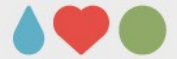


Hands-on Session

LES of wind turbine wakes with PALM

UNIVERSITY OF BERGEN





Goals

- Apply a state-of-the-art LES model (for the first time?)





Goals

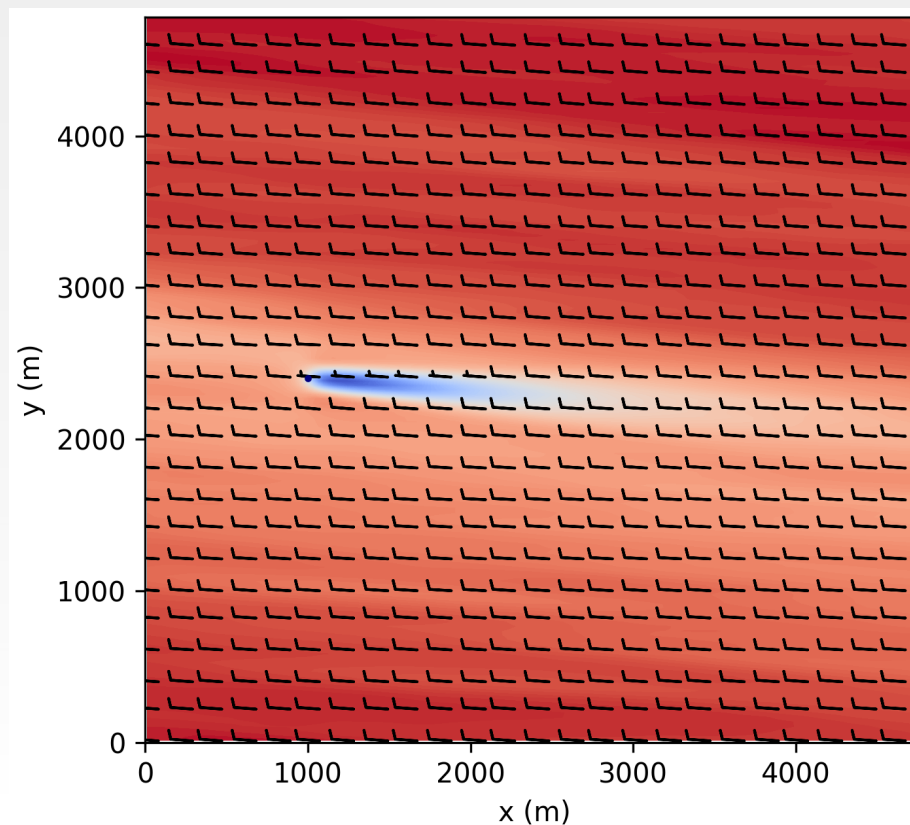
- Apply a state-of-the-art LES model (for the first time?)
- Study power yield of the NREL 5-MW Reference turbine under different environmental conditions (wind speed, wake interference, surface roughness, ...)

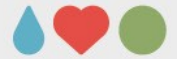




Questions to be answered

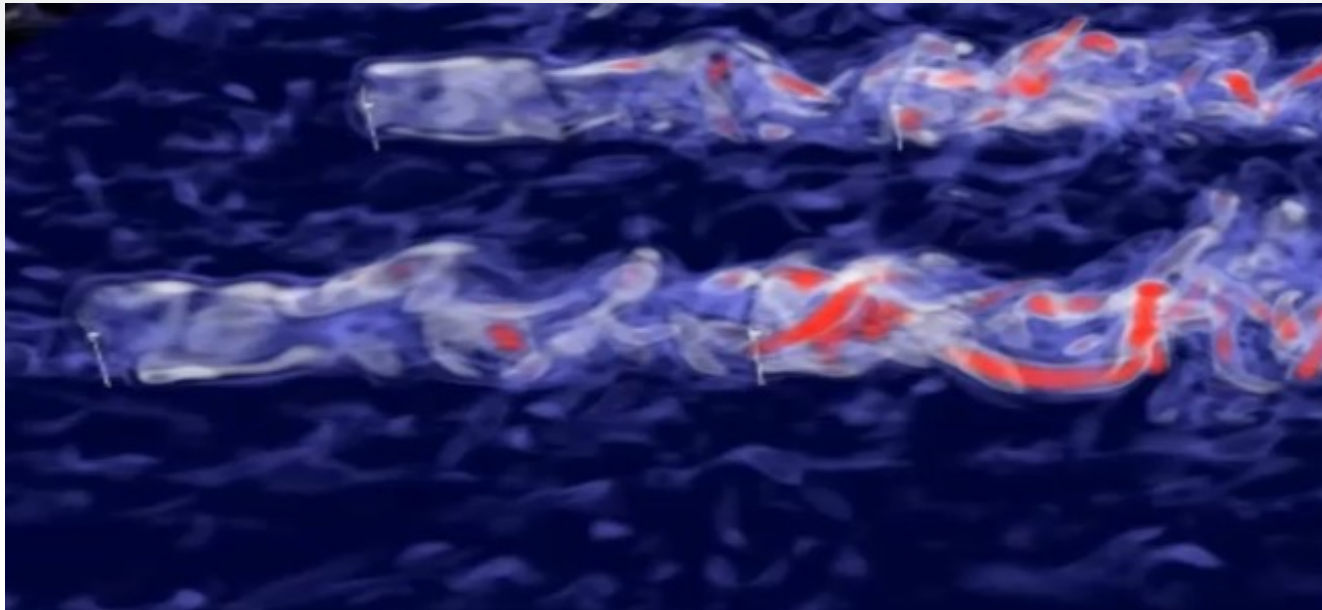
- What is the typical wake length of a wind turbine?

