ACCORD

ATMOSPHERIC CIRCULATION CLASSIFICATION

AND REGIONAL DOWNSCALING

ENV-4-CT97-0530

Minutes of the second progress meeting

26-27 March 1999

ARPA-Servizio Meteorologico Regionale, Bologna, Italy

Summary of agreed action points

- ACCORD groups should contact UEA for access to the extended window of NCEP Reanalysis pressure variables and for daily temperature/precipitation data.

- ACCORD groups are urged to inform UEA about relevant ACCORD publications and to suggest additions/changes to the ACCORD web site. UEA will add a link for downloading the free Adobe Acrobat Reader (*this has been done*.)

- UEA will request a three-months no-fund extension from the EU and check the implications for reporting. (*This has been done. An annual report as well as a final report is required, but guidance from Brussels will be sought on the length of the annual report.*)

- Further details about the final meeting in Thessaloniki will be circulated in September.

- A list of proposed titles/authors of papers to submit to Climate Research in February 2000 will be sought from groups in the autumn.

- UEA will circulate details about the timetable/format of the final report at a later date.

- UEA will check when the next financial payment will be made to groups.

- All groups are urged to consider the points raised in the general discussion when preparing their final reports.

- UEA will circulate details about relevant Framework V documents (*this has been done*).

- A follow-up proposal will be submitted to the EU under Framework V. The following timetable was agreed:

  - UEA to circulate a list of work packages (*this has been done*)

  - All groups to suggest changes to the work packages, indicate which work packages they want to contribute to (with a few sentences of explanation), and indicate whether they want to be principal contractor/assistant contractor/subcontractor (*this has been done*).

  - UEA/work package leaders will ensure that the work packages are balanced and coherent, and then seek more detailed information from groups (by second half of May).

MINUTES OF THE SECOND ACCORD PROGRESS MEETING

ARPA-SERVIZIO METEOROLOGICO REGIONALE,

BOLOGNA, 26-27 MARCH 1999

LIST OF PARTICIPANTS (see Appendix 1)

AGENDA (see Appendix 2)

All groups were asked to bring copies of their progress report to the meeting. These were circulated to all participants and contain further details of the completed work.

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

Subcontractors

	ETH	Eidgenössische Technische Hochschule, Switzerland
	INLN	Institut Non-Lineaire de Nice, France

GENERAL ADMINISTRATIVE ISSUES (Phil Jones/Clare Goodess)

Apologies
Apologies were received from Trevor Davies, Trausti Jonsson and Hans von Storch.

Data
At the last progress meeting UEA agreed, if possible, to extract an extended data window for key NCEP Reanalysis variables. There was some delay before this could be done due to lack of computing storage space and the need to extract additional variables for other users. However, geopotential height pressure data and MSLP data for a window extending out to 90W and down to 20N have now been extracted. These non-standard window files have not been placed on the CRU web site but are available on request by ftp.

As part of the work on ACCORD and other CRU projects, daily station series for a number of variables, including temperature and precipitation, have been assembled, put into a common format and catalogued. The standard station headers provide information about the data source, reliability and availability (public domain or restricted use). The time series have been subject to brief homogeneity checking (e.g. inspection of monthly means/totals). The data archive contains 85 European series (excluding Italy and UK), ~100 Italian series (many

of these appear to be for the same location, but it has not been possible to reconcile the different series) and ~200 UK series (many precipitation only). Further details about these daily data series (including station listings) are available from Phil Jones or Clare Goodess.

There was a major gap in coverage over the Iberian Peninsula. Availability of daily Spanish data has been explored as part of the ACCORD work. It was eventually decided to purchase a set of 15 daily station series evenly distributed over Spain from the Spanish National Meteorological Institute. This station network was identified by Rafael Boren and Jaime Ribalaygua from Servicios Meteorologicos Avanzados, Madrid who attended the last ACCORD progress meeting. Details of the 15 stations are shown in the CRU progress report. The station series received in the CRU required considerable re-formatting and checking for missing values, but are now available in a standard format for use in the ACCORD project (from Clare Goodess).

The ACCORD Web Site

The ACCORD web site (http://www.cru.uea.ac.uk/cru/projects/accord/) has been expanded and updated. It now includes minutes from previous meetings, the annual report summary, the European Climate Science Conference paper and documents relating to the evaluation of methods, all in Adobe Acrobat (*.pdf) format. A list of ACCORD publications has also been added. ACCORD groups are urged to provide material for this list and to suggest additions/changes/links to other sites. A link will be added for downloading the free Adobe Acrobat Reader.

No-funds Extension

It was agreed that UEA would request a three-months no-fund extension from the EU following the meeting. The implications for reporting need to be checked (i.e. will an annual report as well as a final report be required?).

Arrangements for the ACCORD Final Meeting, October 1999

Arrangements for the final ACCORD meeting in Thessaloniki have been finalised. This meeting will run over two full days, 29-30 October 1999, with an optional excursion on 31 October. The estimated cost of the meeting (four nights in the hotel, two lunches, two dinners, coffee and excursion) is 105,000 drachmas (55,000 drachmas for accompanying persons). Further details will be circulated in September. Progress reports will need to be prepared for this meeting.

Framework 5

Time to discuss the continuation of ACCORD under the Framework 5 programme had been scheduled for the following morning. A discussion document and extracts from the published work programme were circulated. It was agreed that UEA would produce a list of important Framework 5 documents.

