

# CMIP6 production at IPSL : a 5-year story

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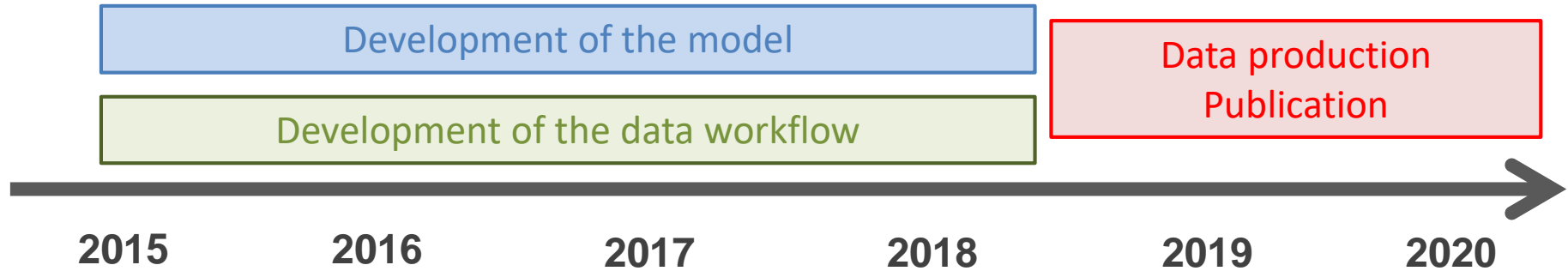
*September, 24<sup>th</sup> 2020, Workshop on Coupling Technologies for Earth System Models*

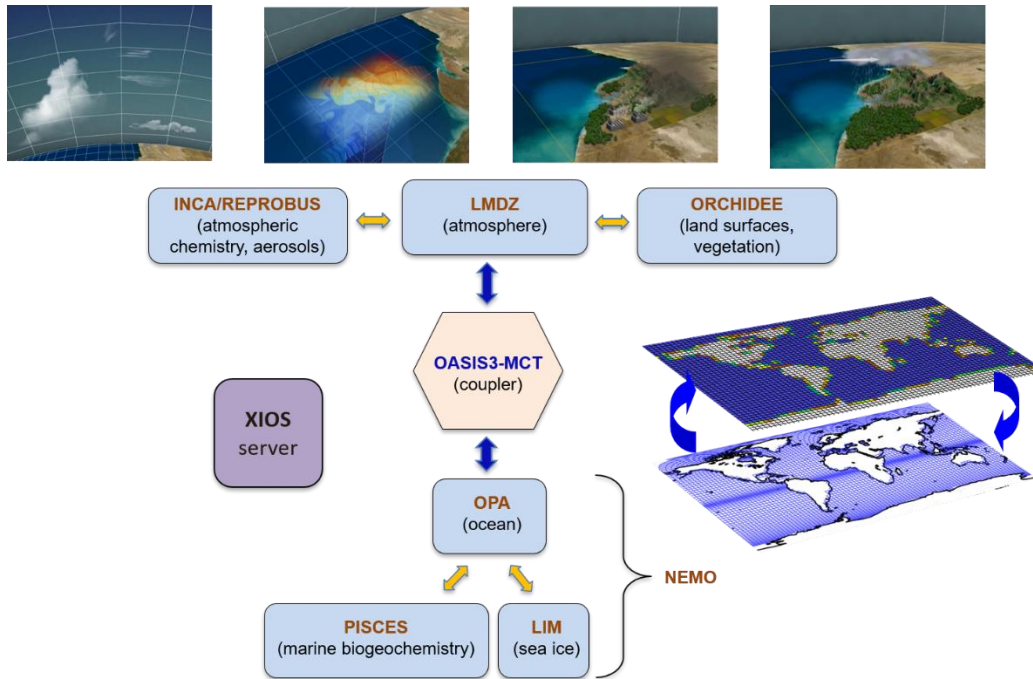
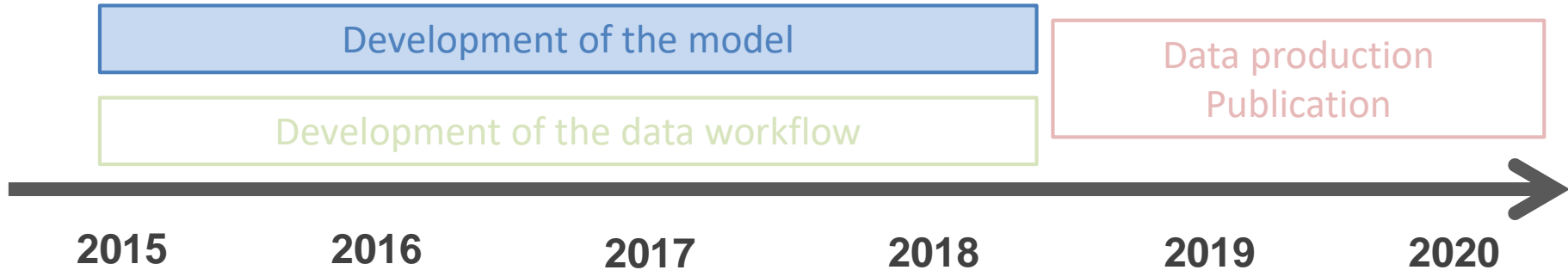


