



# ACROSS AUSTRALIA & AROUND THE WORLD IN MILLIMETRES

**Lucia Plank ▪ Jim Lovell ▪ Jamie McCallum**

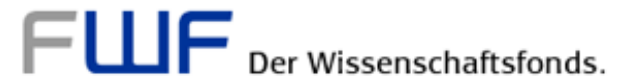
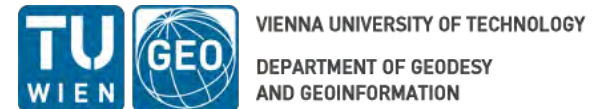
University of Tasmania, Australia

**David Mayer**

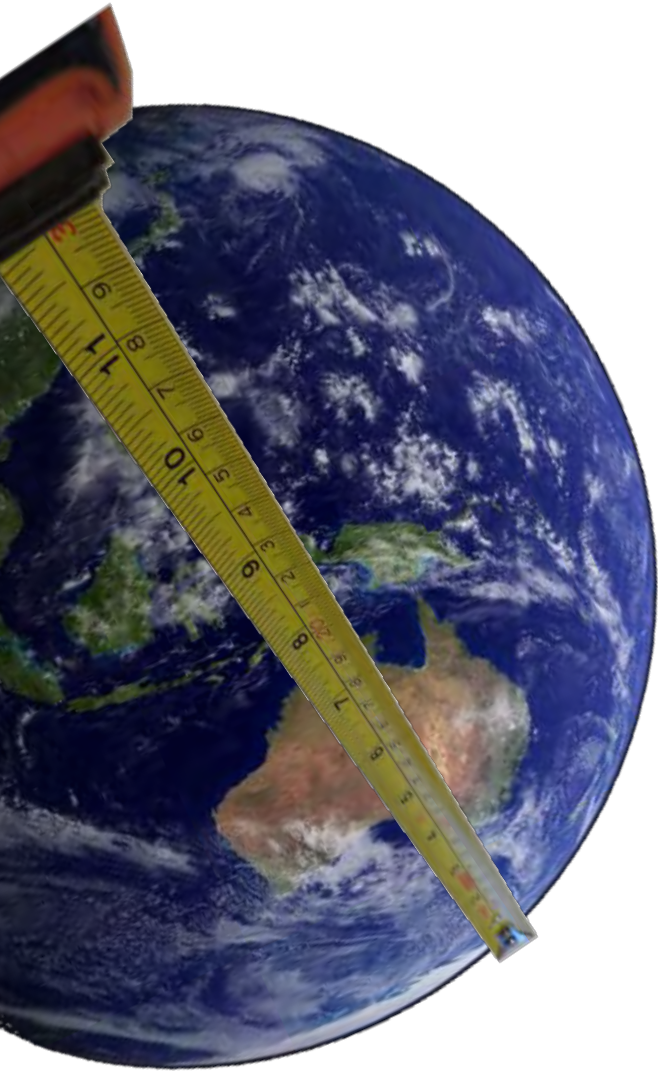
Technische Universität Wien, Austria

**Oleg Titov**

Geoscience Australia, Australia



