

OVERVIEW OF PREDICTABILITY RELATED WORK AT NCEP

Zoltan Toth

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

Acknowledgements:

Colleagues at EMC, HPC, CPC, and outside collaborators

<http://wwwt.emc.ncep.noaa.gov/gmb/ens/index.html>

OUTLINE / SUMMARY

RECENT CHANGES
CURRENT CONFIGURATION
RESEARCH / PLANS
USAGE NOTES

For

- **GLOBAL ENSEMBLE FORECAST SYSTEM**
 - 4 times per day, increased resolution from Dec. 2003
 - North American Ensemble Forecast System
- **REGIONAL ENSEMBLE FORECAST SYSTEM**
 - Multiple model versions
- **COUPLED OCEAN-ATMOSPHERE FORECAST SYSTEM**
 - New coupled model, experiments with bred vectors
- **WINTER STORM RECONNAISSANCE PROGRAM**
 - Operational program to adaptively collect observations
 - THORPEX connection – similar concept tested in Atlantic Regional Campaign

NCEP GLOBAL ENSEMBLE FORECAST SYSTEM

R. Wobus, Y. Zhu

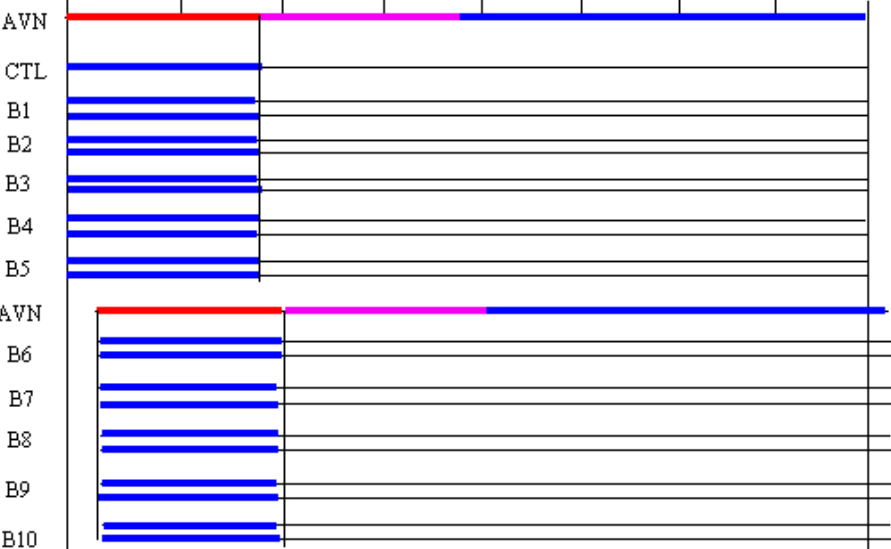
RECENT UPGRADE (Apr. 2003)

10/50/60% reduction
in initial perturbation size over
NH/TR/SH

CURRENT SYSTEM

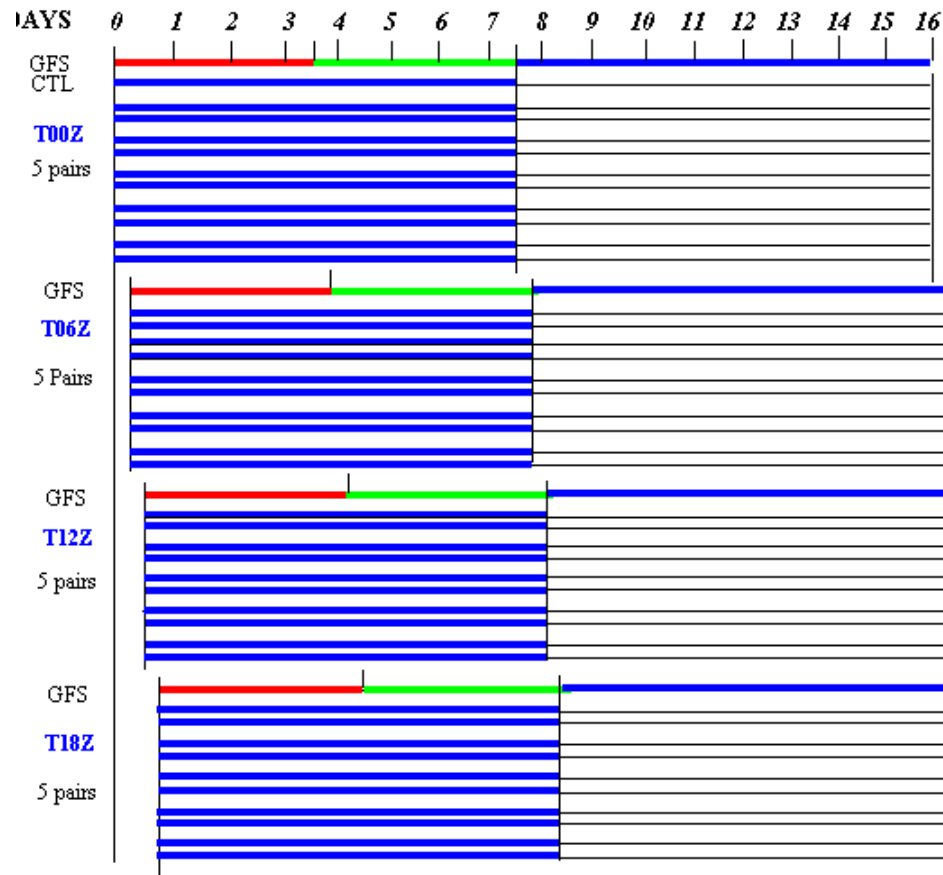
— T254 L64 — T170 L42 — T126 L28 — T62 L28

DAYS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16



NEW CONFIGURATION DECEMBER 2003

— T254 L64 — T170 L42 — T126 L28 — T62 L28

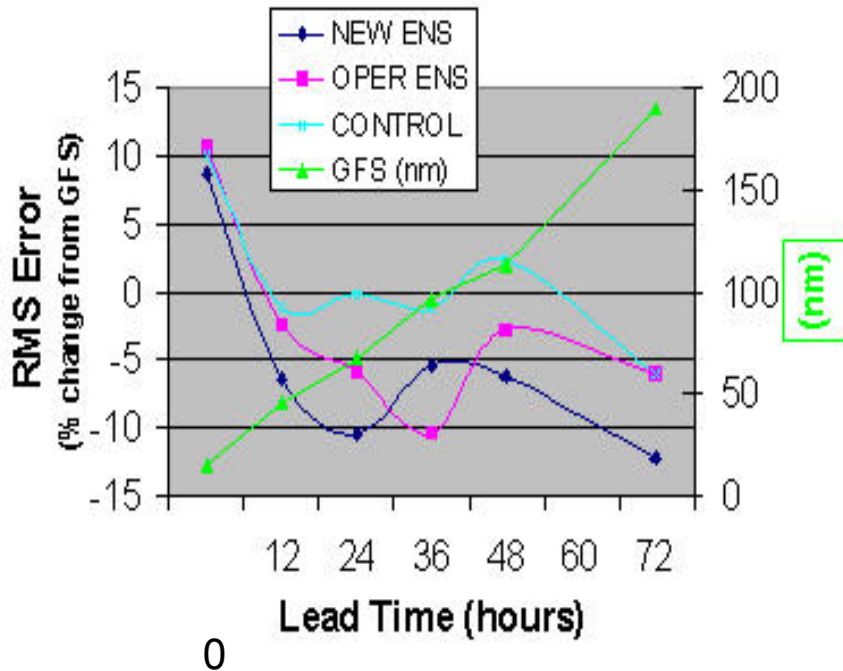


TROPICAL STORM TRACK ERRORS

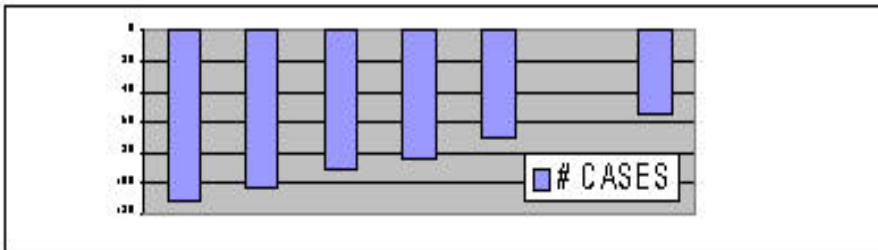
T. Marchok

RECENT UPGRADE

Tested for Aug 24 – Sept 30 2002



- 1) Ensemble mean error lower than GFS hires control
- 2) New reduced initial amplitude improves performance
- 3) SH scores greatly improved



