

Introduction to DKRZ and to the Visualization Server “halo”

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Deutsches
Klimarechenzentrum

*German Climate
Computing Center*



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Earth System Research in Hamburg

KlimaCampus

- University Institutes
 - Meteorology
 - Oceanography
 - Geophysics
 - Sustainable Development
 - ...
- Max Planck Institute for Meteorology
- HZG Institute for Coastal Research
- **DKRZ (national facility)**
- **CSC (national facility)**



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DKRZ – what is it?

- ▶ High Performance Computing Center
- ▶ National Service Facility for Climate- and Earth System Research (Support for Model Parallelization / Optimization, Data Management and Visualization)
- ▶ Limited Company (Shareholder: MPG: 53%, University HH: 27%, AWI: 10%, HZG: 10%)



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High Performance Computing

- IBM "Power6": 264 Nodes
 - 16 DualCore CPUs / Node
 - 8448 Cores
 - 19 GFlops/Core;
 - 158 TeraFlops (sustained)
 - System memory 20 TByte
- Infiniband Interconnect (4xDDR)
- 6 PByte GPFS file system
- Optimized for Climate Modeling
 - Procurement: Benchmark with Climate Models



Top500 (06/2009): Rank 27
(06/2013): Rank 368

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Data Production at DKRZ

6 PByte
GPFS



Hard Disks

158 TFlops
20 TByte Mem.



Supercomputer

7 Silos
70 Drives
100 PByte



Archive System

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Tape Archive

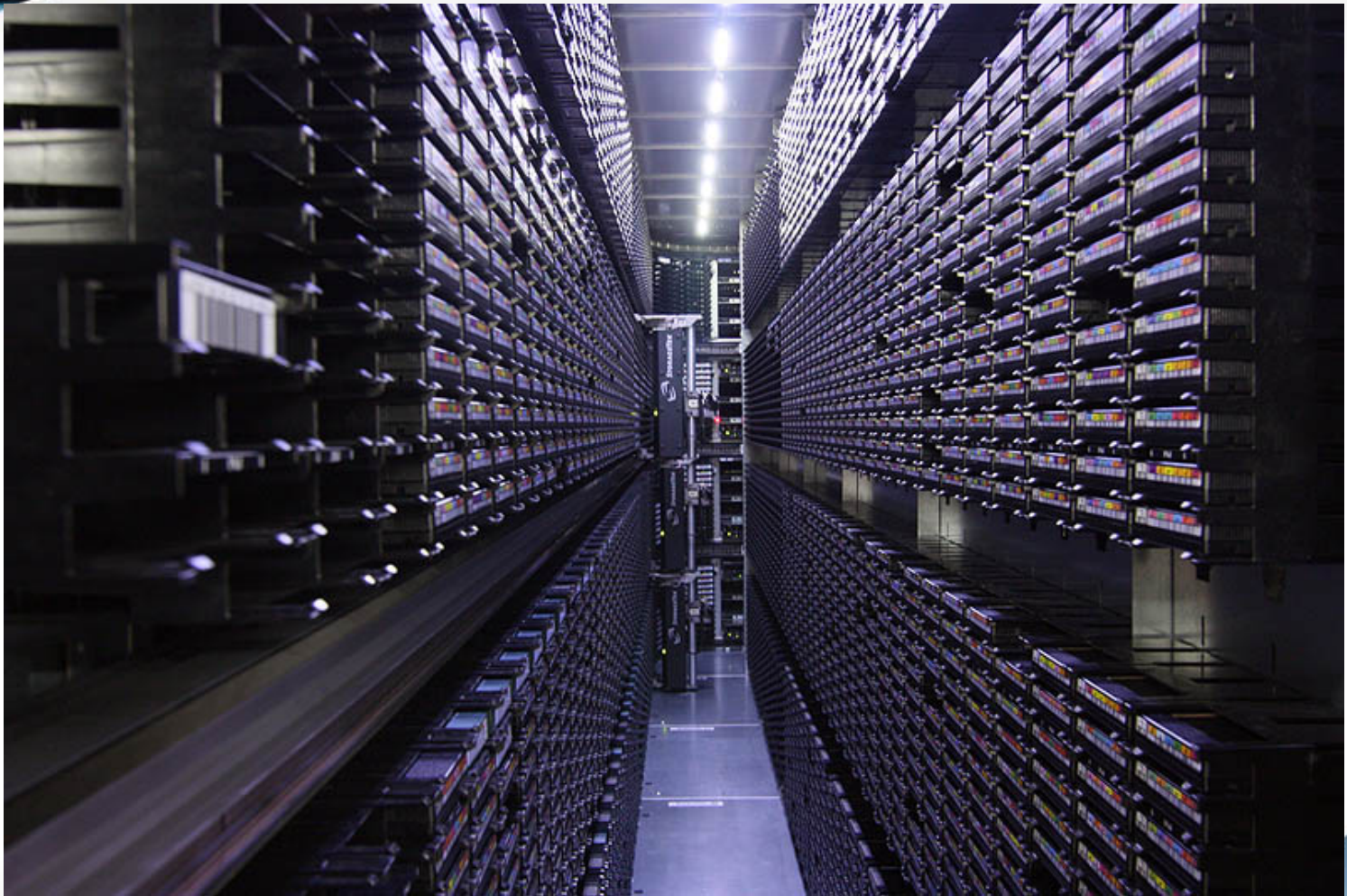
HPSS

7 **STK** SL8500 Silos,
65 000 Tapes
70 Tape Drives
500 TB Disk Cache
Capacity ~ 100 Pbyte



