

Precipitation Forecasting: Past, Present, & Future

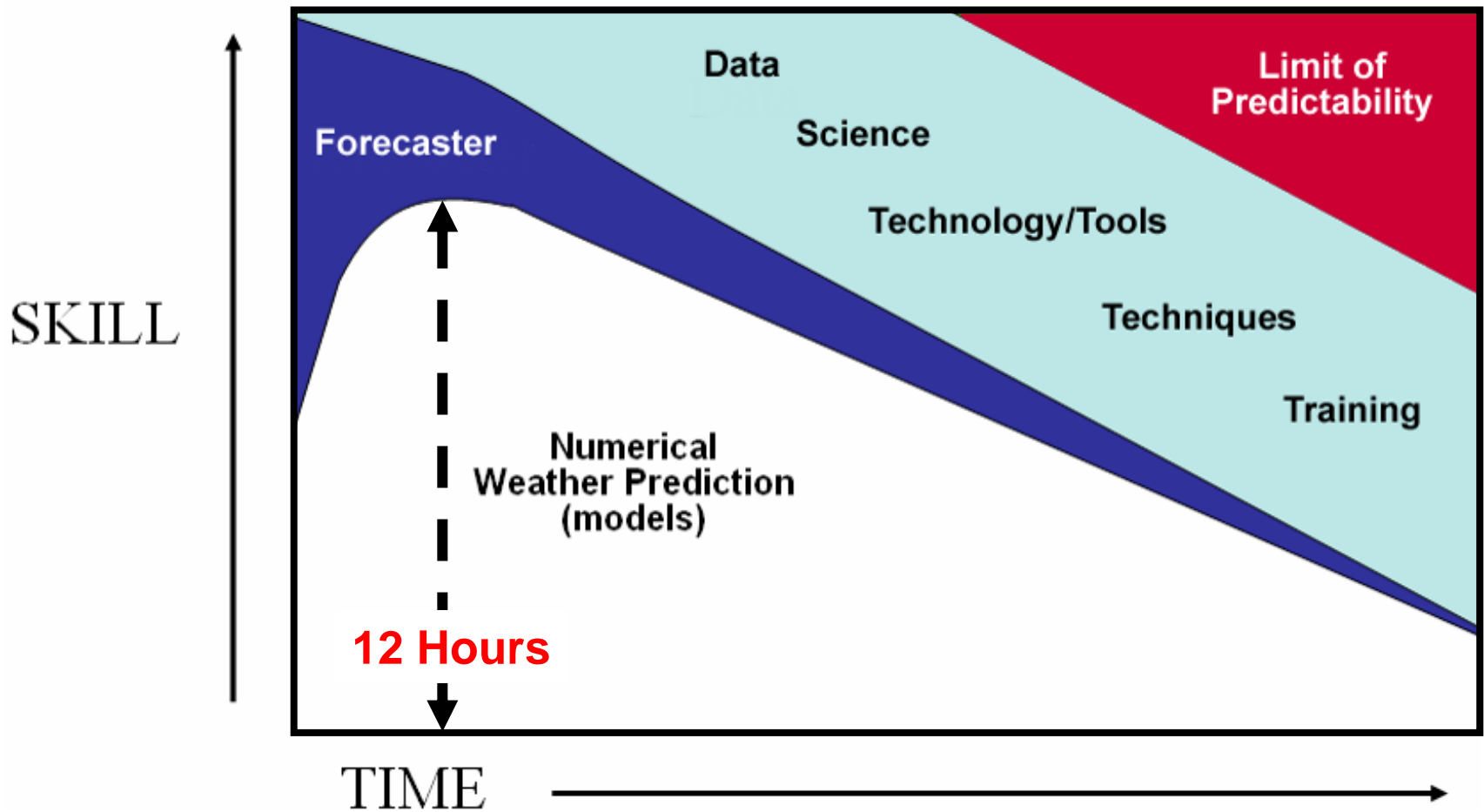
Forecasting Advances since the 1986 Flood

**2006
California
Extreme
Precipitation
Symposium**



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California Nevada River Forecast Center

Precipitation Forecasting



Data

Improved Data Communications

- DOMSAT Satellite

- Enables multi-agency data sharing of precipitation data vs. individual data collection networks
- Allows more remote siting of precipitation gages
- Event-triggered data collection (similar to ALERT)
- More frequent transmissions

- Results in improved maintenance

Improved Data Instrumentation

Science

- Basic concepts still apply:

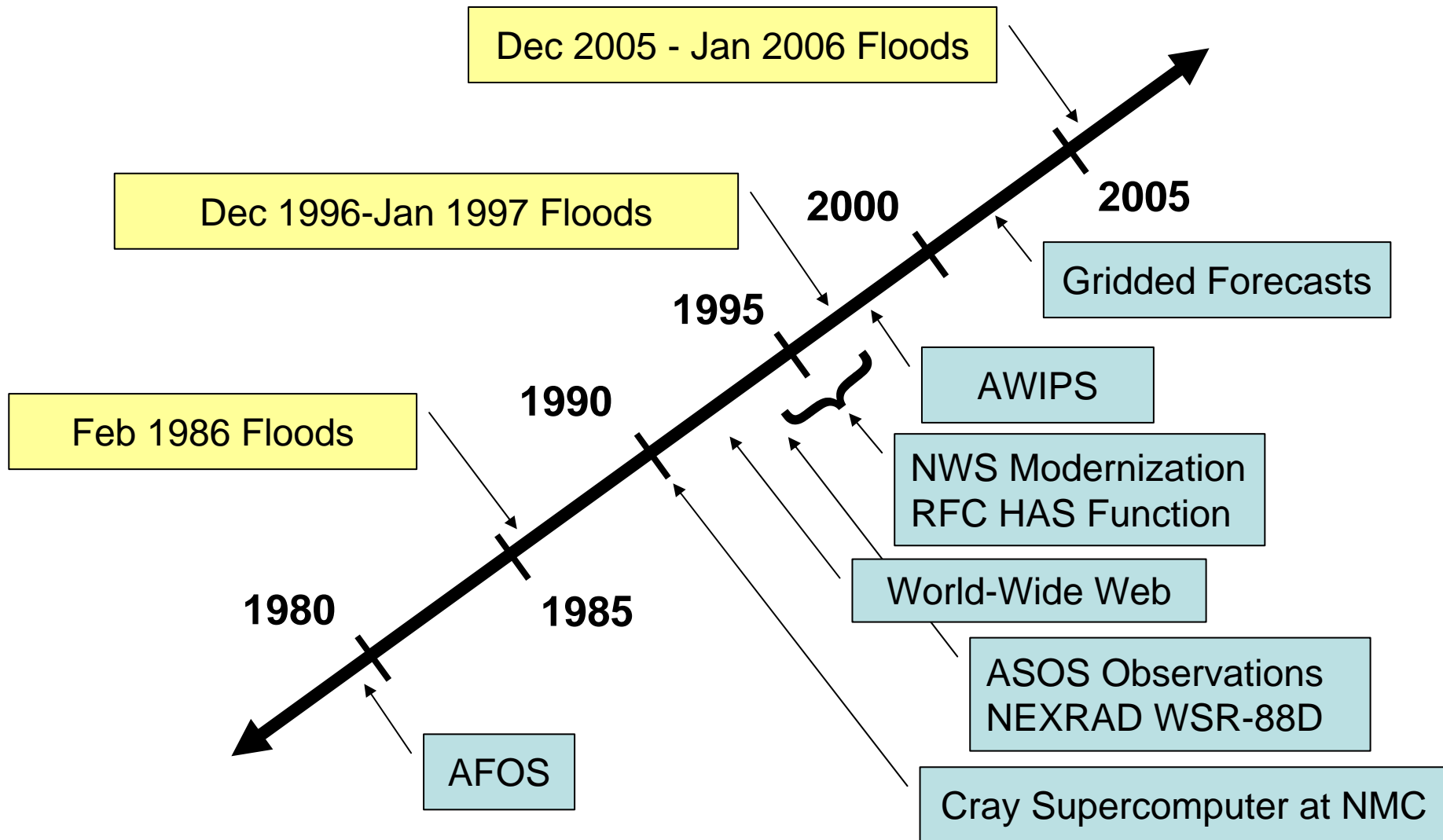
$$\text{Moisture} + \text{Lift} = \text{Precipitation}$$

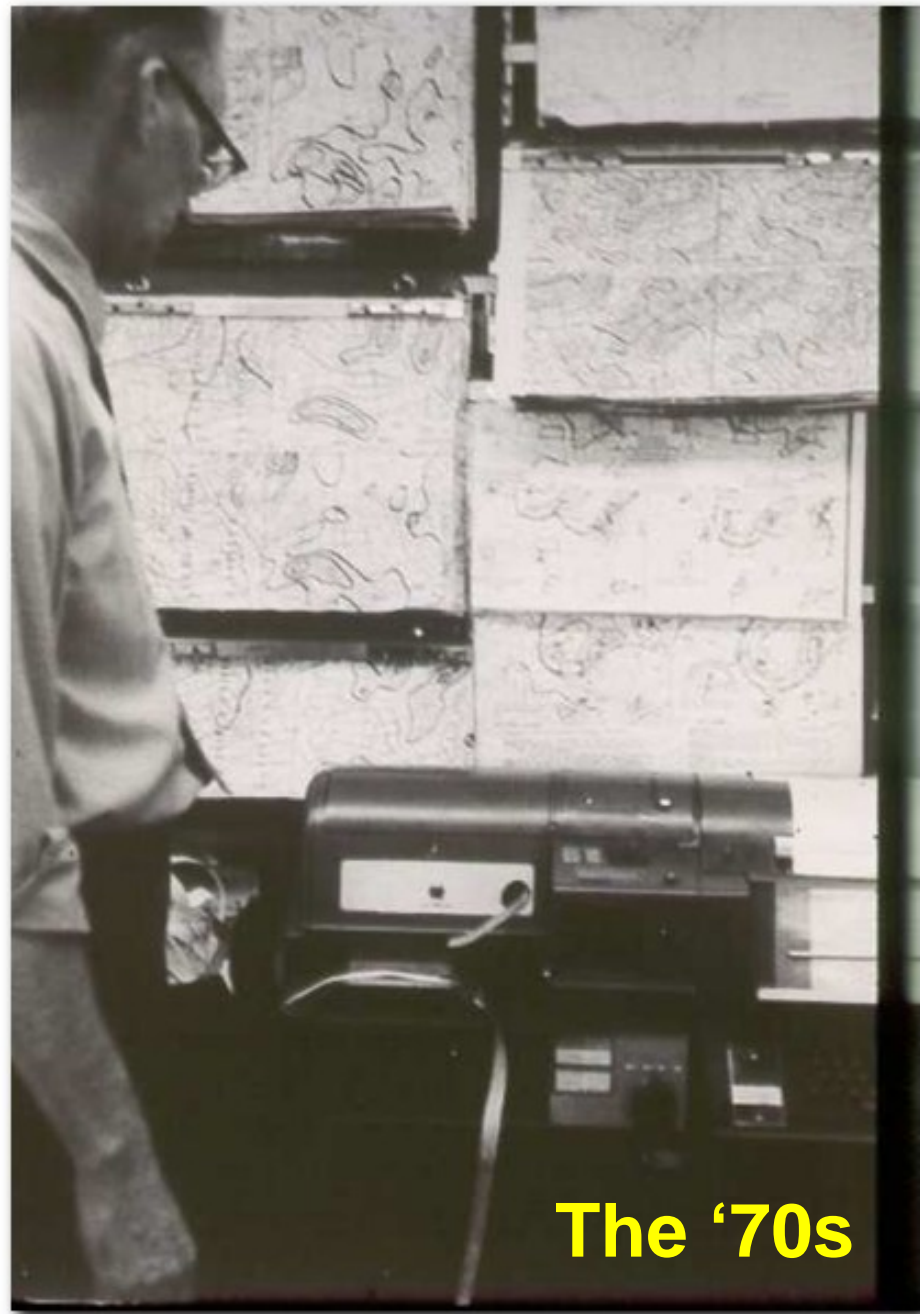
- Vastly improved display tools have made it easier visually to integrate conceptual models into operations
- Faster processing and gridded datasets allow use of tools that in the past were not possible
 - isentropic analysis/forecasting
 - q-vectors
- Faster assimilation of research into operations

