



Regional climate modelling with the **MAR** model

```

M           M           AAAAAAA           RRRRRRR
MM          MM          A           A           R           R
M M          M M          A           A           R           R
M  M  M  M  M  A           A           R           R
M    MM    M    A AAAAA A           R RRRRR R
M          M          A           A           R R
(MODELE tridimensionnel ATMOSPHERIQUE a l'echelle REGIONALE)
M           M           A           A           R           R
M           M           A           A           R           R
M           M           A           A           R           R
M           M           A           A           R           R

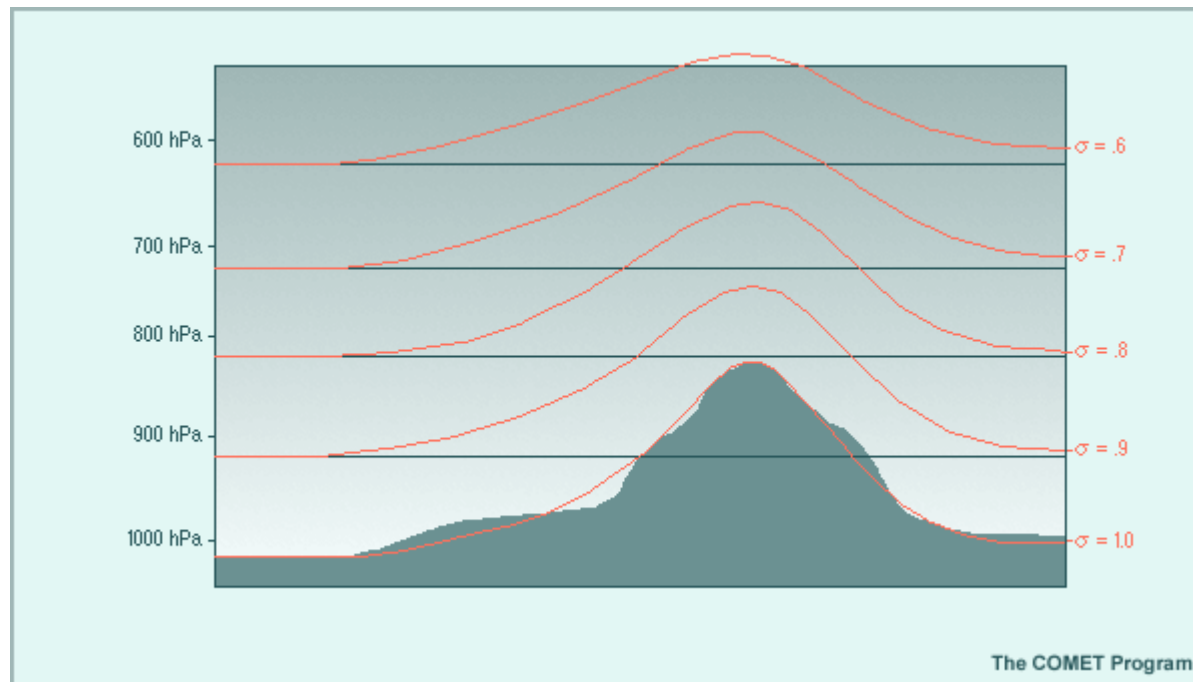
```

by Hubert Gallée (LGGE, Grenoble, France)

