

Characterization and error analysis of statistical retrievals

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Computation of averaging kernels and estimates of retrieval error covariance matrices

A gentle reminder that this is possible also for statistical retrievals

Optimal estimation retrieval error covariance estimate

- $(S_x^{-1} + K^T S_Y^{-1} K)^{-1}$
- But this is only a good estimate if we can provide good estimates of S_x and S_Y

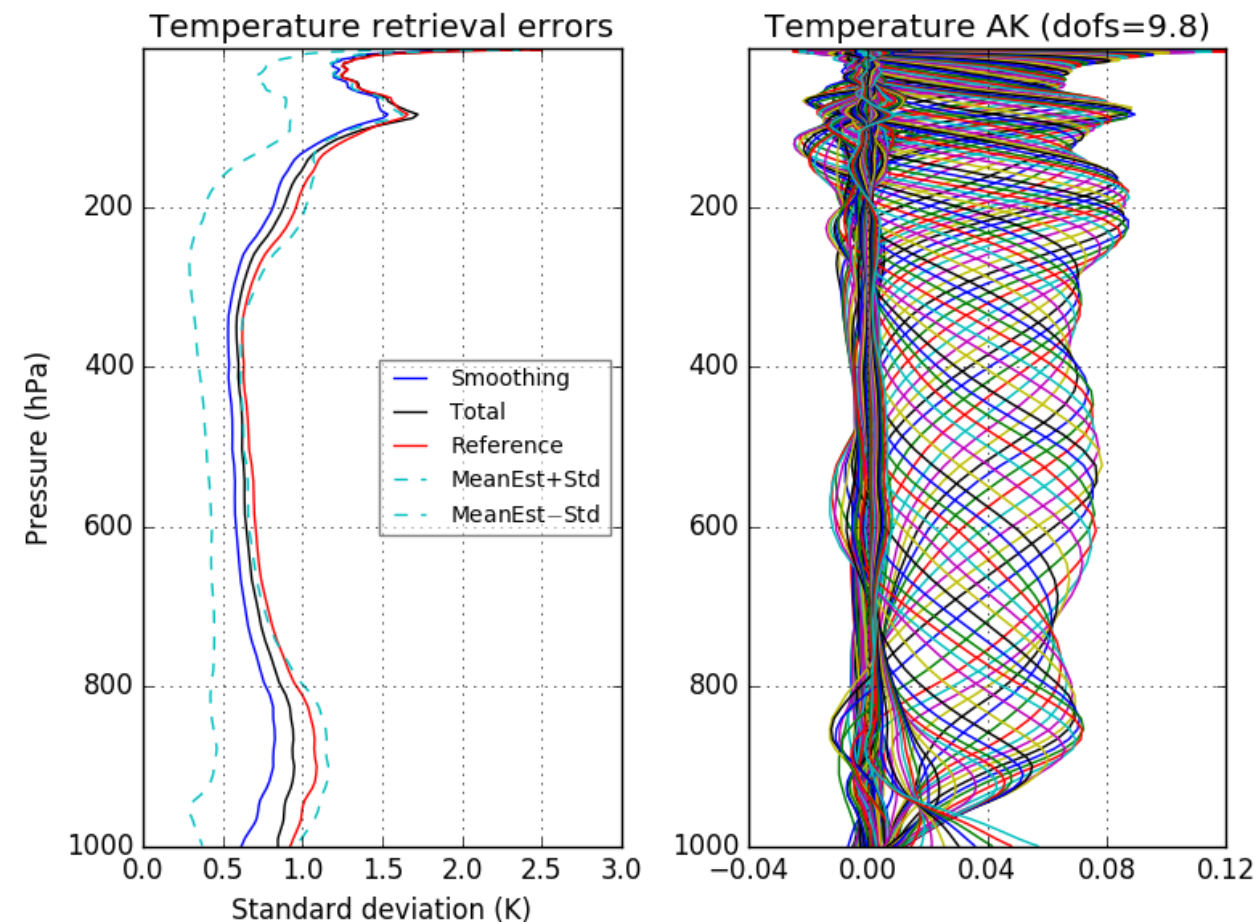
Generic retrieval error covariance estimate

