Space weather, the atmosphere, and human health on Earth and in Space

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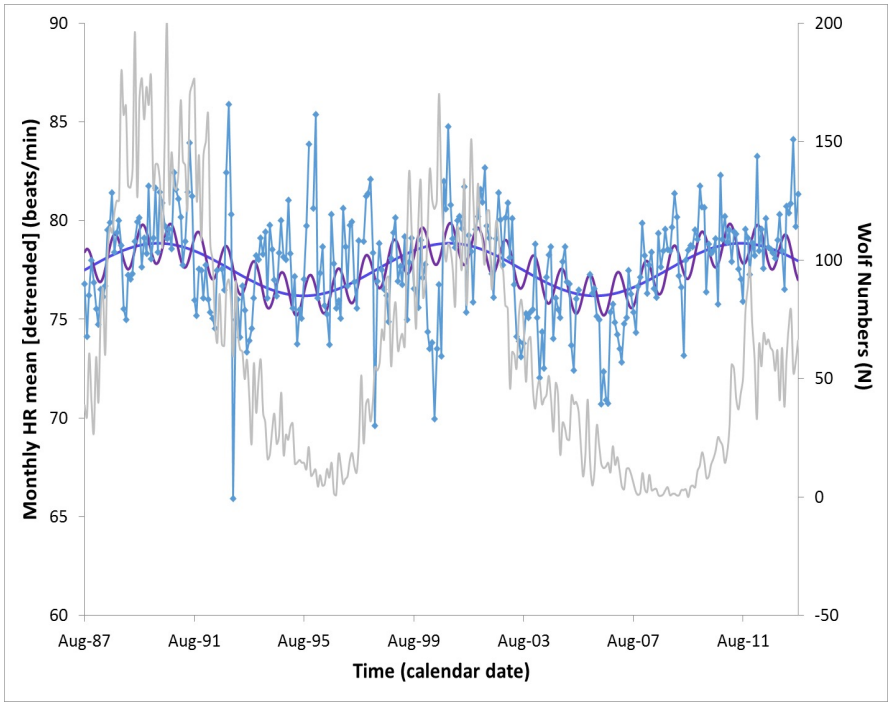
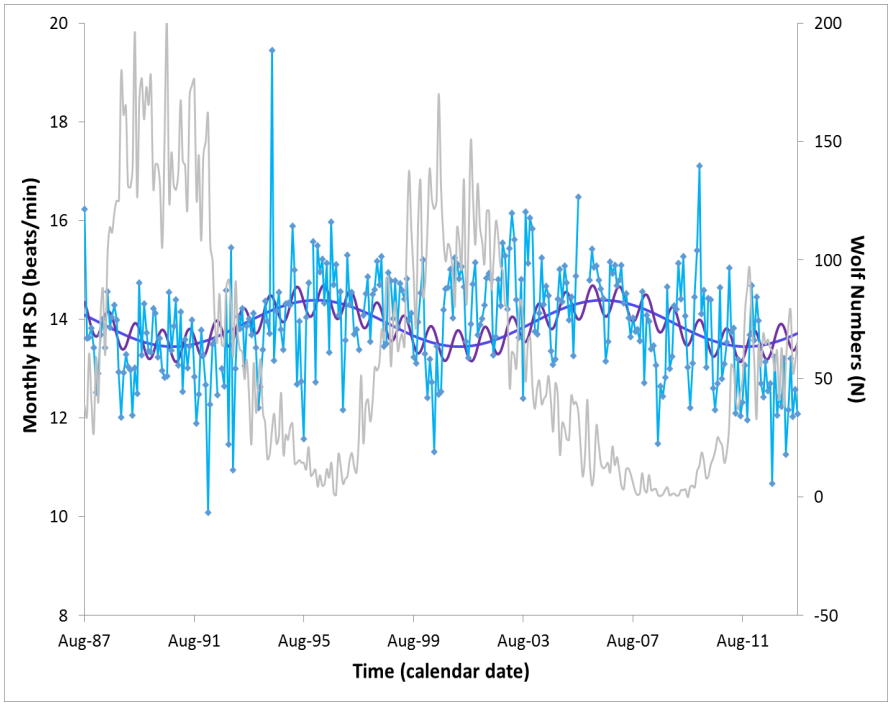
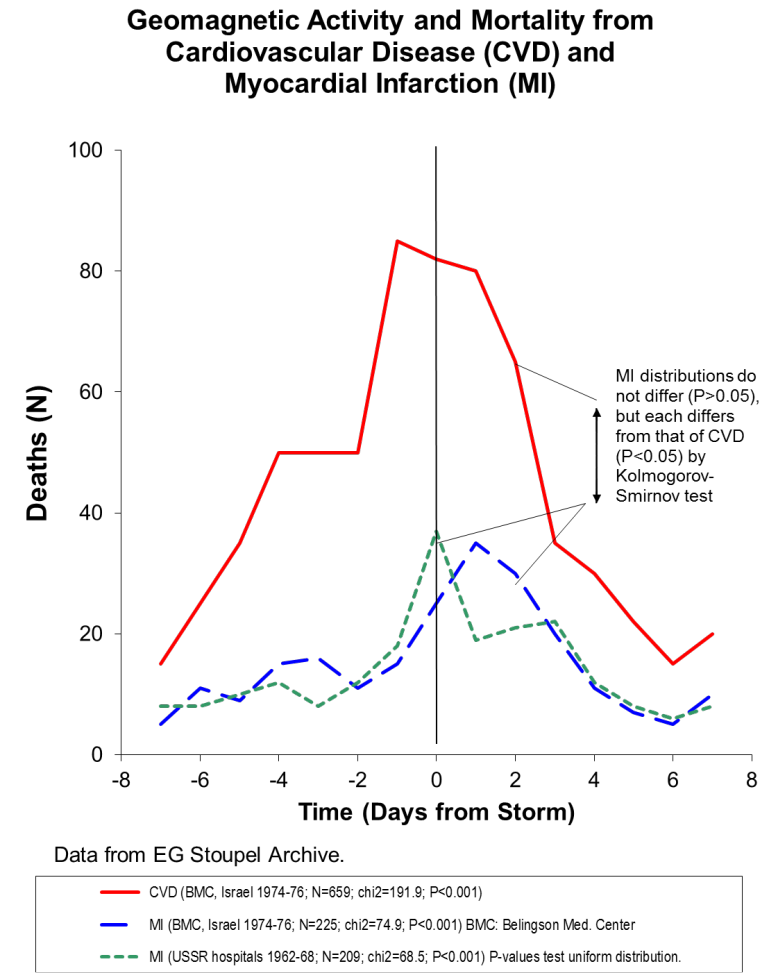
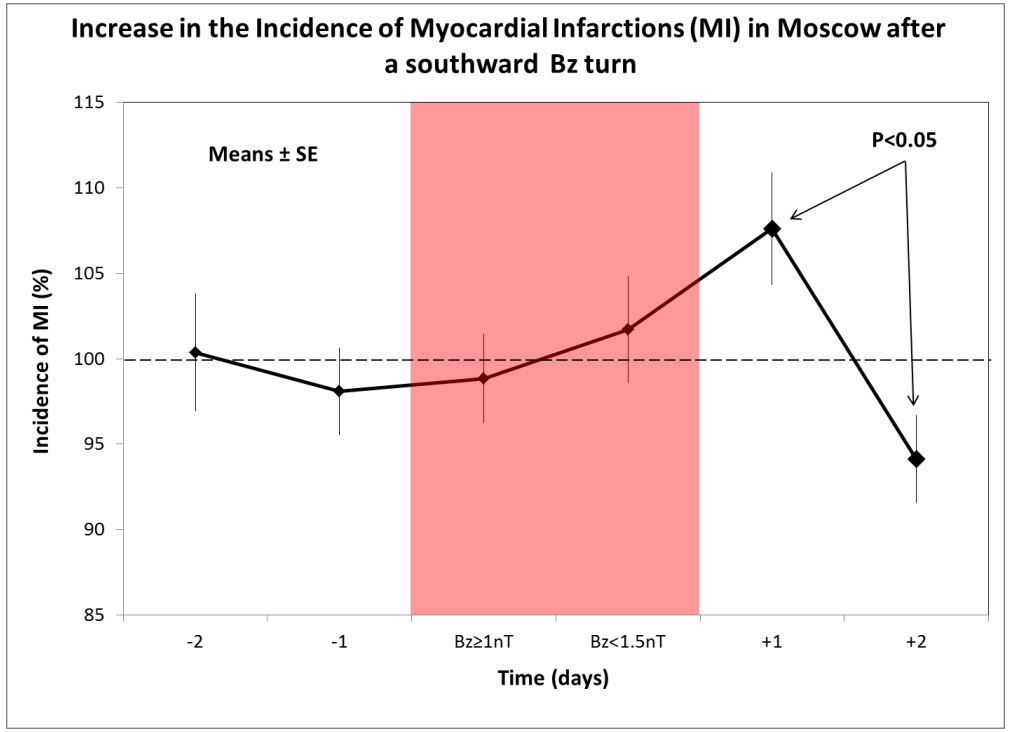
Evidence accumulates for effects of space weather - on human physiology



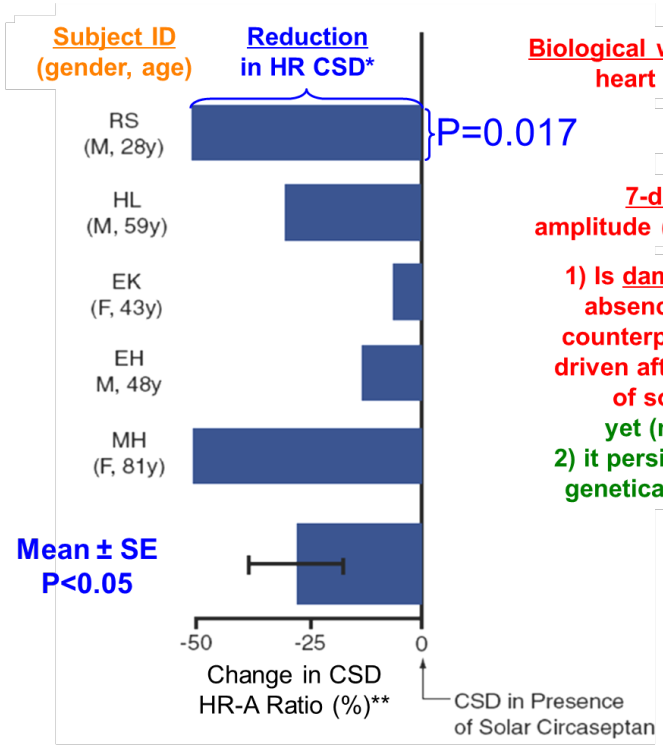


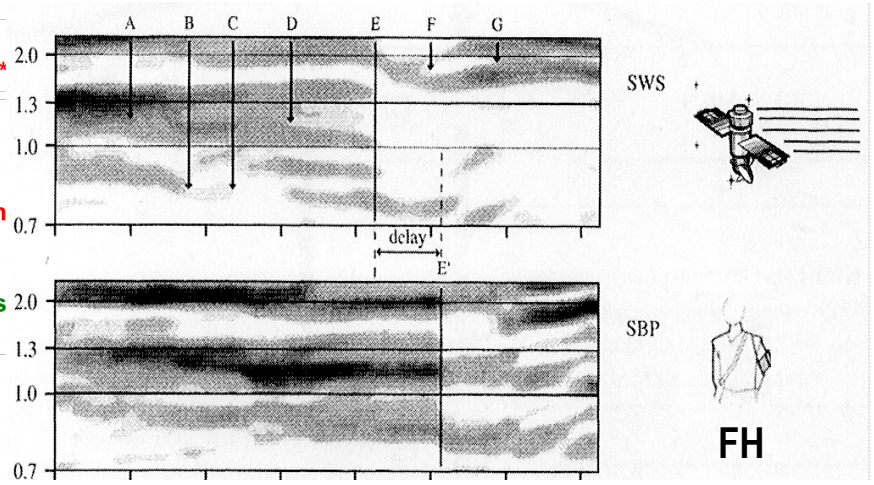
Evidence accumulates for effects of space weather - on human pathology