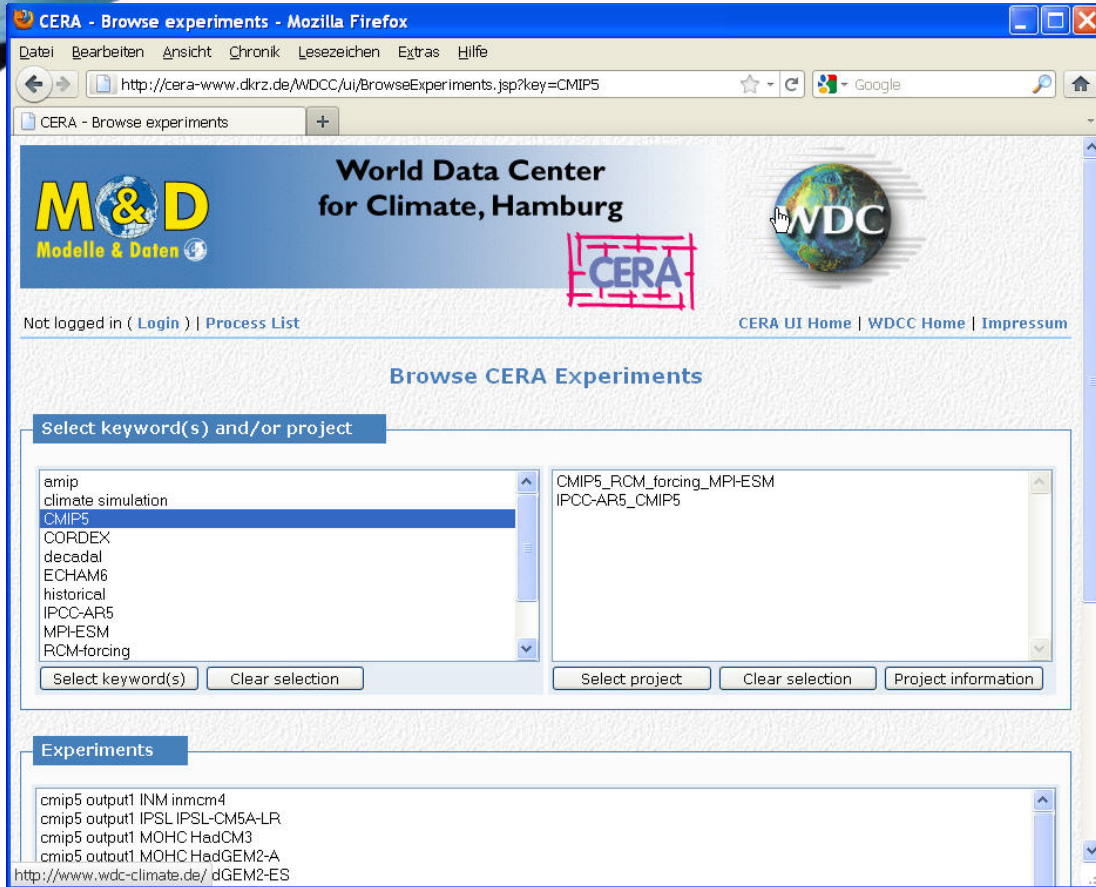
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Tape Archive



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World Data Center for Climate



- ▶ Long-Term Storage
 - ▶ > 500 TB climate data
 - ▶ Free download
- cera-www.dkrz.de**
- ▶ Searchable Index
 - ▶ Data storage in container files

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Visualization in HPC Environments

Supercomputer



Parallel File System (GPFS)

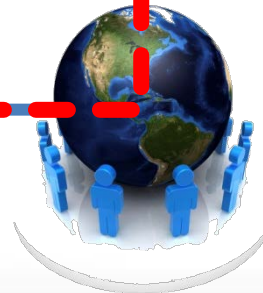
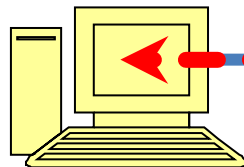


Archive System



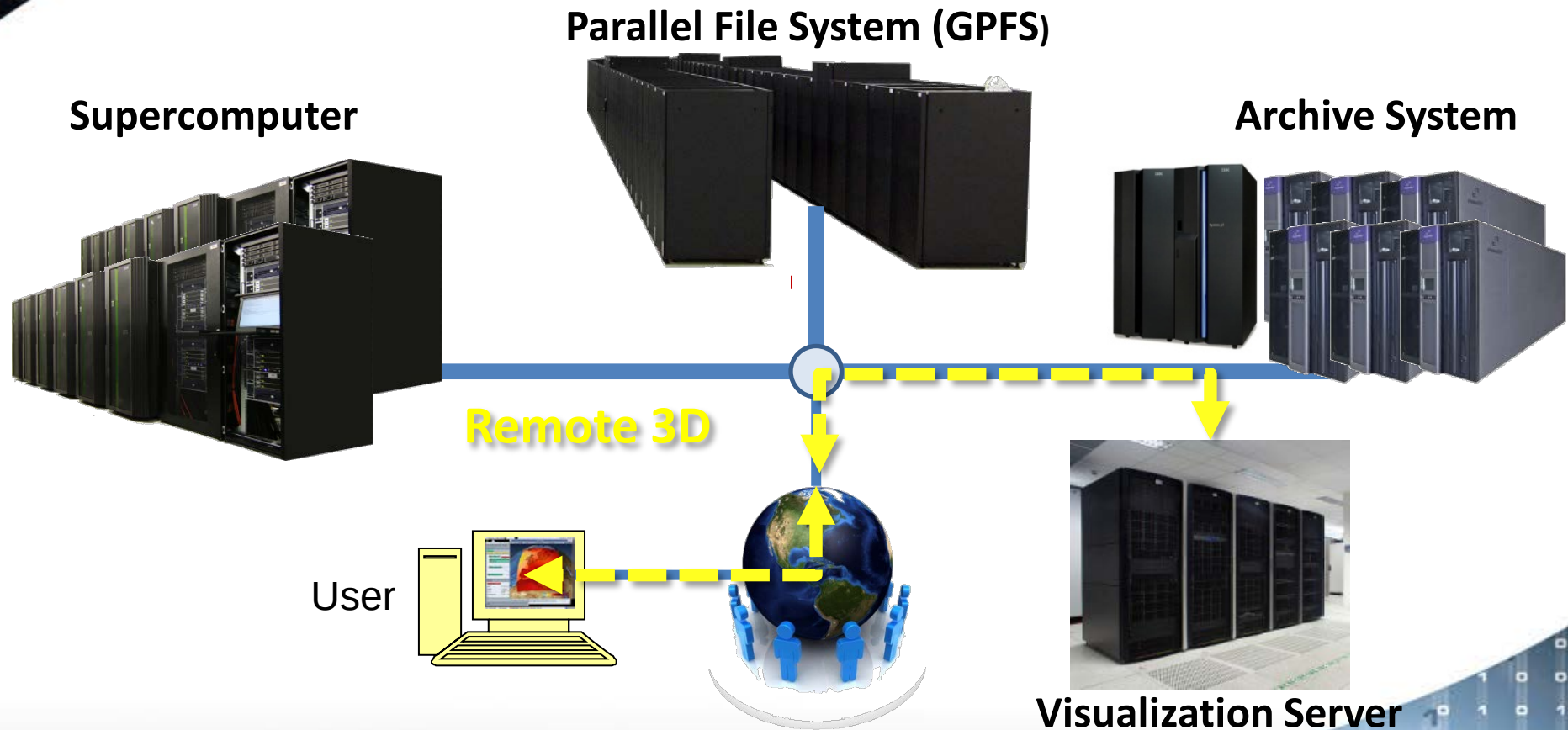
Data Transfer

User



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Visualization in HPC Environments



