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ROAD MANAGERS AND METEOROLOGISTS OVER ROAD METEOROLOGICAL OBSERVATIONS

The result of questionnaires

by

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NOTE

FOREWORD

The twelfth session of the Commission for Instruments and Methods of Observations (CIMO-XII) recognized that the majority of road meteorological measurements were made for purposes of the prediction or detection of ice formation on carriageways. As regards this application area there was general agreement among the experts about the types of meteorological measurements required and about the instruments to be used. There was, however, a very wide range of different observing practices in use, particularly in respect of the location and exposure of sensors. As a result, the meteorological quality of the data derived from these measurements was likely to be uncertain. Such observations should be viewed with caution if they were to be used for purposes other than those for which they were specifically produced. This might be seen as unfortunate, because in some countries the size of the observing network producing these data rivalled or even exceeded that used for conventional synoptic purposes by the relevant national Meteorological Service.

There is a lack of any agreed definitions of meteorological variables required for road and traffic management purposes. There seemed to be no published work that examined this requirement and for the present users appeared simply to apply whatever data their instrumentation delivered to the problems of road management. Since most of that instrumentation was taken directly from conventional meteorology (but in terms of exposure and in other ways was used differently) it was questionable as to whether the data were optimal for the intended application. Furthermore it was concluded that they were unlikely to be of a consistent and known quality even within some national networks themselves and certainly not from network to network.

CIMO-XII recognized the need for a consensus in the guidance related to the specifications for the measurement of meteorological variables for road meteorological purposes and requested the Working Group on Surface Measurements to include this subject in its working programme. The study was based on two questionnaires, one directed to road managers and the other to the meteorologists. The result of the study is presented in this publication.

(Dr. R.P. Canterford)

Acting President of the Commission for
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1. Introduction

Many countries have already installed observing stations, measuring road but also weather parameters, along highways. These road weather stations play an important role in ensuring traffic safety and efficiently dispatching information, especially in wintertime with possible slipperiness. Meteorological offices making road-dedicated forecasts also use road measurements. The World Meteorological Organization (WMO) is a 185 member specialized organization within the UN structure. Among many other tasks, it is also responsible for the development of standards for meteorological observations obtained at meteorological observing stations. This is essential since weather conditions pass from one country to another. In order to make high quality forecasts, it is necessary that meteorological offices exchange standardized measurements and data in a worldwide agreed format. The Commission for Instruments and Methods of Observation (CIMO), one of the eight Technical WMO Commissions, specifically deals with the standardization of meteorological observations and instrumentation. Because meteorological offices are also making road weather forecasts with their standardized measurements, CIMO ponders upon the standardization of road weather measurements. In its eleventh session in 1994, it therefore expressed the opinion that valuable work could be done by standardizing road weather instruments and observation methods. A report of 1997 (ref. 1) describes how observations are being made along roads in various countries and notes that indeed there is no standardization at all – and certainly not between the countries mutually. In most countries, the meteorological data obtained from these weather stations are of lower quality than those generated by the meteorological offices and it seems doubtful that forecasters will use these road data for other purposes than road forecasts. The conclusion of the 1997 report is that CIMO should extend its work in this field, in co-operation and consultation with appropriate national or international road organizations, with a view to come to a consensus upon issues such as the specifications concerning meteorological variables which need to be measured for road meteorological purposes. Furthermore, information on the optimal observational methods needed should be obtained from them.

The writers of this report undertook their tasks by means of questionnaires, one directed to road managers and the other to meteorological experts (forecasters). The received answers and the analysis pertaining to them are described in this report, together with the conclusions and the recommendations. Finally, it is in the interests of the meteorological community to work together with road managers. Therefore, this report published under the auspices of the WMO is addressed both to the meteorological community and to the road managers.

2. Collaboration between both Co-rapporteurs

Two viewpoints are important in this survey, that of the road managers and that of the meteorologists, although the opinion of the road managers prevails. As road managers control road measurements, they had to be asked if they would be interested in standardization and if they would be ready to work together with the meteorological offices. To that end, two slightly different questionnaires have been sent to the experts concerned. Mr. Ledent, Head Road Systems, has drawn up the questionnaire meant for the road managers, while Mr Terpstra, working in the meteorological office, did the same for the meteorological experts (especially forecasters). The same task distribution has been applied for the perusal and the analysis of the replies to the questionnaires.

3. The Questionnaires

Questionnaires have been sent to road managers of 64 countries dealing with winter serviceability. Those who were involved extensively in the earlier mentioned research (ref. 1) have been considered as meteorological experts. The questionnaires directed to the road manager and the forecaster aimed at trying to find out to what extent road managers and forecasters think the standardization of road measurements at the highest (WMO) level is necessary.

This way was chosen because some countries use road measurements not only for making road weather forecasts but also for making other, not specifically road-dedicated, forecasts. The road measurements are then filling up gaps in the regular synoptic network. But in that case why not try to convince the road manager to bring these observations up to WMO-level? Another reason why the questionnaires systematically ask to compare the level of road measurements to WMO-standards is that the WMO-level is the only one that presently exists and can be used as a scale for comparison on how good or bad road measurements are. A third reason was the analogy that can be made with the co-operation between aviation, navigation and the Met. Offices in the world. Hence the following introducing sentences in the cover letter sent with the distributed questionnaires[1]:

Dear Sir/Madam,

As you know, in all countries in the world there is a close co-operation between aviation and meteorology. Accurate meteorological measurements are carried out on airports for assisting pilots, air traffic controllers and meteorologists. Because airplanes are flying worldwide, it is important that identical meteorological observations based on the same standards be made everywhere. The WMO draws up these regulations in agreement with all countries.

The meteorological measurements on airfields provide an important part of all meteorological observations on earth. The same co-operation exists with navigation. Selected ships, drilling platforms and buoys worldwide are making observations based on WMO-regulations.

But the road traffic sector also collaborates with meteorologists. The difference is that most of the time road measurements are only made for the purpose of winter maintenance and that road managers mostly co-operate with weather forecasters during wintertime in order to predict and to warn about road slipperiness. Another difference is the absence of standardization at international and national level. Most measurements along the road do not comply with WMO-standards as applied for instance by meteorological stations on airports. Perhaps it is not necessary for road managers to have the wide range of measurements as required on airports, although for instance the temperature measurements along the road and below its pavement have to be very precise and rich in details.

Anyhow, a lot of meteorological observations carried out along the roads would prove very interesting for meteorological institutes and make the meteorological observation network more dense, thus allowing to fill gaps….."

To give an idea of WMO-specifications with regard to temperature, wind etc., descriptions of WMO-standards on weather elements have been given in the appendix to the questionnaires.

Along the highways in Canada, we shall soon see road weather stations that meet WMO-standards or shall meet them in the near future. Canada is currently developing an Architecture for Intelligent Transportation Systems. It is a very close copy of the United States ITS Architecture with some additions to adapt it for use in Canada. Other countries are of the opinion that WMO-standards are not necessary but that local measurements must be carried out on the most suited observation sites, which do not meet WMO-standards most of the time.

TABLE 1 indicates the countries that returned the completed questionnaires and shows the number of already existing and planned road weather stations. This represents a lot of observation sites. It also gives a hint as to what the experts think about full or imperfect compliance with WMO-standards. However, in view of the conclusions of the 1997 report, one may wonder if the "more or less" answer is not a too optimistic one.

[1] See also Annexes A and B to this document, which contain the complete questionnaires and the related letters.

TABLE 1

#	Country	Type	Number of existing stations	Number of planned stations	WMO-standards applied
1.	Belgium	R	98	1	more or less
2.	Canada	M	80	350	most
3.	Czech Republic	R	87	250	no
4.	Estonia	M	23	27	no
5.	Finland	R	280	50	more or less
6.	France	M	550	?	more or less
7.	Germany	M	450	200	no
8.	Great Britain	R	150	0	no
9.	Ireland	M	48	?	more or less
10.	Italy	R	?	?	more or less
11.	Latvia	R	30	1	more or less
12.	Luxembourg	R	7	7	more or less
13.	Netherlands	R	385	2	more or less
14.	Norway	R	180	20	more or less
15.	Slovenia	R	5	50	yes
16.	Sweden	R	669	10	no
17.	Switzerland	R	400	100	no
18.	Venezuela	M	None	none	

Legend: R = Road Station M = Meteorological Station

4. The answers of the road managers

Before presenting the results of these answers, it should be pointed out that the expression "WMO-standards" in the tables stands for the WMO-standards laid down for synoptic measurements.

The questionnaire was designed so that most questions could be answered with "yes", "no" or "no opinion". But further comments on these short answers have been asked for. Happily for the Co-rapporteurs most road and meteorological experts have given a lot more information in these comments. Therefore the questionnaire has, in the eyes of the drafters of this report, completely fulfilled its purpose.

4.1. A few examples of road measurements deviating from WMO-standards

The road managers have been asked to give examples of deviations of their road measurements from WMO-standards as presented in the Appendix to the questionnaire. An earlier WMO report (ref. 1) already showed examples, but this report illustrates why road managers decide not to comply entirely with these standards. A respondent writes that his department measures the wind at a lower level, at 5 m height instead of 10 m, because it is only interested in observations pertaining to road condition. Measurements are therefore carried out as close as possible to the road surface, but higher than the traffic turbulence zone. To avoid vandalism, air temperature sensors are installed at a higher level, at 3 m height instead of 1.25 – 2 m. On the contrary, another road manager states that, in his country, road weather stations are built according to the suggestions of their Met. Office.

