

NAEFS BRIEFING



Prepared by Zoltan Toth

**Environmental Modeling Center
NOAA/NWS/NCEP
USA**

Acknowledgements: Louis Lefaiivre, MSC, Canada
<http://wwwt.emc.ncep.noaa.gov/gmb/ens/index.html>

OUTLINE

- PARTICIPANTS
- PROJECT GOALS
- TIMELINE
- BACKGROUND
- 1ST OPERATIONAL IMPLEMENTATION, MARCH 2006
- PROJECT MILESTONES
- MULTI-MODEL ENSEMBLE APPROACH
- MAJOR AREAS OF RESEARCH & DEV.
- THORPEX & NAEFS
- TIGGE & THORPEX



NAEFS ORGANIZATION

Meteorological Service of Canada

National Weather Service, USA

MSC

NWS

PROJECT OVERSIGHT

Michel Beland, Director, ACSD

Louis Uccellini (Director, NCEP/NWS)

Pierre Dubreuil, Director, AEPD

Greg Mandt (Director, OST/NWS)

Jim Abraham, MRB

Steve Lord, EMC

PROJECT CO-LEADERS

Louis Lefavre (Implementation)

Zoltan Toth (Science)

Gilbert Brunet (Science)

David Michaud / Brent Gordon (Impl.)

JOINT TEAM MEMBERS

Meteorological Research Branch MRB

Environmental Modeling Center EMC

Peter Houtekamer, Herschel Mitchell,

Bo Cui, Richard Wobus, Yuejian Zhu

Lawrence Wilson

NCEP Central Operations NCO

Hydrometeor. Prediction Center HPC

Canadian Meteorological Center CMC

Peter Manousos

Yves Pelletier, Gerard Pellerin,

Climate Prediction Center CPC

Richard Verret, Alain Patoine,

Ed O'Lenic, Mike Halpert, David Unger

Manon Lajoie

NWS Richard Grumm

National Meteorological Service of Mexico (NMSM) joined in Nov. 2004

Acknowledgements to: J. Whitaker, T. Hamill, Y. Gel

OUTLINE

- ORGANIZATION
- PROJECT DESCRIPTION
- ANTICIPATED BENEFITS
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- MAJOR AREAS OF RESEARCH & DEV.
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PROJECT DESCRIPTION

International project to produce operational multi-center ensemble products

- Combines global ensemble forecasts from Canada & USA
 - 40+ members per cycle, 2 cycles per day from MSC & NWS
- Generates products for
 - Intermediate users
 - E.g., weather forecasters at NCEP Service Centers (US NWS)
 - Specialized users
 - E.g., hydrologic applications in all three countries
 - End users
 - E.g., forecasts for public distribution in Canada (MSC) and Mexico (NMSM)
- Prototype ensemble component of THORPEX Global Interactive Forecast System (GIFS)
 - Operational outlet for THORPEX research using THORPEX Interactive Grand Global Ensemble (TIGGE) archive

ANTICIPATED BENEFITS

- Improves probabilistic forecast performance
 - Earlier warnings for severe weather
 - Lower detection threshold due to more ensemble members
 - Uncertainty better captured via analysis/model/ensemble diversity
- Provides Seamless suite of forecasts across
 - International boundaries
 - Canada, Mexico, USA
 - Different time ranges (1-14 days)
- Saves development costs by
 - Sharing scientific algorithms, codes, scripts
 - Accelerated implementation schedule
 - Low-cost diversity via multi-center analysis/model/ensemble methods
 - Exchanging complementary application tools
 - MSC focus on end users (public)
 - NWS focus on intermediate user (forecaster)
- Saves production costs by
 - Leveraging computational resources
 - Each center needs to run only fraction of total ensemble members
 - Providing back-up for operations in case of emergencies
 - Use nearly identical operational procedures at both centers to provide basic products
 - Offers as default basic products based on unaffected center's ensemble

PROJECT HISTORY & MILESTONES

- February 2003, Long Beach, CA
 - NOAA / MSC high level agreement about joint ensemble research/development work (J. Hayes, L. Uccellini, D. Rogers, M. Beland, P. Dubreuil, J. Abraham)
- May 2003, Montreal (MSC)
 - 1st NAEFS Workshop, planning started
- November 2003, MSC & NWS
 - 1st draft of NAEFS Research, Development & Implementation Plan complete
- May 2004, Camp Springs, MD (NCEP)
 - Executive Review
- September 2004, MSC & NWS
 - Initial Operational Capability implemented at MSC & NWS
- November 2004, Camp Springs
 - Inauguration ceremony & 2nd NAEFS Workshop
 - Leaders of NMS of Canada, Mexico, USA signed memorandum
 - 50 scientists from 5 countries & 8 agencies
- March 2006, MSC & NWS
 - 1st Operational Implementation
 - Bias correction
 - Climate anomaly forecasts
- March 2006, 2007, MSC, NWS
 - Follow-up implementations

