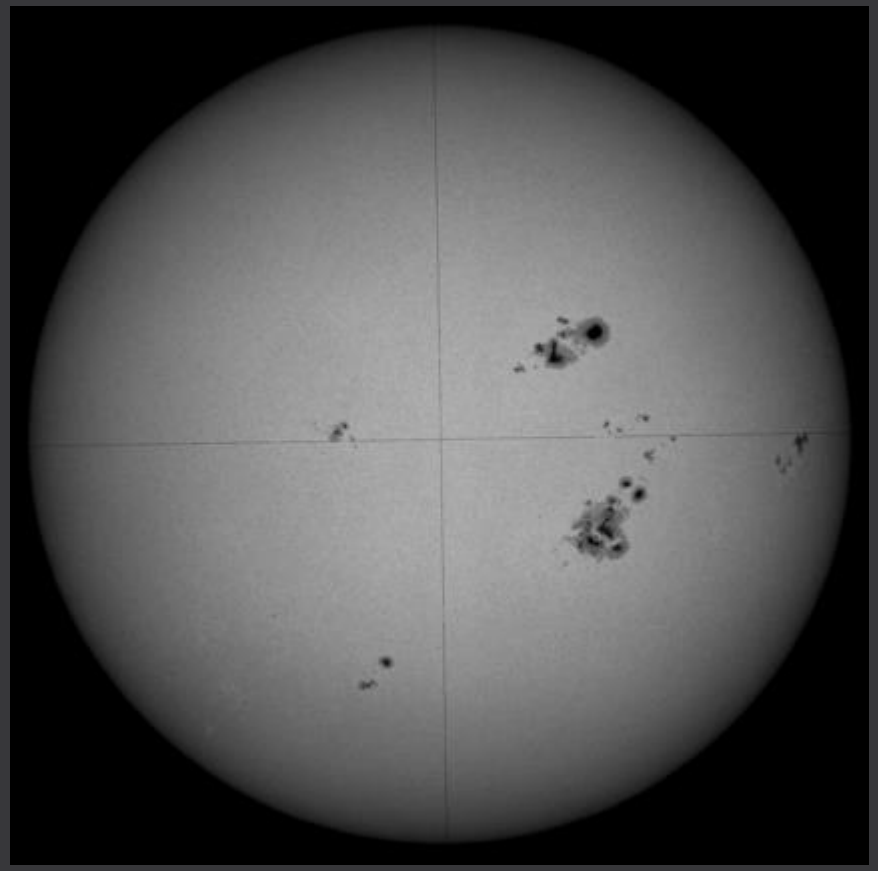


Kanzelhöhe Observatory, Austria

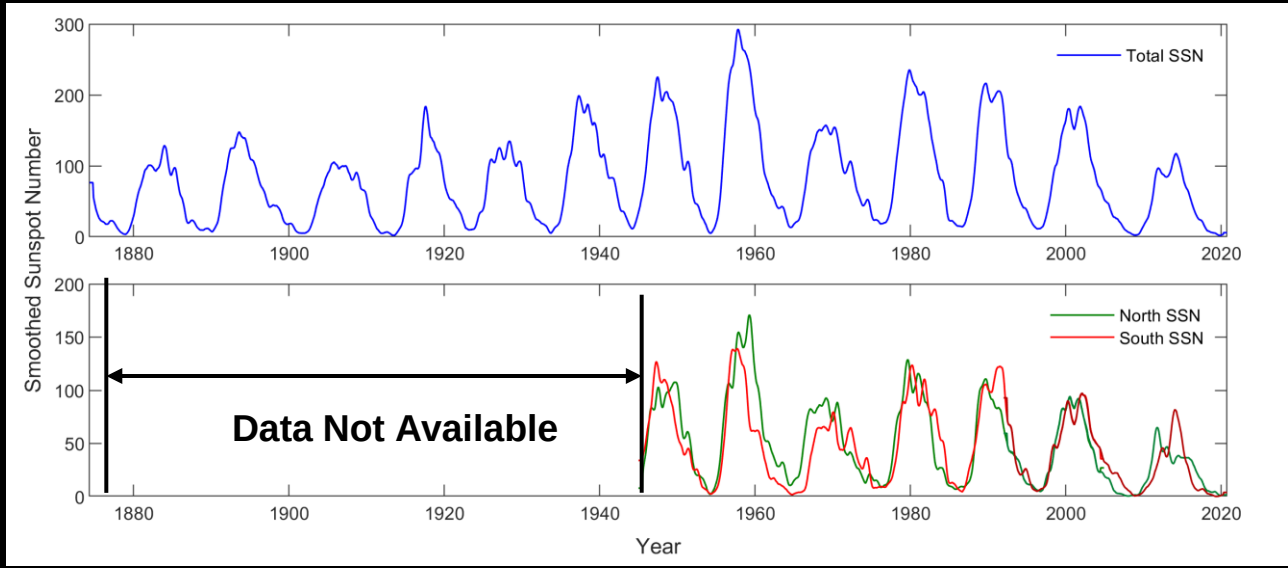
Prediction of 11-year solar cycle strength with Hemispheric Sunspot Numbers

