An open-ended, high cadence, Kp-like geomagnetic Hpo indices

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http://swami-h2020.eu/

Motivation for a Kp-like index with higher time resolution

- The three-hourly Kp and from Kp derived ap, Ap, Cp and C9 indices (https://www.gfz-potsdam.de/en/kp-index/) of global geomagnetic activity are widely used for space weather monitoring, research, modelling, etc.

- Global geomagnetic activity indices with higher temporal resolution give a better-defined start and end time of solar wind energy input into the upper atmosphere

- User survey by the H2020 project SWAMI indicated that
    ☞ Kp is a heavily used geomagnetic index
    ☞ Many users would prefer a time resolution of 60 minutes (and additionally as 30 minutes)

- SWAMI is a project funded by the European Union's Horizon 2020 programme from 2017 to 2020 (grant agreement No 776287) and its objectives related to global geomagnetic indices are:
    ☞ Develop and evaluate improved geomagnetic indices
    ☞ Use these improved geomagnetic indices as input for Unified Model (UM) and Drag Temperature Model (DTM)
    ☞ Make improved geomagnetic indices available to the space weather community

- New high cadence geomagnetic index shell be more nuanced in describing the highest levels of geomagnetic activity

- The range of geomagnetic variations caused by a certain event is dependent on geomagnetic latitude. The discussion below is intended for a geomagnetic latitude of 50°:
  - ☞ The maximum value of Kp = 9 corresponds to geomagnetic variations exceeding a range of 500 nT. In the ap index, these are assigned an equivalent amplitude of 400 (in units of 2 nT), corresponding to geomagnetic variations with a range of 800 nT
  - ☞ Any event with geomagnetic variations just exceeding 500 nT would be assigned Kp = 9 and ap= 400, i.e., a range of 800 nT, which is too large to describe this event properly
  - ☞ Likewise, any event with geomagnetic variations significantly exceeding 800 nT is also assigned Kp = 9 and ap = 400, i.e. a range of 800 nT, which is too small to describe strong events properly

