INTRODUCTION

ECMWF organizes regular workshops to assess the current state of knowledge on topics of direct relevance to its objectives and to provide guidance for its programme of research. The workshop held on 24-26 October 1988 considered the parametrization of fluxes over land surface in Numerical Weather Prediction models. This is a field of growing interest in climate modelling, where the forcing by the lower boundary condition is of prime importance in the determination of the model's steady state. It is only in the last few years that this problem has received attention in forecast models, with a view to improving the simulation of weather elements, near surface temperature, humidity and wind, low-level cloudiness and precipitation and the thermal forcing on medium-range time scales. Since April 1987, the ECMWF model has contained a simple parametrization for the effects of a vegetation cover, and the possibility of validating and improving this scheme was a central concern at this workshop.

The workshop was organized in the usual ECMWF pattern of 1½ days of lectures, followed by one day of discussion within smaller groups and a final general session to discuss the conclusions and recommendations of the working groups.

After a general introduction of the topic, presentations started with a review of data sets from field experiments. This was complemented by a review of modelling studies and the description of numerical experimentation conducted on land surface schemes by various GCM groups, including various aspects of the representation of vegetation and soil properties. The last few talks covered the key question of the availability of relevant data from in situ measurements and satellite observations.

The working groups had the task of synthesising these themes and presenting recommendations for the Centre's future research activity. The first group concentrated on the observational basis, the design of land-surface parametrization schemes and their "local" validation against results from field experiments. The HAPEX-MOBILHY data set is now available for validation studies and it is hoped that this will also be the case for FIFE in the near future.

The second group covered the various problems in relation to the implementation, initialization and impact of land-surface schemes within forecast models and discussed the possibilities of sensitivity studies and the intercomparison of schemes between various research groups.

The third group discussed the availability of global data sets which can be used to define geographically dependent key parameters such as albedo and vegetation resistance. It also addressed the problem of the validation of surface schemes in global models.

In conclusion, this workshop showed that an adequate representation of land surface processes, including the effects of vegetation, is becoming an important component of forecast models. Developments in this field require a constructive dialogue between experimentalists, modellers and specialists of satellite observations and this actually took place during this workshop. It is hoped that this will lead to a better coordination of the use of available and future data sets as input and as validation basis for forecast and climate models.

WORKING GROUP 1

OBSERVATIONAL BASIS, DESIGN, AND LOCAL VALIDATION

1.1 Physical basis and design of land-surface schemes

During the last 5 years, advanced parametrization schemes have been implemented in forecast models for the calculation of the vertical fluxes over land surfaces. The need to include a more accurate and comprehensive treatment of the exchange of radiation, sensible heat, momentum and water was first carried out in global circulation models running in the climate simulation mode. This initial research demonstrated the potential of advanced soil temperature/moisture and vegetation canopy schemes in modulating the heat and moisture flux distributions at various space/time scales.

The goal of a land-surface parametrization should be firstly to supply the correct grid-average fluxes and near surface atmospheric parameters and secondly to allow for a correct long term evolution of soil water content and snow cover. This should be sought with the simplest and most reliable method possible, consistent in complexity with other parametrization schemes in the model.

In the current schemes orographic effects are not dealt with. The schemes focus mostly on heat and moisture fluxes with a very simple treatment of the wind stress. Sea surface processes and sea ice are outside the scope of the present workshop. As will be seen below, the emphasis has been so far on physically based (in contrast with black-box) schemes of the vegetation layer and of the heat/water storage in the soil.

1.1.1 Surface layer

The Monin-Obukhov similarity theory is widely used for the parametrization of surface layer processes but there are uncertainties in the following areas:

- For stable conditions, there is a need for further verification of proposed exchange coefficients with independent data.

- On scales larger than ~5 km the definition of roughness length and exchange coefficients becomes problematic because of inhomogeneous conditions. Detailed meso-scale studies may be used to obtain a better evaluation of these quantities.

- Description of the profiles and exchange coefficients with surface layer theory is, in principle, only valid for heights above the ground which are at least an order of magnitude larger than the roughness length. As such there is a need for reliable profile descriptors in the so-called interfacial sublayer.

