GFZ Helmholtz Centre Potsdam

Session 3: P315

1. Huazhong University of Science and Technology
2. Technical University of Berlin
3. GFZ German Research Centre for Geosciences
4. Shanghai Astronomical Observatory

Comparison between time series of closure analysis and source positions (I)

Ming H. Xu(mhxu@shao.ac.cn)[1,2,3,4], James M. Anderson[2,3], Suxia Gong[3],
Robert Heinkelmann[3], Susanne Lunz[3], Harald Schuh[2,3], Guang L. Wang[4]

Motivation

Source structure has been demonstrated to be the dominate error source in the residuals of geodetic VLBI data analysis for the S/X system (*Anderson & Xu, 2018*). In this poster we show the results of our closure analysis of all the VLBI observations available from IVS archives. The application of closure analysis to the long-term dataset clearly reveals evolution of source intrinsic structure at various time scales for most sources. The evolution of intrinsic structure necessarily leads to changes in the reference position, which can be detected by estimated source positions from geodetic VLBI. This poster will only focus on the first part of the comparison between the evolution of intrinsic structure and the source position variations, closure analysis.

Data

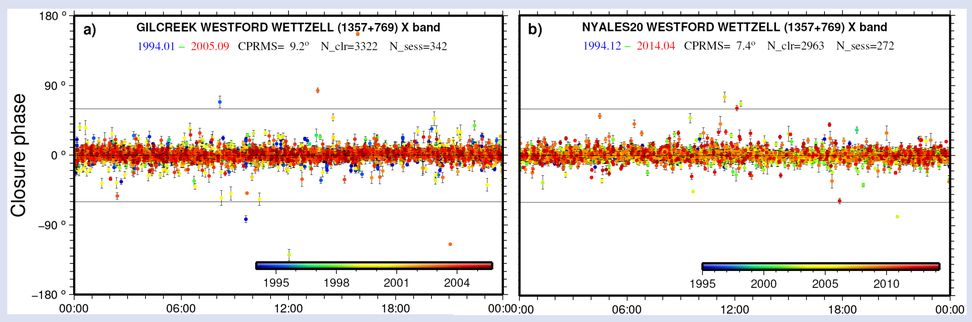
All 24-hour sessions and 1-hour sessions at S/X bands with an observing network of at least 4 stations available through 2018 Feb 26 were used, as shown in the table. Group delay, rate, phase, amplitude, and SNR of each individual baseline were obtained from these sessions. The SNRs were used to derive the uncertainties for phase and amplitude observables.

	24-hour	1-hour
Time period	1979-2018	2016-2018
# of sess.	6533	150
# of obs.	14,741,037	18,523
Sources	5228	157

Closure analysis

Source structures can be addressed simply by demonstrating their effects on phase and amplitude observables by closures without calibrations being needed. A change in the pattern of structure effects on a given triangle or quadrangle necessarily indicates a change in the intrinsic structure, so that closure quantities have a particular application to monitoring radio sources for changes in intrinsic structure, by comparing observational results over 40 years. The plots below show an example of a compact source over a long term.

