Contributions of RMI to Geophysics

Presented by:

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Dourbes

Musée du Cinquantenaire
Musées Royaux d'Art et d'Histoire
Bruxelles, Septembre 27th, 2013

Centenary Celebrations of the
Royal Meteorological Institute of
Belgium

Outline of the talk

- The legacy: geomagnetic measurements
- Early contributions
- The Lahaye and De Vuyst years
- Paleomagnetism contributions
- Instrumentation Craze & Calibration Festival
- The AUTODIF Project
- International Projects and Outreach
- The Future

The Legacy

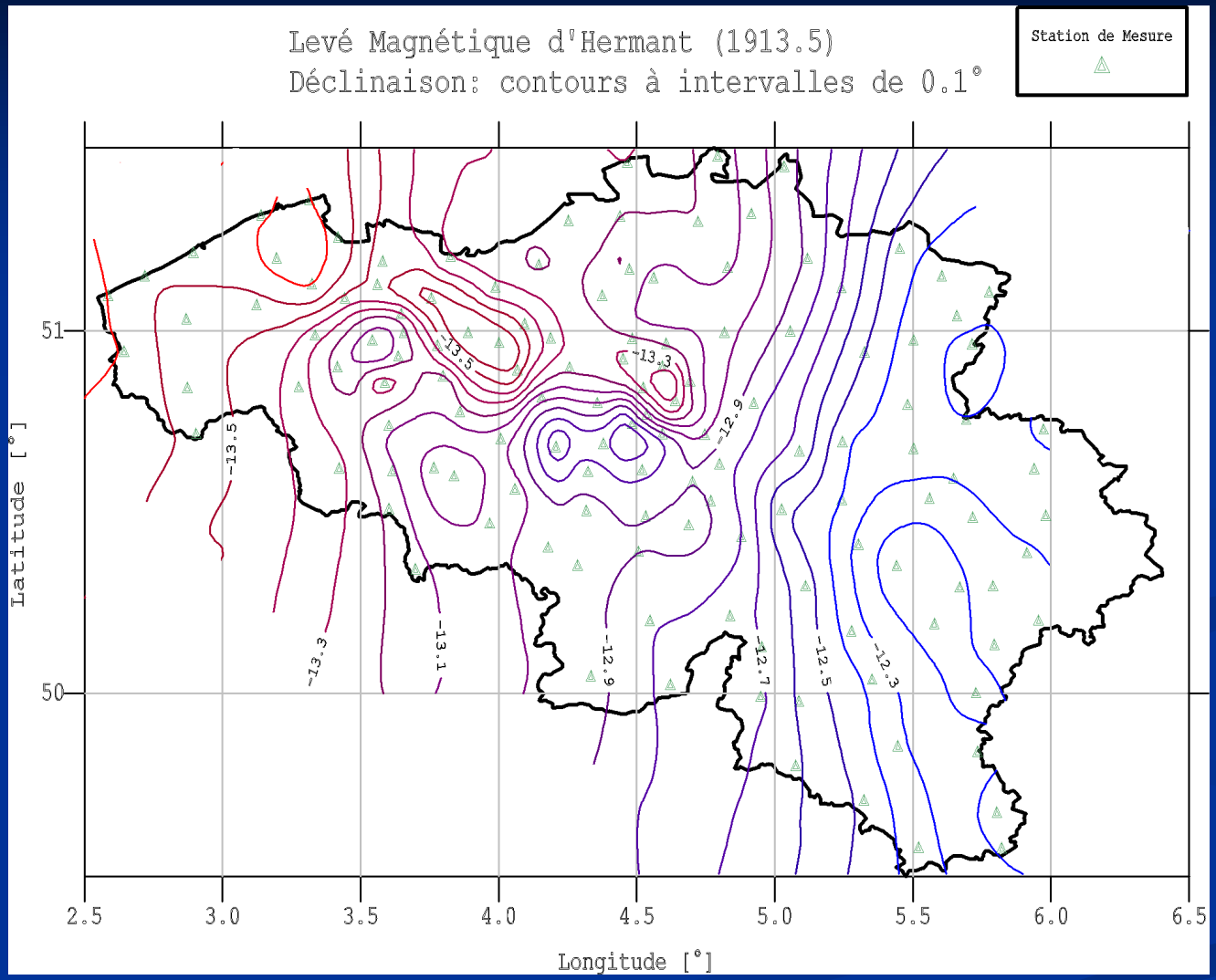
1828: A. Quetelet starting regular magnetic absolute measurements in Brussels

1839-1841: Magnetic measurements are carried out in a "*cabinet magnétique*" located behind the garden of the astronomical Observatory. Changes of the magnetic field are measured 5 times a day. The instruments are moved to the new Uccle Observatory in 1890.

1899: The first isogonal map covering Belgium is prepared by Wilhelm Prinz, based on 19 measurements made by Louis Niesten (1844-1920).

1913: Creation of RMI. Geophysical observations are carried over from the Astronomical Observatory (except seismology and gravimetry).

The Legacy


Levé Magnétique d'Hermant (1913.5)
Déclinaison: contours à intervalles de 0.1°
Station de Mesure
Latitude [°]
Longitude [°]
51
50
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
-13.5
-13.3
-12.9
-13.5
-13.3
-13.1
-12.9
-12.7
-12.5
-12.3

