How to use these models to analyze observations?

$$Bayesian\ framework$$

$$P(y|x)P(x) = P(x|y)P(y)$$

Forward modeling with ForMoSA:

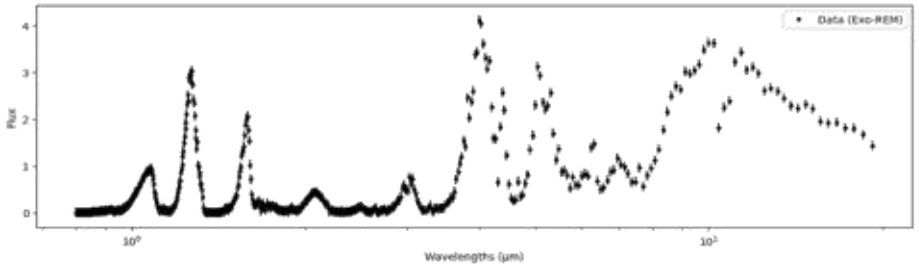
Nested Sampling:

Forward modeling with ForMoSA:

- **Robust comparisons:** Links diverse observational data (spectroscopy and photometry) with physically motivated theoretical models.
- **Statistical flexibility:** Offers a variety of likelihood metrics to optimize model fitting.
- **Comprehensive parameters:** Accounts for both grid-based atmospheric variables and non-atmospheric factors (e.g., RV, *v* sin *i*, CPD, scaling factors).
- **Wide exploration:** Searches a broad range of values for all free parameters.

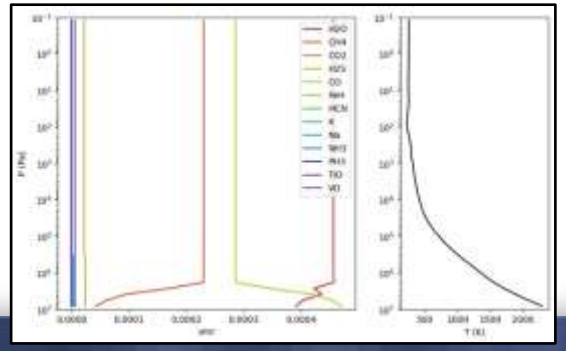
- **Rigid chemistry:** Tied to pre-computed grids, making it inflexible.
- **Limited physical dynamics:** Cannot easily model complex, localized phenomena like auroras causing thermal inversions, patchy/variable clouds, or other unique environmental interactions.

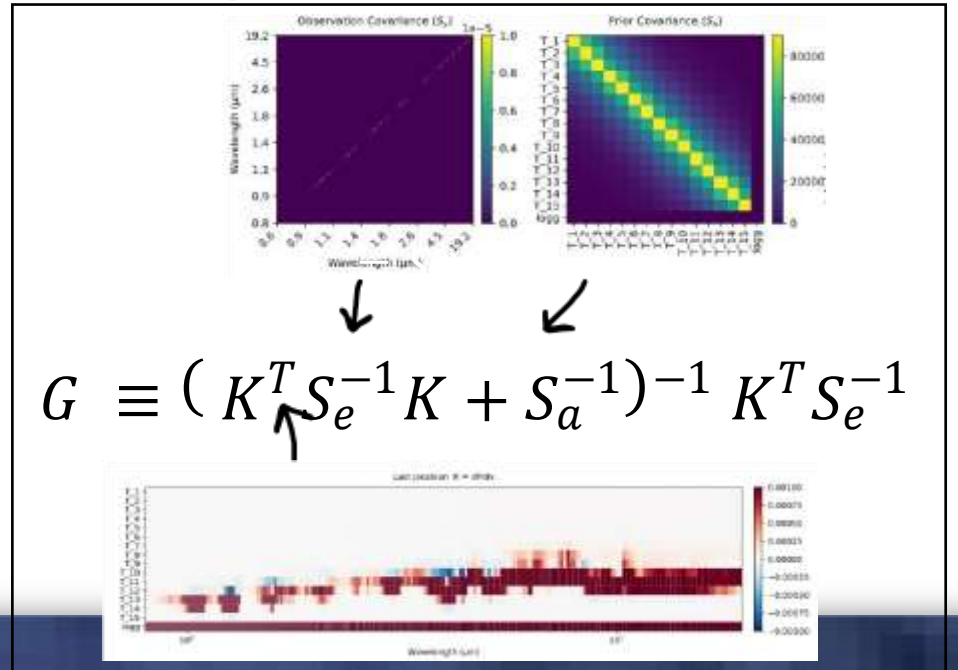
Retrieval with :



