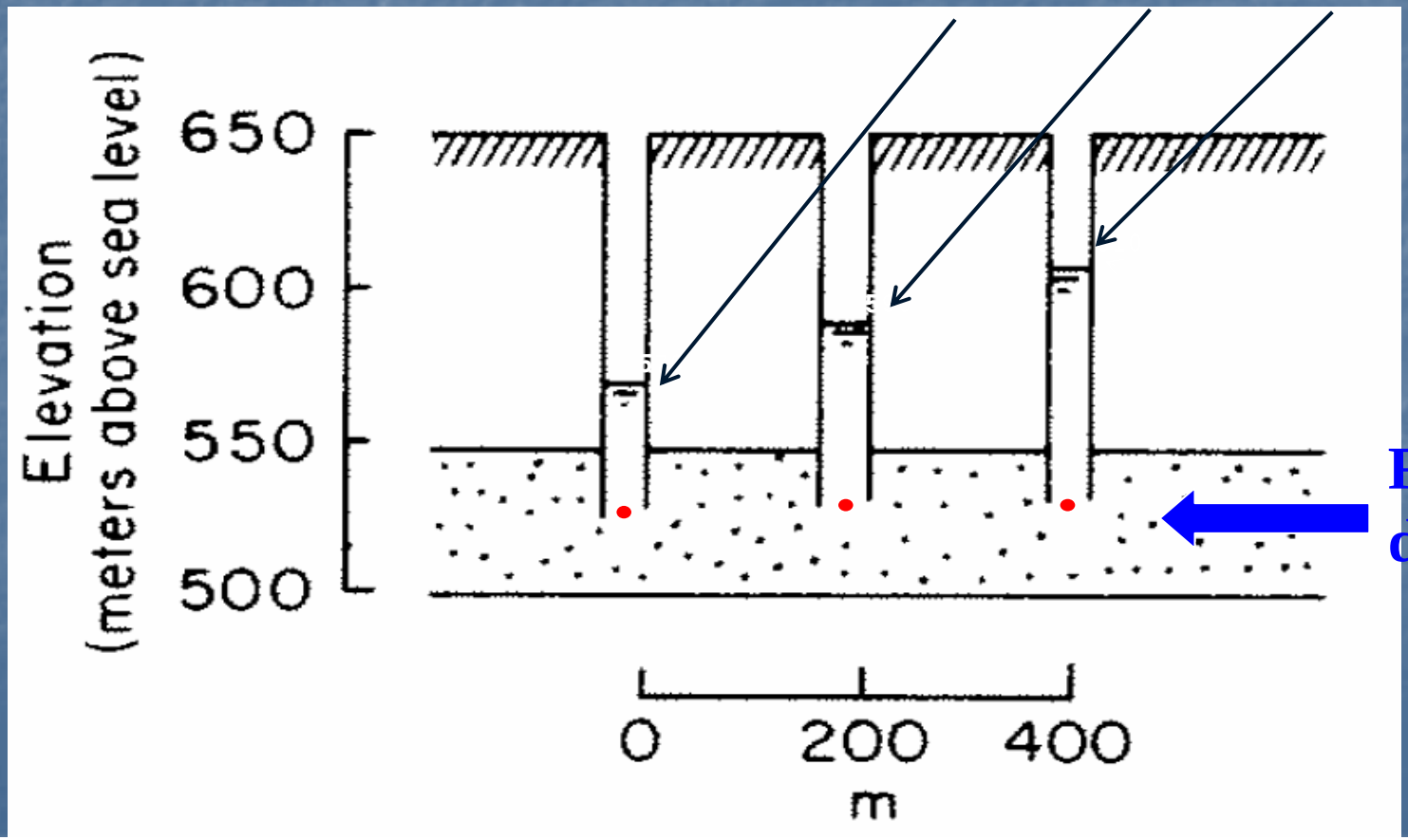
Measuring Water Levels

- Two main reasons:
  1. Measure groundwater gradients to calculate groundwater flow:
     - Horizontal;
     - Vertical;
  2. Measure water levels in a stream to calculate discharge;

