# HinetPy: A Python package for accessing and processing NIED Hi-net seismic data

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Summary

HinetPy is a Python package designed for researchers working with seismic data from the National Research Institute for Earth Science and Disaster Resilience (NIED) Hi-net (High-sensitivity seismograph network) in Japan. The seismic network comprises approximately 800 stations with high-quality seismic data. Accessing and processing the data can be challenging due to the limited functionality of the web UI and backend data server. Additionally, the seismic data is stored in a non-standard format, which adds an extra layer of complexity. HinetPy solves these challenges by offering a user-friendly interface for accessing seismic data from NIED Hi-net and converting it to commonly used data formats. It streamlines the workflow for seismologists, enabling them to more effectively utilize this valuable dataset.

Statement of need

The National Research Institute for Earth Science and Disaster Resilience (NIED) operates and maintains NIED Hi-net, a nationwide high-sensitivity seismograph network in Japan. Since its establishment in October 2000, NIED Hi-net has grown to include approximately 800 seismic stations equipped with three-component short-period seismometers (Obara et al., 2005; Okada et al., 2014). The NIED Hi-net website (https://www.hinet.bosai.go.jp/) provides access to high-quality seismic data from 2004 onwards, including data from other seismic networks such as F-net, S-net, V-net, and more. The NIED Hi-net data has been widely used in various research from the study of earthquakes (e.g., Ishii et al., 2005; Peng et al., 2007) to the structure of the Earth's deep interior (e.g., Niu et al., 2005; Tian & Wen, 2017; Yee et al., 2014). Despite the value of the data provided by NIED Hi-net, accessing and processing it can be challenging.

Challenges in accessing NIED Hi-net data

The NIED Hi-net data is available for free through the NIED Hi-net website after users register for an account. However, accessing them can still be challenging. While most seismic data centers have transitioned to standard FDSN web services (https://www.fdsn.org/webservices/) in recent years, allowing users to request seismic data using open-source tools like ObsPy (Krischer et al., 2015), NIED Hi-net has not yet upgraded to adopt these services. To request data from the NIED Hi-net website, users must log in and click many buttons manually. It is important to note that the NIED Hi-net website has limitations on the data size and length in a single request. Specifically, the record length of a single channel cannot exceed 60 minutes, and the total record length of all channels cannot exceed 12,000 minutes. Considering that NIED Hi-net comprises about 800 seismic stations and 2,400 channels (3 channels per station), the record length in a single request must not exceed 5 minutes. If users require 30 minutes of data, they must divide the time range into six subranges and submit six separate requests. The NIED

Hi-net website does not allow users to post multiple data requests simultaneously. Therefore, to obtain the requested data, users must post a request, wait for the data to be prepared, and then post subsequent requests. After all data is ready, users must manually download the files and combine them into a single file. The entire process can be time-consuming and cumbersome.

Challenges in processing NIED Hi-net data

NIED Hi-net stores seismic data in a non-standard format called WIN32, accompanied by a 'channels table' text file containing metadata for each channel. Most seismic data processing software, such as ObsPy, cannot directly use these non-standard formats. Therefore, additional processing is required to convert the data to commonly used formats, which poses challenges for researchers. Although NIED Hi-net provides a set of commands in their win32tools package to process WIN32 data and convert to the SAC format, there are currently no tools available to convert the channels table to a more commonly used format, such as the SAC polezero file format. This limitation hinders the broader utilization of NIED Hi-net data.

HinetPy for easy data accessing and processing

HinetPy is designed to address specific challenges with accessing and processing NIED Hi-net data through a user-friendly interface. It primarily offers two key components: the `Client` class for data accessing and the `win32` module for data processing.

The `Client` class utilizes the popular HTTP library Requests to handle user authentication, data requests, status queries, and downloads. This simplifies the process of accessing NIED Hi-net data, allowing users to access data without any manual operations on the Hi-net website.

The `win32` module provides several functions for processing WIN32 data, including:

- Merging multiple small WIN32 data files into a single large WIN32 file.
- Converting data from WIN32 format to SAC format.
- Creating instrumental responses in SAC polezero format.

Internally, the `win32` module currently relies on the `catwin32` and `win2sac_32` commands from the NIED win32tools package for WIN32 data processing. Therefore, the win32tools package (at least the two required commands) must be installed before using HinetPy.

This is an example demonstrating how to request 20 minutes of waveform data of the Hi-net network starting at 2010-01-01T00:00 (JST, GMT+0900), convert the data to SAC format and extract SAC polezero files:

```python
from HinetPy import Client, win32

# You need to register a Hi-net account first
client = Client("username", "password")

# Let's try to request 20-minute data of the Hi-net network (with an internal
# network code of '0101') starting at 2010-01-01T00:00 (JST, GMT+0900)
data, ctable = client.get_continuous_waveform("0101", "201001010000", 20)

# The request and download process usually takes a few minutes.
# Be patient...
# Now you can see the data and channels table in your working directory
# Waveform data (in win32 format) : 0101_201001010000_20.cnt
# Channels table (plaintext file) : 0101_20100101.ch

# Convert data from win32 format to SAC format
```

```
win32.extract_sac(data, ctable)
# Extract instrumental responses and save as SAC polezero files
win32.extract_sacpz(ctable)

# Now you can see several SAC and SAC_PZ files in your working directory.
#
# N.NGUH.E.SAC  ...
# N.NGUH.E.SAC_PZ  ...
```

"0101" is the internal network code of the Hi-net network. The full list of supported seismic networks and their internal network codes can be obtained via `client.info()`.

Key features

The key features of HinetPy are:

1. Facilitates easy access to NIED Hi-net seismic data, including continuous/event waveform data and event catalogs.
2. Supports multiple seismic networks (e.g., F-net, S-net, MeSO-net and more in addition to Hi-net) in Japan.
3. Selects a subset of stations based on geographical location or station name (Supports Hi-net, F-net, S-net and MeSO-net only).
4. Converts waveform data to SAC format and instrumental responses to SAC polezero files.
5. Speeds up the downloading and processing workflow via the use of multithreading.

Important notes on the use of NIED Hi-net data

1. Users must register an account on the NIED Hi-net website for accessing the data and renew the account annually.
2. Users should report their research results using NIED Hi-net data to NIED.
3. Redistribution of any NIED Hi-net data is prohibited.

Acknowledgments

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