Brief Overview of VarSITI/SEE

Solar Evolution & Extrema

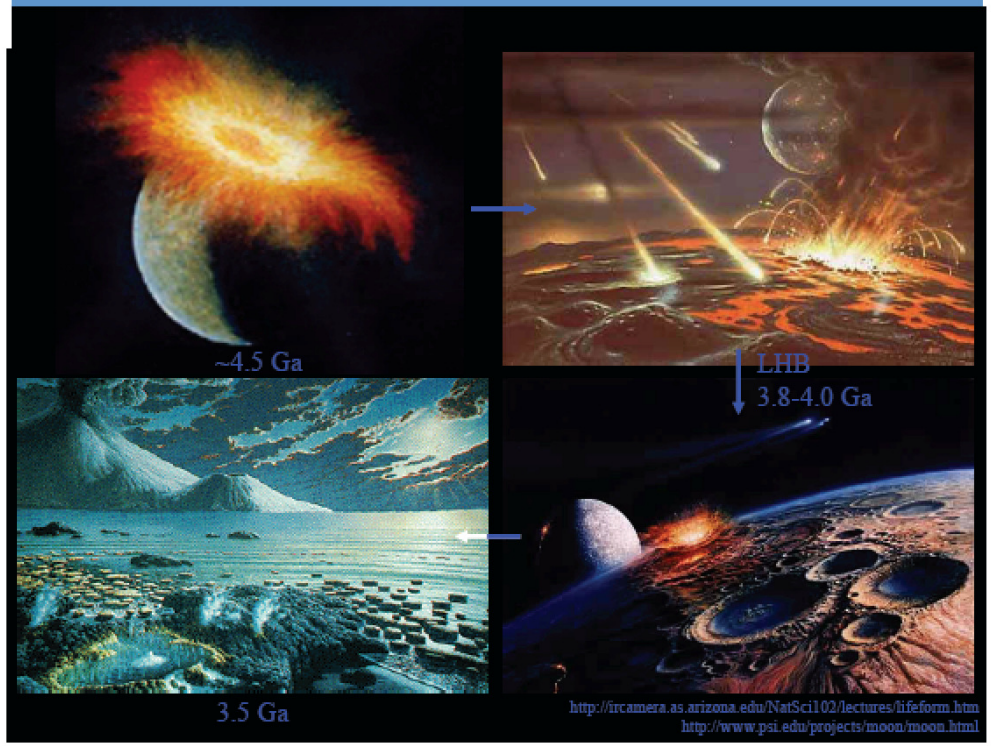
A project under the auspices of SCOSTEP's VarSITI program, Variability of the Sun and Its Terrestrial Impact

SEE Co-chairs:

Prof. Petrus C Martens, Montana State University, USA

Prof. Dibyendu Nandi, Indian Institute of Science Education and Research Kolkata, India

Prof. Vladimir N. Obridko, IZMIRAN. Moscow, Russian Federation



SEE: Science Questions

1) Are we at the verge of a new grand minimum? If not, what is the expectation for cycle 25?

2) Does our current best understanding of the evolution of solar irradiance and mass loss resolve the "Faint Young Sun" problem?

3) For the next few decades, what can we expect in terms of extreme solar flares and storms, and also absence of activity?

SEE: White Paper Team

- Sarah Gibson, High Altitude Observatory (NCAR), USA,
- Katja Matthes, GFZ German Research Centre for Geosciences, Germany,
- Manuel Gudel, University of Vienna, Austria,
- Laurene Jouve, University of Toulouse, France, Email: ljouve@irap.omp.eu
- Steve Saar, Harvard Smithsonian Center for Astrophysics, USA,
- Aline Vidotto, University of St Andrews, UK,
- Andrés Muñoz-Jaramillo, Montana State University, USA,
- Ilya Usoskin: University of Oulu, Finland,
- Kanya Kusano, Nahoya University, Japan,
- Jeremy Drake, Smithsonian Astrophysical Observatory,
- Frederic Clette, Royal Observatory of Belgium, Belgium,
- Vladimir Obridko, IZMIRAN, Russia,
- Dibyendu Nandi, IISER Kolkata, India,
- Piet Martens, Georgia State Univversity, USA

