Ultraviolet Radiation evolution during the 21st century

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Introduction

In the context of a changing climate, the acceleration of the Brewer-Dobson circulation [Butchart 2014] leads to a decrease of the ozone total column in the tropics. This decrease affects directly surface ultraviolet radiation, which are already very high in this area. Following the work of (Bais et al., 2011), (Butchart, 2014) and (Hegglin & Shepherd, 2009) on the future evolution of surface irradiance derived from Chemistry Climate Models (CCM) projections, we projected here surface irradiance from 2010 to 2100 with focus on the tropics. We used the latest chemistry climate projection exercise ; Chemistry Climate Model Initiative (CCMI) coupled with a radiative transfer model (TUV (Madronich, 1993)) to calculate the evolution of surface Ultraviolet radiation throughout the 21st century. Ultraviolet Index (UVi) has been specifically considered (McKenzie, Matthews, & Johnston, 1991).

At first, simulation from RefC2 Chemistry Climate Model Initiative have been coupled with a radiative transfer model, in order to obtained modeled UV index (UVi-M). UVi-M is then compared against available satellite ultraviolet radiation observations (OMI OMUVbd product) between 2005 and 2016. Statistical difference and variance have been analysed versus different parameters: geographical location, model or ensemble of model outputs used in the radiative transfer calculation. From theses conclusions we have computed the UV evolution throughout the 21 st century with the RefC2.

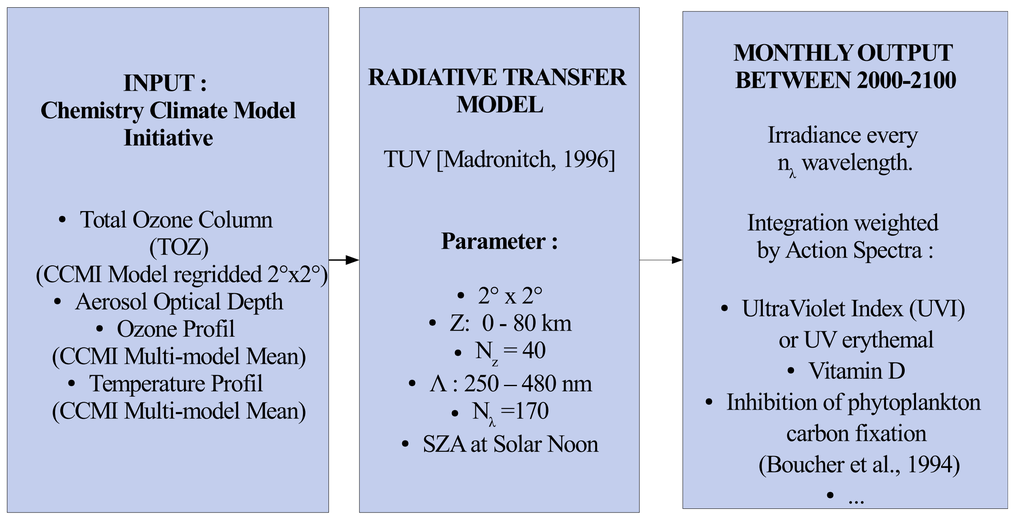
Main Objectives

- CCMI + Radiative Transfer (RT) Modelling in order to retrieve solar irradiance.
- Validation of CCMI and CCMI+RT result against climatological observations from present period.
- Ultraviolet Radiation Evolution throught the 21st century.

