



VIENNA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF GEODESY  
AND GEOINFORMATION

HG retreat, Miesenbach, 28. 4. – 30. 4. 2015

# Current activities and future plans

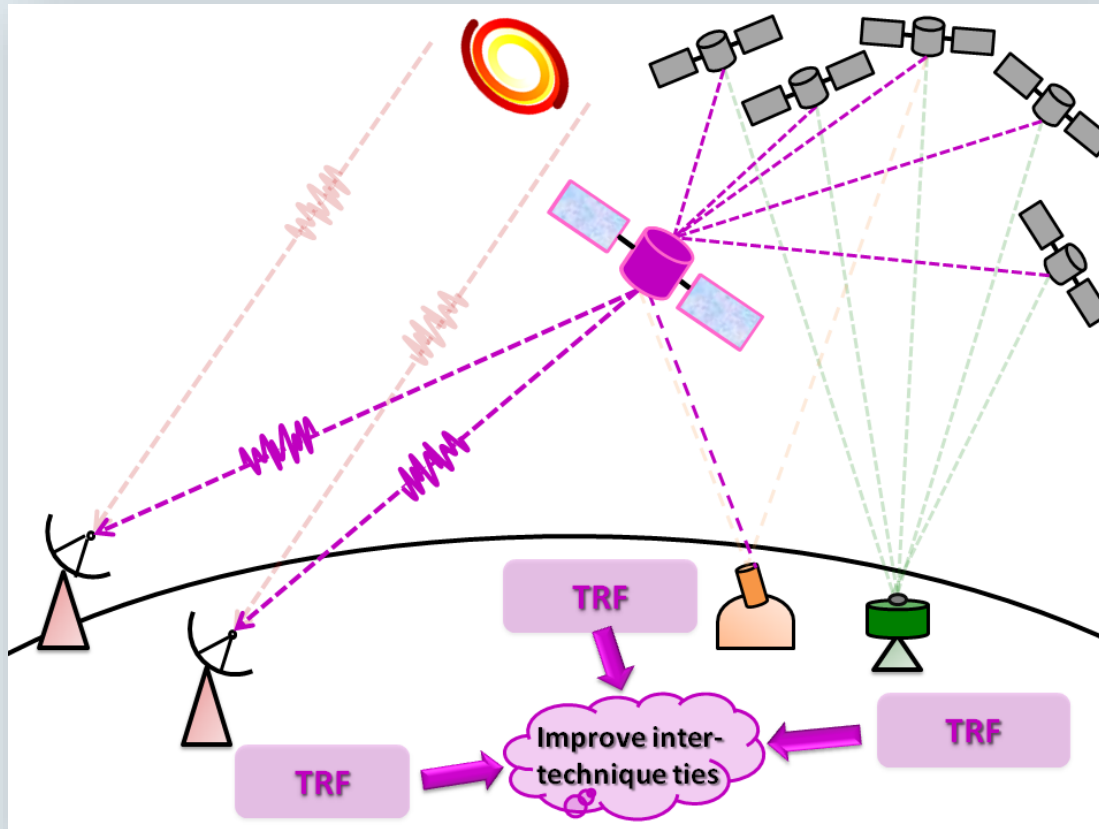
Andreas Hellerschmied

- VieVS administration:
  - Implementation of software updates
  - VieVS automatic processing routines
- VieVS-Wiki webpage
  - <http://viewswiki.geo.tuwien.ac.at/>
  - Open platform for VieVS related topics
- Teaching:
  - “Mathematical Methods of Geosciences” – Exercise
    - Together with David, supported by two tutors (students)
    - Focus on using MATLAB