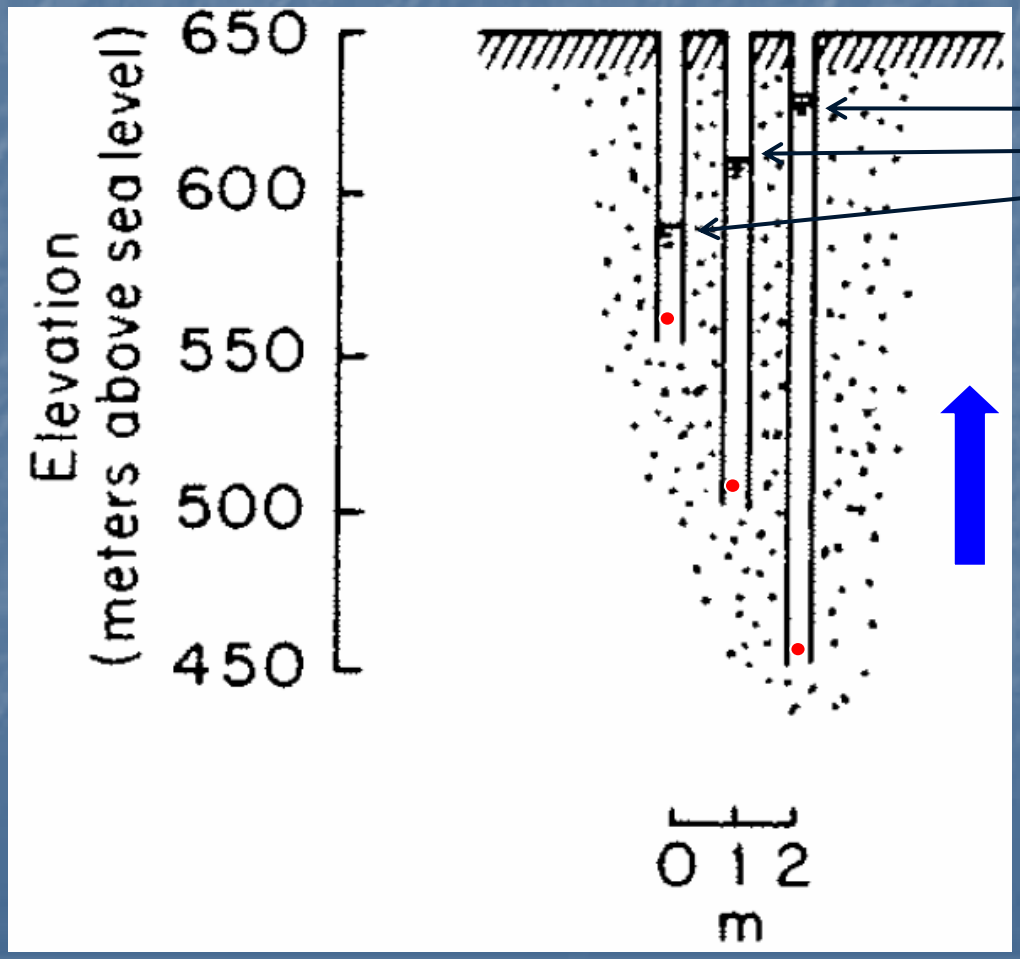
Why measure water levels?

- Determine groundwater gradients:
  - Horizontal flow



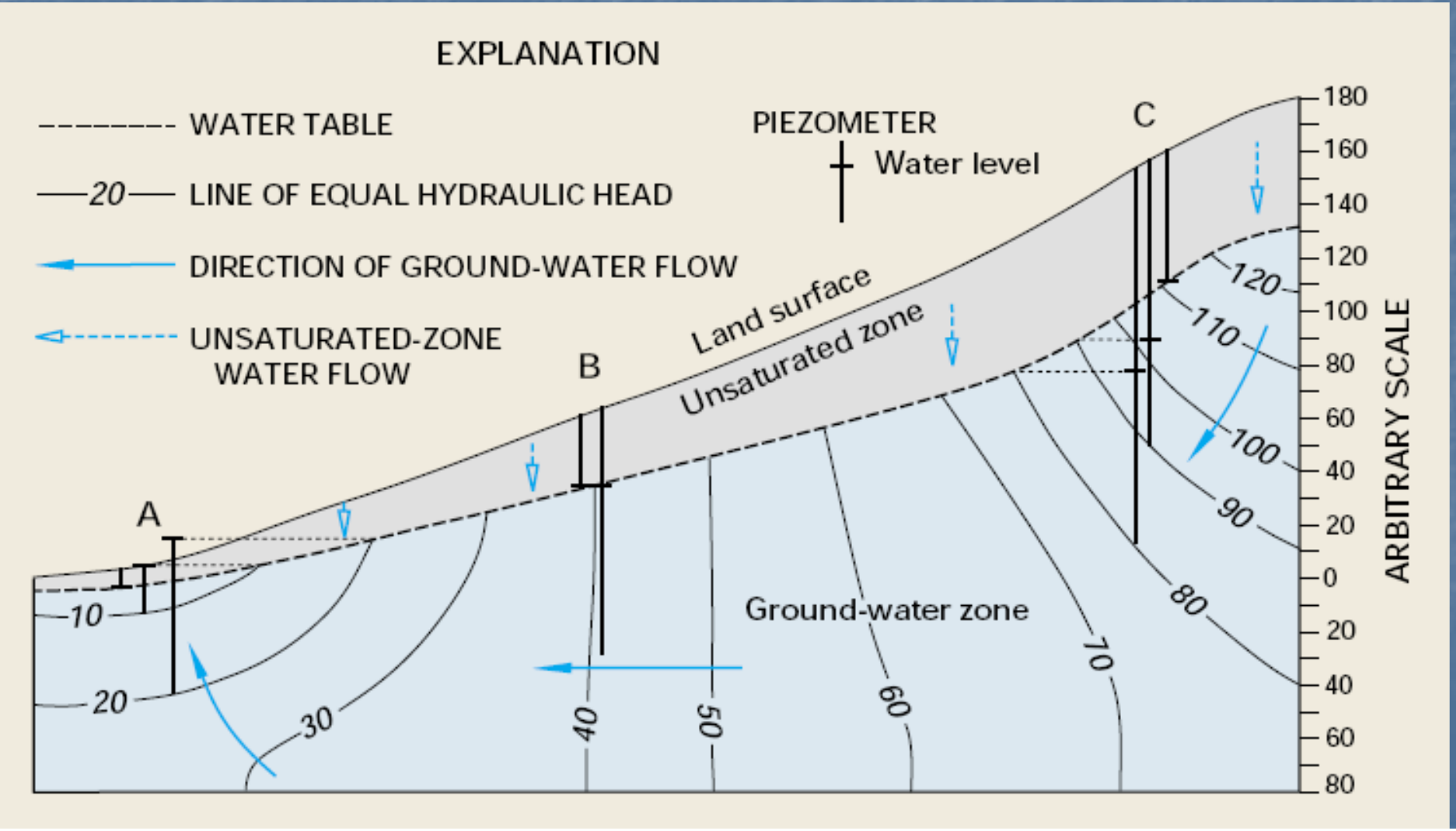
Why measure water levels?

