Monitoring Numerical Climate Simulations

A Tool for EC-Earth 4

EC EARTH 4

Some Numbers I

150 years
~ 65 min/year
~ 1 week/experiment

Some Numbers II

150 years
~ 12 GB/year
~ 1.8 TB per experiment

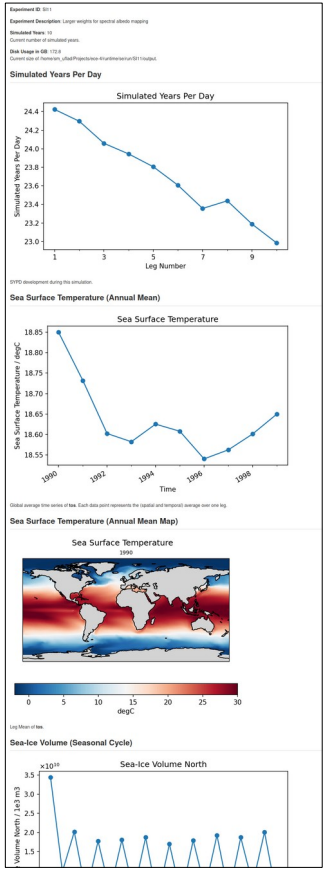
Numerical Climate Simulations are

time consuming
computationally intensive
data intensive

→ Real-Time Monitoring

Goal

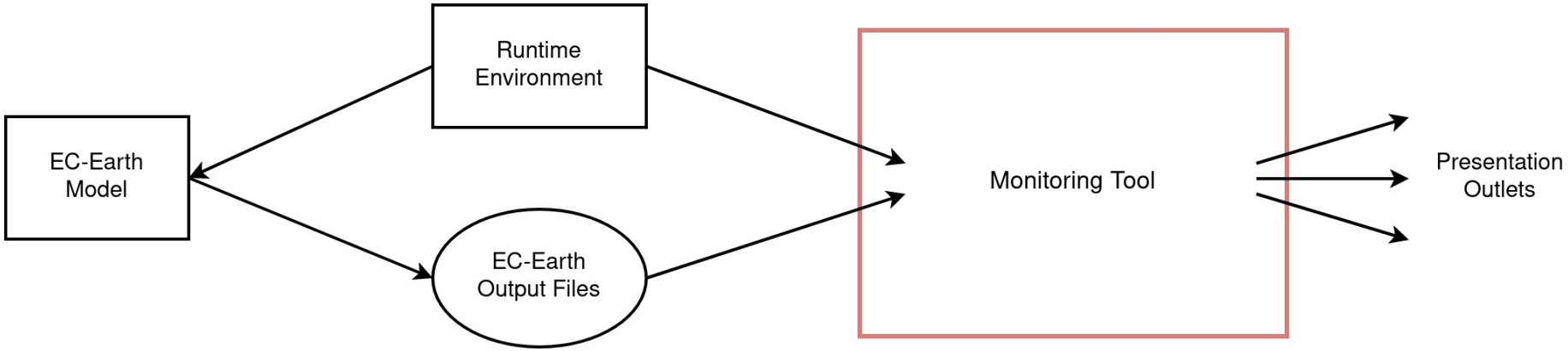
```
domain_cfg.nc                   restart_0057.nc     restart_ice_0040.nc     srf000091310000.0011  srf000091310000.0111
domain_def_nemo.xml             restart_0058.nc     restart_ice_0041.nc     srf000091310000.0012  srf000091310000.0112
EMPave.dat                      restart_0059.nc     restart_ice_0042.nc     srf000091310000.0013  srf000091310000.0113
EMPave_old.dat                  restart_0060.nc     restart_ice_0043.nc     srf000091310000.0014  srf000091310000.0114
field_def_nemo-ice.xml          restart_0061.nc     restart_ice_0044.nc     srf000091310000.0015  srf000091310000.0115
field_def_nemo-oce.xml          restart_0062.nc     restart_ice_0045.nc     srf000091310000.0016  srf000091310000.0116
field_def_nemo-pisces.xml       restart_0063.nc     restart_ice_0046.nc     srf000091310000.0017  srf000091310000.0117
file_def_nemo-ice.xml           restart_0064.nc     restart_ice_0047.nc     srf000091310000.0018  srf000091310000.0118
file_def_nemo-oce.xml           restart_0065.nc     restart_ice_0048.nc     srf000091310000.0019  srf000091310000.0119
file_def_nemo-pisces.xml        restart_0066.nc     restart_ice_0049.nc     srf000091310000.0020  srf000091310000.0120
fort.4                          restart_0067.nc     restart_ice_0050.nc     srf000091310000.0021  srf000091310000.0121
Goutorbe_ghflux.nc              restart_0068.nc     restart_ice_0051.nc     srf000091310000.0022  srf000091310000.0122
grid_def_nemo.xml               restart_0069.nc     restart_ice_0052.nc     srf000091310000.0023  srf000091310000.0123
grids.nc                        restart_0070.nc     restart_ice_0053.nc     srf000091310000.0024  srf000091310000.0124
ICMGGMO10INIT                   restart_0071.nc     restart_ice_0054.nc     srf000091310000.0025  srf000091310000.0125
ICMGGMO10INIUA                  restart_0072.nc     restart_ice_0055.nc     srf000091310000.0026  srf000091310000.0126
ICMSHMO10INIT                   restart_0073.nc     restart_ice_0056.nc     srf000091310000.0027  srf000091310000.0127
ifsdata                         restart_0074.nc     restart_ice_0057.nc     srf000091310000.0028  srf000091310000.0128
iodef.xml                       restart_0075.nc     restart_ice_0058.nc     srf000091310000.0029  srf000091310000.0129
leginfo.yml                     restart_0076.nc     restart_ice_0059.nc     srf000091310000.0030  srf000091310000.0130
leginfo.yml.j2                  restart_0077.nc     restart_ice_0060.nc     srf000091310000.0031  srf000091310000.0131
log                             restart_0078.nc     restart_ice_0061.nc     srf000091310000.0032  srf000091310000.0132
masks.nc                        restart_0079.nc     restart_ice_0062.nc     srf000091310000.0033  srf000091310000.0133
mixing_power_bot.nc             restart_0080.nc     restart_ice_0063.nc     srf000091310000.0034  srf000091310000.0134
mixing_power_cri.nc             restart_0081.nc     restart_ice_0064.nc     srf000091310000.0035  srf000091310000.0135
mixing_power_pyc.nc             restart_0082.nc     restart_ice_0065.nc     srf000091310000.0036  srf000091310000.0136
