Exploitation of ground based GPS for Climate and Numerical Weather Prediction applications

COST action 716

- COST
- Objectives and status of COST 716
- Overview of work packages / projects
- Near real-time demonstration project
- Relation to EUREF

COST

- COST is a framework for international co-operation
- 25 member countries, over 400 COST actions
- Funding for general co-ordination and secretarial services, management committee meetings, experts' travelling expenses and the organisation of events
- It is *not* a source of funding for international research projects
- A COST action is relatively easy to start: at least five COST members must sign
- A management committee implements and co-ordinates the Action

GPS Water Vapour Estimation

The zenith delay (T_{ZD}), estimated by GPS, is converted to integrated water vapour (IWV) using surface pressure and temperature readings

$$IWV = \frac{1}{Q(T_m)}(\hat{T}_{ZD} - T_{ZHD}(P_s, \varphi, h)) \quad , \quad T_m = 70.2 + 0.72\,T_s$$

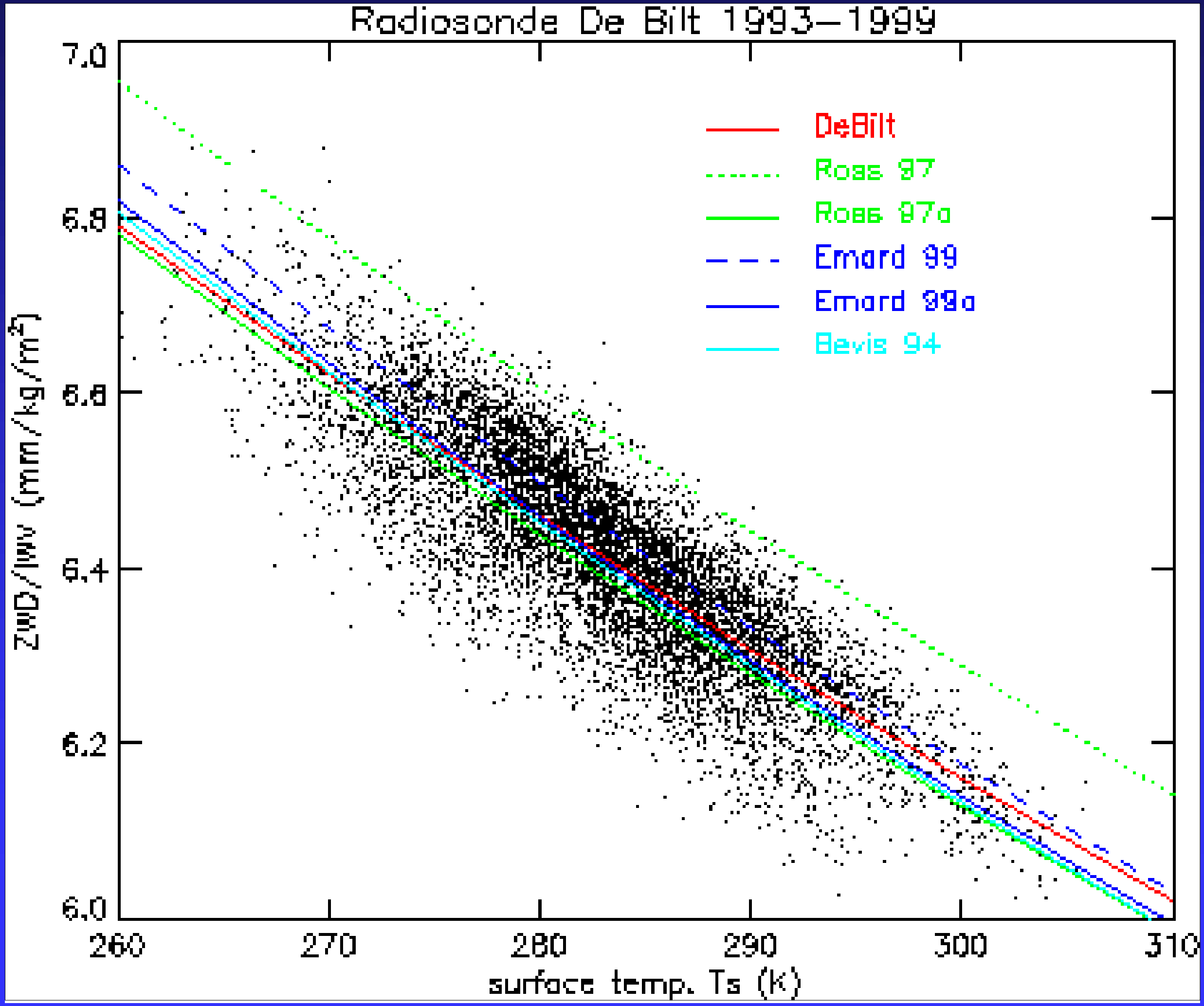
with

- T_{ZHD} the hydrostatic zenith delay, calculated from surface pressure P_s, station latitude and height
- conversion factor $Q(T_m)$ is ~6.5
- unit for integrated water vapour (IWV) is kg/m^2
- accuracy is1-2 kg/m^2

