HAPEX-II-SAHEL

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A WATER AND ENERGY BALANCE MODELLING PROJECT IN DRY TROPICAL CLIMATE

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DRAFT CONTRIBUTIONS

COORDINATION GROUP

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October 1989

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HAPEX-II-SAHEL
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METEOROLOGICAL NETWORKS

Coordination : P. Bessemoulin, Toulouse, France

The objectives of the "meteorological networks" group are twofold :

I - IMPROVEMENT OF THE DESCRIPTION OF THE SYNOPTIC CONTEXT (CNRM/4M).

In order to improve the quality of operational meteorological analyses performed either by ECMWF or by the french Weather Service, it is proposed to complete the existing radiosounding network by two additional stations. This is a necessary step for an optimal use of meso-scale meteorological models, which will use these analyses as forcing conditions. The determination of the sites will be made according to the recommandations of the above mentionned organizations, in order to locate them where they are the most informative. A triangular setting would allow the access to the vorticity and to the divergence of the flow, which are important parameters related to the large-scale circulation.

Soudings will be launched at synoptic times and the data will be transmitted in real time via the GTS for their use in the assimilation schemes.

II - IMPROVEMENT OF THE DESCRIPTION OF THE MESO-SCALE CONTEXT (CNRM/4M).

II.1 GROUND NETWORK (CNRM/4M).

The local meteorological network is not dense enough, and does not measure all the parameters relevant to as HAPEX-type experiment (e.g. the radiation balance).
It is proposed to implement a twelve automatic weather stations network (CNRM/4M), scattered over the whole degree squared, performing conventional meteorological measurements and radiative balance measurements, with the following objectives :

- interpretation of turbulent fluxes measurements with respect to their meso-scale meteorological contex ;
- estimation of potential evaporation ;
- retrieval of the information needed for the validation of remote sensing data ("ground-truth"), and for model simulations ;
- estimation of the variability of the relevant parameters over the degree squared, with a special attention paid to the North-South gradients.

At the moment (August 1989), it is planned to operate this network during the Intensive Period of Observation (IOP) only, from mid-August to mid-October, a period corresponding to the drying phase.
This period of operation could be possibly extended toward the rainy period (from May to August), should the hydrologists needs be expressed accordingly. In that case, it would be essential to find a local assistance for the maintenance of the equipments ; this imply necessarily a technical formation of such people.

II.2 ATMOSPHERIC CORRECTIONS OF REMOTE SENSING DATA

The knowledge of the thermodynamic vertical structure is essential for the correct data delivered by remote sensing devices. A systematic radiosounding once a day at the time of the NOAA satellite pass should satisfy this objective (CNRM/4M).

The experimental set-up described above in items I and II are considered as the core of the meteorological support to the experiment.

III - CONTINIOUS PROFILING OF THE WIND (CNET/CRPE).

The set-up in the degree squared of a wind profiler (sodar + ST radar) would be of great interest for monitoring continuously the kinematic structure of the atmosphere. In that way it could be possible :

- to document the time-evolution of the main atmospheric flow patterns (monsoon circulation, Easterly African Jet (EAJ), Tropical Easterly Jet (TEJ).

- to identify the waves associated to dynamical forcing (propagation of density currents ahead of squall lines, penetration of convective elements above the tropopause...), or thermal forcing (evaporation of water at the surface...).

Using such equipments is subject to minimizing the costs (travel, experimental set-up) which are up to now estimated at 1 500 000 FF.

IV - INTENSIVE RADIO SOUNDING DURING RAINY EVENTS (CNET/CRPE, CNRM/4M).

Intensive radio sounding during rainy events should allow a better knowledge of the atmospheric structure and its time-evolution under those conditions.

As a matter of fact, relatively fast variations of the parameters controlling the activity of precipitating systems occur during the few hours before they arrive (e.g. intensification and moistering of the monsoon (flux allowing down of the mid tropospheric Easterly African Jet, acceleration of the Tropical Easterly Jet located close to the tropopause). In the same way, the rear environment plays an important role in the intensity and stability of the system, especially according to the intensity and dryness of the EAJ.

This kind of information is important for initializing 3D meso-scale models, and for characterizing the type of the observed precipitating systems (isolated storms, super-cells, convective complexes, squall lines...), and could be very complementary to the observations performed by the digitalized radar located in Niamey.

HAPEX-II-SAHEL

HYDROLOGY

Coordination : T. Lebel, Montpellier, France

The hydrologic part of the HAPEX-II-SAHEL experiment aims at giving as precise estimates as possible of the various components of the terrestrial phase of the water cycle in semi-arid regions. Not including the evaporation which will be studied in detail at various scales by other teams involved in the experiment, the four main components are : precipitation ; surface runoff generation ; surface runoff concentration into stream flows and endoreic areas, or dispersion into flood plains ; underground water transfer (including exchanges between the surface and the aquifers).

Precipitation studies

The ground network set up for the EPSAT project and described above will constitute the basic support for precipitation measurement. The association of this unusually dense network with the C band radar system located at the Niamey airport will allow to estimate the rainfall depth over areas ranging from one to a ten thousand square kilometers. The emphasis will be put on the study of the spatial variability of rainfall for various time steps, a work already on progress using the data set of the 1988 and 1989 rainy seasons (Thauvin and Lebel, 1989).

The accuracy of the areal rainfall estimates will also be evaluated using objective analysis methods (such as geostatistical techniques for instance).

Runoff generation processes

From the numerous field campaigns carried out by ORSTOM in Sahelian regions (e.g. Jaccon and Camus, 1967 ; Chevallier et al., 1985; Brunet-Moret et al., 1986) emerged the identification of specific hydrological processes. In particular it appeared that in the arid and semi-arid environment upstream runoff consists mainly of over-land flow caused by surface crusting.

