Reconstruction of cosmogenic radionuclide production and comparison with terrestrial archives since 1610

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Background knowledge

- Inside the Heliosphere Galactic Cosmic Rays (GCR) are modulated by the variable solar activity
- Inside the Earth's atmosphere GCR particles interact with nuclei of atmospheric gasses
- Production of radionuclides ^{14}C and ^{10}Be
- Following different cycles the radionuclides are deposited in terrestrial archives such as tree rings and ice cores

As a result:

Terrestrial archives carry information about the solar variability

How is that useful…

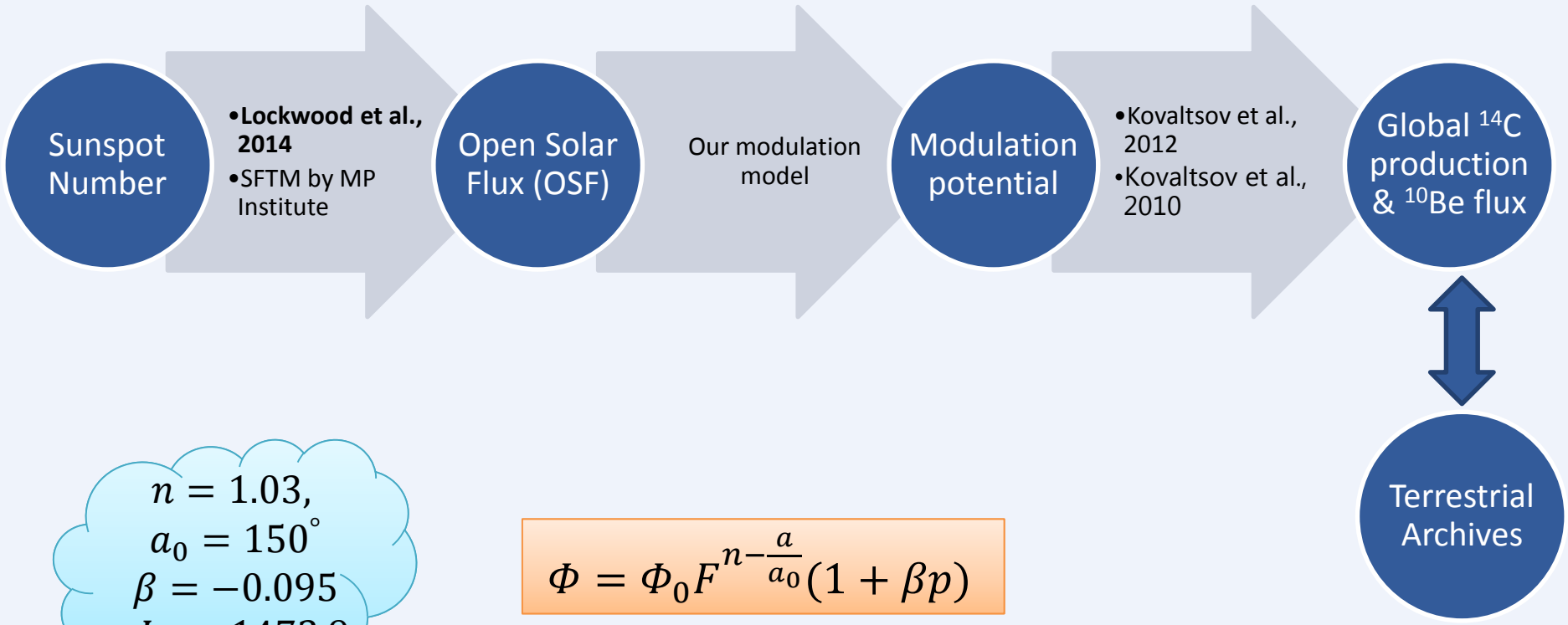
- The solar activity has been monitored via sunspot observations over the past 400yrs

A series of reconstructions of the sunspot number (SN)

- Hoyt & Schatten, 1998 (HS-case)
- Lockwood et al., 2014 (L-case)
- Svalgaard & Schatten, 2015 (SS-case)