# VLBI satellite observations (1)

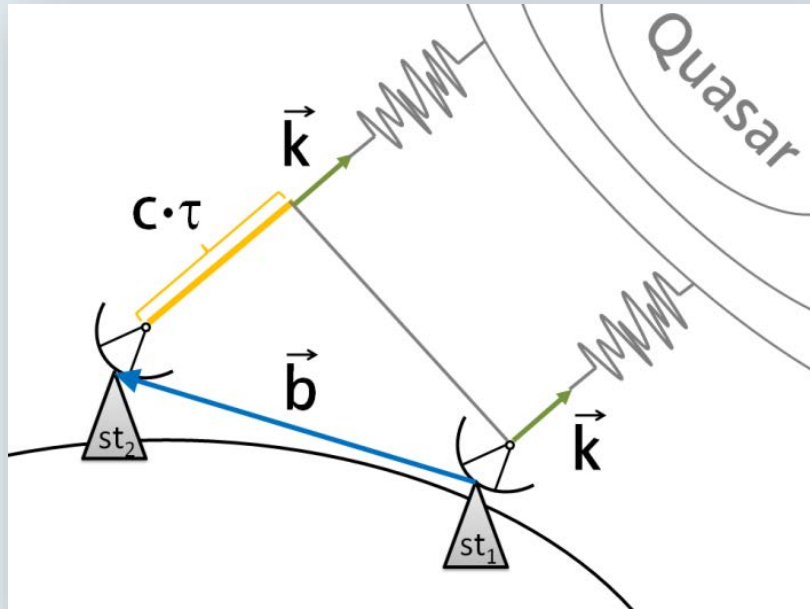
- Motivation
  - Establish inter-technique ties in space
  - Improved ITRF realization, etc...



„Co-Location in space“ (L. Plank, 2014)

# Geometric framework conditions

## Standard VLBI

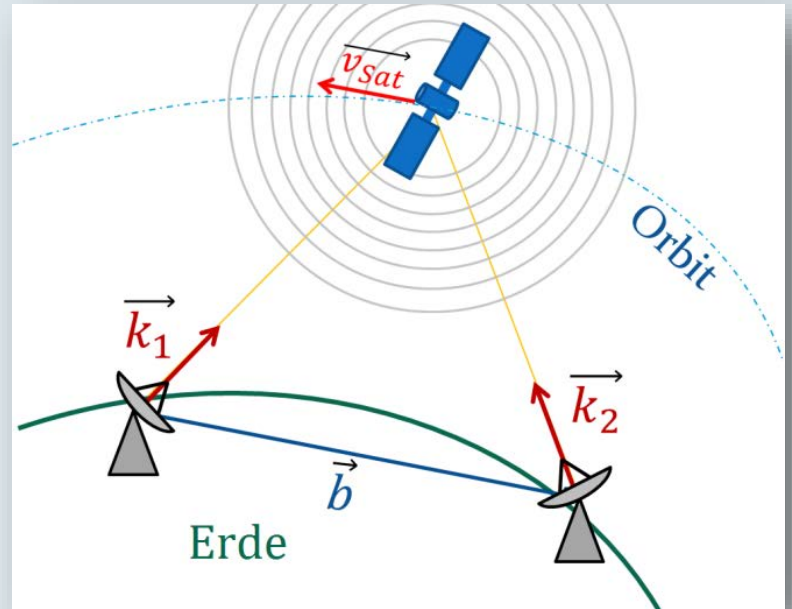


### Natural radio sources (quasars)

- At an infinite distance
- Parallel view directions  $\vec{k}$
- Fixed points in the sky



## Satellite observations



### Artificial signal sources

- In the Earth's near field
- Different view directions ( $\vec{k}_1 \neq \vec{k}_2$ )
- Moving fast

# VLBI satellite observations (2)

- Suitable observation plans („**Schedules**“) are required
  - Defining the time sequence of a VLBI experiment
  - Generated by dedicated VLBI scheduling software
- **Problem:** Available scheduling programs for geodetic VLBI did not support satellites as radio sources routinely.
- **Idea:** Development of a **satellite scheduling module** for the Vienna VLBI Software (VieVS; *Böhm et al., 2012*).