Naming convention for new (open-ended) indices

- The names **Ho** (corresponding to K), **Hpo** (corresponding to Kp) and **apo** (corresponding to ap) are adopted for new open-ended indices
- The names **H30, Hp30, ap30** and **H60, Hp60, ap60** are indicating the time resolution of 30 and 60 minutes, respectively
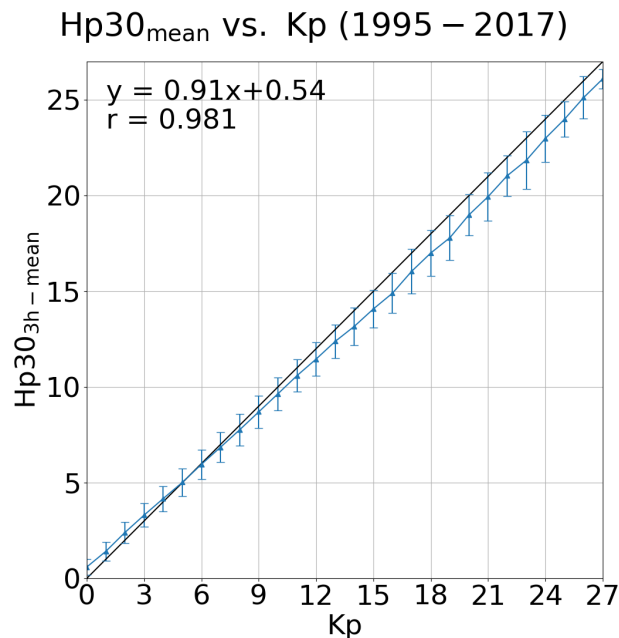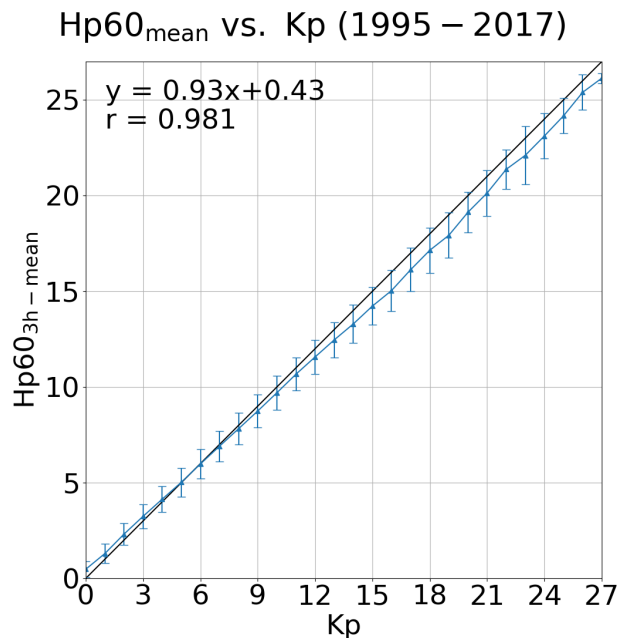
- Almost identical frequency distribution of nowcast Kp and nowcast Hp show that they have similar properties
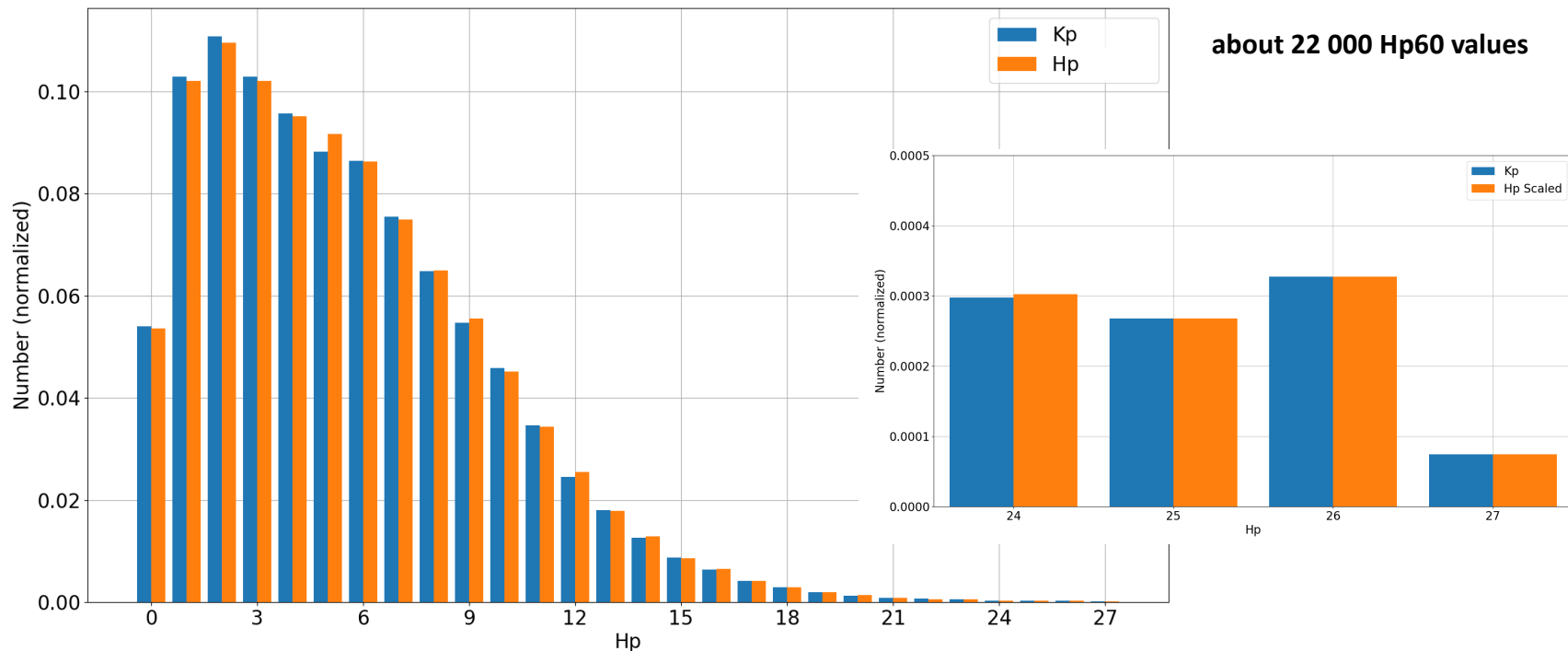
about 22 000 Hp60 values