Extreme Events: Obridko

Much progress is being made by other scientists already on this issue (e.g. the Shibata group in Kyoto)

Prof. Obridko's subgroup will focus on the following:

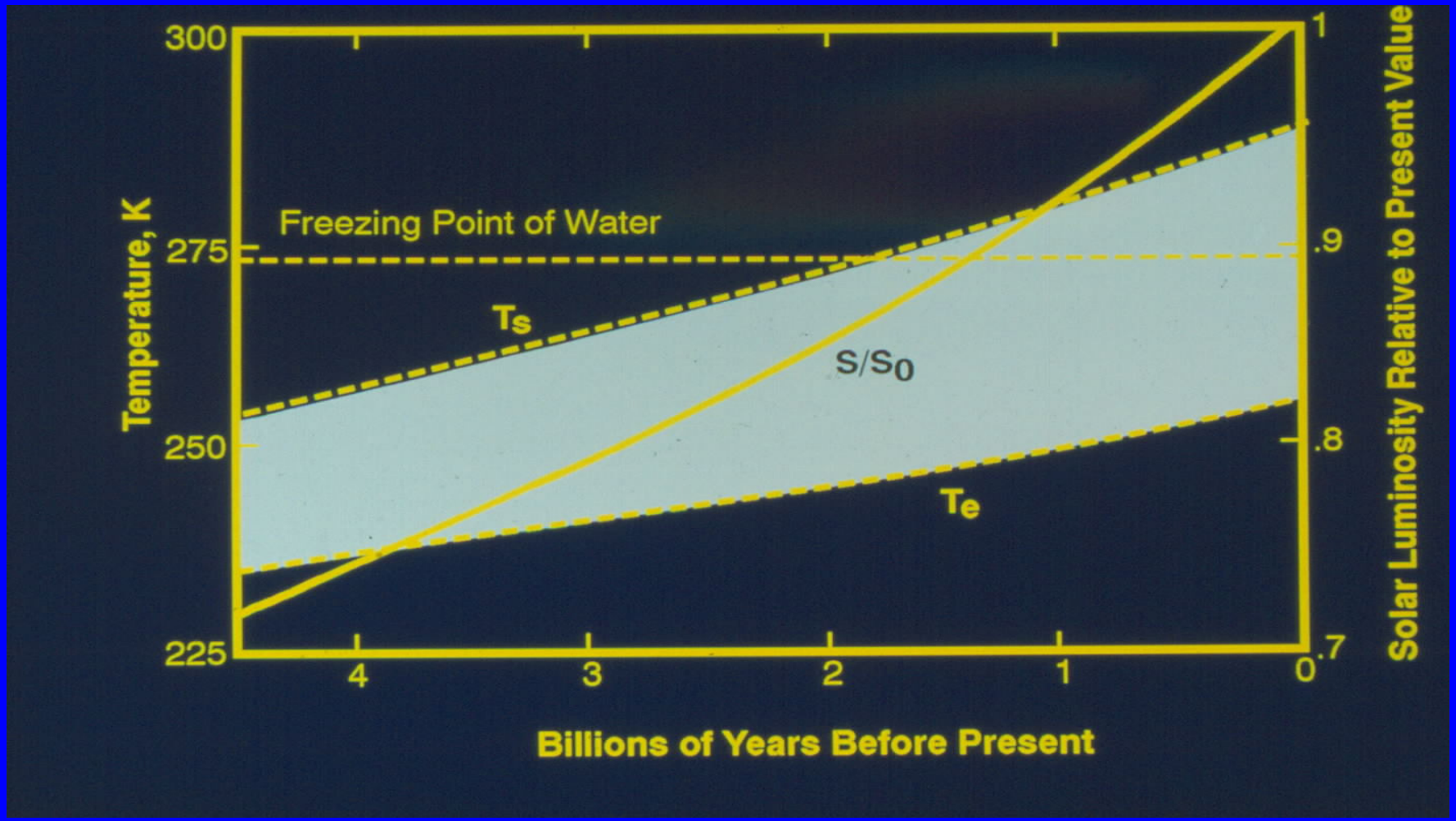
-Really large solar flares and storms, e.g. the Carrington event and the 1921 magnetic superstorm occur in smaller solar cycles. Can that be confirmed from larger data samples?

