



**Australian Government**

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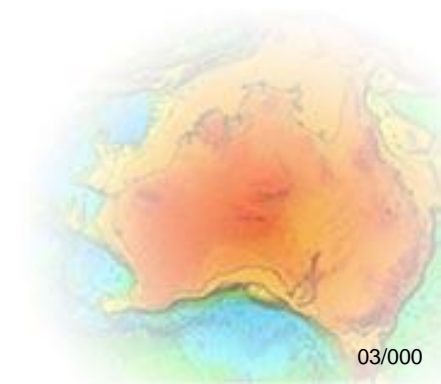
**Geoscience Australia**

***VLBI 2010: from vision to reality***

***VLBI 2020: from reality to vision***

**General IVS Meeting, Hobart**

**8 February 2010**



**A good progress in technology  
development and improvement of  
data for last 10 years**



**This opens new opportunities in  
science, particularly, in further  
analysis of stability of the reference  
frame**



**ICRF1 → ICRF2**

**1995 → 2009**

**formal error 60  $\mu\text{as}$  → 7  $\mu\text{as}$**

**inflated error 250  $\mu\text{as}$  → 41  $\mu\text{as}$**



**If there are systematic errors in the ICRF, the EOP and ITRF would be fine.**

**Otherwise, the EOP and ITRF will be affected in some way.**



**It is essential to check out all priori assumptions and definitions.**

**(Sovers and Walter, 2000)**

**Some of the are based on the state-of-art referred to the ICRF1 epoch (1995)**



# Assumption

**“The reference radio sources have no measurable proper motion”**



**ICRF1 → ICRF2**

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**formal error 60  $\mu\text{as}$  → 7  $\mu\text{as}$**

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# Assumption

**“The reference radio sources have no measurable proper motion  
[*at the level of precision achieved by 1995*]”**



**Apparent proper motions look random**

**Search for systematic has been done  
(Gwinn, Eubanks et al. 1997;  
MacMillan 2005)**

**Motivation – detection of the secular  
aberration drift effect –  $4 \mu\text{as}/\text{year}$   
(many authors)**



# Five reasons why the assumption might be not valid in 2010

**1. Secular aberration drift (acceleration of the Solar system barycentre)** (*Bastian, 1995; Sovers et al., 1998*)

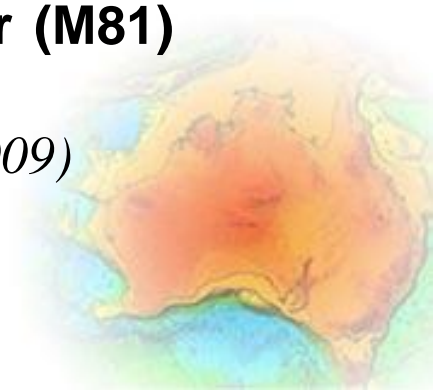
**2. Anisotropy of the Hubble constant** (*Kristian and Sachs, 1966*)

**3. Primordial GW** (*Kristian and Sachs, 1966; Pyne et al., 1996*)

**4. Instantaneous velocity of the Solar System with respect CMB**

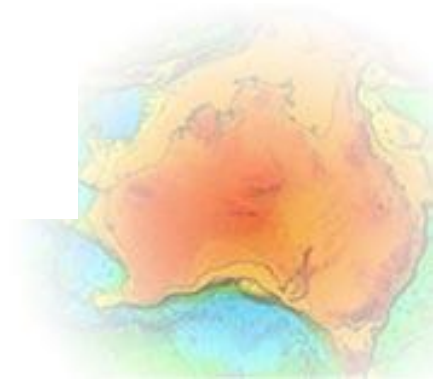
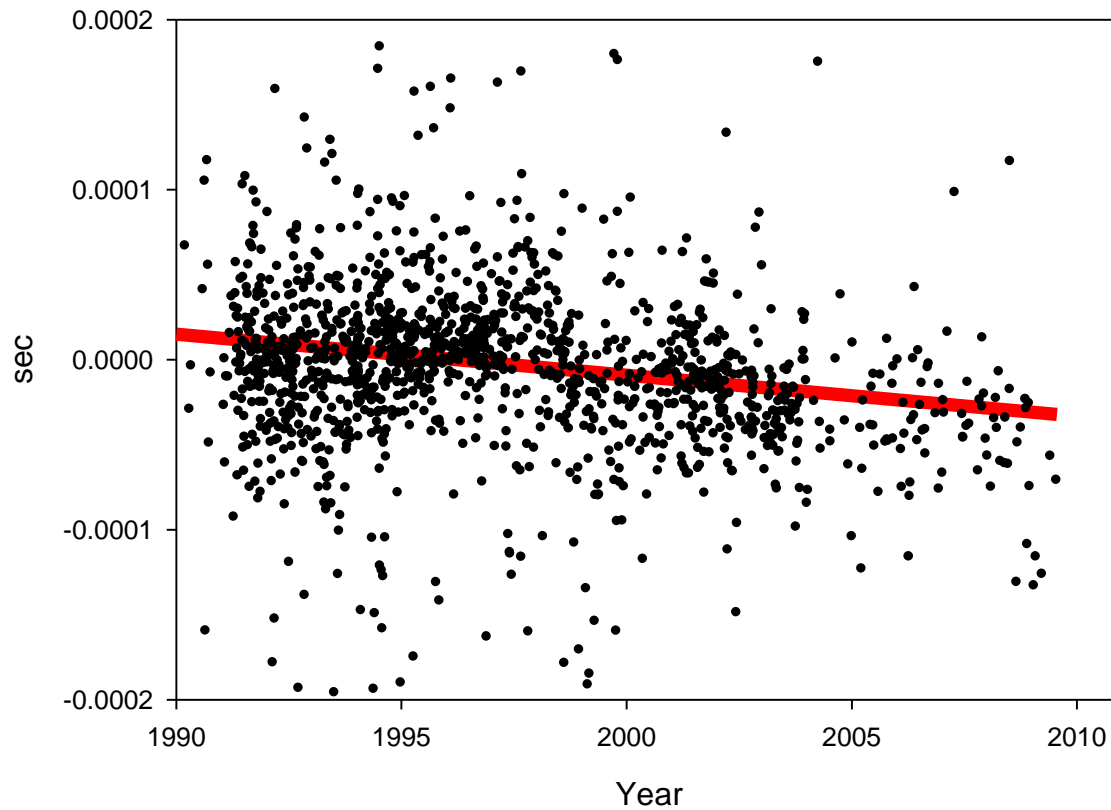
*Kardashev (1986), Sovers et al (1998)* **up to 14  $\mu\text{as}/\text{year}$  (M81)**

**5. Cosmologic effect on the time scale;** *Kopeikin (2009)*

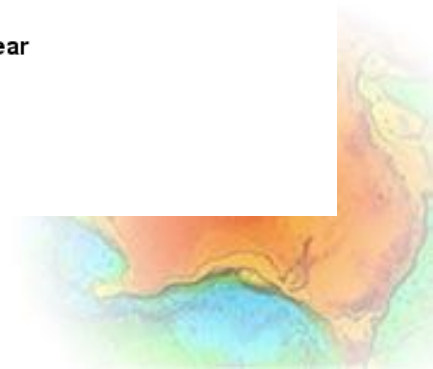
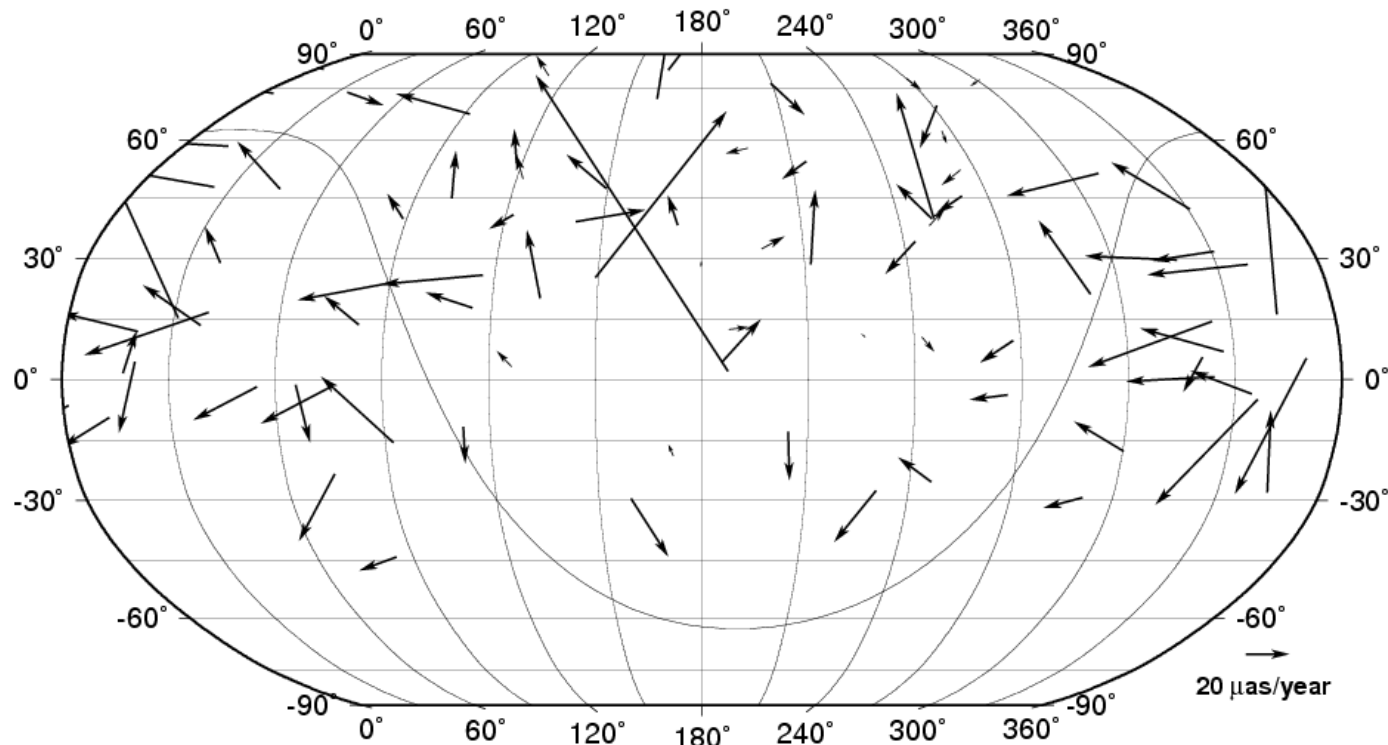


