```
(* This is an example of a world magnetic map using
   coefficients from NOAA.  The particular coefficients used here
   are from an older list of coefficients.  Updates can be found at
   http://www.ngdc.noaa.gov/geomag/WMM/data/WMM2010/WMM2010_Report.pdf or
   https://www.ngdc.noaa.gov/geomag/WMM/data/WMM2010/WMM2010_Report.pdf  The
  representation in the map shown below is for the Total Field and all the
  expressions for other representations (i.e., declination, etc) are given . *)
```

$$\text{legendrep}[\text{n\_}, \text{m\_}, \text{x\_}] := \text{Which}\left[m == 0, 1, m > 0, \sqrt{2}\right] * \sqrt{\frac{(n-m)\,!}{(n+m)\,!}} * \text{LegendreP}[n, m, x]$$

$$v = a\,\text{Sum}\left[\left(\frac{a}{r}\right)^{n+1}\left(\overset{m}{\underset{n}{g}}\,\text{Cos}[m\,\lambda_e] + \overset{m}{\underset{n}{h}}\,\text{Sin}[m\,\lambda_e]\right)\text{legendrep}[n, m, \text{Cos}[\phi]],\ \{n, 1, 10\},\ \{m, 0, n\}\right];$$

$$\text{north} = \frac{1}{r}\,D[v, \phi];$$

$$\text{east} = \frac{-1}{r\,\text{Sin}[\phi]}\,D[v, \lambda_e];$$

$$\text{down} = D[v, r];$$

$$\text{horizontal} = \sqrt{\text{north}^2 + \text{east}^2}\ ;$$

$$\text{total} = \sqrt{\left(\text{north}^2 + \text{east}^2 + \text{down}^2\right)}\ ;$$

$$\text{graddown} = D[\text{total}, r];$$

$$\text{declination} = \frac{180}{\text{Pi}}\,\text{ArcTan}[\text{north}, \text{east}];$$

$$\text{inclination} = \frac{180}{\text{Pi}}\,\text{ArcTan}[\text{horizontal}, \text{down}];$$

$a = 6371.2 \times 10^3;$

$g_1^0 = -2.9775\ 10^4;\ g_1^1 = -1851;$

$g_2^0 = -2136;\ g_2^1 = 3058;\ g_2^2 = 1639;$

$g_3^0 = 1315;\ g_3^1 = -2240;\ g_3^2 = 1246;\ g_3^3 = 807;$

$g_4^0 = 939;\ g_4^1 = 782;\ g_4^2 = 324;\ g_4^3 = -423;\ g_4^4 = 142;$

$g_5^0 = -211;\ g_5^1 = 353;\ g_5^2 = 244;\ g_5^3 = -111;\ g_5^4 = -166;\ g_5^5 = -37;$

$g_6^0 = 61;\ g_6^1 = 64;\ g_6^2 = 60;\ g_6^3 = -178;\ g_6^4 = 2;\ g_6^5 = 17;\ g_6^6 = -96;$

$g_7^0 = 77;\ g_7^1 = -64;\ g_7^2 = 4;\ g_7^3 = 28;\ g_7^4 = 1;\ g_7^5 = 6;\ g_7^6 = 10;\ g_7^7 = 0;$

$g_8^0 = 22;\ g_8^1 = 5;\ g_8^2 = -1;\ g_8^3 = -11;\ g_8^4 = -12;\ g_8^5 = 4;\ g_8^6 = 4;\ g_8^7 = 3;\ g_8^8 = -6;$

$g_9^0 = 4;\ g_9^1 = 10;\ g_9^2 = 1;\ g_9^3 = -12;\ g_9^4 = 9;\ g_9^5 = -4;\ g_9^6 = -1;\ g_9^7 = 7;\ g_9^8 = 2;\ g_9^9 = -6;$

