Overview of predictability related work at NCEP

Zoltan Toth, Environmental Modeling Center NOAA/NWS/NCEP

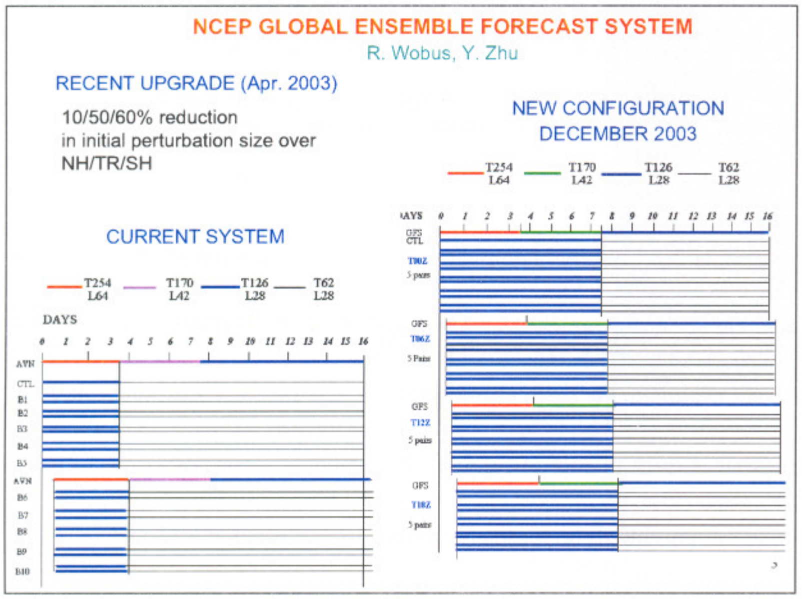
Acknowledgements

Colleagues at EMC, HPC, CPC, and outside collaboratorshttp://wwwt.emc.ncep.noaa.gov/gmb/ens/index.html

Outline / summary

Recent changes, current configuration, research / plans and 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



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)

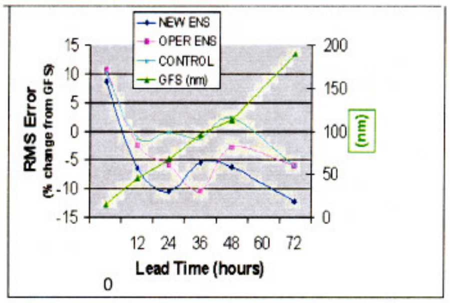
Planned activities: Ensemble data exchange (June 2004)
Research and Development (2003-2007)
- Statistical post-processing, Product development, Verification/ Evaluation
Operational implementation (2004-2008)

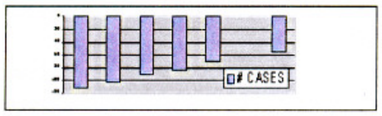
Potential project expansion / links: Shared interest with THORPEX goals of
Improvements in operational forecasts; International collaboration
Expand bilateral NAEFS in future, *Entrain broader research community,*
Multi-centre / multi-national ensemble system, MOA with Japan Meteorological Agency

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

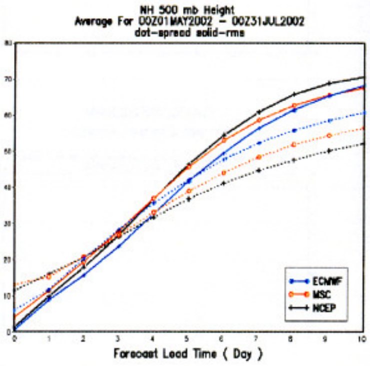
4

3-WAY INTERCOMPARISON: RESEARCH ECMWF, MSC, NCEP

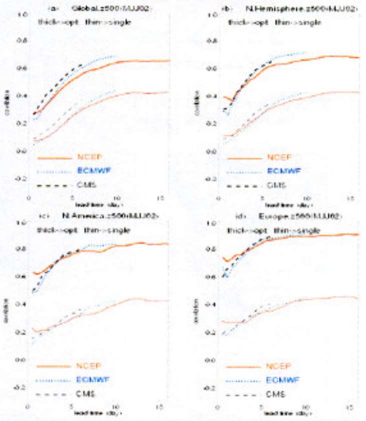
Buizza, Houtekamer et al.

