A Background noise

Table 13 Overview of maritime systems

System	Freq. band [MHz]
GMDSS	0,49 / 0,518 / 2,1875 / 4,2095 / 6,215 / 8,25 / 12,290 / 16,420 / 18,795 / 22,060 / 25,097
VDES (= VDE, AIS, ASM)[40]	156 – 164
VHF radio	156 - 164
C2000	380 – 400
IMT2020	800, 900, 1500, 1800, 2100, 2600, 3500
GNSS[41]	Various links between 1164 and 1616
RADAR	3000 & 10000

Determining the background noise for the wireless communication and navigation tools of Rijkswaterstaat.

The background noise is determined by natural noise sources, such as the universe, the atmosphere and the earth, but also by the presence of electronic equipment and electrical machines.

The human influence ("man made noise") is divided into five categories (the English terms are used to refer to the ITU recommendations)[42]:

a. City
b. Residential
c. Rural
d. Quiet rural
e. Galactic

The lowest noise is found in remote (rural) areas where there are hardly any (switching) electronics. These kinds of conditions are almost impossible to find in the Netherlands, not even on the water, because a ship is also full of various types of electronics. It is therefore logical to start from a "rural" environment (Figure 43, curve C) when determining the lower limit of the ambient noise.

[40] Technical characteristics for a VHF data exchange system in the VHF maritime mobile band (itu.int)
[41] Global positioning system - Wikipedia
[42] Recommendation ITU-R P.372-15, Radio noise

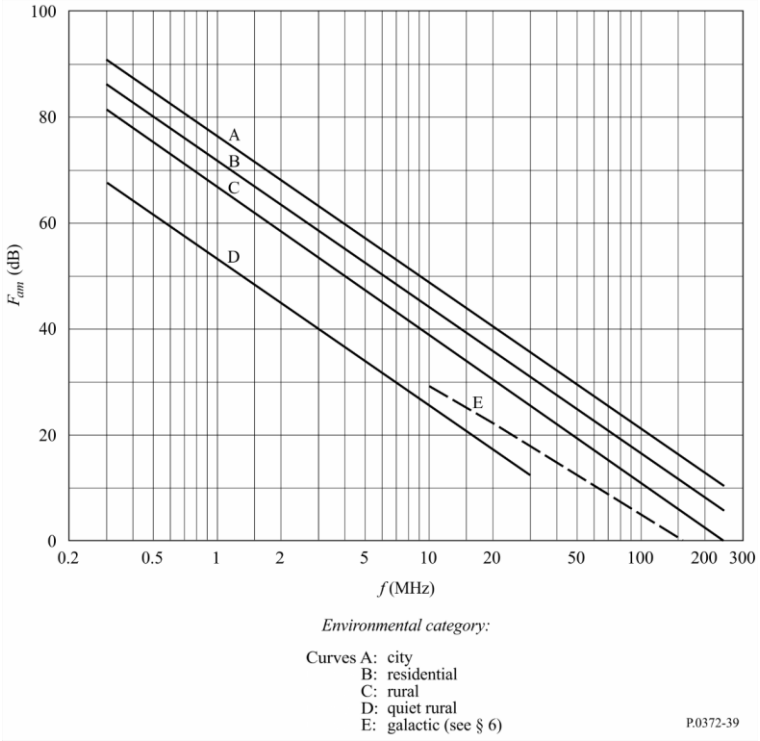


Figure 43 "Man-made" ambient noise levels between 200 kHz and 300 MHz.

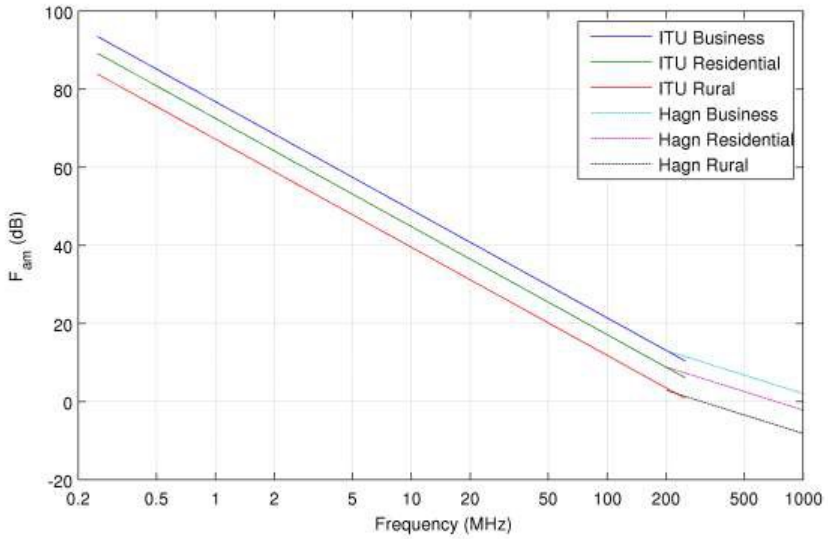


Figure 44 Ambient noise between 0.2 and 1 GHz with expansion according to Hagn[43].

A frequency extension of the influence of human noise to 1000 MHz is shown in Figure 44. From 1000 MHz, the common man-made noise becomes so weak that

[43] NTIA Technical Report TR-11-478, Wideband Man-Made Radio Noise, Measurements in the VHF and Low UHF Bands, Jeffery A. Wepman, Geoffrey A. Sanders

other noise sources begin to dominate, such as galactic noise and effects of the warm earth. Figure 45 shows this contribution.

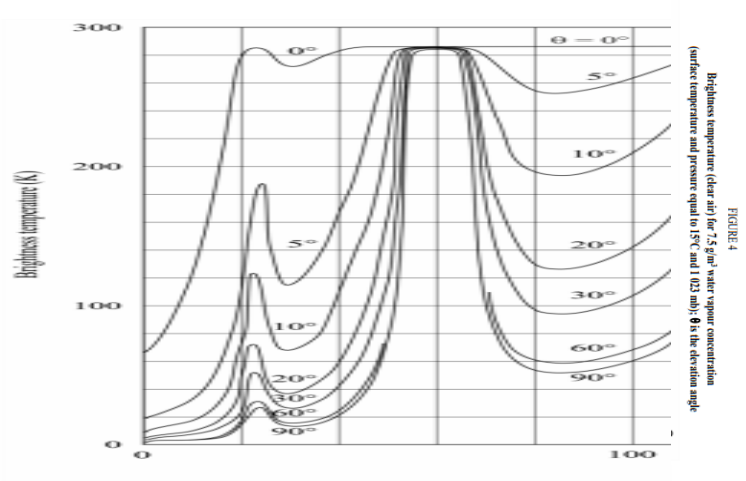


Figure 45 Influence of the earth on the noise temperature at various elevations in relation to the earth's surface[44]

Based on the various noise curves that cover overlapping parts of the frequency spectrum, a curve (Figure 46) for the background noise between 500 kHz and 10 GHz has been compiled for a situation without any man-made noise and a "rural" environment. This curve is used to calculate degradation of environmental noise by PV installations in the report.

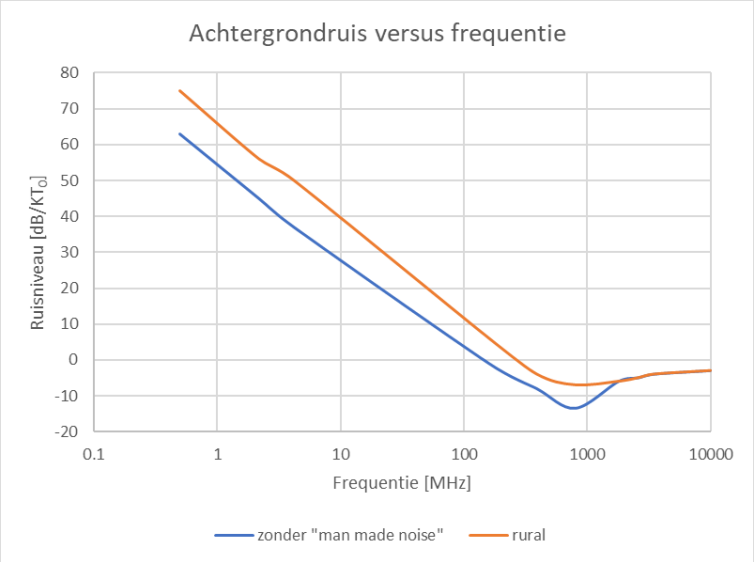


Figure 46 Ambient noise curves for "rural" and an environment without "man-made" noise

B Coverage pictures versus noise increase

Coverage calculations, VHF radio and AIS, according to section 5.1.45.1.4

The contours below have been determined for VHF (left pictures) and AIS (right side) with a constant audio SINAD value of 20 dB (VHF) and PER (AIS).

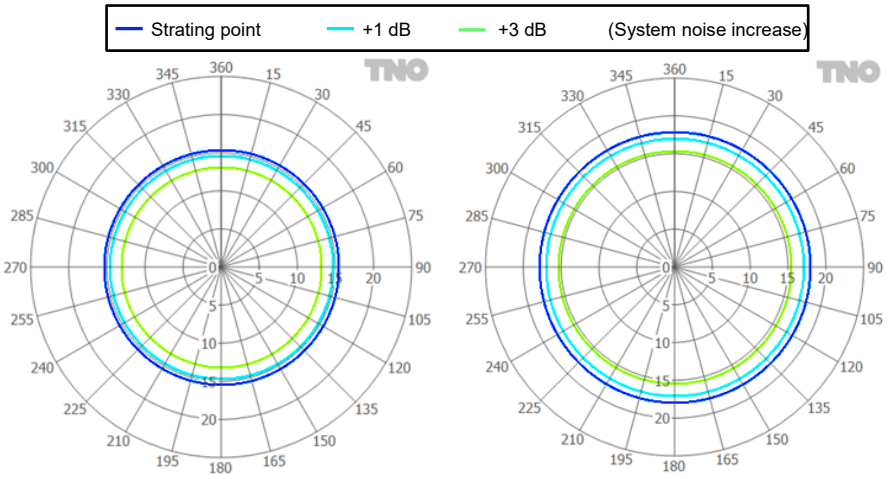


Figure 47 Reduction of the range, if the system increases noise by 1 or 3 dB respectively. Outer circle is the starting situation, the innermost with increased system noise. Ship 1 to bridge/lock. Left VHF radio, right AIS class B, 2 Watt. The x and y axes indicate the distances in kilometers.

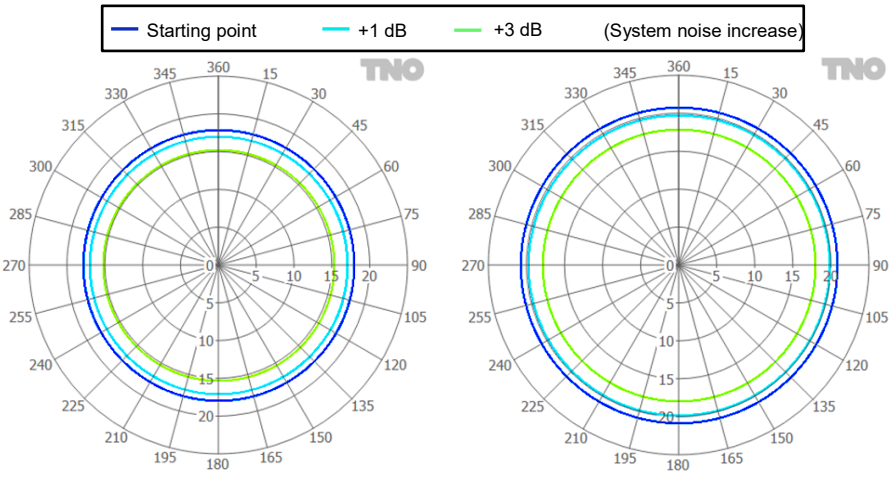


Figure 48 Reduction of the range, if the system increases noise by 1 or 3 dB respectively. Outer circle is the starting situation, the innermost with increased system noise. Ship 2 to bridge/lock. Left VHF radio, right AIS class B. The x and y axes indicate the distances in kilometers.

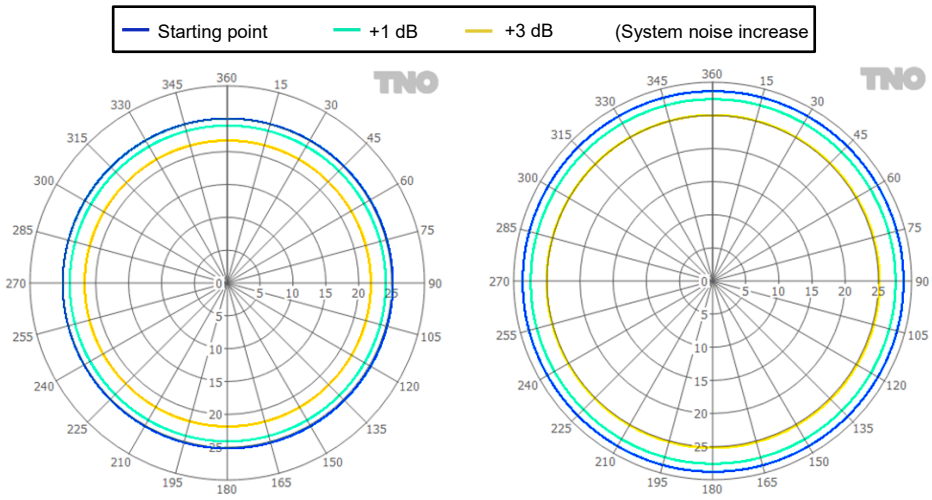


Figure 49 Reduction of the AIS range, if the system increases noise by 1 or 3 dB respectively. Outer circle is the starting situation, the innermost with increased system noise. Left bridge/lock to ship 1, right to ship 2. The x and y axes indicate the distances in kilometers.

