ARPEGE-Climat V6 simulation in yearly chunks
E. Maisonnave
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1- Rationale

ARPEGE-Climat "Actual simulation speed"[1] depends on the whole work flow performance, which is clearly dominated by the main FORTRAN CGCM execution time but not fully captured by it. An estimated gain of dozens of % is also expected from work flow modifications, if restart frequency could be reduced. In the present CNRM-CM6 release[2], the monthly boundary condition files for aerosols and ozone cannot be read during simulation but only at initialization, that blocks checkpoint-restart period to one month. Actually, in addition to model I/O operations, the checkpoint/restart phase takes time during restart file movements, which can become expensive at high resolution on some file systems. In coupled mode, the ocean counterpart is even more costly (and not tolerable at ORCA12 resolution). We propose to remove this important constraint with small modifications in the ARPEGE-Climat code.

2- Implementation

ARPEGE-Climat (ocean coupled mode) needs only two sets of monthly boundary conditions: for aerosols and ozone. Both are read at initialization phase[3] (`SUGRIDF/SUGRIDA`). To be able to launch an update at runtime, our implementation moves this operation in a new separate subroutine (`SUGR2AO`), called, as originally, in `SUGRIDF` (for a field update at time step zero) but also at the beginning of the `CNT4` time loop (for a field update at other time steps). In this new subroutine, aerosol and ozone concentrations are read in files[4] (`AEROZO.YYYYMM`), written in ARPEGE-Climat output format (FA), at start and at the 16th of every month. Values can be interpolated in time (daily frequency, linear interpolation), as presented in Figure 1. ARPEGE namelist values related to simulation duration[5] must be changed to perform a one year long run.

Switch between forcing modes is possible via an additional namelist parameter[6]:

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1   Actual speed is defined in Balaji et al 2017 as the measure in a long production run, of the time between first submission and the date of arrival of the last history file on the storage file system.
2   V6.2.5, adapted to XIOS, february 2017
3   Another reading, directly in `Const.Clim` files, is performed in `SUGRCLIA`, but for diagnostic purpose only
4   These files are built from original IEEE format files:
Aerosols: `~nabat/DATA/AEROSOLS/AOD/t127/TACTIC2/AOD550espece_TACTIC2_11avg_YYYYMM.ieee` and
    `~nabat/DATA/AEROSOLS/AOD/t127/volcans_CMIP6/aod_volcan_strato_CMIP6_YYYYMM_tl127r.ieee`
Ozone: `/scratch/work/stmartin/clim/ozone_slarp_${GEOM}/ozone_slarp624.v1_${GEOM}.7coeffs.YYYYMM.ieee`
A conversion script is available here:
    `/home/ext/cf/cglo/maisonnavee/SAVE/Scripts/Arpege_v6/Outils_prepro/Build_Aerozo_0217/sh_build_AEROZO`
5   Users will particularly take care of NFRRES value,which can produce restart at inappropriate date
6   `&NAMMCC/L2AEROZO`

Parameter value	Chunk & time interpolation mode	Acronym
0	standard mode (monthly chunks)	STD
1	yearly chunk mode without time interpolation of aerosols/ozone	YRL
2	yearly chunk mode with time interpolation of aerosols/ozone	YTI

Table 1: Chunk mode description, associated namelist parameter value and simulation acronym

The yearly mode without interpolation (YRL) only differs from the standard mode (STD) on the reading-on-file procedure.

