



Basic Science of a Changing Climate

Porto: 08.09.2018. Porto

The Climate Clock

A framework climate variability

Prof. Harald Yndestad

Norwegian University of Science and Technology

Norwegian University of Science and Technology

Research

1970-1975: Computer architecture

1975-1980: Cybernetics, Signal theory

1980-1995: Systems Theory

1995-2005: Lunar tide => Climate => Ecosystems

2005-2014: Swarm Intelligence in Virtual Worlds

2014-2016: Solar variability

2016-2018: Global Climate variability

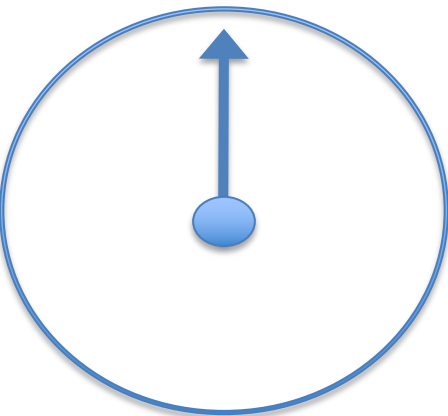
The Lunar Clock

The 18.6-yr lunar period

Earth nutation
The Earth axis



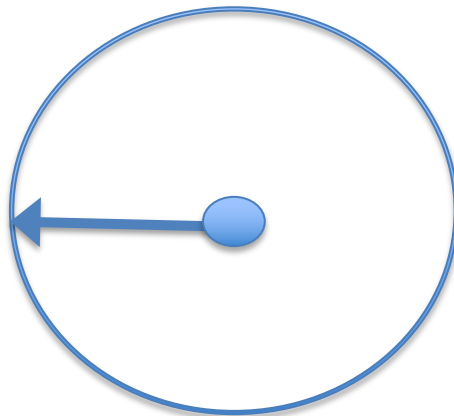
18.6 yr



Lunar nodal tide
Ocean currents



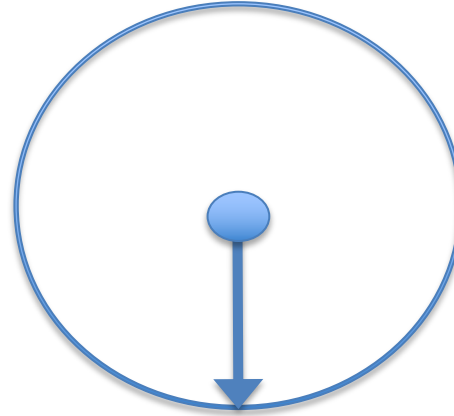
18.6 yr



Lunar periods
Ocean temperature



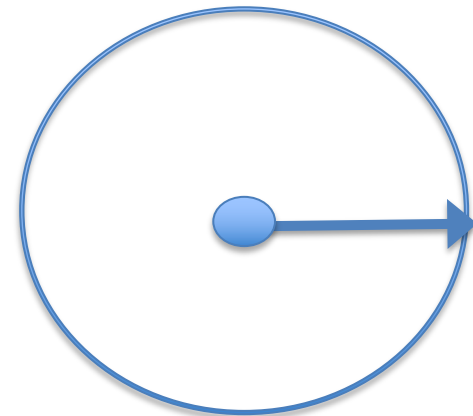
18.6 yr



Lunar periods
NAO-index



18.6 yr

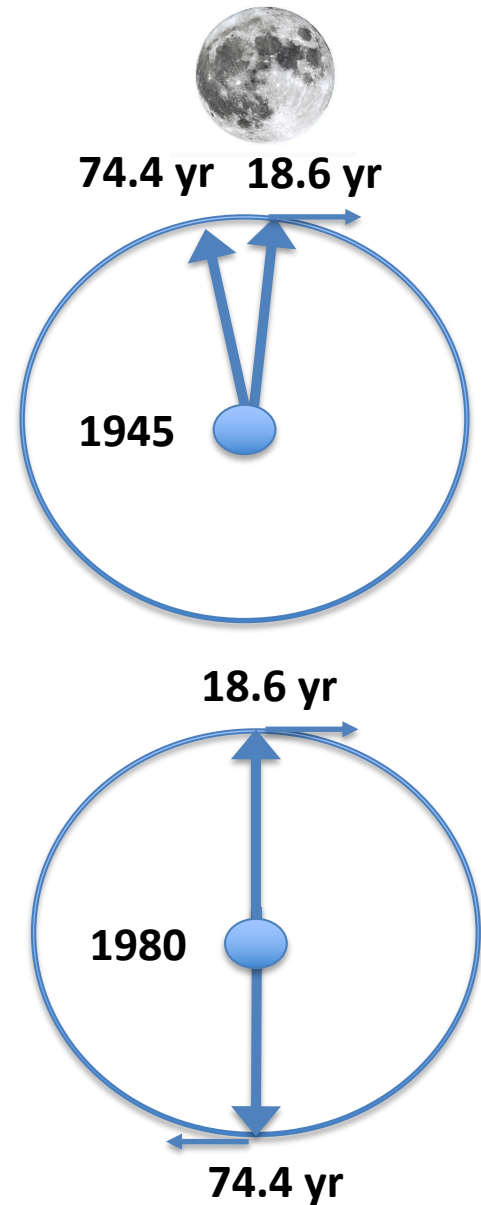
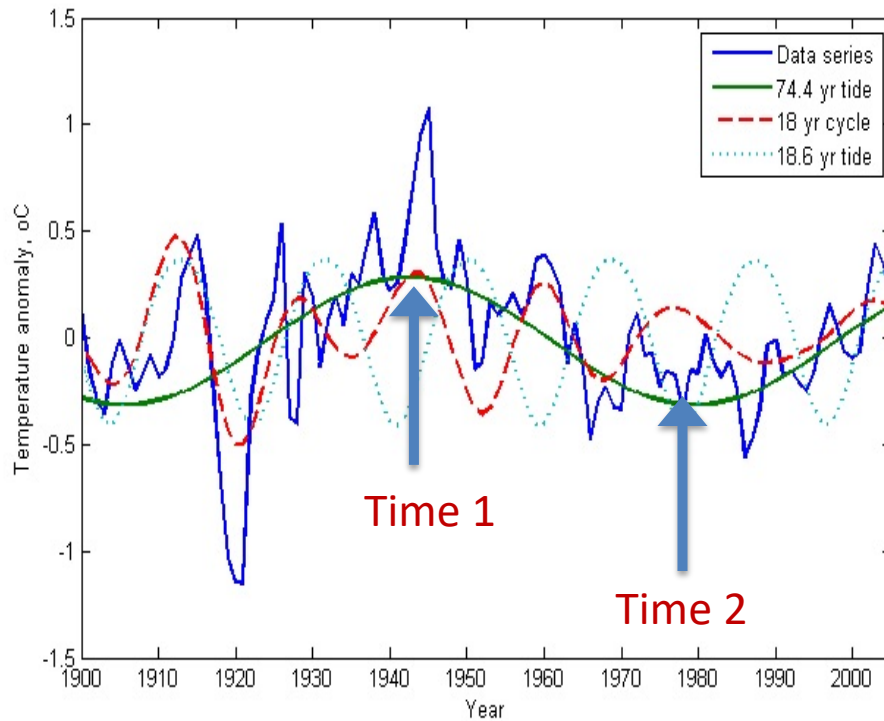