Ten years of simulated rainfall experiments on 77 plots in Burkina Faso and Niger led to identify nine major types of crust. Combining crust types and vegetation, allow to define soil surface features, which are the main explanation factor of overland flow.

As a consequence, once the areal rainfall has been correctly estimated, a good assessment of surface runoff requires a good knowledge of the ground cover and soil repartitions as well as of their runoff potential. Theses studies will have to be carried out in close coordination will the vegetation group, and necessitate both an extensive field work and the utilization of satellite imagery.

Concentration and dispersion of surface runoff

On upstream watersheds, heavy surface runoffs are the result of the frequent soil crusting, but they often dissipate downstream into large flood plains or local endoreic zones, where the water infiltrates. The infiltrated water may then either be reevaporated or seep toward underground water bodies, meaning that locally the evaporation may be much greater than expected from the precipitation. Thus, as underlined by G. Girard (1975) following the modelling of the Oued Ghorfa in Mauritania, any runoff modelling of large sahelian watersheds has to rely on a specific hydrogeomorphological study in order to map the endoreic zones and the flood plains. Airborne survey and satellite imagery are needed to follow the temporal evolution of the extension of these zones. The equipment of watersheds in stream flow gauges will be performed accordingly to the results of these preliminary studies.

Groundwater

The water table recharge is of uttermost importance for the water ressources management of sahelian regions. From the Hapex experiment viewpoint, a careful monitoring of the aquifers is needed to assess the amount of underground water that flows outside the zone of study. The modelling of these processes is impeded by a poor knowledge of the piezometric levels. To gain a better understanding of the water table behaviors, the piezometry will have to be recorded at several wells, the altitude of which should be known accurately. The observation of the recession curve of the main tributaries of the area could also provide some interesting information on the interactions between the aquifers and the surface water.

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HAPEX-II-SAHEL

SOIL MOISTURE MONITORING COMPONENT

Coordination : R. Cuenca, Corvalis, Or., USA

OBJECTIVES

Experience gained in the HAPEX-MOBILHY land-surface processes experiment in France in 1986 proved the value of extensive soil moisture measurements coupled with other ground-based measurements of meteorological variables and surface fluxes (Goutorbe et al., 1989). The soil moisture measurements from HAPEX-MOBILHY have been applied for initialization, calibration and verification of the soil moisture profile component of atmospheric circulation models (Noilhan and Planton, 1989). They have also been used for calibration of flux models of components of the energy balance. The HAPEX-MOBILHY soil moisture data have been applied as input into an independant hydrologic balance model which relies only on precipitation and soil moisture content measurements to compute evapotranspiration fluxes (Cuenca and Noilhan, 1988 ; Cuenca, 1988).

WORK PLAN

Soil moisture measurements will be made in support of other flux measurements in the HAPEX-II-SAHEL project and as an independant data base for soil moisture movement simulation models. The sites chosen will be coincident with the three sites projected for surface flux and micrometeorological measurements. Each site will consist of 10 measurements points for soil moisture content in an area of approximately 0.5 ha in the vicinity of the surface stations. Intensive monitoring of soil moisture one or two times per week will be made throughout the vadose zone to a depth of approximately 2 m during the intensive observation period tentatively planned for summer 1992. In addition, long-term monitoring of soil moisture on a biweekly basis will be made in the vicinity of a proposed background micrometeorological station as long as that station is operated. More concentrated measurements of surface layer soil moisture content will be made using a time domain reflectometer over the test sites in coordination with potential aircraft operations for microwave and other remotely sensed parameters.

Infiltration tests will be made for calibration of an inclusive infiltration model which is applicable to short and long time periods (Swartzendruber and Clague, 1989). The main application of the infiltration model will be for use with precipitation data to separate the surface runoff component. In situ soil moisture tension measurements will be made in conjunction with soil moisture content during infiltration and redistribution tests to develop the soil water characteristic relationship. Soil moisture tension will be measured using tensiometers and a fast-response, direct readout meter which uses a pressure transducer. Inverse modelling methods applied with optimization techniques may offer the best method of determining the unsaturated hydraulic conductivity function (Kabat and Hack-ten Broeke, 1988).

Thermocouples to measure soil temperature will be used to determine the temperature profile and, in conjuntion with laboratory measurements, to infer soil thermal properties including the thermal conductivity. The thermal properties will be used to determine the potential influence of thermally induced vapor movement on the local energy balance and location of the vaporation front. Measurements for soil water properties will be made at enough sites over the experimental area to allow spatial variability of soil water properties to be evaluated by scaling over similar media (Hopmans, 1987). The results of spatial variability analysis will be important in evaluation of the spatial variability of fluxes of various components of the energy balance over the test sites and eventually over the project grid.

The status of the soil moisture profile with depth and comparison to previous profile measurements will be output to a computer terminal for immediate viewing using a graphical interface developed by the Water Resources Engineering Team (WRET) at Oregon State University (OSU). Application of this software will allow checking for any anomalies in the readings which may require further investigation at a particular site. The data will then be automatically processed in the hydrological balance model developed by WRET which indicates evapotranspiration, deep percolation, and drainage for each time period between successive sets of soil moisture readings. Hydrological balance model results will be reported for individual measurements locations to give an idea of the spatial variability of the evapotranspiration phenomenon and for the average at each site. It may also be decided to instrument one field with a linear array of 30 to 50 soil moisture monitoring sites to perform a more detailed analysis of spatial variability of soil moisture distribution and evapotranspiration. The hydrological balance model applied to analyze HAPEX-MOBILHY soil moisture data (Cuenca, 1988) will be upgraded by the start of the intensive measurement period to include recent improvements in infiltration modeling and integration of water table fluxes and soil moisture movement using the SWACROP model developed by Dr. R. Feddes and others at Wageningen (Feddes et al., 1978).

