Cosmic Ray modulation by Corotating Interaction Regions derived from satellite measurements
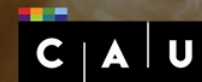
Jaša Čalogović

Hvar Observatory
Faculty of Geodesy
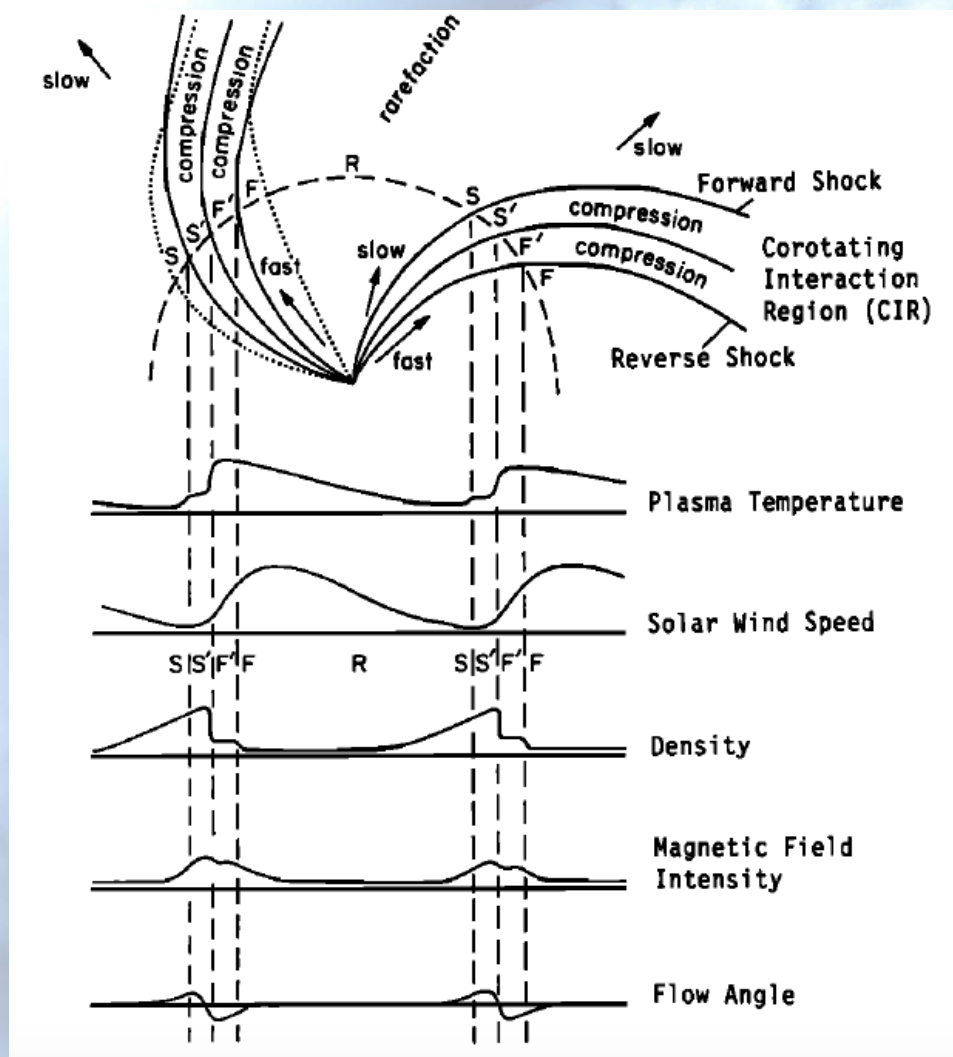Zagreb, Croatia

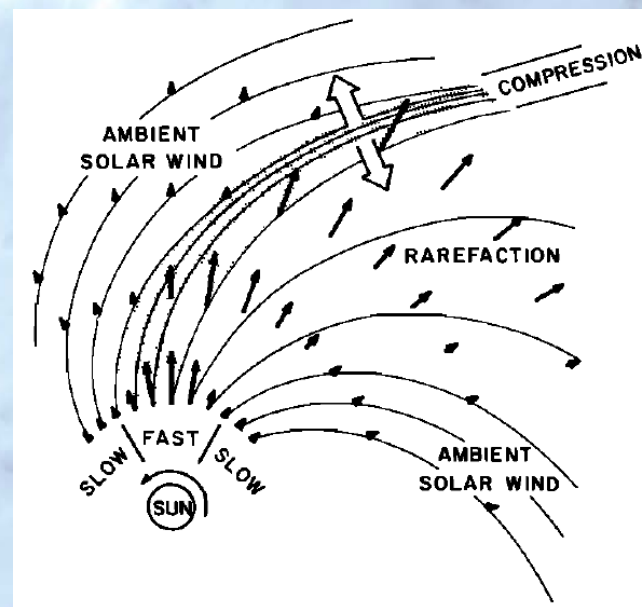Dumbović, M., Vršnak, B., Heber, B., Temmer, M., Veronig, A.

Corotating Interaction Regions (CIR)

Richardson, 1993

- compression regions formed from the interaction of high- and low-speed solar wind streams
- corotating with the Sun
- Major driver of solar-wind disturbances and geomagnetic storms during solar minimum (low CME activity)
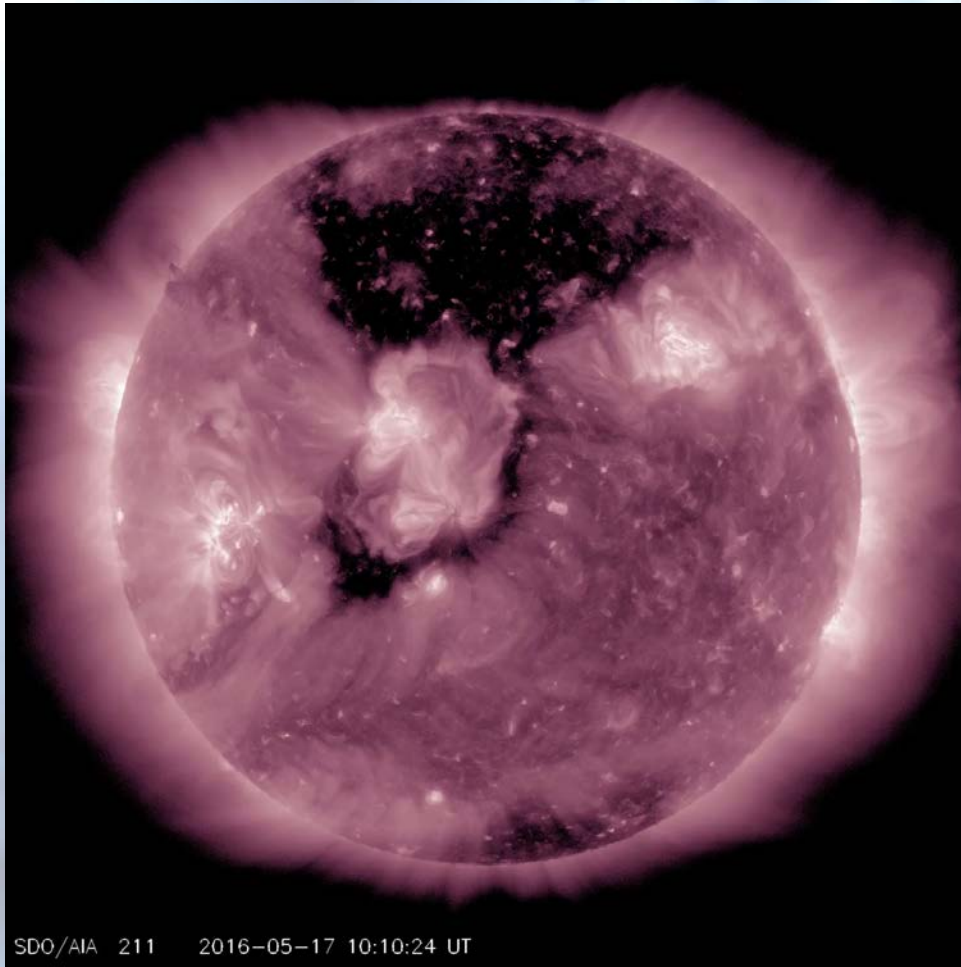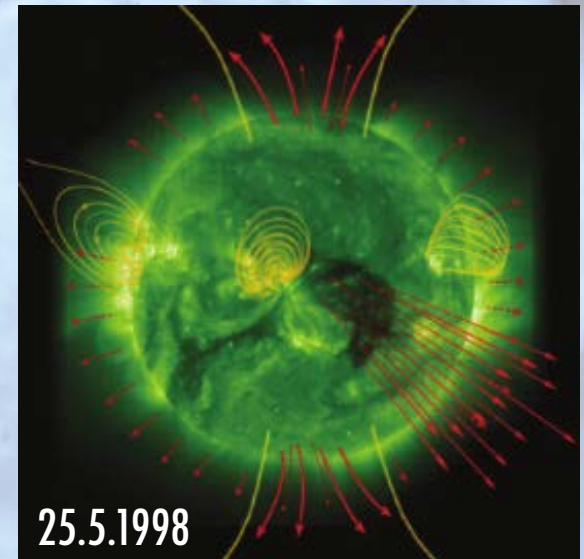