# VieVS satellite scheduling module

**Station network**

**Satellites**

**Observation Time & parameter**

**Graphics & Visibility information**

**User-interface**

**Input data**

Vienna VLBI Software 2.3

Station network: Available (GBT\_VLBA, NRAO20, NYALES20, OHIGGINS, ONSALA60, ONSALDBC, ONSALA85, ORION\_SM, OV-VLBA, OVRO\_130, OVRO\_90, PARKES64), Selected (ONSALA85, WETTZELL), Predefined (INT1.mat, IVSR1.mat, IVSR4.mat, On60Wz.mat, VLBI2010.mat)

Parameters: Sundist [°] 4 [deg], Cut-off el [°] 5 [deg], Source flux 0.25 [Jy]

Time options: Start time 13:00:00

Satellites: Select local TLE file: 16g.tle, Update TLE files from WWW

Available Satellites: GLONASS-720, GLONASS-719, GLONASS-721, GLONASS-723, GLONASS-724, GLONASS-725, GLONASS-730, GLONASS-733, GLONASS-734, GLONASS-735, GLONASS-732, GLONASS-736, GLONASS-737, GLONASS-738, GLONASS-739, GLONASS-742, GLONASS-744

Selected Satellites: GLONASS-719, GLONASS-720, GLONASS-723

Strategy: Source-based strategy (Number of sources observed simultaneously: 2 (1/2/4)), Station-based strategy (Distribute observations over sources), Satellite observations

Buttons: Load new catalogs, Load SCHED parameters, Save SCHED parameters, Save run, Save + Run

**Station: ONSALA85**

**Station: WETTZELL**

**ONSALA85 (obs. type: satellite)**

**End of last obs.:** unaz [deg] = 158.8, el [deg] = 6.6, time = 13:25:27

**Scan start:** unaz [deg] = 114.2, el [deg] = 41.9, time = 13:28:06

**Scan end:** unaz [deg] = 111.5, el [deg] = 44.0, time = 13:33:06

**Curr. epoch:** 13:33:06

**Manual Satellite Scheduling Approach**

```

##### Manual Satellite Scheduling Approach #####

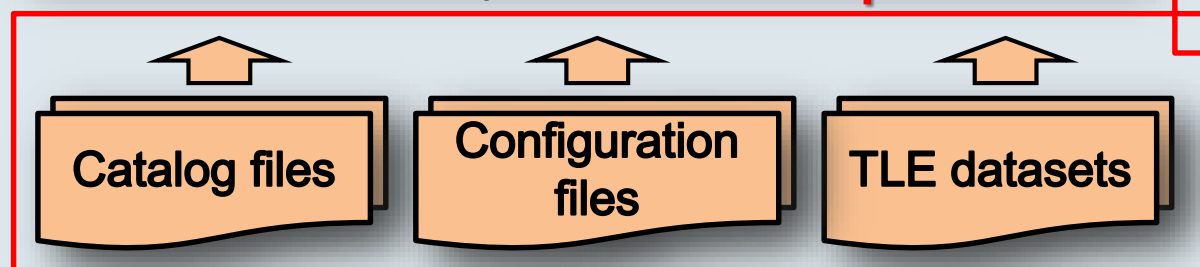
#### Type in an Experiment Name ####
=> Input Length: Between 1 and 4 characters
=> Legal characters: "A-Z", "a-z", "0-9", "_" and "-"
Experiment name: zt

#### Main menu: Choose an action ####

1 - Add a scan to the the current schedule (append)
2 - Get further information
3 - Edit current schedule
4 - Finish user input and create VEX file
5 - Exit

Please select: 1

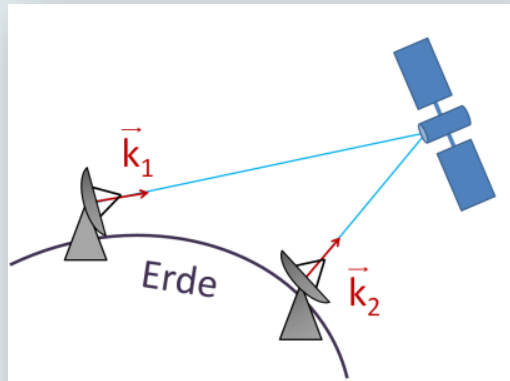
#### Add scan to current Schedule (append) ####
1 - Add a satellite scan
2 - Add a quasar scan
Please select: 1
    
```