3- Validation

Five different[7] one year long simulations of ARPEGE-climat stand alone (1979 boundary conditions) are produced to estimate the impact of our modifications. Three members of an ensemble run are launched in STD mode. One simulation is produced in YRL mode. One simulation is produced in YTI mode. Since the SST field reading system already implemented differs from our new aerosol/ozone reading system, and this SST reading system cannot be activated on yearly chunks, the SST values are kept constant[8] during the whole experiment for all three kind of simulations (STD, YRL, YTI).
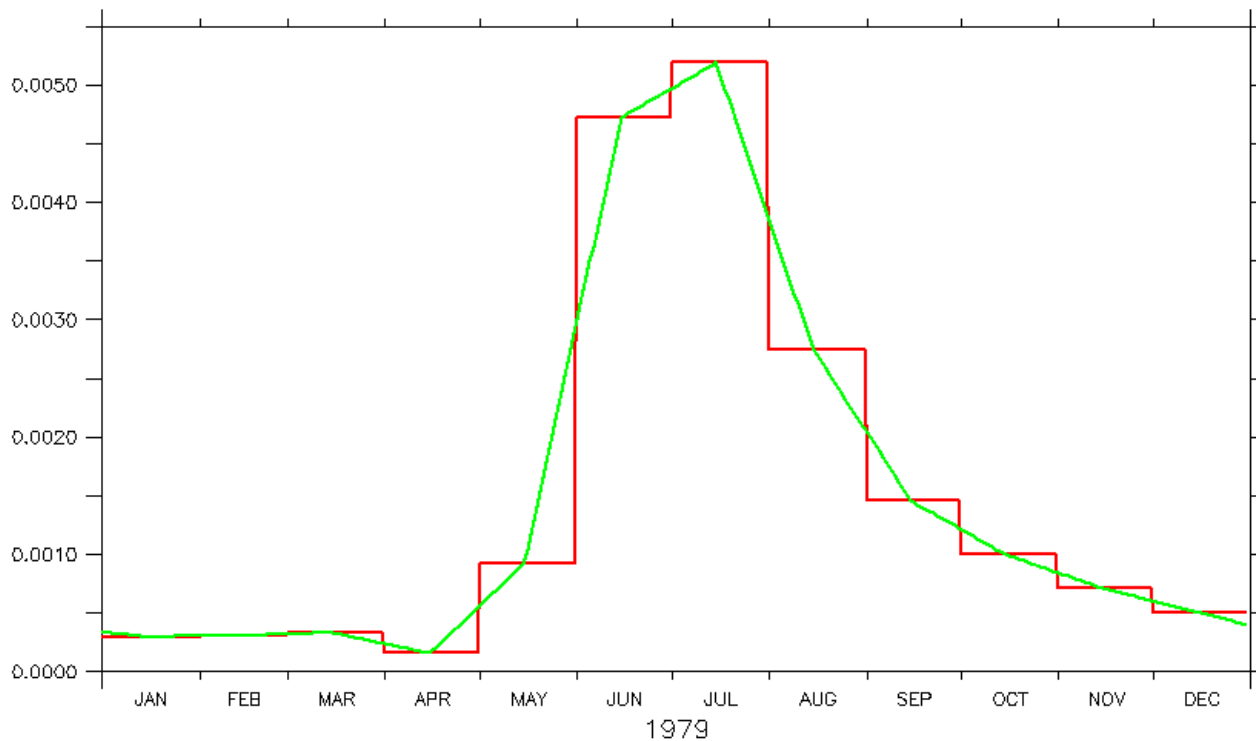

Figure 1: Sea aerosols concentration on an arbitrary grid point, with monthly (red) and yearly aerosols/ozone time-interpolated (green) simulation chunks

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7   The initial conditions are restart of previous daily simulations starting with 1979 January 1st conditions
8   SST, SSS and ice cover SURFEX namelist parameters must be set to UNIF

Input fields

A monthly value comparison between time interpolated values and the standard mode forcing (monthly mean) values, on an arbitrary grid point, for sea aerosol, is given in Figure 1.

