Urban Forest Effects-Dry Deposition (UFORE –D) Model Enhancements

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Surface Weather Data – NOAA Integrated Surface Hourly (ISH) Observations 2005

An ISH surface weather contains measurements at the top of hours (e.g. 9:00) as well as other timings (e.g. 9:53) at a single weather station for a year. Each record has a time stamp of the measurement. Even if a record for a certain time exists a weather value in the record may be missing.

First, missing values in the raw surface weather data are filled with the existing values depending on the locations in the record, time stamps, and weather variables.

Table 1 Missing value estimation algorithm for the raw surface weather data

Location of missing value in records	Surface weather variables		
	Wind direction Wind speed Station altimeter setting Station pressure Temperature Dew point temperature	Cloud ceiling height Sky cover	1-hour liquid precipitation Snow depth
First	Missing value is filled with the closest existing value. [1]	Missing value is filled with the closest existing value.[1]	Missing value is filled with 0.
Middle	Missing value is linearly estimated from two values existing before and after the missing value.[2]	Missing value is filled with the value next to the missing value.[3]	Missing value is filled with 0.
Last	Missing value is filled with the closest existing value.[4]	Missing value is filled with the closest existing value.[4]	Missing value is filled with 0.

[1]: e.g. when the temperature at 0:00 is missing, the value at 0:35 is copied to the missing value.

[2]: e.g. when the temperature at 4:54 is 54 °F, at 5:42 is missing, and at 5:54 is 56 °F, the value at 5:42 is calculated as $54 + \frac{56-54}{5:54-4:54} \times (5:42 - 4:54) = 55.6$

[3]: e.g. when the sky cover at 5:42 is missing, the value at 5:54 is copied to the missing value.

[4]: e.g. when the temperature at 23:00 is missing, the value at 22:00 is copied to the missing value.

Processed with the above method, no missing values exist in the surface weather record; however, a record for a top of the hour may be still missing. The method that follows next fills a value for the top of the hours, depending on weather variables and existing data sequences.

Table 2 Missing value estimation algorithm for data at the top of hours

Location of missing value in records	Surface weather variables		
	Wind direction Wind speed Station altimeter setting Station pressure Temperature Dew point temperature	Cloud ceiling height Sky cover	1-hour liquid precipitation Snow depth
Top of hours	Missing value is linearly estimated from two values existing before and after the missing value.[1]	Missing value is filled with the value closest to the missing value.[2]	Missing value is filled with the previous value if the time difference is less than 60 minutes. If the time difference is larger than 60 minutes, 0 is set to the missing value.[3]

[1]: e.g. when the temperature at 5:54 is 54 °F, at 6:00 is missing, and at 6:54 is 56 °F, the value at 6:00 is calculated as $54 + \frac{56-54}{6:54-5:54} \times (6:00 - 5:54) = 54.2$

[2]: e.g. when the sky cover at 2:54 is 7.5, at 3:00 is missing, and at 3:54 is 10, 7.5 is copied to the missing value.

[3]: e.g. when the 1-hour liquid precipitation at 14:54 is 0.06, at 15:00 is missing, and at 16:00 is also missing, 0.06 is copied to the missing value at 15:00, and 0 is set to the missing value at 16:00.

Mixing Height Calculation

Two US EPA programs, mixing height program (US EPA 1981, US EPA 1998) and PCRAMMET (US EPA 1999) were re-coded and integrated into UFORE D. The US EPA's mixing height program calculates twice-daily (i.e., in the morning and afternoon) mixing heights based on surface weather data and upper air sounding data, whereas the PCRAMMET interpolates hourly mixing heights based on the twice-daily mixing heights and surface weather data. The data employed are NOAA Integrated Surface Hourly (ISH) Observations 2005 and NCDC Global Radiosonde Data 2005.

Air Pollutant Monitor Data – US EPA Air Quality System (AQS) Data

Missing values in hourly CO, NO_2, O_3, PM10, and SO_2 measurements at nearly 2000 US EPA's monitoring sites across the United States in 2005 were interpolated with a newly developed algorithm and database structures (Hirabayashi and Endreny, in review). The missing values were interpolated based on hourly measurements and monthly averages at a nearby representative monitor site that had a full length of records for the year. The representative monitor site was determined for each missing value site based on locations in Air Quality Control Region (AQCR) and a correlation coefficient of the monthly averages of the sites.

LAI calculation

An annual variation of LAI is simulated for both northern and southern hemispheres, in which LAI has its maximum value during the growing season of a year and its minimum value in the winter. Transitions from the minimum to maximum and maximum to minimum values happen in four weeks centered in leaf on and leaf off days, respectively.

Figure 1 illustrates an example of LAI variations in the northern hemisphere in which minimum and maximum LAI is 0.5 and 5.0, respectively, and the leaf on and off day is 97th and 311th day of the year, respectively.

From day 1 to 82, LAI has its minimum value.
From day 83 to 111, LAI increase is calculated by

$$LAI = LAI_{min} + \frac{LAI_{max} - LAI_{min}}{1 + e^{[-0.37 \times (day\ of\ year - leaf\ on\ day)]}}$$

From day 112 to 296, LAI has its maximum value.

From day 297 to 325, LAI decrease is calculated by

$$LAI = LAI_{min} + \frac{LAI_{max} - LAI_{min}}{1 + e^{[-0.37 \times (leaf\ off\ day - day\ of\ year)]}}$$

From day 326 to 365, LAI has its minimum value.

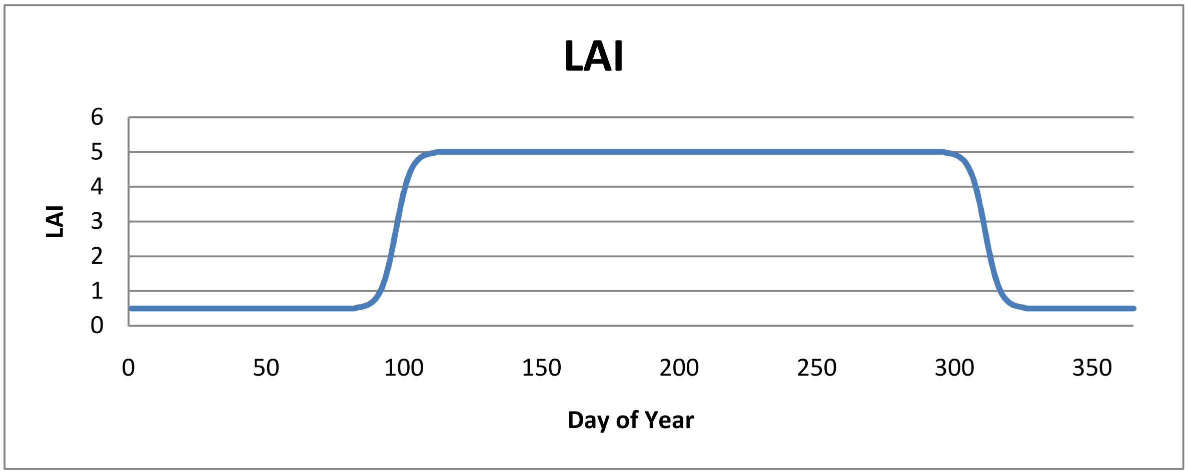

Figure 1 LAI annual variation

References

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