Cosmogenic Radionuclides and Long-term Solar Activity

Jürg Beer
Friedhelm Steinhilber
Jose Abreu
Ken McCracken

beer@eawag.ch

Outline

- Cosmogenic Radionuclides
  - Production
  - Transport
  - Archives
- Interpretation in Terms of Solar Activity
  - Constructing a Composite record of cosmic rays
  - Separation of heliomagnetic and geomagnetic modulation
- Main Results

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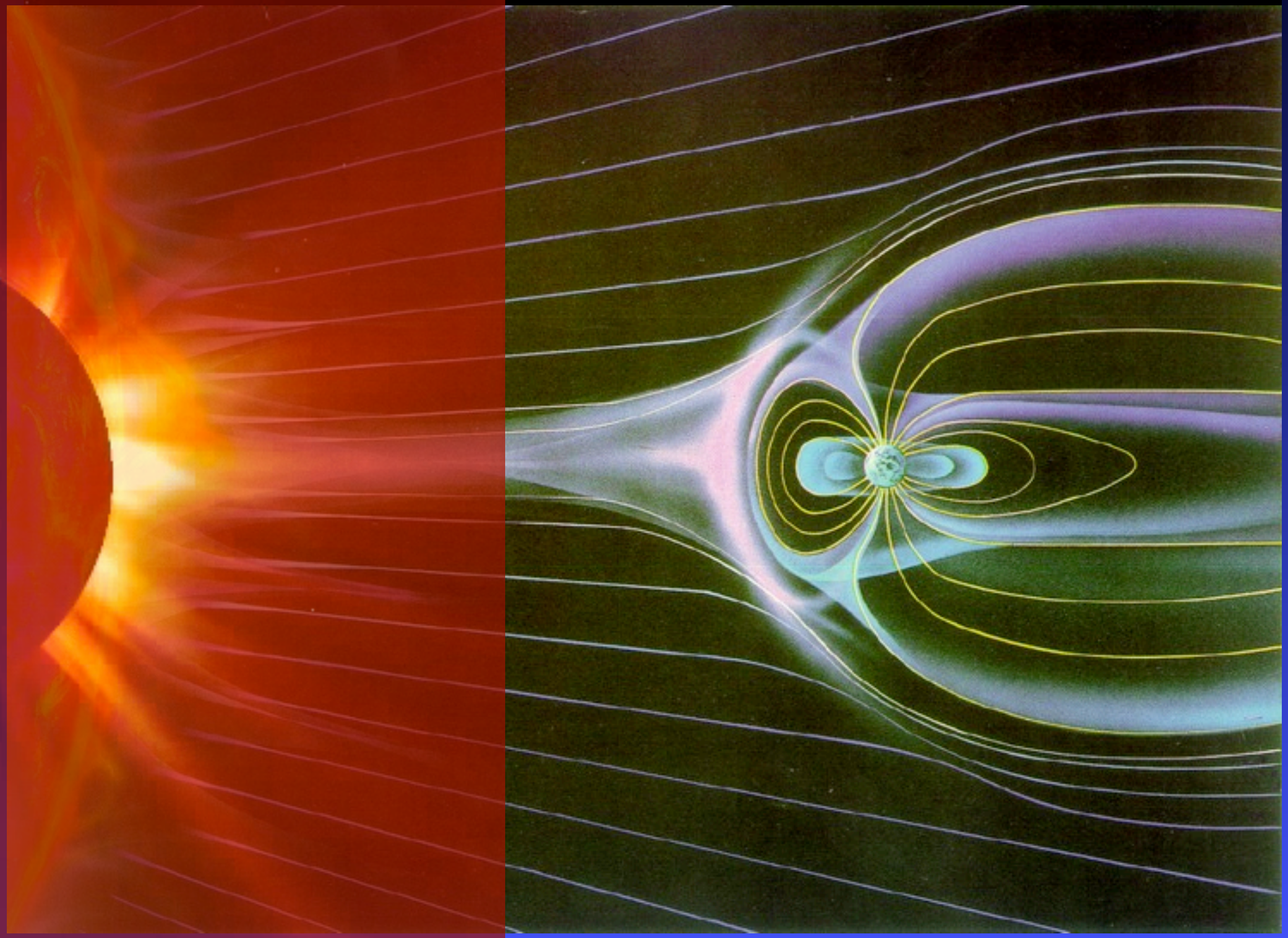
aquatic research

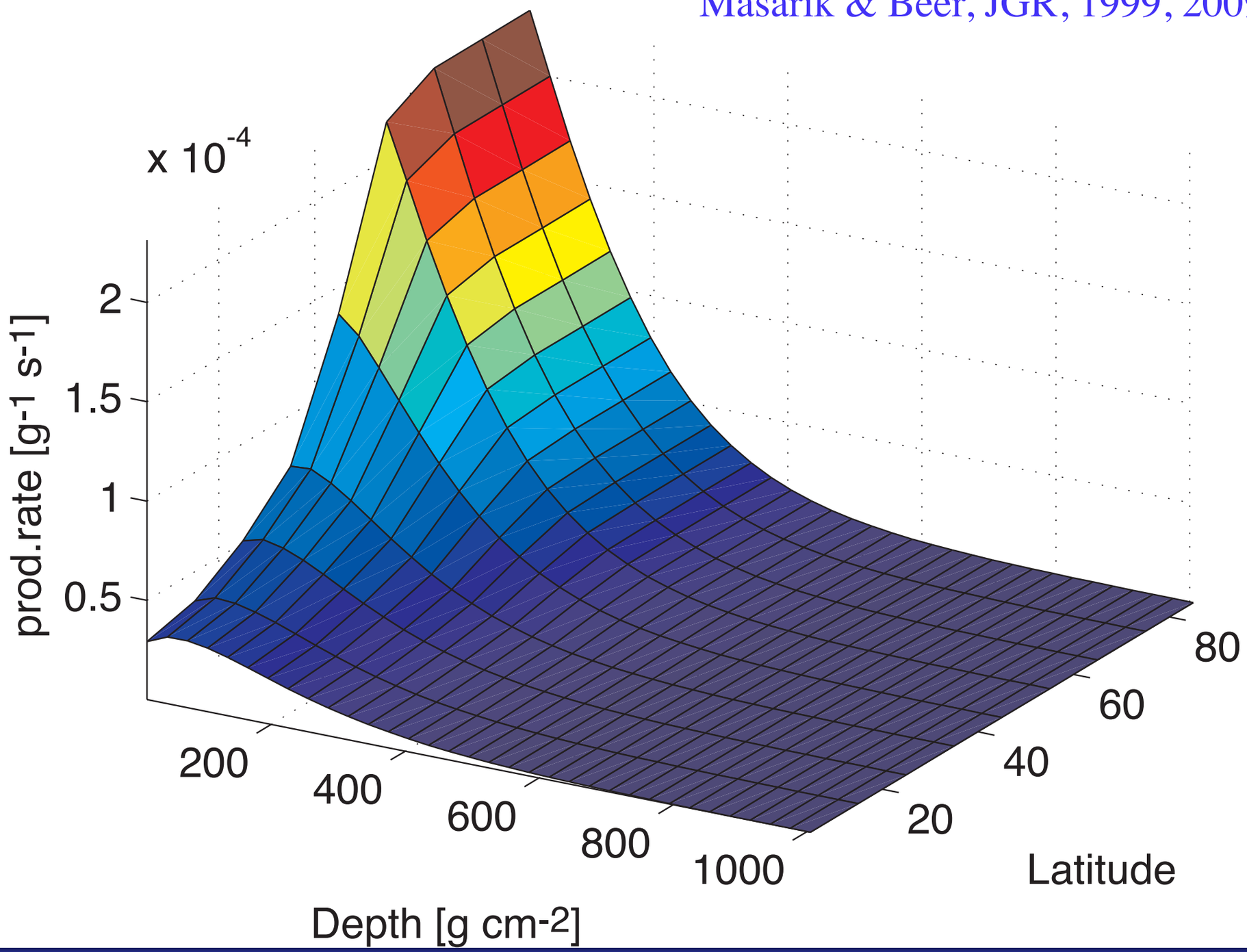
Cosmic Rays in the Heliosphere



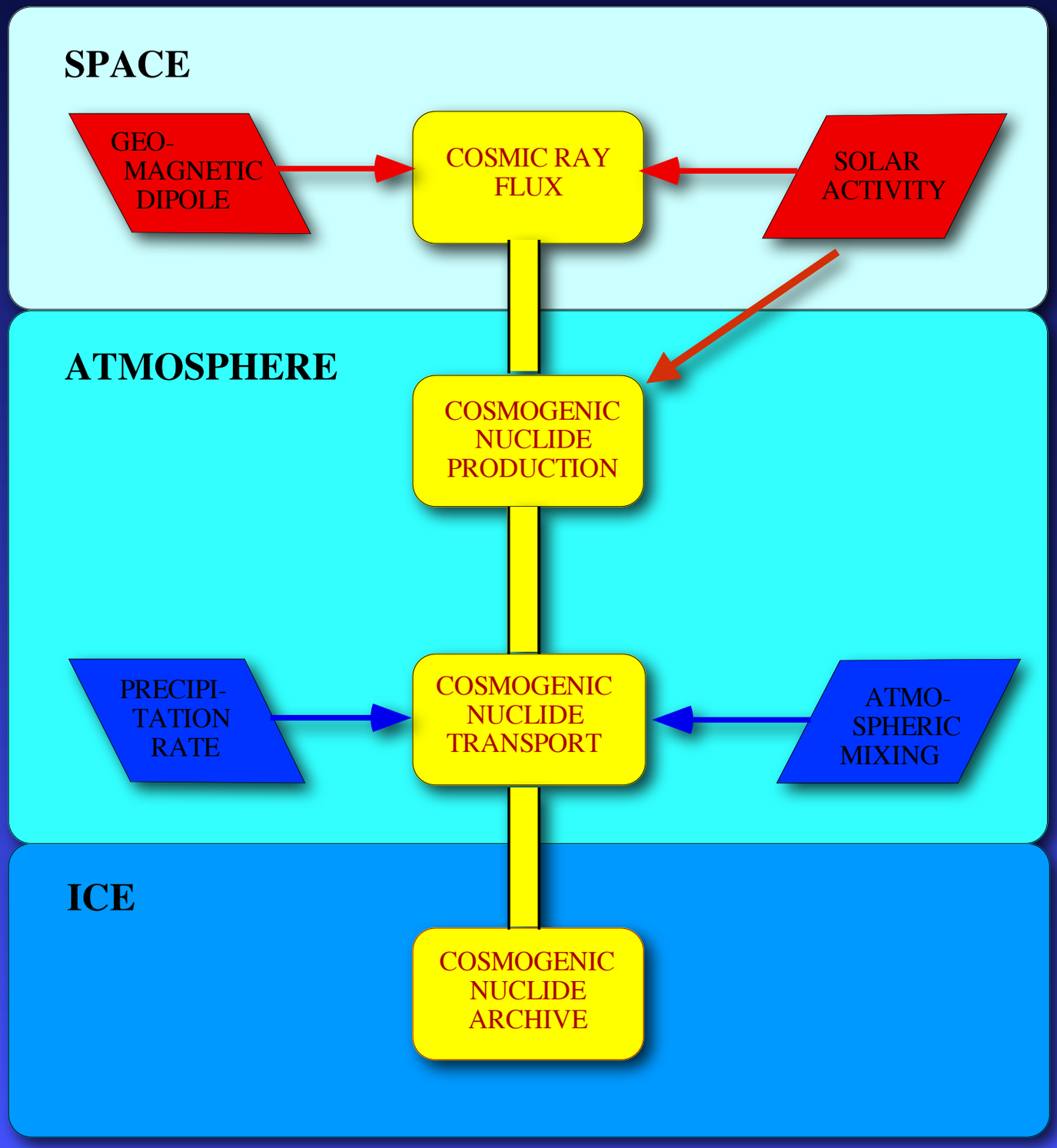
SC 5 Oulu
16.6.2013
Jürg Beer

^{10}Be production versus Depth and Latitude (M=1, Φ=500 MV)

