

Overview of Computing Services

Introduction to ECMWF Computing Services Training week 2025

Daniel Varela

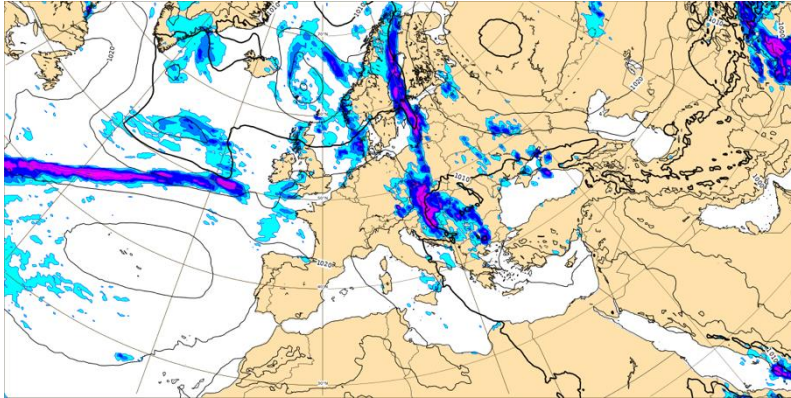
ECMWF - User Services - Computing and Software Support team





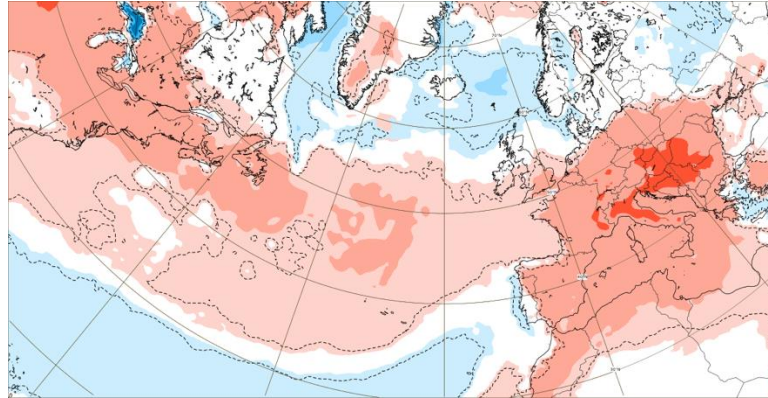
ECMWF operational forecasting system

Medium range: up to 2 weeks



- ~9 km and 137 levels (T_{CO1279} / $O1280$ / $L137$)
- 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

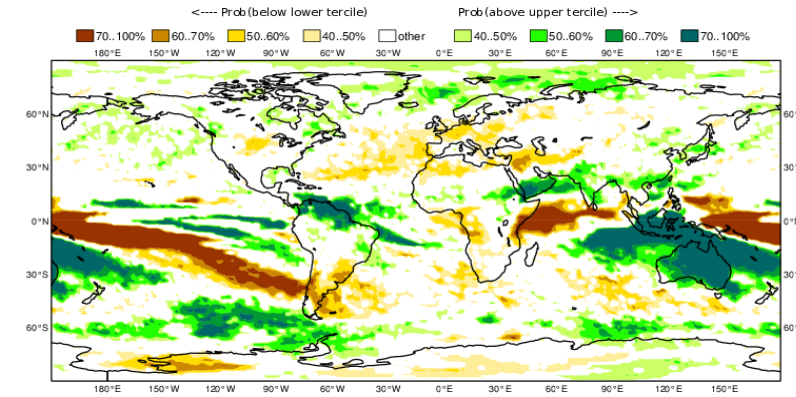


- ~36 km and 137 levels (T_{CO319} / $O320$ / $L137$)
- 100+1 members
- To 46 days (T+1104h) at 00 UTC every day

