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

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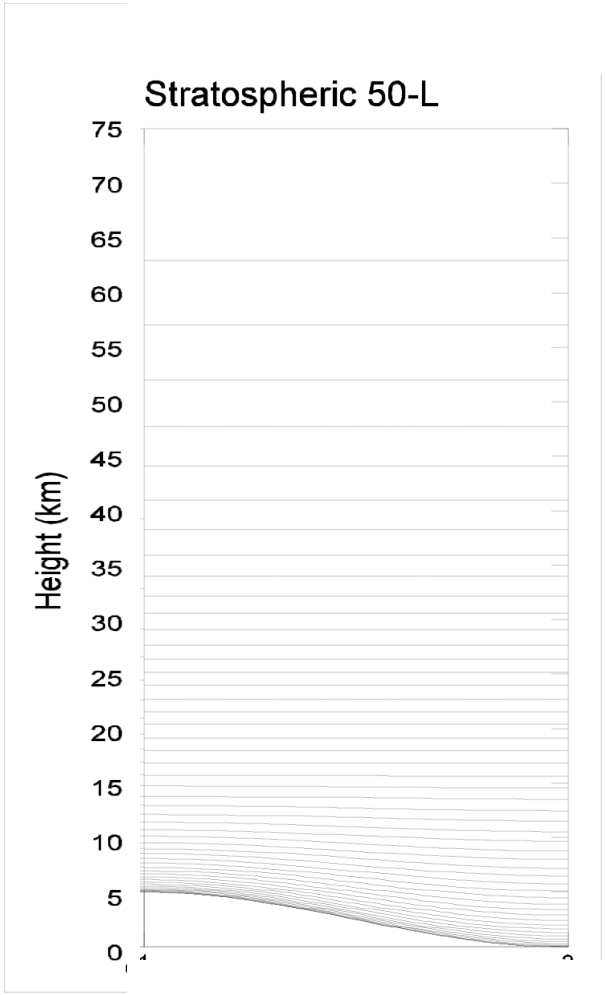
Talk Outline

- 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

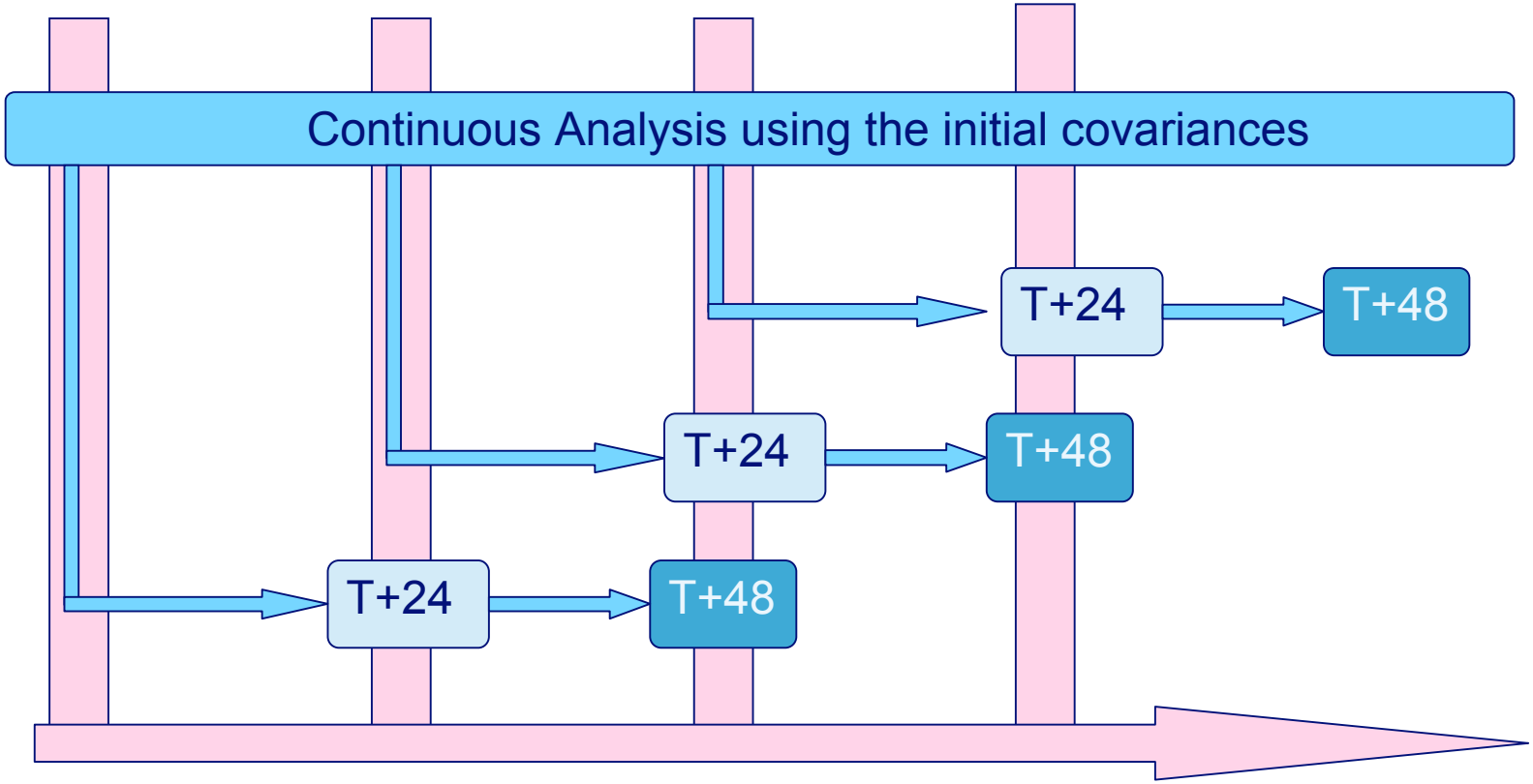
Met Office DA - overview

- 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



NMC covariances: operational strat. model

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!

