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1 Introduction

In this study, a dataset that is homogeneous in time and space was created by using meteorological and hydrological data obtained during HUBEX-IFO (1998/5/1-8/31). This dataset was produced to be used as forcing data for Land Data Assimilation by land surface scheme (SiBUC) and to be utilized to validate regional 4DDA by JSM-SiBUC.

Furthermore, the energy and water budget of the Huaihe River Basin were calculated in hourly increments by using the produced mesh dataset. This data will be used for GAME WEBS(Water & Energy Budget Studies). Also, our dataset will be validated and improved through the analysis of WEBS.

2 Surface meteorological data

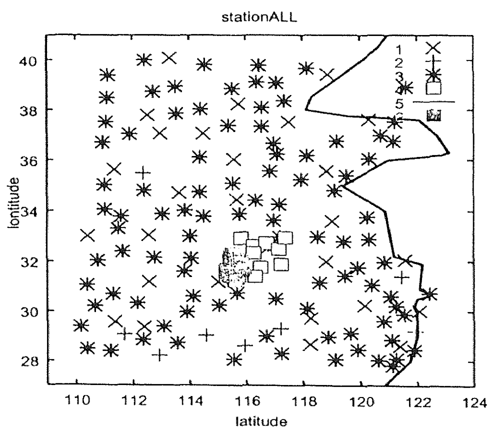

Figure 1: Location of meteorological and hydrological station in HUBEX

Each meteorological element (air temperature, air pressure, wind velocity, vapor pressure, sunshine, and rainfall) obtained at 146 surface meteorological stations, and hourly rainfall data at 48 hydrological stations in Shiguan River Basin during IOP period were used in this study. These data are stored in a basic dataset in the HUBEX data center and will be opened in August 2001. In addition, since rainfall data in the upstream of the Huaihe River Basin were not sufficient, daily data at about 200 hydrological stations were also purchased and used.

3 Creating mesh data

Although our goal is to create an hourly dataset, the majority of meteorological data in the HUBEX Project are at 3-hourly or 6-hourly intervals (see **Table1**). Then, hourly data for 3-hourly or 6-hourly stations should be produced by being interpolated in space or time. After that these stations can be regarded as hourly stations. Owing to this process, we can use more standard points for the spatial interpolation in creating mesh data. As for pressure and temperature, they are highly dependent on altitude. As a result, these data have been corrected to sea level value before the spatial interpolation process was undertaken.

Table 1: Number of observation per 1 day

	A1 (28)	A8 (9)	A0 (98)	AN (11)
air pressure	24	8	4	4or24
air temprature	24	8	4	4or24
vapor pressure	24	8	4	4or24
wind velocity	24	8	4	4or24
sunshine	1	1	1	1
rainfall	2	2	2	2

Using hourly observed data and hourly interpolated data at 146 stations, mesh dataset has been created using spatial interpolation.

- **Huaihe River Basin**
  domain : E111.0-E122.0, N31.0-36.0
  resolution : 5minutes (about 10km)
- **Shiguan River Basin**
  domain : E115.0-E116.2, N31.2-32.4
  resolution : 30seconds (about 1km)

3.1 Spatial interpolation(the number of used stations)

Being searched distances from 3-hourly station(target station) to each hourly station, 3 to 7 stations were selected as the near order of distance. Following this, hourly data were interpolated from these selected stations' values using weights inversely proportional to the 1st or 2nd power of distance. As an example, the relationship for air pressure between interpolation error and number of used station is shown in **Table 2**. In general, the accuracy decreases as the number of stations used increases. This result may imply that the value of stations located far from the point of interest should not be used for interpolation.

Table 2: Interpolation error according to the number of used station (air pressure)

No.	3	4	5	6	7
1st	0.797	0.819	0.859	0.832	0.877
2nd	0.781	0.785	0.800	0.773	0.787

3.2 Spatial interpolation(direction of used stations)

In the conventional technique as described in the previous paragraph, only the distance between standard station (data present) and target station (data absent) is considered in the interpolation process. However, the station-position relationship is not considered. Here we introduce an interpolation technique, which considers both distance and direction of each station.