LESSONS LEARNT FOR NCEP

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



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



USE ETKF FOR RESCALING BRED PERTURBATIONS

Wei, based on Bishop & Wang

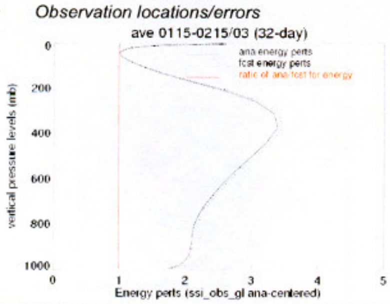
ADVANTAGES COMPARED TO CURRENT REGIONAL RESCALING:

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*

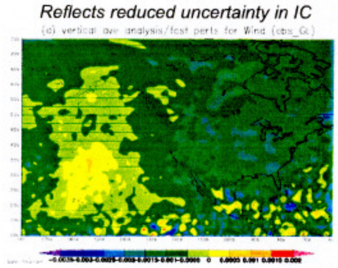


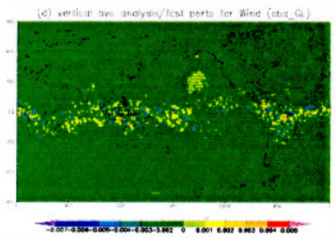
HORIZONTAL DISTRB. OF WIND

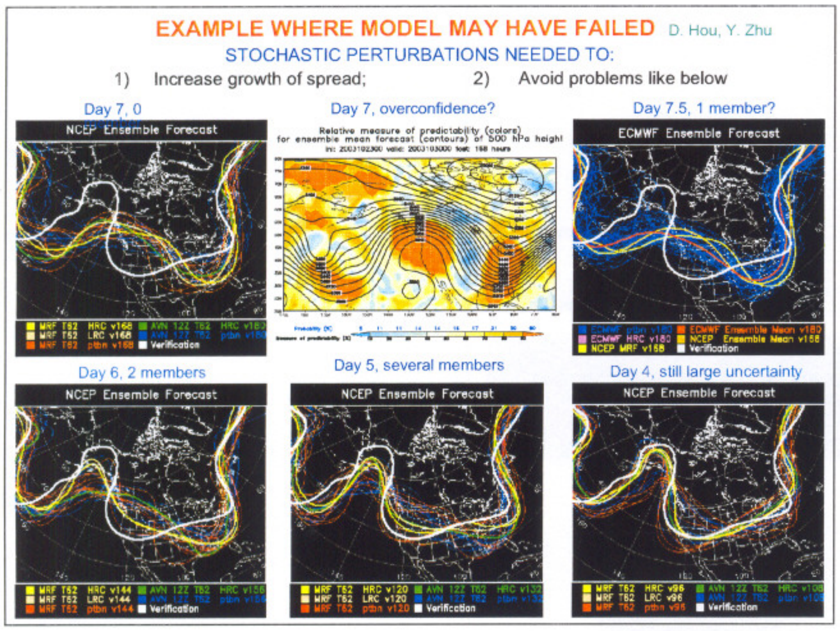
When ~20 dropsondes considered

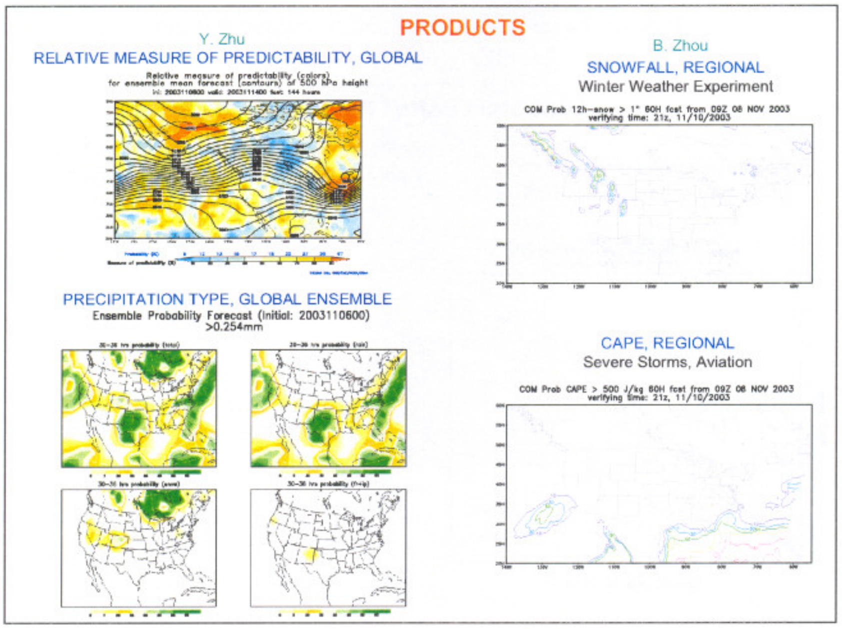
7-Case WSR average initial spread

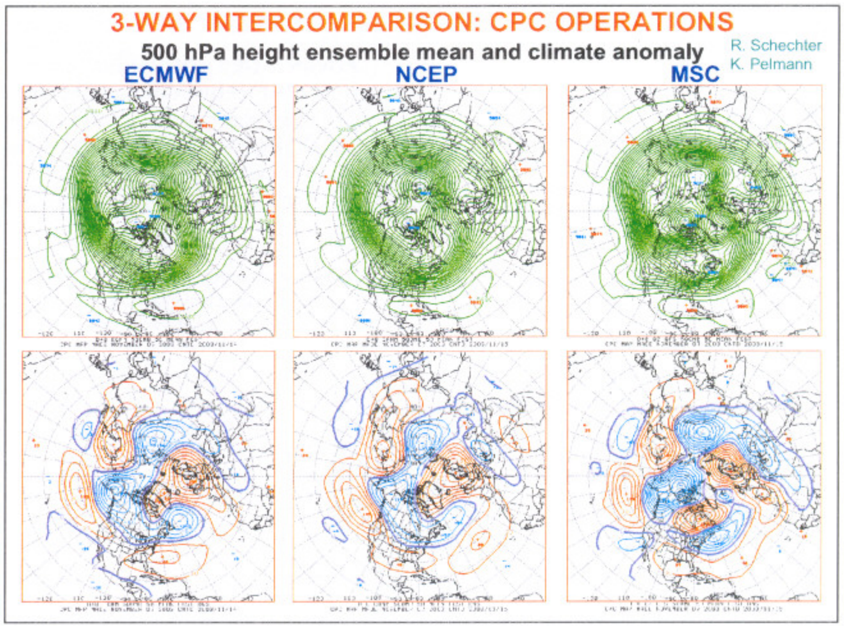
Reflects reduced uncertainty in IC






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
NCEP Ensemble Forecast
Day 7, overconfidence?
Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height
Day 7.5, 1 member?
ECMWF Ensemble Forecast
Day 6, 2 members
NCEP Ensemble Forecast
Day 5, several members
NCEP Ensemble Forecast
Day 4, still large uncertainty
NCEP Ensemble Forecast


PRODUCTS
Y. Zhu
RELATIVE MEASURE OF PREDICTABILITY, GLOBAL
Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height
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
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

NAEFS – Benefits, J.-G. Desmarais et al.

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, FNMOC, etc*

Basis for future multi-centre 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, Univs.)

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

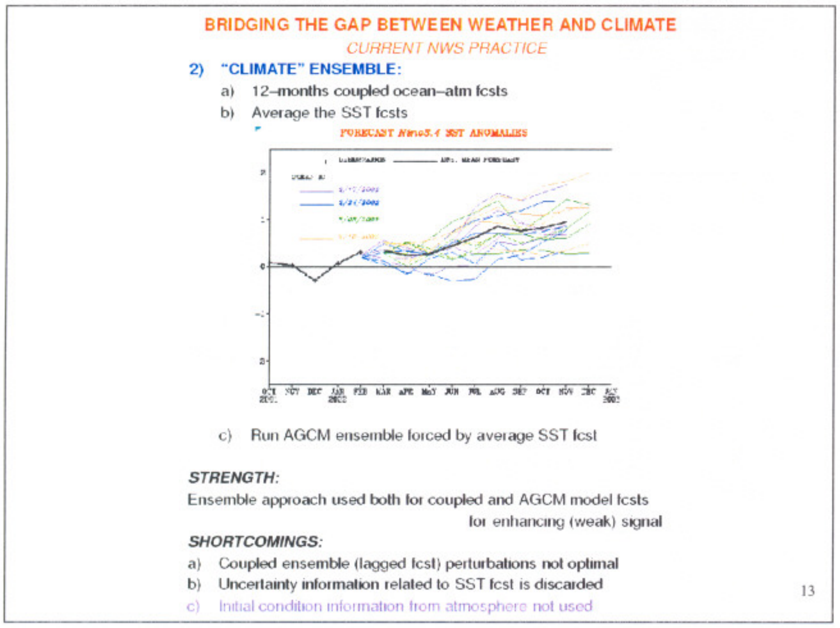
Service goal:

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

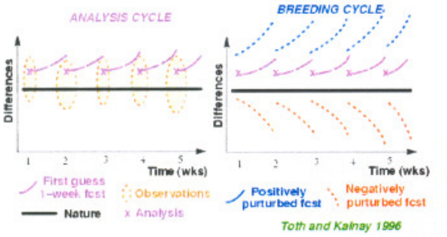
PLANS

3) POSSIBLE FUTURE SYSTEM:

"WEATHER *AND* CLIMATE" ENSEMBLE?

COUPLED MODEL ENSEMBLE –

Use dynamically constructed perturbations



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

AGCM ENSEMBLE – PART OF COUPLED SYSTEM?

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

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

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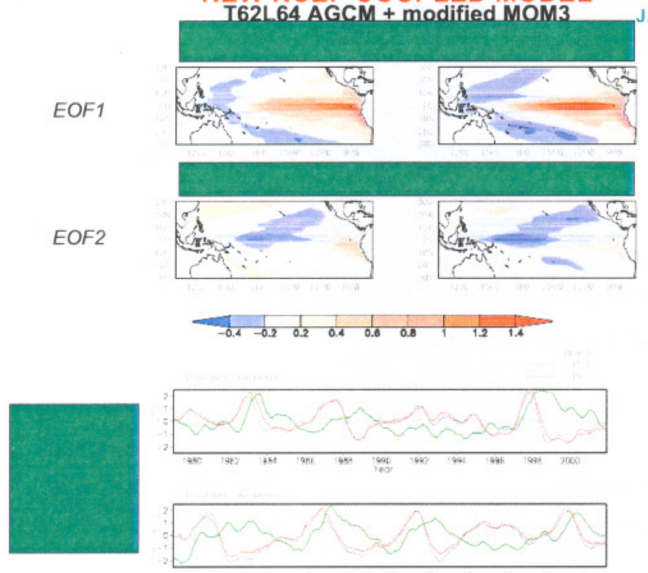
NEW NCEP COUPLED MODEL

T62L64 AGCM + modified MOM3

J. Wang et al.



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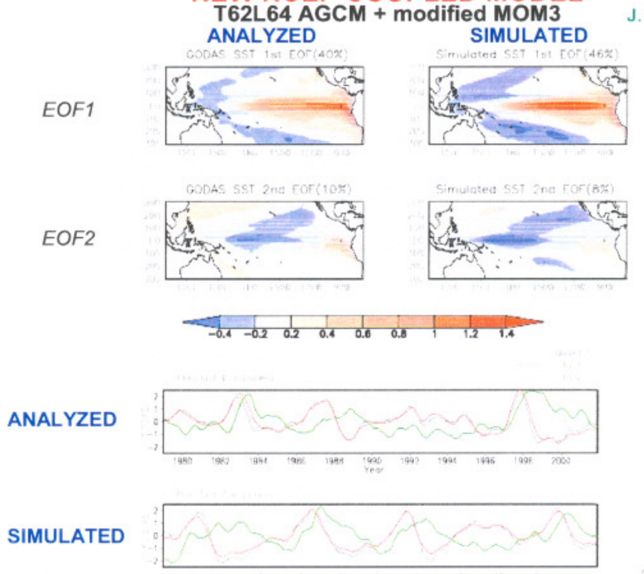

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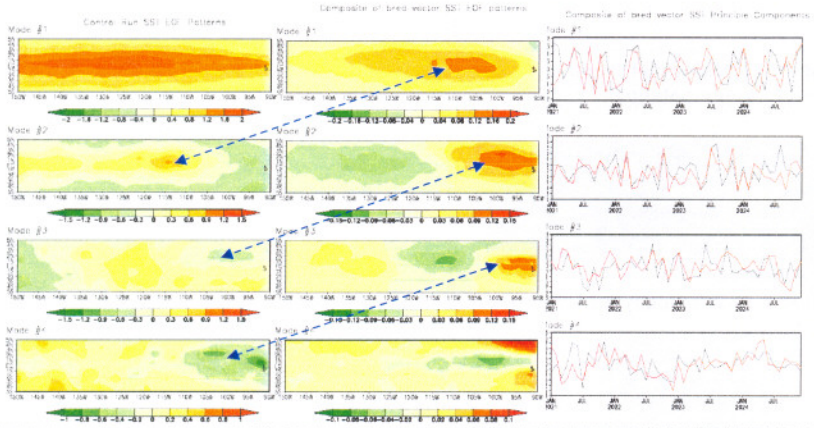
PREDICTABILITY EXPERIMENTS WITH COUPLED MODEL G. Yuan

