Daily Evapotranspiration - Radiation Model

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This document gives a brief description of the solar radiation model, the choice of model, and some justification of the model. We have begun with a model that is a combination of model Heliosat-I [BCH96] and Heliosat-II [RBW00, LAW02] This paper is a comparison of the differences between these models and the 2001 [GL97, FLG89] model.

1 Solar Radiation Model

The Heliosat-I model used a simple solar irradiance prediction model coupled with cloudiness parameters based on ratios of visible pixels from the Satellite. The Heliosat-II model updates the solar radiation model and also determines surface albedos by modeling the diffuse radiance, and transmission of the atmosphere. The 2001 model is a simple model that describes a one layer atmospheric model. Ground and cloud albedos are calculated from this model and then used to predict the surface insolation.

We have chosen to implement the radiative transfer from the Heliosat-II model, while retaining the ratio based approach of albedos to determine the cloudiness factors and their contribution to the solar insolation.

In the future, we plan to include both the Heliosat-II albedo estimations, as well as compare insolation predictions from the 2001 model. The following describes some of the main differences between the Heliosatbased models and the 2001 model.

Basic Radiative Model The Heliosat model basically combines aspects of aerosols, relative humidity, ozone, and molecular scattering into a single parameter, the Linke turbidity, T_l, which relates the optical depth for an arbitrary atmosphere to one of a Rayleigh only scattering atmosphere. Then, besides geometry, elevation, and some second order effects, the predicted insolation is a simple calculation using this parameter. For example, the direct beam calculation is $G_direct\ e^{-0.8662t_l(p/p_0)\gamma_r}$ where T_l is the Linke turbidity factor, p/p_0 is a elevation correction, and γ_R is the rayleigh optical depth. We have seasonal estimations of the Linke turbidity from a world database of this information.

The 2001 model on the other hand, uses six parameters to estimate the atmospheric effects.

The Heliosatmodel's simplicity allows use an easier formulation for modeling predicted changes in radiation. For example, we can use the seasonal model of Linke turbidity, but potentially make spatial changes to this estimation by comparing to the CIMIS radiation measurements.

One potential problem with using a model based on the Linke Turbidity is that it could conceivably be more difficult to tie the Linke Turbidity to the CIMIS based relative humidity measurements, which is another possible way to estimate the turbidity.

Integration The Heliosat-II model uses an analytical integration over solar angles, as opposed to other models which use approximations over instantaneous values. This has a number of advantages. The largest is in filling gaps caused by missing datasets. If for example, we have GOES satellite measurements from 9,11 am, we can simply fill in the missing 10 am value by extending the range of the other measurements. Using an analytical integration will assign the proper weights to the bounding measurements, in this case assigning a greater weight to the measurement at 11.

Even if we decide to use a different radiative transfer model, we can still take advantage of the integration methods developed here, although the integration functions are related directly to formulation of the radiation as described in the heliosat model.

Diffuse Radiation The 2001 model uses a simple model that basically combines direct and diffuse radiance

Cloud Cover One of the major differences between the Heliosat based model, and the 2001 model is in the calculation of the effects of cloud cover. The heliosat model uses an empirical relation that roughly linearly relates a measured cloud brightness with the clear-sky fraction. This empirical relation has been shown to be valid in a number of studies [BCH96]. The 2001 model instead uses a simple cloud model formulation to determine cloud albedo from pixel brightness. This results in a quadratic functional relationship between cloud brightness and downwelling radiance. Since the clear sky Heliosat2 model does not include cloud cover, we could compare these models at a later date.

Albedos One potential advantage of the 2001 model is that the model predicts absolute albedo values, whereas the Heliosat1 model uses relative brightness comparisons. We would like to compare the Heliosat1 and Heliosat2 model formulations, and at that point, we could calculate absolute albedos with

1.1 Comparisons

If we would like to compare the Heliosatmodel with the 2001 model, we would follow the following steps.

- Calculate true surface albedos using scattering and absorption cooeficients based either on the Heliosat2 method or 2001 method.
- Compute cloud albedo using the 2001 model. As discussed above, this is a quadratic equation that usually has a simple empirical formula for the cloud absorption.
- Using the computed cloud albedo, and the 2001 cloud model, compute the 2001 predicted surface radiance.
- Compare the two predicted radiance values to determine where the models differ, and using the CIMIS stations as an estimator of accuracy.

References

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