Weather Research and Forecast (WRF) Scaling, Performance Assessment and Optimization

Comparison of Compilers and MPI Libraries on Cheyenne
NCAR SIParCS Program

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Outline

Background

WRF

WRF is a state-of-the-art atmospheric modeling system designed for both meteorological research and numerical weather prediction. It offers a host of options for atmospheric processes and can run on a variety of computing platforms. WRF excels in a broad range of applications across scales ranging from tens of meters to thousands of kilometers, including the following.

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– Earth system model coupling

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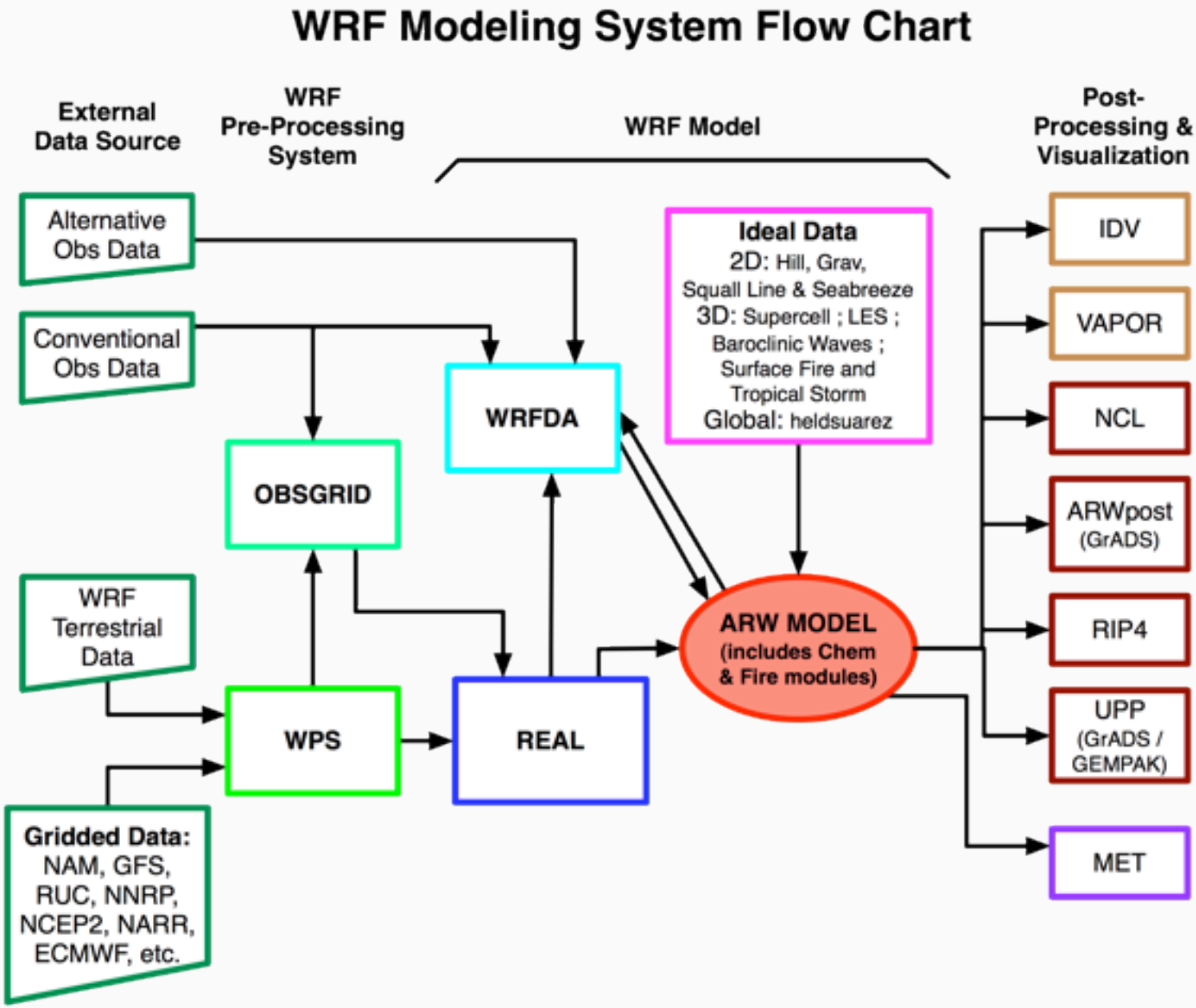
– Earth system model coupling