Radiative Transfer Modelling

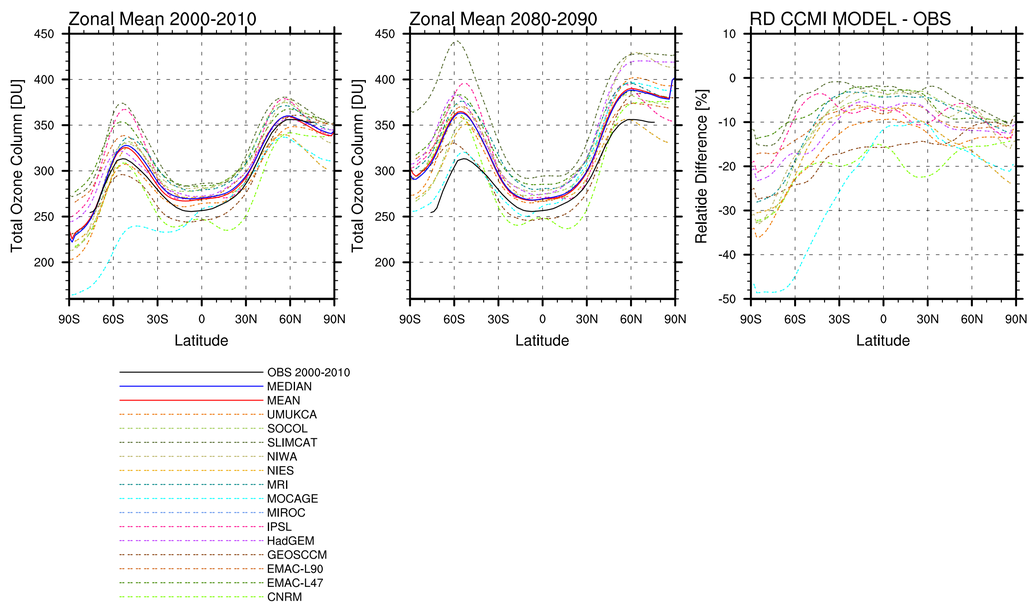
Radiative Transfer Model used is the Tropospheric UltraViolet Model (TUV) (Madronich, 1993), with (Serdyuchenko, Gorshelev, Weber, Chehade, & Burrows, 2014) ozone cross section and (Chance & Kurucz, 2010) extra terrestrial spectra. Modelling was done in clear sky conditions and with aerosols optical thickness from CCMI result.

Figure 2: CCMI + Radiative Transfer Model Coupling



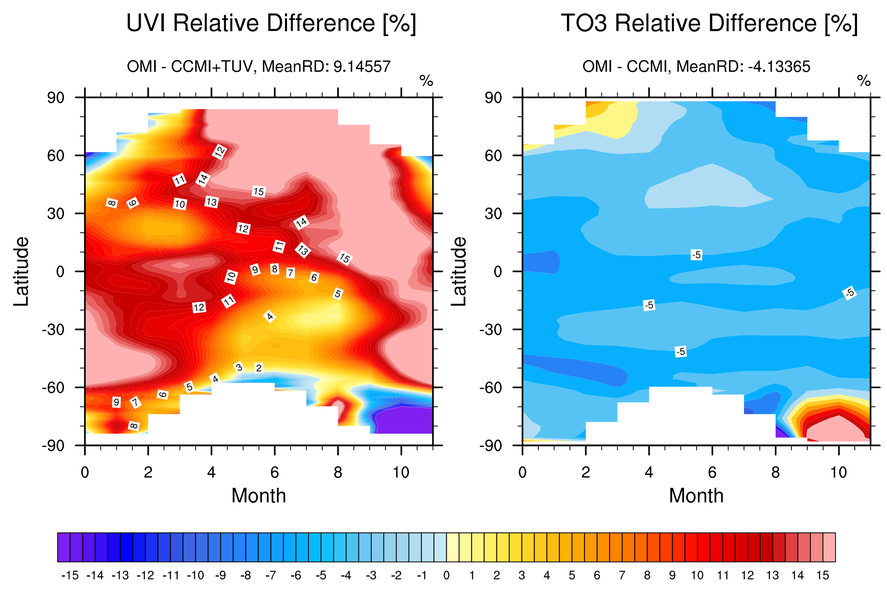
Validation

Figure 3: CCMI-TOZ zonal mean for every model, Mean and Median of all model and observed TOZ from Multi-Satellite Merged Ozone Product(MSOZ) [McPeters, 2012]. a) CCMI Zonal Mean 2000-2010 and MSOZ observations. b) CCMI-TOZ Zonal Mean (2090-2100) and MSOZ Observations (2010-2090). c) Relative Difference (RD) between CCMI-TOZ[2000-2010] and MSOZ[2000-2010].



- CCMI-TOZ Model slightly underestimate TOZ compared to TOZ satellite observations

