

Introduction to ICON

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Deutsches Klimarechenzentrum (DKRZ)

A tall, modern building with a silver, perforated metal facade and large glass windows. The building is set against a blue sky with scattered clouds. In the background, a white telecommunications tower with a red antenna is visible. The foreground shows a paved area and some greenery.

DKRZ
The German Climate
Computing Centre

General Introduction



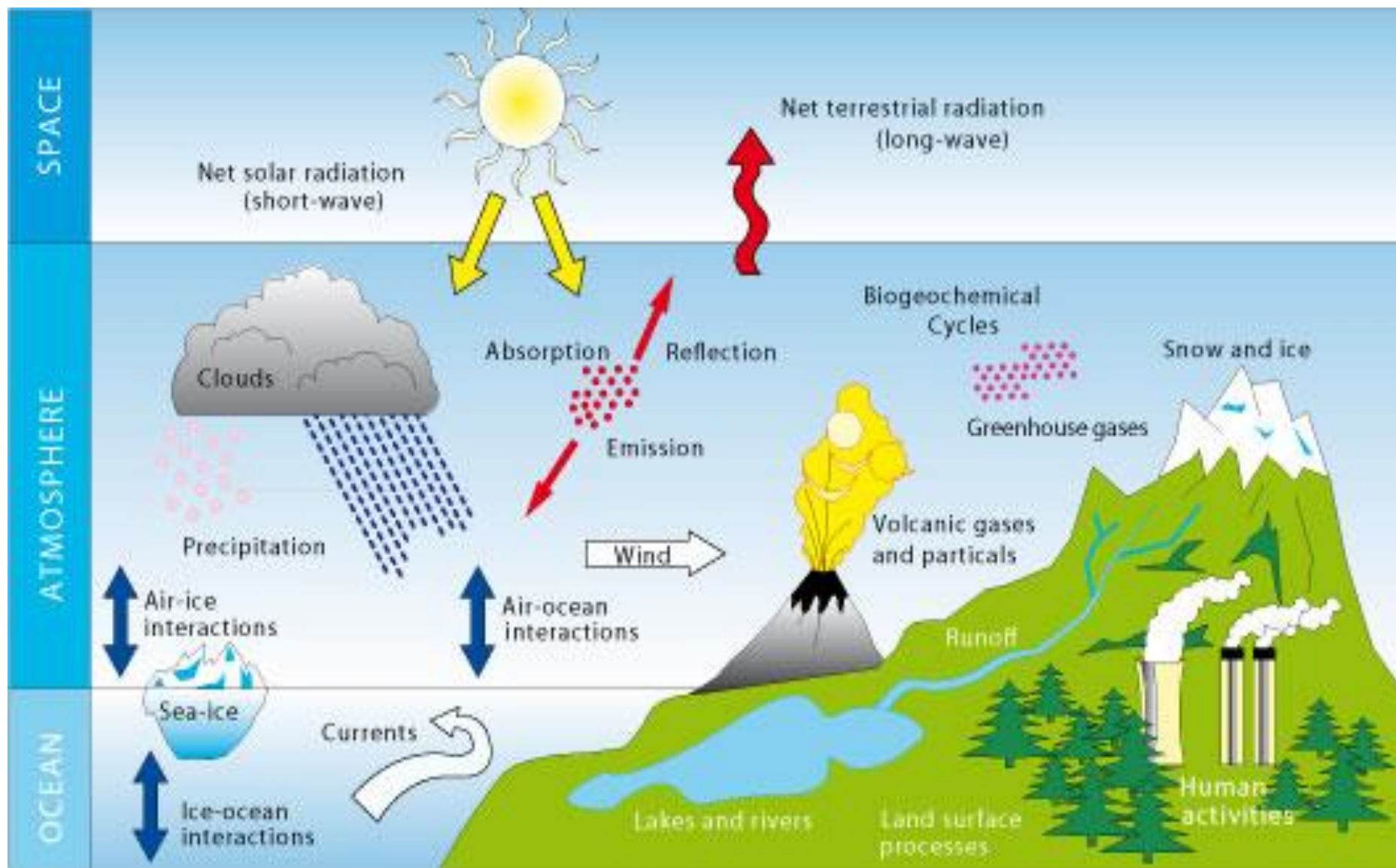
Who am I

- Diploma in Computer Science from the University of Patras in Greece
- PhD in Mechanical Engineering from the University of Stuttgart (Germany), while working at HLRS
- Working area : High Performance Computing with emphasis on parallel numerical algorithms and parallel programming models.