NMC **B** bootstrapping (1)

- Trials failed because of large analysis increments at upper levels.

- Possibly because **B** also large there.

- Various solutions tried and failed.

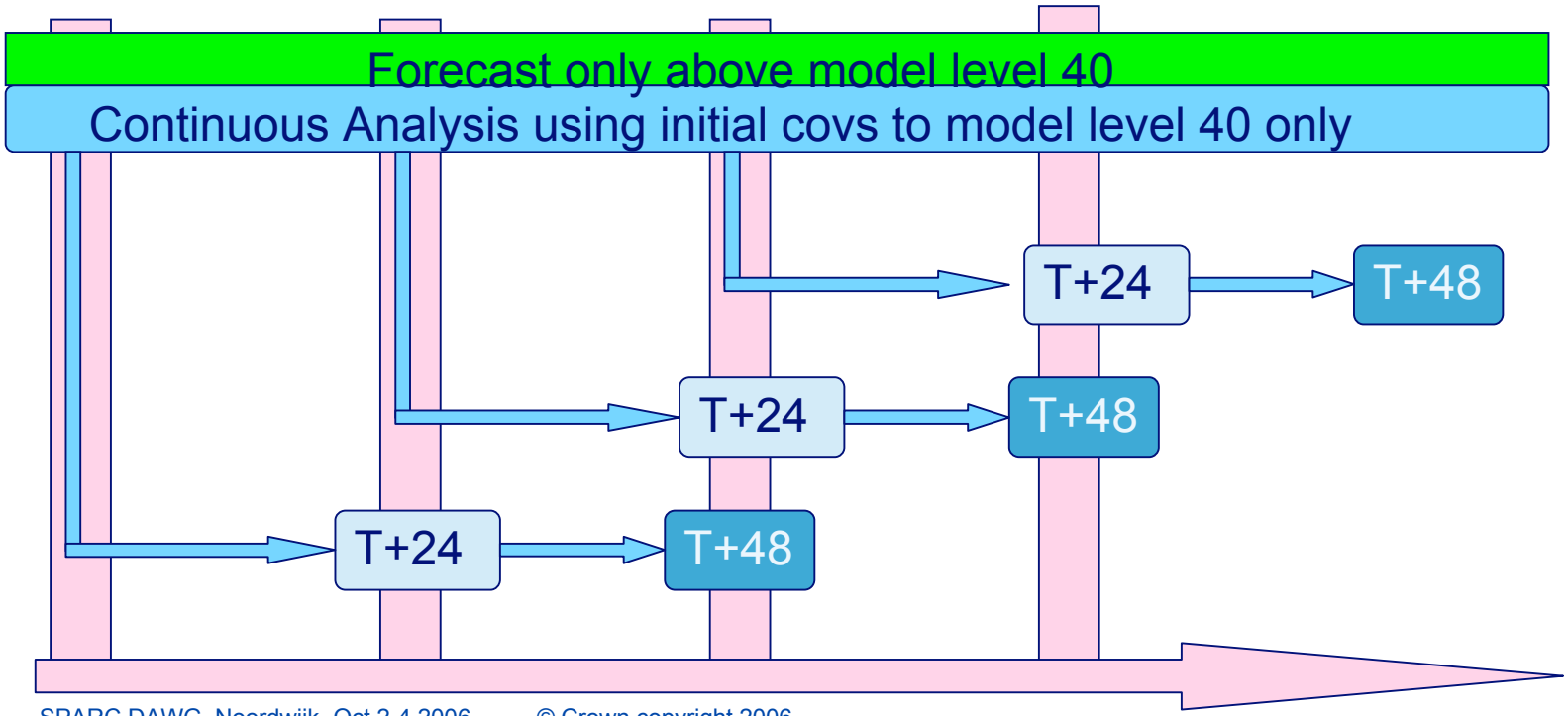
- Re-run with analysis increments off above 10 hPa (level 40).

- Solved problem of trial failure – but still need new **B**.

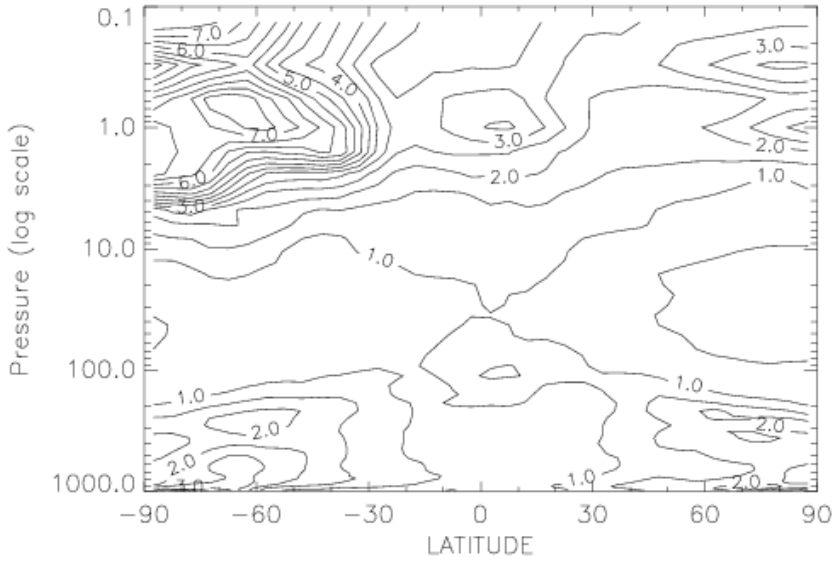
NMC **B** bootstrapping (2)

