Reconstructions of the group sunspot number 1981 - 2012

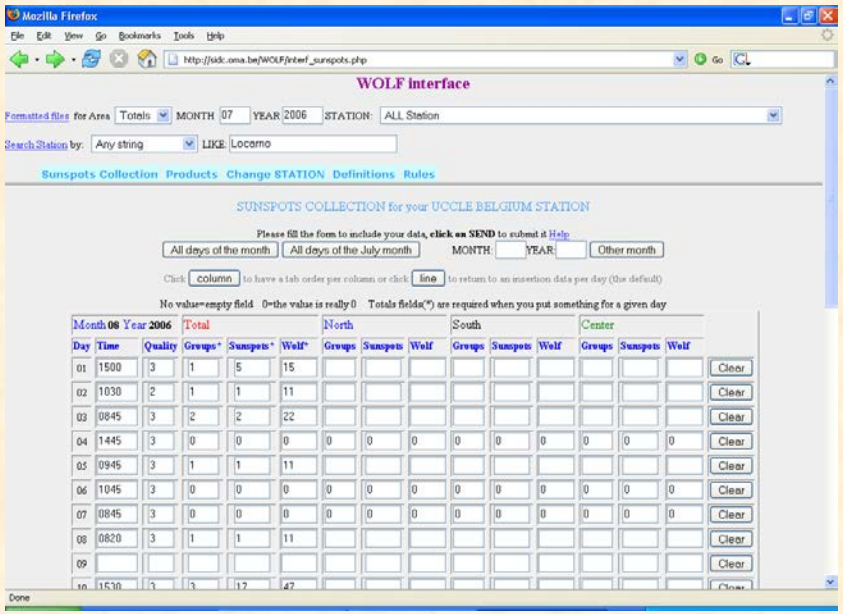
Frédéric Clette & Laurence Wauters

SIDC – WDS "Sunspot Index"

Royal Observatory of Belgium

A new framework for the R_i calculation

- Since 2005, **new Web interface for data input**:
  - On-the-fly data consistency control (PHP)
  - Direct input to the global database
- **Global database of all SIDC data**:
  - Reported group and sunspot counts for each station
  - Total and hemispheric numbers
  - All data since the creation of SIDC (1981-2012 = 31 years)

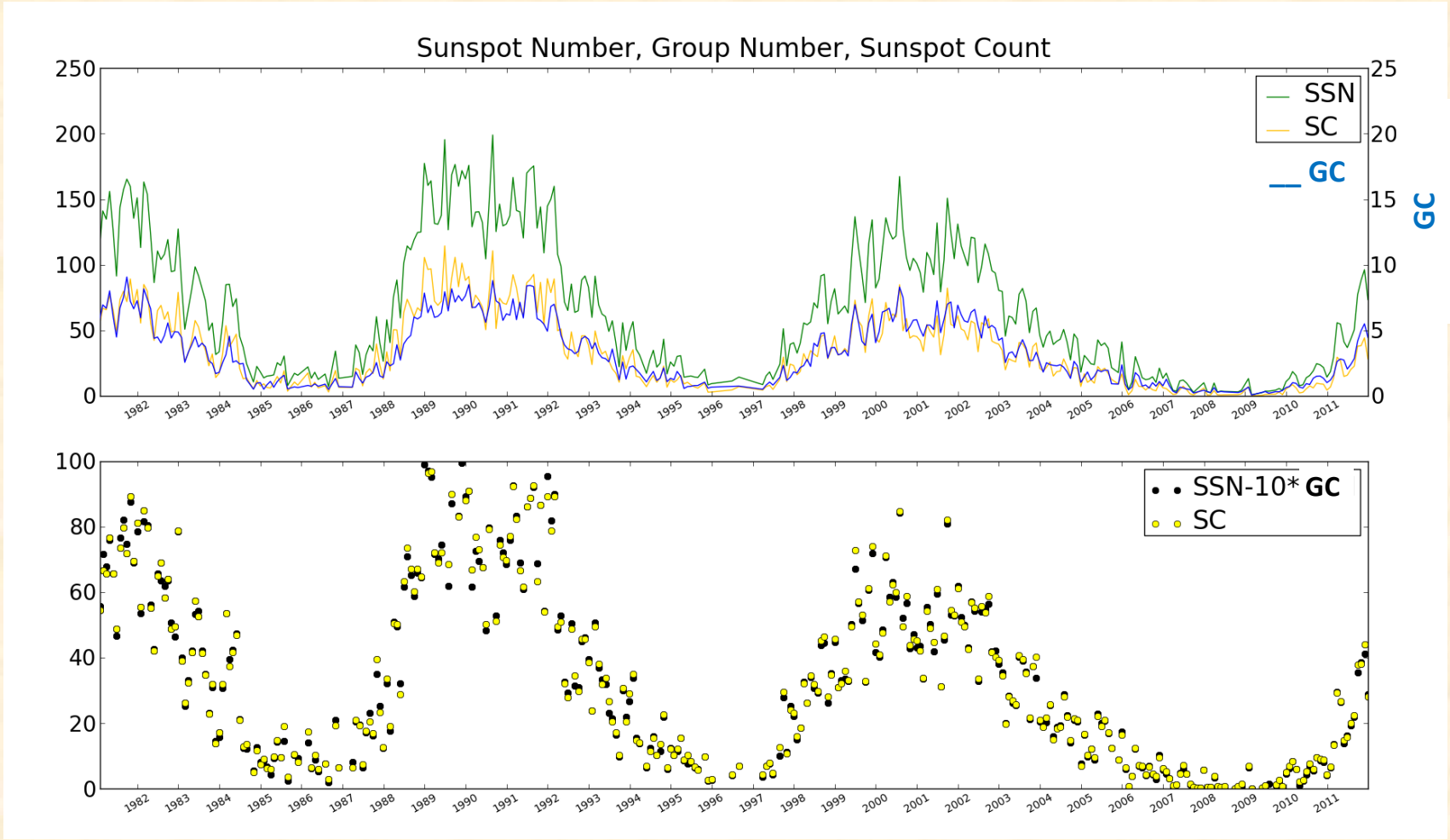


- SSN calculation algorithm converted from FORTRAN to PHP:
  - Direct access to the database
- New possibilities: **full re-computation of the sunspot number**:
  - Change of pilot station (or no pilot station)
  - Computation based on a user-defined subset of the entire SIDC network
  - Exploration of other computing methods or other indices:

e.g. group number

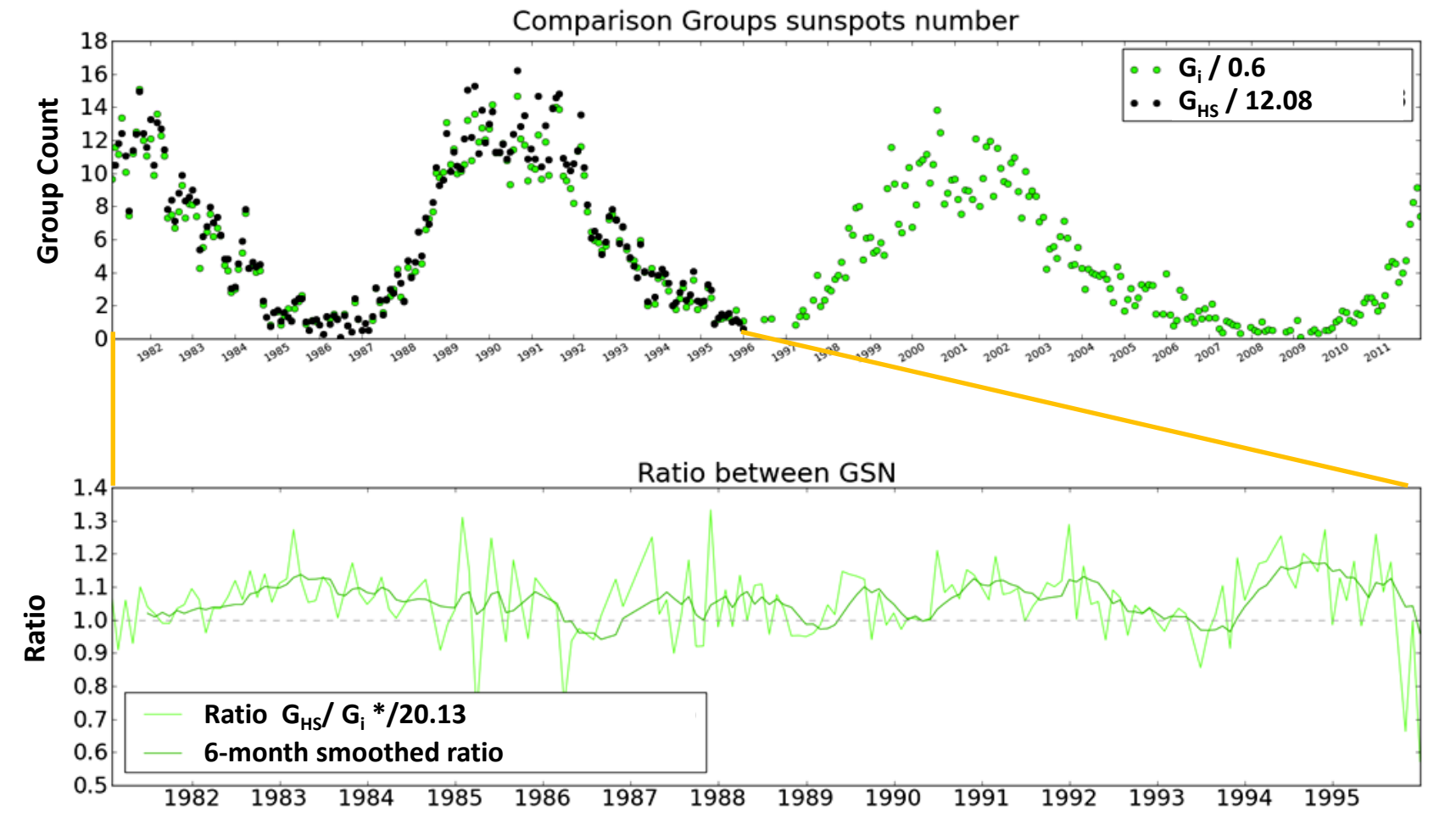
Separating group and spot counts

- GC= group count, SC= spot count, SSN= 10*GC+SC
- Validation test (Pilot station: Locarno)



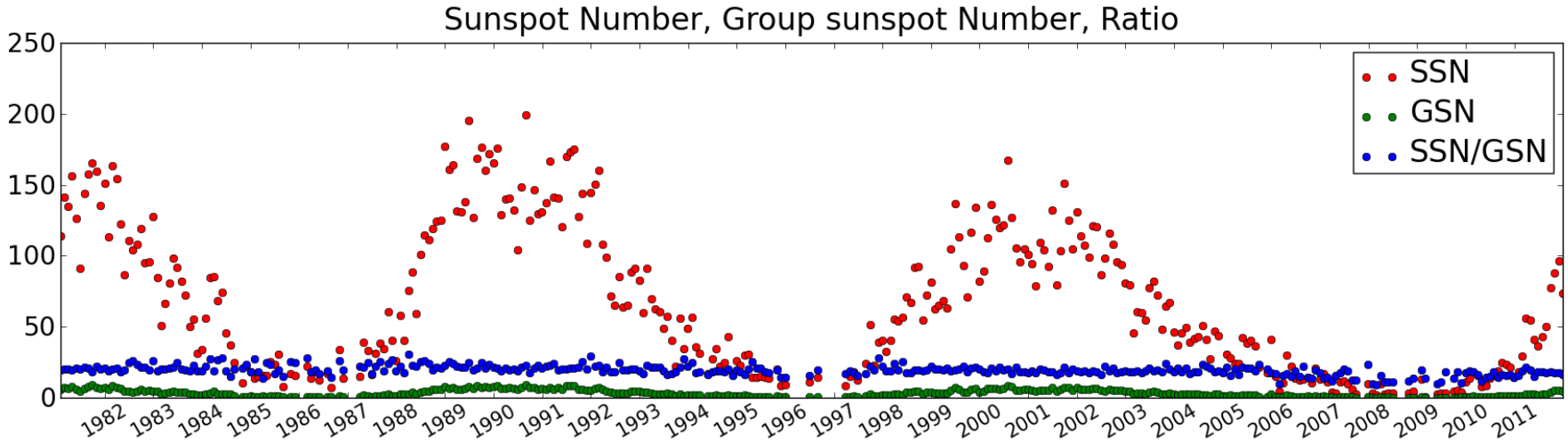
Original GSN versus its SIDC reconstruction