TABLE 2 - Answers received to the questionnaire sent to "Road managers"

#	Question	yes	no	no opinion
1	WMO-standards in the future	5	3	5
2	Better road forecasts with WMO-standards	6	4	3
3	Adjustment to WMO-standards	1	4	7
4	Agreement to maintain at WMO-level	8	3	1
5	No adaptation to WMO-standards because in situ measurements are the best	8		
6	Present choice of location forced by supplies and communications	4	1	
7	If use of solar power and radio communications then moving to WMO-location	3	7	3
8	Possible for road manager to meet WMO-standards in the long run	4	4	4
9	Influence of weather on future smart cars and roads			
	increasing same influence decreasin g	6 5 1		
10	If influence of weather on smart cars and roads increasing, chance of raising to WMO-level	3	4	3
11	Perhaps with smart cars and roads no need anymore of fixed road- weather stations		11	1
12	Using in-vehicle sensors	5	8	
13	In-vehicle sensors make fixed measurements along road superfluous	2	8	
14	Developing warning or forecasting methods using road measurements	2	10	
15	Need for specifications (siting, exposure, data sampling and processing)	10	2	1
16	Interest in workshop about road measurements attended by representatives of international road and meteorological bodies	7		6

A first conclusion can already be drawn from these two answers. The reasons put forward by road managers for deviating from WMO-standards as to the location of their roadside sensors are valid. When the road manager thinks that, for instance, the wind has to be measured at a lower level, closer to traffic, the meteorological community has to prove wind measurements at the WMO-level of 10 m can be correctly extrapolated to traffic level. More generally speaking, if the meteorological community could prove that the observations of a WMO-station, perhaps located somewhat further from the road, can be extrapolated to traffic level especially at dangerous places, this community might perhaps convince the road manager to build WMO-stations. This applies especially when the meteorologists can prove that a single WMO-station provides weather information (except for the measurements in the pavement, of course) for different road sections including the dangerous ones, thus saving money.

When such an extrapolation is not possible or not accepted by the road manager, the best results to measure weather elements would be obtained, as one respondent states, by using the expertise of the Met. Office. The meteorological community knows the best way to measure weather by following WMO-standards. When these standards can not be applied, the meteorologist who knows what is important in the choice of siting and location can suggest a second best location.

A third option, which is appreciated by most road managers, is expounded at the end of this chapter. It would consist in having at their disposal specifications concerning locations and siting tailored to roadside weather measurement requirements.

4.2. Better traffic monitoring and road forecasts with WMO-standards

The road managers have been asked whether they expect better traffic monitoring and road weather forecasts if road measurements were carried out according to WMO-standards? This question intended to arouse the interest of road managers in WMO-specifications so that they would want to learn more about them.

In first instance, it appears some road managers endorse the aforementioned thesis (see TABLE II). But when the question becomes more concrete, they always choose the option "No adaptation to WMO-standards because in situ measurements are the best".

A road manager writes that, for the general use of road weather measurements, it is important to consider the purpose of the measurements when deciding about the location and the means for measuring. He finds it is important that the monitoring takes place where problems might occur. The data needed have to reflect the road conditions. Monitoring should therefore be done mainly at places where difficult conditions, e.g. ice or snowdrift, might occur. These locations do not necessarily conform to the locations as described in WMO-standards. Should WMO-stations have to be installed, they should enable an increased use of weather information to motivate the users. Considering the kind of observations made by WMO-stations, he has his doubts about this incentive.

Another road manager goes even further. He agrees on the need for standards applicable to road weather observations but these standards do not necessarily have to be exactly the same as those applying to synoptic stations. He argues that if the stations are situated according to WMO-standards, features specific to road weather will not be observed and so road weather forecasts may also be worse. In that case, the costs to adapt all the stations will be higher than the benefits.

A third respondent finds it very difficult to move the actual stations to comply with WMO-standards because the locations were chosen for their representativeness. This equipment is installed to anticipate sudden weather changes, in particular during the winter. During the rest of the year, all these measurement data could be used by meteorological services

As already mentioned in the beginning - and this can be the conclusion about this part of the questionnaire – when the question concerning the option “No adaptation to WMO-standards because in situ measurements are the best” is asked directly, road managers give a straight answer “yes” and there are practically no comments.

4.3. In case of road managers endorsing WMO-standards, then road measurements in the future carried out at WMO-level and kept at that level?

In view of the conclusion of last chapter, this question seems superfluous, but yet the answer of the road managers is important. The purpose of this question is to know whether road managers who have set up road weather stations in accordance with WMO-standards are willing to meet WMO-standards in the long run, that is to say not only in wintertime but also in the summer half-year?

Most road managers are clear about it and their conclusion is that, once the road weather stations have been fitted up as WMO-stations, they will maintain them like the present stations. Because the question was not precise enough, we cannot conclude from the answers and the

comments that the road managers will maintain these stations in the summer half-year on the same level as they do in the winter, when their interest is obvious.

One respondent comments that if the road manager thinks the WMO-level is reasonable, he will maintain the road weather measurement devices. Another writes that data accuracy is of the utmost importance and that preventive maintenance is essential to that end.

4.4. Present choice of location forced by supplies and communications. If use of solar power and radio communications in the future, then moving to WMO-locations or too expensive?

TABLE II shows that many road managers did not answer the question : “Present choice of location forced by supplies and communications?”. On the contrary, all of them answered the question (abridged hereafter) "Future solar power and radio communications, then moving to WMO-locations". Again, the results of the questionnaire make clear that many road managers do not intend to transfer their road stations to a WMO-site, even if power supplies and communications are no obstacle anymore.

One respondent is very clear in his answer and writes that, although solar power and call-phones are already used in his country, the ensuing flexibility cannot persuade them to move the present road stations to WMO-locations. As a respondent comments that this flexibility can persuade them to replace some stations in the case of certain locations, but preferably in the course of the replacement of sensors. A third road manager writes such movements are too expensive.

The conclusion that can be drawn from all that has been said before is that future flexibility in power supplies and communications will not persuade most road managers to move their road stations to a WMO-location. The magnitude of the costs is a reason of uncertainty about these future developments.

4.5. Using in-vehicle sensors make fixed measurements along the road (and possibly WMO-stations) superfluous

At first, the road managers have been asked whether they are using in-vehicle sensors to measure road weather conditions. The next question was whether they intend to extend this way of measuring road and weather conditions so that perhaps fixed locations along the road – and, of course, in that case also non-WMO-stations – will become obsolete. The conclusion is that most road managers are convinced that measurements along the road will remain necessary.

As far as in-vehicle sensors are concerned, one country is developing equipment that measures air temperature, road surface temperature, air humidity and road surface friction. The vehicle sends this information automatically to the road management system. But the necessity of many fixed sensors will remain in the future. In another country, sensors are used in salt spreaders. A respondent is using in-vehicle sensors but, in his opinion, fixed sensors are more accurate as built-in sensors cannot measure many parameters. Another road manager thinks it is not necessary to monitor road and weather by gathering a continuous flow of data from in-vehicle sensors. Once the representative locations have been detected by thermal mapping, it is not necessary any more to gather information by criss-crossing the road network with vehicles fitted with sensors. Fitting the car used for thermal mapping with other sensors seems too expensive to a respondent.

4.6. Influence of weather on smart cars and roads in the future? If influence increasing, chance of bringing road measurements to WMO-level? Or smart cars and roads making road measurements superfluous?

These questions tried to deal more thoroughly with future expectations concerning road managers' cars being equipped with road-dedicated sensors (see last chapter) as well as all cars being fitted with all kinds of sensors in order to enhance safety and traffic control. Do the road managers who expect future smart cars and roads to handle all situations in good and bad weather - so that the influence of weather will be strongly reduced or even disappear – think present road measurements will still be necessary in the future? If not, WMO-stations will not be necessary anymore either. However, if the influence of weather on smart cars and roads will increase, perhaps the road manager could be persuaded to bring his weather measurements along the road to WMO-level. We hereby suggest that weather measurements according to WMO-standards are better for the road manager - which remains to be proved. A respondent points out that the quality level of observations will be better, but not only thanks to WMO-standards. There will also be many other aspects like different sensors, data transfer, technical functionality and so on. Most road managers do not dare to express an opinion on the increasing or decreasing influence of weather in the future with the presence of smart cars and roads. According to the results of the questionnaire, even in case of increasing influence, it is not sure whether it will augment the chance to persuade the road managers to bring the measurements along the road to WMO-level.

Nearly all road managers agree that road measurements will remain necessary - even in the future with high-tech cars and roads - because, as a respondent writes, road measurements are not meant only for driver/car information, but mainly for maintenance operations. Or, quoting another road manager, new technologies extend the scope of information activities to road users but data from weather stations have been necessary to logically validate all this information to keep its credibility. According to another respondent, road weather stations will not be superfluous but there will be a decreasing need for fixed sensors. A road manager expects that the change induced by these new technologies will not be so fast due to the implementation costs of such a system. If such a new system should replace the current method of winter maintenance with its effective road weather forecasting, it should provide a high grade of accuracy.

4.7. Developing warning or forecasting methods by using road measurements?

Road managers developing their own dedicated forecasting methods based on road weather measurements could perhaps be persuaded to measure weather along the road in compliance with WMO-standards if the meteorological society could prove their forecasting methods would be better if based on WMO-measurements. However, TABLE 2 indicates few road managers are developing their own forecasting methods. As a respondent writes, road managers work as follows. They gather different information data coming from road weather stations and the national Met. Office and make their own regular forecasts based on their own experience. However one road manager has developed a special forecast for his roads. He can compute the risk of fog with the help of his road weather measurements of dewpoint, wind and atmospheric radiation. Another respondent uses road weather measurements to adjust variable speed limits. He applies certain parameters and boundary layer values. He does not make forecasts with his road weather measurements.