Shantanu Jain (1), Tatiana Podladchikova (1), Astrid M. Veronig (2,3), Olga Sutyrina (1), Mateja Dumbović (4), Frédéric Clette (5), Werner Pötzi (3)

(1) Skolkovo Institute of Science and Technology, Russia
(2) University of Graz, Institute of Physics, Austria
(3) Kanzelhöhe Observatory for Solar and Environmental Research, University of Graz, Austria
(4) Hvar Observatory, University of Zagreb, Croatia
(5) World Data Center SILSO, Royal Observatory of Belgium

EPSM-16, 6-10 September 2021

Existing Data of Hemispheric Sunspot Number



Sunspot Number

Hemispheric Sunspot Numbers are available only from 1945 onwards !!

- 1945-2004: Temmer et. al.(2006)
-1992-2020: SILSO World Data Centre

Sunspot Area

We use the Hemispheric Sunspot Areas (available from 1874 onwards) to reconstruct Hemispheric Sunspot Number

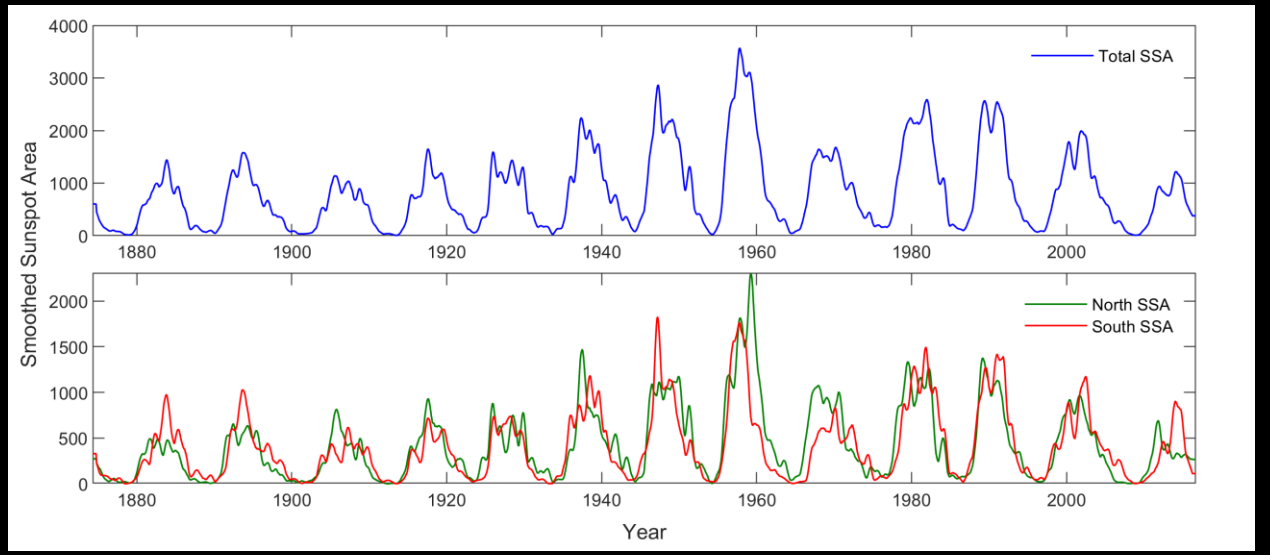
How?

Take Relative Fraction of Sunspot Area and recalibrate with Total Sunspot Number (version 2.0)