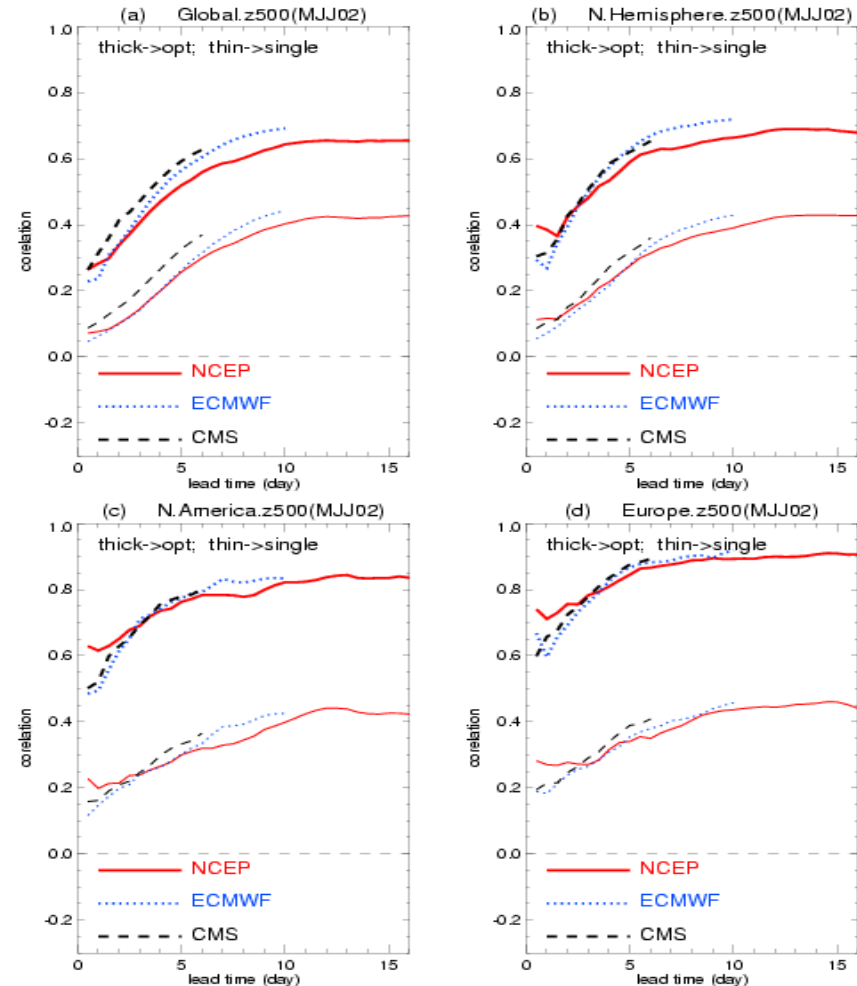
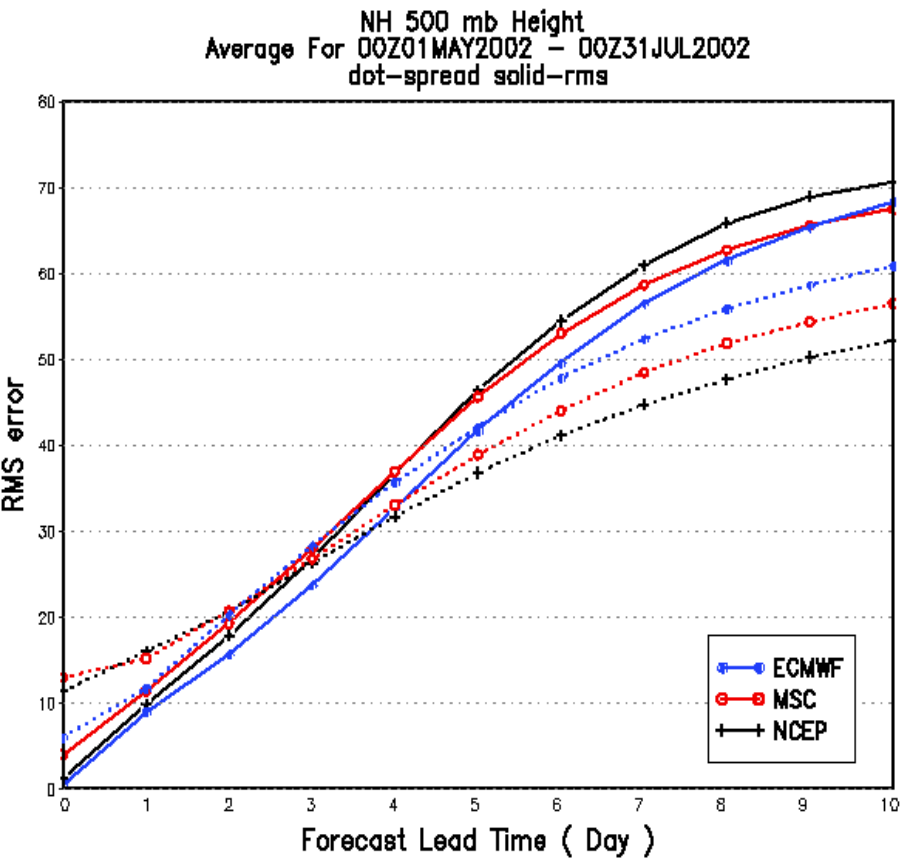
3-WAY INTERCOMPARISON: RESEARCH ECMWF, MSC, NCEP

Buizza, Houtekamer et al.

LESSONS LEARNT FOR NCEP

*Growth of spread is too low =>
Need for stochastic perturbations*

*Orthogonalization of perturbations may help =>
Apply ETKF for generating perturbations*



USE ETKF FOR RESCALING BRED PERTURBATIONS

Wei, based on Bishop & Wang

ADVANTAGES COMPARED TO CURRENT REGIONAL RESCALING:

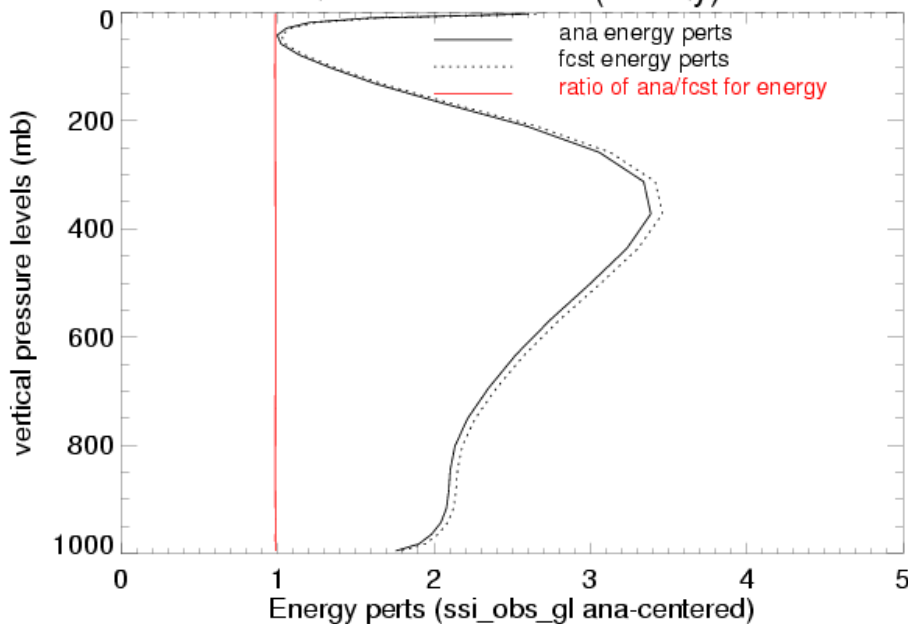
- 1) Effect of actual obs. error/locations considered
- 2) Orthogonalization of initial perturbations
- 3) 6-hr cycling
- 4) Can be further developed into DA scheme

VERTICAL DISTRIBUTION OF TOTAL ENERGY

Reflects combined effect of

- Atmospheric instabilities and
- Observation locations/errors

ave 0115-0215/03 (32-day)

