COST 238/PRIME WORKSHOP

on "Development an Testing of an electron density height profile model for PRIME"

Peter A. Bradley
Daresbury Laboratory. Rutherford Appleton Laboratory
Radio Communications Research Unit
Chilton DIDCOT, Oxfordshire OX11 0QX
ENGLAND

Benito A. de la Morena
INTA/CEDEA. División Ciencias del Espacio
Dpto. Teledetección y Aeronomía /LATMOS
Estación de Sondeos Atmosféricos
Centro de Experimentación "EL ARENOSILLO"
Mazagón - Huelva - SPAIN

EDITORS

OVERVIEW

COST (Cooperation in Scientific and Technological Research) is an initiative of the European Union providing a framework whereby researchers in the different Member States can work together to mutual advantage on common problems, thereby helping to build up an improved Community technological base to better support industry. COST covers a range of disciplines, one of which is Telecommunications, and consists of a number of separate Projects (Actions) each with defined objectives and lifetimes.

PRIME (Prediction and retrospective ionospheric modelling over Europe) was formally initiated as Project COST 238 in March 1991 as a four-year project aimed at developing improved models of the European ionosphere for telecommunications applications, but the work has its origins earlier arising from existing collaborations in the areas of vertical and oblique-incidence sounding. We now have active participation from groups within 18 Western and Eastern European countries.

With separate teams formed from within the different organisations on a topic-by-topic basis, work has progressed by correspondence stimulated by periodic Workshops at which papers have been presented to the full group. With adequate planned times for discussion Workshops have proved valuable fora for the formulation of plans for the ways ahead.

The 7th Workshop in the series with some 40 participants was held at El Arenosillo, Mazagon, Spain on 5-6 September 1994 followed by a three day management meeting. The Workshop theme was the 'Development and testing of an electron-density height profile model for PRIME'. In total 19 papers were presented, also covering other topics in the fields of vertical and oblique sounding, instantaneous and long-term mapping and short-term predictions. Additionally there were some 10 poster papers. This last Workshop to be organised under project auspices can indeed be regarded as most successful. Besides paving the way for specification of a height profile model of electron density (with a specialised group commissioned to meet subsequently in Florence, Italy in October 1994 to finalise this) most important decisions were taken on the methods of long-term and instantaneous mappings to adopt. I am grateful to the Working Group Leaders for their help in formulating the Workshop programme.

This Proceedings contains a selection of Workshop papers. In addition, each Session Chairman and Working group Leader has provided a summary covering the ensuing discussion. Thanks should be extended to all who contributed to the Workshop both in preparing presentations and in participating in the discussions. I believe that in a very full programme optimum use was made of the available time and that good and timely overall progress is being made towards our agreed goals.

We are all grateful to Dr Benito A de la Morena from the Centro de Experimentacion de El Arenosillo of the Instituto Nacional de Técnica Aeroespacial for hosting us. We extend our sincere thanks to him and his colleagues for all they did to ensure the event was a success. We especially thank Colonel Juan Jose Martin Francia, Director of the El Arenosillo facility, for allowing the meeting to take place and INTA, provincial and local governments for their hospitality.

Sadly this was the last occasion on which everyone was present together. It was indeed a fitting and very memorable way to end.

Finally our thanks go to Benito for preparing this publication.

Peter A Bradley
Chairman COST 238

REVIEW OF PROGRESS IN GATHERING, DISTRIBUTING AND USING SATELLITE DATA FOR ACTIVITIES WITHIN COST 238 (PRIME)

Ivan Kutiev, Stanimir Stankov
Geophysical Institute, Acad. G.Bonchev str., bl. 3, Sofia 1113, Bulgaria

1. Introduction

WP-8 of WG-5 formalizes the utilization of satellite data in various studies within the PRIME Project. Satellite data can be used in the long term and instantaneous map testing, testing of electron density profile models, to supplement the studies of ionospheric storms, etc. Among the various parameters measured by satellites, the ion (electron) density is mostly used. It is measured locally by plasma probes and remotely - by topside sounders. The satellite data can not be used for operational purposes (at least in the present PRIME practice), so they are proper for performing retrospective studies. The specifics in the processing and handling of the satellite data restrict their wider use. Being a center for gathering, distributing and using of these data, the Geophysical Institute can supply any potential user with the required portion of data in a format suitable for his particular study. From other side, we develop methods for utilizing the satellite data in the map testing, for studying the F layer disturbances, which also could be of help to the various working teams.

