“ Entire operational system should be focused on multi-Model EPS”

Obs, Model development, Data Assimilation, Products, Interpretations

Global and Regional Ensemble Prediction Systems, and THORPEX

Ken Mylne and David Richardson

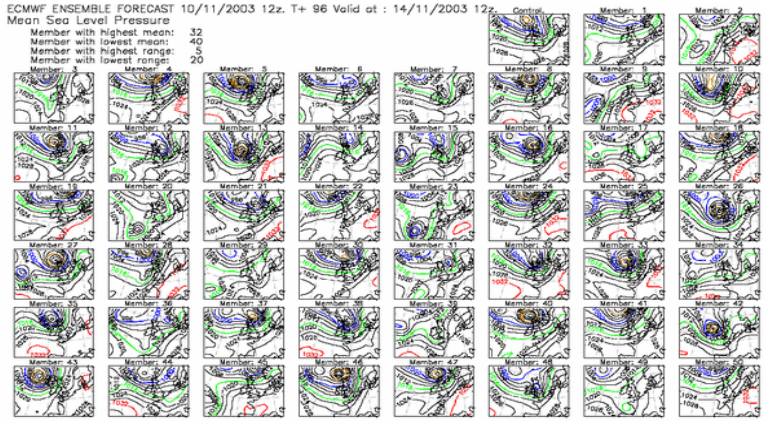
Initial Condition Perturbations - *Plan*

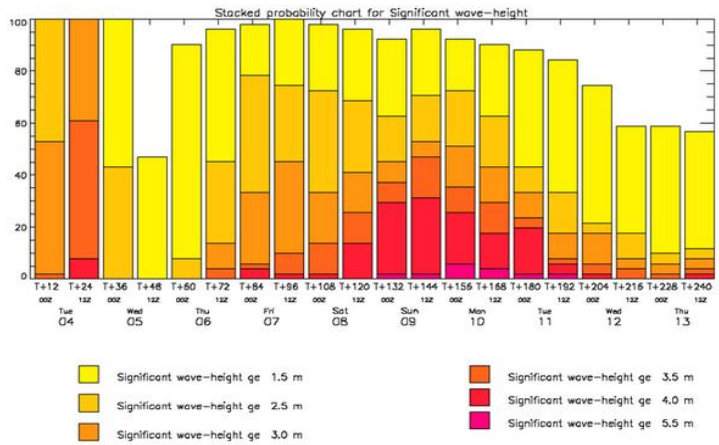
- Multi-analysis
- Singular vectors
- Error breeding
- EnKF
- ETKF

- Implement ETKF
  - added benefit is integrated observation targeting and ensemble prediction
- Collaboration with:
  - Jim Hansen (MIT) for theoretical work and training
  - Craig Bishop and co-workers
- Future comparison work with SVs optimised for short-range (Coutinho and Hoskins)

Background – application of ECMWF EPS

- Met Office makes good use of ECMWF ensemble for medium-range
  - –Medium-range forecasts based on most-probable outcome
  - –Early warnings of severe weather based on EPS probabilities
- Increasing emphasis on risk management tools
  - –Need for short-range probabilities
  - –Previous research shows benefit of multi-model ensembles



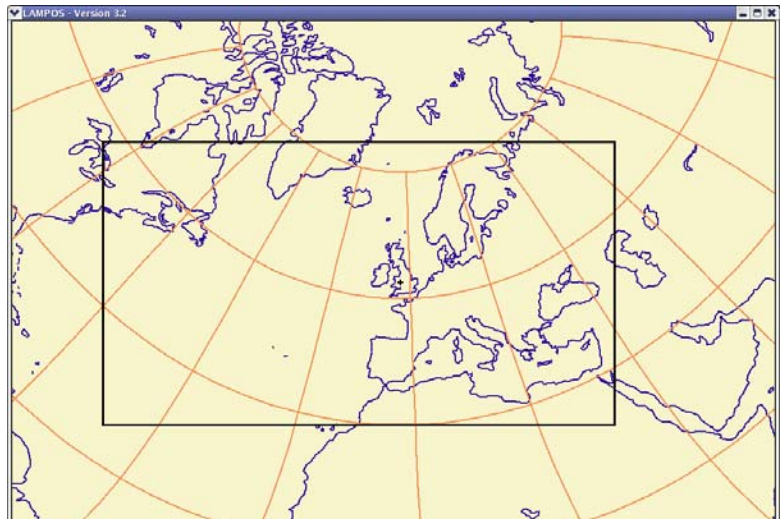


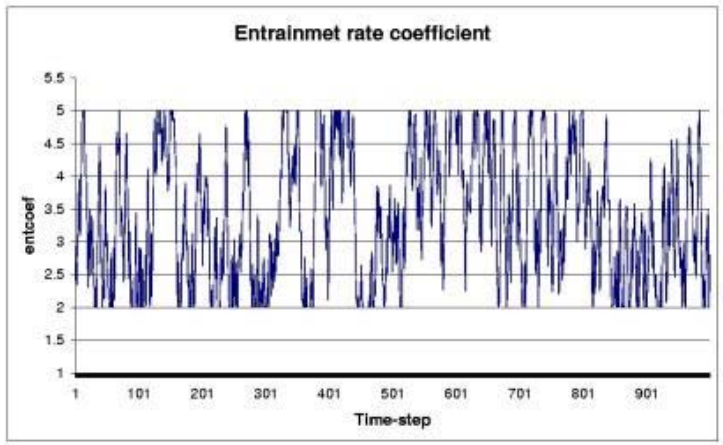
Global EPS

- Global Ensemble provides:
  - Perturbed LBCs for LAMEPS
  - Global coverage for targeting and forecasts
  - Contribution to TIGGE
    - Now planned to run to 15 days with 20 members
  - Operational collaboration with NCEP and MSC

