Dynamical Exascale Entry Platform (DEEP)

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DEEP Partners

The Cyprus Institute

Energy, Environment, and Water
Research Centre (EEWRC)

Science and Technology in Archaeology
Research Centre (STARC)

Computation-based Science and Technology
Research Centre (CaSToRC)

Scientific Applications

Seismic imaging

Brain simulation

Climate simulation

Space weather simulation

Computation fluid engineering

High-temperature superconductivity

Scientific Applications

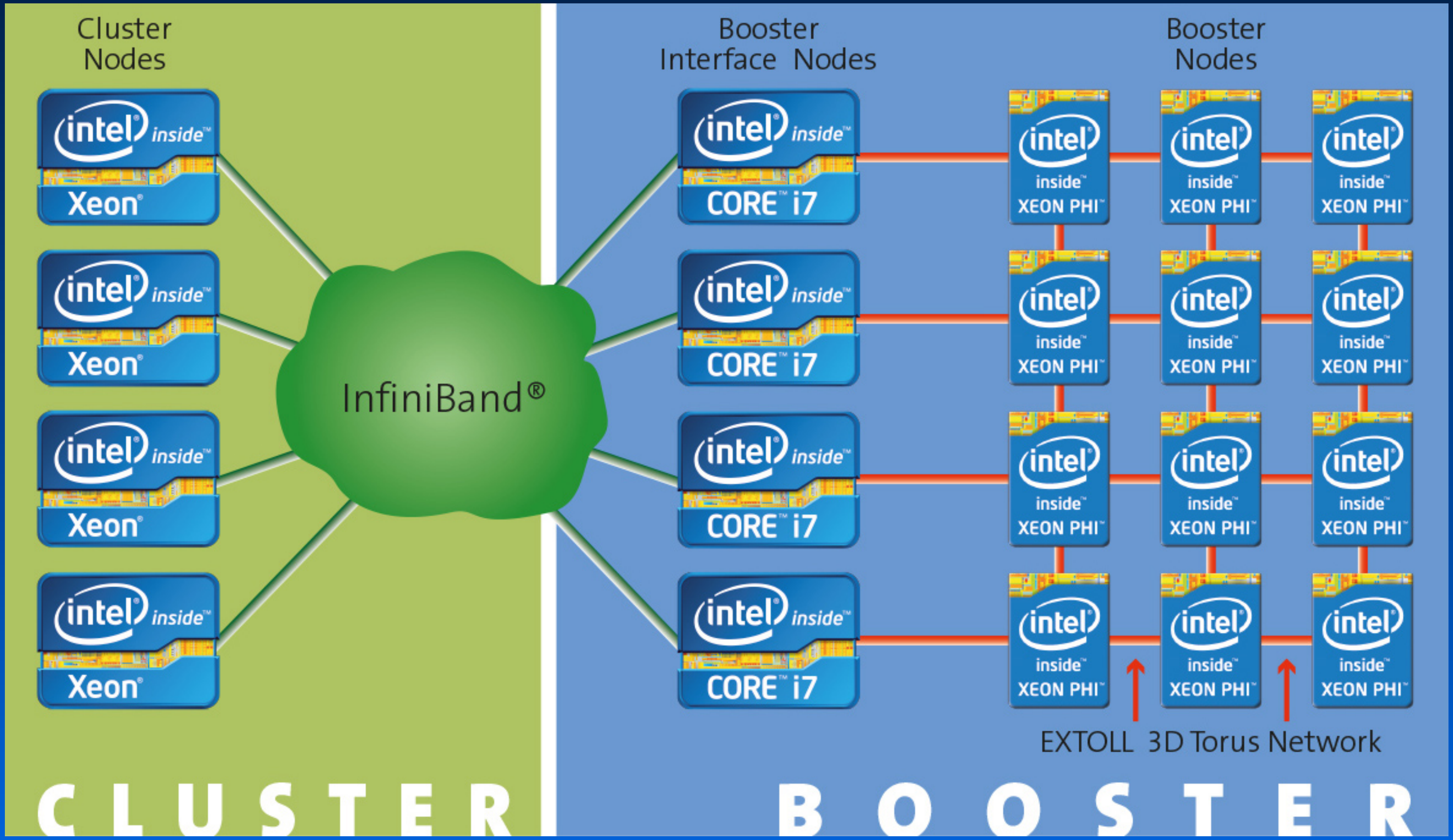
Models of complex systems show

- limited scalability for some processes

while being

- highly-scalable for other processes

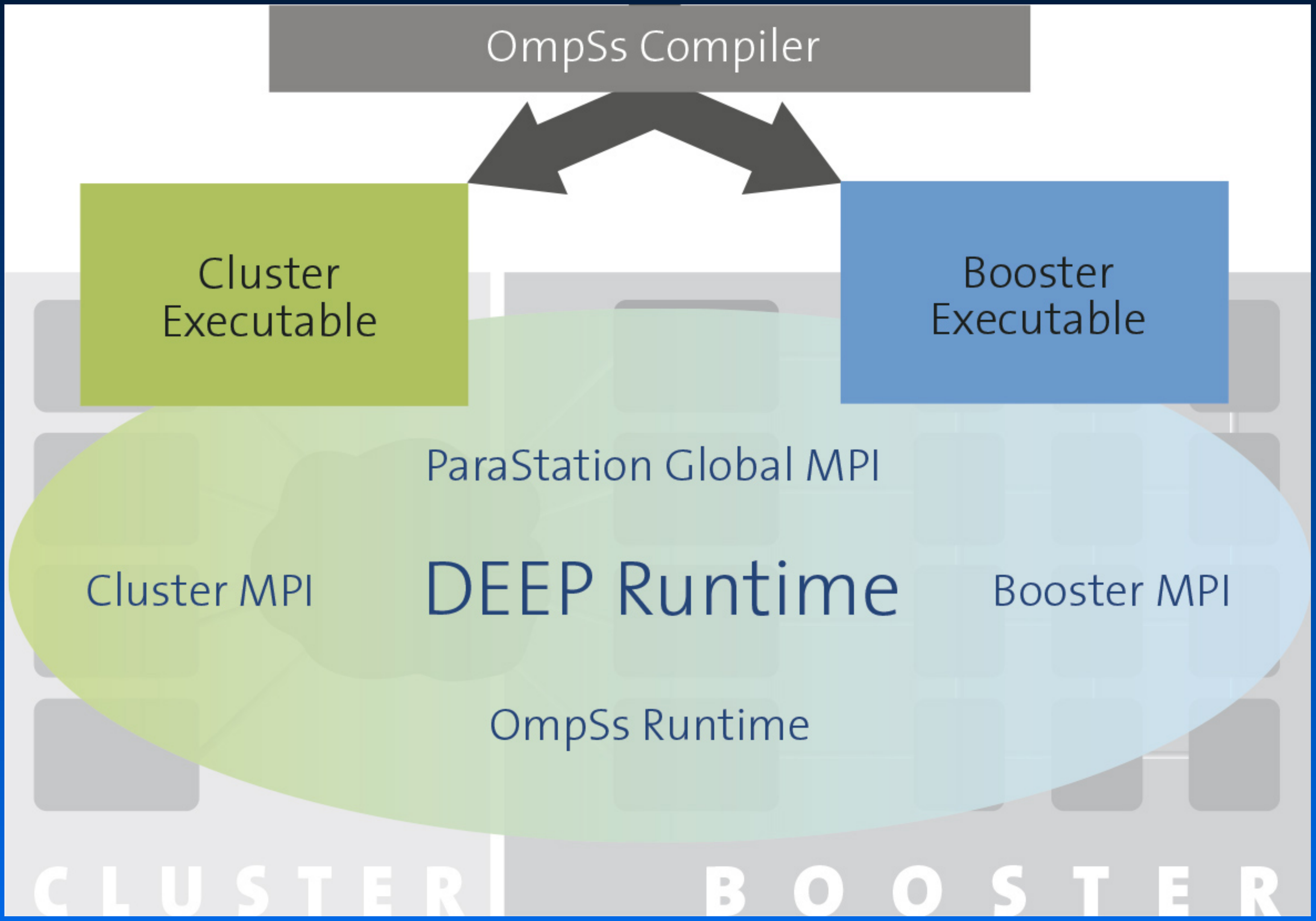
DEEP Hardware



Characteristics

- Intel Xeon Cluster nodes
  - provide I/O
  - run fast mid-scalable model code parts
- Intel Xeon Phi Booster nodes
