LSO/KSO Hα prominence catalogue: status report – 2022/11/09

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AISAS colloquium, Tatranská Lomnica, 2022/11/09

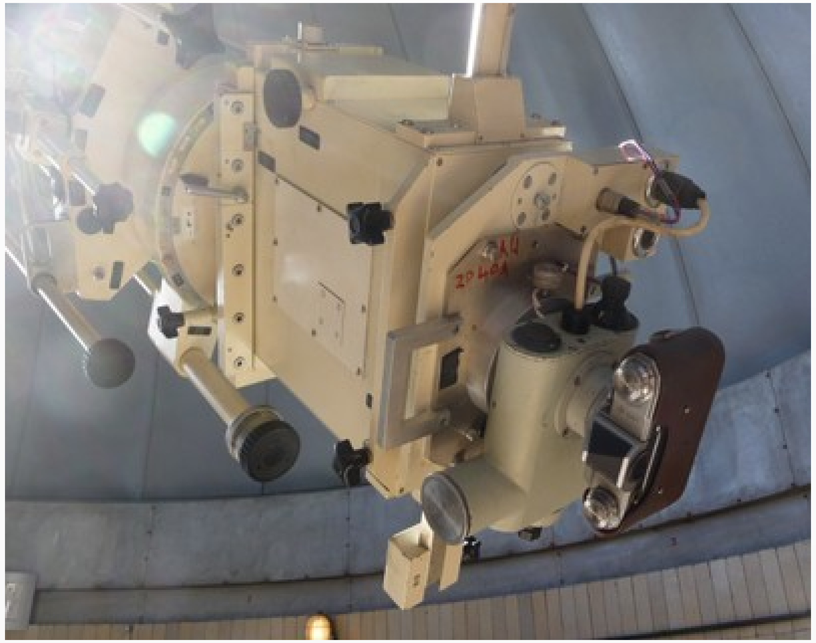
Notes

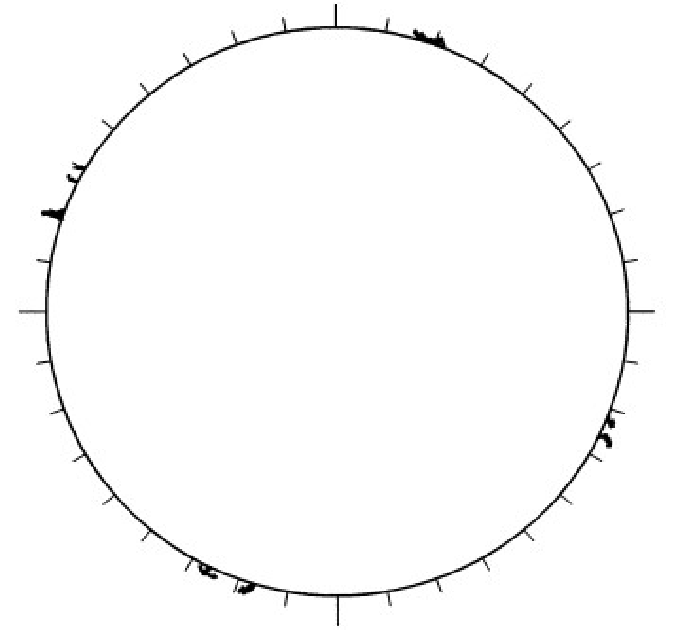
- My third lecture in this year:
  - 23/02/2022, J. Rybák a LSO skupina: 'Lomnicky Stit Observatory: last two years – 2020-2021'
  - 27/04/2022, J. Rybák, 'The Lomnicky Stit Observatory: CMOS detectors for solar observations'
  - 09/11/2022, J. Rybák, V. Rušin, P. Gömöry, M. Morris, W. Pötzi, D. Baumgartner, H. Freislich, H. Strutzmann, A. Veronig, LSO/KSO Hα prominence catalogue: status report – 2022/11/09
- A part of the presentation: old stuff presented more than 10 years ago at the AISAS colloquium – for young colleagues (only briefly)

LSO Hα prominence project

- 1967-2009 - daily measurements, PI: V. Rušin
- coronagraph ZEISS 200/3000/4000, interference filter ~0.6 nm, film 24x26 mm, several exposures along the limb, development with a high contrast, projection for drawing of shapes of prominences, measurement of parameters
- parameters: position angle, limb, latitude, longitude, area, height, subjective brightness (1,2,3)
- 05/1967 - 08/2009:

  41795 data records



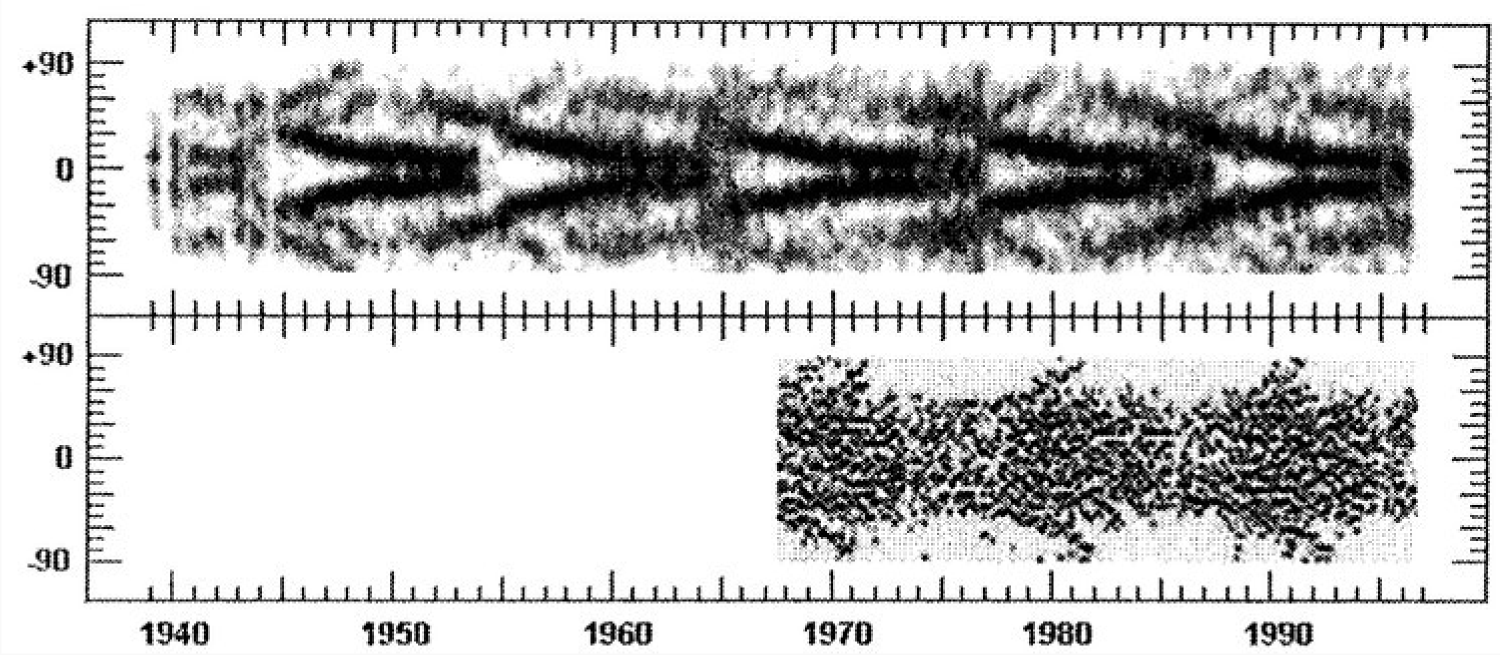


LSO Hα prominence project

- Main articles:
  - “Catalogue of solar prominences (1967 – 1986)”, Rušin, V.; Rybanský, M.; Dermendjiev, V.; Stavrev, K. Ya., CAOSP, Vol. 17, **p. 63 – 292**, 1988 (paper)
  - “Catalogue of solar prominences 1987 – 1993”, Rusin, V.; Rybansky, M.; Dermendjiev, V.; Stavrev, K. Ya., CAOSP Supplement, vol. 24, **p. 135-136**, 1994 (data upon request on “author‘s PC diskettes“)

530.3 nm

656.3 nm



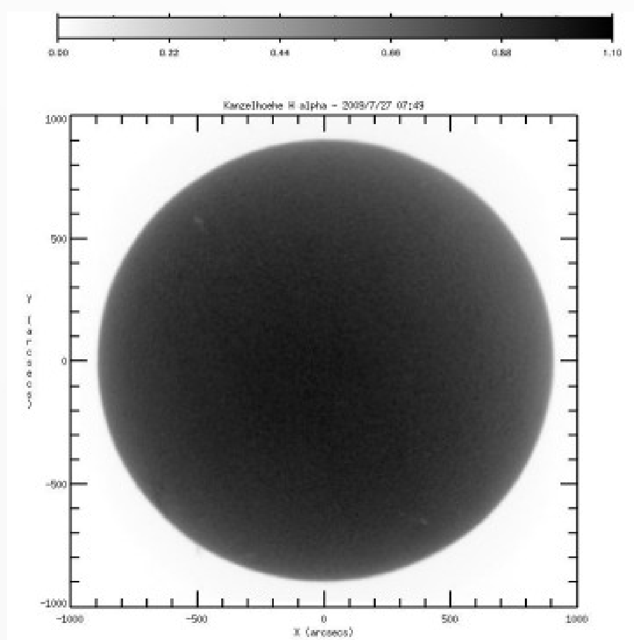
Minarovjech, M, Rybanský, M, Rušin, V, 1998, Solar Physics 177: 357–364

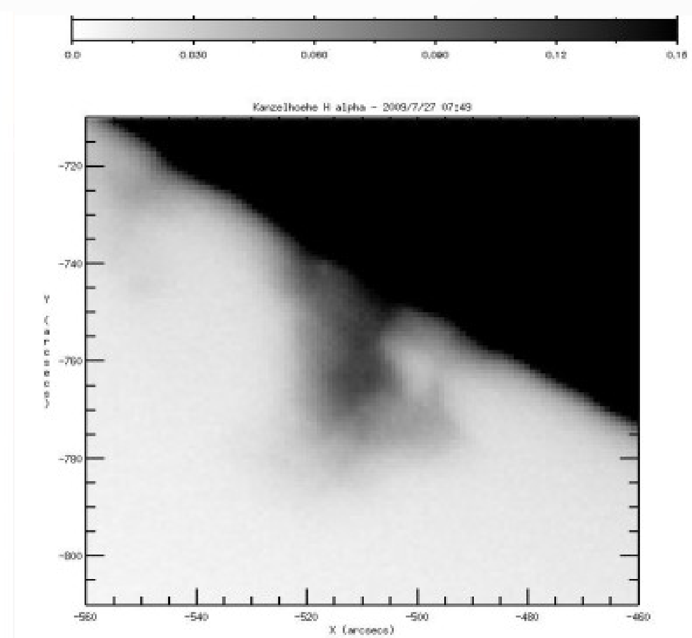
KSO Hα prominence project

- Observatory Kaznelhőhe for solar and environmental research (Austria)
- refractor 100/2000, Lyot filter Zeiss 656.3 nm, FWHM 0.07 nm
- camera Pulnix TM4200GE, 12bit, 2kx2k, 1.02”/px, 3 exposures: 5, 20, 50 ms
- 09/2009 – 12/2021: 27304 prominences

KSO Hα prominence project

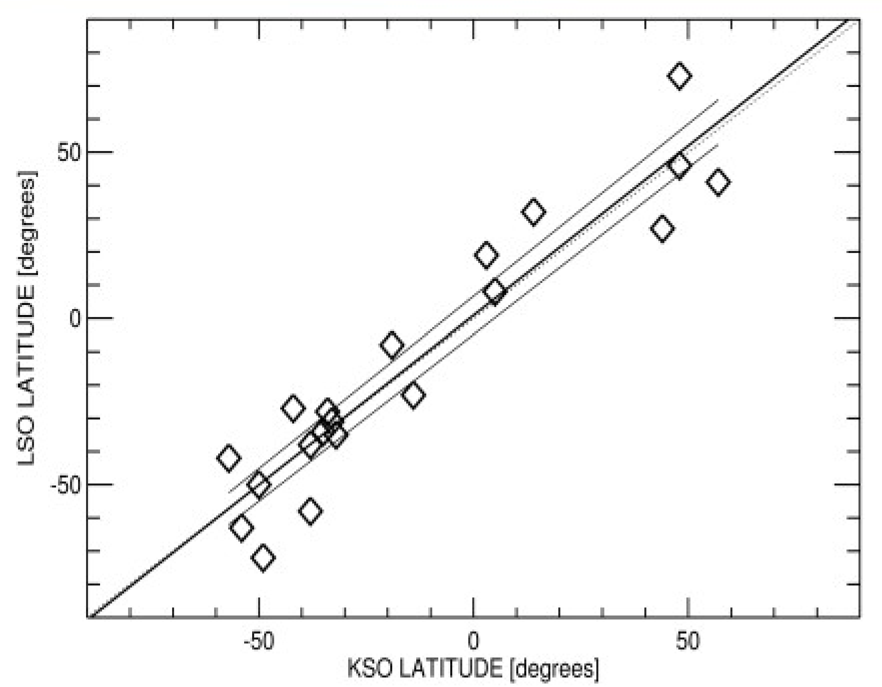
- A careful **manual** 2-step checking of the available KSO data – daily single full set of 3 images – t_exp=5, 20, 50 ms: completeness of the set, clouds effects
- The **automatic** data reduction and determination of the prominence parameters: merging of images, subtracting of the scattered light, calibration to absolute energetic units, identification of the individual prominences
- The prominence parameters: area, maximum & mean & total brightness, position angle, width → heliographic latitude and longitude, height, area