Met Office Short-Range EPS Plans

- Nested Global and Regional ensembles for short-range
  - Grid-lengths:
    - 90km Global
    - 20km Regional
  - Around 16 members
  - Run to T+72
- ETKF initial condition perturbations
- Stochastic physics
- Integrated with observation targeting
- Running for demonstration & testing from August 2005





Medium-range Ensemble Prediction at ECMWF

Roberto Buizza[1], Martin Leutbecher[1], Tim Palmer[1] and Glenn Shutts[1,2]

Contributions from Jean Bidlot, Graham Holt, Martin Miller, Mark Rodwell, Adrian Simmons and Nils Wedi to the development of VAREPS are acknowledged.

[1]: European Centre for Medium-Range Weather Forecasts

The four key messages of this talk

- **The ECMWF Ensemble Prediction System (EPS) has been continuously improving. Results indicate a ~2 day/decade gain in predictability for probabilistic products.**

- **Changes implemented on 28 September 2004 will further improve the reliability of tropical cyclones' track prediction.**

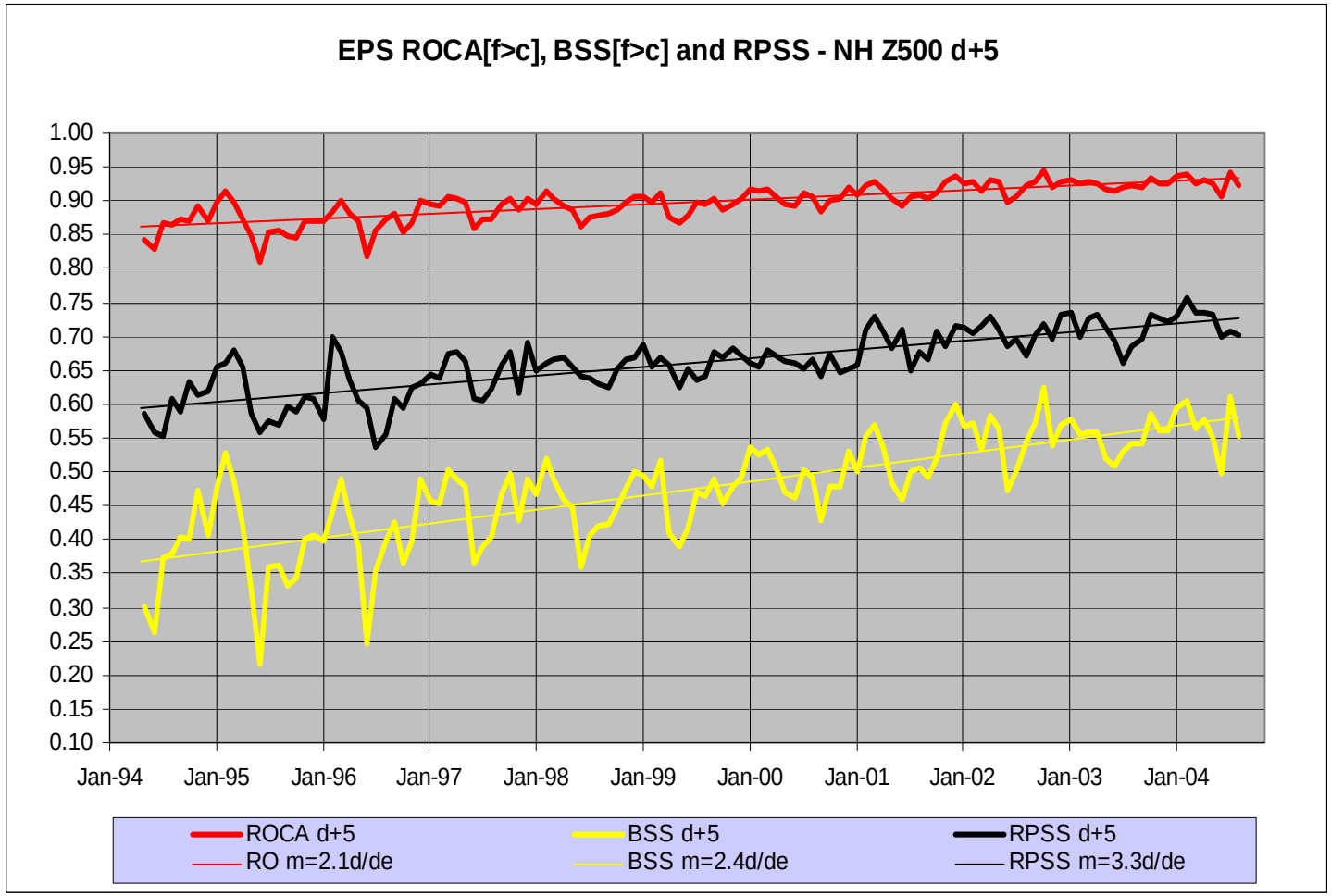
- **Future changes in the singular vectors are expected to improve the accuracy of EPS forecasts, especially in the earlier forecast range.**

- **The future implementation of the VAriable Resolution EPS is expected to improve the EPS accuracy in the early/medium-range, and will extend the EPS forecast length to 14 days. VAREPS will be the first step of the implementation of a seamless EPS.**

The EPS performance has been continuously increasing

These changes helped to continuously improve the EPS' accuracy.