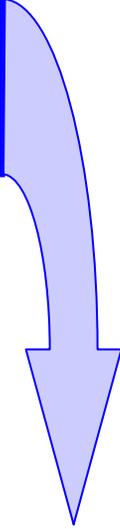
BACKGROUND INFORMATION

- MSC-NCEP Teleconference, June 17 2005
 - Review of progress
 - Discussion on plans, agreement on next steps
 - Implementation plans to be finalized at next teleconference (26 or 27 Sept. 2005)
- Limitations to progress
 - NCEP - Reduced resources for development
 - Only 50% of NAEFS funding available due to THORPEX budget shortfall =>
 - Only one (instead of two) person dedicated to NAEFS development
 - Scaled back execution of research/development
 - Minimal involvement in joint MSC/NCEP verification work
 - Slower progress in bias correction and product development work
 - MSC - Personnel changes
 - Change in project oversight
 - Pierre Dubreuil announced his resignation (July 31 2005)
 - New project leader
 - Louis Lefavre replaced Jean-Guy Desmarais as acting project leader (March 1 2005)
 - Other changes
 - Jim Abraham (former chief of MRB) left MRB, Gilbert Brunet acting as chief
 - Richard Hogue (data transmission) left CMC, Yves Pelletier replaced him

TENTATIVE IMPLEMENTATION SCHEDULE

- March 2006
 - 1st NAEFS product suite
 - NCEP operational web pages (incl. Caribbean & South American products)
 - “Experimental” status for first 60 days
 - NAWIPS grids for NCEP service centers
 - NDGD grids
- Feb 2006
 - Bias correction, Weighting, Climate anomaly (BWC) algorithms
- Dec 2005
 - BWC Codes/scripts delivered to NCO
- Nov 2005 - have to verify with B. Gordon
 - Operational data exchange established
 - New GRIB2 files containing NAEFS variables only
- Oct 2005
 - BWC Codes/algorithms exchanged between MSC-NCEP
- Sept 2005
 - Decision regarding BWC & Product implementation details

CONCEPT OF OPERATIONS

1. Exchange ~50 selected variables
 - Use GRIB2 to reduce volume of data
 2. Generate basic products using same algorithms/codes
 - Reduce systematic error
 - Bias estimation
 - Combine two ensembles
 - Determine weights
 - Express forecast in terms of climatological anomalies
 - Prepare & compare forecast with reanalysis climate distribution
 3. Generate center-specific end products
 4. Evaluate & provide feedback for improvements
 - Verification using same algorithms
 - User feedback
-
2. MSC-NCEP basic production suite
 - Same algorithms/codes used at both centers
 - Duplicate procedures provide full backup in case of problems at either end
 - If one component of ensemble missing, products based on rest of ensemble
 - Basis for different sets of center-specific end products
 - Ensures consistency between end products even if their format is different
 - All basic products to be made available via ftp to user and research community
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BASIC PRODUCTS

- NAEFS basic product list
 - Bias corrected members of joint MSC-NCEP ensemble
 - 40 members, NAEFS variables, GRIB2
 - Bias correction against each center's own operational analysis
 - Weights for each member for creating joint ensemble
 - 40 members, NAEFS variables, GRIB2
 - Weights depend on geographical location (low precision packing)
 - Climate anomaly percentiles for each member
 - 40 members, NAEFS variables, GRIB2
 - Non-dimensional unit, allows downscaling of scalar variables to any local climatology
- Issues – Products to be added in future years
 - No bias correction on precipitation (& possibly on few more problematic vars.)
 - *Need reliable and bias-free satellite-based analysis of precipitation rates*
 - Collaborators needed – CPC, NESDIS?
 - Climate anomalies provided for 15 most frequently used variables
 - Need to process reanalysis data to describe climatology for rest of variables