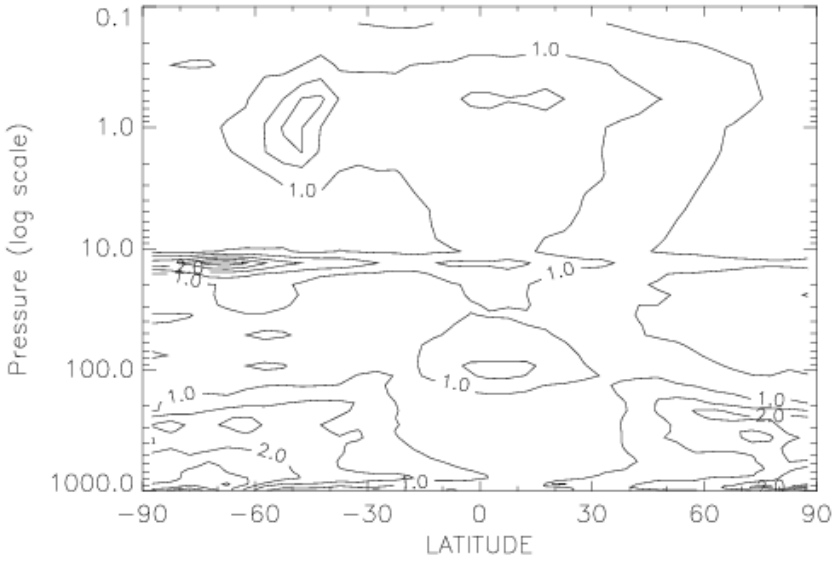
•Re-calculated **B** using forecasts for above trial.

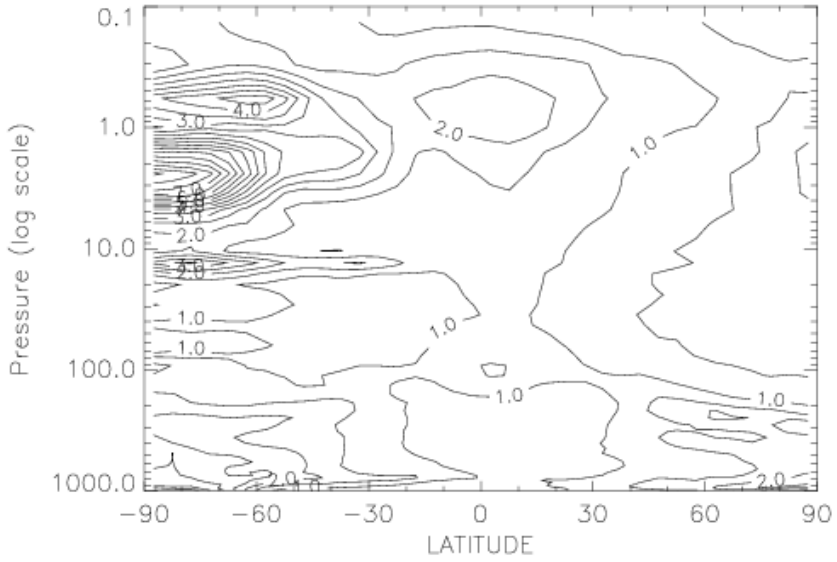
• 2nd iteration – this time with full analysis increments – and recalculation of **B.** More “realistic”.



NMC **B** Bootstrapping (3) (T, June)







- Top left – original reconfigured **B**
- Top right - after 1st iteration
- Bottom left – after 2nd iteration

NMC **B** bootstrapping (4)

•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

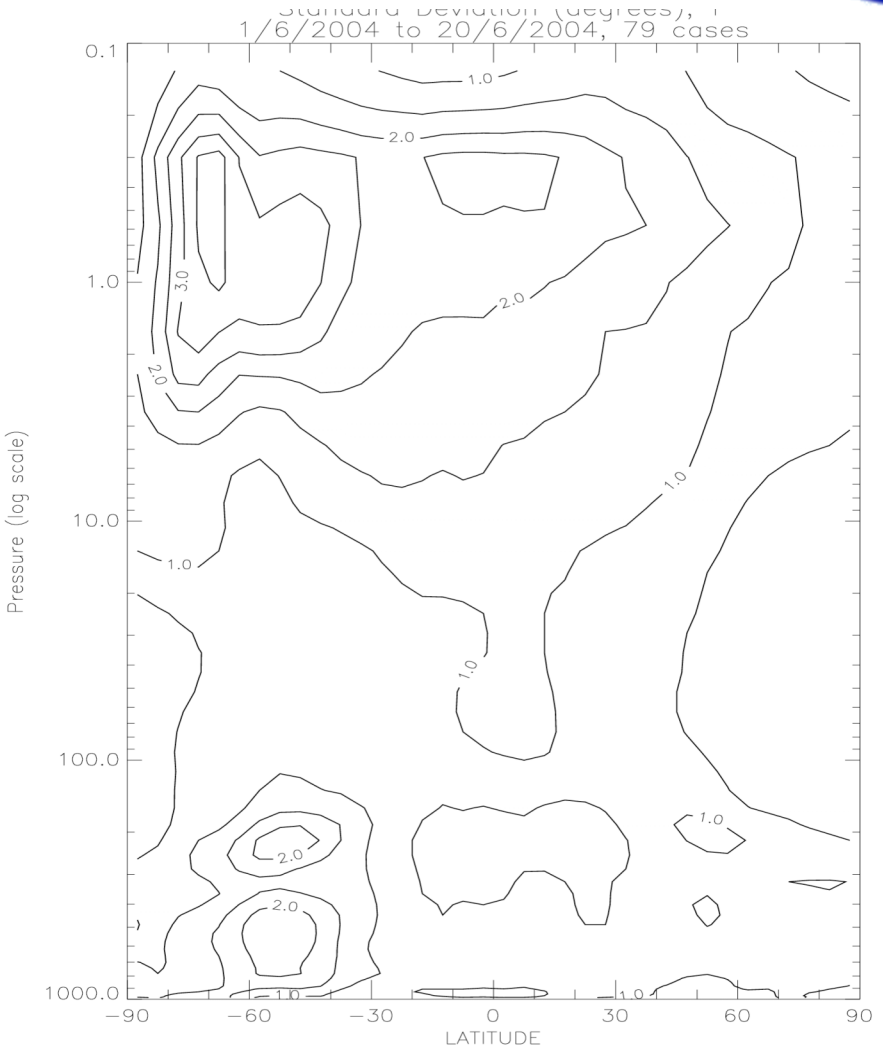
•But there is a lot of “noise” in the new **B**

CQ covariances (Rochon, Polavarapu (MSC))

- 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).