*Schrödinger Fellowship J 3699-N29*



## Geodetic VLBI

*On the hunt for the millimetre...*

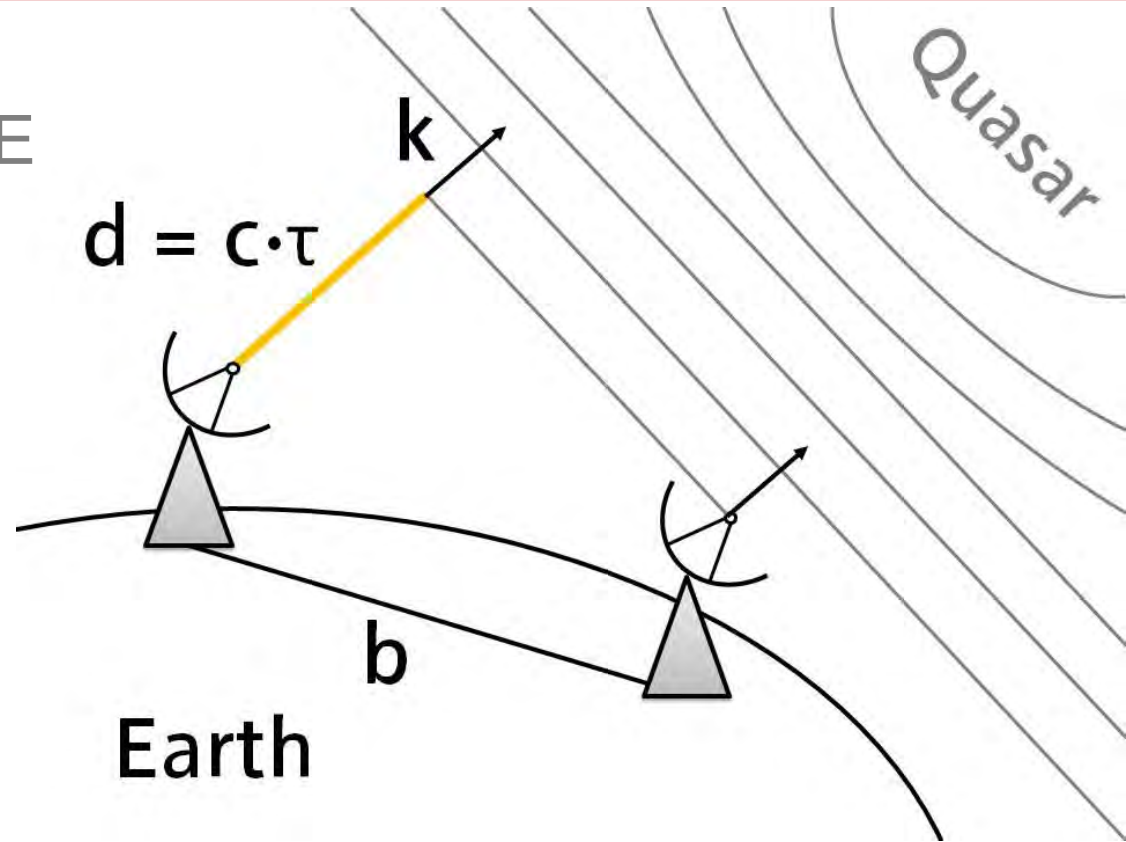
**observation  $\neq$  observation**

*... AuScope VLBI has taken a leading role ...*

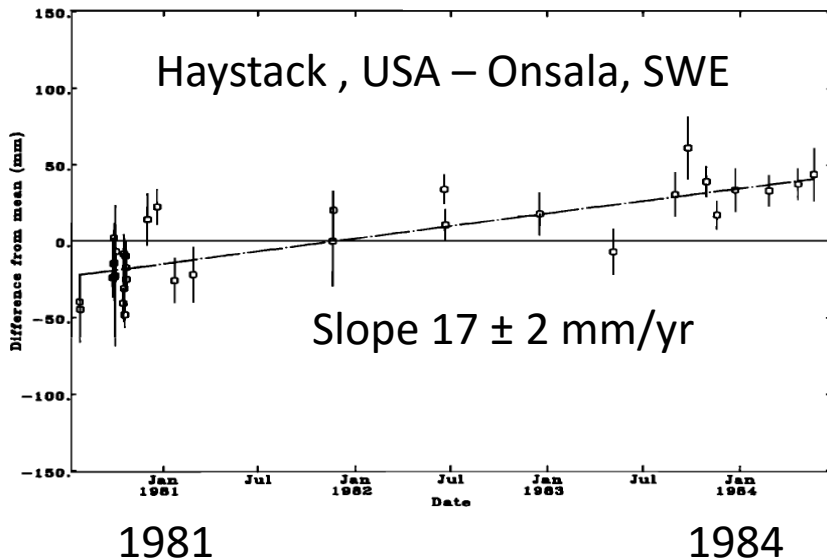
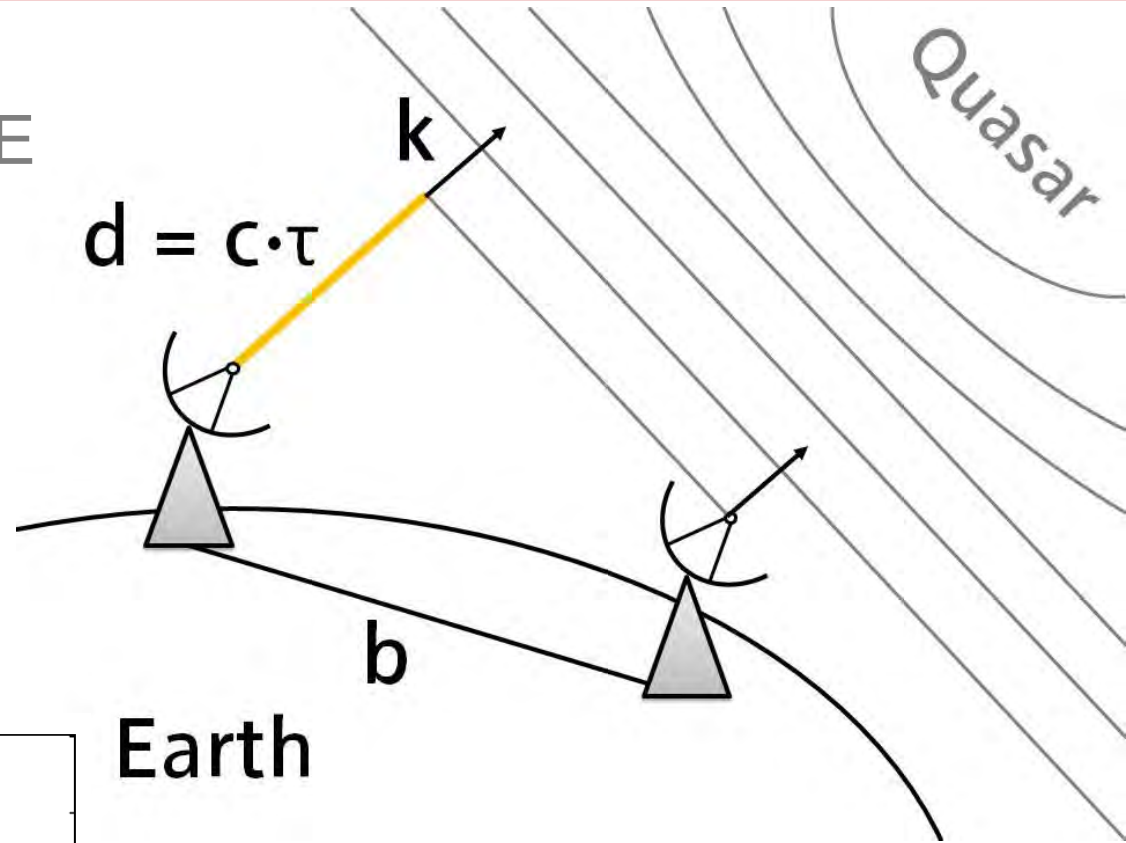
**Why this is important**