- Good correlation of nowcast Kp and nowcast Hp show that they have similar properties

$Hp60_{mean}$ vs. Kp (1995 − 2017)

$y = 0.93x+0.43$
$r = 0.981$

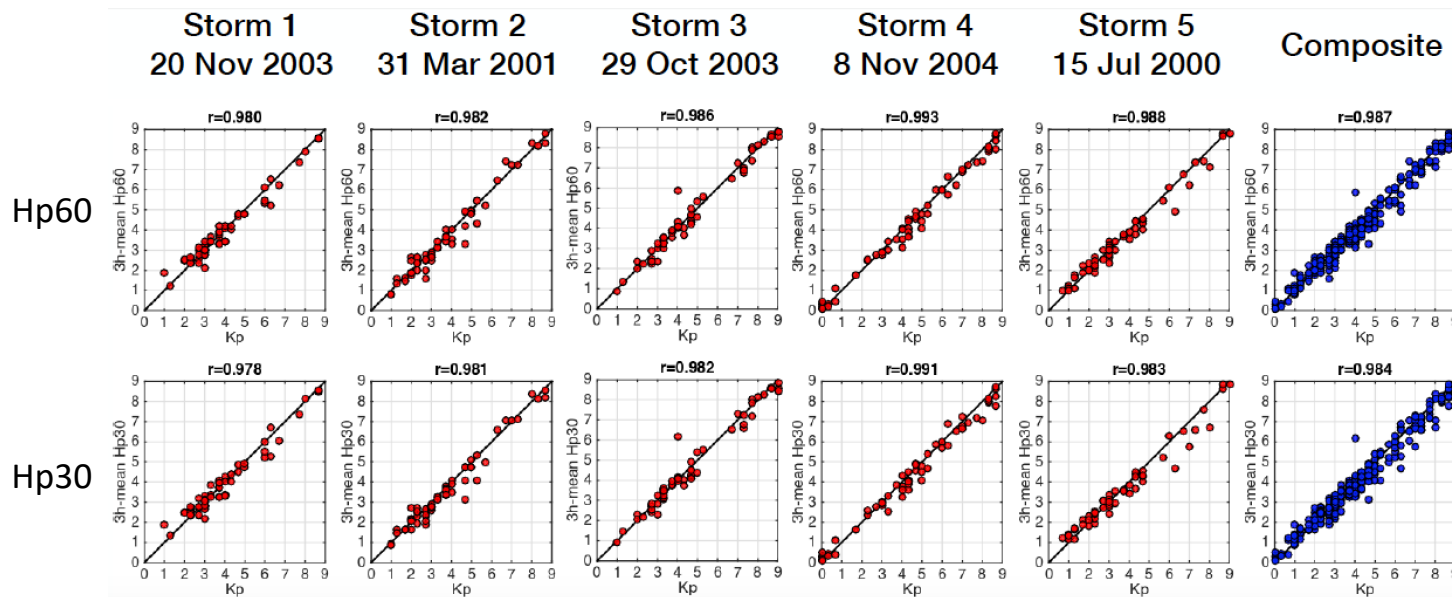$Hp30_{mean}$ vs. Kp (1995 − 2017)

