

Improving the MOGREPS global ensemble using 4D-ensemble variational data assimilation

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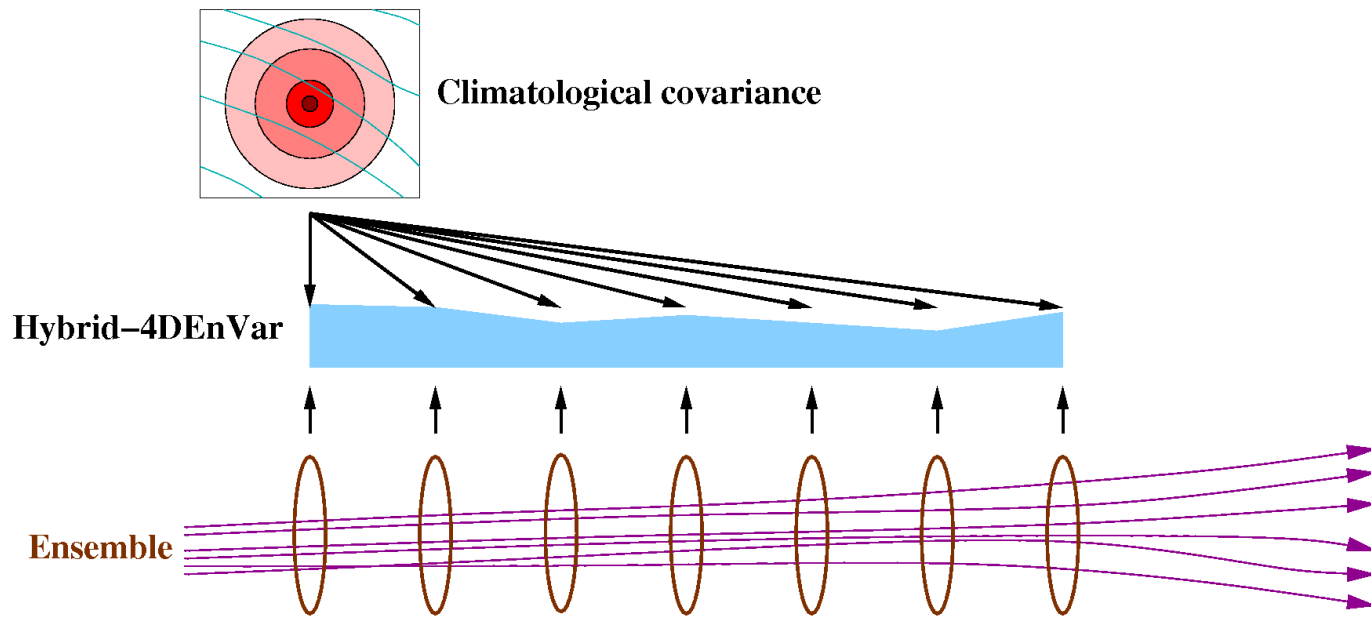
Hybrid 4DVar data assimilation performance

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Motivation for En-4DEnVar

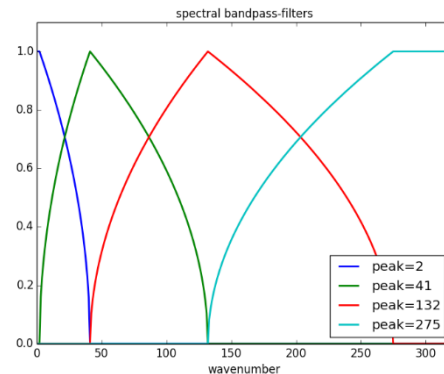
- Replace the current ensemble transform Kalman filter (runs on one node and has its own code repository)
- Shares code with our deterministic hybrid 4DVar system so easier to maintain
- Shares static covariances with hybrid 4DVar
- Future enhancements can be applied to both hybrid 4DVar and En-4DEnVar
- Runs on many nodes so can process more observations more efficiently

Hybrid 4DEnVar: equal static and ensemble weights



En-4DEnVar: horizontal waveband localisation

- Buehner (2012):
[doi:10.1175/MWR-D-10-05052.1](https://doi.org/10.1175/MWR-D-10-05052.1)
- Split ensemble perturbations into horizontal spectral wavebands (should be 1, 27, 89, 185 peaks)
- Localise each waveband separately
- Used Ménérier's [hybrid_diag](#) software to deduce lengthscales



Band: Scale (km)