-If so, what is the expectation value for such super large storms during the upcoming era of less strong solar cycles? Are we in fact facing a larger risk?

The Faint Young Sun Paradox: Martens

The Sun was about 30% less luminous when life developed on Earth, yet geological and biological evidence points to a warm young Earth, 60 to 70 C

A Faint Young Sun Leaves the Earth Frozen Solid



Kasting et al, Scientific American, 1988

Dynamo Modeling: Nandi

Research Projects:

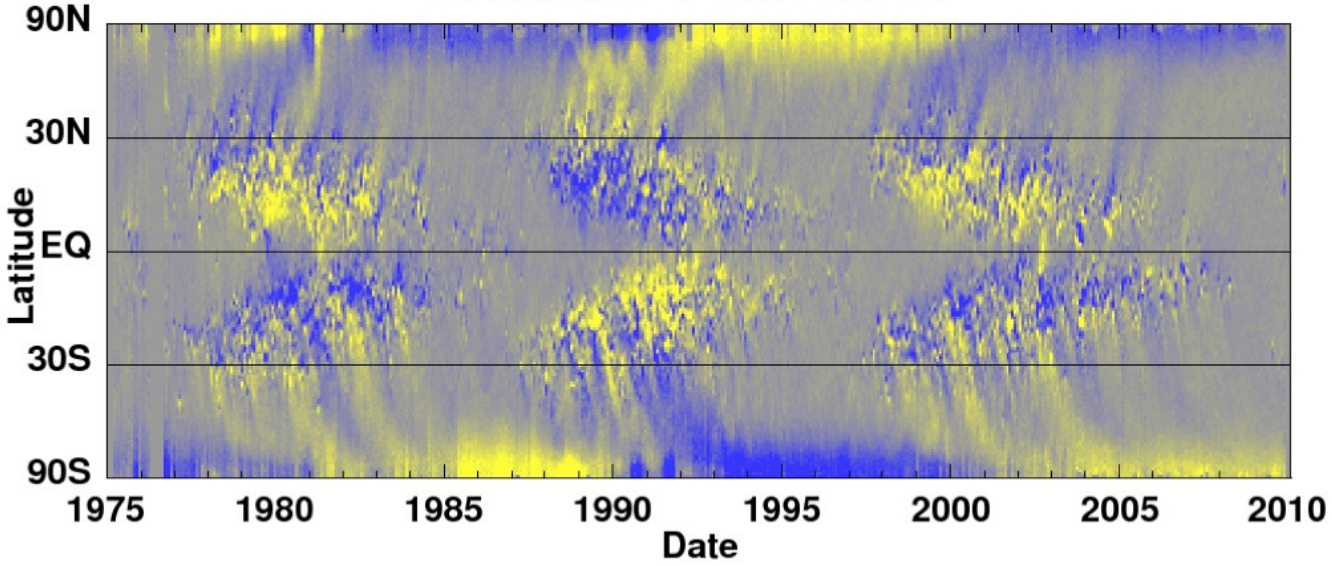
-Turbulent flux pumping: can it replace single cell meridional circulation?

-Full 3D kinematic simulations: Yeates & Munoz, MNRAS 2013, Jouve & Nandi, in progress

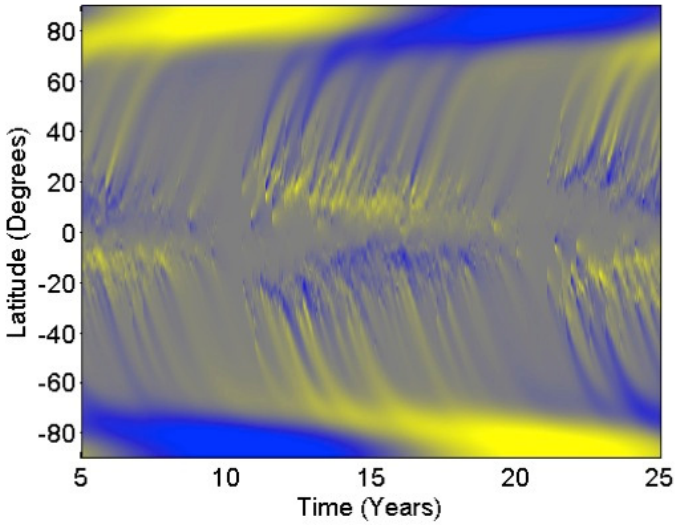
-The "memory" of the solar cycle: how far ahead can we predict?