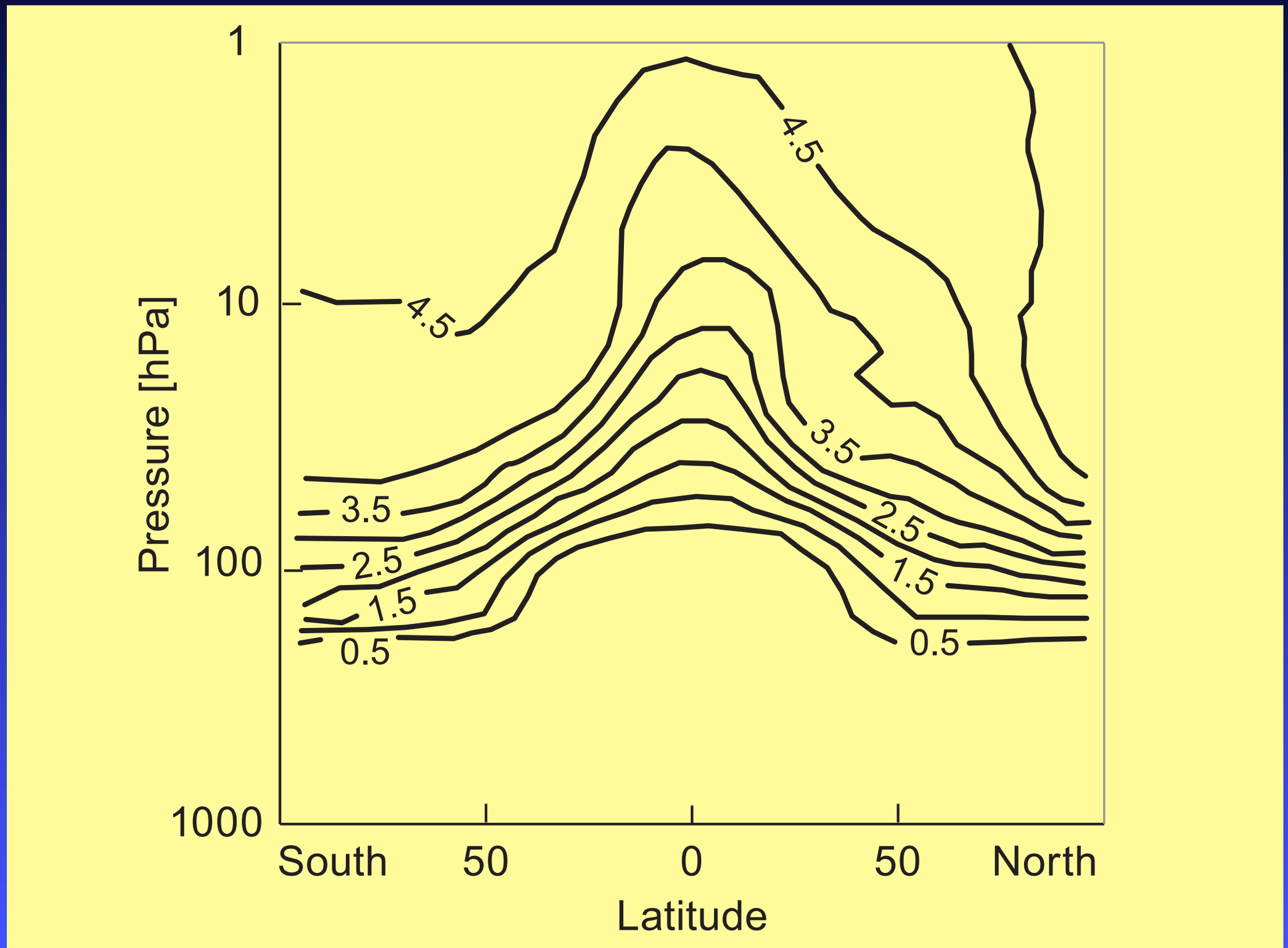
Masarik & Beer, JGR, 1999, 2009



^{10}Be Information from Cosmogenic Radionuclides



Mean Atmospheric Residence Time



Archives: ice core

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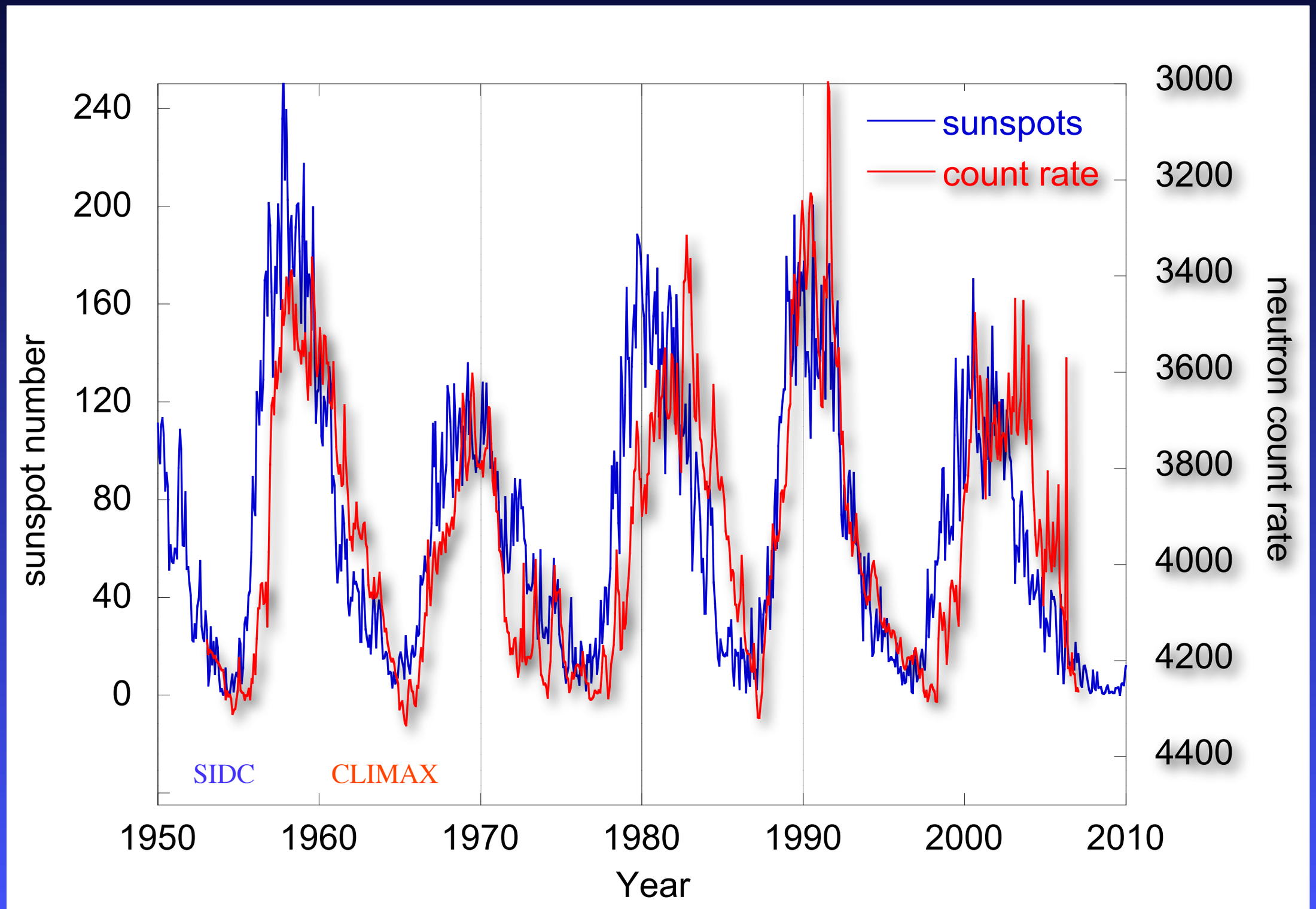
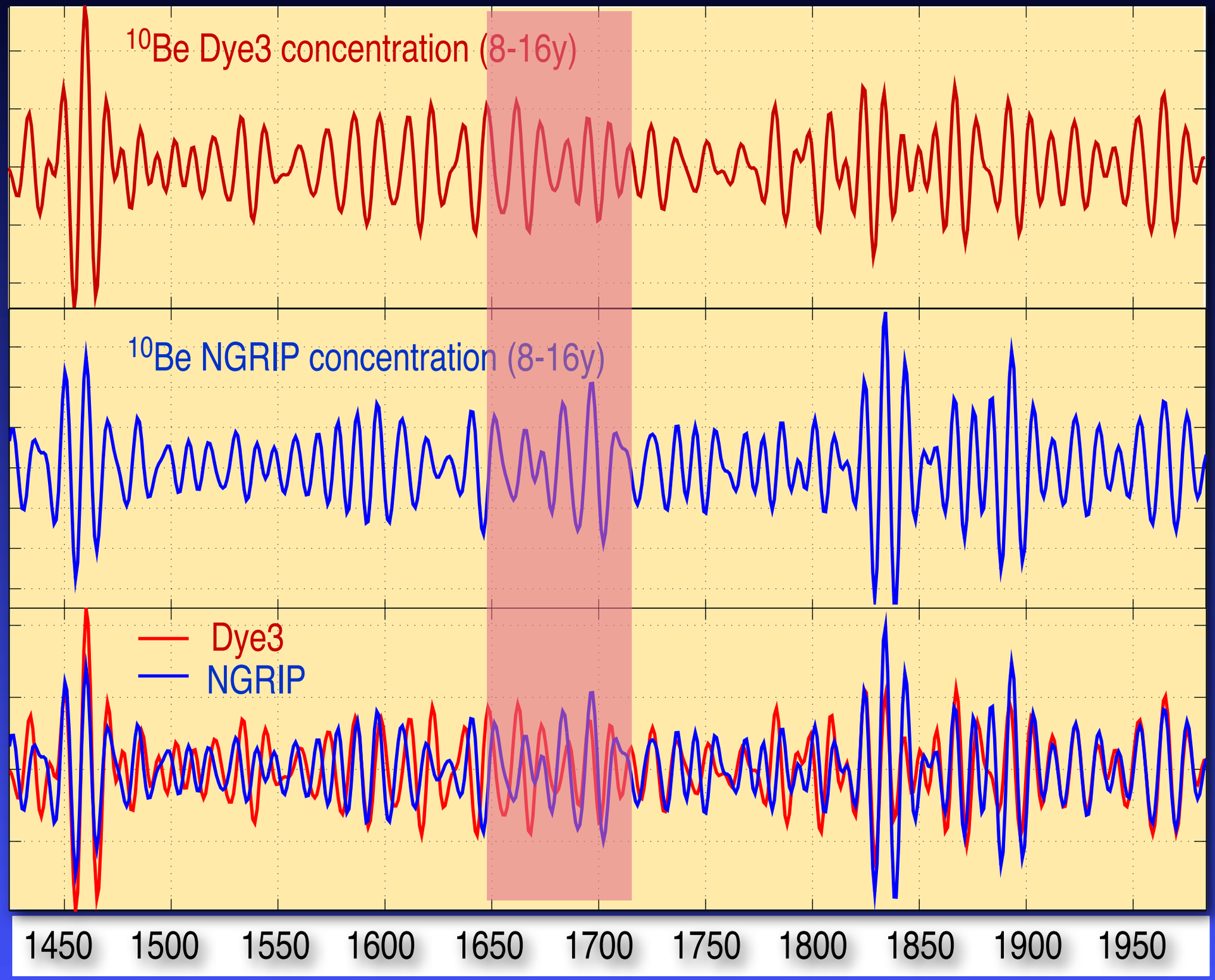
Solar Variability and Cosmic Rays