– Model training and educational support

Flowchart


WRF Modeling System Flow Chart
External Data Source
WRF Pre-Processing System
WRF Model
Post-Processing & Visualization
Alternative Obs Data
Conventional Obs Data
WRF Terrestrial Data
Gridded Data: NAM, GFS, RUC, NNRP, NCEP2, NARR, ECMWF, etc.
OBSGRID
WRFDA
WPS
REAL
Ideal Data
2D: Hill, Grav, Squall Line & Seabreeze
3D: Supercell ; LES ; Baroclinic Waves ; Surface Fire and Tropical Storm
Global: heldsuarez
ARW MODEL (includes Chem & Fire modules)
IDV
VAPOR
NCL
ARWpost (GrADS)
RIP4
UPP (GrADS / GEMPAK)
MET

Intro

Test cases

- `conus12km`
- `conus2.5km`
- `new_conus12km`
- `new_conus2.5km`
- `katrina1km`
- `katrina3km`
- `maria1km`
- `maria3km`

Compilers and MPI Libraries

- GNU Compiler Collection (GCC) versions 6.3.0, 8.1.0
  - WRF compiles with -O2 default
    - Tried -O3 and -mfma (enables FMA instruction set)
    - Use -ofast?
- Intel Compiler versions 17.0.1, 18.0.1
- MPT, MVAPICH