**The same cycle period
Different state or phase**

The Lunar Clock

Has a spectrum

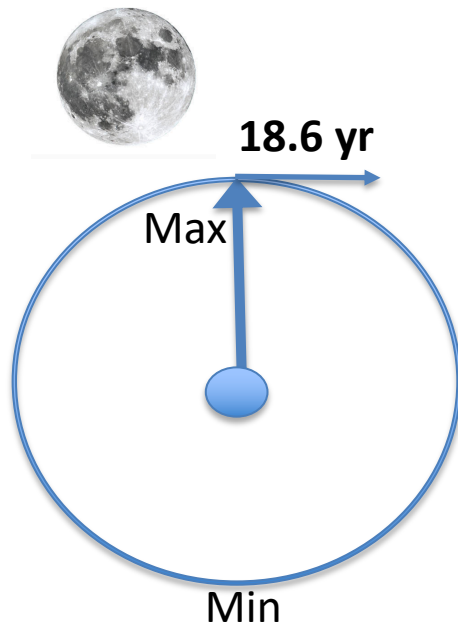
North Atlantic water temperature



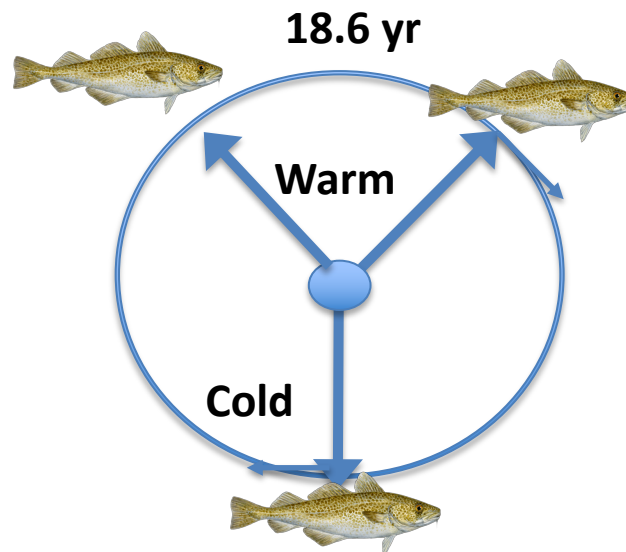
The Lunar Clock

Cod biomass: Period and phase-locked to 18.6 yr Lunar temp

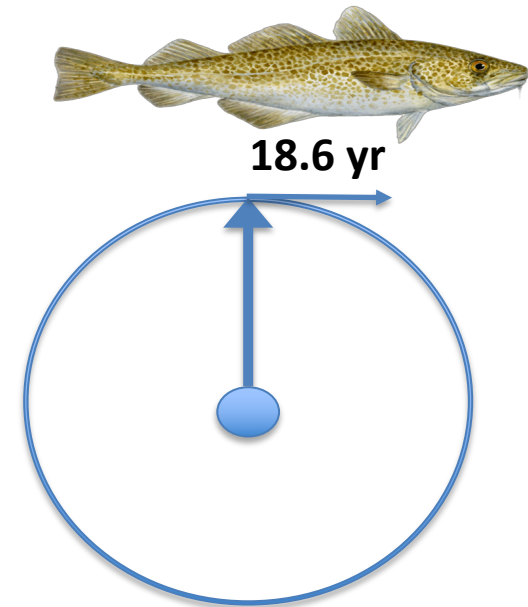
Ocean: Temperature



Cod spawning period
 $18.6/3 = 6.2$ yr

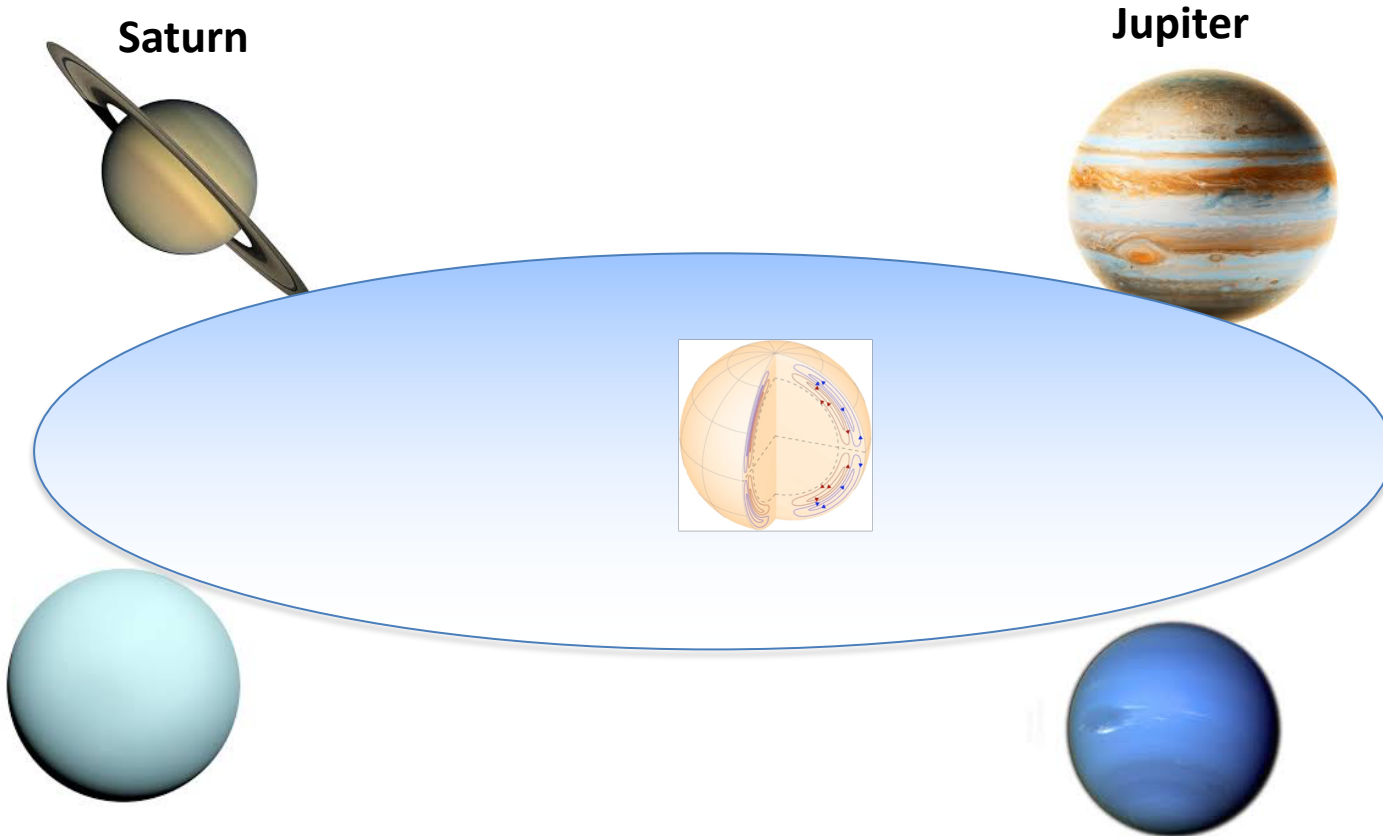


Cod biomass
18.6 yr



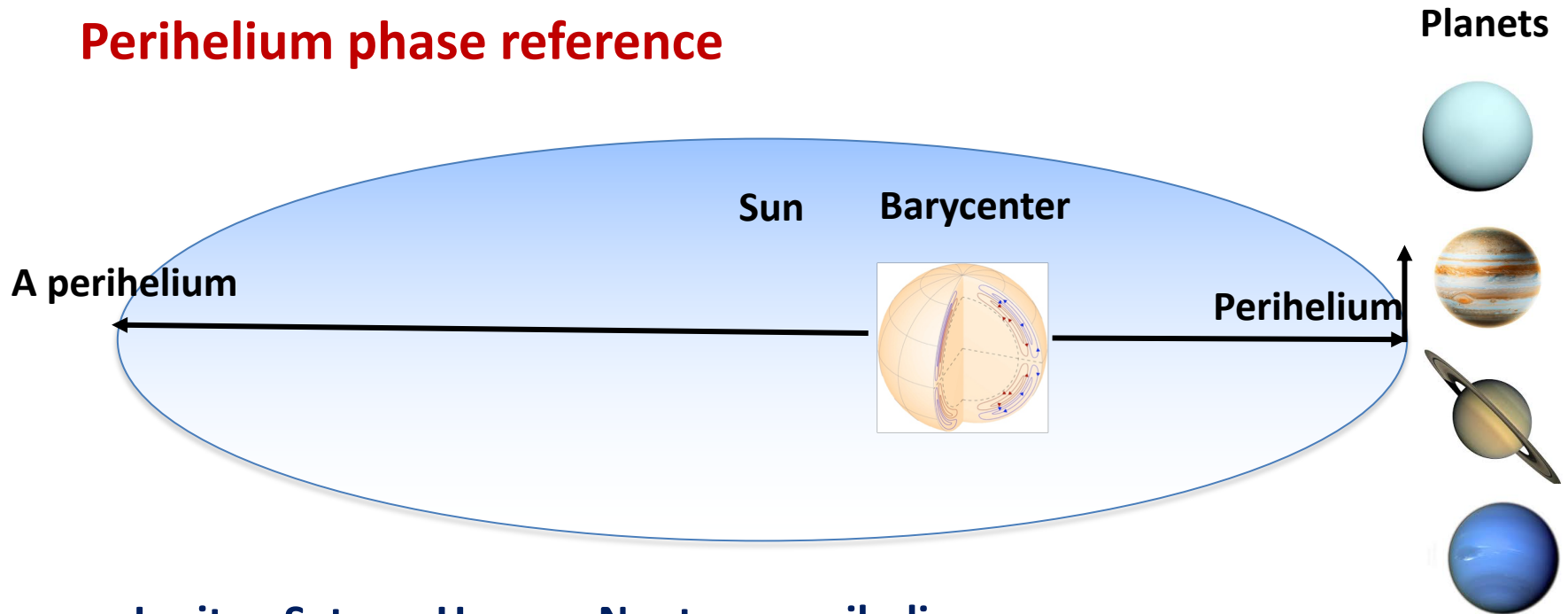
The Solar Clock

Represented by the 4 large planets



The Solar Clock

Perihelium phase reference



Jupiter, Saturn, Uranus, Neptune perihelium:

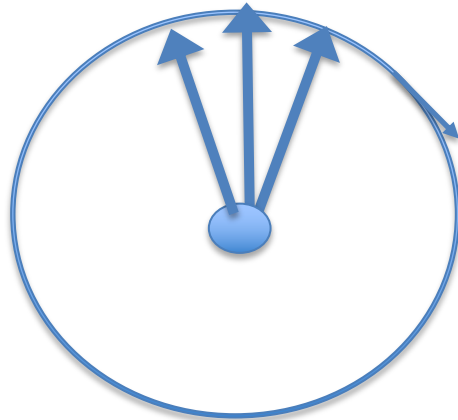
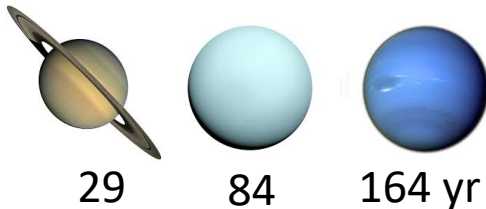
Coincidence period: 4285 years

