Spatial satellite observation-error covariances for AMSU-A: estimation and implications for data assimilation

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Motivation

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Conclusion: spatial statistics for satellite data seems to be now of comparable importance for data assimilation as the widely used background-error statistics

Scope

1. Objective estimation of satellite observation-error spatial statistics for microwave AMSU-A observations

2. Impact assessment of using correct satellite-error covariances in data assimialtion (in 3D-Var)

Estimation: methodology

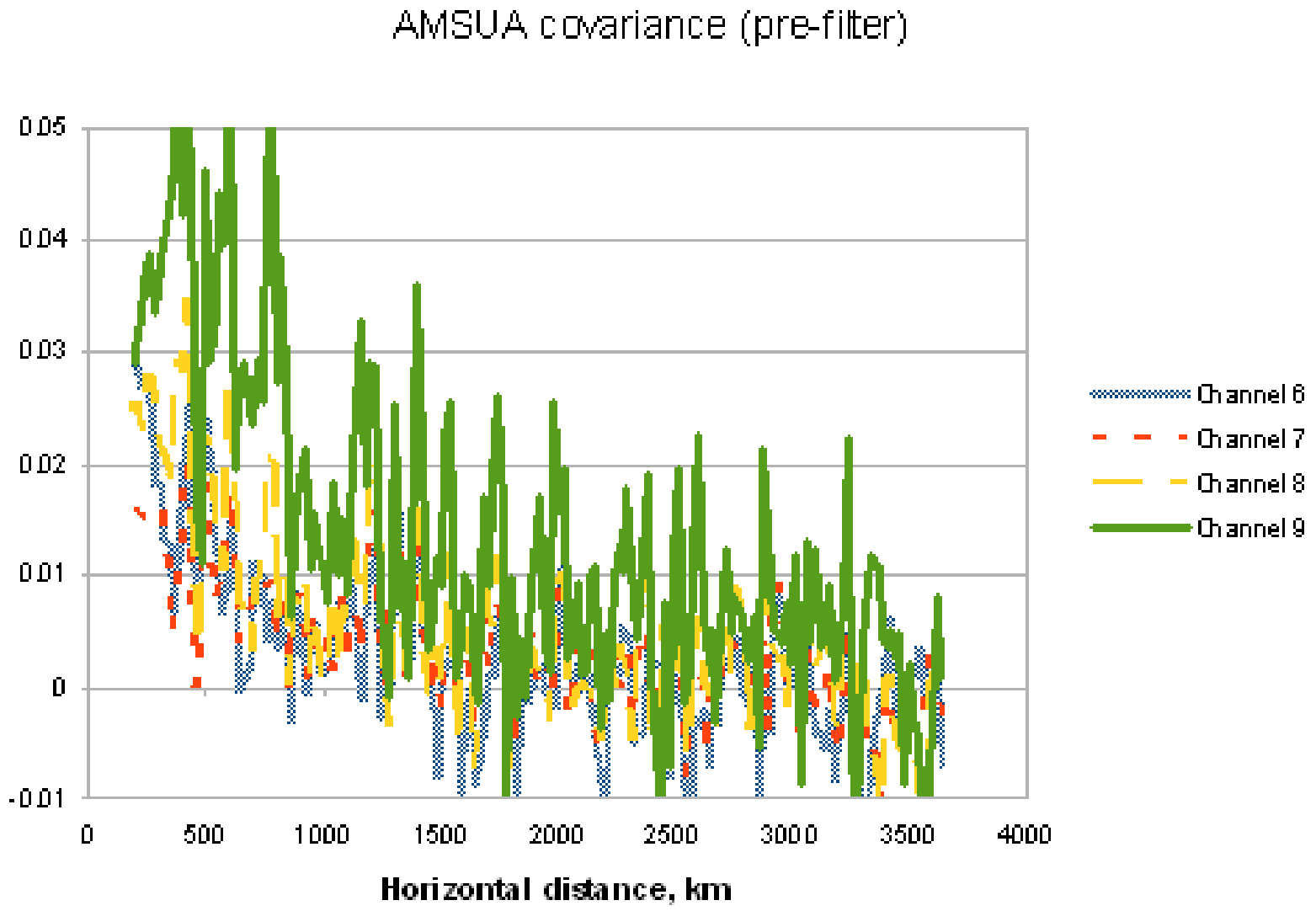
In the most general terms, we compare satellite data with collocated radiosonde observations