  - run standard Linux
  - communicate directly through EXTOLL
  - run self-contained full model code
  - run highly-scalable model code parts
- Dynamical creation of Cluster and Booster node groups

DEEP Software



ECHAM / MESSy

Operational Weather Forecast Model, Cycle 31

- European Centre for Medium-Range Weather Forecast (ECMWF) Reading, United Kingdom

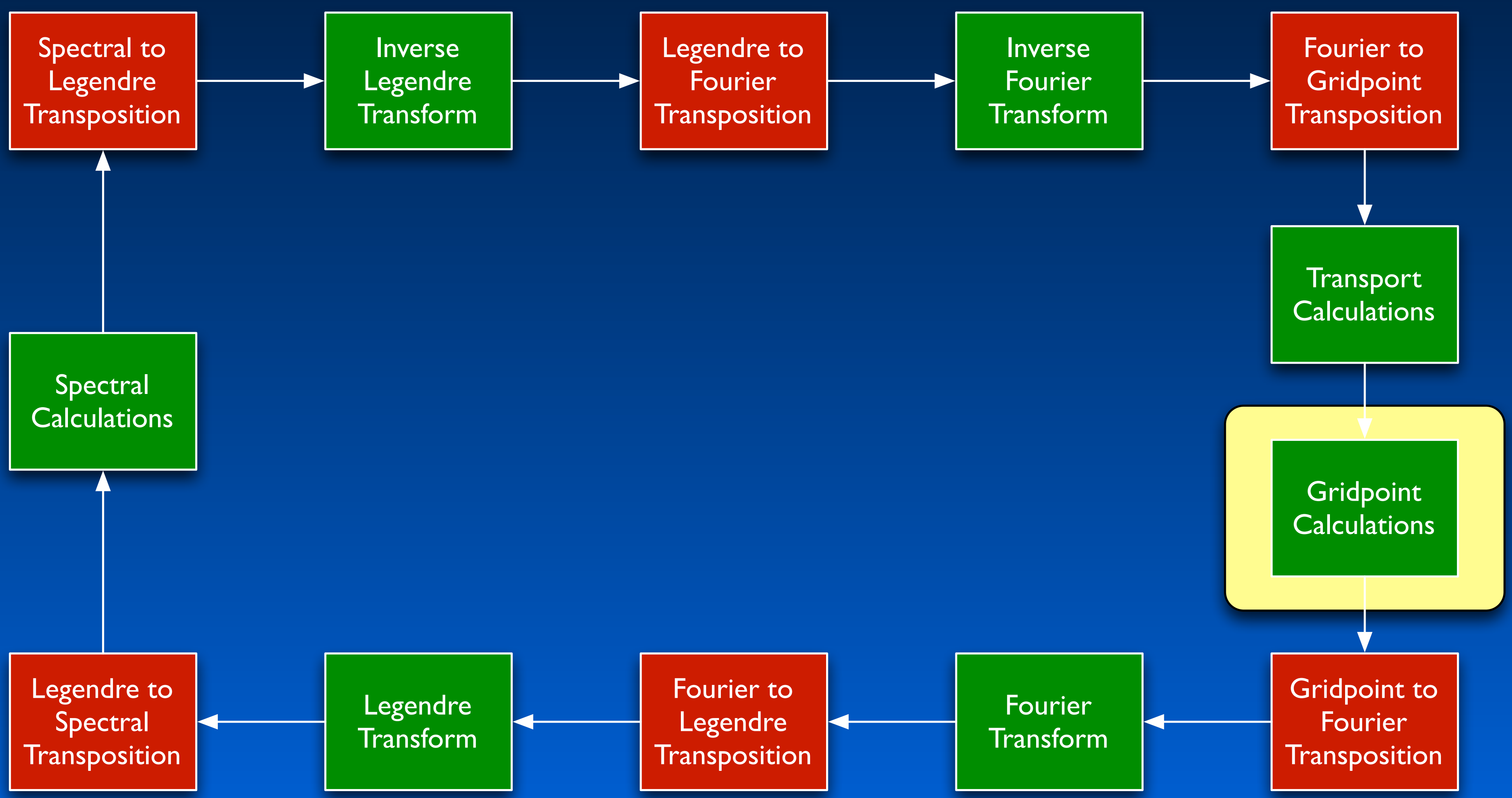
ECMWF Model Hamburg (ECHAM)