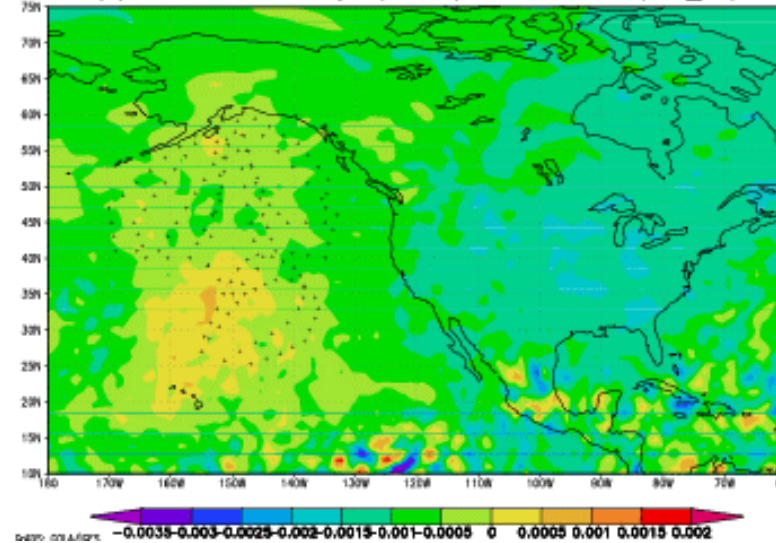


HORIZONTAL DISTRIB. OF WIND

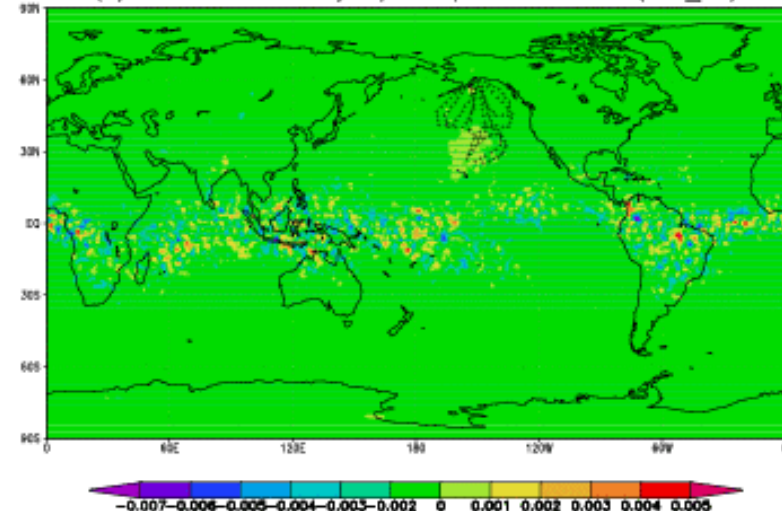
When ~20 dropsondes considered
7-Case WSR average initial spread

Reflects reduced uncertainty in IC

(d) vertical ave analysis/fcst perts for Wind (obs_GL)



(d) vertical ave analysis/fcst perts for Wind (obs_GL)

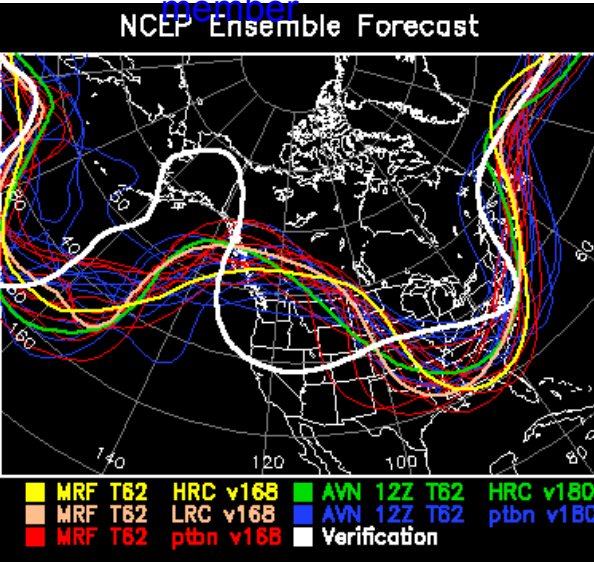


EXAMPLE WHERE MODEL MAY HAVE FAILED D. Hou, Y. Zhu

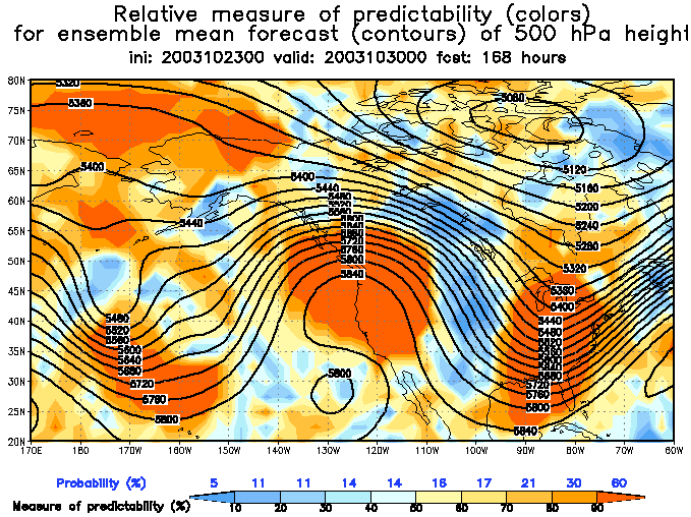
STOCHASTIC PERTURBATIONS NEEDED TO:

- 1) Increase growth of spread;
- 2) Avoid problems like below

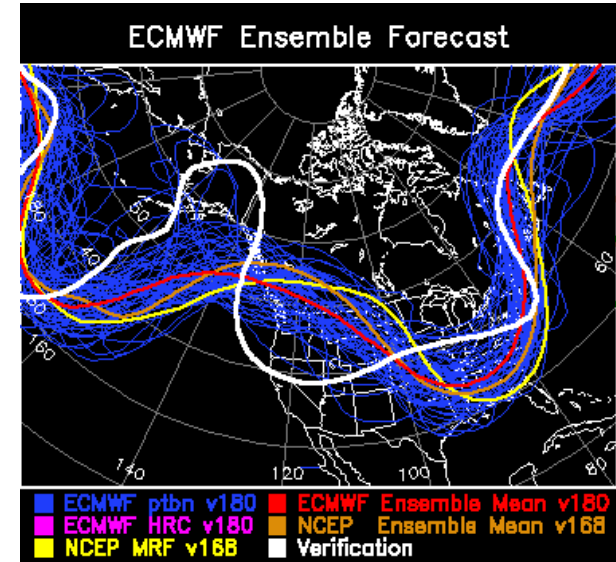
Day 7, 0 member



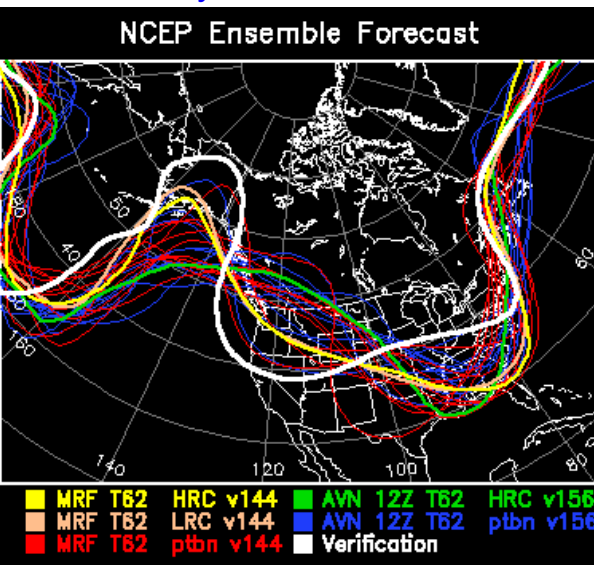
Day 7, overconfidence?



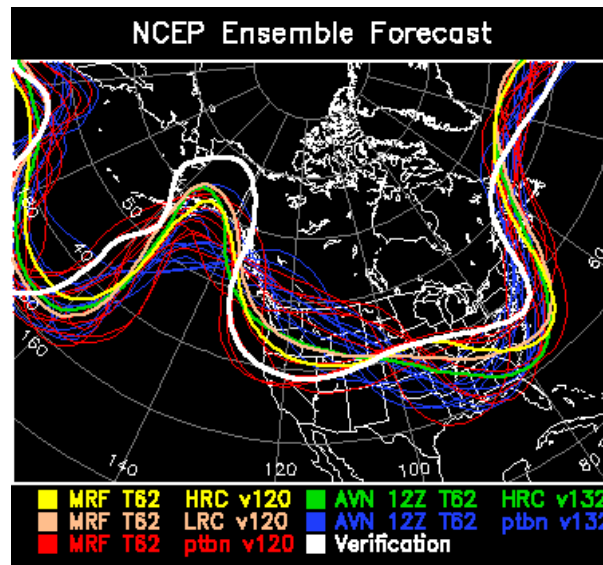
Day 7.5, 1 member?



