

Andrews Experimental Forest

Building the “Cyber Forest”

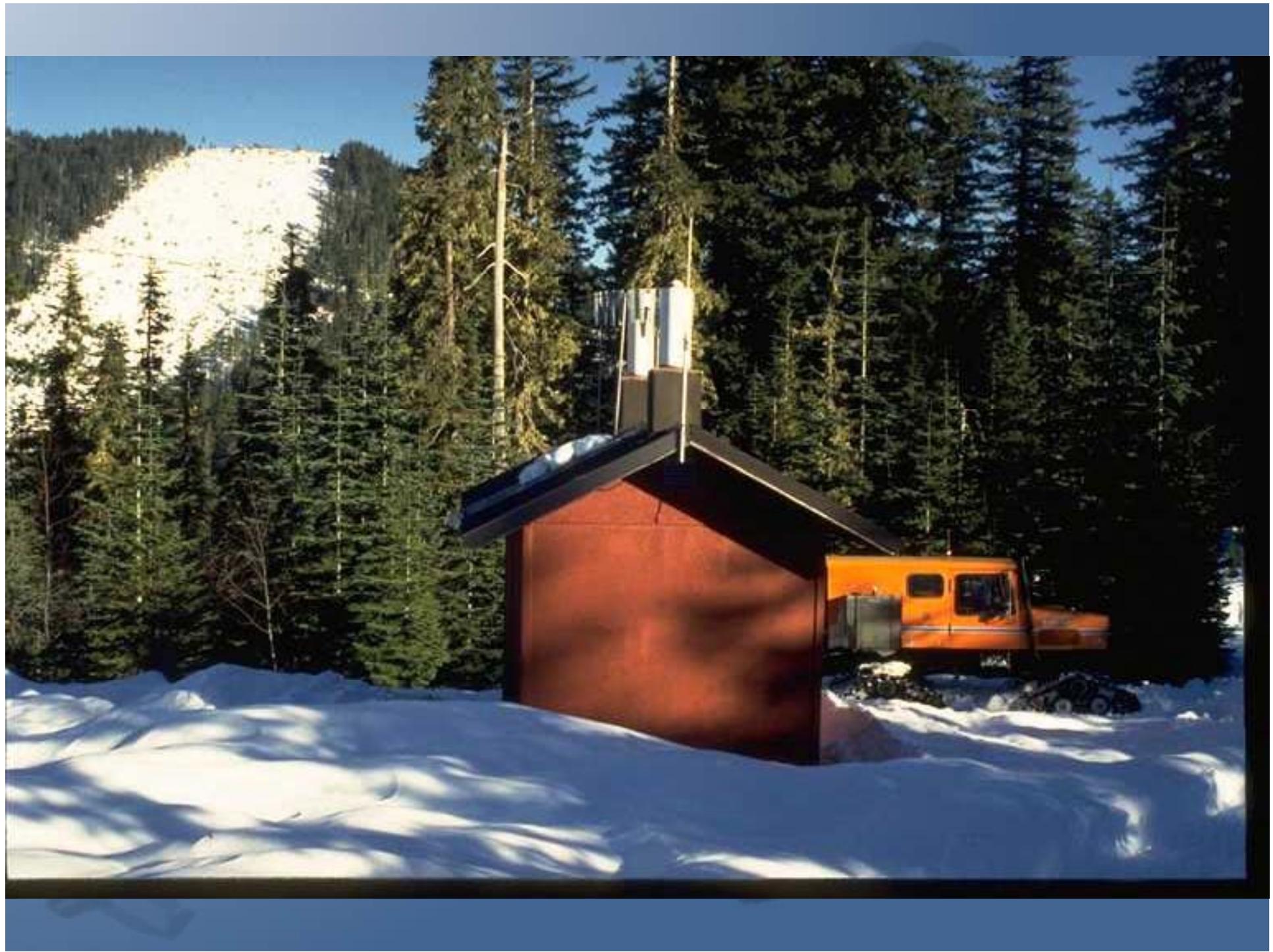
*H. J. Andrews Experimental Forest
Long-Term Ecological Research (LTER) Site*

