

# Atmospheric tides in variations of VLBI station positions

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24 April 2017

# Atmospheric tides in variations of VLBI station positions

1. Introduction
2. Overview of tidal loadings
3. Very Long Baseline Interferometry (VLBI) analysis
4. Results

# Atmospheric tides in variations of VLBI station positions

Atmospheric  
tides

▶ Atmospheric tides:

- diurnal  $S_1$  and semidiurnal  $S_2$  Sun-locked tides have periods of 24 h and 12 h

▶ VLBI analysis:

- utilizes atmospheric tides in reductions; namely, station coordinates undergo small but regular deformations;

⇒ retrieve atmospheric tides

- Petrov & Ma, 2003, "Study of harmonic site position variations determined by very long baseline interferometry";
- $S_1$  and  $S_2$  in variations of station positions ?  $\Leftrightarrow$  ? Earth rotation

Introduction

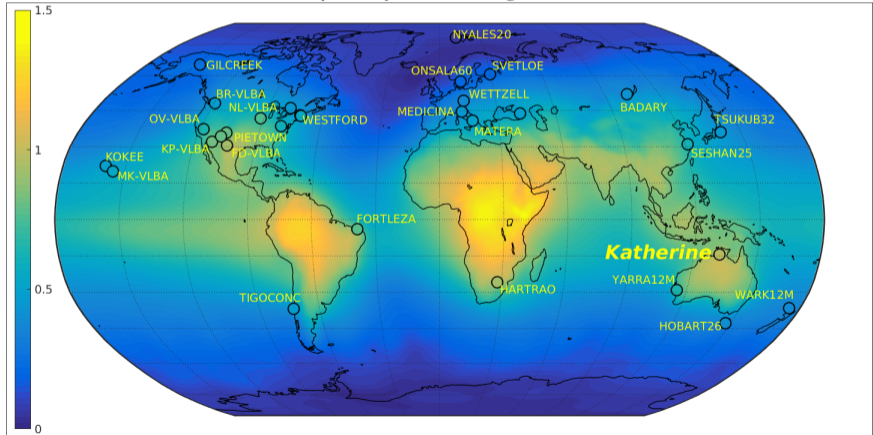
Overview of tidal loadings

VLBI analysis

Results

# Station position reductions for tidal loadings

- ▶ Atmospheric tidal loading (ATL): TU Wien:  $S_1$  &  $S_2$  tidal corrections
  - $S_1$  Radial component, mm:
    - maximum for the frequently observing site: Katherine (Australia)  $\approx 1.0$  mm



Atmospheric tides

Introduction

Overview of tidal loadings

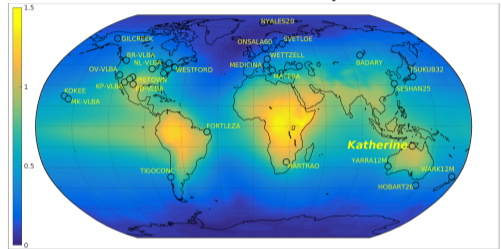
VLBI analysis

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# Station position reductions for tidal loadings

▶ Atmospheric tidal loading (ATL): TU Wien:  $S_1$  Radial component, mm

- $S_1$  and  $S_2$  tidal corrections to the station positions maximum for the frequently observing site:  
Katherine (Australia)  $\approx 1.0$  mm

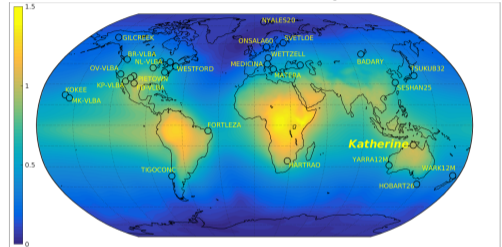


▶ Ocean tidal loading: Finite Element Solution: FES2004 & FES2012 ( $S_1$ )

- Long term tides:  $M_f$ ,  $M_m$ ,  $S_{sa}$ ;
- Major tides:  $Q_1$ ,  $O_1$ ,  $P_1$ ,  $K_1$ ,  $N_2$ ,  $M_2$ ,  $S_2$ ,  $K_2$

► Atmospheric tidal loading (ATL): TU Wien:  $S_1$  Radial component, mm

- $S_1$  and  $S_2$  tidal corrections to the station positions maximum for the frequently observing site:  
Katherine (Australia)  $\approx 1.0$  mm



► Ocean tidal loading: Finite Element Solution: FES2004 & FES2012 ( $S_1$ )

- max  $S_2$ : Fortaleza (South America)  $\approx 1.1$  cm;
- max  $S_1$ : Katherine (Australia)  $\approx 0.4$  mm

# Tidal loading analysis in VLBI

- ▶ ATL maximum is achieved for Katherine (Australia);
  - Observations in period of Jun, 2011 till Feb, 2016 ( 365 000 single observations);
- ▶ In contrast: ATL impact on Westford (North America) is considered as minimal

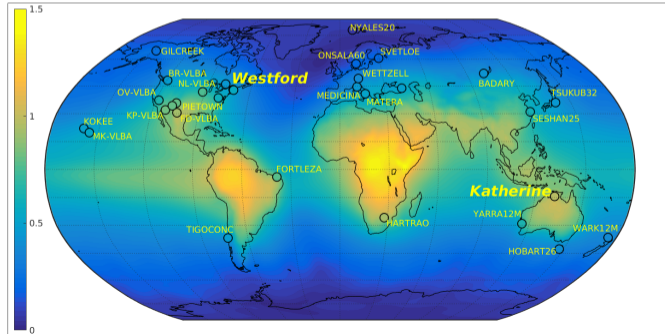
Atmospheric tides

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- ▶ ATL maximum is achieved for Katherine (Australia);
  - Observations in period of Jun, 2011 till Feb, 2016  
( 365 000 single observations);
  - at least 5 stations per session:  $\approx 23 \%$ , 6 and more stations: 77 %
  
