Prediction Accuracy of PHA's Close Approaches with the Earth

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Overview

1. Introduction
2. Cross-identification results
3. Discussion, problems, conclusions

World Ephemeris Services

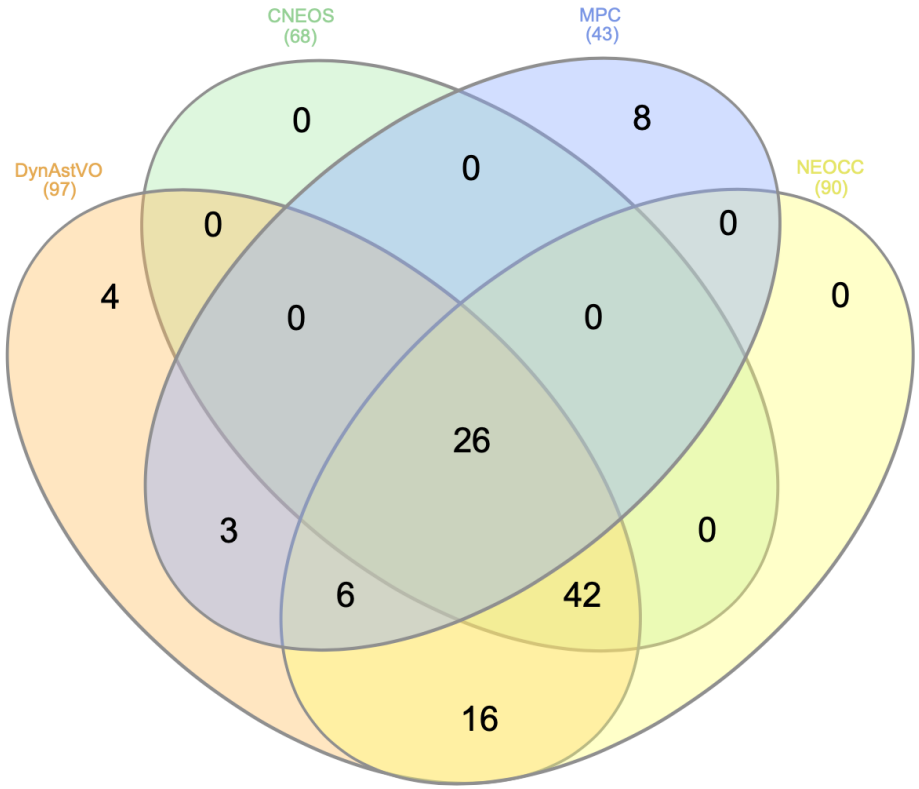
- IAU Minor Planet Center (MPC) by giving the lists for both Forthcoming Close Approaches To The Earth, https://minorplanetcenter.net/iau/lists/CloseApp.html, and Running Tallies, https://minorplanetcenter.net;
- JPL Center for Near Earth Object Studies (CNEOS), https://cneos.jpl.nasa.gov/ca/;
- ESA's Near-Earth Object Coordination Center (NEOCC), http://neo.ssa.esa.int/web/guest/close-approaches;
- DynAstVO service of IMCCE at Paris Observatory PADC center, http://vespa.obspm.fr.

Hypothesis "Similarity in Data–Fitting–Prediction"

While the observational data used in the orbital fitting of asteroids are the same and consist of the astrometric and radar measurements collected by IAU MPC, there is an expectation to have similar predictions for the moments and distances of PHA close approaches with the Earth.

The Venn diagram for cross-identification (Dec. 2, 2018)

The cross-identification of the close approaches within a one-year window: DynAstVO (97), CNEOS (68), MPC (43), NEOCC (90) while the combined set consists of 105 close events.