$$\begin{bmatrix} \\ \\ \end{bmatrix}_k \rightarrow x_k = x_a + G\left(y - F(x_a)\right)$$

$$\begin{bmatrix} T_1 \\ T_2 \\ \dots \\ T_n \\ \log(g) \\ \dots \end{bmatrix}_a$$





$$G \equiv \left(K^T S_e^{-1} K + S_a^{-1}\right)^{-1} K^T S_e^{-1}$$

T_1

T_2

...

T_n

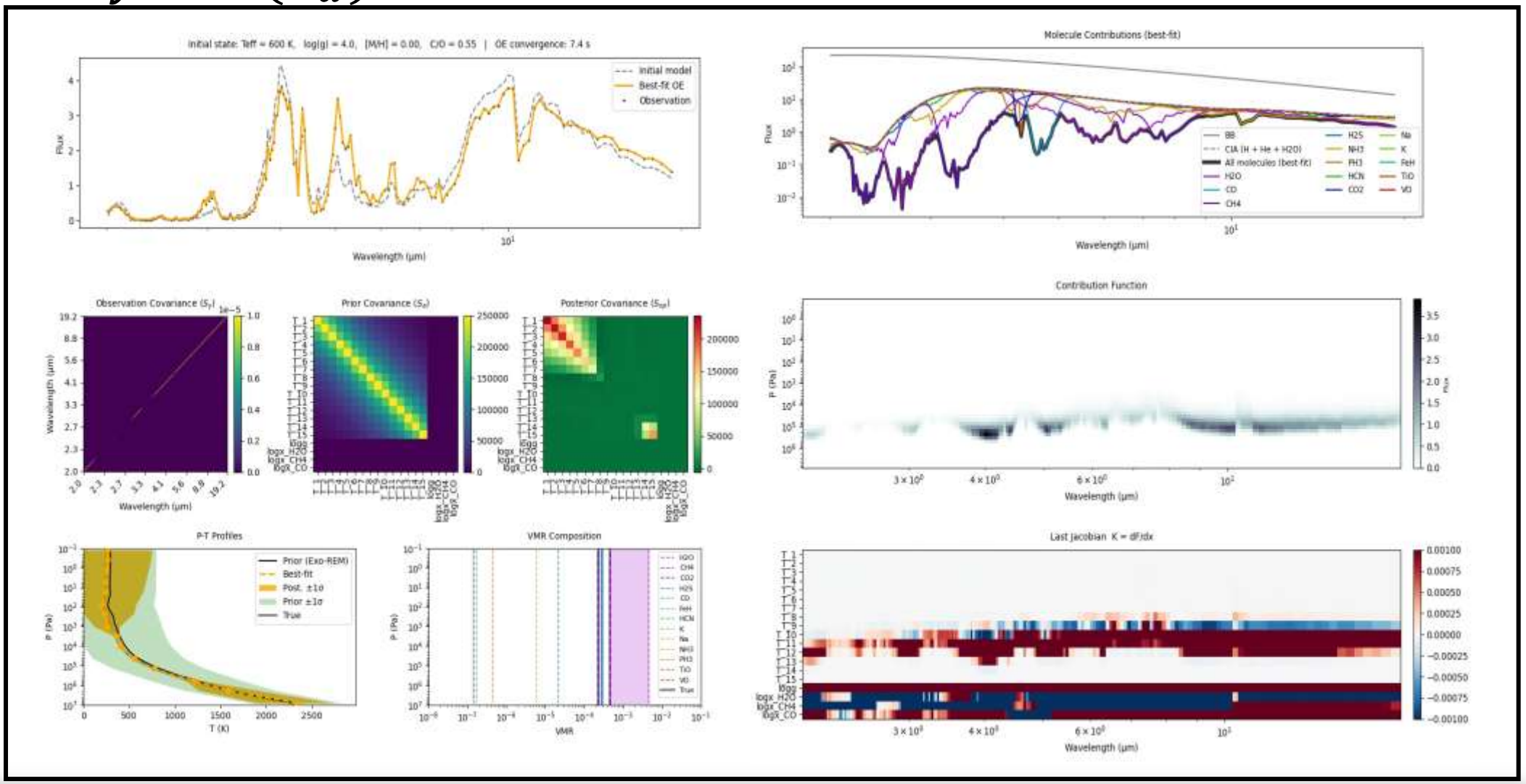
log(g)