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# CMIP6 production at IPSL : a 5-year story





## IPSL-CM6A-LR : “ the standard version”

- ✚ LMDZ : Atmosphere 200 km, lon-lat grid
- ✚ ORCHIDEE : Land Surface 200 km
- ✚ NEMO : Ocean 100 km
- ✚ LIM3 : Seaice 100 km
- ✚ PISCES : Biogeochemistry 100 km
- ✚ INCA : aerosols, atmospheric chemistry
- ✚ OASIS3-MCT : ocean-atmosphere coupler
- ✚ XIOS : Input/Output server
- ✚ MPMD mode
  - ✚ Atmosphere : Hybrid parallelization MPI + OpenMP
  - ✚ Ocean : MPI only
  - ✚ XIOS server : MPI only



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# Development of the model : 25 releases over 3 years

Summer 2015, First long runs :

- Numerical stabilisation within boundary layer.
- Convect. Stochastic triggering.
- Strato-cus with thermics
- Ice Microphysique
- Non orog. Waves → QBO
- L39 → L79

Clouds-convexion  
iflag\_mix=1  
iflag\_coud\_vert=1

RRTM  
+fist  
+lmix

New z0  
overocéans  
Conserv E.1

Orography  
Tuning param  
+ Acceleration x2

Convection

- conditionné by freezing point
- density of cold pocket diff. O/A
- ajustement w base convection
- gust → z0 oceanic Conserv. E.2