Pizzo, 1978

Coronal Holes (CH)

Large CH, May 17 – 19, 2016

SDO/AIA 211   2016-05-17 10:10:24 UT

- source regions of the high-speed solar wind
- connected with open magnetic field form the Sun
- visible as dark regions in EUV or X-ray observations of the solar corona
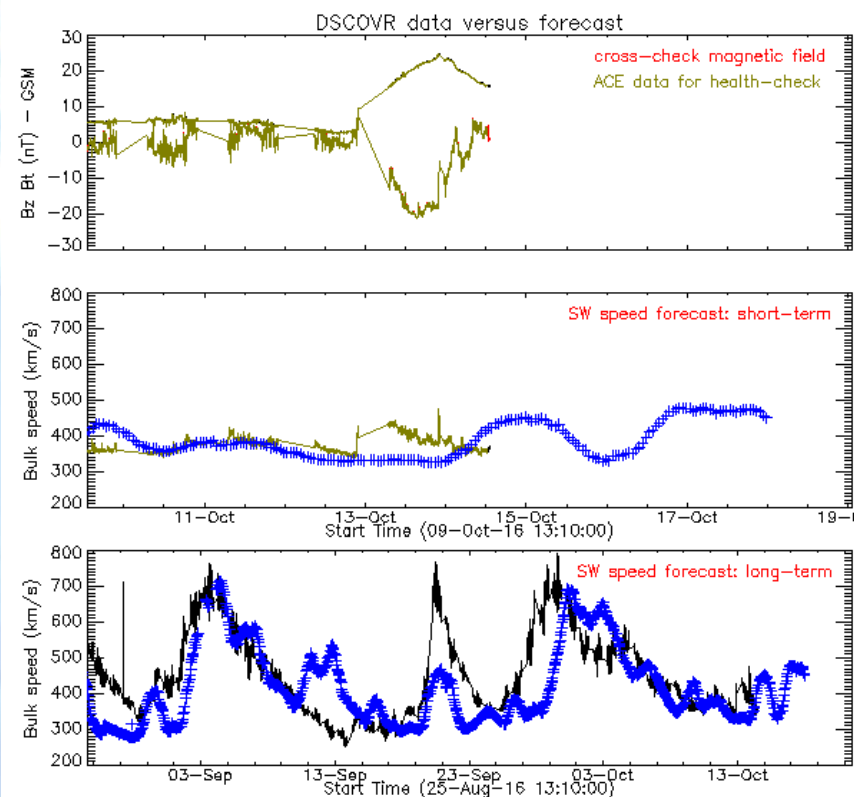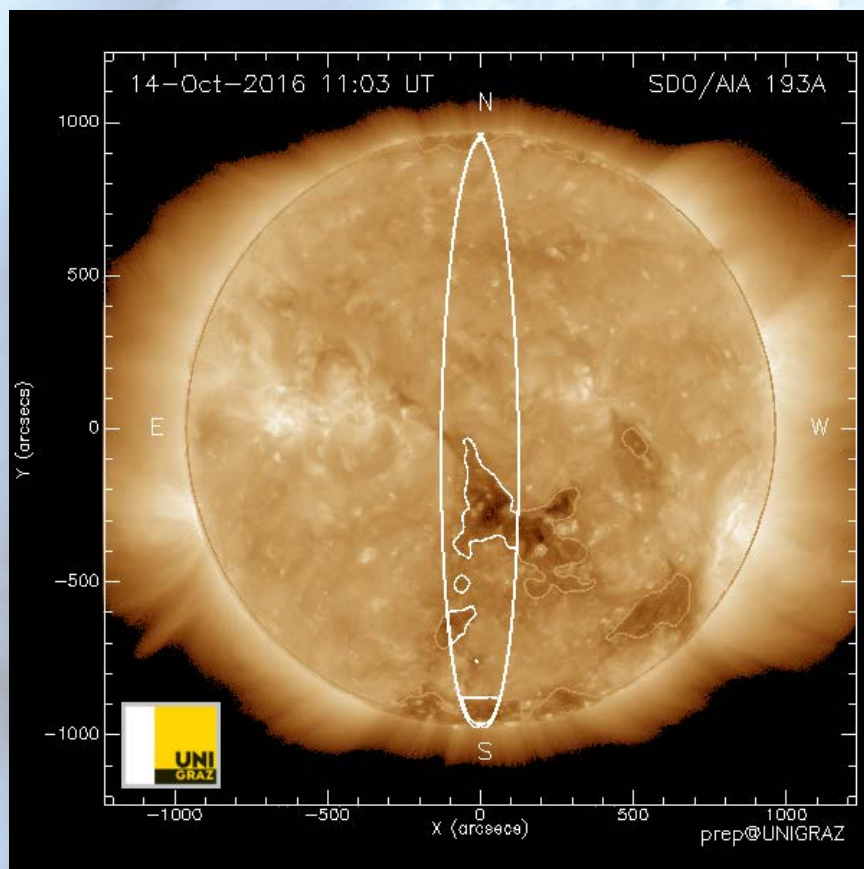

