Overview of Computing Services

Introduction to ECMWF Computing Services Training week 2025

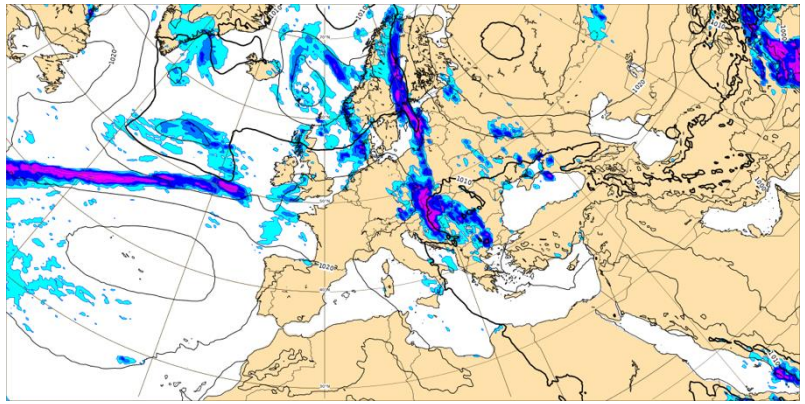
Daniel Varela

ECMWF - User Services - Computing and Software Support team

ECMWF

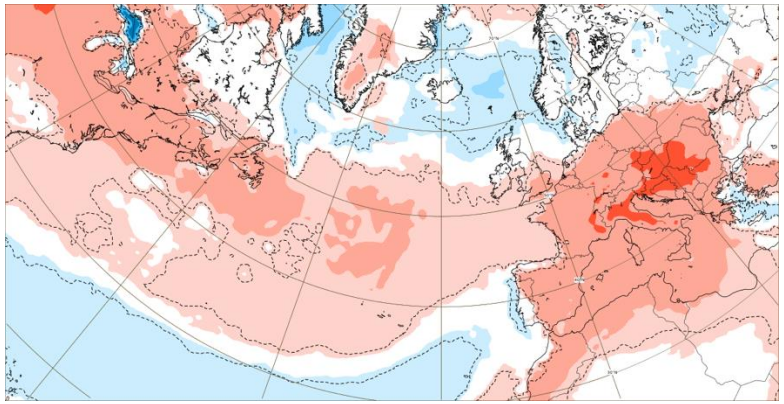
ECMWF operational forecasting system

Medium range: up to 2 weeks



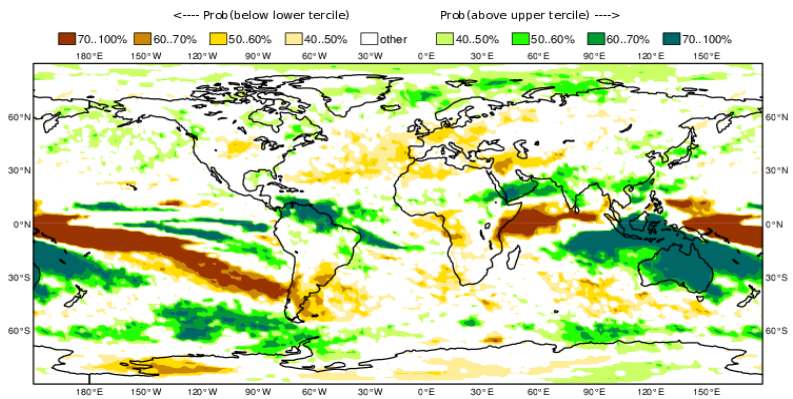
- ~9 km and 137 levels (T_{CO}1279 / O1280 / L137)
- CTRL (former HRES):
  to T+240h at 00 and 12 UTC
  to T+90h at 06 and 18 UTC – “BC run”
- ENS: 50+1 members
  to T+360h at 00 and 12 UTC
  to T+144 at 06 and 18 UTC

Extended range: up to 6 weeks



- ~36 km and 137 levels (T_{CO}319 / O320 / L137)
- 100+1 members
- To 46 days (T+1104h) at 00 UTC every day

Seasonal range: up to 7 months



- ~36 km and 91 levels (T_{CO}319 / O320 / L91)
- 50+1 members
- Once per month to 7 months ahead
- A sub-set of 15 members is run to 13 months ahead every quarter (Feb / May / Aug / Nov)
- 30 years of hindcasts

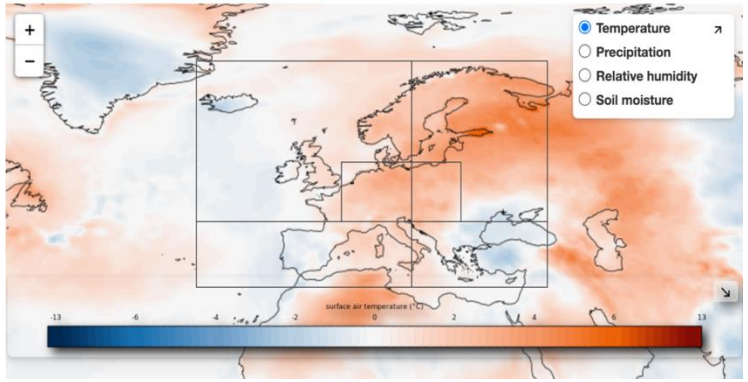
Ocean Waves

- WAM-HRES: ~14km coupled with HRES
- WAM-ENS: 50+1 members, ~14km coupled with ENS
- WAM-ENS-extended: 100+1 members, ~55km
- WAM-SEAS: 50+1 members, ~55km

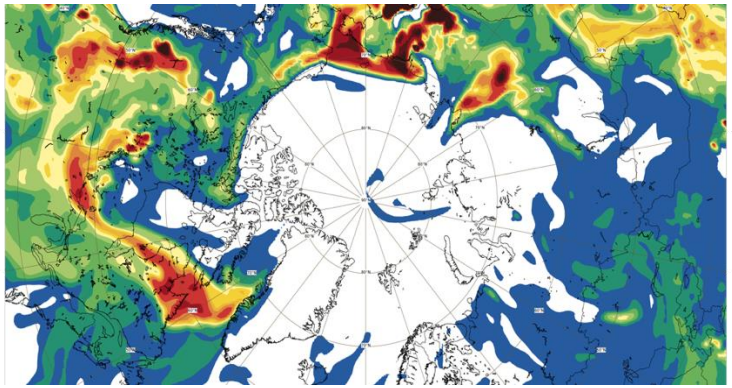
Environmental modelling products

- Copernicus Climate Change Service – C3S
- Copernicus Atmosphere Monitoring Service – CAMS
- Copernicus Emergency Management Service - CEMS

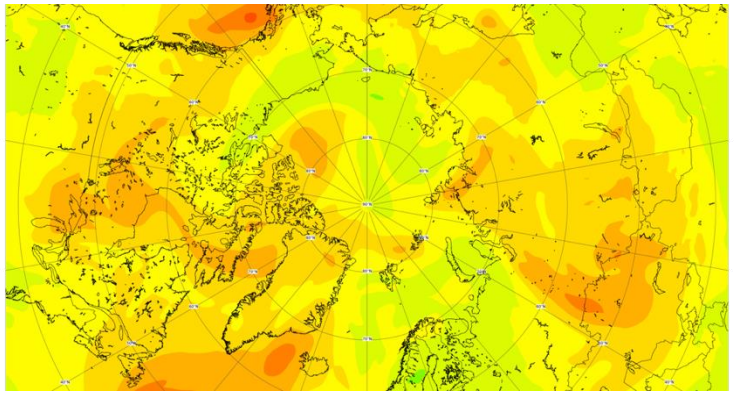
Monthly Copernicus climate monitoring



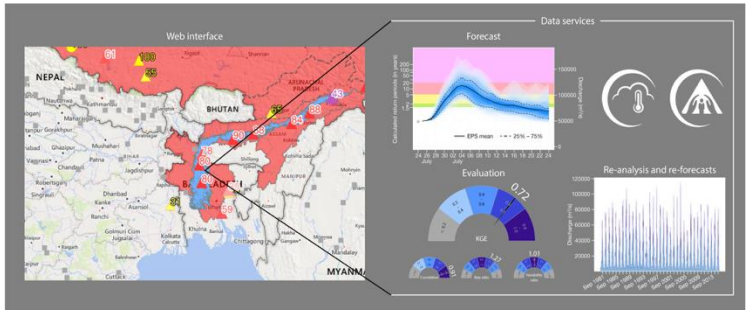
Carbon monoxide forecast



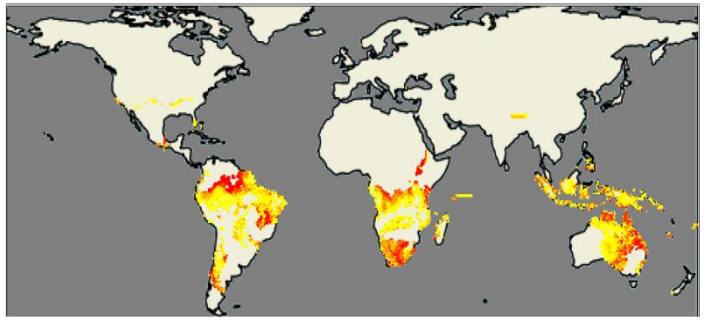
Ozone forecast



Using NWP to drive hydrological global forecasts



Probability of ignition by lightning 2016-02-01



Artificial Intelligence Forecasting System

Utilising the grid-flexibility and parameter efficiency of Graph Neural Networks

25 February 2025: AIFS Single v1

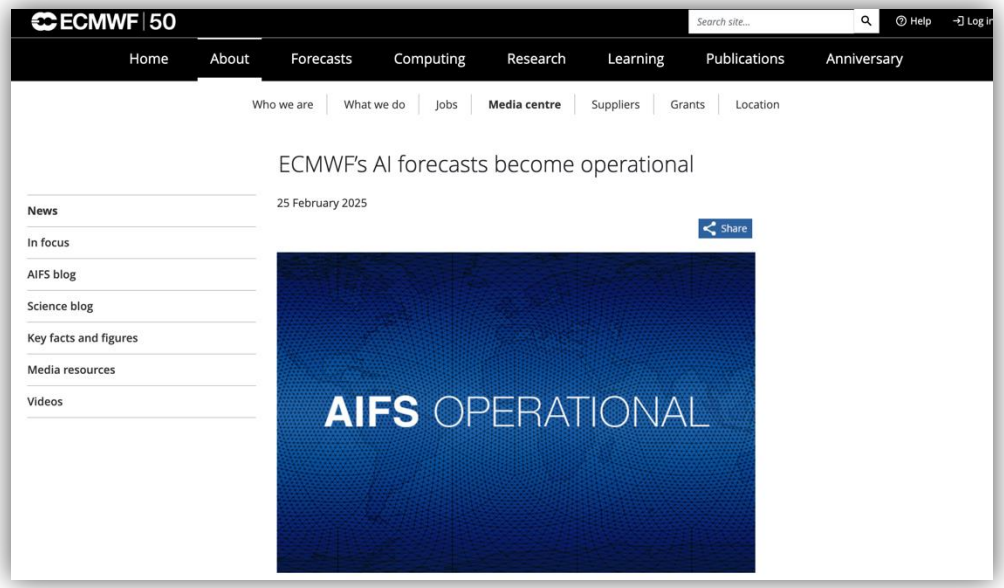
- The first **operational** ML weather forecasting model
- Generates a single forecast
- Includes tropical cyclone track forecasts

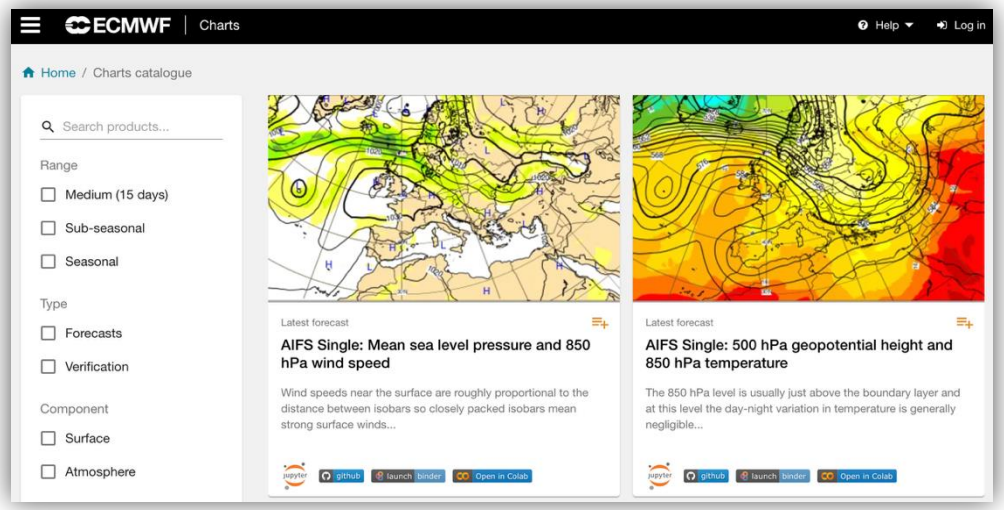
1 July 2025: AIFS ENS v1

- Generates ensemble forecasts (50 perturbed members)
- Optimises the Continuous Ranked Probability Score (CRPS) loss function