IPSLCM6.0.1

IPSLCM6.0.2

IPSLCM6.0.3

IPSLCM6.0.4

IPSLCM6.0.5

IPSLCM6.0.6

IPSLCM6.0.7

IPSLCM6.0.8

IPSLCM6.0.9

IPSLCM6.0.10

Summer 2015

Summer 2016

Spring 2017

New Tmix

Routing

Calving

Routing

Code enhancement

Testing parameters

Bug fixes

Sea ice parameters  
Snow conductivity  
lmixmin  
amaxn  
amaxs  
hstar

Snow temperature (SST->Tice)  
Weighted Rain temperature

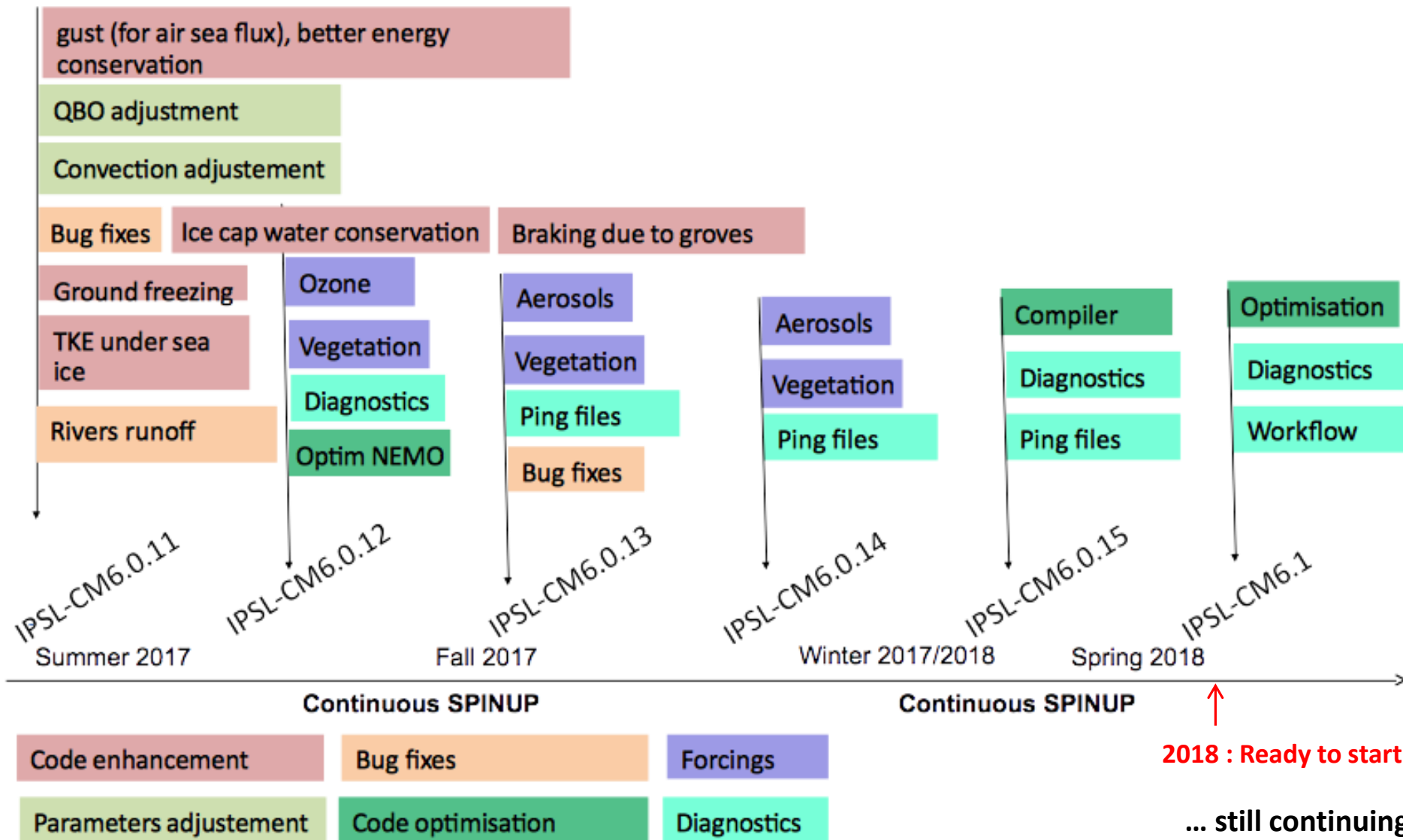
Sea ice parameters  
albedo  
amaxn  
amaxs  
pstar



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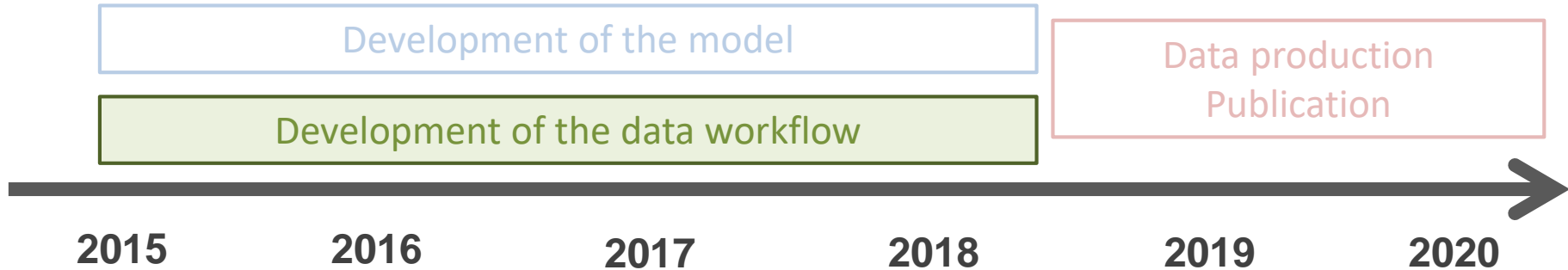
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# Development of the model : 25 releases over 3 years



