



Drought Prediction San Diego Meeting April 29 - May 1, 2013

Potential Interstate Cooperation on Irrigation Scheduling Data

Kent Frame

Program Manager II

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

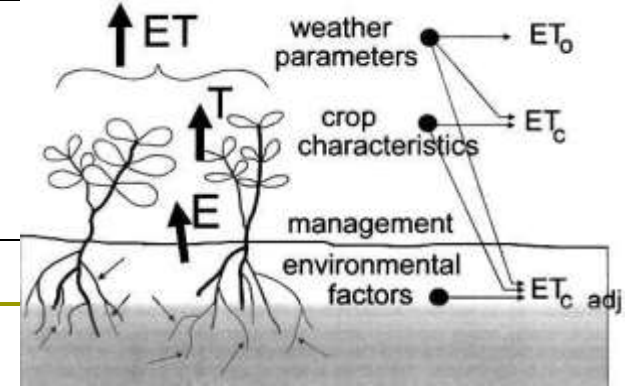
Problems In California

- ❑ 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.
- ❑ Short Supplies

Implications?

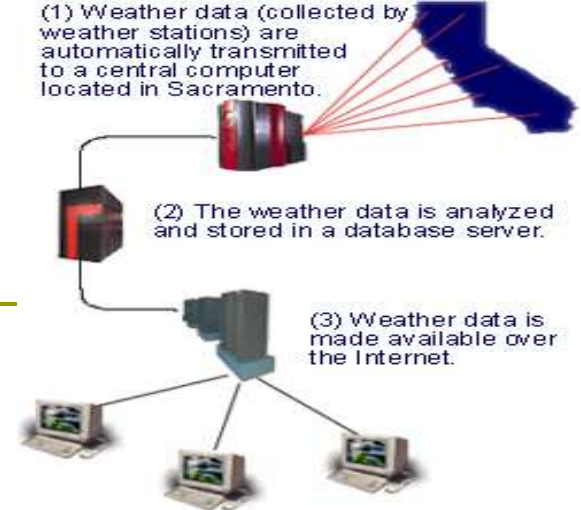
- ❑ There will be an increase in demand and competition for limited water supplies.
- ❑ Water conservation, an efficient use of water by avoiding unnecessary and wasteful uses, can mitigate the problem.
- ❑ Planning – water management planning and WUE can help prepare and mitigate

Evapotranspiration



- ❑ ET – loss of water to the atmosphere by the combined processes of evaporation (E) and transpiration (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?

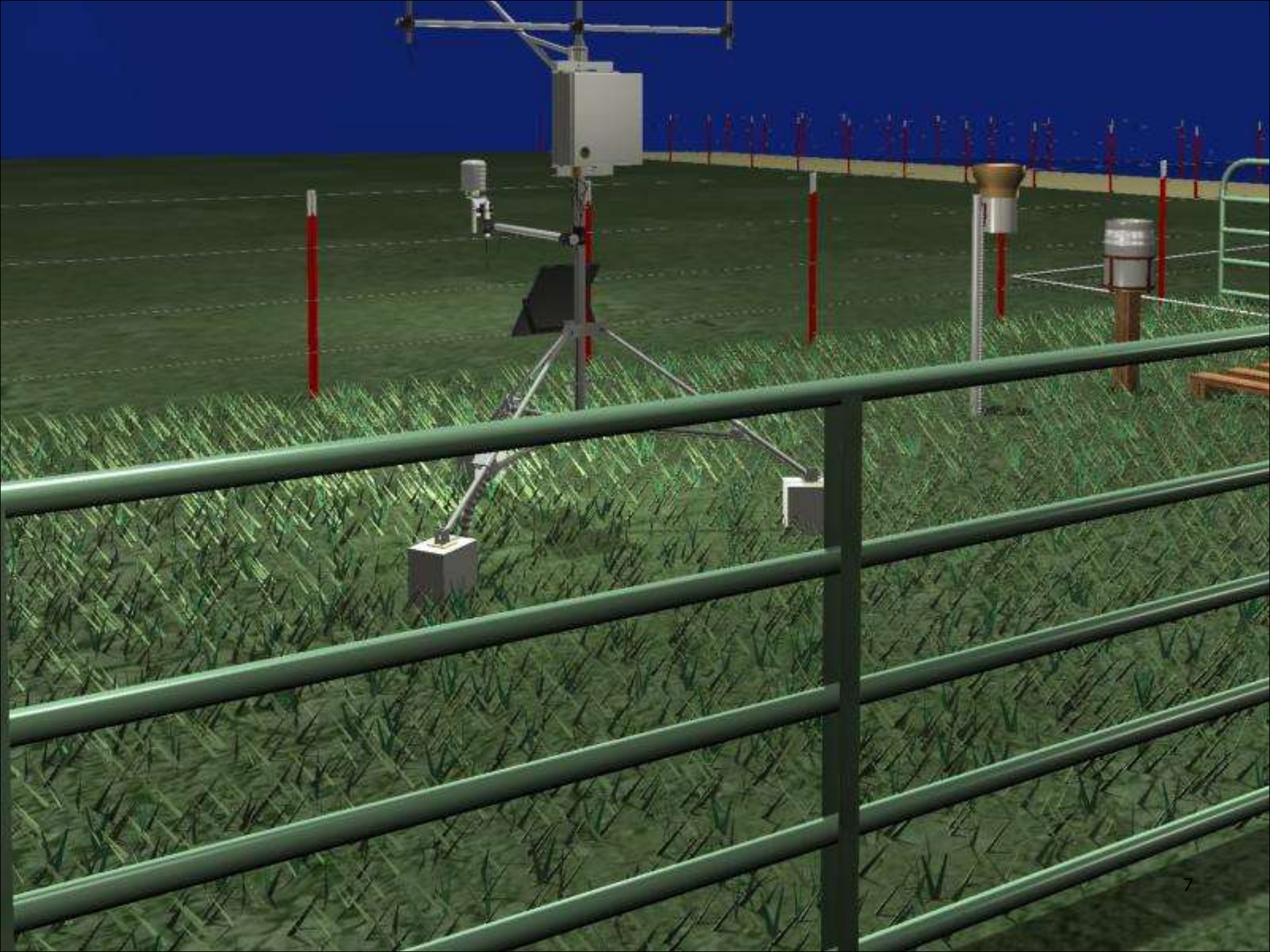


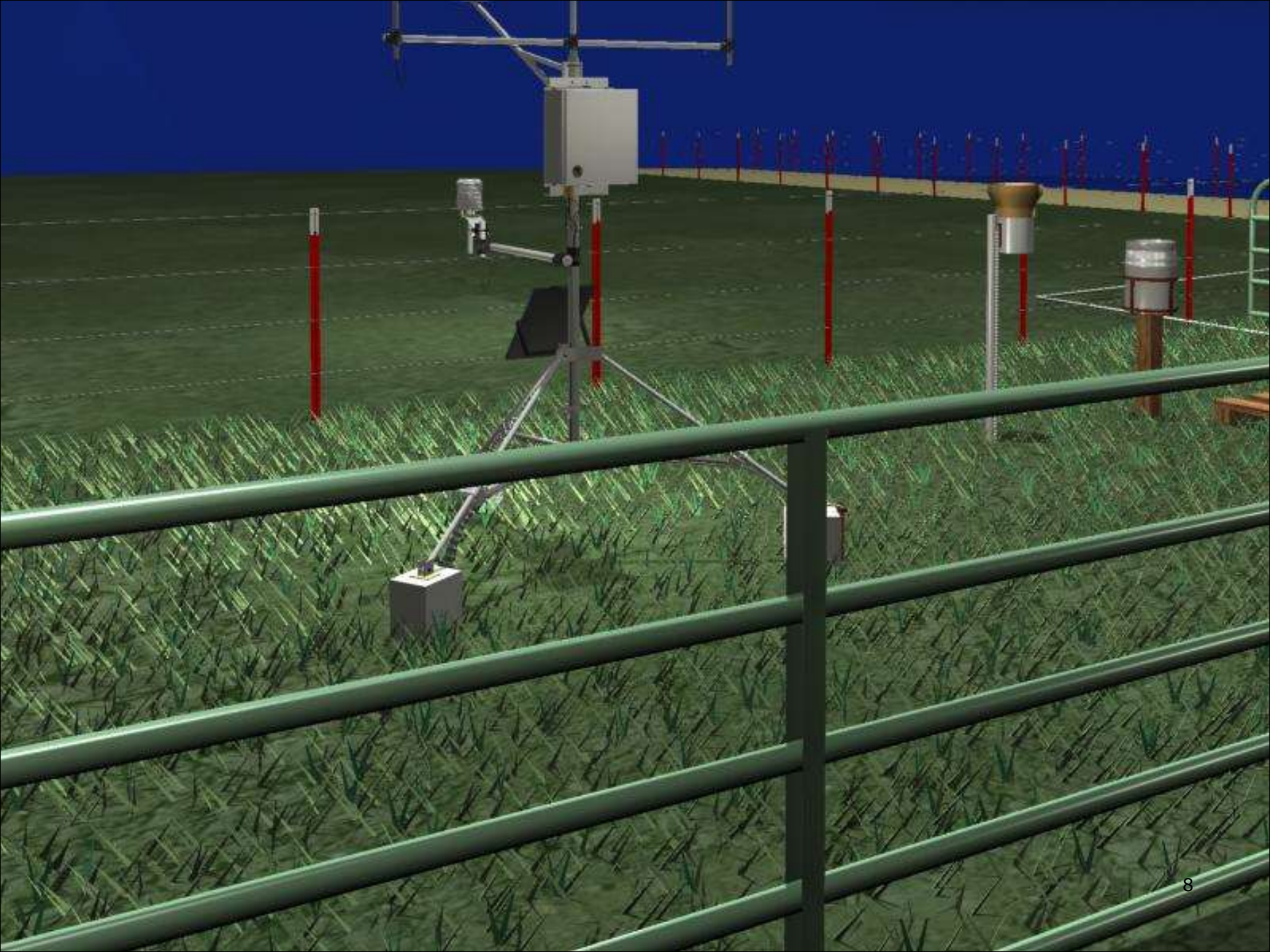
- ❑ **CIMIS** – a network of over 140 fully automated weather stations that collect weather data and provide estimates of reference evapotranspiration (ET_o) to the users.
- ❑ **Reference Evapotranspiration** - ET from standardized grass (ET_o) and/or alfalfa (ET_r) surfaces.