# 2145+067

RA, 2145+067

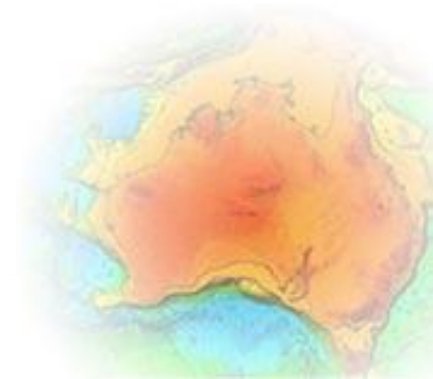
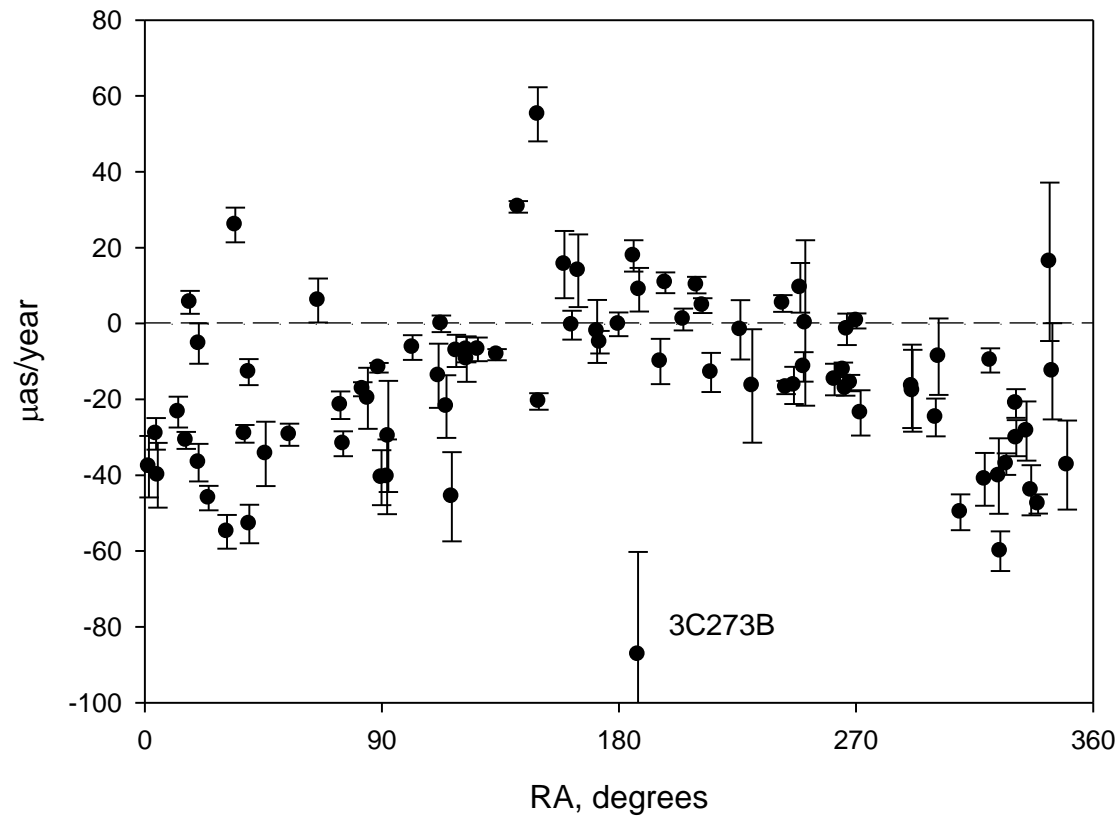


# Apparent proper motion (86 sources; $\geq 200$ sess, $\geq 15$ obs)



# Systematic effects in apparent motion

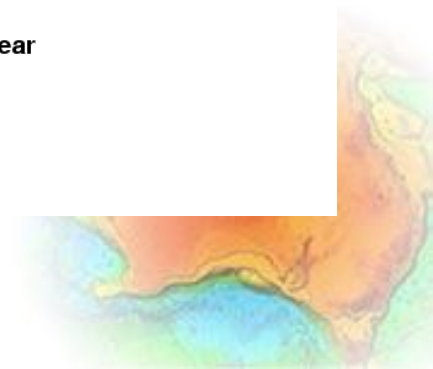
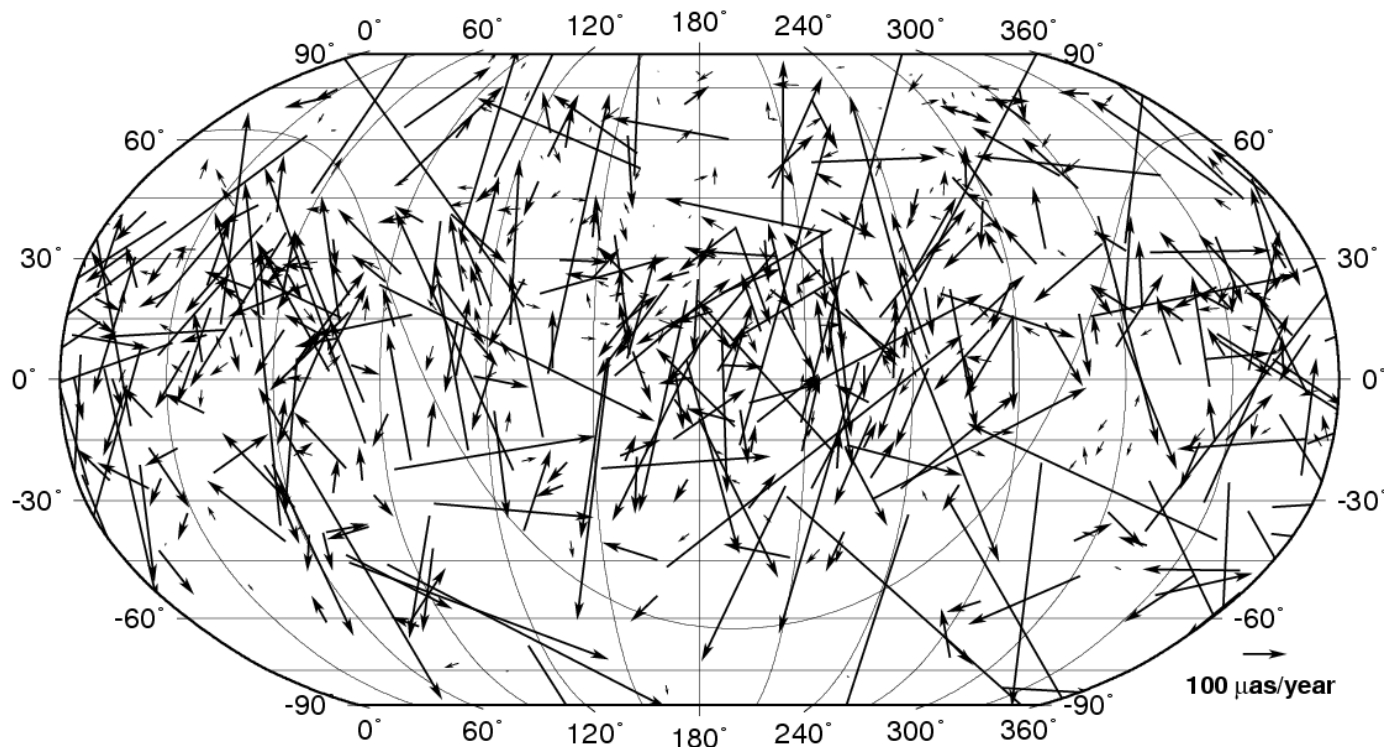
$\mu_\alpha \cos\delta$  for 86 the most observed radio sources  
from VLBI data (1984-2009)