- In weather and climate models, the roughness lengths for moisture, heat and momentum are often taken as equal. It is known that in reality the differences cannot be neglected (see the papers by Holtslag and Beljaars, and Sellers in this volume). In inhomogeneous conditions, much uncertainty still exists in the relationship between these quantities.

1.1.2 Vegetation

Various approaches have been proposed in the recent past to take into account the presence of vegetation. The available parametrizations fall in three broad categories according to their level of complexity. These are:

- Several versions of the "bulk" Penman-Monteith formula.

- Single layer canopy representations, including an explicit prediction of the canopy temperature.

- Multi-layer schemes.

All of these parametrizations recognize the central role of the canopy resistance. For the short time scales, the performance of any parametrization is governed by the ability to predict the space and time variations of the canopy resistance. It is well established that this depends upon several factors: solar radiation, water vapour deficit, temperature, vegetation type and physiological state, and soil moisture. Among these factors, the last two are the most difficult to control. There is still much uncertainty about the natural variability of canopy resistances. However, the existing information should be taken into account as much as possible. In this respect, one may recommend the use of several vegetation types and the use of several soil types in order to compute more realistic values of the wilting point.

At longer time scales, the evolution of soil moisture is influenced by the root depth. The feasibility of accounting for space and time variability of this quantity should be investigated.

The interception of rain water and dew is another important aspect of the role of vegetation. Some of the existing parametrizations appear to represent it reasonably well.

1.1.3 Soil

Land-surface schemes need a specification of the different soil types which occur in the real world. The hydrological, thermal and radiative properties of soils with different textures and water contents need to be established and incorporated into models. The geographical variation of soil types can be derived from global datasets. The soil water content, which also affects soil properties, is already a predicted variable in most models although it is not directly and routinely verified.

The water storage capability of bare soil is particularly important since, in the absence of vegetation, it controls the evaporation from the surface. The infiltration properties of the model soil and the presence or absence of representations of drainage or upward diffusion from a water table in the soil hydrology scheme could prove crucial for good hydrological simulations.

In the current ECMWF model the emissivity of soil and water is given the same value. In reality the emissivities differ, but this is not considered a high priority for research because of the small impact a representation of this variation would have in models. The albedo of the various soil types, on the other hand, should have realistic values.

1.1.4 Snow

Snow differs radically from soil, because of the time variation of its depth and physical properties, particularly its albedo. The conductivity and albedo of snow depend on its age and temperature, because these determine the relative air and water contents of the snow layer. The feasibility of modelling the variability of snow properties should be investigated.

1.2 Validation

The validation of a land-surface parametrization scheme is a difficult task, because of the impossibility of obtaining data at the scale of a model grid-box. It should be undertaken in two steps: firstly at the local scale, secondly at the regional scale.

1.2.1 Validation at the local scale

Since the land surface parametrizations are based on small scale concepts, they should first be validated against local data. This can be done by using existing measurements from various experiments listed in section 1.3. Soil moisture, roughness length, and atmospheric parameters, together with the correct description of the vegetation and the soil on the test site, should be imposed. The evolution of the predicted fluxes should be checked against observations for time scales ranging from a few hours to a few days. The long term evolution of the soil water content should also be verified, whenever possible.

1.2.2 Validation at the regional scale

The purpose of the validation at the regional scale is to define averaged parameters adequately. In this respect, the results of the mesoscale models can be used to study the subgridscale variations which occur with global scale models, within the assumption of local equilibrium of the turbulence. The mesoscale models can provide a relationship between the area-averaged flux and the area-averaged vertical gradient as a function of stability, synoptic situation, topography etc.

Existing aircraft measurements should be used as much as possible to study typical subgrid variations of fluxes. Such measurements are most useful in connection with a network of surface estimates of fluxes and vertical gradients.

1.3 Observational basis

There exists a large number of datasets which have not yet been used to validate the land-surface parametrizations. Some examples are noted below.

i) Local scale

Measurements have been taken on several occasions over the Thetford Forest, UK (Institute of Hydrology), at Cabauw, The Netherlands (KNMI), over the Amazon Forest, Brazil (Institute of Hydrology) and over La Crau, France (Agricultural University, Wageningen).