11-y Schwabe cycle

Berggren et al, GRL, 2009

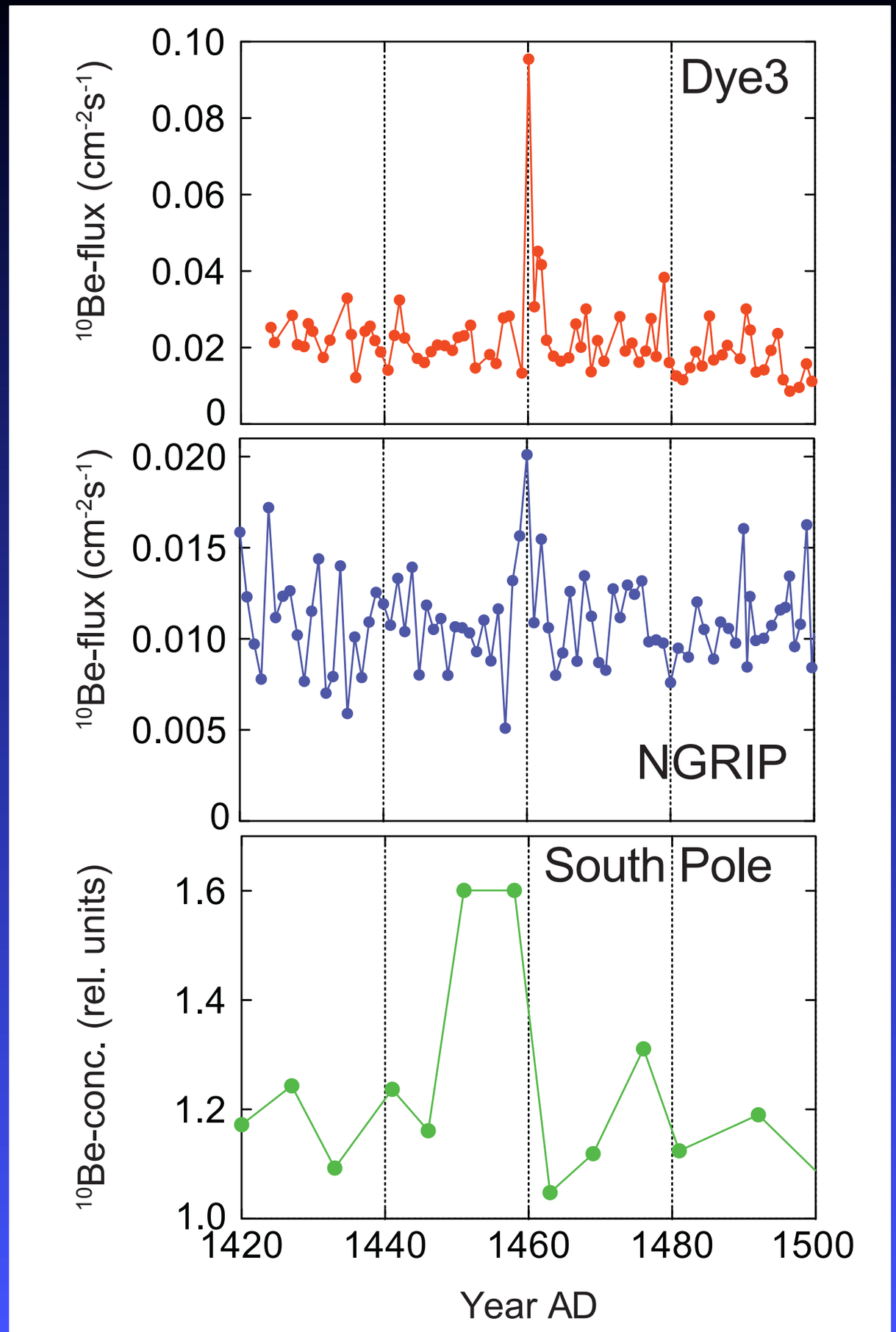


Supernova?

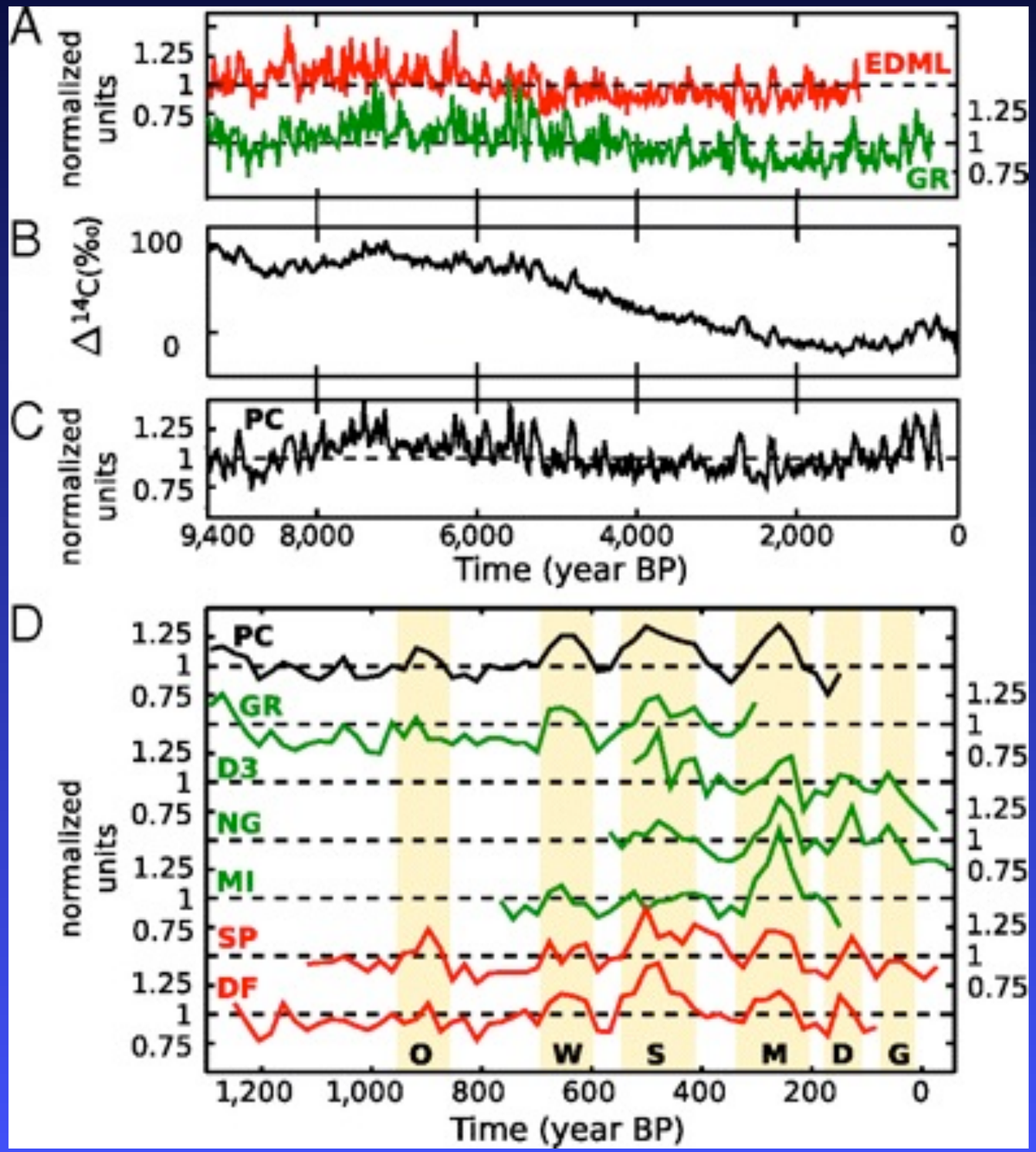
A possible terrestrial record of the occurrence of the Vela Junior supernova (RXJ0852.0-4622/ GROJ0852-4642).

K.G. McCracken, J. Beer, and J. Masarik

submitted



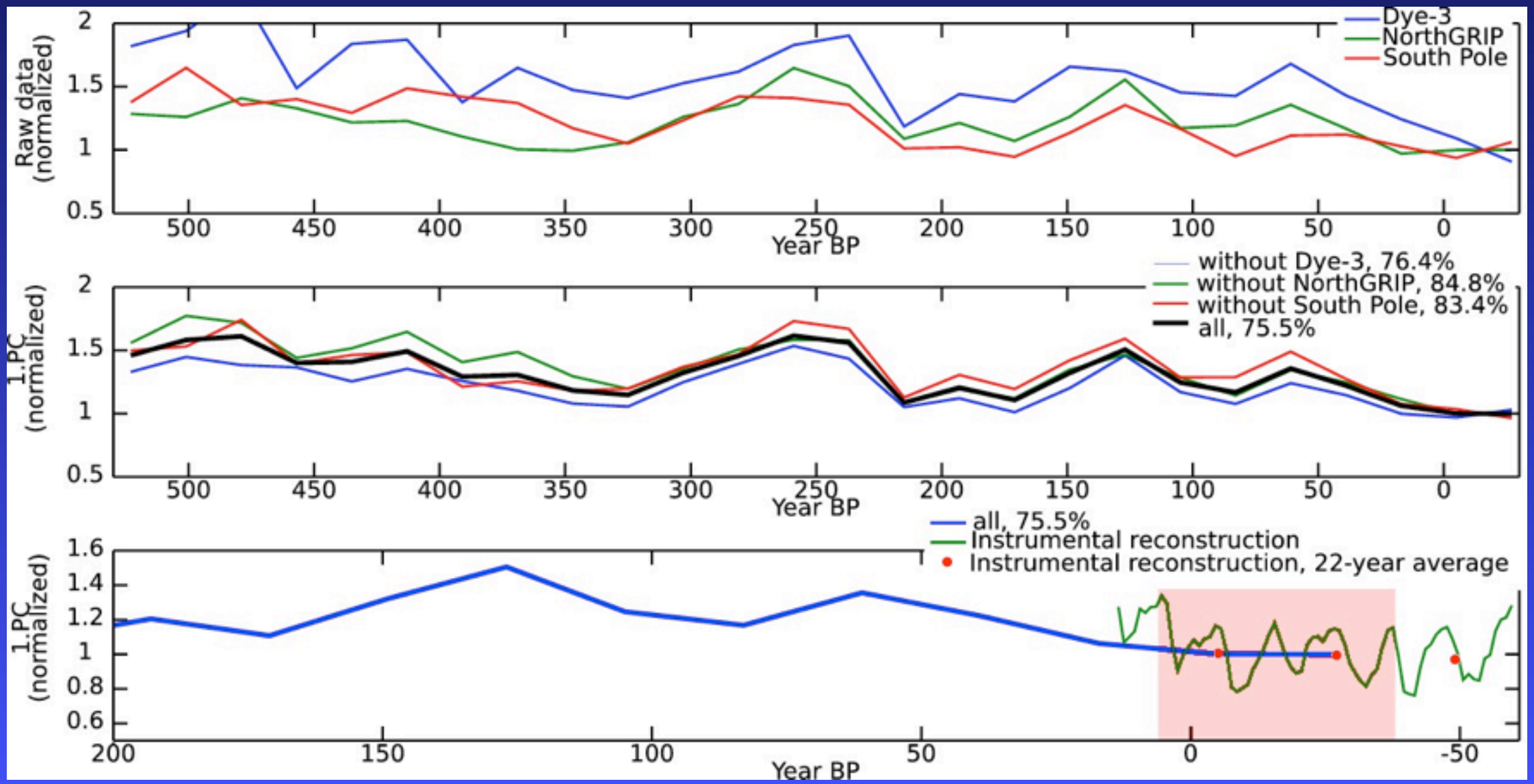
Construction of a Composite of Past Galactic Cosmic Radiation