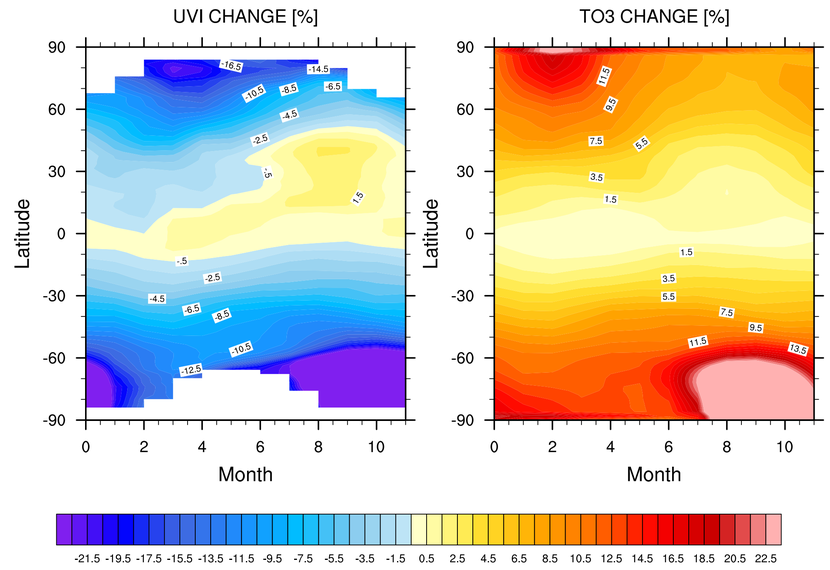
Figure 4: Zonal Mean Monthly Climatological Relative Difference between CCMI-Median+TUV and OMI-OMUVbd product [2004-2015].



While CCMI-Median-TOZ shows a Mean Relative Difference of ≈4.13% versus OMI-TOZ product, CCMI-Median+TUV are higher than OMI-UV by about 9.15 %.

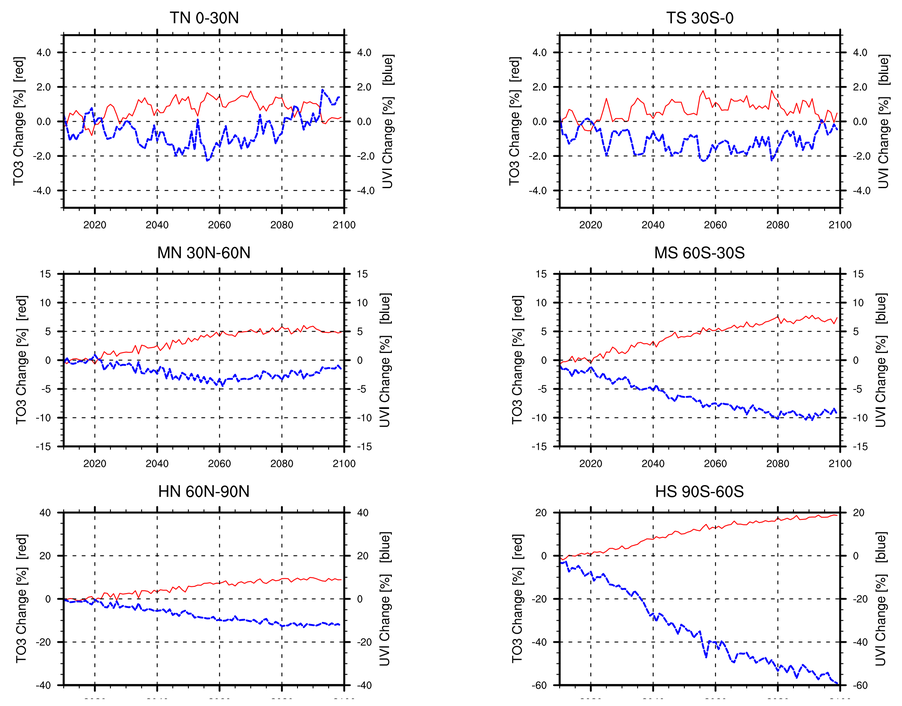
Projections

Figure 5: CCMI-Median+TUV, and CCMI-Median-TOZ Percent Change for the Monthly Climatological Zonal Mean Between 2090-2100 and 2000-2010.



As expected, ozone layer recovery will lead to a decrease in UV radiation in mid to high latitudes.

Figure 6: UVi from CCMI-Median+TUV Percent Change Evolution for the 21st century.



In mid to high latitudes TOZ increases and UVI decreases significantly during the 21st century. Tropical variation of UVI radiation are very small and will need further research.

Conclusion

- CCMI-TOZ Model slightly underestimate compared to TOZ satellite observations.
- CCMI-Median+TUV are 9.15 % higher than observed OMI UV product.
- Surface UVI decreases in mid to high latitude
- Tropical Change are very small for the entire 21st century. A thorough statistical analysis is required in order to conclude.

Forthcoming Research

- CCMI + TUV Validation against Ground UV observations
- Single Model Radiative Transfer Calculation
- Further analysis on tropical variation during the 21st century.
- Multiple scenario studies with ACCMIP or CCMI available SEN-C2 result.

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