A great deal of data should also be available in the near future from the HAPEX-MOBILHY and FIFE experiments. The HAPEX-MOBILHY field phase, in South-Western France, lasted one year with a 2.5 months intensive observation period. The FIFE field phase over the Konza Prairie, was extended in 1987 with four intensive observation periods of two weeks, corresponding to different seasons.

ii) Regional scale

HAPEX and FIFE will provide surface flux estimates, over a range of spatial scales together with satellite data. Aircraft data are also available from several Canadian experiments (Department of Agriculture), German programs (DFVLR), and the MesoGERS experiment in France (CRPE).

Experiments are planned to take place in Niger or Spain, over the Boreal Forest in Canada, and in China (Heife experiment).

1.4 Recommendations

- Proceed towards a more realistic treatment of land-surface processes, by incorporating information on different types of soil and vegetation.

- Investigate the impact of different specifications of the roughness length for momentum, heat and moisture.

- Use existing data from field experiments to conduct 1D validation experiments, and participate in intercomparison projects concerning the results of such 1D tests.

WORKING GROUP 2

IMPLEMENTATION, INITIALIZATION, AND IMPACT OF SCHEMES WITHIN FORECAST MODELS

2.1 Review of current surface schemes used in NWPMs

This section is dedicated to the problems related to the implementation of land-surface schemes in forecast models. Compared to the use of these schemes in climate models there are additional constraints imposed by an operational, real-time environment. The requirement to improve the prediction of near surface and boundary layer weather elements is a strong motivation. The evolution towards more complex schemes has to be gradual. Currently, only local schemes with a few parameters can be implemented. Most of the factors involved are "observable" and we have to rely upon instruments to provide values for initial conditions, verification and parameter specification.

In contrast to early versions of GCMs, current operational Numerical Weather Prediction Models include an explicit representation of the diurnal cycle and a stability correction for the turbulent transfer coefficients used in the surface flux formulation. The parametrization of land-surface processes in the majority of these models is still rather crude, however. Surface evaporation, for instance, is mainly controlled by a soil moisture availability factor, which is assigned either climatic values or depends upon the soil moisture content. The move towards physically more sound schemes was first achieved in the Penman-Monteith type models in which the energy constraint in the partitioning between sensible and latent heat flux depends on a so-called surface resistance. In parallel, the specification of the physical parameters (albedo, roughness) has received some attention and the geographical variation of these parameters is now accounted for. Recently some models, including the ECMWF model, have moved to more advanced schemes in which separation is made between bare land and vegetated areas. Surface resistance is then identified as being a canopy or stomatal resistance, the variation of which depends upon biological, atmospheric and soil controls. In this case, it is necessary to describe the soil with at least two layers, a thin surface layer responding to the direct evaporation of the ground and a deeper one corresponding to the root zone extension. However, only one mean surface/canopy temperature responding to atmospheric (radiation) and surface (sensible and latent heat) forcing is computed.

It is difficult to know the exact performance of such schemes in producing the appropriate surface fluxes. It is especially difficult to see how to use the concept of stomatal resistance at the scale of a grid box. This aspect must receive more attention. The quality of some aspects of the forecast of surface weather elements and atmospheric parameters inside the PBL may benefit from some refinements, like taking into account the effective fraction of open water in a land grid box or the implementation of two level (ground + canopy) temperature schemes.

2.2 Impact of the schemes in forecast models

The simple bucket method for measuring evaporation used in earlier atmospheric models predicted too much evaporation and precipitation. Methods such as the Penman-Monteith type models, or the multi-level models that include both bare soil and vegetation, are able to reduce evaporation and precipitation when vegetation resistance effects are included. Impact of the changes in surface evaporation on the large-scale flow is not clearly evident and this may be due to deficiencies in initialization procedures and other parts of the model physics. On the other hand, effects of changes in the specification of some of the surface parameters (e.g. albedo) are known to influence the large-scale circulation. General circulation model studies should shed more light on the relative importance of these impacts.

The reduction of evaporation over land surfaces in NWP models also leads to larger diurnal variations of the surface temperature and to a more realistic diurnal planetary boundary layer development. This results in a better prediction of the near-surface weather elements such as the 2m temperature.