$y = 0.91x+0.54$
$r = 0.981$

- Nowcast Hp and nowcast Kp for five storms (Dst < -300 nT)
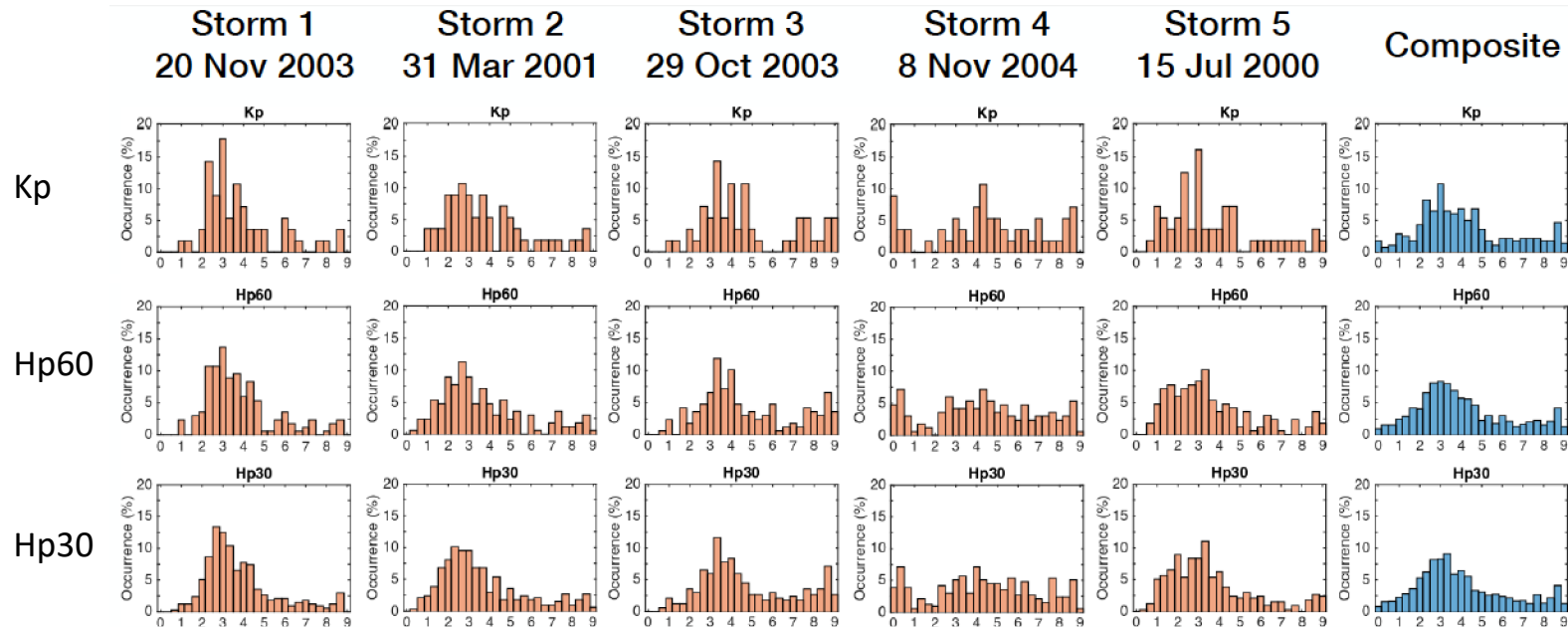
※ 7 days around the storm (the 3rd day corresponds