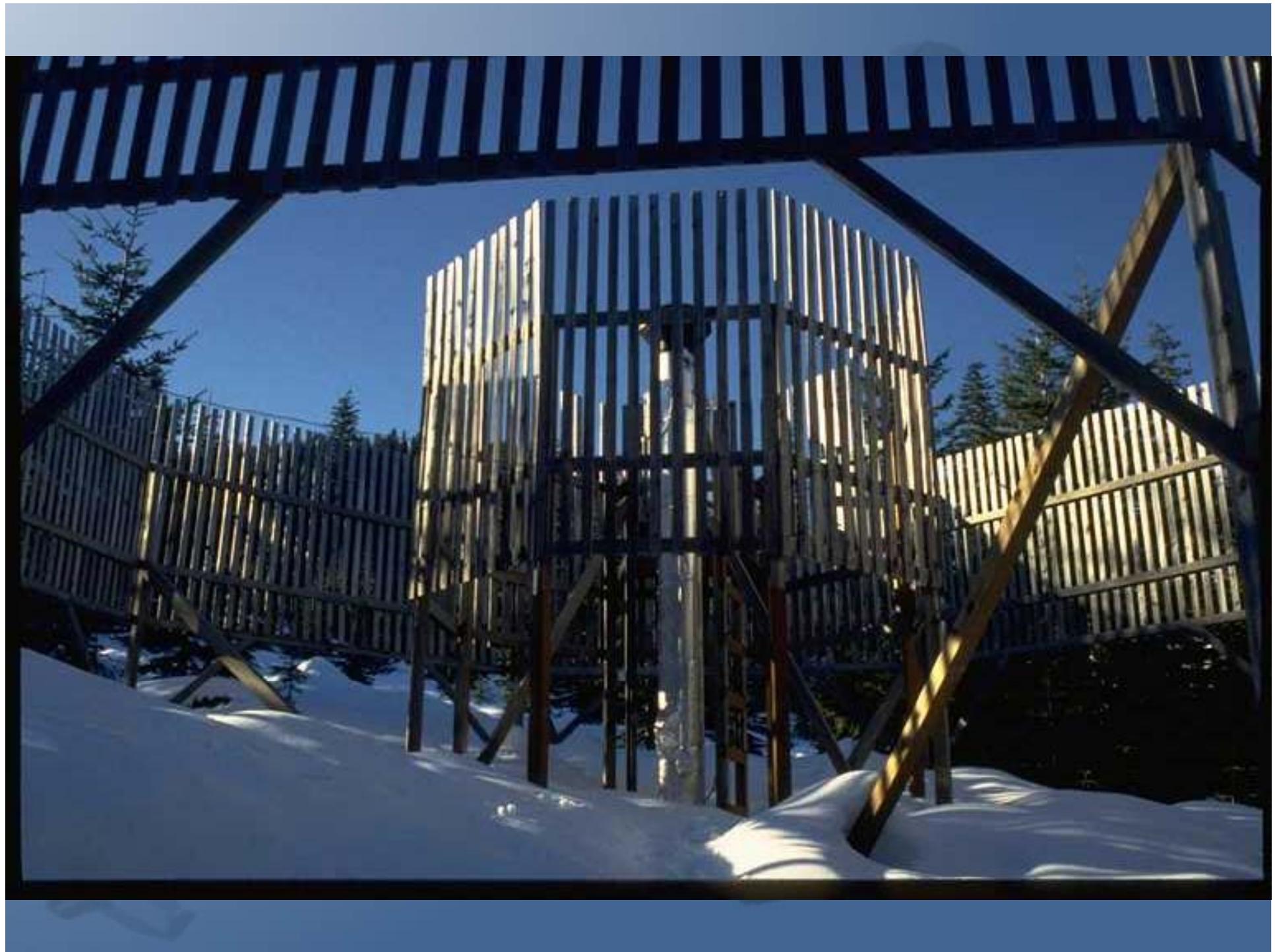
- Don Henshaw
 - U.S. Forest Service, Pacific Northwest Research Station
- Fred Bierlmaier
 - Oregon State University, Department of Forest Ecosystems and Society
- Suzanne Remillard
 - Oregon State University, Department of Forest Ecosystems and Society

LTER Information Management Challenges

- Management of increasing data volumes
 - Balance of timely access with assurance of high quality data
 - Work towards broader community solution
- Development of high quality metadata
 - Requirements for metadata quality/quantity increasing
 - Difficulties in capturing key descriptions of data sets
- Expectation for data accessibility increasing
 - Preparation of data for the LTER NIS
 - Compliance with LTER metadata best practices











Meteorological Sensor Measurements

- Meteorological Stations
 - 4 Benchmark Stations
 - Complete suite of measurements
 - 2 Secondary Stations
 - Partial suite of measurements
 - 10 Air and soil temperature
 - Reference Stand network
 - 12 Air and stream temperature
 - Stream and Gauging Stations network