4.8. Need for specifications (siting, exposure and data sampling processing)?

TABLE 2 indicates that most road managers endorse the necessity of having specifications. Only two respondents say they do not need such specifications because, as one writes, the present equipment fulfils the first goal of anticipating on sudden weather variations dangerous for traffic and thus gives complete satisfaction. The other road manager judges these specifications are not necessary but helpful and useful. Of the persons voting affirmatively, one writes it is important to have an international standard for road weather measurements so that they

will be as uniform as possible. This would enable road managers to use data across countries as well as across national borders. It would also be easier to provide external users with road weather data if there were specified quality requirements on the measurements. Another finds it necessary to have certainty about the measurements. Road managers have to know how accurate they are. If they use weather-controlled speed limits or information boards, it is of utmost importance that sensor values are correct or, at least, that road managers know the error margin. A road manager comments that although the manufacturer of ice detecting systems and other equipment usually specifies the siting etc., a general specification could be useful. A respondent considers that if road managers had such specifications, the quality of data would rise and the system would be more reliable. The experience of countries already possessing standardized road weather measurements can more easily be carried over to other countries. A road manager thinks that this need for specifications induces a close co-operation between road managers and meteorologists.

4.9. Interest in workshop about road measurements for road managers and meteorologists?

Half of the road managers are interested in a workshop attended by road managers and forecasters, the other half thinks it is not so necessary. Both parties have been making following comments. One respondent points out that a commission - SIRWEC (Standing International Road Weather Commission) – already exists. This forum encourages highway engineers, road masters, meteorologists, weather forecasters and others, who are interested in road weather problems, to exchange ideas in order to make roads safer to drive on in all weather conditions. This road manager was interested in attending an international workshop dealing with road meteorology and road weather condition monitoring.

Perhaps, as a road manager states, a more specific workshop could be created inside this Commission. Another road manager informs that they are also working in the international FHWA (= Federal High Way Administration, part of the United States Department of Transportation) AURORA-project. The AURORA-project is an international program for collaborative research, development and deployment in the field of Road and Weather Information Systems (RWIS), serving the interests and needs of public agencies. The program, launched in 1996, brings together a number of United States, Canadian and European agencies. The AURORA vision is to deploy RWIS to integrate state-of-the-art road and weather forecasting technologies with co-ordinated multi-agency weather monitoring infrastructures. Being also a member of SIRWEC, this road manager doubts about the usefulness of another workshop attended by road managers and forecasters. A respondent, who intended to visit such a workshop, thinks there can be an exchange of information about new ideas and needs. According to another respondent, such a workshop must focus on (standard) specifications and guidance.

5. Answers of meteorological experts

TABLE 3 shows the outcome of the “yes", "no" and "no opinion” questions, so that either a complete agreement or different opinions are clearly visible at first glance. However, when the total of answers is not equal to 6, it means that no answer was given to a particular question ; perhaps the question was not clear enough or seemed too trivial.

The following section comments the information provided in the answers to the questions. A number of questions have been brought together because they deal with related matters.

Countries have not been named in the evaluation with the exclusive exception of Canada. This country's policy differs from that of other countries, which have reacted to the questionnaires, concerning the setting up of road weather stations along the road according to WMO-specifications.

TABLE 3 - Answers received to the questionnaire sent to "Meteorological Forecasters"

#	Question	yes	no	no opinion
1.	Better road forecasts with WMO-standards	3	2	
2.	Better monitoring by road manager with WMO-standards	2	3	
3.	Adjustment to WMO-standards	3	1	1
4.	Agreement to maintain at WMO-level	4		1
5.	No adaptation to WMO-standards because in situ measurements are the best	2	2	1
6.	Present choice of location forced by power supplies and communications	2	3	
7.	If use of solar power and radio communications then moving to WMO-location	2	2	1
8.	Possible for road manager to meet WMO-Standards in a long run	2	3	
9.	Influence of weather on future smart cars and roads			
	Increasing	5		
	Decreasing			
10.	If influence of weather on smart cars and roads increasing, chance of raising to WMO-level	3	2	
11.	Your Met. Office is making road forecasts	5		
12.	Road forecast in :			
	Only winter half-year	4		
	Winter- and summer half-year	1		
13.	Development of road-dedicated warning or forecasting methods - for instance, radiation fog - using road measurements	1	4	
14.	Using non-standard WMO road measurements as supplement to WMO synoptic observations	4	1	
15.	Using road measurements if compliance with WMO-standards	4		
16.	Input road observations – even in case of non-WMO-standards – together with conventional data (synop, upper air etc) improve fine mesh computer models	5		
17.	WMO standardized road measurements are necessary for input in operational weather models	3	1	1
18.	Transforming road measurements by physical relations to WMO standardized measurements is possible	3		2
19.	Better and more reliable road weather parameters can be derived from fine mesh weather models, so removing fixed road stations is possible		5	
20.	Convincing the road manager to calibrate his road measurements with the output of fine mesh weather models		3	2
21.	Need for specifications (siting, exposure, data sampling and processing)	6		
22.	Interest in workshop about road measurements attended by representatives of international road and meteorological bodies	6		

5.1. Better monitoring and road forecasts with WMO-standards

Most respondents are convinced that specific road weather information differing from synoptic observations is necessary. Road managers as well as forecasters want to observe the typical phenomena of road weather that cannot be detected by a synoptic site. Although standardization is important, local topography may make this impossible along some stretches of roads.

However, the Canadian respondent is convinced of the merits of WMO-specifications and very strongly encourages adherence to them by meeting the road managers and discussing with them the advantages of uniformity. This is especially important since Canada hopes to eventually be able to integrate the RWIS (= Road Weather Information System) reports into his 3-D numerical

models to further refine the initialization fields of the models. This is necessary to increase model accuracy.

5.2. Is it possible to convince the road manager to adjust measurements to WMO-standards because he will be getting better forecasts and he could better monitor the weather. And will the road manager then maintain weather measurements on WMO-level in the long run

One respondent answers the national road authority has invested a great deal of money in roadside stations and it would be difficult to persuade it to move them. The national road authority acts on the advice of a market leader in the field of road measurements and chooses the location and the type of weather station with no input from the national Met Office. Communications and power lines are generally not a problem as for now or in the future.

Another respondent has no intention of convincing the road manager because, as already mentioned earlier, the locations have been chosen according to their significance and correspond to critical points within the road network. Power supplies and communications are not a problem. It is not a question of money, now or in the future. Even the coming of solar power and radio-based communications will not change the mind of this meteorological expert.

Again Canada has another vision. Road maintenance managers generally co-operate in order to apply WMO-standards which will make their road forecasts as good and as widely usable as possible. In a few instances, it was not possible to comply with WMO-standards because of logistic constraints (proximity of high-tension electrical cables, for example). In such cases, the road maintenance manager was warned of the forecast limitations and accepted them. In other instances, a road weather station is installed at a problem location without regard for WMO-specifications because it is a known troublesome spot and the maintainers have no intention of having a forecast prepared for the site.

Another expert reports that, in the future, the road manager will consult with the meteorological expert as to where to install new stations, but there are financial constraints and communications problems. However, the solving of these communication problems by solar power and radio-based communication systems will be helpful to move road weather stations to locations meeting WMO-standards, even in the long run.

Concerning the maintenance at WMO-level, once these standards would have been applied, most meteorological experts have the opinion that, once persuaded, the road managers will maintain the WMO-standards. But only in wintertime. One respondent thinks the road manager will only run the road stations during summer if he can offer a forecast product of interest for him during the summer.

In one country, the responsibility for maintaining is divided between three organizations, the national road authorities, the local authorities and the seller of the stations. So it is impossible to predict what level of maintenance will prevail.

In Canada, all road managers were approached about running their systems all year round so that the data would be available for the farm and forestry communities. The road managers all have readily agreed to do so provided the associated costs would be covered. Canada has made arrangements with one road manager to access the data throughout this summer so as to test the saleability of the information to the farm community on a trial basis.

5.3. Influence of weather on smart cars and roads increasing or decreasing in the future? And if increasing, will that raise the chance to bring road measurements to WMO-level?

All meteorological respondents are agreeing about the increasing influence of weather on the new high-tech cars and roads to be developed. Someone even predicts more stations for

weather and road measurements along entire roads but very limited in nature and not up to WMO-standards. One respondent names as reasons the distribution of more road user information and the higher efficiency of winter road maintenance. But notwithstanding the increasing influence of weather he does not expect the chance of bringing the road measurements to the high WMO-level to be greater. However, some other respondents expect the chance of bringing the road measurements to WMO-level to be raising because of the increasing influence of weather.

In Canada the road weather stations are incorporated in the already mentioned new Architecture of Intelligent Transportation Systems (ITS). ITS are systems which take advantage of additional sensory packages and the power of communications and computers to more accurately gauge what is happening on motorways so that the whole system can be better managed for efficiency, safety, economics and environmental considerations. The use of road weather stations along with special weather forecasts fits that definition very well. One leading consideration was the severe winter climates through most of Canada. The result is that road maintenance control centres, maintenance vehicles, road weather stations and road weather forecast services are all very much and formally part of the Canadian ITS Architecture. There was an Environment Canada meteorologist in the Steering Committee for the development of Canada's ITS Architecture and Canada is the first country to formally include weather considerations in its ITS Architecture. The ITS Architecture was completed last year. The necessary standards for all of the ITS Architecture elements including road weather stations will follow. As the Canadian provinces start deploying larger numbers road weather stations, they will be required to adhere to ITS standards (WMO-standards for road weather stations) in order to receive the Transport Canada share (50%) of the purchase and installation costs. In the opinion of the Canadian respondent, the influence of weather on road must be considered in order to achieve the greatest efficiency, safety and environmental gains possible. The road transportation community is therefore more aware of those links than ever; so the influence of weather on road transportation is definitely increasing worldwide. He also points out the analogy between the air and land transport sector. Even in the case of the actual very sophisticated and high-tech aircraft with automated navigation and landing systems, weather continues to play an important part in the safety and efficiency of the entire system.

5.4. Does your meteorological service make road forecasts in the summer half-year and is it necessary to use road measurements for summer forecasts?

