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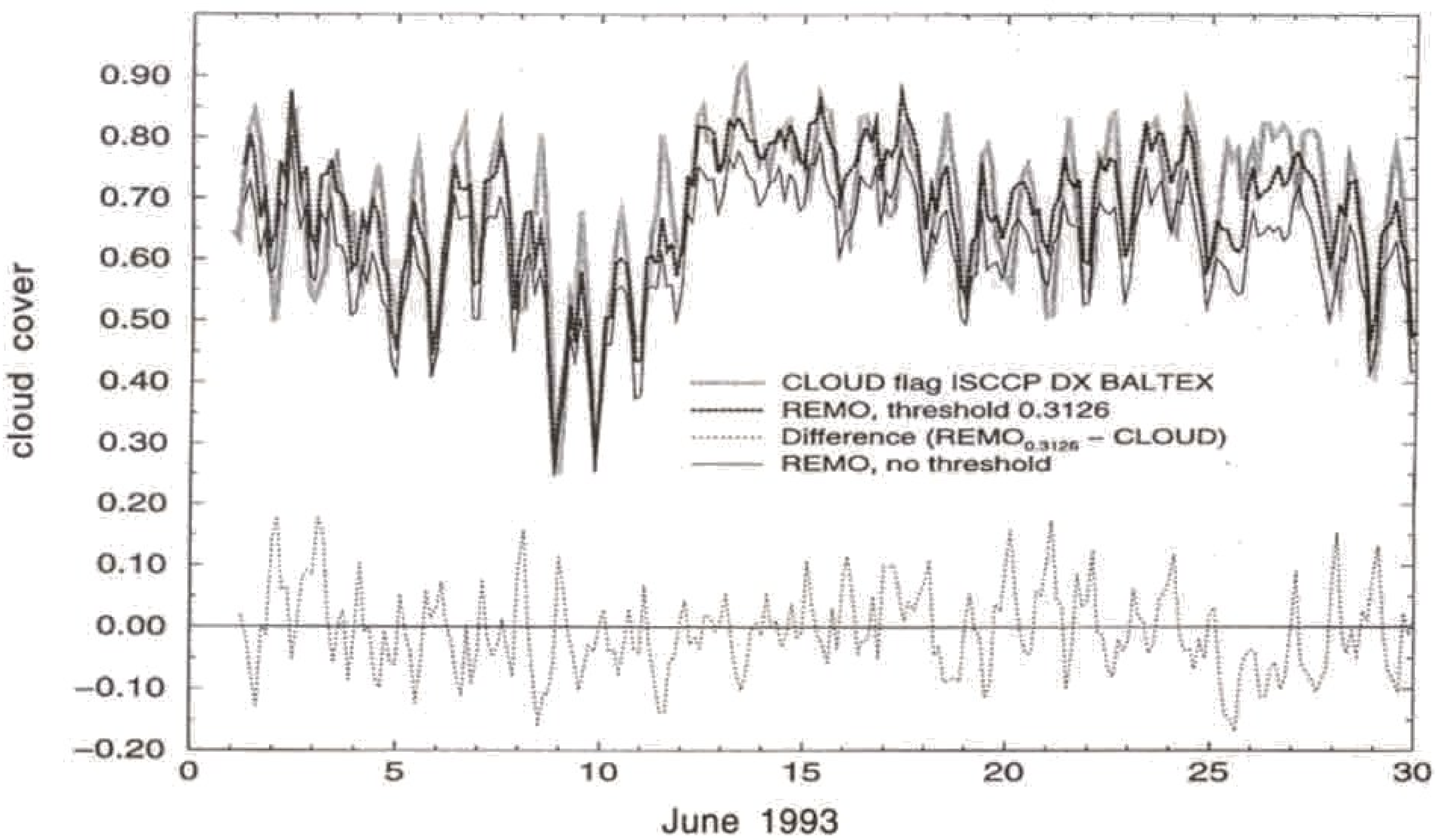

Comparison of satellite cloud data (ISCCP) with high resolution regional scale model output (REMO) for the Baltic Sea region. See Baltic Sea Experiment article on page 6 for explanation.

SATELLITE CLOUD DATA FOR REGIONAL STUDIES

The International Satellite Cloud Climatology Project (ISCCP), a key GEWEX global data set project, is now supporting regional studies with higher resolution satellite data. For more than a decade ISCCP has been collecting satellite data and providing 2.5x2.5 degree global cloud data sets. Now, the new 0.5x0.5 degree data sets are being provided for GEWEX regional studies. These global data sets have supplied investigators with information to greatly improve the understanding of the cloud-to-radiation part of the cloud-climate feedback problem. However, to improve general circulation and climate models there is a recognition that the focus of the cloud-climate problem should change to more emphasis on cloud amount and vertical structure, space-time variations, cloud formation-decay and precipitation processes. The shift in emphasis from cloud-radiation problems to cloud-dynamics problem topics is evident in the GEWEX Cloud System Study working group activities (see articles on pages 8 and 11). These topics are also addressed by other GEWEX projects, such as in the Continental-Scale Experiments regional studies using the ISCCP data sets. The figure above is an example.

WHAT'S NEW IN GEWEX

COMMENTARY
THE SUCCESS OF SEASONAL-TO-INTERANNUAL CLIMATE PREDICTION REQUIRES GEWEX

Moustafa T. Chahine
Chairman, GEWEX SSG

Seasonal-to-interannual (SI) climate prediction is gaining visibility as an important climate issue. The developing capability to extend useful weather and climate prediction based on the knowledge of sea surface temperature and soil moisture patterns over land has given hope that predictions one or two seasons in advance (or longer) will soon be possible for many regions of the world, and GEWEX is making major contributions to advances in this area.

Several fundamental scientific questions must be addressed to more fully understand and demonstrate skill in the prediction of seasonal-to-interannual variations and their effects. These questions range from documenting the patterns of variability to specifying the mechanisms underlying this variability, and understanding how these mechanisms vary in space and time. Ultimately, the objective is to determine the effects (e.g., flood and drought) of SI variability on social and economic activities (e.g., agriculture, water resources), as well as on the biosphere as a whole.

GEWEX programs contribute fundamental studies required to answer these questions:

1. GEWEX is developing regional and global data sets of key climate parameters, such as rainfall, radiation and clouds, and land-surface parameters, to document climate variability on SI time scales and beyond.
2. GEWEX is conducting five continental-scale experiments designed to identify the mechanisms that control the hydrological cycle over land and contribute to SI variability in time and space. Specifically, identifying the contribution of land surface processes and soil moisture to the persistence of atmospheric regimes over periods of months to seasons and the impact of the memory of soil moisture on the predictability of floods and droughts over continents.
3. GEWEX is improving the formulation of energy and fresh water transport and exchanges in atmospheric circulation models. Of particular significance are the GEWEX radiation studies aimed at producing accurate energy fluxes in atmospheric columns from the surface to the top of the atmosphere, with reduced systematic errors to eliminate the need for empirical corrections in general circulation models.
4. GEWEX is working on improving predictive skills through improvements in the formulations of land-surface/atmosphere coupling and in the parameterization of cloud and atmospheric processes in global weather and climate models. The GEWEX stated goal is to demonstrate skill in predicting changes in water resources and soil moisture on seasonal and annual time scales.
5. Closer collaboration between CLIVAR and GEWEX activities is under way to address many SI issues such as the predictability and variability of the Asian monsoon and the Pan-American monsoon.
6. In the impact on human activities area, each of the GEWEX continental-scale experiments is entering into collaborative agreements with water resource agencies and client/users to better utilize improved continental-scale information for regional water resource assessments.

GEWEX is currently the largest international climate research endeavor in WCRP and various aspects of its research are recognized as a prerequisite for investigating and predicting the variability of the Earth climate system on time scales ranging from days to seasonal and interannual and beyond.

Contents

NEW CHAIRS FOR GEWEX CLOUD SYSTEM STUDY (GCSS)

Professor David Randall

David Randall of Colorado State University, is the new GCSS Chair, succeeding **Keith Browning of Reading University, UK**. Due to other commitments, Keith Browning elected to leave the GCSS chair position after more than 5 years of outstanding leadership. David Randall has been a leader in contributing to advances in cloud parameterizations for use in climate models, including tropical convective clouds and mid-latitude stratocumulus clouds, for many years.

The new chair of GCSS Working Group I – Boundary Layer Clouds, is **Peter Duynkerke, University of Utrecht, The Netherlands**. He succeeds **William Cotton, Colorado State University**, who led this group to many achievements, some of which are noted in the GCSS 5th Science Panel Summary on Page 11.

The new chair of GCSS Working Group IV – Precipitating Convective Cloud Systems, is **Steve Krueger, University of Utah, USA**. He succeeds **Mitchell Moncrieff, National Center for Atmospheric Research,** who during his term has provided significant progress in modeling tropical convective cloud systems.

David Starr, NASA Goddard Space Flight Center, USA, succeeded **Erhard Raschke** a year ago, as chair of GCSS Working Group II – Cirrus Cloud Systems. Erhard Raschke pioneered the establishment of the GCSS Working Group II.