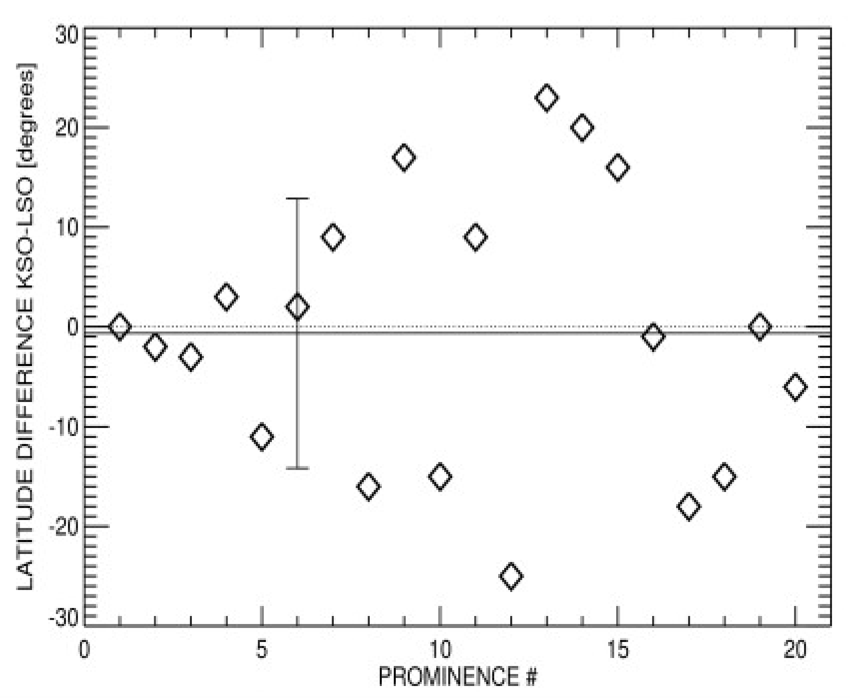




KSO Hα prominence project

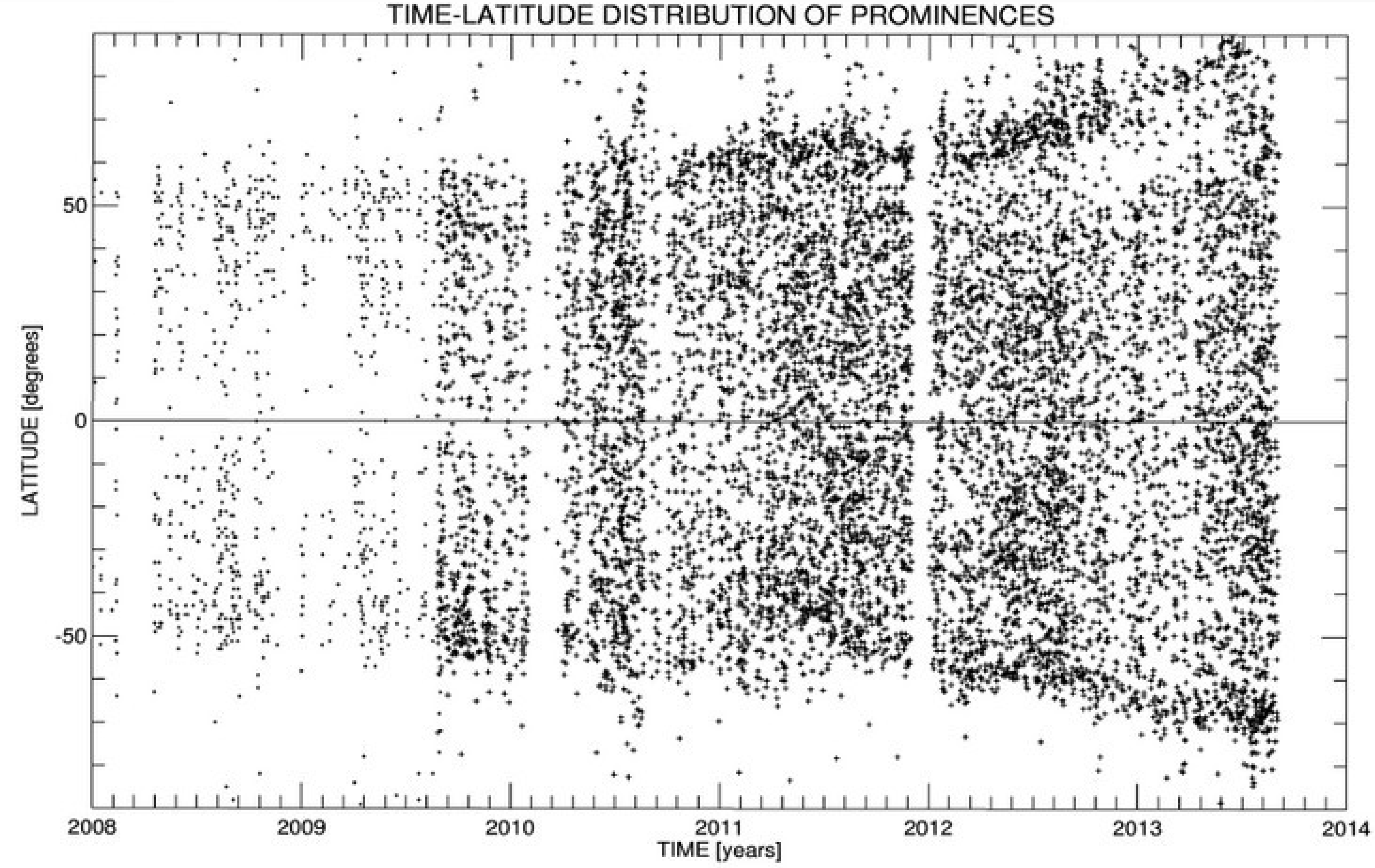
- Intercalibration of the LSO ~ KSO prominence parameters:
  - Rybák, J. ; Gömöry, P. ; Mačura, R. et al., “The LSO/KSO Hα prominence catalogue: cross-calibration of data”, 2011, CAOSP, 41,133-136
  - crosscalibration: the heliographic latitude results – shift 0.65+/-13.5 degrees





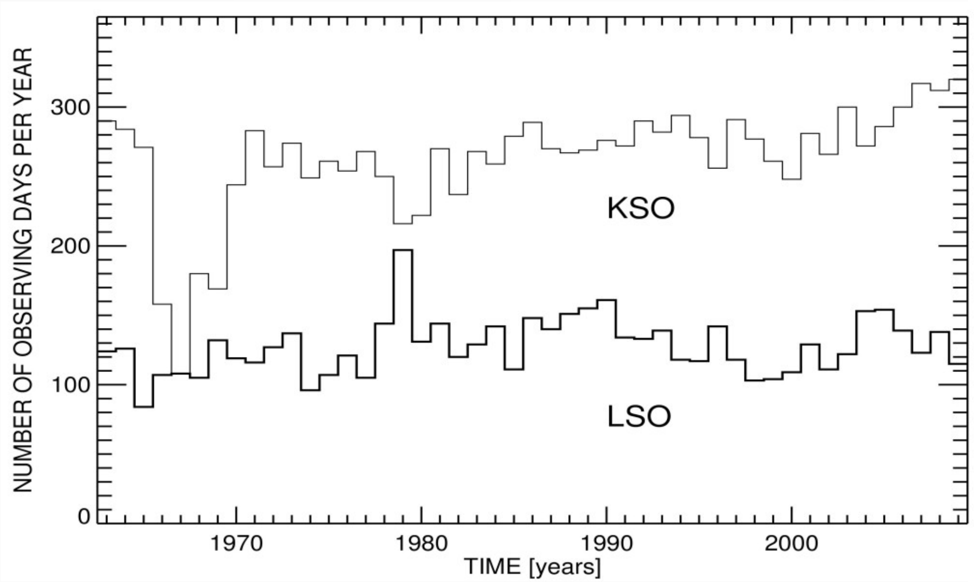
LSO/KSO Hα prominence catalogue

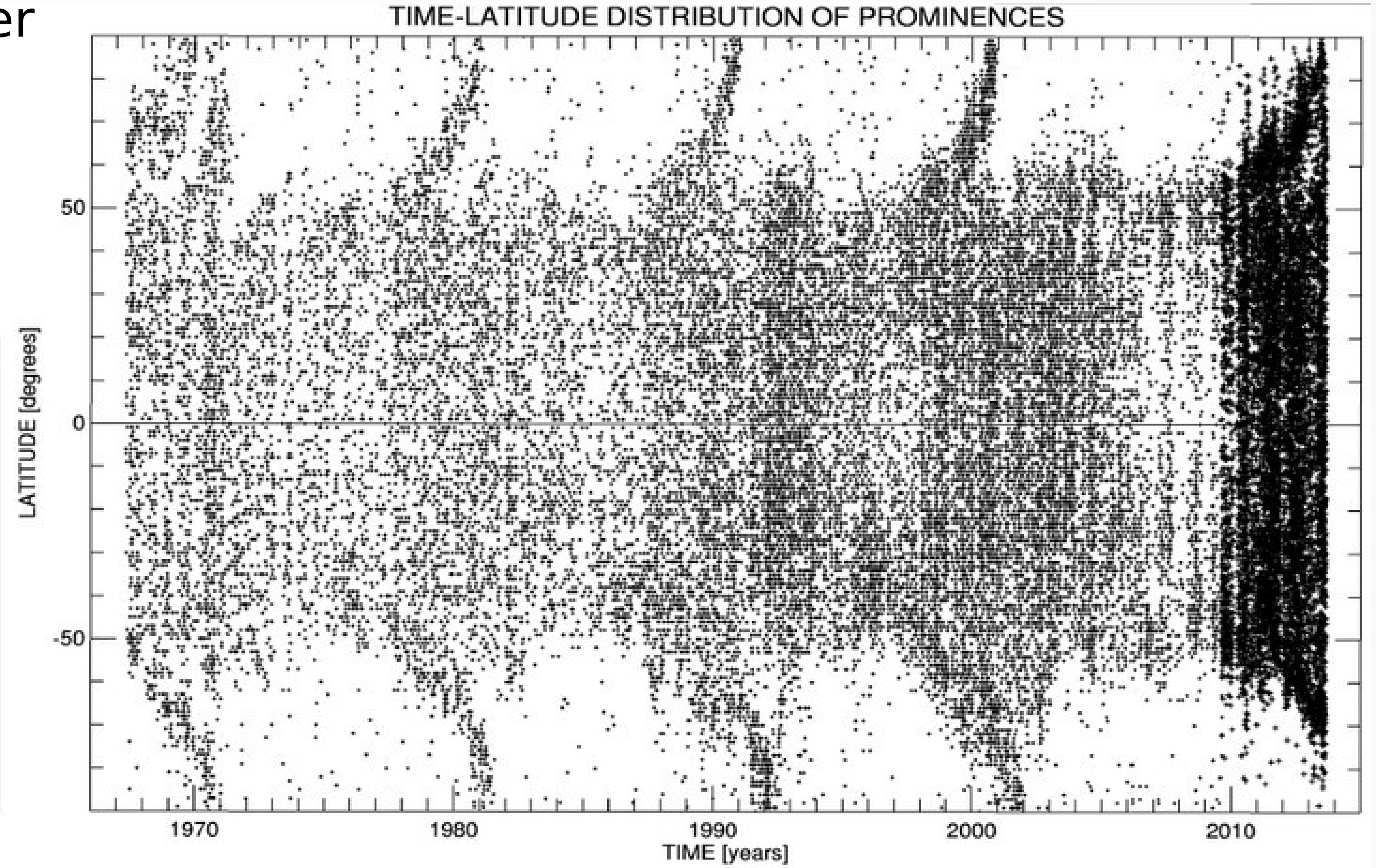
- Pros: more data, more precise determination of parameters
- Cons: narrower filter passband (±150 km/s → ±20 km/s)
- Current status - 31/12/2021:
  - LSO: 05/1967 - 08/2009: 41795 prominences
  - KSO: 09/2009 - 12/2021: 27304 prominences
  - LSO: ~82 proms/month
    KSO: ~182 proms/month



LSO/KSO Hα prominence catalogue

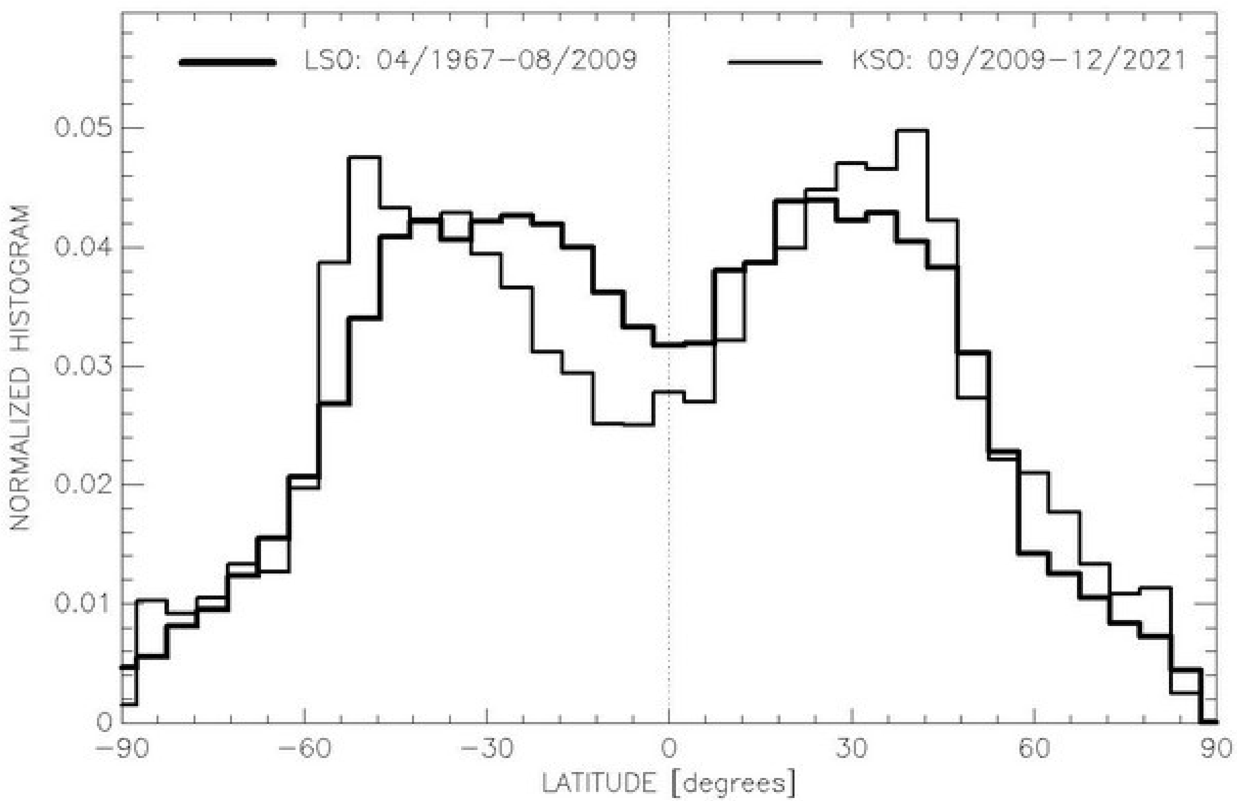
- Current status – 31/12/2021: LSO: 05/1967 - 08/2009: 41795 prominences, KSO: 09/2009 - 12/2021: 27304 prominences → LSO ~82 proms/month and KSO ~182 proms/month
  - Mostly effect of the number of observing days