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Remote-3D-Rendering

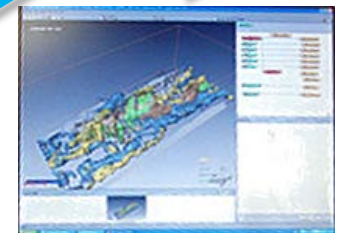
Local Computer:

- Keyboard / Mouse
- Display
- Remote-3D Client



Visualization Server:

- 3-D-Software (OpenGL)
- Remote 3D-Server
- Data



Software Solution: TurboVNC / Virtual GL

Keyboard / Mouse

Capture Keyboard / Mouse

Internet

Capture Framebuffer
Compress Image
Send Image to Client

Uncompress Image

Display Image

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Visualization Cluster Halo

Nodes	Type	CPUs	RAM	Gfx Cards
1	Transtec Lynx 2610R	2 Intel Xeon E5-2690 2.9 GHz, 8-core	256 GB	2 Nvidia Quadro K5000, 4 GB
1	Tanstec Phi 4230	2 Intel Xeon E5-2640 2.5 GHz, 6 Core	96 GB	1 NVidia Quadro 6000, 6 GB 1 XeonPhi 5110P, 8 GB
2	HP ProLiant DL370 G6	2 Intel Xeon X5680 3.33 GHz, 6-Core	96 GB	2 NVidia Quadro 6000, 6 GB
1	Dell Precision R5400	2 Intel Xeon 3 GHz (2-Core)	32 GB	NVidia Quadro 5000, 2.5 GB
5	Dell PowerEdge M610x	2 Intel Xeon E5649 2.53 GHz, 6-Core	96 GB	NVidia Tesla M2070Q, 6GB
1	HP ProLiant DL585	4 Opteron64 2.4 GHz, 2-Core	128 GB	2 Nvidia Quadro FX 5500, 1 GB



- 11 nodes, heterogeneous
- 10 GE Network
- GPFS directly mounted
- CentOS (RH5)

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Local Facilities: Stereo + VR

Thinklogical DVI/USB Infrastructure

- ▶ Transmitter/Receiver/Matrix
- ▶ Fiber optics

Barco „VR-Workroom“

- ▶ 2,90 x 1,63 (16:9)
- ▶ Passive Stereo (circular)
- ▶ 2 Barco ICON H600 (1920x1080)
- ▶ ARTrack 2 optical IR Tracking