Reports and Publications

Hans von Storch had suggested that the ACCORD group might like to produce one overview paper on the project or to submit a number of papers for inclusion in one issue of Climate Research. It was agreed that we should aim to submit a number of papers in February 2000, possibly with a short summary/overview paper prepared by the CRU. A list of proposed papers/authors would be sought in the autumn. It was stressed that this didn't preclude people submitting papers to other journals.

UEA agreed to check the EU requirements regarding the format/timing of the final report and to provide more detailed information about the format, length etc. UEA will need to receive the reports in advance of the final deadline to edit them into a common format and write a summary chapter. It was proposed that all final reports should be received in Norwich by the end of January, leaving time for people to write journal papers once the report is written. The final timetable will be notified to all groups once the no-funds extension has been agreed.

Finances
All groups had provided annual cost statements at the end of December 1998. These had been signed off by Phil Jones and submitted to the EU. UEA will check when the next payment will be made to groups.

UB PROGRESS REPORT (presented by Evi Schuepbach and Mahrut Doctor)
Mahrut Doctor described the persistent northerly flow conditions which had brought extreme weather to the Alps during February 1999. Some regions had 600% of normal precipitation, while southern Switzerland was considerably drier than normal.

Evi Schuepbach described the data sets being used. ECMWF T213 data from December 1991 to November 1996 have been retrieved for the domain 60°W to 70°E, 30°N to 80°N, and interpolated to a 1°x1° grid. The following parameters are available: Z300, Z500, Z700, Z850, Z1000, T700, w700, q700 and MSLP. The data are stored in GRIB format on CD-ROM, and can be made available to ACCORD participants.

Work has focused on the investigation of three main precipitation regimes identified in the northern Italy/southern Alpine region. The seasonal cycles and frequency of extremes have been analysed and compared for the three regions. Composite maps of 300/700 hPa thickness have been produced for each month, for three representative stations, for precipitation events >40 mm. These show a characteristic circulation pattern, associated with a trough and strong south-westerly flow.

Future work will focus on a number of issues, including: (i) investigation of surface weather to upper-air links using ECMWF T213 6-hourly thickness data (including a study of the decay and lifetime of features); (ii) analysis of time trends of atmospheric circulation patterns associated with heavy precipitation; and, (iii) pattern recognition work using neural nets (e.g. do all anomalous patterns lead to extreme precipitation?).

The ensuing discussion focused on the choice of 300/700 hPa thickness data and the statistical significance of anomalous circulation patterns. How, for example, do the thickness anomalies compare with the standard deviation of the observations, and is the trough always present when heavy precipitation occurs or on what percentage of occasions?

ETH PROGRESS REPORT (presented by Juerg Schmidli)
Juerg Schmidli described the work being undertaken on the reconstruction of Alpine precipitation fields for this century, based on the methodology of Smith *et al*. (Smith, T.M., Reynolds, R.W., Livezey, R.E. and Stokes, D.C., 1996: 'Reconstruction of historical sea surface temperatures using Empirical Orthogonal Functions', *Journal of Climate*, **6**, 1403-1420.) originally used for the reconstruction of SST.

The reconstruction methodology is based on PCA. Each station is assigned to a grid point. A least squares technique, with inversion, is used to reconstruct the scores and hence the precipitation fields. Current analyses use a calibration period of 1976-1990 and a reconstruction period of 1971-1975.

Juerg described a reference reconstruction based on 54 stations, i.e. a realistic station density. Varimax rotated EOFs were used, and a conservative choice of 15 EOFs retained. A resolved variance statistic (β) is used to test the spatial dependence of reconstruction skill. An example was presented for regional mean precipitation in the Bologna area.

Sensitivity studies have been performed to evaluate the impacts of station density and distribution. For example, random, reference and inhomogeneous distributions give β values of 0.62, 0.74 and 0.76 respectively. Station densities of 20 (situated in areas of maximum loading on rotated EOFs), 54 (the reference reconstruction) and 100 (randomly distributed) give β values of 0.66, 0.74 and 0.75 respectively. These sensitivity studies can provide guidance as to which of the many available station series extending back to the early years of the century should be digitised. Results indicate that it is possible to make skilful reconstructions with relatively few stations, e.g. 15 EOFs, explaining 75% of the total variance, can be reconstructed with about 50 stations. Success depends on the ability to approximate the monthly precipitation fields with EOFs and on the number and distribution of stations. Rotated EOFs give improved results particularly at low station densities.

The discussion focused on whether it would be possible to classify stations according to their potential for reconstruction. It was concluded that it was probably not, because reconstruction skill is dependent on an ensemble of stations so individual stations can't be ranked. It was noted that the results may be dependent on the EOFs from the calibration period and that there might be a problem if the spatial variability of precipitation changes. This could be explored by doing some split sample analyses.

ARPA-SMR PROGRESS REPORT (presented by Roberta Quadrelli)

Work has focused on four issues: (i) the spatial and temporal variability of precipitation (EOFs and trends); (ii) links between precipitation and upper air circulation (pressure composites constructed for the first 3 EOFs); (iii) the identification of typical precipitation structures or regimes; and, (iv) the investigation of links between precipitation regimes and larger-scale circulation systems.

Gridded data from the Alpine precipitation data set have been used for this work together with 500 hPa Reanalysis data. An extended winter season (December to March) 1971-1992 has been used. As part of the EOF analyses, mean precipitation and standard deviations have been plotted for 5-day members (pentads) with high positive (>1) or negative (<-1) loadings. 500 hPa composites have also been plotted.