Ronald Stewart, Atmospheric Environmental Services, Canada, continues to serve as chair of GCSS Working Group III.

RESULTS FROM THE GPS/MET EXPERIMENT AND POTENTIAL APPLICATIONS TO GEWEX

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University Corporation for Atmospheric Research

The Global Positioning System/Meteorology (GPS/MET) proof-of-concept experiment began with the launch of a small radio receiver into a 750 km low-earth-orbit (LEO) on April 3, 1995. As the receiver circles the Earth about every 100 minutes, occultations occur as the receiver rises or sets relative to any of the GPS satellites orbiting the Earth at approximately 21,000 km altitude. With the current constellation of 24 GPS satellites, approximately 500 such occultations occur each day per LEO satellite. The occultation technique employed was originally developed at Stanford University and the Jet Propulsion Laboratory while investigating planetary atmospheres (see Melbourne et al., 1994). Early GPS/MET results from temperature retrievals presented by Kursinski et al., 1996 and Ware et al., 1996, with further analysis by the authors of this article, indicate accurate vertical profiles of refractivity are consistently obtained from approximately 30 km to 5 km altitude.

The relationship between refractivity, N, and pressure P (in mb), temperature T (in K) and water vapor pressure e (in mb), is

$$N = 77.6\left(\frac{P}{T}\right)+3.73*10^5\left(\frac{e}{T^2}\right) \qquad (1)$$

Pressure is related to temperature and water vapor through the hydrostatic equation. Hence, given a measurement of N and an independent estimate of temperature, (1) may be solved for water vapor pressure. Conversely, given an independent estimate of water vapor pressure and a measurement of N, (1) may be solved for temperature.

GPS/MET temperature data computed under the assumption of e=0 agree closely with independent data from approximately 45 km to 5 km. In this layer the mean differences between the GPS/MET temperatures and the other data are

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approximately 1 °C and the standard deviations of temperature differences range from 2 °C to 3 °C. The GPS/MET temperature profiles show a vertical resolution of about 200 m and resolve the location and minimum temperature of the tropopause very well. They also resolve the temperature structure of atmospheric fronts with an accuracy and resolution comparable to radiosondes (Kuo et al., 1997b).

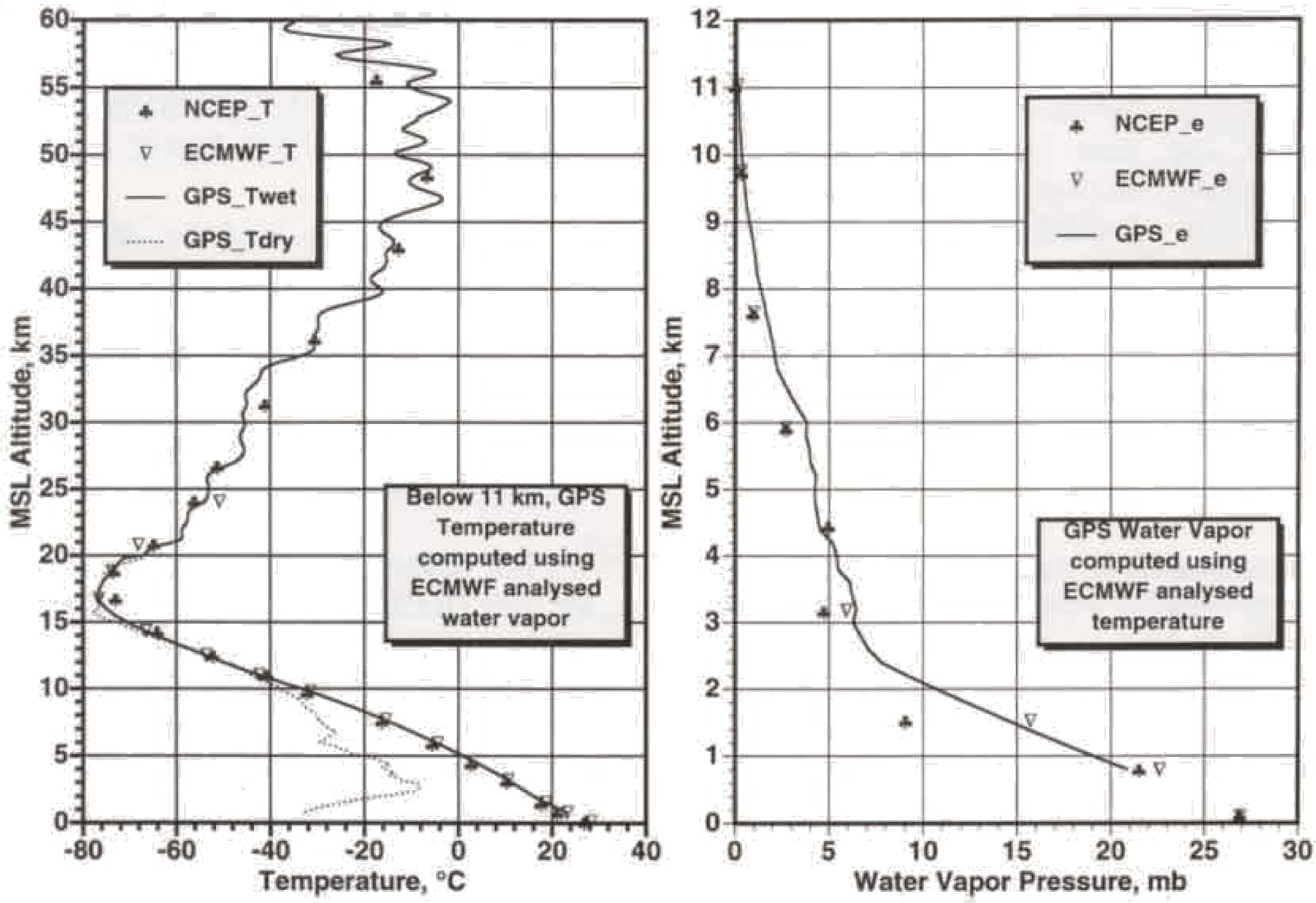
Below 5 km there are difficulties in obtaining refractivity profiles. However, under ideal conditions, accurate soundings have been obtained down to 1 km, and under these conditions it has been possible to calculate the water vapor pressure, using the refractivity and an independent estimate of temperature, or vice versa (see figure on next page). The left side of figure shows the GPS/MET temperature computed under the assumption of a dry atmosphere (the so-called "dry" temperature), the GPS/MET temperature computed from Equation (1) using the European Centre for Medium-Range Weather Forecasts (ECMWF) analyzed water vapor pressure (so-called "wet" temperature) and the ECMWF and National Centers for Environmental Prediction (NCEP) temperatures. The right side of the figure shows the ECMWF and NCEP analyzed water vapor profiles and the GPS/MET water vapor profile calculated from the observed value of N and the ECMWF temperature.

It is likely that the calculation of water vapor pressure (e) from observed values of refractivity N and an independent estimate of temperature will be much more useful for climate studies and numerical weather prediction (NWP) than estimating temperature from N and independent estimates of (e). The temperature calculation is much more sensitive to small errors in water vapor pressure than is the water vapor calculation to small errors in temperature. Ware et al. (1996), for example, indicated that water vapor pressure near the Earth's surface can be estimated within 0.5 mb if the temperature is known to within 2 °C. Conversely, water vapor pressure would have to be known independently with an accuracy of better than 0.25 mb to obtain temperature estimates accurate to within 1 °C. Temperature varies over larger horizontal and temporal scales in the atmosphere than does water vapor, is more easily measured, and hence is better resolved in conventional analyses and model predictions. The present 6-hour forecast of temperature from a state-of-the-art NWP model has a typical temperature error of 1 °C (Eyre, 1994). Thus, given the relatively high accuracy of existing temperature analyses and short-range forecasts together with the weak sensitivity of the water vapor pressure calculation to temperature errors, it should be possible to obtain useful global distributions of water vapor given the global distribution of temperature and refractivity.

High-resolution global observations of refractivity could be useful in GEWEX or other climate-related studies by providing accurate temperature data above 5 km and useful estimates of water vapor below 5 km when a reasonably accurate independent estimate of temperature is available. However, the most powerful use of radio occultation data may be in the direct assimilation of the more fundamental variables such as refractivity, or even bending angles in high-resolution global weather prediction models, rather than trying to separate out temperature and water vapor from the refractivities (Eyre, 1994; Zou et al., 1995; Hoeg et al., 1996). Kuo et al. (1997a) show that the assimilation of refractivity in a numerical model causes the temperature, winds and water vapor fields to adjust in a mutually consistent way, leading to a more accurate prediction of an intense cyclone. Thus, there are good reasons to expect that a dense set of refractivity observations from a constellation of LEO satellites, when continuously assimilated into global models, would produce significant improvements in the global analyses of temperature, winds and water vapor.

Yuan et al. (1993) suggest that monitoring the signal delay from GPS satellites directly will be a powerful method for sensing global and regional climate change. They simulated changes in the delay due to temperature and water vapor changes that would occur in a climate with doubled carbon dioxide as simulated by a global climate model. Increased temperature tends to decrease the delay while increased water vapor tends to increase the delay. The change in delay attributed to "greenhouse effect" can readily be detectable with LEO-atmosphere-GPS data.