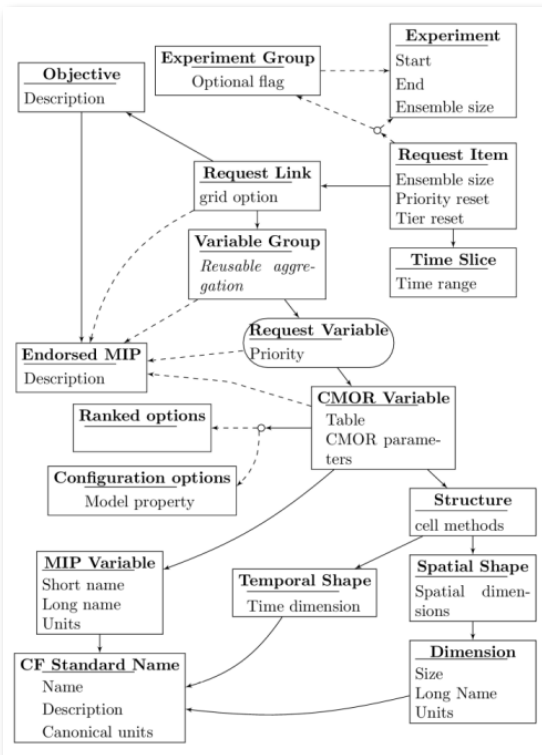
IPSLCM6.1.11 in September 2020

# Development of the data workflow



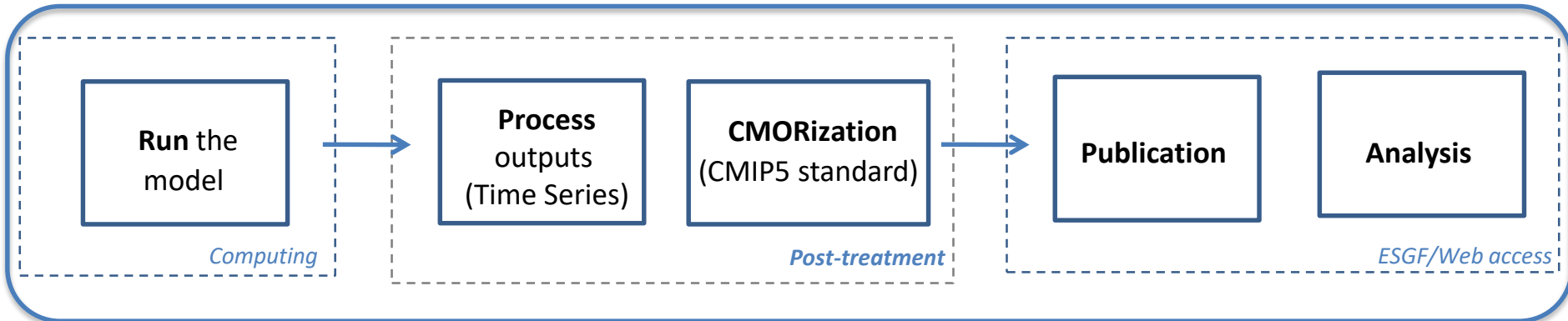
## The challenging CMIP6 Data Request

- What ? Required specific variables directly given by the model or to be processed from model variable : vertical interpolation (pressure levels), sites, ...
- When ? Specifies variables (and sampling) needed for each experiments with high variability : from one experiment to the other, from one simulated year to the next one, from a modelling group to an other depending on the MIPs it is engaged in,...
- How ? Requires a specific format for the data to be published : name of the variable, name of the file, file attributes, variables attributes,...