Use the radionuclides as a selection criteria

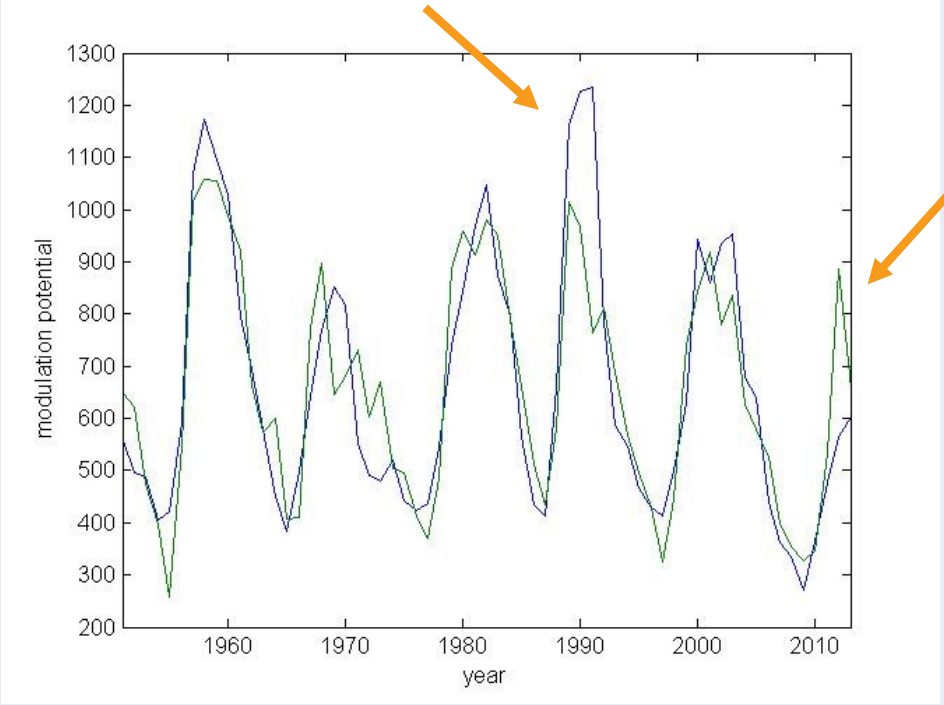
The link



$$n = 1.03,$$
$$a_0 = 150^{\circ}$$
$$\beta = -0.095$$
$$\Phi_0 = 1473.9$$

$$\Phi = \Phi_0 F^{n-\frac{a}{a_0}}(1+\beta p)$$