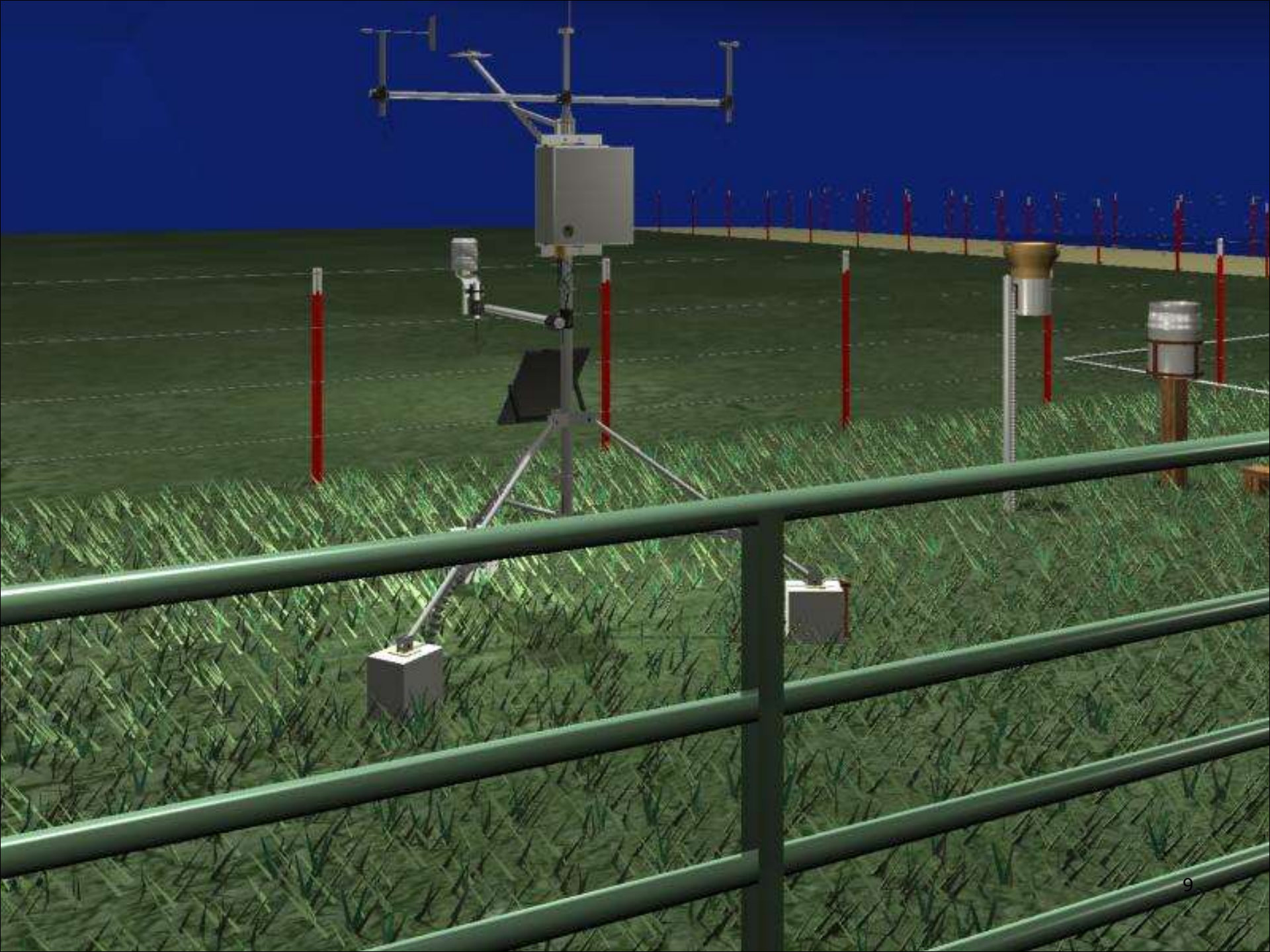
GERBER STATION

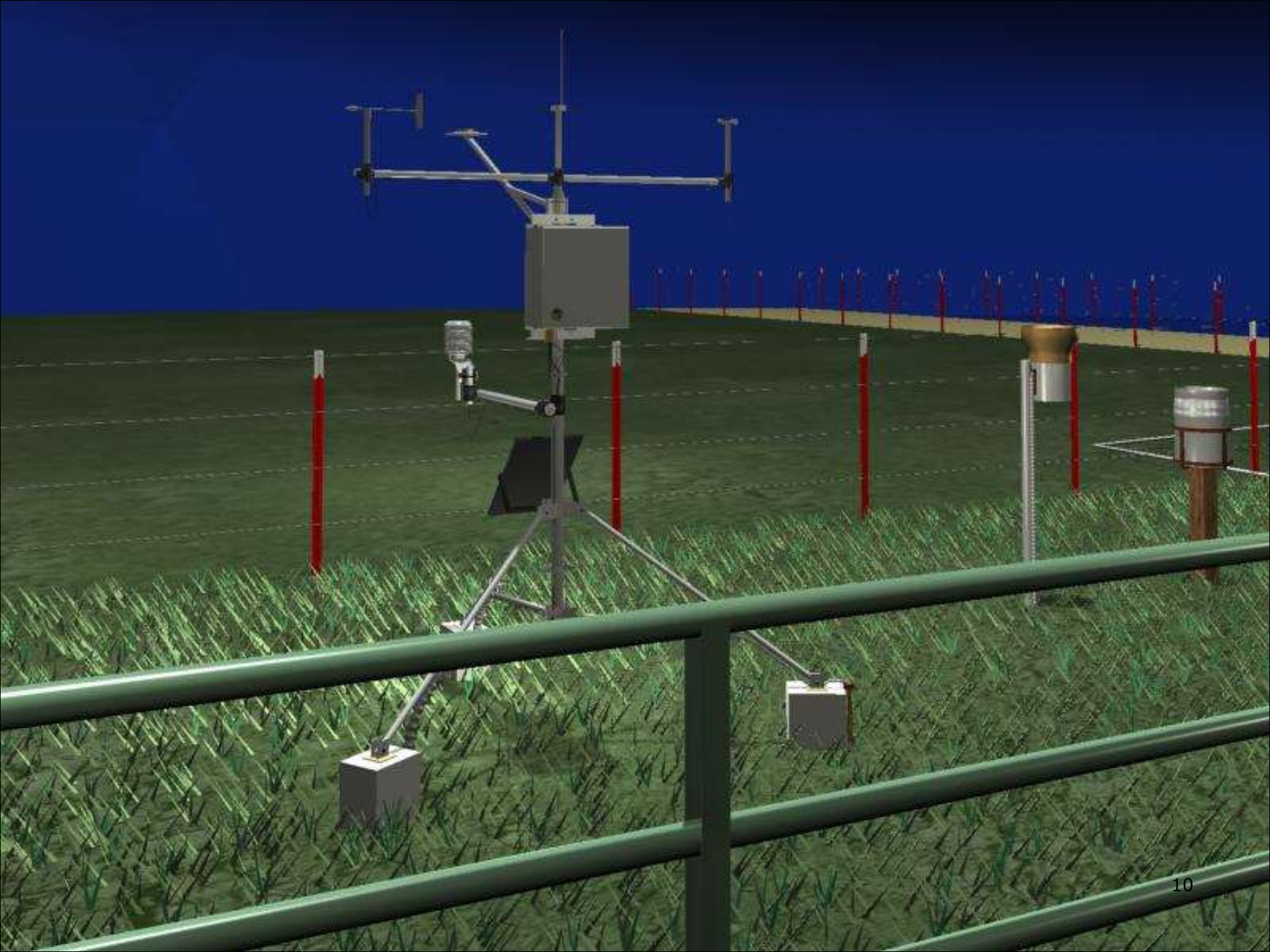
CIMIS

California Irrigation Management Information System

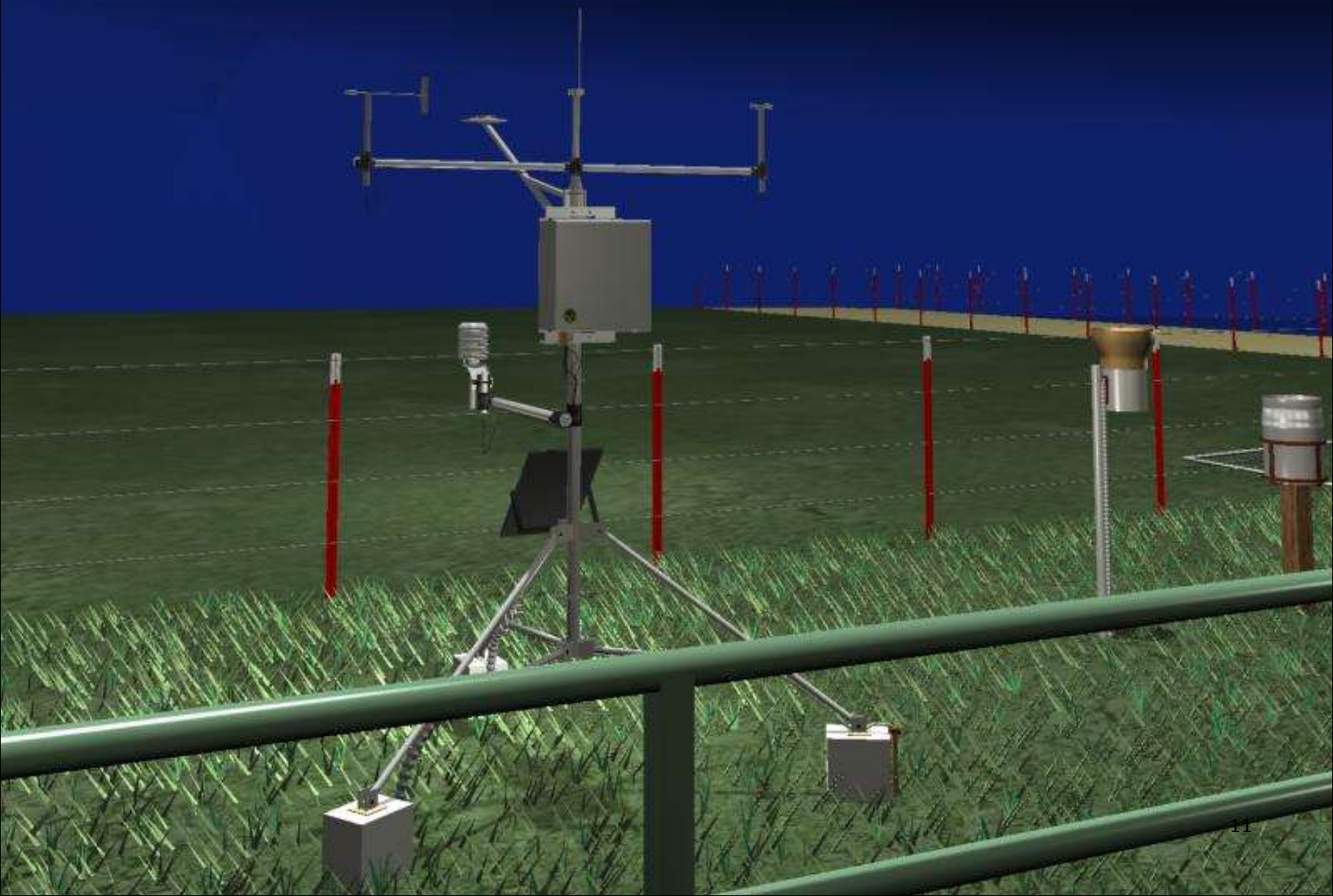




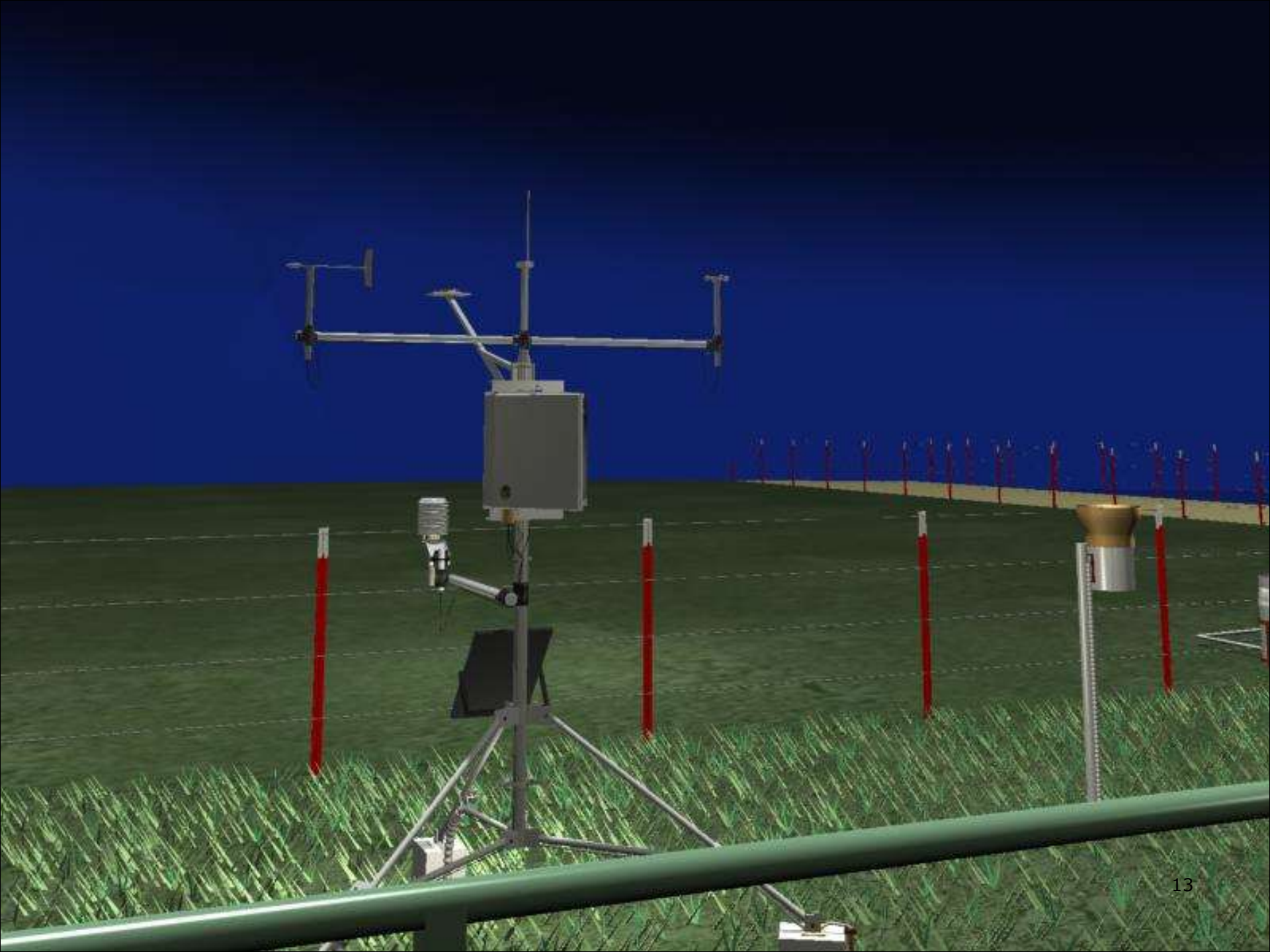


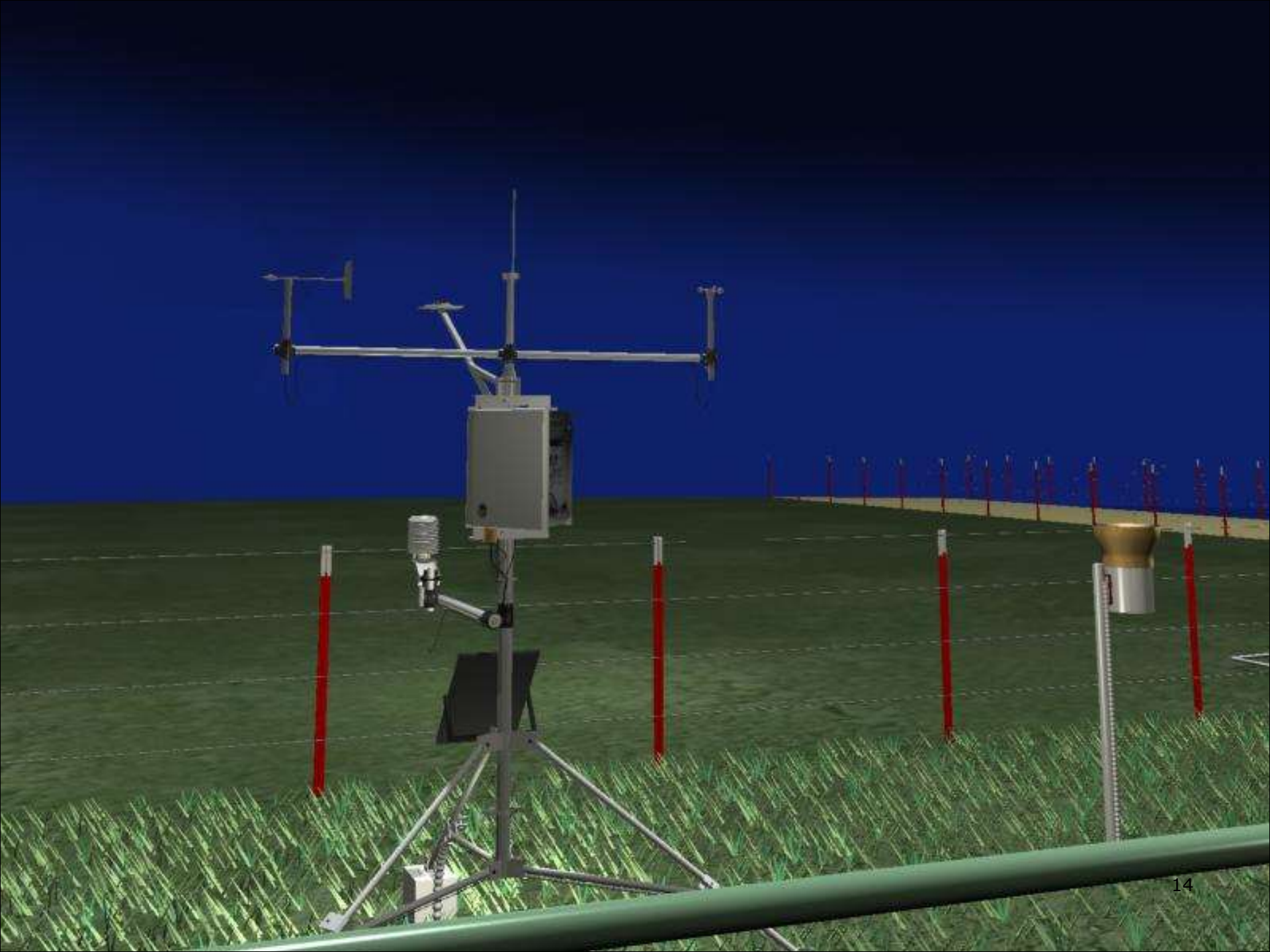


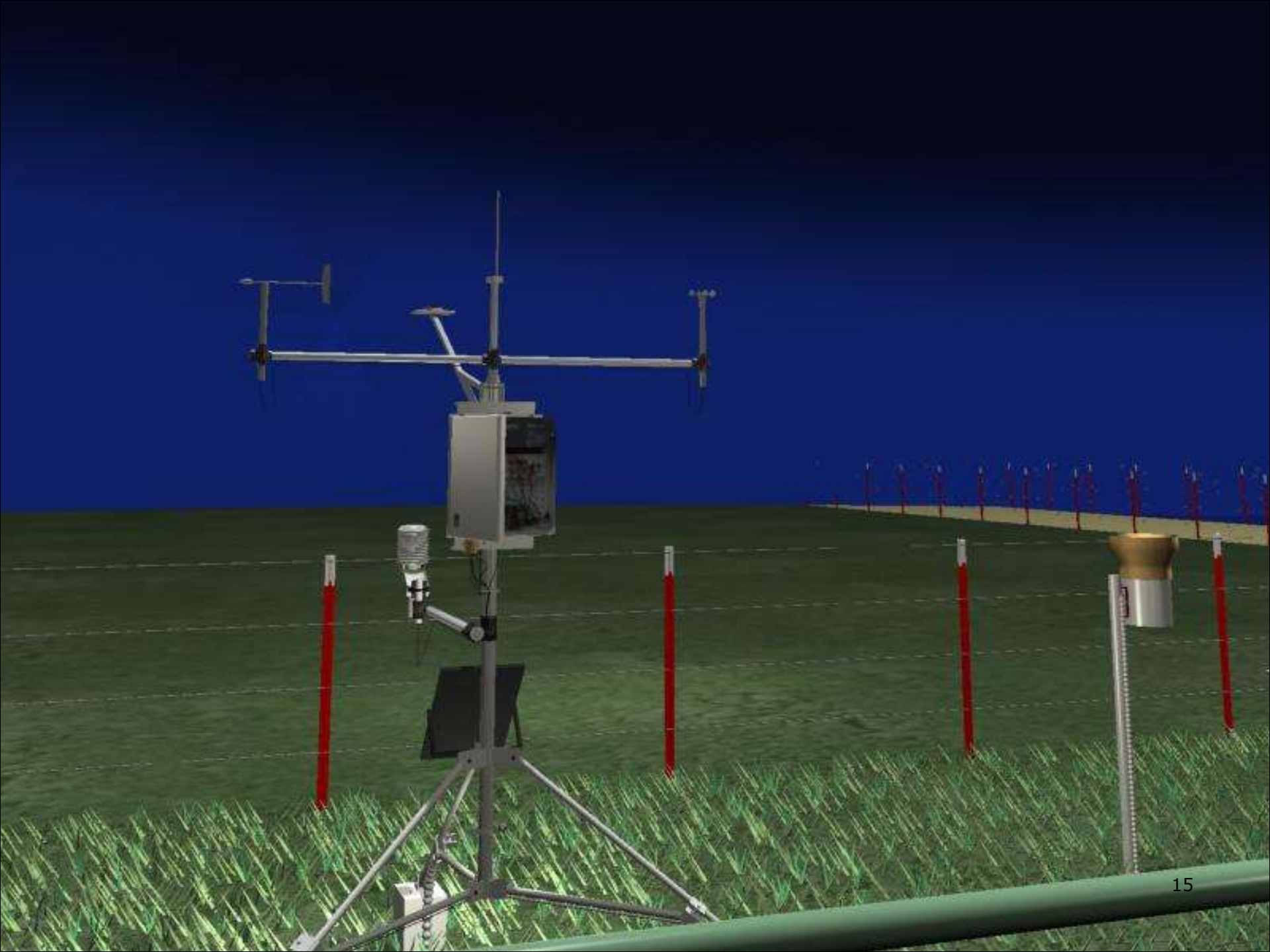
Weather Station

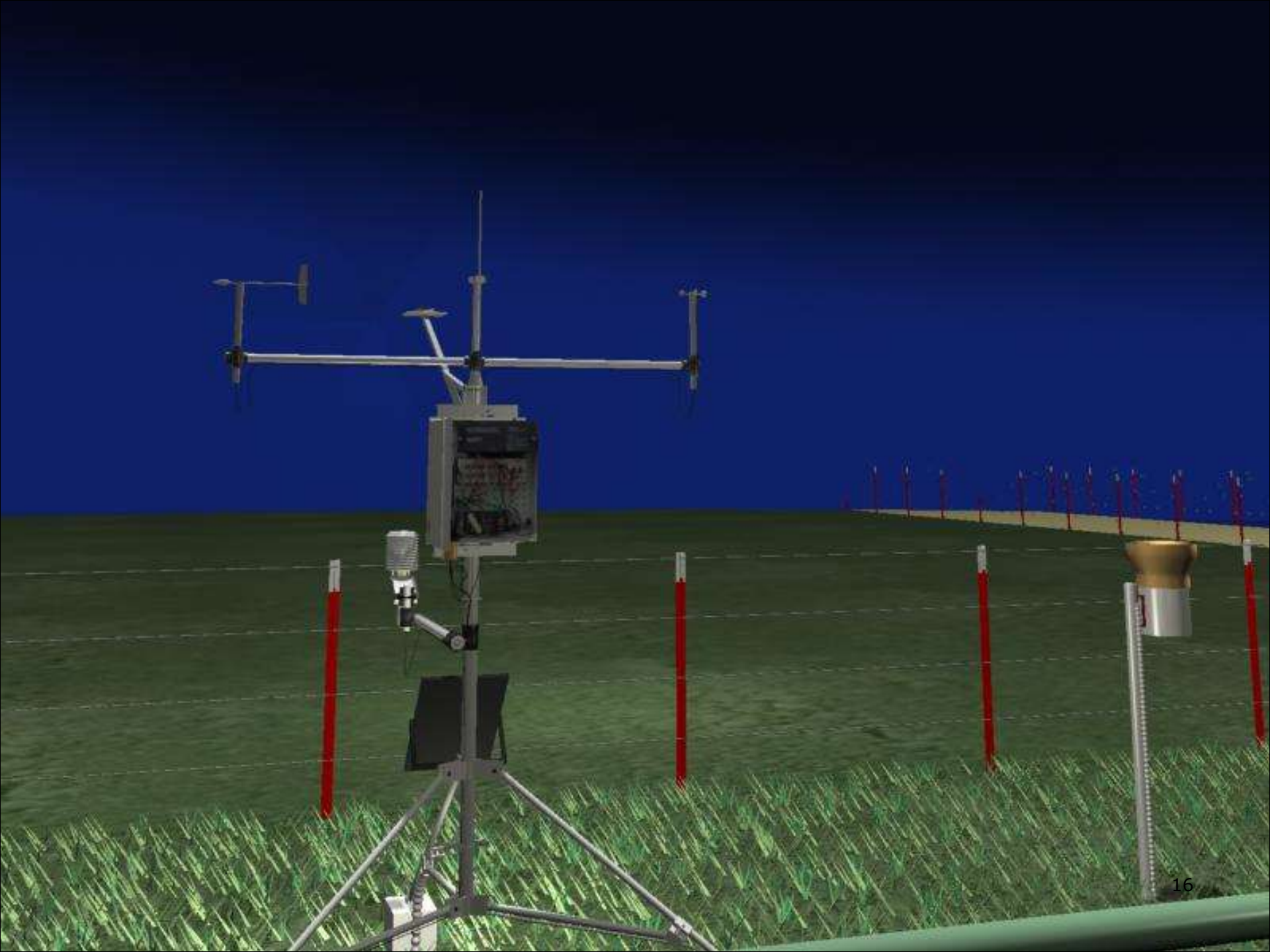




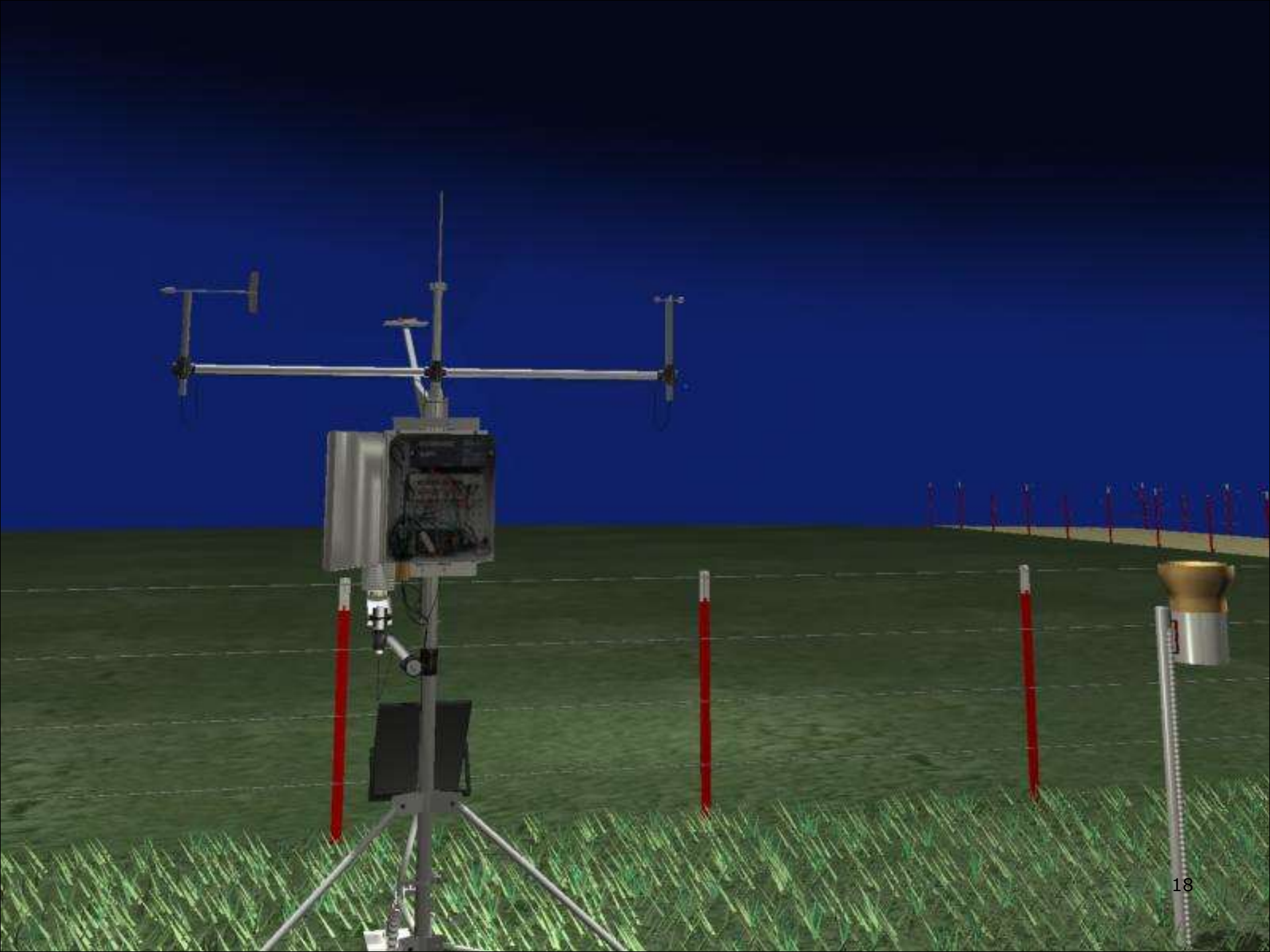














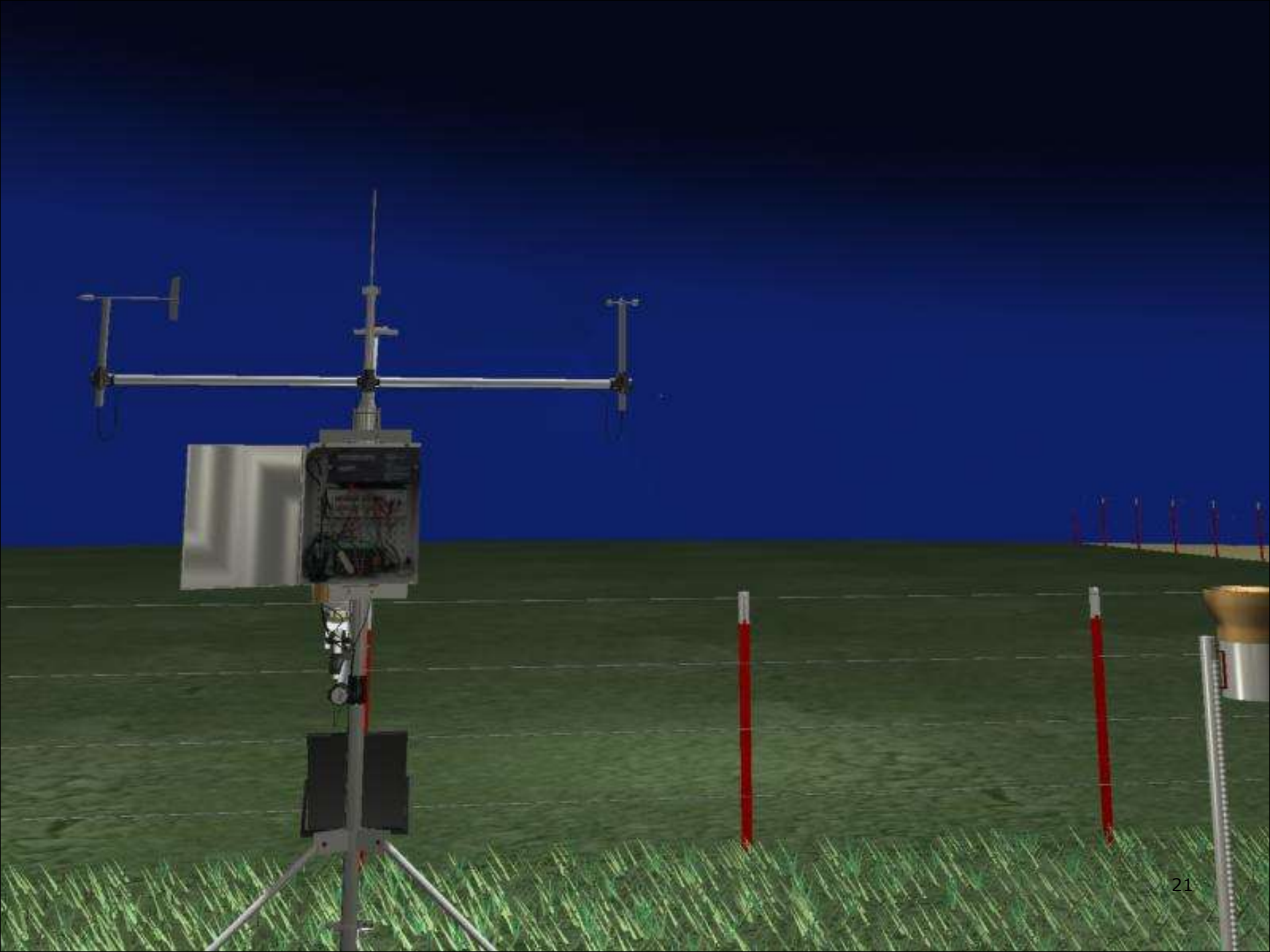
Lightning Rod

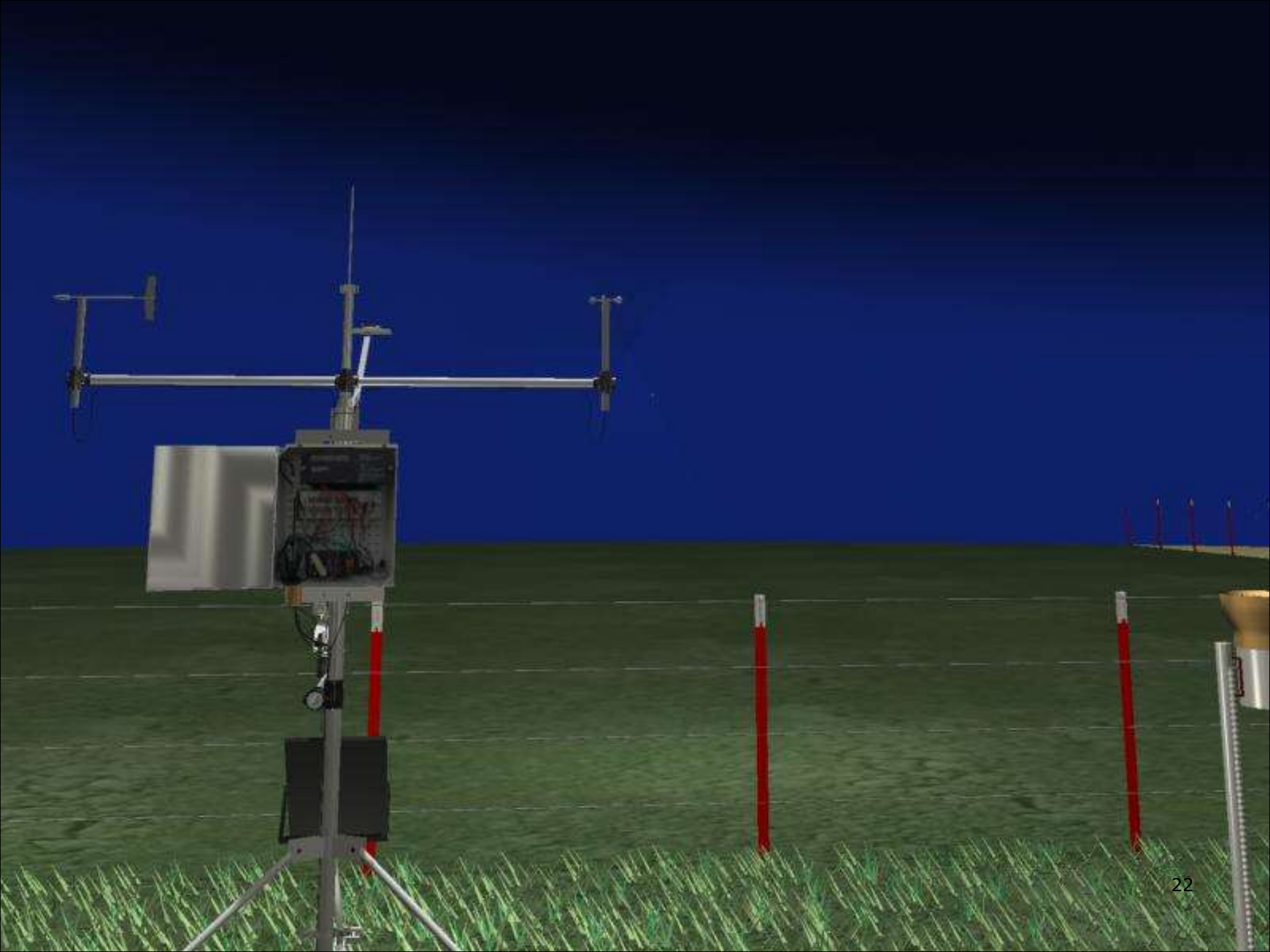
Wind Direction
Sensor

Wind Speed
Sensor

Data Logger Power Supply
ENC 12/14 Enclosure

Rain Gauge

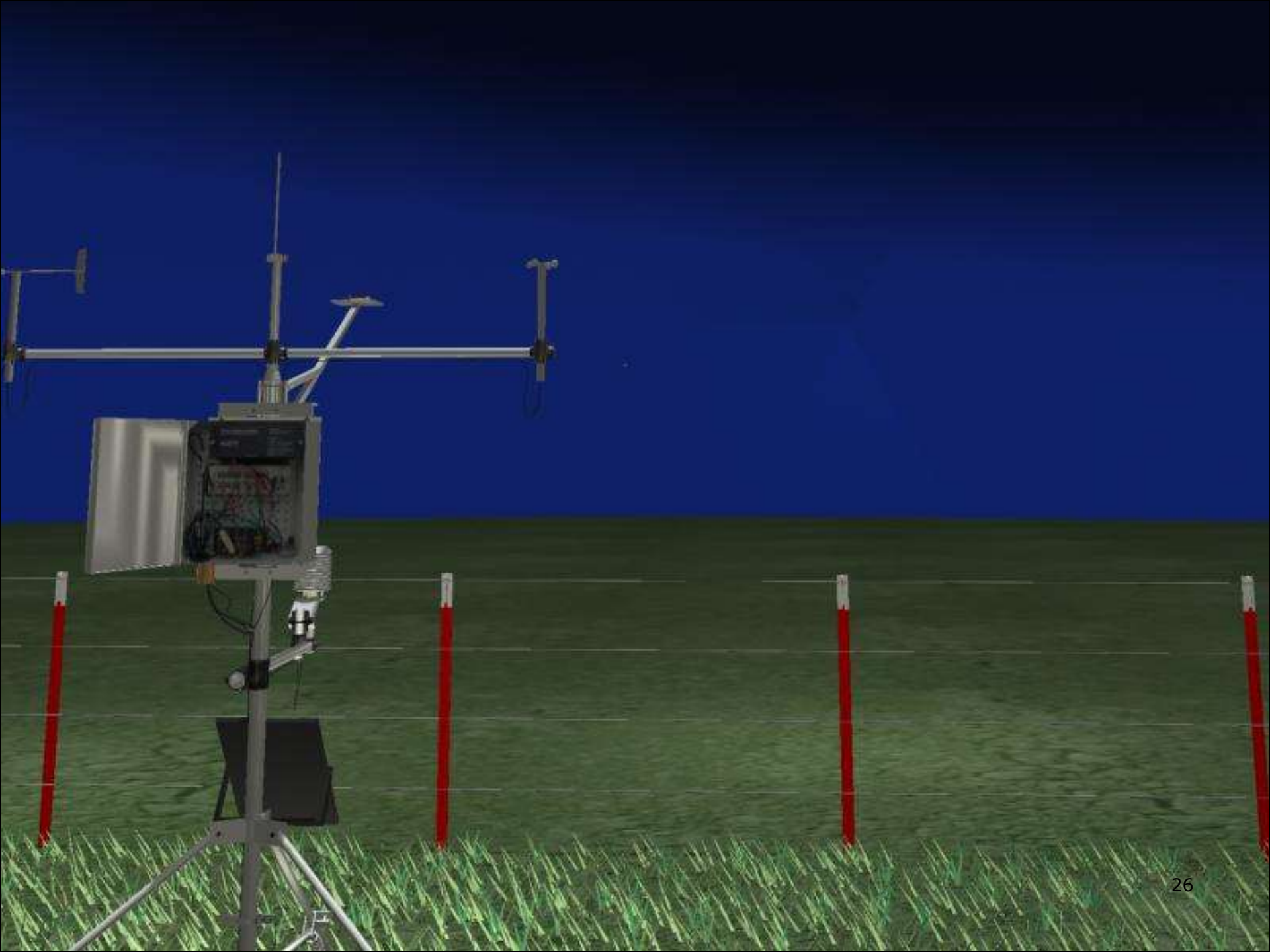




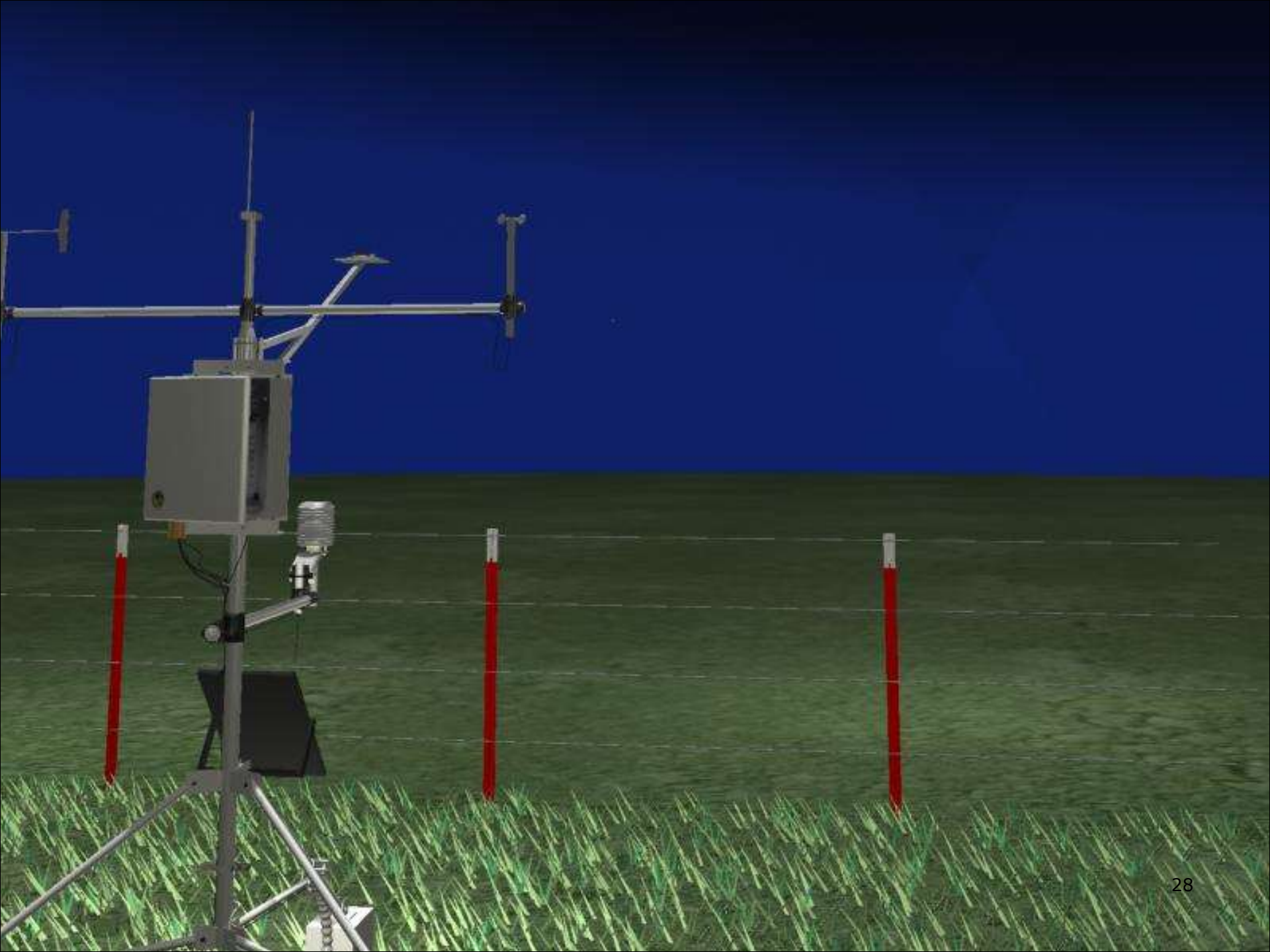














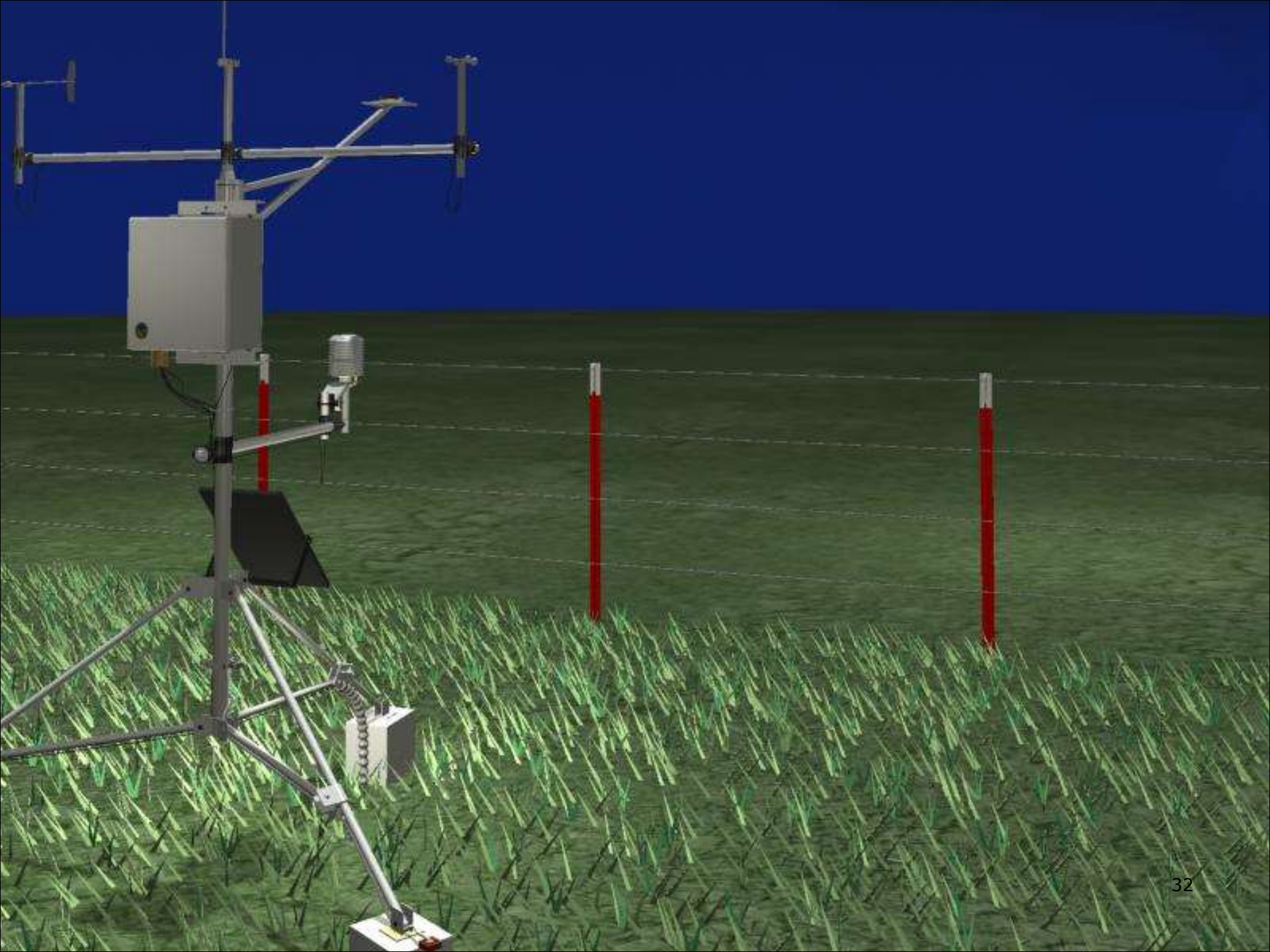
Li-Con Silicon
Pyranometer L1200x

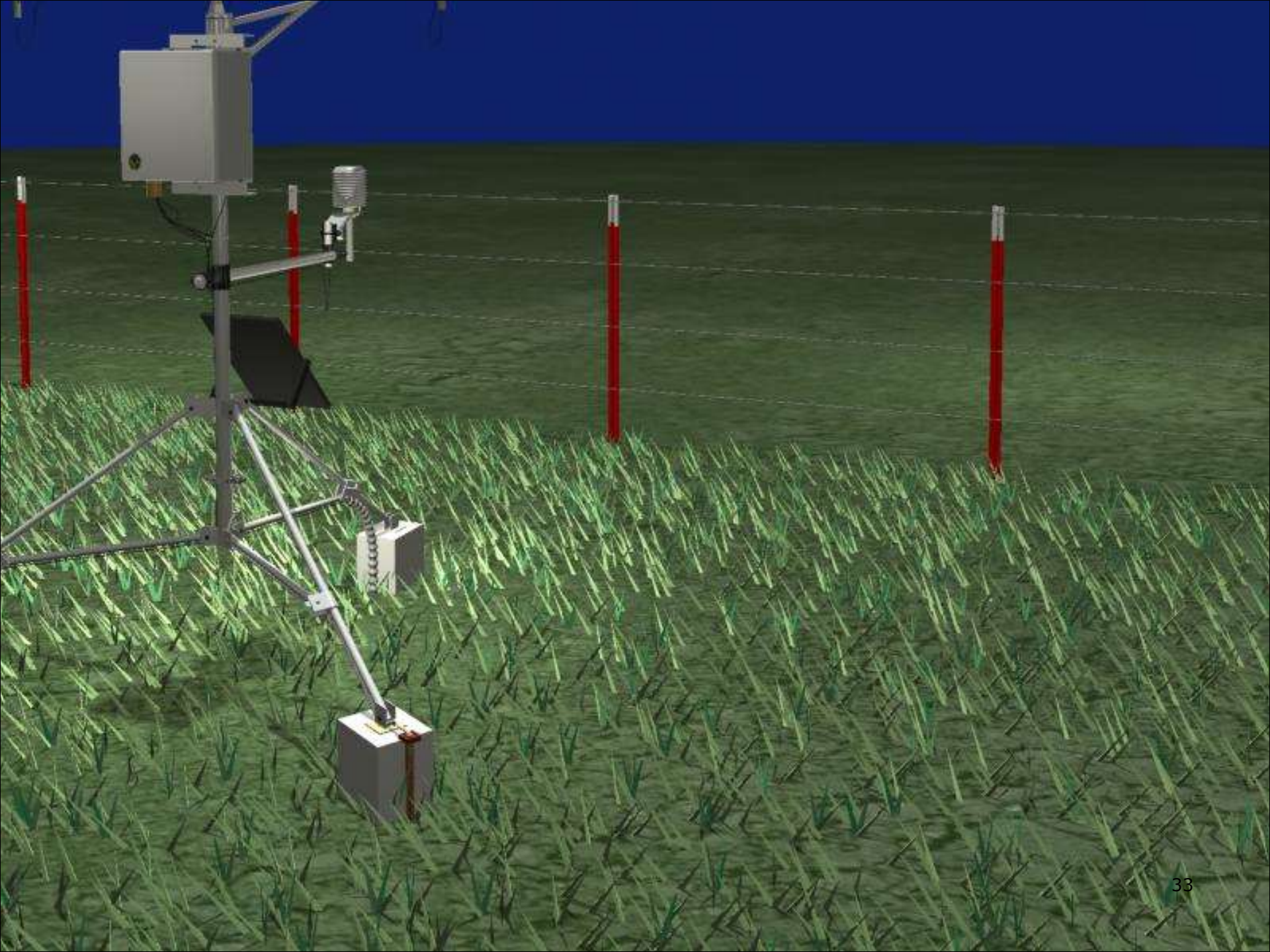