SeeReal CN20 Autostereo Displays

- ▶ Vertical Interlacing
- ▶ 2 Displays 20", 1600x1200

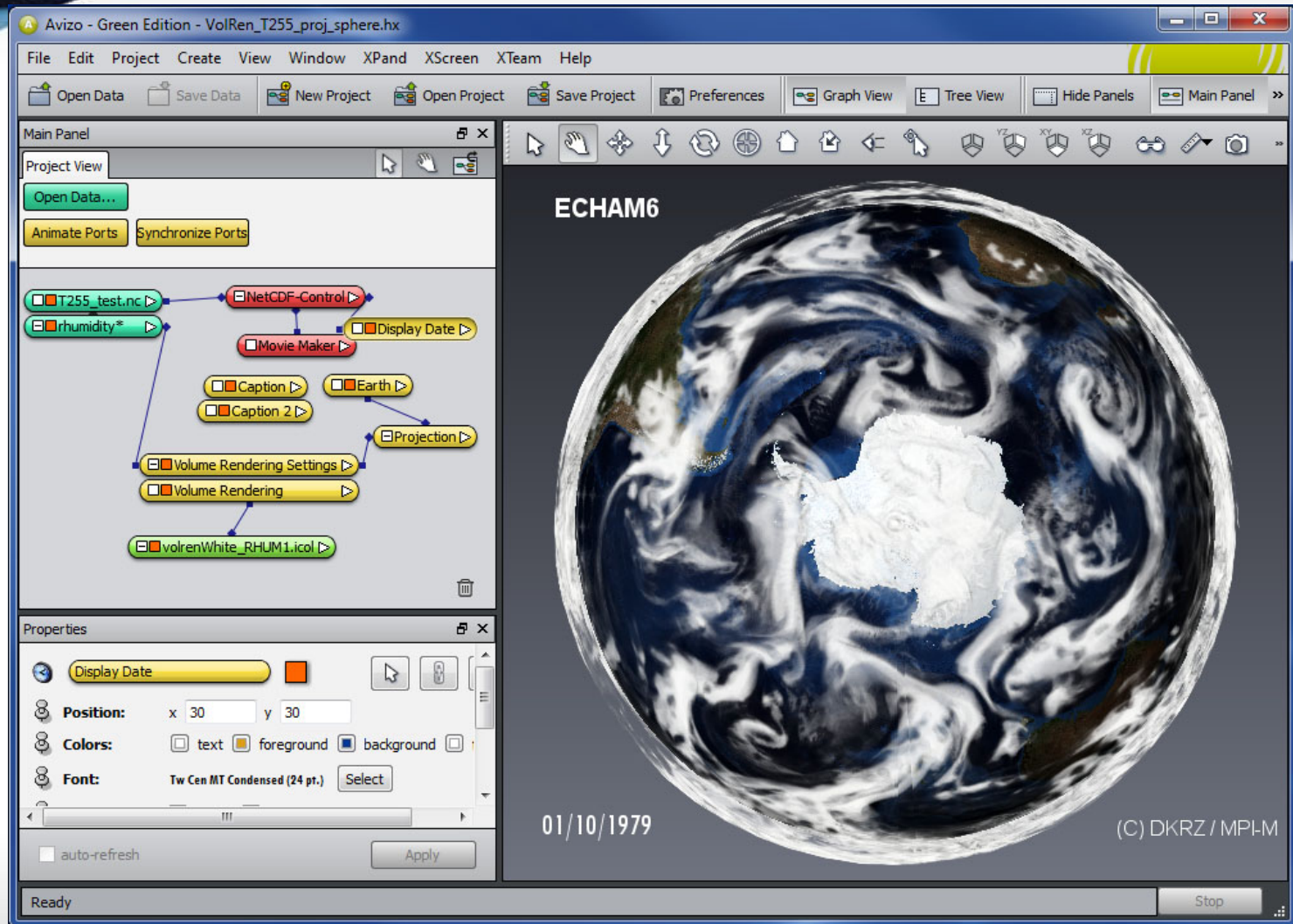


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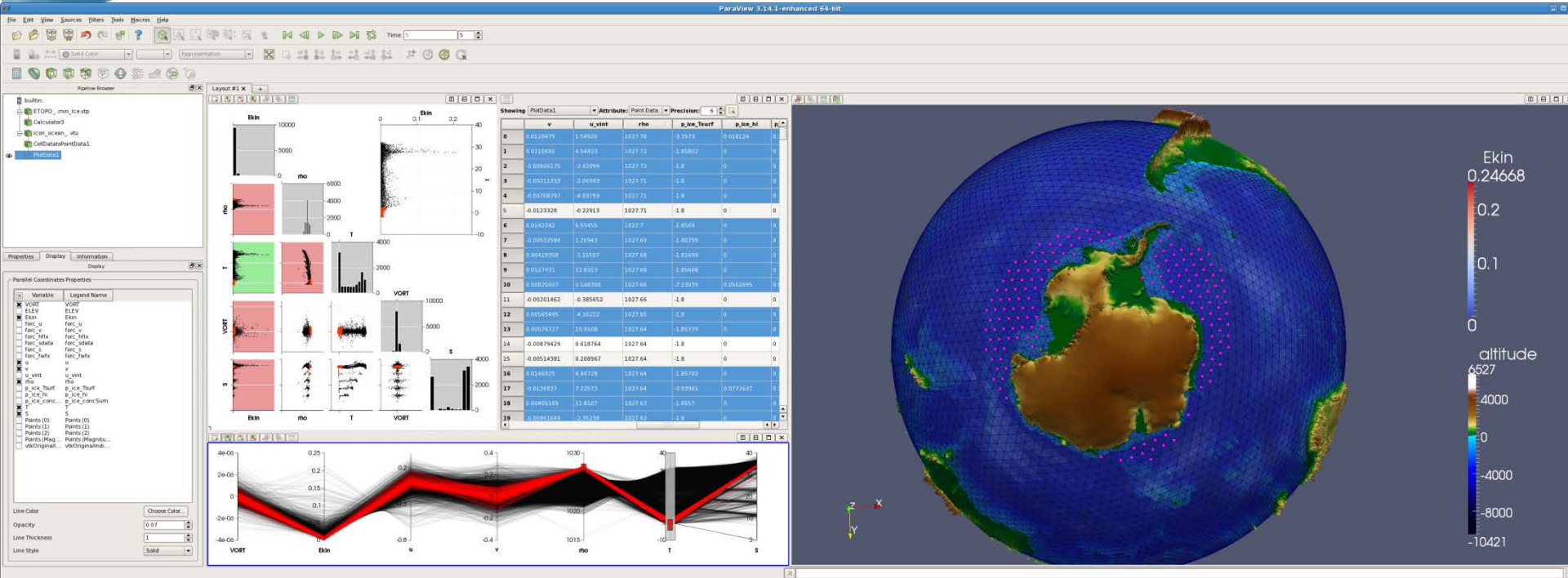
Visualization Software

Categorie	Typ	Name	URL	Features
Programming- and Scripting languages for analysis	\$\$	Matlab	www.mathworks.de/products/matlab	Simulation + Gfx
	\$\$	IDL	www.exelisvis.com	2D+ scripting
	\$\$	Mathematica	www.wolfram.com/mathematica	Simulation + Gfx
	free	R	www.r-project.org	Statistik, 2D script
Domain specific Visualization Software	frei	Ferret	ferret.wrc.noaa.gov/Ferret	2D script based
	frei	GrADs	www.iges.org/grads	2D script based
	frei	Vis5D+	vis5d.sourceforge.net	3D interactive (old)
	frei	GMT	gmt.soest.hawaii.edu	2D script based
	frei	ODV	odv.awi-bremerhaven.de/	2D script based
	frei	IDV	www.unidata.ucar.edu/software/idv	3D interactive
3D Visualization Systems	frei	NCL	www.ncl.ucar.edu/	2D script based
	\$\$	Avizo	www.vsg3d.com/products/avizo.asp	Climate Extensions
	frei	OpenDX	www.opendx.org	3D, alt
	\$\$	AVS/Express	www.avs.com	climate features
	frei	Paraview	www.paraview.org	3D GUI, parallel
	\$\$	SimVis	http://www.simvis.at	3D/2D -> multivariate
	frei	VisIt	wci.llnl.gov/codes/visit	3D, parallel