2. Satellite data base

The Satellite data base (SDB) operates under ACCESS commercial database. It is capable to handle big massifs of data and to arrange output formats that can meet most of the requirements from the users [1]. One example of such queries is the task to select a data subset consisting of ion density measured on a portion of the orbits over the PRIME area, which pass over the ionosonde locations within the limits of $\pm 1^{0}$ on latitude and $\pm 2^{0}$ on longitude. Such data subset was extracted for the purpose of instantaneous map testing. *Table 1* represents the *Catalogue* of the data available in SDB. There are four satellites listed, the time span of data are shown in column 2. Their perigees, apogees and inclination help to select the proper subset of data. The SDB does not contain topside sounding data, at present. *Intercosmos-19* topside ionograms and extracted foF2 are available in IZMIRAN, with S. Pulinets being responsible for their dissemination.

Table 1

SATELLITE	TIME SPAN OF DATA	PERIGEE-APOGEE,km	INCLINATION
AE-C	01-09-74 / 30-01-75	250 - 1200	90^{0}
DE-2	01-09-81 / 30-08-83	300 - 1000	90^{0}
B-1300	01-09-81 / 30-07-82	850 circular	82^{0}
Hinotori	22-02-81 / 18-06-82	650 circular	30^{0}

3. Map testing procedures

For the time being, the map testing is the most important application of the satellite data. While the topside foF2 can directly be applied for testing, the local plasma measurements should undertake some theoretical transformations.

3.1 Instantaneous map testing

Using the theoretical F region code, including continuity and momentum equations of O^+, H^+ and He^+ ions, the accuracy of obtaining NmF is estimated when the measured ion density is traced down to the maximum of the F layer (hmF) [2]. Fig.1 gives the result. The tracing method itself gives a maximum error of 22% in NmF and 10% in corresponding foF2. The same error - 10% is obtained for hmF. While the method of the tracing gives a satisfying accuracy, the total error of the projection is still quite uncertain, because it depends on the plasma temperature (Tp=Te+Ti) and the ratio $n(O)/n(N_2)$; (O+ production rate is proportional to n(O), and loss rate - to $n(N_2)$). So, if we consider the probe measurements as independent data, we cannot use them to obtain foF2 and hmF. A method was consequently developed, which in great extent eliminates the above mentioned uncertainties. If we assume that along the orbit of the satellite over the PRIME area Tp and n(O)/n(N2) remain unchanged, then we can calibrate at a given point the traced $foF2_{sat}$ with the measured by a ground-based ionosonde $foF2_{ion}$. Theoretically, this can be done by adjusting the unknown Tp and neutral ratio until $foF2_{sat}$ coincides with $foF2_{ion}$. Practically, the problem can be simplified by taking the ratio of the two foF2's at the point where this is possible and then foF2 along the orbit is obtained by a simple multiplication of $foF2_{sat}$ with this ratio. Therefore, the question is to what extent Tp and $n(O)/n(N_2)$ are constant along the orbit.