Gill Radiation Shield

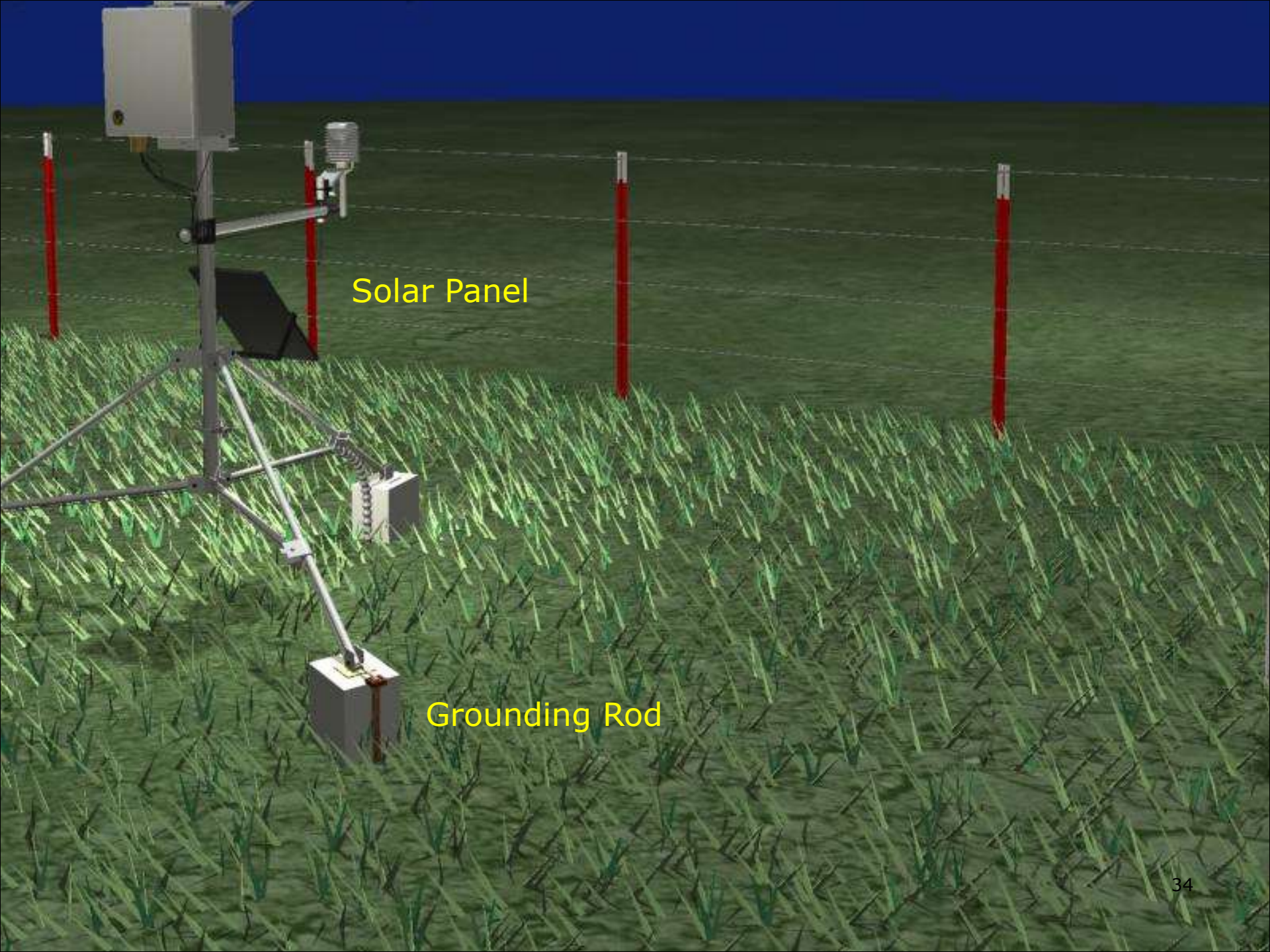
Temperature and Relative
Humidity Probe





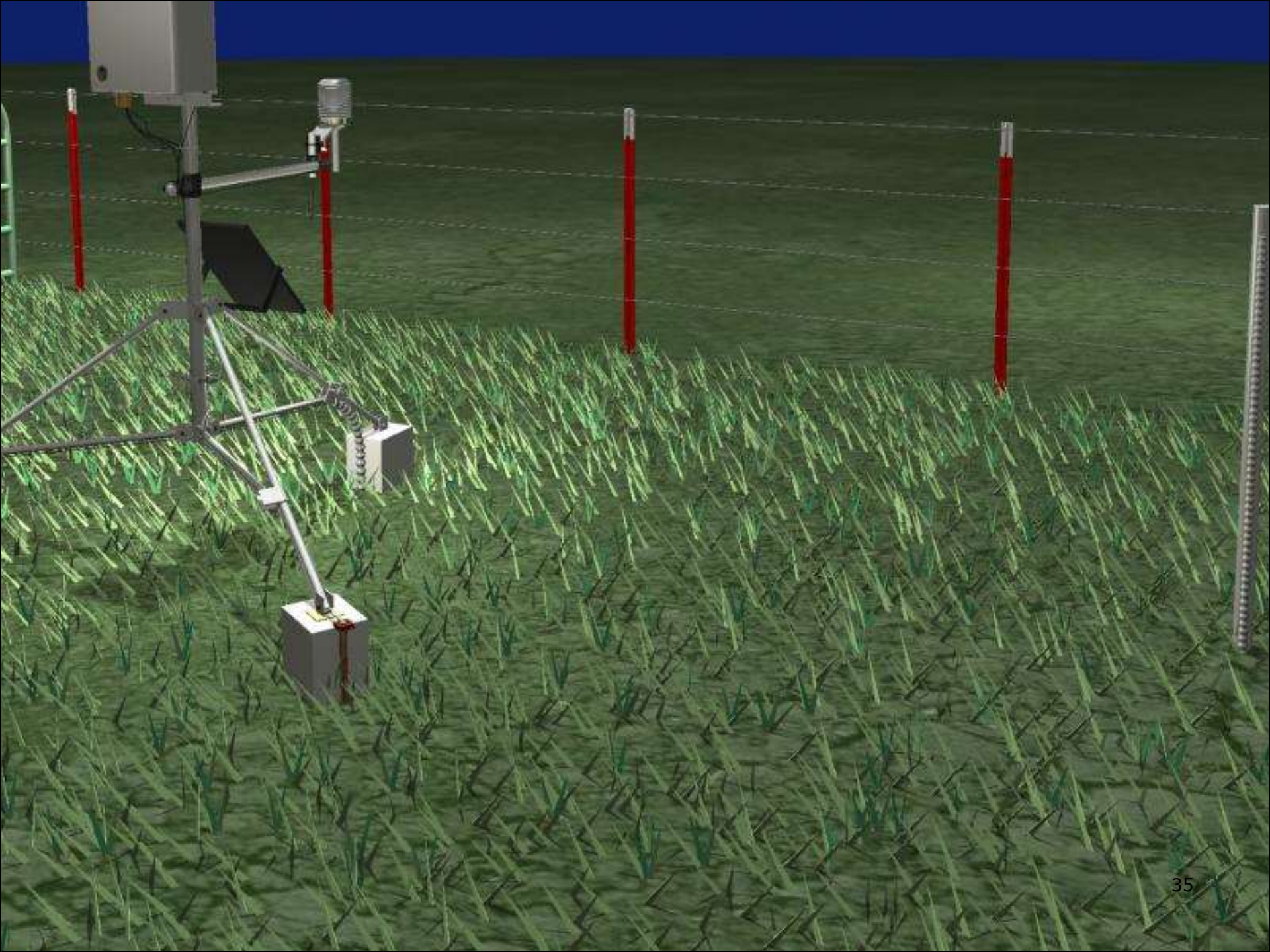


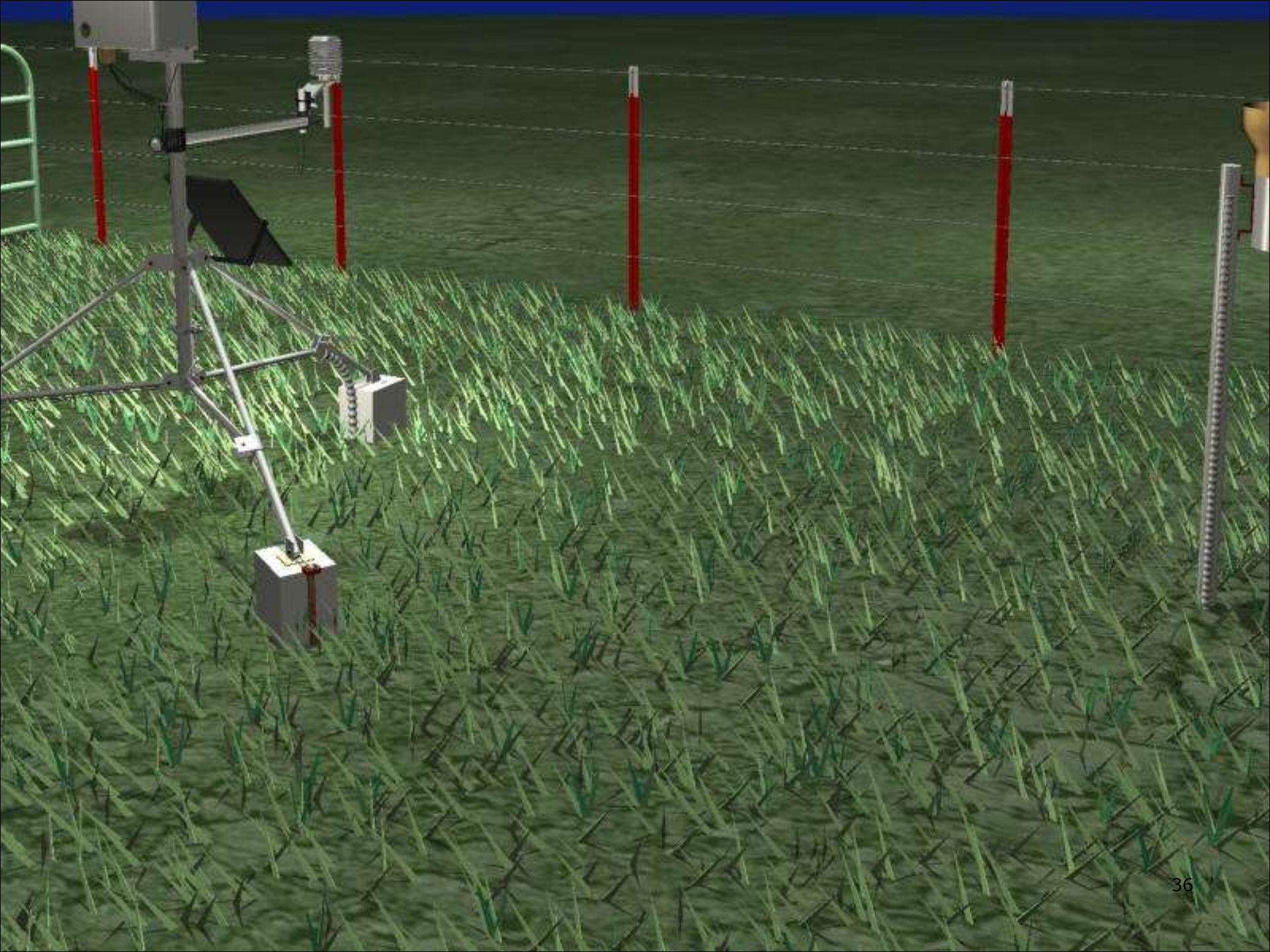


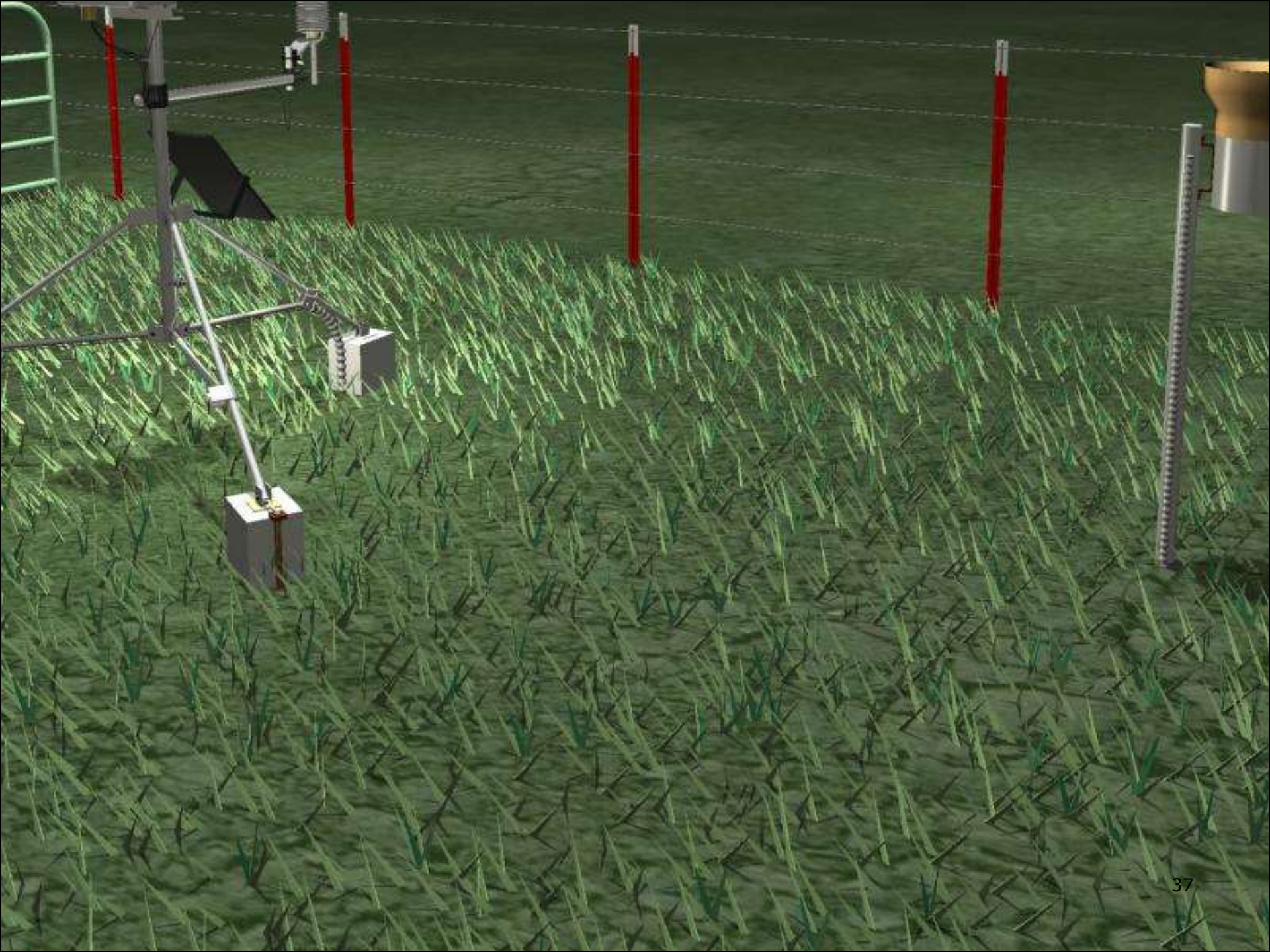


Solar Panel

Grounding Rod







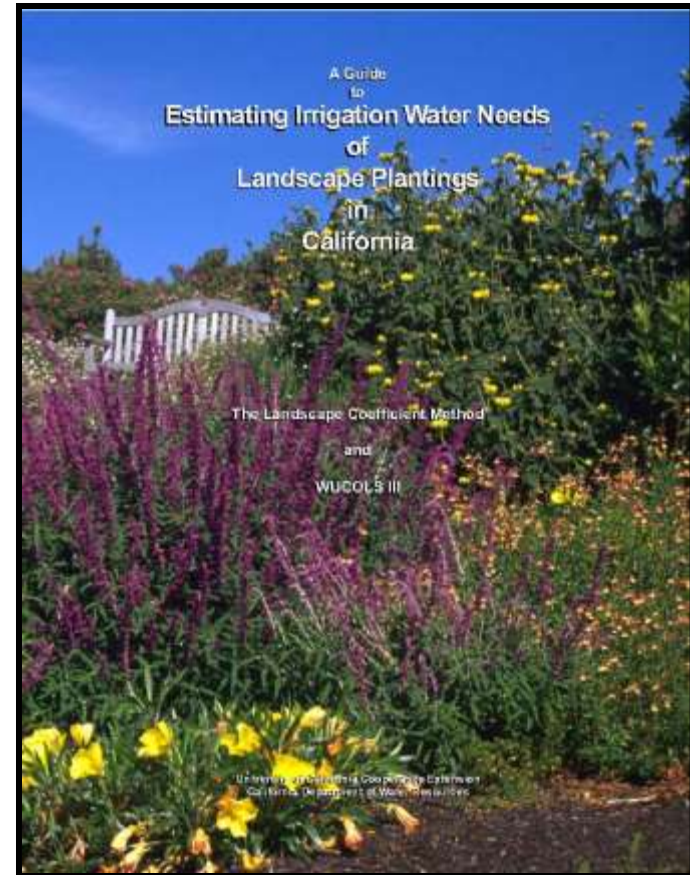
Reference Evapo-transpiration (ET_o) and K_c or Plant Factor

Appendix A - Reference Evapotranspiration (ET_o) Table

County and City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Eto
ALAMEDA													
Fremont	1.5	1.9	3.4	4.7	5.4	6.3	6.7	6.0	4.5	3.4	1.8	1.5	47.0
Livermore	1.2	1.5	2.9	4.4	5.9	6.6	7.4	6.4	5.3	3.2	1.5	0.9	47.2
Oakland	1.5	1.5	2.8	3.9	5.1	5.3	6.0	5.5	4.8	3.1	1.4	0.9	41.8
Oakland Foothills	1.1	1.4	2.7	3.7	5.1	6.4	5.8	4.9	3.6	2.6	1.4	1.0	39.6
Pleasanton	0.8	1.5	2.9	4.4	5.6	6.7	7.4	6.4	4.7	3.3	1.5	1.0	46.2