GPS/MET observations complement other observational systems. The strengths of the



Retrievals from occultation of June 22, 1995, 11:40 UTC, at 9° S/172° W. Left panel compares GPS/MET wet and dry temperatures (Twet & Tdry) to ECMWF and NCEP optimum interpolated temperature analysis. Right panel compares GPS/MET water vapor pressure (e) with ECMWF and NCEP optimum interpolated water vapor analysis.

fundamental refractivity measurements include: (a) they can provide global and roughly evenly distributed coverage at relatively low cost, (b) they are not affected significantly by clouds, precipitation or aerosols, (c) they have high vertical resolution (approximately 200 m), (d) the basic refractivity observations require no first-guess field and are one of the few upper-air measurement systems that are completely independent of radiosonde data, and (e) they are self-calibrating and have no instrument drift because the basic measurement is time. Thus data from different satellites may be used without need for intercalibration.

The limitations of the GPS/MET radio occultation techniques include: (a) the long horizontal scale (approximately 300 km) of a single observation along the path of ray may limit usefulness for resolving fine-scale atmospheric features, (b) the GPS/MET refractivity data do not give direct information on winds, and (c) a significant fraction of the soundings from the GPS/MET experiment fail to penetrate below 5 km and many of those exhibit a negative bias in refractivity.

For climate studies the long horizontal length scale may not be a serious problem; indeed the averaging out of small-scale features may be an advantage. In addition, with several LEO satellites in orbit it will be possible to reduce this length scale to 200 km or less. It is also possible to assimilate the relatively large-scale radio occultation measurements in models while preserving the strong horizontal gradients in the models.

The penetration depth (sounding) limitation appears to be the most serious at this time. Strong vertical gradients in atmospheric water vapor pressure cause rapid variations in the phase of the GPS signal. Especially in the tropics these fluctuations can be rapid, and because they typically coincide with sudden signal-to-noise fluctuations due to defocusing, the current receiver cannot track them. Future satellites will carry receivers with higher gain antennas to mitigate the signal-to-noise fluctuations and the receiver firmware will have more sophisticated tracking loops to maintain signal lock even during periods of rapid phase fluctuations.

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A single satellite produces GPS/MET observations of limited value because of the relatively low resolution of the data in space and time. There is considerable interest in further demonstration of the value of GPS/MET observations for atmospheric research and prediction by launching a suggested constellation of eight small satellites, each carrying a GPS instrument. The GPS/MET observations may be of significant value to the GEWEX Water Vapor Project, GVaP.

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COMPARISON OF ISCCP-DX CLOUD PARAMETERS WITH REGIONAL ATMOSPHERIC MODEL RESULTS OVER THE BALTEX AREA

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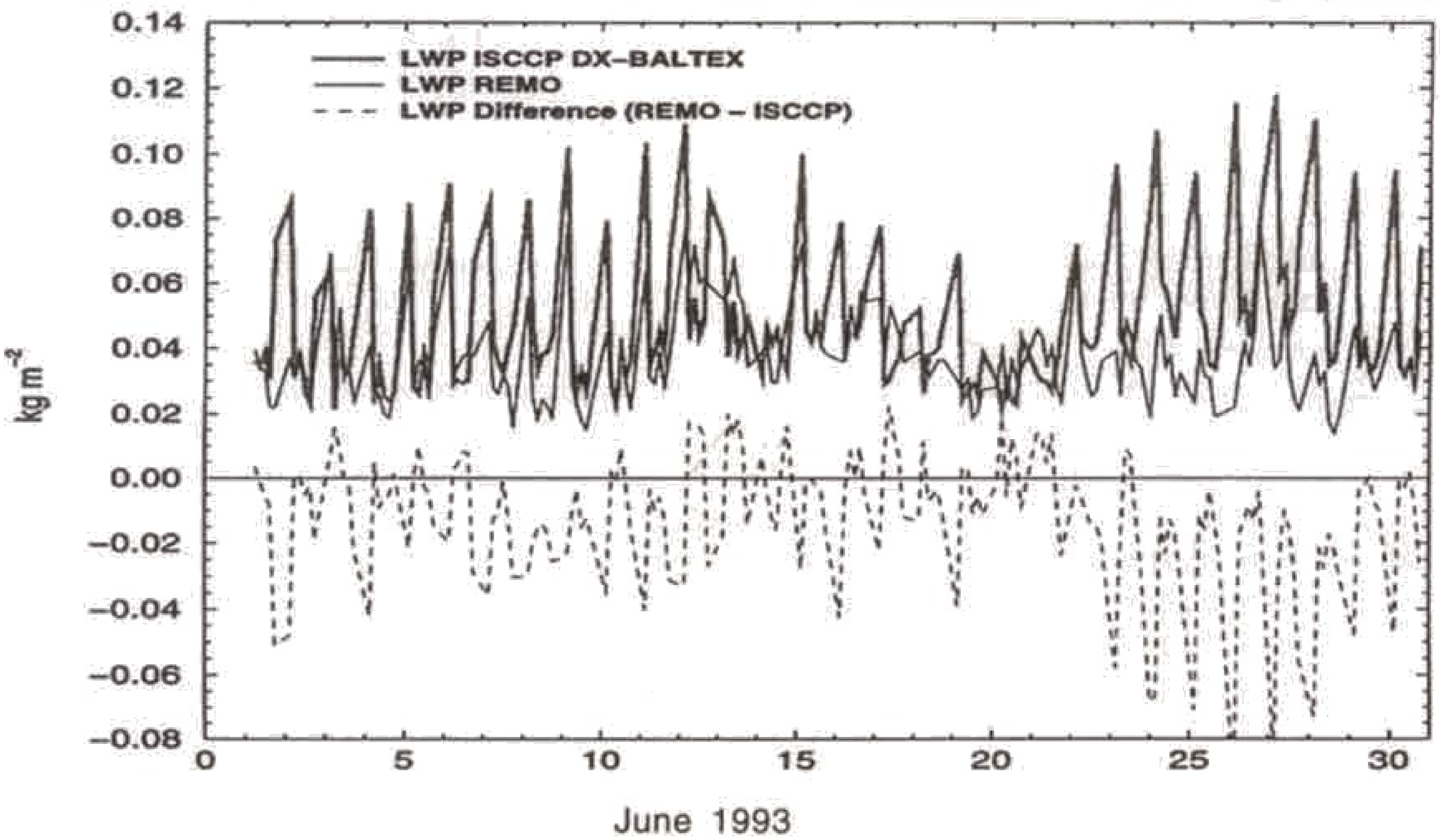
For research within BALTEX, a REgional scale MOdel (REMO) has been implemented in a joint effort of the German Weather Service (DWD), the Max-Planck-Institute for Meteorology in Hamburg, the Deutsches Klimarechenzentrum (DKRZ) in Hamburg, and the GKSS-Research Centre Geesthacht to cover a region including the Baltic Sea catchment area. At GKSS, REMO results of consecutive short range weather forecasts (30 hours) are used to analyze time spans of the order of months with high spatiotemporal resolution (Karstens et al., 1996). To validate the model, satellite data are particularly well suited because of the possibility to cover the whole model area. A first comparison between model output and ISCCP-DX data of cloud cover and cloud water content is presented here for the period June 1993.

The atmospheric model REMO is essentially the same code as the regional weather forecast model "Europa-Modell" (EM, version 2.11) of the German Weather Service (Majewski, 1991). The model uses the hydrostatic approximation with 20 vertical levels in a hybrid coordinate system. The horizontal resolution is 18x18 km^2. The Baltic Sea and its catchment area are located in the centre of REMO's computational domain, covering about 29% of it. Initial and boundary conditions are derived from a model run with coarser horizontal resolution (1/2°) on the larger EM area. The coarser model in turn obtains initial and boundary conditions derived from 6-hourly analyses of the German Weather Service.

The intermediate product ISCCP-DX (Rossow et al., 1996) can be used for a comparison with REMO calculations. In the framework of WCRP (World Climate Research Programme)/GEWEX it was agreed to provide this product for use in the



Area mean of vertically integrated cloud liquid water in June 1993. Only date-times with more than 2000 observation points are taken. The area mean is calculated over all points where observations of the ISCCP-DX cloud flag CLOUD are available.

various GEWEX regional projects. Among the variables are a cloud flag (0/1 for clear/cloudy pixel) and the vertical integral of cloud liquid water, derived from the optical thickness. Time resolution and horizontal resolution are 3 hours and 30 km, respectively. For comparison, the data were transformed to the REMO grid, but no interpolation between the 30 km sampling was done. The following results refer only to those grid points where measurements are available. Consequently, the area mean values are not representative for the whole model area, but only for the strongly varying set of grid points covered at each date.

Cloud Cover

The ISCCP-parameter CLOUD can only assume the values 0 or 1 for clear or cloudy sky, respectively. In contrast, the model includes cloud cover as a continuous variable. Therefore, the mean value of CLOUD over a given set of grid points cannot be compared directly with the mean value of the corresponding model output. As a simple approach to overcome this discrepancy, the continuous cloud cover variable of the model is set to 1 if it is above a certain threshold value, and to 0 if it is below. After this transformation the area mean is calculated. Its value decreases with increasing threshold in a manner determined by the distribution of model cloud cover. In fact, all values between 0 and 1 can be obtained as mean values if the threshold is varied. Model and satellite data result in the same monthly mean for the threshold 0.3126. For thresholds between 0.2 and 0.5 the monthly mean value varies only slowly (between 0.75 and 0.63).

