Spatial CIMIS and Agricultural Water Use Efficiency in CA.

Kent Frame
Program Manager II

California Department of Water Resources (DWR)
Division of Statewide Integrated Water Management
Water Use & Efficiency Branch

Problems In California

- Population is projected to increase to 59.5 million by 2050.
- Urban water demand is estimated to increase.
- Agricultural water demand is expected to decline slightly because of a reduction in agricultural acreage.
- Environmental water demand is expected to increase.

Problems, cont:

- CA is perpetually Water short due to;
  - Hydrology
  - Regulatory
  - Environmental
  - Infrastructure
  - Reliability
  - Climate change

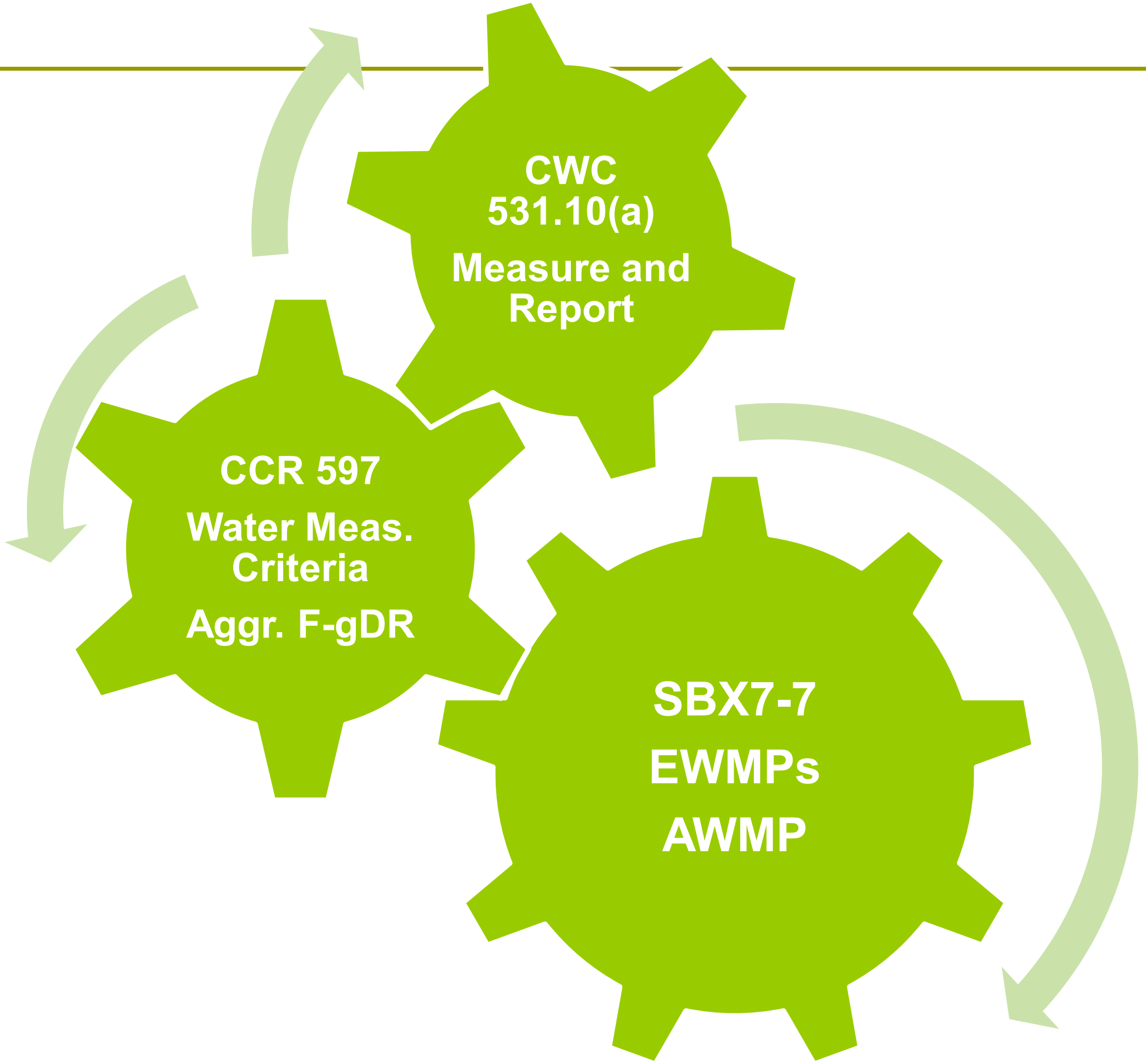
Implications?

- There will be an increase in demand and competition for limited water supplies.
- Water conservation, an efficient use of water by avoiding unnecessary and wasteful uses, can mitigate the problem.
- Planning – water management planning and WUE can help prepare and mitigate

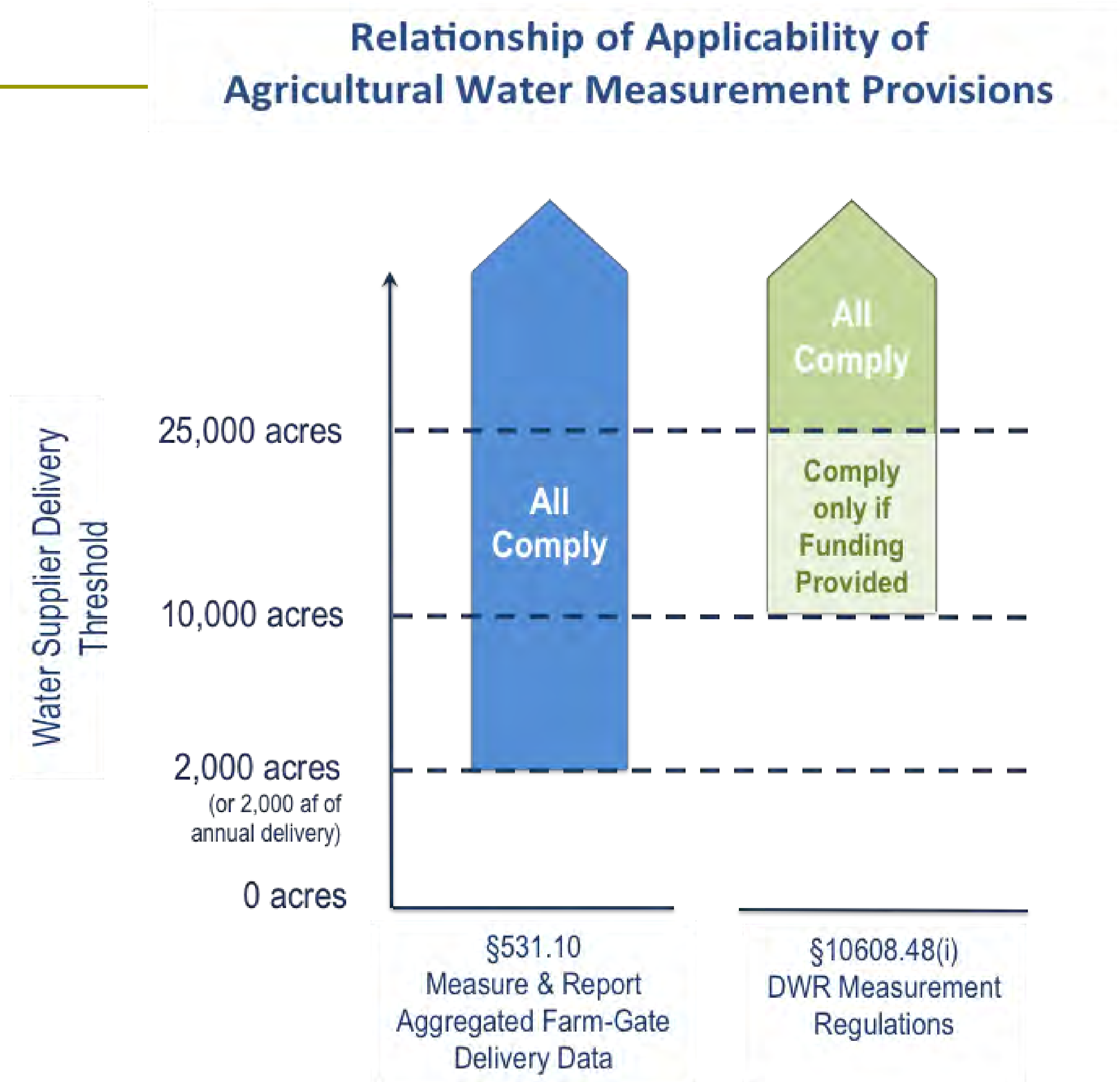
So what did we do?

Planning, regulatory, and data tools and technology

- SB X7-7 (Drought Proclamation Feb, 2009 November, 2009)
  - AWMP & EWMP's
  - Ag Water Measurement Regulation
  - Quantification of Ag Water Use Efficiency
- Spatial CIMIS


CWC 531.10(a)
Measure and Report
CCR 597
Water Meas. Criteria
Aggr. F-gDR
SBX7-7
EWMPs
AWMP

This applies to EWMP's, AWMP and the



Compliance Options

Option 1

- **SBX7-7 AWMP**

Option 2

- **AWMC-MOU** water management plan + additional documentation for EWMPs and Ag. Water Measurement Regulation

Option 3

- **USBR CVPIA/RRA** water conservation plan + additional documentation for Ag. Water Measurement Regulation

EWMPs Comparison

SBX7-7 EWMP	AWMC MOU	USBR BMP
Critical		
1 – Water Measurement	C-1	Critical 1
2 - Volume-Based Pricing	--	Critical 4
Conditional		
1 – Alternate Land Use	B-1	Exemptible 1
2 – Recycled Water Use	B-2	Exemptible 2
3 – On-Farm Irrigation Capital Improvements	B-3	Exemptible 3
4 – Incentive Pricing Structure	C-2	Exemptible 4
5 – Infrastructure Improvements	B-5	Exemptible 5a Exemptible 5b

EWMPs Comparison (cont.)

SBX7-7 EWMP	AWMC MOU	USBR BMP
Conditional *(continued)*		
6 – Order/Delivery Flexibility	B-6	Exemptible 6
7 – Supplier Spill and Tailwater Systems	B-7	Exemptible 7
8 – Conjunctive Use	B-8	Exemptible 9
9 – Automated Canal Controls	B-9	Exemptible 10
10 – Customer Pump Test/Eval.	--	Exemptible 11
11 – Water Conservation Coordinator	A-2	Critical 2
12 – Water Management Services to Customers	A-3	Critical 3
13 – Identify Institutional Changes	A-5	--

EWMP's Reporting

Report in AWMP or water conservation plan to be eligible for State grant funding:

- EWMPs that have been implemented
- EWMPs planned to be implemented
- An estimate of the water use efficiency improvements that have occurred since the last report
- An estimate of the water use efficiency improvements estimated to occur five to ten years
- Information for the determination that an EWMP is not locally cost-effective or technically feasible to be eligible for State grant funding

AWMP Option 1

- Prepare an AWMP in accordance with the Guideline and SBX7-7 Article 2. Contents of Plans §10826
  - Include EWMP information
  - Include Agriculture Water Measurement Regulation documentation
- Coordinate with public and other entities in accordance with §10821(a) and Article 3. Adoption and Implementation of Plans

Option 1

Contents of Plan

Section I: Plan Preparation and Adoption

Section II: Description of the Agricultural Water Supplier and Service Area

Section III: Description of the Quantity of Water Uses of the Agricultural Water Supplier (Demands)

Section IV: Description of Quantity and Quality of the Water Resources of the Agricultural Water Supplier

Section V: Water Accounting and Water Supply Reliability

Section VI: Climate Change

Section VII: Water Use Efficiency Information

EWMP Implementation and Reporting

Documentation For Non-Implemented EWMPs

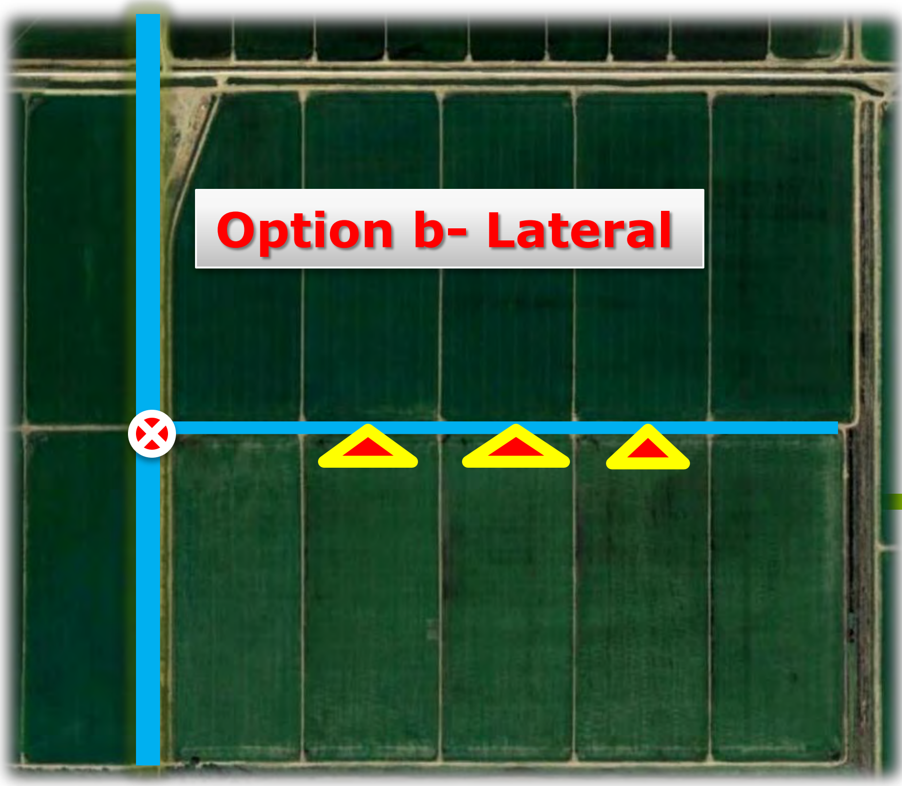
Agricultural Water Measurement Regulation Contents

- Applicability*
- Range of options
  a. Farm-gate standards (5, 10, 12%)
  b. Lateral standards (5, 10, 12%)
- Certification and Performance Requirements
- Document submittal and retention

* DWR, QSA- Exempt

Measurement Options

Accuracy Standards:
Laboratory certified -5%
Non-lab certified- 10%
Field tested/inspected- 12%



Accuracy Standards:
Laboratory certified -5%
Non-lab certified- 10%
Field tested- 12%

SB X7-7 Requirement;

- As specified by the Legislature upon enacting Section 10608.64 of the California Water Code, the Department of Water Resources (DWR) has been directed to "*develop a methodology for quantifying the efficiency of agricultural water use.*"
- *Alternatives to be assessed shall include, but not be limited to, determination of efficiency levels based on crop type or irrigation system distribution uniformity.*
- *the DWR shall report to the Legislature on a proposed methodology and a plan for implementation. The plan shall include the estimated implementation costs and the types of data needed to support the methodology.*

What's in the Report to the Legislature?

- Purpose of Quantification
- Water management methods
- Productivity indicators
- Implementation plan – a plan for implementation by growers, agricultural water suppliers and DWR and the estimated cost of implementation as well as data needed to support the methodology.

Methodologies Considering

- Water management methods applicable at the field, water supplier, and regional scale:
  - Consumptive Use Fraction
  - Agronomic Beneficial Use Fraction
  - Total Beneficial Use Fraction
- Water management method applicable at only the field scale:
  - Distribution Uniformity
- Water management methods applicable at the water supplier and regional scale only:
  - Delivery Fraction
  - Water Management Fraction

Components of a water balance used in the methodology

- *Agronomic needs* = the portion of applied water directed to help produce the desired agricultural commodity, such as water applied for salinity management or frost control, decomposition, and other water applications essential for production of crops.
- *Environmental needs* = the additional portion of applied water directed to environmental purposes, such as water for wetland, riparian or terrestrial habitat.
- *Evapotranspiration of Applied Water (ETAW)* = Total evapotranspiration of a crop minus estimated quantity of effective precipitation.
- *Recoverable Flows* = the estimated or measured quantity of water leaving the defined scale as either surface flows or percolation to underlying useable aquifers.
- *Applied Water* = the total amount of water that is diverted from any source to meet the demands of water users without adjusting for water that is used up, returned to the developed supply or irrecoverable.

Indicators

The productivity indicator compares the input of water to the output of crop production,

Examples of this approach generally attempt to relate elements such as;

(1) productivity – the ratio of tons of crop produced to the volume of water applied, or
(2) value of production – the ratio of gross crop revenue received for a commodity to the volume of water applied while producing it.

Describing Ag Water Use Efficiency

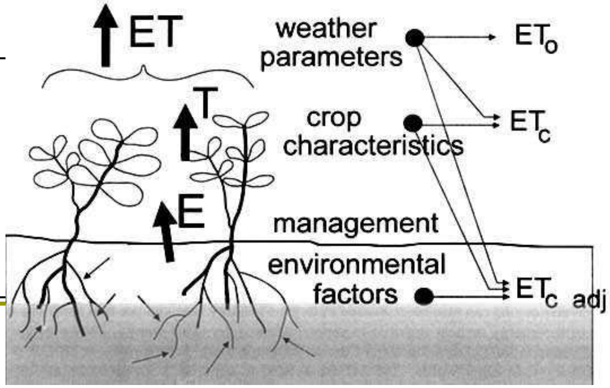
- Reduction in water use -- AW or NW
  - Ag AW decreased 14.5% (1967-2007)
- Crop production efficiency - crop/drop

  (Tons per acre-foot applied water)
  - Increased 38% (32 crops 1980-2000)
- Economic efficiency -- $/drop

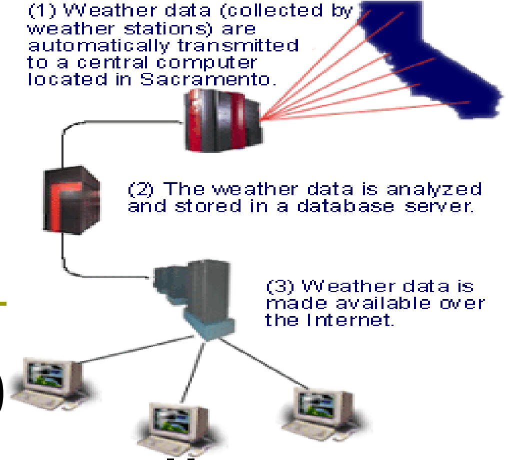
  (Adjusted $ per acre-foot applied water)
  - Increased 11%   (1980-2000)
  - Increased 115% (1967-2007)
- Quantifiable Objectives & Targeted Benefits

22

Evapotranspiration



- ET – loss of water to the atmosphere by the combined processes of <u>evaporation</u> (E) and <u>transpiration</u> (T).
- The California Water Plan Update estimates that 65% of the average 200-maf annual precipitation in California is consumed through ET.
- That is why DWR, in cooperation with UC Davis, developed CIMIS in the 1980s.



What is CIMIS?

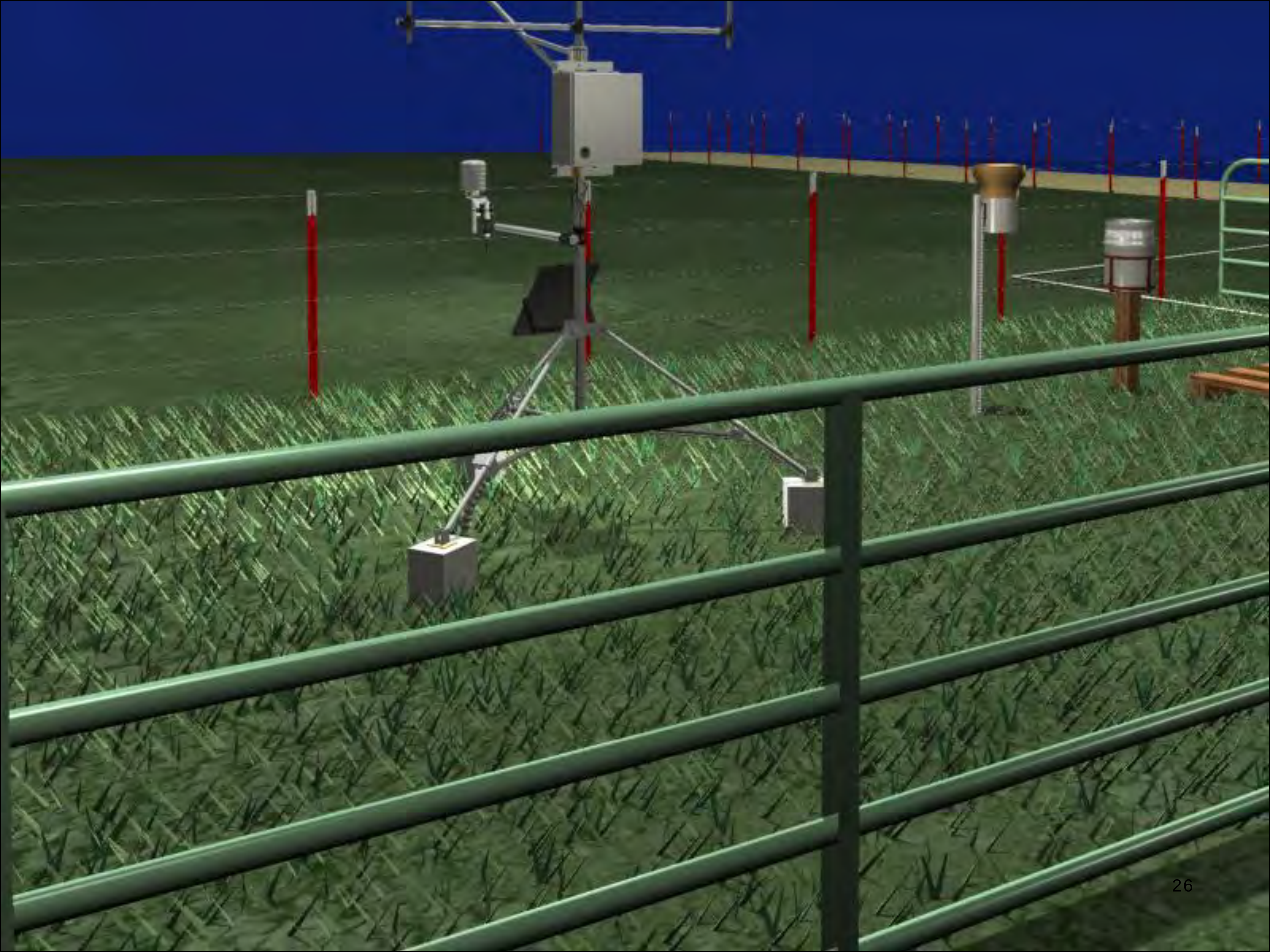
- **CIMIS** – a network of over 140 automated weather stations that collect weather data and provide estimates of reference evapotranspiration (ETo) to the users.