1: 6214

2: 919

3: 389

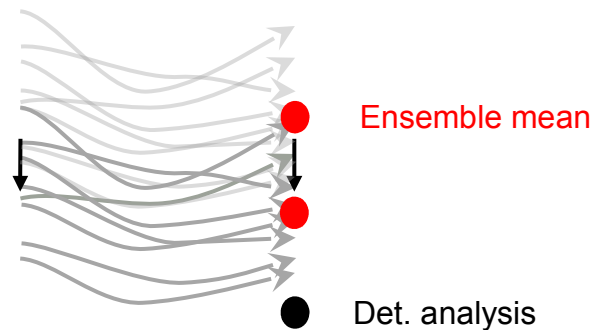
4: 256

En-4DEnVar: inflation

- Compensate for model error using random parameters (to be replaced with SPT (Stochastic Perturbed Tendencies)), SKEB (Stochastic Kinetic Energy Backscatter)
- Additionally, use additive inflation with an archive of hybrid 4DVar analysis increments: population mean + 0.5 (random increment – sample mean)
- Compensate for lower boundary error using random perturbations to sea surface temperature, soil moisture and soil temperature
- Compensate for sampling error with RTPS (Relaxation To Prior Spread, 0.7 factor) and mimic ensemble square root filter with RTPP (Relaxation To Prior Perturbations, 0.5 factor)

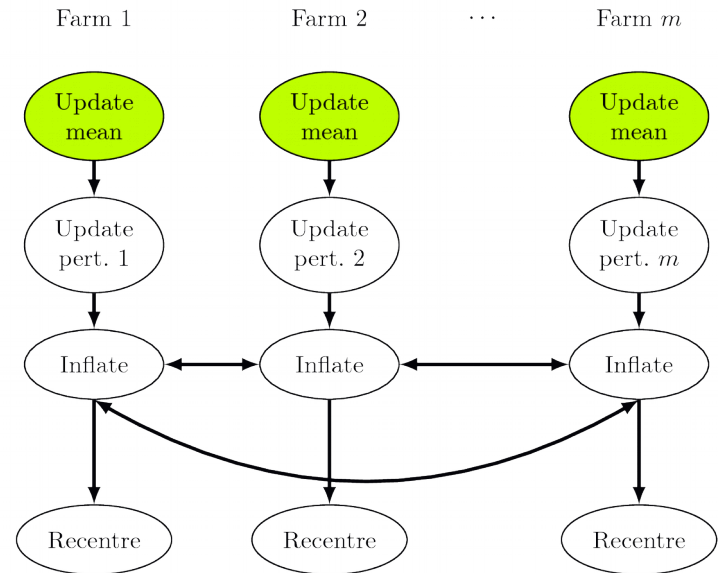
En-4DEnVar: recentring and self-exclusion

- Recentre the ensemble halfway between the 4DVar analysis and ensemble mean
- Exclude the member being updated from the covariance calculation

