A global pattern of the O^+ - H^+ transition level for use in IRI

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1 Introduction

The height where O^+ and H^+ densities are equal - the so called *upper transition level* (TL) - could be a very useful quantity for modelling the ion composition in the outer ionosphere. As long as the International Reference Ionosphere (IRI) model is concerned, it is important to know the abundance of H^+ and He^+ ions and the O^+/H^+ and O^+/He^+ density ratios at all heights because the total ion density is obtained independently. The height profile of the H^+ density is balanced by the charge-exchange reaction between H and O^+ and the diffusion flux *to* and *from* the plasmasphere. In this sense, a knowledge of the transition level together with the rate of charge exchange would allow us to obtain the relative percentage of O^+ and H^+ number densities.

There are some publications on the experimental determination of the O^+ - H^+ transition height. Morphological studies of this height, during solar minimum conditions, have been already made [*Titheridge*, 1976; *Miyazaki*, 1979]. In [*Titheridge*, 1976] the TL is obtained from the slope of the topside electron density profile using Alouette-1 satellite measurements. In [*Miyazaki*, 1979] in-situ TAIYO satellite measurement data of the individual ion densities are used to obtain the level. During solar maximum conditions, the TL variations are measured by a Retarding Potential Analyzer (RPA) on board OGO-6 satellite [*Kutiev et al.*, 1980], by a Bennett Ion Mass Spectrometer (BIMS) on ISS-b [*Miyazaki et al.*, 1982], and Spherical Ion Traps on Intercosmos-2 satellite [*Serafimov et al.*, 1977].

Many experimentally proved TL variations are still not considered in the IRI. For example, it has been shown [*Kutiev et al.*, 1984] that, while the nighttime level reaches 1140 km over the equator, the model gives a value of 400 km. Significant discrepancies are also seen at higher latitudes. That is why in the remaining part of the report we will construct a picture of the TL diurnal, seasonal, and solar-cycle variations. This could help a further improvement of the IRI composition part.

2 Theory

As it has been mentioned above, the transition level variations are determined to a great extent by the O^+ density variations. Responsible for the O^+ distribution, along with the chemical and diffusion processes, are the neutral winds, ascending or descending the F-layer along the magnetic field lines. These winds also drag the ionization across the equator from summer to winter hemisphere, forming a well expressed bulge between -20^o and $+20^o$ dipole latitude. A nighttime winter minimum of O^+ density, affecting also the O^+ - H^+ transition height, is observed at 30^o - 40^o. This is a result of the strongly depressed nighttime winter ionosphere due to recombination [*Miyazaki et al.*, 1983]. The TL increase at higher latitudes is caused by the decreased high-latitude H^+ density.

3 Results

The available experimental data are insufficient to construct the transition level's variations for *all* geophysical parameters. That is why, some simplifications have been applied. First, since the TL depends on magnetic field inclination and declination, it is reasonable to present the global variations in dipole latitude (DL) and geographic longitude. The latitude range is restricted to -60° to +60° DL. Second, noon (12:00 LT) and midnight (00:00 LT) conditions are only considered. Third, the TL response to the solar activity is limited for low (LSA) and high (HSA) solar activity. Finally, two seasons are considered - winter and summer (defined for the North hemisphere).

lat \ long	0°	60°	120°	180°	240°	300°
60°N	1100	1100	1100	1100	1100	1100
50°N	920	910	900	920	940	930
40°N	950	940	930	940	950	950
30°N	1010	990	980	975	970	990
20°N	1040	1030	1030	1025	1020	1030
10°N	1050	1040	1040	1040	1040	1040
0°	1050	1040	1040	1040	1040	1040
10°S	1030	980	990	950	950	950
20°S	660	660	660	700	740	700
30°S	630	630	630	665	700	660
40°S	620	620	620	700	770	700
50°S	1000	900	850	940	1000	1000
60°S	1100	1100	1100	1100	1100	1100

Table I : Nighttime transition level, [km]
HSA , North Summer

lat \ long	0°	60°	120°	180°	240°	300°
60°N	910	910	910	910	910	910
50°N	918	909	900	918	936	927
40°N	775	768	760	768	775	775
30°N	690	677	670	663	663	677
20°N	667	660	660	653	653	660
10°N	687	680	680	680	680	680
0°	909	900	900	900	900	900
10°S	1188	1133	1100	1100	1100	1144
20°S	1050	1050	1050	1113	1176	1113
30°S	1000	1000	1000	1060	1110	1050
40°S	970	970	970	1096	1203	1096
50°S	1239	1113	1050	1165	1239	1239
60°S	1100	1100	1100	1100	1100	1100