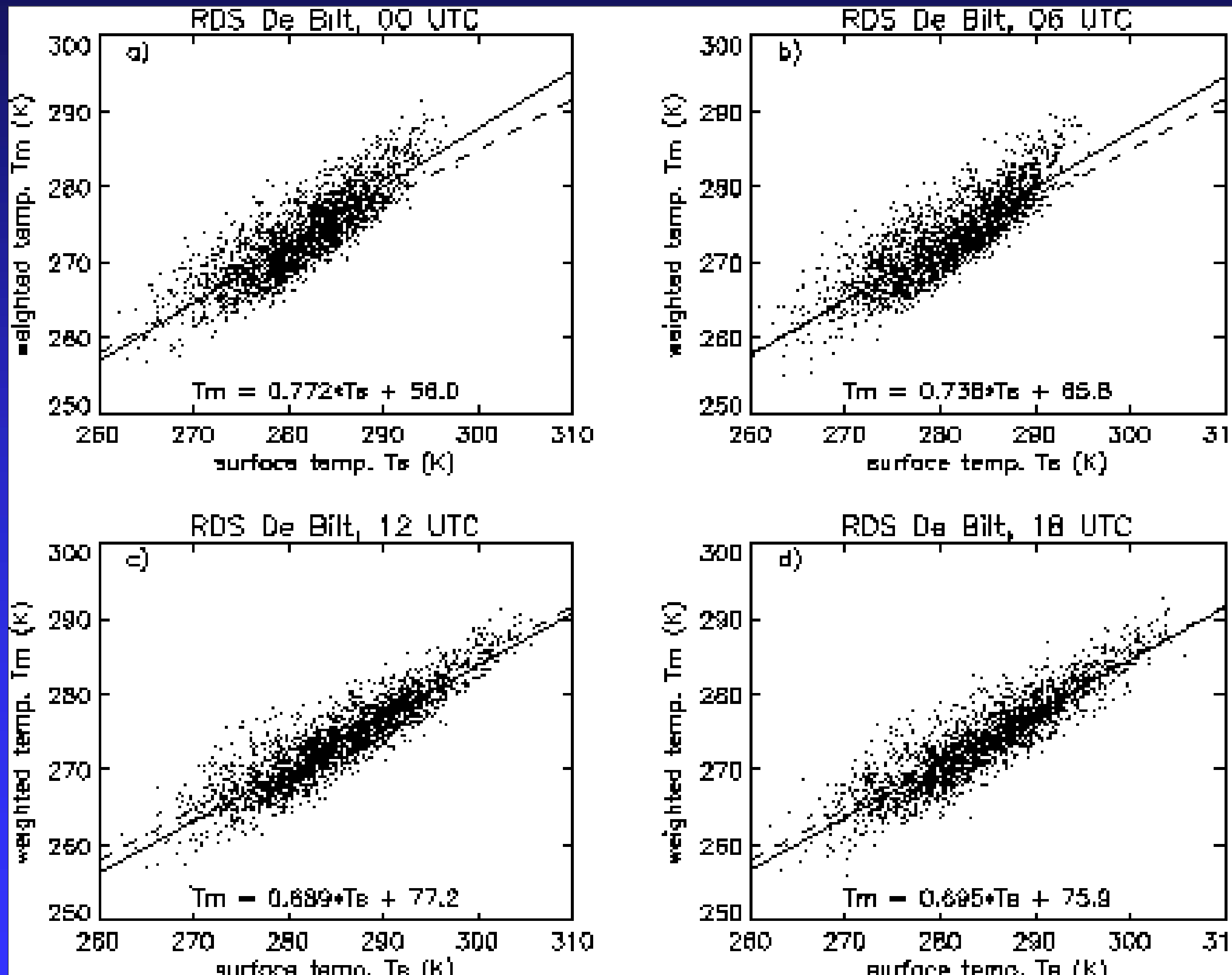
Analysis of $Q(T_m)$ from Radiosonde data

- Radiosonde at De Bilt
  - Vaisala RS80 (accuracy 0.2^0C in T, 0.5 hPa in P and 2% in RH)
  - launched four times daily (0h, 6h, 12h, 18 h UTC)
  - data stored at 10s intervals (resolution in lower atmosphere 60-70 m)
- The radiosonde profile data is integrated to obtain the zenith wet delay (ZWD), integrated water vapour (IWV) and mean temperature (T_m)
- Q(Tm) from De Bilt agrees well with other published results
- Diurnal cycle present
- Lower scatter if Tm is related to temperature at 80 m

Q(T_s) from radiosonde De Bilt 1993-1999



T_m from radiosonde De Bilt 1993-1999



Primary Objective

- Assessment of operational potential on an international scale to provide near real time observations

Secondary Objectives

- Development and demonstration of a prototype
- Validation and performance verification
- Exploitation for numerical weather prediction (NWP) and climate applications
- Requirements for operational implementation