**This is not effect of intrinsic structure !**

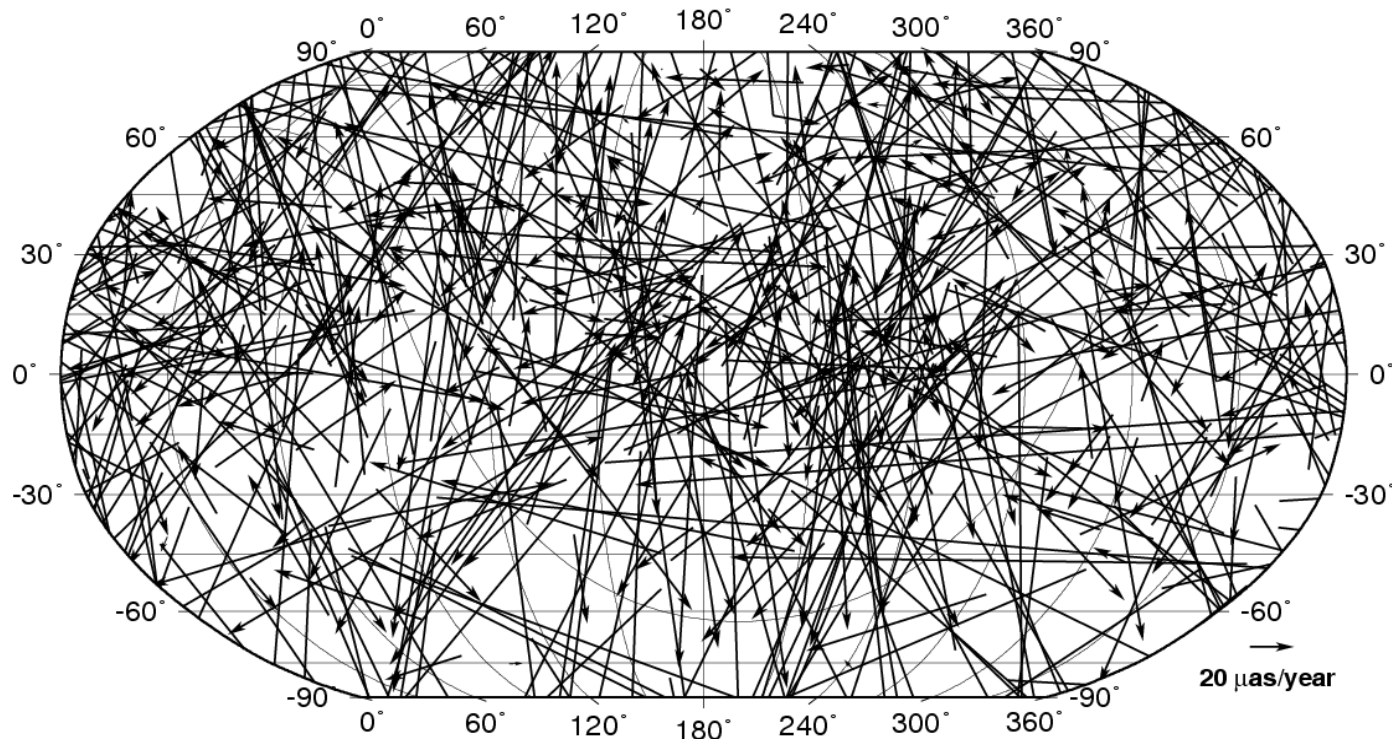


# Systematic effects in apparent motion (645 radio sources)

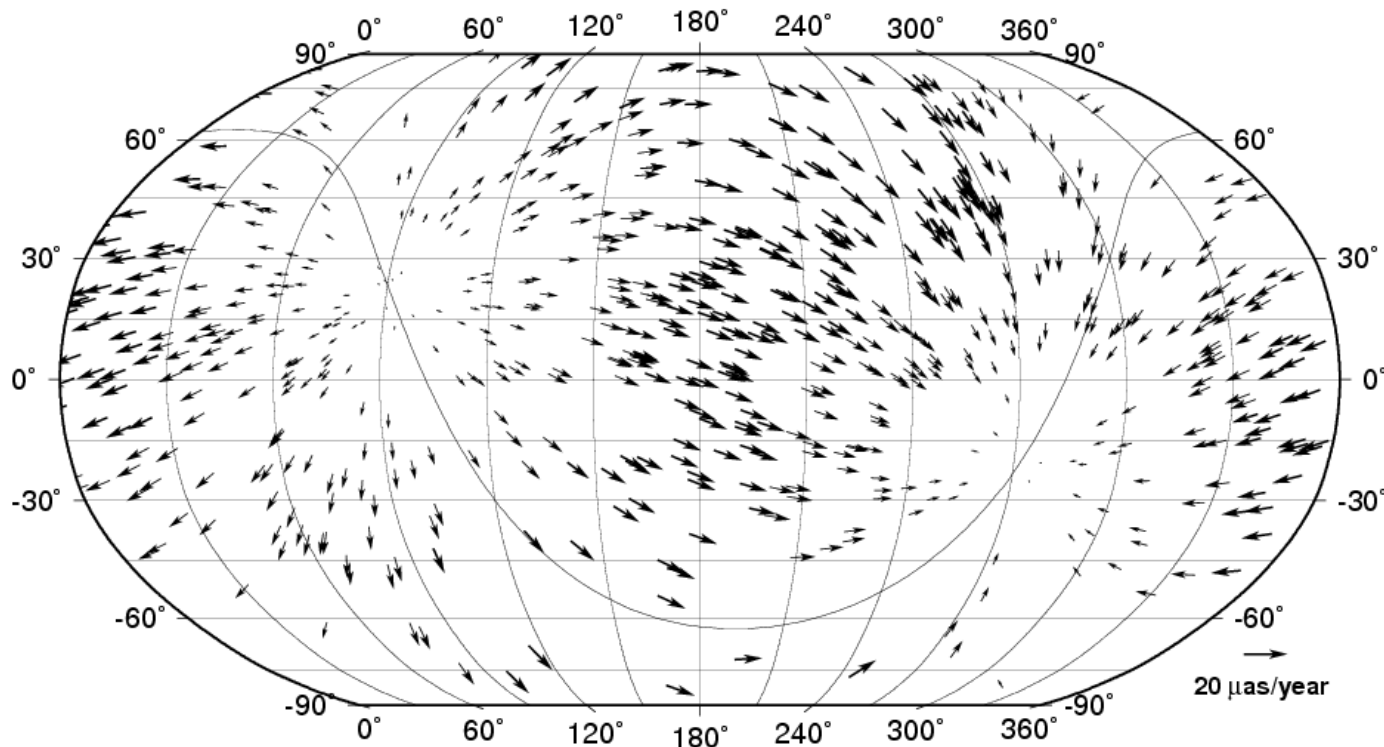




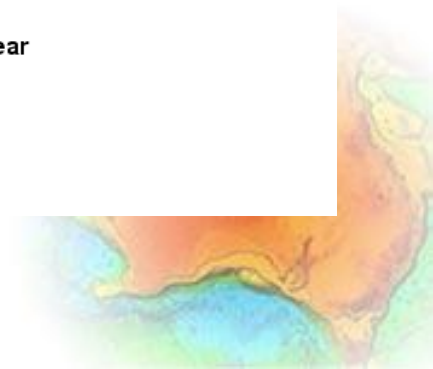
# Apparent proper motion (raw data, 645 sources; $\geq 3$ sess, $\geq 3$ obs)



