

Introduction

SWAMI – Space Weather Atmosphere Model and Indices

is a project funded by the European Union's **Horizon 2020** programme from 2017 to 2020. The **SWAMI** objectives related to global geomagnetic indices are:

- **Develop and evaluate improved geomagnetic indices**
- Use these improved geomagnetic indices and index predictions as input for the two atmosphere models **Unified Model** (UM; the UK Met Office operational numerical weather prediction and climate model) and **Drag Temperature Model** (DTM2013; Bruinsma, 2015)
- **Make improved geomagnetic indices available to the space weather community**

A concise description of geomagnetic activity indices Kp and K

GFZ is in charge of **deriving and disseminating the geomagnetic Kp index** and related products (ap, Ap, international quiet and disturbed days) that date back to 1932 and is endorsed by International Association of Geomagnetism and Aeronomy (**IAGA**). More information about Kp and the related geomagnetic indices can be found at

<https://www.gfz-potsdam.de/en/kp-index/>

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The name **Kp** originates from “*planetarische Kennziffer*” (= planetary index):

- “*Kp indicates the intensity of geomagnetic activity as an expression of solar corpuscular radiation, for every three-hour interval of the Greenwich day*” – Bartels (1957);
- A three-hourly geomagnetic disturbance (**range**) index with values from 0 (quiet), ..., 3+ (moderate active), ... to 9 (very active/disturbed);
- Previously derived by hand-scaling of magnetograms and since the early 90's algorithms are used to derive it from 1-minute geomagnetic observatory data;

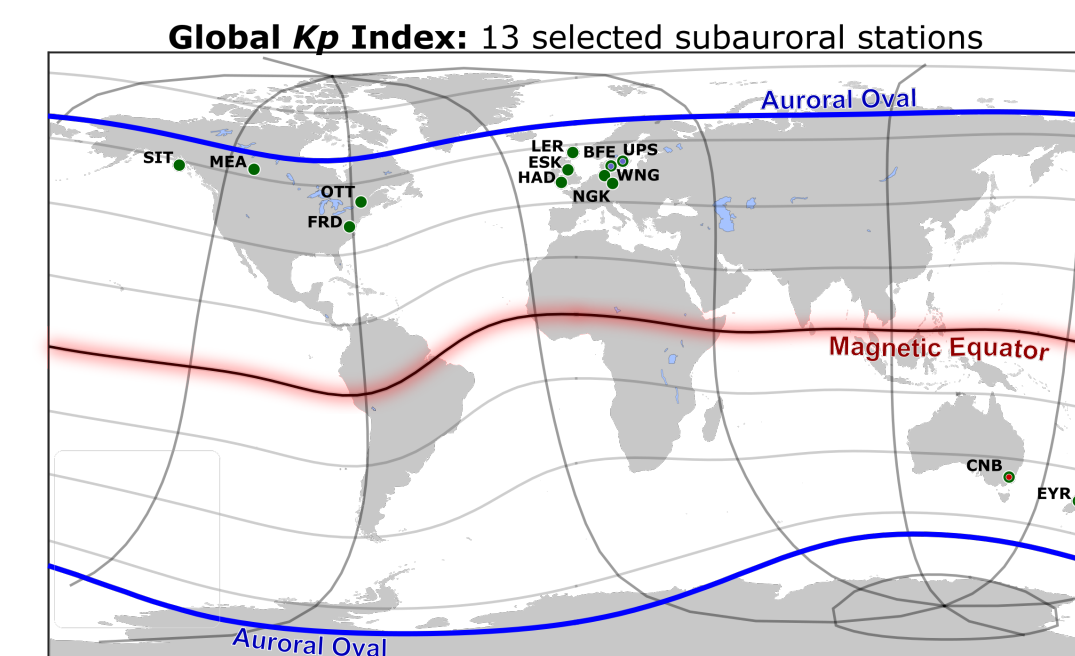


Figure 1.1: Geographic locations of 13 sub-auroral Kp-observatories.