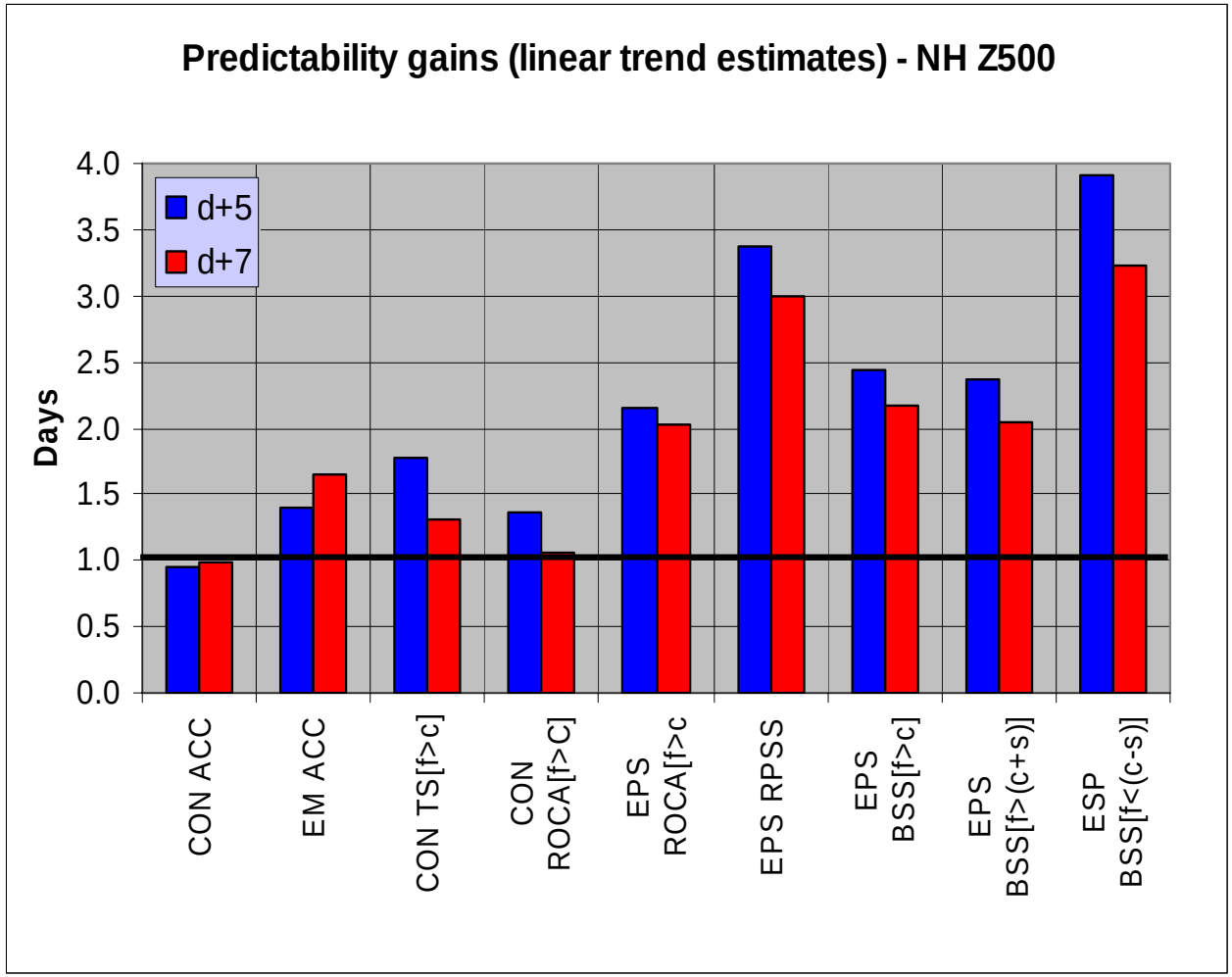
The continuous improvement is shown, e.g., by the time evolution of three accuracy measures, ROCA[f>c], BSS[f>c] and RPPS.



