

Reconstruction of the solar irradiance for nowcasting of the middle atmosphere state on the basis of LYRA measurements

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INTRODUCTION

Nowcasting of the middle atmosphere state requires application of appropriate models and detailed knowledge of the solar spectral irradiance in real time. The LYRA instrument onboard PROBA-2 satellite will measure the solar irradiance for several wavelengths important for the middle atmosphere in real time (Hochedez et al., 2006). The LYRA observations can be used as input data for global climate-chemistry-ionosphere models in order to evaluate the response of the terrestrial atmosphere to the short-term solar UV irradiance variability. However, while it is necessary to have full solar spectrum to drive a nowcasting, the LYRA measurements cover only several spectral intervals. Therefore, to apply the LYRA data it is necessary to reconstruct the solar UV spectrum. Because LYRA is not yet operational we use UARS SUSIM and SOLSTICE daily solar UV irradiance for the year 2000. From these data it is possible to calculate the solar irradiance for the LYRA channels and apply it to reconstruct the full solar UV spectrum using linear regression technique, which can be then evaluated against the reference solar UV spectrum.

MATERIAL & METHODS

For this study we applied 1-D radiative-convective model with interactive photochemistry (RCMP) described by Rozanov et al. (2002) extended to take into account chemistry of the charged species in the middle atmosphere. The heating and photolysis rate calculation scheme spans the spectral region from 120 to 750 nm. The entire spectral region is divided into 73 spectral intervals. The model spans the atmosphere from the ground to 100 km.

First of all we calculated the correlation coefficients between the solar spectral UV irradiance observed with SUSIM and SOLTICE and considered proxies. Ly- α proxy is the solar irradiance in Lyman-alpha line (121-122nm). 205nm proxy is the solar irradiance at 204-205 nm. HERZ proxy is the solar irradiance in the Herzberg channel of the LYRA instrument. The latter has been constructed from the LYRA Herzberg continuum channel taking into account responsivity of LYRA instrument detectors provided by I. Dammasch (ROB, Belgium). These three proxies have been calculated from the both SUSIM and SOLSTICE data. TSI proxy is the total solar irradiance from the VIRGO experiment (<ftp://ftp.pmodwrc.ch/pub/virgo/data>). F10.7 proxy is the solar radio flux at 10.7 cm (www.ngdc.noaa.gov/stp/SOLAR/ftpsolarradio.html) and NMD proxy is the neutron monitor data (www.ngdc.noaa.gov/stp/SOLAR/ftpcosmicrays.html). The smoothed correlation coefficients are shown in the Figure N1. The reconstructions of the solar irradiance using Ly- α , 205nm and HERZ proxies are more accurate than the reconstructions based on the F10.7 proxy. According to our analysis the TSI and NMD proxies do not allow realistic reconstruction of the daily solar UV irradiance variability. The best correlation can be reached using a combination of the HERZ and Ly- α proxies.