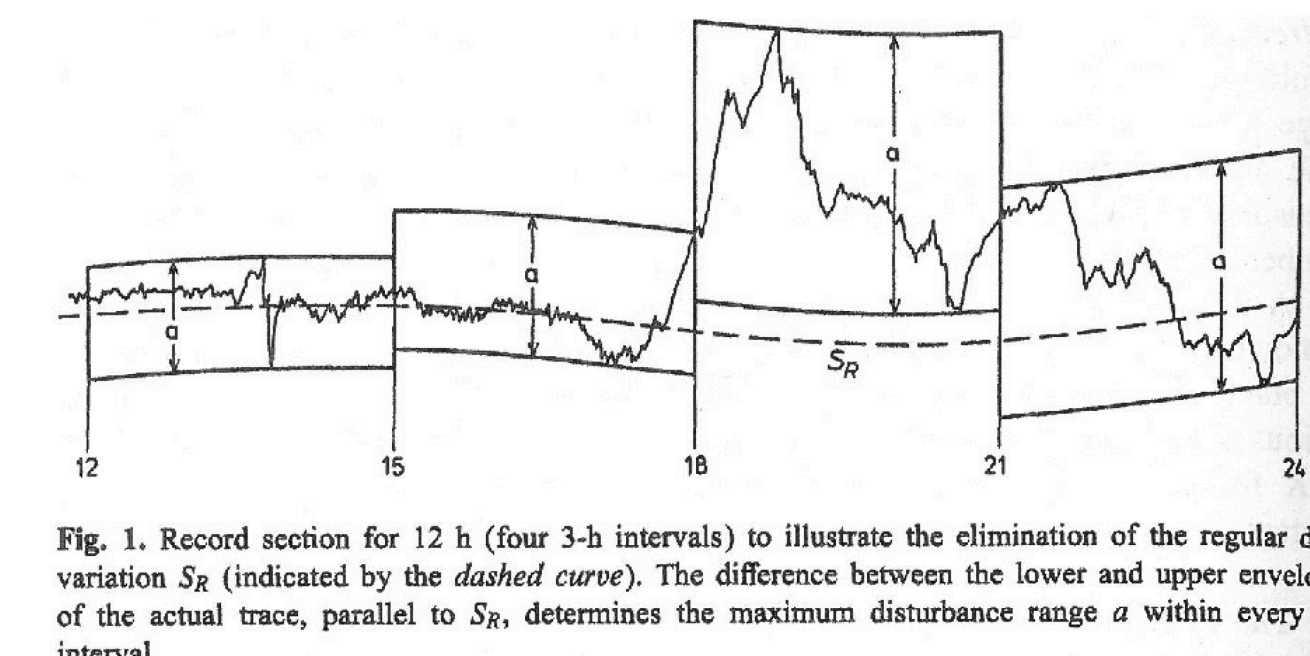


Figure 1.2: Figure 1 from Siebert (1996).

- The **local K** (single station) **index**: the maximum value of the disturbance levels in the horizontal field components observed at 13 selected, subauroral stations;

- The **standardized Ks** (single station) **index**: normalized for seasonal and local time effects;
- The **Kp index** is the (weighted) average of a number of Kp-stations' Ks values.

High cadence – why bother!

A clear advantage of a high-cadence index is the **improved time resolution** to better define a timing of **geomagnetic activity**, especially onset time. The figure below shows (07 Sep 2017) a very good **example** of such a case where the 3-hourly Kp index cannot determine the **storm onset time**.