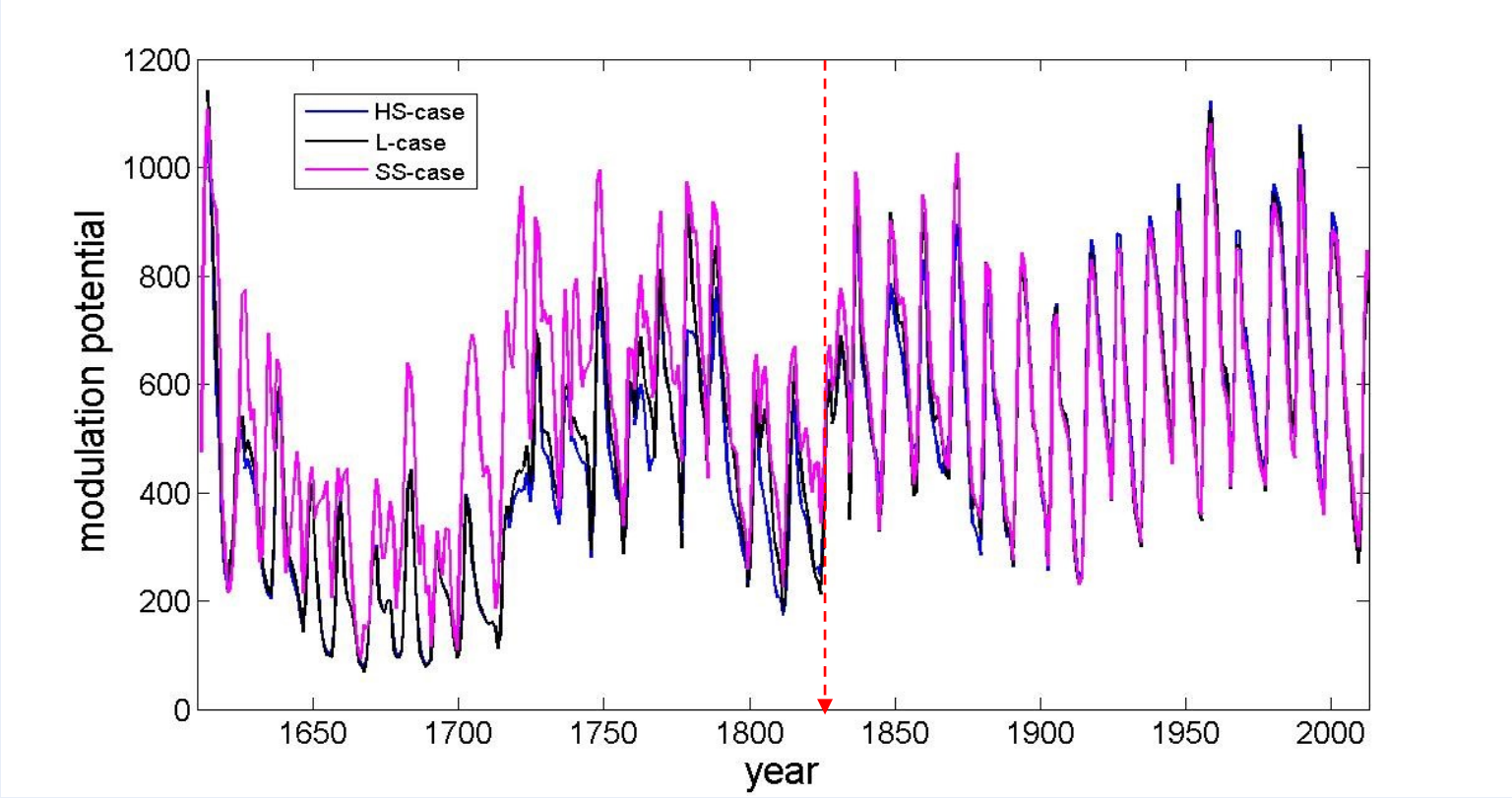
Model's Robustness



Annual variations of the reconstructed by ground based cosmic rays observations (blue curve) and the modelled (green curve) modulation potential for the period 1951-2013.