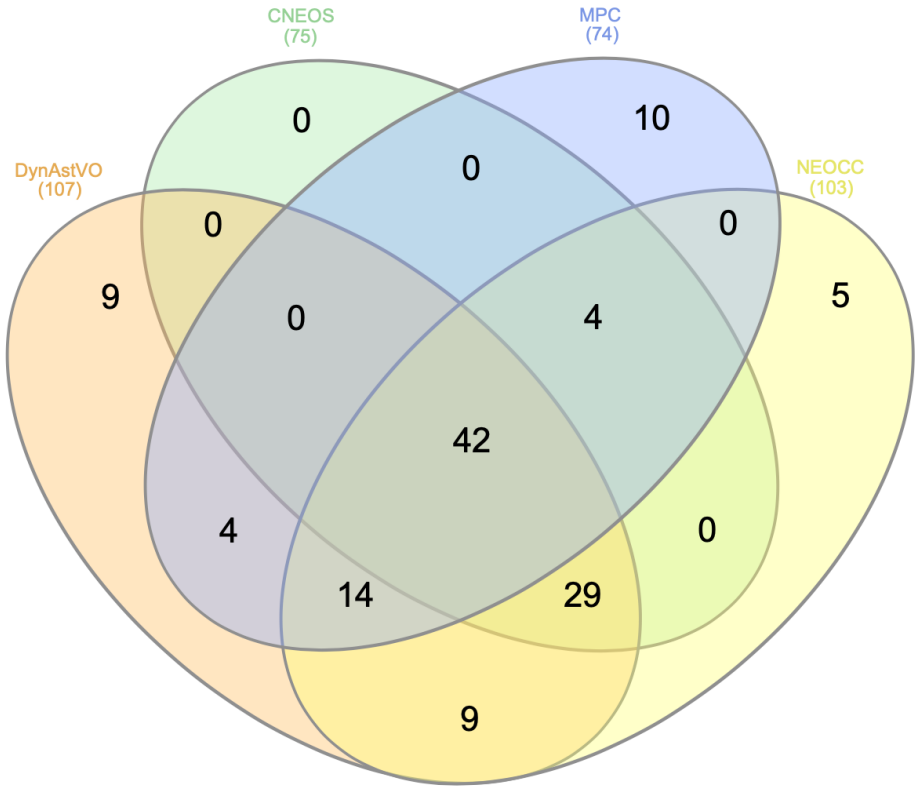
Comparison with the JPL HORIZONS calculations

Service	**Unique findings**	$\Delta_H \leq$**0.05 AU**
DynAstVO	4	3
CNEOS	0	0
MPC	8	2
NEOCC	0	0

Table: The cross-identification starting Dec. 2, 2018

The Venn diagram for cross-identification (Mar. 28, 2019)

The cross-identification of the close approaches within a one-year window: DynAstVO (107), CNEOS (75), MPC (74), NEOCC (103) while the combined set consists of 126 close events.