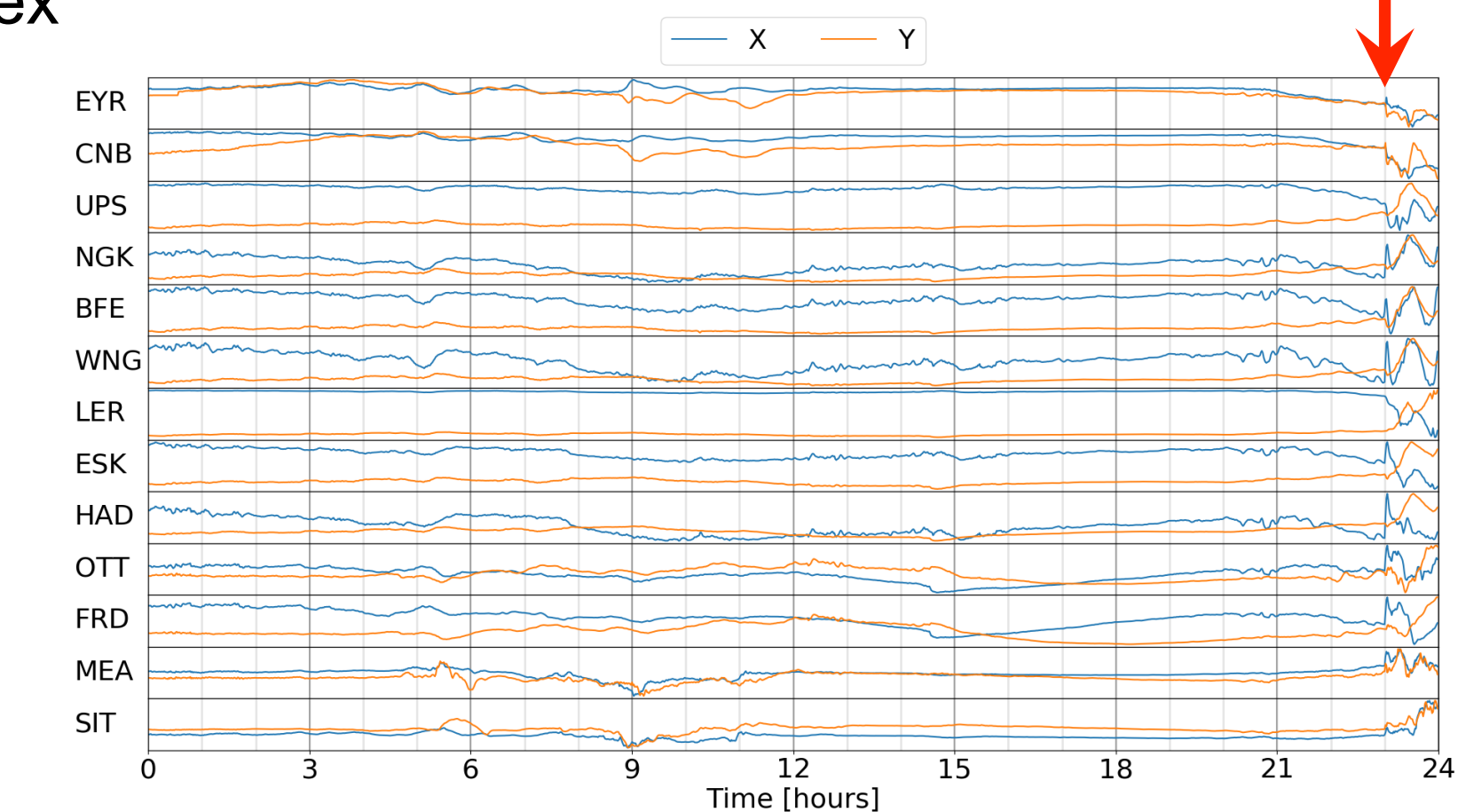


Figure 1.3: One-day example of magnetic field x and y component Measurements for all Kp stations.

The temporal resolution of indices:

- **Kp** – 180 minutes
- **Hp90** – 90 minutes that corresponds orbital period of LEO (Low Earth Orbit) satellites
- **Hp60** – 60 minutes preferred by users, survey: “*Existing and Improved Geomagnetic Indices*”
- **Hp30** – 30 minutes for further investigations

New High Cadence Geomagnetic Indices

New Hp Indices

The improved geomagnetic indices are **derived by algorithms developed for the 3-hourly Kp** and ap indices but will be of higher temporal resolution: **Hp90, Hp60 and Hp30**. The ap90, ap60 and ap30 indices are derived the same way **from Hp as ap from Kp**.