The figure on page 1 shows area means of the cloud cover at all available grid points for all days in June 1993. Model results come closer to the satellite data if the threshold transformation is applied. It should be noted that the agreement of the REMO and ISCCP time series in the figure on page 1 look good partly because the irregular sampling is reflected by all curves. More detailed investigations considering Meteosat and AVHRR data separately are under way.

Cloud Liquid Water

Further ISCCP-DX parameters which can be compared with the REMO output are vertically integrated cloud-liquid water and cloud-ice content. Here the uncertainties involved with the interpretation of the parameters may be higher than for the cloud flag. While cloud water is a prognostic variable in the model, it is derived from the optical thickness in the ISCCP data set (Rossow et al., 1996). This is accomplished by

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classifying a detected cloud as either a water or ice cloud by temperature thresholds in the different channels and then assuming an effective radius for water droplets or ice particles. As cloud ice is not a prognostic variable in the REMO version used for the present study, only a comparison of liquid water paths is shown here. In this interpretation of the satellite data it has been assumed that the clouds contain only liquid water and that the observed optical depth is caused by water droplets and not by ice particles. The figure on page 7 shows area means over all grid points with observations for all dates in June 1993. The model values are systematically smaller than the satellite-derived values, but the locations of extrema mostly coincide. Especially for high satellite derived liquid water paths (>0.07 kg m^{-2}), the corresponding model results are systematically smaller. Different to our treatment of cloud cover, no threshold for cloud liquid water detection was used.

In future investigations, a REMO version that contains cloud liquid water content as well as cloud ice water content as prognostic variables will be used. Cloud top height is an additional ISCCP-DX variable which will be compared with REMO results. The satellite data can thus contribute to model validation and can provide hints for a consistent cloud physics parameterization.

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EVALUATION OF THE ECMWF CONVECTION SCHEME USING CLOUD RESOLVING MODEL DATA

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A core aim of the GEWEX Cloud Systems Study (GCSS) is the use of cloud resolving models (CRMs) to evaluate and develop convective parameterizations for use in general circulation models (GCMs). This procedure is envisaged to be carried out in the context of single column models (SCMs) representing a single grid point of a GCM, which are provided with the same initial conditions and forcings as the CRM. This method is not new, having previously been used by several authors to evaluate the performance of convection schemes using data from observations studies (for example Tiedtke, 1989). However, CRMs are able to provide information not easily obtained from observing experiments and so provide additional insight into the accuracy of the physical representation provided by convection schemes.

This note describes an evaluation of the ECMWF convection scheme using data from simulations of the UK Meteorological Office (UKMO) CRM for two convective regimes. Experiments parallel to the CRM simulations are performed using the single column version of the ECMWF model. A more detailed description of the study is to be found in Gregory (1997). The work parallels a similar study for the UKMO convection scheme in Gregory et al. (1997). The first case concerns an idealized cold air outbreak where the convection is forced by surface fluxes (S=123 Wm^{-2}, LE=492 Wm^{-2}) and grows under a linear westerly shear (from 0 to 10 m/s at 6 km). The second case is based upon Global Atmospheric Research Program Atlantic Tropical Experiment (GATE) data and concerns tropical convection growing in the presence of a westerly low level jet (horizontal wind increasing to 10 m/s at 3 km and decreasing to zero at 6 km) with forcing (cooling and moistening) due to large-scale ascent and surface fluxes (S=12 Wm^{-2}, LE=143 Wm^{-2}). Further details are provided in Kershaw and Gregory (1997). It should be noted that in both cases the convection simulated by the CRM showed no large degree of

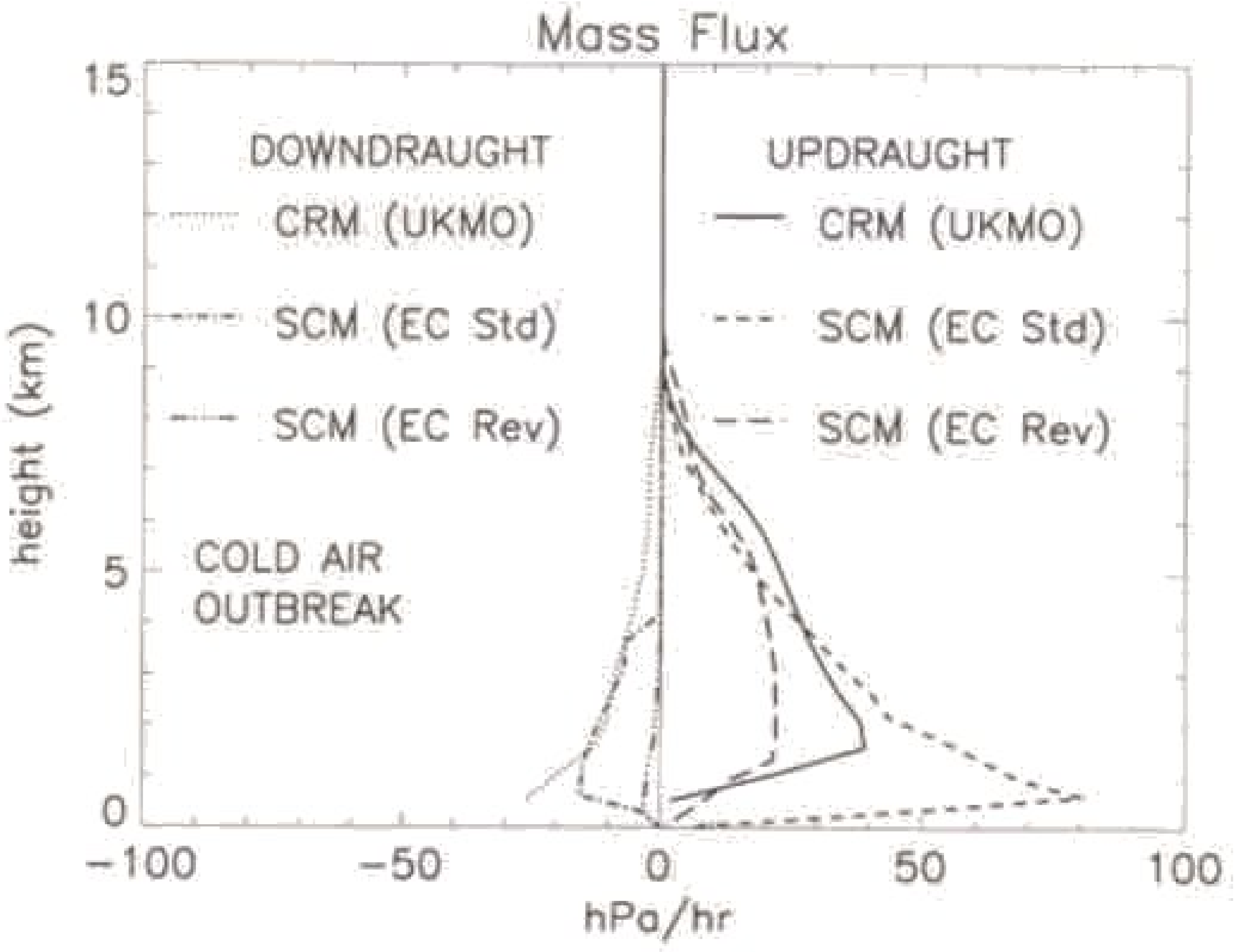

Figure 1: Updraught (UD) and downdraught (DD) mass fluxes for the cold air break case from the CRM (UD: solid, DD: dotted) and SCM simulations with the standard (UD: dash, DD: dash-dot) and revised (UD: long dash, DD: dash-triple dot) ECMWF convection schemes averaged over 10 hours.

