

**OCO-2 Linear Model**  
**Lamont, OK Template**  
June 7, 2024

The supporting datasets on the OCO-2 linear surrogate model include two files for each of the three geophysical templates defined in Hobbs et al. (2021). The templates are constructed near TCCON sites:

- Lamont, OK, USA, October 2015
- Wollongong, Australia, December 2016
- Wollongong, Australia, June 2017

For each template, a CSV file, (`1nd_nadir_201510_lamont_reference_locations.csv`) contains the spatial locations for the OCO-2 orbit considered. The datasets include the locations' longitude and latitude along with the OCO-2 orbit number and a unique sounding ID for each location.

The OCO-2 linear model metadata `example_oco2_linear_model_lamont_201510.h5` includes information for the linear forward model,

$$\begin{aligned}\mathbf{X} &\sim \mathcal{N}(\boldsymbol{\mu}_{\mathbf{X}}, \boldsymbol{\Sigma}_{\mathbf{X}}) \\ \mathbf{Y} &= \mathbf{F}\mathbf{X} + \boldsymbol{\epsilon} \\ \boldsymbol{\epsilon} &\sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\boldsymbol{\epsilon}})\end{aligned}$$

Variables in the HDF5 file include:

- Radiance noise variance  $\boldsymbol{\Sigma}_{\boldsymbol{\epsilon}}$ . The retrieval assumes this is a diagonal matrix,

$$\boldsymbol{\Sigma}_{\boldsymbol{\epsilon}} = \text{diag}(\sigma_{\epsilon,i}^2), \quad i = 1, \dots, n.$$

The *variances*,  $\sigma_{\epsilon,i}^2$  for each of the  $i = 1, \dots, n$  wavelengths are saved as `error_variance_diagonal`.

- Names of state vector elements: `state_vector_names`
- True process mean vector  $\boldsymbol{\mu}_{\mathbf{X}}$ : `state_true_mean_vector`
- OCO-2 operational prior mean vector  $\boldsymbol{\mu}_a$ : `operational_prior_mean_vector`
- OCO-2 operational prior covariance matrix  $\boldsymbol{\Sigma}_a$ : `operational_prior_covariance_matrix`
- Linear operator  $\mathbf{F}$ , based on the Jacobian of surrogate model: `model_matrix`
- $X_{CO_2}$  pressure-weighting function  $\mathbf{h}$ : `pressure_weighting_function`. The column average  $CO_2$  concentration,  $X_{CO_2} = \mathbf{h}'\mathbf{X}_{1:20}$  is a weighted average of the  $CO_2$  vertical profile.
- Viewing geometry relative azimuth: `azimuth_angle`
- Satellite zenith angle: `instrument_zenith_angle`
- Solar zenith angle: `solar_zenith_angle`
- Observed instrument wavelengths: `wavelength`

## References

- Hobbs, J., Katzfuss, M., Zilber, D., Brynjarsdóttir, J., Mondal, A., & Berrocal, V. (2021). Spatial retrievals of atmospheric carbon dioxide from satellite observations. *Remote Sensing*, 13(4), 571. doi: 10.3390/rs13040571