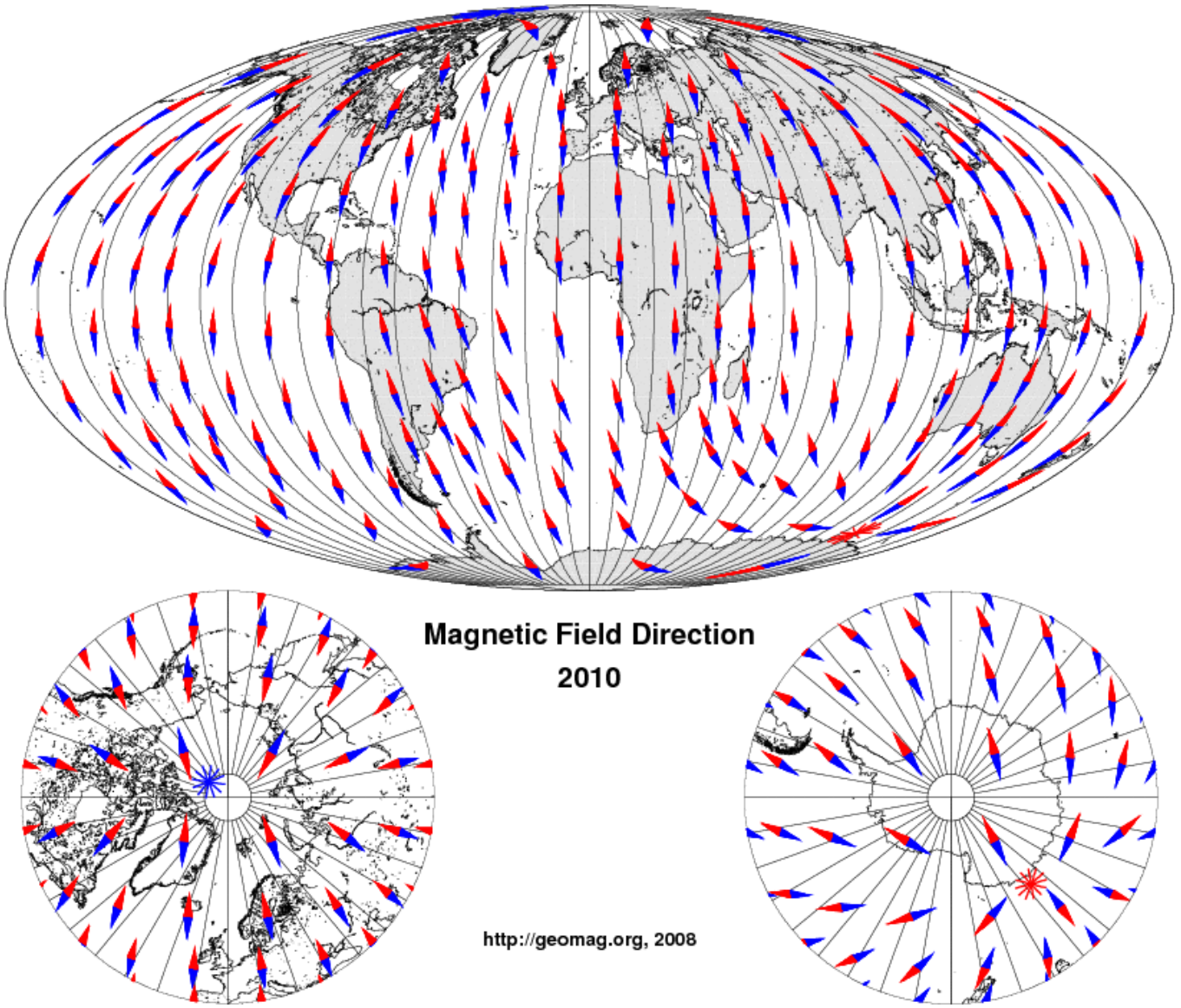
Chapter 7
The compass

Previously



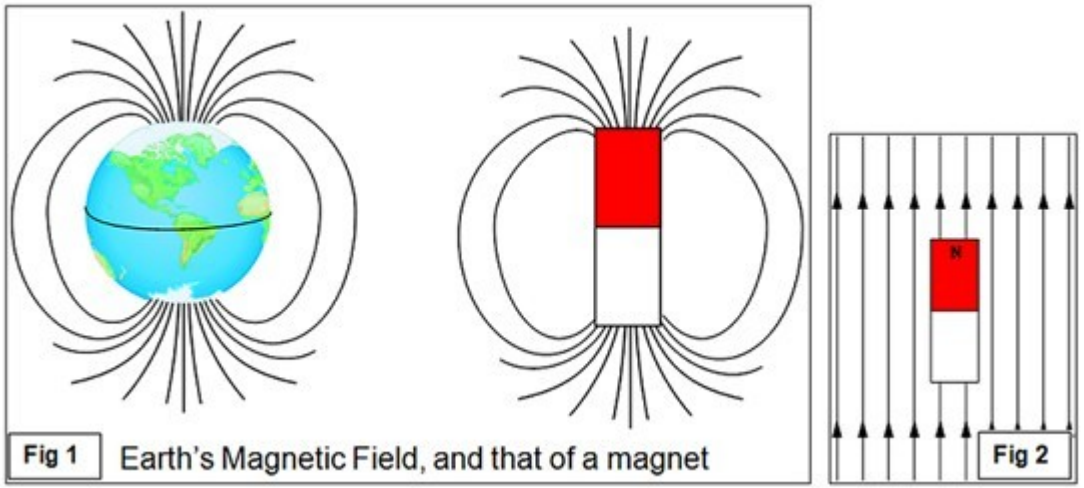
On the Earth's surface, a small, freely turning magnetic needle aligns itself roughly with the north-south direction.

Content

- The compass
- Where does the compass point?

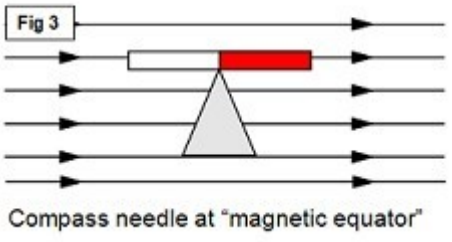
The compass

- A compass is an instrument used for navigation and orientation that shows approximately the direction relative to the geographic north.
- The magnetic compass is the most familiar compass type. It functions as a pointer to magnetic north, the local magnetic meridian, because the magnetized needle at its heart aligns itself with the horizontal component of the Earth's magnetic field. The magnetic field exerts a torque on the needle, pulling one end or pole of the needle approximately toward the Earth's north magnetic pole, and pulling the other toward the south magnetic pole. The needle is mounted on a low-friction pivot point so it can turn easily. When the compass is held level, the needle turns until, after a few seconds to allow oscillations to die out, it settles into its equilibrium orientation.

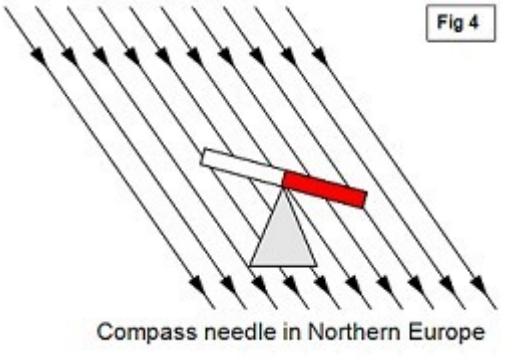


Balancing the compass needle against inclination

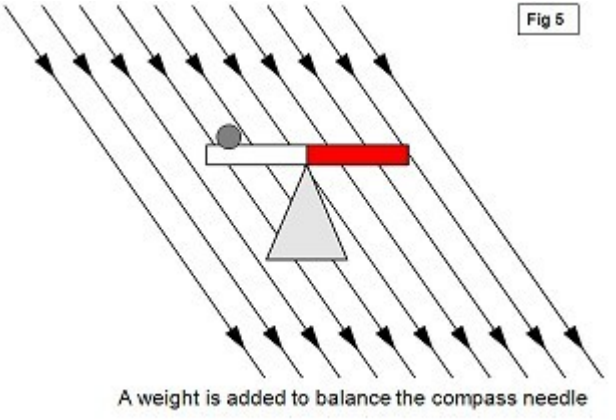
- To work accurately the compass needle must be able to turn freely inside its liquid filled capsule, else it may drag against the compass housing and give an incorrect reading. This is why a compass should be held horizontally when in use.
- At the magnetic equator the needle is perfectly level. Between the magnetic equator and the poles, however, one end of the needle tends to dip down (by the local inclination angle), causing drag, with the potential for inaccurate readings.
- To overcome this situation, manufacturers balance their compasses to allow for inclination.
- Adding an appropriate weight to one side of the compass balances it for a particular area, or zone of the Earth's magnetic field. Not all parts of the world are balanced in the same way.