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

Seasonal range: up to 7 months

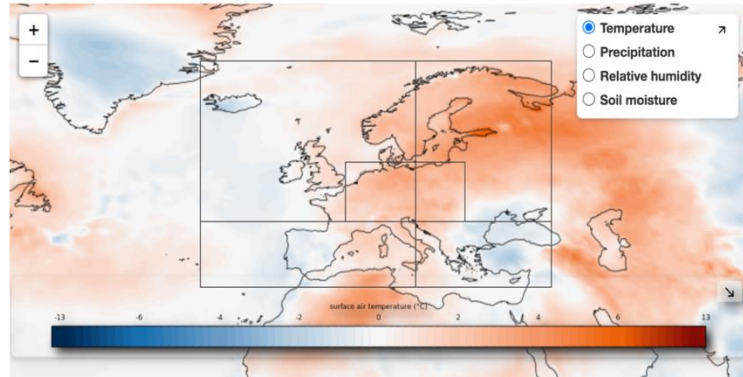


- ~36 km and 91 levels (T_{CO319} / $O320$ / $L91$)
- 50+1 members
- Once per month to 7 months ahead
- A sub-set of 15 members is run to 13 months ahead every quarter (Feb / May / Aug / Nov)
- 30 years of hindcasts

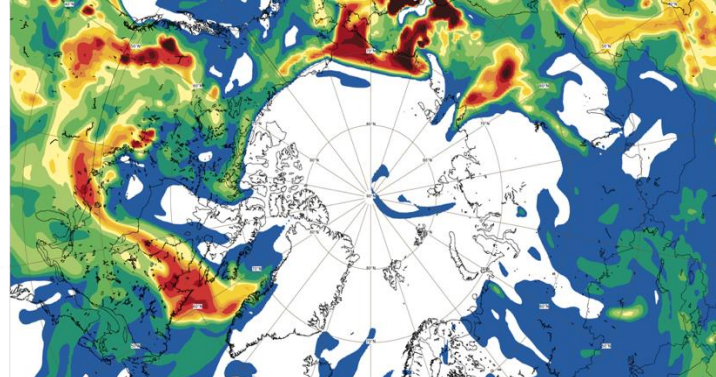
Environmental modelling products

- [Copernicus Climate Change Service](#) – C3S
- [Copernicus Atmosphere Monitoring Service](#) – CAMS
- [Copernicus Emergency Management Service](#) - CEMS

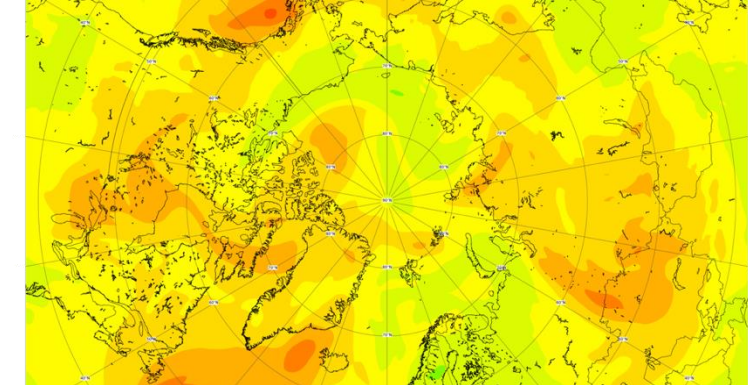
Monthly Copernicus climate monitoring



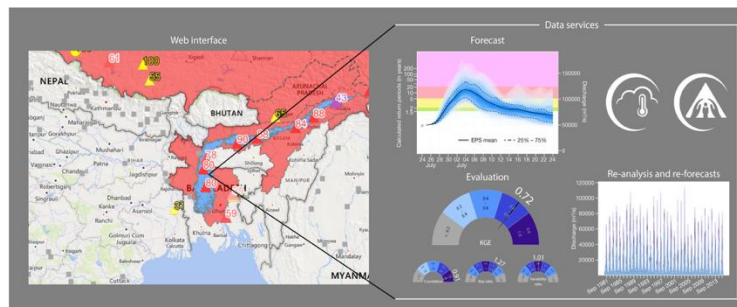
Carbon monoxide forecast



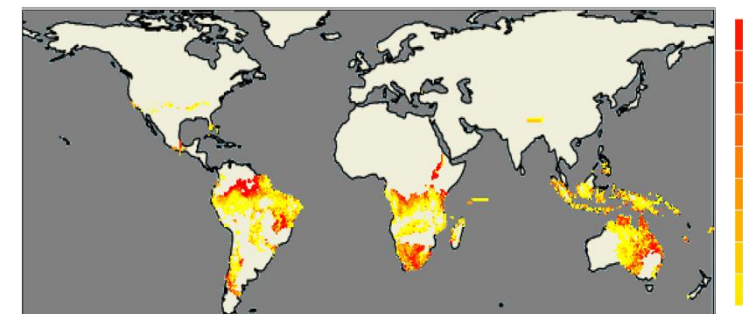
Ozone forecast



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](#)

