Spectrum Planning for Digital Terrestrial Television DVB-T

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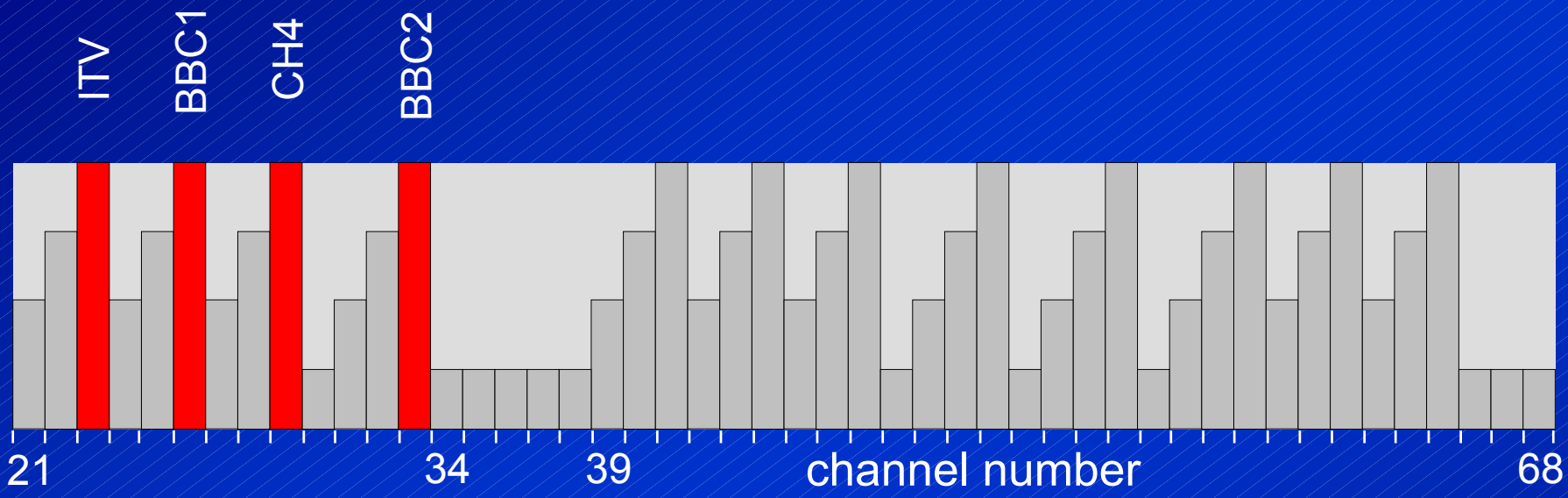
(based on a presentation by Dave Darlington, BBCR&D)

Analogue TV in the UK

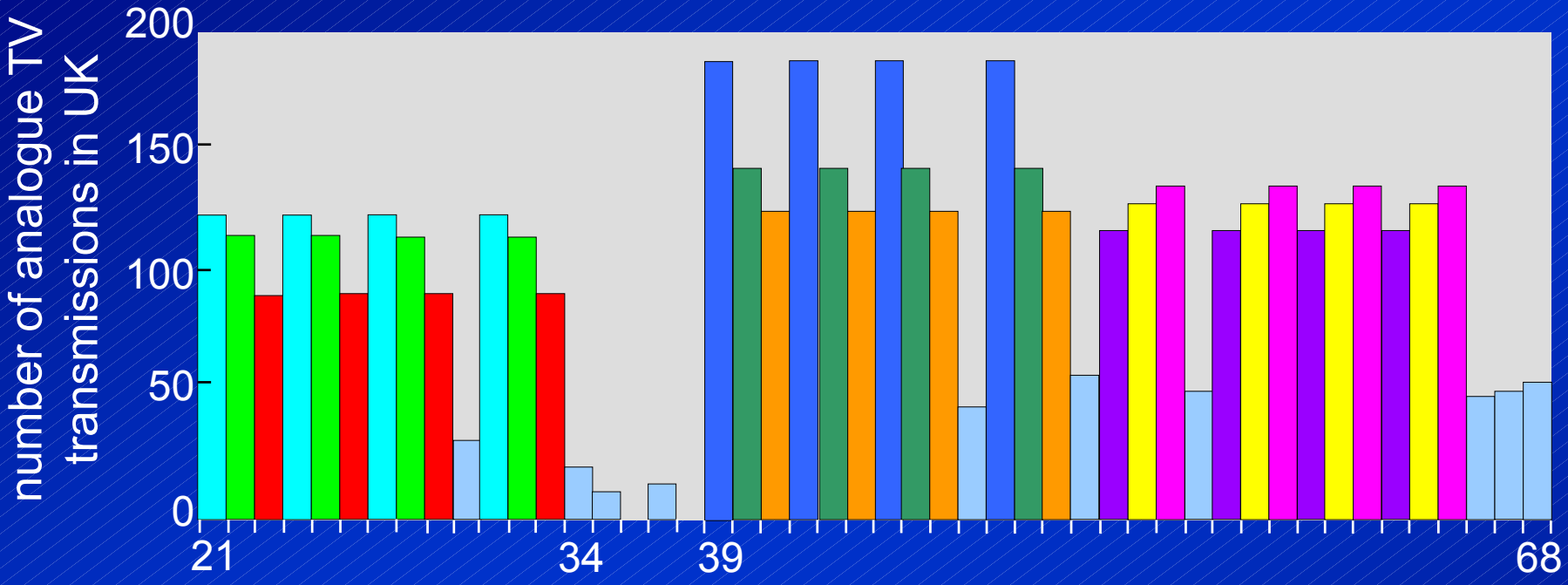
- In the UK, planning of the 4 national analogue TV services was based on the use of 4-channel groups
- There are 9, 4-channel groups in all
  - 3 in UHF Band IV, 470 MHz - 582 MHz
  - 6 in UHF Band V, 615 MHz - 854 MHz
- The four national services are generally provided from a single transmitting station so each household needs only one receiving aerial
- The UK's analogue Channel 5 was planned later and is not accommodated in channel groups, it uses mainly Channel 35 and Channel 37

Analogue TV in the UK



- The four channels are sufficiently close in frequency to allow the use of inexpensive receiving aerials, but sufficiently separated to more easily allow the use of a common transmitting antenna

Distribution Analogue TV Band IV/V



- The total number of analogue television transmissions in the UK is about 5870 (from the 1100+ transmitting stations, plus 350 self-help schemes believed to be on-air)
- Channels 36 and 38 are allocated to Radar and Radio-astronomy

Analogue TV

- The analogue television national network services are provided to the vast majority of the UK population (>99.5%) by terrestrial transmission
- There are more than 1100 terrestrial analogue television transmitting stations in the UK network

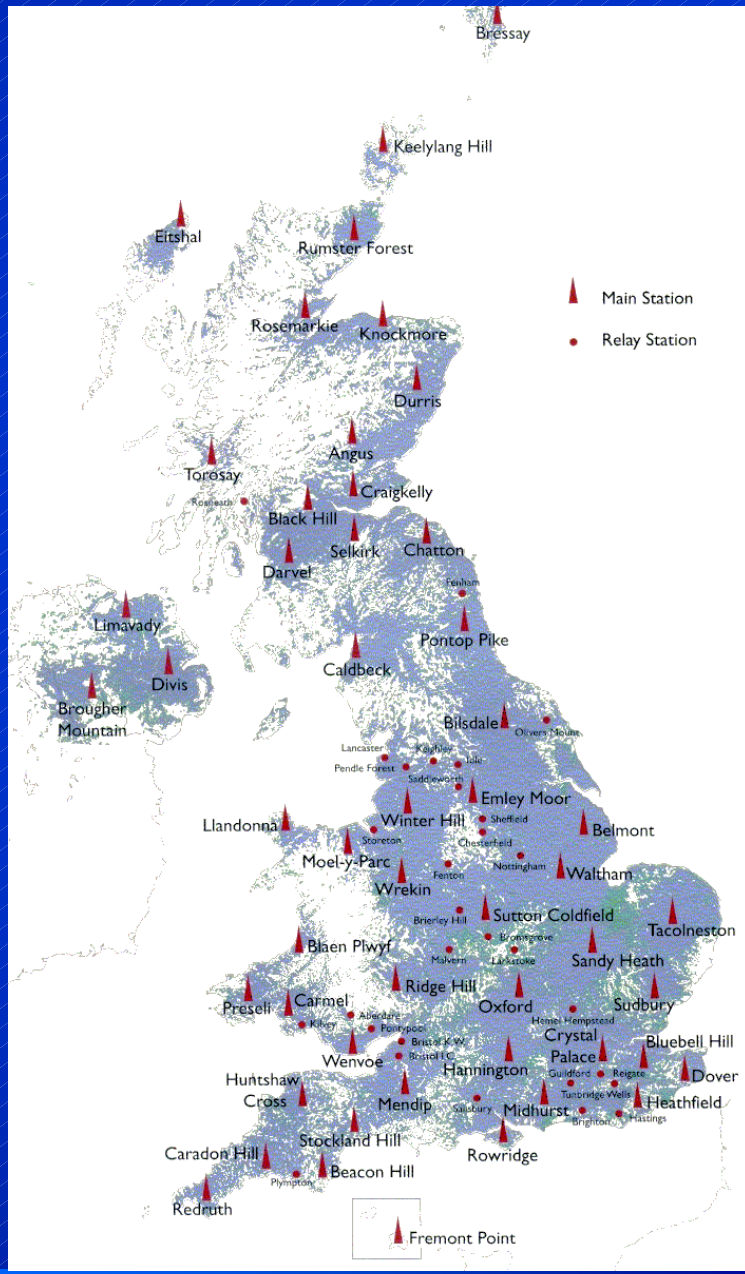
Planning for Digital Terrestrial Television (DTT)

- Public-service broadcasts carry different programmes regionally
  - a Single Frequency Network (SFN) is not appropriate
  - use of a multi-frequency network (MFN) is necessary
- DTT was planned in Bands IV and V using channels interleaved with the existing analogue broadcasting in these bands
  - protection of existing analogue viewers took priority over DTT coverage
  - some interference was expected and there was a procedure to upgrade domestic receiving installations when this was reported by the viewers
- Planned for fixed reception: fixed roof-top directional antennas

The DTT transmitter network

- DTT was launched in 1998 with 80 transmitting stations on-air
  - stations already used for analogue broadcasting

- The BBC shared the initial network planning with NTL in the Joint frequency Planning Project (JPP)