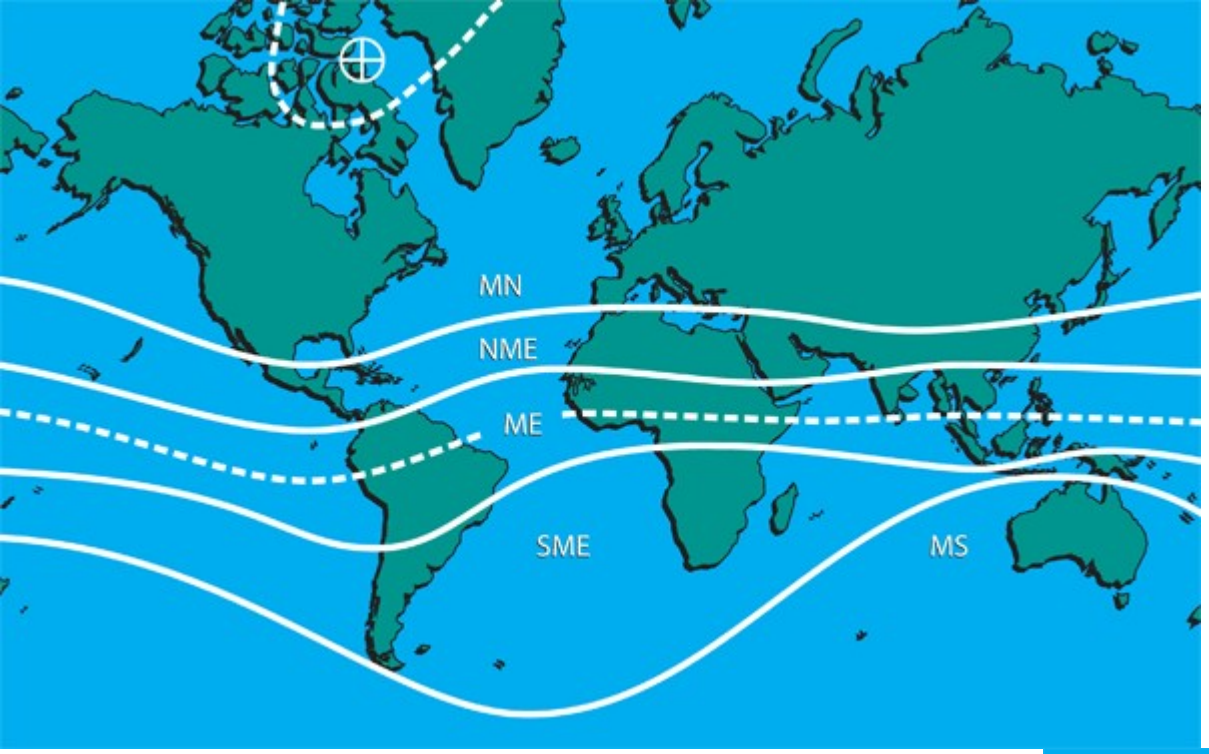
Compass needle at "magnetic equator"



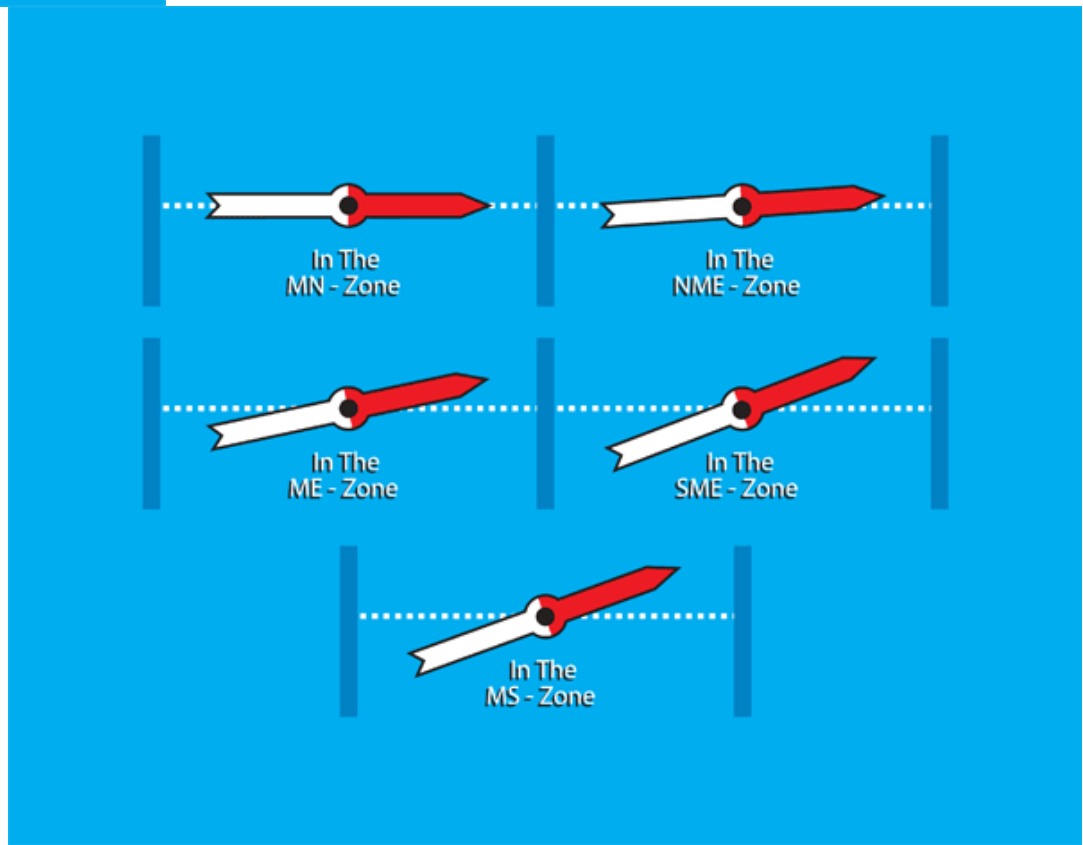
Compass needle in Northern Europe



A weight is added to balance the compass needle



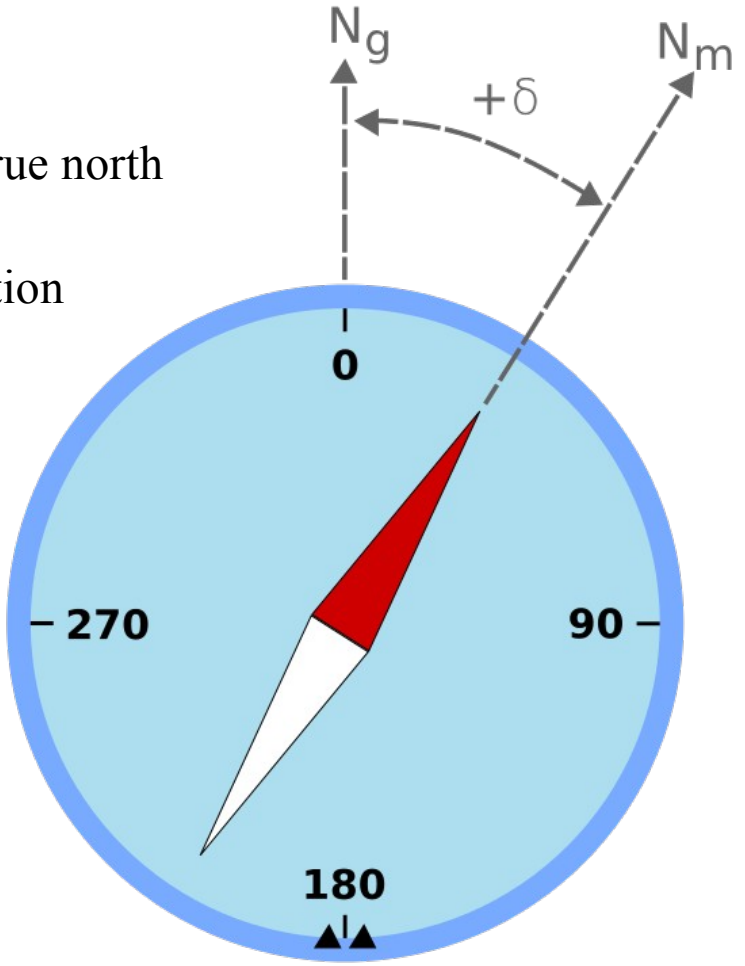
The balance zones used by the manufacturer Silva.