2.3 Use of GCMs in development of parametrization schemes

Although the time-scales relevant for GCMs and weather forecast models do not immediately seem to be related, some of the parametrization schemes are used in both types of simulation. Recently, the demand for more sophisticated GCMs with a realistic level of variability and with biospheric processes included has drawn attention to the fact that land surface processes were inadequately represented in GCMs. Climate models require the representation of processes on short time scales particularly if a diurnal cycle of solar radiation is included and many of the developments of vegetation and soil schemes for climate models have focused on this aspect.

GCMs provide a powerful tool to test proposed parametrization schemes for the balances and budgets that in long integrations ought to be comparable to the observed climate. Furthermore, GCMs can be used to define the parameters which most influence the forecast. In particular, it is important to assess the sensitivity of the evaporation rate to canopy resistance. A further test concerning the generality of the approach is provided if a scheme is applied to a variety of grid points on the globe with different synoptic and boundary conditions.

The modifications made in the formulation of evaporation and heat transfer schemes do not necessarily have a large impact on the general circulation. This impact is in any case not straightforward. It is therefore required to directly test the schemes against climatic observations of surface or near surface variables on a regional scale.

From long integrations, the time scales of the relevant processes can be inferred. This is essential for defining the degree of accuracy that is required for the initialization of NWP models. It also seems to be important to reassess the sensitivity to the initialization of soil moisture content, when new formulations are proposed.

2.4 Initialization of surface parameters

Initialization of the surface parameters is certainly a very important part of any surface parametrization scheme. However, it is at the same time a very difficult problem. The difficulties are arise mainly from the paucity of observations "compatible" with the parameters used in the forecast model, as well as from their unavailability both in real time and delayed mode.

Two main types of surface variables exist: prognostic and non-prognostic. For the non-prognostic surface parameters (albedo, roughness length, vegetation index, emissivity etc.), the current practice is not to initialize them (background values are used). There is a need for initialization on long time scales (weekly or monthly) using satellite observations. On the other hand, for the prognostic parameters (surface temperature, soil wetness, snow) the need for initialization in real time now is recognized. There have been attempts to analyse prognostic surface variables but without much success. Methods making better use of the model's first guess should be developed. Furthermore, the quality of an analysis of the surface parameters should be assessed before using it in the analysis-forecast cycle. Also, it is recognized that a coupling of surface and upper-air analysis has to be achieved, if possible in a way consistent with the forecast model.

2.5 Wintertime surface processes

At high latitudes in the winter the ground is frozen and/or snow covered, and the control by the vegetation almost ceases. This has an impact on the dynamic and thermodynamic processes as well as on the water balance at the interface between the free atmosphere and the deep (unperturbed) soil, because of:

i) changes in heat capacity and conductivity;
ii) albedo depending on snow age and solar angle (in forests);

iii) reduced roughness (outside forests);

iv) no transpiration.

Snow melt primarily takes place around obstacles (rocks, trees, etc.) where heat absorption is at a maximum. It clearly has a large effect on forecast 2m temperatures as shown by Strauss (these Proceedings). It should also be mentioned that the 2m temperature may well rise significantly above 0°C even for a snow cover of 100% since the canopy (pine and spruce trees) absorbs solar radiation with an albedo less than 0.2.

In numerical models snow depth is either prescribed and held constant (climatological or analysed) or forecast. Currently models do not aim at forecasting fractional snow cover, but rather forecast snow depth and deduce snow cover from it (e.g. ECMWF). It should be mentioned that fractional snow cover may (at least subjectively) be analysed from satellite data (e.g. at DNMI).

In order to develop methods to describe land surface processes properly during winter time at high latitudes it seems that, as for vegetation, the snow should be recognized as an active medium influencing many surface parameters (albedo, roughness, etc.).

2.6 Recommendations

- Pursue forecast studies on the impact of multi-layer surface schemes and schemes allowing for multiple heat/water budgets over individual model grid "cells". The second aspect may be important to forecast weather elements in areas with marked surface heterogeneity (such as coastal areas, partial or thin snow field, or the forest/snow combination).