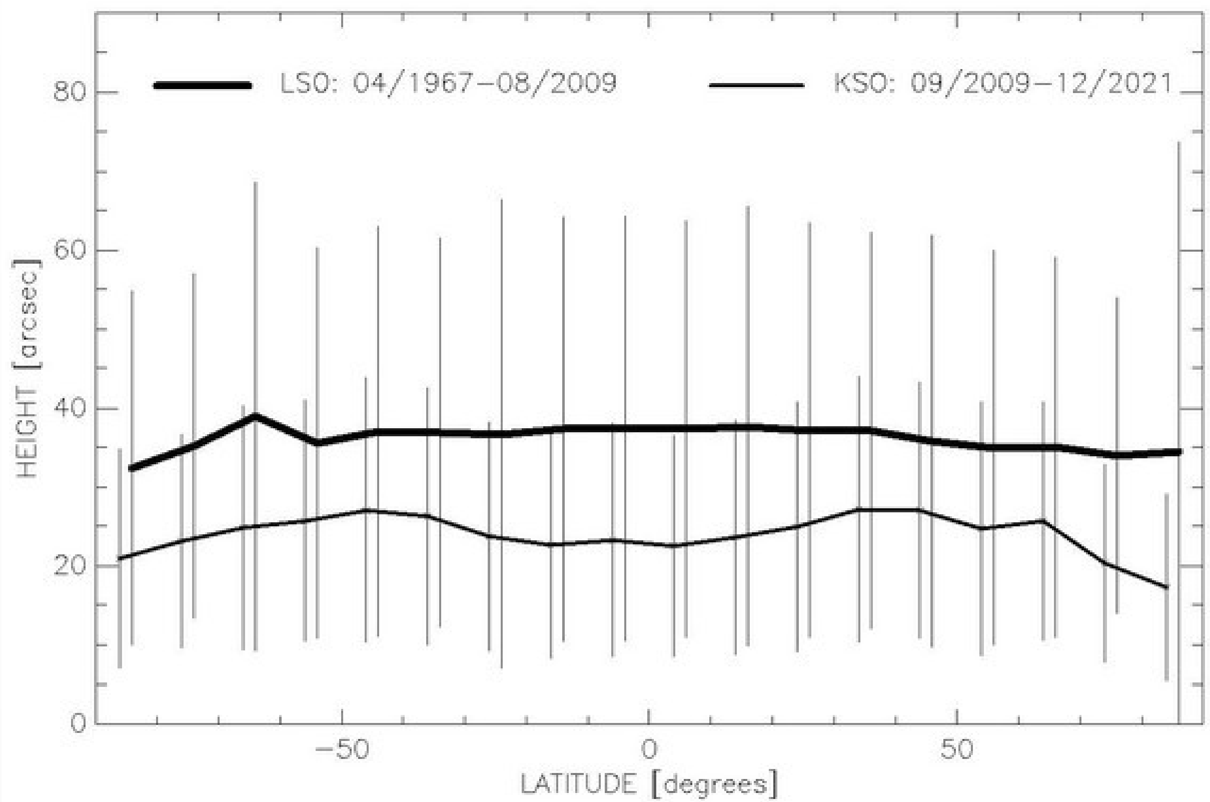




LSO/KSO Hα prominence catalogue

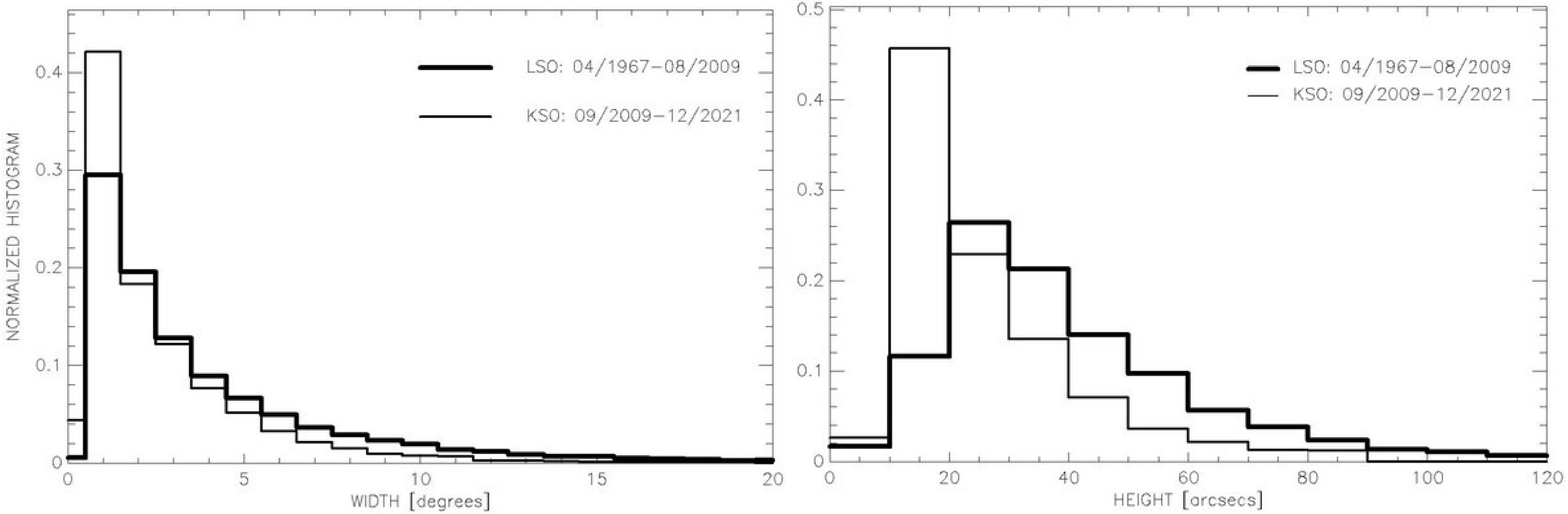
- Statistical properties: distribution in latitude, height ~ latitude





LSO/KSO Hα prominence catalogue

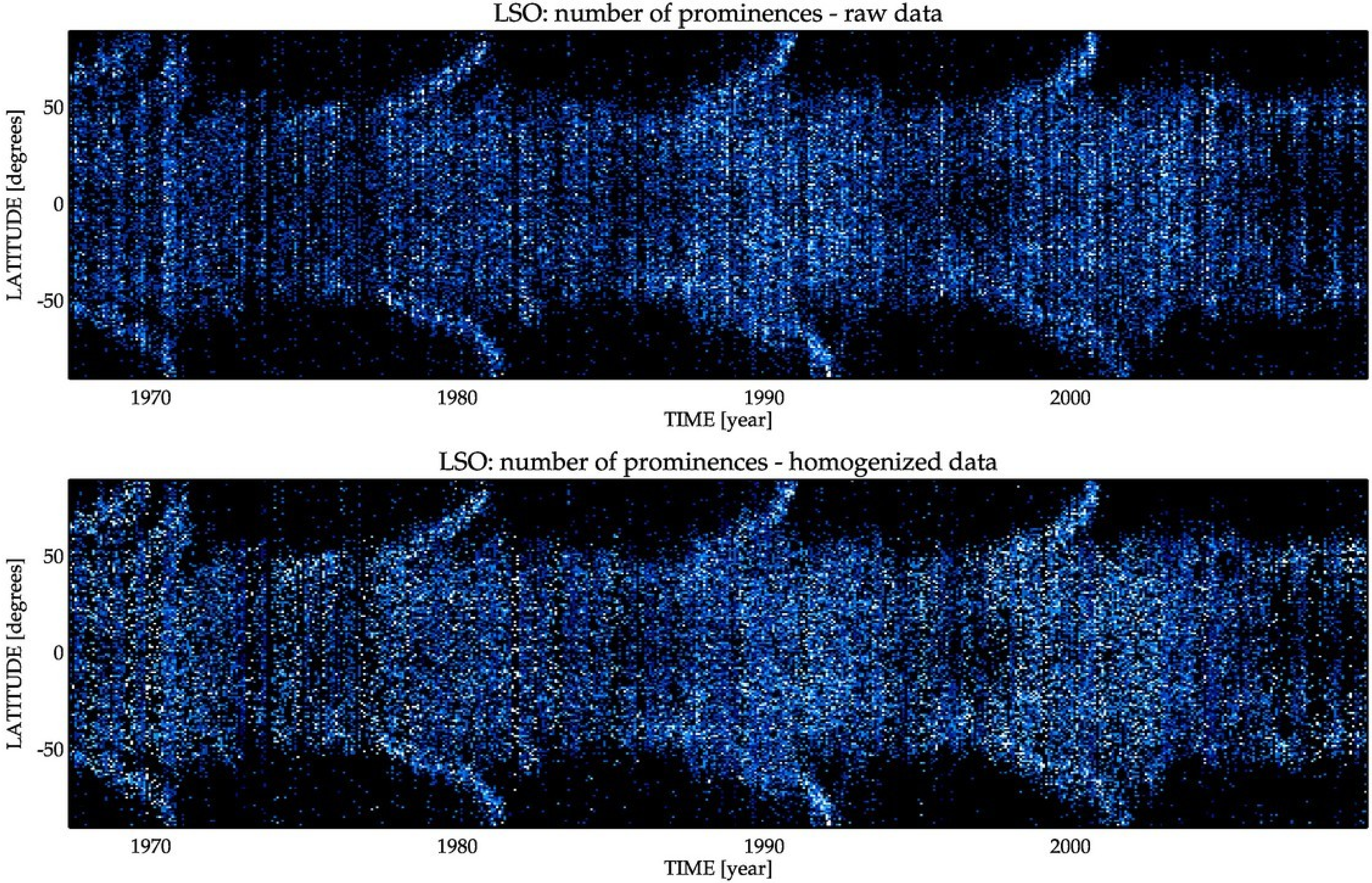
- Statistical properties: width distribution, height distribution → w>1.5°and h>20”



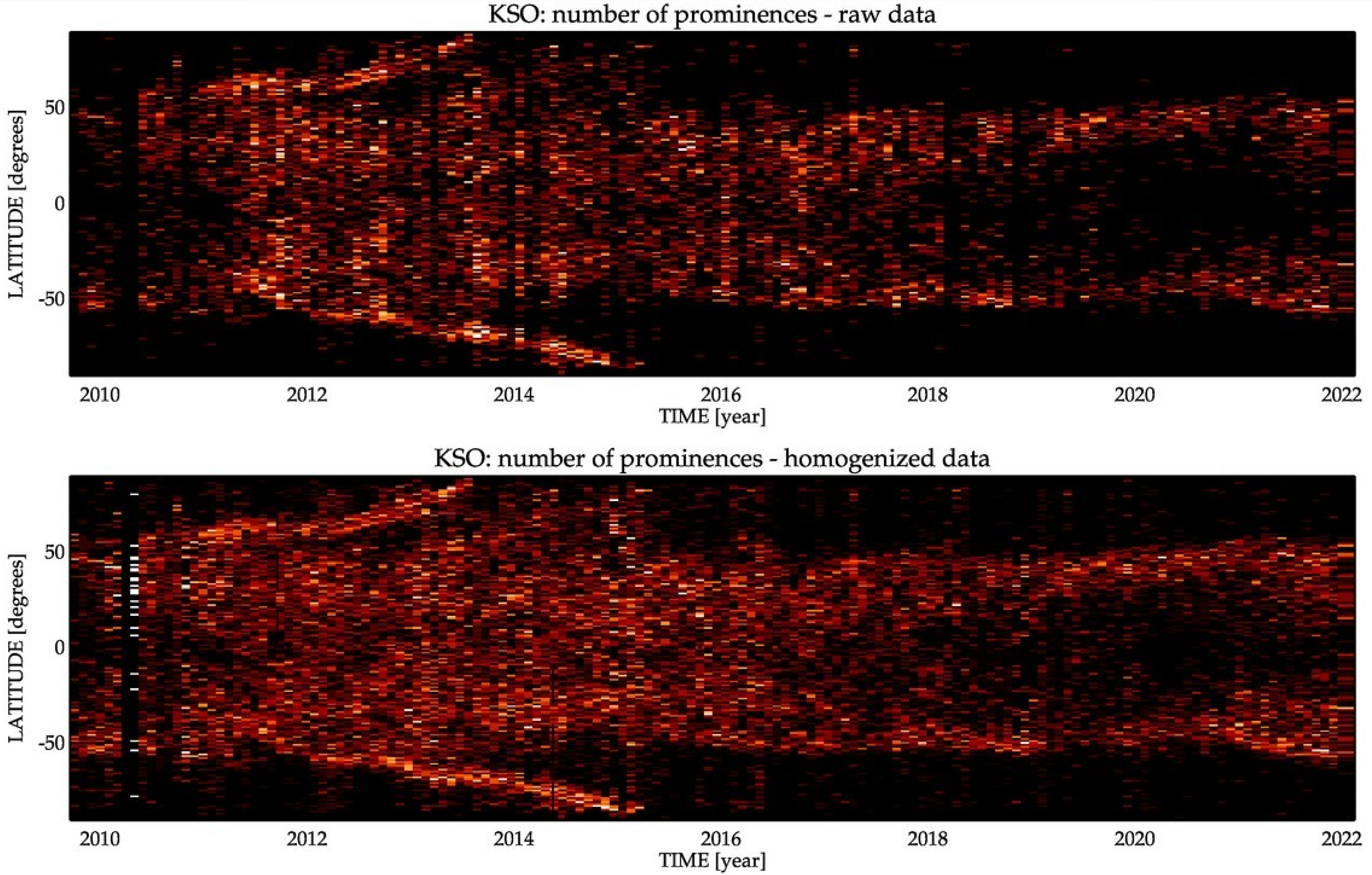
LSO/KSO Hα prominence catalogue

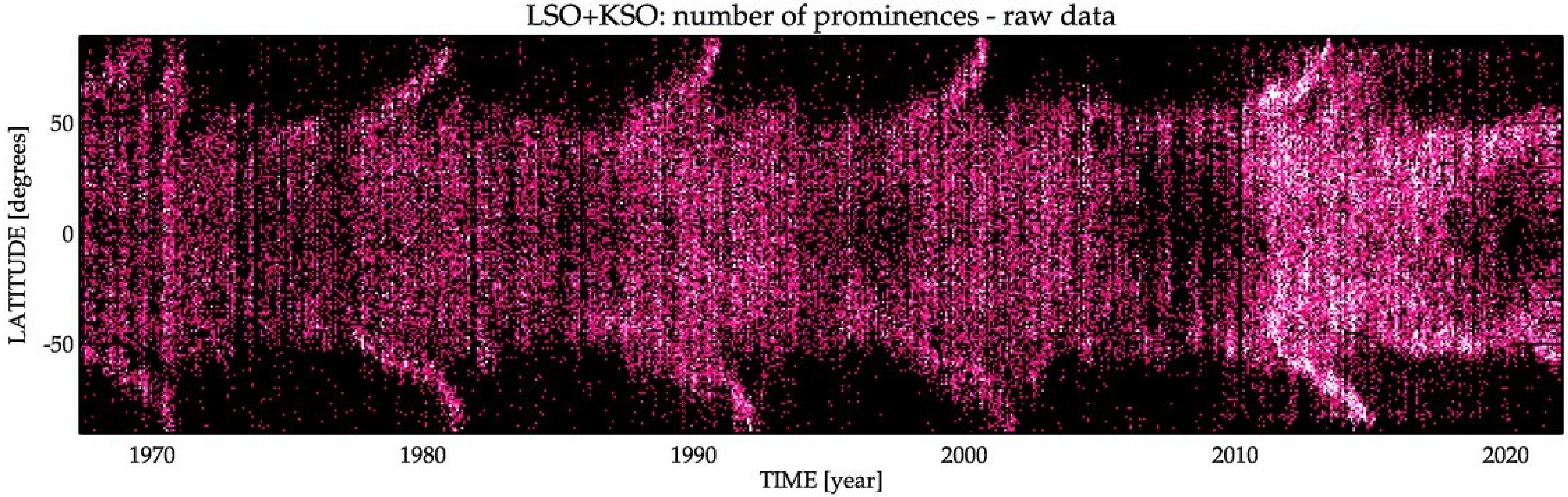
- the targer relation: The time - latitude distribution of the prominences
- the selected parameter: number of the prominences (w>1.5°and h>20”) in bins of dimensions: time - calendar month x latitude - 10°
- homogenization for the filling factor of the observing days in a month