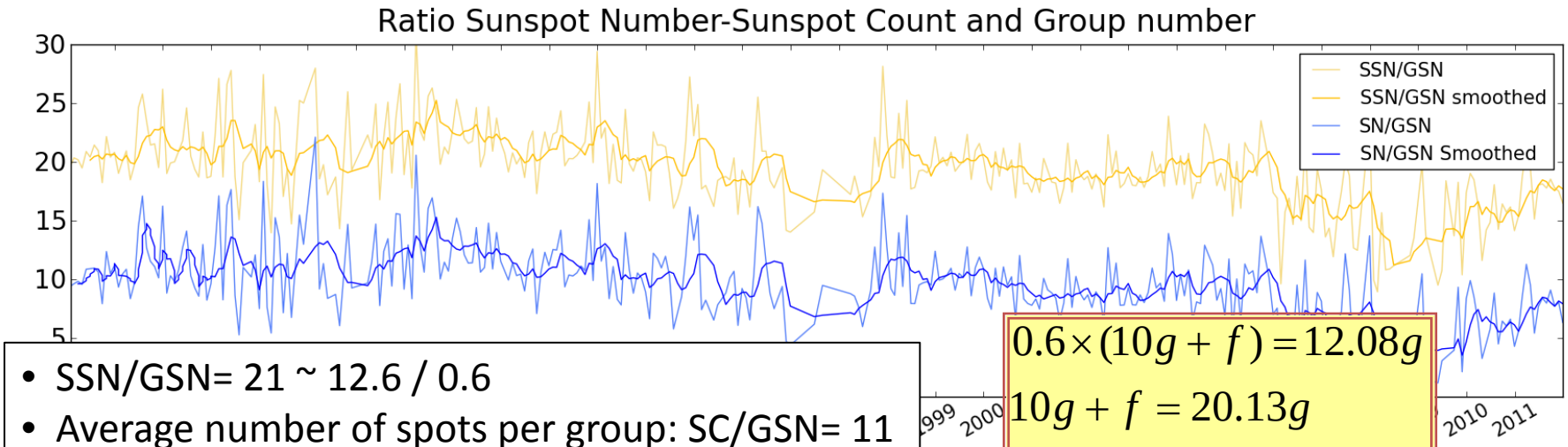
- SIDC pilot station: Locarno (raw group count * 0.6)



- Good agreement: ratio close to 1: G_{HS}= 1.05 G_i over 1981 - 1997

Ratio Group count / spot count *(Locarno)*





- SSN/GSN= 21 ~ 12.6 / 0.6
- Average number of spots per group: SC/GSN= 11
- Decreasing trend in cycle 23