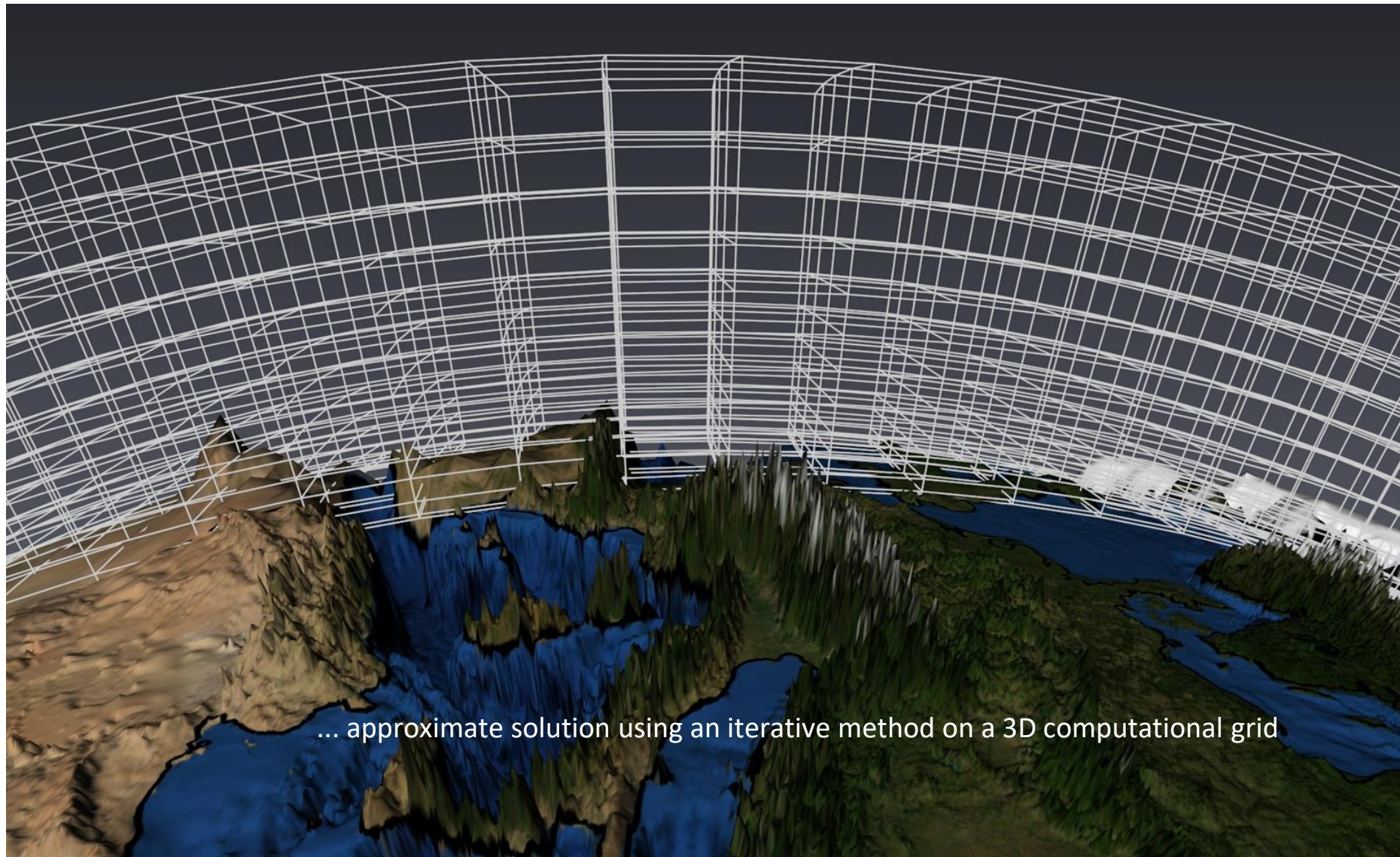
Who am I

- ❑ I joined DKRZ in December 2006
- ❑ Leading the HPC Software Development Group
- ❑ Focus is the development of HPC related software components and libraries for earth system models as well as optimization issues at application level
- ❑ Libraries
 - ❑ YAC (Yet Another Coupler)
 - ❑ YAXT (Yet Another eXchange Tool)
 - ❑ CDI-PIO (Parallel I/O for GRIB and NETCDF Format)