monitor                         restart_0083.nc     restart_ice_0066.nc     srf000091310000.0037  srf000091310000.0137
namcouple                       restart_0084.nc     restart_ice_0067.nc     srf000091310000.0038  srf000091310000.0138
namelist_cfg                    restart_0085.nc     restart_ice_0068.nc     srf000091310000.0039  srf000091310000.0139
namelist_ice_cfg                restart_0086.nc     restart_ice_0069.nc     srf000091310000.0040  srf000091310000.0140
namelist_ice_ref                restart_0087.nc     restart_ice_0070.nc     srf000091310000.0041  srf000091310000.0141
namelist_ref                    restart_0088.nc     restart_ice_0071.nc     srf000091310000.0042  srf000091310000.0142
namelist.runoffmapper           restart_0089.nc     restart_ice_0072.nc     srf000091310000.0043  srf000091310000.0143
nemo.exe                        restart_0090.nc     restart_ice_0073.nc     srf000091310000.0044  srf000091310000.0144
nemo-initial-state.nc           restart_0091.nc     restart_ice_0074.nc     srf000091310000.0045  srf000091310000.0145
nout.000000                     restart_0092.nc     restart_ice_0075.nc     srf000091310000.0046  srf000091310000.0146
oifs.exe                        restart_0093.nc     restart_ice_0076.nc     srf000091310000.0047  srf000091310000.0147
oifs.exe.lnk                    restart_0094.nc     restart_ice_0077.nc     srf000091310000.0048  srf000091310000.0148
output                          restart_0095.nc     restart_ice_0078.nc     srf000091310000.0049  srf000091310000.0149
output.namelist.dyn             restart_0096.nc     restart_ice_0079.nc     srf000091310000.0050  srf000091310000.0150
output.namelist.ice             restart_0097.nc     restart_ice_0080.nc     srf000091310000.0051  srf000091310000.0151
rcf                             restart_0098.nc     restart_ice_0081.nc     srf000091310000.0052  srf000091310000.0152
restart                         restart_0099.nc     restart_ice_0082.nc     srf000091310000.0053  srf000091310000.0153
restart_0000.nc                 restart_0100.nc     restart_ice_0083.nc     srf000091310000.0054  srf000091310000.0154
restart_0001.nc                 restart_0101.nc     restart_ice_0084.nc     srf000091310000.0055  srf000091310000.0155
restart_0002.nc                 restart_0102.nc     restart_ice_0085.nc     srf000091310000.0056  srf000091310000.0156
restart_0003.nc                 restart_0103.nc     restart_ice_0086.nc     srf000091310000.0057  srf000091310000.0157
restart_0004.nc                 restart_0104.nc     restart_ice_0087.nc     srf000091310000.0058  srf000091310000.0158
restart_0005.nc                 restart_0105.nc     restart_ice_0088.nc     srf000091310000.0059  srf000091310000.0159
restart_0006.nc                 restart_0106.nc     restart_ice_0089.nc     srf000091310000.0060  srf000091310000.0160
restart_0007.nc                 restart_0107.nc     restart_ice_0090.nc     srf000091310000.0061  srf000091310000.0161
restart_0008.nc                 restart_0108.nc     restart_ice_0091.nc     srf000091310000.0062  srf000091310000.0162
restart_0009.nc                 restart_0109.nc     restart_ice_0092.nc     srf000091310000.0063  srf000091310000.0163
restart_0010.nc                 restart_0110.nc     restart_ice_0093.nc     srf000091310000.0064  srf000091310000.0164
restart_0011.nc                 restart_0111.nc     restart_ice_0094.nc     srf000091310000.0065  srf000091310000.0165
```