Close to coincidence: 167, 336, 504, 1008, 2436 years

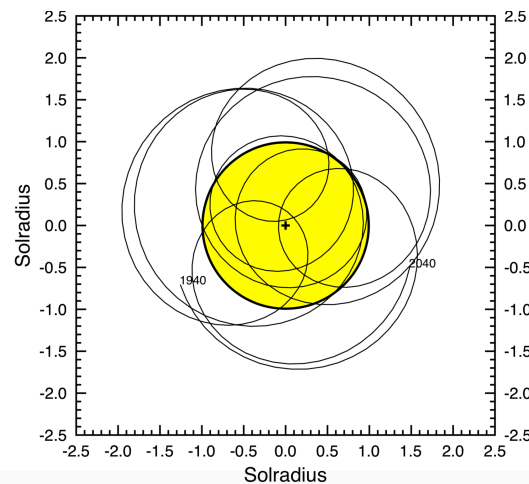
The Solar Clock

Solar position: Periods and phase-locked to large planets osc

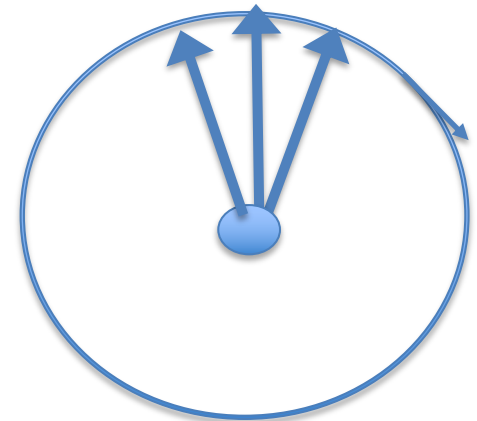
**Planets Position
Oscillation**



**Solar Barycenter oscillation
Gravity Oscillation**



**Solar Position
Oscillation**

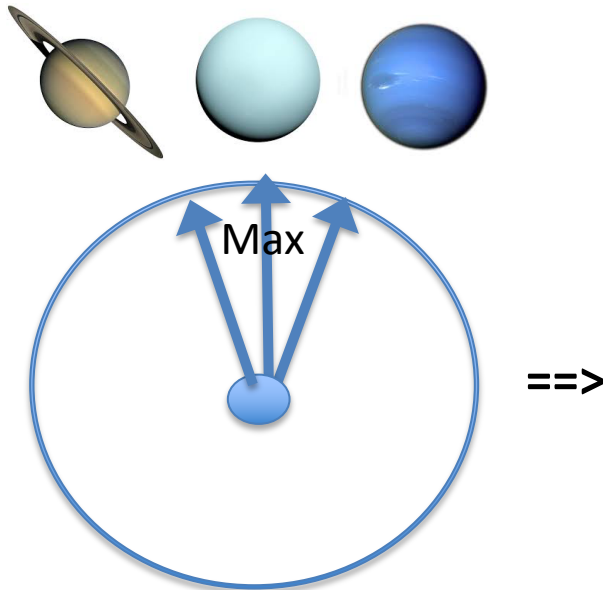


Yndestad and Solheim, 2017, New Astronomy

The Solar Clock

