## Oceans as stabilisers for climate change but at what price?

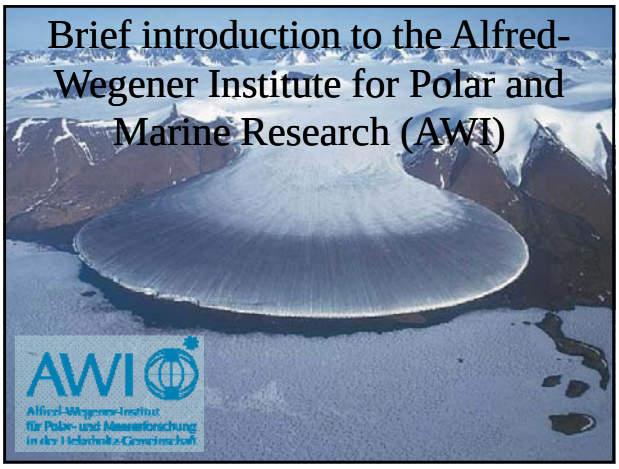
Jelle Bijma (AWI, Bremerhaven, Germany)

**With the help of Henk Brinkhuis (UU) and Richard Feely (NOAA)**

- Introduction to the AWI …..
- The climate system and the global carbon cycle…….
- …..Double trouble!!….

**Annual JSPS Assembly, Rostock May 16, 2008**

## Brief introduction to the Alfred-Wegener Institute for Polar and Marine Research (AWI)




## Alfred Wegener (1880 – 1930)

**Geophysicist / Meteorologist / Climatologist**

1880 * in Berlin

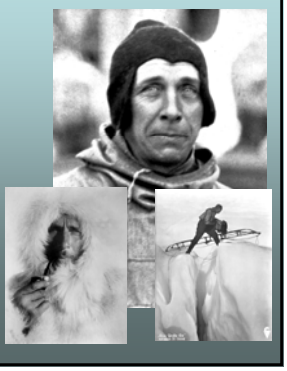
1911 Thermodynamics of the atmosphere

1912 Hypothesis of the **continental drift**

1915 The formation of continents and oceans

1924 **Climate change** over geological periods

1930 † in Greenland



## The AWI - a brief overview
## The most important data

**1980**: Establishment of the institute in Bremerhaven as a foundation under public law

**As of 2006**: - Budget: 110 Mio. Euro
- about 800 Employees

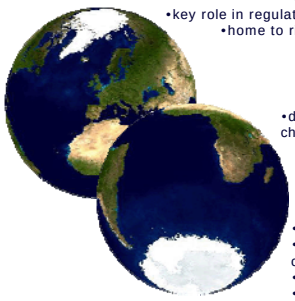
**Funding**: - 90% Federal Ministry of Education and Research (BMBF)
- 8% Federal state Bremen
- 1% Each of the federal states Brandenburg and Schleswig-Holstein
- External funds

Member of the Helmholtz Association of German Research Centres


## AWI tasks:
## Research, Co-ordination, Advice

- Environmental research in extreme habitats.
- Scientific, technical and logistic support to the German polar and marine research community.
- Co-ordination of national and international initiatives in polar and marine research.
- Advice for the Federal Government.

## Marine, Coastal and Polar Systems



**Oceans**
•key role in regulating planetary environment
•home to rich and diverse life

**Coastal areas**
•diverse and competing interests challenge sustainable use

**Poles**
•Drivers of global climate evolution
•Early indicators of impending changes
•Adapted ecosystems
•Sea level changes

