OBLIMAP 2.0:
a fast climate model - ice sheet model coupler

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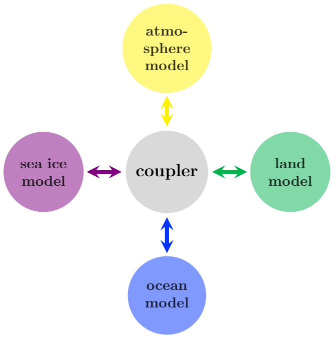
Introduction: *ESM component coupling*

Earth System Model (ESM) component couplers:

- OASIS3, OASIS3-MCT
- CPL6, CPL7, ESMF coupler
- C-Coupler



Specific tasks in GCM – ISM coupling:

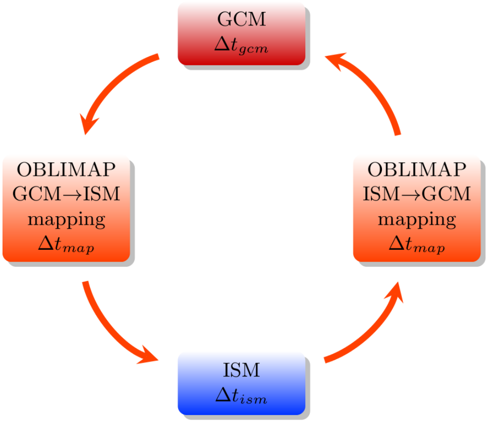
1. An additional projection step.
2. This requires an interpolation method for irregularly spaced grid points.
3. The GCM and ISM resolution ratio can be large, and can differ widely.
4. Mapping ISM fields from a local ISM grid onto a larger scale GCM grid requires a merge of the mapped parts into the existing GCM fields.

Approaches:

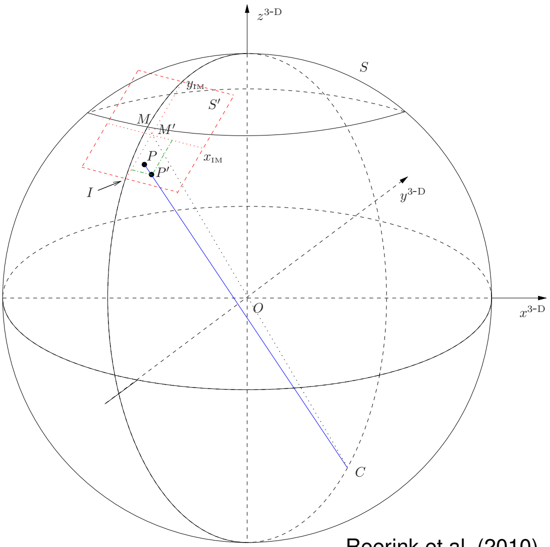
- GCM to ISM mapping
- ISM to GCM mapping
- offline snapshot coupling
- online coupling

Embedding approach:

- Embed ISM in GCM
- Embed GCM in ISM
- Couple via an ESM coupler



Introduction: *projection*



Reerink et al. (2010)

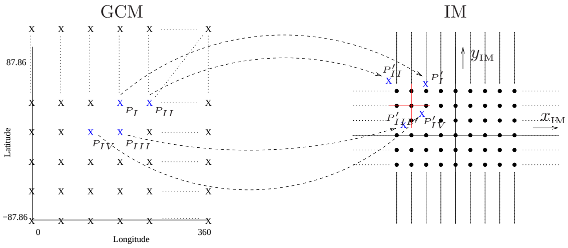
Surface curvatures:

- GCM: earth sphere
- ISM: flat plane
- distortions
- conserved manner

Oblique projections:

- optimal centered
- optimal aligned
- SG and LAEA
- sphere & ellipsoid
- forward & inverse

Introduction: *regridding / interpolation*



Selection methods:

- quadrant method
- radius method
- nearest point

The Shepard inverse squared distance-weighting interpolation

Practical advantages for spatial data, because it identically treats:

1. Regular and irregular spaced grid nodes.
2. 1D, 2D and 3D spatial grids,
3. Any curved destination surface, i.e. the surface of a sphere, an ellipsoid or a flat plane.
4. A variable number of contributions in the weighting.

OBLIMAP 2.0: *new features*

The three main new features in OBLIMAP 2.0:

1. Flexible masked mapping options.
2. The online embeddable mapping routines, in addition to OBLIMAP's stand-alone version.
3. The fast scan option for structured grids.

