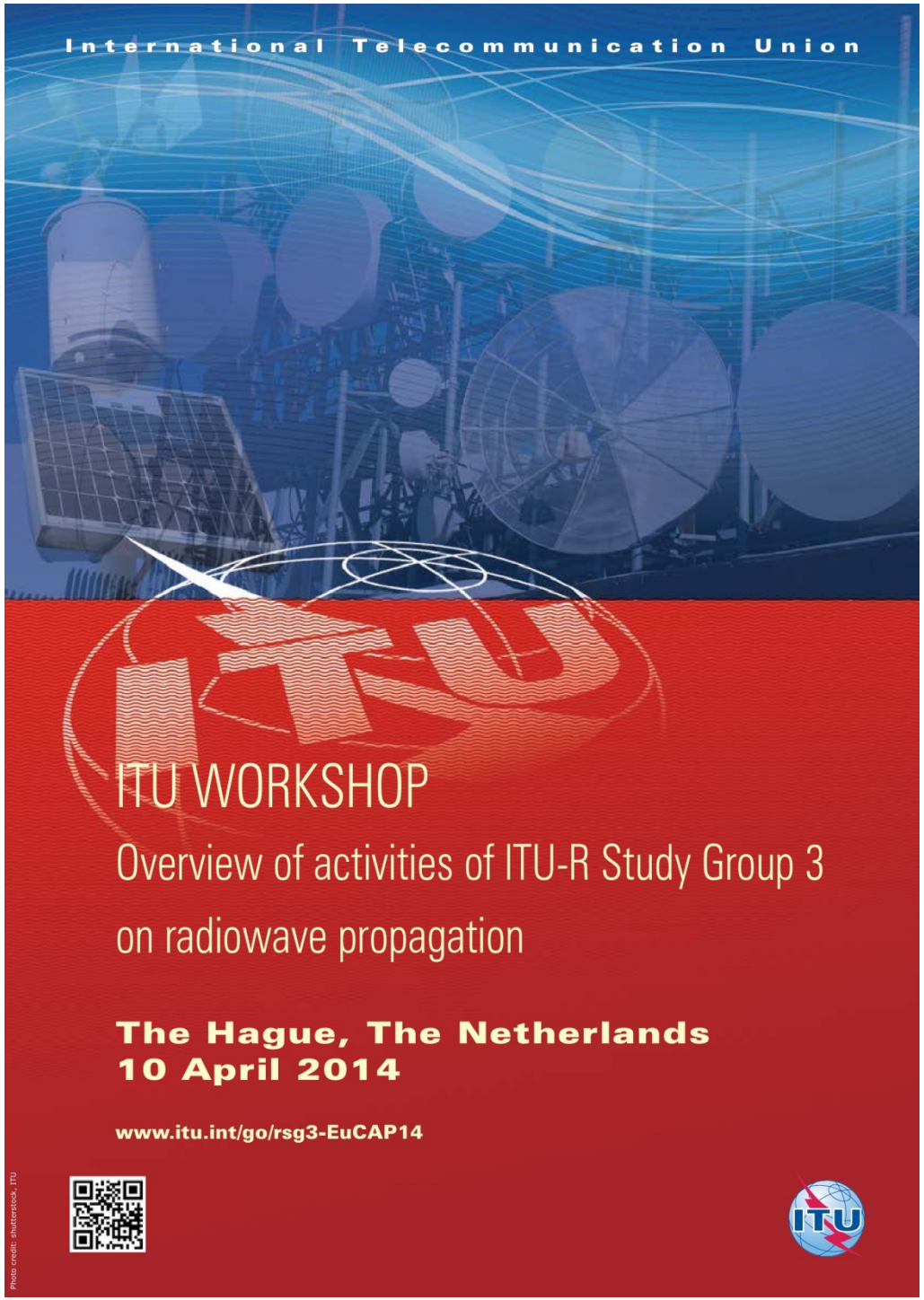
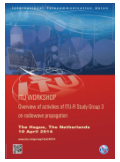


ITU WORKSHOP
Overview of activities of ITU-R
Study Group 3 on radiowave propagation:
(The Hague, 10 April 2014)

WP 3J

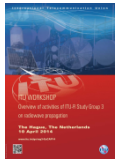
Propagation Fundamentals

Marlene Pontes



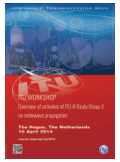
Agenda

- WP 3J – Propagation Fundamentals
  - Scope and Motivation
  - Organization of Work
  - Main Results
    - Questions
    - Recommendations
    - Radiometeorology Handbook
- Critical points and future needs



Scope

WP 3J provides information and develops models describing the fundamental principles and mechanisms of radiowave propagation in non-ionized media



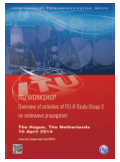
Scope

Radiowave propagation

- Radiowaves have been used to carry information from a source to a destination (or multiple destinations) for over a century.