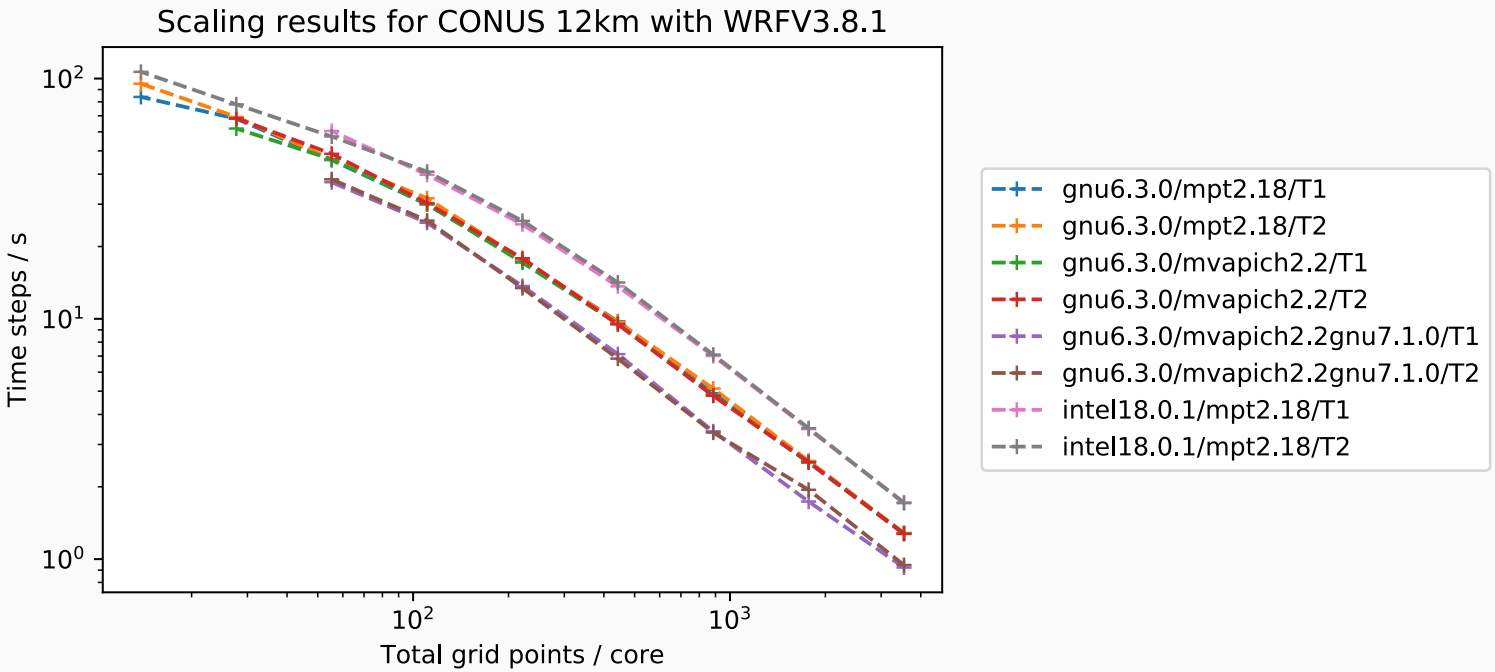
Settings

- MVAPICH

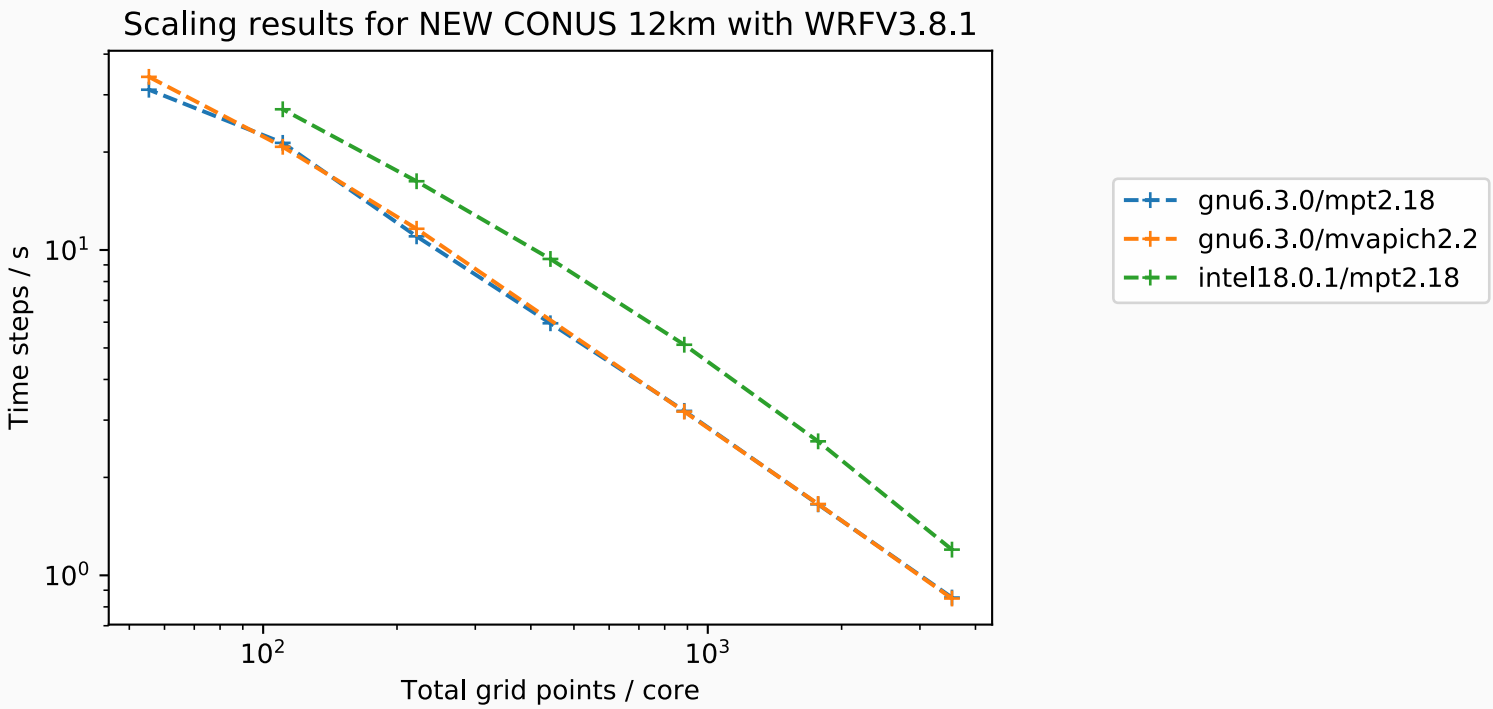
`http://mvapich.cse.ohio-state.edu/static/media/mvapich/mvapich2-2.3rc2-userguide.html#x1-19100011.15`