Hydrological Measurements

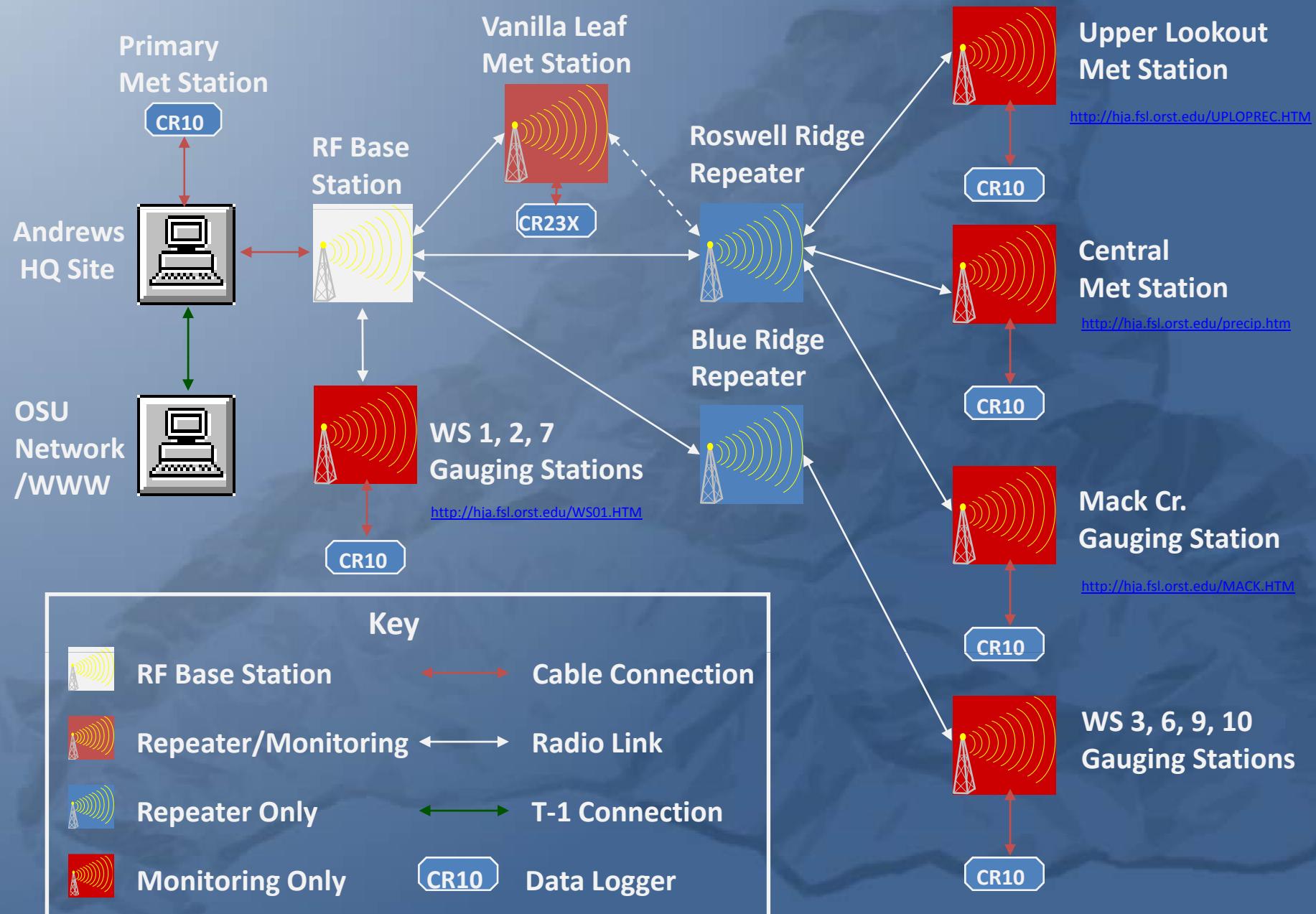
Long-term streamflow measurements at 10 gauging stations



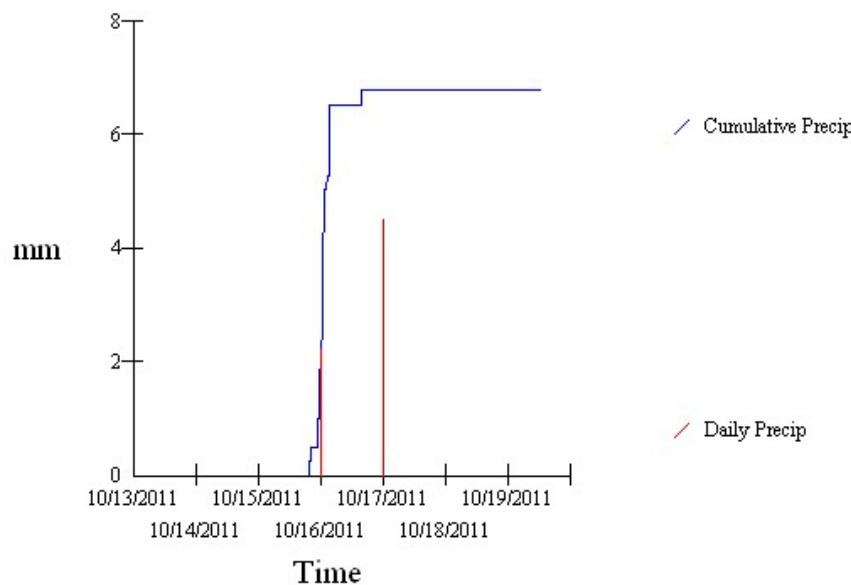
- Stream gage height and discharge for paired watershed studies
 - Lookout Creek – origination 1949 (USGS)
 - WS 1, WS2 (control), WS3 (1952)
 - WS 6, WS 7, WS 8 (control) (1963)
 - WS 9 (control), WS 10 (1968)
 - Mack Creek (1979)