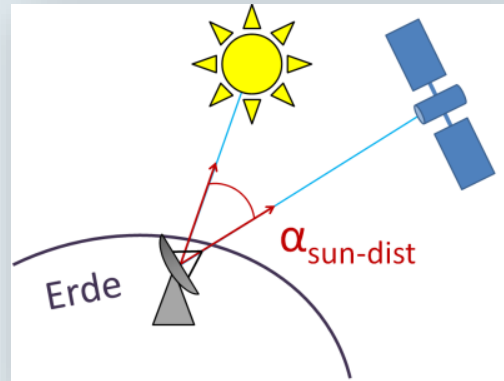
# Satellite observation conditions

- Conditions for the temporal availability of satellites as observation targets:

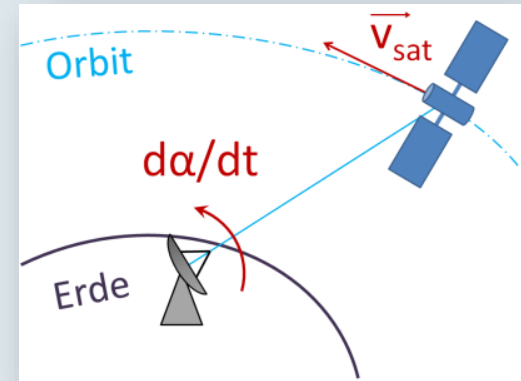
Common visibility?



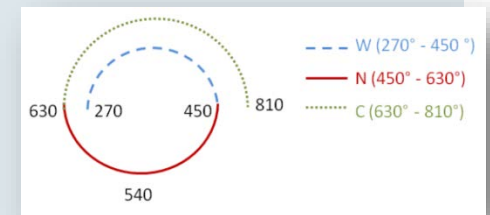
Sun distance?



Antenna slew speeds?



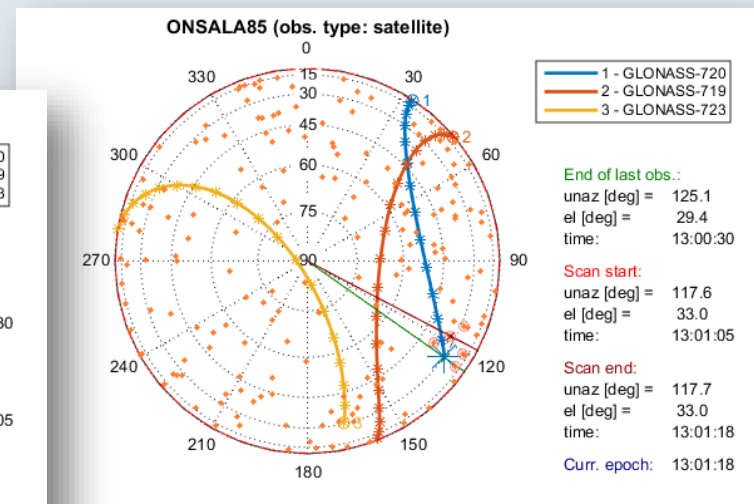
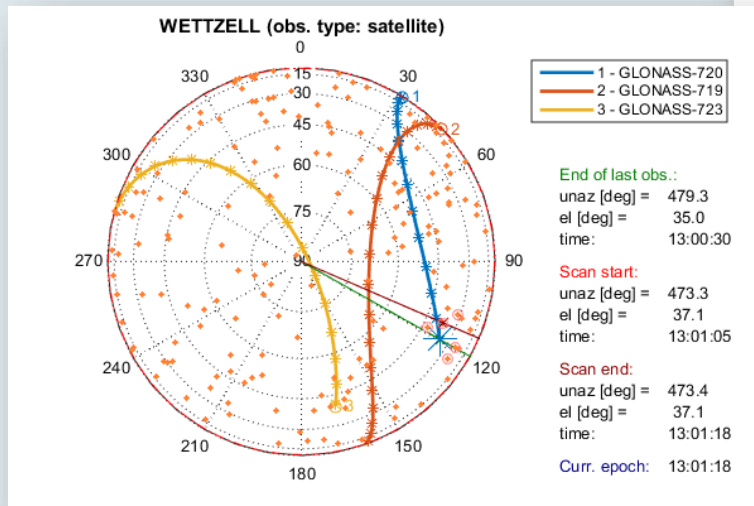
- Tracking of the **cable wrap** of Az/El mount antennas  
 → Calculation of slew times between scans