- ▶ In contrast: ATL impact on Westford (North America)  
is considered as minimal
  - Observations in period of Jan, 1995 till Sep, 2014  
( 930 000 single observations);
  - at least 5 stations per session:  $\approx 15 \%$ , 6 and more stations: 84 %

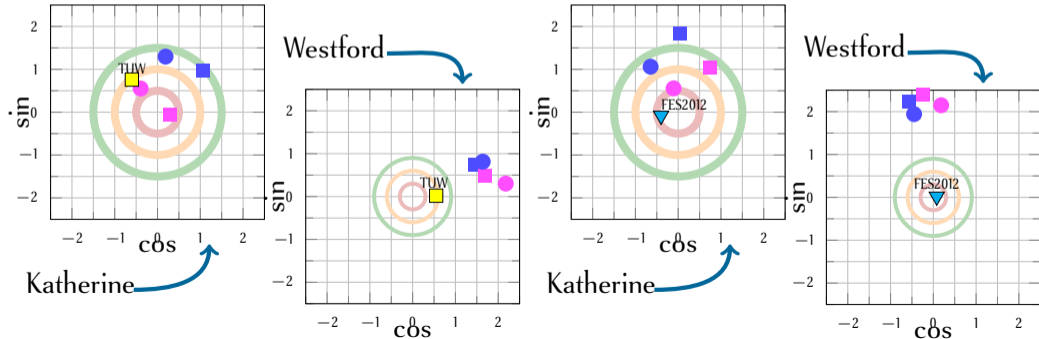


# VLBI analysis: single session solution

the station of interest (Katherine or Westford) is excluded from the datum and the station coordinates are estimated hourly **1 h**

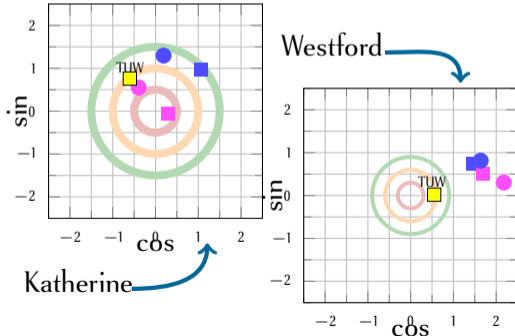
- ▶ stochastic parameters:
  - hourly clock polynomials: 1 h,
  - tropospheric parameters:  
zenith wet delay: 1 h  $\Rightarrow$  **6 h**,  
North & East gradients: 6 h,
- ▶ EOP, source and station coordinates per session (except Katherine or Westford)
- ▶ Standard approach using Vienna Mapping Function,
- ▶ Ray-tracing (RT),
- ▶ Reducing correlations by fixing gradients

- - RT gradients estimated;    ● - Standard gradients estimated;    ○ (red) -  $1\sigma$ ;    ○ (orange) -  $2\sigma$ ;
  - (pink) - RT gradients fixed;    ● (pink) - Standard gradients fixed;    ○ (green) -  $3\sigma$ ;
- Atmospheric tidal loading:                      Ocean tidal loading:  
 $S_1$  Radial, mm                                       $S_1$  radial, mm



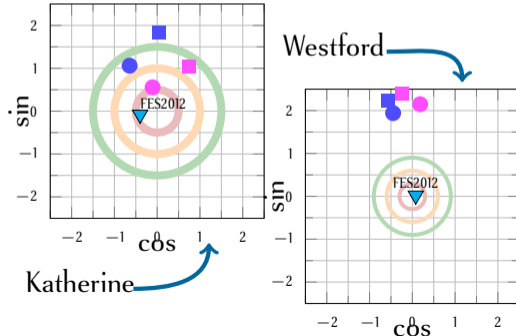
- ▶ Amplitudes  $>$  by factor  $\approx 2$
- ▶  $S_1 > S_2$

Atmospheric tidal loading:  
 $S_1$  Radial, mm



- ▶ ocean tides estimates  $\approx$  modeled
- ▶ A better agreement with FES2012

Ocean tidal loading:  
 $S_1$  radial, mm



- ▶ We derived empirical tidal loading model ( $S_1$ ,  $S_2$ ) from VLBI observations for selected sites (Katherine, Westford);
- ▶ We find significant differences between VLBI observations and geophysical models. The origin is not quite clear;
- ▶ We find a better agreement of the major ocean tides (not shown);
- ▶ VLBI global solutions yield similar results.

Thank you for your attention!

References:

VLBI data: [ivscc.gsfc.nasa.gov](http://ivscc.gsfc.nasa.gov)

The recommended VLBI reductions are described by IERS Conventions [iers.org](http://iers.org)

FES2012 station corrections: International Mass Loading Service [massloading.net](http://massloading.net)

Hydrology loading: EOST Loading Service [loading.u-strasbg.fr](http://loading.u-strasbg.fr)



[viewswiki.geo.tuwien.ac.at](http://viewswiki.geo.tuwien.ac.at)

This study is supported by the Austrian Science Fund  
under project ASPIRE (I1479).