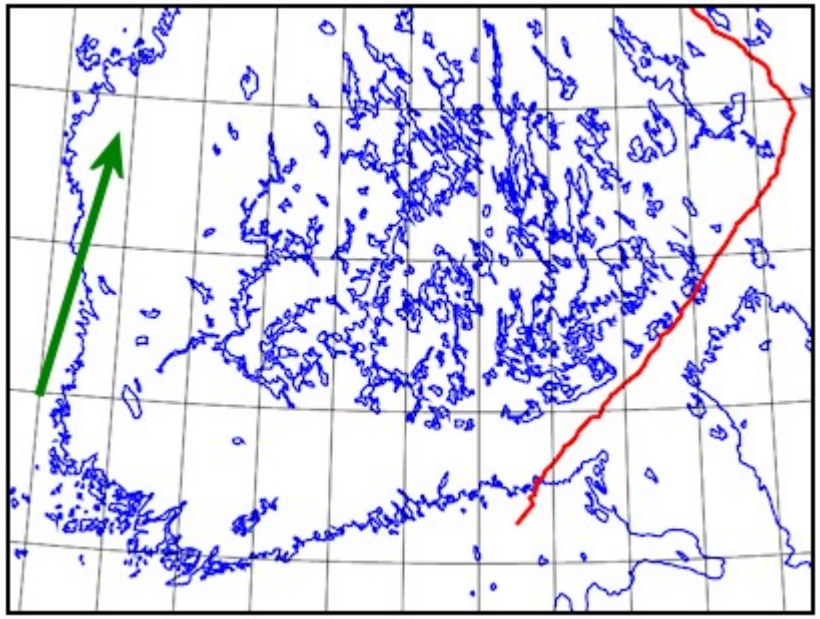
Effect on an MN-zone-balance compass needle in other magnetic zones.

Correcting the compass reading for declination

N_g geographic or true north
N_m magnetic north
δ magnetic declination

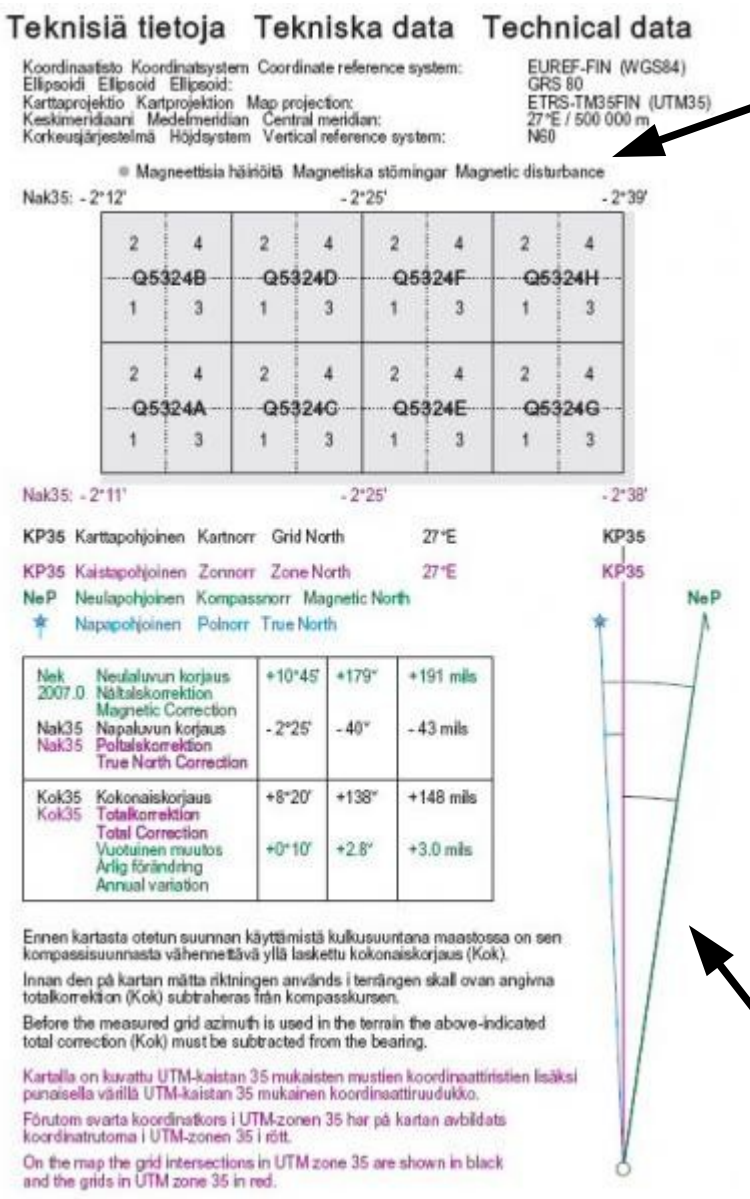


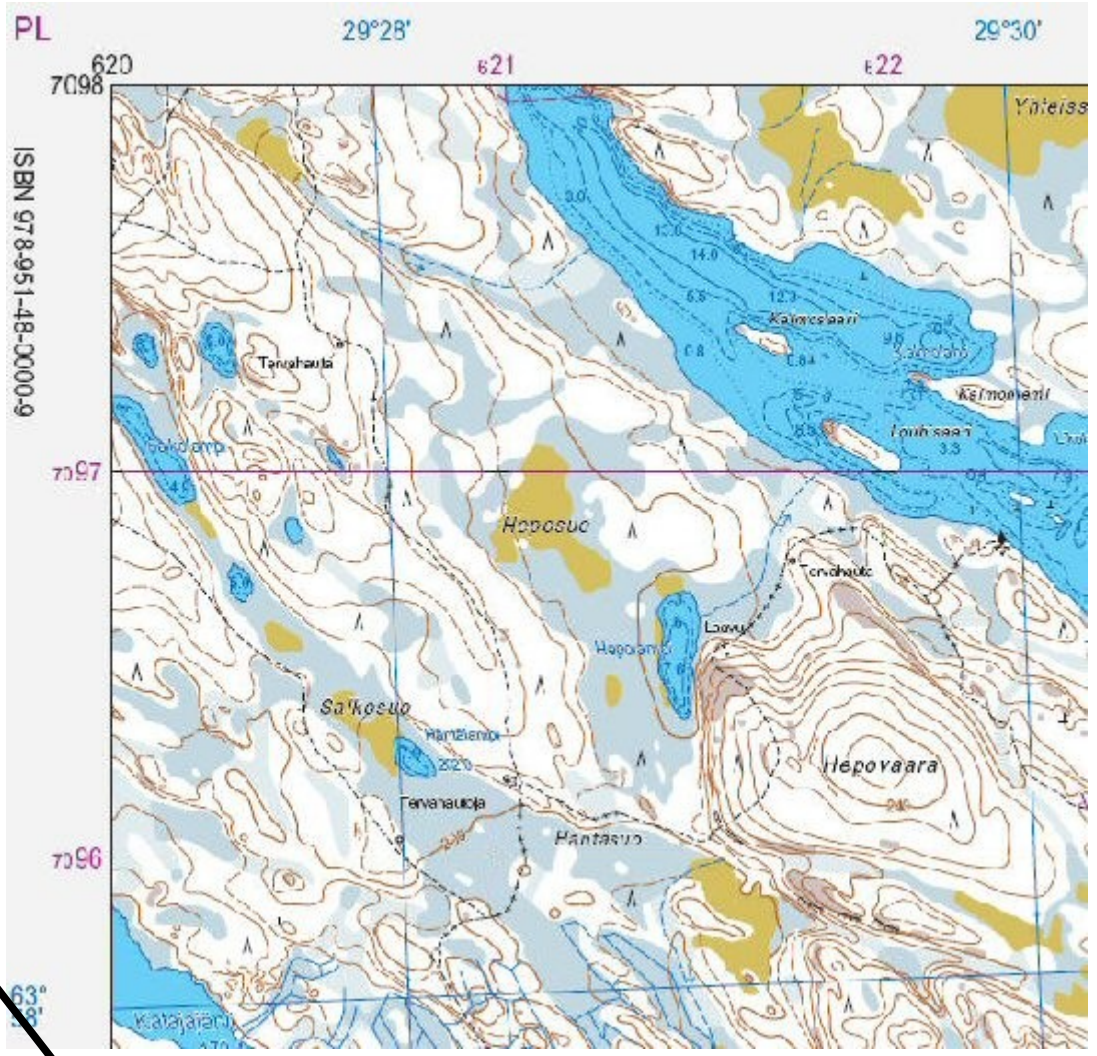
Grid north equals true north, for this map.
Magnetic north is shown by the arrow.