*... and enables exciting research and multiple applications.*

# VERY LONG BASELINE INTERFEROMETRY (VLBI)



# VERY LONG BASELINE INTERFEROMETRY (VLBI)



Earth

Herring et al., 1986:  
*“Evidence for Contemporary Plate Motion”*

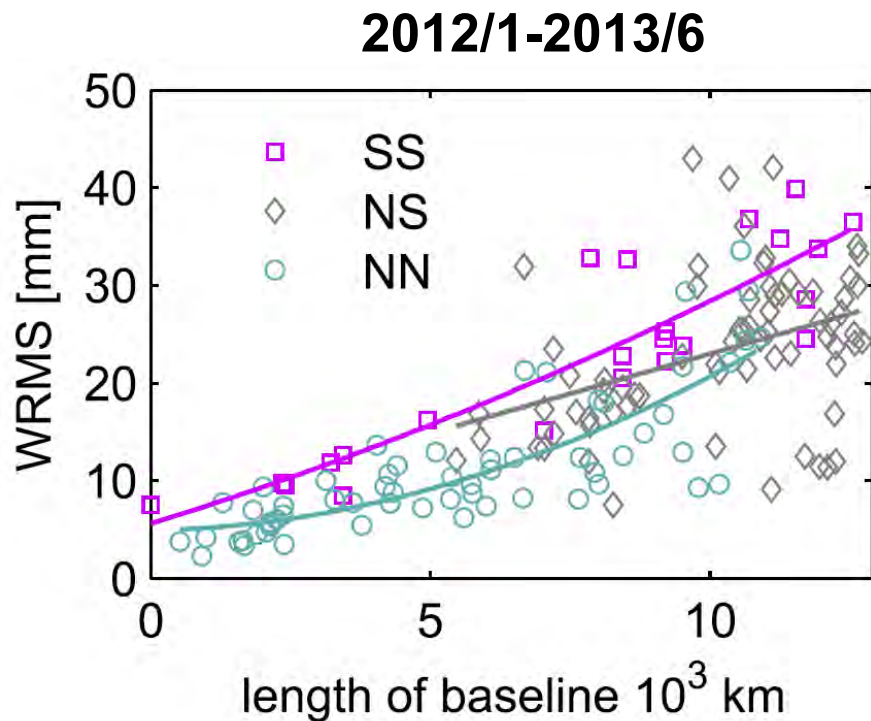
# AUSCOPE VLBI





# BETTER RESULTS IN THE SOUTH

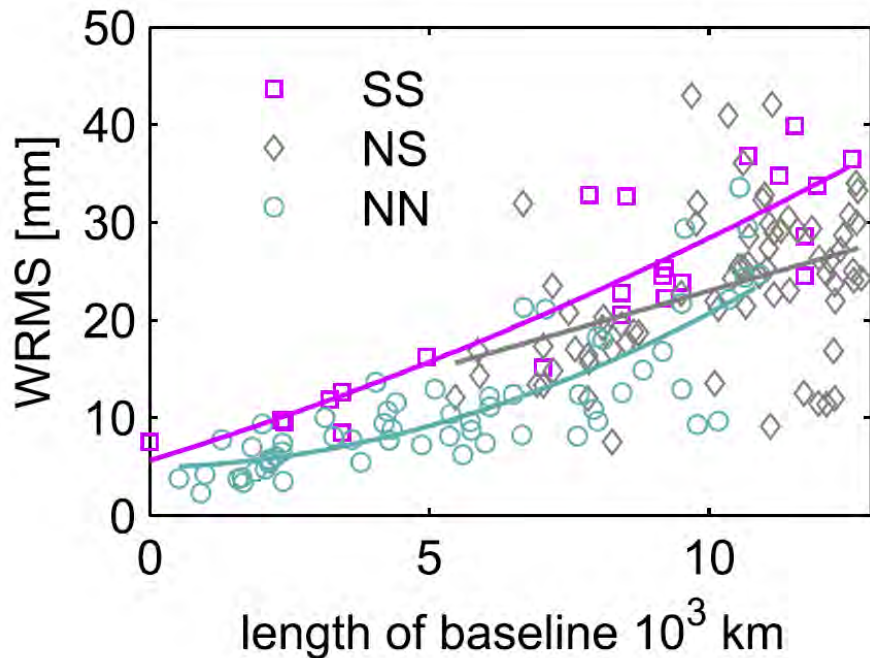
Baseline lengths from IVS R1 & R4 sessions [Plank et al., Adv Space Res 2015 ]



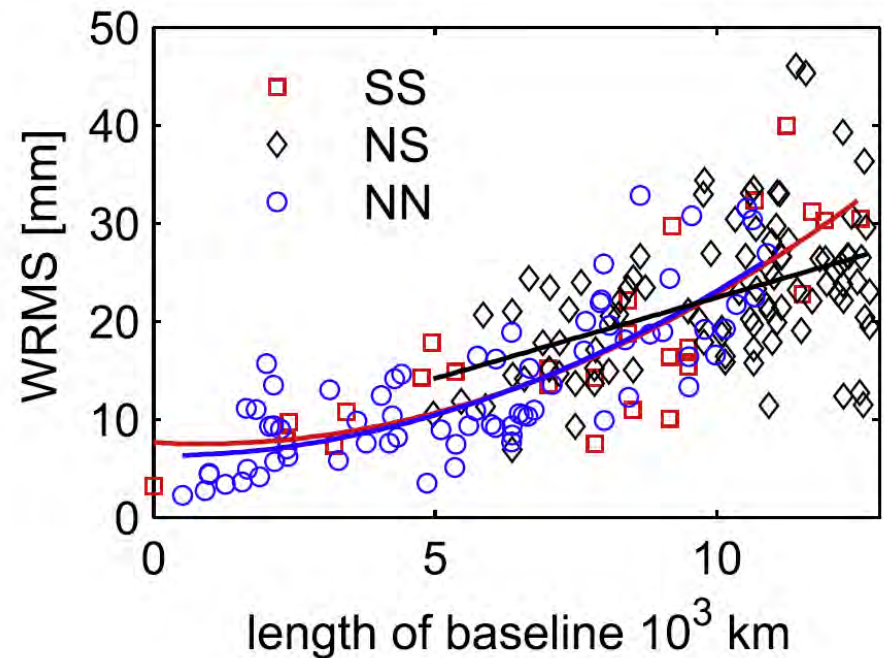
# BETTER RESULTS IN THE SOUTH

Baseline lengths from IVS R1 & R4 sessions [Plank et al., Adv Space Res 2015]

2012/1-2013/6



2013/7-2014/12



**The addition of more southern stations has significantly improved the results!**



- Independent high-cadence observing program to fully exploit the AuScope VLBI array (Lovell et al., 2013)
- All steps (planning, observing, data reduction, analysis) organised by UTAS
- In collaboration with South Africa & New Zealand