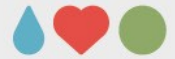




Questions to be answered

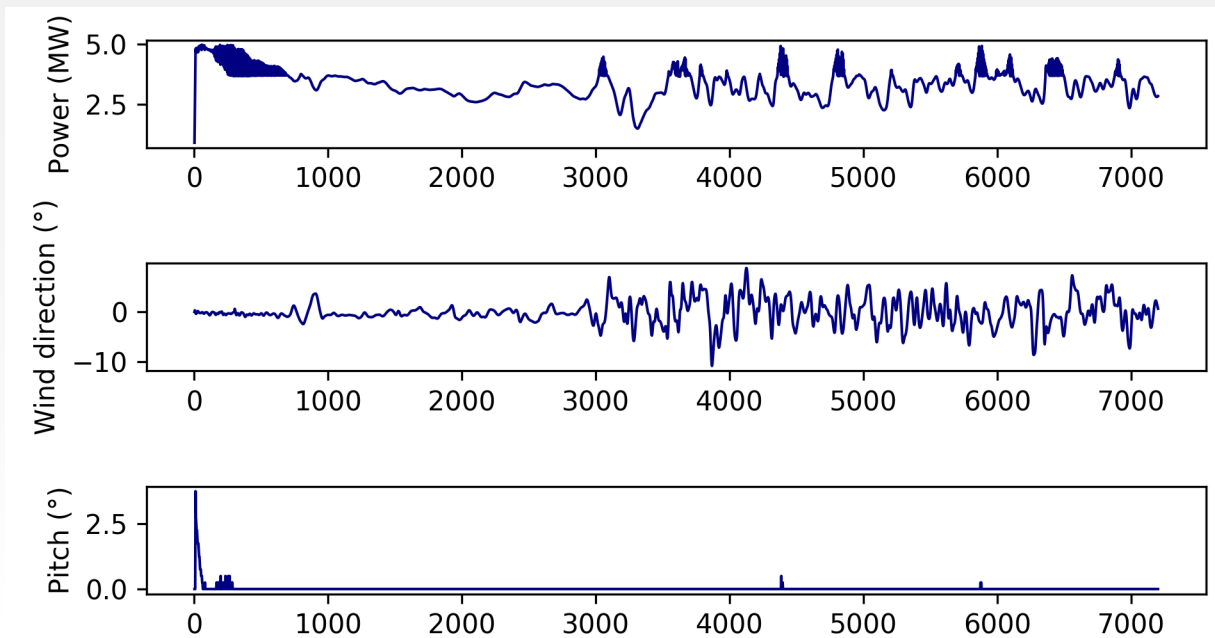
- What is the typical wake length of a wind turbine?
- How do wakes of multiple turbines interact and affect power yield?





Questions to be answered

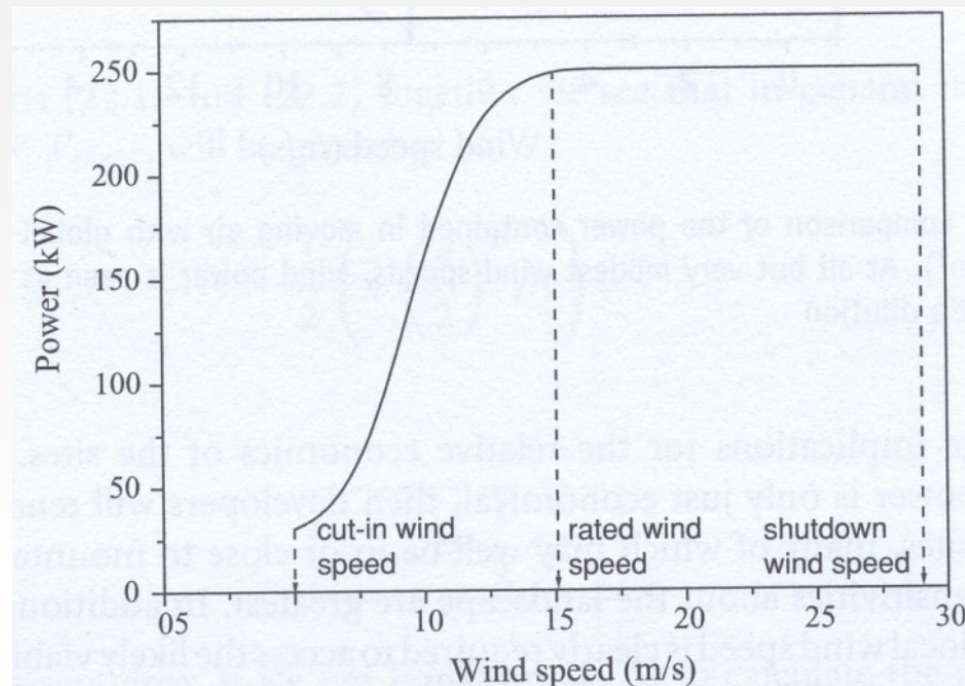
- What is the typical wake length of a wind turbine?
- How do wakes of multiple turbines interact and affect power yield?
- Can you relate power yield to pitch angle, wind speed, etc.?





Questions to be answered

- What is the typical wake length of a wind turbine?
- How do wakes of multiple turbines interact and affect power yield?
- Can you relate power yield to pitch angle, wind speed, etc.?
- Can you determine the power curve of the NREL 5 MW from LES data?





Schedule

- 15:30 – 15:45 How to get started and description of exercises
- 15:45 – 17:45 Hands-on session (exercises 1-3; 4 and 5 depending on available time)
- 17:45 – 18:00 Presentation of results





How to get started II

- All exercises will be performed on cluster *idefix* (64 cores) at Leibniz University Hannover, Germany
- PALM is pre-installed and ready-to-use
- Login to a Desktop PC in the pool room and open a terminal session

Anh Kiet Nguyen	um18629
Frank Agnar Maaø	um18630
Lutz Mütschard	um18631
Yuqing Chang	um18632
Patrick Raanes	um18633





How to get started II

- Login to idefix via SSH:

```
ssh YC4c aes192-ctr user@idefix.muk.uni-hannover.de
```

- *user*: see note on desktop (bow01-bow15)
- *password*: see note on desktop

- Change directory to `~palm/current_version`:

```
cd palm/current_version
```

- Open graphical user interface for PALM job submission script `palmrui`:

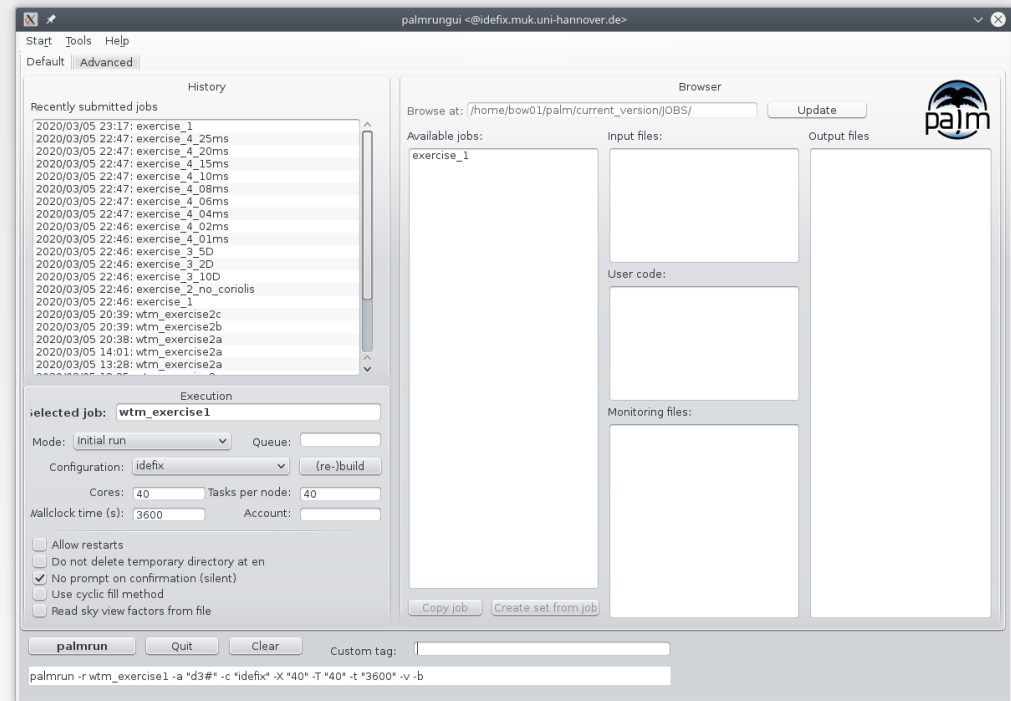
```
palmrui&
```





How to get started III

- A window should pop up:
- **Note:** windows will probably react slowly due to the SSH connection. Please be patient!
- Open a text editor of your choice (do not forget the '&'):
 - nano
 - vi / vim
 - kate (slower)



