3.11 TESTING AND EVALUATION OF POTENTIAL EVAPOTRANSPIRATION SCHEMES FOR NATIONAL WEATHER SERVICE RIVER FORECAST SYSTEM

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1. INTRODUCTION

Potential evapotranspiration (PE) is one of the required inputs to run the Sacramento Soil Moisture Accounting (SAC-SMA) model of the National Weather Service (NWS) River Forecast System (NWSRFS). Currently there are two options to define PE for SAC-SMA: (1) using monthly climatic PE for the modeling area; and (2) using Synoptic Data Transfer (SYNTRAN) utility program of the NWSRFS to compute daily PE.

Apparently the first option is predicated on the premise that PE is not variable year-over-year and seasonal variability is of utmost importance. This premise is questionable because surface meteorological conditions at most US locations can be highly variable in time.

The second option is based on Penman's combination approach to compute PE. To use Penman approach, a full array of surface meteorology forcing data is needed, including air temperature, atmospheric pressure, air humidity, wind speeds and incoming total solar radiation. Of these variables, air temperature observations are the most commonly available. But other variables such as atmospheric pressure, humidity and wind speeds are available for only a very few selected synoptic surface observation stations over the entire US. Incoming solar radiation data have been basically nonexistent for operational hydrologic applications even as of today.

To compensate for the lack of incoming solar radiation data, SYNTRAN uses total sky cover observations to estimate total incoming solar radiation. As the Automated Surface Observation System (ASOS) is being fully implemented in the US, however, the total sky cover observations are now being phased out of existence. At this point there are no alternative observations that are readily available for use by NWS hydrologists.

In light of this development, there is an urgent need in NWS to find alternative data sets that allow PE data to be computed. At least, we can find alternative data to replace the total sky cover information needed by SYNTRAN program.

This paper investigates several surface meteorology forcing data sets that may be used to compute PE. Also a number of different PE schemes will be tested and evaluated. The overall objectives of this work are (1) to develop historical surface meteorology forcing data sets which can be used to compute PE anywhere in the continental United States; (2) to investigate different PE schemes that can produce PE that are consistent with each other; and (3) to evaluate PE obtained from different schemes on selected NWS River Forecast Center (RFC) test basins.

This paper is organized as follows. First available data sets that can be used to compute PE are surveyed. Second, an analysis of the differences between the data sets is given. Third, a future plan for comprehensive comparison of different PE schemes is presented.

2. ALTERNATIVE SURFACE METEOROLOGY DATA SETS FOR COMPUTING PE

This section surveys a number of alternative surface meteorology data sets that can be used to compute PE. Particularly, the data sets examined include the National Climate Data Center (NCDC) Surface Airways observations, the University of Washington gridded meteorological data, the satellite solar radiation data from University of Maryland and National Environmental Satellite Data Information Service (NESDIS), and the National Center for Environmental Prediction (NCEP) 50-year reanalysis data. We will also briefly discuss the PE estimates from the NOAH model, a land surface model developed and operated in NCEP.

2.1 NCDC Surface Airways Data

The NCDC Surface Airways Data set (referred hereafter as SYNTRAN data set) contains surface meteorology observations from more than 110 sites in the US. At the requests of several NWS RFCs,

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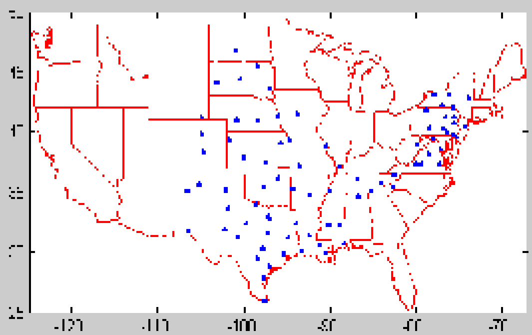

Figure 1. Location of data sites

historical data for about 80 of those sites were processed and made available to the SYNTRAN program (See Figure 1). The observations collected include air temperature, dew point, wind speed and total sky cover. As mentioned previously, total sky cover is used to determine total incoming solar radiation (Thompson, 1976). The SYNTRAN data set has been used extensively by NWS RFCs to drive the SAC-SMA model. The PE values for the synoptic sites are readily available via internet. There are a number of weaknesses associated with the SYNTRAN data set. First, the data network is relatively sparse and many of the historical records are not continuous or complete. Second, total sky cover observations are subjective in nature because human judgment is involved in the observations. Third, total sky cover observations are the only means currently available in NWSRFS to estimate total incoming solar radiation; and despite the inherent flaws in these observations, they will soon cease to be available. Therefore alternative data have to be identified.

