Algorithm	Without CHO	With CHO	Time ratio
BPSS	71463 (BPSS-2)	2205 (BPSS-1)	32.41
BPSS2	530654 (BPSS2-2)	7133 (BPSS2-1)	74.39

TABLE II
COMPUTATION TIMES (AFTER TO) IN SECONDS, FOR A SYNTHETIC DATASET WITH 3 ENDMEMBERS (NO CUTOFF, NO NOISE), FOR BOTH BPSS AND BPSS2, WITH AND WITHOUT CHO. IN THIS EXAMPLE, 944 PIXELS WERE SELECTED FOR THE CHO, AMONG A TOTAL OF 100000. THE NAME OF THE RUN OF TABLES IV-A3G AND IV IS NOTED IN PARENTHESIS.

OMEGA instruments for observation 41_1 has been used [39]. Note that for all the considered simulation scenarii, the number of sources to be estimated has been tuned to the actual number of endmembers used to produce the artificial dataset.

2) Performance: Computation times are about 50 times shorter when pixel selection by convex hull (CHO) is performed as a preprocessing step (see Table II).

3) Accuracy:

a) Analysis of the results: The spectrum of each estimated source has been compared to the spectra from the spectral library containing the pure endmembers used to produce the synthetic dataset. The absolute value of the correlation has been used as a similarity measurement, thus as a criterion for the determination of the best spectral match. On Figures 1, each source is represented along with its best match, according to the aforementioned criterion. Table IV-A3g (resp. Table IV) shows the results for BPSS (resp. BPSS2).

A source is considered a good estimation of a certain endmember if both are each other best spectral match and if their absolute correlation is greater than 80%. For each run, the number of well-estimated sources is mentioned in Tables IV-A3g and IV. Note that endmembers matched by several sources, in case it happens, are only counted once. Along with the number of well-estimated sources, the mean value of the correlations between (only) the well-estimated sources and their best spectral match also helps to the assessment of the accuracy for the estimation of the whole set of sources for each run. Simple distance could not be used here because the scale in usual blind source separation is undetermined [8].

b) BPSS vs. BPSS2: In most of the tested cases, the quality of the estimation is unambiguously better with BPSS2 than with BPSS (see Tables IV-A3g and IV). The improvement appears to be even more significant when the number of endmembers is increasing. Our 3 endmember test dataset is a mixture of two endmembers with strong spectral signatures (CO_2 ice and H_2O ice) and a third one with weaker signatures (albite), as often with minerals. Interestingly, while using BPSS allows one to correctly estimate the ices spectra but not albite, BPSS2 is actually able to correctly estimate the three endmembers. This confirms that adding the sum-to-one constraint is necessary when dealing with such dataset, which is important regarding the analysis of other dataset.

c) Effect of the pixel selection (CHO): With the exception of the asymmetric dataset (see below), the endmembers is less well-estimated when a pixel selection has been performed, the loss seeming less significant when the number of endmembers is low.

Also note that the results with pixel selection do not appear to be very sensitive to the cutoff variations: the loss of quality (between runs performed with and without pixel selection) is similar for cutoffs of 60%, 80% and 100%, which can be explained by the pixel selection's ability to extract the purest available pixels.

d) Effect of the number of endmembers: Due to curse of dimensionality, the more endmembers to be estimated with the fixed number of wavelength, the more difficult is the estimation [43], [44]. Still, BPSS2 gives excellent results even for 10 sources, as all spectra are estimated with a correlation coefficient higher than 99% (see fig. 1).

e) Effect of the maximum abundance cutoff: The cutoff affects the quality of the estimation, which is clearly better, for BPSS and BPSS2, when pure components occur in the dataset. This has to be remembered when dealing with real dataset.

f) Effect of noise: The results clearly show that the method is very robust to noise, as the estimation of the sources does not appear to be significantly affected by the addition of a Gaussian OMEGA-like noise to the synthetic dataset. BPSS2 (without pixel selection) even manages to successfully overcome the addition of a 100-times amplified OMEGA-like noise (see Tables IV and 2).

g) Effect of asymmetry in maximum abundance cutoff : In this case, the results are better with pixel selection rather than without. BPSS2 with pixel selection is the only run (performed on this synthetic dataset) that allows one to successfully estimate the three endmembers that have been used to generate the dataset, including albite, whose abundances have been limited to a cutoff of 35% and whose spectral signature is weaker than the ones of the other endmembers (ices). This result can be explained by the fact that pixel selection is able to extract the pixels with the strongest available albite signature, and consequently overcomes the blinding effect of the ices occurring in the whole dataset, that has affected the results when no pixel selection has been performed.

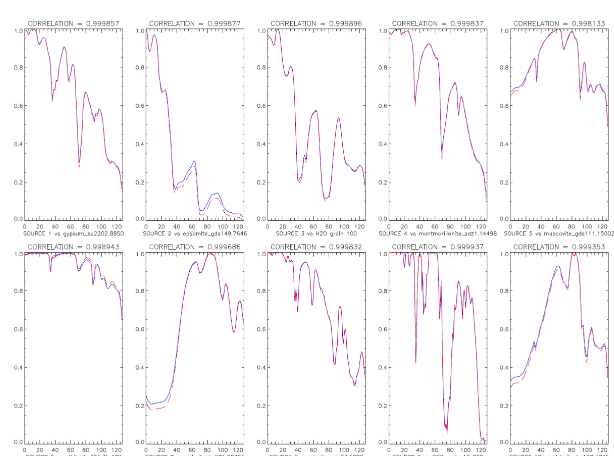

Fig. 1. Sources estimated by BPSS2 (blue lines) and their spectral matches (red dotted lines), for an artificial dataset with 10 endmembers (no cutoff, no noise).