TSI periods: Periods and phase-locked to solar position

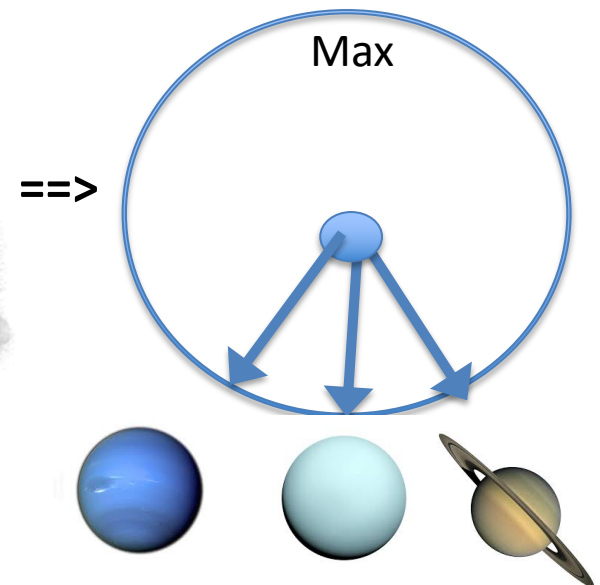
Solar position oscillation



**Solar plasma oscillation
Magnetic oscillation
(Maxwell)**



Solar TSI oscillation

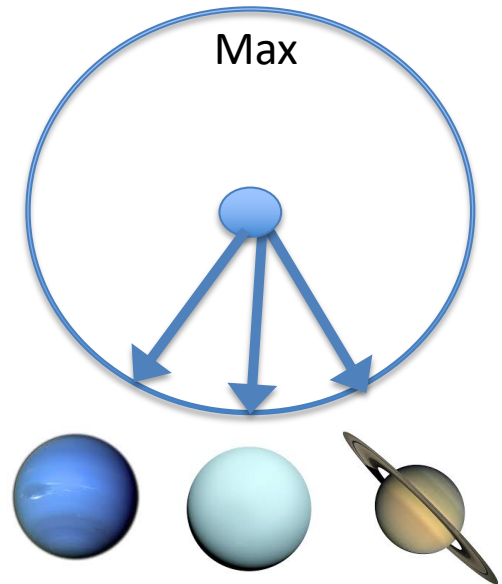
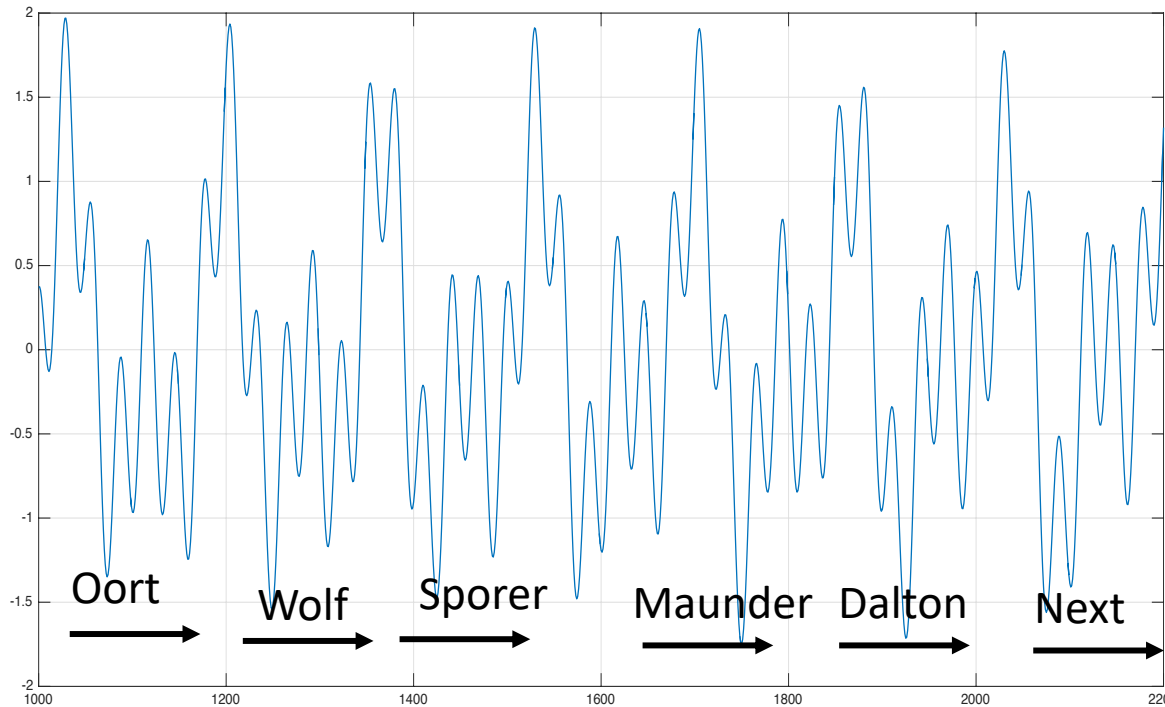


Yndestad and Solheim, 2017, New Astronomy

The Solar Clock

Planets perihelium coincidence

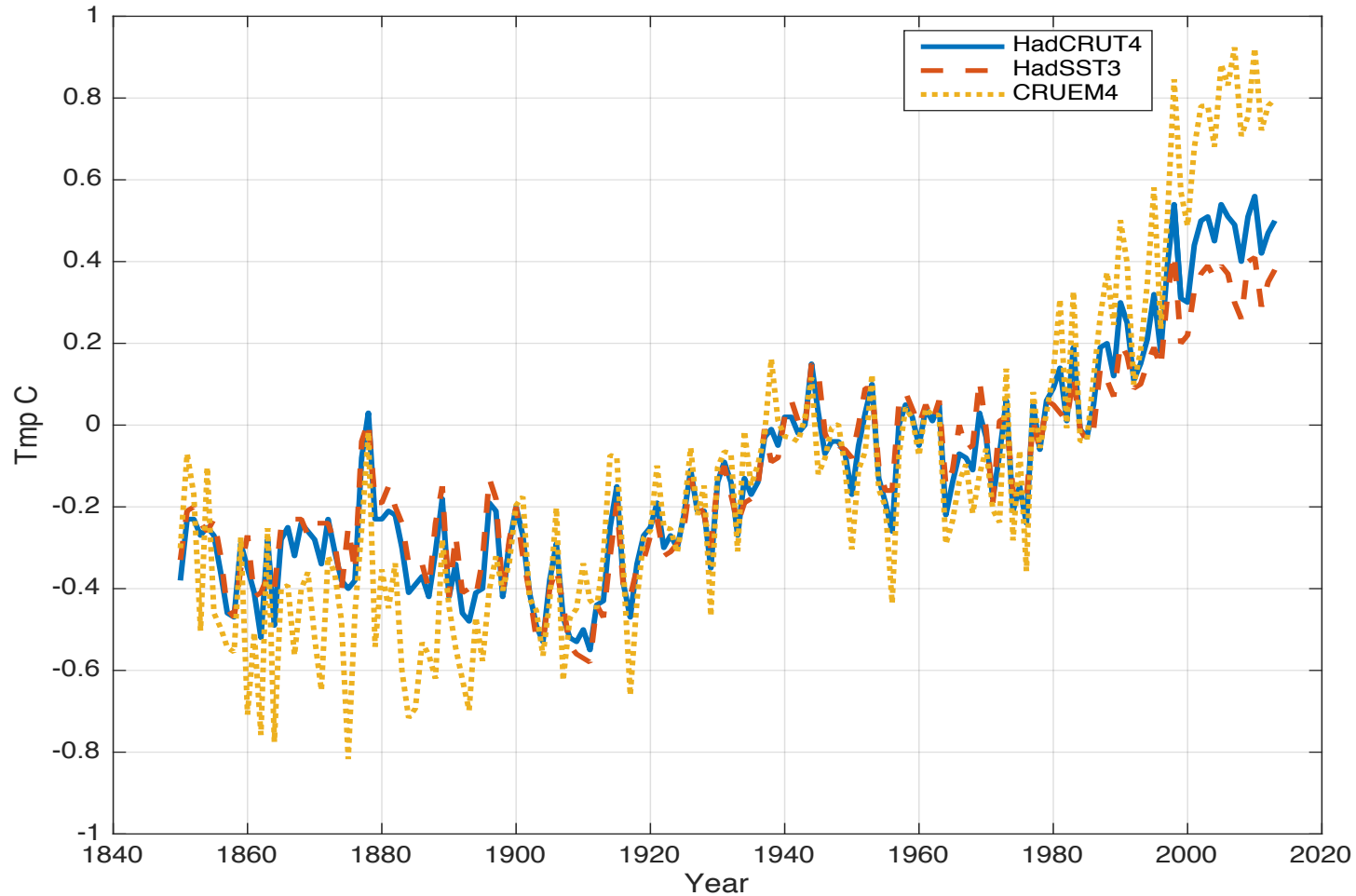
Saturn-Uranus-Neptune Model: 1000 – 2200 AD