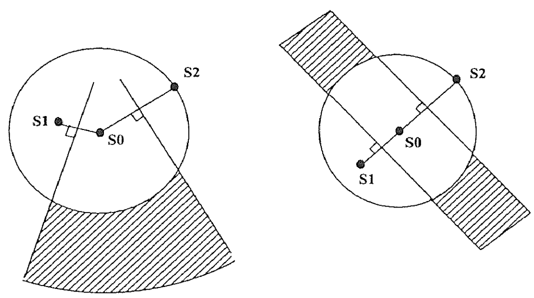

Figure 2: The existence area of third station to be used for spatial interpolation

The target station is defined as S_0, the stations used for interpolation are defined as S_1 to S_5 in the near order from S_0. The nearest 2 stations(S_1 and S_2) are always used. If the distance from S_3 to S_0 is shorter than that from S_3 to S_1 and from S_3 to S_2, S_3 is regarded to be suitable for use in the interpolation. If $S_3 - S_0$ is longer than either $S_3 - S_1$ or $S_3 - S_2$, then S_4 is selected, and judged to be suitable for use or not according to the same requirement (see **Figure 2**). The stations that fill these requirements are searched in order of distance (S_3, S_4 and S_5). If S_5 still doesn't match, only S_1 and S_2 are used for interpolation. When considering direction, it is more appropriate to use a weighting method based on the 1st power of distance, rather than the 2nd power.

3.3 Comparison between spatial and temporal interpolation

In some cases, interpolation in time, which is a simple linear interpolation between 3-hourly or 6-hourly data, is more accurate than spatial interpolation as described in the previous paragraph.

The method of interpolation(time or space) was selected using the following procedure:

1. The data for 3-hourly observation are sampled from hourly station's data. Data for the remaining time are then interpolated from the sampled 3-hourly data. The average value of the standard error of time interpolation at all hourly stations is defined as **standard value** (V_1).
2. The **standard value** (V_2) is defined in the same way as for 6-hourly case.
3. At 3-hourly station, the data for the observed time are estimated using spatial interpolation. If the standard error of this spatial interpolation is smaller than V_1, this station is regarded to be suitable for spatial interpolation. Also, an hourly value is produced using spatial interpolation.
4. As for 6-hourly stations, they are judged using the same method as for a 3-hourly station, using standard value V_2, and spatial interpolation is executed to produce hourly values only for the stations which are judged suitable.
5. Using all hourly data (original) and interpolated hourly data (produced in step **3.** and **4.**), execution of the spatial interpolation process is again attempted.

6. If a station is judged to be unsuitable for spatial interpolation even in step **5.**, the temporal interpolation is executed to produce hourly values. As a result of these procedures, hourly data exist at all 146 stations.

Table 3 shows the results of interpolation of selected interpolation methods for each element. From this table, each meteorological element is suitable for spatial interpolation in order from the top to the bottom. In the case of wind velocity, it varies greatly in time and space, and spatial and temporal interpolation are both considered to be unsuitable. As for air pressure, most of 38 stations which were judged suitable for temporal interpolation are located in mountainous regions or in spatial extrapolation.

Table 3: Selected interpolation method

element	1st	2nd	temporal
air pressure	63	5	38
air temperature	22	13	73
wind velocity	10	0	88
water vapor pressure	0	0	106

3.4 Short-wave and long-wave radiation

In general, short-wave and long-wave radiation flux are not observed in the routine observation network, and they should be estimated from other elements. As shown in **Table 1**, sunshine data to be used in the estimation of downward short-wave radiation at all stations are daily accumulated values. While hourly data are needed as forcing data for the land surface scheme. Thus they are estimated from the location of station, date, daily total of sunshine data.

input: latitude, day of year, local time, sunshine(daily total)
output: daytime, short-wave radiation(hourly)

In addition, daily average value of downward long-wave radiation is also estimated. Although it depends on sky temperature and cloudiness, diurnal variation of long-wave radiation is relatively small. So we use this daily average value as an houry value.

input: temperature(daily), vapor pressure(daily), sunshine(daily total), daytime
output: downward long-wave radiation(daily), dewpoint

4 Energy and Water budget estimation by SiBUC

4.1 Surface Parameters for SiBUC

In this study, NOAA-AVHRR global landuse/landcover dataset (from USGS), which has about 1km resolution, was used. There are 6 kinds of dataset defined by each research community or land surface scheme. A dataset which has a different category for both 'paddy field' and 'farmland' is needed for the application to the Huaihe River Basin. Three vegetation datasets for USGS, BATS, and Global Ecosystems are available. Among them, the Global Ecosystems dataset was selected through the comparison of their landuse components in the HUBEX area.

As for soil type, global digital soil map(from FAO) was used, which has about 10km resolution and more than 1000 categories. According to the detailed soil texture information for each kind of soil, we re-categorized this dataset into 14 categories (sand, loamy sand, etc).

In addition, since the simulation period is four months (123 days), vegetation index (NDVI) was used to produce time varing vegetation parameters in the model.

4.2 Energy Budget

By using meteorological mesh dataset (Ver.1.0) made in the previous section, hourly energy fluxes are simulated using SiBUC for 123 days. Then we checked the results by 10 days mean value, and the latent heat flux in mountainous regions was found to have negative value frequently.

This result was probably brought by too high value of the vapor pressure used as forcing data. The altitudal dependence in vapor pressure wasn't considered in the interpolation process. So the value in mountainous regions (which was interpolated from the data in flat area) was higher than real one (even higher than saturated value).