- The importance of radio communications has never been as evident as today, with globalization a fact of life and real time access to information a necessity to society and industry.

coverage and capacity



Scope

The importance of propagation studies

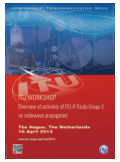
The effects of the propagation medium on the wave are almost always **impairing**

nothing can be done, in terms of engineering, to **improve** this

the propagation medium is immune to engineering

The complex nature of the propagation environment makes fully deterministic models of radiowave propagation impossible or, at best, impractical.

- Only basic physical (usually idealized) models combined with empirical or semi-empirical formulations are available to the system designer.



Scope

Link budget for radiocommunication systems

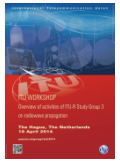
The link budget for radio communication links

accounts for the contribution of various gain and loss sources and ultimately relates the received power to the transmitted power

The core of the link budget is the

free space loss

function of frequency and path length



Scope

Clear air effects

- Refraction resulting in ray bending such that the radio horizon may change.
- Troposcatter from localized fluctuations in the atmospheric refractive index, which can scatter electromagnetic waves.
  - Troposcatter can be used advantageously in transhorizon paths.
- Temperature inversion, abrupt changes in the refractive index with height causing reflection.
  - Ducting, where the refractive index is such that electromagnetic waves tend to be trapped inside a natural lossless waveguide.
- Gaseous attenuation, where interactions between the incident wave and the atmospheric constituents dissipate power.

vary with

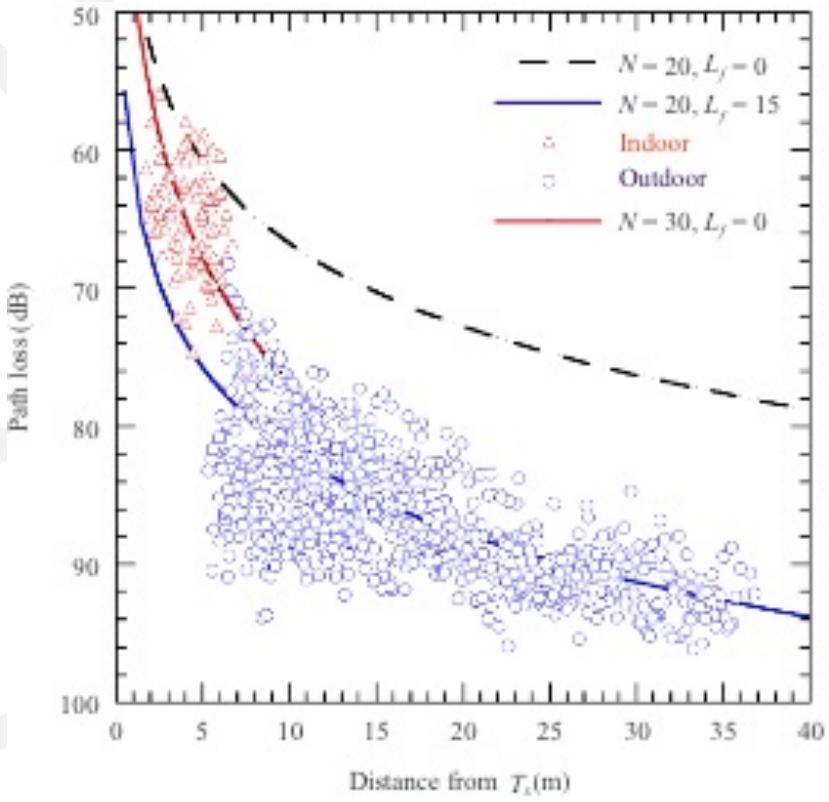
altitude, geographic location, and weather conditions

Scope

Ground and obstacles

- Diffraction
- Attenuation in vegetation
- Effects of building materials and structures on radiowave propagation