Cluster analysis has been used to investigate precipitation regimes. It is not possible to identify clusters for the group of dry pentads (PC1 <-1), but four clusters can be identified for –1< PC1 <0, PC1>0 and PC1>1. The latter two sets of clusters are very similar. 500 hPa composites have been constructed for these clusters. Future work includes the statistical validation of the clusters and the construction of blocking composites.

The ensuing discussion focused on the problems of working with precipitation, a highly non-gaussian variable. It might be desirable to normalise precipitation data before undertaking analyses, but work by a student at ETH suggests that such transformations make little difference to the results. Additional problems arise when working with daily precipitation data because of the distribution and noise.

'USE OF CIRCULATION PATTERNS TO DETECT CLIMATE CHANGES IN THE PRECIPITATION OVER SMALL AREA CATCHMENTS' (Ennio Tosi)

Ennio Tosi described work carried out in the 100 x 100 km area of the Reno catchment. Neural net analyses using 500 hPa and precipitation data gave poor results in this region, particularly in summer when precipitation is not so strongly related to the large-scale circulation. Hence an alternative, four step method was used: (i) identify circulation patterns (CPs) based on 500 hPa data; (ii) calculate observed probability functions relating CPs to precipitation; (iii) classify days and simulate precipitation; and, (iv) compare observed/simulated precipitation.

Three classes of precipitation were used: (i) $p<0.002$; (ii) $0.002 <p <4$; and, (iii) $p>4$. The annual cycle was subtracted from the 500 hPa data and pressure composites produced for each precipitation category (October-March only). The algorithm used was the least squares distance and the correlation coefficient was used to classify each day. A 20-year calibration and 20-year validation period was used. The method has been applied to ECHAM T42 output. The simulated filtered seasonal cycle agrees well with the observed cycle, but sensitivity studies indicate a problem in that the right result can be obtained with the wrong data. A shifted year experiment (in which CP data are shifted by 5 months, i.e. January to December is treated as June-May) and a perpetual winter experiment had no effect on the simulated seasonal cycle of precipitation. Simulated precipitation only changes because of changes in CP frequency, and the CPs change very little between the two experiments or from the observations. It was concluded that the ability of CPs to reproduce present-day climate is not necessarily a good guide to their usefulness for prediction. The question is whether these CPs are sensitive to change?

In the following discussion, Ennio was asked whether the characteristics of the individual CPs are significantly different, e.g. in terms of their probability density functions, and replied that they were. It was suggested that different fields other than 500 hPa/MSL pressure should be looked at for large-scale patterns in summer, e.g. stability and gradients of geopotential temperature.

'LARGE-SCALE VARIABILITY PATTERNS OVER THE EURO-ATLANTIC AND THEIR PREDICTABILITY ON SEASONAL TIME-SCALES' (Valentina Pavan)

Valentina Pavan described two areas of work: (i) analysis of observed Euro-Atlantic large-scale winter-time variability; and, (ii) evaluation of ECMWF winter forecasts under the PROVOST project.

EOFs of winter-time Mediterranean precipitation have been correlated with blocking indices and composites produced. EOFs have also been calculated from NMC 500 hPa data for 1949-1994. The effects of the NAO and blocking are evident in the first four PCs. Two blocking indices have been used in this work: (i) West Atlantic blocking (80-20°W), which is associated with the NAO; and, (ii) European blocking (10°W – 50°E). There is a positive

trend in West Atlantic blocking through the 1980s and 1990s, but no trend in East Atlantic/European blocking.

The PROVOST project is evaluating ECMWF winter ensemble forecasts for the period 1980-1993 and has two main aims: (i) to evaluate model skills; and, (ii) to analyse results through a diagnostic comparison of the forecasts. Nine winter-time ECMWF integrations have been analysed, but the January forecasts were discarded because they are correlated with the initial model conditions. 500hPa anomalies were taken from the forecasts and compared with Reanalysis data. The ECMWF model has positive biases, particularly over Europe. Over the Atlantic, the correlation coefficients for EOFs 1-4 are 0.39, -0.14, 0.38 and 0.68 respectively. The blocking forecasts have a negative bias. Observed and simulated time series of the number of blocked days per month have correlation coefficients of 0.15 and 0.14 for Atlantic and European blocking respectively. It is concluded that the ECMWF forecasts have "moderate predictability" for blocking, but this is not improved by removing the model bias.

DMI PROGRESS REPORT (presented by Torben Schmith)

A simple hindcast model based on MSLP has previously been developed and used to predict winter-time precipitation. Cross-validation has been completed using the scores of the first five PCs, e.g. for Malin Head the correlation coefficient is 0.39. Positive trends are evident in the residuals at many stations. It was commented that the positive trends appeared to be concentrated over Sweden and may reflect step jumps due to homogeneity problems in the precipitation series. Torben replied that some homogeneity testing had been done, including comparing stations from different countries which should have picked up any common problem with the Swedish data.

Links between daily precipitation and local circulation have been modelled using a stochastic two-state, first-order Markov Chain model (as Wilby) with various combinations of flow descriptors. The particular focus of this work is to see how well inter-annual variability is reproduced. Results were presented for Grønbæk, where the rank correlation coefficients are 0.44 with vorticity as a predictor, and 0.73 with SLP only as a predictor. In both cases, a positive trend is seen in the residuals. It is intended to repeat this work once long daily Danish precipitation time series have been digitised.

