WORLD METEOROLOGICAL ORGANIZATION

INSTRUMENTS AND OBSERVING METHODS

REPORT No. 92

NATIONAL/REGIONAL OPERATIONAL PROCEDURES OF GPS WATER VAPOUR NETWORKS AND AGREED INTERNATIONAL PROCEDURES

S. de Haan *(KNMI, Netherlands)*

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NOTE

FOREWORD

Following the request of CIMO-XIII, the CIMO Expert team on Remote Sensing Upper-Air Technology and Techniques was tasked to study the Operational aspects of different ground-based remote sensing techniques for vertical profiling. This IOM Report focuses on one such capability, Global Positioning System (GPS), also known as Global Navigation Satellite System (GNSS) consisting of a series of satellites, ground-based or space-borne receivers, and a network of control and monitoring stations. Much of the information contained in this report was acquired through a survey conducted by Mr Siebren de Haan, KNMI, The Netherlands. The survey targeted meteorological services that were investigating or using GPS observations in support of meteorological services.

Water vapour is one of the least understood and poorly described components of the Earth's atmosphere. GPS water vapour observations are becoming more available due to the range of applications for such measurements. GPS meteorology has transitioned from research into a near global operational network. The collaboration between the geodetic and meteorological communities since 2003 has contributed to the meteorological community's understanding of GPS representation of water vapour. These and other efforts led to the 2005 start of a EUMETNET E-GVAP project focused on the operational use of GPS humidity observations.

The contents of this report briefly address the operational aspects of GPS including data sources, techniques, and accuracies. It also provides a brief description of national networks maintained through partnerships between the public and private sectors and academia. It closes with guidelines for establishing International GNSS Stations (IGSs) and GPS Meteorological networks. The information contained in this publication will assist NMHSs in their decision regarding the selection of remote sensing equipment.

I wish to extend my sincerest thanks to Mr de Haan for the remarkable work done in preparing this document on such short notice on the current state of GPS use and presenting International Guidance for establishing GPS sites and networks.

(Dr. R. P. Canterford)

Acting President
Commission for Instruments and
Methods of Observation

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S. de Haan **(KNMI, Netherlands)**

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NATIONAL/REGIONAL OPERATIONAL PROCEDURES OF GPS WATER VAPOR NETWORKS AND AGREED INTERNATIONAL PROCEDURES

1. Introduction

The Global Positioning System (GPS), also called the Global Navigation Satellite System (GNSS), consists of a constellation of satellites transmitting a radio signal (the space segment), groundbased or space-borne receivers (the user segment) and a network of control and monitoring stations (the ground segment). The primary observable is the time of arrival of the transmitted signal. This observable is influenced by the ionosphere and the atmosphere along the signal path. The influence (or delay in arrival time) of the ionosphere is dispersive (i.e. frequency dependent) while the atmospheric influence depends on the refractivity along the signal path.

For precise positioning (i.e. with millimeter accuracy) the atmospheric term is an error source which needs to be estimated to obtain the acquired accuracy. There are of course other source terms which play also a crucial role with respect the accuracy of exact positioning. Other sources of error are: satellite positions, satellite clock error, receiver clock error, ionosphere and noise.

The observations of a network of receivers, gathered over a certain time window (e.g 12 hours), is necessary to determine the position of a receiver very accurately. The determination is performed using GPS processing software which estimates the position of the receivers in the network and, simultaneously, the atmospheric correction or atmospheric delay. This atmospheric delay is mapped to zenith in the processing and is called Zenith Total Delay (ZTD) expressed generally in meters. From this ZTD an estimate of the integrated water vapor (IWV) can be computed, when surface pressure and temperature observations are available (See Bevis, 1992).

1.1 Processing GPS

The atmospheric observable is thus ZTD (or IWV). The observation technique is schematically depicted below and involves the following data sources/techniques

- Gathering RINEX (Receiver Independent Exchange format) data from a network
- Obtain orbit and clock information (in case of a regional network)
- Process the network
- Disseminate ZTD/IWV

The accuracy of the atmospheric observable depends on

- Network configuration (stability/coverage)
- Accuracy of the orbits
- Method of processing

