RADAR AND RADIO REMOTE SENSING

* LECTURER

- DR ROBERT WATSON

R.J. Watson @ bath.ac.uk
x 6893

- DR MARTIN FULLEKRUG.

M. Fullekrug @ bath.ac.uk
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* LECTURES

- 2 x 1hr x 12 = 24 hrs.
- WEEKS 1 – 10, 14 – 15

- 10:15 – 11:15 TUES 8W2.5
- 11:15 – 12:15 TUES WH1LT

TEXT BOOKS

"PROPAGATION OF RADIO WAVES" M.P.M. HALL, L.W. BARCLAM & M. HEWITT IEE

"INTRODUCTION TO RADAR SYSTEMS" M.I. SKOLNIK, McGRAW-HILL 2001

"ELECTROMAGNETIC WAVE PROPAGATION, RADIATION AND SCATTERING" A. ISHIMARU PRENTICE-HALL, 1991

"ANTENNAS" J.D KRAUS, McGRAW-HILL, 1988.

EXCELLENT BUT TOO EXPENSIVE FOR U/G / P/G USE:

"MICROWAVE REMOTE SENSING: ACTIVE & PASSIVE" IN 3 VOLS ~ £160. — IN LIBRARY.

"COMMS" BOOKS BUT CONTAINING USEFUL INFO.

"WIRELESS COMMUNICATIONS, PRINCIPLES & PRACTICE" T.S. RAPPAPORT. PRENTICE-HALL.

"ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION SYSTEMS" SIMON SAUNDERS, WILEY

* SKOLNIK'S RADAR BOOK IS QUITE READABLE AND IS A GOOD BUY IF YOU PLAN A CAREER IN RADAR.

~ £35.

SYLLABUS 2004 | 2005

* ANTENNAS :
  - WIRE
  - APERTURE
* NOISE AND POWER BUDGETS.
* FREE-SPACE PATH LOSS
* ANTENNA ARRAYS.
  - FIXED
  - AGILE
* THE E-M SPECTRUM : ELF TO EHF.
* ENVIRONMENTAL INFLUENCES FROM EARTH'S SURFACE AND ATMOSPHERE
  - DIELECTRIC PROPERTIES
  - ROUGHNESS
  - TEMPERATURE
  - IONIZATION
  - COMPOSITION.

* PROPAGATION IN ATMOSPHERE: (EARTH)

- REFRACTION
- REFLECTION, SCINTILLATION.
- GASEOUS ABSORPTION.
- HYDROMETEOR SCATTER & ABSORPTION.

* PROPAGATION OVER EARTH

- REFLECTION
- DIFFRACTION

* RADAR SYSTEMS

- RADAR EQUATION
- PULSE, CW, FM-CW SYSTEMS
- AMBIGUITY FUNCTIONS
- FALSE ALARM RATIO | PROB. OF DETECTION
- PULSE COMPRESSION
- SYNTHETIC APERTURE TECHNIQUES

* RADIOMETRY

- RATIATIVE TRANSFER
- RADIOMETER SYSTEMS
- DICKE SWITCH BALANCING TECHNIQUES
- CORRELATION TECHNIQUES

* APPLICATIONS

- TRMM
- ENVISAT.

RADIO WAVE PROPAGATION

THE MECHANISM BY WHICH RADIOWAVES PROPAGATE CAN BE (ROUGHLY) CLASSIFIED INTO ONE OF THE FOLLOWING.

* SURFACEWAVE PROPAGATION
* SKY WAVE PROPAGATION (IONOSPHERE)
* SPACE WAVE PROPAGATION (L.O.S)
* SCATTER PROPAGATION

THE MECHANISM OF PROPAGATION DEPENDS LARGELY ON THE FREQUENCY (WAVELENGTH)

BAND	FREQUENCY	WAVELENGTH
ELF	30 - 300Hz	10000 - 1000 km
SLF	300 - 3000 Hz	1000 - 100 km
VLF	3 - 30kHz	100 - 10 km
LF	30 - 300 kHz	10 - 1 km
MF	300 - 3000 KHz	1km - 100 m
HF	3 - 30MHz	100 - 10m
VHF	30 - 300 MHz	10 - 1m
UHF	300 - 3000 MHz	1m - 10cm
SHF	3 - 30GHz	10 - 1 cm
EHF	30 - 300GHz	1cm - 1m
INFRARED	> 300GHz	< 1mm

BAND USE

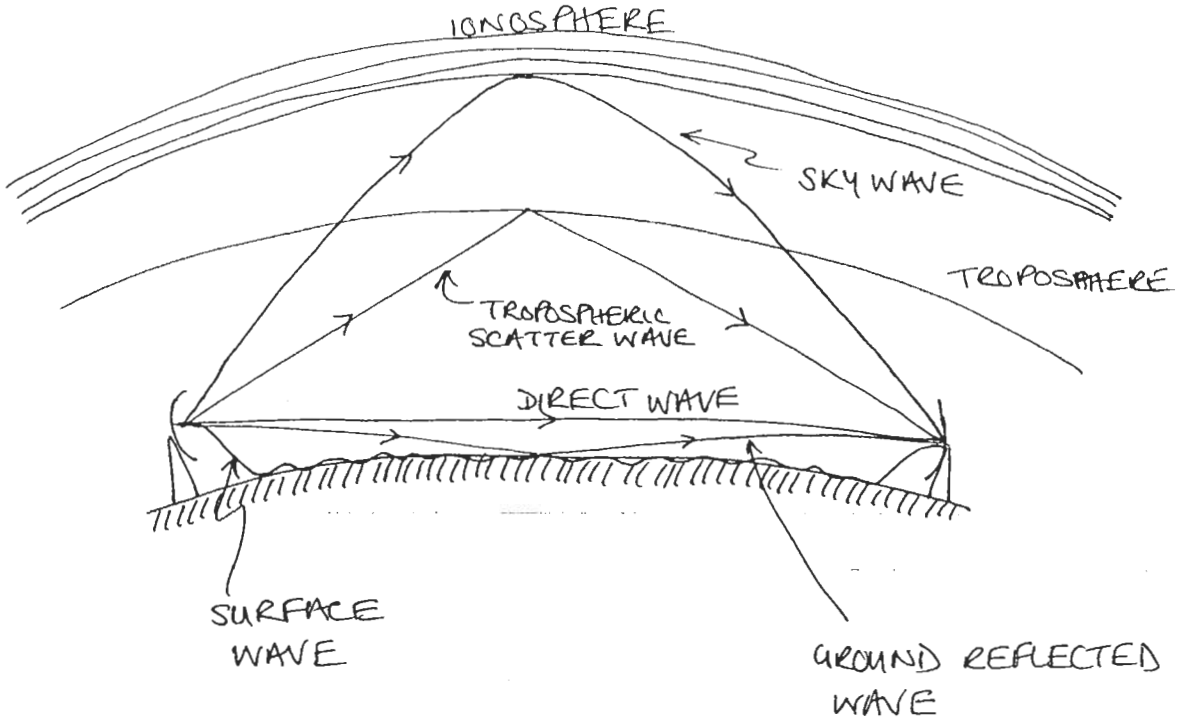
30 Hz
| ELF
300 Hz
| SLF
3 KHz
| VLF - SUBMARINE & OTHER MILITARY
30 KHz
| LF - BROADCAST (LW - AM), NAVIGATION
300 KHz
| MF - BROADCAST (MW - AM) MILITARY
3 MHz
| HF - BROADCAST (SW - AM) OTH RADAR
30 MHz
| VHF - CIVIL, MILITARY AIRCRAFT, FM BROADCAST
300 MHz
| UHF - TV, CELLULAR PHONES, GPS, ASR
3 GHz
| SHF - WEATHER RADAR, SAT. COMMS.
30 GHz
| EHF - MUDS, SAT COMMS
300 GHz