$g_{10}^0 = -4;\ g_{10}^1 = -4;\ g_{10}^2 = 2;\ g_{10}^3 = -5;\ g_{10}^4 = -2;\ g_{10}^5 = 4;\ g_{10}^6 = 3;\ g_{10}^7 = 1;\ g_{10}^8 = 2;\ g_{10}^9 = 3;\ g_{10}^{10} = 0;$

$h_1^0 = 0;\ h_1^1 = 5411;$

$h_2^0 = 0;\ h_2^1 = -2278;\ h_2^2 = -380;$

$h_3^0 = 0;\ h_3^1 = -287;\ h_3^2 = 293;\ h_3^3 = -348;$

$h_4^0 = 0;\ h_4^1 = 248;\ h_4^2 = -240;\ h_4^3 = 87;\ h_4^4 = -299;$

$h_5^0 = 0;\ h_5^1 = 47;\ h_5^2 = 153;\ h_5^3 = -154;\ h_5^4 = -69;\ h_5^5 = 98;$

$h_6^0 = 0;\ h_6^1 = -16;\ h_6^2 = 83;\ h_6^3 = 68;\ h_6^4 = -52;\ h_6^5 = 2;\ h_6^6 = 27;$

$h_7^0 = 0;\ h_7^1 = -81;\ h_7^2 = -27;\ h_7^3 = 1;\ h_7^4 = 20;\ h_7^5 = 16;\ h_7^6 = -23;\ h_7^7 = -5;$

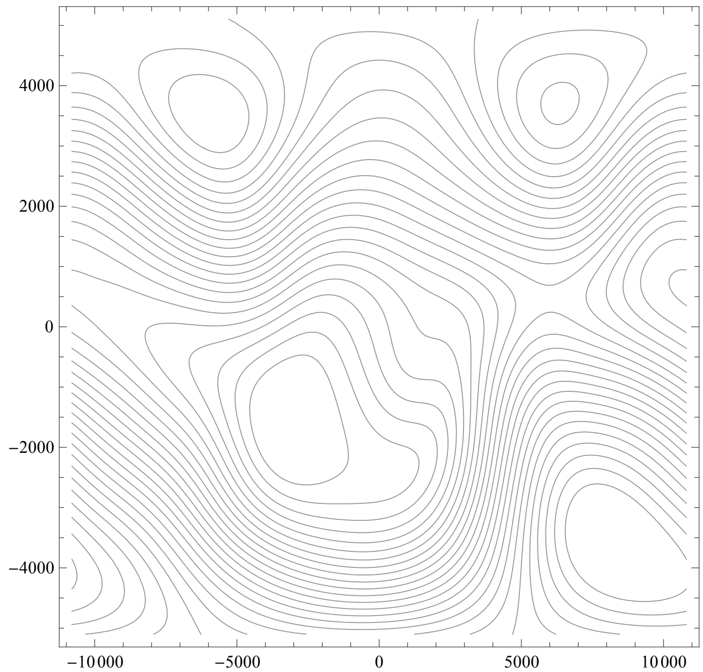
$h_8^0 = 0;\ h_8^1 = 10;\ h_8^2 = -20;\ h_8^3 = 7;\ h_8^4 = -22;\ h_8^5 = 12;\ h_8^6 = 11;\ h_8^7 = -16;\ h_8^8 = -11;$

$h_9^0 = 0;\ h_9^1 = -21;\ h_9^2 = 15;\ h_9^3 = 10;\ h_9^4 = -6;\ h_9^5 = -6;\ h_9^6 = 9;\ h_9^7 = 9;\ h_9^8 = -7;\ h_9^9 = 2;$

$h_{10}^0 = 0;\ h_{10}^1 = 1;\ h_{10}^2 = 0;\ h_{10}^3 = 3;\ h_{10}^4 = 6;\ h_{10}^5 = -4;\ h_{10}^6 = 0;\ h_{10}^7 = -1;\ h_{10}^8 = 4;\ h_{10}^9 = 0;\ h_{10}^{10} = -6;$