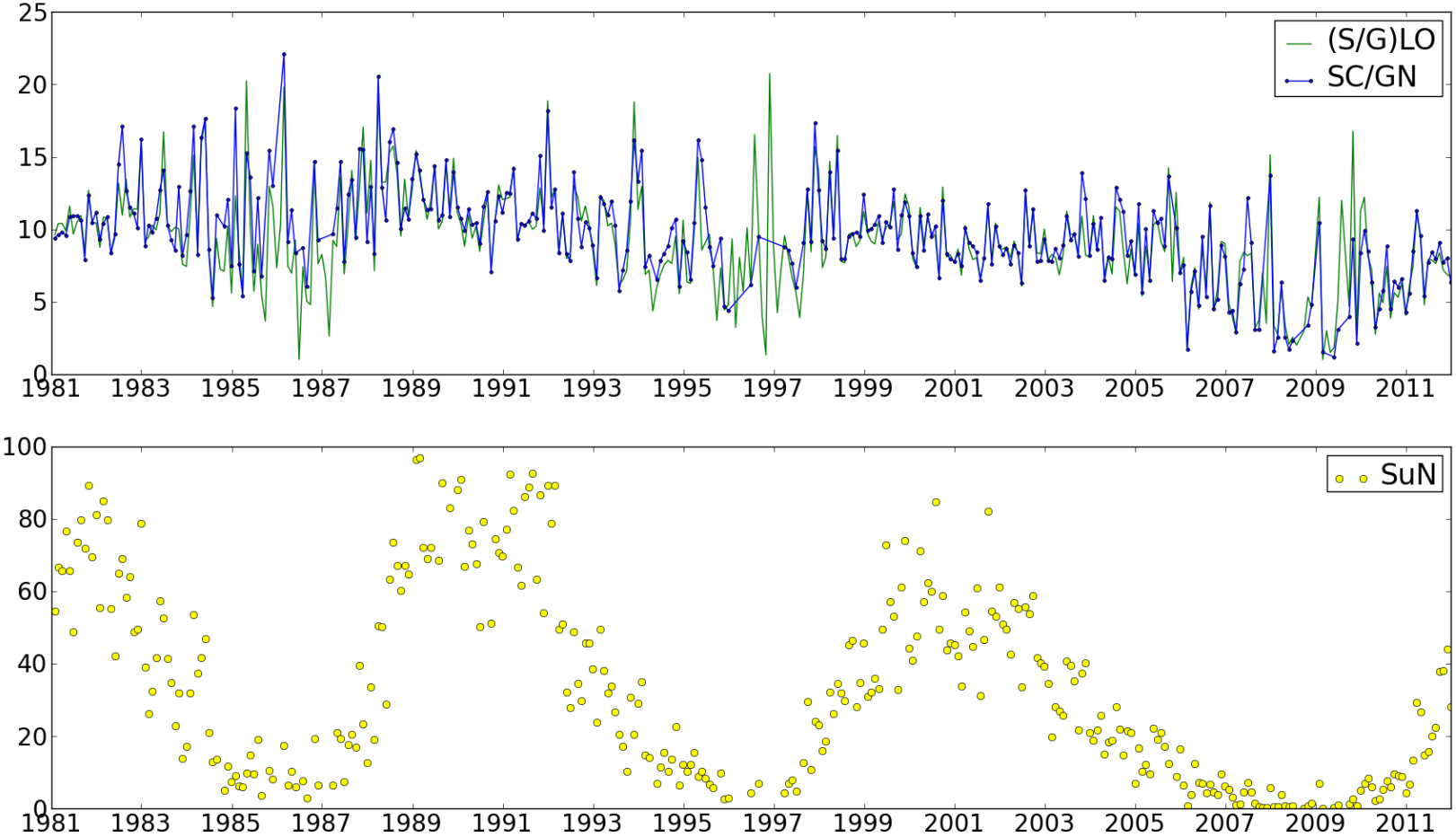
$$0.6 \times (10g + f) = 12.08g$$

$$10g + f = 20.13g$$

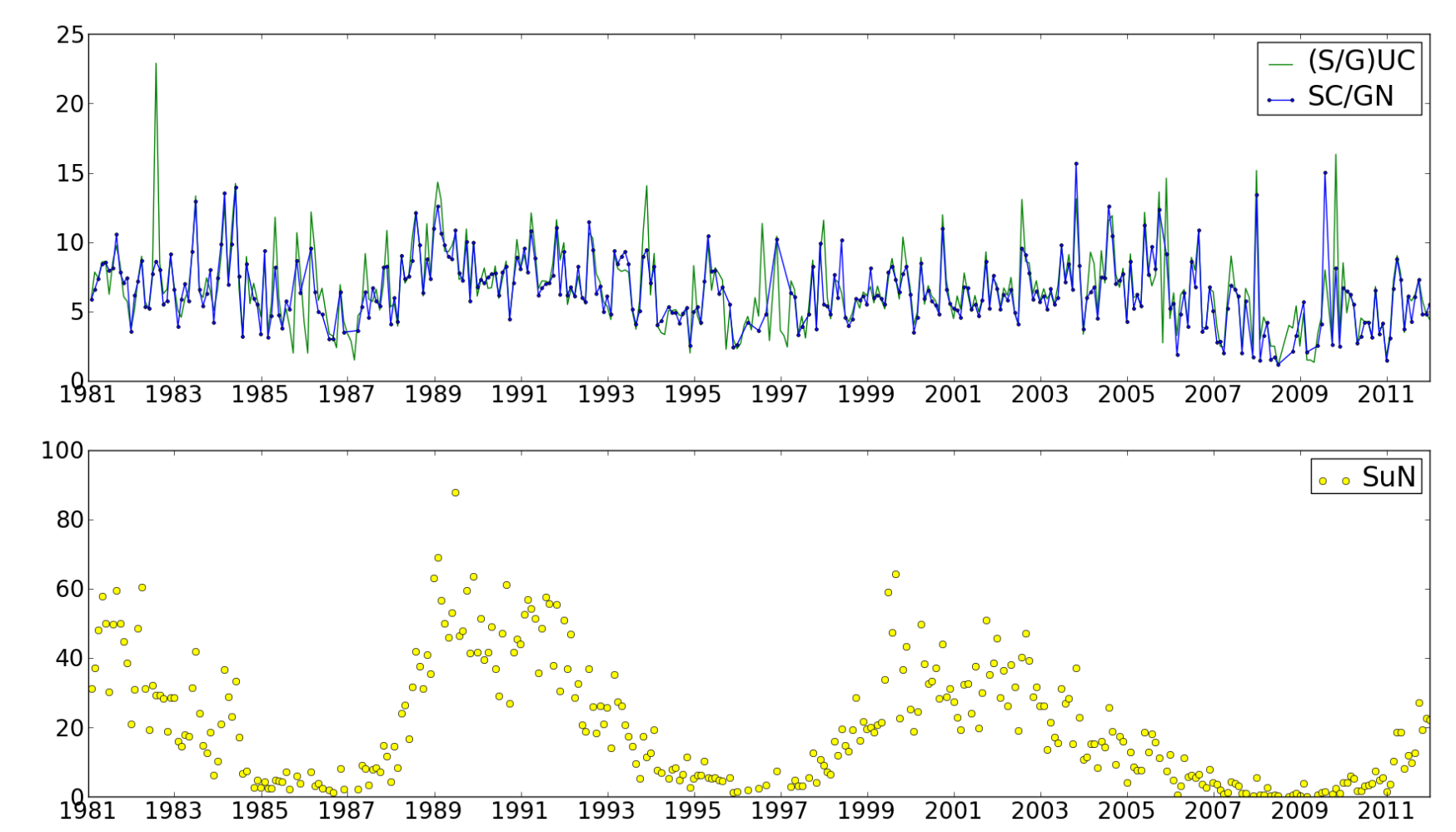
$$f = 10.13g$$

SC/GC ratio: Station Locarno vs network index

- Network index: reduced dispersion compared to station alone.