Both models:

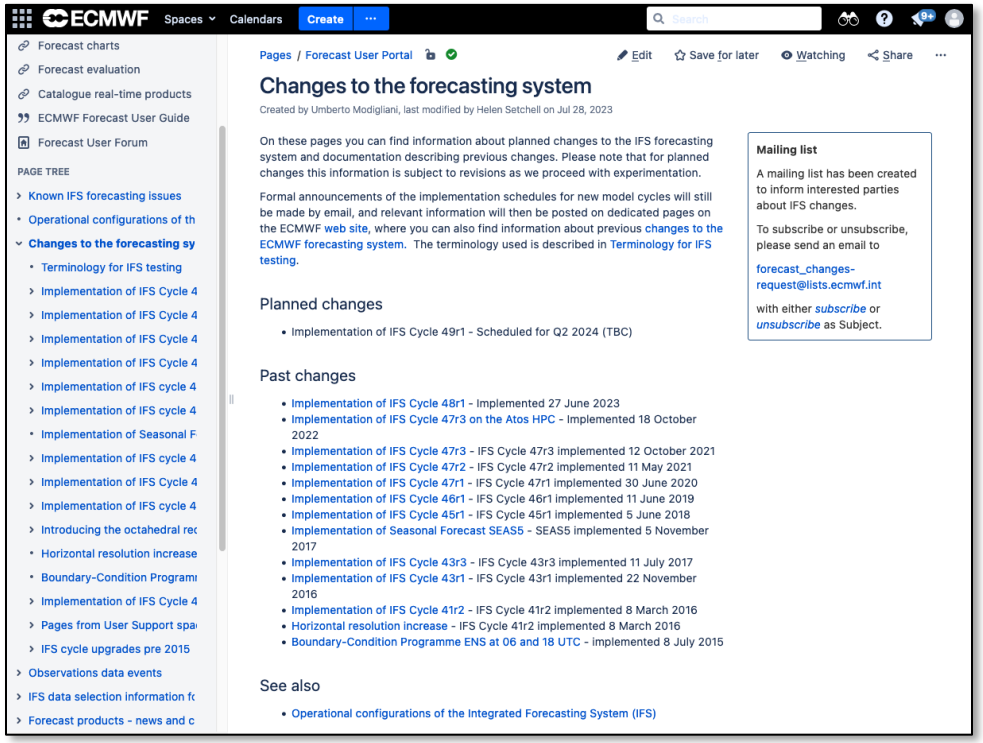
- ~31 km (N320 / 0.25°)
- Parameters on surface, pressure and soil layers
- Graphical, historical and real-time products available

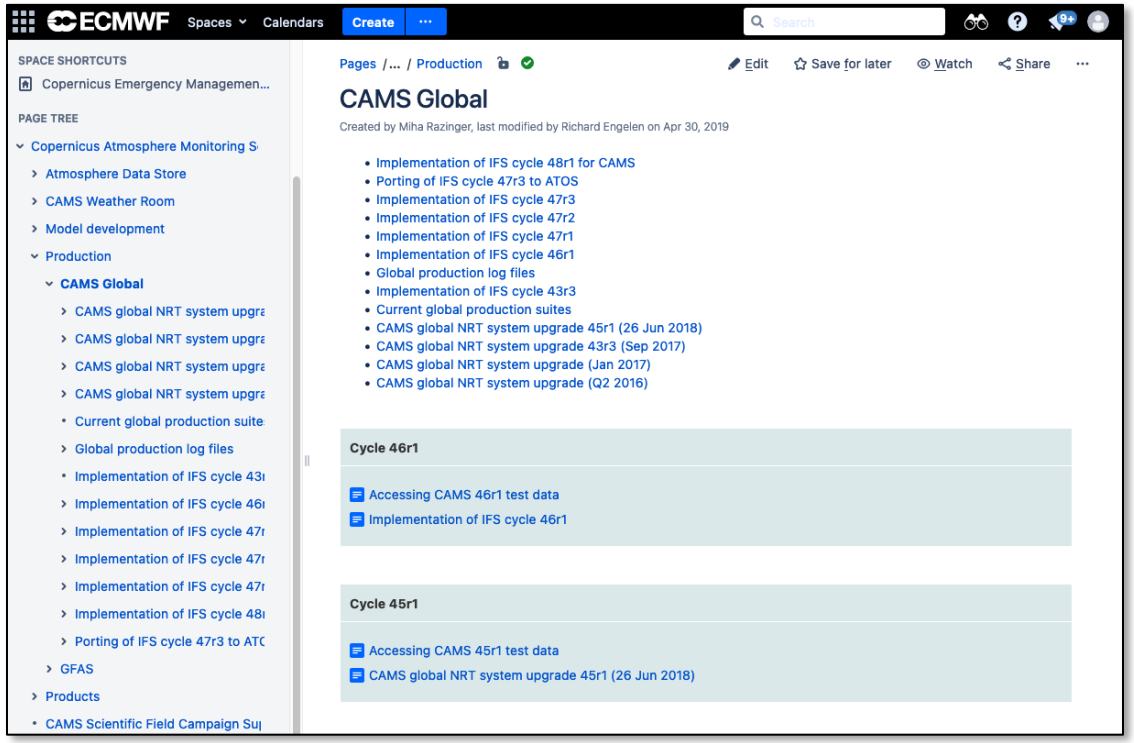




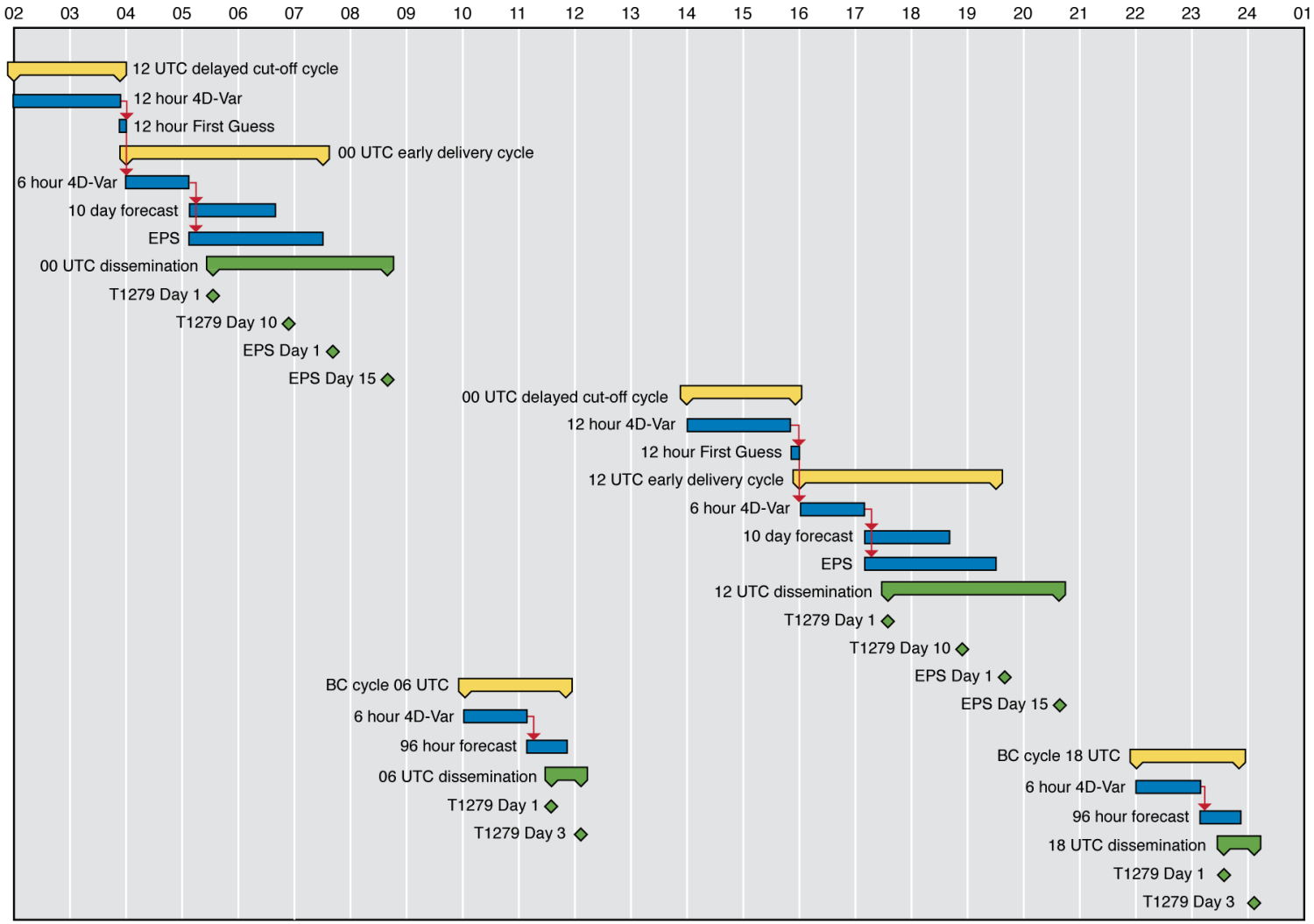
Changes to the operational forecast systems

- ECMWF operational forecasts
  - https://confluence.ecmwf.int/display/FCST/Changes+to+the+forecasting+system
- CAMS global forecasts
  - https://confluence.ecmwf.int/display/COPSRV/CAMS+Global

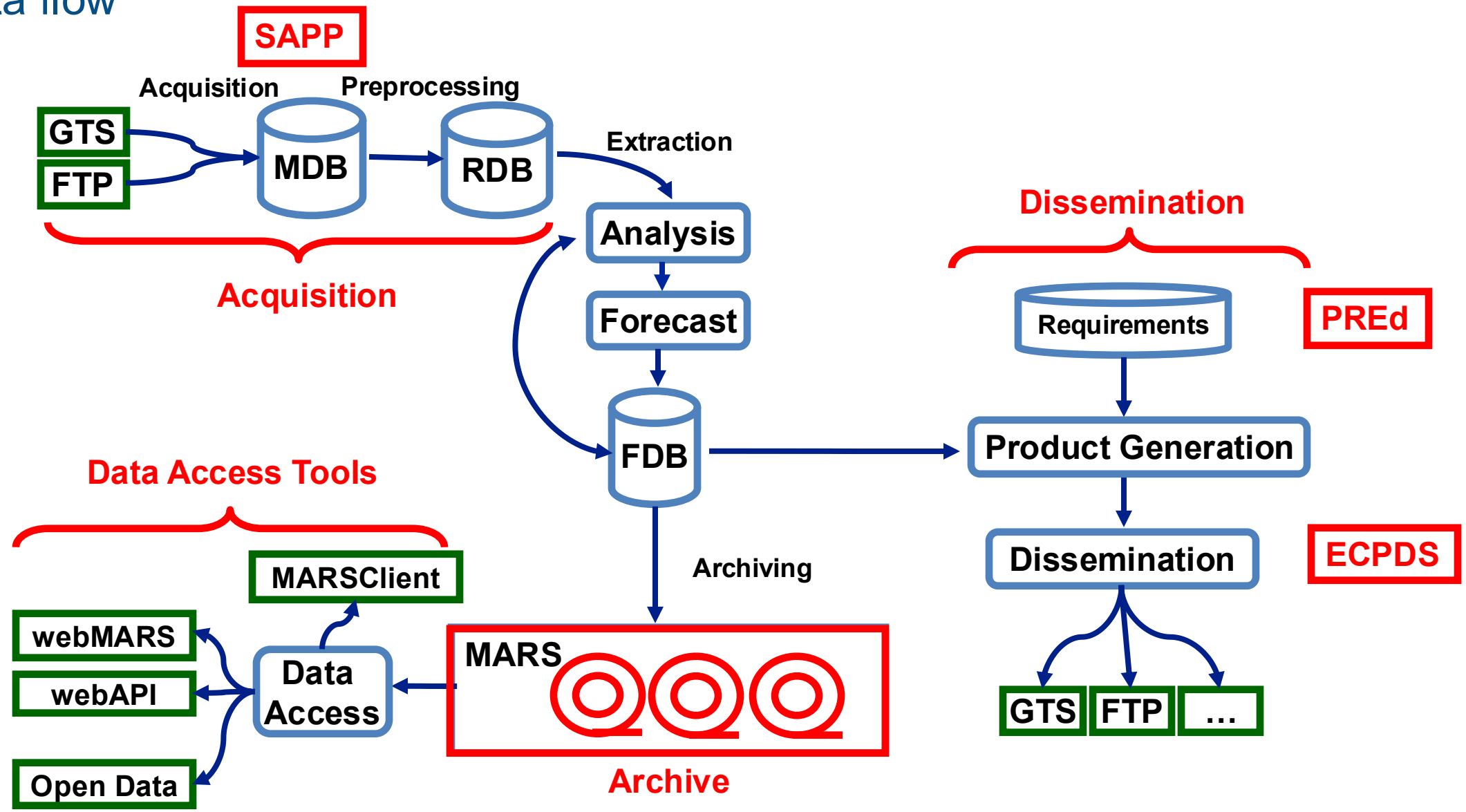




The main operational suites on ECMWF's HPCF



Data flow


SAPP
Acquisition
Preprocessing
GTS
FTP
MDB
RDB
Extraction
Acquisition
Analysis
Forecast
FDB
Dissemination
Requirements
PREd
Product Generation
Dissemination
ECPDS
GTS
FTP
...
Data Access Tools
MARSClient
webMARS
webAPI
Open Data
Data Access
Archiving
MARS
Archive