25.5.1998

Coronal holes and solar wind

Forecasting solar wind high-speed streams (ESWF)
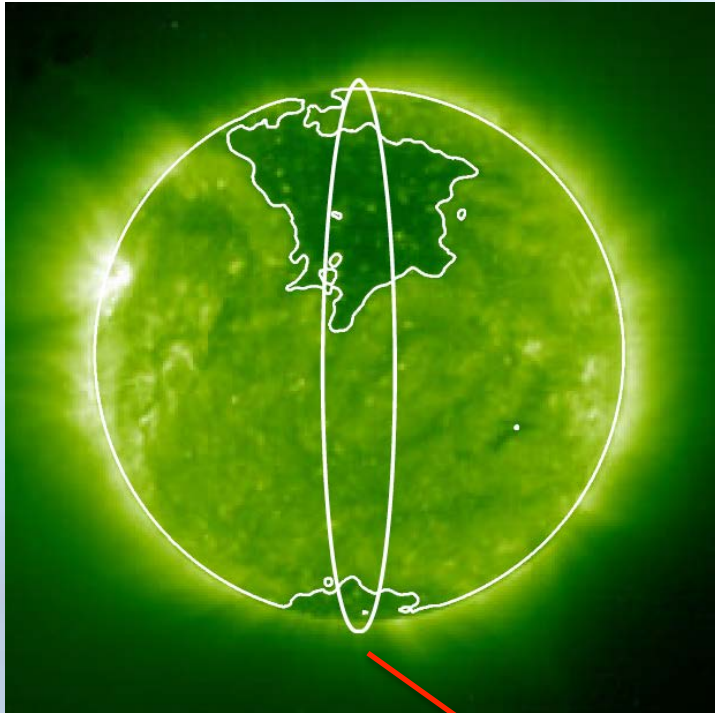http://swe.uni-graz.at/index.php/services/solar-wind-forecast

- based on an empirical relation between CH and high speed streams measured at Earth (Vršnak et al. 2007)
- CH areas are extracted from EUV images (Rotter et al., 2012; Reiss et al., 2015; 2016)
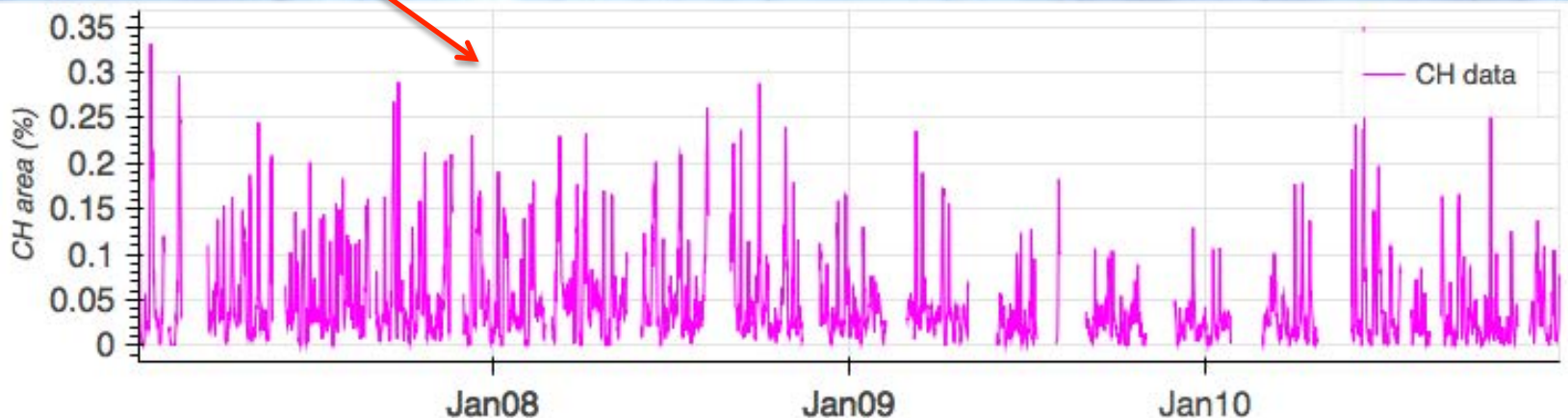
CH area data

- extracted with SOHO EIT 195 Å images
- CH can be identified with intensity-based thresholding technique (Rotter et al., 2012, Reiss et al. 2016)
- fractional coronal hole area is derived from a central meridional slice (±7.5°) corresponding to the solar rotation within aprox. 1 day
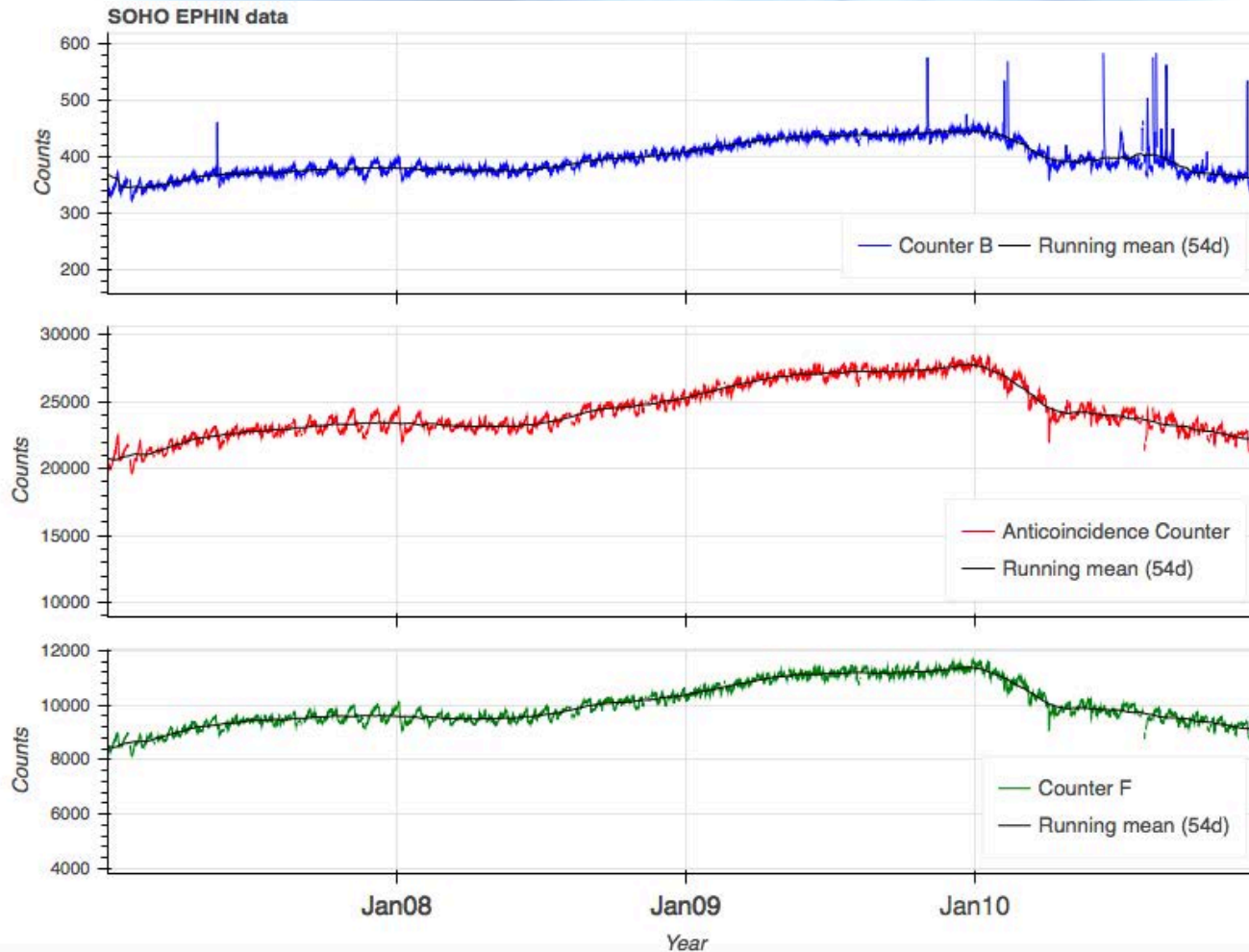- period of CH data: 1.1.2007 – 31.12.2010