Results

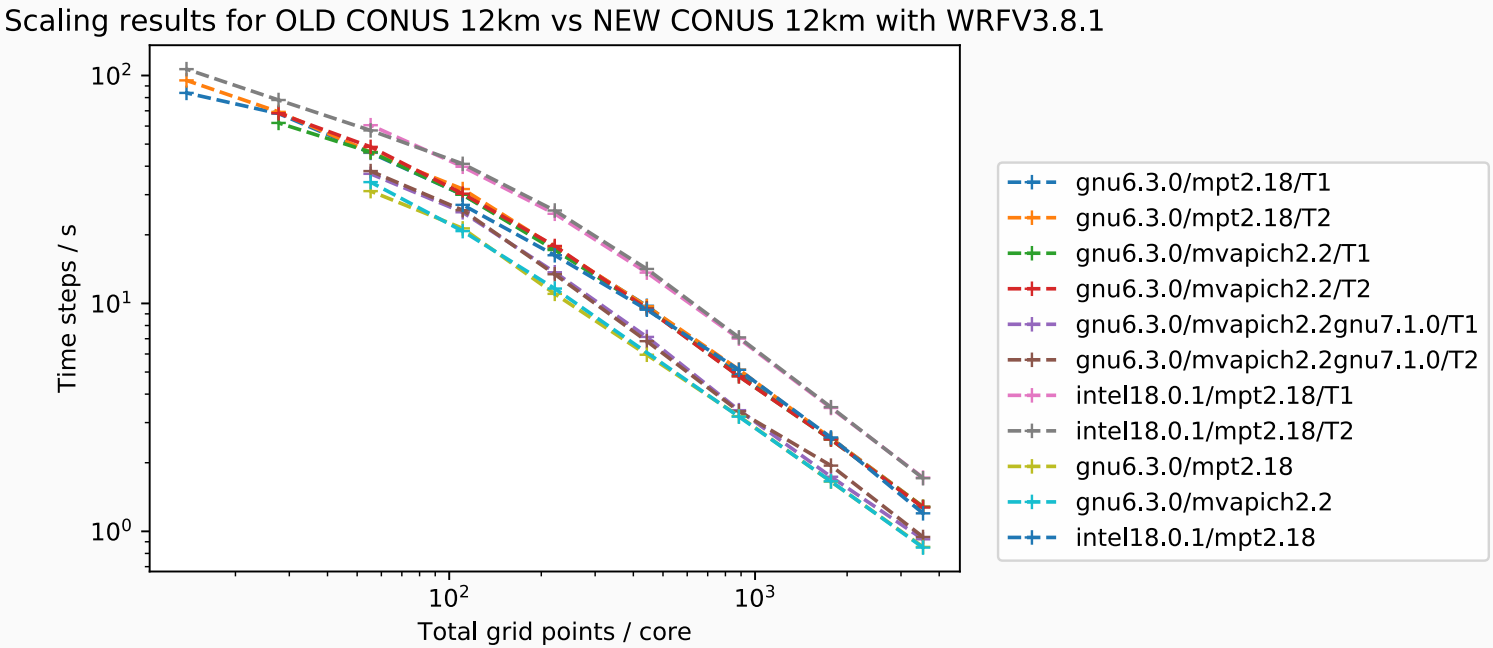
CONUS 12km


Scaling results for CONUS 12km with WRFV3.8.1
Time steps / s
Total grid points / core
10^0
10^1
10^2
10^2
10^3
gnu6.3.0/mpt2.18/T1
gnu6.3.0/mpt2.18/T2
gnu6.3.0/mvapich2.2/T1
gnu6.3.0/mvapich2.2/T2
gnu6.3.0/mvapich2.2gnu7.1.0/T1
gnu6.3.0/mvapich2.2gnu7.1.0/T2
intel18.0.1/mpt2.18/T1
intel18.0.1/mpt2.18/T2

