

WRF4G Intro

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Thanks to:

J. Fernández

C. Blanco

A.S. Cofiño

L. Fita

M. García-Díez



- Motivation
- WRF4G
 - Accessing distributed resources
 - Workflow
 - Experiment types
 - Side-products
 - Projects supporting WRF4G
- Conclusions

WRF experimental setup scen.

Reanalysis/Reforecasts/Hindcast

- High number ($\sim 10^4$) of independent simulations
- High volume of output-data (>TB)
- Requires **scalability**

Regional climate simulation

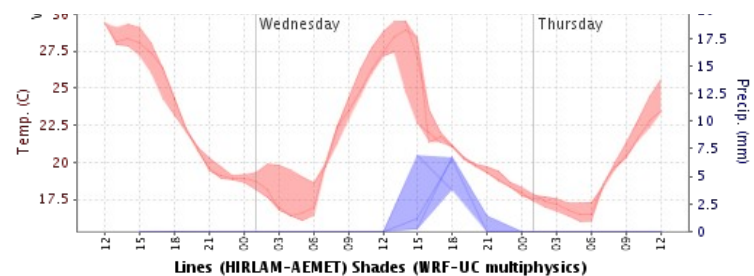
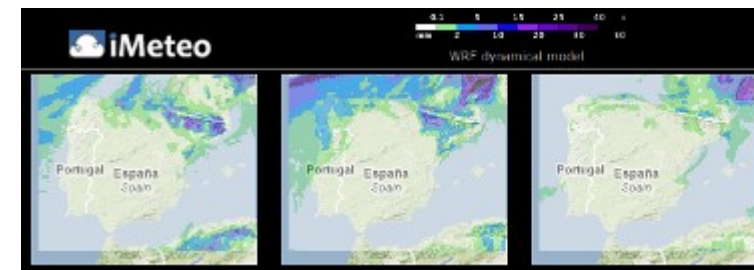
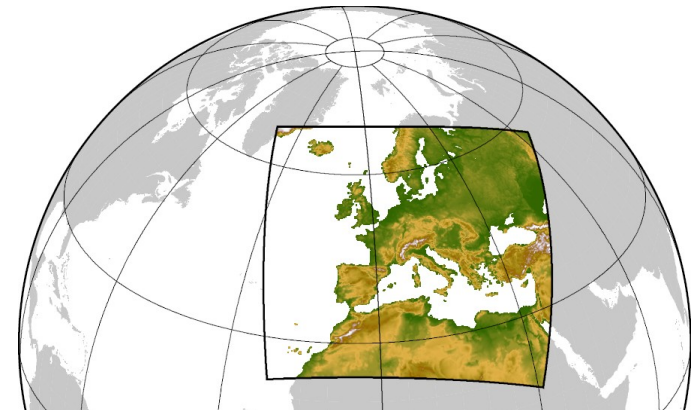
- Long, continuous simulations; weeks of walltime
- High volume of output data (>TB)
- Recovering system for **simulation restart**

Weather Forecasting

- QoS and optimal resources: **deadline for delivery**

Sensitivity/ensemble studies

- Physical schemes, initial conditions and boundary conditions: uncertainty sampling
- Resource demanding experiments composed of many **independent simulations**



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Examples: Santander MetGroup

Reanalysis/Reforecasts/Hindcast

- SEAWIND project
- 21 years of daily reforecasts (36h each)
- 7,665 independent simulations



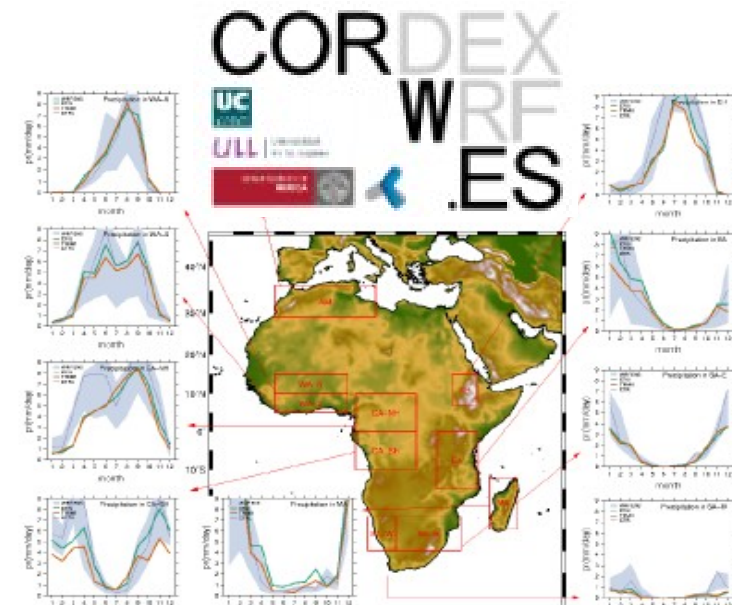
Regional climate simulation

- ESCENA project
- 50 years (continuous run, 28-day restarts)
- 650 dependent simulations



Sensitivity/ensemble studies

- CORWES project
- Physics sensitivity study for CORDEX-Africa
- 8-member ensemble of 5-year continuous simulations
- 8 independent groups of 65 dependent simulations



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Computer resource scenarios

Desktop/Laptop (UI)

- Low computational power and storage
- **User interface** to other computer resources



Workstation

- Multi-core, shared memory, moderate storage
- **ssh access**



Local group/institutional cluster

- Multi-node, distributed memory, large storage
- ssh access, **batch system** (PBS, SGE, ...) to submit jobs

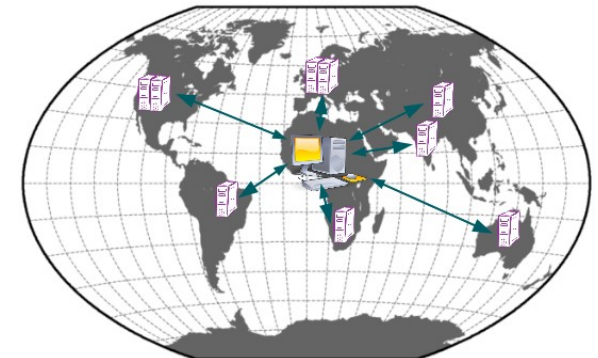


Mainframe/HPC site

- **Different architectures** and memory arrangements
- ssh or higher security access

Grid infrastructure

- “Cluster of clusters”, geographically distributed
- **Huge amount of computational power** and storage (not trivial to take advantage of it for meteo/climate apps)



WRF4G, developed by the Santander Meteorology Group, provides:

- Flexible WRF experiment **design, execution** and **monitoring**, and ...
- ... the ability of running these experiments on different computing resources at the same time in a **transparent** way.

It is, currently, a set of **command line tools** (Web interface planned)

WRF is **not installed in the host resources**. Binaries are transferred for each simulation.

The **output and log files are centralized** in a single repository

A broken experiment (due to a temporal failure of the resources) is **restarted by resubmitting the whole experiment**: only the unfinished simulations will be restarted from their last restart file

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- Flexible WRF experiment **design**, **execution** and **monitoring**, and ...
- ... the ability of running these experiments on different computing resources at the same time in a **transparent** way.

The only **dependencies to be met** by the host are:

- python (usually present, no need to install)

WRF4G, developed by the Santander Meteorology Group, provides:

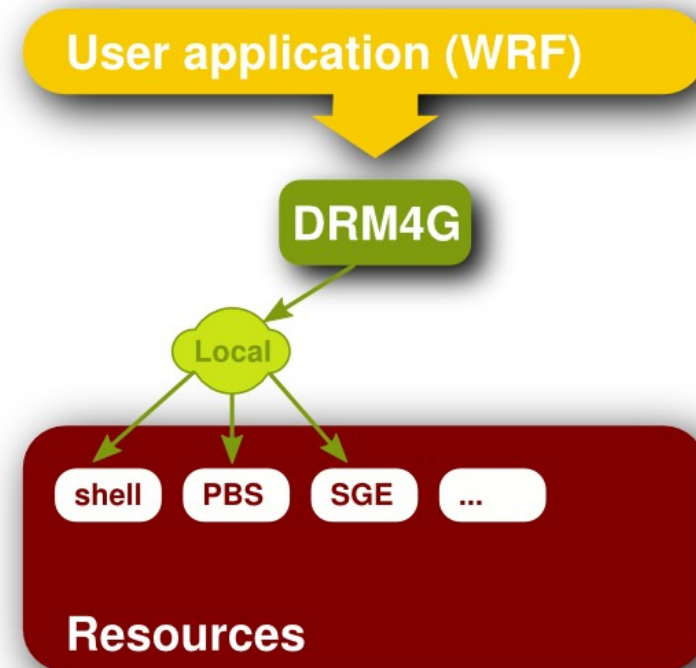
- Flexible WRF experiment **design**, **execution** and **monitoring**, and ...
- ... the ability of running these experiments on different computing resources at the same time in a **transparent** way.

Access to heterogeneous resources

DRM4G (Distributed Resource Manager) allows the user to **merge different computing resources** at hand in a transparent way:

Local resources (UI)

- Directly in a shell session
- Interacting with LRMS
 - PBS
 - SGE
 - SLURM
 - ...



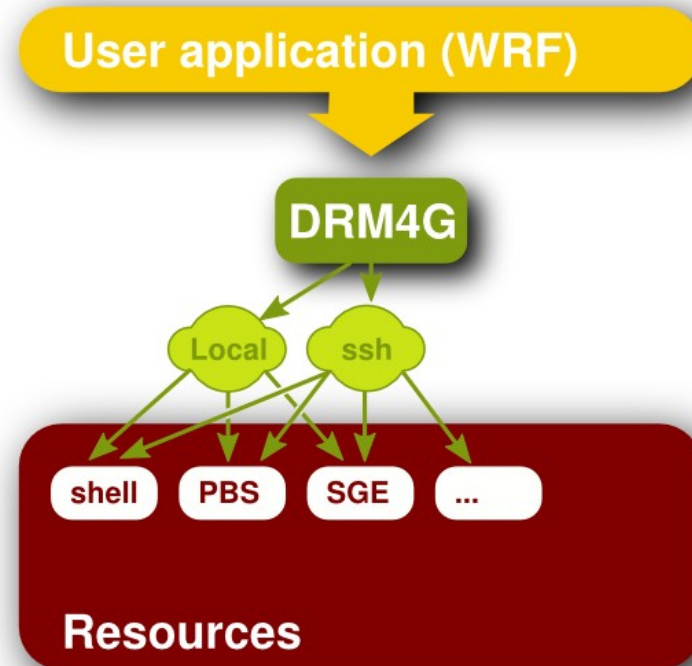
Access to heterogeneous resources

DRM4G (Distributed Resource Manager) allows the user to **merge different computing resources** at hand in a transparent way:

Local resources (UI)

Remote resources (via ssh)

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 - SLURM
 - ...



Access to heterogeneous resources

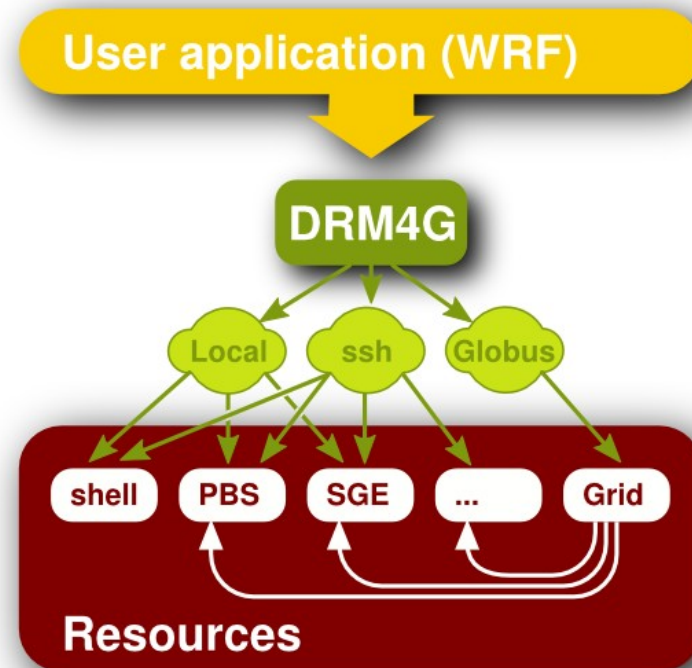
DRM4G (Distributed Resource Manager) allows the user to **merge different computing resources** at hand in a transparent way:

Local resources (UI)

Remote resources (via ssh)

Grid infrastructures (via Globus)

- Directly in a shell session
- Interacting with LRMS
 - PBS
 - SGE
 - SLURM
 - ...