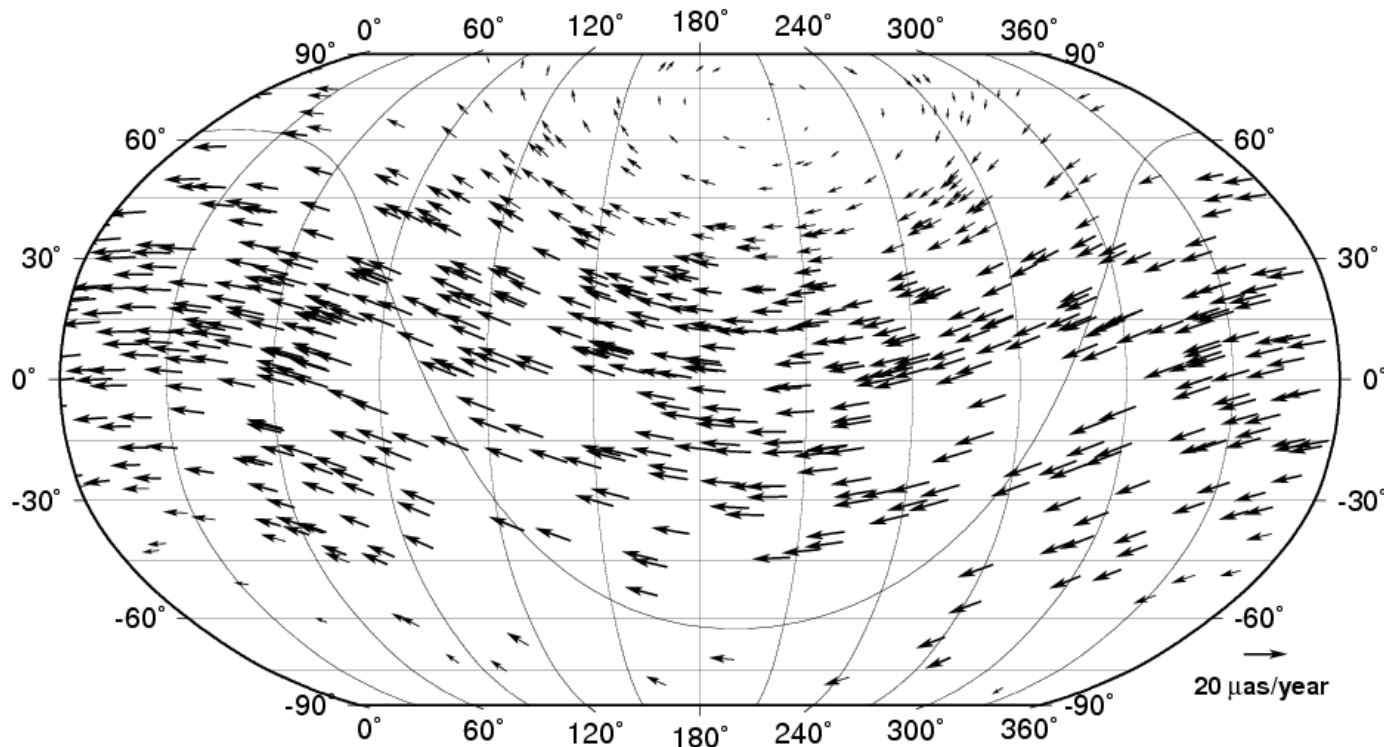
# Systematic effects in apparent motion (dipole)



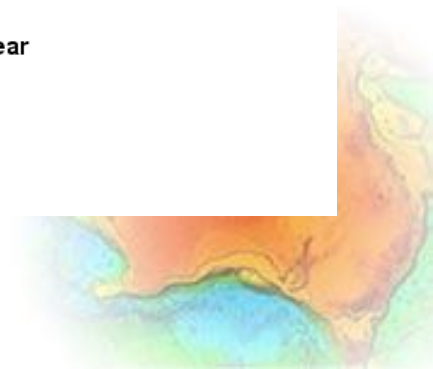
**$13.5(+/- 1) \mu\text{as}/\text{year}$**



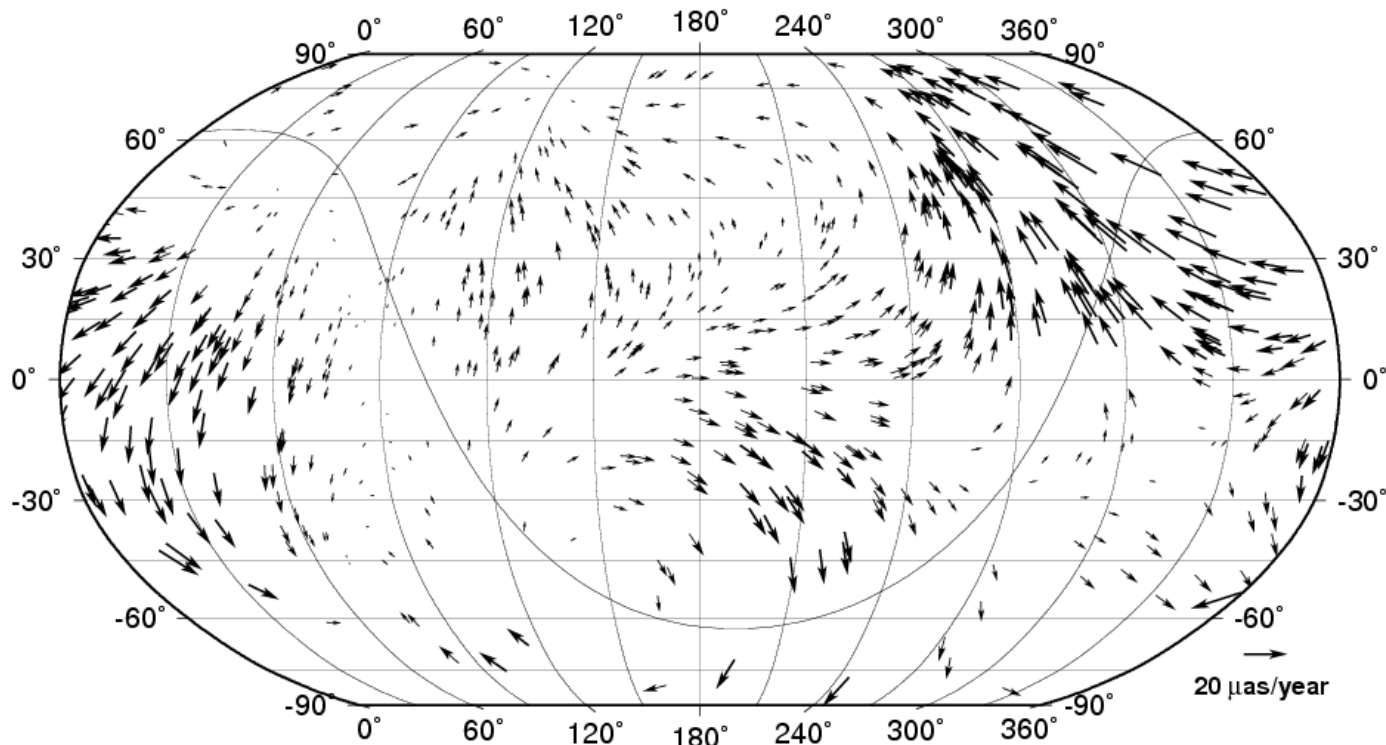
# Systematic effects in apparent motion (rotation)



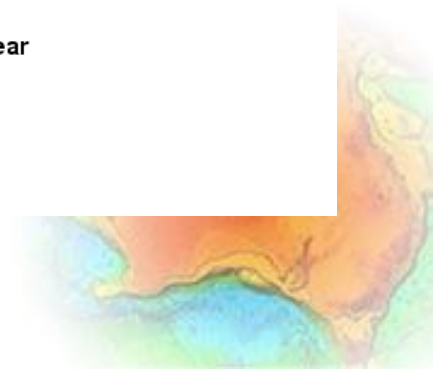
**20 (+/- 1)  $\mu\text{as}/\text{year}$**