# SCHEDULING - THEORY

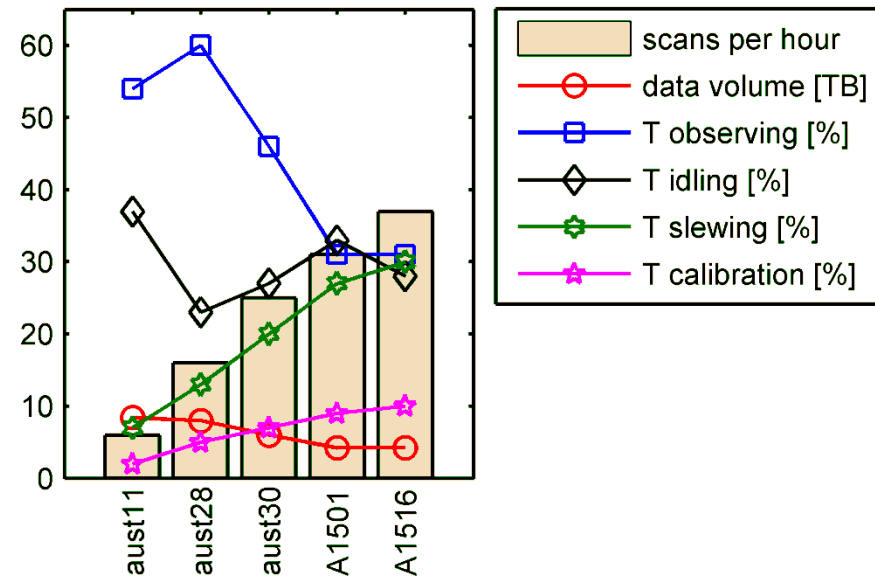
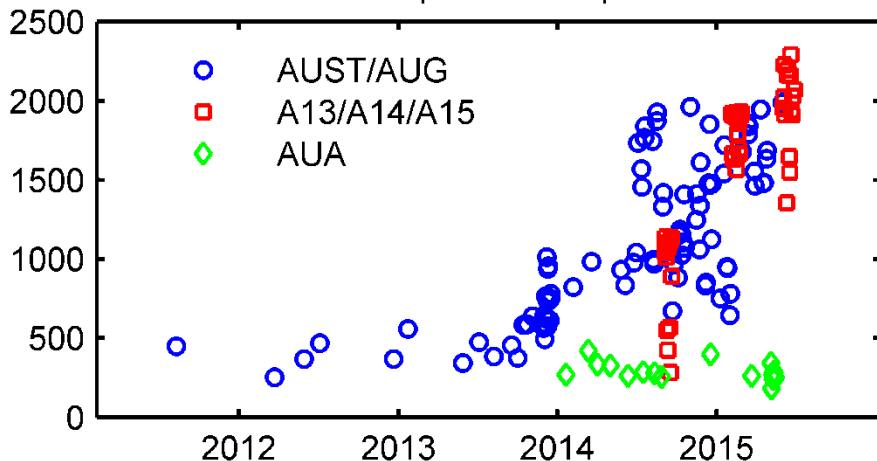
- Which **antennas**? Which **sources**? For **how long**?
- Scan length
  - < for large antennas
  - < for strong sources
  - < for higher bandwidth
- Slew times
  - < for small antennas
- Scheduling strategy
  - sky coverage
  - # of scans
  - special sources



# SCHEDULING IMPROVEMENTS

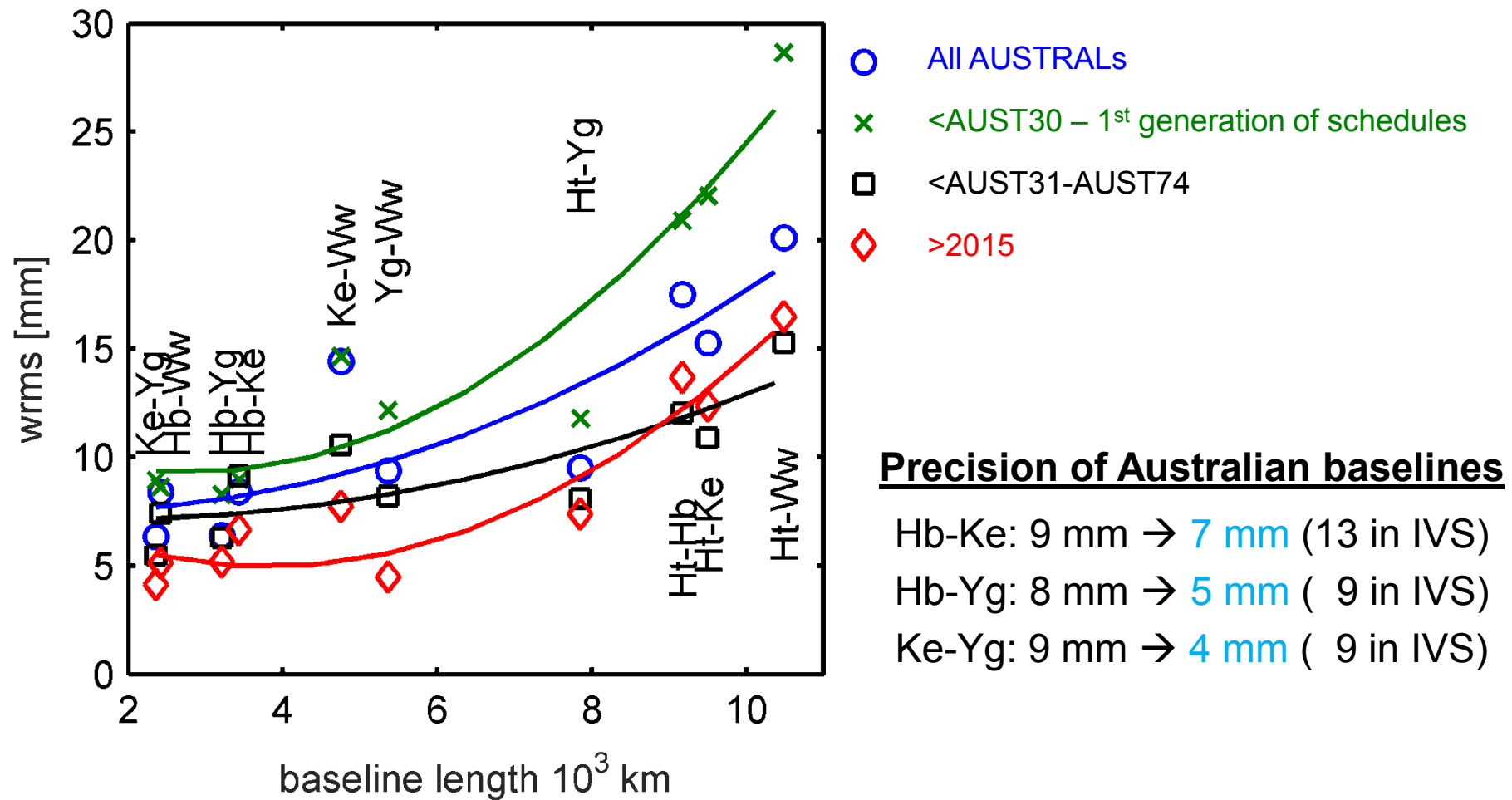
- Record more data in less time (1 Gbps)
- „sweet spot“ of source strength at 0.8 Jy (simulations)
- improve scheduling algorithm (optimisation problem)