**Deep minimum: Coincidences to known minimum solar periods:
Next deep solar minimum: 2090**

The Global Earth Temperature

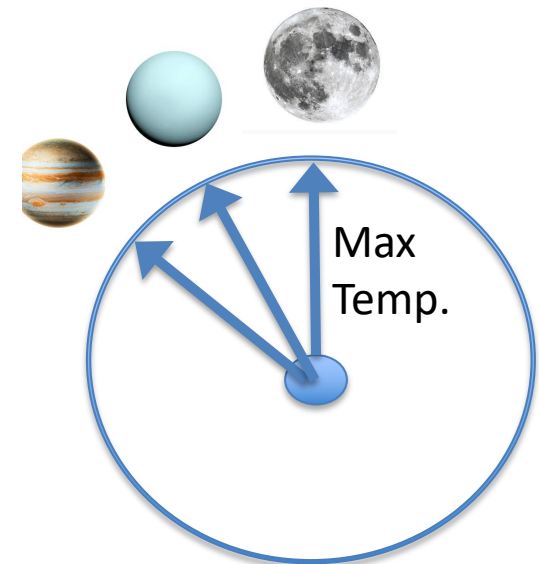
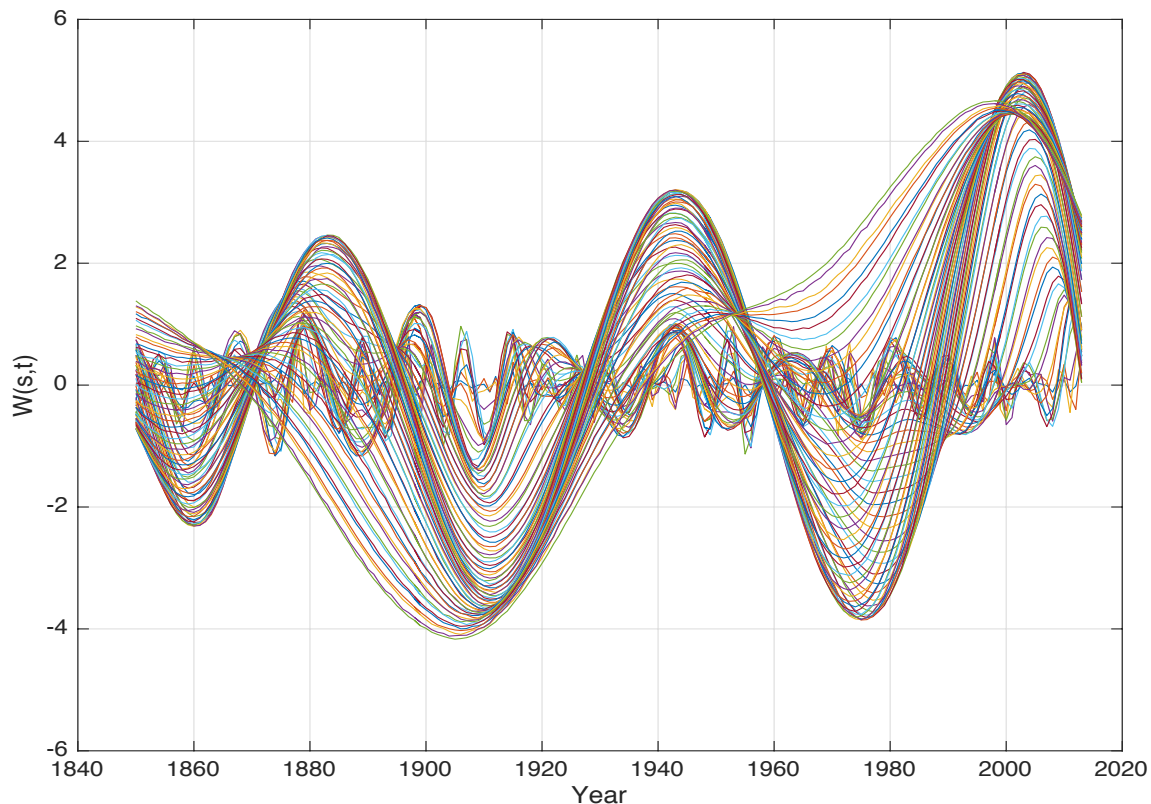
Global temperature (HadCRUT4): 1850 to 2017 AD



The Climate Clock

Global temperature: Period and phase-locked to solar-lunar periods

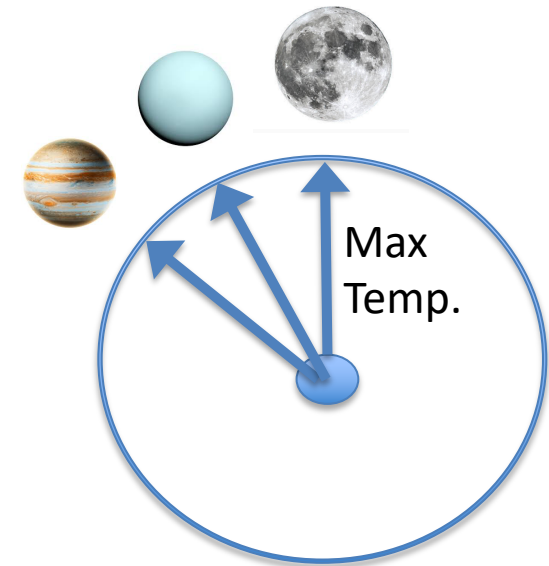
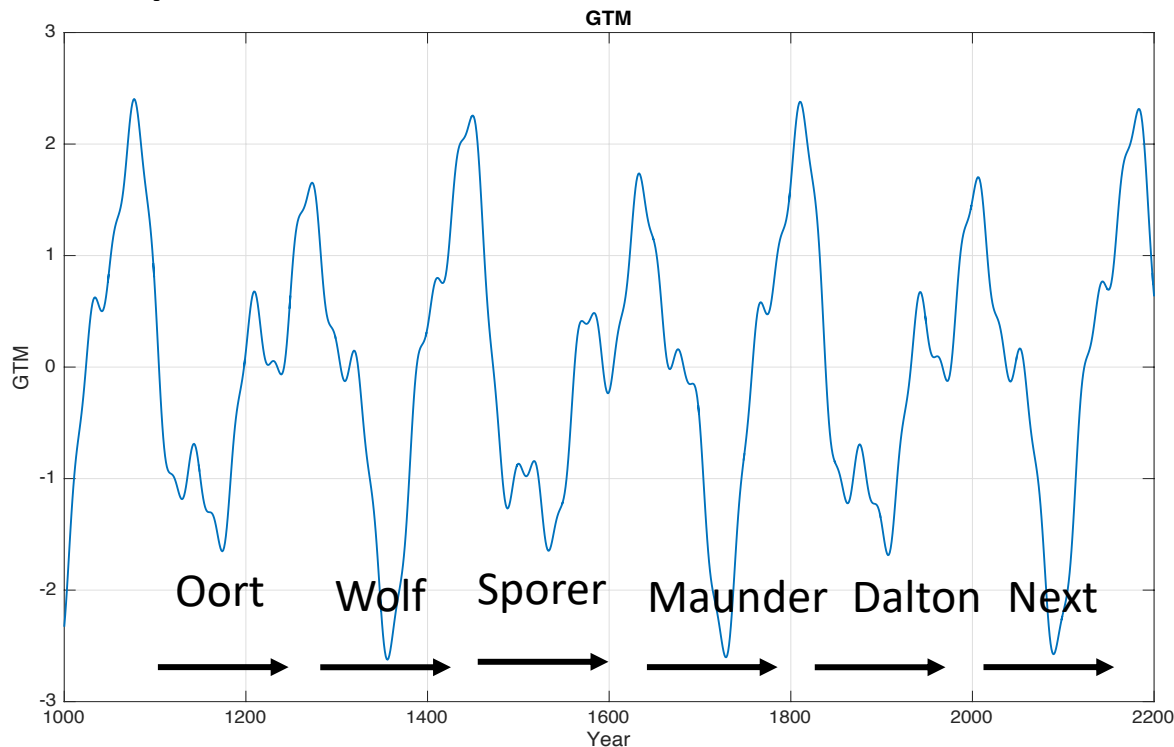
HadCRUTE4: wavelet spectrum