**Objectives require large scale infrastructures**




Research vessels and airplanes

## FS „Polarstern“

Polar Research and supply vessel

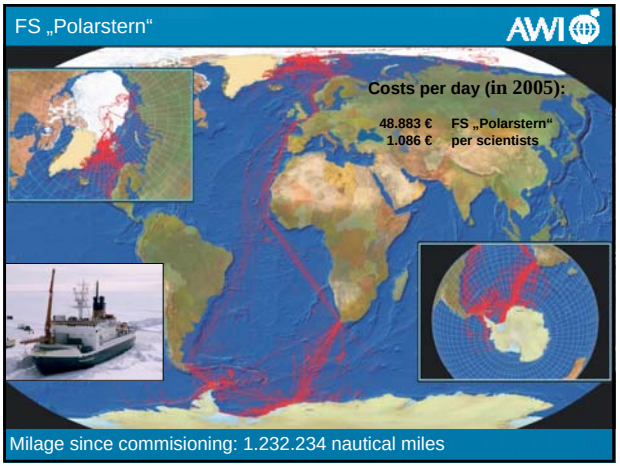
Commissioning: 1982

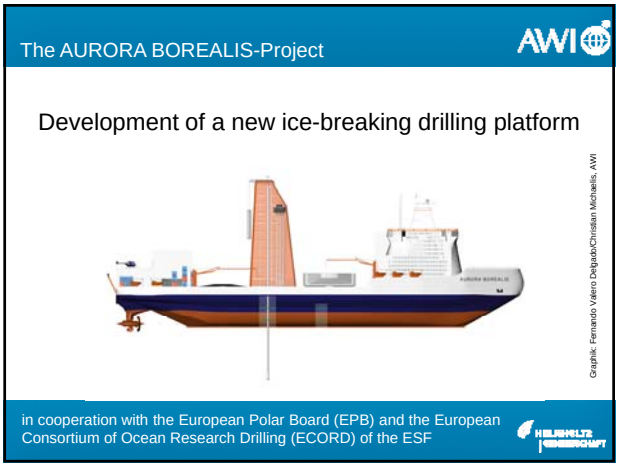
Length: 118 m

crew: 41- 44 persons

Work facilities: 50 scientists and technicians

www

Research station

## Neumayer-Station

Year-round manned research station

Main research topics in meteorology, geophysics, air chemistry

Long-term monitoring of ozone, radiation and aerosols

Base for the supply of the Kohnen-Station and land expeditions


## Neumayer-Station

## The Neumayer-Station III


Estimated cost of the station: **37.0 Mio €**

International Cooperation

## Europe and World Wide



International Cooperation

## Europe and World Wide

| | | |
|---|---|---|
| **Cooperation in Marine and Polar Sciences** | **Japan Marine Science and Technology Centre (JAMSTEC)** | **Since 1995** |
| **Scientific Cooperation on joint aircraft and groundbased measurements in the Arctic** | **National Institute for Polar Research of Japan (NIPR), Tokyo** | **1999-2005** |
| **Cooperation in research and logistic operation in the Arctic and Antarctic** | **National Institute for Polar Research of Japan (NIPR), Tokyo** | **2007-2013** |
| **MOU on Multilateral Scientific Cooperation for the IPY „PANDA" Programm** | **National Institute for Polar Research of Japan (NIPR), Tokyo** | **2007-2009** |

## Oceans as stabilisers for climate change but at what price?

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- **The climate system and the global carbon cycle…….**
- …..Double trouble..…