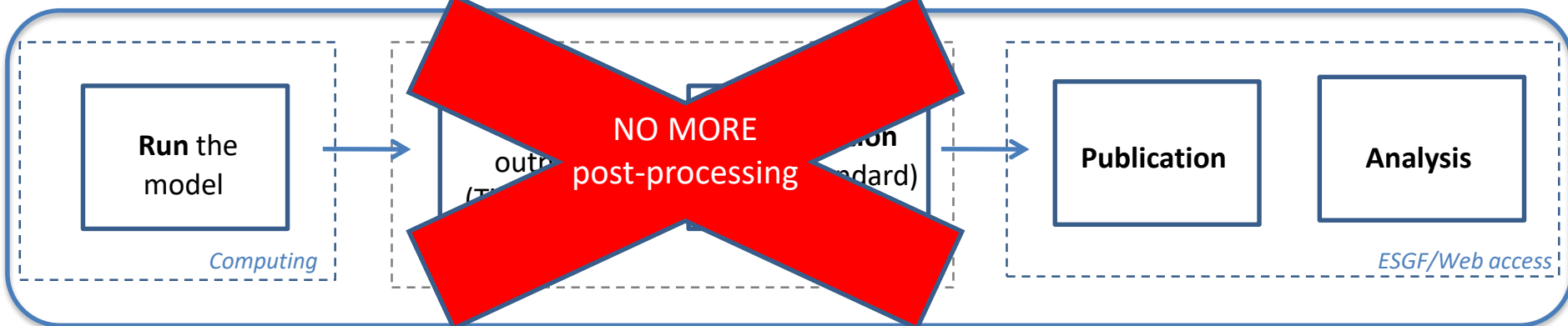


# Development of the data workflow

## *CMIP5 workflow (bad memories, traumas,...)*



## *CMIP6 workflow*



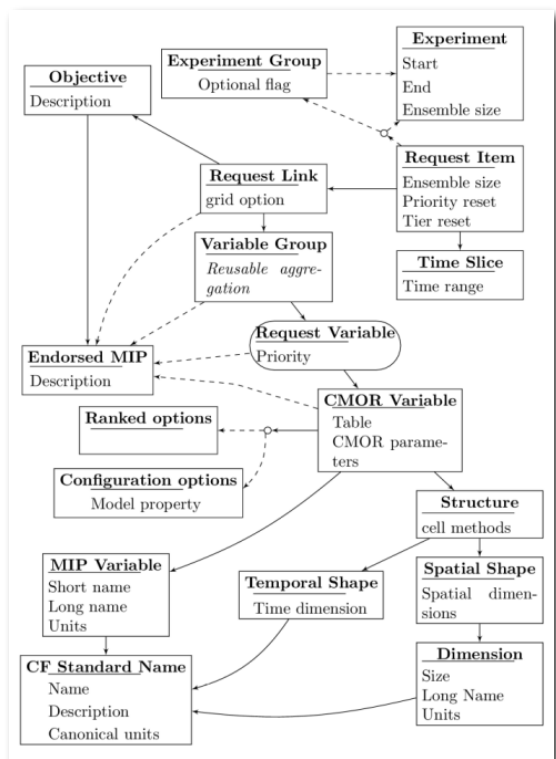




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# Development of the data workflow