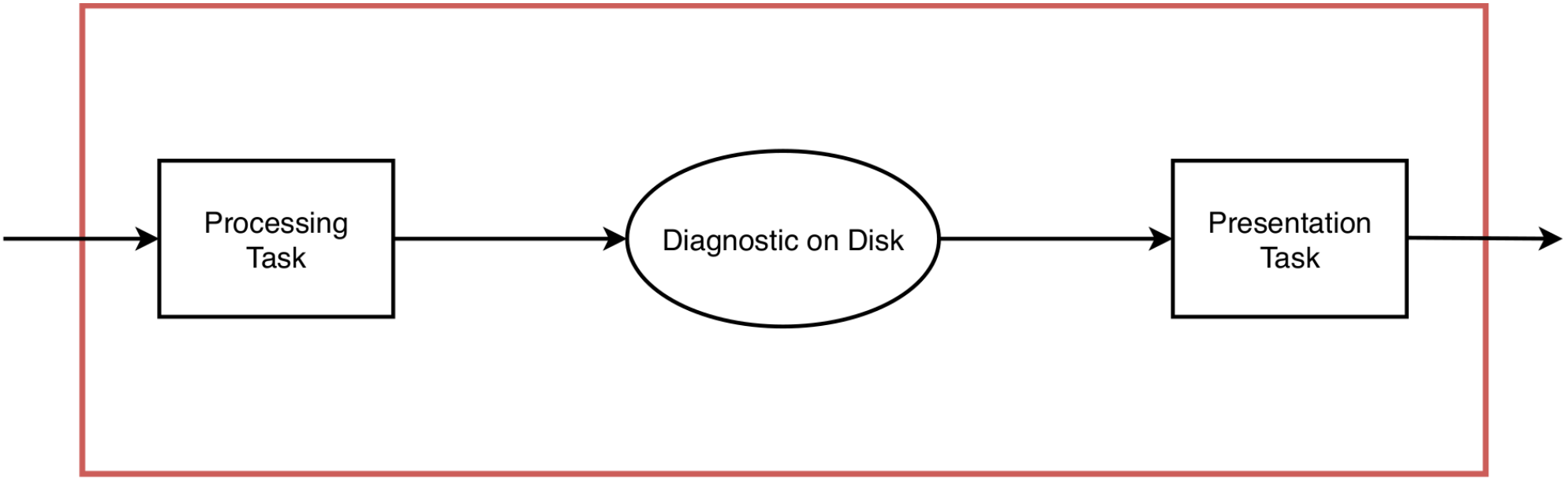
Goal

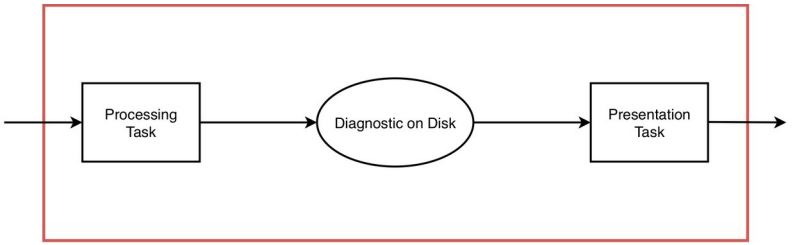
… automatically
… at runtime
… component-agnostic
… customizable
… extendable