Adapted procedure:

- **Rescale** the range of magnetic variation that corresponds to a local K index (so-called K-table, Bartels, 1957). The **new local high cadence indices** are called **H indices** (H-table). By rescaling, we aim for **equal occurrence distribution of K and H indices** (see Fig. 2.1 for the example of Niemegk observatory);

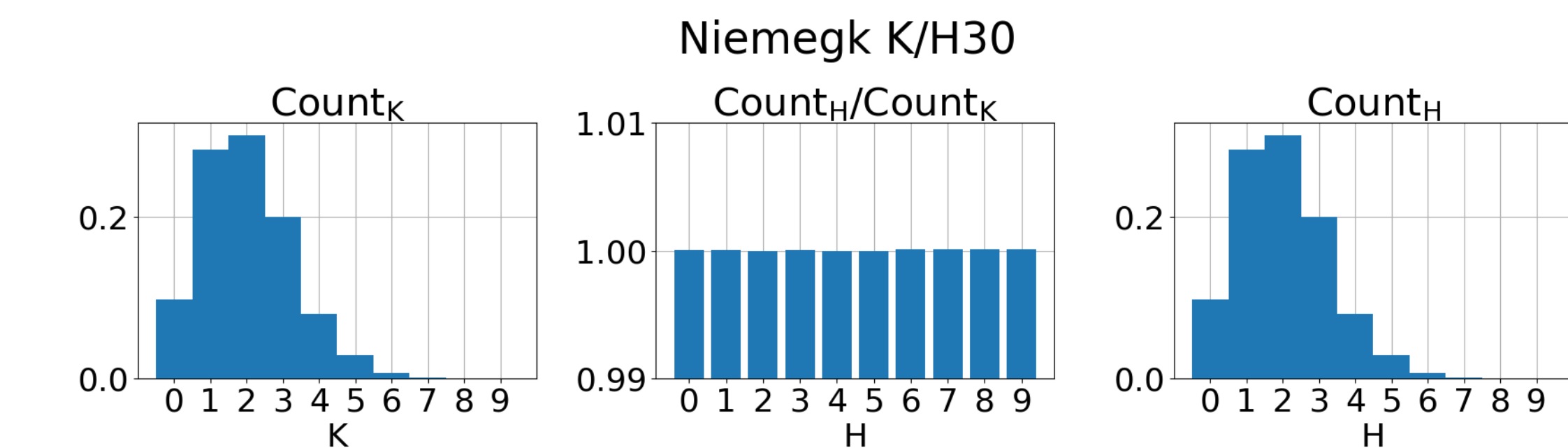


Figure 2.1: Normalized frequency distribution of K and H30 indices for the Niemegk observatory.

- The **rescaled H** values were defined based on the statistical distribution of K values during the last 22 years **from 1995 to 2017**. This was done for each contributing observatory and Hp index separately.

The Hp60 and Hp30 indices determine the **onset time** of geomagnetic activity (see Fig. 2.2) in **excellent agreement** with the **magnetic field x and y component** measurements (see Fig. 1.3).