P.2040-29



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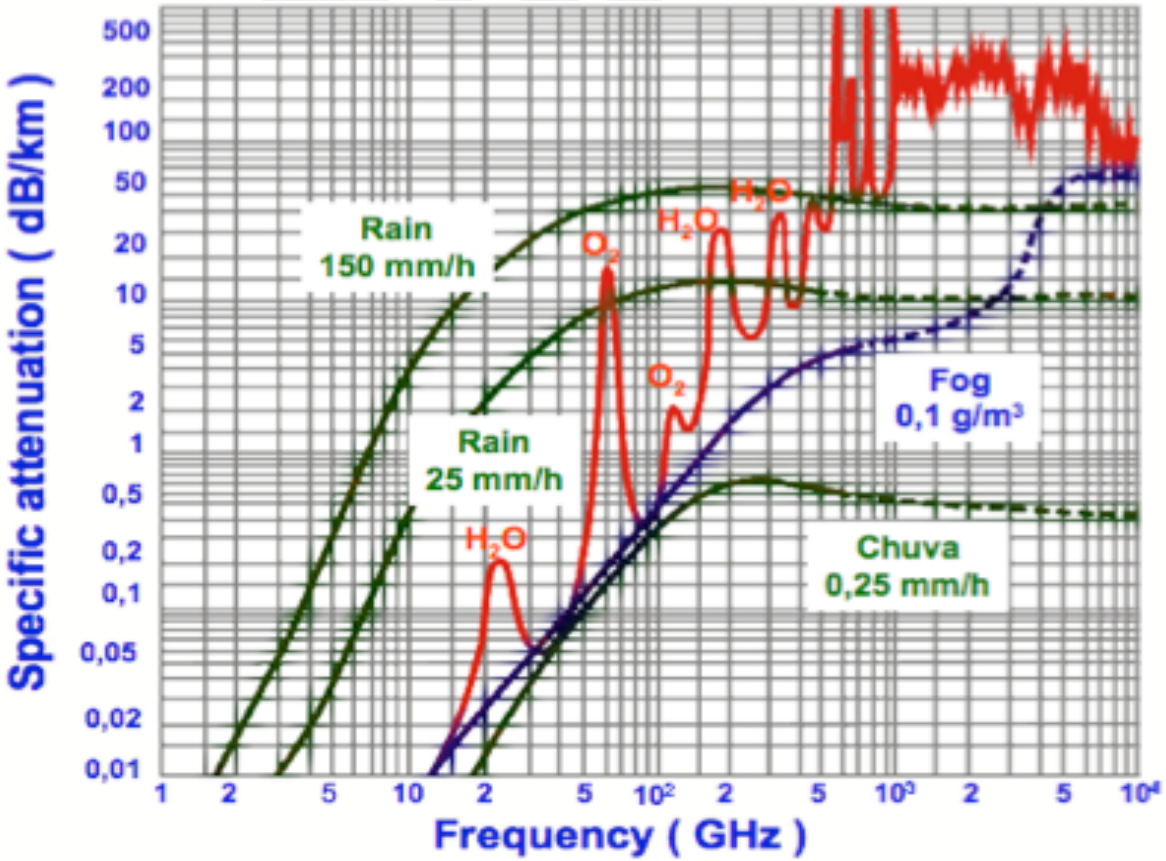
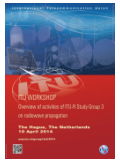
Scope

Fog Clouds Rain



the importance increases as the frequency increases



Organization of work in WP 3J

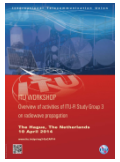
- WP 3J – Propagation Fundamentals **4 Questions**
  - ITU-R 201-4/3:Radiometeorological data required for the planning of terrestrial and space communication systems and space research application
  - ITU-R 202-3/3:Methods for predicting propagation over the surface of the Earth
  - ITU-R 209-1/3: Variability and risk parameters in system performance analysis
  - ITU-R 232/3:The effect of nanostructure materials on propagation.