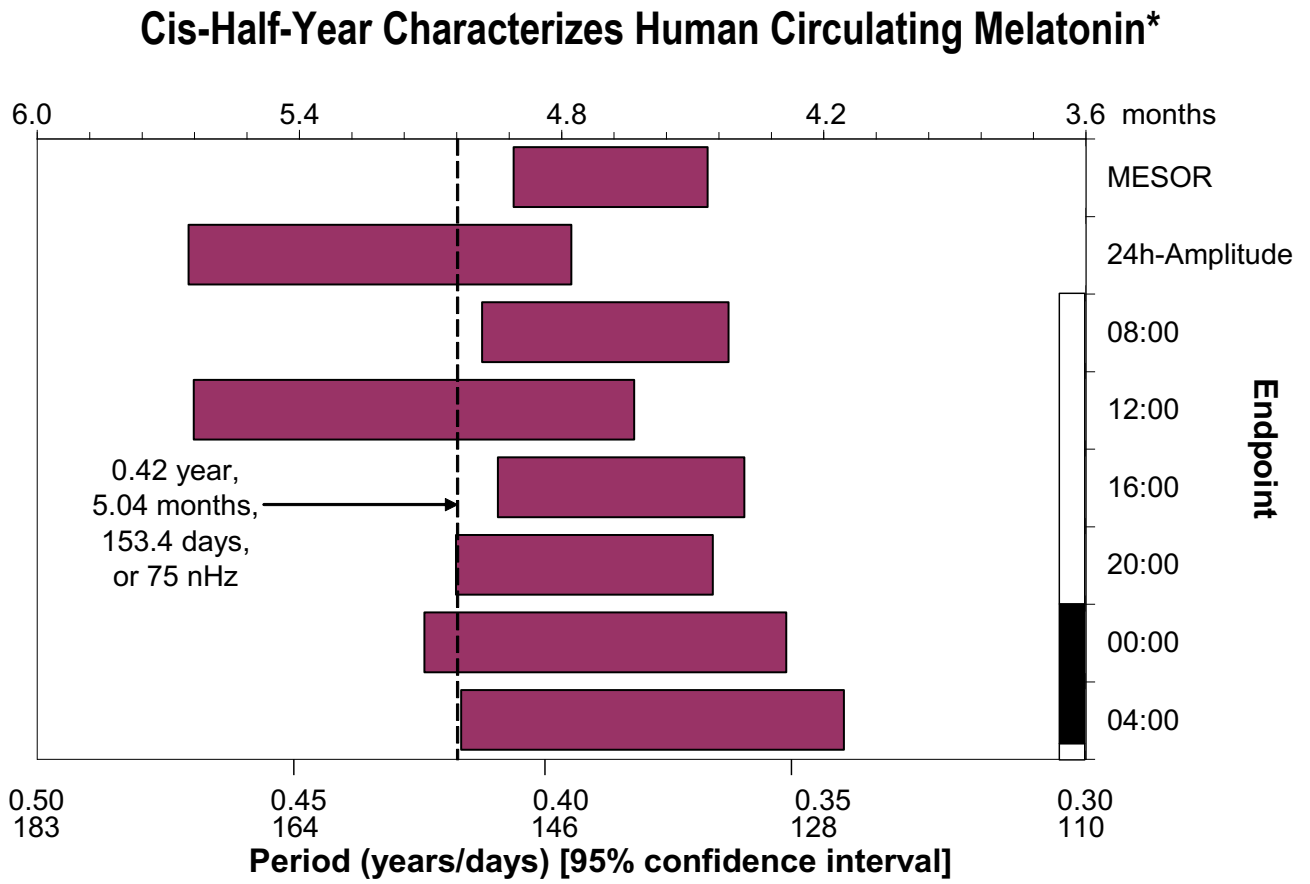
Documentation by superposed epochs, remove-and-replace, and periodicities shared between environment and biota





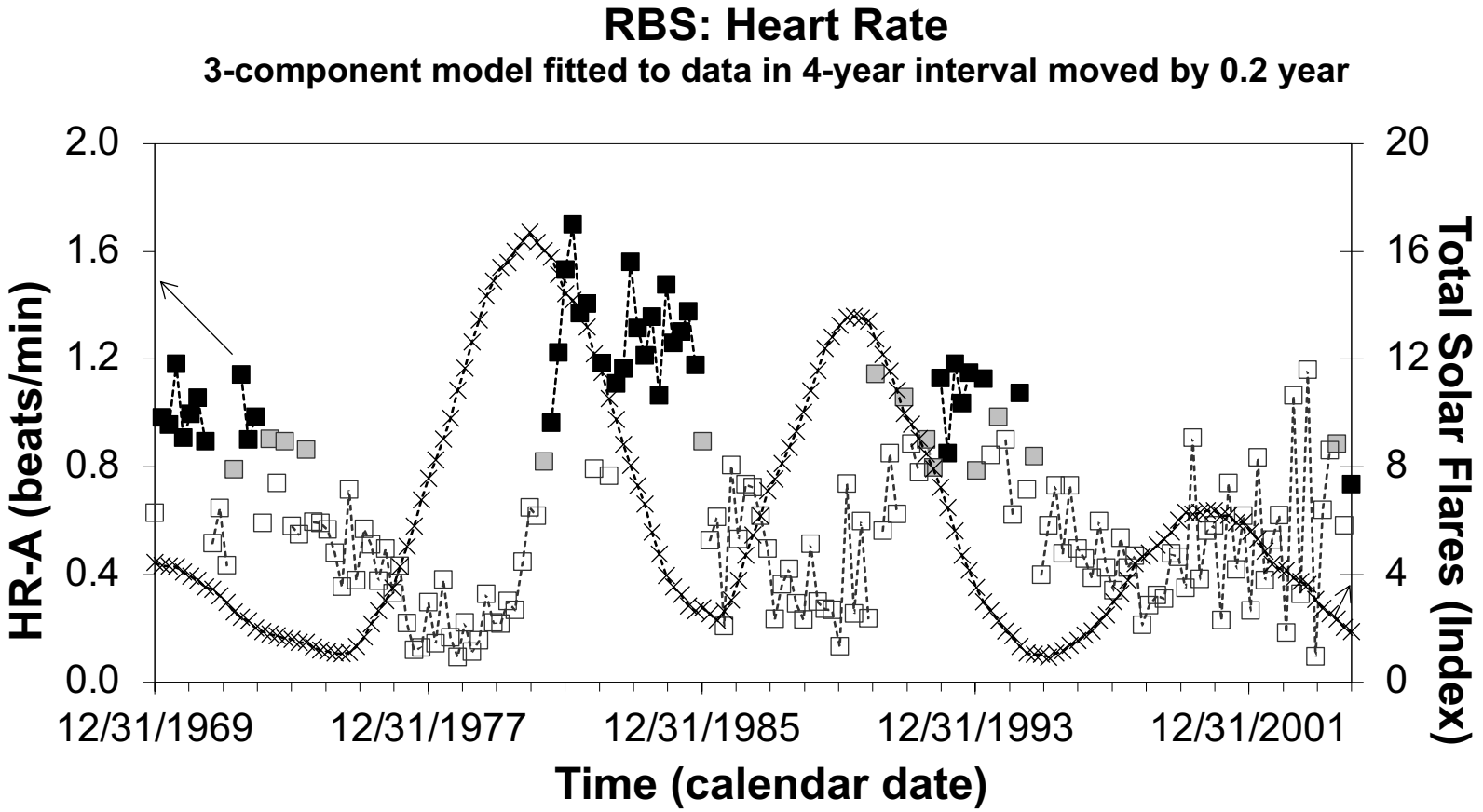
*CSD: circaseptan (7-day)-to-circadian (1-day) A ratio
**When 7-day component in sunspot area has no 7-day component (as analyzed by Y.S. Vernova et al., Geomagnetism and Aeronomy 1983; 23: 425-427).

Shared periodicities include about 5-month cycles found in solar flares

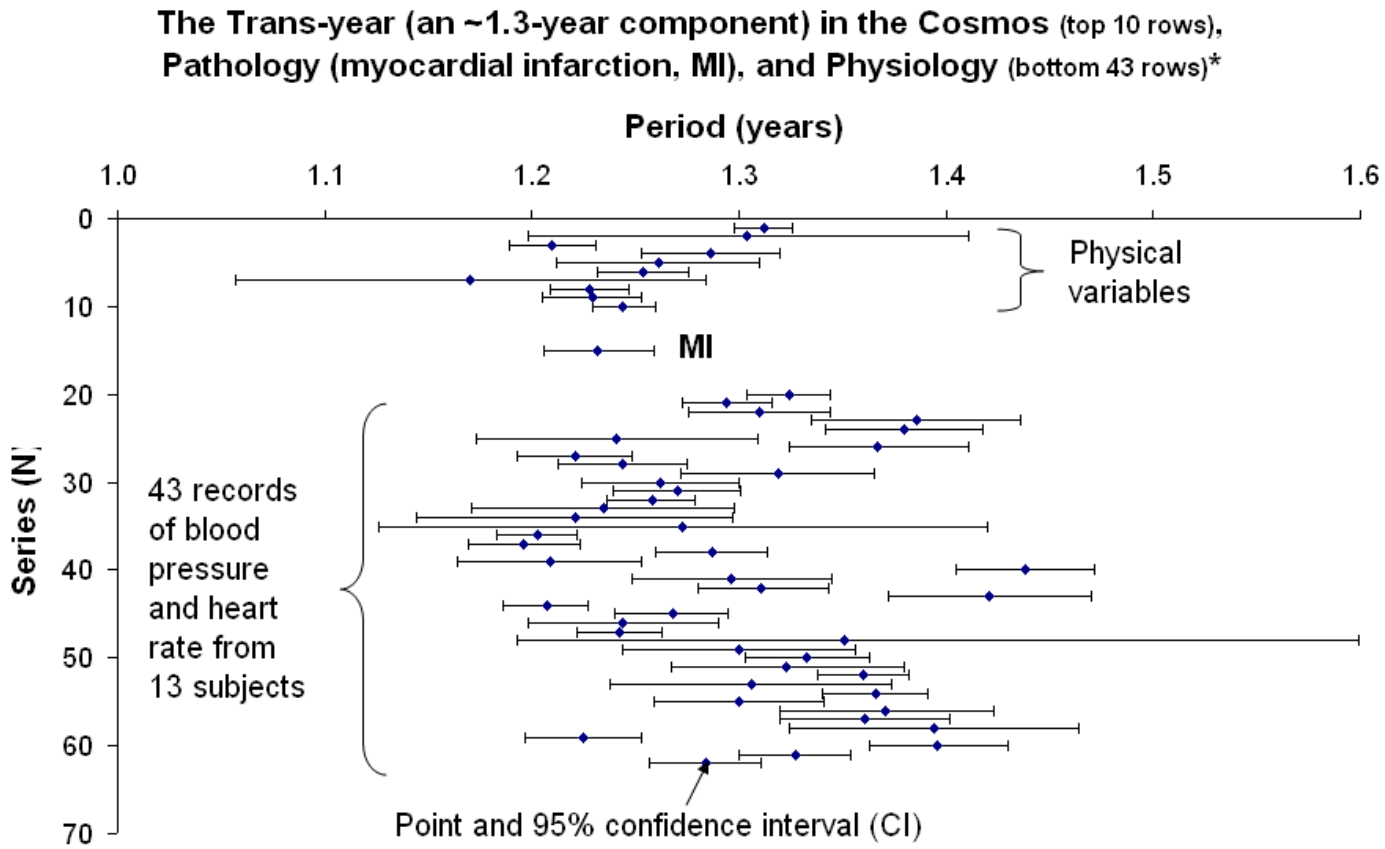


* 172 patients (Oct 1992 - Dec 1995), each providing 4-hourly blood samples for 24 hours in Florence, Italy.

