GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

Karlsruhe Institute of Technology

Institute of Meteorology and Climate Research

Efficiency optimization in PALM-4U model setups – towards sustainable computing

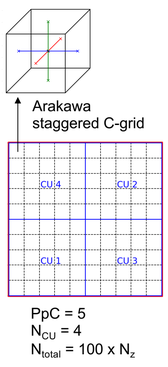
A simple method to optimize computational efficiency in parallelized gridded models

Christopher Claus Holst[1], Tobias Gronemeier[2]

The state-of-the-art micrometeorological process model system PALM consists of a turbulence-resolving large-eddy-simulation model and the PALM-4U urban components. PALM can be used to simulate atmospheric processes and fluxes of mass, energy, moisture and trace materials, including gas-phase and aerosol chemistry, radiative transfer and interactions the land-surface (urban, vegetation, soil, ocean).

Computation cost

- Number of grid points N_{total}
  - Domain size
  - Grid spacing
- Number of time steps $N_{timesteps}$
  - Simulated time
  - Time step length
- Operations per time step
  - Model complexity
  - Parametrizations

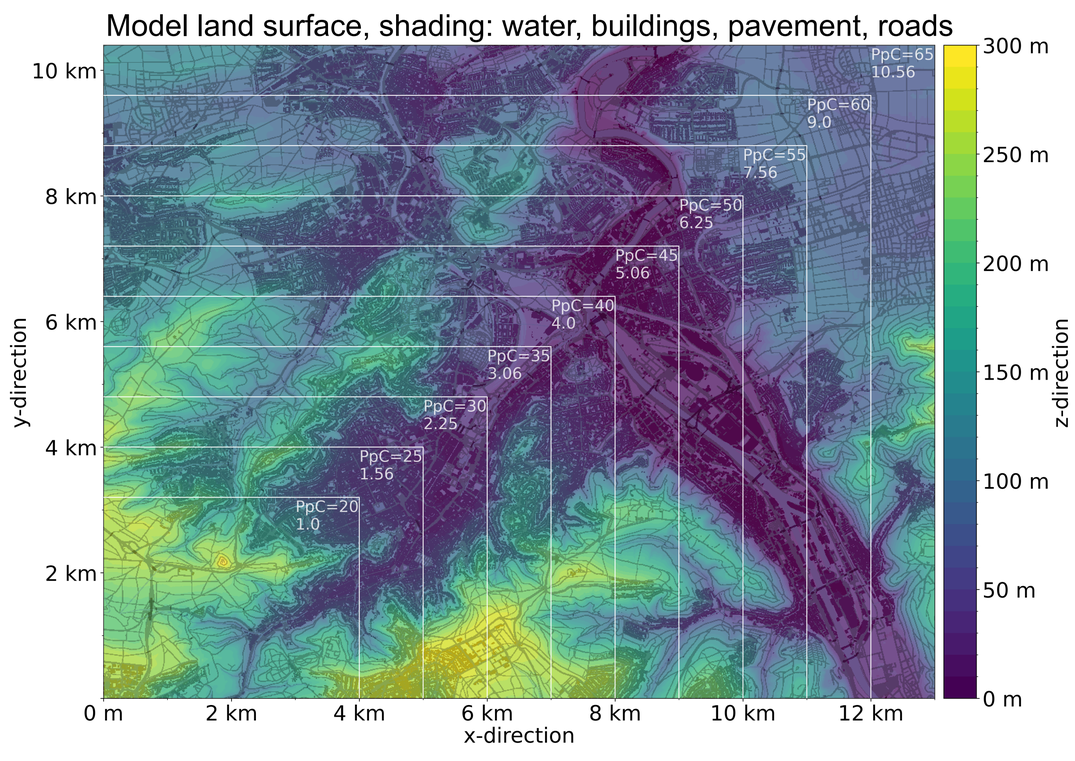


Parallelism in PALM

Each Compute Unit (CU) solves a horizontal tile of numerical grid points. Tiles are chosen to be square shaped.

Research Question

How to maximize the number of grid points processed per second CPU time (thus kWh)?



Computational Resources

- 4 Nodes (Intel Cascade Lake)
- N_{CU} = 320, N_{CUx} = 20, N_{CUy} = 16

Model Setup

- Meteorological test case
- Nocturnal shear flow in Stuttgart
- 60 minutes simulation time
- 10 metres grid spacing
- 240 vertical levels
- Radiative transfer, land surface, urban surface
- Simulation of wind, temperature, moisture

Computational Performance Metrics

Calculation rate

$$R := \frac{N_{timesteps}}{\text{run time}} \times \frac{N_{total}}{10^6}$$

i.e., the number of grid points processed per second (MHz)

Calculation speed

$$S := \frac{\text{simulated time}}{\text{run time}} \times \frac{N_{total}}{10^6}$$

i.e., the relative simulation time

Method

Vary PpC (grid Points per Compute unit in x-direction) to evaluate most feasible domain setup.

Results

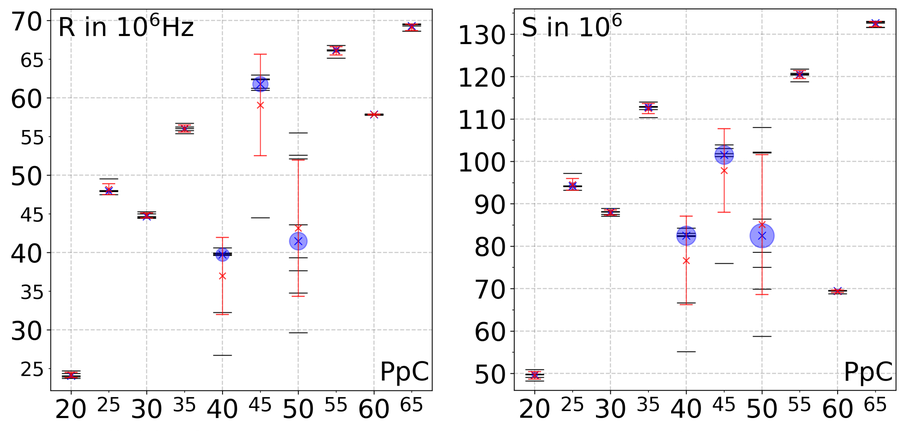
- Increases of R and S with PpC
- Observed increases substantially larger than expected
- Differences between even and odd PpC due to pressure solver
- Effect of ghost layers diminishes with $(PpC)^{-1}$ as expected
- Effects of networking bottle necks (shared infiniband router) can produce large spread

Meteorology IC/BC

3 ms^{-1} westerly flow
Ideal θ, q profiles
Initialization midnight

Lower BC

Realistic terrain
Buildings
Water
Pavement/roads
Vegetation



Individual runs, averages and standard deviations, medians

[1] Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research
Atmospheric Environmental Research
[2] Leibniz University Hannover, Institute of Meteorology and Climatology

Contact: christopher.holst@kit.edu

Scan me!

[UC]² Urban Climate Under Change
Stadtklima im Wandel

FONA
Forschung für Nachhaltigkeit

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research