11 Selection of ICRF2 Defining Sources (SBL, PC, AMG)

This section reports on the establishment of a preliminary ordered list of sources based on their positional stability, and of the cross-correlation between this preliminary ranking and the list of source structure indices. A list of defining sources for ICRF2 is proposed.

11.1 Positional Stability of Sources

11.1.1 Ranking method

The ranking is based on the data files gsf005a.stats (time series statistics) and gsf008a.cat (non-aligned final ICRF2 catalog), from which the sources considered for special handling were removed. We keep 593 sources observed in at least ten sessions. All these sources are estimated globally and have an observational history longer than 2 years.

From the former file, one can compute the positional stability as

$$r = \sqrt{\mathrm{wrms}^2_{\alpha\cos\delta}\chi^2_\alpha + \mathrm{wrms}^2_\delta\chi^2_\delta}. \tag{8}$$

From the latter, an overall formal error on the position estimate can be computed as

$$d = \sqrt{\sigma^2_{\alpha\cos\delta} + \sigma^2_\delta + \sigma_{\alpha\cos\delta}\sigma_\delta C(\alpha,\delta)}, \tag{9}$$

where $C(\alpha, \delta)$ is the correlation between estimates of α and δ. Figure 33 displays the values of r and d as functions of the declination.

One could define an overall positional stability as $p = r + d$. However, d appears to be lower than r by a factor of 10, so that p would be dominated by information from time series. Moreover, a ranking based on the above-defined quantities only will obviously reject the southern hemisphere sources.

In the following, we implement a method inspired by Section 3 of Fey et al. [2001].

1. First of all, data are binned by intervals of declination. We chose 4 nodes ($-31°$, $0°$, $18°$, and $40°$) so that the number of sources in each interval is approximately the same (around 110 sources).
2. In each interval of declination, sources are given a mark between 0 and 10 on the basis of r. Again, the binning is such that the number of sources in each category is approximately the same.
3. Point (2) is repeated for d.
4. The scaled r and d are summed and normalized to 100: this constitutes the final "quality" index p. The distribution of p is displayed in Figure 34.

It is interesting to note that if one leaves the special handling sources into the input catalog and time series statistics file before doing the ranking, the special handling sources arrive between the 334th place and the 632nd place. Five of them (0235+164, 0607-157, 1611+343, 0637-752, 0528+134) arrive before the 400th place. This indicates that the ranking method can fail to exclude sources known to be of poor quality and that sources ranked after the 300th row must be considered cautiously.

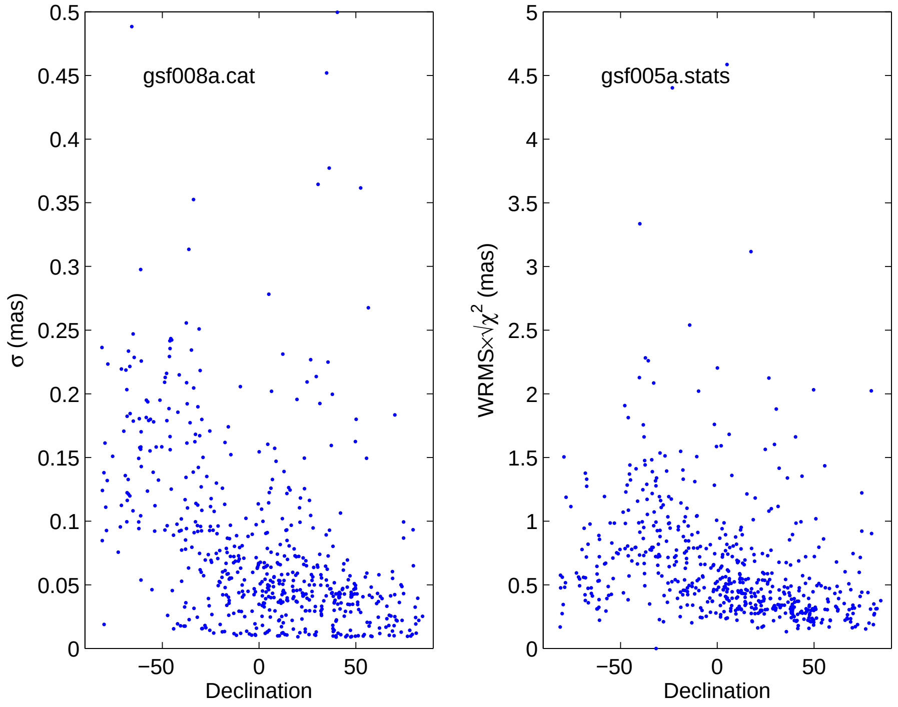

Figure 33: Quantities r and d vs. the declination.