$$HSN_{north} = \frac{N_{area}}{N_{area} + S_{area}} * TSN_{2.0}$$

$$HSN_{south} = \frac{N_{area}}{N_{area} + S_{area}} * TSN_{2.0}$$

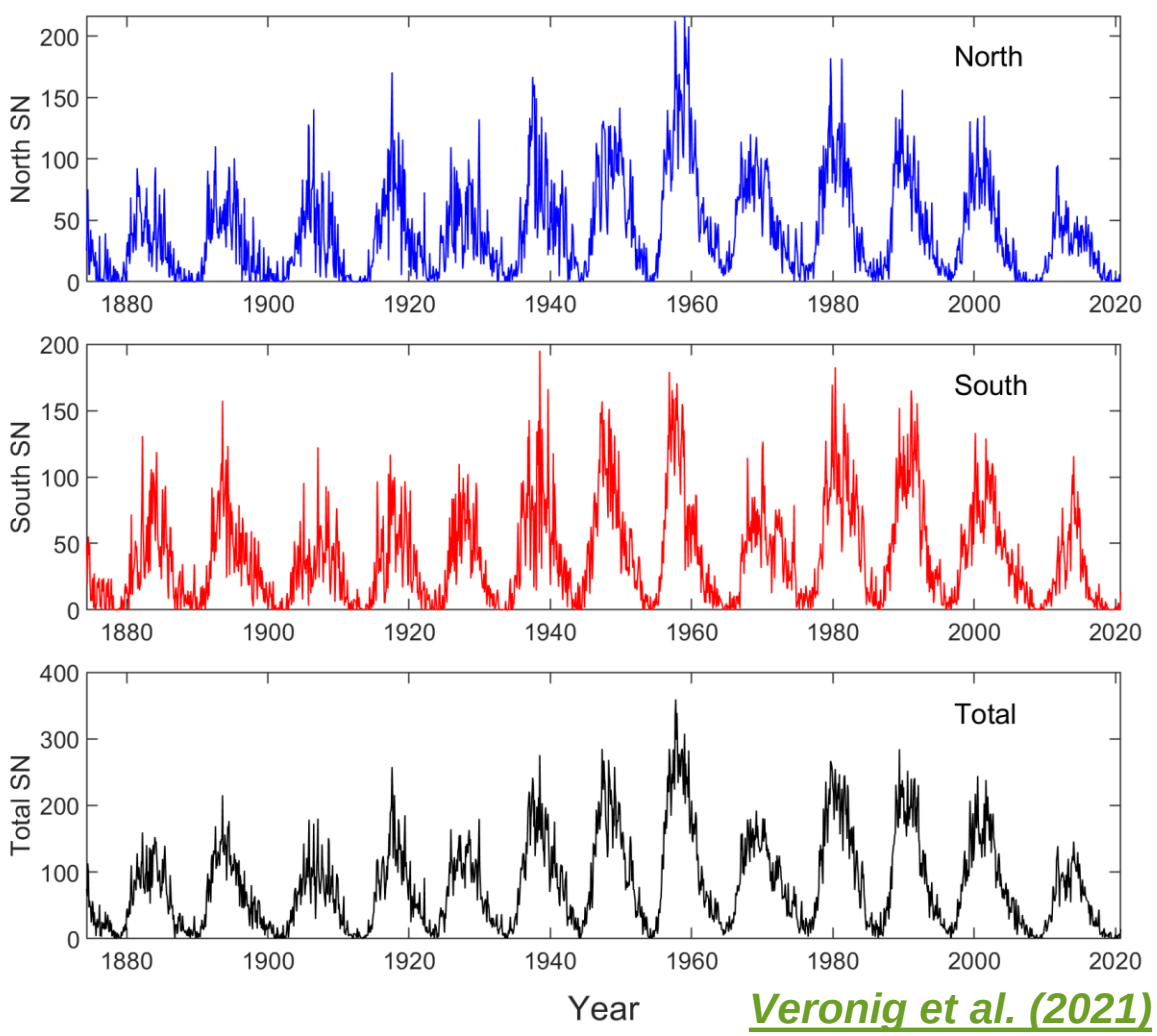
$$HSN_{north} + HSN_{south} = TSN_{2.0}$$



Hemispheric Sunspot Number 1874-2020

1874-1944 : *Reconstructed from Sunspot Areas*
1945-1991: *Derived from Temmer et al (2006)*
1992-2020: *Taken from World Data Centre SILSO*

Monthly Series (1874-2020)