- Null space error $S_s = (I - A)C_{xx}(I - A)^T$
- Retrieval noise $S_n = GS_yG^T$
- Total retrieval error covariance $S_s + S_n$
- G is the gain matrix
- A is the averaging kernel
- C_{xx} is the variability of x

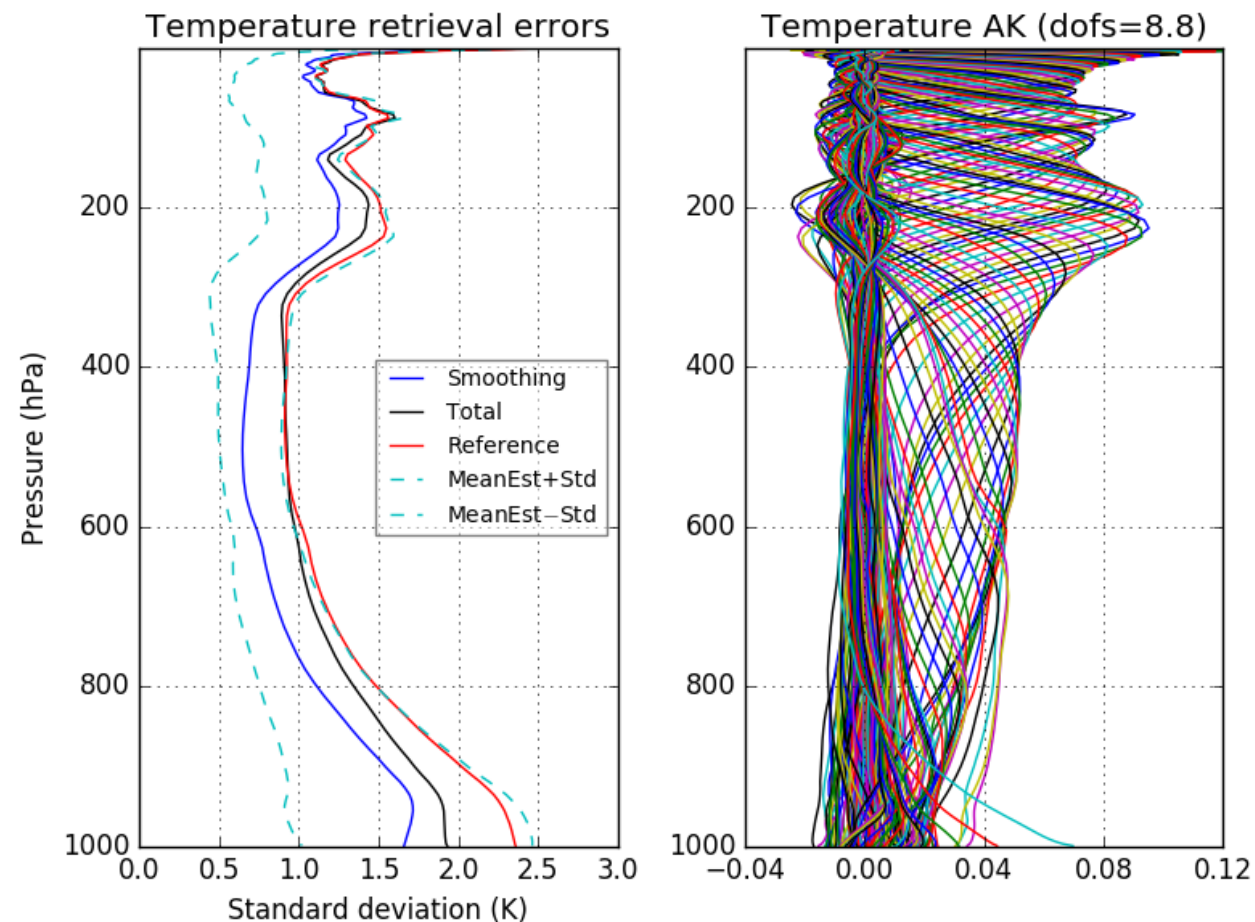
In a PWLR context

- $= C_{xy}C_{yy}^{-1}$ and $A = GK = C_{xy}C_{yy}^{-1}C_{yx}C_{xx}^{-1}$
- in general G is just the derivative of the retrieval function – available via automatic differentiation for any retrieval code.