-The physics of Grand Minima. Are we going in to a Maunder minimum?

Observations



Double-ring



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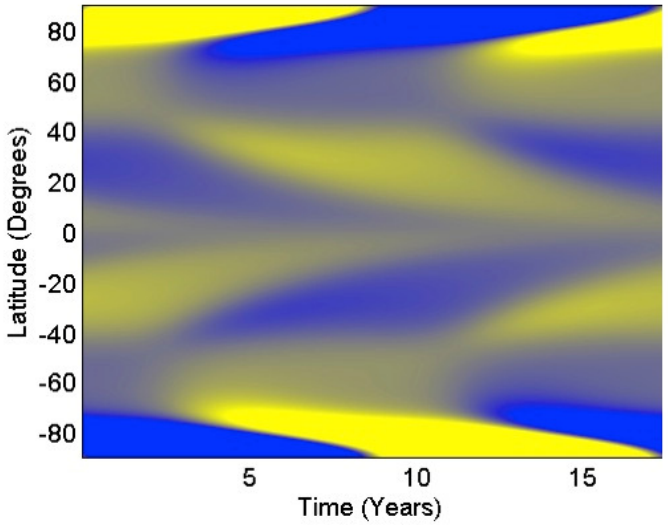
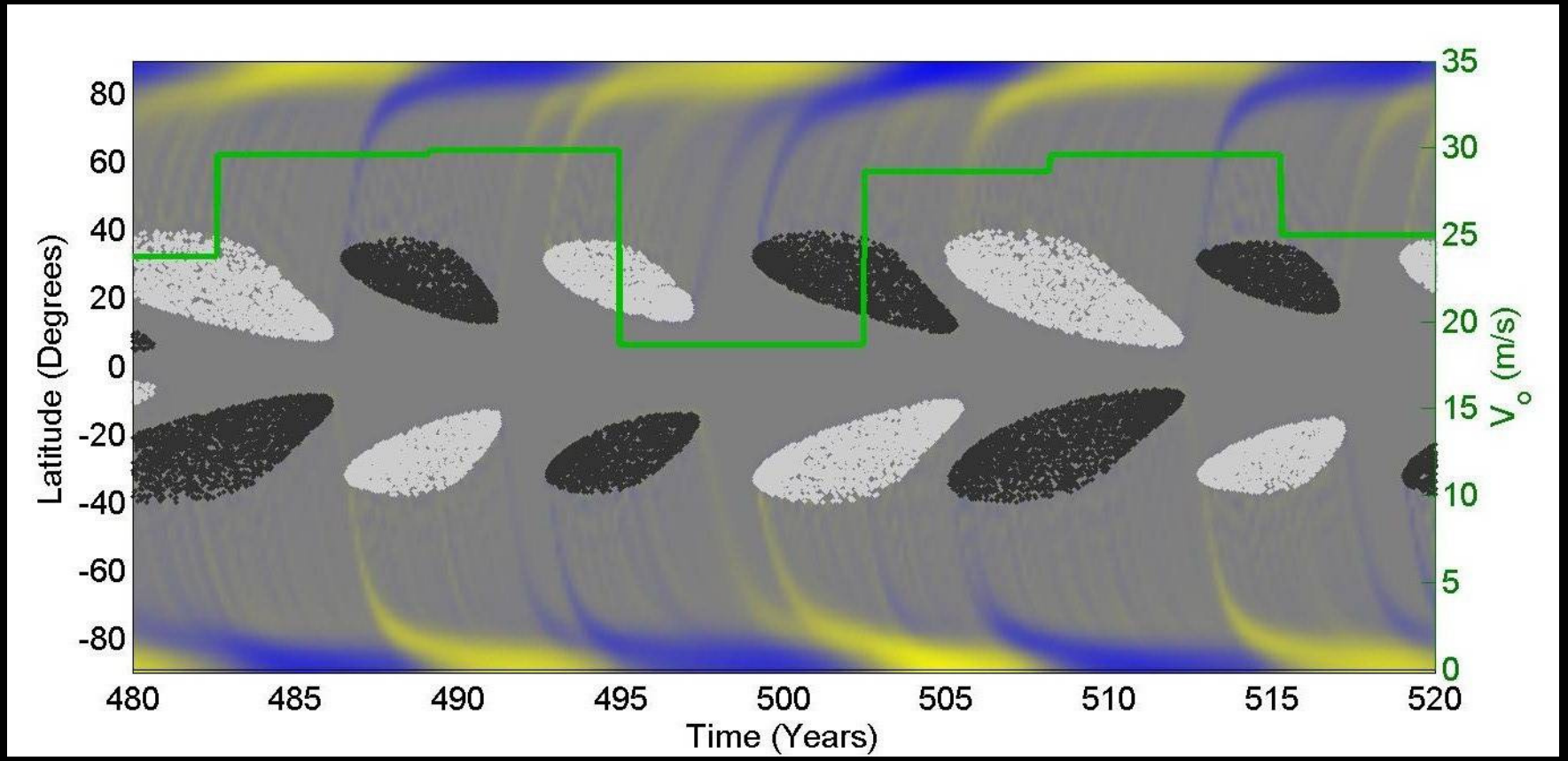