Union City	1.4	1.8	3.1	4.2	5.4	5.9	6.4	5.7	4.4	3.1	1.5	1.2	44.2



www.cimis.water.ca.gov

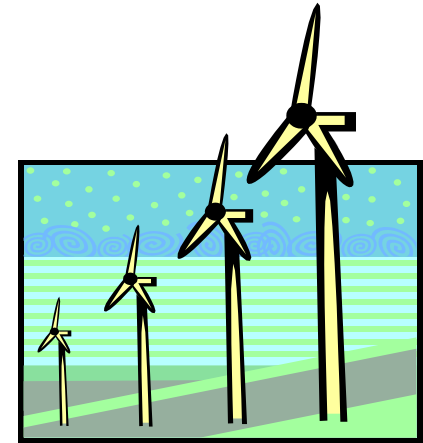


Water Use Classification of Landscape Species (WUCOLS)

www.owue.water.ca.gov/docs/wucols00.pdf

For What Purposes?

- ❑ Irrigation scheduling.
- ❑ Pest management.
- ❑ Air quality monitoring.
- ❑ Engineering designs.
- ❑ Weather forecasting.
- ❑ Research.
- ❑ Planning.
- ❑ Drought monitoring & Mitigation.
- ❑ Water use billing



Best Viewed With Internet Explorer

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)

-

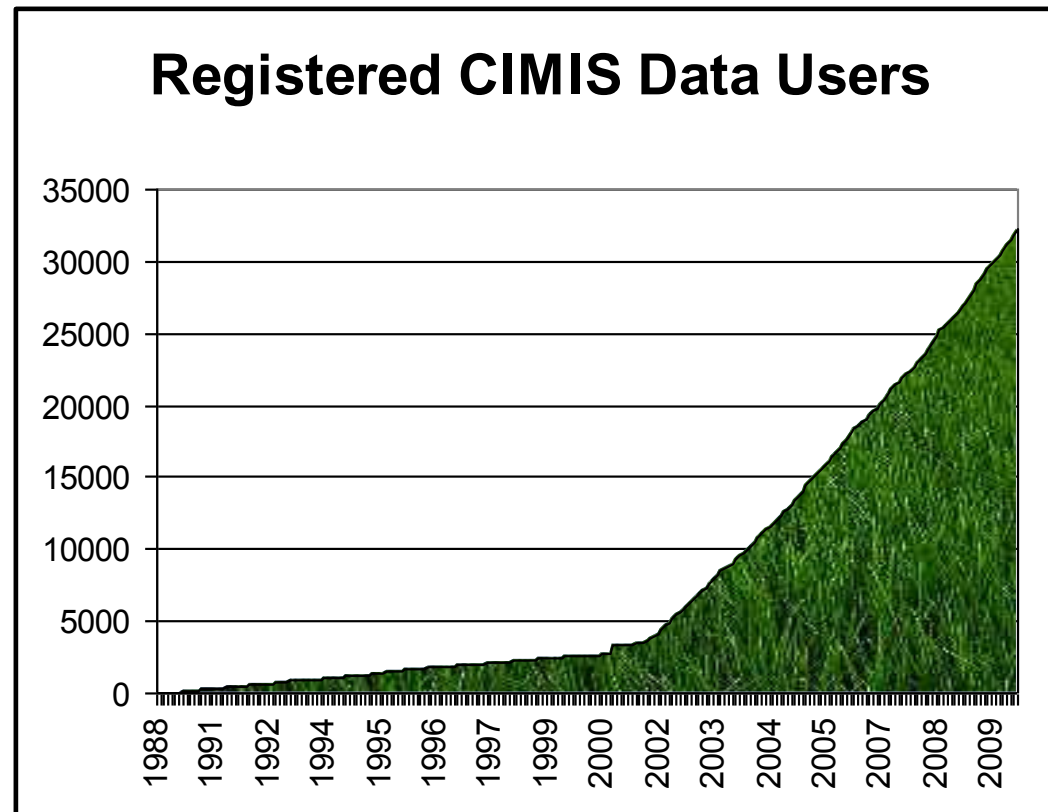
➤ Economic efficiency -- \$/drop (Adjusted \$ per acre-foot applied water)

- Increased 11% (1980-2000)
- Increased 115% (1967-2007)

➤ Quantifiable Objectives & Targeted Benefits



Registered Primary Users.



Over 2 million requests for data per month in 2013

CIMIS station locations & Network