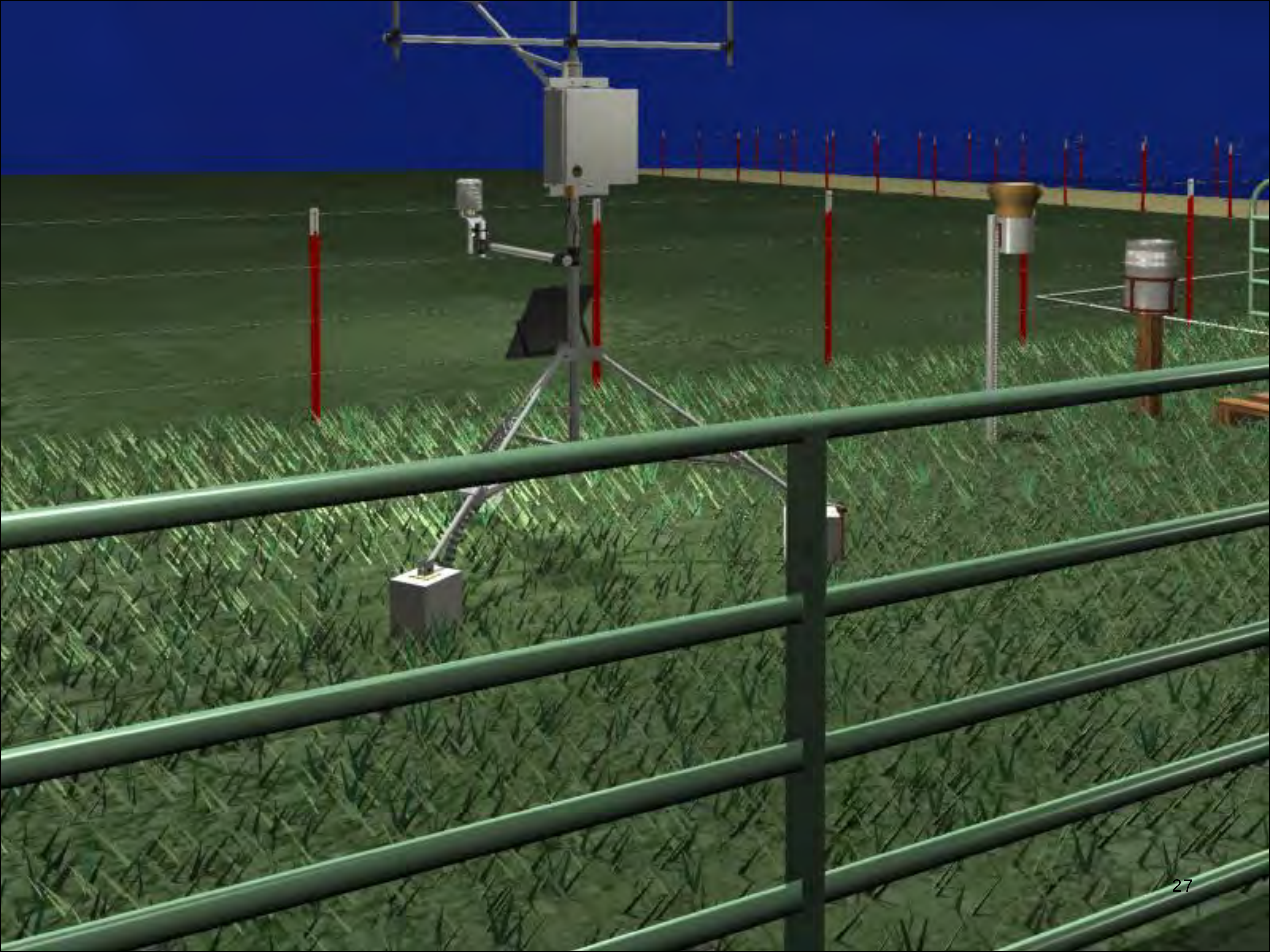
- **Reference Evapotranspiration** - ET from standardized grass (ETo) and/or alfalfa (ETr) surfaces.