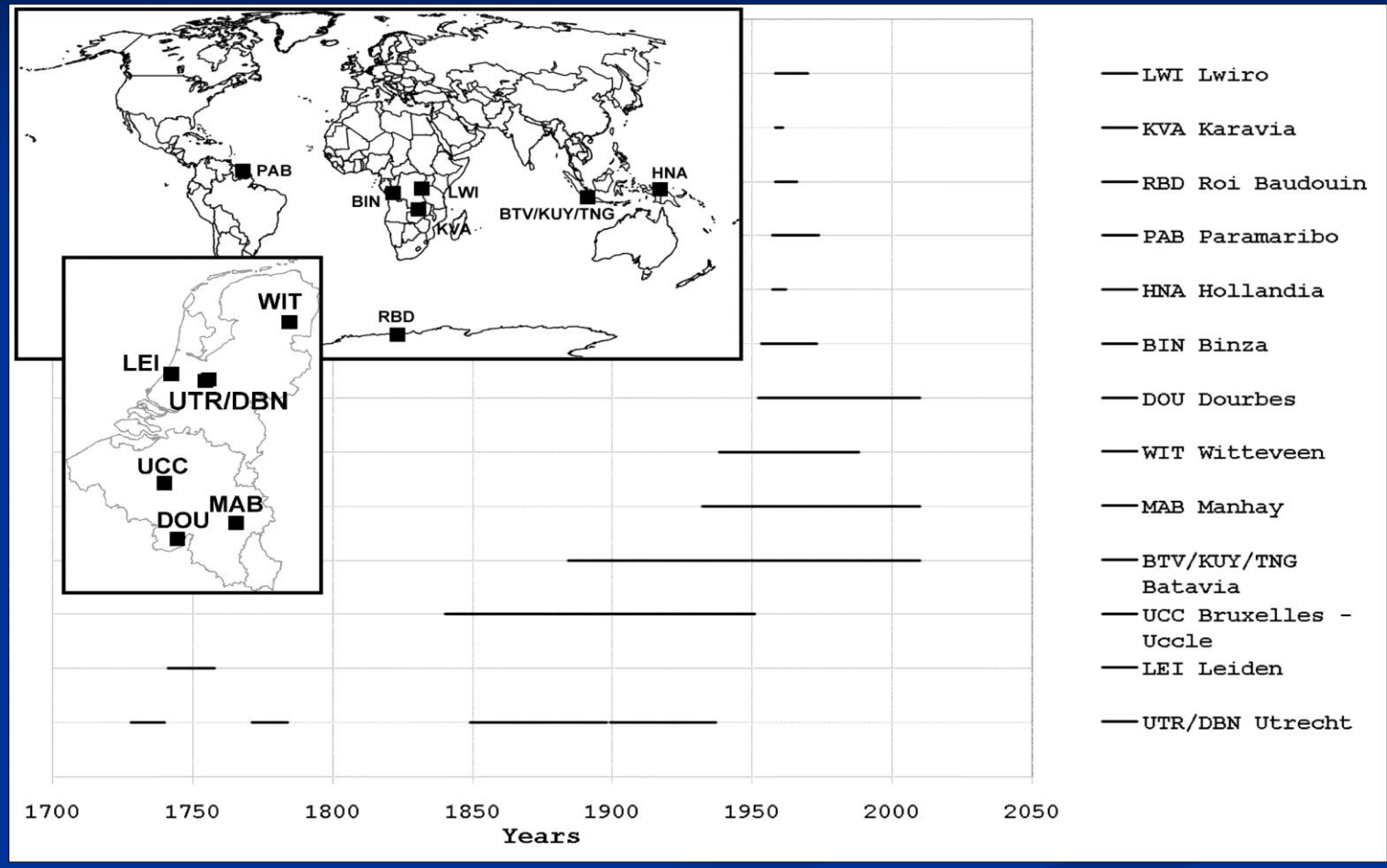
Early contributions

The Uccle magnetic Observatory

The Manhay magnetic Observatory "*International Polar Year (IPY) 1932-1933*"

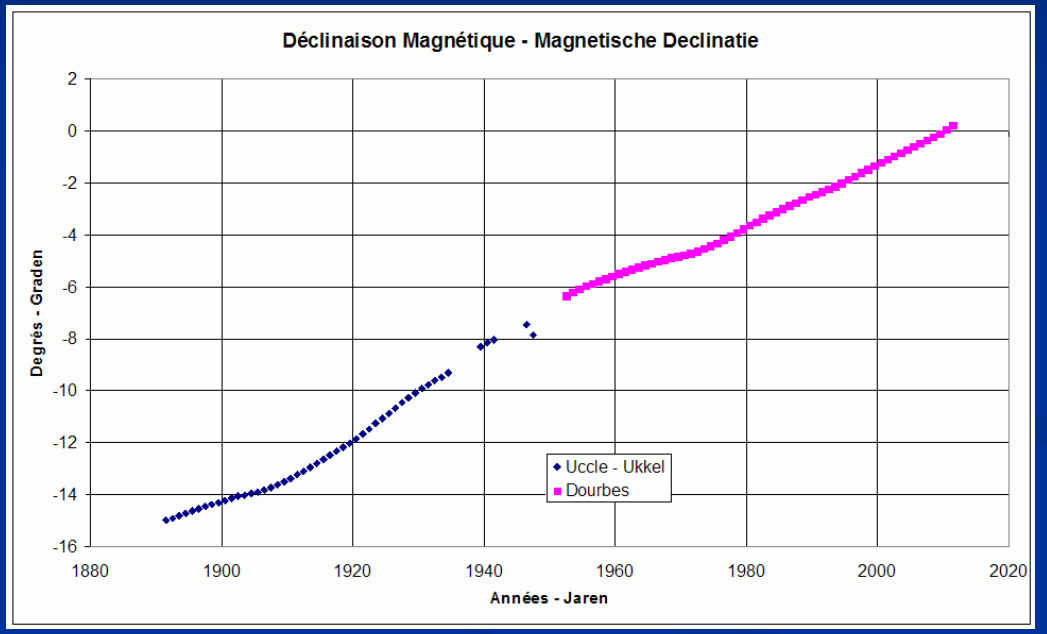
Early contributions

Observatories abroad



Early contributions

Dourbes magnetic observatory construction starts 1948



The Lahaye and De Vuyst years

1951: Edmond Lahaye (1897-1982) becomes RMI Director. He is assisted by A.P. De Vuyst

1952: Magnetic measurements start in Dourbes Observatory

1957 (IGY) : Ionospheric soundings are started in Dourbes by L. Bossy; creation of autonomous unit "external geophysics"