to the storm main phase)
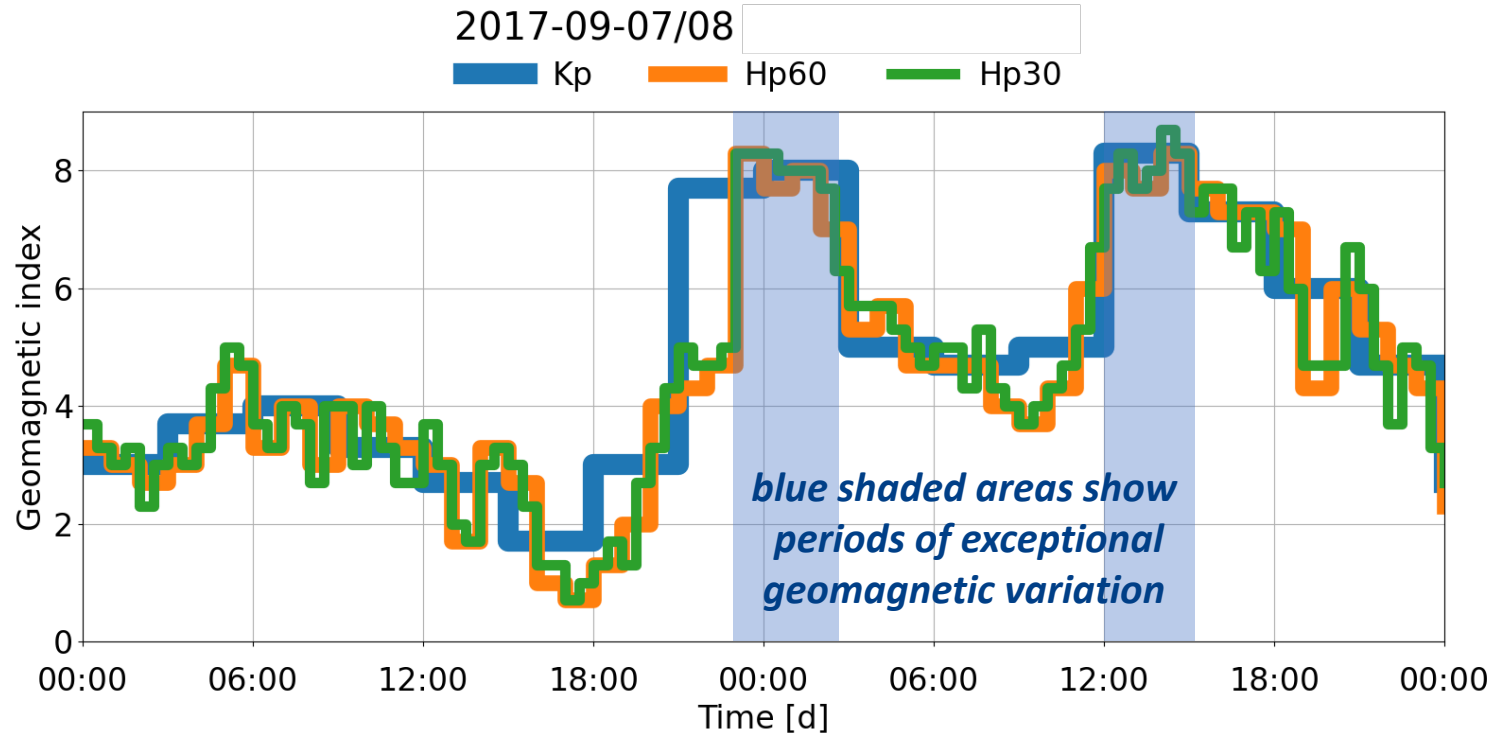
- Frequency distributions (previous slide) are very similar and overall agreement of Kp with Hp60 and Hp30