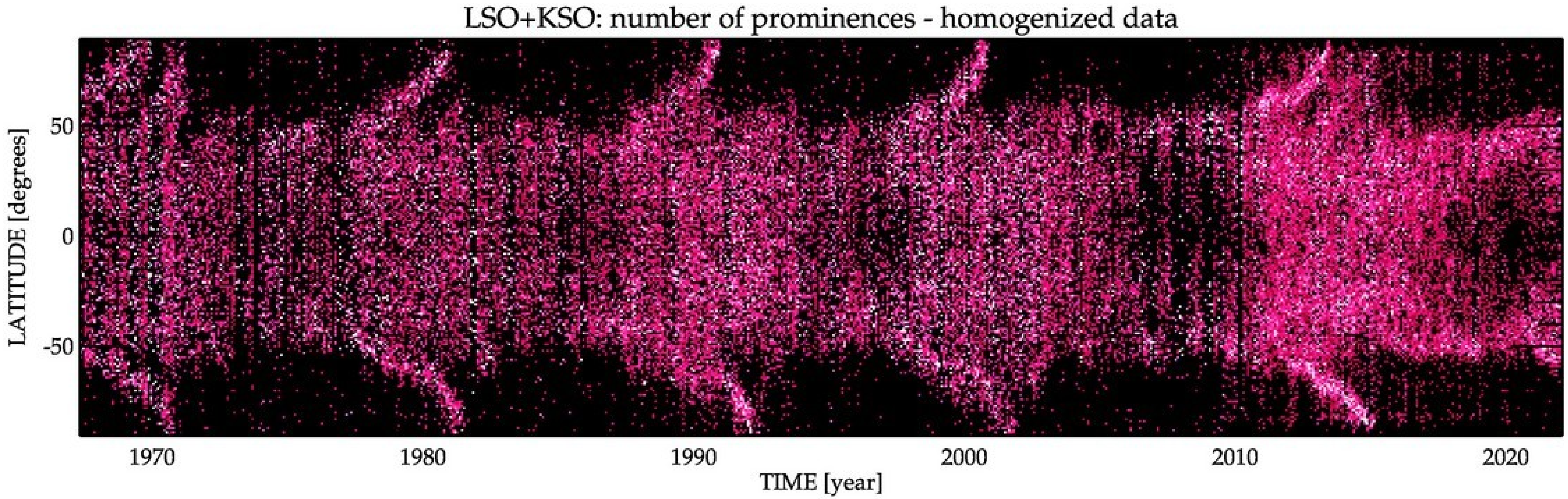
- LSO/KSO catalogue – actual status & used display settings:
  - Time: 05/1967 – 12/2021, d_time: 1 month
  - Latitude: -90, +90, d_latitude: 10°
  - Parameter: number of the prominences – raw data ~ homogenized data
  - the optimum dynamic range for display purposes: limits, sqrt(number)



LSO: number of prominences - raw data
LATITUDE [degrees]
50
0
-50
1970
1980
1990
2000
TIME [year]
LSO: number of prominences - homogenized data
LATITUDE [degrees]
50
0
-50
1970
1980
1990
2000
TIME [year]


KSO: number of prominences - raw data
LATITUDE [degrees]
50
0
-50
2010
2012
2014
2016
2018
2020
2022
TIME [year]
KSO: number of prominences - homogenized data
LATITUDE [degrees]
50
0
-50
2010
2012
2014
2016
2018
2020
2022
TIME [year]

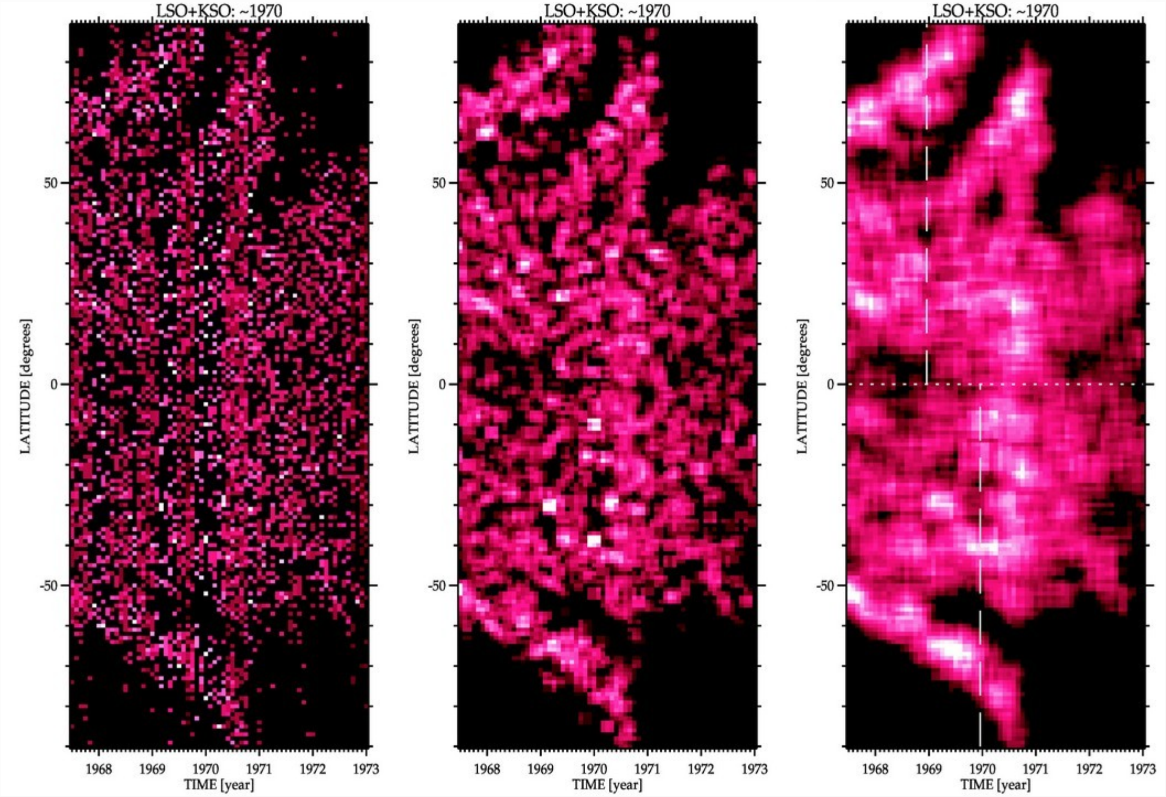

LSO+KSO: number of prominences - raw data
LATITUDE [degrees]
50
0
-50
1970
1980
1990
2000
2010
2020
TIME [year]

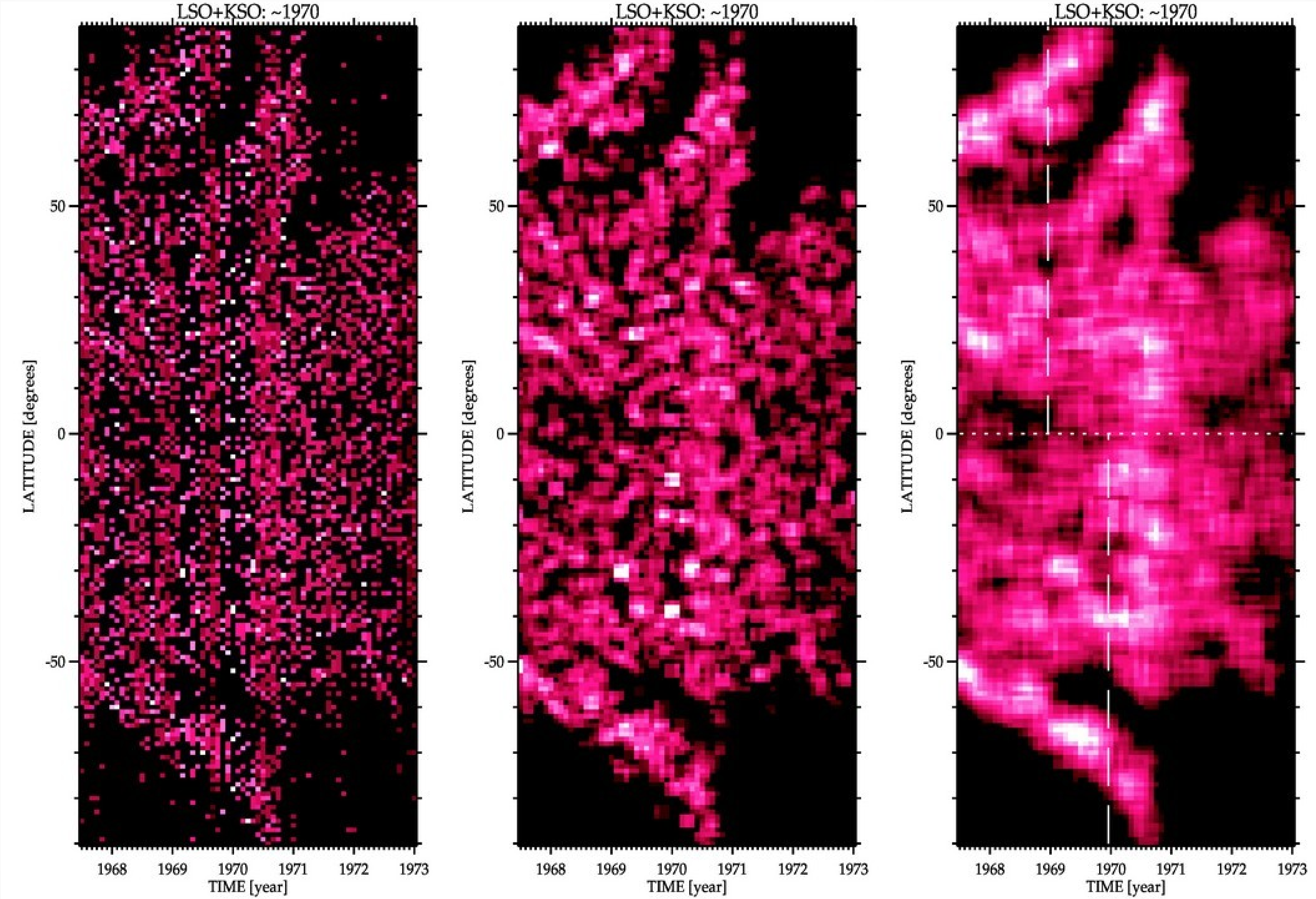

LSO+KSO: number of prominences - homogenized data
LATITUDE [degrees]
50
0
-50
1970
1980
1990
2000
2010
2020
TIME [year]

Polar branches

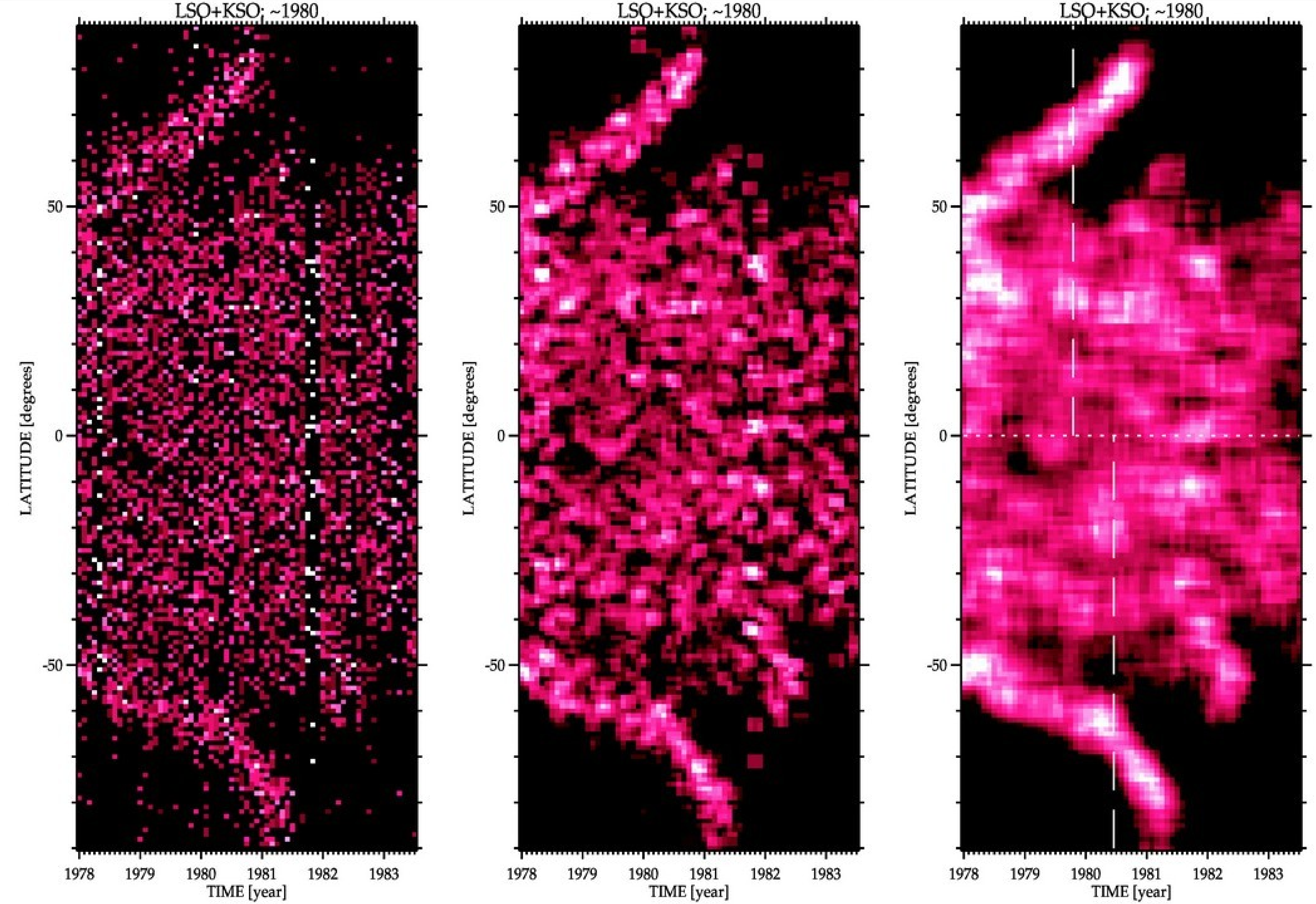
- Cycles & hemispheres
- The primary and the secondary polar branches
- The presented results: homogenized data:

  without + with a smaller + with a larger smoothing (marks: sunspot maxima)