observations per session per station

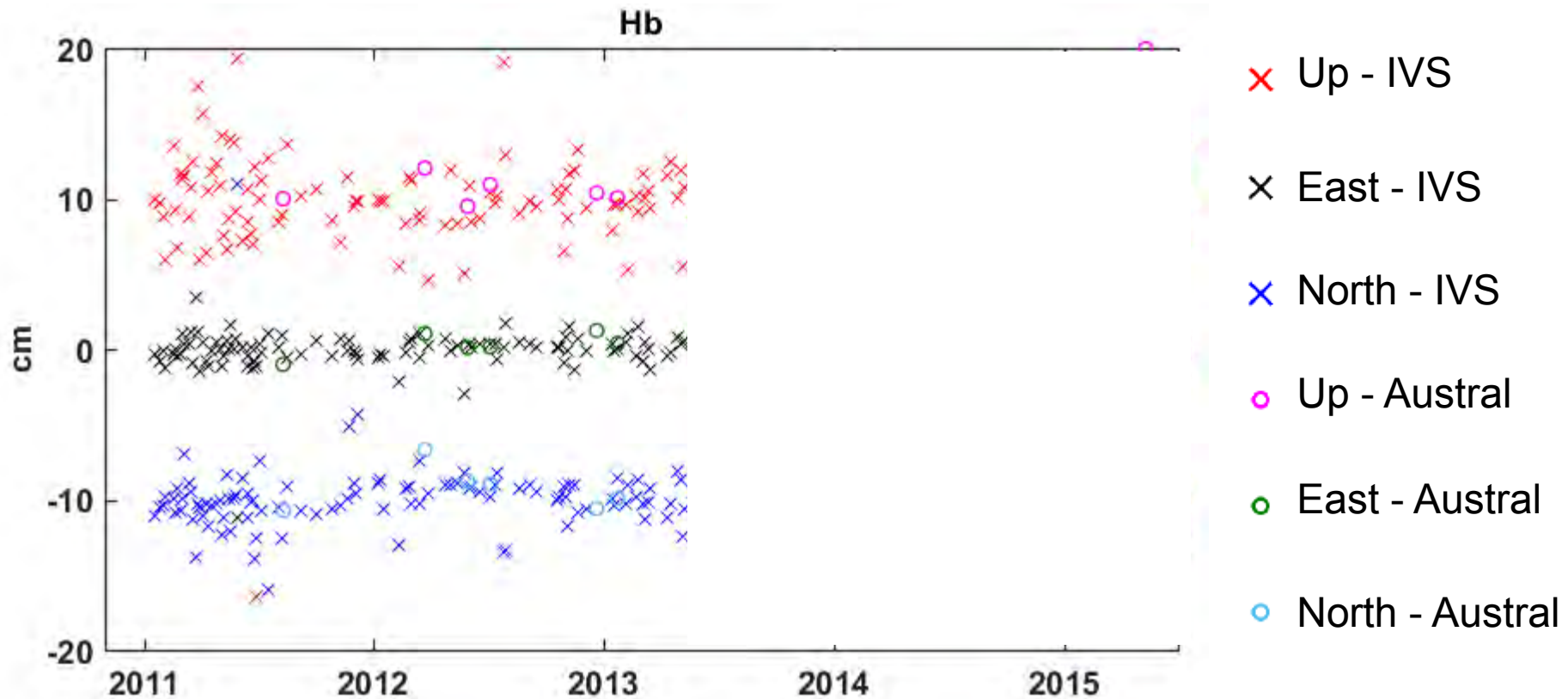


- From ~10 to ~40 scans per hour
- From 500 to >2000 observations per station per day
- Decrease data volume from 8 to 4 TB/day