- Determine groundwater flow:
  - Vertical gradients

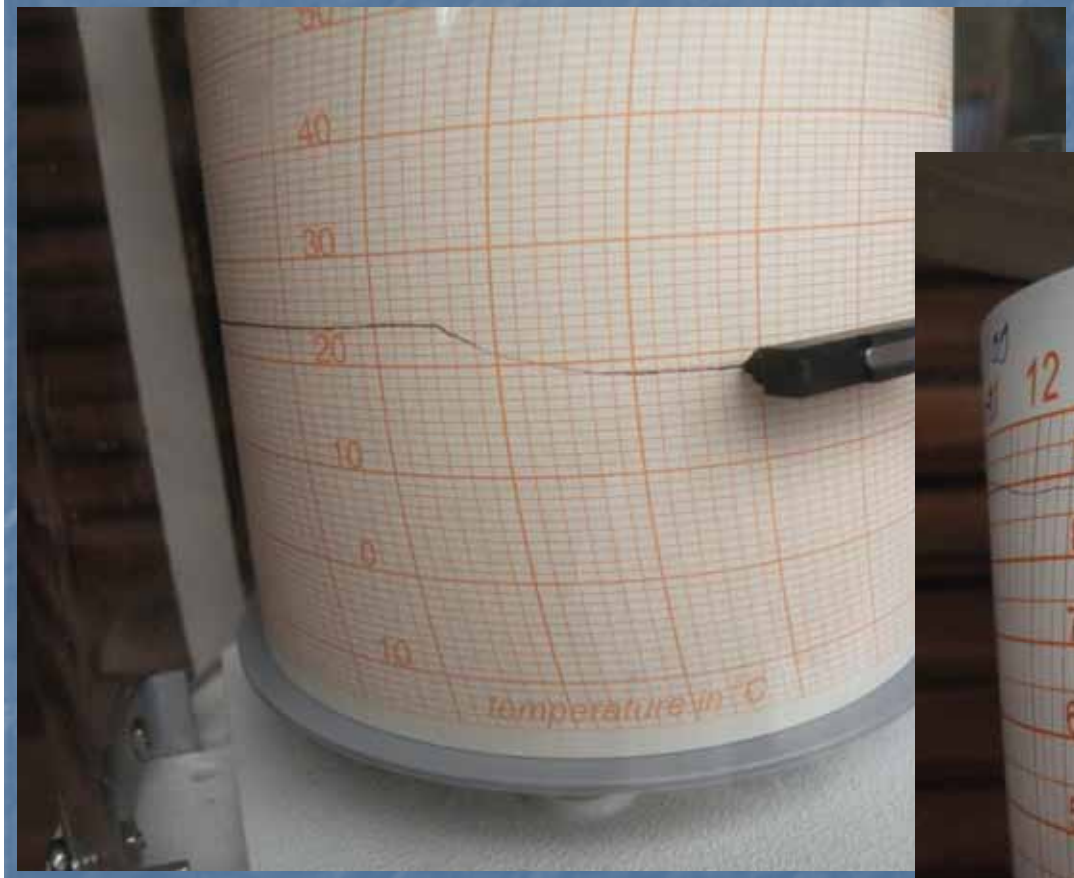


Why measure water levels?

- Develop groundwater flow maps



Effect of rain on temperature and relative humidity at VFU, 20 February 2009



Temperature

Relative humidity

Electronic vs. Manual Data Collection

- In developed countries there is a trend away from manual measurements, while in Vietnam most data still collected manually;

- What are the advantages and disadvantages of electronic data collection systems vs. manual data collection? (list with students)

Electronic Data Collection

- All systems require:
  1. Sensors (e.g., temperature, number of tips, water level, radiation, . . .);
  2. Data storage;
  3. Power supply;
  4. Clock to keep track of time;
  5. Software to download data.
- Wide range of choices for each of these except the clock.

Electronic Data Collection

- Most decisions depend on your objectives:
  - What measurements do you want to make (e.g., just temperature), or many types of measurements at a location (e.g., temperature, humidity, radiation, soil moisture, etc.)?
  - What accuracy and precision?
  - What frequency of measurements?
    - Every second?
    - Hourly?
    - Daily?

Electronic Data Collection

- Most decisions depend on your objectives:
  - Frequency x number of sensors = data storage capacity;
  - Data storage rarely limiting, but can affect cost;
  - Do you want to collect data at specific intervals, or be able to calculate the mean, minimum, or maximum, and store those values?
  - Do you want the sensors to be smart?
    - E.g., if the water level changes by x, then y?

Electronic Data Collection

- Most decisions depend on your objectives:
  - How frequently will you visit the site?
  - What supply of power is available?
    - Line power, but need backup in case the power fails!
    - Solar power, but need battery for storage!
    - Batteries, which will eventually need replacing!
  - What range of conditions will you experience?
    - Freezing;
    - Animals chewing on wires;
    - Theft or disturbance by people?
    - Wind, rain, lightning, etc.

Electronic Data Collection

- Most decisions depend on your objectives:
  - How do you want to collect the data?
    - Download by site visit with laptop?
    - Download to a data shuttle?
    - Bring sensor back to your office?
    - Swap out storage units?
    - Remotely:
      - Cell phone
      - Wireless
      - Satellite

Electronic Data Collection

- Most decisions depend on your objectives:
  - How much do you want to spend?
  - What level of expertise and manpower do you have for data collection?

Electronic Data: Cautionary Notes

- Collecting electronic data is like trying to drink from a fire hose:
- Example: Five sites
  - Temperature, relative humidity, wind, soil moisture at two depths (n=5);
  - Measurements every hour (n=24 per day);
  - 5 x 5 x 24 = 600 data points per day, or 219,000 data points per year!
- Who will check these data for accuracy and consistency?
- Collecting data is the easy part!