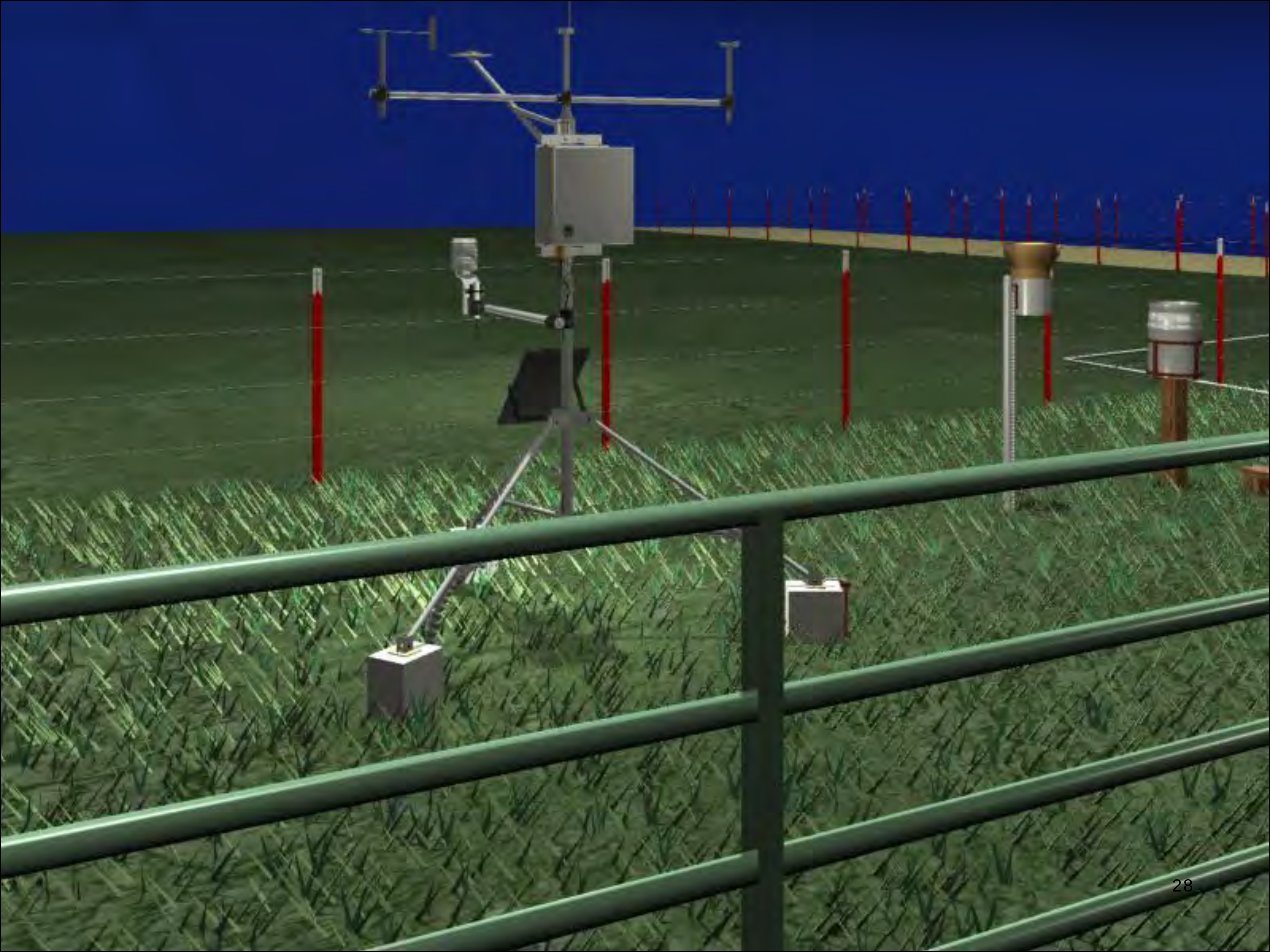
GERBER STATION

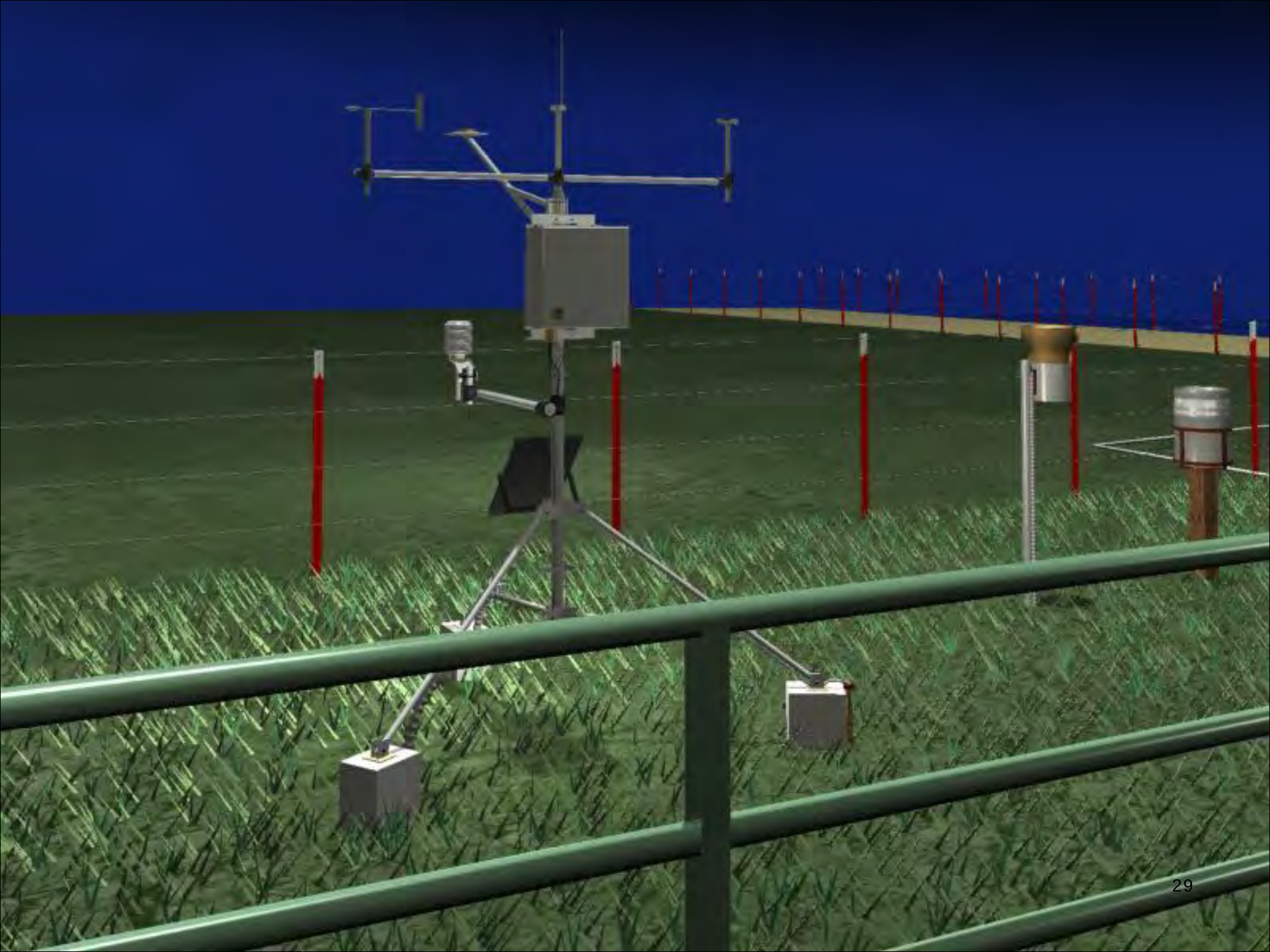
CIMIS

California Irrigation Management Information System

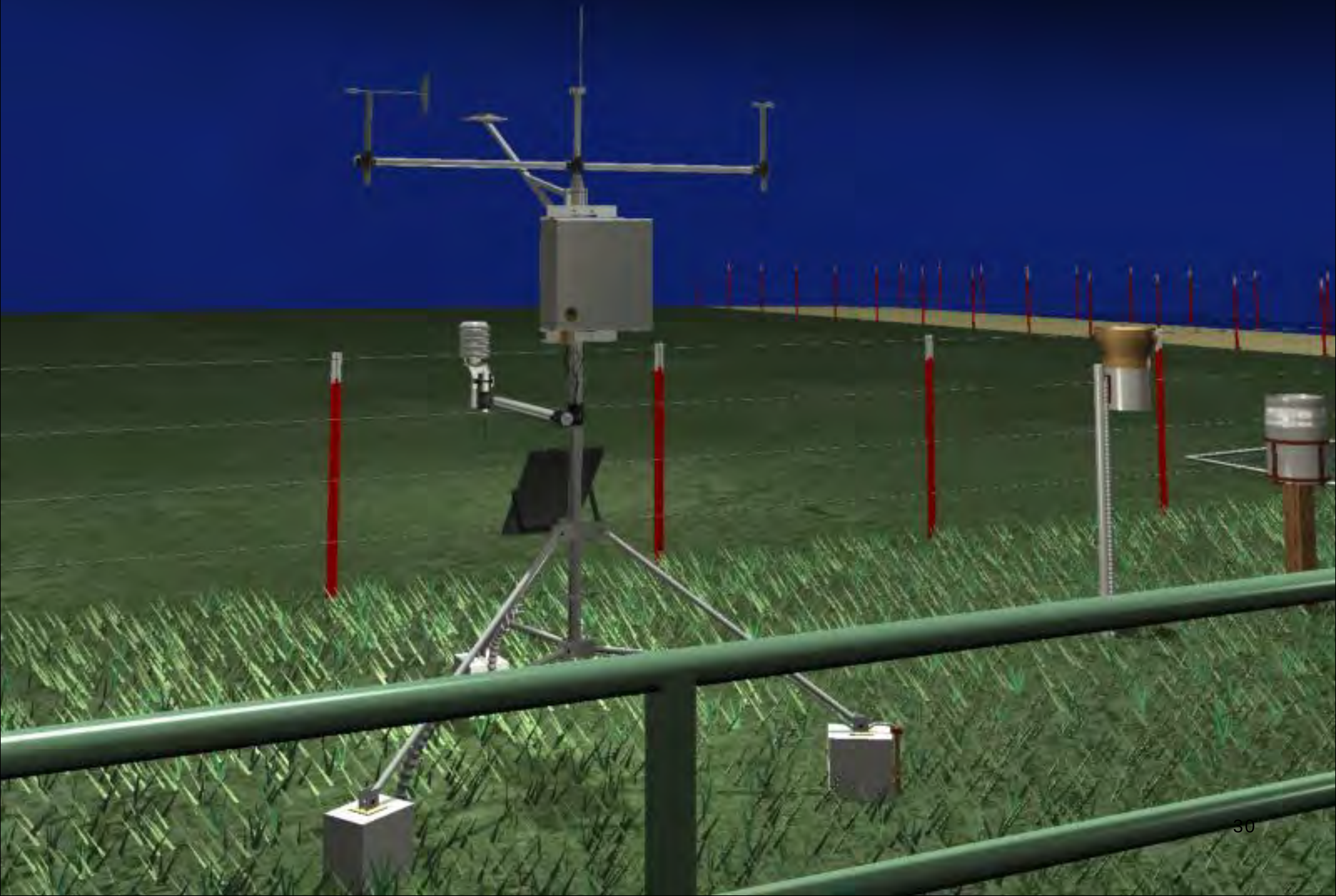


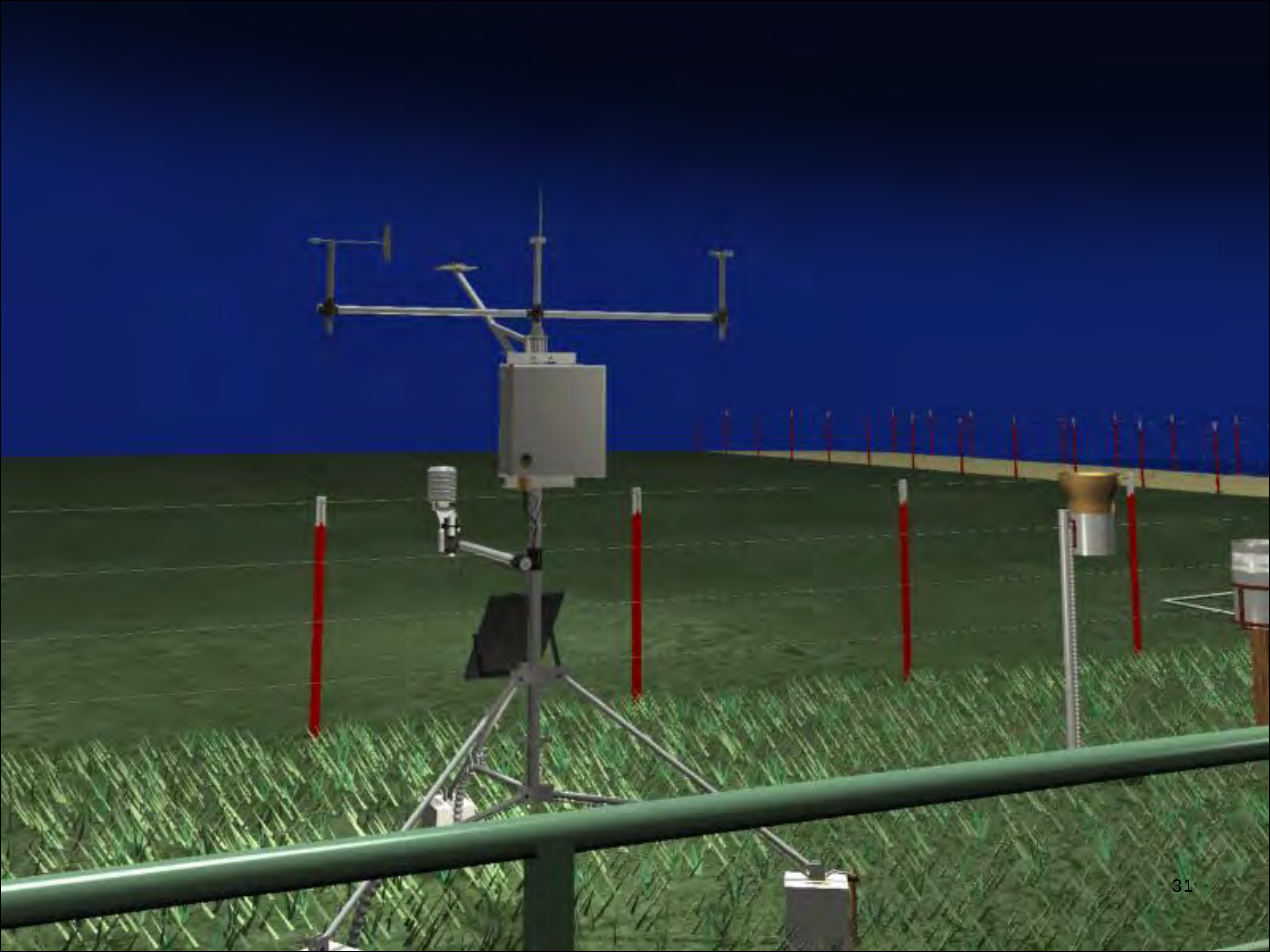


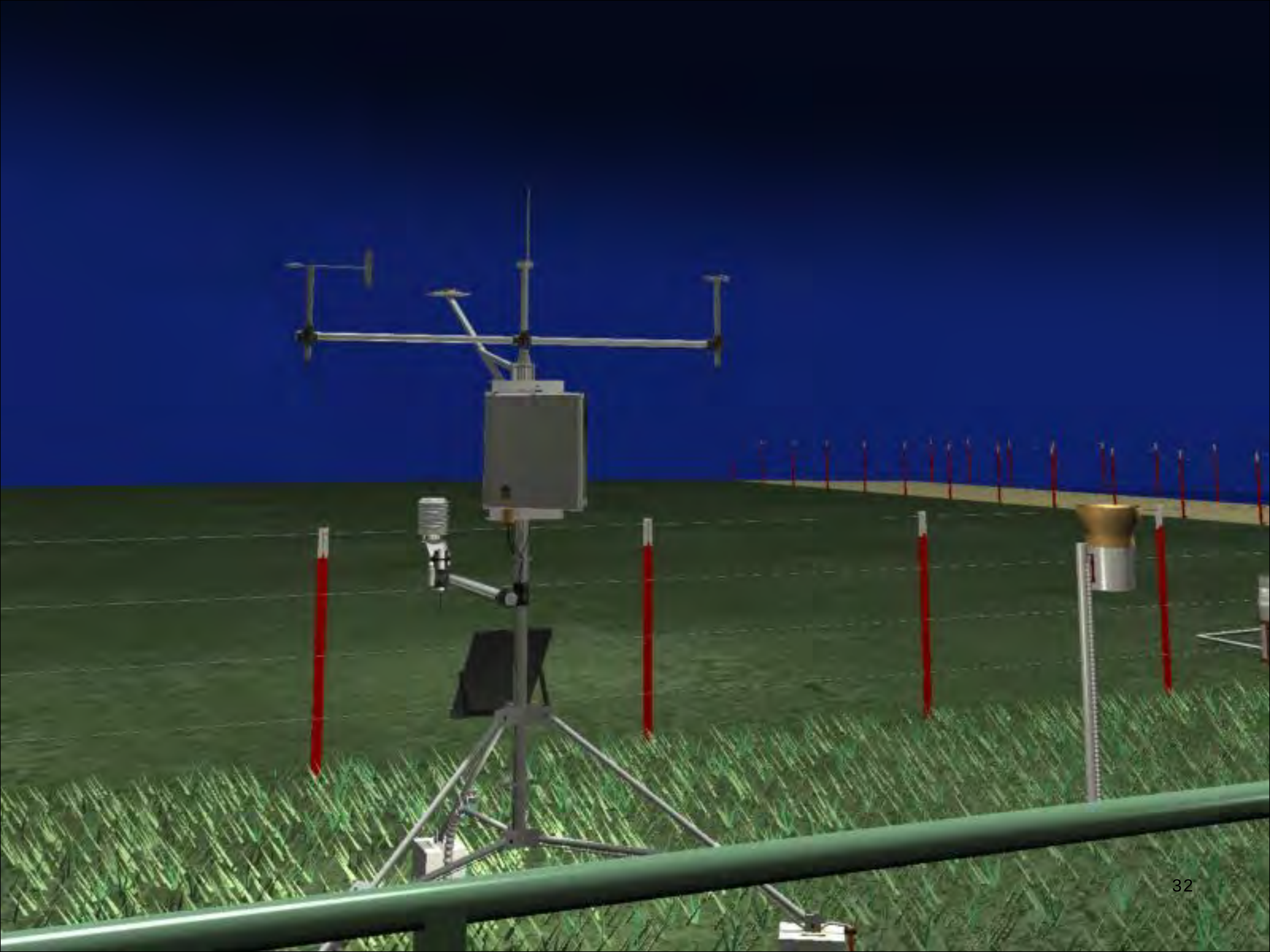


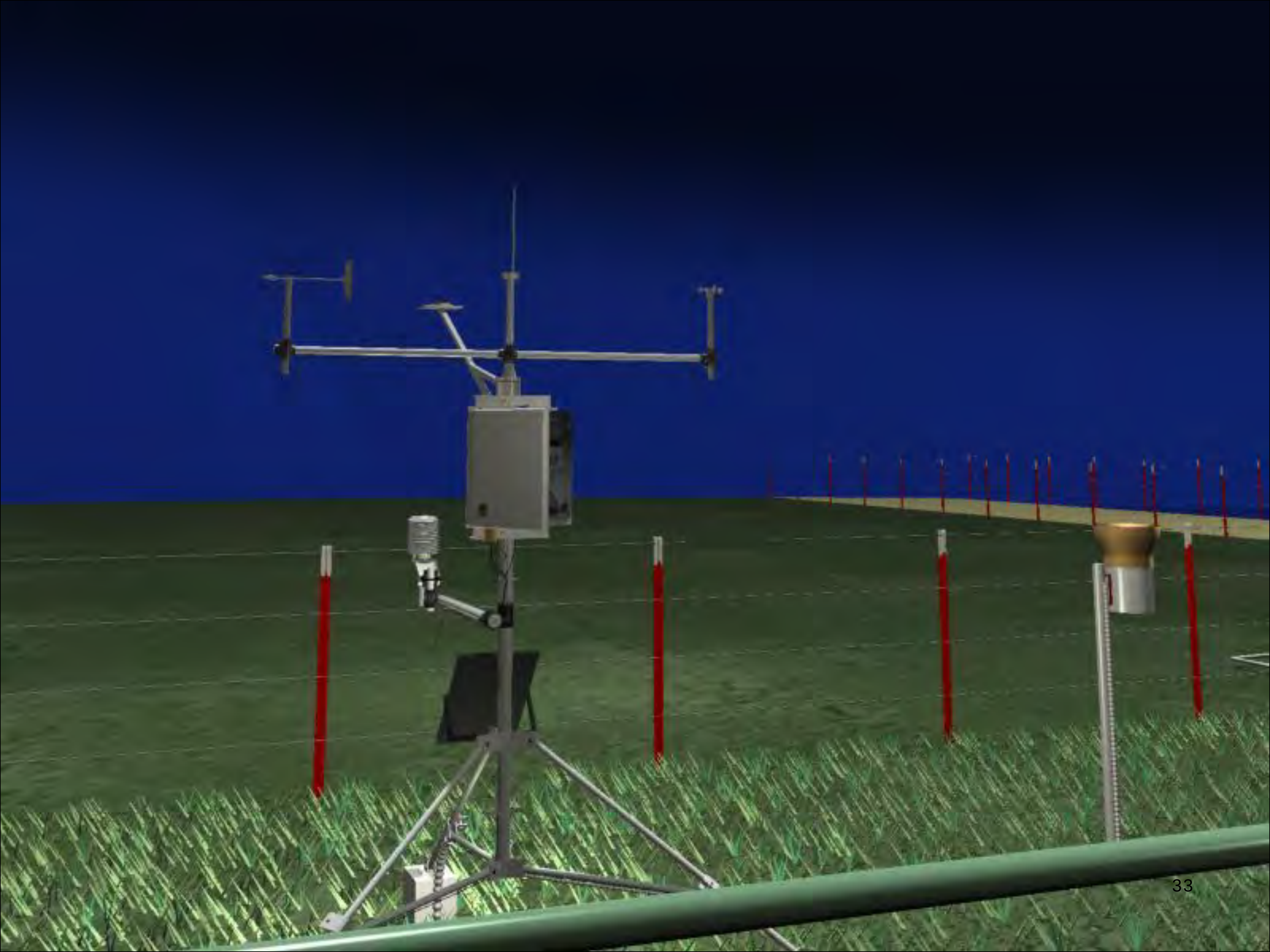