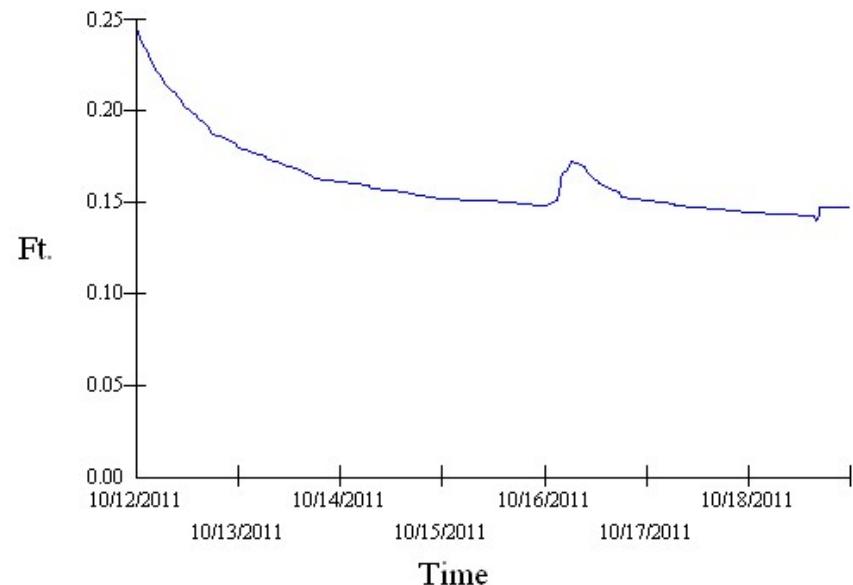
H. J. Andrews Experimental Forest Telemetry System



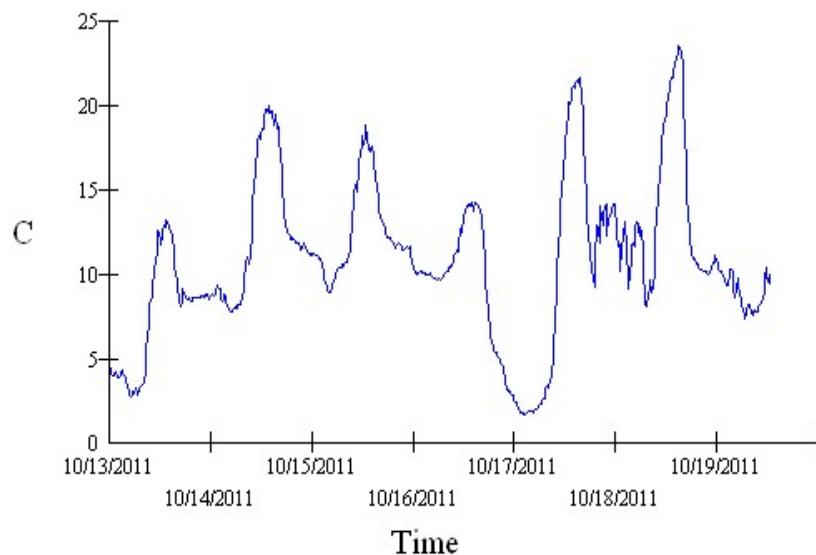
Primary Met Station Precip



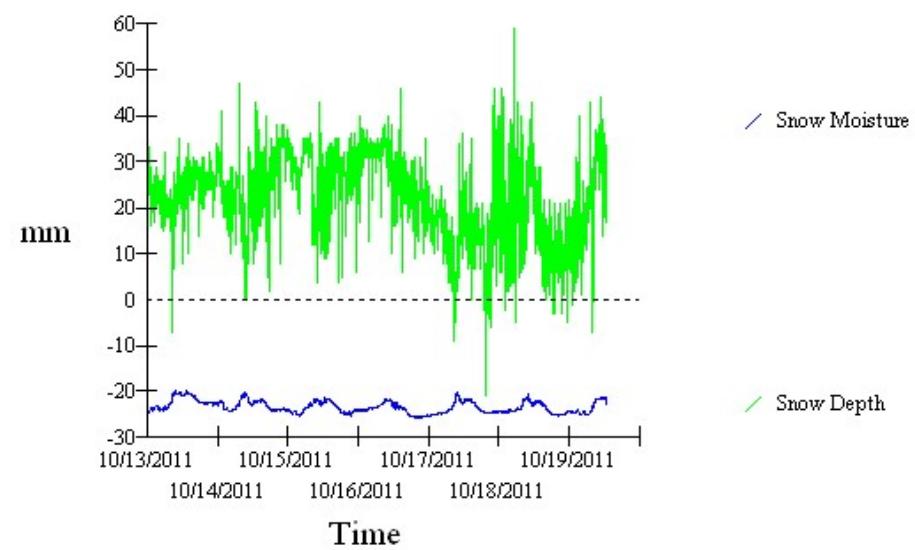
Mack Creek Stage



Central Met Station Air Temperature (4.5m)