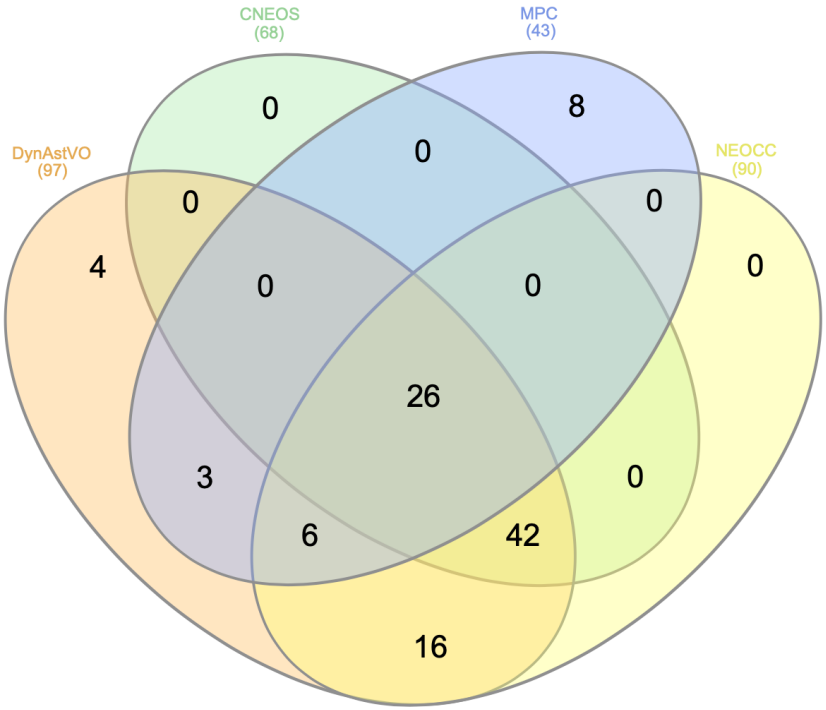


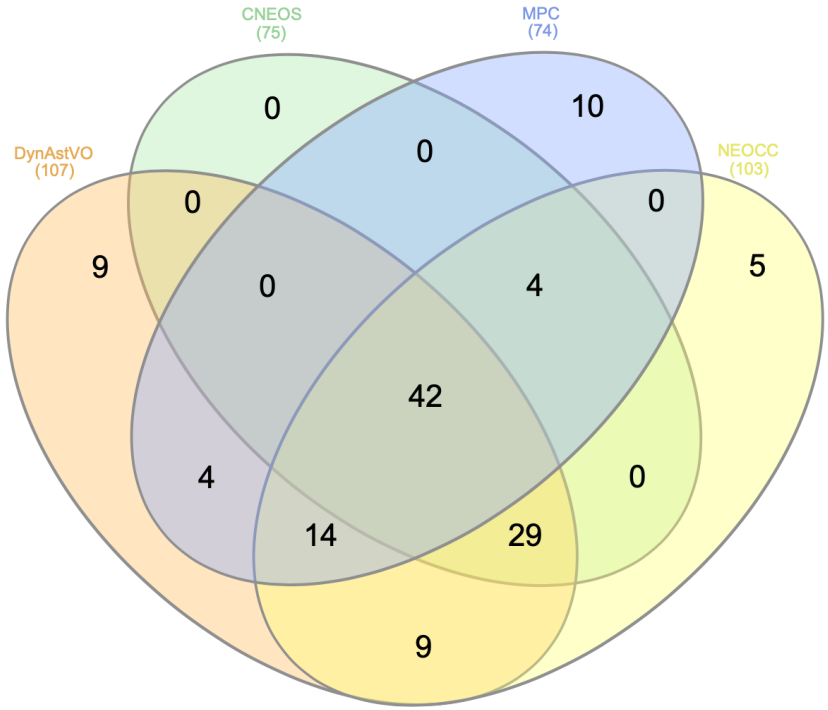
Comparison with the JPL HORIZONS calculations

Service	**Unique findings**	$\Delta_H \leq$**0.05 AU**
DynAstVO	9	1
CNEOS	0	0
MPC	10	1
NEOCC	5	1

Table: The cross-identification starting Mar. 28, 2018

Comparison of the cross-identifications





Example

The asteroid 2011 SC25 has been declared by IAU MPC to have a close approach on October 3, 2019, at the geocentric distance 0.04446 AU, the JPL HORIZONS confirms approximately the date and distance of close approach while the DynAstVO propagation gives the date September 22, 2020, with geocentric distance 0.21660 AU (almost one year difference!).

Discussion and problems

- Different orbital models are used;
- Orbital fitting can use different weights;
- Data set of measurement used can be different (completeness of data sets); this argument can be reduced to the weighting schemes used in *orbital fitting*; assume all the measurements is available and zero weights are assigned to missing data;
- Low frequency updating the prediction data;
- Different time length of data prediction;
- Search of close approaches failures.

Conclusions

- The predictions provided by all 4 ephemeris services have the same identification for less than 1/3 of entries.
- Prediction of close approaches of asteroids results from the application of several algorithms: search of close encounters while the orbital data is available, completeness of the orbital data, dynamical models of motion, the weighting of measurements at the orbital fitting process.
- Reliability of predictions has to be evaluated against measurements or observations. We suggest making additional observations for the asteroids which have been found to have differences both in the asteroid's entry and in the moments and distances of close approaches.

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