HAPEX-II-SAHEL

ECOLOGY AND VEGETATION

Coordination : J. Wallace, Wallingford, U.K.

SUMMARY

Vegetation has a crucial role in the energy and water balance of the Sahel. Moreover, desertification is, by definition, a loss of vegetation which is linked with climatic change. Any attempt to understand and model these phenomena must take explicit account of the individual roles of the plants and soil. The specific goals of this "vegetation" sub-area are centred around the quantification of different vegetations and the measurement and modelling of transpiration and soil evaporation. Currently six* groups have been identified (2 French, 2 UK and 2 USA) whose complementary expertise has the potential to make significant progress in this field. Furthermore, their contribution to the entire HAPEX-II-SAHEL experiment should greatly assist with the objective of modelling the water balance of a large area of the Sahel, which is required by the GCM's which are used to predict climatic change and desertification.

* not all have been contacted and asked to participate.

INTRODUCTION

This sub-area of the HAPEX-II-SAHEL experiment is specifically concerned with the role of vegetation in the water balance of the Sahel. One of the central objectives of the main experiment is the quantification of areal average energy fluxes (including sensible and latent heat fluxes). These arise from two principle types of land surface - tiger bush and millet crops. Another sub-area, "Surface flux studies", intends to measure total fluxes of sensible and latent heat over these two types of surface using micrometeorological techniques. Although these methods may give the total fluxes they cannot separate those which arise from soil and the vegetation. Any attemp to understand and model the water balance of these types of surface must take explicit account of the individual roles of the plants and soil.

The specific goals of this sub-area are therefore centred around the quantification of vegetation type and amount and the measurement and modelling of transpiration and soil evaporation. The combination of these results will allow comparison with the total fluxes measured independently using the micrometeorological techniques defined in the surface flux study sub-area. This will require :

1. Mapping and monitoring of natural vegetation (savannah) and cultivated (millet) areas.

2. Characterization of the spatial variability of vegetation and the classification of basic hydrologically-functional units (with different water balances) according to vegetation cover, soil condition and topographical location.

3. Direct measurements of transpiration and soil evaporation in principal vegetation types.

4. Development of soil and plant models for predicting transpiration and soil evaporation.

5. Studies of CO2 uptake at a plant and canopy level in order to assess the possibility of using remotely sensed changes in biomass as an indicator of cumulative transpiration over larger areas.

METHODS

The mapping and characterization of vegetation and its spatial variability will be done using a combination of remote sensing and ground-based measurements. Remote sensing of vegetation indices and surface temperature can be carried out using satellites (SPOT, LANDSAT TM, etc.) and aircraft. Simultaneous ground-based measurements of vegetation type, amount and soil surface condition should be carried out using conventional sampling techniques. Geostatistical and fractal mathematical analyses techniques could be used to assess the patterns and scales of vegetation variability.

The direct measurement of transpiration in the diverse savannah plant community is not simple. However, it would be possible to make measurements in a few of the dominant species and, subject to the variation found in these data, extrapolation to the whole plant community may be possible. Specific techniques could include :

(i) *Portable infra-red gas analysers* : to measure leaf stomatal conductance and CO2 uptake. Stomatal conductances and leaf area indices could be used to estimate transpiration. The simultaneous measurement of water vapour and CO2 fluxes may provide some information on the conversion efficiency which could be used in the process of spatial averaging -see above-.

(ii) *Heat flow/pulse devices* : for the measurement of transpiration in bushes and trees. Modern techniques including invasive and non-invasive devices are reported to work well in some woody species and are currently in use in an agroforestry project in Niger.

(iii) *Soil microlysimeters* : for the direct measurement of evaporation from the soil.

(iv) The exchange of CO2 between the surface and the atmosphere can be studied at a "canopy" scale using eddy correlation. This information would be complementary to the individual plant scale data obtained using technique (i) above.

The combination of ground-based measurements of transpiration, soil evaporation and CO2 exchange and remote sensing of vegetation type and amount, should provide a unique opportunity to extend our scientific capability in this field. Furthermore, the study placed within the framework of the HAPEX-II-SAHEL experiment should contribute significantly to the objective of being able to model the water balance of sahelian vegetation at the scale which is required by the GCM's which are used to predict climatic change and desertification.

HAPEX-II-SAHEL

GROUND BASED FLUX STUDIES IN HAPEX-II-SAHEL

Coordination : J. Gash, Wallingford, U.K.

SUMMARY

The objective of parameterizing a semi-arid area of equivalent size to a GCM grid square requires a knowledge of the energy input at the surface. This will be met by a network of ground based micrometeorological systems making measurements over representative samples of vegetation and soil. Integration to the grid-size scale will be achieved by sampling higher in the planetary boundary layer and by aggregation of the measurements from the representative sites.

Introduction

The objective of ground based flux measurements is to quantify the inputs of sensible heat, evaporation and momentum into the atmosphere above the whole experimental square. The measurements must be made at a sufficiently short time scale to detect the response of the vegetation to the changing environmental variables through the day, and to compare with "snapshot" estimates of the fluxes made by remote sensing methods. Hourly average data are suitable. The measurements must also be made over a sufficiently long period to detect the response of the vegetation to changes in soil moisture and the variation in transpiration through the season, as leaf area increases. Micrometeorological techniques are best suited to meet these criteria.