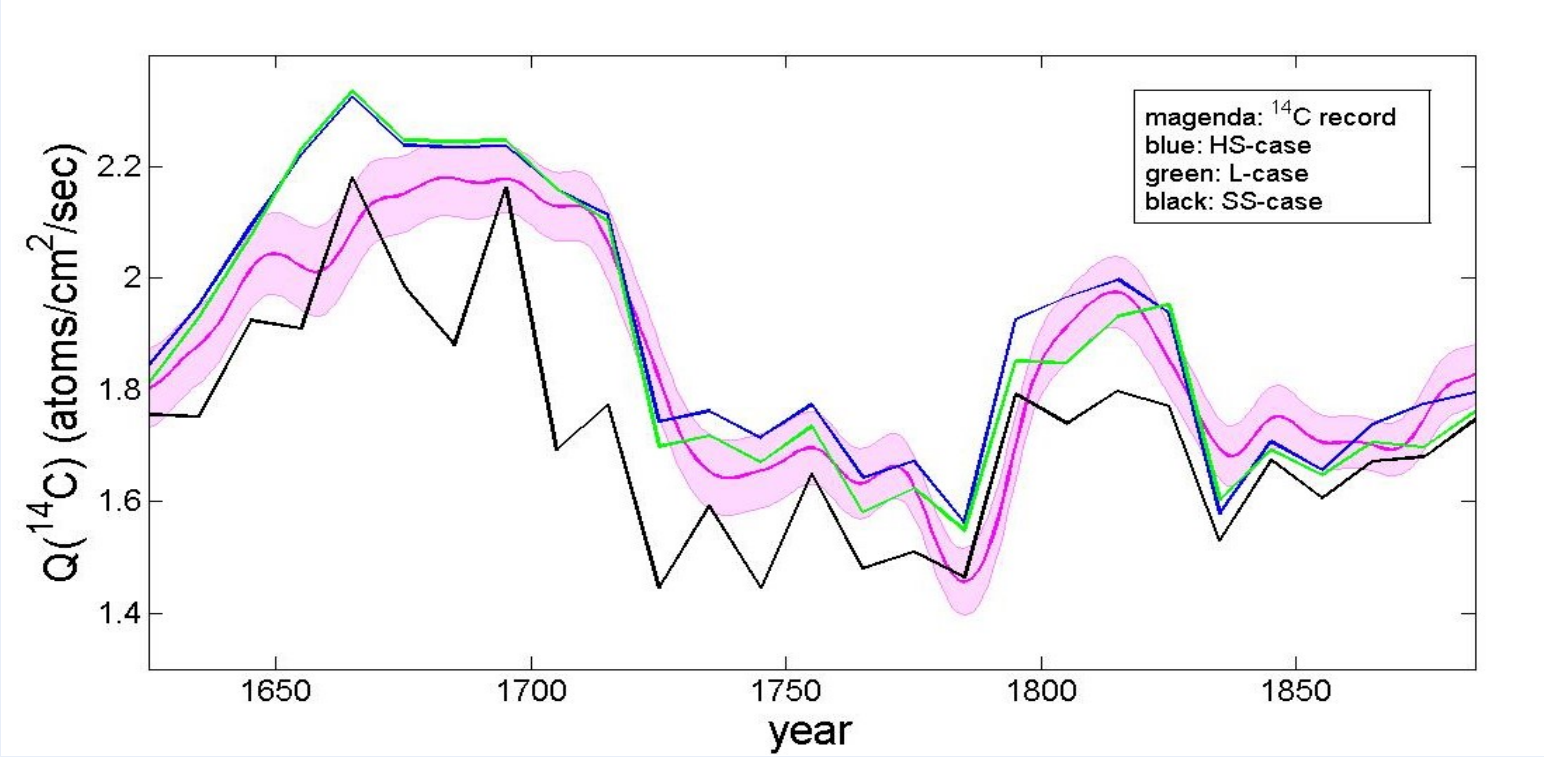
- The correlation coefficient between the two is $R = 0.88 \pm 0.03$
- Due to high solar wind plasma flow pressure during years 1991-1992
- Related to the polarity reversal leading to positive polarity of both north and south polar fields during the maximum phase of the cycle