Viewing the Earth as a System



General Introduction



ICON : ICOSahedral Nonhydrostatic

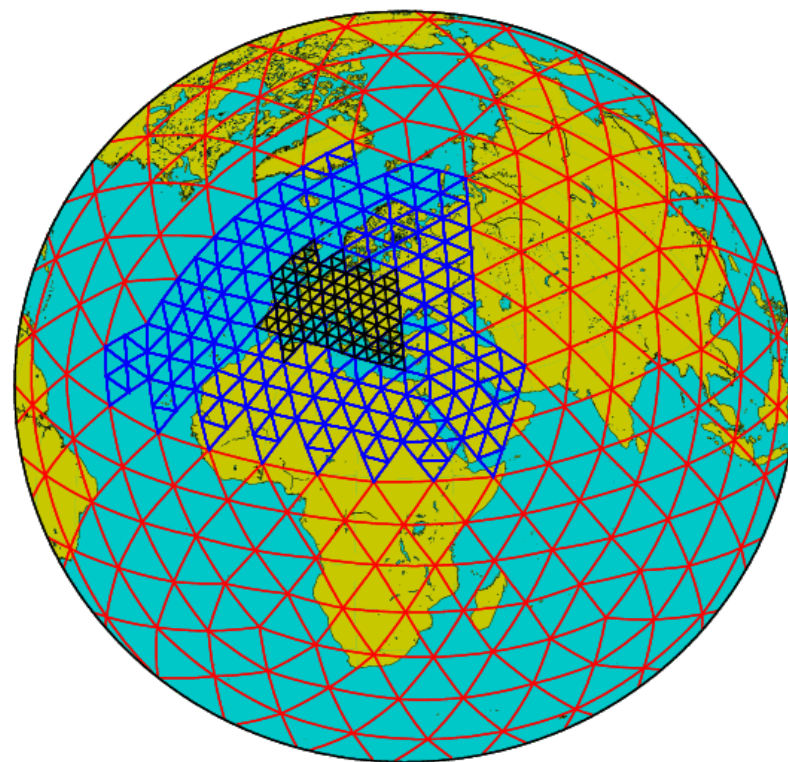
- ❑ The ICON (ICOSahedral Nonhydrostatic) earth system model is a unified next-generation global numerical weather prediction and climate modelling system.
- ❑ It consists of an atmosphere and an ocean component and is designed to simulate multiple scales of the atmosphere and ocean processes

ICON : ICOSahedral Nonhydrostatic

- ❑ ICON is a non-hydrostatic global model with a local zoom function.
- ❑ Its dynamical core solves the fully compressible non-hydrostatic equations of motion for simulations at very high horizontal resolution

ICON : ICOSahedral Nonhydrostatic

- ❑ The system of equations is solved in grid point space on a geodesic icosahedral grid
- ❑ It provides the option to run locally nested highly refined resolutions, allowing simulations at a very fine scale
- ❑ Unstructured Grids
- ❑ FORTRAN 2003
- ❑ MPI/OpenMP Parallel
- ❑ WIP: GPU Port
 - ❑ ICON-A with OpenACC mostly done
 - ❑ ICON-O first attempts with OpenACC and OpenMP