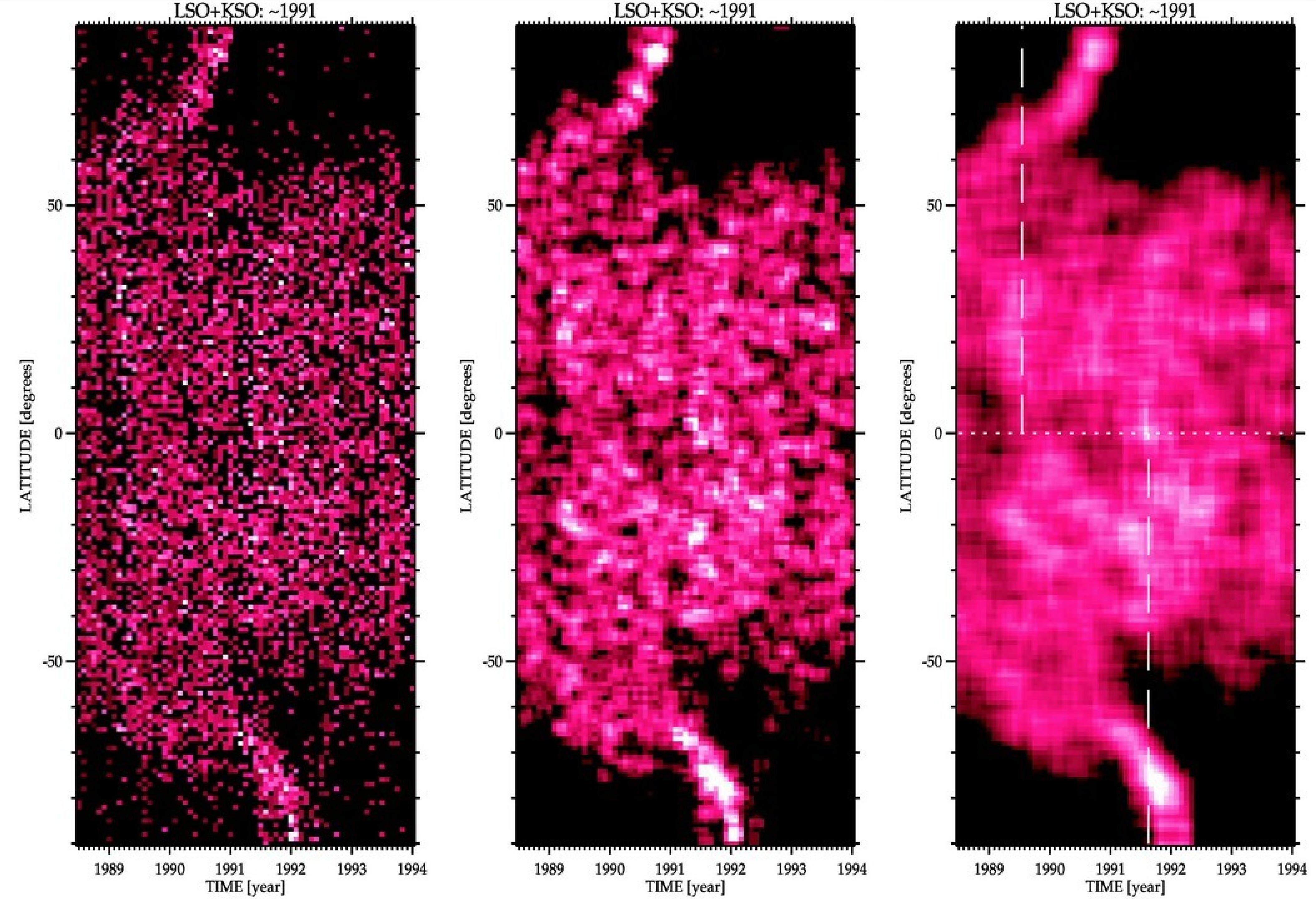


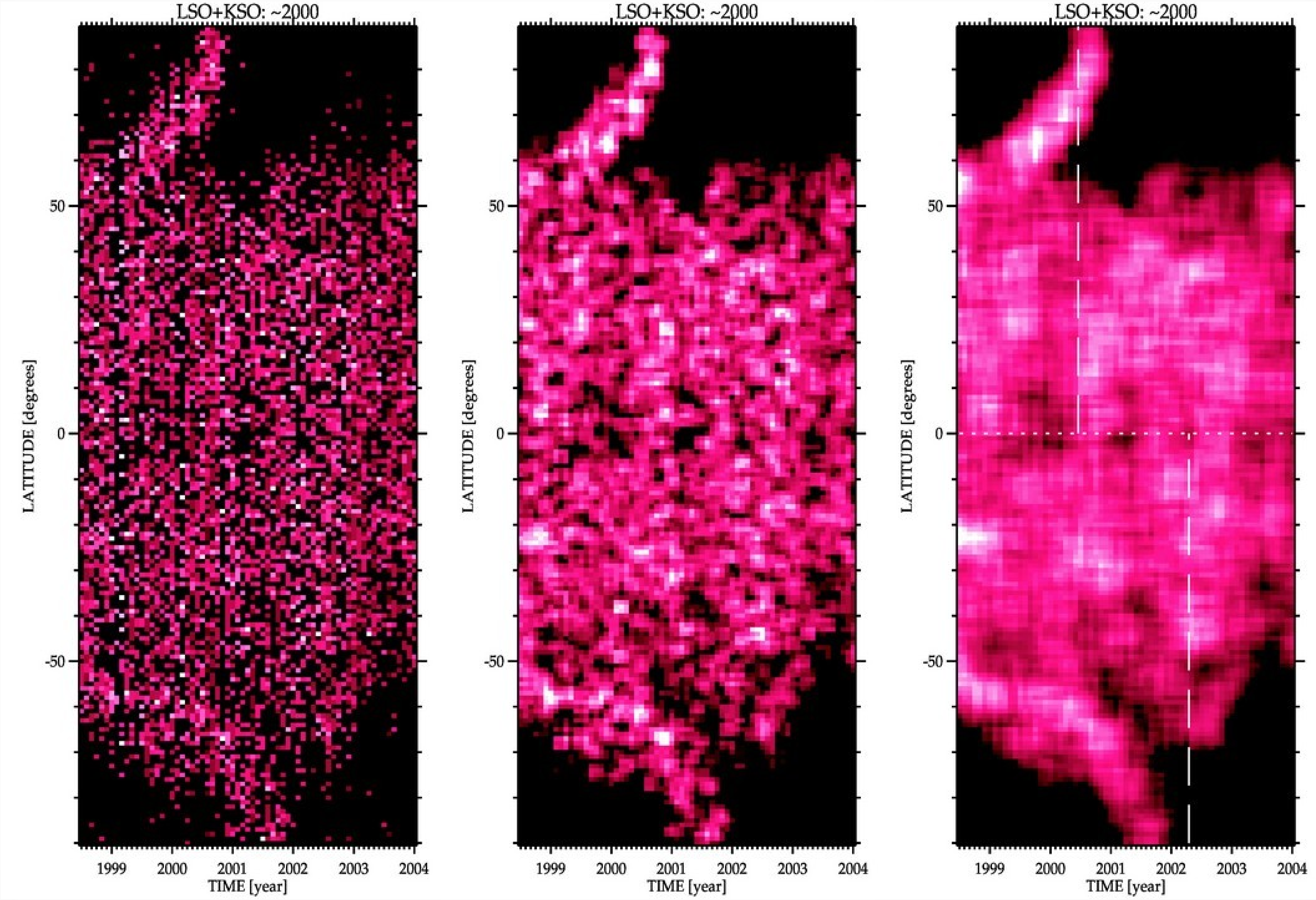


LSO+KSO: ~1970
LSO+KSO: ~1970
LSO+KSO: ~1970
LATITUDE [degrees]
50
0
-50
1968
1969
1970
1971
1972
1973
TIME [year]

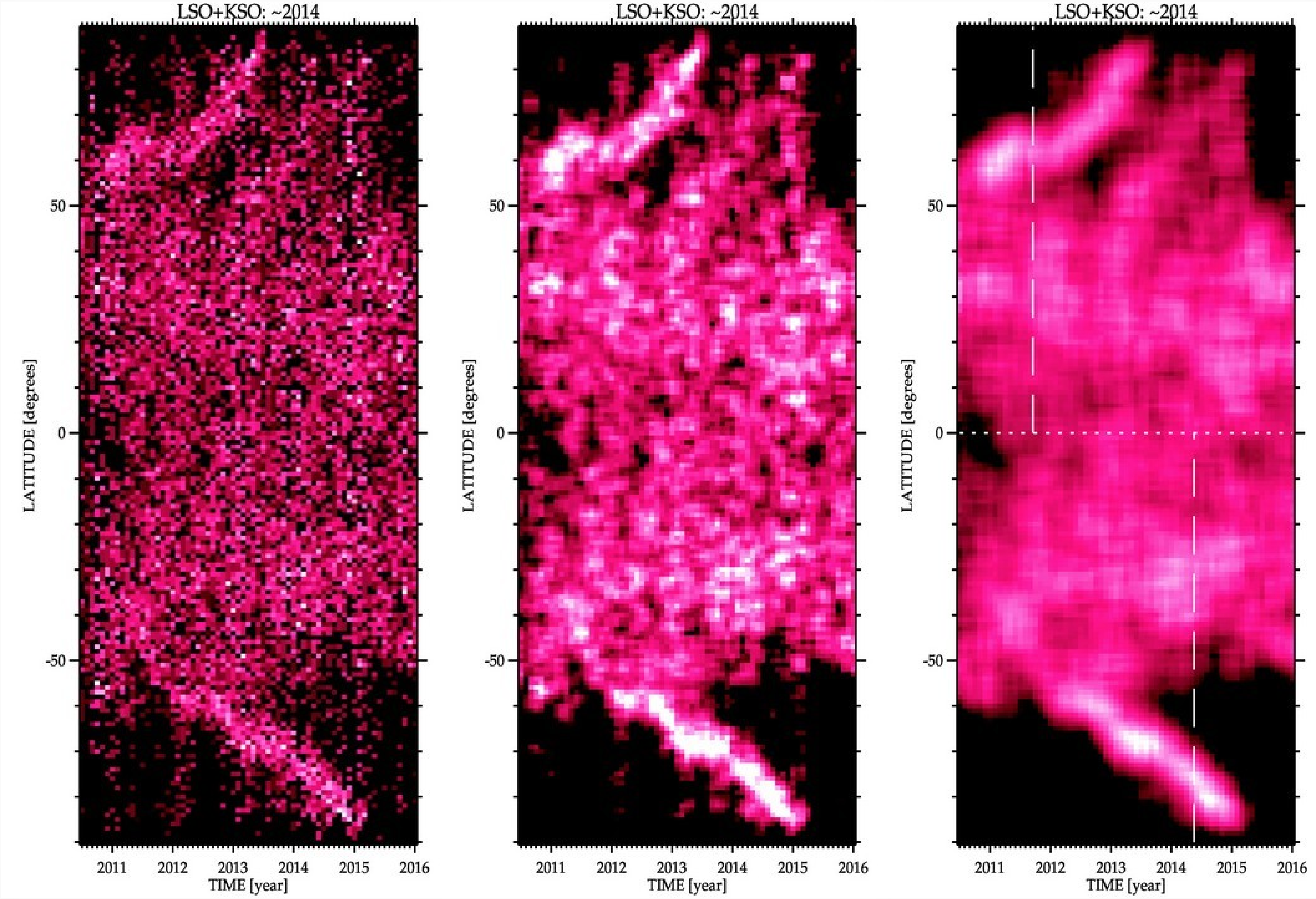


LSO+KSO; ~1980
LSO+KSO; ~1980
LSO+KSO; ~1980
LATITUDE [degrees]
50
0
-50
1978
1979
1980
1981
1982
1983
TIME [year]

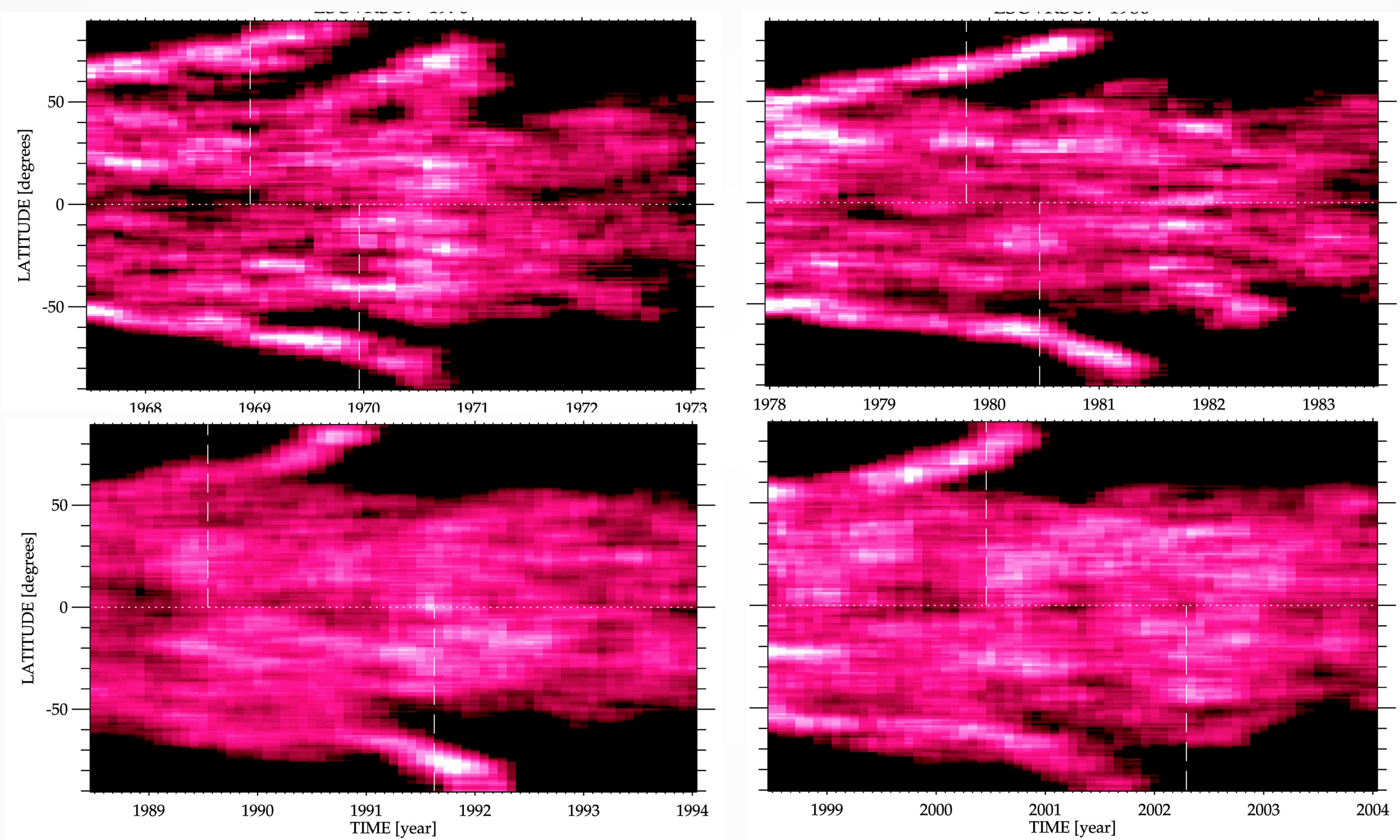

LSO+KSO: ~1991
LSO+KSO: ~1991
LSO+KSO: ~1991
LATITUDE [degrees]
50
0
-50
1989
1990
1991
1992
1993
1994
TIME [year]