Temperature averaging kernels



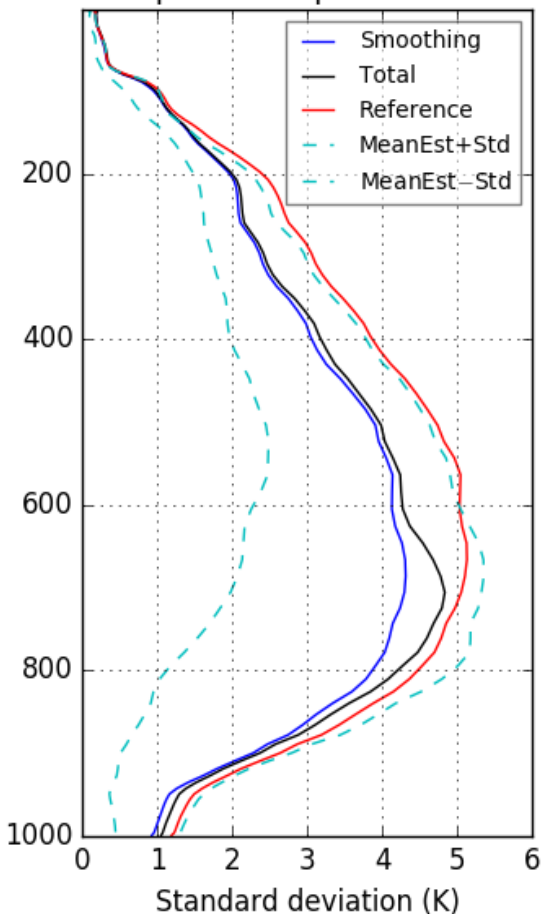
A “Clear” regression class



A “Cloudy” regression class

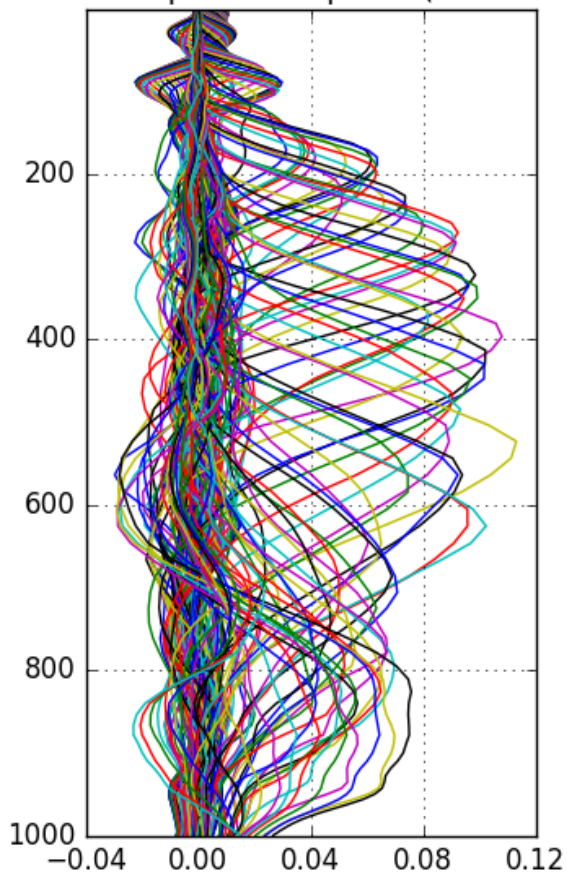
Water vapour averaging kernels

WV dew point temp. retrieval errors

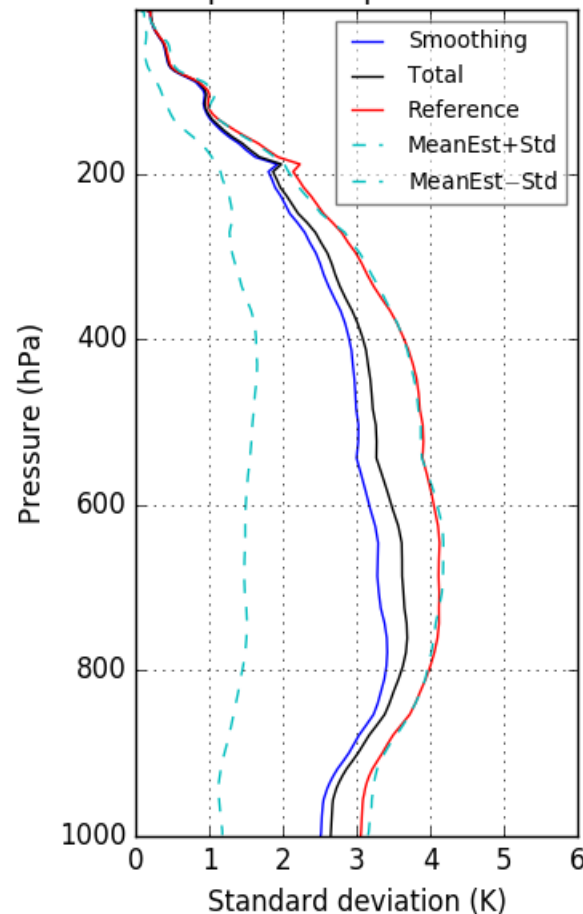


A "Clear" regression class

WV dew point temp. AK (dofs=5.2)

