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# NOAA Climate Program

*"The urgent always crowds out the important."  
Madeline Albright*

**Chet Koblinsky**  
Climate Program Director  
NWS Corporate Board  
June 30, 2004



# Overview





# Background

## Important 21st Century Issues

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### Altered Biogeochemical Cycles

- Humans have appropriated about 50% of the Earth's primary productivity
- We have doubled the global cycling of nitrogen and impacted the carbon cycle
- The NAS concludes that nitrogen pollution is the most serious coastal pollution issue
- Global warming and the human impacts on biodiversity (the risk of a mass extinction) might be our outstanding legacy for the 20<sup>th</sup> and 21<sup>st</sup> centuries – only history will tell!



# Background

## Important 21st Century Issues

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### Population Growth and Associated Issues

- 9 billion (B) people by 2050 (50% increase)
- Increasing urbanization into mega-cities – 4B new city dwellers – aging populations
- Food availability requires sustainable increases in food output/hectare of 200-300%
- Energy security
- Others
  - Water availability
  - health threats – pollution, others

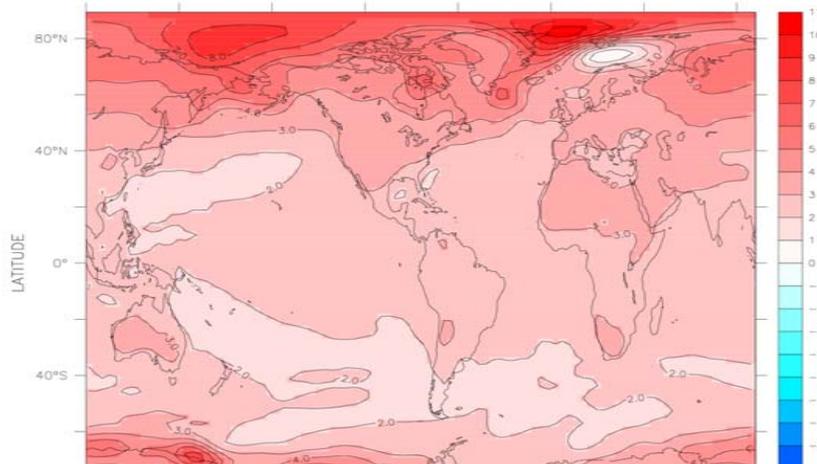


# Background

## Important 21st Century Issues



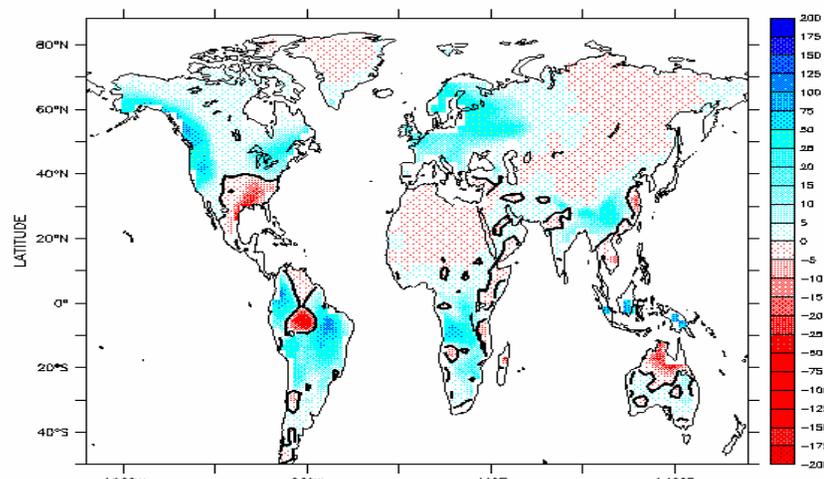
### Annual Surface Air Temperature (deg C)



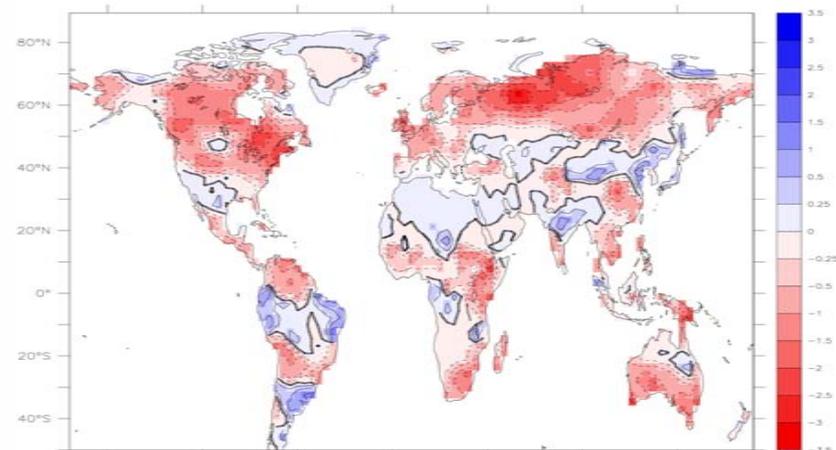
These changes will present new opportunities and threats

Conditions at double pre-industrial values of CO<sub>2</sub>:  
GFDL model

### Winter runoff (cm/yr)



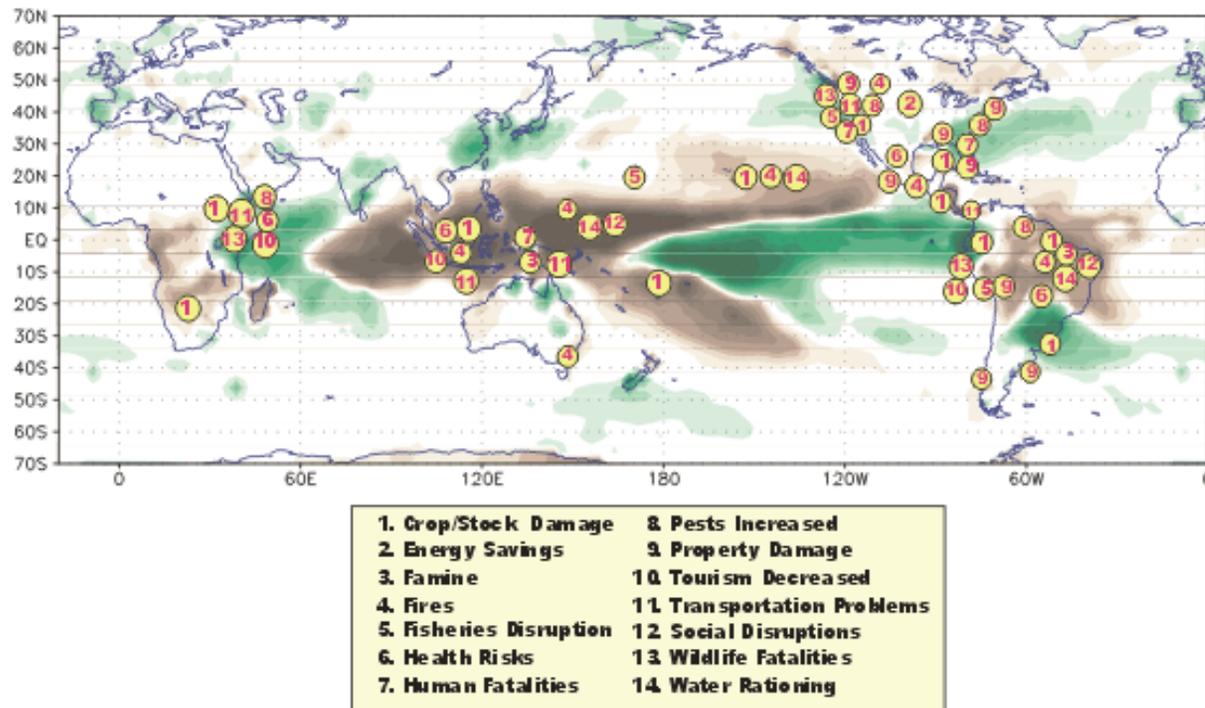
### Summer Soil Moisture (cm)



# Globalization and Climate

- risks and opportunities are globally correlated
- U.S. security, economic competitiveness and policy are impacted and interrelated
- who will make the global forecasts for the U.S.?