Example of magnetic declination showing a compass needle with a positive (or easterly) variation from geographic north.

In an area where there is a magnetic disturbance, the compass direction may differ several degrees from the given declination.



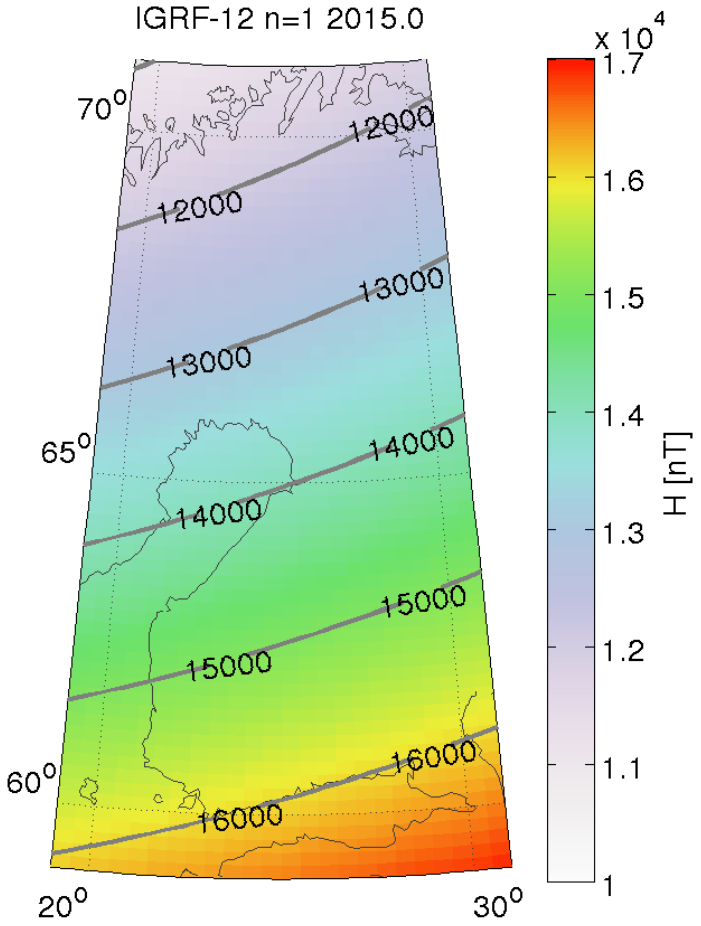


The information are based on the local magnetic field models of Finland described in chapter 6.

http://www.maanmittauslaitos.fi

Where does the compass point?

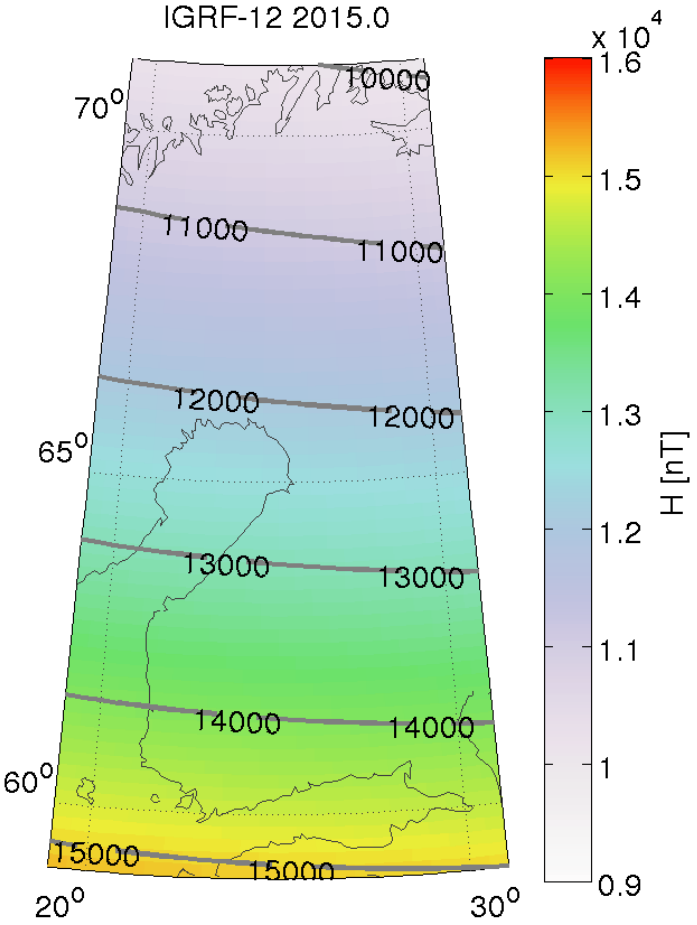
- A compass needle points to the direction of the magnetic north, which is the same as the direction of the horizontal component of the magnetic field, *H*.
- In general, a compass needle is estimated to point towards the north geomagnetic (dipole) pole or magnetic pole.
- The north geomagnetic pole and magnetic pole lie roughly northwest of Finland.
- Nonetheless, in Finland declination is eastern (positive) and a compass needle generally does not point northwest.

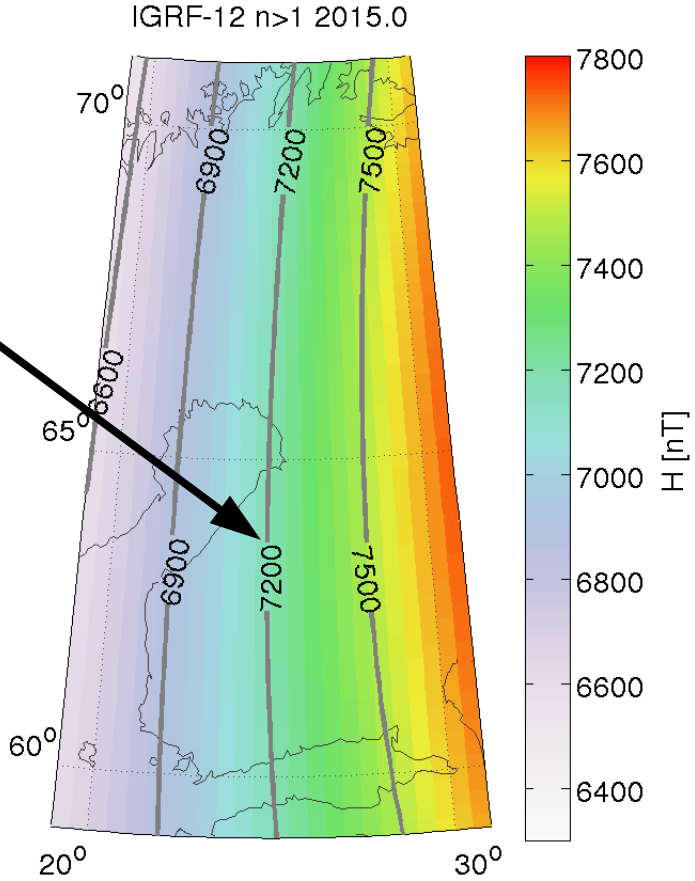


If $\boldsymbol{H}_{anomalous}=0$

$H_{anomalous}$ almost 50% of H_{dipole}.