- GCM's and forecast models, including the ECMWF model (with simple as well as complicated evapotranspiration processes), are needed to provide better impact assessments as well as guidance on the important biosphere processes we should parametrize. This calls for a coordinated programme of sensitivity studies with models having various degrees of complexity for their surface schemes.

- The quality of a surface analysis should be assessed before it is used in the analysis-forecast cycle. Tests could be performed during the validation period mentioned in the report from Working Group 3. Coupling of the surface and upper-air analysis should be sought, as well as consistency with the forecast model.

- Evaluate the quality of surface fields (temperature and moisture) obtained in the ECMWF data assimilation process since April 1987.

WORKING GROUP 3

GLOBAL DATASETS AND LARGE SCALE VALIDATION OF LAND SURFACE PARAMETRIZATION

3.1 Introduction

Within a few years, a wide range of land surface parametrizations (LSP's) will have been developed and implemented in GCMs. It is highly desirable that procedures for the intercomparison of these LSP-GCM combinations be kept as simple as possible. In section 3.2 we propose a strategy for standardizing some aspects of the global datasets used by LSP's and describe a procedure for intercomparing the associated fields of albedo, surface roughness and minimum stomatal resistance. It is further proposed that improved global soil moisture climatologies, each consistent with its respective LSP, be generated in subsequent work. All of the above should eliminate differences between the performances of different LSP-GCM combinations which are generated by the use of various vegetation classifications and soil moisture initializations.

Procedures for validating LSP-GCM performance are discussed in section 3.3. It is proposed to make use of the opportunity presented by the surface radiation budget (SRB) validation effort scheduled for April 1989 in which selected data on atmospheric cloudiness and radiation divergence fields will be collected at 10-20 baseline stations around the world. It is suggested that near-surface meteorological observations (T, q, u, p), satellite data for deriving surface temperatures, vegetation index and insolation, and hydrological data (snow and runoff) be collected for the same period with particular emphasis on the European and North American continental areas.

Specific recommendations are listed in section 3.4.

3.2 Global Datasets for LSPs

The importance of land surface datasets may be illustrated by the example afforded by GCM experiments on the effect of albedo changes. Changes in soil moisture have comparably important effects.

Increases of surface albedo over a fraction of a continent modify the impact of energy to the surface, so influencing evaporation and sensible heat flux by decreasing the available energy. If the convergence of moisture is unchanged, precipitation must decrease. However and in addition, a weakened heat source is compensated by energy convergence achieved through subsidence, which further diminishes the precipitation. Typically, the modelled impact of a 5% increase in albedo is a reduction in precipitation of between 5 and 20%.

The variety of biome classifications and soil moisture initializations used in climate models leads to problems in isolating the influence of the LSP in the model calculations. There is therefore an urgent need to standardize this primary input data set in all GCMs. Each GCM will then generate its appropriate fields of albedo, roughness, surface resistance and possibly soil moisture climatology which will be directly comparable to those used in other LSP-GCM combinations.

3.2.1 Vegetation type

The vegetation type on a global scale is available from Matthews (1985), Wilson and Henderson-Sellers (1985) and Olson et al. (1983) at a 1° x 1° resolution. From these data, most of the other data required by land-surface parametrizations can be derived. The global distribution of vegetation can be considered as the most important single source of data, especially if it is combined with a soil dataset (see 3.2.2 below). Vegetation index maps computed from NOAA-AVHRR satellite data do not seem, at the present stage, to be able to replace conventional vegetation maps as input for forecast models.

3.2.2 Soil type

For modelling purposes, Wilson and Henderson-Sellers (1985) provide the most suitable soil data (at a 1° x 1° resolution). Soil colour, texture and drainage characteristics are provided. This and a more detailed (Gildea and Moore, 1986) soil map of the world were derived from the FAO/UNESCO datasets.

3.2.3 Albedo

A proper treatment of the interaction between radiation and vegetated surface requires shortwave radiative calculations performed in at least 2 spectral intervals, split at around 0.7 µm. At present, surface albedo estimates derived from satellite data do not provide information in these required spectral intervals. Also, viewing limitations lead to an undersampling of the bi-directional reflectance properties of the surface which prevent the proposed albedo from being fully consistent with the model requirements.