Solar Cycle Simulations

Nandi, Munoz and Martens 2012, *Nature*



- Self-consistent variation in length of minimum and polar field strength
- 210 solar cycles (1860 solar years) simulated to establish a robust relationship between flow speed variations and nature of minimum

Space Climate Extremes: Dynamo-Climate Coupling

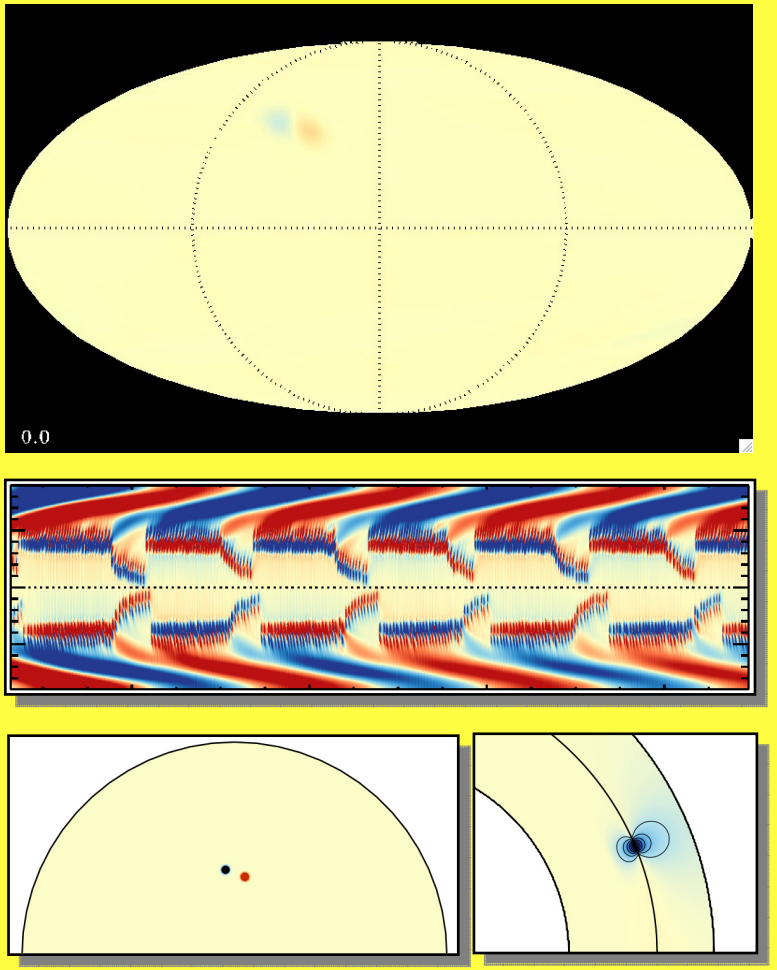
Gibson et al. NCAR/HAO

Our goals are:

- To run controlled experiments in flux emergence within 3D dynamo simulations to characterize the variation of the Sun's surface magnetic field
- To quantify the resulting solar radiative and particulate variations and use them as inputs to community climate and geospace models.