Which enables:

1. Masking of fields with missing values or of internal boundaries.
2. High-frequency online coupling of an ISM with a GCM.
3. High resolution data with a large number of nodes have become feasible. The scan phase has become much faster.

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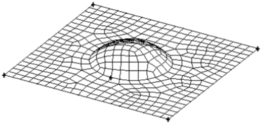
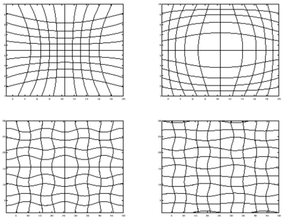
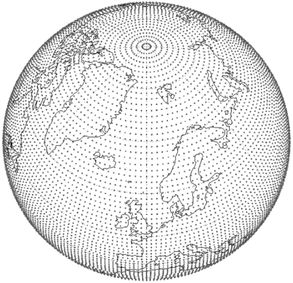
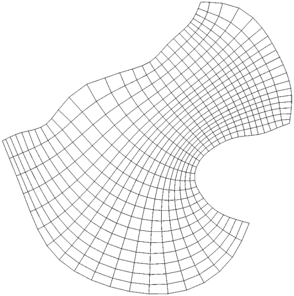
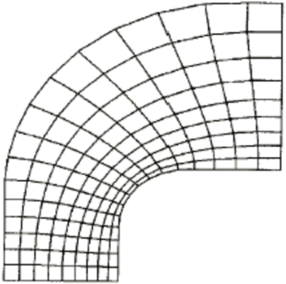
OBLIMAP 2.0: *structured / curvilinear grid example*

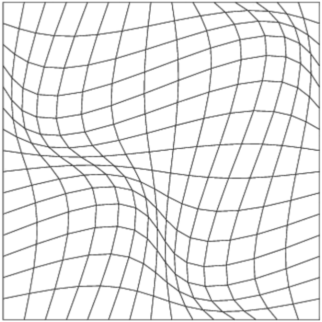


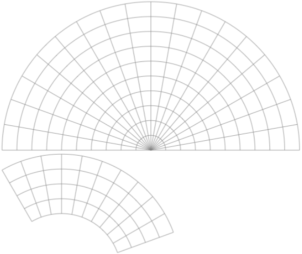




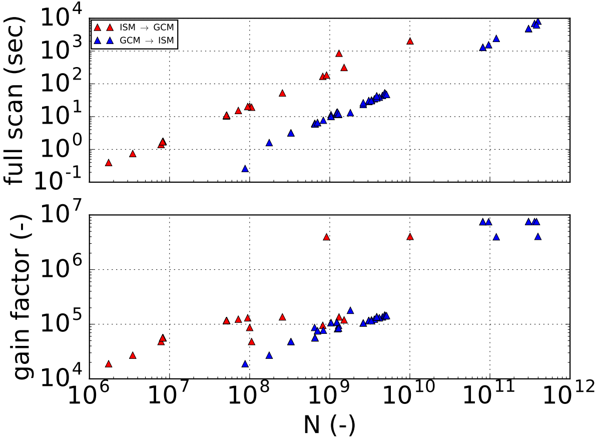








Performance: *fast scan versus full scan method*



Prior calculated "weight factors" can be used with:

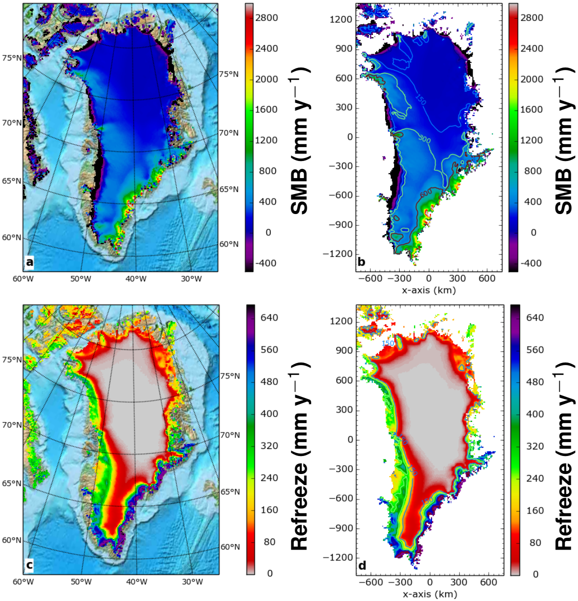
1. OBLIMAP's stand-alone version
2. OBLIMAP's embedded routines

Applications: *examples*

Various data sets which differ in Δ and in curvature are mapped on the ISM grid, some of these fields have to be masked mapped.