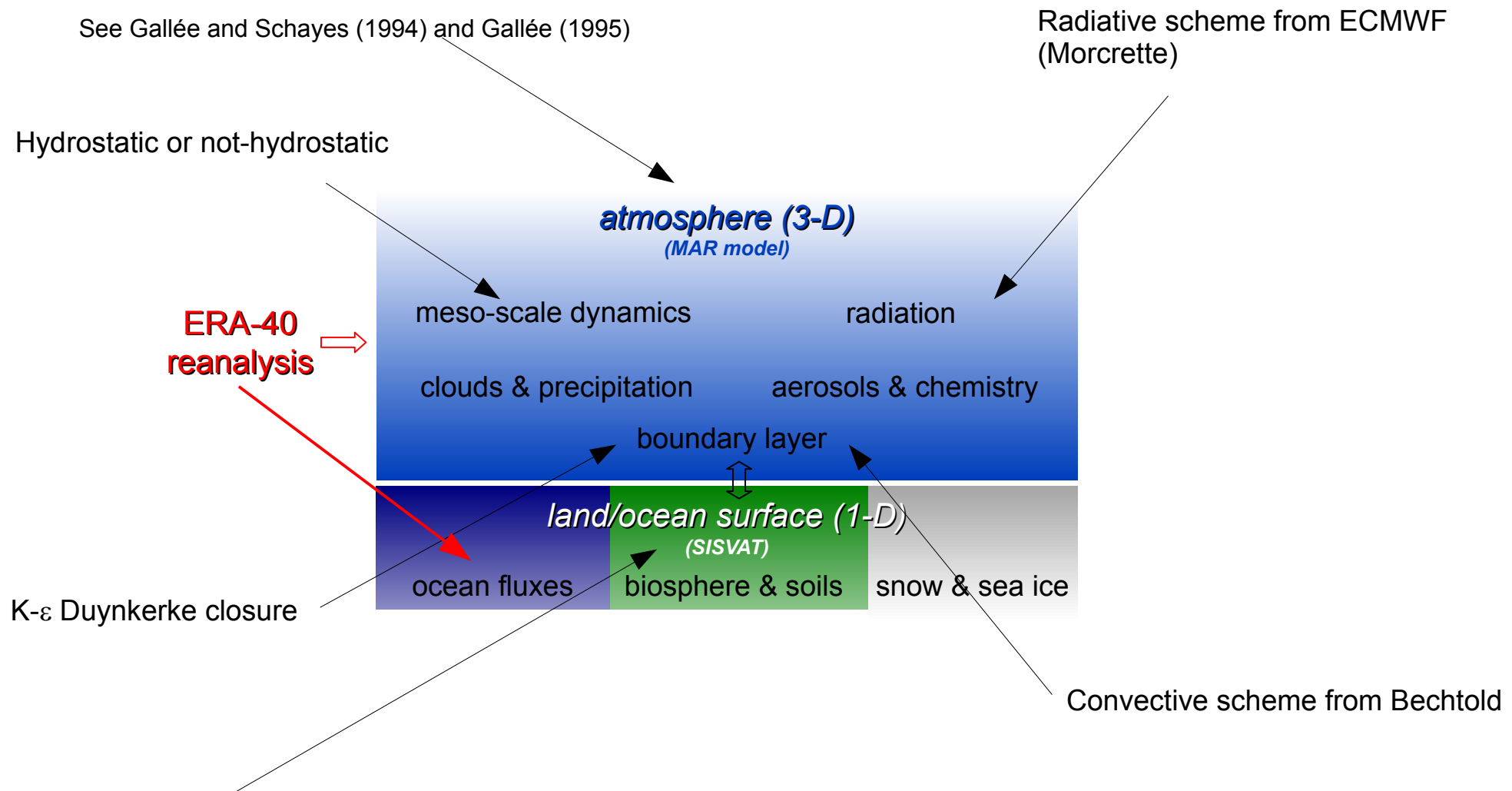
1. Introduction to MAR

- The MAR (Modèle Atmosphérique Régional) model was funded by Hubert Gallée (LGGE, France).
- It is (non-)hydrostatic primitive equation model.
- The vertical coordinate is the normalized pressure sigma:

$$\sigma(k) = \frac{p(k) - p_{top}}{p_{surface} - p_{top}}, k \in [1, 40]$$



1. Introduction to MAR

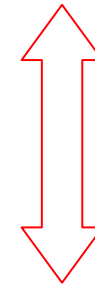


SISVAT: Soil Ice Snow Vegetation Atmosphere Transfer

See De Ridder and Gallée (1998) and Gallée et al. (2001)

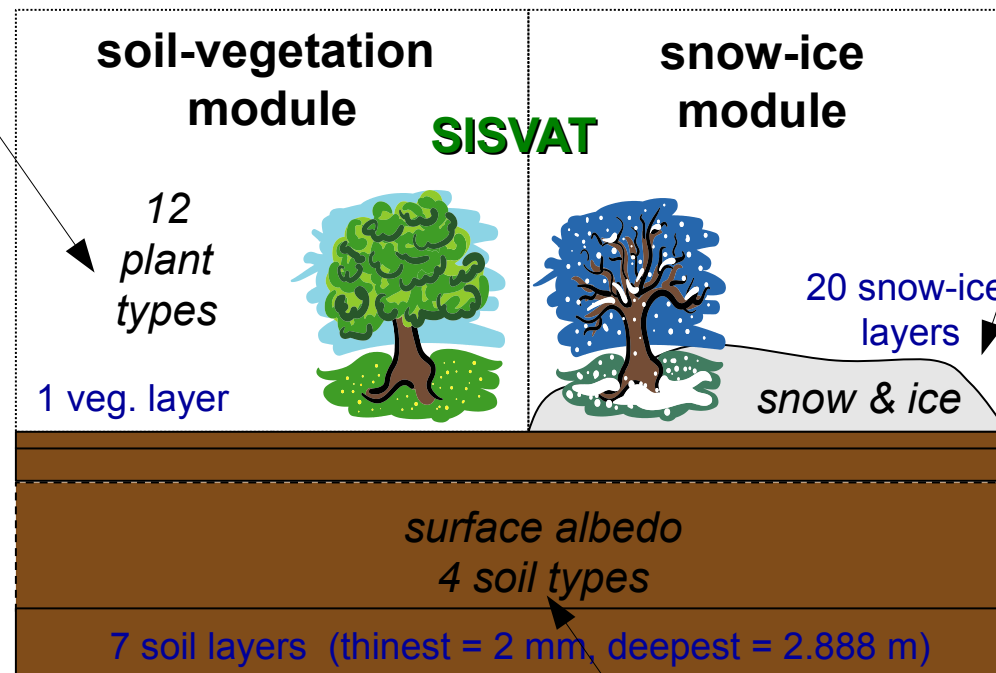
1. Introduction to MAR

MAR



*solar & infrared radiative fluxes
turbulent momentum fluxes
sensible & latent heat fluxes*

displacement height
roughness length
root fraction
min. stomatal resistance
global plant resistance
canopy spatial distrib.
canopy temporal evol.