3D Visualization Software: Avizo Green



Paraview 4

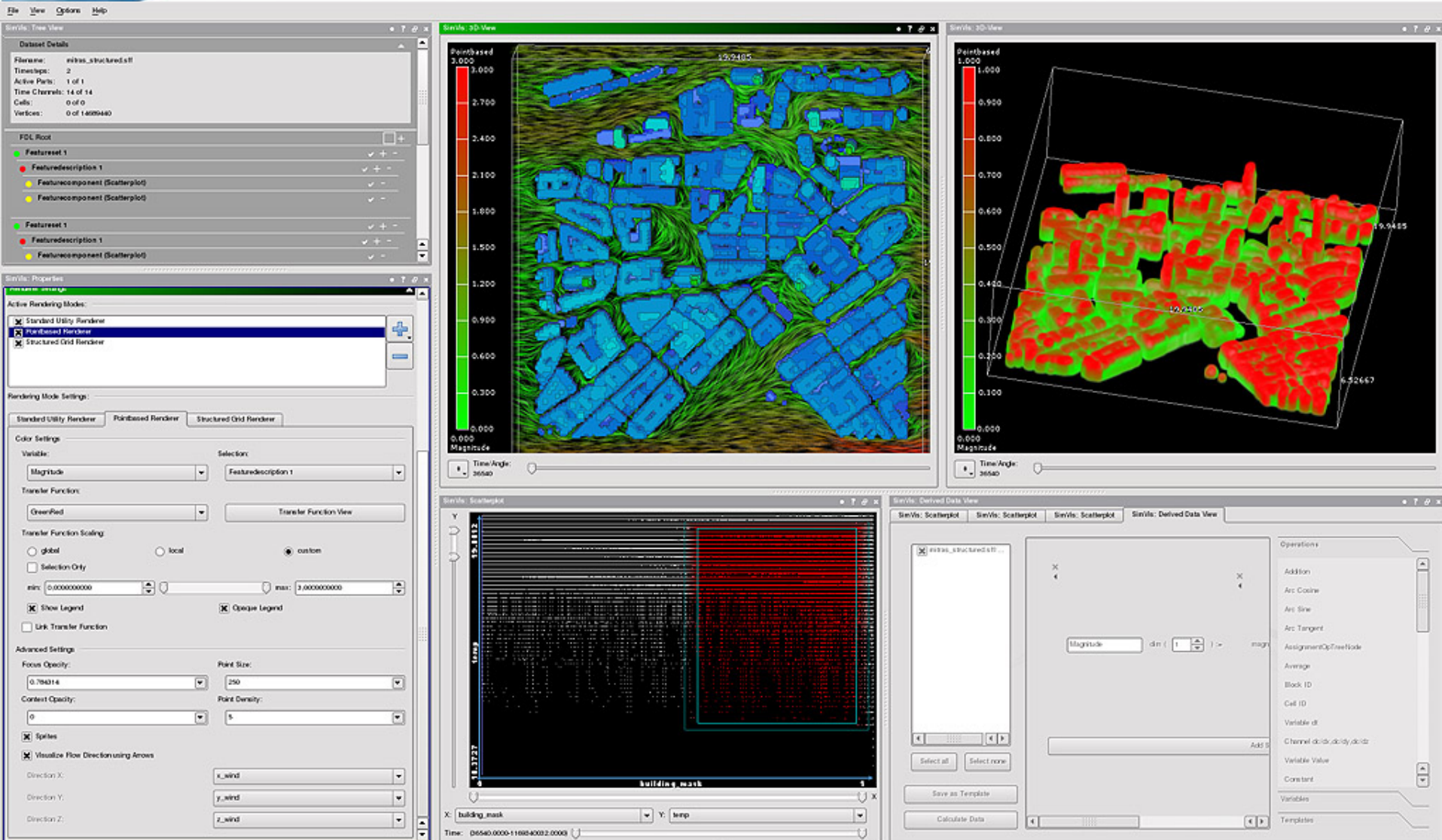


Soon: Tutorial on Paraview

<http://www.dkrz.de/Nutzerportal-en/doku/halo/sw/paraview>

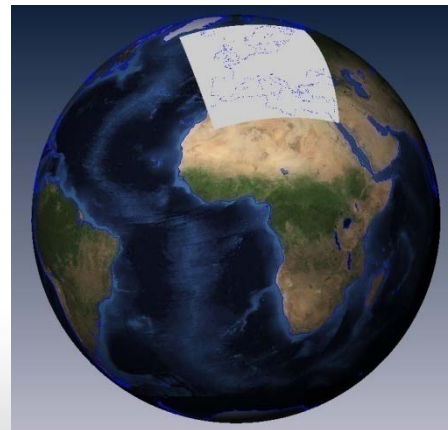
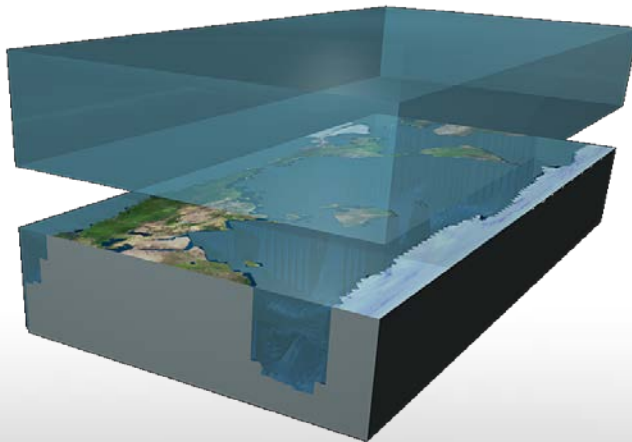
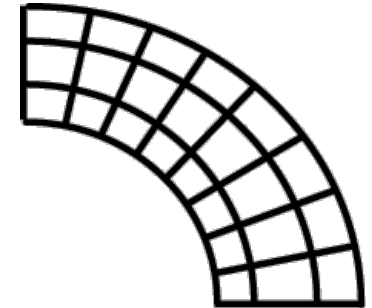
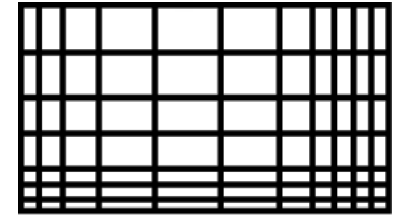
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Another 3D-Visualization Paradigm: SimVis



Climate Data

- Georeferenced data -> Mapping
- Relatively coarse 3D grids, some quantities only 2D
- Grids: rectilinear, curvilinear, rotated, irregular ...
- Multivariate / scalar and vector fields
- Special values
- Time axis: very long time series
- Coupled models: distinct grids
- Multi run experiments (ensembles)



File Formats and other requirements

- ▶ Formats: GRIB and **NetCDF**
 - *Conventions* for Metadata (NetCDF/**CF-1.0**)
- ▶ Other domain specific features
 - Geographical mapping of data
 - *Special Values* (masking of grid cells with “no data”)

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Processing of NetCDF data

- ▶ ncdump – view metadata
- ▶ ncview - quicklook
- ▶ CDO – Climate data Operators
 - <https://code.zmaw.de/files/cdo/html/1.6.1/cdo.pdf>
 - <https://code.zmaw.de/embedded/cdo/1.6.1/cdo.html>
- ▶ NCO – NetCDF Operators

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Requirements to the (NetCDF) Data with respect to the visualization with Avizo

- ▶ NetCDF-CF 1.0 or later
- ▶ rectilinear, curvilinear, or rotated grids
- ▶ **Preferably** regular/rectilinear grids!
- ▶ Coordinates in the ranges -180 to 180, -90 to 90
- ▶ All time steps in one file
- ▶ Temporally short distance between time steps
- ▶ Vector components need to share one single grid
- ▶ Vector Components defined relative to N-S and E-W

