A portable framework to generate initial conditions for IFS/OpenIFS from ERA reanalysis products using OpenIFS

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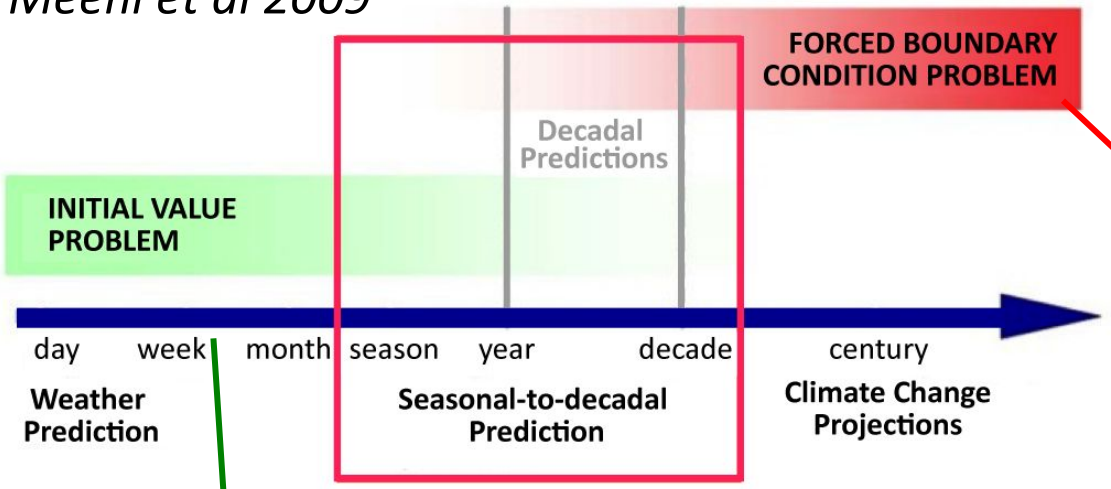
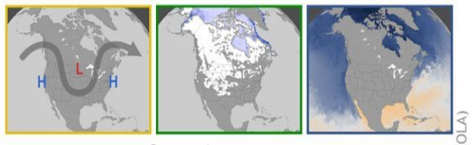
Introduction

- Models used in weather and climate forecasts must initialize the state of the Earth system (atmosphere, ocean, land and cryosphere) from observations

Cornerstones of climate prediction

Meehl et al 2009





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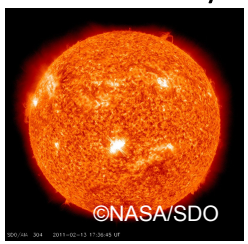
Mariotti et al 2018

Predictability relying on good guess of future changes in the forcing

Solar Activity



Volcanic Aerosols

GHGs

Predictability arising from the memory of slow processes/components in the climate system