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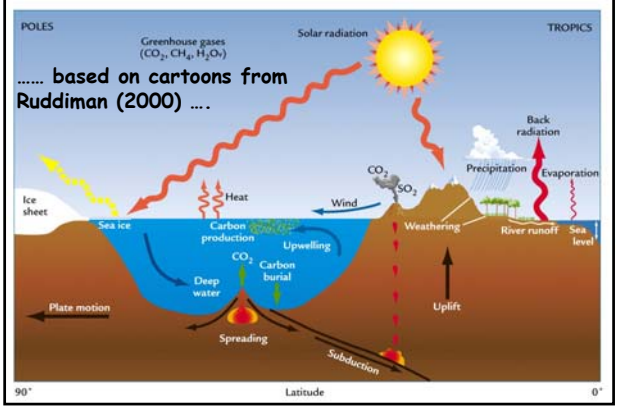
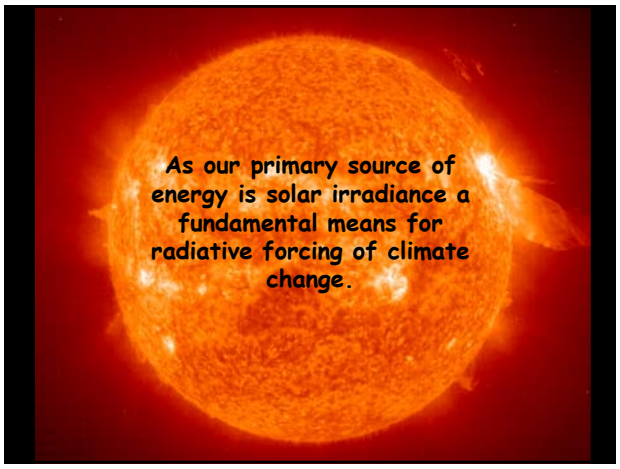
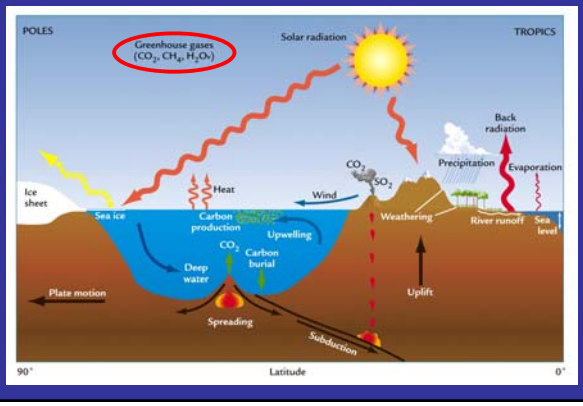
## The Earth's climate




..... based on cartoons from Ruddiman (2000) ....




## The climate system (see Ruddiman, "Earth's climate")

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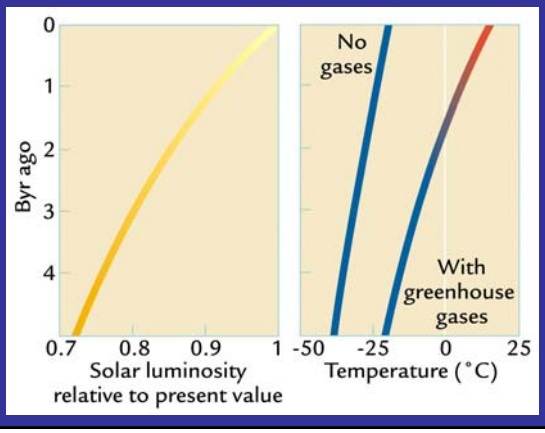


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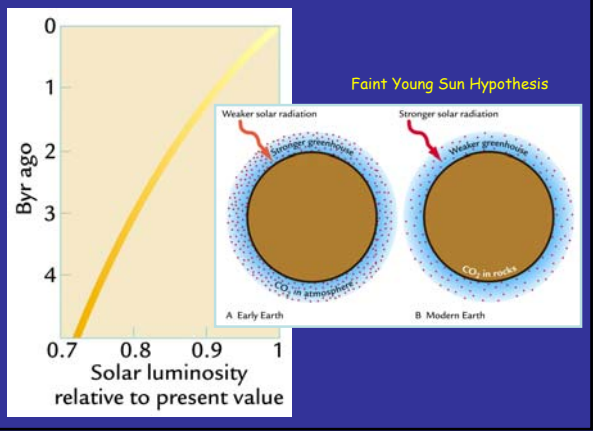


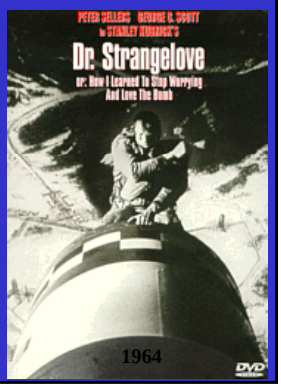

**The global carbon cycle is largely driven by biology (organics): On G-IG timescales, atmospheric $pCO_2$ is slave to the average oceanic surface [$CO_2$(aq)]!**

**What happens if biology is turned of?**

**The „Strangelove ocean":**

- **The biological pump stops**
- **The surface-deep $CO_2$ gradient disappears**
- **Within 250 yrs atmospheric $CO_2$ increases 2.4 times**

**see: Maier-Reimer, Mikolajewicz and Winguth (1996); Zeebe and Westbroek (2003)**



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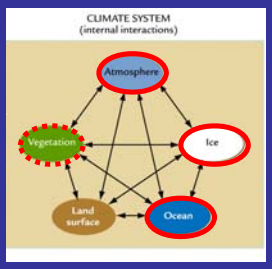


Hydrological cycle plays a prominent role!

