Statistics of Solar Activities: Statistics application to solar-terrestrial connection

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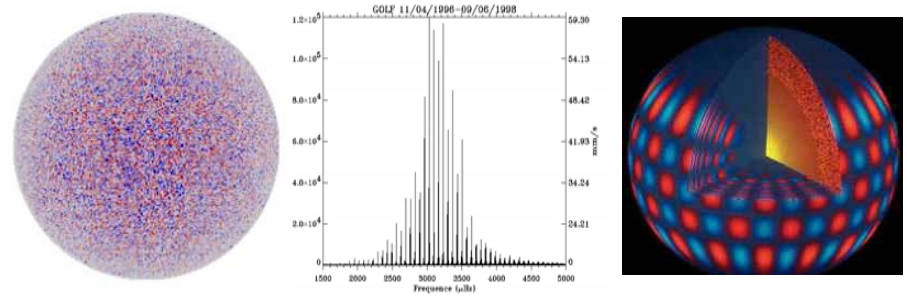
T-A University, 03/04/2005

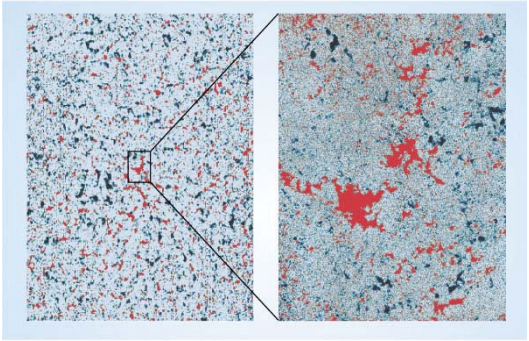
Solar activity as a field for statistics

- Solar surface oscillation – helioseismology –

Sun Interior Tomography



- Magnetic structure - ***fractal nature***

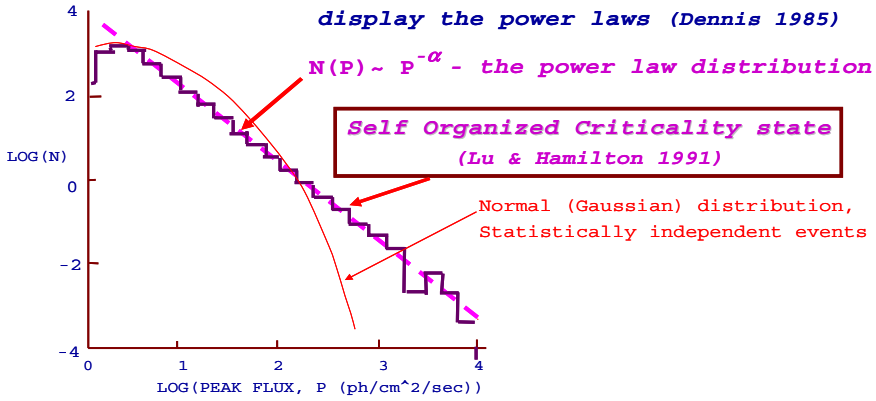


Avalanche in flares energy release - ***Self Organized Criticality***

New observational data on the statistics of solar flares:

Frequency distributions of Peak energy flux,
of Total energy flux,
of Flare duration
display the power laws (Dennis 1985)

$N(P) \sim P^{-\alpha}$ *- the power law distribution*



Solar-Terrestrial Connection

- Solar activity – Heliosphera – Space weather (solar wind, cosmic ray, Earth magnetic field)

  yes, without doubts 

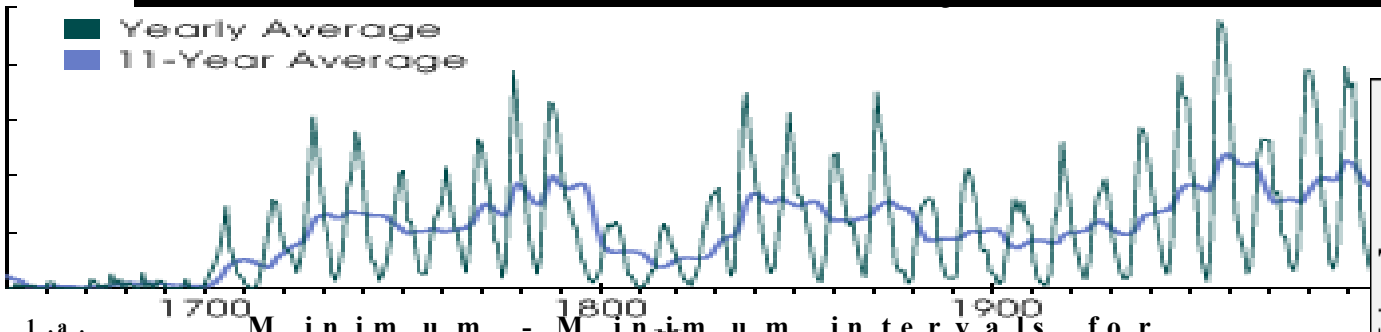
- Space weather – Earth weather (condensation, pressure map, clouds, rains)

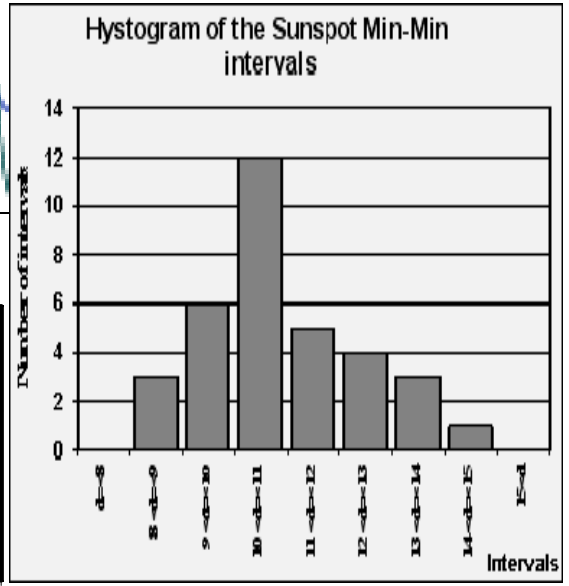
  may be, may be, but … 

- Earth weather – agriculture – crop – price -…

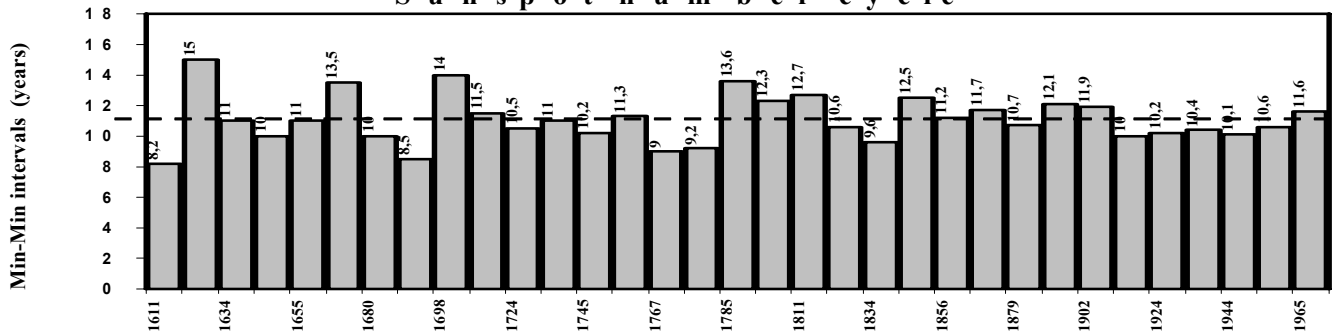
  well, well …. 