EOFs of long model run	*EOFs of bred vectors*	*EOF timeseries of 2 BVs*
Simulated ENSO variab.	*Instabilities (at gradients)*	*~3-4 degrees of freedom*



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

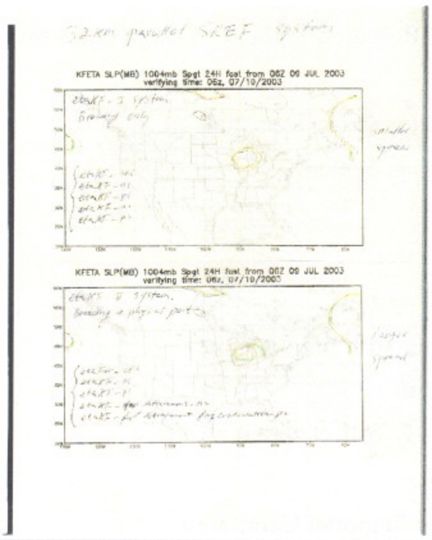
Plans

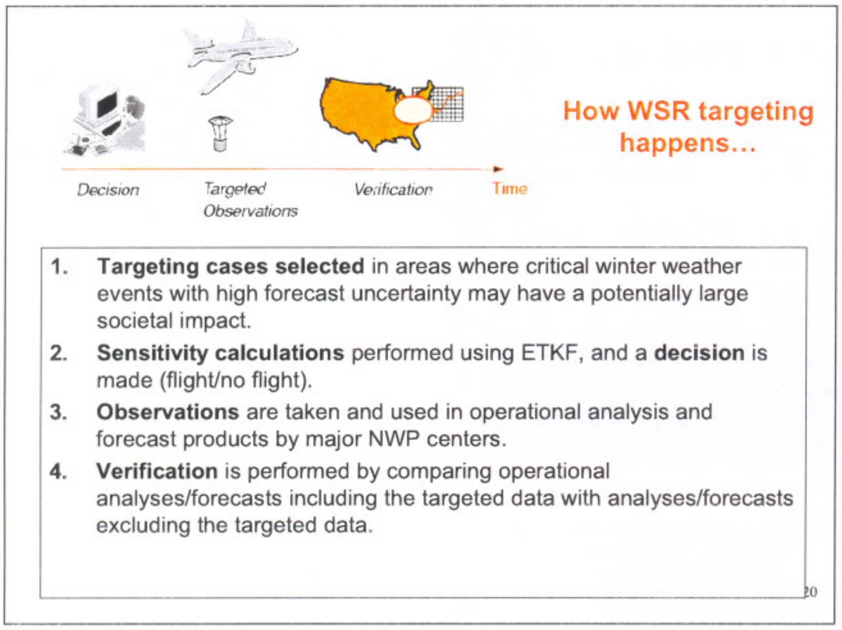
- More model diversity -5+2 model versions
- 4 cycles per day (3&15 UTC)
- 32 km resolution
- New products
- Aviation
- AWIPS
- Winter Weather Experiment
- Transition to WRF