Concept


Runtime
Environment
EC-Earth
Model
EC-Earth
Output Files
Monitoring Tool
Presentation
Outlets

Concept

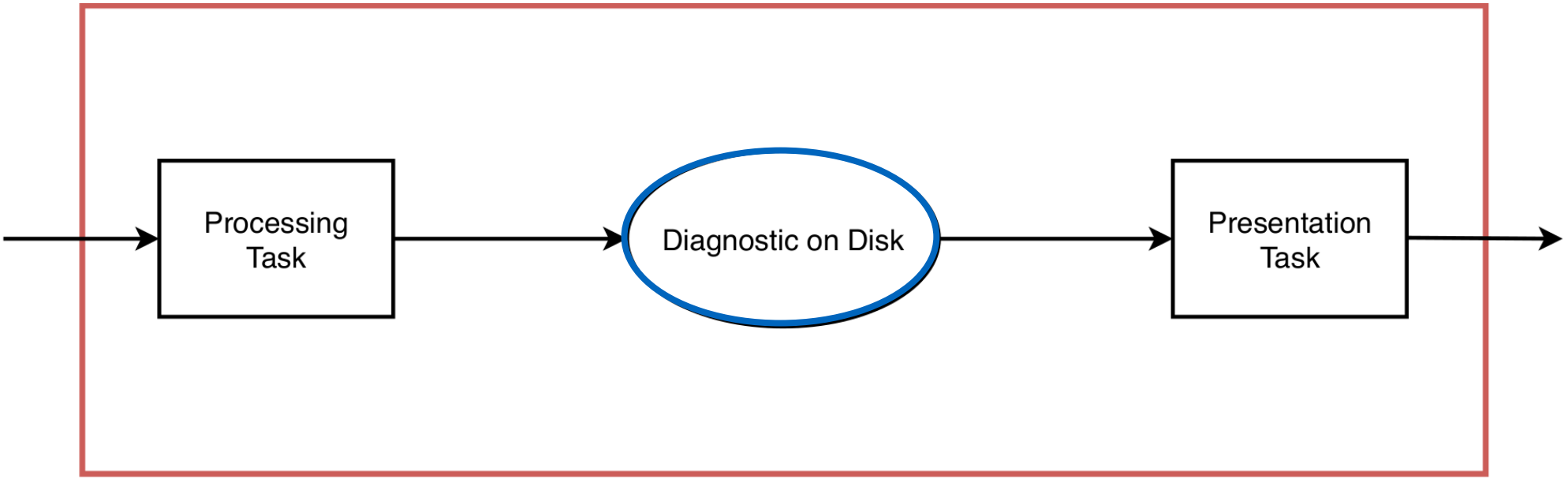




Goal

… automatically
… at runtime
… component-agnostic
… customizable
… extendable

Concept



Example

Processing Task
annual global mean of oceanic variable

Diagnostic
annual global mean of sea surface temperature
on disk: NetCDF file

Presentation Task
create Markdown document with all diagnostics

Implementation

ScriptEngine

execute YAML scripts
used to compile & run EC-Earth 4

```yaml
name_of_task:
    param_1: 'value'
    param_2: 'other value'
```

```
param_1 = 'value'
param_2 = 'other value'
name_of_task = NameOfTask(param_1, param_2)
name_of_task.run()
```

EC-Earth 4 Monitoring: What

extendable set of ScriptEngine Tasks
→ users create monitoring scripts
→ they are executed during runtime

EC-Earth 4 Monitoring: How

open-source Python code
automated tests
user documentation & developing guidelines

EC-Earth 4 Monitoring: Where

scriptengine-tasks-ecearth.rtfd.io

</> /valentinaschueller/scriptengine-tasks-ecearth

/valentinaschueller/ece-4-monitoring-resources

Thank You!

Questions?