SOHO EPHIN

- Electron Proton Helium Instrument (EPHIN)
- onboard SOHO spacecraft
- data available from December 07 1995
- consists of several semiconductor detectors in layers (A-F) and a scintillation detector, operated in anticoincidence
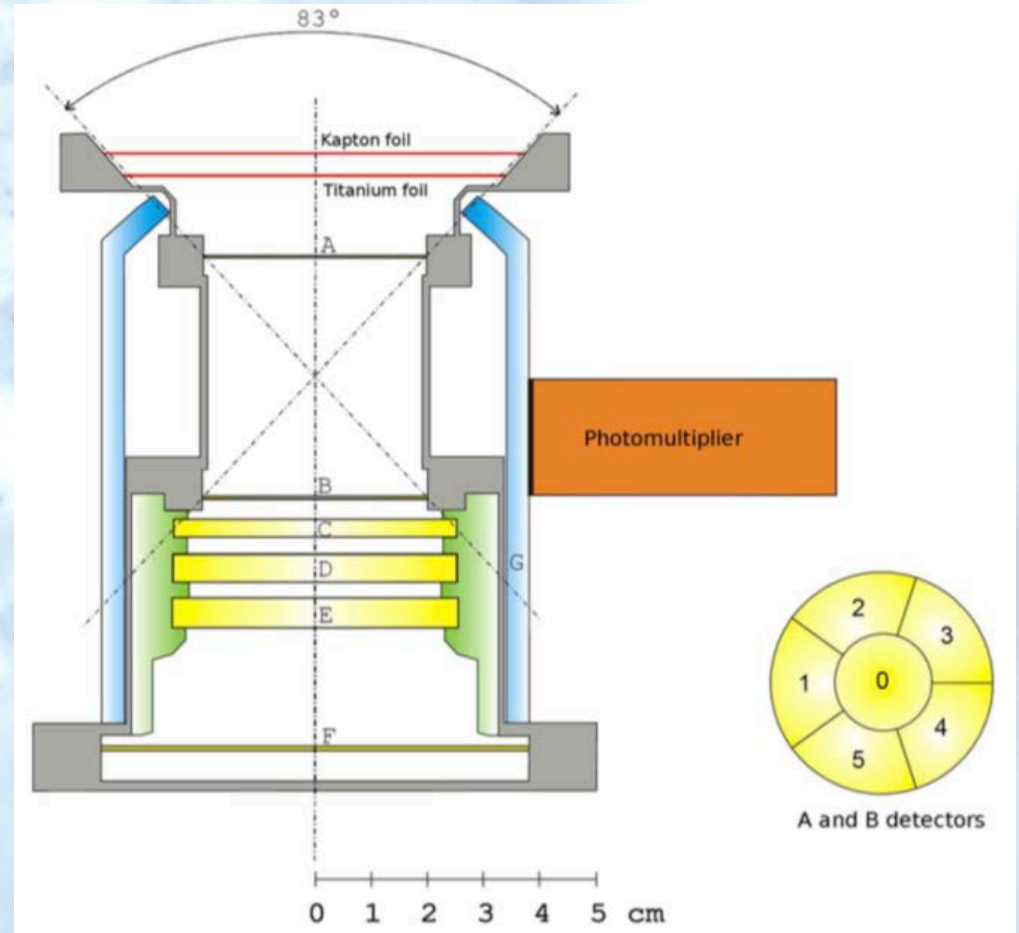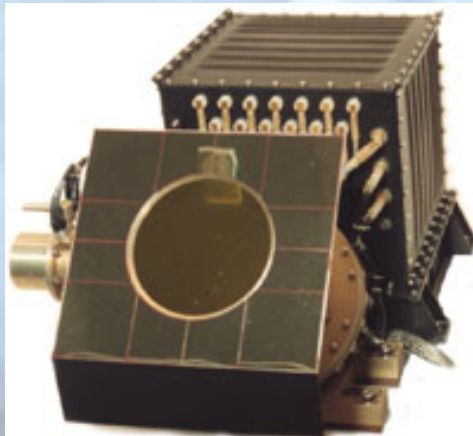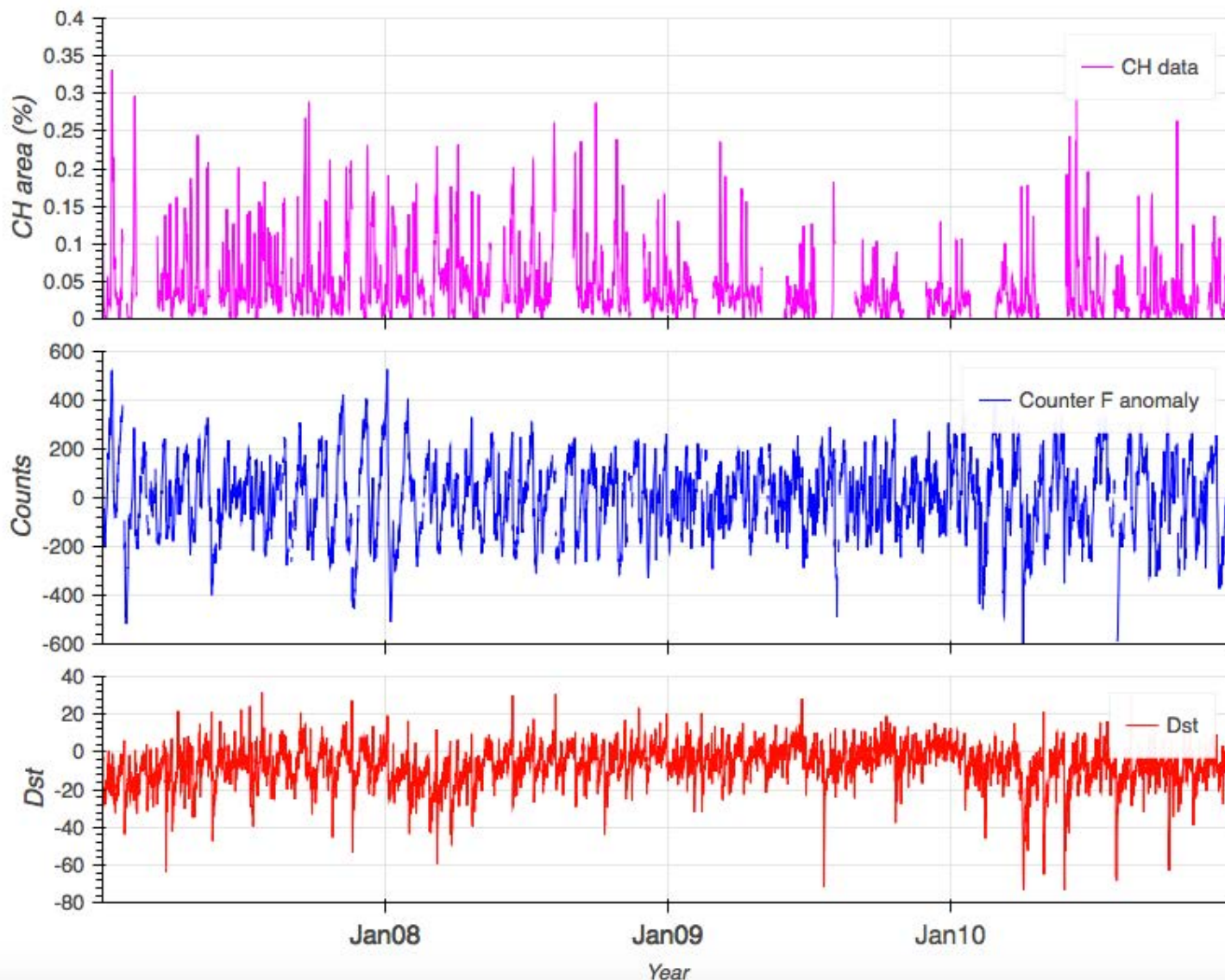
SOHO EPHIN data