The minimum need is for two reflectance values for each 1° x 1° grid square, one for >.7µm, and one for <.7µm. Ideally, reflectances for direct and diffuse radiation (i.e. a total of four reflectances per grid square) should be provided. These data should be snow free and for a specified soil wetness, so that the total albedo for any given soil moisture distribution could be derived.

The vegetation and soil classification provide a basis for construction of datasets of spectrally split albedos.

3.2.4 Roughness

A global data set has been devised by Baumgartner et al. (1977), it may however be updated by using the above proposed biome data sets. A significant contribution to the roughness to be used in a model, especially for momentum transfer, arises from the small scale orography. An estimate of larger scale (>10 km) roughness may be obtained from the available orography data, and at the moment, the only practical way is to use it as an indicator of smaller scale irregularities.

3.2.5 Soil moisture

The only soil moisture data set is from Mintz and Serafini (1981) which is a monthly climatology at a 4° x 5° resolution. It was generated using global climatology of air temperature and precipitation combined with a β-function/Thornthwaite evaporation calculation and a water budget model.

3.2.6 Physiology

Global fields of the minimum stomatal resistance, the fraction of the grid square that is vegetated and other required physiological parameters can be derived from the biome classification. There are no global data sets available at present. Future work may generate such fields using satellite data under the sponsorship of ISLSCP (International Satellite Land Surface Climatology Programme).

3.2.7 Topography

Available at a 1° x 1° resolution from Scripps or at a 10' x 10' resolution from the US Navy. Finer scale topographic data has been generated by the ARPEGE project for Europe at 1 x 1 km resolution.

3.2.8 Water

Surface water characteristics and distributions at sub-grid scales can be obtained from Cogley (1986). Wilson and Henderson-Sellers (1985) indicate the presence of surface water in a grid square if the water covers >25% of the grid square. The US Navy orography data set also contains the percentage of sub-grid water cover.

3.3 Validation of LSPs under a large range of conditions

In addition to local and regional scale validation efforts, see for example FIFE and HAPEX-MOBILHY, a large scale validation effort for LSP-GCM combinations is desirable. It is proposed to collaborate with the SRB validation effort scheduled for April 1989 in which measurements of radiative flux divergence and cloudiness will be made around the world. In this section, after listing the types of data which may be available for validation, we give some indications about how this project could be carried out.

3.3.1 Data available for validation

i) Meteorological Observations

Humidity observations and 2 m temperature are made every 3 hours at most of the synoptic stations throughout the world and are exchanged via the Global Telecommunication System. Only 6 hourly observations are exchanged globally (for 00, 06, 12 and 18 UTC); the so-called intermediate times (for 03, 09, 15 and 21 UTC) are exchanged only within each WMO Regional Association (for example, ECMWF receives only data from Europe). Wind at 10 metres is also available under the same conditions but its use for validation over land remains problematic due to the magnitude of local effects.

As far as the quality of these data is concerned, there is a great number of problems, mainly due to the rather archaic technology involved in the transmission. It is recognized that the preparation of a reliable quality controlled dataset, even on a short period, requires a considerable amount of work; the availability and quality of such data sets in World Climate Centres should be explored.

Precipitation data, usually available on a daily basis over some areas of the globe, can also be used as an indirect mean of validating the response of a forecast model to land surface parametrization.

ii) Surface temperature from satellite

Research algorithms allow to estimate the "skin" temperature from satellite infrared data, after correction of brightness data from atmospheric effects. The thermodynamic surface temperature, which is equivalent to the actual surface temperature computed by the model, can be derived from the "skin" temperature by empirical formulae. Such surface temperature estimates for 0300 and 1500 (local time) from the NOAA, HIRS/MSU and AVHRR instruments are available on selected cases from NCAR/JPL and NOAA.

iii) Radiation and clouds

Shortwave radiation fluxes are routinely measured at the surface and by agrometeorological organisations; these data are usually available on request. Few measurements of longwave radiation are carried out. No global data sets of any surface radiation parameter are currently available.