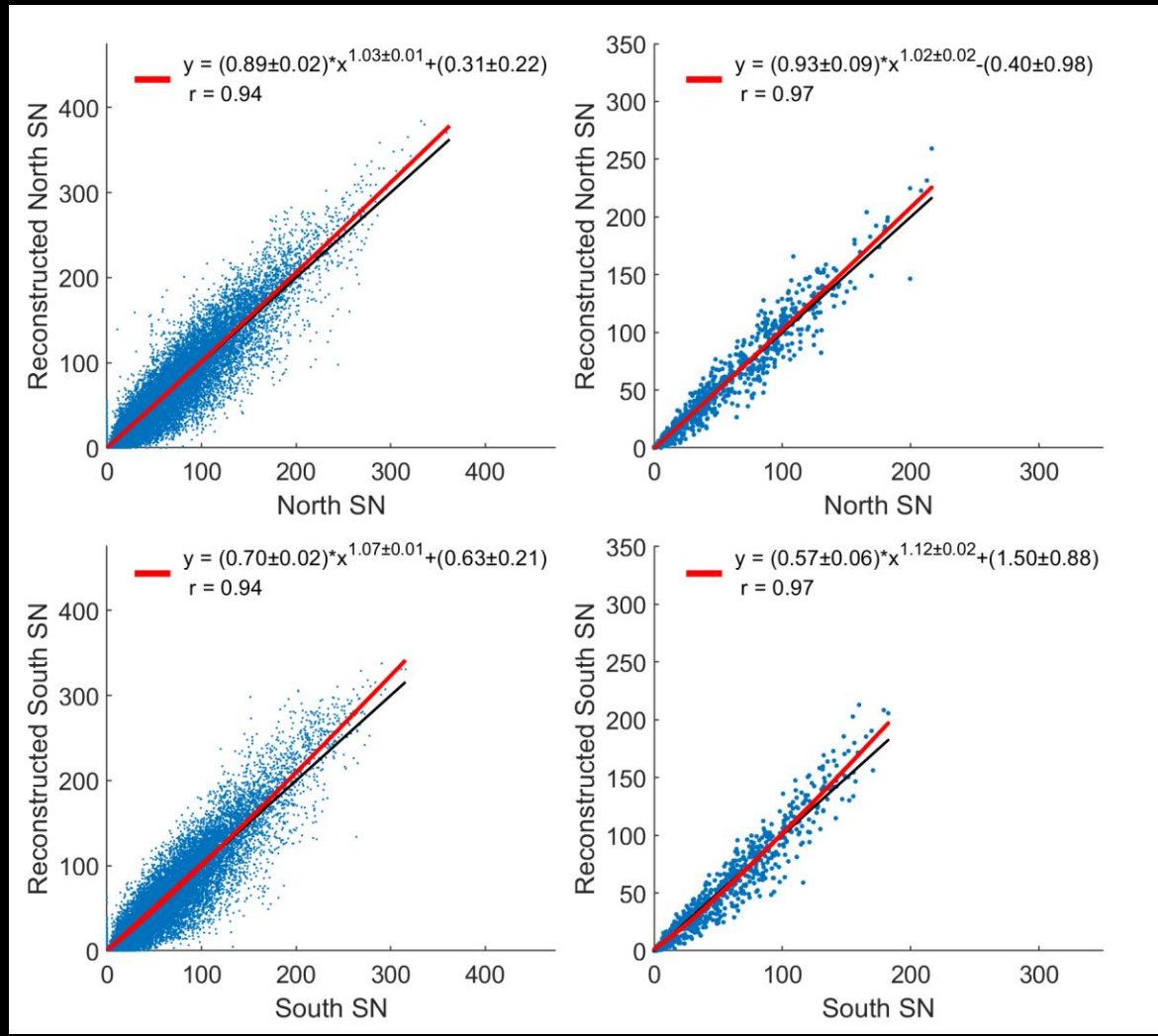


Veronig et al. (2021)

Validation

Reconstructed HSN to the existing HSN for the common time period (1945-2016)

Daily **Monthly**



Online Catalogue

The Catalogue of Hemispheric Sunspot Numbers is already **embedded in SILSO, which is the World Data Center for the production, preservation, and dissemination of the international sunspot number**

Sunspot Index and Long-term Solar Observations

Menu

- Home
- Data
  - Sunspot Number
  - Group Number
  - Past versions
  - Extended hemispheric number
  - Raw Data - Carrington
- Products

Home | Data | Products | Analyses | FAQ & NEWS | Observers | Contact

Extended hemispheric sunspot numbers

A catalogue consisting of Hemispheric Sunspot Numbers from 1874-2020

Reconstructed hemispheric sunspot numbers extending the base international hemispheric sunspot numbers before 1992. This series is based on hemispheric sunspot numbers from the Kanzelhöhe and Skalnate-Pleso Observatories back to 1945, and on total sunspot areas from the Greenwich photographic catalogue back to 1874.

Any use of this data set should include the citation of the original reference below.

Daily Hemispheric Sunspot Data (1874-05-01 to 2020-10-31)

- Daily Hemispheric Sunspot Data — TXT CSV INFO

Monthly Mean and Smoothed Hemispheric Data (1874-05 to 2020-10)

- Monthly Hemispheric Sunspot Data — TXT CSV INFO

Reference article:

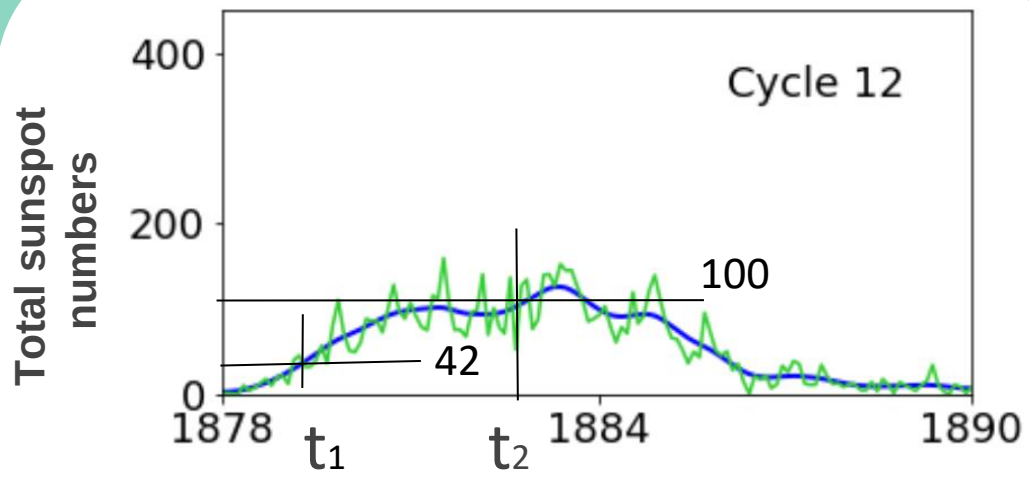
Astrid M.Veronig, Shantanu Jain, Tatiana Podladchikova, Werner Poetzi, Frederic Clette, 2021: Hemispheric Sunspot Numbers 1874-2020
Astronomy & Astrophysics