Counter B
> 4 MeV/n

Anticoincidence
Counter

Counter F
> 50 MeV/n

- interpolation of small gaps in the data (up to 18h)
- anomalies are calculated subtracting the running mean (54 days)
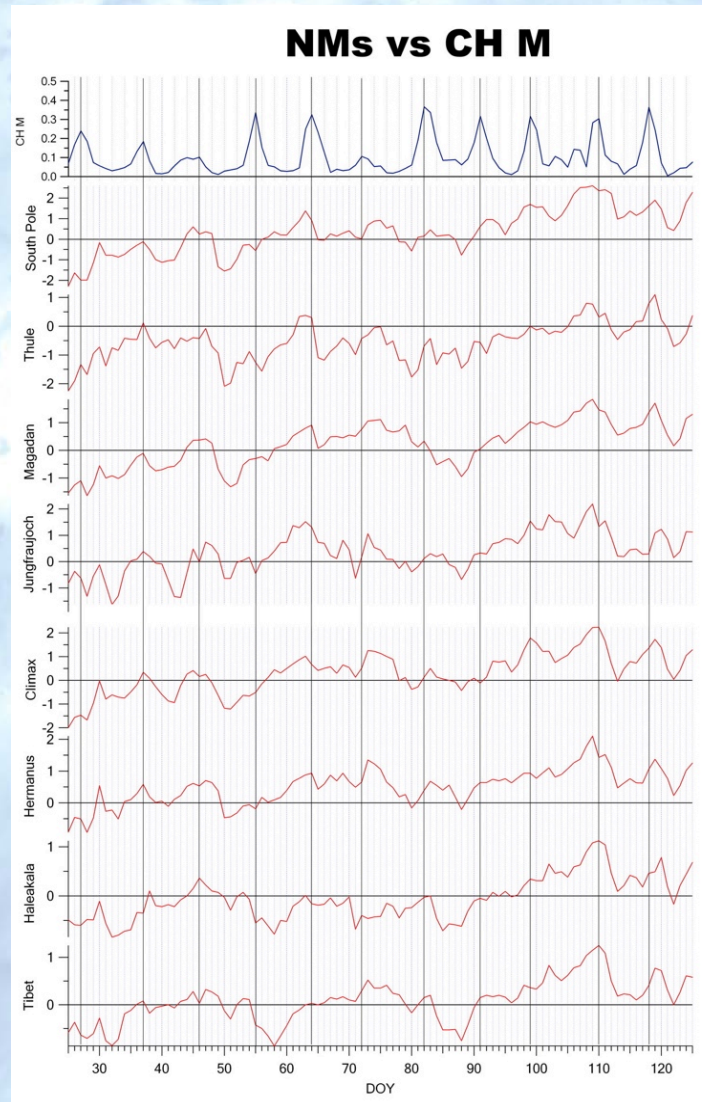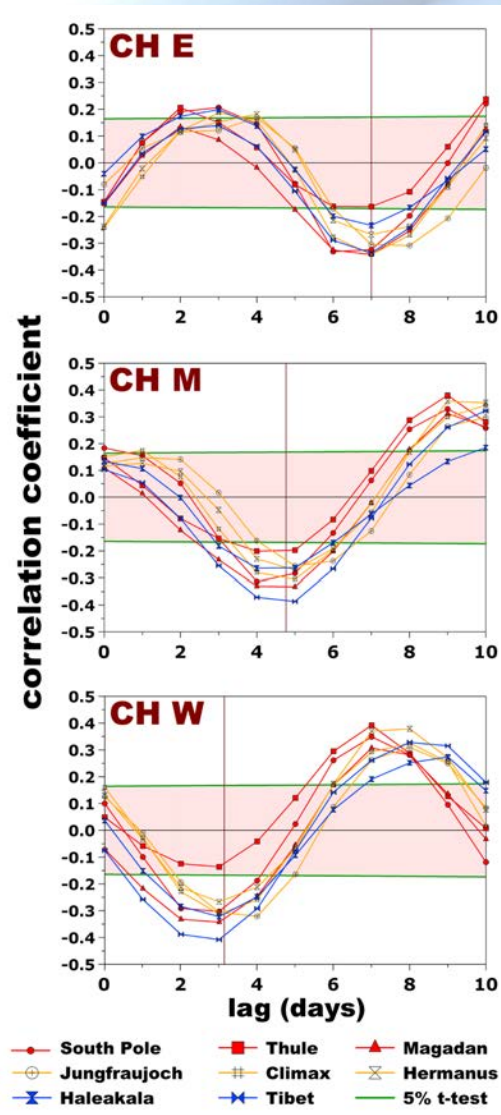
CH – EPHIN – Dst data (2007 – 2011)