- Correlation between Kp and Hp60/30 is very good (> 97) during the 5 strongest storms from 1995 to 2017

- Hp indicates more precisely than Kp the onset of exceptional geomagnetic activity

blue shaded areas show periods of exceptional geomagnetic variation

Conclusions

- Nowcast Hp60 and Hp30 work similarly well as a geomagnetic Kp-like index

- No systematic degradation of the high cadence index properties with decreasing time resolution of the indices is observed

- Hp60 and Hp30 are further developed towards open-ended indices

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Development of the open-ended, high cadence Hp30 and Hp60 indices

Note

- We evaluated two versions of open-ended Hp30 and Hp60 indices: the first version (**Scale A**) is designed to give lower Hp values than the second version (**Scale B**) for the same event of severe geomagnetic disturbance.

Development of the open-ended, high cadence Hp30 and Hp60 indices

- The **station specific scales** for mapping geomagnetic variation ranges to Ho values are **extended to Ho = 10, 11, 12, …** . This results **in open-ended Ho** indices

- Two different scales are used and evaluated:
    - ☞ **Scale A** increases the range limits by a factor of ~1.4 to get the lower limits for Ho = 10, 11, ...
    - ☞ **Scale B** increases the range limits by a factor of 1.35/1.30/1.20 to get the lower limit for Ho = 10/11/ 12, 13, 14, ...

    Scale A is **steeper** than scale B, leading to **higher Ho** values for **scale B**

- The open-ended Hpo index is calculated according to the following rules:
    - ☞ The open-ended **Hpo < 9** index is calculated from Ho capped **to 9**
    - ☞ The open-ended **Hpo ≥ 9** is calculated from Ho according to the new, extended **scale A/B**

    Hpo is identical to the **non-open-ended Hp** up to Hpo = 9-

- Number of events for **Hpo ≥ 9** from 1995 to 2017

| number \	Hp = 9.0	9.3	9.7	10.0	10.3	10.7	11.0	11.3	11.7	sum
scale A, Hp60	-	4	6	2	1	1	1	-	-	15
Hp30	2	5	6	10	7	1	1	-	-	32
scale B, Hp60	-	2	1	7	2	1	1	-	1	15
Hp30	-	3	5	5	5	8	4	-	2	32

Conclusions

- **Scale B gave better agreement** with the composite polar cap index PCC as well as with merging electric field (not shown here) **than Scale A** for both Hp30 and Hp60 indices

- The **highest value** observed from 1995 to 2017 for **Scale B** was Hp30 and Hp60 = **11.7**:

Hp30: 29-Oct-2003 at 06:30-07:00
     30-Oct-2003 at 21:00-21:30

Hp60: 30-Oct-2003 at 21:00-22:00
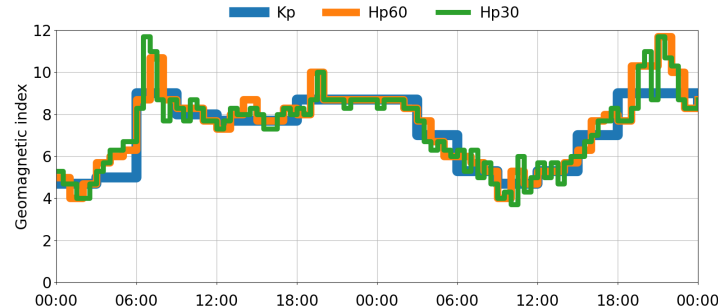
- The high cadence **open-ended (Hpo)** indices are identical to the previous **not open-ended (Hp)** high cadence version indices for **0 ≤ Hpo < 9**

- Both high cadence indices will be distributed in an **open-ended version in the future**, utilizing **Scale B**

Ongoing work in SSA SWE G-ESC

- Implementation of nowcast Hp60 and Hp30 geomagnetic indices as a demo product by February 2021

Test dataset (CC-BY 4.0) **for the not open-ended-version available from GFZ since since June 2019**

- at https://doi.org/10.5880/GFZ.2.3.2019.002 (see also http://swami-h2020.eu)

- with the following content

  - ☞ Hp90, Hp60, Hp30, ap90, ap60, ap30 indices
  - ☞ Years 2003, 2004, 2005, 2017
  - ☞ Technical Note

- **Further years** of the dataset can be provided after request

Disclaimer to users of the Hp indices test dataset (Feedback welcome!)

- Please carefully test and validate all your model output and services for which you use the Hpo indices (including the ap90, ap60, ap30) as input parameter. This is especially true when these models and services were originally derived or parameterized with the Kp index

We acknowledge INTERMAGNET and the contributing observatories for providing high quality geomagnetic data