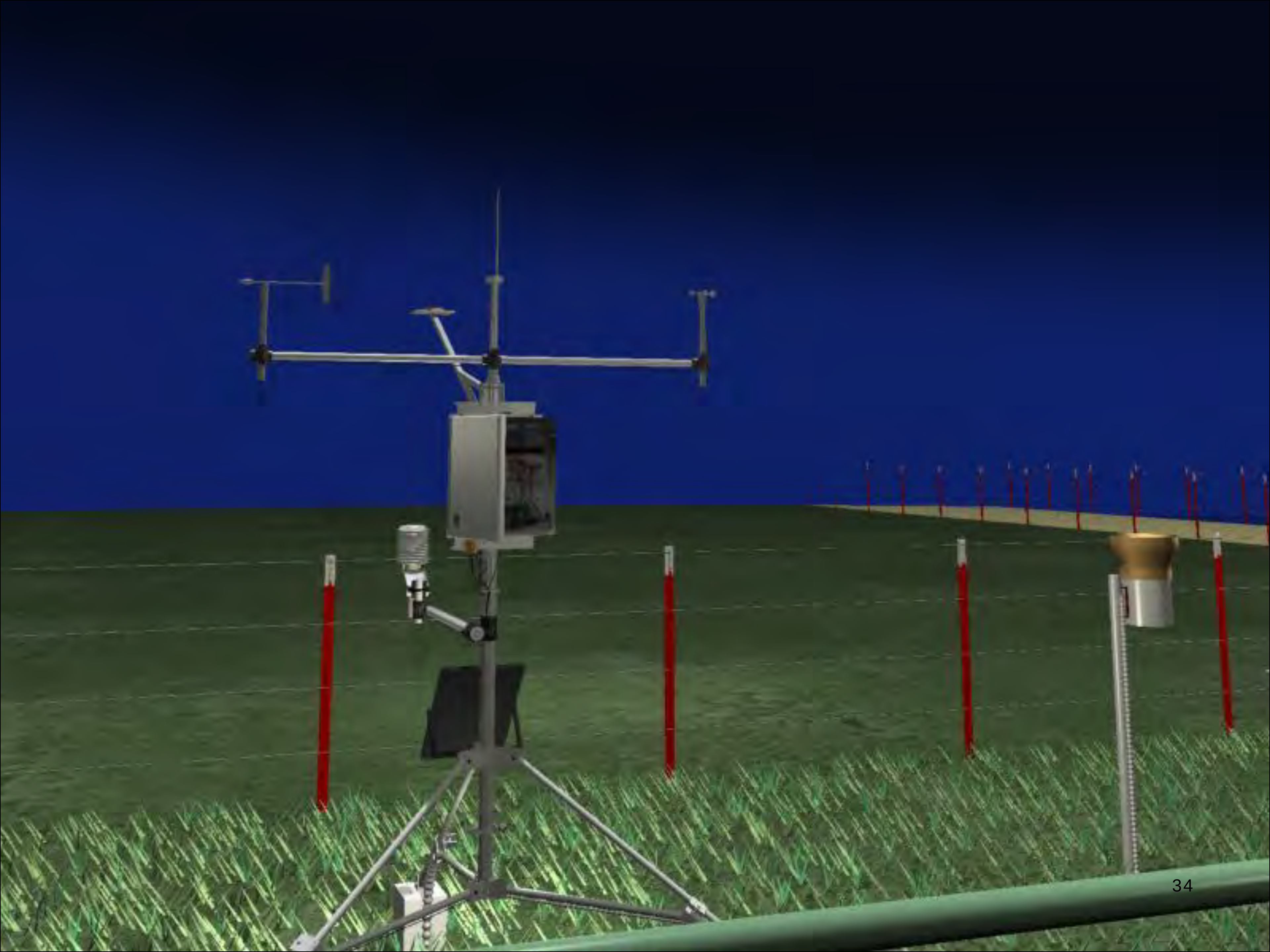
Weather Station

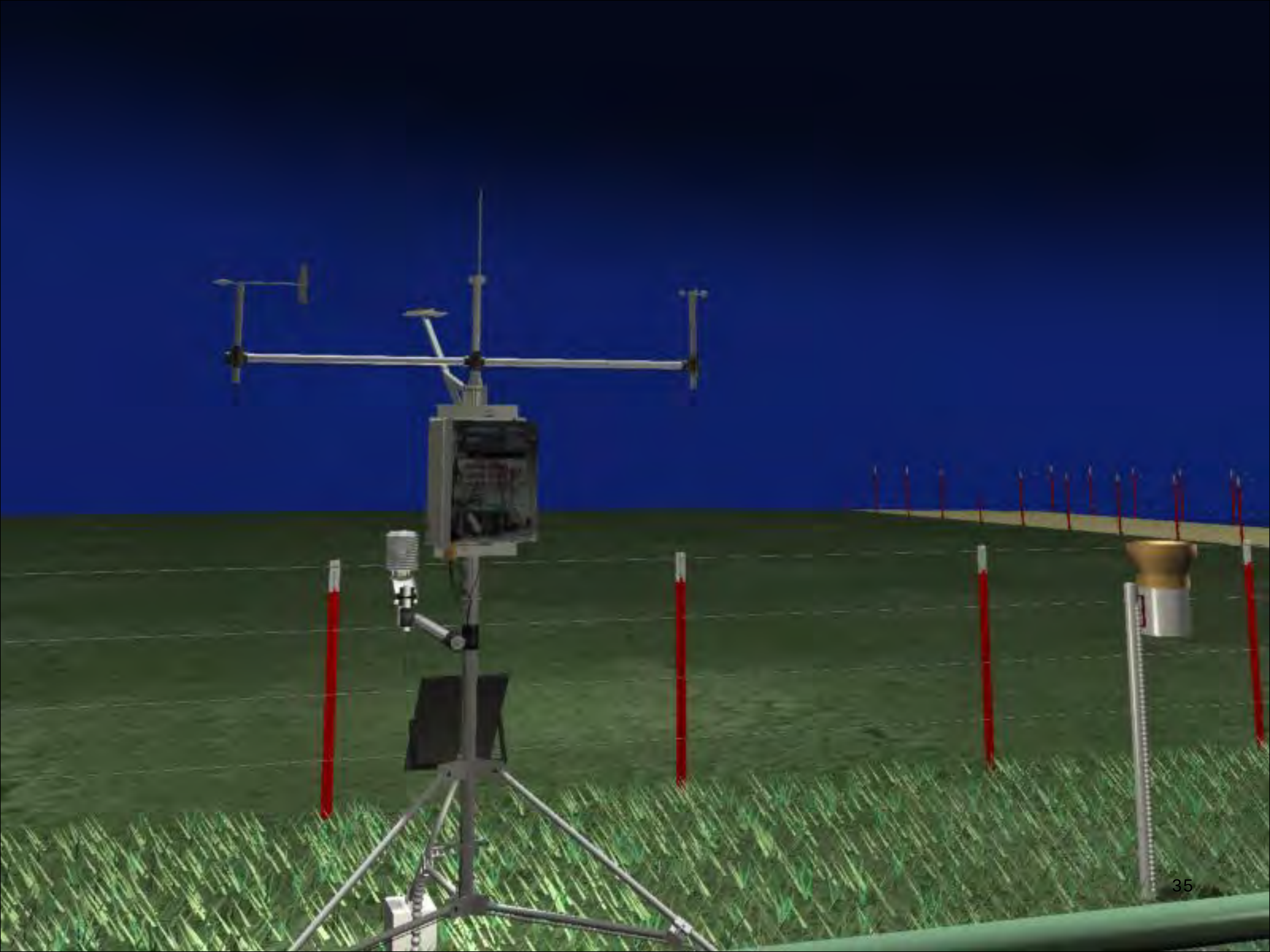


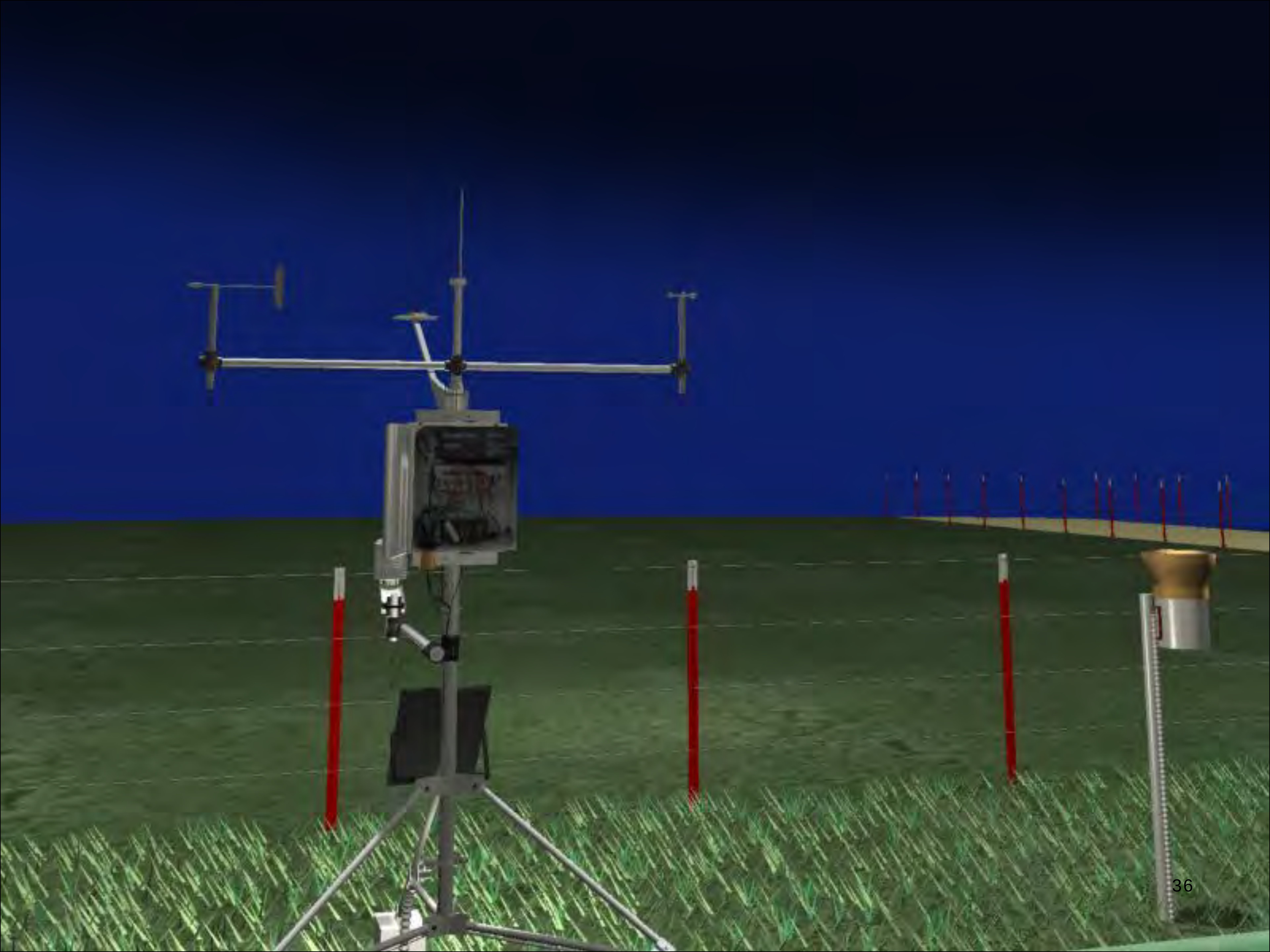


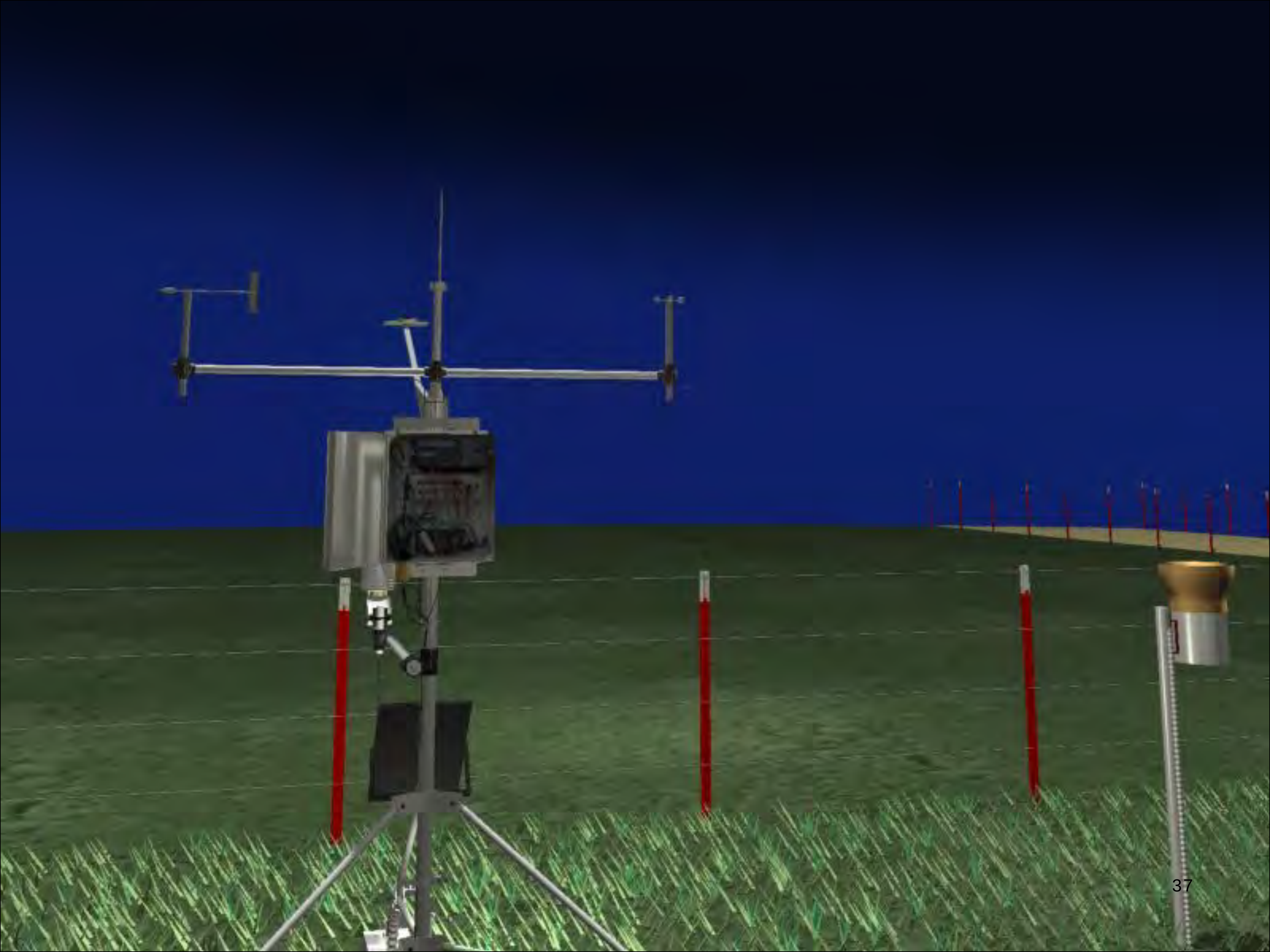


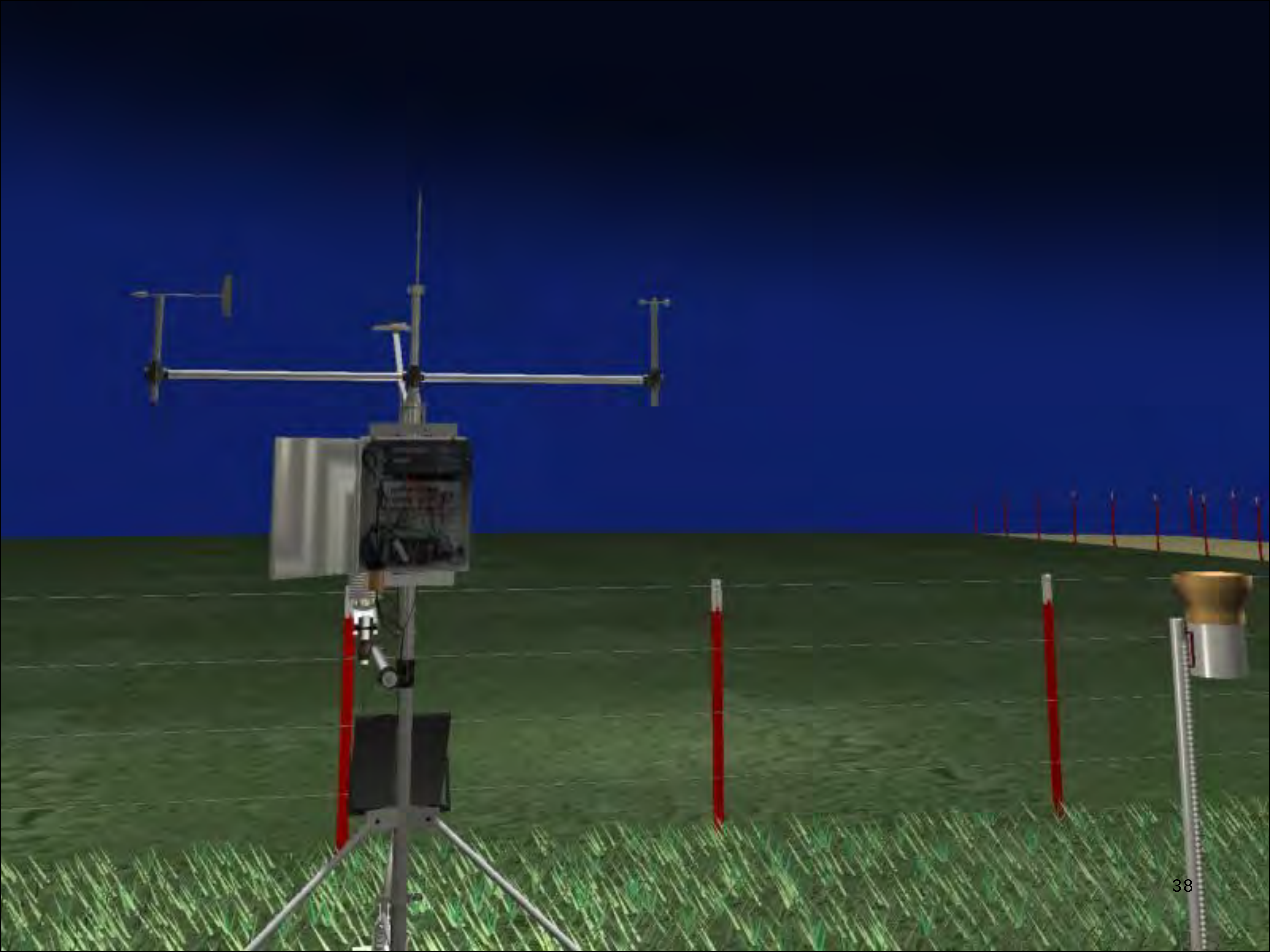


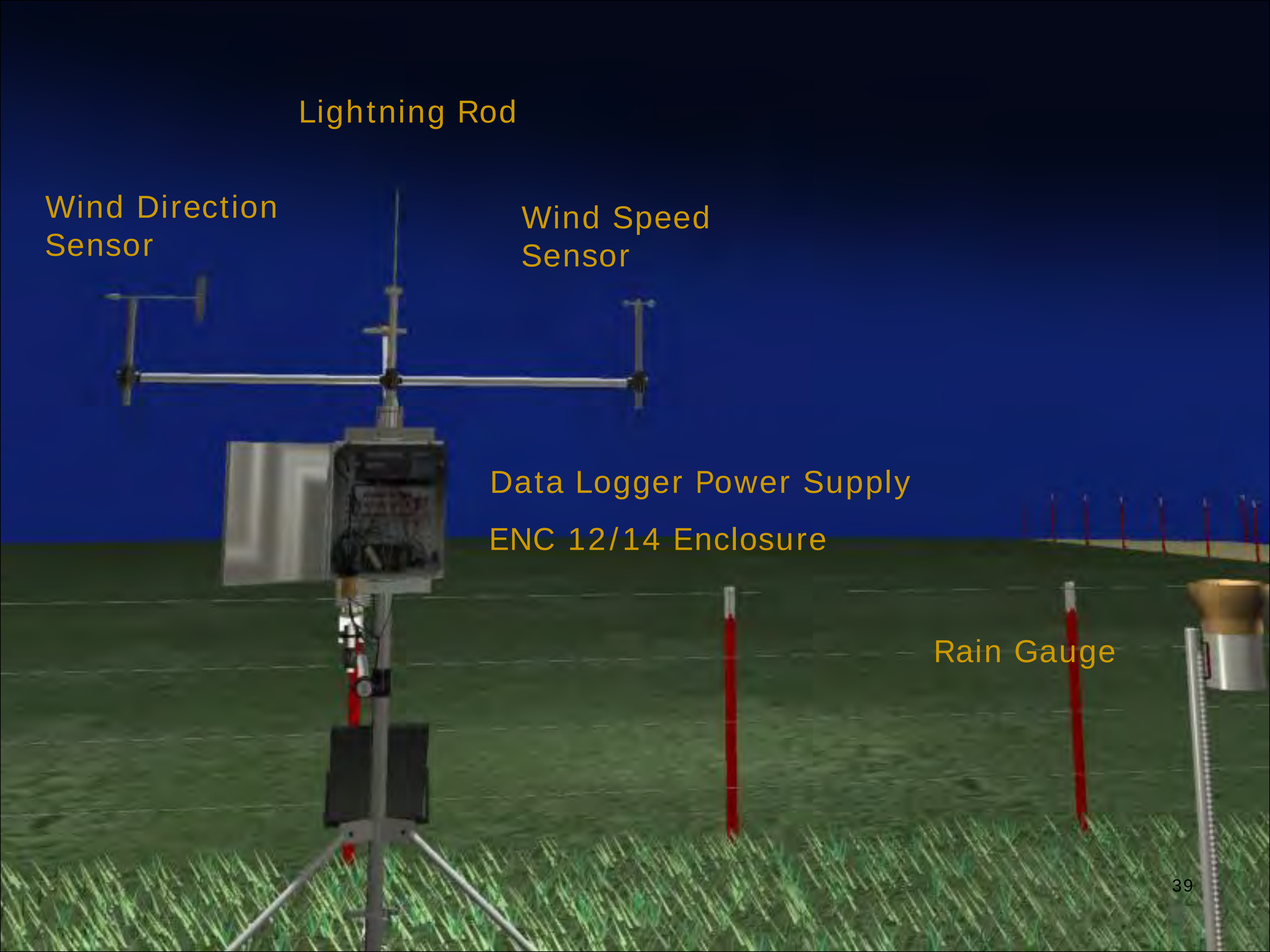