Shared periodicities include about 5-month cycles found in solar flares

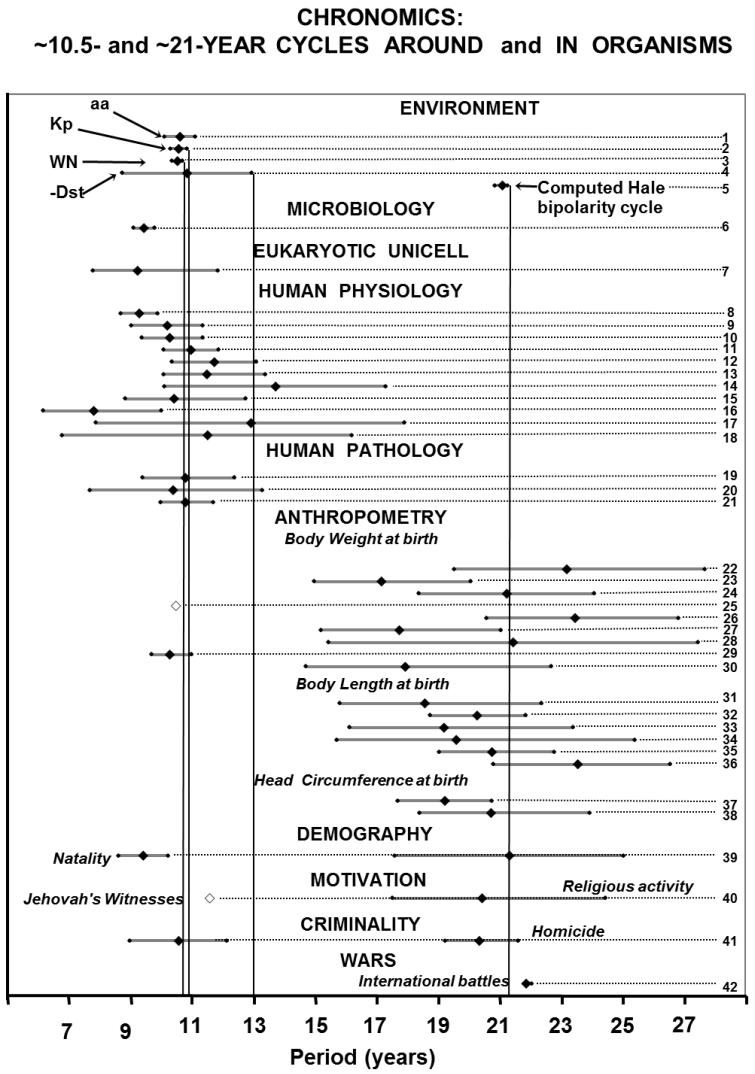


Shared periodicities include about 1.3-year cycles found in the solar wind



*** All differing by non-overlapping 95% CIs from the precise calendar year and many differing among each other, a putative hint of endogenicity.**

Shared periodicities include about 11- and 22-year cycles found in solar activity

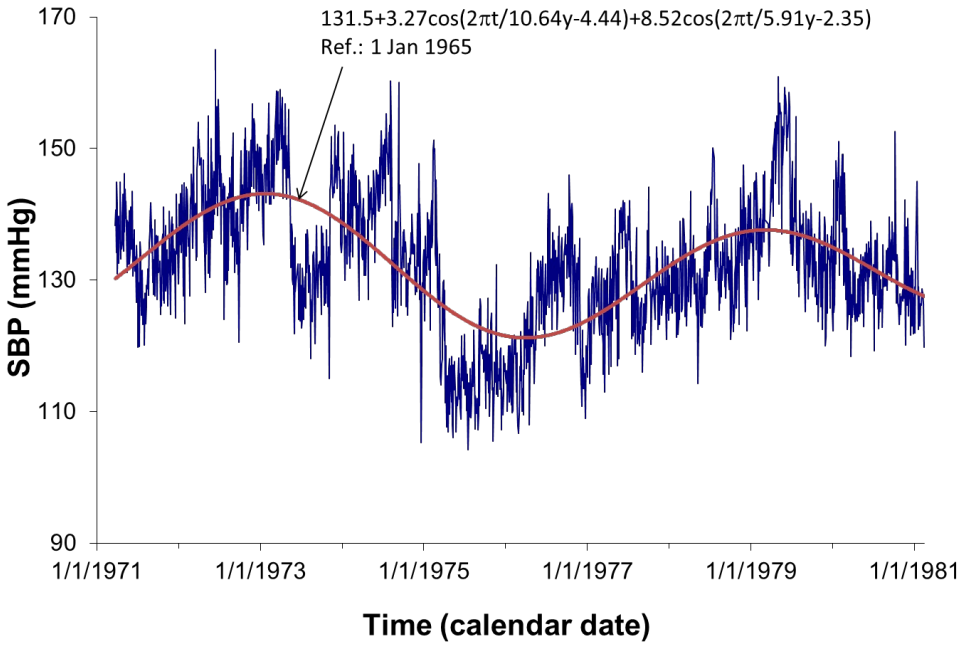


Chronomics: ~10.5- and ~21-year cycles in and around us

	Line		Period (years) Lower limit*	Best Fit	Upper limit*	Series duration Dates	Years	Number of data	Geographic site
Environment	1	aa = Antipodal Geomagnetic Index	10.12	**10.63**	11.13	1890-1999	110	1 / year	
	2	Kp = Planetary Geomagnetic disturbance	10.32	**10.58**	10.85	1932-1999	68	1 / month	
	3	WN = Wolf relative sunspot number	10.37	**10.54**	10.70	1890-1999	110	1 / year	
	4	-Dst = Equatorial geomagnetic disturbance	8.75	**10.85**	12.96	1973-1999	27	"	
			10.48	**10.51**	10.55	1700-1999	300	"	
	5	Bipolarity "Hale Cycle" **	20.86	**21.10**	21.26	1890-1999	110	"	
			21.42	**21.428**	21.43	1700-1999	300	"	
Biology	6	Prokaryotes: Air Bacterial Sectoring	9.12	**9.45**	9.81	1970-1982	13	3,744	Italy
	7	Eukaryotes: Unicellular Algal O_2 Production	7.79	**9.24**	11.87	1980-1991	11	324	Germany
Physiology* **	8	Mood (RBS)	10.11	**11.50**	13.41	1966-1998	33	~5 / day	USA
	9	Time (1-Minute) Estimation (RBS)	9.38	**10.29**	11.37	1966-1998	33	"	"
	10	Urinary 17-ketosteroid excretion (CH)	8.70	**9.30**	9.90	1948-1963	15	1 / day	Denmark
	11	Peak Expiratory Flow (RBS	10.36	**11.74**	13.11	1966-1998	33	~5 / day	USA
	12	Respiratory Rate (RBS)	10.13	**12.50**	17.32	1966-1998	33	"	"
	13	Systolic Blood Pressure - SBP (RBS)	9.05	**10.21**	11.36	1966-1998	33	"	"
	14	Standard Deviation of SBP (YW)	8.85	**10.43**	12.76	1987-1998	11	~48 / day	Japan
	15	Diastolic Blood Pressure - DBP (RBS)	10.09	**10.98**	11.87	1966-1998	33	~5 / day	USA
	16	Standard Deviation of DBP (YW)	6.18	**7.82**	10.02	1987-1998	11	~48 / day	Japan
	17	Heart Rate - HR (YW)	9.54	**12.93**	17.91	1987-1998	11	"	"
	18	Standard Deviation of HR (YW)	8.27	**11.52**	16.22	1987-1998	11	"	"
Pathology	19	Myocardial Infarction	10.00	**10.80**	11.70	1960-1996	37	129,205	USA
	20	Leptospirosis	9.40	**10.80**	12.40	1949-1995	47	2,907	Slovakia
	21	Diabetes	7.70	**10.40**	13.30	1985-1995	11	1,369	"
Anthropo-metry at birth		***Body Weight*** ***Boys***							
	22	Minnesota	19.53	**23.19**	27.67	1963-1998	36	2,136,745	USA
	23	Alma-Ata Russians	14.99	**17.17**	20.07	1946-1998	53	9,056	Kazakhstan
	24	" Kazakhs	18.39	**21.24**	24.05	1946-1998	53	3,459	"
	25	Moscow		**10.49**		1874-1985	112	5,987	Russia
		Girls							
	26	Minnesota	20.58	**23.46**	26.83	1963-1998	36	1,039,464	USA
	27	Alma-Ata Russians	15.21	**17.75**	21.06	1946-1998	53	9,105	Kazakhstan
	28	" Kazakhs	15.44	**21.45**	27.45	1946-1998	53	3,448	"
	29	Moscow	9.70	**10.29**	11.01	1874-1985	112	5,840	Russia
		Both genders							
	30	Denmark	14.71	**17.94**	22.68	1973-1994	22	1,166,206	Denmark
		Body Length ***Boys***							
	31	Alma-Ata Russians	15.82	**18.58**	22.38	1946-1998	53	9,026	Kazakhstan
	32	Moscow	18.76	**20.28**	21.86	1874-1985	112	5,976	Russia
		Girls							
	33	Alma-Ata Russians	16.13	**19.20**	23.39	1946-1998	53	9,105	Kazakhstan
	34	" Kazakhs	15.72	**19.60**	25.40	1946-1998	53	3,485	"
	35	Moscow	19.05	**20.76**	22.78	1874-1985	112	5,976	Russia
		Both genders							
	36	Denmark	20.81	**23.55**	26.55	1973-1994	22	1,166,206	Denmark
		Head Circumference							
	37	***Boys*** Moscow	17.71	**19.23**	20.75	1874-1985	112	5,976	Russia
	38	***Girls*** "	18.42	**20.73**	23.95	1874-1985	112	5,820	"
Demography	39	Birth rate	8.63	**9.43**	10.23	1940-1996	57	57	USA
			17.61	**21.33**	25.05	1940-1996			
Motivation	41	Religious activity of Jehovah's Witnesses	17.52	**20.44**	24.45	1950-1999	50	328,572# 5,653,987##	Worldwide
Criminality	40	Homicide	8.99	**10.58**	12.16	1900-1998	99	99	USA
			19.23	**20.35**	21.62				
Wars	42	International battles	21.87	**21.96**	22.06	599BC-1957	2556	2556	Worldwide