Computing Services

The Atos HPC Facility

- 4 Atos complexes (AA, AB, AC, AD)
  - HPC
  - ECS
- For serial and parallel workloads
- Slurm batch system (sbatch, squeue, scancel)
- Multiple storage options for different needs
  - HOME, PERM, HPCPERM, SCRATCH
- Software environment via modules

Atos Sequana XH2000	
Clusters (AA, AB, AC, AD)	4
Total number of compute nodes	7,680
Total number of GPIL nodes	448
Processor type	AMD EPYC Rome
Cores	64 cores / socket 128 cores / node
Base frequency	2.25 GHz (compute) 2.5 GHz (GPIL)
Memory/node	256 GiB (compute) 512 GiB (GPIL)
Total memory	2.1 PiB
Total number of cores	1,040,384
Operational storage - SSD	1.3 PiB
Operational storage - HDD	12 PiB
Research storage	77 PiB

HPFC – purpose

Batch submission
- Slurm
- ECaccess Tools
- ecinteractive

Time-critical applications
- Option 1
- Option 2
- Option 3

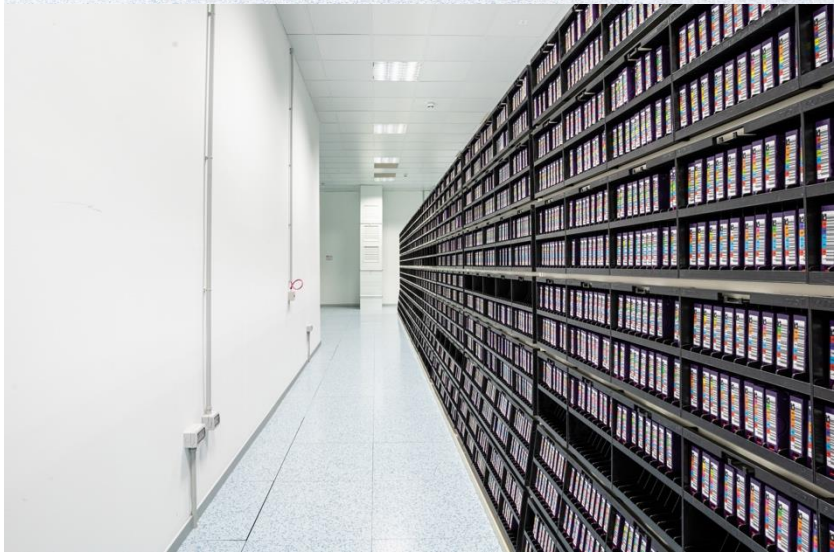
Access to archives
- MARS
- ECFS

Data transfer
- ftp / sftp
- ectrans

Running meteorological models
- Member State models
- ECMWF's IFS

Data Handling System

Disk Cache Storage	Capacity/Tape	
IBM Storage Array Systems	~50 PB	
Libraries Primary Copy	**#Drives 1160**	**#Drives 1170**
8 x IBM TS4500 Enterprise	336	48
1x Spectra – Tinfinity Enterprise	60	0
Tapes Primary Copy	**Capacity/Tape**	**#Tapes**
JE1160	20 TB	42427
JE1170	50 TB	514
Totals		**42941**
Libraries Secondary Copy	**#LTO**	
2 x IBM TS4500 LTO	64	
Tapes Secondary Copy	**Capacity/Tape**	**#Tapes**
LTO-7	6 TB	338
LTO-7(M8)	8 TB	6420
LTO-8	12 TB	13033
LTO-9	18 TB	4589
Totals		**24380**

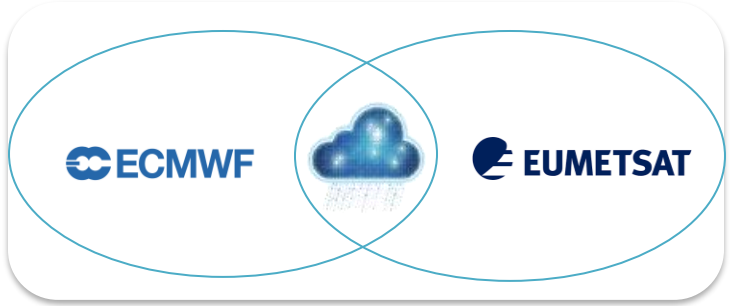


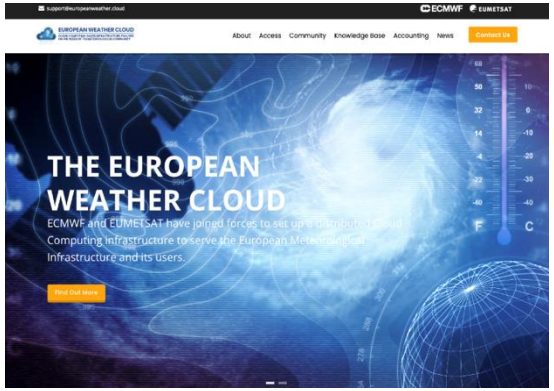
Data Handling Services

- MARS – Meteorological Archive and Retrieval System
  - Data is accessed via a meteorological meta-language interface
  - Bulk of the data, few files (but holding billions of fields in total)
  - Relies upon excellent tape drive performance when retrieving lots of small parcels of data from tape
- ECFS – ECMWF File System
  - HSM-like (Hierarchical Storage Management) service for “ad-hoc” files that are not suitable for storing in MARS
  - Data is accessed via an rcp-like interface
  - Millions of files, many very small
- HPSS – High-Performance Storage System
  - Both MARS and ECFS rely on HPSS as the underlying data management system that is used to store the data
  - Users do not have direct access to HPSS, only via MARS and ECFS

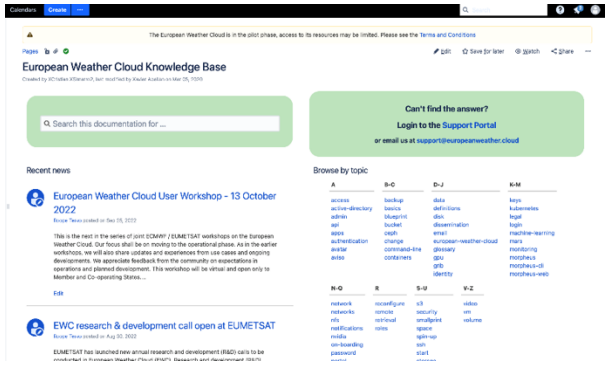
European Weather Cloud

- Pilot project started in 2019 by ECMWF and EUMETSAT
- Operational since 26 September 2023

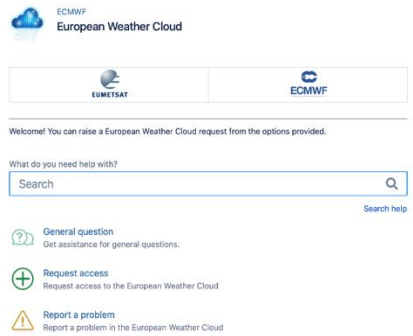




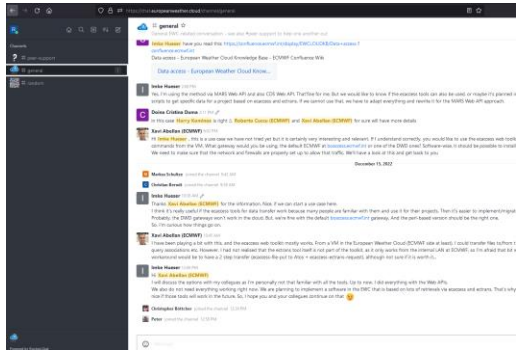
[Main Website]



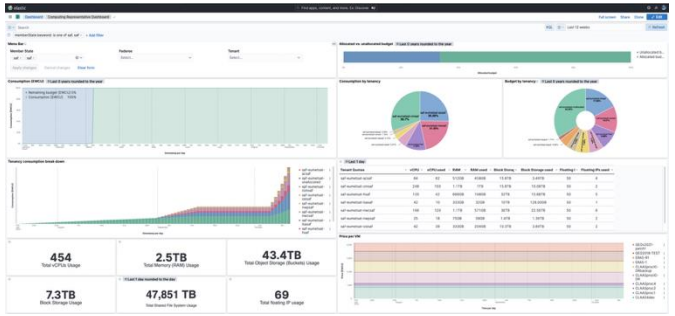
[Knowledge Base]



[User Support Portal]



[Discussion Platform]



[Accounting Platform]

EWC – Operational Infrastructure

EUMETSAT

Cores	3830
Memory	30.7 TB
Storage	3.8 PB usable
GPUs	240 VGPUs (10 GB partitioning)

- Hosted externally with 10 Gbps link to EUM
- Sizing may increase in future based on demand

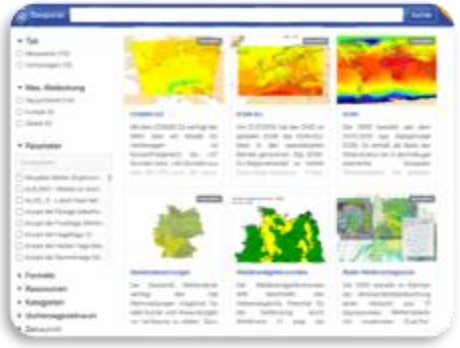
ECMWF
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

Cores	5632
Memory	53 TB
Storage	4.2 PB usable
GPUs	32 x A100 80 GB

- New Cloud Infrastructure ready in Bologna
- 2 Production clouds - one on each computer hall

- Resources allocated to each Member and Co-operating State
- Managed by Computing Representatives

EWC: What could you do with it ?



OGC web map services integrating maps in DWD's Geoportal

Forecast and climatology of cloud cover for Energy and Spatial sectors Météo-France Hosted on both ECMWF and EUMETSAT

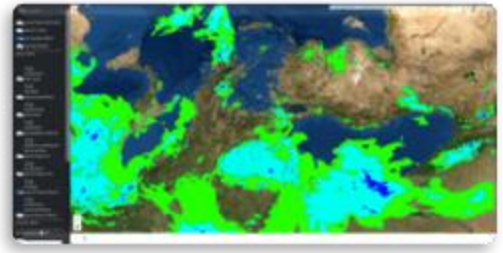
Oxford University Jupyter notebook environments for ML on weather & climate data sets

Virtual laboratories for training courses and workshops

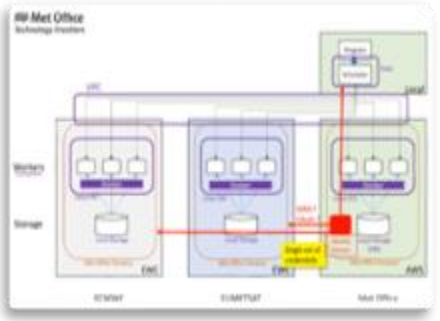
KNMI Climate Explorer setup on EWC

Atmospheric dispersion modelling from RMI

NordSat developing imagery generation tools for satellite products

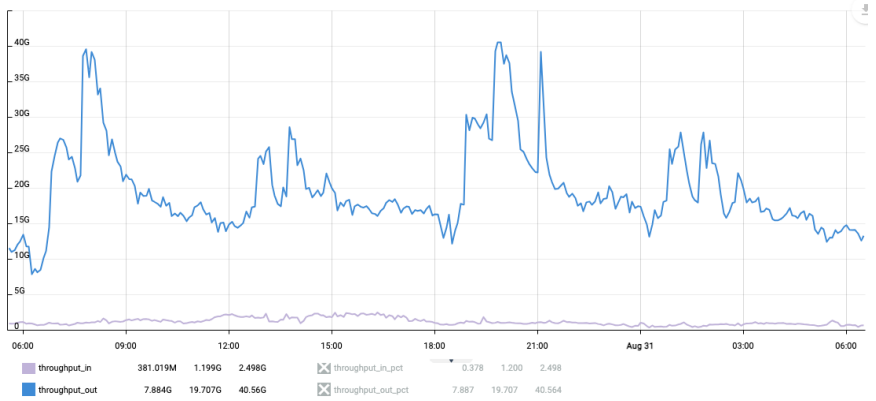


South-East European Multi-Hazard Early Warning Advisory System Common Interface Platform