...

Retrieval with PTEX :

$$x_{k+1} = x_a + G\left(y - F(x_a)\right)$$

$$\begin{pmatrix} T_1 \\ T_2 \\ \dots \\ T_n \\ \log(g) \\ \dots \end{pmatrix}_k$$

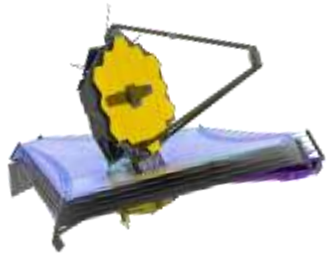


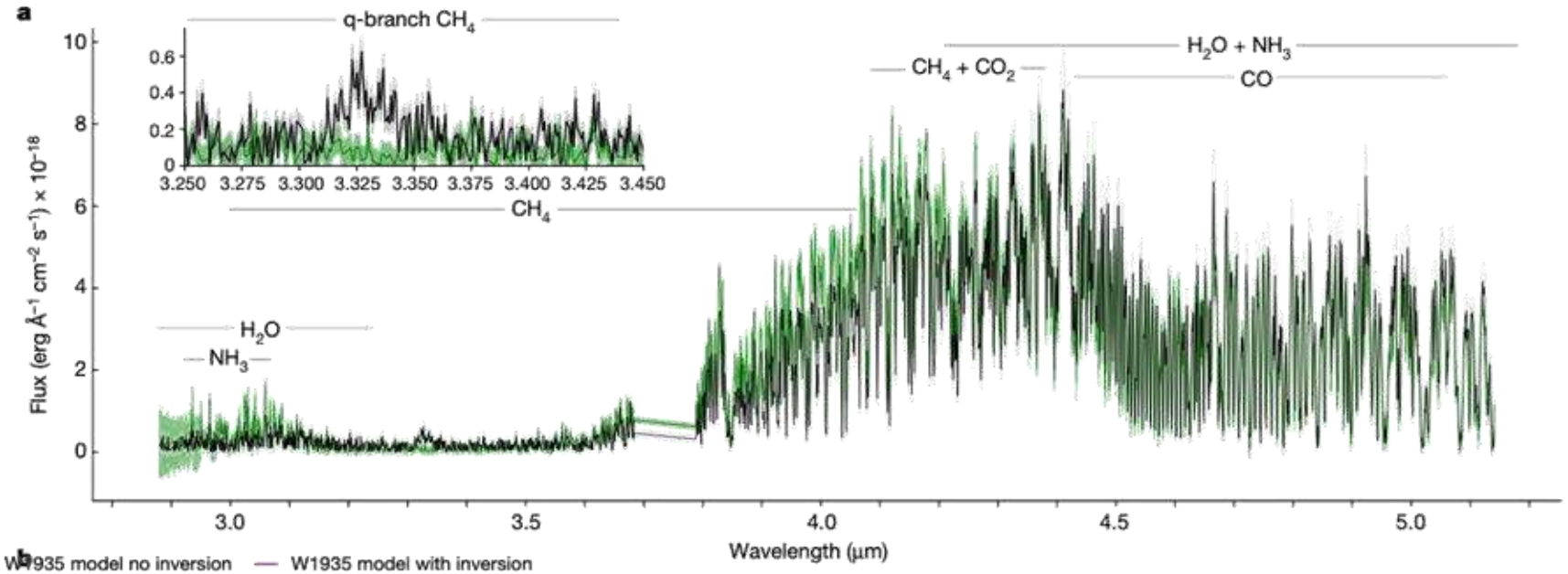
Preliminary results :