Configuration files

wrf4gframework.conf

[Computing Resources]

```
mycomputer      local://localhost?  
                LRMS_TYPE=none;  
                NODECOUNT=1;
```



```
myworkstation  ssh://workstation.unican.es?  
                LRMS_TYPE=none;  
                NODECOUNT=16;
```



```
PBS_cluster    ssh://pbs.cluster.edu?  
                LRMS_TYPE=pbs;  
                QUEUE_NAME=long;  
                NODECOUNT=256;
```

```
SGE_cluster    ssh://sge.cluster.edu?  
                LRMS_TYPE=sge;  
                PROJECT=1.project;  
                NODECOUNT=256;
```

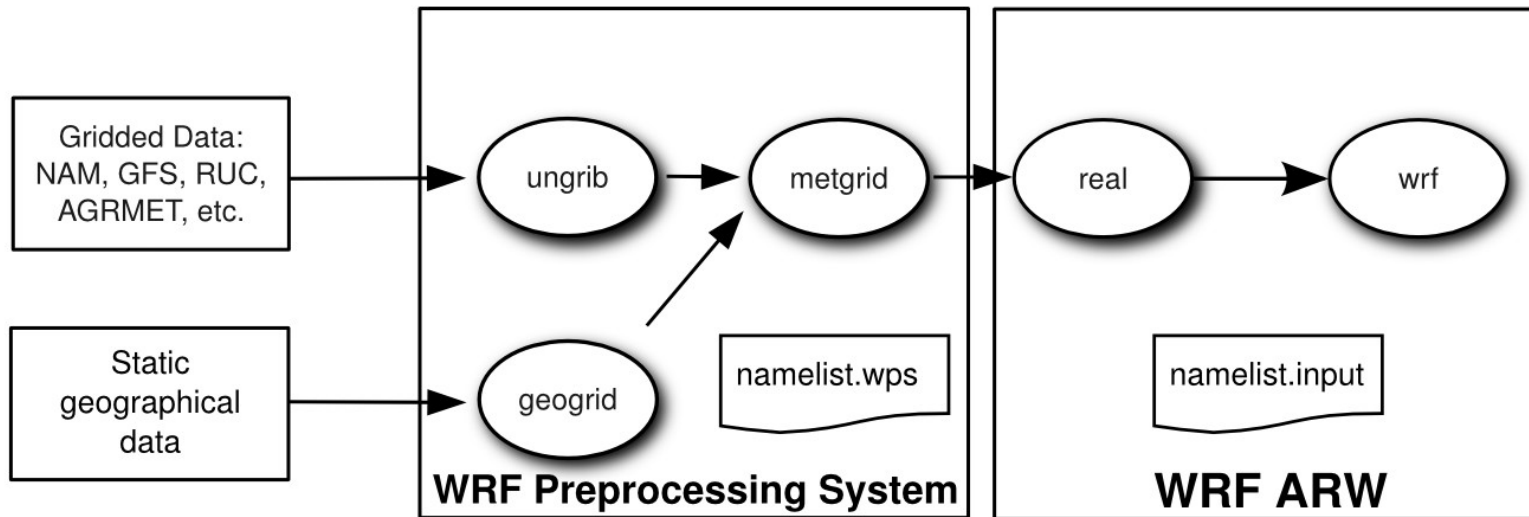


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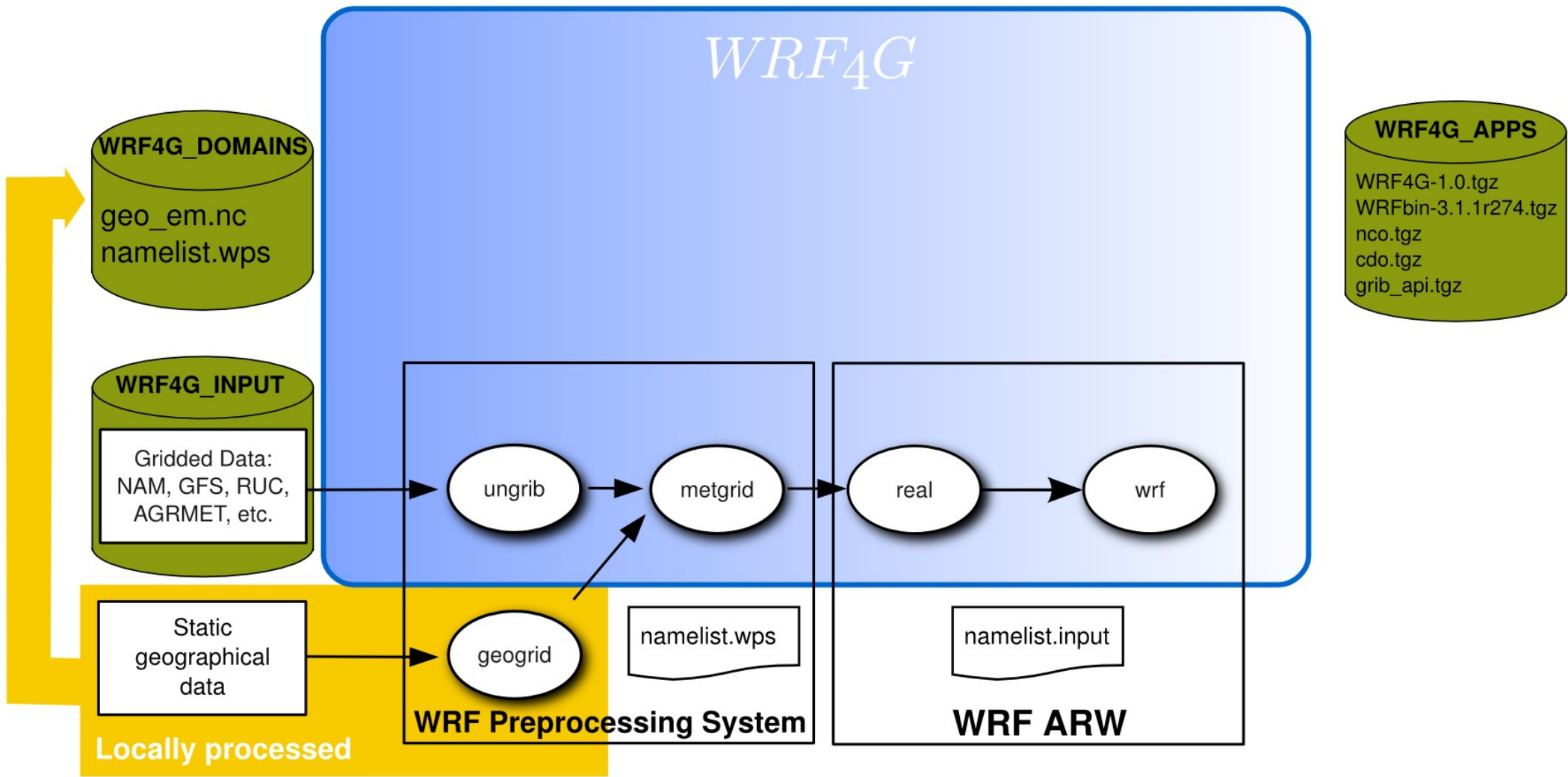


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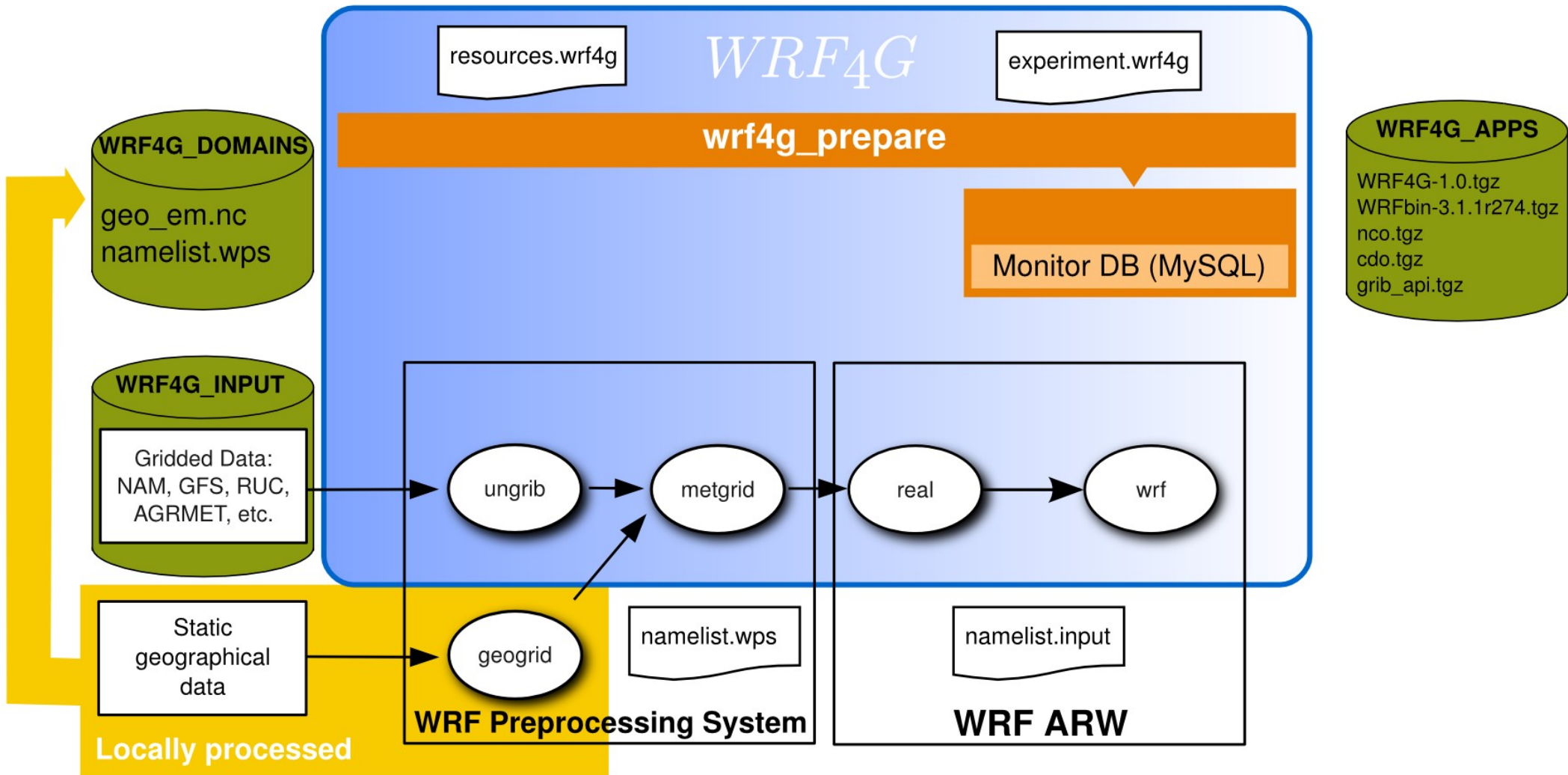
multidisciplinary approach to weather & climate

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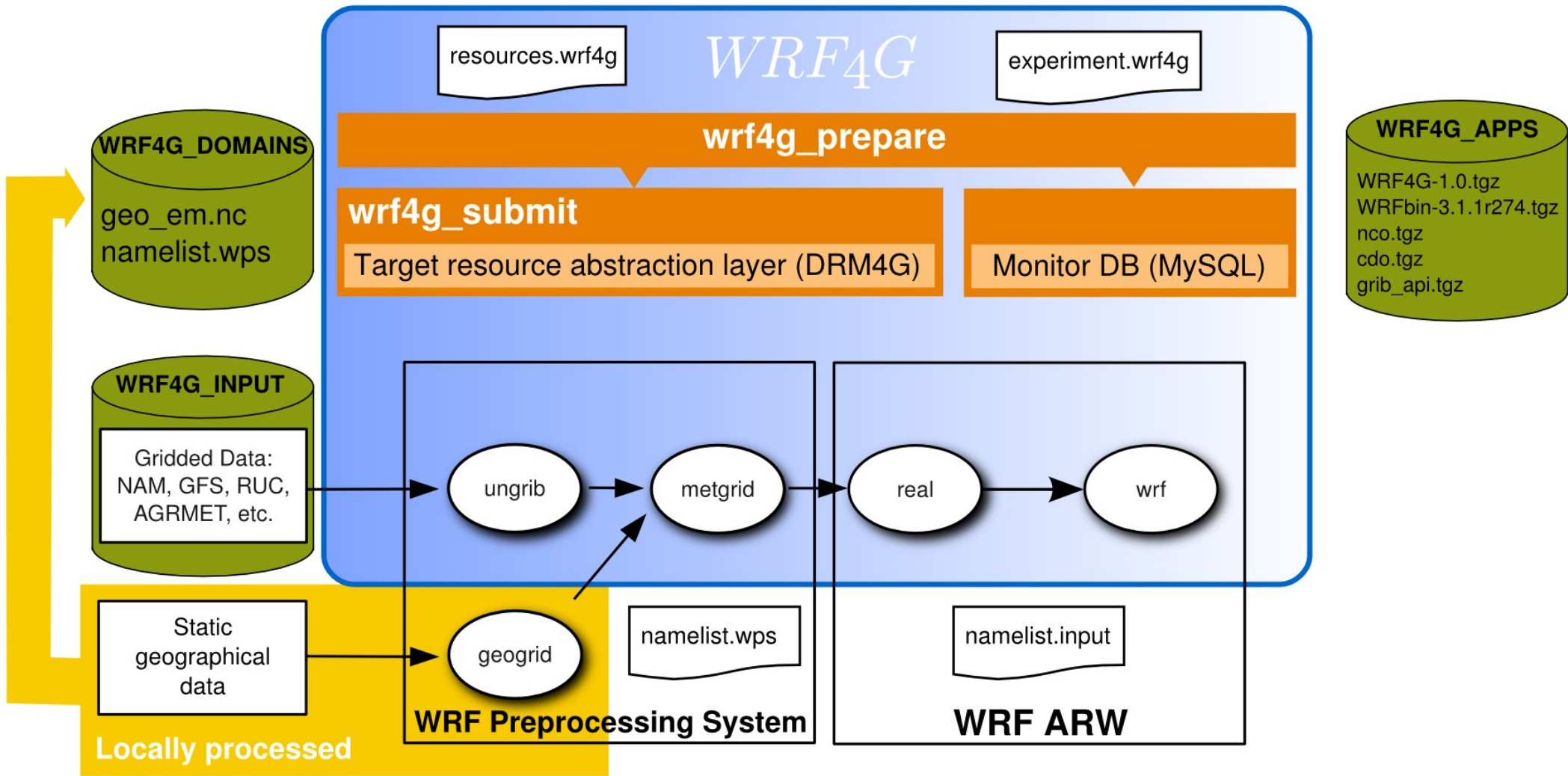
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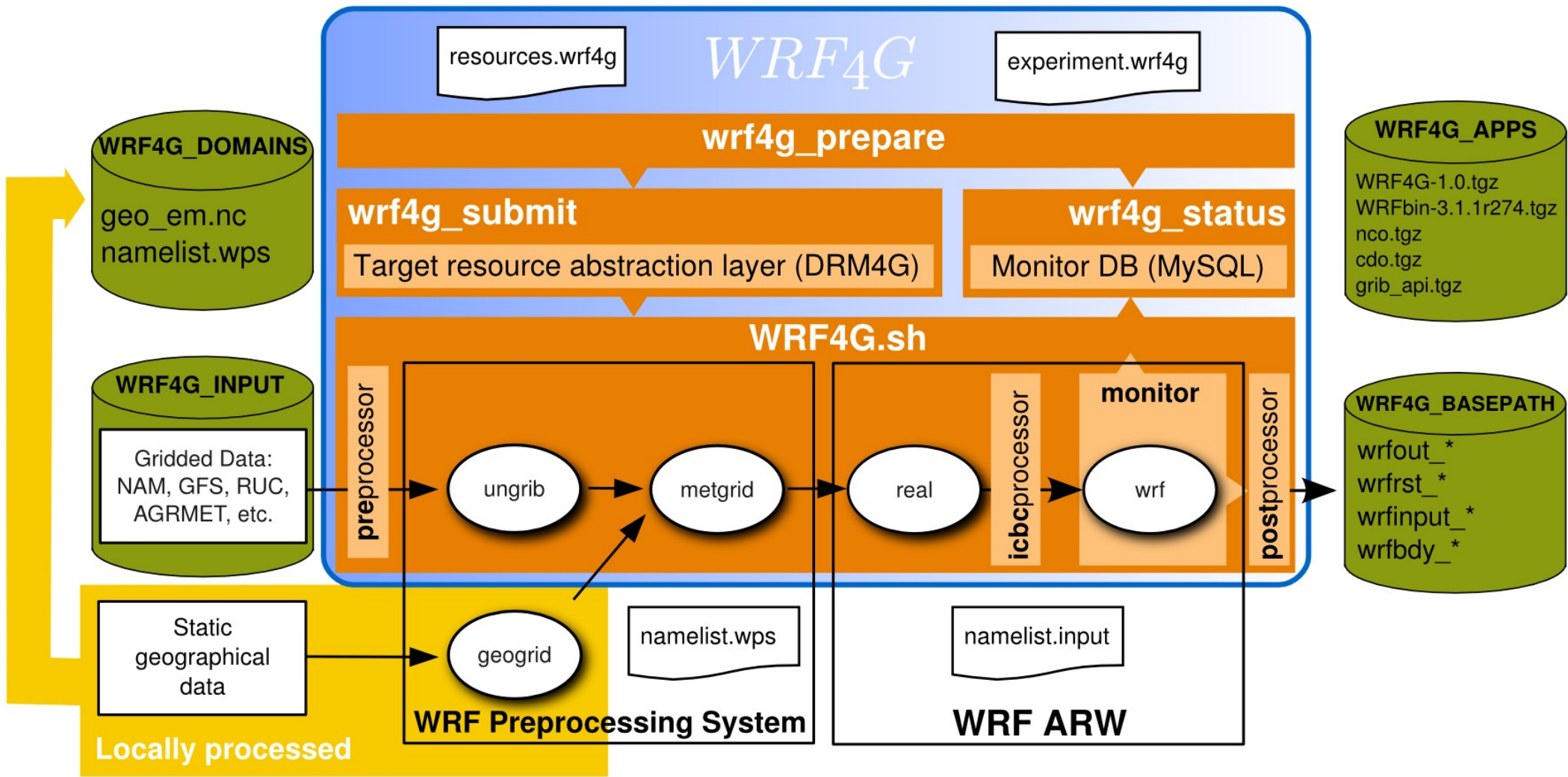
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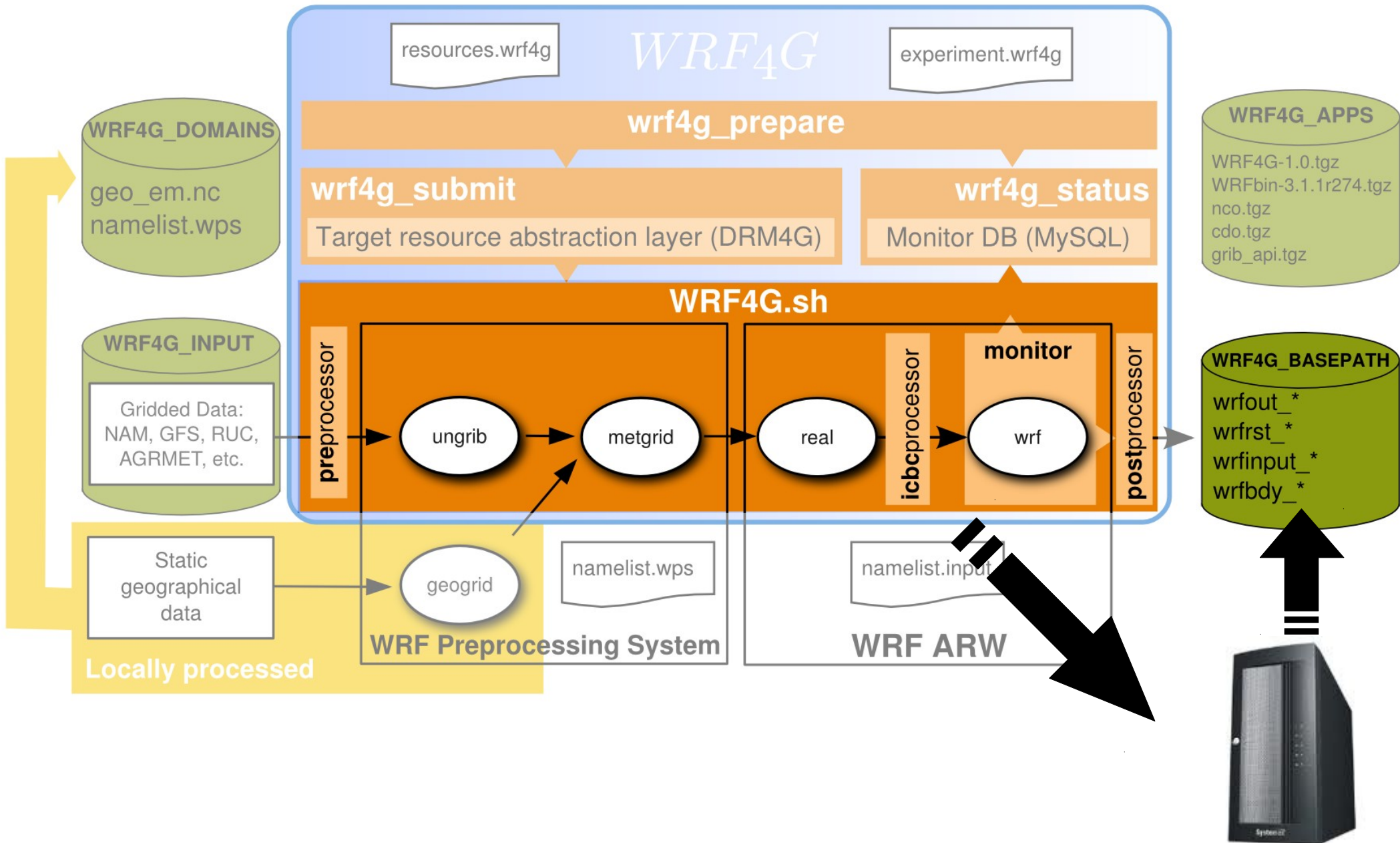
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Configuration files