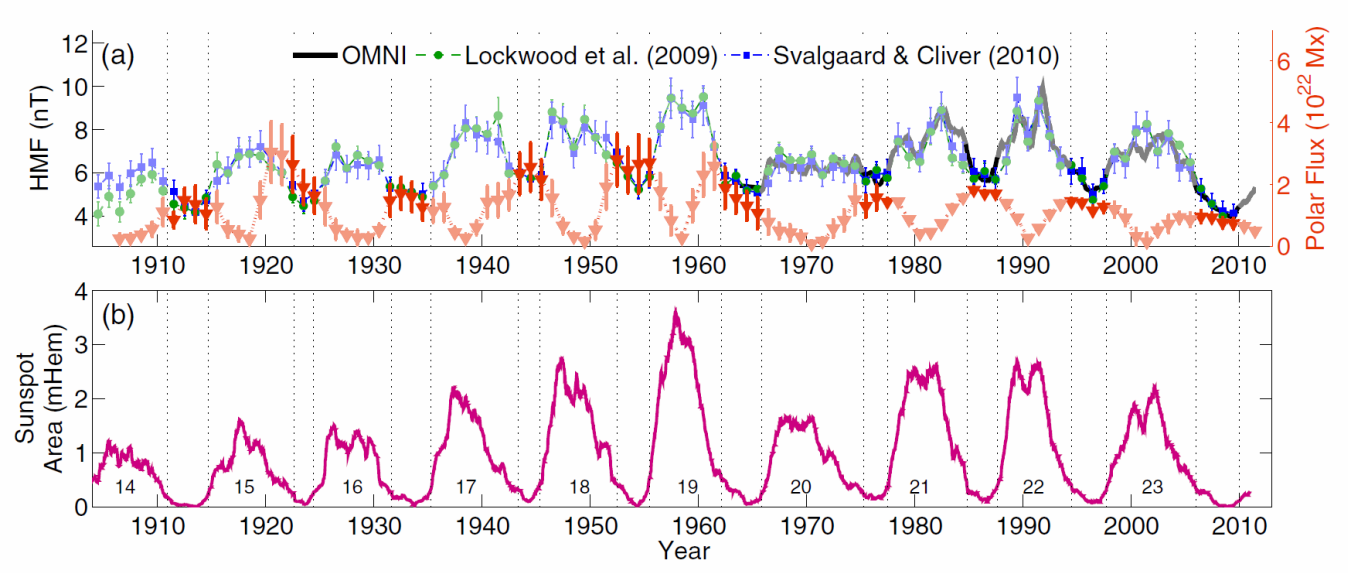
This will allow us to address questions, such as:

- What happens to the solar atmosphere and heliosphere, and, by extension, the Earth's space environment and climate, if flux emergence occurs only on scales too small to form sunspots?



BASH: A 3D Babcock-Leighton dynamo model with explicit inclusion of sunspot pairs.

Polar Flux Measurements (*Munoz, MSU*)