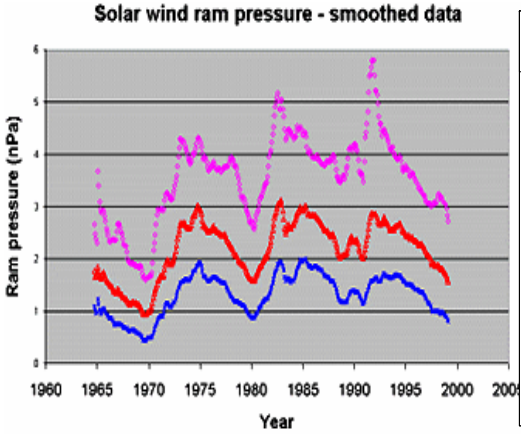
Solar Activity – Heliosphera – Space weather (solar wind, cosmic ray, Earth magnetic field)

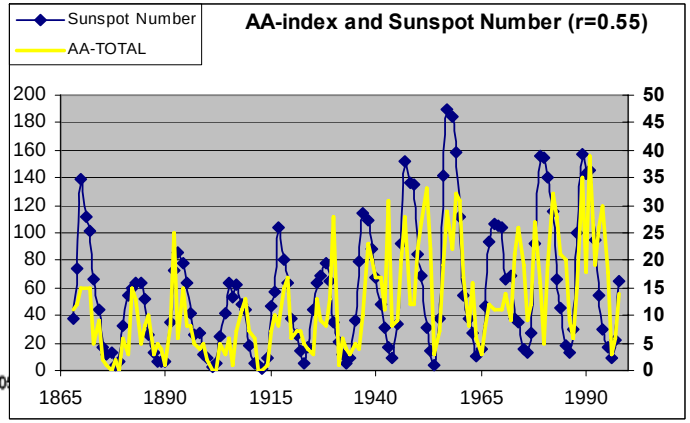


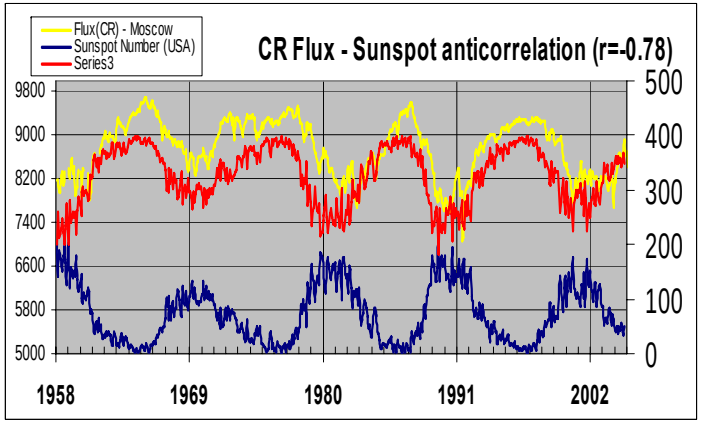


1.a. Minimum - Minimum intervals for Sunspot number cycle







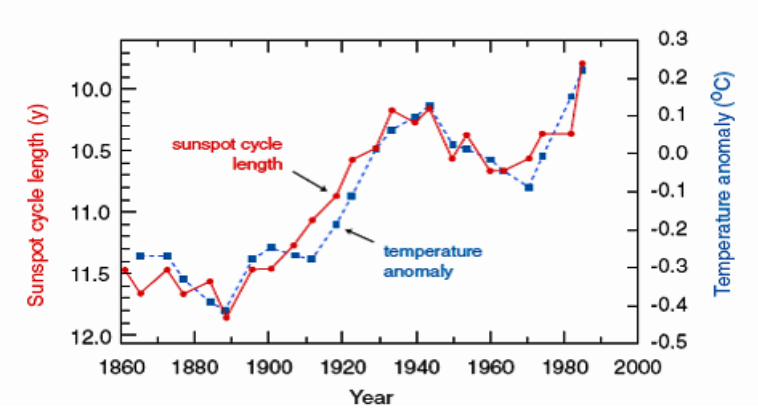


Space weather – Earth weather (condensation, pressure map, clouds, rains)

1. Global warming

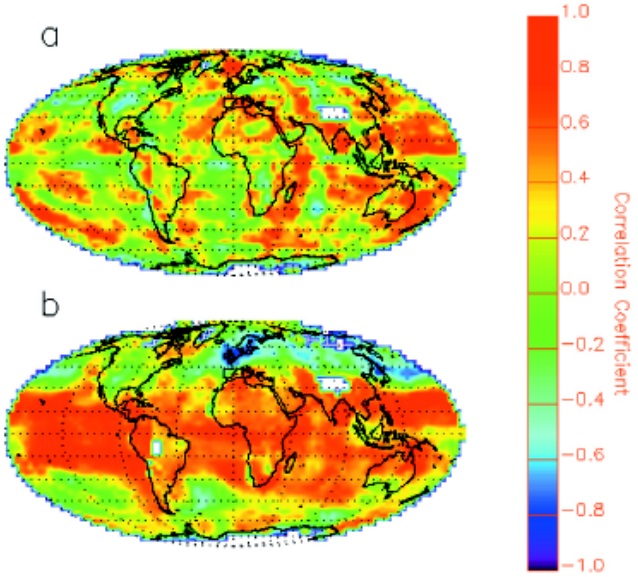
($T_{anom} \propto$ L(min-min))

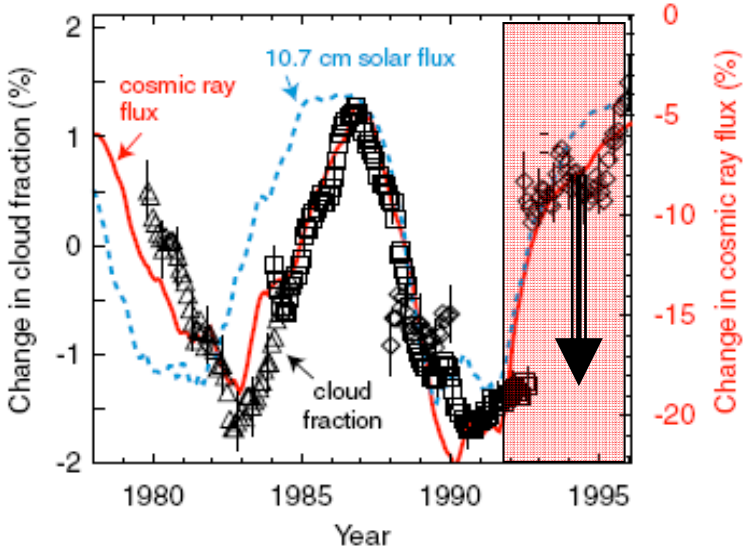
E. Friis-Christensen and K. Lassen, 1991



