GNSSMET

Contribution of tropospheric zenith delays derived from GNSS data to weather forecast in alpine areas

A. Karabatić, R. Weber, S. Leroch

EGU 2008, Vienna, Austria

Summary

- Introduction & Motivation
- Realization
- Results
- Conclusions
- Outlook

PROJECT CONSORTIUM

- TU WIEN – Institute of Geodesy and Geophysics, Vienna University of Technology

- ZAMG – Central Institute for Meteorology and Geodynamics, Austria

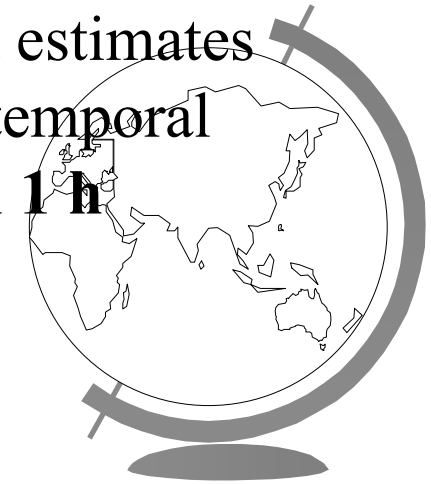
- KELAG – Carinthia Power Supply Company

DURATION OF PROJECT

September 2006 – February 2008

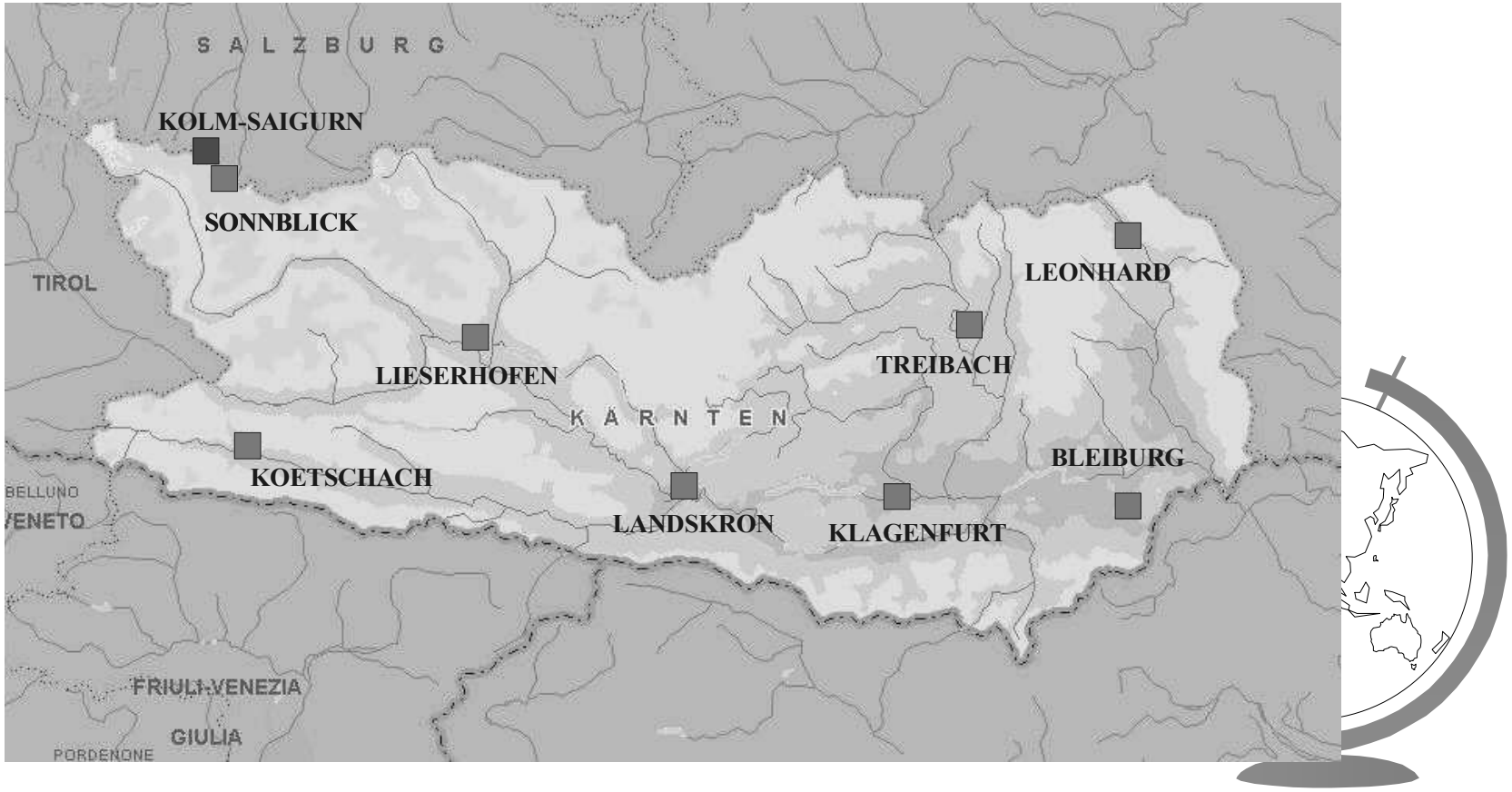
Introduction

- Increasing importance of high resolution meteorological analysis in mountain areas over the past years
- Already available:
  - INCA – Integrated Nowcasting through Comprehensive Analysis, operated by ZAMG
  - TAWES network, operated by ZAMG
  - Rarely meteo-ballon data
- The aim of the project is to provide GNSS based estimates of the tropospheric water vapour content with a temporal resolution of 1 h and temporal delay of **less than 1 h**
- $\sigma PW \leq 1mm$