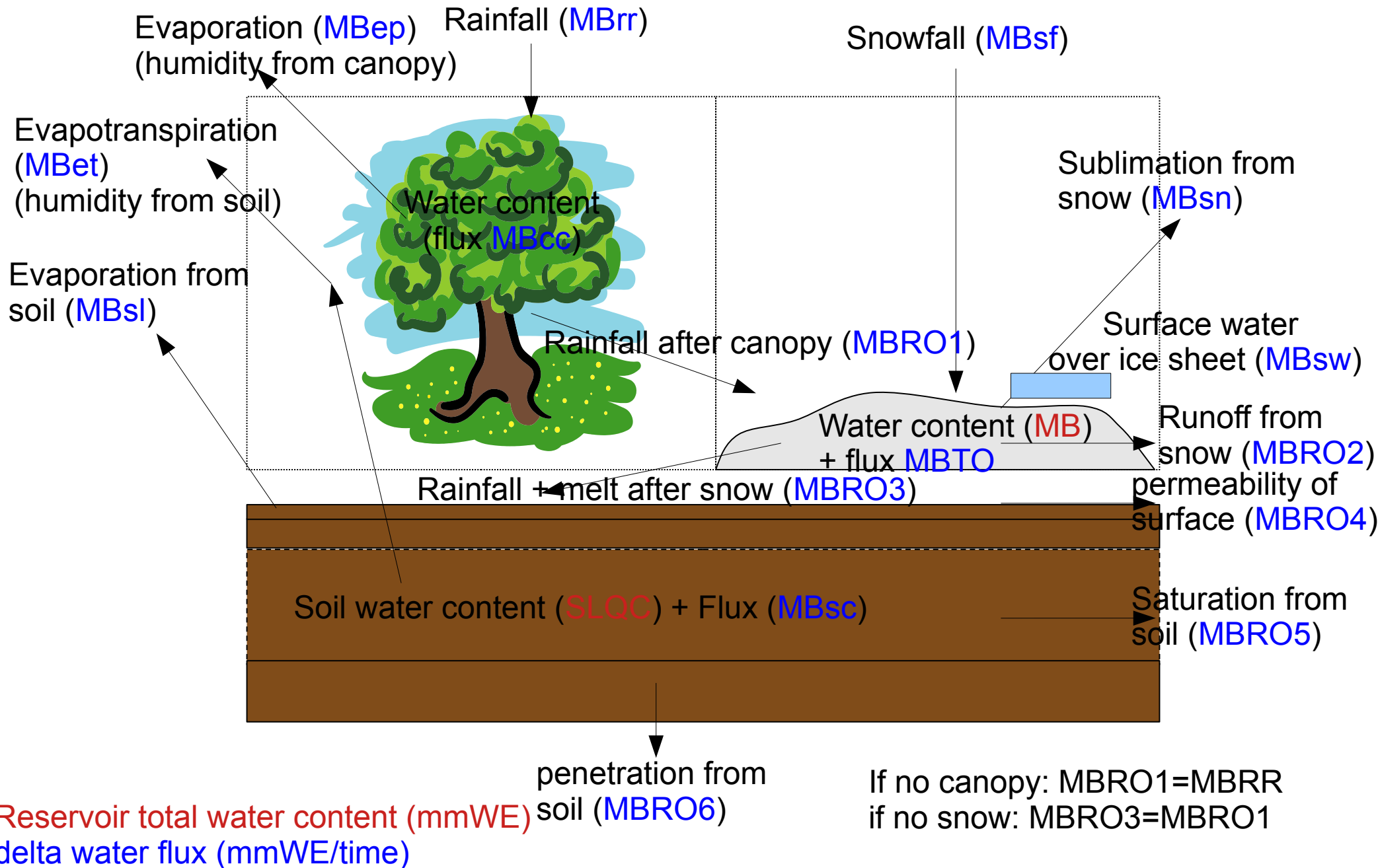
temperature
density
liquid water cont.
grain size
dendricity
sphericity
ages
ice lens



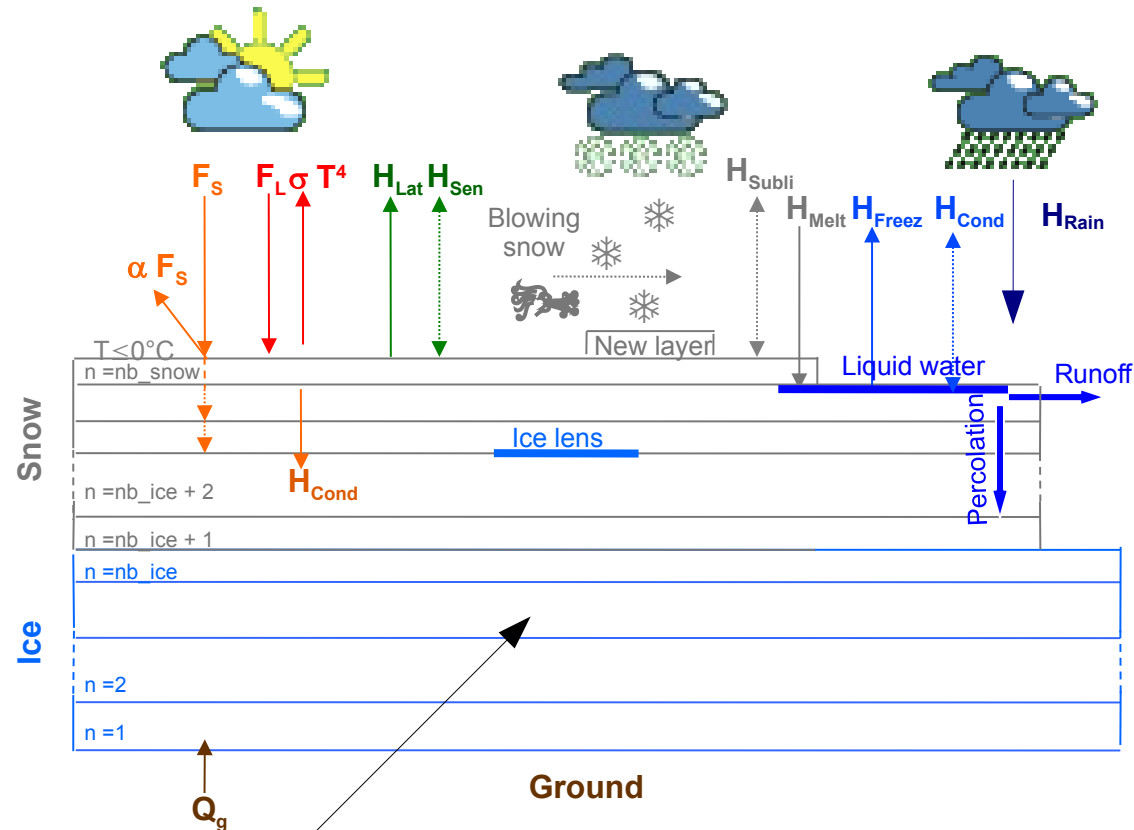
**Ocean and sea-ice concentration
from reanalysis**

saturated water content
water potential at saturation
hydraulic conductivity at saturation
exponent of the water retention curve