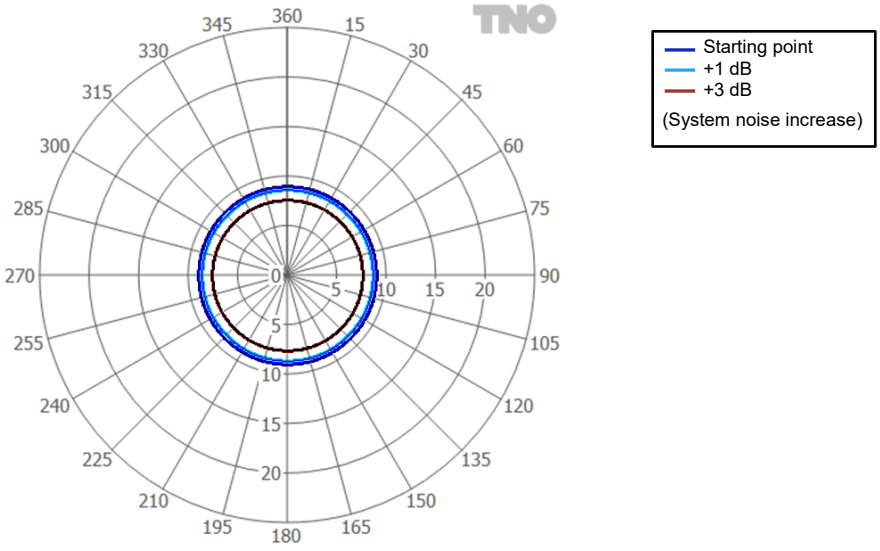


Figure 50 Range of a marginal VHF system: 0.5 W, 3 dB cable loss and -6 dB antenna gain. Outer circle is the starting situation.

Limits required distance to PV installation versus communication system and antenna height.

Installations with an output of less than 20 kVA
In the antenna height variations, no distinction has been made between base stations (or support transmitters, repeaters) and mobile installations. For standard noise field strengths see Table 1.

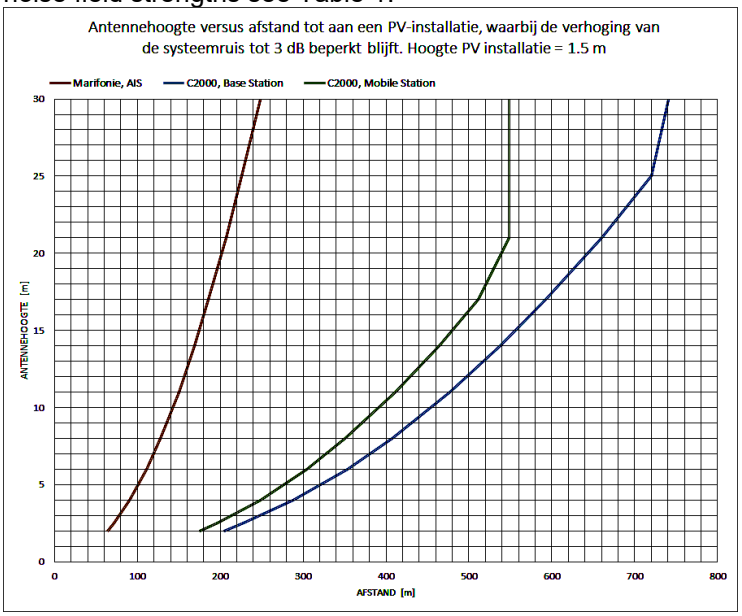


Figure 51 Minimum distance AIS/VHF radio/C2000 to PV installation with installation height of 1.5 m, versus antenna height for 3 dB system noise increase.

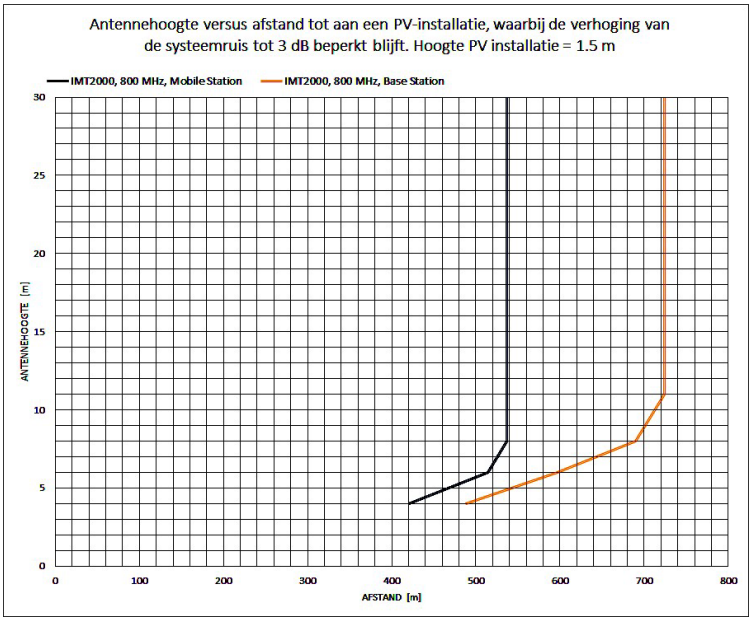


Figure 52 IMT-2020 800 MHz 4G system distance to PV installation with installation height of 1.5 m, versus antenna height for 3 dB system noise increase.

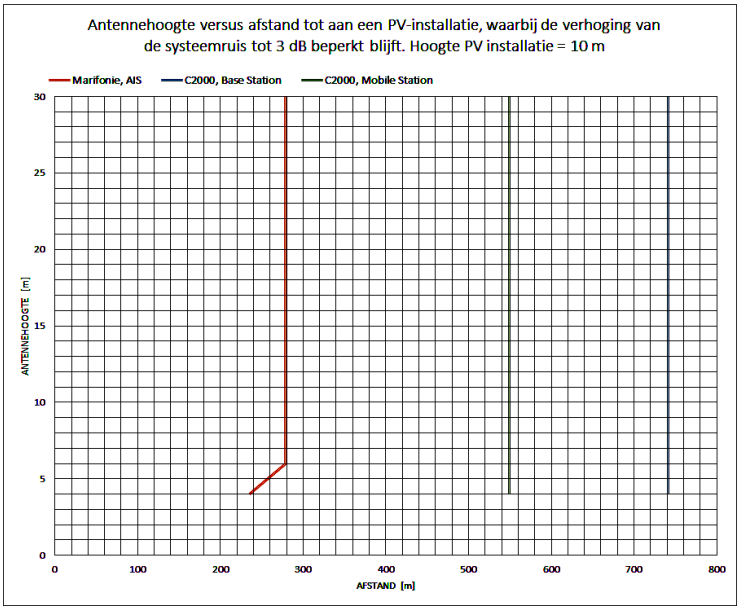


Figure 53 Distance to PV installation with installation height of 10 m, versus antenna height for 3 dB system noise increase.

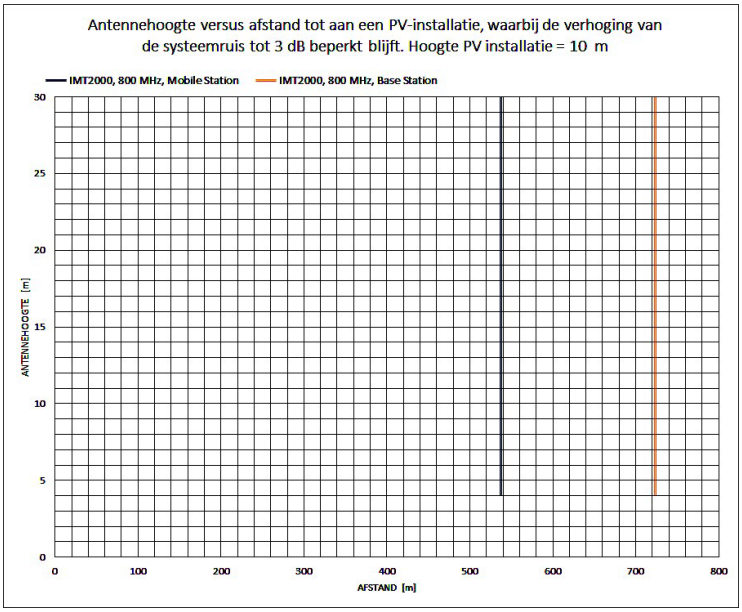


Figure 54 IMT-2020 800 MHz 4G system distance to PV installation with surface-mounted height of 10 m, versus antenna height for 3 dB system noise increase.

Installations larger than 20 kVA

In the antenna height variations, no distinction has been made between base stations (or support transmitters, repeaters) and mobile installations. For standard noise field strengths see Table 1.

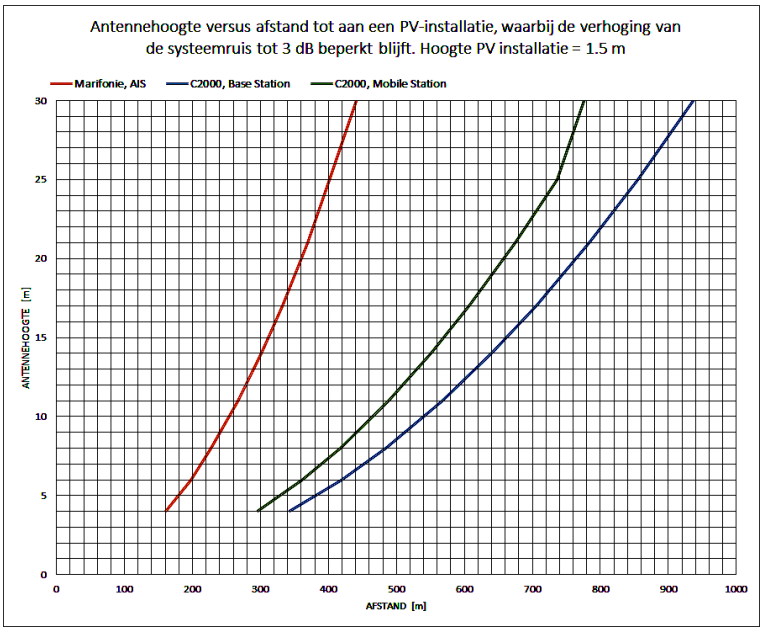


Figure 55 AIS/VHF radio/C2000 distance to PV installation versus antenna height for 3 dB system noise increase. PV-installation installation height is 1.5 m.

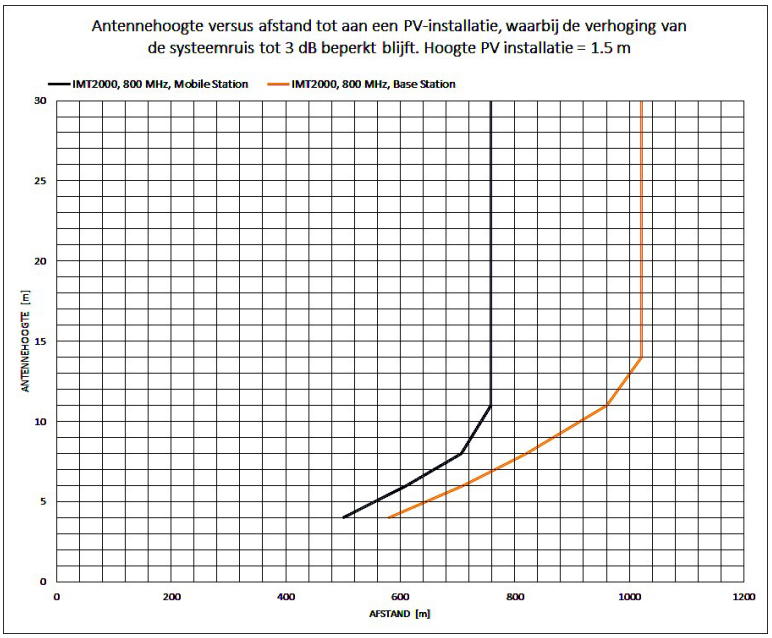


Figure 56 IMT-2020 800 MHz 4G system distance to PV installation versus antenna height for 3 dB system noise increase. PV-installation installation height is 1.5 m.

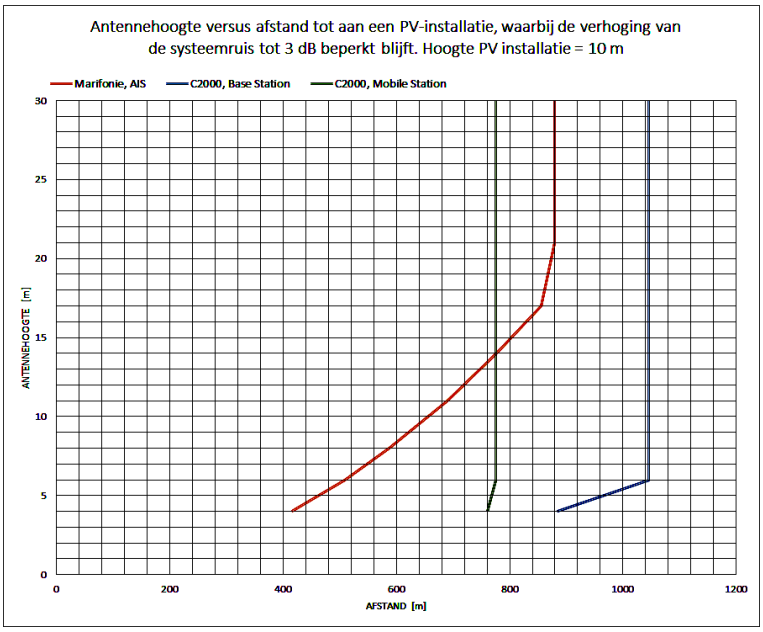


Figure 57 Distance to PV installation versus antenna height for 3 dB system noise increase. PV installation installation height is 1.5 m

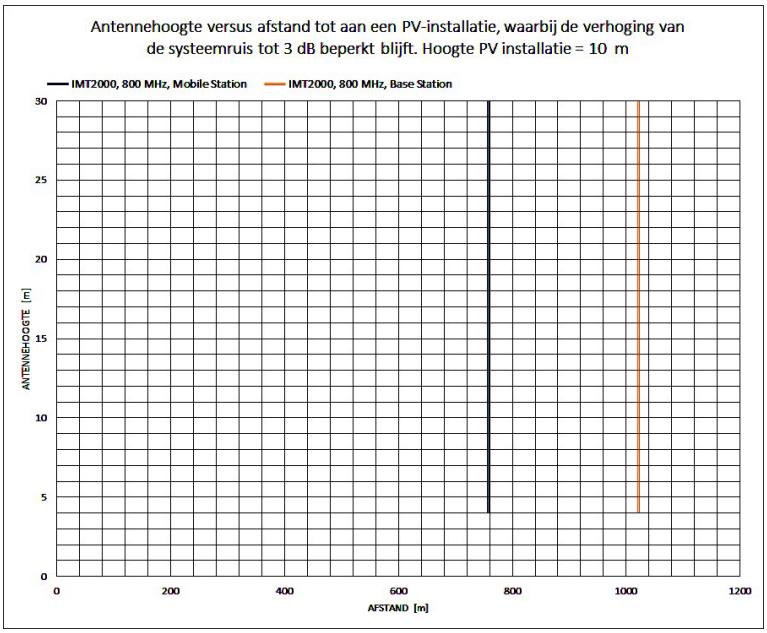


Figure 57 IMT-2020 800 MHz 4G system distance to PV installation versus antenna height for 3 dB system noise increase. PV installation installation height is 10 m

Limits required field strength of PV installation at a given distance, versus communication system and antenna height.