Full Catalogue available on: https://wwwbis.sidc.be/silso/extheminum

Growth Rate Vs Cycle Amplitude

Existing approach:

Relation between
average growth rate and cycle peak

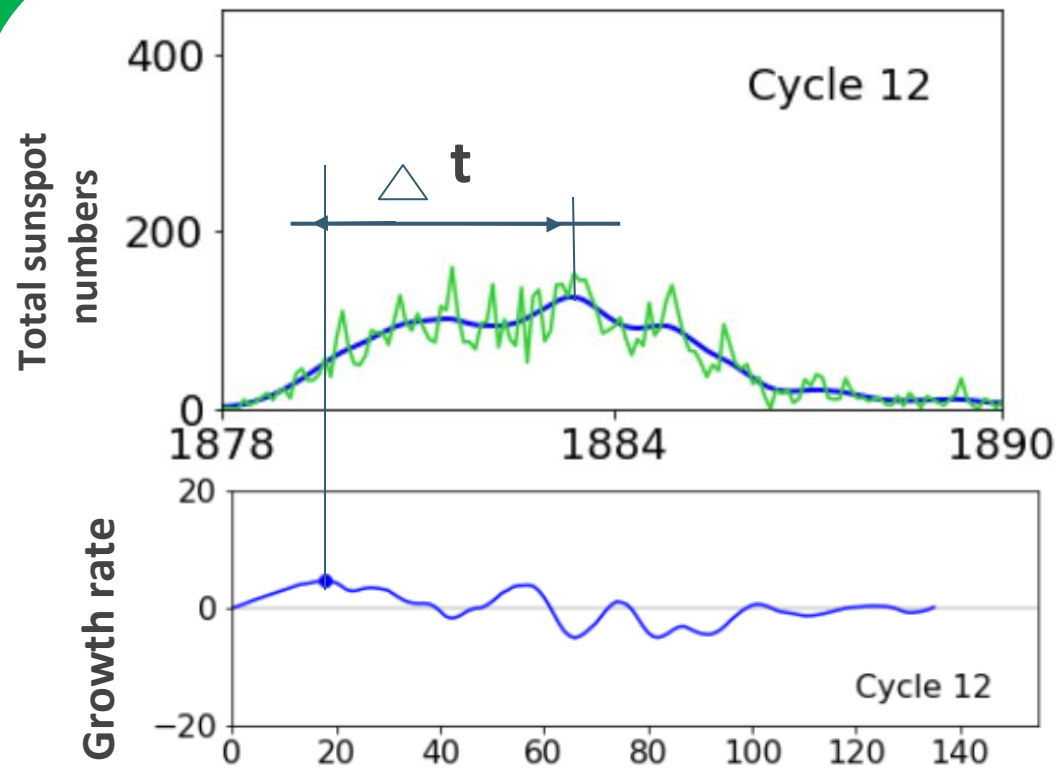


The average growth rate = $(100-42)/t_2 - t_1$

Cameron and Schüssler, 2008

Our approach:

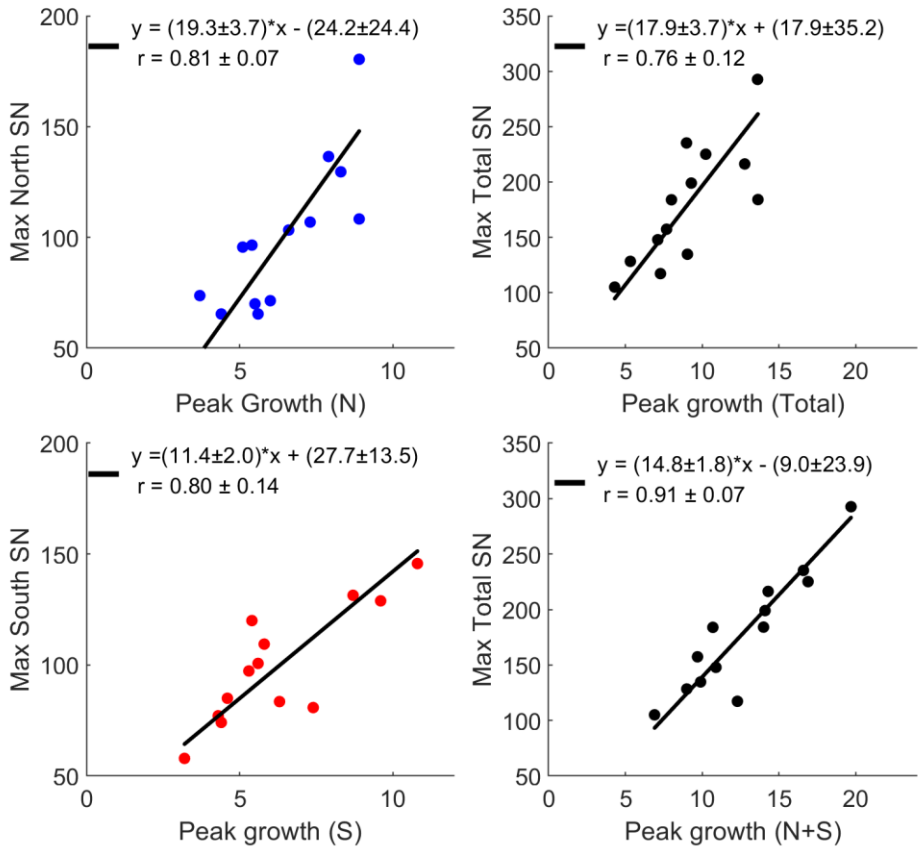
Analyze relation between
maximal **growth rate and cycle peak**