2.2 University of Washington Gridded Meteorological Forcing Data

University of Washington recently developed a 50-year retrospective surface meteorology forcing data (referred hereafter as UW data set) over the entire continental US (Maurer et al, 2002). The UW data set contains precipitation, air temperature, humidity, wind speeds, incoming short and long wave solar radiation. The truly observed variables in the UW data set are precipitation and air temperature. Incoming solar radiation and air humidity data are estimated indirectly from daily maximum and minimum air temperature and precipitation (Thorton and Running, 1999; Kimball et al., 1997). The wind speed values were extracted from a version of the NCEP atmospheric model reanalysis data. The reliability of the UW data rests on the validity of the equations that relate incoming solar radiation and air humidity to daily maximum and minimum temperature. The reliability of wind speeds is limited because it is derived from model reanalysis, not direct observations. UW data set does have a number of advantages over SYNTRAN data set. It has a long period of record and covers the entire conterminous US. Some of the data may directly replace the forcing inputs needed by SYNTRAN program, provided that they are consistent with each other.

2.3 NESDIS Satellite Radiation Data

There are other potential data sets that can be useful in computing PE. Satellite based incoming solar radiation data have been developed recently by University of Maryland and NESDIS and have been used in the multi-agency/multi university Land Data Assimilation Project (LDAS). This data product can be used in NWSRFS in the future. One concern with this product is that satellite based incoming radiation data are available only relatively recently. Much longer periods of observations have to be available before meaningful comparative studies can be done to ensure the consistency of the radiation data.

2.4 NCEP Reanalysis Surface Meteorology Data

NCEP is developing a 50-year surface meteorology data based on new version of the atmospheric model reanalysis (referred hereafter as the NCEP reanalysis data set). This data set contains all the variables needed to compute PE using a Penman based approach. The advantage is that the data period is very long and the spatial coverage includes the entire conterminous US. Another advantage is that the reanalysis data can be easily made available operationally. The disadvantage is that these are not real observations and their truthfulness is hard to ascertain.

2.5 NCEP NOAH Model PE Estimates

The outputs from the NOAH Land Surface Model (LSM), which is the land surface component of the NCEP atmospheric model and one of four LSMs running on LDAS, contain PE estimates over the entire conterminous US. These PE estimates (referred as NOAH PE) can be provided in realtime mode and can be easily made available to hydrologists in NWS RFCs. The NOAH PE values are computed based on a Penman type approach

PE data capture local temporal variation in PE values and may be directly used by rainfall-runoff models such as the SAC-SMA.

3. INTERCOMPARISON OF DIFFERENT SURFACE METEOROLOGY DATA

This section compares different surface meteorology forcing data. Particularly the SYNTRAN data set and UW data set are intercompared. Each of the meteorological variables such as air temperature, humidity, wind speeds and derived solar radiation are compared.

The SYNTRAN data for about 80 sites are included for comparison study. Also included are the data from the corresponding grid boxes from the UW data set. It is clear from Figure 1 that, the NCDC coverage is not evenly distributed in the country and is sparse.

Figures 2a-d show the scatter plots of the two data sets for Pierre Municipal Airport in South Dakota. From this figure, we notice that air temperature and dew point temperature have the most agreement between the two data sets. However, the differences in wind speed and solar radiation data are substantial. Figure 3 shows the overall sorted correlation between the SYNTRAN and UW data sets on each of the data sites. This figure confirms the observations made in Figure 2 that air temperature and dew point temperature between the two data sets are most correlated while the correlation for wind speed and solar radiation is less clear.

Apparently the differences between the SYNTRAN data set and the UW data set are large, especially in wind speed. Therefore the UW data set cannot be used directly to substitute the SYNTRAN data set without resolving the differences between them.

4. FURTHER PLAN FOR EVALUATION OF PE DATA SETS AND SCHEMES

There is a need to continue to conduct more detailed investigation into the relationship between the two data sets for wind speed and solar radiation. In the case of solar radiation, despite the differences in the data sets, the correlation between them is still quite strong. A possible way to reduce the differences is to introduce the regional correction factors to the UW data that have already been applied to the SYNTRAN values (Thompson, 1977).

There is a plan to examine the NCEP 50-year reanalysis data and to study the difference between SYNTRAN, UW and NCEP reanalysis. Further the satellite radiation data from University of Maryland and NESDIS are beginning to be available. Investigation should be done to determine the correlation between satellite incoming solar radiation estimates and other estimates.