CQ covariances (T, June)

- Lot of similarity to NMC **B**, but variances smoother
- No scaling done (as at MSC) – used unaltered in trials



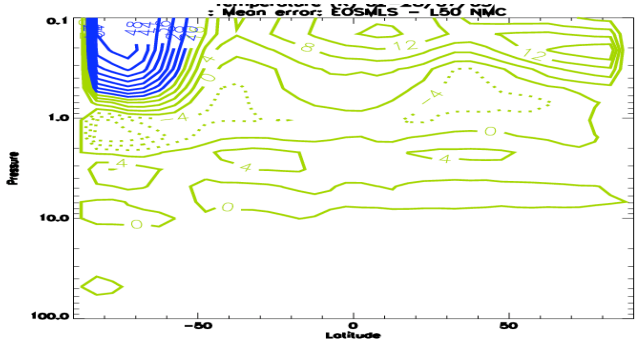
N48L50 Trials

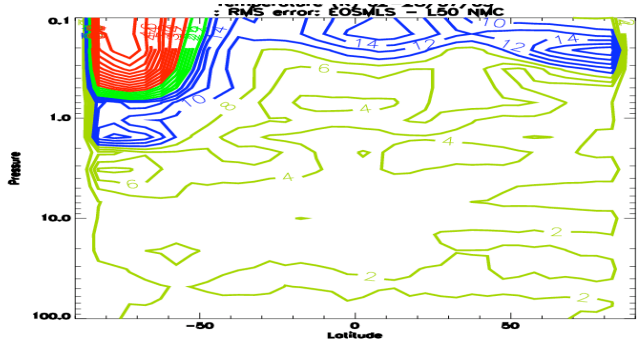
- Pairs of N48L50 trials run, with NMC and CQ covariances
- Trials run for Jul 2005 and Jan 2005
- Focus on T - validation against EOSMLS data
  - bias wrt ACE/HALOE/CHAMP/GEOS-4: 0 to 4 K (variable)100-1 hPa (Livesey et al, 2005)

Trials: NMC v CQ (July)

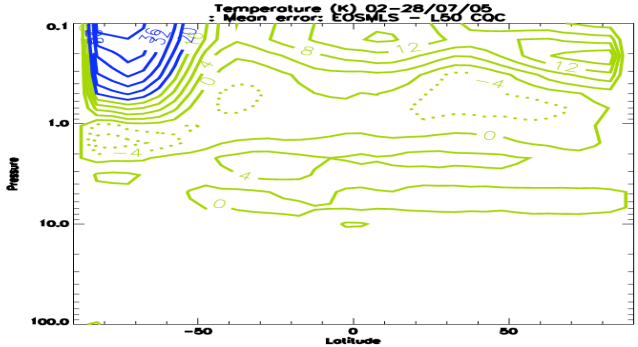
Error v EOSMLS Mean RMS

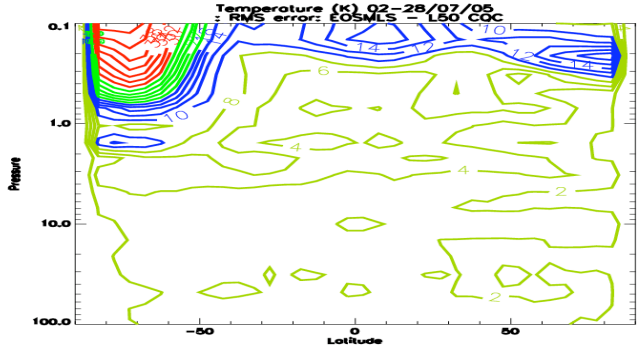
L50NMC



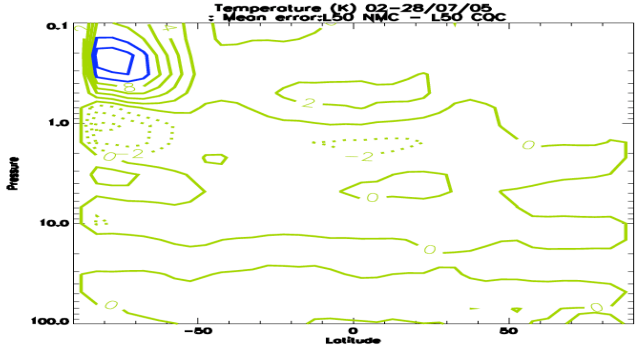


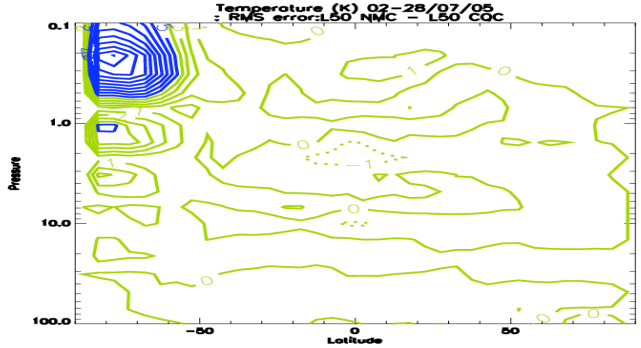
L50CQ





NMC-CQ





Trials: NMC v CQ (January)