- Topography (Bamber et al., 2013), $\Delta = 1$ km, Greenland
- Topography (Fretwell et al., 2013), $\Delta = 1$ km, Antarctica
- RACMO2.3 forcing (Noël et al., 2015), $\Delta =\sim 11$ km, Greenland
- RACMO2.3 forcing (Van Wessem et al., 2014), $\Delta =\sim 27$ km, Antarctica
- Geothermal heat flux (Shapiro & Ritzwoller, 2004), $\Delta = 1^\circ$, global
- Ice surface velocities (Rignot & Mouginot. 2012), $\Delta = 150$ m, Greenland
- Ocean surface temperature

Applications: *Greenland atmospheric forcing fields*



$\Delta = 11$ **km** $\Delta = 5$ **km**

Oblique mapping with OBLIMAP (Reerink et al. 2010, 2016)

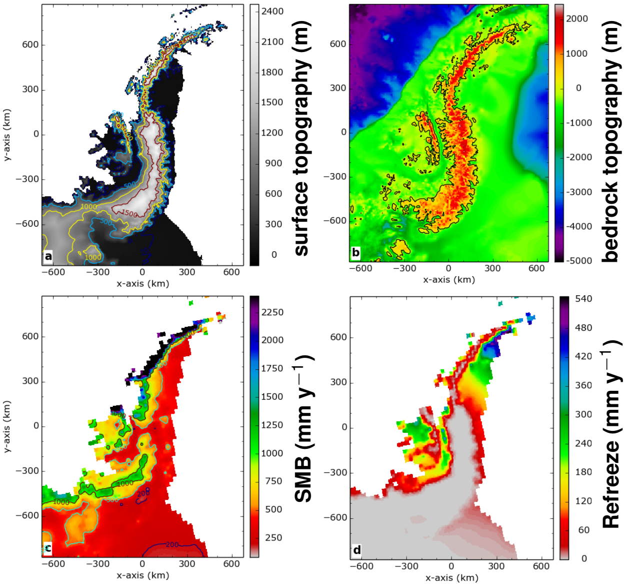
From a RACMO sphere to the ISM flat plane

Source: RACMO2.3 (Noël et al., 2015) the 1958-1989 mean

Mapping parameters ISM grid

N_x	N_y	Δ (km)	α (°)	λ_M (°)	ϕ_M (°)
301	551	5	7.1	319	72

Applications: *Peninsula topographic & forcing fields*



$\Delta = 5$ **km** $\Delta = 5$ **km**

Oblique (re)mapping with OBLIMAP (Reerink et al. 2010, 2016)

Source: Bedmap2 (Fretwell et al., 2013)

Source: RACMO2.3 (Van Wessem et al. 2014) the 1979-2014 mean

Mapping parameters ISM grid

N_x	N_y	Δ (km)	α (°)	λ_M (°)	ϕ_M (°)
271	351	5	5.54	293.5	-70.2

Conclusion: *OBLIMAP 2.0 release*

The main OBLIMAP improvements:

1. The flexible masked mapping is very useful in practice.
2. The embeddable mapping routines enable high-frequency online coupling.
3. The fast scan method is a large performance improvement.

The OBLIMAP 2.0 open source release includes:

1. OBLIMAP 2.0 source code
2. Applications: see the config files
3. Time average RACMO2.3 data sets
4. OBLIMAP User Guide

Further OBLIMAP development

OBLIMAP code:

- Fortran
- MPI # For the parallel code
- netcdf

The main OBLIMAP improvements:

- First oblimap-par developments at the Polar Science Hackathon in MIAMI in 2016.
- The OBLIMAP-PAR project is funded by ESiWACE2 (a joined call by ATOS & eScience center):

  David Guibert (ATOS, CEPP, France) is working on an efficient shared memory MPI implementation & on further upscaling the MPI application

Other desired developments:

- Extending the fast scan method for unstructured grids
- A radius method option which selects a lower density of contributions

Public svn & git access to the latest OBLIMAP 2.2 release:

1. git clone https://github.com/oblimap/oblimap
2. svn checkout https://svn.science.uu.nl/repos/project.oblimap

OBLIMAP 2.0 : a fast climate model - ice sheet model coupler including online embeddable mapping routines
Reerink et al. (2016), in GMD