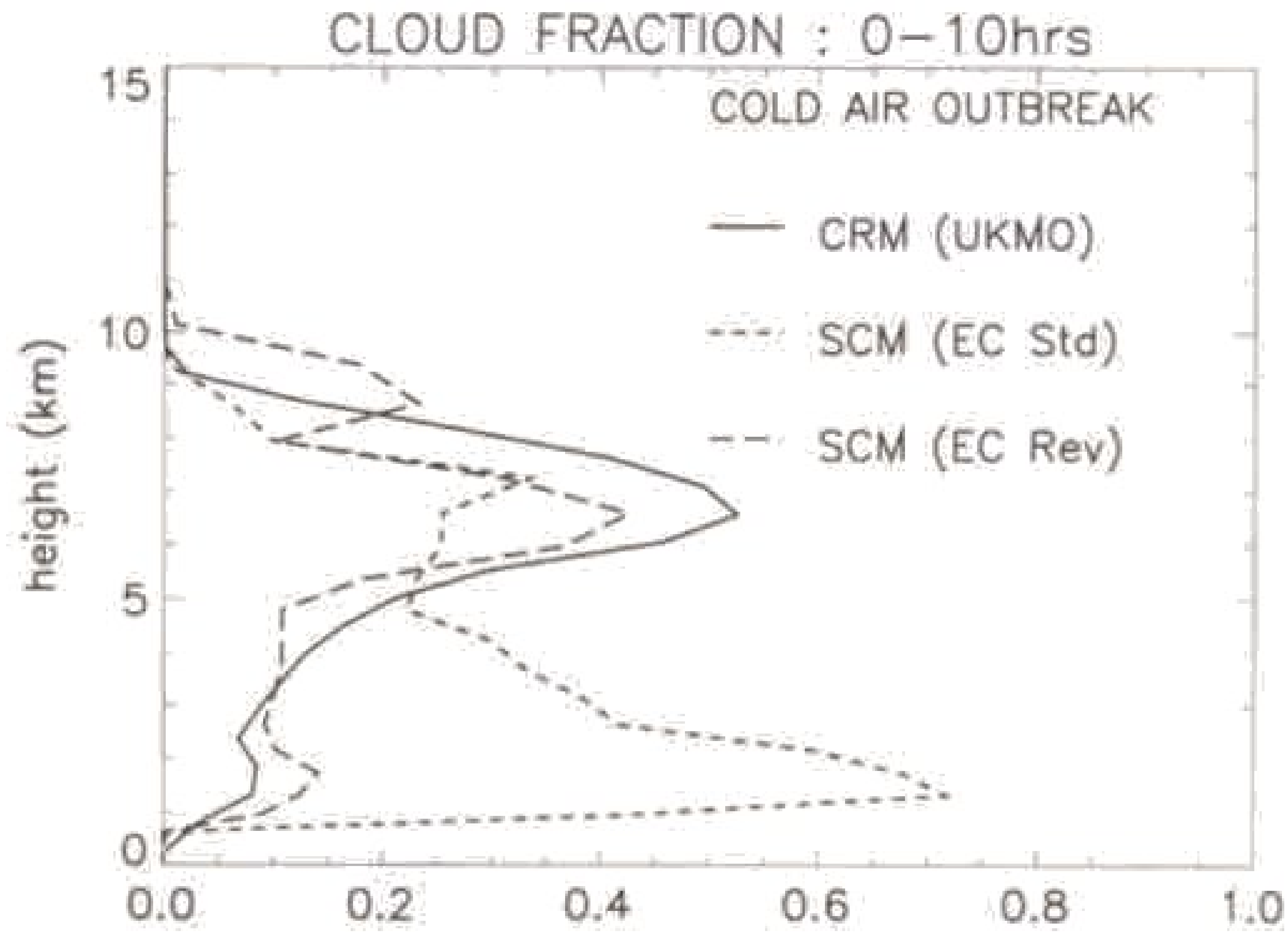

Figure 2: Fractional cloudiness in the cold air outbreak case predicted by the CRM (solid) and SCM simulations with the standard (small dash) and revised (long dash) ECMWF convection schemes averaged over 10 hours.

organization and so the results discussed below pertain to unorganized convection.

Two versions of the ECMWF convection scheme are compared against the CRM data. The standard scheme is similar to that discussed by Tiedtke (1989), being a bulk mass flux scheme in which the cloud base mass flux is estimated through an assumption of boundary layer quasi-equilibrium (Raymond, 1995), on either moisture (deep convection) or moist static energy (shallow convection). The choice between deep and shallow convection is made on the basis of whether the moisture convergence into a column of the atmosphere is greater than surface evaporation. In a recently revised scheme, the estimation of cloud base mass flux for deep convection has been changed to one based upon the assumption that convection reduces Convective Available Potential Energy (CAPE) back to zero over a specified timescale (2 hours in this case) as described by Nordeng (1994). However, unlike the Nordeng approach, the version used in this study makes the distinction between deep and shallow convection on the basis of cloud depth; if the cloud depth is greater than 200 mb then convection is deemed to be deep and the CAPE adjustment closure is used. If the cloud depth is lower than this critical value, then it is assumed to be shallow convection and the boundary layer quasi-equilibrium closure of the original scheme is used. The single column model simulations are 10 hours in length and the radiative processes are neglected.

Figure 1 compares the updraught and downdraught mass fluxes estimated by the standard and revised versions of the ECMWF convection scheme and diagnosed from the CRM simulation for the cold air outbreak case (averaged over 10 hours). The SCM is forced only by surface fluxes, causing the standard convection scheme to switch on shallow convection even though the convection simulated by the CRM is deep. The updraught mass flux is overestimated near cloud base and underestimated above 4 km. The convective ascent is diluted by large entrainment rates and reaches zero buoyancy at a lower height than in the CRM. However, the strength of the downdraught mass flux is reasonably simulated. With the revised scheme deep convection is triggered. Entrainment rates are three times lower than for shallow convection, and the depth of the cloud simulated by the scheme is in agreement with that in the CRM. The shape of the updraught mass flux profile is also in better agreement with the CRM, although its magnitude is underestimated, partially compen-

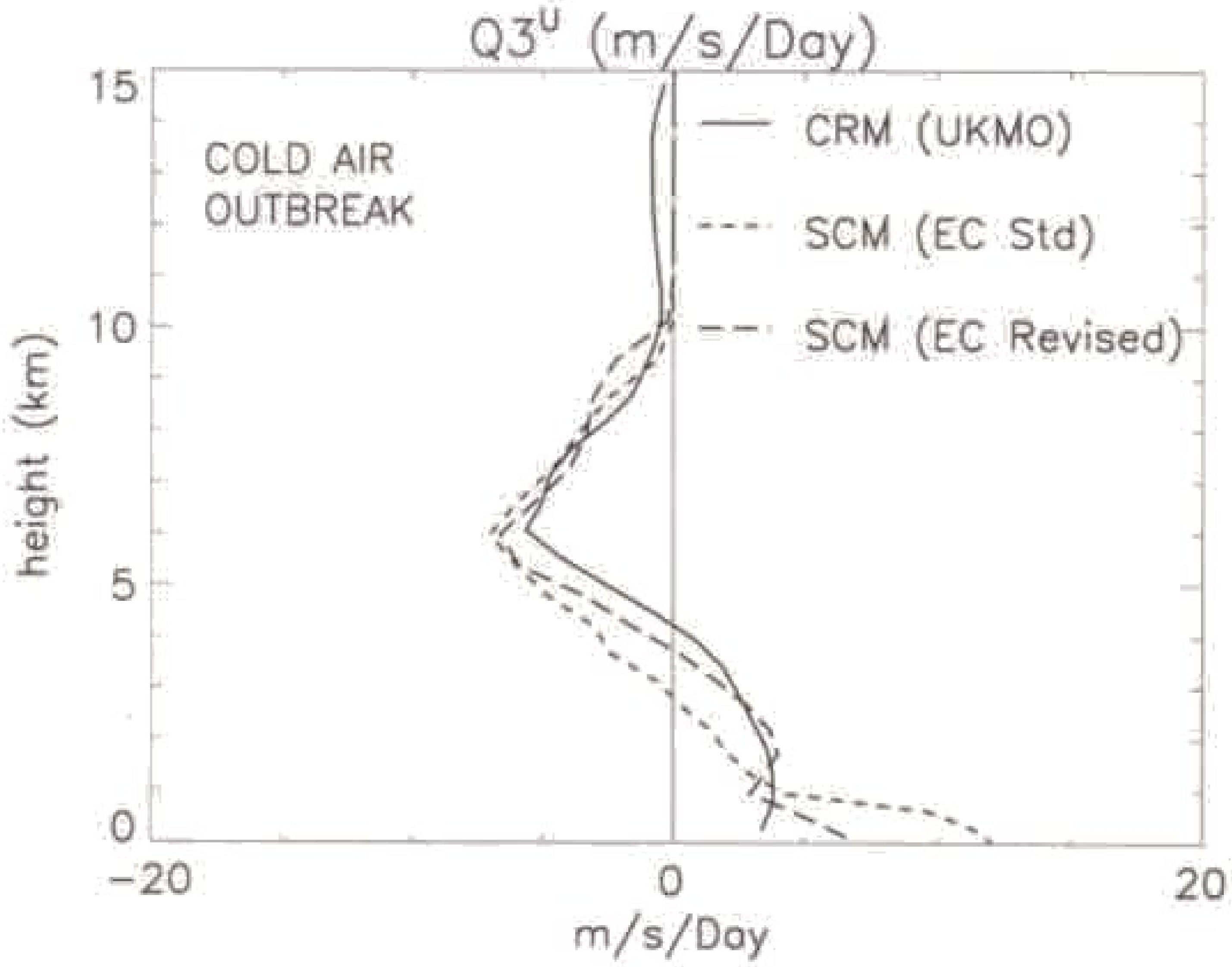

Figure 3: Q3^U for the cold air outbreak case predicted by the CRM (solid) and SCM simulations with the standard (small dash) and revised (long dash) ECMWF convection schemes averaged over 10 hours.

