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Uncertainty quantification for remote sensing data: Sensitivity to *a priori* conditions in optimal estimation retrieval algorithms

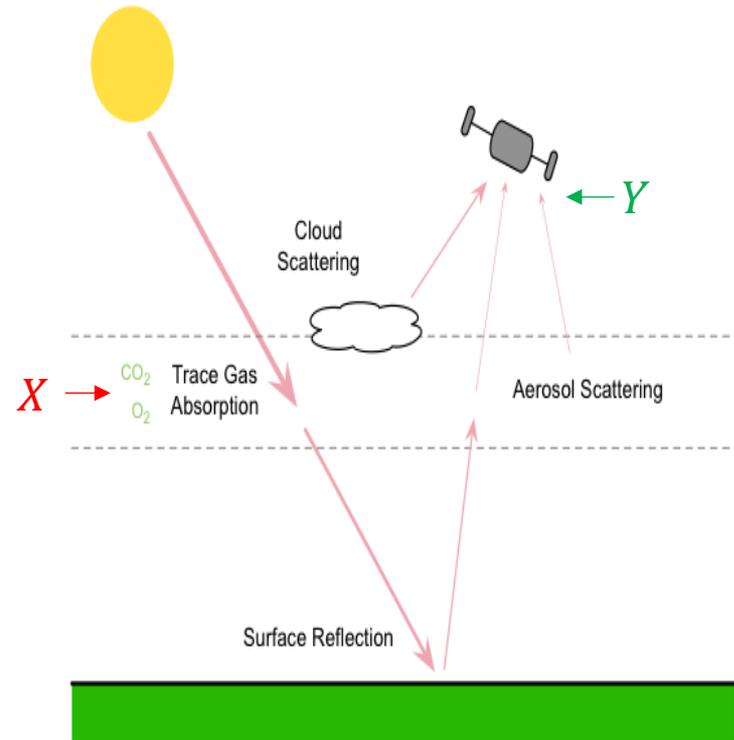
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Remote Sensing

- Greenhouse gas monitoring satellites—such as the Orbiting Carbon Observator-2 —rely on remote sensing to infer atmospheric state and quantity of interest (X)
- Fit measured spectral radiance (Y) to radiative transfer model F , where:

$$F(X, B) = Y$$



Optimal Estimation

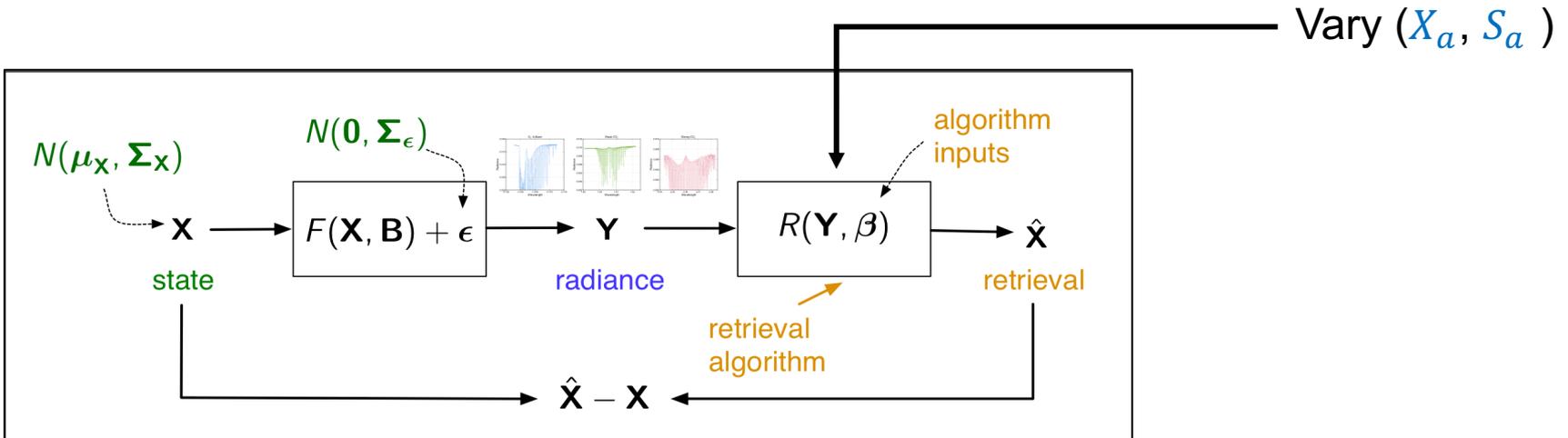
- Assume *a priori* distribution of atmospheric state (X_a, S_a)
- Minimize cost function:

$$c = \left(Y - F(X, B) \right)^T S_e^{-1} \left(Y - F(X, B) \right) + \left(X - X_a \right)^T S_a^{-1} \left(X - X_a \right)$$

- Observe Y + Assume $X_a, S_a \rightarrow$ Infer X given F, B
- Retrieval sensitive to assumptions made in *a priori* conditions