END PRODUCTS

- End product generation
 - Can be center specific
 - Need to conform with procedures/requirements established at different centers
- End products generated at NCEP
 - Based on prioritized list of requests from NCEP Service Centers
 - Graphical products (including Caribbean, South American, and AMMA areas)
 - NCEP official web site (gif)
 - NCEP Service Centers (NAWIPS metafile)
 - Gridded products
 - NAWIPS grids
 - » NCEP Service Centers
 - GRIB2 format
 - » Products of general interest (Possible ftp distribution, no decision yet on products)
 - » NDGD (10-50-90 percentile forecast value + associated climate percentile)
- End products generated at MSC
 - TBD
- End products generated jointly
 - Experimental probabilistic Week-2 forecast
 - Fully automated, based on basic products: bias corrected, weighted climate anomalies
 - Can become official product once performance reaches current operational level

DETAILS

- Data exchange

- Coordination needed with Yves Pelletier from MSC (Brent Gordon, has been out)
 - Operational transmission arrangements
 - Change to GRIB2 format

- Basic products

- Bias correction (Bo Cui, Dave Unger)
 - First moment method works, accepted for use by both parties
 - Second moment correction
 - Moment adjustment & Bayesian Model Averaging, BMA methods to be compared
 - May or may not be included in 1st operational implementation
- Weighting (Bo Cui, Dave Unger)
 - Skill, Ridging, BMA methods to be compared
- Climate anomalies (Yuejian Zhu)
 - Detailed algorithm to be developed

- End product generation

- One stream to generate multiple product formats (Dave Michaud)
 - Start with highest priority items from prioritized list from Service Centers (Z. Toth)
 - Required NAWIPS tools ready by Sept & Dec 2005 (Maxine Brown)
 - Default graphical setup to be developed & JIF'd for web display (Maxine Brown)
 - NAWIPS graphical products using web default display (Dave Michaud)
 - NAWIPS & GRIB2 product generation as part of one product stream (Dave Michaud)

EXPANSION OF NAEFS

- Discussions with other centers for expansion of NAEFS
 - Experimental status - March 2006
 - Operational status – 2007-2008
 - UKMet – Agreement
 - FNMOC, AFWA – Expert discussions
 - Need to formalize, use operational center forum
 - Product distribution
 - Issues
 - Name change from NAEFS to Global Ensemble Prediction Center
 - *Disc space requirements will grow*
- Other centers that expressed interest in learning more about NAEFS
 - ECMWF, NCMRWF, JMA, KMA
- Link with THORPEX Interactive Grand Global Ensemble (TIGGE)
 - THORPEX research organized in 4 science Working Groups
 - TIGGE data base supports ensemble-related research
 - NAEFS – GEPS provides
 - Testing in and transition to operational use
 - Real time forecast data for demonstration projects

FUTURE IMPLEMENTATIONS

- Add missing and newly developed
 - Basic products, eg
 - Bias-corrected precipitation
 - Climate anomalies for most variables
 - End products, eg
 - Wind speed, direction
- Incorporate ensemble data from other centers
 - FNMOC
 - UKMet
- Unified evaluation/verification procedures
- Strengthen relationship with THORPEX
 - Consider further expanding system
 - Possible redesign?
 - Stronger link with smaller group of partners
 - Looser collaboration with others

DETAILS - 2

- Product distribution

- NAEFS basic products (Brent Gordon)

- 3 new data sets, in addition to raw NCEP global ensemble data
 - Use GRIB2, low precision (for weights & climate anomalies) to control resource requirements
 - Must be made available via ftp for
 - Community use
 - » Real time forecasts
 - » Archive for research (THORPEX-TIGGE)
 - Backup in case of problem at either generating center
 - Resource implications
 - *HPSS disc storage*
 - Ftp servers
 - » *NCDC is to post & keep ensemble data?*

- NAEFS end products

- Supercede current global ensemble products based on NCEP ensemble only
 - As NAEFS products are introduced, they replace current NCEP products
 - NCEP official web site
 - Public
 - NAEFS partners/users
 - » Central & South America
 - » Africa (AMMA)
 - » Polar regions (IPY)