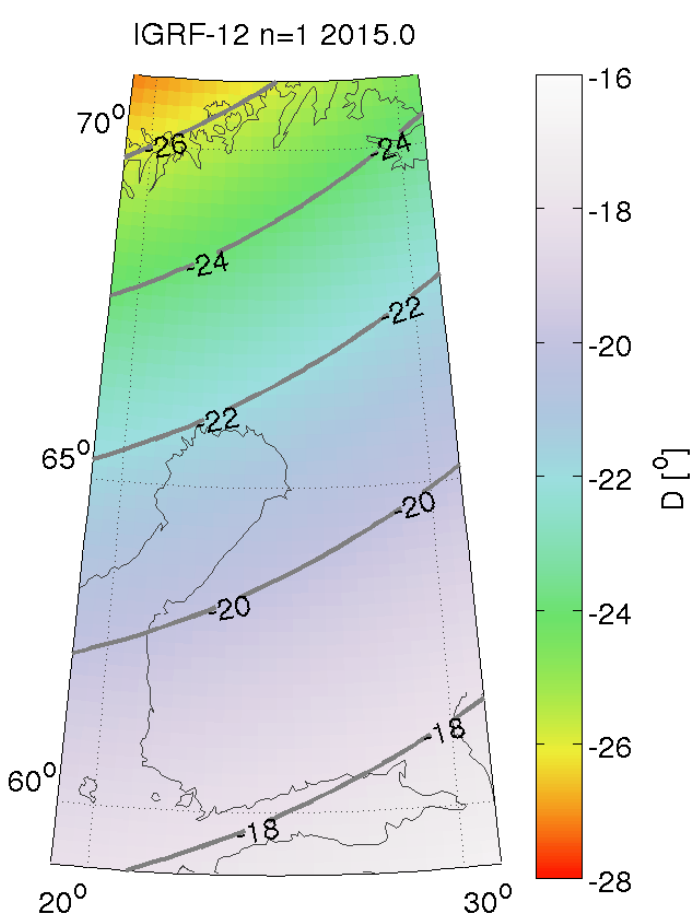
$$\boldsymbol{H}=\boldsymbol{H}_{dipole}+\boldsymbol{H}_{anomalous}$$