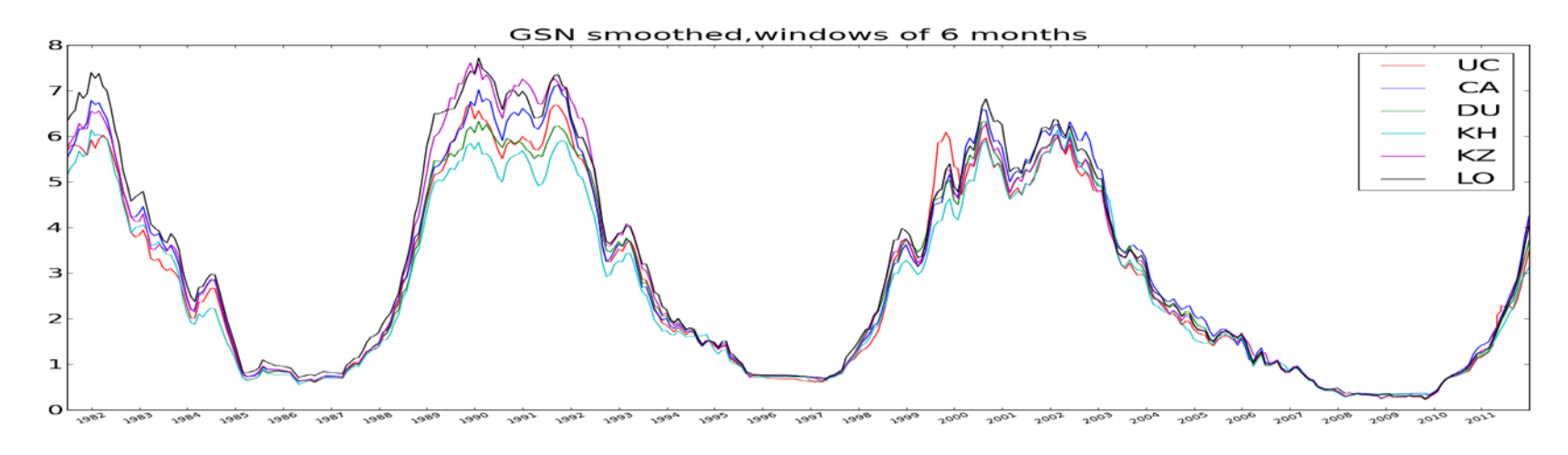


SC/GC ratio: Station Uccle vs network index

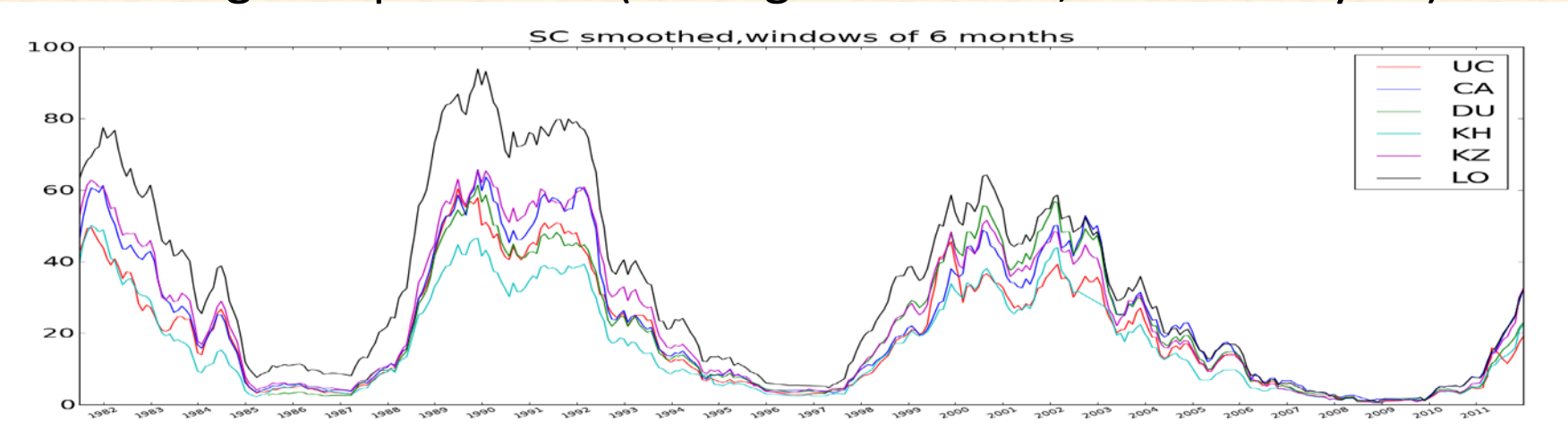


Dependance on the pilot station

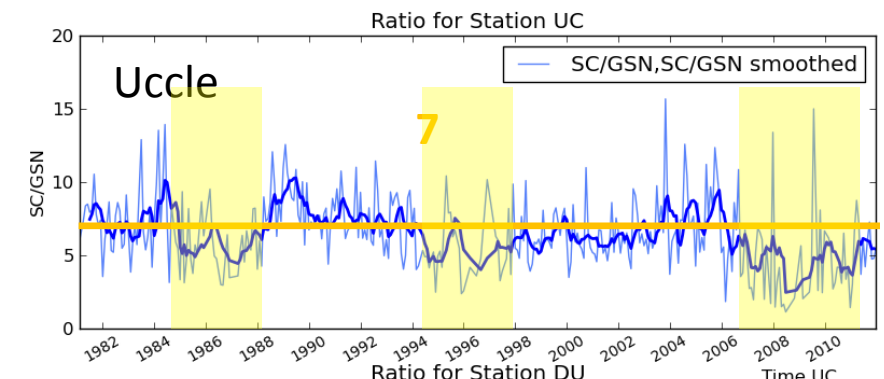
- GC: limited dependance (in particular cycle 23)

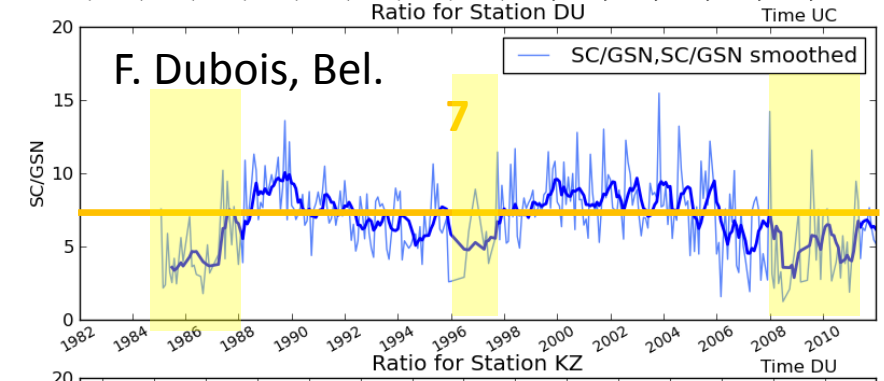


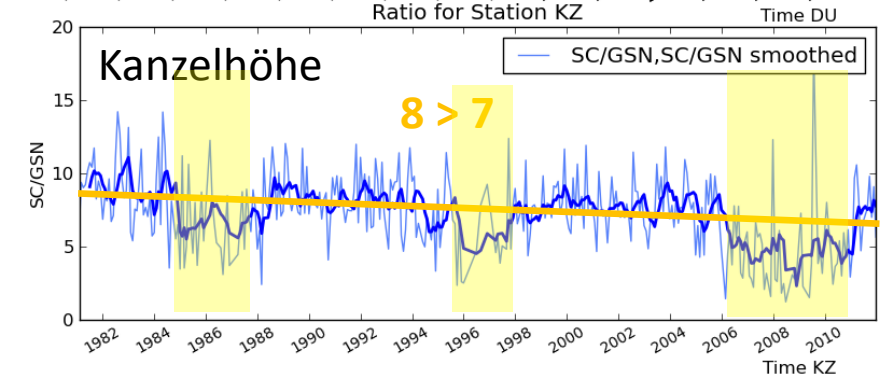
- SC: larger dependance (LO: highest counts, followed by KZ)