Cable wrap at Kokee (Sun J., 2013)

# Combined schedules

- **Combination of quasar- and satellite scans in one schedule**
  - Dedicated functions to select quasars, e.g. *“Find quasars which are approaching closest to the satellite track at a defined epoch”*



Sky plots: The 5 closest quasars to satellite GLONASS-720 at 13:01:18 are highlighted.



# Experiments (1): WTZ – ONSALA85

- Scheduled with



➔ GLONASS satellites

- L1 band signals (1602.56 - 1615.5 MHz)

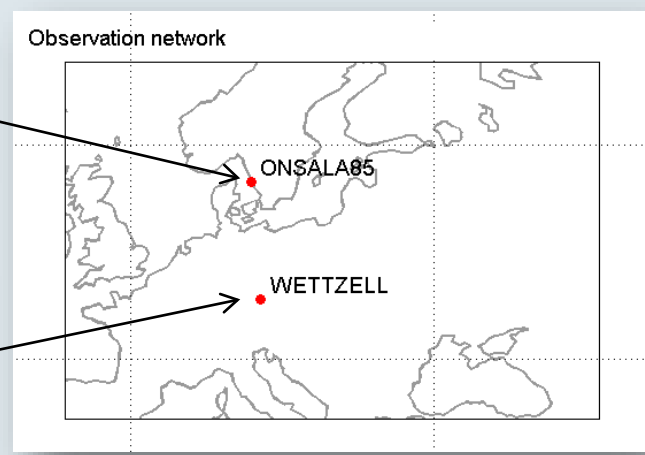
- Onsala, Sweden:

- R. Haas
- 25 m antenna, L-band feed



- Wetzell, Deutschland

- A. Neidhardt
- 20 m antenna, S/X-band feed
- New L1-band GNSS receiver  
*(Kodet et al., 2014)*

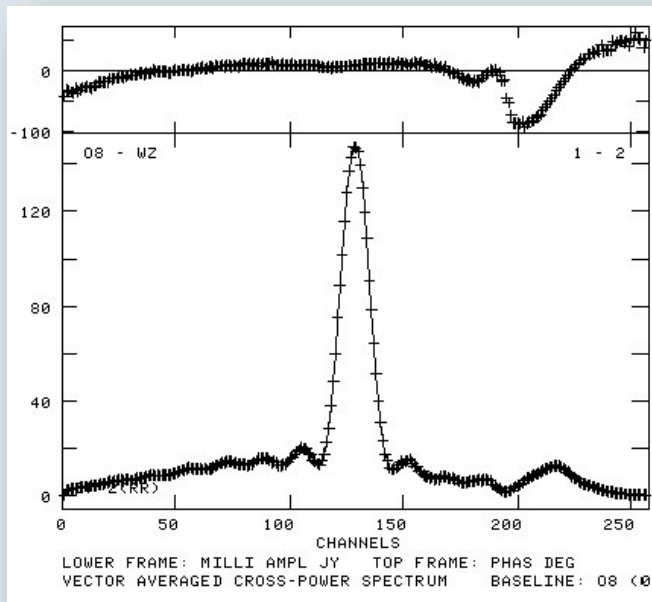


- Four test sessions, one hour duration each

- 16. January 2014: G140116a, G140116b
- 21. January 2014: G140121a, G140121b

# Experiments (2): preliminary results

- Correlation of the acquired data with the DiFX software (*Deller et al., 2007*) by R. Haas
- ➔ Continuous phases and strong amplitudes could be found for all observed satellites



Fringe Plot of GLONASS-732.  
 The data was recorded during  
 the G140121a experiment.  
 Correlation with DiFX (0,25 sec  
 Integration time) and Fringe  
 Fitting with AIPS (*AIPS, 2014*).