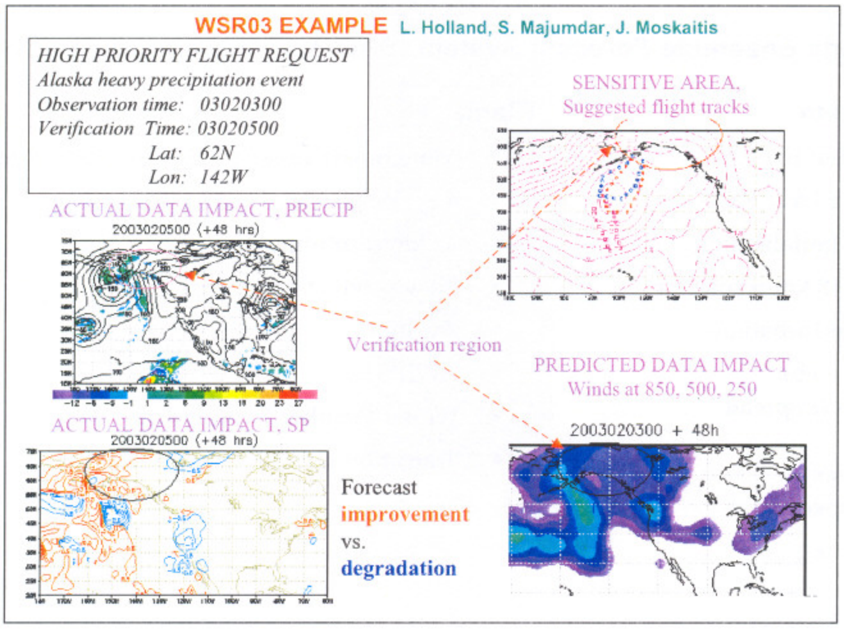
NCEP SHORT-RANGE ENSEMBLE FORECAST SYSTEM (SREF) J. Du

Parallel SREF Systems (32km)

IC ensemble (SREF_I)		*physics ensemble (SREF_II)*
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**







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NOAA POES data delivery study

Stacie Bender, Stephen Lord, Zoltan Toth

Introduction and Methodology

- Data assimilation systems rely on timely data delivery
  - NCEP Global Forecast System
    - T + 2:45 (00, 06, 12, 18 UTC)
      - *Early cycle (15 day forecast)*
    - T + 6:05 (00 UTC), T + 5:50 (06, 18 UTC), T + 8:05 (12 UTC)
      - *Late cycle (6 h forecast for Early and Late cycle background)*
  - NCEP Regional (Eta) System
    - T + 1:10 (00, 12 UTC), T + 0:50 (06, 18 UTC)
      - *Early cycle (84 h forecast)*
    - T + 10:40 (t-12 EDAS 00, 12 UTC), T + 11:20 (t-12 EDAS 06, 18 UTC)
      - *Late cycle (3 h forecast from t-12 to t-09)*
    - T + 7:40 (t-09 EDAS 00, 12 UTC), T + 8:20 (t-09 EDAS 06, 18 UTC)
      - *Late cycle (3 h forecast from t-09 to t-06)*
    - T + 4:40 (t-06 EDAS 00, 12 UTC), T + 5:20 (t-06 EDAS 06, 18 UTC)
      - *Late cycle (3 h forecast from t-06 to t-03)*
    - T + 2:00 (t-03 EDAS 00, 12 UTC), T + 2:20 (t-03 EDAS 06, 18 UTC)
      - *Late cycle (3 h forecast from t-06 to t-03 for Early and t-12 Late cycle background)*
- POES observations transmitted orbitally
- Continued user pressure to deliver forecasts earlier
- Possible earlier data delivery in NPOESS era
- Earlier data assimilation cut-off conflicts with data receipt
- This study
  - Considers POES availability at NCEP
  - Quantifies operational data receipt for various cut-off times
  - Simulates operational data preparation process
    - Retrieves POES radiances from operational data storage files
    - Duplicate checking
    - Prepares data for use in assimilation cycle

NOAA POES Observations Availability – Platforms and Instruments

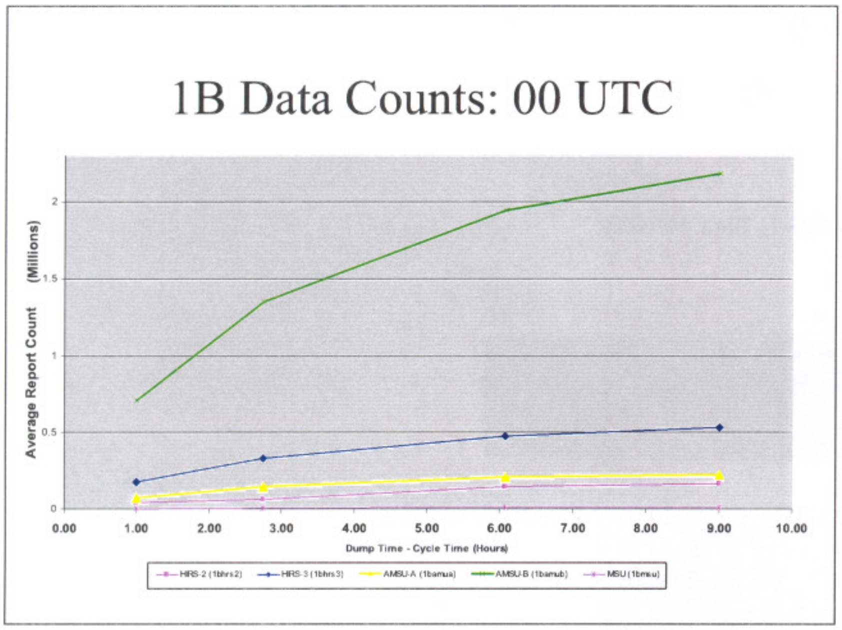
NOAA Satellite	Instrument
NOAA-14	HIRS-2 MSU
NOAA-15, 16, 17	HIRS-3 AMSU-A AMSU-B