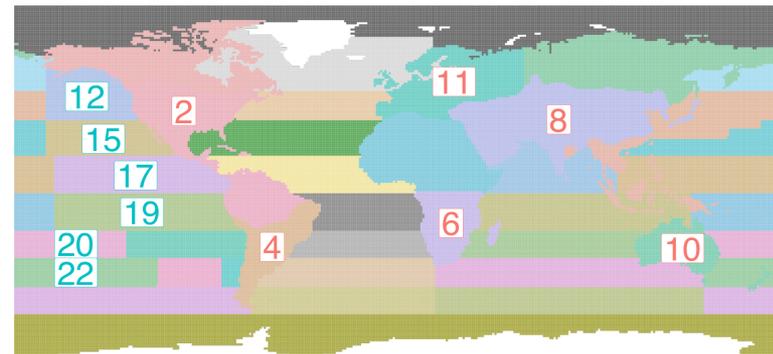
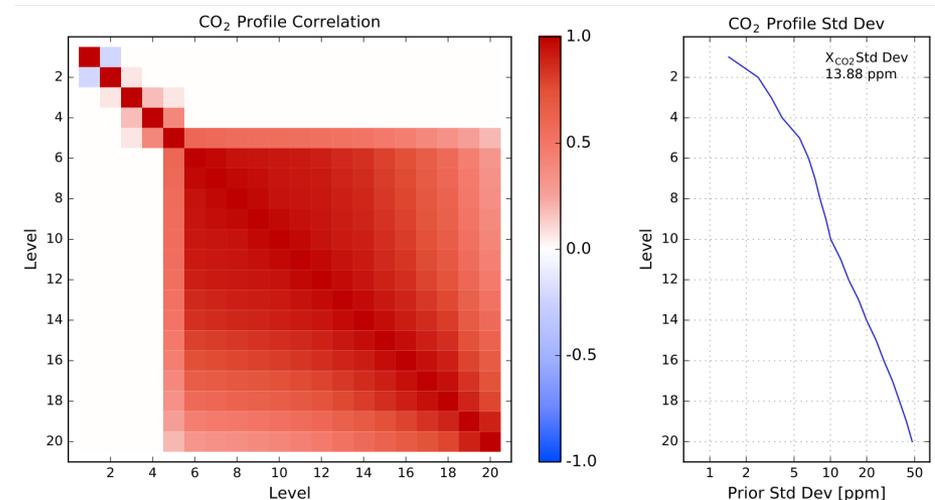
Simulation Framework

- Monte Carlo simulation framework useful approach for testing retrieval algorithm sensitivity
- Generate synthetic radiance using distribution of marginal states
- Retrieve synthetic radiances and compare with true state *under different sets of a priori conditions*



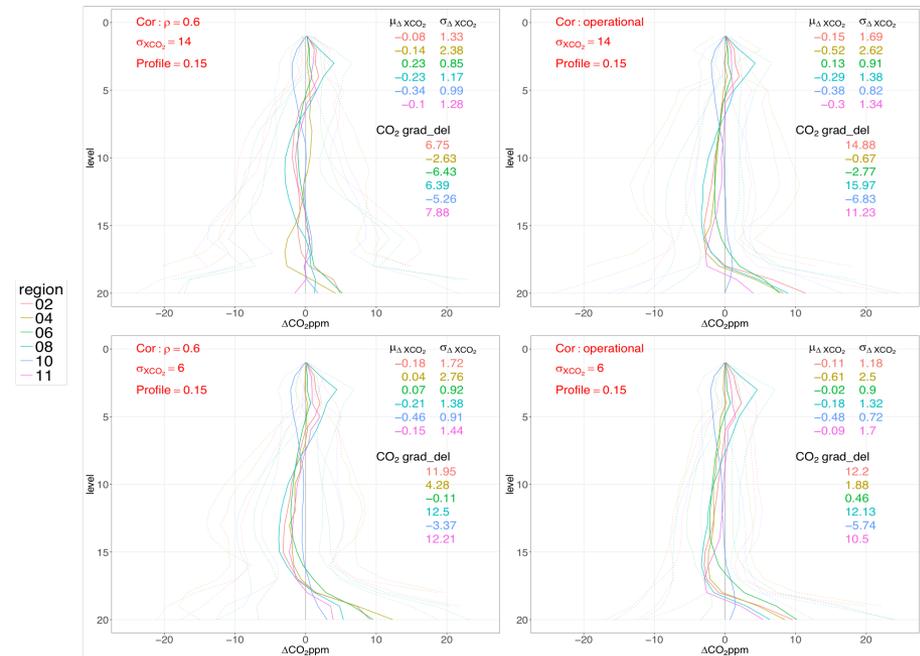
Test Case: Sensitivity to choices in prior covariance

- Generate alternative prior covariances to test
- Manipulate:
 - Correlation patterns across vertical levels
 - Column-averaged standard deviation
 - Standard deviation profile
- Simulate under different geophysical conditions



Test Case: Results

- Choice of *a priori* covariance affects CO₂ vertical profile
- Does not significantly affect column-averaged CO₂ (XCO₂), the main quantity of interest
- Results invariant across geophysical conditions
- No recommendation to change operational *a priori* covariance



Conclusions

- Simulation framework ideal for testing sensitivity to a *priori* conditions
- Customization of parameters
- Varying geophysical conditions
- Comparison against simulated true state



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Questions?

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