History of simulations (should be empty)

The screenshot shows the palmrun GUI with the following components:

- Window Title:** palmrun gui <@idefix.muk.uni-hannover.de>
- Menu:** Start Tools Help
- Tabs:** Default | Advanced
- History Panel:** Recently submitted jobs. A list of 20 simulation jobs is shown, including dates, times, and job names like 'exercise_1', 'exercise_4_25ms', etc. An arrow points to the first entry: '2020/03/05 23:17: exercise_1'.
- Execution Panel:** Selected job: wtm_exercise1. Mode: Initial run. Configuration: idefix. Cores: 40. Tasks per node: 40. Wallclock time (s): 3600.
- Browser Panel:** Browse at: /home/bow01/palm/current_version/OBS/. Available jobs: exercise_1. Input files, Output files, User code, and Monitoring files sections are empty.
- Buttons:** palmrun, Quit, Clear, Copy job, Create set from job.
- Terminal:** palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b

Available PALM setups

The screenshot shows the PALM GUI interface. At the top, the window title is "palmrungui <@idefix.muk.uni-hannover.de>". The menu bar includes "Start", "Tools", and "Help". Below the menu bar, there are tabs for "Default" and "Advanced".

The main interface is divided into several sections:

- History:** A list of "Recently submitted jobs" with columns for date, time, and job name. The list includes jobs like "exercise_1", "exercise_4_25ms", "exercise_4_20ms", etc.
- Execution:** A section for configuring the current job. It includes fields for "Selected job" (set to "wtm_exercise1"), "Mode" (set to "Initial run"), "Queue", "Configuration" (set to "idefix"), "Cores" (set to "40"), "Tasks per node" (set to "40"), "Wallclock time (s)" (set to "3600"), and "Account". There are also checkboxes for "Allow restarts", "Do not delete temporary directory at en", "No prompt on confirmation (silent)" (checked), "Use cyclic fill method", and "Read sky view factors from file".
- Browser:** A section for browsing available setups. It includes a "Browse at:" field with the path "/home/bow01/palm/current_version/OBS/" and an "Update" button. Below this is a list of "Available jobs:" with "exercise_1" highlighted in a blue box. There are also fields for "Input files:", "Output files:", "User code:", and "Monitoring files:". At the bottom of this section are buttons for "Copy job" and "Create set from job".

At the bottom of the GUI, there are buttons for "palmrun", "Quit", and "Clear", along with a "Custom tag:" field. A terminal window at the very bottom shows the command: `palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b`

Input files for the selected job

The screenshot shows the 'palmrun' GUI window. The title bar reads 'palmrun gui <@idefix.muk.uni-hannover.de>'. The interface is divided into several sections:

- History:** A list of 'Recently submitted jobs' with columns for date, time, and job name. The last entry is 'wtm_exercise1'.
- Execution:** A section for configuring the selected job. The 'Selected job:' field contains 'wtm_exercise1'. Other fields include 'Mode: Initial run', 'Queue:', 'Configuration: idefix', 'Cores: 40', 'Tasks per node: 40', 'Wallclock time (s): 3600', and 'Account:'. There are also checkboxes for 'Allow restarts', 'Do not delete temporary directory at end', 'No prompt on confirmation (silent)', 'Use cyclic fill method', and 'Read sky view factors from file'.
- Browser:** A section for file management. The 'Browse at:' field shows '/home/baw01/palm/current_version/OBS/'. Below it, 'Available jobs:' lists 'exercise_1'. The 'Input files:' section is highlighted with a blue box and an arrow from the title above. Other sections include 'Output files:', 'User code:', and 'Monitoring files:'. Buttons for 'Copy job' and 'Create set from job' are at the bottom.
- Footer:** A 'palmrun' button, 'Quit' and 'Clear' buttons, and a 'Custom tag:' field. A terminal-like window at the bottom shows the command: 'palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b'.

Output files for selected job (if any)

The screenshot shows the 'palm' GUI interface. At the top, the window title is 'palmrungi <@idefix.muk.uni-hannover.de>'. The interface is divided into several sections:

- History:** A list of 'Recently submitted jobs' with columns for date, time, and job name. The selected job is 'wtm_exercise1'.
- Execution:** Configuration options for the selected job, including Mode (Initial run), Queue, Configuration (idefix), Cores (40), Tasks per node (40), Wallclock time (3600), and Account.
- Browser:** A file browser section with a 'Browse at:' field containing '/home/bow01/palm/current_version/OBS/'. It includes an 'Update' button and a 'palm' logo.
- Available jobs:** A list of jobs, with 'exercise_1' selected.
- Input files:** A field for specifying input files.
- User code:** A field for specifying user code.
- Monitoring files:** A field for specifying monitoring files.
- Output files:** A large, empty blue rectangular area, which is the focus of the red arrow and the text 'Output files for selected job (if any)'. It is currently empty, indicating no output files are present for the selected job.

At the bottom, there are buttons for 'palmrun', 'Quit', and 'Clear', along with a 'Custom tag:' field. The command line at the very bottom reads: `palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b`

You can create new setups by copying existing ones

The screenshot displays the palmrun web interface. At the top, a title bar shows the browser address: `palmrungui <@idefix.muk.uni-hannover.de>`. The interface is divided into several sections:

- History:** A list of recently submitted jobs with columns for date, time, and job name. The list includes jobs like `exercise_1`, `exercise_4_25ms`, `exercise_4_20ms`, `exercise_4_15ms`, `exercise_4_10ms`, `exercise_4_08ms`, `exercise_4_06ms`, `exercise_4_04ms`, `exercise_4_02ms`, `exercise_4_01ms`, `exercise_3_5D`, `exercise_3_2D`, `exercise_3_10D`, `exercise_2_no_coriolis`, `exercise_1`, `wtm_exercise2c`, `wtm_exercise2b`, `wtm_exercise2a`, `wtm_exercise2a`, and `wtm_exercise2a`.
- Execution:** A section for configuring a job. The selected job is `wtm_exercise1`. The mode is set to `Initial run`, and the queue is empty. The configuration is `idefix`, with a `(re-)build` button. Cores are set to `40` and tasks per node to `40`. Wallclock time is `3600` seconds, and the account is empty. There are several checkboxes for execution options: `Allow restarts` (unchecked), `Do not delete temporary directory at en` (unchecked), `No prompt on confirmation (silent)` (checked), `Use cyclic fill method` (unchecked), and `Read sky view factors from file` (unchecked).
- Browser:** A section for browsing jobs. The browse path is `/home/bow01/palm/current_version/JOBS/`. The available jobs list contains `exercise_1`. There are sections for input files, output files, user code, and monitoring files, all of which are currently empty.
- Buttons:** At the bottom, there are buttons for `palmrungui`, `Quit`, and `Clear`. A custom tag field is also present. At the very bottom, a terminal-like window shows the command: `palmrungui -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b`.