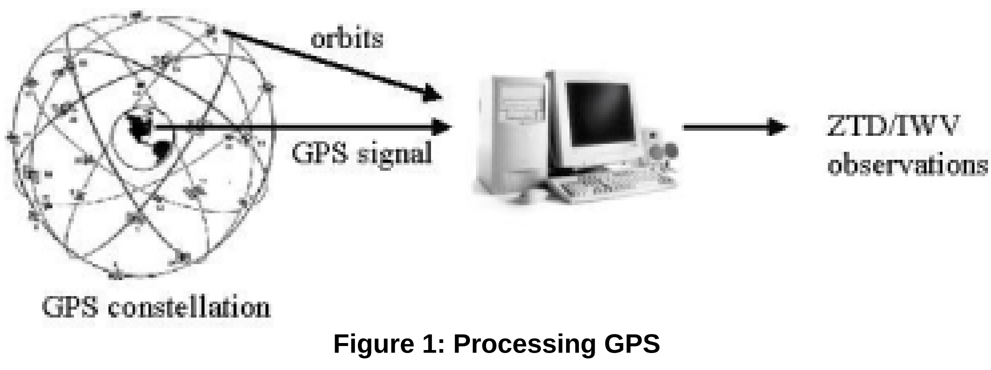

Figure 1: Processing GPS

The current standard processing software (e.g. Bernese, GAMIT/CLOBK or GPSY-OASIS) for processing GPS observations are capable of estimating ZTD with good accuracy in near-real time. The accuracy of ZTD depends on the processing parameters, such as processing time window, elevation cut-off angel, update frequency of a priori coordinates. Another import factor is the quality network and the accuracy of the orbits. The quality of the network is related to

- Quality of the receivers (2 frequencies)
- Location of the receivers (minimizing multipath, free sky (even at elevations around 5 degrees)
- Knowledge of antenna phase centers (needed for processing)
- Reliability of the datalinks (latency)
- Size and coverage of the network

The network should be large enough to guarantee an absolute value of the GPS ZTD estimate.

1.2 Accuracy of GPS ZTD

The accuracy of the GPS ZTD estimates in the order of 10-15 mm. The accuracy is dependent on the used processing scheme and software. The accuracy of IWV derived from ZTD is around 2 kg/m^2 deduced from collocated GPS and radiosonde observations.

Within the EU-TOUGH project a near real time GPS ZTD data stream was established. A comparison with the operational numerical weather prediction model run at KNMI is shown in the table below. Comparison with numerical weather prediction models should be performed carefully because of the approximation of the orography in these models.

Table 1: Statistics between HIRLAM analysis ZTD and GPS ZTD for station Brussels over the period 2005/10/05 - 2006/02/21 (*KNMI 2006/01/12-2006/02/21)

Processing Center	Number of Comparison	Bias	RMS	Standard deviation
ASI	7994	-5.58	11.74	10.32
BKG	9632	-6.66	12.04	10.03
GFZ	9205	-4.76	9.94	8.73
KNMI*	1377	-2.39	7.14	6.73
LPT	10286	-5.87	11.39	9.76
METO	8766	-3.75	10.81	10.14
SGN	8354	-7.57	13.60	11.29

ASI = Agenzia Spaziale Italiana, Matera, Italy
BKG = Bundesamt für Kartographie und Geodäsie, Frankfurt, Germany
GFZ = GeoFoschungsZentrum Potsdam, Potsdam, Germany
KNMI = Koninklijk Nederlands Meteorologisch Instituut, De Bilt, The Netherlands
LPT = Federal Office of Topography, Wabern, Switzerland
METO = Met Office, Exeter, United Kingdom
SGN = Insitute Geopgraphique National, Paris, France

2. Collection of GPS data in real time

At the time of writing there are a number of national networks of GPS receivers which supply raw GPS data with a latency of a second and as far as we know none of them is solely dedicated to meteorology. These networks are maintained by commercial companies, government agencies (such as survey departments) or universities. Some of these networks are set up in cooperation with national meteorological services (examples are Switzerland, United Kingdom and The Netherlands, United States of America).

On a global scale, the geodetic community has created an international body called the IGS (International GNSS Service) which formally started on 1 January 1994. IGS is a member of the Astronomical and Geophysical Data Analysis Services (FAGS) and it operates in close cooperation with the International Rotation and Reference System Services (IERS). One of the objectives of the IGS is to strive to "provide the highest quality, reliable GNSS data and products, openly and readily available to all". The IGS provides products like

- RINEX data from IGS stations
- Satellite orbits and clocks with various latencies and qualities
- Earth rotation parameters
- Atmospheric parameters (with a latency of more than two hours)

The IGS stations are set up by national geodetic partners (agencies, universities) and follow the IGS Site Guidelines (see Chapter 4).

2.1 IGS data

The RINEX data available through IGS has currently three types of latency, where the latency determines the length of the window:

- Daily data
- Hourly data
- 15 minute data

In the figures below the coverage of the three data sets are shown. The daily datasets are valuable for climatology purposes, while the hourly data, when the latency is small enough, can be used as input for GPS processing which is dedicated for numerical weather prediction. The 15 minute data set can be valuable for processing more than once per hour which in turn can be valuable for nowcasting purposes by for example presenting two dimensional IWV maps to forecasters. The coverage of the 15 minute data set is not good enough on its own to create a valuable nowcasting product; additional (national) networks are necessary. The 15 minute IGS data set can thus be used to form nowcasting network with a higher quality. In all cases orbit information has to be derived, or obtained from external sources (e.g. IGS).

