission, DG XII

Annual and final reports will be prepared in the format requested by DG XII, together with such other reports as may be requested by the EC, according to the schedule shown in Figure 1. These reports will include details of scientific progress and, where appropriate, details of recommended methods and computer software. The final report will contain a synthesised evaluation of the entire research programme, in addition to descriptions of the individual tasks.

Publication in the peer-reviewed literature

All ACCORD members will be encouraged to submit papers for publication in peer-reviewed journals. Particular emphasis will be given to papers prepared jointly by members of different research groups.

3. ROLE OF PARTICIPANTS

The precise scientific roles of the participants in each task are specifically itemised in the Project Methodology (Section 2.2). This information is also presented in time-frames in Figure 1.

The ACCORD co-ordinator (UEA) will ensure that the work programme shown in Figure 1 is followed, as far as possible. The UEA will also co-ordinate the preparation of reports and their submission according to the schedule shown in Figure 1. Catalogues of data sets (see Section 4.1) and Working Papers (see Section 4.3) will be maintained at the UEA and appropriate arrangements made for their distribution.

The Eidgenössische Technische Hochscule (ETH), Zurich will provide high-resolution precipitation data from the Alps for use by Partners 3 and 7 in Task 3.7, and will contribute to the analysis of the data (also attending some meetings). The Institut Non-Lineaire de Nice (INLN) will develop the software for MSSA and CCA and will undertake part of the MSSA and CCA analysis in Task 2.2. They will also assist Partner 4 in developing probabilistic downscaling schemes for Task 3.5.

The role of the three external experts is described in Section 2.3.

4. DELIVERABLES AND WORK PLANNING/SCHEDULE

4.1 Data Sets and Deliverables

A number of major quality-controlled data sets will be produced during the ACCORD programme and are listed below:

a) gridded daily data sets of climatological variables, e.g. sea level pressure and upper air data;
b) daily surface weather variables in a common format, e.g. temperature and precipitation;
c) synoptic indices derived from observed data, e.g. North Atlantic Oscillation index, daily vorticity index for southern Scandinavia, central Mediterranean cyclone index, and blocking catalogues; and,
d) time series of circulation classification frequencies derived from observed data using various methods, e.g. semi-automated schemes, neural networks, principal component analyses and cluster analyses.

The point in the contract period by which these data sets will be largely complete and available for use by ACCORD members is indicated in Table 1. Partner 1 will maintain a central catalogue of available data sets and make arrangements for their distribution. Data will be documented and disseminated through the ACCORD Web pages which will be maintained by Partner 1. Where appropriate, data sets will be made available to the scientific community during the course of the project. All the data sets will be made available to the scientific community from an agreed date following the end of the contract period, excluding any original data obtained with restrictions on their use.

Table 1: Timetable for production of ACCORD data sets.

Month	***6***	***12***	***18***	***24***
	(a)			
		(b)		
			(c)	
			(d)	

4.2 Project Planning

The planning schedule, including the schedule for completion of the 13 milestones and report production, is shown in Figure 1. The timetable for production of the ACCORD data sets (the project deliverables) is shown in Table 1. The ACCORD co-ordinator (UEA) will ensure that, as far as possible, these timetables are adhered to. Scientific progress over the previous six months/year will be reviewed at each of the ACCORD meetings (see Section 2.3) and the programme of work for the following six months/year will be finalised at these meetings, with the assistance of the external experts.

4.3 Interdependence between tasks

Figure 2 shows the interdependence between the tasks (described further in Section 2.2).

It is anticipated that Partners working jointly on the same tasks (see Figure 1) and on interdependent tasks will keep in regular contact, much of it by electronic means. Most data exchange should also take place using electronic means. These methods will also be used for document exchange. The UEA will also be responsible for maintaining the ACCORD Web pages which will include documentation of the data sets.

In order to improve communication and to make interim results available as quickly as possible, ACCORD members will be encouraged to contribute to a series of internal Working Papers. Members from different research groups will also be encouraged to produce joint journal papers.

Figure 2: Interdependence between the ACCORD tasks.