Review of Selected Presentations and Discussions at the Exeter Workshop

The Workshop

- Joint WGNE/WGSIP/WGCM **Workshop on Ensemble Methods,** *From weather forecasting to climate change*
- 18-21 October 2004, Met Office, Exeter, UK
- Organized jointly by

  CLIVAR Working Group on Seasonal to Interannual Prediction **(WGSIP**)

  JSC/CAS Working group on Numerical Experimentation (**WGNE**)

  JSC/ClIVAR Working Group on Coupled Modelling (**WGCM**)
- 5 Sessions:
  (1) Introduction and Analysis
  (2) Ensemble Generation
  (3) Ensemble Forecast Systems
  (4) Climate
  (5) Combination, Calibration and Verification
- 150 registrants, 10 invited talks, 50 oral presentations and 50 poster presentations.

Ensemble Generation

- Initial Condition Uncertainty

Breeding in NASA/NSIPP coupled GCM (Shu-Chi Yang, UMD)

A natural filter to pick up slow-varying coupled instabilities. Dominant BVs could be used for ensemble forecasting

Comparison of perturbation strategies using a simple model (300 variable Lorenz 95 model, Perfect model env.) (Neill Bowler, Met Office, UK)

BV, SV, Random Perturbation, EnKF, and ETKF

EnKF clearly superior; RP+ETKF and RP+BV are better individual methods.

Adjusting the Spread of Breeding EPS by controlling the Spatial Correlation (Lorenz 96 Model) (Cristina Primo et al. Spain)

geometric bred vectors to control the spatial correlation of bred vectors.

Impact of Moist Singular Vectors and Horizontal Resolution on Short-Range Limited Area ensemble forecast for extreme weather Events. (ECMWF 51 member EPS, Andre Walser, MetoSwiss)

Ensemble Generation

- Multiple Model

Multi-Convective parameterization for Seasonal Climate studies (Timothy LaRow et al., Florida State Univ.)

Coupled model, Multi-model version vs. multi-analysis, combination. Probabilistic skill scores favor MM and Comb.

Difference is small.

Model diversity in Cumulus Parameterization and Horizontal Diffusion (Hou etal, NCEP)

Role of Model Physics (Du, NCEP)

Hybrid Ensembling: A new concept (Du, NCEP)

Influence of boundary conditions and multi-parameterization in medium-range ensemble forecast for regional purpose. (Breogan Gomez et al., Univ. Santeiago de Compostela, Spain)

Ensemble Generation

- Stochastic Physics

  Using singular vectors and markov chains in a limited-area ensemble prediction system. (Martin Charron, MSC)

  stochastic perturbation to the physics tendencies and to some physics parameters by simple Markov chain

  Limited Area model

  A stochastic physics scheme for the Met Office Unified Model (Alberto Arribas, Met Office, see slides 6-9)

  Stochastic Convective Vorticity (SCV). Random Parameters (RP)

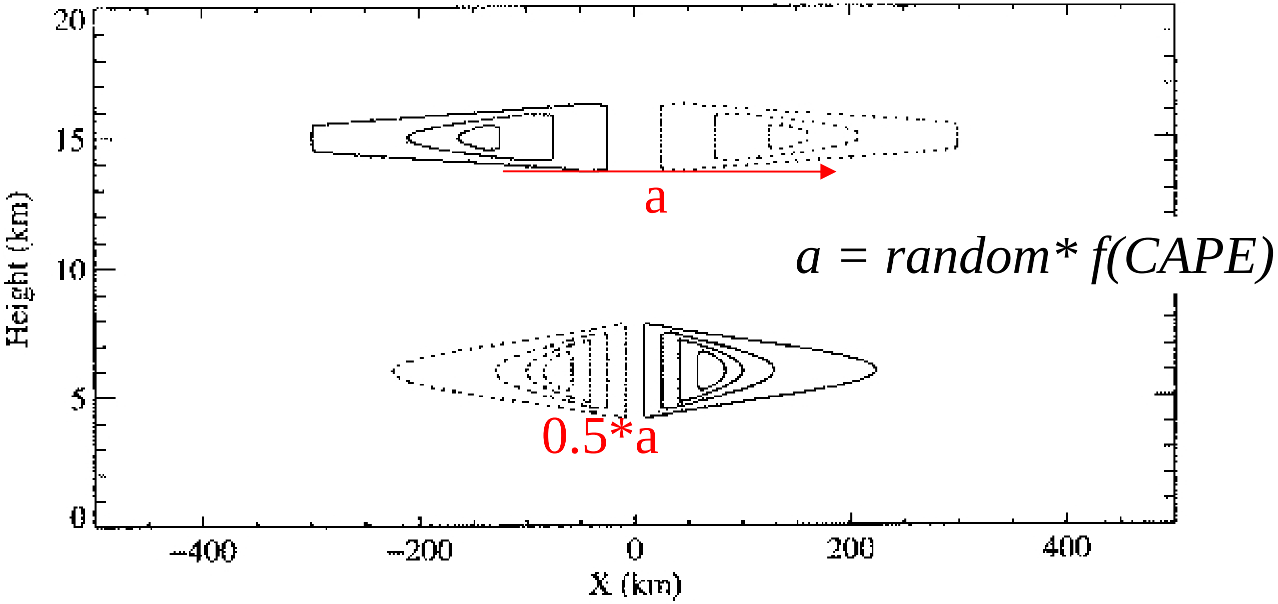
  Substantial impact in short range and neutral on climate