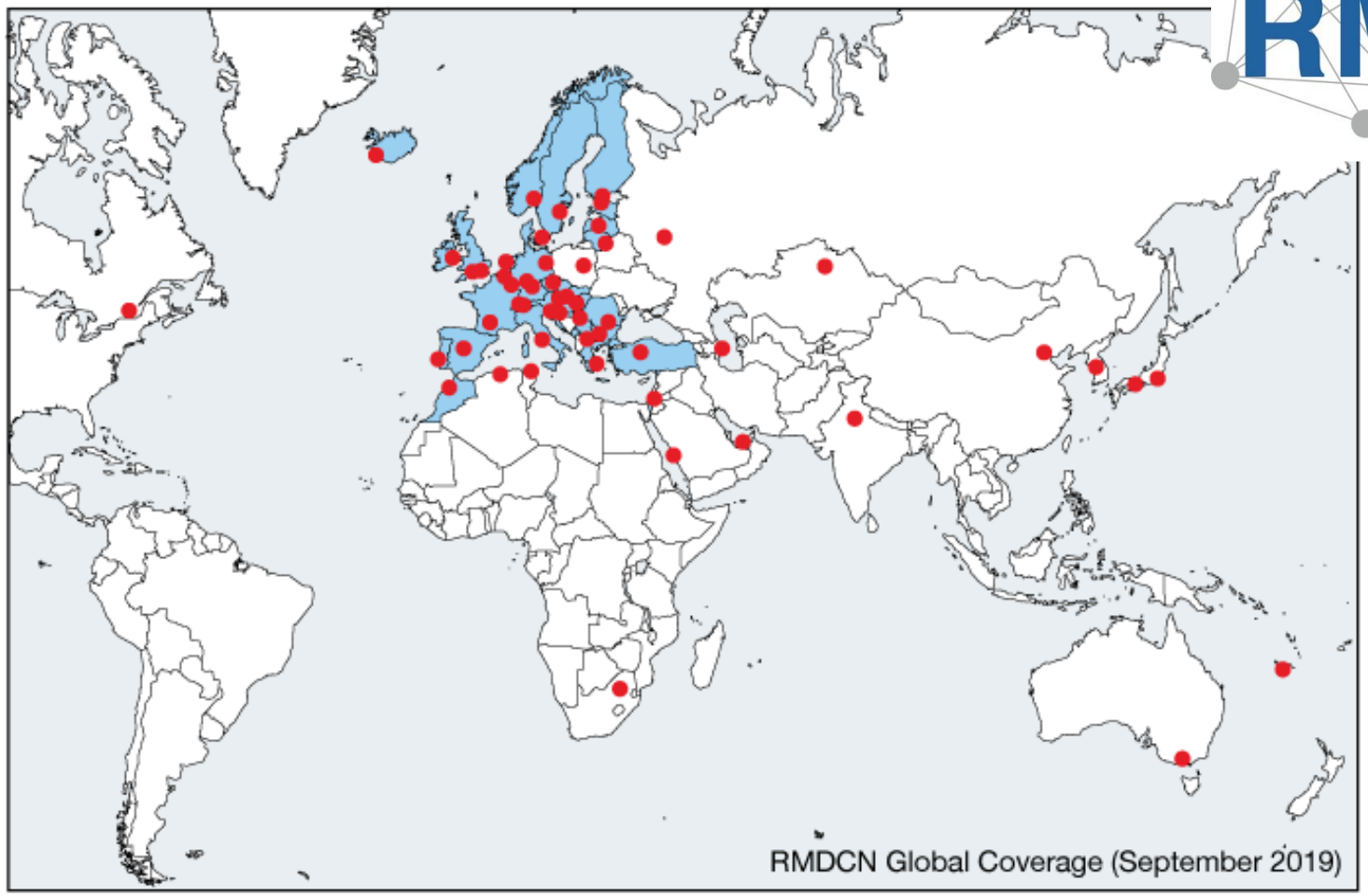
UK Met Office demonstrates Data Proximate Compute use case

Networks



- Internet
  - Dual links to local networks at each of ECMWF's sites
    - Jisc in the UK, GARR in Italy, and DFN in Germany
    - high-speed connections to the rest of the Internet, e.g. GÉANT
  - Bologna: 60Gbit/s uplink to GARR
    - Two routers on our side, each of which has a single connection to a separate GARR router
- RMDCN (Regional Meteorological Data Communications Network)
  - Secured VPN provided through MPSL (Multi Protocol Label Switching)
  - Supplied by Interoute Communications Limited
  - Bandwidth to Member States: 1 - 100 Mbps
  - Managed by ECMWF for WMO Region VI
- ECMWF is a participating organisation in the eduroam federation

RMDCN connections

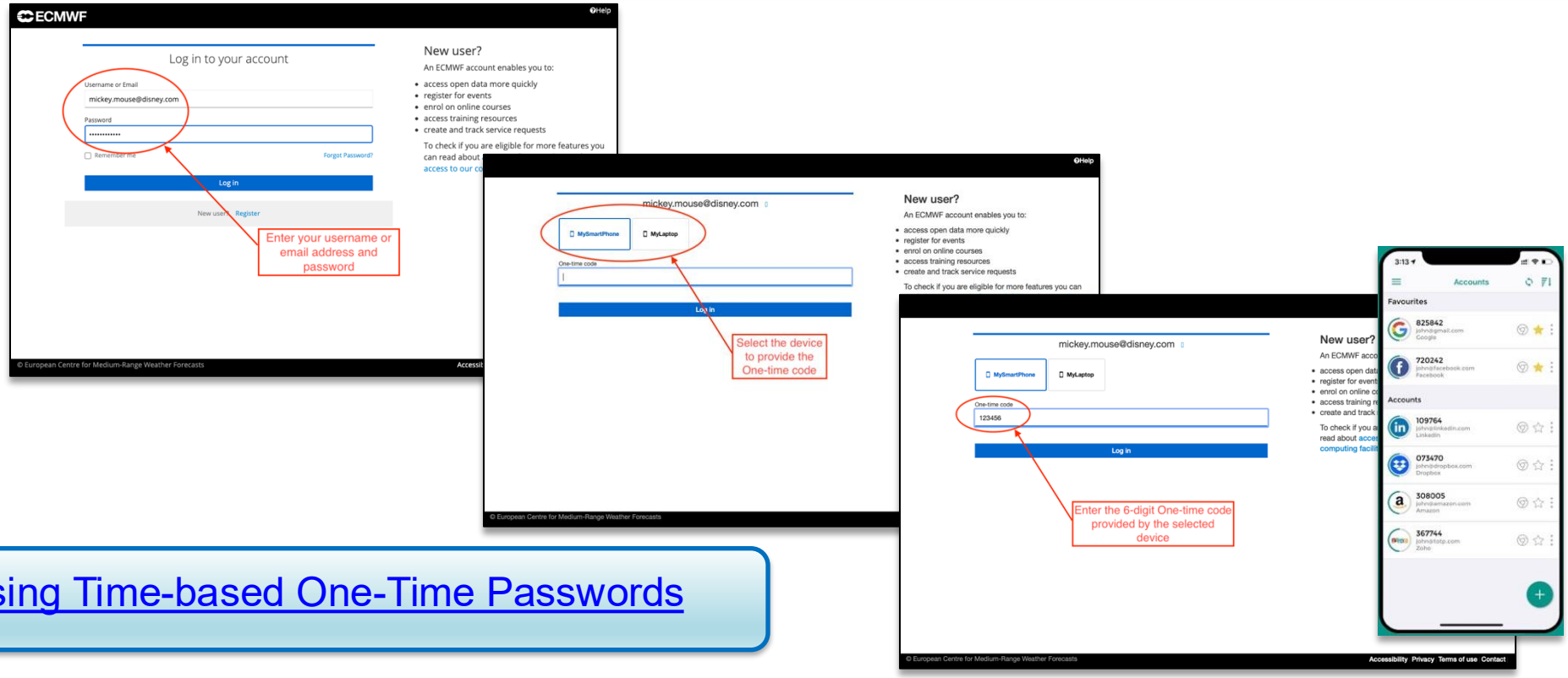


53 sites currently connected

Access to ECMWF resources

All interactive login access to ECMWF's computing system requires Multi-Factor Authentication (MFA)

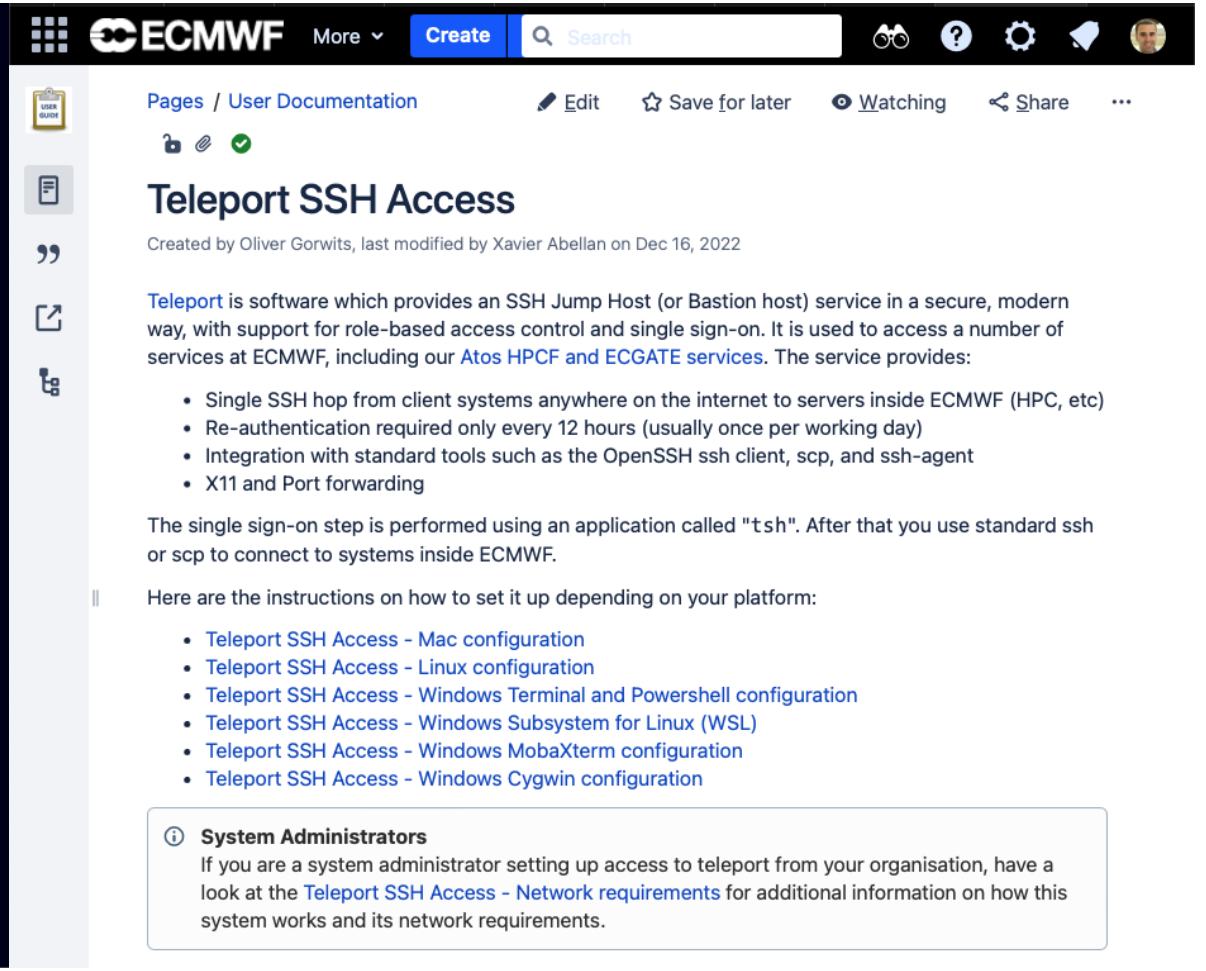
Password
+
One-Time Password provided by a Time-based one-time Password (TOTP) device