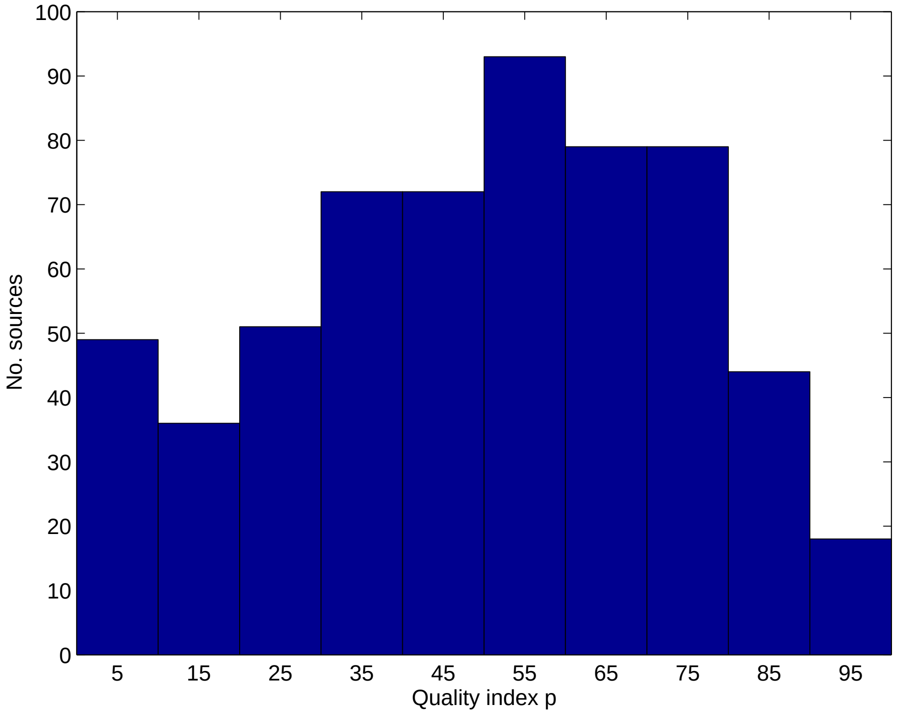

Figure 34: Distribution of the final quality index p.

11.1.2 Tests of stability

Method 1: tests on annual catalogs A first test of stability is done using annual reference frames computed from coordinate time series (method explained in Lambert & Gontier [2009]). Results are reported in Figure 35 by the solid, thick line (left scale). The thin line represents a degree-2 polynomial fit. By this method, the stability of the 212 ICRF defining sources is close to 25 μas. The red, dashed line (right scale), shows the average declination of the considered set. Figure 35 indicates that the minimum value of N should be around 200. Taking the first $N > 200$ sources of the ranking would provide a frame definitely more stable than the current 212 ICRF1 defining sources by a factor of two, and would moreover present a much better coverage of both hemispheres. There seems to be an optimal value at N close to 380, after which the stability is degraded.

Method 2: tests on randomly-selected subsets We ran another series of tests of stability similarly to what was proposed in Ma et al. [1998], Section 11. To assess the stability of the axes defined by a set of N sources, we estimate the relative orientation between this set and a reference catalog (e.g., ICRF-Ext.2) on the basis of different subsets of size $N/2$. The scatter of the rotation parameters obtained from the various subsets gives the stability of the axes. The different subsets are randomly selected and are as large as a half of the tested set. The stability of the 212 ICRF1 defining sources checked by this method is $\sim$18 μas, in agreement with the conservative value of $\sim$20 μas mentioned in Ma et al. [1998].

The solid line in Figure 36 (left scale) represents the stability of the frame as a function of the number of defining sources. The stability is computed as the maximum of the respective scatters of the four usual transformation parameters A_1, A_2, A_3, and dz. The horizontal, green line indicates the stability of the 212 ICRF1 defining sources. For example, take a number of defining sources of 200: they are the first 200 lines of the ranking list, i.e, the most stable 200 sources. Among these 200 sources, 100 are selected randomly, and the orientation of these 100 sources is evaluated. The scheme is repeated a thousand times. The obtained stability is close to 10 μas, and the average declination is approximately 5°. (The average declination of the 212 ICRF1 defining sources is around 14°.)