In general the IGS stations can serve as useful data sources for

- Area's with no (commercial) network (remote area's such as South Pole)
- Create large baseline when added to a small (national) network

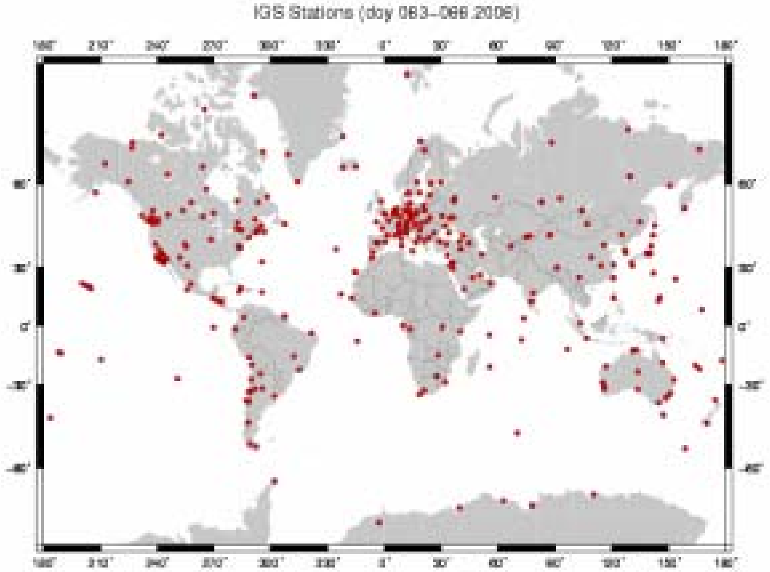

Figure 2: IGS stations with daily data.

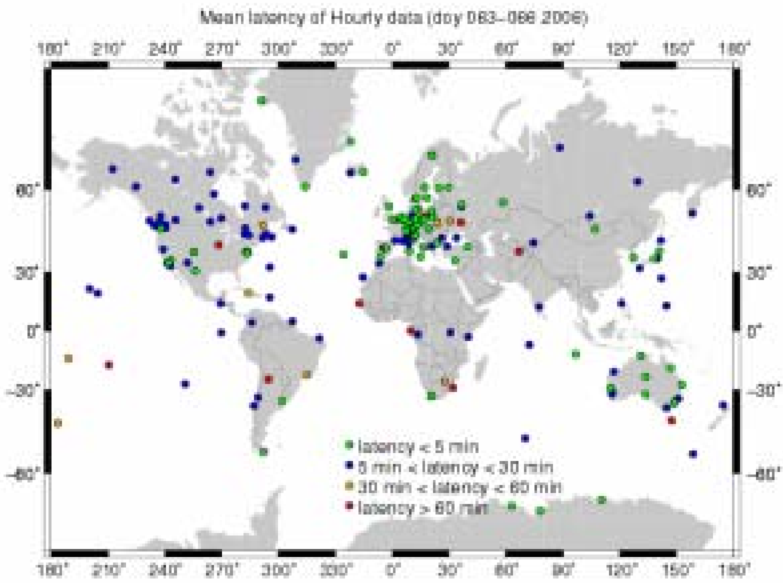

Figure 3: IGS Hourly data availability. Colors indicate the latency of an hourly RINEX file.