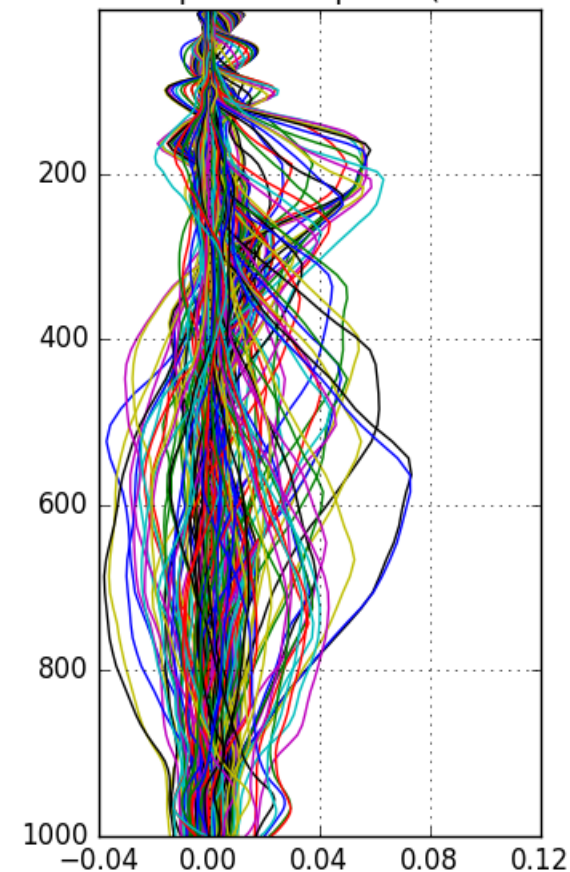


WV dew point temp. retrieval errors

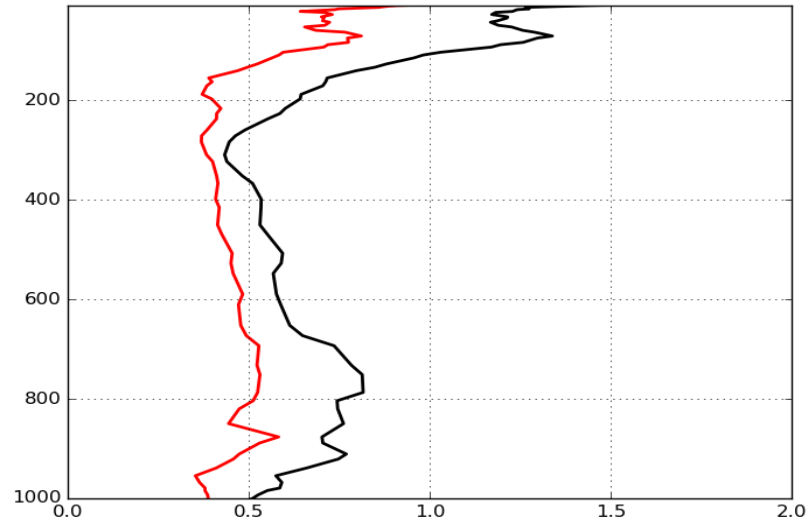
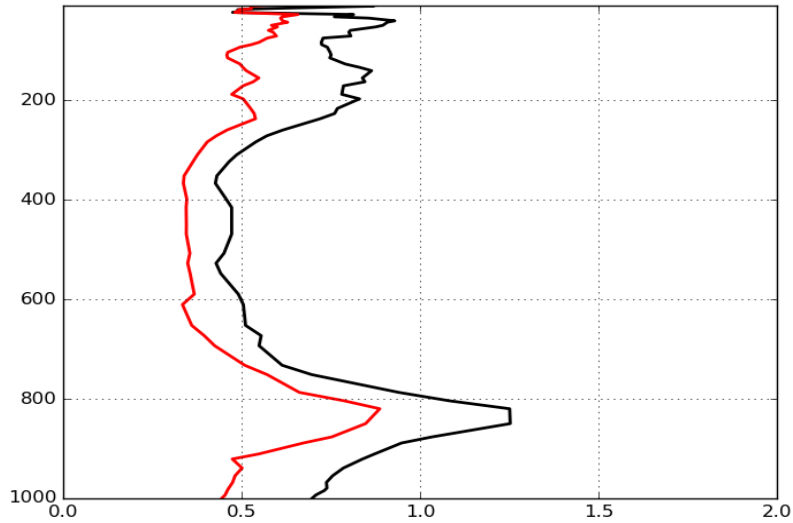


