

Linked Environments for Atmospheric Discovery: Web Services for Meteorological Research and Education



What Would YOU Do if These Were About to Occur?



Warren Faidley/Weatherstock®

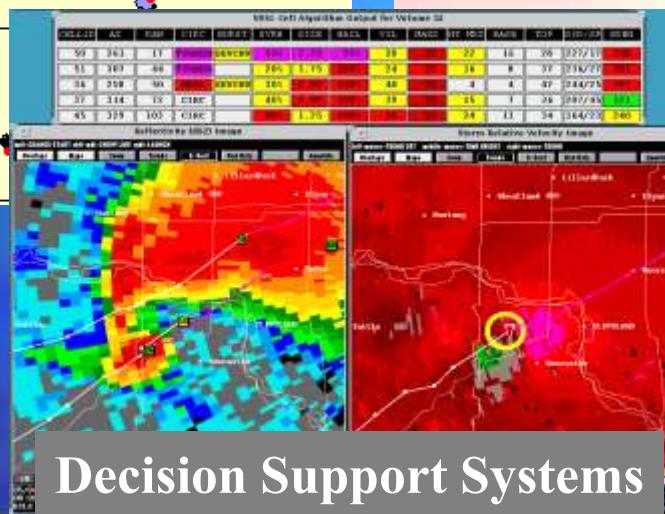
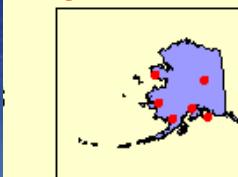
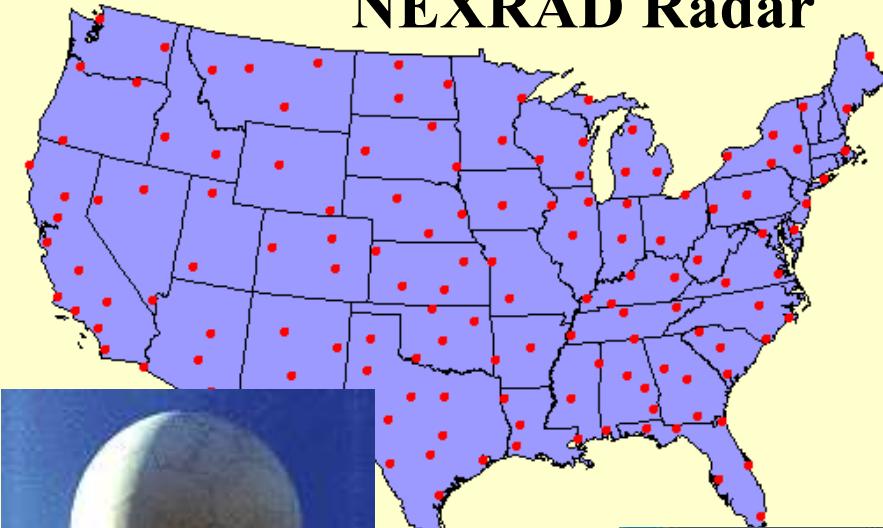
What THEY Do to Us!!!

- Each year in the US, **mesoscale weather** – local floods, tornadoes, hail, strong winds, lightning, and winter storms – causes hundreds of deaths, routinely disrupts transportation and commerce, and results in annual economic losses > \$13B.



What Weather Technologies Do...

NEXRAD Radar



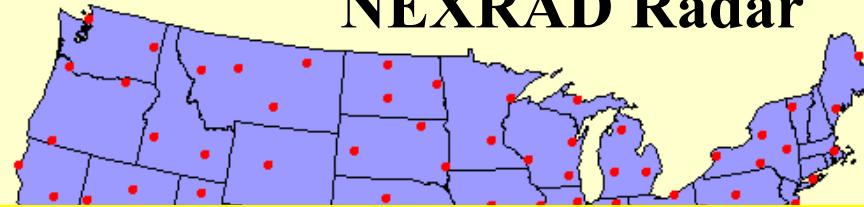
Forecast Models



Decision Support Systems

What Weather Technologies Do...

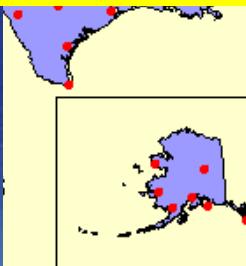
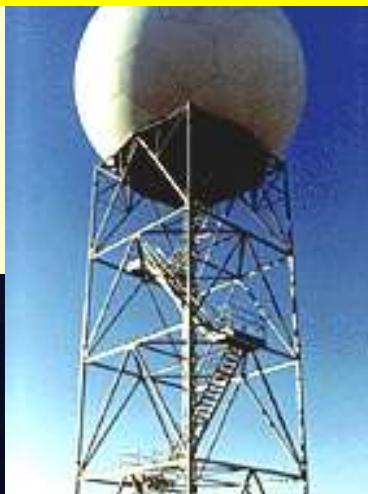
NEXRAD Radar



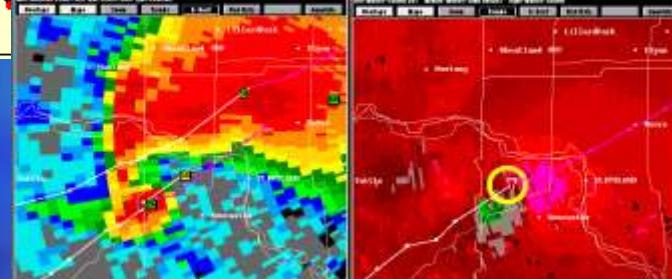
Forecast Models



Virtually Nothing!!!

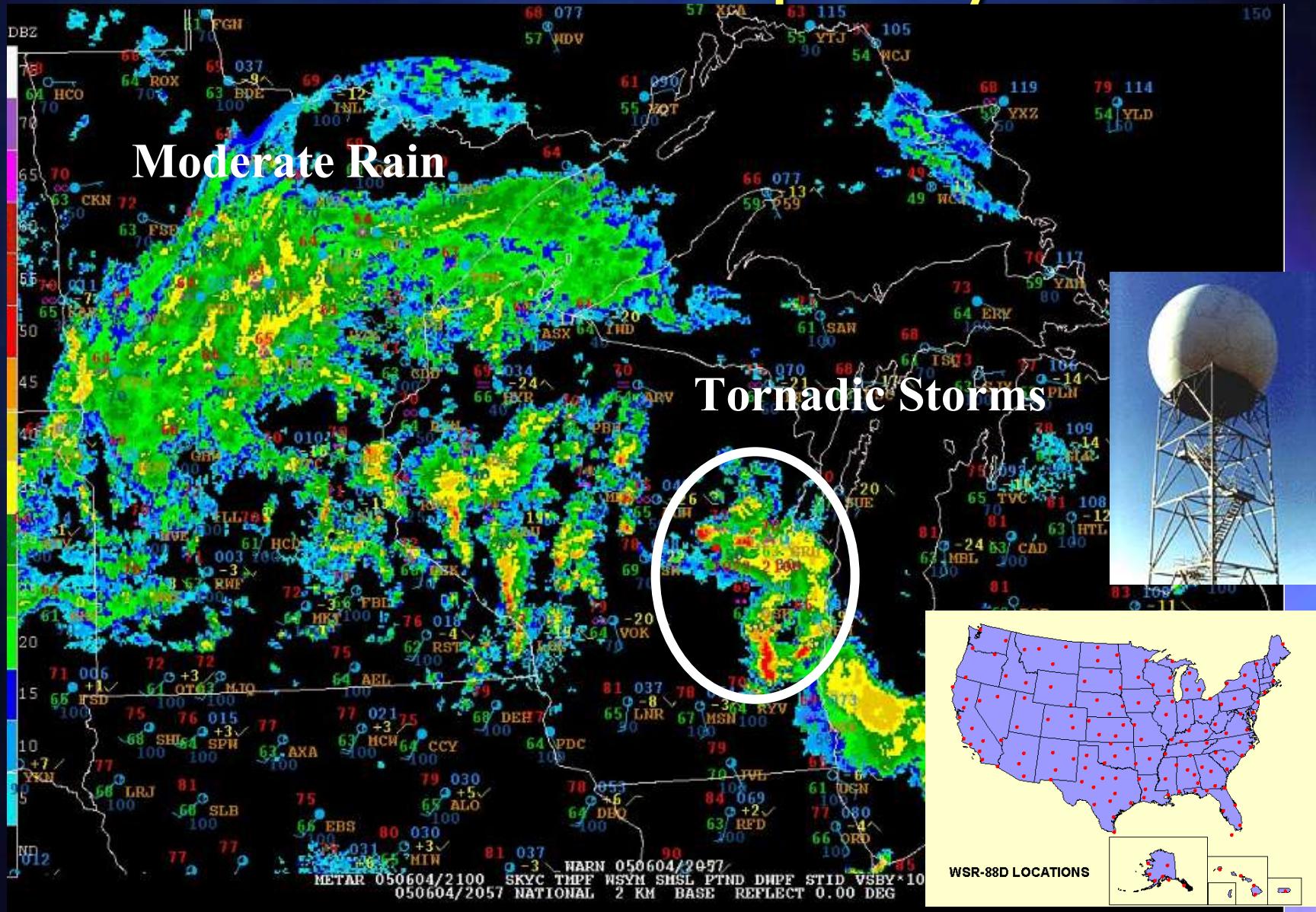


WBC-Offizielle Rangliste der Weltmeister																
WBC-Offizielle	AC	RAMP	DEDEC	WURST	STYX	DISSE	BLSS	YOL	GRACE	HTF	MCB	RABUS	EDP	CDR	SPR	SPR
93	243	17	1	WURST	1	1	1	23	1	22	18	1	227	1	1	1
93	167	66	1	WURST	1	1	1	24	1	24	8	1	234/275	1	1	1
94	228	90	1	WURST	1	1	1	48	1	4	4	1	244/275	1	1	1
97	214	19	1	DEDEC	1	1	1	38	1	25	1	1	267/355	1	1	1

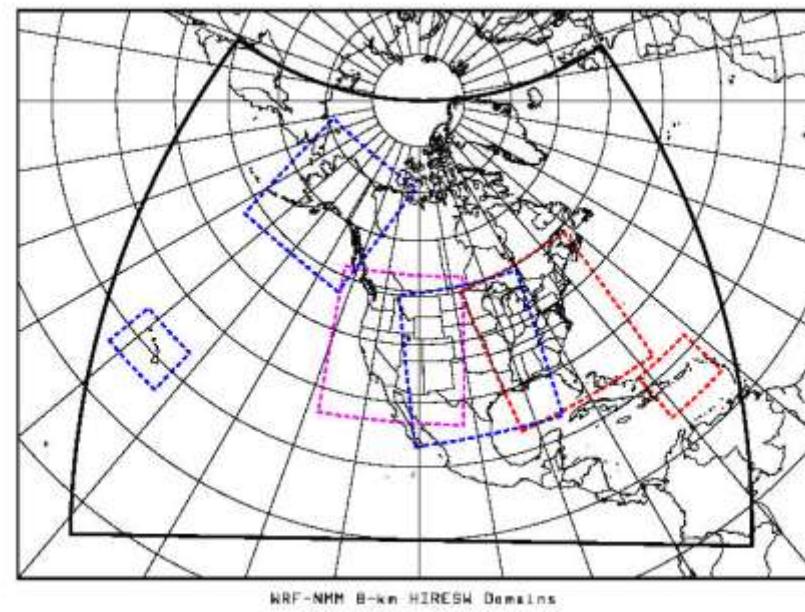
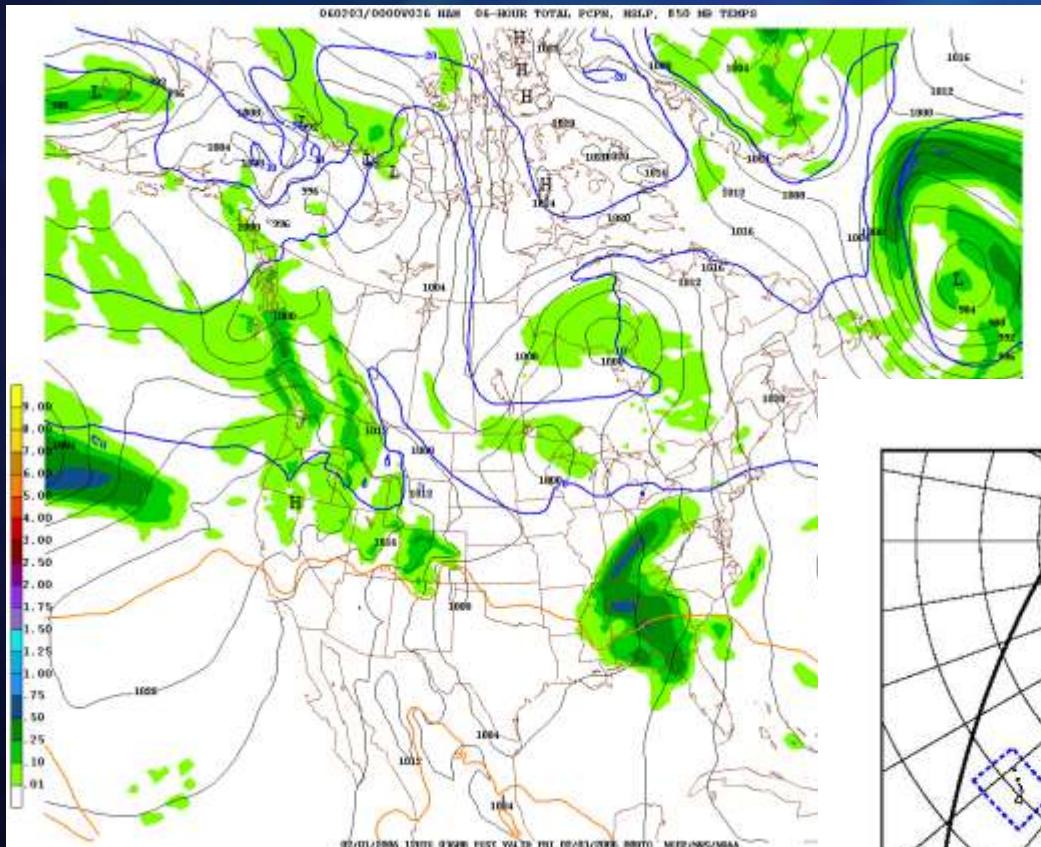