Centenial Reconstructions



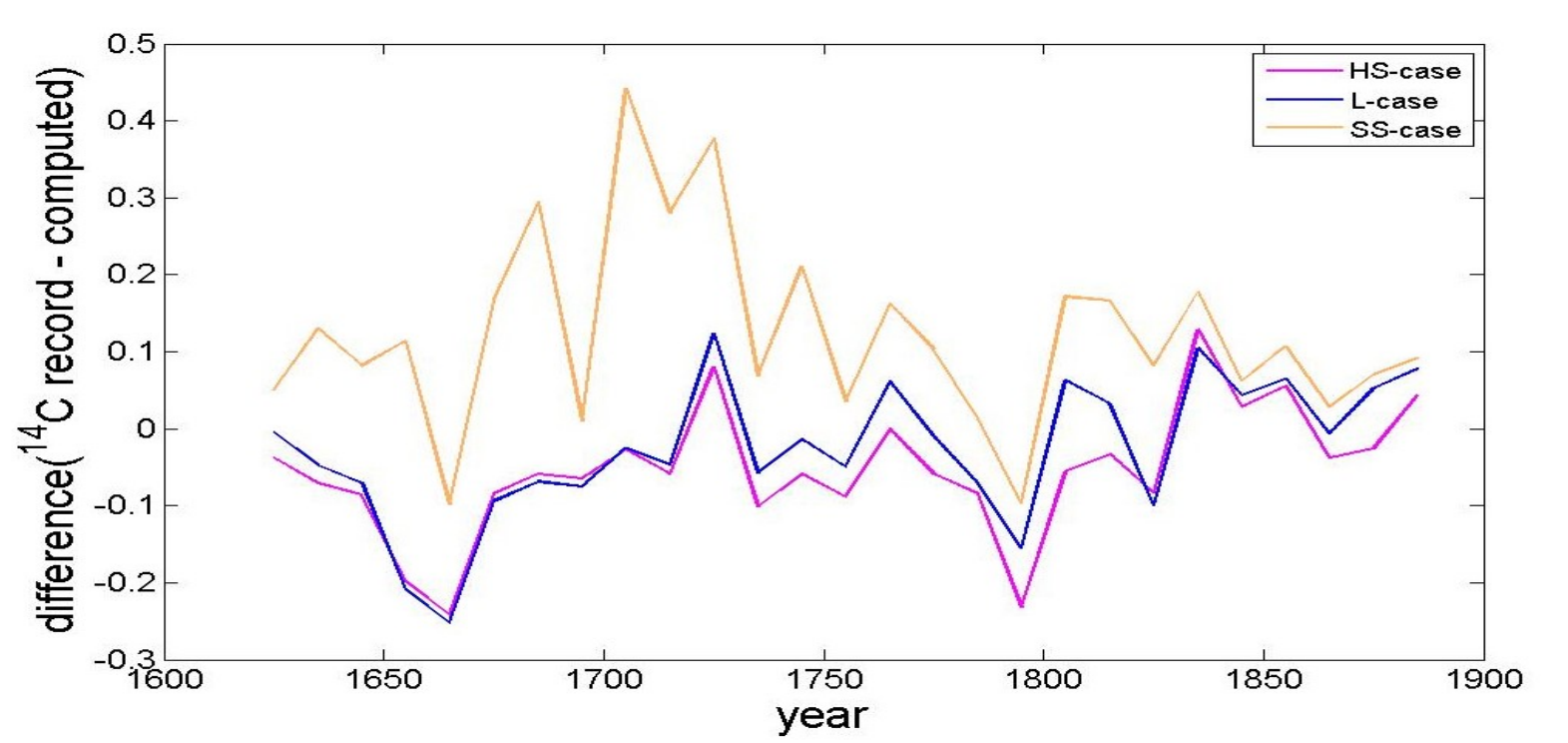
Global Radiocarbon Production

- Used the model for cosmogenic production of radiocarbon ^{14}C by Kovaltsov et al. (2012)
- Compared the global carbon production estimated by model with the ^{14}C INTCAL09 data (Roth & Joos, 2013)



Decadal variations of the global radiocarbon production

Global Radiocarbon Production



Temporal variation of the difference between the record curve and the reconstruction curves shown in Figure 3 for different cases.

^{10}Be Flux

- Used the model for cosmogenic production of radionuclide ^{10}Be by Kovaltsov & Usoskin, 2010
- Compared the beryllium production estimated by model with the ^{10}Be records (Berggren et al., 2009)
- The relation between ^{10}Be production and measurements is not absolute and includes a scaling factor, related to the unknown wet/dry deposition as a free parameter.
- The model results cannot be actually compared with the data for ^{10}Be .
- There is a good agreement in the overall time variability but the distinction between different SN reconstructions is not possible.

Conclusions

- There is a number of Sunspot Number (SN) series tracing the solar variability, but which one is more accurate?
- There are good records of terrestrial archives of radionuclides tracing the solar variability.
- We use our semi-empirical model to compute the modulation potential using OSF reconstructions based on each SN series and we translate that into radionuclides production.
- The reconstructions based on HS and L-cases appear to agree well with the radiocarbon record, however the computations based on the SS-case show that it underestimates the global radiocarbon production.
- The relation between ^{10}Be production and measurements is not absolute and includes a scaling factor, related to the unknown wet/dry deposition as a free parameter. Thus, the model results cannot be compared with the data for ^{10}Be. There is a good agreement in the overall time variability but the distinction between different SN reconstructions is not possible.