There are three dominant vegetation types in the experimental area : arable agricultural land under a millet monoculture, fallow agricultural land, and degraded natural forest (tiger bush). Each of these vegetation types must be expected to respond differently. For example the greater proportion of bare soil in millet fields may expected to give greater evaporation early in the season before the millet is established, or late in the season after the harvest. It is thus essential that the fluxes from each of these three vegetation types be sampled. Models of the individual vegetation types must subsequently be developed so as to allow the prediction of fluxes in terms of all their controlling variables. These can then form the basis of further models which aim to integrate up to the grid square scale.

Energy fluxes from wider areas may be inferred from measurements made higher in the planetary boundary layer. This can be done either by studying the growth of the boundary layer with frequent radio sonde ascents, or by measuring the turbulence with, for example, doppler radar. These techniques give estimates of the sensible heat flux from distances of the order of tens of kilometers upwind, rather than the hundreds of meters which is the upwind sample of a micrometeorological measurement.

Micrometeorological methods

There are three micrometeorological methods which will be used to measure evaporation : the aerodynamic, the Bowen ratio and the eddy correlation method. The aerodynamic method is most straightforward, but there are empirical assumptions which may not be valid when the measurements are made close to tall crops. The evaporation is calculated as the difference between net radiation and sensible heat flux, so there may also be large relative errors when the heat flux is comparable in size to the radiation. The Bowen ratio is a reliable method although it generally requires more field maintenance than the aerodynamic method. The eddy correlation method is suitable for use over any surface, but the instrumentation is complex and there are few systems which are capable of working for long periods at remote sites. Under unstable conditions the sensible heat flux is proportional to the variance of the temperature fluctuations. This is a relatively straightforward measurement and offers a useful complement to the aerodynamic method, as it is most accurate when the aerodynamic method is least so.

During 1989 there will be an intercomparison of micrometeorological techniques at a site north of Niamey. Measurements will be made over a millet crop by teams from INRA, the University of Copenhagen and the Institute of Hydrology. During the first stage of IFEDA in Spain in 1991 an intercomparison of methods will also be made by the principle participating groups. These tests will enable a better assessement to be made of how the different instruments available should be deployed.

Particular attention must be paid to obtaining good areal samples of soil heat flux and net radiation which are required to complete the energy balance. Concurrent measurements of solar radiation, temperature, soil moisture deficit and leaf area are also needed to model the influence of these variables on the evaporation.

Boundary layer measurements

Measurements of the diurnal evolution of the growth of the planetary boundary layer will be made on a limited number of days using frequent radio sonde ascents. These data will be used to derive the fluxes at the larger regional scale. During clear sky conditions a doppler radar will be used to estimate the momentum and also possibly the heat flux up to 1500 m altitude. These latter measurements will be representative of an area within 25 km of the measurement site.

Measurement philosophy

The measurement problem is to obtain a representative sample of the fluxes from each of the different vegetation types while at the same time sampling the variation in those fluxes which results from the rainfall and soil differences across the experimental square. It is proposed that there should be three densely instrumented reference areas : one on or near the Say plateau in the southeast of the square, one near the centre of the square, and one in the northeast on the Dallol Bosso plain. At each of these locations measurements will be made over each of the three major vegetation types using the most appropriate and accurate methods available.

At present it is envisaged that the Institute of Hydrology will use their eddy correlation instrumentation mainly over the tiger bush on the Say plateau, CNRM will concentrate on the fluxes in the centre of the square and the other teams will work on the Dallol Bosso plain.

HAPEX-II-SAHEL

AIRBORNE FLUXES

Coordination : B. Benech, Lannemezan, France

OBJECTIVES

The aim of this study is to quantify surfacial fluxes and their properties using well-equiped (remote sensing and turbulence sensors) airborne. This research is a contribution to the water and energy balance study at the continuum soil-atmosphere. It is possible with the help of the airborne fluxes studies to analyse atmospheric boundary layer proprieties and energy balance, too. This research is related very closely to :

1) local scale fluxes integration to an other scale compatible with large and mesoscale models grids. This study is linked with "Meteorological networks" and "Ground based fluxes" research.

2) airborne fluxes monitoring and their variability during the soil drying of the HAPEX-II-SAHEL experiment which is situed between the wet season and the dry season.

3) determination of the interaction which link atmospheric fluxes (sensible heat, latent heat) with ground surface characteristics (soil temperature, soil moisture, roughness, altitude, relief) and boundary layer related to size grid.

4) remote sensing methods validation (for their determination) with the help of the ground based measurements and the satellite remote sensing applications.

These objectives require a precise knowledge of these atmospheric characteristics (cloud percentage, aerosols, horizontal and vertical advections).

The HAPEX-II-SAHEL airborne must be equiped with :

- turbulence fluxes sensors operating in clear sky,
- remote sensing sensors (radiometer, lidar...),
- aerosols and microphysical sensors.

The aim is to measure the energy balance principal parameters (radiation and advection terms...) and atmosphere radiation transfer functions.

HAPEX-II-SAHEL

REMOTE SENSING

Coordination : Y. Kerr, Toulouse, France

OBJECTIVES

The objectives of the "remote sensing" fold of the HAPEX-II-SAHEL experiment is to develop techniques which would allow to derive radiation, momentum heat and mass transfer (moisture and eventually CO2) exchange between the surface and the atmosphere through the use of satellite data. (This study will be performed in the Sudano-Sahelien area during the drying period end of the rainy season).

In order to achieve this goal, a number of points must be fulfilled :

First, during the experimentation phase, sufficient satellite, airbone and ground data must be collected.

Models and theories related to the links between surface processes and radiometric measurements must be tested, improved and validated.