Introduction

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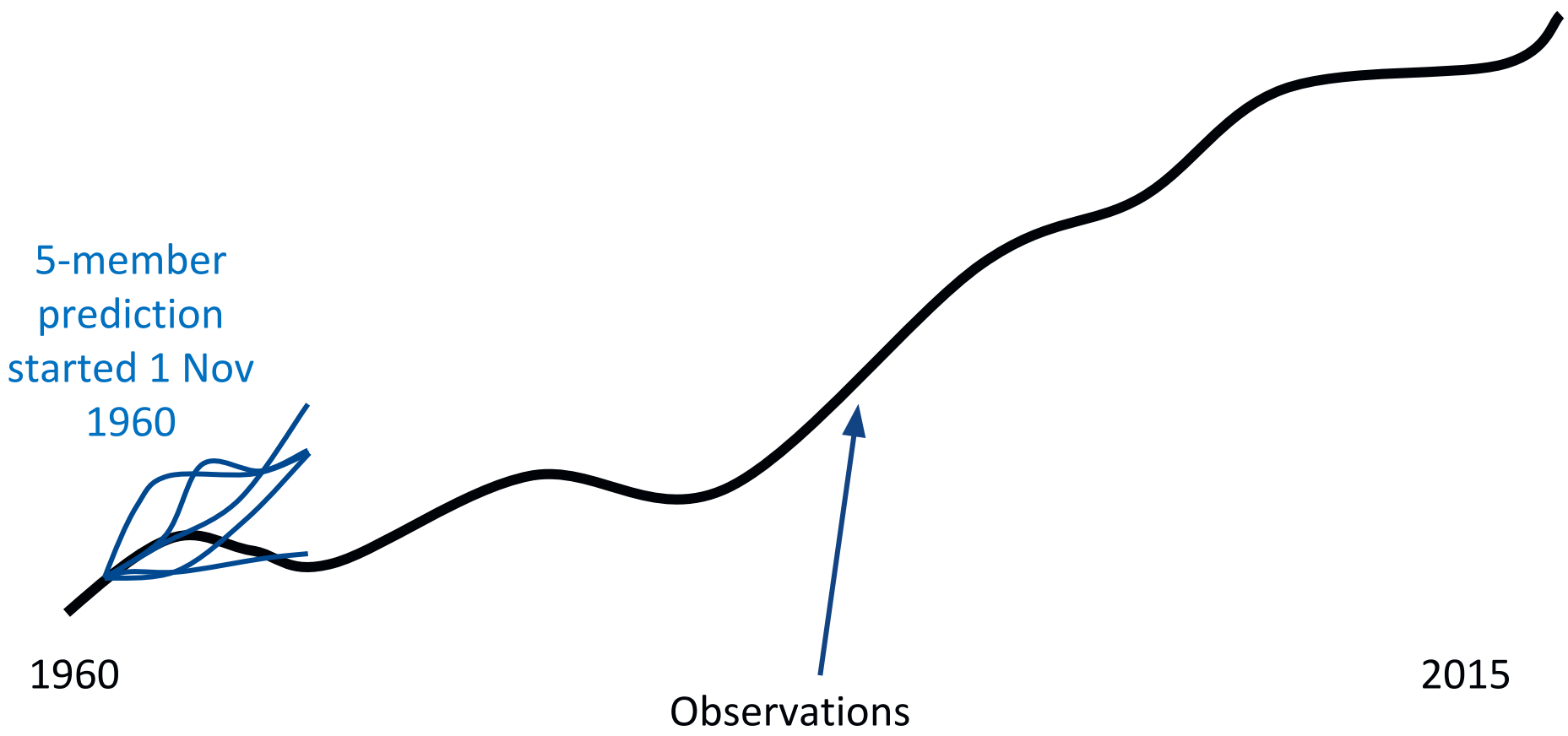
- Retrospective forecasts (or hindcasts) in weather or climate prediction mode are used to evaluate the model's performance and are typically initialized from reanalysis products

