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humpi: The python code for the Hurricane Maximum Potential Intensity (HuMPI) model

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Software

- Review
- Repository
- Archive

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Summary

The potential intensity (PI) of tropical cyclones (TCs) is the maximum surface wind speed and minimum central pressure limits found by representing the storm as a thermal heat engine (Emanuel, 1986; Gilford, 2021; Holland, 1997). The PI theory proposed by Emanuel (1986) (hereafter E-PI) has been widely accepted as the upper bound for TCs intensity (Garner, 2015; Kieu & Moon, 2016; Kowaleski & Evans, 2016). In the E-PI theory, the dynamic and thermodynamic processes of the TC are described as an energy cycle like a Carnot engine, absorbing heat from the ocean, giving it up at the tropopause. Nevertheless, the "superintensity" phenomenon, which occurs when the observed or modelled TC intensity is higher than the E-PI prediction, is a research challenge nowadays (Li et al., 2020; Persing & Montgomery, 2003; Rousseau-Rizzi & Emanuel, 2019).

In a recent attempt to avoid the "superintensity" phenomenon, Pérez-Alarcón et al. (2021) proposed a new hurricane maximum potential intensity (HuMPI) model based on the E-PI theory. HuMPI describes the TC thermo-energetic cycle as a generalized Carnot cycle and includes a TC model for the atmospheric boundary layer (Smith, 2003; Smith & Vogl, 2008). For further details of HuMPI physics description, see Pérez-Alarcón et al. (2021).

Bister & Emanuel (2002) coded the E-PI as a FORTRAN subroutine, while Kerry Emanuel later converted it for use as a MATLAB function. Despite the widespread use of the E-PI theory, the codes in FORTRAN and MATLAB have not been well documented (Gilford, 2021). Due to the advantages of the Python programming language, Gilford (2021) recently developed the Tropical Cyclone Potential Intensity Calculations in Python (piPy) to implement the E-PI theory. Therefore, this work aims to implement the HuMPI model formulation in Python.

Statement of Need

The humpi Python package implements the HuMPI model for its extensive use in scientific research to understand the changes in TC intensity due to climate change.

Python implementation

humpi (v1.0) is written in Python v3.8 and uses the mpi4py package for parallel runs. The humpi package requires netCDF4, numpy, scipy, mpi4py, os, time and datetime packages. Similar to piPy, the run times of humpi will depend on the user's particular implementation and computing resources. Computing the maximum intensity of TCs with humpi requires the sea surface temperature as input. Below we provided the basic commands for humpi usage:

- For help

```
import humpi
humpi.help()
```

- To get HuMPI input parameters templete file

```
import humpi
humpi.get_HuMPI_inputs_template()
```

- To get HuMPI input data file for multiple runs

```
import humpi
humpi.get_HuMPI_input_data()
```

Additionally, you can use the basic implementation to run the HuMPI model, as indicated in the run_HuMPI.py script in the Github repository (https://github.com/apalarcon/HuMPI-master):

```
import humpi

args = humpi.read_args()
if args.HuMPI_help:
    humpi.help()
elif args.get_template:
    humpi.get_HuMPI_inputs_template()
elif args.get_input_data:
    humpi.get_HuMPI_input_data()
else:
    humpi.HuMPI_main(args.parameterfile)
```

- For help

```
python run_HuMPI.py -hh t
```

- For getting input paramters template

```
python run_HuMPI.py -gt t
```

- For getting input data file for multiples runs

```
python run_HuMPI.py -id t
```

- For running using MPI

```
mpiexec -n N python run_HuMPI.py -pf input_paramters_file
```

Example of humpi usage

In the 'example' subdirectory in the Github repository (https://github.com/apalarcon/HuMPI-master) of humpi we provided a real case for calculating de TC maximum potential intensity using humpi.

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