Tool for translating a CMIP  
Data Request to publishable  
datafiles using XIOS



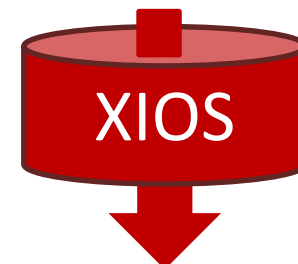
Developed at CNRM

```

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  <variable name="source_id" type="string"> ipsl-cm6p6@ipses.ipsl.fr </variable>
  <variable name="data_specs_version" type="string"> 01.00.21 </variable>
  <variable name="dr2xml_version" type="string"> 1.3 </variable>
  <variable name="experiment_id" type="string"> CMIP6 historical </variable>
  <variable name="description" type="string"> CMIP6 historical </variable>
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  <variable name="experiment" type="string"> all-forcing simulation of the recent past </variable>
  <variable name="external_variables" type="string"> areacella </variable>
  <variable name="frequency" type="string"> 3hrPt </variable>
  <variable name="further_info_url" type="string"> https://furtherinfo.es-doc.org/CMIP6.IPSL </variable>
  <variable name="grid" type="string"> LMDZ grid </variable>
  <variable name="grid_label" type="string"> gr </variable>
  <variable name="nominal_resolution" type="string"> 250 km </variable>
  <variable name="history" type="string"> none </variable>
  <variable name="initialization_index" type="int"> 1 </variable>
  <variable name="institution_id" type="string"> IPSL </variable>
  <variable name="institution" type="string"> Institut Pierre Simon Laplace, Paris 75252, F </variable>
  <variable name="license" type="string"> CMIP6 model data produced by IPSL is licensed unde </variable>
  <variable name="mip_era" type="string"> CMIP6 </variable>
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  <variable name="parent_variant_label" type="string"> r3i1p1f1 </variable>
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  <variable name="branch_time_in_child" type="double"> 0.00 </variable>
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  <variable name="product" type="string"> model-output </variable>
  <variable name="realization_index" type="int"> 3 </variable>
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  <variable name="variant_label" type="string"> r3i1p1f1 </variable>
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## XIOS