- Max Planck Institute for Meteorology (MPI-M), Hamburg, Germany

Modular Earth Subsystem Model (MESSy)

- Max Planck Institute for Chemistry (MPI-C), Mainz, Germany
- German Aerospace Centre (DLR), Oberpfaffenhofen, Germany
- The Cyprus Institute (CyI), Lefkosia, Cyprus
- … and others

MESSy


Spectral to Legendre Transposition
Inverse Legendre Transform
Legendre to Fourier Transposition
Inverse Fourier Transform
Fourier to Gridpoint Transposition
Transport Calculations
Gridpoint Calculations
Gridpoint to Fourier Transposition
Fourier Transform
Fourier to Legendre Transposition
Legendre Transform
Legendre to Spectral Transposition
Spectral Calculations

MESSy

Links physical and chemical processes

Some models compute columns of air

Consumes ~ 80% of total run time

MESSy

bufly_physc
d14co_physc
dradon_physc
e4chem_physc
gmxe_physc
h2o_physc
hetchem_physc
jval_physc
lnox_physc
m7_physc
made_physc
mecca1_physc
mecca_physc
mmforce_physc
msbm_physc
o3orig_physc
photo_physc
plumegas_physc
psc_physc
qbo_physc
satsims_physc
scav_physc
sedi_physc
spe_physc
spacenox_physc
trexp_physc
vahr_physc