Climate prediction experiments



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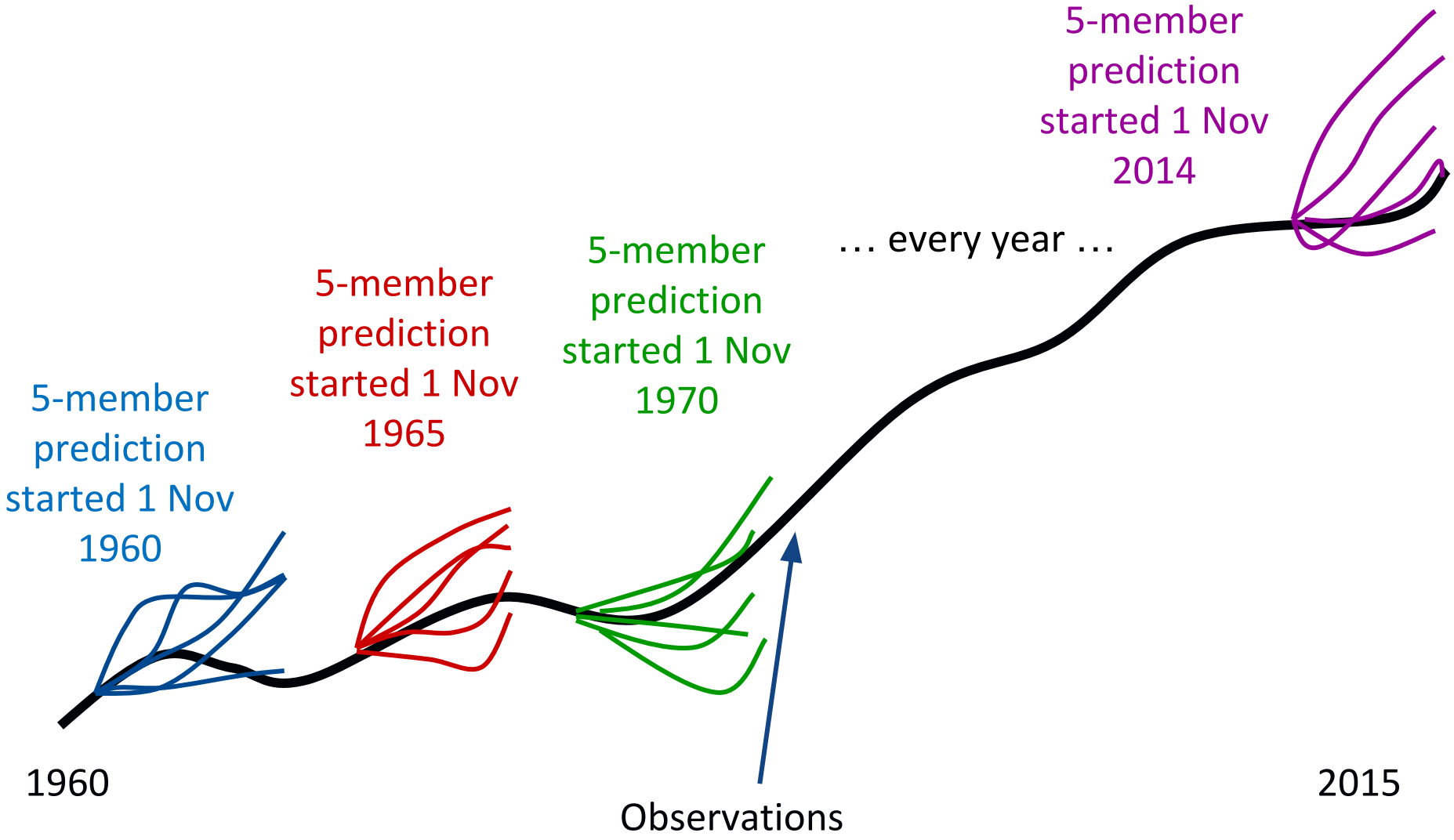

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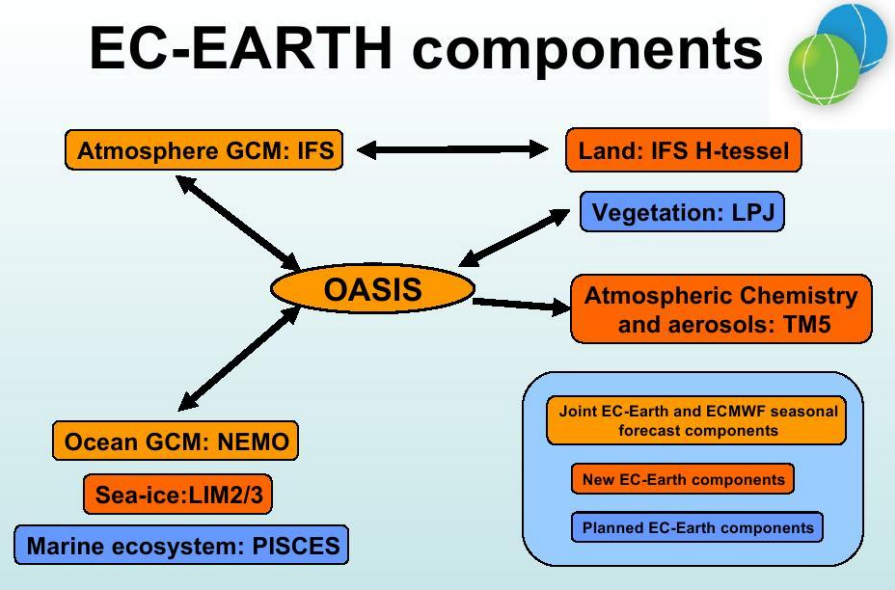
- Retrospective forecasts (or hindcasts) in weather or climate prediction mode are used to evaluate the model's performance and are typically initialized from reanalysis products
- However, the horizontal and vertical resolution of the reanalyses can be different and additional operations are needed to fit the grid model of the hindcast
- This is the case of EC-Earth

EC-Earth

- EC-Earth is a global coupled climate model, which integrates a number of components models in order to simulate the Earth system
- The two main components are IFS as the atmospheric model and NEMO as the ocean model