QUESTION ITU-R 202-2/3

considering
a) that the presence of obstacles on the propagation path may modify, to a large extent, the mean value of the transmission loss, as well as the fading amplitude and characteristics;
b) that, with increase in frequency, the influence of the detailed roughness of the surface of the Earth as well as that of vegetation and natural or man-made structures on or above the surface of the Earth becomes more significant;
c) …..

decides that the following Question should be studied

1 What is the influence of terrain irregularities, vegetation and buildings, the existence of conducting structures and seasonal variability, both for locations within the service area around a transmitter and for the evaluation of interference at much greater distances, on the transmission loss, polarization, group delay and angle of arrival?
2 What is the additional transmission loss in urban areas?
3 What is the screening provided by obstacles near a terminal, taking into account the propagation mechanisms over the path?
4 What are the conditions under which obstacle gain occurs and the short-term and long-term variations of transmission loss under these conditions?
5 …..



Working groups in WP 3J

The work of WP 3J is carried out in five **Working Groups**

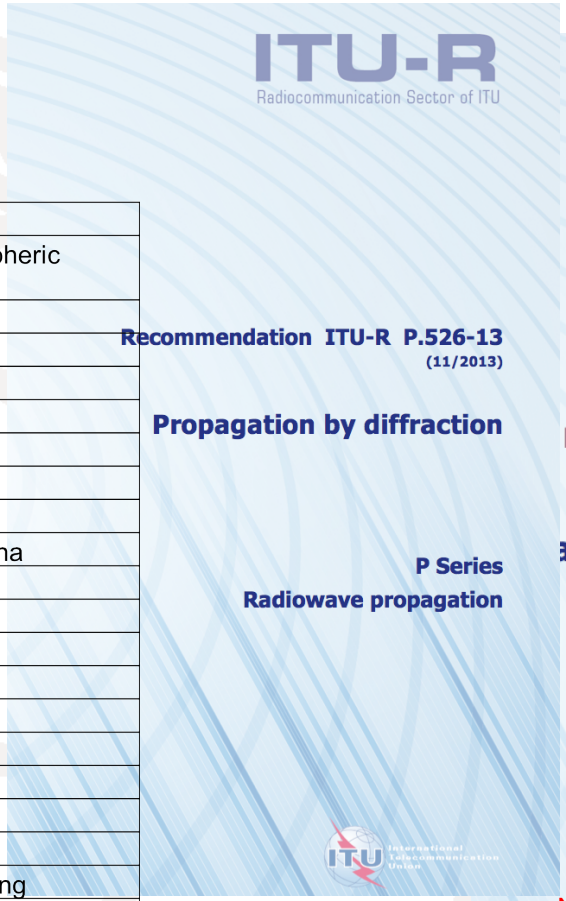
- WG 3J-1 Effects of the clear atmosphere (D. Rogers)
- WG 3J-2 Effects of clouds and precipitation (A. Martellucci)
- WG 3J-3 Global mapping and statistical aspects (L. Castanet)
- WG 3J-4 Vegetation and obstacle diffraction (R. Rudd)
- WG 3J-5 Handbook (M. Pontes)