wrf4gframework.conf

resources.wrf4g

```
# WRF4G version to use (packed scripts must be in $WRF4G_APPS)
WRF4G_VERSION="1.0"
# Name of the packed WRF binaries (the file must be in $WRF4G_APPS)
WRF_VERSION="3.1.1_r832INTEL_OMPI"

# Common path to save all output and log files
WRF4G_BASEPATH="/oceano/gmeteo/WORK/ASNA/WRF/experiments"
# Path to the preconfigured WRF domains
WRF4G_DOMAINPATH="/oceano/gmeteo/WORK/ASNA/WRF/domains"
# Path to the global data for the boundary and initial conditions
WRF4G_INPUT="/oceano/gmeteo/DATA"
# Path to the packed binaries (WRF4G script, WRF, cdo (preprocessor), ..)
WRF4G_APPS="/oceano/gmeteo/WORK/wrf4g/repository/apps"

# Number of parallel processors (cores) per simulation
NP=8
# Computer resources to use
RESOURCES="myworkstation,PBS_cluster"
# Fine tuning
ENVIRONMENT='MAXWALLTIME = 36000, MAXMEMORY = 1000'
```

Configuration files

wrf4gframework.conf

resources.wrf4g

```
# WRF4G version to use (packed scripts must be in $WRF4G_APPS)
WRF4G_VERSION="1.0"
# Name of the packed WRF binaries (the file must be in $WRF4G_APPS)
WRF_VERSION="3.1.1_r832INTEL_OMPI"

# Common path to save all output and log files
WRF4G_BASEPATH="rsync://my.storage.edu/path/to/WRF/experiments"
# Path to the preconfigured WRF domains
WRF4G_DOMAINPATH="rsync://other.computer.edu/path/to/WRF/domains"
# Path to the global data for the boundary and initial conditions
WRF4G_INPUT="rsync://other2.computer.edu/path/to/input/DATA"
# Path to the packed binaries (WRF4G script, WRF, cdo (preprocessor), ..)
WRF4G_APPS="rsync://other3.computer.edu/path/to/apps"

# Number of parallel processors (cores) per simulation
NP=8
# Computer resources to use
RESOURCES="myworkstation,PBS_cluster"
# Fine tuning
ENVIRONMENT='MAXWALLTIME = 36000, MAXMEMORY = 1000'
```

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Configuration files

wrf4gframework.conf

resources.wrf4g

experiment.wrf4g

```
experiment_name = "MyExperiment"
domain_name = "Europe15km"
max_dom = 2

extdata_vtable = "ECMWF" # Vtables must exist as Vtable.[input_extdata]
extdata_path = "${WRF4G_INPUT}/ECMWF/INTERIM"
extdata_interval = 21600 # Seconds between global analysis input times
extdata_preprocessor = "ECMWF"
postprocessor = "SEAWIND2"

start_date = "1989-01-01_06:00:00"
end_date = "2001-01-02_00:00:00"
chunk_size_h = 36

multiple_dates = 1
  simulation_interval_h = 24
  simulation_length_h = 1*chunk_size_h

multiple_parameters = 0
  multiparams_variables = "mp_physics,cu_physics,e_vert"
  multiparams_nitems = "${max_dom},${max_dom},${maxdom}"
  multiparams_combinations = "3,1,28 / 3,3,28 / 4,1,36 / 3,1,36"
  multiparams_labels = "WSM3_KF_L28/WSM3_GD_L28/WSM5_KF_L36/WSM3_KF_L36"

### Override namelist.input variables here ###
# Single valued:
NI_restart_interval = 2880 # minutes
NI_spec_bdy_width = 10
NI_spec_zone = 1
NI_relax_zone = 9
NI_sst_update_physics = 1
# One value per domain:
NIM_history_interval = 180,60 # minutes
NIM_frames_per_outfile = 4,12
# One value per domain; but all equal (provide a single value here):
NIN_e_vert = 42
```

Boundary data

Experiment dates

Multi-parameter
experiment

namelist.input
modifications

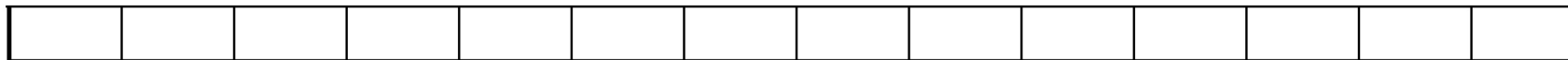
- WRF4G splits a regular WRF simulation **experiment** into:
 - **realizations**
 - A realization is any **independent WRF simulation**, which does not need as input the output (e.g. restart file) of another simulation.
 - **chunks**
 - For convenience, a WRF realization can be split into chunks. By definition, a chunk is a **dependent simulation** and requires the previous chunk to finish.
- Chunks are convenient to create WRF jobs finishing before the job is kicked out of a queue. Also, they allow fine tuning of the size of the input files.