Analyse how local scale models could be integrated up to a scale compatible with satellite measurements.

Considering the large ambitions of this project we will put the stress on hydrological parameters, though, if possible, data usefull for other analysis will be collected. The main parameters of interest we intend to derive are : surface fluxes, rainfall, evapotranspiration, soil moisture, vegetation water content, and vegetation characteristics.

PROBLEMS TO BE SOLVED

The chosen test site in Niger is characterized by very strong heterogeneities, which will make any attempt to study the relationship between local scale and large scale parameters difficult to handle.

Satellite and airbone data will be obtained under a great variety of formats and it will be necessary to set up data base well organised as well as a GIS so as to allow easy inter-comparisons.

Finally, satellite and airbone data preprocessing will be a major task needing much man power.

DATA

- Satellite data

The data sets which will most probably be available are given here after. Apart from a core of essential data sets, others might be acquired following the needs expressed by the community and the funding and man power available.

METEOSAT

From ESOC. Scale 5X5 and 30 x 30 km. Temporal resolution 0.5 and 3 Hrs.

Surface temperature diurnal cycle measurements (with associated problems of calibration and atmospheric and emmissivity corrections), albedo and global irradiance estimate, possible estimation of evapotranspiration and rainfall amounts.

NOAA/AVHRR

From Mas Palomas or Niamey (AGRHYMET). Scale 1X1 km. Temporal resolution up to 4 times/day (2:30, 7:00, 14:30, 19:00).

Temporal evolution of the vegetation, surface temperature (with associated problems of atmospheric corrections, angular effects, emessivity problems). Estimation of primary production, evapotranspiration, rainfall amounts.

NOAA/TOVS

From Mas Palomas (Niamey ?). Atmospheric soundings.

SPOT or LANDSAT/TM

From Spot Image, Eosat. Scale 10 to 30 m. Temporal resolution 16 to 20 (5) days (9:45 and 10:30).

Characterization of land use and surface heterogeneity. Problems associated with the cloud cover during acquisition.

MOS-1

From ESA (Mas Palomas). Scale varying according to sensor between 50 m and 32 km. Temporal resolution 34 days (14:20).

Problems are linked to the fact that the test site might not be directly visible. The satellite has 3 main sensors which can be grossly compared to the AVHRR, SPOT HRV or LANDSAT TM and a microwave radiometer.

The microwave radiometer can be used to derive atmospheric water vapour and droplets.

ERS-1/ATSR

From ESA. Scale 1 km. Temporal resolution varying between 3 and 35 days, to be launched in 1990-1991.

Surface temperature corrected for atmospheric effects. Several other sensors (AMI) will also be available on the satellite.

DMSP/SSM/I

From NASA NSSDC. Scale 70 to 14 km. Temporal resolution every 2 days (approx.).

Atmospheric characteristics, rainfall etc.

- Airborne data

It seems absolutely necessary to have access to airbone measurements, even though they prove more cumbersome to obtain and process, for the following reasons. They offer the only mean to get access to a scale intermediary between the local and the global (satellite) scales ; they are necessary to validate and correct models ; and, finally, they allow to test methods using data not available on current satellites.

Microwave radiometers : PORTOS and PBMR (different frequencies and characteristics) for soil moisture, vegetation water content, soil roughness determination. If available the ESTAR prototype would be useful for assessing the improvements and drawbacks of the new technique used as well as to perform inter-comparisons.

Thermal radiometers : TIMS. Surface temperature, emissivities.

SW radiometers : Spot and Landsat spectral bands ; POLDER. If available, a sensor having large spectral bands similar to the ones on the AVHRR would be useful.

Even though it might not be feasible, the Jet Propulsion Laboratory SAR would be a very useful addition to this set of sensors (soil moisture, polarimetry, etc.).

- Ground data.

The ground experiment will perform a number of measurements on the soil and vegetation characteristics but it seems necessary to interact with the teams involved in this part of the project to make sure all the necessary data will be collected in a manner which will suit our needs as much as possible. We will also need some specific measurements such as for instance photometers measurements, radio soundings, radiometer measurements (SW, LW, near infra-red and microwaves).

HAPEX-II-SAHEL

MODELLING UP TO THE CANOPY LAYER (AT DIFFERENT SCALES)

Coordination : P. Kabat, Wageningen, The Netherlands

Objectives of the subgroup :

- To quantify, parametrize and to model dominant transport processes and fluxes in the system soil-water-plant-atmosphere at a site scale, especially for the conditions of arid region, i.e. scarce vegetation and extremely dry topsoil.

- To develop methodology to upscale transport parameters stemming from theories of inverse modelling, homogenization, averaging and stochastic modelling.

- To simplify methodology of upscaling by using easy obtainable (e.g. remote sensing) spatially distributed data.

A synthesis of the subgroup proposal

Previous large scale experiments on land surface energy processes including HAPEX-MOBILHY pointed out the importance of extensive evaluation and modelling of the soil-water-vegetation-atmosphere (SWVA) continuum linked to the ground-based measurements of meteorological variables and surface fluxes. Namely under situation of a non-complete soil cover and unsaturated conditions in the top/soil the system is very complex and its parametrization and modelling even on a small plot scale becomes complicated. In a (semi) arid region of Sahel, specific processes related to scarce vegetation and extremely dry top soils, resulting in a high magnitude of soil heat flux and deep evaporation front are contributing to the system complexity (Bastiaanssen et al., 1989). On a plot scale, a physicaly based 1-D simulation model SWATRE/SWACROP describing the transport of water/vapour in the system soil-plant-atmosphere is often used to estimate the terms of the water budget of the system (Feddes et al., 1988 ; Kabat et al., 1988). Upper boundary of the vertical 1-D profile considered by this model is assigned to be the interface between interfacial sublayer and dynamic sublayer. This implies that the calculated potential and actual (evapo) transpiration fluxes are fluxes entering in the dynamic sublayer with the logarithmic profiles. Parameters and overall input data for dynamic SWVA model on a plot scale are usually measured in (semi)-laboratory conditions and an extensive data set is requested to calibrate and verify the model. Though the plot scale represents the basic unit for physical reasoning, the complexity of such small scale models is likely to outrun the practical requirements of parametrization on large scales as required e.g. for GCMs. On the other hand, effects of spatial heterogenity and variability in time of soil, vegetation and meteorological data has to be investigated and modeled to make any parametrization on a large scale feasible.