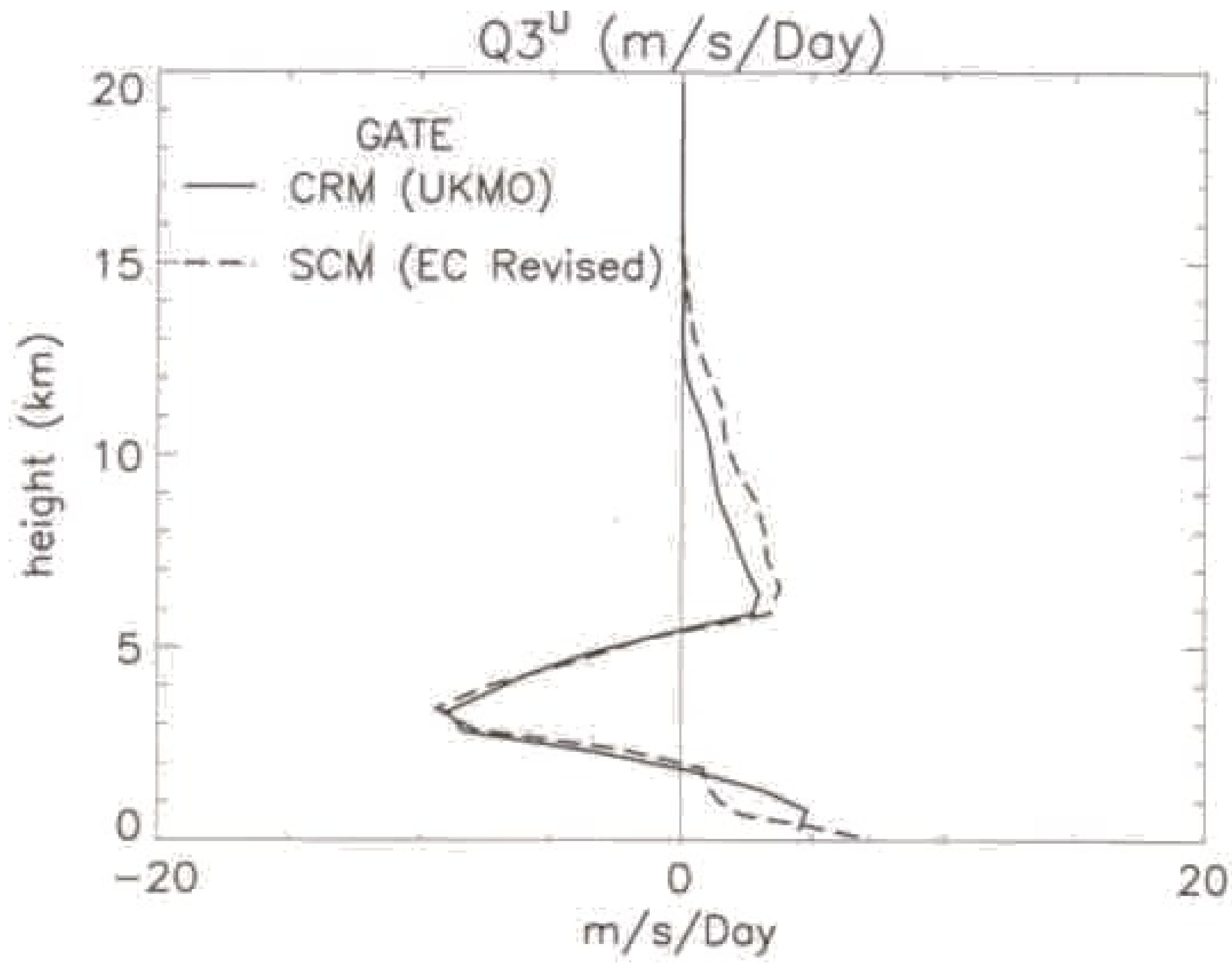

Figure 4: Q3^U for the GATE case predicted by the CRM (solid) and SCM simulation with the revised (long dash) ECMWF convection scheme averaged over 10 hours.

sating the underestimation of the downdraught mass flux.

A further area that is difficult to evaluate from observations is cloud amount. Figure 2 (page 9) compares the cloud amount in the CRM simulation (Kershaw, personal communication) with that predicted by the Tiedtke (1993) cloud scheme used in the ECMWF model. In convective situations the generation of cloud area and water content is linked to the detrainment of cloudy air from convection. The standard ECMWF convection scheme overpredicts low cloud, while cloudiness predicted by the revised scheme is in reasonable agreement with that of the CRM simulation, maximum cloudiness being in the upper half of the convecting layer.

Convective momentum transports are also difficult to obtain from observational studies but can be readily diagnosed from CRM simulations. Of importance here is the representation of across cloud pressure gradients which for unorganized convection force the cloud winds towards those of the large-scale flow. In the ECMWF convection scheme the effects of these are represented through a doubling of entrainment and detrainment rates for horizontal momentum, i.e., increasing the mixing of the in-cloud horizontal momentum with that of the cloud environment. Convective momentum transports have been included in the ECMWF model for some time but previously the performance of the scheme has not been evaluated. Figure 3 compares the net effect of convection and boundary layer processes (only important in the lowest kilometer) in the SCM upon the horizontal wind ($Q3^U$) for both the standard and revised schemes with the convective momentum transport diagnosed from the CRM simulation. Both schemes produce a westerly acceleration of the low level flow and easterly acceleration of the upper tropospheric flow. However, the transport of momentum predicted by the revised scheme is found to be in better agreement with the CRM.

It is important that convection schemes can respond to the wide variation in synoptic conditions found in reality in a realistic manner. The GATE case provides a very different wind regime in which to test the momentum transport parameterization, with wind increasing and decreasing with height. However, the revised scheme (Figure 4) is able to capture the deceleration of the westerly low level jet and westerly acceleration of the initially stationary flow above 6 km, although the latter is overestimated due to the depth of the convection being overestimated by the parameterization.

This note demonstrates the utility of data provided by CRM simulations for the evaluation and development of convection schemes, especially for those aspects of the convection's impact upon the large-scale flow that are difficult to assess from observational data. Further evaluation of the revised schemes performance is also being carried out for cases of convection during Tropical Ocean-Global Atmosphere Program Coupled Ocean-Atmosphere Experimental (TOGA COARE) as part of the GCSS Working Group IV intercomparison of convection schemes and CRM simulations (Moncrieff et al., 1997). However, the cold air outbreak case used here is idealized. Such idealized simulations may be a powerful way of exploring the performance of convection schemes over a much wider range of situations than has been previously possible using observational data.

Acknowledgements: The author thanks Mr. Kershaw of the UK Meteorological Office for making the CRM data available.

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Tiedtke, M., 1993. Representation of clouds in large-scale models, *Mon. Wea. Rev.*, **121**, 3040–3061.

GEWEX CLOUD SYSTEM STUDY SCIENCE PANEL MEETING

Toulouse, France
9–13 December 1996

The 5th Session of the GEWEX Cloud System Study (GCSS) Science Panel was held in Meteo-France, Toulouse. Keith Browning opened the session and was followed by short reports on plans and progress of projects related to GCSS—specifically, those projects with goals to develop better parameterizations of cloud systems within climate and numerical weather prediction (NWP) models. Case studies from a wide variety of past field campaigns are being used from around the world and new initiatives such as the Fronts and Atlantic Storm Experiment (FASTEX) will provide additional information. The GCSS modelling activities are being carried out under the auspices of initiatives such as the European Cloud Resolving Modelling (EUCREM) Project. A FASTEX field campaign is scheduled for the January to March 1997 time period. Data acquired from ships, aircraft and satellites will be used to improve numerical weather predictions of storms crossing the Atlantic.

The objective of GCSS is to develop a better understanding of coupled processes within cloud systems and to improve cloud parameterization schemes for general circulation models (GCMs) and climate models using cloud resolving models (CRMs). The GCSS approach is to use data from field experiments to develop the parameterizations for CRMs and then use the CRMs as experimental testbeds and sources of synthetic data to develop parameterizations for large-scale GCMs used in climate studies.

The work of the GCSS is structured by the recognition of four cloud system types: (1) boundary layer cloud systems, (2) cirrus cloud systems, (3) extratropical layer cloud systems, and (4) precipitating convectively driven cloud systems. For each of these four types there is a corresponding GCSS working group.

William Cotton, Chairman of Working Group I – Boundary Layer Clouds, reported the 3rd GCSS Boundary Layer Cloud Workshop held 13–16 August 1996 in Clermont-Ferrand, France. The August

1996 workshop was organized around the first Lagrangian experiment of the Atlantic Stratocumulus Experiment (ASTEX), specifically a case study of solid stratocumulus with sustained drizzle. A total of eight three-dimensional large eddy simulations, one two-dimensional cloud-resolving model and four single-column models were considered using this ASTEX data set. All the models predicted entrainment velocities of 1.1 +/0.3 cm/s while the magnitudes inferred from the observations were 1.1 +/0.5 cm/s. This is an example of the continuing achievements of WG–I. The next GCSS Boundary Layer Clouds Workshop will be held near Seattle, Washington, 24–25 July 1997.