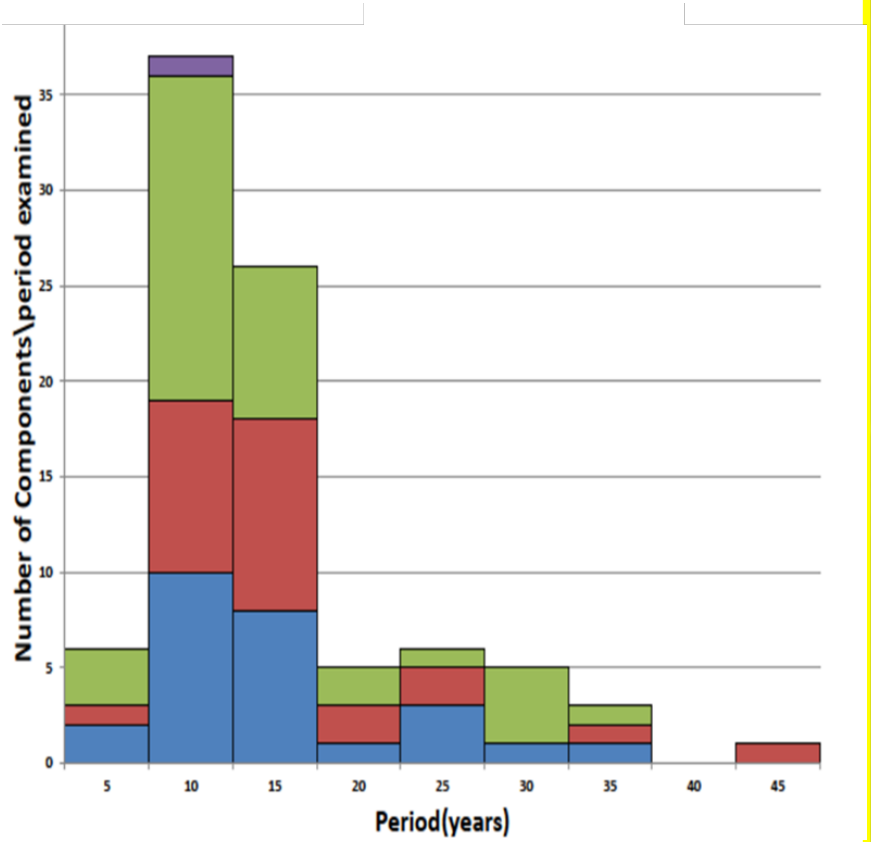
* 95% confidence limit; not shown if cycle is not statistically significant.
** Computed by changing the sign of WN at each WN minimum.
***RBS - Dr. Robert B. Sothern, CH - Dr. Christian Hamburger, YW - Dr. Yoshihiko Watanabe.
in 1950, ## in 1999, pool of 103 plus other unspecified number of sites.

Shared periodicities include about 11- and 22-year cycles found in solar activity



About 11-year cycles are found in many of the longitudinal records of blood pressure and heart rate from normotensive as well as treated hypertensive subjects

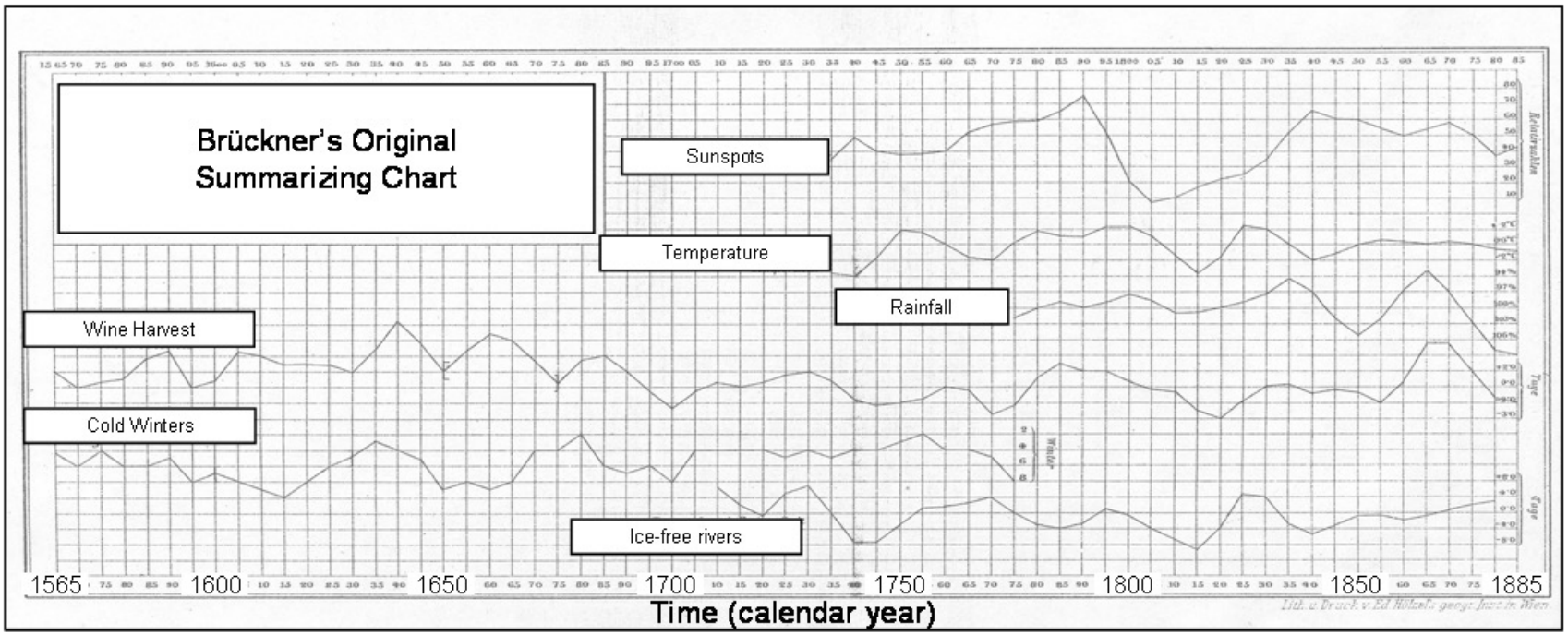
About 11-year cycles



Shared periodicities include about 35-year cycles found in solar activity

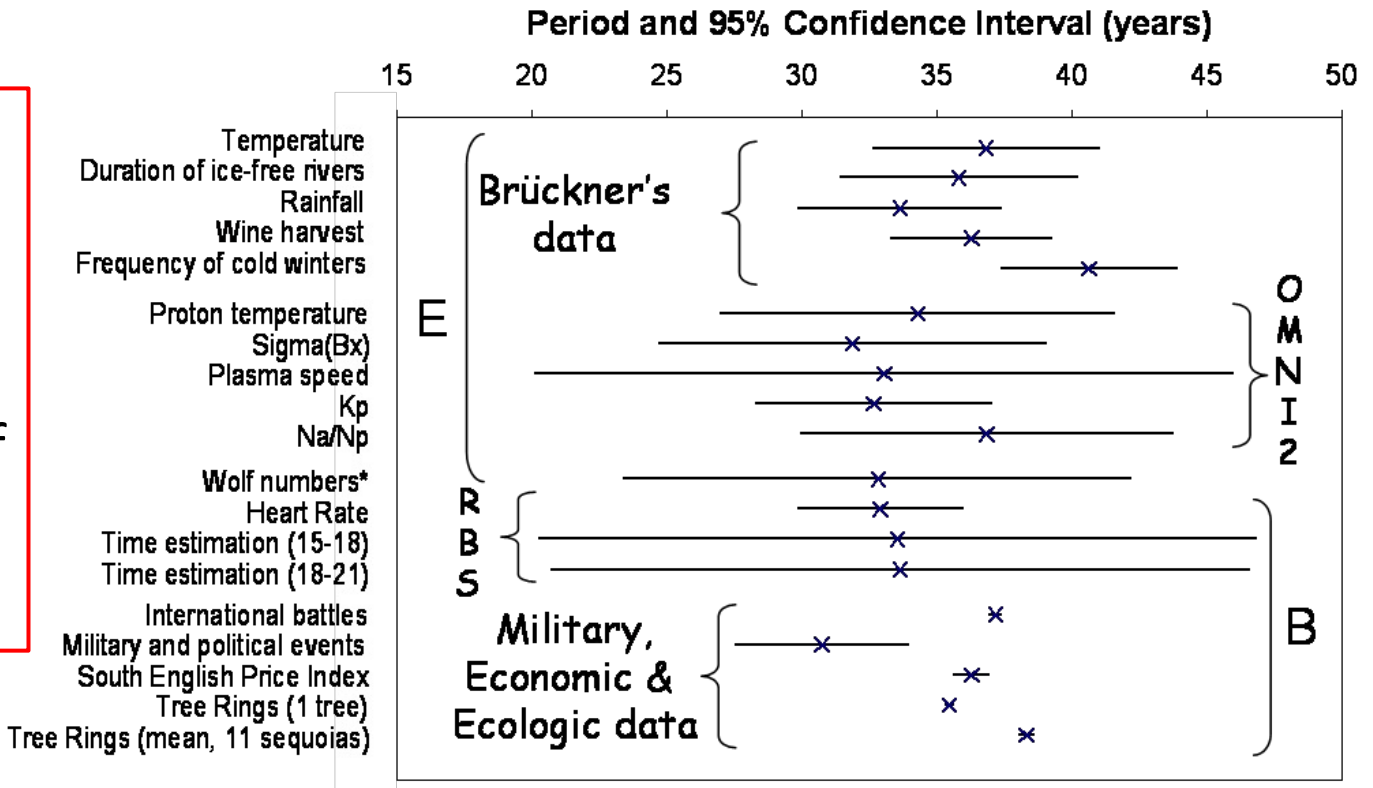
Brückner-Egeson-Lockyer (BEL) Cycle

Historical Macroscopy (top) and Time-Microscopy (bottom)



Shared periodicities include about 35-year cycles found in solar activity

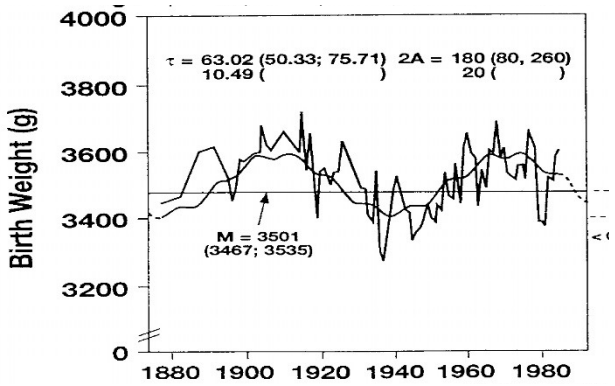
The ~ 35-year BEL cycle likely represents a modulation of the solar activity cycle



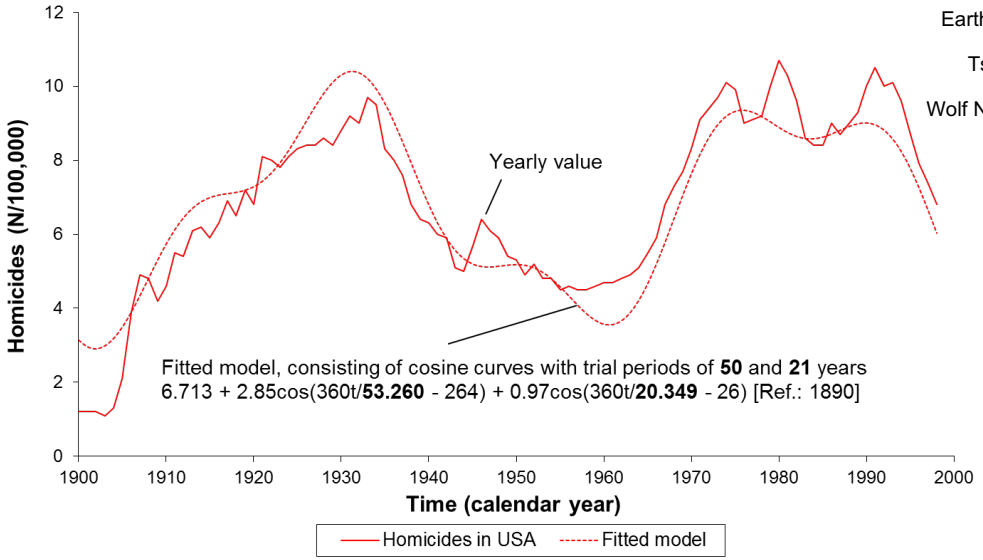
* Same about 40-year span as that of heart rate of 20-60 year-old man (RBS), assessed in 3-component model; RBS also estimated 1 minute by counting; results shown for measurements taken between 15:00 and 18:00 and between 18:00 and 21:00