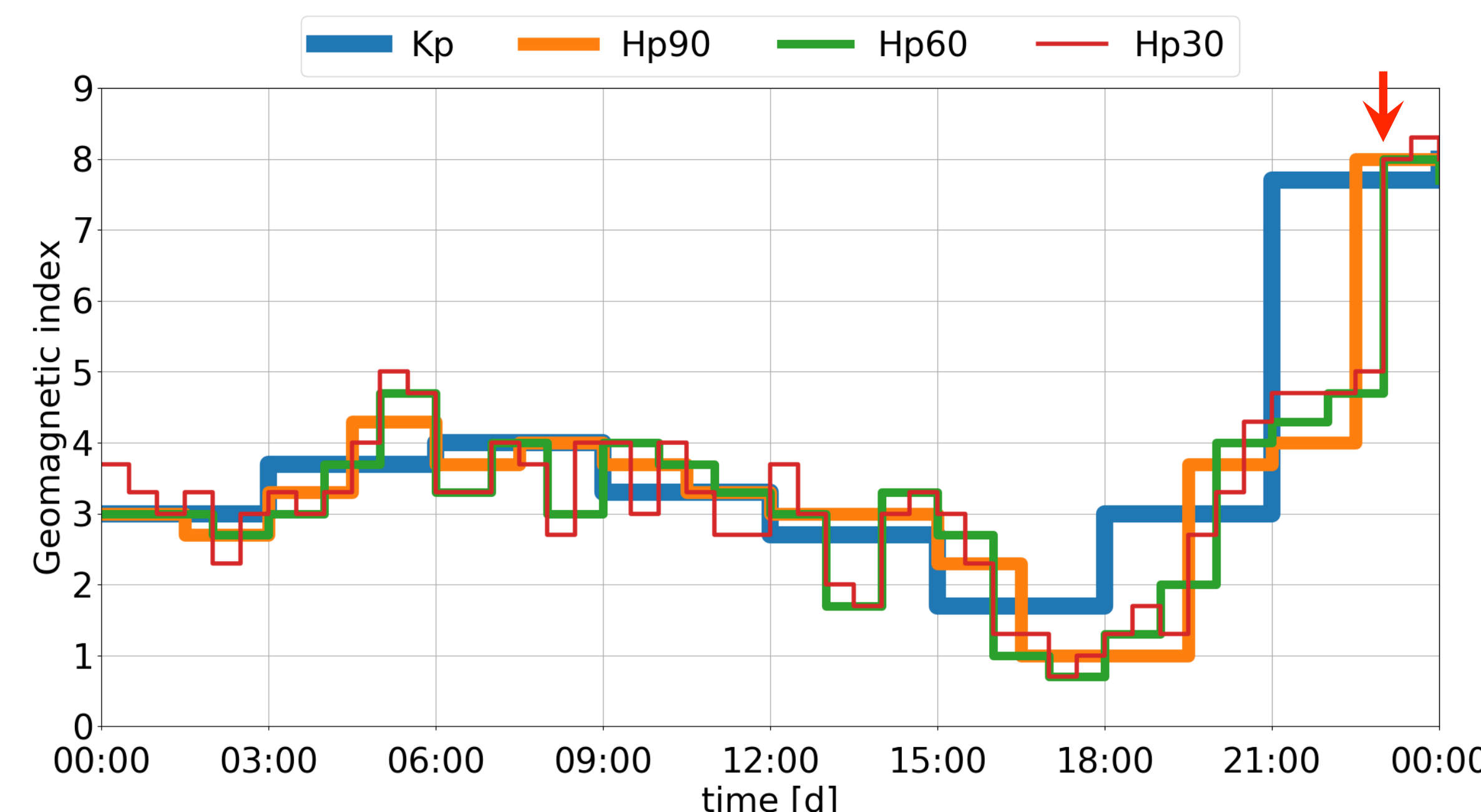


Figure 2.2: One-day (07 Sep 2017) comparison example of Kp and Hp indices.