Collecting Data: Cautionary Notes

- The events of most interest will occur at inconvenient times (e.g., during Tet holiday, at 3 a.m., etc.);
- Equipment is most likely to fail when the data are of most interest (e.g., large storms and floods);
- Timing is critical (if your laptops are set to different times, the data will not match and relationships will not be accurately represented!

Collecting Data: Cautionary Notes

- Relying on electronic data can lead to a lack of field-based understanding;
- Less field observations means that important processes or factors may be overlooked;
- People usually have excessive faith in the accuracy of electronic data;

Davis weather station, VFU

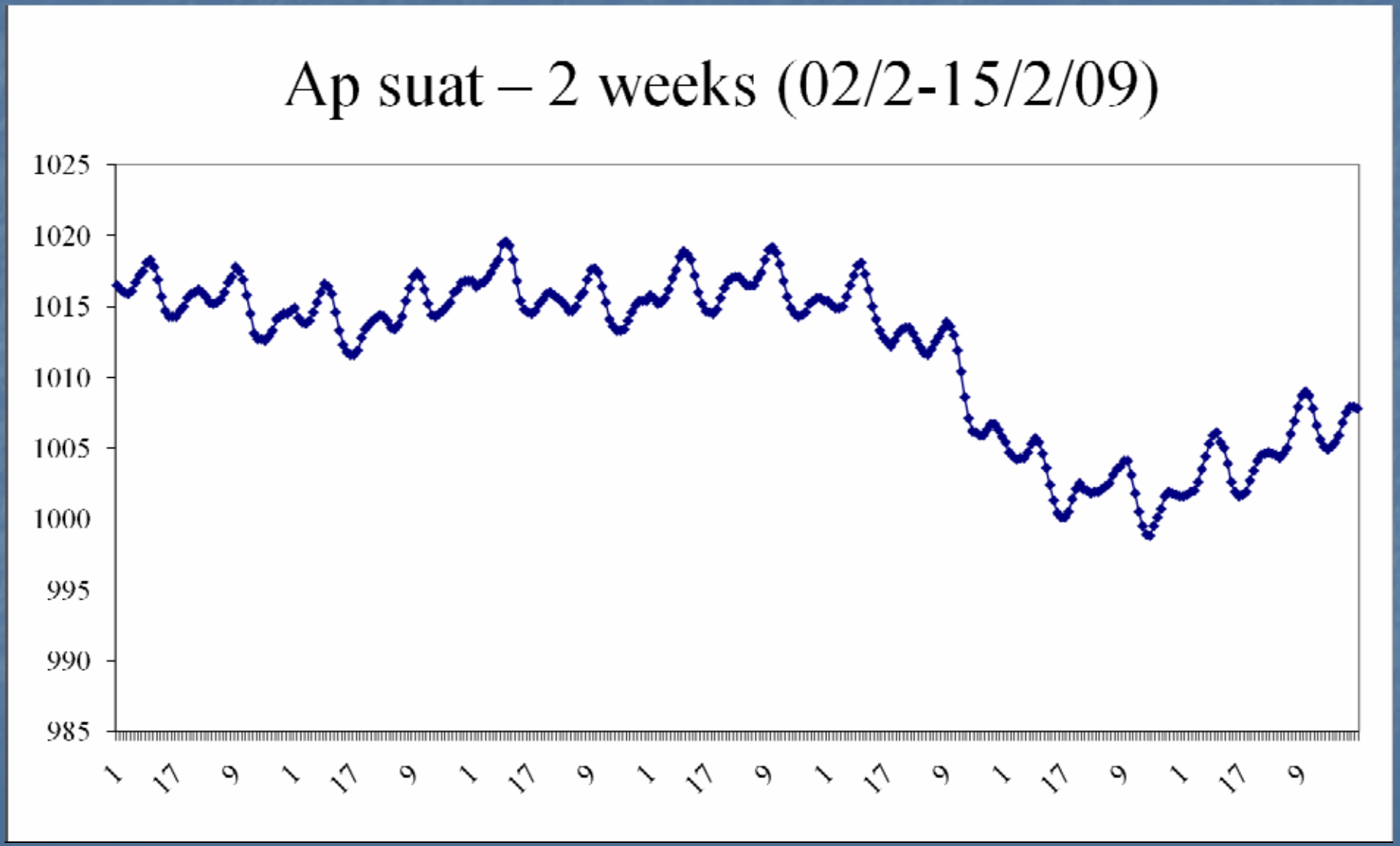


Figure by Mr. Li

Davis weather station, VFU

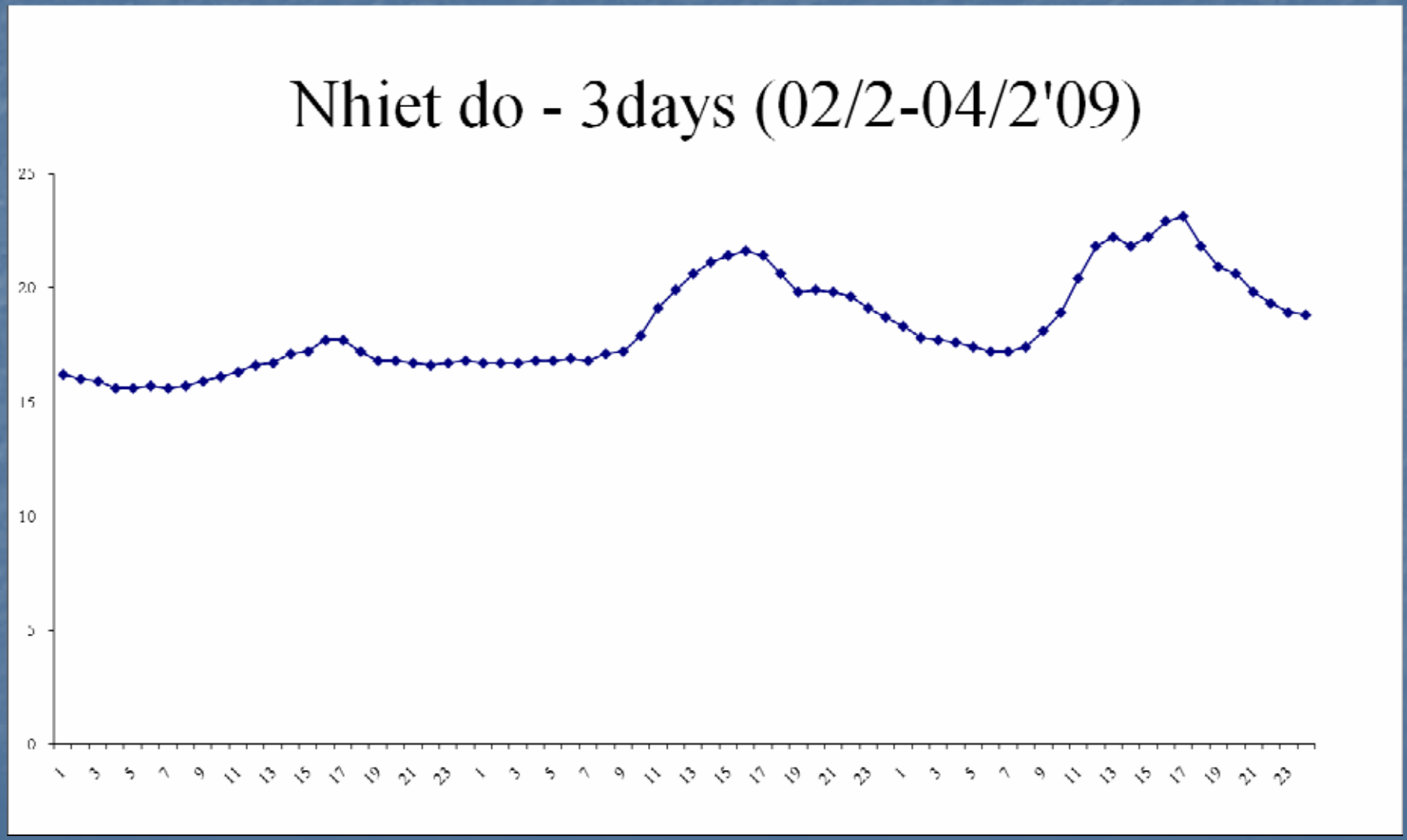


Figure by Mr. Li

Davis weather station, VFU

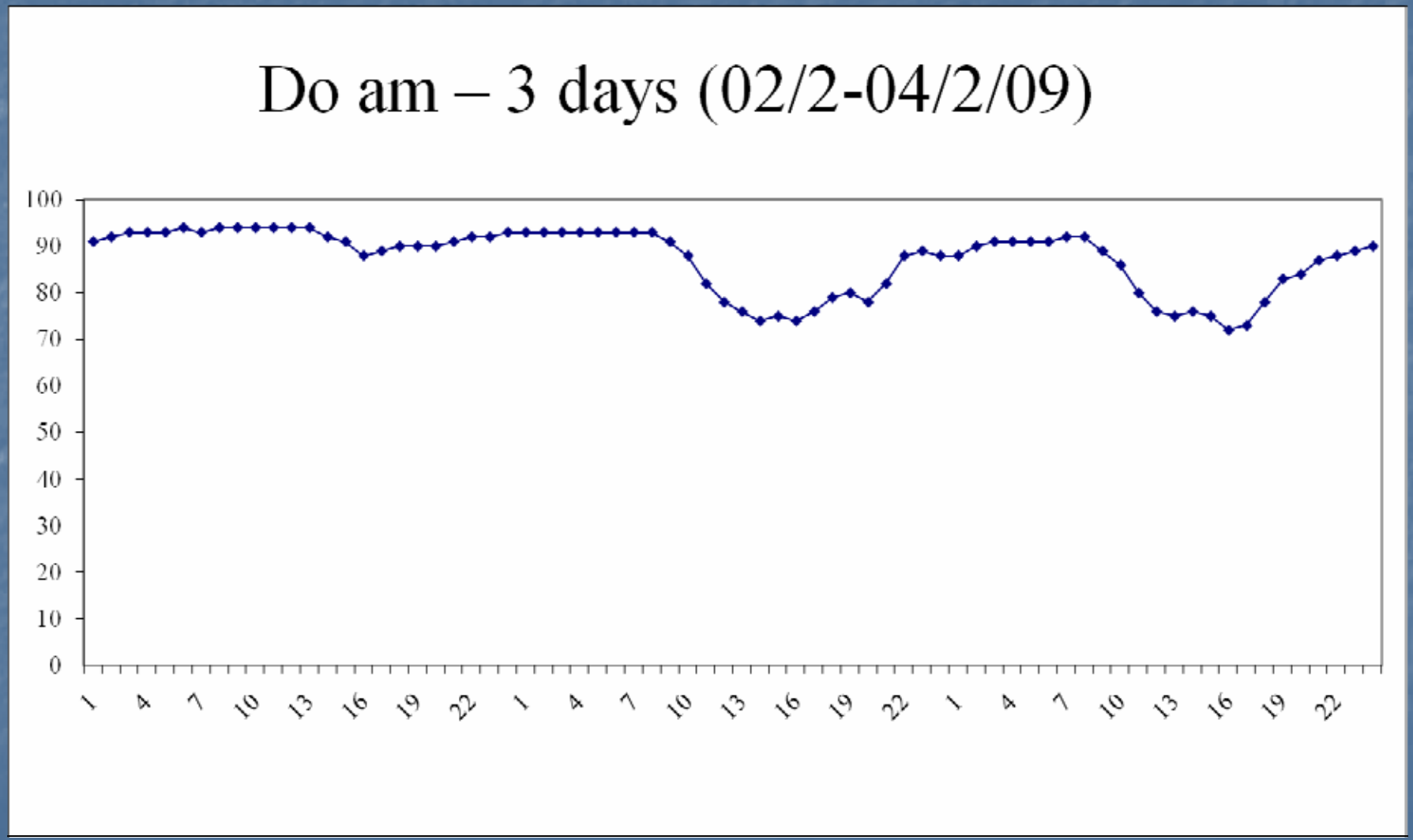


Figure by Mr. Li

Davis weather station, VFU

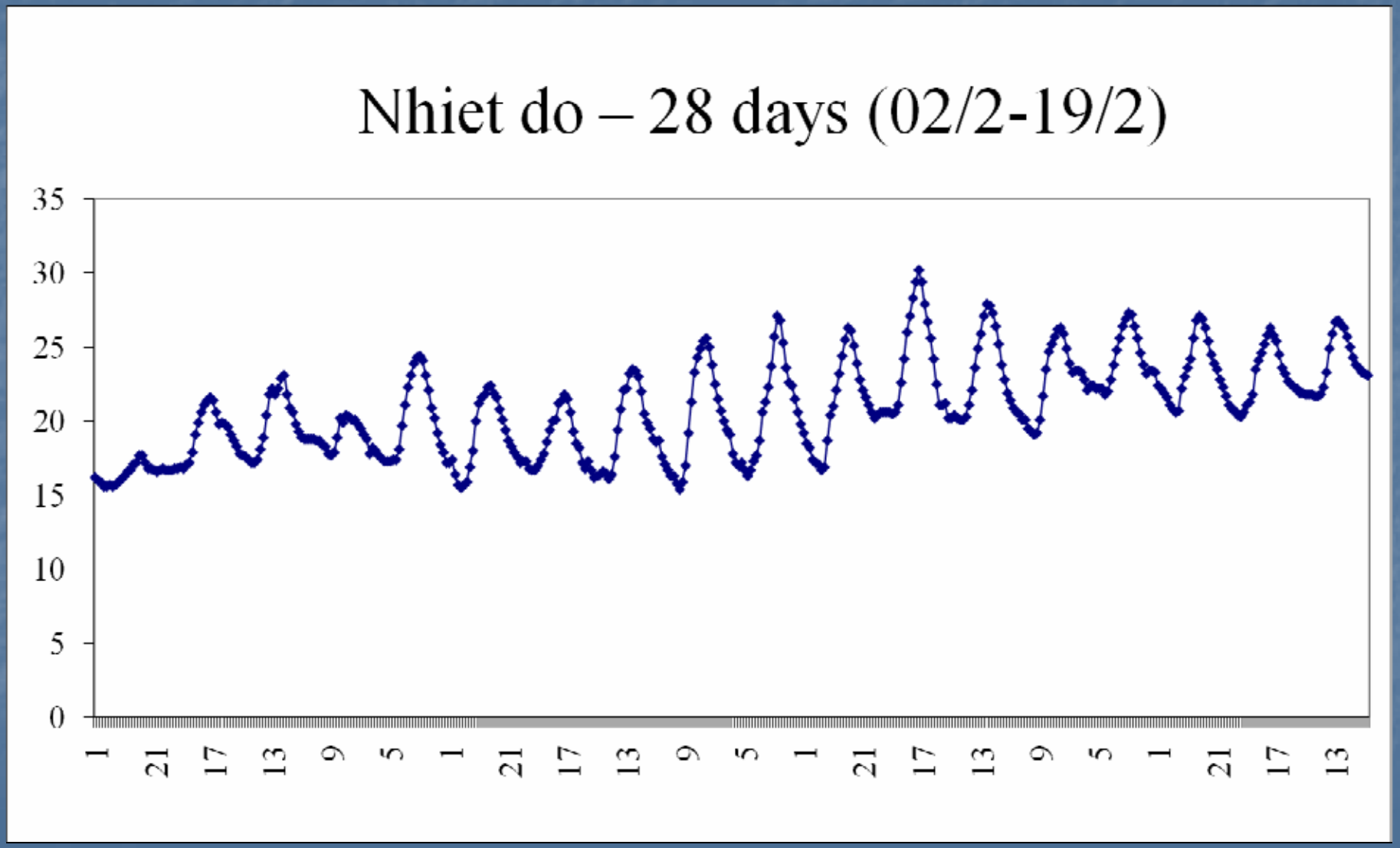


Figure by Mr. Li