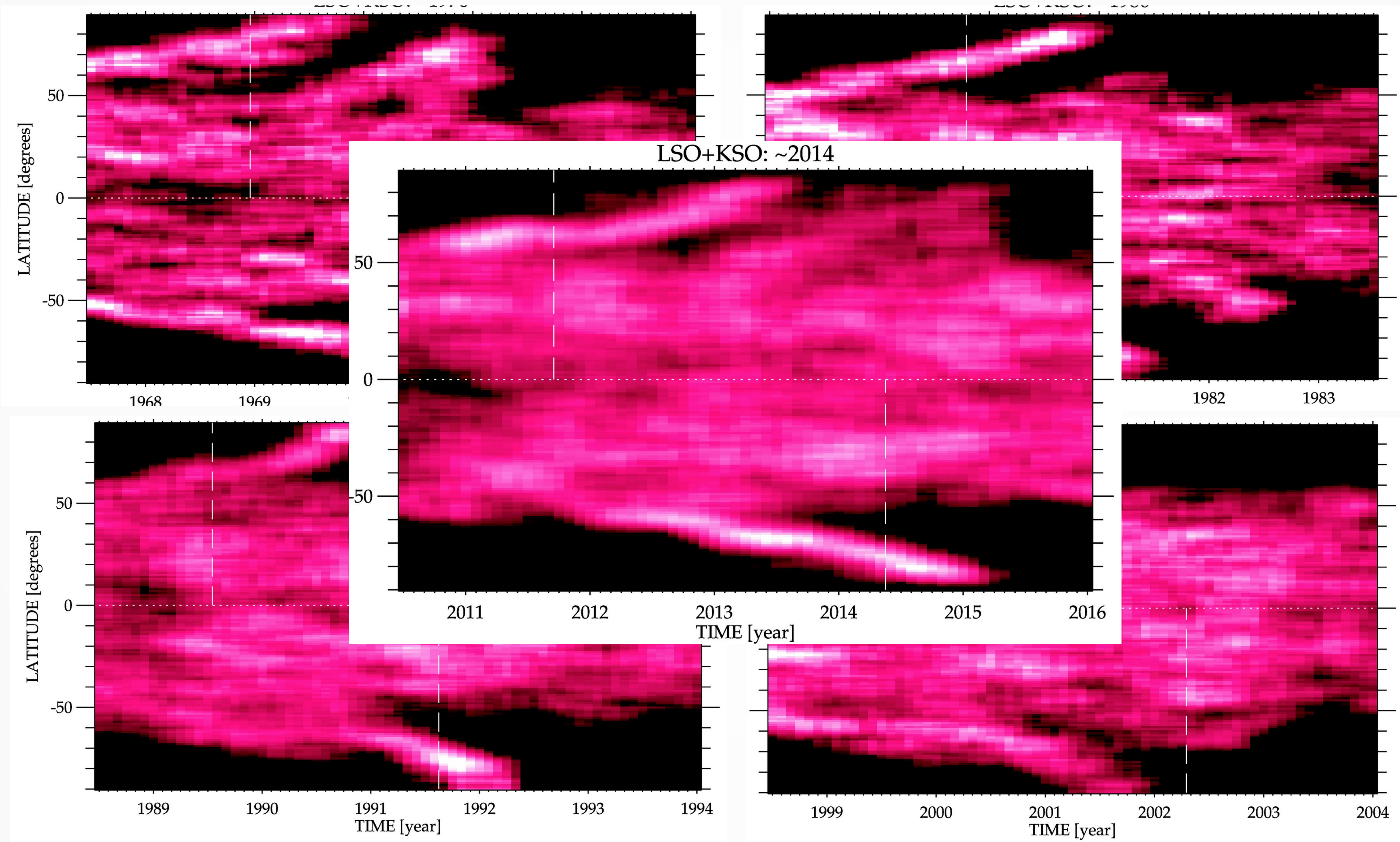
LSO+KSO: ~2000
LSO+KSO: ~2000
LSO+KSO: ~2000
LATITUDE [degrees]
50
0
-50
1999
2000
2001
2002
2003
2004
TIME [year]



LSO+KSO: ~2014
LATITUDE [degrees]
TIME [year]
50
0
-50
2011
2012
2013
2014
2015
2016
LSO+KSO: ~2014
LATITUDE [degrees]
TIME [year]
LSO+KSO: ~2014
LATITUDE [degrees]
TIME [year]



LATITUDE [degrees]
50
0
-50
1968
1969
1970
1971
1972
1973
1978
1979
1980
1981
1982
1983
1989
1990
1991
1992
1993
1994
1999
2000
2001
2002
2003
2004
TIME [year]



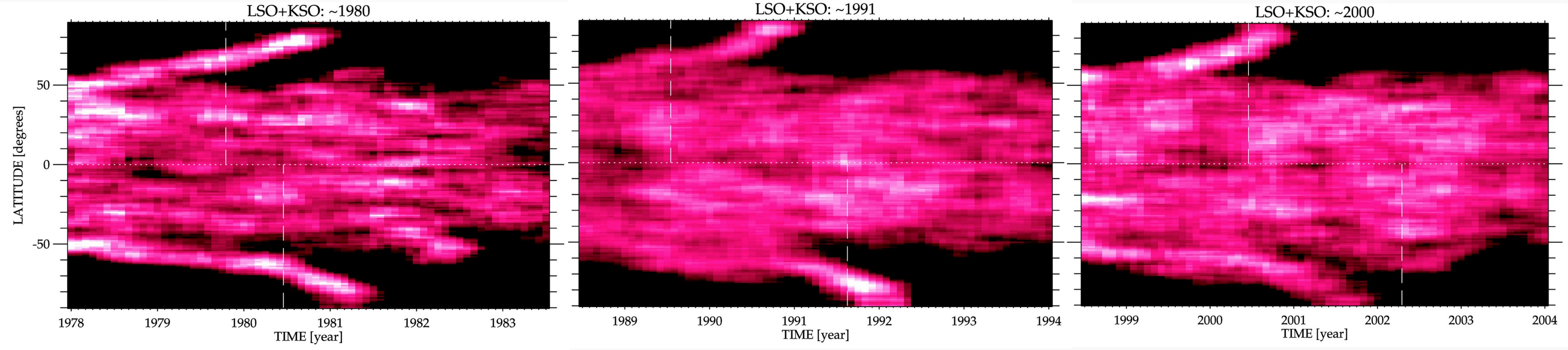
LSO+KSO: ~2014
LATITUDE [degrees]
50
0
-50
1968
1969
1982
1983
2011
2012
2013
2014
2015
2016
TIME [year]
1989
1990
1991
1992
1993
1994
1999
2000
2001
2002
2003
2004

Polar branches: arrival to poles

Cycle		-	Secondary PB – before primary	-	Primary PB	-	Secondary PB – after primary	-
20	N S			<- 69.0 <- 70.2	69.0-70.0 70.5-70.8	70.0-70.5 71.0 ->	70.5-71.2	71.3 ->
21	N S			<- 80.5 <- 81.0	80.5-81.0 81.0-81.5	81.0-> 81.5->		
22	N S			<- 90.3 <- 91.4	90.4-91.1 91.4-92.3	91.2 -> 92.5 ->		
23	N S				00.4-01.0 01.4-02.0			
24	N S			<- 13.0 <- 13.3	13.4-13.6 14.5-15.2	? 15.3 ->	? 14.8-15.4 ?	15.4 ->

Polar branches ~ pole MF reversals

- single/double arrivals (e.g. Dermendjiev, Stavrev, Rusin, et al., 1994, A&A 281, 241)
- the arrival times (e.g. Pinter, Rybansky, Dorotovic, 2013, IAUS Proc. 300, 456)
- the arrival speeds: slower / faster
  - Faster: 1981 S, 1991N, 2001 S
  - Slower: 1969 N, 2014 N
- the arrival speed change: 1980.5 S, 1991.0 N/S, 2001.0 S



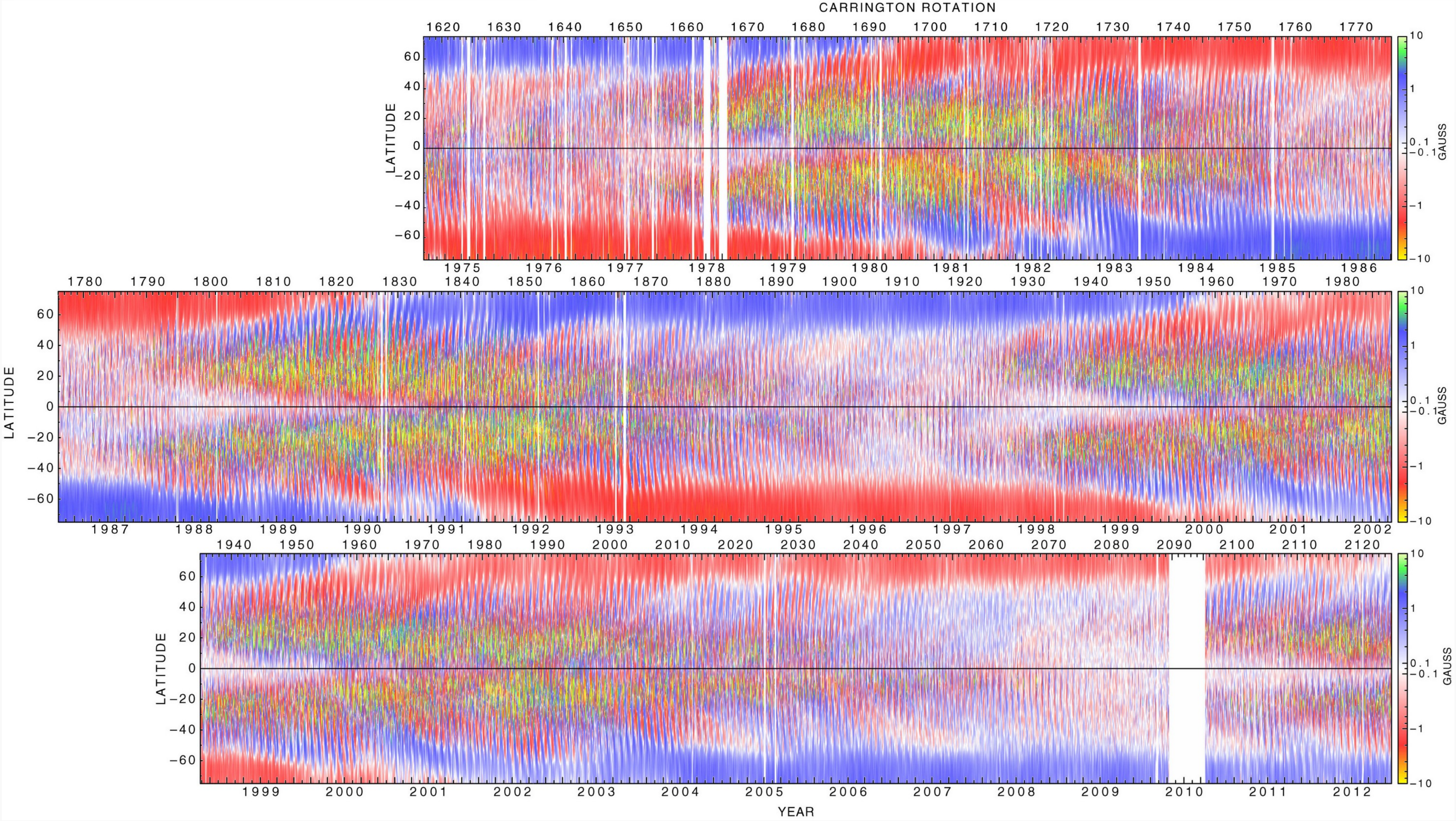
Polar branches ~ pole MF reversals

- Cycles & hemispheres: cycle 21 ~1980, 22 ~1991, 23 ~2000, 24 ~2014
- Several previous articles on this relation, e.g. by LSO group (Rušin, Rybanský, Minarovjech et al.) or by HAO group (McIntosh et al.) - **only the qualitative comparisions**
- The actual aim: the magnetic field **BKG** data (MFs) - from **figures only**:
  - Magnetic Supersynoptic Chart for 1974 to 2012, R. Ulrich, *http://obs.astro.ucla.edu/images/supersynoptic_18-cr1617_2124.jpg*
  - Supersynoptic map for Cycle 24 based on GONG data, A. Pevtsov et al., J. Space Weather Space Clim. 2021, 11, 4

    https://doi.org/10.1051/swsc/2020069
  - Any hypothesis ?
- A future goal: The magnetic field **BKG** data (MFs) - from digital **data for a quantitative results**