Error v EOSMLS

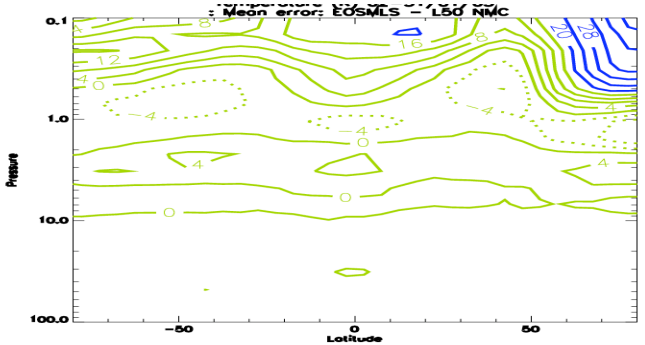
Mean

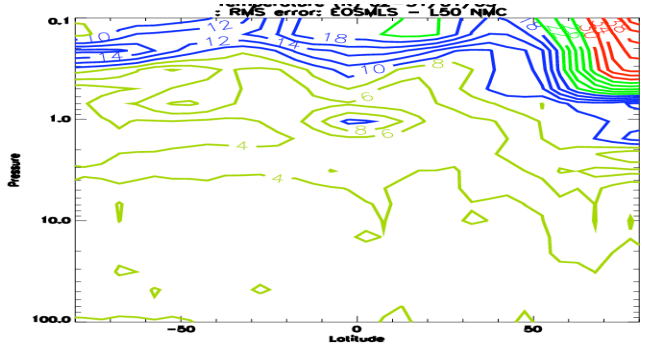
RMS

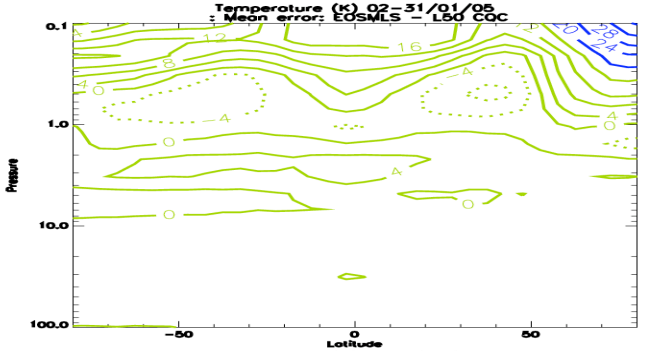
L50NMC

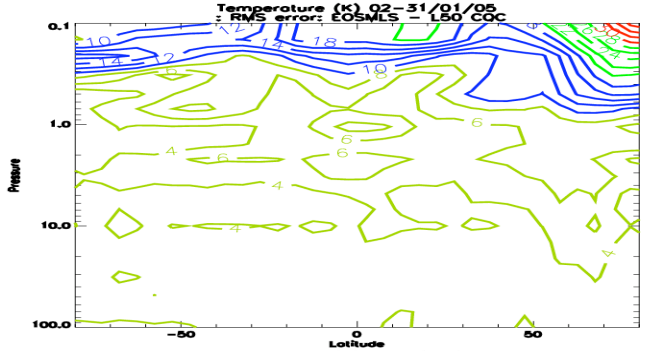
L50CQ

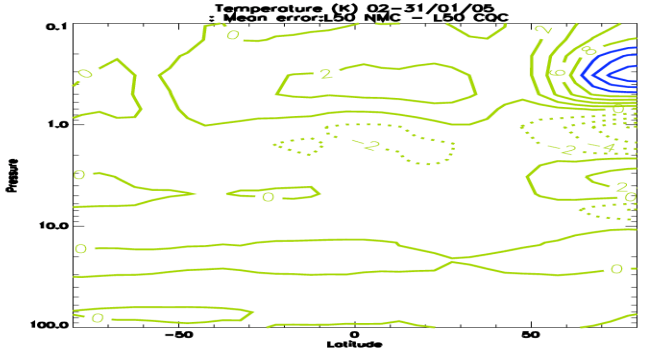
NMC-CQ

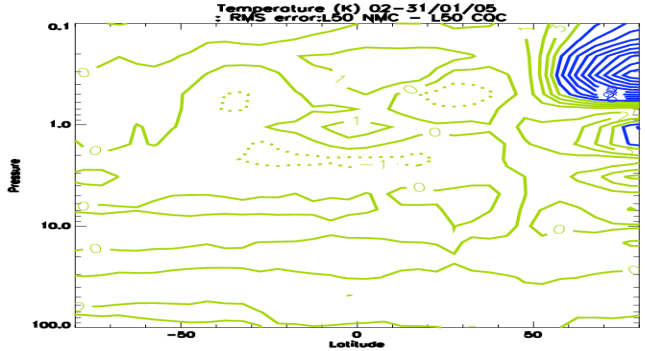






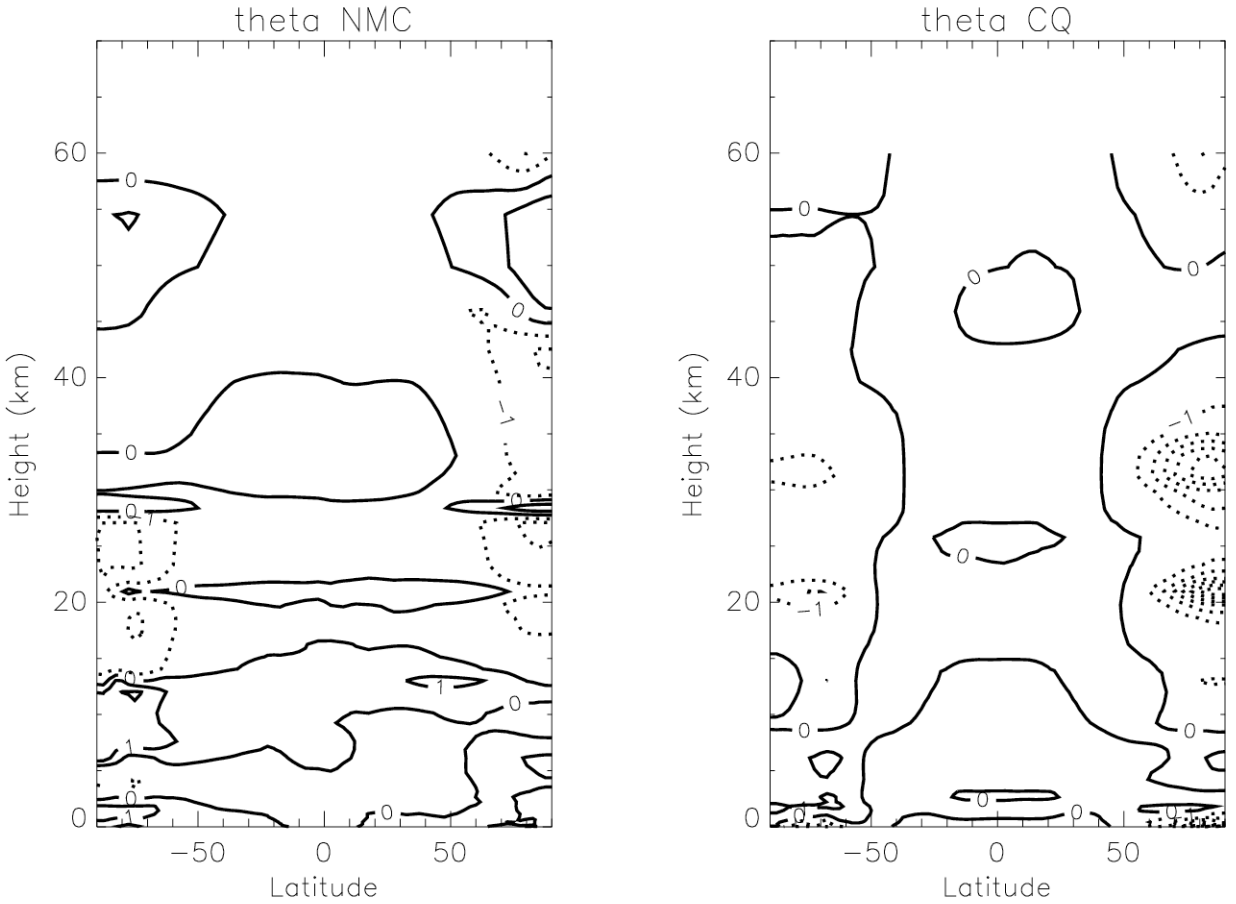






Theta (normalised) increments (January)

- 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**.

CQ Trials with L60 model

- A research N48L60 model is available, with levels from surface to ~84 km

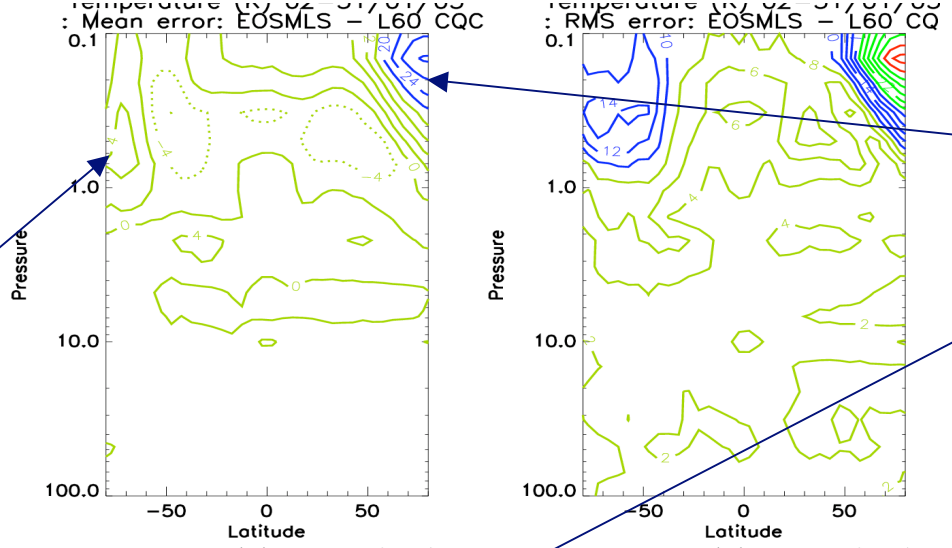
- CQ covariances calculated; July 2005 trial run

Trials: NMC v CQ L60 (July)

Error v EOSMLS Mean RMS

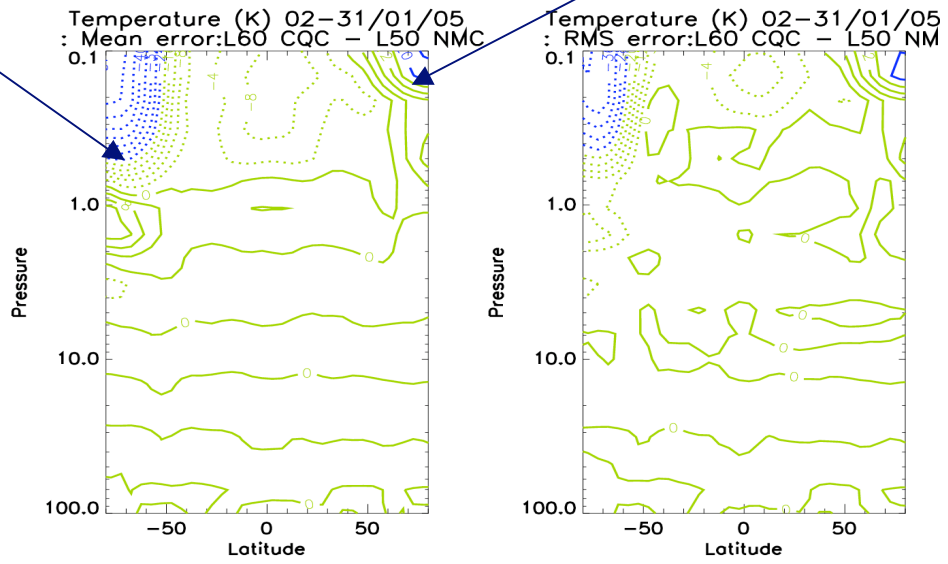
L60CQ

Cold bias much reduced



Larger cold bias

L60CQ -L50NMC



Stronger MMC in L60 model

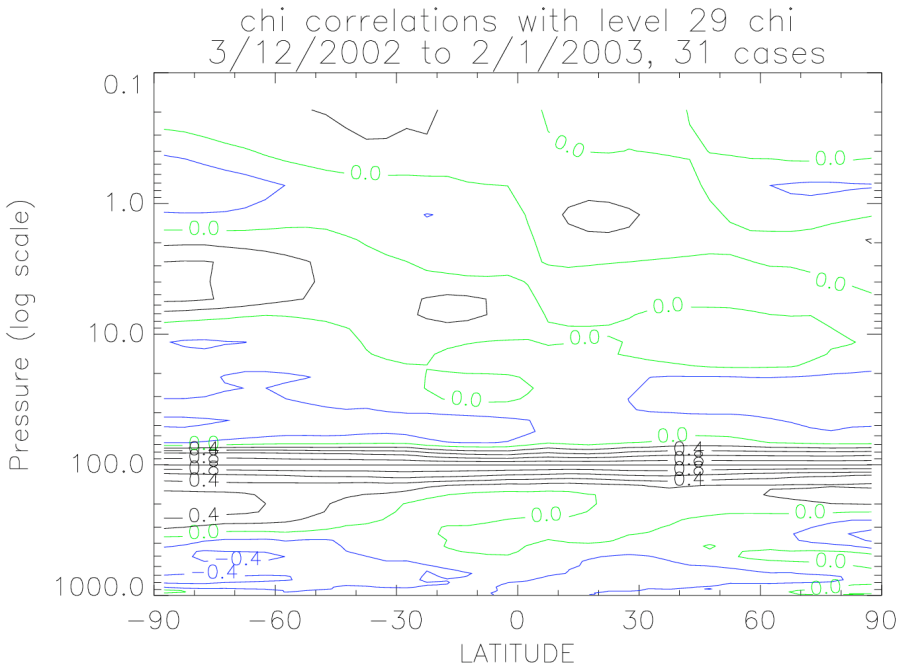
Reduction in error at mid-high winter lats. similar to L50 comparison

Inertial Gravity Wave Signals?

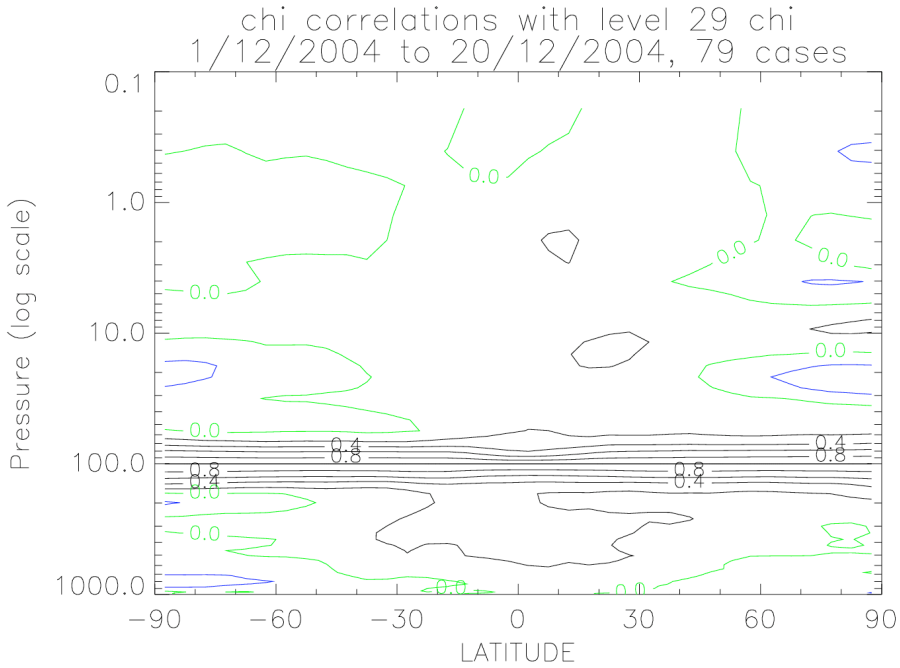
- 3D-Var analyses have imperfect mass/wind balance.
- Leads to spurious IGWs which are generated to restore this balance.
- These waves have a lifetime of ~1 day – their signal could be seen in T+48-T+24 differences used for NMC **B.**
- Little or no such signal in CQ

Velocity potential correlations (January)

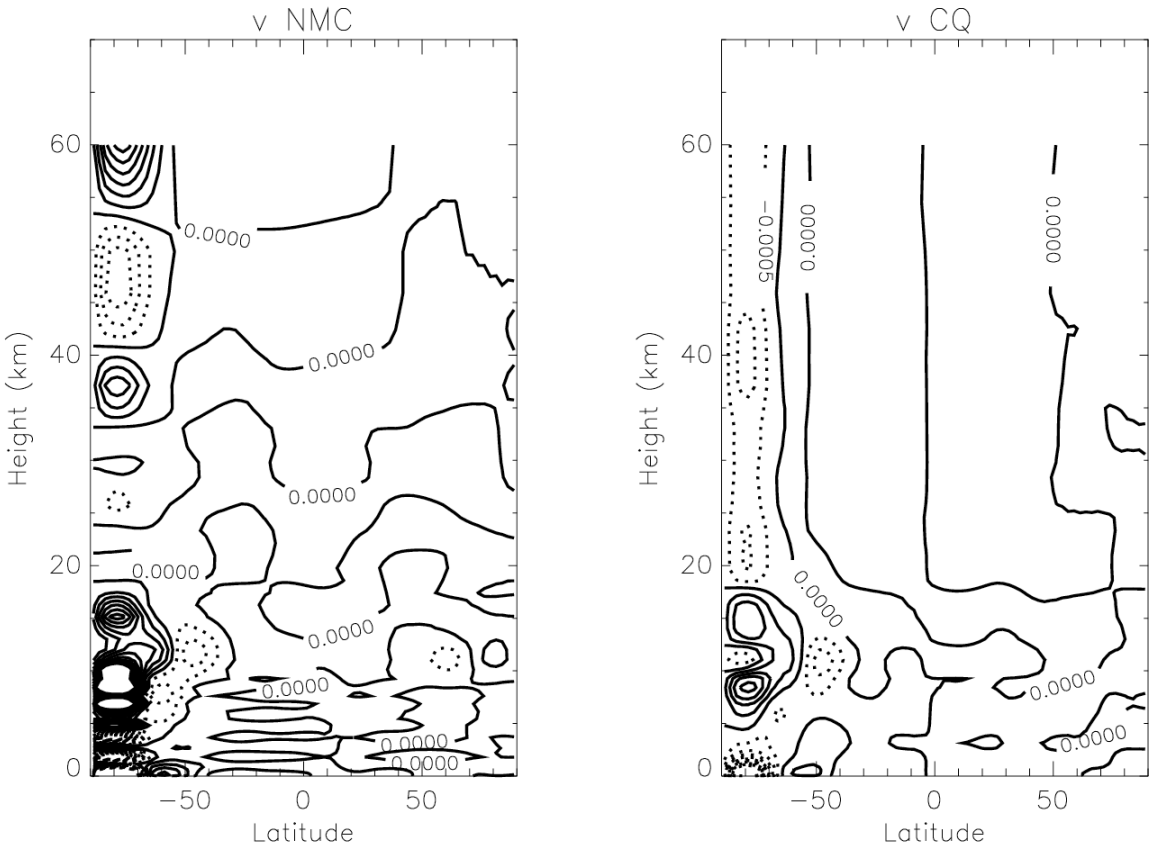
NMC



CQ



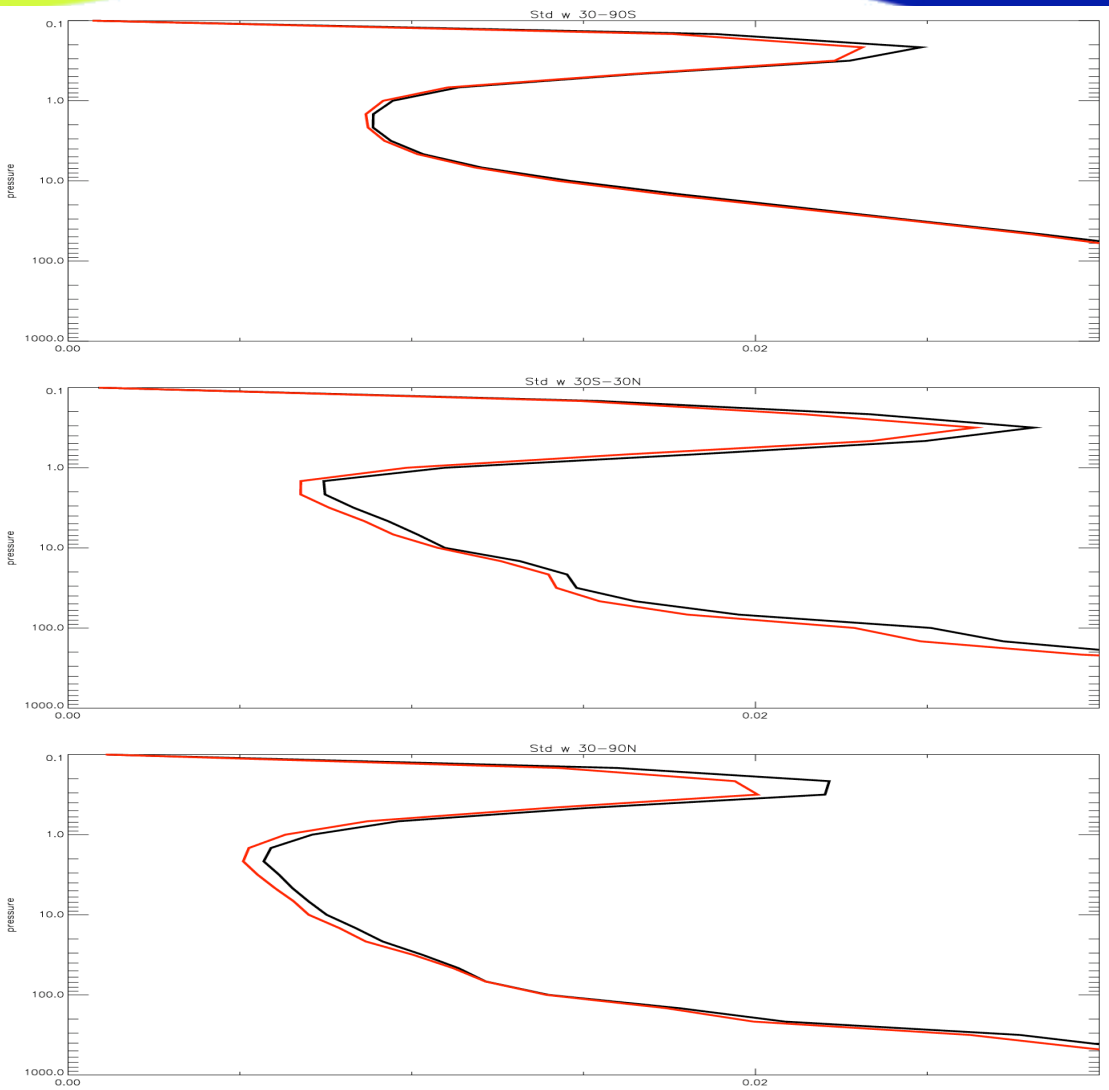
V analysis increments (January)



- Is this a realistic increment?
- Could spurious signals be spread to other locations?

Vertical velocity standard devs (July)

- Smaller stdevs = less spurious IGWs?
- Stdevs always sl smaller for CQ.
- But so what?
- Need further transport / trajectory / constituent assim studies



CQ (red), NMC (black)

Summary

- 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?