Steinhilber et al, PNAS, 2012

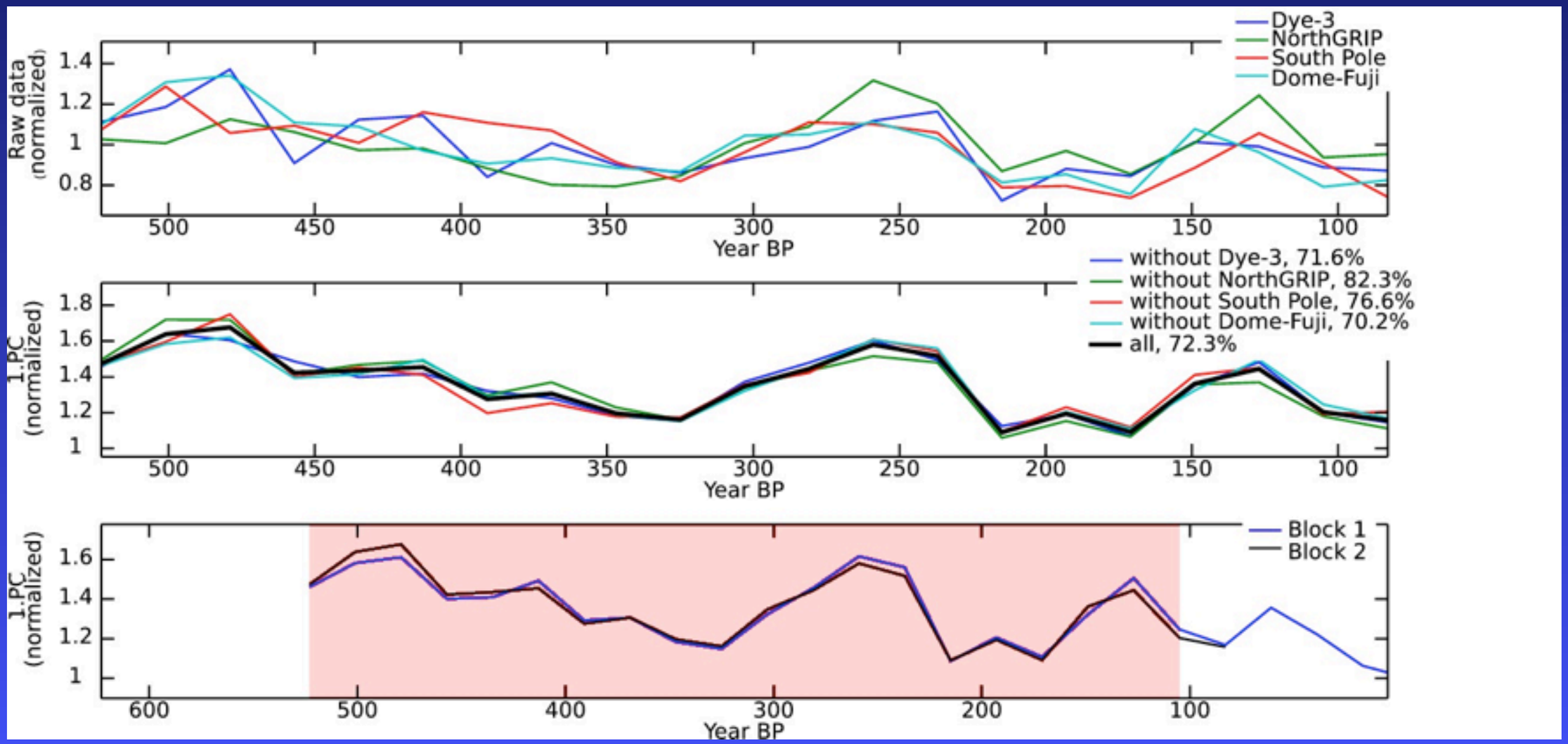
Construction of a Composite of Past Galactic Cosmic Radiation