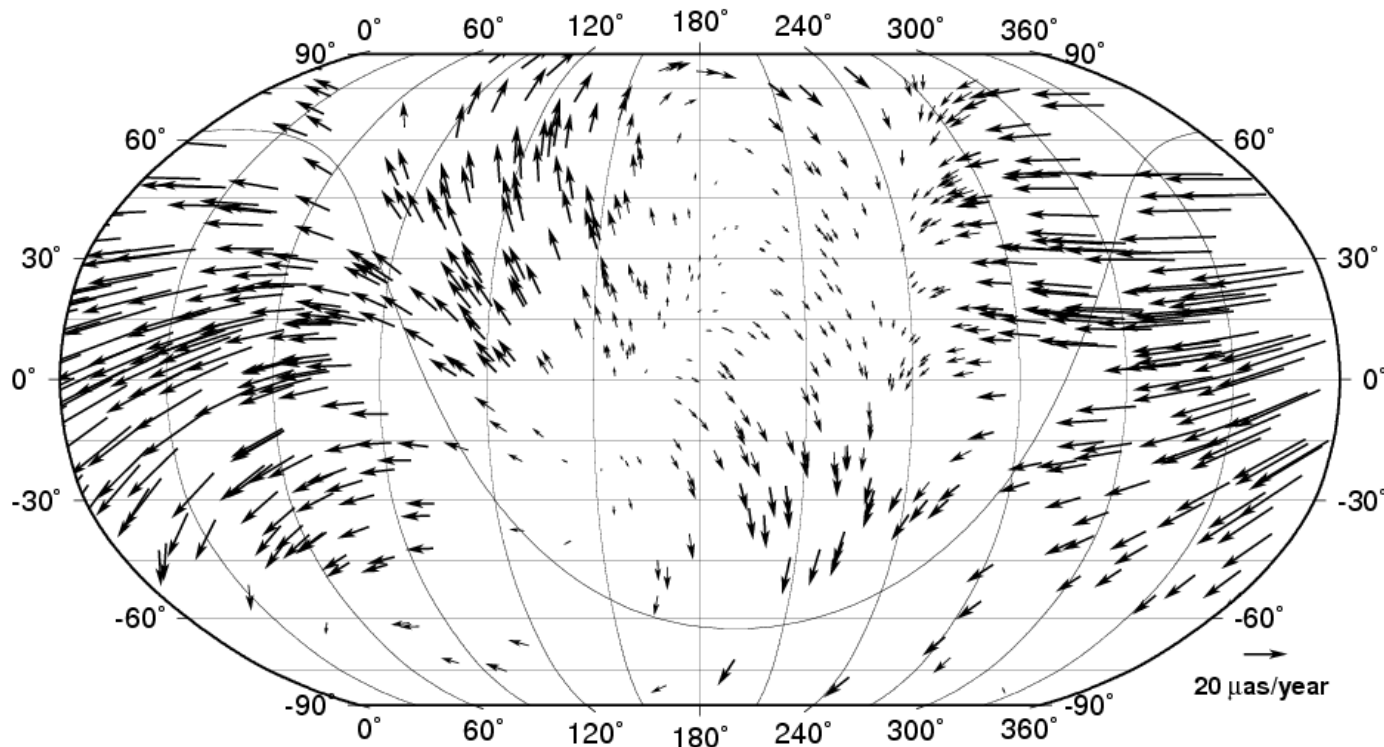
# Systematic effects in apparent motion (2<sup>nd</sup> degree harmonics)



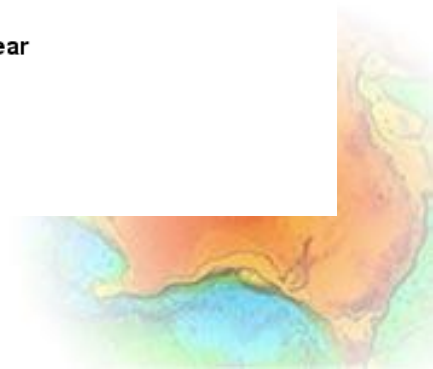
**20(+/- 3)  $\mu\text{as}/\text{year}$**



# Systematic effects in apparent motion (resultant systematic)

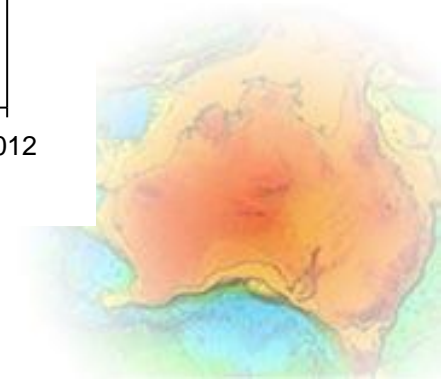
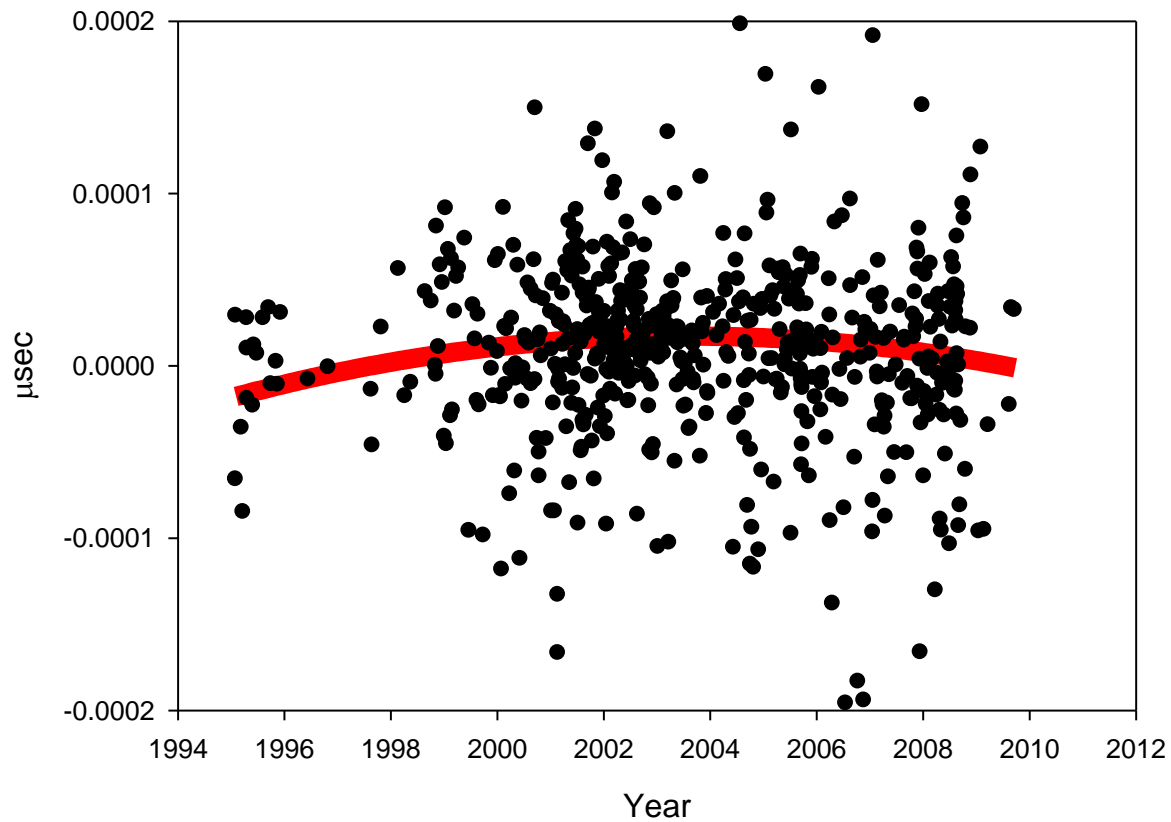