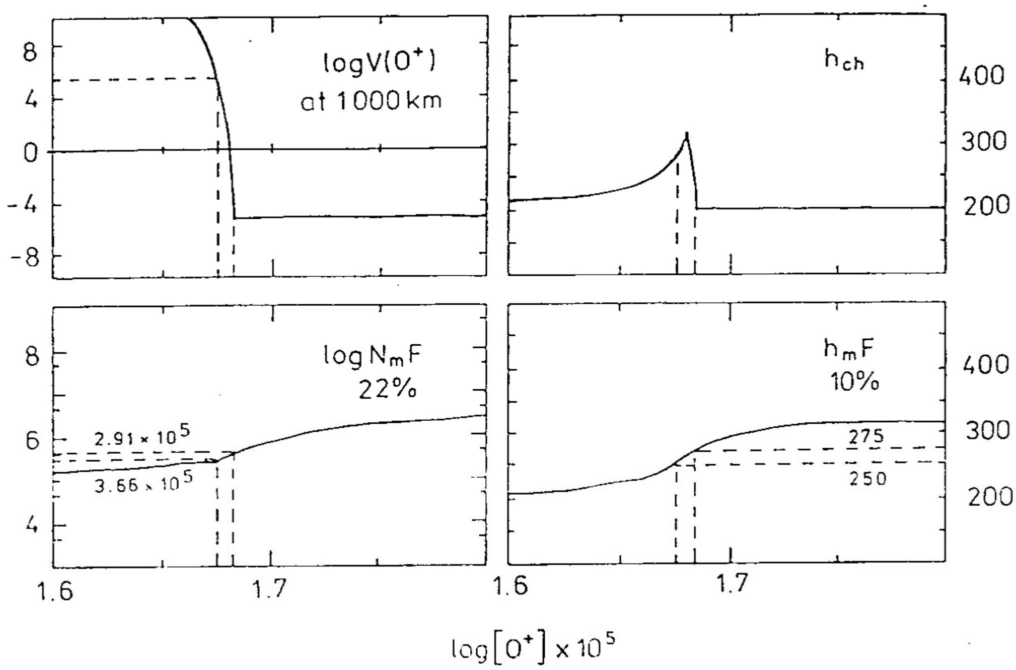

Fig. 1

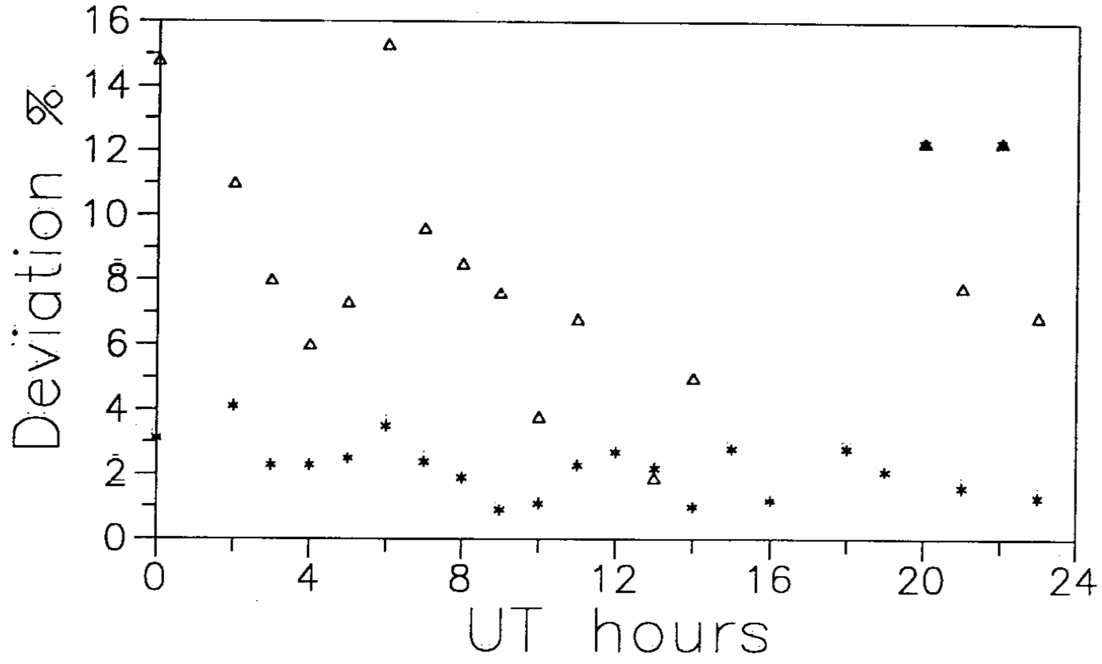

Fig. 2 The average relative deviations of plasma temperature (*) and the ratio $n(O)/n(N_2)$- (Δ) along the orbits depending on UT of measurement.

To check how plasma temperature and neutral density ratio deviate along the orbits, all available passes of DE-2 over the PRIME area were grouped on UT and averaged, relative to the corresponding values at 45^o latitude. No correction for altitude changes has been made. It is seen that Tp deviations at all local times are less than 4%. The density ratio variations do not exeed 16%, as most of the time they are less than 10%. The larger deviation of the neutral ratio reflects the lower accuracy of the measurement. However, this result shows, that the scale height remains almost constant along the satellite path and the total error (tracing plus Tp uncertainty) is ~14%. The larger error take place in determining the F peak shape, which reflects in larger error in hmF, but it will have a minor effect on $foF2_{sat}$.