Steinhilber et al, PNAS,2012



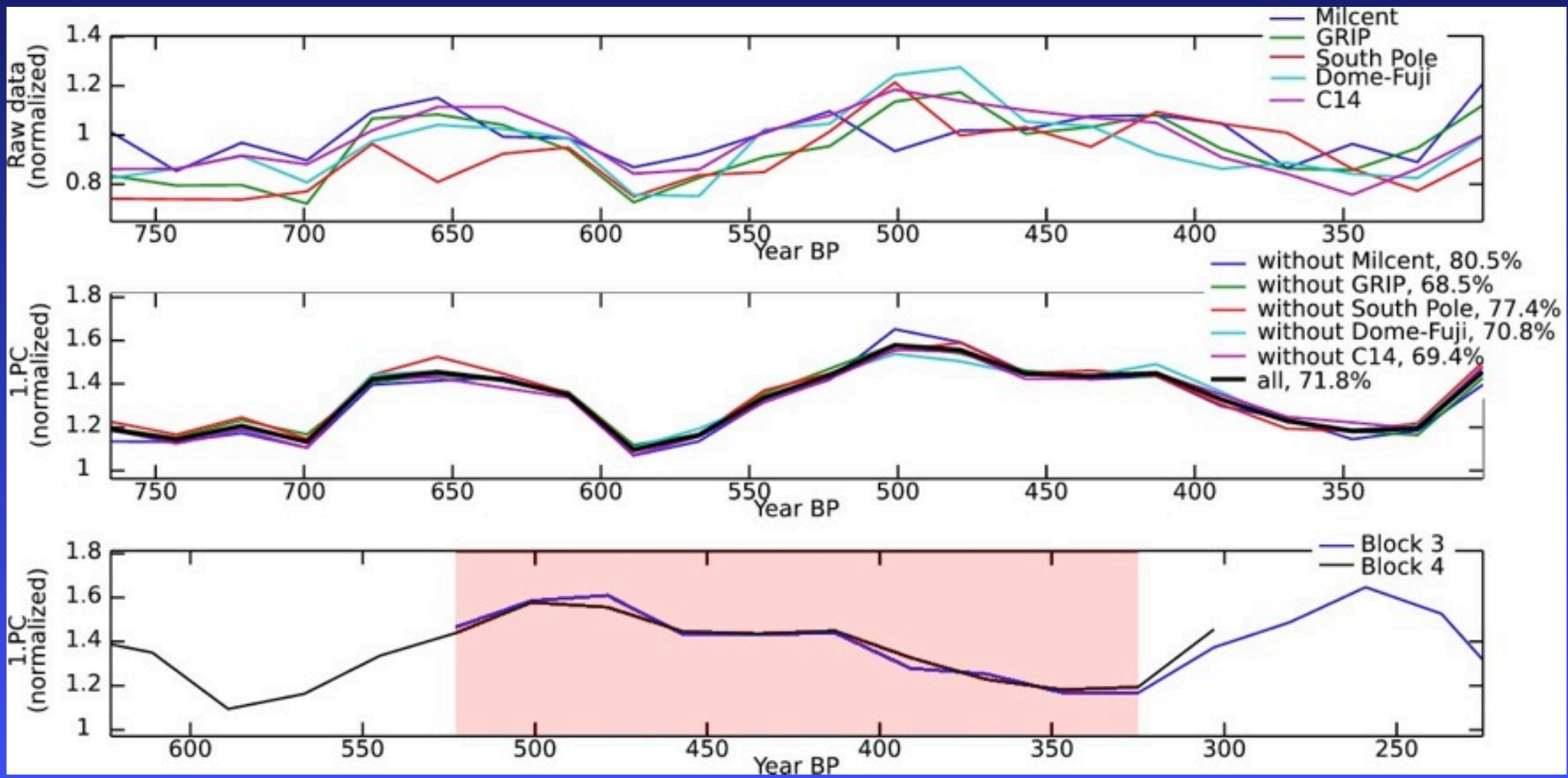
Composite

Steinhilber et al, PNAS,2012



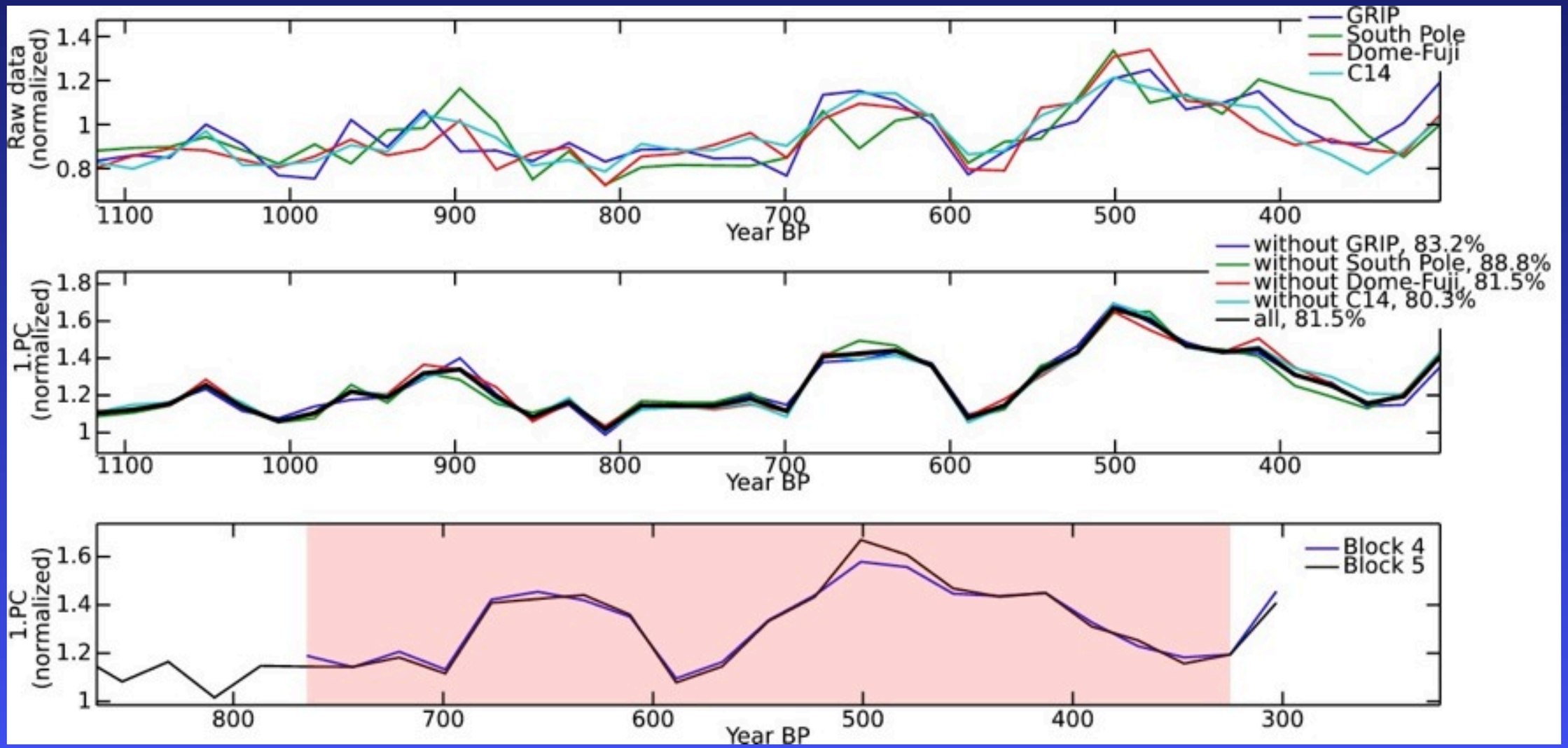
Composite

Steinhilber et al, PNAS,2012



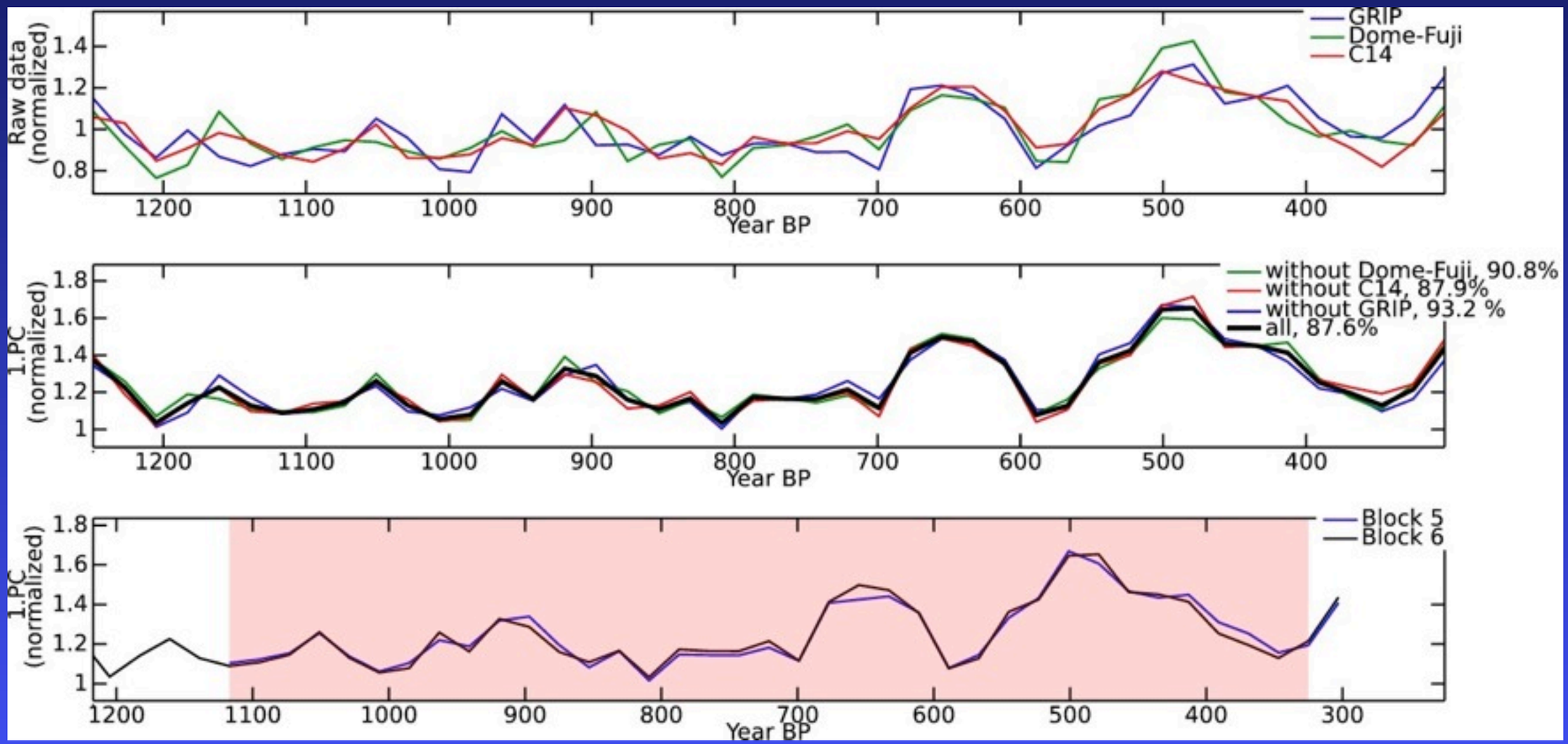
Composite

Steinhilber et al, PNAS,2012



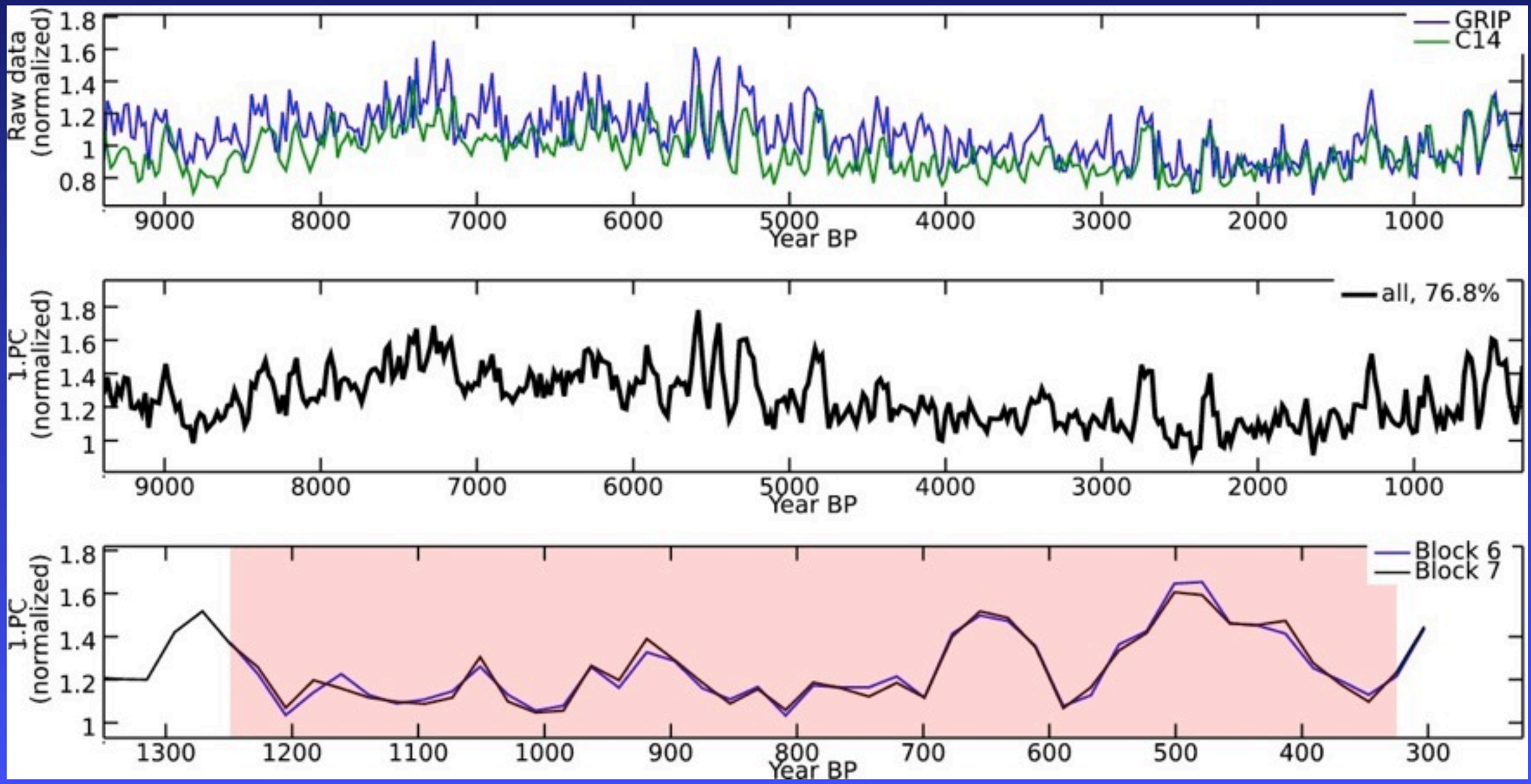
Composite

Steinhilber et al, PNAS,2012



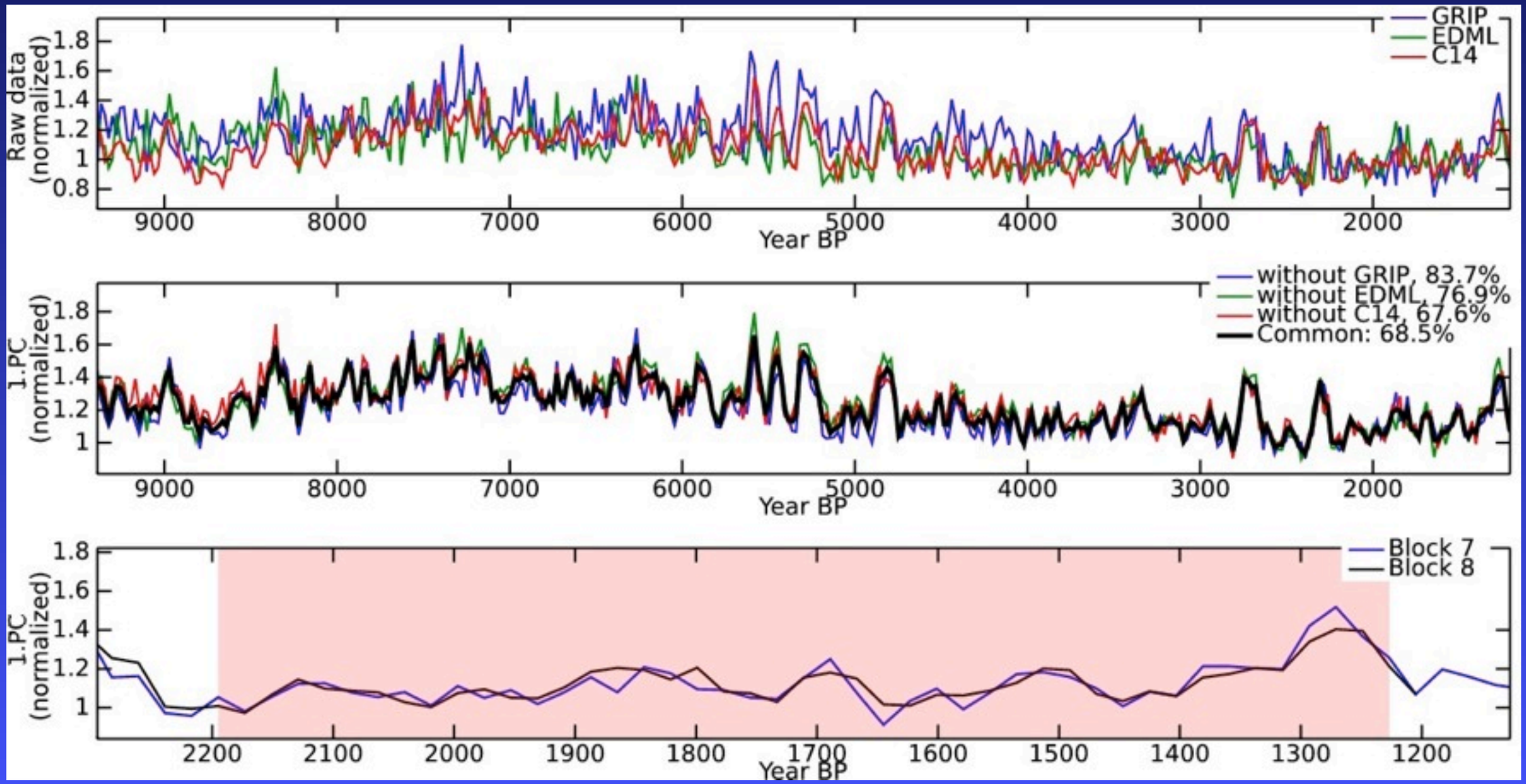
