Atmospheric Effects

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Types of Propagation

- Propagation environments are typically defined as
  - Free space (F = 1)
  - Near standard
    - “Standard” does not mean common
  - Sub-refractive
  - Super-refractive
  - Ducting, also known as trapping

- Sub-refractive environments typically lead to a reduction in radio horizon
- Super-refractive environments typically lead to an increase in radio horizon
- Ducting can lead to significant increases in radio horizon
Ideализированное, стационарное представление атмосферы Земли от поверхности до 1000км при периоды умеренной солнечной активности

Оригинально было разработано как стандарт Национального консультативного совета по аэронавтике
Categories of Refractive Conditions Explained

“Standard” Atmosphere

Sub-refraction

Evaporation Duct

“Bilinear” Surface Duct

“Trilinear” Surface-Based Duct

Elevated Duct

“M” = Modified Refractivity

“M” is a function of atmospheric pressure, temperature, humidity and altitude

Credit: Tom Hanley, JHU APL
Atmospheric Data Sources

- Radiosondes (Weather Balloons)
  - Launch twice per day from hundreds of stations around the world and have been for decades per World Meteorological Organization standards
  - Measure temperature, pressure, and humidity as a function of altitude from the surface up to an altitude of 30 km (100 kft)
  - Everything we need to calculate refractivity
Atmospheric Data Sources

- **Numerical Weather Prediction (NWP) Models**
  - Computer models that ingest measured meteorological data and apply complicated algorithms and equations to solve for the temporal and spatial distributions of various parameters (temperature, humidity, winds, etc.)
  - Input data sets are assimilated from multiple sources: Radiosondes, satellites (Including Global Positioning System occultation constellations), aircraft, buoys, ships, surface stations, etc.
  - NWP models can also be run in a “Reanalysis” mode using quality-controlled historical data sets and the latest algorithms
Statistical Atmospheric Databases

- 1987, Patterson, “Historical Electromagnetic Propagation Conditions”
- European Centre for Medium-Range Weather Forecasts Reanalysis – Europe’s mesoscale NWP model run in a “reanalysis” mode
- Naval Postgraduate School Evaporation Duct Climatology Database
- Naval Postgraduate School Upper Air Climatology Database