# RESULTS

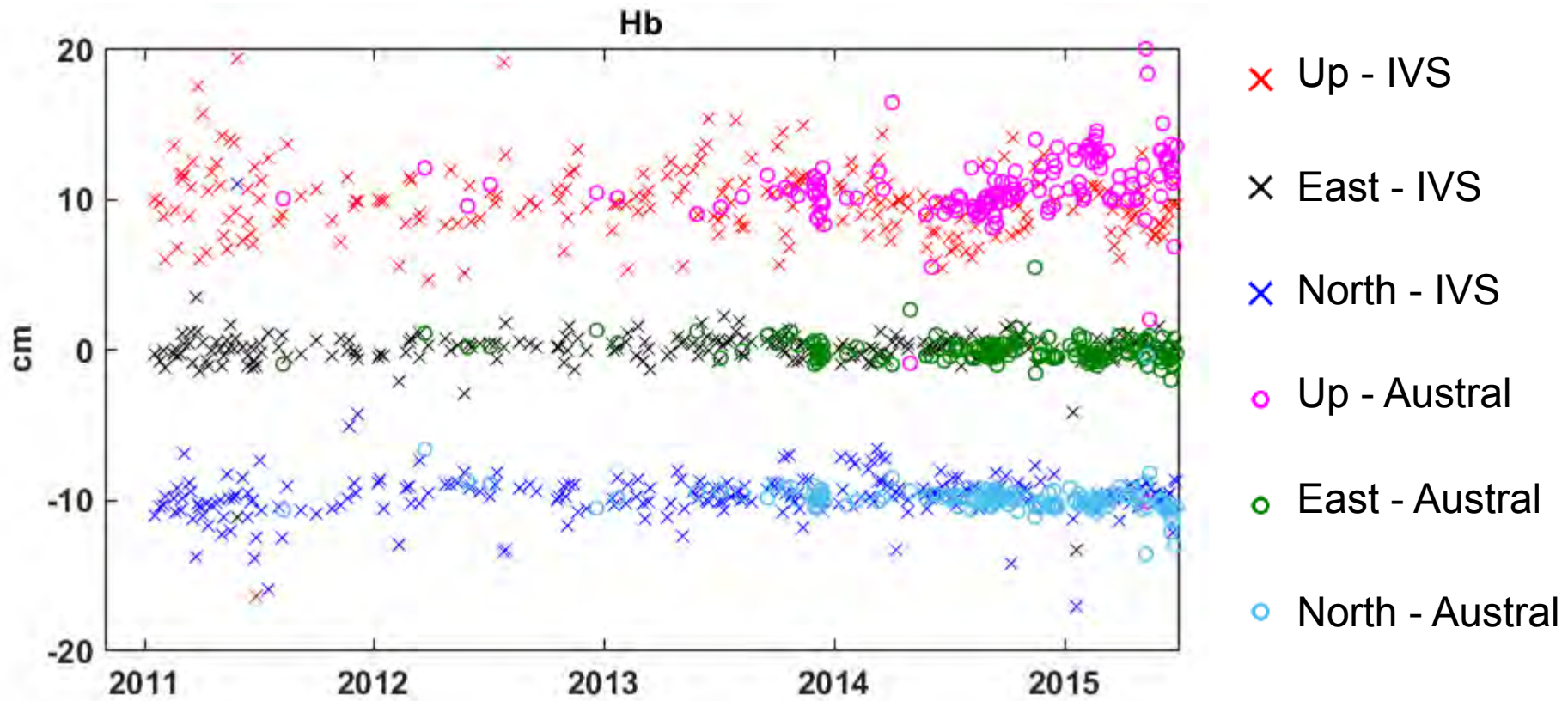


# HIGH CADENCE OBSERVING



- Residual estimates in Up, East and North w.r.t all known (modelled) station movements

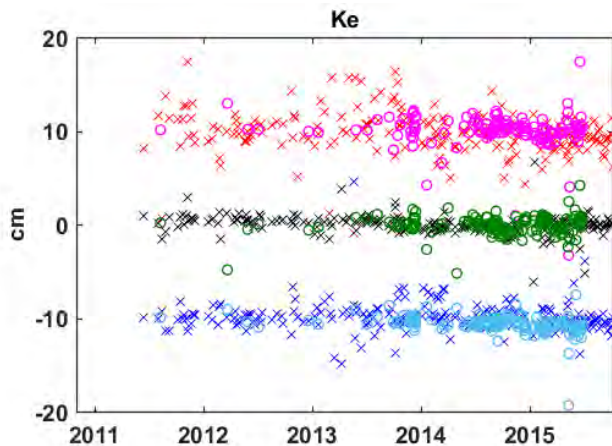
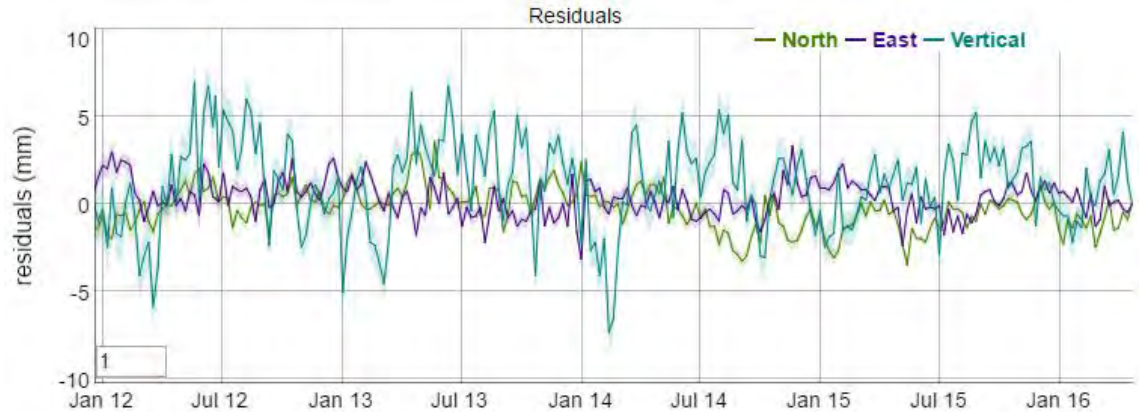
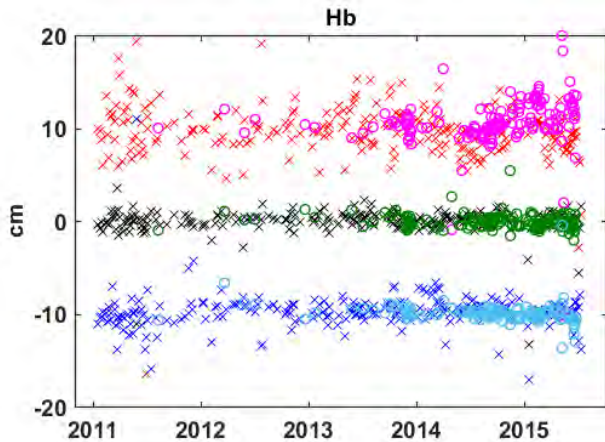
# HIGH CADENCE OBSERVING



- Residual estimates in Up, East and North w.r.t all known (modelled) station movements