Introduction

- Measurements performed at the 8+1 GPS/GLONASS reference station network KELSAT in Carinthia, extended with 3 stations of the IGS/EUREF network (Graz, Wettzell, Zimmerwald)



Realization

- Calculate Zenith Total Delay (ZTD) per station from network processing with temporal resolution of 1 hour
- Use surface meteorological data (TAWES data) to correct a priori ZHD
- Delivery of most recent ZWD values to ZAMG
- Assimilation of data → INCA

Realization

- Calculate Zenith Total Delay (ZTD) per station from network processing with temporal resolution of 1 hour
- Use surface meteorological data (TAWES data) to correct a priori ZHD
- Delivery of most recent ZWD values to ZAMG
- Assimilation of data → INCA

Realization

Calculation

- *Bernese v5.0*
- Estimation of tropospheric parameters and station coordinates based on double differencing approach
- Use of IGS ultra rapid orbits
- Ionospheric free narrow lane combination
- Parameter estimation:
  - Elevation mask 5°
  - Wet Niell mapping function (test with GMF, VMF)

$$\Delta L(e) = \Delta L_h^z \cdot mf_h(e) + \Delta L_w^z \cdot mf_w(e)$$

Realization

- Calculate Zenith Total Delay (ZTD) per station from network processing with temporal resolution of 1 hour
- Use surface meteorological data (TAWES data) to correct a priori ZHD
- Delivery of most recent ZWD values to ZAMG
- Assimilation of data → INCA

Realization

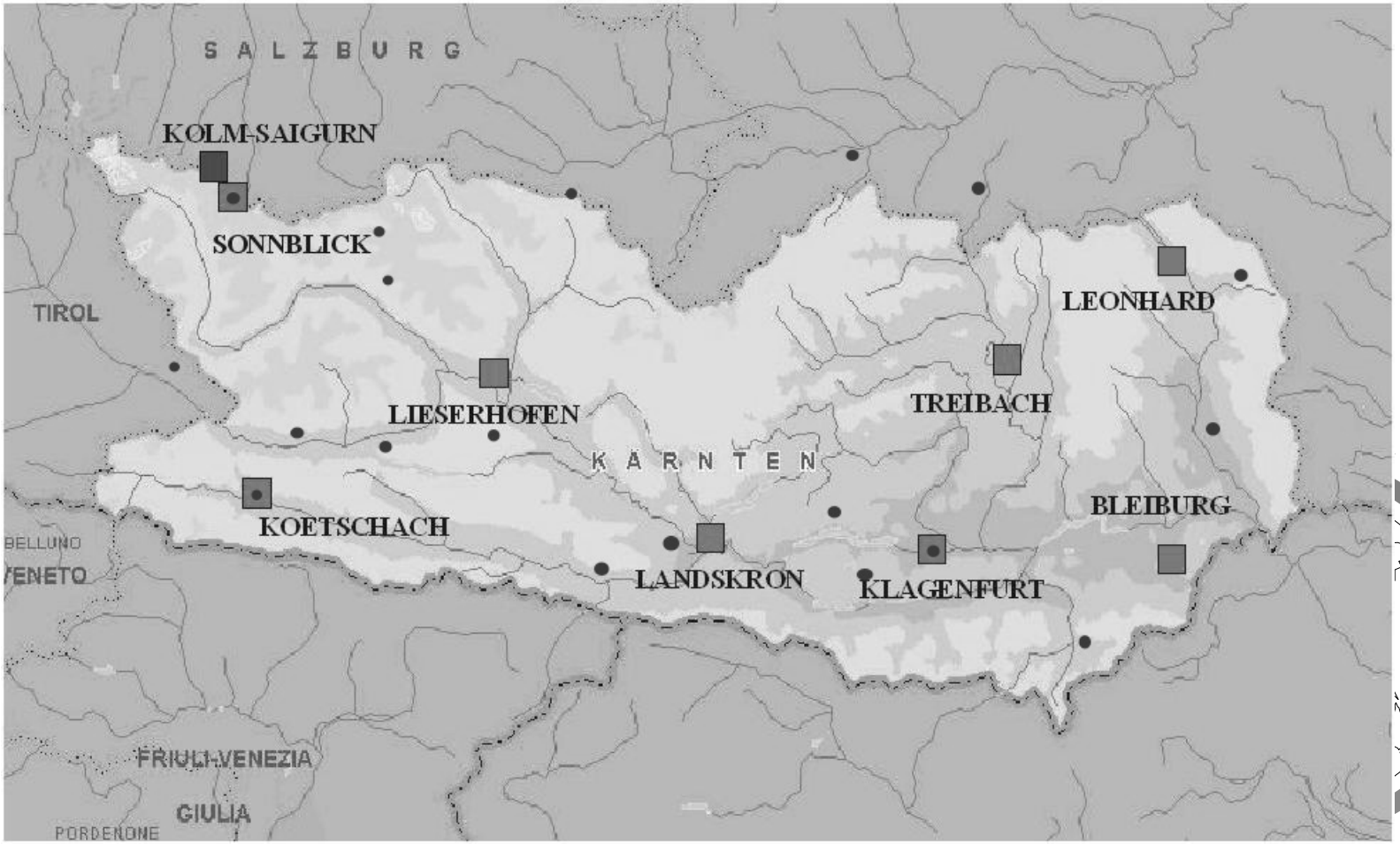
Introduction of TAWES

- TAWES network of Meteorological Sensors
- Temperature, pressure, humidity updates every 10 minutes