up to 40  $\mu\text{as}/\text{year}$



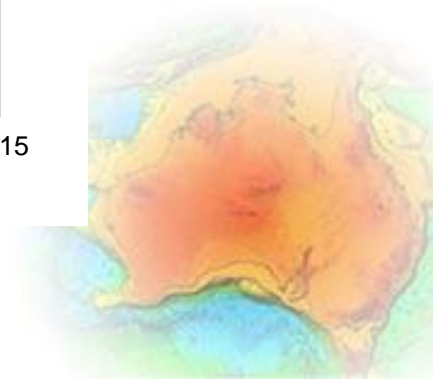
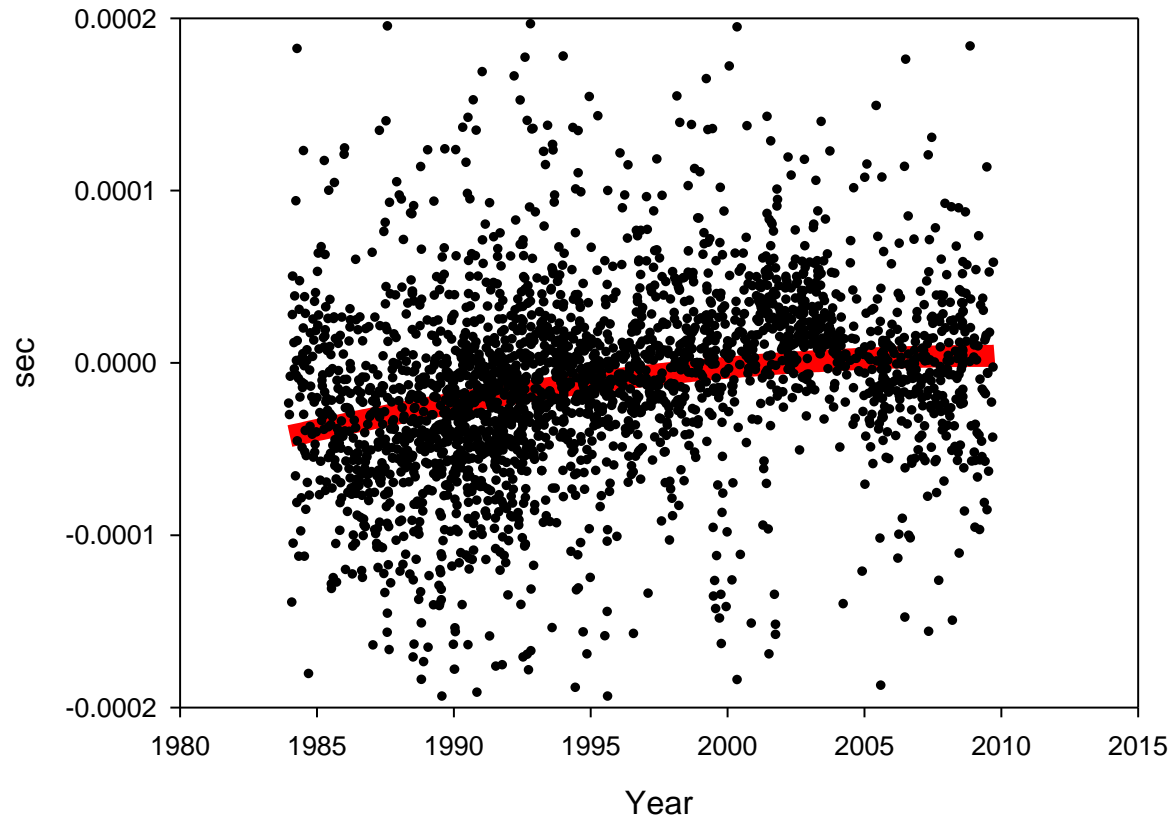
# Trend in RA

RA time series; 0718+793



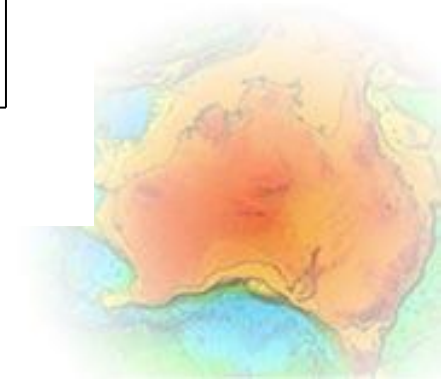
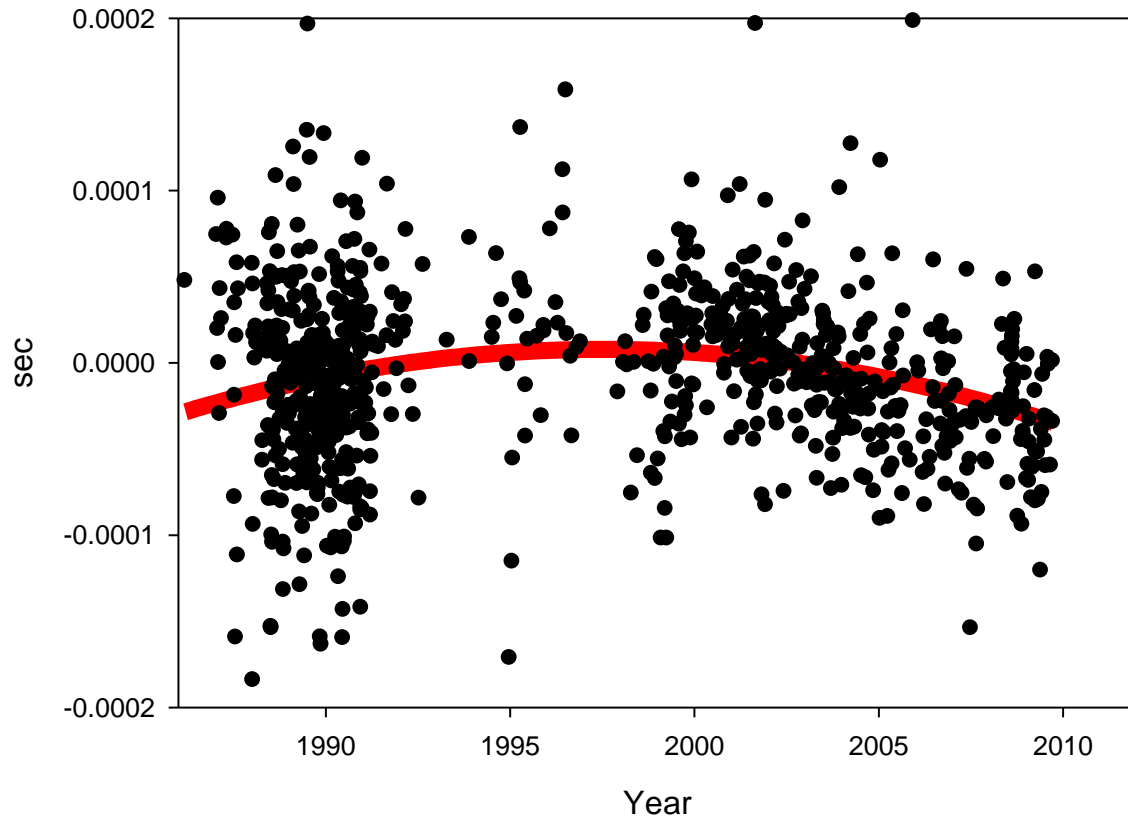
# Trend in RA