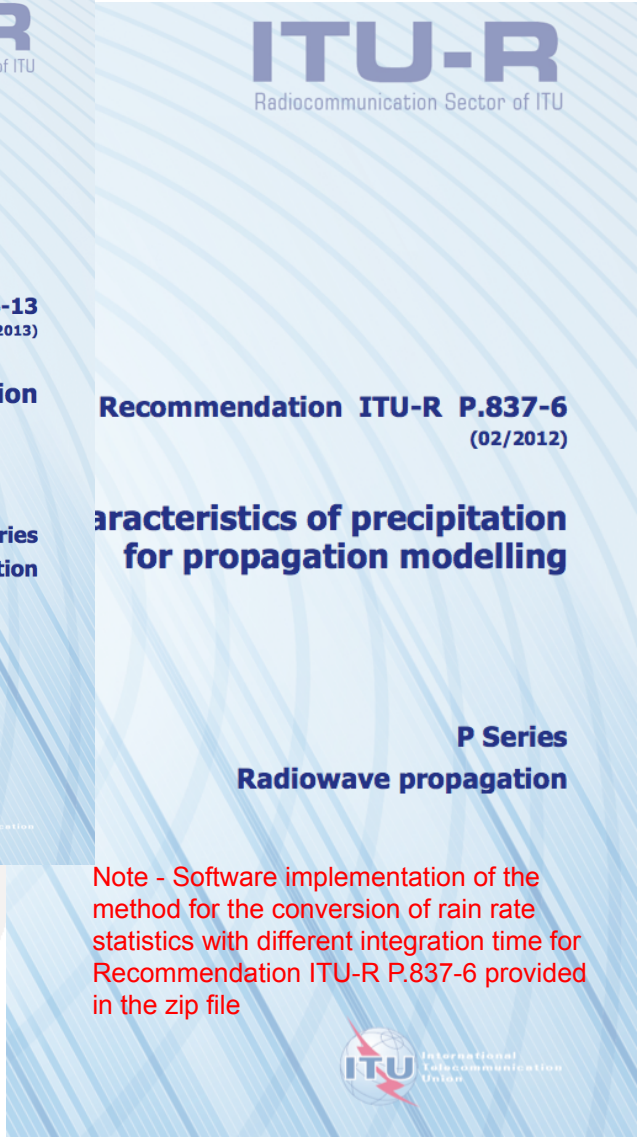
Result of the work

- 27 Recommendations

most of them on the topic Radiometeorology

Definitions of terms relating to propagation in non-ionized media
Acquisition, presentation and analysis of data in studies of tropospheric propagation
The concept of transmission loss for radio links
The radio refractive index: its formula and refractivity data
Calculation of free-space attenuation
Propagation by diffraction
Electrical characteristics of the surface of the Earth
The concept of “worst month”
Attenuation by atmospheric gases
Characterization of the natural variability of propagation phenomena
Attenuation in vegetation
Effects of tropospheric refraction on radiowave propagation
Reference standard atmospheres
Water vapour: surface density and total columnar content
Characteristics of precipitation for propagation modelling
Specific attenuation model for rain for use in prediction methods
Rain height model for prediction method
Attenuation due to clouds and fog
Conversion of annual statistics to worst-month statistics
Probability distributions relevant to radiowave propagation modelling
Digital topographic databases for propagation studies
Guide to the application of the propagation methods of Radiocommunication Study Group 3
Radiometric estimation of atmospheric attenuation
Multipath propagation and parameterization of its characteristics
Annual mean surface temperature
Topography for Earth-to-space propagation modelling
Building material effects





Note - Software implementation of the method for the conversion of rain rate statistics with different integration time for Recommendation ITU-R P.837-6 provided in the zip file

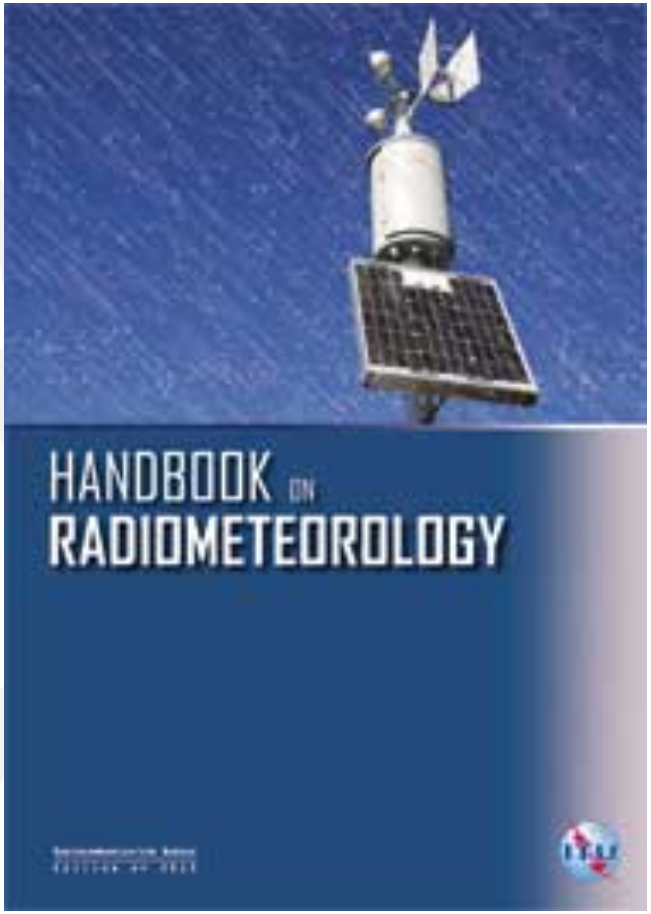
Result of the work

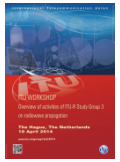
Handbook

Provides general information on radiometeorology for those who use the ITU-R P series Recommendations