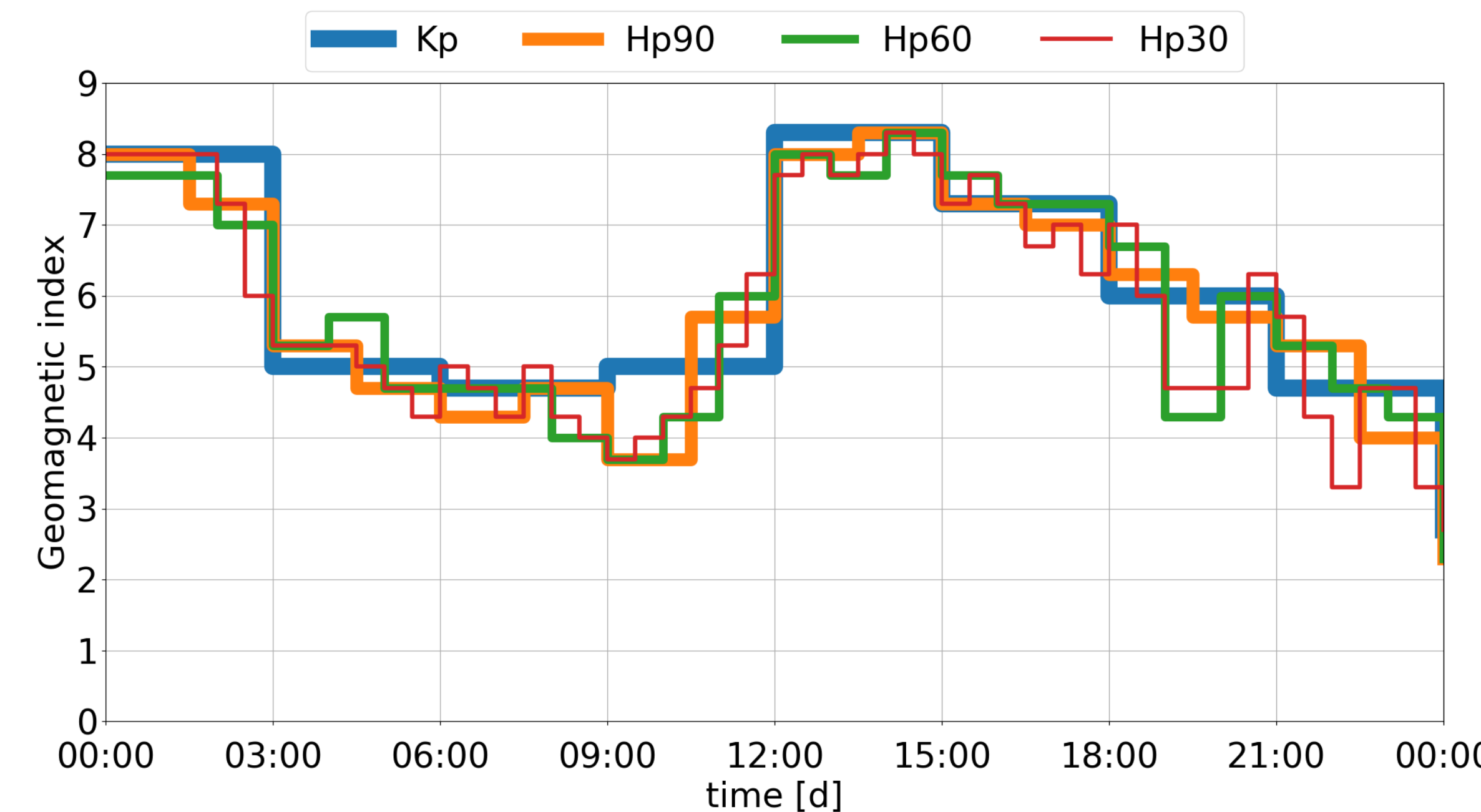


Figure 2.3: One-day (08 Sep 2017) comparison example of Kp and Hp indices.

Statistical Distribution Analysis of new High Cadence Indices

Normalized Frequency Distribution: 22 years (1995 – 2017) of data.