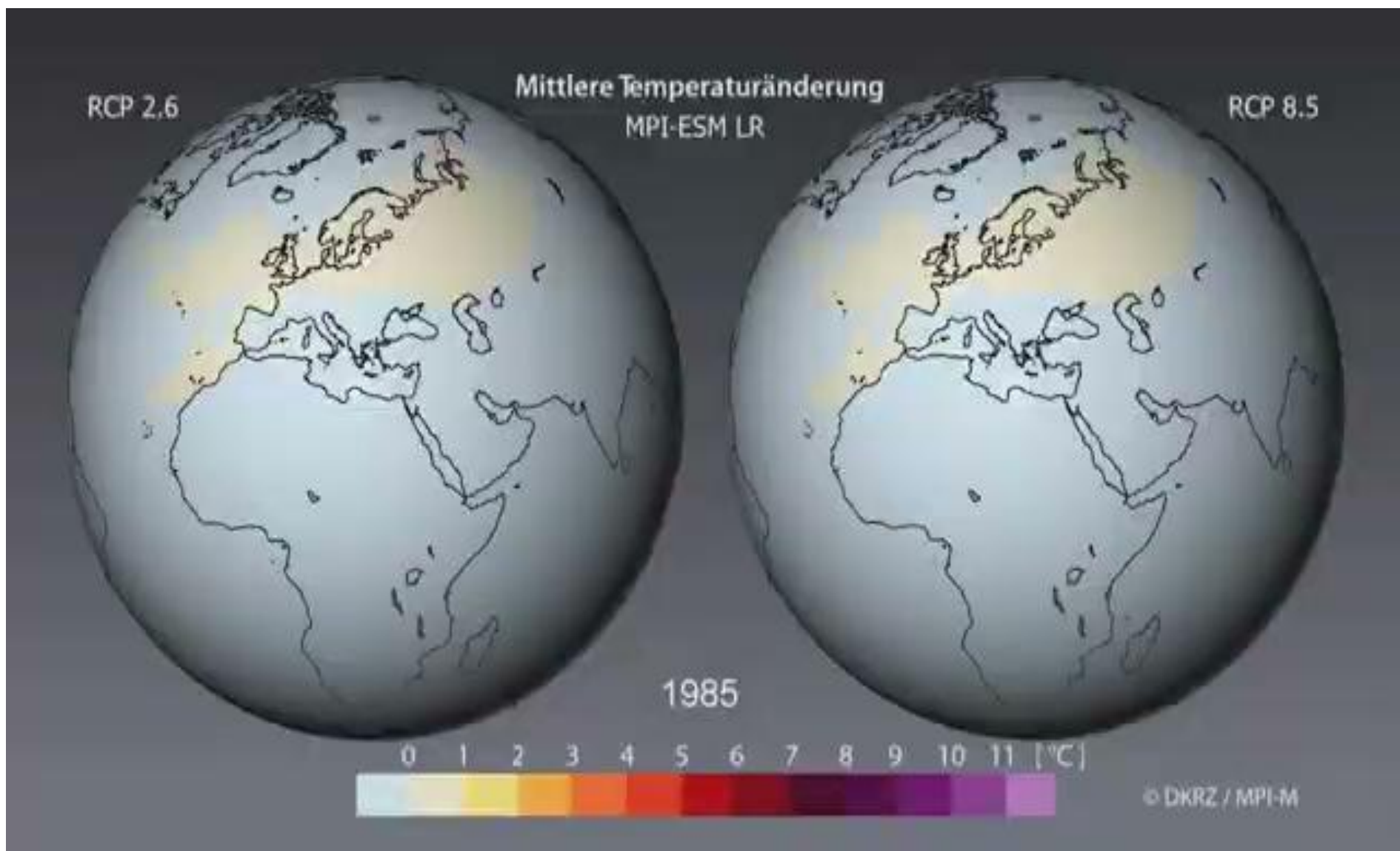
Operational Use of ICON

- The ICON model has been introduced into DWD's (German Weather Service) operational forecast system in January 2015 and is used in several national and international climate research projects targeting high resolution simulations.
- Soon to be used by MeteoSwiss

The Intergovernmental Panel on Climate Change

- ❑ The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change
- ❑ <https://www.ipcc.ch/>

The Intergovernmental Panel on Climate Change



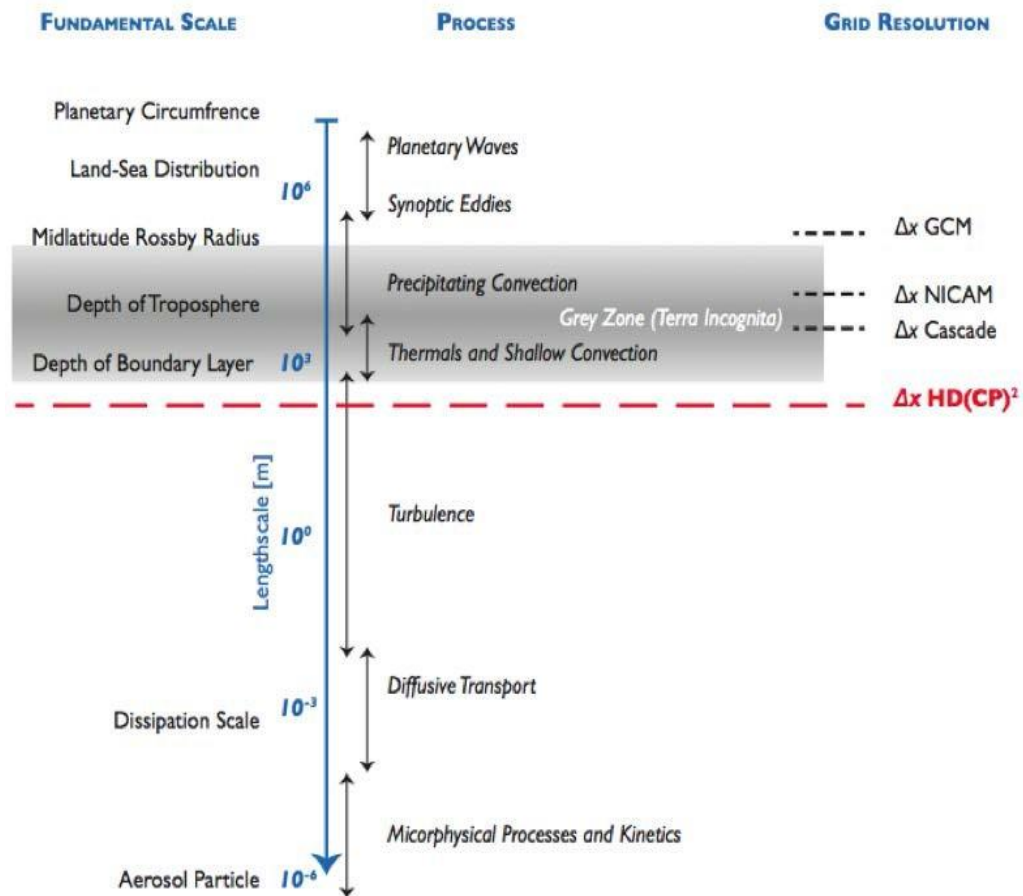
CMIP6 : Coupled Model Intercomparison Project