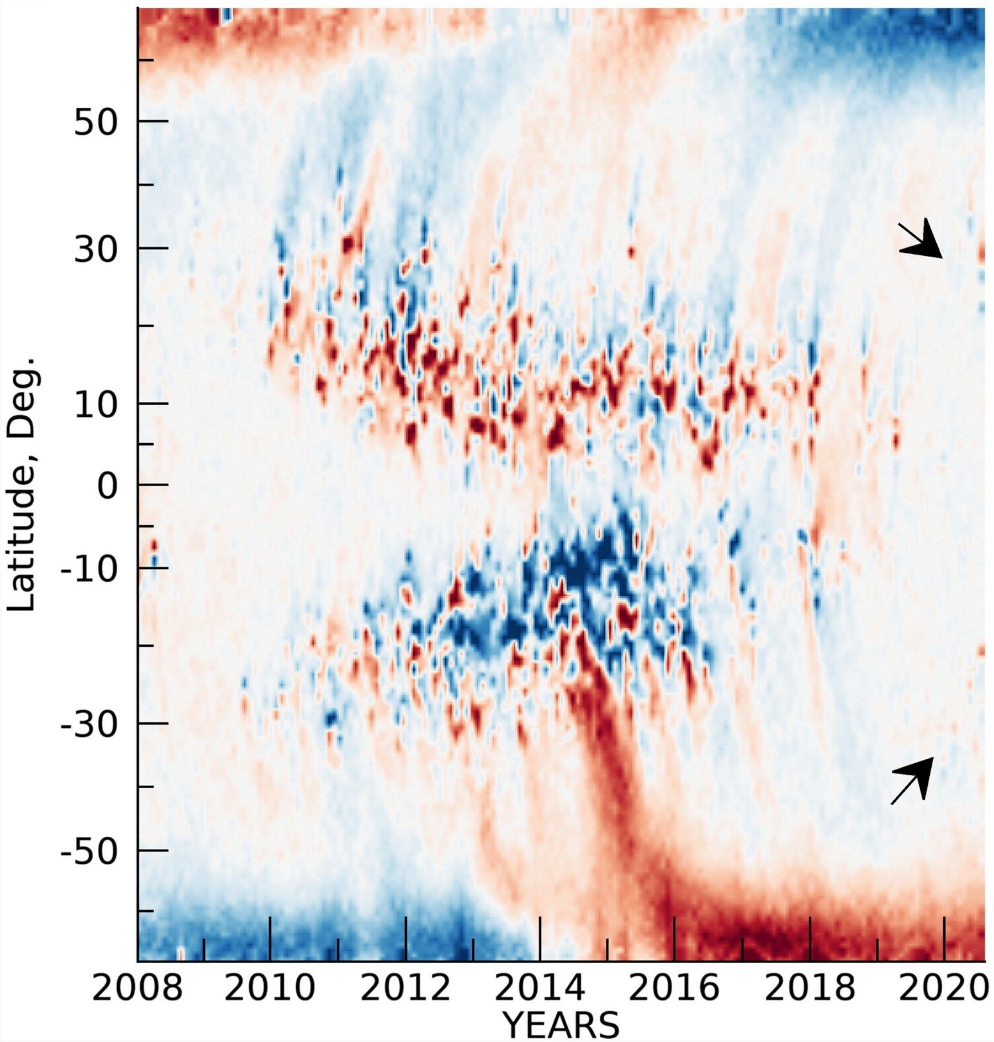
Polar branches ~ pole MF reversals

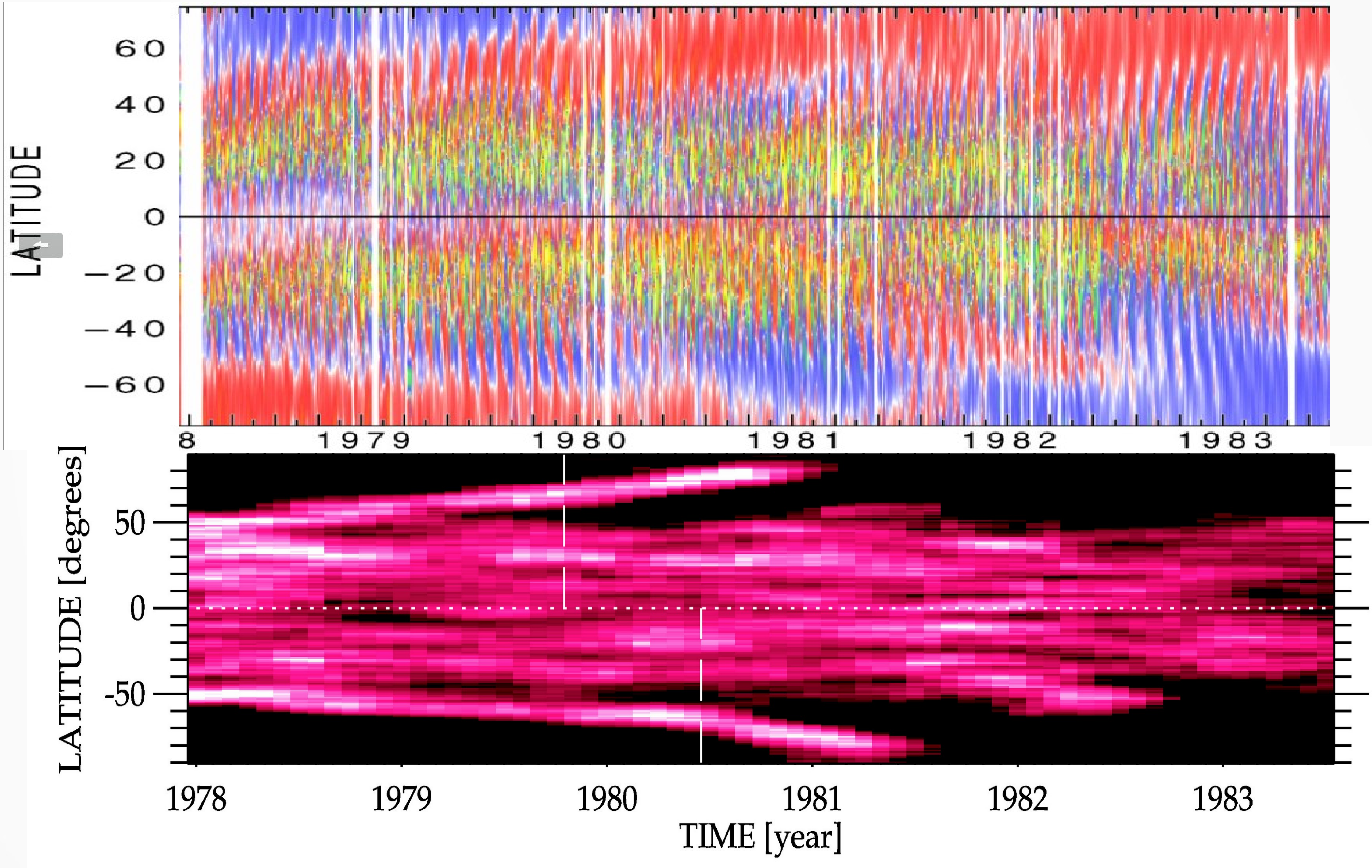
- Magnetic Supersynoptic Chart for 1974 to 2012, R. Ulrich (Mt Wilson, USA)

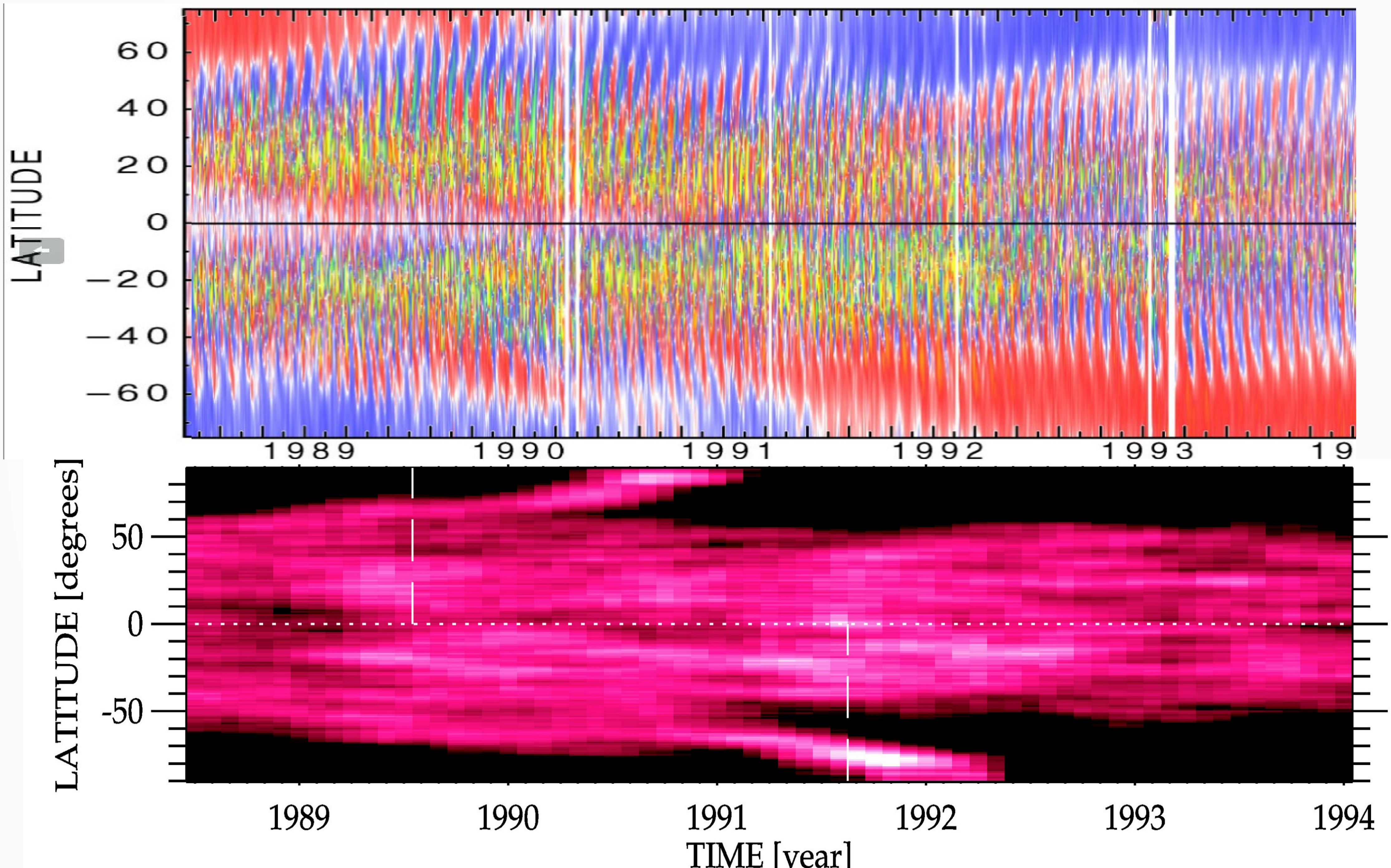


Polar branches ~ pole MF reversals

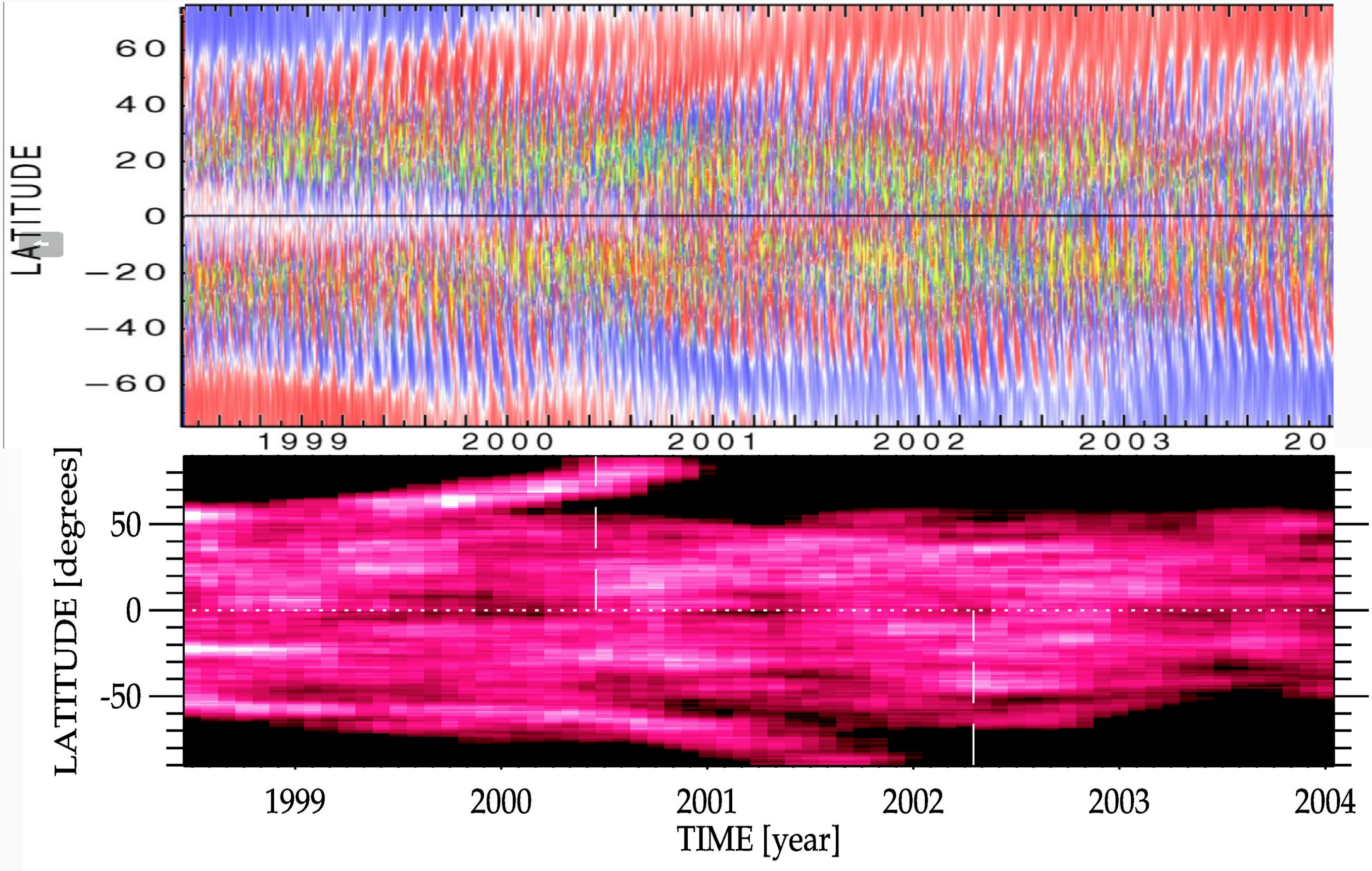
- Supersynoptic map for the Cycle 24 (GONG data, A. Pevtsov et al.)