See Using Time-based One-Time Passwords

Remote access: the SSH service

```
usrc-> tsh login
> Profile URL:        https://jump.ecmwf.int:443
  Logged in as:       roberto.cuccu@ecmwf.int
  Cluster:            jump.ecmwf.int
  Roles:
  Logins:             usrc
  Kubernetes:         disabled
  Valid until:        2023-09-11 22:22:02 +0200 CEST [valid for 11h55m0s]
  Extensions:         permit-X11-forwarding, permit-agent-forwarding, permit-port-forwarding, permit-pty

usrc-> ssh hpc-login

#------------------------------------------------------------------------------#
Welcome to ac6-100 of cluster ac!


  ##    ####
 #  # #    #
#    # #
###### #
#    # #    #
#    #  ####


[IMPORTANT] Read carefully the following documentation:

https://confluence.ecmwf.int/display/UDOC/HPC2020+User+Guide

Have fun!

EC_GIT_TAG='commit e34fd29 deployed at 20230905_081008'
#------------------------------------------------------------------------------#

Last login: Mon Sep 11 08:25:37 2023 from 10.120.16.4
[ECMWF-INFO -ecprofile] /usr/bin/bash INTERACTIVE on ac6-100 at 20230911_082720.337, PID: 3058110, JOBID:
[ECMWF-INFO -ecprofile] $SCRATCH=/ec/res4/scratch/usrc
[ECMWF-INFO -ecprofile] $PERM=/perm/usrc
[ECMWF-INFO -ecprofile] $HPCPERM=/ec/res4/hpcperm/usrc
[ECMWF-INFO -ecprofile] $TMPDIR=/etc/ecmwf/ssd/ssd1/tmpdirs/usrc.3058110.20230911_082720.337
[ECMWF-INFO -ecprofile] $SCRATCHDIR=/ec/res4/scratchdir/usrc/6/ac6-100.3058110.20230911_082720.337
[usrc@ac6-100 ~]$
```



ECMWF More Create Search

Pages / User Documentation Edit Save for later Watching Share

Teleport SSH Access

Created by Oliver Gorwits, last modified by Xavier Abellan on Dec 16, 2022

Teleport is software which provides an SSH Jump Host (or Bastion host) service in a secure, modern way, with support for role-based access control and single sign-on. It is used to access a number of services at ECMWF, including our Atos HPCF and ECGATE services. The service provides:

- Single SSH hop from client systems anywhere on the internet to servers inside ECMWF (HPC, etc)
- Re-authentication required only every 12 hours (usually once per working day)
- Integration with standard tools such as the OpenSSH ssh client, scp, and ssh-agent
- X11 and Port forwarding

The single sign-on step is performed using an application called "tsh". After that you use standard ssh or scp to connect to systems inside ECMWF.

Here are the instructions on how to set it up depending on your platform:

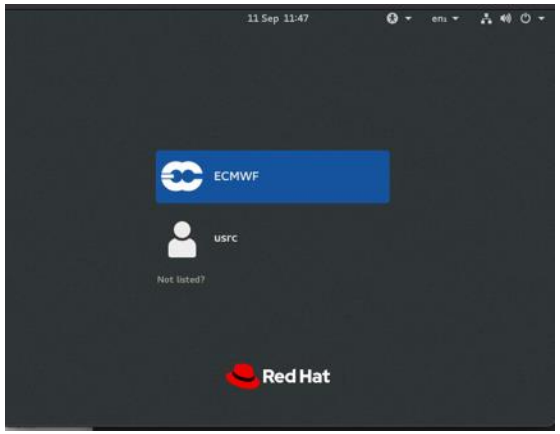
- Teleport SSH Access - Mac configuration
- Teleport SSH Access - Linux configuration
- Teleport SSH Access - Windows Terminal and Powershell configuration
- Teleport SSH Access - Windows Subsystem for Linux (WSL)
- Teleport SSH Access - Windows MobaXterm configuration
- Teleport SSH Access - Windows Cygwin configuration

System Administrators
If you are a system administrator setting up access to teleport from your organisation, have a look at the Teleport SSH Access - Network requirements for additional information on how this system works and its network requirements.

✓ See Teleport SSH Access documentation

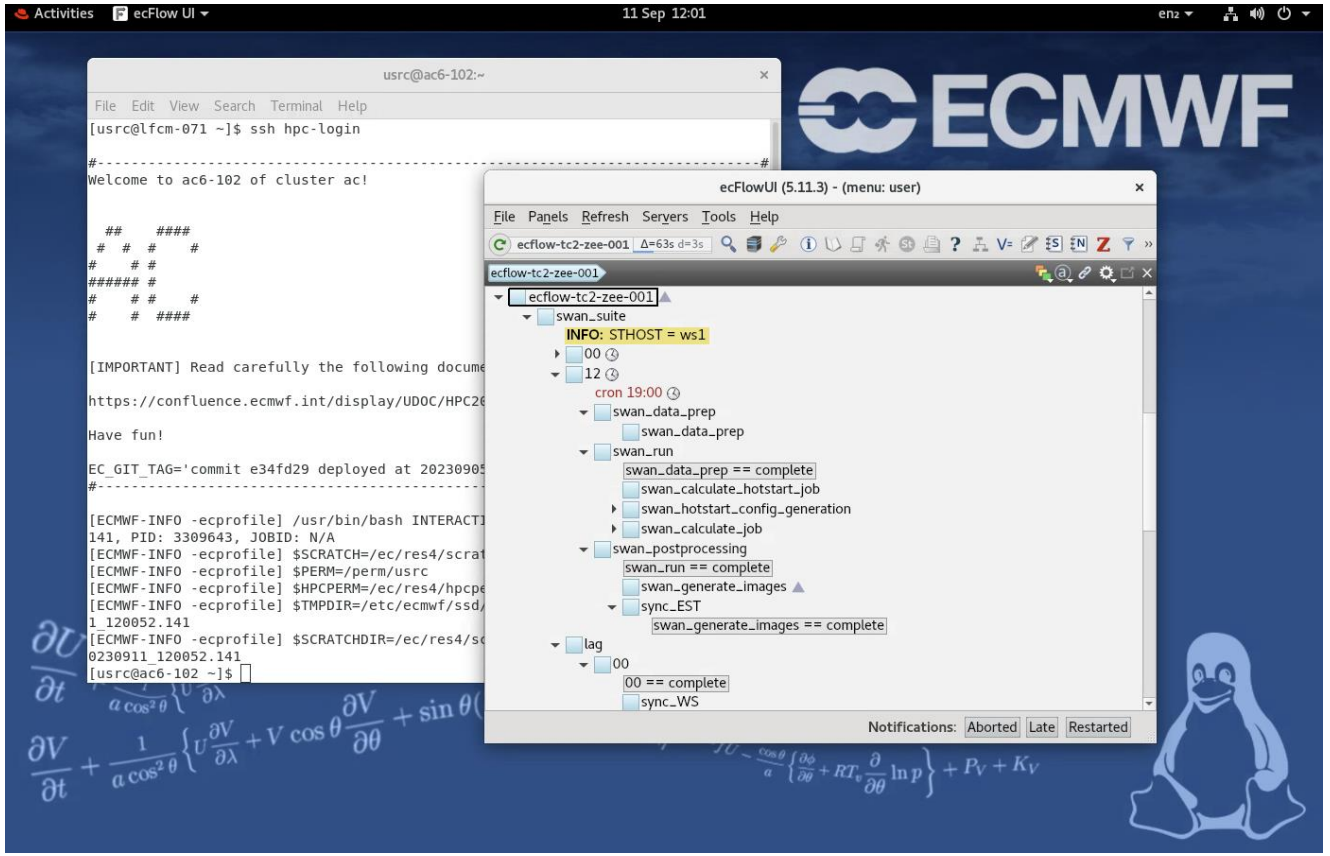
Remote access: the Linux VDI service

https://desktop.ecmwf.int/



Limited software installed

- **No MARS**
- **No ECMWF software**
- **No 3rd party software**
- **No addition Python packages**