Davis weather station, VFU

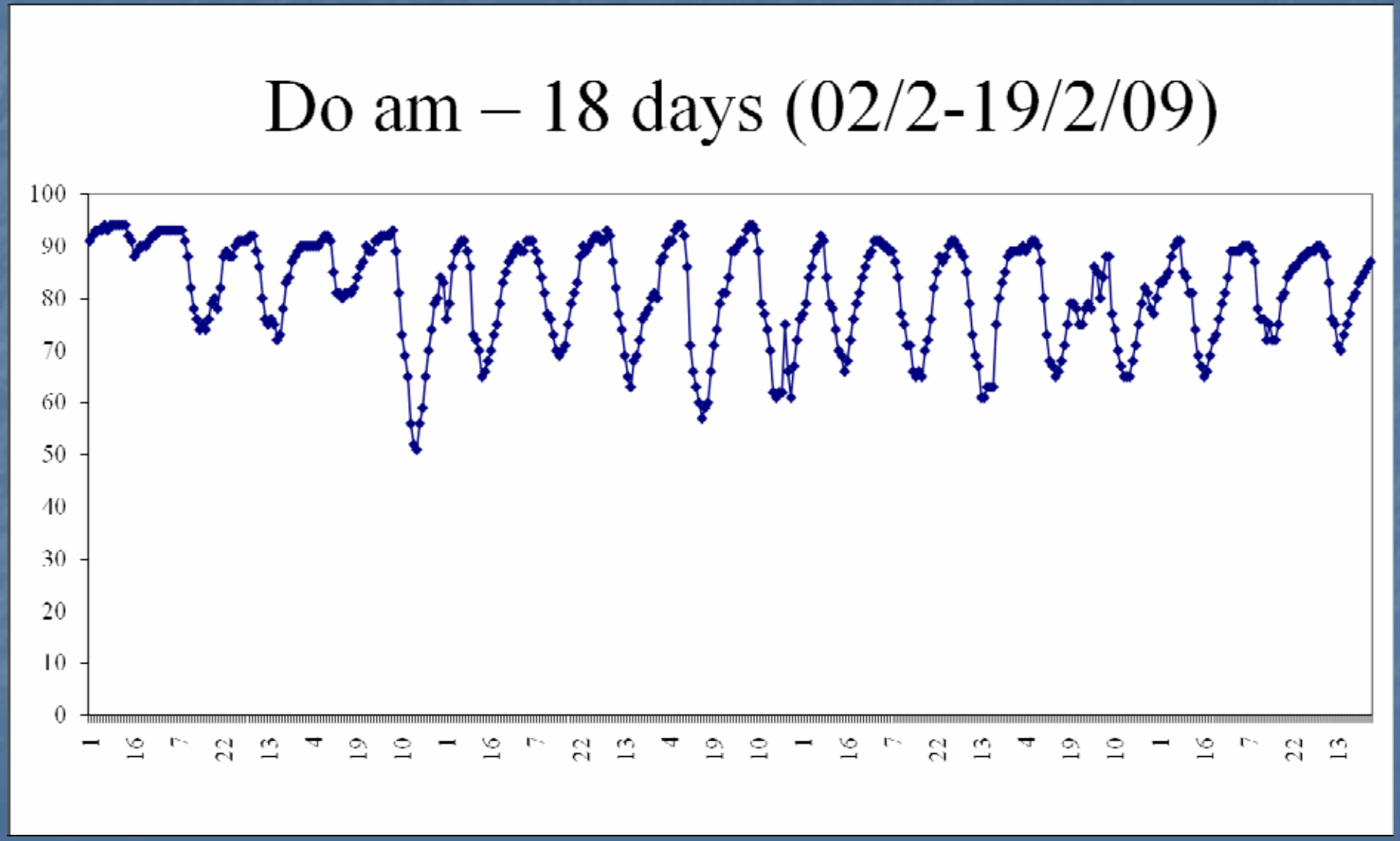


Figure by Mr. Li

Davis weather station, VFU

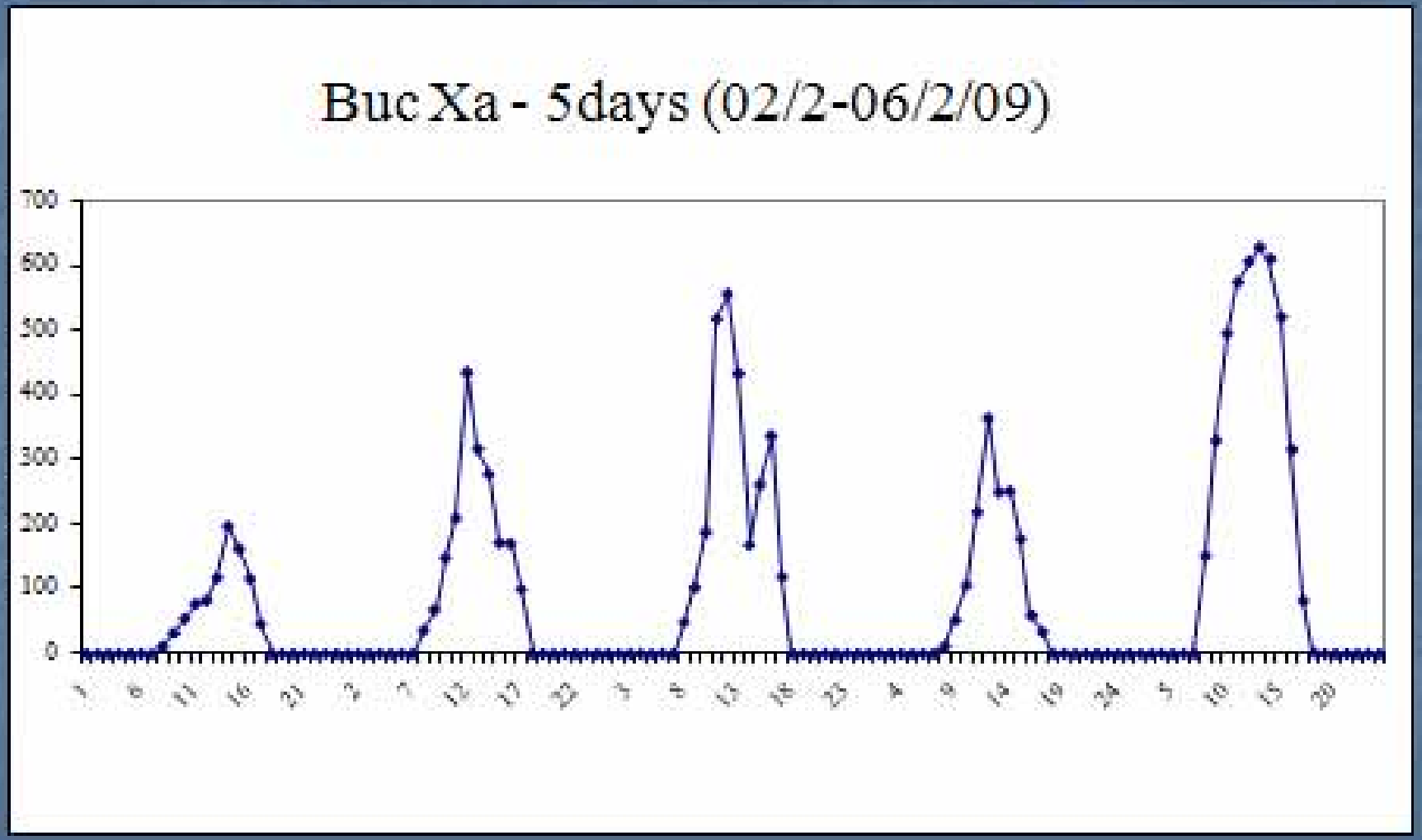
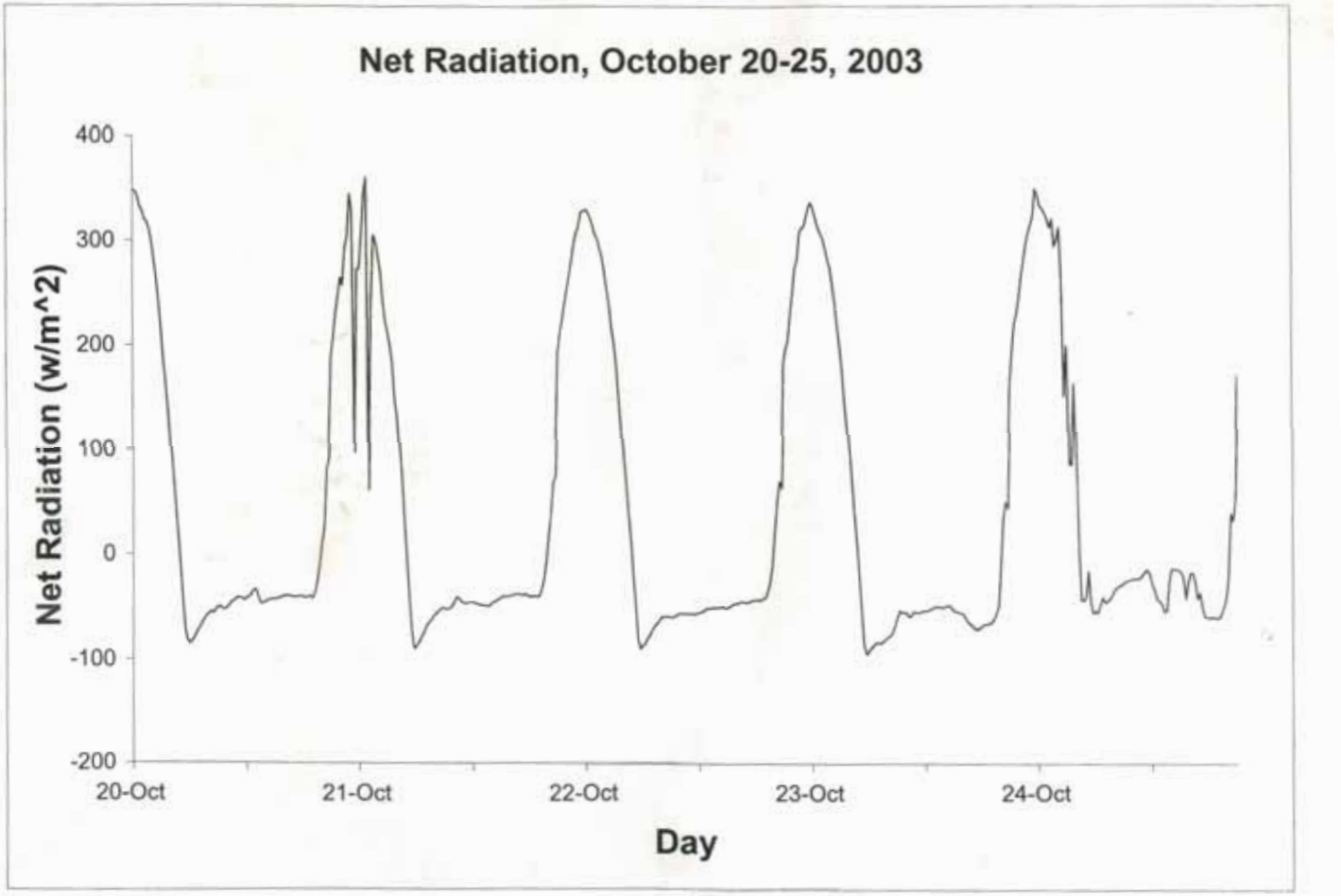


Figure by Mr. Li

Net radiation, Fort Collins, CO



Electronic Data: Bottom Line

- You need to be very specific and clear about what you are trying to accomplish and what you want to represent;
- Objectives and budget drive the decisions;
- You need to build some redundancy into the system if you want to be absolutely certain to collect data;
  - For example, have an electronic sensor **and** a chart recorder.
- Things are generally getting easier and cheaper!