Due to the nonlinearity of major processes involved in the transport in SWVA system, simple extrapolation or averaging over different time and space scales is not possible. Instead, methods based on a principle of similar media as scaling, homogenization and averaging will be used (Rubin and Gomez-Hernandez, 1989). Generally, by means of these methods the so called "effective transport parameters" are derived,, making areal upscaling and modelling of the transport processes on larger scales possible. To increase the interpretation range of large scale modelling results of a SWVA system, a stochastic approach will be employed rather than deterministic one.

The basic question is, in what extend can be the essential transport parameters "homogenized" without forcing the basic physics of the system. An inverse modelling approach combined with optimization procedures and stochastic techniques (Kabat and Hack-Ten Broeke, 1988, Feddes et al., 1989) will be used to parametrize the transport of water/vapour through the (unsaturated) soil. The inverse modelling will be applied to different "blocks" with gradually changing scales considered to represent units with the same "effective" parameters. The necessary input data (fluxes, soil water status of the top soil, eventually soil moisture profiles) to perform the inverse simulation will be principally collected within soil moisture monitoring programme, remote sensing and both ground based and airborne fluxes measurements.

On the generated set of groups of "effective soil hydraulic parameters" a network of data on the dynamics of the vegetation (cover, height, LAI) and a network on meteorological data will be superposed. (To be measured within the meteorological networks, ecology and vegetation component and remote sensing component of the experiment).

In such way derived spatially distributed set of data and transport parameters will be used to simulate evapotranspiration fluxes leaving the canopy layer during few arbitrarly choosen periods within the experiment (verification). An areal picture of (evapo) transpiration fluxes can be generated by superposing parameter and data fields over different scales within the basic grid and running the (adapted) SWATRE/SWACROP model. This field of fluxes can be used as a lower boundary conditon for the second order models (above the canopy).

Besides modelling of the SWVA system focused on parametrization at different scales, some routines of existing SWATRE/SWACROP model will be adapted using site specific information. A new soil-heat transport and runoff routines will be incorporated and some of the newest versions of the model dealing with deep evaporation front and with macropore flow will be tested.

REFERENCES

BASTIAANSSEN, W.G.M., KABAT P. and MENETI M., 1988. A new simulation model of bare soil evaporation in arid regions (EVADES). Nota 1938. Institute for Land and Water Management Research, Wageningen, The Netherlands. 40 pp.

FEDDES R.A., KABAT P., VAN BAKEL P.J.T., BRONSWIJK J.J.B. and HALBERTSMA J., 1988. Modelling soil water dynamics in the unsaturated zone - State of the art. Journal of Hydrology 100 : 69-111.

FEDDES R.A., MENENTI M. and KABAT P., 1989. Modelling the soil water balance and surface energy balance in relation to climate models. European Coordination Group on Land-Surface Processes, Hydrology, Desertification in Europe, Barcelona, Spain, 12-15 March 1989. 21 pp.

KABAT P. and HACK-TEN BROEKE M.J.D., 1988. Input data for agrohydrological simulation models : some parameter estimation techniques. In : H.A.J. van Lanen and A.K. Bregt (eds). Proc. EC-workshop "application of computerized EC soil maps and climate data", 15-16 november 1988, Wageningen, The Netherlands.

KABAT P., WESSELING J.G., VAN DEN BROEK B.J. and FEDDES R.A., 1988. SWATRE/SWACROP. Version 2.0. A dynamic transient simulation model for unsaturated/satured zone and crop production. Manuel and simulation software. ICW, Wageningen, The Netherlands.

RUBIN Y. and GOMEZ-HERNANDEZ J.J., 1989. A stochastic approach to the upscaling of transmissivity in disordered media - 1 : Theory and unconditional simulations. Submitted to Water Resources Research.

HAPEX-II-SAHEL

MESOSCALE MODELLING STUDIES

Coordination : R. Rosset, Clermont-Ferrand, France

OBJECTIVES

- to document sub-grid (mesoscale) variability at the scale of individual GCMs grids,
- to accomodate micrometeorological data and assiciated 1D modelling results within a 3D numerical framework in order to proceed to spatial scale integrations from 5-10 km to about 100-500 km,
- more generally, a 3D mesoscale model is apt to merge in a deterministic sense the information collected from the surface, the soil, the vegetation and the atmosphere in the range of the above horizontal scales.

ONE KEY PROBLEM TO BE SOLVED IN PRELIMINARY TO MESOSCALE MODELLING :

What are the most significant scales of the heterogeneities for the surface fluxes ?

Are they commensurate with the maxi resolvable scales (grid sizes about 5 to 10 km) of the mesoscale models so as to be explicitly simulated ?

DATA AND METHODS

- Development, testing and validation of ID "vertical" micrometeorological models to be inserted within the mesoscale models and coupling the soil, the vegetation and the atmospheric boundary layer for the few typical ecosystems identified in the HAPEX-II-SAHEL and adjacent areas (500 x 500 km2).