CH area
23% missing data
4 measurements per day
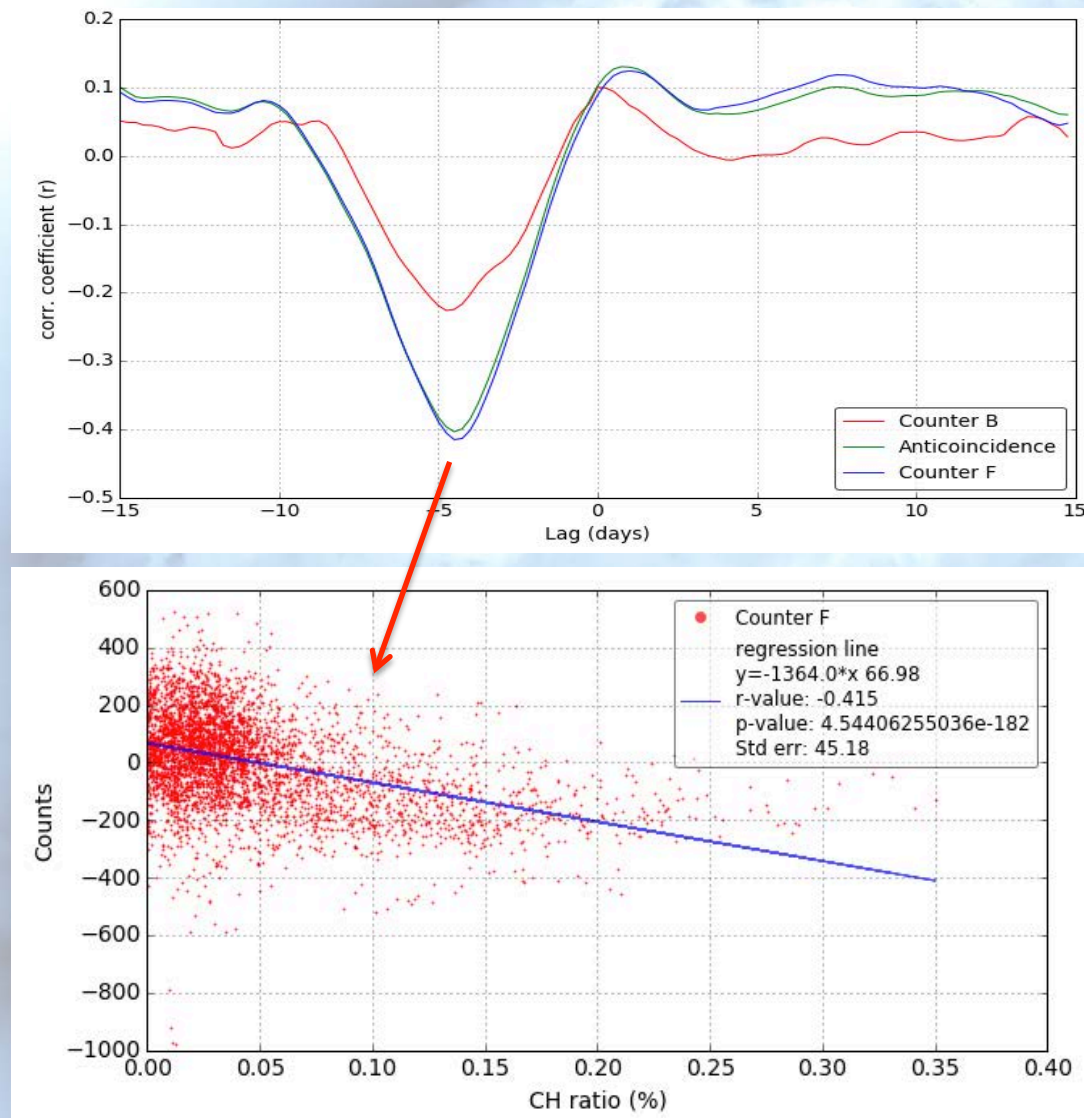
Counter F anomaly

Dst index

CH and neutron monitor data

- Period of analysis: DOY 25 – 125 in 2005

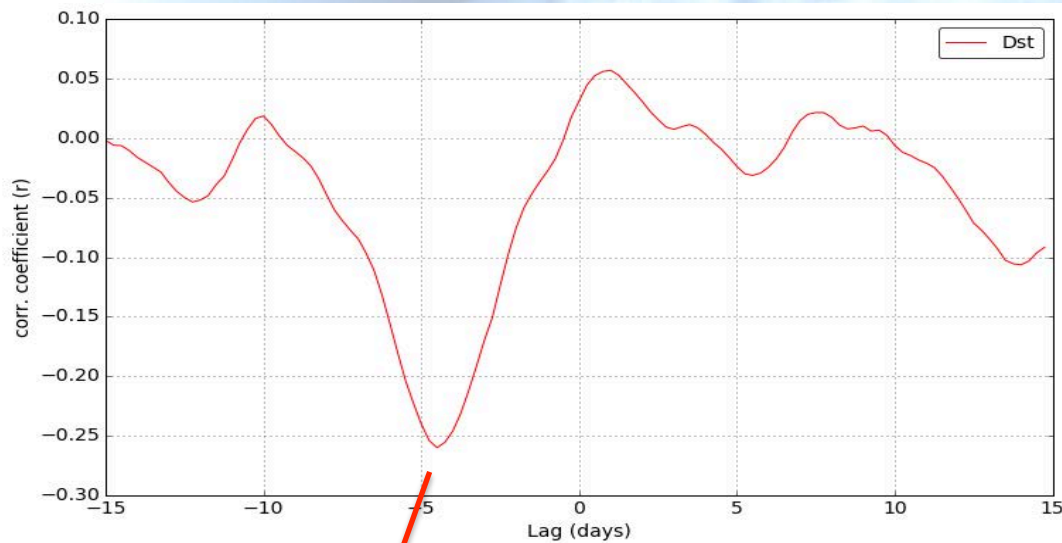- GCR flux reduced by 0.5% – 2%
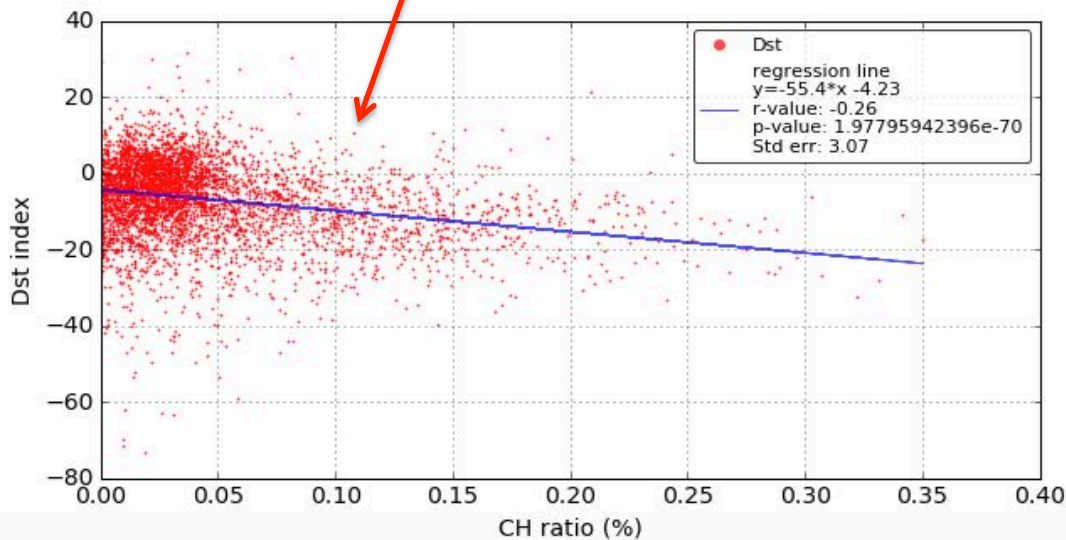- Typical lag: 4 - 5 days

