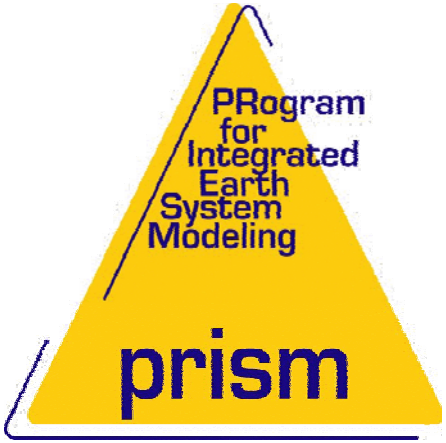


The PRISM project

Technical overview

&

details on the OASIS coupler

presented by S. Valcke

GENIE Earth System Modelling workshop
Cambridge, June 26-28, 2006

Outline

- PRISM:
  - the project
  - the Areas of Expertise
- OASIS:
  - historical background
  - the community today
  - some key notes
- The OASIS4 coupler:
  - model adaptation
  - component model description
  - coupled model configuration
  - communication
  - regridding/transformations
  - grids supported
  - future developments and conclusions

PRISM: the project

Promote the development of a standard software infrastructure for Earth system coupled modelling

(http://prism.enes.org)

Help climate modellers spend more time on science:

PRISM: the project

- 2001-2004: the PRISM EU project
  - a European project funded for 4.8 M€ by the EC
  - 22 partners
- 2005-2008: the PRISM Support Initiative:
  - 7 partners: CERFACS, CGAM, CNRS, ECMWF, MPI-M&D, UK MetOffice, NEC-CCRLE
  - 8 associate partners: CRAY, IPSL, Météo-France, MPI-M, NEC-HPCE, SGI, SMHI, SUN
  - investing their own manpower in PRISM (8 py/y for 3 years)

PRISM: the Areas of Expertise

2006: reorganisation in 5 "PRISM Areas of Expertise" (PAE):

- Promotion and, if needed, development of software tools for ESM
- Organisation of related network of experts
- Technology watch
- Promotion of community standards
- Coordination with other international efforts

1. Code coupling and I/O (S. Valcke, CERFACS)
2. Integration and modelling environments (M. Carter, UK Met Office)
3. Data processing, visualisation & management (M. Lautenschlager,M&D)
4. Meta-data (L. Steenman-Clark, CGAM)
5. Computing issues (R. Redler, NEC-CCRLE; M.-A. Foujols, IPSL)

PRISM: the Areas of Expertise

1. Code coupling and I/O
   - **OASIS3** and **OASIS4** couplers, the **PALM** coupler
2. Integration and modelling environments (source version control, compilation, job configuration & running)
   - Standard Compiling and Running Environments (**SCE/SRE**)
   - GUI for model configuration: **prepIFS, prepOASIS4**
   - GUI for job monitoring: **SMS**
   - **FCM**: software control and compilation management
3. Data processing, visualisation and management: includes data networking and federated archive architecture
   - **CERA database** (Hamburg)
4. Meta-data: definition of metadata standards with other ESM projects
5. Computing issues: petacomputing, performance, portability, parallelism, algorithmic developments

OASIS: historical background

OASIS: developed since 1991 to couple existing GCMs

1991 **2001**

|--→ |--- PRISM →

OASIS 1 → OASIS 2 → OASIS3 (demo runs) →

→ OASIS4 →

OASIS1, OASIS2, OASIS3:

- low resolution, low number of 2D fields, low coupling frequency:

  ➔flexibility very important, efficiency not so much!