Ultimately the goal is to obtain the most consistent PE estimates for hydrologic modeling. Therefore, the difference between the PE values computed from different data sets should be investigated. There are a number of different source codes that are used to compute PE values. Because of the assumptions made in each source code, the PE values may be different. For the new data set to be used, it should

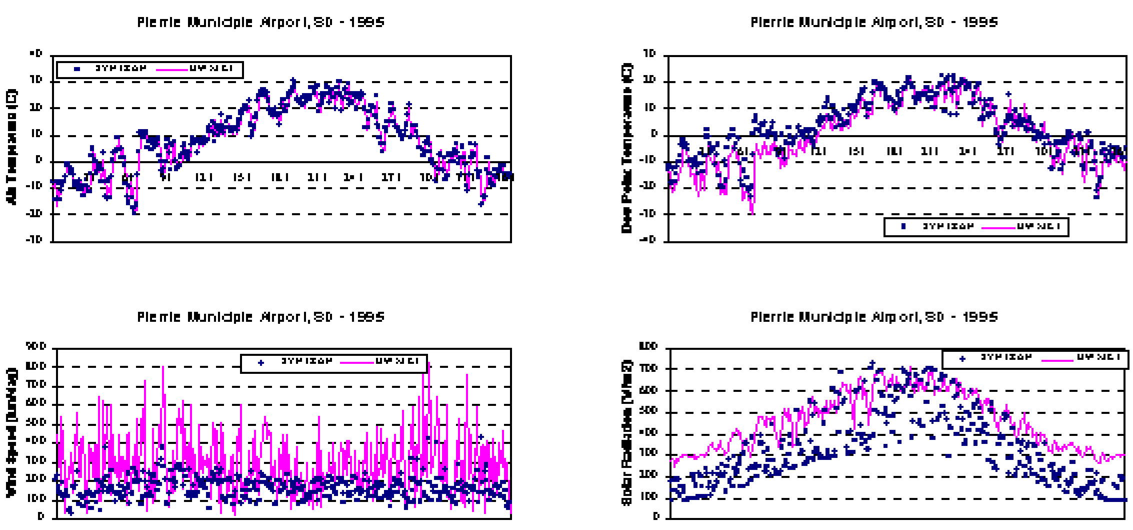

Figure 2. Comparison of NCDC and UW data sets

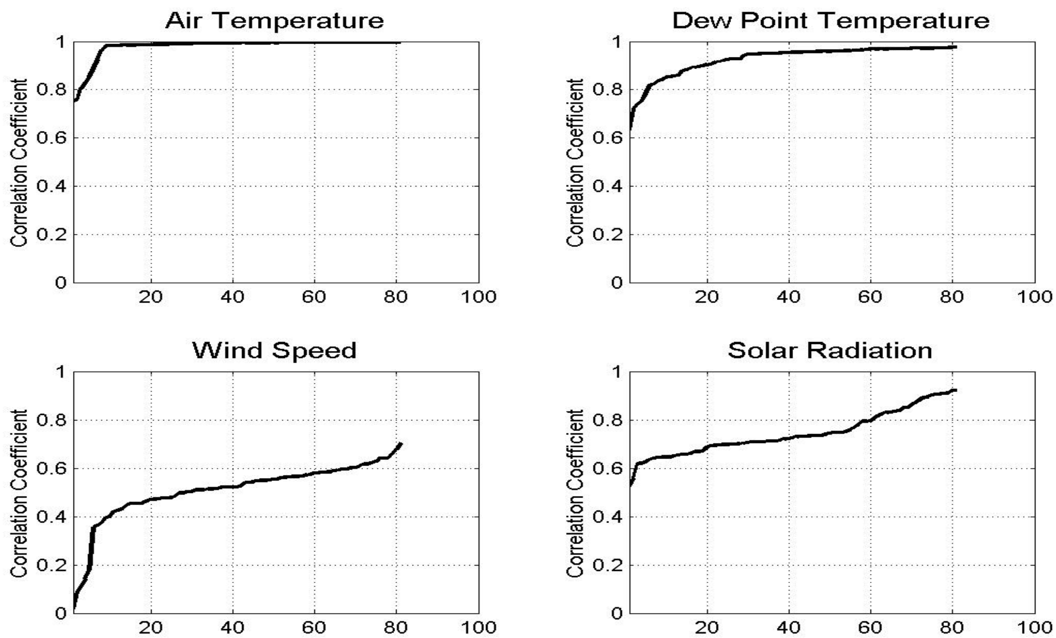

Figure 3 Correlation between SYNTRAN data and UW data

be consistent with the existing data set to reduce the need to re-calibrate hydrologic models. The PE estimates from NOAH land surface model should also be evaluated because these estimates can be easily available operationally.

Whether the PE values obtained are reasonable should be tested ultimately on real test basins. Hydrologists from NWS RFCs have been contacted to identify test basins where the different PE values can be evaluated. At the meeting, some highlights of these tests along with other progresses will be reported.

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