Spatial data gaps exist.

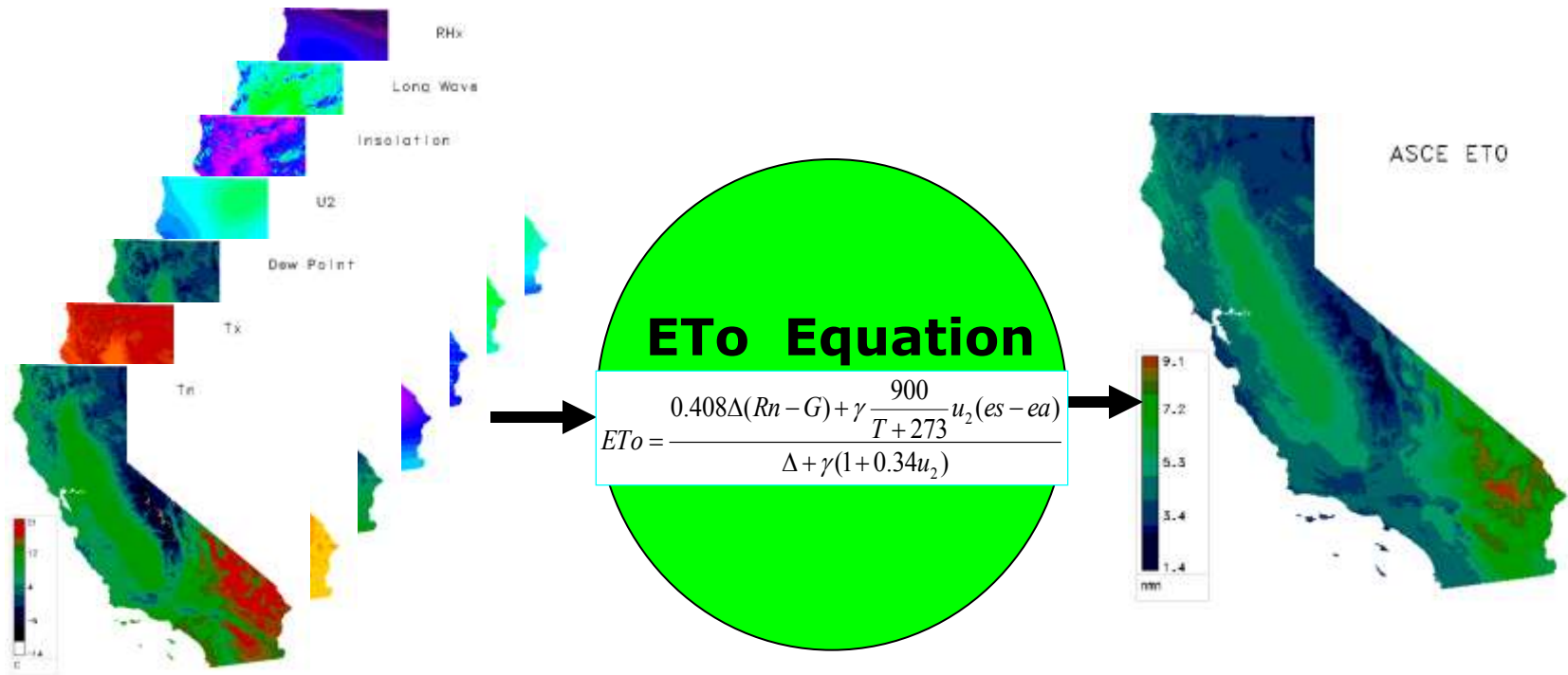


The Spatial CIMIS



- ❑ 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.

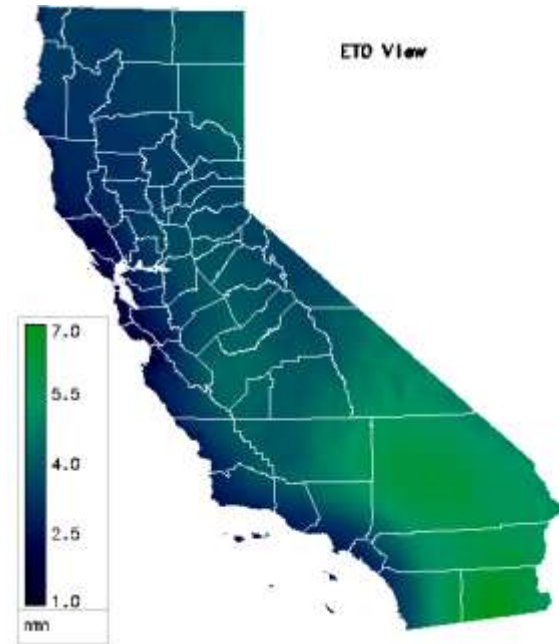
ET_o Estimation (cont.)





Spatial CIMIS System

- Statewide ETo and Solar Radiation (R_s) at a 2km resolution.
- Request data by Coordinate, Address, or Zip Code.

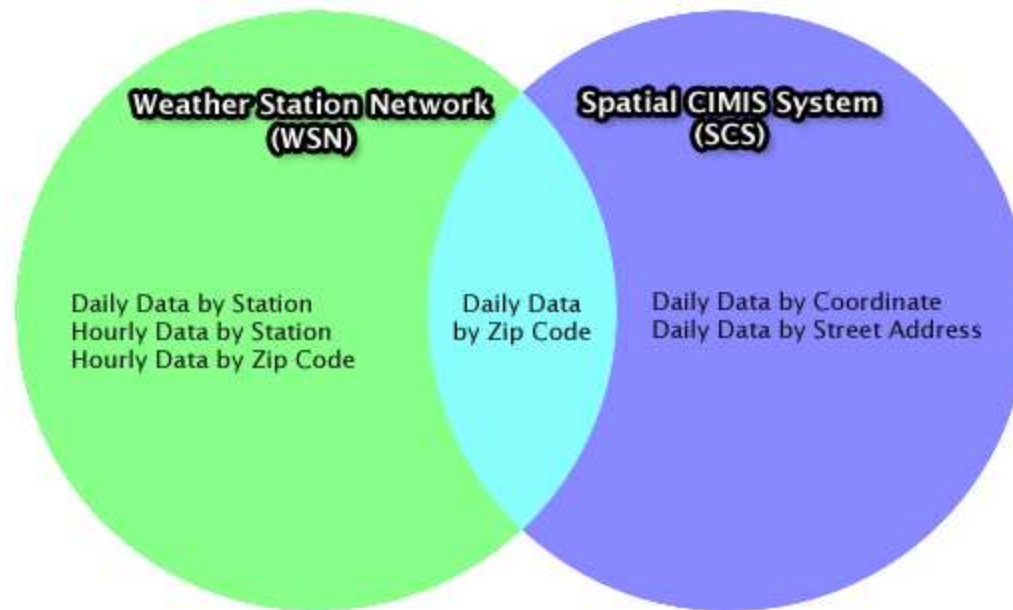


CIMIS Data Providers

- ❑ ***CIMIS Weather Station Network (WSN)***
- ❑ ***Spatial CIMIS System (SCS)***



Data Types by Data Provider



CIMIS Web API

SOAP SERVICES

ET-XML Services

Station and Spatial Weather Data

Daily Station Data by ID

Daily Station by Zip Code

Daily Spatial Data by Coordinate

Daily Spatial Data by Zip Code

Hourly Data by Station ID

Hourly Data by Zip Code

Funded by IRWD Contract

CIMIS Meta Data Services

CIMIS Meta Data

Station List

Station List by Number

Station Zip Code List

Station Zip Code by Zip Code

Spatial Zip Code List

Spatial Zip Code by Zip Code

Daily Spatial Data by Address

Funded by DWR Contract

REST SERVICES

ET-XML Services

Station and Spatial Weather Data

Daily Station Data by ID

Daily Station by Zip Code

Daily Spatial Data by Coordinate

Daily Spatial Data by Zip Code

Hourly Data by Station ID

Hourly Data by Zip Code

REST Conversion funded by IRWD CR

CIMIS Meta Data Services

CIMIS Meta Data

Station List

Station List by Number

Station Zip Code List

Station Zip Code by Zip Code

Spatial Zip Code List

Spatial Zip Code by Zip Code

Daily Spatial Data by Address

REST Conversion funded by DWR CR

An ***application programming interface (API)*** is a protocol intended to be used as an interface by software components to communicate with each other

