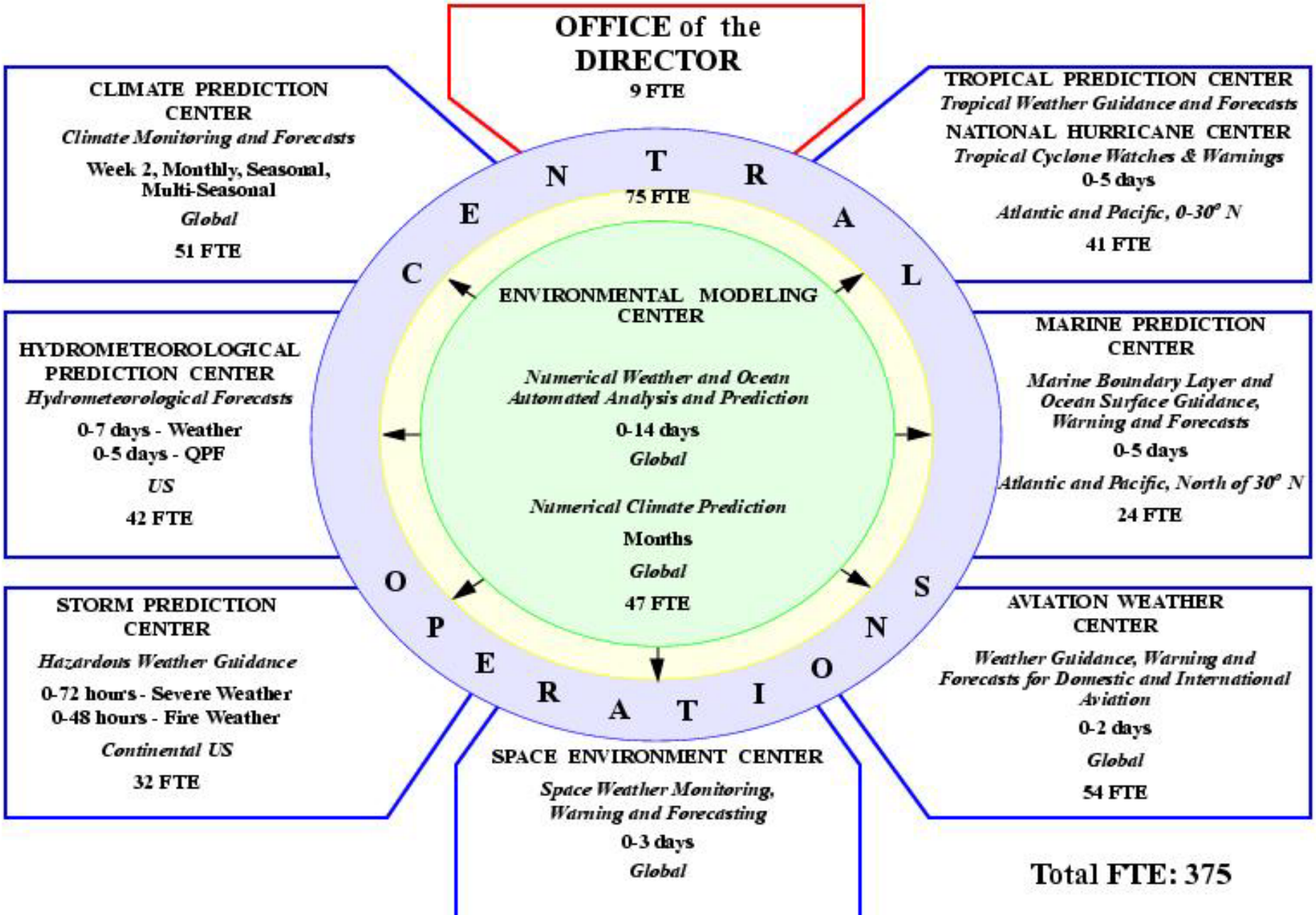
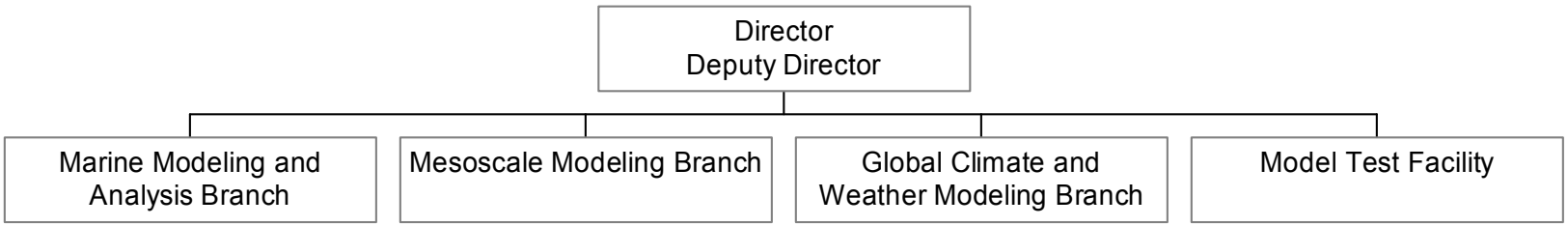
NATIONAL CENTERS for ENVIRONMENTAL PREDICTION