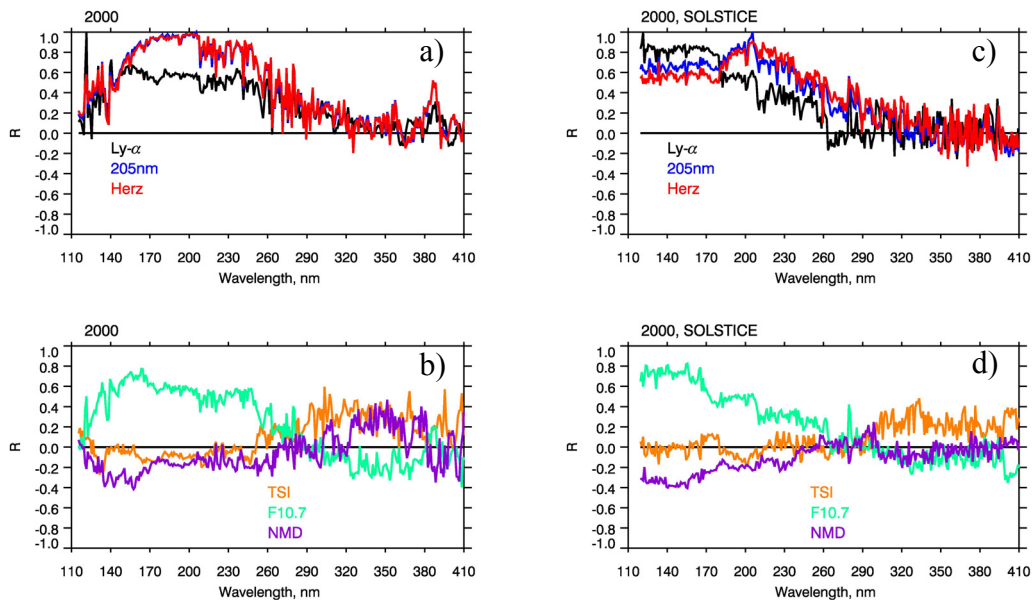


Fig.1: The correlation of the spectral SUSIM (a,b) and SOLSTICE (c,d) solar irradiance with different proxies: Ly- α (thin line), 205 nm (dashed line), Herz (thick line) (a, c) and TSI (thick line), F10.7(thin line), and NMD (dashed line) (b, d) for the year 2000.

RESULTS

Using above described proxies we have reconstructed solar UV irradiance for spectral interval 120-750 nm required by the model applying linear regression analysis. Two reference model runs were driven by the observed solar irradiance from UARS SUSIM and SOLSTICE instruments. The other twelve runs have been performed with the solar irradiance reconstructed from different proxies: Ly- α , 205nm, LYRA, TSI, F10.7, and NMD for the both instruments.

To characterize the accuracy of the reconstruction we calculated the correlation coefficients and relative RMS difference between the daily temperature, ozone (Figure N2), hydroxyl and total positive ions concentration simulated with the observed and reconstructed solar spectral UV irradiance. The analysis of these quantities shows which proxy is the most accurate for any particular altitude. The reconstruction of the full spectrum using linear regression equation based on the solar irradiance in two LYRA channels can be successfully used for nowcasting of the middle atmosphere state above 40 km. Some problem with ozone simulation between 40 and 70 km has been encountered when the SOLSTICE solar irradiance is used as the reference. This problem is caused by the enhanced variability of the SOLSTICE solar irradiance in the ozone Hartley band. Lower accuracy has been obtained using Ly- α , HERZ and 205nm proxies. Ly- α proxy can be successfully used in the mesosphere and HERZ and 205nm proxies give reasonable accuracy in the stratosphere, but the accuracy of the combined LYRA proxy is superior. The solar irradiance reconstructed from F10.7, TSI and NMD proxies does not provide reasonable accuracy. It is important to emphasize that all conclusions are valid for daily time scale. The correlation between solar irradiance and considered proxies can be rather different for the monthly and annual time scales.