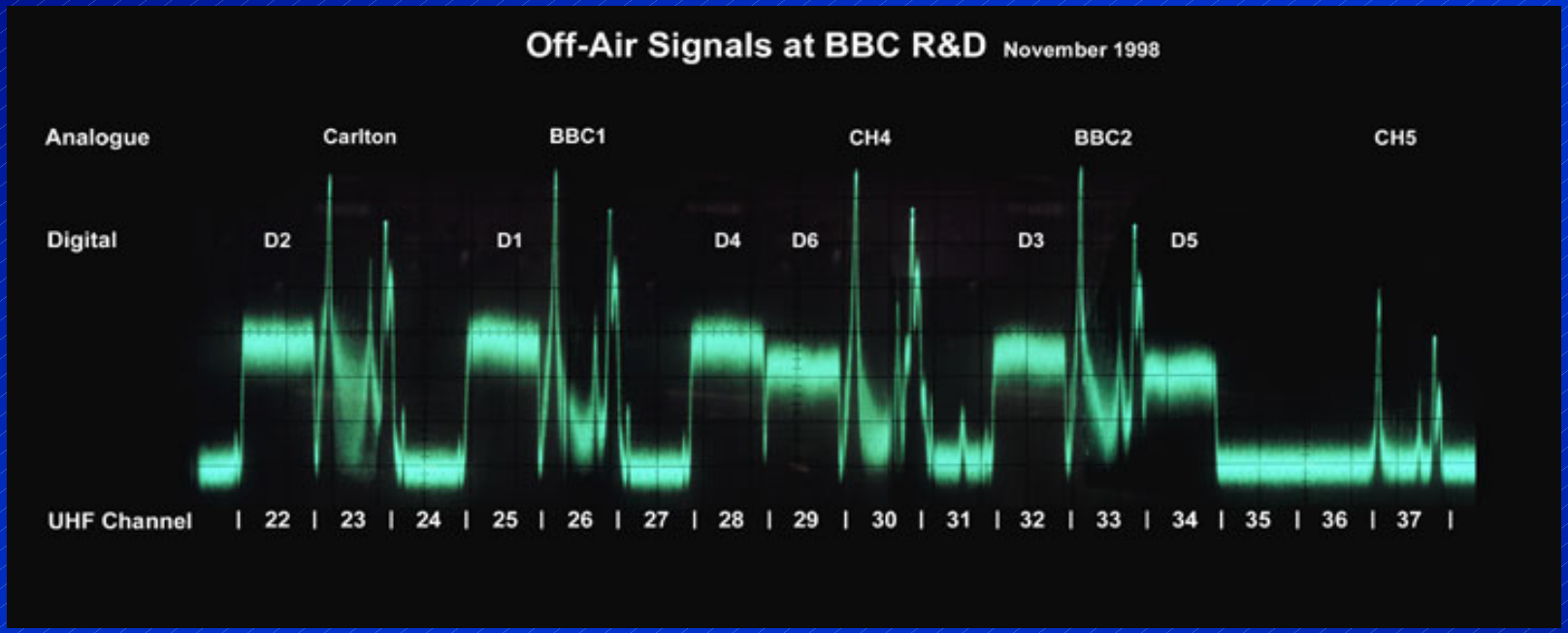
Planning for DTT

- For analogue transmissions:
  - we never used adjacent analogue/analogue transmissions as the protection requirement meant they would interfere with each other
  - at relay stations which transpose and re-broadcast a main station, we also never used adjacent channels because this would make the transposition too difficult

- Adding DTT to a station, we can make use of channels adjacent to analogue transmissions
  - DTT is lower power (won't interfere with analogue) and it is more rugged (analogue won't interfere with it)

- A considerable amount of planning was based on the use of DTT occupying channels adjacent to existing analogue transmissions

Channels used at a single transmitting station



- Signals from Crystal Palace at launch of DTT
  - 5 channels adjacent to analogue transmissions

Planning for DTT

- However, in general all DTT transmissions could not be located in channels adjacent to analogue; normally four were possible
- Conventional frequency planning was necessary to accommodate the other channels up to a maximum of 6 multiplexes
  - unfortunately these other channels may give lower coverage
- Unequal coverage between multiplexes

DTT Coverage estimates at launch

Mux. 1	BBC	82%
Mux. 2	Digital 3 & 4	81%
Mux. A	SDN	80%
Mux. B	ONdigital	77%
Mux. C	ONdigital	68%
Mux. D	ONdigital	66%
Core		57%

- ONdigital was the commercial operator licensed to operate multiplexes B, C and D
- Core means all 6 multiplexes can be received

DTT initial observations

- Following launch, it became clear that ‘core’ coverage affected the take up of DTT
  - this was claimed a significant factor in the fortunes of ONdigital
- The interference to our analogue network that we had expected never materialised
  - we could relax our protection of analogue
- It seemed that the coverage of DTT was worse than we expected
  - we realised that our planning assumptions for the performance of domestic aerials (based on ITU recommendations) were not correct

Aerials: Planning parameters!

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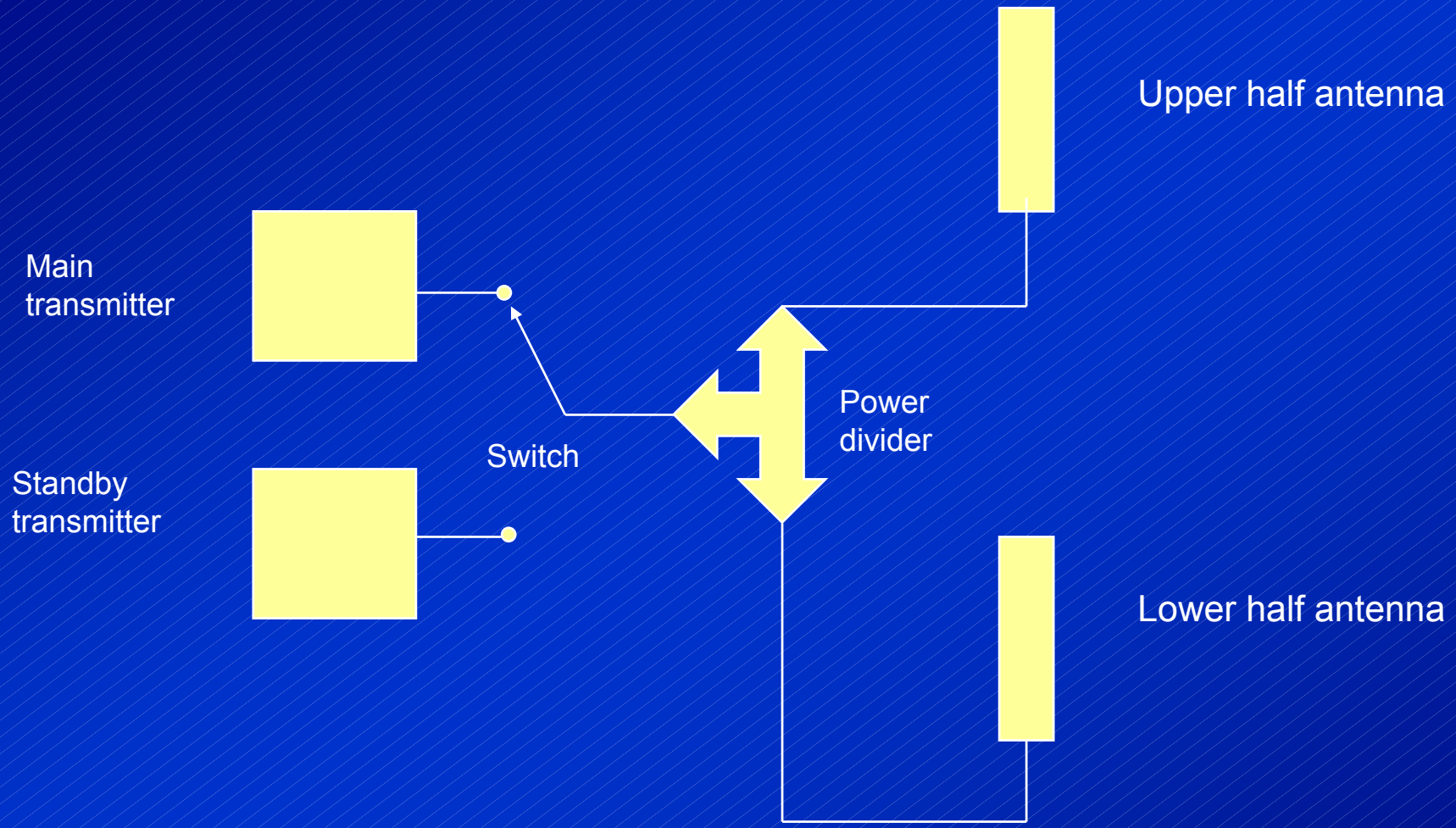
DTT re-planning begins

- In mid-1999 the JPP started further planning to equalise and improve the coverage
  - by transmitting antenna changes
  - by increasing the transmitter powers
  - by channel changes

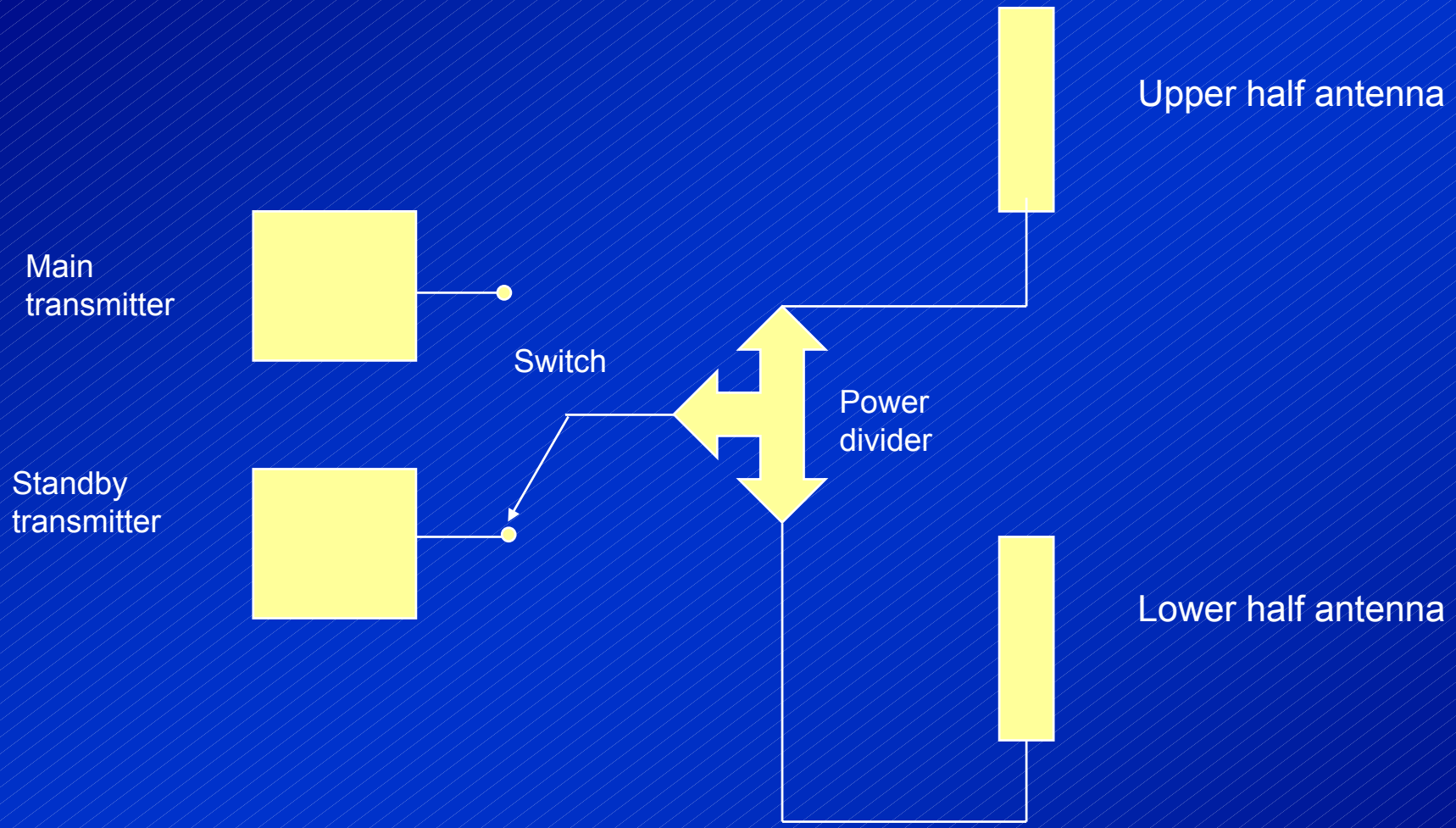
Power increases

- Due to the DTT station architecture we were able to consider doubling the power at a relatively modest cost