Čalogović et al. 2008

CH area vs EPHIN

- Correlation with lag 4417 points (1104 days)

- Counter B:
  r = -0.23 (lag -4.75 days)

- Anticoincidence Counter:
  r = -0.40 (lag -4.50 days)

- Counter F:
  r = -0.42 (lag -4.50 days)

- Difference in travel time ±1 days (solar wind speed)

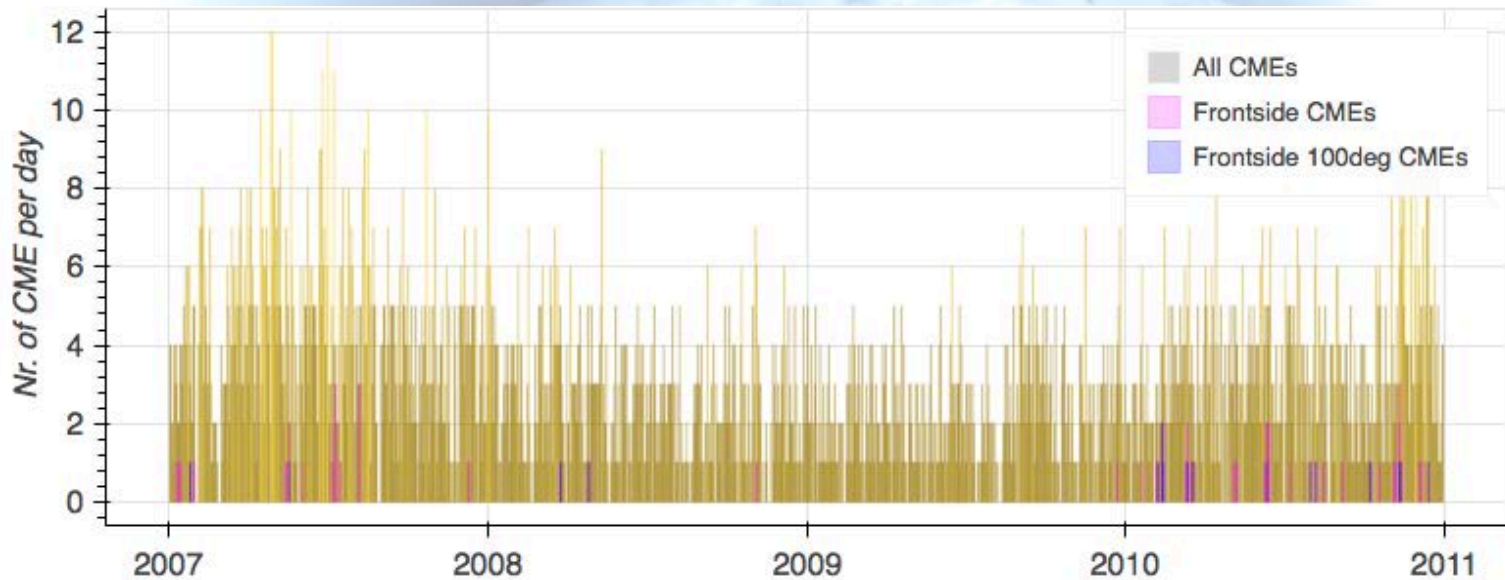# CH area vs Dst

- Correlation with lag 4417 points (1104 days)
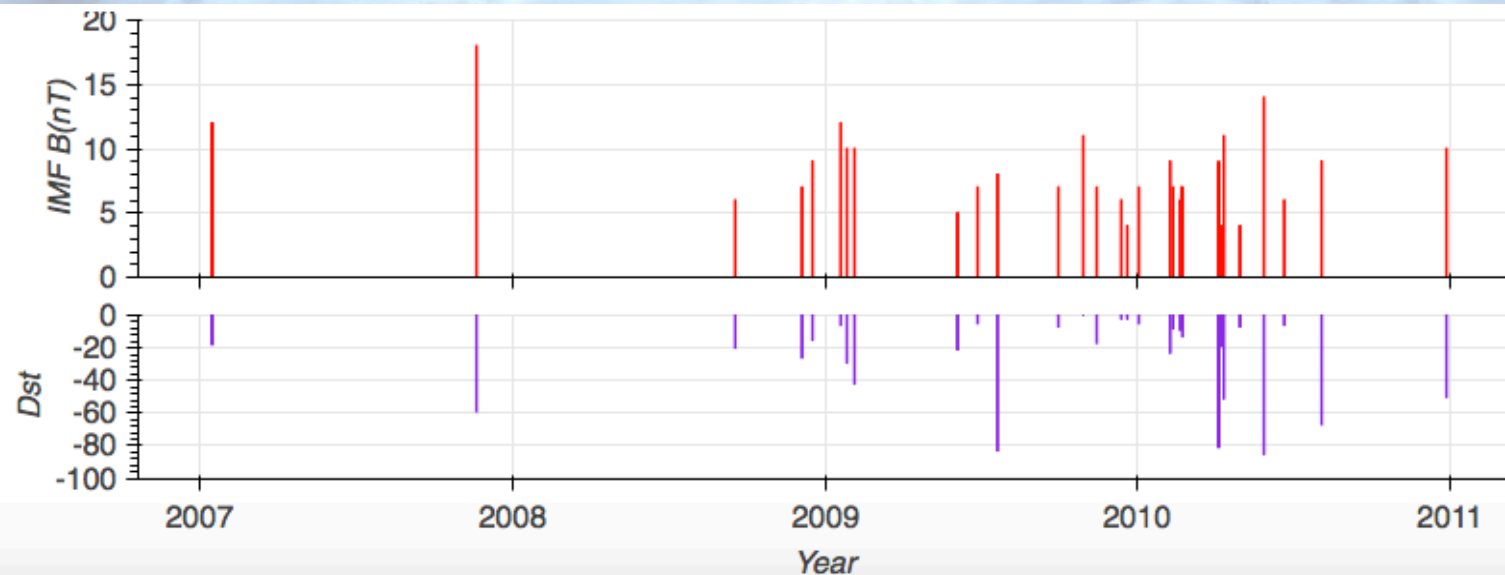
- Dst
  r = -0.26
  (lag -4.50 days)