# GEODETIC SIGNAL?



**VLBI**

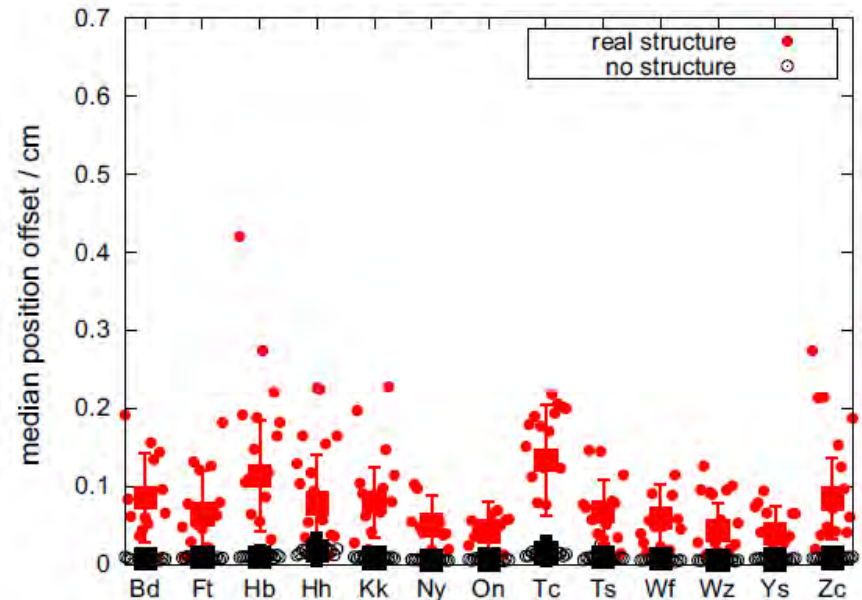
**GPS**

Source: igs.org

# GPS VS VLBI

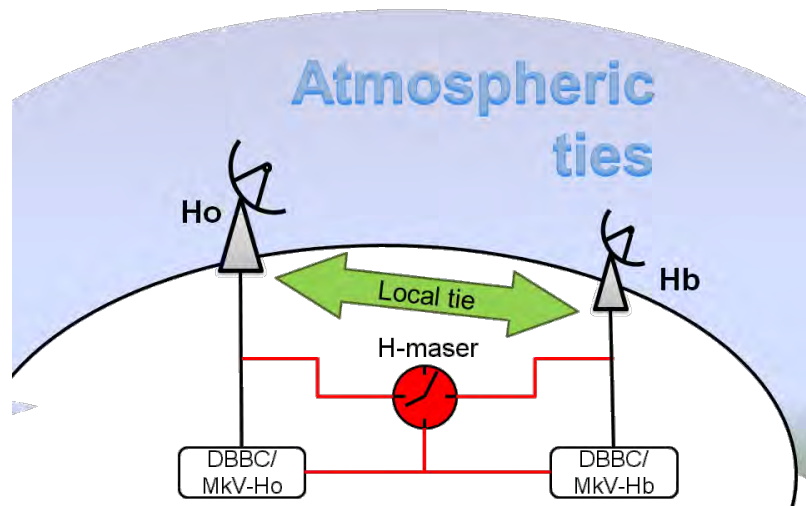
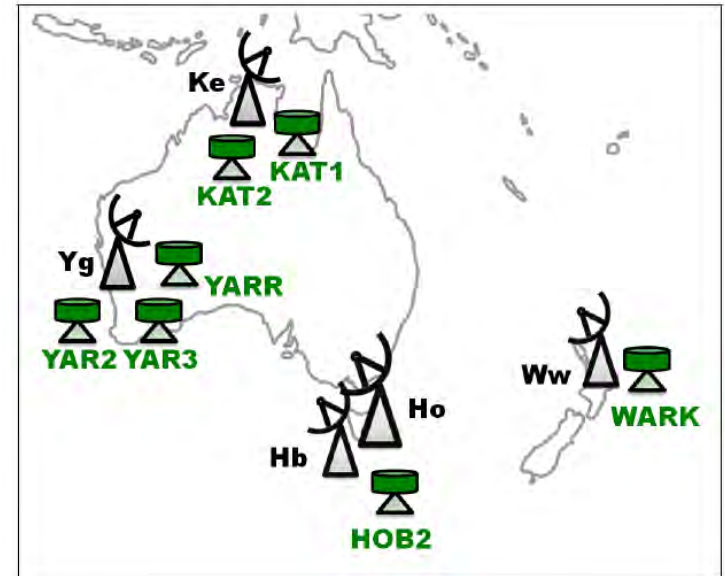
- Real signal (e.g. hydrology)
- Thermal expansion of monument / antenna
- Local deformation
- Technique specific errors (multipath, troposphere, orbit, technique systematics)
  - Source structure

Shabala et al., JoG, 2015:  
*“Source structure can cause systematic errors in station positions at the mm-level”*