Over NH, Z500 EPS predictability has increased by ~2d/dec

Results indicate that considering Z500 d+5 and d+7 forecasts over NH:

- **The EPS control has improved by ~ 1 day/decade**
- **The EPS ens-mean has improved by ~ 1.5 day/decade**
- **The EPS probabilistic products have improved by ~2-3 day/decade**

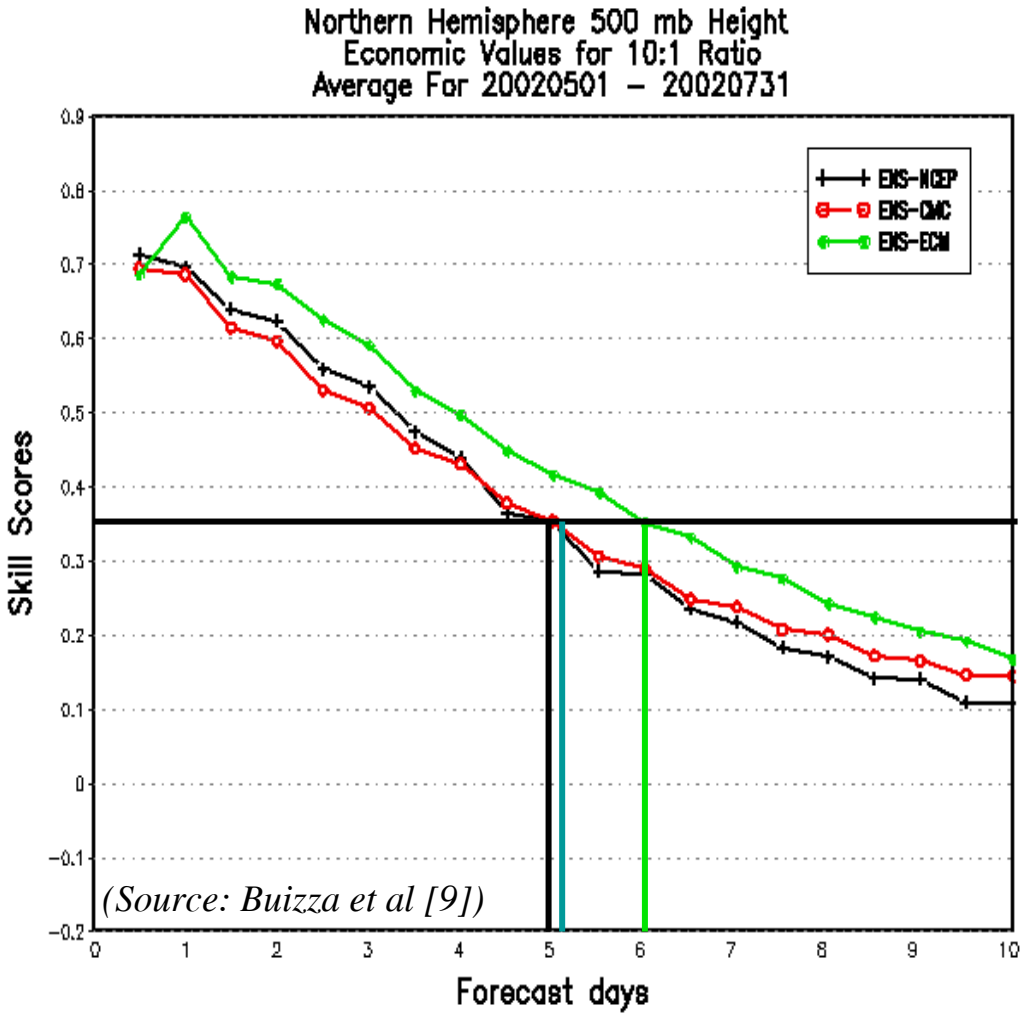


ECMWF, MSC and NCEP performance for 3 month (JJA02)

Recent studies *[2,9]* have shown that, accordingly to many accuracy measures, the ECMWF EPS can be considered the most accurate single-model ensemble system.

This is shown, e.g., by the comparison of the EV* of 10-member ensembles based on the ECMWF, MSC (Meteorological Service of Canada) and NCEP (National Centers for Environmental Predictions) EPSs *[9]* (Z500 over NH).

*** EV, the potential economic value, is the reduction of the mean expenses with respect to the reduction that can be achieved by using a perfect forecast *[4,16]*.**

