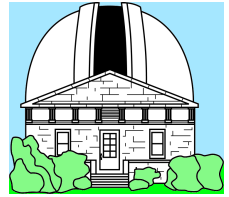# The Naval Observatory Merged Astrometric Dataset (NOMAD)

Norbert Zacharias (nz@usno.navy.mil)
Dave G. Monet (dgm@nofs.navy.mil)
Stephen E. Levine (sel@nofs.navy.mil)
Sean E. Urban
Ralph Gaume
Gary L. Wycoff

www.nofs.navy.mil/nomad

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Abstract: The U.S. Naval Observatory (USNO) announces the release of the first version of the Naval Observatory Merged Astrometric Dataset (NOMAD). The almost 100 GB dataset contains astrometric and photometric data for about 1.1 billion stars derived from the Hipparcos, Tycho-2, UCAC2, Yellow-Blue 6, and USNO-B catalogs for astrometry and optical photometry, supplemented by 2MASS near-infrared photometry. For each unique star the "best" astrometric and photometric data are chosen from the source catalogs and merged into a single dataset. A sequence of priorities is followed and NOMAD contains flags to identify the source catalogs and gives cross-reference identifications. This first release of NOMAD is not a compiled catalog; that is, if a star is identified in more than 1 of the above mentioned catalogs, only 1 catalog entry is chosen. Thus the local and global systematic errors of the various source catalogs will be present in this version of NOMAD. All source catalogs astrometric data are on the International Celestial Reference System within the limitations of the source catalogs. For more information and data retrieval see our homepage www.nofs.navy.mil/nomad.

Here is a screen capture of the NOMAD web interface.

Sample Data
Across the bottom of this poster paper a sample of the NOMAD catalog output for a field at $\alpha = 0^h$ and $\delta = 0°$ is given. The data are retrieved from the web interface.

Notes on the format
- NOMAD id numbers consist of a zone number (0 to 1799 in 1/10 degree steps of declination, starting from the south celestial pole), and a running star number in that zone (increasing along RA).
- Positions are on the International Celestial Reference System (ICRF), which is consistent with a "J2000 equinox". The epoch of the positions (update for proper motions) is for J2000.
- A zero in the proper motion field indicates no significant proper motion. Thus the given position is the same as for the original epoch in these cases.
- 30.000 in any magnitude field indicates "no data".
- Flags field: see NOMAD "readme" file. The source for all astrometric and photometric data are identified here; and additional bits are set for certain cases.

Catalogs used
Here are some remarks and explanations about the source catalogs which went into NOMAD.

Hipparcos Catalogue: Positions, proper motions and errors are used; however, no parallaxes are included in NOMAD.

Tycho-2: is a compiled catalog with proper motions derived from the combination of Hipparcos satellite measures (mainly its star tracker data) and over 100 ground-based astrometric catalogs which provided the early epoch data. Most of the Tycho B and V magnitudes (which includes Hipparcos stars) went into NOMAD as well.

UCAC2: is also a compiled catalog, including all catalogs used for Tycho-2 (thus also including Tycho and Hipparcos astrometric data), plus the recent epoch ground-based observations of the UCAC project. However, only 86% of the sky are covered by UCAC2 (the north celestial pole area is missing). For stars not in USNO-B, the UCAC2 magnitude has been used as "R" photometry value, although the UCAC2 bandpass is between V and R.

YB6: (Yellow-Blue catalog version 6) is unpublished data obtained from complete scans of the NPM and SPM plates performed on the PMM at NOFS, Flagstaff. The limiting magnitude is about 18 and YB6 is the major source of faint B and V magnitudes in NOMAD.

2MASS: the near IR photometry without errors or flags has been copied into NOMAD. For those stars without optical counterpart the 2MASS astrometric information was used (no proper motions).

USNO-B:
provides positions and proper motions for most faint stars in NOMAD. Most R photometry in NOMAD comes from this catalog.
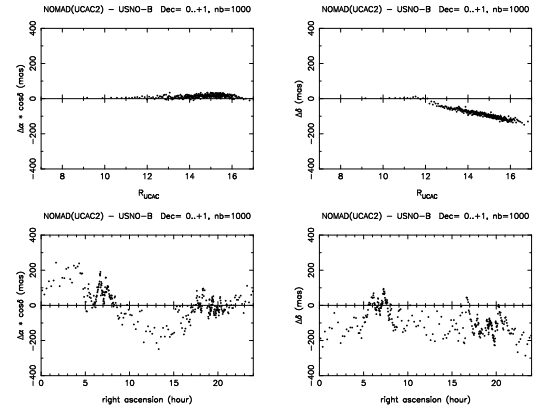
Priority of data
NOMAD is not a compiled catalog, no average values are taken if a star appears in more than 1 source catalog. Each astrometric and photometric entry in NOMAD is taken from a specific source catalog. The priority order is as follows:

astrometry brighter than 8 mag	
Hipparcos	
Tycho-2	
UCAC2	
astrometry of fainter stars	photometry: optical
Hipparcos	Tycho-2 (incl. Hipparcos stars)
UCAC2	YB6
Tycho-2	USNO-B
USNO-B	UCAC2
YB6	photometry: near IR
2MASS	2MASS