An arrow points from the text "You can create new setups by copying existing ones" to the `Copy job` and `Create set from job` buttons in the available jobs section.

Open selected files via context dialog ("right mouse click")

The screenshot displays the palmrun GUI interface. At the top, the window title is "palmrun gui <@idefix.muk.uni-hannover.de>". The menu bar includes "Start", "Tools", and "Help". Below the menu bar, there are tabs for "Default" and "Advanced".

The interface is divided into several sections:

- History:** A list of "Recently submitted jobs" with columns for date, time, and job name. The list includes jobs like "exercise_1", "exercise_4_25ms", "exercise_4_20ms", etc.
- Execution:** A section for configuring the selected job. The "Selected job:" field contains "wtm_exercise1". Other fields include "Mode:" (Initial run), "Queue:", "Configuration:" (idefix), "(re-)build" button, "Cores:" (40), "Tasks per node:" (40), "Wallclock time (s):" (3600), and "Account:". There are also several checkboxes for options like "Allow restarts", "Do not delete temporary directory at en", "No prompt on confirmation (silent)", "Use cyclic fill method", and "Read sky view factors from file".
- Browser:** A section for browsing files. It includes a "Browse at:" field with the path "/home/bow01/palm/current_version//OBS/", an "Update" button, and a "palm" logo. Below this are sections for "Available jobs:" (listing "exercise_1"), "Input files:", "Output files:", "User code:", and "Monitoring files:". The "Input files:" and "Output files:" sections are highlighted with blue boxes, and arrows from the title point to these areas.

At the bottom, there are buttons for "palmrun", "Quit", and "Clear", along with a "Custom tag:" field. A terminal window at the very bottom shows the command: `palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b`

Settings for job execution

The screenshot shows the palmrun GUI interface. At the top, the window title is 'palmrun gui <@idefix.muk.uni-hannover.de>'. The main interface is divided into several sections:

- History:** A list of recently submitted jobs with their timestamps and names, such as '2020/03/05 23:17: exercise_1'.
- Browser:** A section for navigating to job directories, with a 'Browse at:' field containing '/home/bow01/palm/current_version/OBS/' and an 'Update' button. It also features the 'palm' logo.
- Available jobs:** A list of jobs available for execution, currently showing 'exercise_1'.
- Input files:** A field for specifying input files.
- Output files:** A field for specifying output files.
- User code:** A field for entering user code.
- Monitoring files:** A field for specifying files to be monitored.

The 'Execution' settings panel, highlighted by a black arrow, contains the following configuration:

- Selected job:** wtm_exercise1
- Mode:** Initial run
- Queue:** (empty)
- Configuration:** idefix
- (re-)build:** (button)
- Cores:** 40
- Tasks per node:** 40
- Wallclock time (s):** 3600
- Account:** (empty)
- Checkboxes:**
 - Allow restarts
 - Do not delete temporary directory at end
 - No prompt on confirmation (silent)
 - Use cyclic fill method
 - Read sky view factors from file

At the bottom of the GUI, there are buttons for 'palmrun', 'Quit', and 'Clear', along with a 'Custom tag:' field. The command line at the very bottom shows the execution command: `palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b`



- Use the following settings:
 - Configuration: idfix
 - Cores: 8 or 16, (64 will work but block all other participants)
 - Tasks per node: equal to cores
 - Wallclick time: 3600 (= 1 h)
 - Leave the rest untouched!

History

Recently submitted jobs

- 2020/03/05 23:17: exercise_1
- 2020/03/05 22:47: exercise_4_25ms
- 2020/03/05 22:47: exercise_4_20ms
- 2020/03/05 22:47: exercise_4_15ms
- 2020/03/05 22:47: exercise_4_10ms
- 2020/03/05 22:47: exercise_4_08ms
- 2020/03/05 22:47: exercise_4_06ms
- 2020/03/05 22:47: exercise_4_04ms
- 2020/03/05 22:46: exercise_4_02ms
- 2020/03/05 22:46: exercise_4_01ms
- 2020/03/05 22:46: exercise_3_5D
- 2020/03/05 22:46: exercise_3_2D
- 2020/03/05 22:46: exercise_3_10D
- 2020/03/05 22:46: exercise_2_no_coriolis
- 2020/03/05 22:46: exercise_1
- 2020/03/05 20:39: wtm_exercise2c
- 2020/03/05 20:39: wtm_exercise2b
- 2020/03/05 20:38: wtm_exercise2a
- 2020/03/05 14:01: wtm_exercise2a
- 2020/03/05 13:28: wtm_exercise2a

Execution

Selected job: **wtm_exercise1**

Mode: Initial run Queue:

Configuration: idfix (re-)build

Cores: 40 Tasks per node: 40

Wallclock time (s): 3600 Account:

Allow restarts

Do not delete temporary directory at en

No prompt on confirmation (silent)