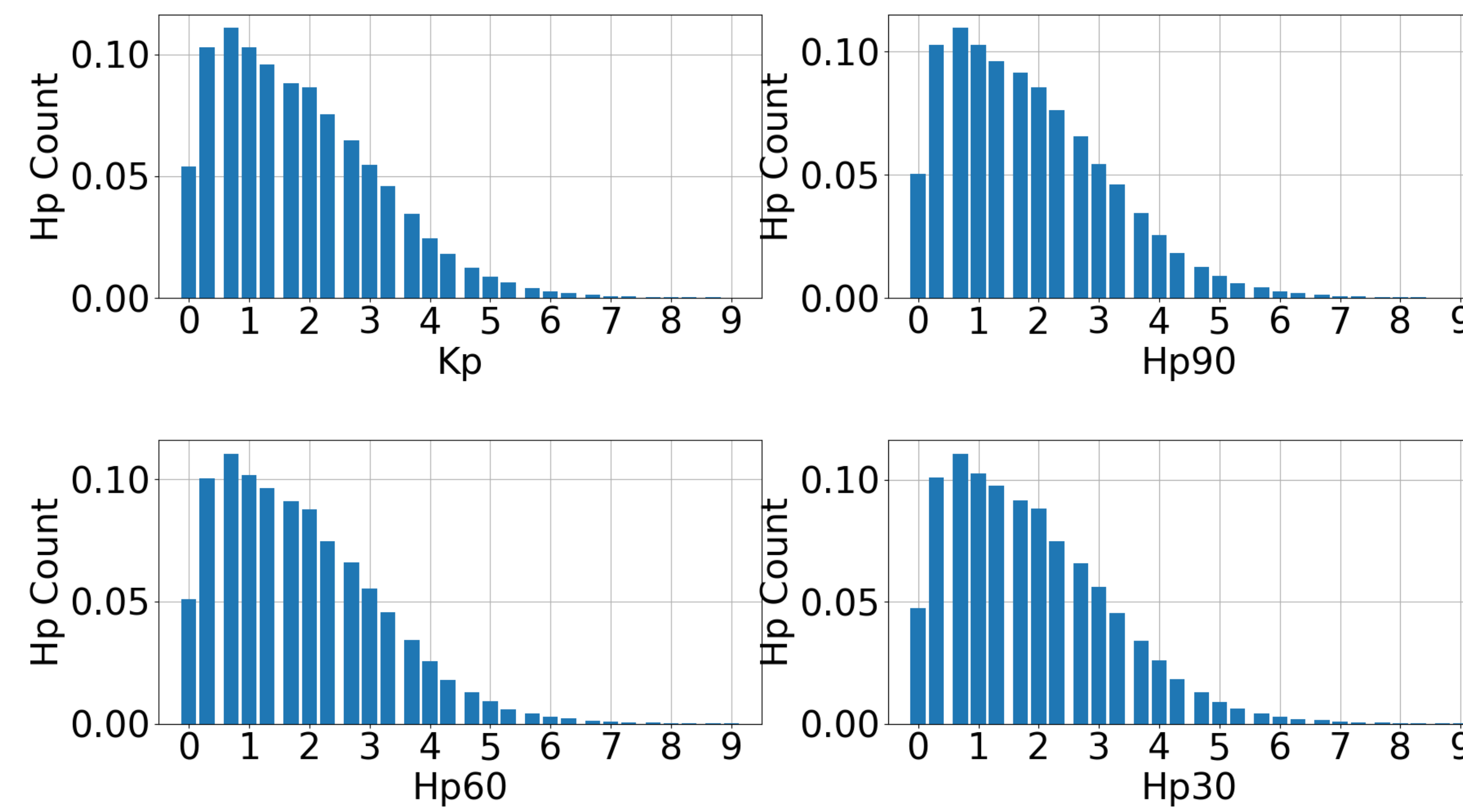


Figure 2.4: Normalized frequency distribution of Kp and Hp indices.

Correlation Analysis: 22 years (1995 – 2017) of data.

The **white** diagonal line corresponds to the **line of equality** and the **red** one shows the current regression line.

- Results based on **mean** values of Hp indices within a 180-minutes Kp-interval.