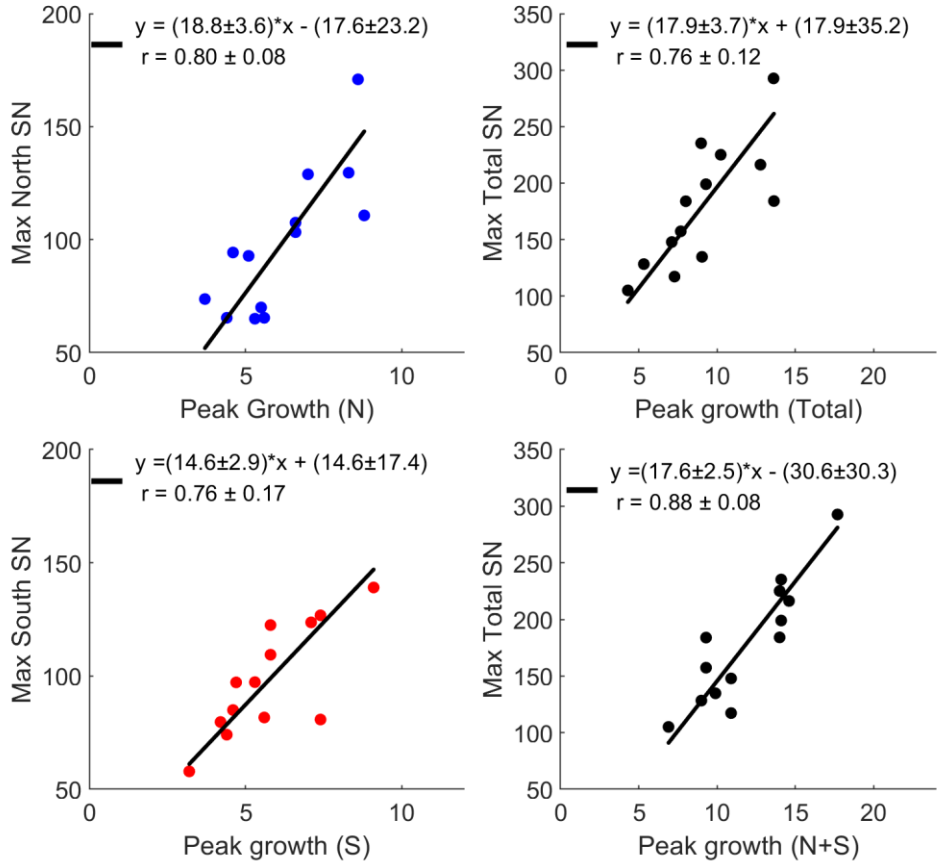
△ t≈ 21 months (on average)