E: Environment; B: Biosphere

Shared periodicities include about 50-year cycles

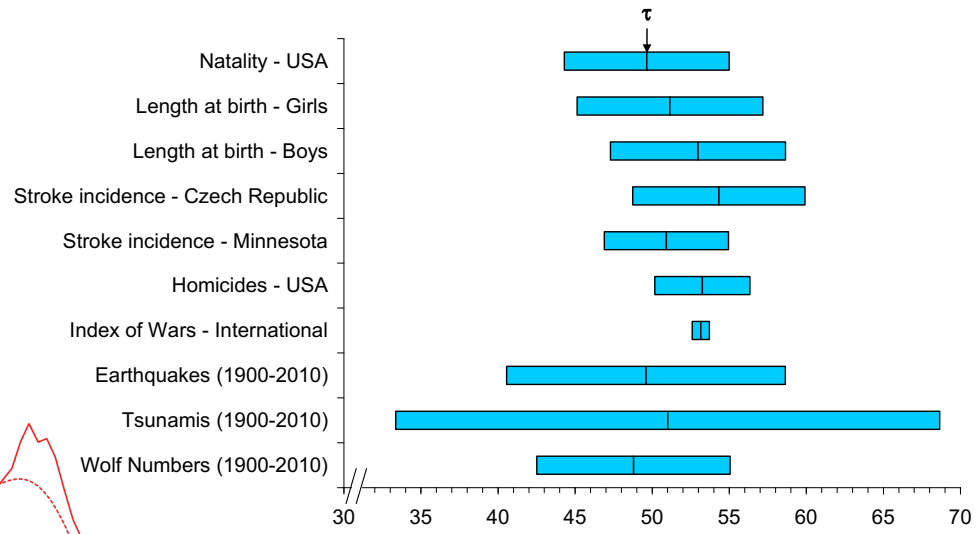


Changes in Homicides in the USA (1900-1998)*



* National Center for Health Statistics (Homicide rates from the Vital Statistics: http://www.ojp.usdoj.gov/bjs/glance/hmrt.htm)

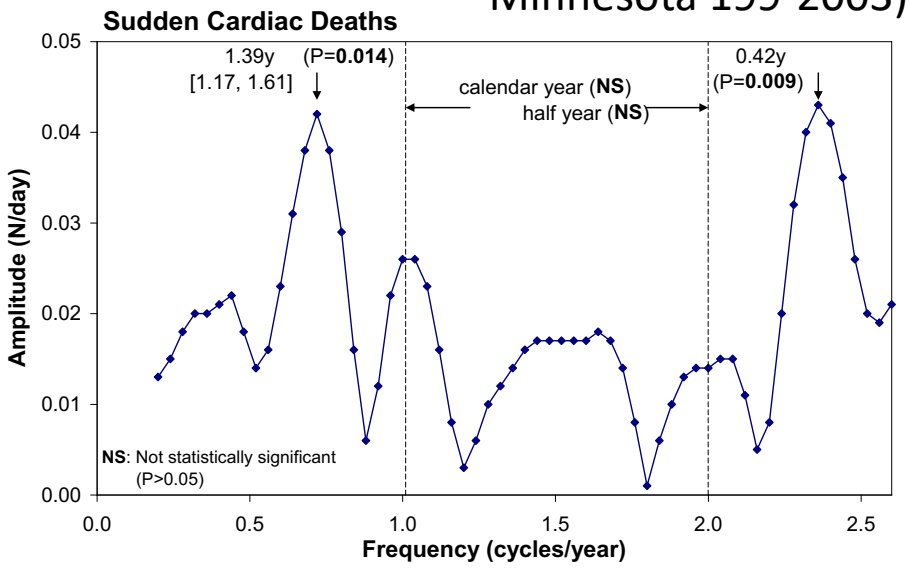
Transdisciplinary Mapping of about 50-year Spectral Components

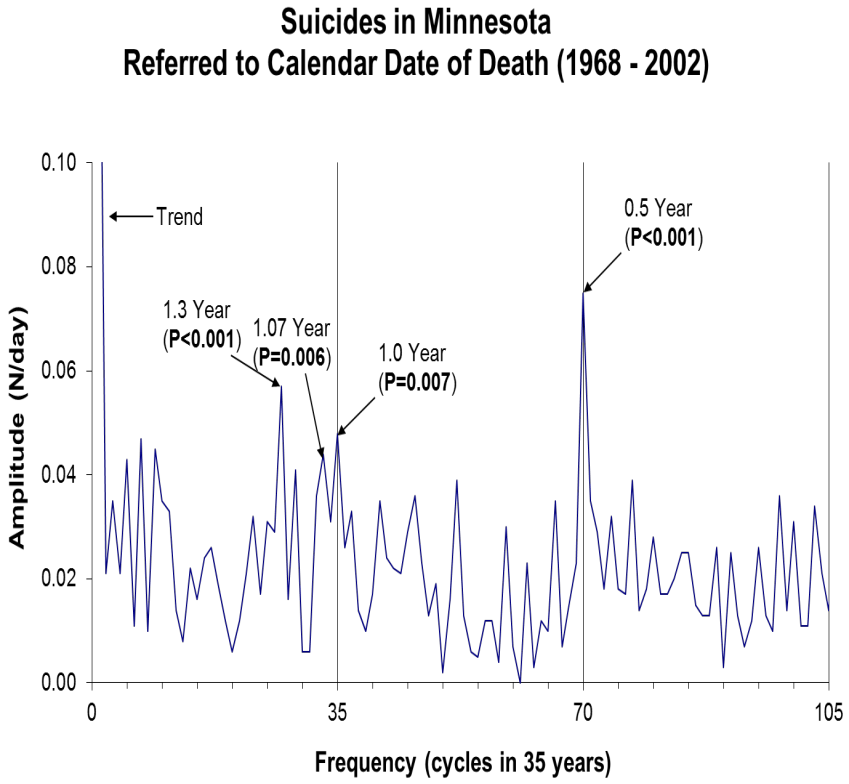


Solar signatures are found in mortality statistics (sudden cardiac death, suicide)

Transyear: about 1.3-year

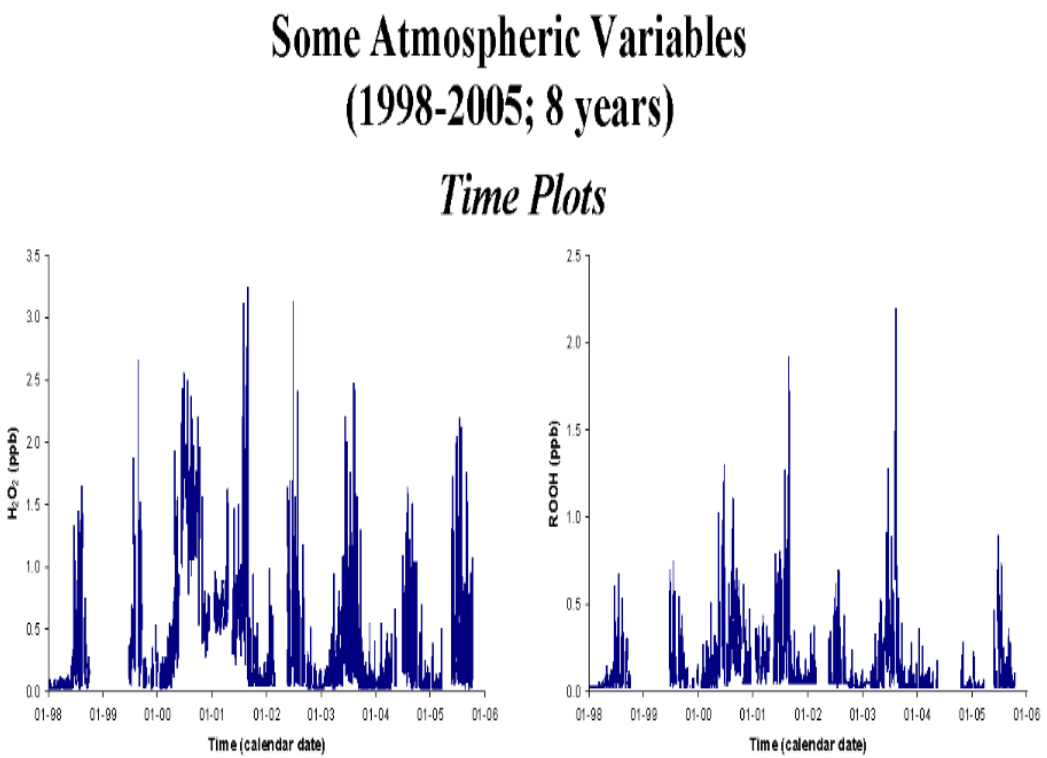
Minnesota 199-2003)





Transyears characterize atmospheric compounds

Measurements at Zugspitze/Hohenpeissenberg station, Germany

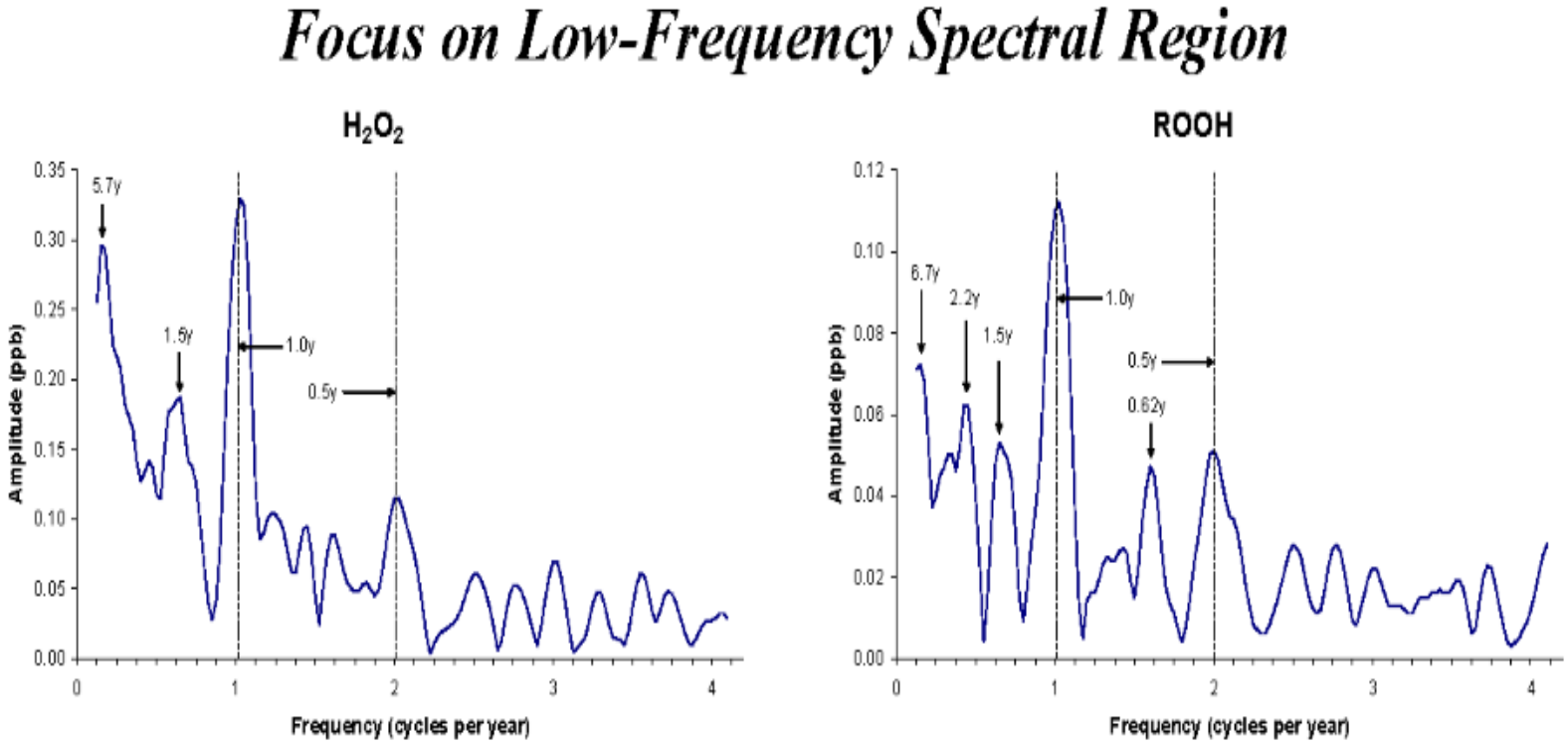


In addition to prominent daily rhythms in hydrogen peroxide (H_2O_2) and higher organic peroxides (ROOH), a transyear with a period of about 1.3 years is detected with statistical significance along with a yearly variation.