RULE OF THUMB:

UPTO MF : SURFACE WAVE

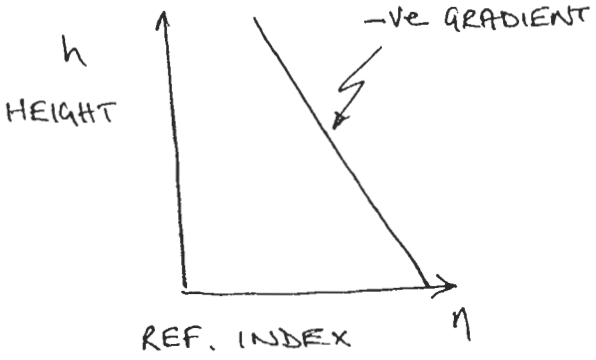
MF - HF : SKY WAVE

VHF AND UP : SPACEWAVE

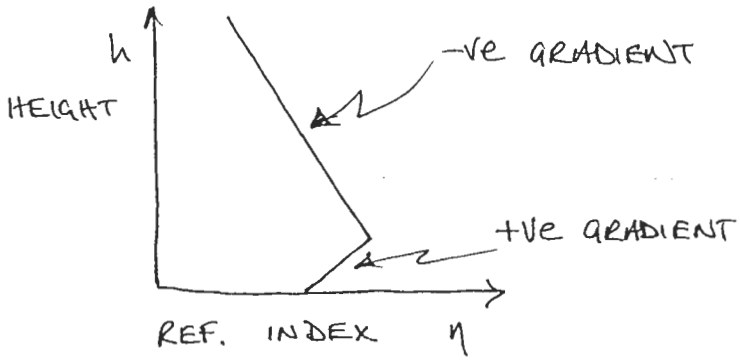


METHODS OF PROPAGATION.

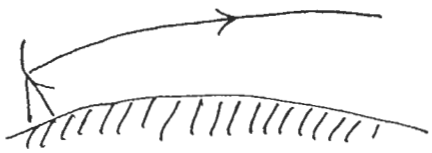
REFRACTION



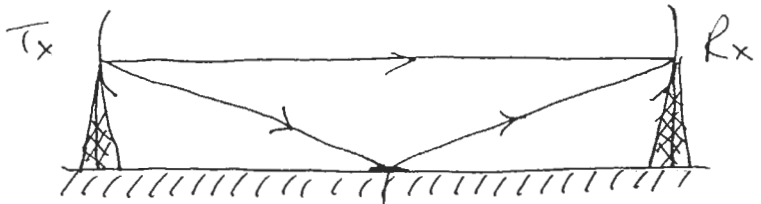
STANDARD ATMOSPHERE



NON-STANDARD ATMOSPHERE



REFLECTION

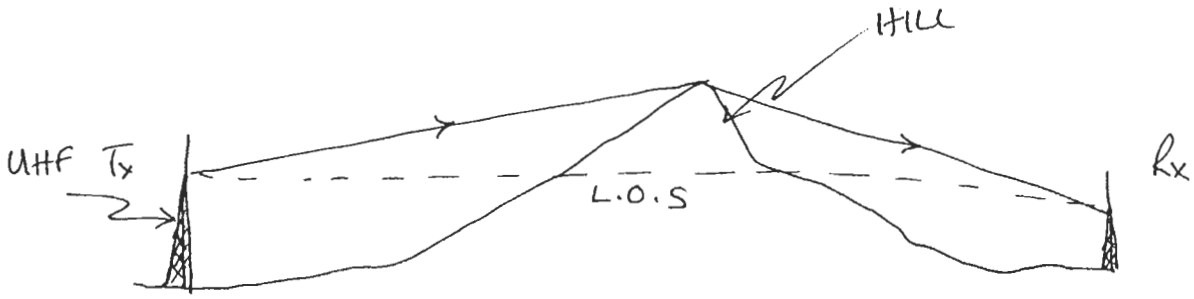


REFLECTION COEFFICIENT

SPECULAR OR DIFFUSE

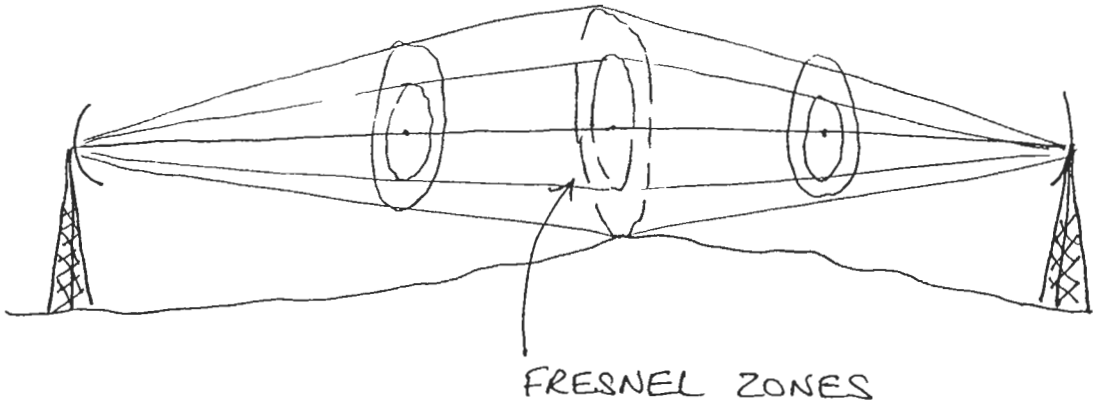
(SMOOTH) (ROUGH)