Table II : Nighttime transition level, [km]
HSA , North Winter

In Tables I-IV the TL values are given at every 10° in latitude and every 60° in longitude. Table I, taken from *Kutiev et al.* [1980], refers to solar maximum, North summer and 00:00 LT. Table II, referring to North winter, is constructed from OGO-6 and Intercosmos-2 satellite data available only at 120° longitude; it was accepted that the longitudinal variations are similar to those of Table I.

lat \ long	0°	60°	120°	180°	240°	300°
60°N	854	854	854	854	854	854
50°N	780	775	770	780	790	785
40°N	794	790	785	790	794	794
30°N	820	812	808	806	803	812
20°N	832	828	828	826	824	828
10°N	836	832	832	832	832	832
0°	836	832	832	832	832	832
10°S	828	808	794	794	794	812
20°S	628	628	628	655	681	655
30°S	607	607	607	632	655	628
40°S	600	600	600	655	699	655
50°S	816	770	745	790	816	816
60°S	854	854	854	854	854	854

Table III : Nighttime transition level, [km]
LSA , North Summer

lat \ long	0°	60°	120°	180°	240°	300°
60°N	775	775	775	775	775	775
50°N	779	775	770	779	788	783
40°N	702	698	693	698	702	702
30°N	649	640	635	630	630	640
20°N	633	629	629	623	623	629
10°N	646	642	642	642	642	642
0°	775	770	770	770	770	770
10°S	880	865	854	854	854	868
20°S	836	836	836	858	877	858
30°S	816	816	816	814	857	836
40°S	803	803	803	853	884	853
50°S	893	858	836	874	893	893
60°S	854	854	854	854	854	854

Table IV : Nighttime transition level, [km]
LSA , North Winter

The relative longitude variations of TL, extracted from *Kutiev et al.* [1980], are further used when constructing Table III and Table IV. The TL latitude profiles at solar minimum are taken from *Titheridge* [1976]. The tables are visualized in Fig.1.