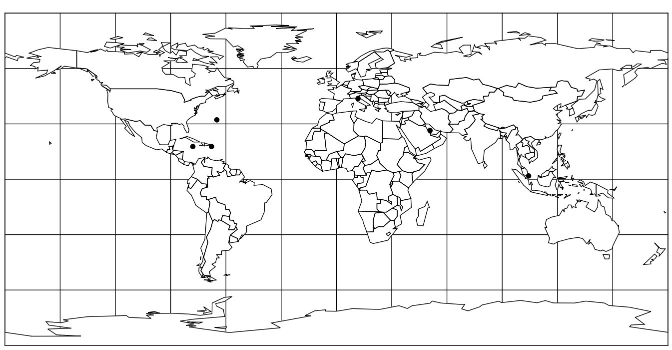
$$r = a + 1000;\ \phi = -\left(90 + \frac{\text{latitude}}{60}\right)\frac{\text{Pi}}{180} + \text{Pi};\ \lambda_e = \frac{\text{longitude}}{60}\ \frac{\text{Pi}}{180} + \text{Pi};$$

```
tfcon = ContourPlot[total, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```

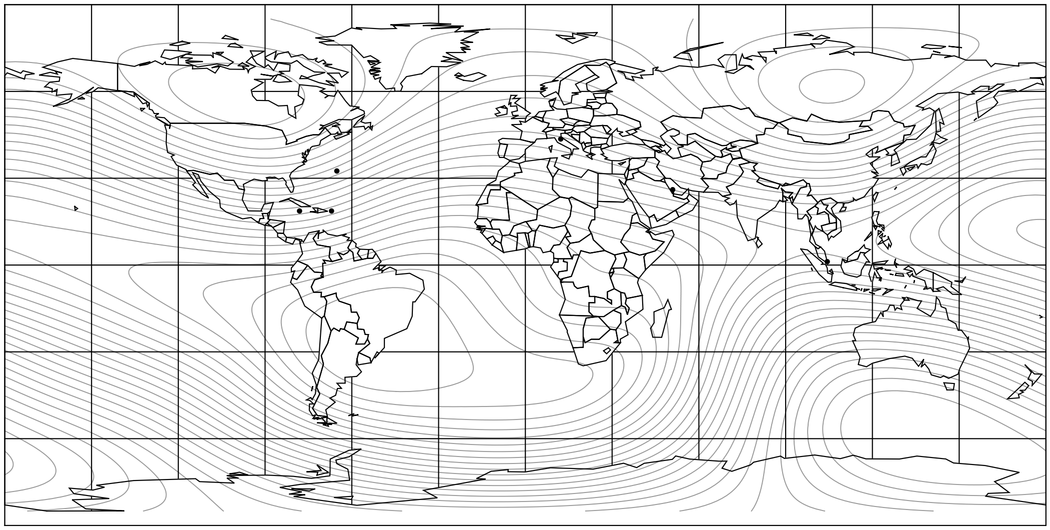