DIFFRACTION



NO L.O.S. PROPAGATION VIA DIFFRACTION

CLEARANCE (FRESNEL ZONES)



FADING

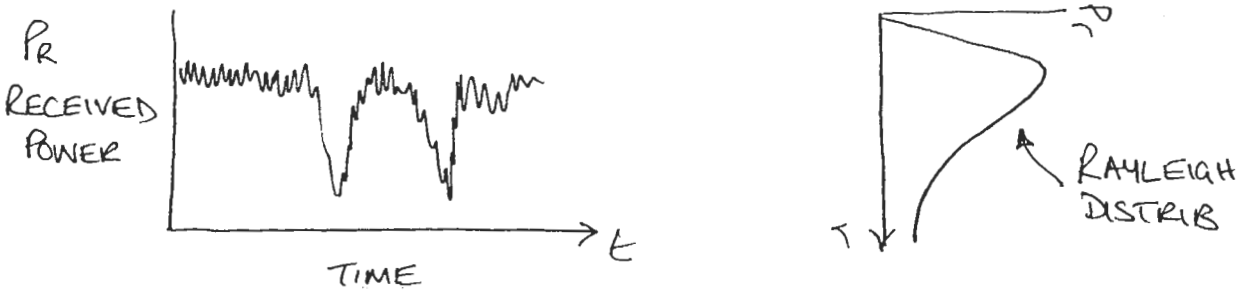
ALL NON FREE-SPACE LOSSES

* RAIN, CLOUD (ABSORPTION & ATTENUATION)
* DEPOLARIZATION
* MULTI PATH

SHORT-TERM FADING (FAST FADING)

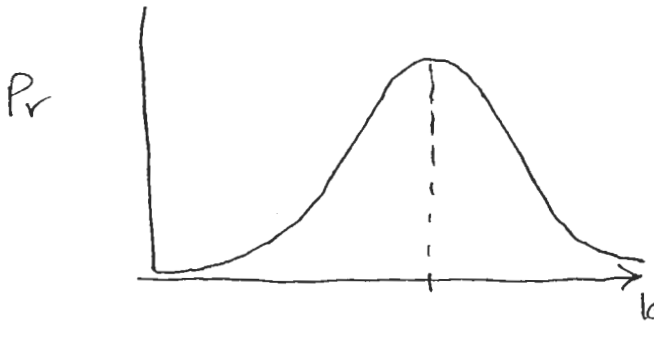
MULTI-PATH : SUM OF MANY PATHS OF DIFFERENT AMPLITUDES AND PHASES

→ MODELLED BY RAYLEIGH DISTRIBUTION



LONG-TERM FADING (SLOW FADING)

FLUCTUATIONS OVER LONG PERIODS, FOR EXAMPLE DIURNAL OR SEASONAL VARIATIONS



SLOW FADES HAVE A LOG-NORMAL DIST

← NOTE: LOG.

FROM: RADIO COMMUNICATION HANDBOOK
pub. RSGB 5th EDN.

