Introducing pyPI: Tropical Cyclone Potential Intensity Calculations in Python

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Description & Motivation

pyPI is a Python package developed to calculate/document tropical cyclone (TC) potential intensity (PI), adapted from the Bister and Emanuel (2002) algorithm.

pyPI Goals:

- Supply a freely available and validated Python PI calculator
- Document the PI algorithm and its Python implementation
- Demonstrate & encourage use of PI theory in TC analyses

What is Potential Intensity?

PI is a tropical cyclone's maximum wind speed, found by treating it as a thermal heat engine

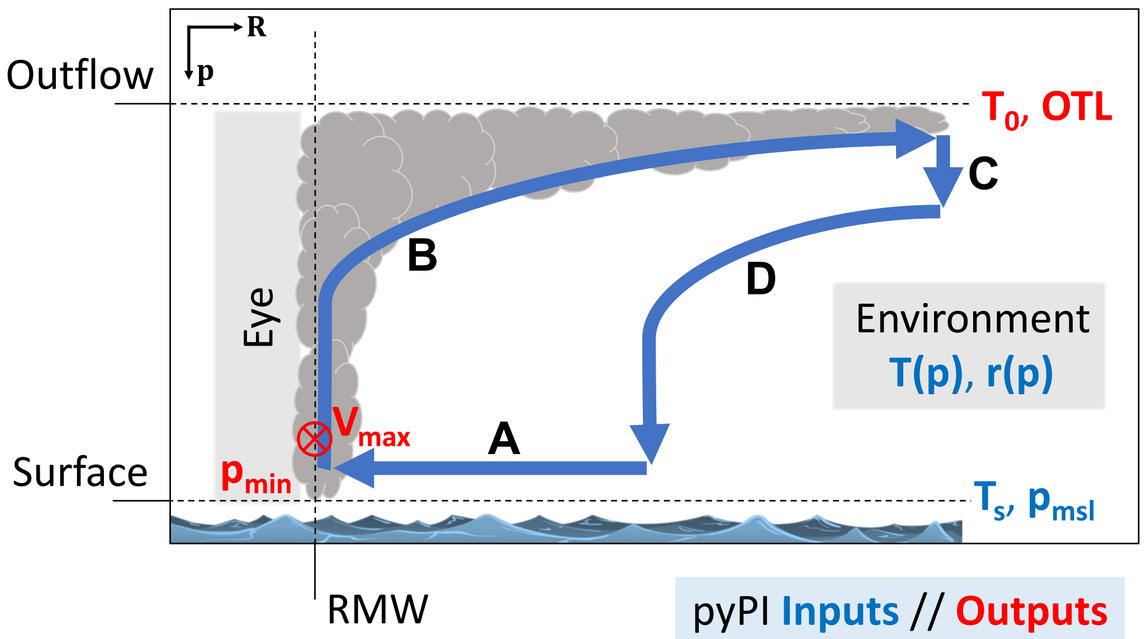
Input Profile:

- Temperatures (**T**) and water vapor mixing ratios (**r**) on a pressure grid (**p**)
- Sea surface temperatures (T_s), and mean sea-level pressures (p_{msl})

pyPI Outputs:

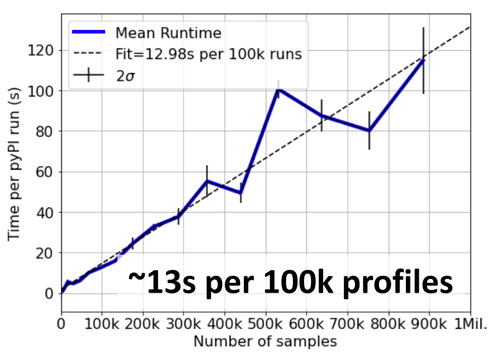
- Potential intensity (V_{max}/p_{min}), outflow temperature (T_0) and level (**OTL**)