^{14}C tree rings - ^{10}Be GRIP

Steinhilber et al, PNAS,2012

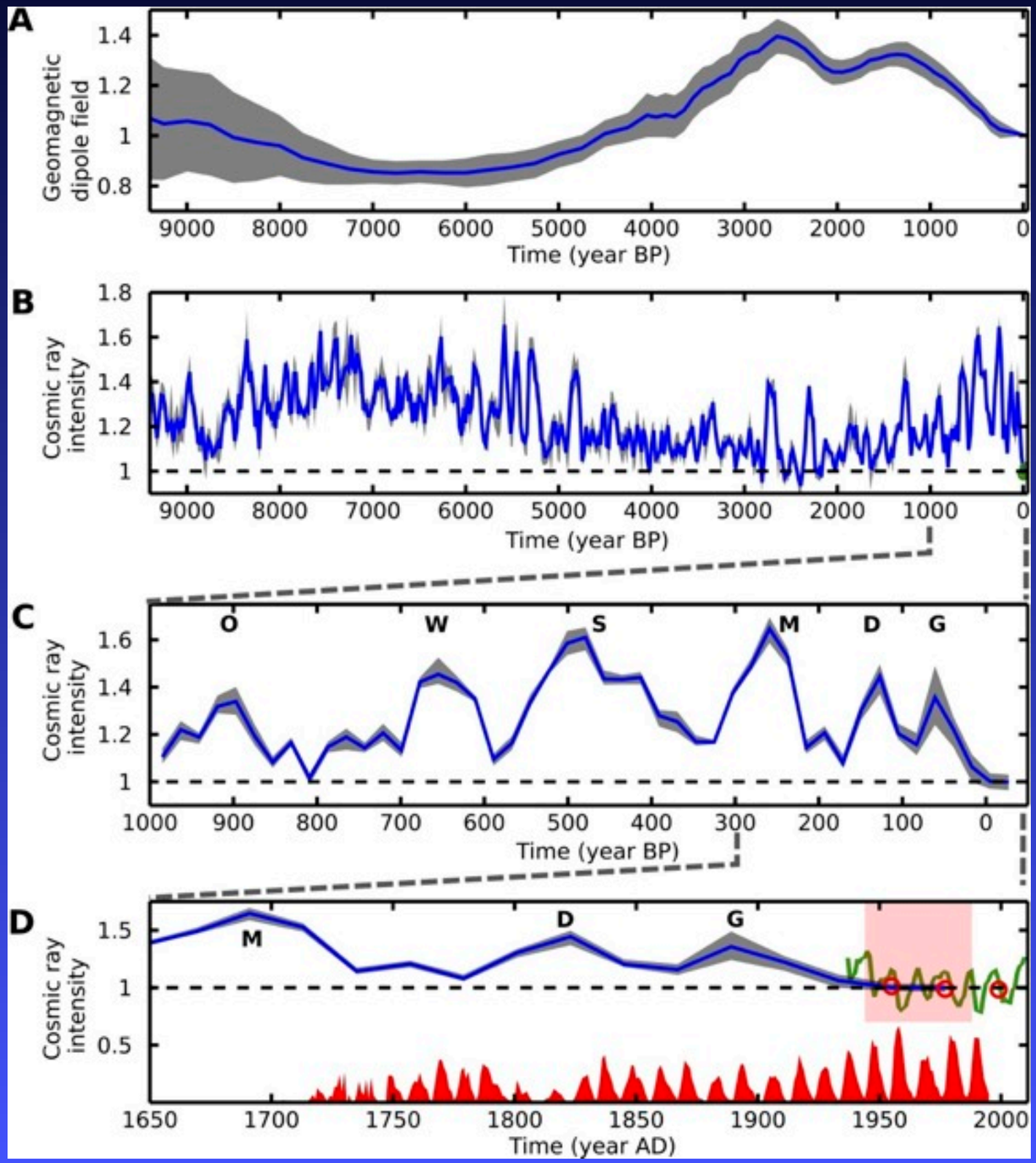


^{14}C tree rings - ^{10}Be GRIP & EDML

Steinhilber et al, PNAS,2012

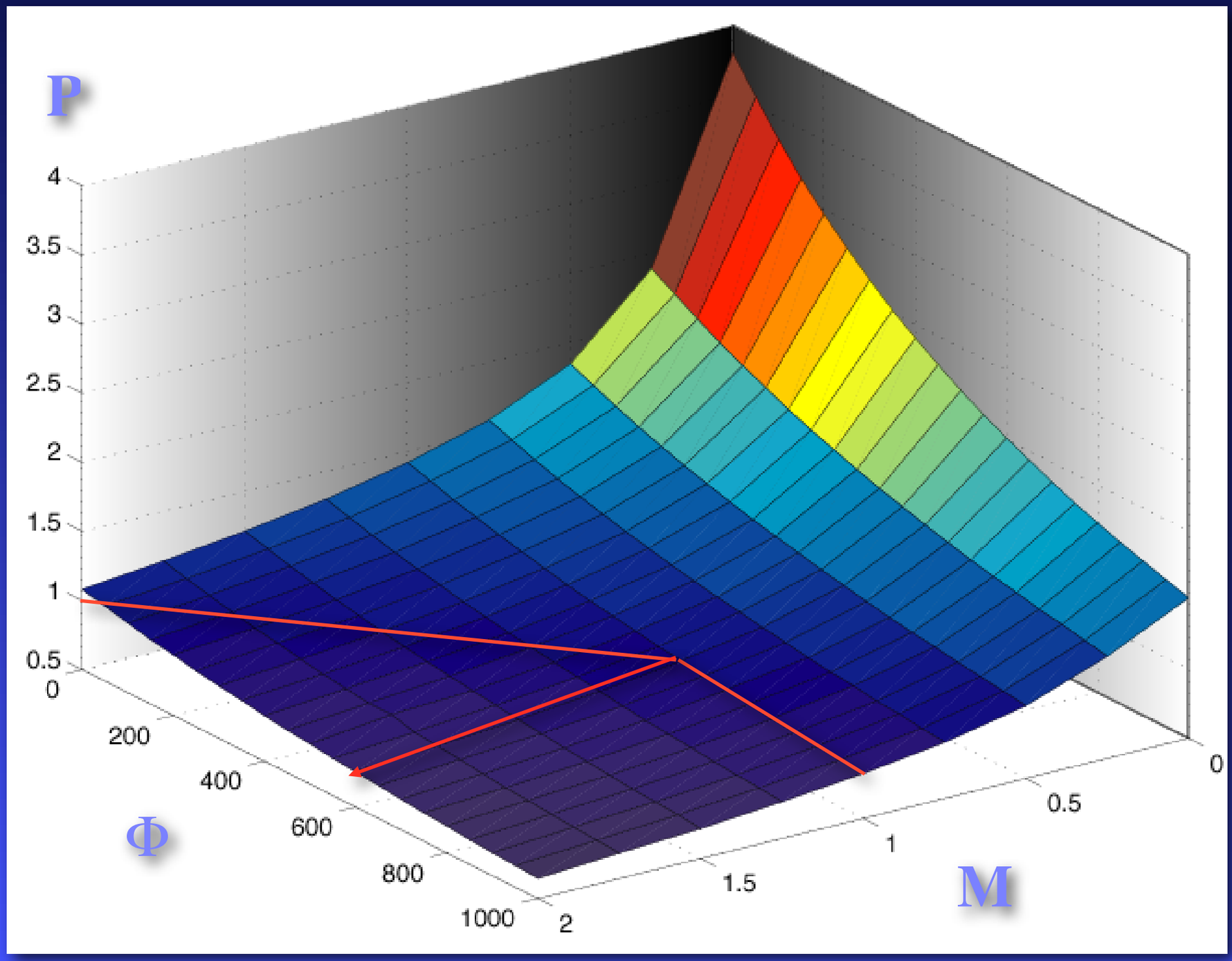


Composite cosmic ray intensity



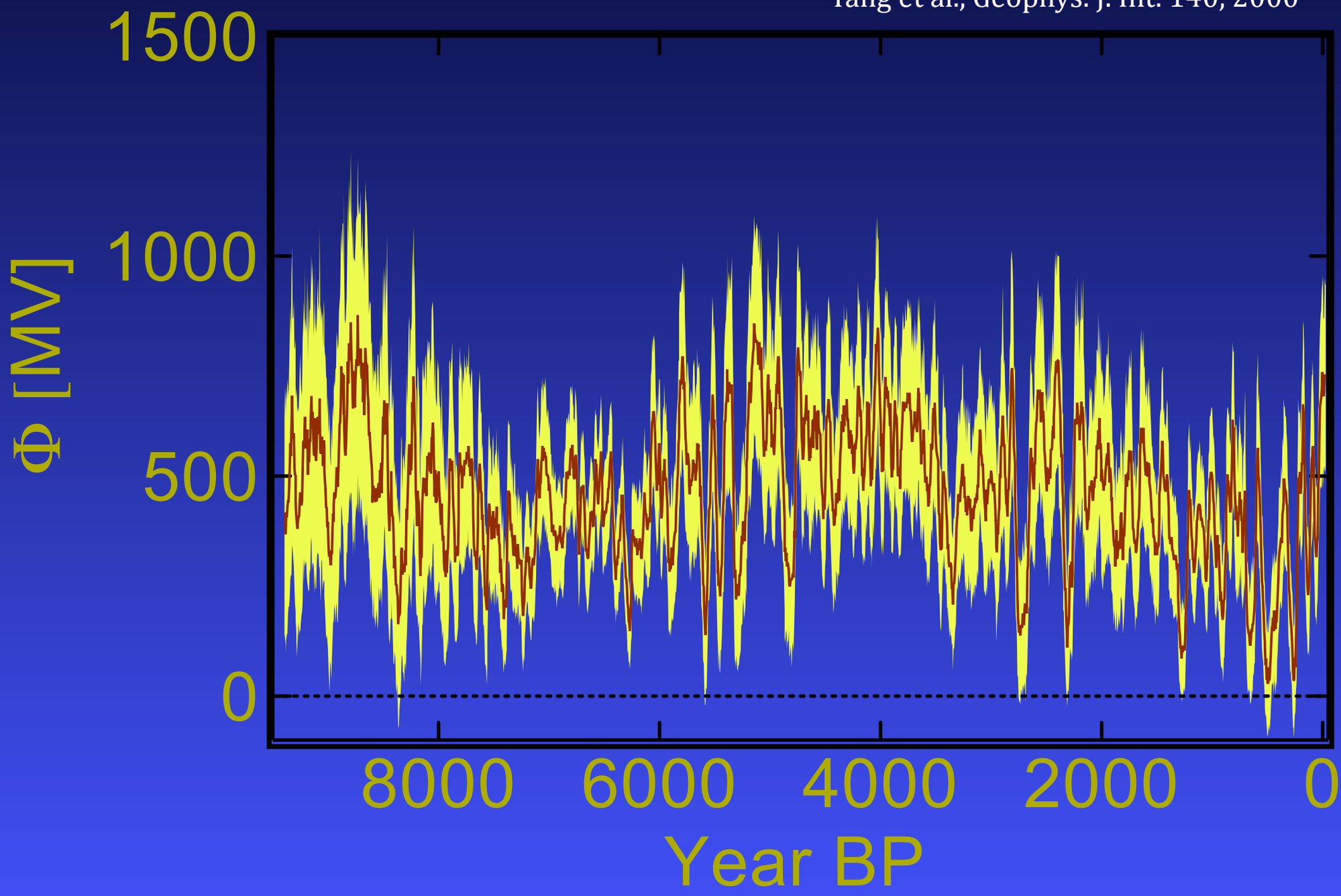
Steinhilber et al, PNAS,2012

Dependence of Production Rate on Φ and M



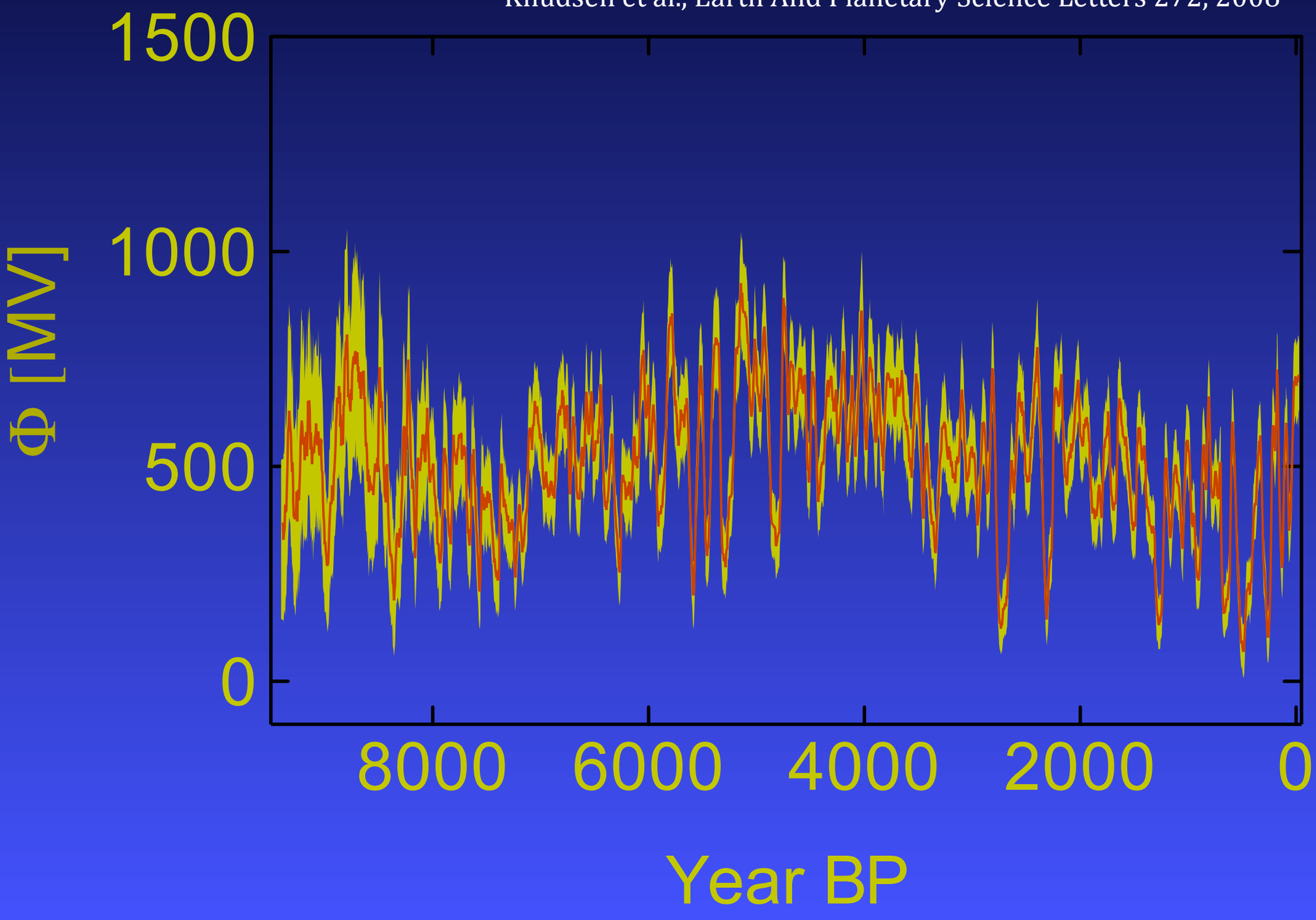