Tools/Technology

- Data Display
 - teletypes and facsimile machines in the '70s
 - AFOS in the '80s
 - AWIPS since the mid '90s
 - Internet
- Remote Sensing
 - Weather Radar
 - WSR-57 (66) / 74C (62) – mostly central and eastern U.S.
 - NEXRAD WSR-88D (158 w/overlapping coverage)
 - GOES and polar-orbiting satellites
 - Improved remote sensing of winds and moisture over the Pacific Ocean

Tools/Technology - Timeline





The '70s



**The
'80s**

AFOS

Automation of Field Operations and Services



The '90s - present

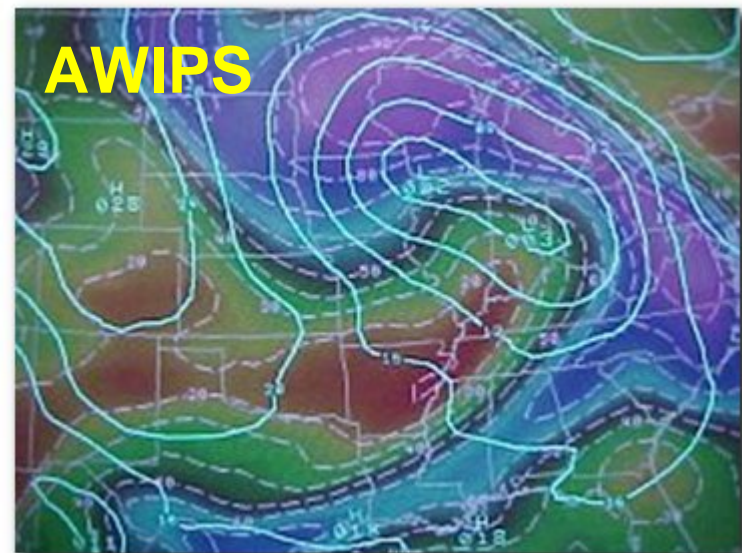


AWIPS

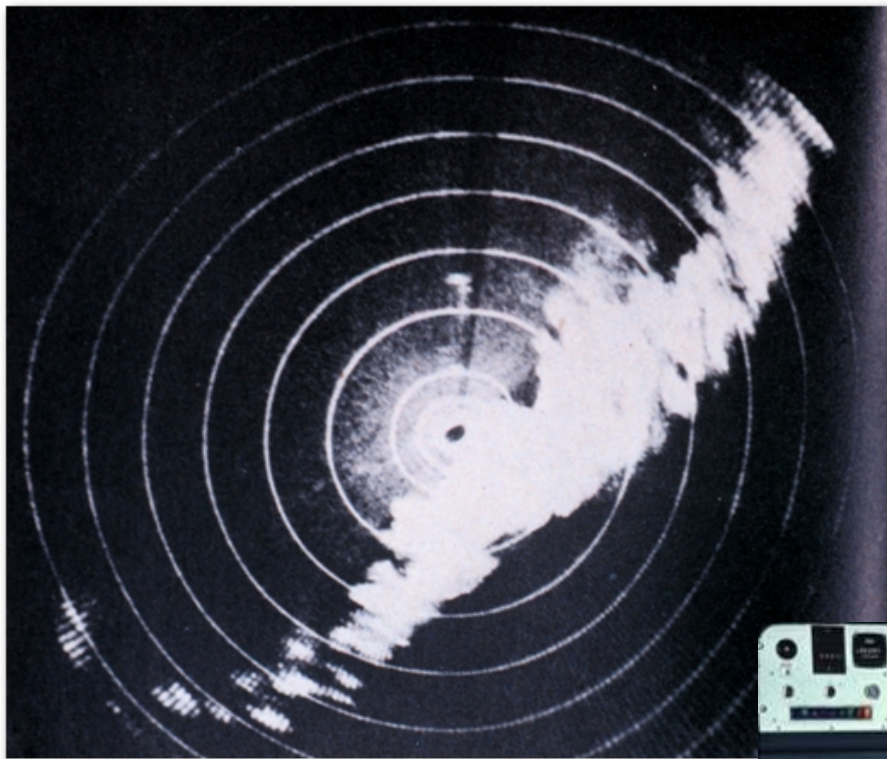
Advanced
Weather
Interactive
Processing
System



- Proprietary Hardware (Ford Aerospace)
- Proprietary OS (Data General) w/dumb terminal interface
- Crude B&W graphics
- Cumbersome user interface – ex. (0ai, 0ad)
- No satellite capability and limited radar (WSR-57)

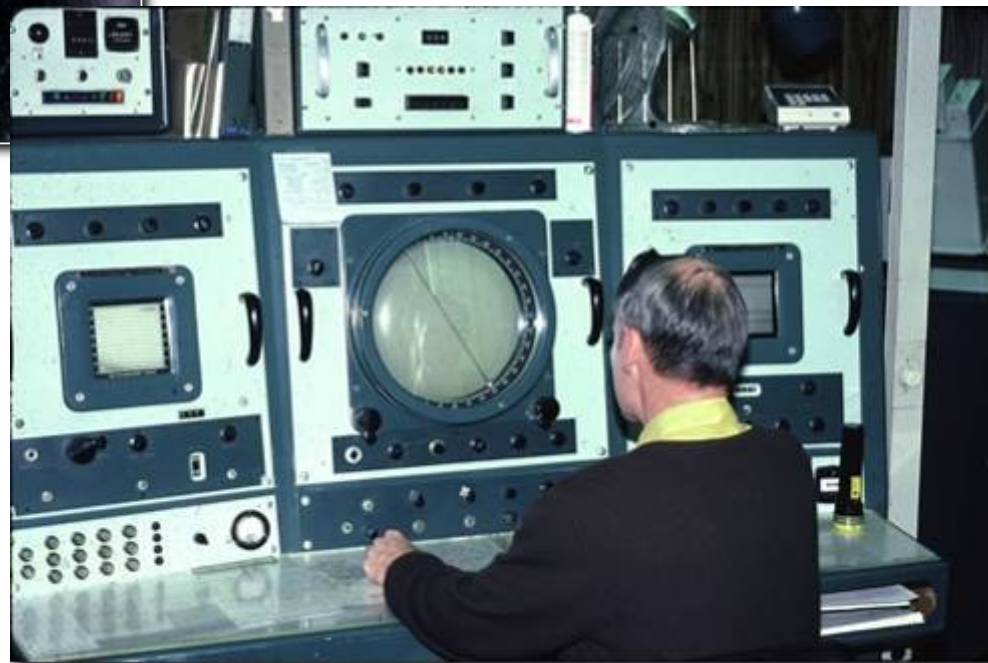


- Off the shelf hardware (HP, Dell, IBM)
- Unix/Linux OS - Informix/Postgres DB
- Color display of gridded fields
 - plan view
 - cross-sections
 - time-height
 - model soundings
- Windows-type interface with pull down menus
- Full satellite/NEXRAD radar capability



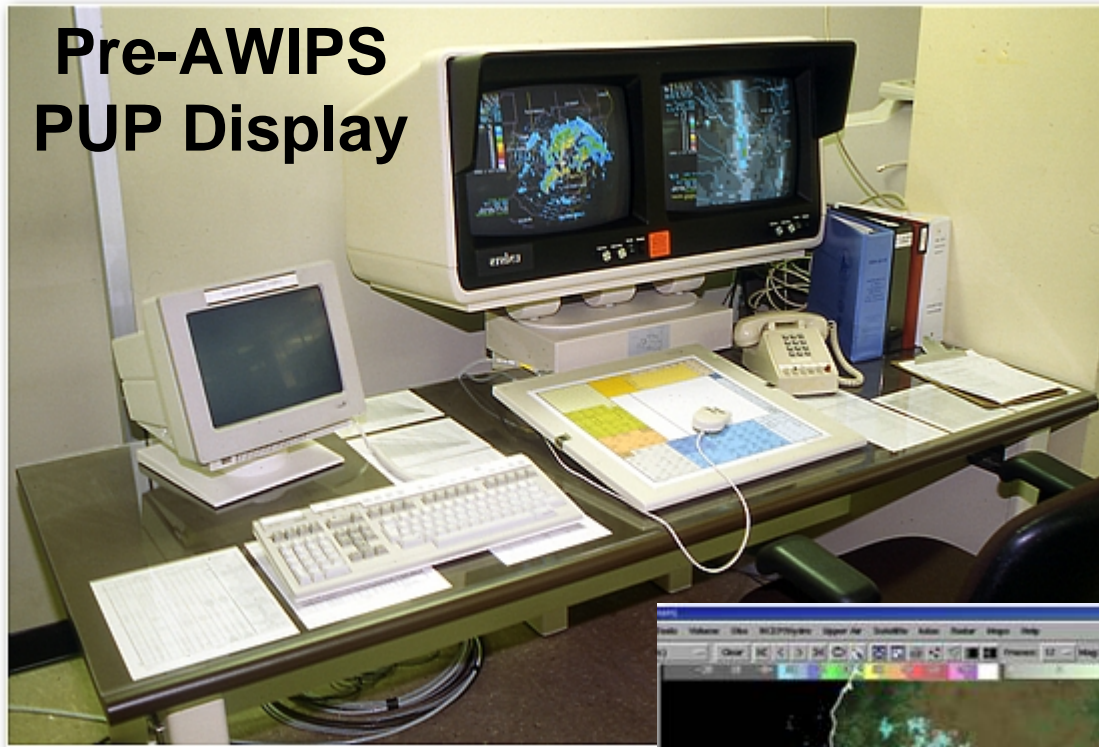
- early 60s to mid 90s!
- vacuum tube technology
- primitive graphics
- sparse coverage
- reflectivity only
- single elevation slice
- manual RHI (vertical)