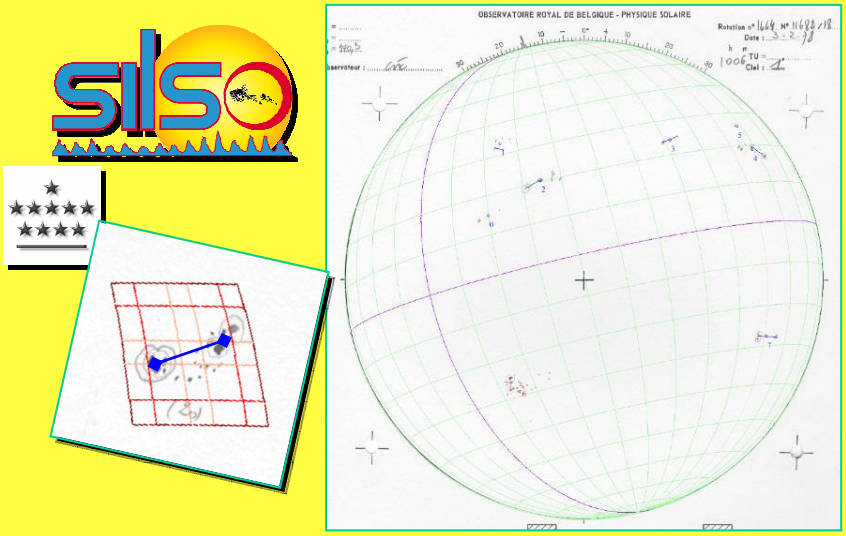


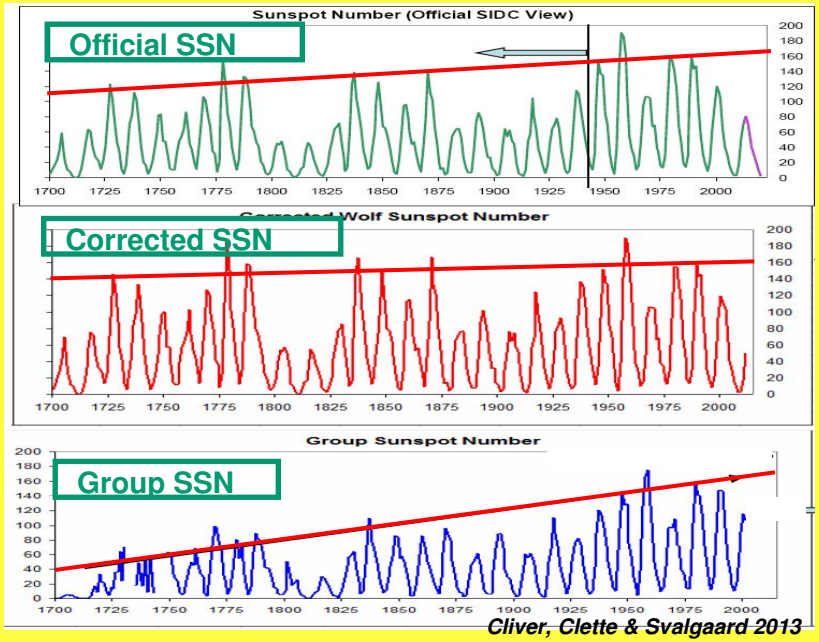
Muñoz-Jaramillo et al. 2012

- Polar flux (as an indicator of the solar axial dipole moment) is crucial for determining solar wind conditions at solar minimum. Polar flux is predictor for next cycle.
- Our dynamo and surface flux transport simulations will yield a self-consistent picture of the evolution of this baseline during long time-scales.

Contribution of the ROB *(F. Clette, Belgium)*

- Expertise in long-term solar indices of the World Data Center – SILSO *(ROB, Royal Observatory of Belgium)*
- New long-term observational constraints to solar dynamo models:
  - Exploitation and construction of digital sunspot catalogs:
    - Sources: visual and photographic observations
    - Validation of new proxies combining multiple properties of individual sunspot groups *(location, morphology, evolution, rotation, magnetic dipole, etc.)*
    - ⇨ Opens the way to sunspot-based proxy series spanning several centuries (18th to 20th): *(patterns of magnetic flux emergence, solar irradiance)*
  - Improved sunspot time series (sunspot number, group number):
    - Based on results from e.g. Sunspot Number Workshops (2011-2014)