$$cov(s - r, s - r)$$

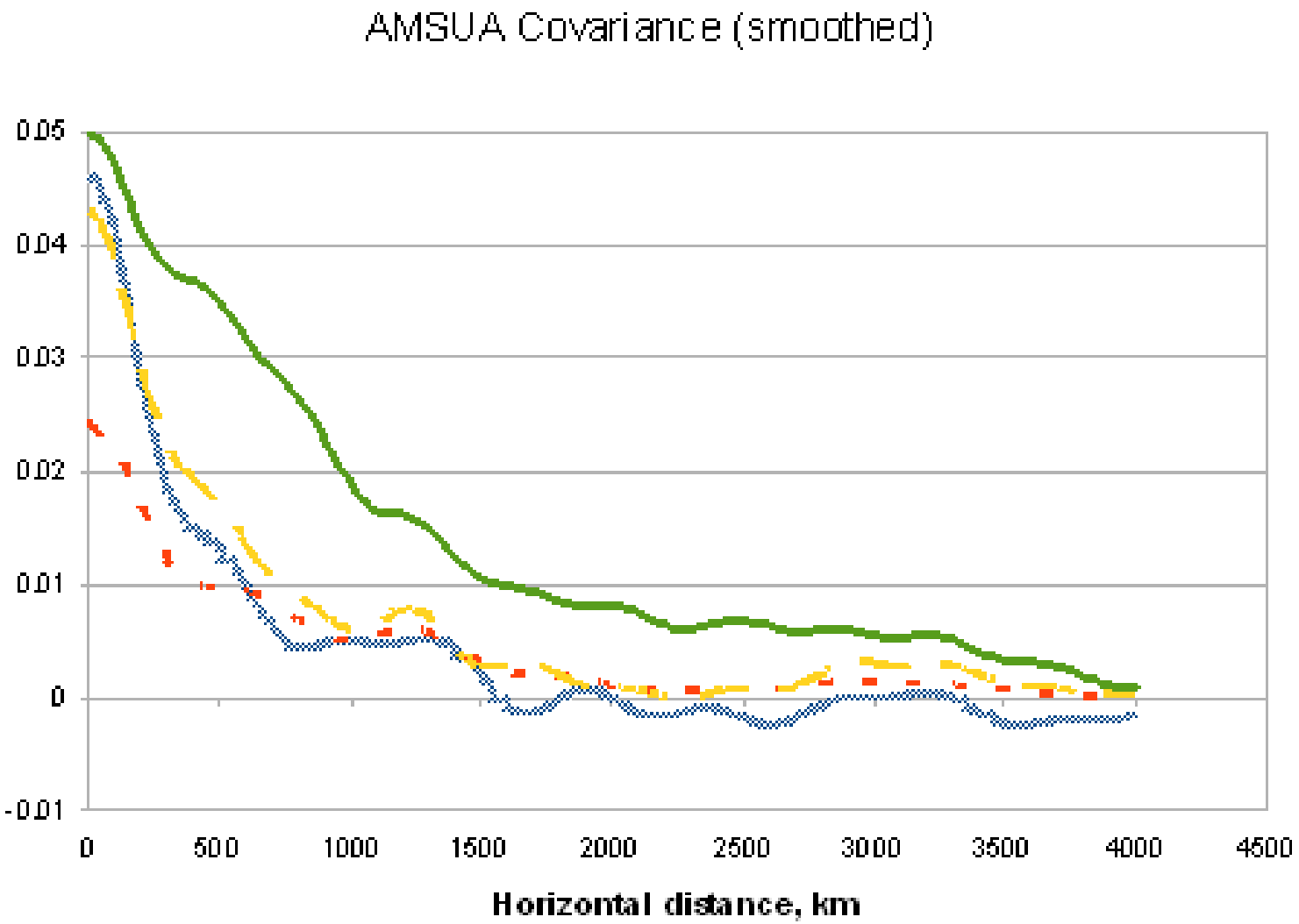
$$r = \mathcal{H}(\mathbf{X}^{obs}_{raob})$$

The basic assumptions in this study: radiosonde errors $r' := r - t$ do not correlate with:
(i) radiosonde errors for different radiosonde ascents,
(ii) satellite errors $s' := s - t$, and
(iii) forecast errors $f' := f - t$