Another area of work is the study of relationships between supra-regional winter flow and local daily flow which requires three steps: (i) identification of fractiles for the daily flow descriptors; (ii) PCA of winter North Atlantic flow; and, (iii) linear regression. In the example for SLP from 1900 onwards, negative trends are seen in the residuals for the 0.05, 0.25 and 0.50 fractiles. This indicates a tendency towards a higher frequency of low pressure values.

In the following discussion, Torben replied that he didn't know if changes in humidity had accompanied the precipitation/pressure changes. It was remarked that analysis of long temperature time series indicates a trend towards fewer cold days in recent years rather than more warm days. So it is possible that the fractile changes/residual trends reflect the increased frequency of extremes at one end of the distribution. However, they could also reflect a shift rather than a deepening of storm tracks. It is important to determine whether the precipitation/circulation relationships or just pressure is changing.

IWS PROGRESS REPORT (presented by Andras Bardossy)
Andras Bardossy reported progress on work in three areas: (i) improvement of the fuzzy classification methodology; (ii) analysis of stationarity; and, (iii) the inclusion of SST as a predictor variable.

The objective function used to evaluate the fuzzy classification has been modified in order to stress the importance of 'abnormalities', i.e. to ensure that the characteristics of each CP differ from mean values. Other issues which have been investigated (for Germany and Greece) are:

- The ability to simulate areal or point precipitation;
- The scale of analysis – local vs. global;
- The optimal size of window over which to calculate CPs;
- The optimal number of CPs to use; and,
- Whether to use 500/700 hPa data or MSLP (for several stations in Germany, 500 hPa is best, more locally it doesn't matter, but for Greece 700 hPa is definitely best).

Correlation coefficients between CP occurrence and the number of rain days/precipitation amount have been used to provide an indicator of stationarity. High correlations imply a stable relationship. Correlations are generally higher for the number of rain days than for precipitation amount, but there are problems with the drier CPs because of the occurrence of many 0 values. It was remarked that the correlations also provide information about the level of noise as well as, possibly, stationarity.

An attempt has been made to incorporate SST into the classifications: days are classified differently depending on whether negative or positive SST anomalies occur in an area 6° south of Iceland. Comparison of the conditional precipitation probabilities for the different classifications indicates that SST may be important for extremes (which are associated with two particular CPs in Germany). Bootstrap testing has been used on the two samples, using a non-parametric model to test the two means against random perturbations.

Two multi-site precipitation models have been tested. In the first model, precipitation is dependent on CPs and a transform normal process is used to model the mean/standard deviation, spatial and temporal correlations and the annual cycle. In the second model, precipitation is dependent on temperature and a Fourier series is used. Precipitation is modelled as a continuous process and a good representation of dry/wet spells is obtained.

Andras concluded by outlining planned future work which will include improving parameter estimation for the precipitation model, applying the model in Greece, and optimizing and applying the temperature model. Direct downscaling of the mean and standard deviation will also be carried out.

FTS PROGRESS REPORT (presented by Hans Caspary)
Hans Caspary described work on validating the CP/precipitation model in the Aller catchment. The fuzzy classification scheme has been used with 500 hPa data to reproduce the Grosswetterlagen classification for 1980-1989 and to identify 12 optimal fuzzy-classified CPs for the period 1961-1989. Validation studies have been undertaken for 1970-1979 using 22 precipitation series and the list of diagnostic statistics from Wilby *et al*. (Wilby, R.L., Wigley, T.M.L., Conway, D., Jones, P.D., Hewitson, B.C., Main, J. and Wilks, D.S., 1998: 'Statistical downscaling of general circulation model output: A comparison of methods', *Water*

Resources Research, **34**, 2995-3008.), including spell statistics. A tendency to overestimate precipitation is found in most months.

Future work will include calibration/validation of the temperature model for the Aller, further development of the stochastic downscaling model and calibration/validation of the downscaling model in Greece.

Results from this work will be presented at the AGU meeting in Boston this spring. The fuzzy classification can be made available to ACCORD participants.

UT PROGRESS REPORT (presented by Panagiotis Maheras and Ioannis Patrikas)
An automated circulation classification for Greece has been completed using the extended NCEP Reanalysis window which reaches down to 20°N. Circulation time series are available for 1958-1997 for five time periods: 00, 06, 12 and 18 h, and daily. Mean monthly pressures have been calculated for these five time periods, and the seasonal variability/trends of the circulation types investigated. There is a positive trend in the frequency of the stable circulation types and a negative trend in the frequency of the unstable types over the period of record. These are accompanied by a general negative trend in precipitation, particularly in winter.

Correlation coefficients have been calculated between circulation-type frequency and precipitation for the five time periods. Correlations with the stable circulation types are negative, those with the unstable types are positive. Correlations have also been calculated for minimum and maximum temperature. All correlations are significant at the 1% level.

The circulation types have been used to predict mean monthly raindays and rainfall amount for the wet season (October-March) and dry season (April-September). Results are good for the validation period (odd years of 1958-1977).

The circulation classification method has also been used to investigate the frequency of Mediterranean cyclones during winter for the period 1958-1997 at 00 and 12 h. Cyclone centres can be identified in the Western and Eastern Mediterranean. Differences between the 00 and 12 h analyses reflect the influence of the diurnal temperature cycle. There are negative trends in the frequency of Eastern Mediterranean (Cyprus) and Western Mediterranean (Gulf of Genoa) cyclones. The trends are stronger in the Western Mediterranean, but no significance testing has been undertaken. Analyses of average vorticity centres associated with the cyclone centres have also been undertaken.