From this method, it seems that taking 200, 400, or more sources is equivalent in terms of stability and sky coverage. However, one must keep in mind that the tests are not done on N sources, but on subsets of $N/2$ sources. For example, the stability for $N = 500$ is computed from subsets of 250 sources. Although containing also 'bad' sources, the axes of such a frame are strongly maintained by the good ones that were selected in the random process.

11.2 Structure Information and Selection of Defining Sources

The final list of defining sources results from the cross-correlation between the ranked list of sources described above, based on positional stability, and the ranked list of sources based on structure indices described in §5. Overall, the two criteria (positional stability and source structure index) show good consistency, with positional stability increasing as the structure index decreases (see Figure 37).

The effect of the cross-correlation was to filter out an initial list of defining sources derived from positional stability only. This initial list comprises a total of 423 sources, corresponding to sources with stability index larger than or equal to 40. Setting the threshold for structure index to

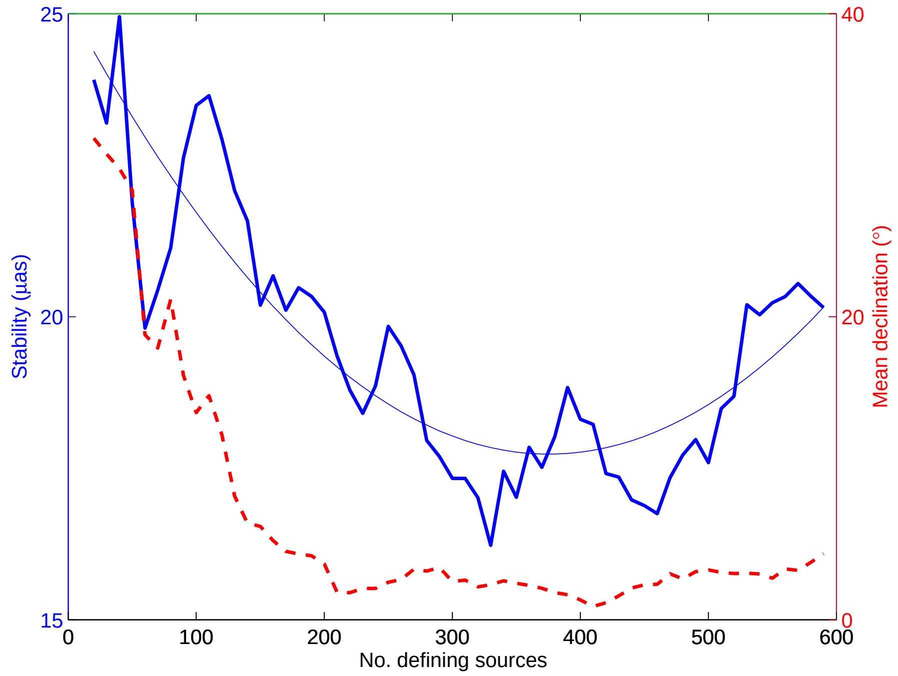

Figure 35: Axes stability and average declination of various subsets of sources of increasing size tested on annual catalogs.