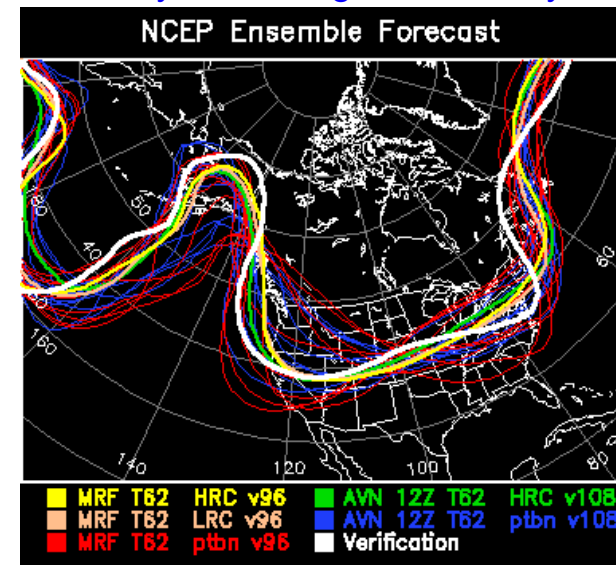
Day 6, 2 members



Day 5, several members



Day 4, still large uncertainty

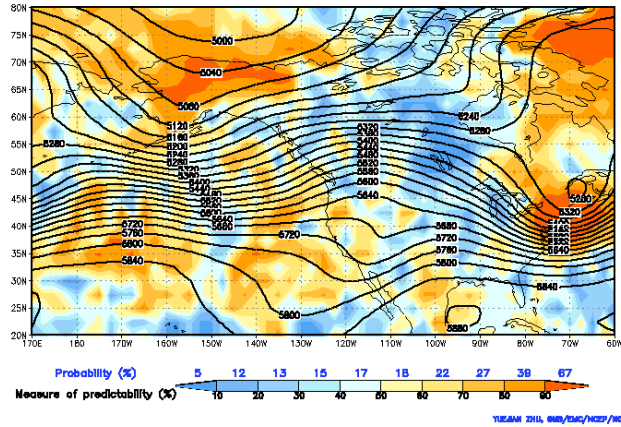


PRODUCTS

Y. Zhu

RELATIVE MEASURE OF PREDICTABILITY, GLOBAL

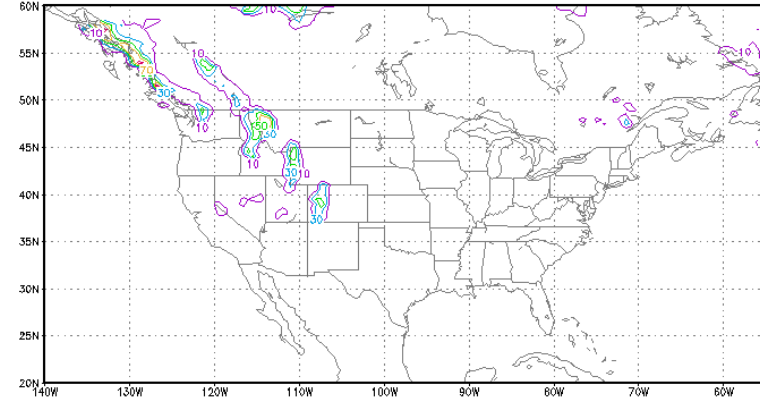
Relative measure of predictability (colors)
for ensemble mean forecast (contours) of 500 hPa height
ini: 2003110800 valid: 2003111400 feet: 144 hours



B. Zhou

SNOWFALL, REGIONAL Winter Weather Experiment

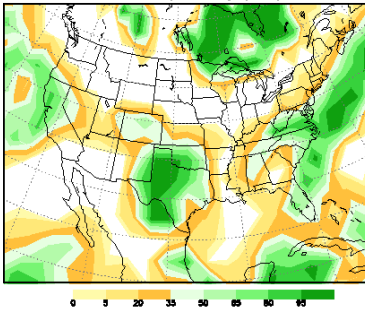
COM Prob 12h-snow > 1" 60H fcst from 09Z 08 NOV 2003
verifying time: 21z, 11/10/2003



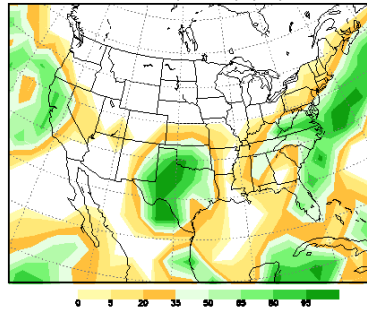
PRECIPITATION TYPE, GLOBAL ENSEMBLE

Ensemble Probability Forecast (Initial: 2003110600)
>0.254mm

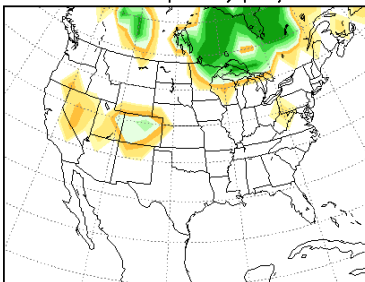
30-36 hrs probability (total)



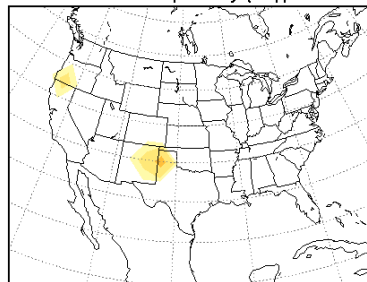
30-36 hrs probability (rain)



30-36 hrs probability (snow)

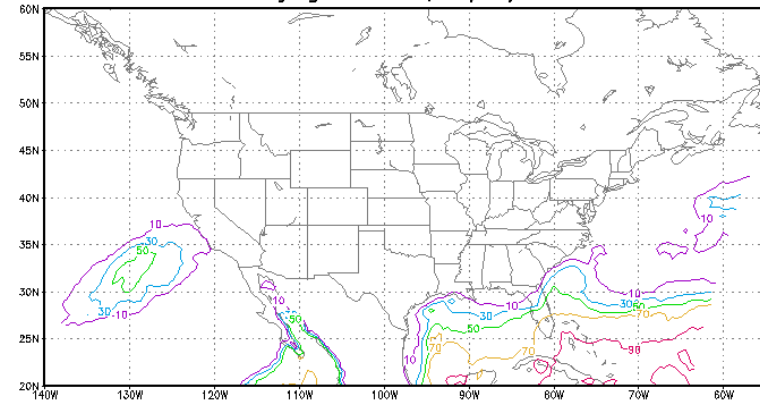


30-36 hrs probability (fr+fp)



CAPE, REGIONAL Severe Storms, Aviation

COM Prob CAPE > 500 J/kg 60H fcst from 09Z 08 NOV 2003
verifying time: 21z, 11/10/2003