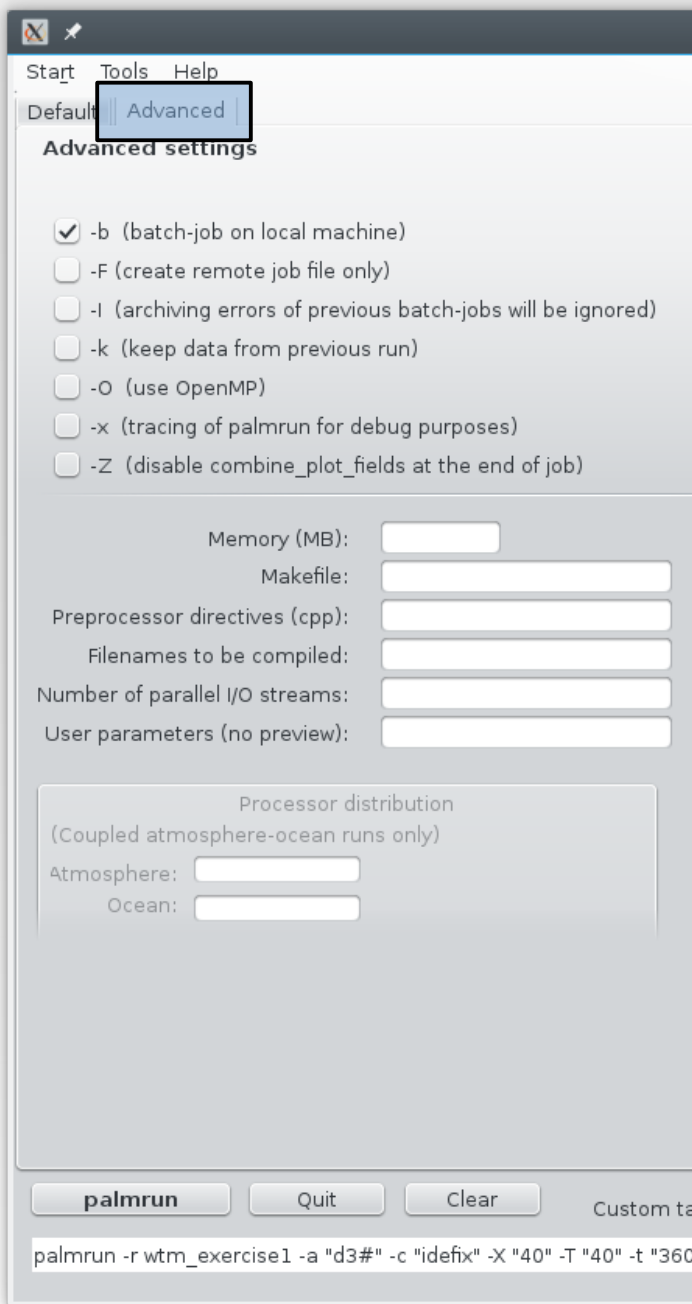
Use cyclic fill method

Read sky view factors from file

palmtree Quit Clear Custom tag:

```
palmtree -r wtm_exercise1 -a "d3#" -c "idfix" -X "40" -T "40" -t "3600" -v -b
```





- Use the following settings:
 - Configuration: idefix
 - Cores: 8 or 16, (64 will work but block all other participants)
 - Tasks per node: equal to cores
 - Wallclick time: 3600 (= 1 h)
 - Leave the rest untouched!
- Advanced tab:
 - Activate option -b





- Execute PALM (= send job to queuing system on idifix) via button **palmrn**
- The bottom line shows the palmrn command. You could also directly execute this command in the shell!
- palmrn will be executed in separate window:

```
...  
*** creating executable and other  
sources for the remote host  
*** nothing to compile for this run  
*** executable and other sources  
created  
  
*** submit the job  
1357.idifix  
  
--> palmrn finished  
  
--> Press enter to continue...
```

Start Tools Help

Default | **Advanced**

History

Recently submitted jobs

2020/03/05 23:17: exercise_1
2020/03/05 22:47: exercise_4_25ms
2020/03/05 22:47: exercise_4_20ms
2020/03/05 22:47: exercise_4_15ms
2020/03/05 22:47: exercise_4_10ms
2020/03/05 22:47: exercise_4_08ms
2020/03/05 22:47: exercise_4_06ms
2020/03/05 22:47: exercise_4_04ms
2020/03/05 22:46: exercise_4_02ms
2020/03/05 22:46: exercise_4_01ms
2020/03/05 22:46: exercise_3_5D
2020/03/05 22:46: exercise_3_2D
2020/03/05 22:46: exercise_3_10D
2020/03/05 22:46: exercise_2_no_coriolis
2020/03/05 22:46: exercise_1
2020/03/05 20:39: wtm_exercise2c
2020/03/05 20:39: wtm_exercise2b
2020/03/05 20:38: wtm_exercise2a
2020/03/05 14:01: wtm_exercise2a
2020/03/05 13:28: wtm_exercise2a

Execution

Selected job: **wtm_exercise1**

Mode: Initial run Queue:

Configuration: idifix (re-)build

Cores: 40 Tasks per node: 40

Wallclock time (s): 3600 Account:

Allow restarts
 Do not delete temporary directory at en
 No prompt on confirmation (silent)
 Use cyclic fill method
 Read sky view factors from file

palmrn Quit Clear Custom tag:

```
palmrn -r wtm_exercise1 -a "d3#" -c "idifix" -X "40" -T "40" -t "3600" -v -b
```



Wait for results in output file list...

Press Update button once in a while

The screenshot shows the palmrun GUI interface. At the top, there are two annotations: "Wait for results in output file list..." with an arrow pointing to the "Output files" panel, and "Press Update button once in a while" with an arrow pointing to the "Update" button. The interface includes a "History" panel on the left with a list of jobs, an "Execution" panel with configuration options, a "Browser" panel with a file path and an "Update" button, and three panels for "Available jobs", "Input files", and "Output files". The "Output files" panel is highlighted with a blue border. At the bottom, there are buttons for "palmrun", "Quit", and "Clear", along with a "Custom tag" field and a terminal window showing the command: `palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b`

Start Tools Help

Default | Advanced

History

Recently submitted jobs

- 2020/03/05 23:17: exercise_1
- 2020/03/05 22:47: exercise_4_25ms
- 2020/03/05 22:47: exercise_4_20ms
- 2020/03/05 22:47: exercise_4_15ms
- 2020/03/05 22:47: exercise_4_10ms
- 2020/03/05 22:47: exercise_4_08ms
- 2020/03/05 22:47: exercise_4_06ms
- 2020/03/05 22:47: exercise_4_04ms
- 2020/03/05 22:46: exercise_4_02ms
- 2020/03/05 22:46: exercise_4_01ms
- 2020/03/05 22:46: exercise_3_5D
- 2020/03/05 22:46: exercise_3_2D
- 2020/03/05 22:46: exercise_3_10D
- 2020/03/05 22:46: exercise_2_no_coriolis
- 2020/03/05 22:46: exercise_1
- 2020/03/05 20:39: wtm_exercise2c
- 2020/03/05 20:39: wtm_exercise2b
- 2020/03/05 20:38: wtm_exercise2a
- 2020/03/05 14:01: wtm_exercise2a
- 2020/03/05 13:28: wtm_exercise2a

Execution

Selected job: **wtm_exercise1**

Mode: Initial run Queue:

Configuration: idefix (re-)build

Cores: 40 Tasks per node: 40

Wallclock time (s): 3600 Account:

Allow restarts

Do not delete temporary directory at en

No prompt on confirmation (silent)

Use cyclic fill method

Read sky view factors from file

Browser

Browse at: /home/bow01/palm/current_version/jobs/ Update

Available jobs: exercise_1

Input files:

User code:

Monitoring files:

Output files

Copy job Create set from job

palmrun Quit Clear Custom tag:

```
palmrun -r wtm_exercise1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b
```

Use context menu to open output files with ncview

The screenshot displays the palmrun web interface. On the left, the 'History' panel lists recently submitted jobs. The 'Execution' panel shows details for the selected job 'exercise_1', including mode, configuration, and wallclock time. The 'Browser' panel shows the current directory and lists available jobs, input files, and output files. A context menu is open over the 'Output files' list, highlighting the file 'exercise_1_3d.000.nc'. The 'palmrun' logo is visible in the top right corner.