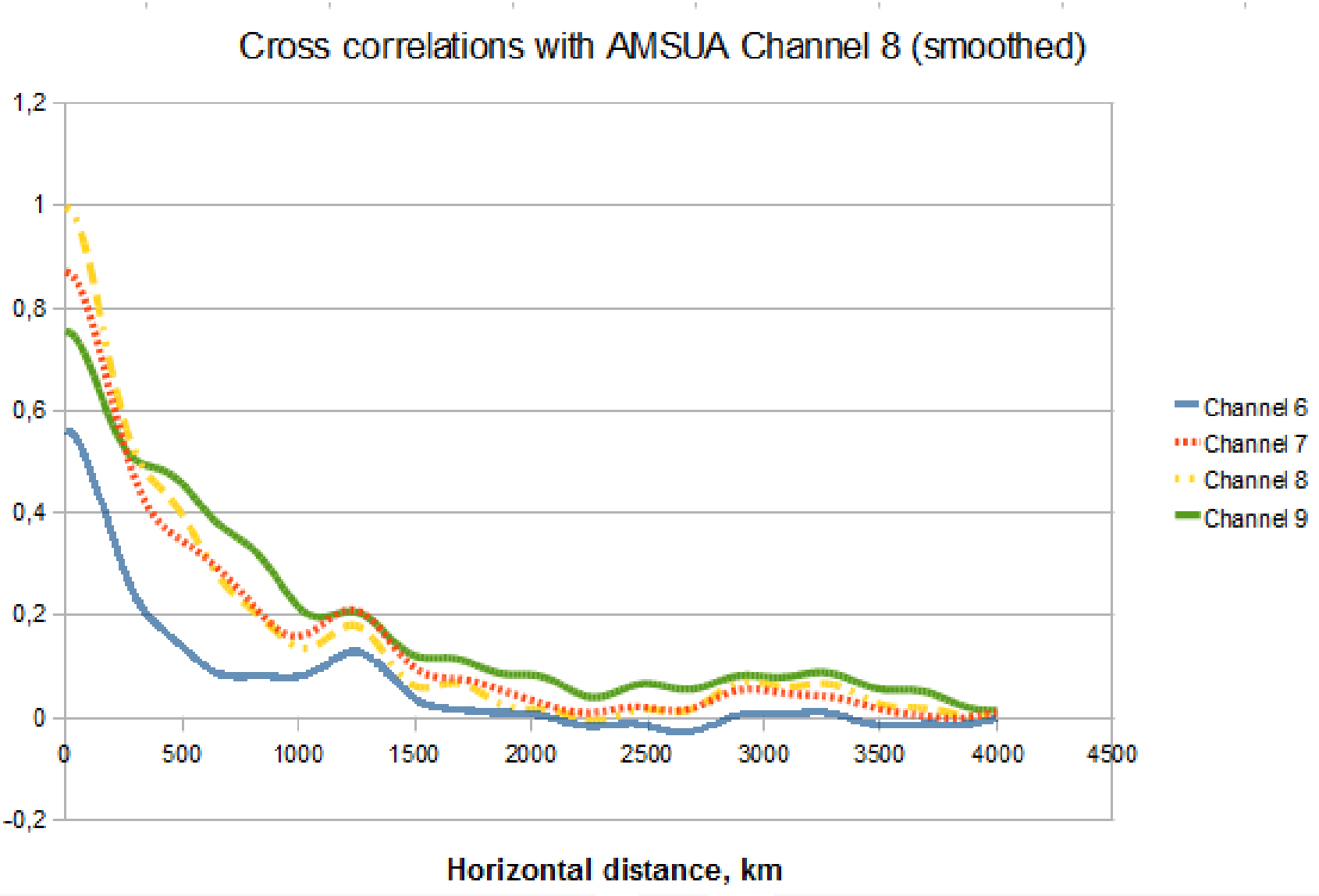
Estimation results. Horizontal covariances



Horizontal covariances (smoothed)