The displayed lower limit distance from a PV installation to a receiving installation is usually greater than 10 meters in the graphs in this appendix because the required field strength values otherwise fall to unrealistically low values (< 10 dB µ V/m).

Limit field strengths generated by a PV system for a system noise increase of 3 dB, PV height is 1.5 m.
In the antenna height variations, no distinction has been made between base stations (or support transmitters, repeaters) and mobile installations. For standard noise field strengths see Table 1.

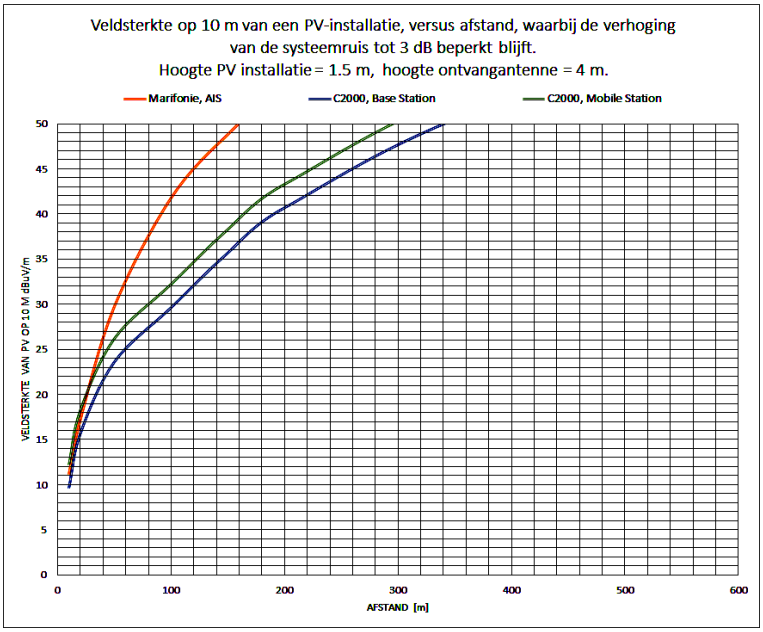


Figure 59 Acceptable EM field strength of the PV installation at 3 dB system noise increase. Height PV system is 1.5 m, height receiving antenna is 4 m.

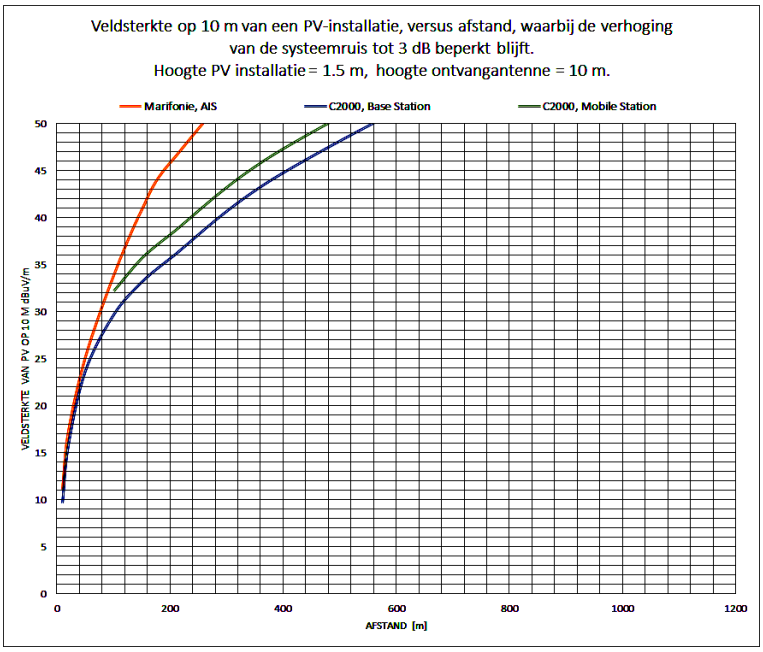


Figure 60 Limit field strength of the PV installation at 3 dB system noise increase. Height PV system is 1.5 m, height receiving antenna is 10 m.

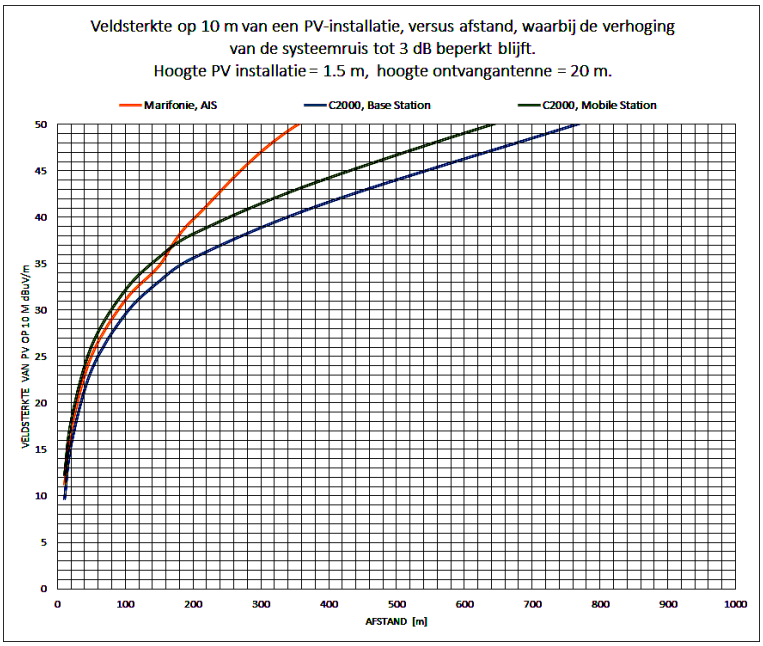


Figure 61 Limit field strength of the PV installation at 3 dB system noise increase. Height PV system is 1.5 m, height receiving antenna is 20 m.

Limit field strengths generated by a PV system for a system noise increase of 3 dB. PV installation height is 10 meters.

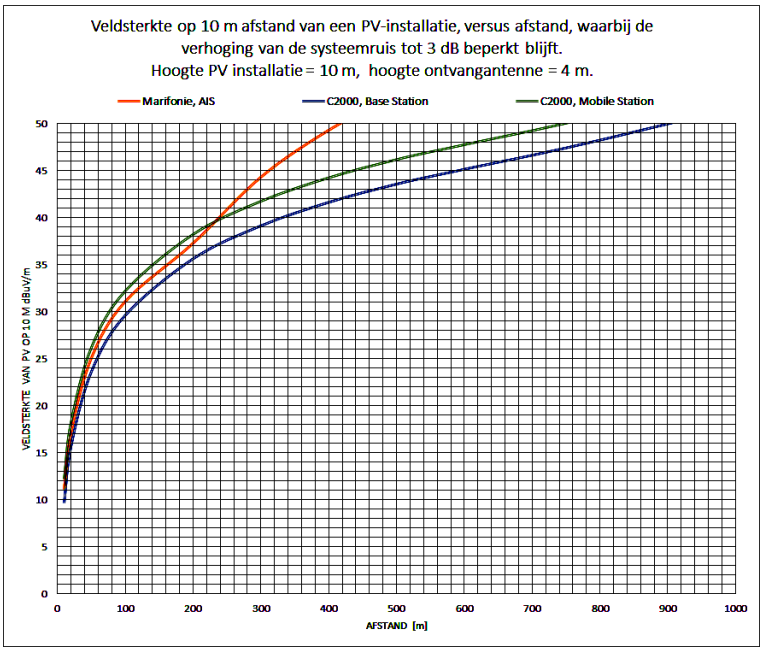


Figure 62 Limit field strength of the PV installation at 3 dB system noise increase. Height PV system is 10 m, height receiving antenna is 4 m.

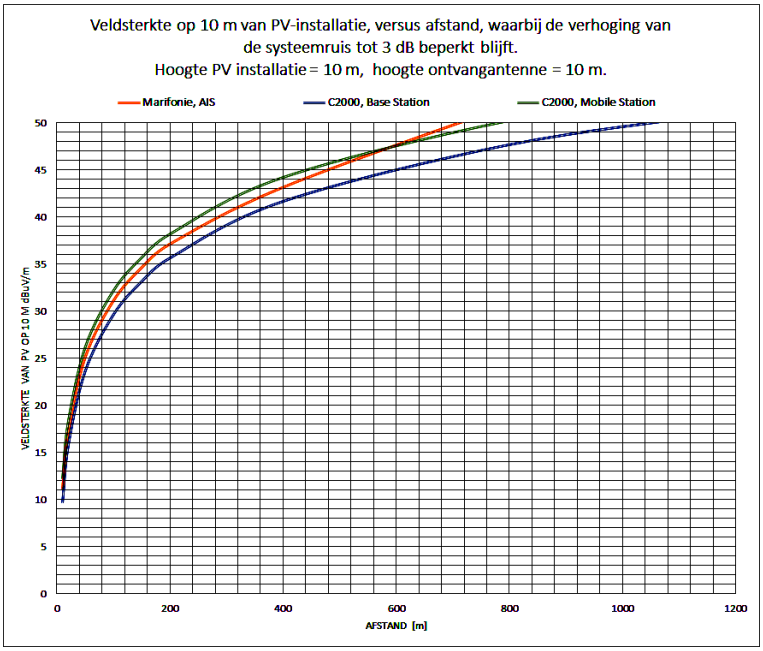


Figure 63 Limit field strength of the PV installation at 3 dB system noise increase. Height PV system is 10 m, height receiving antenna is 10 m.

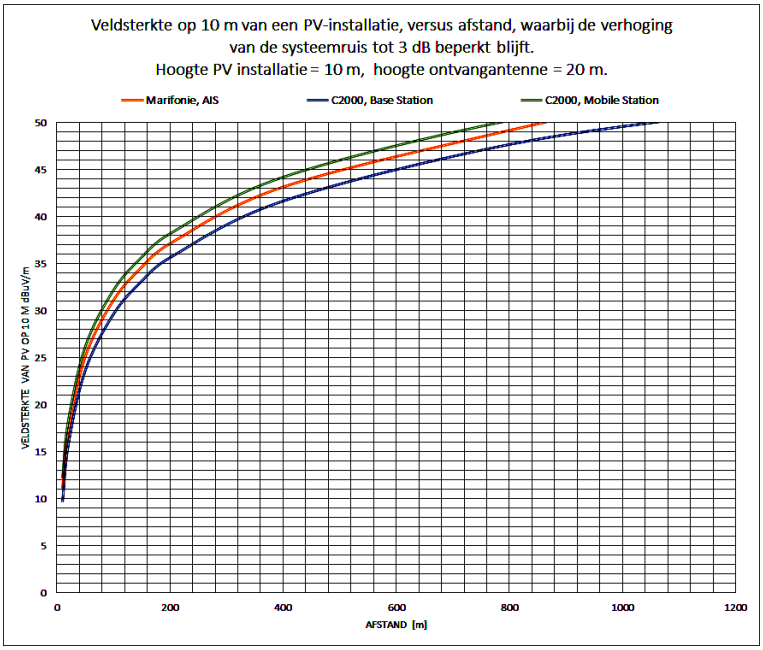
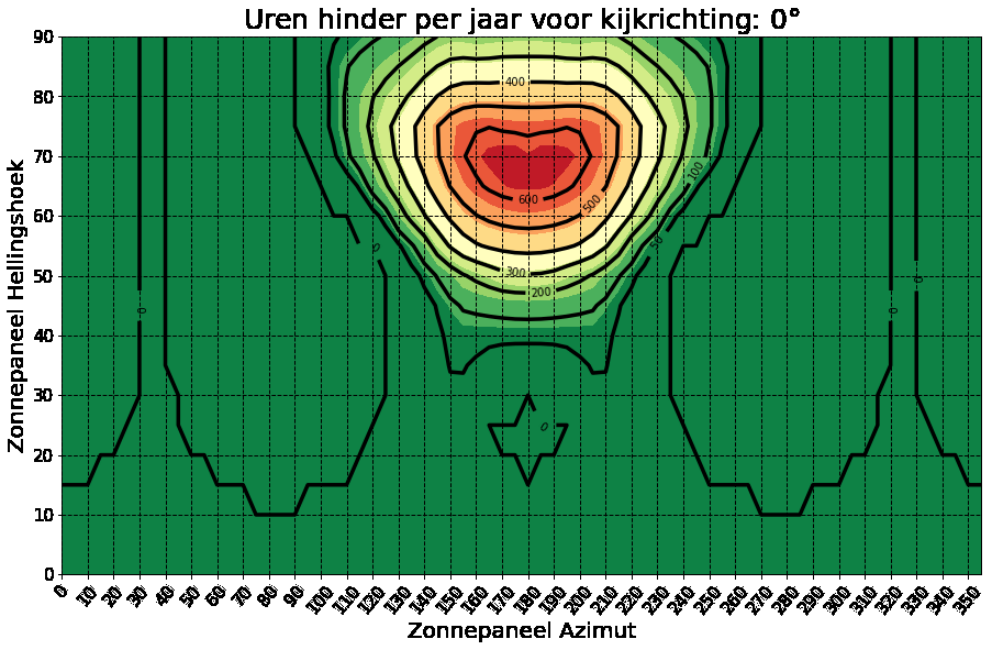


Figure 64 Limit field strength of the PV installation at 3 dB system noise increase. Height PV system is 10 m, height receiving antenna is 20 m.

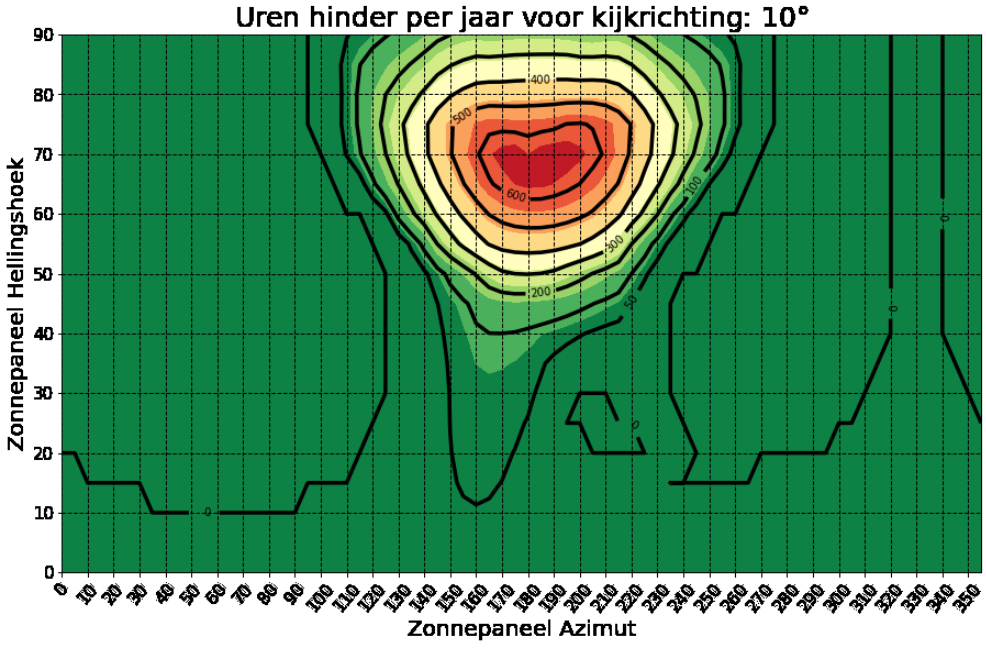
C Visual hindrance per viewing direction

In this appendix you can find all graphs that indicate how much hindrance occurs for each orientation of solar panels. As elaborated in section **Fout! Verwijzingsbron niet gevonden.** , this differs depending on the viewing direction of the observer. In this appendix there is therefore a separate graph for each viewing direction (steps of 10°)..

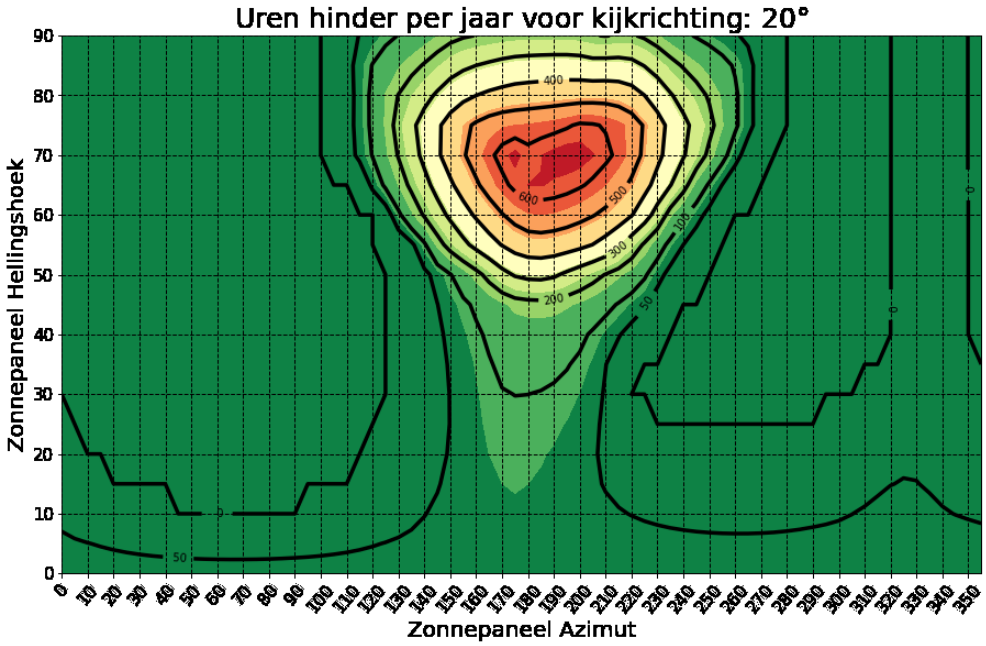
Viewing direction 0° (North)