1. Introduction to MAR



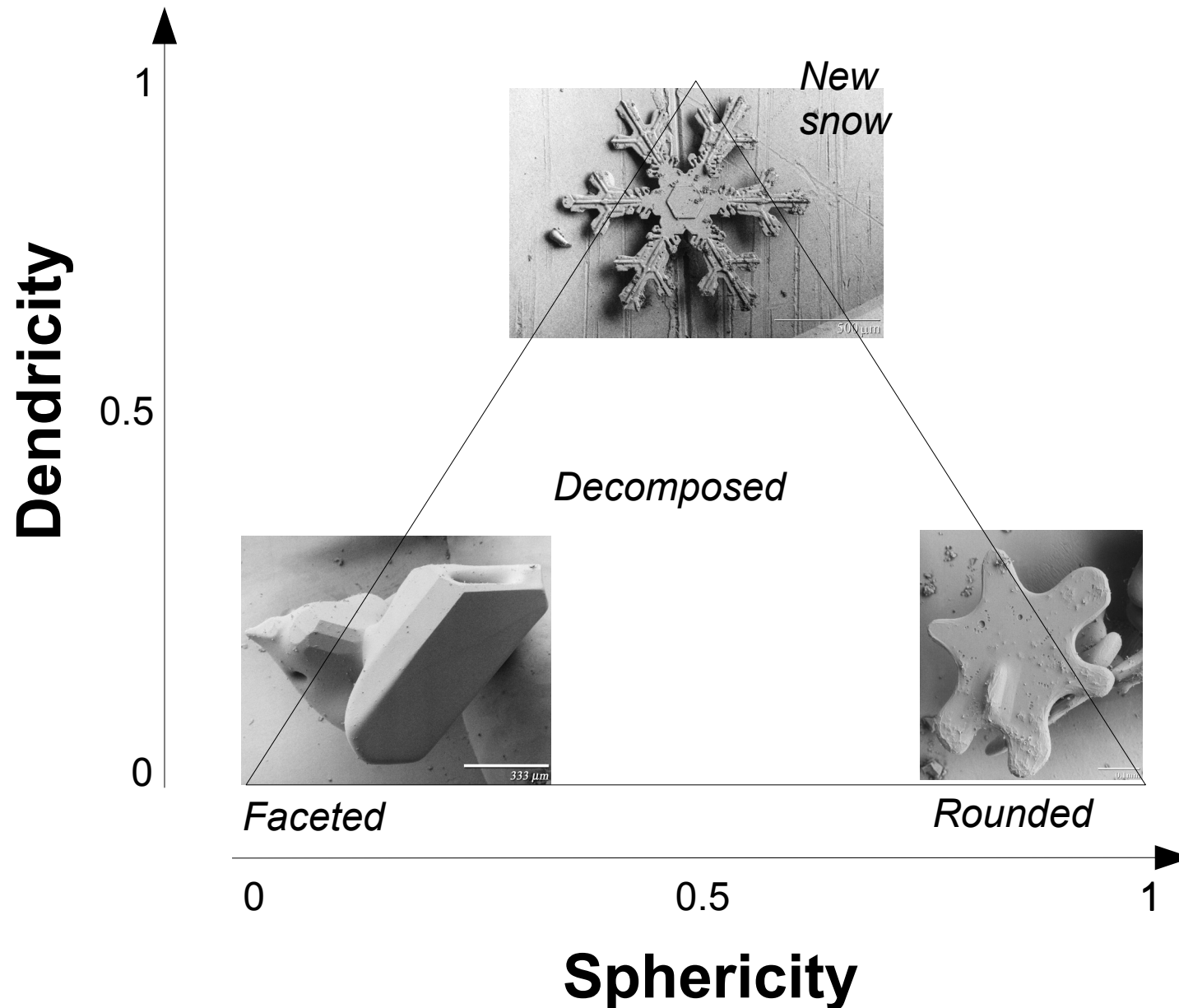
1. Introduction to MAR



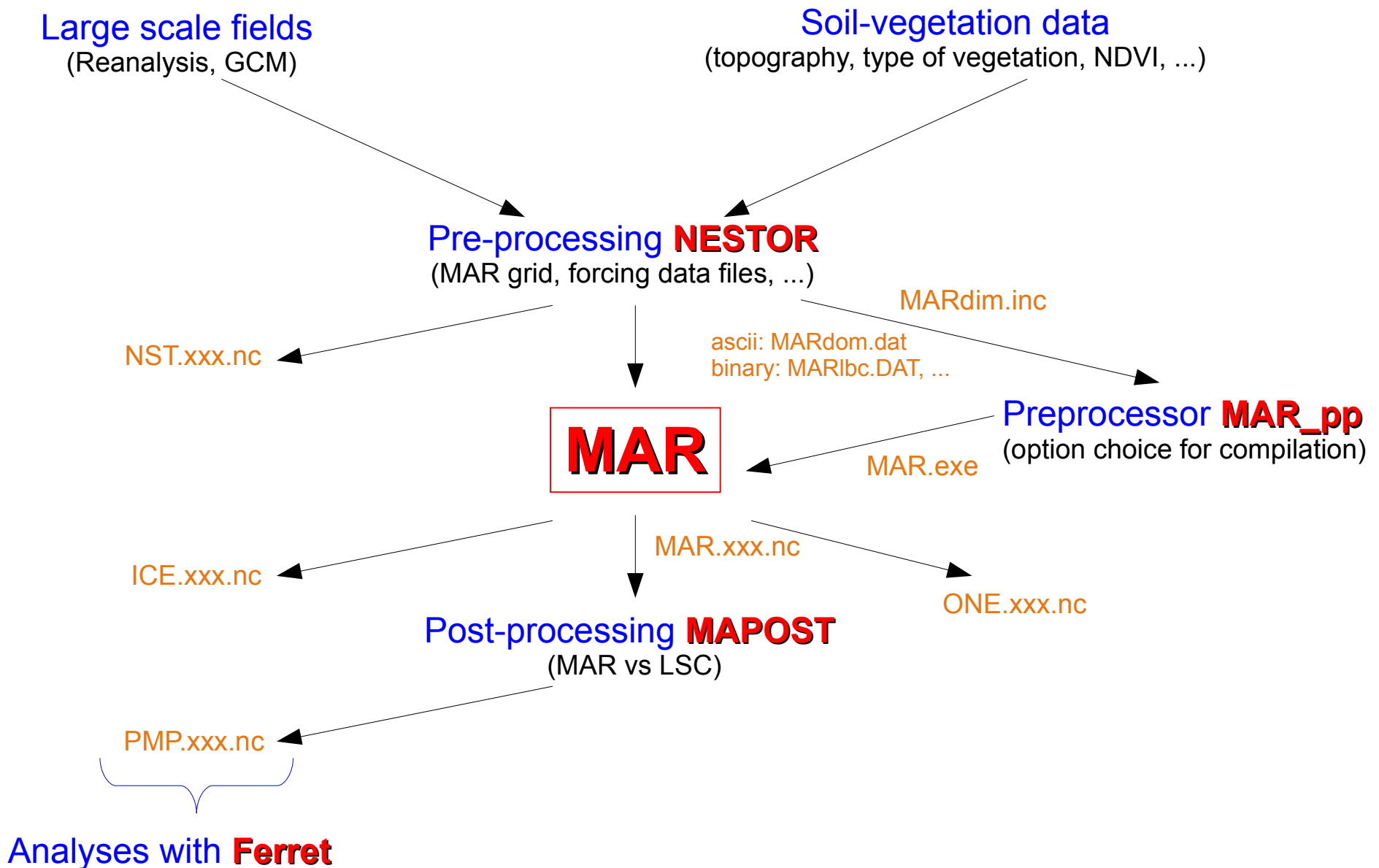
A snow layer is described by:

- density
- temperature
- height
- liquid water content
- age
- dendricity (% of original crystal shapes)
- sphericity (% of rounded versus angular shapes)
- grain size

1. Introduction to MAR



2. MAR scheme



3. Installation

Check after that your ssh key is working well.