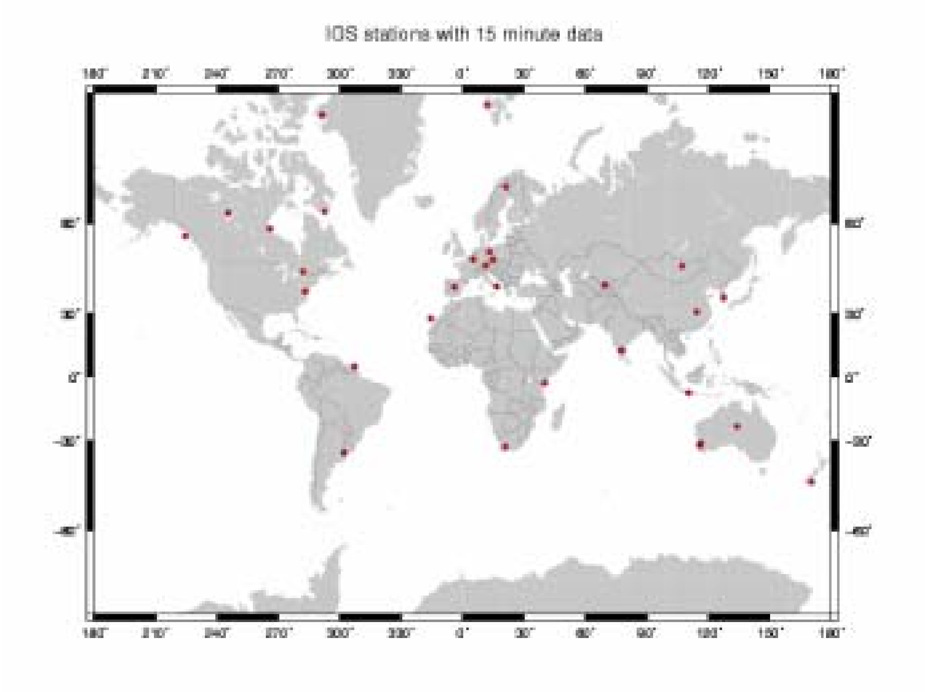

Figure 4: IGS sites delivering 15 minute data with a latency of 5-10 minutes.

2.2 EUREF

The EUREF Permanent GPS Network is the European densification of the Global Network of the IGS. The EUREF has only two types of data

- Daily data
- Hourly data

In the figures below the current network is shown. Currently there is no information available on the latency of the hourly stations.

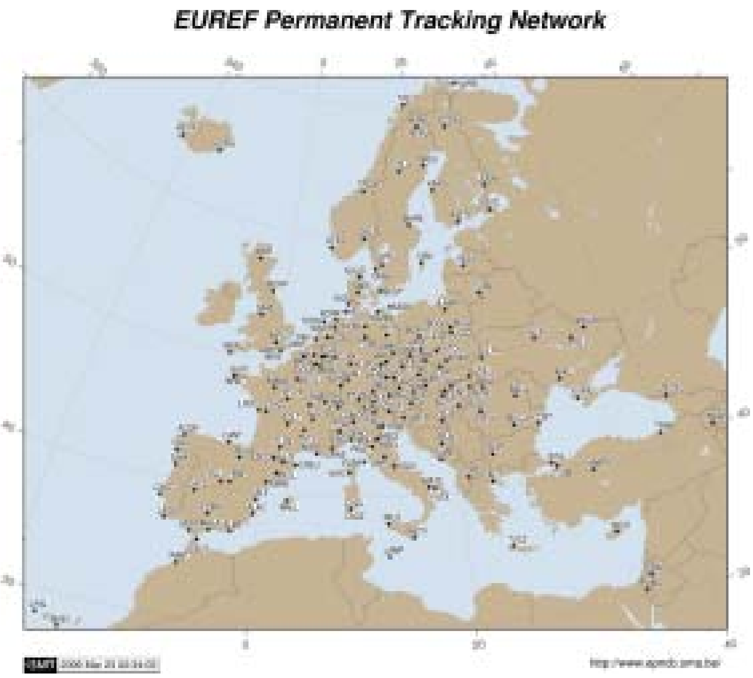

Figure 5: The EUREF permanent Network

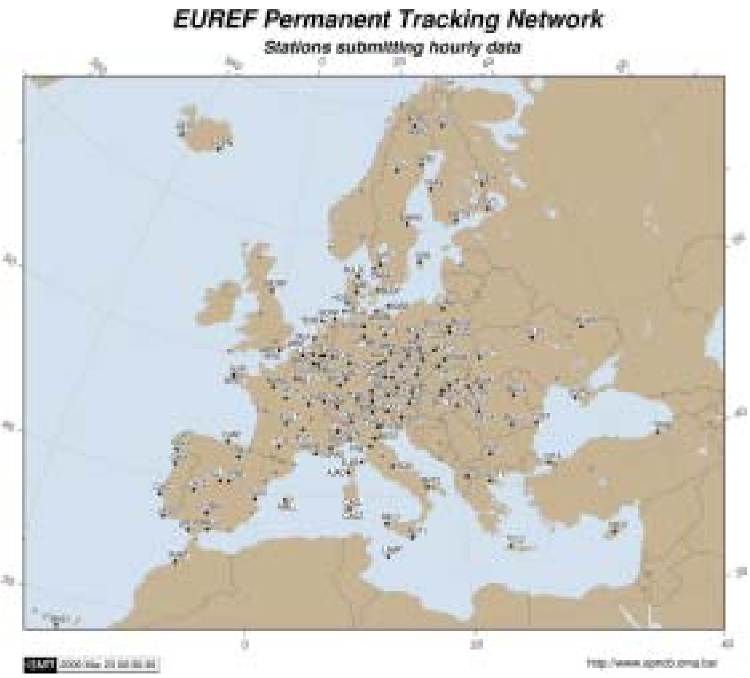

Figure 6: Stations submitting hourly data to the local data centres.

2.3 NOAA network

NOAA network which provides ZTD and IWV data to models, forecasters and researchers in near real-time. Expansion of the network over North America, and eventually throughout he Western Hemisphere in collaboration other nations is contemplated. A map reflecting the current configuration of the network is shown in the figure below.