- publication ready data files thanks to workflow in-situ functionalities
  - CF and CMIP6 compliant
  - Units rescaling
  - Time integration (averaging, minimum, maximum)
  - Vertical interpolation on pressure levels
  - Horizontal remapping (ex : NEMO grid to regular grid, Icosaedral grid to regular grid)
  - Transects (flux across ocean straight)
- asynchronous parallel writing in server mode

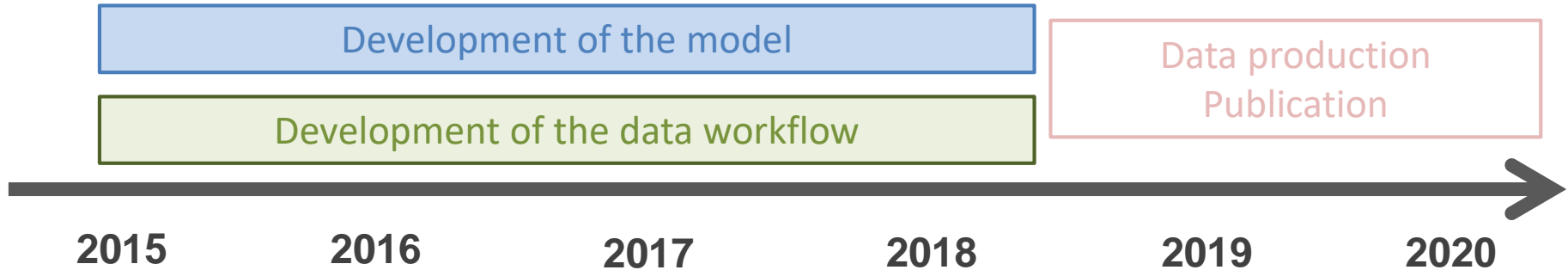


Developed at IPSL

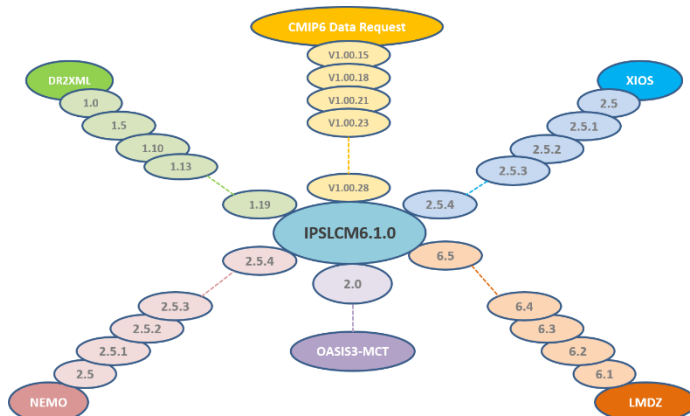
CMIP6-publication-ready data files



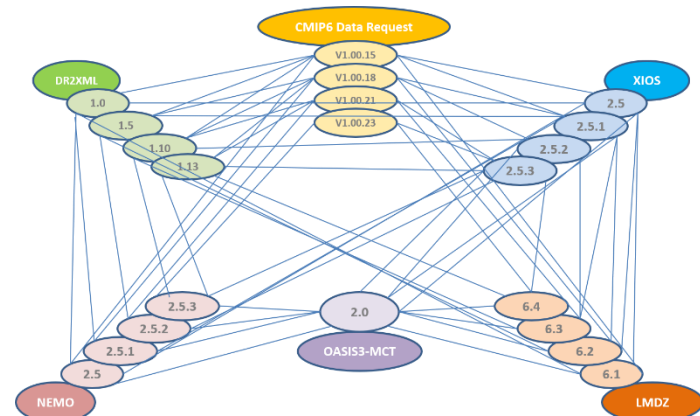
# Assembling model and workflow



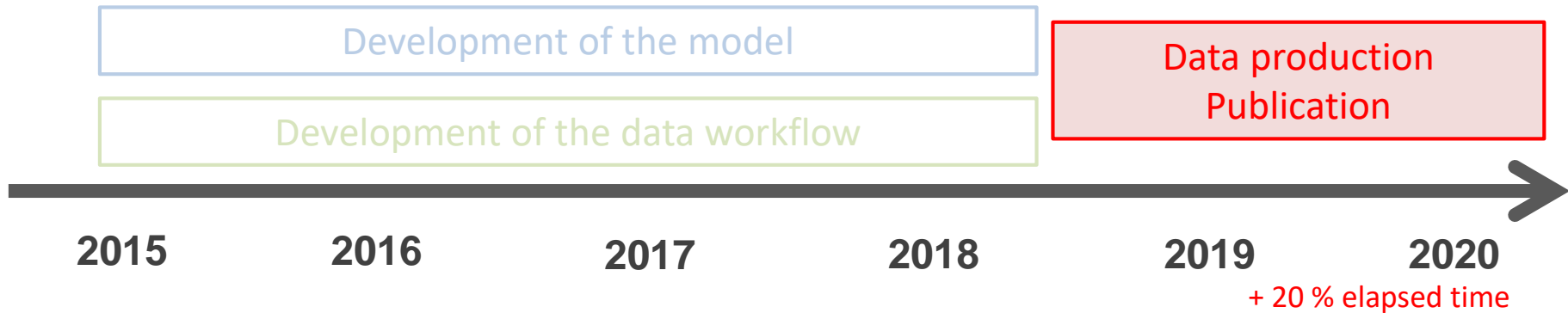
- ✚ Many tools evolved simultaneously = not easy to assemble Data Request, dr2xml, XIOS, NEMO, LMDZ, Oasis3-MCT into 25 releases
- ✚ A rigorous quality control was needed to validate each release
  - ✚ Technical validation : basic quality tests on short simulation, reproducibility tests during production phase (on the same machine)
  - ✚ Scientific validation : long simulation in development phase (and also to validate the use of a new machine)



Evolution of components during development phase



Assembling of components during development phase



## IPSL-CM6A-LR : “ the standard version”

- ✦ Atmosphere 200 km, Ocean 100 km
- ✦ Lon-lat atmospheric grid

## IPSL-CM6A-INCA-LR (Interactive aerosols)

## IPSL-CM5A2-INCA (Atmospheric chemistry)

- ✦ Atmosphere 300 km, Ocean 200 km

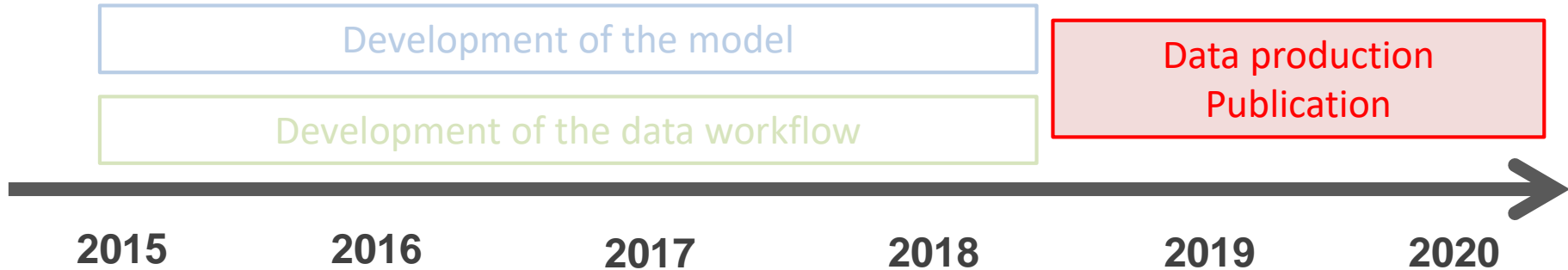
## IPSL-CM6A-ATM-HR (High resolution)

- ✦ Atmosphere 50 km, lon-lat grid

## IPSL-CM7A-ATM-HR

- ✦ DYNAMICO icosaedric grid 50km (and 25 km soon)

	No IO	IOs CMIP6
<b>IPSL-CM6A-LR</b> <ul style="list-style-type: none"> <li>✦ Lon-lat grid</li> <li>✦ Atmosphere 200 km</li> <li>✦ Ocean 100 km</li> </ul>	<b>23 SYPD</b> 928 cores	<b>19 SYPD</b> 940 cores (928 + 12 XIOS servers)
<b>IPSL-CM5A2-INCA</b> <ul style="list-style-type: none"> <li>✦ Lon-lat grid</li> <li>✦ Atmospheric chemistry</li> <li>✦ Atmosphere 300 km</li> <li>✦ Ocean 200 km</li> </ul>	<b>13 SYPD</b> 609 cores	<b>11 SYPD</b> 621 cores (609 + 12 XIOS servers)