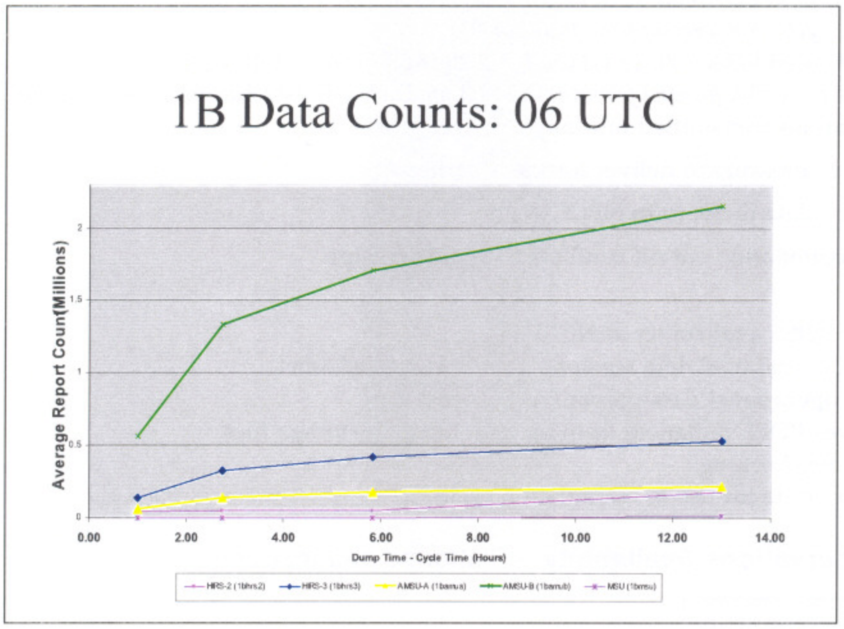
- Reported data counts for each instrument are sum of all platforms