EC-Earth

- The EC-Earth climate model relies on atmospheric initial conditions derived from ERA-Interim
- These data must be obtained for several start dates (4 each year) for the entire period covered by the reanalysis product

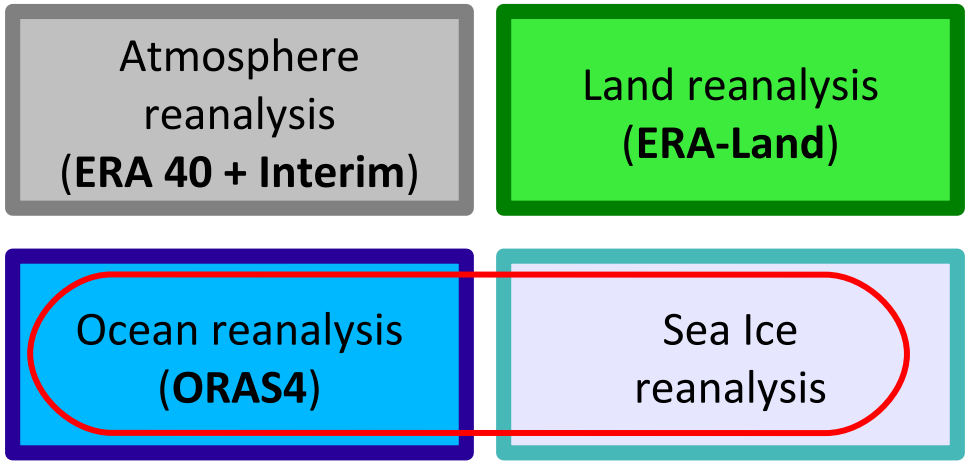
Initial conditions produced at BSC

ATM:
Interpolated to model grid with IFS + prepIFS

Now at BSC with OpenIFS + Autosubmit

Etienne Tourigny / Xavier Yepes

Initial Conditions



produced in-house

LAND:
Offline land-surface simulation with corrected fluxes from ERA-Interim

Emanuel Dutra / Etienne Tourigny

ocean

sea ice

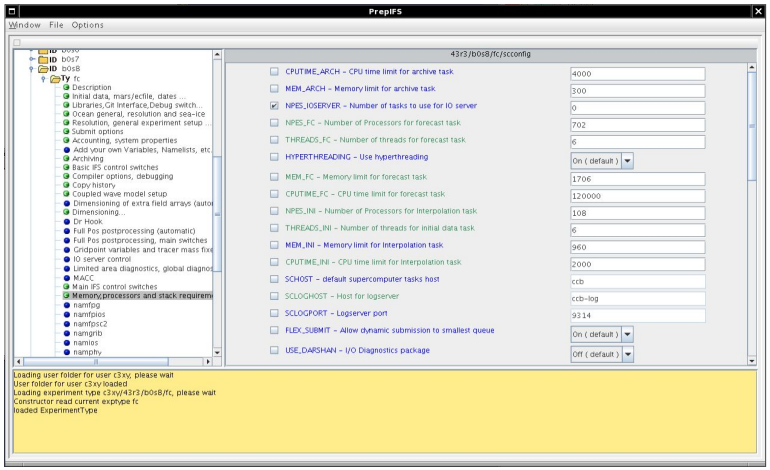
soil moisture

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

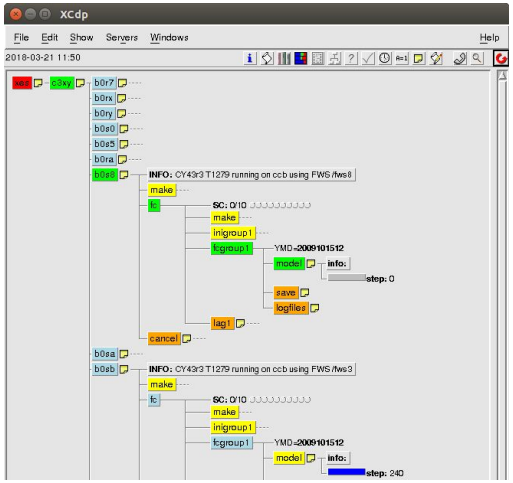
esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