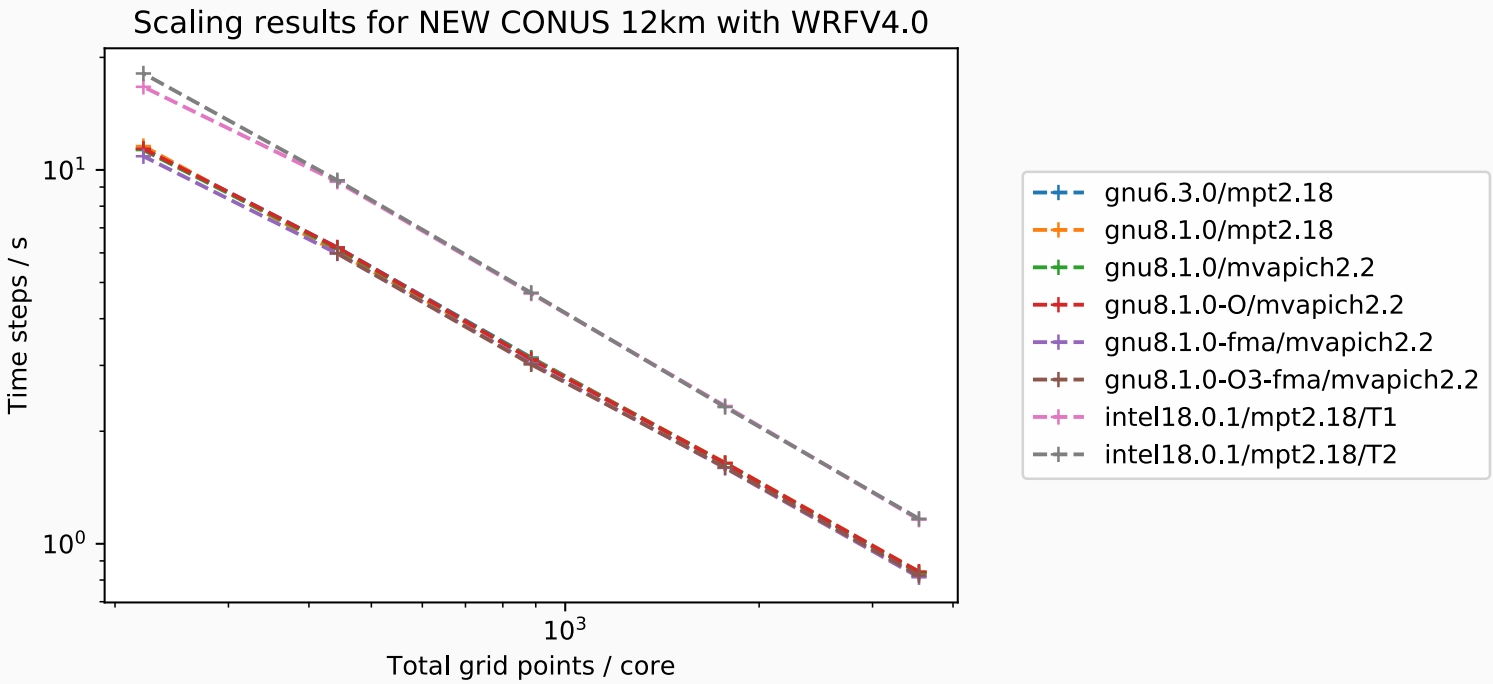
NEW CONUS 12km WRFV3.8.1



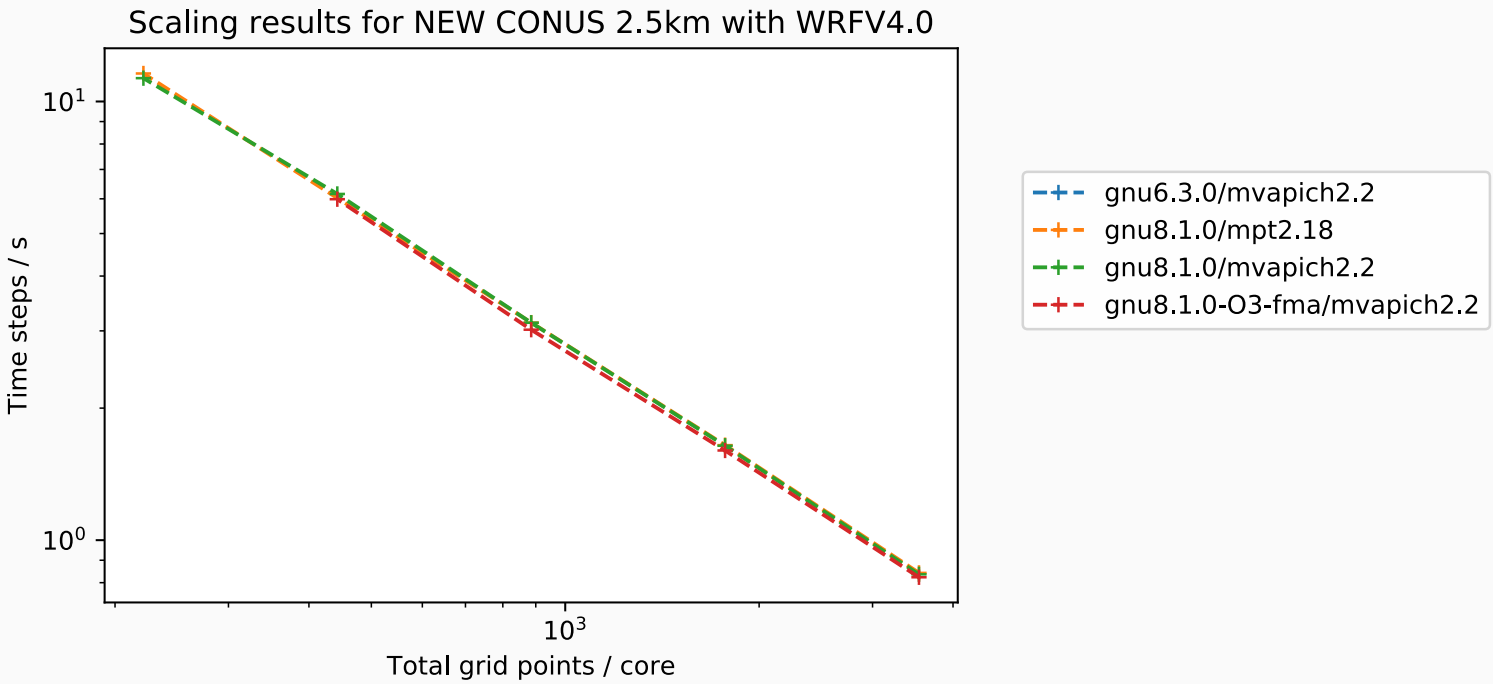
Old CONUS 12km vs New CONUS 12km WRFV3.8.1