Upper Lookout Cr. Met Station Snow Moisture and Depth



Sensor Measurements: 2002-Present

New LTER experiments are being established with high-volume data streams

- Airshed Watershed 1 (“cyber watershed”)
 - Tower: atmospheric carbon, temperature, wind, solar
 - 8 transect plots; 10 data loggers communicate by radio telemetry at 900 mHz
- Phenology Study
 - 120 temperature measurement sites established
 - 12 bird acoustic recording stations
- Snow hydrology study
 - 12 weather stations in and around the Andrews
- Cold air drainage transects – air temperature
- New technologies planned
 - Distributed Temperature Sensor (dts) evaluation (fiber-optic cable)
 - In stream channel, in snow pack
 - Web cams: plant phenology, snow pack
 - Virtual classroom

Roswell Mountain to Carpenter



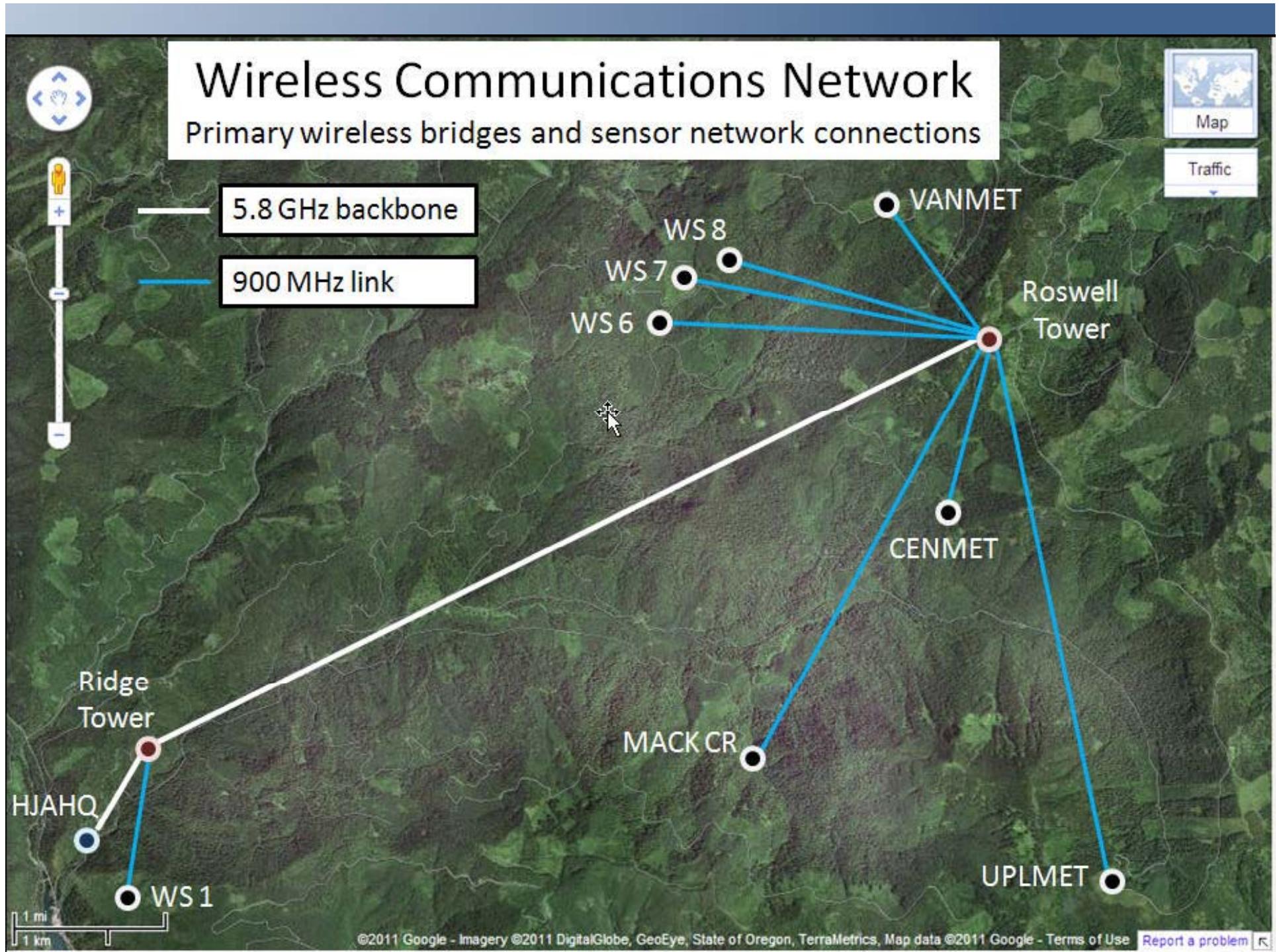
Building the “cyber forest”

Roswell Mountain to Upper Lookout



A high performance wireless communications network

- Goals
 - Improve field-to-headquarters data transmission capability
 - Extend Ethernet (LAN) into the forest
 - Develop quality control tools for streaming data
- Science drivers
 - Accommodate new sensor arrays streaming fine temporal data
 - Bond (WS1), Nolin (WS7), Daly (cold-air drainage transects), Johnson, Schulz, et al. (phenology), Betts (bird acoustics)