The Climate Clock

Global temperature minimum: Controlled by solar-lunar coincidence

Computed data series: 1000 - 2200 AD



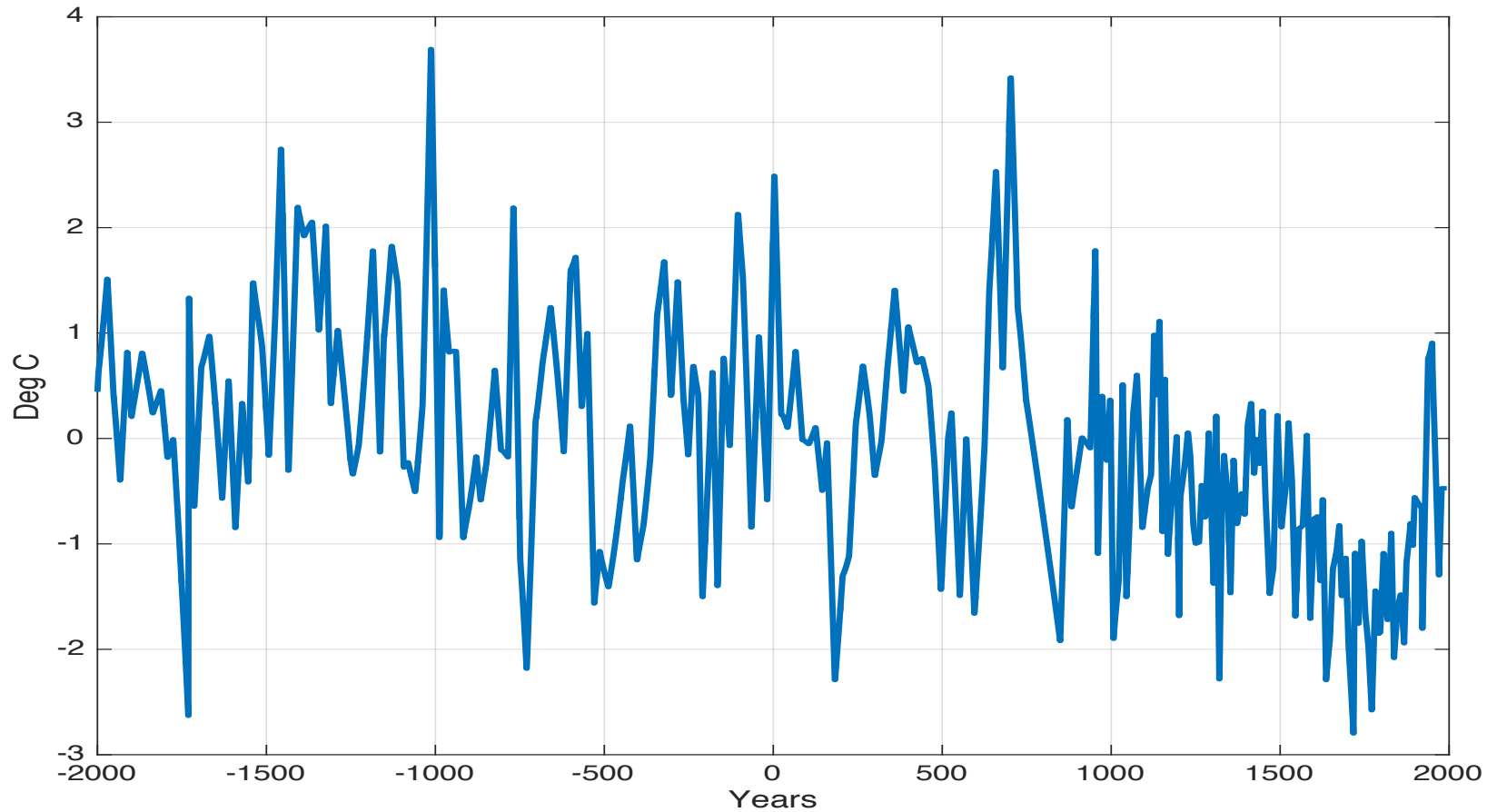
Period-phase locked to Solar-Lunar periods

Minimum temperature => Known minimum solar variability

Next deep minimum temperature: 2090 AD

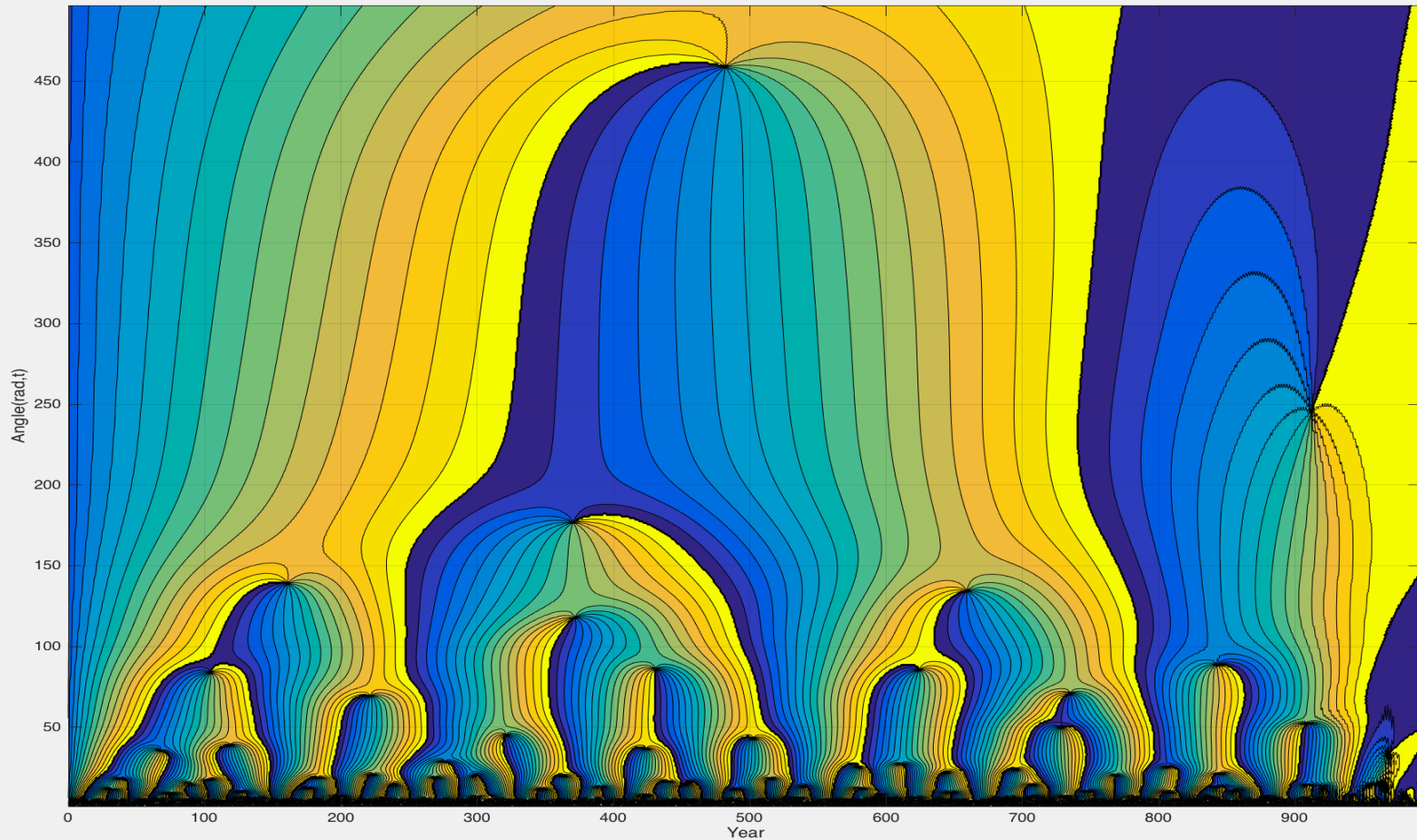
Greenland Temperature (GISP2)