Decision Support Systems

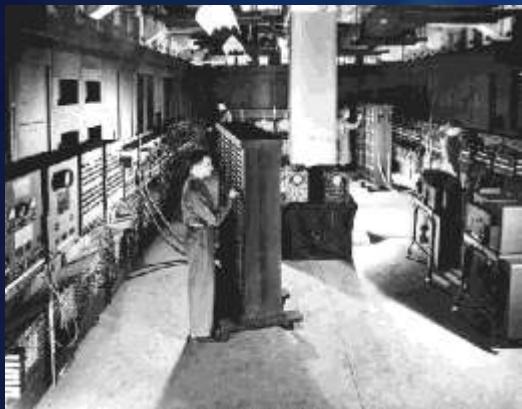
Radars Do Not Adaptively Scan



Operational Models Run Largely on Fixed Schedules in Fixed Domains



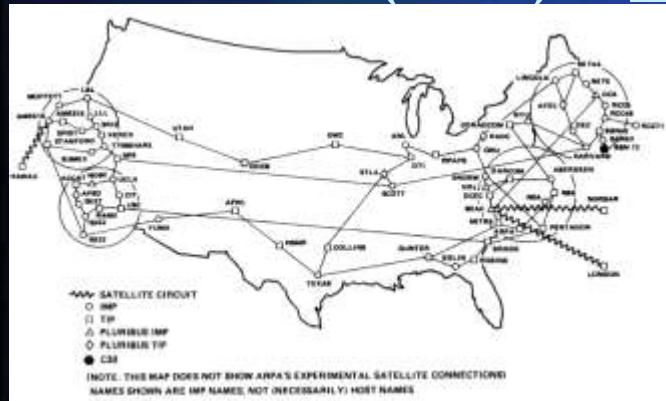
Cyberinfrastructure is Virtually Static



ENIAC (1948)



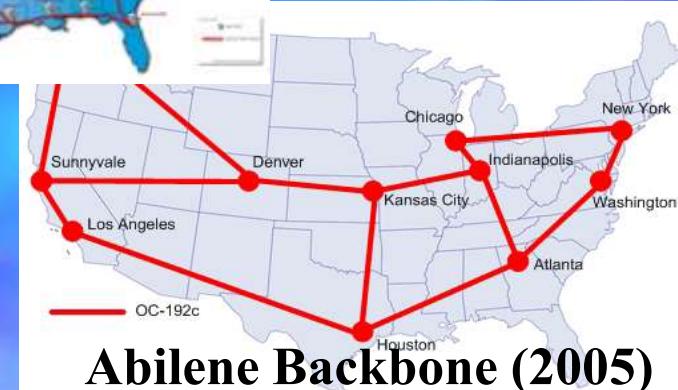
Earth Simulator (2005)



ARPANET (1980)

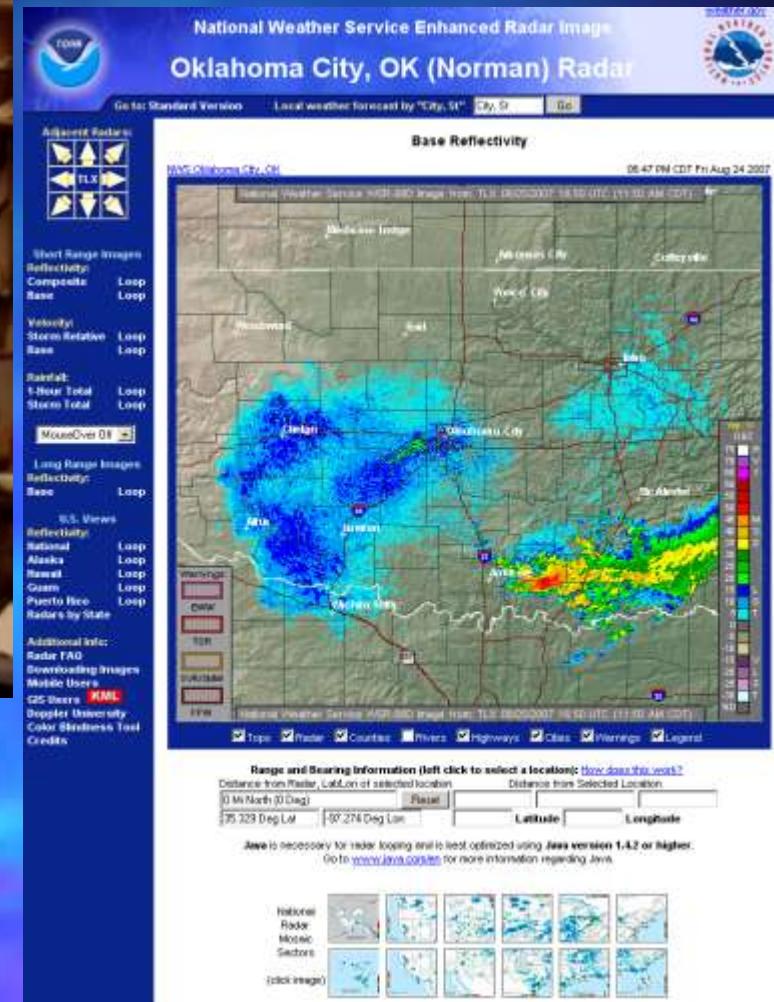


National Lambda Rail (2005)

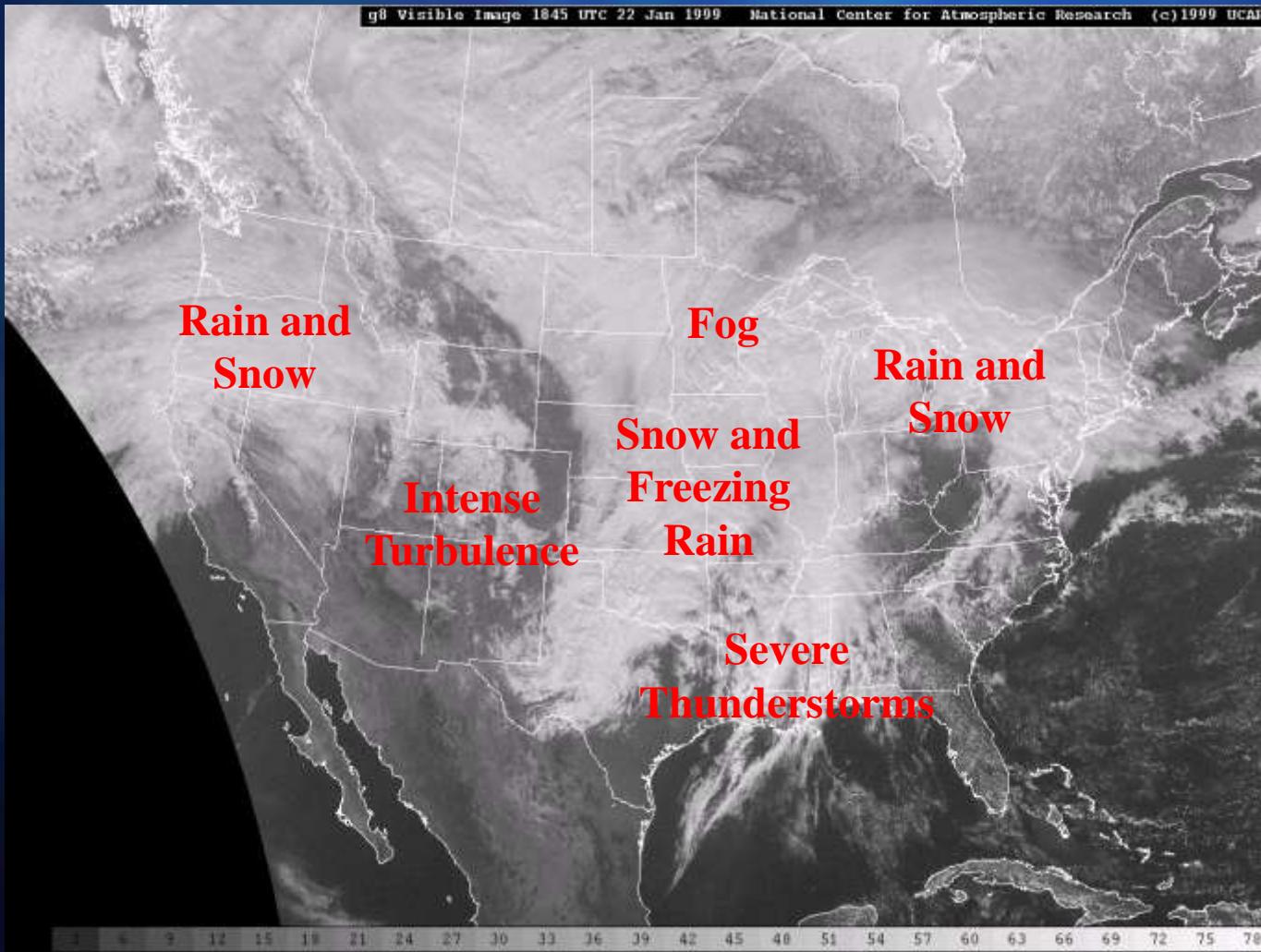


Abilene Backbone (2005)

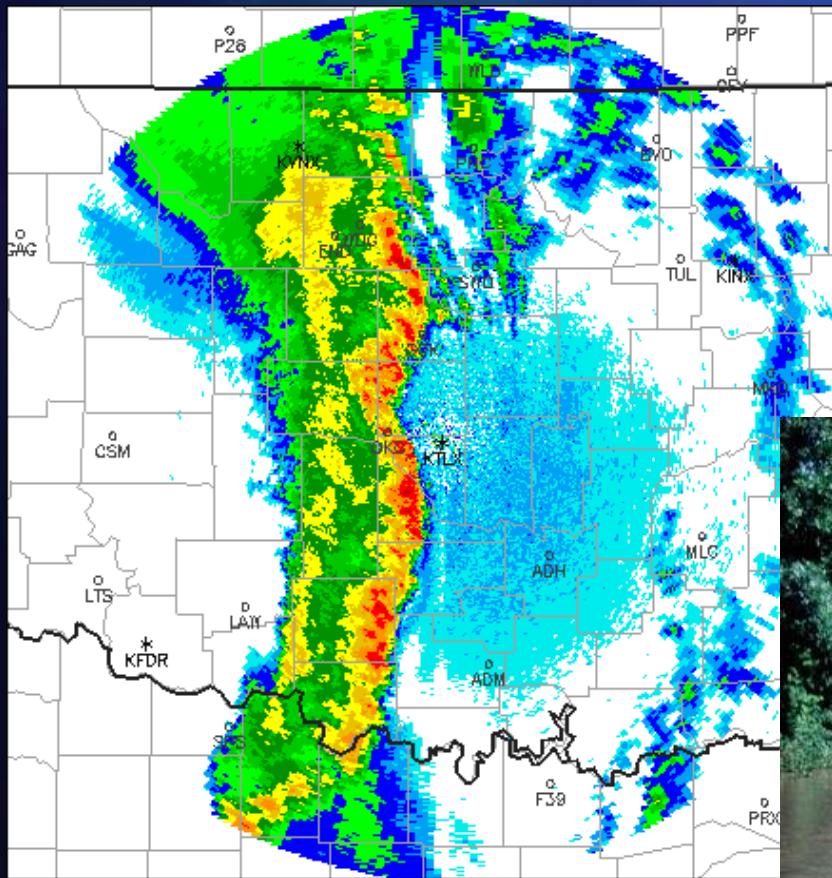
We Teach Using Current Weather Data But Students Don't Interact With It



So What??? Weather is Local, High-Impact, Heterogeneous and Rapidly Evolving...Yet Our Technologies and Thinking are **Static**



The Reality for Society: Dynamic, Local and High Impact



KTLX
Oklahoma City
Sun 16 Apr 2000
02:26 UTC
Reflectivity
Tilt 1 Elev 0
Precip Mod
Max: 61.0 <



A Fundamental Research Question

- Can we better understand the atmosphere, educate more effectively about it, and forecast more accurately if we adapt our technologies and approaches to the weather as it occurs?
- People, even animals adapt/respond: Why don't our resources???