To prevent this problem, before spatial interpolation was performed, vapor pressure was transformed into relative humidity. Then vapor pressure value was inversely transformed from interpolated relative humidity. As a result of this procedure, the value in mountainous regions always becomes lower than saturated value, but a little bit higher than the real one (This dataset was defined as Ver.1.1).

A result of energy budget simulation forced by the meteorological dataset (Ver.1.1) is shown in **Figure 3** as a time series of daily mean energy budget at four landuse (paddy field, forest, farmland, lake).

The heat budget of farmland shows that latent heat is dominant to sensible heat until about 6/20, then their relation becomes reverse on 6/26. It is explained by the decrease of soil moisture. Owing to the rainfall on 7/5, soil moisture was recovered. After that latent heat is dominant to sensible heat until 8/31.

However it must be noted that this result is only an first trial and brought by an initial condition of sufficient soil moisture. If the initial soil moisture is smaller, time series of heat budget may be different.

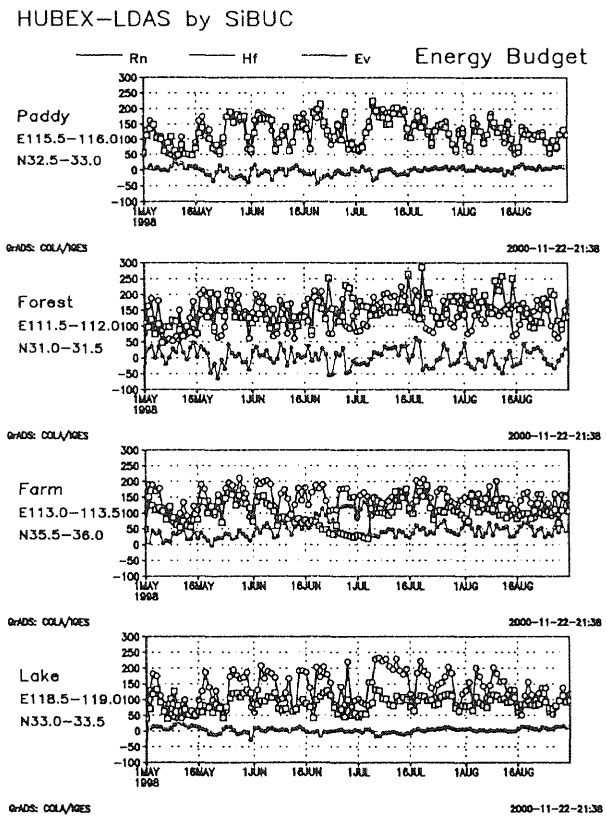

Figure 3: Time series of daily mean energy budget at four landuse (1998/5/1-8/31)

4.3 Water Budget

Figure 4 shows an accumulated value of water budget components (rainfall, evapotranspiration, and runoff) in the upstream of Bengbu station(catchment area is about 120 thousand km^2). As for the runoff from model, it is a total amount of each grid's output, and time lag of routing process(river system) isn't considered.

According to **Figure 4**, runoff is smaller than observed one. So simulated evapotranspiration is thought to be larger than actual one. Some of the reasons of this over estimation of latent heat are listed as follows:

1. **rainfall data**
   Most of hourly rainfall are mean value of 12hour accumlated one. Then the intensity of rainfall becomes smaller than real one. This may lead to the over estimation of interception loss.

2. **landuse data**
   Although the dataset can describe the paddy field and farmland separately, the coverage for paddy field is thought to be over estimated (more than 60 %).

3. **baseflow**
   The under estimation of runoff is caused by the shortage of baseflow. It is expressed by mean slope of grid area and hydraulic conductivity.

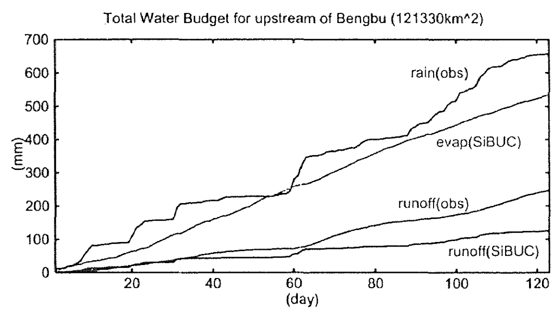

Figure 4: Water budget in the upstream area of Bengbu (accumulated rainfall, evapotranspiration, runoff)

5 Conclusion

In this study, surface meteorological mesh dataset (ver.1.1) for the Huaihe River Basin was created, and energy and water budget are estimated using the land surface scheme (SiBUC) and this dataset.

Through the utilization of GMS data, the diurnal variation of shortwave radiation and rainfall will be improved in the future. Further study must be done in the framework of GAME-WEBS for the improvement of energy and water budget estimation.