Status

- Memorandum of Understanding approved Dec. 97
- 14 countries have signed the MoU: *Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and UK.* Action now in force.
- Will be in force for 5 years
- Management committee meetings in Brussels (Jan. 99) and Delft (Apr. 99)
- Chairman Gunnar Elgered (vice chair Alan Dodson)
- Secretary: Zoltan Dunkel (COST bureau)

Status (continued)

- Projects 1, 2 and 3 have been started
- Coordinators for each project appointed:

  Peter Pesec (State of the Art),

  Hans van der Marel (Demonstration)

  Sylvia Barlag (Applications)
- Workshop on 27 and 28 September 1999 in Brussels
- Two workshops are foreseen & specific workshops for projects where appropriate

Projects

1 State of the art and production requirement: *workshop & review*

2 Demonstration: *near real time network demonstration and trial report*

3 Applications: *Assimilation & data utilisation for NWP and Climate; impact assessment & recommendations*

4 Planning for the operational phase: *cost/benefit analysis, recommendations for international operational work*

1 State of the art and production requirement

Deliverables

- review of the state of the art
- equipment specification
- recommended software and data format
- preliminary user specification

Status

- Draft report has been prepared
- Several issues have been identified
- Questionnaire will be sent out

2 Demonstration

Deliverables

- near real time network demonstration (March 2001)
- benchmark dataset
- verification of hardware and software codes
- assessment of sensitivity to site variables
- quality control and validation scheme (site specific issues)

Status

- just started (MC has to identify workgroup members)
- first issue: project plan (based on actual requirements)

3 Assimilation and data utilisation for NWP….

Deliverables

- impact assessment for numerical weather prediction and climate research
- recommendations for data exploitation, quality control and performance monitoring and data archiving
- revised user requirements and system specifications

Status

- just started (MC has to identify workgroup members)
- first issue: requirements for “Demonstration” project

Demonstration - The Start

Proof of concept given by several (inter)national studies

Several (candidate) networks/projects are already in operation (MAGIC, GASP, UK network, ...)

Several open issues have been identified by project 1

- near real time delivery and processing of GPS data
- monitoring of changes at stations
- unified pressure, temperature and humidity readings
- relation to other organisations (EUREF, IGS)
- type of data to exchange and data exchange formats

Requirements to be formulated by project 3

Demonstration - Network design

- Co-ordination and embedding of (local) networks
- Organisation and support in terms of
  - regional and global data centre issues
  - near real-time reference network
    - $\Rightarrow$ ‘absolute’ water vapour information
    - $\Rightarrow$ near real-time orbits
  - combined solutions
  - monitoring (quality control and validation)
- Adoption of ‘lone’ stations
- Standards

Demonstration - GPS data handling

Existing approaches

- IGS and EUREF hourly data downloading scheme
  - mix of scheduled downloads and pushed data
  - local/regional/global data centres
- UNIDATA’s approach (used in SuomiNet USA)
  - broadcast technology build on point-to-multipoint communications
  - highly decentralised (no dedicated data centre)
- Meteorological data communication networks and technology

Demonstration - Meteo sensor issues

- Meteo sensors GPS stations (option or mandatory?)
  - instrument type and installation guidelines
  - calibration procedures (‘flying’ unit?)
  - log files (height above sea-level/ground/antenna)
  - format (RINEX met files)
- Data from nearby synoptic stations?

Some data must be available in near real-time for the GPS processing, even if only TZD’s are produced

Role in conversion of ZWD to IWV?

Demonstration - Processing centre issues

- What to exchange? (IWV, <u>zenith</u> and/or slant delays, <u>absolute</u> or relative)
- Which interval and smoothing techniques
- Binning, sliding windows and overlaps
- Latency (the latest estimate, or the one before?)
- Interchange format (SINEX or meteorological format)
- Predicted orbits with or without orbit relaxation
- How to handle correlation
- Distributed processing and combination scheme
- Data archiving

Demonstration - Quality control/validation

- Will concentrate on site specific issues
- Station history
  - log of changes (input from station managers, processing centres, EUREF)
  - planned changes with assessment of effects
- Monitoring tools?

Demonstration - Sensitivity analysis

- Original title: Equipment field trials….
- Sensitivity assessment to meteorological and site variables, operational reliability, code validation and tests (much work has already been done)

- Production of a reference dataset for benchmarking and comparison purposes
- Studies of low elevation data, antenna phase centre variations and near field environment,mapping functions, gradients and azimuth dependencies, sample rate and estimation interval, slant delays, etc.

Relation to EUREF

- Operates a permanent network of 90+ stations
- Data is collected at Local and Regional Data Centres; some centres already collect at a one hour interval
- Common interests and problems

What can EUREF Offer?

- Experience, contacts and insights in the GPS data quality and processing
- Analysis centres already do routine computations & combined solutions
- Good quality control (changes in antenna, radomes, multipath)

What will EUREF gain?

- More research on height related topics: height and tropospheric delays are affected by the same error sources (antenna,multipath)
- Improved GPS heights
- Boost for hourly data collection (also useful for other applications)

The COST action is a challenge and opportunity to further extend the application of permanent GPS networks