History

Recently submitted jobs

- 2020/03/06 09:20: exercise_1
- 2020/03/05 23:17: exercise_1
- 2020/03/05 22:47: exercise_4_25ms
- 2020/03/05 22:47: exercise_4_20ms
- 2020/03/05 22:47: exercise_4_15ms
- 2020/03/05 22:47: exercise_4_10ms
- 2020/03/05 22:47: exercise_4_08ms
- 2020/03/05 22:47: exercise_4_06ms
- 2020/03/05 22:47: exercise_4_04ms
- 2020/03/05 22:46: exercise_4_02ms
- 2020/03/05 22:46: exercise_4_01ms
- 2020/03/05 22:46: exercise_3_5D
- 2020/03/05 22:46: exercise_3_2D
- 2020/03/05 22:46: exercise_3_10D
- 2020/03/05 22:46: exercise_2_no_coriolis
- 2020/03/05 22:46: exercise_1
- 2020/03/05 20:39: wtm_exercise2c
- 2020/03/05 20:39: wtm_exercise2b
- 2020/03/05 20:38: wtm_exercise2a
- 2020/03/05 14:01: wtm_exercise2a

Execution

Selected job:

Mode: Queue:

Configuration: (re-)build

Cores: Tasks per node:

Wallclock time (s): Account:

Allow restarts

Do not delete temporary directory at en

No prompt on confirmation (silent)

Use cyclic fill method

Read sky view factors from file

Browser

Browse at: Update

Available jobs:

- exercise_1

Input files:

- exercise_1_p3d
- exercise_1_wtm

Output files:

- exercise_1_3d.000.nc
- exercise_1_av_3d.000.nc
- exercise_1_av_xy.000.nc
- exercise_1_pr.000.nc
- exercise_1_ts.000.nc
- exercise_1_wtm.000.nc
- exercise_1_xy.000.nc

User code:

Monitoring files:

- exercise_1_cpu.000
- exercise_1_header.000
- exercise_1_rc.000
- exercise_1_stdout.000

Copy job Create set from job

palmrun Quit Clear Custom tag:

```
palmrun -r exercise_1 -a "d3#" -c "idefix" -X "40" -T "40" -t "3600" -v -b
```



Using ncvview

Ncview 2.1.7 <@idefix.muk.uni-hannover.de>

PALM 6.0 Rev: 4445 run: exercise_1.00 host: idefix 2020-03-05 23:15:25

displaying ti
frame 1/12
displayed range: 0 to 0.354643 1/s
Current: (i=159, j=80) 0.0327765 (x=4785, y=2415)

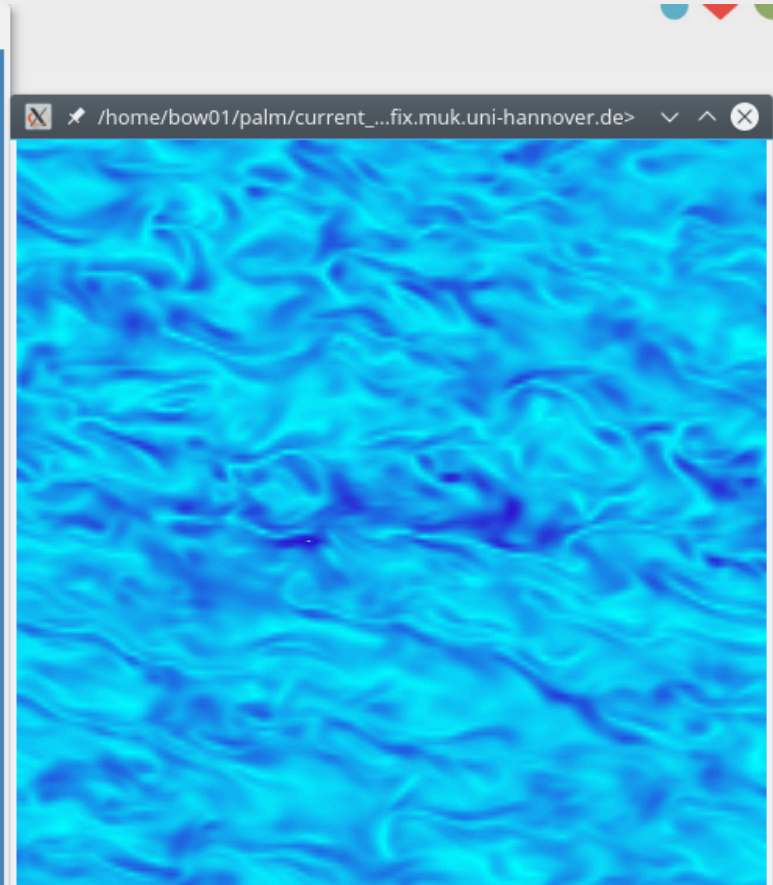
Quit ->1 << < || > >> Edit ? Delay: Opts

3saw Inv P Inv C M X3 Linear Axes Range Bi-lin Print

0 0.05 0.1 0.15 0.2 0.25 0.3 0.35

Var: E_UTM N_UTM Eu_UTM Nu_UTM
Ev_UTM Nv_UTM lon lat
lonu latu lonv latv
ti

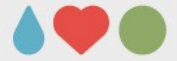
Din:	Name:	Min:	Current:	Max:	Units:
Scan:	time	600,77	7200,09	7200,09	seconds
	zu_3d	0	75	1579,56	meters
Y:	y	15	-Y-	4785	meters
X:	x	15	-X-	4785	meters



Color map

Plot size

Axes to show (e.g. xy, xz, yz)



Using ncvview

Click on the plot to get profiles

NCVIEW 2.1.1 <@idefix.muk.uni-hannover.de>

PALM 6.0 Rev: 4445 run: exercise_1.00 host: idefix 2020-03-05 23:15:25

displaying ti
frame 1/12
displayed range: 0 to 0.354643 1/s
Current: (i=159, j=80) 0.0327765 (x=4785, y=2415)