Sponsored by the National
Science Foundation

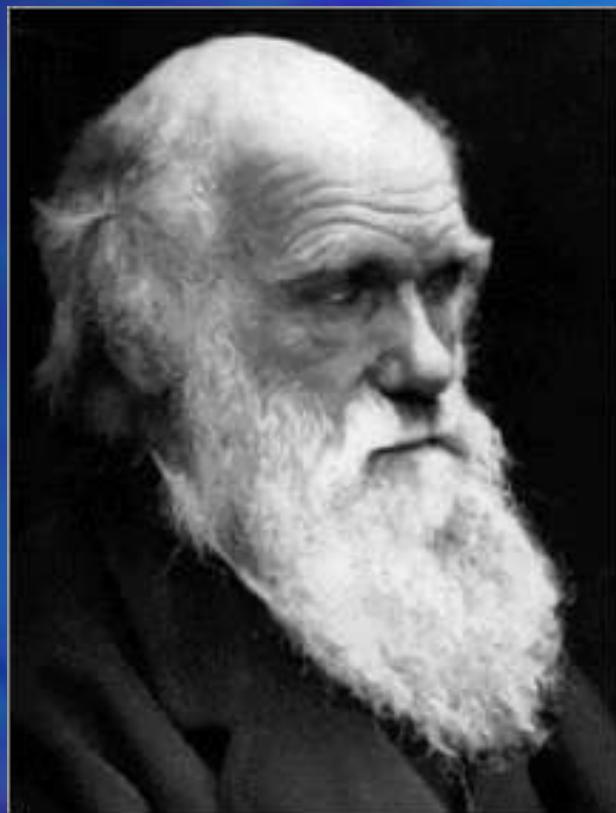


The LEAD Vision

Revolutionize the ability of scientists, students, and operational practitioners to observe, analyze, predict, understand, and respond to intense local weather by interacting with it dynamically and adaptively in real time



What Does Adaptation Really Mean? What Does it Buy?



Charles Darwin

Sample Problem: March 2000 Fort Worth Tornadic Storm

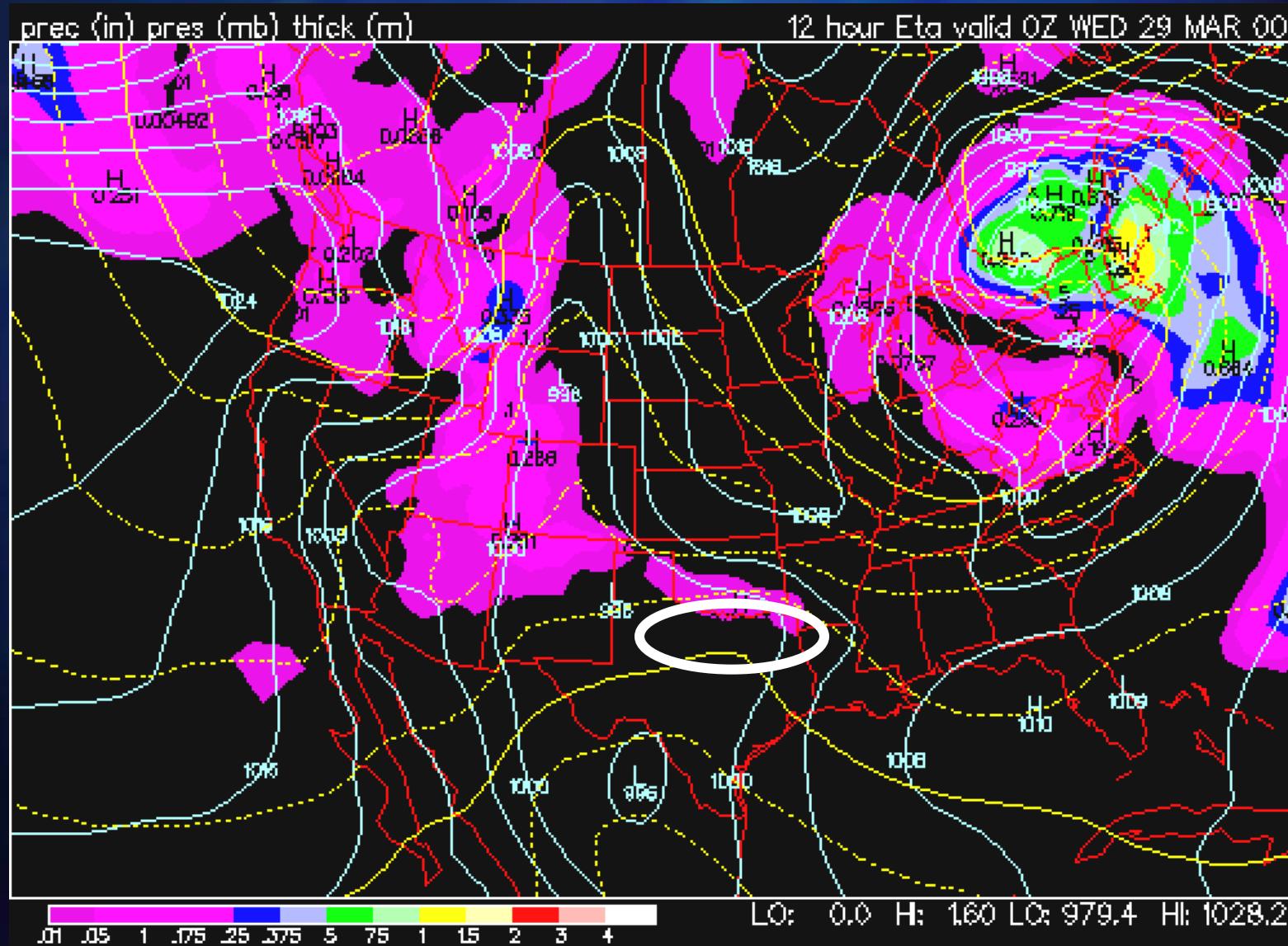


Local TV Station Radar

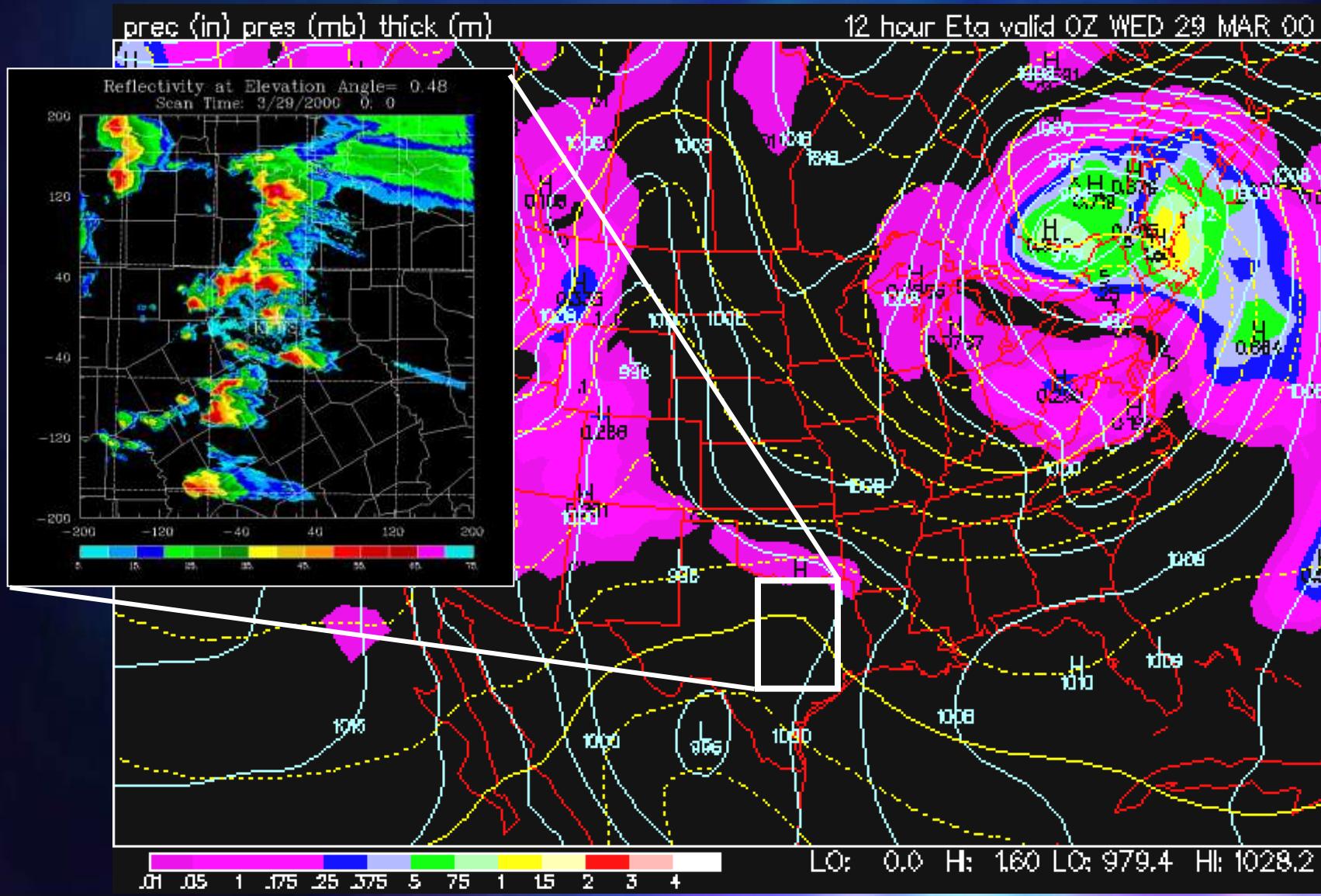


NWS **12-hr** Computer Forecast Valid at 6 pm CDT (near tornado time)

No Explicit Evidence of Precipitation in North Texas



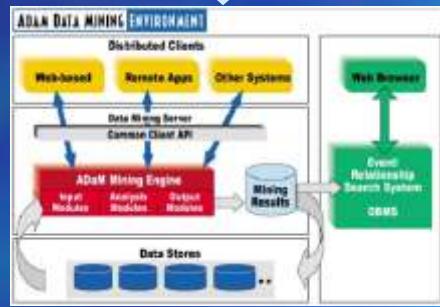
Reality Was Quite Different!



LEAD Approach



Streaming Observations



Data Mining



Storms
Forming or
Conditions
Favorable



TeraGrid and the Alliance



On-Demand
Grid Computing

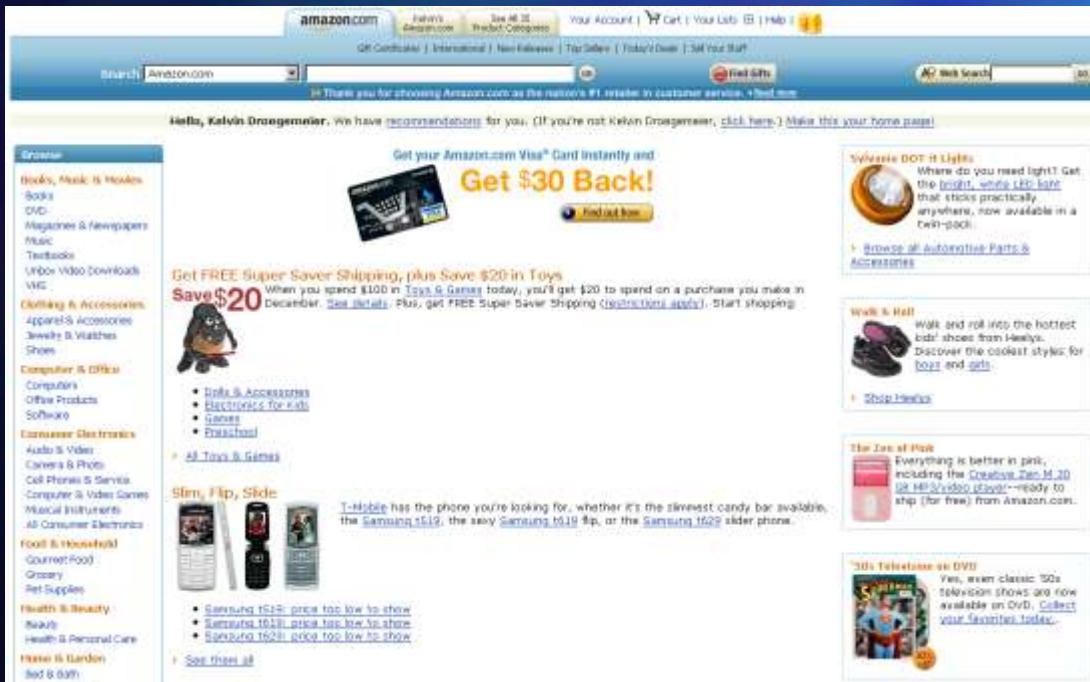
What Does it Take to Make This Possible?

- Adaptive weather tools
- Adaptive sensors
- Adaptive cyberinfrastructure

In a User-Centered Framework
Where Everything Can
Mutually Interact



How Does LEAD Do It? The Notion of a Web Service

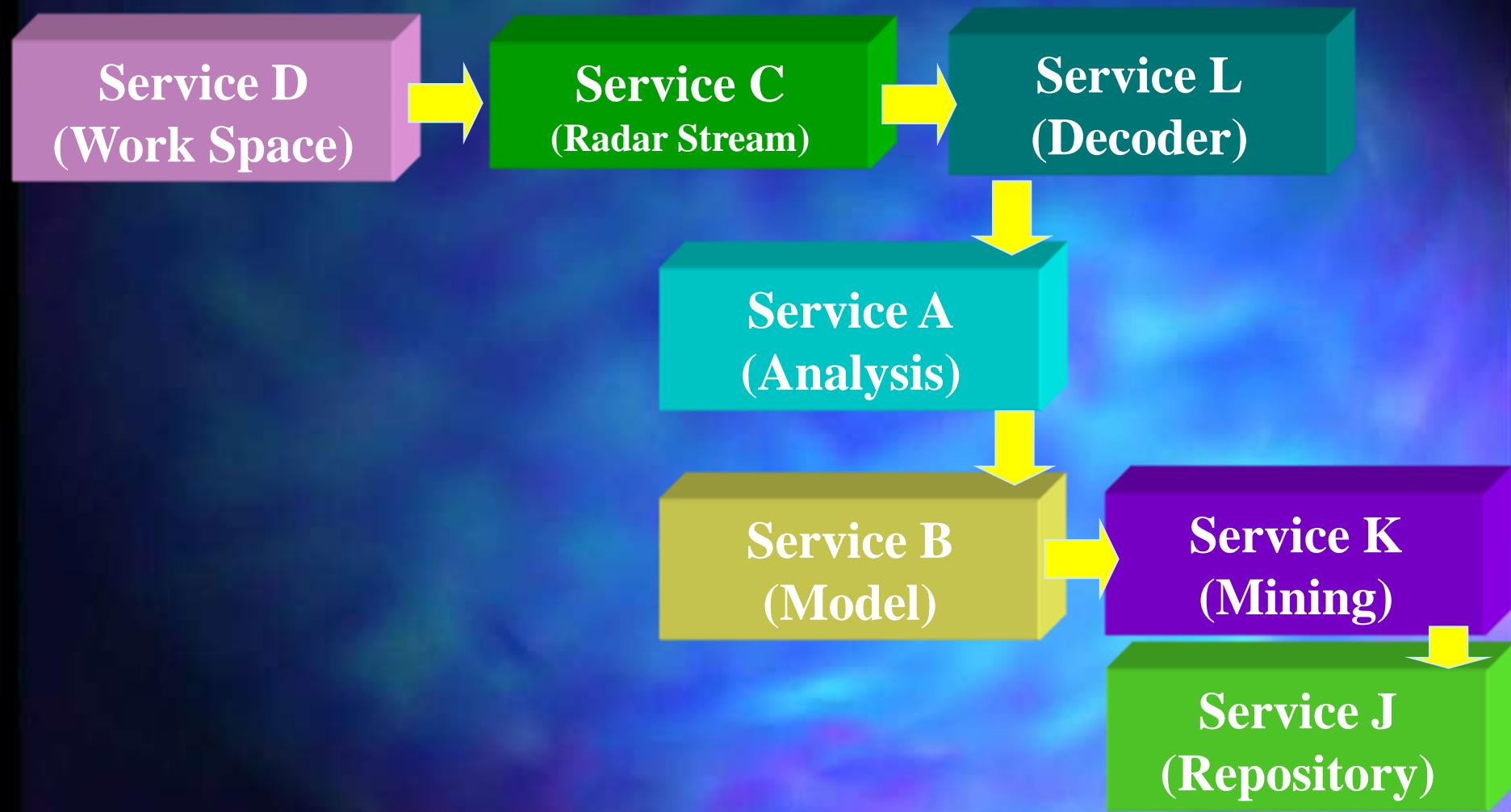


- **Web Service:** A program that carries out a specific set of operations based upon requests from clients
- **The LEAD architecture is a “Service Oriented Architecture” (SOA), which means that all of the key functions are represented as a set of services.**

Service-Oriented Architecture



Can Solve Broad Classes of Problems by Linking Services Together in Workflows



A LEAD Weather Prediction Workflow

LEADPORTAL
LINKED ENVIRONMENTS FOR ATMOSPHERIC DISCOVERY

SPONSORED BY THE NATIONAL SCIENCE FOUNDATION

NSF

Search powered by Google

HOME MY WORKSPACE ABOUT LEAD DATA SEARCH EXPERIMENT VISUALIZE EDUCATION RESOURCES HELP

Introduction Experiment Builder

Experiment Builder Portlet

Experiment Wizard

User: Kelvin Droegemeier Project: Testing 24 Feb 2007

Specify a name, description, and select workflow

Name: test

Description:

Workflow

Sample Workflows (9)

Start Options

You may choose when you would like your experiment to start:

Immediately

At a specified time: 02

Trigger based on mining of weather

Customize

I have SPROCE tokens and I would like to have the option of running SPROCE workflows.

Use the Fault Tolerant Recovery (FTR) service when submitting workflow

Workflow Configuration Overrides

Use the following overrides when configuring a workflow:

Input data source: Please select an input data source

Execution host: Please select an execution host

My Workflows (10)

NAM Initialized WRF Forecasting

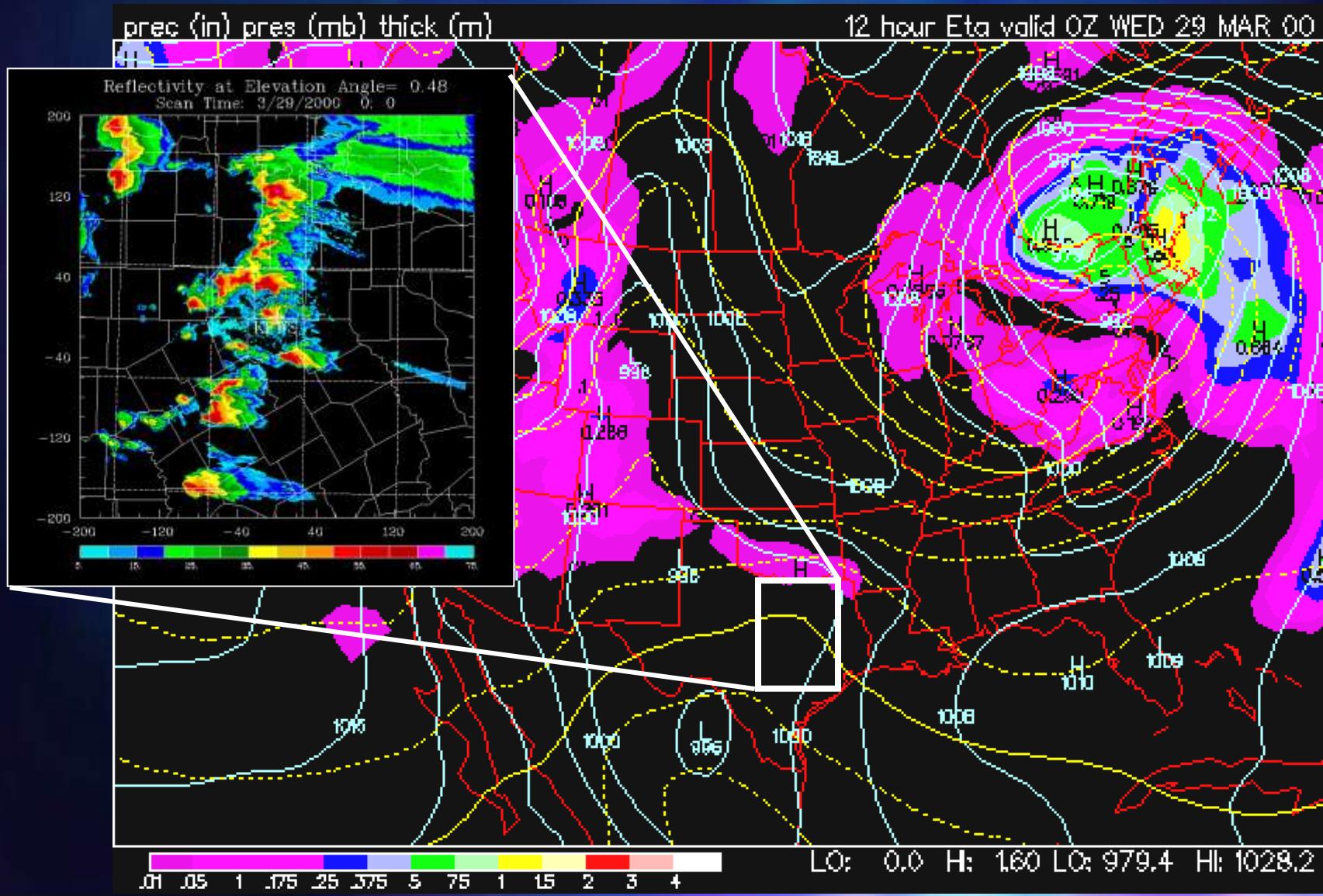
Description

Workflow to run WRF Forecast using NAM 48km initial conditions and lateral boundary data.

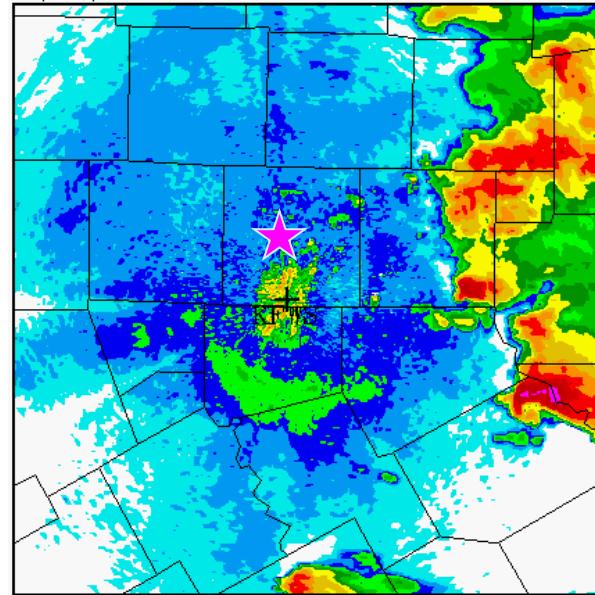
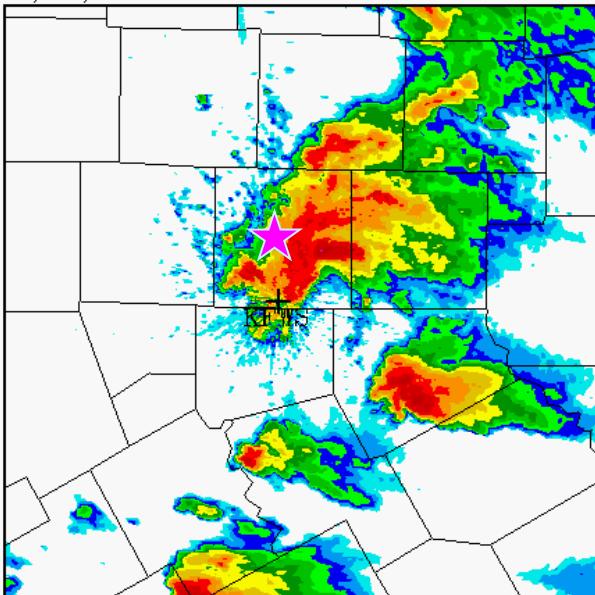
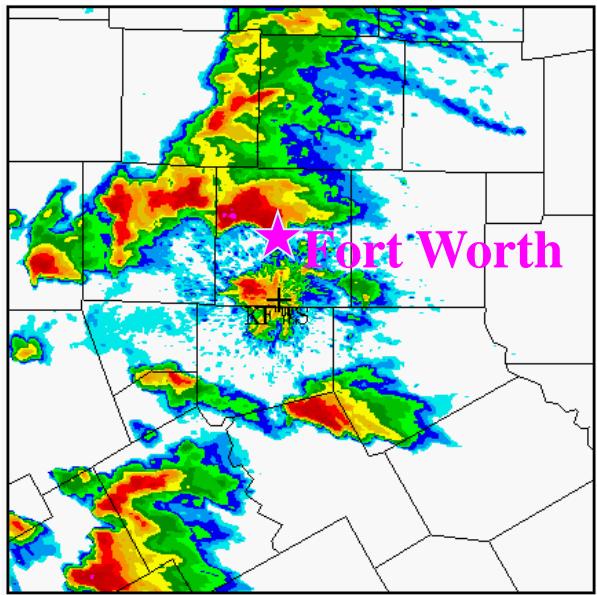
```
graph TD; NAM_InitialData_Config --> NAM_Initial_Conditions_Interpolator; NAM_InitialData_Config --> WRF_Forecasting_Model; NAM_InitialData_Config --> ARPS2_WRF_Interpolator; NAM_InitialData_Config --> NAM_Lateral_Boundary_Interpolator; NAM_InitialData_Config --> WRF_Static_Preprocessor; NAM_InitialData_Config --> Terrain_Preprocessor; NAM_InitialData_Config --> CrossCuttingConfigurations_Config; NAM_Initial_Conditions_Interpolator --> WRF_Forecasting_Model; NAM_Initial_Conditions_Interpolator --> ARPS2_WRF_Interpolator; NAM_Initial_Conditions_Interpolator --> NAM_Lateral_Boundary_Interpolator; NAM_Initial_Conditions_Interpolator --> WRF_Static_Preprocessor; NAM_Initial_Conditions_Interpolator --> Terrain_Preprocessor; NAM_Initial_Conditions_Interpolator --> CrossCuttingConfigurations_Config; WRF_Forecasting_Model --> WRF_Output_Files_Config; ARPS2_WRF_Interpolator --> WRF_Output_Files_Config; ARPS2_WRF_Interpolator --> NAM_Lateral_Boundary_Interpolator; ARPS2_WRF_Interpolator --> WRF_Static_Preprocessor; ARPS2_WRF_Interpolator --> Terrain_Preprocessor; ARPS2_WRF_Interpolator --> CrossCuttingConfigurations_Config; NAM_Lateral_Boundary_Interpolator --> WRF_Static_Preprocessor; NAM_LateralBoundaryData_Config --> WRF_Static_Preprocessor; NAM_LateralBoundaryData_Config --> Terrain_Preprocessor; NAM_LateralBoundaryData_Config --> CrossCuttingConfigurations_Config; Terrain_Preprocessor --> WRF_Static_Preprocessor; Terrain_Preprocessor --> CrossCuttingConfigurations_Config; WRF_Static_Preprocessor --> CrossCuttingConfigurations_Config
```

Next > Cancel

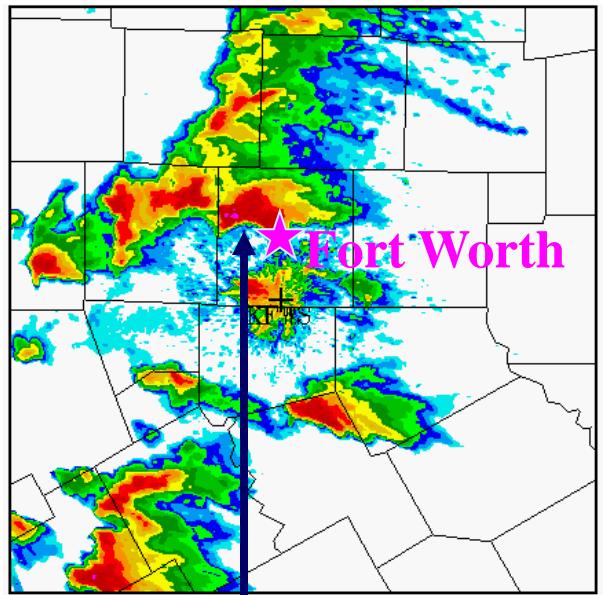
Back to the Earlier Example...



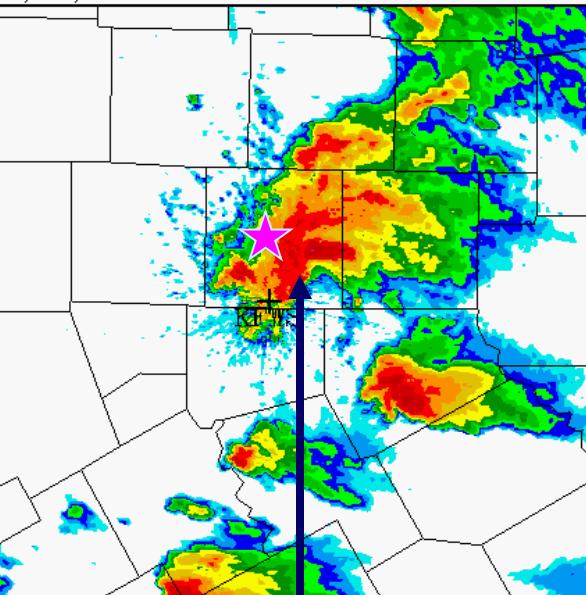
Radar



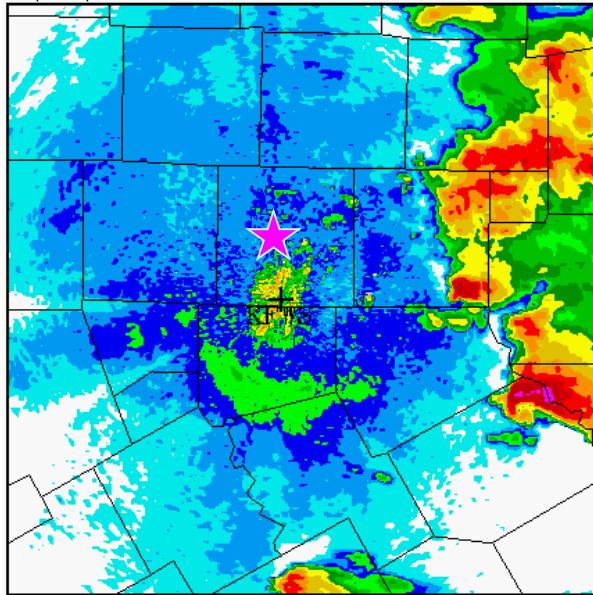
Radar



6 pm

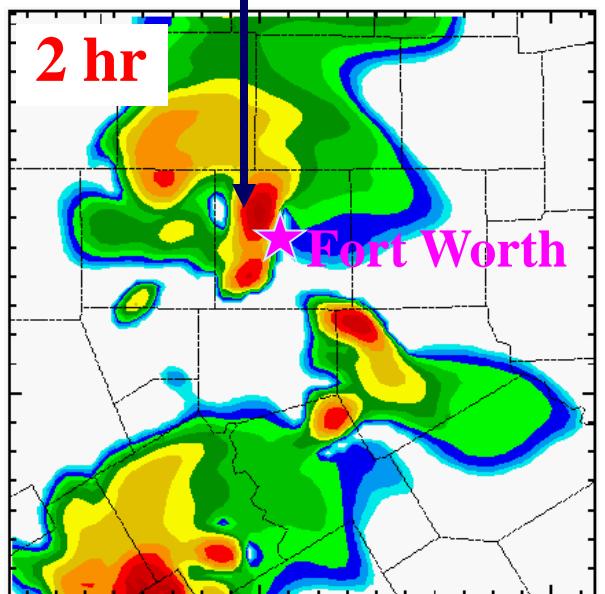


7 pm

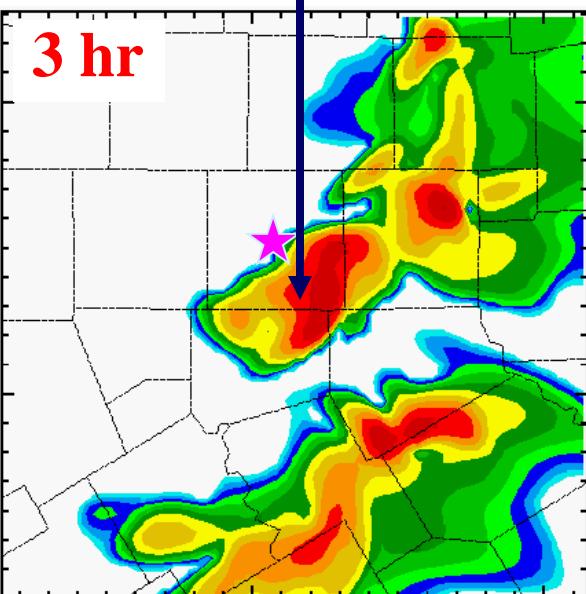


8 pm

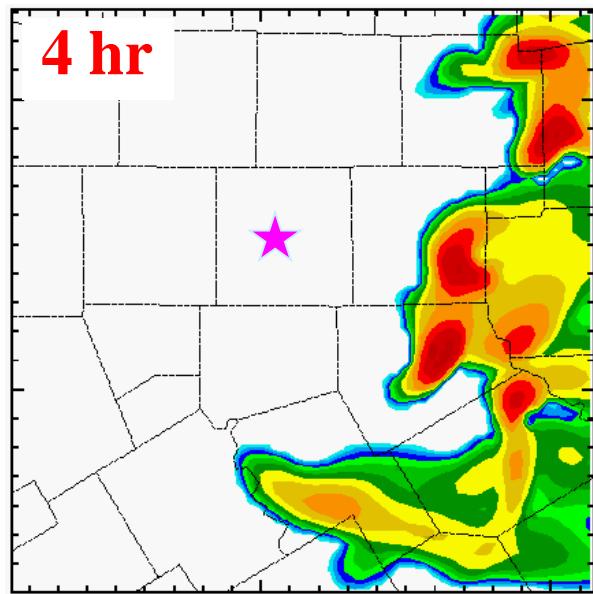
Fest With Radar Data



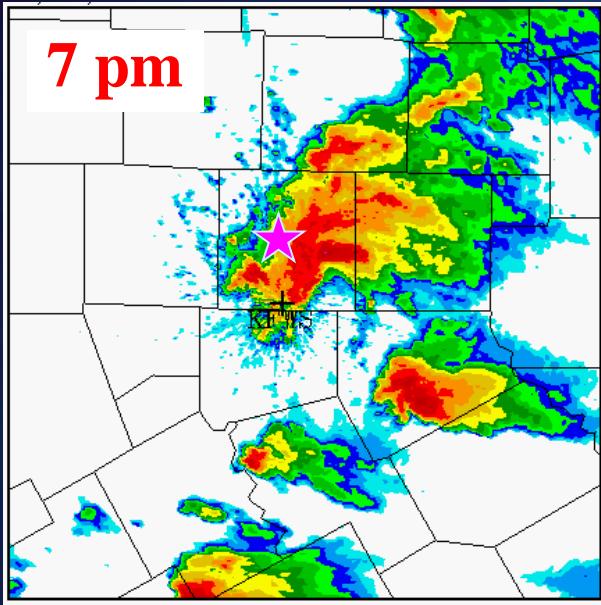
2 hr



3 hr

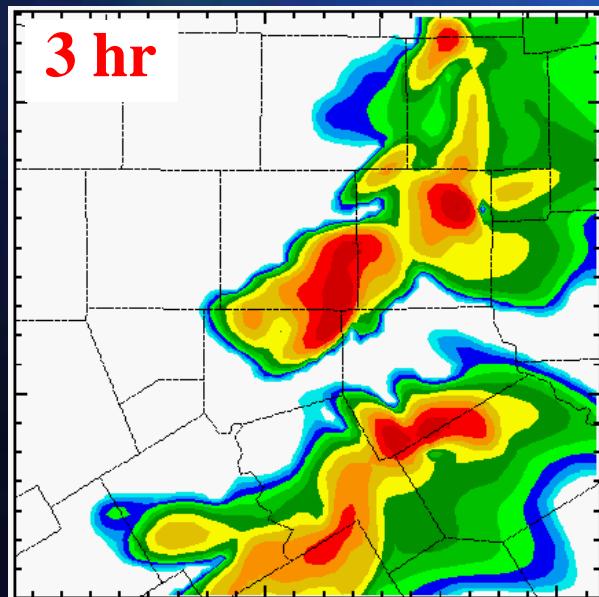
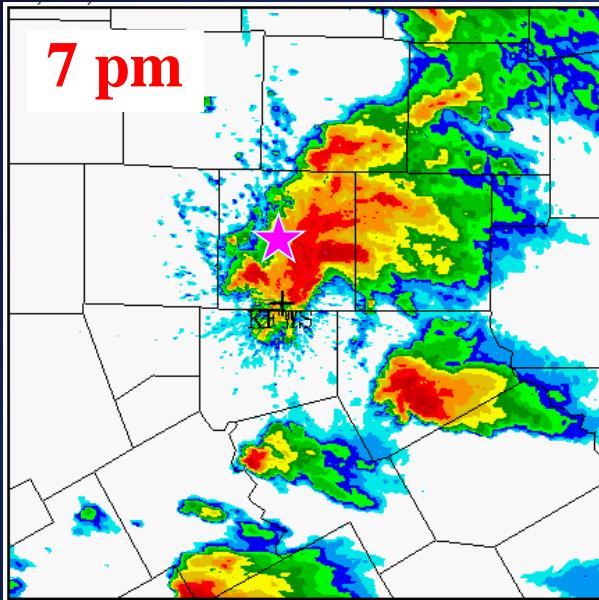


4 hr



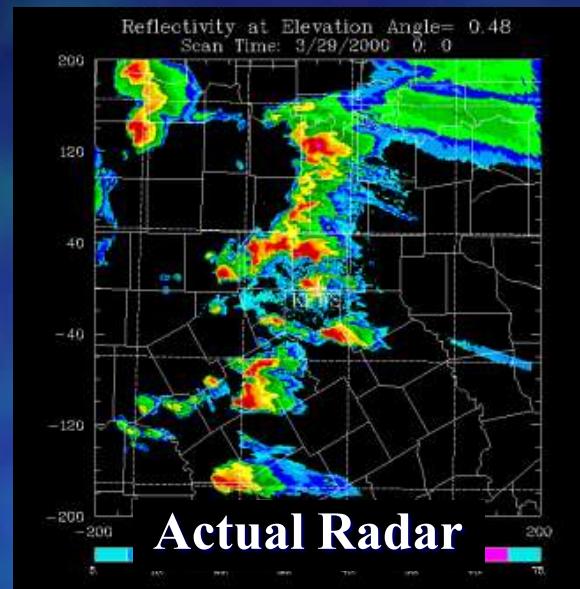
As a Forecaster
Worried About
This Reality...



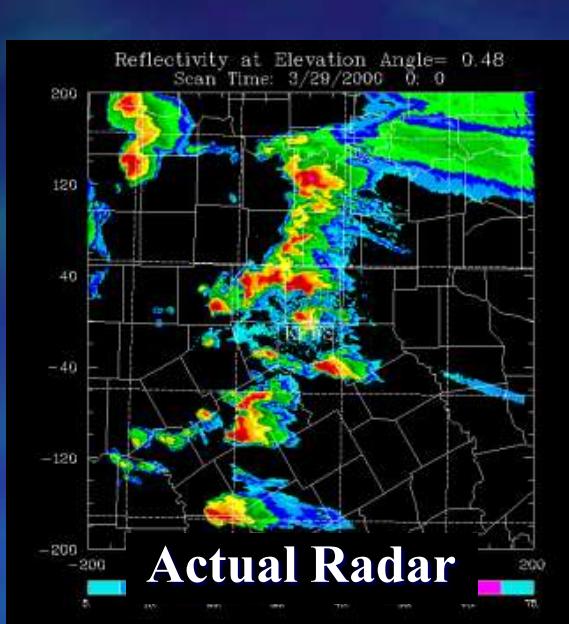


As a Forecaster
Worried About
This Reality...

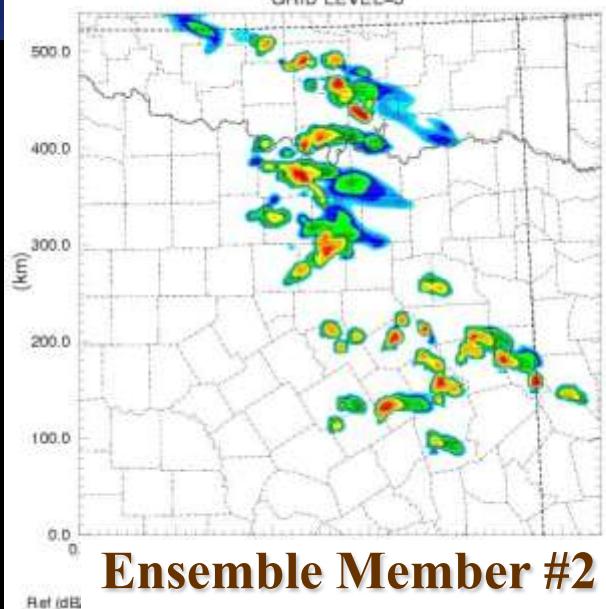
How Much Trust
Would You Place
in This Model
Forecast?



00:00Z Wed 29 Mar 2000 T=7200.0 s (2:00:00)
GRID LEVEL=5



00:00Z Wed 29 Mar 2000 T=7200.0 s (2:00:00)
GRID LEVEL=5



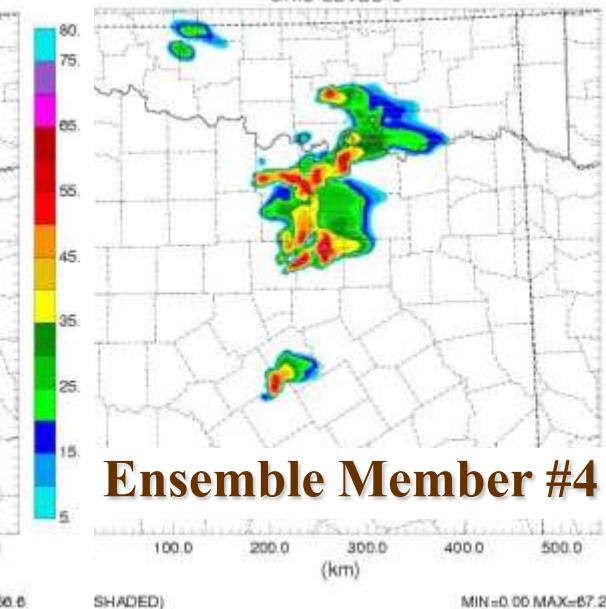
00:00Z Wed 29 Mar 2000 T=7200.0 s (2:00:00)
GRID LEVEL=5



00:00Z Wed 29 Mar 2000 T=3600.0 s (1:00:00)
GRID LEVEL=5

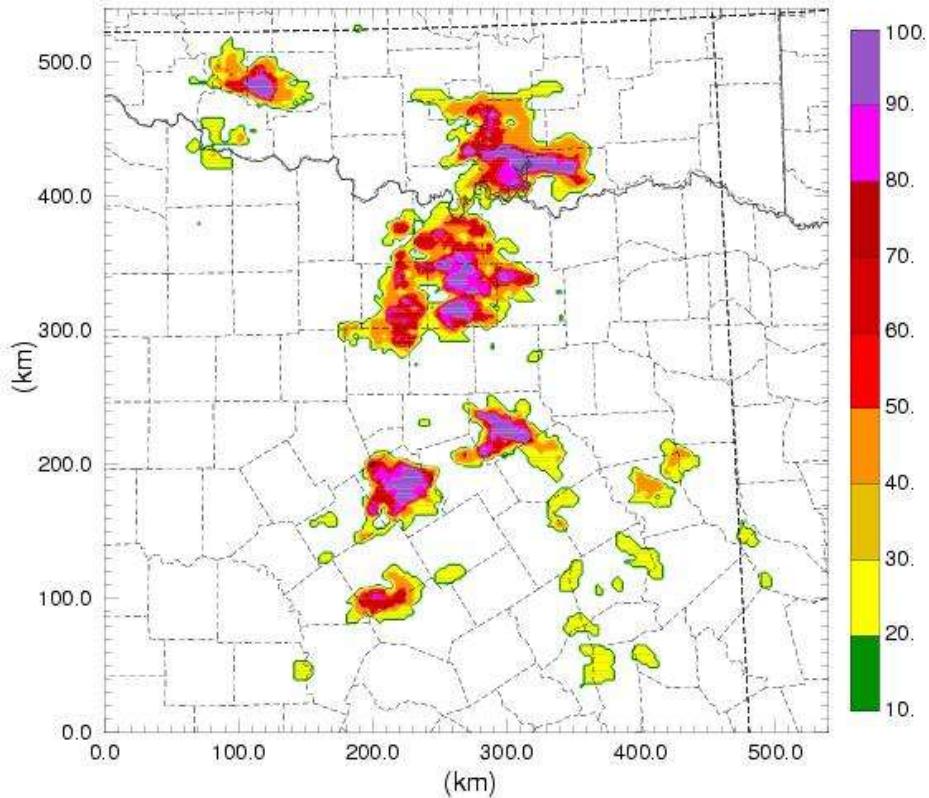


00:00Z Wed 29 Mar 2000 T=7200.0 s (2:00:00)
GRID LEVEL=5



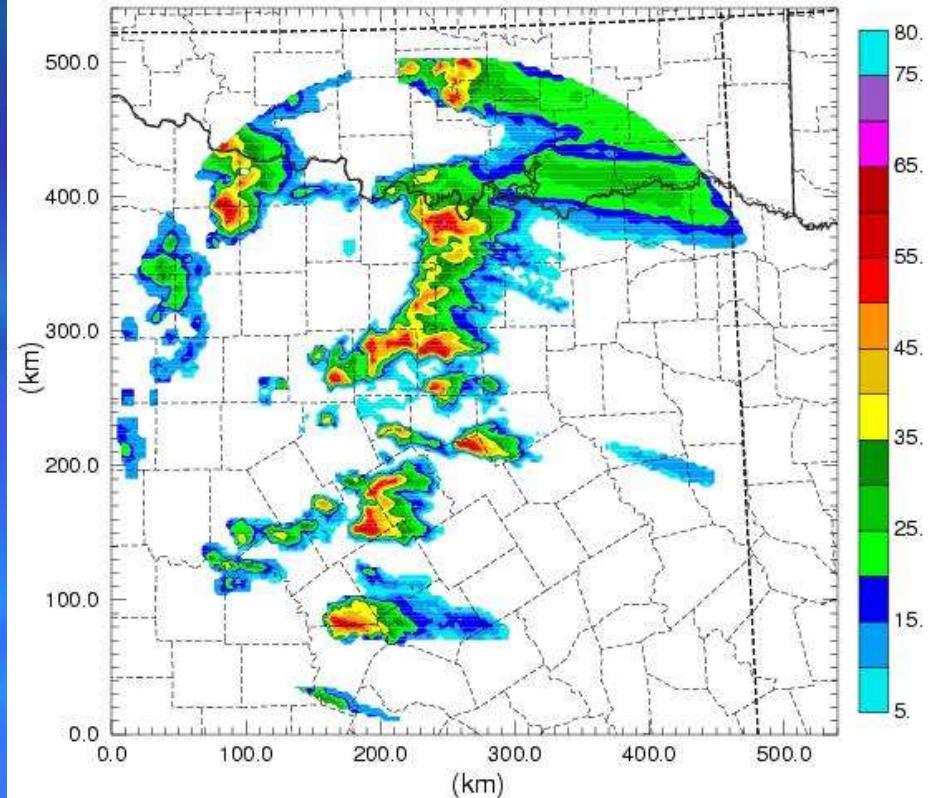
Probability of Intense Precipitation

00:00Z Wed 29 Mar 2000 T=3600.0 s (1:00:00)



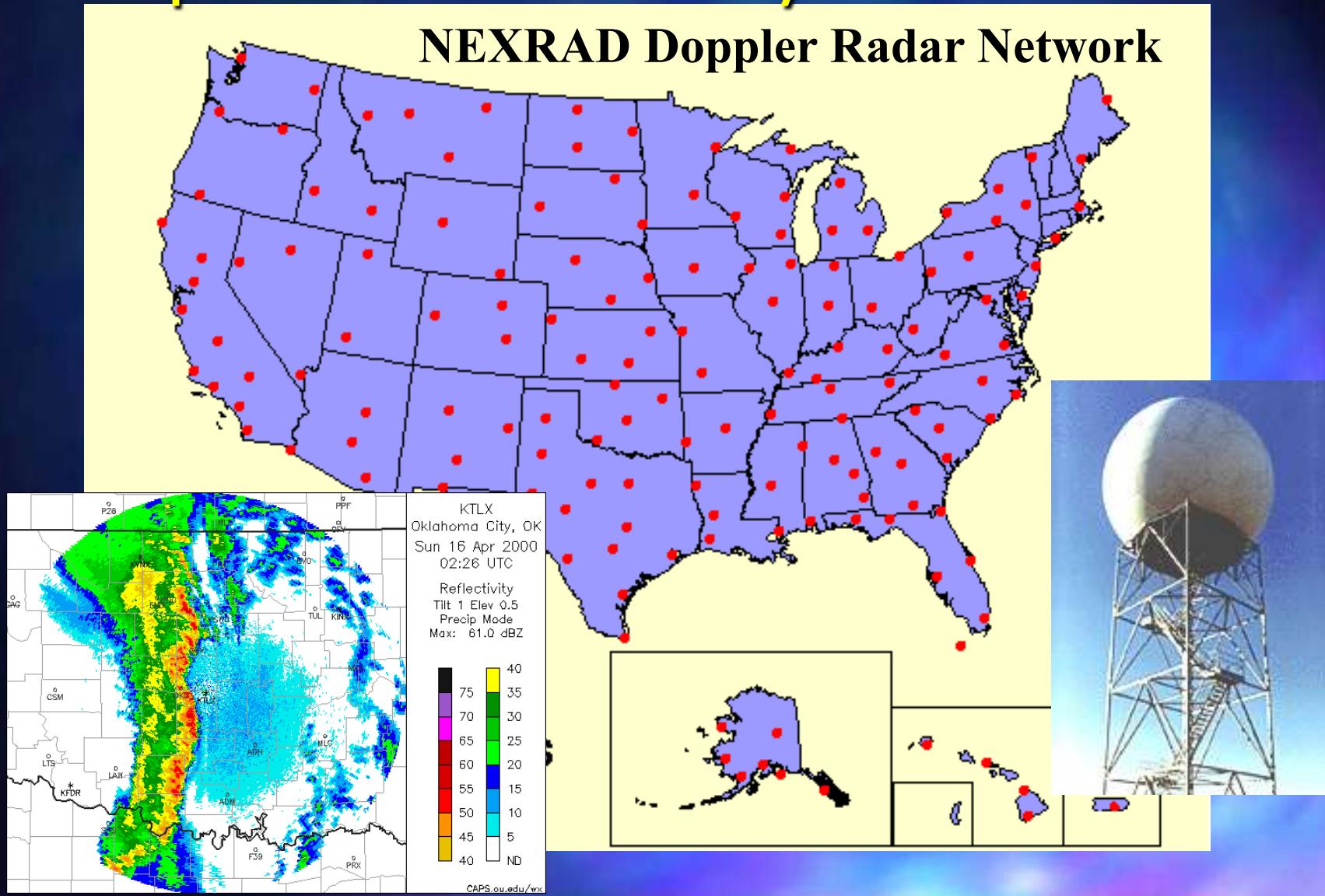
■ Model Forecast

00:00Z Wed 29 Mar 2000 T=3600.0 s (1:00:00)



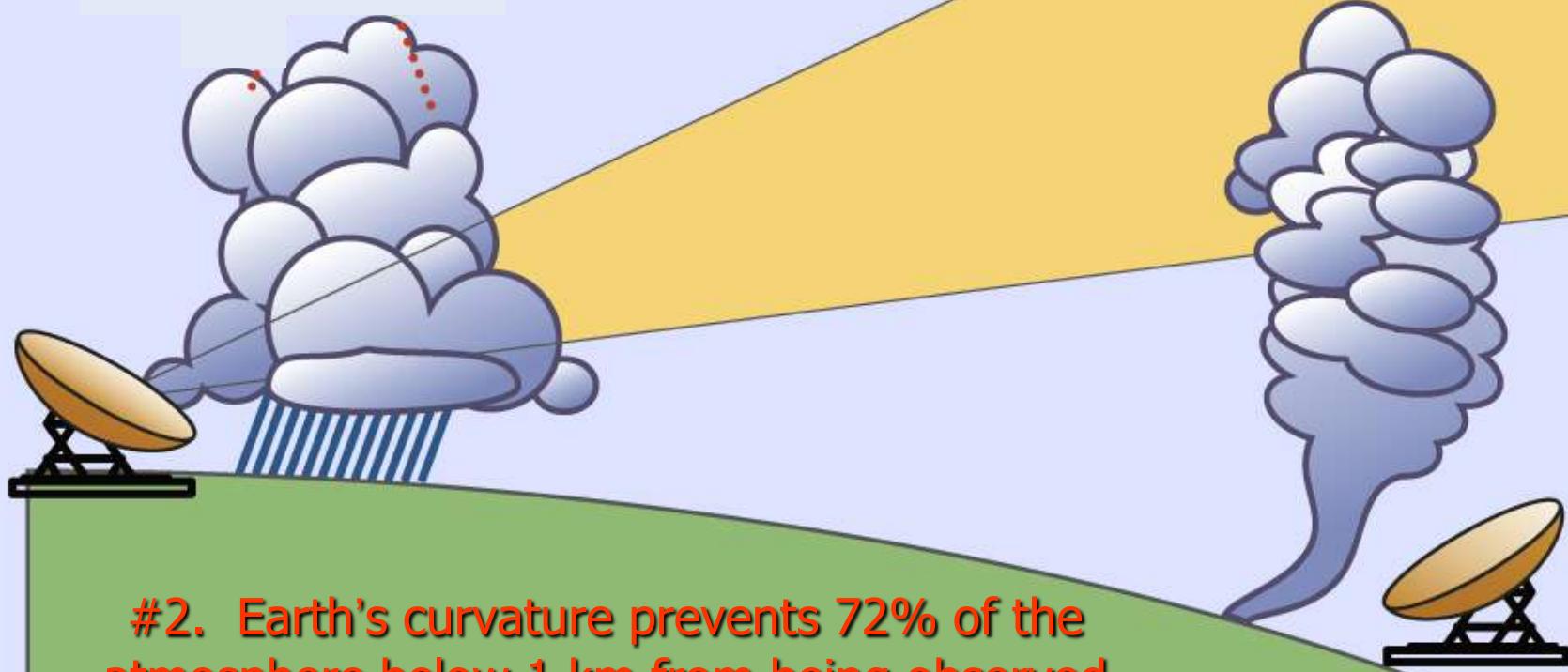
■ Radar Observations

Adaptive Observing Systems: Current Operational Radar System in US



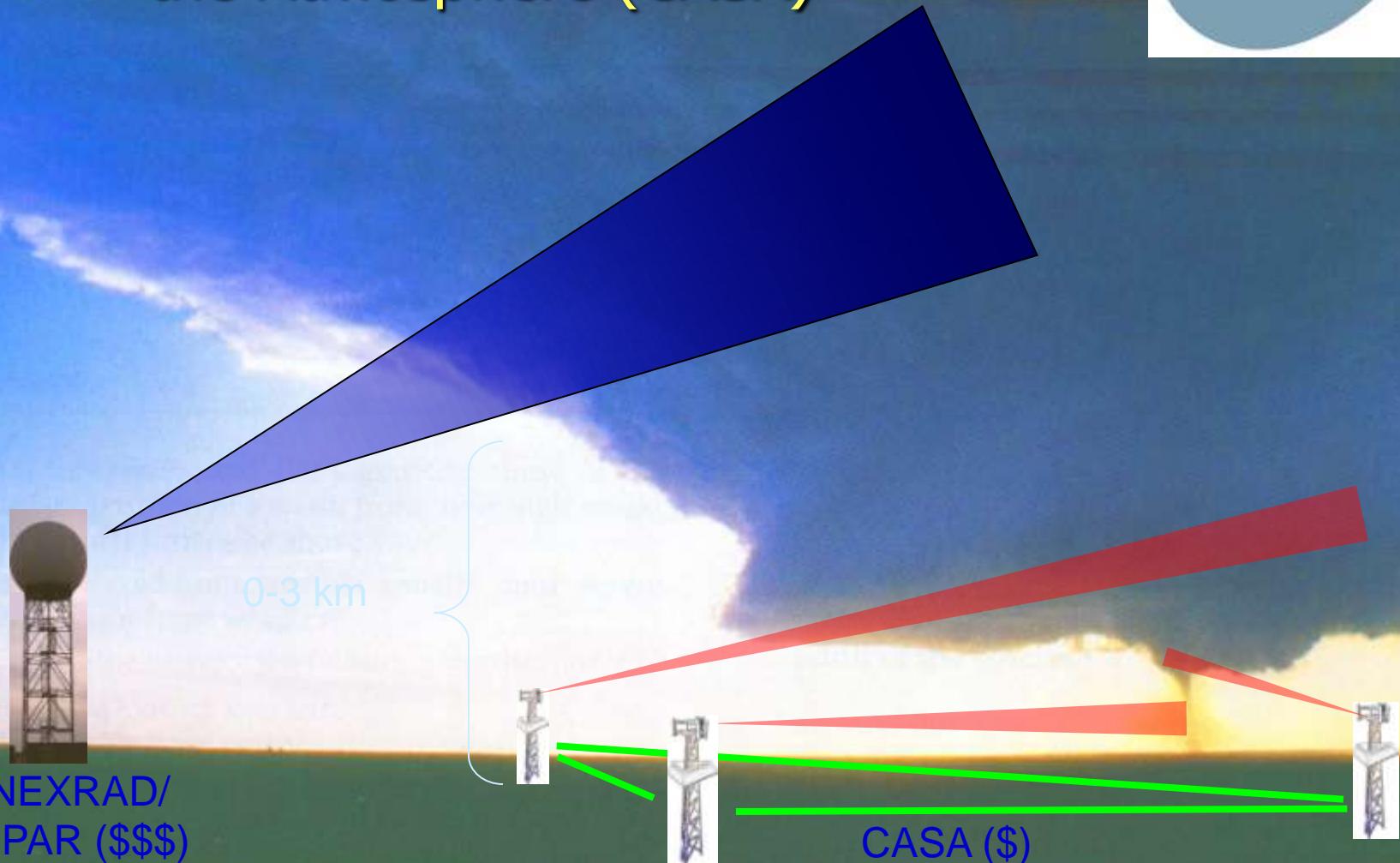
The Limitations of NEXRAD

- #1. Operates largely independent of the prevailing weather conditions
- #3. Operates entirely independent from the models and algorithms that use its data