In the summer half-year, most Met. Offices of the respondents are making road-dedicated forecasts (like wind and precipitation) but two report the use of road measurements to help with these forecasts in the summer half-year. In Canada, one agency has begun using road surface temperature forecasts all year round. This was done in order to be able to carry out resurfacing or other road works such as line marking as early as possible in spring and as long as possible in autumn.

5.5. Are road measurements – even when not meeting WMO-standards - a supplement to your own synoptic observations? Is it possible to use them as input in operational fine mesh weather computer models (not the model to forecast road surface temperature)?

All respondents agree that the large amount of road weather measurements help to monitor weather, especially on local scale. They complete the synoptic observations or, in other words, they fill gaps. The parameters used are wind, air temperature, road temperature, dewpoint, road surface condition (dry, wet, humid, snow ice), precipitation (yes/no or intensity or rain/snow). In Canada, some road weather stations in mountainous regions also provide snow depth on the ground. Subsurface data can also be extremely useful in the preparation of specialized agricultural and forestry products. It gives an estimate of the depth of frost penetration in autumn and in spring as well, which has many uses. Even when they do not meet WMO-standards, road measurements (observations on local scale) can be used for nowcasting and warnings. After having dealt with the pavement forecasts, the forecaster cannot just forget about them. So road weather measurements

have of course a beneficial effect on all issued forecasts, including those meant for the general public. Two respondents answer that if road measurements were on WMO-level, the forecasts for strong wind, local fog, precipitation and sort of precipitation or frost/ice would be better. When most road weather stations in Canada will be installed, some marine forecasts will even be improved because road weather stations with WMO-standards are going to be installed on roads along a shoreline.

Regarding the input in operational fine mesh weather computer models (therefore not the models computing only road surface temperatures), most respondents agree that only road measurements made according to WMO-standards should be used. When a larger network of stations - all meeting WMO-standards – will be available, the next step planned in Canada is to integrate road weather stations' data in the 3-D numerical models to help with the initialization of the models. Then all forecasts will benefit from a denser standardized weather observation network. And that is correct in the opinion of the Canadian correspondent since the road weather stations' equipment in his land is generally paid for with public funds. So they should benefit the entire public and not just the motorists. On the other hand, another respondent thinks the increasing density of surface observations improves numerical models only by a small amount.

To the question: “Is it possible to upgrade non-WMO standardized road measurements to the high WMO-level by using physical relations?”, some meteorological experts sometimes answer "yes", for instance, as regards wind and temperature. However, corrections for local topography are probably too difficult due to dependency on wind direction and seasonal growth.

5.6. Do you agree with some builders of fine mesh numerical models for weather prediction with their interpolation schemes when they claim that if they were given some data points along a road, they would provide better and more reliable air temperature, wind and precipitation forecasts for that road, not only for the fixed locations but also for the places in between? But if the road manager does not want to loose his present road measurements will he calibrate his stations with the output data of these fine mesh computer models?

All meteorological experts reject the idea of replacing most road weather stations by fine mesh model output saying: ”Good measurements can never replaced by forecasts! Fine mesh models need to be very sophisticated to simulate local topography, vegetation, road characteristics and influence of traffic. Fine mesh models for synoptic weather forecasting will not be able to substitute special models for road weather forecasting.” And: ”Conditions can vary quite a lot over a road network, models tend to average over grid squares so it is good from road managers' point of view to have as many sites as possible. From the numerical modelers' point of view, increasing the density of surface observations only improves numerical models by a small amount.” And: ”Our road stations number will increase and that is useful for road managers and forecasters.” And finally: ”Models must be re-initialized and re-launched at least twice daily. Data will always be required and the richer and better quality the data set, the better the predictions for the entire length of the road way will become.”

Calibration of the road measurements encounters opposition too. A respondent does not like the idea, while another meteorological expert states: ”It actually works the other way around, the outputs from the fine mesh modelling are corrected with data from the road stations.”

5.7. Do you develop other forecasting methods – e.g. for radiation fog - by using road weather measurements besides road forecasts.

Two Meteorological Offices are using road weather measurements for other purposes. One meteorological expert reports they used them to improve an energy balance model and says they are willing to use them for other models too, depending on the resources of the Met. Office. The other respondent mentions the considerable success they have with freezing precipitation.

5.8. Is it necessary to develop guidance material dedicated to road meteorological purposes like siting, exposure, data sampling and processing?

All meteorological respondents think it is necessary. As one expert notices: ”Standards are needed for road surface measurements as well as for all the other parameters. Consideration should be given to drawing up a complete set of standards for roadside stations, which could be different and possibly less stringent than those for synoptic stations. The road manager needs reliable information to an internationally recognized standard”. In one country, all measurements are already taken according to a national standard. But it surely is still necessary to improve the standard. Standardization is needed to make data from different types of equipment comparable, to set up a network and to exchange data. Another respondent recommends that WMO should consider the preparation of standards for the road sensors themselves. It would be quite useful if standard international practices for the installation of road sensors could be adopted and promoted worldwide. Meteorological packages relying on the use of the data from those sensors could more easily be exchanged internationally and road maintenance practices and decision-making software could be easily transferred from country to country.

The French respondent answers they are preparing French standards pertaining to this subject. In the discussion of this report we shall draw attention to a very interesting French article describing site classification, going from the good WMO-site (class 1 site) to a bad one (class 5 site).

5.9. Are you interested in an international workshop attended by representatives of international road and meteorological bodies about the present state-of-the-art of road meteorology and charting the way forward on road meteorological observations?

All meteorological experts are interested in such a meeting. One respondent comments that such a meeting will take place within the context of COST 344. But COST (= European **CO-**operation in the field of **S**cientific and **T**echnical Research) is a European project, not a worldwide one. One respondent thinks it is necessary to bring up the installation of road weather stations in tropical regions.

6.1 Conclusions road managers

Thirteen countries have answered the questions seriously : Switzerland, Sweden, the United Kingdom, Finland, Italy, Latvia, Norway, the Netherlands, the Grand Duchy of Luxembourg, Belgium with the Flemish and the Walloon Regions, Slovenia and the Czech Republic.

We deplore not to have received any answer from countries that have to deal with winter serviceability such as Denmark, France or Germany. Nevertheless it appears that in the countries having answered, nearly 3000 weather stations are set up along the road networks. These stations are very well adapted to the road managers' needs and comprise sensors particularly suited to road meteorology.

The need to comply with WMO standard specifications has not been felt by a majority of the road managers who are satisfied with the measurements provided by the sensors installed at present.

The managers are not against the standardization of the measurements related to meteorological observation but there is not yet any standardization concerning road sensors. In most cases, the compliance of weather stations with WMO-standards can be considered but three main critical remarks cast a shadow over this prospect :

1. Road managers have doubts as to the improvement of road weather forecasts. Will raising the sensor requirements to WMO-standards increase road forecast precision?

2. The present road weather stations would have to be moved to comply with WMO-standards but the new locations would not meet the road managers' needs. Moreover, it is highly likely that the location of the existing stations does not satisfy the national meteorological institutes either.

3. There is an important financial problem related to the adaptation of existing weather stations. It appears that the "modification costs/advantage" ratio is rather low. It is necessary to achieve compromise between the expenditures and the asked for precision.

Recommendations about the stations' maintenance methods and servicing issued by bodies depending on WMO would be well received on condition that the service provided would be well-defined and manageable. Many weather stations used by road network managers know problems of energy supply and data communication.

These two problems, which are characteristic of automatic weather stations, must be solved before thinking of changing the sensors in order to make them comply with WMO-standards.
New technologies such as « intelligent » motorways and on-board driving aids will exert very little influence on safety as regards atmospheric conditions.

The only in-vehicle measurement sensors operated by road managers are used either to determine the best location for road weather stations or to measure road surface temperature at the back of the lorries spreading chemical melting agents or abrasive materials.

As far as the other on-board sensors are concerned, the road managers think that they are too expensive, fragile and not reliable enough and that it is better to increase the number of fixed sensors. Fixed sensors make it possible to get an historical account of events and to consider carrying out climatic studies at a given location.

On the other hand, nearly half of the managers who answered have developed or are developing an alert and forecast generating method independent from the national meteorological institutes. Nevertheless it appears that the institutes provide weather forecasts that are supplemented by information from the road sensors.

The two information sources enable real-time management of winter serviceability based on alerts as well as danger prevention based on forecasting software specific to road conditions.

In conclusion, the majority of road network managers thinks that measurements proper to road meteorology should be specified - or even standardized - by drawing up a general rule for sensor location, for instance.

Standardization would allow the measured values to be validated and to be granted credibility. These measurements have a great influence on the systems for controlling the users' speed as well as on the systems on board of private vehicles.

Such a standardization would further the exchanges of meteorological experience and data between countries and would make data acquisition systems more easily compatible with each other.

An international working group would be welcome in order to study the possibility of standardizing road weather sensors but it would prove judicious that its activities take place within the framework of SIRWEC (Standing International Road Weather Commission).

6.2 Conclusions meteorologists

The two most important conclusions that can be drawn are the following ones.

The first conclusion is that there is a difference of opinion between the Canadian meteorological expert and the other meteorological experts on to what extent weather measurements along the road have to comply with WMO-specifications to get the best weatherwatch and weather forecasting along the road. Road weather measurements in Canada are carried out by stations conforming to WMO-standards. According to the Canadian road managers and forecasters, this enables to monitor road traffic in the best way and to obtain the best road weather forecasts. Because these Canadian road weather stations are synoptic weather stations, these measurements are also used for forecasts other than the road-dedicated ones. These measurements meeting WMO-specifications are naturally fit to be input into the 3-D numerical computer weather models.

The meteorological respondents of the other countries are sharing the view of their road managers and think that a synoptic site can not detect typical road weather phenomena. The argument that a synoptic site cannot be installed because of the absence of power supplies and fixed communications systems is not the real reason. Money for displacements is not the problem, but these meteorological experts agree with their road managers when the latter decide to set up their road weather stations only at the critical points within their road network. These countries are also using road weather measurements - although these measurements do not meet WMO-standards and are not therefore as reliable as synoptic weather measurements – in addition to their synoptic observations for weather monitoring and for making weather forecasts other than road forecasts.