<b>IPSL-CM7A-ATM-HR</b> <ul style="list-style-type: none"> <li>✦ DYNAMICO icosaedric grid, 50km</li> <li>✦ Data output both on native and regular grid</li> </ul>	<b>8 SYPD</b> 2560 cores	<b>6 SYPD</b> 2848 cores (2560 + 12 XIOS servers, 24 cores/XIOS server)

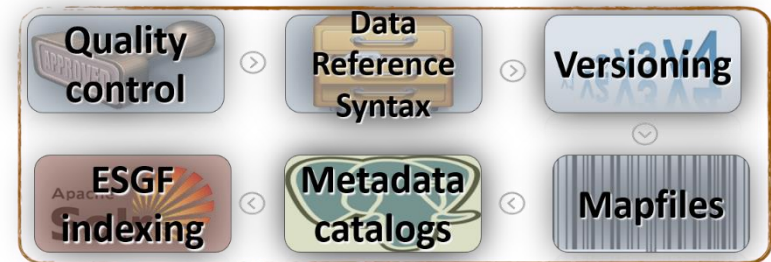


## CMIP6 production at IPSL

- ✚ 28 MIPs, 228 experiments, 850 simulations
- ✚ 55 000 years of simulation performed
- ✚ 20 logins (means different users) for the production campaign
- ✚ 200 logins for the climate model development and CMIP6 analysis
- ✚ in average 20 000 cores, with peak at 80 000 cores (one week at the end of Curie)
- ✚ ~400 millions computing hours (development + production) on TGCC (Curie Intel SandyBridge, Irene Intel Skylake, Irene AMD Rome)
- ✚ 4 Pb of data produced

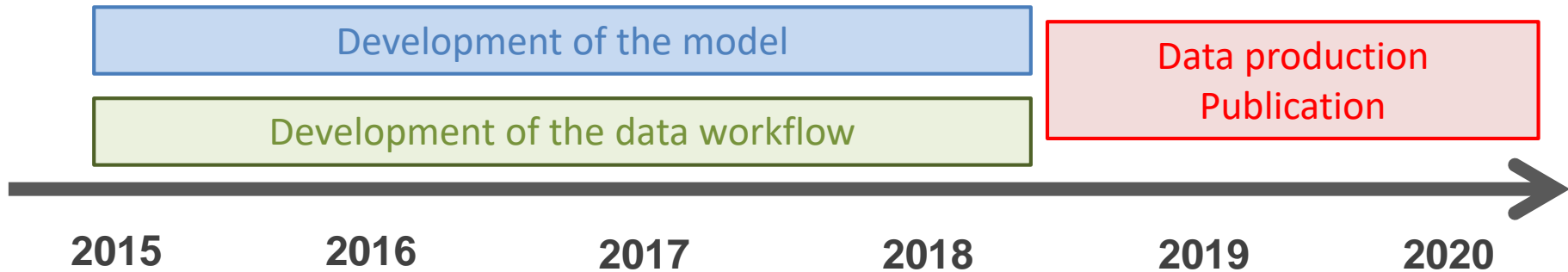
## CMIP6 publication at IPSL

### Publication process



- ✚ 1st group to publish CMIP6 datasets (2018-07-17T18:17:18.913Z)
- ✚ 655 488 datasets published = 1.2 Pb

# Conclusion



- ✚ CMIP6 exercise at IPSL was a scientific, technical and human challenge
- ✚ Production on the fly of data ready to publication
  - ✚ work to do in development phase to set up the workflow
  - ✚ nothing to do in post-treatment step
- ✚ CMIP6 production is still in progress : HighResMIP 25 km,...
- ✚ Special Collection of articles in the JAMES AGU journal (2019/2020)

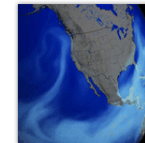
## JAMES | Journal of Advances in Modeling Earth Systems

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### The IPSL Climate Model Used in CMIP6

Earth System Modeling 2018-2020 | First published: 30 December 2019 | Last updated: 11 September 2020



This special collection presents the French IPSL-CM6A-LR which have been developed, tested, evaluated, and used for the sixth phase of the Coupled Model Intercomparison Project (CMIP6). This collection will include manuscripts that provide a description of the atmospheric component, the development process of the climate model, the climate model itself, and the implementation of the boundary conditions. It will also present the first analyses of the simulated climate and its response to natural and anthropogenic forcings.



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**Thank you !**