Output fields

A validation of our implementation is done on fields output from ARPEGE/SURFEX with the new XIOS I/O server (Sénési, 2016). Figure 2,3 and 4 show comparison of daily values of sea level pressure, long wave flux on top of atmosphere and ozone at 200hPa, averaged on the global domain. Results of the YRL (YRI) mode simulation is plotted in red (green). Both simulations can be considered as members of the STD ensemble (black). The impact of our implementation is negligible on such large scale variables.
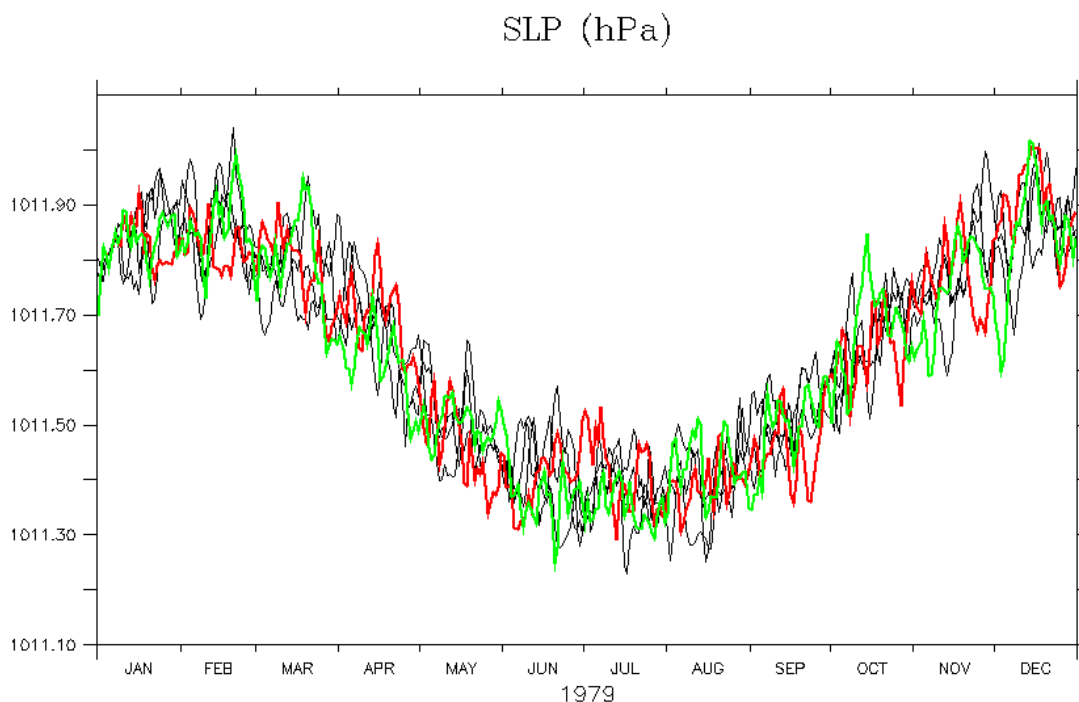
SLP (hPa)