The second conclusion is that all meteorological respondents agree on the necessity of developing guidance material especially dedicated to road meteo. Even if these guidelines were drawn up and followed by the road managers to locate their road weather stations, there is still a chance that these new locations will not comply with WMO-rules. But the importance of a French article (ref. 2) titled “Meteorological measurement representativeness nearby obstacles' influence” and concerning siting classification should then be emphasized. As the author of this article writes: ”*To take in account the existence of stations not respecting the WMO recommendations, a classification has been defined for each weather variable to document the representativeness of a site. This classification ranges from 1 to 5. By convention, a class 1 site follows the WMO recommendations. A class 5 site is a site where nearby obstacles create an inappropriate environment for meteorological measurements…… The proposed classification allows to objectively document a site to inform users about the quality and how representative is a measure*.” This report aims at making it possible for the road manager - but perhaps even more for the forecaster who has gaps in his synoptic observation network - to know how reliable roadside weather measurements are.

There are two further conclusions. Firstly, none of the meteorological experts thinks it is possible that numerical weather models with their fine grids and interpolation schemes will be able, starting from only a few measurements along the road, to monitor the other critical locations along the road and to make forecasts for these sensitive points. Secondly, all meteorological experts are interested in an international workshop attended by representatives of international, road and meteorological bodies. The representative of the Canadian community has been offered to help organize this workshop.

6.3 Overall conclusions

In co-operation with the aviation and navigation community, the World Meteorological Organization (WMO) has been appointed to draw up specifications on behalf of these users on how to observe weather as correctly as possible. These standard rules are necessary because of the worldwide activities of both communities.

A third community making a lot of weather measurements is that of the road managers. However, in contrast to the two preceding communities, there is no standardization at all and road weather measurements can differ from land to land, even from region to region. The urgency of standardizing is possibly less because most road traffic is not worldwide. However, as meteorological offices with their WMO standardized measurements are also making road weather forecasts, WMO wonders about the standardization of road weather measurements and thinks that standardizing road weather instruments and observation methods could be valuable.

For the purpose of this report, a survey by means of questionnaires (one for the road manager and another for the meteorologist) was carried out on how the road manager and meteorological community stands towards the standardization of road weather measurements. It would be a good thing if weather measurements along the road were meeting the WMO-specifications of the meteorological synoptic stations. The road manager gets high-level weather measurements and the meteorologist has the opportunity of extending his synoptic weather measurements' network or to fill up present gaps. The questionnaires therefore take WMO-specifications as frame of reference, in the hope that road managers would endorse these standards. Such an endorsement would lead to a wider use of these road weather observations, which could then be used not only for road monitoring and road weather forecasts in wintertime.

In Canada, road managers and meteorologists have indeed come to the conclusion that the best results of road weather monitoring as well as road weather forecasts are achieved when roadside stations comply with the WMO-requirements for synoptic stations.

Road managers and meteorologists of all other countries who have been interrogated hold the opinion that road weather measurements have to be carried out at that places which are the most dangerous for road users or where the road manager can monitor the road in the best way. In their opinion, these locations mostly do not correspond with the locations as prescribed by the WMO – specifications for synoptic stations. Accordingly, almost all these respondents - road managers and meteorologists – agree that it is necessary to develop guidance material especially dedicated to road meteo. These road weather specifications shall deviate from the WMO-standards for synoptic weather measurements. Compliance with such new road weather measurement specifications will of course lead to standardization which will enable the exchange of road weather data between regions and countries, as is the case with synoptic weather measurements meeting WMO-standards.

It goes without saying that these road meteo specifications can be best drawn up under the auspices of WMO with its long experience of weather measurements. In order to make use of this experience, some respondents recommend that experts of the national meteorological institutes help road managers to choose an appropriate location along the road. Standardization of road weather measurements also makes industrial competition possible.

Yet, as road weather measurements come in addition to the other weather observation data gathered by the meteorological offices, a French research about siting classification (ref. 2) could prove interesting. The proposed classification allows to objectively document a site to inform users (road managers and forecasters) about the quality and how representative these measurements are.

Finally, the difference in the conception of road weather measurements in Canada and in the other countries needs further investigation and clarification especially when one realizes the Canadian decision has been based on their new set-up wherein the road weather stations are incorporated in the new Architecture of Intelligent Transportation Systems (ITS). These ITS are systems which take advantage of additional sensory packages and the power of communications and computers to more accurately gauge what is happening on motorways so that the total system can be better managed for efficiency, safety, economics and environmental considerations. Canada is the first country to formally include weather considerations in its ITS Architecture.

This exchange of views about this difference of conception could occur in an international workshop attended by road managers and meteorologists. The representative of the Canadian meteorological community has been offered to help organize this workshop. Likewise the standardization of specifications pertaining to road weather measurements and the guidance of meteorological experts could be talked about as suggested by some road managers.

All meteorological experts are interested in such an international workshop attended by representatives of international road and meteorological bodies. One half of the road managers are interested in the workshop, the other half thinks it is not so necessary. Road managers point out the already existing commission SIRWEC (Standing International Road Weather Commission). This forum has been set up to encourage highway engineers, road masters, meteorologists, weather forecasters and others, who are interested in road weather problems, to exchange ideas to make the roads safer to drive on in all weather conditions.

Road managers and meteorologists are also working together in the international FHWA (= **F**ederal **H**igh**W**ay **A**dministration, part of the United States Department of Transportation) AURORA-project. The AURORA-project is an international program of collaborative research, development and deployment in the field of **R**oad and **W**eather **I**nformation **S**ystems (RWIS), serving the interests and needs of public agencies. The program, launched in 1996, brings together a number of United States, Canadian and European agencies. The AURORA vision is to deploy RWIS to integrate state-of-the-art road and weather forecasting technologies with co-ordinated multi-agency weather monitoring infrastructures.

In view of the result of this question about a workshop where one half of the key road managers are interested, the co-rapporteurs have decided not to arrange an international workshop during their period of research.

7. Recommendations

As result of our work, we make the following recommendations.

1. The new chapter on "*Road Meteorological Observations*" for the Guide on Meteorological Instruments and Methods of Observation describing the weather phenomena - visibility, rain, icing, snow, storm, etc. - alongside the road should be written in close collaboration with road managers in order to come to a consensus about observing methods, definitions and specifications. A widely acceptable set of observing practices for road meteorology can then be obtained.

2. Most road managers and meteorologists think that road weather measurements have to be carried out at places which are the most dangerous for the road users or where the road manager can monitor the road in the best way. In their opinion, these locations mostly do not correspond with the locations as prescribed by the WMO – specifications for synoptic stations. These road weather measurements, described in the new chapter about road meteorology (see point 1 of these recommendations), therefore deviate from the current observations (SYNOP, METAR etc) as made by the meteorological community. To incorporate these road weather measurements in the current meteorological observations, it is recommended to follow the French approach to site classification. This classification ranges from 1 to 5. By convention, a class 1 site complies with WMO recommendations. A class 5 site is a site where nearby obstacles create an inappropriate environment for meteorological measurements. This method allows to objectively document a site to inform road managers and meteorologists about the quality and how representative is a measure.

3. Because of the strongly deviating opinion of the Canadian road managers and meteorologists who, within the framework of the new architecture of Intelligent Transportation Systems (ITS), are installing road weather stations meeting the WMO-standards for synoptic stations, it is recommended to organize a meeting attended by road managers and meteorologists to talk

about these different views on future developments. It has been recommended to accept the offer of the Canadian meteorological office to help organize this meeting.
The second part of this meeting could be used for the co-operation between road managers and meteorologists so that they could come to a consensus about observing methods, definitions and specifications concerning road meteo.

References

1. Pettifer, R.E.W. and J. Terpstra, 1997. Road meteorological observations. IOM-Report No. 61 (*WMO/TD-No. 842*).

2. Leroy, M, 1998. Meteorological measurement representativity, nearby obstacles influence. IOM-Report No 70 (*WMO/TD – No 877*).

QUESTIONNAIRE ON ROAD METEOROLOGICAL OBSERVATIONS

Addressed to Road Managers

Dear Sir/Madam,

In all countries in the world there is a close co-operation between aviation and meteorology. Accurate meteorological measurements are made on airports in aid of pilots, air traffic controllers and meteorologists. Because airplanes are flying worldwide, it is important to get everywhere the same meteorological observations based on the same standards. The World Meteorological Organization (WMO), part of United Nations, draws these regulations up with agreement of all countries.

The meteorological measurements on airfields provide an important part of all meteorological observations on earth. The same co-operation exists with navigation. Selected ships, drilling platforms and buoys worldwide are making observations based on WMO-regulations.

Meanwhile, the field of road traffic is also working together with meteorology. But a difference is, the road measurements are most of the time only made for winter maintenance and, likewise, the co-operation between road managers and weather forecasters is mostly during wintertime in view of road slipperiness. Another difference is, there is no standardization, not worldwide and not national. Most measurements along the road are not following the WMO-standards as applied for instance on the meteorological stations on airfields. Perhaps it is not necessary for road managers to have the wide range of measurements as required on airports, although for instance the temperature measurements along and inside the road have to be very precise and rich in details.

Anyhow, there are a lot of meteorological observations along the roads very interesting for meteorological institutes to make the meteorological observation network more densely and to fill gaps.

This is the reason why the World Meteorological Organization appointed T. Ledent (Ministère Wallon de l'Equipment et des Transports) and J. Terpstra (Royal Netherlands Meteorological Institute) to investigate on the analogy of the aviation whether a closer co-operation between the road - and the meteorological - world is possible.