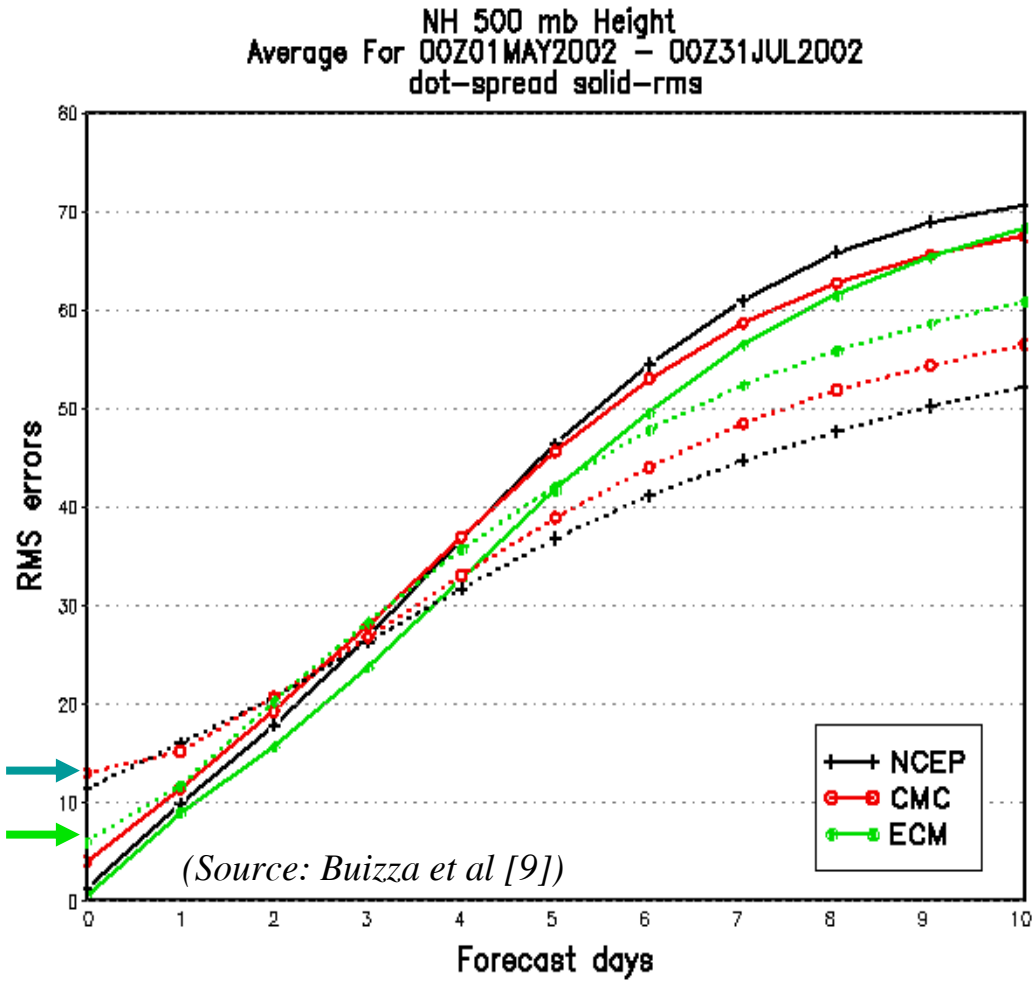


ECMWF, MSC and NCEP performance for 3 month (JJA02)

The ECMWF leading performance *[9]*, estimated to be equivalent to a gain of ~1 day of predictability, has been linked to:

- **A better analysis**
- **A better model**
- **A better estimation of the PDF of forecast states.**

This latest point can be seen, e.g., by comparing the ensemble spread and the ensemble-mean forecast error of 10-member ensembles based on the NCEP, MSC and ECMWF EPSs (Z500 over NH).



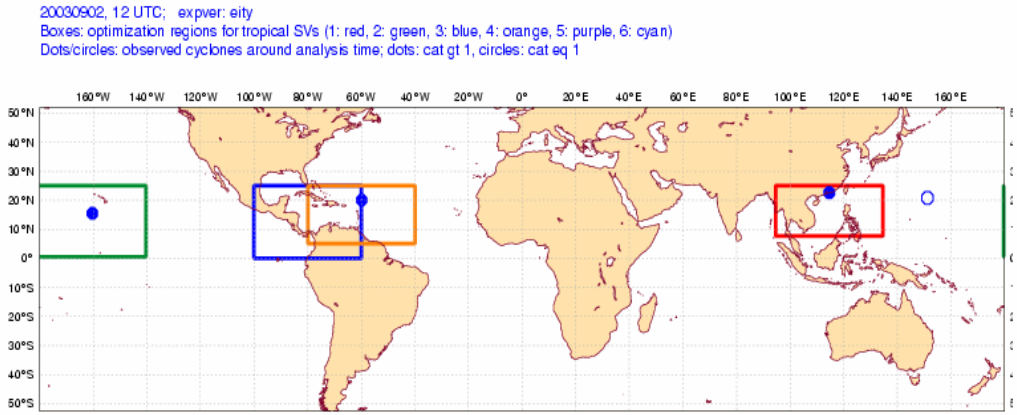
The Sep ’04 change in the definition of TR-SVs’ target areas

On 28 Sep, one major change was introduced in the EPS. In the new system:

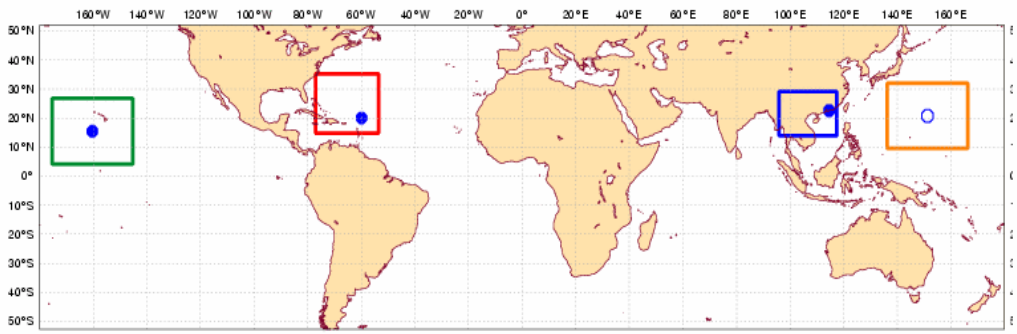
- **Target areas are computed considering TCs’ predictions**
- **Areas are allowed to extend north of 30ºN**
- **Up to 6 areas can now be targeted**
- **Tropical depression (WMO cl≥1) detected between 40°S-40°N are targeted**
- **SVs are computed using a new ortho-normalization procedure**