2. Cloudiness – CR Flux

H. Svensmark and E. Friis-Christensen, 1997

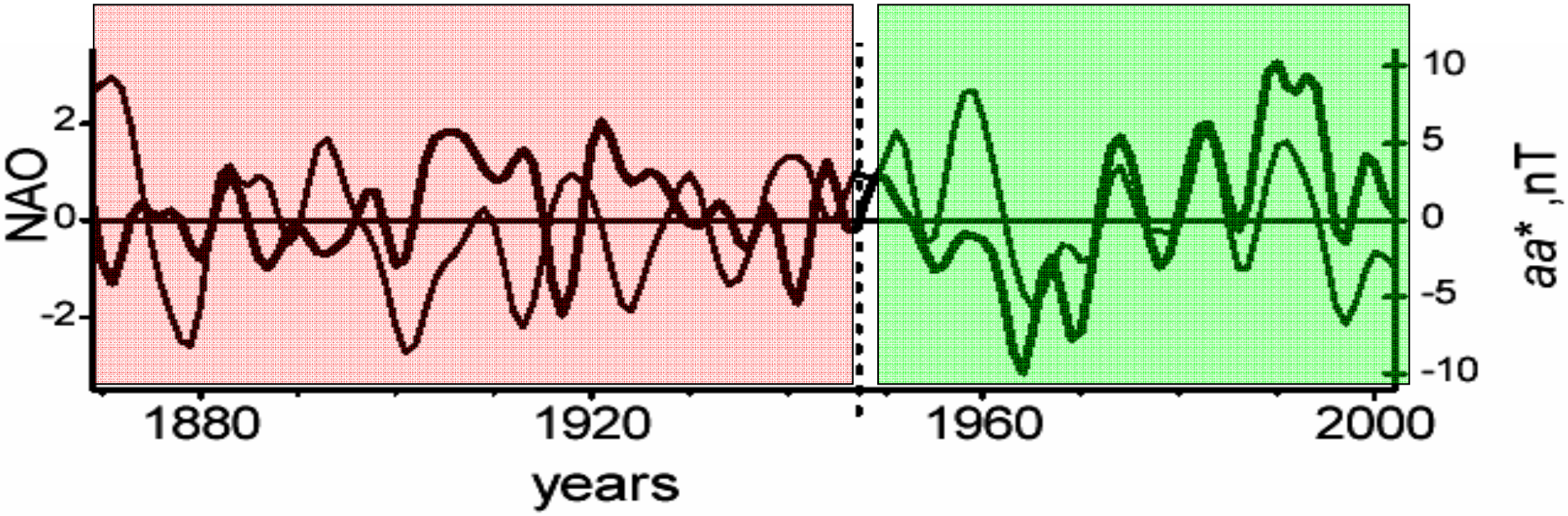


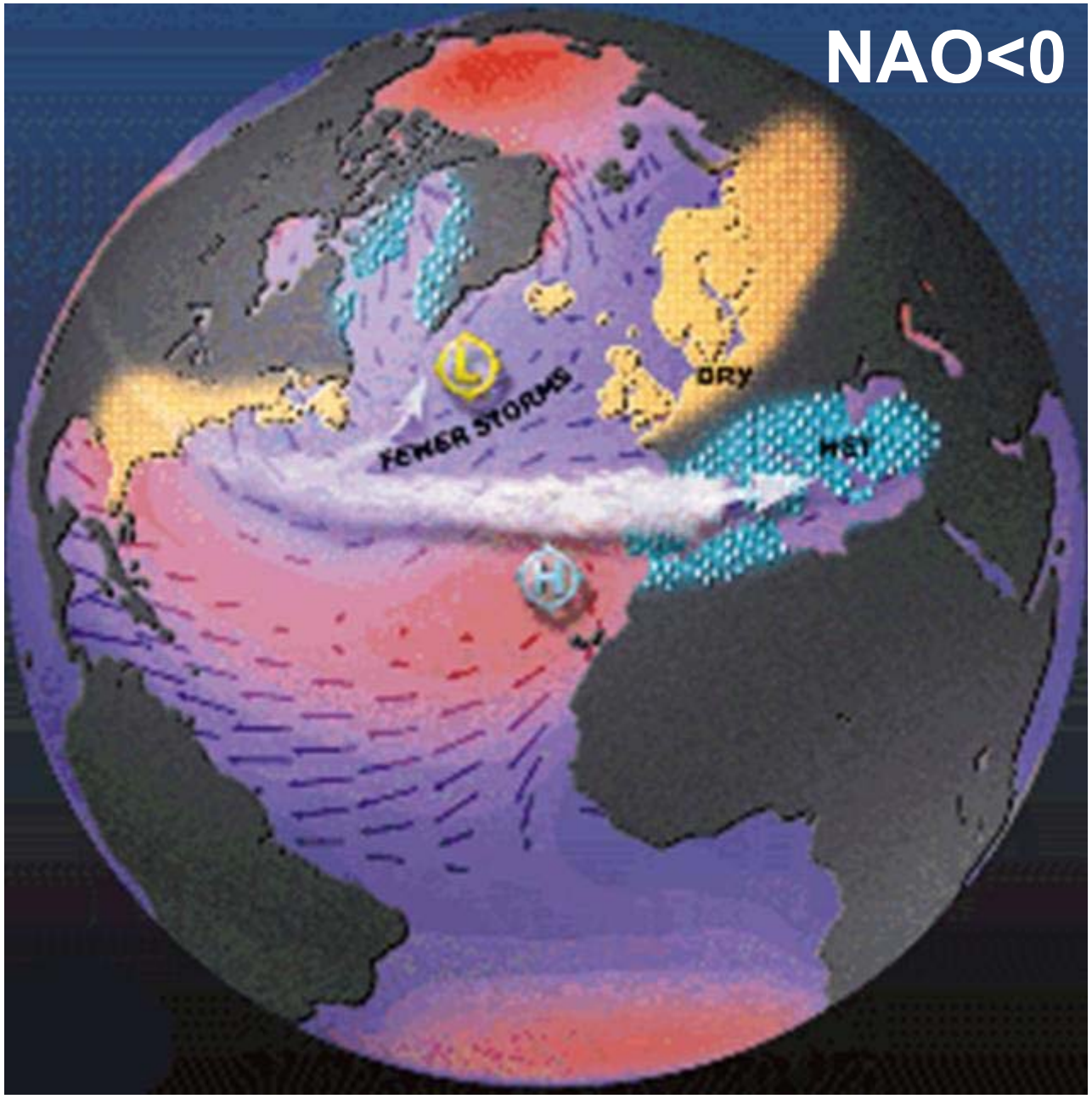


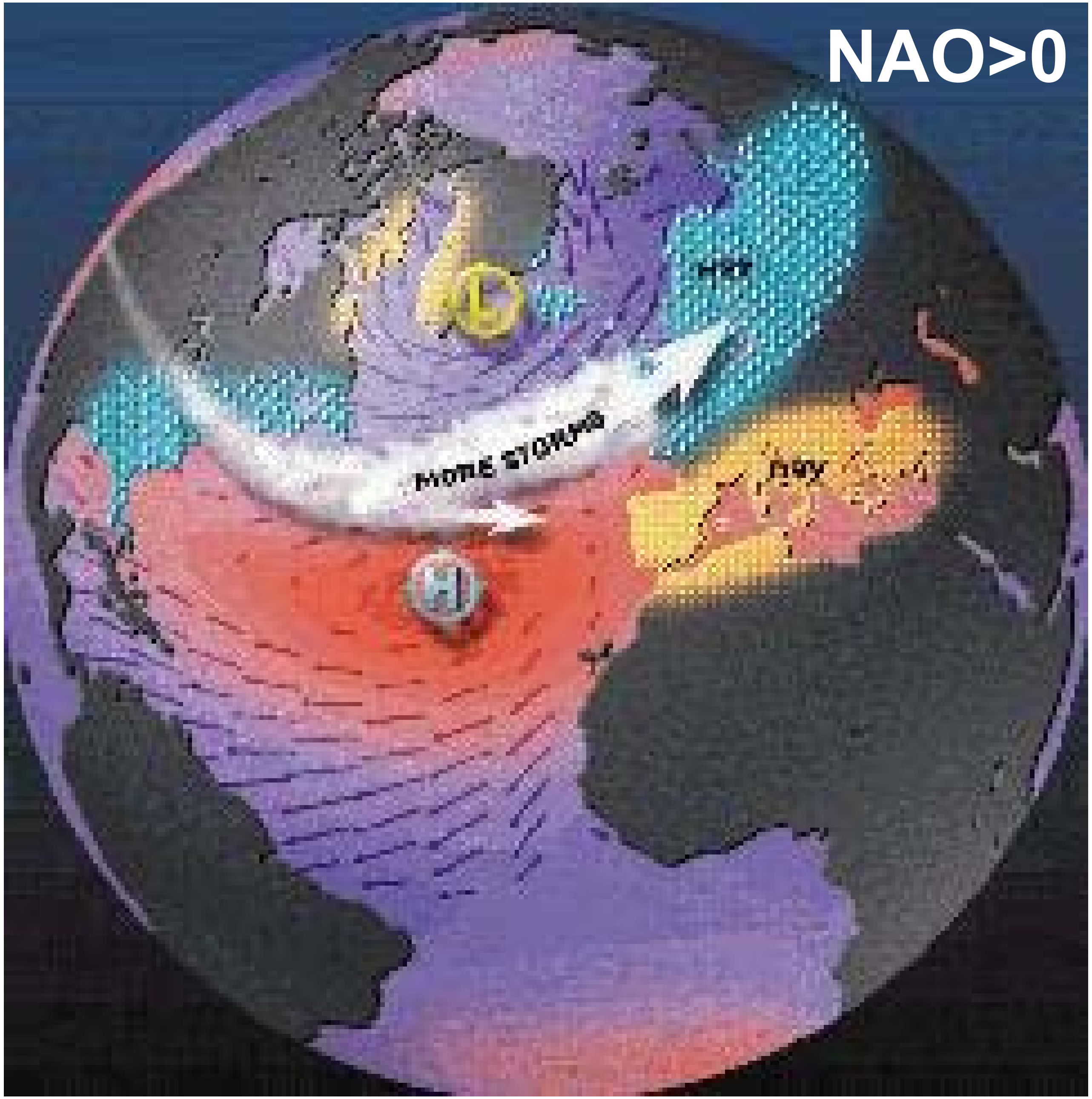
Space weather – Earth weather (condensation, pressure map, clouds, rains)

