USE OF DECISION SUPPORT SOFTWARE SUCH AS PCM, WISP, AND WISDOM
requires input data on management and weather factors. There are two ways
to obtain the needed weather data: from measurements made somewhere
nearby, or from your own weather monitoring equipment. Is data gathered
nearby at the airport adequate, or do you need one or several weather stations
in your own fields? The goal is to have data from locations near enough to
each field to use and fully realize the benefits of decision aids like WISP, but to
not waste time and money collecting more data than is useful. In deciding how
and where to collect data for a specific field several questions arise:

- How does the weather factor vary across the landscape?
- How accurately do various weather factors need to be measured?
- How much time is required to manage and enter the data?
- What is the total cost of purchasing and maintaining any equipment
  needed?

Spatial Variation

How far away from a weather station are its measurements still accurate
eough to use? This is a longstanding problem that we have only partial
answers for. First, as with most all answers from Extension people, it
depends, mostly on what factor you are discussing. Daily maximum air
temperature is often quite similar across much of Wisconsin, while daily
minimums may vary more (Fig. 1). This is because during the day the wind
mixes up the atmosphere pretty well, so differences are wiped away across large
distances. At night, however, calm winds allow cold air to drain into and pool
in low areas, so the immediate setting of the thermometer can strongly
influence the measured temperature. While differences among sites may be
small, consistently higher readings from one site compared to another will
accumulate in thermal time calculations (degree-days). Even small differences
in how thermometers are displayed and shielded from the sky can cause
differences in accumulations like degree days. Before getting upset about
differences between degree day totals from two sources, check to see if just a 1°
difference in the thermometers might be the cause.

Spatial variation in solar radiation across the potato growing regions
was studied a few years ago. A discussion of some of this research was
radiation estimated from satellite data allowed us to simulate having hundreds
of pyranometers (which measure solar radiation) around the state. From this
we determined that a grid of weather stations spaced at about 60 miles apart
would provide adequate coverage for irrigation scheduling. This estimate
assumes that there are about 10 stations arranged neatly on a grid, and some
interpolation is done between the sites. If you rely on a single measurement, it should be within 25 mi of the field.

![Daily air temperatures at Arlington, Hancock, Antigo, and Chetek](image)

**Fig. 1** Daily maximum and minimum air temperatures at automated weather stations on agricultural sites at Arlington, Antigo, Hancock, and Chetek, during early summer of 1994. Note the several days when daily maximums differed from one another by much more than did the minimums.

An important measurement for fungicide spray scheduling is relative humidity within the canopy. This measurement is used to estimate how long the leaves of the crop are wet, and thus conducive to the onset of disease. Do you need a measurement in every field? Or county? This is one of the questions our current work on computer simulation of the potato canopy environment will help us answer. A couple of years ago we measured the amount of water condensed in a canopy at night, along with the weather factors we needed to test a computer model of the process. Two nights yielded nearly complete datasets, one with quite dry soil (Figure 2) and the other
immediately after irrigation (Figure 3). In both cases the computer simulation (after some persuasion) reproduced the measured amounts of water as well as can be expected. Thus the simulation does a reasonable job of telling us about the canopy environment. This allowed us to then run the computer model with both wet and dry soil on both nights. The results in Fig. 2 and 3 show that we expect about a 2-hour increase in the duration of leaf wetness depending on whether the soil is dry or wet. Large differences can occur in soil wetness due to when the field was last irrigated. Since this appears to be an important factor in leaf wetness, measurements in nearby fields may be necessary, or a correction made to data if it is used in another field with different soil wetness.

Figure 2. Measured and simulated mass of water condensed on a canopy of potato leaves on a night when the soil was wet.
Summarizing the importance of how weather factors vary across the landscape, it appears that solar radiation (and so evapotranspiration) can be measured at up to 25 miles from the site where it will be used. (We will be producing satellite-derived maps of evaporation for the entire state next summer, so you will be able to get a value for exactly your location.) Temperature measurements vary as much due to how the thermometer is displayed as due to real differences in temperature across counties. Serious errors can result in maximum temperature if a thermometer is not properly shielded from sunlight, while smaller differences arise in minimum temperature due to the topography surrounding the thermometer. A measurement made miles away can be used as long as the weather station is properly setup and not in a very low area. The duration of leaf wetness (represented by canopy humidity) must be estimated with more care than the others, probably, because of the effect of soil wetness where the measurement is made or applied.

Figure 3. Measured and simulated mass of water condensed on a canopy of potato leaves on a night when the soil was dry.
Accuracy

The pyranometers and thermometers in most automated weather stations are sufficiently accurate for potato crop management. Pyranometers costing about $200 are very stable, and calibration checks are needed only every 2 or 3 years; changes will be less than 5%. Even new instruments must be kept free of dust to perform properly.

Temperature sensors in even inexpensive home units are likely accurate enough when new (±1°F), but continued performance over a few years may be a problem. You should check them carefully. Good quality sensors, costing around $50, should be stable for years unless the waterproof seal is broken and they are exposed to water (say if used in soil).

Relative humidity is the most difficult of these three factors to measure. Sensors (alone, no electronics) costing $300-$500 seem to be stable to within a few % of relative humidity for at least 2 years. I would be suspicious of very inexpensive units, since calibrations could shift enough to underestimate the duration of high canopy humidity. The specifications from the manufacturer are inevitably optimistic, some wildly so. Accurately measuring humidity above about 95% is pretty tough for any instrument, so do not be greatly concerned about precision near 100%.

Data collection and Management

Data can be gathered from a number of automated weather station designs by telephone (both cellular and regular), radio, infra-red beam, wires, by momentarily connecting a memory pod or computer that you carry from site to site, or by writing-down numbers from a display. Except for the last option, these choices result in rapid transfer from your weather station to your computer. Getting the needed numbers from a file on your computer into the decision support software (eg, WISDOM) depends on the software, but there is no reason for it to be a problem. All manual steps required in data collection and transfer must be done frequently, and are annoying repetitive, so it is worth getting the equipment or programs needed to make it as automatic as possible.

We are working on new data products such as evapotranspiration estimates and leaf wetness duration guidance that will be produced by satellite and radar observations, and computer models. These will be made available to you by way of the Internet, in a way that your computer will be able to retrieve the data you need. We believe that most of the weather factors you will require to run programs like WISDOM will be available this way, but it will be another 2 years before all are online.
Cost

Automated weather stations cost between $1000 and $2500. Annual operation cost include a permanent telephone line dedicated to the station at $300 to $400, expense of recalibrating sensors at least $100 every two years, and the labor needed to check the data, look-over the station, and troubleshoot the inevitable problems. Our experience with the Agricultural Research Station staff is that they find it difficult to add regular checks of our weather stations to their schedules. It is one more task that is easily forgotten.

Conclusions

It appears that weather observations made some distance from a particular field can be used for potato crop management. An important exception may be canopy relative humidity, although this has not been proven, and the available disease models may not merit very precise data. One current reason for having a weather station on-farm is ease of getting data from the station into your computer. We believe, however, that improvements in computer networking, especially the World Wide Web, will soon make it easy to grab data from remote computers. New data products derived from satellite observations and computer models may provide all your needs within a few years.

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