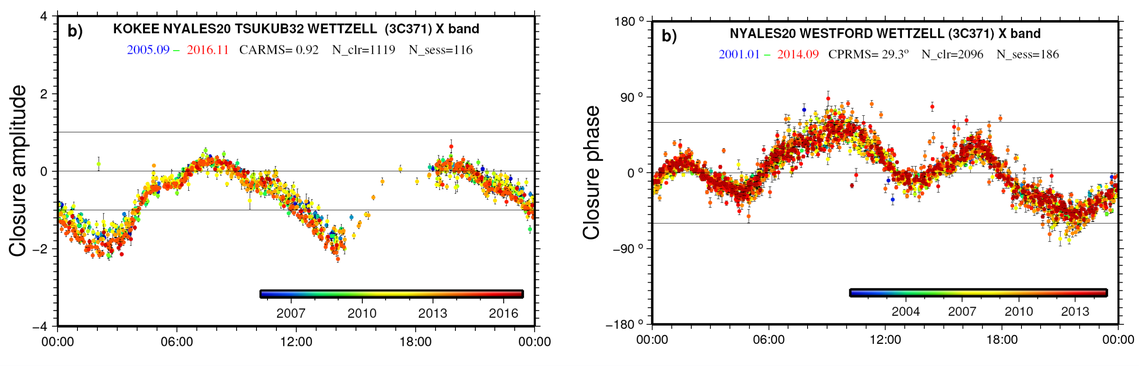
Stable and compact



EXAMPLES OF STRUCTURE EFFECTS FOR VARIOUS SOURCES

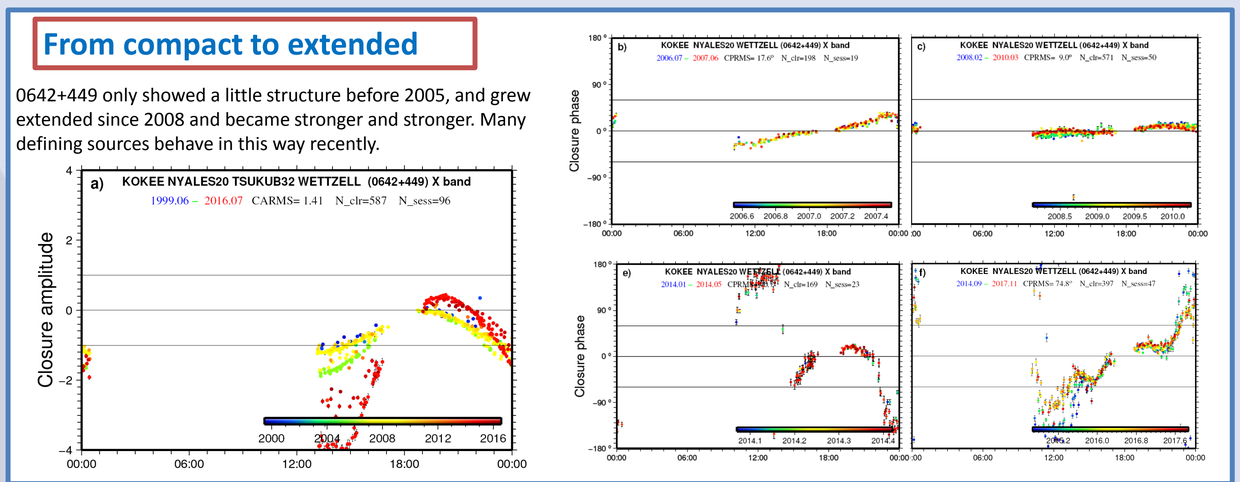
Stable and extended

3C371 has extended structure and its structure is quite stable over VLBI observing history. In CRF, only a few sources maintain a constant structure over a long period of time like it.



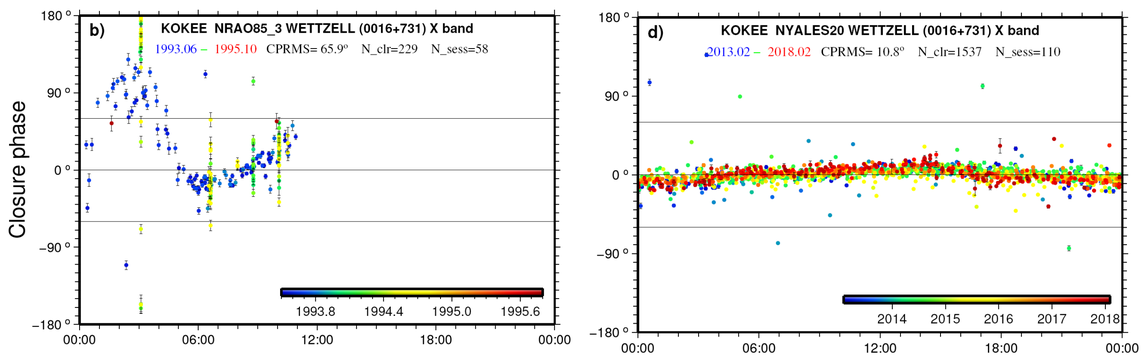
From compact to extended

0642+449 only showed a little structure before 2005, and grew extended since 2008 and became stronger and stronger. Many defining sources behave in this way recently.