Michael Böttinger: Vector Field
Visualization

View and change Metadata

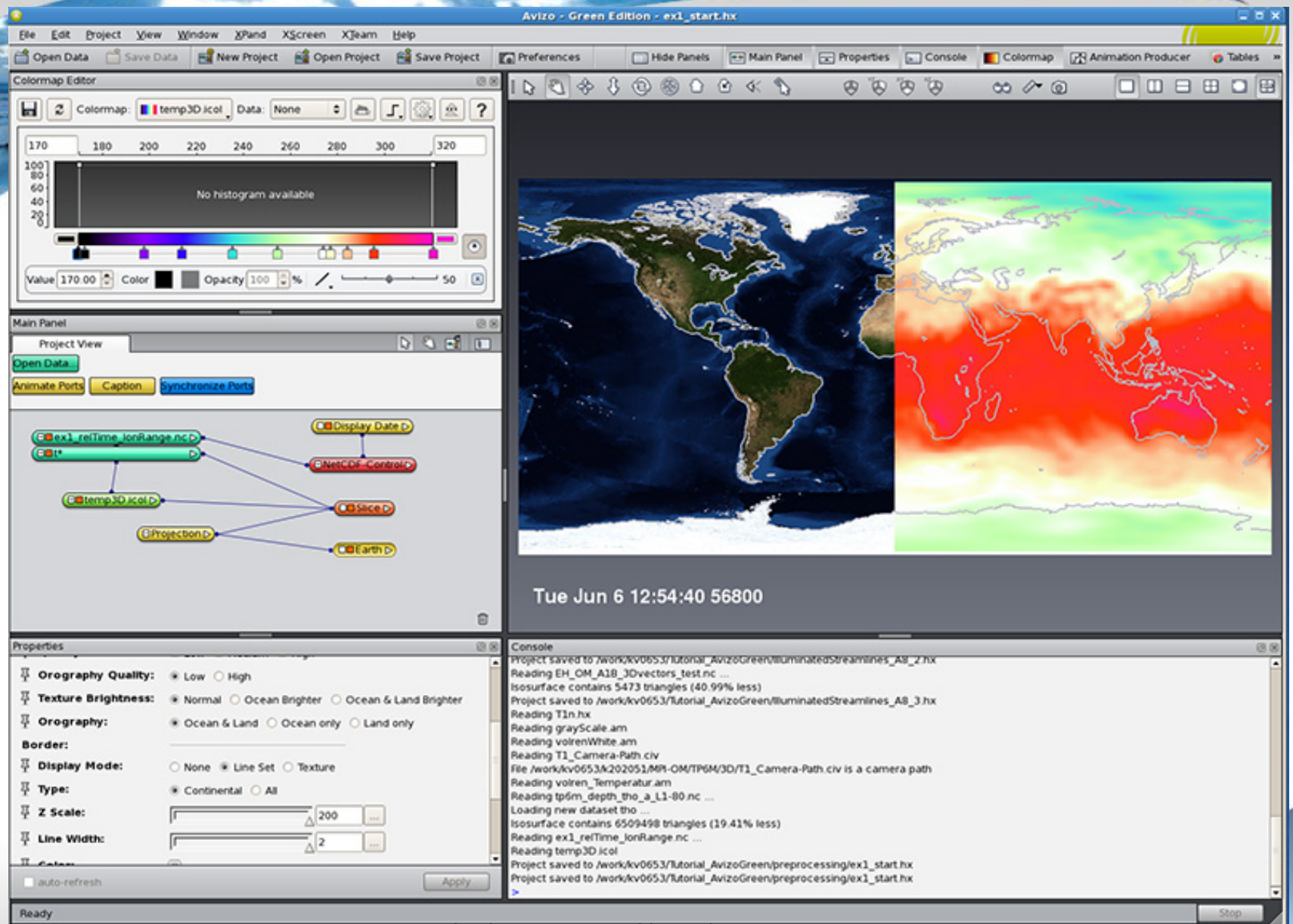
Example 01

/work/kv0653/Tutorial_AvizoGreen/preprocessing/ex1_relTime_IonRange.nc

► Prerequisites for Avizo:

- Coordinates need to be in the range $(-180,180)(-90,90)$
- Relative time axis

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View Metadata

Example 01

/work/kv0653/Tutorial_AvizoGreen/preprocessing/ex1_relTime_IonRange.nc

► **Ncdump -c <filename>**

...

```
double time(time) ;
```

```
    time:units = "day as %Y%m%d.%f" ;
```

...

```
lon = 0, 1.875, 3.75, 5.625, 7.5, 9.375, 11.25, 13.125, 15, 16.875, 18.75,  
      20.625, 22.5, 24.375, 26.25, 28.125, 30, 31.875, 33.75, 35.625, 37.5,  
      39.375, 41.25, 43.125, 45, ...
```

...

```
331.875, 333.75, 335.625, 337.5, 339.375, 341.25, 343.125, 345, 46.875,  
348.75, 350.625, 352.5, 354.375, 356.25, 358.125 ;
```

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Change and view Metadata

- ▶ Change the time format of the NetCDF file from absolute to relative time.
- ▶ Change the value range of the longitudes from [0;360] to [-180;+180].

```
cdo -r selindexbox,97,96,1,96 ex1_relTime_lonRange.nc avizol.nc
```

```
ncdump -c avizol.nc
```

```
...
```

```
double time(time) ;
```

```
time:units = "days since 2001-01-01 00:00:00" ;
```