We have decided that the optimum way in which to proceed with the task set us is to request appropriate experts to fill in and return a quite comprehensive questionnaire relating to their opinions about standardization of road measurements.

To give a framework, the questionnaire starts with a short outline of WMO-specifications for the general set-up of the observation station and the wind. More details for the measurement of other weather parameters are given in the Appendix.

You are kindly requested to complete the questionnaire to the greatest extent possible, consulting as necessary within your own national Organizations responsible for this matter.
When completed, please return the questionnaire to:

T. Ledent
Ministère Wallon de l'Equipment et des Transports
PEREX
Rue del' Grète, 22
5020 DAUSSOULX
BELGIUM

We apologise in advance for the length and complexity of this questionnaire, but as this is the first time such a subject has been dealt with it is important that as much information as possible is obtained. We hope that you will not find the task of completing the document too onerous and thank you sincerely for your co-operation.

T. Ledent J. Terpstra

A short introduction on: "How to measure weather according to standards of the World Meteorological Organization (WMO)"

In this introduction we highlight some parts of the guide drawn up by WMO. The WMO has made this guide to get the same meteorological observations all over the world. This is very important because weather measurements of different regions or countries can now be compared with each other for monitoring, warning and forecasting purposes. For more details on the WMO-standards, we refer to the APPENDIX. After starting with a quotation out of the Site Selection, we also described the WMO recommendations concerning wind measurement.

Wind measurement is rather sensitive to surroundings, even on greater distances and this is the reason why it is difficult to meet WMO-standards when wind measurement devices are located along the road. The purpose of following two quotations is that you as road manager can quickly scan whether your road weather measurements comply with WMO-standards.

In the first quotation the adjective "synoptic" has been used. The definition of synoptic is: "In general pertaining to or affording an overall view. In meteorology, this term has become somewhat specialized in referring to the use of meteorological data obtained simultaneously over a wide area for the purpose of presenting a comprehensive and nearly instantaneous picture of the state of the atmosphere. Thus, to a meteorologist, "synoptic" takes on the additional connotation of simultaneity."

First quotation:

"Site selection

……. the following considerations apply to the selection of site and instrument exposure requirements for a typical synoptic or climatological station in a regional or national network (detailed information appropriate to specific instruments and measurements is given later):

a) Outdoor instruments should be installed on a level piece of ground, approximately 10 metres by 7 metres (the enclosure), covered with short grass or a surface representative of the locality, and surrounded by open fencing or palings to exclude unauthorized persons;
b) There should be no steeply sloping ground in the vicinity and the site should not in a hollow. If these conditions are not complied with, the observations may show peculiarities of entirely local significance;
c) The site should be well away from trees, buildings, walls or other obstructions. The distance of any such obstacle including fencing from the rain gauge should not be less than twice the height of the object above the rim of the gauge, and preferably four times the height;
d) The sunshine recorder, rain gauge and anemometer must be on sites with exposures to satisfy their requirements and they need to be on the same site as the other measurements;
e) It should be noted that enclosure may not be the best place from which the estimate the wind speed and direction; another observation point, more exposed to the wind, may be desirable;"

End of the first quotation.

Second quotation:

"**Wind**

…..The standard exposure of wind instruments over level, open terrain is 10 m above the ground. Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstruction. Wind observations that are made in the direct wake of tree rows, buildings or any other obstacle are of little value and contain little

information about the unperturbed wind. Since wakes can easily extend downwind to 12 or 15 times the obstacle height, the requirement of 10 obstruction heights is absolute minimum.

In practice, it is often difficult to find a good location or even an acceptable location for a wind station. The importance of optimising the location can hardly be overstressed, although it is difficult to give universal guidelines. An optimum location is one where the observed wind is most representative for the wind over an area of at least a few kilometres, or can be easily be corrected to make it representative. Two aspects are very important. Firstly, either the sensors should be kept away from local perturbations or the wind station should be moved in cases where new buildings arise nearby. Secondly, the local perturbations should well be documented. Simple calculation procedures exist nowadays to determine the effect of local topography and the climatology of the gustiness observations can be used to determine exposure corrections for non-uniform vegetation or other obstructions.

Where a standard exposure is unobtainable, the anemometer might be installed at such a height that its indications are reasonably unaffected by local obstructions and represent as far as possible what the wind at 10 m would if there where no obstructions in the vicinity."

End of the second quotation.

Questionnaire addressed to road managers

1) How many road weather stations have been installed in your country?

Amount:

2) Do you have plans to install more of those stations in the future and on how many locations?

Amount:

3) Are your road weather measurements of wind (direction and speed), air temperature, dewpoint etc meeting WMO-standards qua siting and exposure as described in the Introduction or in more details in the APPENDIX below?

Yes: More or less: No:

Please add your comments here:

4) In case your weather measurements along the road do not meet WMO-standards at the moment, are you of the opinion as road manager that weather and traffic monitoring would be better if these measurements effectively met WMO-standards?

Yes: No opinion: No:

Please add your comments here:

5) Are you of the opinion that you would get better road weather forecasts if the weather measurements carried out along the roads and put at the weather forecaster's disposal complied with WMO-standards?

Yes: No opinion: No:

Please add your comments here:

6) In case your answer to question 4 and 5 was “yes”, do you agree to adjust your weather measurement conditions along the road, if they do not meet WMO-standards at this moment? For instance, by choosing another location along the road, which conforms to WMO-standards, or by fitting present location - for instance, by cutting down close standing trees which alter wind speed measurement?

Yes:
Possible:
No:

Please add your comments here:

7) And, as road manager, do you also agree to keep the weather measurements at WMO-level through appropriate maintenance?

Yes:
Possible:
No:

Please add your comments here:

8) If you do not intend to adapt your road measurements to WMO-standards, is it either because you think the measurements in situ are carried out in the best possible way at the moment, giving to the road manager all information he needs?

Yes:
Other reason(s):

Please add your comments here:

9) Or because the present choice of location and type of road measurements is dictated by the availability of services, such as power supplies and communications?

Yes:
Other reason(s):

Please add your comments here:

10) If, in the future, the use of solar power and radio-based communications (such as cellular telephone systems) made the choice of a location for road measurements independent of the availability of power supplies and fixed communication systems, would you then agree to move road weather measurement sensors to locations meeting WMO-standards? And are you also inclined to expose these sensors by following the same WMO-standards?

Yes:
Possible:
No:

Please add your comments here:

11) Or are you of the opinion that keeping those solar powered and radio-based road weather stations at the level of WMO-standards will also be too expensive? Or, in other words, would it be impossible for you as road manager to meet WMO-standards in the long run?

Yes:
Possible:
No:

Please add your comments here:

12) Considering the expected development of smart highways and cars which will provide electronic protection against collision, the instrument steering of strings of cars etc., what do you think about the influence of weather conditions on roads and cars equipped with these new future technologies?

Decreasing:
Same influence:
Increasing:

Please add your comments here:

13) If you think the influence of the weather on these smart roads and cars is increasing, do you think the chance to raise and to maintain the measurement standards at WMO-level will be greater?

Yes:
No opinion:
No:

Please add your comments here:

14) Or do you expect that thanks to these new techniques which will be implemented along the road and in the cars, dependency on the weather shall only decrease and that perhaps even road measurements will become superfluous?

Yes:
No opinion:
No:

Please add your comments here:

15) Do you develop, as road manager, your own warning or forecasting methods using the road weather measurements gathered apart from the meteorological institute? An example : by combining data about wind speed, air temperature, dewpoint and global radiation, it is perhaps possible for you to deduce a statistical method to forecast the occurrence of radiation fog on the road.

Yes:
No:

If the answer is "Yes"*, can you describe briefly the forecasting methods you are using?*

16) Until now most of the questions focused on the compliance or not with the WMO-standards which have been developed for synoptic meteorological observations. Do you think it is necessary to develop guidance material specially intended for road meteorological purposes? Do you need specifications for the measurement of meteorological variables along the road, which may include issues related to siting, exposure, data sampling and processing?

Yes:
No opinion:
No:

17) Can you explain your answer to question 16)?

Please add your comments or suggestions here:

18) Do you use in-vehicle sensors? For example, do you have a car with built-in sensors to measure road surface temperature or slipperiness, ...?

Yes:
No:

Please add your comments or suggestions here:

19) If you do not use at the moment in-vehicle sensors, will you use them in the future? Do you think that by using in-vehicle sensors, the present method of road measurements with fixed sensors will then be superfluous?

Yes:
No:

Please add your comments or suggestions here:

20) Are you interested in an international workshop, attended by representatives of international, road and meteorological bodies, about the present state of art of road meteorology and charting the way forward for road meteorological observations?

Yes:
Possible:
No:

Please add your comments or suggestions here:

APPENDIX
Addressed to Road managers

Site selection

Meteorological observing stations are designed to enable representative measurements (or observations) to be made according to the type of station involved. Thus a station in the synoptic network should make observations to meet synoptic scale requirements whereas an aviation meteorological observing station should make observations that describe the conditions specific to local (aerodrome) site. Where stations are used for several purposes, e.g. aviation, synoptic and climatology, the most stringent requirement will dictate the precise location of an observing site and its associated sensors.