tropical SV optimisation regions, 2 September 2003, 12 UTC

old EPS config



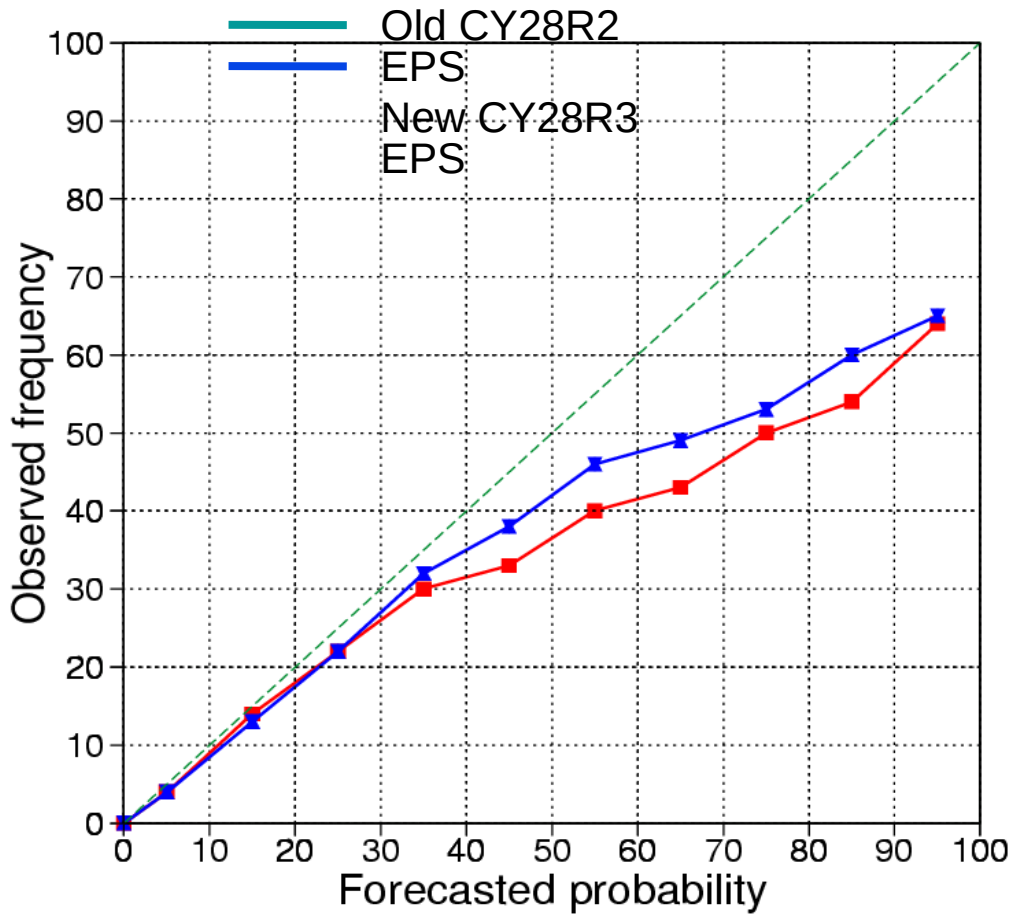
new EPS config



Impact of the Sep ’04 change in the TR-SVs’ target areas

Reliability diagram for strike probabilities

Results based on 44 cases (from 3 Aug to 15 Sep 2004) indicate that the implemented changes in the computation of the tropical areas has a positive impact on the reliability diagram of strike probability.

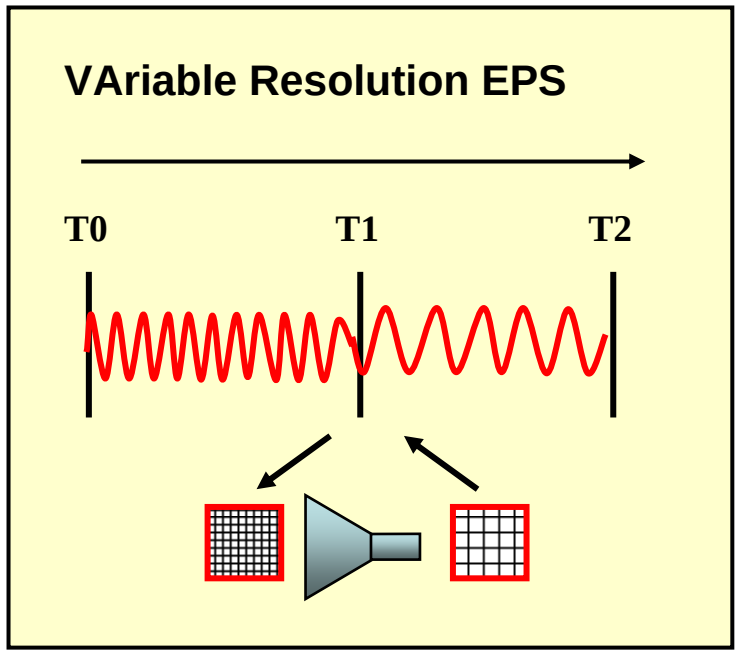


VAREPS: definition, and planned implementation schedule

- **VAREPS configuration:**
  - **D0-7: T_L399L40, dt=1800s**
  - **D7-14: T_L255L40, dt=2700s**