OASIS4:

- higher resolution parallel models, massively parallel platforms, 3D fields

  ➔need to optimise and parallelise the coupler

OASIS: the community today

- **CERFACS** (France)
  - ARPEGE3 - ORCA2LIM
  - ARPEGE4 - OPA9/NEMO
- **METEO-FRANCE** (France)
  - ARPEGE4 - ORCA2
  - ARPEGE3 - OPA8.1-GELATO
  - ARPEGE medias -OPAmed
- **IPSL- LODYC, LMD, LSCE** (France)
  - LMDz - ORCA2LIM
  - LMDz - ORCA4
- **MERCATOR** (France) (for interpolation only)
- **MPI - M&D** (Germany)
  - ECHAM5 - MPI-OM
  - ECHAM5 - C-HOPE
  - PUMA - C-HOPE
  - EMAD - E-HOPE
  - ECHAM5 - E-HOPE
  - ECHAM4 - E-HOPE
- **ECMWF**
  - IFS - CTM
  - IFS Cy23r4 - E-HOPE

OASIS: the community today

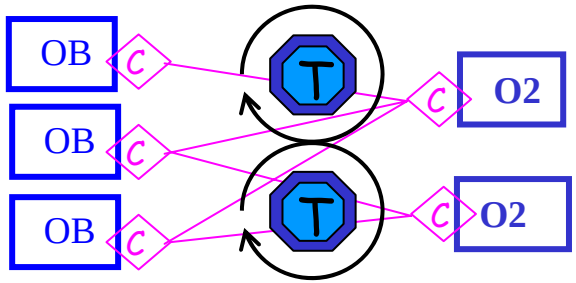
•**IFM-GEOMAR** (Germany)	ECHAM5	-	NEMO
•**CGAM-Reading** (UK)	UM4.5	-	OPA (diff. res.)
•**SMHI** (Sweden)	RCA(region.)	-	RCO(region.)
•**NERSC** (Norway)	ARPEGE	-	MICOM
•**U. of Bergen** (Norway)	MM5	-	ROMS
•**KNMI** (Netherlands)	ECHAM5	-	TM5
•**INGV** (Italy)	ECHAM5	-	MPI-OM
•**ENEA** (Italy)	ECHAM5	-	OPA8.2
	MITgcm	-	REGgcm
•**IRI** (USA)	ECHAM5	-	MOM3
•**JAMSTEC** (Japan)	ECHAM4	-	OPA 8.2
•**IAP-CAS** (China)	AGCM	-	LSM
•**BMRC** (Australia)	BAM4	-	MOM4
•**U. of Tasmania** (Australia)	Data Atm.	-	MOM4
•**RPN-Environment Canada** (Canada)	MEC	-	GOM

OASIS: Some key notes

- Developers: CERFACS, NEC CCRLE, CNRS, SGI, (NEC HPCE)
- Public domain; open source license (LGPL)
- Programming language: Fortran 90 and C
- Public domain libraries; vendor optimized versions may exist:
  - MPI1 and/or MPI2; NetCDF/parallel NetCDF; libXML
  - mpp_io; SCRIP

The OASIS4 coupler

- *A* **parallel model interface library (PSMILe)** that performs:
  - weight-and-address calculation for the coupling field interpolations
  - MPI-based coupling exchanges between components
  - component I/O (GFDL mpp_io library)



- *A* **parallel central Driver/Transformer**:
  - launches models at the beginning of the run (MPI2)
  - reads the user-defined configuration information and distributes it to the component PSMILes
  - performs parallel transformations of the coupling fields during the run

OASIS4: model adaptation (1/3)

- **Initialization:**

```
call prism_init_comp (comp_id, comp_name, ierr)
call prism_get_localcomm (comp_id, local_comm, ierr)
```

- **Definition of grid (3D)**

```
call prism_def_grid (grd_id, grd_name, comp_id, grd_shape, type, ierr)
call prism_set_corners(grd_id, nbr_crnr, crnr_shape, crnr_array, ierr)
```