As an example, the following considerations apply to the selection of site and instrument exposure requirements for a typical synoptic or climatological station in a regional or national network (detailed information appropriate to specific instruments and measurements is given later):

a) Outdoor instruments should be installed on a level piece of ground, approximately 10 metres by 7 metres (the enclosure), covered with short grass or a surface representative of the locality, and surrounded by open fencing or palings to exclude unauthorized persons;
b) There should be no steeply sloping ground in the vicinity and the site should not in a hollow. If these conditions are not complied with, the observations may show peculiarities of entirely local significance;
c) The site should be well away from trees, buildings, walls or other obstructions. The distance of any such obstacle including fencing from the rain gauge should not be less than twice the height of the object above the rim of the gauge, and preferably four times the height;
d) The sunshine recorder, rain gauge and anemometer must be on sites with exposures to satisfy their requirements and they need to be on the same site as the other measurements;
e) It should be noted that enclosure may not be the best place from which to estimate the wind speed and direction; another observation point, more exposed to the wind, may be desirable;

f) the following point are concerning clouds and visibility, we disregard them

Maintenance

Observing sites and instruments should be maintained regularly so that the quality of observations does not deteriorate significantly between station inspections. Routine (preventive) maintenance schedules include regular “housekeeping” at observing sites (e.g. grass cutting and cleaning of exposed instrument surfaces) and manufacturers’ recommended checks on automatic instruments. Routine quality control checks carried out at the station or at a central point should be designed to detect equipment faults at the earliest possible stage. Depending on the nature of the fault and the type of station, the equipment should be replaced or repaired according to agreed priorities and time scales.

Temperature

Radiation from the Sun, clouds, the ground and other surrounding objects passes through the air without appreciably changing its temperature, but a thermometer exposed freely in the open can absorb considerable radiation. As a consequence, its temperature may differ from the true air temperature, the difference depending on the radiation intensity and on the ratio of absorbed radiation to dissipated heat. For some thermometer elements, such as the very fine wire used in open-wire resistance thermometer, the difference maybe very small or even negligible, but with the more usual operational thermometers difference may reach 25 K under extremely unfavourable conditions. Therefore, in order to ensure that the thermometer is at true air temperature it is necessary to protect the thermometer from radiation by a screen or shield which also serves to support the thermometer. This screen also shelters it from precipitation while allowing the free

circulation of air around it, and prevents accidental damage. Maintaining a free circulation may, however, be difficult to achieve under conditions of rime ice accretion.

Practices for reducing observation errors under such conditions will vary and may involve the use of special designs of screens or temperature measuring instruments.

In order to achieve representative results when comparing thermometer readings at different places and at different times, a standardized exposure of the screen and, hence, of the thermometer itself is also dispensable. For general meteorological work, the observed temperature should be representative of the free air conditions surrounding the station over as large an area as possible, at a height of between 1.25 and 2 m above ground level. The height above ground level is specified because large vertical temperature gradients may exist in the lowest layers of the atmosphere. The best site for measurements is, therefore, over level ground, freely exposed to sunshine and wind and not shielded by, or close to trees, buildings and other obstructions. A site on a steep slope or in a hollow is subject to exceptional conditions and should be avoided. In towns and cities, local peculiarities are expected to be more marked than in rural districts. Observations of temperature on the top of buildings are of doubtful significance and use because of the variable vertical temperature gradient and the effect of the building itself on the temperature distribution.

Humidity

The general requirements for the exposure of humidity sensors are similar to those for temperature sensors, and a suitably positioned thermometer screen may be used for that purpose. Particular requirements include:

a) Protection against direct solar radiation, atmospheric contaminants, rain, and wind;
b) Avoidance of the creation of a local microclimate within the sensor housing structure or sampling device. Note that wood and many synthetic materials will sorb or desorb water vapour according to the atmospheric humidity.

Wind

Due to the effects of friction, wind speed increases considerably with height. For this reason, a standard height has been defined for the exposure of wind instruments above open terrain. The corresponding shift of wind direction with height over open terrain is relatively small and can be ignored in surface wind observations.

For terrain that is uneven, contains obstacles, or is non-homogeneous in surface cover, both wind speed and direction can be affected considerably. Corrections are often possible, and the tools to compute such corrections are becoming available. To improve the applicability of wind data, the essential information to perform such corrections should be transmitted to the users in addition to the direct measurements.

The standard exposure of wind instruments over level, open terrain is 10 m above the ground. Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstruction. Wind observations that are made in the direct wake of tree rows, buildings or any other obstacle are of little value and contain little information about the unperturbed wind. Since wakes can easily extend downwind to 12 or 15 times the obstacle height, the requirement of 10 obstruction heights is absolute minimum.

In practice, it is often difficult to find a good location or even an acceptable location for a wind station. The importance of optimising the location can hardly be overstressed, although it is difficult to give universal guidelines. An optimum location is one where the observed wind is most representative for the wind over an area of at least a few kilometres, or can be easily be corrected to make it representative. Two aspects are very important. Firstly, either the sensors should be kept away from local perturbations or the wind station should be moved in cases where new

buildings arise nearby. Secondly, the local perturbations should well be documented. Simple calculation procedures exist nowadays to determine the effect of local topography and the climatology of the gustiness observations can be used to determine exposure corrections for non-uniform vegetation or other obstructions.

Where a standard exposure is unobtainable, the anemometer might be installed at such a height that its indications are reasonably unaffected by local obstructions and represent as far as possible what the wind at 10 m would if there where no obstructions in the vicinity. If the terrain varies little with azimuth, this may be affected by placing the anemometer at a height exceeding 10 m by an amount depending on the extent, height, and distance of the obstructions; but it is impracticable to give any general rule for determining this, since local conditions differ so widely. This method of anemometer height increase does not work well if local sheltering varies strongly with azimuth.

Special precautions must be taken to keep the wind equipment free from sleet and ice accumulations. In some localities it may be desirable to provide some form of artificial heating for the exposed parts, such as thermostatically controlled infra-red radiator. Sleet and ice shields have been designed for particular types of wind equipment.

Precipitation

Any method of measuring precipitation should aim to obtain a sample which is representative of the true amount falling over the area which measurement is intended to represent, whether on the synoptic, meso or microscales. The choice of site, as well as the systematic measurement error is, therefore important. The location of precipitation stations within the area of interest is important, because the number and locations of the gauge sites determine how well the measurements represent the actual amount of precipitation falling in the area. Areal representativeness is discussed at length in WMO for rain and snow. The effects on the wind field of the immediate surroundings of the site can give rise to local excesses and deficiencies of precipitation. In general, objects should not be closer to the gauge than a distance twice their height above the gauge orifice. For each site, the average vertical angle of obstacles should be estimated, and a site plan should be made. Sites on a slope or on the roof of a building should be avoided. Sites selected for measurement of snowfall and/or snow cover should be in areas sheltered from the wind as much as possible. The best sites are often found in clearings within forests or orchards, among trees, in scrub or shrub forests, or where other objects act as an effective windbreak for winds from all directions.

Preferably, however, the effects of the wind, and of the site on the wind, can be reduced by using a ground level gauge for liquid precipitation or by making the airflow horizontal above the gauge orifice using the following techniques. These are listed in order of decreasing effectiveness:

a) In areas having homogeneous dense vegetation, regular clipping should keep the height of such vegetation at the same level as the gauge orifice;
b) In other areas, by simulating the effect in (a) by the use of appropriate fence structures;
c) By using windshields around the gauge.

The surface surrounding the precipitation gauge can be covered with short grass, gravel or shingle, but hard, flat surfaces, such as concrete, should be avoided to prevent excessive in splashing.

Radiation

The site selected for exposing a radiation sensor should be free from any obstruction above the plane of the sensing element and, at the same time, should be readily accessible. If it is impracticable to obtain such an exposure, the site must be as free as possible from obstructions that may shadow it any time in the year. The radiation sensor should not be near light-coloured

walls or other objects likely to reflect sunlight onto it, nor should it be exposed to artificial radiation sources.

In most places, a flat roof provides a good location for mounting the stand for the radiometer. If such a site cannot be obtained, then a stand placed some distance from buildings or other obstructions should be used. If practicable, the site should be chosen so that no obstruction, in particular within the azimuth range of sunrise and sunset over the year, should have an elevation exceeding 5 degrees. Other obstructions should not reduce the total solar angle by more than 0.5 steradians. At stations where this is not possible, complete details of the horizon and the solid angle subtended should be included in the description of the station.

A site survey should be made before the initial installation of a radiometer whenever its location is changed or if a significant change occurs in regard to any surrounding obstructions. An excellent method of doing this makes use of a survey camera that exposes azimuthal and elevation grid lines on the negative. A series of exposures should be made to identify the angular elevation above the plane of receiving surface of the radiation sensor and the angular range azimuth of all obstructions throughout the full 360 degrees around the radiometer. If a survey camera is not available, then the angular outline of obscuring objects may be mapped out by means of a theodolite or a combination of compass and clinometer.

The description of the station should include the altitude of the radiation sensor above sea level (i.e. altitude of station plus height of radiometer above ground), together with its geographical longitude and latitude. It is also most useful to have a site plan, drawn to scale, showing the position of the recorder, the radiometer and all connecting cables.

Probably the most important single consideration in choosing a site is the accessibility of instrumentation for frequent inspection. It is most desirable that radiation sensors and recorders be inspected at least daily, preferably more often.

****

QUESTIONNAIRE ON ROAD METEOROLOGICAL OBSERVATIONS

Addressed Meteorological Forecasters

Dear Sir/Madam,

As you know, in all countries in the world there is a close co-operation between aviation and meteorology. Accurate meteorological measurements are made on airports in aid of pilots, air traffic controllers and meteorologists. Because airplanes are flying worldwide, it is important to get everywhere the same meteorological observations based on the same standards. The WMO draws these regulations up.

The meteorological measurements on airfields provide an important part of all meteorological observations on earth. The same co-operation exists with navigation. Selected ships, drilling platforms and buoys worldwide are making observations based on WMO-regulations.

Meanwhile, the field of road traffic is also working together with meteorology. But a difference is, the road measurements are most of the time only made for winter maintenance and, likewise, the co-operation between road managers and weather forecasters is mostly during wintertime in view of road slipperiness. Another difference is, there is no standardization, not worldwide and not national. Most measurements along the road are not following the WMO-standards as applied for instance on the meteorological stations on airfields. Perhaps it is not necessary for road managers to have the wide range of measurements as required on airports, although for instance the temperature measurements along and inside the road have to be very precise and rich in details.