Peak growth rate and relation to solar cycle amplitudes

Purely Reconstructed from Area



Merged Dataset

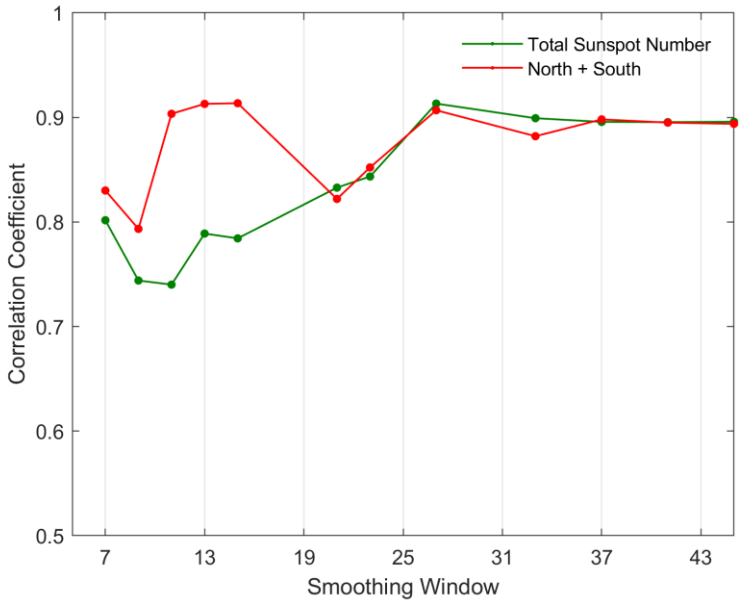


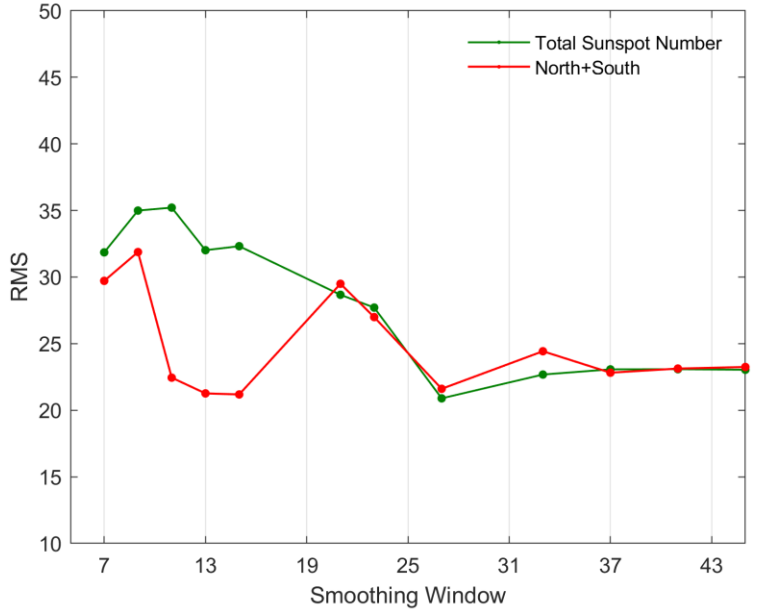
- ✓ Peak Growth of *hemispheric activity (N+S)* provides **higher correlation** with cycle peak than than the peak growth derived from the *total sunspot numbers* characterizing the full Sun
- ✓ Supporting the importance of the regular monitoring, record, and analysis of solar activity separately for the two hemispheres for space weather science and predictions

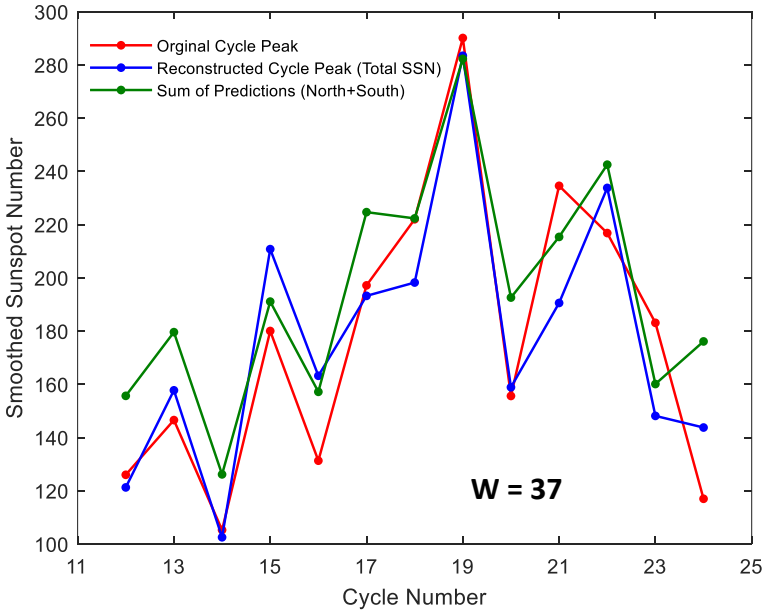
PREDICTION OF CYCLE STRENGTH USING TOTAL AND HEMISPHERIC SUNSPOT NUMBERS(MERGED DATA)

RED: RMS/Correlation coefficient between true and predicted cycle peaks using **Hemispheric Sunspot Number**

GREEN: RMS/Correlation coefficient between true and predicted cycle peaks using **Total Sunspot Number**







Smoothing Windows : 7,9,11,13,15,21,27,33,37,41,45

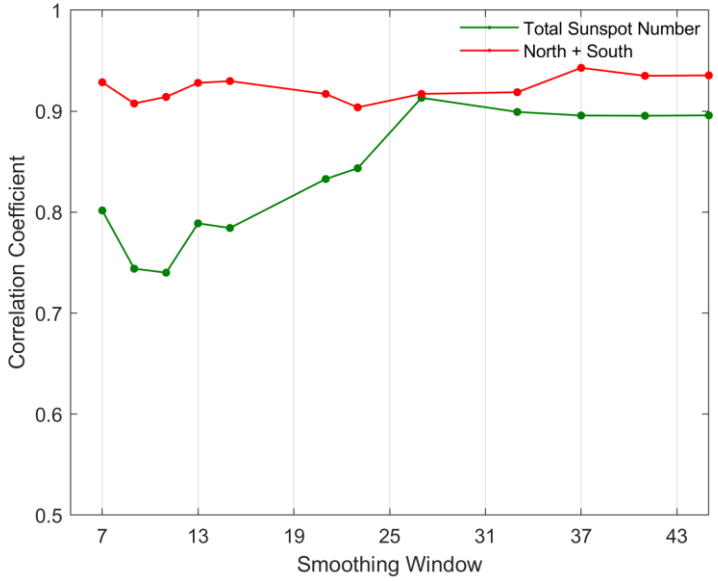
ESTIMATES OF CYCLE PEAK FROM **NORTH** + **SOUTH** **IS *MORE ACCURATE* THAN** **TOTAL**

