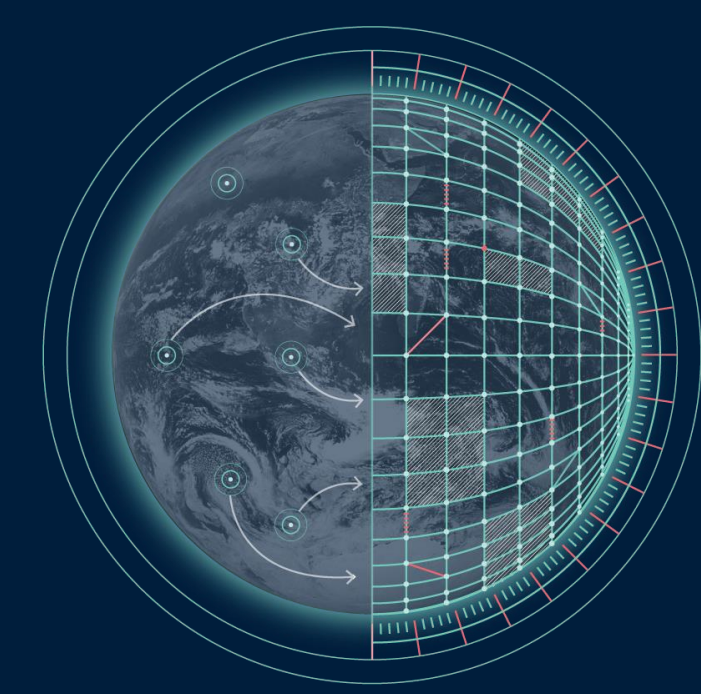


# Bringing the Destination Earth Continuous Extremes Digital Twin to Operations



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## 1. Introduction

A fundamental part of the Destination Earth project is the deployment of the Continuous Extremes Digital Twin (DT) to operations on EuroHPC infrastructure, underpinned by ECMWF's Integrated Forecasting System (IFS) earth system model.

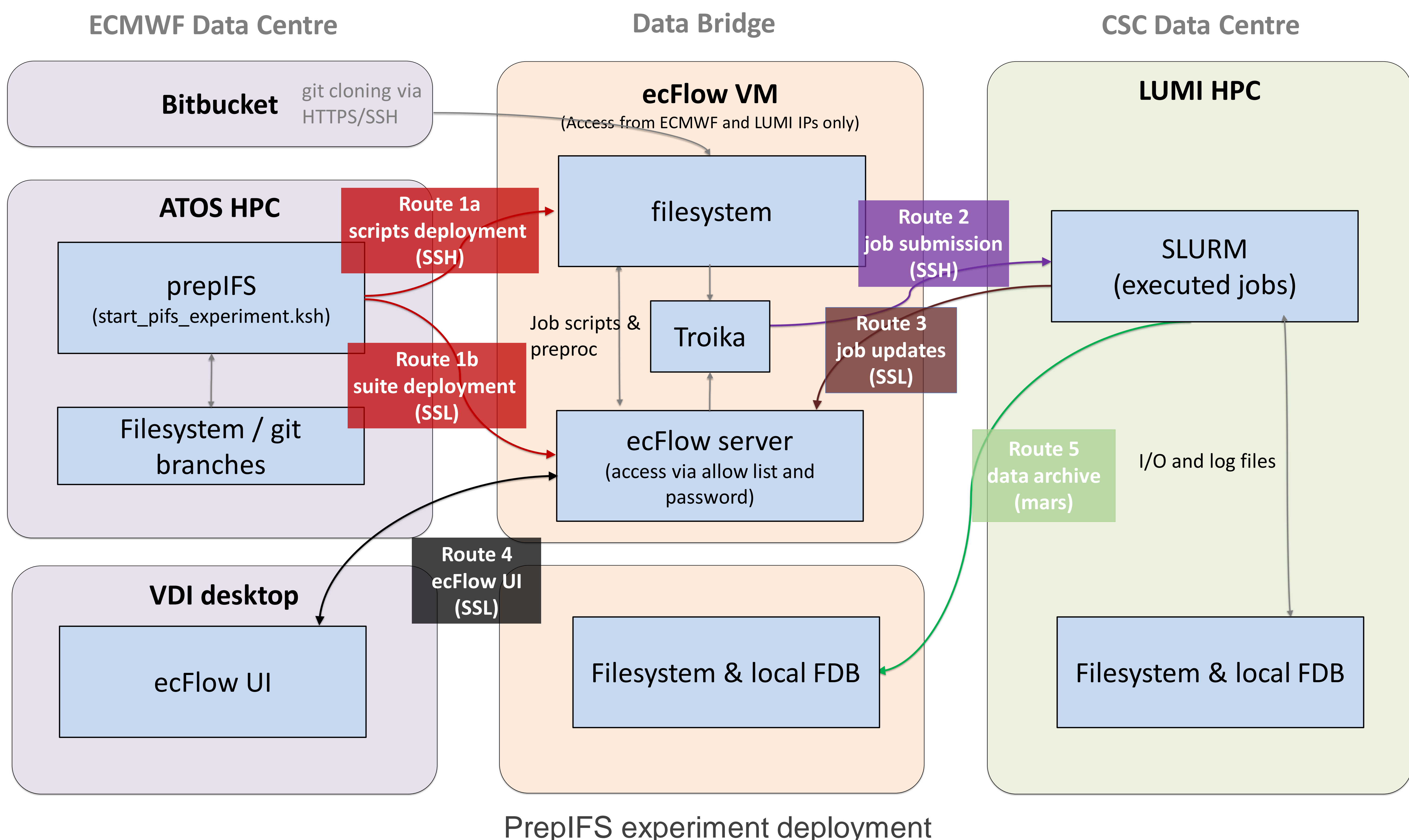
Our goals include:

- Continuous run of an operational suite taking in latest initial conditions from ECMWF's IFS analysis
- Leveraging the latest scientific additions to the ECMWF Destination Earth development
- Preparing a framework to enable researchers to submit configurable forecast experiments
- Dissemination of IFS model results to Data Bridge
- Supporting continuous development and integration (CD/CI) of the consortia contributions to all the Destination Earth DTs

## 2. Technical considerations

To achieve the stated goals, several technical tasks had to be completed:

- Deployment of ECMWF's workflow management servers (ecFlow)
- Adaptation of the submission tool used at the ECMWF (troika)
- Definition of configurations to target different EuroHPCs
- Adaptation of submission workflow and software (prepIFS)
- Integration of ECMWF analysis and IFS forecast run on EuroHPC
- Adaptation of IFS to GPU architectures
- Deployment of a software stack for each EuroHPC supporting prepIFS experiments
- Building the infrastructure to allow data transfers between EuroHPC and Data Bridge



## 3. Environment

One of the main tasks which leads us to a position where we can deploy a successful prepIFS experiment outside the ECMWF was to prepare an environment capable of compiling the IFS source code and running the IFS job scripts which form its core.

- Installing shell at user space: ksh93
- Installing modules using EasyBuild: ecFlow, eclib...
- Deploying legacy software: pmkdir, banner...
- Installing libraries with compatible interfaces: Boost (python)
- Defining module aliases for compatibility: hdf5, netcdf, python3
- Deploying shell scripts and functions: pifsenv
- Fixing library issues: libtirpc
- Deploying ECMWF software: ecmwf toolbox
- Deploying wrappers for ECMWF archiving commands: ecp, echmod, eumask
- Introducing workarounds: ecFlow client
- Identifying static files and deploying them on EuroHPC file systems
- Adapting input/output to write to the EuroHPC file systems and transfer data in the desired format to the Data Bridge

## 5. Workflow

A prepIFS experiment starts with its setup on ECMWF Data Centre. The setup deploys the experiment on the ecFlow server which submits jobs to the HPC which write data to the file systems of the HPC and the Data Bridge where they are prepared for dissemination.

**Data and workflow routes:**

- 1a. After configuration, the experiment job files are uploaded to the ecFlow server.
- 1b. PrepIFS deploys an ecFlow suite and commands it to start.
2. The ecFlow server submits jobs to the HPC using Troika.
3. HPC jobs use ecFlow client to update the state of the ecFlow server.
4. ecFlow UI is used to visualise the status of an experiment and interact with it - tweaking configuration and job control.
5. Output fields are written to the local FDB (Fields Data Base) on the HPC, with selected data also written to the Data Bridge FDB using a MARS client.

## 6. Future work

Our first steps have been setting a framework to run prepIFS experiments on EuroHPC and particularly, LUMI. Next, we will target other HPCs like Leonardo, Meluxina, ...



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