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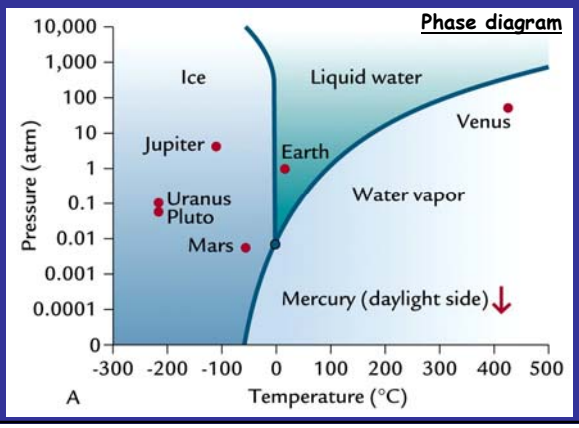


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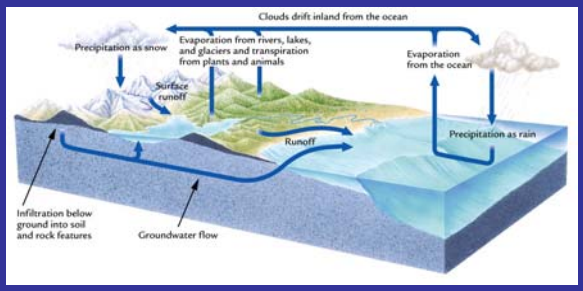
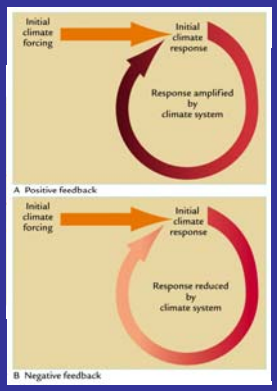



Ocean currents and phase transitions are the basic transport sytem of heat

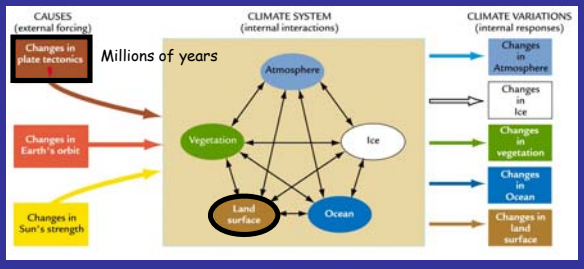
## Deep Water Source Regions are Found in the Atlantic; Surface Return Flow Originates in the Pacific

## The climate system (see Ruddiman, "Earth's climate")




## The climate system (see Ruddiman, "Earth's climate")

Timescales are important!



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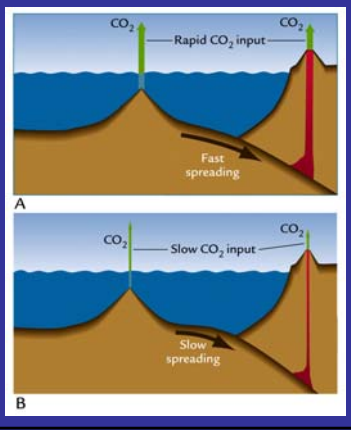


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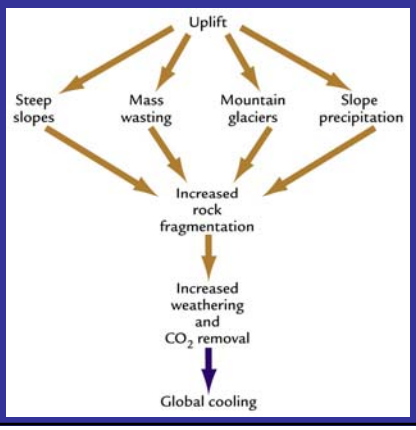