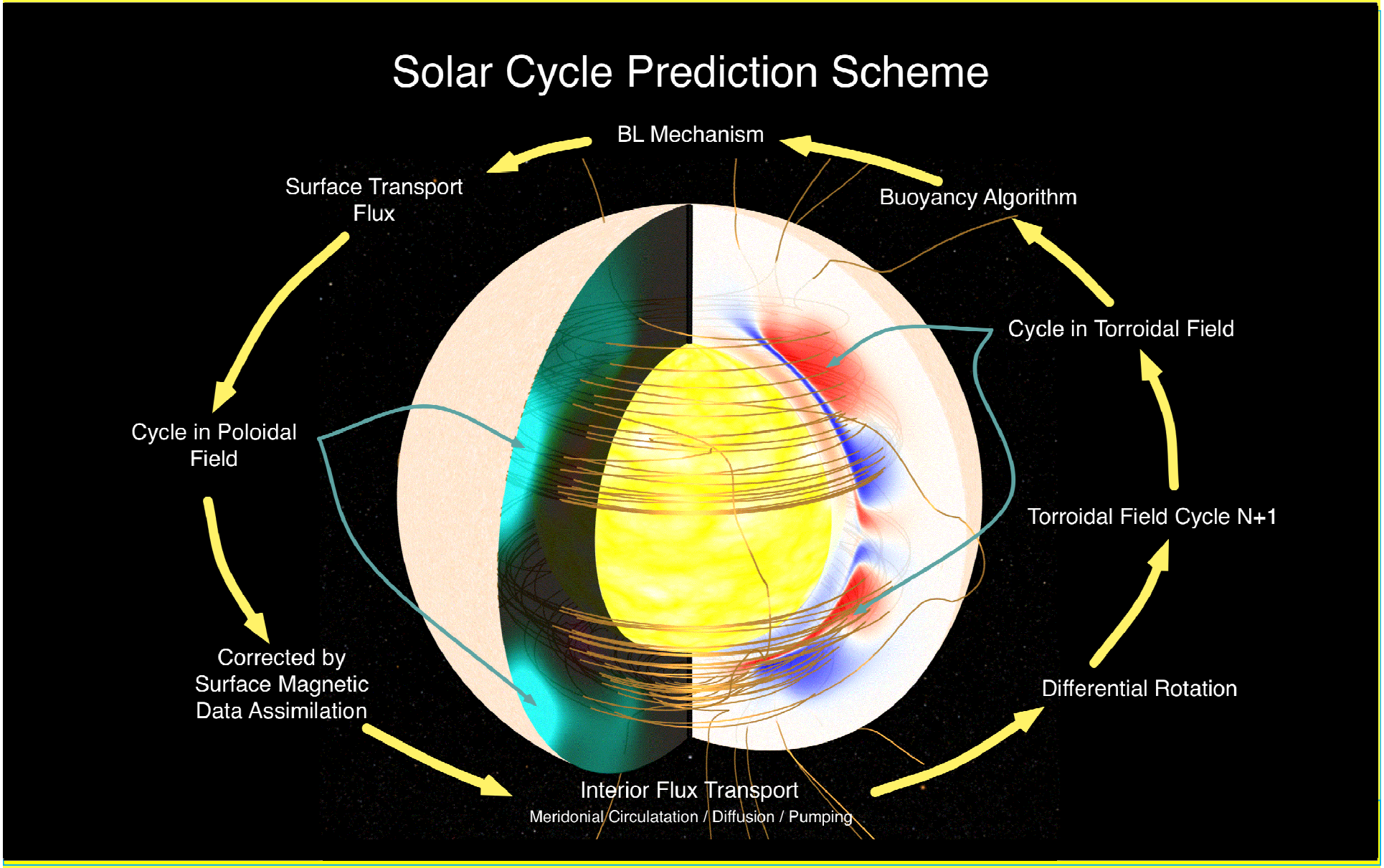




Cliver, Clette & Svalgaard 2013

SCOSTEP
Scientific Committee on Solar-Terrestrial Physics

VarSITI/Solar Evolution & Extrema



VarSITI/Solar Evolution & Extrema: Activities

SEE Kick-off Meeting

May 26-31, 2014, Sunny Beach, Bulgaria

Follow-up Meeting(s)

XVIII All-Russian Annual Conference with international participation, "Solar and Solar - Terrestrial Physics 2014" 20-24 Oct, Pulkovo

http://www.gao.spb.ru/russian/solphys/2014/

VarSITI/Solar Evolution & Extrema: Activities

Follow-up Meetings

International Living With a Star Meeting, Goa, India, October 2015 or February 2106

Conference Proceedings

"Space factors of the evolution geosphere and biosphere", V. Obridko (ed.), Oct 2014 (in Russian, with English abstracts).

Presentations on the site:

http://www.sai.msu.su/EAAS/rus/confs/cosm

VarSITI/Solar Evolution & Extrema (SEE)

Information/Questions/Comments:

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You are welcome to join the SEE team