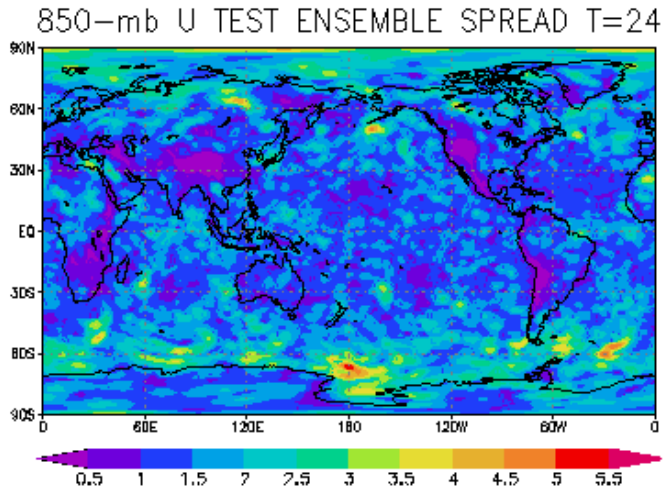
- **Rationale: predictability of small scales is lost relatively earlier in the forecast range. Therefore, while forecasts benefit from a resolution increase in the early forecast range, they do not suffer so much from a resolution reduction in the long range.**

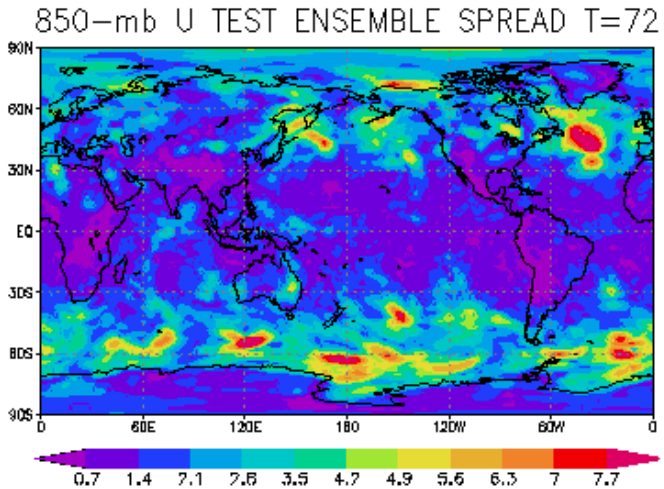
- **Implementation: Q3-Q4 2004**

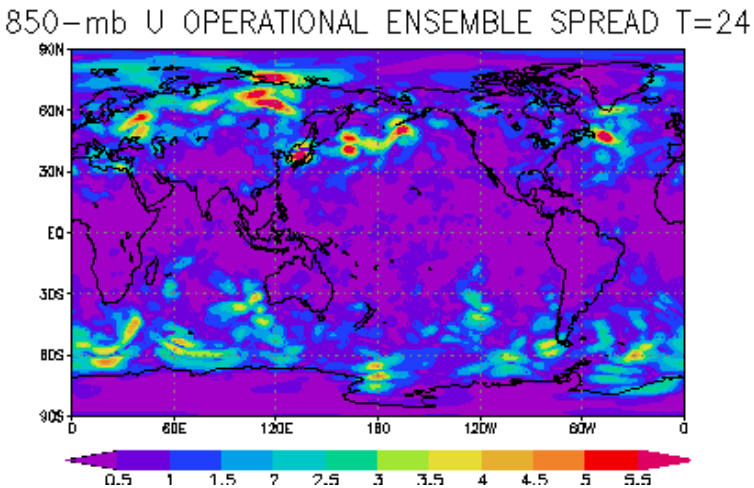


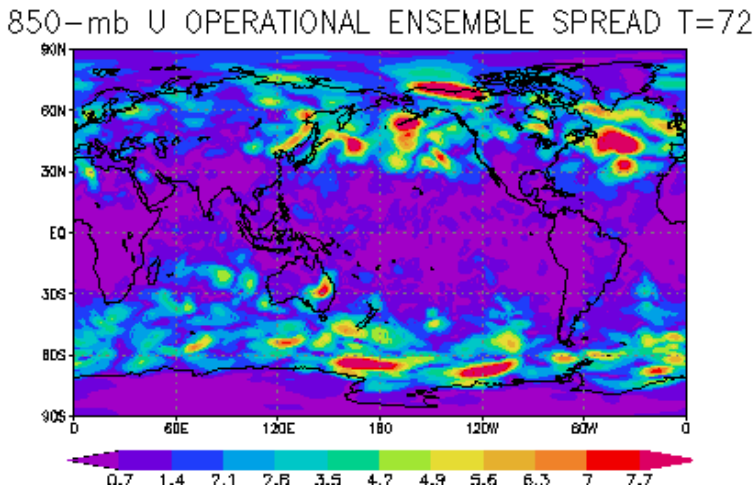
NRL Ensemble Research

Carolyn Reynolds (reynolds@nrlmry.navy.mil)