LIST OF VARIABLES IDENTIFIED FOR ENSEMBLE EXCHANGE BETWEEN CMC - NCEP

Parameter	CMC	NCEP
Ensemble	8 SEF, 8 GEM	
GRID	2.5x2.5 deg, (144x73 lat-lon) [1.2 X 1.2 (300X151 lat-lon)]	1x1 deg (360x180 lat-lon) for day 1-7 2.5x2.5 deg (144x73 lat-lon) day 8-15
DOMAIN	Global	Global
FORMAT	WMO Grib Format	WMO Grib Format
HOURS	0, 12, 24, 36, 48, 60, 72, 84, 96, 108, 120, 132, 144, 156, 168, 180, 192, 204, 216, 228, 240	0, 12, 24, 36, 48, 60, 72, 84, 96, 108, 120, 132, 144, 156, 168, 180, 192, 204, 216, 228, 240, 252, ... 384
GZ	[200], 250, 500, 700, 850, [925, 1000]	[200], 250, 500, 700, 850, [925], 1000
TT	[200], 250, 500, 700, 850, [925, 1000]	[200], 250, 500, 700, 850, [925], 1000
U,V	[200], 250, 500, 700, 850, [925, 1000]	[200], 250, 500, 700, 850, [925], 1000
TT	12000 Now redefined in grib file to be 2m AGL	2m
U,V	Now redefined in grib file to be 10m AGL	10m
ES	12000 Now redefined in grib file to be 2m AGL	RH at 2m
MSLP	(PN) level 0, i.e. at surface	PRMSL, i.e. at surface
PR	level 0, i.e. at surface	level 0, i.e. at surface
NT	level 0	Total Cloud Cover
IH	level 0	Total Precipitable Water
Sfc Pres	(SEF) (P0) level 0 at surface	Sfc Pressure
Model Topography	Model Topography	Model Topography
CAPE	Sept 2004	June 2004
Precip type	Sept 2004	Precip type
T _{max}	June 2004	2m
T _{min}	June 2004	2m
WAM	2005-2006	2005-2006

Black : data exchanged in early 2004

Blue : items added to CMC and NCEP production by July 2004

Red : items added to CMC production by October 2004

Green : items in development (CMC) and testing (NCEP) by June 2005

ENSEMBLE PRODUCTS - FUNCTIONALITIES

List of centrally/locally/interactively generated products required by NCEP Service Centers for each functionality are provided in attached tables (eg., *MSLP, Z,T,U,V,RH, etc, at 925,850,700,500, 400, 300, 250, 100, etc hPa*)

	<i>FUNCTIONALITY</i>	<i>CENTRALLY GENERATED</i>	<i>LOCALLY GENERATED</i>	<i>INTERACTIVE ACCESS</i>
1	Mean of selected members <i>Done</i>			
2	Spread of selected members <i>Done</i>			
3	Median of selected values <i>Sept. 2005</i>			
4	Lowest value in selected members <i>Sept. 2005</i>			
5	Highest value in selected members <i>Sept. 2005</i>			
6	Range between lowest and highest values <i>Sept. 2005</i>			
7	Univariate exceedance probabilities for a selectable threshold value <i>FY06?</i>			
8	Multivariate (up to 5) exceedance probabilities for a selectable threshold value <i>FY06?</i>			
9	Forecast value associated with selected univariate percentile value <i>Sept. 2005 - FY06?</i>			
10	Tracking center of maxima or minima in a gridded field (eg – low pressure centers) <i>Sept. 2005, Data flow FY06?</i>			
11	Objective grouping of members <i>FY08?</i>			
12	Plot Frequency / Fitted probability density function at selected location/time (lower priority) <i>FY07?</i>			
13	Plot Frequency / Fitted probability density as a function of forecast lead time, at selected location (lower priority) <i>FY07?</i>			

Additional basic GUI functionalities:

- Ability to manually select/identify members
- Ability to weight selected members *Sept. 2005*

Potentially useful functionalities that need further development:

- Mean/Spread/Median/Ranges for amplitude of specific features 18
- Mean/Spread/Median/Ranges for phase of specific features