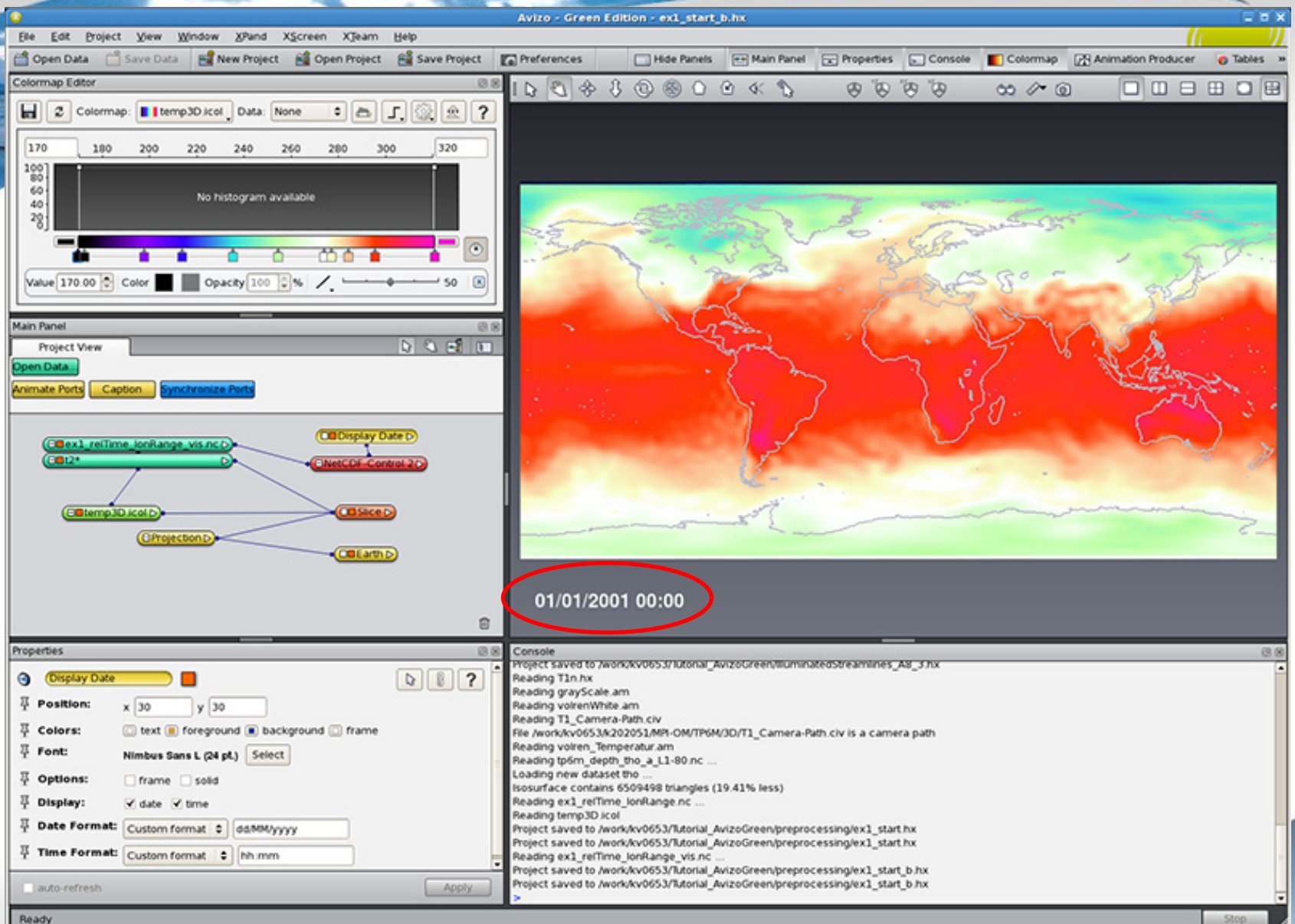
```
...
```

```
lon = -180, -178.125, -176.25, -174.375, -172.5, -170.625, -168.75,  
-166.875, -165, -163.125, -161.25, -159.375, -157.5, -155.625, -153.75,  
-151.875, -150, -148.125, -146.25, -144.375, -142.5, -140.625, -138.75,
```

```
...
```

```
157.5, 159.375, 161.25, 163.125, 165, 166.875, 168.75, 170.625, 172.5,  
174.375, 176.25, 178.125 ;
```

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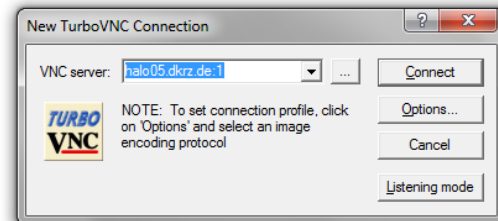
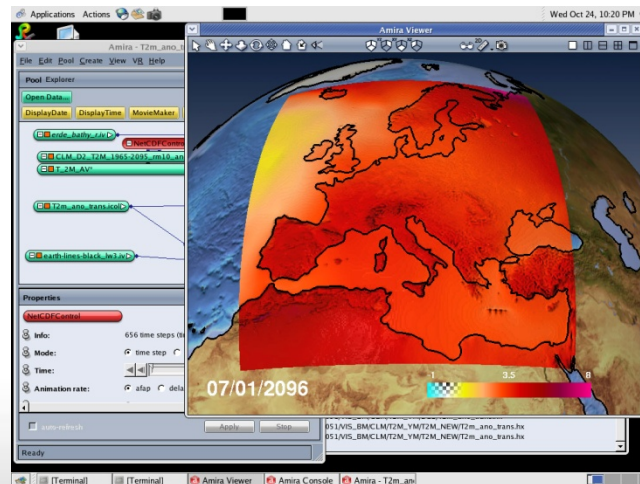
Other cdo operations

- ▶ Selections
- ▶ Filtering
- ▶ Interpolation
- ▶ Arithmetic Operations
- ▶ Statistics
- ▶

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Access to halo

- ▶ Using the usual project administration web page, **project administrators** of existing HLRE projects can apply for access to **halo** for their users
- ▶ In order to use the system, users with **halo** account can start remote 3D rendering sessions using a web interface
- ▶ For access to the web interface, the usual DKRZ UserID and password are required



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halo: Filesystems and Quota

- ▶ **Home-Directory** (-> NFS mount)
 - /pf/[a,b,k,m,u,g]/<user>
 - For Scripts, Source code etc.
 - **Quota: 1 GB per User**
 - Daily Backup
- ▶ **Work-Directory** (GPFS, blizzard)
 - /work/<prj>
 - For data files, images etc.
 - **Quota: defined per project (No Backup)**
- ▶ **SCRATCH-Directory** (GPFS, blizzard)
 - /scratch/[a,b,k,m,u,g]/<user>
 - For temporal storage (2 weeks)

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Reservation System

- ▶ Start / stop „sessions“ immediately
 - Make a reservation starting now and ...
 - Remote Sessions using VNC/VGL (HP-RGS)
 - Local Sessions using X Server
 - Select resolution
- ▶ Reservation in Advance
 - Resolution
 - Reservation period (duration)
- ▶ Calendar
 - Managed via mySQL data base

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Starting a Session



DKRZ
DEUTSCHES
KLIMARECHENZENTRUM

Login

Username:

Password:

Login

<https://halo.dkrz.de>

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Web GUI – Main Menu



**Welcome
k202073**

Start task now

Perform reservation only

Delete reservation

Start task from existing reservation

Show calendar

Download TurboVNC Software

Logout Report bug

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Resources Calendar

2011-03-08

	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
halo01																								
halo02																								
halo03																								
halo04																								
halo05																								
halo06																								
halo07																								
halo08																								
halo09																								

2011-03-09

	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
halo01															u290065	u290065	u290065	u290065	u290065					
halo02																								
halo03																								
halo04																								
halo05										k202073	k202073	k202073	k202073	k202073	k202073	k202073	k202073	k202073	k202073					
halo06																								
halo07																								
halo08																								
halo09																								