CMEs / ICMEs
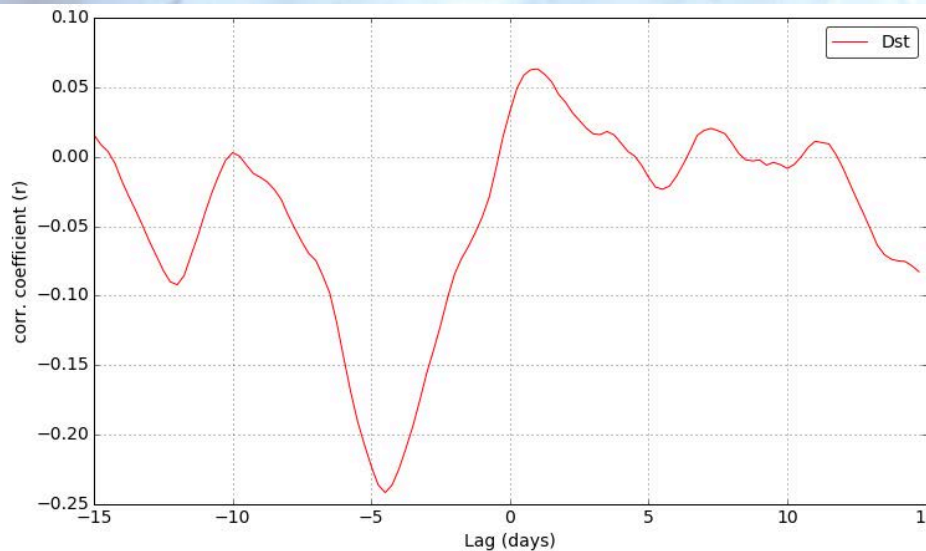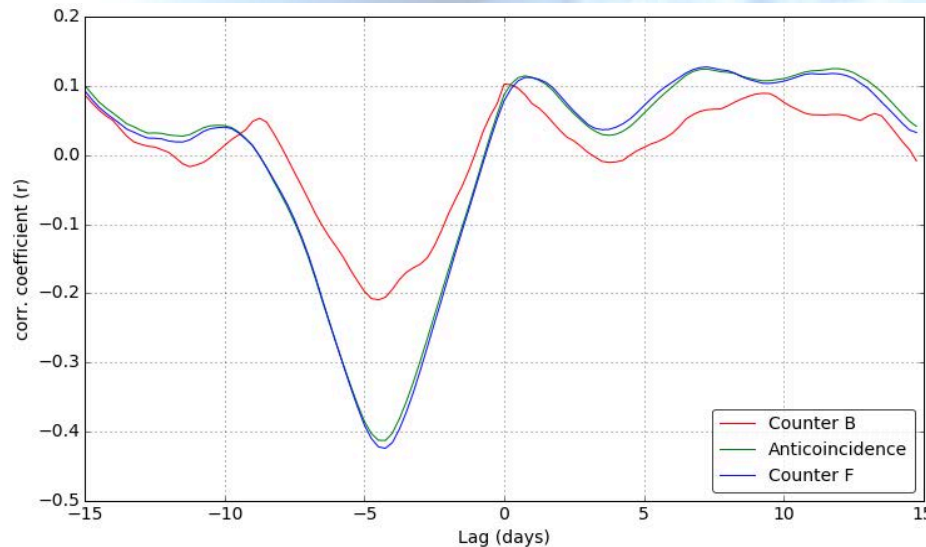## major driver of solar wind disturbances

SOHO/ LASCO CME daily data

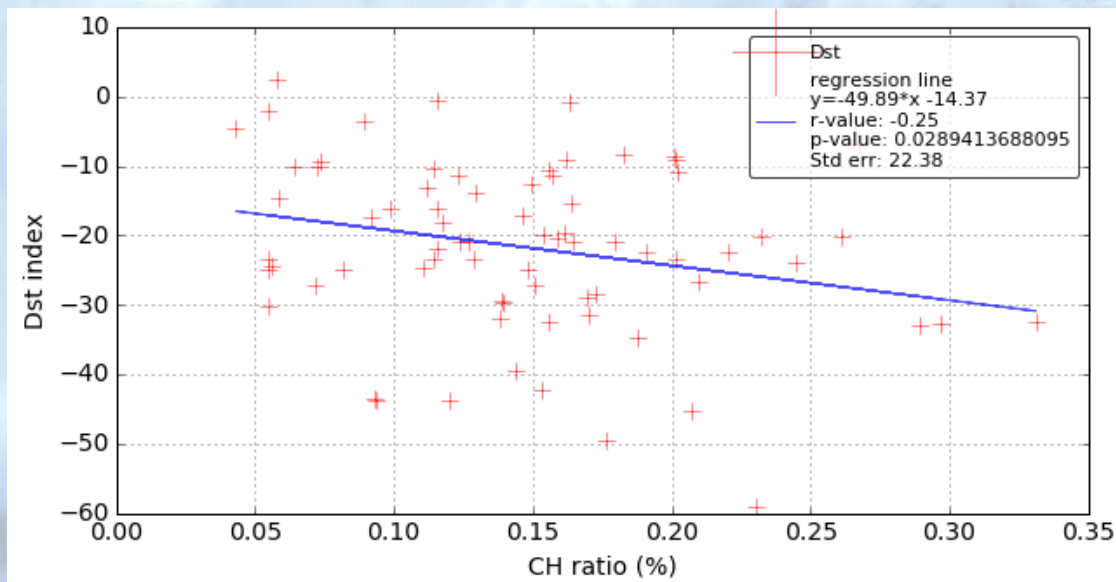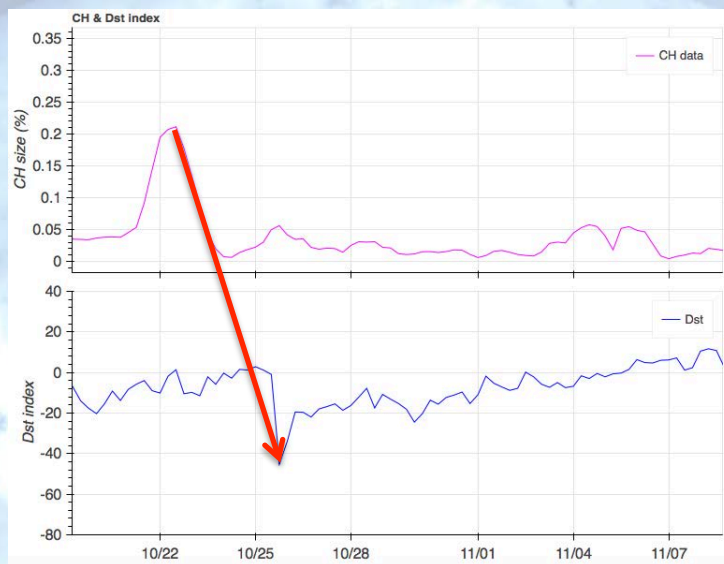ICME list (Richardson & Cane, 2010)

30 ICMEs during 2007 – 2011 period

Correlation without ICME events

- 12h before ICME event removed
- 72h after ICME event removed
- in total 9.2% data excluded (101 days)

- Counter F:
  r = -0.42 (lag -4.25 days)
- Dst
  r = -0.24 (lag -4.50 days)

- Very small difference in correlation when using all data and data without ICME events (only 30 events)

Peak to peak analysis

r = -0.25

Conclusions

- Longer analysis period 2007 – 2011 allows better statistics than in the previous studies

- Distinct correlation between Coronal Hole (CH) area and EPHIN cosmic ray flux measurements (r=0.4) as well as Dst index (r=0.26)

- Max. correlation for lag of 4.5 days

- Opportunity to forecast a geoeffectiveness of CIRs as well as their effect on the cosmic-ray flux during the solar minimum in the absence of ICMEs

- Better forecast should be obtained by including the CH polarity data

Thank you for your attention!