3. AA-index – NAO (North Atlantic Oscillation) =
=Pressure(Azors)-Pressure(Iceland) =>
Atlantic storm circulation tracks - (r=0.7 for 1948-2002)

R. Lukianova and G. Alekseev, 2004



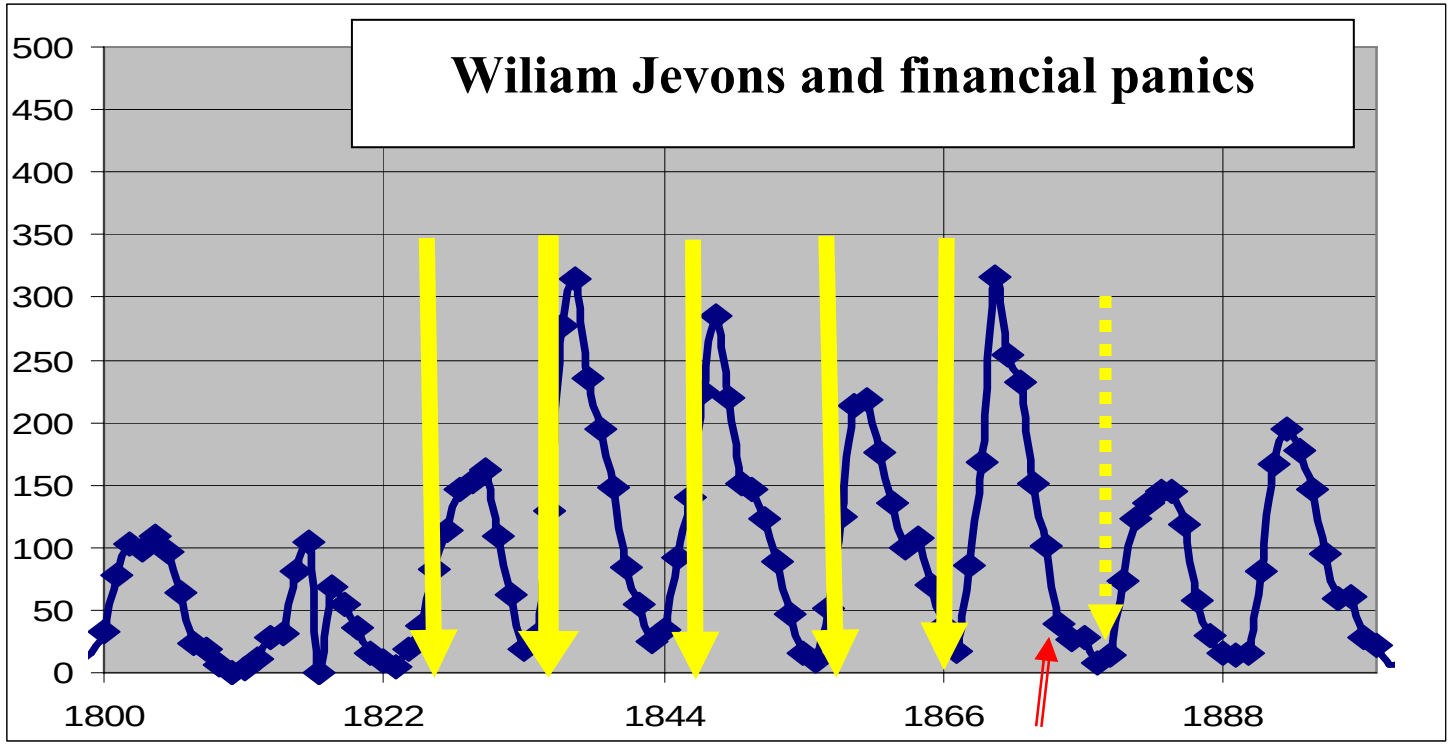

NAO<0
L
FEWER STORMS
DRY
WET
H


NAO>0
L
More storms
H

Earth weather – agriculture – crop – price -…

1. **History: Forerunners and victims**

   Jonathan Swift (1726), William Herschel (1801), William Stanley Jevons (1875)

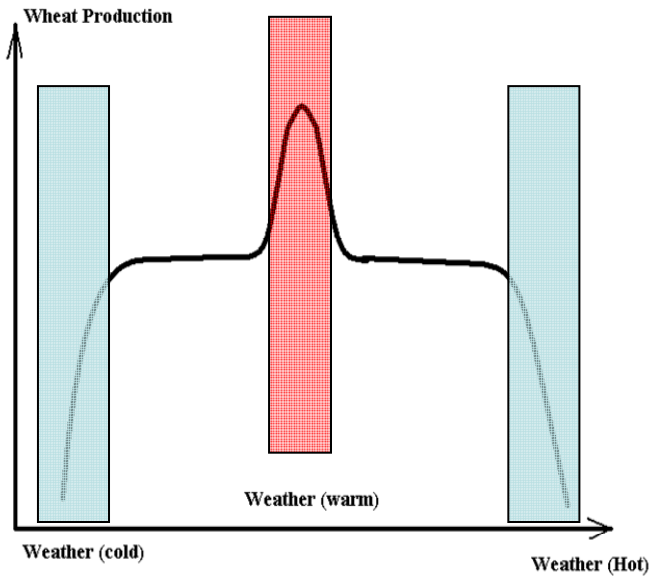


2. Problem – instability of the effects

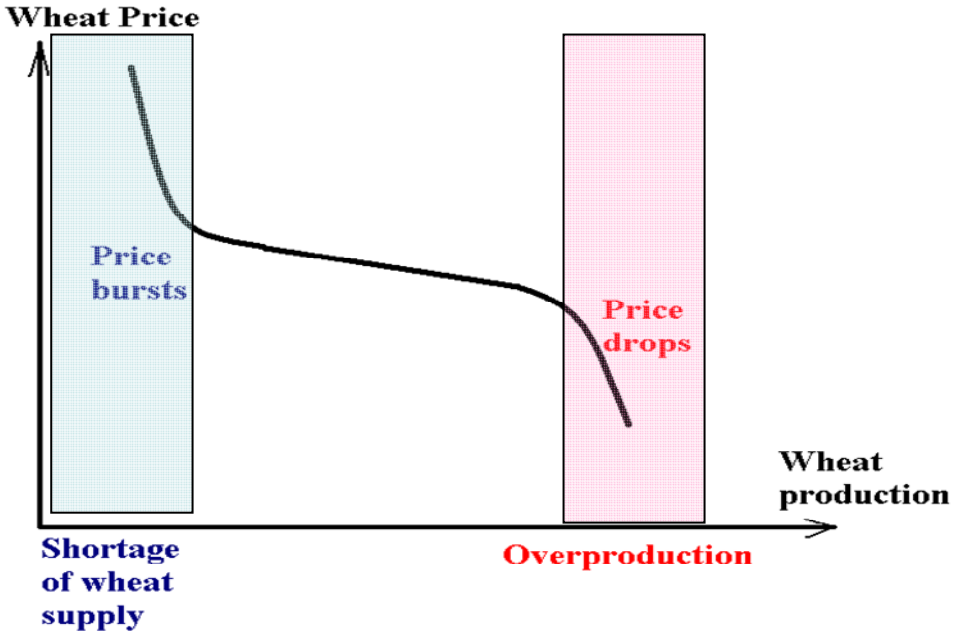
Statistical problem – search of possible price reaction on space weather abnormality on the background of numerous another factors of influence

1. **Solution –price burst effect** as result of threshold type of sensitivities.