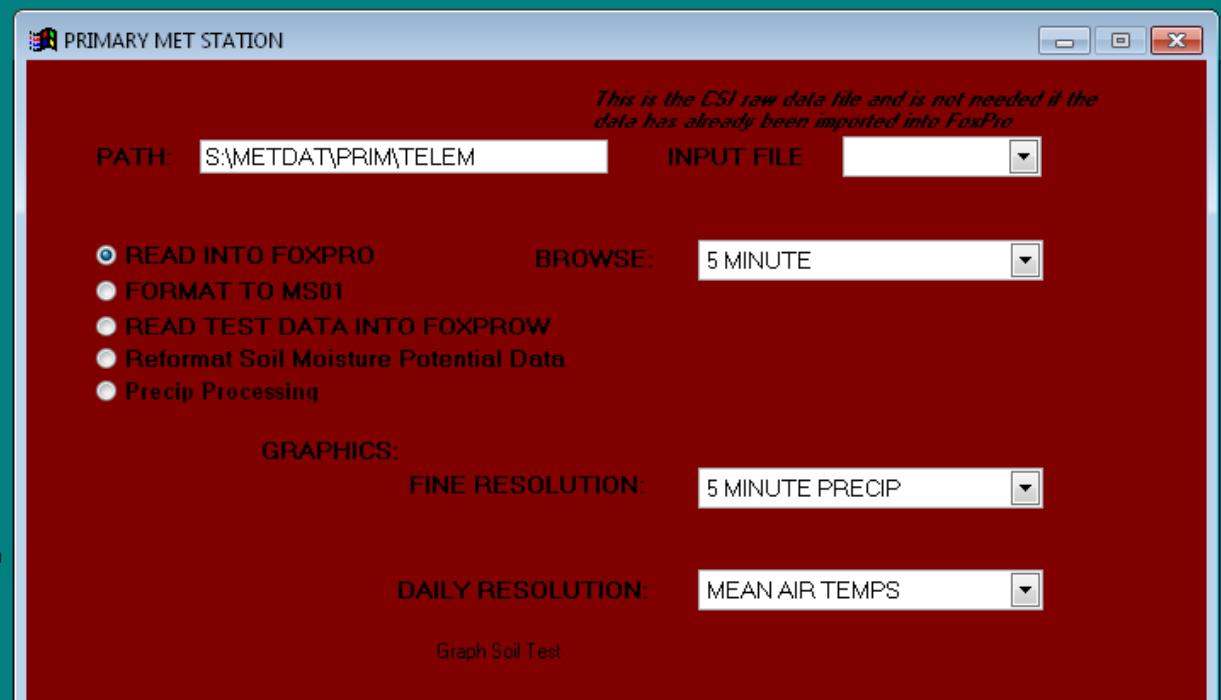
Roswell Mountain Tower





Met Data Reformatting and Graphics Program

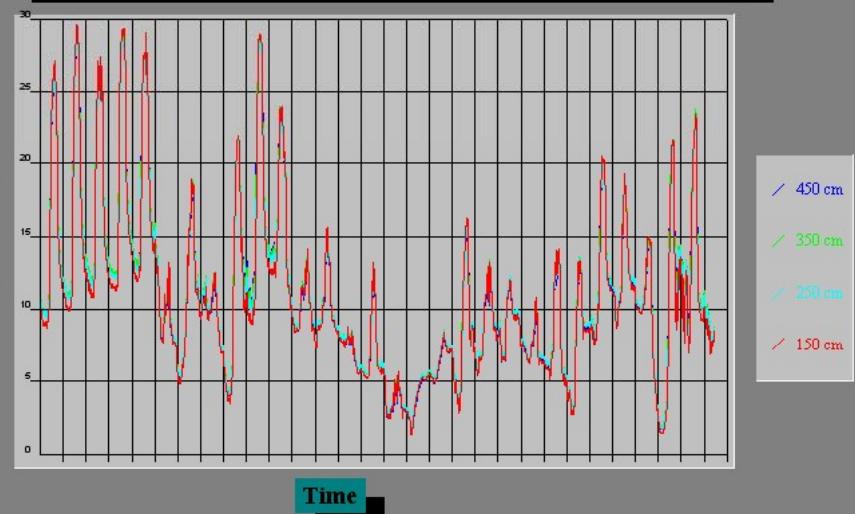
- Big Tree
- Primary Met
- Central Met
- Climatic Station
- Hill5 Met
- Reference Stand (prior to hourly)
- Reference Stand
- Reference Stand (RS86 and RS89 have RH)
- Stream Temperature - Old Format
- Stream Temperature - New Format
- Upper Lookout Met
- Vanilla Leaf Met
- Vanilla Leaf Rain Gage (prior to 8/18/99 @1515)
- Vanilla Leaf Raingage
- Multiple Site Graphics
- Problems Data Base