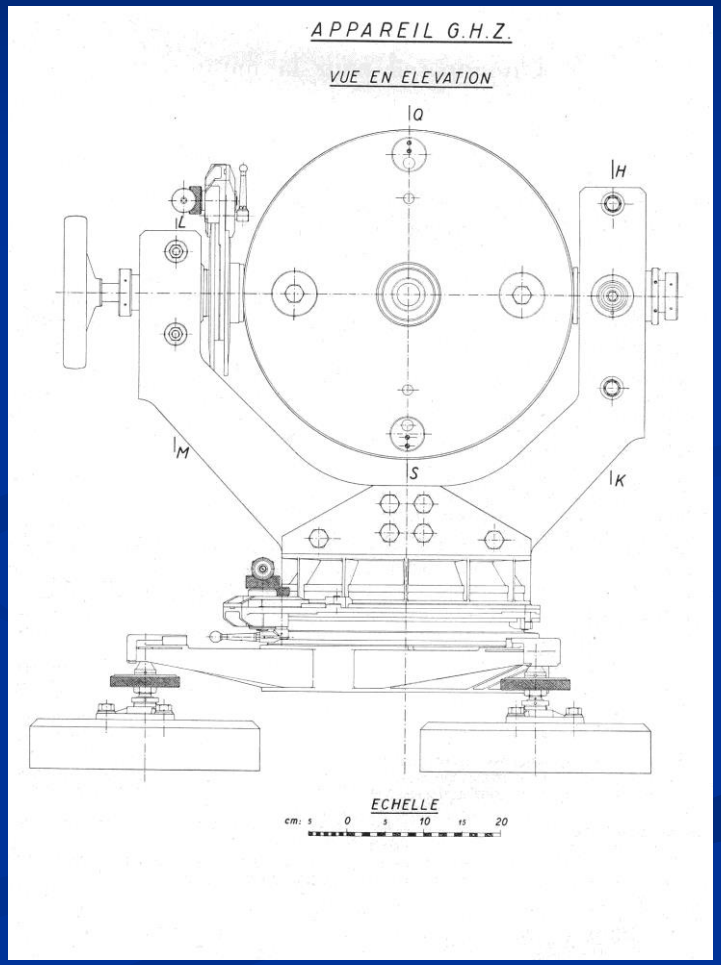
In the sixties, atmospheric electricity, seismology, gravimetry and Earth tides observations are continued/started

The Lahaye and De Vuyst years

Geophysical Centre in Dourbes is one of the first collocated geophysical observatory in the world (magnetism, seismology, meteorology, ionosphere, atmospheric electricity and radioactivity, Earth tides, …

The Lahaye and De Vuyst years

Instrumentation is high on the agenda: lots of efforts to get precise and reliable instruments (calibration) – own design if not available



The Lahaye and De Vuyst years

De Vuyst develops a new absolute instrument: the MTP

The Lahaye and De Vuyst years

Realized that the future lies in digital data acquisition

IAGA Resolutions approved in St. Gall

Resolution No. 1 (1967): ***A standard magnetic observatory in South America***

The IAGA **recognising** the need for highest accuracy in magnetic observations, **recommends** the selection and establishment of a magnetic observatory in South America which will serve as a primary standard of accuracy and assist in the inter-comparison of instruments from other observatories.

Resolution No. 2 (1967): ***Geomagnetic data in digital form***

The IAGA **considering** the great value for geomagnetic investigations of the output-data of magnetic observatory and the great advantage that would accrue from having these data in machine readable form, **recommends** that magnetic observatories should, whenever possible, be modernised, and their read-outs be registered in digital form.

The Lahaye and De Vuyst years

ASMO as installed in DOURBES in 1966:
first digital magnetic observatory

Heroic times!