Diagnostics (on Disk)

diagnostic types
file types
file structure
(meta)data requirements
naming scheme

Diagnostics (on Disk)

scalars – YAML files

time series – NetCDF files

maps – NetCDF files

temporal maps – NetCDF files

Implementation Examples

Scalars

```
- ece.mon.scalar:
    title: "Experiment Description"
    value: "{{main.experiment_description}}"
    dst: "{{main.mondir}}/description_scalar.yml"
- ece.mon.simulatedyears_rte_scalar:
    start: "{{schedule.start}}"
    end: "{{schedule.leg.end}}"
    dst: "{{main.mondir}}/simulatedyears_rte_scalar.yml"
```

Result: YAML Files

```yaml
title: Experiment Description
value: A monitoring test with EC-Earth 4
diagnostic_type: scalar
```

```yaml
title: Simulated Years
comment: Current number of simulated years.
value: 25
diagnostic_type: scalar
```

Time Series

```
- ece.mon.nemo_global_mean_year_mean_timeseries:
    src: "{{oce_t_files}}"
    varname: "tos"
    domain: "{{main.rundir}}/domain_cfg.nc"
    dst: "{{main.mondir}}/tos_nemo_global_mean_year_mean_timeseries.nc"

- ece.mon.oifs_global_mean_year_mean_timeseries:
    src: "{{atm_gg_files}}"
    dst: "{{main.mondir}}/2t_oifs_global_mean_year_mean_timeseries.nc"
    grib_code: 167
```

Result: NetCDF Files

```
(base) valentina@valentina-XPS-13-9360:~/monitor$ ncdump -h tos_nemo_global_mean_year_mean_timeseries.nc
netcdf tos_nemo_global_mean_year_mean_timeseries {
dimensions:
        time_counter = 25 ;
        bnds = 2 ;
variables:
        double tos(time_counter) ;
                tos:standard_name = "sea_surface_temperature" ;
                tos:long_name = "sea surface temperature" ;
                tos:units = "degC" ;
                tos:cell_methods = "time_counter: mean (interval: 1 month) area: mean" ;
                tos:coordinates = "nav_lat nav_lon" ;
        double time_counter(time_counter) ;
                time_counter:axis = "T" ;
                time_counter:bounds = "time_counter_bnds" ;
                time_counter:units = "seconds since 1900-01-01 00:00:00" ;
                time_counter:standard_name = "time" ;
                time_counter:long_name = "Time axis" ;
                time_counter:calendar = "gregorian" ;
                time_counter:time_origin = "1900-01-01 00:00:00" ;
        double time_counter_bnds(time_counter, bnds) ;
        float nav_lat ;
                nav_lat:bounds = "nav_lat_bnds" ;
                nav_lat:units = "degrees_north" ;
                nav_lat:standard_name = "latitude" ;
                nav_lat:long_name = "Latitude" ;
        float nav_lat_bnds(bnds) ;
        float nav_lon ;
                nav_lon:bounds = "nav_lon_bnds" ;
                nav_lon:units = "degrees_east" ;
                nav_lon:standard_name = "longitude" ;
                nav_lon:long_name = "Longitude" ;
        float nav_lon_bnds(bnds) ;

// global attributes:
                :comment = "Global average time series of **tos**. Each data point represents the (spatial and temporal) average over one leg." ;
                :diagnostic_type = "time series" ;
                :source = "EC-Earth 4" ;
                :title = "sea surface temperature (Annual Mean)" ;
                :Conventions = "CF-1.7" ;
}
(base) valentina@valentina-XPS-13-9360:~/monitor$
```

Redmine Presentation

```
- ece.mon.presentation.redmine:
    src:
        - "{{main.mondir}}/expid_scalar.yml"
        - "{{main.mondir}}/description_scalar.yml"
        - "{{main.mondir}}/simulatedyears_rte_scalar.yml"
        - "{{main.mondir}}/sypd_timeseries.nc"
        - "{{main.mondir}}/tos_nemo_global_mean_year_mean_timeseries.nc"
        - path: "{{main.mondir}}/tos_nemo_year_mean_temporalmap.nc"
          value_range: [-2, 30]
        - "{{main.mondir}}/sivol_north_sum_mar+sep_mean_timeseries.nc"
        - "{{main.mondir}}/sivol_south_sum_feb+sep_mean_timeseries.nc"
        - path: "{{main.mondir}}/siconc_si3_north_point_mar_mean_temporalmap.nc"
          value_range: [0, 100]
          colormap: 'Blues_r'
        - path: "{{main.mondir}}/siconc_si3_north_point_sep_mean_temporalmap.nc"
          value_range: [0, 100]
          colormap: 'Blues_r'
        - path: "{{main.mondir}}/siconc_si3_south_point_feb_mean_temporalmap.nc"
          value_range: [0, 100]
          colormap: 'Blues_r'
        - path: "{{main.mondir}}/siconc_si3_south_point_sep_mean_temporalmap.nc"
          value_range: [0, 100]
          colormap: 'Blues_r'
        - "{{main.mondir}}/2t_oifs_global_mean_year_mean_timeseries.nc"
        - "{{main.mondir}}/2t_oifs_all_mean_map.nc"
        - "{{main.mondir}}/istl1_oifs_year_mean_temporalmap.nc"
    local_dst: "{{main.mondir}}/presentation/redmine"
    api_key: # api key
    subject: "EC-Earth 4 experiment: {{main.experiment_id}}"
    template: "scriptengine-tasks-ecearth/docs/templates/redmine_template.txt.j2"
```