Current procedure

- The current procedure to get initial conditions derived from ERA-Interim is using the ECMWF HPC infrastructure
- It runs an IFS experiment created with the prepIFS tool and managed with the XCdp manager
- These two softwares are ECMWF-dependent



experiment submission



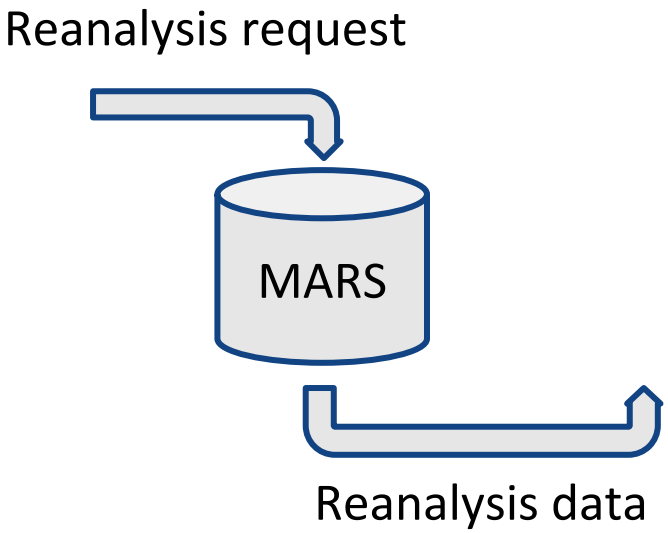
prepIFS

XCdp

Current procedure

The three main steps are:

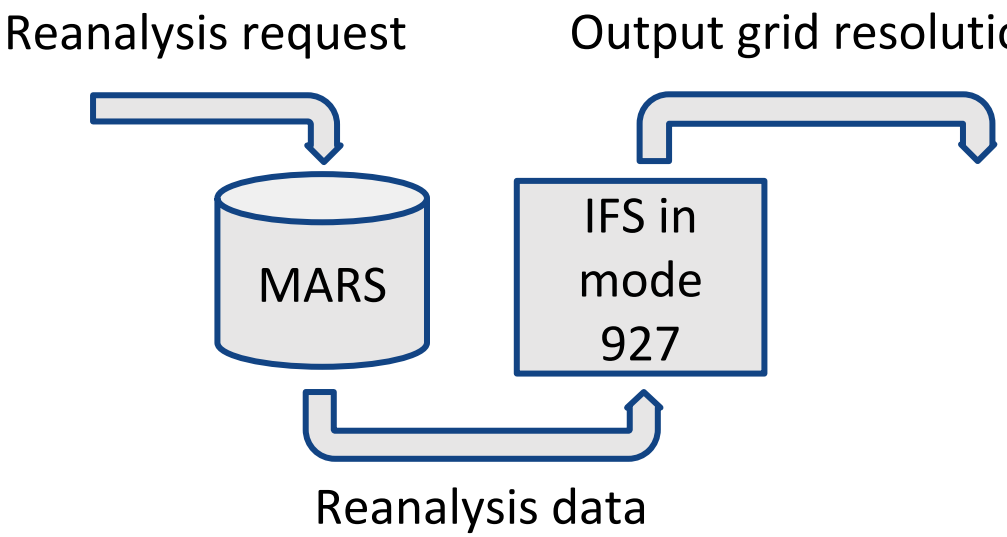
- Download the reanalysis data at its native resolution using MARS requests



Current procedure

The three main steps are:

- Download the reanalysis data at its native resolution using MARS requests
- Running IFS in mode 927 to make use of FullPos, a powerful post-processing package that performs horizontal and vertical interpolations