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Session Start



Start task now

Node Class

- ☒ VIS-node
- ☐ CUDA-node
- ☐ SIMVIS-node

End of operation

Time: 15:00:00

Resolution

- ☐ 1920x1200
- ☐ 1920x1080
- ☒ 1600x1200
- ☐ 1400x1050
- ☐ 1280x1024
- ☐ 1280x960
- ☐ 1152x900
- ☐ 1024x768
- ☐ 800x600
- ☐ 640x480

**End of Reservation
(Duration!)**

Resolution

Start

[Back to main menu](#)

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Session Start (2)



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Connect to halo03

Please start your TurboVNC vncclient now and connect to `halo03.dkrz.de:1`

Your VNC password for this session is `9L+/G05t`

Remember: VNC is an insecure protocol, your keystrokes are transmitted unencrypted over the network. You may always use ssh to setup a secure tunnel to halo. Build a tunnel that forwards your local port 5901 to halo03.dkrz.de:5901

```
ssh -f -L 5901:localhost:5901 -N k202073@halo03.dkrz.de
```

and tell TurboVNC to connect to the local end of the tunnel:

```
vncviewer localhost:1
```

DO NOT CLOSE THIS WINDOW!

- ☒ Delete reservation after "End task"
- ☐ Don't delete reservation after "End task"

End task

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Turbo VNC / VGL

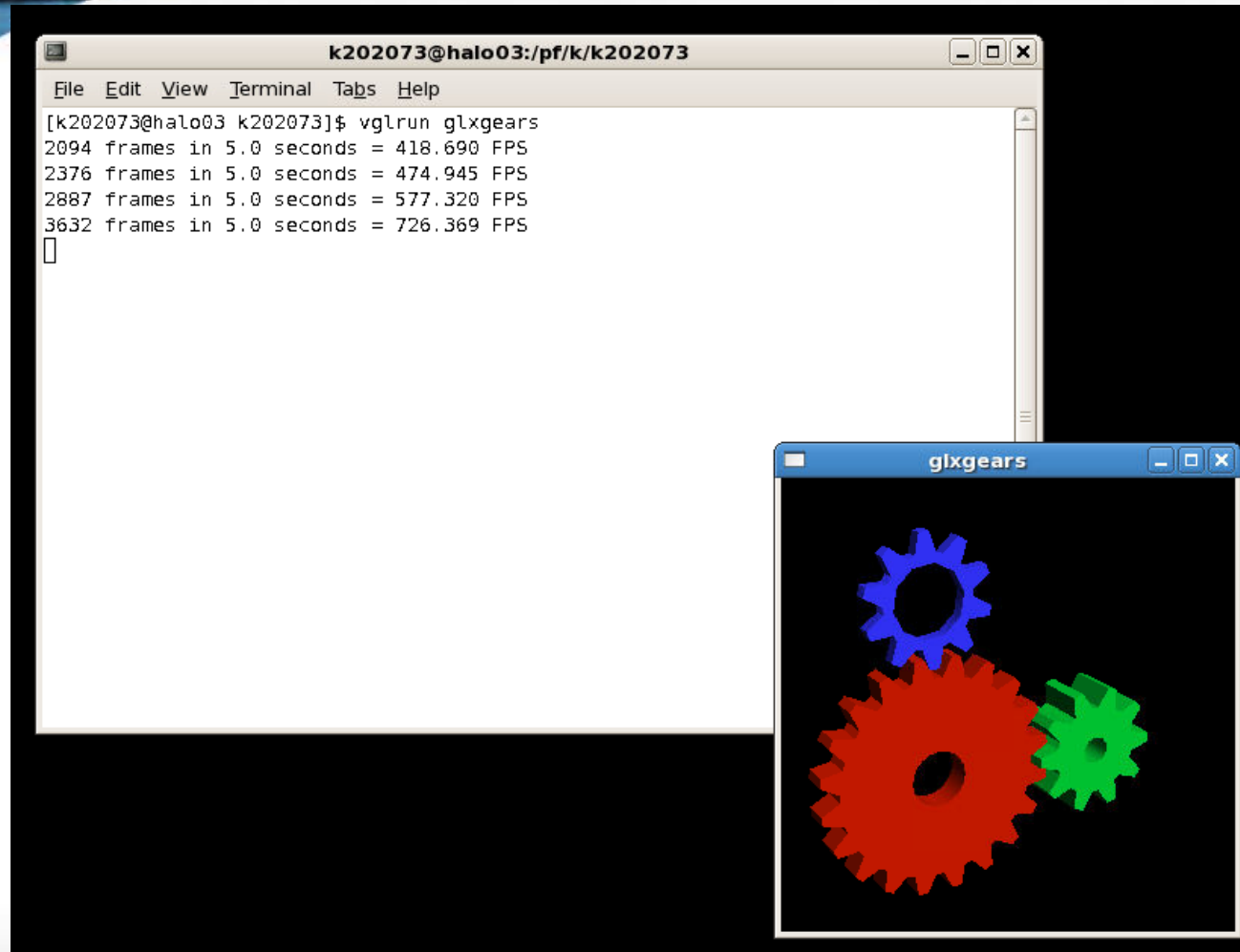
- ▶ Login using vnc using the one time command with DKRZ UserID / PW (SSL Encryption) - `/opt/TurboVNC/bin/vncviewer`

`/opt/TurboVNC/bin/vncviewer -encodings "tight zlib" -compresslevel 9 haloXX.dkrz.de:X`

- ▶ Collaboration Mode (view-only)
- ▶ Session Termination:
 - **Log Out** or use „End Task“ Button of Web GUI
 - Please: **Don't just terminate the client window!**
 - A “disconnect” in the client window doesn't terminate the session!
- ▶ A re-connect to an interrupted session is possible
- ▶ **Delete Reservation!**

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Check with glxgears



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Perform Reservation Only

Resolution

- ☐ 1920x1200
- ☐ 1920x1080
- ☒ 1600x1200
- ☐ 1400x1050
- ☐ 1280x1024
- ☐ 1280x960
- ☐ 1152x900
- ☐ 1024x768
- ☐ 800x600
- ☐ 640x480

2010-12-03

AM		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
☐	halo02	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
☒	halo03	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		☒	☒	☒	☐	☐	☐	☐	☐
☐	halo04	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐

Submit

Reset

[Back to main menu](#)

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Start Existing Reservation



Welcome
k202073

Start task now

Perform reservation only

Delete reservation

Start task from existing reservation

Show calendar

Download TurboVNC Software

Logout Report bug

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boettinger@dkrz.de

<http://www.dkrz.de>

Questions?



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