Data from S Gilge.

Transyears characterize atmospheric compounds

Measurements at Zugspitze/Hohenpeissenberg station, Germany



Data from S Gilge.

Transyears characterize atmospheric compounds

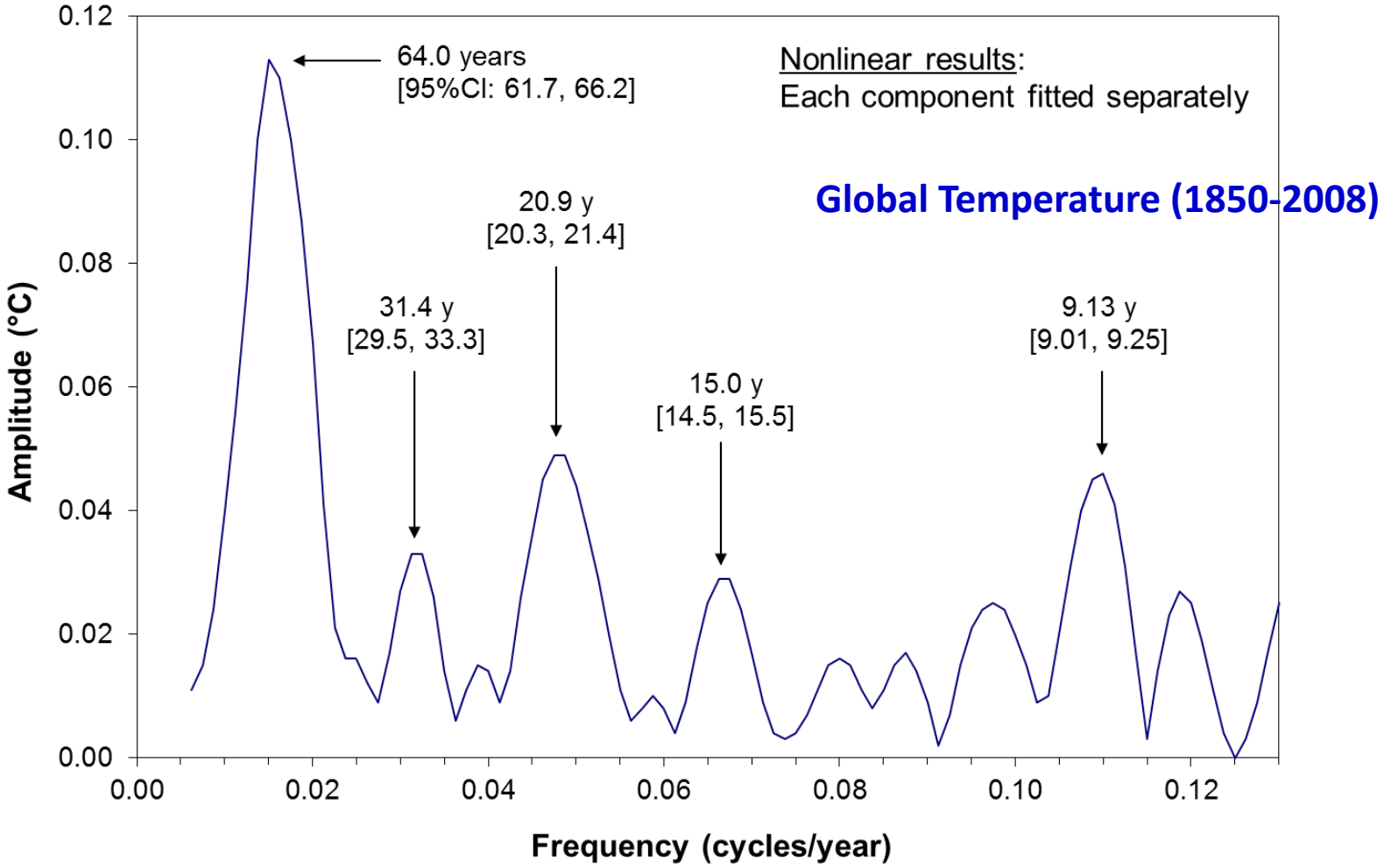
Measurements at Zugspitze/Hohenpeissenberg station, Germany

A transyear was further documented to characterize the F10.7 cm index (2007-2012).
Since F10.7 correlates well with a number of ultraviolet and visible solar irradiance records, and
since ultraviolet irradiance is absorbed in the upper atmosphere, which heats the upper atmosphere and ionizes it to create the ionosphere,
it is likely that periodicities such as the transyear detected in several atmospheric variables may reflect solar variability, transmitted through changes occurring in the ionosphere.

Data from S Gilge.

Decadal cycles and economics

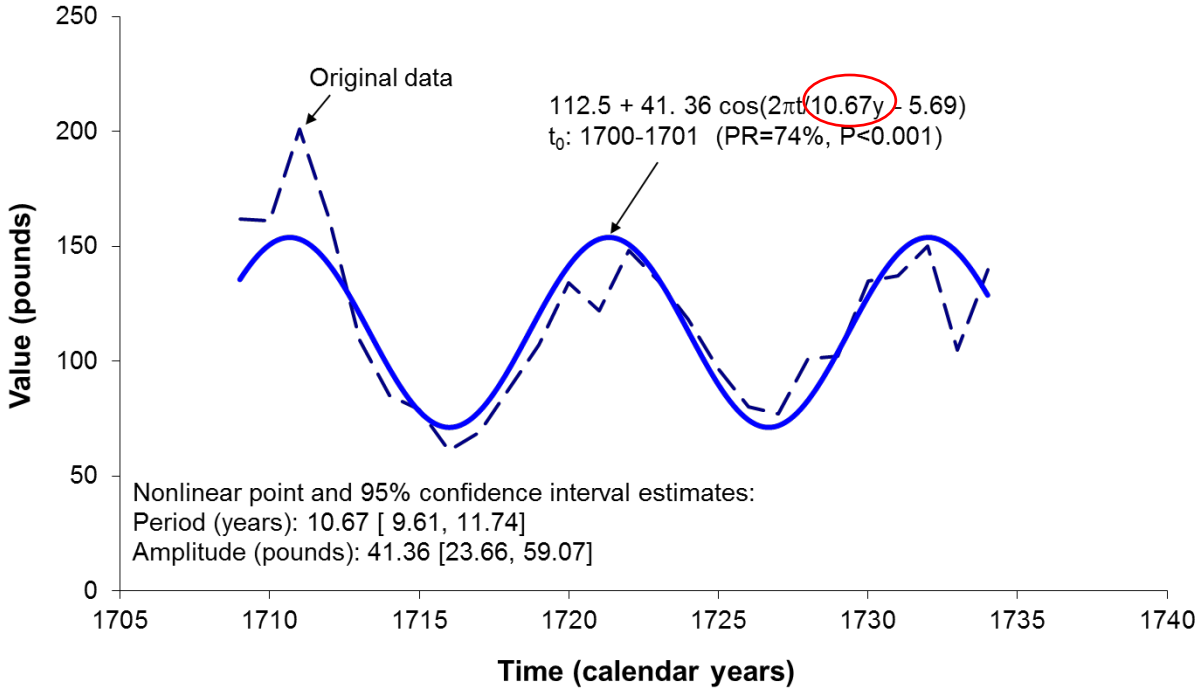
Decadal cycles characterize changes in the Earth's surface temperature



Decadal cycles and economics

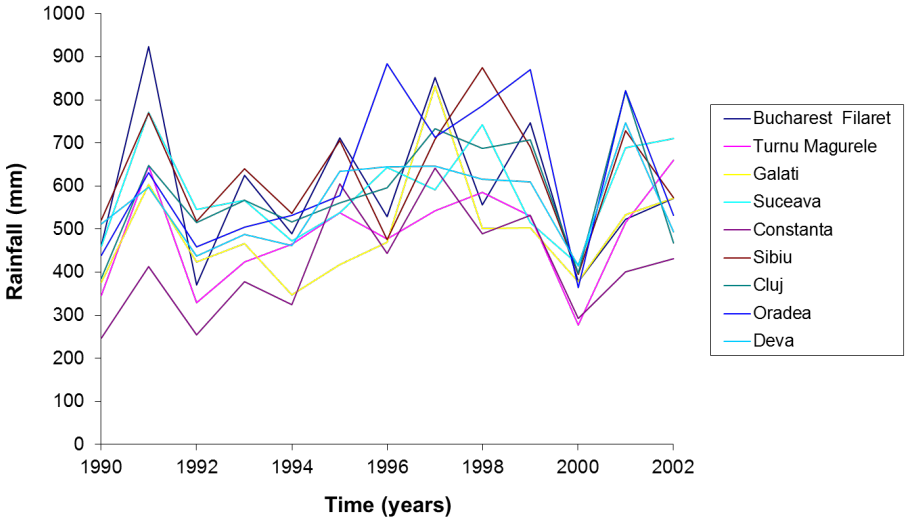
Hyde Clarke (1838) first reported an about 11-year economic cycle.