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Experiment definition

Days



start_date

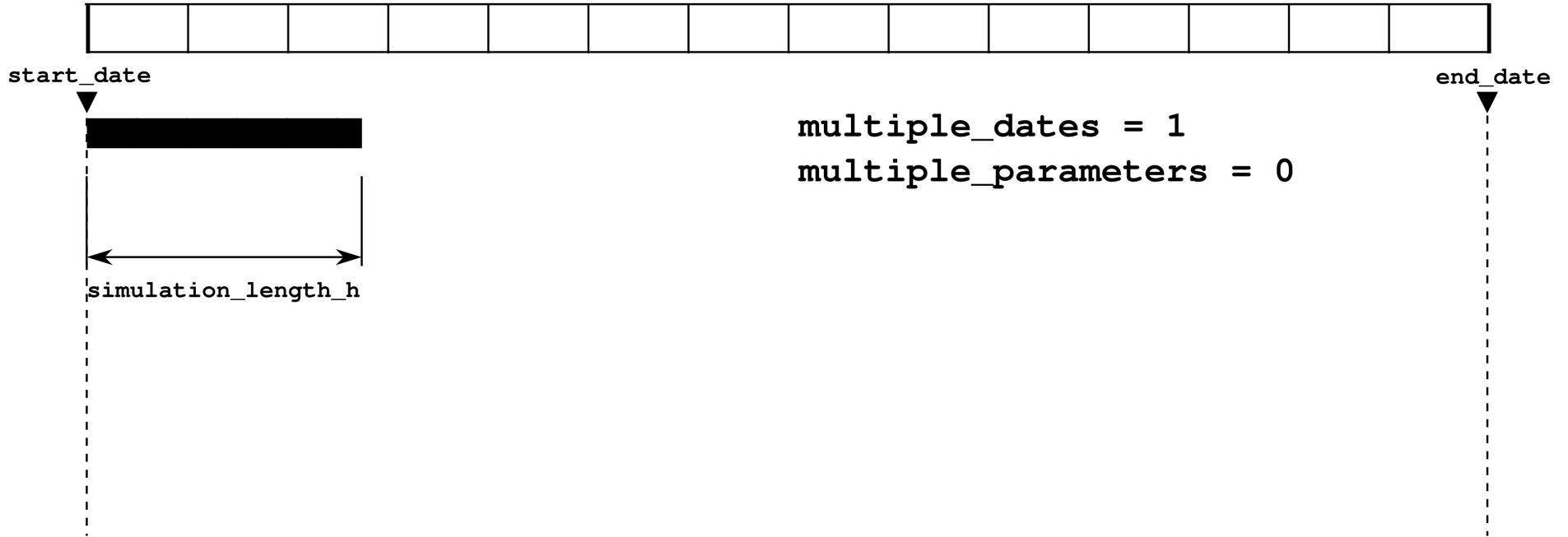
end_date

`multiple_dates = 1`

`multiple_parameters = 0`

Experiment definition

Days

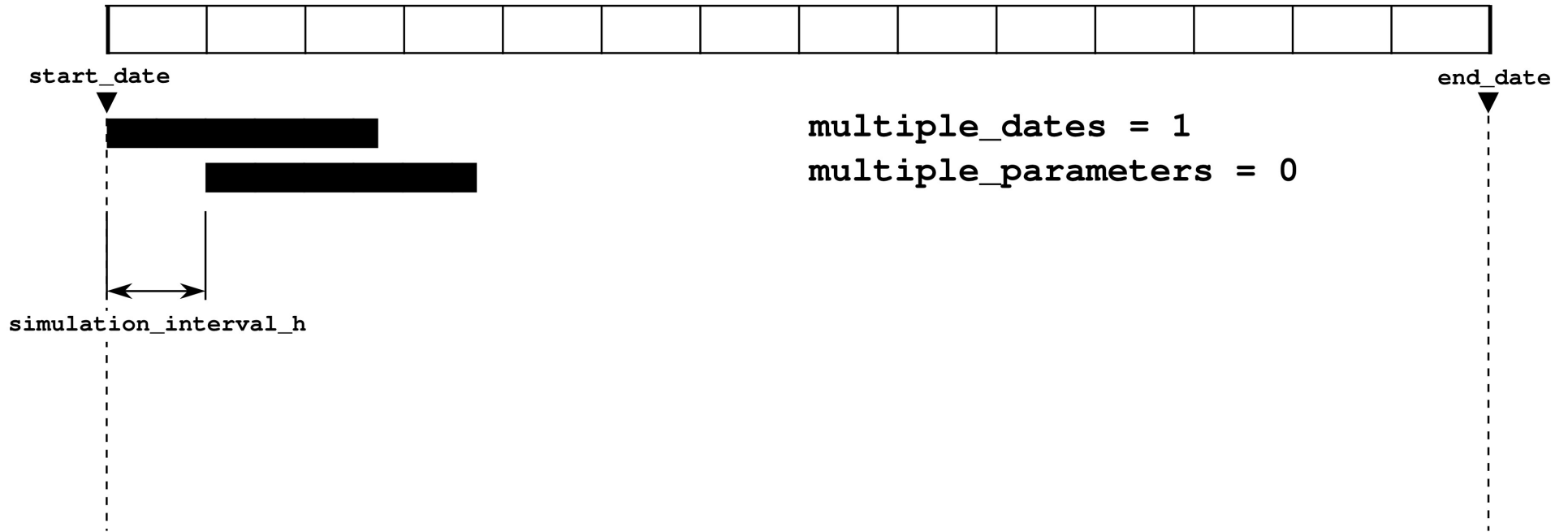


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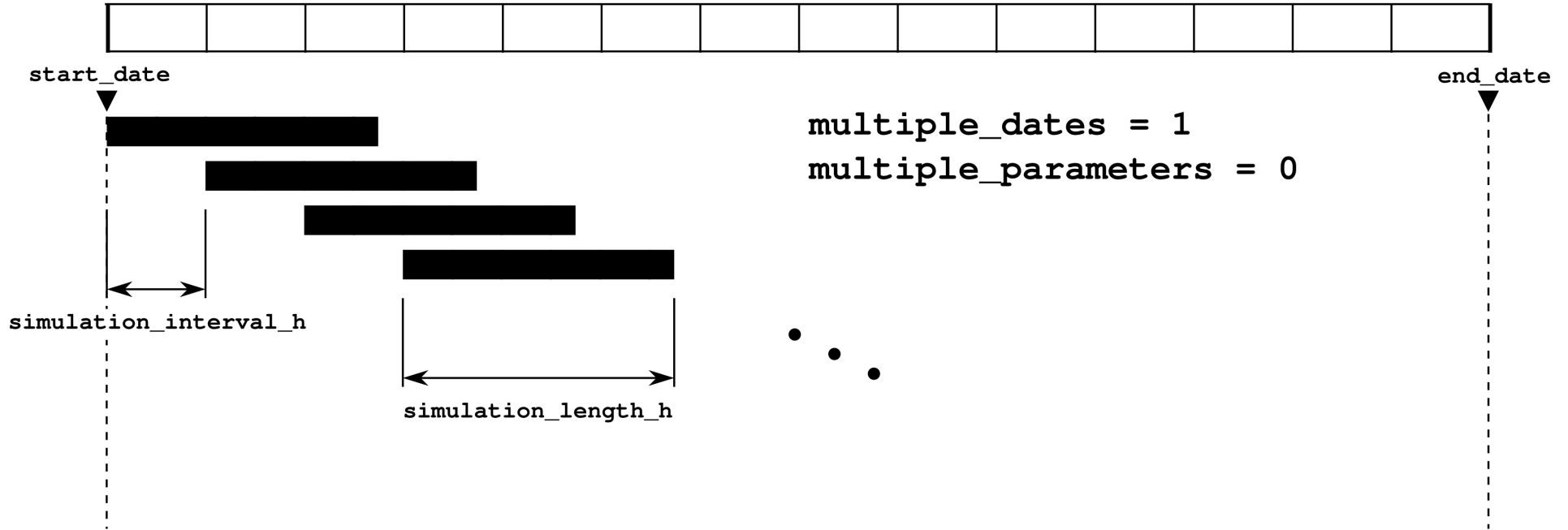
Experiment definition