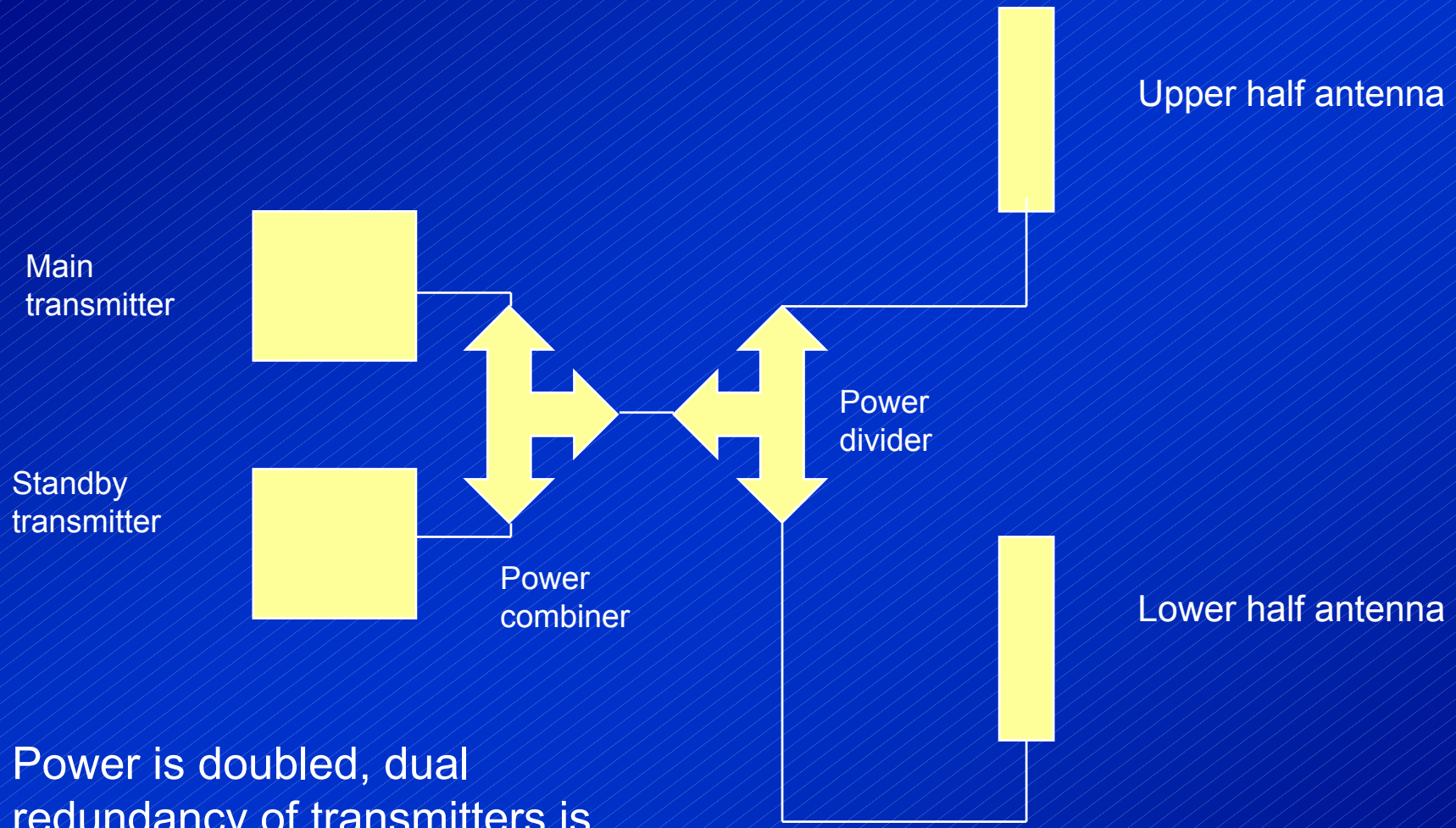
3 dB power increases: layout at launch



3 dB power increases: layout at launch



3 dB power increases: layout after implementation



Power is doubled, dual redundancy of transmitters is lost

DTT Coverage estimates after equalisation and some power increases

Multiplex 1	BBC	80% (82%)
Multiplex 2	Digital 3 & 4	79% (81%)
Multiplex A	SDN	78% (80%)
Multiplex B	ITV Digital *	78% (77%)
Multiplex C	ITV Digital	74% (68%)
Multiplex D	ITV Digital	72% (66%)
Core		66% (57%)

*ONdigital changed its name to ITV Digital

Engineering tests

- In 2002 the commercial operator ITV Digital ceased operations
- The free-to-view multiplexes continued but the ITV Digital multiplexes went off the air
- These three clear multiplexes were used to make engineering tests to compare the performance of the 64QAM rate 2/3 modulation, that had been used, with 16QAM rate 3/4 - a more rugged scheme
- 16QAM gave a clear improvement both in terms of coverage and an increased resistance to impulsive interference

DTT mode change

- In October 2002 Freeview was launched
- The mode was changed for the 4 multiplexes under the control of the Freeview consortium
- The change to 2k, 16QAM, rate 3/4, 18 Mbit/s payload was made to increase the ruggedness of the signal, improving coverage and resistance to impulsive interference
- The proprietors of the other 2 multiplexes, D3/4 and SDN, don't wish to change mode, probably because of the reduction in payload per multiplex

Coverage of the DTT network

- At launch (pre-equalisation):

mux	*BBC*	*D3/4*	*SDN*	*B*	*C*	*D*	*Core*
% of UK	82	81	80	77	68	66	57

- At the time of the demise of ITV Digital:

mux	*BBC*	*D3/4*	*SDN*	*B*	*C*	*D*	*Core*
% of UK	80	79	78	78	74	72	66

- Following the mode changes:

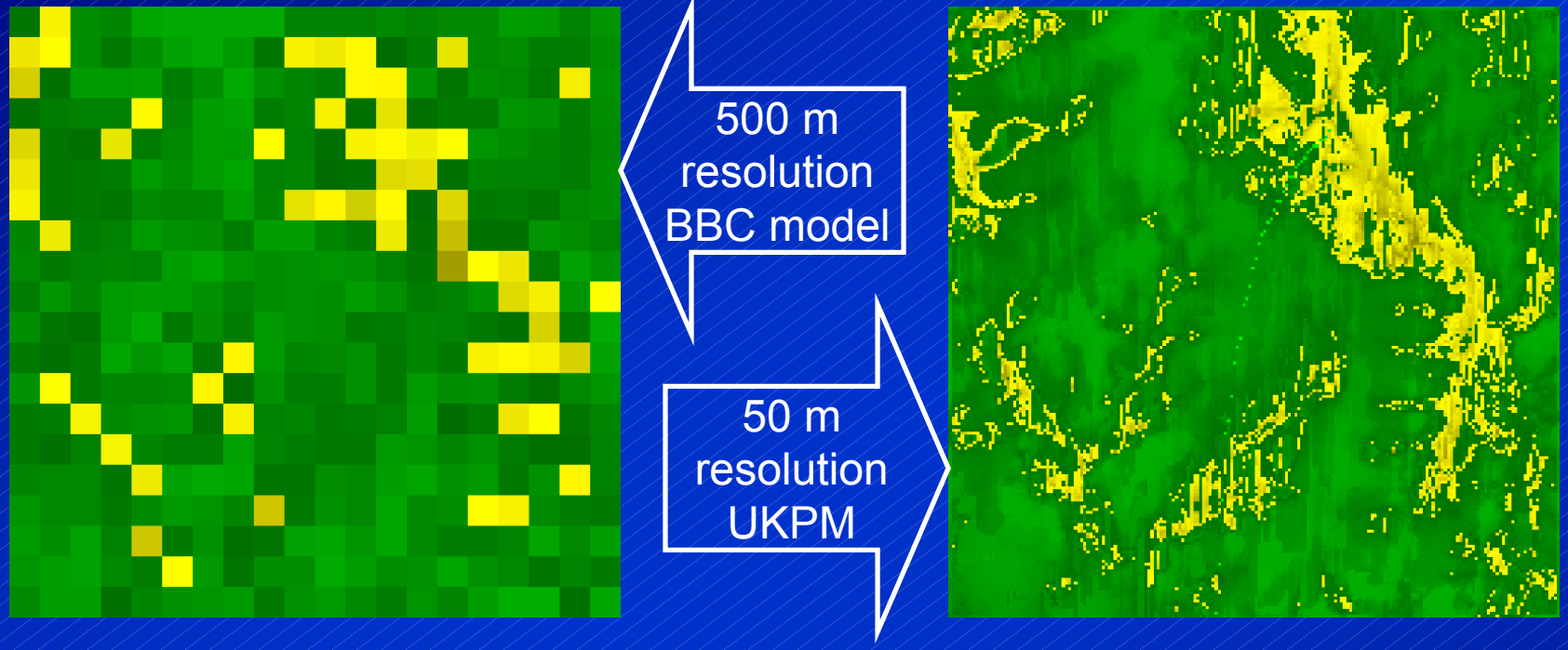
mux	*BBC*	*D3/4*	*SDN*	*B*	*C*	*D*	*Core*
mode	*16QAM*	*64QAM*	*64QAM*	*16QAM*	*16QAM*	*16QAM*	
% of UK	85	79	78	83	79	78	72

- By the end of July 2003 – following SDN power increases:

mux	*BBC*	*D3/4*	*SDN*	*B*	*C*	*D*	*Core*
% of UK	87	81	80	85	81	81	73

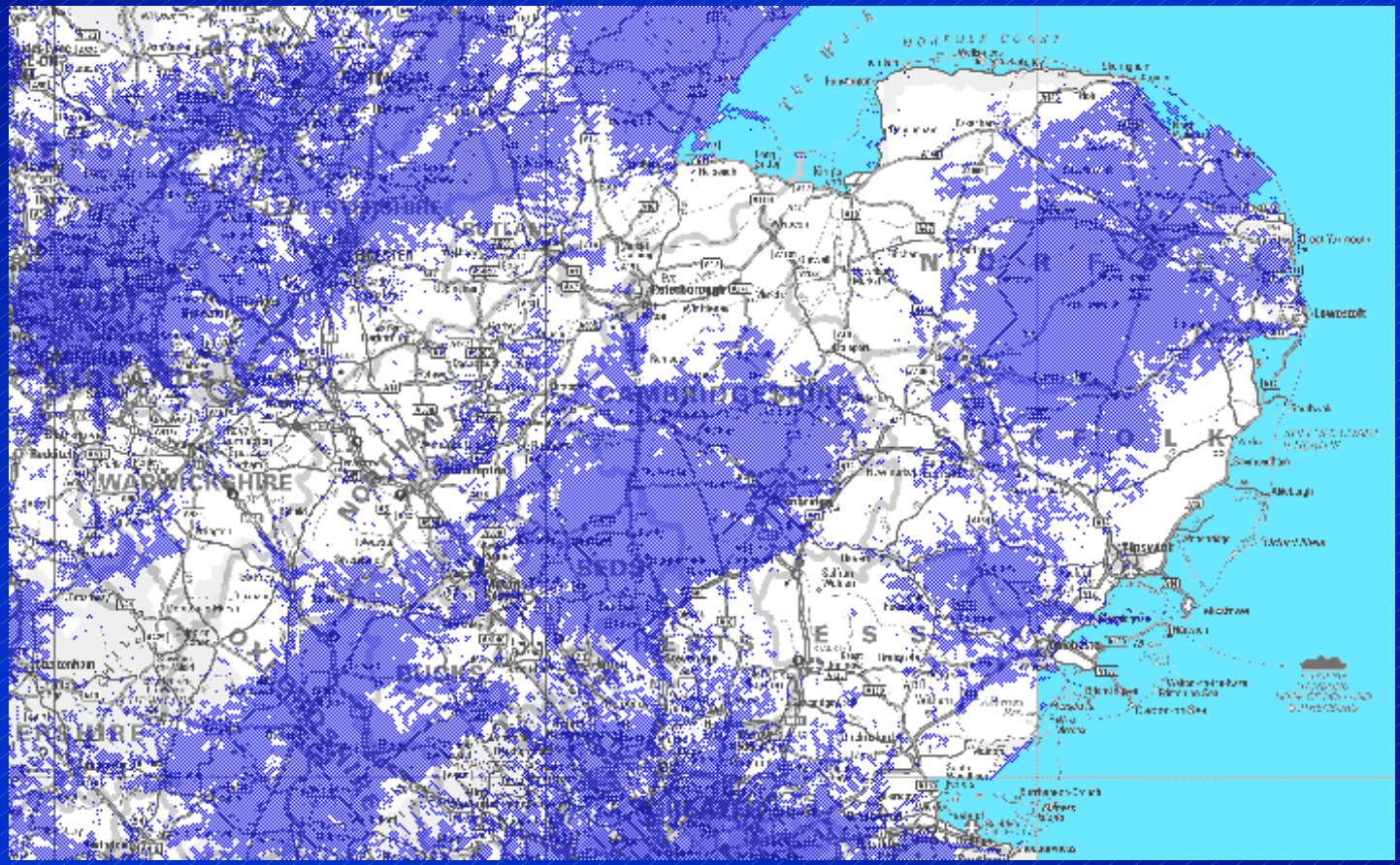
Coverage calculations and prediction models

The UKPM (common planning method)



- The industry and Government have sought an agreed common ‘planning method’ for predicting terrestrial television coverage
- We are developing this, based on the BBC prediction model with NTL, Crown Castle and the ITC
- It provides greater accuracy and up to 10× greater resolution than any such ‘method’ used before for terrestrial broadcasting

Area of interest: Norwich



Map image © George Philips Ltd

Area of interest: Norwich

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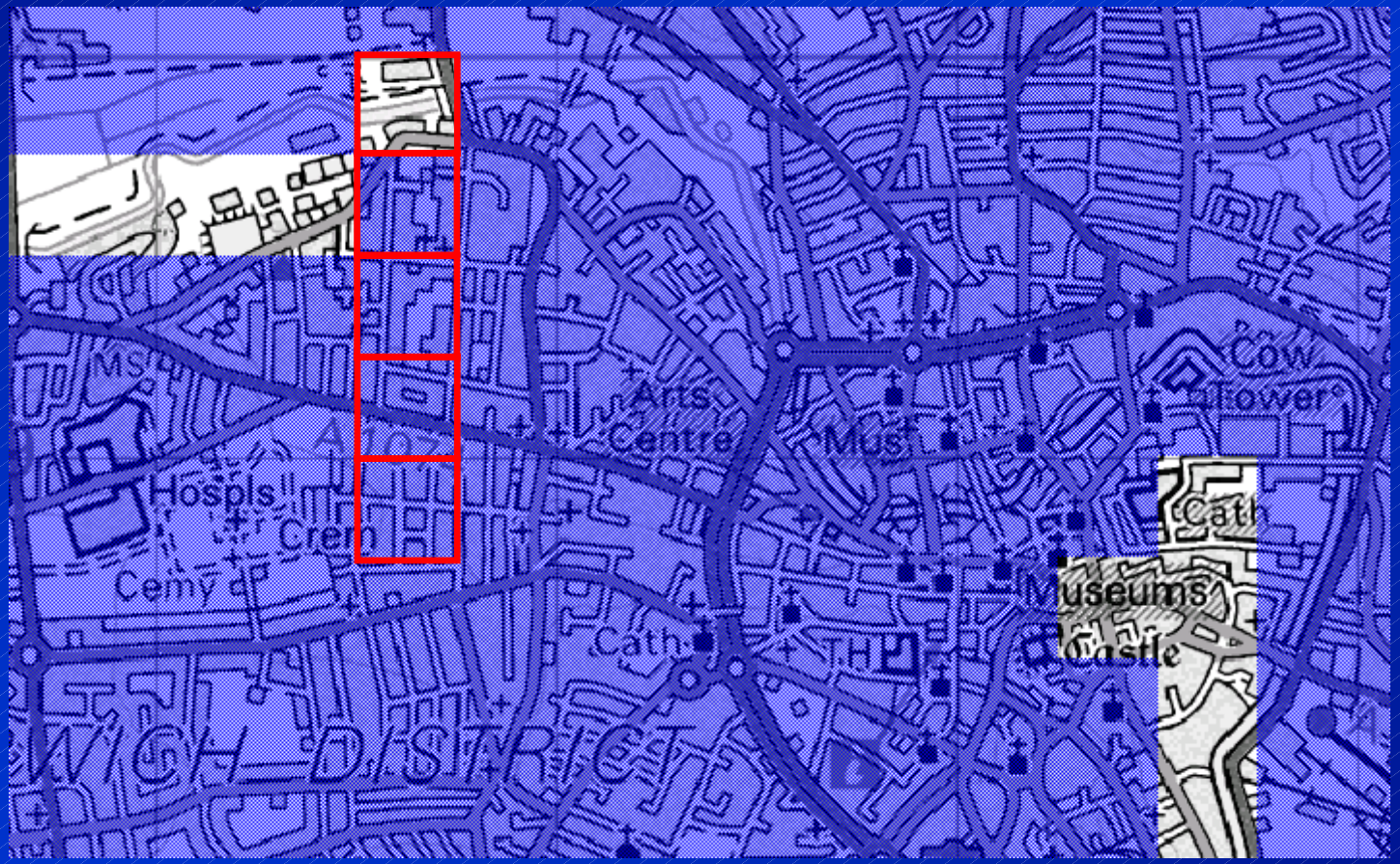
Predictions are made to 100² m ‘cells’



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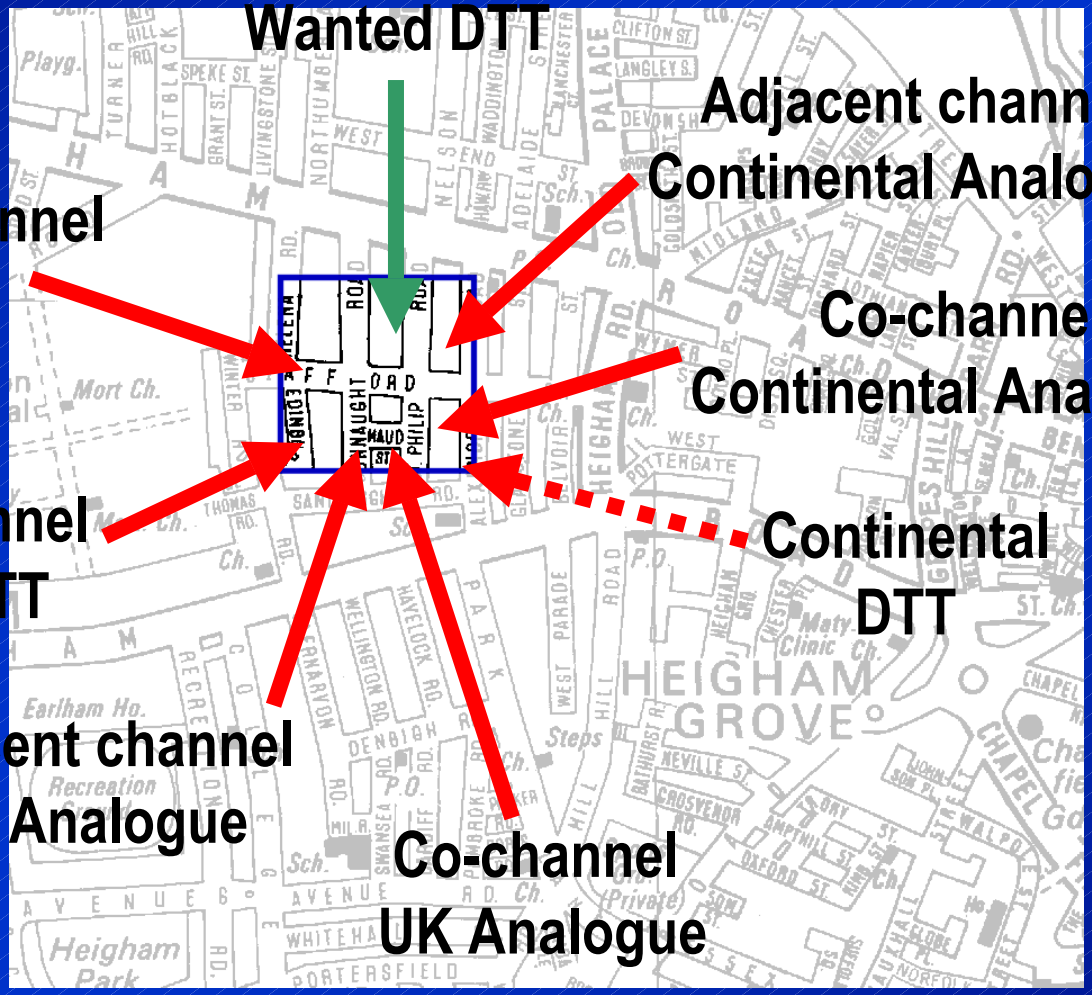
Making a prediction to a cell



