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Spectral retrieval of exoplanetary signatures using evolutionary computational methods

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The spectral information provided by the next generation of extra-solar planet exploration missions will be averaged over the visible disk and the exposure time. Most probably, the interpretation of the observed spectra will not be unique, but families of solutions will provide equally good explanations of the spectral features (degeneracy). Traditional retrieval techniques developed to study the environments of planets in our solar system are inadequate to analyze disk/time-averaged spectra because they assume homogeneous environments, short observational time scales and search only for solutions belonging to the local domain of the initial conditions. We developed an innovative technique that couples evolutionary computational methods to a 3D model that simulates the spectral response of the planet rotating (Tinetti et al., 2005). We have performed a set of preliminary experiments in retrieving the earthshine spectrum recorded by Woolf et al. (2002): nine weighting parameters were retrieved, corresponding to different surface/cloud types (ocean, forest, grass, ground, tundra, ice, high/medium/low clouds) uniformly distributed over 48 planetary pixels. Two distinct retrieval experiments were run: i) evolution of one large solution population with 1000 individuals and ii) evolution of multiple solution islands with 100 individuals in each island. These two experiments returned over 2700 automatically generated retrievals satisfying the error criterion (fitness) of 10% least squares match to the observed spectra. The spectral retrieval procedure with this reduced set of parameters already resulted in a high quality fit of the earthshine spectrum, in agreement with ground truth. The retrieved solutions were divided into classes of spectral fit using clustering tools, which helped visualize the degeneracy in the set of solutions. As a next step we are repeating the experiment using non-uniformly distributed 9 surface/cloud types in 12

planetary pixels (108 retrieved parameters).