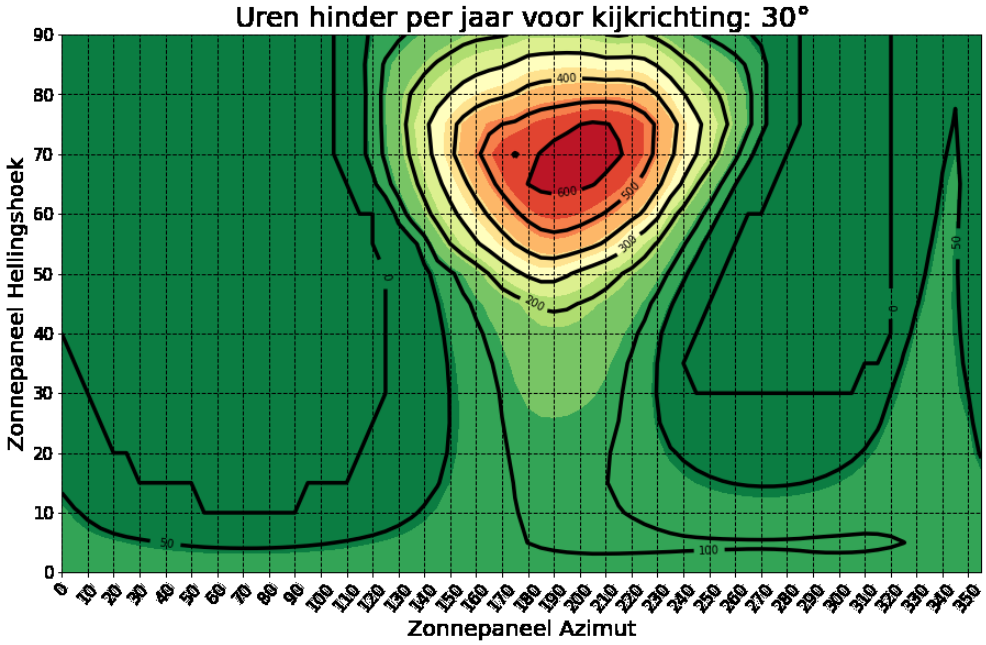
Viewing direction 10°



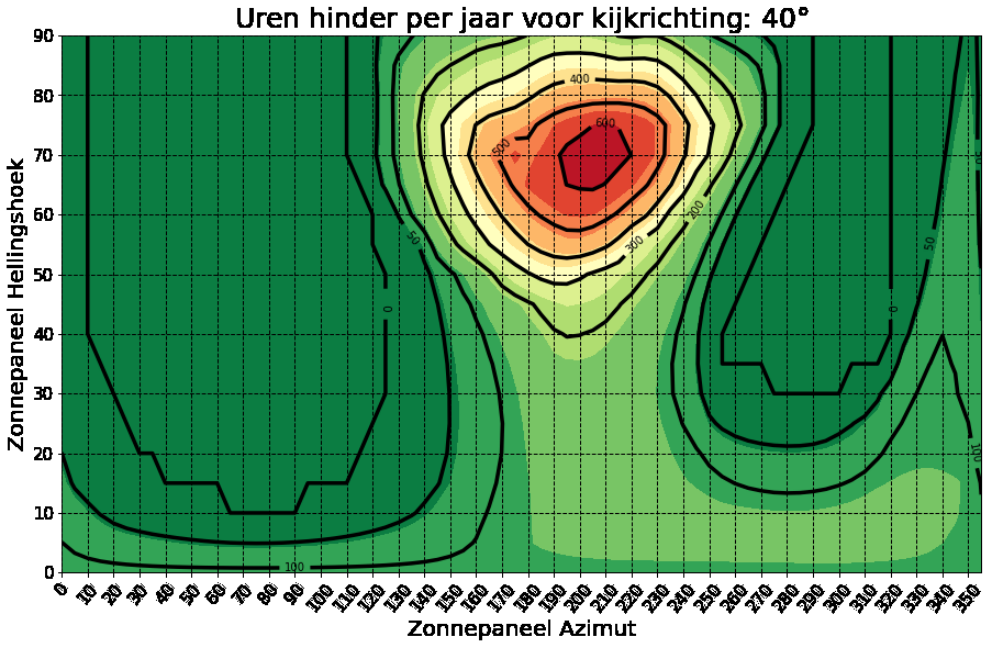
Viewing direction 20°



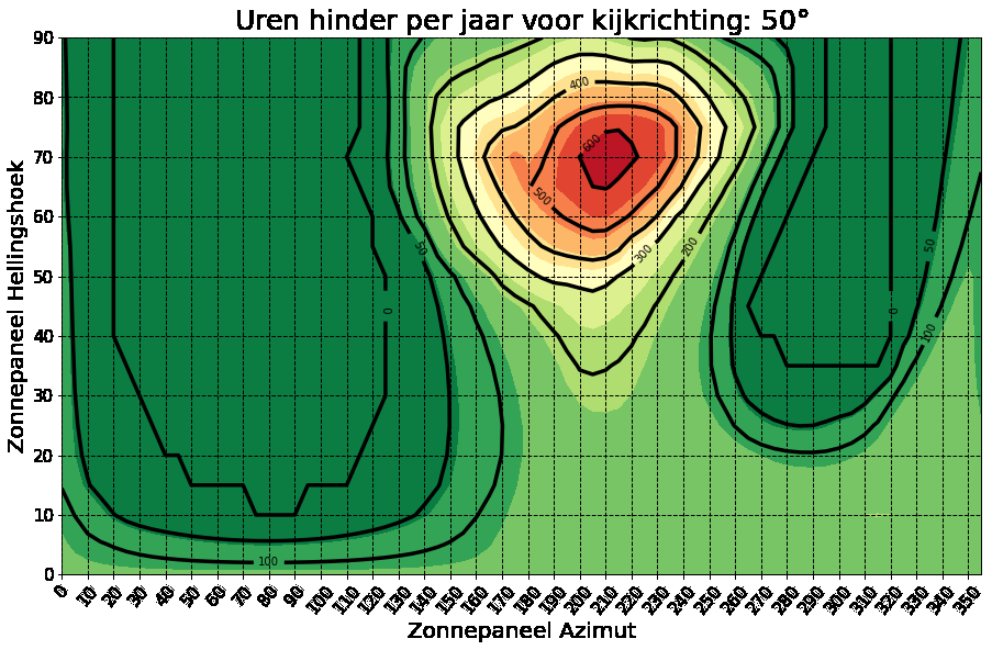
Viewing direction 30°



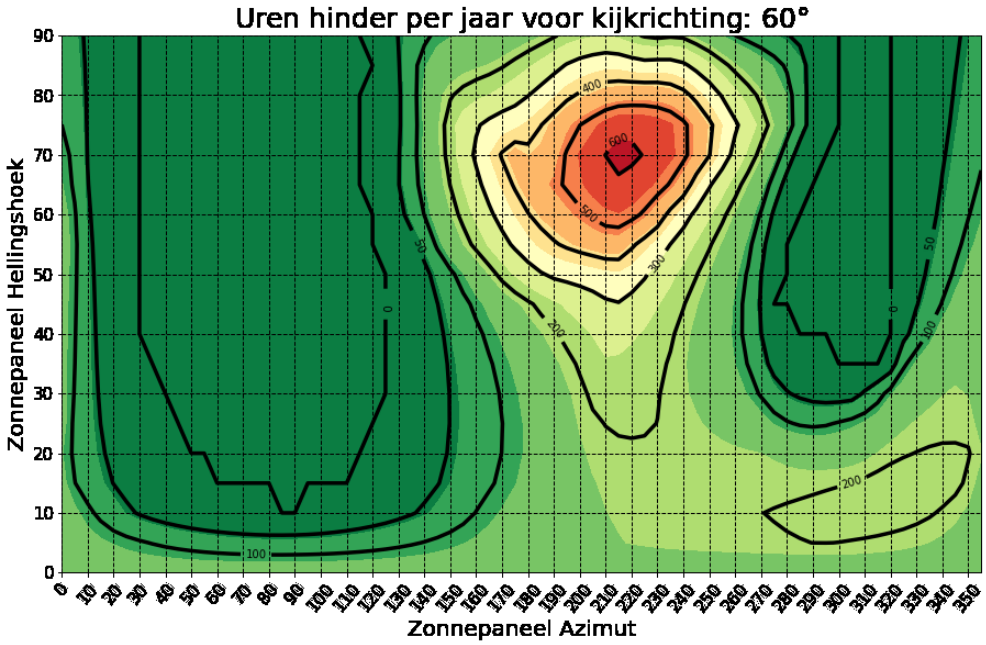
Viewing direction 40°



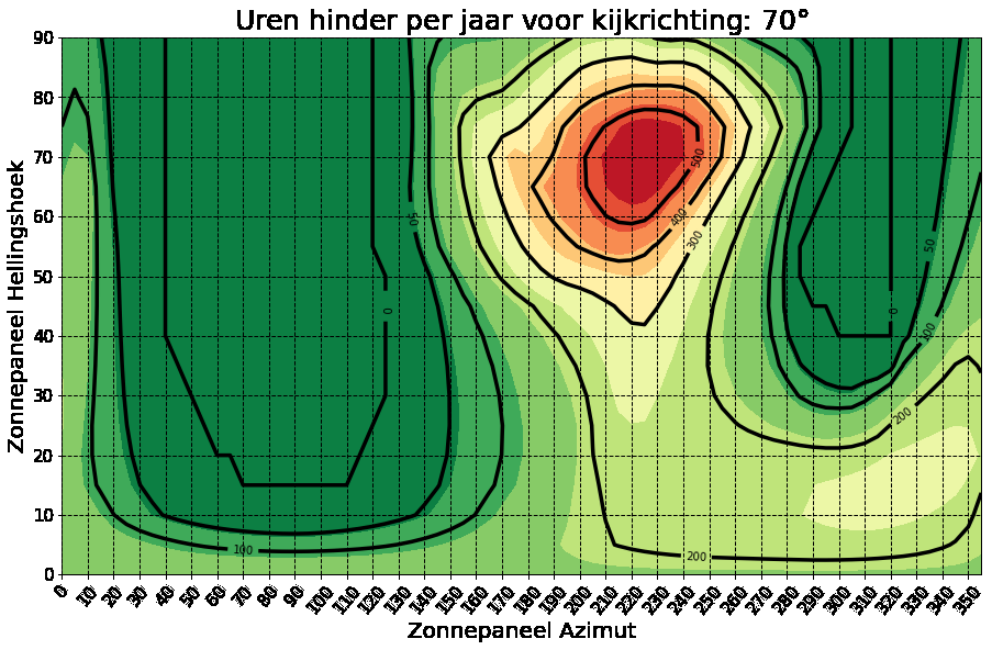
Viewing direction 50°



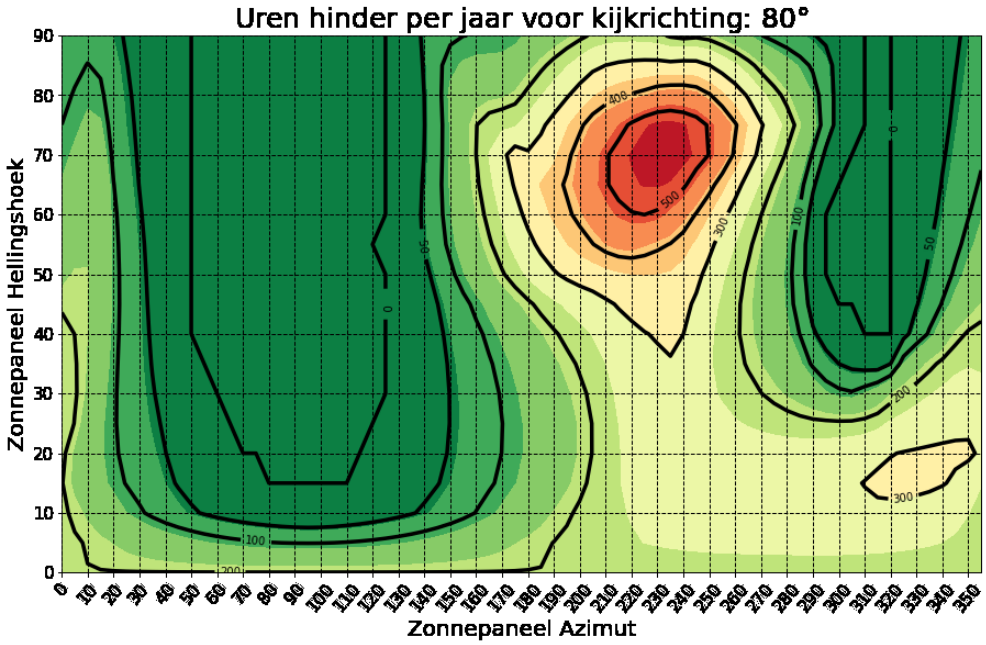
Viewing direction 60°



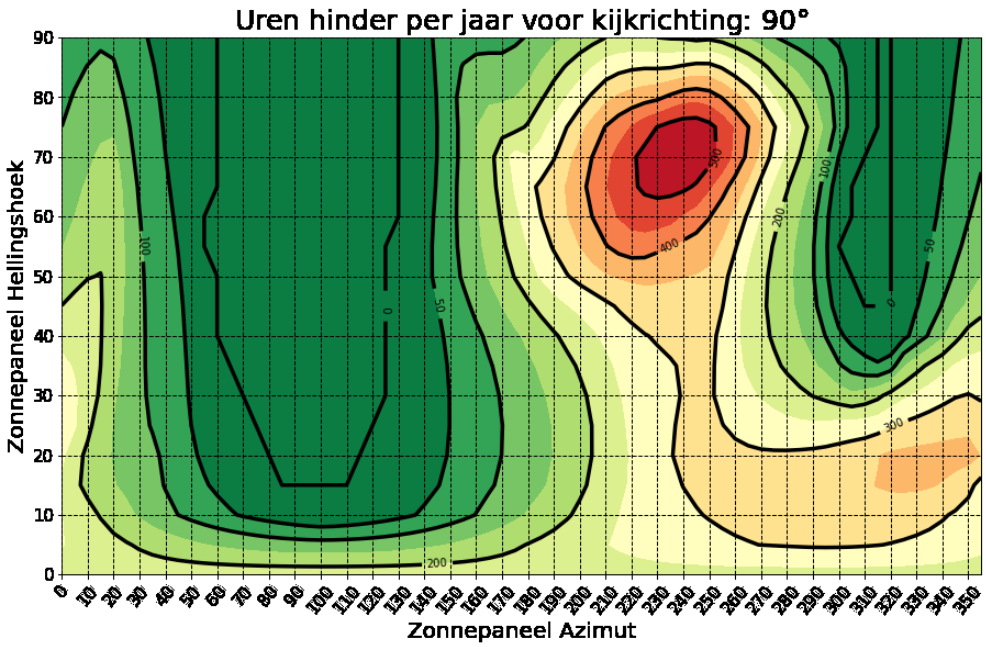
Viewing direction 70°



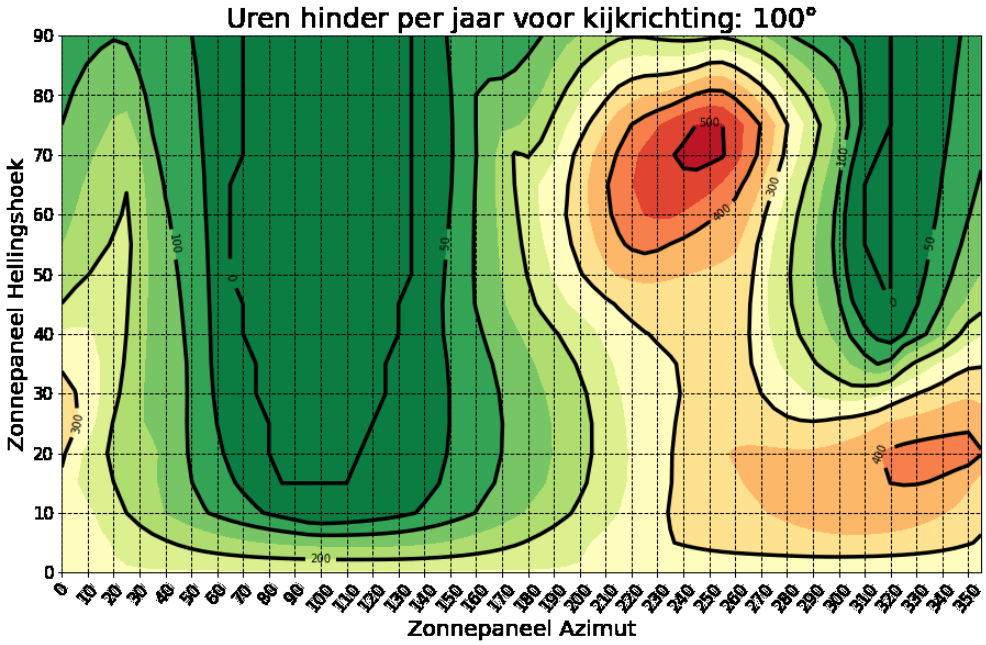
Viewing direction 80°



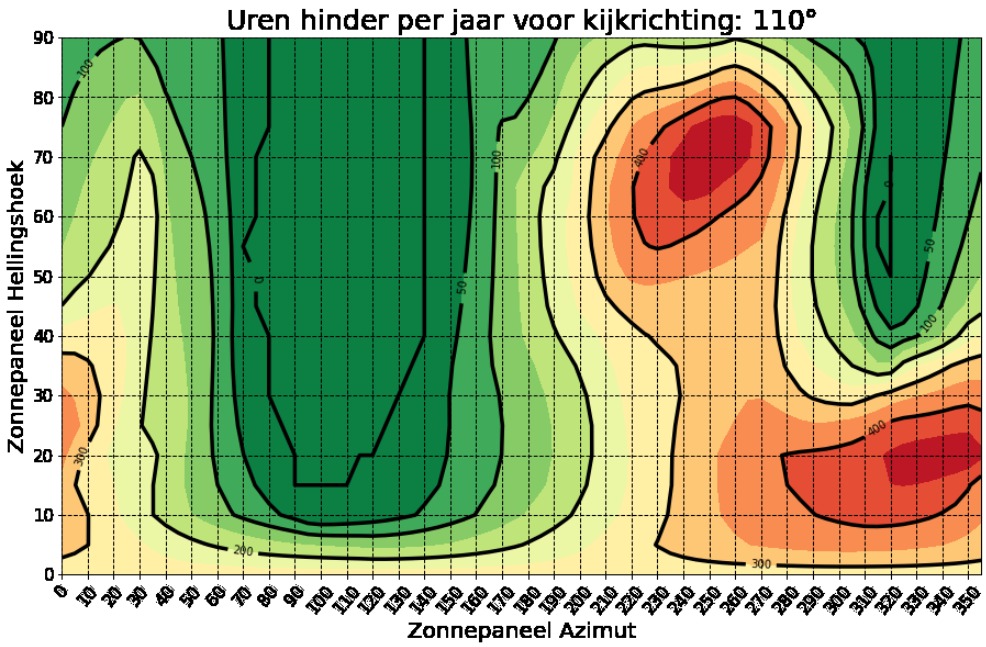
Viewing direction 90°



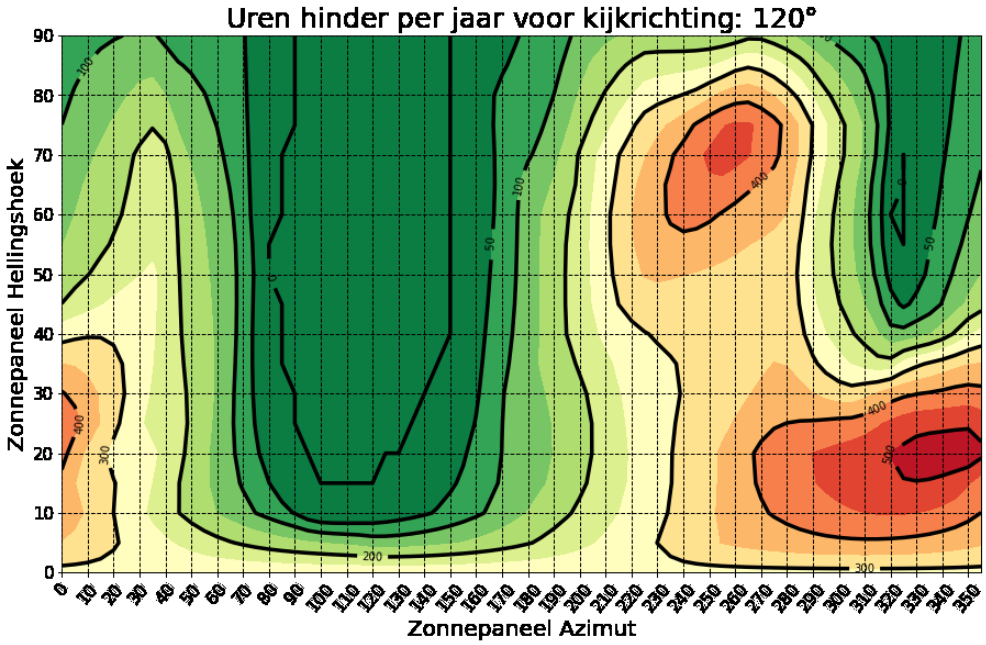
Viewing direction 100°



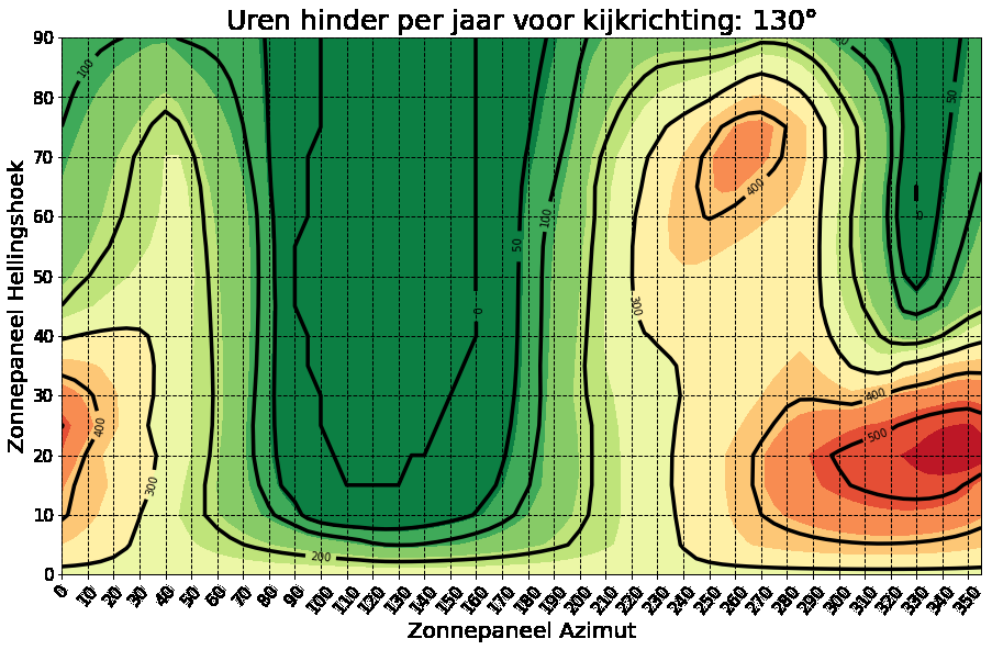
Viewing direction 110°



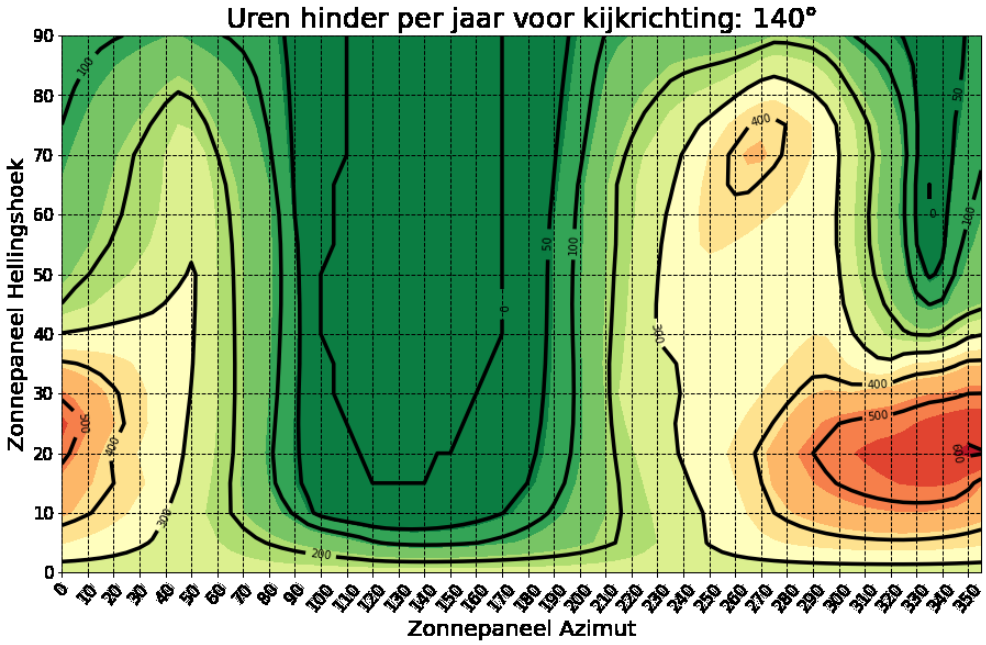
Viewing direction 120°



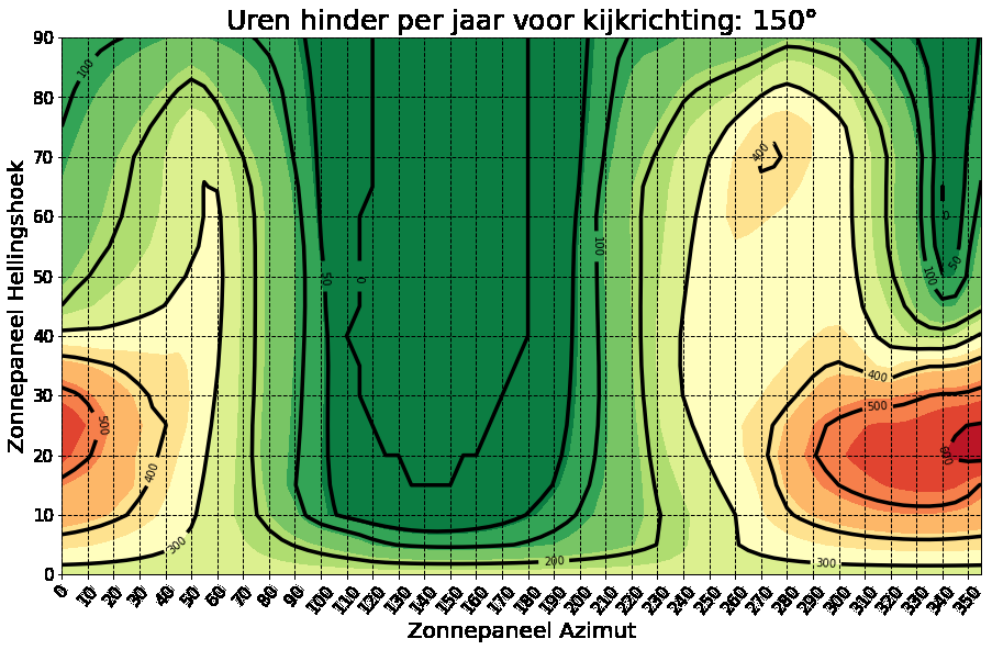
Viewing direction 130°



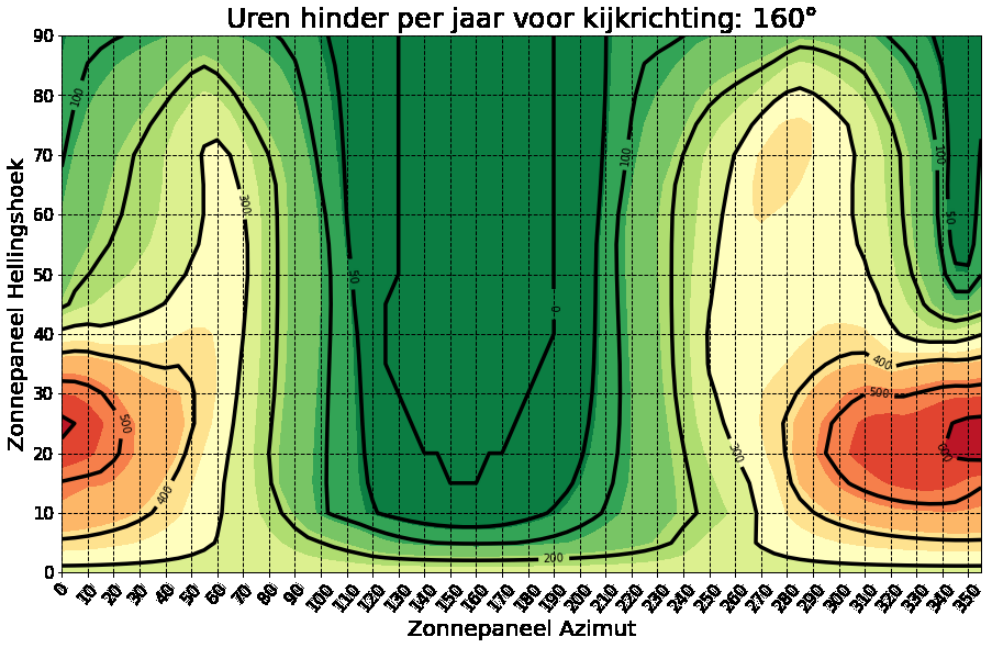
Viewing direction 140°



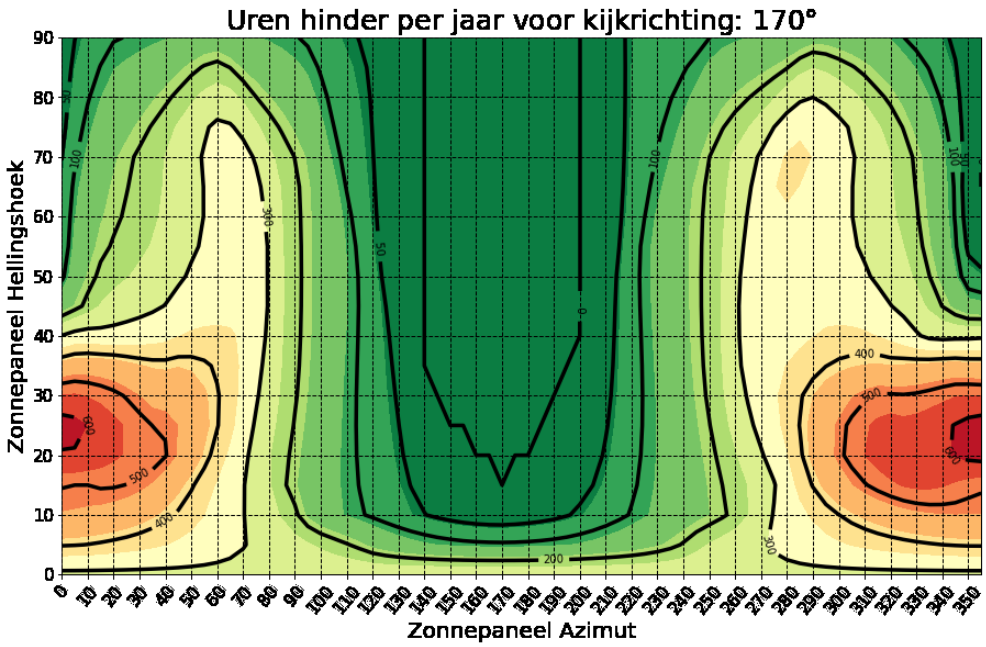
Viewing direction 150°



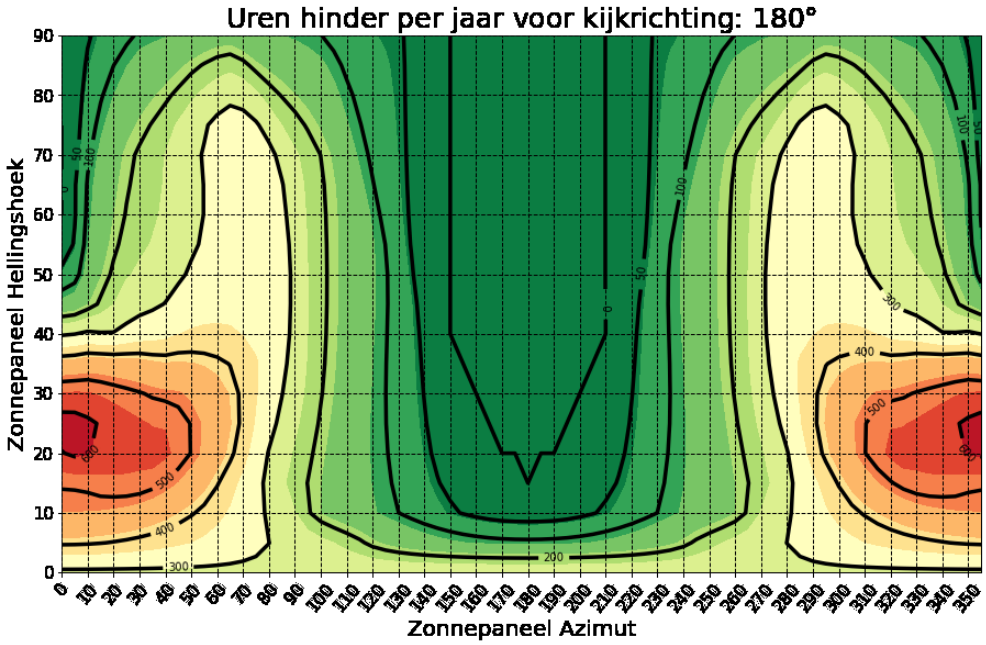
Viewing direction 160°



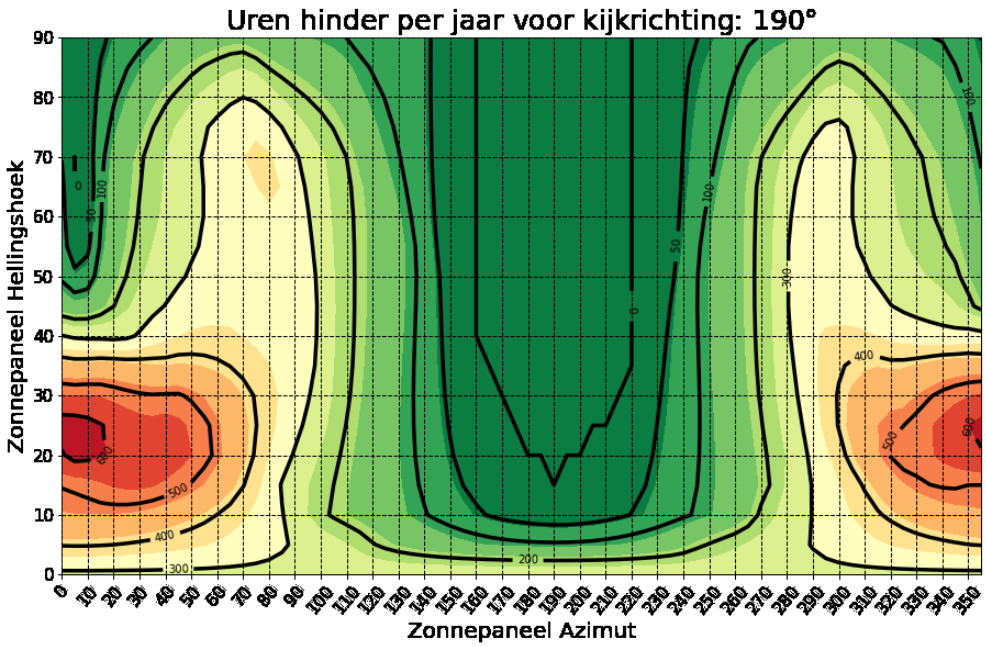