Days



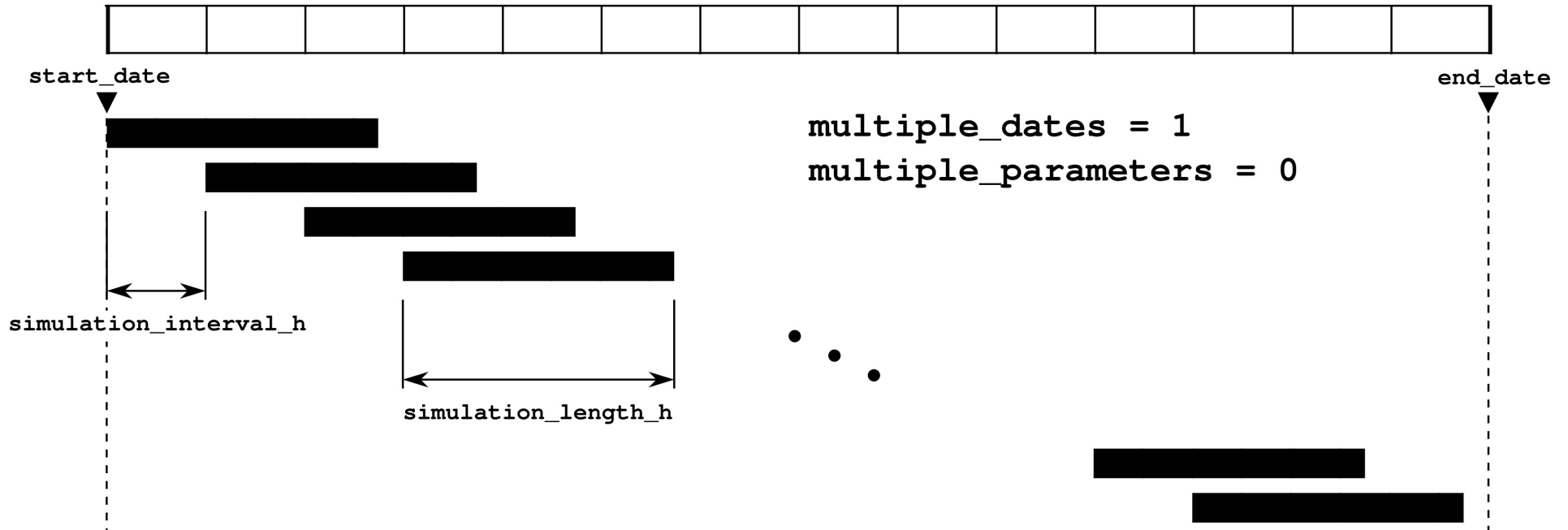
Experiment definition

Days



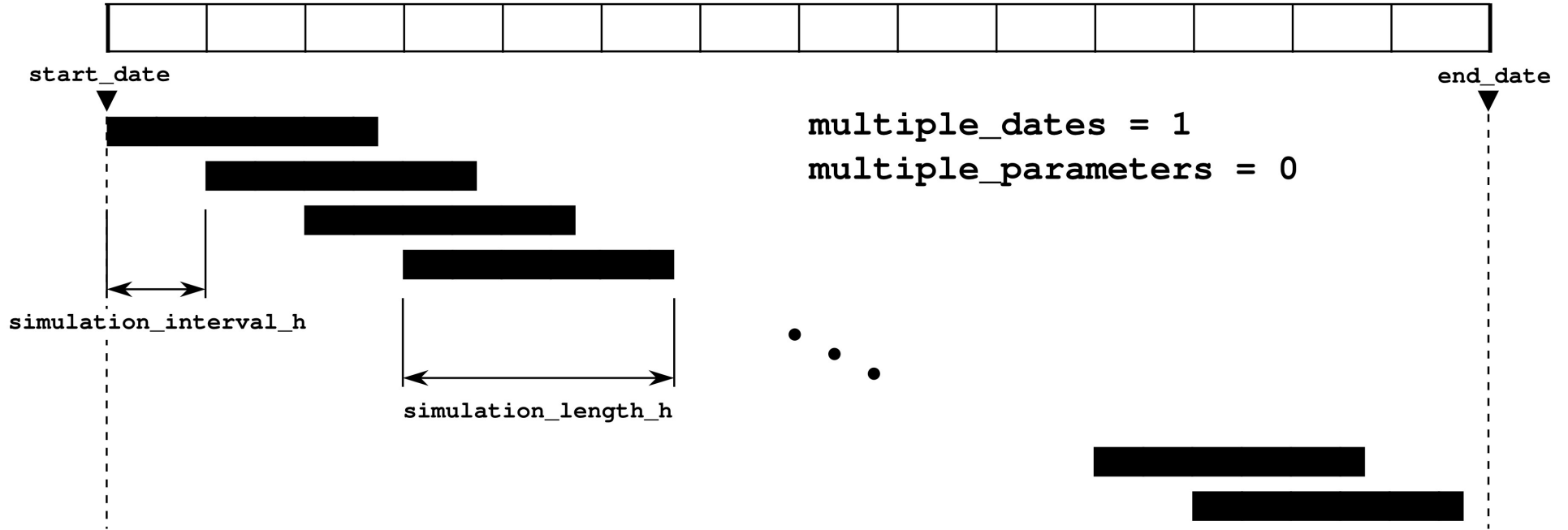
Experiment definition

Days



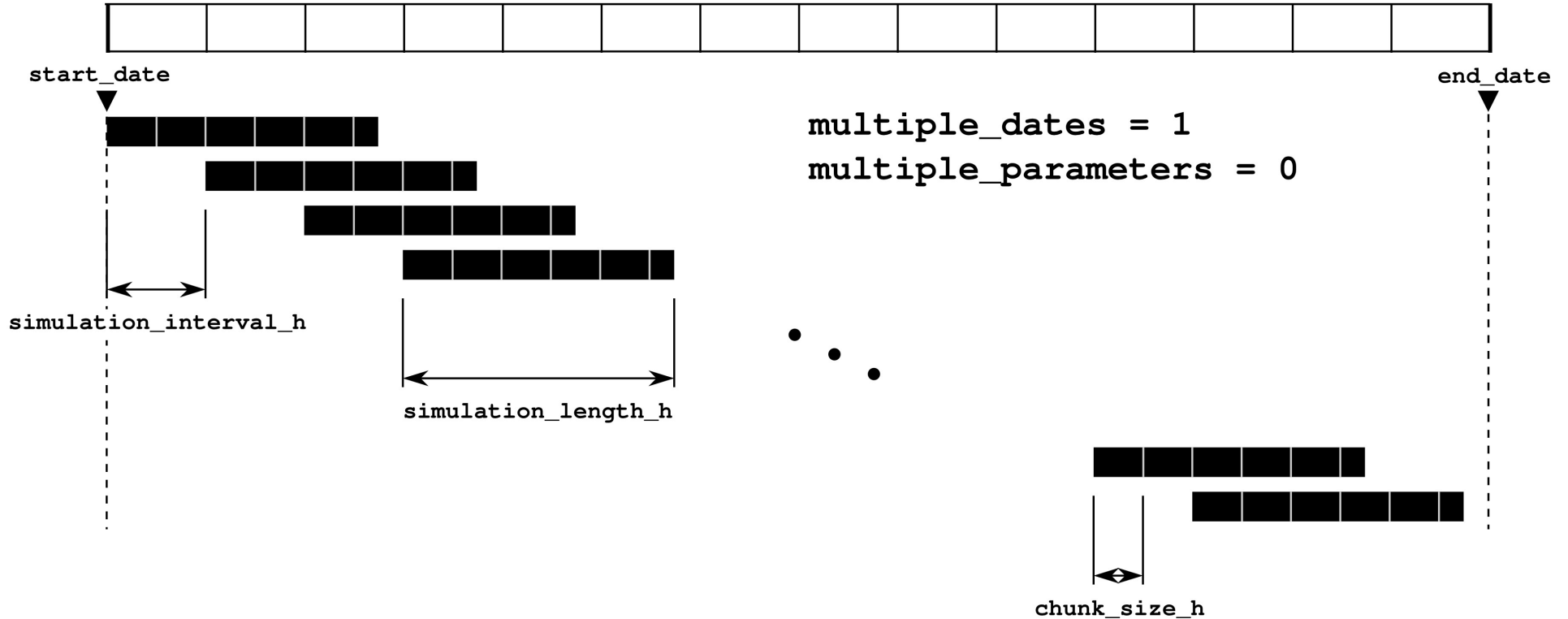
Experiment definition

Months



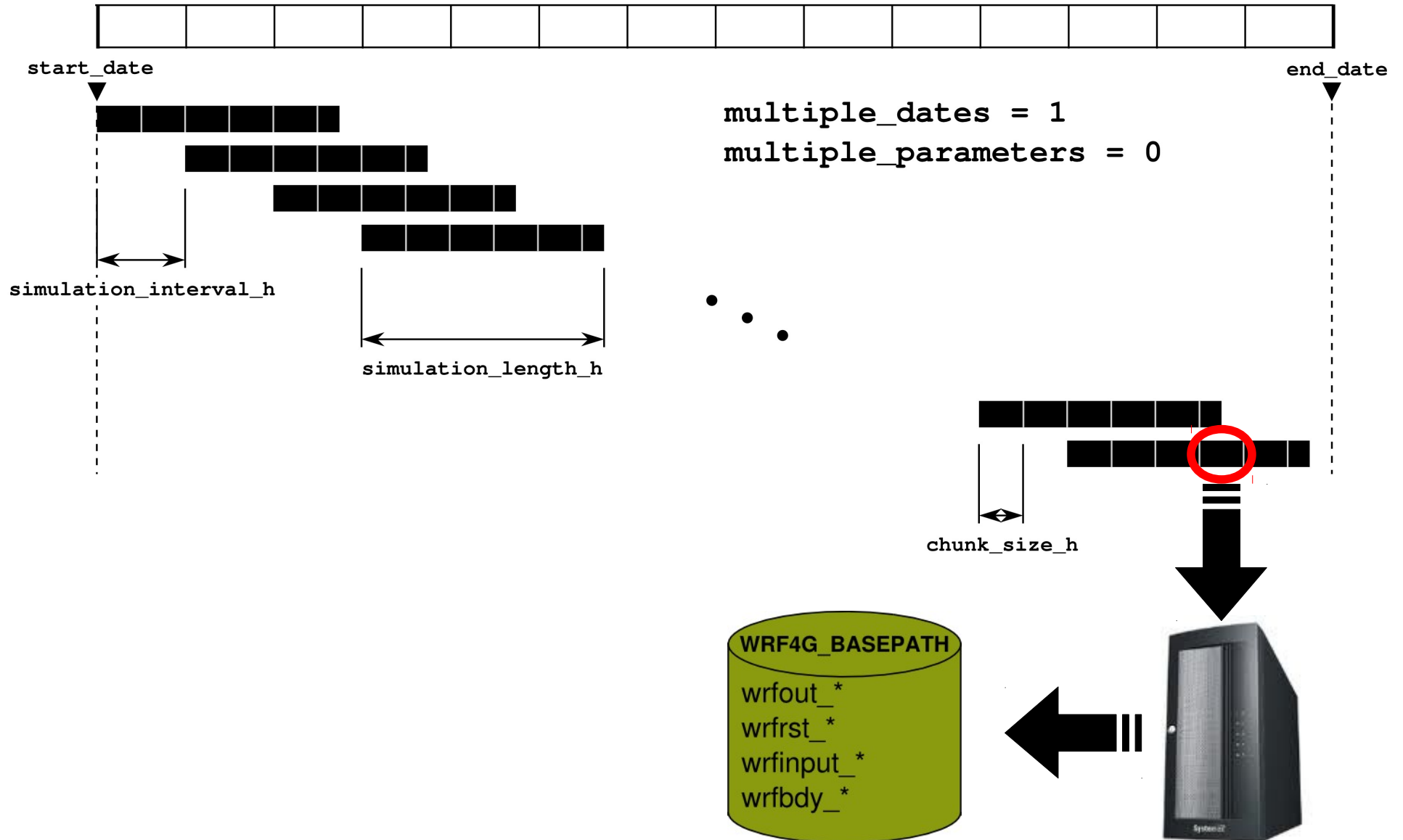
Experiment definition

Months



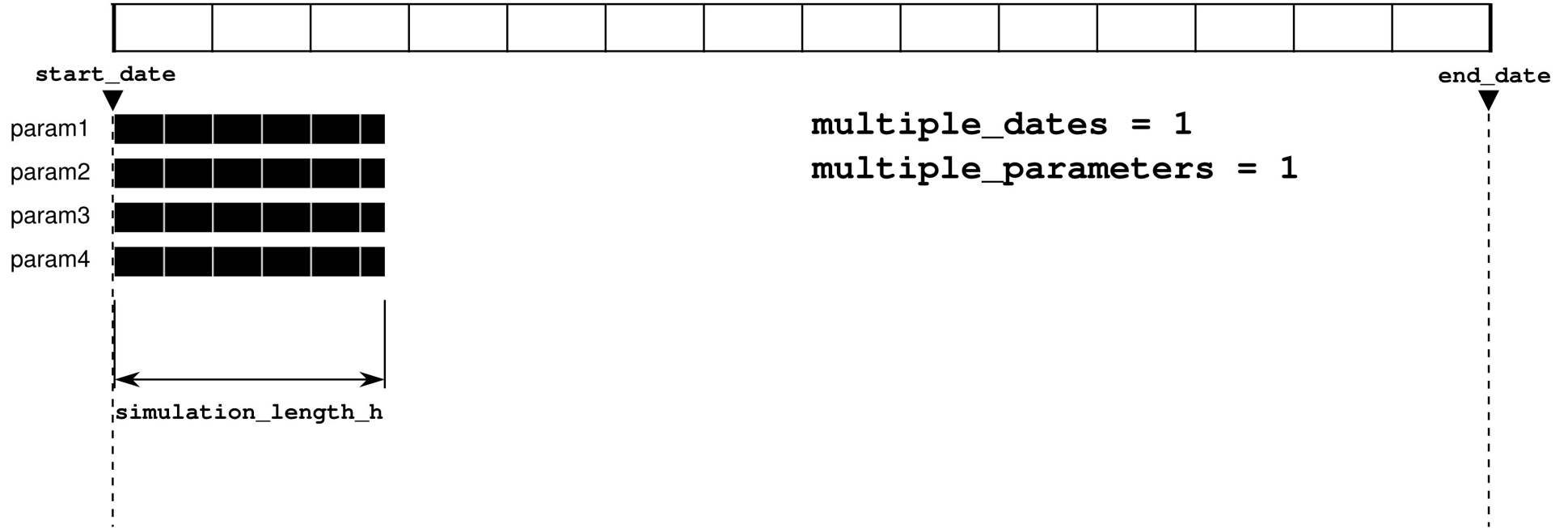
Experiment definition

Months



Multi-parameter & multi-date

Months



Example:

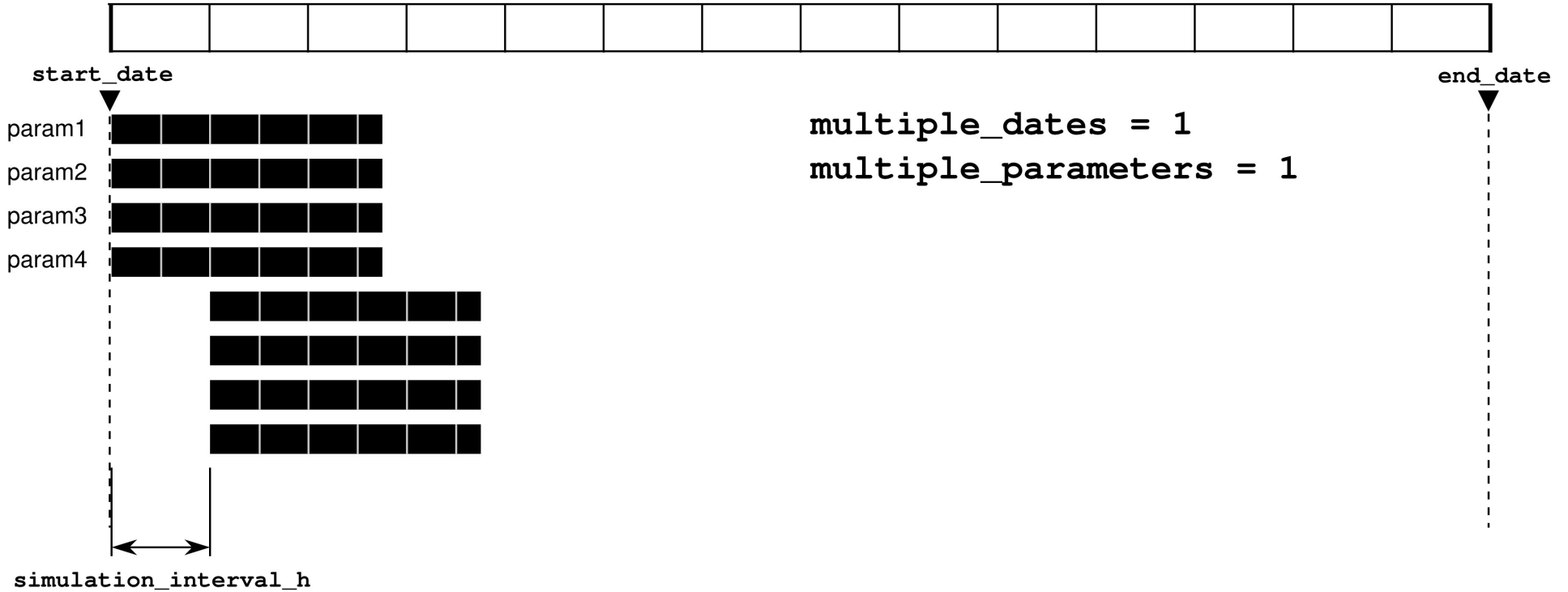
```
multiple_parameters = 1
multiparams_variables = "mp_physics,cu_physics,e_vert"
multiparams_nitems = "${max_dom},${max_dom},${maxdom}"
multiparams_combinations = "3,1,28 / 3,3,28 / 4,1,36 / 3,1,36"
multiparams_labels = "WSM3_KF_L28/WSM3_GD_L28/WSM5_KF_L36/WSM3_KF_L36"
```

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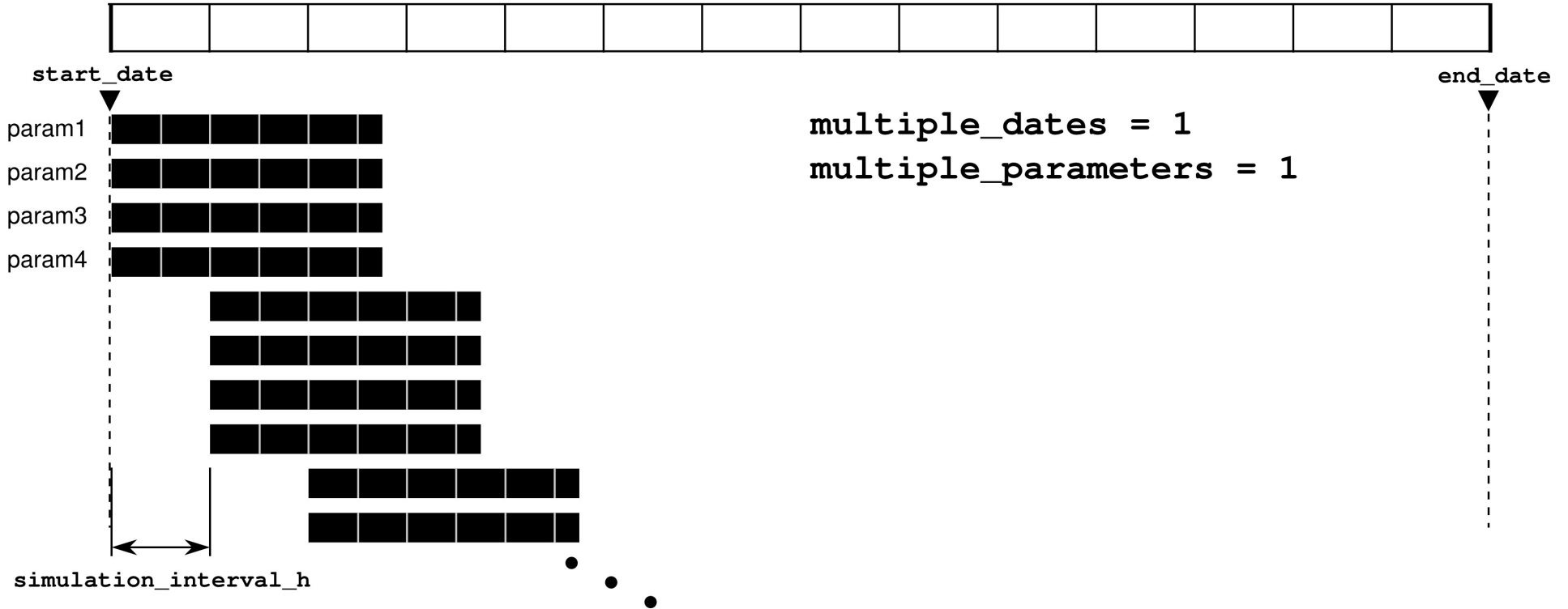
Multi-parameter & multi-date

Months



Multi-parameter & multi-date

Months

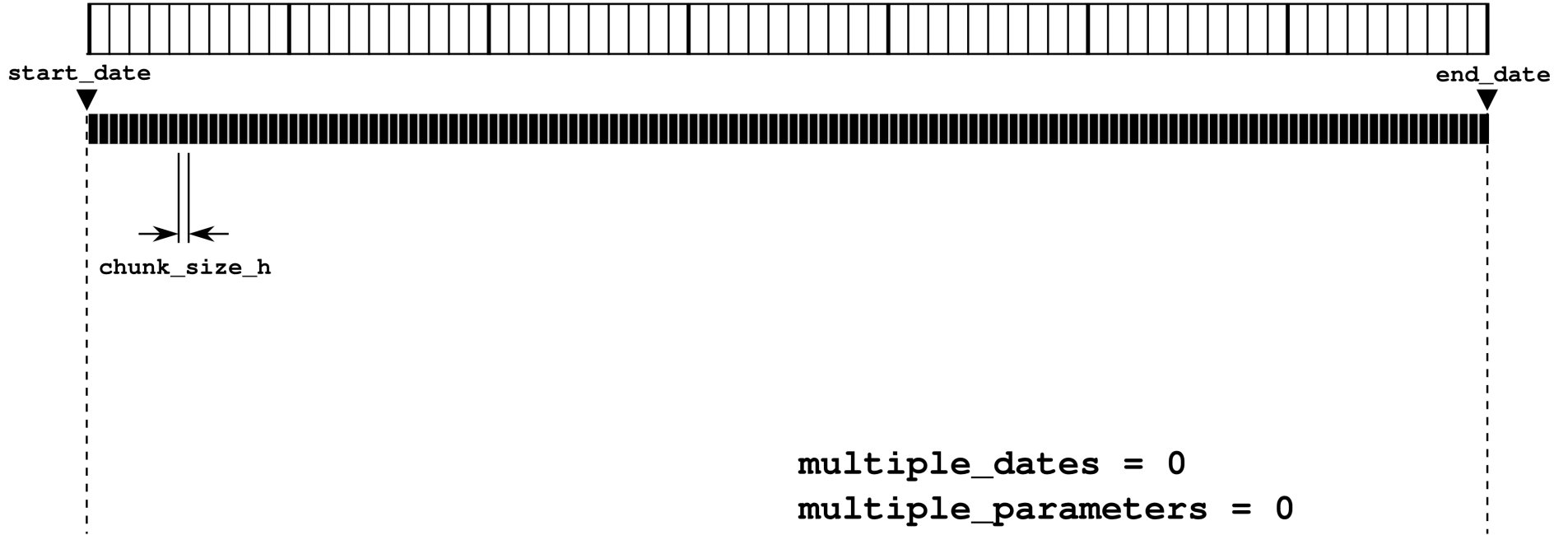


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Climate simulation (continuous)