On your main server, build the links:
cd ~/MAR
In -sf \$STKsrf in
In -sf \$STKmar out
In -sf \$WRKdir run
in fct of INI.ctr.



Installation of MAR

```
tar xzf MARsrc_2009-01-23.tgz
cd ~/MAR/bin
```

Check ~/MAR/bin/INI.ctr and after

./INSTALL

Type "bash"

./INI \$DOM

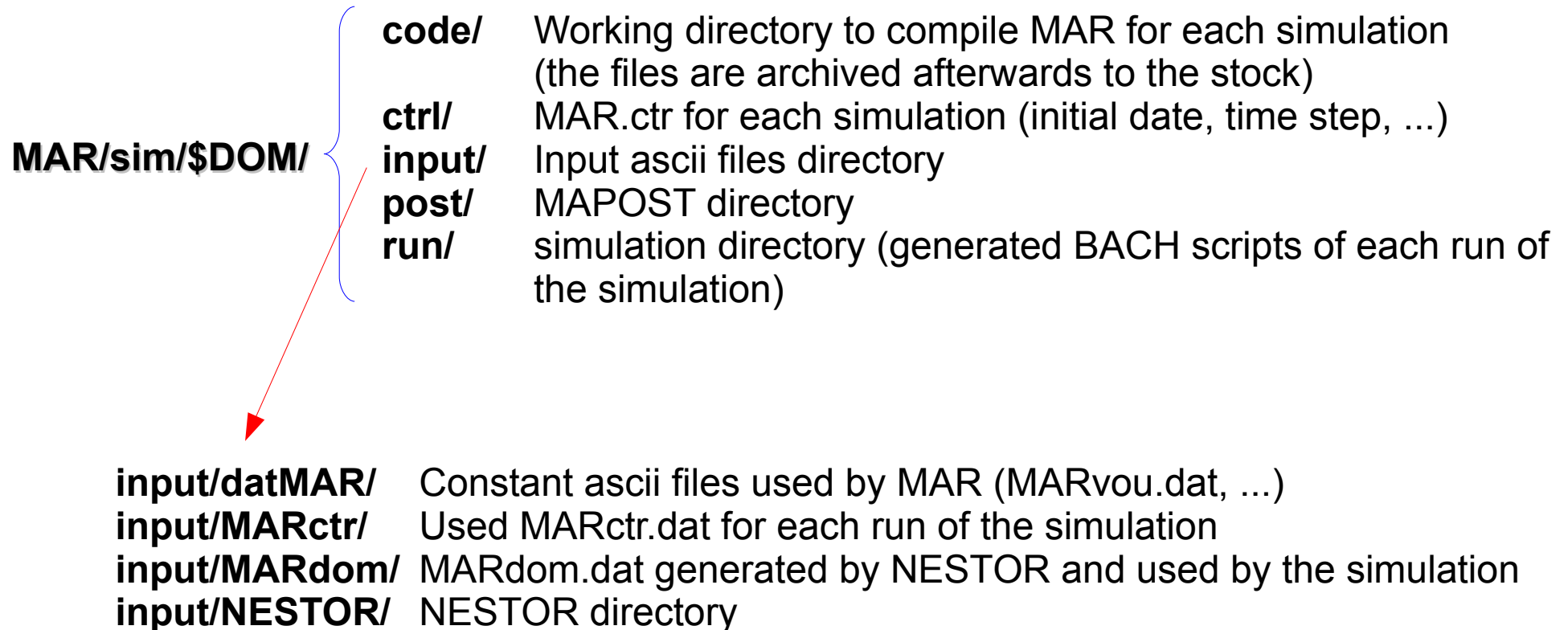
Update the \$HOME/.bashrc for \$PATH
+ build the ssh-key for no-password ssh connection

Domain name (ex. EUa, GRd, ...)

MAR	bin/	Main BASH scripts
	in/	Input files (LSC, TOPO, ...) (It can be on a remote server!)
	msg/	Batched message (log files)
	out/	Output files (MAR.xxx.nc, ...) (It can be on a remote server!)
	run/	Working directory (or scratch directory)
	sim/	Simulations directories (NESTOR, MAPOST, run scripts, ...)
	src/	Sources
	tmp/	Temporary directory
	usr/	User's files (Fortran, MARvou.dat, ...)

3. Installation

Directories of ~/MAR

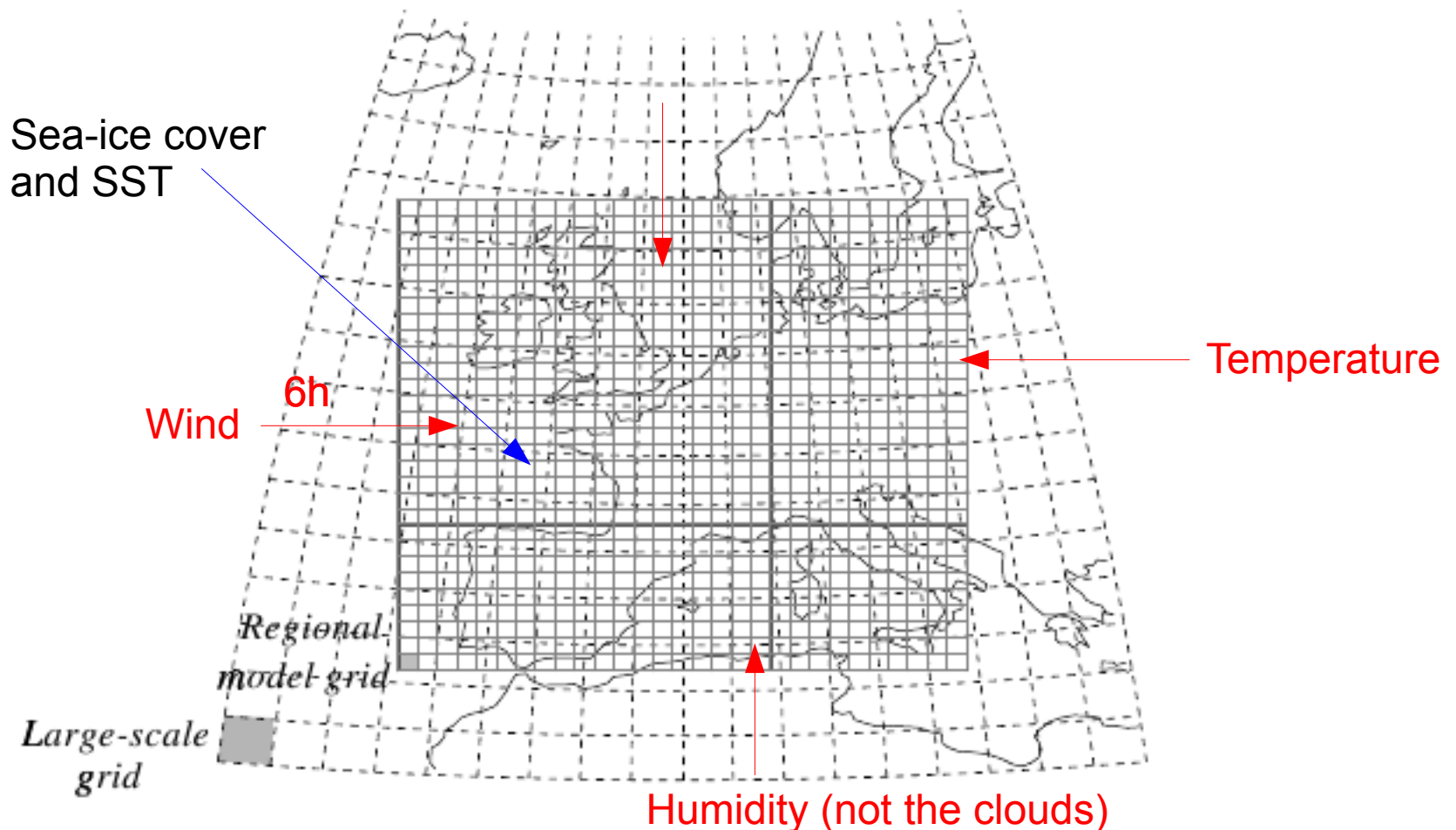


4. NESTOR

They are linearly interpolated in MAR between each 6 hours.