3-WAY INTERCOMPARISON: CPC OPERATIONS

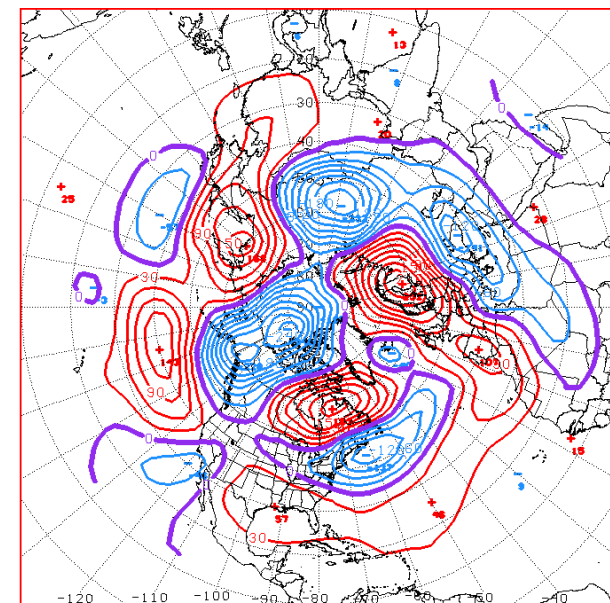
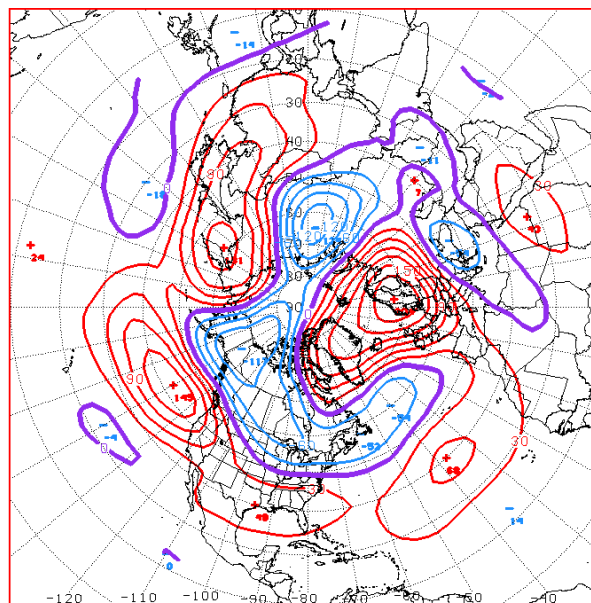
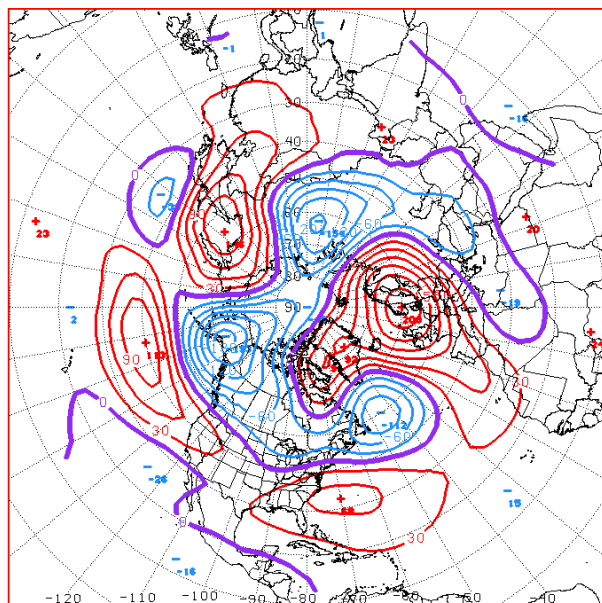
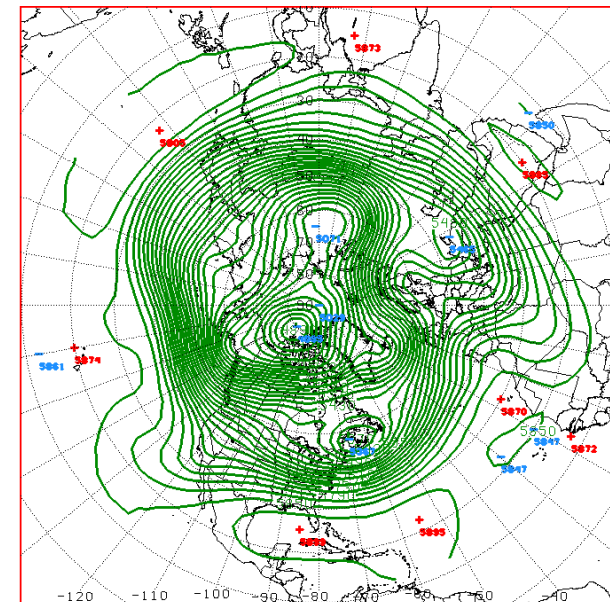
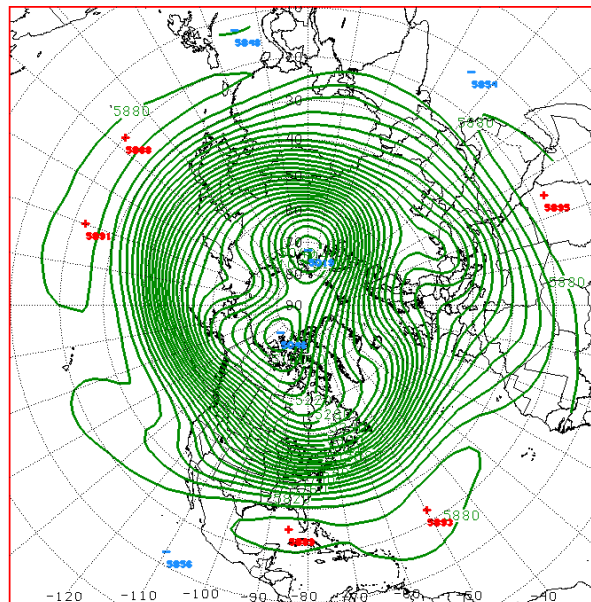
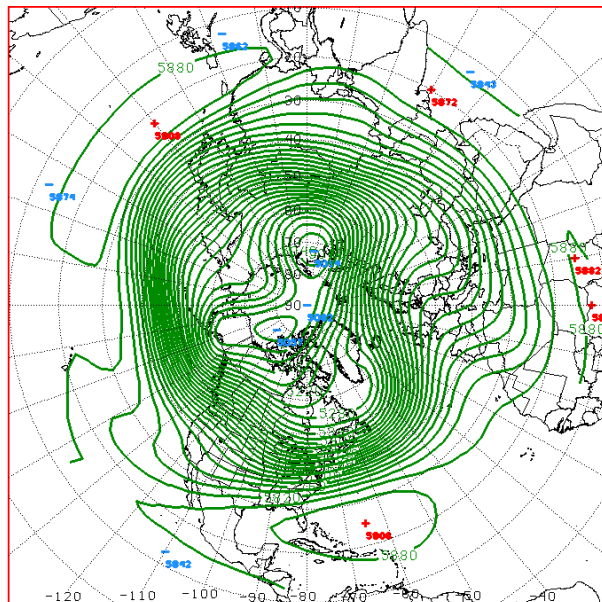
500 hPa height ensemble mean and climate anomaly

R. Schechter
K. Pelmann

ECMWF

NCEP

MSC



0+8 ECMW 500MB 50 MEAN FCST
CPC MAP MADE NOVEMBER 07 2003 CNTD 2003/11/14

0+8 CNRM 500MB 50 MEAN FCST
CPC MAP MADE NOVEMBER 07 2003 CNTD 2003/11/15

0+8 02 GFS 500MB 50 MEAN FCST
CPC MAP MADE NOVEMBER 07 2003 CNTD 2003/11/15

0+8 ECMW 500MB 50 MEAN FCST DNS
CPC MAP MADE NOVEMBER 07 2003 CNTD 2003/11/14

0+8 CNRM 500MB 50 MEAN FCST DNS
CPC MAP MADE NOVEMBER 07 2003 CNTD 2003/11/15

0+8 02 GFS 500MB 50 MEAN FCST DNS
CPC MAP MADE NOVEMBER 07 2003 CNTD 2003/11/15

Two independently developed systems combined, using different:

Analysis techniques

Initial perturbations

Models

Joint ensemble may capture new aspects of forecast uncertainty

Procedures / software can be readily applied on other ensembles:

ECMWF

JMA

FNMOOC, etc

Basis for future multi-center ensemble

Collaborative effort

Broaden research scope -

Enhanced quality

Share developmental tasks -

Increased efficiency

Seamless operational suite -

Enhanced product utility

Framework for future technology infusion (MDL, NOAA Labs, Univs¹)

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

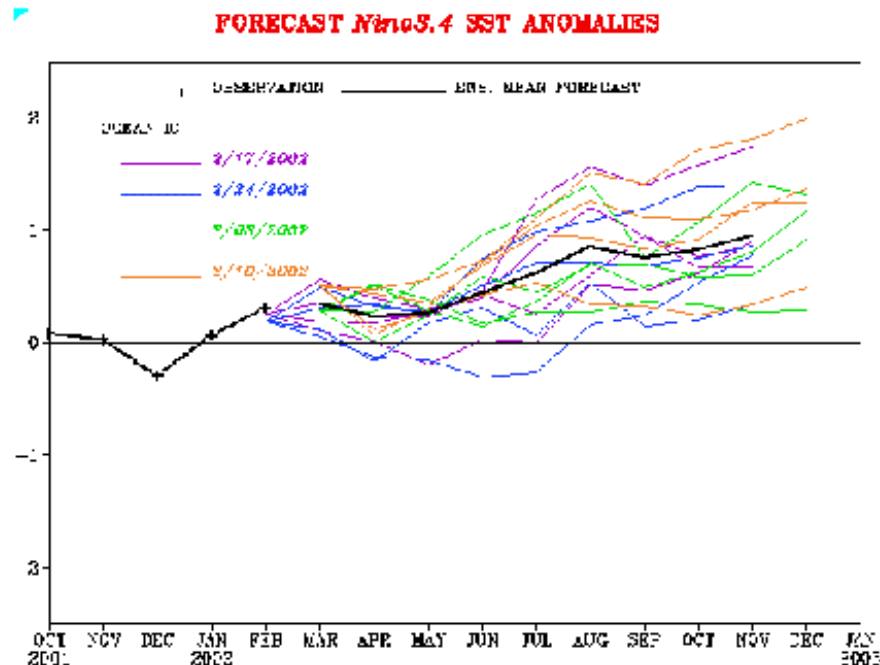
Example: North American Ensemble Forecast System (NAEFS)

BRIDGING THE GAP BETWEEN WEATHER AND CLIMATE

CURRENT NWS PRACTICE

2) "CLIMATE" ENSEMBLE:

- a) 12-months coupled ocean-atm fcsts
- b) Average the SST fcsts



- c) Run AGCM ensemble forced by average SST fcst

STRENGTH:

Ensemble approach used both for coupled and AGCM model fcsts
for enhancing (weak) signal

SHORTCOMINGS:

- a) Coupled ensemble (lagged fcst) perturbations not optimal
- b) Uncertainty information related to SST fcst is discarded
- c) Initial condition information from atmosphere not used

BRIDGING THE GAP BETWEEN WEATHER AND CLIMATE

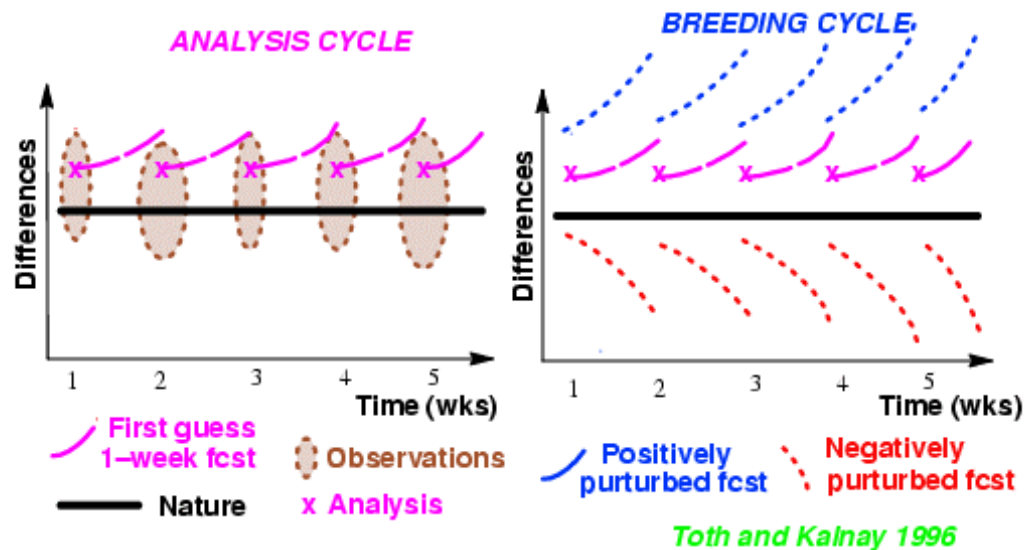
PLANS

3) POSSIBLE FUTURE SYSTEM:

“WEATHER AND CLIMATE” ENSEMBLE?

COUPLED MODEL ENSEMBLE –

Use dynamically constructed perturbations



- Nonlinear bred perturbations capture dominant ENSO instability*
- Initial error present in analysis dominated by same instability*
- Symmetrically placed perturbed fcsts provide optimal ensemble*

AGCM ENSEMBLE – PART OF COUPLED SYSTEM?

- Use ensemble SST fcsts as various boundary scenarios
- Single set of AGCM fcsts for all time ranges (*D1-climate*)

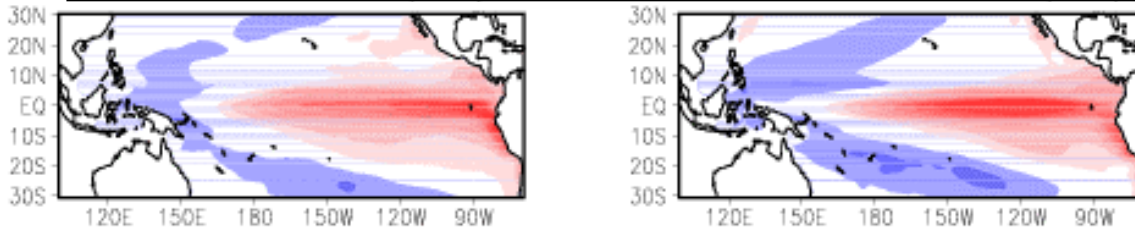
ONE-TIER SYSTEM – If possible, with coupled ocean model

NEW NCEP COUPLED MODEL

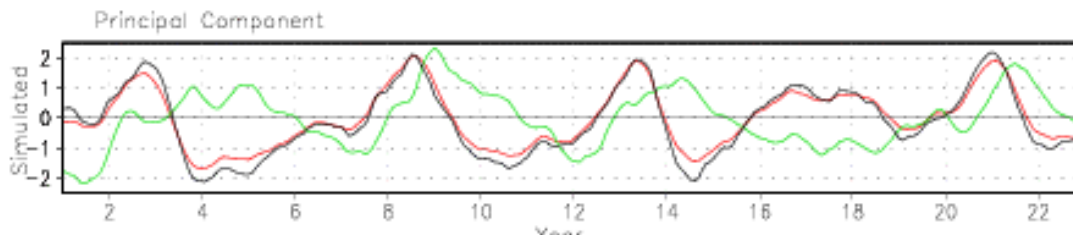
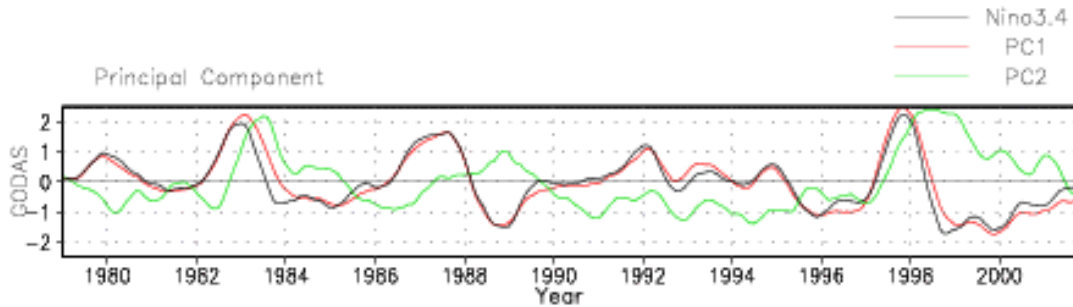
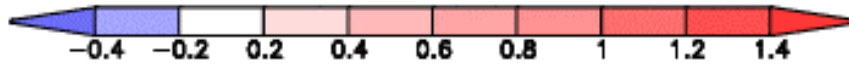
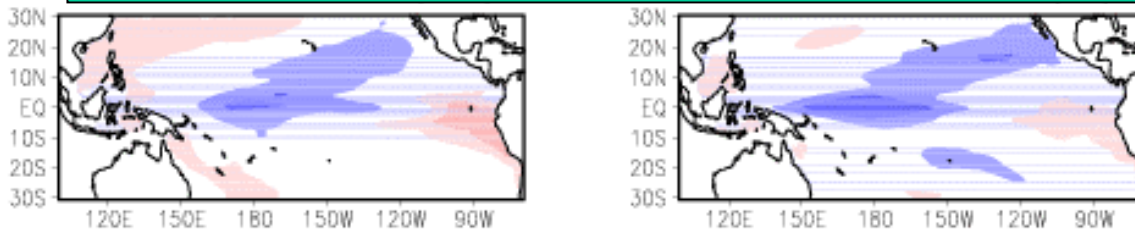
T62L64 AGCM + modified MOM3

J. Wang et al.

EOF1



EOF2



NEW NCEP COUPLED MODEL

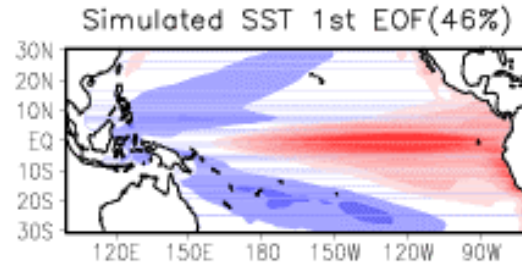
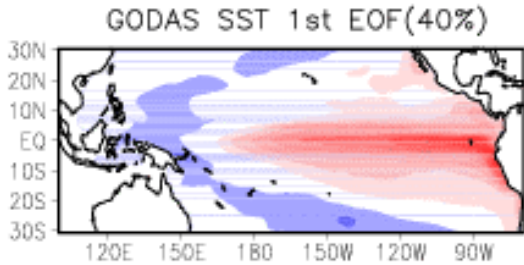
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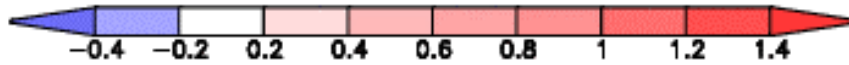
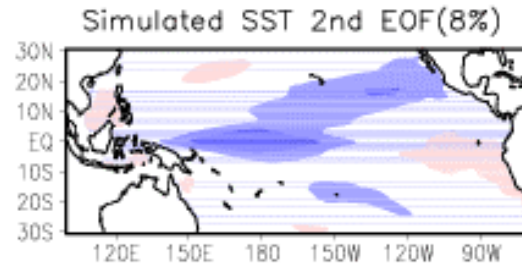
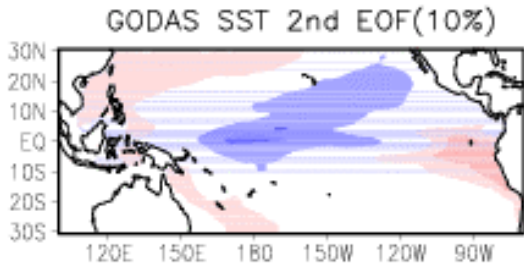
ANALYZED