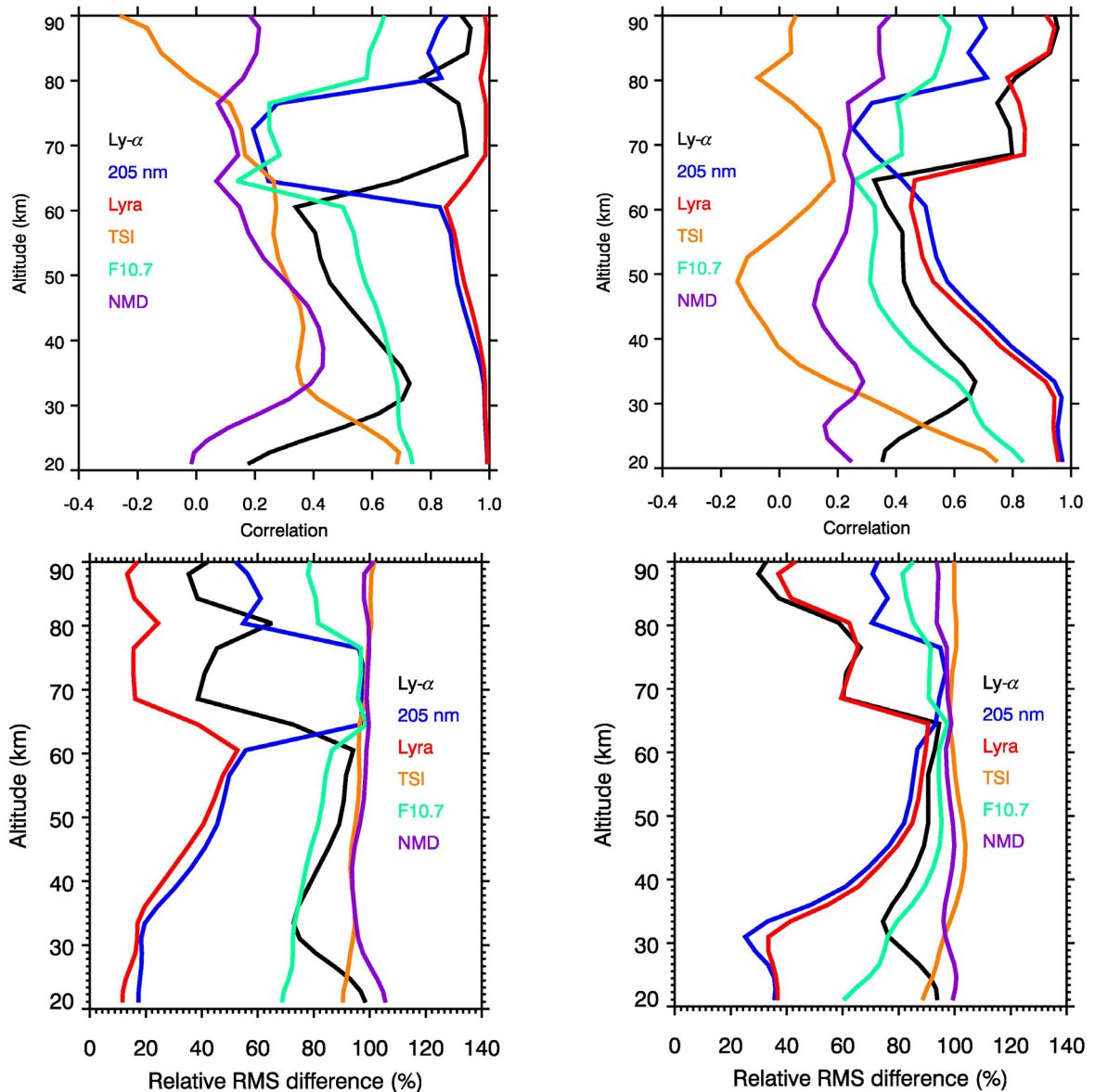


Fig.2: Vertical profiles of the correlation (upper row) and relative RMS difference (lower row) of daily variations of the ozone for SUSIM (left column) and SOLSTICE (right column) with different proxies.

CONCLUSIONS & OUTLOOK

In the paper we evaluate the applicability of the data from the future LYRA experiment onboard ESA PROBA2 satellite for the nowcasting of the middle atmosphere state. The LYRA instrument onboard ESA PROBA2 satellite will provide 6-hourly solar irradiance at the Lyman-alpha (121.6 nm) and the Herzberg continuum (~200-220 nm wavelength range). To reconstruct the solar irradiance for the wide spectral area (120-680 nm) needed for nowcasting models we have applied the statistical tool based on the correlation of the solar spectral UV irradiance with different proxies using the daily solar spectral irradiance measured with SUSIM and SOLSTICE instruments onboard UARS satellite. To estimate the accuracy of the reconstructed solar irradiance we have applied 1-D transient radiative-convective model with neutral and ion chemistry. We compared the results of transient 1-year long model simulations for 2000 driven by the observed and reconstructed solar irradiance and showed that the reconstruction of the full spectrum using linear regression equation based on the solar irradiance in two LYRA channels can be successfully used for nowcasting of the middle atmosphere state above 40 km. Some problem with ozone simulation between 40 and 70 km has been encountered when the SOLSTICE solar irradiance is used as the reference.

This problem is caused by the enhanced variability of the SOLSTICE solar irradiance in the ozone Hartley band. At the moment it is hard to say whether this problem is real or it is just instrumental error. Probably, further study with different reference solar irradiance data set (SORCE, Rottman et al., 2006) would help to solve this problem. Lower accuracy has been obtained using Ly- α , HERZ and 205nm proxies. Ly- α proxy can be successfully used in the mesosphere and HERZ and 205nm proxies give reasonable accuracy in the stratosphere, but the accuracy of the combined LYRA proxy is superior. The solar irradiance reconstructed from F10.7, TSI and NMD proxies does not provide reasonable accuracy. It is important to emphasize that all conclusions are valid for daily time scale. The correlation between solar irradiance and considered proxies can be rather different for the monthly and annual time scales.

REFERENCES

- Hochedez, J-F et al. (2006), 'LYRA: the Solar UV radiometer aboard the ESA Proba-2, LYRA, a solar UV radiometer on Proba2', *Adv. in Space Research*, 37, 303-312.
- Rozanov E, Egorova T, Fröhlich C, Haberreiter M, Peter T, and Schmutz W (2002), 'Estimation of the Ozone and Temperature Sensitivity to the Variation of Spectral Solar Flux', in: A. Wilson (ed.) *SOHO 11 Symposium 'From Solar Min to Max: Half a Solar Cycle with SOHO'*, ESA SP-508, ESA Publications Division, Noordwijk, The Netherlands, p. 181.