WSR - 57



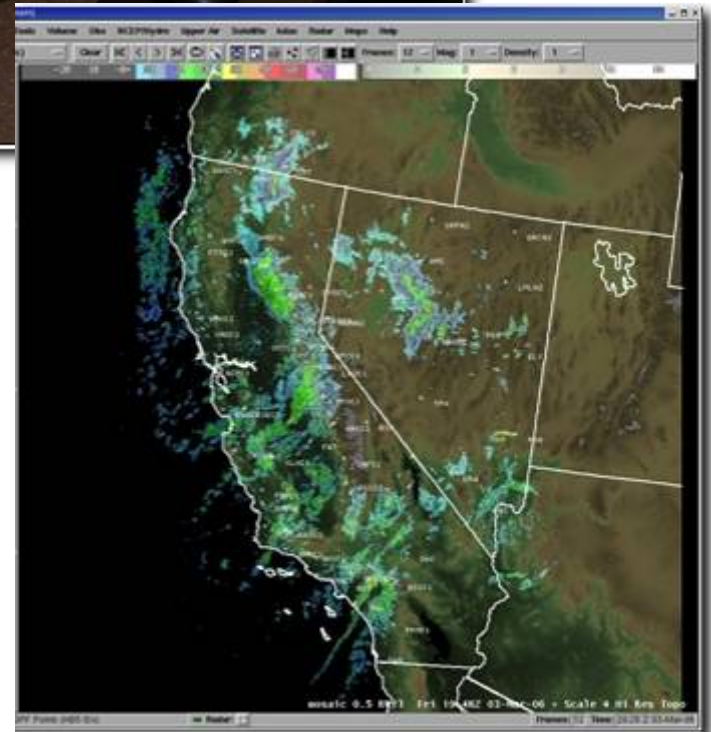


Pre-AWIPS PUP Display

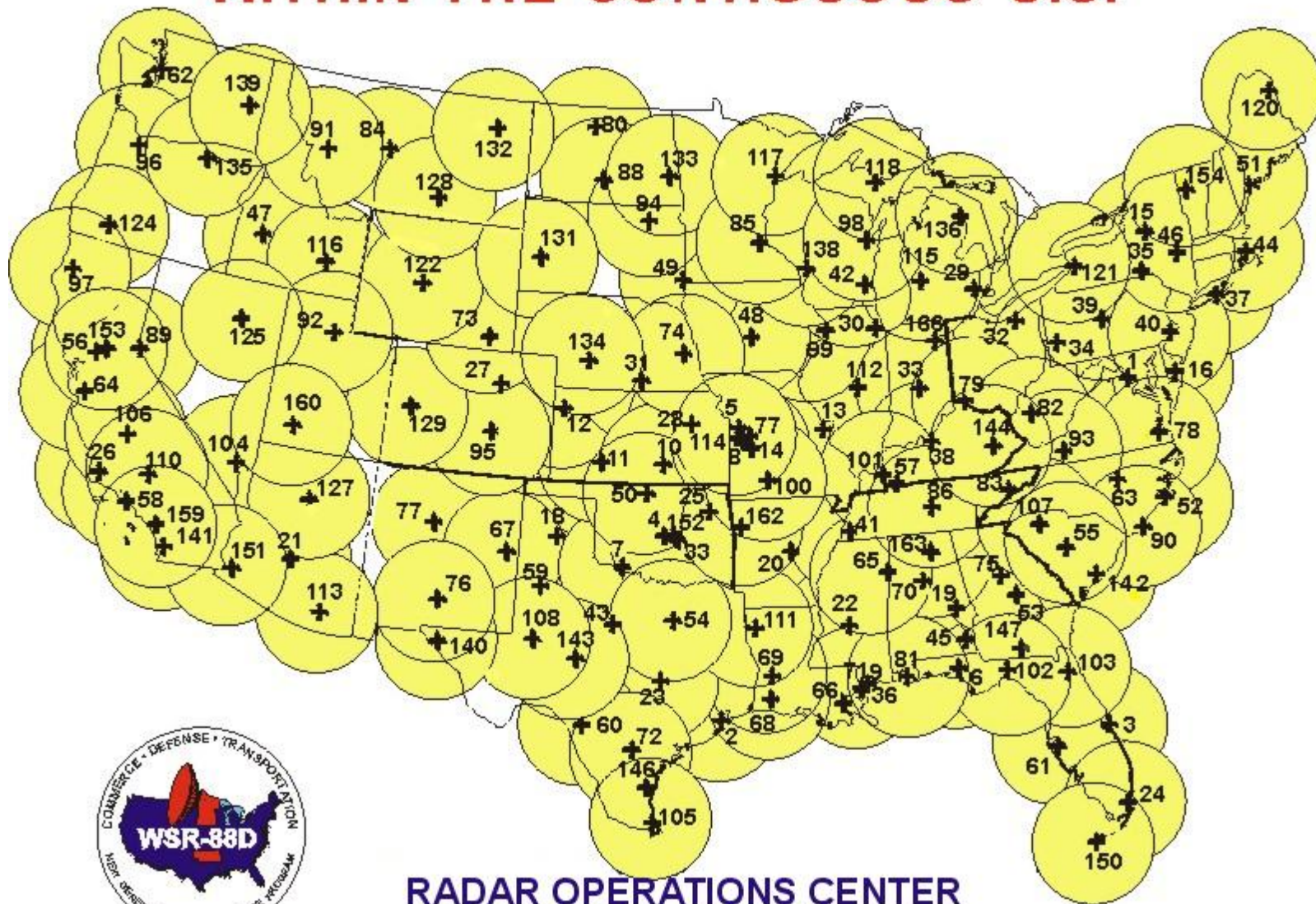


NEXRAD WSR-88D

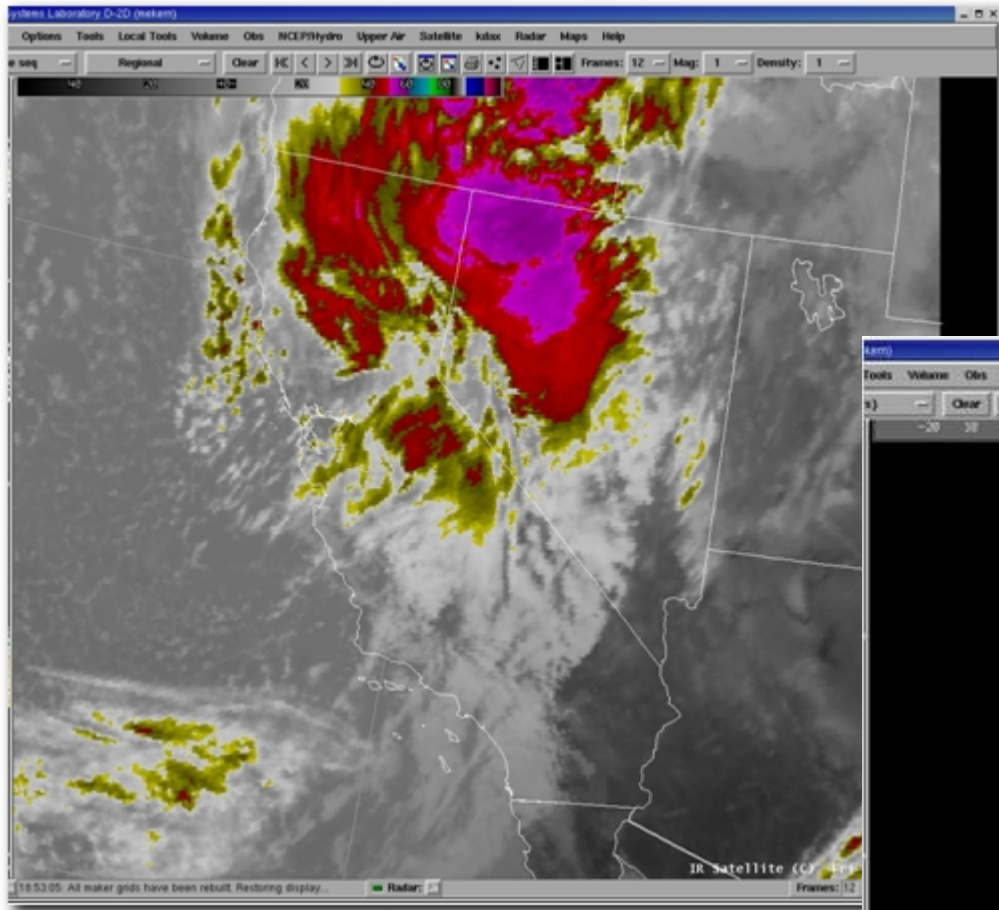
- Dense coverage (15:2)
- 3-D Scans every 4-10 min.
- Velocity Data
- Detection algorithms for hail, mesocyclones, tornadoes.
- Precipitation Estimation?



COMPLETED WSR-88D INSTALLATIONS WITHIN THE CONTIGUOUS U.S.

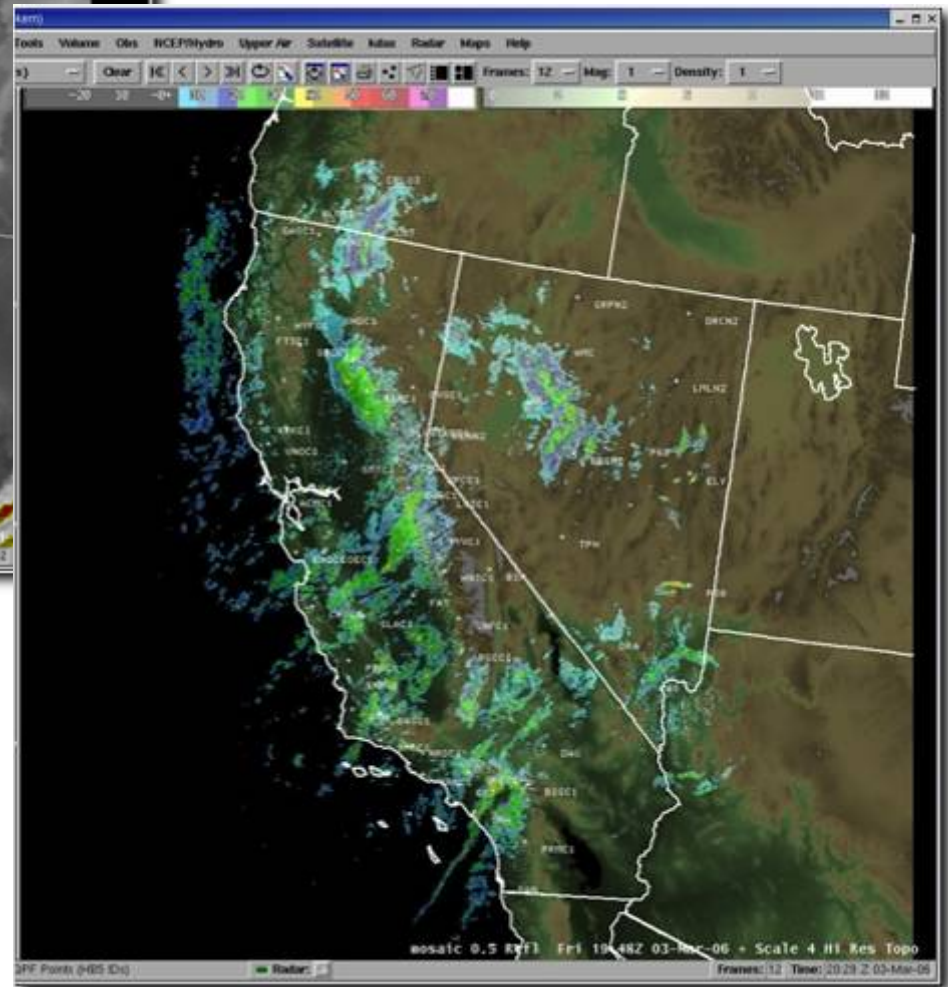


**RADAR OPERATIONS CENTER
NORMAN, OKLAHOMA**



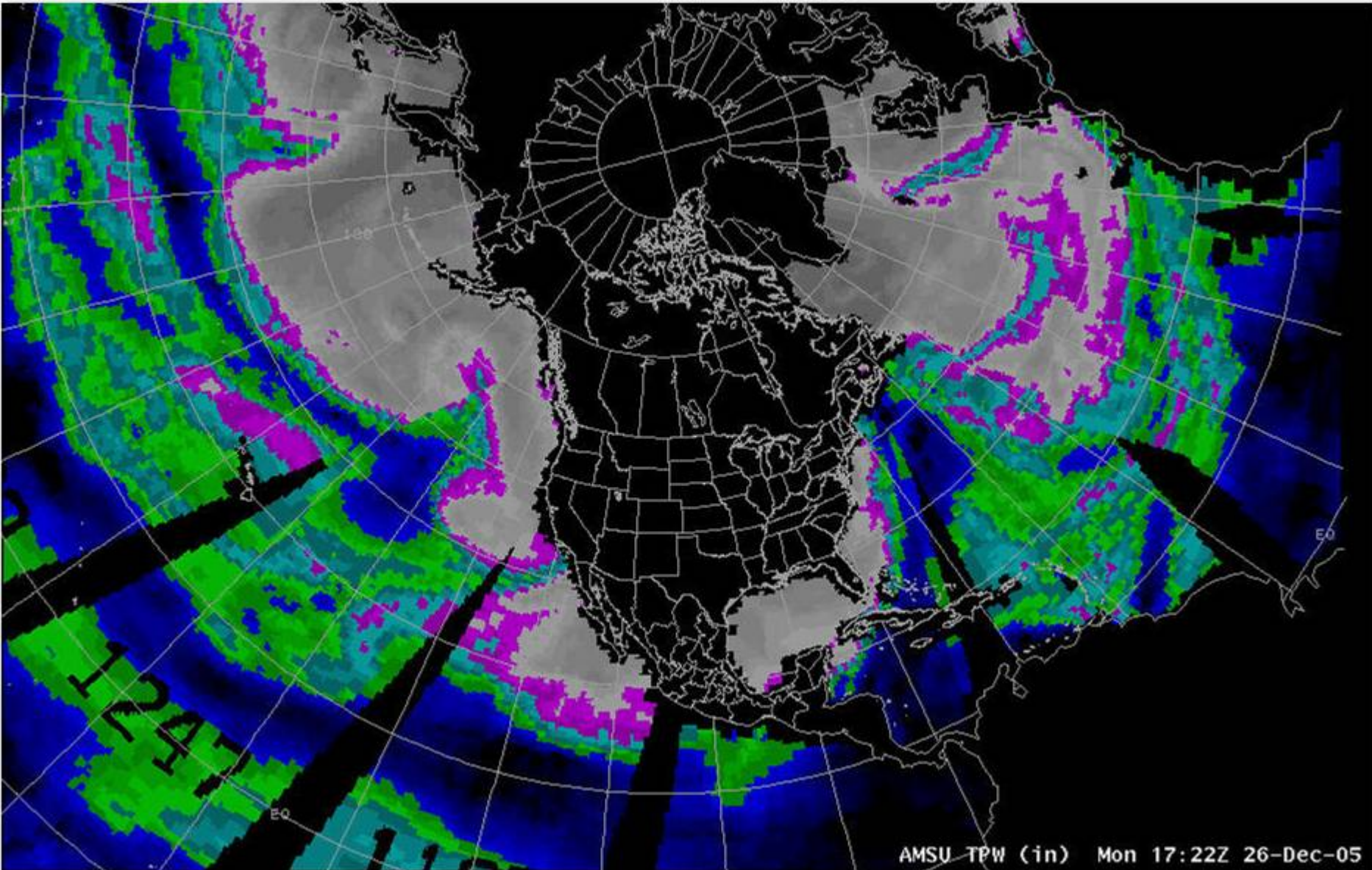
**Assessment:
Heavy Rain
in Nevada ???**

**NEXRAD as a
Qualitative Tool**



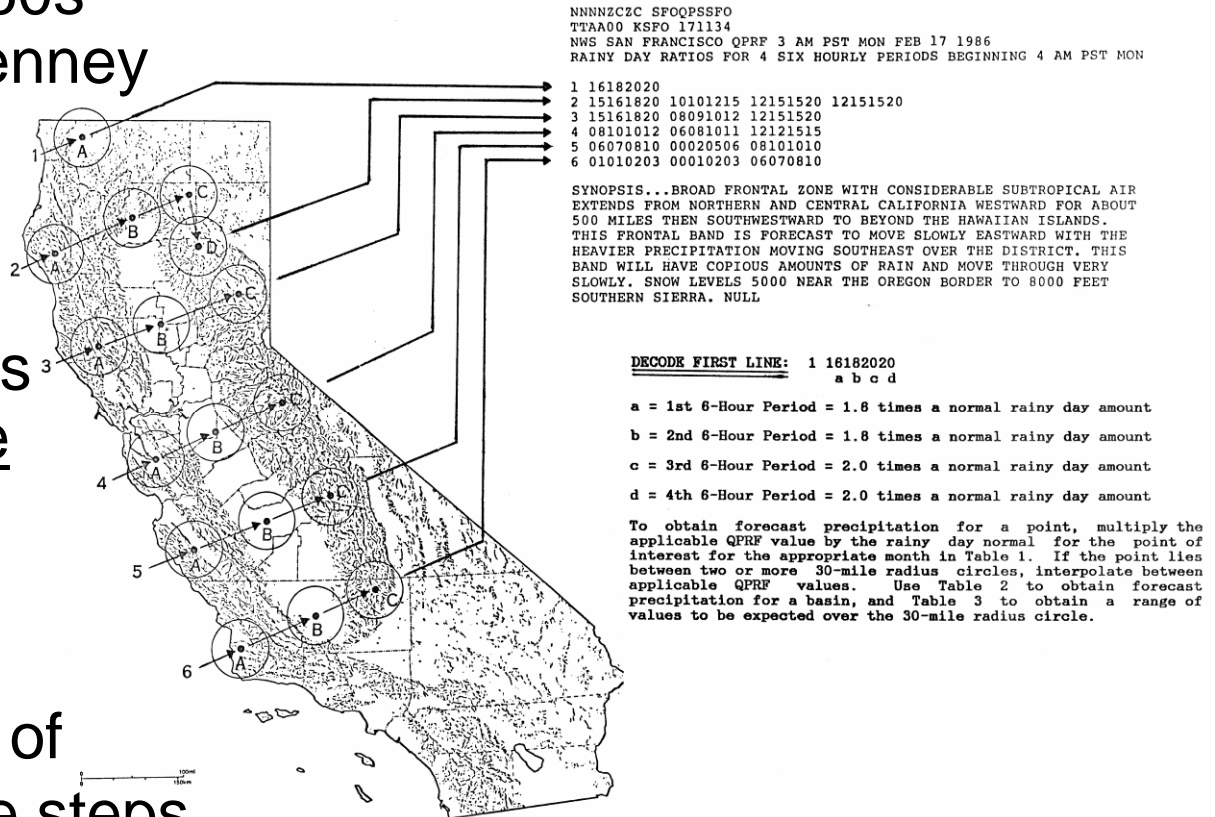
Total Precipitable Water

NOAA Polar Orbiting Satellite - Advanced Microwave Sounding Unit



Techniques – Rainy Day Ratios

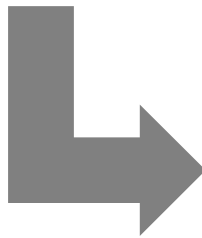
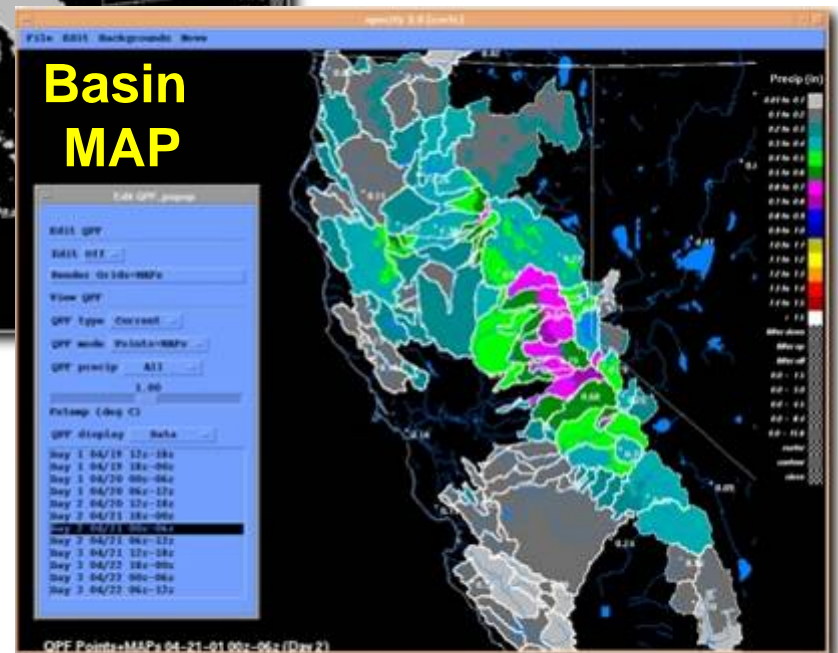
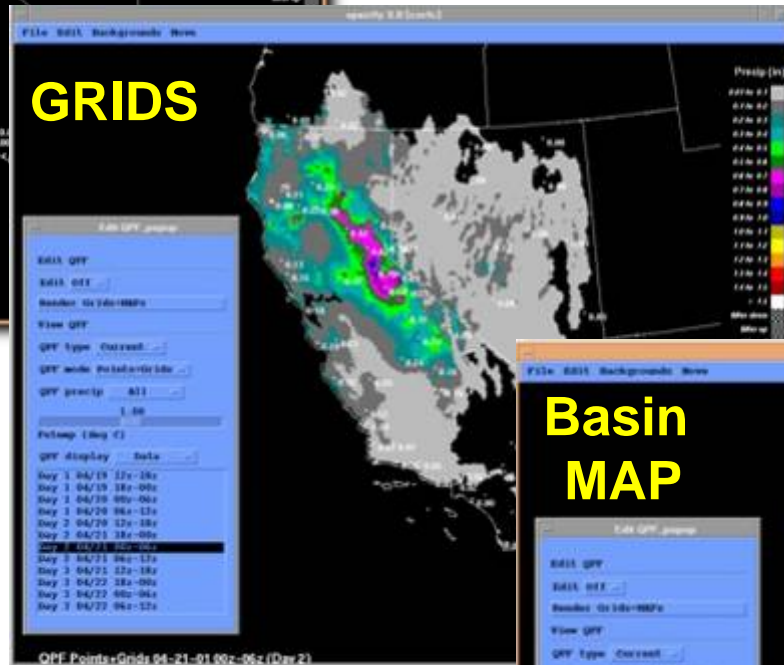
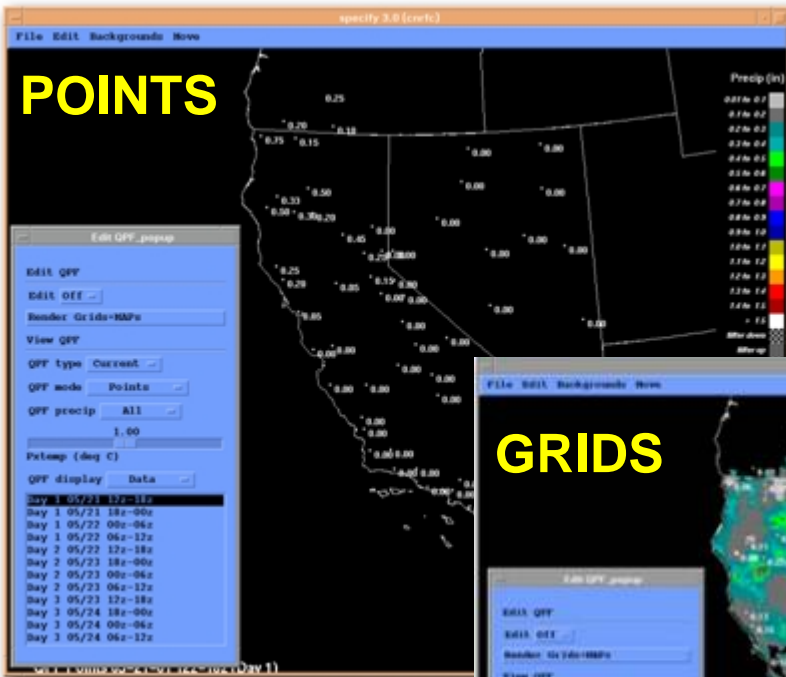
- developed in the '60s by Weaver and Denney at WSFO SFO
- used operationally until 1997
- allowed forecasters to make subjective forecasts quickly dealing with storm magnitude
- provided 24 hours of QPF in 6-hour time steps
- QPF at the CNRFC was performed on a basin-by-basin basis – fewer basins and limited reservoir inflow forecasts



Techniques – Mountain Mapper

- Concept and software developed at the CBRFC in Salt Lake City and implemented at the CNRFC in 1997 (after the 96-97 floods)
- Calculates a 4-km QPF grid over the entire CNRFC area from fixed point QPF input using a PRISM normal distribution and inverse-distance-squared weighting
- **72 Hours** of QPF in 6-hour time steps for ~200 basins
- Days 4 & 5 use MM output from Rhea Orographic Aid
- Originally implemented at the Weather Forecast Offices with the data mosaiked by the CNRFC HAS
- In year 2000, QPF responsibility shifted from WFOs to HPC with local modifications performed by HAS.

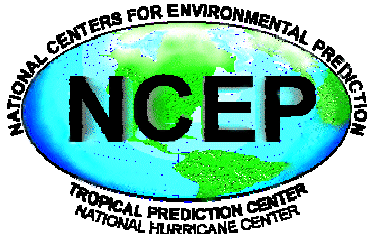
Mountain Mapper



Training

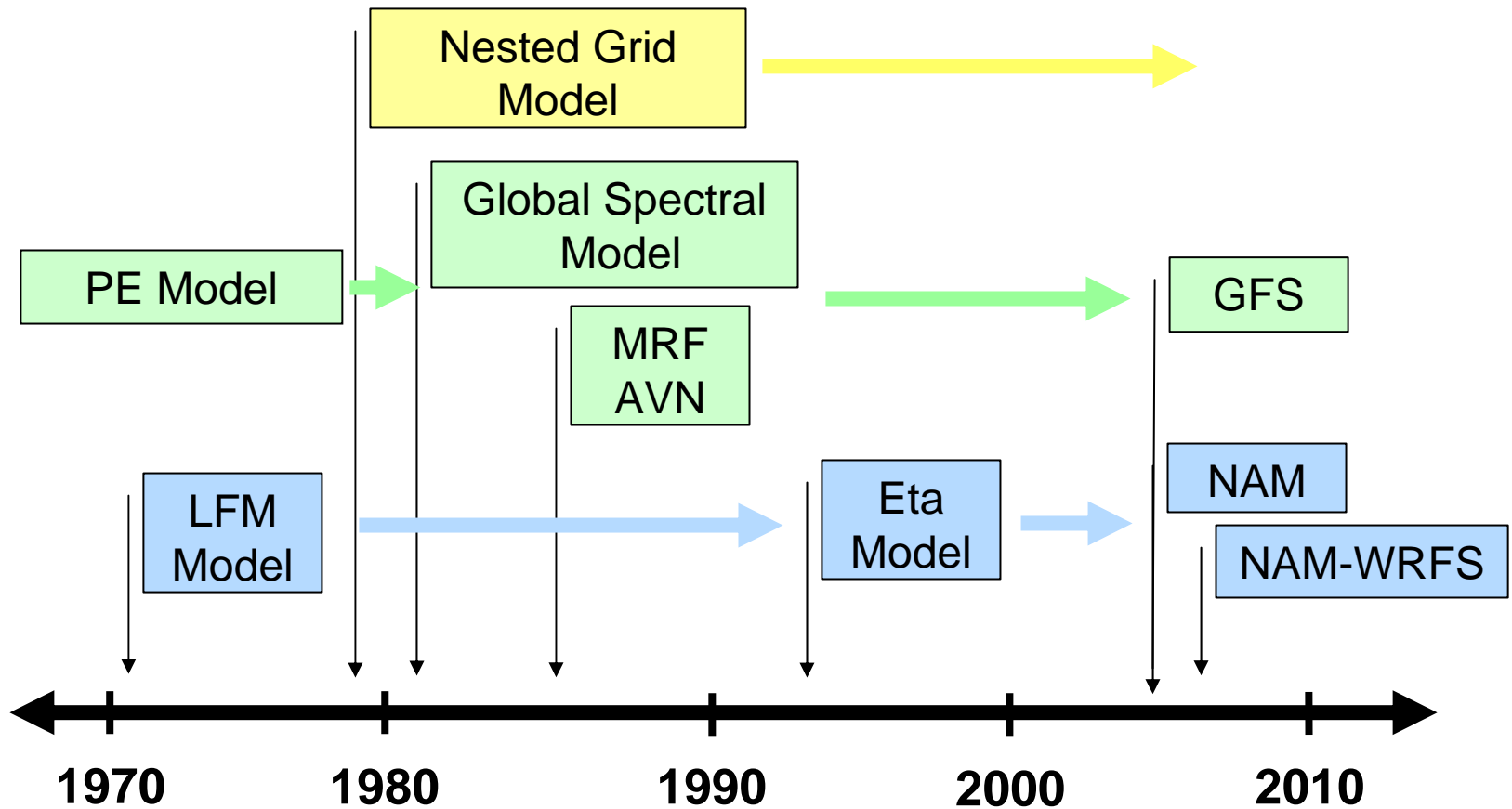
Internet has revolutionized training

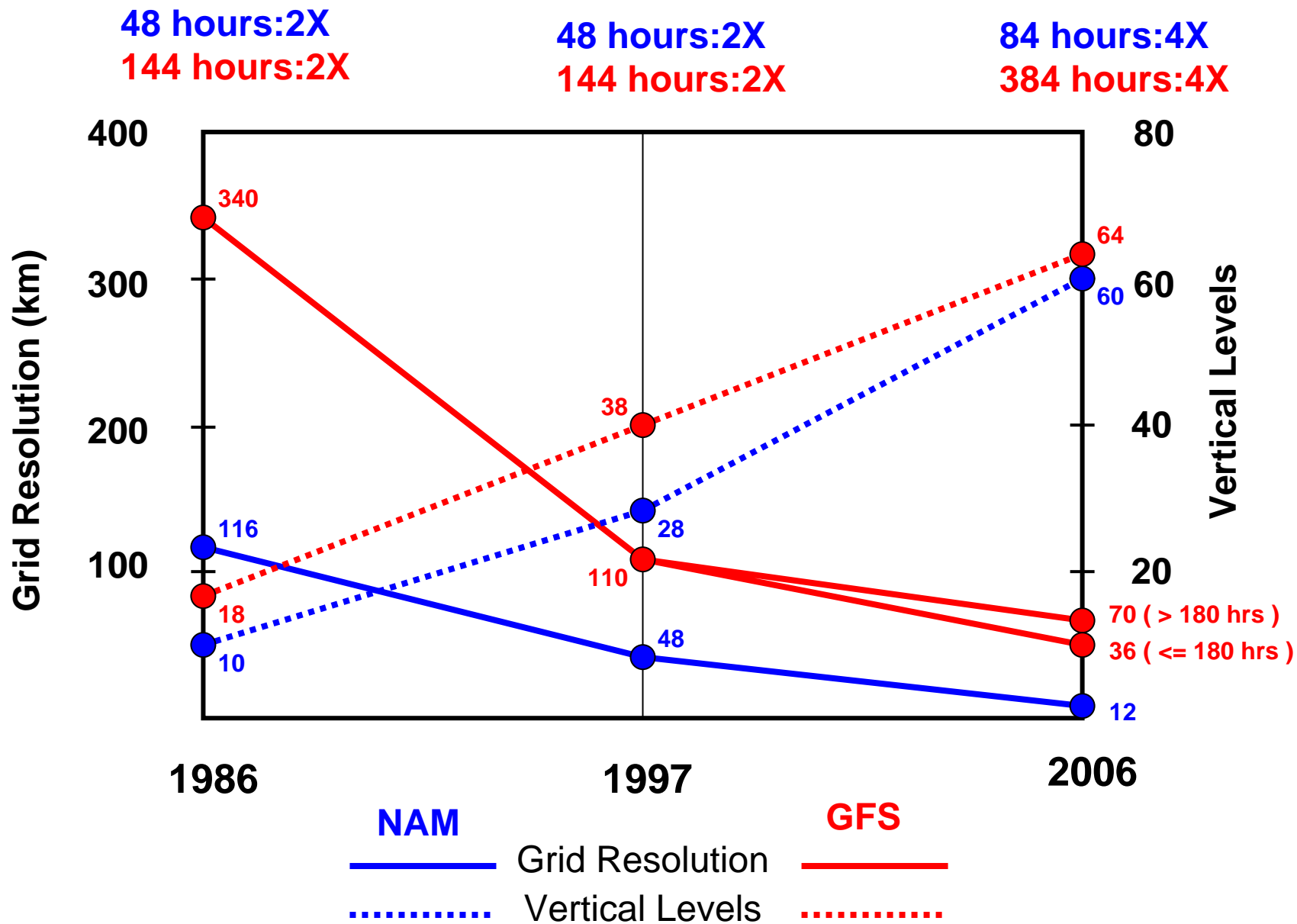
- sharing of data and research
- web video/audio capabilities have made remote training modules made possible
- more cost effective
- accessible to everyone



Numerical Weather Prediction

A History of the Models





Numerical Weather Prediction

- NCEP Models
 - NAM
 - RUC
 - GFS
 - DGEX
 - Ensembles
 - Long range
 - Short range
- Military
 - NOGAPS
 - COAMPS
- European Models
 - UKMET
 - ECMWF
- Canadian
 - GEM (regional)
 - GSM (global)

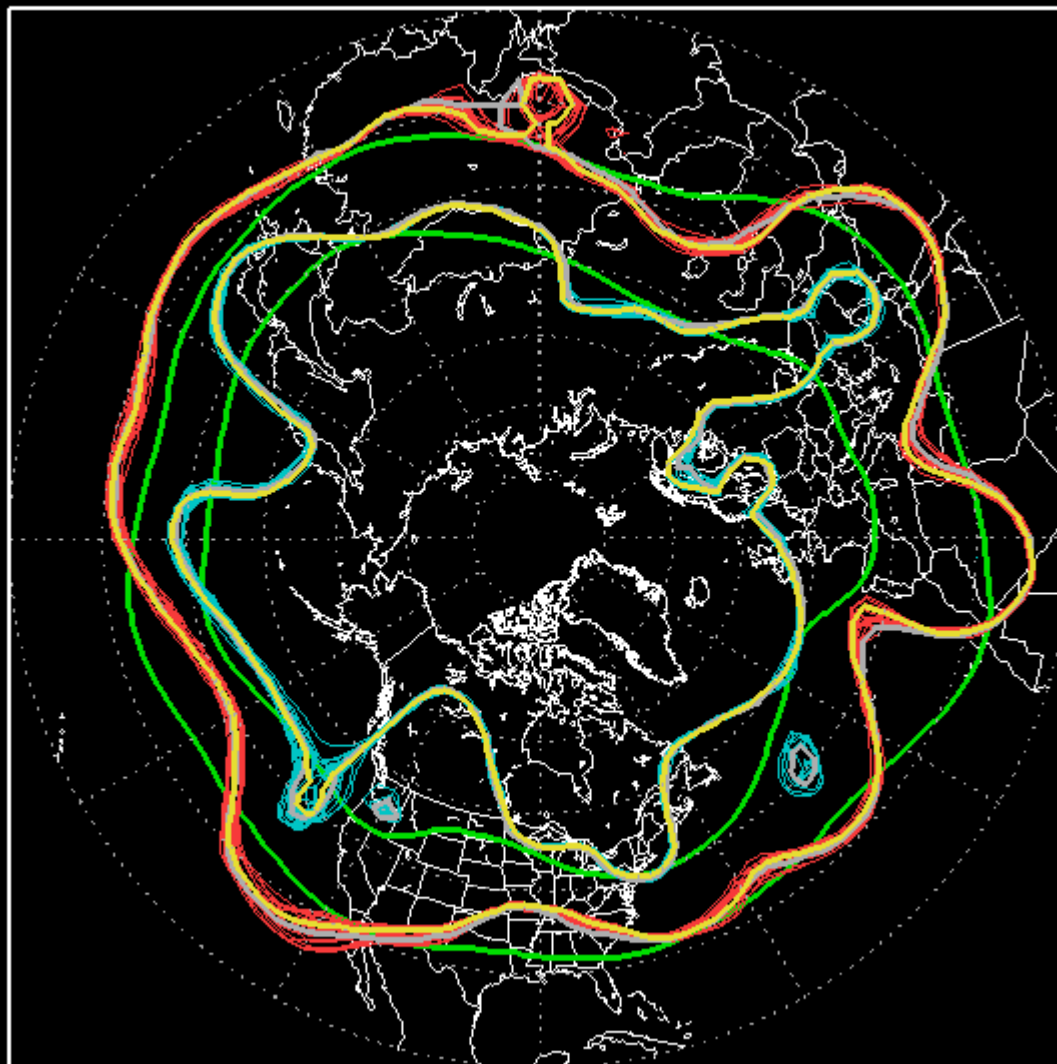
Ensemble Forecasts

- a set of forecasts run changing the initial conditions (assumed to be within the range of analysis error) and/or changing model parameters
- **Consensus Forecasting** - The mean on average should have higher skill than any individual member.
- **Ensemble spread is often inversely proportional to skill.**
- **Help quantify forecast uncertainty**

NCEP ENSEMBLE 500mb Z

000H Forecast from: 00Z Tue APR,25 2006

Valid time: 00Z Tue APR,25 2006



00z Runs:(12)

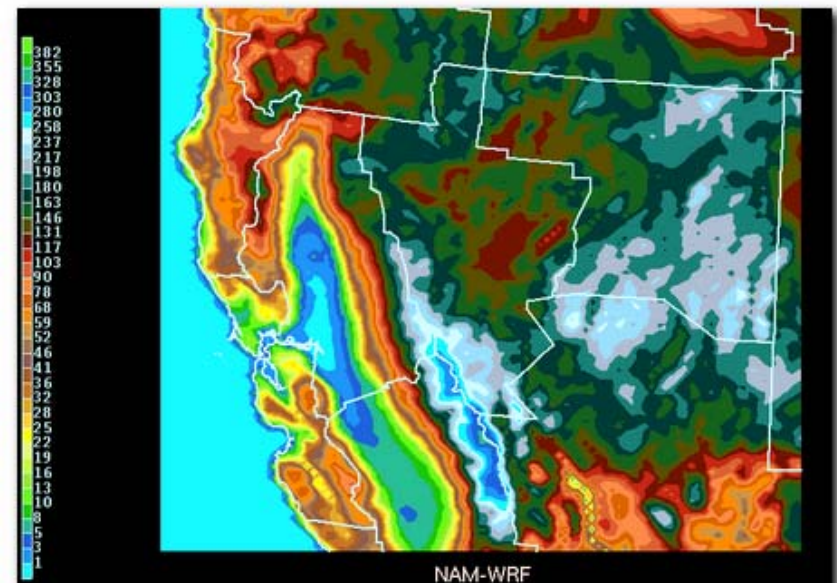
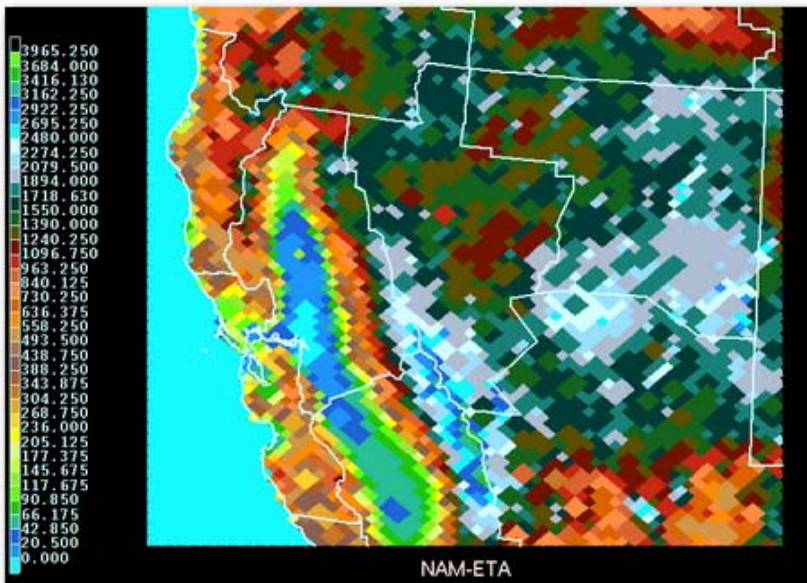
12z Runs:(11)

— 5580m — 5760m — Cntrl 00z — Cntrl 12z — CLIM

NAM-WRF

(North American Mesoscale – Weather Research & Forecasting Model)

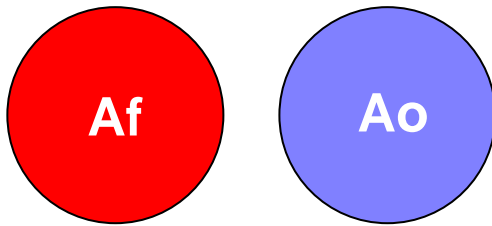
- NWS operational model as of June 20, 2006
- Community research model
- Many partners, NCAR, NCEP, FAA, NSF, Navy (NRL), ESRL/GSD(FSL), U of OK



Skill: Threat Score

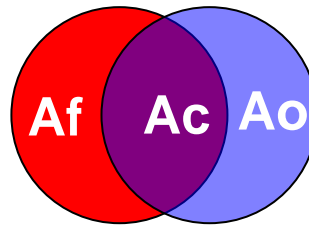
Af = area forecast
Ao = area observed
Ac = area correct

$$TS = Ac / (Af + Ao - Ac)$$



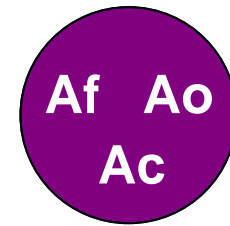
Af = Ao, Ac = 0
Threat Score = 0

**What were
you thinking???**



Af = Ao, Ac = 1/2 Af
Threat Score = 0.33

**Not bad,
Pretty good**

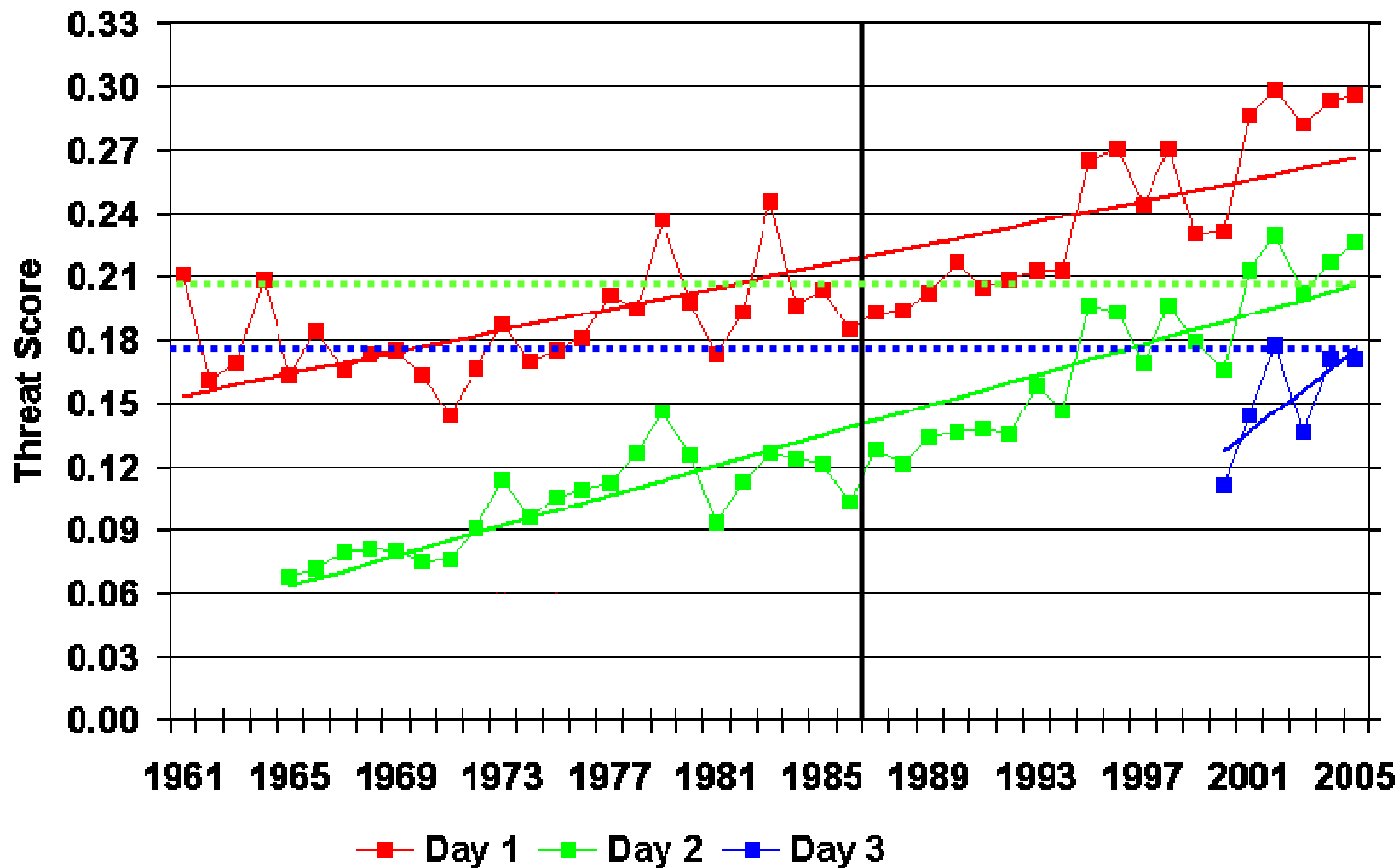


Af = Ao = Ac
Threat Score = 1

**You're the next
American Idol!**

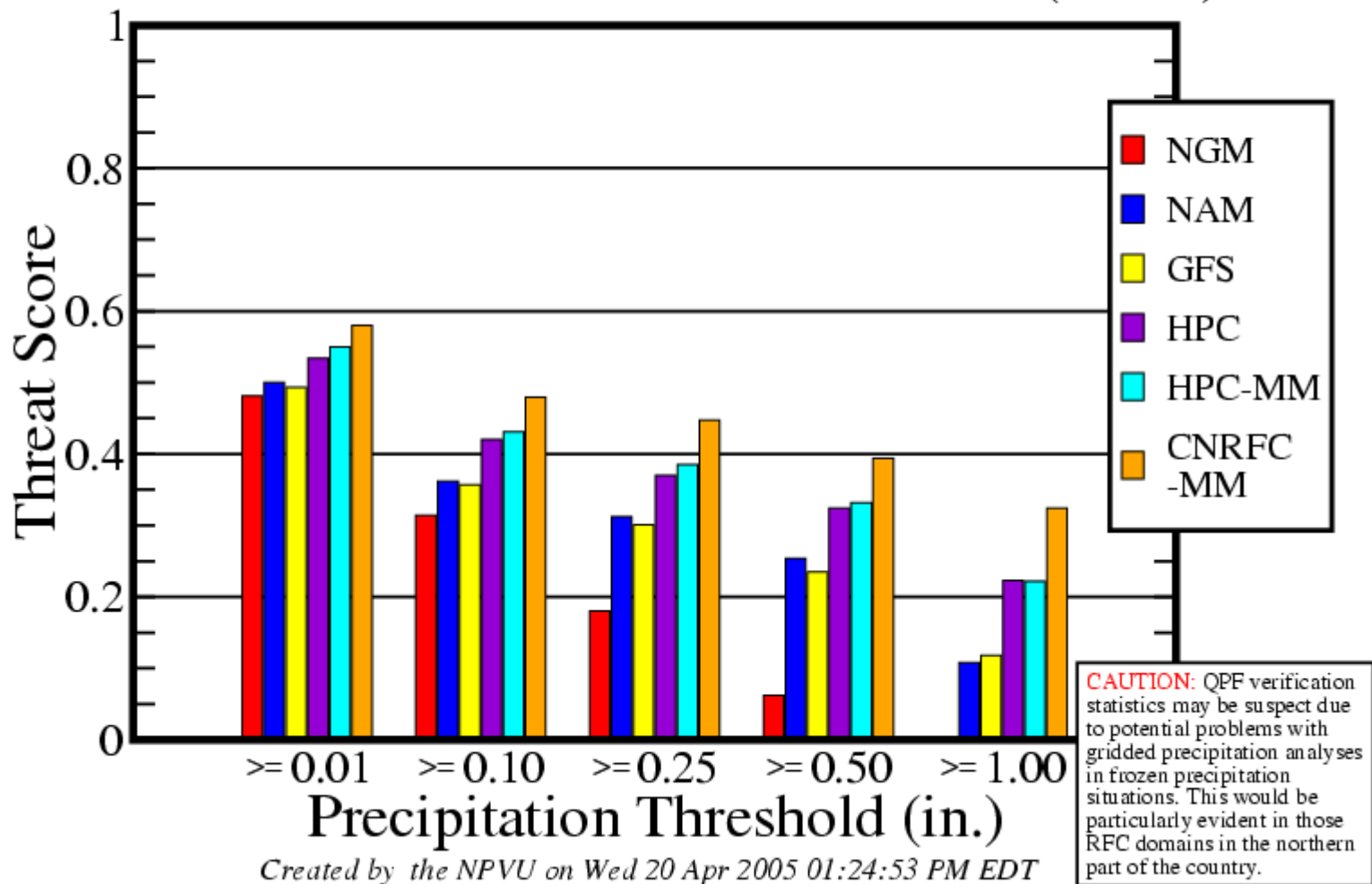
Annual HPC Threat Scores: 1.00 Inch

Day 1 / Day 2 / Day 3



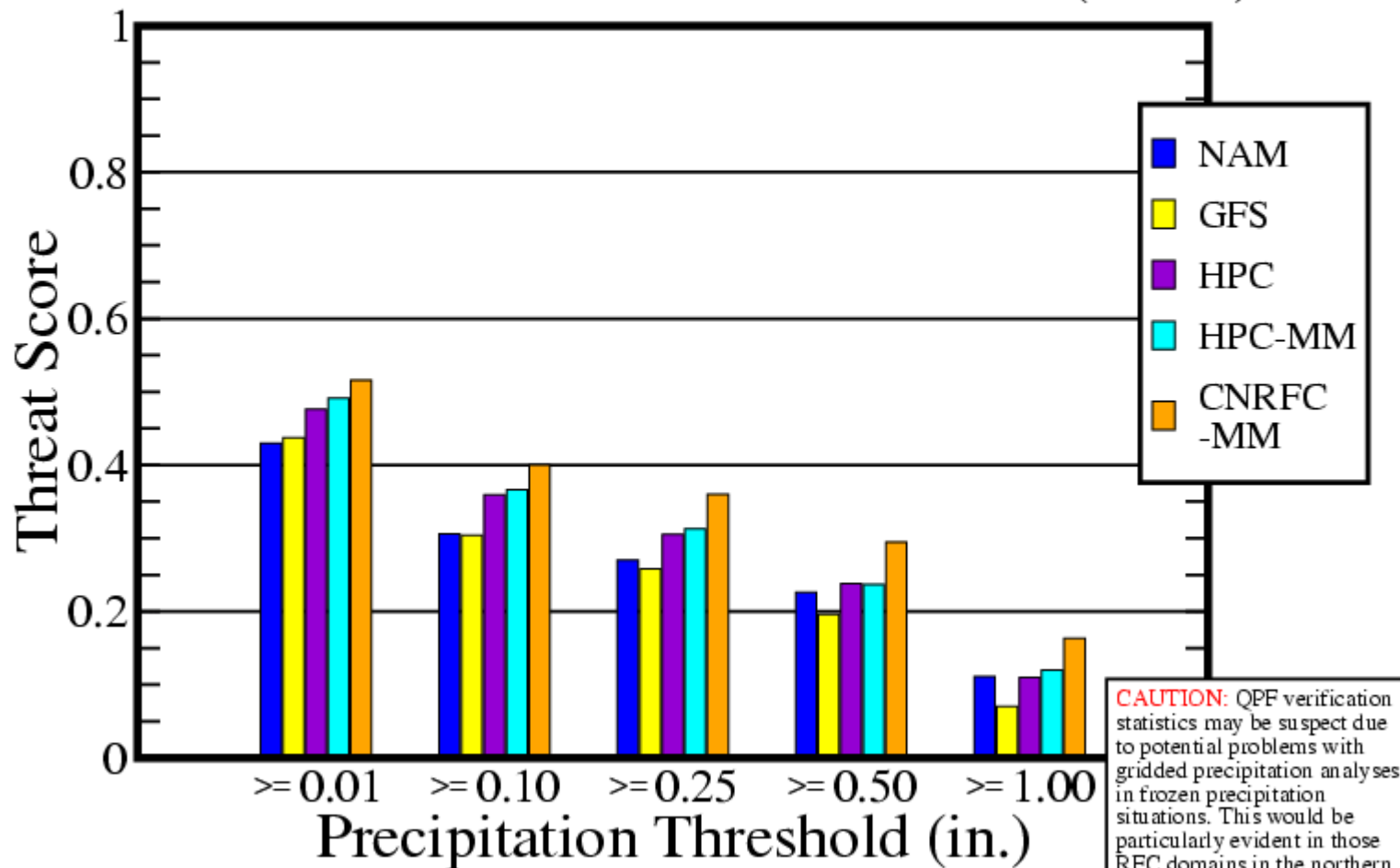
California Nevada - TS

Oct2004-Mar2005 DAY1 06H GRD(32km)



California Nevada - TS

Oct2004-Mar2005 DAY2 06H GRD(32km)