Φ based on M-Field of Yang

Yang et al., Geophys. J. Int. 140, 2000



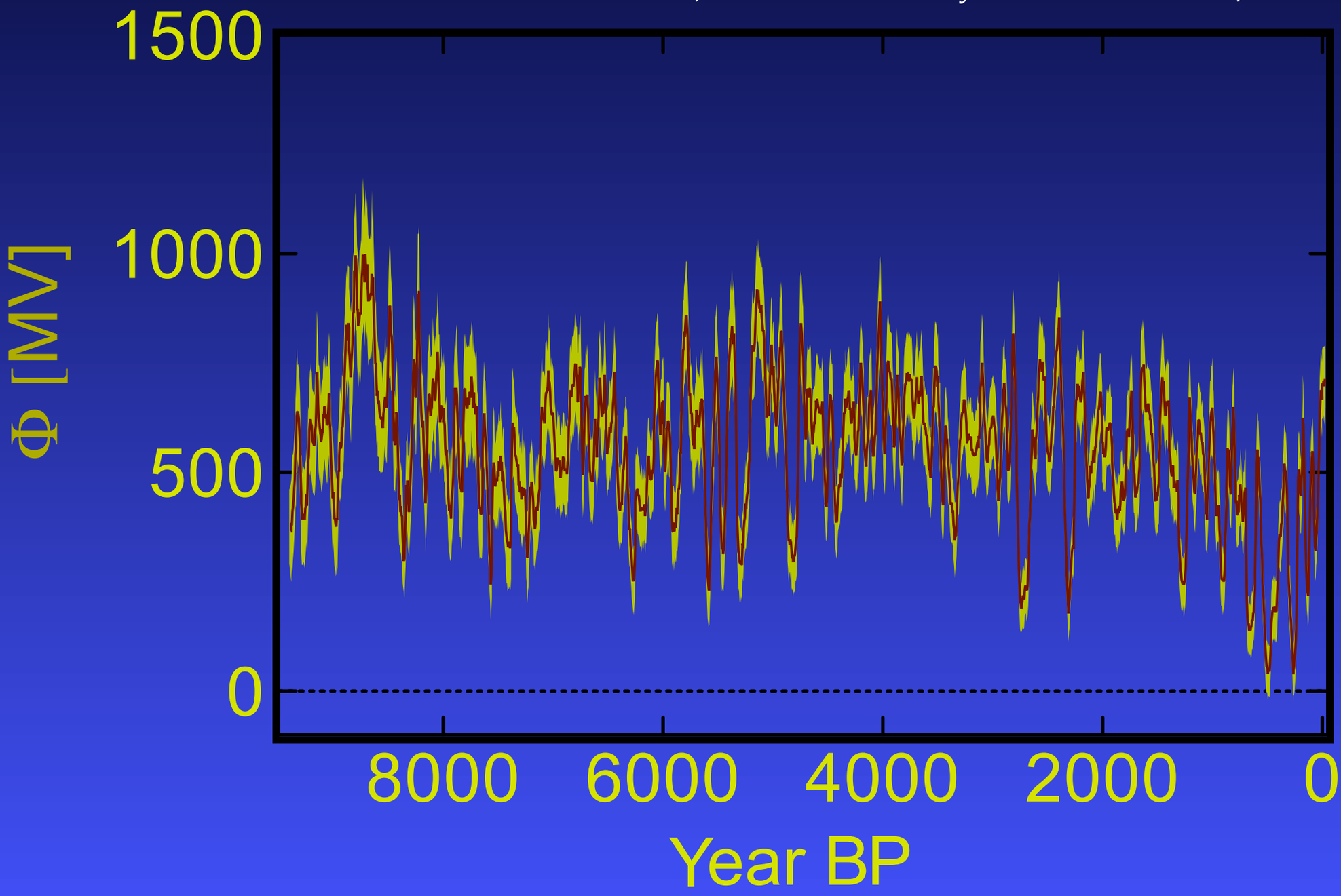
Φ based on M-Field of Knudsen

Knudsen et al., Earth And Planetary Science Letters 272, 2008

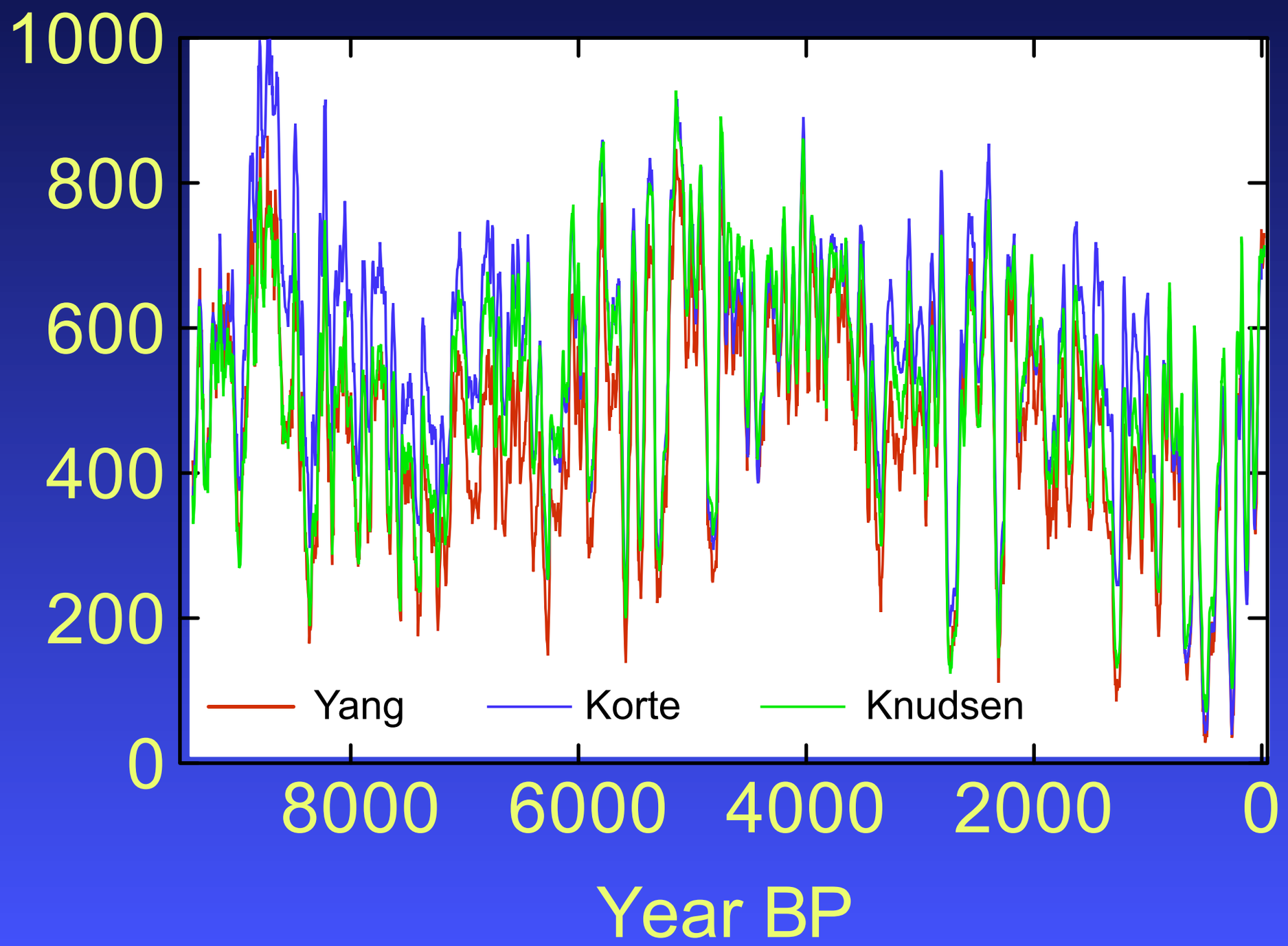


Φ based on M-Field of Korte

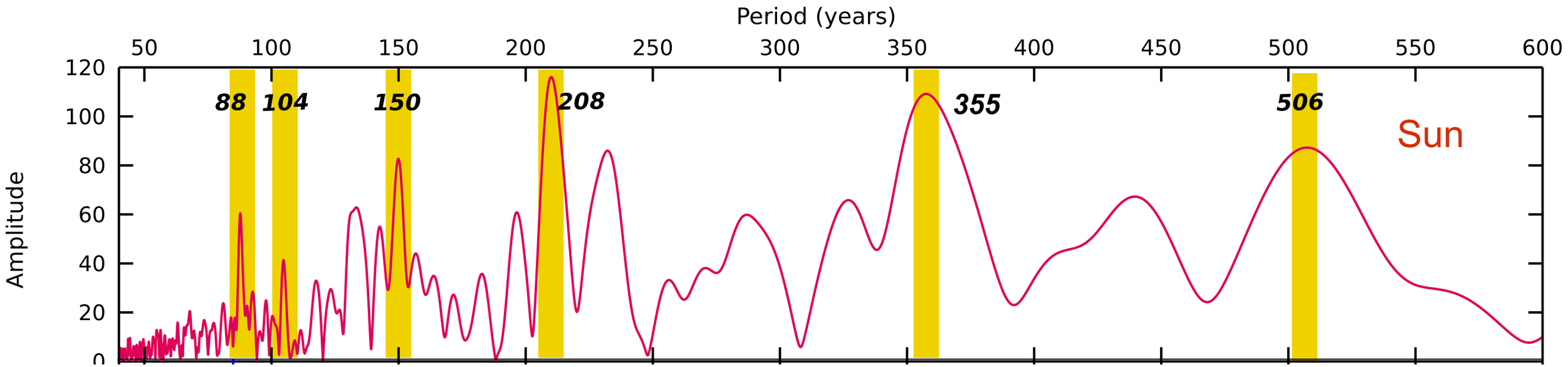
Korte et al., Earth And Planetary Science Letters 312, 2011