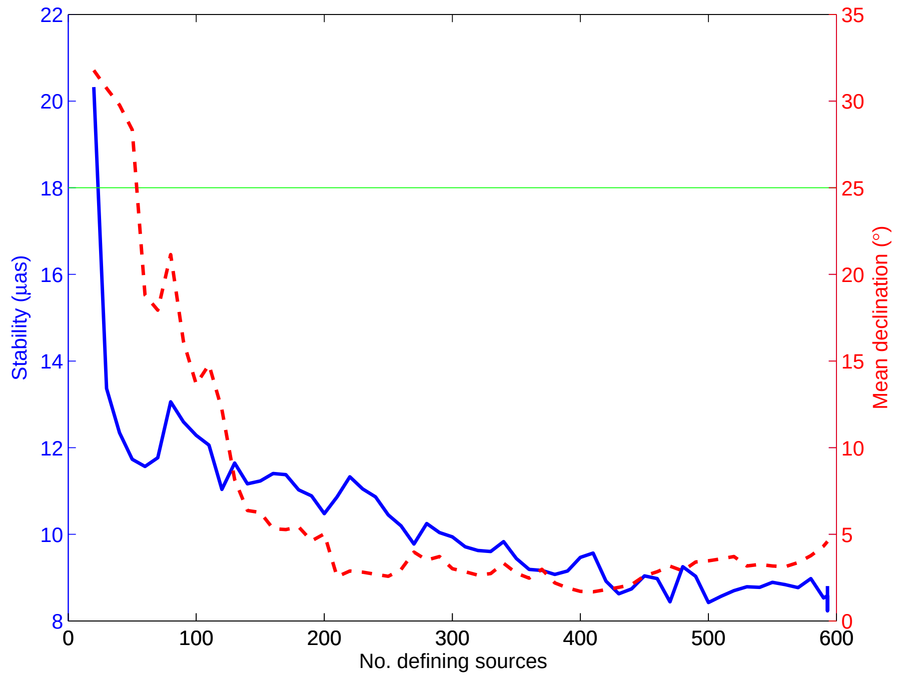

Figure 36: Axes stability and average declination of various subsets of sources of increasing size checked on randomly-selected subsets.

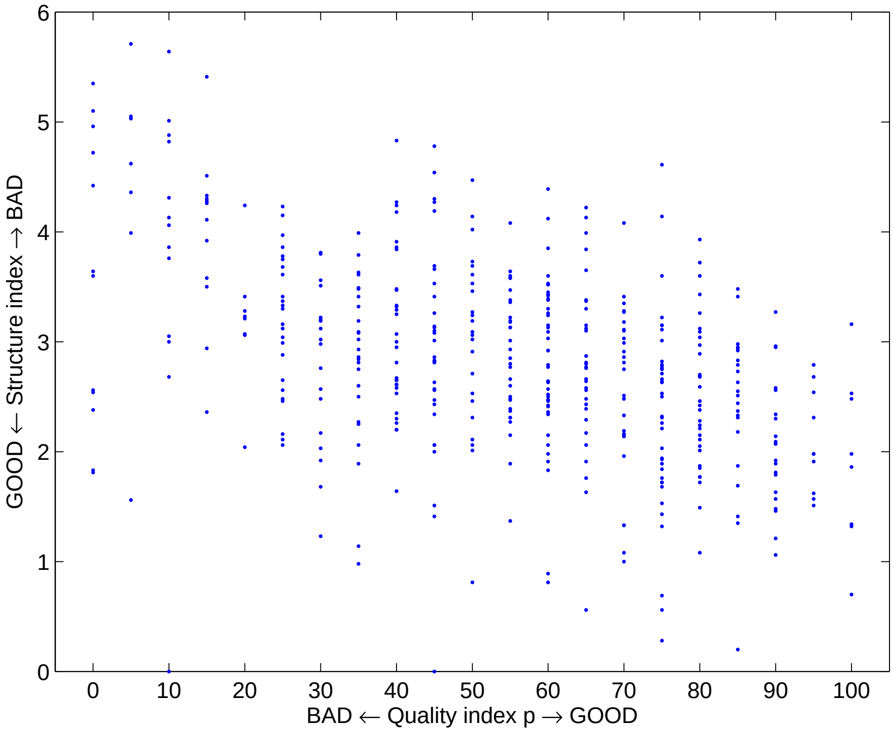

Figure 37: Source structure index vs. stability index p.

3.0, all sources with structure index values larger than or equal to this threshold were removed from the list, leaving 297 sources. About a quarter of these, mostly in the southern hemisphere, were found to have no structure index. When available, VLBI images from these sources were examined, which led to excluding two additional sources. The other sources (with no structure information available) were kept on the basis of their good positional stability only. Thus, the proposed set of defining sources comprise 295 sources.

The stability of the frame based on these 295 sources is 20 μas using the first method above and 10 μas using the second method, which is satisfactory (the corresponding stability's for the 212 ICRF1 defining sources are 26 μas and 18 μas). The mean declination of the sample is 0.7°. The distributions in declination, in p, and in structure index are shown in Figure 38, with the sky distribution plotted in Figure 39.

Preliminary checks against the ICRF1 revealed that rotation parameters towards the ICRF1 are at the level of ∼30 μas. The tilt parameter is negligible as well as the deformation parameters.