Opportunities

- ❑ CIMIS is now ready to explore expanding Spatial CIMIS
- ❑ Is there interest and the market?
- ❑ Opportunities for data sharing?
- ❑ Propose pilot project with neighboring states shared regional interests

Some Possible Partnerships

- ❑ Minute 319 to the 1944 Treaty with Mexico
- ❑ USBR Water Smart
- ❑ Basin Studies
- ❑ NIDIS
- ❑ WSWC, WGA
- ❑ AZMET, AgriMet, and NICE

Potential Benefits

- ❑ Established Infrastructure
- ❑ Is a production model (not experimental)
- ❑ Resource Sharing
- ❑ Standardized data protocols and technology
- ❑ Utilization of data dissemination prototype

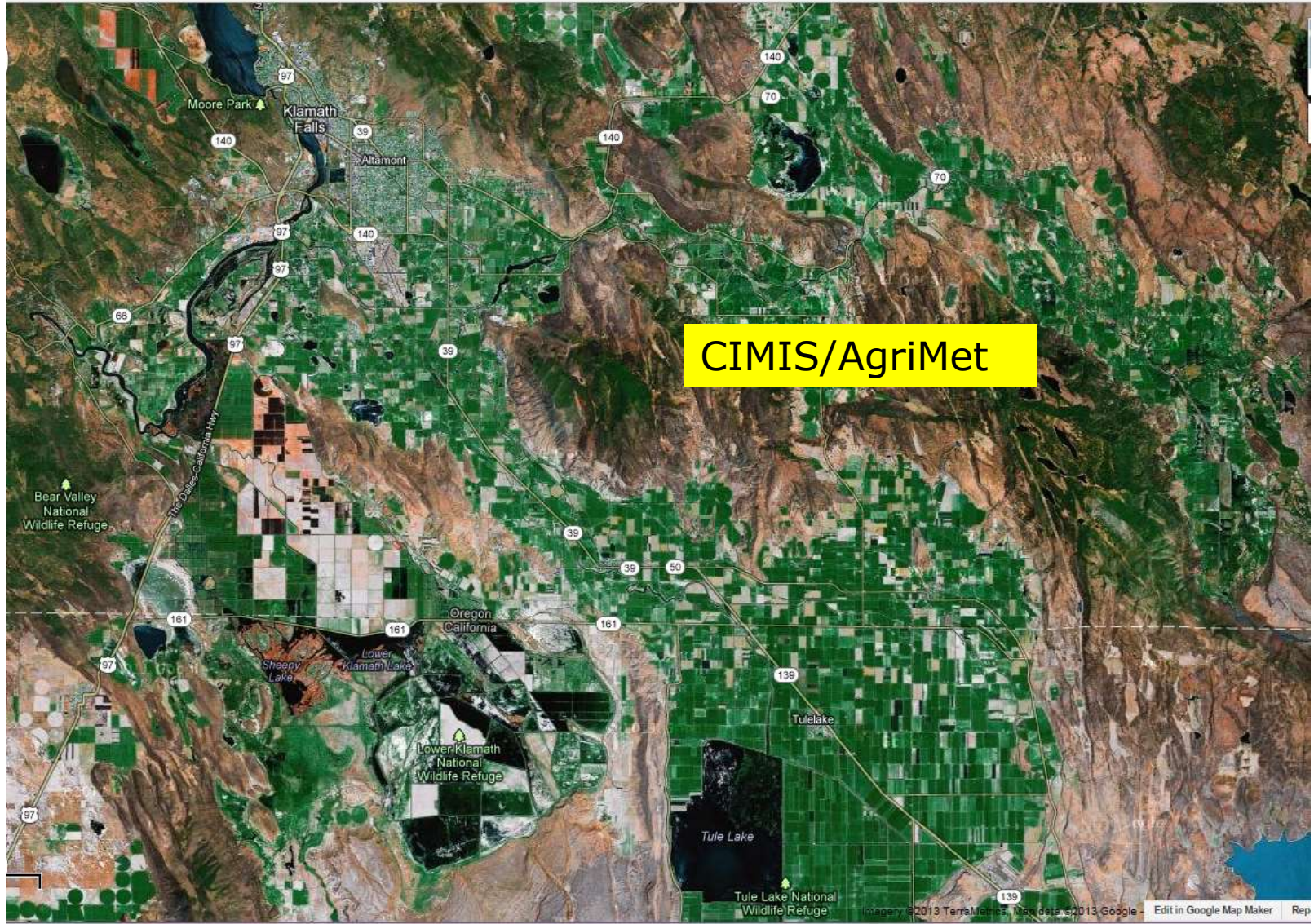
Mexicali, Yuma, Blythe Regions



Reno & Minden Valleys Truckee Carson Basins



Klamath River Basin



Clouds



2013-04-22



2013-04-23



2013-04-24



2013-04-25

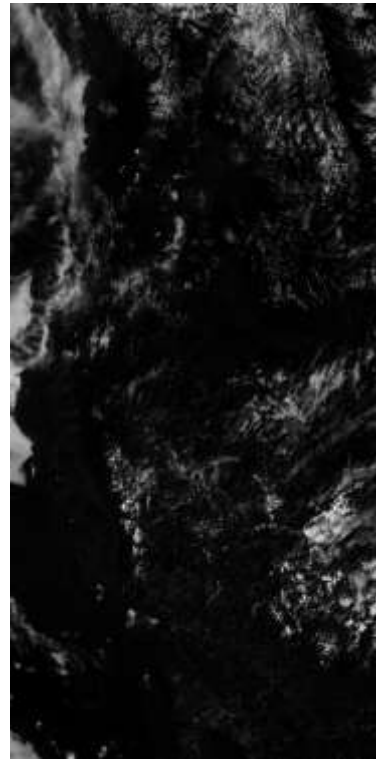
Cloud Daily Aggregation 2013-04-25



09:00



12:00

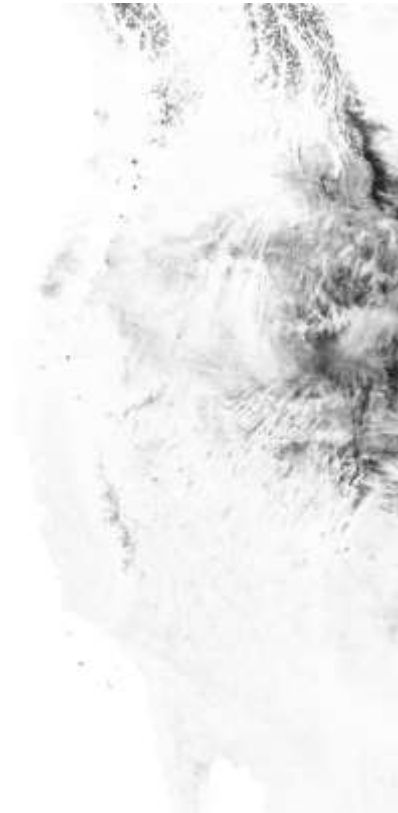


16:00



Aggregation

Clear Sky Factors (Bright = clear)



2013-04-22



2013-04-23

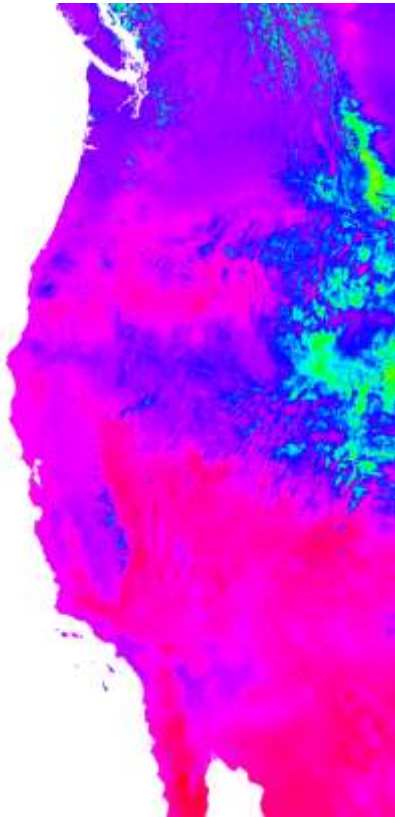


2013-04-24



2013-04-25

Solar Radiation



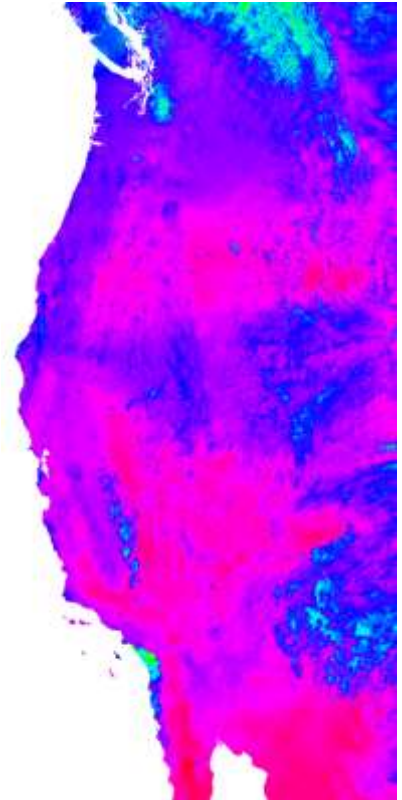
2013-04-22



2013-04-23

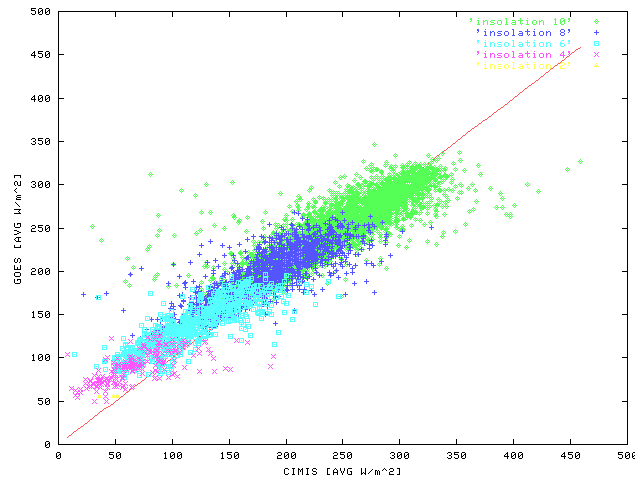


2013-04-24



2013-04-25

Solar Radiation



- Using 3 years worth of data for comparison, the GOES Rs was higher by only 2% with an R^2 of 0.99.

USBR Pacific Northwest, Mid – Pacific, Upper & Lower Colorado Regions



Issues to be addressed for Interstate Data sharing

- ❑ CIMIS is currently funded by California tax payers. What will be the justification for DWR to get involved in such a project?
- ❑ Expanding Spatial CIMIS requires more resources (man power, hardware, software, etc). Who will be responsible for the additional resources?
- ❑ Once developed, who maintains the system? How is it presented to end users, in a centralized way or each state will be on its own? Who pays for continuous maintenance?
- ❑ What is the status of the weather station networks in each state? How about the station siting? Do they have plans to expand ground stations? Data formats.
- ❑ How do we plan to handle future refinements? Each state separately or together?

CIMIS Current & Future Plans.

- ❑ ETo forecasting, precipitation maps.
- ❑ Crop-coefficient (Kc) maps Tops-Sims cooperation with NASA. Terrestrial Observation and Prediction System (TOPS), The Satellite Irrigation Management Support (SIMS)
- ❑ 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 CIMIS Web API\ET - XML