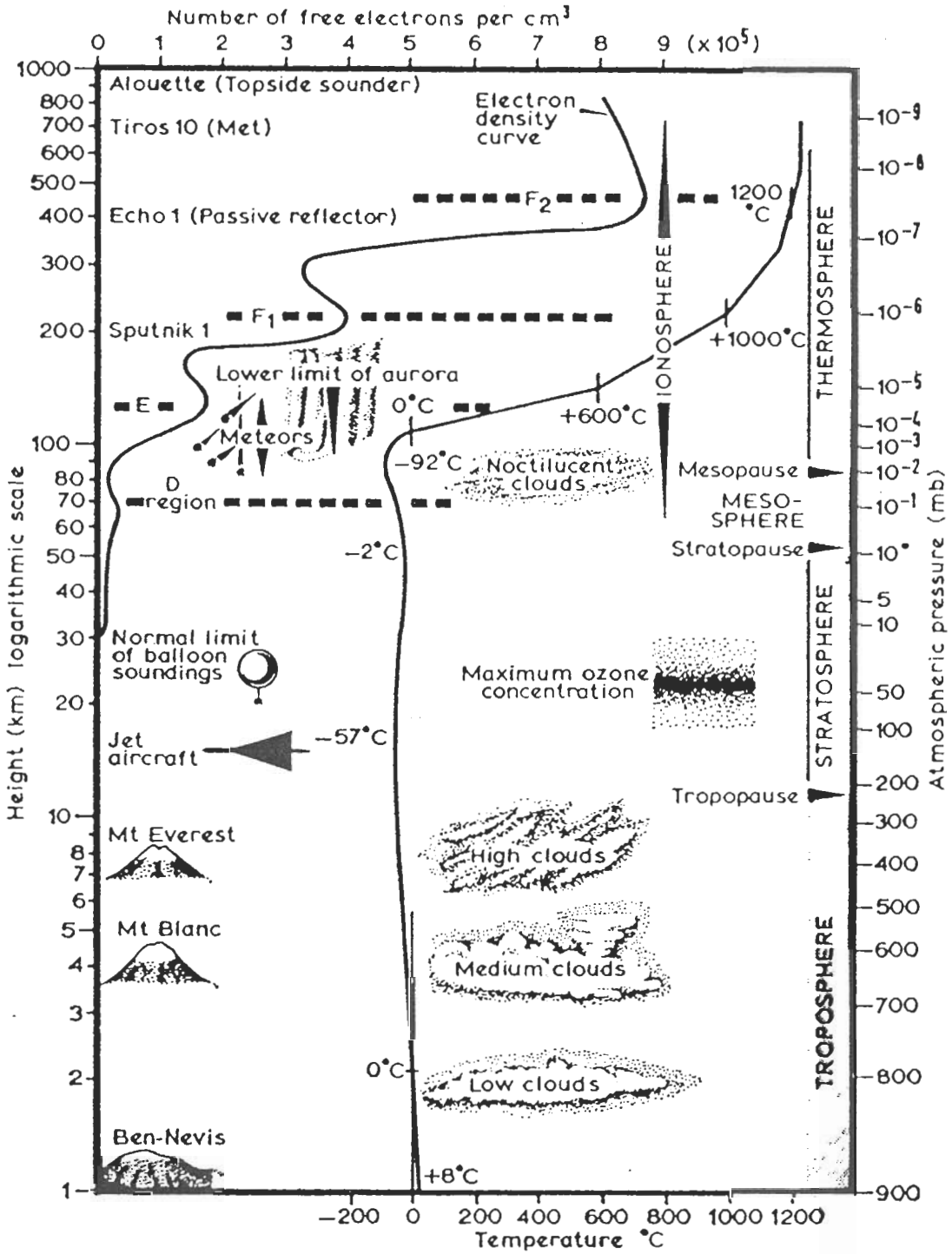
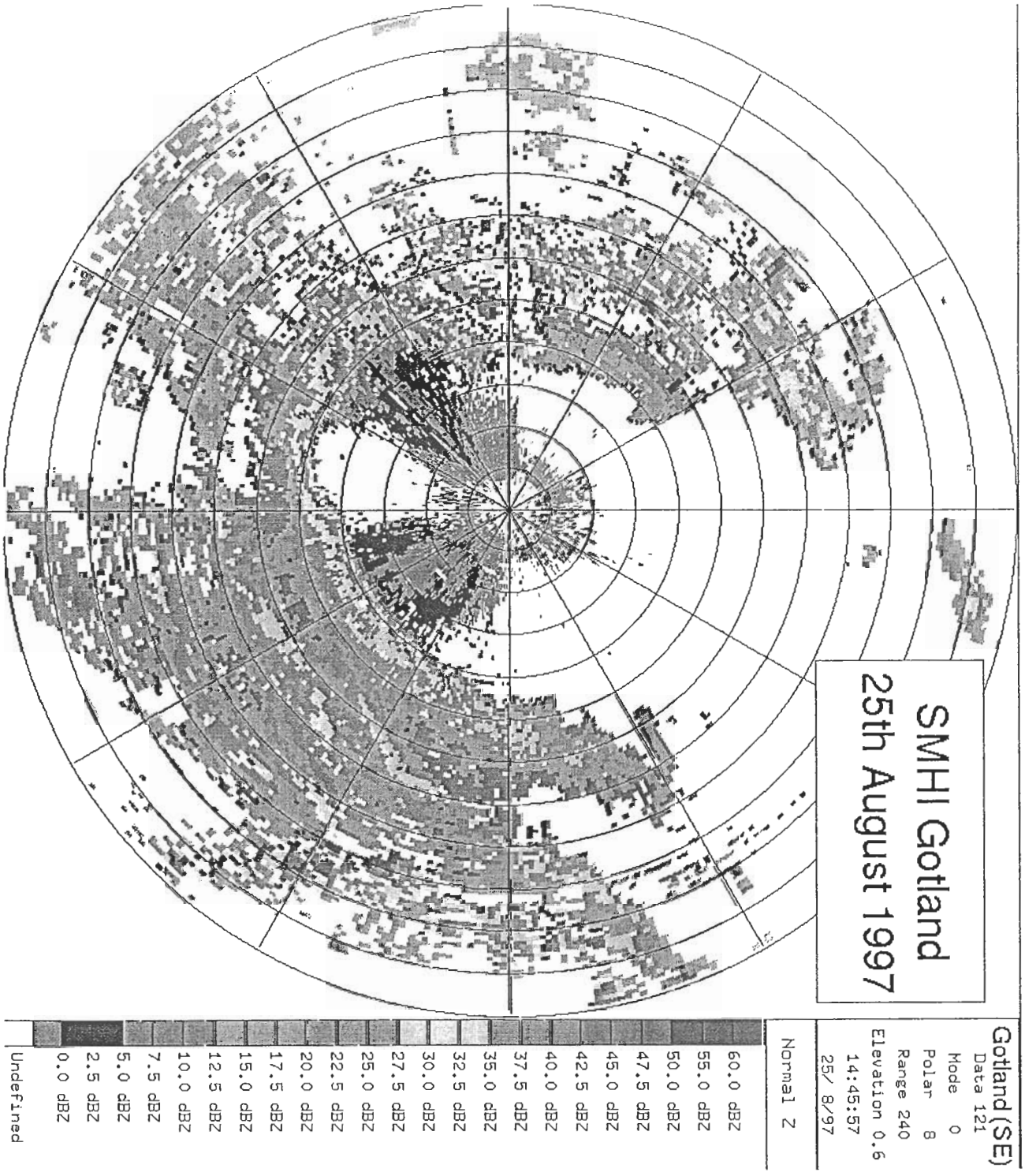