Retrieving a thermal inversion

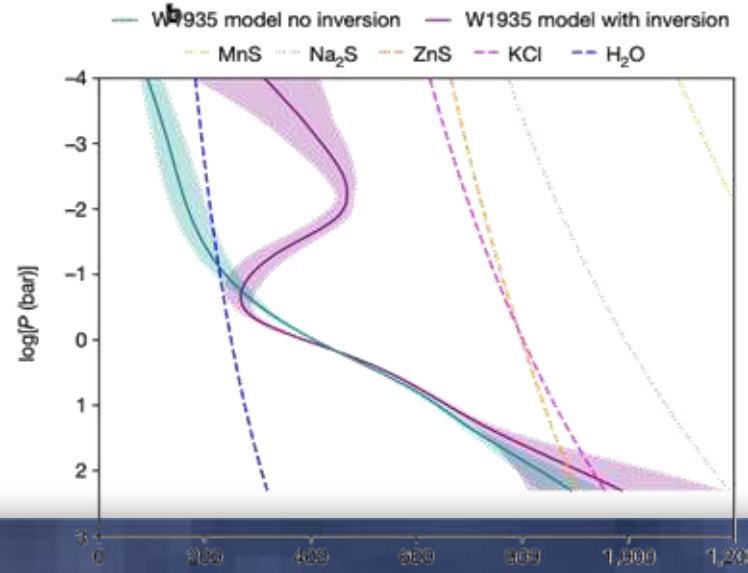
Benchmark brown dwarfs: W1935 & W2220

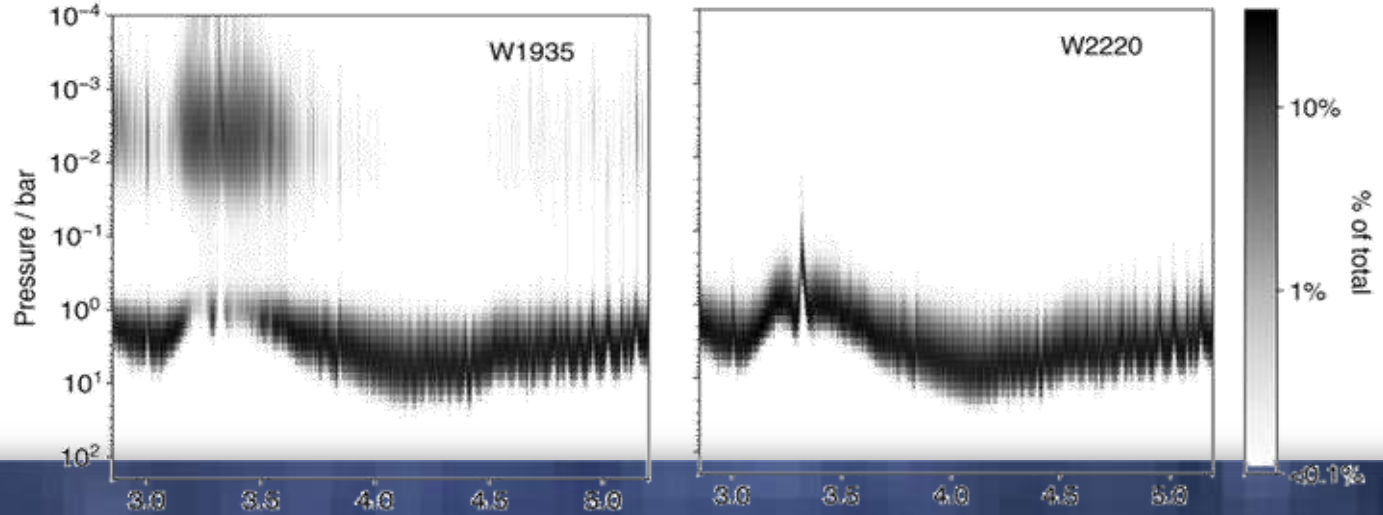
W1935





Faherty et al. 2024





Exo-REM k26
(Radcliffe et al. 2026)

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PH3: Burgasser et al. 2025