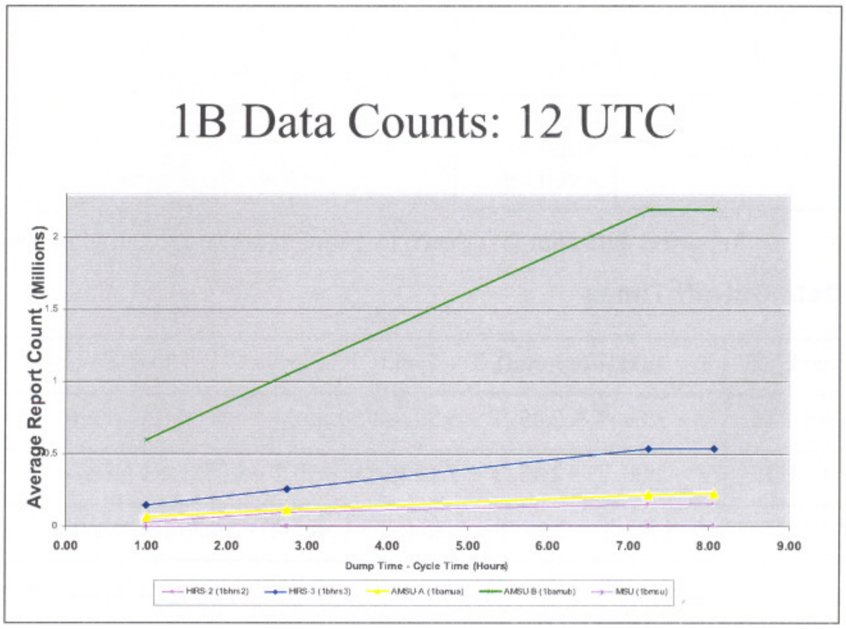
Data Cut-off Times

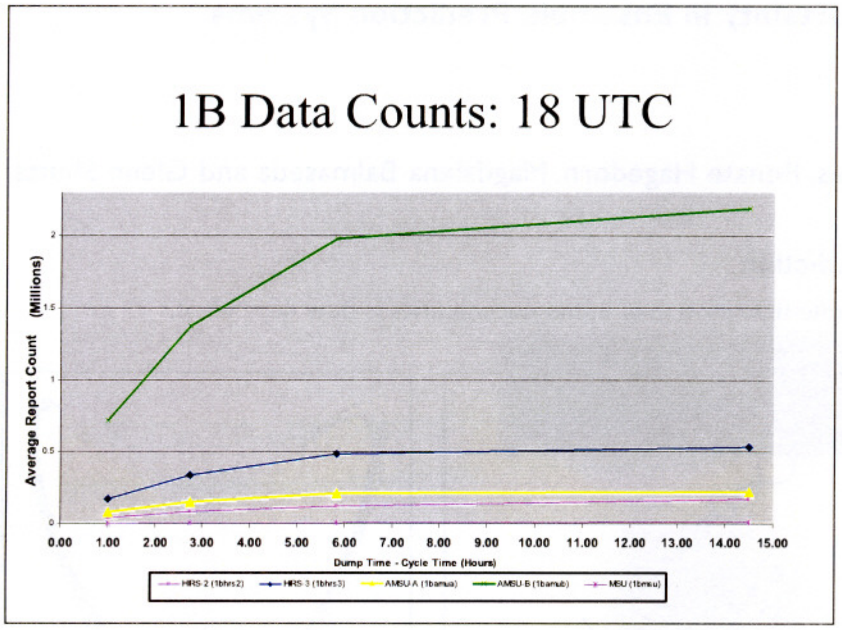
00 UTC	T + 1:00 (Regional), T + 2:45 (GFS Early), T + 6:00 (GFS Late), T + 9:00 (ECMWF)
06 UTC	T + 1:00, T + 2:45, T + 5:50 (GFS Late), T +13:00 (ECMWF)
12 UTC	T + 1:00, T + 2:45, T + 7:15 (ECMWF),T +8:05 (GFS Late)
18 UTC	T +1:00, T + 2:45, T + 5:50 (GFS Late), T + 14:30 (ECMWF)

- Data counts are one-month means except T+1:00 & ECMWF (16 days)


1B Data Counts: 00 UTC
Average Report Count (Millions)
0
0.5
1
1.5
2
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Dump Time - Cycle Time (Hours)
HIRS-2 (1bhrs2)
HIRS-3 (1bhrs3)
AMSU-A (1bamua)
AMSU-B (1bamub)
MSU (1bmsu)


1B Data Counts: 06 UTC
Average Report Count(Millions)
0
0.5
1
1.5
2
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Dump Time - Cycle Time (Hours)
HIRS-2 (1bhrs2)
HIRS-3 (1bhrs3)
AMSU-A (1bamua)
AMSU-B (1bamub)
MSU (1bmsu)


1B Data Counts: 12 UTC
Average Report Count (Millions)
0
0.5
1
1.5
2
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
Dump Time - Cycle Time (Hours)
HIRS-2 (1bhrs2)
HIRS-3 (1bhrs3)
AMSU-A (1bamua)
AMSU-B (1bamub)
MSU (1bmsu)



Conclusions

- POES data delivery gives all data at ECMWF cut-off times for all cycles
- Ramp up to total data counts is cycle dependent
  - 12 UTC is slowest delivery and affects NCEP GFS early cycle most
- NCEP GFS
  - Late cycle receives typically 90-95% of ECMWF
  - Early cycle receives typically 70-75% of late cycle
- Regional models affected most due to short data cut-off

Other Factors

- 'Blind orbit problem'
  - Delays transmission for all POES instruments at 06 UTC
- NOAA-15 affected most at 06 UTC
- 'Priority' satellite data transmission
  - NOAA-15 deemed lower priority
  - Important due to NOAA-17 AMSU-A demise
- Impact on assimilation system performance untested