The Carnot Cycle and Potential Intensity



pyPI **Inputs** // **Outputs**

Codebase, Runtime, & Validation



pyPI uses **numba** to optimize PI computations; climatological PI may be computed on gridded data using the **xarray** package

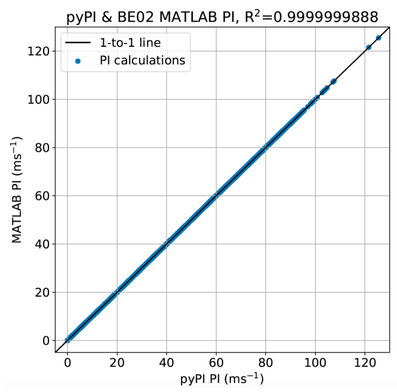
Avg. runtime for one year of monthly 0.25° x 0.25° ERA5 data is ~27 mins.

The pyPI Git repository includes the algorithm, utility files, sample run code, and example analyses in Jupyter notebooks

Validation:

pyPI code improves on the Bister and Emanuel (2002) formulation by fixing minor errors and offering consistent handling of missing data

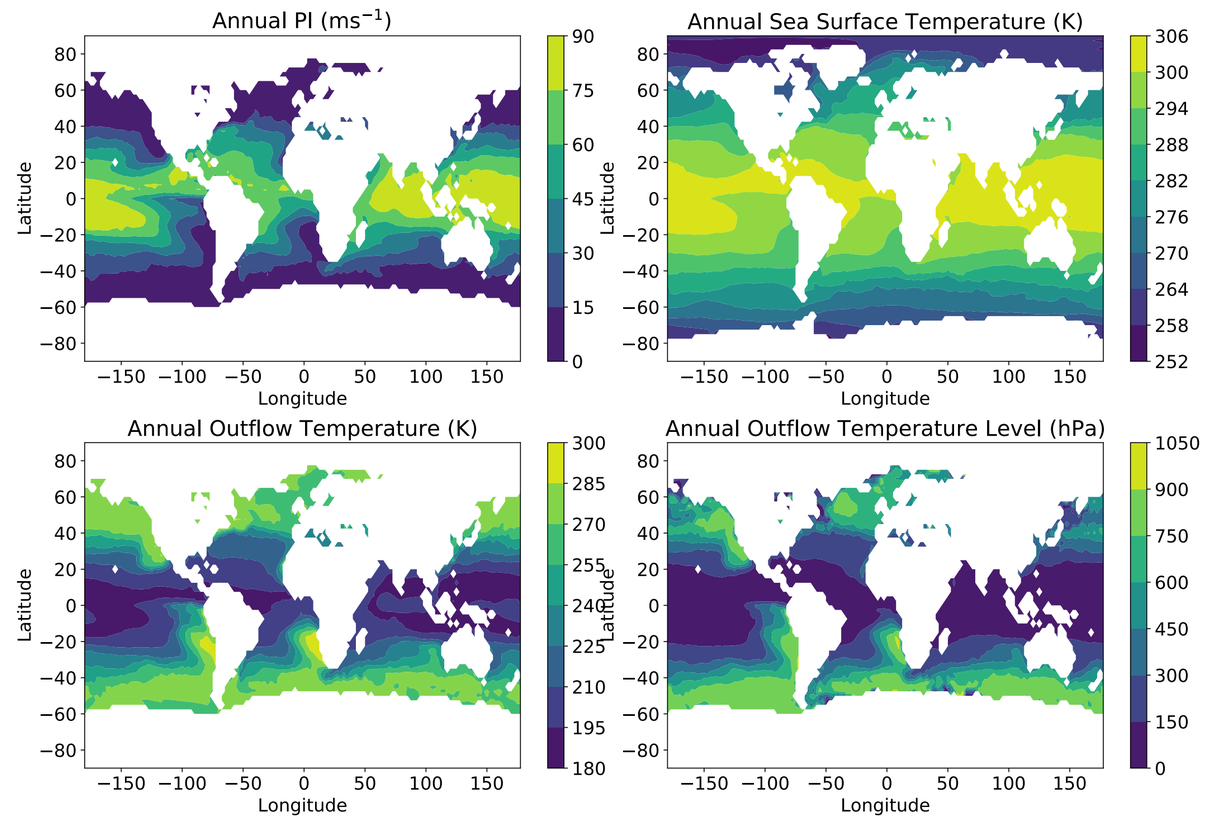
pyPI still strongly agrees with the original algorithm, R^2>0.999...