Inter-channel cross-correlations

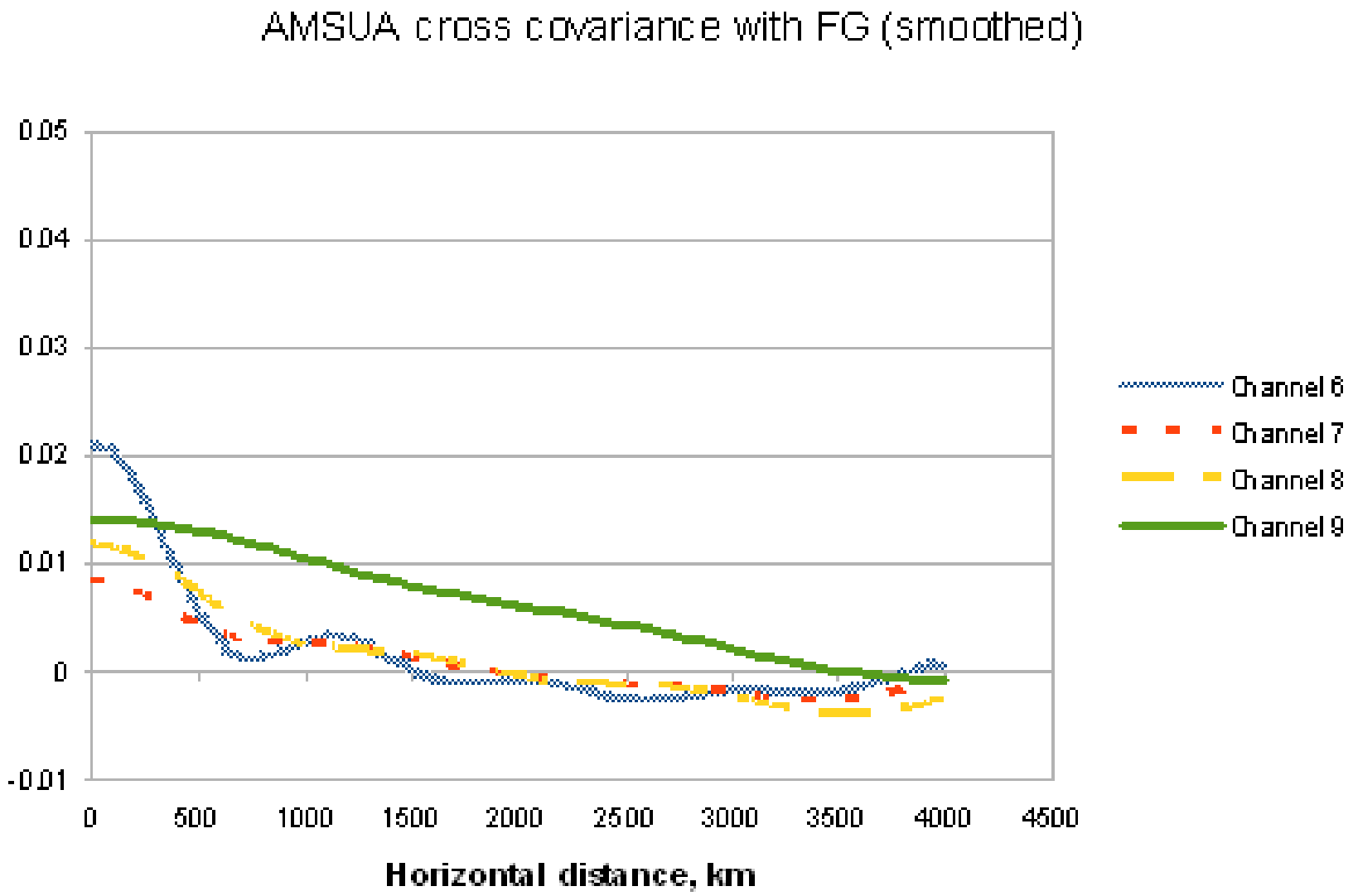


Other correlations

Seasonal contrasts: winter horizontal correlations appear to be about twice as broad as summer correlations.

Inter-satellite cross-covariances (NOAA-18 against NOAA-19): no significant differences as compared to auto-covariances for each satellite separately.