Result: Local Directory & Issue

```
redmine/
├── 2t_oifs_all_mean_map.png
├── 2t_oifs_global_mean_year_mean_timeseries.png
├── issue_description.txt
├── istl1_oifs_year_mean_temporalmap.png
├── siconc_si3_north_point_mar_mean_temporalmap_frames
├── siconc_si3_north_point_mar_mean_temporalmap.gif
├── siconc_si3_north_point_sep_mean_temporalmap_frames
├── siconc_si3_north_point_sep_mean_temporalmap.gif
├── siconc_si3_south_point_feb_mean_temporalmap_frames
├── siconc_si3_south_point_feb_mean_temporalmap.gif
├── siconc_si3_south_point_sep_mean_temporalmap_frames
├── siconc_si3_south_point_sep_mean_temporalmap.gif
├── sivol_north_sum_mar_sep_mean_timeseries.png
├── sivol_south_sum_feb_sep_mean_timeseries.png
├── sypd_timeseries.png
├── tos_nemo_global_mean_year_mean_timeseries.png
├── tos_nemo_year_mean_temporalmap_frames
└── tos_nemo_year_mean_temporalmap.gif

5 directories, 13 files
```

Experiment #876

MO10: A monitoring test with EC-Earth4

Added by **Uwe Fladrich** 3 days ago. Updated 22 minutes ago.

Status: ONGOING
Priority: Medium
Assignee: Uwe Fladrich

Description

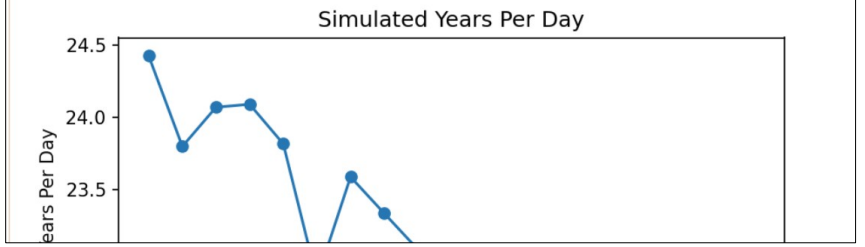
Experiment ID: MO10

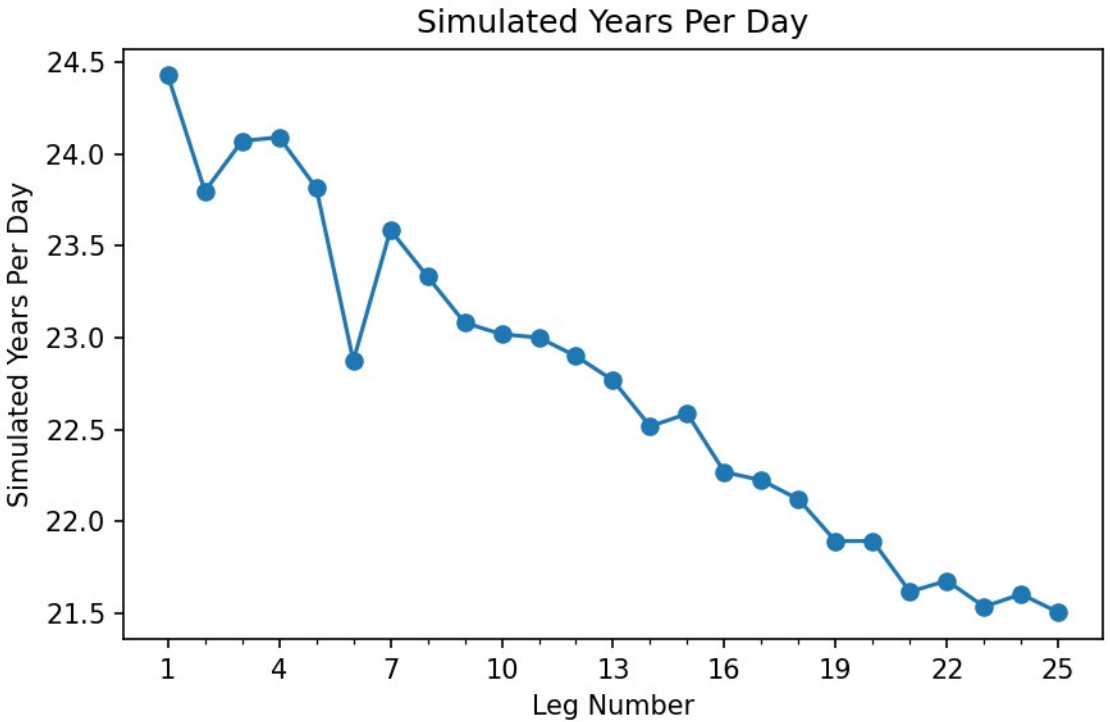
Experiment Description: A monitoring test with EC-Earth4