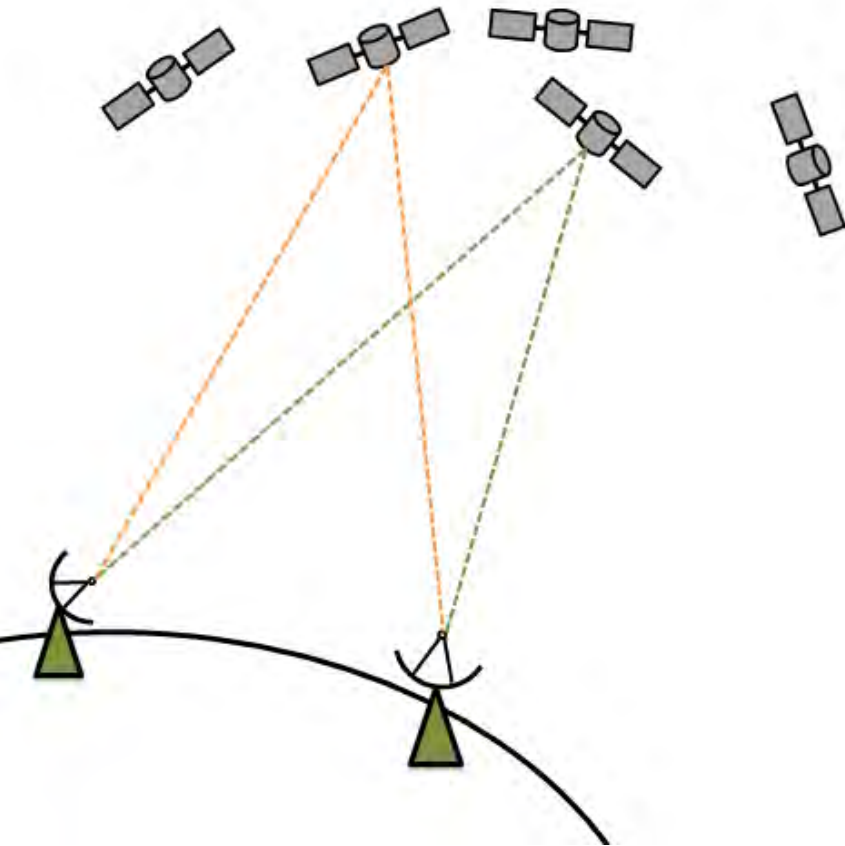
# LOCAL TIES

- AuScope has co-located VLBI and GPS antennas with local tie surveys provided by GA.

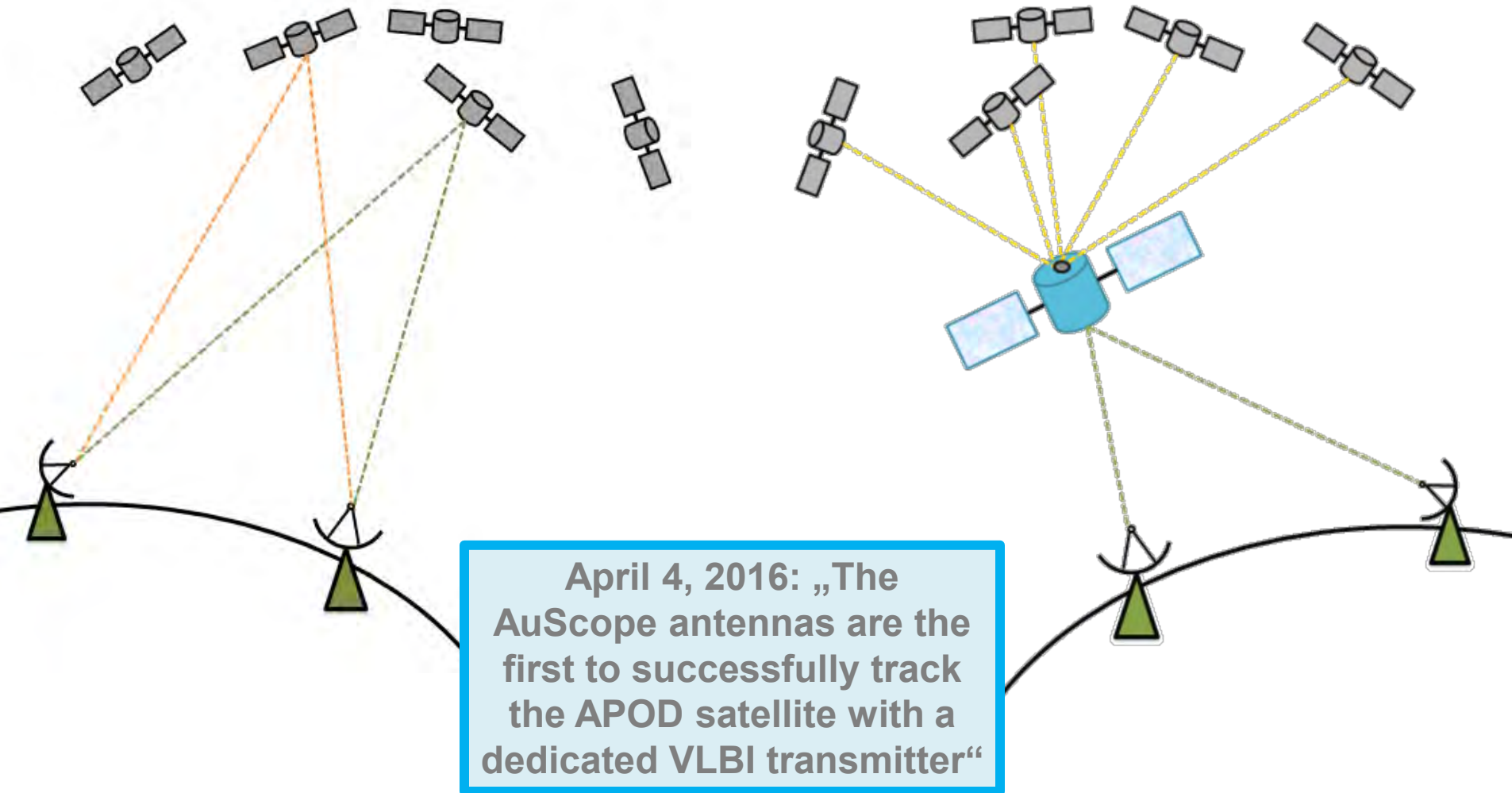


- Analysis of co-located VLBI
  - Real error estimate
  - Reveal station-specific errors

# VLBI SATELLITE TRACKING



# VLBI SATELLITE TRACKING





# SUMMARY

- **VLBI** is a space geodetic technique capable of measuring **precise station positions**, **Earth orientation** and defining a **celestial reference frame**.
  - **AuScope VLBI** has made a difference and is **leading the field** with measuring Australian baselines with ~5mm precision
  - Research on the observing strategy pays off!

# SUMMARY

- **VLBI** is a space geodetic technique capable of measuring **precise station positions**, **Earth orientation** and defining a **celestial reference frame**.
  - **AuScope VLBI** has made a difference and is **leading the field** with measuring Australian baselines with ~5mm precision
  - Research on the observing strategy pays off!
- Geodesy has reached mm-precision; in order to identify new geodetic signals (e.g. hydrology), **technique-specific systematics** need to be identified and understood.
  - There is ongoing research at UTAS to identify VLBI-specific errors
  - AuScope VLBI offers great opportunities for inter-technique combination through multiple **co-location** and **innovative approaches**