Future work includes the application of the Bardossy/Caspary fuzzy-rule classification and comparison with existing Greek classifications, and the development and testing of a multivariate stochastic model for analysis of extreme events in the Greek area.

In the following discussion it was noted that the differences in analyses for different times of the day may reflect variations in the underlying amount of data in the Reanalysis. It was argued that the reason for looking at 6-hourly values was to look at thermal structure effects.

INLN PROGRESS REPORT (presented by Guy Plaut)
Guy Plaut reported that preliminary work has been undertaken on intraseasonal oscillations of MSLP over the North Atlantic during the last 120 years using MSSA. This work indicates that wavelength transforms are needed. Results will be presented at the final meeting in Thessaloniki.

Work has focused on the analysis of heavy precipitation events during the last 25 years in five sub-regions of the Alps, including Savoy and the Alpes-Maritimes. A threshold of 40mm precipitation at, at least, one grid point is used for this analysis, although this gives too few values in the Innsbruck region.

At the last progress meeting in Stuttgart, it was shown that Cluster 1 was a good discriminating and stable cluster for the analysis of extreme precipitation in the Alpes-Maritimes sub-region. Similar clusters have been identified for other Alpine sub-regions although the discriminating power is not always so good. In the Savoy region for example, two clusters have been identified: Cluster 1 is mainly important in summer (May-September) and Cluster 2 in winter (October-February). The discriminating power of these two clusters is good.

Trend analyses have been undertaken in each sub-region to investigate changes in the frequency of occurrence of the clusters, the number of extreme events per year and the amount of precipitation per extreme event. For the Chamonix region, positive trends are seen for all three parameters and are the same for both clusters. In other regions the trends are different for the three parameters. In the Queyras region, for example, there are positive trends associated with Cluster 1, and a negative trend in the amount of precipitation per extreme event associated with Cluster 2. These analyses suggest that it is probably not possible to reconstruct past intense events on the basis of the similarity of clusters.

A number of conclusions and issues for future work arise from the completed work. The best window of Z700 data for cluster analysis is the larger Atlantic region. Future work will determine whether Z300/700 thickness is a better predictor. It is also proposed to compare the results with those from a reverse methodology, i.e. to classify the precipitation and then look at circulation patterns. Links between the NAO and the frequency of occurrence of clusters will also be investigated. Trends in the frequency of intense precipitation events and total precipitation will be compared.

The ensuing discussion focused on the difficulties of determining the significance of trends particularly for time series of extreme events with relatively few data points.

UEA PROGRESS REPORT (presented by Clare Goodess and Phil Jones)
Clare Goodess described work on the investigation of relationships between circulation type, precipitation and the NAO in Spain using four data sets: (i) a catalogue of 14 circulation types defined using NCEP Reanalysis data; (ii) NAO index constructed using NCEP-interpolated data for Gibraltar and Reykjavik; (iii) a standardised anomaly index of daily precipitation for the Guadalentin Basin, southeast Spain; and, (iv) 15 daily precipitation series for Spain.

Correlations between the NAO and circulation types are strongest in winter and restricted to a few types. Correlations with the cyclonic circulation types are negative, while those with the

anticyclonic circulation types are positive. These relationships are supported by SLP composites and published studies (e.g. Hurrell, J.W., 1995: 'Decadal trends in the North Atlantic Oscillation: regional temperatures and precipitation', *Science*, **269**, 676-679.).

Analysis of all the correlation results indicates that there are major spatial and temporal variations in circulation/precipitation relationships across Spain. This is also evident in the results of stepwise linear multiple regression analysis carried out for each station using the NAO index and circulation-type frequencies as predictor variables and winter precipitation as the predictand. It was remarked that correlated predictor variables were being used. Clare acknowledged this and pointed out stations were correlated variables were picked. However, this was intended as a preliminary analysis to investigate which predictor variables were picked for different stations. The analysis would be repeated using sets of non-correlated predictor variables, separate calibration/validation periods, and split samples.

A preliminary inspection had been made of the residuals from the regressions. For Murcia, which has a positive trend in winter precipitation, there is no trend in the residuals. This suggests that the precipitation trend can be largely explained by circulation-type changes, particularly the increased frequency of the E/SE circulation types. However, only 43% of total variance is explained. For Orense, with no trend in winter precipitation, the residuals have a positive trend. Further analysis of the residuals will be undertaken, ensuring that more appropriate trend lines are fitted than those initially obtained using SPSS.

Phil Jones described the work undertaken by Gavin Cawley and Steve Dorling on the use of simple statistical pattern recognition techniques in reproducing the Grosswetterlagen classification. The results indicate that this problem can be addressed using linear techniques. Separate classifications have been undertaken using PCs calculated from MSLP, 500 and 700 hPa data. The optimal number of PCs to use has been explored. The seasonal performance of the method has also been investigated: it does slightly better in seasons other than summer. Typically, about 50% of days are correctly classified. Performance improves with increasing prior class probability. Results have also been summarised for the three main circulation types (zonal, mixed and meridional) and are considered good (overall accuracy is ~74%). The next step is to combine surface and 500 hPa data. The persistence of types and sequences of days will also be considered: it may be possible to flip days to the type of the previous/next day if both types have similar probabilities/characteristics.

VI PROGRESS REPORT (presented by Phil Jones)

Phil Jones described the work undertaken by Trausti Jonsson on prediction of temperature and precipitation using circulation features. An example was shown predicting annual temperature at Stykkishólmur from 500/1000 thickness data. The residuals show 2-year variability and a general negative trend, which is also seen at a number of other Icelandic stations. The shorter-term fluctuations may to linked to variations in sea ice and SST, but the cause of the longer-term trend is not known.