Become quiet

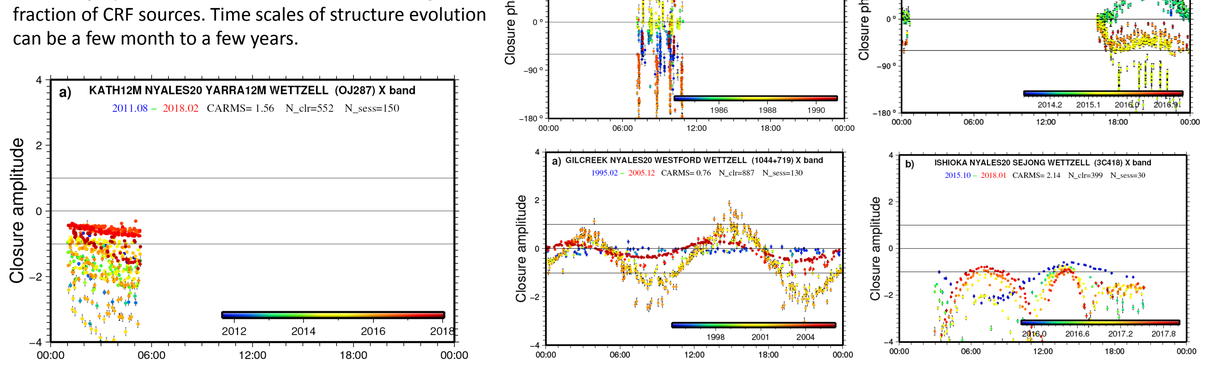
0016+731 shows a good example, which had very extended structure before 2000, even 1990, and become quiet since 2010. For astrometry and geodesy, compact sources should be selected from time to time, for instance, for observations of the Intensive sessions.



Highly variable

Examples: OJ287, 0528+134, 0607-157, 1044+719 and 3C418

This category has been demonstrated to have a large fraction of CRF sources. Time scales of structure evolution can be a few month to a few years.

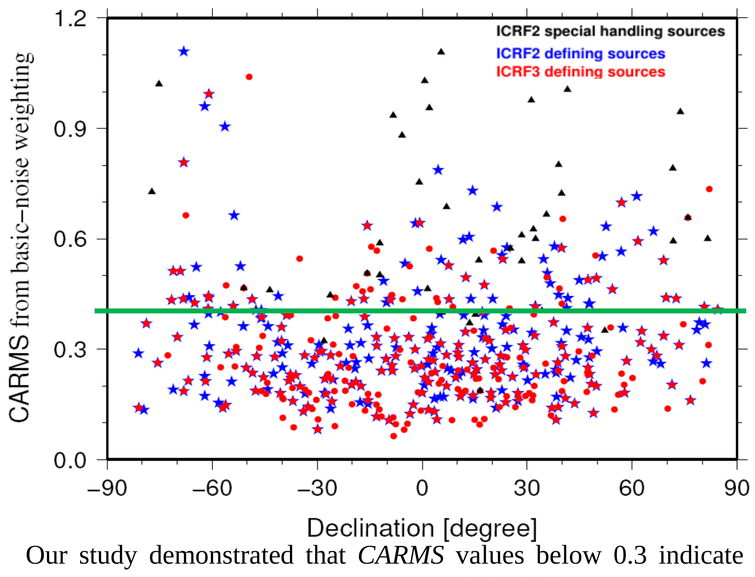


The table shows that many sources, even defining sources, have significant structure problems, and many other sources are much worse than some of the special handling sources. (This table shows the most observed sources.)