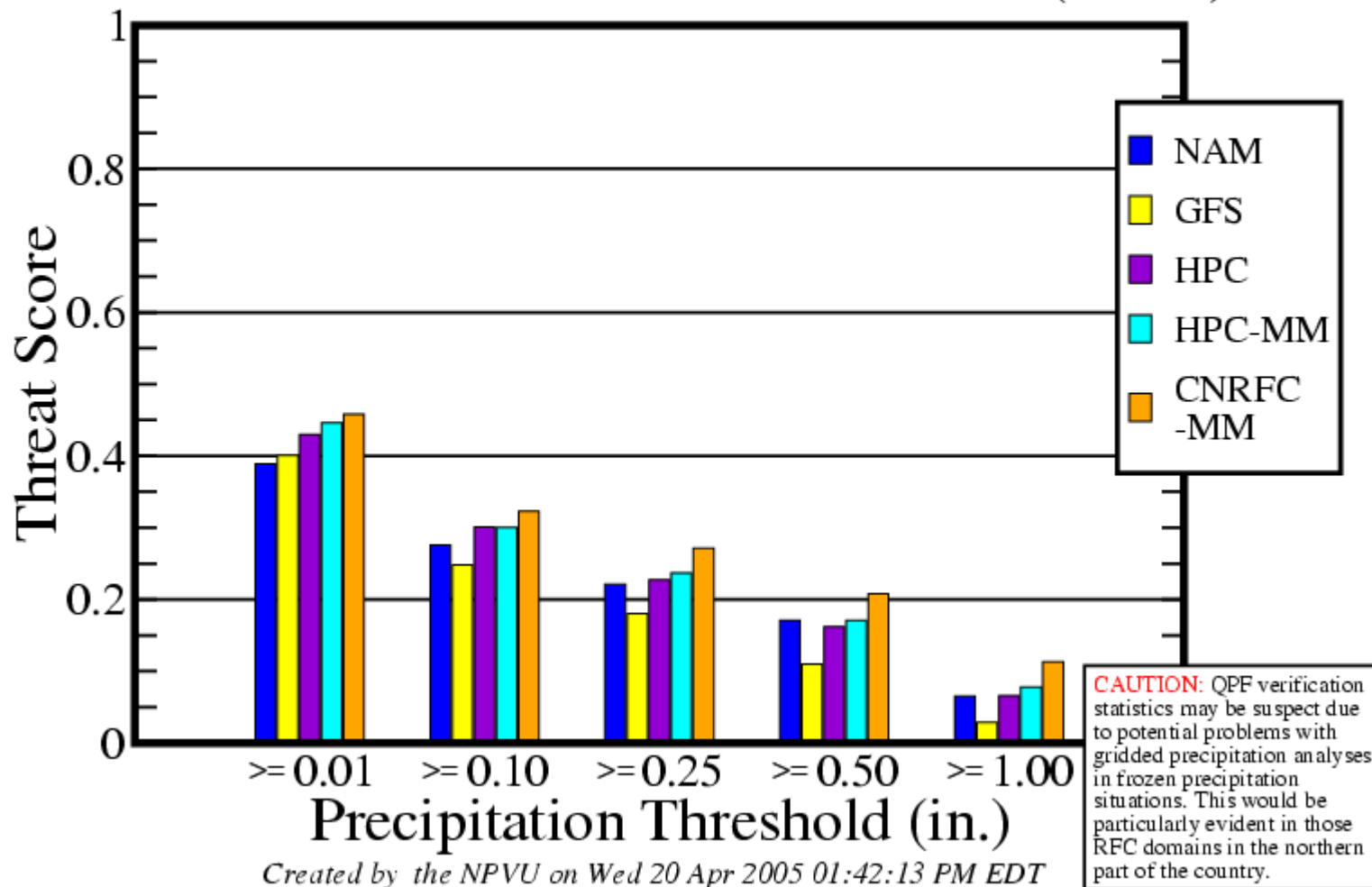


CAUTION: QPF verification statistics may be suspect due to potential problems with gridded precipitation analyses in frozen precipitation situations. This would be particularly evident in those RFC domains in the northern part of the country.

Created by the NPVU on Wed 20 Apr 2005 01:37:42 PM EDT

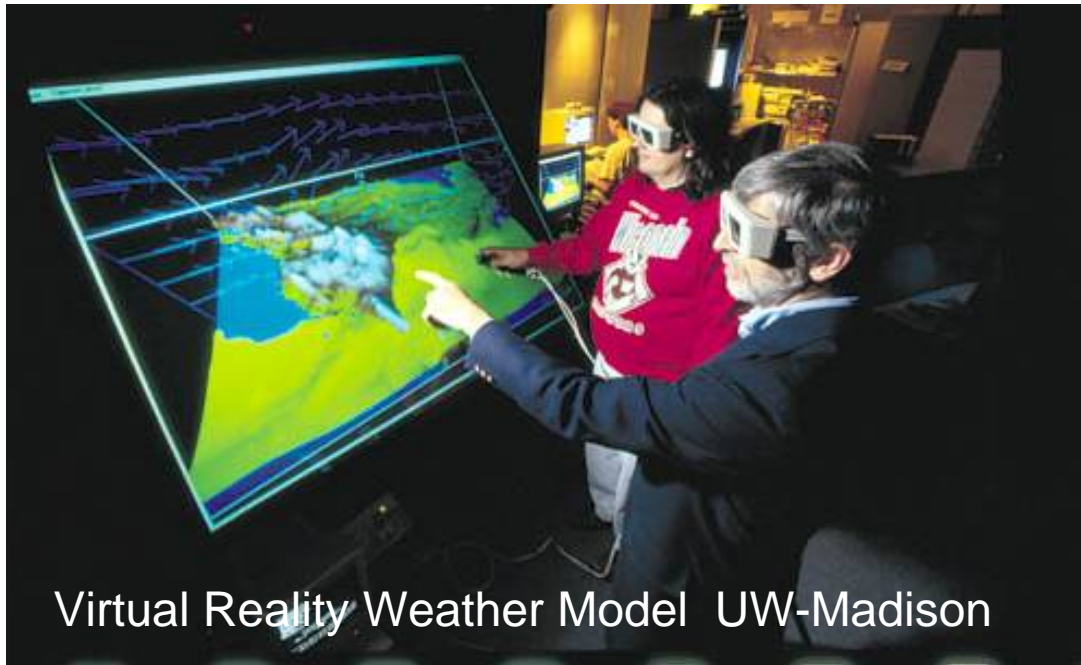
California Nevada - TS

Oct2004-Mar2005 DAY3 06H GRD(32km)



Precipitation Forecasting in the Future

- Improved Numerical Weather Prediction Models
- Improved understanding of atmospheric processes
- Improved remote sensing and data collection and analysis
- Improved display of data and grid-editing tools



Virtual Reality Weather Model UW-Madison

What is the future role of human forecaster as technologies progress?



- Forecasters should focus their efforts in the 0-12 hour range (Dr. Clifford Mass, U.Wash. – IFPS and the future of the NWS, *Weather Forecasting*)
- Maintain skills through continuous training and building upon local experience.