David Starr, Chairman of GCSS WG–II – Cirrus Cloud Systems, reported activities on a broad spectrum of models ranging from detailed microphysical development models to two- and three-dimensional dynamical cloud resolving models. These models have varying degrees of microphysical and radiative detail and application. Initial focus of WG–II is on mid-latitude situations with simulations of well observed cirrus cloud systems using data from experiments such as the European Cirrus Experiment (EUCREX). Presently, WG–II is planning a workshop from 2–7 June 1997 at a U.S. mid-Atlantic coast site. Joint workshops with WG–III and WG–IV are anticipated in the future.

Ronald Stewart, Chairman of GCSS WG–III – Extra Tropical Layer Clouds, discussed WG–III concerns with the parameterization of extra-tropical clouds within climate and large-scale models. Workshops are being held to develop and validate high resolution simulations of these cloud systems and to use this information for parameterization of clouds within large-scale models such as not reproducing diabatic heating profiles and water cycling. In addition to the workshops, WG–III investigators are participating in field experiments that currently or will obtain measurements for validation purposes. An important part of the WG–III activities will be incorporating remote sensing tools in the development and validation of new cloud parameterizations. A result from these WG–III efforts will be an assessment of present climate models to account for clouds over continental coastal or oceanic regions. The latter region is now being addressed by FASTEX, a key experiment for supporting GCSS WG–III activities.

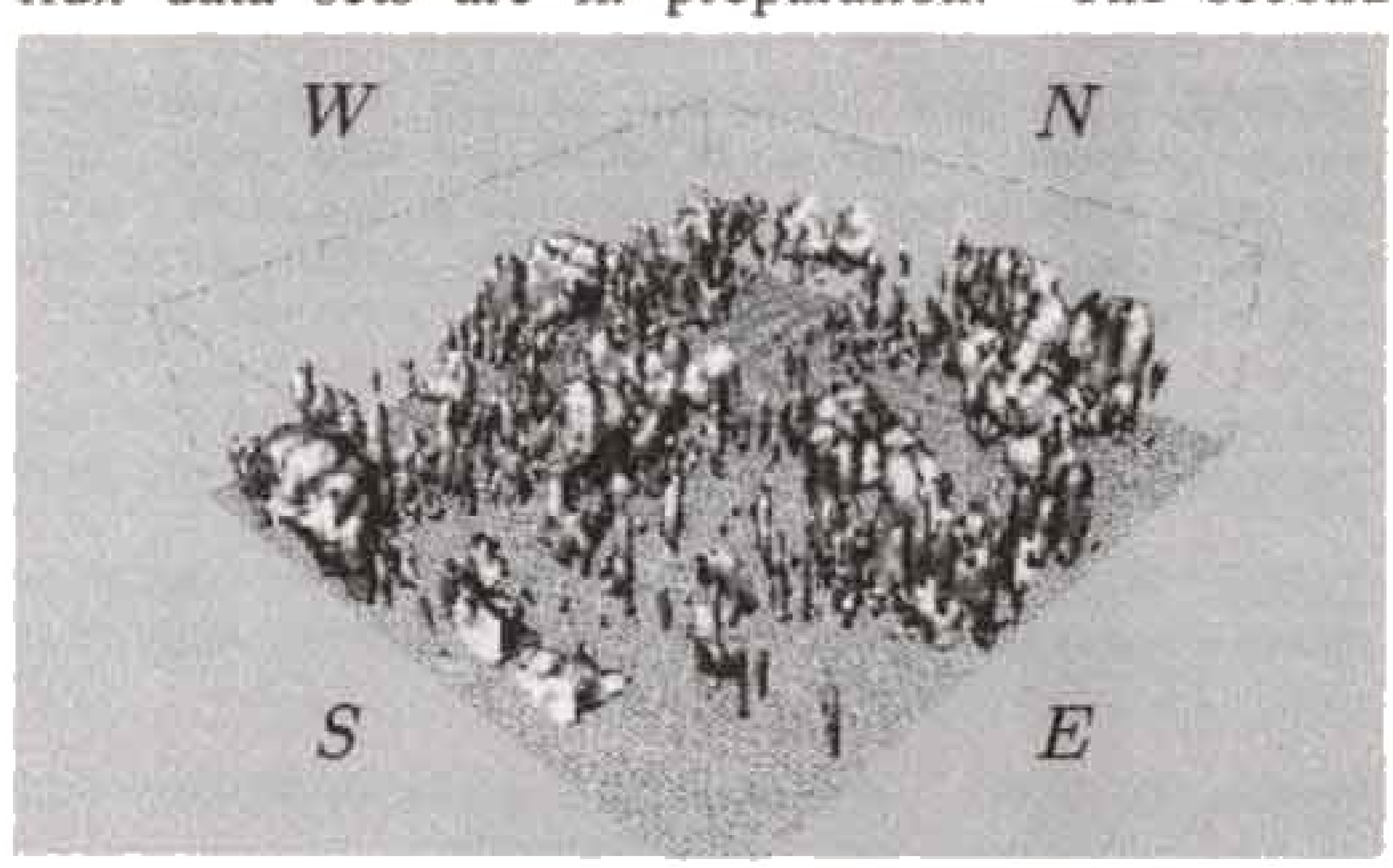
Accomplishments of WG–III include: (1) the demonstration that sometimes mesoscale cloud structure can make a major impact on GCM grid-scale parameters such as not reproducing the layered clouds observed, (2) preparation of several model-observation data sets, and (3) publishing overview articles, e.g. "On the Global Variation of Precipitating Layer Clouds" by B.F. Ryan in the *Bulletin of the American Meteorological Society*, in January 1996.

A WG–III workshop will be held in Australia, 10–12 July 1997. This workshop will focus on results from a hierarchy of models simulating a typical Australian cool change event as well as development of an orographic cloud strategy for GCSS.

Mitchell Moncrieff, Chairman of GCSS WG–IV – Precipitating Convective Cloud Systems, reported on the results from a series of workshops that were held to intercompare two- and three-dimensional CRMs, evaluate these models against observations, and use the verified results to improve one dimensional single column models. Single-column models are an important part of the development testing and implementation of parameterization schemes in NWP and climate models.

As part of the GCSS WG–IV objective to develop physically based parameterization schemes for global models, large-scale observations are used to force the model which explicitly calculates the effect of clouds. An example of the total condensate field (ice, cloud water and rain) in a three-dimensional domain (400 km x 400 km x 26 km) is shown below.

The first intercomparison project of WG–IV is focussing on convection over the tropical Western Pacific Ocean. Two-dimensional mass flux data sets are now available and three-dimensional mass flux data sets are in preparation. The second



Nonsquall Cluster, viewed from southeast

WG–IV intercomparison project will address modeling convection during the warm season over the United States Great Plains.

The next GCSS Science Panel Meeting is scheduled for 1–5 December 1997, in Boulder, Colorado, USA.

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Web Site: http://www.tor.ec.gc.ca/GEWEX/GCSS/GCSS_wg3.html

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Web Site: http://www.cnrm.meteo.fr:8000/gcss/

ISCCP REGIONAL DATA ON-LINE

The International Satellite Cloud Climatology Project (ISCCP) Global Processing Center posts detailed case study data sets on-line for ongoing work and planned studies. These data sets contain satellite measurements of cloud and surface properties (ISCCP data) every 3 hours at two spatial resolutions, approximately 30 km and 280 km for the duration of the field campaigns (in some cases plus and minus one week). The spatial domain is usually larger than the experiment area. These data sets can be viewed on screen or downloaded and represent subsets of the large number of ISCCP data products that can be obtained from the ISCCP archives.

ISCCP has provided data sets to Continental Scale Regional Experiments, e.g., BALTEX, GCIP, MAGS, as well as for regional case studies for the field campaigns of GEWEX Cloud System Study and International Satellite Land-Surface Climatology Project, e.g., Boreal Ecosystem-Atmosphere Study. For additional information see the ISCCP Web Site:

http://www.isccp.giss.nasa.gov

NEW GLOBAL WATER VAPOR CD-ROM AVAILABLE

A key contributing element for the GEWEX Water Vapor Project (GVaP) Pilot Study is the National Aeronautics and Space Administration Water Vapor Project (NVAP), which has now produced a 5-year (1988-1992) data set on CD-ROM. The 1°x1° global grids of daily, pentad and monthly averages of a blended global product of precipitable water or water vapor derived from radiosonde and satellite observations are included along with animation software for display. The NVAP data set shows interannual variability of the order 1 to 1.5 mm on the global average. The annual cycle and interannual variability is stronger in the Northern Hemisphere than the Southern Hemisphere. For more information on this, contact STC-METSAT, 515 South Howe Street, Fort Collins, Colorado 80521, USA, Tel: 970-221-5420; Fax: 970-493-3410 or Web Site at:
http://www.cira.colostate.edu/climate/NVAP/NVAPCIRA.HTM

CONTINENTAL-SCALE EXPERIMENT OFFICES (CSEs)

The last issue of GEWEX News (Vol. 6, No. 4, November 1996) contained summaries of activities for each CSE. The mailing address, telephone, facsimile, e-mail address and web site for each CSE follows:

GEWEX Continental-Scale International Project (GCIP)
Dr. Rick Lawford or Dr. John Leese
1100 Wayne Avenue, Suite 1210
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Tel: 301-427-2089 ext. 511
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E-mail: gcip@ogp.noaa.gov
Web Site: http://www.ncdc.noaa.gov/gcip/gcip_home.html

Mackenzie GEWEX Study (MAGS)
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Web Site: http://www.ihas.nagoya-u.ac.jp/game/index.html

Large Scale Biosphere Atmosphere Experiment in Amazonia (LBA)
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e Estudos Climaticos
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E-mail: nobre@cptec.inpe.br or
marengo@cptec.inpe.br
Web Site: http://yabae.cptec.inpe.br/lba/

NEW ARM CLOUD RADAR

The Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Program recently turned on one of its newest observational tools at its Cloud and Radiation Testbed (CART) site in central Oklahoma, an 8 mm wavelength cloud-sensing Doppler radar. Under sponsorship from ARM, the NOAA Environmental Technology Laboratory (ETL) designed, assembled and installed the radar at the ARM/CART site. This is the first of five sensitive cloud radars to be built for DOE by ETL. The radar uses phase-coded modulation for maximum sensitivity allowing it to detect clouds more tenuous than those observable by the best current research-grade cloud radars. It is vertically pointing, has a resolution of 90 m or less, and is built for continuous, unattended operation. The first system has been operating continuously in an unattended and uncalibrated test mode since it was first installed at CART and activated on November 8, 1996. Over 2,000 hours of operation were logged up to the end of January. A major aircraft-radar field measurement program will be undertaken in April 1997 to allow more quantitative interpretation of the radar data. This first radar and others like it will allow the vertical distribution of clouds and cloud properties to be measured directly, rather than inferred, at various strategic sites around the globe and will be an important contributor to GEWEX as well as ARM. More information is available on the ARM Web Site:

http://info.arm.gov/docs/instruments/static/mmcr.html

WCRP FIRST INTERNATIONAL CONFERENCE ON REANALYSES

Silver Spring, Maryland, USA
27-31 October 1997

The primary objective of this Conference will be to present the results of the reanalysis projects undertaken by several groups in the past few years. For information contact: International GEWEX Project Office, 1100 Wayne Ave., Suite 1210; Silver Spring, MD 20910 USA; Tel: (301) 427-2089 ext.33; Fax: (301) 427-2222; E-mail: gewex@cais.com. For the Conference Web Site and links to reanalysis projects web sites:
http://www.cais.com/gewex/gewex.html

WCRP/GEWEX MEETINGS CALENDAR

For calendar updates consult GEWEX Web Site http://www.cais.com/gewex/gewex.html

17–21 March 1997—JOINT SCIENTIFIC COMMITTEE FOR WCRP, Toronto, Canada.

24–25 March 1997—GAME INTERNATIONAL SCIENCE PANEL MEETING, Cheju Island, Korea.

26–28 March 1997—THIRD INTERNATIONAL STUDY CONFERENCE ON GEWEX IN ASIA AND GAME, Cheju Island, Korea.

21 April–25 April 1997—NOPEX-BALTEX SYMPOSIUM AT THE EUROPEAN GEOPHYSICAL SOCIETY XXII GENERAL ASSEMBLY, Vienna, Austria. For information contact EGS Office, Max-Planck-Str. 1, 37189 Katlenburg-Lindau, Germany, Tel: 49-5556-1440; Fax: 49-5556-4709; E-mail: egs@linax1.dnet.gwdg.de.

28 April–2 May 1997—CLIVAR SSG, Washington, D.C.

19–22 May 1997—GPCP WORKING GROUP ON DATA MANAGEMENT, Frascati, Italy.

18–20 June 1997—GVaP SCIENCE AND DATA PANELS, Washington, D.C.

24–25 June 1997—GCSS WORKING GROUP 1 – BOUNDARY LAYER CLOUDS WORKSHOP, Seattle, Washington. For further information contact Prof. Chris Bretherton, University of Washington, Tel: 206-685-7414; Fax: 206-685-9302; E-mail: breth@math.washington.edu.

25–27 June 1997—PROJECT FOR INTERCOMPARISON OF LAND-SURFACE PARAMETERIZATION SCHEMES (PILPS) WORKSHOP. For information contact Dr. Bertrand Timbal, BMRC, GPO Box 1289K, Melbourne, VIC 3001, Australia; Tel: (61)-3-9669-4412; Fax: (61)-3-9669-4660; E-mail: bxt@bom.gov.au.

1–9 July 1997—EARTH-OCEAN-ATMOSPHERE FORCES FOR CHANGE, Melbourne, Australia. For details contact IAMAS/IAPSO Secretariat, Convention Network, 224 Rouse Street, Port Melbourne, Victoria 3207, Australia; Tel: +61-3-9646-4122; Fax: +61-3-9646-7737; E-mail: mscarlett@peg.apc.org.

22–25 July 1997—GEWEX RADIATION PANEL MEETING, Oahu, Hawaii.

26–29 August 1997—WMO/ICSU/IOC CONFERENCE ON THE WORLD CLIMATE RESEARCH PROGRAMME, Geneva, Switzerland.

8-12 September 1997—THIRD GEWEX HYDROMETEOROLOGY PANEL MEETING, Sapparo, Japan, for further information contact Tetsuzo Yasanari, Univ. of Tsukuba, Tsukuba, Ibaraki, Japan; Tel: 81-298-53-4399; Fax: 81-298-51-9764; E-mail: yasanari@atm.gev.tsukuba.ac.jp.

27-31 October 1997—WCRP FIRST INTERNATIONAL CONFERENCE ON REANALYSES, Washington, D.C. See announcement on page 14.

3-6 November 1997—POLAR PROCESSES AND GLOBAL CLIMATE, Orcas Island, Washington, USA (about 120km Northwest of Seattle). Abstracts are due 15 May at the ACSYS Office (E-mail: acsys@polar.no). For further information contact ACSYS International Project Office, P.O. Box 5072 Majorstua, 0301 Oslo, Norway. Tel: 47-22-95-96-05; Fax: 47-22-95-96-01, or ACSYS web site: http://www.npolar.no.

GEWEX REPORTS AND DOCUMENTS

(Available from IGPO)

MAJOR ACTIVITIES PLAN FOR 1997, 1998 AND OUTLOOK FOR 1999 FOR THE GEWEX CONTINENTAL-SCALE INTERNATIONAL PROJECT (GCIP), IGPO Publication Series No. 25 (This is the updated version of IGPO Series Pub. No. 16).

CABAUW SENSITIVITY EXPERIMENTAL RESULTS FROM THE PROJECT FOR INTERCOMPARISON OF LAND-SURFACE PARAMETERIZATION SCHEMES (PILPS), December 1996, IGPO Publication Series No. 24.

GCIP COUPLED MODELING WORKSHOP, SILVER SPRING, MARYLAND, 9-10 MAY 1996, November 1996, IGPO Publication Series No. 23.

BEHIND THE SCENES OF THE PHASE 2(A) EXPERIMENT OF THE PROJECT FOR INTERCOMPARISON OF LAND-SURFACE PARAMETERIZATION SCHEMES (PILPS): THE CABAUW STORY, August 1996, IGPO Publication Series No. 22.

TACTICAL DATA COLLECTION AND MANAGEMENT REPORT FOR THE 1995 ENHANCED SEASONAL OBSERVING PERIOD (ESOP-95), IGPO Publication Series No. 21 (in press).

TACTICAL DATA COLLECTION AND MANAGEMENT PLAN FOR THE 1994 GCIP INTEGRATED SYSTEMS TEST (GCIP), June 1996, IGPO Publication Series No. 20.

INTERNATIONAL SATELLITE LAND SURFACE CLIMATOLOGY PROJECT (ISLSCP) ACTIVITY PLAN 1996-1998, September 1996, IGPO Publication Series No. 19.

POTENTIAL INTERNATIONAL SATELLITE LAND SURFACE CLIMATOLOGY PROJECT (ISLSCP) CONTRIBUTIONS TO THE GEWEX CONTINENTAL-SCALE INTERNATIONAL PROJECT (GCIP), September 1996, IGPO Publication Series No. 18.

INTERNATIONAL SATELLITE LAND SURFACE CLIMATOLOGY PROJECT (ISLSCP) INITIATIVE II: GLOBAL DATA SETS 1986-1995, September 1996, IGPO Publications Series No. 17.

INTERNATIONAL GEWEX WORKSHOP ON COLD-SEASON/REGION HYDROMETEOROLOGY, Summary Report and Proceedings, Banff, Alberta, Canada, September 1995, IGPO Publication Series No. 15.

PREPRINT VOLUME AVAILABLE for the Second International Scientific Conference on the Global Energy and Water Cycle 17–21 June 1996 Washington, D.C. USA

We have a limited number of the Preprint Volume of the GEWEX meeting held in June 1996. If you would be interested in obtaining a copy, please e-mail, or use conventional mail for your request along with your current mailing address to the International GEWEX Project Office.

GEWEX support activities were emphasized at the Twelfth Session of the Working Group on Numerical Experimentation held 28 October to 1 November 1996 at the Japan Meteorological Agency (JMA) in Tokyo, Japan. Photograph courtesy of Nobuo Sato, JMA.

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