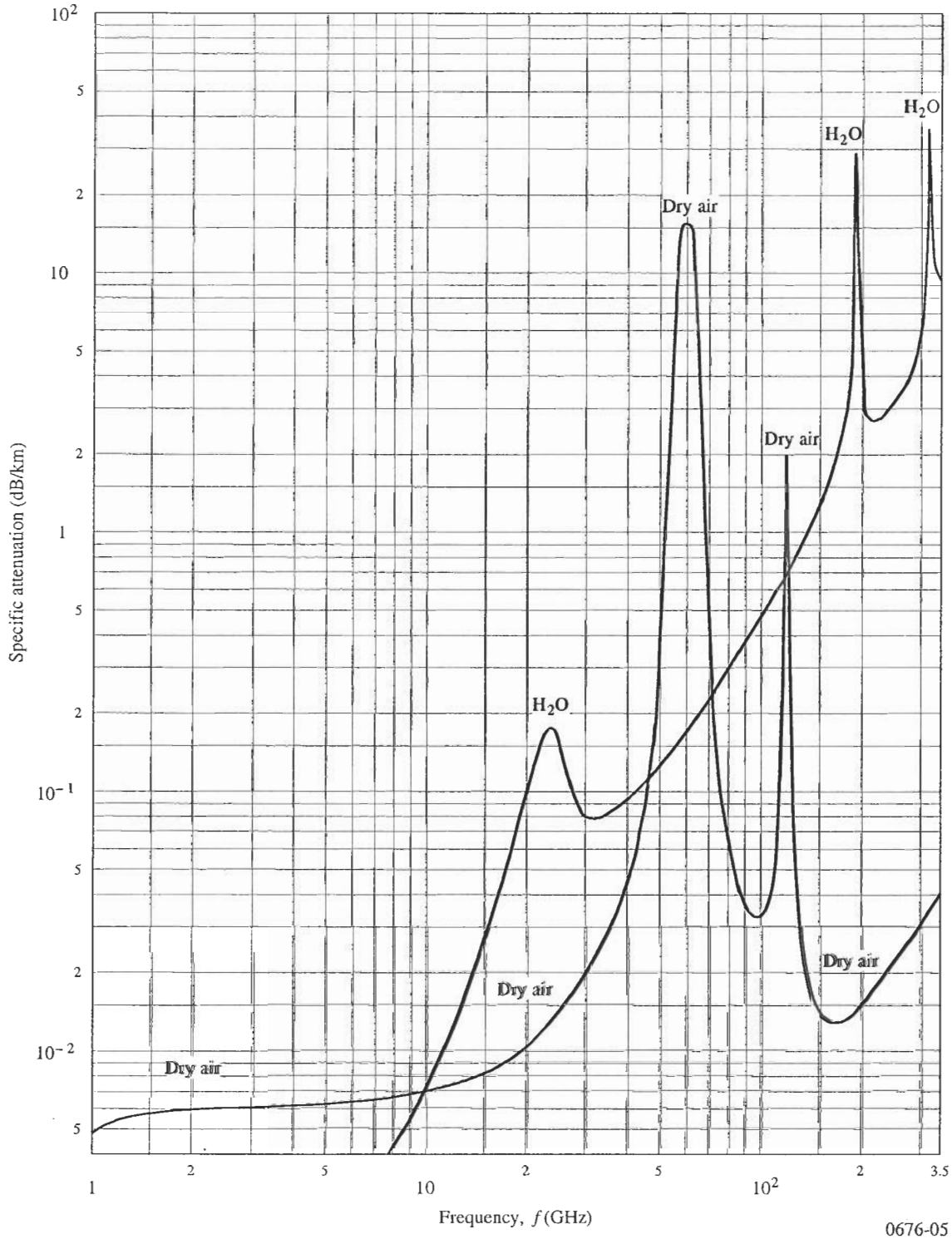
Fig 11.1. Some features of the earth's atmosphere. The height scale is logarithmic beginning at 1km above sea level. The equivalent pressure scale on the right is not regularly spaced because the relationship between pressure and height depends on temperature, which does not change uniformly with height.



(11)

FIGURE 5

Specific attenuation due to atmospheric gases



Pressure: 1 013 hPa
Temperature: 15° C
Water vapour: 7.5 g/m^3

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RECOMMENDATION ITU-R PN.837-1

CHARACTERISTICS OF PRECIPITATION FOR PROPAGATION MODELLING

(Question ITU-R 201/3)

(1992-1994)

The ITU Radiocommunication Assembly,

considering

a) that information on the statistics of precipitation intensity is needed for the prediction of attenuation and scattering caused by precipitation;

b) that the information is needed for all locations on the globe;

c) that a digitized version of the rainfall climate zone maps has been prepared that may be valuable in some computer applications,

recommends

1. that Figs. 1 to 3 be used to select the rain climate region for the prediction of precipitation effects;

2. that Table 1 be used to obtain the expected median cumulative distribution of rain rate for the rain climate region;

3. that when the rain climate zone is required in computer applications for any given set of geographic coordinates, the program RAINZONE be used. (The software for RAINZONE may be obtained from the ITU Radiocommunication Bureau.)

TABLE 1

Rain climatic zones

Rainfall intensity exceeded (mm/h) (Reference to Figs. 1 to 3)

Percentage of time (%)	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
1.0	<0.1	0.5	0.7	2.1	0.6	1.7	3	2	8	1.5	2	4	5	12	24
0.3	0.8	2	2.8	4.5	2.4	4.5	7	4	13	4.2	7	11	15	34	49
0.1	2	3	5	8	6	8	12	10	20	12	15	22	35	65	72
0.03	5	6	9	13	12	15	20	18	28	23	33	40	65	105	96
0.01	8	12	15	19	22	28	30	32	35	42	60	63	95	145	115
0.003	14	21	26	29	41	54	45	55	45	70	105	95	140	200	142
0.001	22	32	42	42	70	78	65	83	55	100	150	120	180	250	170

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FIGURE 1
(See Table 1)