Figure 2: Daily sea level pressure (global mean) in standard ARPEGE-Climat V6 simulations -black-, in yearly chunk mode with (without) time interpolated aerosols/ozone – green - (-red-)
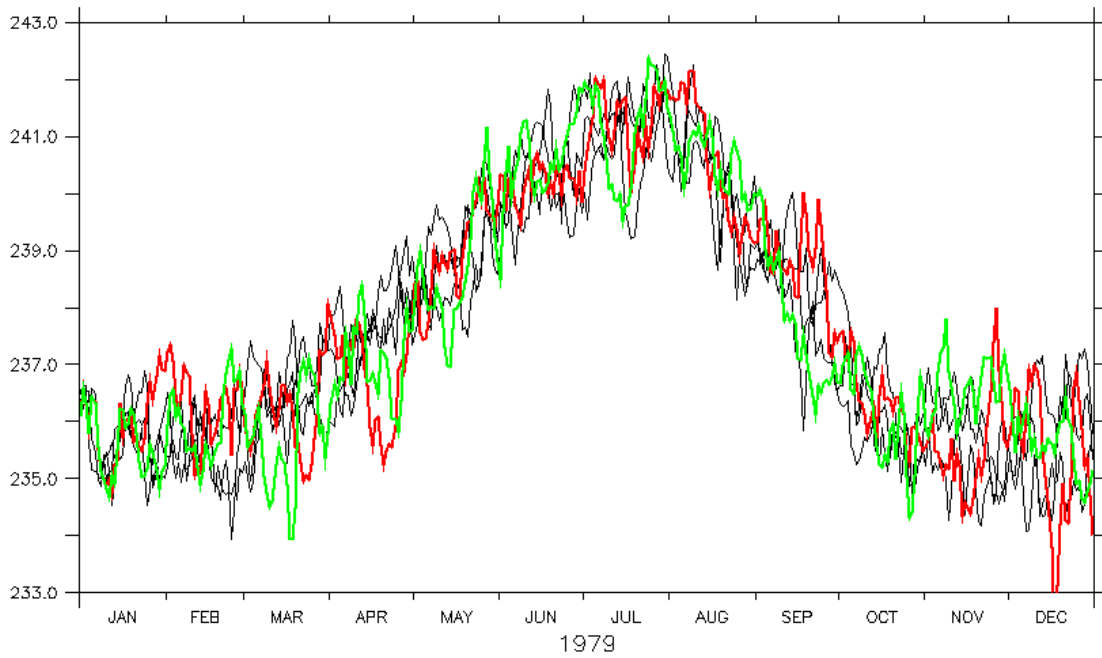
Figure 3: Radiation Longwave at the top of the atmosphere (global mean) in standard ARPEGE-Climat V6 simulations -black-, in yearly chunk mode with (without) time interpolated aerosols/ozone – green - (-red-)
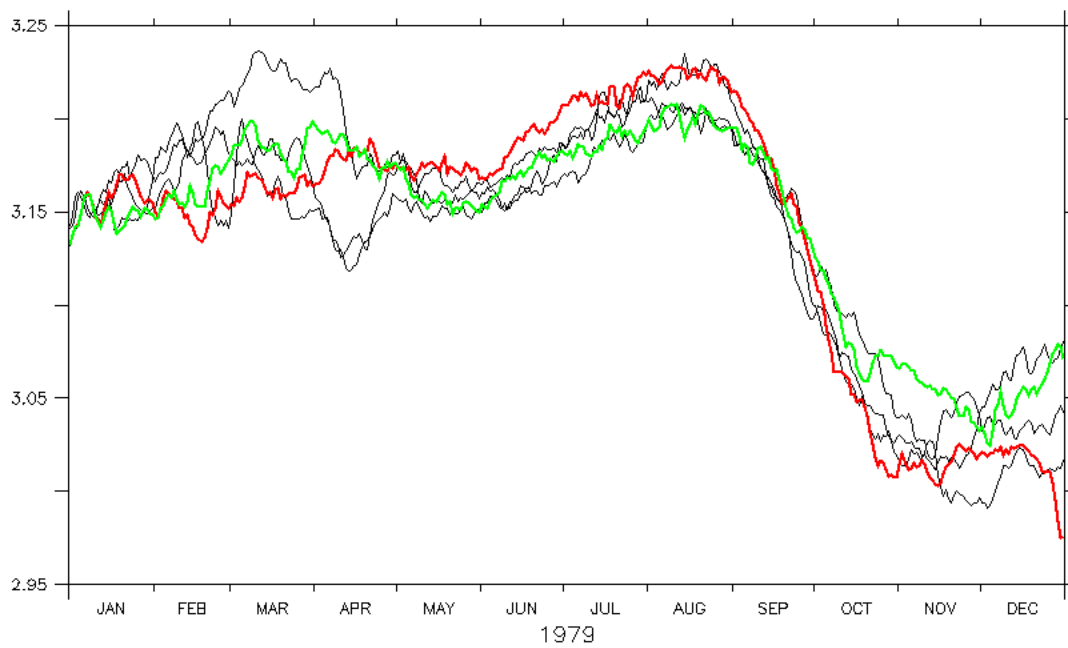

Figure 4: Mole fraction of ozone in air at 200hPa (global mean) in standard ARPEGE-Climat V6 simulations -black-, in yearly chunk mode with (without) time interpolated aerosols/ozone –green - (-red-)

4- Performances

The "Actual simulation speed", measured in simulated year per day (SYPD), is provided in table 2 for the previously described experiments. In each case, ARPEGE V6 (T127 resolution) simulates 1 year of climate. In STD mode, 12 monthly chunks are necessary to perform the simulation, but all chunks are chained in the same scheduler request. The time spent in queue is never taken into account. The amount of output data is 830Mb per simulated month, or a data intensity of 0.0015 Gb/CH.

Simulation acronym	Actual speed (SYPD)
STD	8.0 +/- 0.0
YRL	8.7
YTI	8.7

Table 2: Performances of ARPEGE V6 (T127) for different chunk & aerosols/ozone time interpolation modes

Even at this low resolution, some extra performance can be obtained with the yearly chunk mode. Results have to be expanded with higher resolutions on forced and ocean coupled mode. An extension of our reading system, if not rapidly obsolete compared to the XIOS reading system, can be considered for SST reading.

References

Balaji, V., Maisonnave, E., Zadeh, N., Lawrence, B. N., Biercamp, J., Fladrich, U., Aloisio, G., Benson, R., Caubel, A., Durachta, J., Foujols, M.-A., Lister, G., Mocavero, S., Underwood, S., and Wright, G., 2017: CPMIP: Measurements of Real Computational Performance of Earth System Models in CMIP6 , *Geosci. Model Dev.*, **46**, 19-34, doi:10.5194/gmd-10-19-2017

Sénési, S., 2016: XIAS, XIOS Interface for ARPEGE-Climat and SURFEX