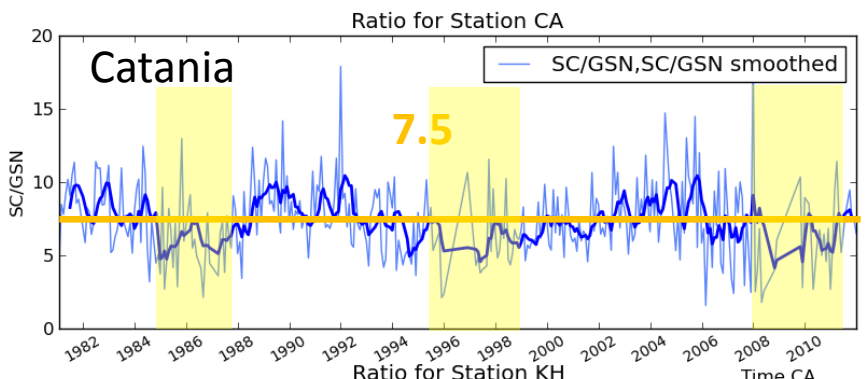


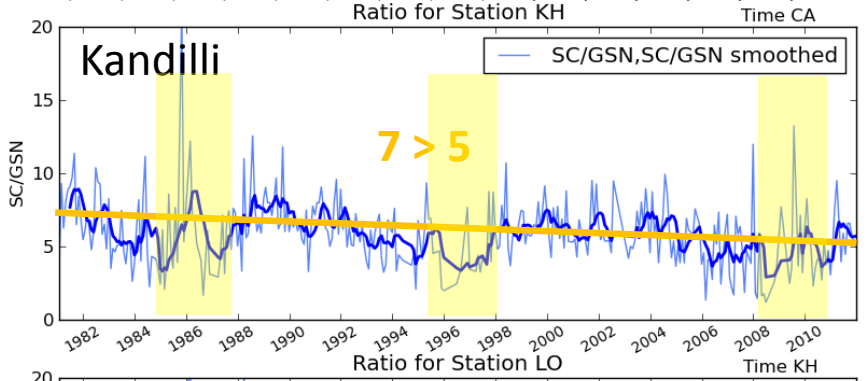
SC/GSN for different stations

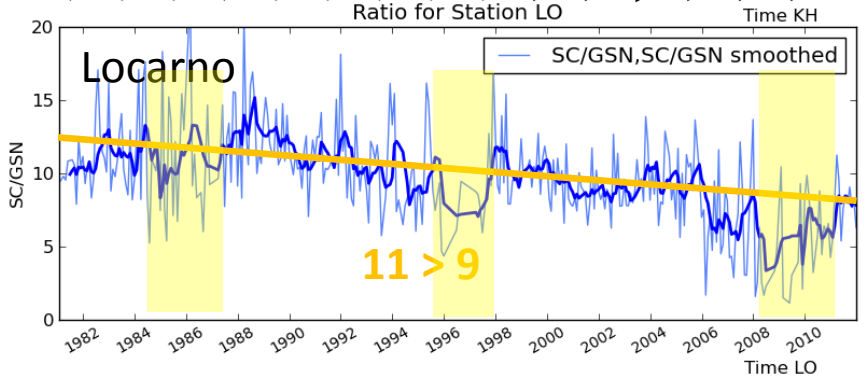




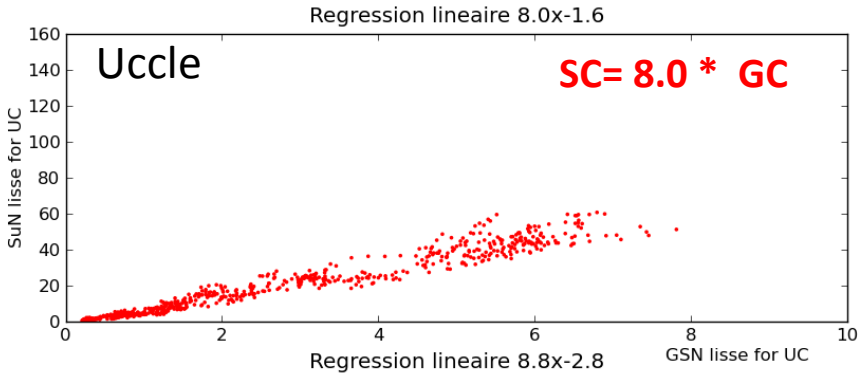


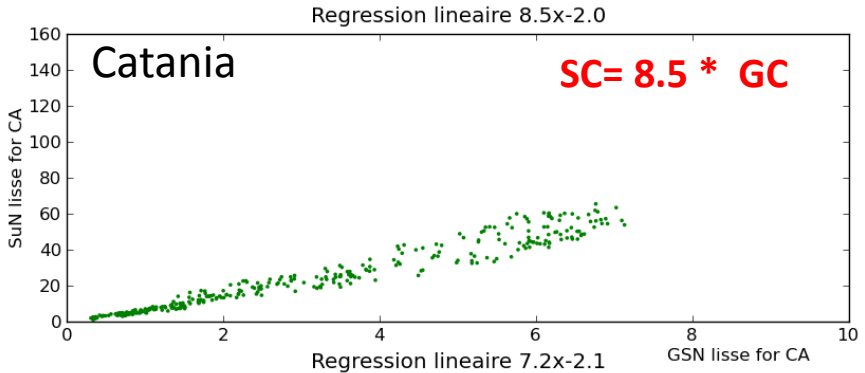


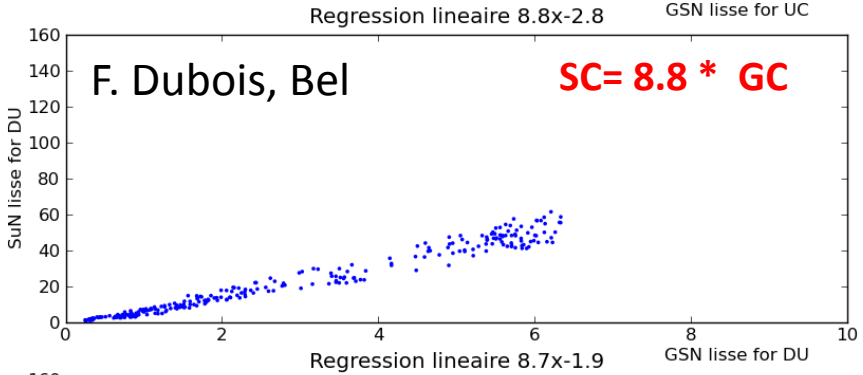


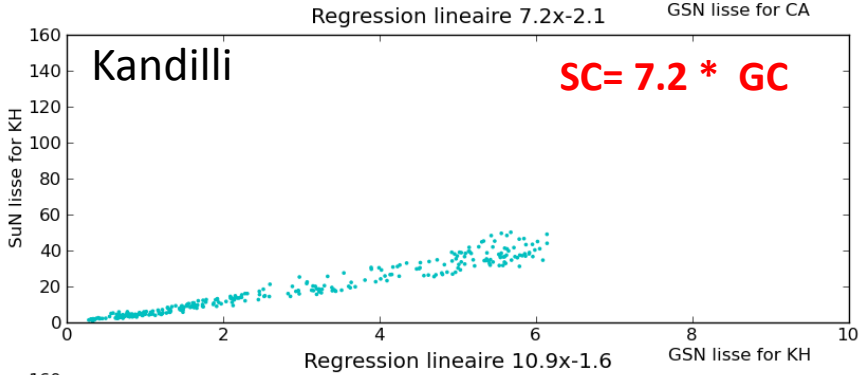


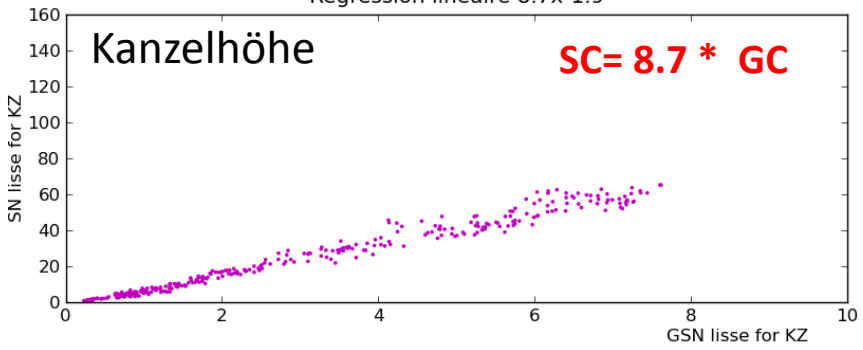
SC/GC for different stations

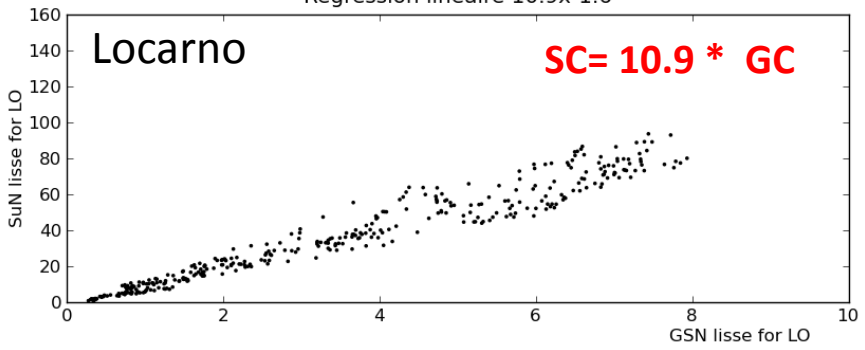




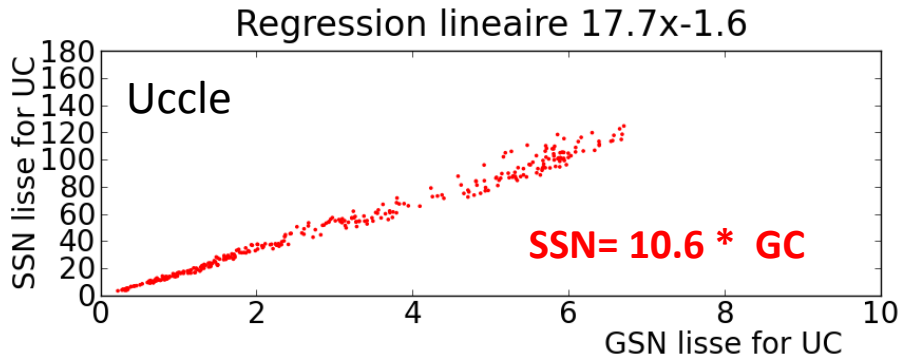


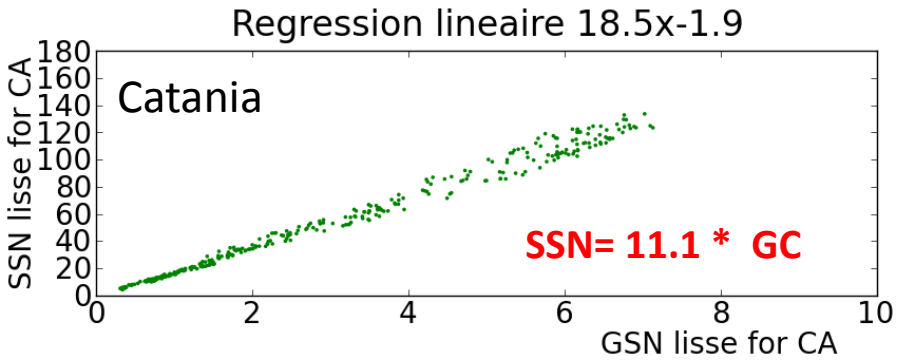


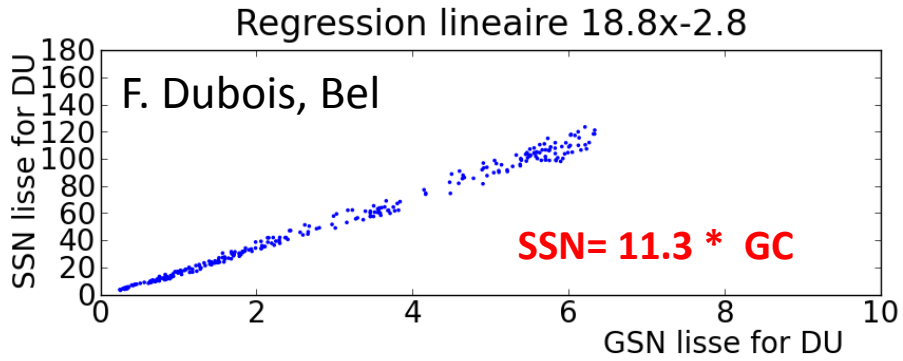


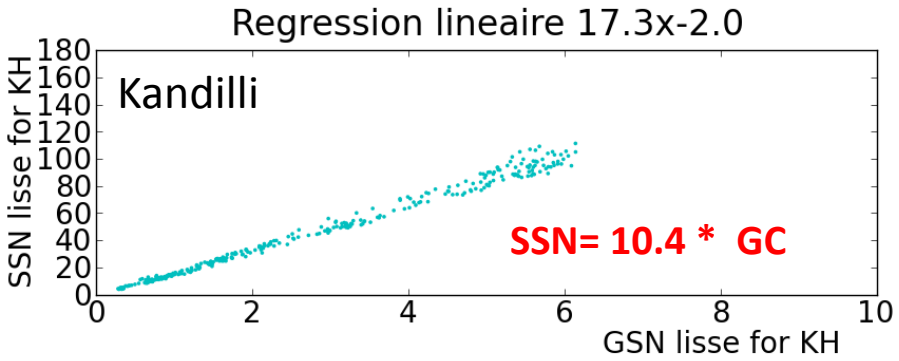


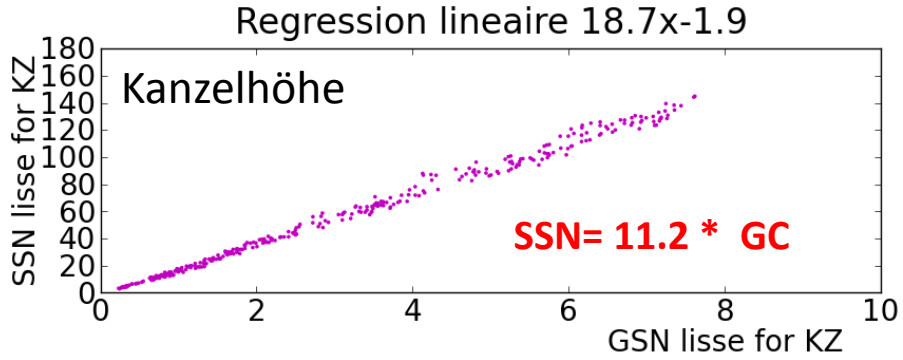
SSN/GC for various stations

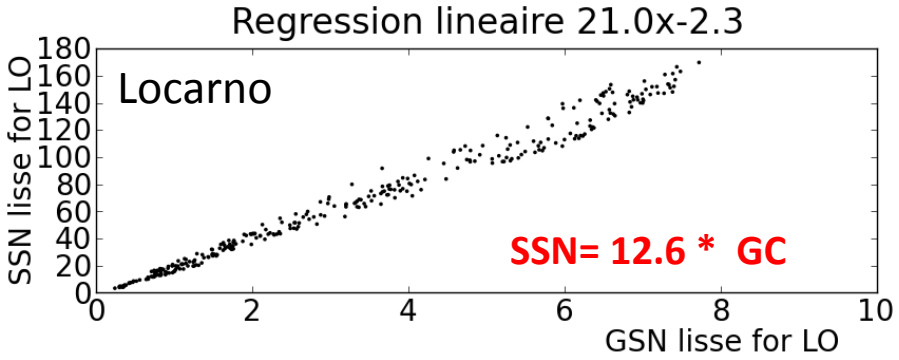






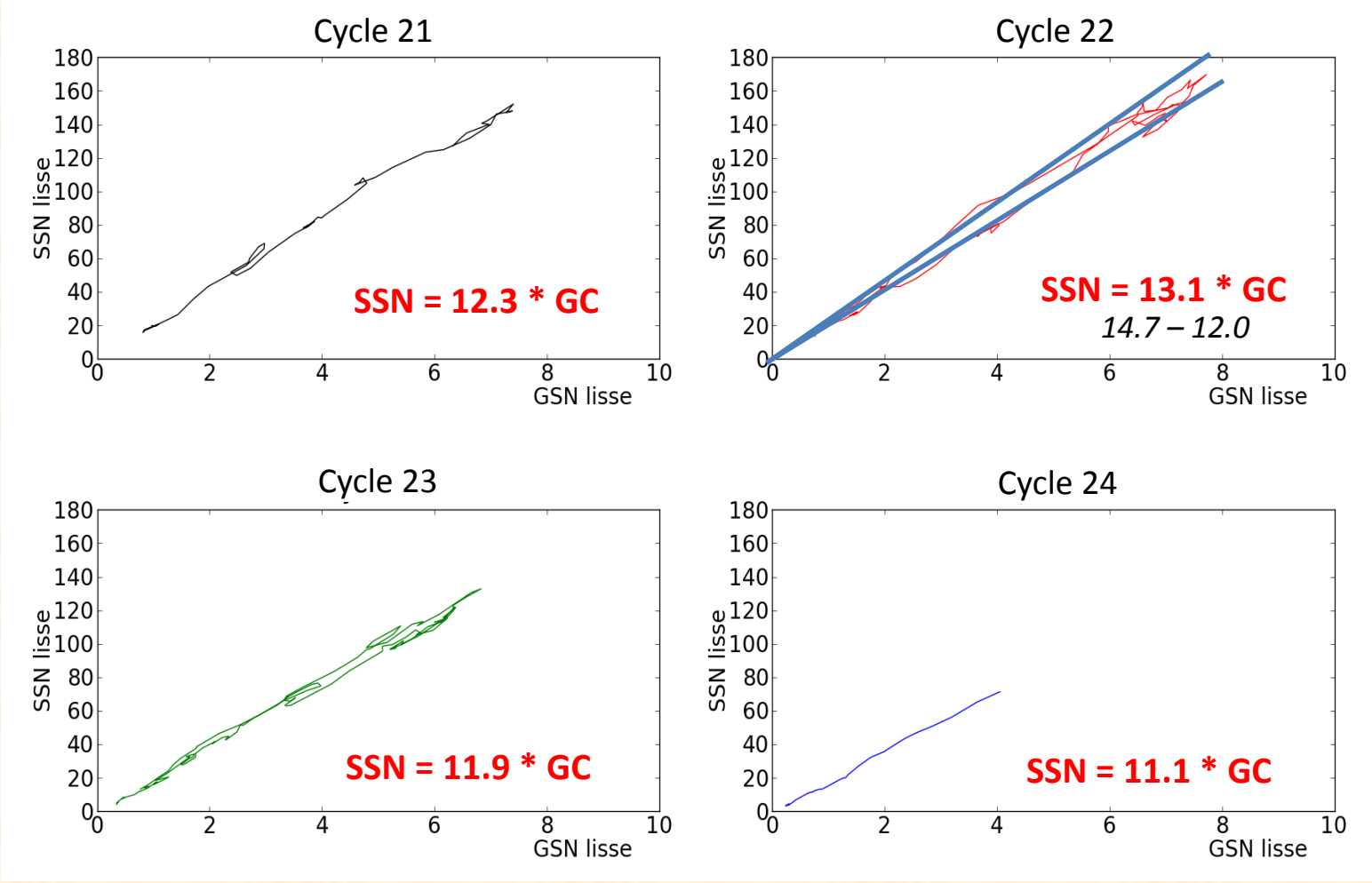






SC versus GC over 3 cycles *(Locarno)*

- Ascending and descending phases do not overlap for cycle 22 (loop)