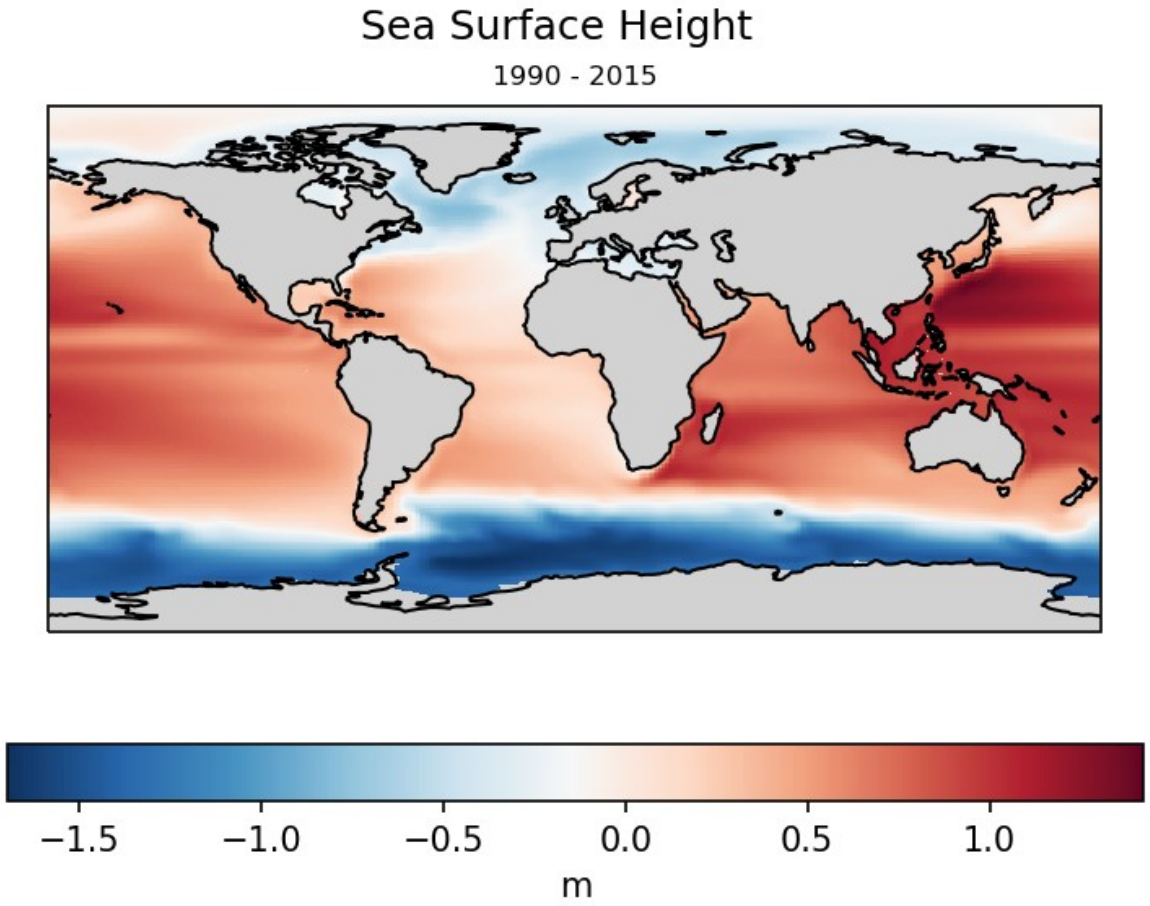
Simulated Years: 19
Current number of simulated years.