RA time series of 4C39.25



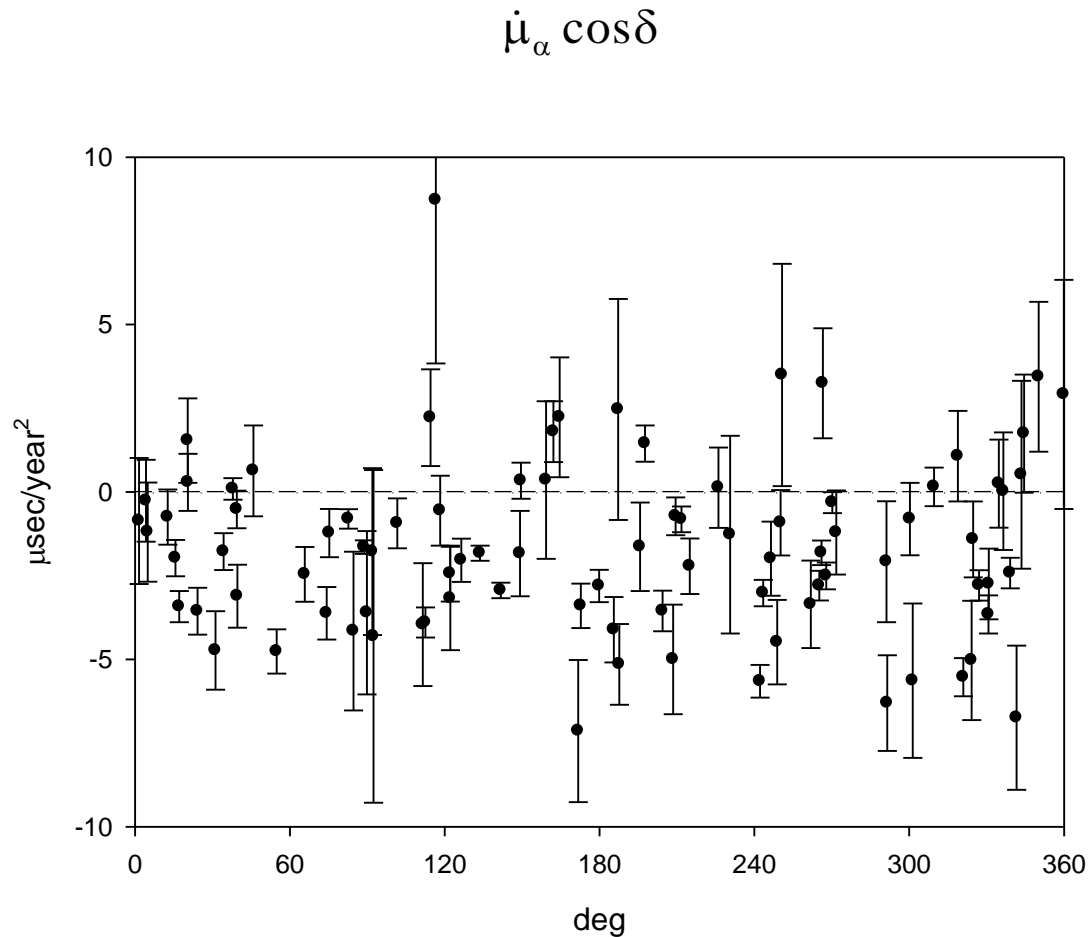
# Trend in RA

RA time series; 2121+053

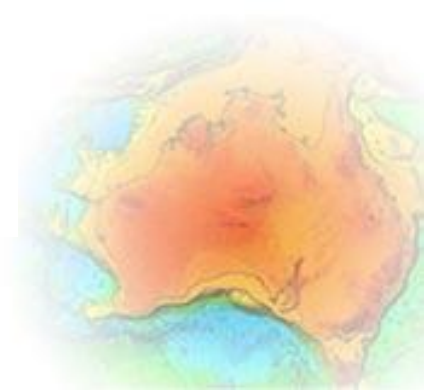




# Proper “acceleration” for 86 sources



$$-2.2(+/- 0.4) \mu\text{as}/\text{year}^2$$



**Possible explanation:  
Cosmologic effect on time scale  
(Kopeikin, 2009)**

$$TCB \rightarrow TCB + \frac{H}{2} TCB^2$$

**This could cause the observed the  
“acceleration” effect in the rotational  
systematic**

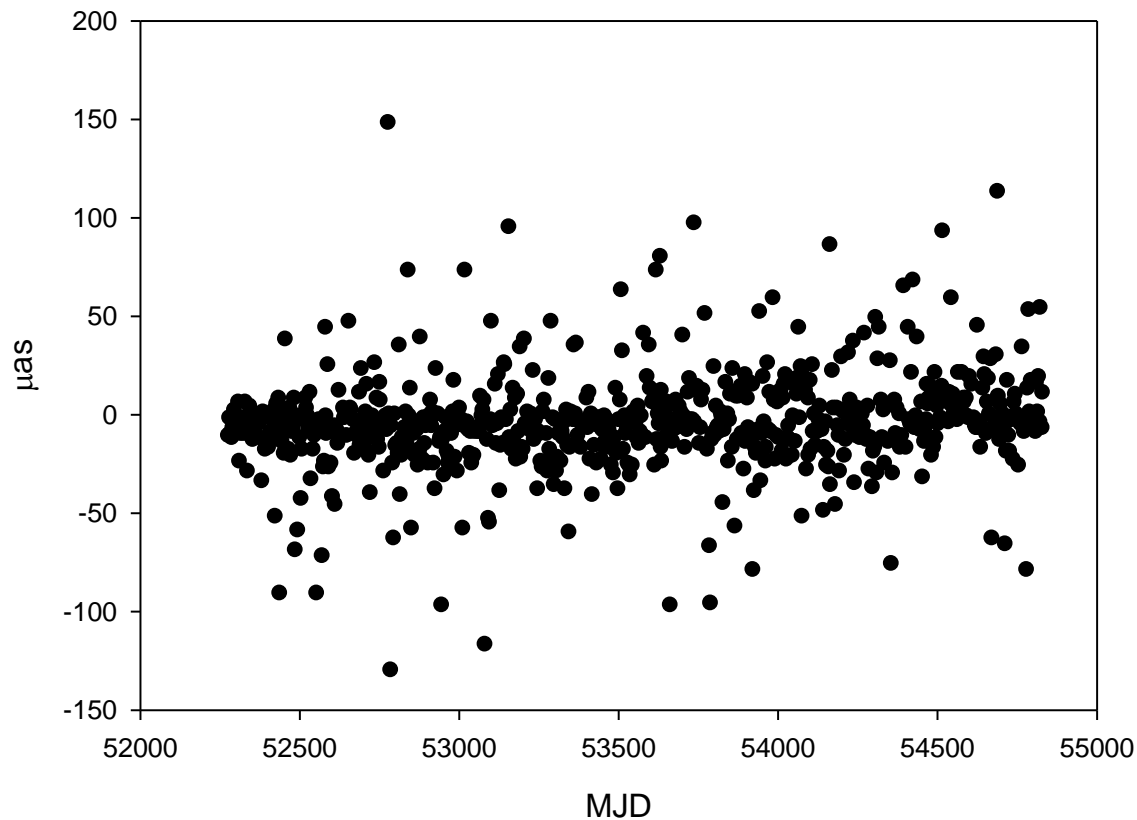


# Effect of the systematics (dipole and rotation) in EOP



# Effect on EOP (2001-2008)

X pole component



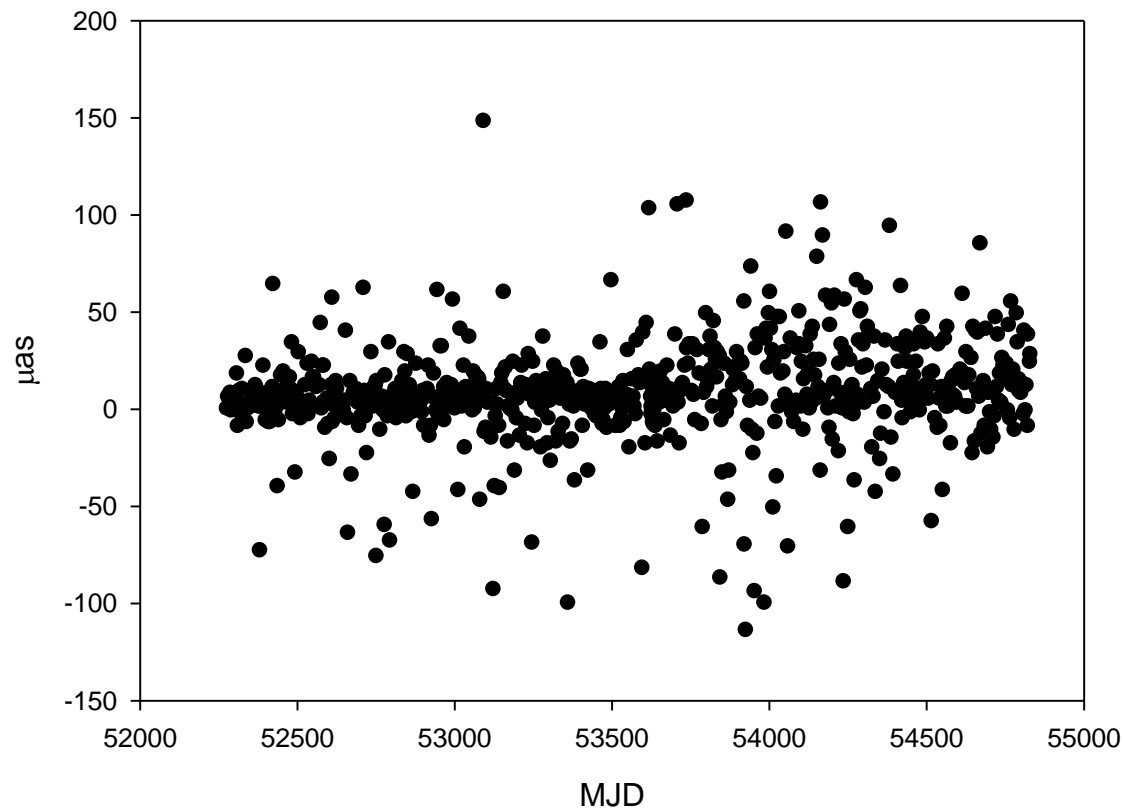
**dispersion  
~25 μas**

**1/4÷1/3 of total  
error budget**

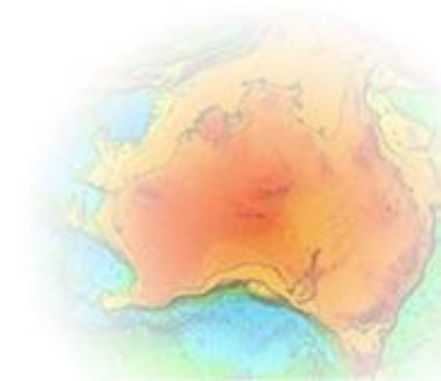


# Effect on EOP (2001-2008)

Y pole component

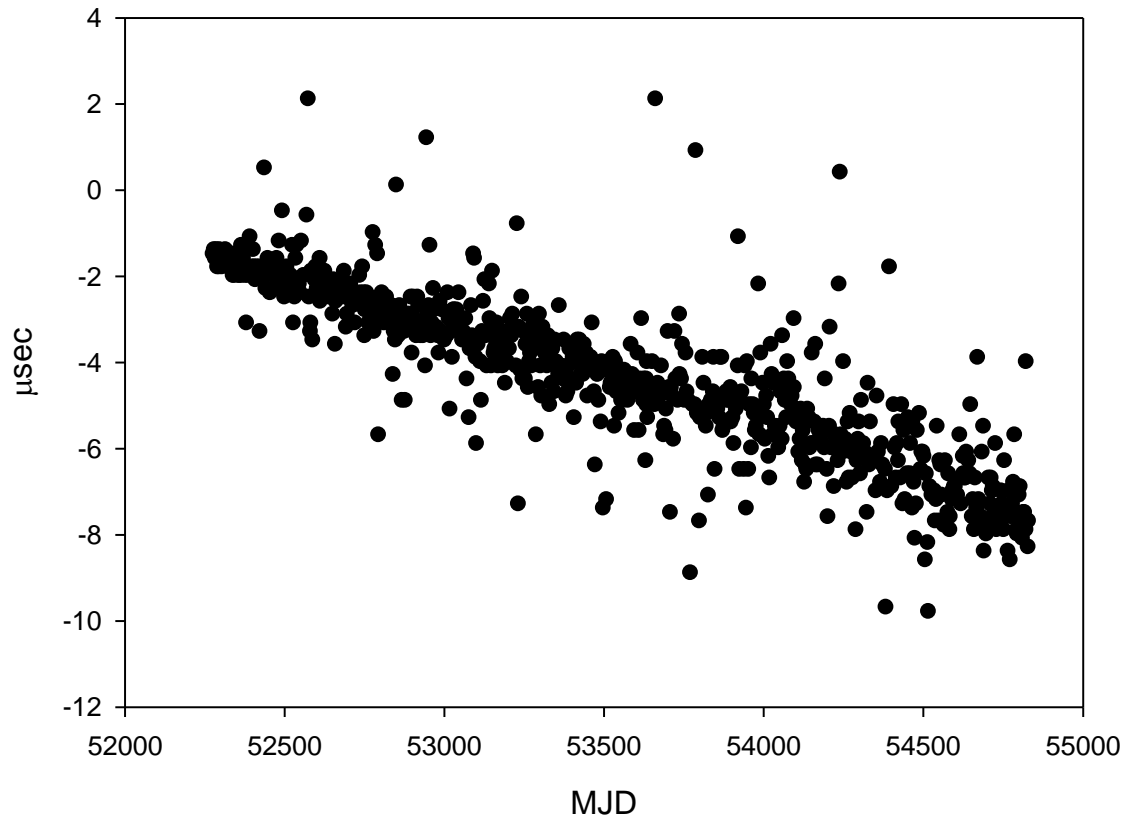


**dispersion  
~25  $\mu\text{as}$**

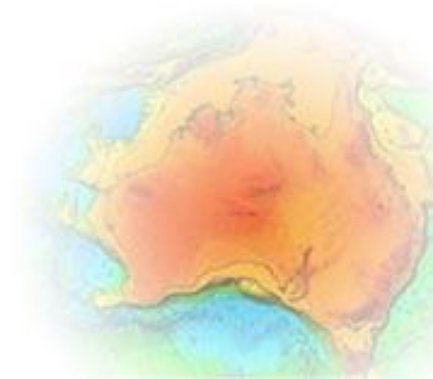


# Effect on EOP (2001-2008)

UT1-UTC

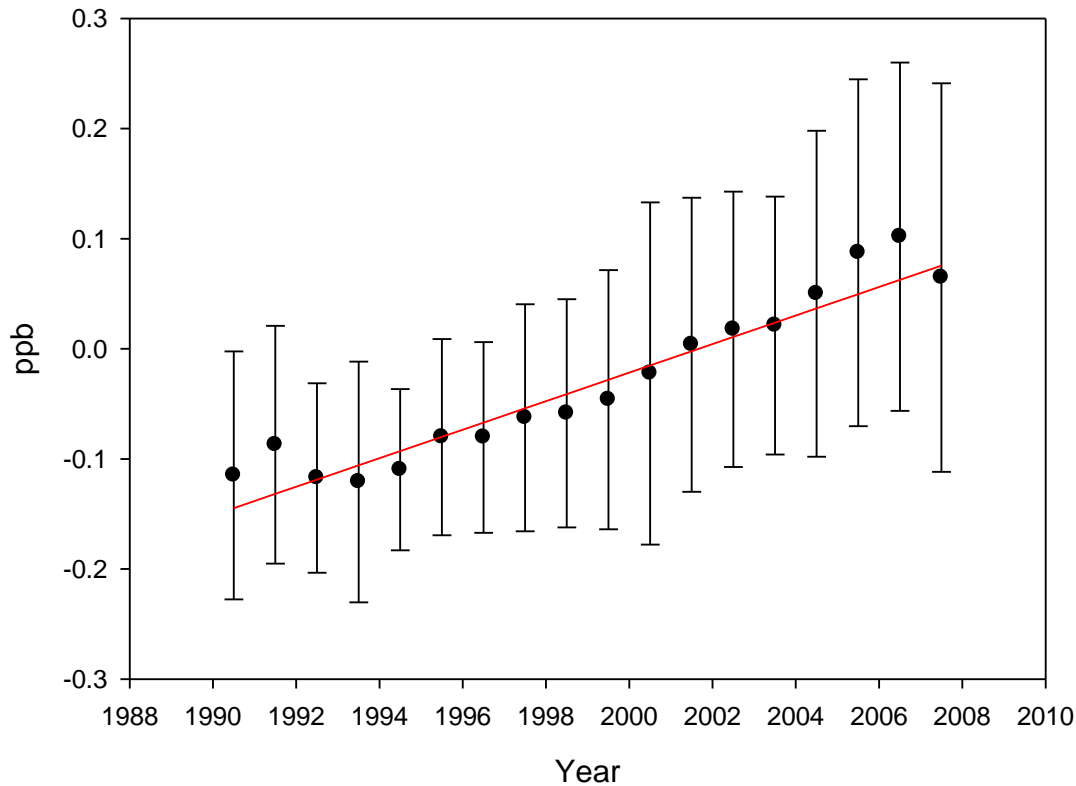


**$-0.81 \pm 0.02$**   
**μsec/year**



# Effect on the TRF scale

Effect of the dipole systematic on the TRF scale  
and linear fitting



$0.013 \pm 0.001$  ppb/year

$0.083 \pm 0.006$  mm/year

1.7 mm for 20 years