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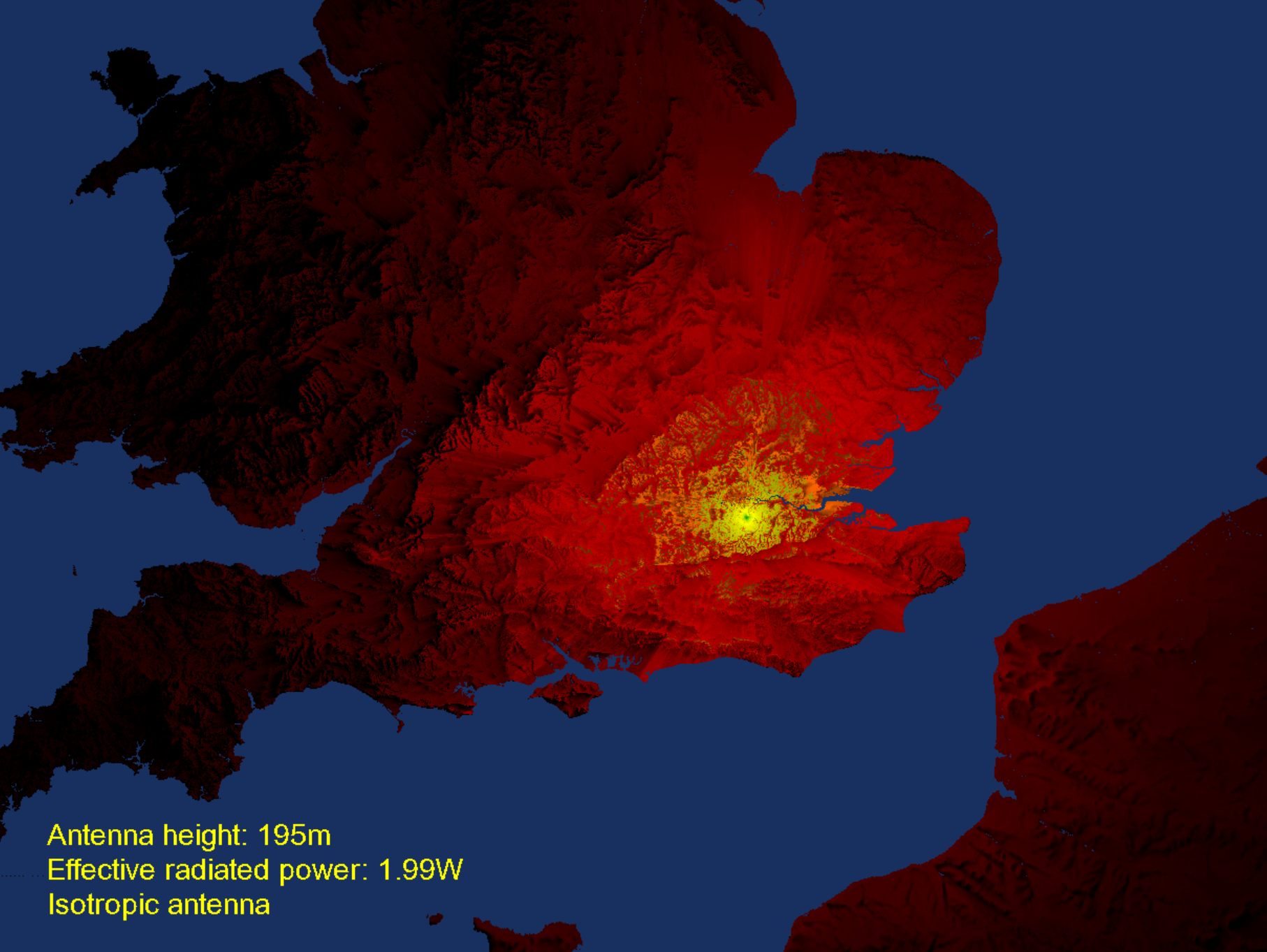
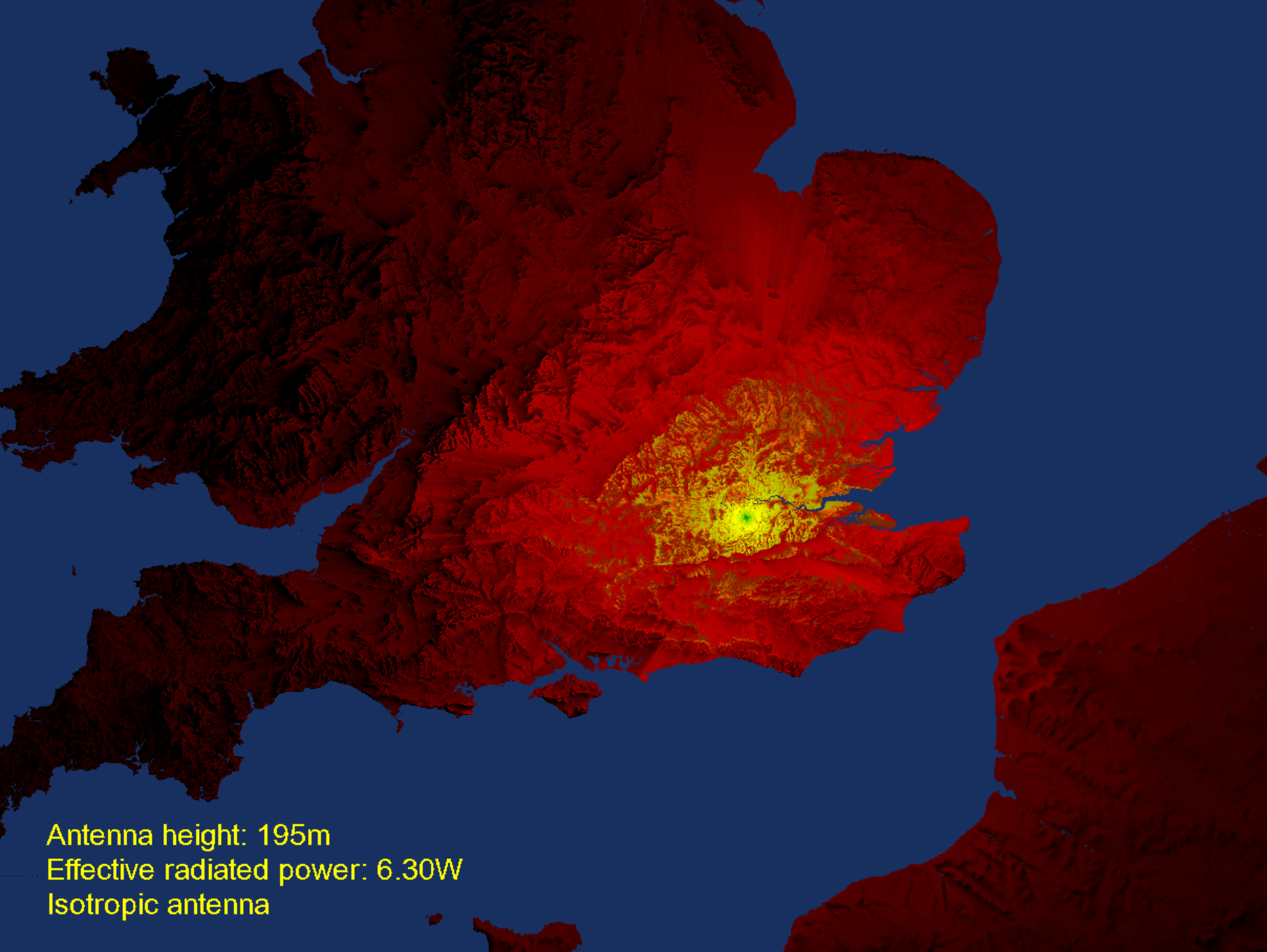