The radiative fluxes are important (upward and downward, shortwave and longwave) components of the energy budget of the surface and are important parameters in any parametrization of surface processes. Validation of the downward fluxes can be considered in two steps: first, the verification of the radiation transfer parametrization (through comparison with state-of-the-art reference line-by-line model computation of radiative fluxes for standard atmospheres as carried out in the ICRCCM programme); second, comparison of computed fluxes with good quality measurements of the surface radiative fluxes such as those likely to be obtained from the baseline radiation station network deployed by WMO. On the other hand, surface radiation budget derived from satellite data may become available in the not too distant future, and model generated surface radiation fluxes may be compared with these satellite-derived fluxes.

In other respects, radiances at the top of the atmosphere include information about the state of the surface-atmosphere system. Comparison of satellite-observed radiances and/or fluxes (e.g., ISCCP B3 radiances, with their 3 hour temporal resolution and their 40 km horizontal resolution) with model-generated radiances is a powerful if indirect way of validating various aspects of the parametrization of surface-cloud-radiation interactions.

iv) Surface hydrology

- Run-off

UNESCO (1969) provides river basin runoff data for the globe, averaged over a number of years. The area of the basin and the gauging point are specified. Annual mean values of runoff are given for most basins but seasonal variation is only available for a limited numbers of basins.

A GCM validation of run-off for selected basins may be envisaged but it is probably meaningful only over a one-year period.

- Snow

In addition to daily snow depth maps available from in situ measurements over the USA and Western Europe, NOAA snow extent analyses based on satellite and surface observations are available on a weekly basis. They can be used for verification and should also be considered as input for the snow cover analysis.

3.3.2 Proposed validation exercise

A Surface Radiation Budget (SRB) project has been set up as part of the World Climate Research Programme. Its first goal is the intercomparison and validation of algorithms for SRB determinations from satellite. In April 1989 a set of 10-20 selected stations around the world will be equipped to serve as baseline for this project and investigators working on satellite algorithms have agreed to use this month for a concerted intercomparison exercise. It is proposed to use this opportunity to validate some aspects of our land-surface parametrization scheme.

On and around the baseline points it is suggested to monitor the detailed diurnal evolution of the near-surface air temperature and humidity in the forecast model (3 hour sampling for the first 2-3 days). The relevant observations (T, q and precipitation) should be archived at the same frequency. The verification of the diurnal evolution as well as of the terms of the model surface budget can provide a comprehensive validation of surface schemes. The comparison with satellite-derived quantities will provide clues about correction methods to be applied.

The above project could be extended to a regional scale validation over areas where a sufficient data coverage is available, such as Europe and USA.

3.4 Recommendations

- Biome classification

There is a need for a single biome and soil type data set at least at a 1° x 1° resolution, containing at most about 20 vegetation types, which would be used as a basis for global land surface parametrization studies. It can be compiled from existing atlas-type data sets and may be improved later by the use of adequate satellite data.

- Vegetation/soil parameters

Global data sets used as input parameters in the model should be revised, taking into account vegetation and soil types. This is particularly important for the albedo and vegetation resistance calculations. Seasonal dependency and moisture dependency of the albedo should be considered. Modifications of the roughness length and emissivity should also be considered but with a lesser priority.

- Soil moisture climatology

There is a need for an updated soil moisture climatology making use of a more recent surface parametrization scheme. However, in the present situation, it would be advisable to decrease the climate control of the soil moisture in the ECMWF model.

- ECMWF and ISLSCP

ECMWF should closely follow the progress of ISLSCP and ensure that the data sets being produced take into account the needs of global weather forecast models at high spatial resolution with respect to the parametrization of land surface processes.

- ECMWF and the SRB programme

Given the importance of radiation fluxes in the surface energy budget (over land, but also over the ocean (TOGA)), ECMWF should participate in the intercomparison exercise of SRB algorithm presently performed under the auspices of WCRP.

- Large-scale validation of LSPs

It is proposed to organize a large-scale validation exercise for which available data including meteorological near surface data, precipitation and relevant satellite derived fields would be gathered, and compared with model short-range forecasts. The one-month period already chosen by the radiation community for the SRB intercomparison, April 1989, is a good candidate. The validation would focus on areas where a good data coverage is available and would include as a major component the model simulation of the diurnal cycle in various climatological conditions.

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