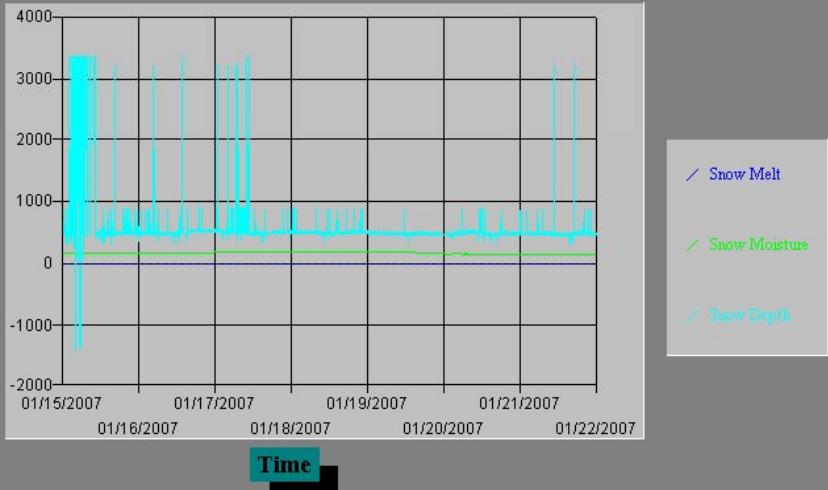
Primary Met Station 15 Minute Mean Air Temperatures 01/24/2010



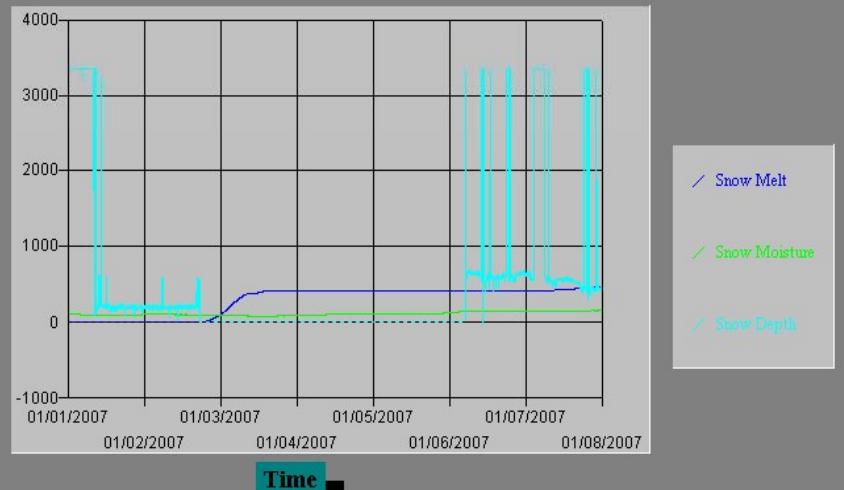
Central Met Station 15 Minute Mean Air Temperatures 09/20/2011 To 10/19/2011



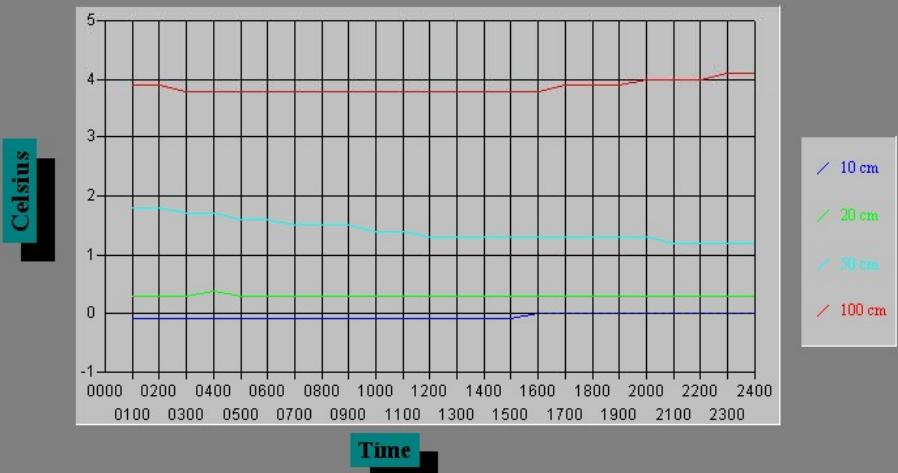
Central Met Station Five Minute Snow Values 01/15/2007 To 01/21/2007