UD PROGRESS REPORT (presented by Rob Wilby)

The starting point for the UD work is that conventional weather generators/downscaling methods often fail to reproduce low-frequency behaviour (the over dispersion problem). Thus the aim is to evaluate the possible use of novel combinations of quickly/slowly varying predictors. A two-stage analysis has been undertaken: (i) the identification of UK regions of

most pronounced North Atlantic forcing; and, (ii) inter-comparison of different conditional/unconditional models.

Over 90 UK stations, 1961-1990, were used. The three weather generator parameters (pww, pdd, mean precipitation) were calculated and correlated with the NAO index and North Atlantic SST. The correlations, and hence forcing, were found to be strongest at two stations: Stornaway (NAO index) and Bude (SST). The downscaling models have, therefore, been tested for these two locations.

Two models have been used: (i) model U (unconditional, using daily airflow indices only); and, (ii) model C (conditional, using daily airflow indices plus low-frequency conditioning). Two-state conditioning is used in model U, i.e. positive NAO/SST anomalies, and negative NAO/SST anomalies. There was some discussion of why two states were used, and it was noted that this may introduce a potential problem of inter-correlated predictor variables. A third model (model L) has also been tested. This incorporates daily vorticity and low-frequency conditioning, but a continuum (linear forcing) is used rather than two-state conditioning. 100x15 year simulations were run for the validation period 1976-1990. Two sets of statistics were calculated: daily precipitation statistics and longer-term diagnostic statistics.

A number of conclusions can be made from the completed work. The spatial analysis of correlations indicates the fine signature of North Atlantic forcing across the UK. Conditioning only gives modest improvements, even for sites located in regions of maximum North Atlantic forcing. However, better results have been obtained from the US using a similar method. For the UK there are still problems with the time series attributes and the method suffers from a lack of generality. The strength of forcing varies over time so it may be necessary to incorporate non-linear relationships. Further testing of the models for other sites and seasons is needed.

In the ensuing discussion it was noted that there may be some low-frequency forcing in the unconditional model because the daily flow parameters have some relationship with the NAO/SST. Decadal variability has not been assessed, but appropriate diagnostic statistics could be added. A method of optimal conditioning (based on picking the best pressure index) had been found to work well for California. It was argued that the NAO was not being used on a daily basis, but to define or stratify broad sample sets. Other conditioning variables could be used, e.g. North Sea SST rather than North Atlantic SST. There were questions as to how to select the optimal domain, which is likely to vary for different sites.

GENERAL DISCUSSION

Phil Jones started the general discussion by summarising how the work presented during the meeting fell into two main categories: (i) the investigation of large-scale parameters to try to improve the large-scale conditioning of downscaled variables (e.g. work by IWS, FTS, UD, UEA and DMI); and (ii) analysis of Alpine precipitation (e.g. work by ARPA, INLN and UB). No group has yet tried to incorporate temperature, i.e. to consider the ability of warmer air to hold more moisture. It must be remembered that the methodologies will eventually be applied to GCM output and to global warming integrations. Such considerations may be particularly important for extremes. Another issue which needs to be addressed further is whether the structure of precipitation distribution will change.

It was argued that the increase in winter precipitation in Germany can be explained in terms of the observed increase in the frequency of cyclonic/westerly circulation types. However, problems of data and anthropogenic influences on the frequency of flooding, mean that it is not possible to investigate whether similar relationships existed when the NAO was very strong during the period 1880-1920. It was also noted that precipitation trends over NW Switzerland can't be explained by variations in the frequency of the Schuepp weather classes. This implies that changes in precipitation intensity have occurred, which can't be explained by changes in local temperature.

It was argued that the local causes of precipitation need to be considered. For example, atmospheric pollution can affect droplet size, but this is unlikely to be a consideration over Scandinavia.

There are also questions about the confidence we should have in precipitation measurements. Is it possible to rule out factors such as instrumentation changes, improvements in the recording of precipitation, particularly snow, and changes in precipitation type? It was noted that such factors could only account for a very small part of the precipitation trends in NW Switzerland.

Land-use changes should also be considered as they could be a factor particularly in summer. It was argued that changes in surface properties and soil moisture are less likely to affect large-scale moisture transport. However, land use changes could be a factor in changes in summer convective events in Germany.

It was remarked that care was needed when working with temperature because of the seasonal cycle. This would probably have to be removed and anomalies used.

There are also questions concerning the statistical significance of trends, particularly when working with time series with sparse data points. Trend analysis results are likely to be sensitive to the chosen thresholds. It may be better to work with quantiles because a lot of information is lost when working with threshold values.

These issues need to be brought out in the final report. Consideration must also be given to how consistent trends and circulation/climate relationships are across Europe, or where local effects are more important. Stronger statistical demonstration/explanation is needed of the trends and their causes (particularly in terms of circulation-type frequency changes). Consideration should also be given to the consistency of results obtained for the Alpine region by the different groups who are working with different parts of the same data set.

CONTRIBUTIONS FROM THE EXTERNAL EXPERTS (Bennert Machenhauer)

Bennert Machenhauer reported that he had emailed the ACCORD group details of how to access the recent report on 'Validation and analysis of regional present-day climate and climate-change simulations over Europe' produced as part of the RACCS project (see http://www.mpimet.mpg.de).