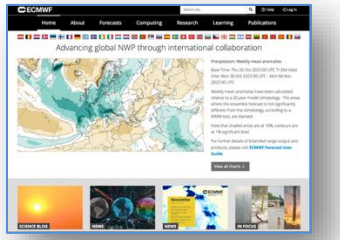


See Linux Virtual Desktop – VDI documentation

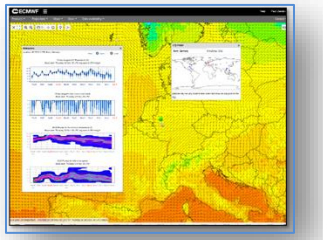
Web Services

Web services – overview

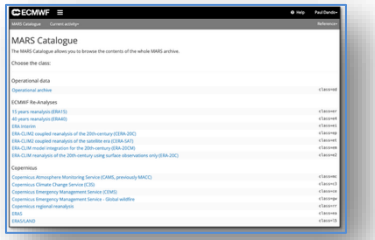
Key service areas



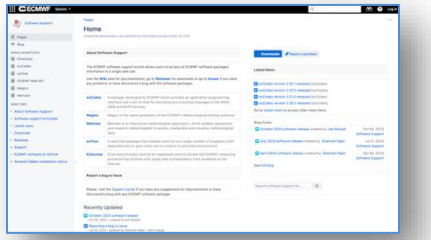
www
Everyone



ecCharts
Forecasters



Apps
Everyone



Atlassian
Everyone

C3S
Everyone

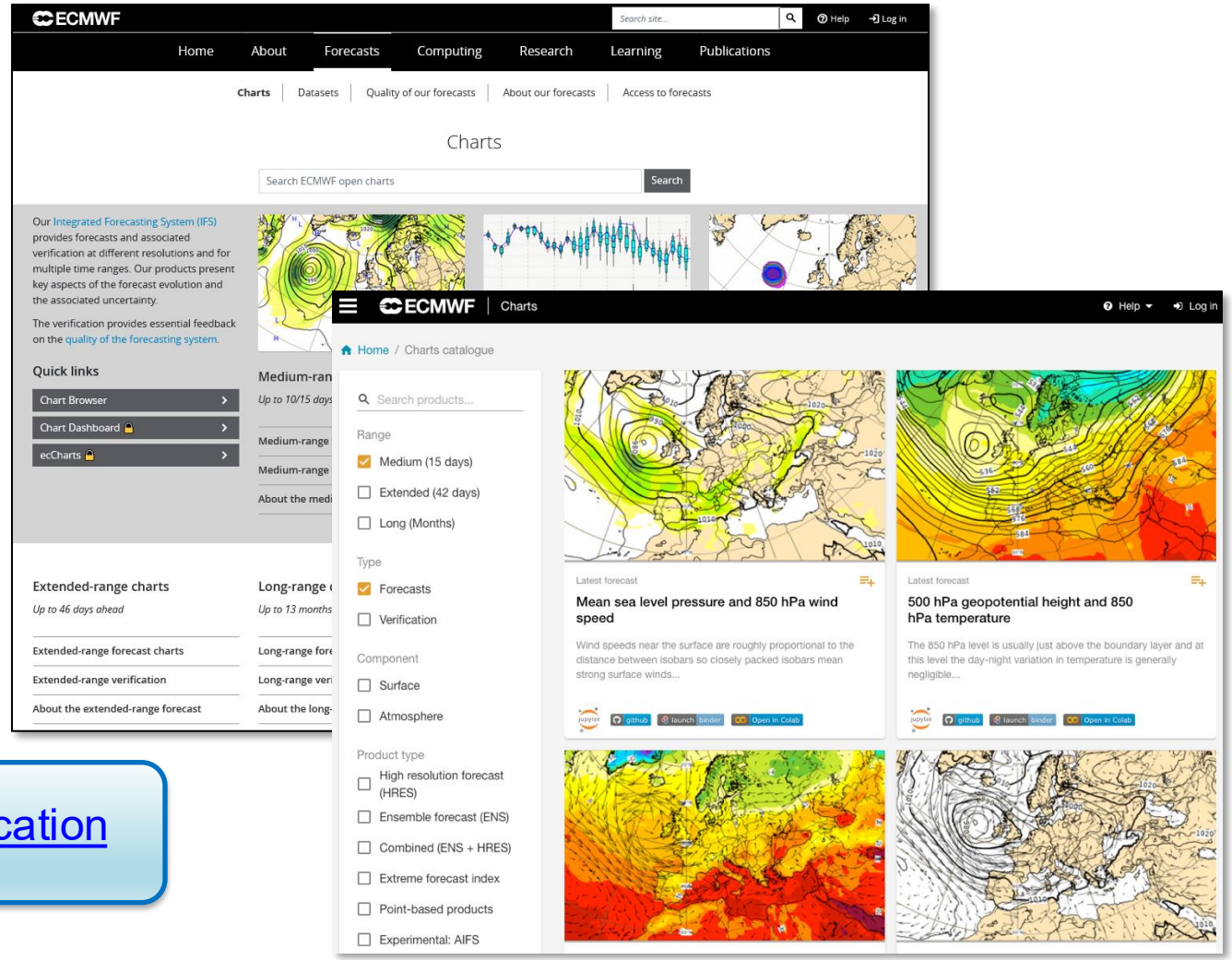
CAMS
Everyone

EFAS
EFAS Partners

Web services – ECMWF Open Charts

https://www.ecmwf.int/en/forecasts/charts

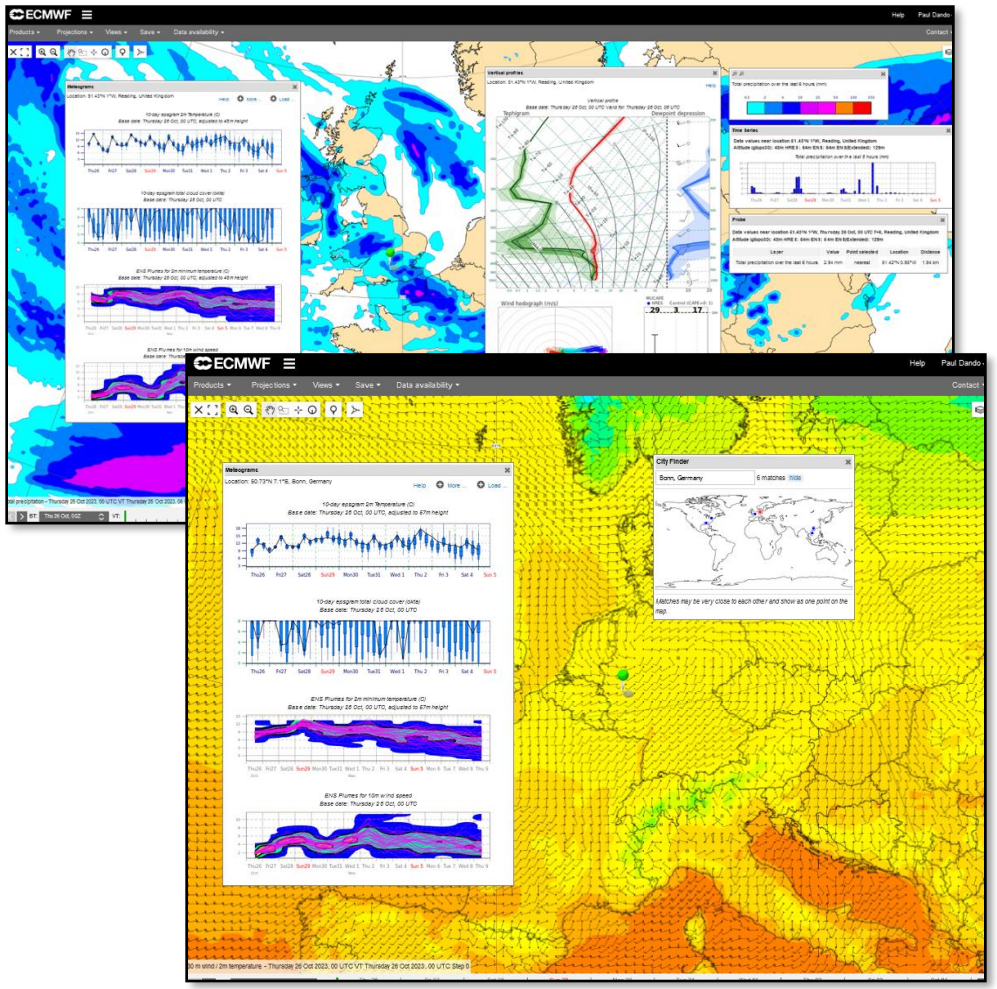
- Charts published under a Creative Commons Attribution 4.0 International (CC BY 4.0)
- Open Charts API can be used to download charts by script



See Changes on web charts application

Web services – ecCharts: http://eccharts.ecmwf.int/

- Highly interactive (products created on-demand)
  - Interactivity (zoom-pan) and animation
  - Layer customisation (e.g. thresholds)
  - Charts with bespoke layers and optional styles
  - HRES, ENS, WAM products
  - Standard and bespoke ENS meteograms
  - Extreme Forecast Indices (EFI)
  - Point probing to explore data
- Highly available and operationally supported (24x7)
- Use of agreed dissemination schedule
- OGC WMS standards for machine-to-machine access

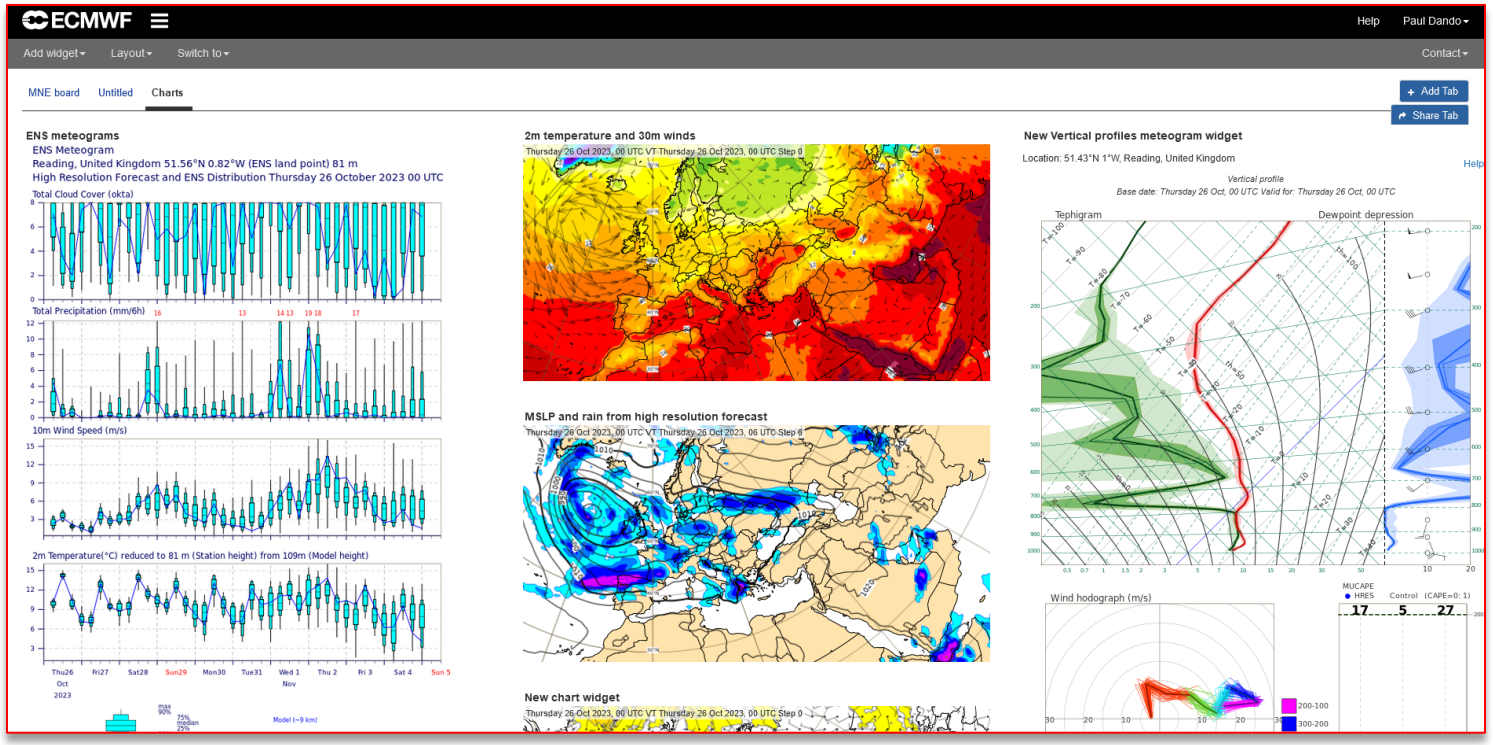


Access requested via your Computing Representative

Web chart dashboard

- Documentation: https://confluence.ecmwf.int/display/FCST/Chart+dashboard

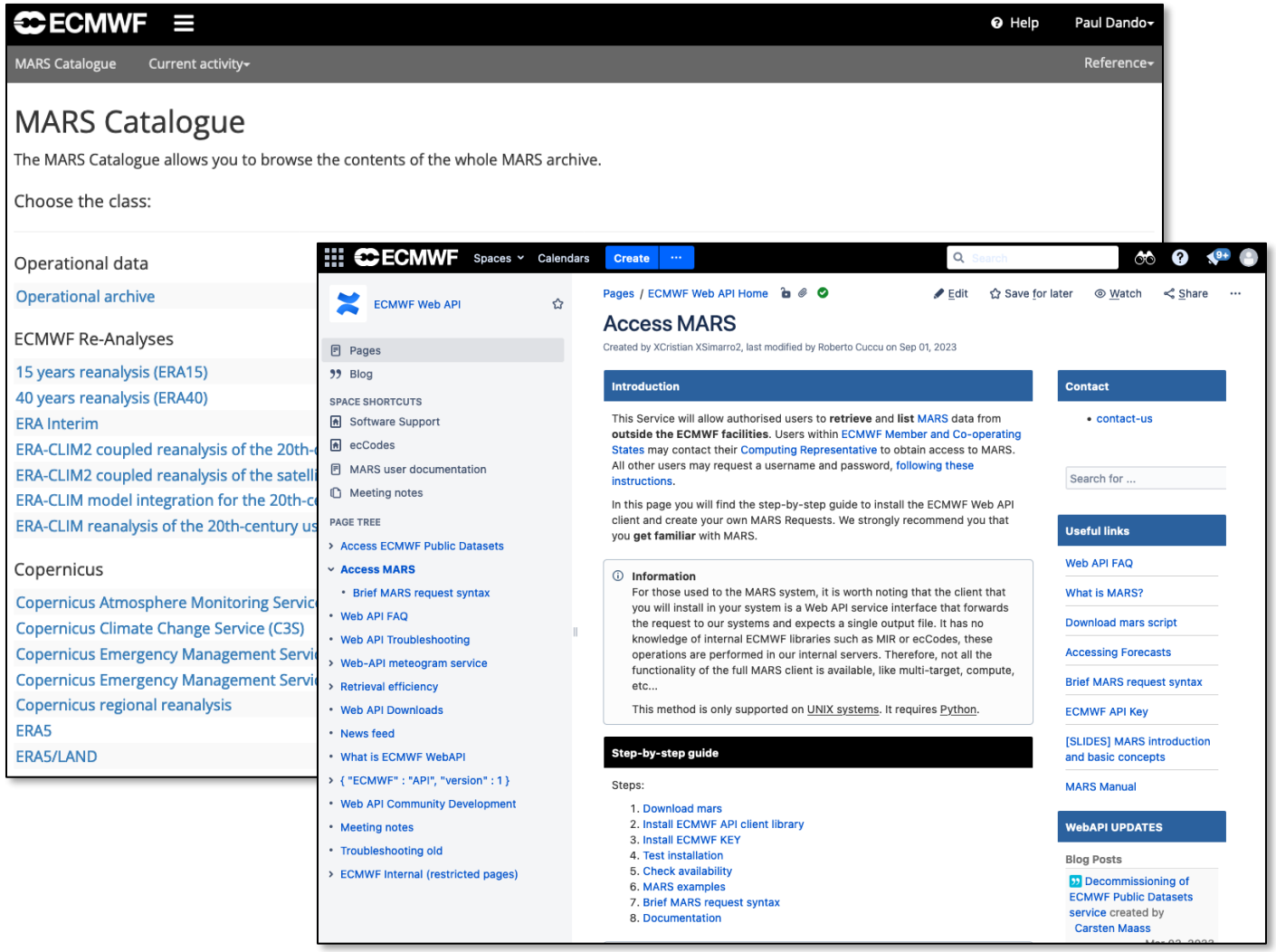
- Place to organise regularly accessed charts
- Shared with the ecCharts dashboard