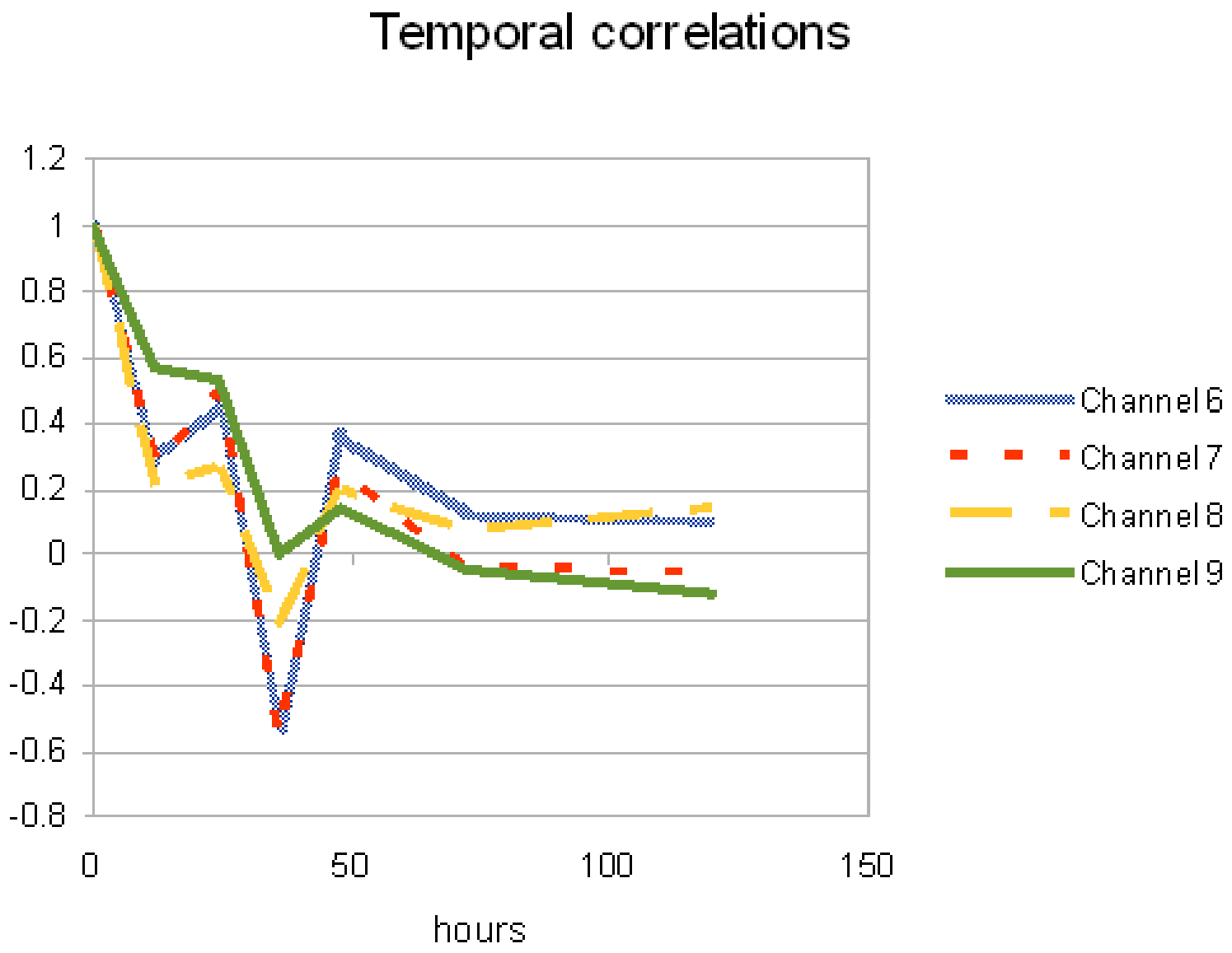
Satellite-error vs. forecast-errors cross-covariances