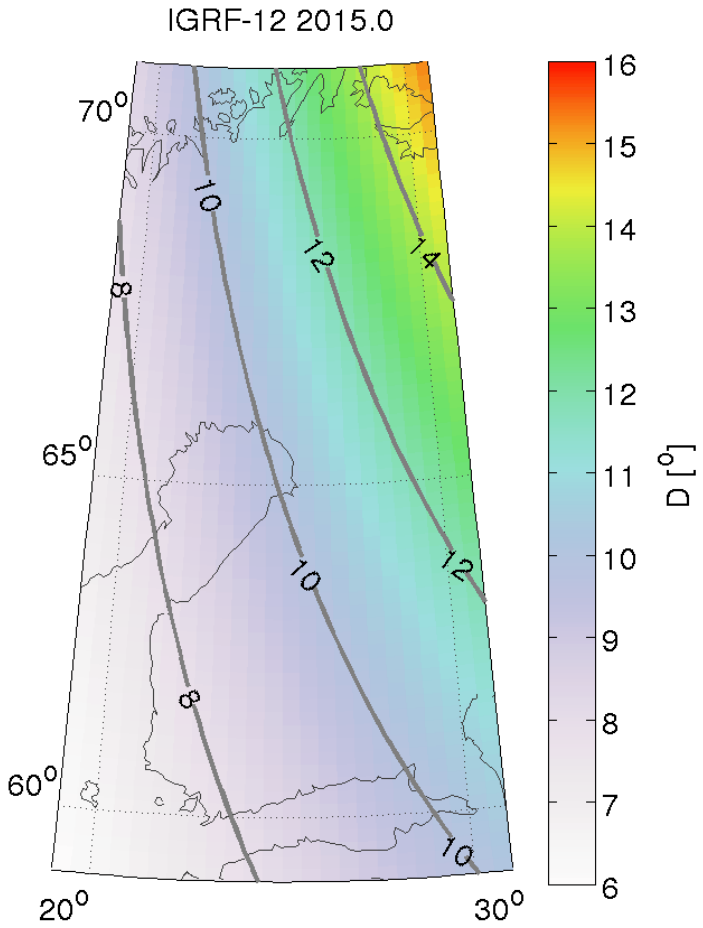


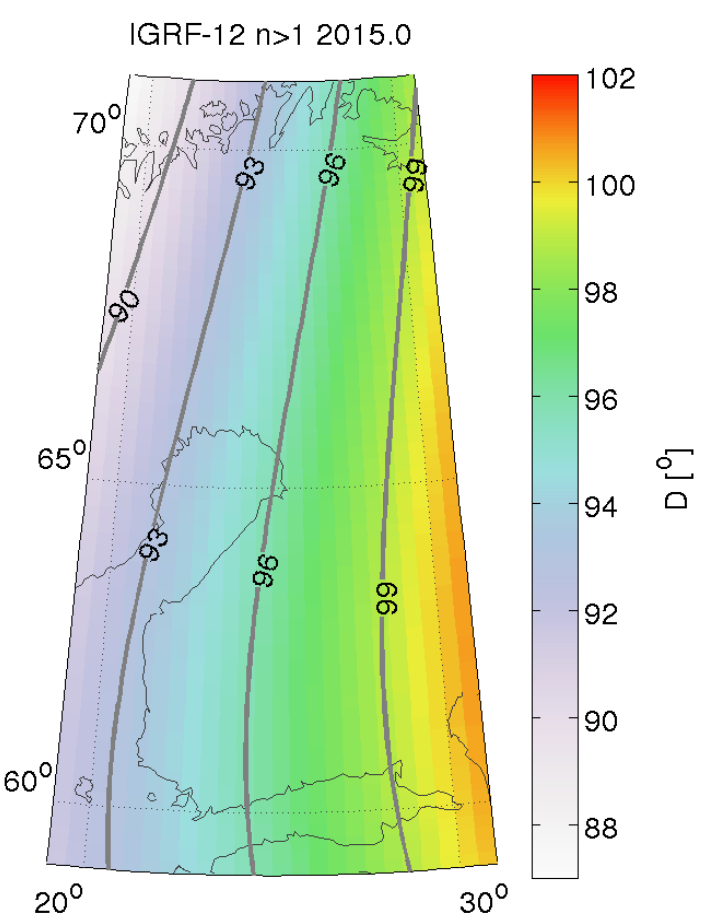


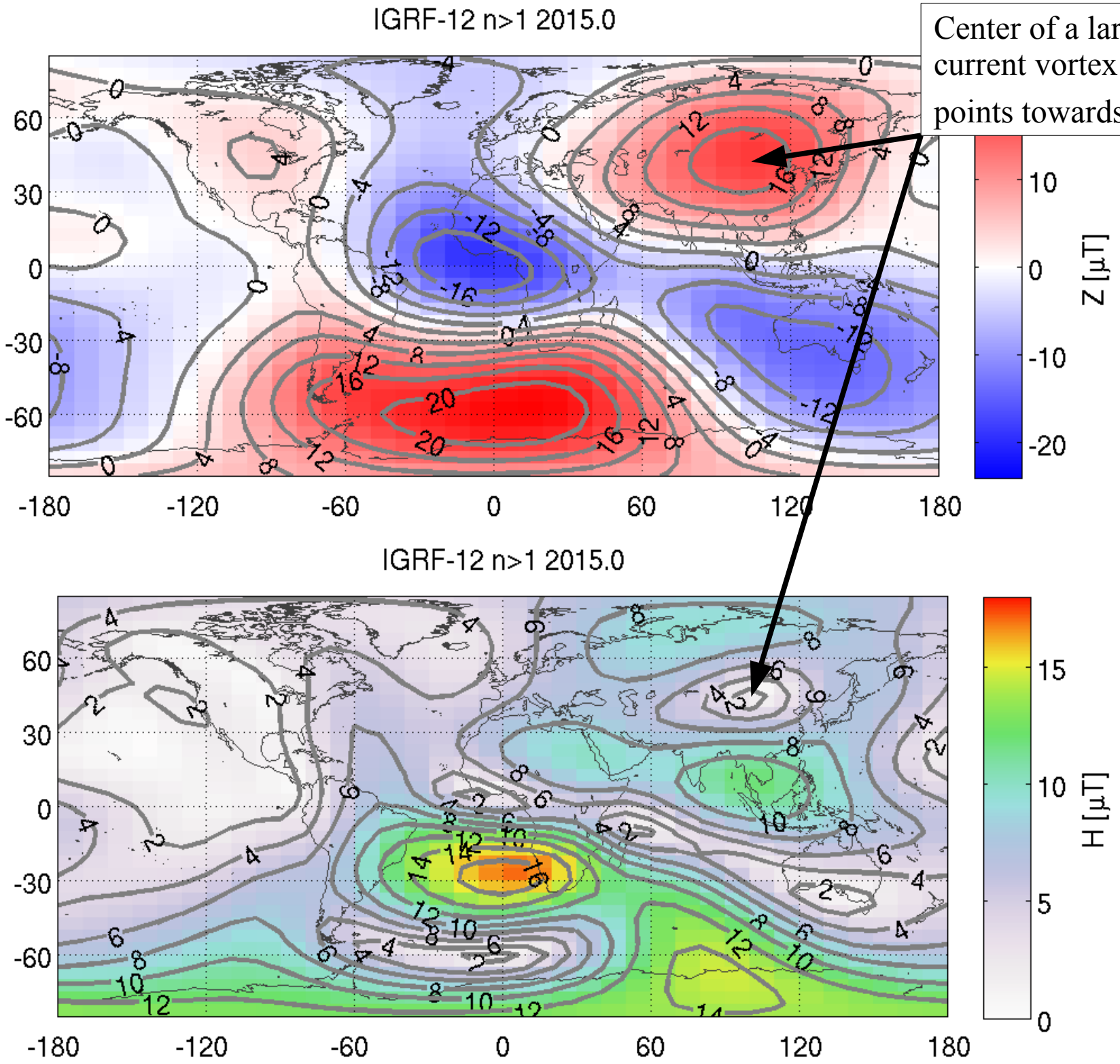
If $\boldsymbol{H}_{dipole}=0$

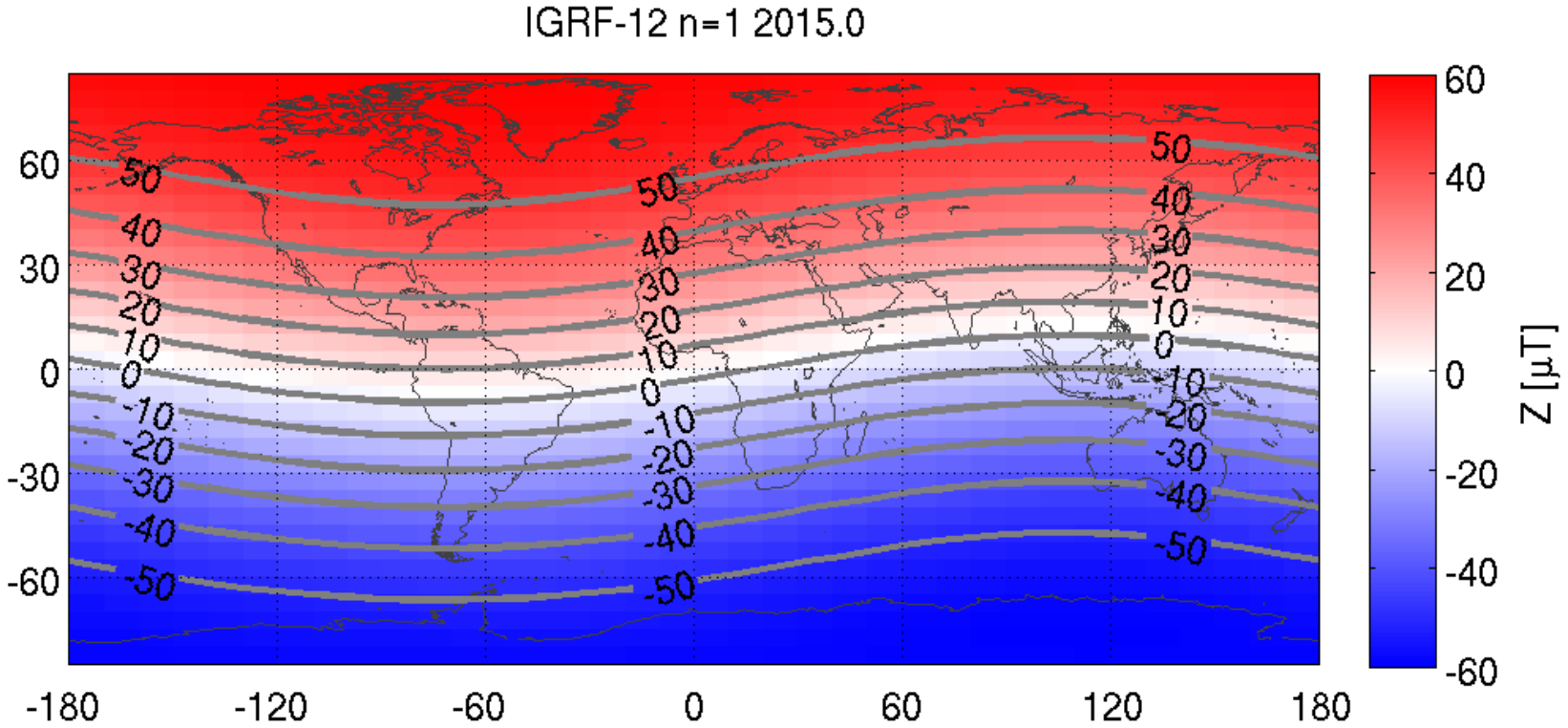
(In these plot, $\boldsymbol{H}_{anomalous}$ only consists of the non-dipolar terms if IGRF. In reality, $\boldsymbol{H}_{anomalous}$ also includes the crustal field.)