Wheat production depends on weather conditions as a nonlinear function with threshold transitions

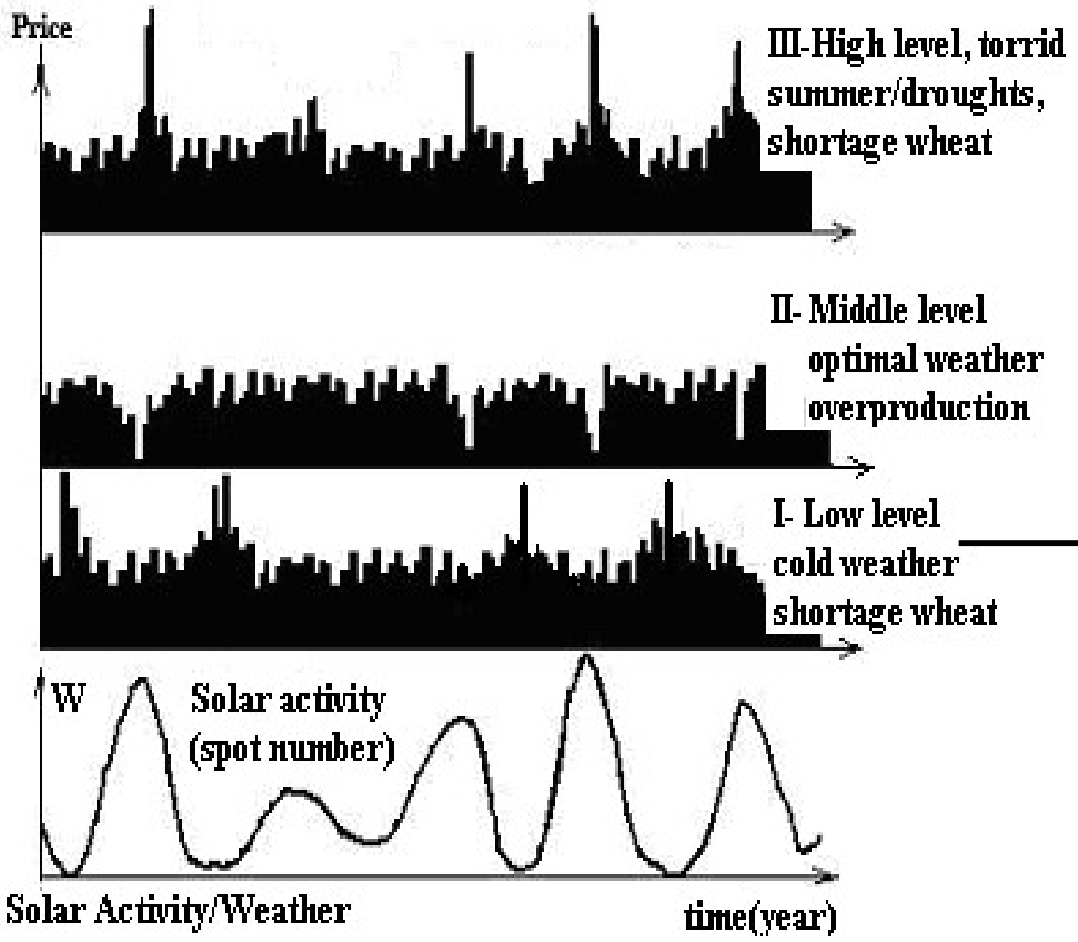


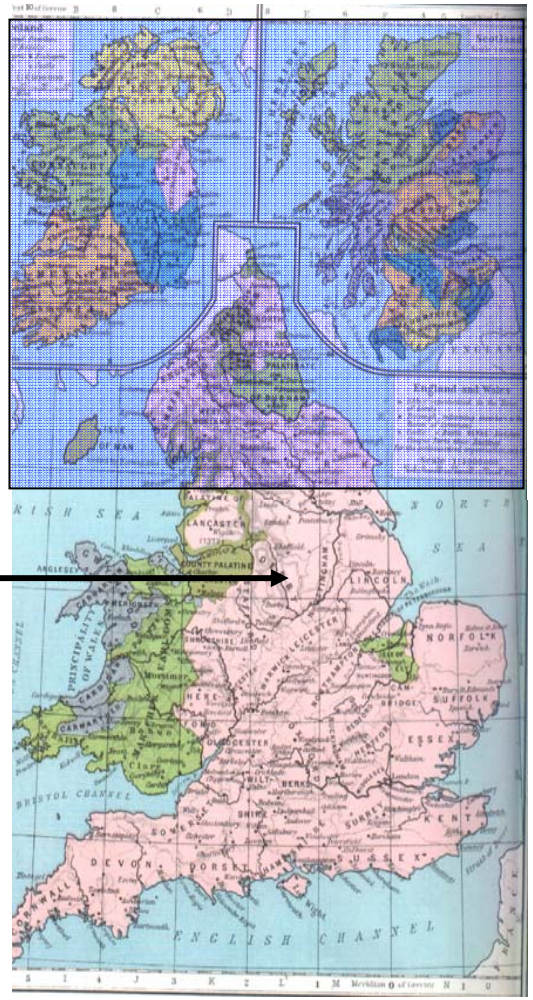
A wheat market with a limited supply is highly nonlinearly sensitive to wheat supply



Statistical problem – search of possible price reaction on space weather abnormality on the background of numerous another factors of influence

- **Three types of expected burst-like price reactions on solar activity state**





Example – Medieval England
(high risk agriculture zone, isolated market)

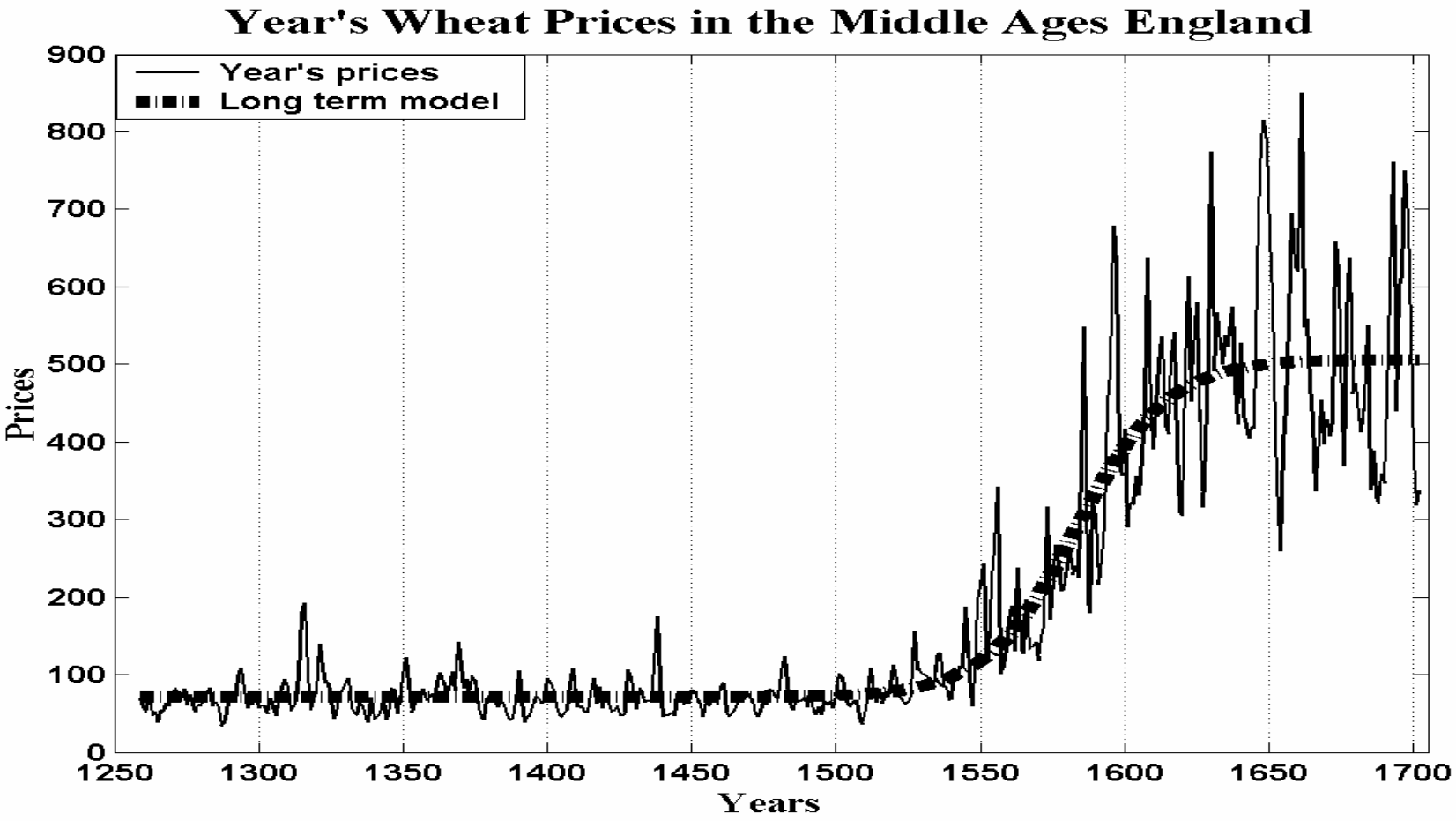
Data for Analysis

- Agricultural prices **P(t)** in England for 1259-1702 from Prof. Rogers (1887).