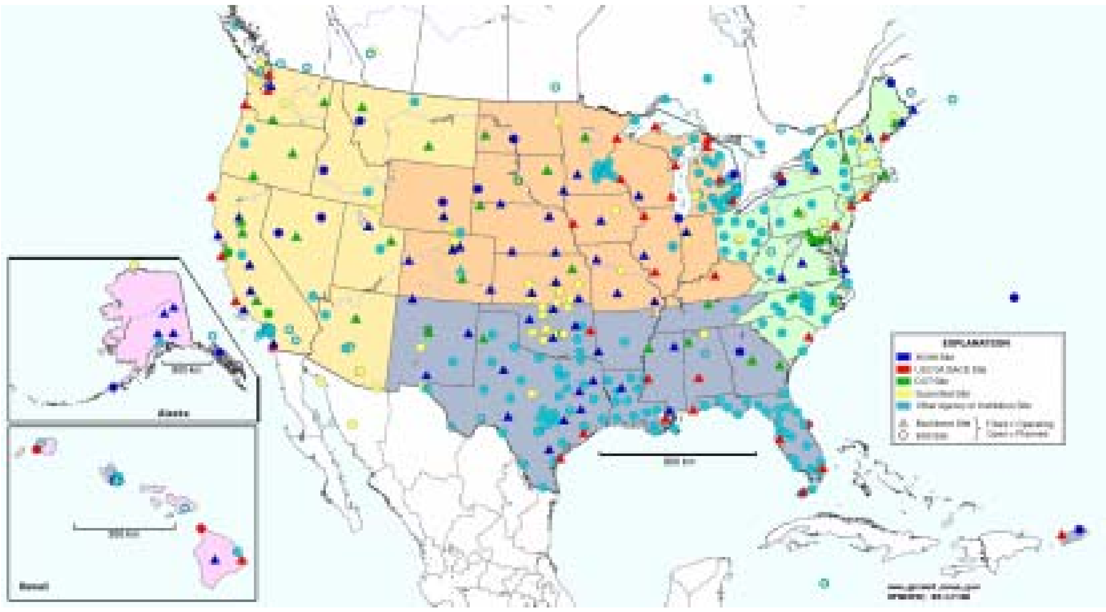

Figure 7: NOAA near real time GPS data network

3. Current and future use of GPS

A survey has been performed on a selected number of meteorological services which were at the time of writing investigating or using GPS observations for meteorology. The survey was held using the questionnaire which can be found in the Appendix.
The main topic of the survey was to gain insight in the current status of GPS meteorology and the future plans of the selected agencies. The result is presented in alphabetical order with respect to the country.

3.1 National responses

Canada

S. Macpherson and G. DeBlonde (Environment Canada)
As yet, there is not an operational GPS network suitable for meteorology.

In research mode, we currently process hourly data from 35 continuously operating GPS sites in Canada for which near real time (NRT) data are available. These sites are operated by another federal government agency, Natural Resources Canada (NRCan). Twenty of the 35 sites are equipped with collocated surface weather stations.

We have recently submitted a proposal for the development of a prototype operational Canadian GPS network for atmospheric monitoring, consisting of ~100 sites. NRCan owns/operates ~50 GPS sites. Additional receivers that could be part of our proposed network are owned by other federal government agencies, provincial governments, and commercial companies. Our agency may install additional sites, but their operation may be trusted to one or several of the above agencies.

We plan to establish formal agreements for data access that include commercial contracts, inter-departmental agreements, and federal-provincial government agreements. Some of these agreements may be based on data exchange.

We are responsible for the data processing for ZTD purposes. We currently use GAMIT. We are in the process of testing other alternative options (notably GIPSY).

Our emphasis is on data assimilation for NWP, but we are also considering other applications such as

- real-time IWV monitoring in our forecast offices for nowcasting,
- NWP model validation,
- quality control and calibration of other observations, etc.

Denmark

H. Vedel (DMI)
There exist three operational GPS networks in Denmark capable of delivering GPS data for hourly processing. They are owned by respectively the national mapping agency (Kort- og Matrikelstyrelsen, KMS) and two commercial companies.

Data are currently available for processing at Chalmers (NKGS) from KMS and one of the private companies, based on informal agreements between Chalmers and the network owners. DMI expects to make formal agreements with the networks owners. The data will be processed at the coming Nordic centre for NRT GPS data processing at SMHI.

GPS data will initially be used for validation of the HIRLAM model. As a standard monitoring tool, but with more specific goals, such as determining and correcting HIRLAM problems with the diurnal cycle may be developed. When the GPS data are of sufficient quality and the variational quality control for ZTD in HIRLAM is good enough GPS data will be assimilated.