```
<< WorldPlot`
```

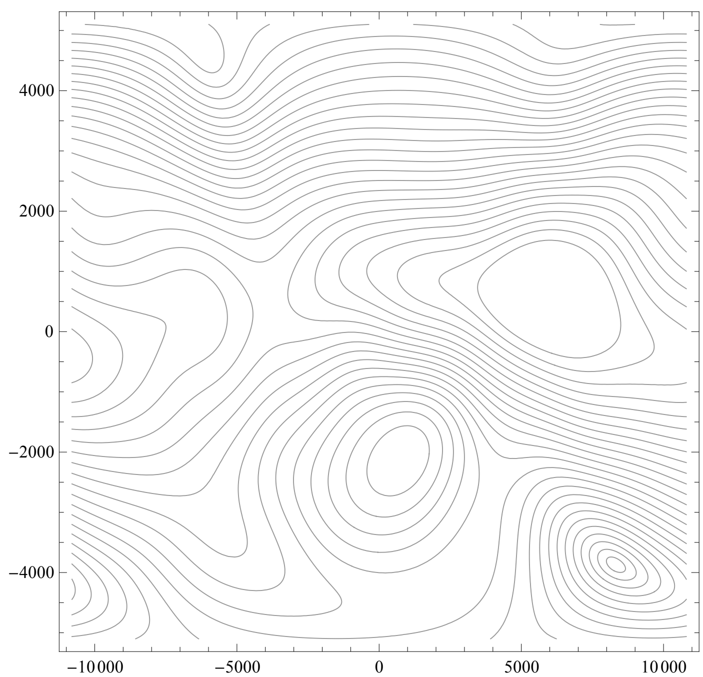
```
world = Graphics[WorldPlot[World]]
```



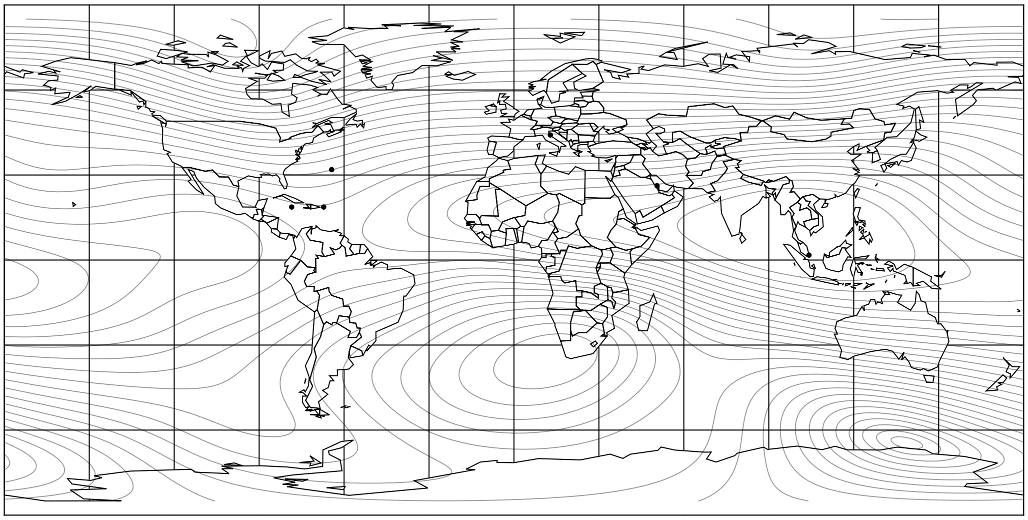
```
Show[world, tfcon] (* Total Field Countour Plot on World Map*)
```



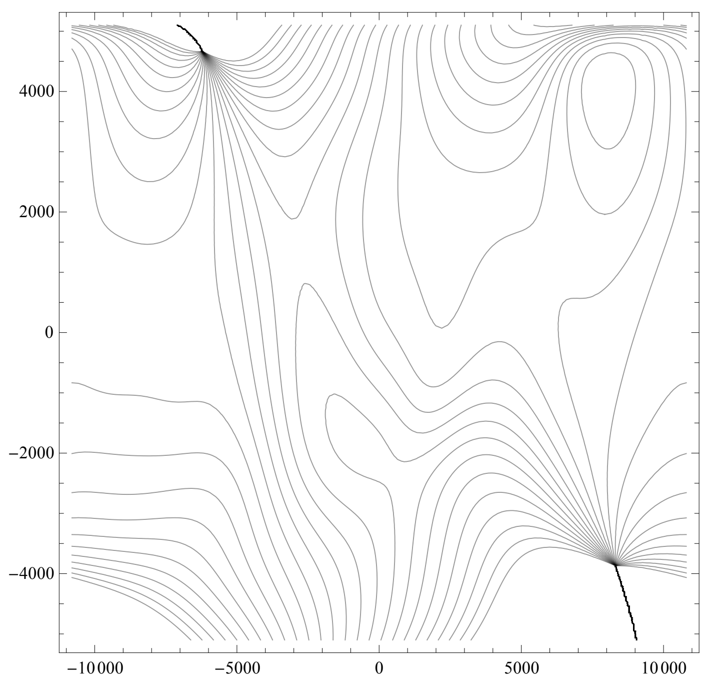
```
horizontalcon = ContourPlot[horizontal, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```



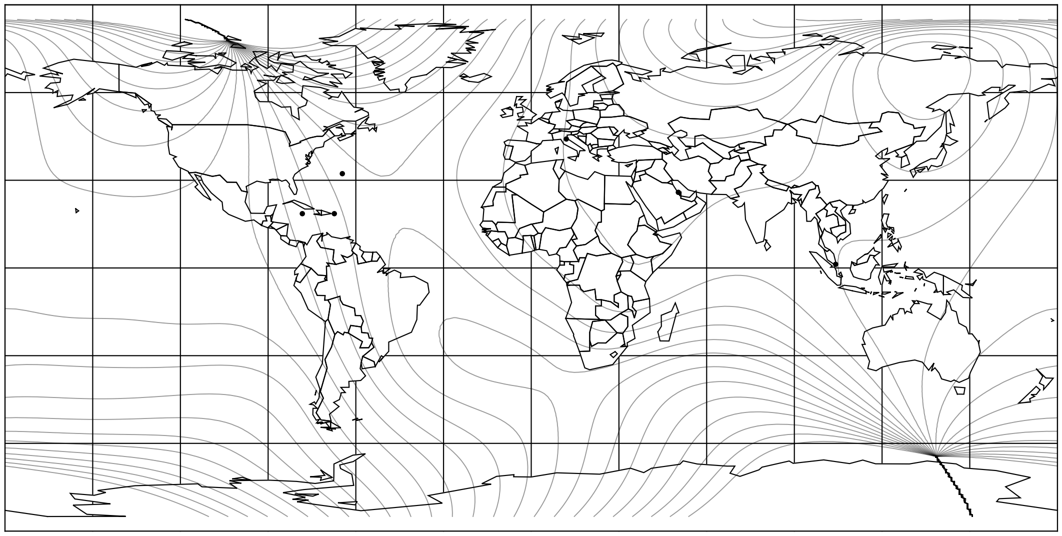
```
Show[world, horizontalcon]
(* Horizontal Component of Total Field Countour Plot on World Map*)
```



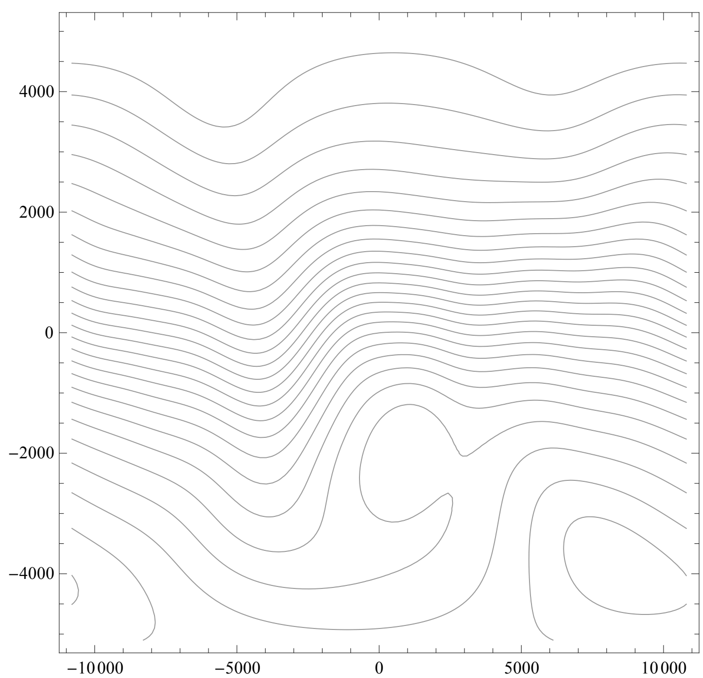
```
declinationcon = ContourPlot[declination, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```



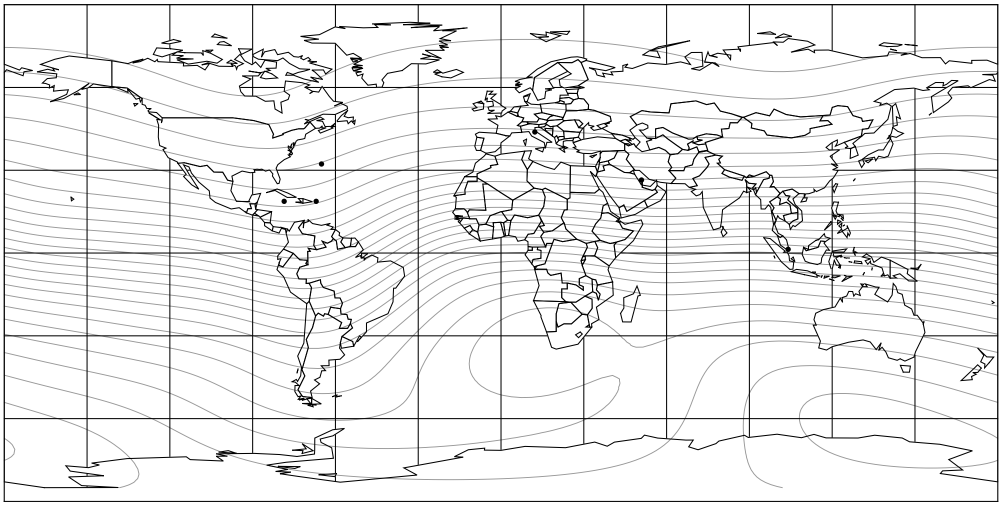
```
Show[world, declinationcon] (* Declination  Countour Plot on World Map*)
```



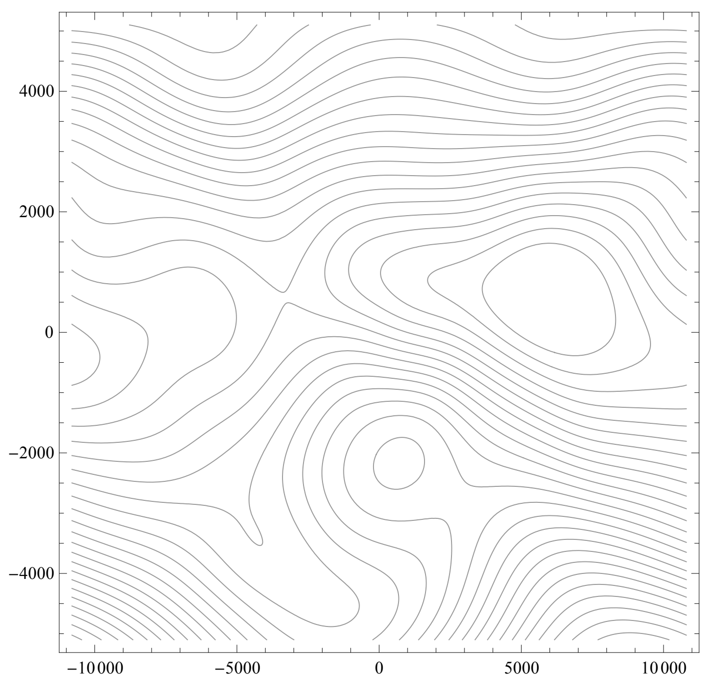
```
inclinationcon = ContourPlot[inclination, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```



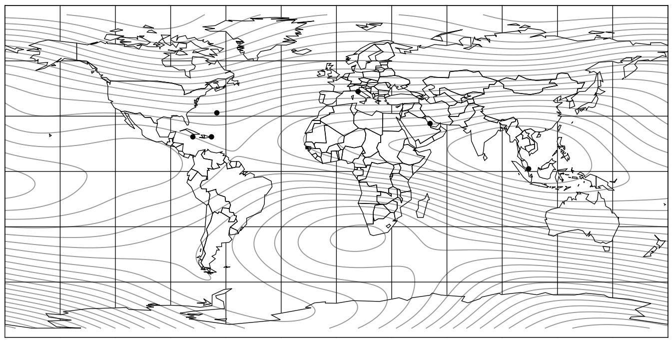
```
Show[world, inclinationcon] (* Inclination  Countour Plot on World Map*)
```



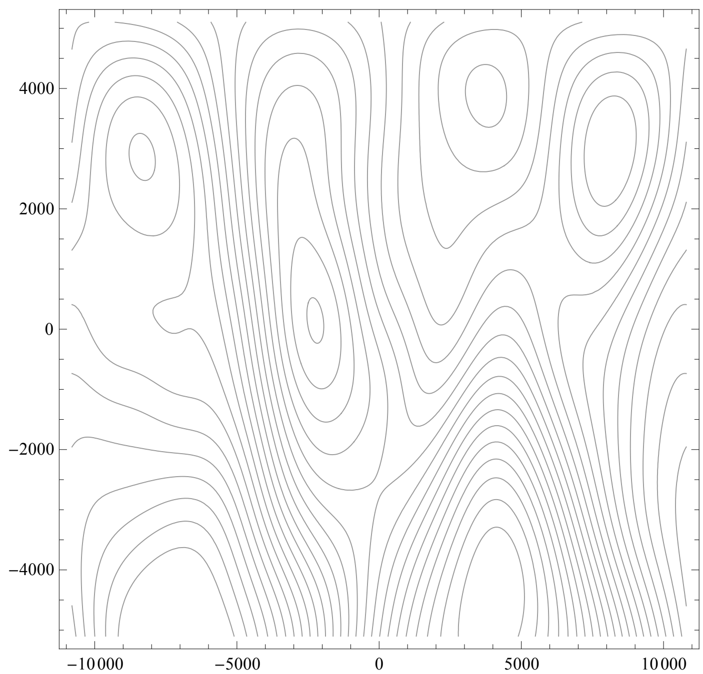
```
northcon = ContourPlot[north, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```



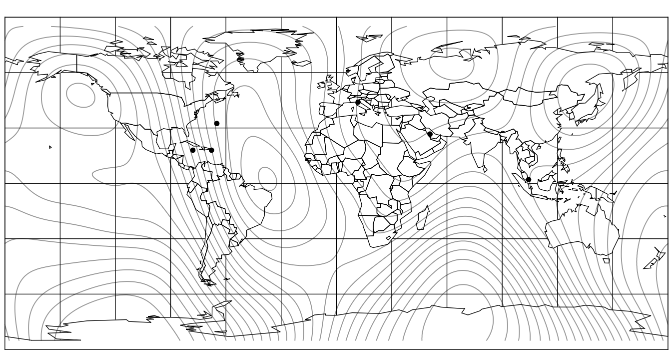
```
Show[world, northcon] (* North Component Countour Plot on World Map*)
```



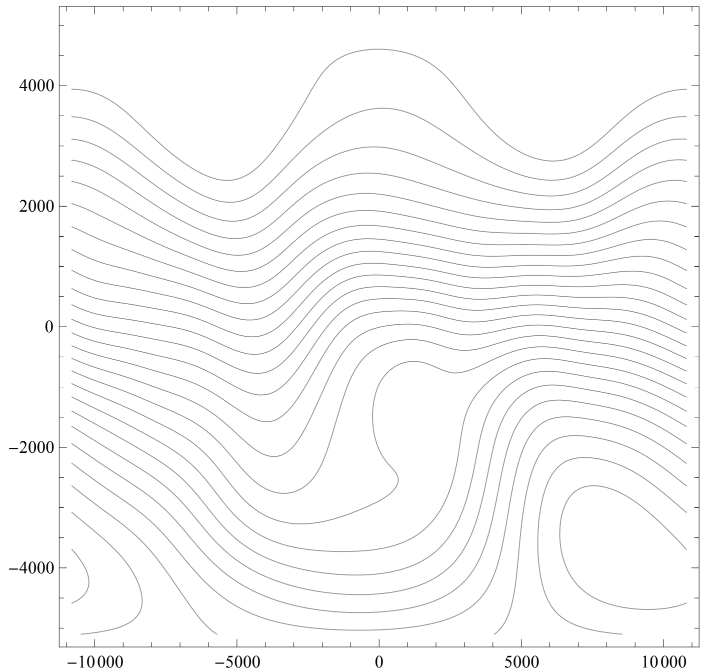
```
eastcon = ContourPlot[east, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```