LATITUDE
60
40
20
0
−20
−40
−60
8
1979
1980
1981
1982
1983
LATITUDE [degrees]
50
0
-50
1978
1979
1980
1981
1982
1983
TIME [year]



60
40
20
0
−20
−40
−60
LATITUDE
1989
1990
1991
1992
1993
19
50
0
-50
LATITUDE [degrees]
1989
1990
1991
1992
1993
1994
TIME [year]



LATITUDE
60
40
20
0
−20
−40
−60
1999
2000
2001
2002
2003
20
LATITUDE [degrees]
50
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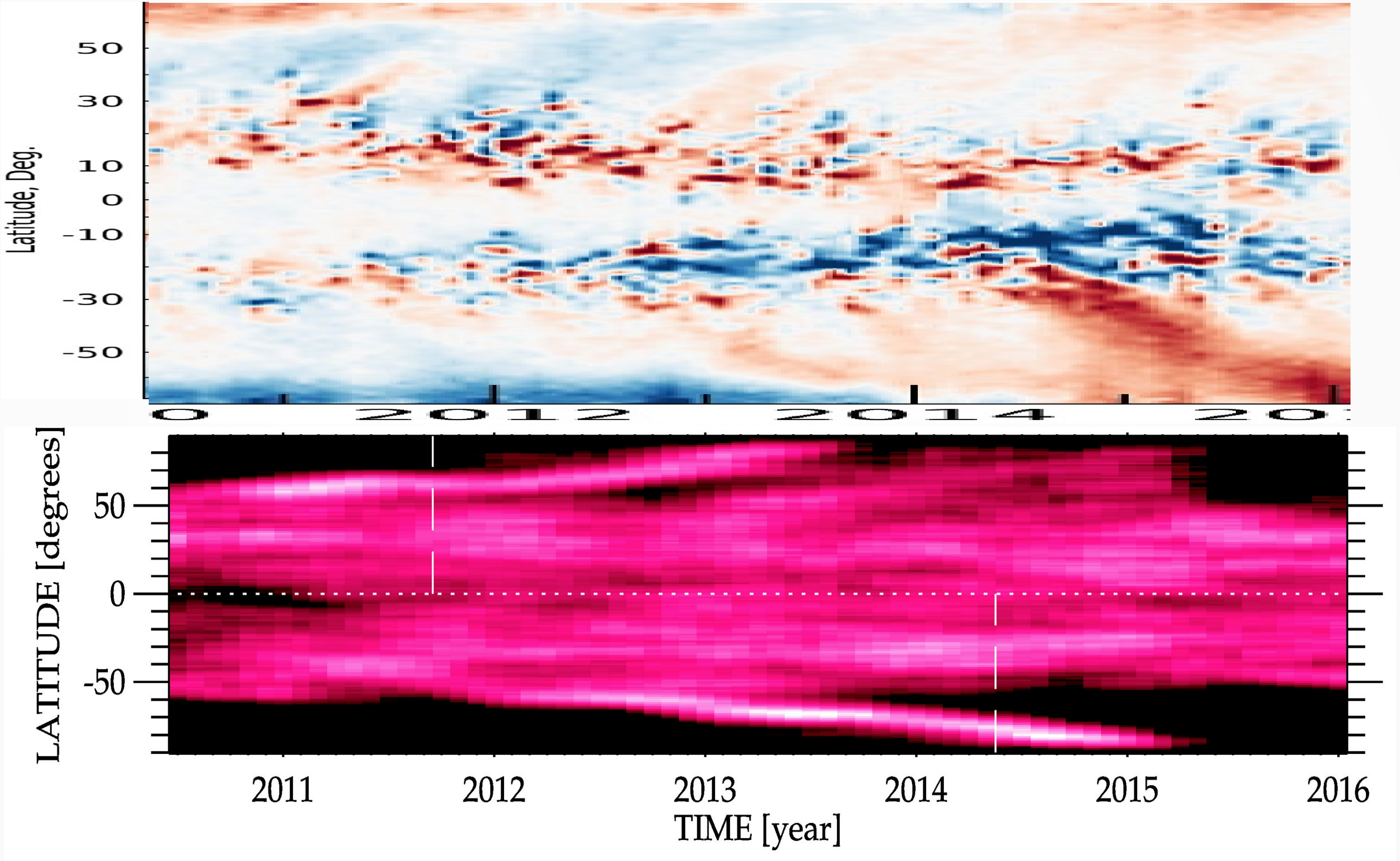
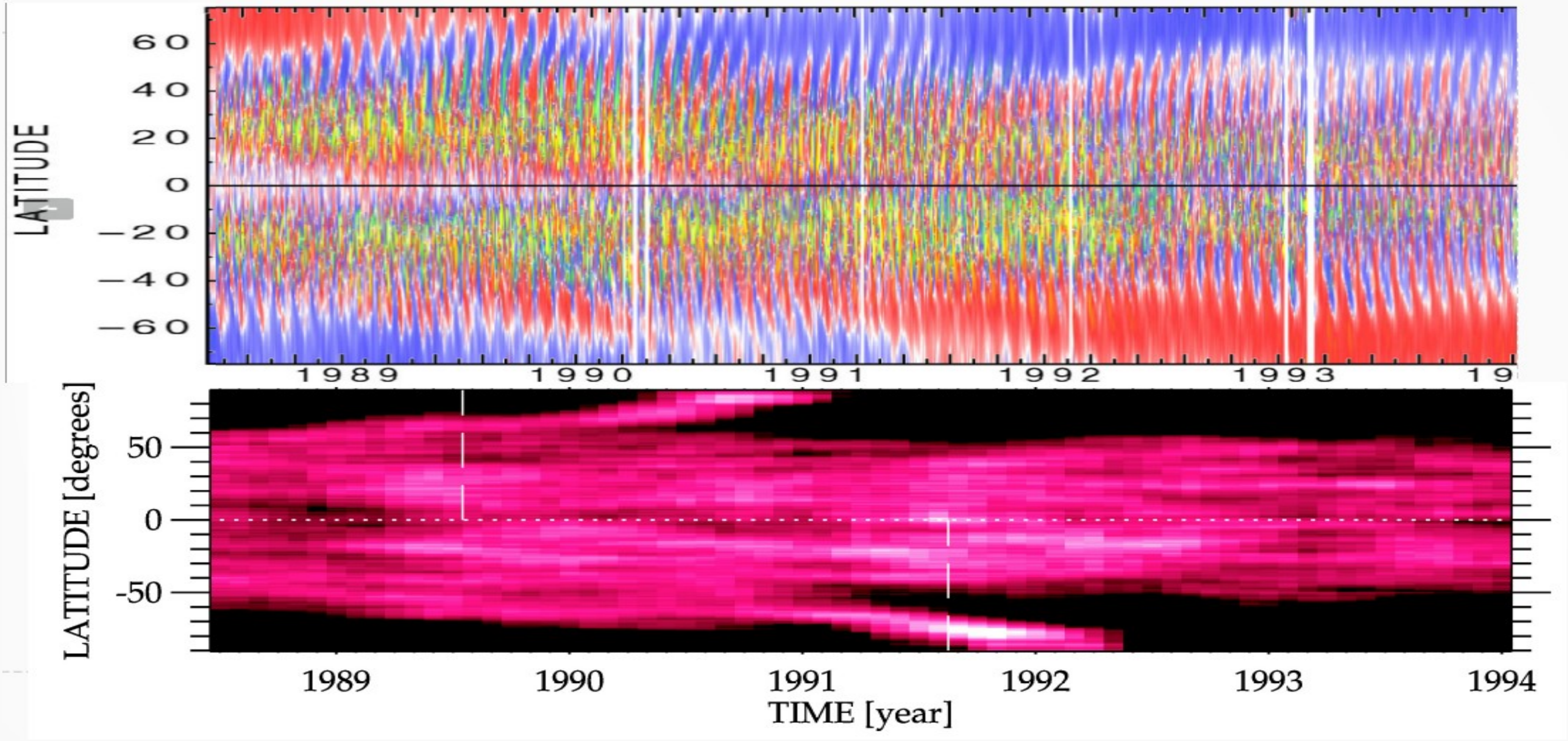
1999
2000
2001
2002
2003
2004
TIME [year]



Latitude, Deg.
50
30
10
0
-10
-30
-50
2012
2014
LATITUDE [degrees]
50
0
-50
2011
2012
2013
2014
2015
2016
TIME [year]

Polar branches ~ pole MF reversals

- **Our hypothesis** (from the qualitative analysis): the arrival speeds and the arrival speed change are caused by multiple surges of the dispersed magnetic flux → very probably the original concept of the primary and possible (later on appearing) secondary branches is not adequate
- The magnetic field **BKG MF data** to be used for the **quantitative** results



Summary

- the LSO/KSO catalogue data: close to the final version of the method
- the primary branches and the secondary branches (before/after) primary ones quite clearly detected
- the prominence primary polar branch pole arrival time and the BKG MF pole reversal time in a close relation - to be quantified
- the hypothesis: arrival speed and its change in relation to the surges of the emerging magnetic flux and their dispersion – to be verified by quantitative analysis

Next?

- KSO:
  - continuation of the special „korona“ image acquisition
- LSO:
  - some additional tests of the prominence determination & additional tests of the homogenization improvement fixing the method/codes: January 2023
  - new version of the catalogue after each calendar year
  - PhD student: 2 attempts in 2021 and 2022 failed, new attempt

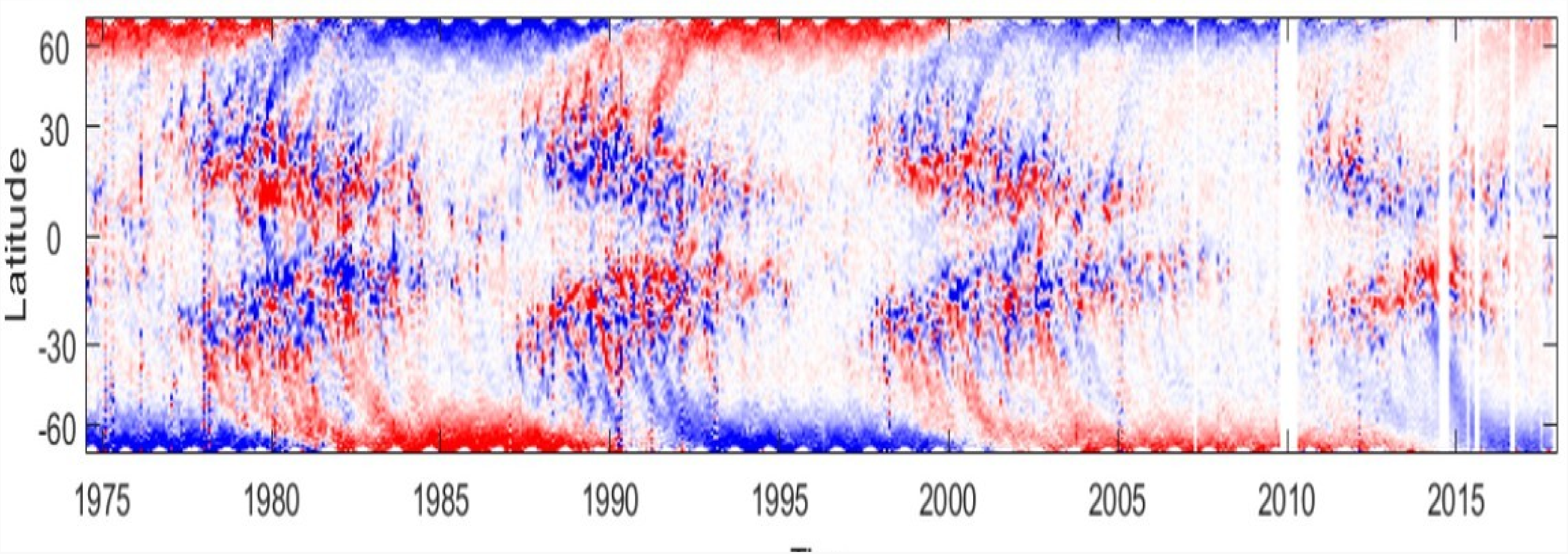
Next?

- Verification of our hypothesis by the digital data:
  - The magnetic field BKG data → different types of parameters
  - Quantification the primary and the secondary prominence branches (before/after) primary ones and the BKG MF flux
  - Relations of arrival time/speed on the magnetic flux surges
- Results ob the cycles 21,22,23,24 relations -> the MF reversals in the cycle 20
- Limb prominences ~ disk filaments for different data sets
  - A possible extension for the MF reversals since 1880
  - Another comparisons: velocity fields

Next?

- **The magnetic field BKG data:** Virtanen, I. and Mursula, K. A&A 626, A67 (2019). data of WSO, the MWO, Kitt Peak, SOLIS/VSM, SOHO/MDI, and SDO/HMI.

  Data range: [-1000,+1000] Gauss

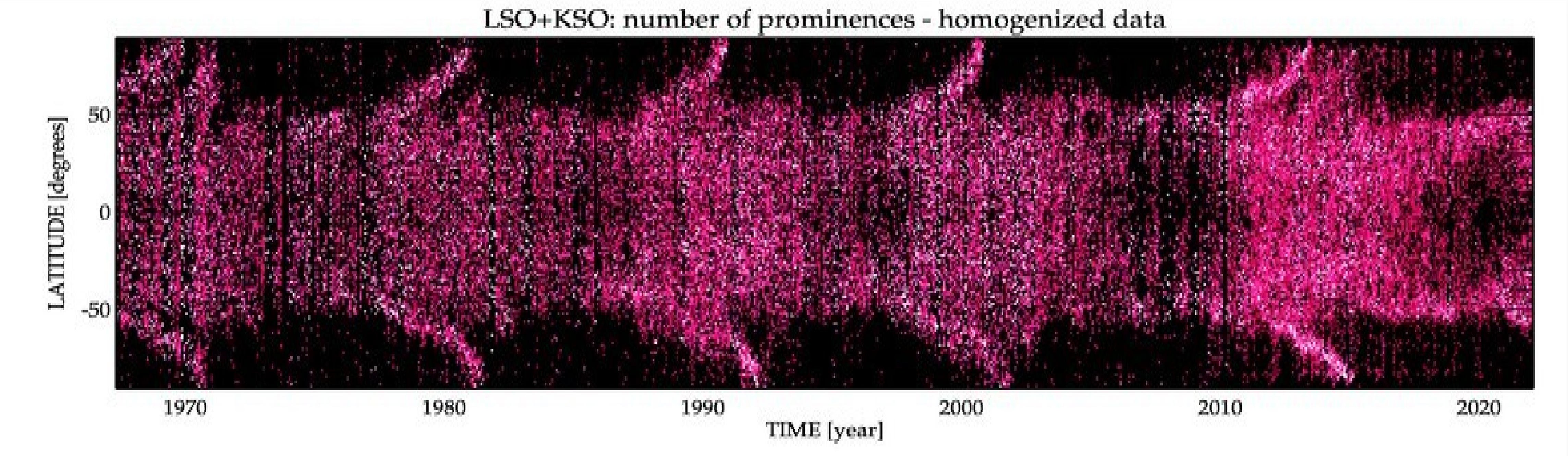


Contributions of the authors

- **J. Rybák:** the IDL code for automatic determination of the KSO prominence parameters, the LSO+KSO catalogue merging, the regular update of the LSO/KSO catalogue, this presentation
- **V. Rušin:** the PI of the LSO catalogue project, discussions on the LSO catalogue preparations and data
- **P. Gömöry:** the introduction of the “korona” imaging at the KSO
- **M. Morris,** Westminster school, London (UK) – LSO summer intership: prominences ~ MF time-latitude distributions comparison
- **W. Pötzi, D. Baumgartner, H. Freislich, H. Strutzmann:** the KSO observers + KSO data reduction/management
- **A. Veronig:** head of the KSO

Acknowledgment

- An institutional long-time support of LSO/AISAS and KSO/Uni_Graz
- Work of many observers
- Your attention



LSO/KSO H alpha prominence catalogue:
https://www.astro.sk/~choc/open/lso_kso_h_alpha_promimence_catalogue/lso_kso_h_alpha_promimence_catalogue.html

Next?

- (hemispherically symmetrized) torsional oscillation near the solar surface (Howe et al. 2000, Sci, 287, 2456) -> McIntosh, S. et al., ApJ, 792:12, 2014