One-point (co)variances

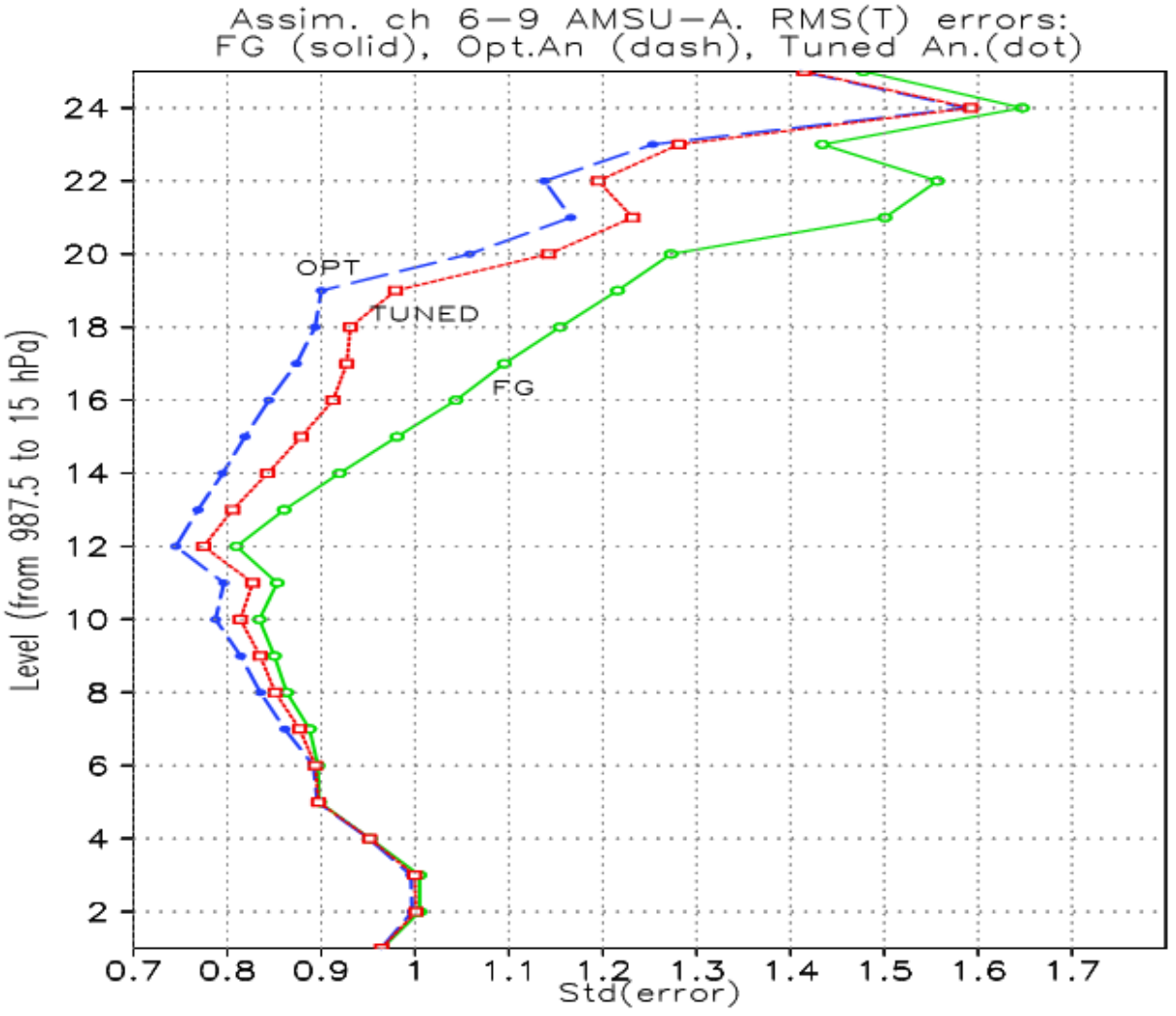
Channel	σ_w	σ_c	σ_f	σ_w/σ_c	$corr(c', f')$
6	0.12	0.15	0.20	0.6	0.50
7	0.14	0.21	0.16	0.9	0.34
8	0.17	0.21	0.15	0.8	0.39
9	0.14	0.22	0.15	0.6	0.42