Data from: William Milburn (1813)

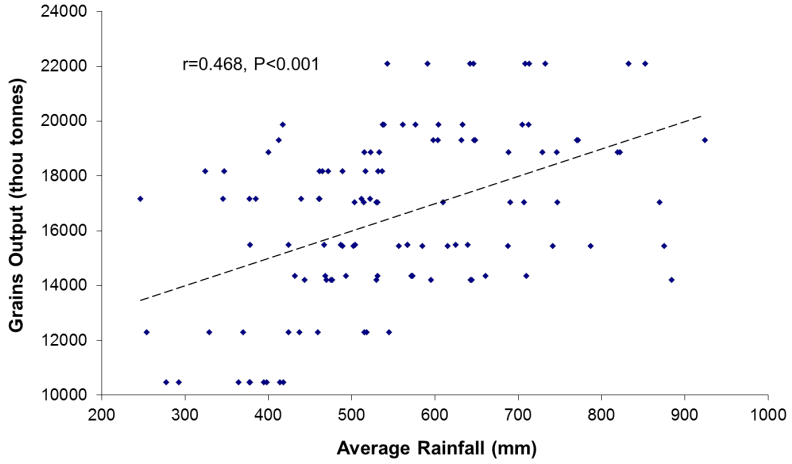


Decadal changes were quantified for a number of data published by **William Milburn** in relation to goods imported by the Honorable East India Company between 1708-1709 and 1733-1734

Cycles in economics and agriculture



Grain Yield in Romania (1990 - 2002) Correlates with Rainfall



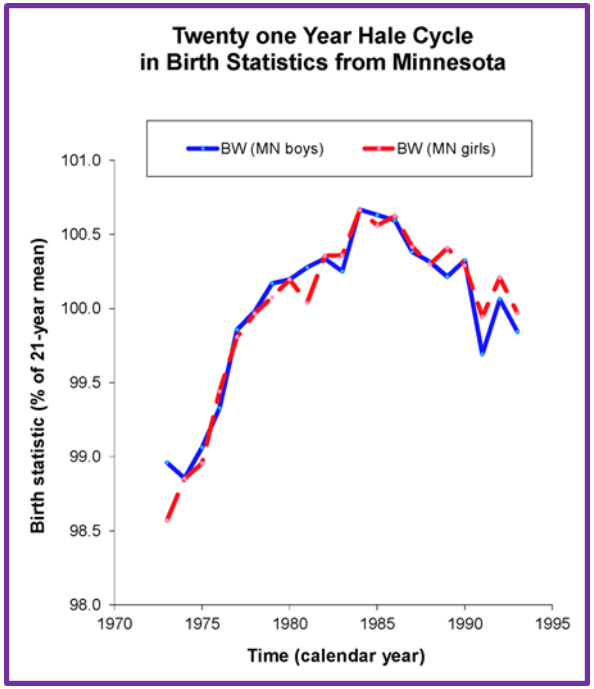
Decadal changes were also quantified for agricultural productivity during nearly 3 decades in Romania.

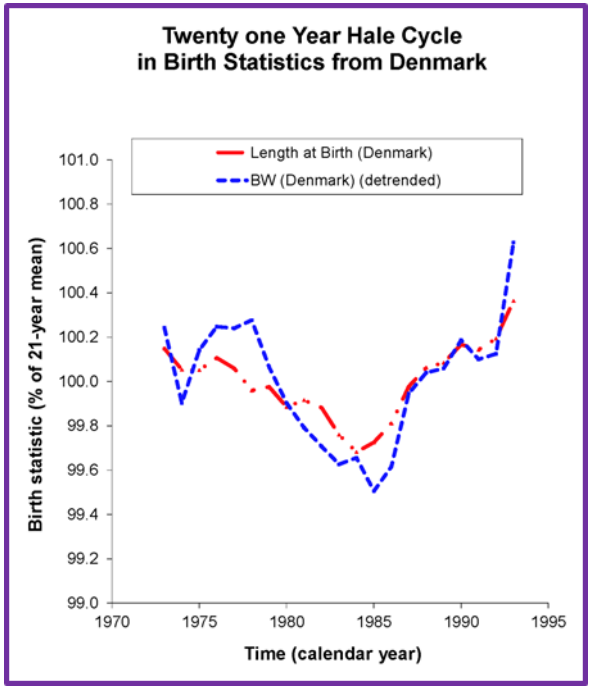
Total cultivated area and total production of wheat and rye, barley, corn, soya and sunflower in Romania: on average, all 5 crops follow an about 10.7-year component.

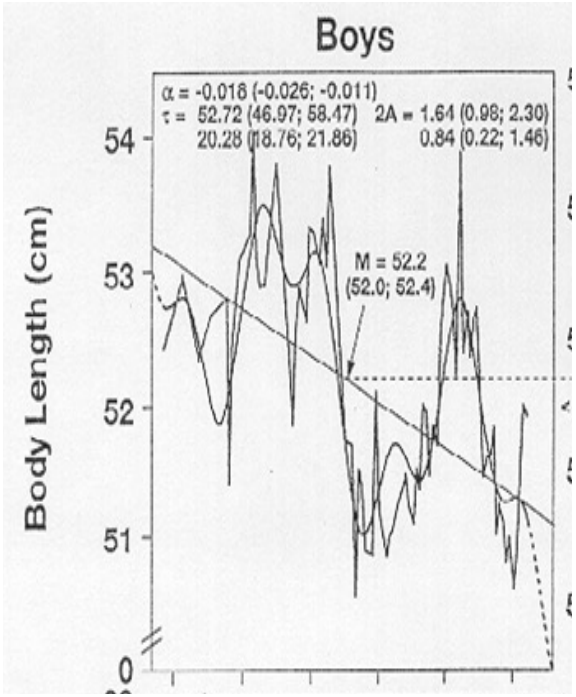
Data from C Turtoi.

Influence on health at birth?

Agriculture and economic cycles may affect health via epigenetics.



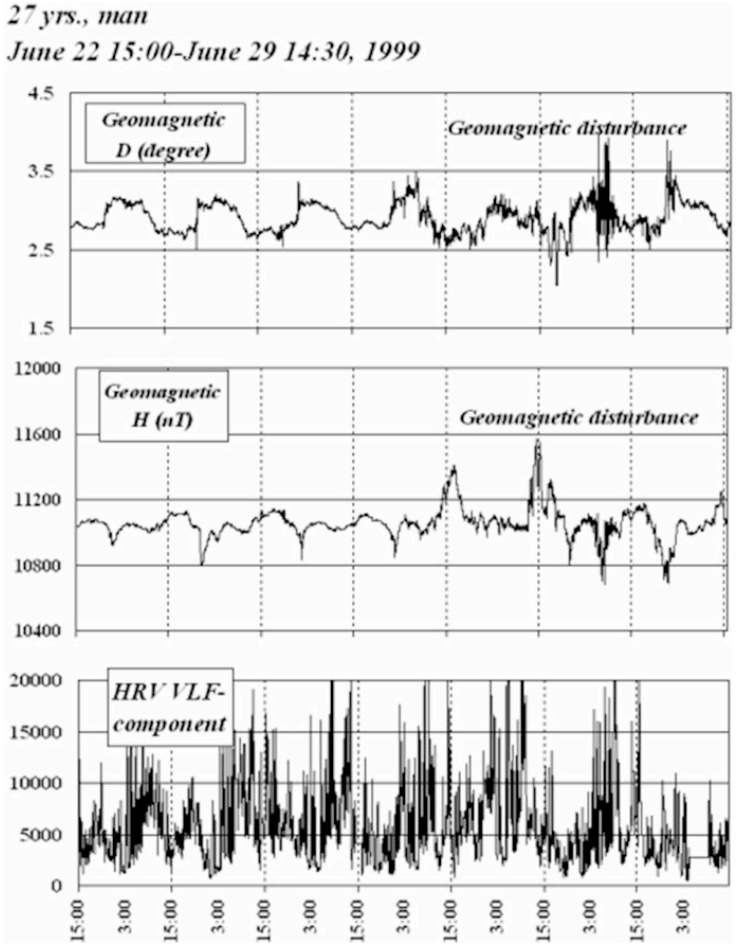


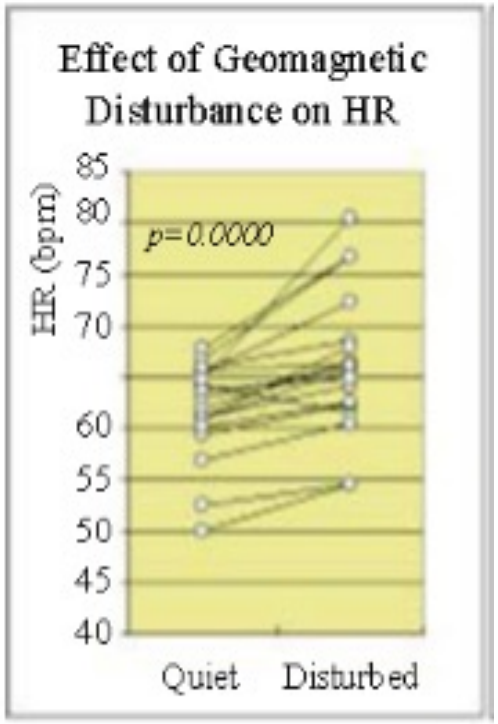


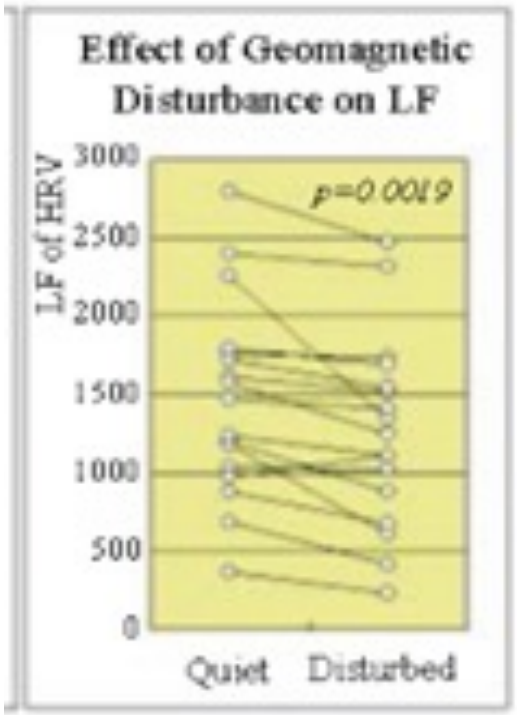
Oscillations with periods of about 50, 21, and 10.5 years have been documented for anthropometric measurements at birth in Russia, Kazakhstan, Spain, Denmark, and Minnesota (USA) and during adulthood in Austria.

Mechanisms - Heart

Geomagnetic storms are associated with a decrease in HRV.