SIMULATED

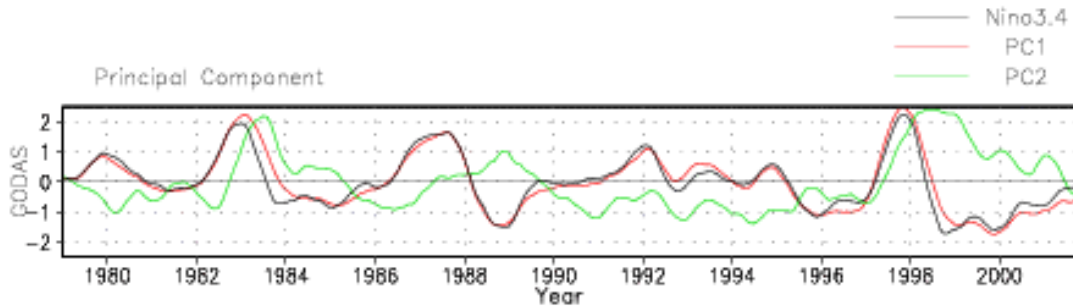
EOF1



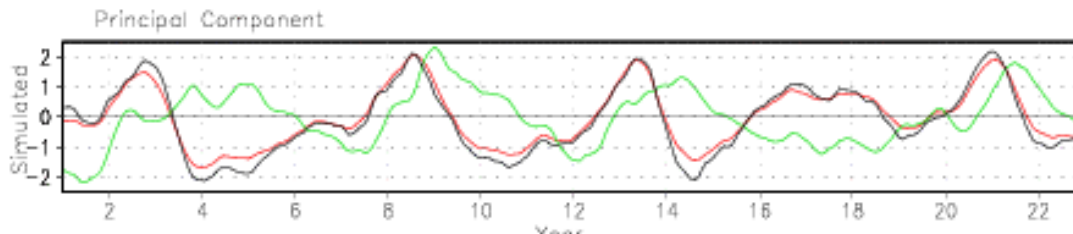
EOF2



ANALYZED



SIMULATED



PREDICTABILITY EXPERIMENTS WITH COUPLED MODEL G. Yuan

*EOFs of long model run
Simulated ENSO variab.*

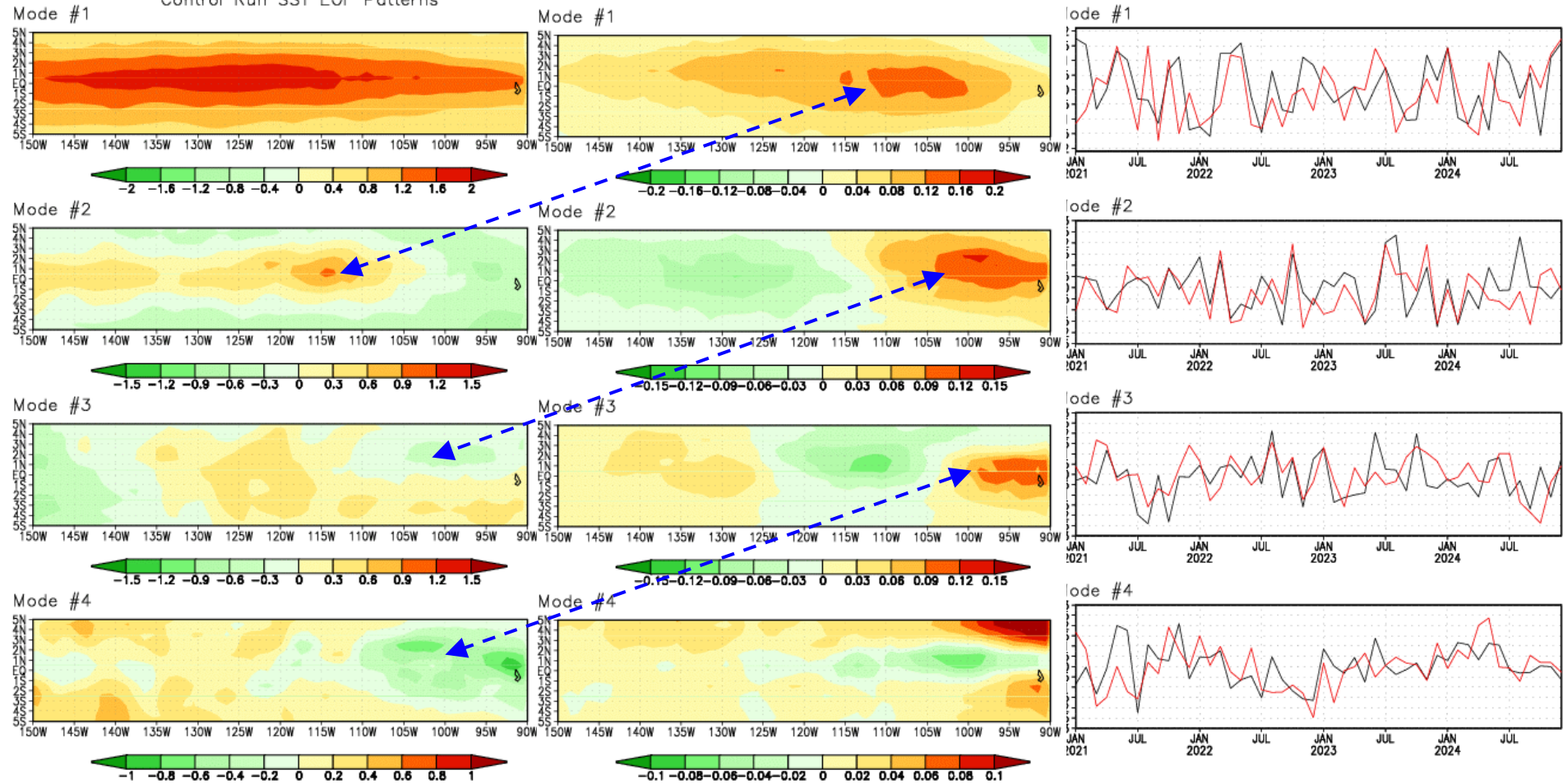
*EOFs of bred vectors
Instabilities (at gradients)*

*EOF timeseries of 2 BVs
~3-4 degrees of freedom*

Composite of bred vector SST EOF patterns

Composite of bred vector SST Principle Components

Control Run SST EOF Patterns



NCEP SHORT-RANGE ENSEMBLE FORECAST SYSTEM

(SREF) J. McQueen, J. Du, B. Zhou, B. Ferrier

OPERATIONAL SYSTEM

- 15 Members out to 63 hrs
- 2 versions of ETA & RSM
- 09 & 21 UTC initialization
- NA domain
- 48 km resolution
- Bred initial perturbations
- Products (on web):
 - Ens. Mean & spread
 - Spaghetti
 - Probabilities
 - Aviation specific
- Ongoing training

PLANS

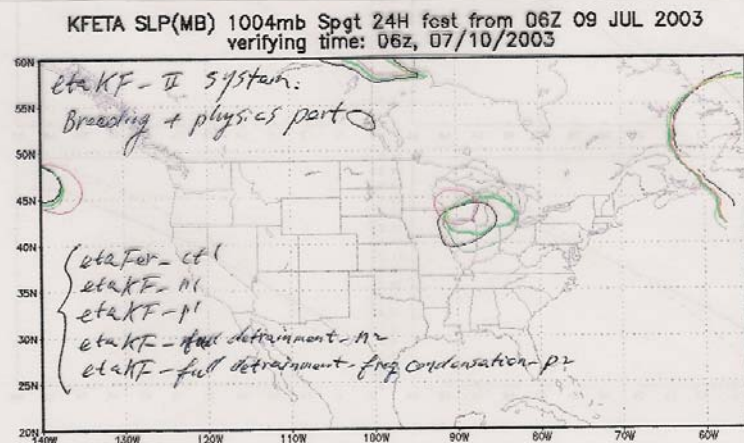
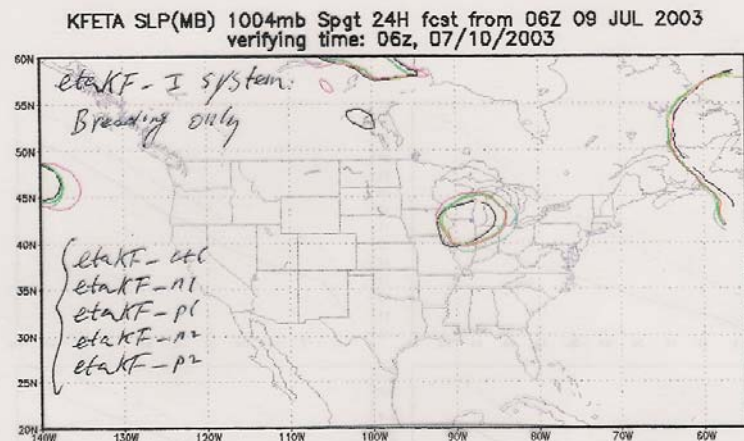
- *More model diversity -
5+2 model versions*
- *4 cycles per day (3&15 UTC)*
- *32 km resolution*
- *New products*
 - *Aviation*
 - *AWIPS*
 - *Winter Weather Exper.*
- *Transition to WRF*