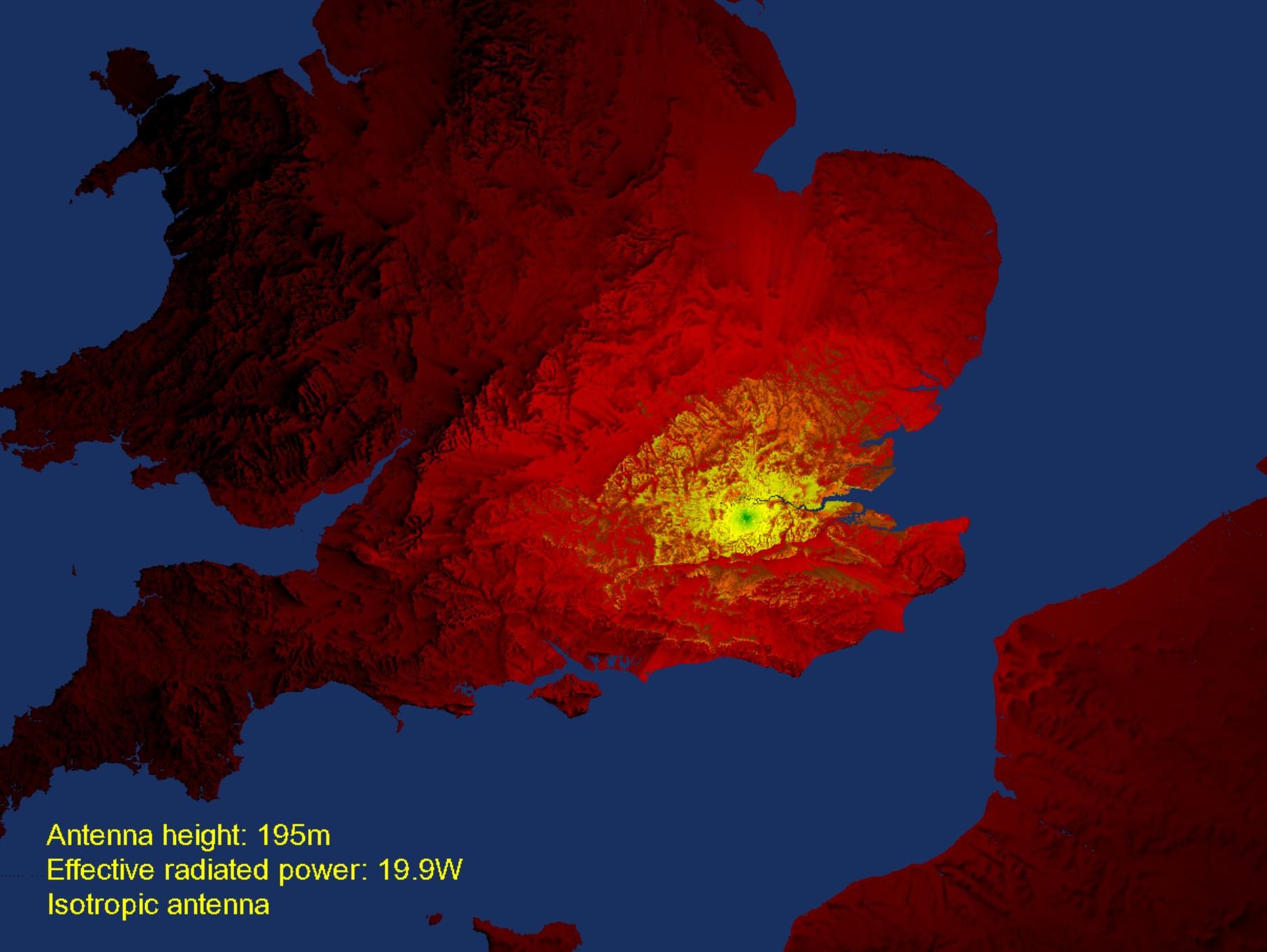
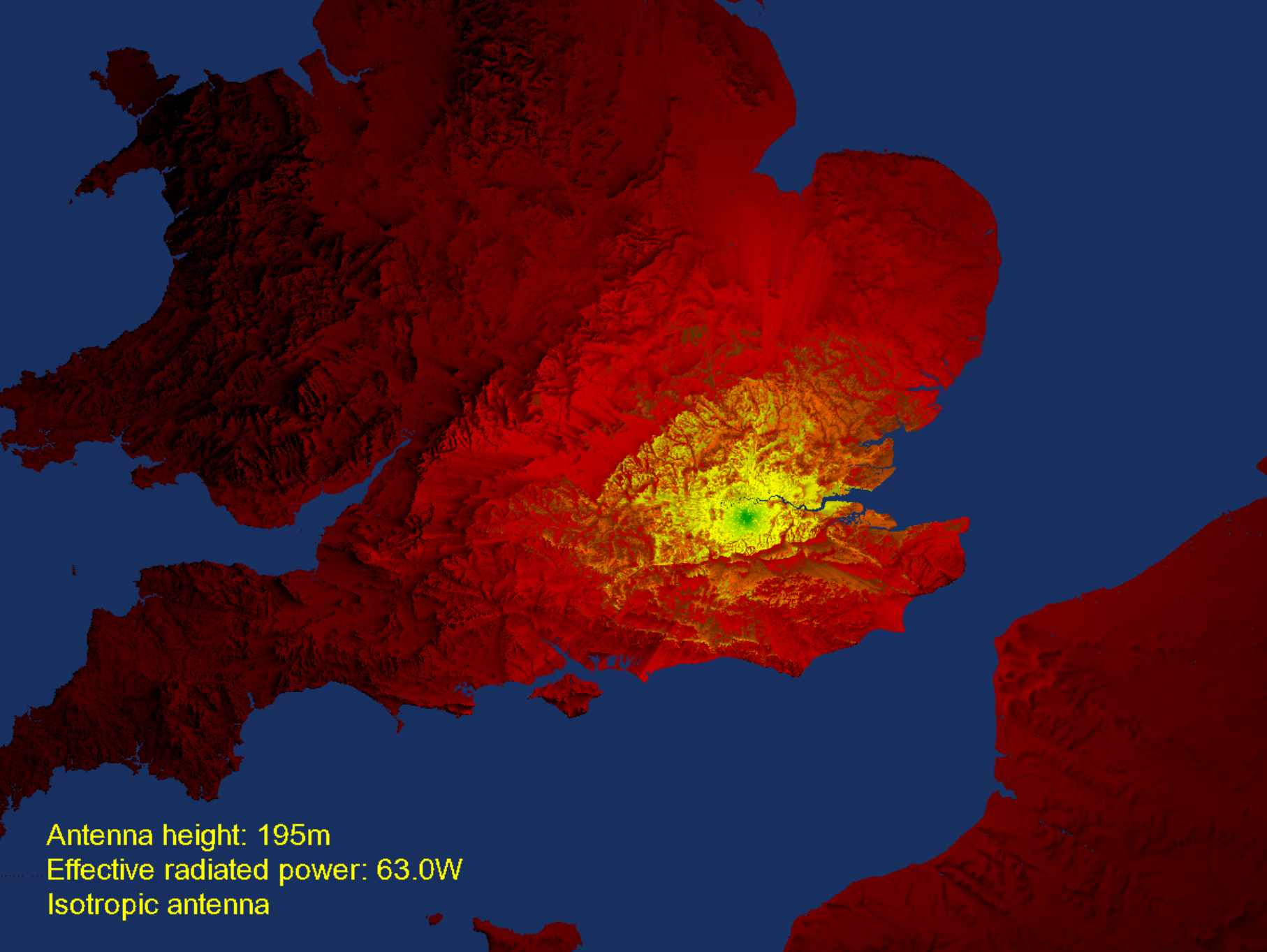
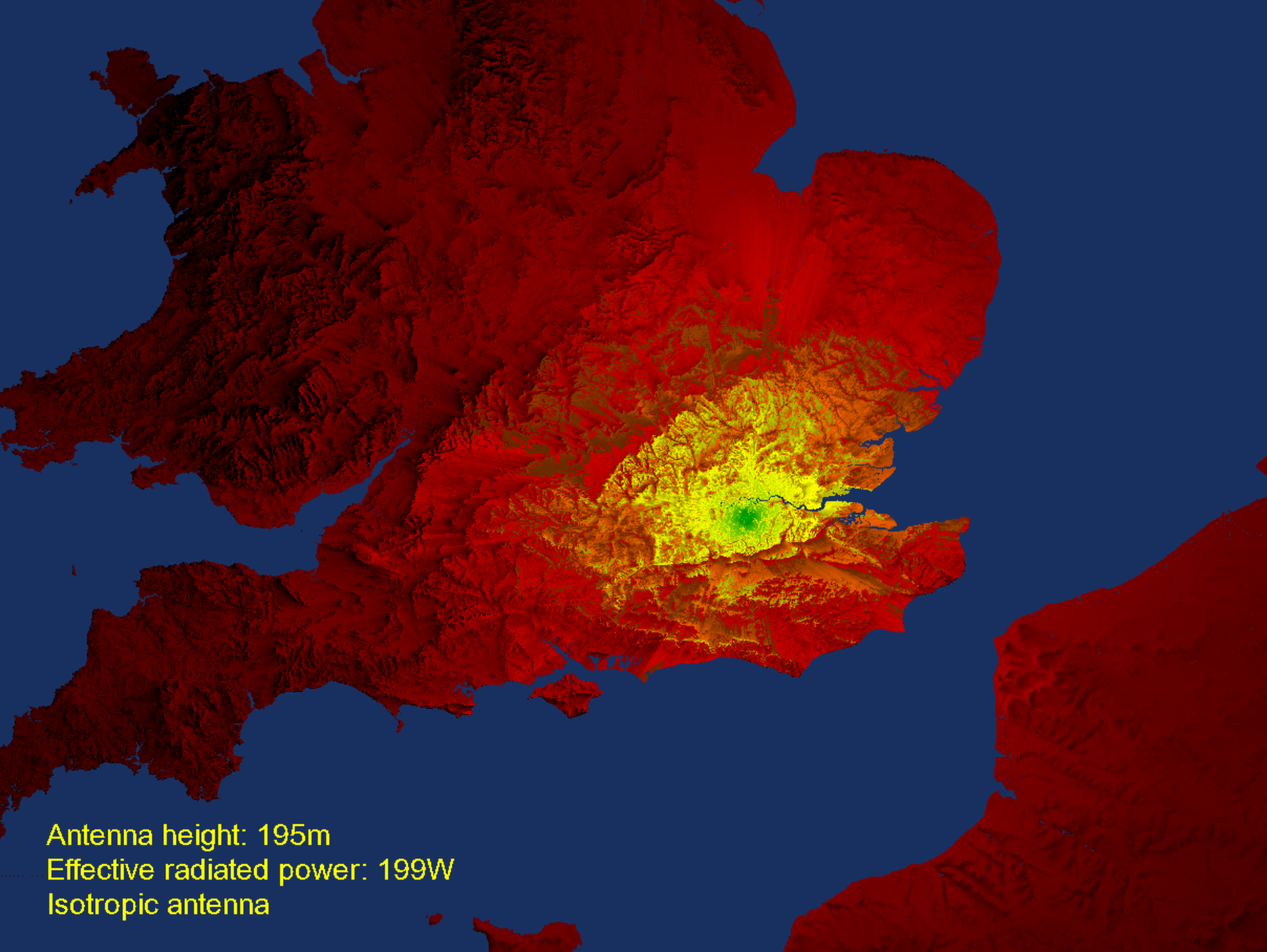
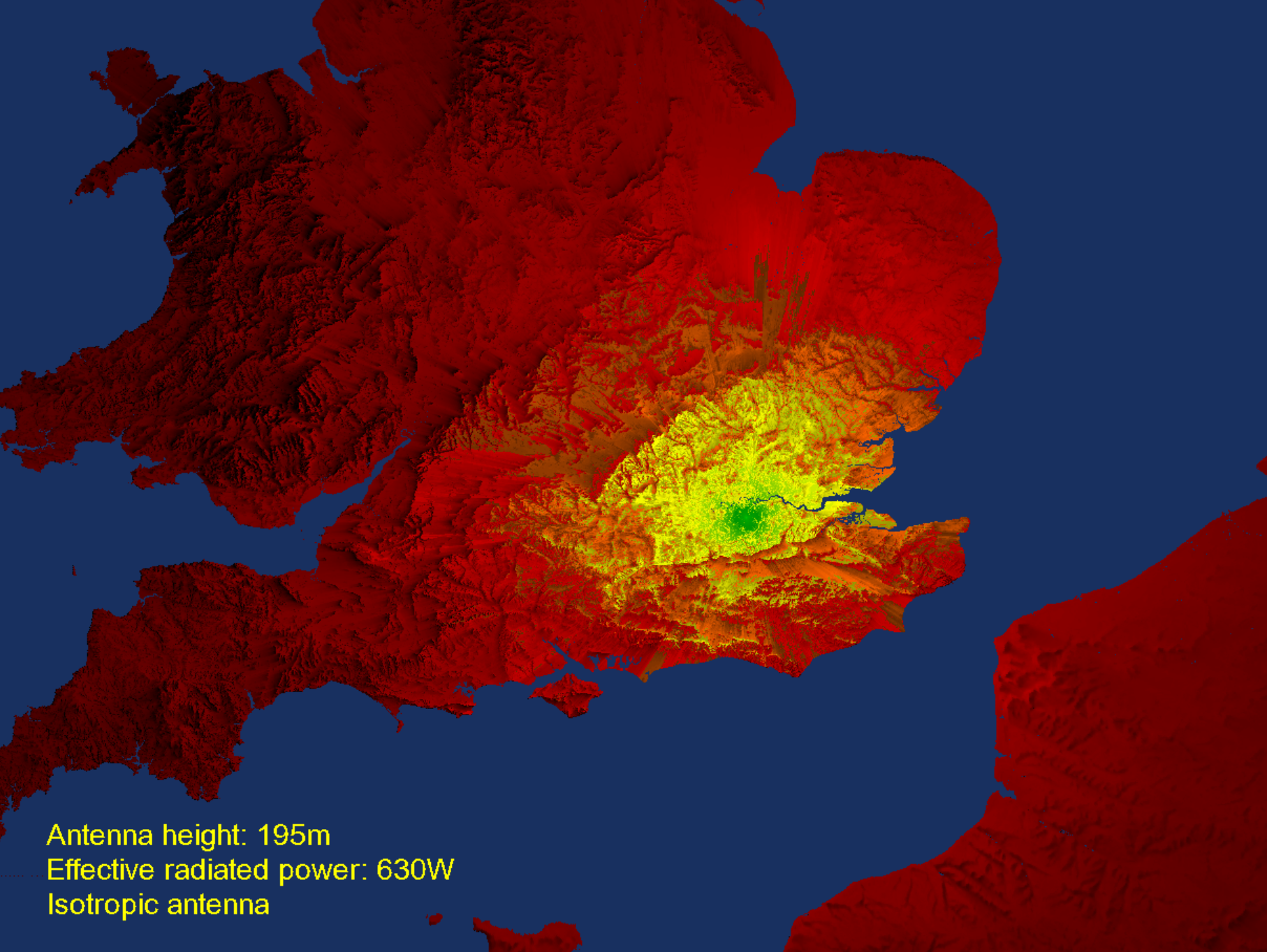