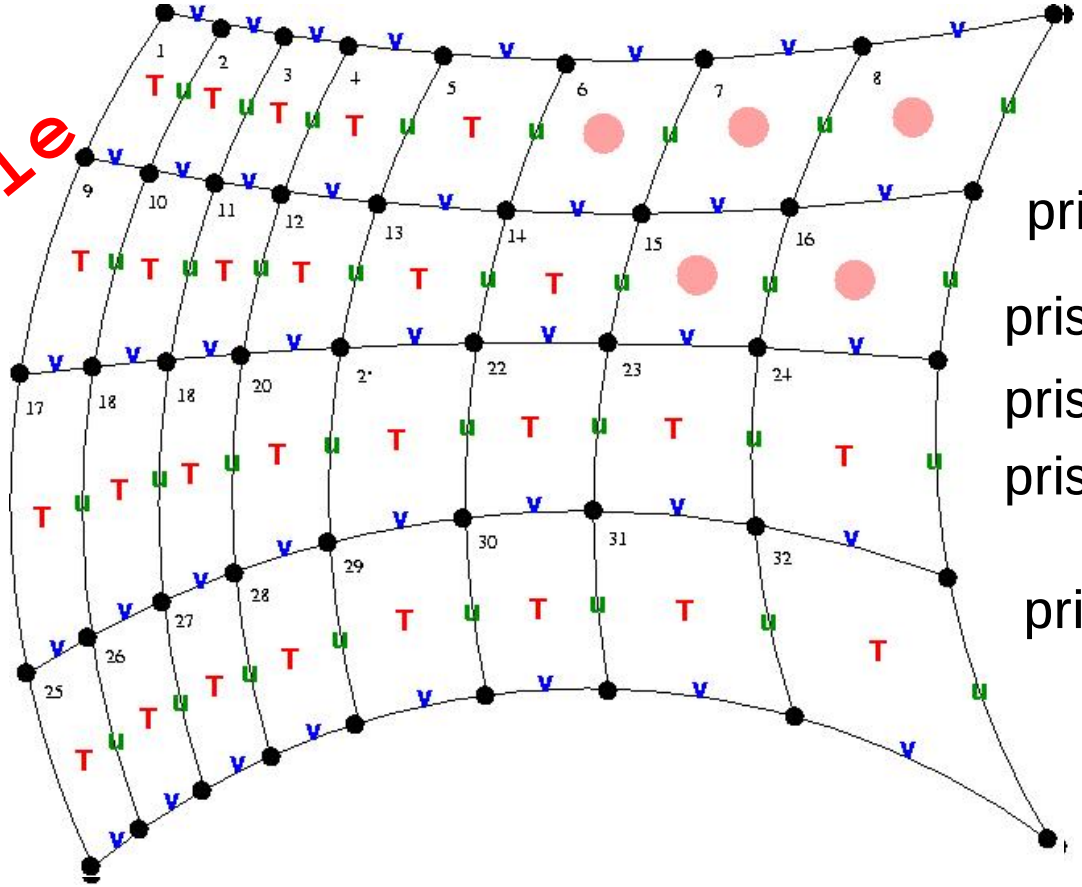
- **Placement of scalar points and mask on the grid:**

```
call prism_set_points (pt_id, pt_name, grd_id, pt_shape,
                       pt_lon, pt_lat, pt_vert ,ierr)
call prism_set_mask (msk_id, grd_id, msk_shape, msk_array, ierr)
```

➢ Function overloading to keep the interface concise and flexible

OASIS4: model adaptation (2/3)

Example



prism_def_grid

prism-set-corners

prism_set_points

prism_set_points

prism_set_points

prism_set_mask

OASIS4: model adaptation (3/3)

- **Coupling or I/O field declaration**

```
call prism_def_var
    (var_id, var_name, grd_id, pt_id, msk_id, var_nbrdims,
     var_shape, var_type, ierr)
```

- **End of definition**

```
call prism_enddef (ierr)
```

- **Coupling or I/O field sending and receiving:**
  - in model time stepping loop
  - depending on user's specifications in SMIOC:
    - user's defined source or target, component or file (end-point communication)
    - coupling or I/O sending or receiving at appropriate times
    - averaging/accumulation

```
call prism_put (var_id, date, date_bounds, var_array, info, ierr)
call prism_get (var_id, date, date_bounds, var_array, info, ierr)
```

- **Termination**

```
call prism_terminate (ierr)
```

OASIS4: component model description

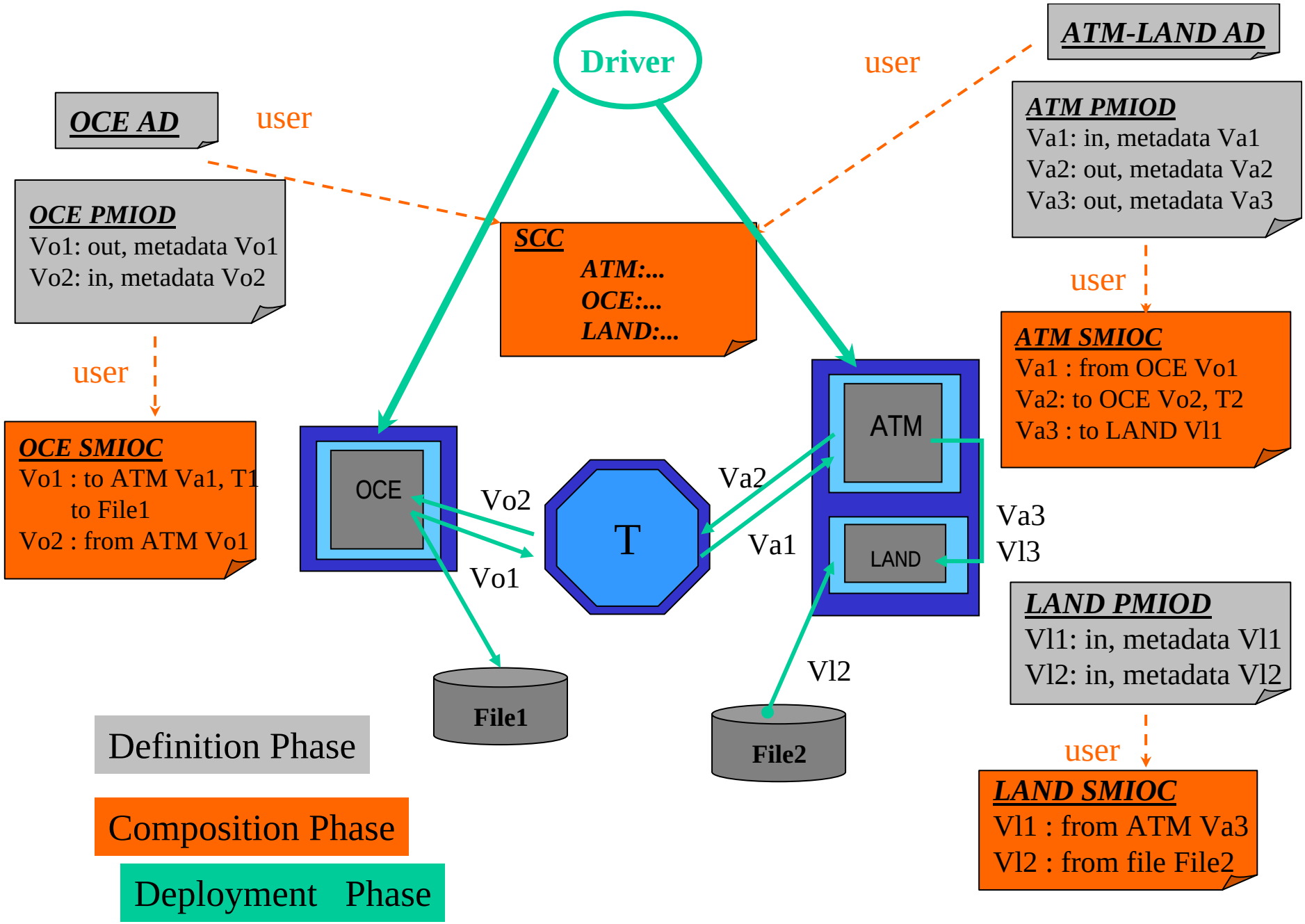
Application and component description (XML files):