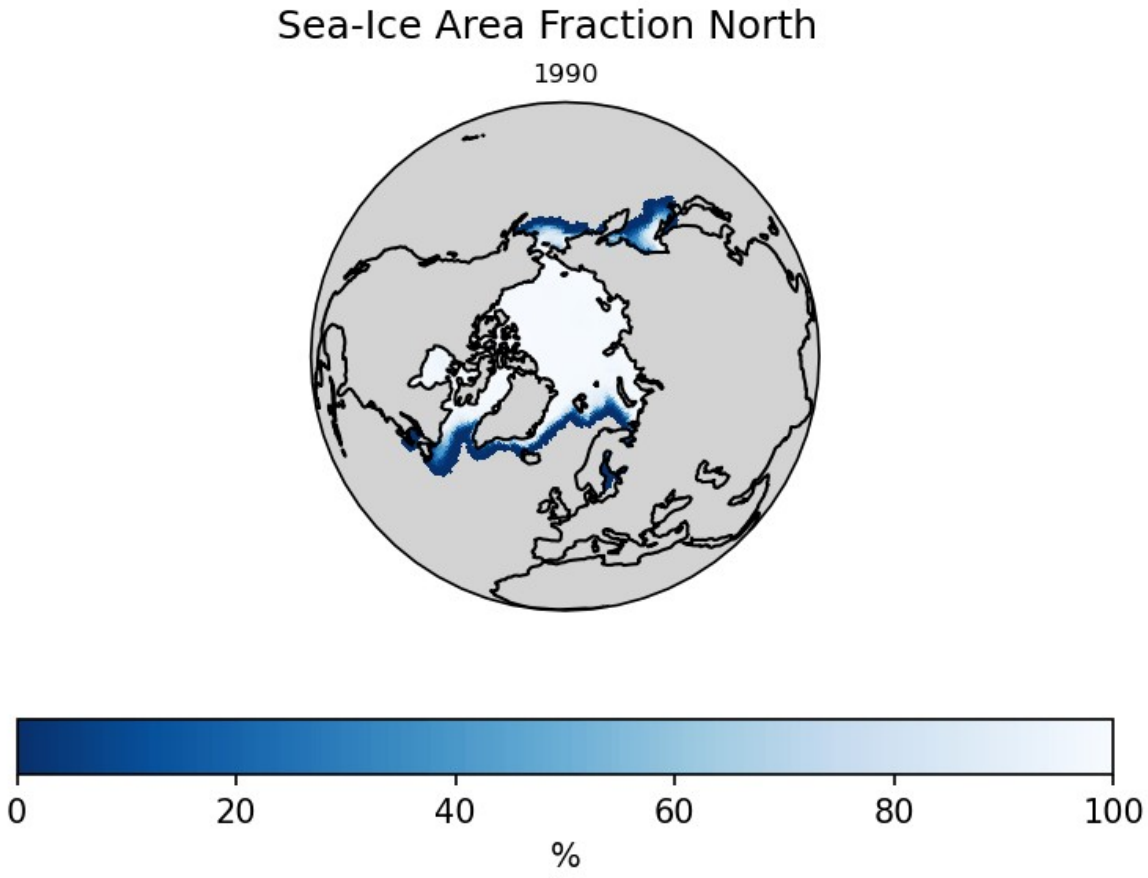
Disk Usage in GB: 328.4
Current size of /home/sm_uflad/Projects/ece-4/runtime/se/run/MO10/output.

Simulated Years Per Day




Simulated Years Per Day
Simulated Years Per Day
24.5
24.0
23.5
23.0
22.5
22.0
21.5
1
4
7
10
13
16
19
22
25
Leg Number


Sea Surface Height
1990 - 2015
−1.5
−1.0
−0.5
0.0
0.5
1.0
m


Sea-Ice Area Fraction North
1990
0
20
40
60
80
100
%

Concept

Processing Task

create a diagnostic & save it

Concept

Presentation Task

visualize and summarize diagnostic(s)

Concept

Diagnostic

meaningful quantity about the physical or computational performance