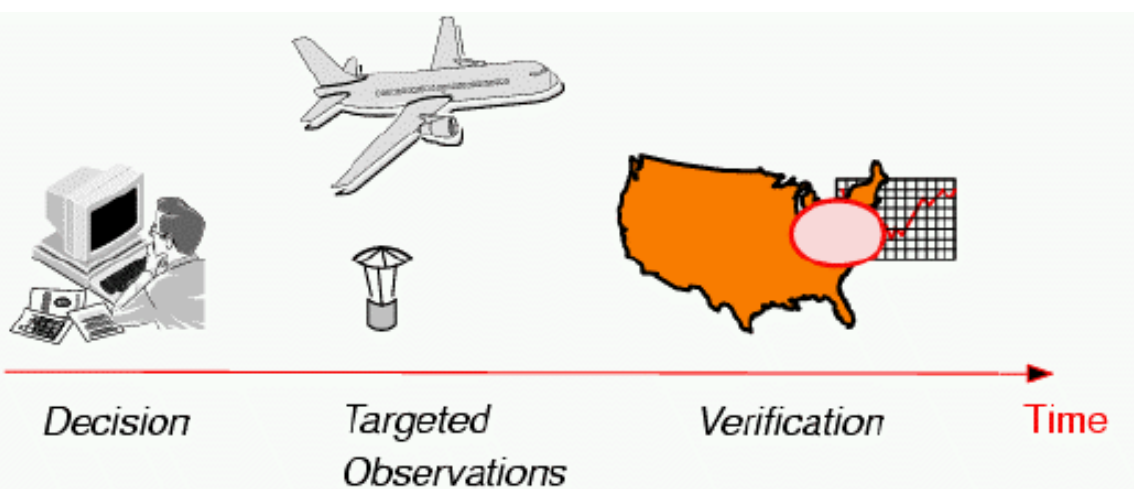
NCEP SHORT-RANGE ENSEMBLE FORECAST SYSTEM (SREF) J. Du

Parallel SREF Systems (32km)

<i>IC ensemble (SREF_I)</i>		<i>physics ensemble (SREF_II)</i>
eta_bmj_ctl	-->	same
eta_bmj_n1	-->	same
eta_bmj_p1	-->	same
eta_bmj_n2	-->	eta_ras_n2
eta_bmj_p2	-->	eta_ras.mic_p2
rsm_sas_ctl	-->	same
rsm_sas_n1	-->	same
rsm_sas_p1	-->	same
rsm_sas_n2	-->	rsm_ras_n2
rsm_sas_p2	-->	rsm_ras_p2
eta_kf_ctl	-->	eta_Fer_ctl
eta_kf_n1	-->	same
eta_kf_p1	-->	same
eta_kf_n2	-->	eta_kf_fulldetr_n2
eta_kf_p2	-->	eta_kf_fulldetr.freqcon_p2

32 km parallel SREF system





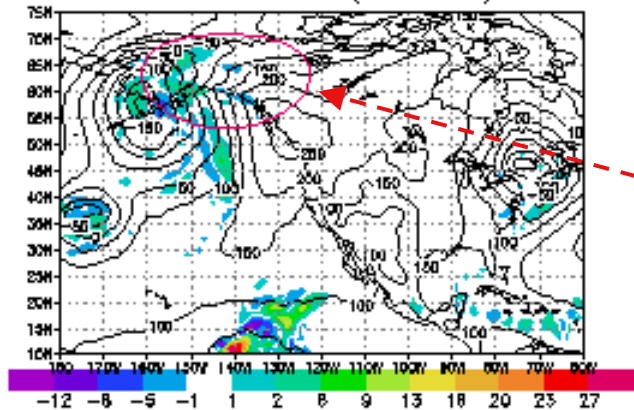
How WSR targeting happens...

1. **Targeting cases selected** in areas where critical winter weather events with high forecast uncertainty may have a potentially large societal impact.
2. **Sensitivity calculations** performed using ETKF, and a **decision** is made (flight/no flight).
3. **Observations** are taken and used in operational analysis and forecast products by major NWP centers.
4. **Verification** is performed by comparing operational analyses/forecasts including the targeted data with analyses/forecasts excluding the targeted data.

HIGH PRIORITY FLIGHT REQUEST
Alaska heavy precipitation event
Observation time: 03020300
Verification Time: 03020500
Lat: 62N
Lon: 142W

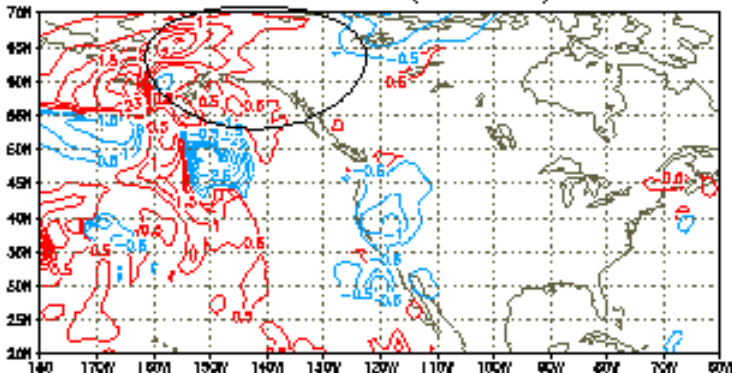
ACTUAL DATA IMPACT, PRECIP

2003020500 (+48 hrs)

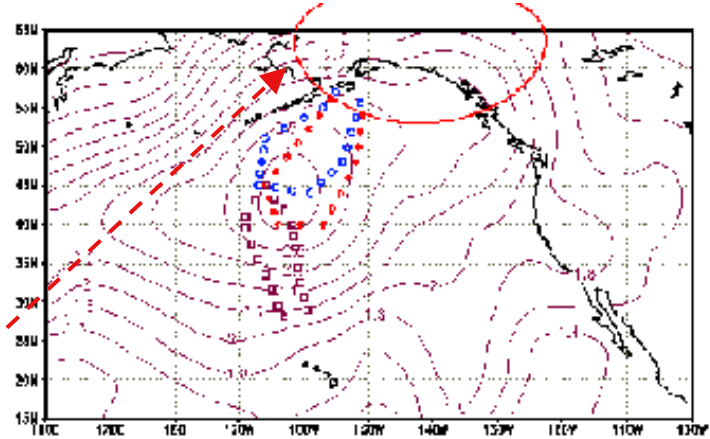


ACTUAL DATA IMPACT, SP

2003020500 (+48 hrs)



**SENSITIVE AREA,
Suggested flight tracks**

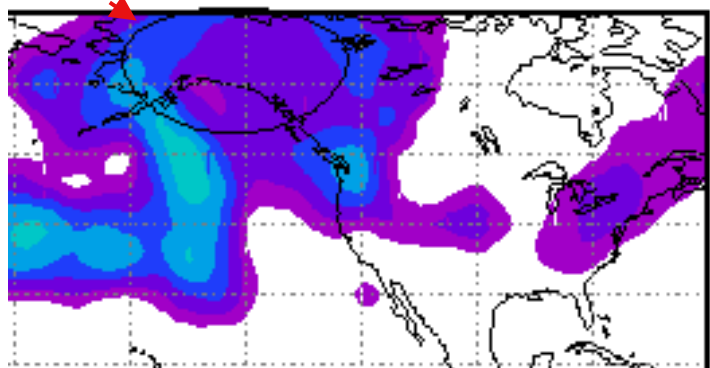


Verification region

PREDICTED DATA IMPACT

Winds at 850, 500, 250

2003020300 + 48h



Forecast
improvement
vs.
degradation

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