- Required :

  * for 3D simulations, good enough large-scale atmospheric analysis in a 400 x 400 km domain centered on the HAPEX intensive observational area are necessary. This requires a set of additional radiosounding data and a specific assimilation effort using either the Emeraude or the ECMWF assimilation system,

  * land-use data (gridded vegetational and textural parameters),

  * exhaustive data base sets (soil, ground surface and atmospheric soundings, first to initialize, then to validate the mesoscale models),

- Application of the mesoscale models on well-documented selected situations and validation on the basis of data collected during the IOP.

HAPEX-II-SAHEL

DATA BANK AND DATA BASE

Coordination : Ch. Mazaudier, St Maur des Fossés, France

The "Data base methodology" group will have the following objectives :

- definition of the project e.g. a data bank or a data base,
- data medium, code and format definition and choice to exchange the data.

It is important to underline that the project will strictly depend of the informatic equipment (calculators and personnel) of the staff. This staff will constitute the bank or the base for all the others HAPEX-II-SAHEL teams.

DATA BANK

The scientific manager of the bank must receive all the magnetic tapes, control the quality and, like a radio, broadcast information to the other scientific teams which are interested.

The quality control of the magnetic tapes set is a very important phase of the work because each problem will be emphasize by the high number of the teams involved in HAPEX-II-SAHEL.

The recommended data medium to the exchange is the magnetic tape 1600 or 6250 Bpi (without label). The recommended code is the ASCII code. However, the binary code will be accepted for very high definition data. This code oblige to do an other work stage with a code converter.

The scientific manager recommends the use of Fire format which is enough universal to be the support of the HAPEX-II-SAHEL project.

The data bank scientific manager must be in possess of a calculator (micro or macrocalculator) equiped with a data base operating system. So it will be possible to edit the data catalogue and, after, print up-to-date editions.

DATA BASE

An overloading job for the data manager will be the consequence of the decision to constitute a data base. Firstly, the data manager receives the tapes. Secondly, he has to organize a work operating system with a calculator (or with a set of on-line calculators). Thirdly, the data manager has to insert various interfaces between data and potential users (menus to find the data address, graphics...).

This work is useless if you have chosen as framework a data bank.

CONCLUSION

A data bank management is not so hard than a data base management. However, each scientist when he receives a set of data must do an useless work (if a data base was set up).

TEAMS INTERESTED IN THE PROJECT

(VEGETATION STUDIES IN HAPEX-II-SAHEL)

1) Centre National de la Recherche Scientifique (CNRS).
Montpellier, France.
Contact : M. S. Rambal.
Subject areas : Spatial variability of vegetation and evapotranspiration. Soil and plant evaporation modelling.
Use of satellite Ts and NDVI.

2) Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM).
Montpellier, France.
Contact : M. A. Cornet.
Subject areas : Mapping vegetation, landscape and heterogeneity. Characterization of functional unit (based on vegetation, soil and hydrological regime). Use of satellite (SPOT, Landsat TM) and ground based measurements of vegetation and soil surface condition.

3) Institute of Hydrology (IH).
Wallingford, United Kingdom.
Contact : M. J.S. Wallace.
Subject areas : Measurement and modelling of transpiration and bare soil evaporation. Using IRGAS, heat pulse devices and soil microlysimeters.

TEAMS HAVE BEEN THOUGHT

(VEGETATION STUDIES IN HAPEX-II-SAHEL)

(not contacted yet formally or few days ago contacted)

1) Edingburg University (EU).
Edinburgh, United Kingdom.
Contacts : M. P. Jarvis & M. J. Moncrief.
Subject areas : Canopy scale CO2 fluxes.

2) University of Maryland (UM).
Maryland, USA.
Contact : M. G. Suttle.
Subject areas : Estimating biomass and plant physiological status through the use of airborne based imaging and analysis system (ICAS).

3) National Aeronautics & Space Administration (NASA/Goddard Space Flight Center).
Washington, District of Columbia, USA.
Contacts : M. S. Prince (via M. R. Murphy).

4) Other possible collaborators in "vegetation" sub-area include :

- AGRHYMET, Niamey, Niger.
- ICRISAT, Niamey, Niger.
- INRAN, Niamey, Niger.

5) Other possible collaboration with French teams as :

- INRA, Montfavet.
- IRAT, Montpellier.

TEAMS INTERESTED IN THE PROJECT

(GROUND-BASED FLUXES IN HAPEX-II-SAHEL)

1) Centre National de Recherches Météorologiques (CNRM).
Toulouse, France.
Contact : M. P. Bessemoulin.

2) Departement of Meteorology. University of Reading (Reading-Met).
Reading, United Kingdom.
Contact : M. G. Dugdale.

3) Institute of Hydrology (IH).
Wallingford, United Kingdom.
Contact : M. J.H.S. Gash.

4) Flinders University (Flinders).
Beldford Park, SA, Australia.
Contact : M.J. Hacker.

5) Centre de Recherche en Physique de l'Environnement Terrestre et Planétaire (CRPE).
Issy-les-Moulineaux, France.
Contact : M. F. Roux.

6) Department of Geography. University of Reading (Reading-Geog).
Reading, United Kingdom.
Contact : M. R.D. Thompson.

TEAMS HAVE BEEN THOUGHT

(not contacted yet formally or few day ago contacted)

(GROUND-BASED FLUXES IN HAPEX-II-SAHEL)

1) Institut National de la Recherche Agronomique (INRA).
Montfavet, France.
Contact : M. J.P. Lagouarde.

2) University of Copenhagen (Copenhagen).
Copenhagen, Denmark.
Contact : M. H. Sögaard.