According to requirements in [3], we prepared a data subset, consisting of orbits of DE-2 and AE-C satellites passing over the ionosonde stations, where foF2 are available for the same time. The value of $foF2_{ion}$ used for calibration was interpolated between the two hourly values when the time difference exceeded 15 min. To check the accuracy of the method, those orbits which pass over two ionosonde location were selected and the values of $foF2_{sat}$ and $foF2_{ion}$ of the second station compared on *Table 2*. The total number of these orbits is 35. The histogram of the differences, grouped in 0.4 MHz intervals is presented on Fig.2. The number of the cases in each interval are indicated in the columns. The distribution looks very much like normal, with exemption of 0.8 MHz interval. The number of cases is

Table 2

Date	UT	foF2ion	foF2sat	Diff. [MHz]
810819	1202	9.5	8.4	-1.1
810827	1222	9.0	8.6	-0.4
810904	1054	11.0	10.7	-0.3
810928	0848	8.0	10.2	2.2
820416	0740	7.5	7.0	-0.5
820505	0625	6.2	7.5	1.3
820705	1414	7.9	7.9	0.0
820813	1138	7.6	7.6	0.0
820824	1102	7.5	7.5	0.0
820926	0850	7.6	7.6	0.0
820928	0913	6.6	7.5	0.9
821010	0750	10.4	9.5	-0.9
821020	0715	6.4	7.3	0.9
821024	0729	8.2	8.1	-0.1
821103	0746	4.8	4.9	0.1
821105	0613	5.3	6.0	0.7
830101	1553	8.0	8.7	0.7
830203	1248	11.3	9.4	-1.9
811008	2039	8.0	6.9	-1.1
811011	1955	7.6	8.4	0.8
811020	1922	5.3	6.2	0.9
820214	2336	3.5	2.0	-1.5
821005	2049	6.8	6.6	-0.2
821012	2052	5.5	5.5	0.0
821013	2012	5.0	6.3	1.3
821017	2034	5.1	5.5	0.4
821228	0315	4.6	4.0	-0.6
830125	0220	4.1	3.7	-0.4
830202	0150	3.0	3.2	0.2
741217	1133	5.8	6.4	0.6
741126	0338	2.3	2.3	0.0
741211	1343	4.9	5.9	1.0
741212	2248	3.4	3.5	0.1
741220	1158	6.7	8.3	1.6
741223	1938	3.8	3.8	0.0

differences, grouped in 0.4 MHz intervals is presented on Fig.3. The number of the cases in each interval are indicated in the columns. The distribution looks very much like normal, with exemption of 0.8 MHz interval. The number of cases is insufficient to expect a statistical significance of this result, but a conclusion can be made that $foF2_{sat}$ is of the same character as $foF2_{ion}$. The standard deviation is only 0.15.

As far as M(3000)F2 is concern, we can not use the same procedure as for foF2. The propagation factor cannot be reproduced by the satellite data. The relation between M(3000)F2 and hmF is statistical and depends on the geomagnetic conditions. Analysis made recently, show that M(3000)F2 depends stronger on the width of the F layer, than on its height. However, the relation between the propagation factor and the ion density at satellite heights needs to be carefully examined.

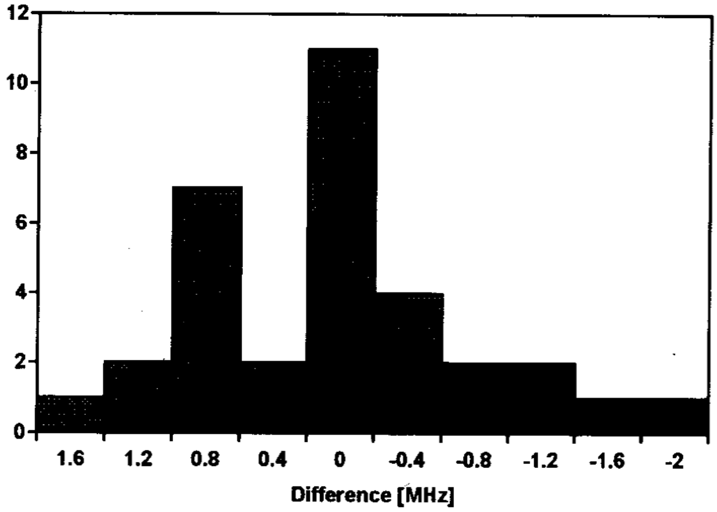

Fig 3

3.2 Monthly median map testing

Only data from the Retarding Potential Analyzer (RPA) on AE-C satellite were used to compile this data subbase. Due to a technical problem we failed to supply data for testing by 31 March 1994 and did this just before the computer experts pre-meeting in Eindhoven. The method of tracing were slightly changed because we have to gather data from different orbits within a given month and hour. So, from the actual height the measured ion density was first traced down to the height of 400 km and then calibrated with the $foF2_{ion}$ taken from several ionosonde stations.

