

On the Optimal Spectral Sampling Method

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ESFT and correlated-*k* techniques

Problem in extending ESFT or correlated-*k* method to vertically inhomogeneous atmospheres is in maintaining physical consistency between *k*'s in the different layers

No satisfactory solution to date for handling gas mixtures when relative concentration of the constituents changes with altitude

High numerical accuracy may only be obtained with a formalism that describes the multi-variate probability distribution of $\{k_{lm}^i, i=1, \dots, L, m=1, \dots, M\}$ where *L* is the number of layers and *M* the number of gases in the mixture

OSS method

OSS solution is to reduce the problem to a one-dimensional spectral search problem. OSS models the channel radiance as:

$$\bar{r} = \int_{\Delta\nu} \phi_r r_i d\nu \approx \sum_{i=1}^N w_i r_i$$

Training requires a set of monochromatic transmittances (or radiances) obtained with a line-by-line model for a globally representative ensemble (*S*) of atmospheres. Method searches within the initial set of *M* spectral points (denoted by \mathfrak{S}_N) on which transmittances (or radiances) are specified, for the smallest subset of wavenumbers, $\mathfrak{S}_{N'}$ such that

$$\epsilon_N = \left[\sum_i \left(\bar{r}^i - \sum_{j=1}^N w_j r_j^i \right)^2 \right]^{1/2}$$

is less than a prescribed threshold

Search Procedure

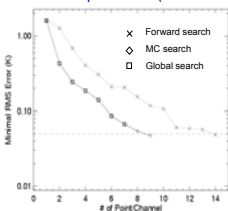
N is incremented by 1 at each step of the procedure until $\epsilon_N \leq \epsilon_{tol}$

Search method proposed by Wiscombe and Evans (1977) (forward search method) looks at each step for the combination that provides smallest rms error. Elements are successively added w/o changing previous selection until a negative weight is produced. Method is fast but sub-optimal.

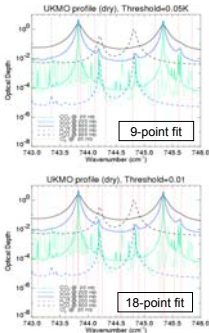
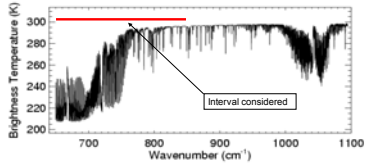
Monte-Carlo procedure adds a new "node" chosen at random and makes, at each step, a number of attempts at substituting one element from \mathfrak{S}_N by one element from $\mathfrak{S}_M - \mathfrak{S}_N$. Each new trial solution is retained with probability,

$$p = 1 / \left[1 + \exp((\epsilon_{new} - \epsilon_{old}) / \theta) \right]$$

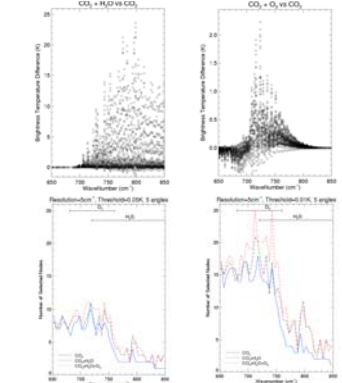
where θ is an adjustable parameter used to control the statistical convergence of the search procedure (heat-bath algorithm).



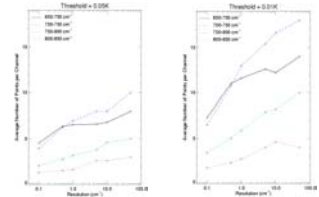
Forward vs. MC. vs. Global search



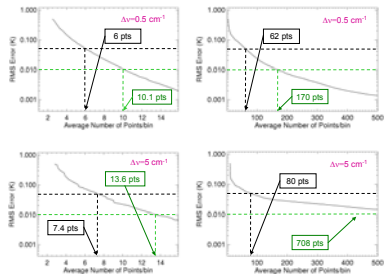
Example of OSS selection



Number of selected points versus accuracy and number of constituents



Dependence of number of nodes on instrument's bandwidth



OSS versus Radiance (Frequency) Sampling Method (RSM) (700-750 cm⁻¹)