Source	*CARMS*	*CPRMS* (°)	# obs.	ICRF2	ICRF3
0059+581	0.27	10.7	439113	D	D
0552+398	0.57	15.5	422704	D	D
0851+202	0.44	14.7	302899	D	O
1803+784	0.35	15.1	261085	D	O
0923+392	0.80	17.8	249852	S	O
0727-115	0.24	9.0	236668	D	D
1741-038	0.33	12.9	235088	D	D
1357+769	0.16	10.4	224798	D	D
1739+522	0.35	12.5	217757	S	O
0955+476	0.25	10.9	212492	D	D
0133+476	0.23	11.1	208666	D	D
2037+511	0.61	18.3	207200	O	O
1749+096	0.22	10.8	205810	D	D
0642+449	0.49	11.8	165605	D	O
1611+343	0.40	17.6	161179	S	O
1807+698	0.65	22.6	145325	O	O
0528+134	0.37	13.8	134265	S	O
1044+719	0.59	14.9	129766	S	O

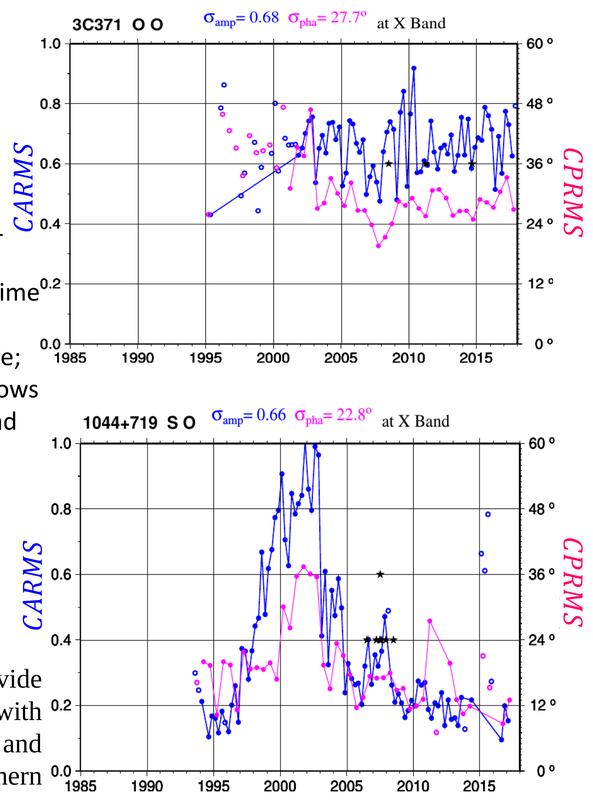
Statistics of closure analysis

$$CPRMS = \sqrt{\frac{\sum_i \omega_i \left(\phi^i_{\mathrm{clr}}\right)^2}{\sum_i \omega_i}} \qquad CARMS = \sqrt{\frac{\sum_i \omega_i \left(v^i_{\mathrm{clr}}\right)^2}{\sum_i \omega_i}}$$



Upper-right plot shows that 3C371 has extended structure all the time but its structure seems to be stable; the lower plot shows that 1044+719 had very extended structure during 2000-2003, and recently become relatively quiet.

Time series of closure analysis



Our study demonstrated that *CARMS* values below 0.3 indicate sources can provide good position estimates while a value of *CARMS* larger than 0.4 suggests a source with extended structure. Special handling sources generally have larger *CARMS* values and still a large fraction of defining sources have quite large *CARMS* values. Southern Hemisphere defining sources often have significant structure.

Reference:
Anderson & Xu, 2018, JGR, 132, 10162
Xu et al, 2019, submitted to ApJS

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