Qu ->1 << < <> >> Edit Delay: 0pts

3saw Inv P Inv C M X3 Linear Axes Range Bi-lin Print

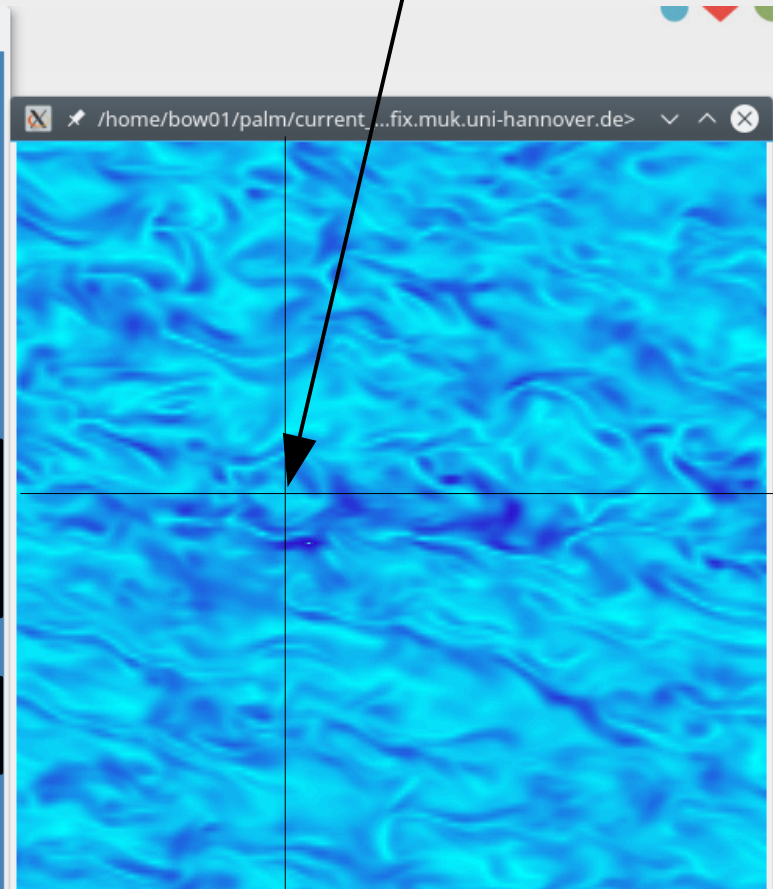
Var:

E_UTH	N_UTH	Eu_UTH	Nu_UTH
Ev_UTH	Nv_UTH	lon	lat
lonu	latu	lonv	latv
ti			

pick variable

Din:	Name:	Min:	Current:	Max:	Units:
Scan:	time	600.77	7200.09	7200.09	seconds
	zu_3d	0	75	1579.56	meters
Y:	y	15	-Y-	4785	meters
X:	x	15	-X-	4785	meters

Browse in time and space





Using plot_data

- Use ncview if you want to browse manually through output data
- For the hands-on workshop you may use the python script plot_data.py
- Go back to the terminal on idefix and navigate to ~/palm/current_version

```
cd ~/palm/current_version
```

- Run the plotting script

```
./plot_data.py jobname
```

where *jobname* has to be provided (e.g. 'exercise_1')

```
./plot_data.py exercise_1
```

- After the plots are created they should be displayed
- You also find them in ~/palm/current_version/plot/





Using plot_data

- You also find them in ~/palm/current_version/plot/ as png files

- Display via:

```
eog filename.png
```

or

```
display filename.png
```





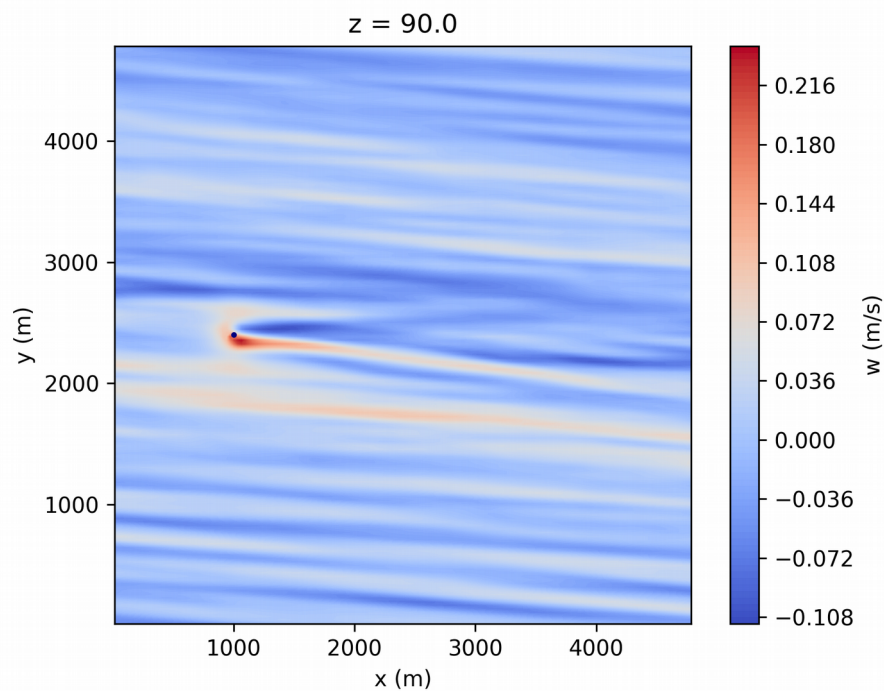
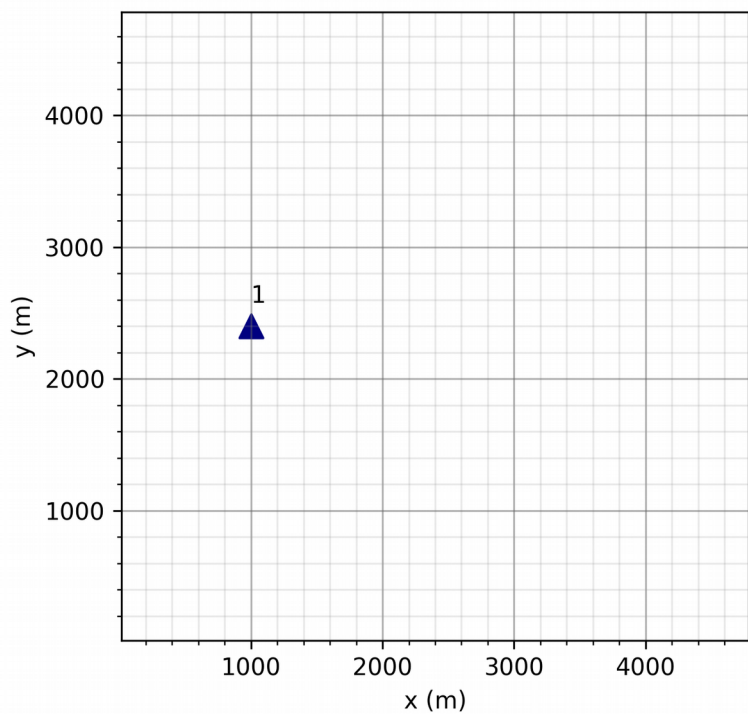
Exercise 1

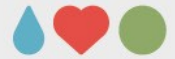
- LES of a single NREL 5-MW Reference turbine:
 - Hub height: $h = 90$ m
 - Blade diameter: $D = 126$ m
 - Rated power: 5 MW
- Location: FINO1
- Geostrophic wind speed: ~ 11 m/s
- Grid spacing: 30 m
- Cyclic horizontal boundary conditions
- Neutral boundary layer with capping inversion
- Roughness length (ocean): 0.001 m





Exercise 1

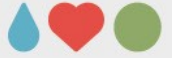




Exercise 1

- The setup for exercise_1 is already ready to run
- Follow the steps outlined on the previous slides to run PALM:
 - Start **palmrungui**
 - Select **exercise_1**
 - Review settings of palmrungui
 - Submit job via button **palmrn**
 - Wait for results (use **Update all** button to check for new output files)
 - Run plot_data.py to automatically create plots
 - Display plots
- Answer the question:
 - What is the length of the wind turbine wake?