MECCA

Models homogeneous gas-phase chemistry

Solves a system of differential equations

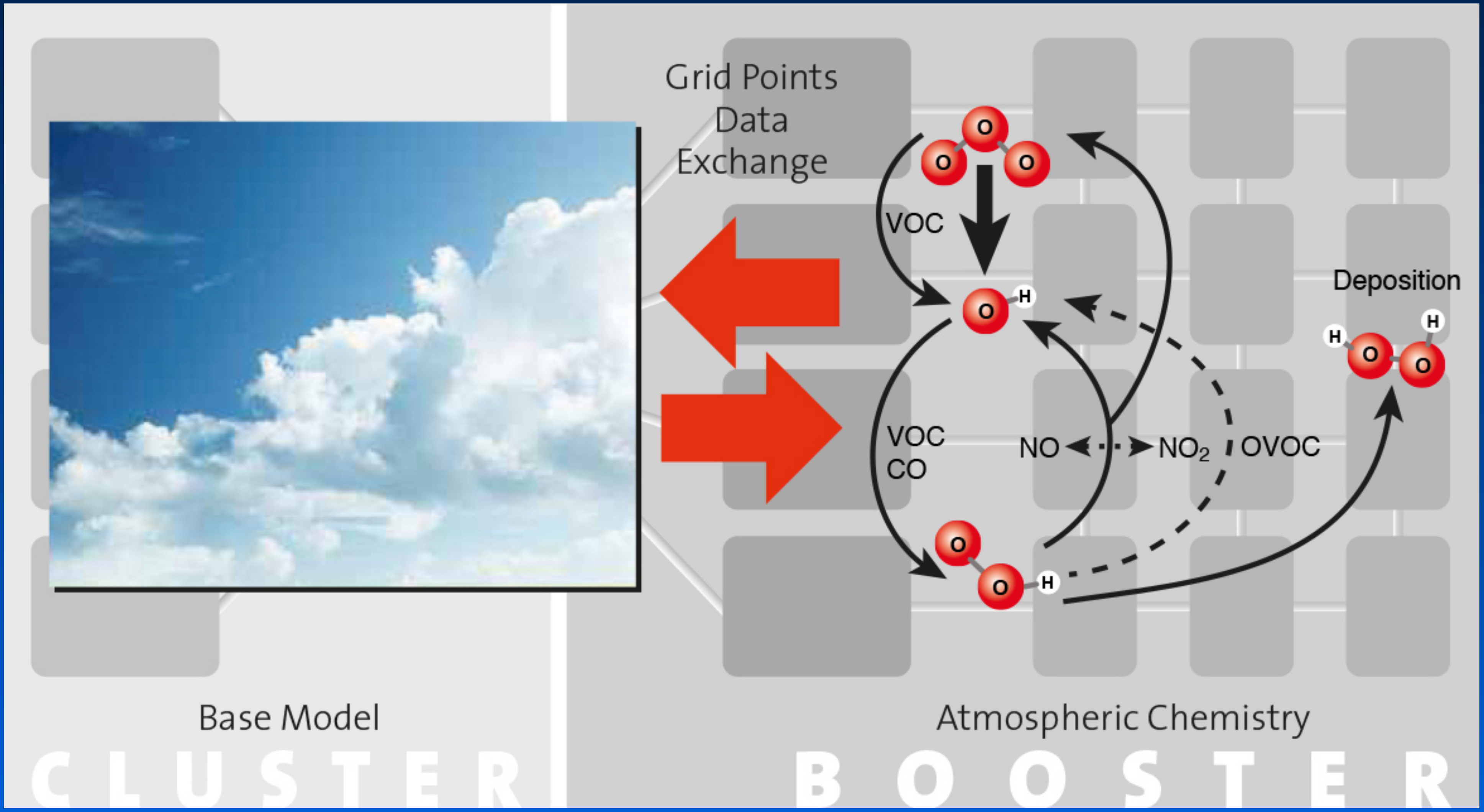
System is integrated by adaptive integrator

Change in light intensity leads to stiff system

Run time varies by two orders of magnitude

Consumes ~ 80 % of MESSy run time

Atmospheric Chemistry



OmpSs

```
REAL(dp) :: zmr(ntrac_gp)  ! tracer mixing ratio

level_loop: DO jk = 1, nlev

#!omp task inout(pxtm1(:,jk,:), pxtte(:,jk,:)) &
#!omp      private(zmr) &
#!omp      output(c(:,jk,:))

  kproma_loop: DO jp = 1, kproma

    CALL update_physc  ! update rate coefficients

    ! estimate tracer mixing ratio before chemistry
    zmr(:) = pxtm1(jp,jk,:) + pxtte(jp,jk,:) * time_step_len

    CALL kpp_integrate(time_step_len)  ! works on x(jp,jk,:)
```

Advantages

Task off-loading provides an additional run-time degree of freedom for parallelisation

Increase threads for grid point calculations, decrease tasks for spectral calculations, improving implicit load balancing

From multi-core to many-core architectures due to reduced memory constraints in multi-threaded parallelisation

Status

Thank you