Validation results from the UKMO, ARPEGE, ECHAM and HIRHAM regional models were presented, using ECMWF data for the observations. Systematic errors occur in simulated MSLP which is too low over much of Europe and the Mediterranean, and too high to the south and north in winter. The pattern of errors is dependent on the vertical package used in

each model. These MSLP errors are also evident in simulated temperature and precipitation. Individual cyclones tend to be too frequent and too deep through the zone of low pressure anomalies. This has an effect on mean transport and eddy transports.

It is desirable to separate out those model errors due to dynamical problems and those due to poor parameterisations. A question for the ACCORD group is whether it is possible to use statistical relationships between flow and temperature/precipitation to explore this issue?

The completed comparisons are for long-term seasonal averages. In the future, work will focus on extremes, and whether it is better to use GCM output with downscaling or regional model output for this purpose.

In the ensuing discussion, it was noted that questions concerning data resolution arise in verification studies: ideally, data sets should be used which have the same resolution as the models. It was reported that the MERCURE project is the successor of the RACCS project. It is using perfect boundary conditions (taken from ECMWF Reanalysis data) rather than GCM-simulated boundary conditions and improved parameterisations (e.g. for the land surface). The resolution of regional models is currently about 50 km (25/14 km for the new generation). Even at this scale it may still be necessary to downscale for some applications, e.g. for hydrologists.

CONTINUATION OF ACCORD UNDER FP5

Initially discussion focused on the relationships between statistical downscaling methods and Limited Area Models (LAMs). It was argued that while the emphasis may be on LAMs as the best path in the long-term there is still a need for verification and validation. The high resolution simulations planned for the future are likely to be of relatively short duration (e.g. 30 year time slices) so there is still a need for downscaling from GCMs if long time slices are required. Downscaling will also be needed for risk applications where many ensembles are required. Three possible areas in which ACCORD2 might use LAM output were identified: (i) comparison with statistically downscaled scenarios based on GCM output; (ii) validation of LAMs; and, (iii) downscaling from LAM output. It was noted that the MERCURE project (co-ordinated by Richard Jones) is ongoing and a major modelling project or cluster of projects will be submitted to FP5 co-ordinated by John Mitchell and others.

Torben Schmith outlined the high-resolution model output from MPI and DMI (including ECHAM4 and HIRHAM4) that would be available for use in ACCORD2. Panagiotis Maheras outlined the proposed contribution of the UT group which includes an investigation of droughts.

In the continuing general discussion it was argued that it is important to be aware of other related projects. Work should concentrate on a few regions, but, so far as possible, use the same input data sets. The importance of application orientated downscaling was stressed: we should try to standardise more. A strong impacts component is needed and a focus on the ultimate point of downscaling. More communication with the impacts community is desirable. The diagnostic statistics used should be suitable for use in impacts studies. Most impacts people want to work with ensembles rather than single realisations. It was a good idea to emphasis extremes (droughts, avalanches, heat waves) but this work should be process/climate-led rather than case studies. Current ACCORD work considered daily/monthly time scales, but other time scales (e.g. 5 days) may be more appropriate for

some extremes. The possibility of applying these methodologies to detection studies was discussed but it was concluded that this was not an appropriate or feasible issue for ACCORD2.

Following the general discussion, answers to the key questions posed in the discussion document were discussed and answers agreed.

1. Should a follow-up proposal be submitted? Yes.

2. Who should co-ordinate the proposal? UEA said that they were happy to continue as co-ordinator or hand over to another group. It was agreed that they should continue.

3. How much use should be made of high-resolution models? This had been addressed during the general discussion. DMI would be able to provide some high-resolution data (Torben Schmith and Bennert Machenhauer would both be involved). It was possible to include other groups, such as MPI, as subcontractors if necessary to ensure access to data. Bennert Machenhauer agreed to talk to his colleague at MPI who would be taking over the regional modelling work when he returned to DMI. Phil Jones would talk to Richard Jones and/or John Mitchell about the large modelling project/cluster being submitted under FP5. It was also possible to involve members of the regional-modelling community as external experts.

4. Can an appropriate group of existing and new partners be identified? All groups were asked to inform UEA if they did not wish to be involved in ACCORD2. It was reported that Rafael Boren and Jaime Ribalaygua from Servicios Meteorologicos Avanzados, Madrid had expressed an interest in ACCORD2. It was agreed that they should be involved. Otherwise it was felt that the ACCORD group contained the appropriate expertise, although it might be desirable to include additional people as external experts.

5. Should the follow-up project be called ACCORD2 or is a new name/acronym required? It was agreed that a new name was needed to stress the emphasis on scenario development and applications of the methodologies.

It was agreed that UEA would prepare a list of five or six work packages based on the topics listed in the discussion document and reflecting the general discussion. It was agreed that the focus of each workpackage should be thematic rather than regional. It was noted that some groups ought to apply the same method(s) across different regions. It was agreed that the study regions used in ACCORD provide an appropriate spread across Europe. The following timetable for proposal preparation was agreed:

- UEA to circulate a list of work packages (by 9 April)

- All groups to suggest changes to the work packages, indicate which work packages they want to contribute to (with a few sentences of explanation), and indicate whether they want to be principal contractor/assistant contractor/subcontractor (by end of April).

- UEA/work package leaders will ensure that the work packages are balanced and coherent, and then seek more detailed information from groups (by second half of May). A brief meeting of work package leaders may be held in May if necessary/feasible.