- ❑ World Climate Research Program
- ❑ The Coupled Model Intercomparison project
- ❑ <https://mpimet.mpg.de/en/science/projects/integrated-activities/translate-to-englisch-cmip6-das-gekoppelte-modellvergleichsprojekt>

ICON in Research Projects

- ❑ HD(CP)² : High Definition Cloud and Precipitation for Advancing Climate Prediction
- ❑ Main target of HD(CP)² project is to improve the understanding of cloud and precipitation processes in climate simulations. By addressing this topic, we expect a significant reduction in the uncertainty in climate change projections of more than 50 % - both on global and regional scales.
- ❑ <https://hdcp2.eu/>

Very High Resolution Climate Modelling HD(CP)²



Cloud-resolving simulation over Germany through ICON HighRes

Simulation and Visualization produced by the HD(CP)² project
of the German Ministry of Education and Research (BMBF).



Bundesministerium
für Bildung
und Forschung

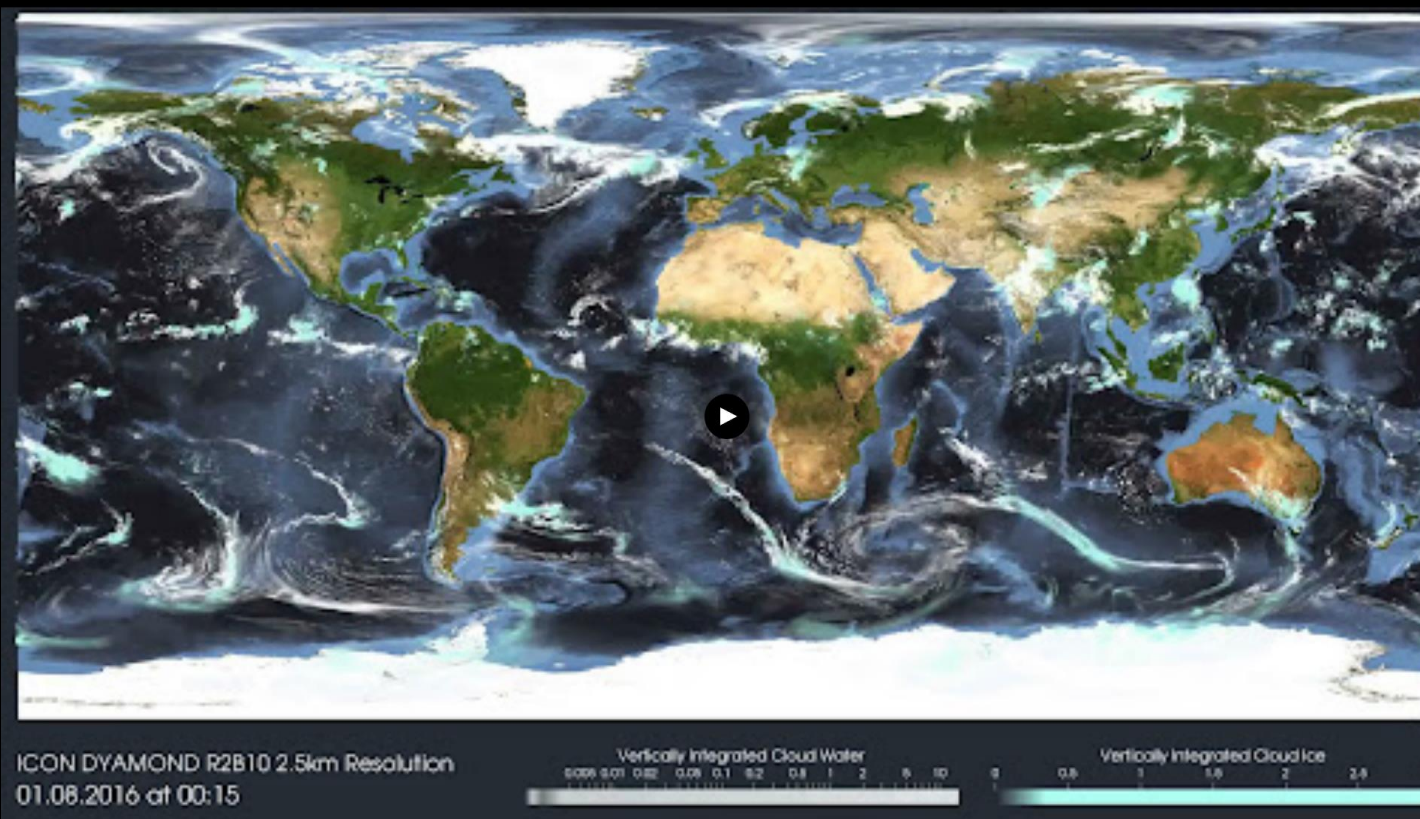


HD(CP)²

High definition clouds and precipitation
for advancing climate prediction

ICON : High Resolution Simulations

- ❑ ICON is increasingly being used in climate simulations with high resolution grids, in order to resolve small-scale physical processes.
- ❑ In this way, parameterisation and the inherent uncertainty can be avoided, thus improving significantly climate change projections.



ESIWACE

- ❑ The Centre of Excellence in Simulation of Weather and Climate in Europe
- ❑ ESiWACE — for future exascale weather and climate simulations
- ❑ <https://www.esiwace.eu/>
- ❑ Global Storm Resolving and Large-Domain Large-Eddy Simulations
 - ❑ <https://www.youtube.com/watch?v=ji4nno-fsvw>

ICON Ocean Model Submesoscale Telescope Project

YouTube video player

Resolution: 550m - 11km/6 minute at 50m depth



Data: Leonidas Linardakis, Peter Korn