Currently there is no climate use of ground based GPS data, but we will be very interested in GPS data of 'climate quality' (=post processed) for validation of the NRT GPS data.

France

P. Poli (MétéoFrance)

There exists an operational network in France which is owned by the IGN (Institut Géographique National; government agency). IGN processes the data on an hourly basis for meteorological purposes. There is a network of stations producing data for meteorology processed by IGN with a one-hour time resolution. Another processing also currently exists by ACRI which has been processing data at a higher time frequency and resolution more suitable for meteorological applications (15 minutes).

There is an agreement with IGN on a data exchange basis.

We plan to use the data for NWP applications (high ranking), and hopefully for more applications later on (nowcasting in particular).

Germany

C. Schraff (DWD)

The network is not operational, but providing data very regularly in near-real time for research purposes. There are no firm plans yet to make the network operational; this will depend on results of research and funding. The current GPS processing is performed routinely with an observation frequency of 30 minutes.

The network is owned and operated by government agencies: GFZ: GeoForschungsZentrum Potsdam (www.gfz-potsdam.de), SAPOS: Satellite Positioning Service of the German State Survey (www.sapos.de) and the Federal Office for Radiation Protection (BfS, www.bfs.de). The latter operates only one-frequency receivers and is not processed routinely yet.

A research agreement, based on exchange of data with GFZ has been made; GFZ obtains synop data.

Finland

(Antti Lange, FMI)

The Finnish Geodetic Institute (government agency) operates a network of 13 permanent GPS stations. The observing interval is 30 s. From 10 stations the data is downloaded hourly and from 3 stations daily. Currently, the processing scheme is set up on a daily basis for this network.

A commercial company Geotrim LTD operates a network of 86 permanent GPS stations, called GPSnet.fi. GPSnet.fi service offer both real time VRS RTK/DGPS service and GPS-postprocessing data. The observing interval is 1 s and storing real time to data center.

University of Helsinki operates Station SG40 of the US SuomiNet meteorological and Geodetic global GPS network in Helsinki. The observing interval is 1 sec. The data is collected in real-time using a dedicated ADSL-line by the National Center for Atmospheric Research (NCAR) in Boulder, Colorado.

There are plans to enhance the cooperation for meteorological purposes; there are no agreements between Geotrim, FGI and FMI yet.

Ireland

L. Burke (MetEireann)

In Ireland there is an operational network suitable for GPS meteorology, however there are no plans to process GPS routinely. The network is owned by the Ordnance Survey Ireland (OSi, a government agency). When the GPS data from this network will be used, Met Eireann would pay a sum allegedly to cover the costs incurred by OSi in supplying the data, including security on its server.

Island

H. Hjartarson (IMO)

Currently 5 CGPS stations in Iceland are delivering hourly data. The present network consists of 20 stations which are all planned to deliver hourly data. The operational processing is now daily but will soon become hourly. Most stations are owned and operated by the Icelandic Met Office but a few by other governmental agencies.

Our agency is responsible for the processing.

Japan

M. Ishihara (JMA)

GEONET(GPS Earth Observation NETwork) is a GPS network operated by the Geographical Survey Institute, Japan and the Ministry of Land, infrastructure and transportation, Japan. Approximately one thousand GPS receivers are located throughout Japan with a separation of 15-25km in order to monitor crustal deformation of the earth. GPS meteorology in Japan has been developed along with GEONET. The time resolution of receiving GPS satellite signal in GEONET is 30 seconds.

The survey and technical development for derivation of precipitable water vapor (PWV) from GPS meteorology has been finished in Japan. The operational processing of the derivation for numerical weather predictions is, however, not started yet, because the accurate information on orbits of GPS satellites is not available in real-time. JMA is currently investigating a semi-real time processing scheme using the ordinary orbit information and are obtaining good results. When it will be ascertained that the accuracy of the semi-real time processing is enough for assimilation to numerical weather prediction, with high possibility, JMA will start the processing routinely. Currently, there are no agreements for usage of GPS data by JMA.

The Netherlands

S. de Haan (KNMI)

In the Netherlands an operational GPS network exists suitable for meteorology. This network (30 GPS receivers) has been set up in collaboration with the Ministry of Public Works and the Kadaster (the Dutch Land Registry Office); on three KNMI weather observations sites GPS receivers are installed. The data is available every 5 minutes. KNMI is processing the data every hour and (experimentally) every 15 minutes.
The network is owned by the Kadaster and the data is made available through an agreement based sharing site locations.

Spain

E. Terradellas (INM)

There are different networks, with different characteristics, not a national-scale network suitable for meteorology. There are ongoing talks between the meteorological and the geographical national institutes, but not defined plans.
By now, 10-minute observations are processed. The networks are have different owners, mainly national or regional government agencies

IEEC (Institut D'estudis Espacials De Catalunya), a non-government foundation, with participation of different universities and research institutes, has been processing GPS data but there is not any guarantee of continuity.