4000 years: 2000 BC to 2000 AD



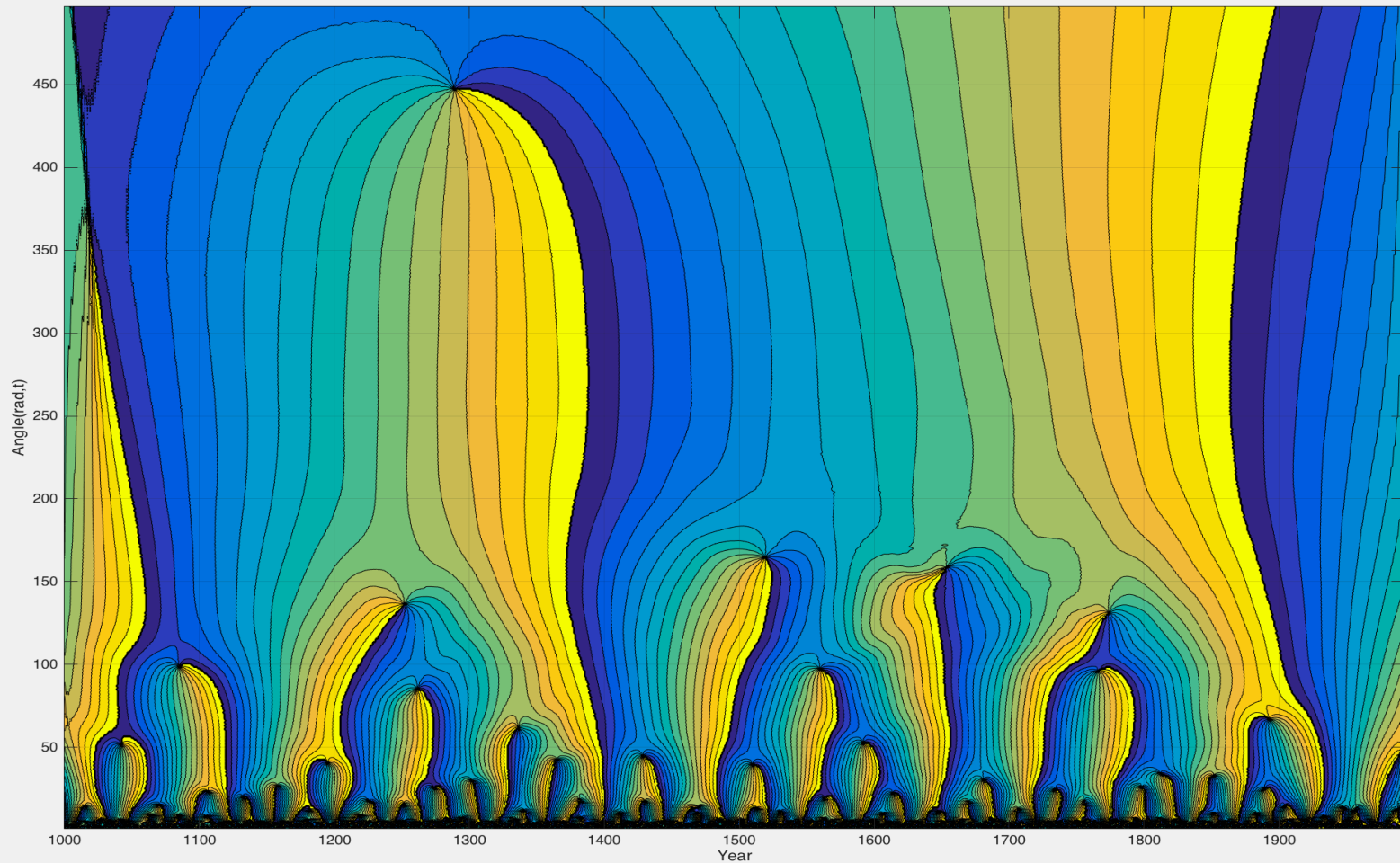
The Climate Clock

Greenland temperature: A spectrum of solar-lunar periods



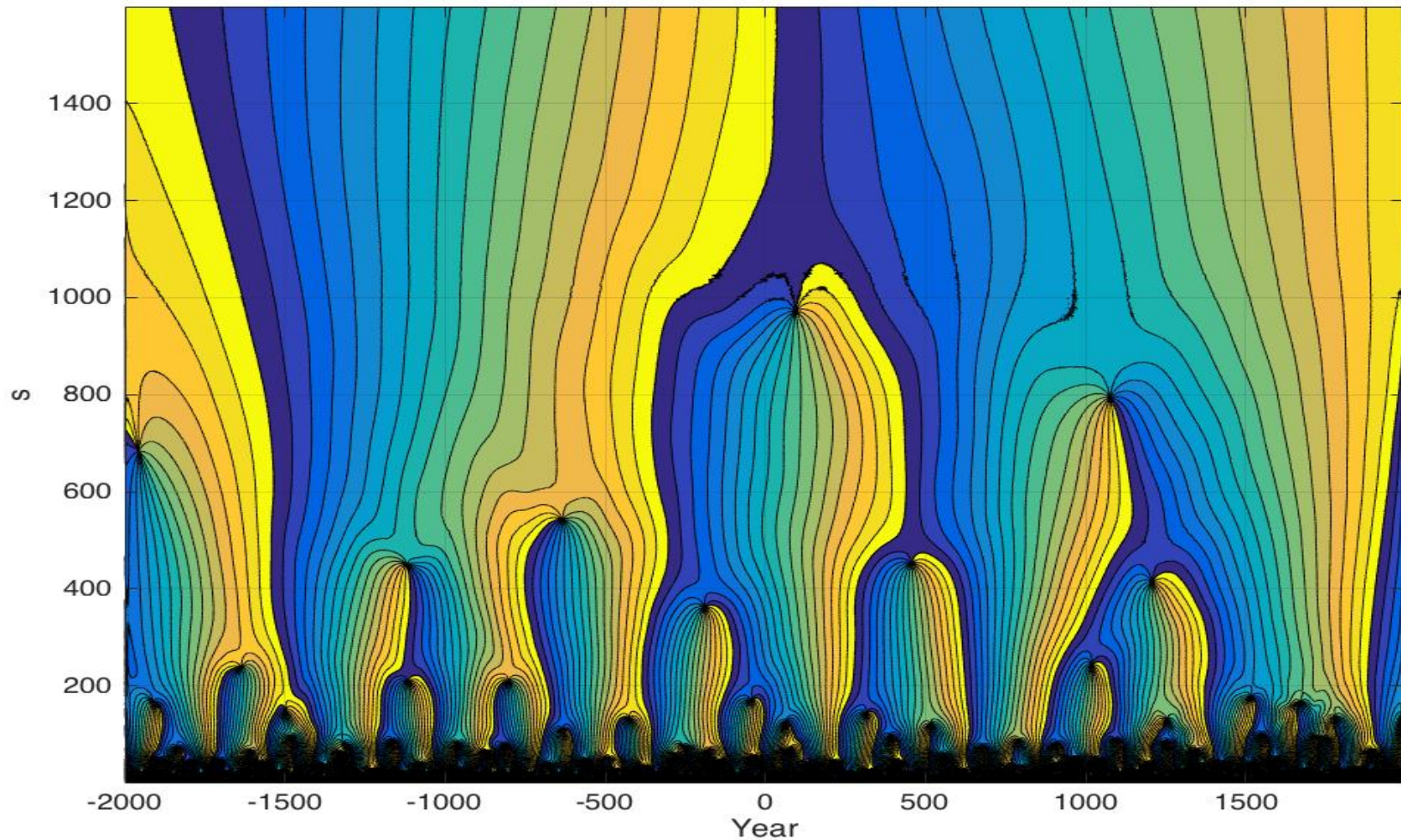
The Climate Clock

Greenland temperature: Climate shifts 1000-2000 AD



The Climate Clock

Greenland temperature: Climate shifts 2000 BC – 2000 AD



Summary

We can learn from the cod

Forced periods:

Modulates a period spectrum

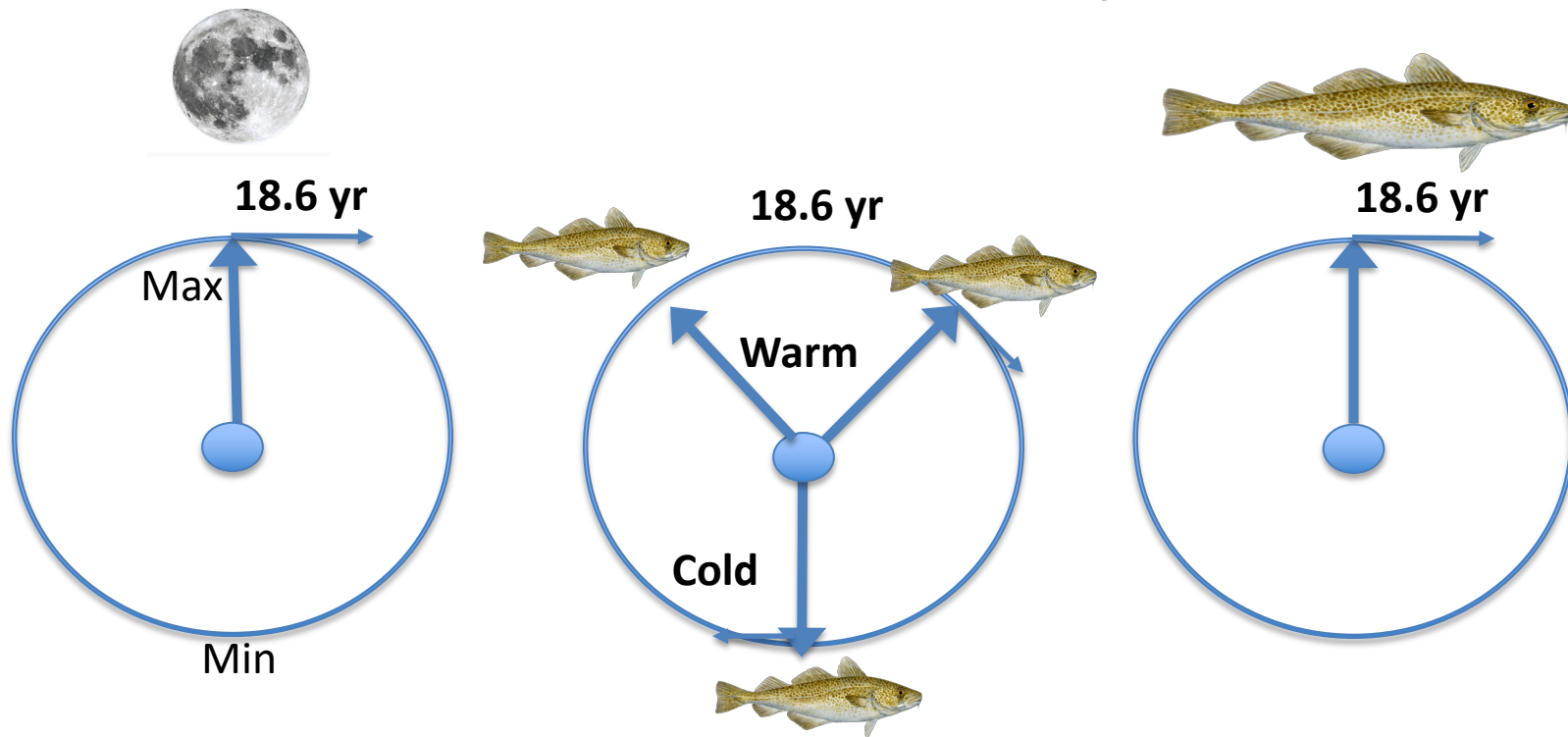
Climate variability:

Chain of coupled oscillators

Save energy by phase-locked oscillations

The Climate Clock:

A visualization of phase-relations



Thank you

More information?

You will find me, at the end of the rainbow

<http://www.ntnu.no/ansatte/harald.yndestad>

Twitter: @HaraldY

Perihelion coincidences

Planet perihelium coincidences from 1000 A.D

	Oort	Wolf	Spører	Maunder	Dalton	1. Next	2. Next
	Perihelion	Perihelion	Perihelion	Perihelion	Perihelion	Perihelion	Perihelion
Saturn	1208	1385	1562	1709	1797	2062	2209
Uranus	1210	1378	1546	1714	1798	2050	2218
Neptun	1218	1382	1547	1712	1877	2041	2206
Distances	10	7	15	5	80	21	14

Planet perihelion are related to minimum solar irradiation

Next minim has the best Uranus coincidence in since 1000 A.D

This mean we may expect the deepest solar minimum since 1000 A.D

Summary

Independent data show same results

	Oort	Wolf	Spører	Maunder	Dalton	Next 1	Next 2
Solar minimum (Usoskin,)	1040	1305	1470	1680	1805		
Sunspots minimum (Yndestad, Solem, 2017)	1026	1249	1473	1696	1811	2035	
TSI-LS minimum (Yndestad, Solam, 2017)	1035	1289	1418	1672		2060	
Solar Model Minimum	1074	1249	1425	1749	1865	2090	2250
Solar-Lunar Model Minimum	1075	1245	1428	1747	1895	2100	2250
Global Temperature Model (HadCRUTE4)		1354		1729		2090	
Greenland 420-yr (GISP2-1k)		1290		1754		2155	
Greenlan 2046-yr (GISP2-4m)				1613			263

Thank you