A "Cloudy" regression class

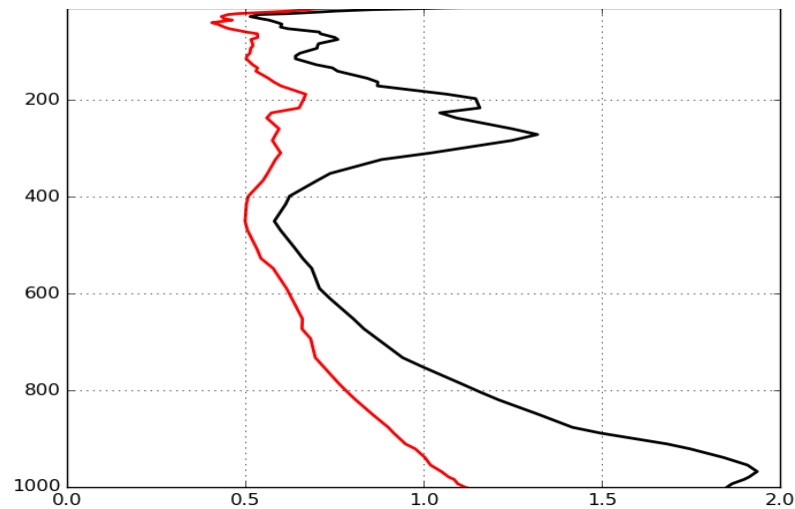
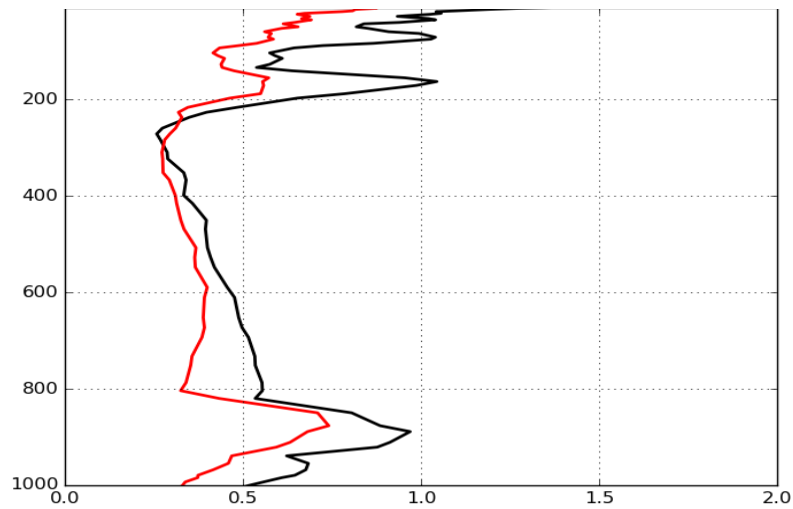
WV dew point temp. AK (dofs=3.0)