NESTOR is used:

- to create the MAR grid.
- to initialize the MAR fields at the beginning of the simulation
- to make the needed forcing fields every 6h. The forcing fields are the temperature, wind, humidity at each MAR level as well as the SST and sea ice cover above the ocean.



4. NESTOR

First step with NESTOR

Check that `n03=NC1`, `n24=T`, `n26=T` in `~/MAR/bin/NST.ctr`

NST \$DOM 2003 07 set

and follow the instructions (check that your `$SCRATCH` is not in `~/MAR/run`)
`cd $SCRATCH/NST_$DOM_set-up`

{	Compile.exe*	To compile NESTOR
	input/	Input files
	LSCfil.dat	Path of the large scale forcing files
	MARgrd.ctr	Parameters of the MAR grid
	NESTOR.exe*	NESTOR executable
	NSTing.ctr	Parameters of NESTOR
	NSTvou.dat	Selection of variables in the NetCDF output file
	output/	Output files
	src/	Source in Fortran

4. NESTOR

Some configurations (1/2)

NSTing.ctr:

To have a NetCDF file
of the output
(not used by MAR)

See: [src/USRgrd.f](#)
(f.e.: use of a special
topography above Greenland)

```
...
GRD          | Region .e.g. GRD,ANT,EUR,GRD          (a3)
...
T            | - graphic check file          (NST*.nc)    (F/T)
...
F            | - border of constant topography at boundaries |
F            | - imposed LSC topography in the const. border |
F            | - imposed LSC topography in the whole domain |
F            | - zero topography          in the const. border |
T            | - filtering of topography          |
-----| CORRECTION APPLIED TO METEO. FIELDS :
F            | - 600-hPa geopotential height          (F/T)
T            | - mixed surface layer          (F/T)
...
F            | - Correction with NDVI index (res. 1 km) (T/F)
F            | - Correction with NDVI index (res. 8 km) (T/F)
...
T            | De Ridder and Schayes (1997) soil model (T/F)
40.          | Imposed soil wetness in all layers (0 to 100 %)
T            | Soil wetness from ECMWF fields          (T/F)
...
F            | Imposed Reynolds sea surface temperature (T/F)
```

See [src/NSTdim.inc](#)
for the **dimension**
of the relaxation zone
the dimension
of the LSC files
and your domain!

Input files are
needed.

For using SISVAT

SST from ERA

4. NESTOR

The dimensions of the MAR grid are: $m_x \times m_y \times m_z$
The dimensions of the LSC grid are: $n_i \times n_j \times n_k$
in `src/NSTdim.inc` (+ `nsno=10` and `nvx=3` if EU)

Some configurations (2/2)

MARgrd.ctr:

Latitude and longitude
of the grid centre

```
-40      | MAR domain center longitude  
41       | MAR domain center longitude (grid point = imez)  
70.50    | MAR domain center latitude  
70       | MAR domain center latitude (grid point = jmez)  
-----  
25.0     | MAR mesh size (km)
```

Coordinates (i,j)
of the centre

Resolution used

```
...  
0.01     | Pressure at top (kPa)  
...
```



Max a factor 10 between
the LSC model and MAR

See `src/NSTdim.inc` for
the dimensions (m_x , m_y)
of the grid

For the sigma
vertical grid

```
2.       | zzmin= STD NEW (0=>OK) Vertical discretisation  
0        | aavu=  STD NEW (0=>OK) "  
0        | bbvu=  STD NEW (0=>OK) "  
0        | ccvu=  STD NEW (0=>OK) "
```

First level

Form of the
vertical grid



The number of vertical levels (m_z)
should be 19, 30, 40, 60. Otherwise, *aavu*, *bbvu* and *ccvu* must be specified.

4. NESTOR

Don't forget to check the output
NetCDF file with ferret !

cancel data/all ; use NST.2003.08.01.00.EUa.nc ; shade sh,lon,lat ; go land

Launch of NESTOR

- After configuring NESTOR (mainly **src/NSTdim.inc** and **MARgrd.ctr**):

```
./Compile.exe  
./NESTOR.exe
```

- If all is Ok, you have to copy your configuration files (*MARgrd.ctr*) as well as *src/NSTdim.inc* and *NESTOR.exe* to

```
~/MAR/sim/$DOM/input/NESTOR
```

by using the *dont_forget_to_copy_files_after.bash*.

and don't forget to change **~/MAR/bin/NST.ctr**

- Afterwards

```
NST $DOM 2007 01
```

```
qsub ~/MAR/sim/$DOM/input/NESTOR/run/NST_$DOM.07.01.01-31.cmd
```

```
NST $DOM 2007 02
```

...

4. NESTOR

~/MARsim/out/\$DOM/input/NESTOR/19XX/

Outputs of NESTOR (1/2)

MARdim.inc
MAR_SV.inc

Dimension of the MAR grid and the nbr of snow/soil layers in SISVAT **for the MAR compilation**

ascii

MARdom.dat:

Input files for MAR: label, date of the start, grid properties latitude, longitude, sigma, ...

MARdyn.DAT
MARsol.DAT
MARsvt.DAT

Initialisation files for the date of the start of the simulation. These files are made after by MAR to restart the simulation.

binary

MARglf.DAT
MARlbc.DAT
MARsic.DAT
MARubc.DAT

Lateral boundaries files for each 6h of the NESTOR period.

NST.2008.12.01.00.GRa.nc : Outputs in NETCDF only for checking

4. NESTOR

Outputs of NESTOR (2/2)

Only use at
the initialisation

MARdyn.DAT: temp., X and Y-wind, humidity, pressure, ... at each levels.