Environmental Modeling Center



THORPEX OBJECTIVES

INTERNATIONAL PROGRAM

SCIENCE GOAL:

Promote research leading to new techniques in:

Observations *(Collect data)*

Data assimilation *(Prepare initial cond.)*

Forecasting *(Run numerical model)*

Socioeconomic Applications

(Post-process, add value, apply)

SCIENTIFIC RESEARCH MUST ENABLE SERVICE GOALS

SERVICE GOAL:

Accelerate improvements in utility of 1-14 day forecasts for high impact weather

THORPEX ANSWER:

Develop new paradigm for weather forecasting through

Enhanced collaboration:

- Internationally
- Among different disciplines
- Between research & operations

Example: North American Ensemble Forecast System (NAEFS)

THORPEX ORGANIZATION

EXECUTIVE OVERSIGHT ***SCIENTIFIC DIRECTION***

INTERNATIONAL LEVEL – LINK WITH WMO

International Core Steering Committee

Michel Beland (Co-chair)

Louis Uccellini (US Representat.)

International Science Steering Comm.

Co-chaired by

Mel Shapiro & Alan Thorpe

INTNTL PROGRAM OFFICE UNDER WMO – IMPLEMENTATION PLAN

REGIONAL (NORTH AMERICAN) LEVEL – LINK WITH USWRP

Oversight provided by

North American members of International Core Steering Comm.

North American Science Steering Com

Co-chaired by

David Parsons & Pierre Gauthier

NOAA LEVEL – LINK WITH CORPORATE MANAGEMENT

NOAA THORPEX USWRP Sub-Com.

L. Uccellini (Chair), M. Uhart,

M. Colton, and Jack Hayes

NOAA Science Steering Committee

Z. Toth (Chair, Program Manager)

12 NOAA and outside members

THORPEX OBJECTIVES

NOAA'S ROLE

Existing NOAA, USWRP and other programs aimed at:

Short-range forecast problem: PACJET, IHOP, Cold Season Precip., etc

Seasonal & climate forecast problem: CLIVAR, GAPP, etc

THORPEX fills critical gap between short-range weather & climate programs:

NOAA'S SERVICE APLLICATION GOAL

Accelerate improvements in weather forecasts to facilitate issuance of skillful

- **3-7 day precipitation forecasts**
- **8-14 day daily weather forecasts**

THORPEX SOLUTION:

REVOLUTIONIZE NWP PROCESS

Invest in major new NWP program =>

- Develop new NWP procedures

  INTEGRATED, ADAPTIVE, USER CONTROLLABLE

  Return – Pace of forecast improvement maintained/accelerated
- Assess costs and societal/economic benefits of new procedures
- Implement operationally most cost effective new methods

  Return – Enhanced operational capability

  Improved cost effectiveness

SCIENCE OBJECTIVE:
REVOLUTIONIZE NWP PROCESS -
INTEGRATED, ADAPTIVE, USER CONTROLLABLE

TRADITIONAL NWP

Each discipline developed on its own

Disjoint steps in forecast process

Little or no feedback

One-way flow of information

Uncertainty in process ignored

NEW NWP

Sub-systems developed in coordination

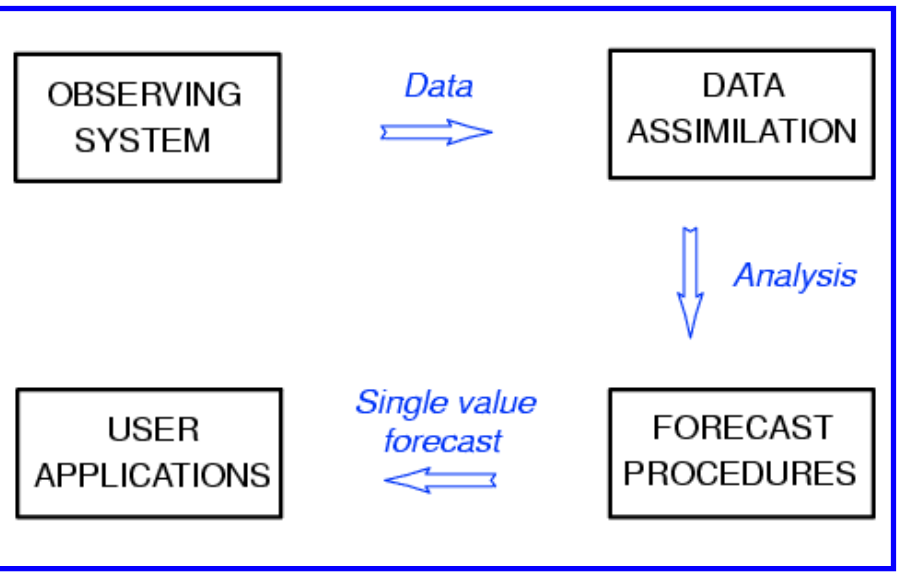
End-to-end forecast process

Strong feedback among components

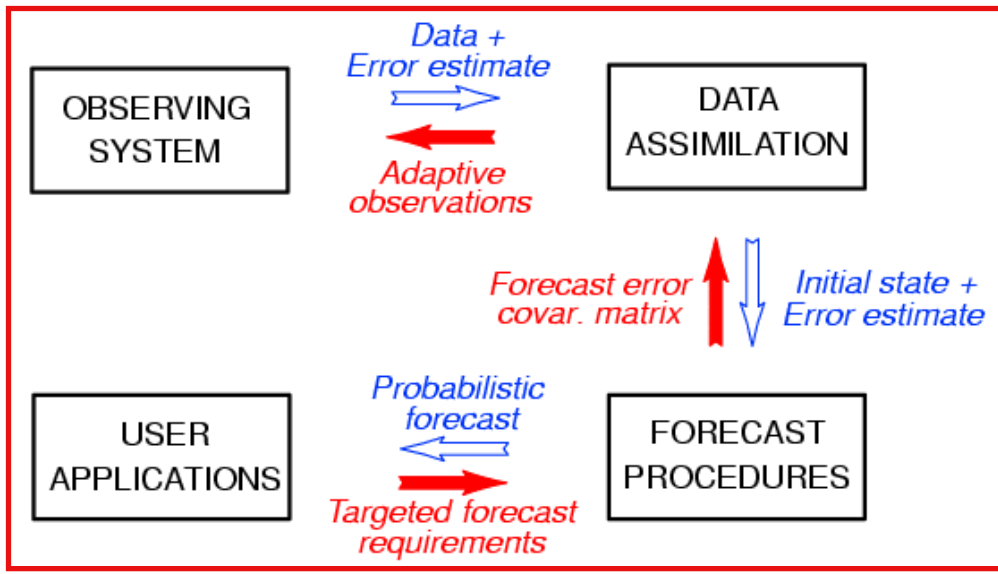
Two-way interaction

Error/uncertainty accounted for

TRADITIONAL NWP PROCESS



INTEGRATED NWP PROCESS



SERVICE GOAL: IMPROVE 3-14 DAY FORECASTS

NOAA THORPEX PROGRAM OVERVIEW – ACTIVITIES

ANSWER SCIENCE QUESTIONS

Advance basic knowledge,
directed explicitly toward NWP applications

Each task conceived as part of overall program

DEVELOP NEW METHODS

Sub-system development
- Academic research

Cross-cutting activities
- Academic + operational centers
  - Observing System Simulation Experiments (OSSEs)
  - Real-time test and demonstration

Infrastructure / Core tasks
- Facilitate other activities - Strong agency involvement
  - THORPEX Data Base
  - Operational Test Facility

RECOMMEND/PREPARE OPERATIONAL IMPLEMENTATION

Integral part of program

Strong participation by operational centers

NOAA THORPEX PROGRAM OVERVIEW - DELIVERABLES

DELIVERABLES	COSTS
New forecast techniques Observing, data assimilation, forecasting, application tools	Research Grant Program Integrated program - Four sub-areas & cross-cutting activities
Accelerated forecast improvements Integrated, adaptive, user controllable NWP	Operational Test Facility Simulated forecast process; Database
Cost effective operational system Based on cost/benefit analysis Enhanced user interface	Real-time test/implementation Data transmission, Computations, Training

OVERALL MEASURE OF SUCCESS:

SOCIO-ECONOMIC BENEFITS
MUST OUTWEIGH OPERATIONAL COSTS

BACKGROUND MATERIAL

NORTH AMERICAN ENSEMBLE FORECAST SYSTEM PROJECT

GOALS: **Accelerate improvements in operational weather forecasting**

through Canadian-US collaboration

Seamless (across boundary and in time) suite of products

through joint Canadian-US operational ensemble forecast system

PARTICIPANTS: Meteorological Service of Canada (CMC, MRB)

US National Weather Service (NCEP)

PLANNED ACTIVITIES: Ensemble data exchange (June 2004)

Research and Development (2003-2007) -*Statistical post-processing*
-*Product development*
-*Verification/Evaluation*

Operational implementation (in phases, 2004-2008)

POTENTIAL PROJECT EXPANSION / LINKS:

Shared interest with THORPEX goals of

Improvements in operational forecasts

International collaboration

Expand bilateral NAEFS in future

Entrain broader research community

Multi-center / multi-national ensemble system:

MOA with Japan Meteorological Agency

CROSS-CUTTING ACTIVITIES

Integrating NWP procedures from four sub-systems

Observing System Simulation Experiments (OSSEs)

- Data needs of NWP
  - What variables/resolution/accuracy required
  - Instrument/platform neutral assessment
- What instruments/platforms can provide data needs
  - Existing and new in-situ & remote platforms
  - Adaptive component to complement fixed network
  - Most cost effective solution
- Relative value of improvements in four sub-systems
  - Improvements in which sub-system offer best return?
  - Reallocation of resources
- Test of proposed operational configurations
  - Major field program if needed
  - Cost/benefit analysis - **Select most cost effective version**

CORE TASKS

Needed for efficient research & planned operations

Strong agency involvement

- THORPEX data base (observations, forecasts)
  - Information Technology challenge
    - High data volume
    - Transmission
    - Storage of data
- Foster collaboration in critical areas
  - Workshops (Societal and economic impacts)
  - Joint proposals – Interdisciplinary collaboration
  - Critical in past programs like FASTEX
- Test-bed – Pathway from research to operations
  - Formal procedure for researchers to follow
  - Melting pot for new ideas
  - Venue for cross-cutting activities

NOAA THORPEX ORGANIZATIONAL CHART

NOAA THORPEX USWRP Sub-Committee

Louis Uccellini (Chair)	NWS	Michael Uhart	OWAQ
Marie Colton	ORA/NESDIS	Jack Hayes	NWS

NOAA THORPEX Science Steering Committee

Zoltan Toth *Chair, Program Manager NOAA/NWS*

Observations:		***Data Assimilation***	
Jaime Daniels	NOAA/NESDIS	Craig Bishop	NRL
David Emmitt	SWA	L.-P. Riishojgaard	JCSDA
Thomas Schlatter	NOAA/FSL		
Chris Velden	CIMSS		

Forecasting/Predictability:		***Socioeconomic Applications:***	
Jim Hansen	MIT	Rebecca Morss	NCAR
Jeff Whitaker/T. Hamill	NOAA/CDC	Marty Ralph	NOAA/ERL
George Kiladis	NOAA/AL		

THORPEX:
A GLOBAL ATMOSPHERIC RESEARCH PROGRAM

NOAA LONG-TERM RESEARCH PROGRAM

Scientific Guidance Provided by

NOAA THORPEX Science Steering Committee

Presentation prepared by Z. Toth

SCIENCE QUESTIONS – ACTIVITIES - 1

- **OBSERVING SYSTEM**
  - New in-situ and remote instruments/platforms to complement existing network
  - Adaptive observing instruments/platforms
  - For large data sets
    - Super-obing etc prior to OR within data assimil.