3) Agricultural University of Wageningen (Wageningen).
Wageningen, The Netherlands.
Contact : M. H.A.R. De Bruin.

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TEAMS INTERESTED IN THE PROJECT

(AIRBORNE FLUXES IN HAPEX-II-SAHEL)

1) Laboratoire d'Aérologie (LA).
Toulouse, France.
Contact : M. A. Druilhet.
Subject areas : Local scale fluxes, flux variation during the drying, soil surface characteristics/boundary layer/atmospheric fluxes relationships.
Airborne : ARAT (Fokker 700) and FAIRCHILD - MERLIN IV.

2) Flinders University (Flinders).
Beldford Park, SA, Australia.
Contact : M.J. Hacker.
Subject areas : Hydrologic and energetic balance in the semi-arid lands.
Airborne : 1.

3) Laboratoire d'Etudes et de Recherches sur la Télédétection Spatiale (LERTS).
Toulouse, France.
Contact : M. Y. Kerr.
Subject areas : Soil surface parameters linked with energy balance.
Airborne : ARAT (Fokker 700).

4) Laboratoire de Météorologie Dynamique (LMD).
Palaiseau, France.
Contacts : M. M. Desbois and M. D. Cadet.
Subject areas : Remote sensing data/ground based data relationships, squall lines.
Airborne : ARAT (Fokker 700).

5) Laboratoire d'Optique Atmospherique (LOA).
Lille, France.
Contact : M. Y. Fouquart.
Subject areas : Remote sensing data/ground based data relationships.
Airborne : ARAT (Fokker 700).

6) Centre de Recherche en Physique de l'Environnement Terrestre et Planétaire (CRPE).
Issy-les-Moulineaux, France.
Contact : M. F. Roux.
Subject area : Hydric balance measurements with radar.
Airborne : FAIRCHILD - MERLIN IV.

7) Natural Environment Research Council (NERC).
United Kingdom.
Contact : M. White.
Subject area : Airborne remote sensing.

8) National Center Atmospheric Research (NCAR).
Boulder, Colorado, USA.
Contact :
Subject areas : Hydrologic and energetic balance in semi-arid lands.

9) Oregon State University (OSU).
Corvalis, Oregon, USA.
Contact : M. R. Cuenca.
Subject areas : Hydrologic and energetic balance in semi-arid lands.

10) USDA.
Beltsville, Maryland, USA.
Contact : M. T. Schmugge.
Subject area : Airborne remote sensing.

TEAMS INTERESTED IN THE PROJECT

(REMOTE SENSING IN HAPEX-II-SAHEL)

At time of print (August, 1989), the following teams have indicated they are interested in participating :

1) Centre de Recherche en Physique de l'Environnement Terrestre et Planétaire (abbréviation CRPE).
   Issy-les-Moulineaux, France.
   Contact : M. F. Roux.
   Subject areas : Precipitation measurements through the use of microwave radiometry (SSMI/DMSP).

2) Laboratoire des Sciences de l'Image et de la Télédétection. (GSTR/LIST).
   Strasbourg, France.
   Contact : M. Ph. Stoll.
   Subject areas : Derivation and analysis of surface temperature with use of infra-red spectro-radiometer.

3) Groupement Scientifique de Télédétection Spatiale (GSTS).
   Strasbourg, France.
   Contact : M. J.C. Pion.
   Subject areas : Lineaments and fractures network mapping. Relationships between water infiltration and geohydrological balance.

4) Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM).
   Bondy, France.
   Contact : M. M. Pouget.
   Subject areas : Soil surface features characterization and medium -scale mapping. Soil surface features dynamic studies.

5) Laboratoire d'Etudes et de Recherches sur la Télédétection Spatiale (LERTS).
   Toulouse, France.
   Contact : M. Y. Kerr.
   Subject areas : Soil moisture, vegetation water content, soil roughness.

6) Centre National de la Recherche Scientifique (CNRS).
   Montpellier, France.
   Contact : M. S. Rambal.
   Subject areas : Spatial variability of evaporation and vegetation.

7) Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM).
   Montpellier, France.
   Contact : M. A. Cornet.
   Subject areas : Vegetation mapping and characterization of functional units.

TEAMS WITH POSSIBLE INTEREST

(REMOTE SENSING IN HAPEX-II-SAHEL)

1) Institut National de la Recherche Agronomique (INRA).
   Montfavet, France.
   Contact : M. J.P. Lagouarde.
   Subject areas : Evapotranspiration.

2) Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (IRAT).
   Montpellier, France.
   Contact : M. J. Imbernon.
   Subject areas : Vegetation evolution in relation to hydric stresses.

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TEAMS HAVE BEEN THOUGHT

(REMOTE SENSING IN HAPEX-II-SAHEL)

(not contacted yet formally or few days ago contacted)

1) Centre National de Recherches Météorologiques (CNRM).
Toulouse, France.
Contact : M. J. Phulpin.

2) USDA.
Beltsville, Maryland, USA.
Contact : M. T. Schmugge.
Subject areas : Soil moisture.
Contact : M. Jackson.
Subject areas : Runoff water stocks.

3) National Aeronautics & Space Administration (NASA/Goddard Space Flight Center).
Washington, District of Columbia, USA.
Contacts : M. C. Justice & M. S. Prince.
Subject area : Vegetation monitoring.

4) Jet Propulsion Laboratory
USA.
Contacts : M. A. Kahle & M. Palluconi.
Subject areas : Surface temperatures and emmissivities.
Contact : M. J. Van Zyl.
Subject areas : Polarimetry and soil moisture.
Contact : M. J. Cimino.
Subject areas : Synergims studies.