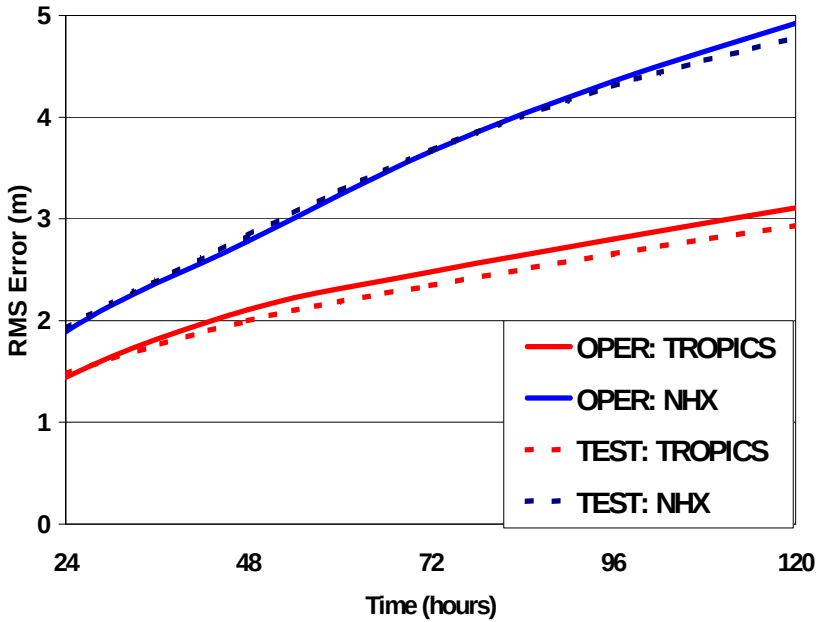


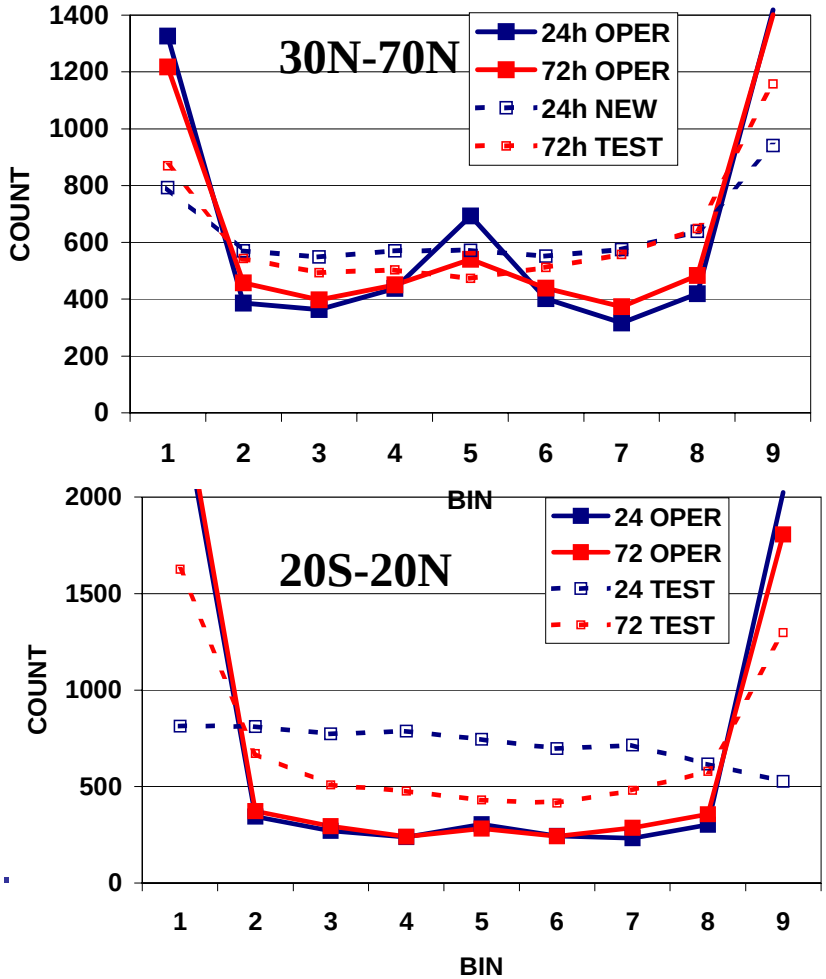




New (NCAR-NRL) ensemble perturbation system based on NAVDAS analysis error variance estimates. Larger amplitudes in the tropics and sub-tropics than the current operational (bred-mode) scheme.

NRL Ensemble Research





New method has comparable or better mean skill than current (above). Rank histograms (right) shows new method still under dispersive, though better than current system. (Results for 850-mb U: April 01-10)

Preliminary results: Comparable (better) performance in the mid-latitudes (tropics). Current and future work will consider model error and ensemble transform (Bishop and Toth, 1999) for both global and mesoscale.