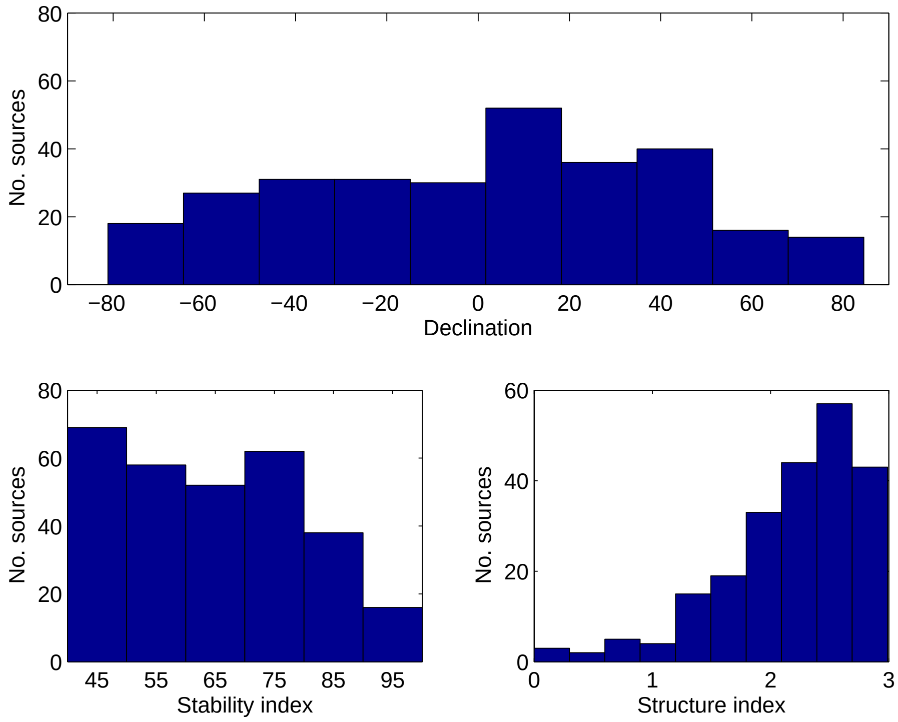

Figure 38: Defining sources' distribution in declination (top), in stability index (bottom-left), and in structure index when available (bottom-right).

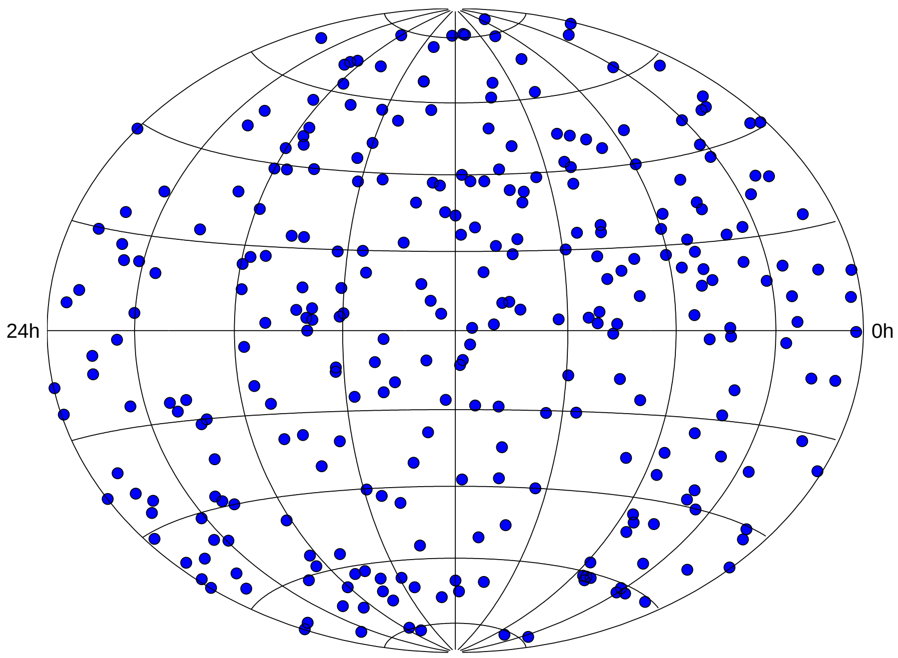

Figure 39: Distribution of the defining sources.