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

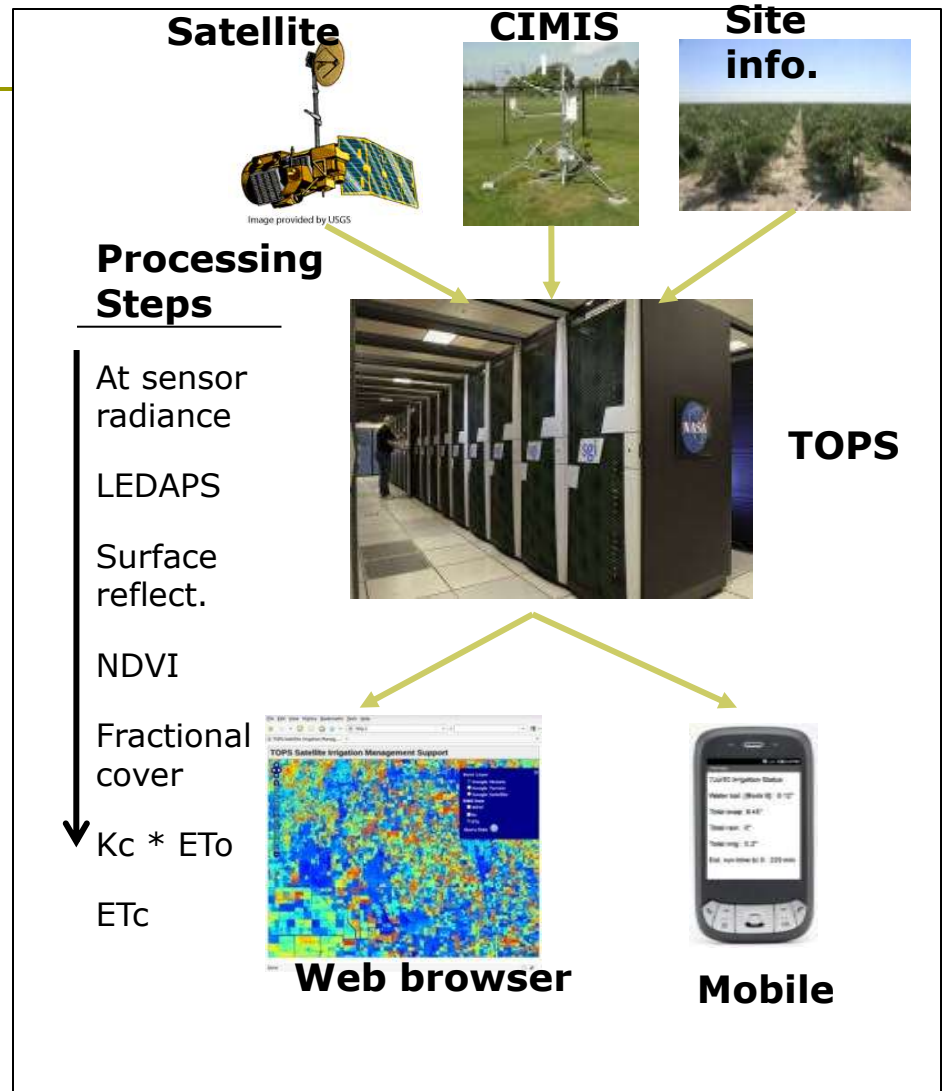
$$ET_{cb} = ET_o * K_{cb}$$

CIMIS

satellite



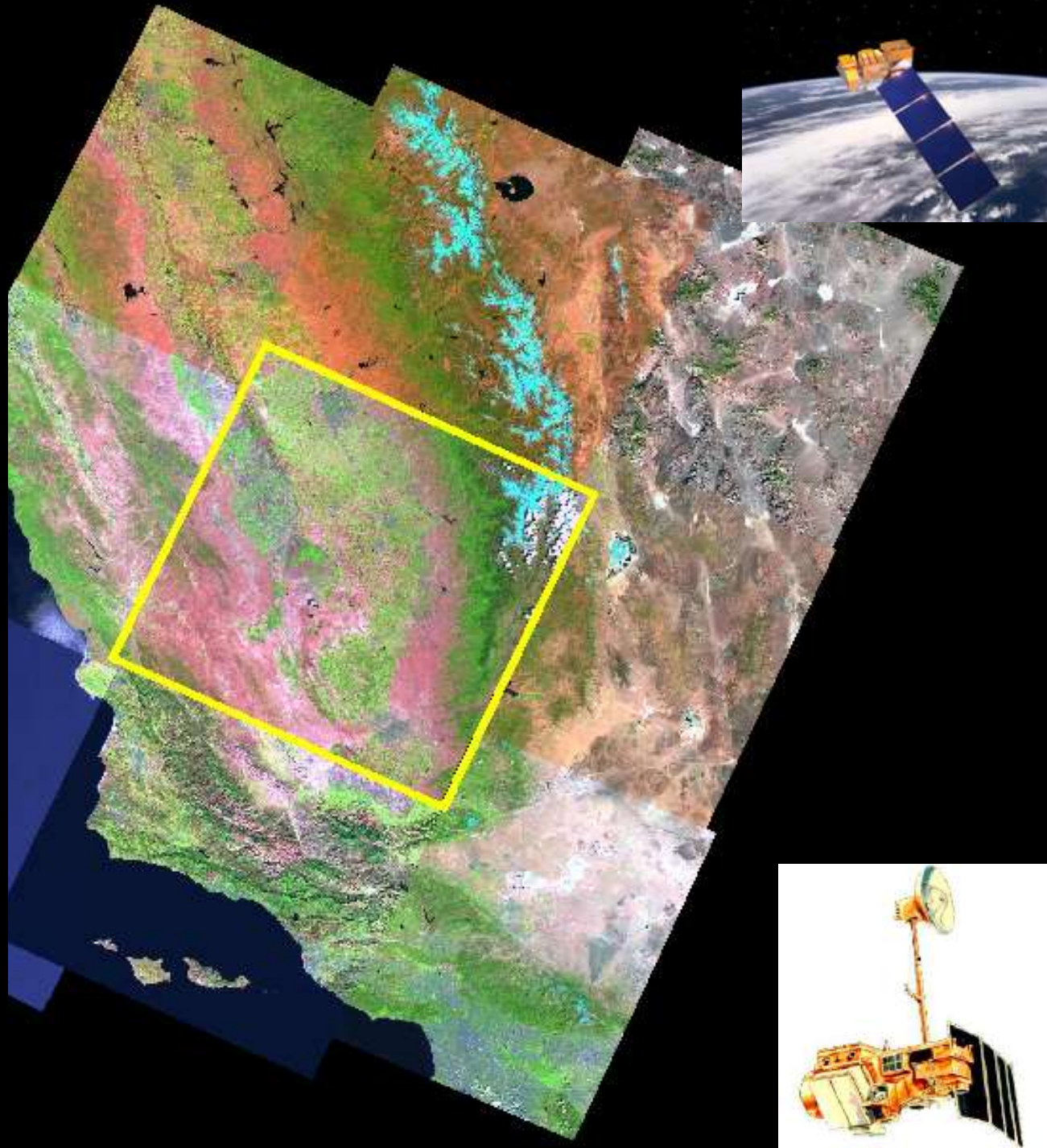
Spatial CIMIS ET₀
March 31, 2011



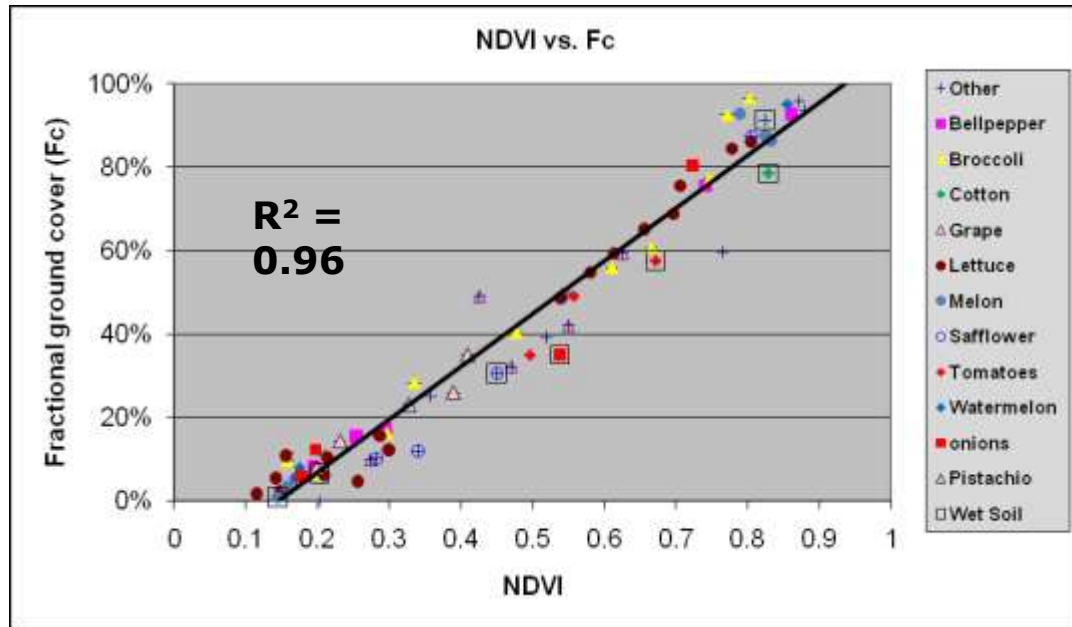
Integration of satellite and surface observation networks

Satellite Imagery

- Landsat
5/7 satellites pass
over California
every 8 days; daily
overpass by
MODIS
- Collect data at
30m/250m
resolution
- Landsat 8 launched
in 2013



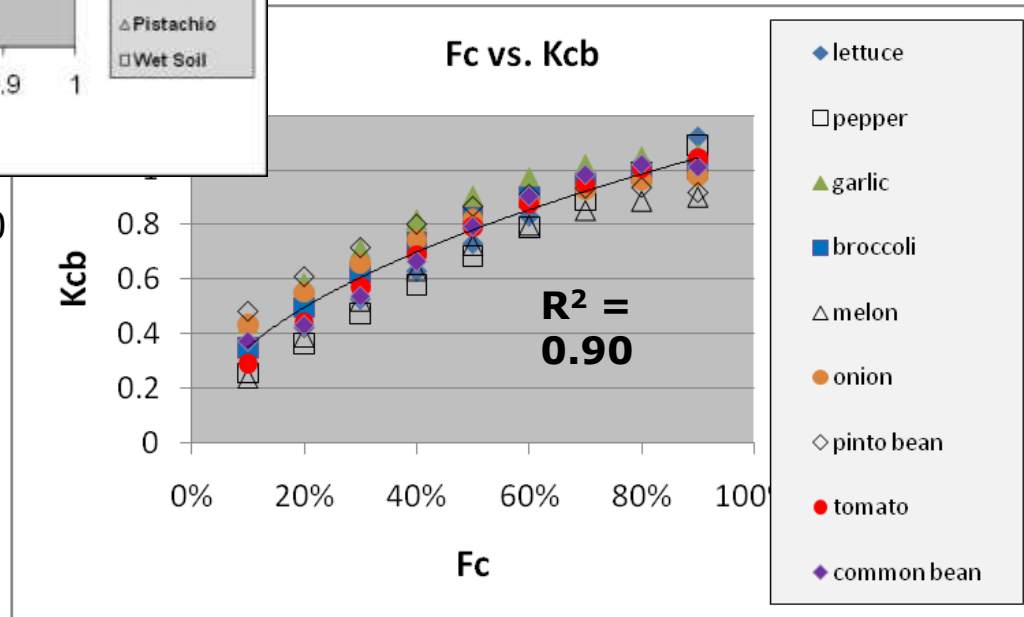
Deriving Indicators of Crop Conditions from Satellite Data



USDA studies provide basis for linking NDVI to fractional cover, and fractional cover to crop coefficients for multiple crops

Johnson & Trout, in review; Trout et al., 20

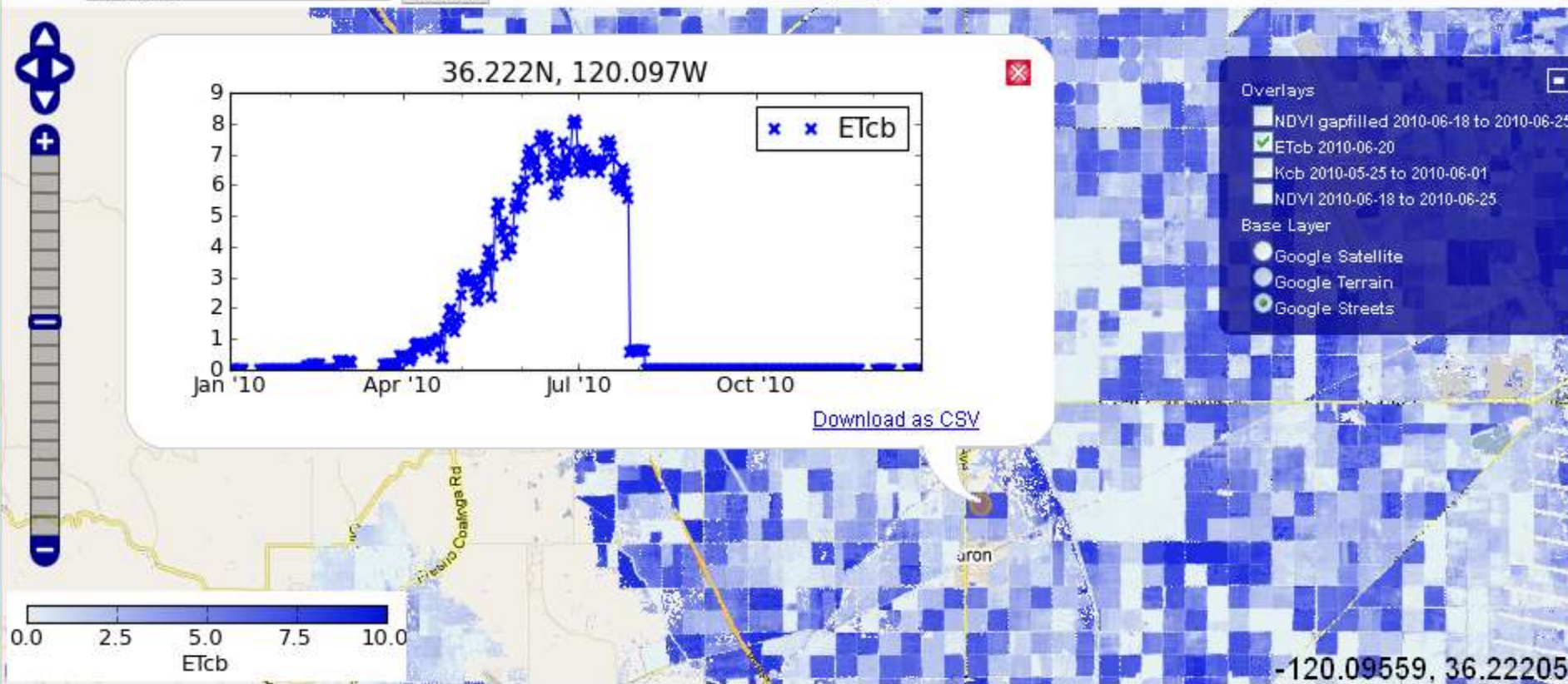
Additional studies ongoing in collaboration with CSU Fresno and UC West Side Research & Extension Center



From Bryla et al., 2010; Grattan et al., 1998; Hanson & May, 2006; Lopez-Urrea et al., 2009; Allen & Pereira, 2009

TOPS Satellite Irrigation Management Support

Go to: [About](#) [Help](#) Select Date:



Data Services Accessible via Excel

2011_NDVI_summary_stats_Stonewall_Grape.xlsx - Microsoft Excel non-commercial use

Home Insert Page Layout Formulas Data Review View

From Access From Web From Text From Other Sources Existing Connections Refresh All Edit Links Connections

Security Warning Data connections have been disabled Options...

Dataset: CA30M_L5L7_201101010000_201112312359_ndvi_8day_gapfilled.nc

Connection Properties

Connection name: Connection

Description:

Usage Definition

Connection type: Web Query

Connection file: Browse...

☐ Always use connection file

Connection string: `http://ecocast.arc.nasa.gov/opendap/pub/for/sam/2011/CA30M_L5L7_201101010000_201112312359_ndvi_8day_gapfilled.nc.ascii?ndvi[0:1:20][12752:12754][6706:6715]`

☐ Save password

Command type:

Command text:

Excel Services: Authentication Settings...

Edit Query... Parameters... Export Connection File...

OK Cancel

	J	K
2	-133532	-133502
6	0.643879	0.60424
6	0.613807	0.655208
8	0.655208	0.685688
9	0.550496	0.515055
8	0.560416	0.58349
8	0.561168	0.617478
3	0.625338	0.554228
4	0.607446	0.64867
4	0.639967	0.633686
9	-9999	-9999
9	-9999	-9999
9	-9999	-9999
7	0.586207	0.509565
9	0.62983	0.578002
2	0.569466	0.603802
8	0.140073	0.161132
8	0.157674	0.189844
8	0.15594	0.203859
9	-9999	-9999
	-9999	-9999
	-9999	-9999
	0.45	0.468063
	0.461481	0.494407
	0.4485	0.475029
	0.534354	0.505627
	0.515523	0.495319

Raw Data Processed Data TempMath Summary

Ready 100%

Information Products: Summary

Sample TOPS-SIMS Report

ET_o = reference ET (in.), ET_{cb} = crop water use (in.), K_{cb} = basal crop coefficient, SWB = soil water balance (in.), Runtime = estimated irrigation runtime (hrs.) to restore neutral soil water balance

Past 3 days:							Next 3 days:				
Field	ET _o	K _{cb} mean	K _{cb} max	K _{cb} min	ET _{cb}	SWB	Runtime 8/8/2010	ET _o	ET _{cb}	SWB	Runtime 8/11/2010
F-01	0.83	1.05	1.09	0.95	0.87	+0.30	--	0.79	0.83	-0.53	2.5
F-02	0.83	0.97	1.04	0.91	0.81	-0.12	1	0.79	0.77	-0.77	4
F-03	0.83	1.09	1.12	1.02	0.90	+1.14	--	0.79	0.86	0.28	--
...											



- Currently obtaining input from growers on system design
- Will consider weather, soil texture, crop type, root depth, precipitation, prior irrigation amounts, method of application, and application rate.
- Parameters to include measures of within-field variability.
- Summary reports planned for delivery via text messages / PDFs sent to mobile devices.

User Requirements for Information Products

Requirements for Kc/ETc mapping (from workshops with growers):

- **Timely:** available within 24-48 hours of satellite overpass (system must be fully automated)
- **Frequent:** ETc updated daily, Kc updated at least every 8-16 days
- **High resolution:** must provide multiple measurements per field for fields 5 acres or larger
- **Accessible:** quantitative information available via web browsers, mobile phones
- **Easy to use:** must be convertible to run-times for irrigation systems; compatible with other irrigation scheduling software

Validation Strategy

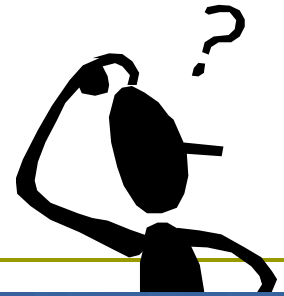
- 1) Comparison against other satellite-based estimates
- 2) Comparison against ET estimates from surface renewal stations
- 3) Use of wireless sensor networks to calculate a water balance and track relative changes in soil water content and soil water potential
- 4) Weighing lysimeter experiments
- 5) Grower interaction and feedback

Contacts

- ❑ 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
- ❑ Bekele Temesgen (916) 651-
btemesgen@water.ca.gov

Questions?



THANK YOU

What is Currently Available?

- ❑ Daily ETo & Rs 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
- ❑ CIMIS Web API/ET-XML web services