Exercise 1: notes + hints

- After job submission you can monitor all running and queued jobs on idfix: `watch qstat`
- Depending on number of cores, your job might take a few minutes to finish
- If the graphical user interface is too slow, you can also work directly in the terminal:

```
palmsrun -r exercise_1 -a d3# -c idfix -X 16 -T 16 -t 3600 -b
```

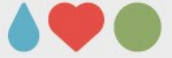
- Output files are stored in:

```
~/palm/current_version/JOBs/exercise_1/OUTPUT/
```

- Use ncview, e.g.:

```
ncview exercise_1_av_3d.000.nc
```

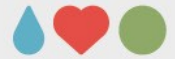




Exercise 2: no Coriolis force

- In exercise 1, the wind was not oriented to the numerical grid due to wind turning with height (Coriolis force)
 - > Difficult to place multiple turbines in the direct wake
- In exercise 2 we want to switch off the Coriolis force
- Step 1: create a new setup based on exercise 1:
 - Use **Copy job** button in palmrungi to create *exercise_2_no_coriolis*
- Step 2: Edit the input file *exercise_2_no_coriolis_p3d* (via context menu click)
 - Remove Coriolis force (*omega = 0.0*)
 - Change wind speed to 12 m/s from west (*ug_surface = 12.0*)
 - See https://palm.muk.uni-hannover.de/trac/wiki/doc/app/initialization_parameters
- Step 3: Use the same work flow as for exercise 1





Exercise 2: no Coriolis force

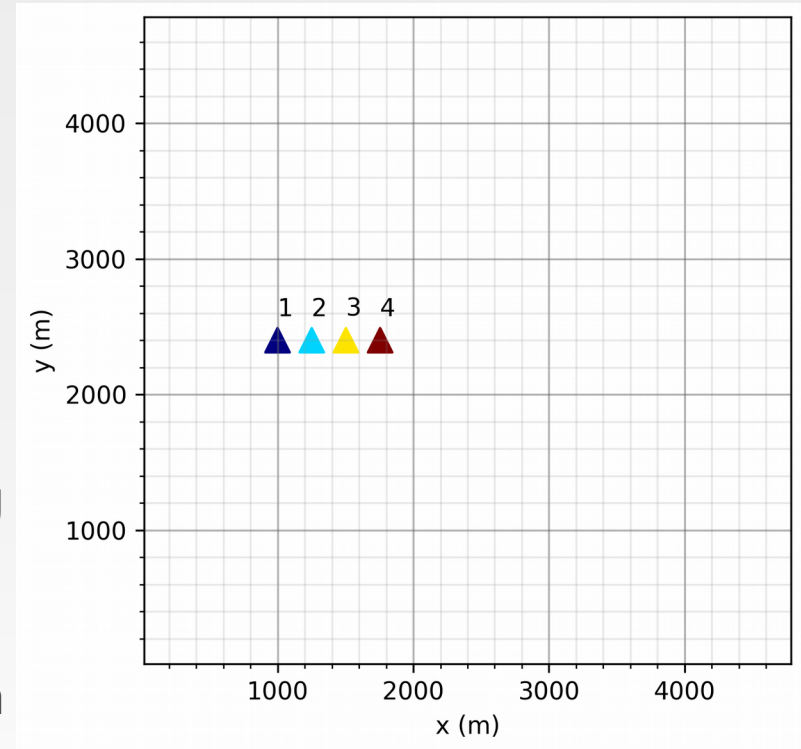
- Step 4: Compare results to exercise 1
- Answer the question:
 - Is the wake flow aligned to the numerical grid?
 - Does the power yield change?





Exercise 3: Multiple turbines

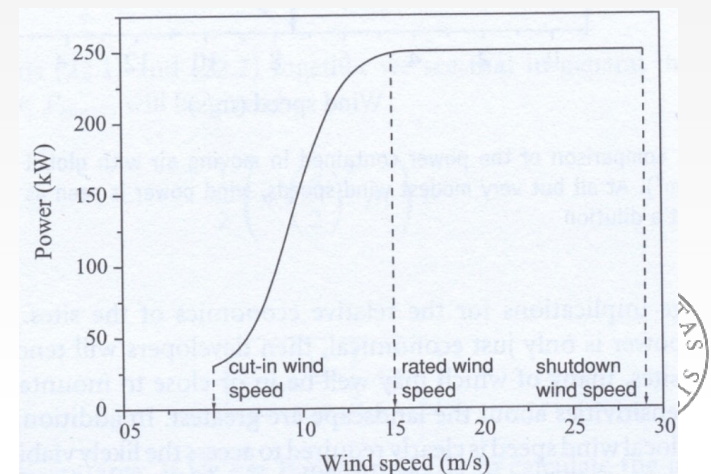
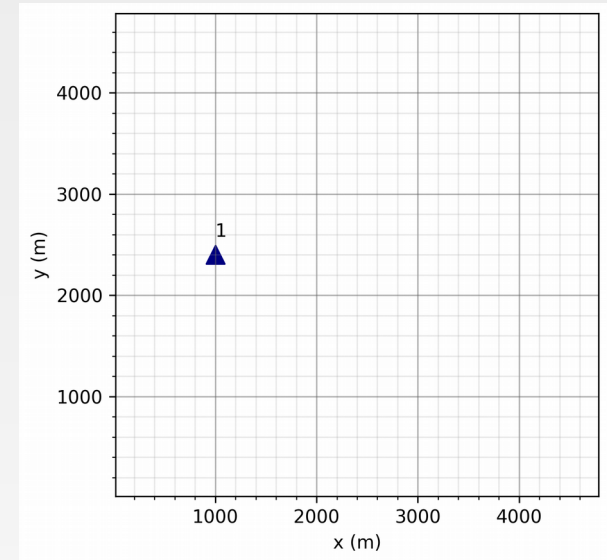
- Use exercise 2 as template
- Create a new setup with 4 turbines in a row
- Baseline simulation: distance between turbines of 2 D (252 m)
- Run baseline simulation
- Create a set of simulations with increasing distance between turbines (e.g. 5 D, 10 D, 20 D, ...)
- **Attention:** turbines must be located within the model domain!
- Answer the question:
 - Do you see power yield losses due to wake effects? Can you optimize the yield by increasing the distance?





Exercise 4: Wind speed dependence

- Use exercise 2 as template (single turbine)
- Create a new set of setups with varying wind speeds (1-25 m/s)
- Answer the questions:
 - Do you see a power yield dependence on wind speed?
 - How do pitch and power relate to each other (for different wind speeds)?
 - Can you determine the power curve of the NREL 5-MW?





Exercise 5: Surface roughness

- If there is time left...
- Create a set of simulations with varying surface roughness to mimic different ocean wave heights



