Use of Canadian Quick covariances in the Met Office data assimilation scheme

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Talk Outline

♣ Overview of Met Office DA system
♣ NMC covariances in the N48L50 model
♣ Canadian Quick (CQ) covariances
♣ Comparison of results for N48L50 model
♣ Onwards and upwards – first results with a 60 level model
♣ Summary and Outlook
♣ Operational system uses 4D-Var, N320L50. 50 levels from surface to ~63 km.

♣ But here, trials use 3D-Var, N48L50 (old oper. strat. model)

♣ Operationally, B is from NMC method (Parrish and Derber, 1992).
Calculation of NMC covariances

- Need initial covariances from somewhere
- Based on T+48-T+24 forecast differences
Some Recent History

♣ In 2003, operational strat. model changed (L40 (Eulerian) to L50 (semi-Lagrangian)).

♣ New B needed:
  - reconfiguration.
  - run N48L50 analyses,
  - calculate T+48-T+24 diffs,
  - calculate B

♣ However, NH summer acceptance tests failed.

♣ Quick solution (fudge?) was required!
• Trials failed because of large analysis increments at upper levels.

• Possibly because $B$ also large there.

• Various solutions tried and failed.

• Re-run with analysis increments off above 10 hPa (level 40).

• Solved problem of trial failure – but still need new $B$. 
• Re-calculated $B$ using forecasts for above trial.

• 2\textsuperscript{nd} iteration – this time with full analysis increments – and recalculation of $B$. More “realistic”.

\begin{itemize}
  \item Forecast only above model level 40
  \item Continuous Analysis using initial covs to model level 40 only
\end{itemize}
NMC B Bootstrapping  (3)  (T, June)

- Top left – original reconfigured B
- Top right - after 1\textsuperscript{st} iteration
- Bottom left – after 2\textsuperscript{nd} iteration
• Acceptance trials ran successfully. Verification v sondes and analyses seemed to indicate positive benefit.

• Bootstrapped B was used in Met Office strat analyses Oct 2003-Mar 2005

• But there is a lot of “noise” in the new B
Based on 6 hour differences through a long forecast model run.

Can generate B MUCH faster than NMC method.

Easily applicable to new model resolutions, without need to reconfigure pre-existing B.

Migrating diurnal and semi-diurnal tidal signals are removed (by subtracting monthly means).
Lot of similarity to NMC B, but variances smoother

No scaling done (as at MSC) – used unaltered in trials
Pairs of N48L50 trials run, with NMC and CQ covariances

Trials run for Jul 2005 and Jan 2005

Focus on T - validation against EOSMLS data

* bias wrt ACE/HALOE/CHAMP/GEOS-4: 0 to 4 K (variable)100-1 hPa (Livesey et al, 2005)
Trials: NMC v CQ (July)

Error v EOSMLS

Mean

RMS

L50NMC

L50CQ

NMC-CQ
Trials: NMC v CQ (January)

Error v EOSMLS

L50NMC

Mean

RMS

L50CQ

NMC-CQ
Theta (normalised) increments (January)

♣ 6 hour assimilation cycle (ATOVS only)
Summary of differences in results

♣ Oscillating pattern in NMC errors in winter mid-high lats above 10 hPa; mean and RMS errors higher for NMC.

♣ Differences largely similar with T+24, T+48 forecasts – “noise” does not quickly leave the system.

♣ Explains why these features not seen in previous verification v sondes, analyses. Shows value of EOSMLS data.

♣ Spurious vertical oscillations in operational analyses reported by other scientists (eg G. Manney) – so the problem appears to lie with the NMC B.
A research N48L60 model is available, with levels from surface to ~84 km

CQ covariances calculated; July 2005 trial run
Trials: NMC v CQ L60 (July)

- **L60CQ**
  - Cold bias much reduced

- **L60CQ - L50NMC**
  - Larger cold bias
  - Stronger MMC in L60 model
  - Reduction in error at mid-high winter lats. similar to L50 comparison
Inertial Gravity Wave Signals?

♣ 3D-Var analyses have imperfect mass/wind balance.

♣ Leads to spurious IGWs which are generated to restore this balance.

♣ These waves have a lifetime of ~1 day – their signal could be seen in T+48-T+24 differences used for NMC B.

♣ Little or no such signal in CQ
Velocity potential correlations (January)

NMC

CQ

chi correlations with level 29 chi
3/12/2002 to 2/1/2003, 31 cases

chi correlations with level 29 chi
1/12/2004 to 20/12/2004, 79 cases
Is this a realistic increment?
Could spurious signals be spread to other locations?
Smaller stdevs = less spurious IGWs?

Stdevs always slightly smaller for CQ.

But so what?

Need further transport / trajectory / constituent assim studies

CQ (red), NMC (black)
♣ CQ produces very good results, without scaling – quick and easy!

♣ EOSMLS is an excellent dataset for validating the results.

♣ Noise in NMC B leads to noisy analyses and forecasts – issue for researchers (eg G. Manney, pers. comm).

♣ More spurious inertial gravity waves in NMC than CQ? – issue for constituent assimilation?
Outlook for CQ at the Met Office

♦ CQ can be easily and effectively applied to new model formulations (eg L60).

♦ Met Office will change operational model from L50 to L70 (~80 km upper level) in 2007.

♦ Current view is that NMC will be retained for operational model.

♦ But CQ will play a vital role in developing initial covariances for trialling (and possibly more..)
Questions?