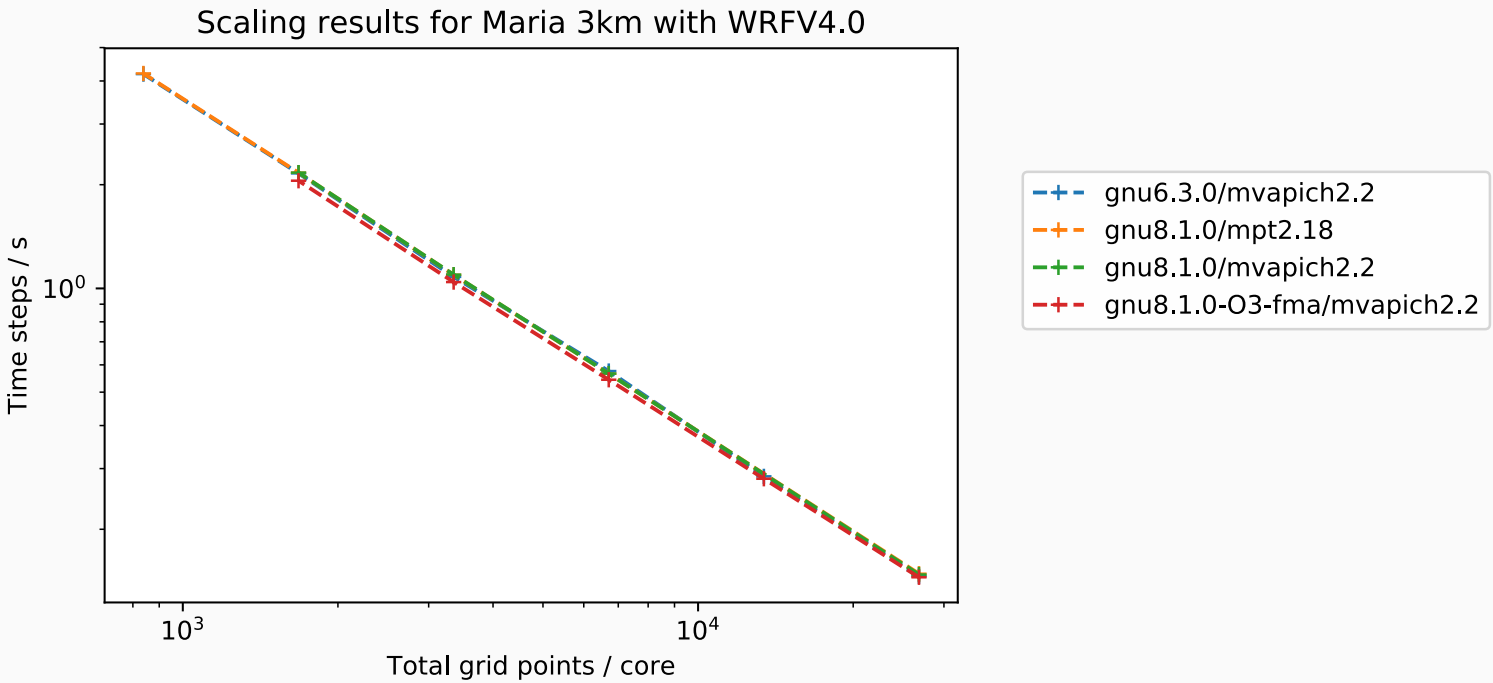
New CONUS 12km



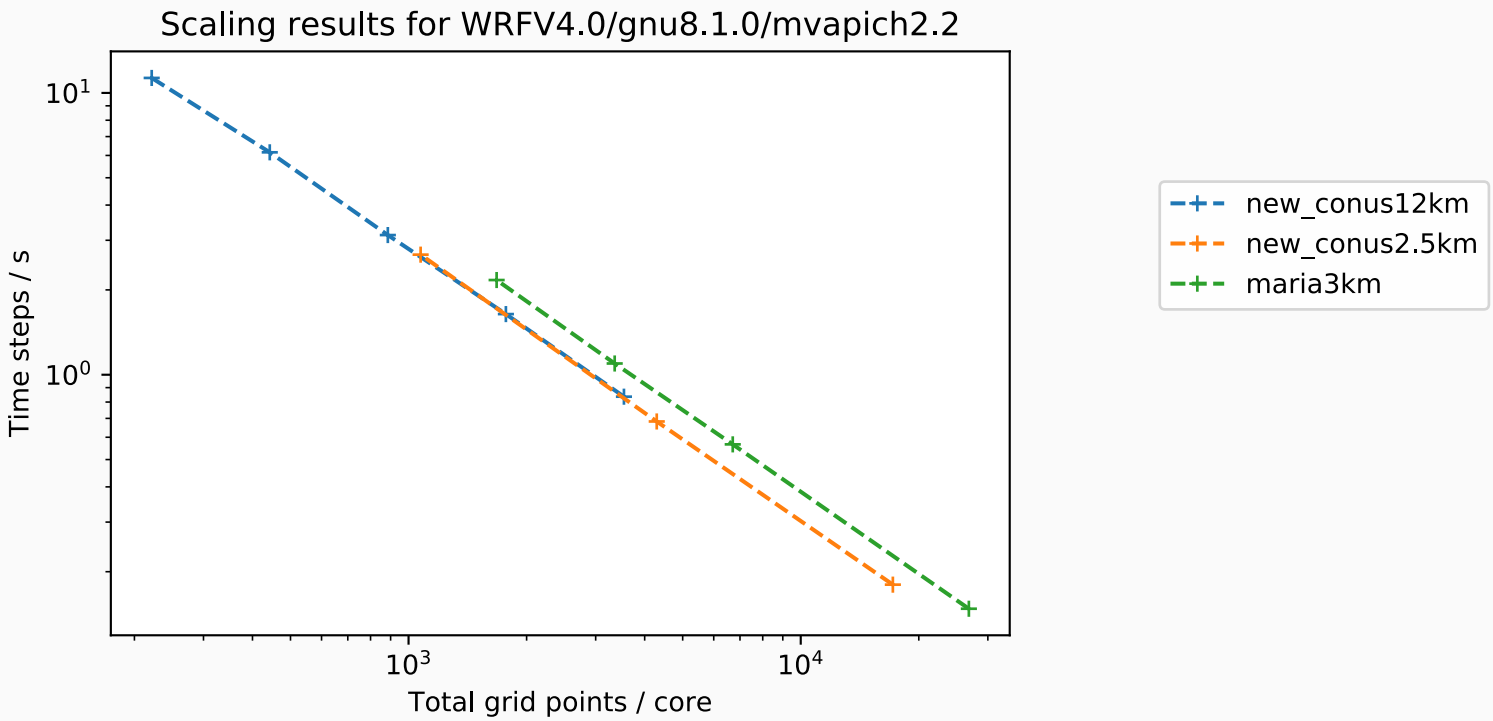
New CONUS 2.5km



Maria 3km


Scaling results for Maria 3km with WRFV4.0
Time steps / s
10^0
10^3
10^4
Total grid points / core
gnu6.3.0/mvapich2.2
gnu8.1.0/mpt2.18
gnu8.1.0/mvapich2.2
gnu8.1.0-O3-fma/mvapich2.2

Case comparison



Summary

Conclusions?

- Brownian motion begins with a random walk
- $\langle R_N^2 \rangle = NL^2$ can be related to physical quantities through forces
    - Randomness is very helpful: it allows us to average out a terms[1]

[1] The Feynman Lectures on Physics, Vol. I