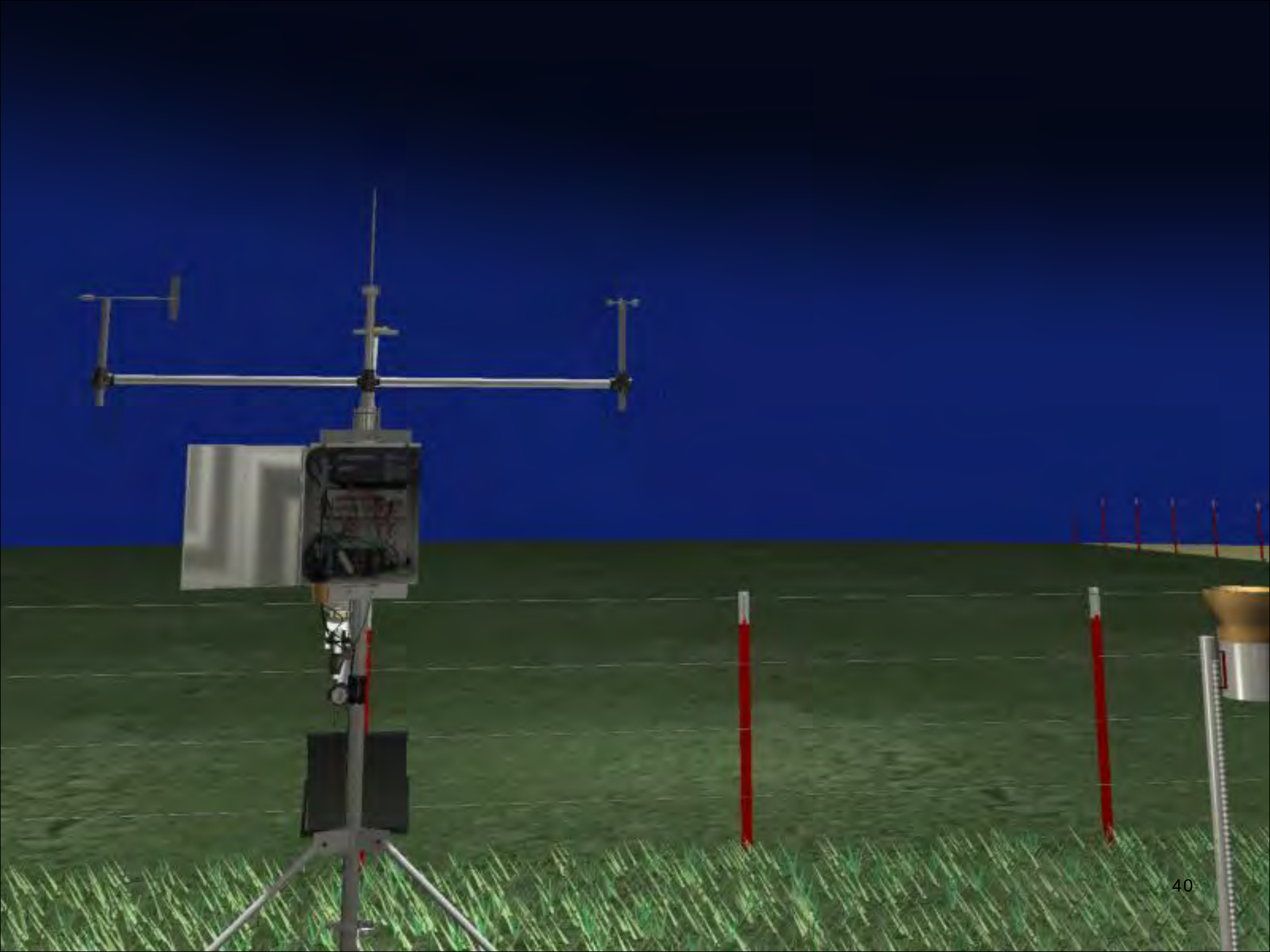


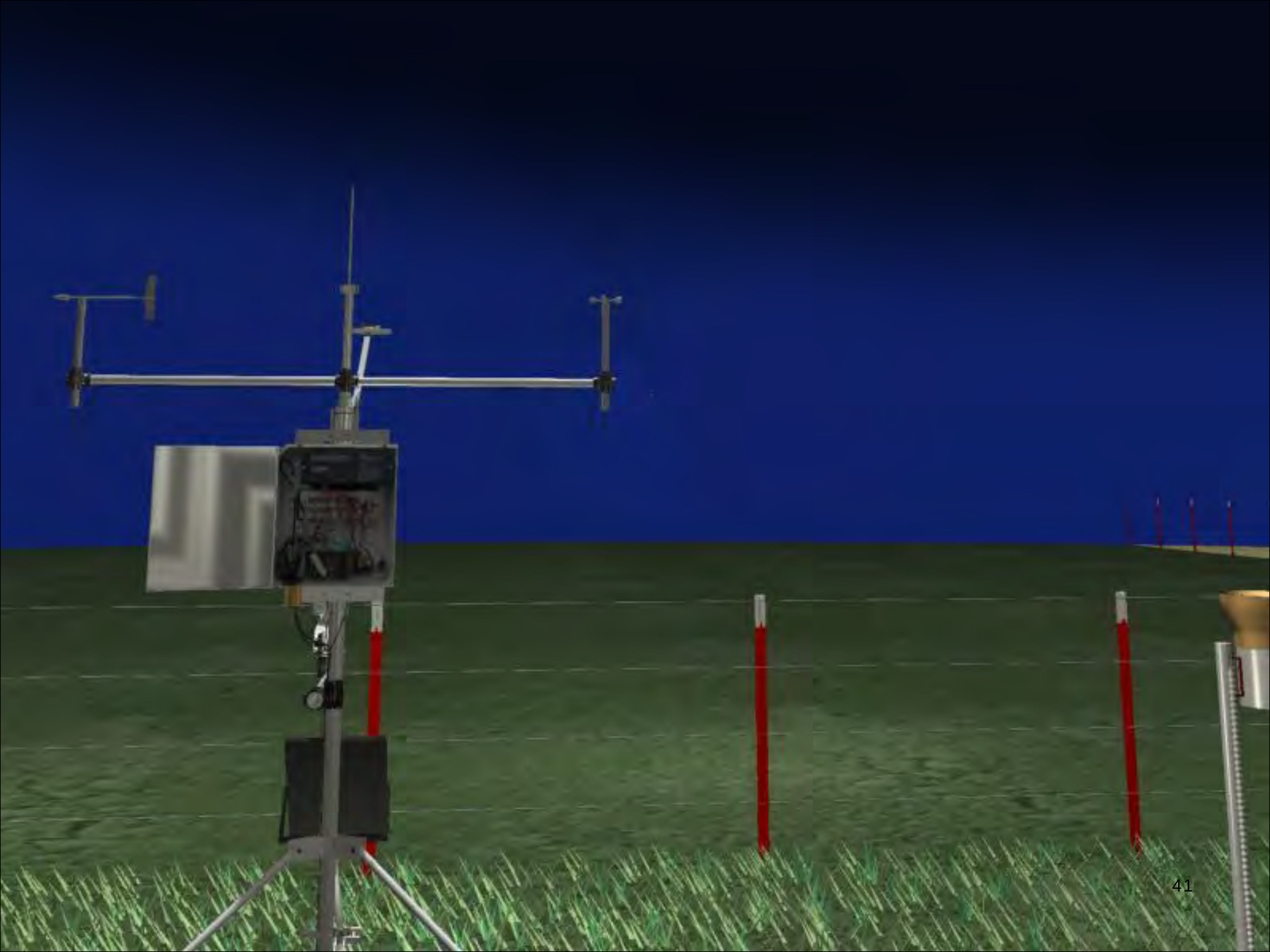


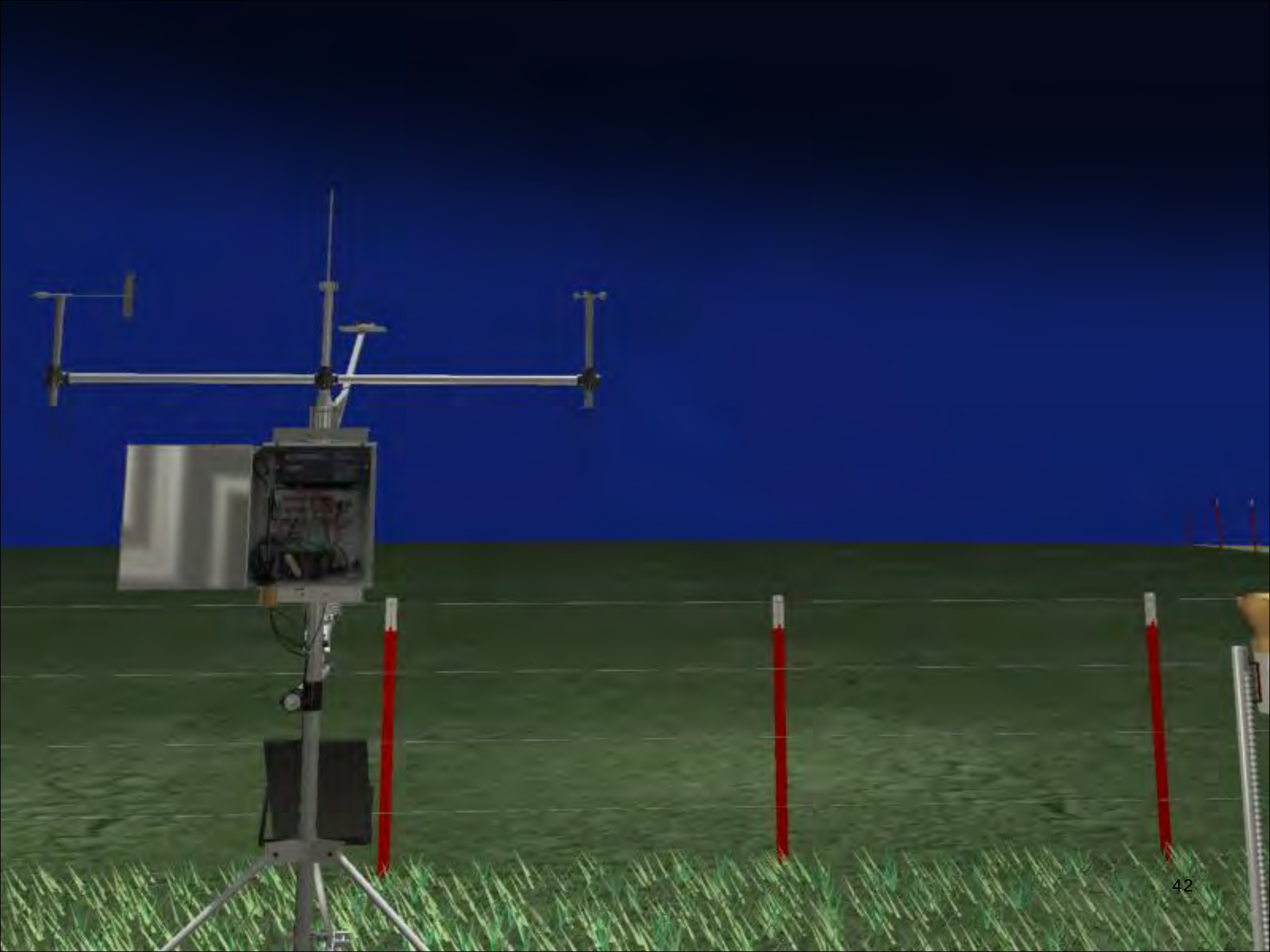


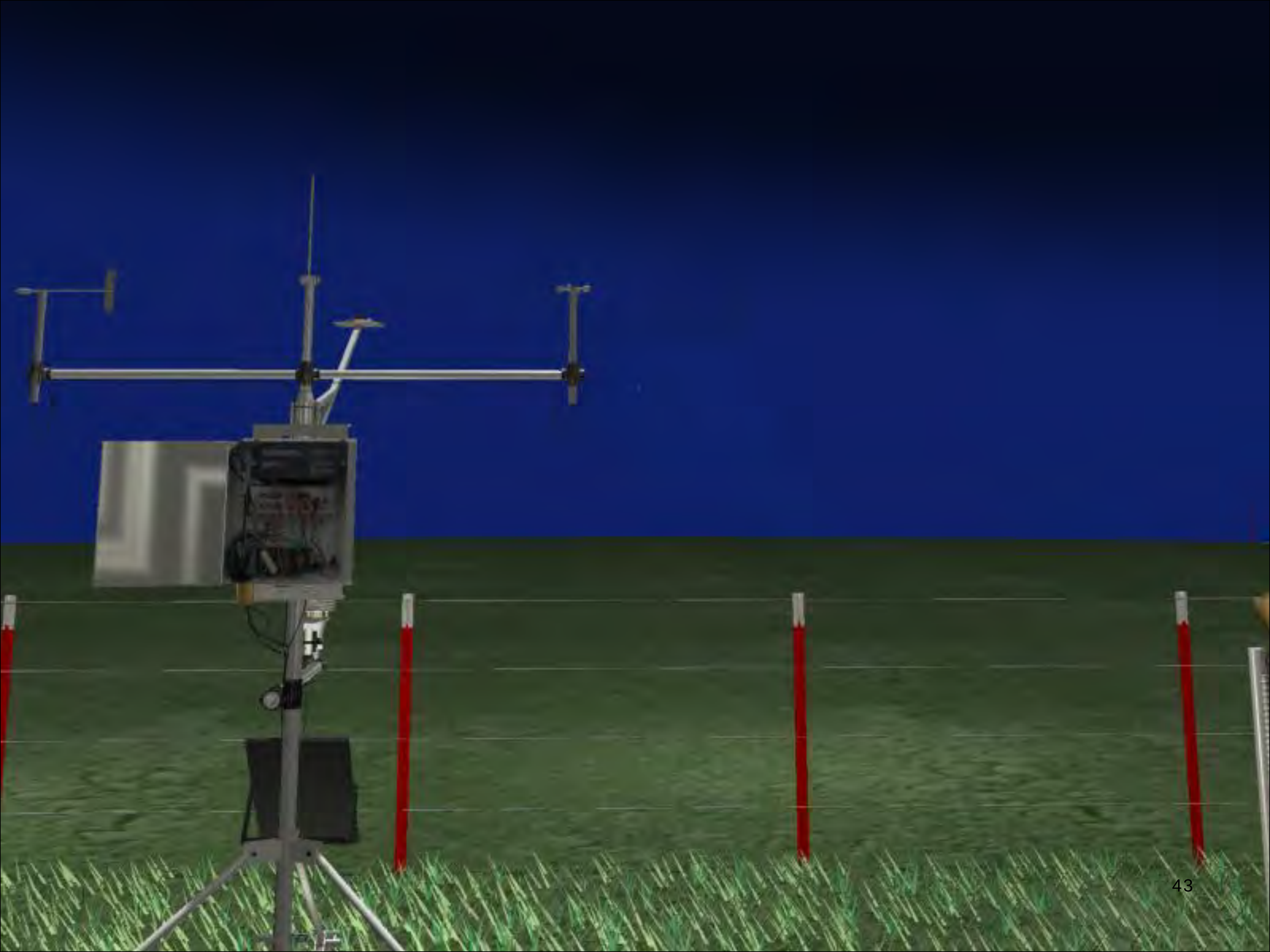


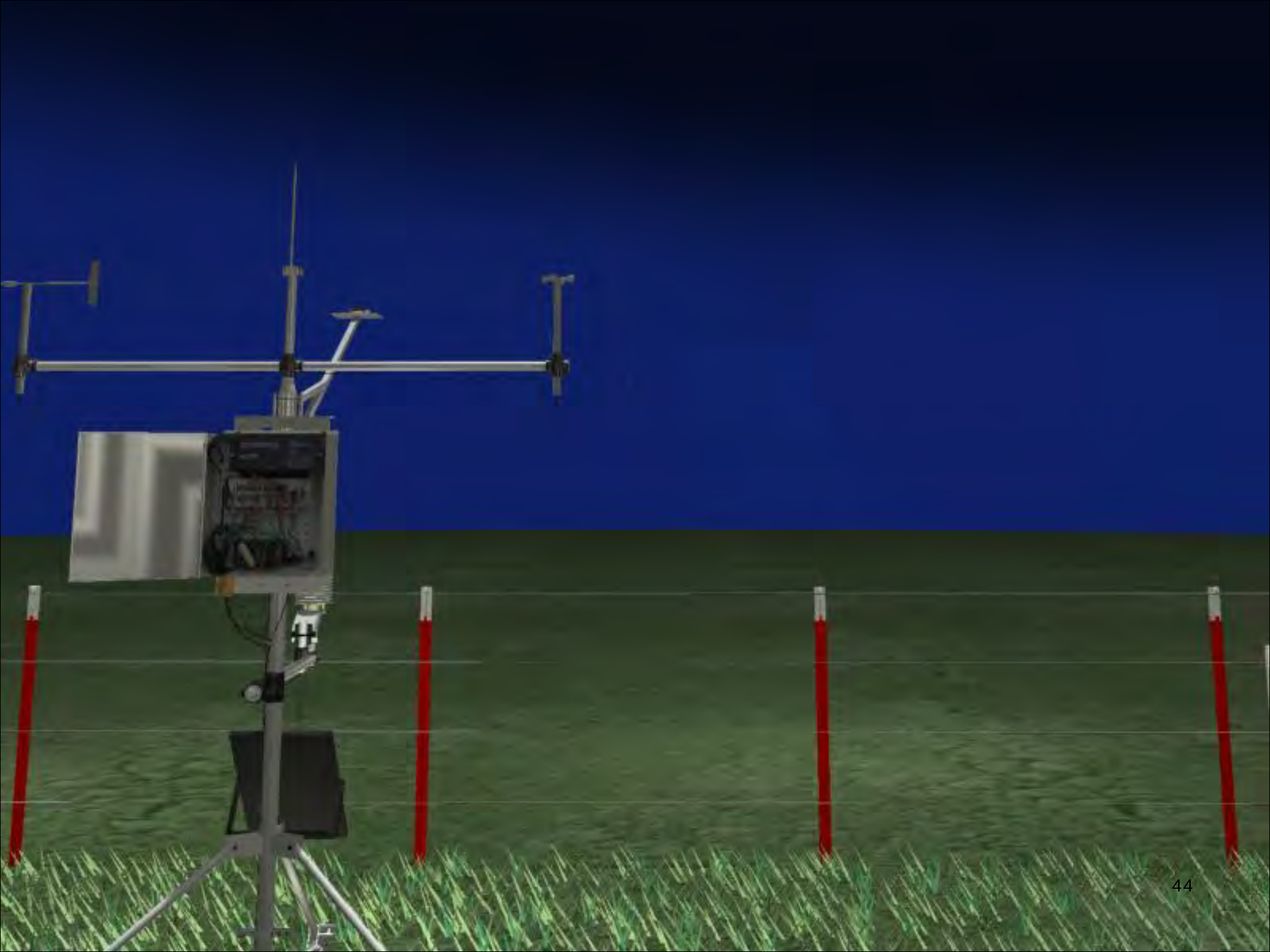

Lightning Rod
Wind Direction Sensor
Wind Speed Sensor
Data Logger Power Supply
ENC 12/14 Enclosure
Rain Gauge