## Societal Impacts from 1997/98 El Niño





# Background Climate Impacts



- **Climate Variability (El Nino, Seasonal Variations, etc)** continues to have major impacts on Nation
  - *Cause \$11B in damage per year – 523 Casualties*
- **Drought is a growing national concerns**
  - *\$6B-\$8B in losses per year*
- **Coastal erosion due to sea-level rise** will claim roughly 1,500 homes in the United States each year for several decades, at a cost to property owners of US\$530 million year.
  - *Increased storm damage due to sea-level rise increases the direct damages from erosion of the shoreline by 5%*
- **Changes in fish stocks resulting from climate change** will include poleward shifts in distributions of some marine populations, and shifts in the distribution of commercially important species (e.g. several species of Pacific salmon will have decreased distribution and productivity)
- **The projected number of people in water-stressed countries** that will experience an increase in *water scarcity* due to climate change: 400 million (GFDL) - 750 million (CSIRO)



# Background Climate Goal



“Understand climate variability and change to enhance society’s ability to plan and respond”

## Draft Outcomes for Climate goal in 2004 Strategic Plan

- A scientifically and observationally based understanding about past, present and future states of the global climate system with quantified uncertainties sufficient for making informed and reasoned decisions
- A climate-literate public that recognizes the importance of a scientific basis for responding to climate change and variability
- Enhanced public and private sector use of climate information, including predictions and projections, in planning and decision-making



# NOAA Climate Program

## CCSP and NOAA goal structure



### Climate Change Science Program

- Improve knowledge of the Earth's past and present climate .... and improve understanding ... of observed variability and change
- Improve quantification of the forces...
- Reduce uncertainty in projections....
- Understand the sensitivity and adaptability of ... ecosystems ...
- ... manage risks and opportunities related to climate variability and change.

### NOAA Climate Goal Structure

- ➔ – *Observations and Analysis*
- ➔ – *Climate Forcing*
- ➔ – *Climate Predictions and Projections*
- ➔ – *Climate Impacts on Ecosystems*
- ➔ – *Regional Decision Support*



# NOAA Climate Program Budget

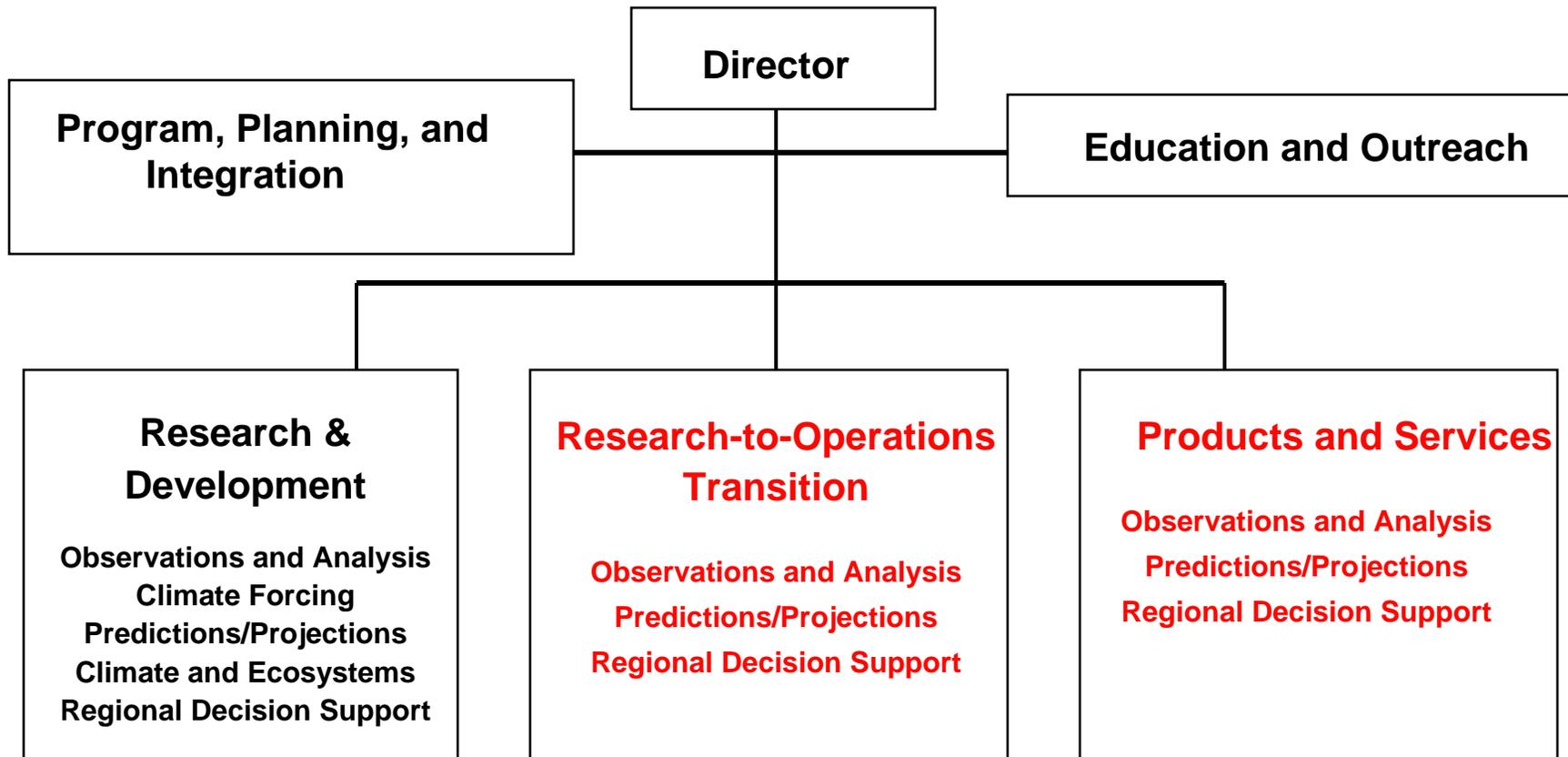


<u>Climate Program Element</u>	<u>(\$M - FY04)</u>	<u>Program Element Lead</u>
Observations and Analysis	(146.3)	Tom Karl/NESDIS
Climate Forcing	(35.5)	Dan Albritton/OAR
Predictions and Projections	(59.4)	Ants Leetmaa/OAR
Climate and Ecosystems	(1.5)	Ned Cyr/NMFS
Regional Decision Support	<u>(16.6)</u>	<b>Bob Livezey/NWS</b>
	259.3	

<u>Budget by Category (FY04)</u>		<u>Budget by Line Office (FY04)</u>	
Research	53%	OAR	69%
Development	14%	<b>NWS</b>	<b>6%</b>
Operations	33%	NESDIS	24%
		NOS	0%
		NMFS	1%



# Climate Program Office Organization



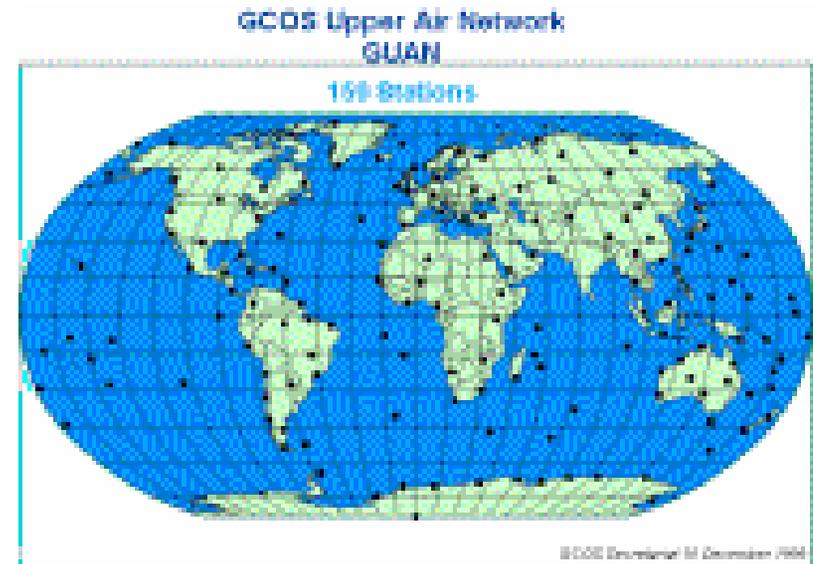
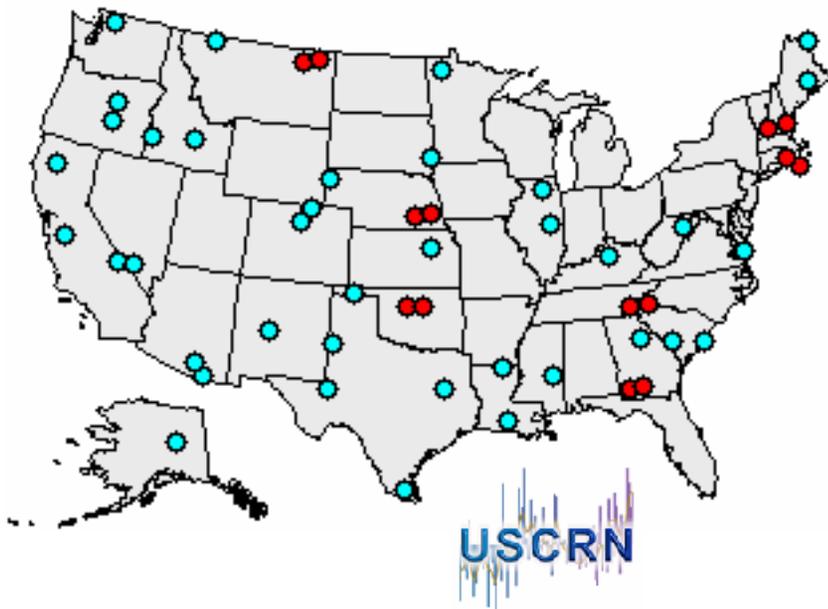


# NOAA Climate Program

## Atmospheric Observations

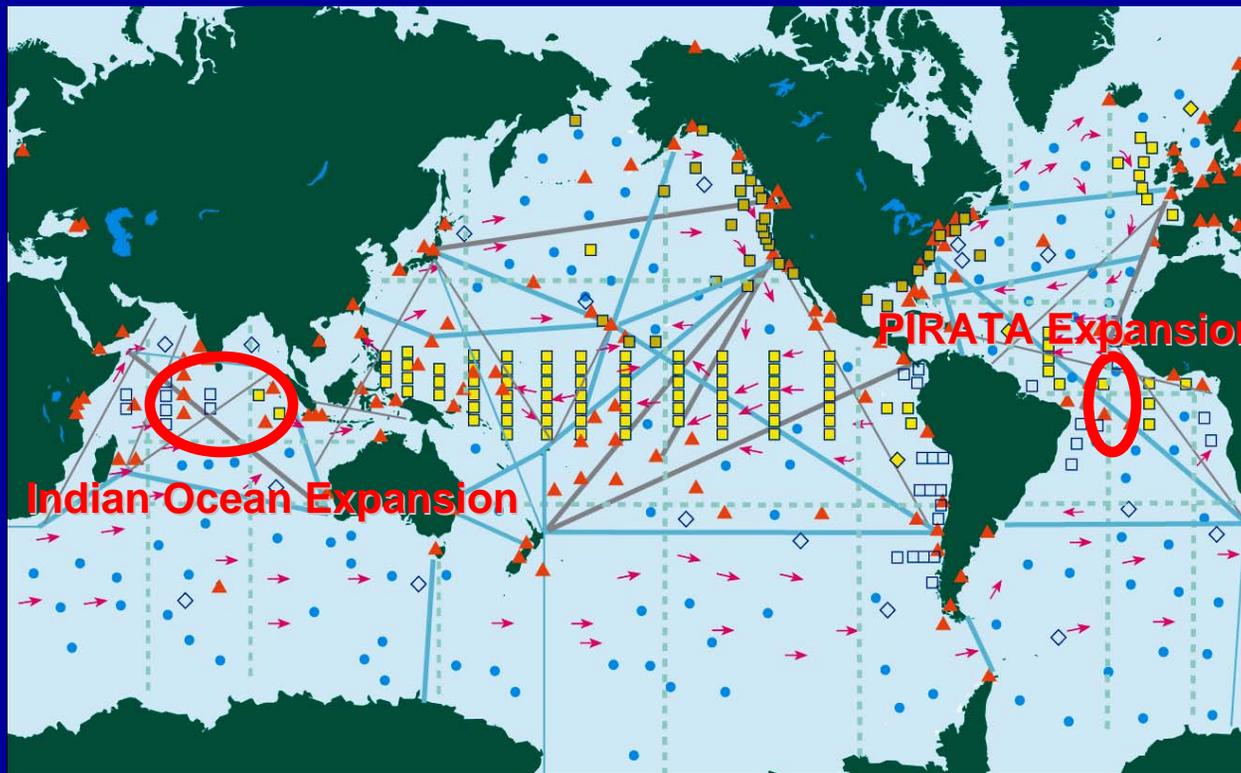


- Atmospheric observing networks
  - *Climate Reference Network (CRN), COOP, ASOS, GUAN, GSN, GWA*
  - ***Challenge: Integration***





# NOAA Climate Program Ocean Observations



• **Variables:** Sea Level, Circulation, Sea Surface Temperature, Fluxes, Heat Content, Carbon

• **Challenges:** Integration, Transition, Assimilation, User Orientation, Coastal regions



# Sea Level Rise

– an increasingly important threat to U.S coasts, eastern cities and low lying islands.

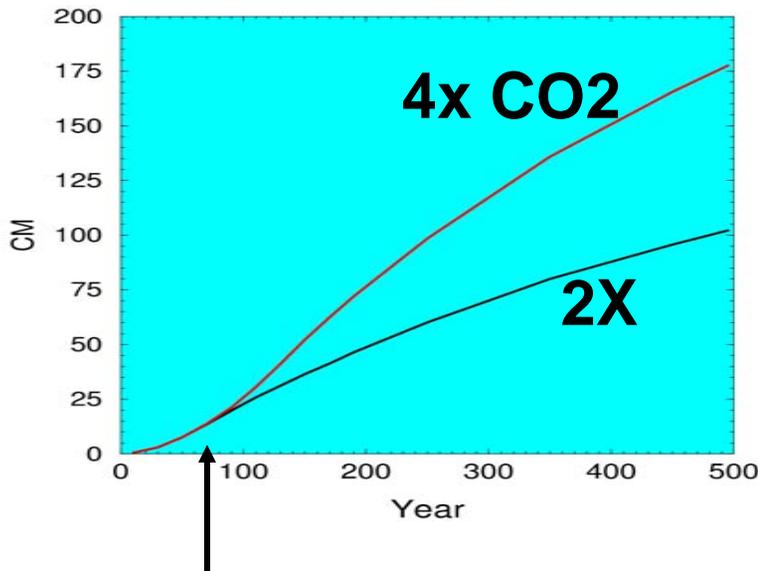
**Trends + variability + extreme events = flooding**



80 degrees, partly cloudy, winds calm

OR?

Levels expected to stay high for the next month



**Time of doubling of CO2**



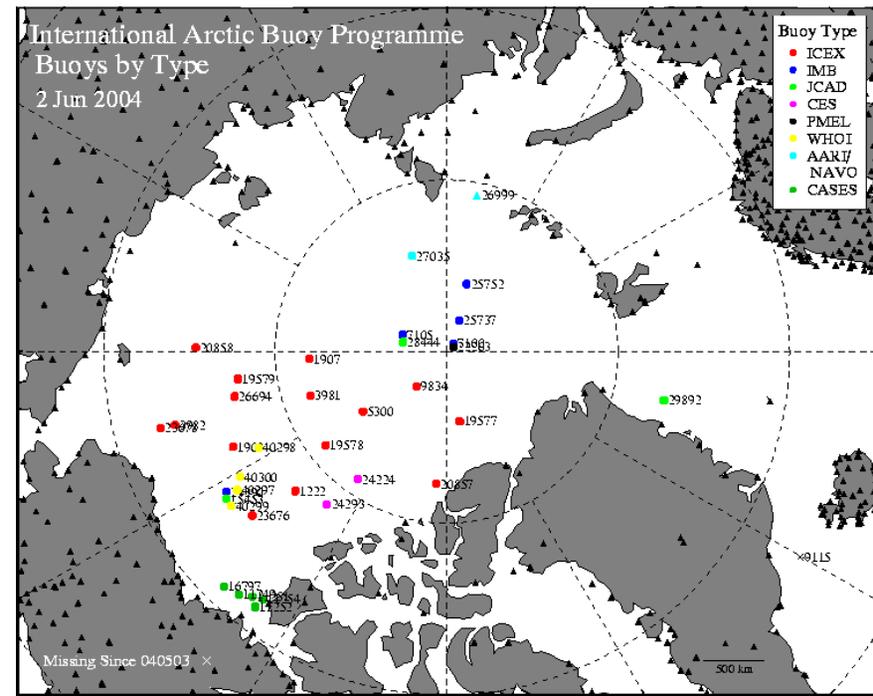
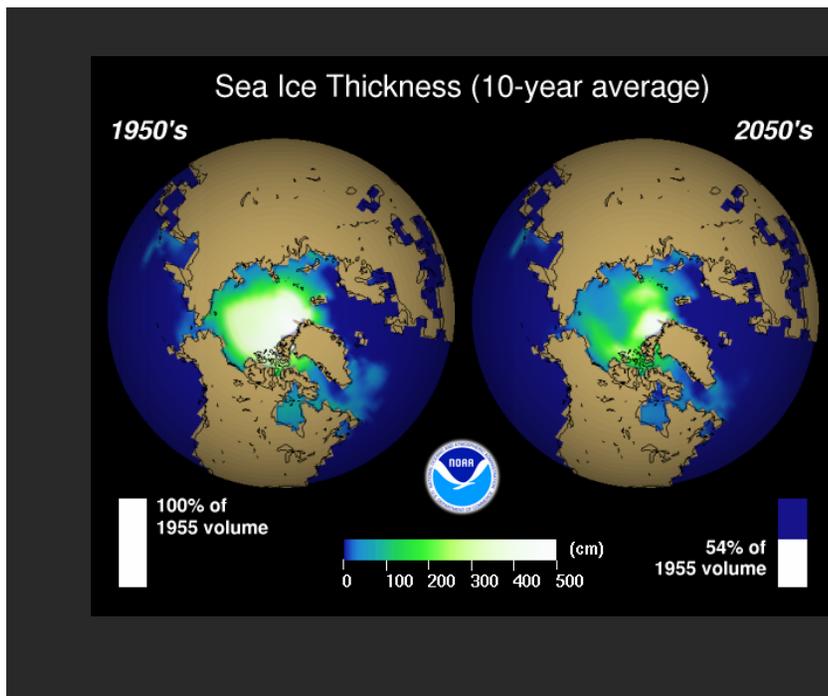
**Staff of Tuvalu, Funafuti, Meteorological Service**



# NOAA Climate Program Observations and Analysis



- NOAA buoy program focused on sea ice mass balance
  - Challenge: *Receding sea ice pack*
  - *IPY, ACIA*





# NOAA Climate Program Observations and Analysis



**Shismaref,  
Alaska**  
**Coastal erosion  
of barrier islands  
forces  
populations  
Inland**

**Challenge:  
Polar weather in  
changing ice  
conditions**

***As the sea ice pack recedes, open water leads to more coastal erosion***

7/7/2004



## **Northern Sea Route**

**The ACIA  
models projects  
that the current  
navigation  
season of 20-30  
days per year  
will increase to  
90-100 days by  
2080, with one  
model  
indicating it is  
likely to open to  
this degree by  
mid-century.**

**Opening new shipping routes and extending the navigation season could have very important economic implications**



# NOAA Climate Program Observations and Analysis



- Observation Challenges
  - *Expansion*
    - Indian ocean, TAO, PIRATA, ARGO, Flux references
    - Alaska CRN
  - *Integration*
    - Integrated Surface Observations w/ NWS
    - GEOSS
  - *Transition*
    - TAO
  - *Utilization*
    - Data Assimilation
    - Observing System Simulation Experiments
    - Testing the system
    - Science/Expert Teams
    - User requirements



# NOAA Climate Program Analysis Programs



- **Office of Global Programs**
  - *Climate Change and Data Detection*
    - **Paleo**
  - *Climate Variability and Change (CLIVAR)*
    - **Abrupt Climate Change, Pacific/Atlantic**
  - *Climate Dynamics and Experimental Prediction*
    - **Climate Model Test Bed**
  - *Global Water and Energy Experiment (GEWEX)*
    - **NAME**

**What are next climate research challenges for NWS?**

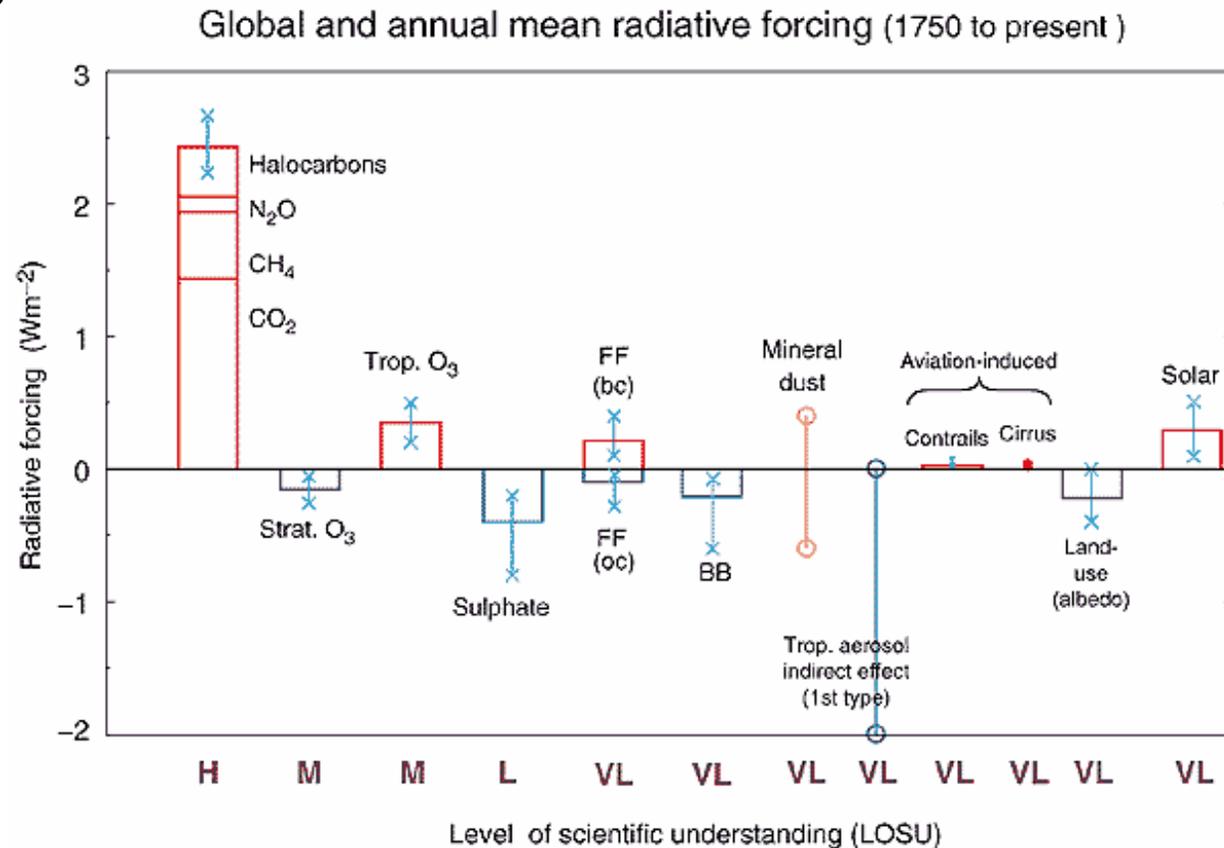


# NOAA Climate Program

## Climate Forcing



- Atmospheric Composition
- Carbon Cycle



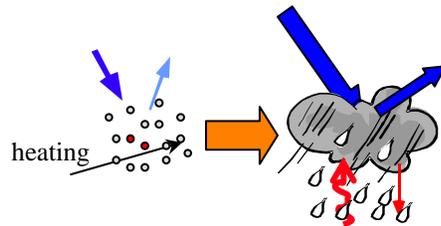


# NOAA Climate Program

Atmospheric Composition Program  
Priorities: What should we focus on?



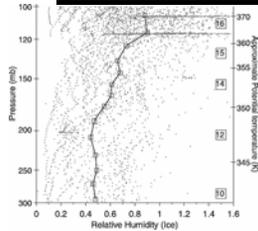
## 1. Aerosols



Direct forcing of climate - scattering & absorption  
Atmospheric T-structure- Absorption of radiation (heating)  
Cloud changes- Alteration of clouds & their properties  
- feedbacks  
Change in precipitation- Hydrology

*A current activity with continued focus*

## 2. Water Vapor



Growth factors

Amplification of forcing (through its  $\Delta$  abundance)  
- Altering aerosol properties  
- Altering chemistry  
- Changes in cloud distribution, properties  
Precipitation- Hydrology

*A new activity with future expansion*

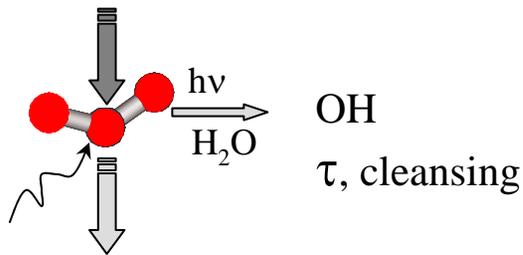


# NOAA Climate Program

Atmospheric Composition  
What we can do about it? (contd.)



## 3. Trop./Strat. Ozone



Radiative forcing by short-lived gas- policy options

Atmospheric composition

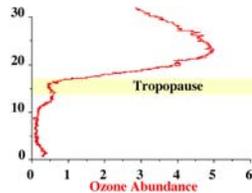
- Impacts on air quality
- lifetime of radiative gases
- contributor to global burden

Stratospheric ozone changes- impact below

- portend tropospheric changes?

**A current activity with continued focus**

## 4. Vertical profiles



Vertical profiles - key for initialization

- model validation/diagnosis
- Indicators of change

**A new (future) activity**

## 5. Data Integration



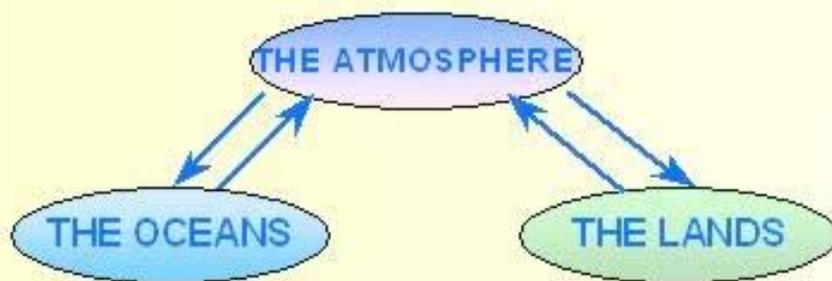
Seamless integration of data for

- initializing models
- understanding processes
- process representation

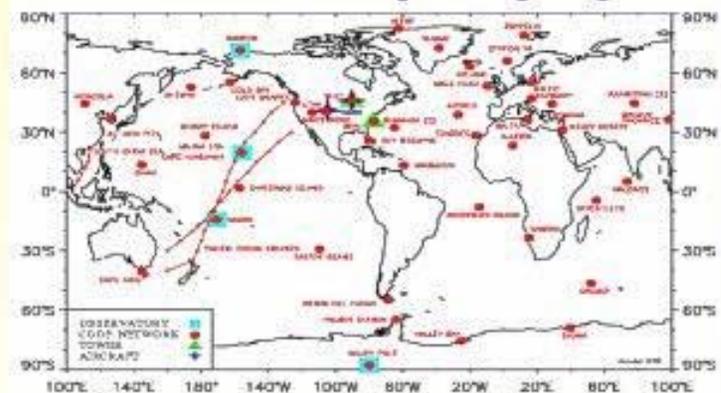
**A clear future need**

# Where Does Carbon Dioxide GO?

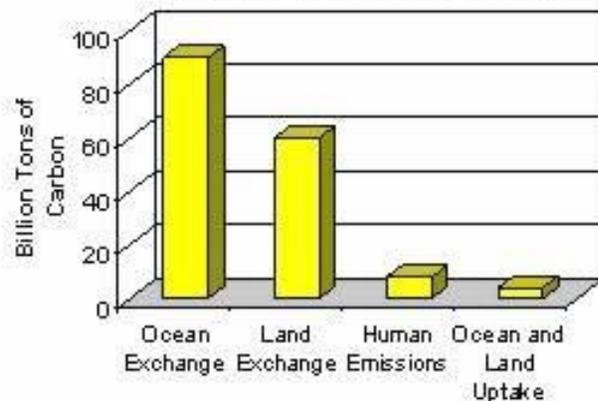
Carbon Dioxide is Exchanged  
Between Three Major Reservoirs



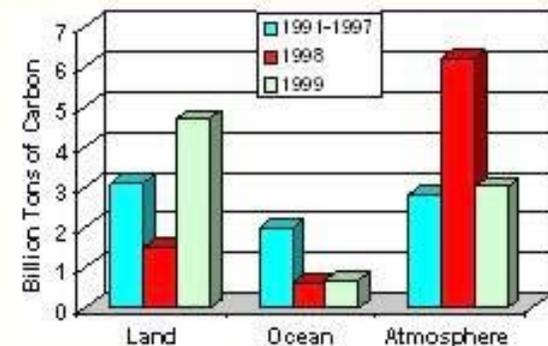
CMDL Global Coop Sampling Sites



Carbon Dioxide on the Move

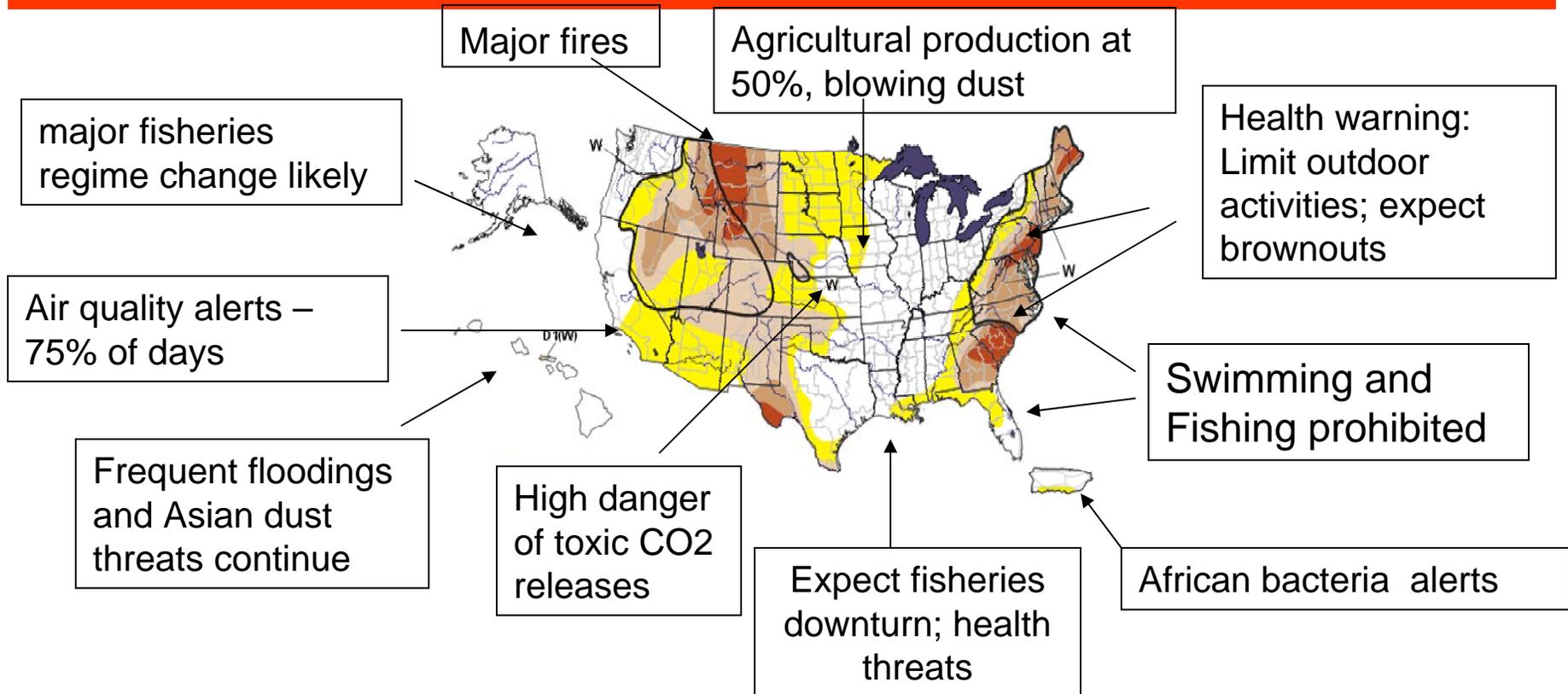


What We've  
Learned – the  
Land Plays  
an Important  
Role in  
Taking up  
Excess CO<sub>2</sub>!





# Possible Threats-Summer 2030: hot, dry and unhealthy (after 7<sup>th</sup> consecutive year of droughts)



**ALERT FORECASTs:** US Economy – code **orange**; US health – code **orange**; International Economy – code **red**; Global Security – code **red**



# NOAA Climate Program Predictions and Projections



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## 15 year plan - overarching goals

- to provide quantitative, reliable probabilities of extremely hazardous events, such as floods, heat-waves, droughts, cold-waves and high-wind.
- to develop the capability for providing probabilistic forecasts of quantities beyond traditional 'weather' variables.
- to improve information delivery systems so that users have direct access to probabilistic forecast information at all relevant space and time scales.
- **Challenge: Computer cycles**



# NOAA Climate Program Predictions and Projections



## Additional Prediction Capabilities to Target

- Probability Distributions - Full distribution available in digital form for all prediction products (monthly, seasonal, extremes,...)
- Verifications – Promote/Achieve international consistency in formats for all product verifications
- ENSO events – Routinely predict even moderate ENSO events 2-5 years in advance
- Seasonal, Monthly, Weekly Predictions - Extend seasonal prediction to year two, monthly prediction to month two, weekly prediction to week five



# NOAA Climate Program Predictions and Projections



## Additional Prediction Capabilities to Target

- Coupled Land-Ocean-Atmospheric -- Data assimilation system and coupled extended-range predictions to week five
- Assimilation/Forecast Suite - Climate reanalyses, reforecasts, seasonal coupled forecasts, and coupled extended-range forecasts all utilize consistent and bias correction techniques
- Multi-models - Objective probabilistic seasonal forecasts and the infrastructure to support a multi-model approach
- Interactive vegetation in GCMs and ensemble of dynamical drought forecasts
- Climate Trends -- Dynamical "nowcasting" of climate trends and their application in seasonal forecasts

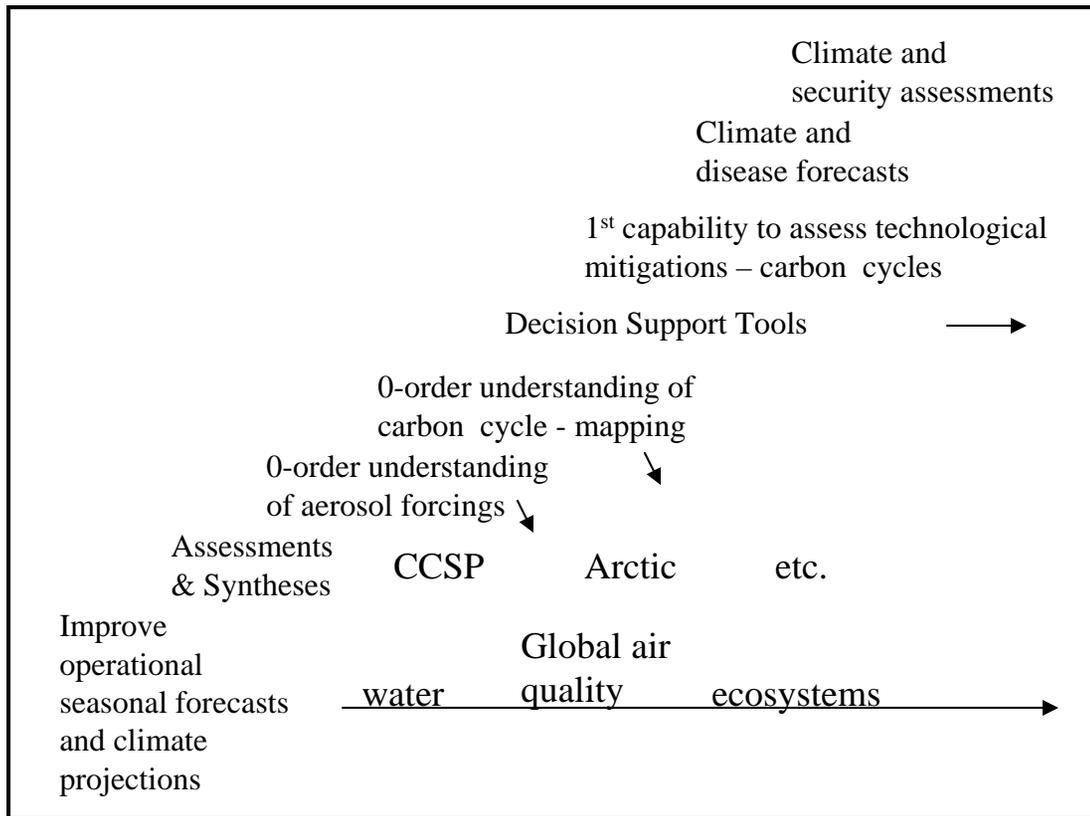


# NOAA Climate Program

## A NOAA Climate Roadmap: One View



### Knowledge Plateaus – leading to new products



### Impacts

- International Policy - security
- Manage/policy - health
- Policy-energy/security
- Policy support for global change
- Policy – energy, land use
- Health – air & water quality, policy - energy
- Manage – resources/water
- Resource management – policy – global change