Visualization: Niklas Röber



Max-Planck-Institut
für Meteorologie



ESIWACE

- ❑ GOAL : Coupled Atmosphere-Ocean Simulations at a Resolution of 1km with a performance of 1 SYPD (Simulated Year per Day)
- ❑ <https://www.youtube.com/watch?v=j7hDcQn0Cfl>

SCC Task

- ❑ You will be running a coupled atmosphere-ocean experiment with ICON, which simulates 1 model year
- ❑ The performance of this setup on 4 nodes, equipped with 36 Intel Broadwell processors per node, is 1 Simulated Year in 30 minutes Wallclock Time
- ❑ YOUR GOAL is to speedup the execution time of this setup by porting and tuning ICON to the newer architecture of Niagara and Bridges-2 cluster

Model Tuning

- ❑ Porting and tuning for specific processor architecture
- ❑ Load Balancing
- ❑ Profiling Analysis, Identify Bottlenecks

SCC Task

- Check the correctness of your results by using the python script `scc_plots.ipynb`, as described above in the section “Postprocessing”.

SCC Task: Test for Correctness

Activities Firefox Web Browser Wed 26 Jan 17:32

work/fk20200/fk202061/... scc_plots - Jupyter Note...
https://jupyterhub.dkrz.de/user/fk202061/preset/notebooks/work/fk20200/fk202061/fsc22_scc/icon-scc/post_processing/scc_plots.ipynb 133%

DKRZ Project Manage... ICON dict.cc | German-Engli... BigBlueButton Google Calendar Anmeldung Cambridge Dictionary ... Welcome to the IS-EN... Rußbereitschaft - Syst... Das Generalkonsulat L... Bash Reference Manual Introduction to Parall... HPCC http://netlib.org/blas/... Other Bookmarks

DKRZ scc_plots Last Checkpoint: 12/14/2021 (autosaved) Logout Control Panel

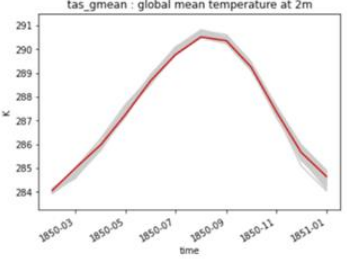
File Edit View Insert Cell Kernel Widgets Help Trusted Python 3 unstable (using the module python3/unnstable) Memory: 69.7 MB

To get a whole lot of additional plots set `plot_all` to `True` below.