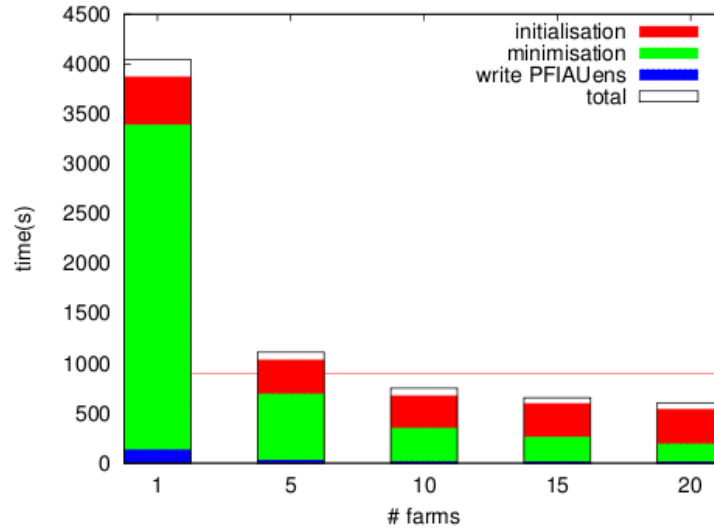


En-4DEnVar: mean-perturbation method

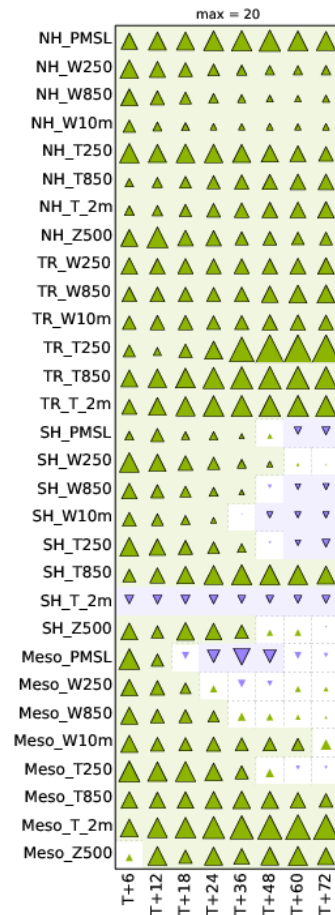
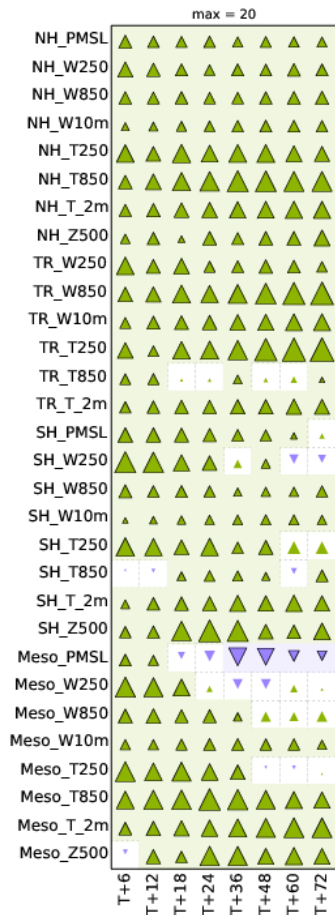
- Lorenc et al. [doi:10.1002/qj.2965](https://doi.org/10.1002/qj.2965)
- Minimise a penalty function for the ensemble mean then individual penalty functions for each member
- Each farm processor stores a geographical segment of each member, waveband and time



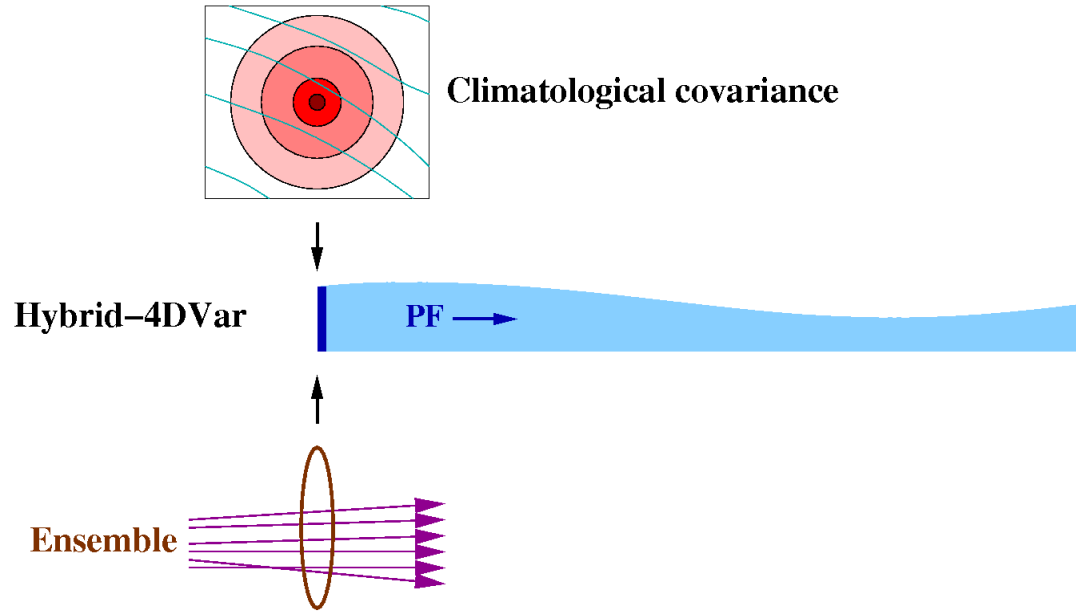
Timing: 100 members



May to Jul 2015
 Fully recentred 44
 member ETKF vs
 half recentred 44
 member En-
 4DEnVar

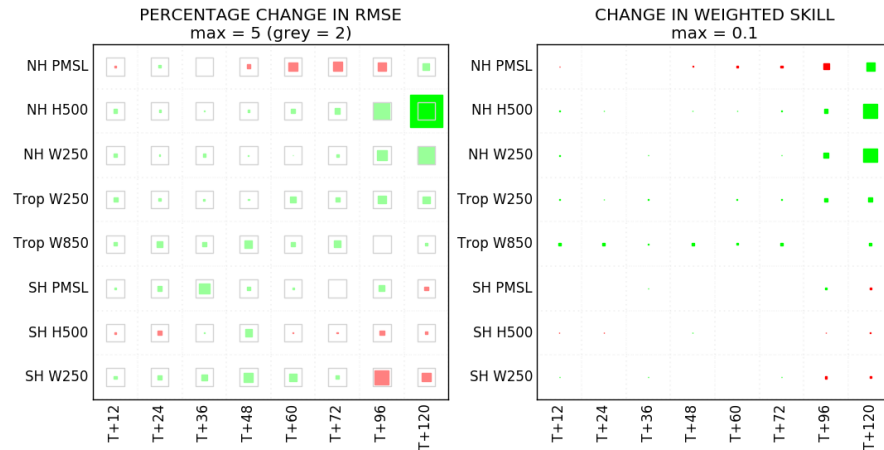


Hybrid 4DVar: 0.7 static, 0.3 ensemble weights (0.63 and 0.27 upper atmosphere)