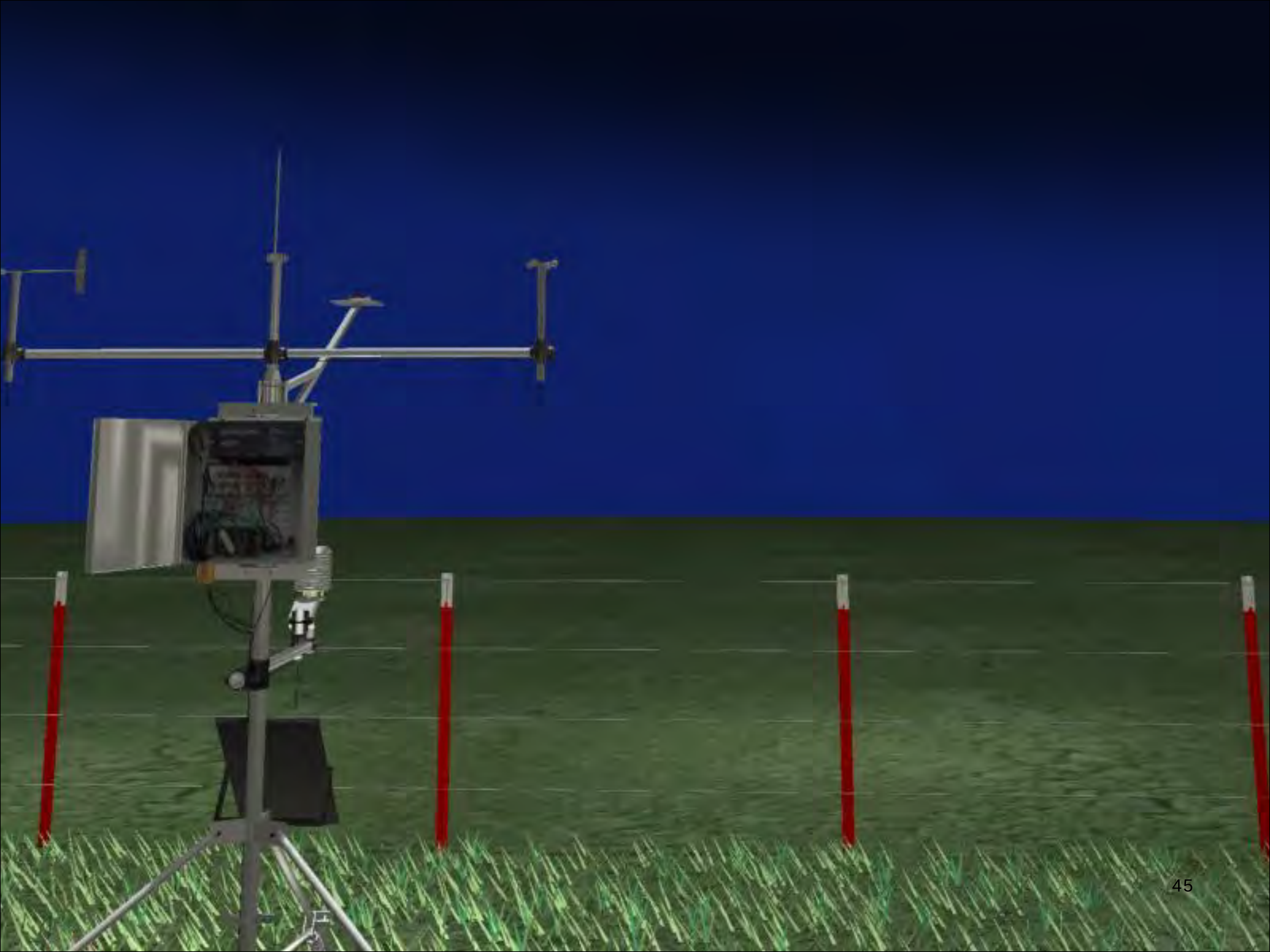


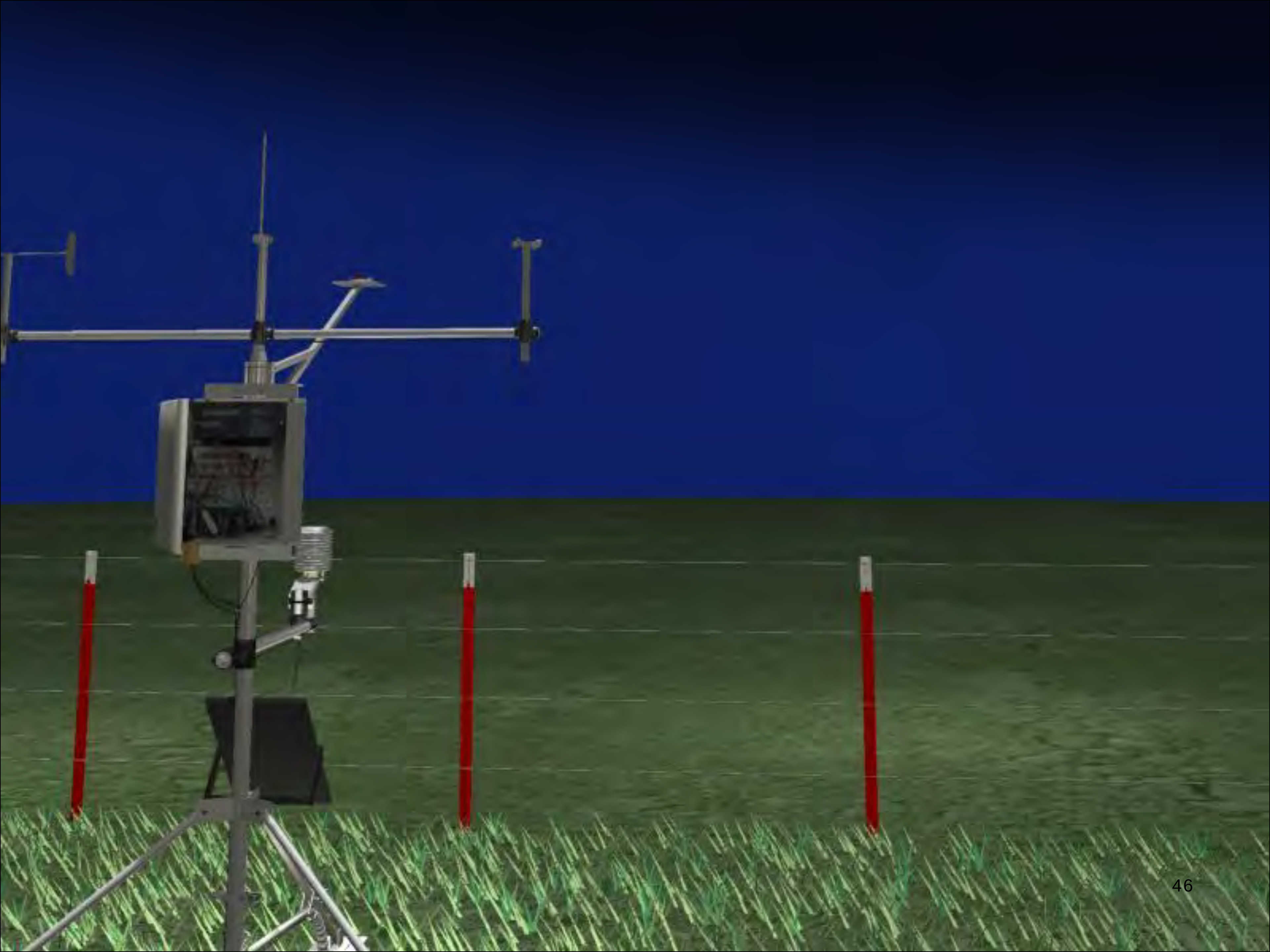


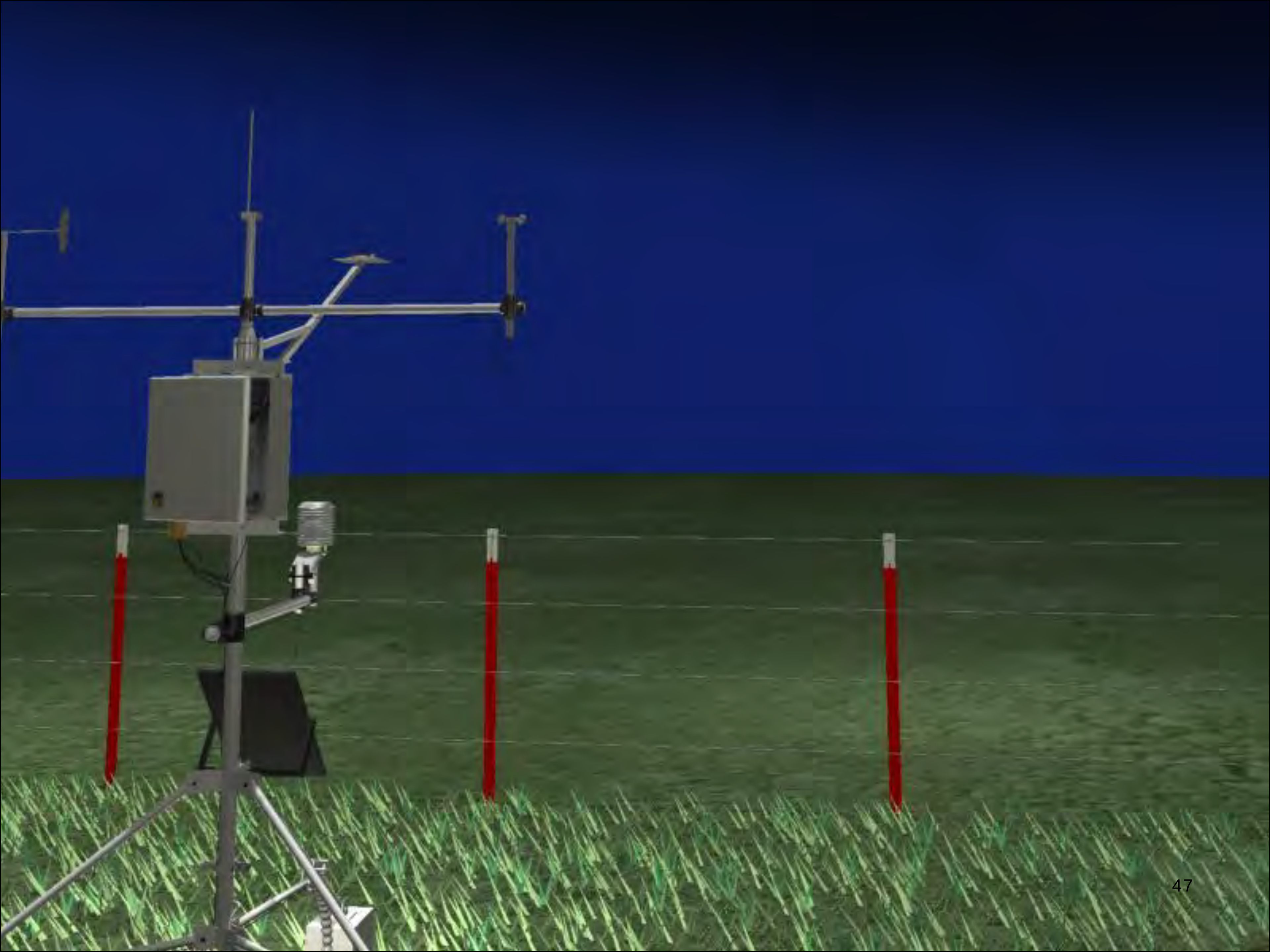


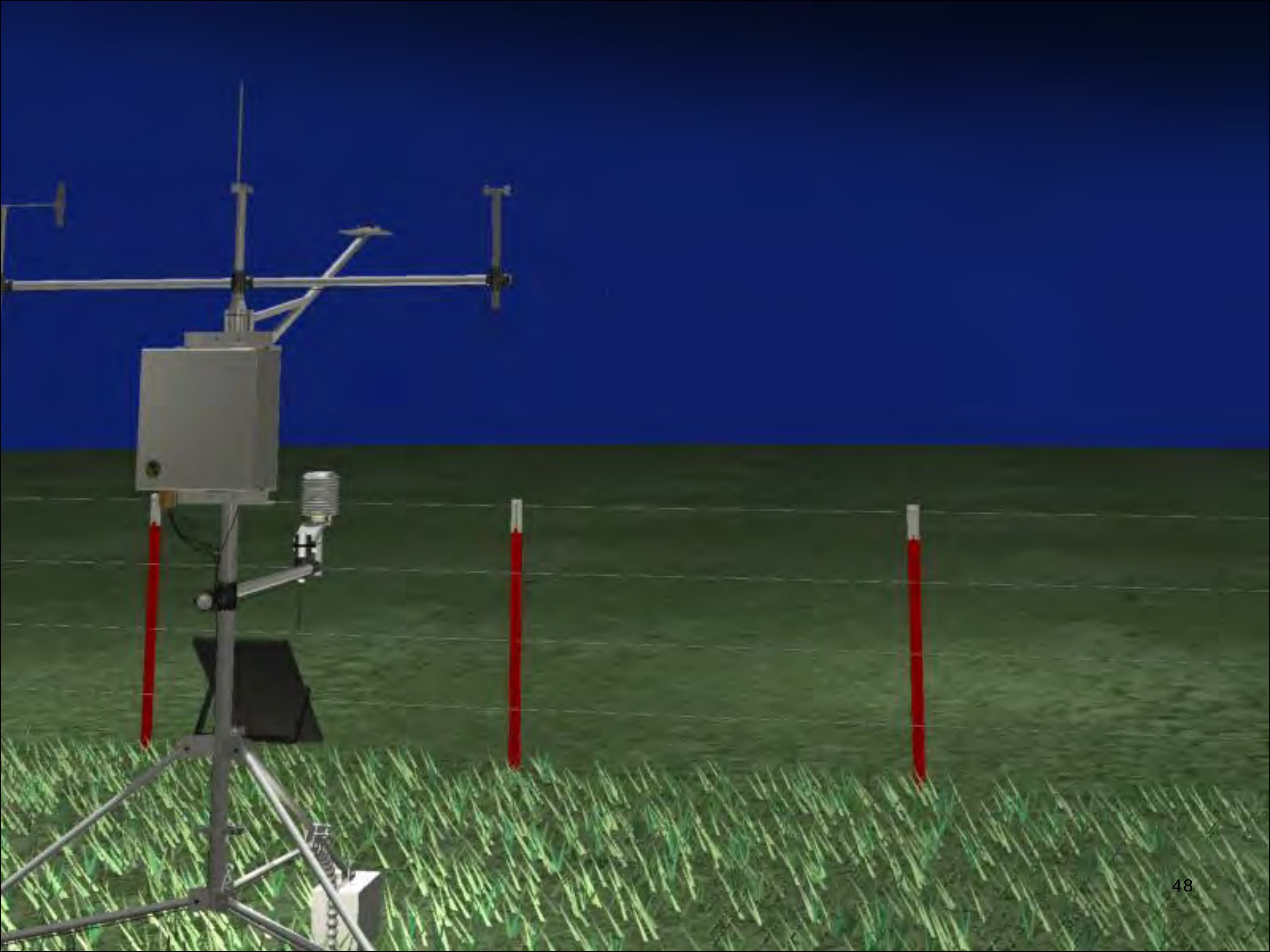


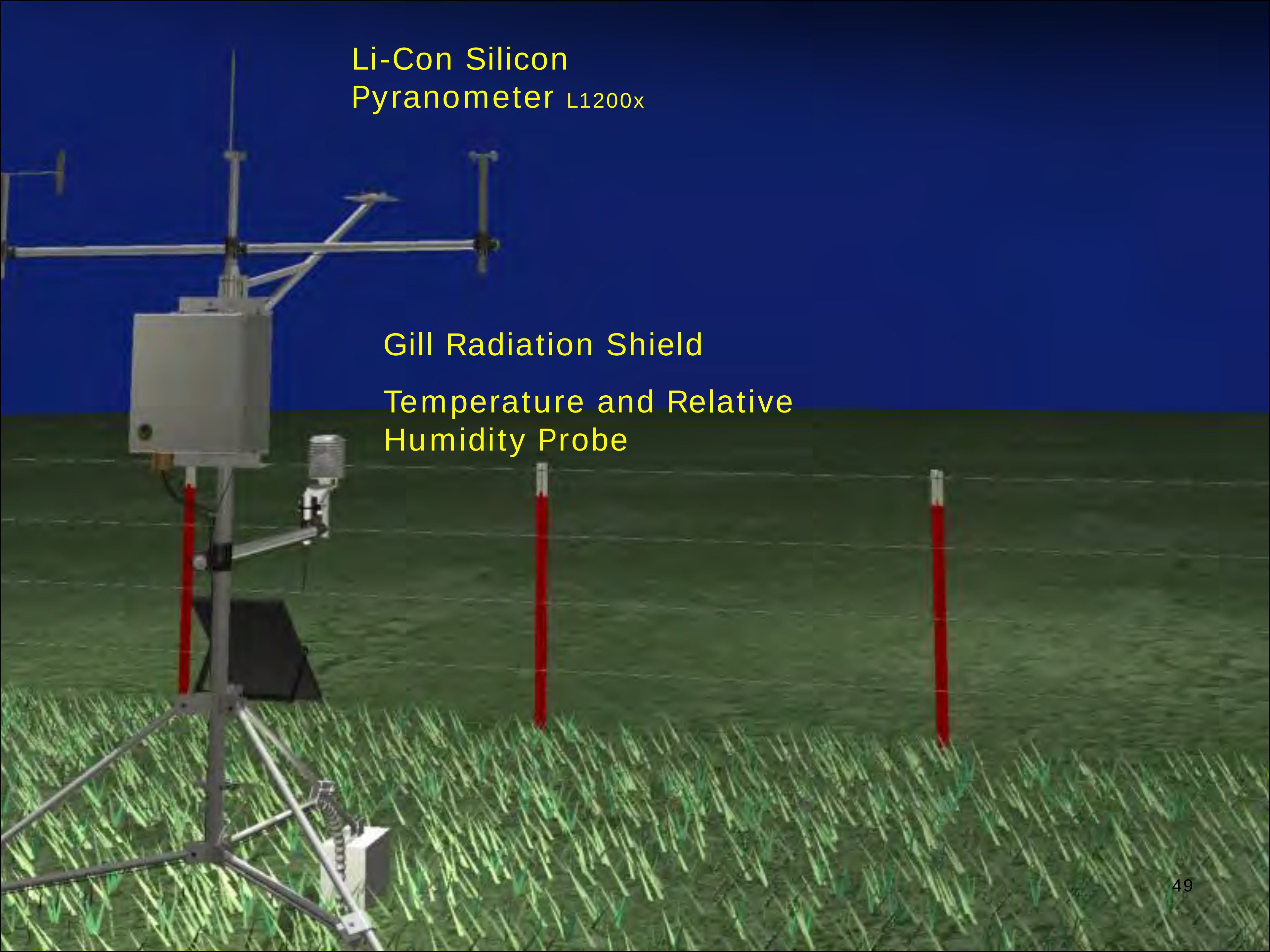


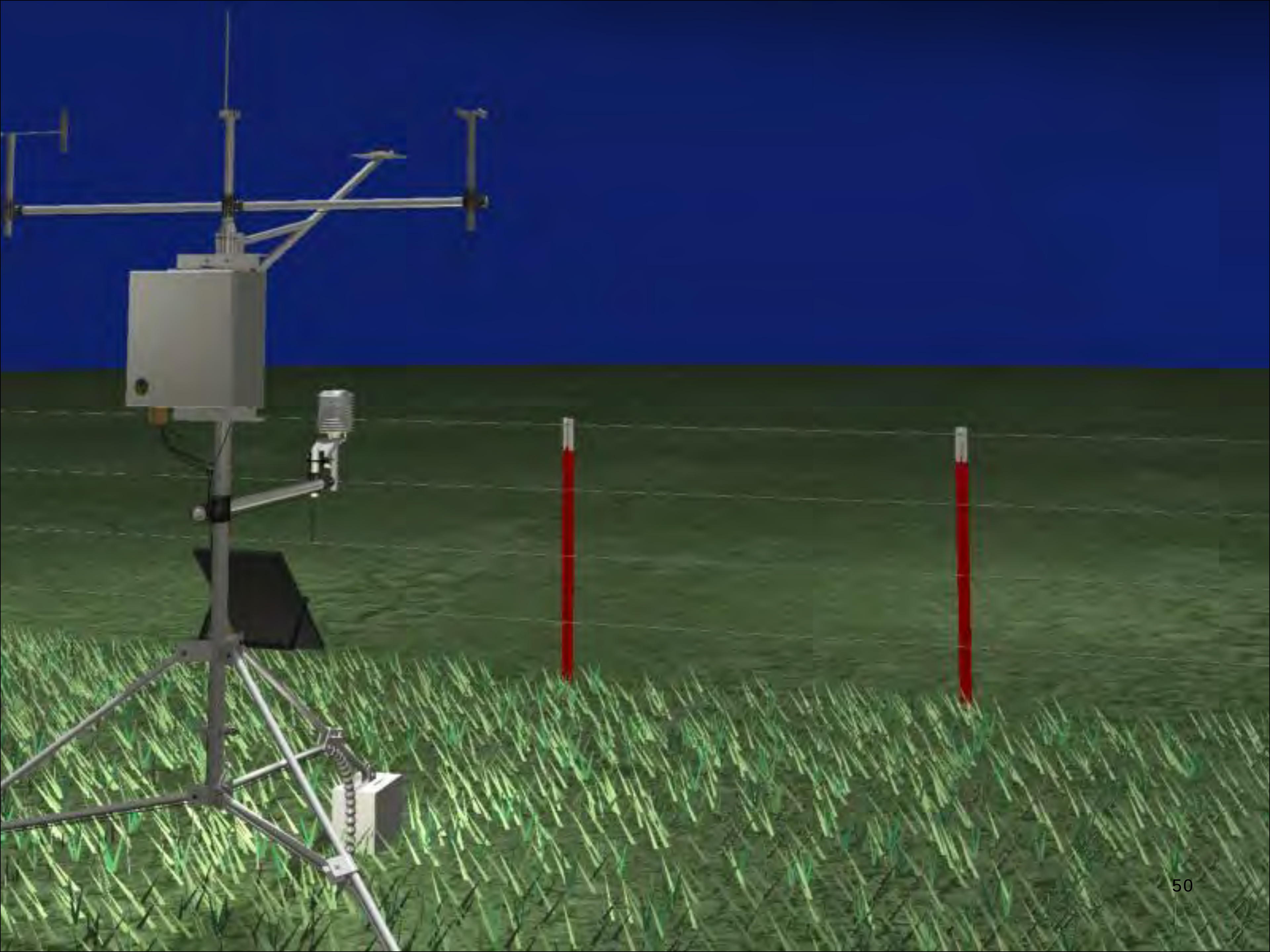


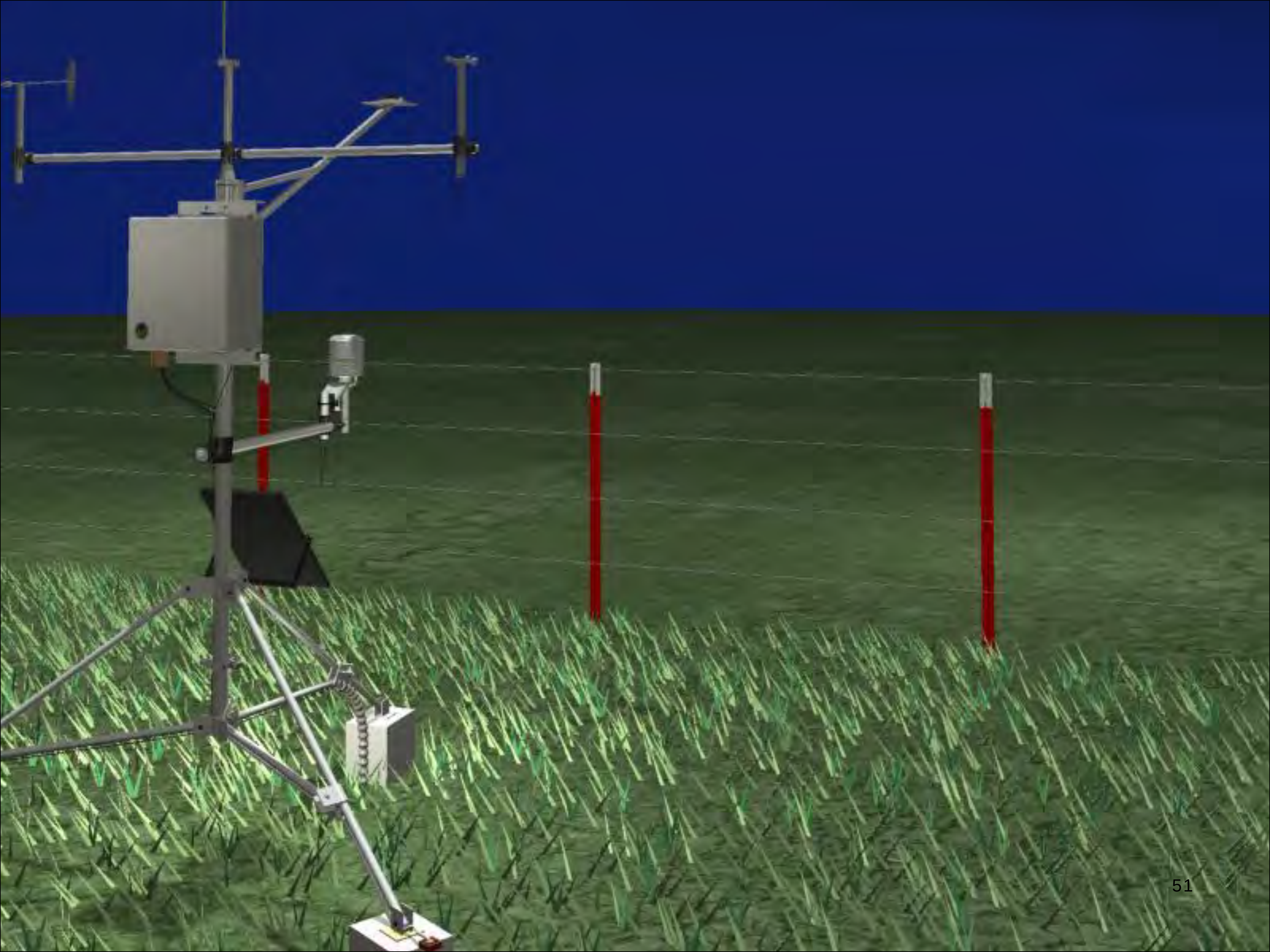


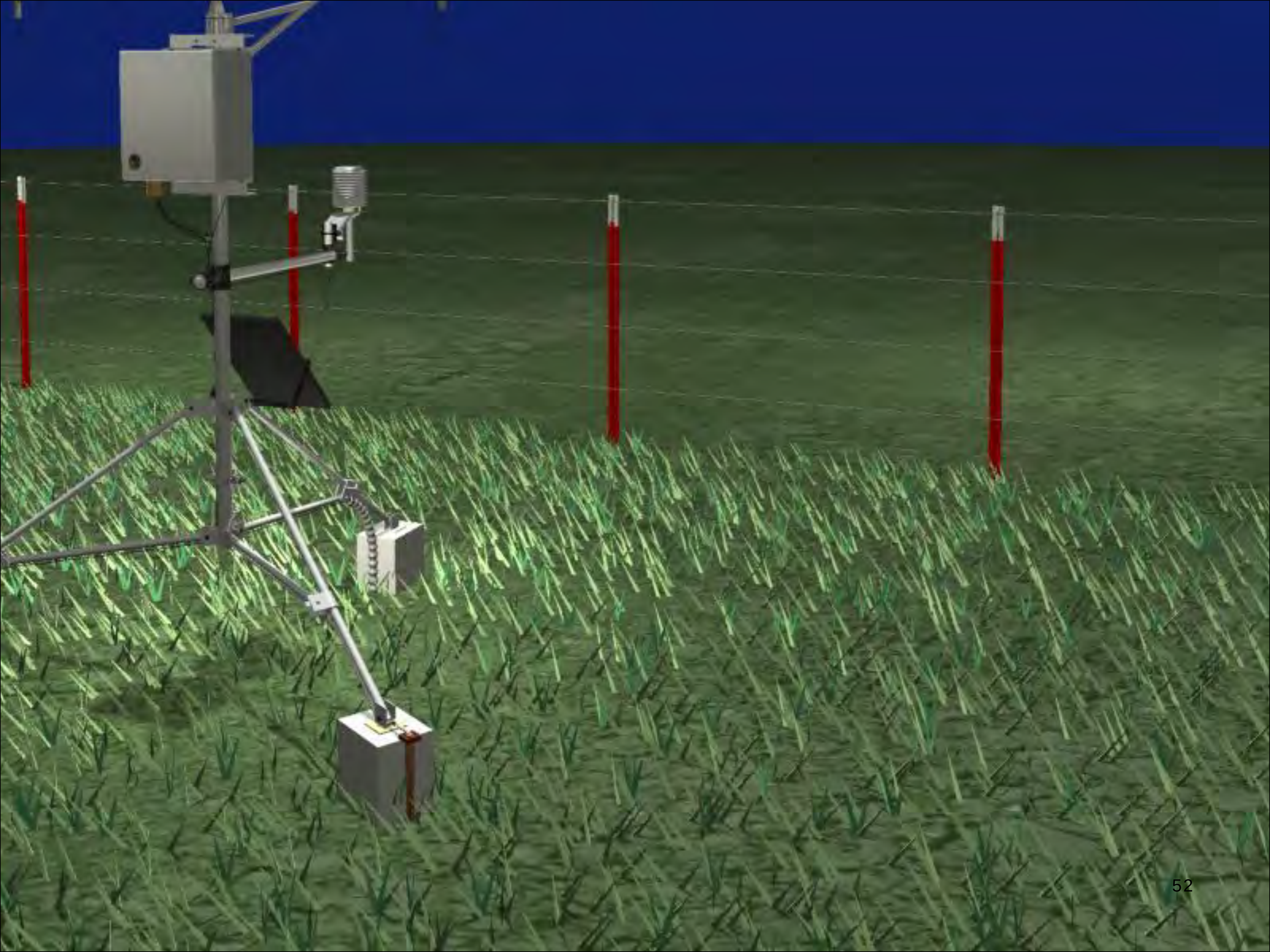


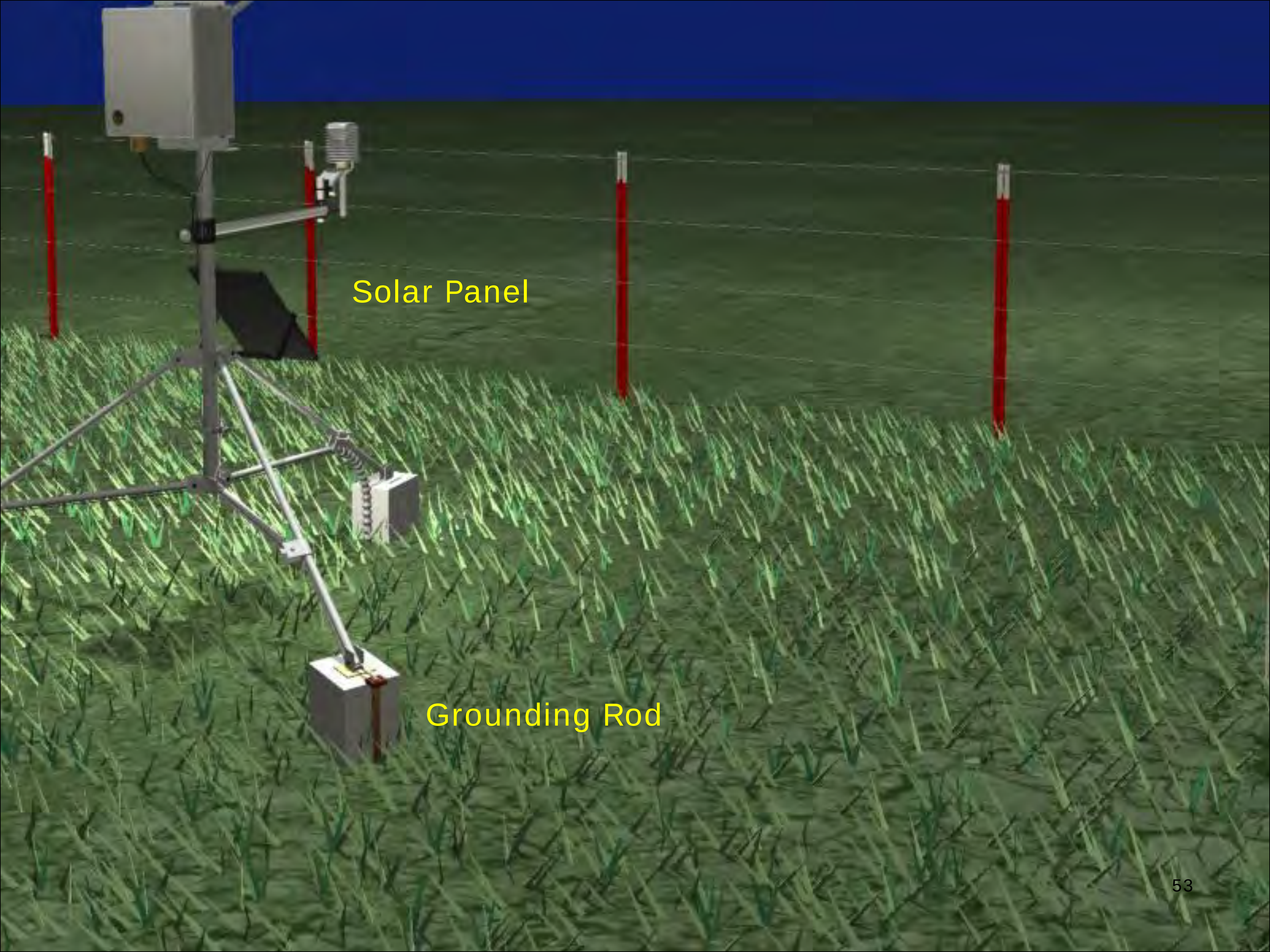


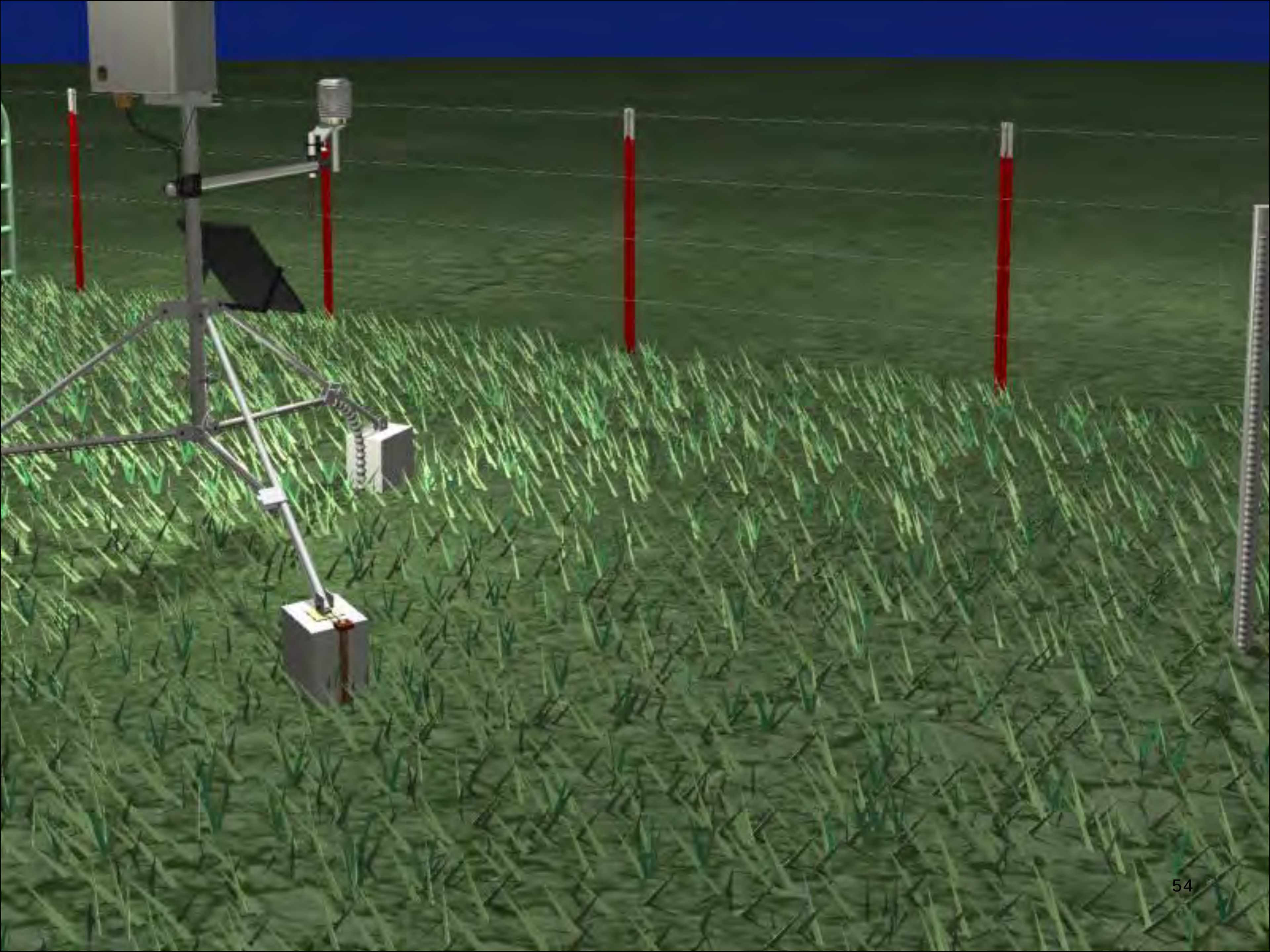

Li-Con Silicon
Pyranometer L1200x
Gill Radiation Shield
Temperature and Relative
Humidity Probe

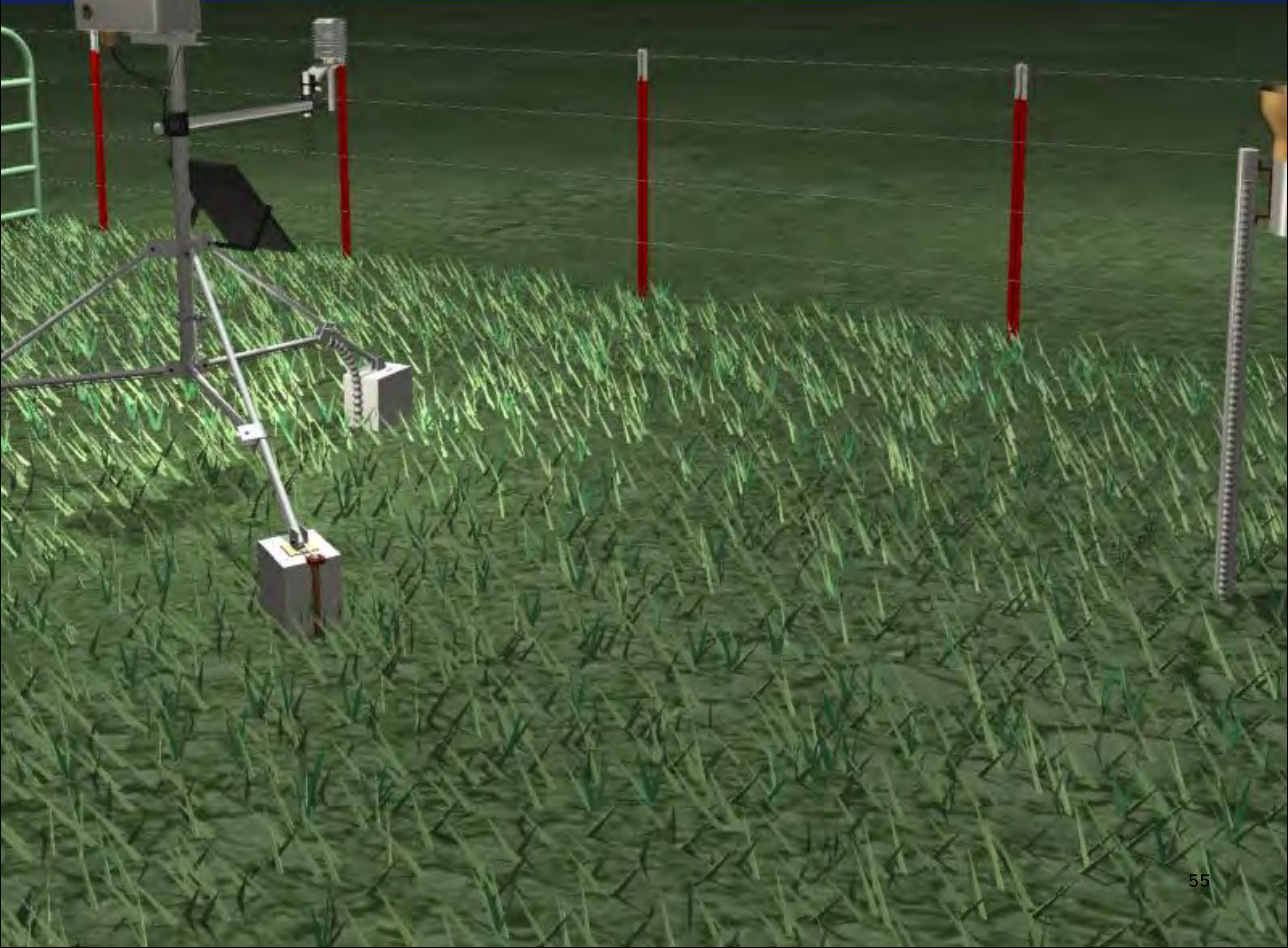


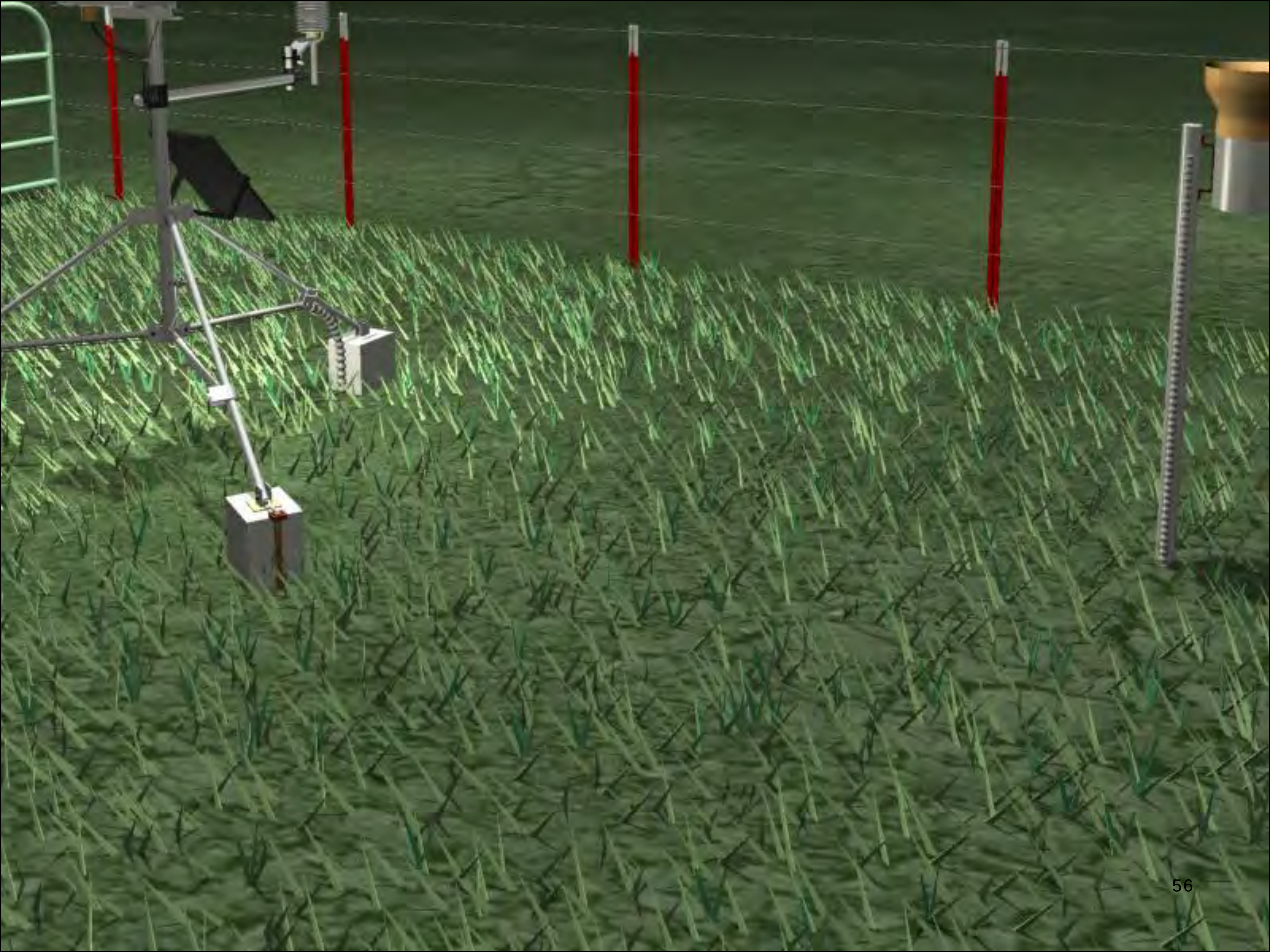





Solar Panel
Grounding Rod

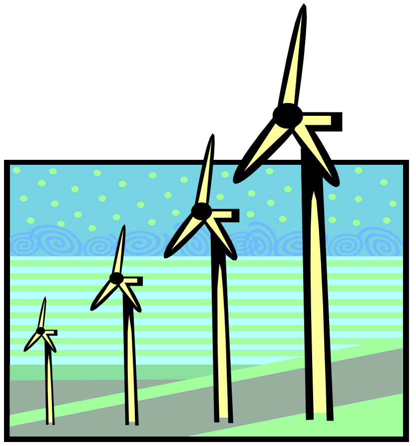






For What Purposes?

- Irrigation scheduling.
- Pest management.
- Air quality monitoring.
- Fire fighting.
- Energy generation.
- Engineering designs.
- Weather forecasting.
- Research.
- Planning.
- Drought monitoring.



Crop and landscape coefficients

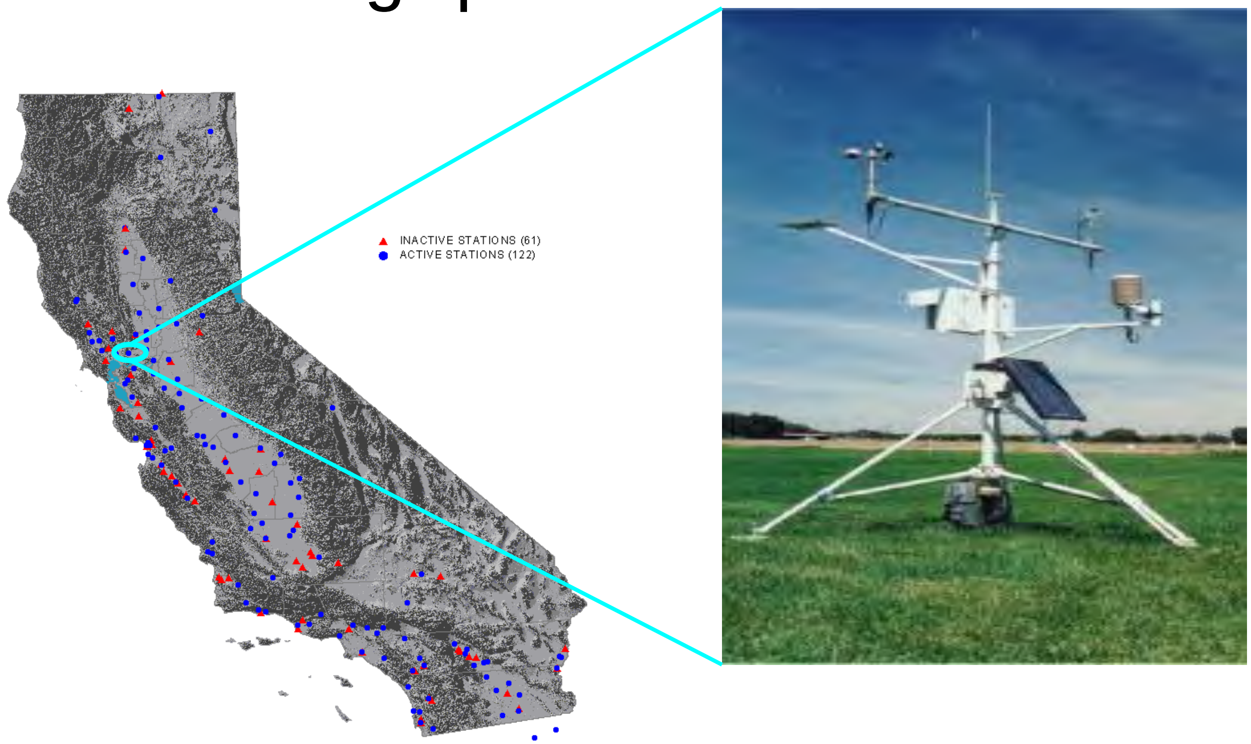
- **Crop Coefficient (K_c)**
  - $ETc = K_c * ETo$

- **Landscape Coefficient (K_L)**
  - $ETc = K_L * ETo$

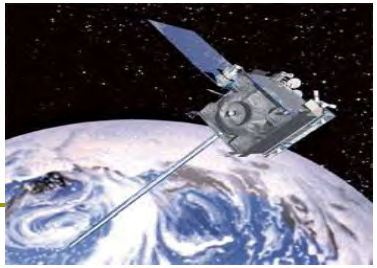
- K_L is a function of species factor (Ks), density factor (Kd), and microclimate factor (Kmc).
  - $K_L = Ks*Kd*Kmc$