Viewing direction 170°



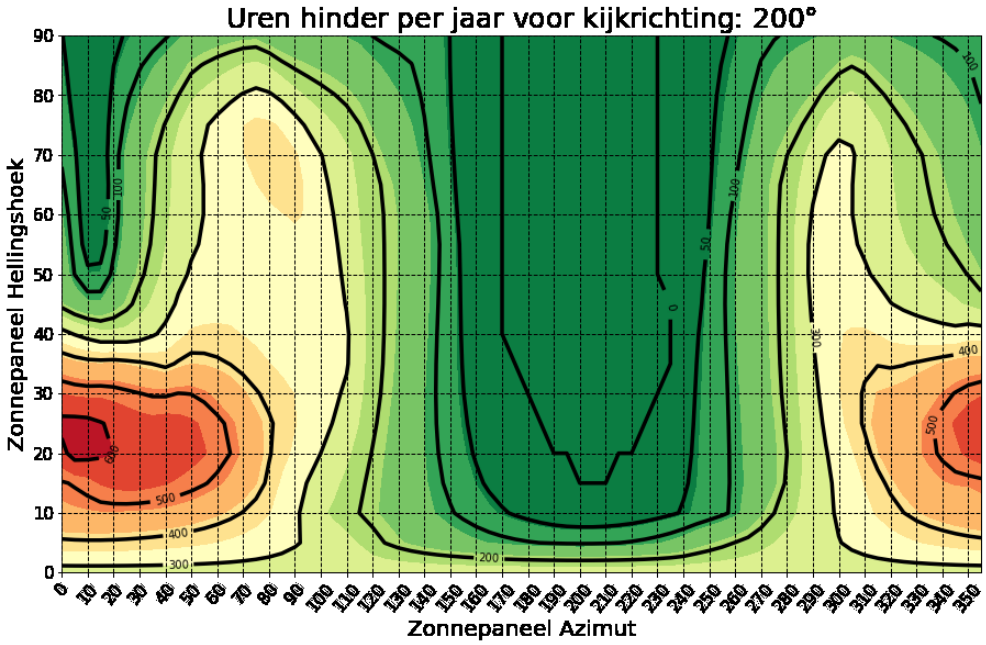
Viewing direction 180 (South)°



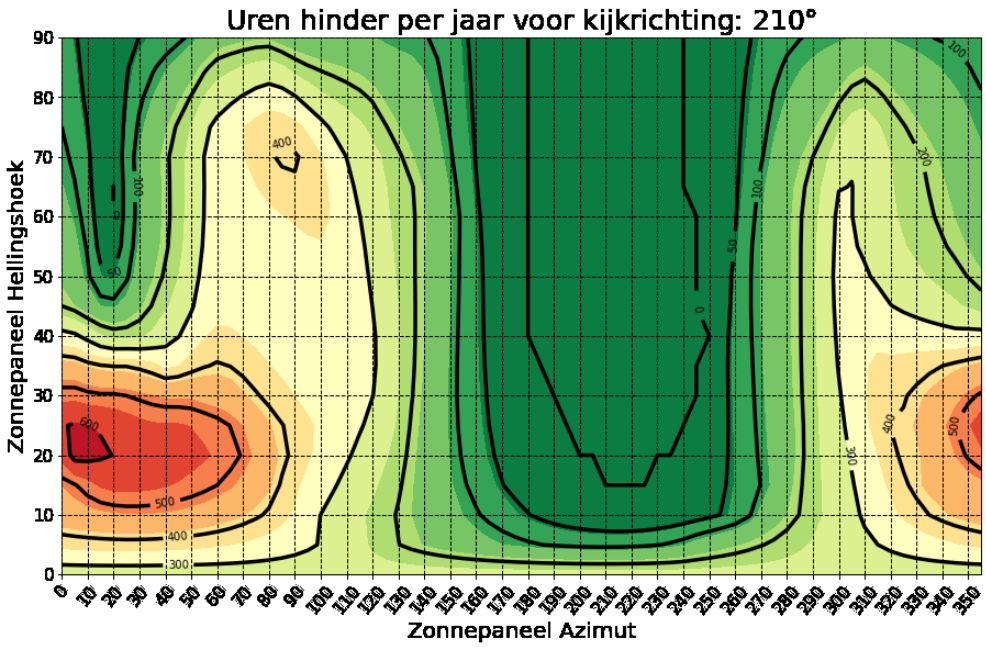
Viewing direction 190°



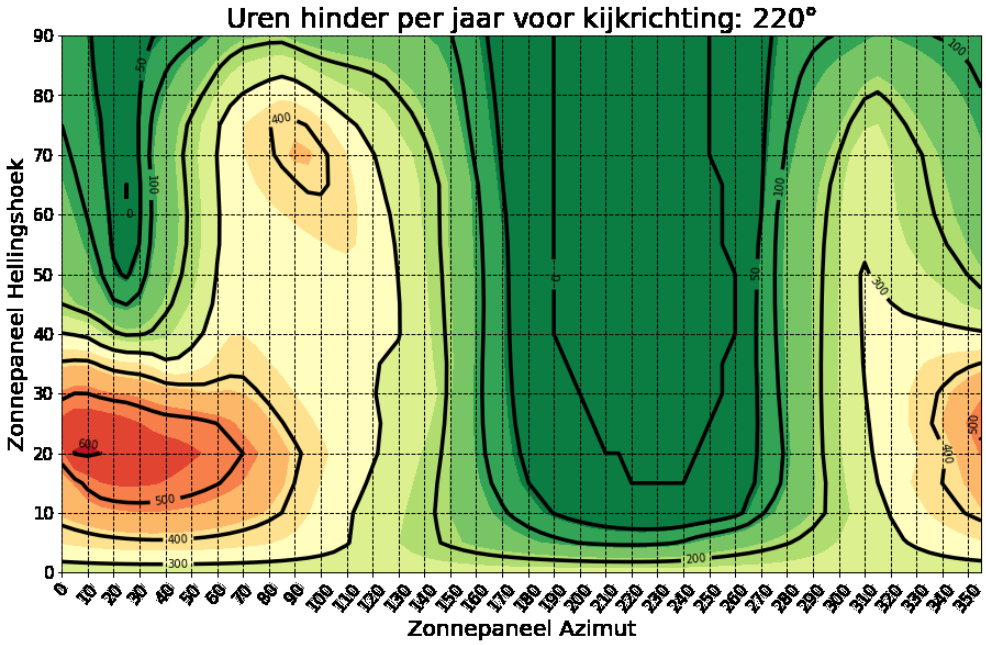
Viewing direction 200°



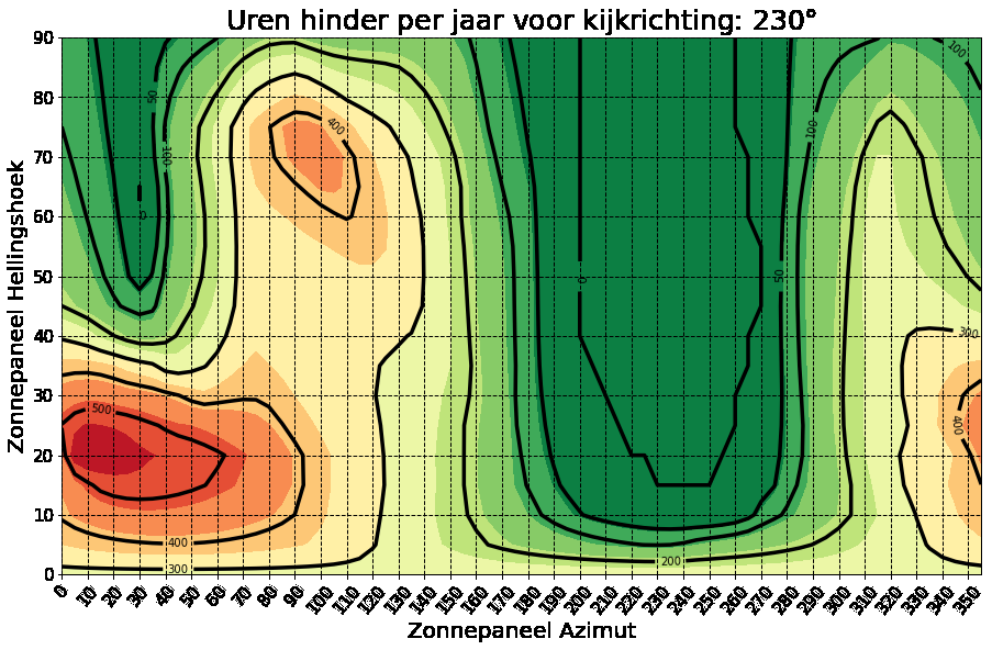
Viewing direction 210°



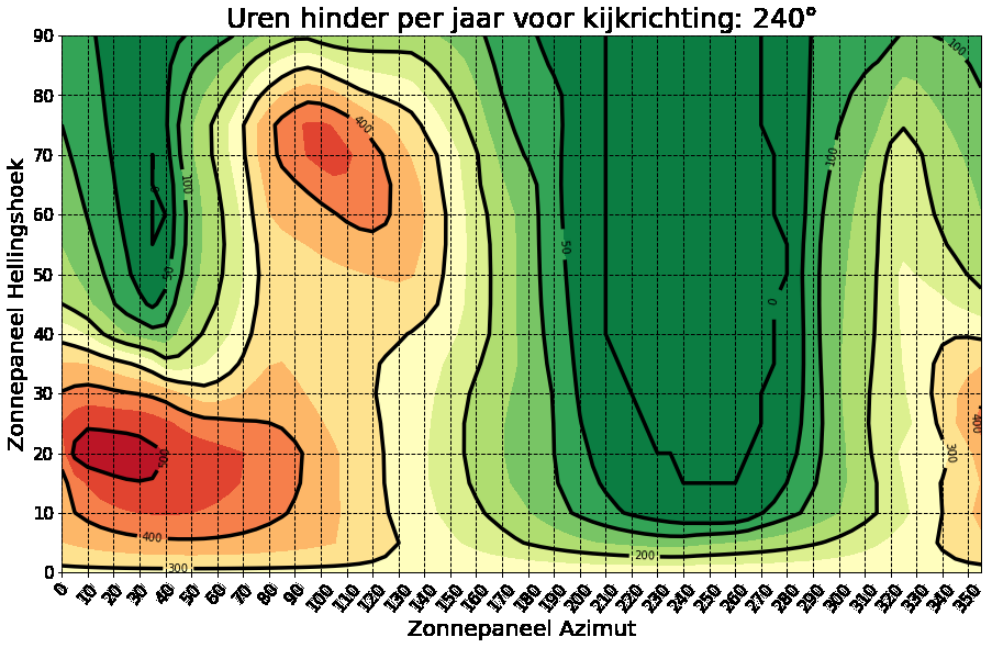
Viewing direction 220°



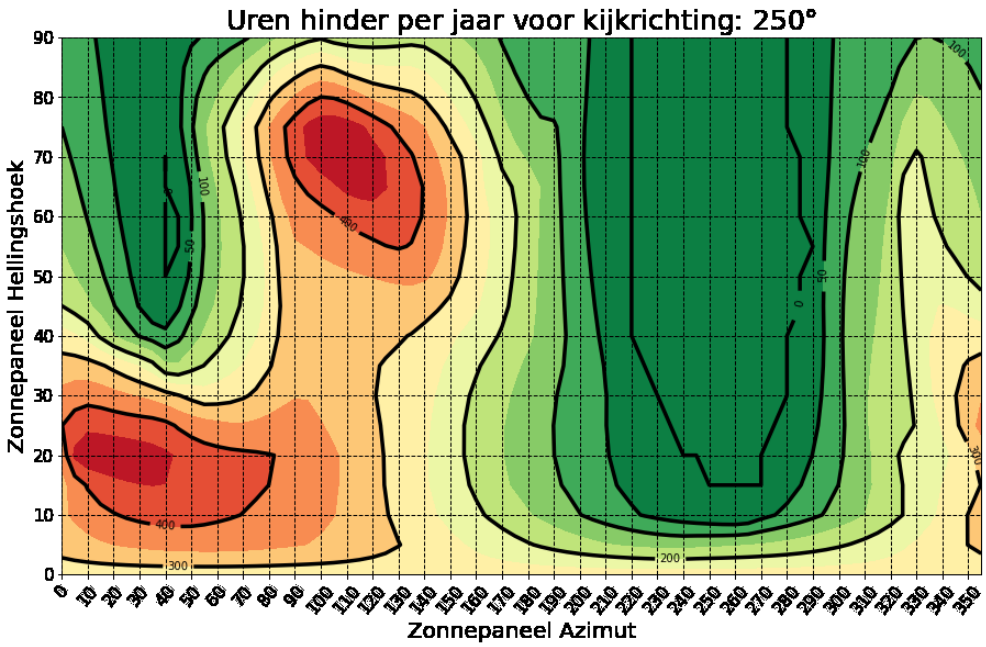
Viewing direction 230°



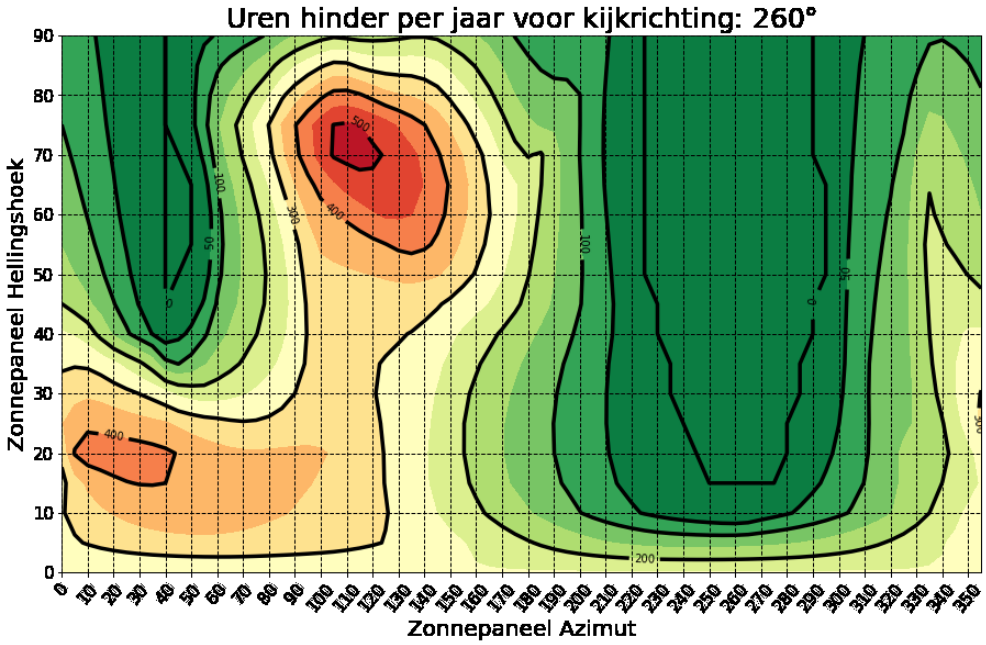
Viewing direction 240°



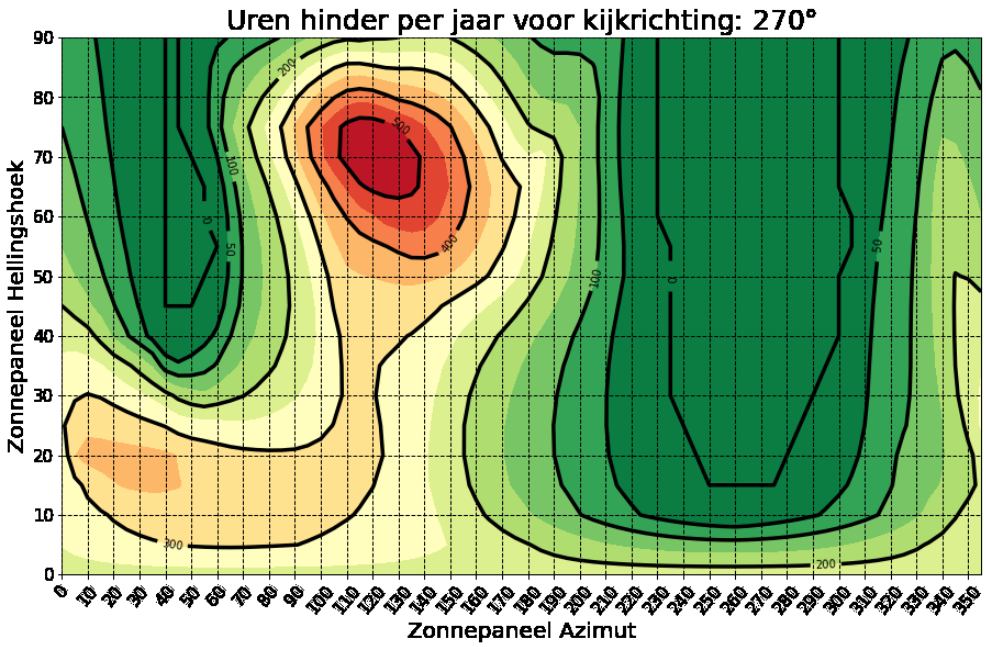
Viewing direction 250°



