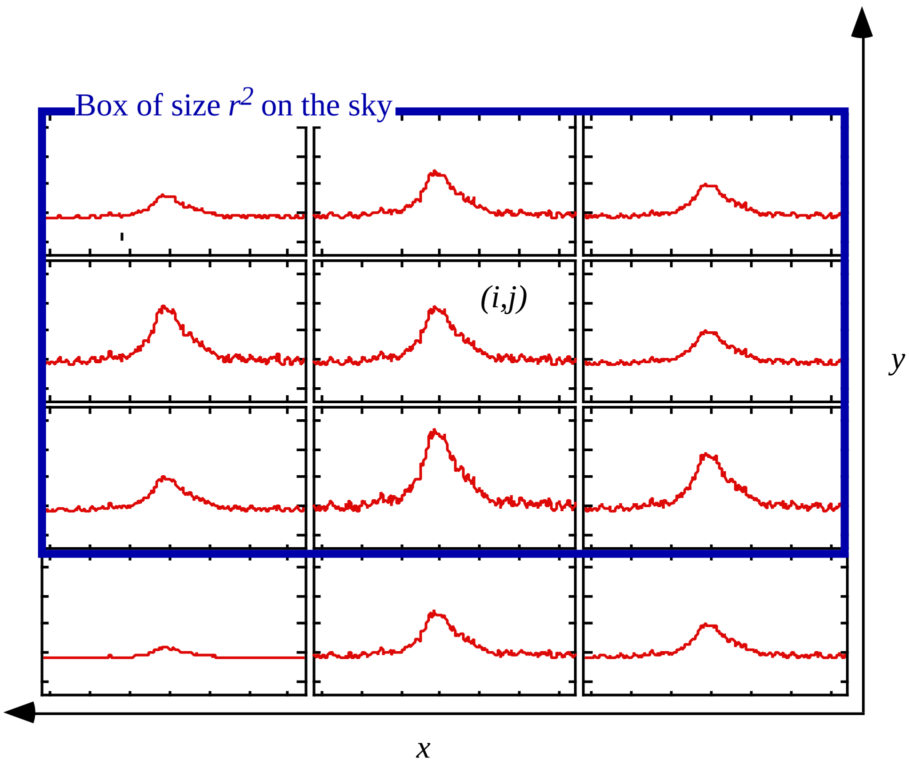
THE SPECTRAL-CORRELATION FUNCTION METHOD (SCF METHOD)

Assume that the spectra below represent a small segment of a much larger data cube.



Let the indices on the spectra in the cube be *(i,j)*.
Let the abscissa of each spectrum be velocity, v.
Let the ordinate of each spectrum be antenna temperature, T_A^*.
Let the total dimensions of the data cube be *(0...X, 0...Y,0...V)*.

Given the above, the basic SCF subroutine proceeds as follows:

1. Estimate line parameters , $T_A^*, \Delta v, v_{LSR}$, for each spectrum in the map (can be done by fitting Gaussians, or calculating moments--initially, test which procedure is more reliable).
2. Remove baseline, using windows based in Step 1, and determine the rms, σ_{rms}, for each spectrum in the map.
3. Re-fit line parameters, using same method as in Step 1. This post-baseline-subtraction set of parameters is referred to below as $T_A^*(x,y), \Delta v(x,y), v_{LSR}(x,y)$.

4. Select resolution for SCF, *r*. Minimum is *"r=3"* meaning a spectrum and all of its nearest neighbors.
5. Consider a spectrum at position *(x,y)=(i,j)*, and perform the following mathematical operations, considering only the restricted velocity range (within *q* FWHM linewidths of v_{LSR})

$$v_{LSR}(i,j) - q\Delta v(i,j) < v_{LSR}(i,j) < v_{LSR}(i,j) + q\Delta v(i,j)\,,$$

i.) Calculate the integrated intensity, $T_{\rm int}(x,y)$, over this velocity range. Then, for each of the spectra satisfying the criteria

$$i-(r-1)/2 < x < i+(r-1)/2 \text{ but } x \neq i$$
$$j-(r-1)/2 < y < j+(r-1)/2 \text{ but } y \neq j,$$

ii.) determine the optimum lag, $\tau_{a,b,i,j} \equiv \tau_{a,b}$, and scaling, $s_{a,b,i,j} \equiv s_{a,b}$, between the spectrum being considered (call it *(a,b)*) and the one at *(i,j)* and, by sliding and scaling *(a,b)* until the function

$$[\delta_{a,b,i,j}(v)]^2 = [s_{a,b}T_A^*(a,b,(v-\tau_{a,b}) - T_A^*(i,j,v)]^2$$

is minimized. $\delta(v)$ represents the deviation between the spectrum at *(i,j)* and the shifted one at *(a,b)*, and is a function of velocity, but only exists over the velocity range specified above.

iii.) Calculate the velocity-averaged deviation,

$$[\delta_{a,b,i,j}]^2 \equiv [\delta_{a,b}]^2 = \frac{\int_{v_{LSR}(x,y)-q\Delta v(x,y)}^{v_{LSR}(x,y)+q\Delta v(x,y)} [\delta_{a,b,i,j}(v)]^2\,dv}{2q\Delta v}$$

for each spectrum *(a,b)*, which is just a number.

iv.) Calculate the "average" deviation, $\delta_{i,j}$, at the position *(x,y)=(i,j)* by averaging over all the *(a,b)*'s within the resolution element, *r*.

$$\delta_{i,j} = \frac{\sum_{a=i-(r-1)/2}^{i+(r-1)/2}\ \sum_{b=j-(r-1)/2}^{j+(r-1)/2} \delta_{a,b}}{r^2-1}\,;\quad a \neq i, b \neq j$$

v.) Calculate the "average" lag, $\tau_{i,j}$, at the position *(x,y)=(i,j)* by averaging over all the *(a,b)*'s within the resolution element, *r*.

$$\tau_{i,j} = \frac{\sum_{a=i-(r-1)/2}^{i+(r-1)/2} \sum_{b=j-(r-1)/2}^{j+(r-1)/2} \tau_{a,b}}{r^2 - 1}; \quad a \neq i, b \neq j$$

vi.) Repeat, calculating all relevant parameters, for cases where various combinations of lag and scaling are employed, producing results as follows:

	Scaling ON	Scaling OFF ($s \equiv 1$)
Lag ON	$\delta_{i,j}$, $\tau_{i,j}$	$\delta^l_{i,j}$, $\tau^l_{i,j}$
Lag OFF ($\tau \equiv 1$)	$\delta^s_{i,j}$	$\delta^\circ_{i,j}$

6. Repeat Item 5 for every spectrum in the map that has at least $r^2 - 1$ neighbors.

7. The output of the subroutine, for a given resolution, is:

x, y, i, j, $T_A^*(x,y)$, $\Delta v(x,y)$, $v_{LSR}(x,y)$, $T_{\rm int}(x,y)$, σ_{rms}, $T_A^*(x,y)/\sigma_{rms}$, $\delta_{i,j}$, $\tau_{i,j}$, $\delta^\circ_{i,j}$, $\delta^l_{i,j}$, $\tau^l_{i,j}$, $\delta^s_{i,j}$

8. This output is then used to generate contour maps of all the (non-coordinate-like) parameters listed above.

9. The sub-routine can be run again at a different resolution, where a new output table is produced.

<u>Possible modifications:</u>

Only include spectra with S/N above a threshold. (Should not be necessary).