In [10]:

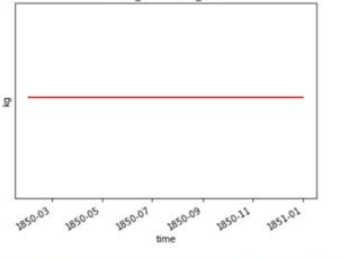
```
for x in ref_mon_files.keys():
    call_plots(ref_mon_files[x], exp_mon_files[x], grey=True, plot_all = False)
```

tas_gmean : global mean temperature at 2m



All values of `total_salt` are identical :)

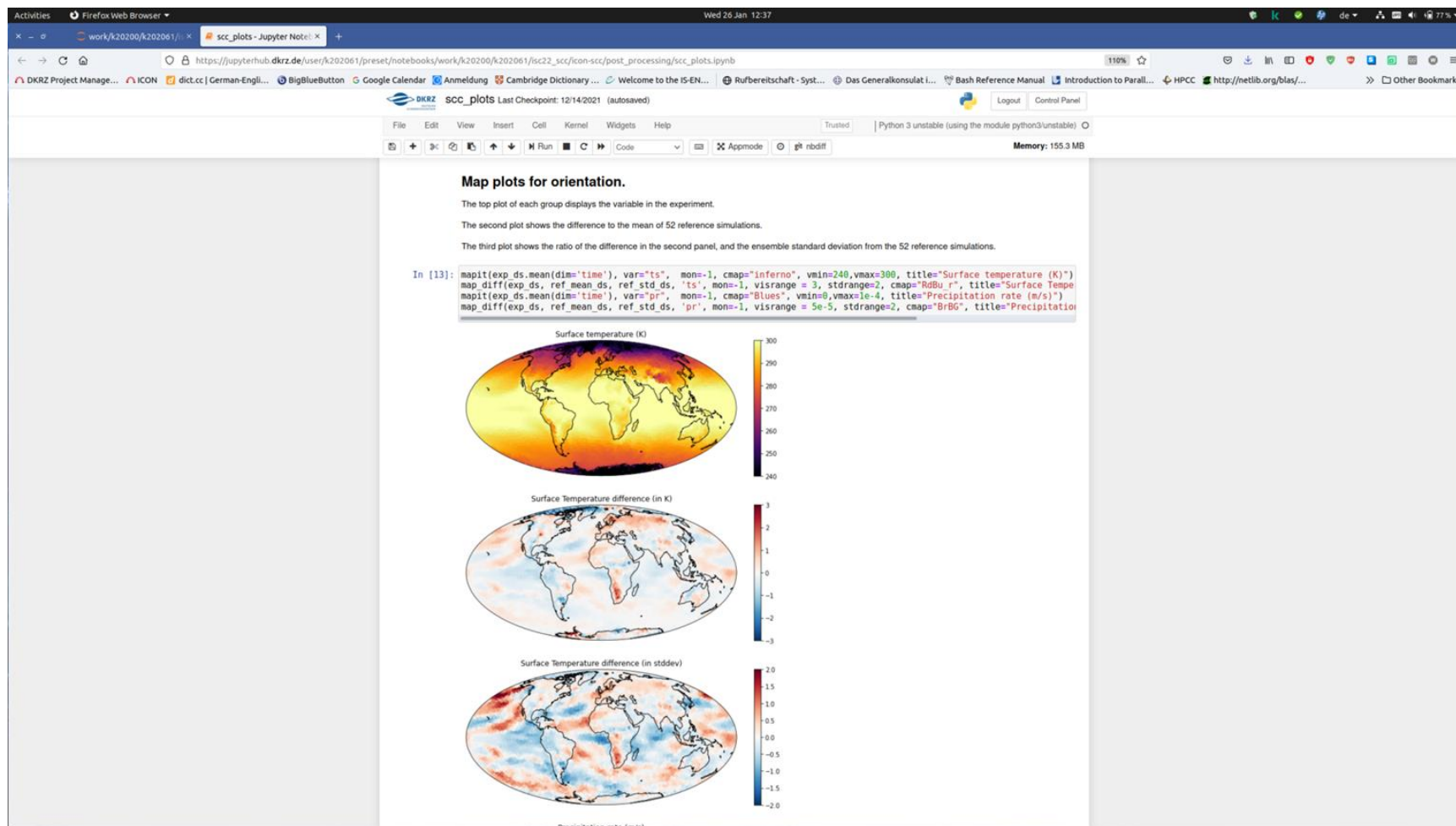
total_salt : total_salt



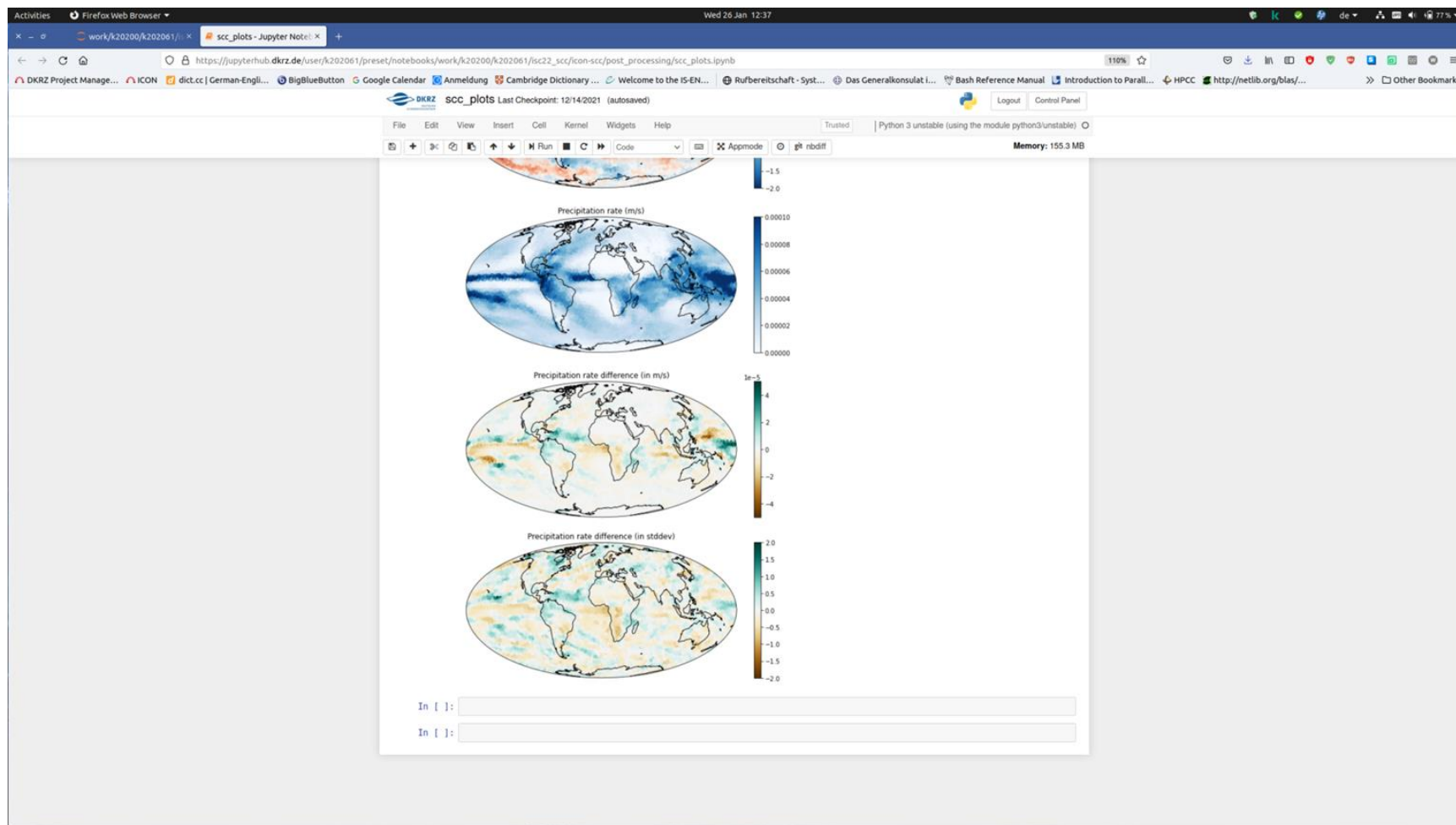
In [11]:

```
def mapit(ds, member=None, var="ts", mon=0, cmap='inferno', vmin=240, vmax=300, title=""):
    fig = plt.figure(figsize=(10,4))
    ax = fig.add_subplot(1,1,1, projection=crs.Mollweide())
    ax.set_global()
    # print (raw dot size*1.0/skip/len(lon). " as dot size")
```

SCC Task Results: Temperature



SCC Task Results : Precipitation



Thanks for your attention !!