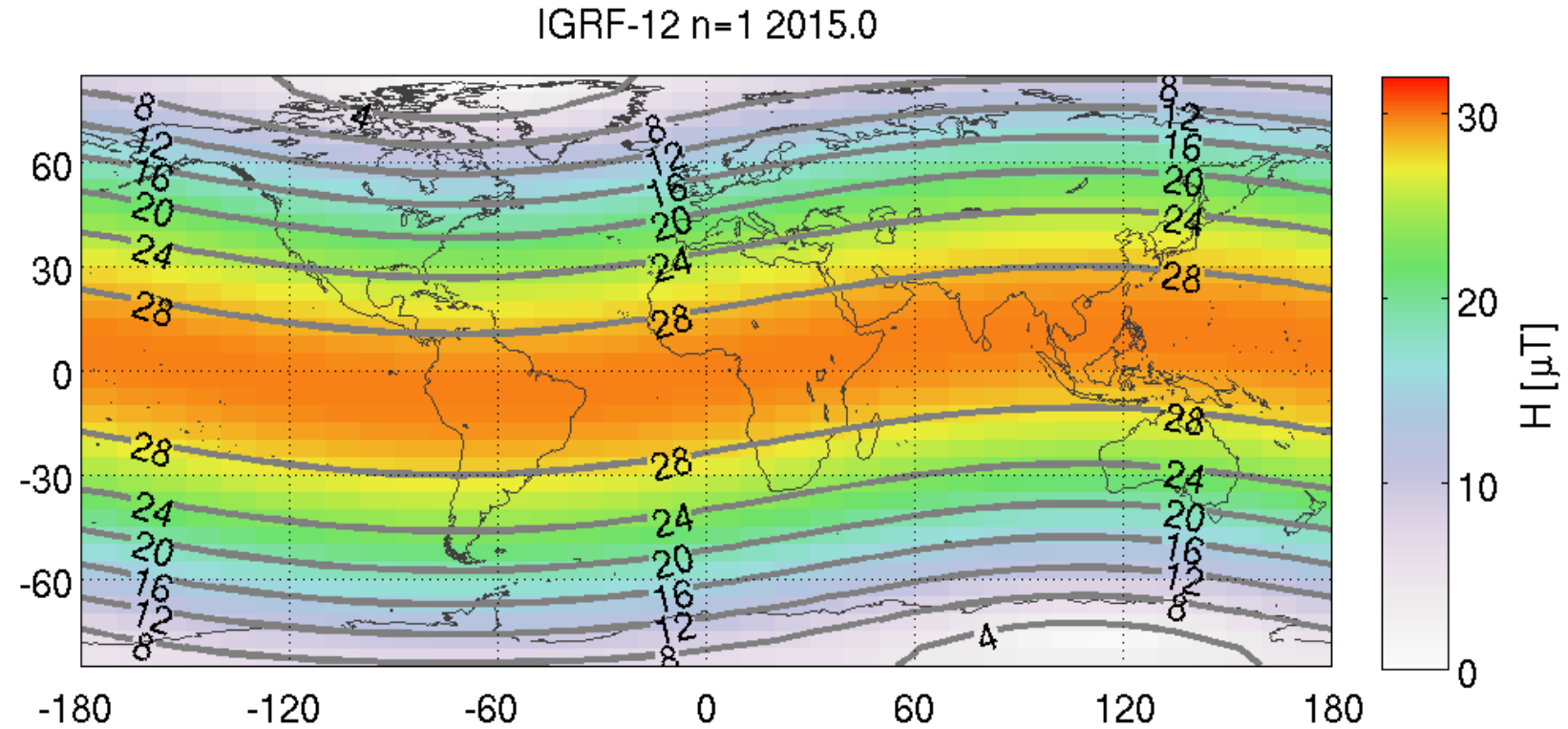

IGRF-12 n=1 2015.0
70°
65°
60°
20°
30°
-26
-24
-24
-22
-22
-20
-20
-18
-18
-16
-18
-20
-22
-24
-26
-28
D [°]

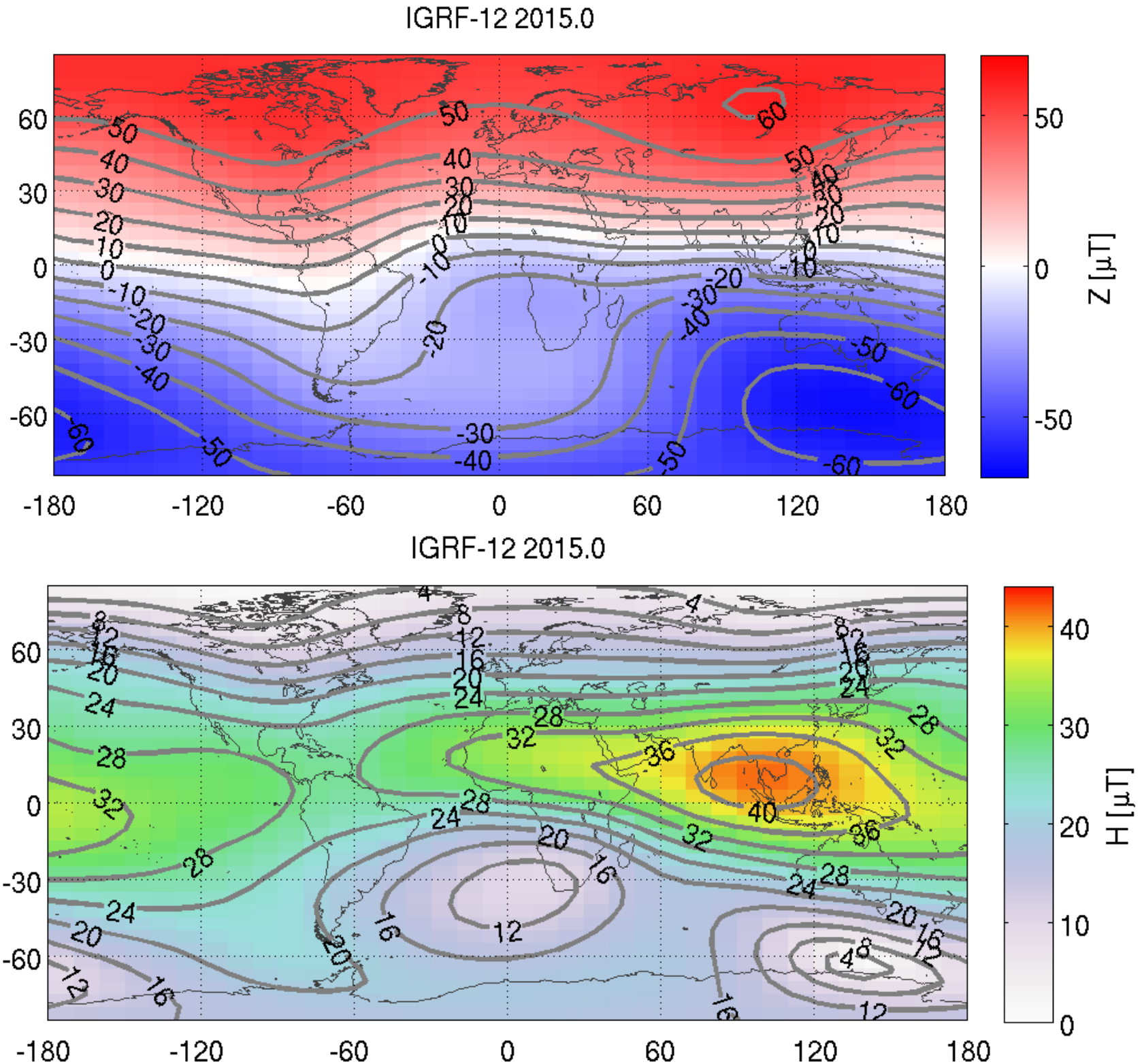

IGRF-12 2015.0
70°
65°
60°
20°
30°
10
12
14
8
10
12
8
16
15
14
13
12
11
10
9
8
7
6
D [°]