Anyhow, there are a lot of meteorological observations along the roads very interesting for meteorological institutes to make the meteorological observation network more densely and to fill gaps.

This is the reason why CIMO XII appointed T. Ledent (Ministère Wallon de l'Equipment et des Transports) and J. Terpstra (Royal Netherlands Meteorological Institute) as joint Rapporteurs to investigate on the analogy of the aviation whether a closer co-operation between the road - and the meteorological - world is possible.

The Rapporteurs have decided that the optimum way in which to proceed with the task set them is to request National contacts to fill in and return a quite comprehensive questionnaire relating to their opinions about standardization of road measurements.

To give a framework, the questionnaire starts with a short outline of WMO-specifications for the general set-up of the observation station and the wind. More details for the measurement of other weather parameters are given in the Appendix.

You are kindly requested to complete the questionnaire to the greatest extent possible, consulting as necessary within your own national Organizations responsible for this matter.
When completed, please return the questionnaire to:

J. Terpstra
Royal Netherlands Meteorological Institute
PO Box 201
3730 AE De Bilt
NETHERLANDS

The Rapporteurs apologise in advance for the length and complexity of this questionnaire, but as this is the first time such a subject has been dealt with it is important that as much information as possible is obtained. We hope that you will not find the task of completing the document too onerous and thank you sincerely for your co-operation.

T. Ledent J. Terpstra

Pay Attention. The short introduction on: “How to measure weather according to standards of the World Meteorological Organization (WMO) and the APPENDIX with the paragraphs Site selection, Maintenance, Temperature, Humidity, Wind, Precipitation and Radiation are equal for both road managers and meteorologists. Therefore they do not have been repeated in this ANNEX B for meteorologists.

Questionnaire addressed to meteorological forecasters

1) How many road weather stations have the road managers installed in your country?

Amount:

2) Have the road managers in your country plans to install more stations in the future and at how many locations?

Amount:

3) Are these road weather measurements of wind (direction and velocity), air temperature, dewpoint etc up to the WMO-standards qua siting and exposure as described in the Introduction or in more details in the APPENDIX below?

Yes: More or less: No:

Please add your comments here:

4) Are you as forecaster of the opinion that you would make better forecasts for the roads if you could have at your disposal road measurements into agreement with the WMO-standards?

Yes: No opinion: No:

Please add your comments here:

5) When at the moment these weather measurements along the road do not meet the WMO-standards, are you of the opinion that the road manager could be better monitoring the weather and traffic if these measurements should satisfy the WMO-standards?

Yes: No opinion: No:

Please add your comments here:

6) If you as forecaster can show the road manager he can better monitor the weather and traffic using measurements meeting the WMO-standards and he get more reliable forecasts, do you think you can convince the road manager to fit his weather road stations to the WMO-standards? For instance by the choice of another location along the road, which meets the WMO-standards? Or by fitting the present location for instance by cutting down close standing trees, who disturb the wind measurement?

Yes:
No opinion:
No:

Please add your comments here:

7) Put the case that the road manager follows your advice to bring the road measurements on the WMO-level, do you think the road manager will maintain the weather measurements on that WMO-level? And during all seasons or only in the wintertime, the period most road managers are more interested in weather due to winter maintenance of the roads?

Yes:
No opinion:
No:

Please add your comments here:

8) If the road manager has not the intention to fit his road measurements to the WMO-standards, is it because the road manager thinks, he is getting at this moment the best measurements at the location and in the manner as he, the road manager, needs?

Yes:
No opinion:
No:

Please add your comments here:

9) Do you agree with the road manager when he argues that the present choice of location and of his road measurements, not following the WMO-standards, have been dictated for financial reasons by the availability of services such as power supplies and communications?

Yes:
No opinion:
No:

Please add your comments here:

10) When in the future by the use of solar power and of radio-based communications (such as cellular telephone systems) the location of the road measurements is independent of the availability of powers supplies and fixed communications, do you think you will be able to convince the road manager to move the road weather measurements sensors to locations meeting the WMO-standards and to expose the sensors by following the same WMO-standards?

Yes:
No opinion:
No:

Please add your comments here:

11) Or are you of the opinion that the maintenance of those solar power and radio-based road weather stations to keep them on the level of the WMO-standards shall be also too expensive? That means, in the long run it should be impossible for the road manager to fit the WMO-standards?

Yes:
No opinion:
No:

Please add your comments here:

12) With in the future more smart highways and cars giving electronic protection against collision, the steering of strings of cars by instruments along the road etc., what do you as forecaster think about the influence of the weather on the road and the cars using these new, future technologies? Is the influence increasing or decreasing?

Yes:
No opinion:
No:

Please add your comments here:

13) If the influence of the weather on these smart roads and cars is increasing, do you think there is a greater chance that the road manager will bring the measurements up to WMO-level and will maintain them on this level?

Yes:
No opinion:
No:

Please add your comments here:

14) Or do you expect that by the new, future techniques along the road and in the cars the dependency on the weather shall only decrease and that perhaps even the road measurements are getting superfluous?

Yes:
No opinion:
No:

Please add your comments here:

15) Does your meteorological service make forecasts dedicated to the road with its traffic? If the answer is yes, are you only making forecasts in the winter for the winter maintenance of the road? Or are you also making forecasts for the traffic in other seasons, for instance for bad visibilities in fog or for high road surface temperatures in the summer to avoid ruts in the warm and soft asphalt by heavy loaded trucks?

Yes: No:

If the answer is Yes: What kind of forecasts dedicated to the road?

16) Are the weather road measurements necessary for you to make the road forecasts in summer half-year (if you do so) as well as in winter half-year?

Yes: No:

Please add your comments here:

17) Are these road weather measurements, even when they do not meet the WMO-standards, a supplement to your own synoptic observations, so that forecasts other than the road forecasts, are getting more reliable and can be better monitored?

Yes: No:

Please add your comments here:

18) What can be the reason in the future (or is it already) that you would use (or already use) road measurements, although they do not meet the WMO-standards? A forcing reason, by which perhaps you have to use these measurements, can be the too little cover of your own synoptic observations in parts of the country. In this case road measurements are filling gaps.

Please give your reason here:

19) If you are using the road weather measurements, which forecasts, except the road forecasts, are getting better by the use of these measurements even if they are not up to the WMO-standards?

Please write down here those forecasts:

20) Which road measurements, not following the WMO-standards, such as air temperature, road temperature, dewpoint, wind direction, wind velocity, precipitation intensity, sort of precipitation etc. would you like to use (or you are already doing) by the making the other forecasts, not dedicated to the road and traffic? Please indicate what road measurements you are using at this moment.

Please add your comments here:

21) If you do not use the road measurements at this moment, because they do not obey the WMO-rules, would you use them in the case they meet the WMO-standards?

Yes:
No opinion:
No:

Please add your comments here:

22) And what could be the reason to use road measurements supposing they follow the WMO-standards? To fill gaps in the cover of your present observation network to monitor and make better forecasts (not only for the road and traffic)?

Please add your comments here:

23) Can you specify forecasts that you expect they are getting more reliable when you would have at your disposal road measurements following the WMO-rules?

Please write down here these forecasts:

24) Put the case, the road measurements are satisfying the WMO-standards. Which road measurements, as air temperature, road temperature, dewpoint, wind direction, wind velocity, precipitation intensity, sort of precipitation etc. would you like to use for making other forecasts, not dedicated to the road and traffic?

Please write down the parameters here:

25) Do you think, that input of road measurements together with the other, “conventional” data (synoptic and upper air observations etc) in operational fine mesh computer models will improve the output (= forecast) of these weather models?

Yes:
No opinion:
No:

Please add your comments here:

26) Is it necessary for the input for the operational weather models that these road measurements meet the WMO-standards?

Yes:
No opinion:
No:

Please add your comments here:

27) Is it in your opinion possible by using physical relations to translate wrong observations - for instance, wrong wind or temperature measurements due to the non standard WMO surroundings - to values that should have been measured if the location and the placing have been well in agreement with the WMO-standards?

Yes:
No opinion:
No:

Please add your comments here:

28) Do you agree with the thesis of some builders of fine mesh computer weather models that the road manager locally makes too many observations? In their opinion the measurement of road surface temperature is necessary to make good forecasts for this road temperature. But their operational fine mesh models with their interpolation schemes provide better and more reliable air temperature, wind(direction and velocity) and precipitation data. Not only for the locations fixed by the road manager, but the output weather data of these fine mesh models can also be used for the places along the road between these fixed locations.

Yes:
No opinion:
No:

Please add your comments here:

29) If you endorse this thesis of point 28), do you think you can convince the road manager to exchange his hardware road measurements for these software data, being the output of the fine mesh computer weather models?

Yes:
No opinion:
No:

Please add your comments here:

30) In the case the road manager does not want to lose his present road measurements, do you think you can convince him to let calibrate his fixed road measurements with the output data of the operational fine mesh weather computer models?

Yes:
No opinion:
No:

Please add your comments here:

31) Do you develop as meteorological forecaster, using the present road weather measurements, apart warning or forecast methods? An example : by combining the wind velocity, air temperature, dewpoint and global radiation it is perhaps possible to deduce a statistical method to forecast the occurrence of radiation fog on the road.

Yes:
No:

Please add your comments here:

32) Until now most of the questions have been directed on well or not satisfying the WMO-standards, which have been developed for synoptic, meteorological observations. Do you think it is necessary to develop guidance material specially dedicated for road meteorological purposes? Do you think the road manager needs specifications for the measurement of meteorological variables along the road, which may include issues related to siting, exposure data sampling and processing?

Yes:
No opinion:
No:

Please add your comments here:

33) Can you explain your answer on question 32)?

Please add your comments here:

34) Are you interested in an international workshop, attended by representatives of international, road- and meteorological bodies, about the present state of art of road meteorology and charting the way forward on road meteorological observations?

Yes:
No opinion:
No:

Please add your comments here:

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