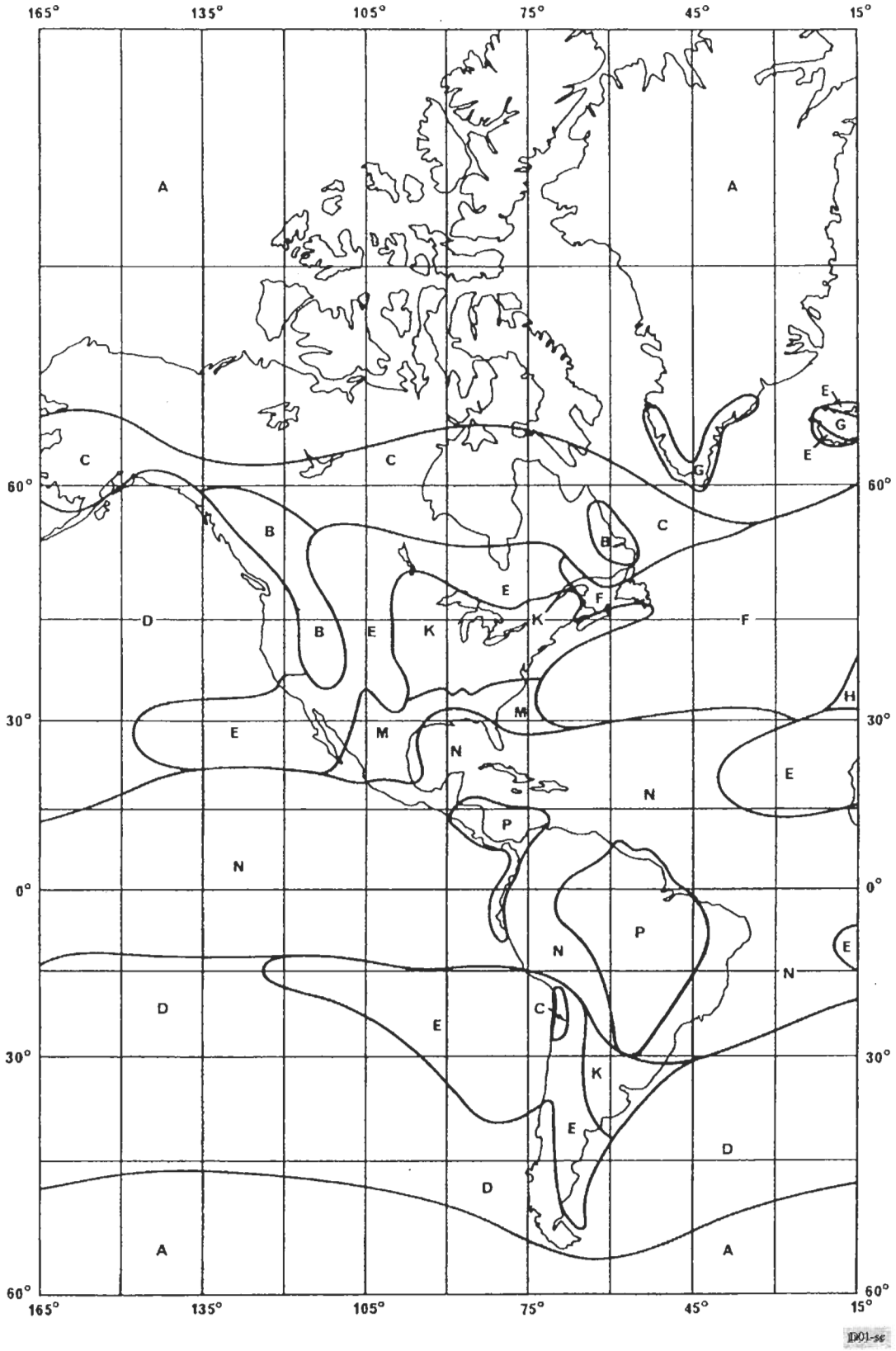

FIGURE 2
(See Table 1)