Realization

Introduction of TAWES

- KELSAT network with nearby TAWES stations



Realization

Introduction of TAWES

- Extrapolate air pressure to GNSS stations

$$p_{GNSS} = p_{TAWES}\left(\frac{T_{TAWES} - \gamma\left(h_{GNSS} - h_{TAWES}\right)}{T_{TAWES}}\right)^{\frac{g}{R_\gamma}}$$

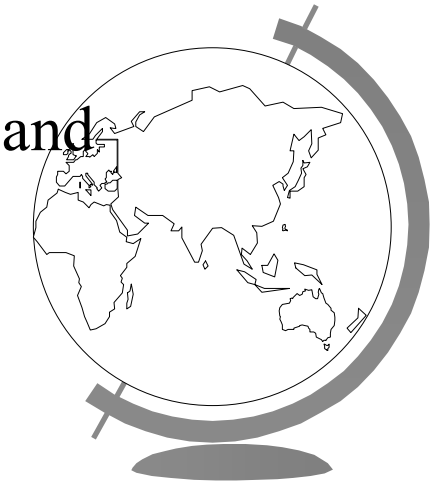
$$g(h,\phi) = 9.8063\left(1 - 10^{-7}h\right)\left(1 - 0.0026373\cos(2\phi) + 5.9\cdot 10^{-6}\cos^2(2\phi)\right)$$

- Correction of hydrostatic delay

$$\Delta = ZHD_{TAWES} - ZHD_{STANDARD\_ATMOSPHERE}$$

- Calculate hydrostatic part from surface-met-data and correct ZWD estimates afterwards

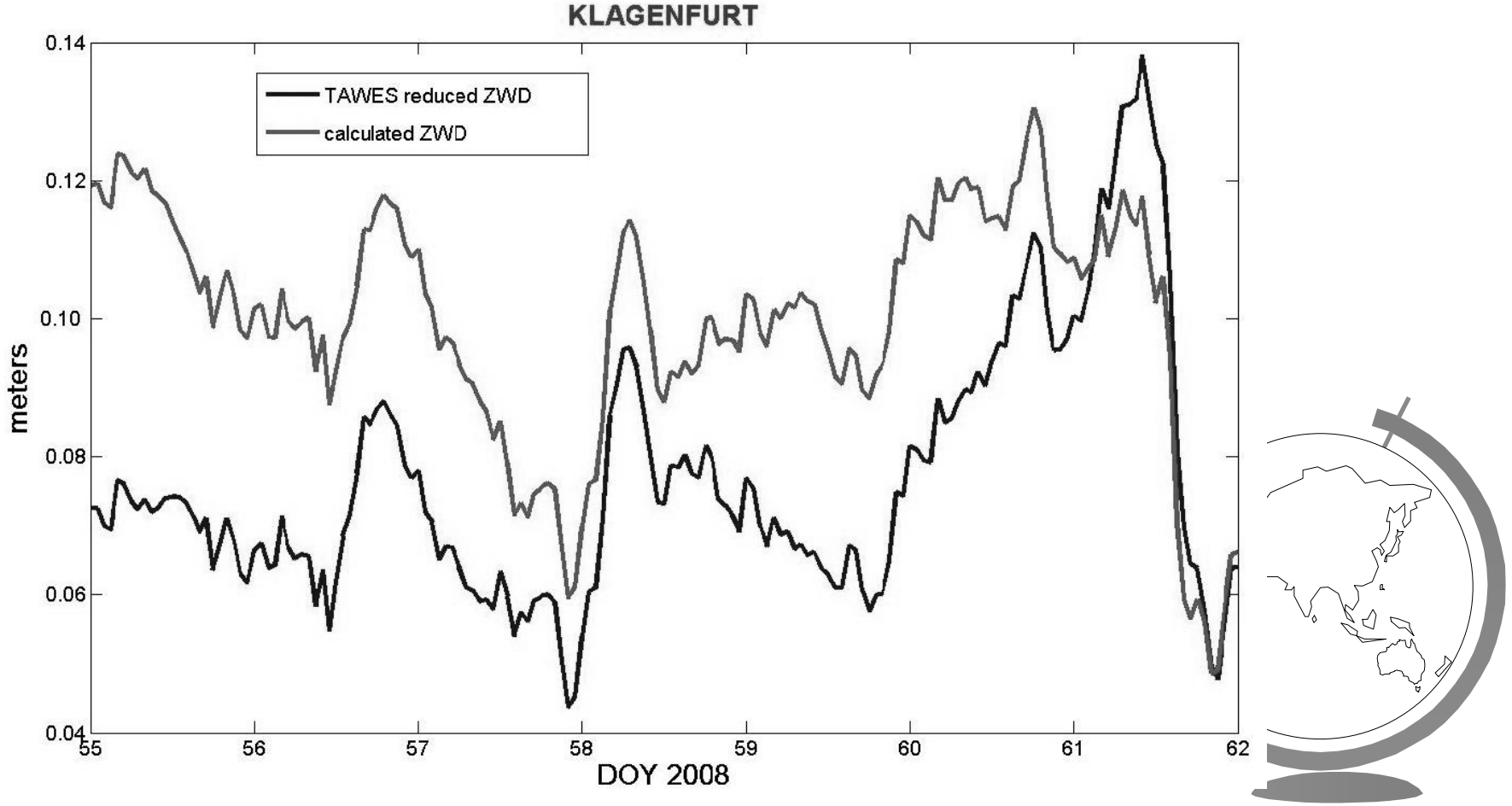
$$ZWD_{corr} = ZTD - ZHD_{corr}$$



Realization

Introduction of TAWES

- Station Klagenfurt → comparison of TAWES reduced ZWD and calculated ZWD



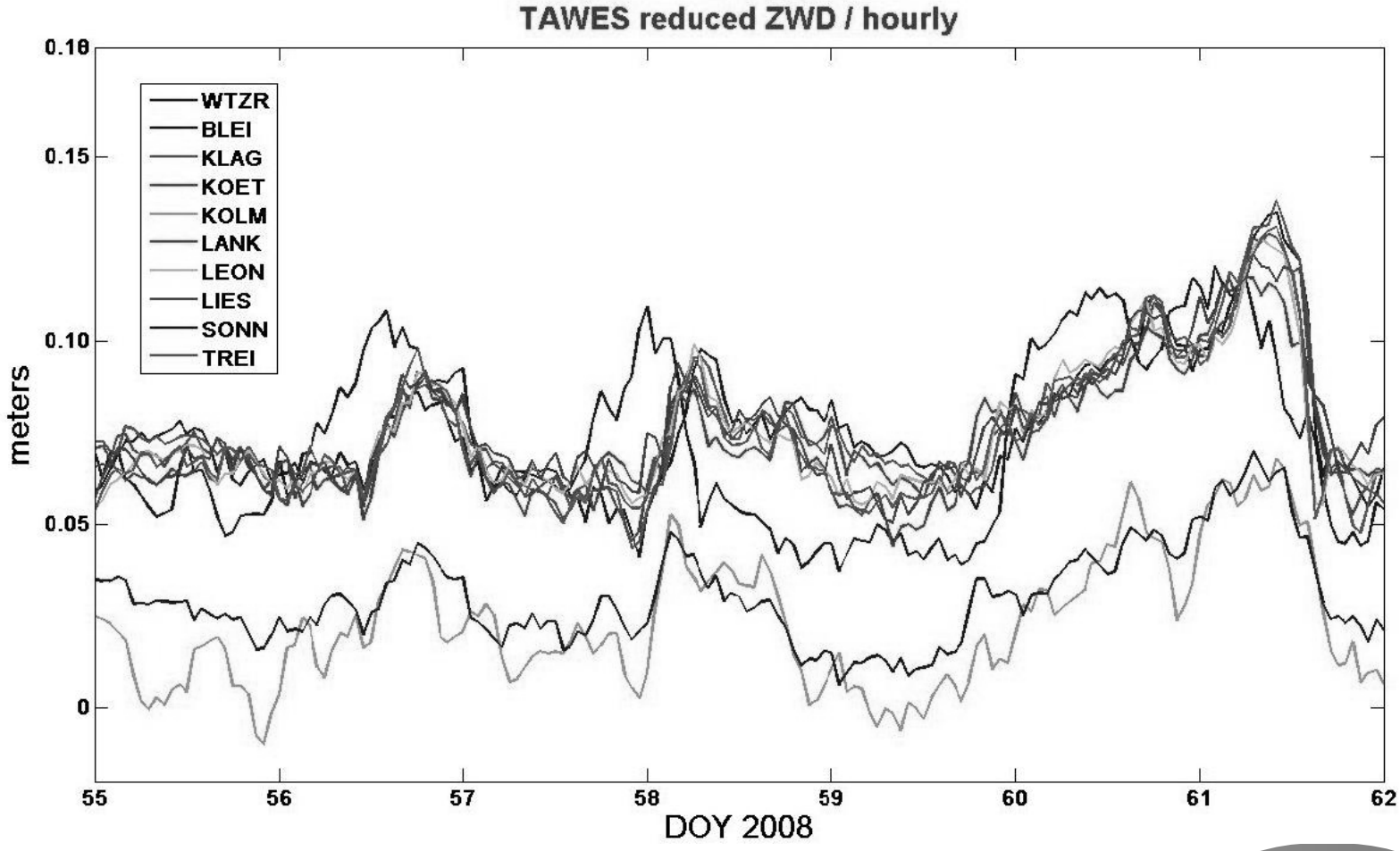
Realization

- Calculate Zenith Total Delay (ZTD) per station from network processing with temporal resolution of 1 hour
- Use surface meteorological data (TAWES data) to correct a priori ZHD
- Delivery of most recent ZWD values to ZAMG
- Assimilation of data → INCA

Realization

Delivery of ZWD

- Calculation of the last 12 hours, extraction of last (last but one) value of ZWD



Realization

- Calculate Zenith Total Delay (ZTD) per station from network processing with temporal resolution of 1 hour
- Use surface meteorological data (TAWES data) to correct a priori ZHD
- Delivery of most recent ZWD values to ZAMG
- Assimilation of data → INCA

Realization

Assimilation

$$PW \approx 0.16 ZWD$$

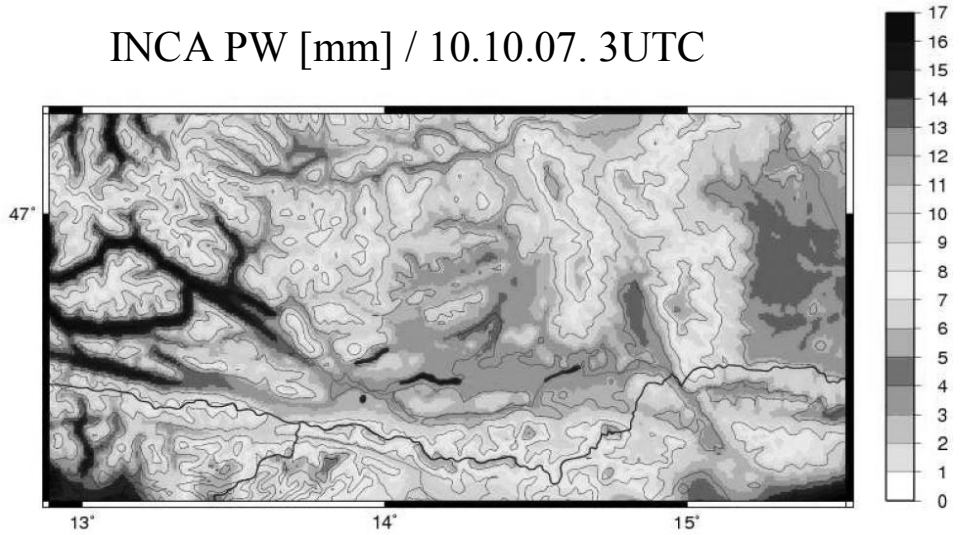
$$f_k(\theta,\phi) = \frac{PW^{GNSS}}{PW^{INCA}}$$

$$f_{ij} = \sum_{k=1}^{N} w_{ij}^{k} f_k(\theta,\phi)$$

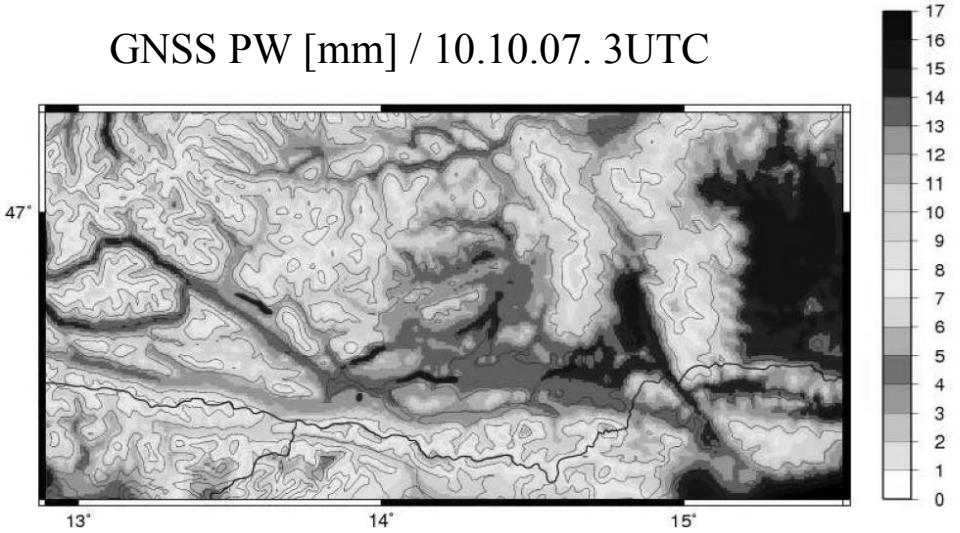
$$w_{ij}^{k} = \begin{cases} \dfrac{\dfrac{1}{r_k^2}}{\sum_l \dfrac{1}{r_l^2}} & \text{when } r_k \le 100km; \\ 0 & \text{when } r_k > 100km. \end{cases}$$

$$PW_{ij} = f_{ij} PW_{ij}^{INCA}$$

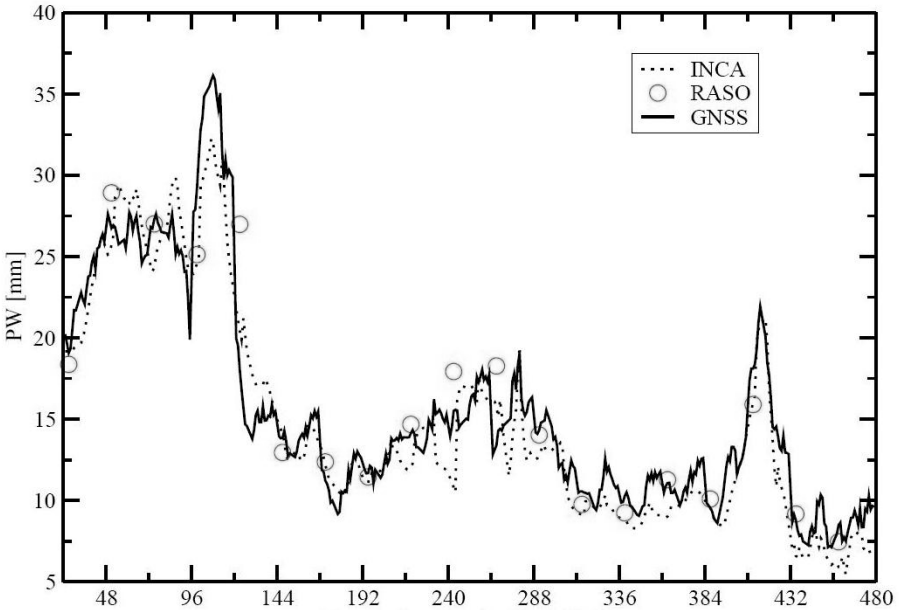
INCA PW [mm] / 10.10.07. 3UTC

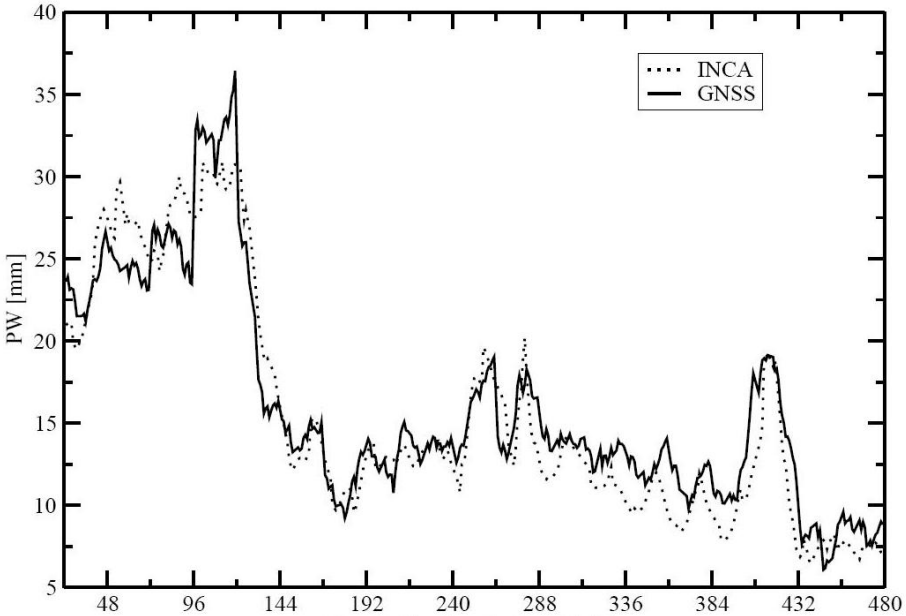


GNSS PW [mm] / 10.10.07. 3UTC



Results

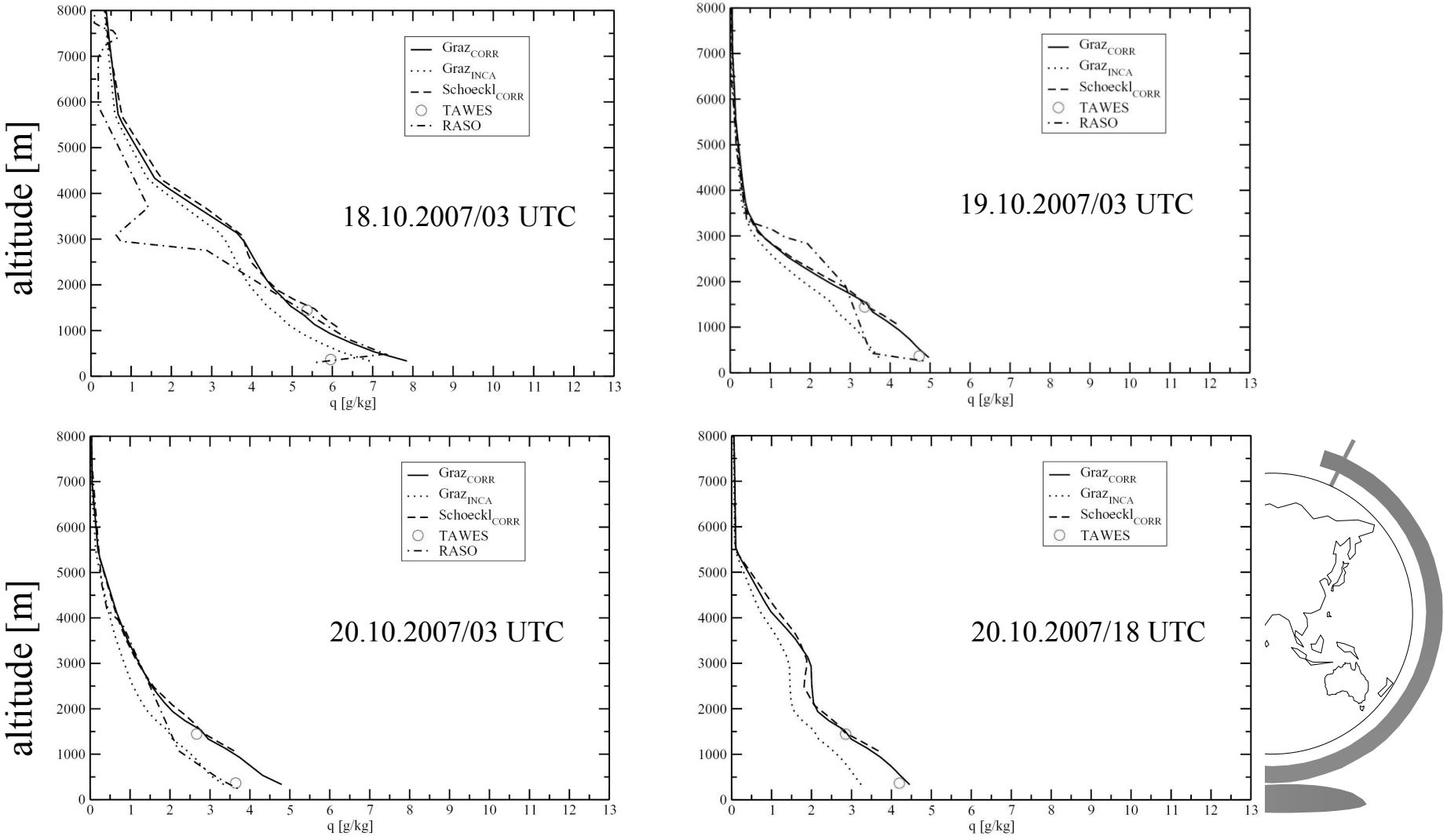




- Comparison of percipitable water between INCA model and GNSS estimates for station Graz (left) and Landskron (right) – 2.-20.10.2007

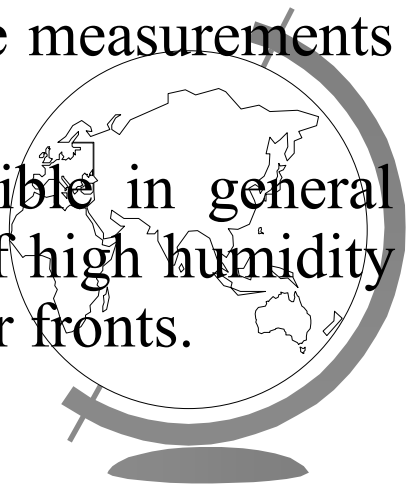
Results

Humidity profiles over station Graz



Conclusions

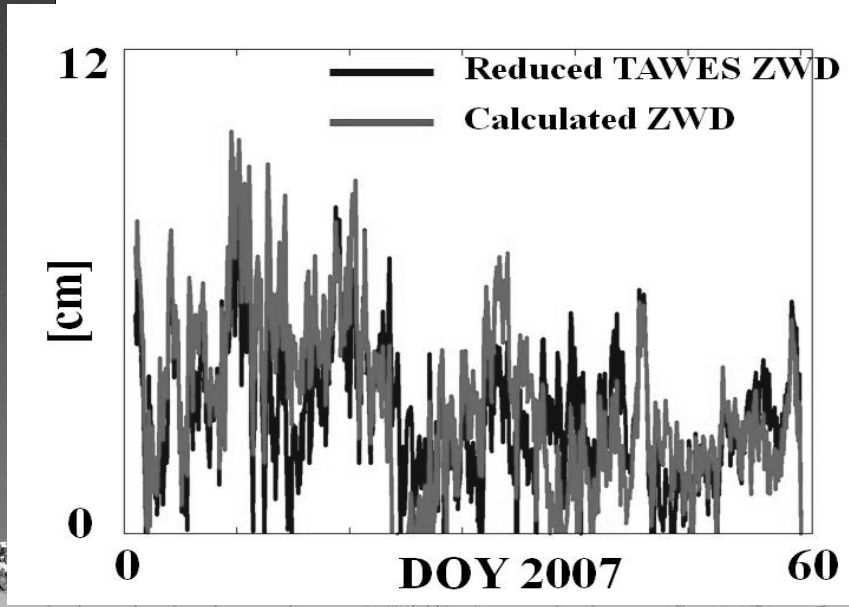
- We deliver Zenith Wet Delays for a regional network located in alpine area with an hourly resolution and a time delay of 30min (best case)
- The accurcay of our estimates is in most cases better than 1mm PW
- The hydrostatic part is calculated from ground meteo measurements nearby the GNSS stations
- ZAMG assimilates the ZWD values for test purposes into the real-time forecast system
- GNSS corrected humidity profiles match radiosonde measurements quite well
- Improvements of INCA humidity profiles are visible in general during summer (GNSS constraints during periods of high humidity more tight) and in special in times of passing weather fronts.



Outlook

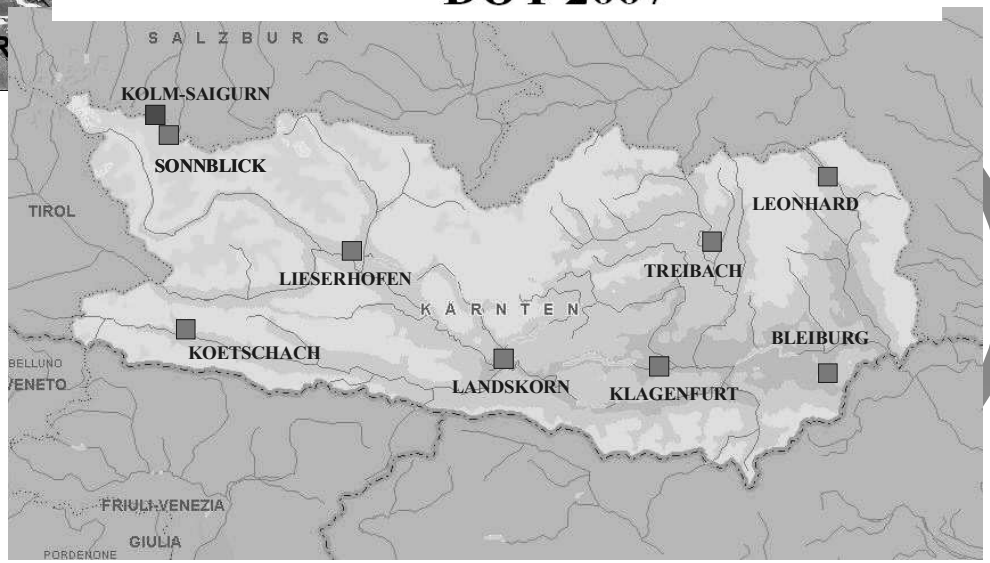
- Include GLONASS data
- Integration of Numerical Weather Model for a priori hydrostatic model
- Extension of project to whole territory of Austria
- Local PW with high temporal resolution for station Sonnblick

Sonnblick station



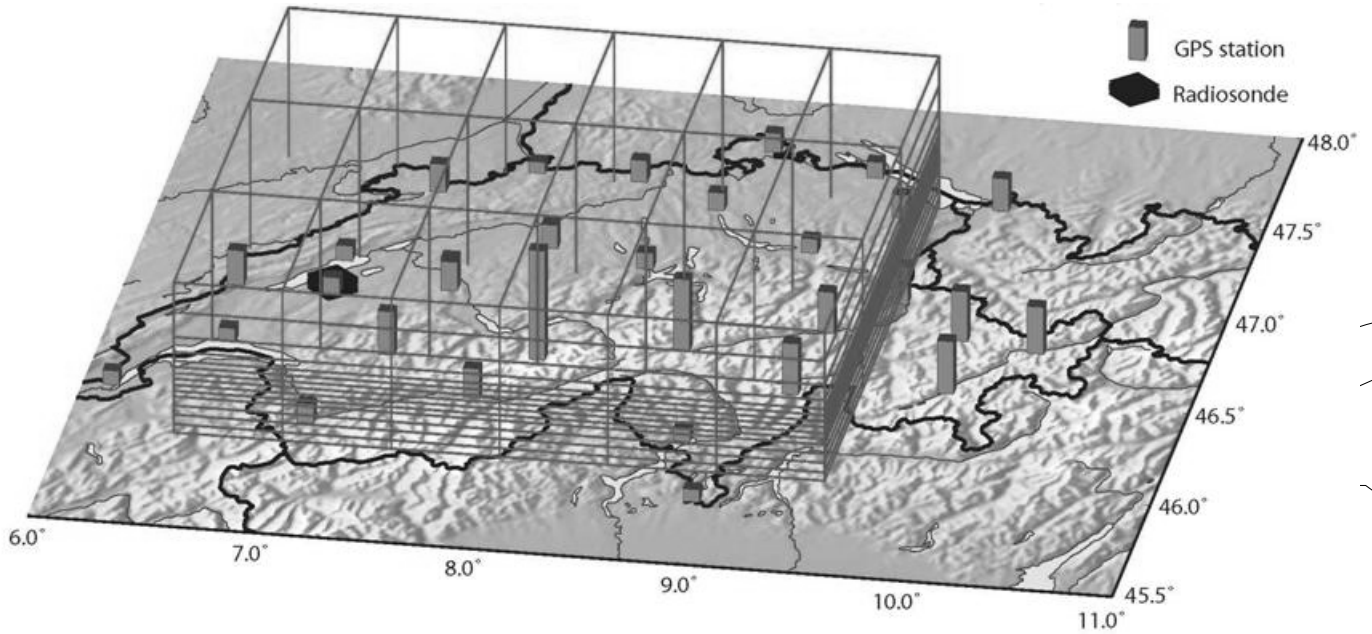
Station Sonnblick: Height 3118 m

www.sonnblick.net



Outlook

- Introduction of Galileo-IOV data
  - Allows increased temporal resolution of ZWDs
  - New signals (E5) would allow to model higher order terms of ionospheric refraction (max. 1cm) and subsequently improve ZWD accuracy
  - Improved spatial resolution (tomography)



Source: M.Troller, 2006, ETHZ, Switzerland

Thank you!