Examples of PWLR null space error estimates



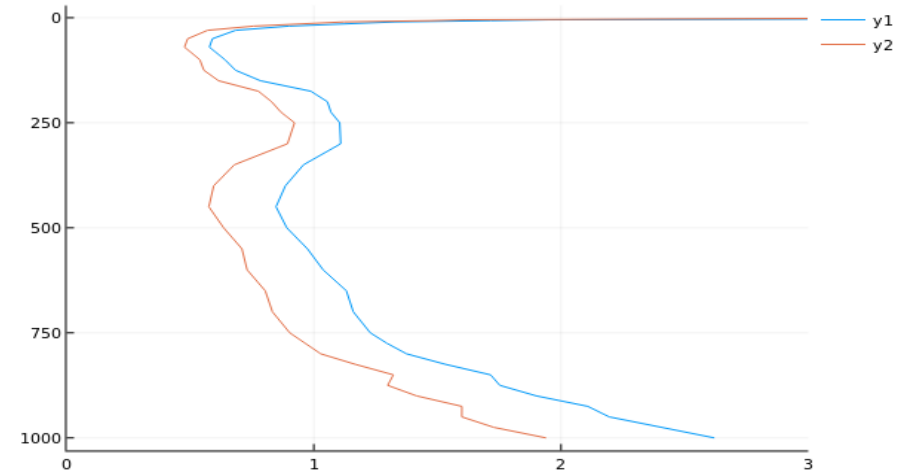
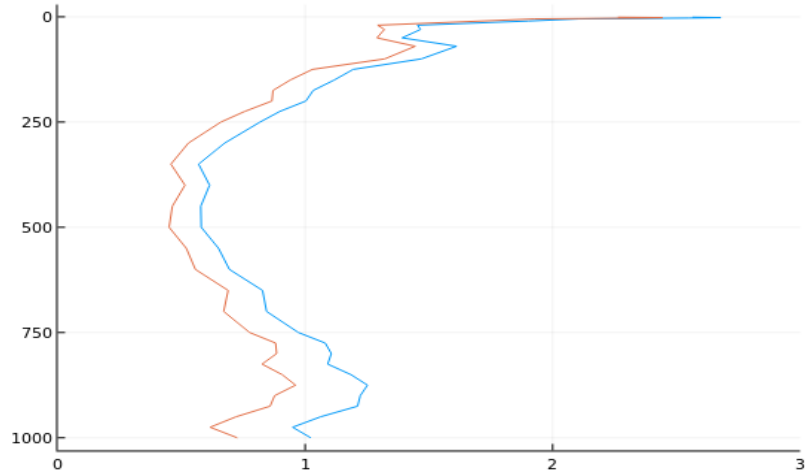
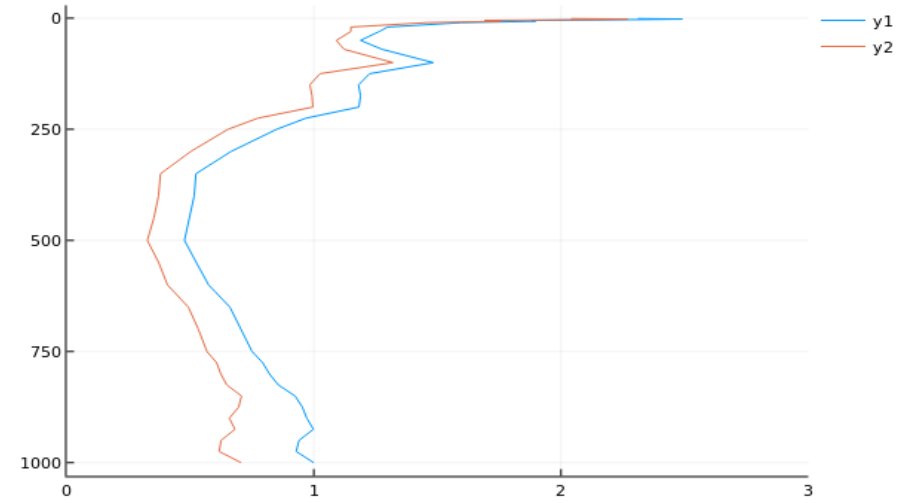
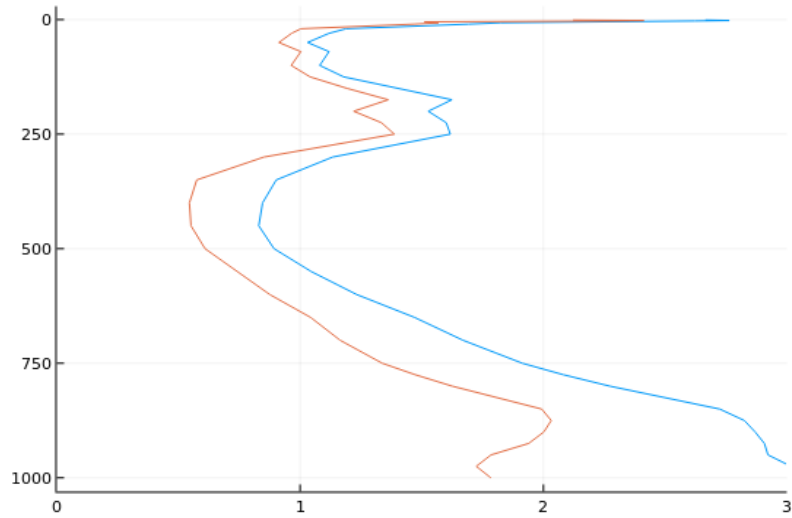
Black: FCT free PWLR
Red: FCT as prior in PWLR