Sample plots
The following 3 plots show a sample area around M35 and NGC2158 with stars taken from Tycho-2, UCAC2 and NOMAD, respectively. The many faint stars in NOMAD are USNO-B stars.
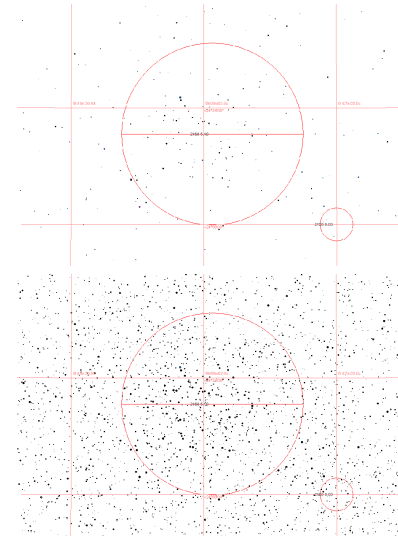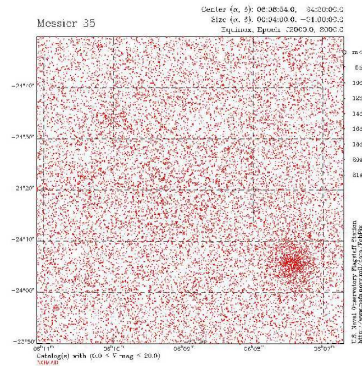

Systematic differences
The following plots illustrate possible systematic position differences between the various catalogs merged into NOMAD. These differences are present in the NOMAD release 1 data; no attempt has been made to "average out" these systematic errors inherent in the individual catalogs.

Statistics of NOMAD stars

Astrometry from Hipparcos	120,242
Astrometry from Tycho-2	364,091
Astrometry from UCAC2	48,219,557
Astrometry from USNO-B	992,508,499
Astrometry from YB6	14,613,180
Astrometry from 2MASS	61,787,163
total number of stars in NOMAD	1,117,612,732

photometry from	B	V	R
Tycho-2	2,546,128	2,546,128	0
UCAC2	0	0	910,583
YB6	234,598,772	264,856,052	0
USNO-B	675,416,340	0	999,780,649
no photometry	205,051,492	850,210,552	116,921,500

Hipparcos
   The Hipparcos and Tycho Catalogues 1997, ESA SP-1200
Tycho-2
   Høg, E. et al. 2000, A&A, 355, L27
UCAC2
   Zacharias, N. et al. 2004, AJ, 127, 3043
NPM
   Klemola, A.R., Jones, B.F., & Hanson, R.B. 1987, AJ, 94, 501
SPM
   Platais, I. et al. 1998, AJ, 116, 2556
YB6
   Monet, D. G. 2004, complete scan of NPM and SPM plates
2MASS
   http://www.ipac.caltech.edu/2mass/releases/allsky/
USNO-B
   Monet, D. G. et al. 2003, AJ, 125, 984
NOMAD
   http://www.navy.mil/nomad

We thank Geoff Chester for providing the figures on the M35 field.

Messier 35

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#       1|          2|       3|       4|       5| 6|       7|            8| 9| 10|     11|      12|   13|   14|   15|   16|   17|    18|    19|    20|    21|    22|    23|
#      id|    USNOB1|   2MASS|    YB6| UCAC2|TYCHO2|     RA|         DEC|sra|sde| RA Epoch| DEC Epoch| MuRA| MuDEC| sMuRA| sMuDE| Flags|    B|    V|    R|    J|    H|    K|
#      id|        id|      id|     id|    id|    id|hh mm ss|     dd mm ss|mas|mas| yyyy.yyyy| yyyy.yyyy| mas/yr| mas/yr| mas/yr| mas/yr| hex|   mag|   mag|   mag|   mag|   mag|   mag|
0899-0000010 635982766 224910226       0       0  0 00 00 02.2733 -00 00 02.510  74 152 1982.5000 1982.5000   4.0 -26.0   3.0   8.0  209 20.820 30.000 19.750 16.422 16.111 15.210
0900-0000004 636609982        0       0       0  0 00 00 04.5047 +00 00 26.860 779  59 1972.2000 1972.2000   0.0   0.0   0.0   0.0    9 20.820 30.000 30.000 30.000 30.000 30.000
0899-0000023 635982779 563750561       0       0  0 00 00 05.1373 -00 01 25.240 111 101 1982.5000 1982.5000   0.0   0.0   0.0   0.0  209 20.140 30.000 19.150 17.024 15.840 17.233
0900-0679467 637228241        0       0       0  0 23 59 55.1853 +00 28.680 168 131 1976.3000 1976.3000   0.0   0.0   0.0   0.0  209 20.150 30.000 18.590 30.000 30.000 30.000
0899-0682101 636609967        0       0       0  0 23 59 55.6340 -00 00 15.410 118  50 1976.3000 1976.3000   0.0   0.0   0.0   0.0 1209 19.550 30.000 18.590 30.000 30.000 30.000
0900-0679475 637228249 224910248 195872733 31967487  0 23 59 57.5008 +00 00 44.244  45  44 1998.0250 1998.1240   2.2 -17.6   5.5   5.4 12dc 16.130 15.220 14.990 13.750 13.194 13.140
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