- **For each application** (code):
  - **one Application Description (AD):**
    - possible number of processes
    - components included
- **For each component** in the application:
  - **one Potential Model Input and Output Description (PMIOD)**
    - component general characteristics: name, component simulated, …
    - grid information: domain, resolution(s), grid type, …
    - **potential I/O or coupling variables**:
      - local name, standard name
      - units, valid min and max
      - numerical type
      - associated grid and points
      - intent –input and/or output

OASIS4: coupled model configuration

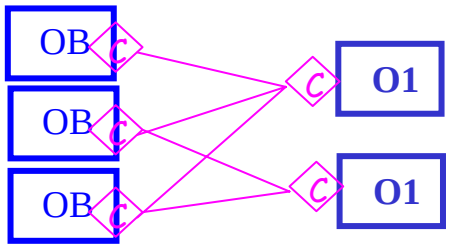
(Through a GUI), the user produces

- a **Specific Coupling Configuration (SCC):**
  - experiment and run start date and end date
  - applications, components for each application
  - host(s), number of processes per host, ranks for each component
- **For each component,**
  a Specific Model Input and Output Configuration (SMIOC)
  - grid information: chosen resolution, …
  - I/O or coupling variables:
    - *name, units, valid min max, numerical type, grid*
    - activated intent –input and/or output
    - source and/or target (component and/or file)
    - coupling or I/O dates
    - transformations/interpolations/combinations


Driver
OCE AD
user
OCE PMIOD
Vo1: out, metadata Vo1
Vo2: in, metadata Vo2
user
OCE SMIOC
Vo1 : to ATM Va1, T1
to File1
Vo2 : from ATM Vo1
SCC
ATM:...
OCE:...
LAND:...
OCE
Vo2
Vo1
T
Va2
Va1
ATM
LAND
Va3
Vl3
File1
Vl2
File2
user
ATM-LAND AD
ATM PMIOD
Va1: in, metadata Va1
Va2: out, metadata Va2
Va3: out, metadata Va3
user
ATM SMIOC
Va1 : from OCE Vo1
Va2: to OCE Vo2, T2
Va3 : to LAND Vl1
LAND PMIOD
Vl1: in, metadata Vl1
Vl2: in, metadata Vl2
user
LAND SMIOC
Vl1 : from ATM Va3
Vl2 : from file File2
Definition Phase
Composition Phase
Deployment Phase

OASIS4 communication (1/2)

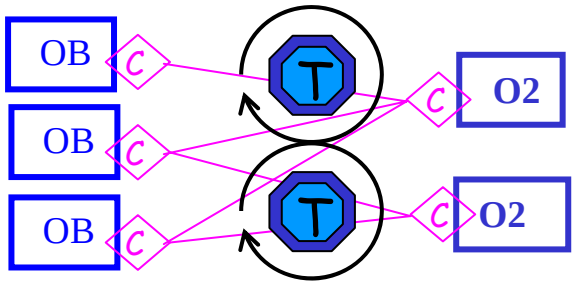
- Model interface library: PSMILe based on MPI1 or MPI2
- Parallel communication **including repartitioning**:
  - based on geographical description of the partitions
  - parallel calculation of communication patterns in source PSMILe



Same grid, different decomposition

⇒ direct repartitioning:

• for each target point, parallel calculation of source matching point in source PSMILe



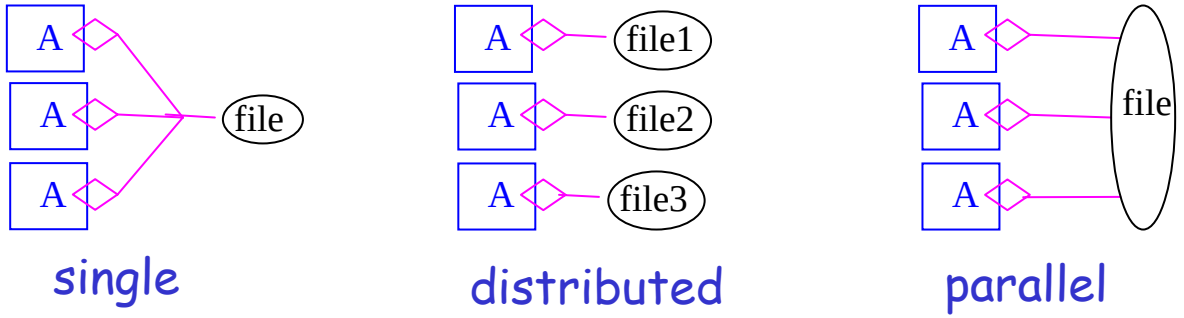
Different grid and decomposition

⇒ via parallel Transformer:

• for each target point, parallel calculation of source interpolation neighbours in source PSMILe

OASIS4: communication (2/2)

- end-point communication (source doesn't know target and vice-versa)
- parallel 3D neighbourhood search, based on efficient multigrid algorithm, in each source process PSMILe
- extraction of useful part of source field only
- one-to-one, one-to-many
- parallel I/O (vector, bundles, vector bundles) : GFDL mpp_io, parNetCDF



OASIS4 regridding/transformations

- source time transformations (prism_put):
  - average, accumulation
- target time transformations (prism_get)
  - time interpolation (for I/O only)
- statistics
- local transformations:
  - addition/multiplication by scalar
- interpolation/regridding (3D):
  - nearest-neighbour 2D in the horizontal, "none" in the vertical
  - nearest-neighbour 3D
  - bilinear in the horizontal, "none" in the vertical
  - bicubic (gradient, 16 nghbrs) in the horizontal, "none" in the vertical
  - trilinear

Grids supported by OASIS4

- Regridding, repartitioning, I/O:
  - Regular in lon, lat, vert ("Reglonlatvrt"):
    - lon(i), lat(j), height(k)
  - Irregular in lon and lat, regular in the vert ("irrlonlat_regvrt"):
    - lon(i,j), lat(i,j), height(k)
  - Irregular in lon, lat, and vert ("irrlonlatvrt") *(not fully tested)*
    - lon(i,j,k), lat(i,j,k), height(i,j,k)
  - Gaussian Reduced in lon and lat, regular in the vert ("Gaussreduced_regvrt")
    - lon(nbr_pt_hor), lat(nbr_pt_hor), height(k)
- Repartitioning and I/O only:
  - "Non-geographical" fields
    - no geographical information attached
    - local partitions described in the global index space (prism_def_partition)
- I/O only:
  - Unstructured grids ("unstructlonlatvrt")
    - lon(npt_tot), lat(npt_tot), height(npt_tot)

OASIS4: future developments

Short term:

- 2D conservative remapping
- Parallel global search for the interpolation
- Transformer efficiency
- Error messages, debugging info, documentation, user support
- Evaluation of OASIS4 for CICLE (French ANR funded project)
  - LMDZ - OPA9/NEMO (IPSL)
  - reg. atm + reg. ocean + global atm. + global ocean (Météo-France)
- Work on the OASIS4 GUI (prepOASIS4) in collaboration with ECMWF
- Test UK Met Office FCM environment for compiling.
- Coupling workshop (PALM, BFG, FLUME, ESMF, GENIE?)

Long term:

- Support types of exchange dates other than fixed frequency
- 3D conservative remapping
- User-defined 3D and 2D remapping
- Field reduction, combination
- Full support of unstructured grid
- Support of adaptive grids

OASIS4: conclusions

- OASIS4 tested and run with toy examples on:
  - Intel Pentium 4 Workstation Cluster
  - SGI O3000/2000 server with MIPS 4 processors and IRIX64
  - SGI IA64 Linux server Altix 3000
  - NEC SX
  - AMD 2800 Cluster
  - IBM Power 4
- OASIS4 now being used in a reduced number of real applications:
  - IN EU project GEMS, for atmospheric dynamic and chemistry coupling
  - At SMHI, for ocean-atmosphere regional coupling
  - At UK Met Office for global ocean-atmosphere coupling (currently prototyping)
  - At GFDL, for MOM4 + toy atmosphere coupling
  - At IFM-GEOMAR (Kiel) in pseudo-models to interpolate high-resolution fields.
- OASIS4 full public release planned beginning 2007.

The end