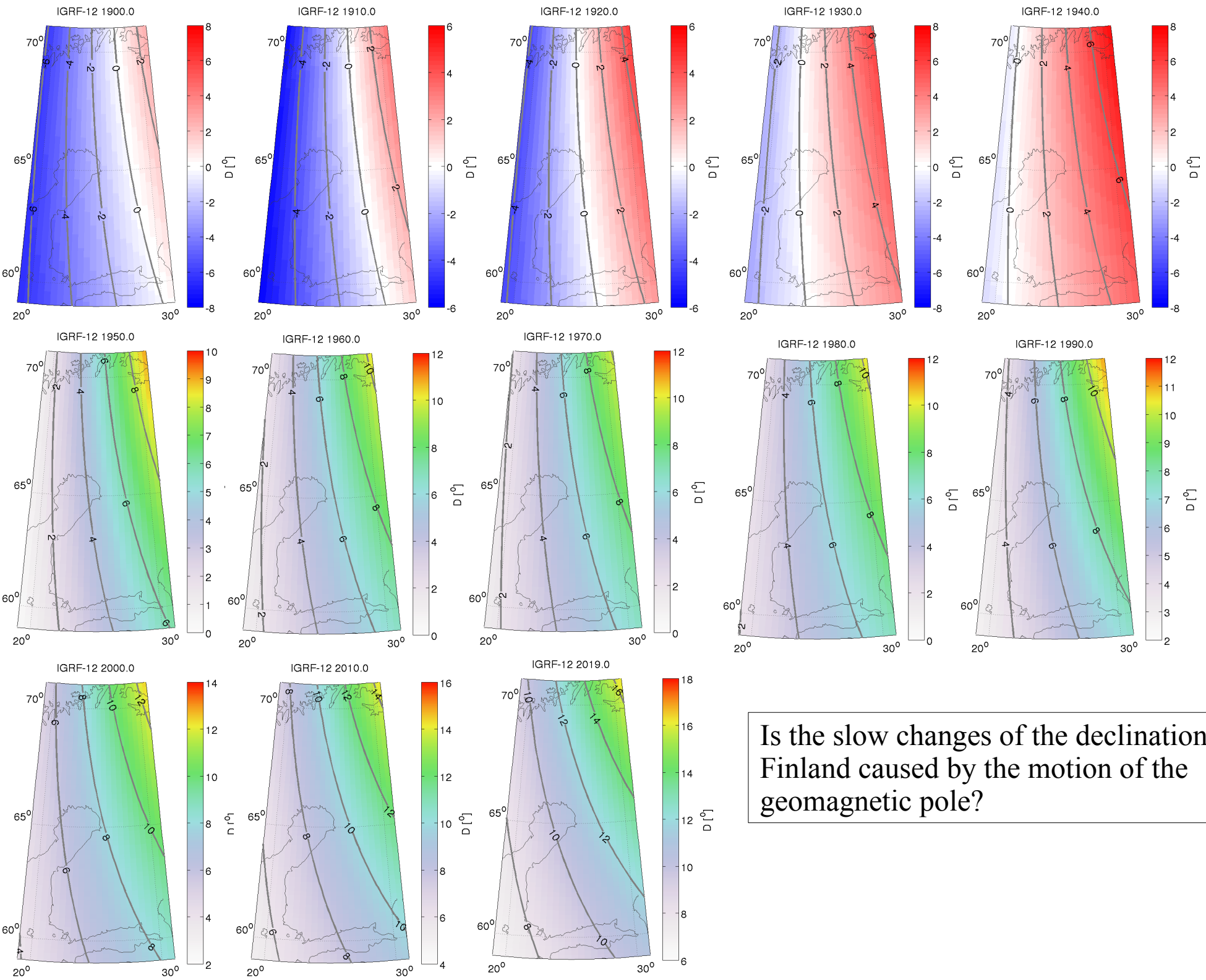

IGRF-12 n>1 2015.0
70°
65°
60°
20°
30°
90
93
96
93
96
96
102
100
98
96
94
92
90
88
D [°]


IGRF-12 n>1 2015.0
Center of a large-scale current vortex: $\boldsymbol{H}_{anomalous}$ points towards it.
Z [μT]
10
0
-10
-20
60
30
0
-30
-60
-180
-120
-60
0
60
120
180
IGRF-12 n>1 2015.0
H [μT]
15
10
5
0

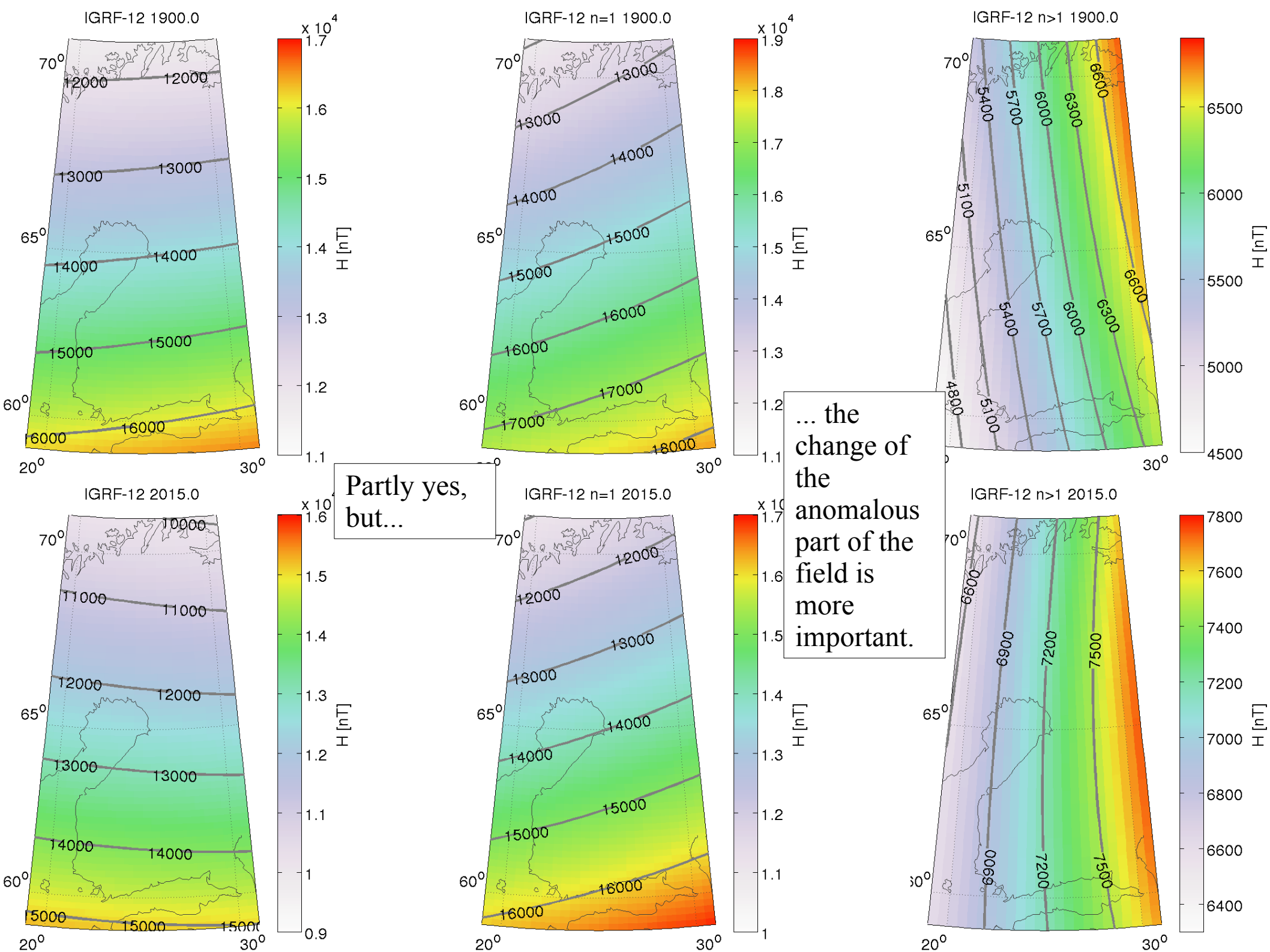

IGRF-12 n=1 2015.0
60
30
0
-30
-60
-180
-120
-60
0
60
120
180
50
40
30
20
10
0
-10
-20
-30
-40
-50
60
40
20
0
-20
-40
-60
Z [μT]


IGRF-12 n=1 2015.0
60
30
0
-30
-60
-180
-120
-60
0
60
120
180
4
8
12
16
20
24
28
30
20
10
0
H [μT]


IGRF-12 2015.0
Z [μT]
50
0
-50
60
30
0
-30
-60
-180
-120
-60
0
60
120
180
IGRF-12 2015.0
H [μT]
40
30
20
10
0



Is the slow changes of the declination in Finland caused by the motion of the geomagnetic pole?


IGRF-12 1900.0
IGRF-12 n=1 1900.0
IGRF-12 n>1 1900.0
IGRF-12 2015.0
IGRF-12 n=1 2015.0
IGRF-12 n>1 2015.0
H [nT]
x 10^4
70°
65°
60°
20°
30°
Partly yes, but...
... the change of the anomalous part of the field is more important.