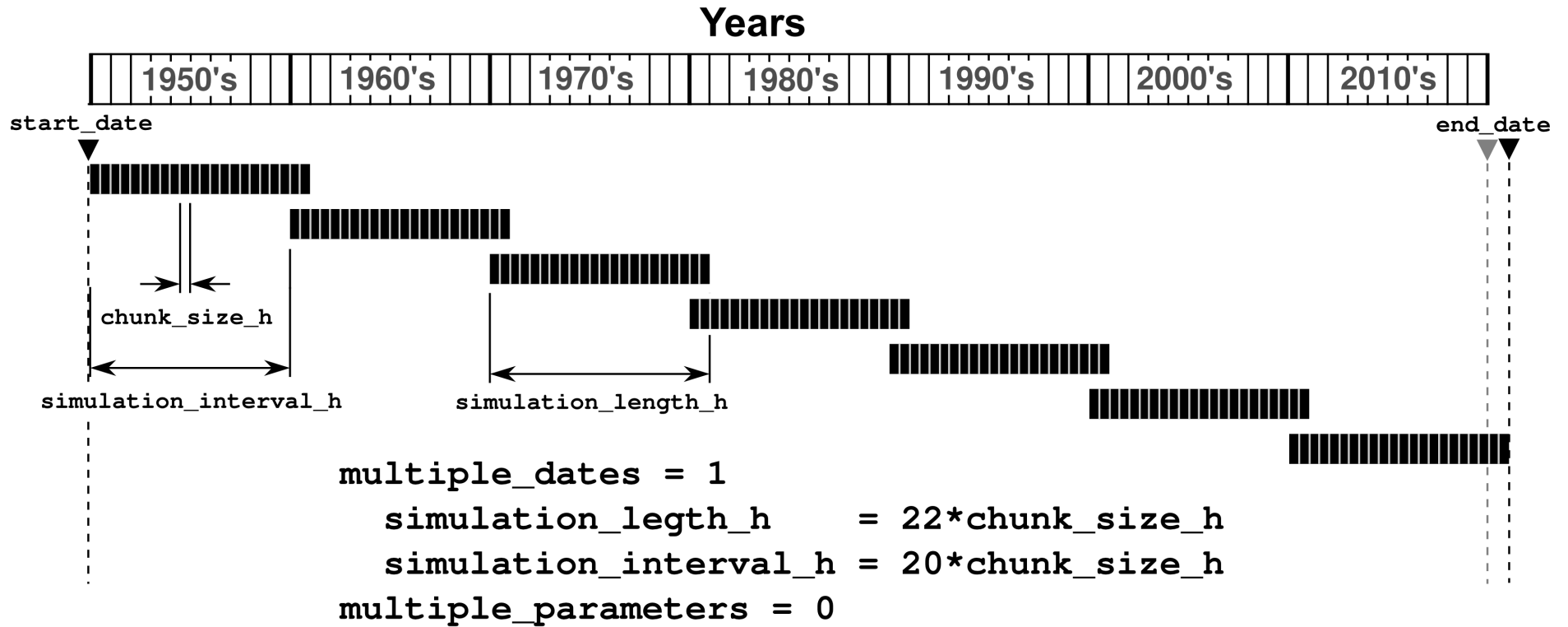
Years



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Climate simulation (split)



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Monitoring

```
Shell$ wrf4g_status -e example
```

Realization	GW	Stat	Chunks	Comp.Res	WN	Run.Sta	ext	%
example__ph1	-	P	0/4	-	-	Prepared	-	0.00
example__ph2	-	P	0/4	-	-	Prepared	-	0.00
example__ph3	-	P	0/4	-	-	Prepared	-	0.00
example__ph4	-	P	0/4	-	-	Prepared	-	0.00
example__ph5	-	P	0/4	-	-	Prepared	-	0.00

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Monitoring

```
Shell$ wrf4g_status -e example
```

Realization	GW	Stat	Chunks	Comp.Res	WN	Run.Sta	ext	%
example__ph1	32	R	1/4	mycomputer	legolas	metgrid	-	0.00
example__ph2	36	R	1/4	mycomputer	legolas	Down. Bound.	-	0.00
example__ph3	40	W	1/4	-	-	Submitted	-	0.00
example__ph4	44	W	1/4	-	-	Submitted	-	0.00
example__ph5	48	W	1/4	-	-	Submitted	-	0.00

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Monitoring

```
Shell$ wrf4g_status -e example
```

Realization	GW	Stat	Chunks	Comp.Res	WN	Run.Sta	ext	%
example__ph1	32	R	1/4	mycomputer	legolas	real	-	0.00
example__ph2	36	R	1/4	mycomputer	legolas	metgrid	-	0.00
example__ph3	40	W	1/4	-	-	Submitted	-	0.00
example__ph4	44	W	1/4	-	-	Submitted	-	0.00
example__ph5	48	W	1/4	-	-	Submitted	-	0.00

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Monitoring

```
Shell$ wrf4g_status -e example
```

Realization	GW	Stat	Chunks	Comp.Res	WN	Run.Sta	ext	%
example__ph1	32	R	1/4	mycomputer	legolas	WRF	-	0.00
example__ph2	36	R	1/4	mycomputer	legolas	WRF	-	0.00
example__ph3	40	W	1/4	-	-	Submitted	-	0.00
example__ph4	44	W	1/4	-	-	Submitted	-	0.00
example__ph5	48	W	1/4	-	-	Submitted	-	0.00

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Monitoring

```
Shell$ wrf4g_status -e example
```

Realization	GW	Stat	Chunks	Comp.Res	WN	Run.Sta	ext	%
example__ph1	33	W	2/4	-	-	Submitted	-	25.00
example__ph2	37	W	2/4	-	-	Submitted	-	25.00
example__ph3	40	R	1/4	mycomputer	legolas	WRF	-	10.37
example__ph4	44	R	1/4	mycomputer	legolas	WRF	-	9.23
example__ph5	48	W	1/4	-	-	Submitted	-	0.00

- Motivation
- WRF4G
 - Accessing distributed resources
 - Workflow
 - Experiment types
 - Side-products
 - Projects supporting WRF4G
- The Grid
 - Grid computing for meteo/climate apps
- Conclusions

Useful tools developed

- vcp
 - Virtual copy
 - Provides transparent copy between any of:
 - local file
 - ssh host (via rsync)
 - gridftp URL
 - local link (as destination)
 - E.g:

```
vcp /local/file /other/local/path/  
vcp /local/file rsync://remote.comp.edu/remote/path/  
vcp rsync://remote.comp.edu/remote/path ln:/local/path # (copies)  
vcp /local/file ln:/other/local/path # (links)  
vcp -r /local/dir gridftp://server:port/remote/path  
vcp gridftp://srv1:port/rmt/file gridftp://srv2:port/other/file
```

Useful tools developed

- **fortnml**
 - Fortran namelist
 - Provides Fortran namelist manipulation from the command line along with some WRF namelist checks.
 - E.g:

```
fortnml -f namelist.input
fortnml --wrf -f namelist.input
fortnml -f namelist.input -s variable value
fortnml -f namelist.input -s variable value1 value2 value3 ...
fortnml -f namelist.input -s variable@record value
```

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Projects supporting WRF4G

European commission (7FP):



EELA2: E-science grid facility for Europe and Latin America

Partners: 52 institutions in Latin America and Europe

Spanish Ministry of Science and Innovation:



WRF model port to Grid infrastructures and proof-of-concept for a high-resolution wind hindcast over Europe

Universidad de Cantabria



Coordinated regional climate downscaling experiment using WRF:
a contribution to the CORDEX initiative by the Spanish WRF community

Partners: 3 Spanish universities and a supercomputing center

- The WRF user usually:
 - designs experiments where several (many?) simulations are required
 - has several computer resources available for her simulations
- WRF4G simplifies the design, execution and monitoring of WRF on several computer resources
- WRF4G is freely available for use...

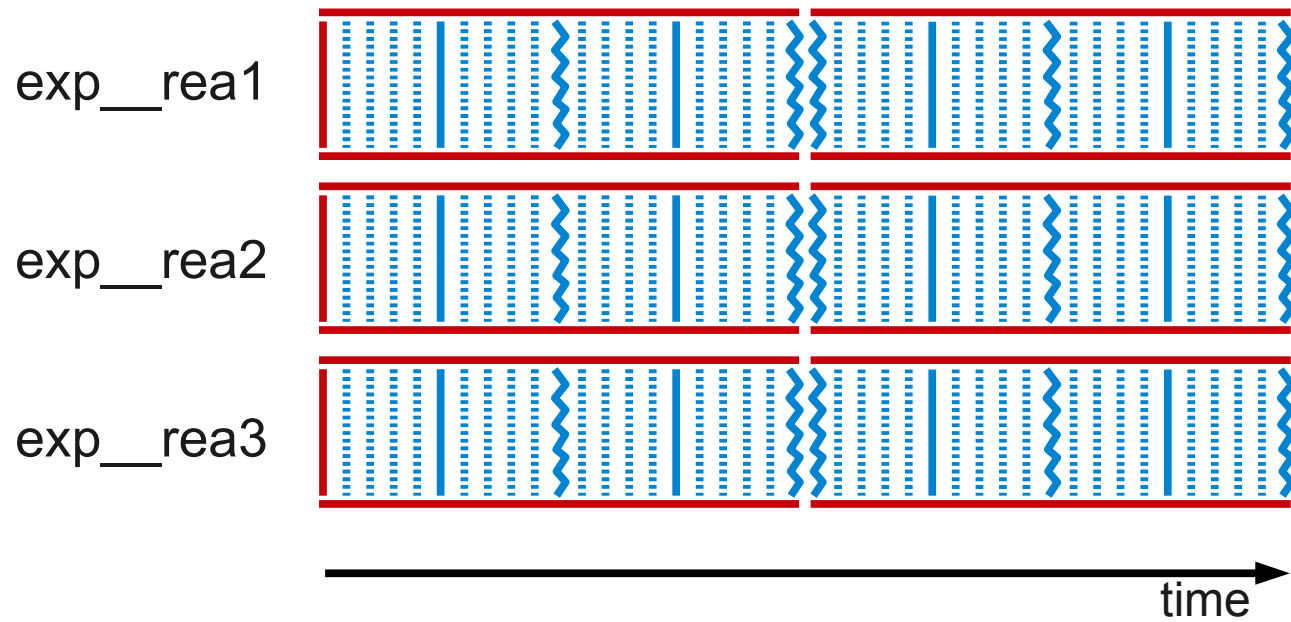
www.meteo.unican.es/software/wrf4g

Thank you!

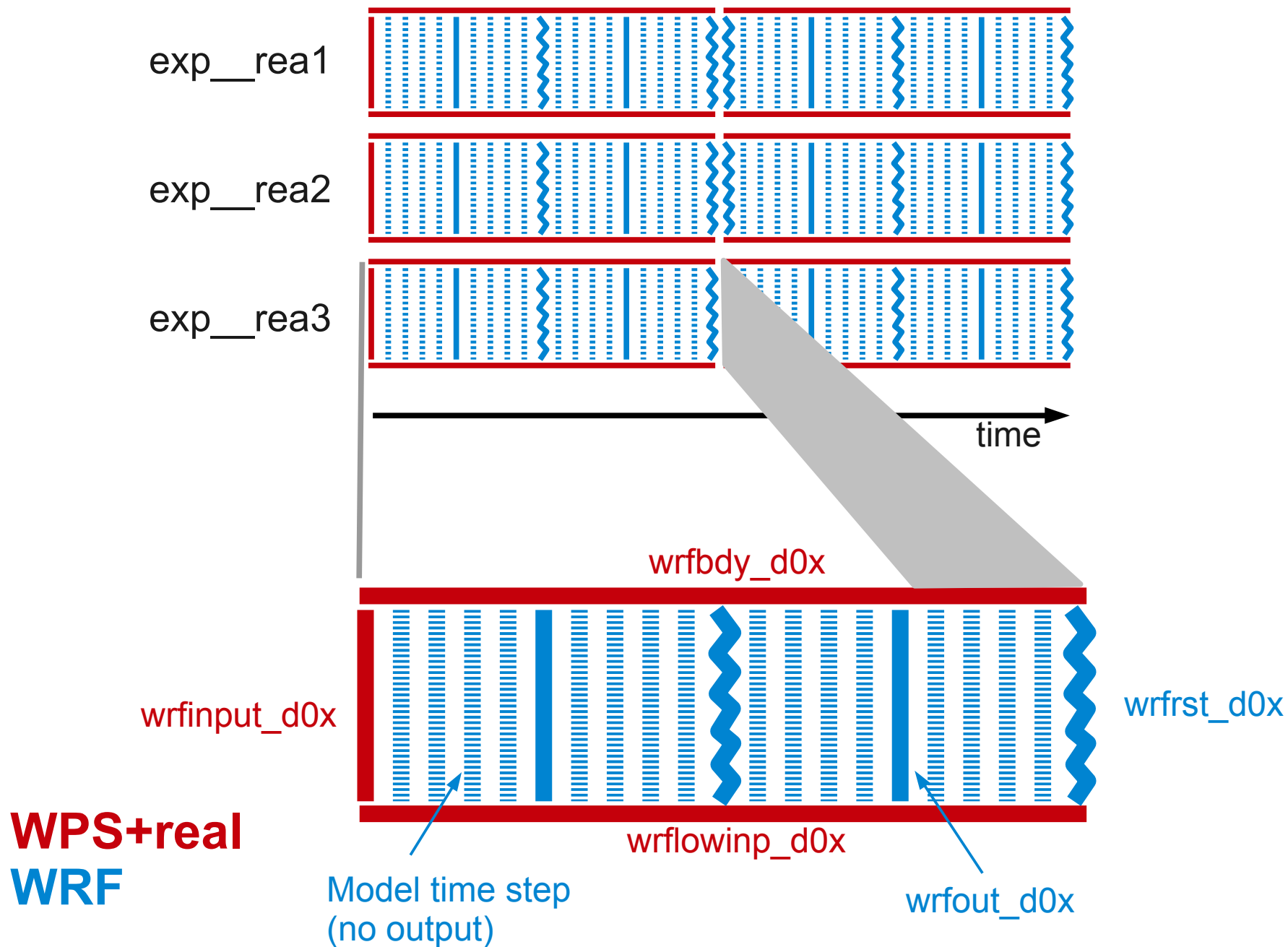
Contact: jesus.fernandez@unican.es

More info: www.meteo.unican.es/software/wrf4g
(or just “wrf4g” → Google)

Three realizations split into two chunks each:



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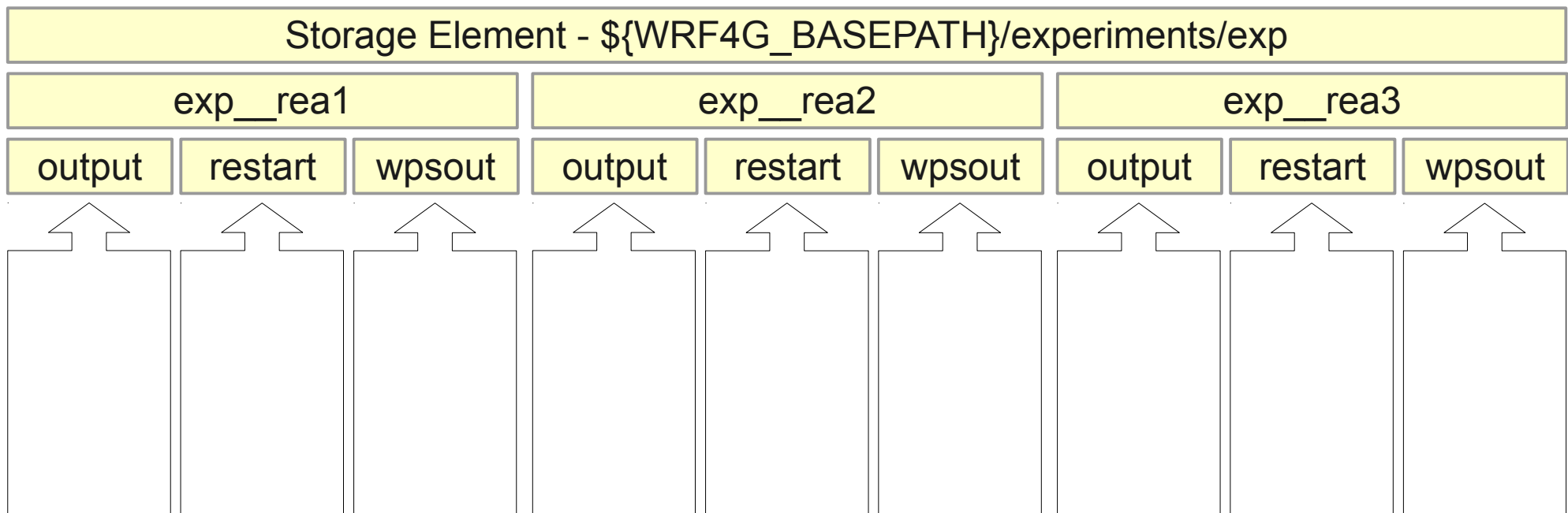


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

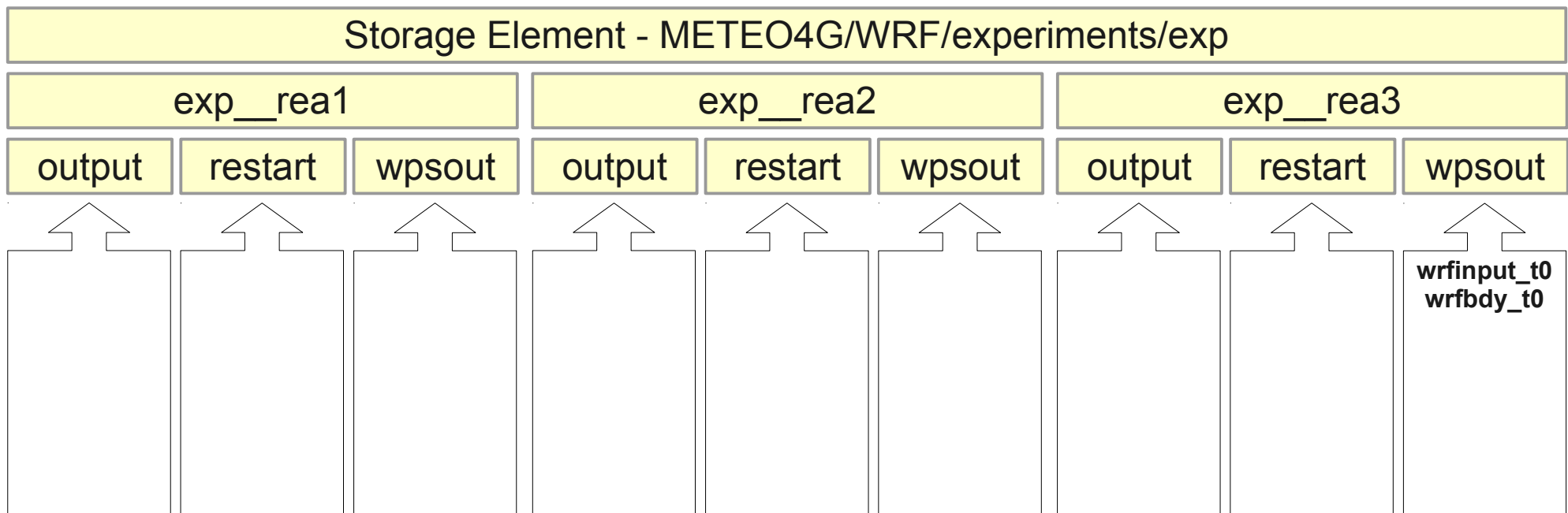
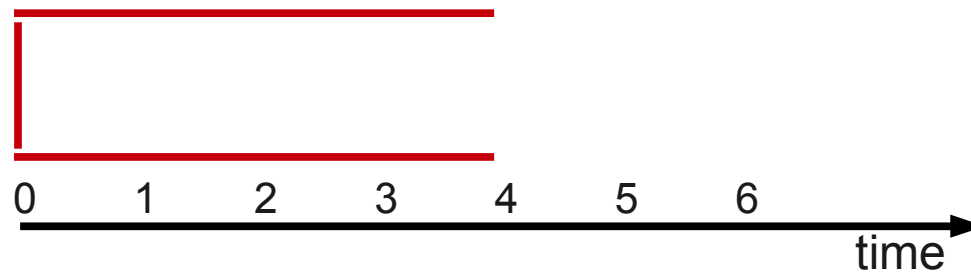


Three realizations split into two chunks each:

exp__rea1

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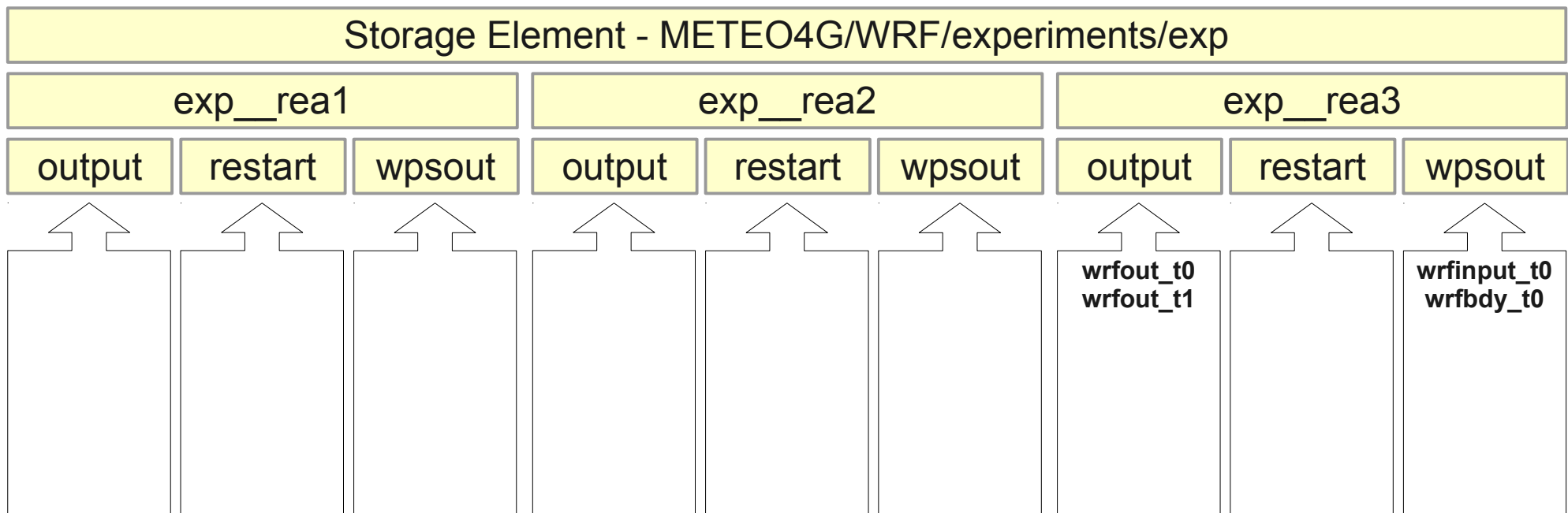
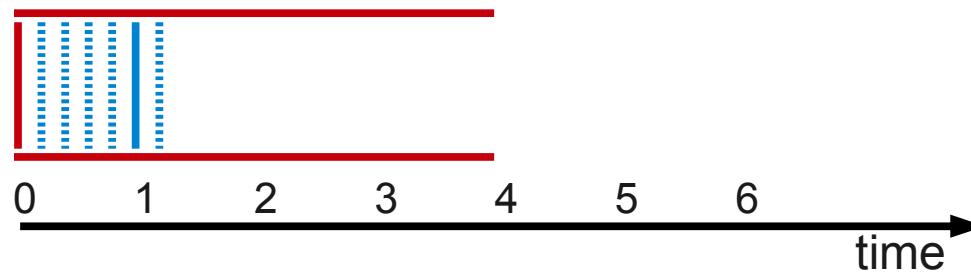


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

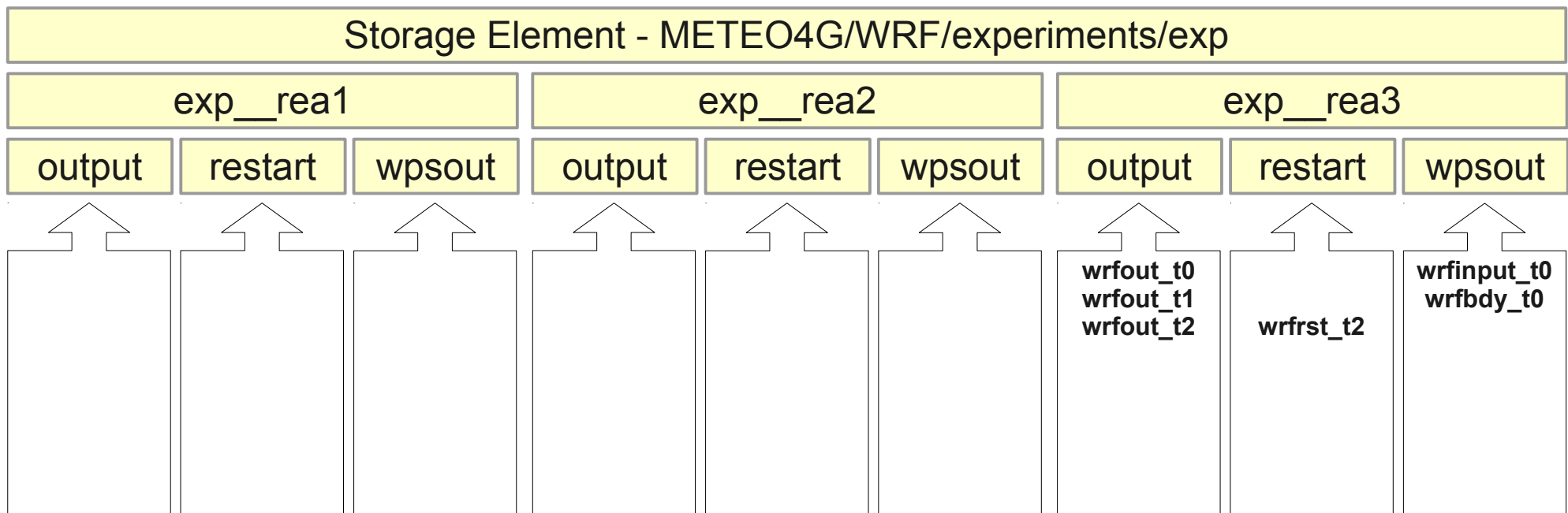
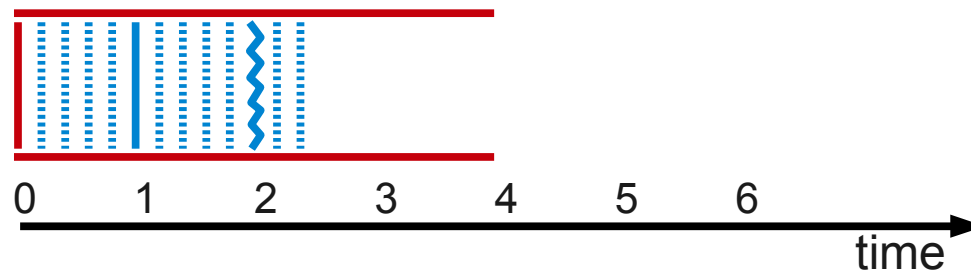


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

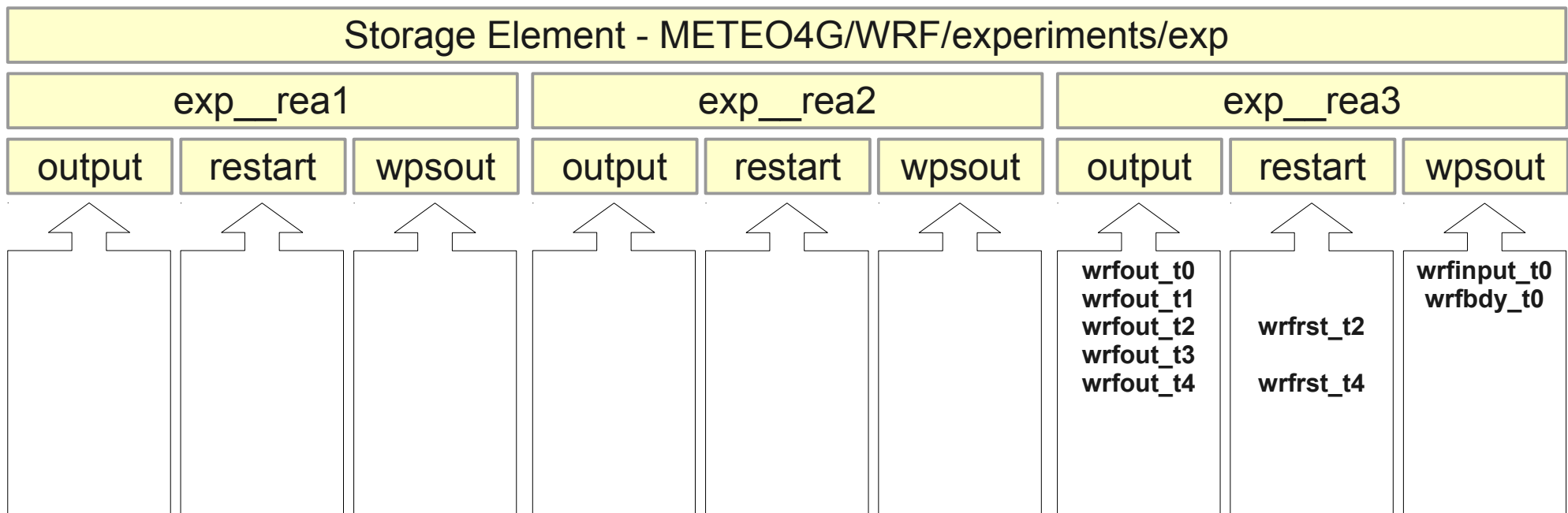
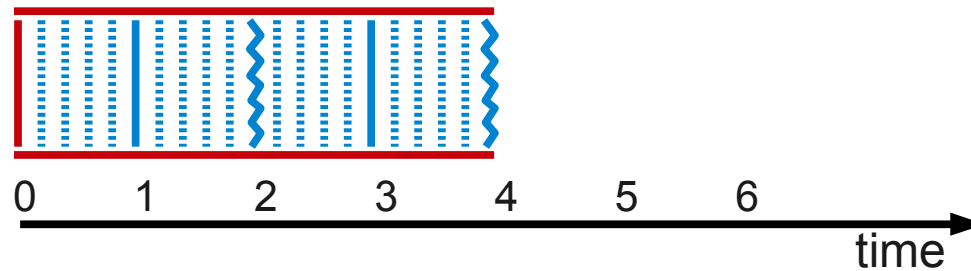


