# GRUAN GNSS Precipitable Water (GNSS-PW) Task Team: 10 members from 7 countries



## Outline

- 1. Guidelines: 8 Tasks
- 2. Implementation:
  - Lauder GNSS data processing & intercomparisons
  - GNSS Data Central Processing (Galina)
  - GNSS Data Flow (Kalev, next talk)
- 3. Collaborations:
  - COST ES1206 Advanced GNSS Tropospheric Products for monitoring Severe Weather Events and Climate (Johnathan)
  - Participation in workshops and meetings (IGS & AGU)

#### **GNSS-PW Task Team: Motivation, Goal, & Operation**

Goal: To develop explicit guidance on hardware, software and data management practices to obtain GNSS PW measurements of consistent quality at all GRUAN sites with eight specific Tasks.

Operation: Bi-annual conference call, emails, ICMs, sub-teams for each task & documentation, collaborations with sites and GNSS community.



Task	Milestone	Progress
#1 To define GRUAN requirements	<b>"GRUAN GNSS Product</b> <b>Requirements"</b>	Done
#2 To document and review current status	"GRUAN GNSS Site Survey Table"	Done
#3 To prepare "GRUAN GNSS Site Guidelines"	GRUAN TD-6: "GRUAN Ground- based GNSS Site Guidelines"	Done
#4 To develop guidance on data	<b>"GRUAN GNSS Data and Product Table" &amp; "Format Specification for COST-716 Processed GPS Data"</b>	E-GVAP format Add uncertainty data
#5 To identify best practices in making and verifying GNSS observations	joint WMO CIMO/GRUAN document	Finalizing
#6 To provide guidelines for GNSS- PW uncertainty analysis	A document and a journal paper	Need work!!!
#7 To recommend practices on managing changes	Managing changes in GRUAN GNSS- PW product	Draft
#8 To encourage and recommend experiments and research for resolving the tasks		On going

### **PW uncertainty estimation**

#### **1. Theoretical Analysis**

$$\sigma_{IWV} = \sqrt{\sum_{i=1}^{N} \left(\frac{\partial f(v_1, \dots, v_N)}{\partial v_i}\sigma_i\right)^2}$$

#### **2. Statistical Analysis**

$$S_{A-B} \approx \sqrt{\overline{E_A^2}} + \overline{E_B^2}$$

Meteorological data (Ps, Ts) & estimated Tm

Immler et al. (2010) Tong (2012)



 $ZHD = f(P_s)$   $PW = \prod * ZWD \prod = f (Tm)$ NCAR

## **PW uncertainty estimation**

$$\sigma_{IWV} = \sqrt{\left(\frac{\sigma_{ZTD}}{Q}\right)^2 + \left(\frac{2.2768\,\sigma_{P_0}}{f(\lambda,H)\,Q}\right)^2 + \left(\frac{V}{Q}\,10^{-6}\,\rho_w\,R_w\,\sqrt{\left(\frac{\sigma_{k_3}}{T_m}\right)^2 + \sigma_{k_2'}^2 + \left(k_3\frac{\sigma_{T_m}}{T_m^2}\right)^2}\right)^2}(1)$$

**1.ZTD and P0 uncertainties dominate (>94%).** 2. P0 uncertainty: Help from surface obs. group?? 3. Tm uncertainty: calculated from the input source. 4. Understand, quantify and correct the biases in ZTD 5. Dynamic ZTD uncertainty: To use the ZTD measurements within a "reprocessing" of the coordinates at the same time interval that the ZTD value was estimated. If the previously estimated ZTD is used as the apriori in a solution that only calculates the height, the difference represents the ZTD uncertainty within the interval.

#### Lauder GPS-PW measurements







Days in 2012



PW\_LAUD (mm)

PW\_93844 (mm)

- The vertical separation contributes most to mean differences.
- 2. The instrument difference has the largest effect on the scatters, then the next is horizontal separation.





PW/ 01192 (mm)





$$E_A = E_B = S.D./\sqrt{2}$$

OUS2/DUND:  
$$E_A = E_B = 0.86/\sqrt{2}=0.61 \text{ mm}$$

Theoretical analysis: 0.81/0.76/0.69 mm *(Tong 2012)* 









### **Operational GNSS data analysis at GFZ**

#### **GPS + GLONASS + Galileo processing with GFZ EPOS software**

GFZ



- High accuracy and reliability of tropospheric data products
- Use of high accurate GNSS orbits and clocks from GFZ
- Optional: software for generation of combined solutions from different analysis centers



COST ES1206 - Advanced GNSS Tropospheric Products for monitoring Severe Weather Events and Climate

- 4yr COST Action starting May 2013
- 55 participants from 23 European countries
- Primary Objectives
  - Coordinate the development of new, multi-GNSS techniques and products.
  - Improve the understanding of short-term atmospheric processes.
  - Promote the use of, and determine the impact of, re-processed long-term GNSS tropospheric datasets for climate.
  - Link its activities to the IGS and EUREF, and work in support of E-GVAP.
  - Coordinate the exploitation of GNSS and meteorological data for mutual benefit.
  - Lead to a consolidation of collaborating groups.

# Future Plan

- > 2/2014: Finalize the documents for the tasks #4, #5, #7
- 2/2014: Draft manuscript on GNSS PW uncertainty estimate.
- Work with the LC and GCDP on GNSS data flow and central processing. The RINEX files should be sent to the LC and centrally archived. So the TT members can analyze and evaluate the data, and publish the results.
- Lauder data inter-comparisons: GPS, radiosonde, FTIR, NASA WV lidar ...

After all tasks are done, TT continues to serve (at minimum) until the "GRUAN GNSS-PW" data become available, are inter-compared with other GRUAN data and are used for other applications.

# GNSS-PW TT side meeting (4:30-6:00pm)

- 1. 4:30-4:45 Michael/Kalev, overall data flow from sites to LC and GDCP (GNSS Data Central Processing)
- 2. 4:45-5:00 Galina, GFZ proposal to host GDCP
- 3. 5:00-5:30 GDCP discussions
- 4. 5:30-6:00 Other GNSS-PW discussions.