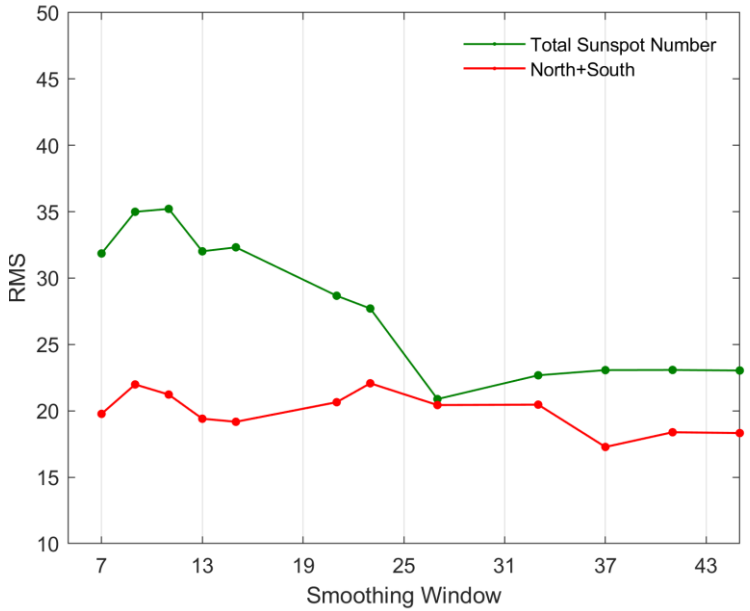
RMS is lower by 9%, Coefficient correlation is higher by 5% (on average)

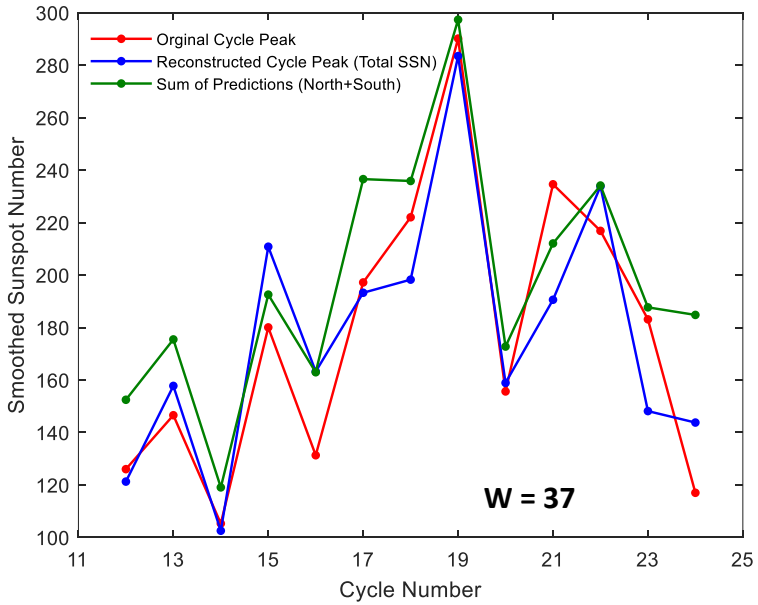
PREDICTION OF CYCLE STRENGTH USING TOTAL AND HEMISPHERIC SUNSPOT NUMBERS (PURELY RECONSTRUCTED FROM SUNSPOT AREAS)

RED: RMS/Correlation coefficient between true and predicted cycle peaks using **Hemispheric Sunspot Number**

GREEN: RMS/Correlation coefficient between true and predicted cycle peaks using **Total Sunspot Number**







Smoothing Windows : 7,9,11,13,15,21,27,33,37,41,45

ESTIMATES OF CYCLE PEAK FROM **NORTH** + **SOUTH** **IS *MORE ACCURATE* THAN** **TOTAL**

RMS is lower by 27%, Coefficient correlation is higher by 11% (on average)

Conclusions and Outcomes

1. A **new data product – Catalogue of Hemispheric Sunspot Numbers** is developed. **It is embedded in to World Data Center SILSO**

   Link : https://wwwbis.sidc.be/silso/extheminum

2. We demonstrated that the **peak of growth rate has a higher correlation** to cycle peak (>0.80) than mean growth rate (0.60-0.65) for all considered smoothing windows.

3. The **peak of growth rate from HSN purely reconstructed from Sunspot Area (1874-2016)** has a **higher correlation (0.90 – 0.95)** than combined HSN (~0.80 – 0.90) and Total SN (~ 0.75 – 0.89) for all considered smoothing windows.

4. We showed that the solar cycle strength predictions can be done **more accurately with the newly developed catalogue (r = 0.90 to 0.95)** with respect to total sunspot numbers characterizing the **full Sun (r = 0.75 to 0.89)** depending on the smoothing window. The **average improvement** in **RMS, Correlation Coefficient is 9%, 5% for merged HSN** data set and **27%, 11% for HSN purely reconstructed from Areas** compared to Total Sunspot Numbers. A **new and important result** for space weather predictions and necessity of regular monitoring and record of hemispheric sunspot numbers