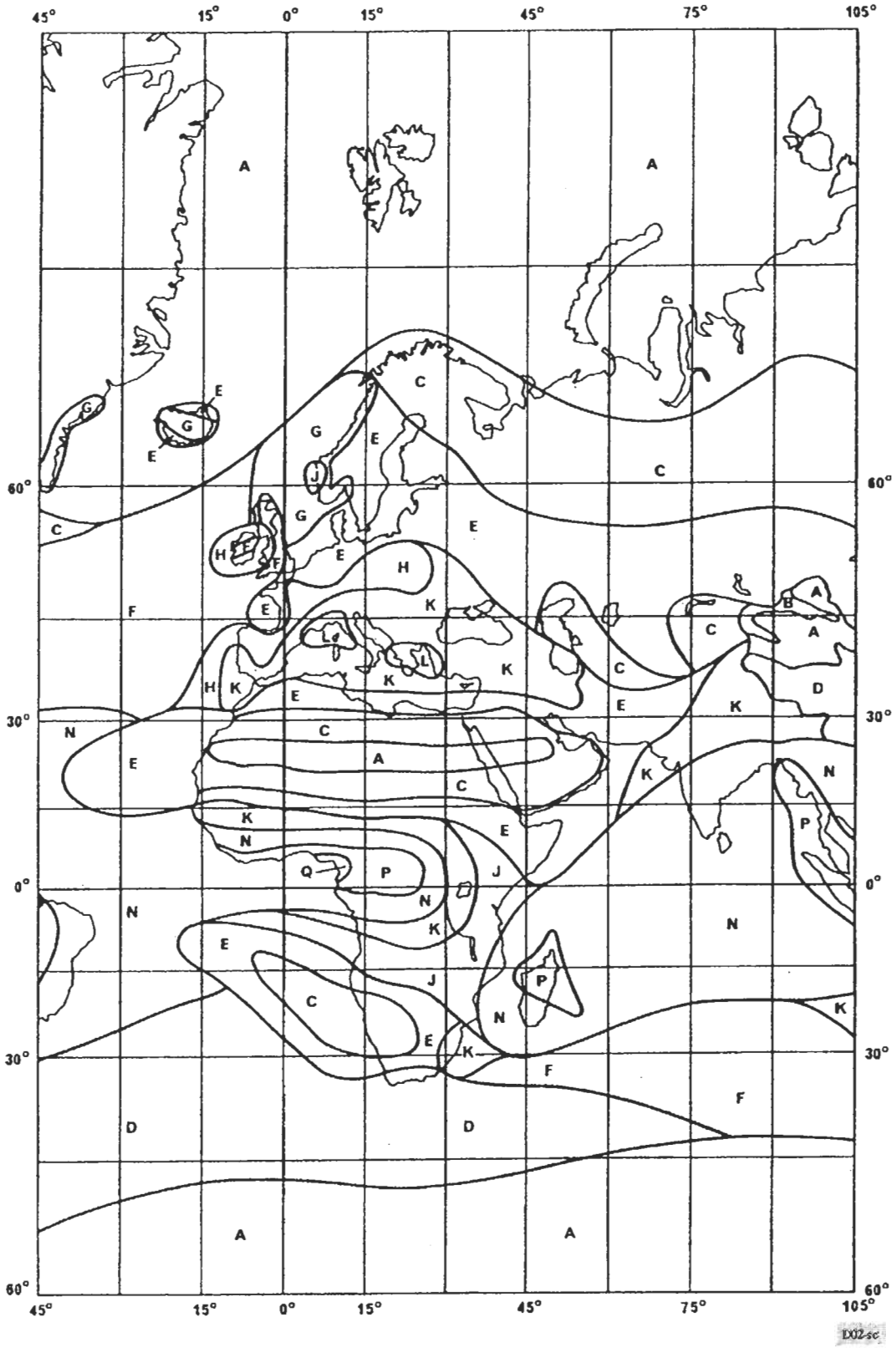

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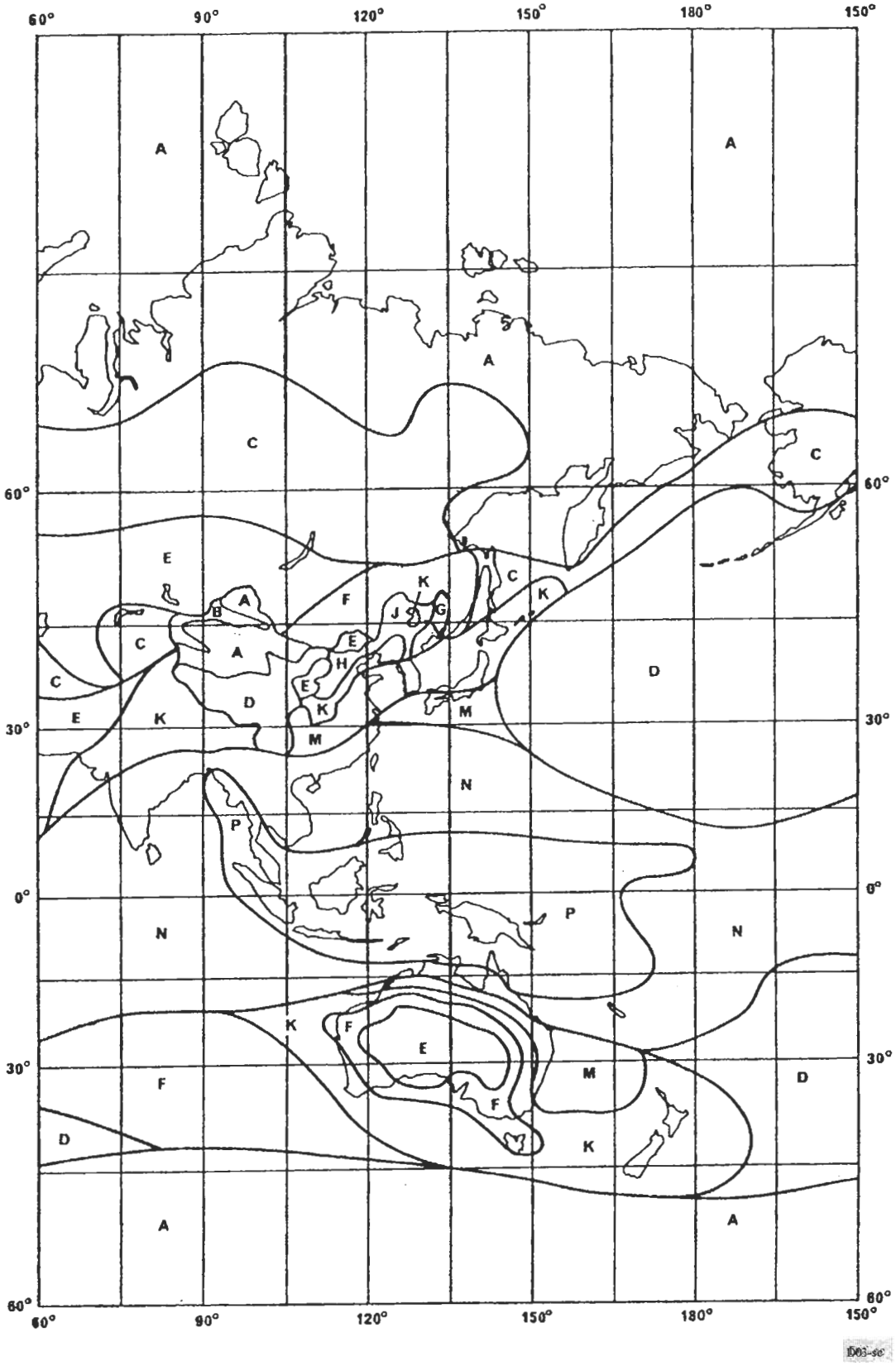
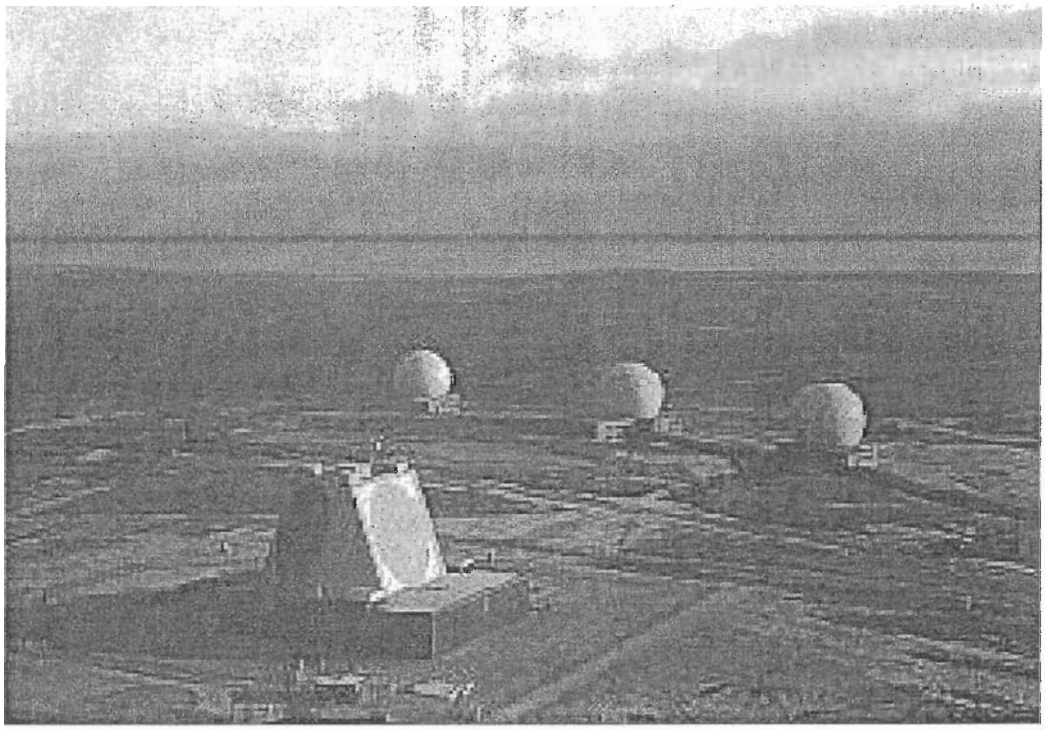
FIGURE 3
(See Table 1)