→ **pyPI is sufficiently accurate for TC research applications**

Example pyPI Analyses

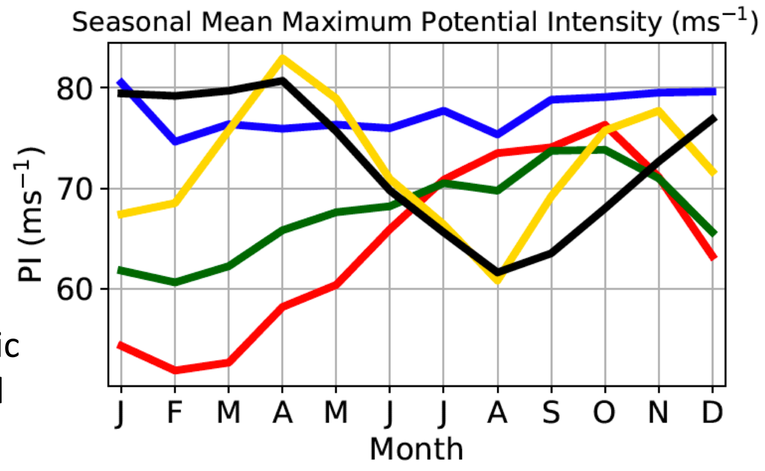
2004 Annual Mean Outputs from 2.5° x 2.5° MERRA2 Input Profiles:



Potential Intensity Seasonal Cycles:

Main Development Regions

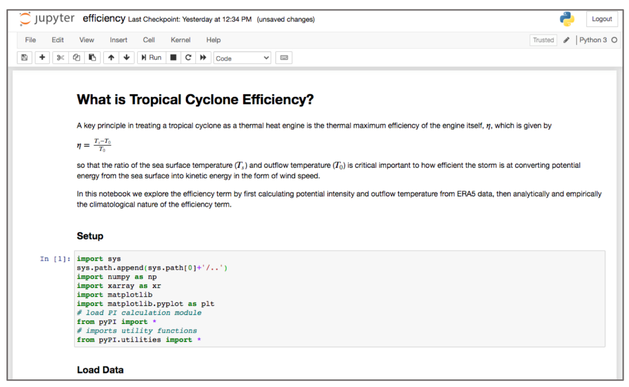
North Atlantic
Western North Pacific
Eastern North Pacific
North Indian
Southern Hemisphere



→ The Western North Pacific seasonal cycle is damped by warm boreal winter tropopause temperatures

see also Gilford et al. (2017)

pyPI as a Teaching Tool?



Combining Jupyter notebooks with pyPI, I am exploring the development of teaching tools for a Meteorology/Climatology course.

One such example can be found in the repository: **efficiency.ipynb**

Getting Started

Requirements and Dependencies

- pyPI requires **Python version** 3.7+, **NumPy** 1.18.1, and **Numba** 0.48.9 to run.

Installation

- Use the Python Package Index from the command line, type

```
> pip install tcpypi
```

If you have feedback on this project, please visit the Git repository or email me

Geosci. Model Dev.

Submitted to

Gilford 2020

Download/Discussion

Many thanks to Kerry Emanuel for encouragement & support for pyPI; Daniel Rothenberg for numba optimization; Dan Chavas, Jonathan Lin, and Raphael Rousseau-Rizzi for early feedback

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