- Moments of maximums/minimums of sunspots $\mathbf{T_{Max}(t)}$, $\mathbf{T_{Min}(t)}$ for years 1610 - 2000 from NOAO Satellite and Information Center at ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/maxmin.new

- Data on solar activity maximums from isotope ^{10}Be in Greenland for the years 1600-1700 from Beer *et al*. (1998) and Usoskin *et al*. (2001).

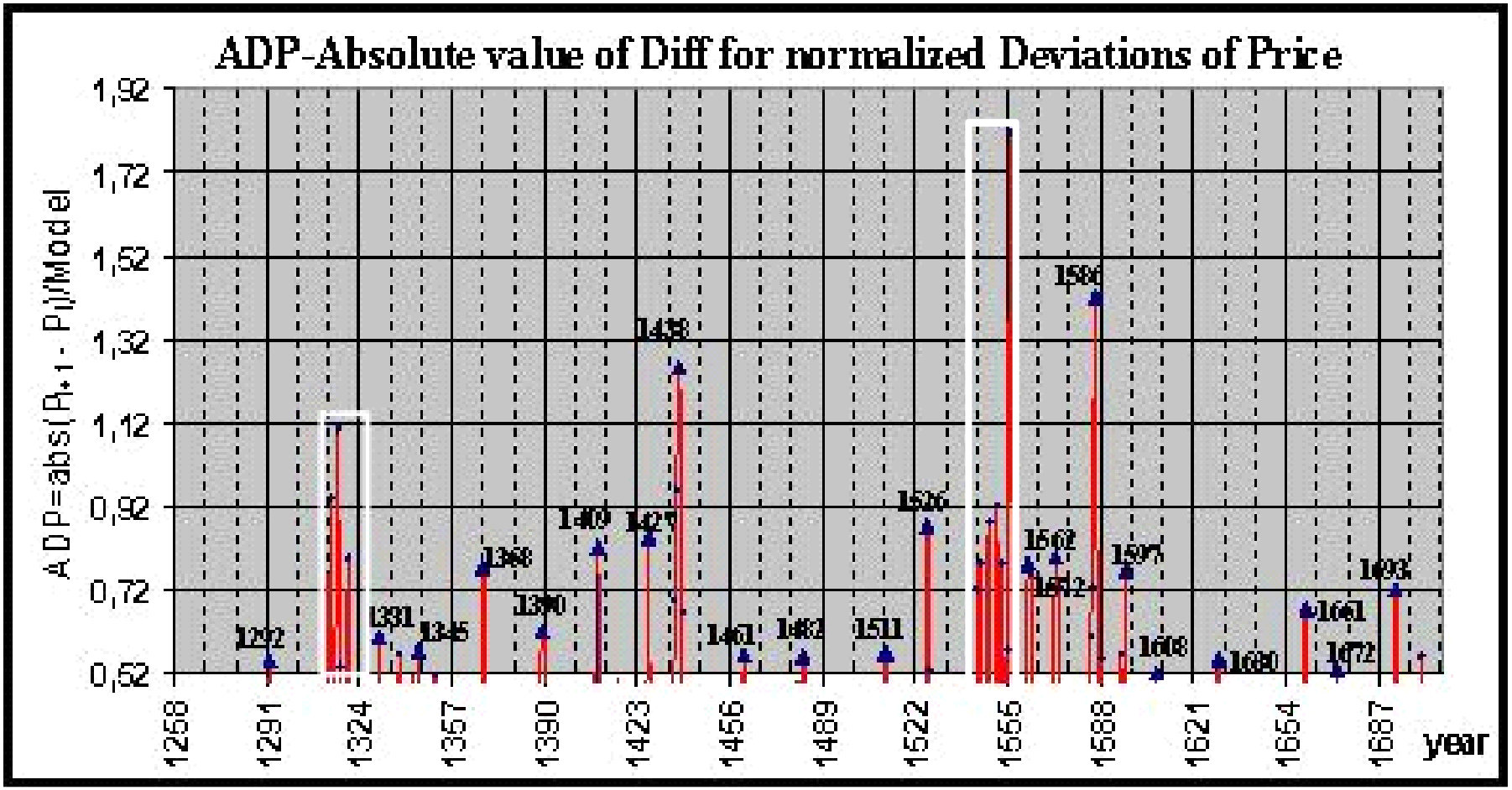
Three components of price variability: transition, noise-like, bursts



Main object – price bursts intervals

$$\delta P(t_i) = \Delta P(t_i) / \hat{P}(t_i)$$

$$AVNPV(t_i) = Abs(\delta P(t_i))$$



Statistics of Interval Analysis

Year of bursts	1292	1331	1345	1368	1390	1409	1427	1438	1461	1482	1511	1526	1562	1572	1586	1597	1608	1630	1661	1672	1693
Number of cycles	4	1	2	2	2	2	1	2	2	2	1	3	1	1	1	1	2	3	1	2	
Interval	9.75	14	11.5	11	9.5	9	11	11.5	10.5	14.5	15	12	10	14	11	11	11	10.3	11	10.5	

- **price burst intervals (1249-1703):**

median - 11.0 years;

mean – 11.14 years;

standard deviation - 1.44 years

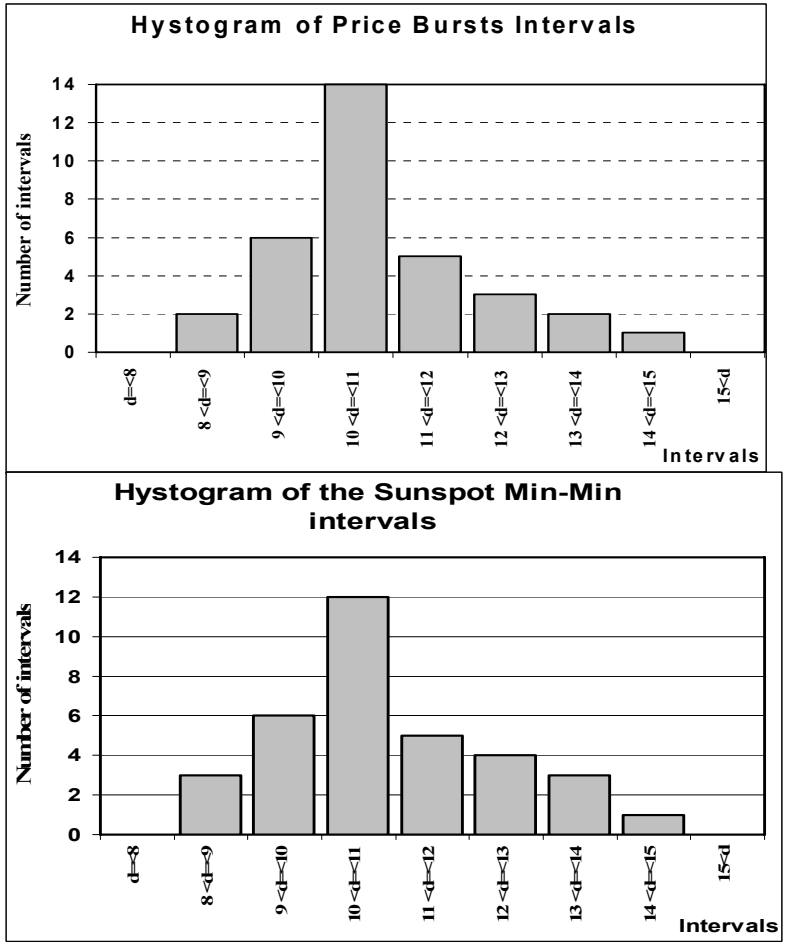
- **sunspot minimum-minimum intervals (1700-1999) :**

median - 10.7 years;

