Evolution of the global data assimilation at Météo-France

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Numerical Weather Prediction at Météo-France

ARPEGE
7.5 km - 37 km

AROME
1.3 km
Operational global assimilation

Deterministic 4D-Var

25 perturbed 4D-Var
Operational global assimilation

- **Deterministic 4D-Var**
  - 6 hour time window
  - 2 outer loops: T1198c2.2 resolution, L105 vertical levels
    - 1st inner loop TL149c1.0 (135 km), very simplified physics
    - 2nd inner loop TL399c1.0 (50 km), simplified physics
  - Jc-DFI, VarBC
  - $B^{1/2} = K^b \sum^b C^{1/2}$, $K^b$ = spectral + non-linear balances, wavelet $C$

- **Ensemble assimilation**
  - 25 perturbed 4D-Var
  - 1 outer loop TL479c1.0 (40 km) / inner loop TL149c1.0 (135 km)
  - Observation errors simulated from random draws of $R$
  - Model errors: multiplicative inflation of 6h background errors

- **Provides**
  - filtered $\Sigma^b$ from last 25 perturbations, updated every 6 h
  - wavelet $C$ from last 6 x 25 perturbations (last 30 h), updated every 6 h
Global assimilation $B^{1/2} = K^b \Sigma^b (C^w)^{1/2}$

vorticity $\sigma^b$

850 hPa

diagnosed
u length-scale
850 hPa
Normalisation of a wavelet-based correlation matrix $C = W^{-1} D W^{-T}$

- **Diagnosis of diagonal values $\sigma^2$ of $C$**

- **Explicit formula** (accurate, at low cost):
  \[ \sigma^2 = \frac{1}{W} d \]

  i.e. apply a modified inverse wavelet transform $\frac{1}{W}$
  (using squared values of wavelet filters in $W$)
  to variance fields $d$ of wavelet coefficients.

- **Randomization approach** (with $N=10,000$ vectors, less accurate and more costly):
  \[ \sigma^2 = \text{var} \left( W^{-1} D^{1/2} \eta \right) \]

  (Chabot, Berre and Desroziers 2017)
Number of observations

Evolution of cumulated monthly number of observations used for each type

- IASI
- AIRCRAFT
Degrees of Freedom for Signal (DFS)

Part of DFS for each type of observations
Cumulated DFS from 2017011900 to 2017011918 : 528551
Operational global assimilation
Next configuration

- **Deterministic 4D-Var**
  2 outer loops T1198c2.2 → T1798c2.2 (7.5 → 5 km)
  1\textsuperscript{st} inner loop : 135 → 90 km
  2\textsuperscript{nd} inner loop : 50 → 40 km

- **Ensemble assimilation**
  25 → 50 perturbed 4D-Var.
  1 outer loop, 40 km
  Inner loop : 135 → 90 km

- **Gives**
  - finer filtered $\Sigma^b$ from last 25 → 50 perturbations (less sampling noise), updated every 6 h,
  - more localised wavelet $\mathbf{C}$ from last 6 x 25 → 3 x 50 pert. (last 30 h → 12h), updated every 6 h.
Increase of increment resolution

diagnosed
u length-scale
850 hPa
50 km (T399)

diagnosed
u length-scale
850 hPa
40 km (T499)
Decrease of time-averaging for correlations
(30 h with 25 members / 12 h with 50 members)

diagnosed $u$ length-scale
850 hPa
40 km (T499)
25 members

diagnosed $u$ length-scale
850 hPa
40 km (T499)
50 members

Small length scales more pronounced and localised
Deterministic 4D-Var additional microphysics package

- **Characteristics**
  - only Qv prognostic
  - added to current moist simplified physics
    - based on Smith cloud scheme
  - autoconversion / collection / melting / evaporation

- **Impact**
  - needs many tunings
  - improvement in the representation of moist processes in the TL an AD
  - improvement of the TL approximation
  - evaluated in the new version of the global assimilation
Conclusion

- Global data assimilation at Météo-France
  - Deterministic incremental 4D-Var.
  - Ensemble assimilation with 25 perturbed 4D-Var.
  - Flow-dependent background error variances and correlations.
  - Continuous increase of the number of observations.

- Significant update planned for the next future
  - 5 km resolution over France and improved resolution of analysis increment.
  - 50 perturbed 4D-Var.
  - Better representation of background error covariances $B$.
  - Simplified microphysics package.

- Towards 4DEnVar
  - No more TL and AD models.
  - Still improved representation of $B$.
  - Potentially more scalable.