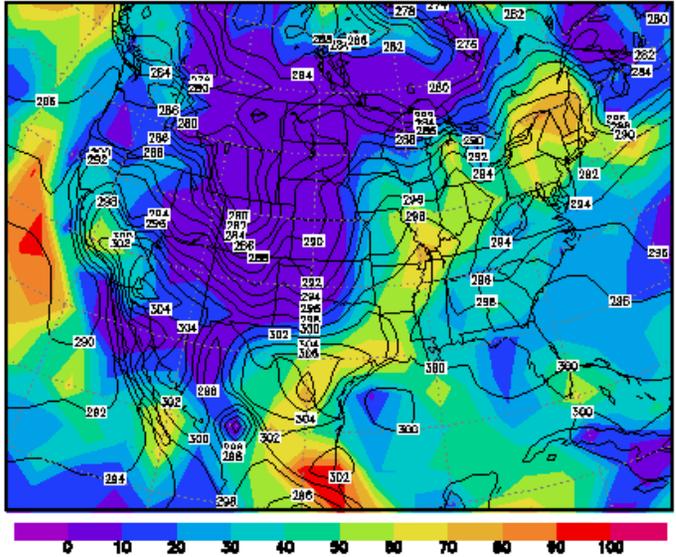
ENSEMBLE PRODUCT REQUEST LIST FROM NCEP SERVICE CENTERS - *EXCERPT*

PR	FUNCTIONALITY	CENTRALLY MADE PRODUCTS	CENTER
1	Mean of selected members (Web)	Z: 500mb, 700mb, 850mb	HPC,SPC,OPC,TPC
2		T (K): 500, 700, 750, 800, 850, 900mb	HPC,OPC,TPC
2		Wind: 250, 500, 700, 850mb	HPC,OPC,TPC
3		Z: 250mb	HPC,SPC
3		MSLP	OPC,TPC
3		T (K): 925, 300, 250, 200mb	OPC,TPC
3		Wind: 10m, 925, 300, 200mb	OPC,TPC
4		Z: 925mb	SPC
4		Trop Height	AWC
4		Climatological mean 500 mb heights	SPC
4		Climo variance in 500 mb heights	SPC
4		1000-500 mb thickness	SPC
4		pmsl	HPC
4		pmsl \leq 1000mb, 980, 960	SPC
4		Trop Temp	AWC
4		T (K): BL	HPC
4		T (F): 2m (\geq 70)	SPC
4		T 850 (C): \leq 2 , \leq 0 , \leq -2	SPC

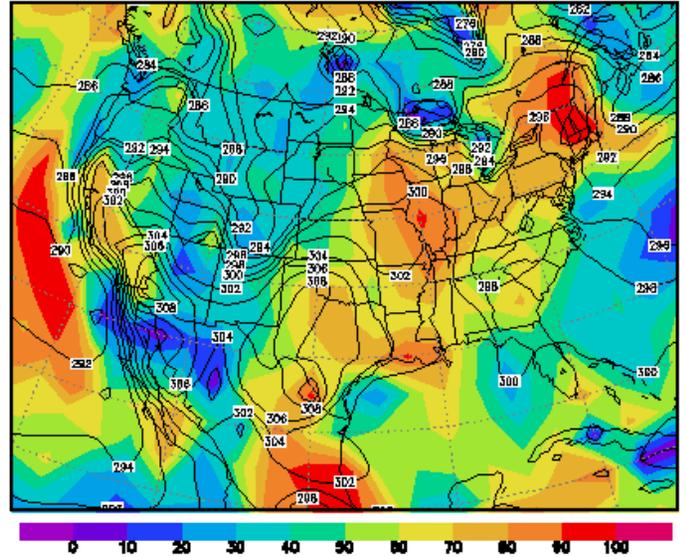
ENSEMBLE 10-, 50- (MEDIAN) & 90-PERCENTILE FORECAST VALUES (BLACK CONTOURS) AND CORRESPONDING CLIMATE PERCENTILES (SHADES OF COLOR)

2-meter temperature 5-day forecast (valid at 06/15/2005)

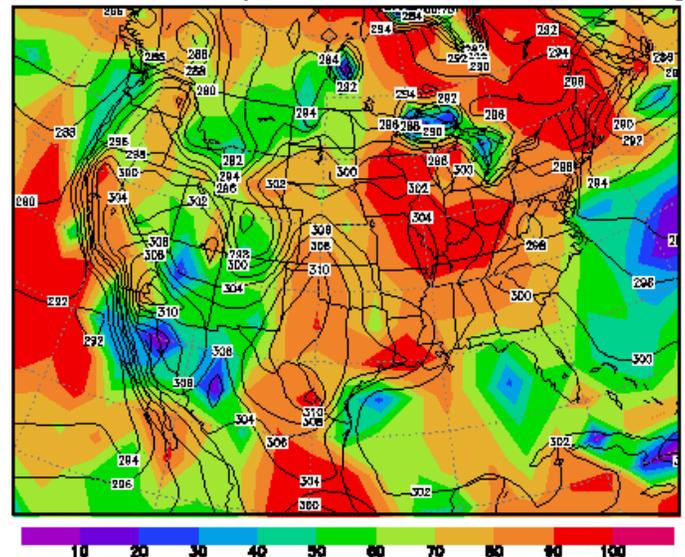
contour - 10% ens prob fcst, shaded - % of climatology