There is no agreement, processing has been funded within research projects.
The use in NWP is low by now, but the NWP community has plans for an intensive use when there is secured access to data. Not known use or defined plans for use in other fields.

Sweden

M Ridal (SMHI)
In Sweden there is a GPS network that is suitable for GPS meteorology. The processing is done on an hourly basis but we produce data with a 15 minute time resolution. The network is owned by the Swedish national land survey (Government agency). At present Chalmers Technical University is responsible for the processing of GPS data, but in the near future (first half of 2006) the responsibility will be moved to our agency (SMHI).

The current agreements are made based on the exchange of data.

Switzerland

D. Ruffieux (MétéoSwiss)
In Switzerland we have the AGNES network managed and owned by Swisstopo (governmental agency). The GPS processing is undertaken by Swisstopo (estimating ZTD) in an hourly basis. MétéoSwiss is calculating IWV on a daily basis.

Swisstopo and MétéoSwiss have a commercial contract based on proforma bill (until end of 2006).

United Kingdom

J. Jones (MetOffice)
In the UK an operational GPS network suitable for meteorology exists. The data is available on an hourly basis at the moment, looking to go sub-hourly in the next few years.

The network is owned by the Met Office, Ordnance Survey (national mapping agency), Tide Gauge Authority and some Universities. The Met Office is responsible for processing for meteorological purposes. The agreement is a non contractual, non-fee based memorandum of understanding.

United States of America

S.I. Gutman (NOAA/ESRL)
In the USA a GPS network suitable for meteorology exists. The current processing is every 30 minutes, with eventual migration to 15 minute sessions being contemplated.

The "backbone" of the network consists of GPS receivers owned by NOAA. The "backbone" is augmented with receivers belonging to other U.S. Federal Government Agencies, including U.S. Departments of: Transportation (Federal Aviation, Railways, and Highways Administrations); Homeland Security (U.S. Coast Guard); Defense (Army, Navy, and Air Force); NASA; and Interior (U.S. Geological Survey).
Receivers belonging to State and Local Government Agencies, Universities, and the private sector further augment the backbone.

No agreements are necessary to acquire or process these data in the U.S. All data is made available in real or near-real time through the NOAA NGS CORS Program (see http://ngs.noaa.gov/CORS). Exchange of GPS and surface observations is in RINEX format.

3.2 (Envisaged) Application and relevancy of GPS meteorology

The above agencies were asked to give an indication of the application and relevancy in which GPS observations will be used

	High	**Moderate**	**Low**	**No use**
Numerical weather prediction	CA, CH, DK, F, FI, IS, J, NL, UK, USA	SE	SP	IRL
Nowcasting	FI, NL, USA	CA, D, DK, SE, UK	IS	SP, CH
Climate	FI	NL, USA	CA, UK, SE	CH, DK, IS, SP
Other	CH: • namely radiosounding/microwave radiometer/lidar validation (moderate) D • Bench forecaster to monitor NWP analysis (moderate) IS: • Crustal deformation monitoring USA: • Radiosonde quality control (high) • Satellite calibration and validation (high) • Generation of atmospheric correctors for high accuracy GPS positioning and navigation (high) • Correction of InSAR data (low)			

CA=Canada, CH=Switzerland, D=Germany, DK=Denmark, F=France, FI=Finland, IS=Island, IRL= Ireland, J=Japan, NL=The Netherlands, SP=Spain, SE=Sweden, UK=United Kingdom, USA=United States of America.

4. Operational Procedure for GPS MET networks

The IGS and EUREF has developed useful guidelines for setting up an IGS station. The guidelines are copied here and adapted when necessary (see the list with links in Section 5). Within the COST716 action user requirements were developed for the use of GPS in meteorology. This knowledge is used as a starting point here.

4.1 GPS Stations

1. The GPS equipment, and its surroundings, must not be disturbed or changed unless a clear benefit outweighs the potential for discontinuities in the time series. Examples include:
    a. Equipment failure
    b. Planned replacement of obsolete equipment
    c. Vendor-recommended firmware updates
2. The GPS receiver must
    a. track both code and phase on L1 and L2 under non-AS (anti-spoofing) as well as AS conditions. Required observables are L1, L2, P2, and at least one of C1 or P1. Equipment capable of reporting both C1 and L1 should do so.
    b. be capable of, and set to, record data from at least 8 satellites in view, simultaneously
    c. track with a sampling interval of 30 seconds or smaller
    d. be set to record data down to a cutoff angle of 5 degrees or less.
    e. synchronize the actual instant of observation with true GPS time to within +/- 1 millisecond of the full second epoch
3. The GPS antenna must
    a. be accurately modeled and accurately represented in the IGS phase center variation file
    b. be leveled and oriented to True North using the North reference mark and/or antenna RF connector
    c. be rigidly attached, such that there is not more than 0.1mm motion with respect to the antenna mounting point.
4. Radomes
    a. Avoid using radomes unless required operationally, for instance due to weather conditions, antenna security, wildlife concerns, etc.
    b. Non-hemispherical radomes especially must be avoided when the shape is not required by site characteristics (e.g. for snow rejection)
    c. If a radome must be used, an entry for antenna+radome pair must be in the phase center variation file.
5. Eccentricities:
    a. The eccentricities (easting, northing, height) from the primary marker to the antenna reference point (defined for the antenna type in ftp://igscb.jpl.nasa.gov/pub/station/general/antenna.gra) must be surveyed and reported in site logs and RINEX headers to ≤1 mm accuracy.
    b. Each eccentricity component must be less than 5 m.

4.2 GPS networks

A network for GPS meteorology may consist off more than one real network (e.g. a local network combined with IGS/EUREF stations)
A network for GPS meteorology should satisfy the following:

- The network is large enough for absolute estimation of the atmospheric delay (long baselines approximately 1000 km)
- The network should be centered around a dense sub-network , when it exists
- The density of the network
    - 30-100 km, for numerical weather prediction
    - 10-100 km, for nowcasting
- At least one receiver in the network should be collocated with a radiosonde site for quality control
- A number of IGS/EUREF stations should be included in the network for validation with other GPS processing centers
- The latency of data collection should be
    - Smaller than 20 minutes, for numerical weather prediction (assuming assimilation cycles of 3 hours)
    - Smaller than 5 minutes, for nowcasting
- RINEX format should be used to exchange GPS observations

For NWP application currently a density of 30-100 km is adequate. This density is roughly related to the current density of radiosonde observations. For nowcasting purposes a higher density is preferred to gain insight in for example the high horizontal variability of IWV.

4.3 GPS processing

GPS processing should be preformed using standard software. The processing should follow the following:

- Use (ultra rapid) orbits (from for example IGS) when necessary
- The processing time should be such that the total latency
    - Is less than 45 minutes, for numerical weather prediction
    - Is less than the repetition cycle of the product, for nowcasting
- The correct phase center variation file

4.4 GPS atmospheric observables

The atmospheric observable should satisfy

- Hourly ZTD/IWV must be disseminated within 45 minutes
- Sub-hourly ZTD/IWV estimates should be disseminated within the length of the repetition cycle
- The accuracy of the should be
    - ZTD 10-15mm/ IWV 1-2 kg/m^2 , for numerical weather prediction
    - IWV 1-3 kg/m^2 , for nowcasting
- The output should be disseminated in BUFR

References and Links

References

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CIMO Expert Team on Remote Sensing Upper-Air Technology and Techniques, First Session, Final Report, Geneva, Switzerland 14-17 March 2005:

http://www.wmo.ch/web/www/IMOP/reports/2003-2007/ET-RSUTT1_Geneva2005.pdf

Links

EUREF:	http://www.epncb.oma.be
EUREF guidelines:	http://www.epncb.oma.be/_organisation/guidelines/
IGS:	http://igscb.jpl.nasa.gov
IGS Site Guidelines:	http://igscb.jpl.nasa.gov/network/guidelines/guidelines.html
TOUGH:	http://tough.dmi.dk

Contact Persons for processing GPS for Meteorology

(@ is changed to "(AT)")

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Appendix

Questionnaire

A questionnaire has been sent to a number of colleagues. We did not send the questionnaire to all WMO delegates. This could be done in a later stage

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1a) Is there an operational GPS network suitable for meteorology (i.e
hourly data logging)?

1b) If not, are there plans to setup such a network in your country?

2) Is/will the operational GPS processing performed routinely and what
is the observation frequency?
 - hourly
 - daily
 - other, namely ....

3) Which agencies/companies own the GPS receivers in the network
(multiple answers possible)?
 - your agency
 - government agency (if not your agency)
 - commercial companies
 - other, namely ....

4) What agency is responsible for the processing (i.e. your agency or
a survey dept.) and who is the contact person?
 - your agency
 - government agency (if not your agency)
 - commercial company
 - other, namely ....
 contact person: ....

5) If the processing is performed or the receivers or owned by another
agency, what kind of agreement has been established to obtain and
process the GPS data?
 - no agreement
 - exchange of data (i.e. surface pressure versus GPS RINEX)
 - commercial contract
 - other, namely ....

6) What is/will be the use of the processed GPS data (please give a
ranking : 0=no use, 1=high, 2=medium, 3=low, etc)?
 - Numerical weather prediction
 - Nowcasting
 - Climate
 - other, namely .....
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