  A stochastic kinetic energy backscatter algorithm for EPS (Glenn Shutts, ECMWF and Met Office) (not a presentation in the workshop)

  improved KE spectrum

Stochastic scheme for the UM

The SCV component (Developed by Gray and Shutts)



- In the SCV scheme the PV dipole is formed by two vortices which scales are determined by a randomised function

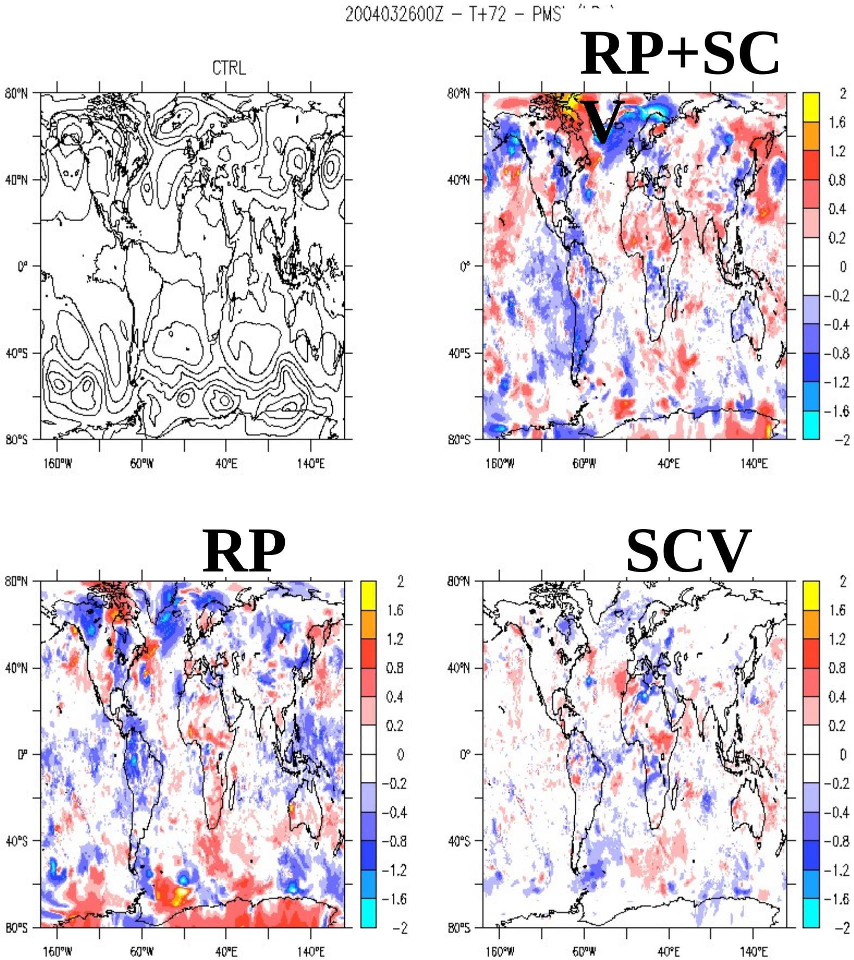
Stochastic scheme for the UM

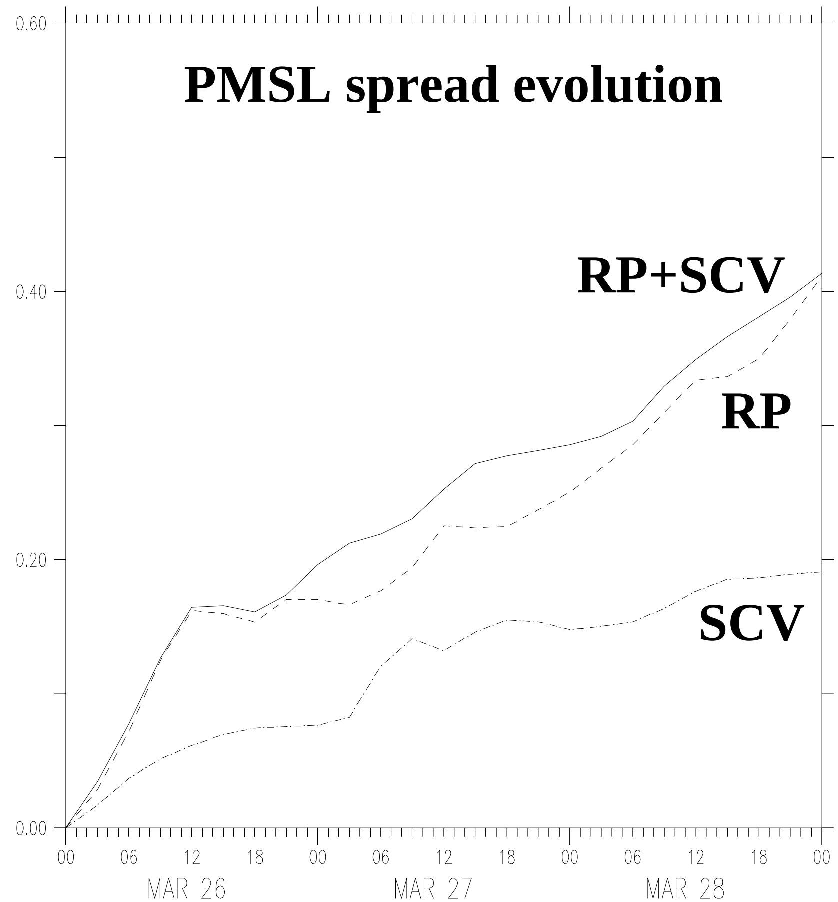
The Random Parameters component

Parameter	Scheme	min/std/Max
Entraiment rate	CONVECTION	2 / 3 / 5
Cape timescale	CONVECTION	30 / 30 / 120
Rhcrit	LRG. S. CLOUD	0.6 / 0.8 / 0.9
Cloud to rain (land)	LRG. S. CLOUD	1E-4/8E-4/1E-3
Cloud to rain (sea)	LRG. S. CLOUD	5E-5/2E-4/5E-4
Ice fall	LRG. S. CLOUD	17 / 25.2 / 33
Flux profile param.	BOUNDARY L.	5 / 10 / 20
Neutral mixing length	BOUNDARY L.	0.05 / 0.15 / 0.5
Gravity wave const.	GRAVITY W.D.	1E-4/7E-4/7.5E-4
Froude number	GRAVITY W.D.	2 / 2 / 4

Short-range impacts

Contributions from RP and SCV:



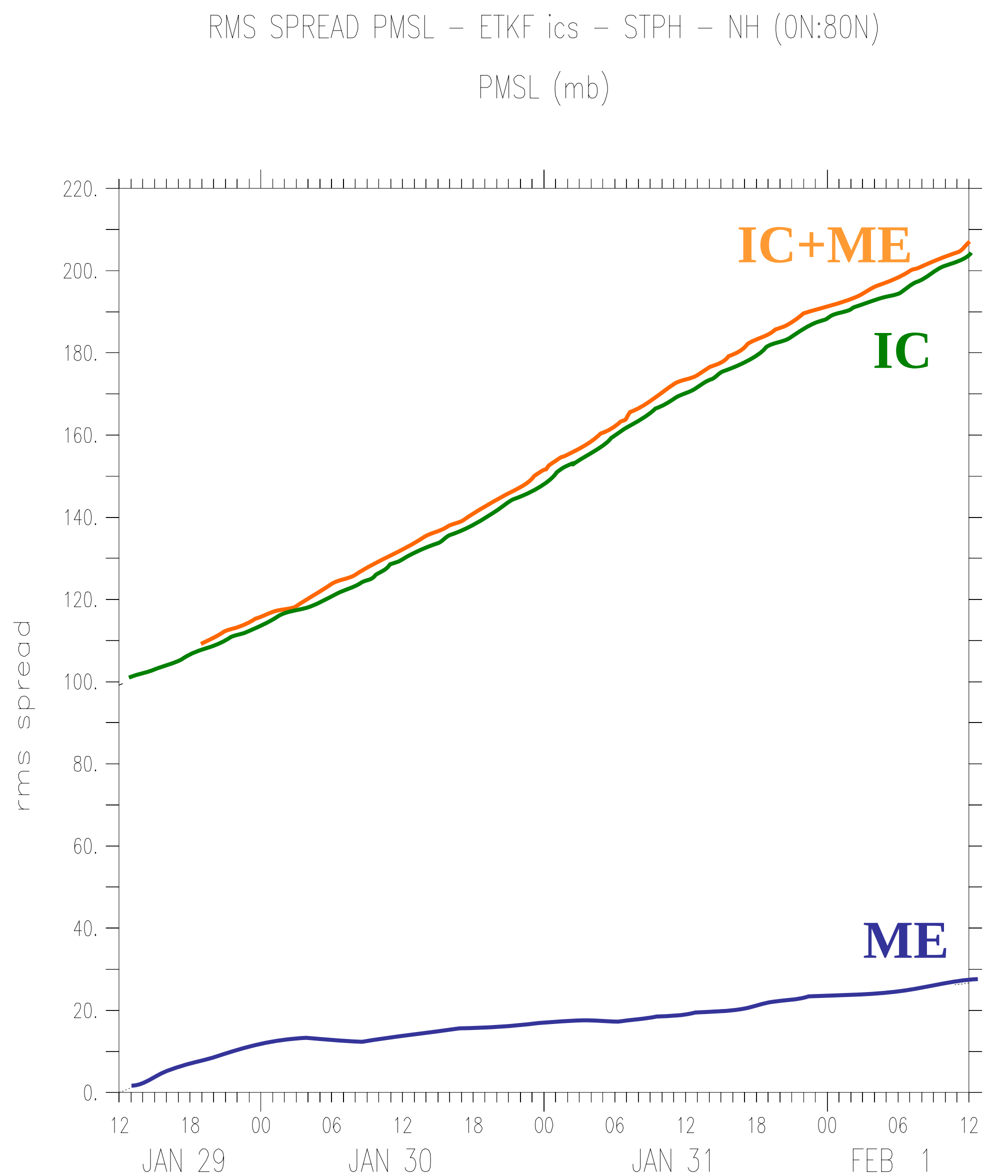


Short-range impacts

Spread: IC vs Model err

Three 8-member ensembles:

- ME (SCV+RP) only
- IC only
- IC + ME



Small increase in spread

… are IC and ME exploring the same regions of phase space?

Ensemble Generation

- Discussions

  Trade off between No. of models and no. of IC perturbations (answer varying)

  IC perturbation in seasonal forecast
  - Ocean (PT in wind and SST, Breeding in GCM)
  - Land (not addressed, potentially important)

  Multi-model and Perturbed Physics (trend towards latter)
  - Convergence of different models

  Goals of ensemble forecasts on different time scales (NWP, seasonal and climate change)

Do we have a best Ensemble Generation method?

Ensemble Forecasting Systems

- Wiseman’s summary (B. Kirtman)

Major themes

. Wide spread use of ensemble methods in Global and regional forecasts

Wide spread, yet ad-hoc use of multi-model (multi-parameterization) ensembles to probe uncertainty due to parameterized physics in forecasting.

Increasing assessment through probablistic perspective but deterministic measures are still applied.

Forecast users need to define utility of predictors based on specific-application.

THORPEX-TIGGE, global grand ensembl

Generating ensembles

generating sufficient spread remains a main concern

SV+BV, Lagged start

Human involment in determining Initial Perterbation

How to combine models

Deterministic weighting based on past data

Probabilistic approaches for combining model (Bayesian)

Ensemble Forecasting Systems

- Wiseman’s summary (B. Kirtman)

  Global Models

    Major issues related to systematic error REMAIN

      How to improve models

      1-tier vs. 2-tier prediction system

        The community is slowly moving towards 1-tier system

  Regional Models

      Additional ensemble generation issues (i.e. uncertainty in LB)

      Need to introduce uncertainty in meso-scale stabilities

Ensemble Forecasting Systems

- Interesting Points

Two categories of LAM-EPS: (Schar et. al., Switzerland)

down scaling of the synoptic scale uncertainties

addressing uncertainties that may arise from meso-scale processes (10-50km)

Severe weather forecasts from an ensemble of human perturbed simulations. (Santaner et al., NSLL)

identify areas of interest in control run, and using adjoint model to generate perturbations targeting these areas.