contour - 90% ens prob fcst, shaded - % of climatology



contour - 50% ens prob fcst, shaded - % of climatology



BACKGROUND

NOAA SERVICE GOAL: ACCELERATE IMPROVEMENTS IN 3-14 DAY FORECASTS

NOAA SCIENCE OBJECTIVE: REVOLUTIONIZE NWP PROCESS

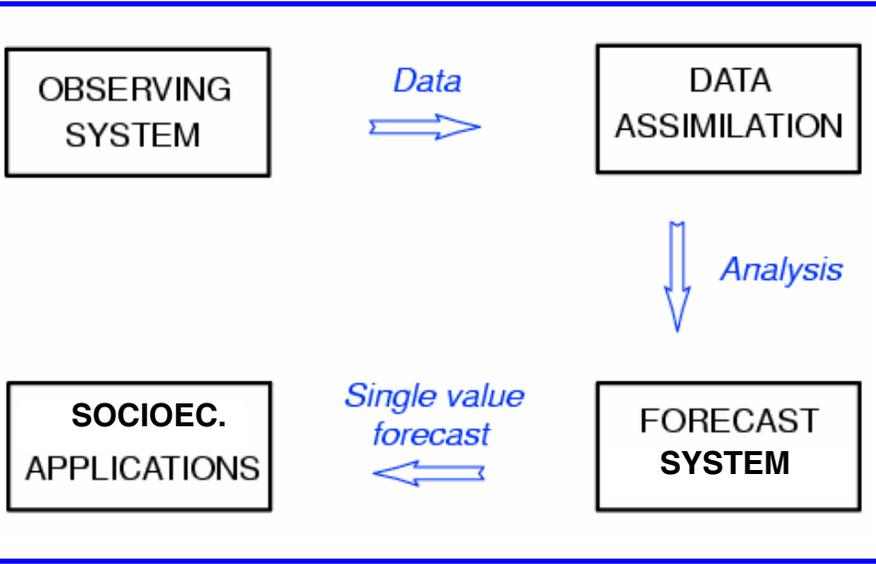
TRADITIONAL NWP

- Each discipline developed on its own
- Disjoint steps in forecast process
- Little or no feedback
- One-way flow of information
- Uncertainty in process ignored