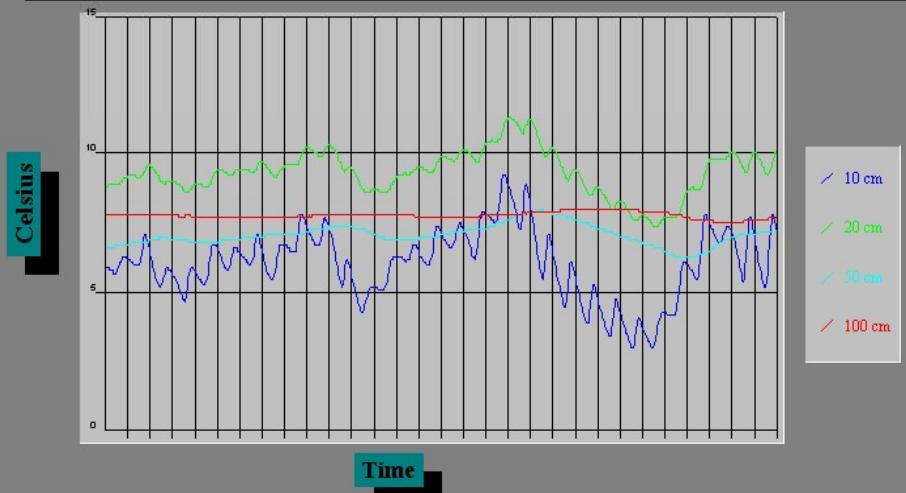
Central Met Station Five Minute Snow Values 01/01/2007 To 01/07/2007



Vanilla Leaf Met Station Hourly Mean Soil Temperatures 01/01/2010



Primary Met Station Hourly Mean Soil Temperatures 01/30/2010 To 02/28/2010



Andrews LTER Mid-term Review 2011

- The NSF review panel recommended:
“the preparation of the IM system to accept
the large volumes of streaming data from
current and planned sensor networks.
On-the-fly quality assurance and archival of
streaming data will be key to ensure that
data will be ready for downstream analysis.”

Data model strategy

- Develop a consistent data transmission protocol
- Develop key metadata
 - Catalog all data loggers and document individual data streams (arrays) to allow dynamic input
 - Document collection methods, instrumentation, calibrations, and dates of key changes to sensors
- Map raw streaming data into final stored formats and preserve for later resampling
- Provide near real-time screening of data and add data qualifiers to each data value:
 - range checking, comparisons with redundant or nearby sensors, or other QA approaches

Datalogger



C# program reads Campbell raw comma-delimited file

```
166,2011,89,940,64,13,91,7,327,0,784,7,28,10,08
170,2011,89,945,6,141,6,662,6,787,6,661,0,03142,59,4
166,2011,89,945,64,08,91,7,326,8,0,785,7,27,9,94
166,2011,89,950,64,16,91,9,326,6,0,78,7,32,9,9
```

Imported Data

array_id	year	julian_day	time
170	2011	89	945
170	2011	89	945
170	2011	89	945
170	2011	89	945

variable_order	value
5	6.141000
6	6.662000
7	6.787000
8	6.661000

Use look-up tables to identify the data type and store raw data in relational database tables

DataLogger	
Y	datalogger_id
	datalogger_name
	sitecode
	program_name
	model

ArrayField	
Y	field_id
	table_id
	datalogger_id
	site_abbrev
	array_id
	[order]
	field_code
	parameter

ArrayTable	
Y	table_id
	datalogger_id
	sitefilename
	array_id
	[current]
	begindatetime
	enddatetime

field_id	table_id	datalogger_id	site_abbrev	array_id	order	field_code	parameter	entity_number	attribute_name	probe
12	2	1	CEN	170	1	ARRAY_ID	15MIN	0	NULL	NULL
13	2	1	CEN	170	2	YEAR	15MIN	0	NULL	NULL
14	2	1	CEN	170	3	JULDAY	15MIN	0	NULL	NULL
15	2	1	CEN	170	4	TIME	15MIN	0	NULL	NULL
16	2	1	CEN	170	5	AIR04	15MIN	11	MEANTEMP	AIRCEN04
17	2	1	CEN	170	6	AIR03	15MIN	11	MEANTEMP	AIRCEN03
18	2	1	CEN	170	7	AIR02	15MIN	11	MEANTEMP	AIRCEN02
19	2	1	CEN	170	8	AIR01	15MIN	11	MEANTEMP	AIRCEN01

Output data into final format , and assign value qualifiers

STCODE	FORMAT	SITECODE	PROBE	DATE_TIME	MEANTEMP	FT1
MS001	11	CENMET	AIRCEN02	2011-03-30 09:45:00.000	5.6	NULL
MS001	11	CENMET	AIRCEN03	2011-03-30 09:45:00.000	NULL	M
MS001	11	CENMET	AIRCEN04	2011-03-30 09:45:00.000	NULL	M
MS001	11	CENMET	AIRCEN01	2011-03-30 10:00:00.000	5.4	NULL
MS001	11	CENMET	AIRCEN02	2011-03-30 10:00:00.000	6.8	NULL
MS001	11	CENMET	AIRCEN03	2011-03-30 10:00:00.000	6.6	NULL
MS001	11	CENMET	AIRCEN04	2011-03-30 10:00:00.000	-16.1	Q
MS001	11	CENMET	AIRCEN01	2011-03-30 10:15:00.000	5.7	NULL

Andrews Forest LTER Meteorological Metadata Schema