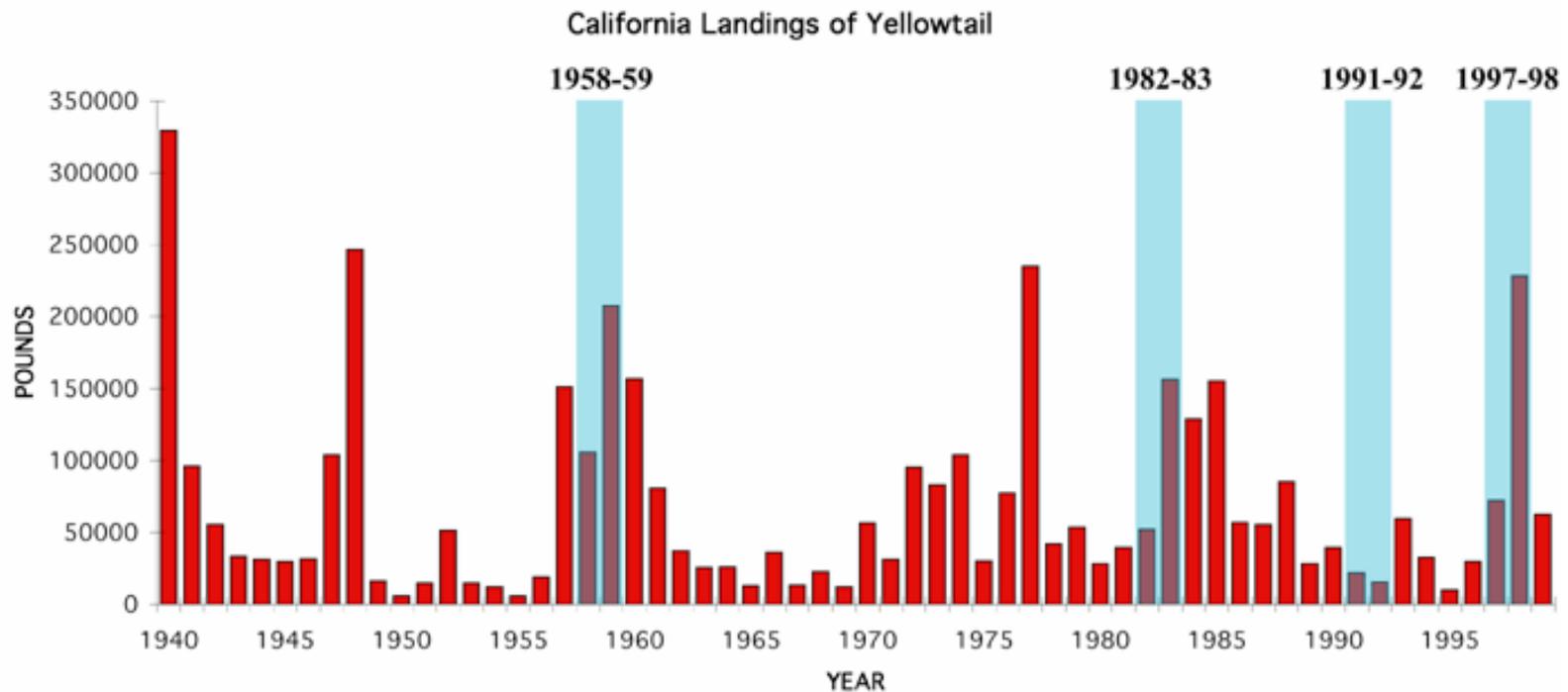
2004

2020



# NOAA Climate Program

## Climate and Ecosystems



***“Climate impacts on fish are the rule not the exception.”***



# NOAA Climate Program

## Climate and Ecosystems



### **Challenges for Climate and Ecosystems relevant to NWS:**

Coastal and island regions

Marine weather/climate - esp., extreme events

River runoff

Integrated observations

Regional models

Decision support in coastal regions



# NOAA Climate Program Regional Decision Support



*The Pacific ENSO Applications Center (PEAC) is a great success story for NWS/Climate.*

7/7/2004

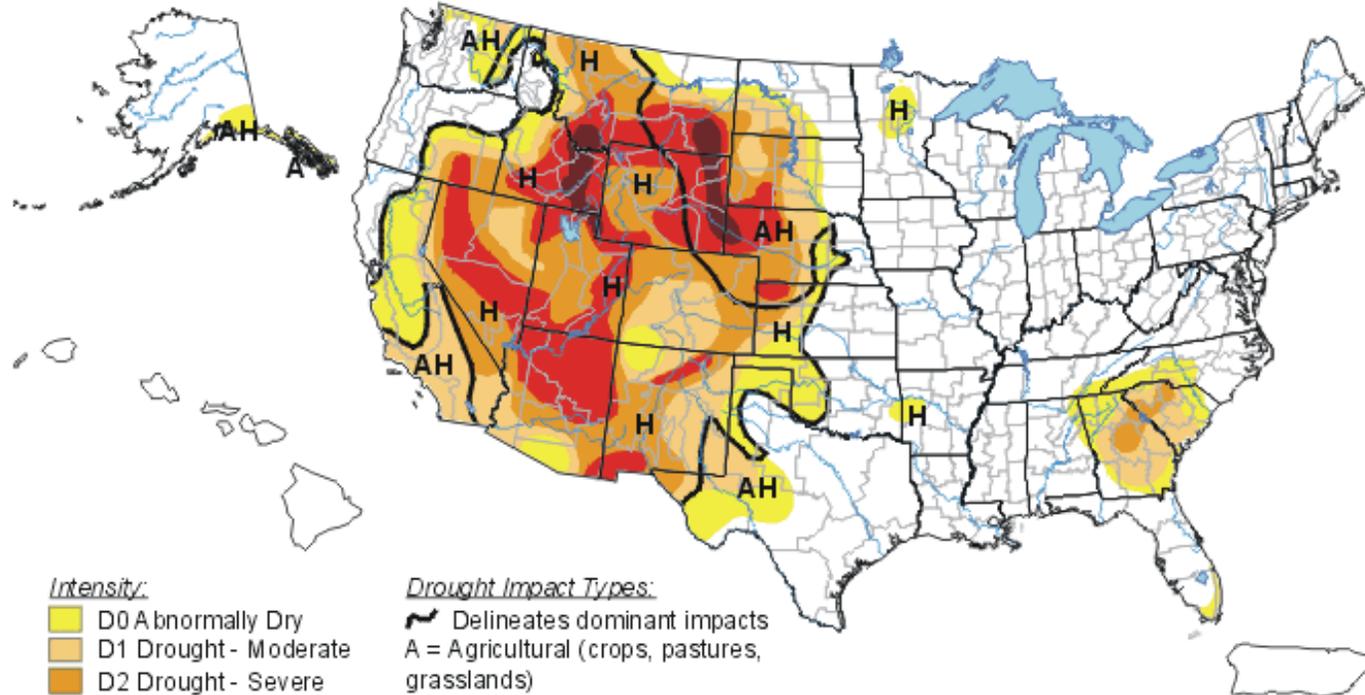


# NOAA Climate Program Regional Decision Support



## U.S. Drought Monitor

June 22, 2004  
Valid 8 a.m. EDT



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:

- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)
- (No type = Both impacts)

*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*



**Released Thursday, June 24, 2004**

**Author: Brad Rippey, U.S. Department of Agriculture**



## Digression DROUGHT



- Drought is a normal part of Climate
- “With drought causing between \$6B and \$8B a year in direct estimated losses to the US economy and devastating impacts on our society, we cannot overlook the need for science to predict, monitor, and mitigate this phenomena.”
- VADM Lautenbacher
- Challenge: NOAA leadership in NIDIS
- What is the best way for Climate program and NWS to work together to address this challenge?



# NOAA Climate Program Regional Decision Support



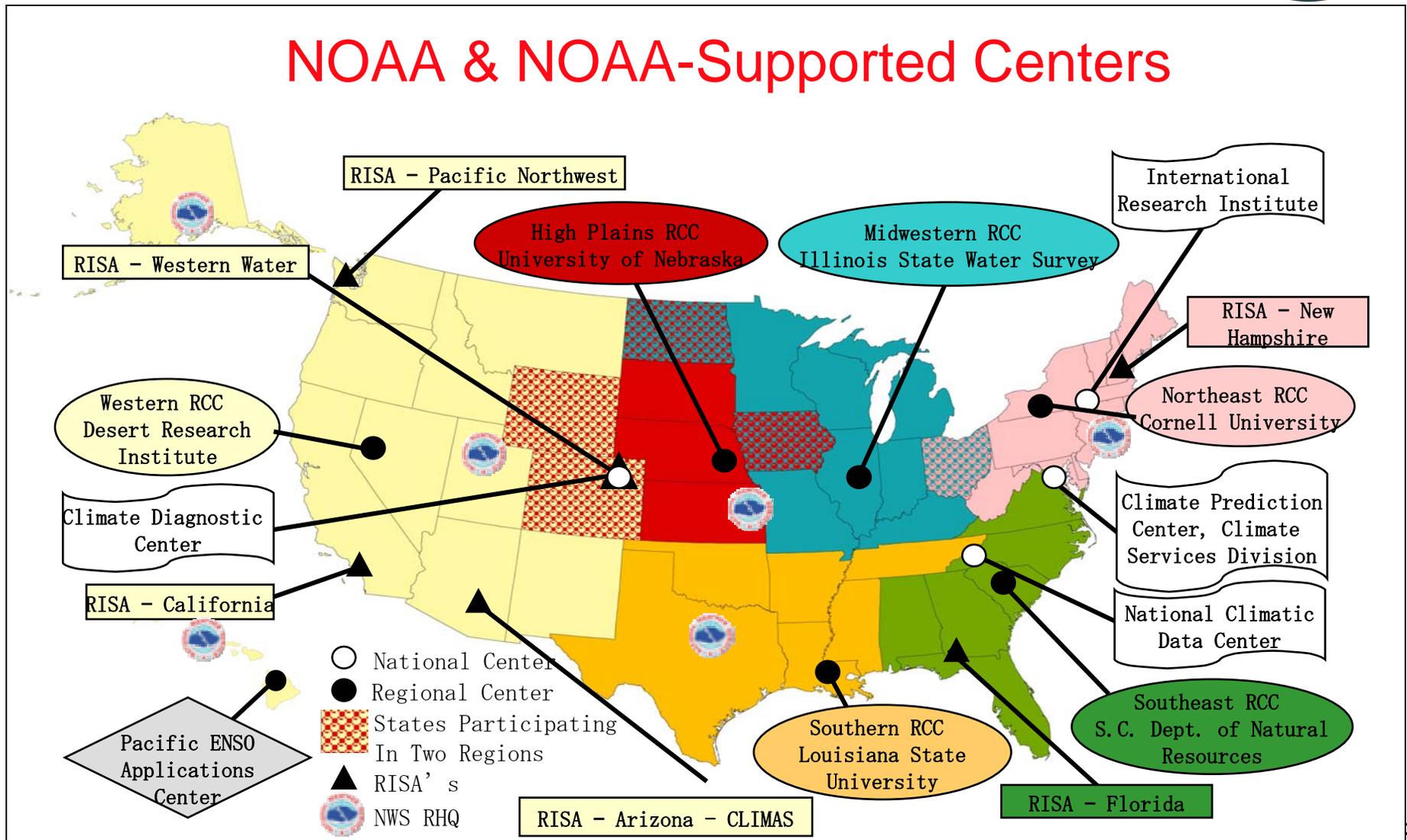
- **Current Climate Product Suite: Survey by Climate Services Clearinghouse (supported by NOAA OGP)**
  - <http://sciencepolicy.colorado.edu/climateservices/>      *VERSION 1.0 (FIRST DRAFT)*
  - ***Providers of services identified (611):***
    - NOAA (481)
    - Non-NOAA government (58)
    - Academic (66)
    - Private Sector (6)
  - ***Types of services identified:***
    - Prognostic (157)
    - Diagnostic (274)
    - Historical (192)
    - Educational (144)
    - Experimental (29)
    - Operational (50)