Contents

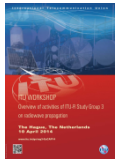
- Physical characteristics of the atmosphere
- Atmospheric refraction
- Influence of refraction on propagation
- Single-particle scattering
- Attenuation and dispersion by atmospheric gases
- Attenuation by atmospheric particles
- Radio emissivity of atmosphere and ground
- Cross-polarization and anisotropy
- Statistical aspects of modelling





Result of the work

- 3 Fascicles
  - The statistical distribution of integrated water vapour and liquid water contents given in Recommendations ITU-R P.836-4 and ITU-R P.840-4
  - Physical modelling for the conversion of rain rate statistics at different integration times
  - The rainfall rate model given in Annex 1 to Recommendation ITU-R P.837-6



Future needs

- Studies on **Refractive Index of the Atmosphere** are of major interest in the activities carried out in Working Party 3J.

A variety of issues associated with accurate estimation of the atmospheric refractive index and its spatial variability need to be addressed.

- world maps of atmospheric refractivity
- vertical gradient of refractivity

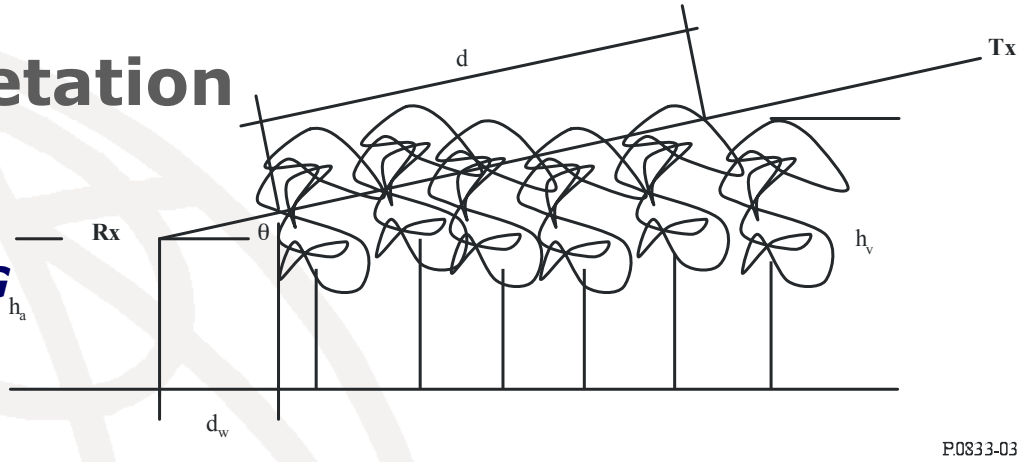
based on ERA Interim database are being considered.

Contributions on the topic are welcome.

Future needs

- **Attenuation by vegetation**

$$L(\text{dB}) = A\, f^{B}\, d^{C} (\theta + E)^{G}{}_{h_a}$$



A,B,C,E and G empirical parameters

Cherry, Japanese:	**Prunus serrulata var. spontanea**
Common lime:	**Tilia x. Europaea**
Dawn redwood:	**Metasequoia glyptostroboides**
Ginkgo:	**Ginkgo biloba**
Horse chestnut:	**Aesculus hippocastanum L**
Himalayan cedar:	**Cedrus deodara**
London plane:	**Plantanus hispanica muenchh**
Korean pine:	**Pinus Koraiensis**
Plane tree, American:	**Platanus occidentalis**
Silver maple:	**Acer saccharinum L**
Sycamore maple:	**Acer pseudoplatanus L**
Trident maple:	**Acer buergerianum**