CLOSE OF MEETING

The local organisers were thanked for ensuring that the meeting had gone so smoothly and comfortably, with particular thanks to Carlo Cacciamani and Barbara Ramponi.

APPENDIX 1

List of Participants in the second ACCORD progress meeting

Name	Organisation
Bardossy, Andras	IWS, Germany
Cacciamani, Carlo	ARPA-SMR, Bologna
Caspary, Hans	FTS, Germany
Doctor, Mahrut	U.BERN, Switzerland
Frei, Christoph	ETH, Switzerland
Galliani, Gianfranca	ARPA-SMR, Bologna*
Goodess, Clare	CRU/UEA, UK
Jones, Phil	CRU/UEA, UK
Karakostas, Theodore	UT, Greece
Lazzeri, Marco	ARPA-SMR, Bologna
Machenhauer, Bennert	MPI, Germany
Maheras, Panagiotis	UT, Greece
Navarra, Antonio	IMGA-CNR, Bologna*
Paccagnella, Tiziana	ARPA-SMR, Bologna*
Patrikas, John	UT, Greece
Pavan, Valentina	Cineca Computer Centre, Bologna*
Plaut, Guy	INLN, France
Quadrelli, Roberta	ARPA-SMR, Bologna
Ramponi, Barbara	ARPA-SMR, Bologna (local organiser)*
Schmidli, Juerg	ETH, Switzerland
Schmith, Torben	DMI, Denmark
Simonnett, Eric	CNRS, France
Tibaldi, Stefano	ARPA-SMR, Bologna*
Tosi, Ennio	Bologna University, Bologna*
Schuepbach, Evi	U.BERN, Switzerland
Vautard, Robert	CNRS, France
Wilby, Rob	UD, UK/UCAR, USA*

* present for part of the meeting

Contact details for most of the participants are available on the ACCORD web site (http://www.cru.uea.ac.uk/cru/projects/accord/partners.htm) and in the minutes of the start-up meeting or the minutes of the first progress meeting (also available on the web site). Contact details for the other participants are given here:

Doctor, Mr Mahrut m.doctor@meteonews.ch

Navarra, Dr Antonio IMGA – CNR
Via Gobetti 101
Bologna, Italy
navarra@rigoletto.imga.bo.cnr.it

Pavan, Dr Valentina
CINECA Centro de Calcolo InterUniversitario
Via Magnanelli 6/3
Casalecchio di Reno
Bologna, Italy
pavan@cineca.it

Quadrelli, Dr Roberta
ARPA-Servizio Meteorologico Regionale
Viale Silvani n.6
Bologna, 40122, IT
roberta@adgb.df.unibo.it

Schmidli, Dr Juerg
Eidgenössische Technische Hochschule
Institute of Geography, ETH
Winterhurerstrasse 190
CH-8057, Zurich, CH
schmidli@geo.umnw.ethz.ch

Simonnett, Dr Eric
Laboratoire de Meteorologie Dynamique du CNRS
Ecole Normale Superieure, 24 Rue Lhomond
Paris, 75231m Cedex 05, FR
esimon@lmd.ens.fr

Tosi, Dr Ennio
Università degli Studi di Bologna
Gruppa di Dinamica Atmosferica
Dipertimento di Fisica
Viale Berti Pichat 6/2
40127 Bolgona, Italy
e.tosi@adgb.df.unibo.it

APPENDIX 2

Agenda of the second ACCORD progress meeting

Friday 26 March 1999

0900-1000	General administrative issues (Phil Jones/Clare Goodess): Matters arising from the previous meeting (data, web site) Arrangements for the final ACCORD meeting in Thessaloniki Reports: progress reports and production of the final report Publications (Hans von Storch has suggested that the ACCORD group submit several papers for inclusion in one issue of Climate Research or one overview article)
1000-1030	UB progress report (Evi Schuepbach, Mahrut Doctor)
1030-1100	Coffee
1100-1130	ETH progress report (Christoph Frei, Juerg Schmidli)
1130-1200	ARPA/SMR progress report (Carlo Cacciamani, Roberta Quadrelli, Marco Lazzeri)
1200-1215	'Use of circulation patterns to detect climate changes in the precipitation over small area catchments', Ennio Tosi, Atmospheric Dynamic Group, Dept. of Physics, Bologna University
1215-1230	'Large-scale variability patterns over the Euro-Atlantic and their predictability on seasonal time-scales', Valentina Pavan, Cineca Computer Centre, Bologna
1230-1400	Lunch, in the same location as the meeting
1400-1430	DMI progress report (Torben Schmith)
1430-1500	IWS progress report (Andras Bardossy)
1500-1530	FTS progress report (Hans Caspary)
1530-1600	UT progress report (Panagiotis Maheras, Theodore Karacostas, John Patrikas)
1600-1630	Coffee
1630-1700	CNRS/INLN progress report (Guy Plaut, Robert Vautard, Eric Simmonnett)
1700-1730	UEA progress report (Phil Jones, Clare Goodess)
1730-1745	VI progress report (to be presented by Phil Jones)
2000	Dinner at the "Osteria Merlot" in the historical town centre

Saturday 27 March 1999

0900-0930	UD progress report (Rob Wilby)
0930-1000	Evaluation of ACCORD results (general discussion)
1000-1030	Contributions from the external experts
1030-1100	Coffee
1100-1230	Continuation of ACCORD under Framework V Introduction and General discussion
1230	Close of meeting
1245	Lunch in the Porta San Felice Restaurant