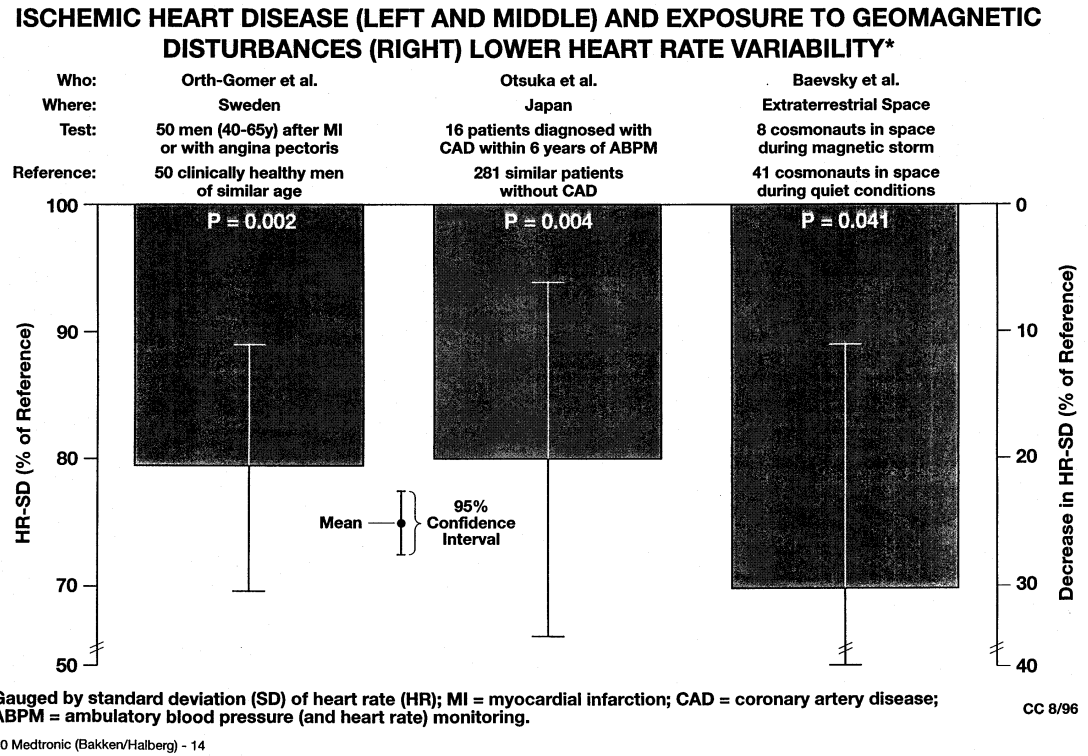


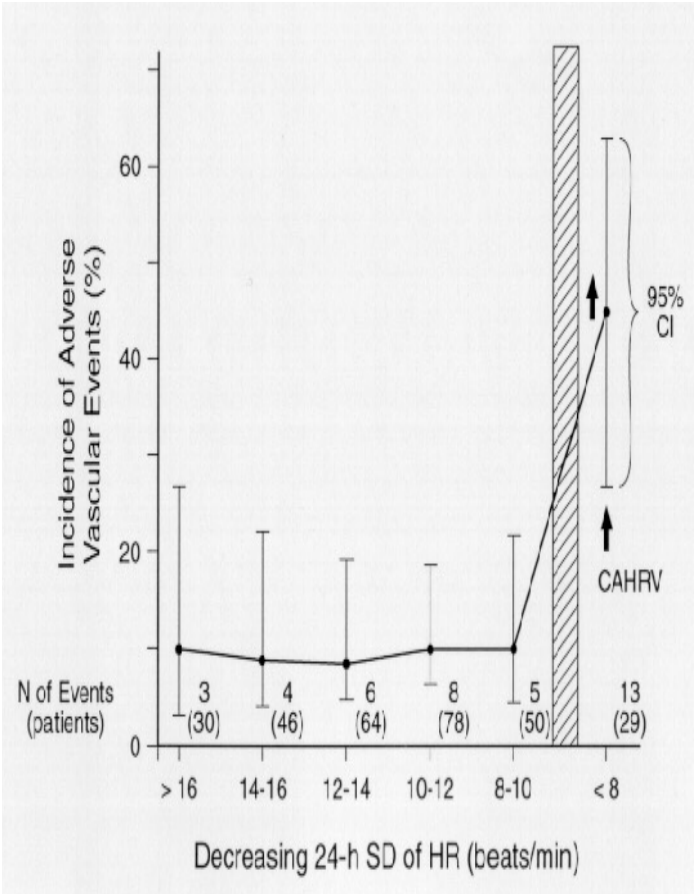




Mechanisms - Heart

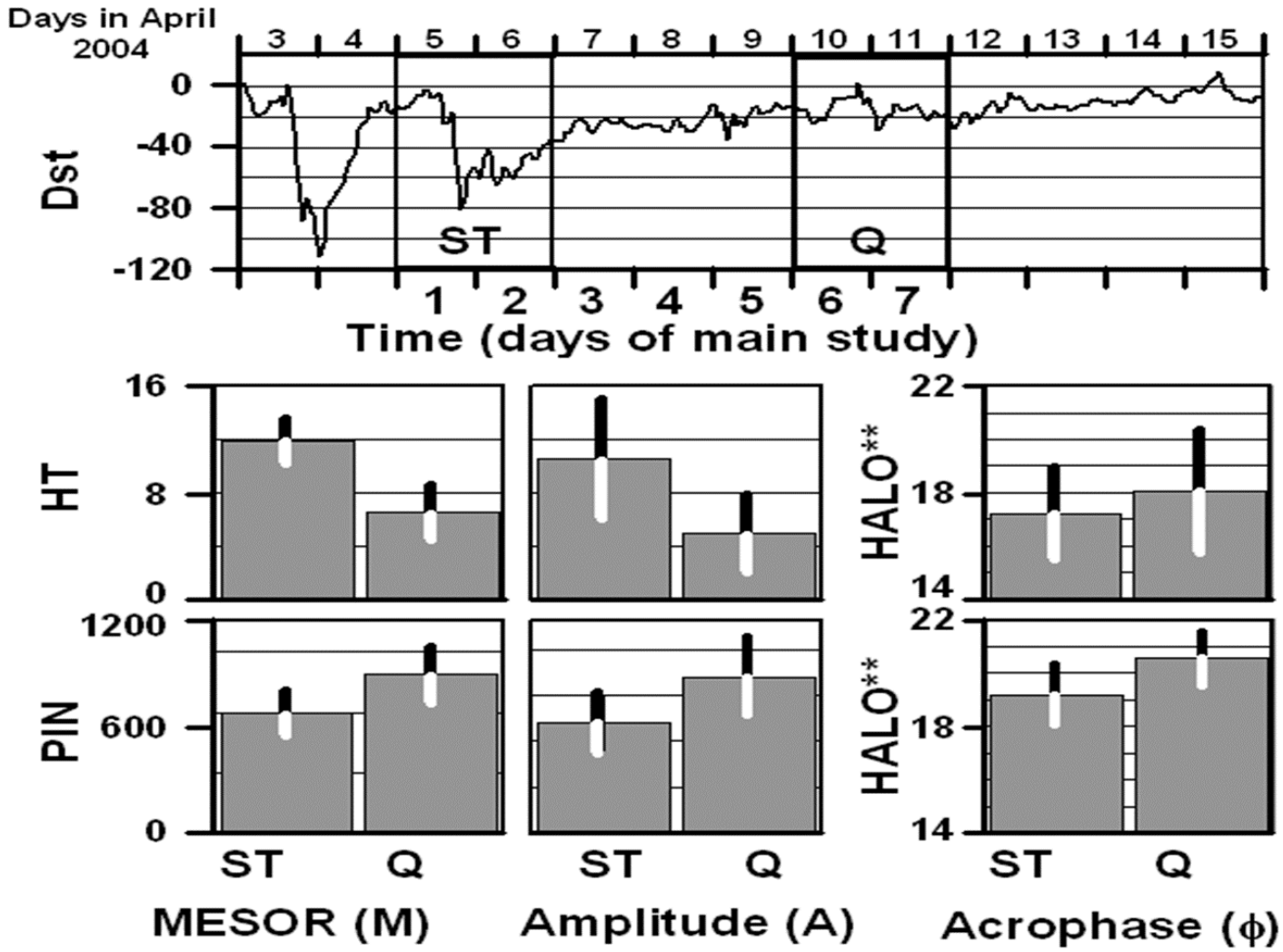
A decreased HRV constitutes a cardiovascular disease risk.





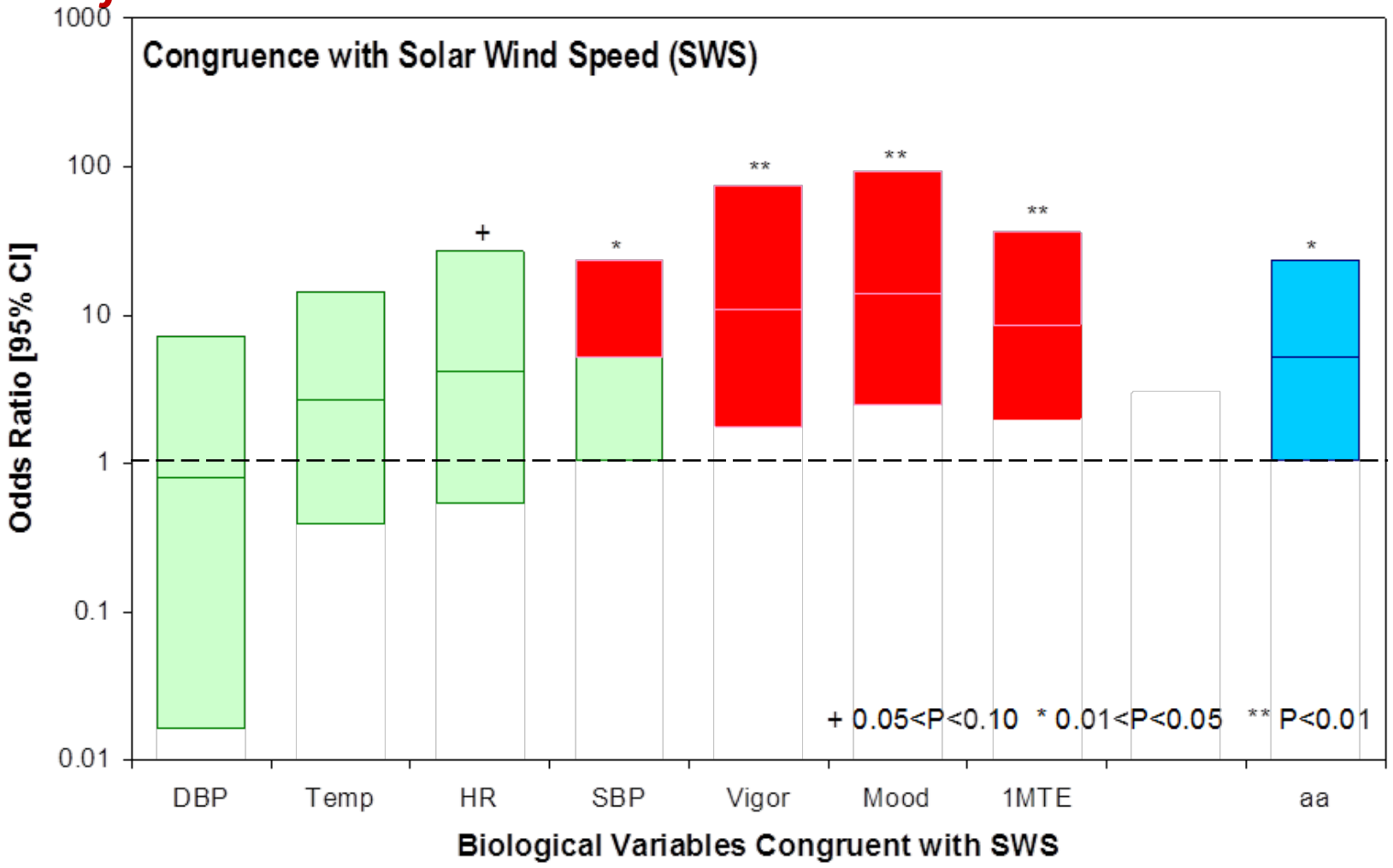
Mechanisms - Brain

Magnetic storms are associated with decreased nocturnal melatonin.

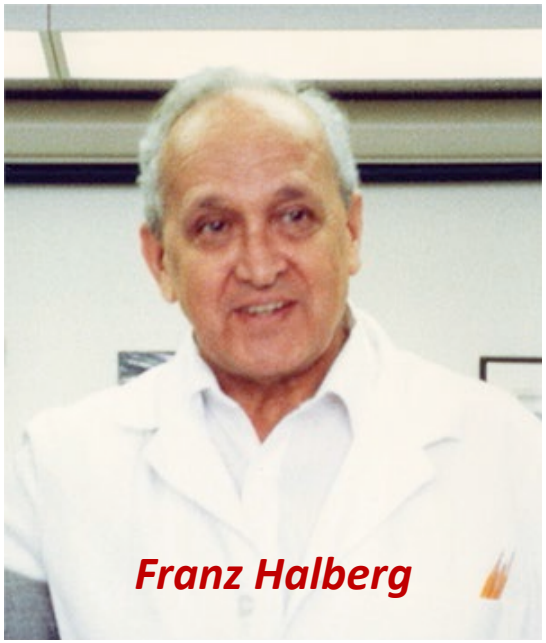


Mechanisms - Brain

Mental functions are more closely associated with space weather than somatic functions.



These results are being compiled into an “Atlas of Chronomes”.



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Thank you