Temporal satellite error covariances

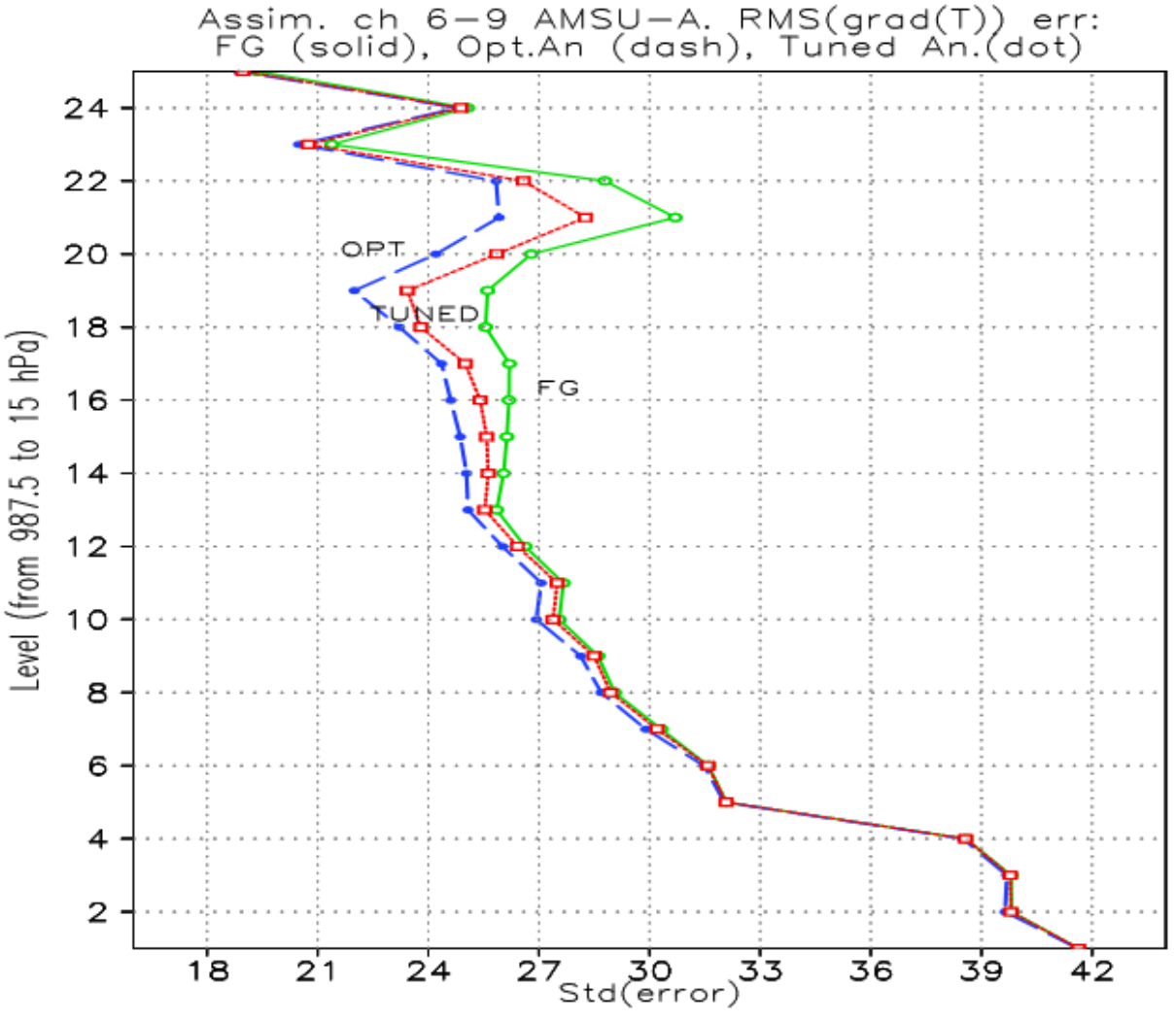


Consequences for data assimilation. Spatial correlations

Effect in 3D-Var. Temperature



Spatial correlations: Effects in 3D-Var. grad(T)



Temporal correlations: impact study

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Join the two state vectors and the two forecast models, getting the system driven by the (augmented) white-noise sequence.

Design a KF for the extended state vector.

Temporal correlations: Effect in 0D-KF

6-h. correl.	0.5	0.7	0.8	0.9	0.95	0.99
Benefit	0.6%	1.6%	3.3%	4.8%	7%	14%

Conclusions

- *Horizontal* AMSU-A correlations are about as large as background-error correlations.
- *Inter-channel* AMSU-A correlations are also high.
- There is significant *cross-correlation* between background and AMSU-A errors.
- There are significant *temporal* AMSU-A error correlations.
- An impact study with simulated data reveals that:
  1. Accounting for *horizontal and inter-channel* observation-error correlations
     can substantially improve the 3D-Var performance.
  2. For a scalar dynamical system, the estimated observation-error *temporal* correlations do not lead to any tangible benefit in data assimilation.