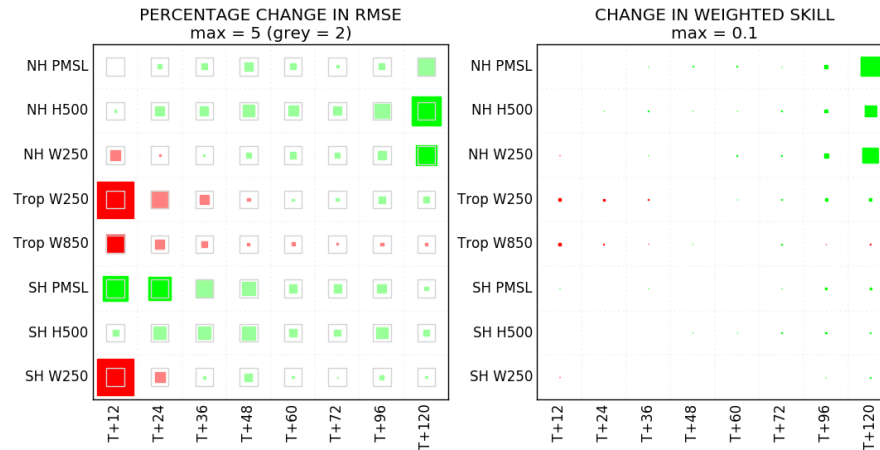
En-4DEnVar driving hybrid 4DVar: observations

VAR TRIAL: 4DEnVar_EOTD100_vs_ETKF_EOTD (Summer_2015)
VERIFICATION VS OBSERVATIONS
FROM 20150525 TO 20150703
OVERALL CHANGE IN NWP INDEX = 0.506

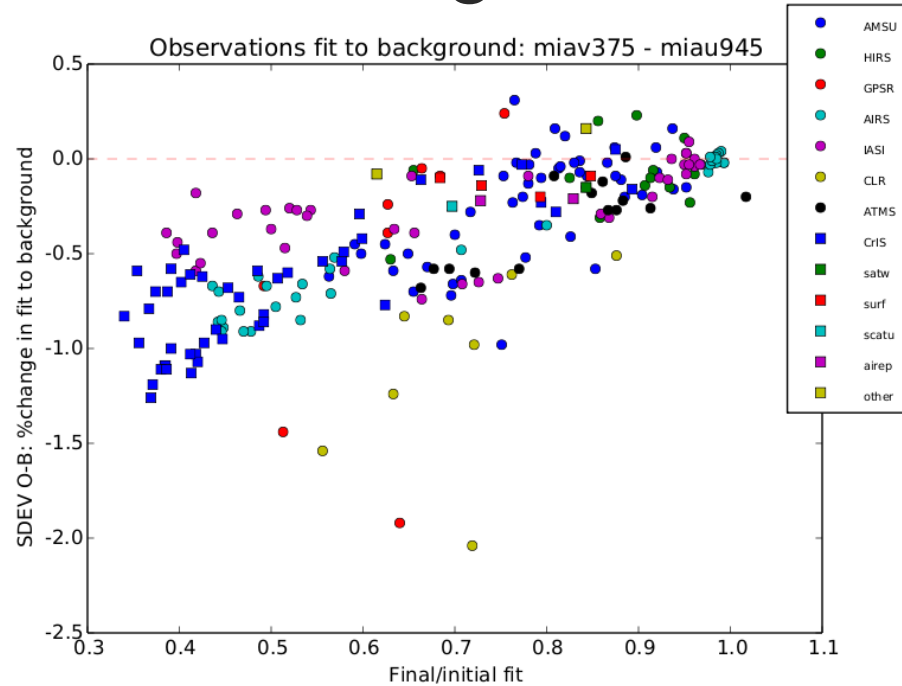


En-4DEnVar driving hybrid 4DVar: own analyses

VAR TRIAL: 4DEnVar_EOTD100_vs_ETKF_EOTD (Summer_2015)
VERIFICATION VS ANALYSIS
FROM 20150525 TO 20150703
OVERALL CHANGE IN NWP INDEX = 0.957



Observations fit to background



Conclusions

- Further work since Bowler et al (2017), [doi:10.1002/qj.3004](https://doi.org/10.1002/qj.3004)
- Upgraded to a later operational suite configuration, updated static covariances based on En-4DEnVar training data and retuned En-4DEnVar setup
- Ensemble forecasting performance and hybrid 4DVar data assimilation both improved
- Operational implementation with 100 members planned for late 2018 / early 2019

Questions?

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