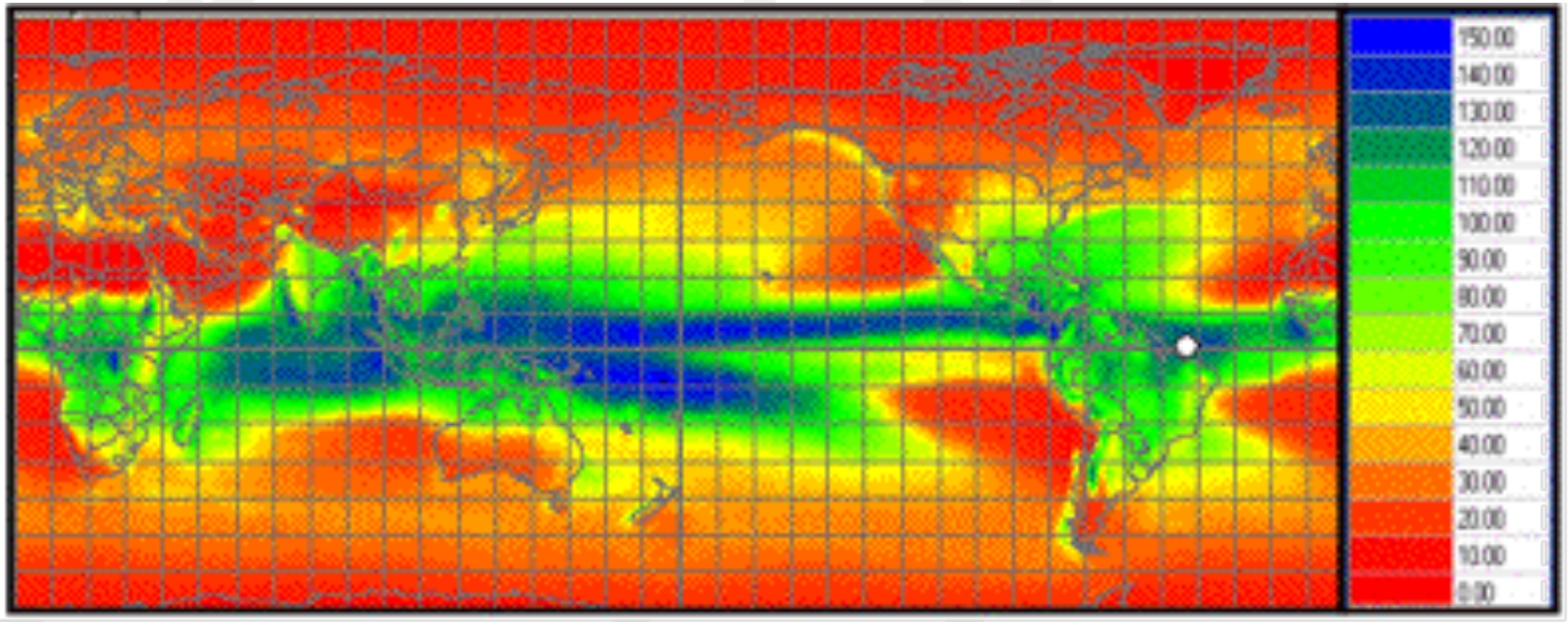
Investigations on vegetation loss and comparisons with measurements are still necessary to further extend the applicability of models.

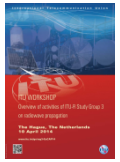
Data for various types of vegetation are needed.

Future needs

- Topics related to **Rain Rate distributions and Rain Height** are being revised.

- The proposed models to predict the Rain Rate distributions is being re-visited to model the costal areas and some regions of equatorial and tropical climate.



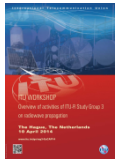


Future needs

Studies of **systems operating at low angle elevation** needs to be considered.

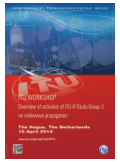
- **gas loss estimation at low elevation is being considered**
  based on integrated water vapour data as the basis for path loss calculations**.**
- **modelling of refractive fading at low path angles**
  based on new data of radiometeorological parameters available.

These data are becoming available via updated Study Group 3 global maps.



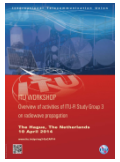
Future needs

- Initiate work on the **modelling of joint temporal fading statistics**.
- Continue work on **characterization of the variability of propagation phenomena** and estimation of the risk associated with propagation margin.
- The new Recommendation on **effects of building materials** on radiowave propagation is a valuable resource and there is a clear requirement to perform studies to determine the characteristics of materials to be used in the models and improve the prediction for radio systems planning related to losses and interference in outdoor to indoor and indoor to outdoor systems



Critical points

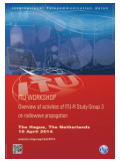
- There are lots of measurements made by operators and researchers but …
- … comparatively, very little data in the ITU-R data banks.



Invitation to collaborate

It is important to assemble propagation data bases and made then available to researchers/partners interested in working in new, more accurate and more reliable prediction methods and channel models.

Researchers, specialists are invited to collaborate in the activities of WP 3J



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