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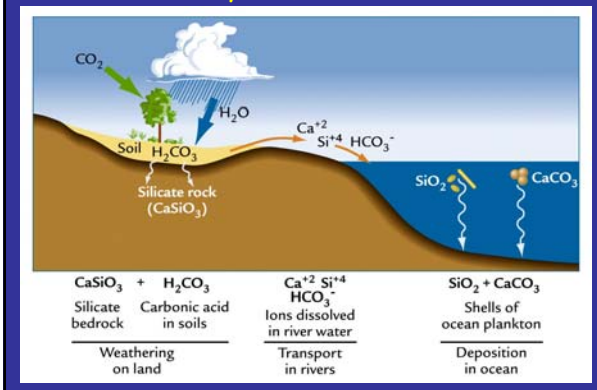


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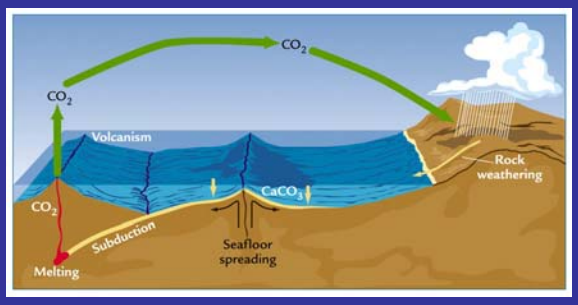
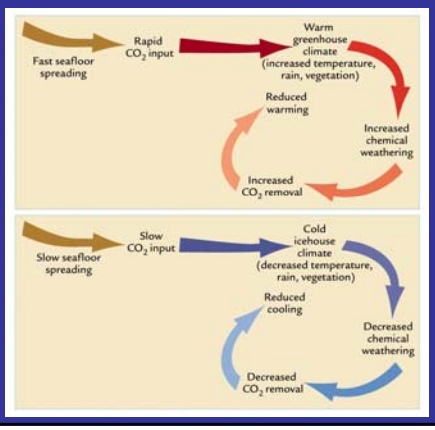



Rock weathering is reinforced by vegetation

**The climate system** (see Ruddiman, "Earth's climate")

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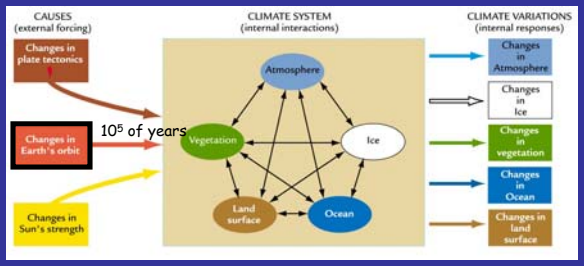

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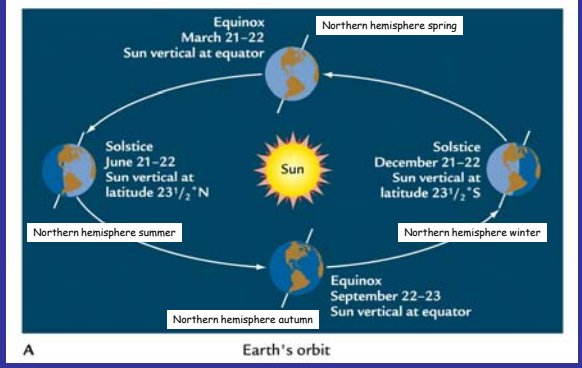
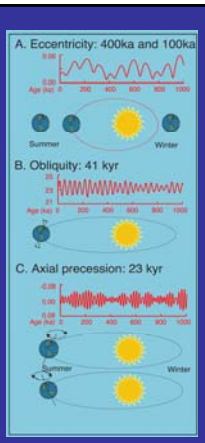


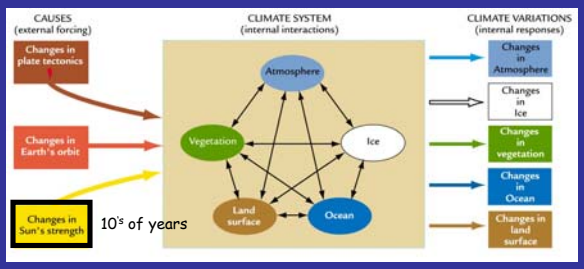




Zachos et al. 2001

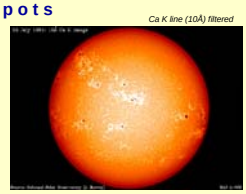
## Milutin Milankovitch (1879-1958)

born on May 28, 1879 in Dalj, Serbia
1904, doctorate in technical sciences, Vienna Institute of Technology
1909, faculty position in applied mathematics, University of Belgrade
1914, PoW Austro-Hungarian Army
1920 - 1941, mathematical theory of climate change
1955, retirement from University of Belgrade

## The climate system (see Ruddiman, "Earth's climate")




## Some Sunspots



Ca K line (10Å) filtered

Sunspots are made of a central, dark and roughly circular region (**umbra**) which is surrounded by a lighter ring (**penumbra**). They can be 1,500 km to >50,000 km in diameter. Their lifetimes measure weeks to months.

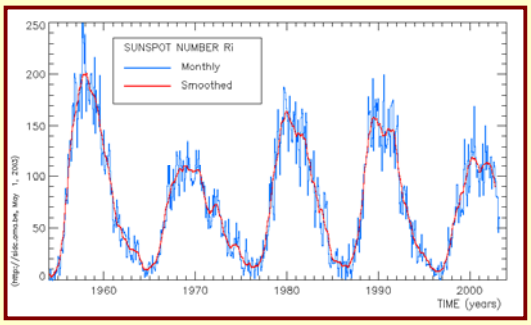
Samuel Heinrich Schwabe
Born on 25 October 1789 in Dessau, near Berlin
Pharmaceutical studies in Berlin
Astronomical and botanical researches
Won his first telescope at a lottery in 1825
Sold the family pharmacy in 1829
Died in Dessau on 11 April 1875.

| Jahr. | Gruppen. | Fleckenfreie Tage. | Beobachtungs-Tage. |
|---|---|---|---|
| 1826 | 118 | 22 | 277 |
| 1827 | 161 | 2 | 273 |
| 1828 | 225 | 0 | 282 |
| 1829 | 159 | 0 | 244 |
| 1830 | 190 | 1 | 217 |
| 1831 | 149 | 3 | 239 |
| 1832 | 84 | 49 | 270 |
| 1833 | 33 | 139 | 267 |
| 1834 | 51 | 120 | 273 |
| 1835 | 173 | 18 | 244 |
| 1836 | 272 | 0 | 200 |
| 1837 | 333 | 0 | 168 |
| 1838 | 282 | 0 | 202 |
| 1839 | 162 | 0 | 205 |
| 1840 | 152 | 3 | 263 |
| 1841 | 102 | 15 | 283 |
| 1842 | 68 | 64 | 307 |
| 1843 | 34 | 149 | 312 |
| 1844 | 52 | 111 | 321 |
| 1845 | 114 | 29 | 332 |
| 1846 | 157 | 1 | 314 |
| 1847 | 257 | 0 | 276 |
| 1848 | 330 | 0 | 278 |
| 1849 | 236 | 0 | 285 |
| 1850 | 186 | 2 | 308 |

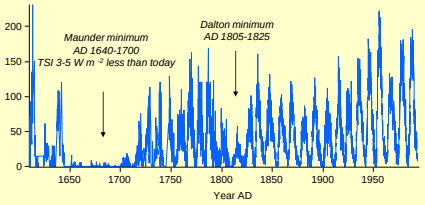
Table of Schwabe's sunspot observations, as published in volume III of Alexander von Humboldt's *Kosmos*. The Table lists, for years between 1826 and 1850 (first column), the total number of sunspots groups observed on that year (second column), the number of days without sunspots (third column), and the number of days for which the Sun was observed (fourth column).

in von Humboldt, A. 1850, *Kosmos. Entwurf einer physischen Weltbeschreibung*, Stuttgart

**Sunspot numbers for the latest four cycles.**




| Sunspot cycles: | Schwabe cycle | 10.8 - 11.3 yr | mean 11 yr |
|---|---|---|---|
| | Hale cycle | 21.6 - 22.6 yr | 22 yr |
| | Gleissberg cycle | 72 - 83 yr | mean 80 yr |




„Little ice age"