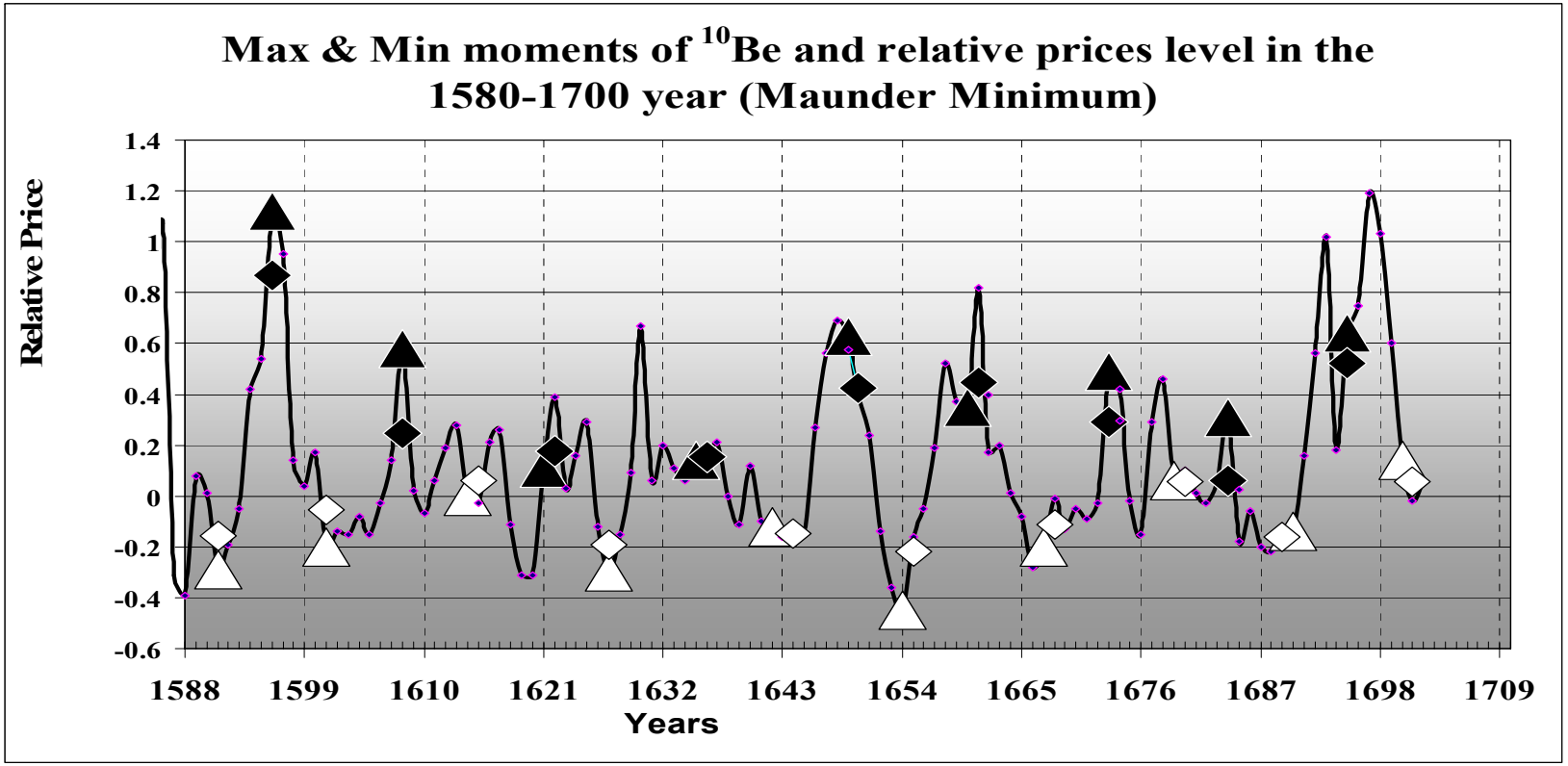
mean - 11.02 years;

standard deviation – 1.53 years

- **χ2-test of the same general distribution give significance level >95%.**

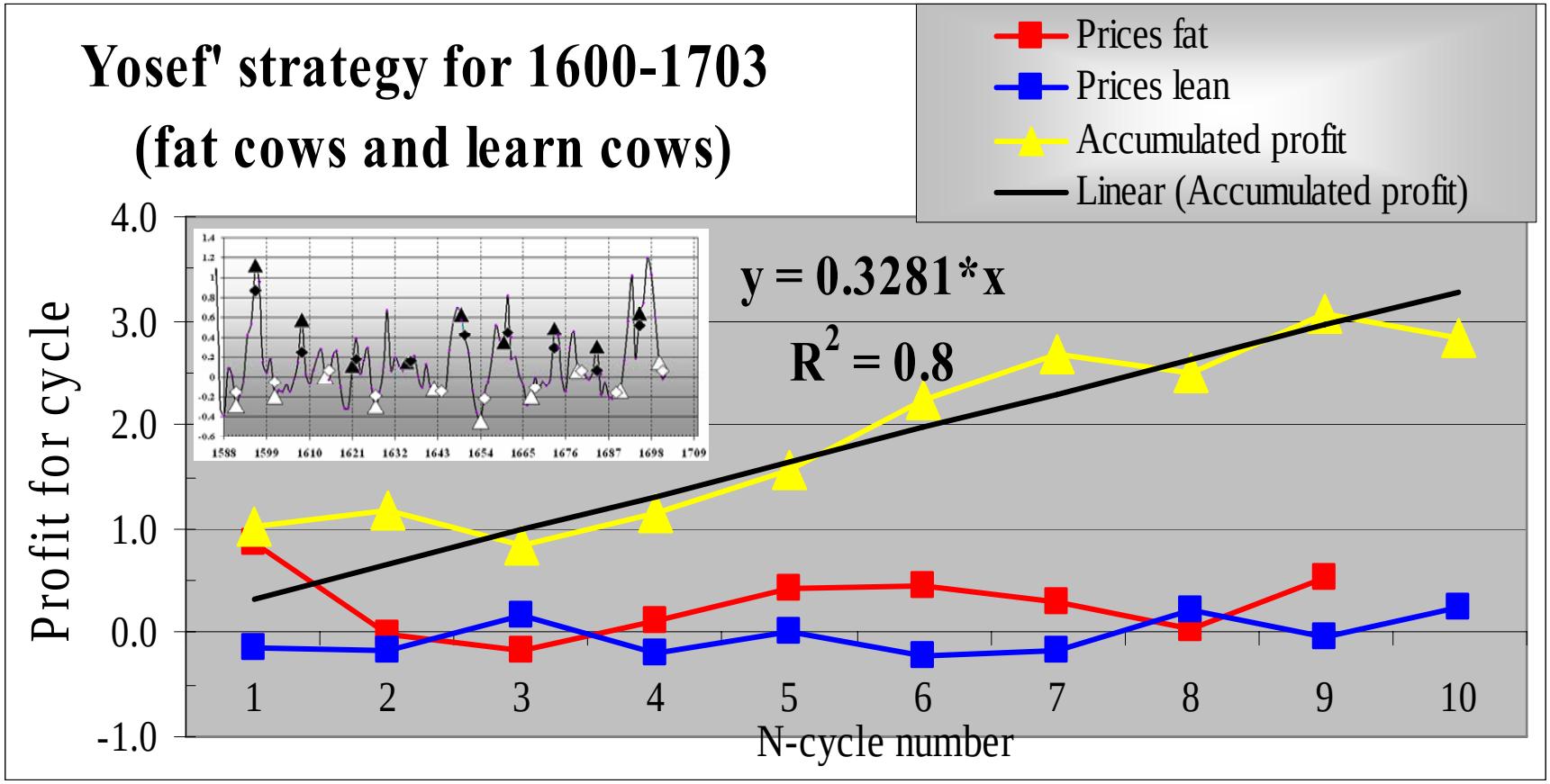


Statistics of Max/Min price Asymmetry-Correspondence between wheat price level and solar cycle phase for 1600-1700 from ^{10}Be in Greenland ice