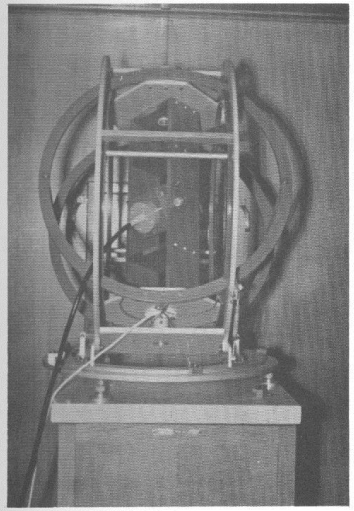


Figure 2
Helmholtz Coil System

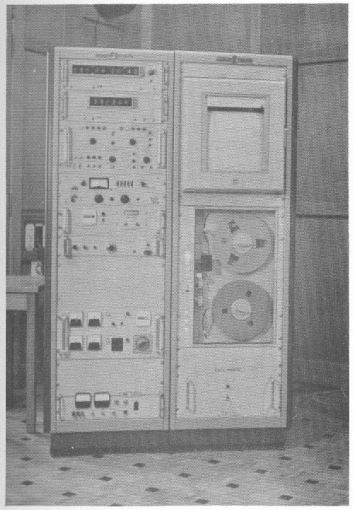


Figure 4
System Electronics and Recorder

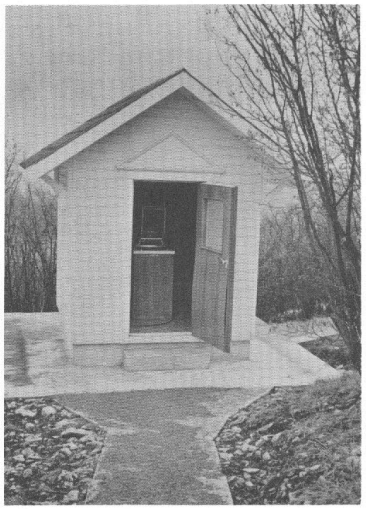
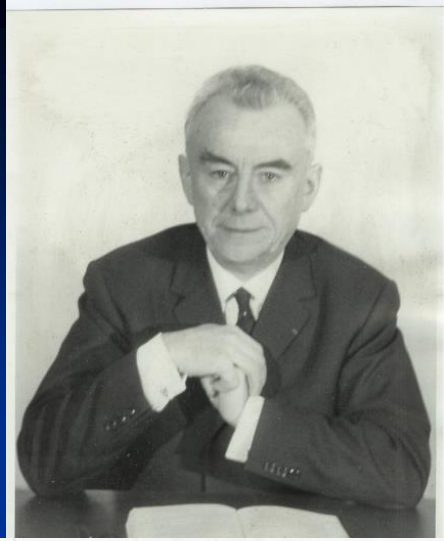
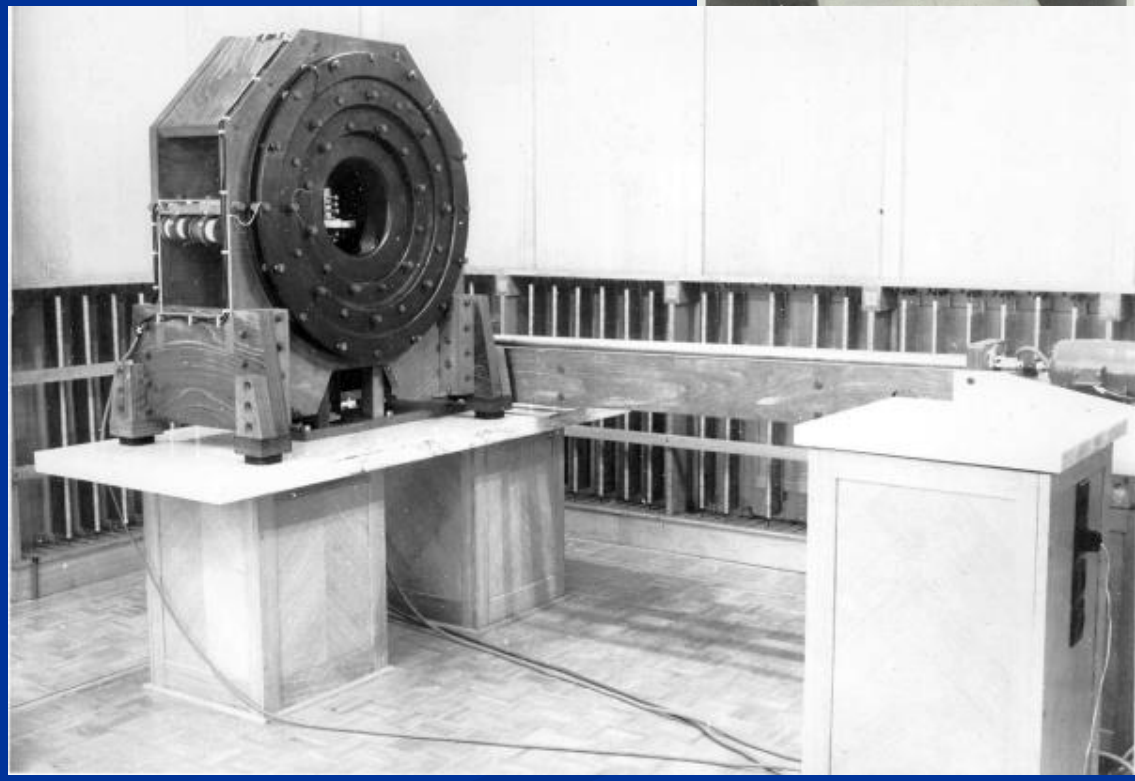


Figure 3
Observatory Building Containing
Helmholtz Coil and Sensor

Paleomagnetism



- The Unit "Magnetodynamics and Paleaomagnetism" is created by A.P. De Vuyst in 1965 and is active in Dourbes
- J. Hus visits E Thellier in France for training and starts paleaomagnetic research; several rock magnetometers are installed in Dourbes



Paleomagnetism

- Laboratory for Paleo-Archeomagnetism
- Rock Magnetism

Paleomagnetism

Loess Magnetism (Belgium, Europe, China)

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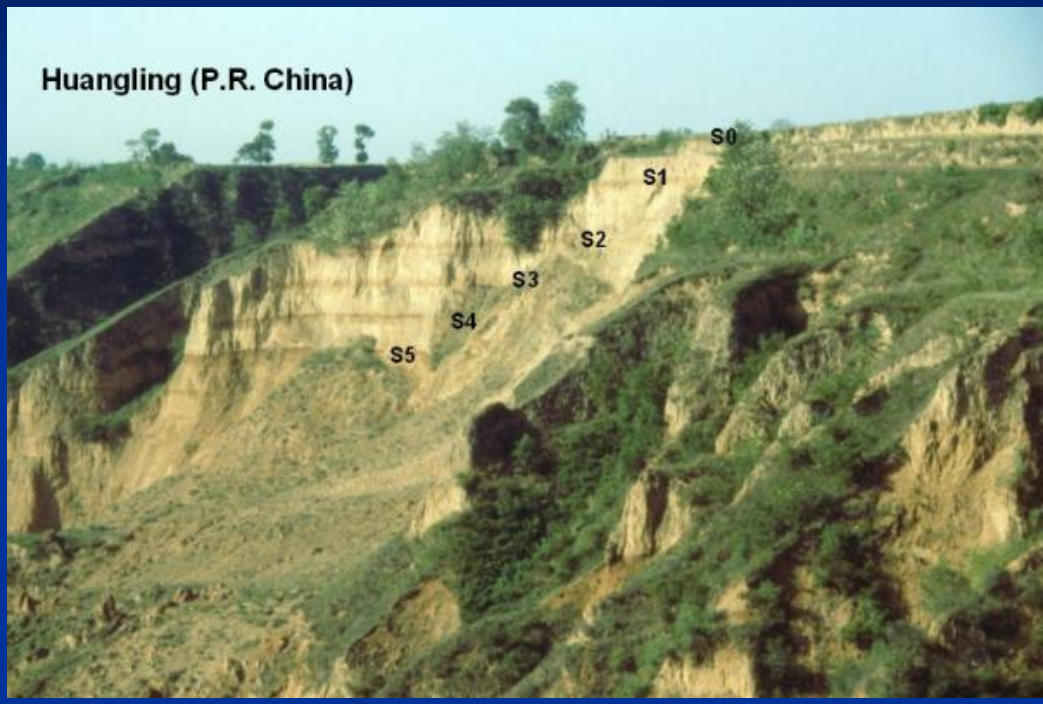
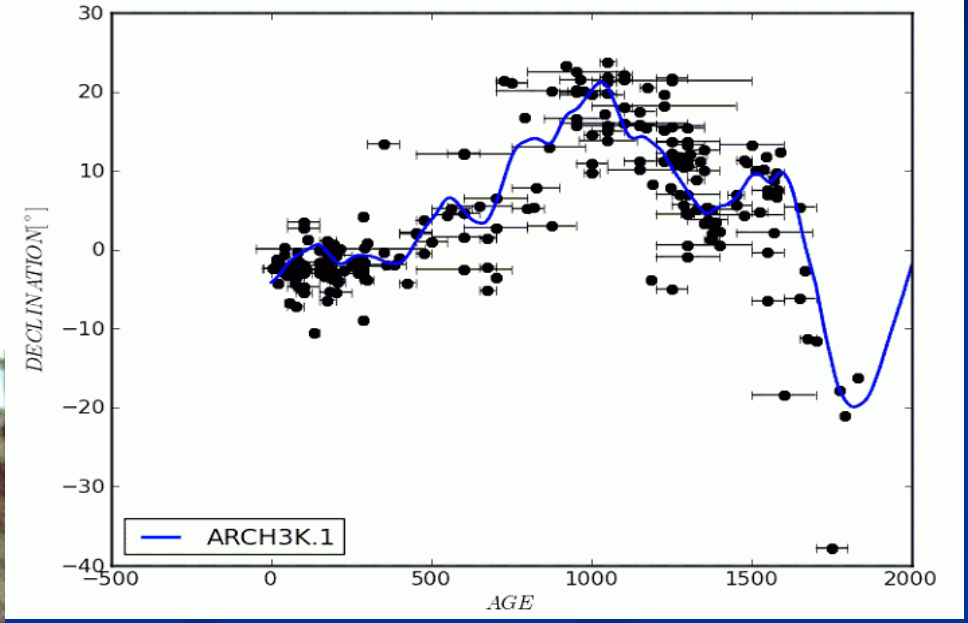