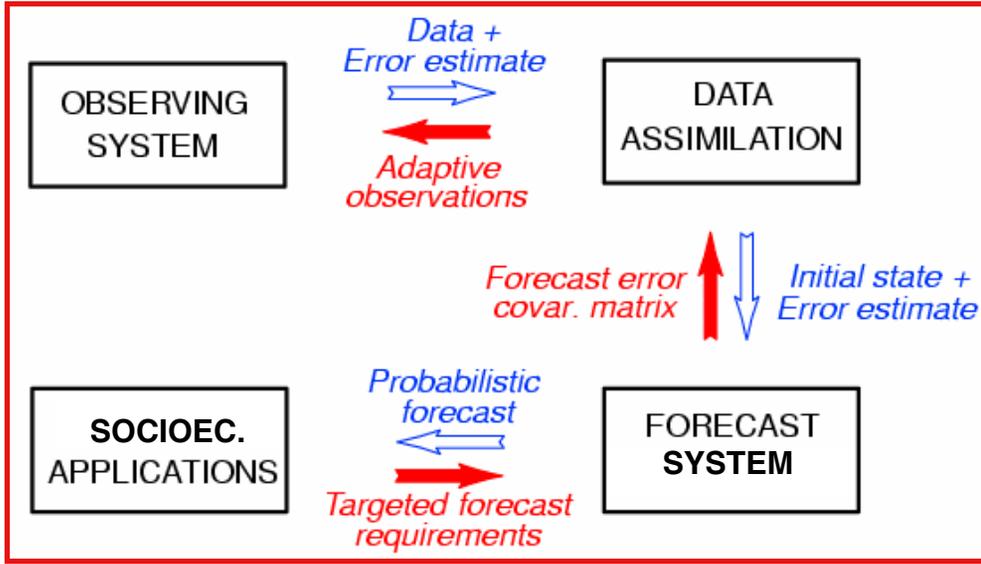
NEW NWP

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

TRADITIONAL NWP PROCESS



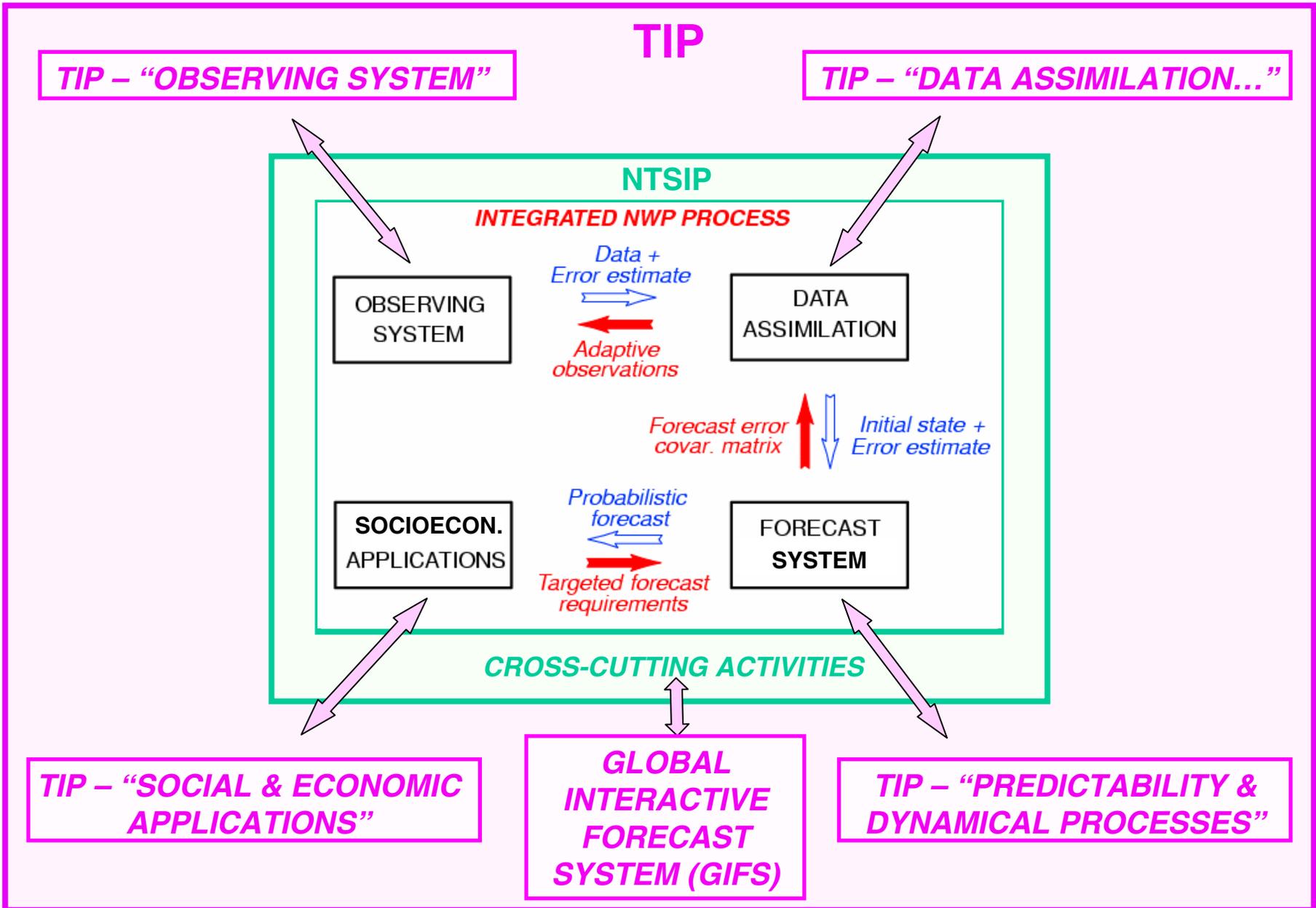
INTEGRATED NWP PROCESS



INTEGRATED, ADAPTIVE, USER CONTROLLABLE

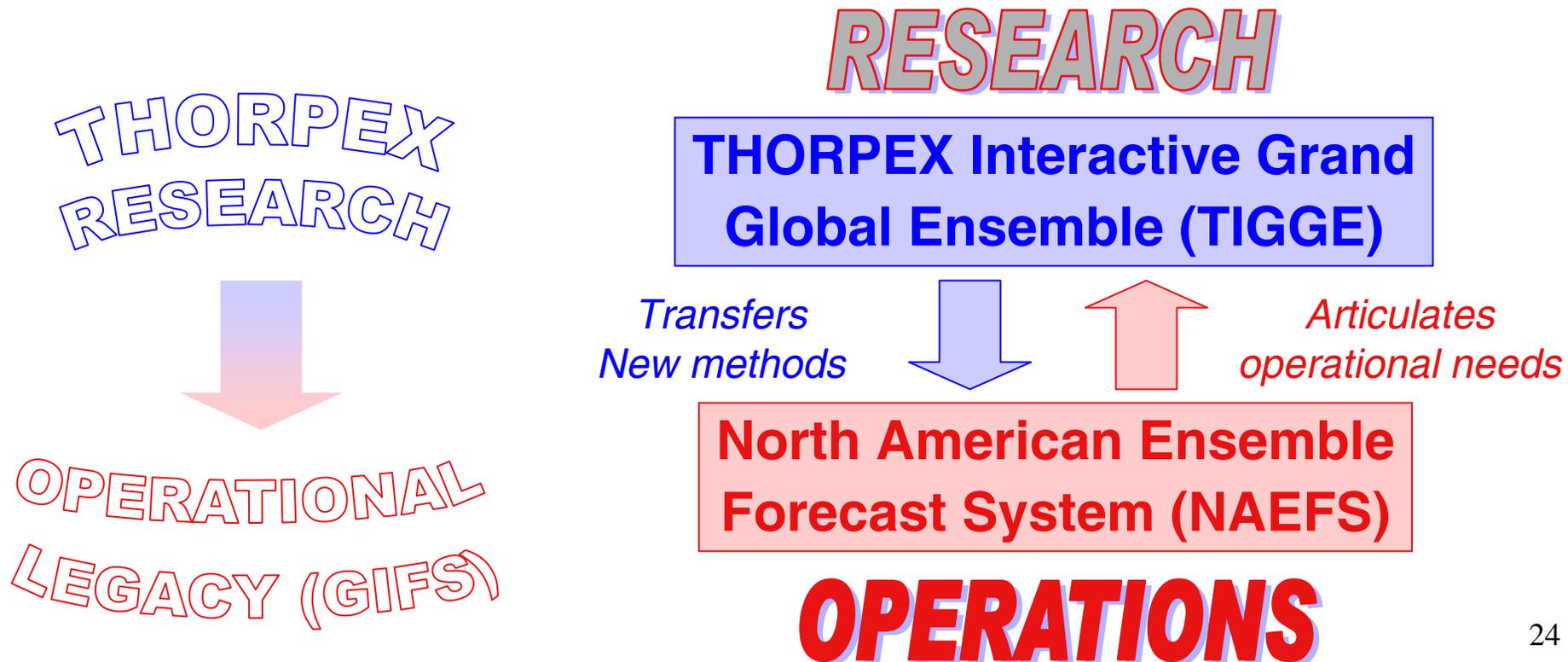
DIRECT LINK BETWEEN

NOAA THORPEX SCIENCE AND IMPLEMENTATION PLAN (NTSIP-2002) AND THORPEX INTERNATIONAL SCIENCE PLAN & THORPEX IMPLEMENTATION PLAN (TIP)



NAEFS & THORPEX

- Expands international collaboration
 - Mexico joined in November 2004
 - UK Met Office to join in 2006
- Provides framework for transitioning research into operations
 - Prototype for ensemble component of THORPEX legacy forecast system:
Global Interactive Forecast System (GIFS)



INAUGURATION CEREMONY



The National Oceanic and Atmospheric Administration
of the United States,
The Meteorological Service of Canada and
The National Meteorological Service
of Mexico

Recognizing the importance of scientific and technical international cooperation in the field of meteorology for the development of improved global forecast models;

Considering the great potential of model diversity to increase the accuracy of one to fourteen day probabilistic forecasts;

Noting the significant international cooperation undertaken to develop and implement an operational ensemble forecast system for the benefit of North America and surrounding territories;

The signatories, hereby inaugurate the North American Ensemble Forecast System at Camp Springs, Maryland, USA, on this 16th Day of November 2004.

Ray Cline, Chief of Mission, USAF (PAC)
National Oceanic and Atmospheric Administration
Assistant Administrator for Weather Services

Dr. Mario Denis Escudé
Assistant Deputy Minister
Meteorological Service of Canada

Dr. Miguel Zamora
Head of Unit
National Meteorological Service of Mexico