**EOP are sensitive to the  
systematic effects in proper  
motion (extra noise and bias)**





**All the systematic effects in proper motion should be removed**

- revision definitions and assumptions**
- more proper motions to be measured**



# Proposal

-by 2010:  $\sim 700$  proper motions unevenly distributed over the sky (**reality**)

-by 2020:  $\sim 3000$  proper motions evenly distributed over the sky (**vision**).

All VCS sources should be observed 3-4 times for the next 10 years with sufficient number of scans



# Proposal

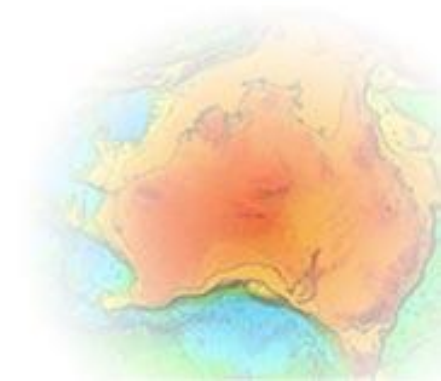
- to run a dedicated network comprising the Australian and New Zealand 12-m dishes + Asia-Pacific sites for radio sources between  $-40^\circ$  and  $0^\circ$ , and strong sources between  $-90^\circ$  and  $-40^\circ$ .
- other network: Parkes, Hartrao(?), DSS45(?), Hobart26(?) for weaker sources between  $-90^\circ$  and  $-40^\circ$  (3-4 sessions/year)



# Proposal

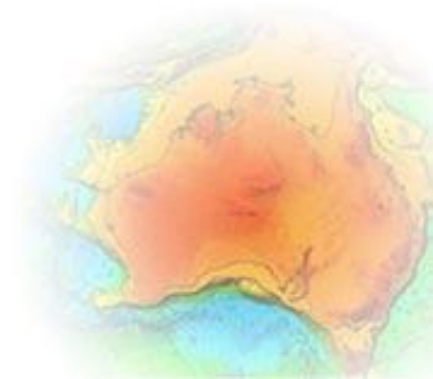
3 large telescopes ( $\sim 30$  meters) in the southern hemisphere

- Australia (Ceduna?)
- Africa (Hartrao?)
- South America ??



# Motivation

1. Fundamental science (cosmology)
2. Improvement of the major IVS products - ICRF, EOP, ITRF



**Thank you!**