MARsol.DAT: surf. Temp., albedo, Z0, R0, flux, ... at the surface

MARsvt.DAT: idem but in each mosaics in SISVAT

Use every 6 hours

MARglf.DAT: green leaf fraction for SISVAT

MARlbc.DAT: lateral boundaries conditions: temp., X and Y-wind, humidity, pressure, ... at each levels of the boundaries + SST

MARsic.DAT: sea-ice concentration

MARubc.DAT: upper boundaries conditions: idem but at top of the atmosphere

4. NESTOR

Some specificities about NESTOR:

1. *Over the Greenland ice sheet, we use our own ice sheet mask and topography.*
 - *Use the default one for building your grid.*
 - *Interpolate the GIMP based 1 km DEM over your grid.*
 - *Read you new topo/ice sheet mask in **USRgrd.f***
2. *WARNING WARNING about **TOPcor.f** which imposes the LSC topo at your boundaries.*
 - *run NESTOR with ERA5*
 - ! - *keep an output netcdf file with SH*
 - *read this file when ERA40 is used*
 - *be careful that the filtering will be applied 2 times if NST_SH is not read at the end of TOPcor.f*
3. *EU domain => vegetation and not permanent ice (mw=3)*
GR domain => not vegetation but permanent ice (mw=2)
(with some handmade changes, it is possible to have permanent ice, LAI (read by MAR) and vegetation if n24=T in NST.ctr)
4. *mzabso > 4 is needed for large domains.*

5. MAR

Compilation of MAR (1/4)

Includes: `~/MAR/src/forMAR/forMAR/*.inc`
`~/MAR/usr/*.inc`
`~/MAR/out/$DOM/input/NESTOR/19XX/MARdcl_$DOM.tar`

Main code: `~/MAR/src/forMAR/forMAR/*.f`

External subroutines:

`~/MAR/src/forMAR/forMAR/*.f90`
`~/MAR/usr/SBCnew.f`
`~/MAR/src/libMAR/*.f`

MAR preprocessing: *MAR_pp (via BASH)*

f90 *.f90 *.f *.mod ← `libnetcdf.a`

MAR.exe

5. MAR

Compilation of MAR (2/4): CODE a01

- The choice of the MAR options has been a lot simplified in

~/MAR/bin/CODE.ctr

from MARv3.10 and is fixed in CODE following the domain used.

- To recompile MAR:

```
cd ~/MAR/out/EUa/a01/code
rm -f MAR_a01.exe
mkdir src
tar xzf compilink.tar.gz -C src
cd src
./COMPILE
cd ..
ln -sf src/MAR_a01.exe .
```

The MAR executable must be in

~/MAR/out/EUa/a01/code/MAR_a01.exe

5. MAR

~/MAR/out/\$DOM/input/NESTOR/19XX/MARdcl_\$DOM.tar

Compilation of MAR (3/4): *.inc and sbcnew.f90

MAR is parallelised on my or mz

mx, **my** and **mz** are the X, Y and Z dimensions.

klon=1 if NO vectorization (it is the case here).

n6 et n7 determine a relaxation zone towards lateral boundaries.

mw is the nbr of mosaics (2 or 3) in SISVAT

mardim_mod.f90

Klonv=1 if OpenMP is turned on

nsol is the nbr of soil layers in SISVAT

nsno is the nbr of snow layers

mar_sv_mod.f90

- **sbcnew.f90** is called at the end of every time step.

It contains the code developed by the users for specific use.

By default, ~/MAR/bin/CODE use

~/MARsim/src/forMAR/forMAR/sbcnew.f90

or

~/MAR/usr/SBCnew.f90

5. MAR

Some specificities about MAR:

- Be careful about the used version of SBCnew!!
- Don't forget to define your domain in SBCnew if you want to use the MARinisnow files.
 - we have f90 programs to interpolate and build these files from previous low resolution simulations.
 - this allows to decrease the spin-up time of 10 years.
- Be careful of the mzhyd value in mardim_mod.f90 which needs to be manually changes for some large domains (Arctic, Antarctica, ...).
- Tune your model by using marmagic_mod.f90

5. MAR

Launch of MAR (the first time)

Edition of

```
~/MAR/bin/MAR.ctr
```

and after

```
MAR a01 2003 01 a
```

```
qsub ~/MAR/sim/EUa/run/a01/MAR_${DOM}01.03.01.01-15.cmd
```



dt should be a divisor of 1800 (30min)

e.g.: dt=30s for 5km

dt=60s for 10km

dt=120s for 20km

*dt is now adapted by
the model itself.*

Initial and final date
Nbr of CPUs
Time step **dt**

Restart of MAR to continue simulations

```
cd ~/MAR/sim/EUa/run/a01/
```

```
MAR -again ../../ctrl/a01/MAR.ctr.030101-031231 a01 2003 01 b
```

```
qsub MAR_EUa01.03.01.16-31.cmd
```

This step is normally automatic

5. MAR

Inputs:

Radiative scheme

MARs01.dat
MARs02.dat
MARinf.dat

~/MAR/sim/\$DOM/input/datMAR

files read by SBCnew.f

MAR_GRa.dat
....

Boundaries forcing files as well as the files need to relaunch MAR

MARdyn.DAT
MARsvt.DAT
MARlbc.DAT
MARxxx.DAT

from NESTOR/MAR

~/MAR/usr/

Domain, run name, date, ...

MARdom.dat

from NESTOR

Parameters, time step; ...

MARctr.dat

~/MAR/sim/\$DOM/ctrl/a01/MAR.ctr

Files to chose the output variables in the NetCDF files

MARvou.dat,
ICEvou.dat, ...

~/MAR/sim/\$DOM/input/datMAR

~/MAR/usr/

MAR.exe

5. MAR

Outputs:

