The development of a hybrid 4D-ensemble variational assimilation system


ISDA 2016

We acknowledge the Korea Meteorological Administration (KMA) for the use of their HPC and for hosting Adam Clayton
Contents

• Hybrid-4DVar and hybrid-4DEnVar
• Operational data assimilation and ensemble generation
• En-4DEnVar ensemble
• Results
• Conclusions
Hybrid-4DVar and hybrid-4DEnVar
Hybrid-4DVar
Clayton et al. (2013), *QJR Meteorol Soc, 139*:1445-1461

- Background error covariance at start of window:

\[
B = \beta_c^2 B_c + \beta_e^2 B_e
\]

- Localise control variables.

\[
B_e = C \otimes P_e
\]

Climatological covariance  Ensemble covariance

Spatial localisation covariance  Raw ensemble covariance
• No PF model and adjoint, but much more IO required to read ensemble data.

• Static $B_c$ with $B_e$ computed from ensemble.

• Localisation is currently in space only: same linear combination of ensemble perturbations at all times.
Operational data assimilation and ensemble generation
Operational data assimilation

- N320L70 (40 km at mid-latitudes, 80 km model top) hybrid-4DVar analysis increment
- Stationary covariance model (1.0 weight)
- Ensemble covariance with 44 members (0.3 weight)
- Evolved by perturbation forecast model
- MetUM forecast model runs on N768L70 grid (17 km at mid-latitudes)
Operational MOGREPS-G ETKF ensemble

- 1 control and 44 perturbed members at N400L70 (32 km at mid-latitudes, 80 km model top) run to T+7 days
- Centred on hybrid-4DVar analysis reconfigured to ensemble grid
En-4DEnVar ensemble
En-4DEnVar ensemble

- Experiments with 23, 44, 176 and 200 members
- Perturbed observations
- Additive inflation together with RTPP and RTPS multiplicative inflation
- Time-invariant localisation
- Self-exclusion
Results
Experimental setup

• August 2012
  • N512L70 New Dynamics forecasts
  • ETKF ensemble N320L70 (23 and 176 members)
  • Hybrid-4DVar DA at N216L70
  • Hybrid-4DEnVar DA at N320L70

• February 2014
  • N320L70 ENDGAME forecasts
  • ETKF ensemble N216L70 (44 members)
  • En-4DEnVar ensemble N216L70 (44 and 200 members)
  • Hybrid-4DVar and hybrid-4DEnVar DA at N216L70
Effect of changing ensemble source on NWP index

- Hybrid-4DVar improves with increasing ensemble weight
- Hybrid-4DEnVar now beats non-hybrid-4DVar
- En-4DEnVar improves both hybrid-4DVar and -4DEnVar
Non-hybrid-4DVar → Hybrid-4DVar

ETKF 44 member ensemble; 100% Bc, 30% Be
Hybrid-4DVar

ETKF → En-4DEnVar 44 member ensemble; 100% Bc, 30% Be
Hybrid-4DVar
ETKF → En-4DEnVar 44 member ensemble; 30% Bc, 70% Be
Hybrid-4DVar
En-4DEnVar 44 → 200 members; 100% Bc, 30% Be
Hybrid-4DVar

En-4DEnVar 200 member ensemble;
100% Bc, 30% Be → 30% Bc, 70% Be
Hybrid-4DVar
ETKF $\rightarrow$ En-4DEnVar; 44 $\rightarrow$ 200 members;
100% Bc, 30% Be $\rightarrow$ 30% Bc, 70% Be
Summary and future work

- Hybrid-4DEnVar now outperforms non-hybrid-4DVar with an En-4DEnVar ensemble

- Both hybrid-4DVar and hybrid-4DEnVar improve when going from the operational ETKF ensemble to an En-4DEnVar ensemble

- Hybrid-4DVar still outperforms hybrid-4DEnVar

- Continue using hybrid-4DVar for the life of our Cray XC40, aspiring to change the ETKF ensemble to an En-4DEnVar ensemble