Antenna height: 195m
Effective radiated power: 1.99W
Isotropic antenna

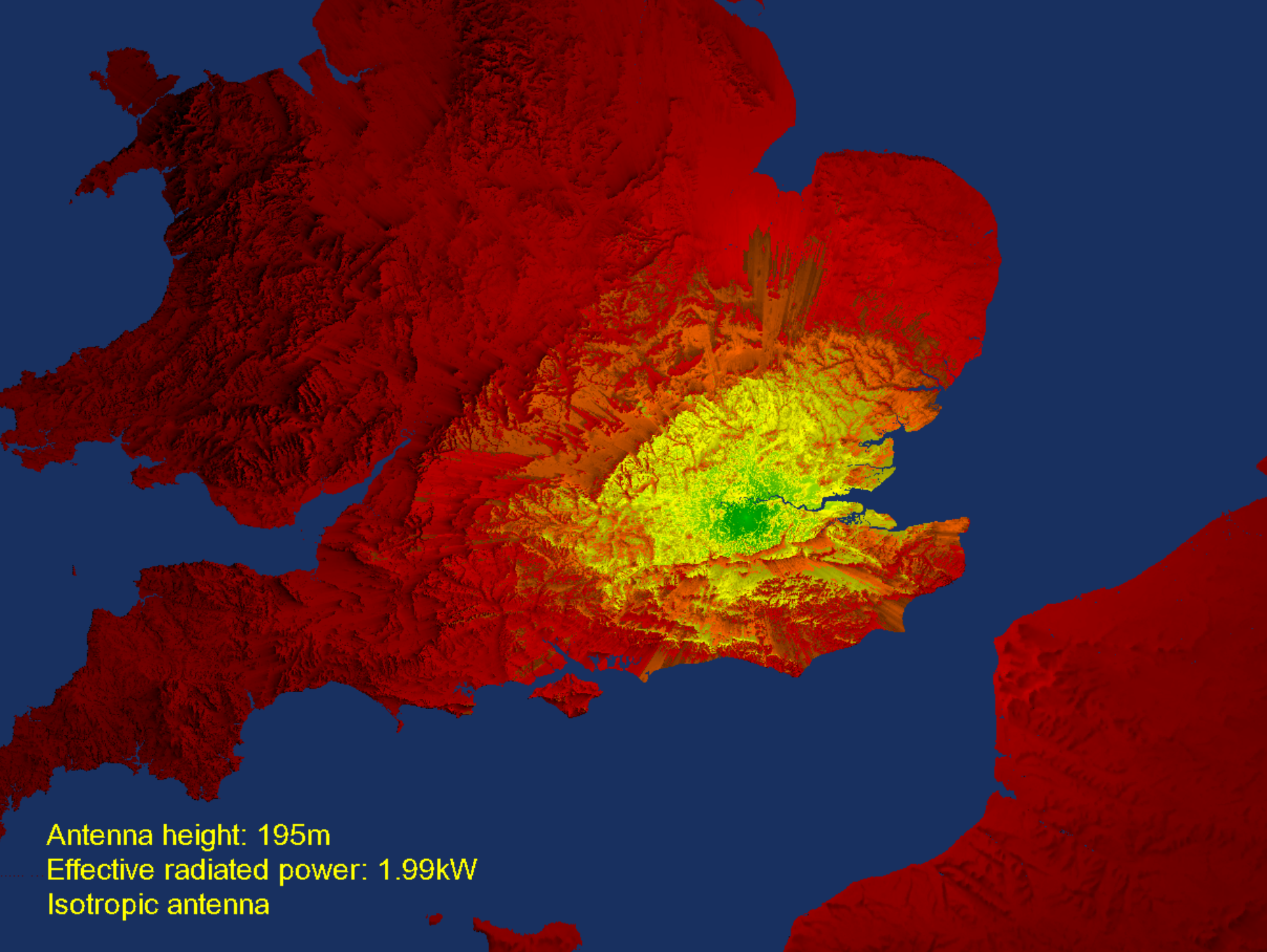

Antenna height: 195m
Effective radiated power: 6.30W
Isotropic antenna

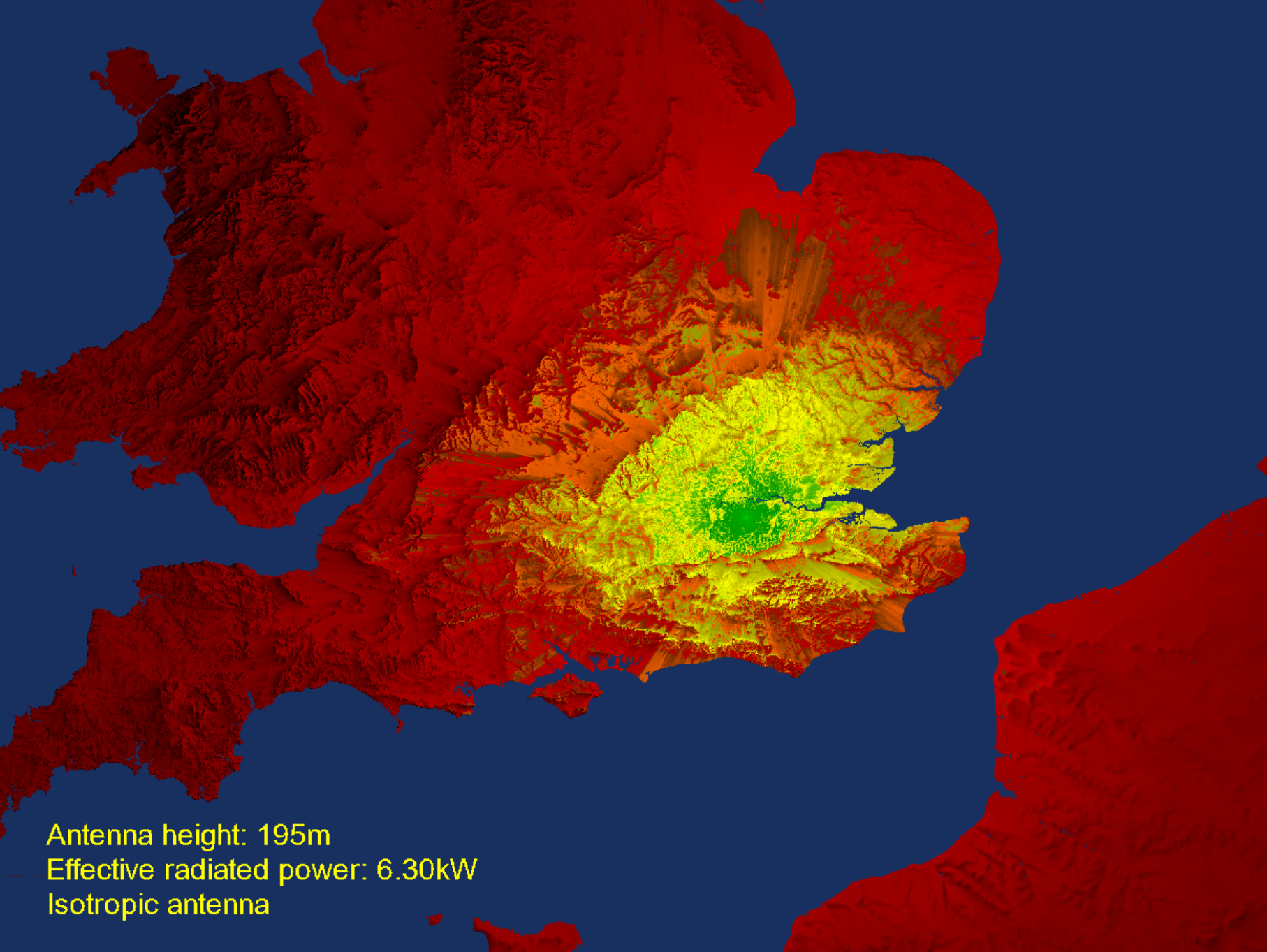

Antenna height: 195m
Effective radiated power: 19.9W
Isotropic antenna

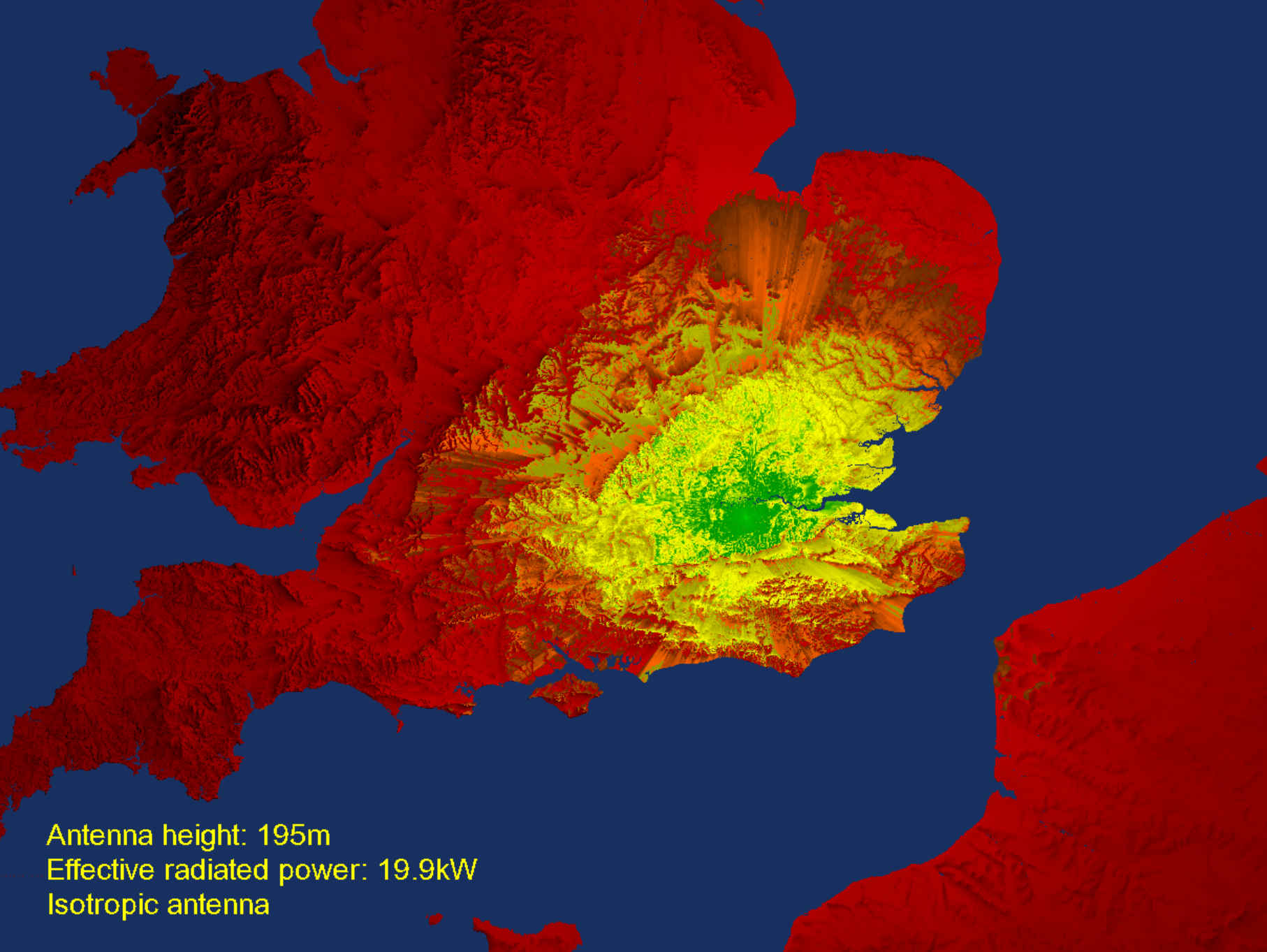

Antenna height: 195m
Effective radiated power: 63.0W
Isotropic antenna

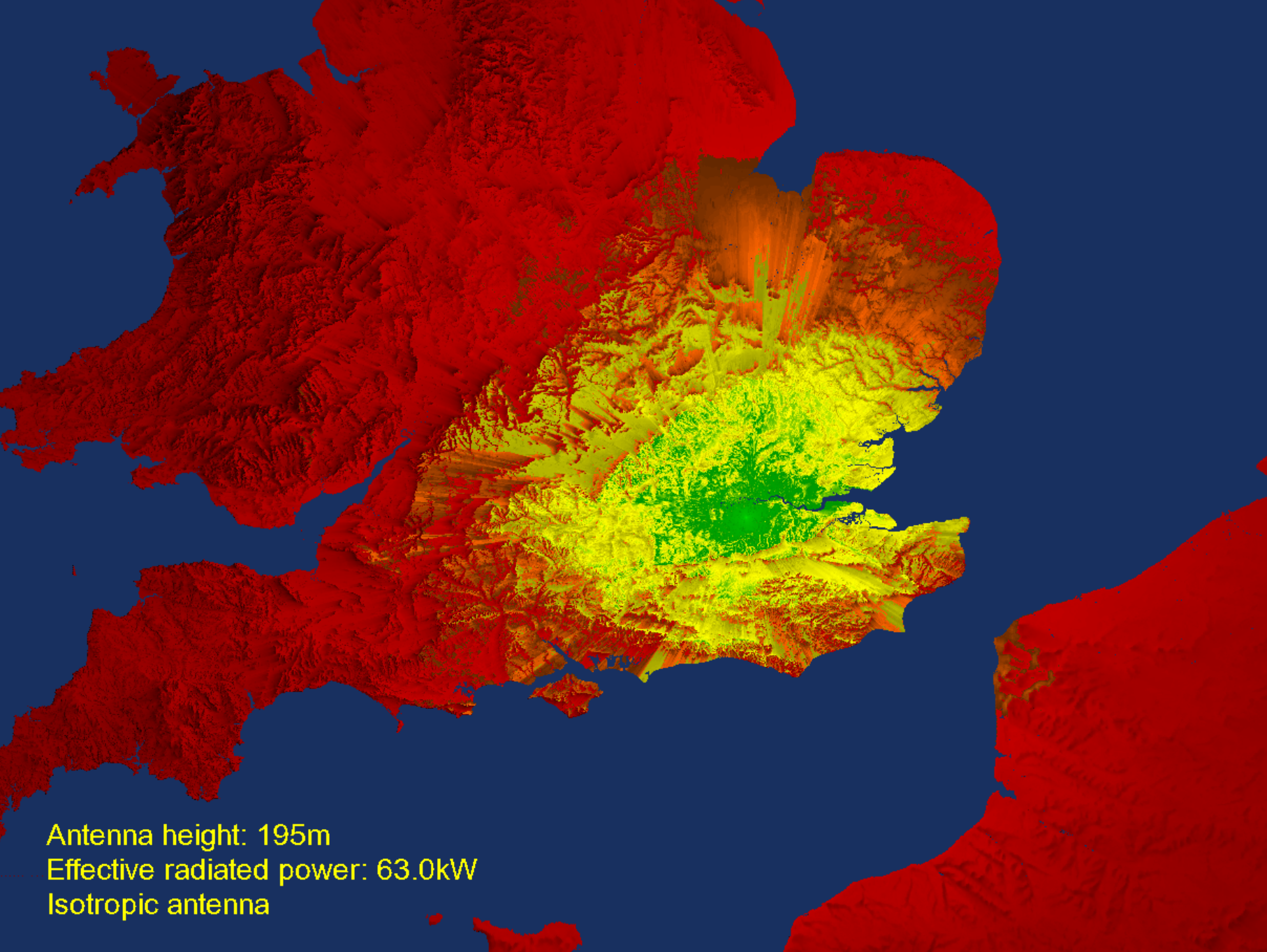

Antenna height: 195m
Effective radiated power: 199W
Isotropic antenna

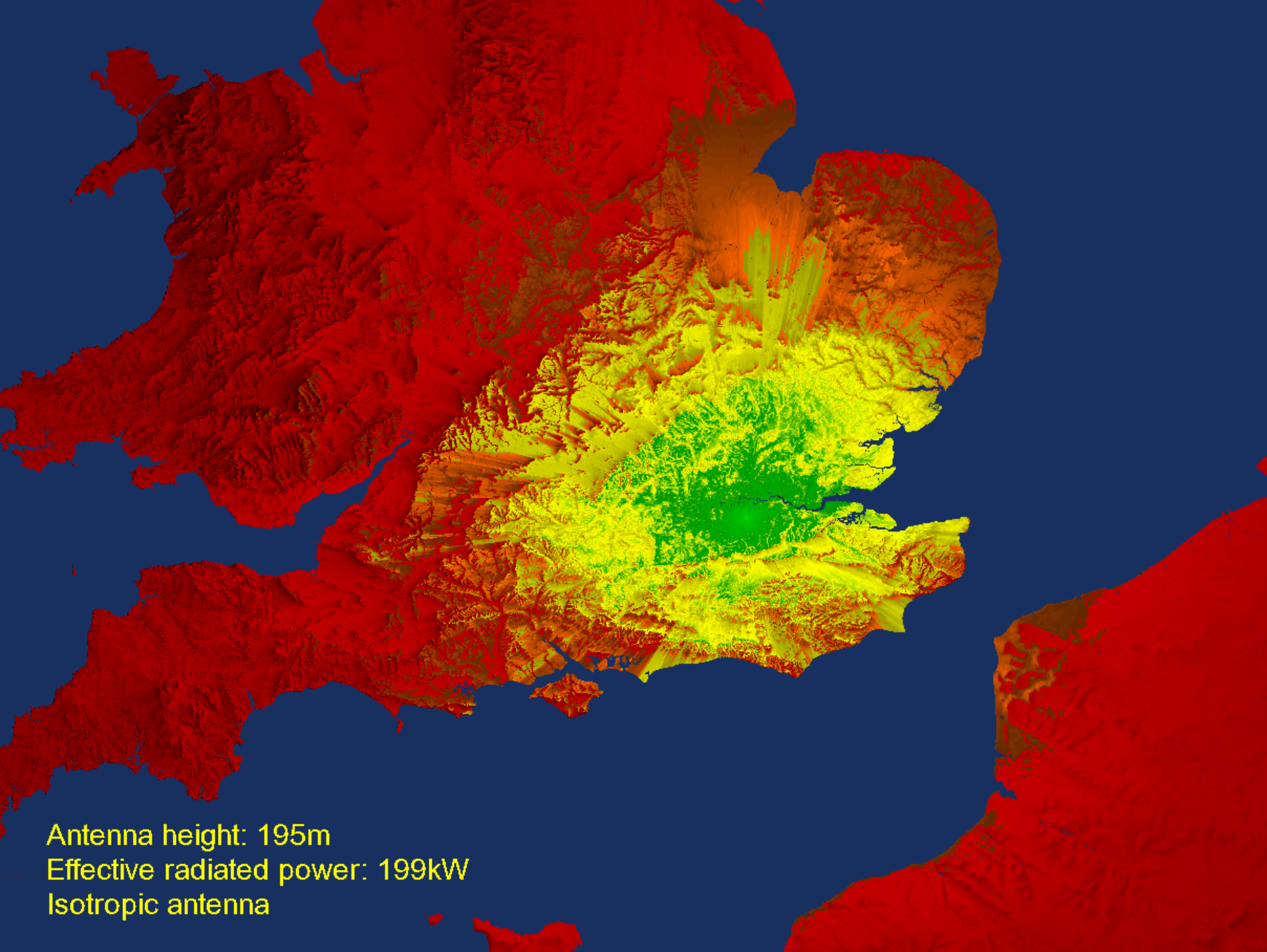

Antenna height: 195m
Effective radiated power: 630W
Isotropic antenna

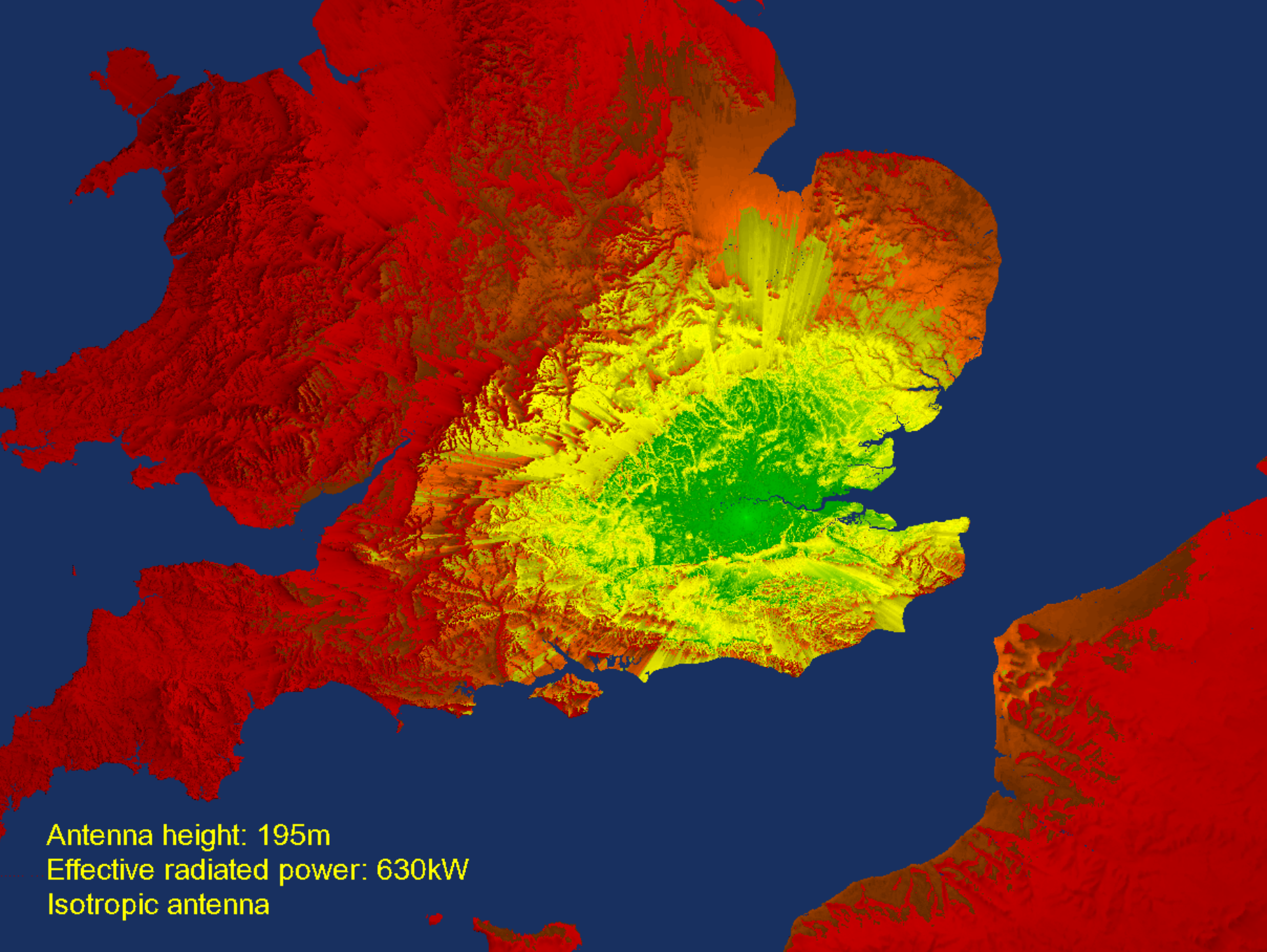

Antenna height: 195m
Effective radiated power: 1.99kW
Isotropic antenna

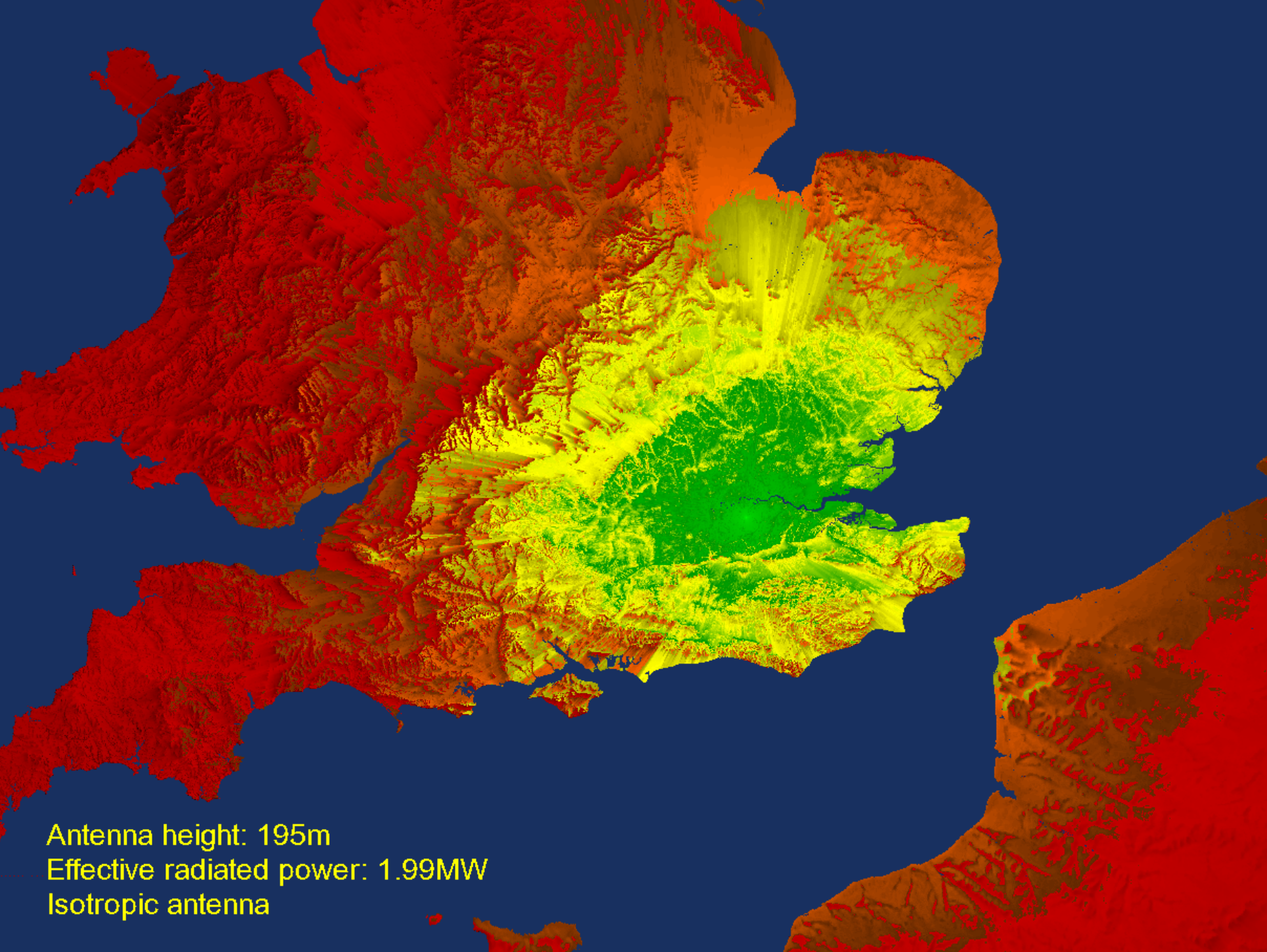

Antenna height: 195m
Effective radiated power: 6.30kW
Isotropic antenna


Antenna height: 195m
Effective radiated power: 19.9kW
Isotropic antenna


Antenna height: 195m
Effective radiated power: 63.0kW
Isotropic antenna


Antenna height: 195m
Effective radiated power: 199kW
Isotropic antenna


Antenna height: 195m
Effective radiated power: 630kW
Isotropic antenna


Antenna height: 195m
Effective radiated power: 1.99MW
Isotropic antenna

Measurements

Coverage assessment from the ground . . .

- Sometimes there is no substitute for taking measurements in the field
  - to validate our computer predictions
  - to investigate ‘anomalies’ that may not be correctly predicted by computer

. . . and transmitter assessment from the air

- Sometimes we use a hired helicopter to check what is actually being radiated by a transmitting station

- We have developed special hardware and a procedure for doing this
- With it, we have discovered errors in the construction of several transmitting antennas

The End
Thank you for your attention