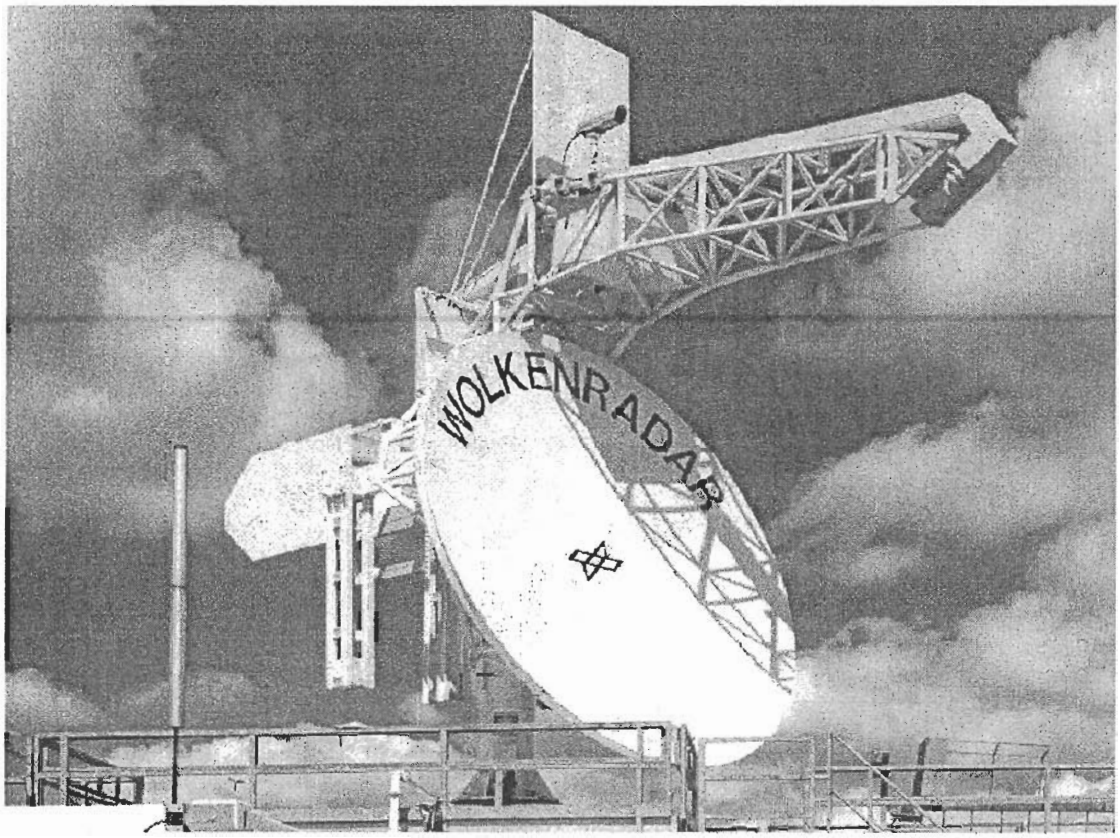
Fylingdales BMEWS, Yorkshire

Golfballs: mechanically scanned parabolic reflector



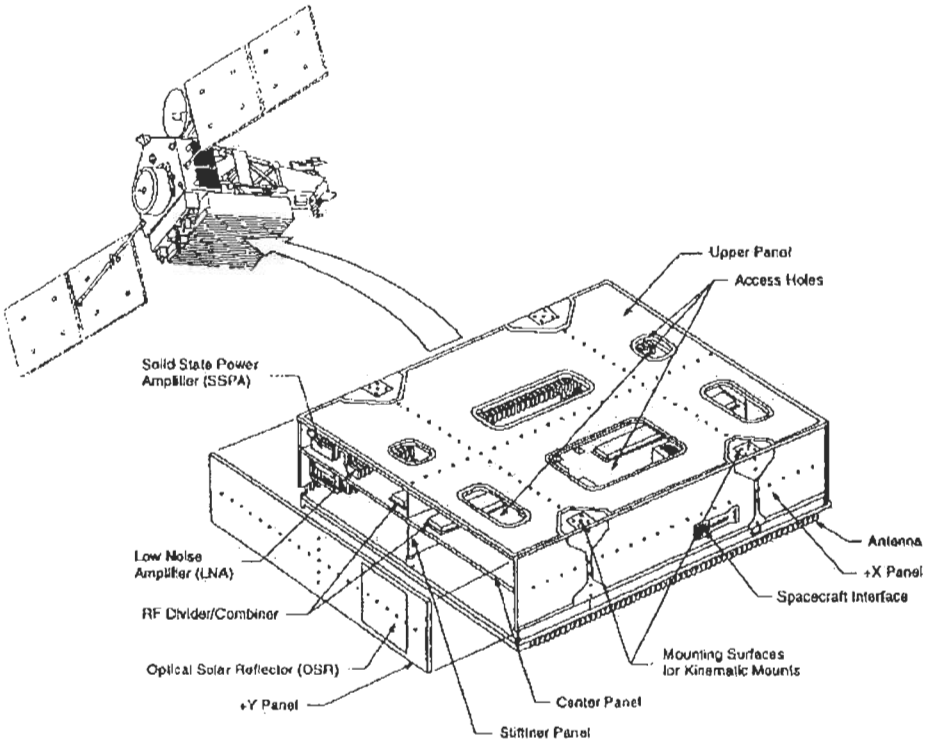
Agile steerable phased array radar, UHF 2.5MW

Research weather radar, C-band 450kW



Only (non-military) fully coherent, fully polarimetric weather radar in the world

TRMM: First ever spaceborne rain radar (1997)



PR Instrument Performance Characteristics

Parameter	Value
Observation Band Frequency	13.796 and 13.802 Gigahertz (GHz)
Pulse Repetition Frequency	2778.3 Hertz (Hz)
Horizontal Resolution (IFOV)	4.3 km
Swath Width	215 km
Pulse Width (each frequency)	1.67 μs @ nadir
Beam Width	0.71° @ nadir
Scan Angle (Cross track)	±17°

NASA/NASDA joint project

Largest fully steerable reflector antenna Max Plank Radio Astronomy Institute, Germany