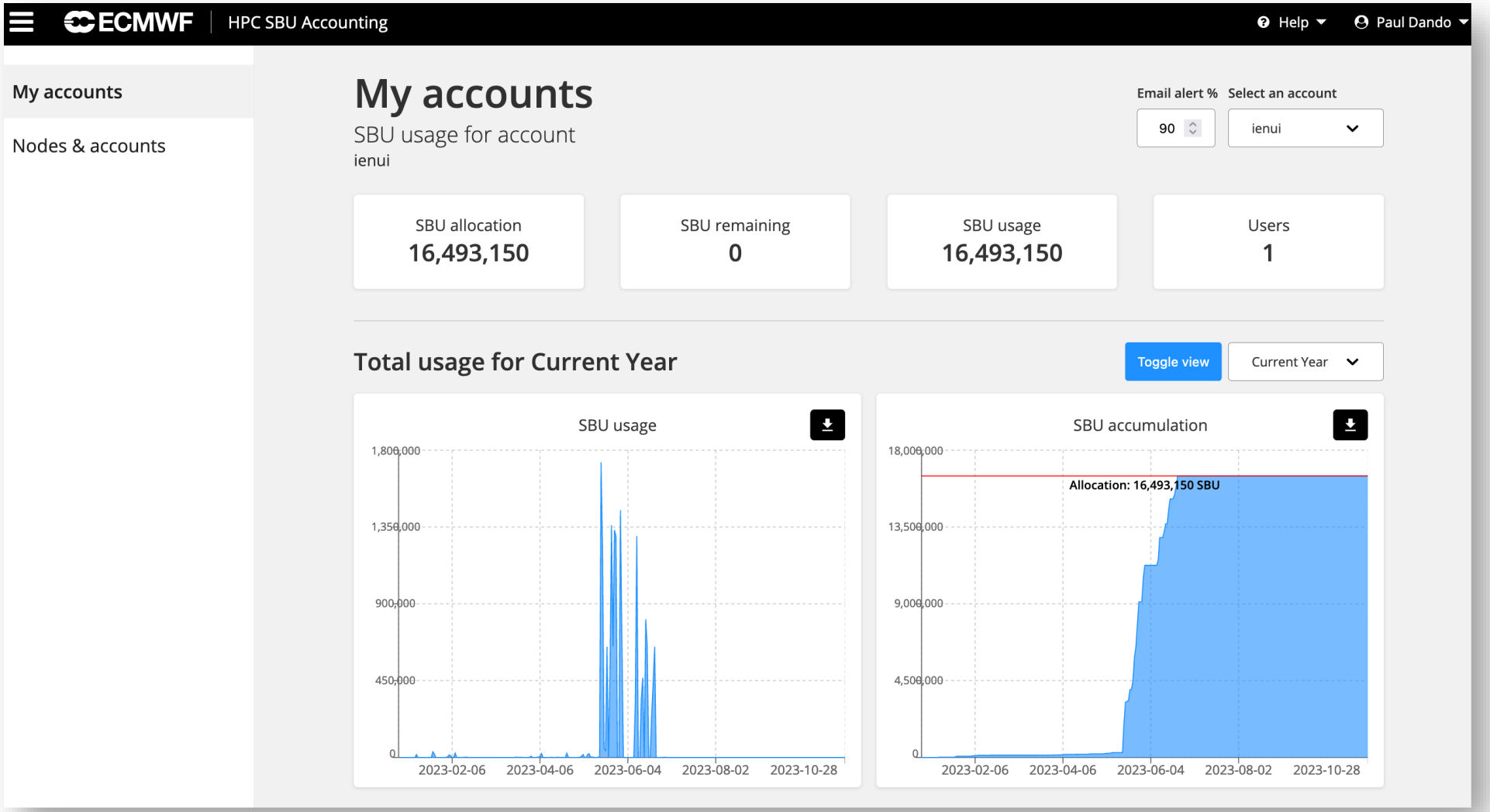
Web Services – MARS http://apps.ecmwf.int/services/mars/catalogue/

- Web based interface to MARS
- Available to registered users only
- Retrievals (GRIB and NetCDF)
- Batch access with WebAPI (Python)

- View current activity
- Access documentation



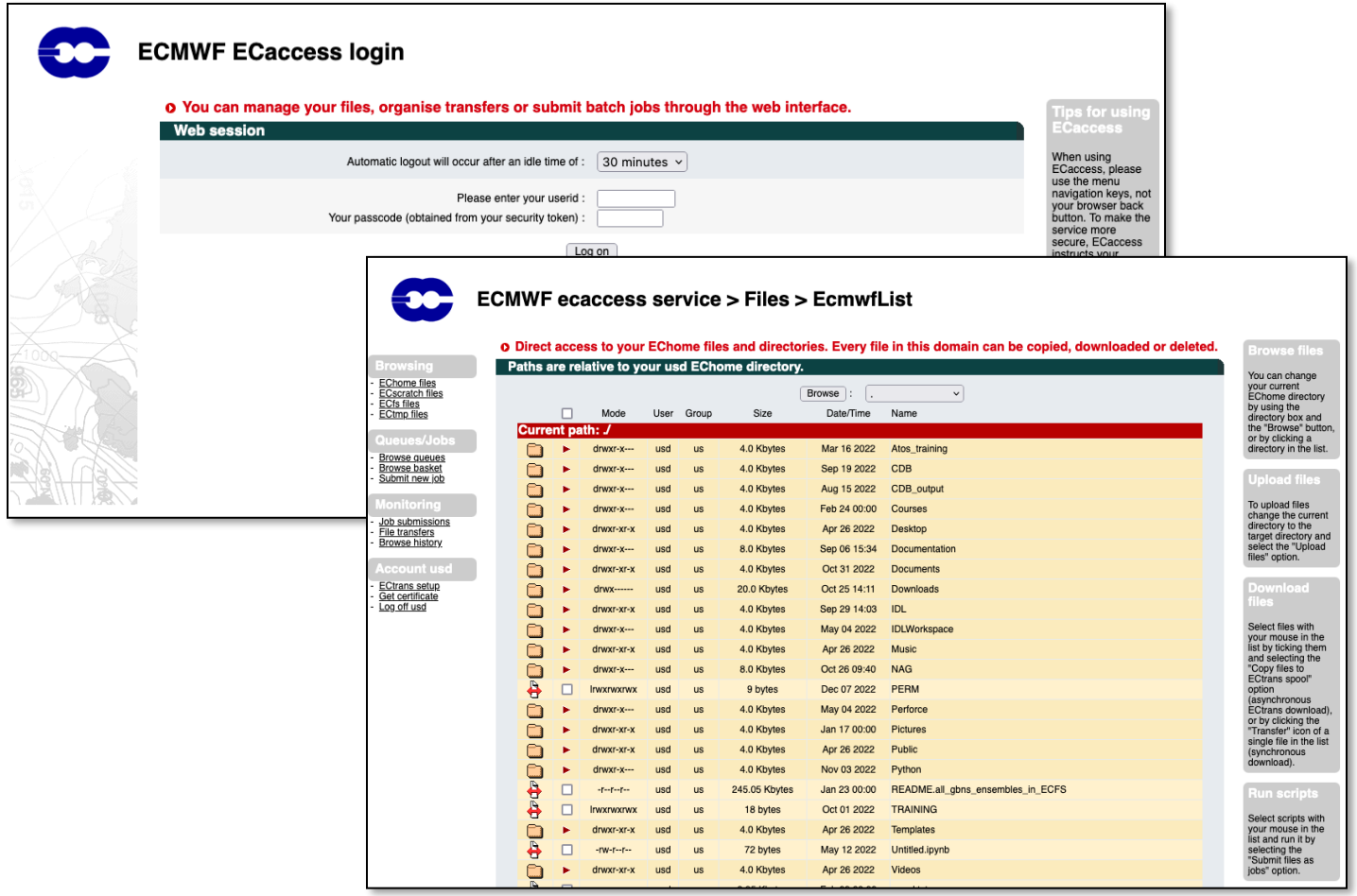
Web services – HPC SBU accounting interface https://hpc-usage.ecmwf.int/



Web Services – https://boaccess.ecmwf.int

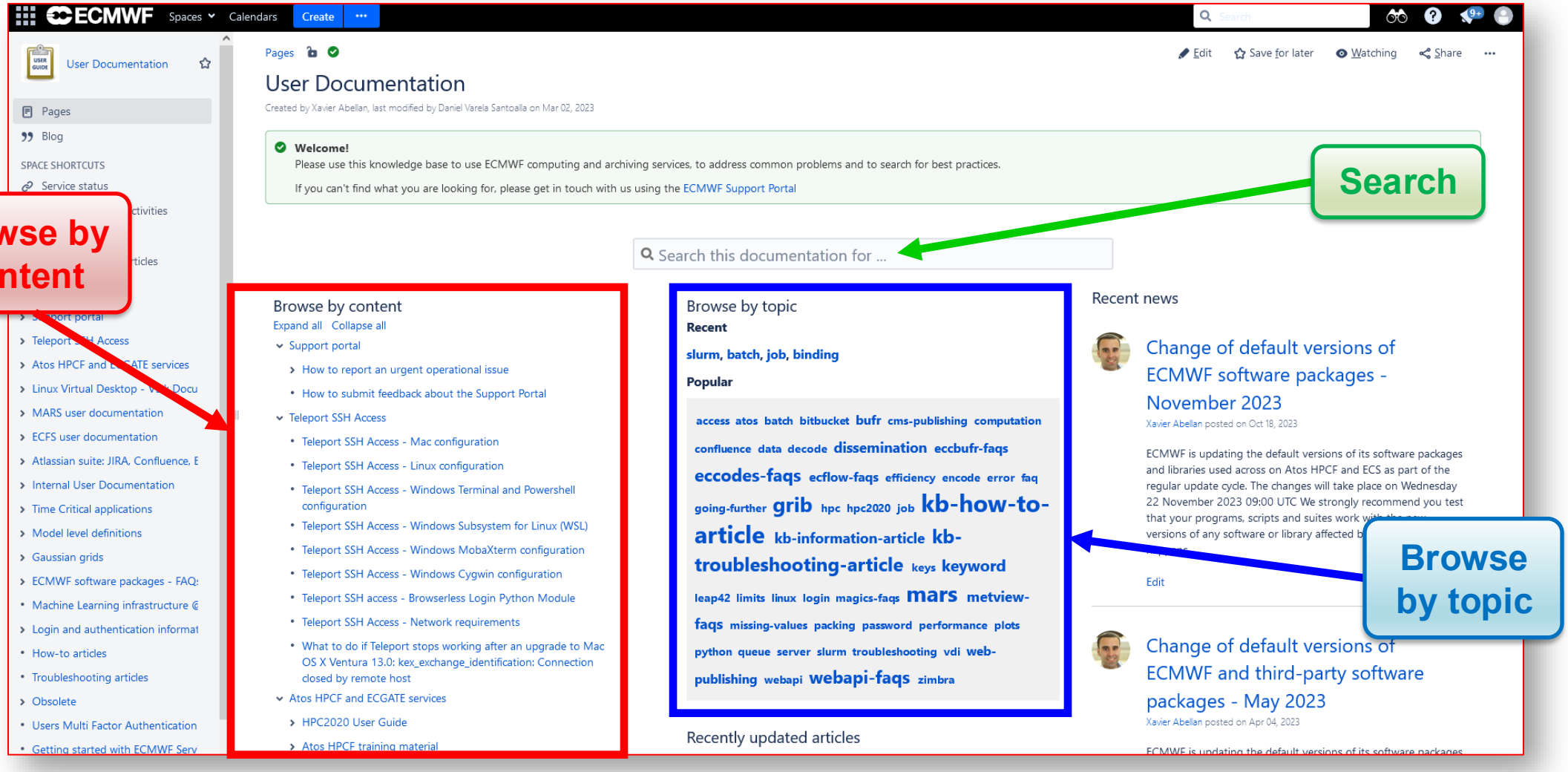
- Interface to browsing, transfers, editing, submission of files to ECMWF
- Online help
- TOTP login needed

Only the code from the default TOTP device is accepted !