- **VieVS Satellite Scheduling Module**
  - ✓ Planning of real VLBI satellite observations
  - ✓ Generation of schedule files (VEX Format)
  - ✓ Combination of quasar- and satellite scans
  - No automatic source selection so far
  
- **First test experiments on the baseline Wettzell – Onsala were carried out in January 2014**
  - ✓ Successfully scheduled with VieVS

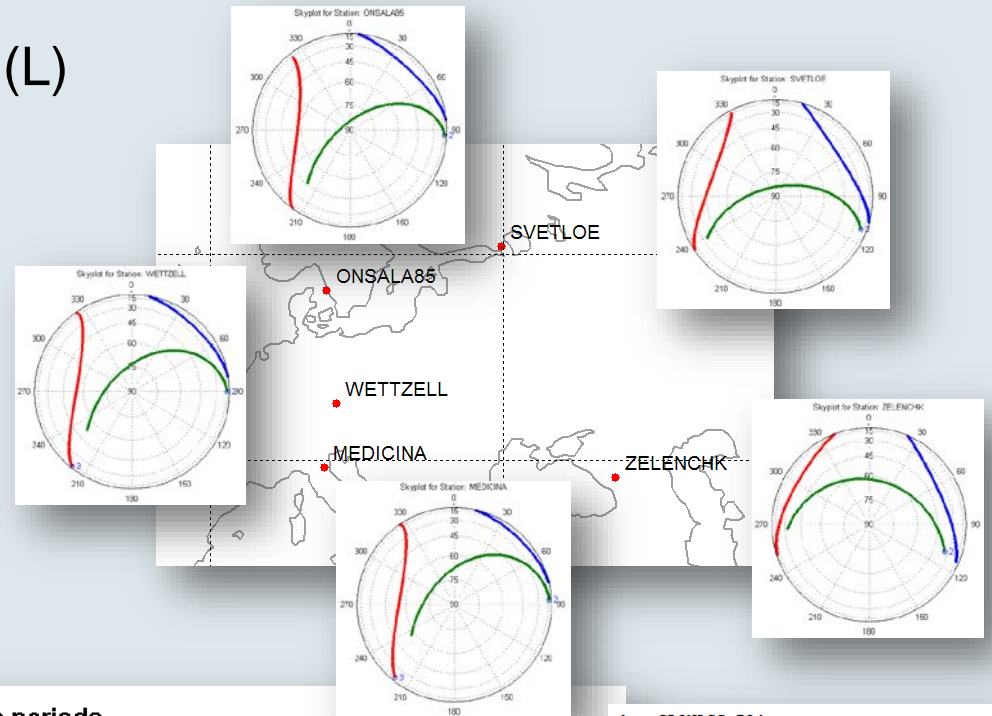
# Future plans (1)

- Improve the VieVS satellite scheduling module
  - Use the new schedule file format **VEX 2.0**
    - Provides dedicated functions for satellite tracking
  - Automated source selection
  - etc...
- **Simulations** of VLBI satellite observation sessions based on fully realistic observation schedules
  - Evaluate different scheduling strategies
  - *Cooperation:*
    - *Lucia?*
    - *Younghee?*