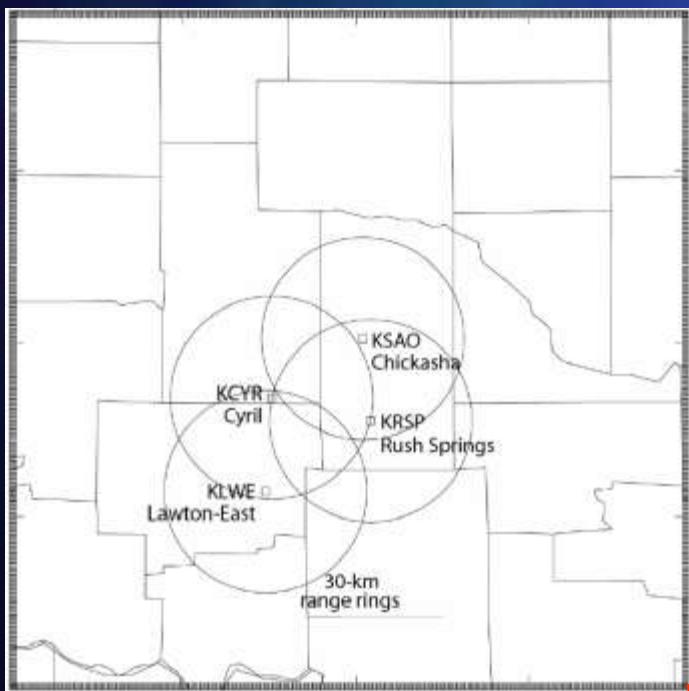


- #2. Earth's curvature prevents 72% of the atmosphere below 1 km from being observed

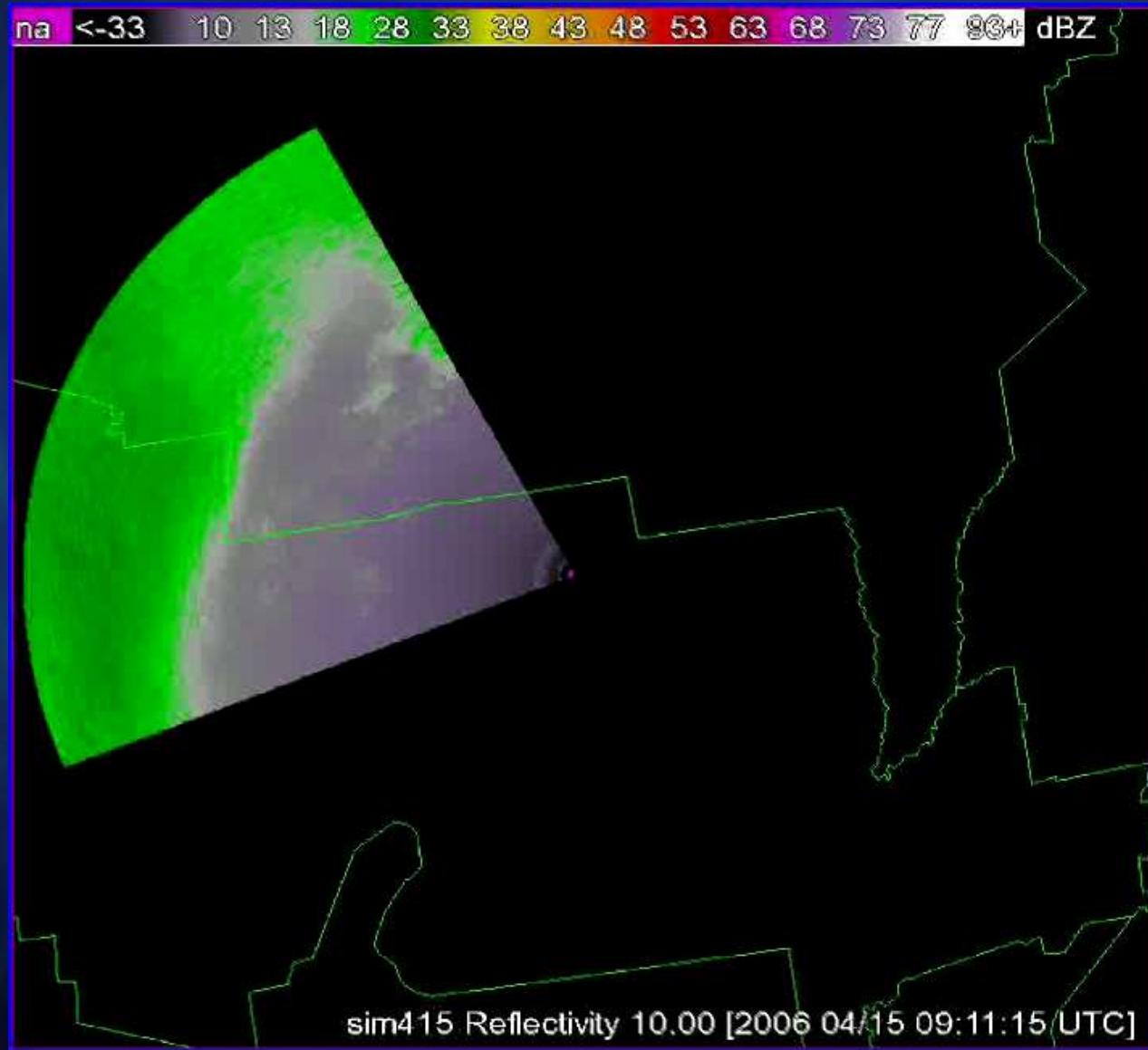
NSF Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA)



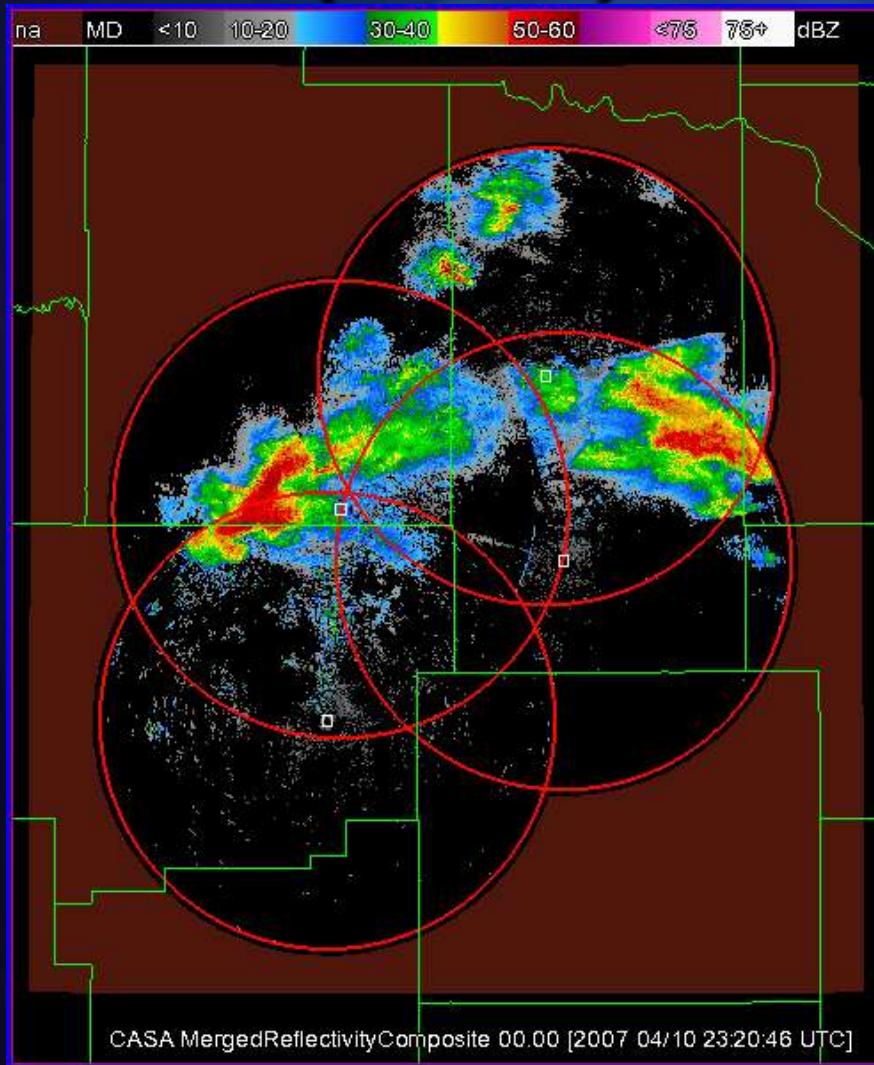
Oklahoma Test Bed



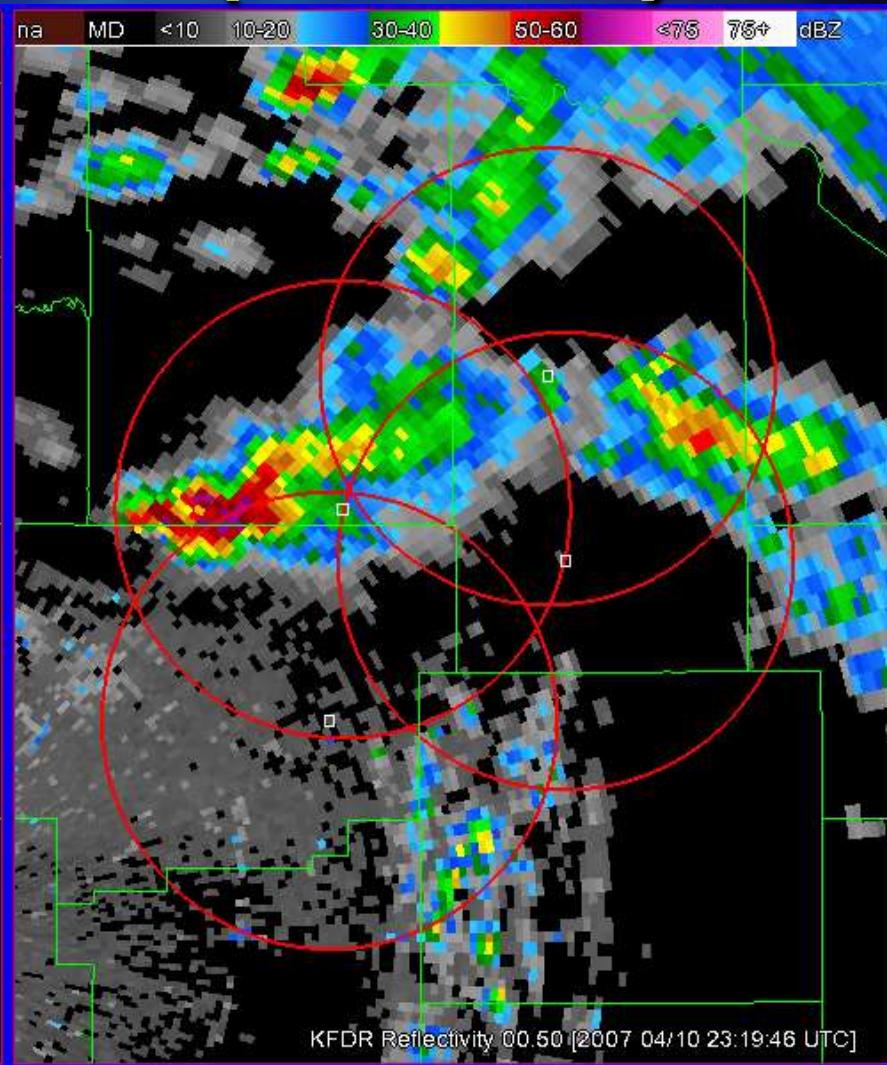
Example of Adaptive Sampling



Experimental (CASA)



NWS Operational (NEXRAD)



LEAD: Potential to Transform Meteorological Research And Education

A man in a light blue shirt is standing on a stage, presenting to an audience. He is positioned in front of a large screen that displays a slide titled "Anticipating Tornados". The slide lists four goals for Project LEAD, each preceded by a yellow circular bullet point. To the right of the text is a photograph of a large, dark, funnel-shaped tornado in a bright, cloudy sky. The stage has a dark background, and the overall lighting is focused on the speaker and the screen.

Anticipating Tornados

- Project LEAD
 - Using technology to dynamically adapt to weather conditions
 - Decrease false alarm rate
 - Dramatically improve probability of detection