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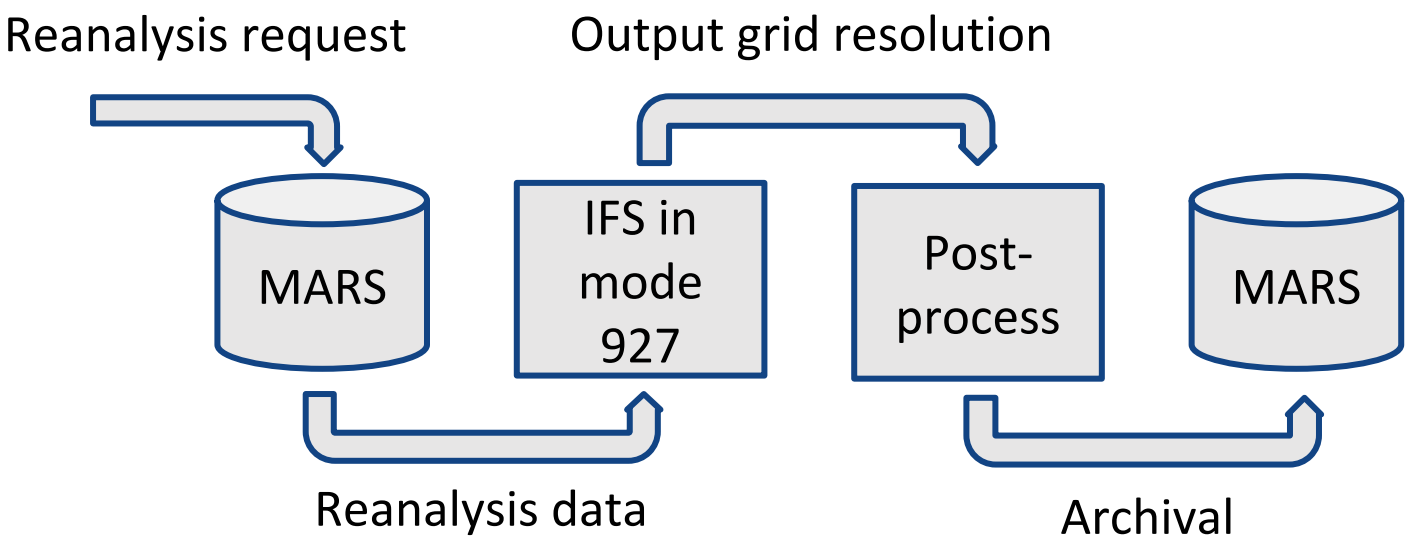
- Post-processing the result and archival on MARS



New procedure

- The current procedure is robust and relatively fast
- However, there are two main drawbacks:
  - It relies on ECMWF infrastructure and support
  - It is vulnerable to changes in the HPC platform used
- To overcome them, the original scripts have been simplified to run on other HPC platforms
- The new framework is made of three scripts:
  - Get initial data
  - Initial data interpolation
  - Initial data post-processing

Get initial data

- Retrieves reanalysis data from MARS at the native resolution:
  - Land surface and upper-air fields from ERA-Interim (T255L60), ERA5 (T639L137), etc
  - Optionally, surface fields from ERA-Land like experiments. Ongoing work to generate these surface fields with EC-Earth OSM.
- Runs on ecgate with some MARS commands, for efficiency and ease of porting
- Result can be automatically uploaded to a remote HPC machine (e.g. MareNostrum4 at BSC)

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However, it could be adapted to run on a remote HPC machine by using the CDS API instead of MARS client

Initial data interpolation

- OpenIFS 40r1 can be deployed and set up on a remote HPC machine to run on mode 927 (e.g. MareNostrum4 at BSC):

```
mpirun -n $NPES ./master.exe -v ecmwf -e $EXPVER \
      -t1. -ft0 -aeul 2>stderr.lst >stdo.lst
```

- Mode 927 uses FullPos to interpolate input GRIB files to a given output resolution
- It is necessary to adjust the OpenMP stack size from 128M to 512M
- Several output resolutions have been successfully tested, such as T255, T511 and T1279

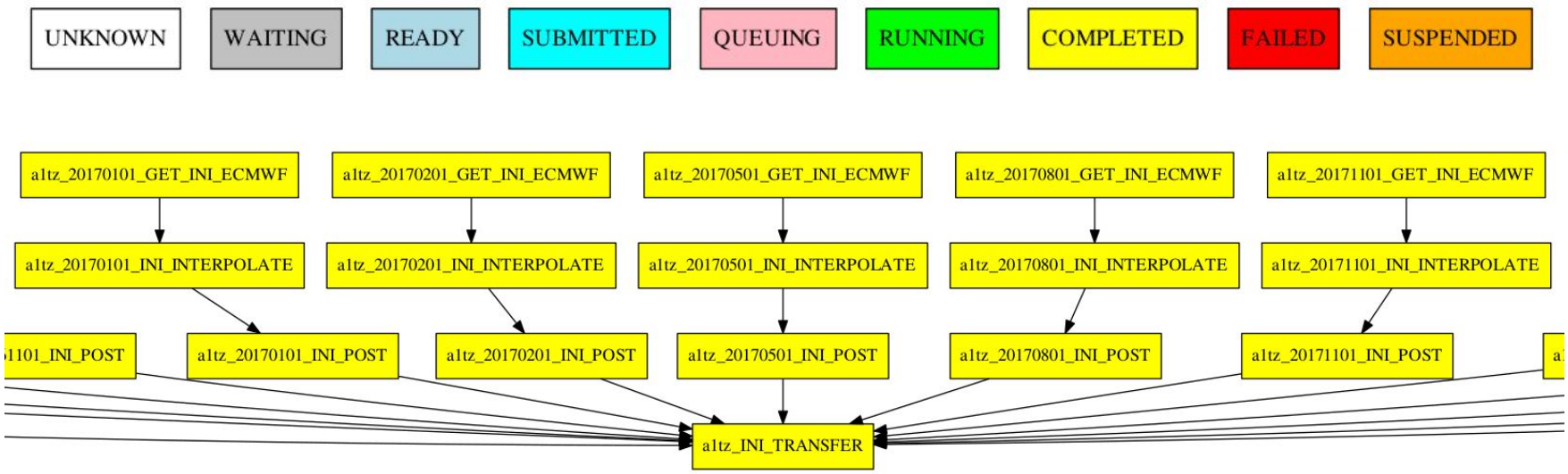
Initial data post-processing

- Performs post-processing such as:
  - Re-ordering the fields of the output GRIB files (replacing MARS get/put commands of the previous procedure)
  - Replace some land fields from the ERA-Land data
  - Perturb the 3D temperature field using Python (grib_api + random) for generation of additional members (used for seasonal prediction)
- Runs on a remote HPC machine (e.g. MareNostrum4 at BSC)
- Initial conditions data is ready to be used for IFS/OpenIFS
- Packaged in a .tar file compatible with the Autosubmit workflow manager for initializing EC-Earth historical/seasonal prediction experiments

Automation with Autosubmit

- Autosubmit is a python-based tool to create, manage and monitor experiments by using computing clusters, HPCs and supercomputers remotely via ssh
- It is an open source software developed by BSC and publicly available on the PyPI repository
- The three previous scripts are automated with Autosubmit to:
  - Minimize user intervention
  - Minimize errors
  - Optimize some processes

Automation with Autosubmit



Results

Initial conditions were created using ERA-Interim:

- For years 1979-2018 (last year available)
- Start of each calendar year (Jan 1st)
- Each seasonal prediction start date (Feb 1st / May 1st / Aug 1st / Nov 1st)
- At T255 resolution (a1tz) and T511 resolution (a1uc)
- ERA-Land conditions from existing experiments (gbg4, gbg6)

Results

Performance:

- Bottleneck in the get_inidata: can take from 5 minutes to one hour per start date, depending on MARS status, 24h sufficient to download entire ERA-Interim period with 5 dates/year
- Interpolation and post-processing take each < 1 minute per start date
- Using the Autosubmit workflow manager allows to do tasks in parallel: the interpolation and post-processing are done as soon as data is available for each start date
- Queuing times on MN4 much longer than computation times
- Improvements can be done by grouping several interpolation/post-processing tasks in one scheduler task

Results

Validation:

- Results were compared to ICs from those generated using prepIFS (b0q0, b0q2): very few differences were found
- Differences in climatology between 2 sets of ICs:
  - GG SFC fields: 100% identical
  - GG ML fields: differences < 1% in scarce grid points for cc and clwc
  - SH lnsp systematic differences < 0.00013243% , due to minor differences in orography
  - SH ML: {t, vo, d} small differences in scarce grid points, much smaller than observational errors, probably due to differences in compilers
- A seasonal prediction hindcast was done for all start years (1979-2018), and 4 start dates:
  - No instabilities were found
  - Results statistically similar to those initialized with ICs from prepIFS

Conclusions

- In the EC-Earth community there is a need to generate initial conditions to run climate prediction experiments
- The current procedure is not manageable for large periods and relies on ECMWF infrastructure
- To overcome these shortcomings, a framework to generate initial conditions for IFS/OpenIFS has been implemented being:
  - Portable across other HPC platforms rather than ECMWF
  - Easy to use
  - Uses OpenIFS to interpolate reanalysis data
  - Interpolations are fast, including configuration T1279L137
  - Results have almost no differences between the two procedures
  - Everything is automated with Autosubmit

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EXCELENCIA SEVERO OCHOA

Thank you

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