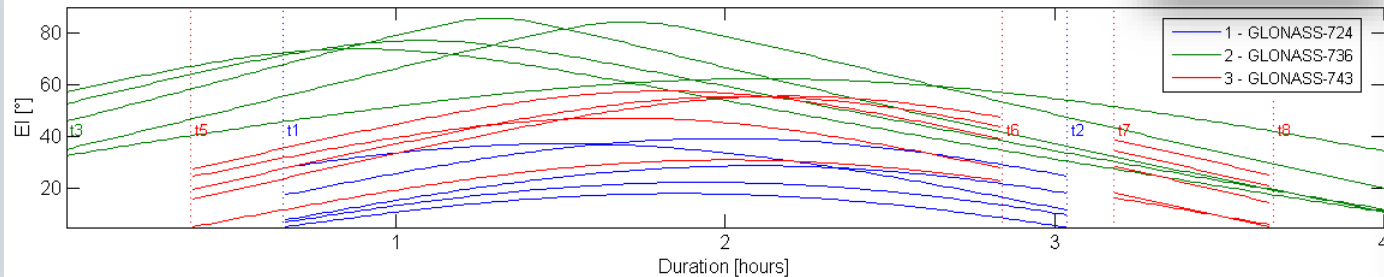
# Future plans (2)

- Carry out additional satellite VLBI experiments
  - More stations
  - Quasars (S/X) & satellites (L)

Possible observation scenario:  
 2014-04-01  
 12:00 – 16:00 UT  
 - ONSALA  
 - MEDICINA  
 - WETTZELL  
 - ZELENCHUKSKAYA  
 - SVETLOE  
 Glonass-724/736/743



Potential observation periods



1 - GLONASS-724	t1 - 2014	4	1	12:39:25.08 (start)
	t2 - 2014	4	1	15:02:06.72 (end)
2 - GLONASS-736	t3 - 2014	4	1	12:00:00.00 (start)
	t4 - 2014	4	1	15:59:60.00 (end)
3 - GLONASS-743	t5 - 2014	4	1	12:22:43.73 (start)
	t6 - 2014	4	1	14:50:24.66 (end)
	t7 - 2014	4	1	15:10:48.12 (start)
	t8 - 2014	4	1	15:39:46.39 (end)

# Questions?

**Contact:**

***andreas.hellerschmied@geo.tuwien.ac.at***

## References:

**AIPS (2014)**, Astronomical Image Processing System. <http://www.aips.nrao.edu/index.shtml>.

**Böhm et al. (2012)**, The New Vienna VLBI Software, Proceedings of the 2009 IAG Symposium, Buenos Aires, Argentina, 31 August 2009 - 4 September 2009, Series: International Association of Geodesy Symposia, Vol. 136, Kenyon S, Pacino MC, and Marti U (eds.), ISBN 978-3-642-20337-4, pp. 1007-1012.

**Deller A et al. (2007)**, DiFX: A Software Correlator for Very Long Baseline Interferometry using Multiprocessor Computing Environments. The Publications of the Astronomical Society Of the Pacific, 119, 318-336.

**Haas R et al. (2014)**, The Wettzell-Onsala G130128 Experiment – VLBI observations of a GLONASS satellite, 8th IVS General Meeting, Shanghai, March 2014.

**Hoots FR & Röhrich RL (1988)**, Spacetrack Report No. 3 – Models for Propagation of NORAD Elements Sets, Project Spacetrack Reports, Office of Astrodynamics, Aerospace Defense Center, Peterson.

**Kodet J et al. (2014)**, Co-locations of Space Geodetic Techniques on Ground and in Space, 8th IVS General Meeting, Shanghai.

**Plank L (2014)**, Precise station positions from VLBI observations to satellites: a simulation study, J Geod, 88: 659 – 673.

**Tornatore V et al. (2010a)**, Planning of an Experiment for VLBI Tracking of GNSS Satellites, IVS 2010 General Meeting Proceedings, p.70–74.

**Tornatore V et al. (2010b)**, Tracking of Glonass satellites by VLBI radio telescopes, 5th ESA International Workshop on Tracking, Telemetry and Command Systems for Space Applications, 21 – 23 September 2010.

**Tornatore V et al. (2014)**, Direct VLBI Observations of Global Navigation Satellite System Signals, International Association of Geodesy Symposia, Proc. IAG General Assembly, Melbourne - 2011, 139 pp. 247-252.

**Vandenberg N (1997)**, SKED's Catalogs – Program Reference Manual, NASA, GSFC.