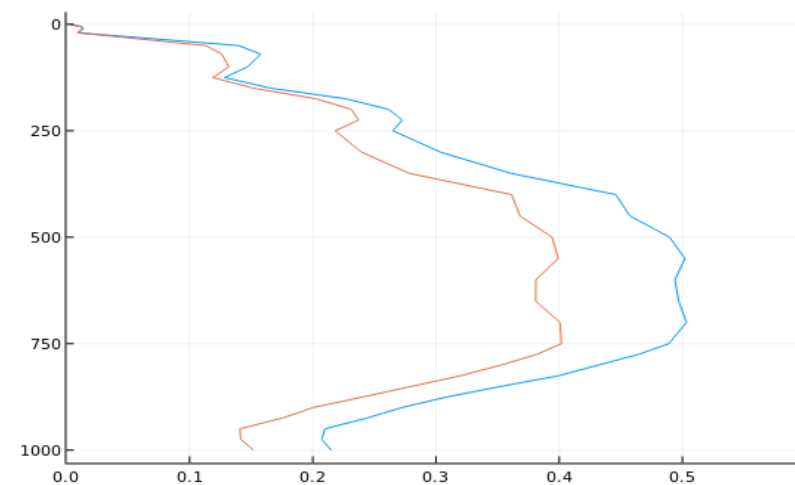
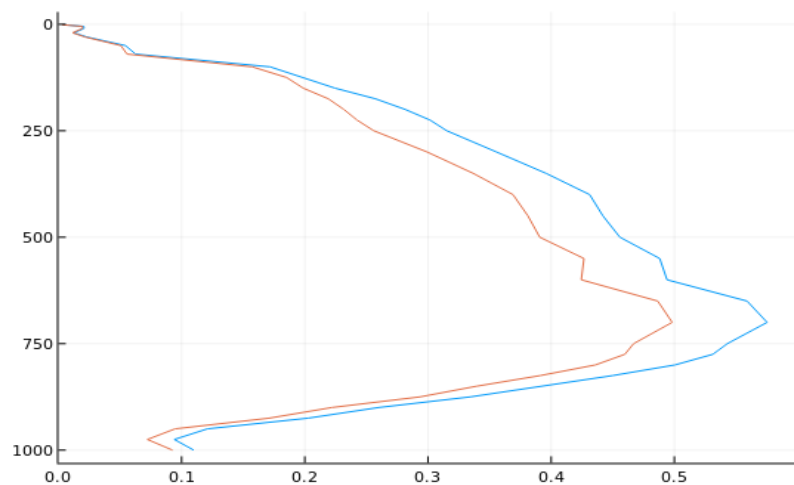
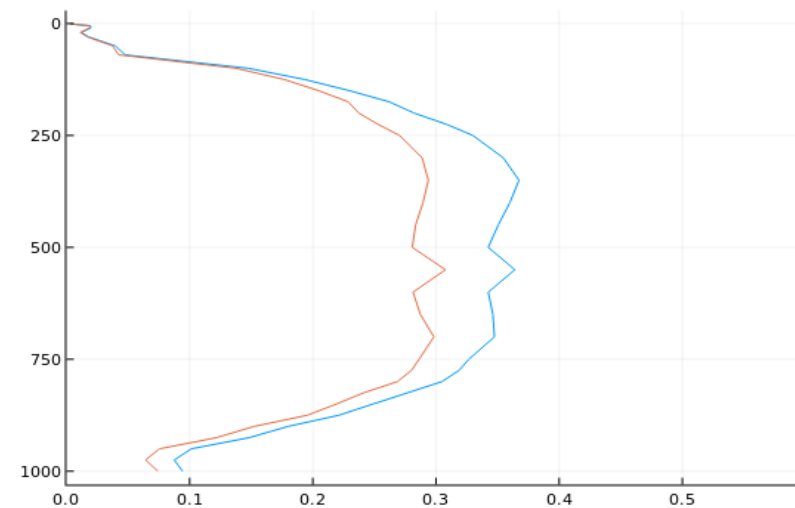
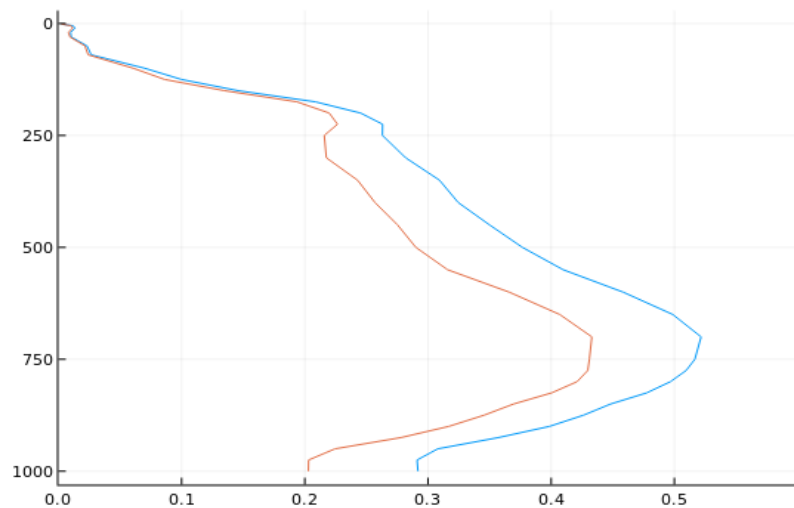
Salient points

- Error characterization of statistical retrievals is easy to obtain
- Good agreement between the error estimates and the actual errors!
- Averaging kernels (needed for assimilation of L2 profiles) can be precomputed for each regression class and distributed in advance to keep disseminated data volume manageable

Temperature



Log(humidity)



Rigorous error characterization

- *Careful to look at or consider every part of something to make certain it is correct or safe*