Following the requirements in [4], the measurements over Europe were distributed in 64 subareas, 2.5^o by 5^o in size. AE-C Unified Abstract Format has a 16 sec data sampling, e.g. 130 km separation. In this case, in each subarea 2 or 3 values were allocated. Collected in each subarea in a given month and hour UT, data were traced down along the magnetic field lines to the fixed level of 400 km, using scale heights calculated from IRI plasma temperature model. At 400 km level median values were found in each space/time bin when the number of the values exceeds 4. The scatter and the standard deviations were calculated for each bin in order to control the accuracy of the method. To trace further the values to hmF, which is unknown, corresponding median foF2 from

5 European ionosondes were taken and compared with the 400 km satellite medians. The five ratios were averaged to obtain a single coefficient which is used then to reduce the satellite data to the maximum F layer height. This procedure actually combines satellite and ground-based ionosonde data for the testing. On the upper panel of *Table 2*, as a sample, the calculated monthly median foF2 are given for September 1974, 12 UT. The numbers in brackets show the corresponding standard deviation. On the lower part, the hourly averaged standard deviations for September and December are also given.

char. : foF2 (st.dev.)

month: September

year: 1974

Table 2

long / *lat*	350 - 355	355 - 360	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30
52.5 - 55.0								
50.0 - 52.5					**6.1** (0.2)	**6.3** (0.1)		
47.5 - 50.0			**5.7** (0.1)	**5.7** (0.1)		**6.0** (0.1)		**6.5** (0.1)
45.0 - 47.5			**5.5** (0.1)	**5.7** (0.1)		**6.2** (0.1)		**6.2** (0.1)
42.5 - 45.0			**5.6** (0.1)		**6.2** (0.1)		**6.1** (0.1)	**6.0** (0.1)
40.0 - 42.5			**5.3** (0.1)		**6.2** (0.1)		**6.0** (0.1)	**6.1** (0.1)
37.5 - 40.0			**5.3** (0.1)		**6.3** (0.1)		**5.9** (0.1)	**6.4** (0.1)
35.0 - 37.5			**5.4** (0.1)	**6.6** (0.1)			**6.7** (0.3)	

Averaged standard deviations

UT	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Sep	.1	.1	.2	.1	.1	.1	.1											
Dec			.1		.2	.1	.1	.3			.2	.1	.2		.1	.1	.1	.1

4. Other application of satellite data and future activities

As it was mentioned before, there are two more applications of the satellite data which are foreseen at this stage. First is the testing of the models which give the vertical electron density profiles above the hmF. Here, the probe measurements can directly be used in the testing. The second application is in ionospheric storm studies. Although in these type of studies the solar and geomagnetic indices are generally used, some measured parameters as electric field, plasma drifts, energetic particle precipitation, plasma and neutral temperatures and composition, etc. give more adequate information of the processes controlling the midlatitude F region ionization. These parameters are already involved in a 'case study' analysis of several ionospheric storms

Satellite data would be also in use in the proposed follow up Project COST 251 [5]. In its WG 2- 'Validation of COST 238 models for Earth-space system', plasma measurements will be necessary in evaluation of the 'ionospheric corrections for navigational and geodetic satellite systems and interpretation of radio astronomical measurements'. The satellite data base can include also navigational, geodetic and radio astronomical data to supply the theoretical studies in this working group. WG 3- 'Further development of COST 238 models' pays larger attention on short-term variability which mainly include ionospheric storm studies, where the satellite data are already in use.

REFERENCES

1. I. Kutiev, St. Stankov, Satellite data base for map testing, Proc. of PRIME Workshop held in Eindhoven, May 1994 (in print).
2. I. Kutiev, St. Stankov, Satellite data for use in the ionospheric mapping, Proc. of PRIME Workshop, Roquetes, Publ. del Observatorio del Ebro, 16, 1992, 100.
3. I. Stanislawska, G. Juchnikowski, Proposal for map testing procedure for El Arenosillo computer experts pre-meeting, 2 August 1994, Warsaw.
4. H. Sizun, M. Dick, Standard map-testing procedure for the May 1994 Eindhoven computer experts pre-meeting, Doc COST238(94)005, June 1994.
5. DRAFT Memorandum of Understanding for COST Action 251, Annex 2 of Doc. COST238TD(94)005, June 1994.