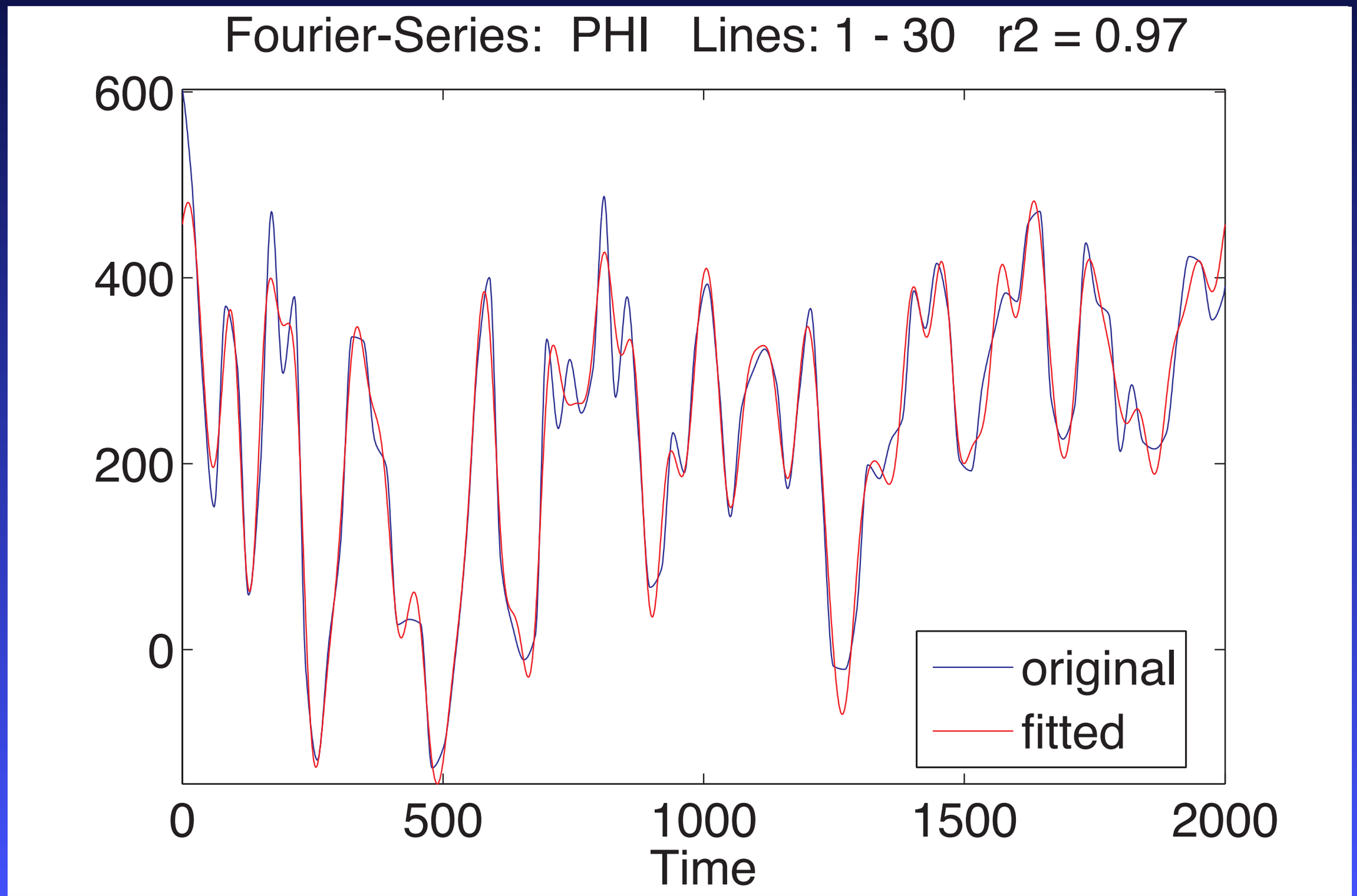
Φ depending on M-Data



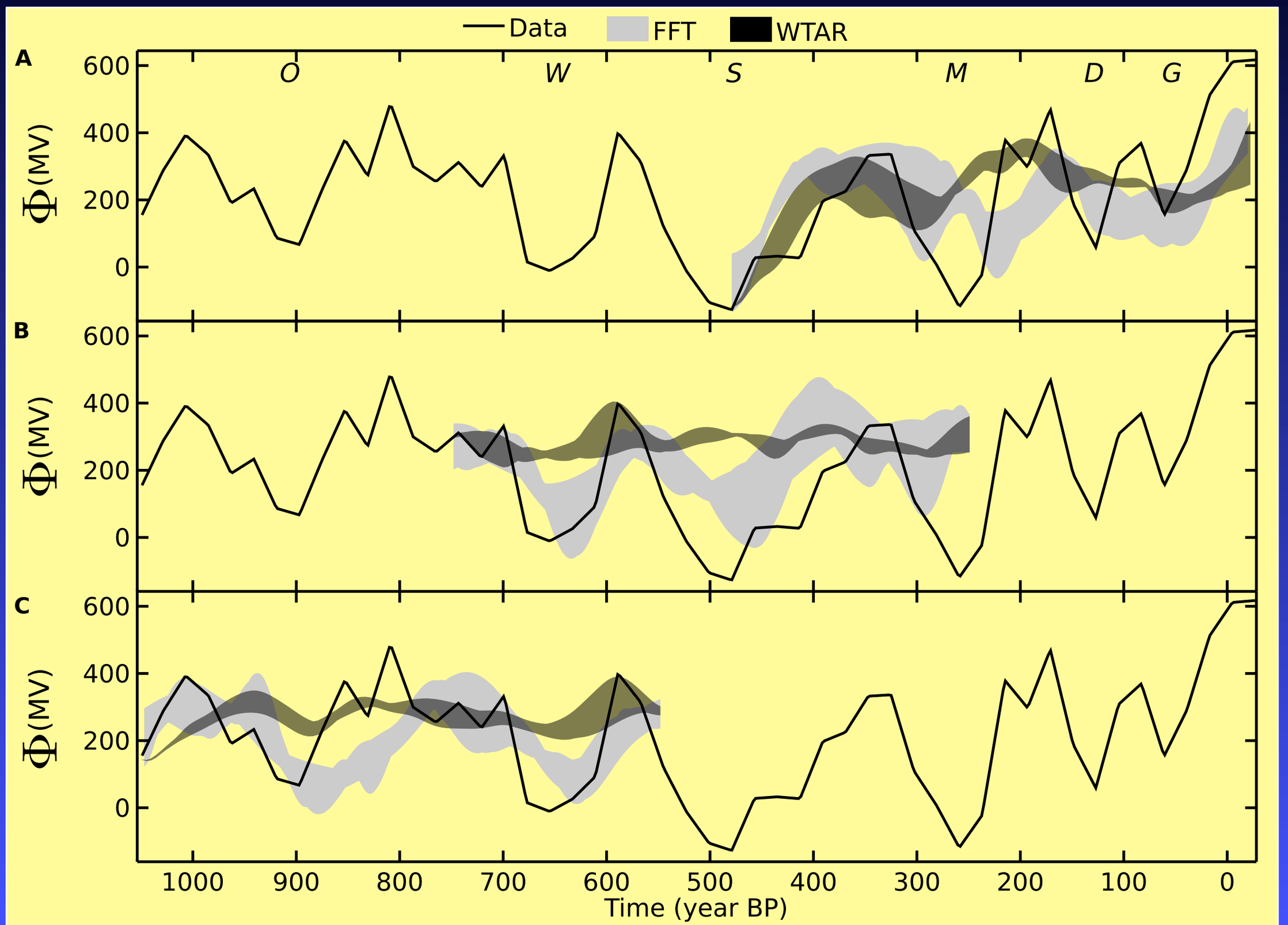
Solar Cycles



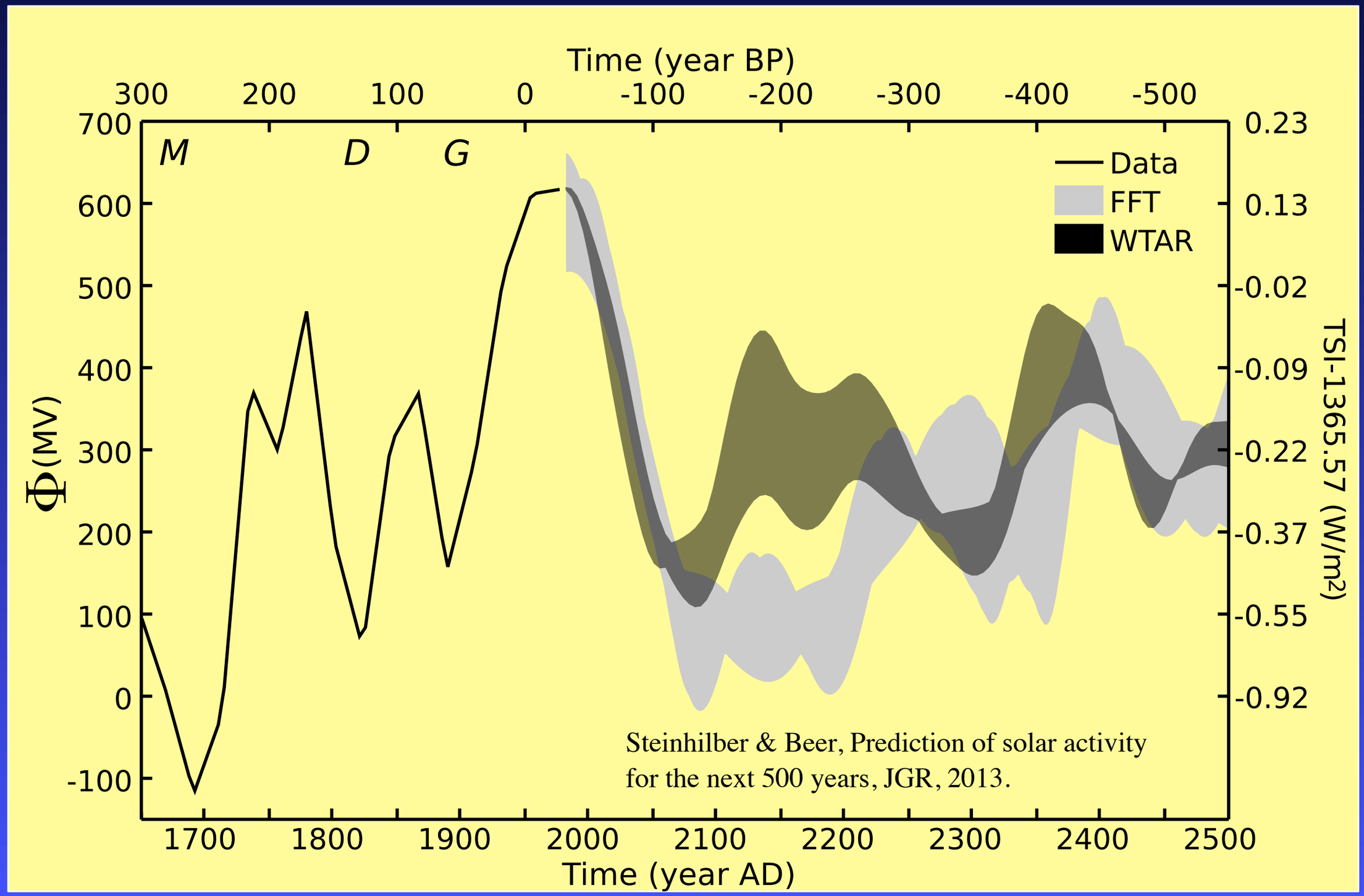
Spectral composition of Φ (2 kyr)



Prediction of past 500 y intervals



Predictions of future 500 y



Conclusions: long-term solar activity

- Reconstruction based on cosmogenic radionuclides
- Main Results:
  - 11-y Schwabe cycle always active (dynamo)
  - multidecadal cycles: stable frequencies, variable amplitudes (session 5)
  - grand minima (70-110 y): ~2-3/kyr
  - grand maxima: e.g. instrumental period
  - grand maxima to come

Conclusions: long-term solar activity

- Solar Modulation Potential Φ:
  - composite (PCA) removes transport effects
  - available for ~10,000 years
  - extension difficult (glacial climate, missing ^{14}C)
- Main Uncertainties:
  - Local Interstellar Spectrum (LIS)
  - Calibration of Φ
  - Geomagnetic Field

Final remark:

Niels Bohr 1885-1963

Prediction is very difficult,
especially about the future

Further Reading:

http://www.springer.com/astronomy/extraterrestrial+physics%2C+space+sciences/book/978-3-642-14650-3