      (Joint work with data assimilation)
    - Obs. error estimation (correlated/uncorrelated)

SCIENCE QUESTIONS – ACTIVITIES - 2

- Observing system
- **DATA ASSIMILATION**
  - Improve techniques
    - Forward models, transfer codes
    - Thinning of data
    - Treatment of data with correlated errors
  - Advanced methods to use flow dependent covariance
    - 4DVAR research, e.g., continual update of error covariance
    - Ensemble based techniques
    - Treatment of model errors
  - Adaptive observing techniques
    - Quick use of targeted data (“pre-emptive” forecasting)
    - Methods in the presence of
      - Strong non-linearities
      - Model error
    - Effectiveness of targeted data in analyses/forecasts
    - Effect on climatological applications of data

SCIENCE QUESTIONS – ACTIVITIES - 3

- Observing system
- Data assimilation
- **FORECAST PROCEDURES**
  - Initial ensemble perturbations *(Joint with data assimilation)*
    - Role of non-modal behavior
  - Separate model related error from initial value errors
    - Systematic vs. random errors
    - Atmospheric features most affected
  - Critical model features responsible for different errors
    - Improve model formulation to reduce errors (Coupling techniques)
    - Techniques to account for remaining uncertainty in ensembles (physics, etc)
    - Adaptive modeling and ensemble techniques

SCIENCE QUESTIONS – ACTIVITIES - 4

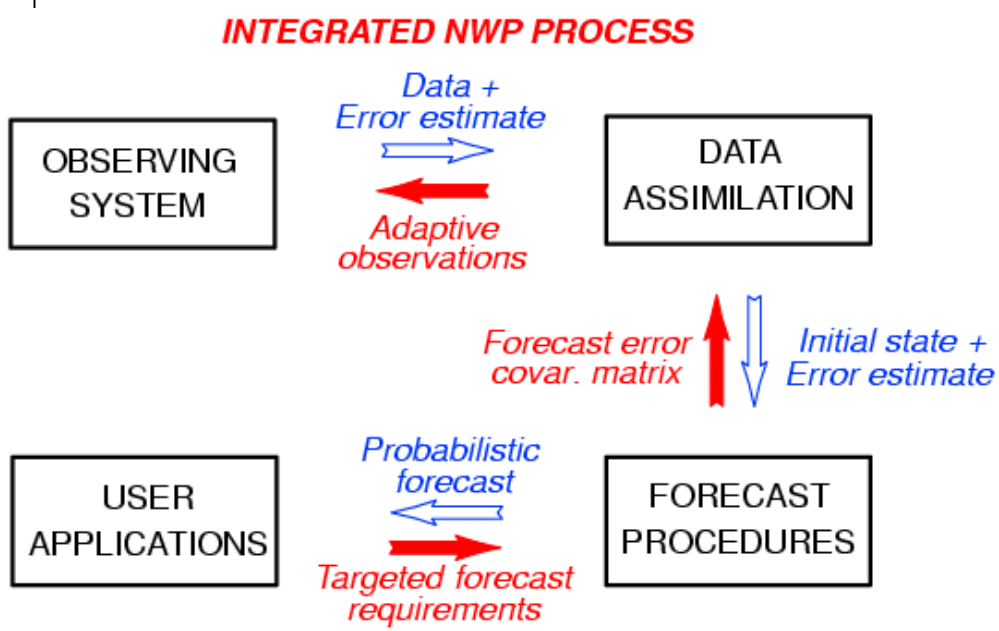
- Observing system
- Data assimilation
- Forecast procedures
- **SOCIO-ECONOMIC APPLICATIONS**
  - Probabilistic forecasting
    - Statistical post-processing
    - New procedures for intermediate and end users
  - Add-on costs of new THORPEX NWP process
    - Cost of data from multi-use satellite platforms *(Joint with Observtns.)*
  - Incremental societal/economic benefits of new NWP process
    - New NWP verification measure
  - Societal aspects of new adaptive NWP procedures
    - Equitable use of NWP resources, how adaptive procedures applied nationally and internationally