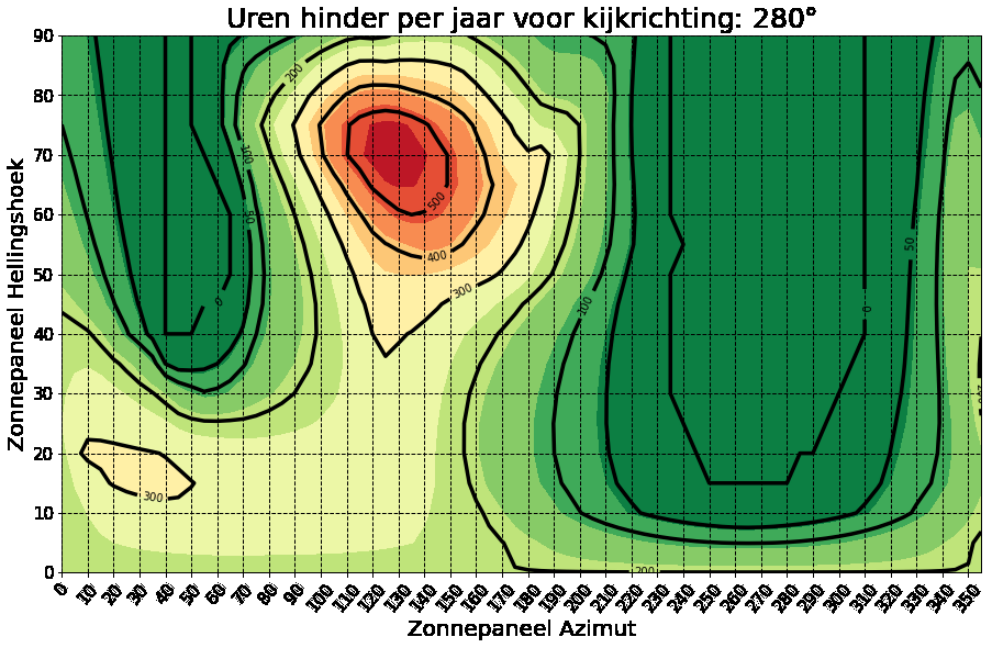
Viewing direction 260°



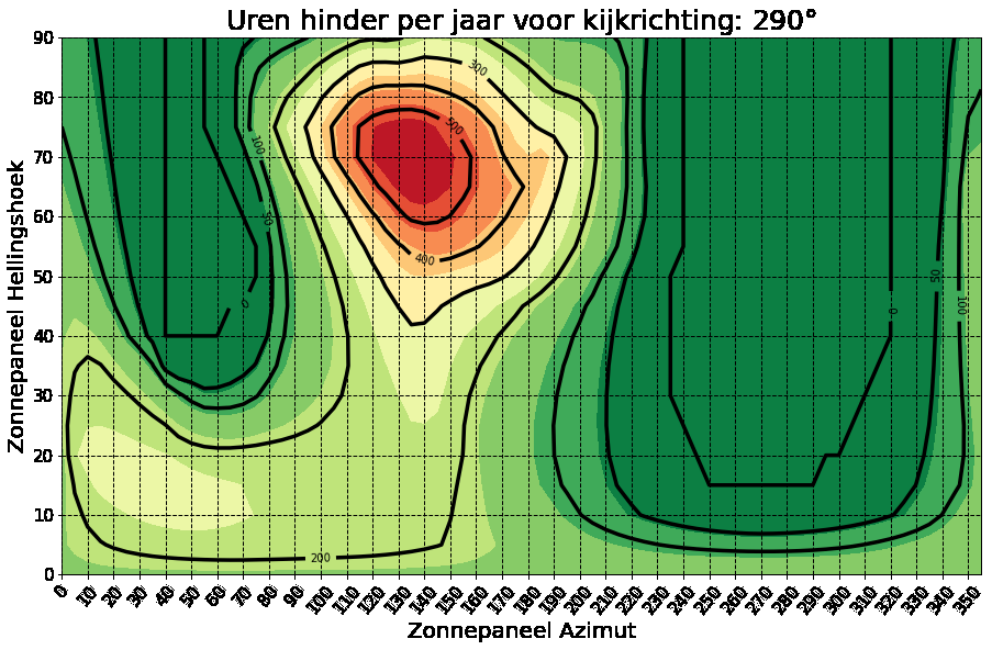
Viewing direction 270° (West)



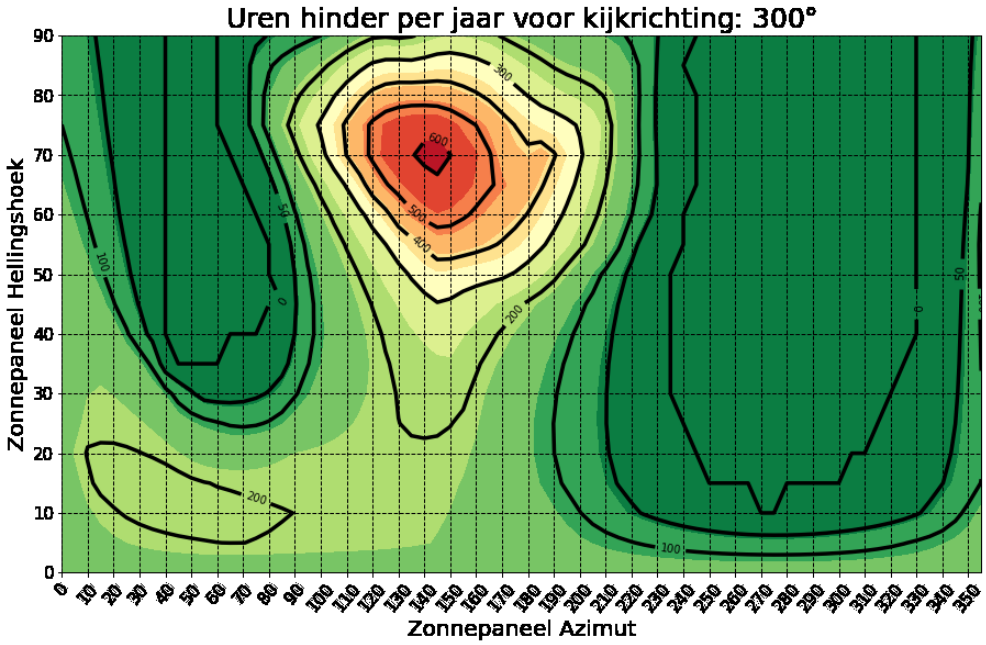
Viewing direction 280°



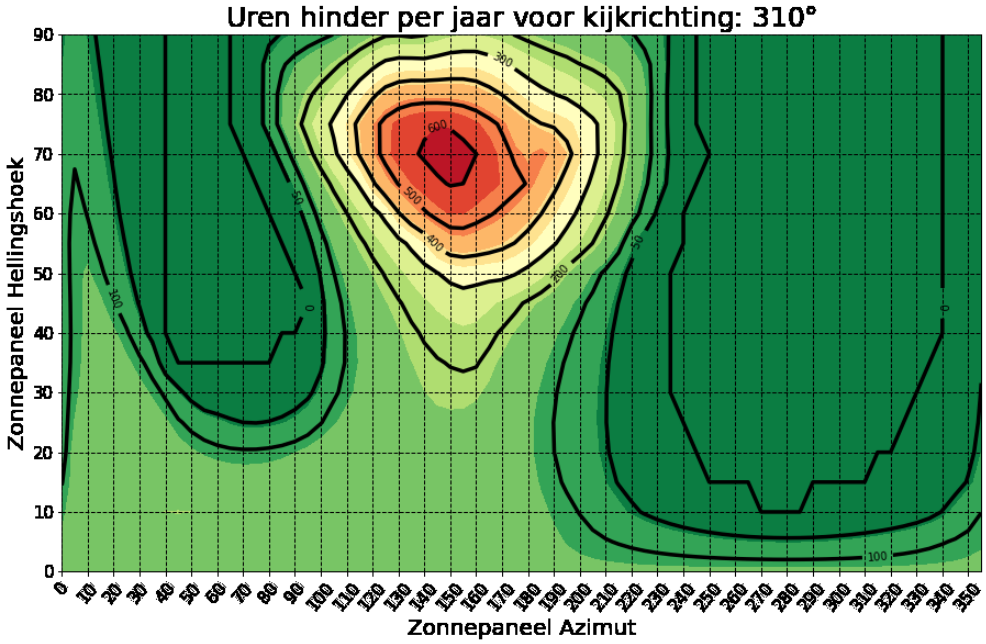
Viewing direction 290°



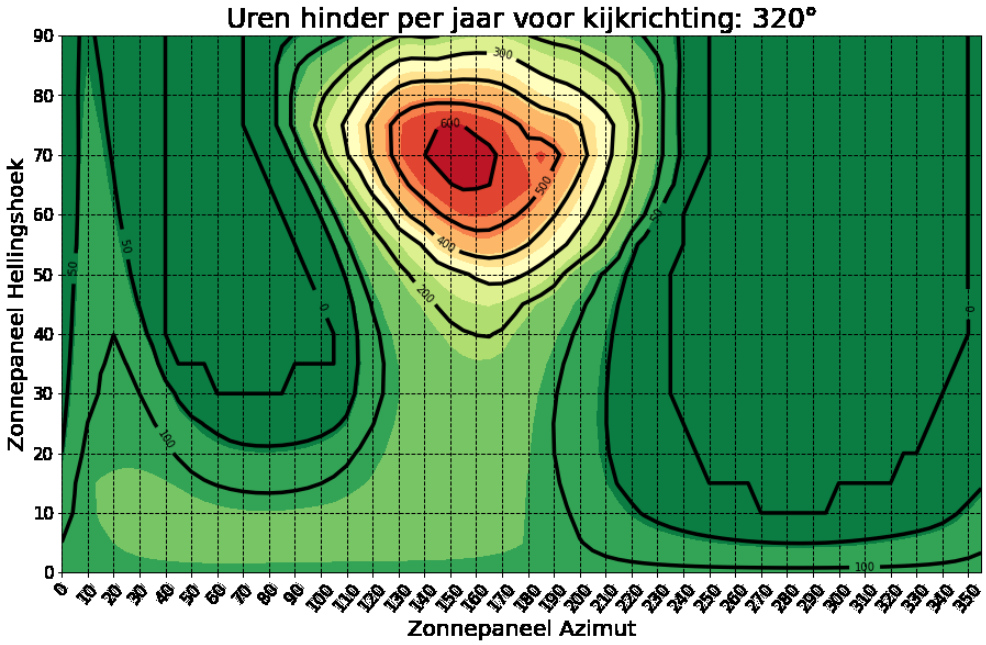
Viewing direction 300°



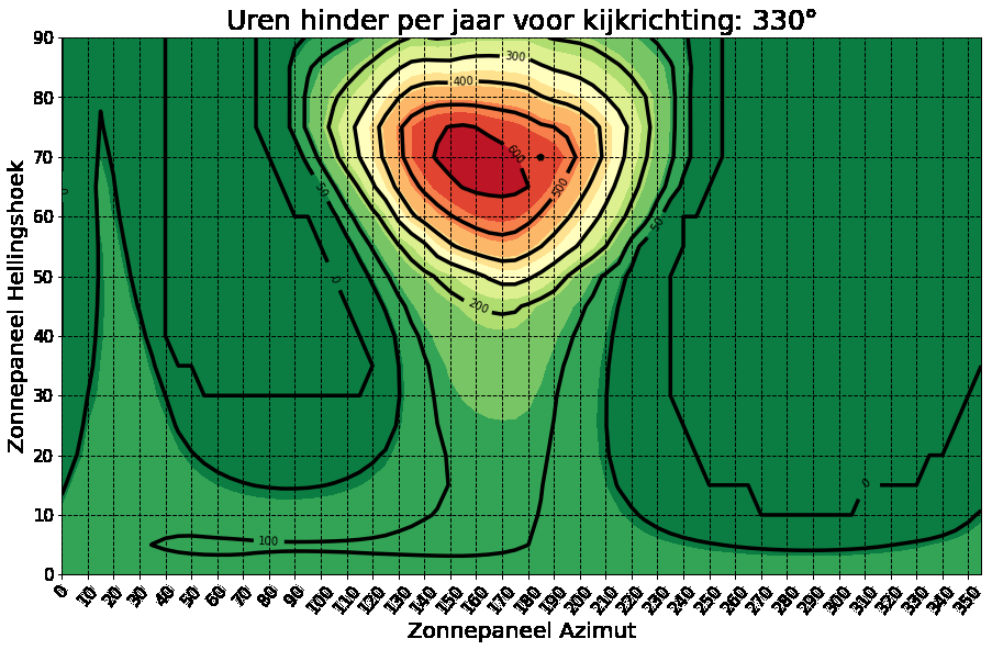
Viewing direction 310°



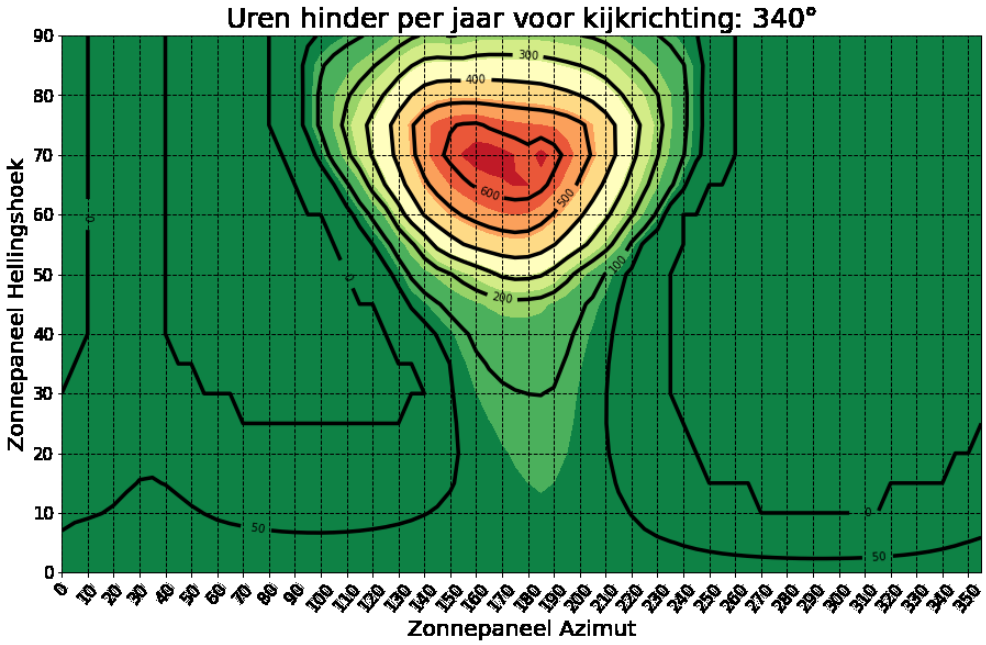
Viewing direction 320°



Viewing direction 330°



Viewing direction 340°



Viewing direction 350°