Skill improvement due to multi-model approach is primarily the consequence of an increase in forecast reliability (Doblas-Reyes et al., ECMWF)

Calibration

- Discussions

  Definition of Probability: frequentist belief

  Sample size

  Scores and their use

  Multi-model average

  - empirical methods of averaging: dressing
  - deriving weights
  - suitability for deriving probability

  Community aspects

  - across time scales, a success of the workshop
  - gradient between mathematicians and forecasters

Calibration

- Interesting topics

An Information theory Perspective of Ensemble Methods (Timothy DelSole, COLA)

Predictable component: component of the model output whose forecast distribution differs from the model climatology. A method for extracting it from finite sample. Results suggest little benefit from multi-model.

Limitation to the objective evaluation of ensemble prediction system (Candille and Talagrand)

Two Numbers: N=Ensemble size; M=Sample size.

reliability-resolution decomposition of Brier Score

relationship between M and N. one fixed, the minimum of the other.

Brier and Brier-like scores (Talagrand)

RPS is an extension of BS. Both are particular examples of a much broad class, which has a number of interesting properties

Calibration

- Interesting topics – Beyesian Model

probability forecast based on ensembles: A simple Bayesian approach (Ian Jolliffe, Reading university)

prior pdf (B-model) + data (ensemble forecast) = posteior pdf

example of usage: if the ef gives 0 probability, what value do you use to issue a forecast?

Using Bayesian Averaging to Calibrate Forecast Ensembles (Adrian Raftery, Univ. Washington; Wilson, MSC)

Calibration of Canadian EF using Bayesian Model averaging (Wilson)

Probabilistic quantitative Precipitation and wind forecasting use BMA (Sloughter, UWA)

Other presentations

a standard method for combining predictive distributions from different sources.

Bayesian dressing

Calibration

- Interesting topics-Error and spread

  Amplitude and Phase in ensemble spread (Hacker, NCAR)

  damping in a model will lead to underdispersive ensembles and over-estimated predictability. Amplitude deficiency can be corrected using single forecast.

  Redefine spread-skill relationship from a probabilistic perspective (Grimit and Mass, UWA)

  lager spread does not necessarily mean larger error, just higher probability of larger error.

  Role of ensemble mean and spread in MOS-like forecasting (A poster not in the program. I can't recall names of authors, but will check the workshop website later for more info.)

  MOS-like forecast is produced by regressions. It is found that the ensemble mean by far is the most important predictor while spread is unimportant.

Climate Change

- Example of Recent Work

UK Met Office, Perturbed physical ensemble

UK, Italy, Germany, Norway, France: Multi (5)-(coupled) model, Decadal variability of Atlantic Ocean Meridional Overturning Circulation

Korea, Multi-Model OGCM, East Asia Climate Scenorios

ClimatePrediction.net: Multi-thousand member grand Ensemble

(UK, Oxford University et al.)

Grand science or Grand game?

Univ. Quebec, Ensemble downscaling with regional Climate Models

Climate Change

- Discussions

CC is not principally an IC problem, can not apply NMP methods.

Principal source of uncertainty in models and in forcing agents. We are only starting to think about the former.

No verification cycle. Rely on physics in the model.

Great demand for prediction

- Existing and Possible Techniques

Multi-model perturbed physics or perturbed parameters

Scheme-switching or Stochastic physics

Define distance between ensemble members in terms of outputs rather than inputs

Analysis

- Wiseman’s summary (A, Lorenc)

  T.H explained how to fit data by linear combination, not ideal for Non-liner model of bi-modal.

  C.B. : biased variance in ETKF due to assumption.

  4-D var will remain to be the central analysis component at ECMWF

  4-D var selectively analyze growing modes

  Questions

  - how often
  - how much on fast growing mode
  - how much from model errors
  - can ensemble info on “error of the day” be used to enhance 4-D var