CIMIS station locations

Spatial data gaps exist.



The Spatial CIMIS



- CIMIS initiated a project with the UC Davis to explore the potential for using remotely sensed data for the estimation of ETo (to mitigate the spatial data gap).
- Geostationary Operational Environmental Satellites (GOES) were selected.

ETo estimation.

- The ASCE version of the PM equation is used:

$$ETo = \frac{0.408\Delta(Rn - G) + \gamma \dfrac{900}{T + 273} u_2 (es - ea)}{\Delta + \gamma(1 + 0.34 u_2)}$$

- Net radiation (Rn) is calculated from net shortwave (Rns) and net longwave (Rnl) radiations.
- Rns is calculated from solar radiation (Rs), which is in turn derived from the GOES.

ETo Estimation (cont.)

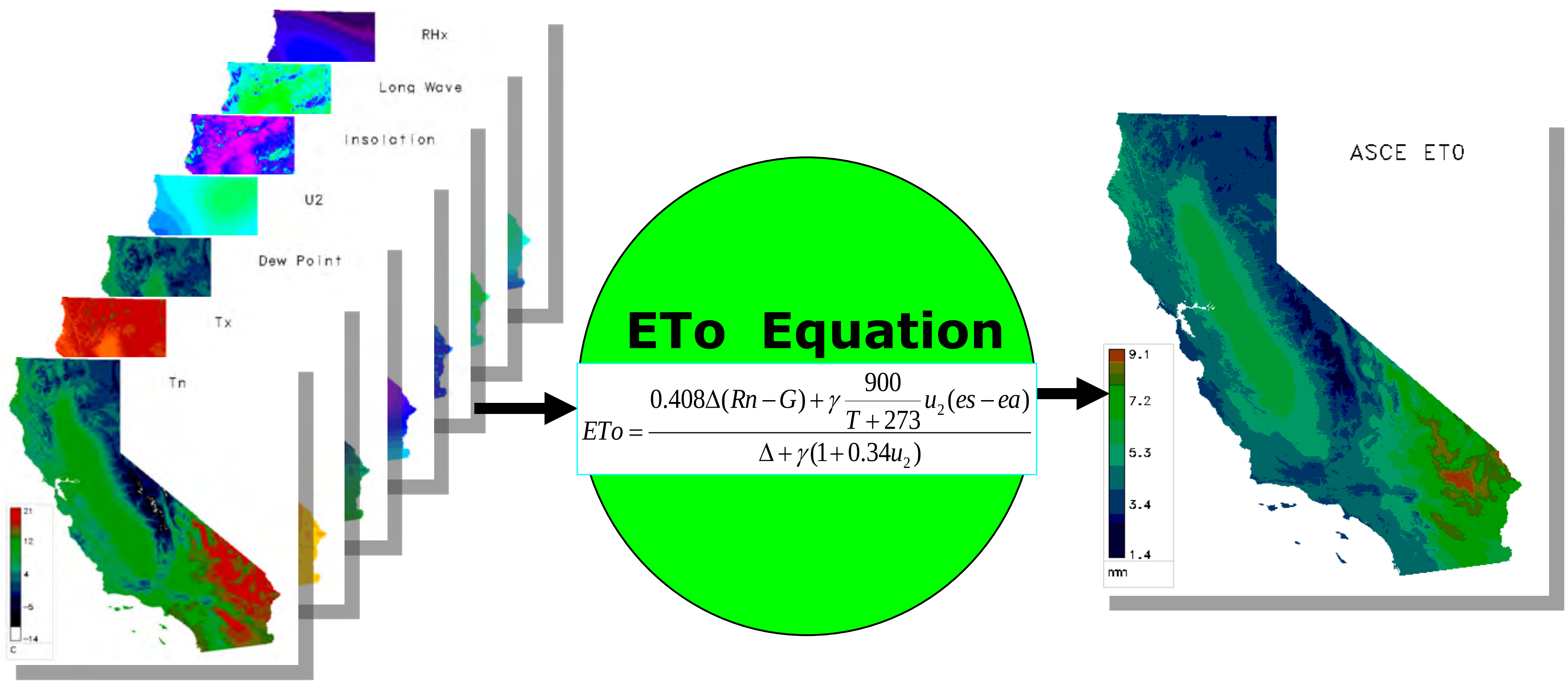
- Rnl is calculated from air temperature, vapor pressure, and solar radiations (actual and clear sky).

$$R_{nl} = \left(1.35\frac{R_s}{R_{so}} - 0.35\right)\left(0.34 - 0.14\sqrt{e_a}\right)\sigma\left[\frac{T_{K\max}^4 + T_{K\min}^4}{2}\right]$$

ETo Estimation (cont.)

- Air temperature, relative humidity, and wind speed are interpolated from CIMIS stations
- We have been looking at the option of using the WRF model to derive some of these parameters and to forecast ETo.

ETo Estimation (cont.)