Conclusions

- **SIDC database: brand new tool to:**
  - Validate past calculations
  - Explore the influence of different parameters:
    - observer quality & location
    - temporal bin size
    - thresholds used in statistical data filters
  - Explore different sunspot indices (versus the canonical Wolf formula)
- **Group sunspot number:**
  - Overlap period 1981 – 1997: good scaling agreement with the reference group SSN *(Hoyt & Schatten 1998)*
  - **Solar cycle variation in the ratio SSN/GSN**:
    - Flat ratio during most of the cycle
    - **30% reduction during minima:** small A, B, C groups dominate
  - **Deviation/trend in the ratio (cycle 23) only for a few stations, including Locarno**:
    - Requires further investigation

Conclusions

- **Group sunspot number:**
  - **Average SSN/GSN is station-dependant:**
    - Close to the 12.08 value (Hoyt & Schatten) only for “good” stations reporting the largest sunspot counts (incl. Locarno)
    - Values lower than 12 for most other stations.

SSN/GSN	Cycle Max	Cycle Min
GSN (H&S)	12.08	12.08
Locarno	12.6	8.8
Others	10.4 – 11.3	7.3 – 7.9

SC/GC	Cycle Max	Cycle Min
GSN (H&S)	10.13	10.13
Locarno	11.0	4.7
Others	7.3 – 8.8	2.2 – 3.2

(12.6 x **9.5** + 8.8 x **1.5**) / 11 = 12.08

Future developments

- Relation between the SSN/GSN ratio and the personal K coefficient of each station
- Conversion and extension of computing programs in Python language
- **Addition of the raw data from the Zürich network from 1950 to 1981** (except Zürich itself!):

➡ Doubling the length of the reconstruction

➡ Diagnostic of the Zürich series and the Zürich-SIDC transition:

  - Several stations contributing both to the Zürich and SIDC numbers.