Absolute determinations of the magnetic field intensity in the past

Paleomagnetism

Archeomagnetism

- Investigations into causes of error (anisotropy, magnetic refraction)
- First SV curve for post-Roman era in Belgium



Paleomagnetism

First cryo-coolfree cryogenic rock magnetometer by 2G installed in Dourbes

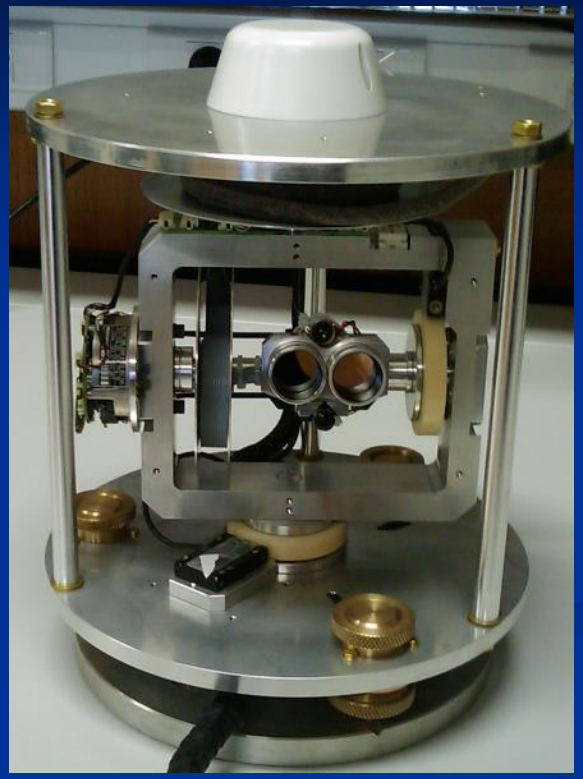
Instrumentation Craze & Calibration Festival

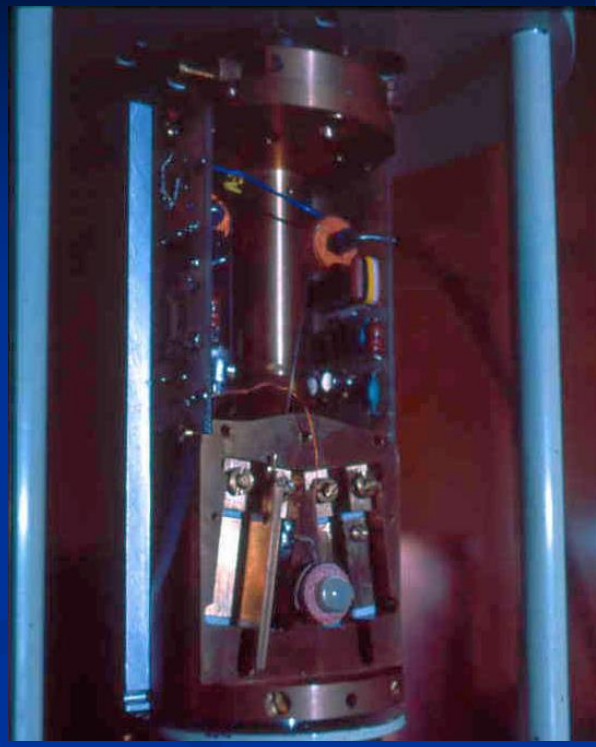
- Dr Lahaye was enthusiastic for instrumentation, and Dourbes was built with extended mechatronic facilities
- Attention for perfectly calibrated instruments has always been high
- Several projects were launched because of this "attitude":
  - Dynamic calibration of seismometers and gravity meters by a step function excitation
  - Conical pendulum gravimeter for calibration in Earth tidal research (Love numbers)
  - Magnetic induction absolute SI units in the geomagnetic range with K optically pumped magnetometers: aiming for 0.1nT
  - Controlling time-stamp accuracy in magnetic measurements (0.01s)
  - Development of fully automatic magnetic observatories

Instrumentation Craze & Calibration Festival

New instruments were designed and built in-house:

- Conical pendulum gravity meter
- Low-noise fluxgate electronics
- Geomagnetic 3-axis variometer
- Automatic non-magnetic theodolites





The AUTODIF project

Design an Automatic Magnetic Observatory by automating manual Field angle measurements (DIflux procedure):

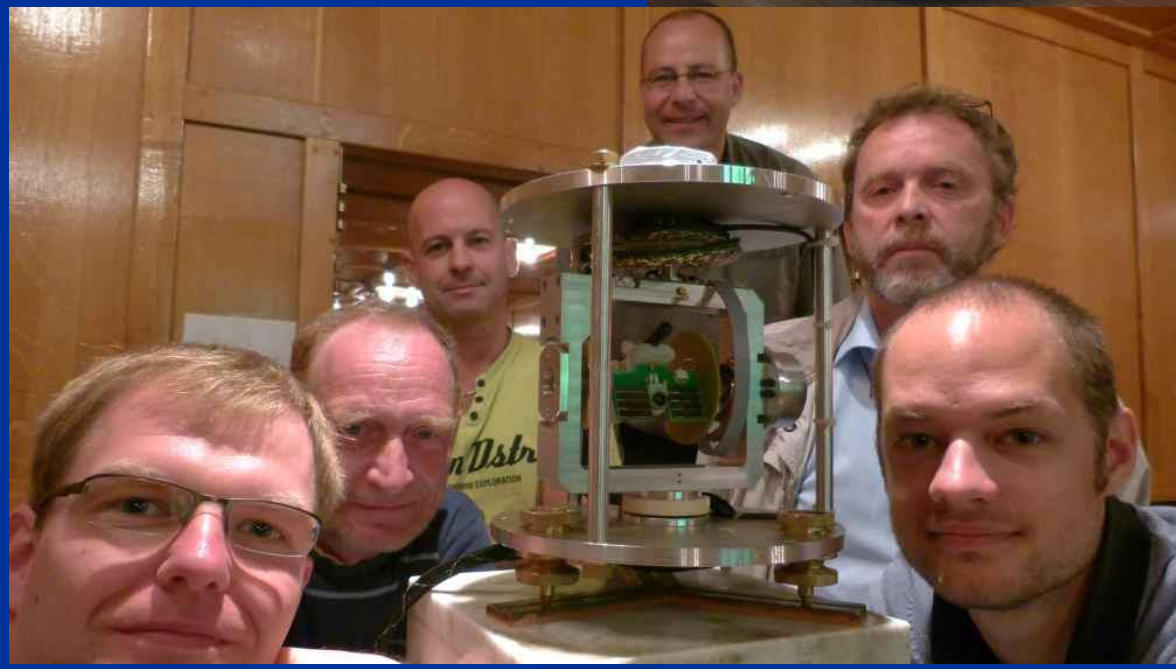
- Point to a target with known azimuth
- Level the theodolite axis
- Perform telescope plungings
- Sense magnetic field vector orientation
- Read the angles of the theodolite

The AUTODIF project

The Automatc DIflux AUTODIF.

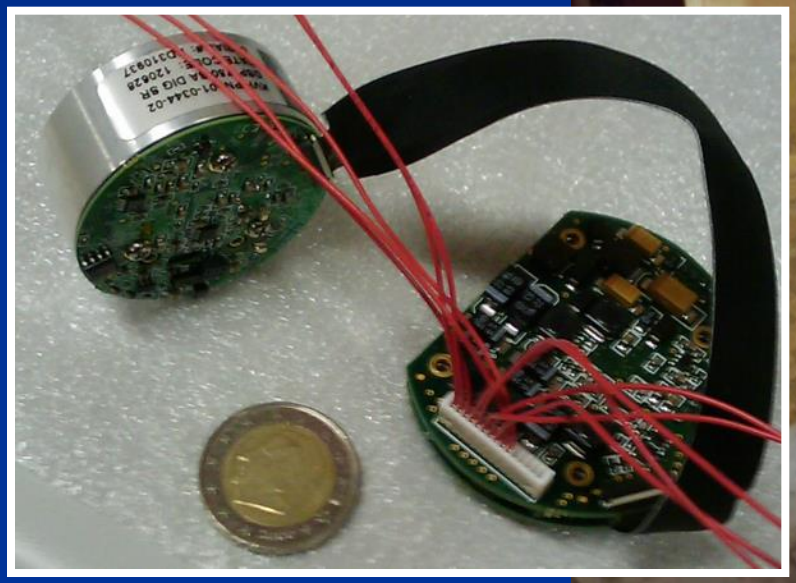
Challenges:

- Create non-magnetic robot theodolite
- With high-accuracy (1seca)
- Able to point a target
- Able to sense magnetic field direction



The AUTODIF project

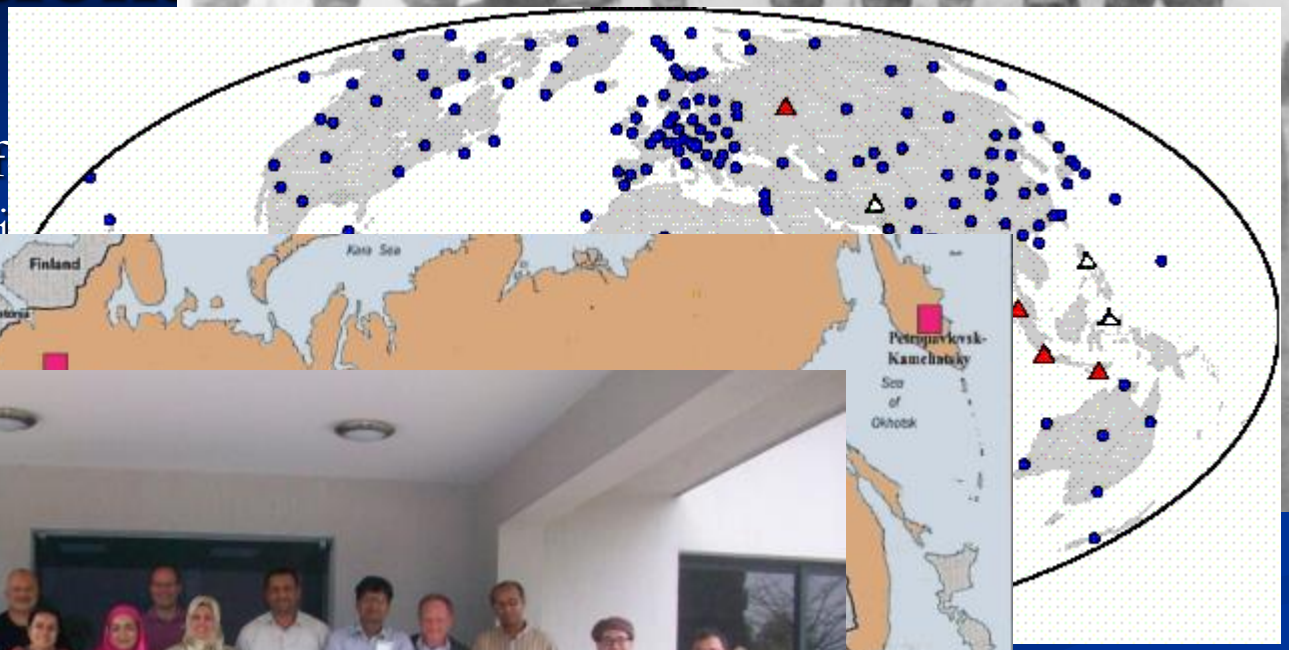
- AUTODIF is already operational in Dourbes with equal or better precision than manual measurements
- Able to measure more frequently
- Is mature enough for commercial production. Fellow observatories are interested especially for remote places (seafloor, Antarctica,…)
- Will be supporting Directional drilling for oil wells
- Variant with gyroscopic North-seeker is in test.



Internationa

Worldwide support f

- Argentina: Afri
- IND
- INT



International Projects & Outreach

- Creation and maintenance of IAGA V obs webpage : http://www.meteo.be/IAGA_WG_V.1/

List of Magnetic Observatories and Variation Stations sorted by IAGA three-letter code

Status Key:

o: open i: open with INTERMAGNET status
u: uncertain c: closed

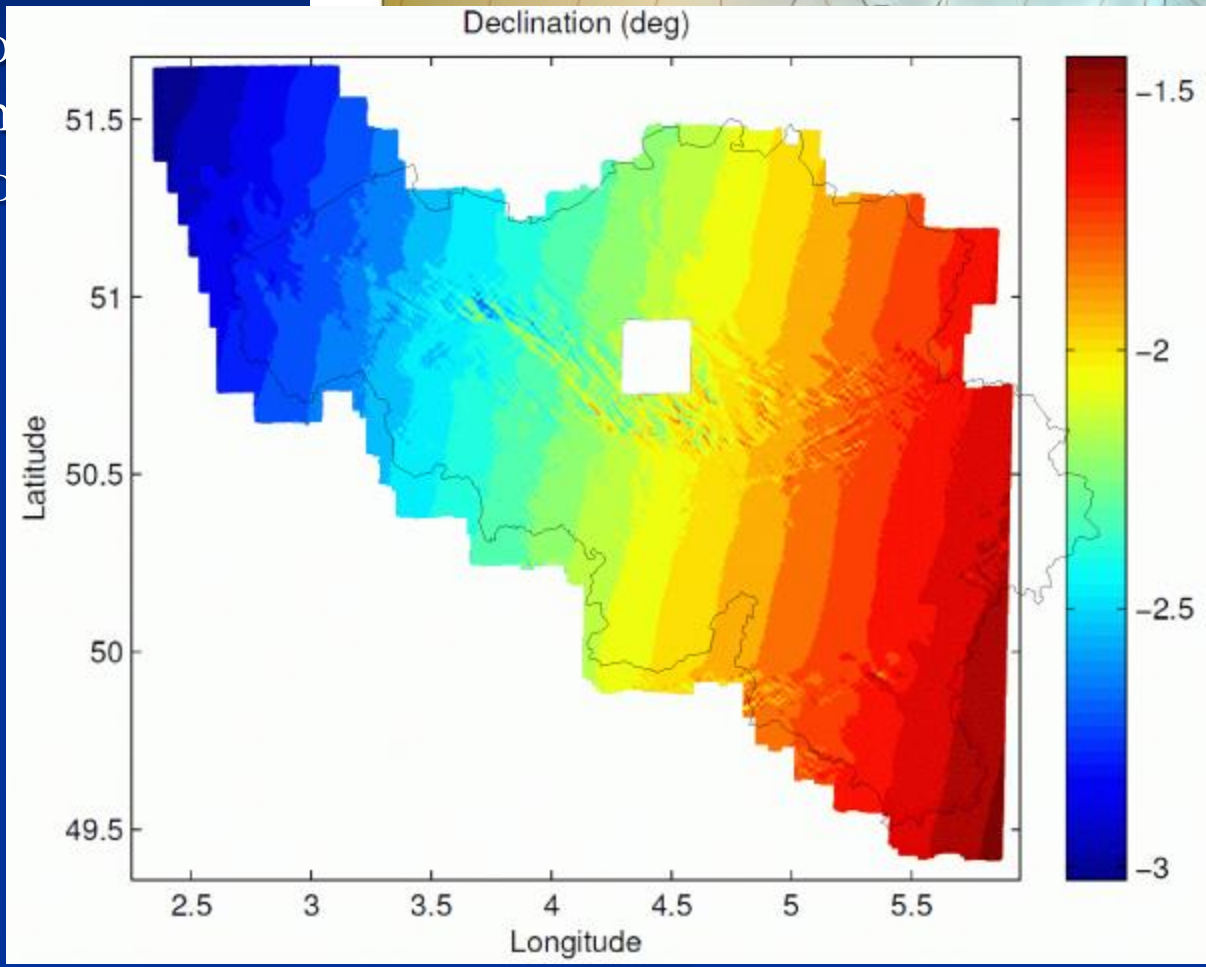
IAGA Code	Observatory Name	Geogr Lat degrees	Long	Alt. m	Open-Close	status	Google Earth
AAA	ALMA_ATA	43.250	76.917	1300	1963-	i	view
AAE	ADDIS_ABABA	9.030	38.765	2442	1958-	i	
ABG	ALIBAG	18.638	72.870	7	1904-	i	
ABK	ABISKO	68.358	18.823	380	1921-	i	
ABN	ABINGER	51.180	359.610	244	1925-1957	c	
ACR	ACCRA	5.630	359.830		1963-1965	c	
ADA	ADAK	51.867	183.350		1964-1966	c	
ADE	ADELAIDE	-34.600	138.400		1973	c	
AED	AEDEY	66.090	337.350			c	
AGN	AGINCOURT	43.780	280.730	175	1881-1969	c	
AHM	AHMEDABAD	23.020	72.600		1973	c	
AIA	ARGENTINE_ISLAND/VERNADSKI	-65.245	295.742	10	1957-	i	view
AIF	ARCTIC_ICE_FLO	83.520	193.050		1957-1958	c	
ALE	ALERT	82.497	297.647	60	1961-	o	
ALG	ALGER_ISLAND	80.367	56.100		1905	c	

International Projects & Outreach

Macedonia & Slovenia repeat station network creation

International Projects & Outreach

Since 1999 monitoring o
BENELUX geomagn
on demand from aero
and cartography



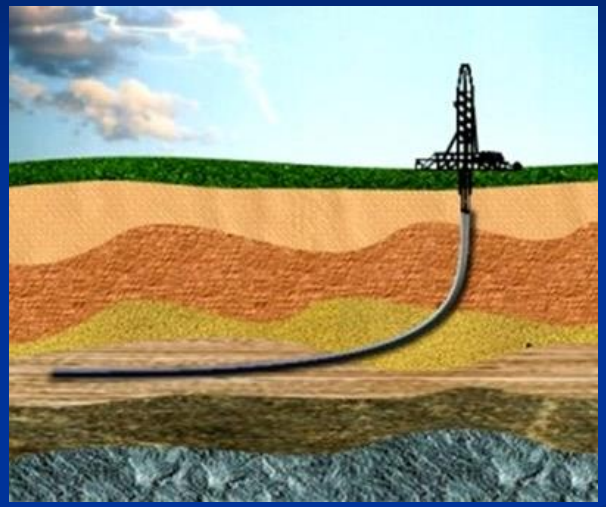
The Future

- Princess Elizabeth Antarctic Base BAB magnetic observatory
  - To be installed 2014
  - Nonmagnetic fiberglass shelter
  - Fully Automatic with AUTODIF

The Future

- MPMS Squid-VSM Magnetic Property Measurement System
  - T: 1.2 - 1000 °K
  - Fields from 0 to 7T
- Magnetically shielded room

The Future



Widif and Gyrodif (i.a. for Directional Drilling)

The Future

Magtap

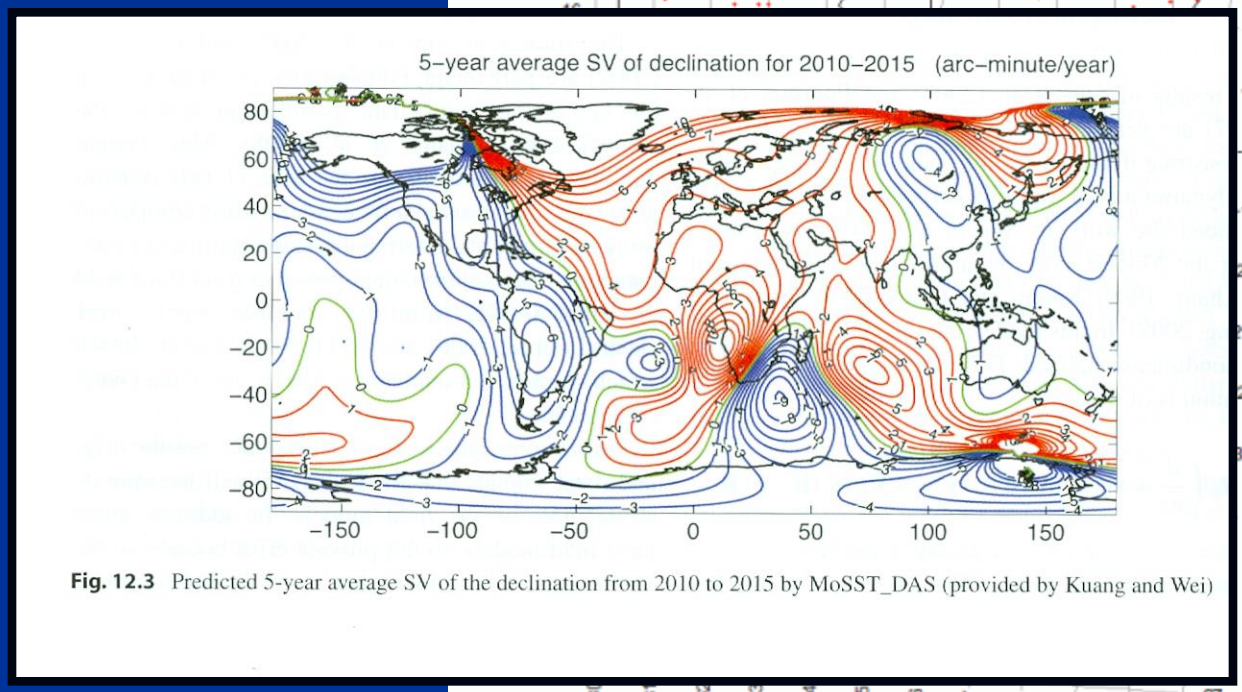


Fig. 12.3 Predicted 5-year average SV of the declination from 2010 to 2015 by MoSST_DAS (provided by Kuang and Wei)

The Future

Moons of Jupiter: Ganymede gravity monitoring with a conical pendulum

Thank You