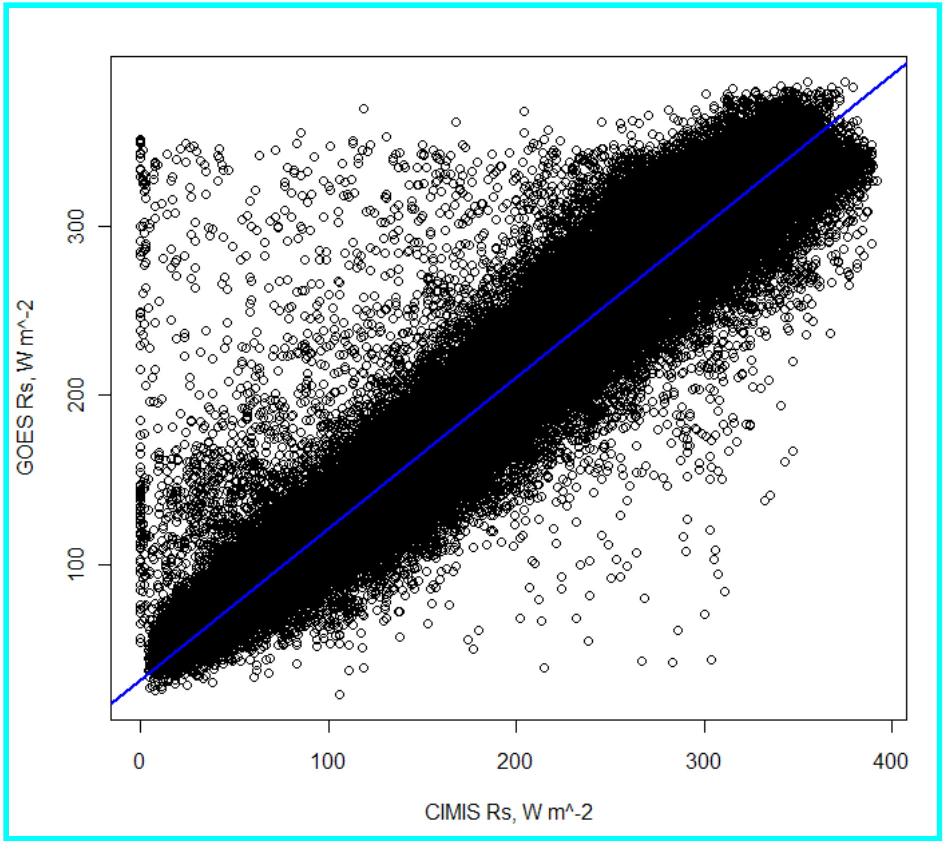
$$ETo = \frac{0.408\Delta(Rn - G) + \gamma \frac{900}{T + 273} u_2 (es - ea)}{\Delta + \gamma(1 + 0.34u_2)}$$

Solar Radiation.

- Cloud brightness (n) is estimated from GOES visible images.
- Clear sky factor (k) is calculated as a function of cloud brightness. K = f(n).
- Clear sky solar radiation (Rso) is calculated using the Heliosat II model.
- Rs is then calculated from k and Rso.

  Rs = k * Rso

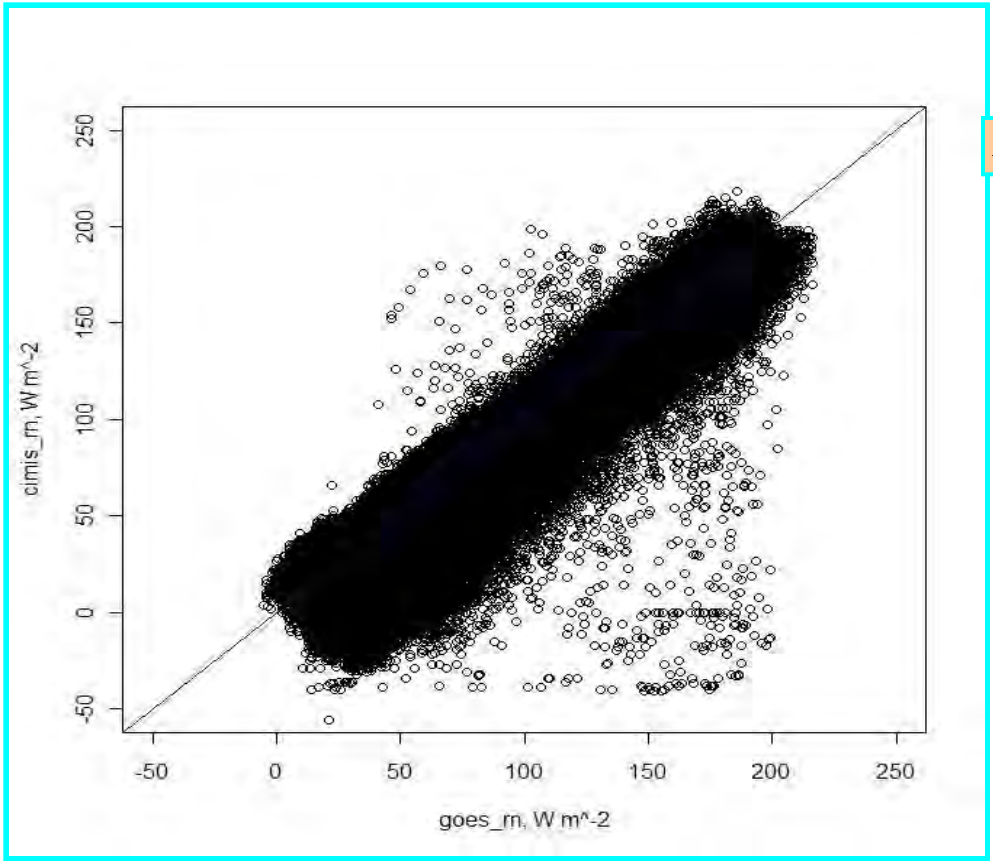
Solar Radiation (cont.)



$$Rs(goes) = 0.89 Rs(cimis) + 31.9$$

$$r^2 = 0.94$$

Net Radiation



$$Rn(goes) = 0.92 Rn(cimis) + 14.01$$

$$r^2 = 0.92$$

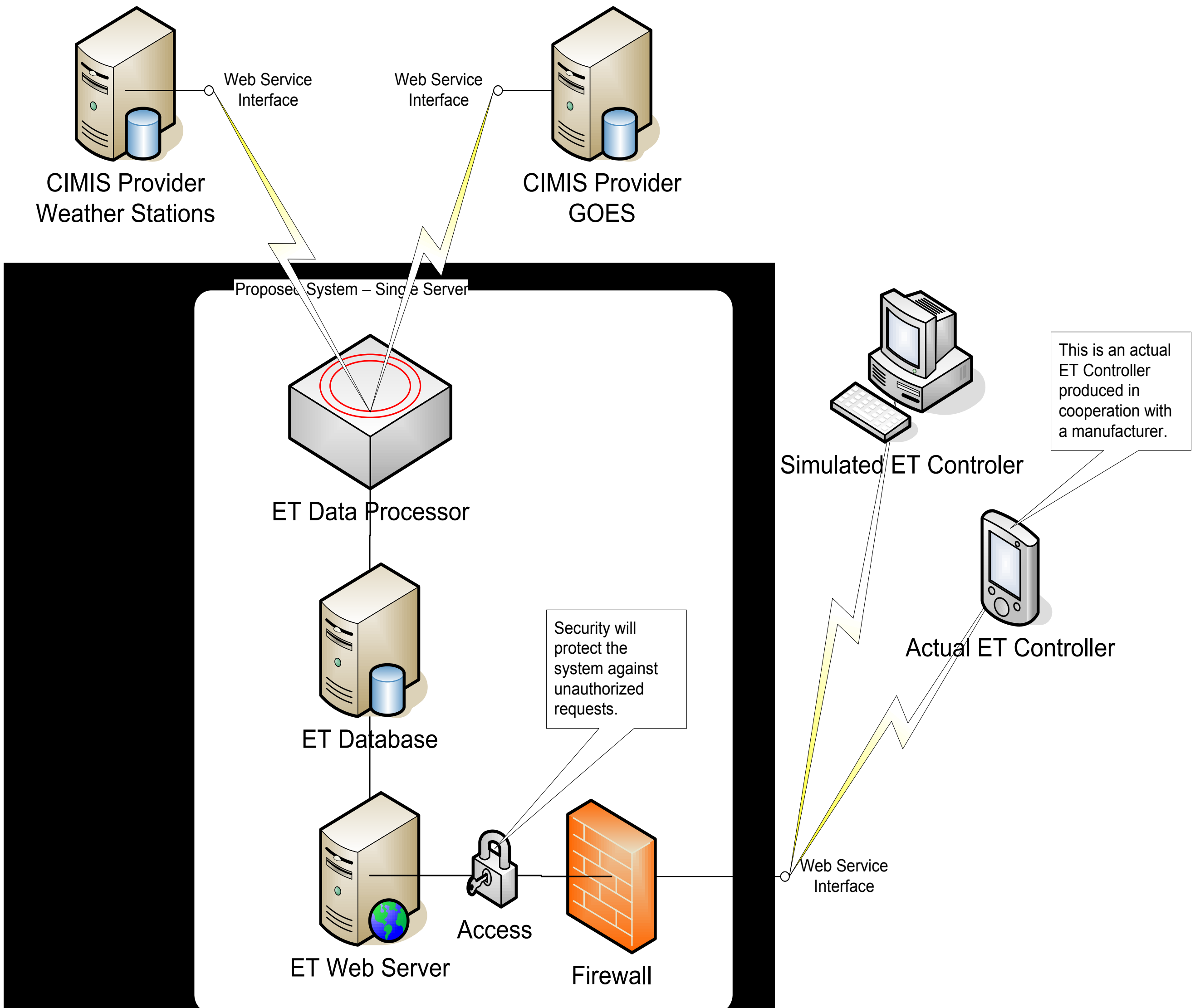
Ta, RH, and U2.

- Two interpolation methods were used; DayMet and Spline.
- DayMet - generates daily surfaces of temperature, humidity, precipitation, and radiation over large regions of complex terrain using truncated Gaussian weighting filter.
- Spline – fits a surface through or near known points using a function with continuous derivatives

Ta, RH, and U2 (cont.)

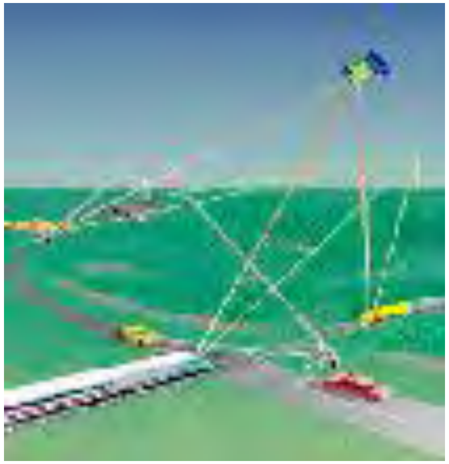
- Cross validation analyses showed that both methods have similar errors.
- Statistical analyses and visual inspections were used to determine which method to use for each weather parameter.
- In some cases, there were significant differences between the two interpolation methods.

ET System Overview



What is Currently Available?

- Daily ETo data map sets of CA
- Archived data from Feb. 2003
- 2 kilometer resolution
- Data available through web services, CIMIS web site, or automated email reports
- Can request data by geographic coordinate, address or zip code
- ETXML web services



Spatial CIMIS Report.

Return to Report Criteria

CIMIS (California Irrigation Management Information System)

CIMIS-GOES Report

Rendered in English Units.
August 26, 2009 - September 01, 2009
Printed on September 02, 2009

Point #1 - (40.3060, -122.5708)

Date	ETo (in/day)	Rs (Ly/day)
08/26/2009	0.23	581.98
08/27/2009	0.22	576.86
08/28/2009	0.16	312.21
08/29/2009	0.26	570.89
08/30/2009	0.24	568.06
08/31/2009	0.22	566.06
09/01/2009	0.19	556.51
Totals/Avgs	1.52	533.23

Point #2 - (38.4829, -120.8729)

Date	ETo (in/day)	Rs (Ly/day)
08/26/2009	0.23	580.81
08/27/2009	0.24	568.59
08/28/2009	0.22	502.00
08/29/2009	0.26	585.75
08/30/2009	0.27	567.02
08/31/2009	0.23	562.96
09/01/2009	0.23	571.08
Totals/Avgs>	1.67	562.60

HTML, CSV, or XML
Spatially as:
Point or Zip code
Time Stamp is:
Daily on up
Google map interfaced:

CIMIS Current & Future Plans.

- ETo forecasting, precipitation maps.
- Crop-coefficient (Kc) maps Tops-Simms cooperation with NASA.
- Actual ET (ETc) maps.
- Interactive (web services) data delivery with improved features to automatically deliver data to any type of end user (ET controllers, data bases, PDA's, & etc..)
- Standard data prototype ET.XML

Overview

Objectives:

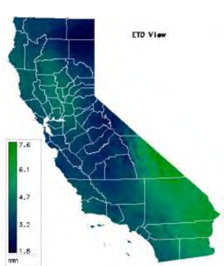
- Build data processing systems required to integrate data from satellites and surface observation networks in real-time to map crop coefficients and basal crop ET
- Develop new information products to support growers in managing irrigation
- Develop new information products to support water managers in making decisions about scheduling of water deliveries

Approach:

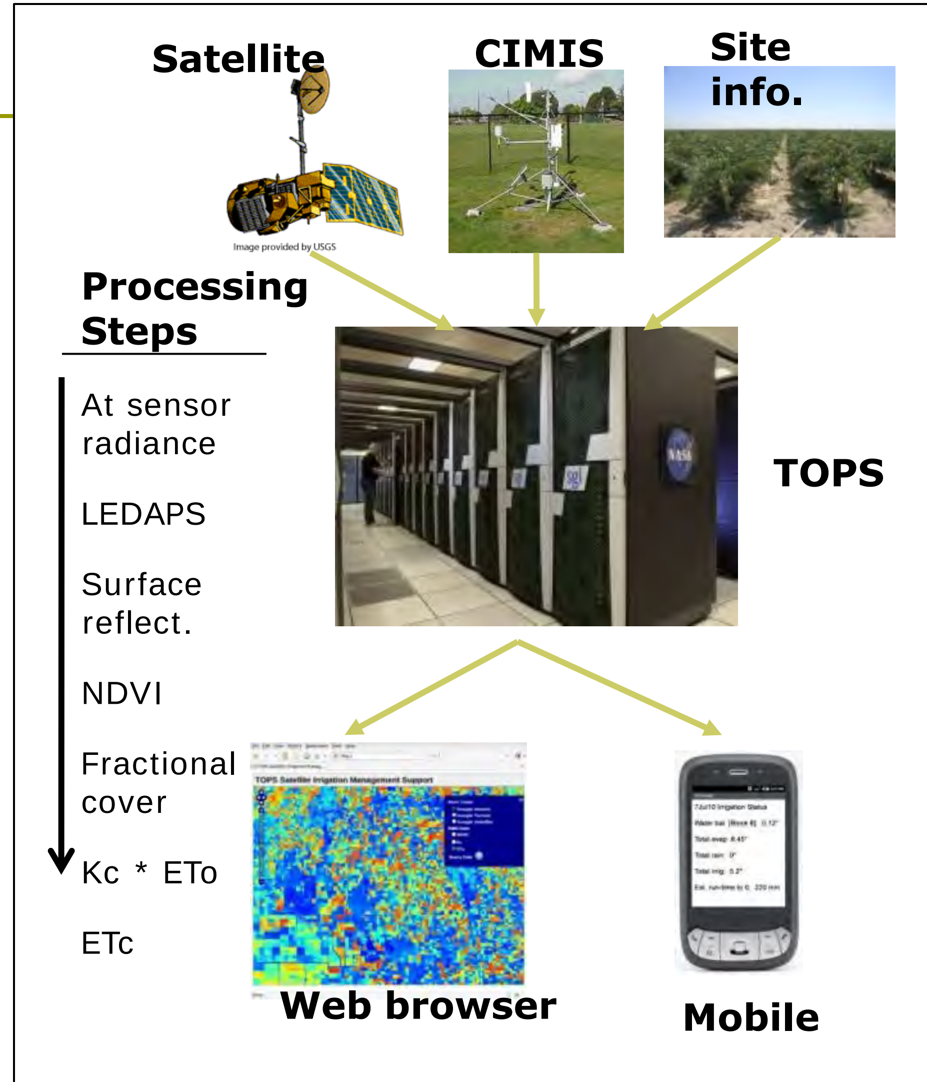
- Builds on CIMIS and VSIM, and integrates satellite Kc maps with CIMIS ETo maps
- Standard approach for incorporating weather information into irrigation management practices

ETcb = ETo * Kcb

CIMIS ↗ satellite ↖



Spatial CIMIS ET_0
March 31, 2011

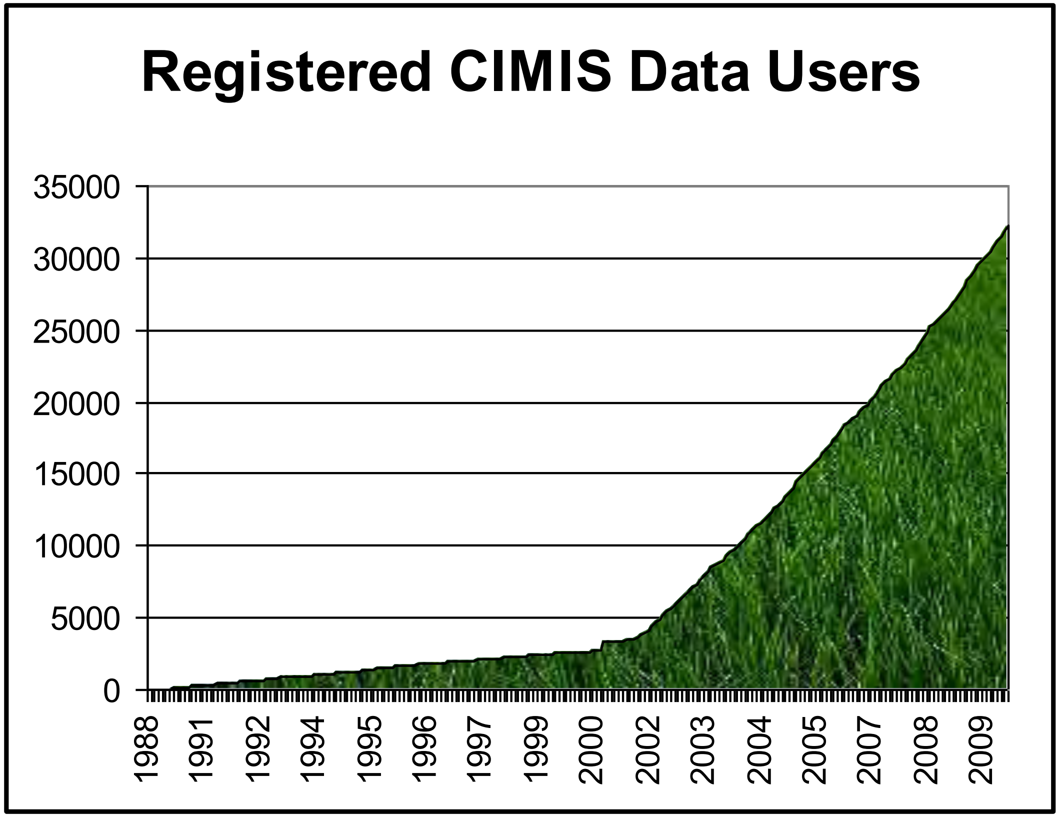


Integration of satellite and surface observation networks

Model Refinements.

- Snow versus cloud.
- Surface reflectance (albedo) values.
- Turbidity.
- Interpolation versus model.
- Interactive data delivery with improved features.

How do we Measure Success?



Benefits of using CIMIS data

- Water and money savings.
- Increased yields and crop quality.
- Reduced runoff and deep percolation
- Better looking landscape.
- Improved water quality.
- Increased energy efficiency.
- Reduced green house gas emissions

Quantifying the Benefits (cont.)

- According to National Agri-Marketing Association at UC Davis:
  - 23% Growers increased crop yield.
  - 28% Growers increase in crop quality.

- UC Berkley Department of Agriculture and Resource Economics(1996):
  - Appproximately 10% Reductions of applied water

Quantifying the Benefits (cont.)

Crop	Dollars/Acre
Almonds	165
Apples	148
Avocados	308
Cauliflower	352
Celery	717

How do we build success?

CIMIS development and management;

- From the end user up
- Partnerships, partnerships and partnerships with focused actions
- Validated data and user acceptance products

WUE in the State;

- Encourage with TA
- Carrots through Grants & Loans…
- Laws, Regulations and Third party litigation

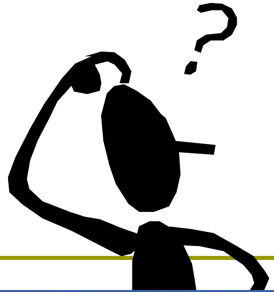
Cooperators and Partnerships.

- Some CIMIS stations are owned by DWR.
  - Local water agencies.
  - Universities.
  - Cities.
  - U.S. Department of Agriculture (USDA).
  - U.S. Bureau of Reclamation (USBR).
  - Conservation Districts (CD).
  - Private industries.
  - NASA

Contact

- Department of Water Resources
  Water Use Efficiency Office
  901 P Street, Third Floor
- P.O. Box 942836
  Sacramento, CA 94236-0001
- Kent Frame (916) 651-7055
- kframe@water.ca.gov

Questions?



THANK YOU