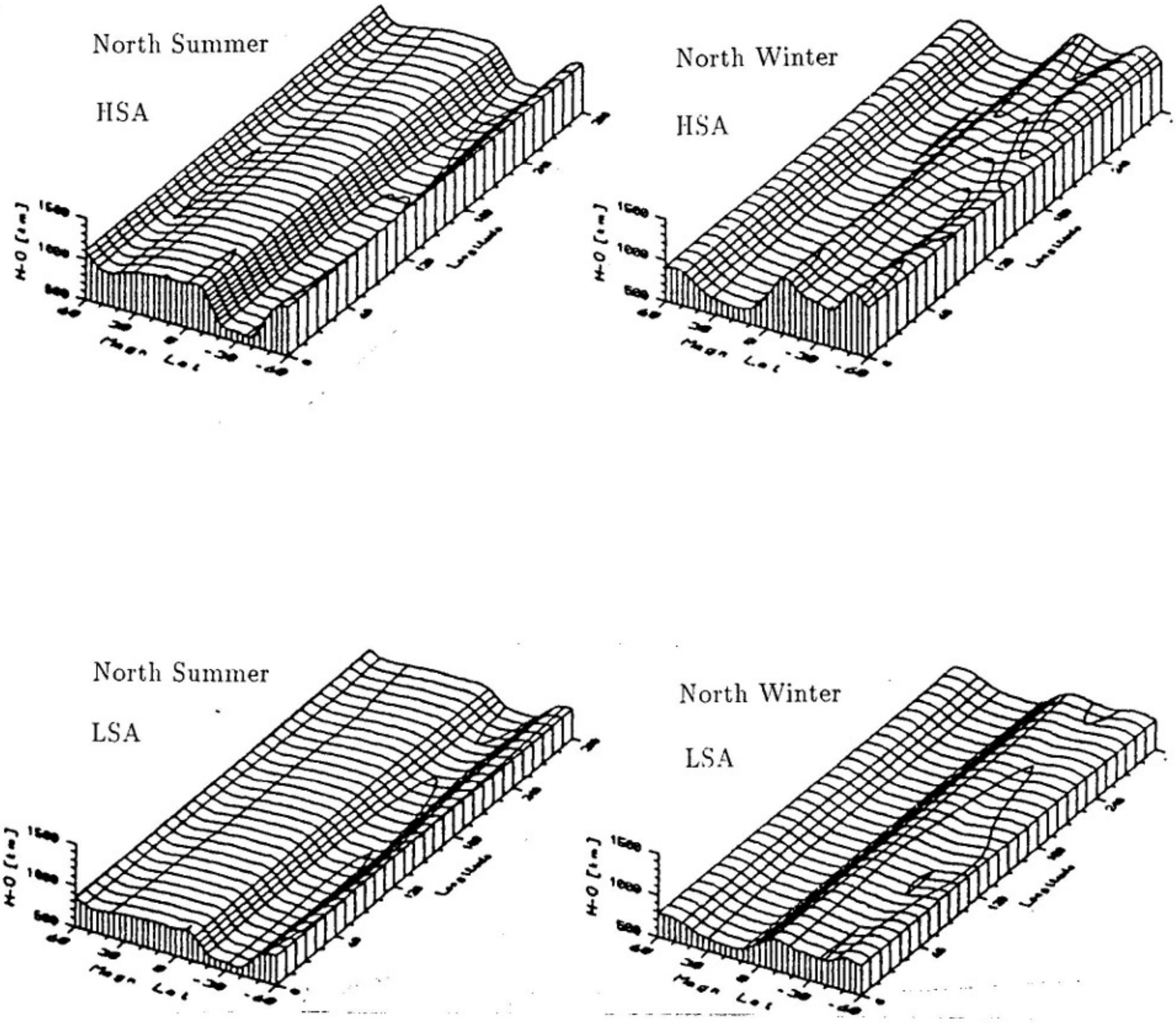

Fig.1 The nighttime O^+ - H^+ transition level

Table V represents the daytime transition height. The summer and winter values (defined for North) are adopted from *Miyazaki* [1979] and *Titheridge* [1976] respectively.

lat	HSA summer	HSA winter	LSA summer	LSA winter
60°N	1578	1363	1250	1100
50°N	1578	1293	1250	1050
40°N	1506	1224	1200	1000
30°N	1321	982	1070	820
20°N	1115	865	920	730
10°N	956	725	800	620
0°	930	713	780	610
10°S	956	700	800	600
20°S	995	700	830	600
30°S	1115	725	920	620
40°S	1224	826	1000	700
50°S	1293	969	1050	810
60°S	1363	1035	1100	860

Table V : Daytime O^+ - H^+ transition level, [km]

The longitudinal variations of the level are neglected; it is based on the assumption that the photoionization prevails over the effect of the neutral winds.

4 Discussion

Considering the global behaviour of O^+ - H^+ transition level, the observed latitudinal variations are of particular interest. During night, a maximum of TL is established at the geomagnetic equator, varying from 800 km at solar minimum up to 1100 km at solar maximum conditions. Minima, about 600 km, are observed at middle dipole latitudes, being deeper in the winter side. At higher latitudes the TL increases again reaching its equatorial values. During day, the level at low latitudes preserves the nighttime values and increases towards higher latitudes. The transition height demonstrates also longitudinal variations. At a fixed height, these variations are similar to the corresponding O^+ density variations. Along a given geomagnetic latitude, the H^+ distribution should be (to a great extent) uniform, thus reflecting its symmetrical distribution in the plasmasphere within a given L shell. Density iso-contours of the nighttime O^+ near 1100 km altitude are constructed by *Kutiev et al.*, [1979] and *Miyazaki et al.*, [1983]. These maps show that the longitudinal variations are most prominent around the TL minima where the latitude gradients of O^+ density are largest. The variations in the Northern hemisphere are different from those in the Southern hemisphere. In the Northern hemisphere two minima of O^+ are observed around 30° DL and 30° and 240° longitude. In the Southern hemisphere only one minimum of O^+ is observed between 330° and 30° longitude. The measured TL values show that the TL longitudinal variations are much more supressed than those of O^+ density [*Kutiev et al.*, 1979]. This is probably due to the charge-exchange reaction converting the exceeding O^+ ions into H^+ and vice versa.

5 Acknowledgements

The work was supported by the Bulgarian Ministry of Science and Higher Education under grant NZ 868 / 88 .

6 References

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