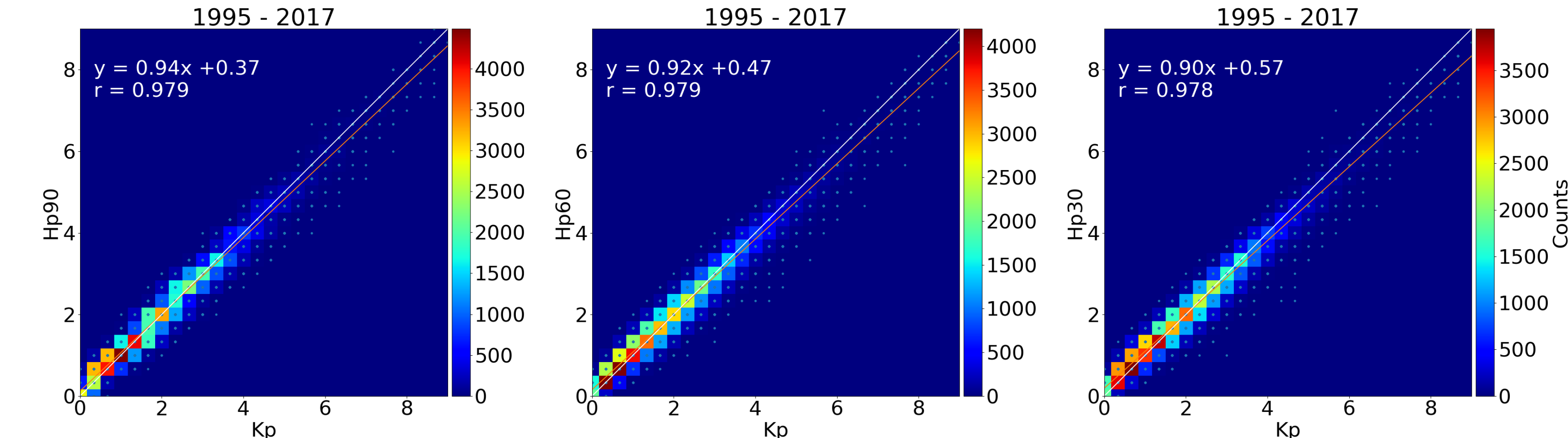


Figure 2.5: Correlation analysis results between Kp and mean values of Hp indices.

- Results based on **maximum** values of Hp indices within a 180-minutes Kp-interval.

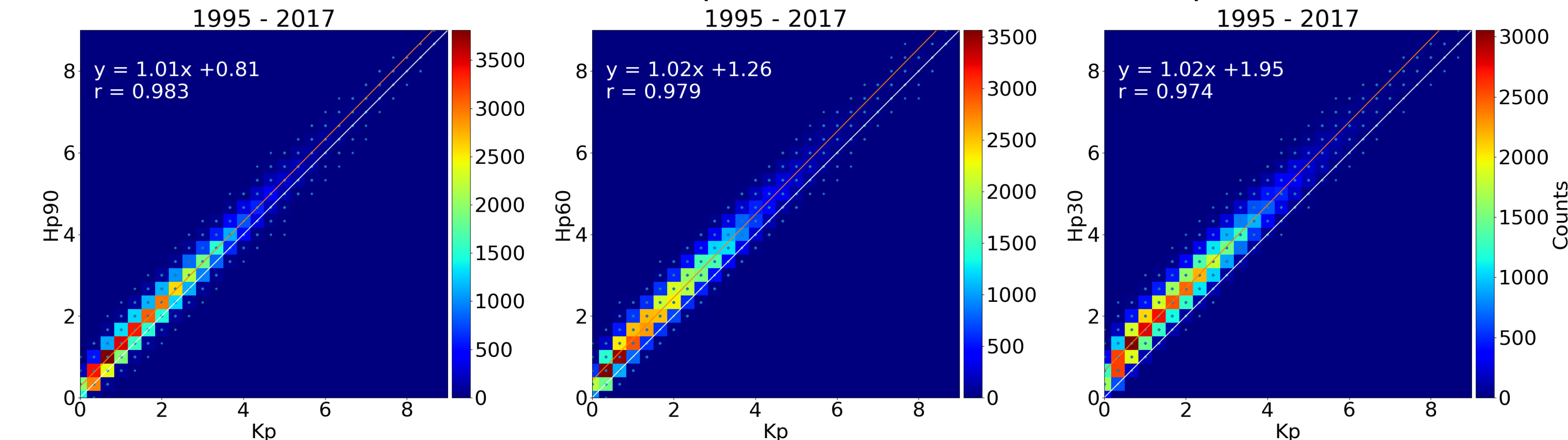


Figure 2.6: Correlation analysis results between Kp and maximum values of Hp indices.

180-minutes **mean** of Hp90, Hp60 and Hp30 are **lower** for high Kp activities and **maximum** values of Hp indices are **higher** for all Kp values. This means that all **Kp activities** are **represented in Hp indices** with higher values but with shorter time intervals.

On-going and Future Activities

- Scientific **verification and validation** of Hp values at the examples of the **Drag Temperature Model** (DTM) parameterization and **Unified Model** (UM).
- **Dissemination** of Hp indices to the space weather/general user community:
→ Your **feedback** is **highly appreciated**.