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

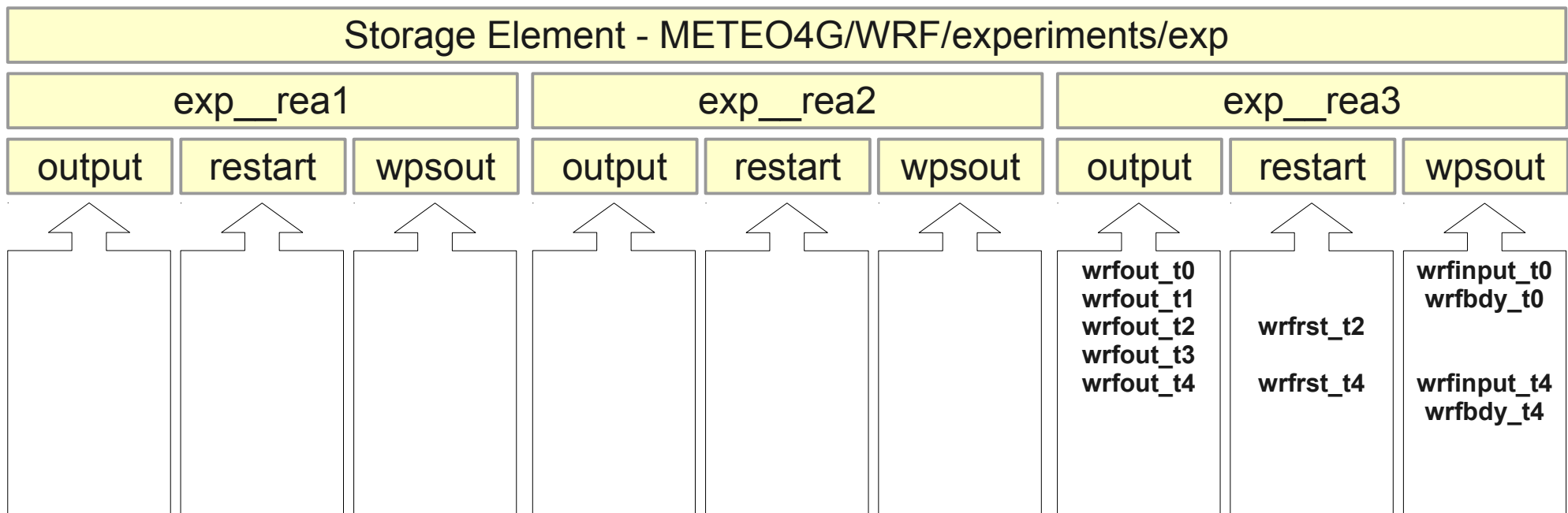
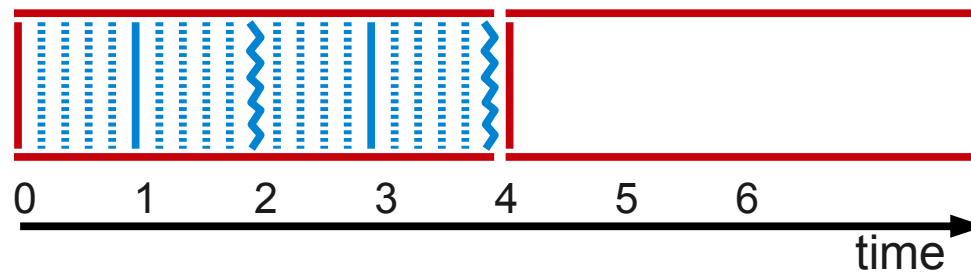


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

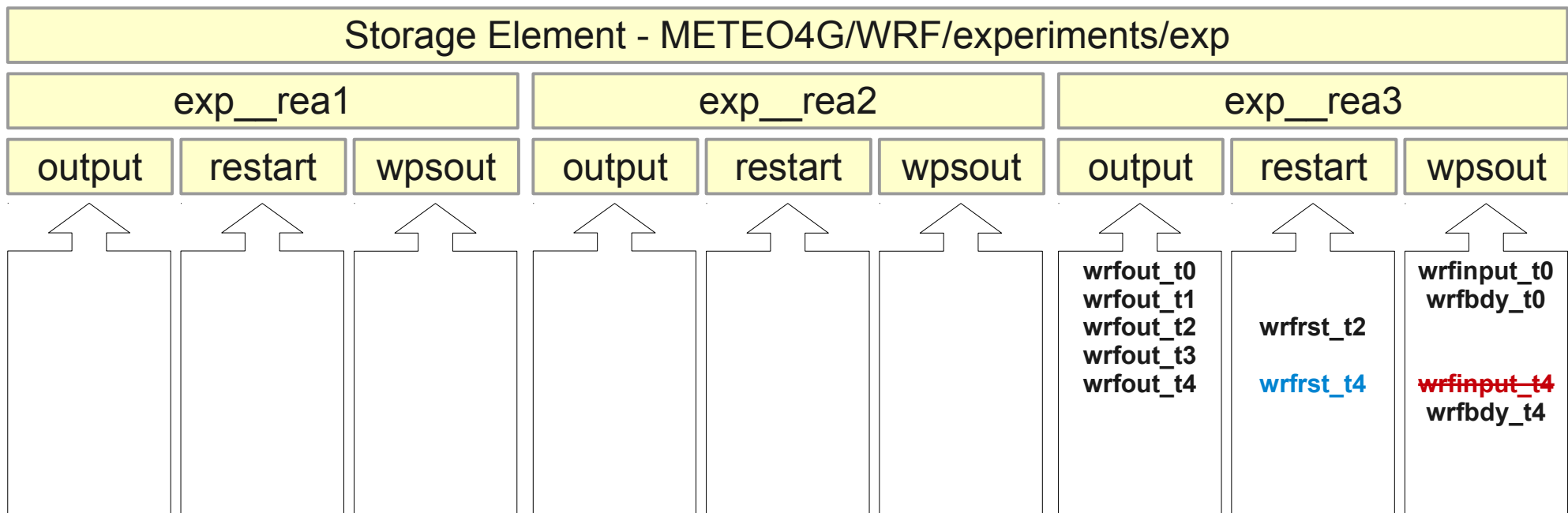
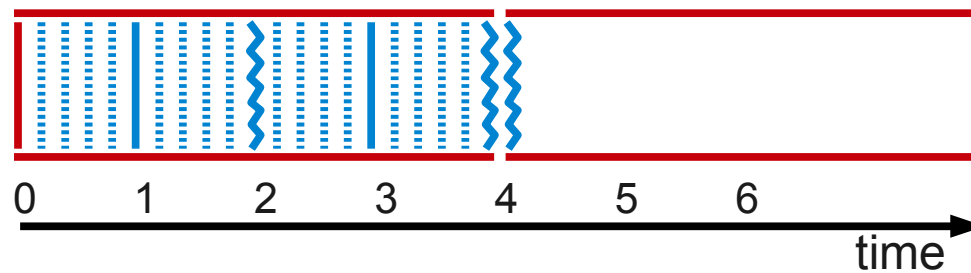


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

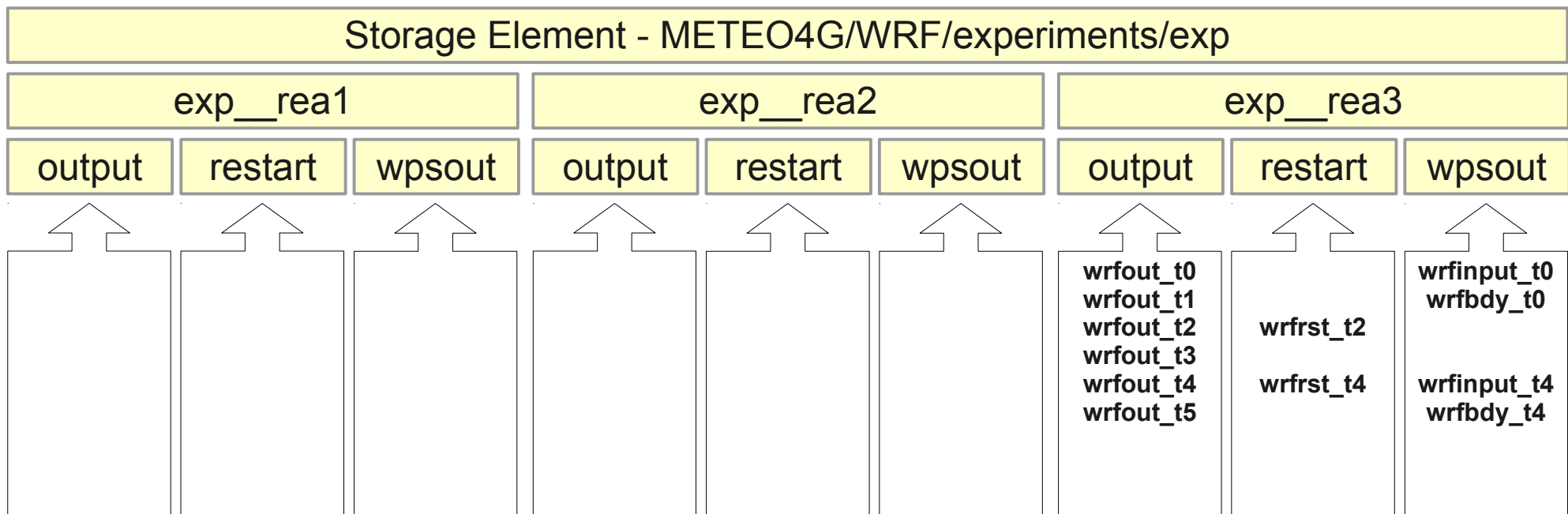
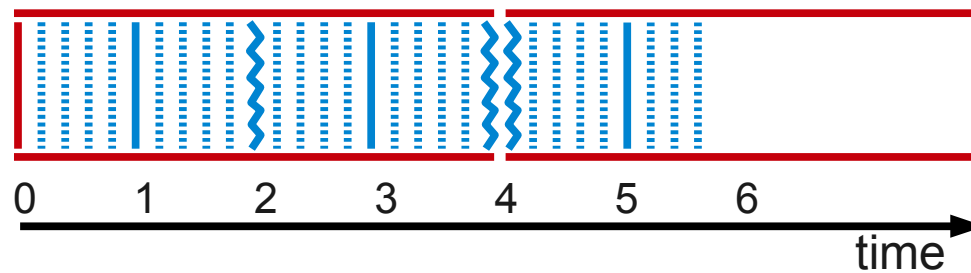


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3

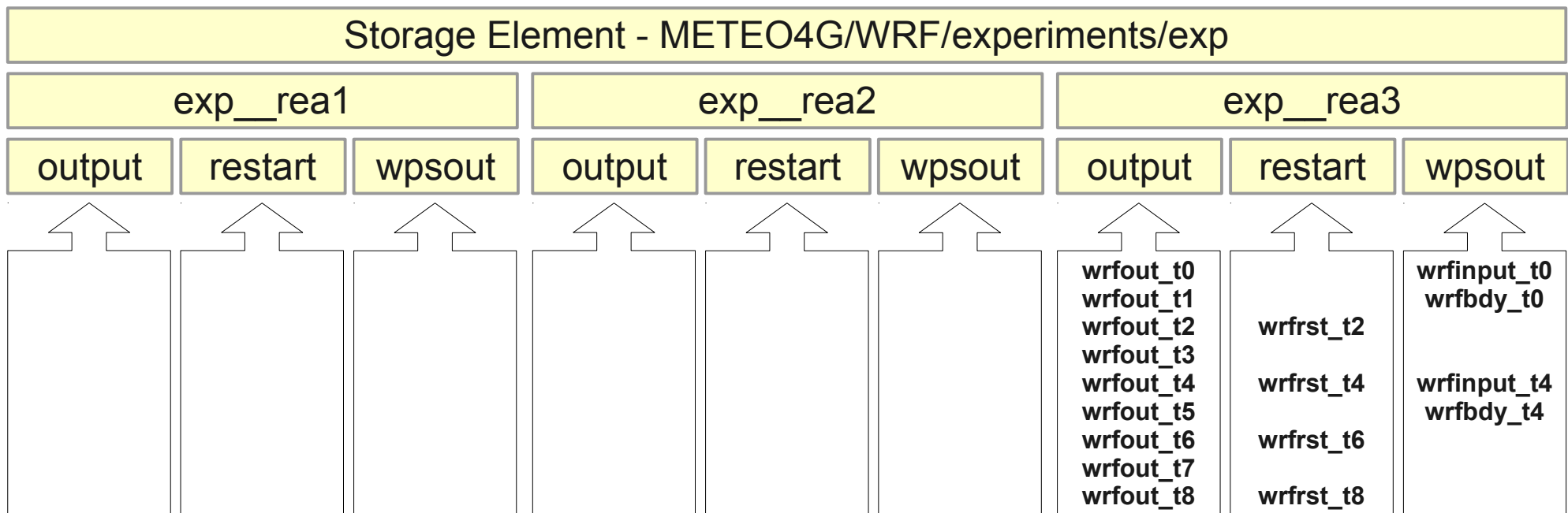
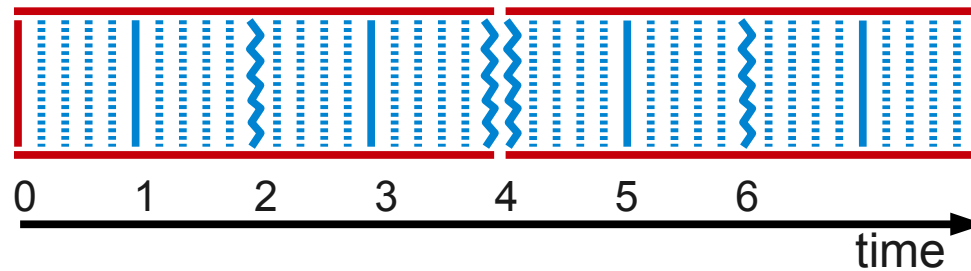


Three realizations split into two chunks each:

exp__rea1

exp__rea2

exp__rea3



Three realizations split into two chunks each:

