A comprehensive spectroscopic sky brightness model for Cerro Paranal in Chile

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Ground-based astronomical observations are affected by emission, absorption, and scattering in the Earth's atmosphere. The signal-to-noise ratios of astronomical exposures strongly depend on these effects. For an effective use of the telescope time, it is, therefore, crucial to reliably estimate the sky brightness.

We have developed a sky radiation model of unprecedented complexity and accuracy for ESO's Very Large Telescope (VLT) at Cerro Paranal. It covers the wavelength range from 0.3 to 30 μm with a resolution of up to 10^6.

The sky model consists of several components. As direct non-atmospheric radiation, zodiacal light is considered. Indirect contributions by scattering in the atmosphere are taken into account for moonlight (which varies with moon phase), starlight, and zodiacal light. The scattering is calculated by means of a 3D radiative transfer code and optimised extinction and ground reflection functions. The thermal emission of the lower atmosphere in the IR and the molecular absorption is computed by means of the atmospheric radiative transfer code LBLRTM and optimised molecular abundance and temperature profiles as input. The non-thermal airglow emission of the upper atmosphere is considered by a semi-empirical model consisting of measured and calculated line and c ontinuum data. The complex variability was modelled mainly based on more than 1000 VLT FORS spectra. Finally, thermal emission by the telescope itself can be added.

The resulting sky model achieves an accuracy of about 20% in the optical, where it could thoroughly be evaluated with the available test data. This is significantly better than the quality of other models used for exposure time calculators.

Except for the very specific airglow model, all other components can be adapted to other locations. For light pollution estimates, our sky model could be a valuable tool, since it provides reasonable estimates for the natural sky brightness.