NEW NWP PARADIGM - 1

INTEGRATED NWP

Based on better understanding of forecast process

- Sub-systems developed in coordintation
- End-to-end forecast process
- Strong feedback
- Two-way interaction among components
- Error/uncertainty accounted for at each



NEW NWP PARADIGM - 2

Integrated

ADAPTIVE

Based on more detailed understanding of natural processes

- Allows more differentiated, case dependent methods/procedures
- Exmples
  - Observations – Adaptive platform collects data to fill gaps due to clouds
  - Data assimilation – Flow dependent forecast error estimates
  - Forecasting – Situation dependent modeling algorithms –
    e. g., hurricane relocation
  - Applications – Probabilistic forecast reflects all forecast info => ultimate adaptation of user procedures to weather

NEW NWP PARADIGM - 3

Integrated
Adaptive

USER CONTROLLABLE

Based on:

- *2-way interactions (improved forecast process)*
- *Adaptive approach (better understanding of nature)*

- Forecast process
  - Traditionally driven by FIXED user requirements
  - Now responsive to CHANGING user needs
- User needs connected to observational, data assimilation, and forecast systems
  - Dynamical analysis of nature & forecast process
  - New, NWP model based tools
  - Fully interactive forecast process
- Example: User identifies critical forecast weather event
  Special observational or forecast procedures
  Improved targeted forecast

LINK WITH NOAA MISSION GOAL

NOAA'S 3rd MISSION GOAL – sounds like excerpt from **THORPEX doc.:**

NOAA will "provide integrated observations, predictions, and advice for decision makers to manage… environmental resources".

Mission strategies and measures of success

directly correspond with

THORPEX Sub-program areas:

NOAA MISSION STRATEGY	***THORPEX FORECAST COMPONENTS***
Monitor and Observe	Observations
Understand and Describe	Data Assimilation
Assess and Predict	Forecasting
Engage, Advise, and Inform	Socio-economic Applications

Different Line Offices responsible for various forecast components –

NEED FOR NEW MATRIX MANAGEMENT CONCEPT FOR INTEGRATION

LINK WITH NWS STIP PROCESS

National Weather Service (NWS) –

NOAA's operational weather forecast provider

NWS Science and Technology Infusion Plan (STIP) –

Operational requirements should motivate all service oriented research

Research must have thread to operations &

Credible path to operational implementation

SCIENTIFIC RESEARCH MUST ENABLE SERVICE GOALS

THORPEX seeks advanced knowledge on two fronts:

Nature *(atmospheric and related processes)*

Forecast procedures *(OBS, DA, FCST & SA techniques)*

Integrating knowledge from two areas leads to new forecast paradigm of

INTEGRATED, ADAPTIVE, AND USER CONTROLLABLE FCST PROCESS

THORPEX:
A GLOBAL ATMOSPHERIC RESEARCH PROGRAM
OVERVIEW OF NOAA'S THORPEX-RELATED ACTIVITIES

ACCOMPLISHMENTS:

- Contributed to International Science Plan
- Contributes to forming THORPEX International Program Office (Under WMO auspices in Geneva)
- Contributes to North American Implementation Plan
- Formed NOAA THORPEX Science Steering Committee
- Developed NOAA THORPEX Long-Term Research Plan
- Issued First NOAA THORPEX Announcement of Opportunity (AO)

ONGOING EFFORT:

- Evaluation of research proposals in response to AO
- Atlantic Regional Campaign

OUTSTANDING ISSUES:

- Funding for AO unresolved
- Funding for Operational Test Facility (FTO) needed

NOAA'S INVOLVEMENT IN THORPEX

- 1998-99 Discussions started with involvement of NOAA scientists
- Apr 2000 First International Meeting
- Mar 2002 First Workshop, International Science Steering Committee formed
- Aug 2002 NOAA Tiger Team Meeting
- **Oct 2002 NOAA THORPEX Planning Meeting**
- **Nov 2002 1st Draft NOAA THORPEX Science and Implementation Plan**
- Jan 2003 NOAA THORPEX Science Steering Committee formed
- Feb 2003 Pacific TOST Experiment
- **Jun 2003 First NOAA THORPEX Announcement of Opportunity**
- Sep 2003 25 Full Proposals received, evaluation ongoing
- Oct-Dec 03 Atlantic Regional Campaign