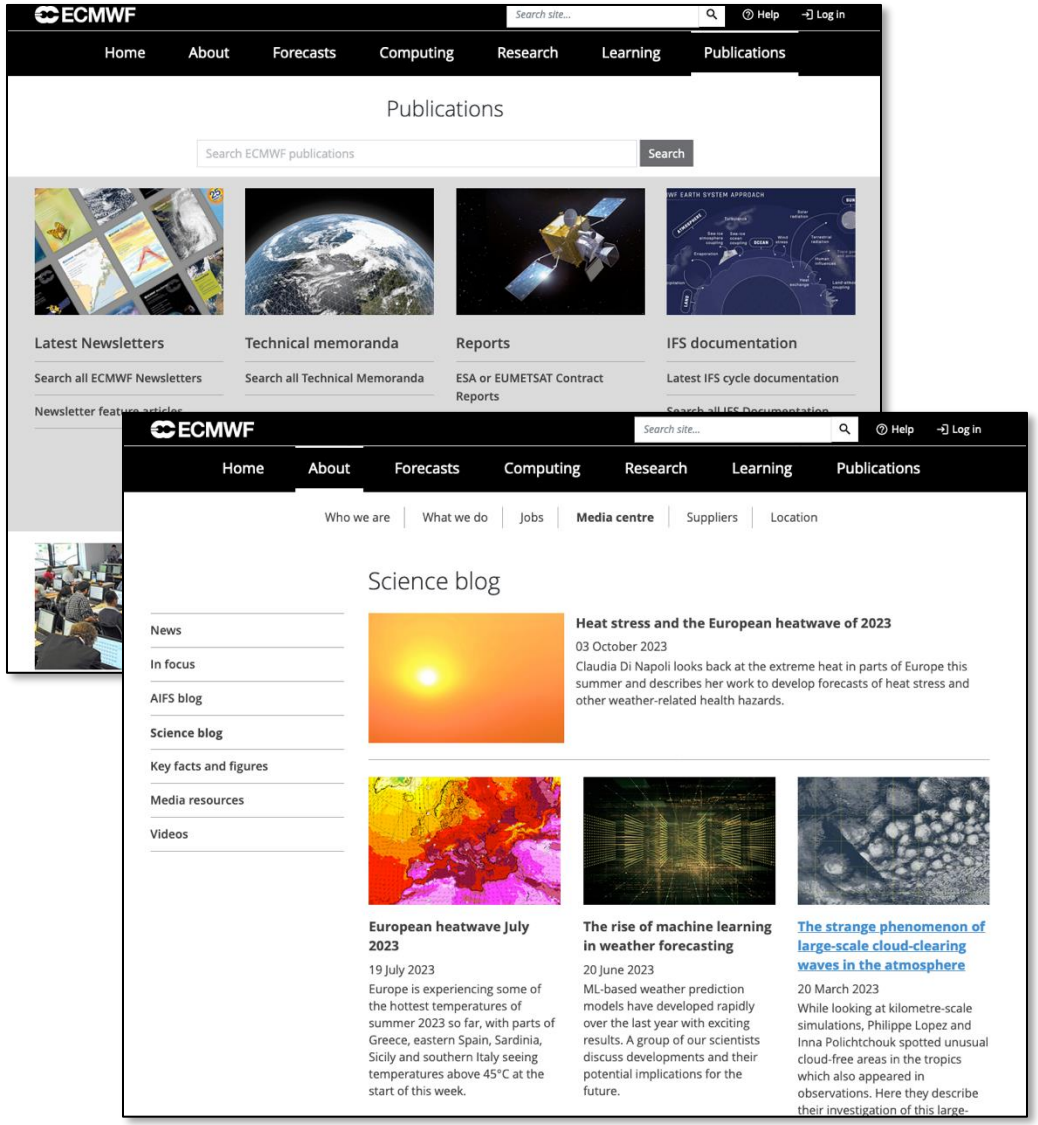
User Documentation

https://confluence.ecmwf.int/display/UDOC/User+Documentation



Web Services – documents and documentation

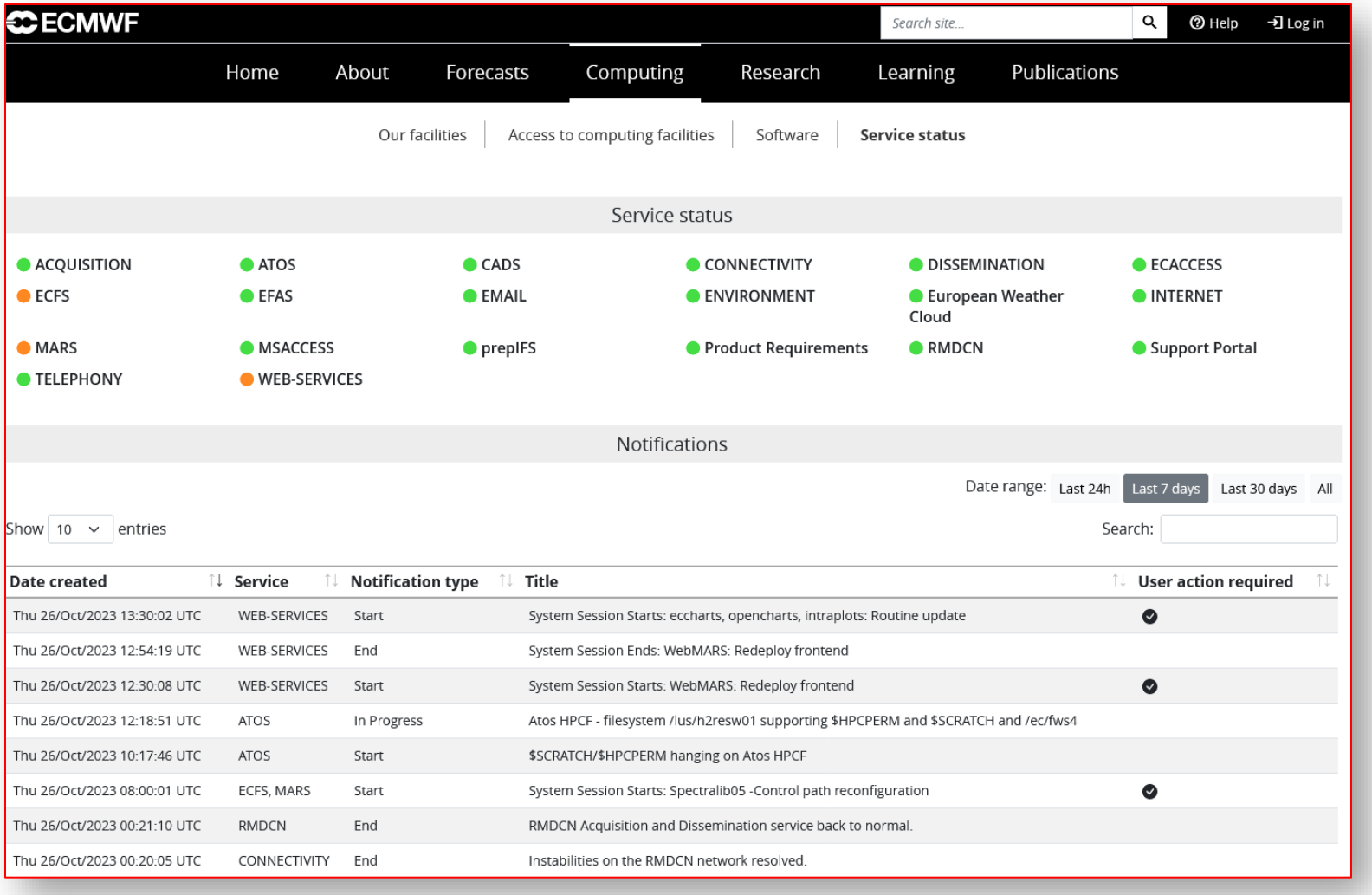
- Official documents (restricted access)
  - https://www.ecmwf.int/en/about/who-we-are/governance
- ECMWF publications
  - https://www.ecmwf.int/en/publications
- Research at ECMWF
  - https://www.ecmwf.int/en/research
- Computing Services
  - https://www.ecmwf.int/en/computing
- Science Blog
  - https://www.ecmwf.int/en/about/media-centre/science-blog
- And much more …



Operational Service Status

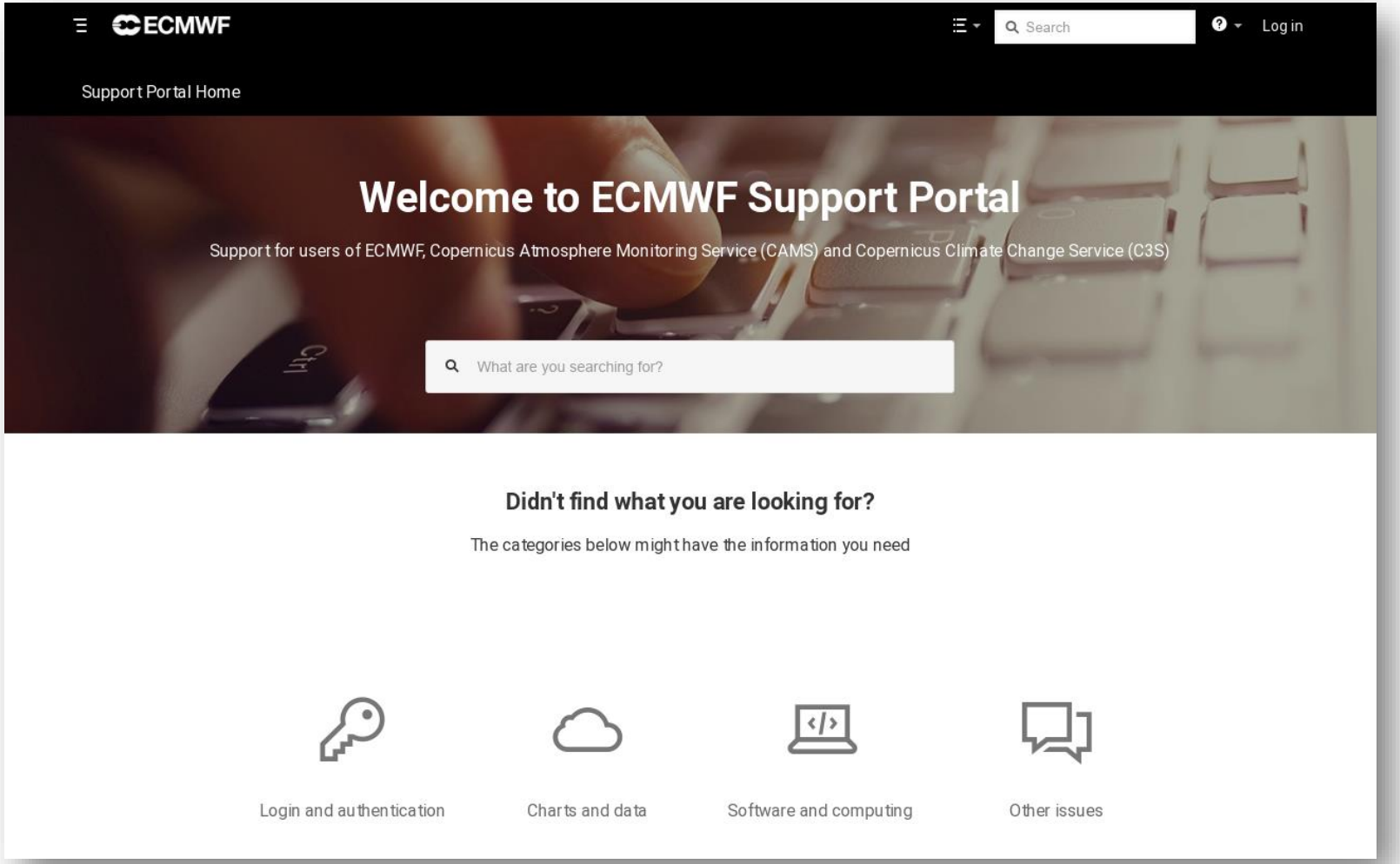
https://www.ecmwf.int/en/service-status

Email sent only when user action is required

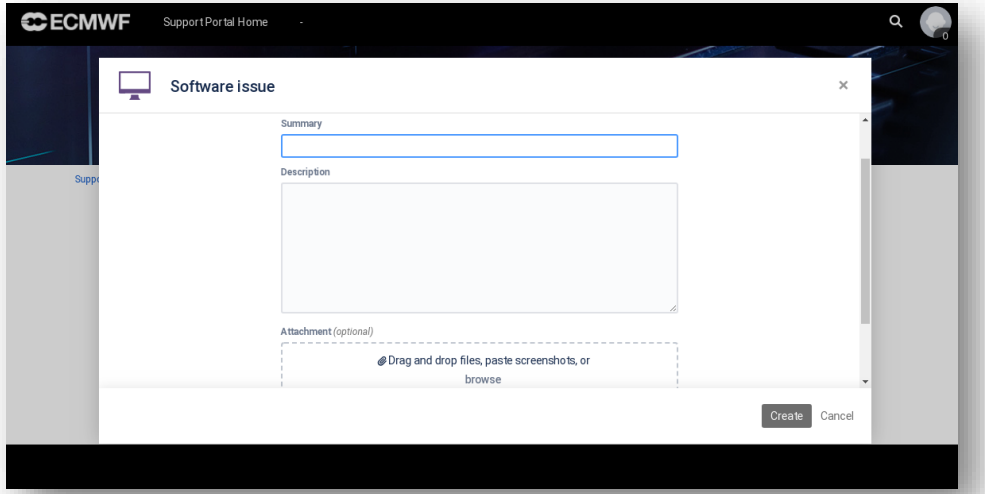


Getting help and reporting problems

https://support.ecmwf.int/



How to provide a good problem report



- Tell us which system you are using
- For problems with software, provide the version used
- Provide a good description of the problem
  - Actual Results: What happened when you got the bug?
  - Expected Results: What was supposed to happen?
  - The exact error message printed
- Provide a small example with data that shows how to reproduce the problem if possible
- For MARS issues, provide your retrieval request and all output

The better the problem report, the faster it will get fixed!

Questions ?