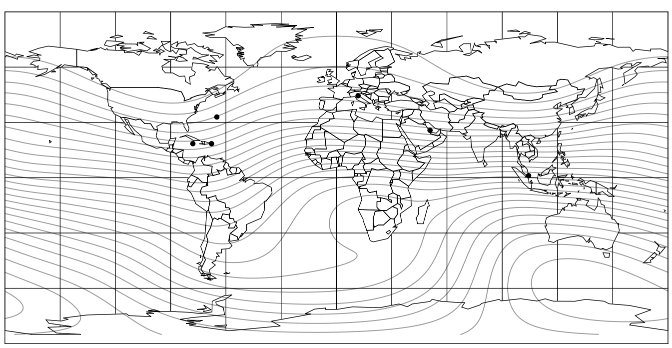

```
Show[world, eastcon] (* East Component Countour Plot on World Map*)
```



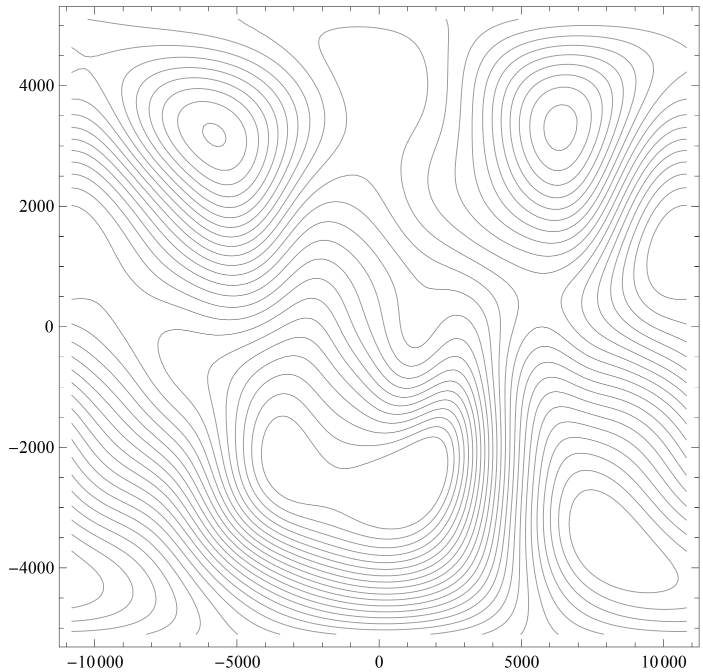
```
downcon = ContourPlot[down, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```




```
Show[world, downcon] (* Down Component Countour Plot on World Map*)
```



```
graddowncon = ContourPlot[graddown, {longitude, -180 * 60, 180 * 60},
  {latitude, -85 * 60, 85 * 60}, Contours → 25, PlotPoints → 50, ContourShading → None]
```




```
Show[world, graddowncon]
(* Gradient Downward Component of Total Field Countour Plot on World Map*)
```