CHARACTERIZING AND USING SWOT ERROR COVARIANCES FOR STATE ESTIMATION PROBLEMS

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Why examine SWOT error covariances?

- Reason 1: because we want to derive velocity from SSH. At first order, velocity is the gradient of SSH.

\[ y = \eta + \epsilon \Rightarrow \nabla y = \nabla \eta + \nabla \epsilon \]

High spatial error correlations result in small error gradients.
Why examine SWOT error covariances?

- Reason 1: because we want to derive velocity from SSH. At first order, velocity is the gradient of SSH.

(Images showing different correlation types and SSH errors)

(From Brankart et al., 2009)
Why examine SWOT error covariances?

- Reason 2: because we need the error covariance matrix for the inversion of SWOT:

\[ J(x) = \| x - x^b \|_B + \| y - Hx \|_R \]

where \[ \| a \|_A = a^T A^{-1} a \]
How to quantify SWOT error covariances?

- We perform a large number (5000) of realizations of the SWOT error with the simulator.
- Five sources of error are simulated, including the space-independent Karin error.
How to quantify SWOT error covariances?

Results show long-range correlations between measurement errors.
How to use this for practical inversion?

- The SWOT error variances and covariances compose the error covariance matrix $R$ in

$$\mathcal{J}(x) = \| x - x^b \|_B + \| y - Hx \|_R$$

where $\| a \|_A = a^T A^{-1} a$

- Problem: $R$ is big and needs being inverted.
How to use this for practical inversion?

- Following Brankart et al (2009), we form the extended observation vector:

\[ y^+ = Ty = \begin{pmatrix} I & \nabla \cdot f \\ \nabla^2 \cdot f \end{pmatrix} y \]

where \( f \) is a Lanczos filter meant to reduce Karin noise.

- And we seek a diagonal covariance matrix \( R^+ \) such that:

\[
R^{-1} = T^T R^+ T
\]

- It is equivalent to use \((y, R)\) or \((y^+, R^+)\) in the inversion (Brankart et al, 2009).
How to use this for practical inversion?

Covariances obtained from:
- The simulator realizations (left);
- The transformation of the diagonal covariance matrix of the extended observation vector (right).

(Simulator outputs at a 10-km resolution here)
How to use this for practical inversion?

Error variances of the extended vector (SSH, along-track gradient, cross-track gradient)
Conclusions

- There will be information in the SWOT error covariances;
- We are trying to design a simple method to quantify and use these covariances in the inversion or the assimilation of SWOT;
- The method introduces pseudo-observations of the derivatives of SSH;
- We are achieving promising advances but more work is needed.

- This method requires a large number of realizations of the SWOT simulator;
- These realizations must be replayed at each upgrade of the simulator.