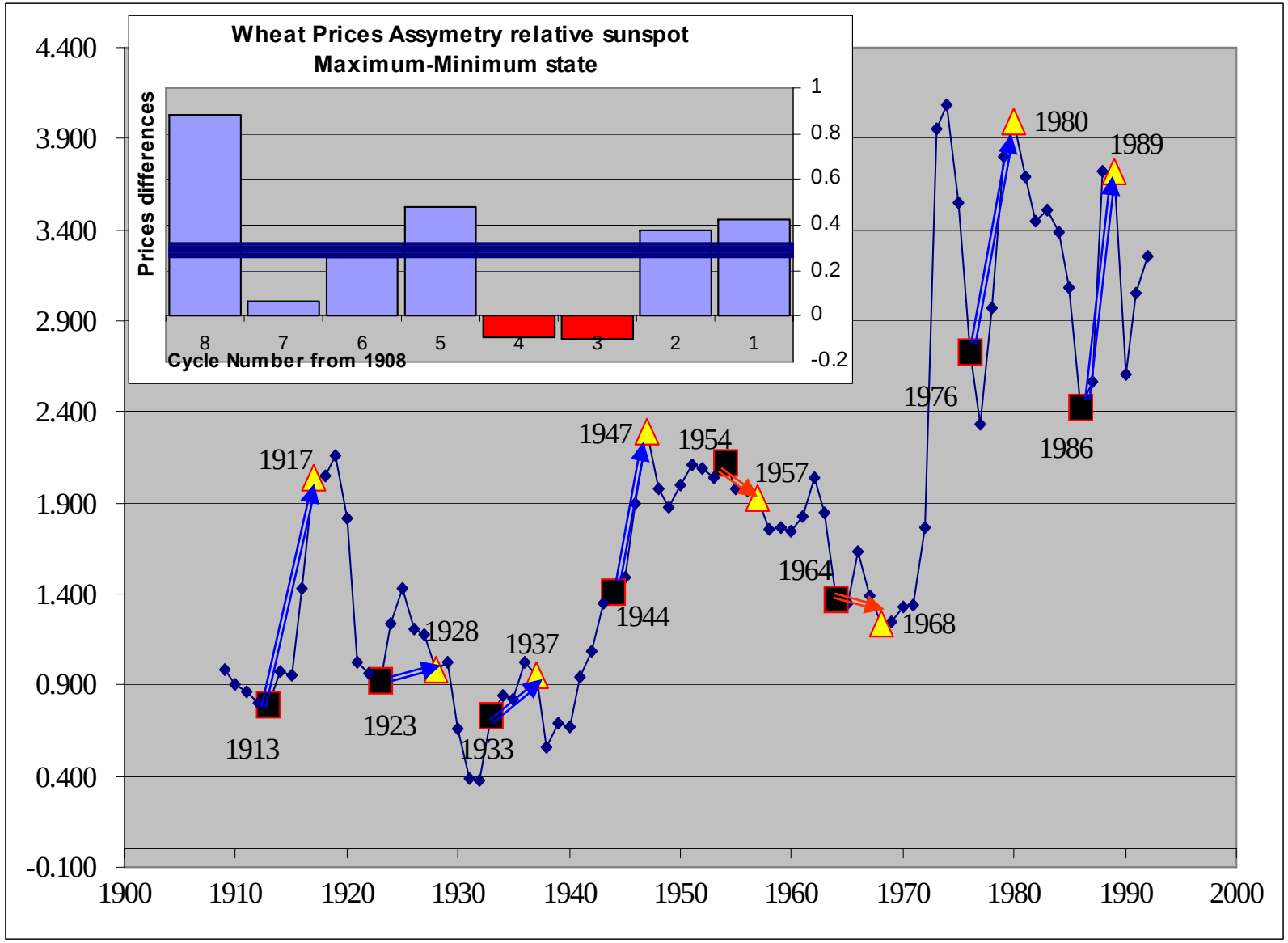


- Consistent differences in prices at moments of maximum and minimum states of solar activity (1600-1700). White and black triangles are prices in the moment of the maximum and minimum of solar activity from ^{10}Be. White and black rectangles are prices averaged for 3-years intervals centered on moments of maximum and minimum.
- $W = (1/2)^9 < 0.2\%$

Speculations on the corn exchange as test of statistical reliability of conclusions

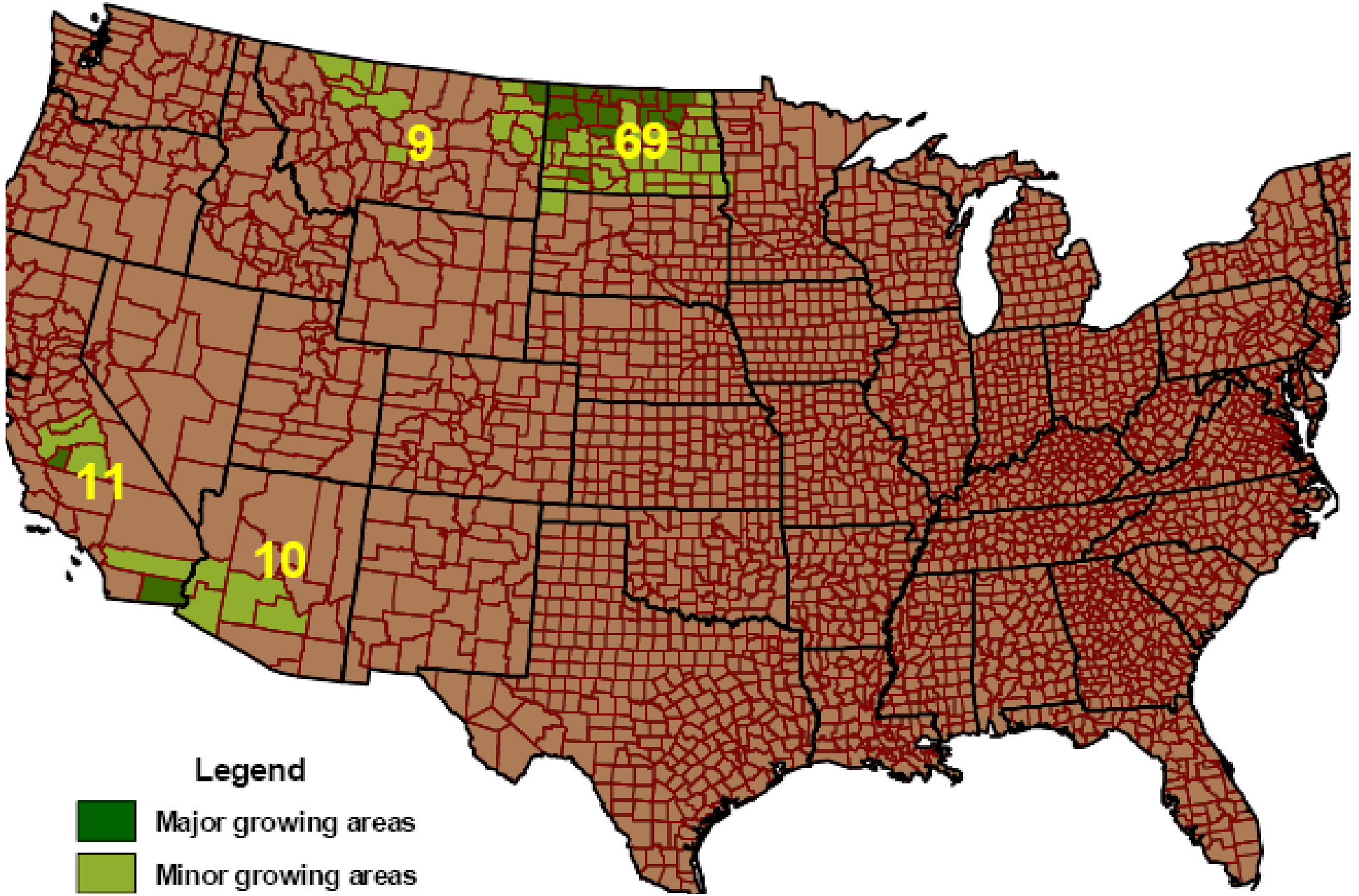


Wheat Price Asymmetry in USA (1910-1992)



ıited States: Durum

Yellow numbers indicate percent of national total
state contributes to national production annually
not numbered contribute less than 1% to the nati



Interval analysis in search of optical "fluctuars" = isolated black holes in ISM

Victor Schwartzman, Josef Bernshtein,1973

- Bright hallo around BH
- Energy release – flare like reconnection
- Expected time curve – numerous bursts on 2-3 R_g with time $\tau \approx R_g/c$=10-100 μs
- For intensity 10^3-10^4 counts/sec standard approach is impossible
- **Solution: statistics of the intervals between photons –> excess above Poisson on the $\Delta t \approx \tau$**