# NOAA Climate Program Regional Decision Support Network



## NOAA & NOAA-Supported Centers





# Climate Products and Services Growth Areas (FY05, FY06)



- FY05
  - *Enhance observations of oceans and atmospheric composition for improved diagnostic and prognostic climate products.*
  
- FY06
  - *Improve information to minimize impacts and reduce the costs of extreme weather and climate events*
  - *Research to develop climate attribution products*
  - *Climate forecast products for sectoral applications (agriculture, water, energy)*
  - *Regional experimental product development in areas such as water management, disaster reduction, fire management, health, and agricultural decision making.*
  - *Develop various decision tools for water managers to increase resource efficiencies*
  - *Begin first stage development of early warning system for West Nile Virus.*
  
- FY07
  - ?



# NOAA Climate Program

## Regional Decision Support



- *The Diffusion of Innovations*, Everett Rogers
  - *Innovation*
  - *Communication channels*
  - *Time*
  - *Social system*



# NOAA Climate Program

## Challenges for NWS FY07-11



- *Observing Systems*
  - Expansion, Integration, Transition, Assimilation, User requirements
- *Analysis Programs*
  - What's beyond Climate Model Test Bed, Weather-Climate?
- *Climate Forcing*
  - How do air quality programs overlap with climate?
- *Predictions and Projections*
  - *ESM, ESMF, Multi-models, global view*
- *Climate and Ecosystems*
  - *Coastal Regions*
- *Regional Decision Support*
  - *Enhancing the Product Suite*
  - *Building a larger user base*
  - *Integrating regional and sector approaches toward a Climate Extension Service*



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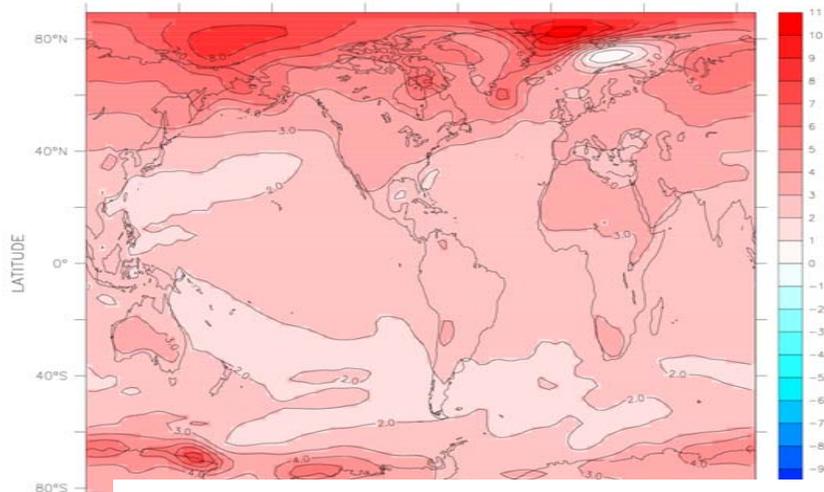
# BACKUP



# Possible Global Warming Impacts



## Annual Surface Air Temperature (deg C)

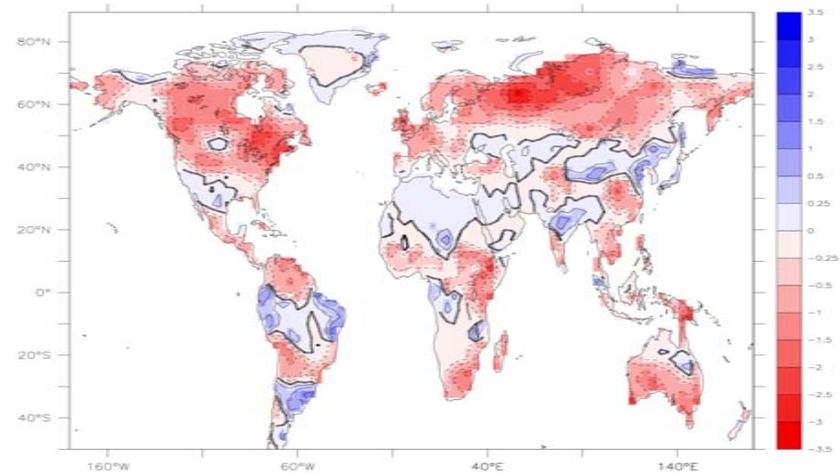
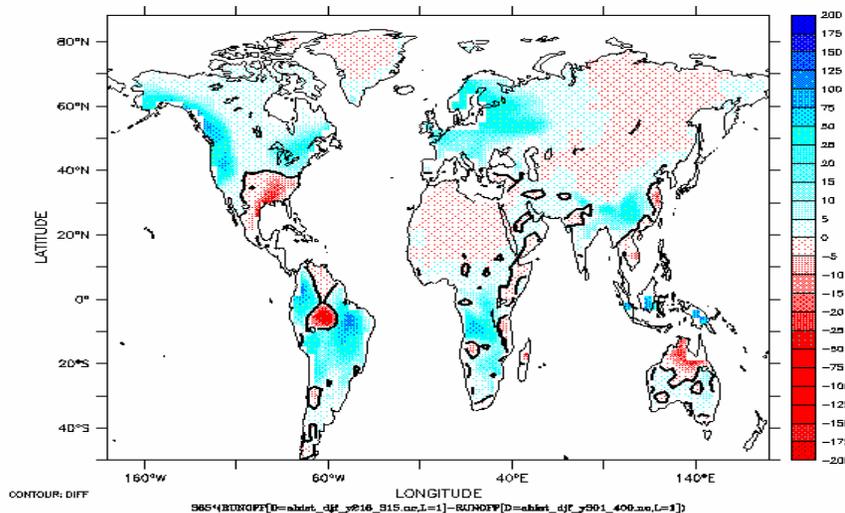


These changes will present new opportunities and threats

Conditions at double pre-industrial values of CO<sub>2</sub>:  
GFDL model

**Winter runoff (cm/yr)**

**Summer Soil Moisture (cm)**





# NOAA Climate Program

## Regional Decision Support



### NOAA's Climate Services

The research view