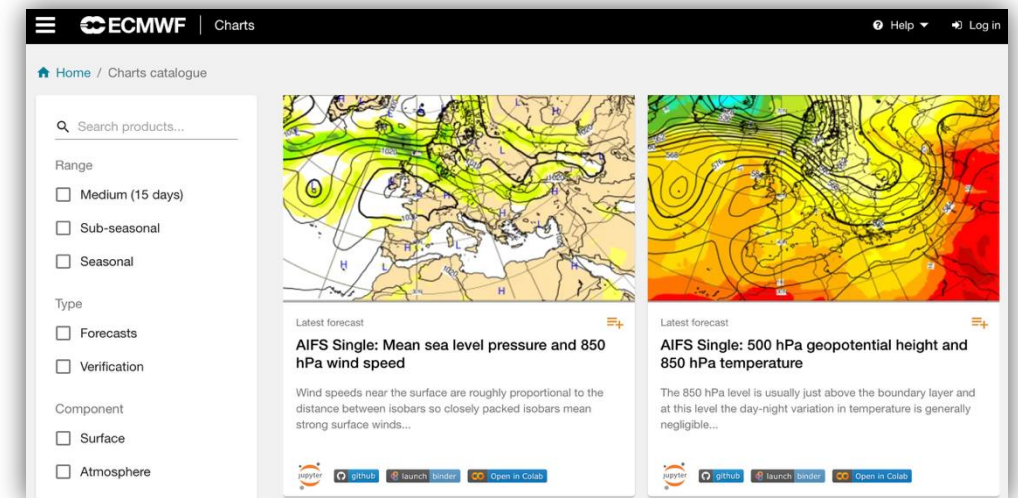
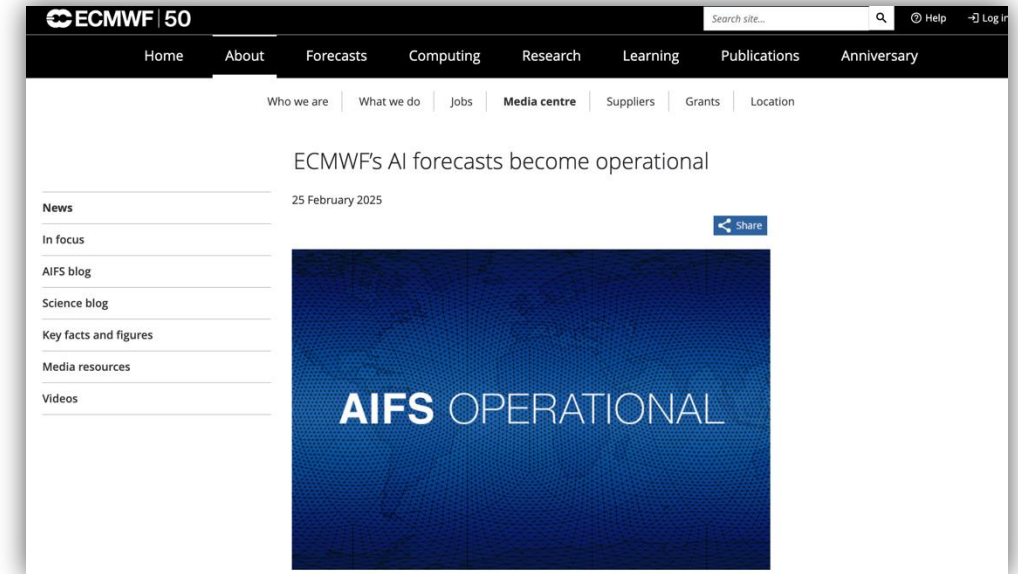
- The first **operational** ML weather forecasting model
- Generates a single forecast
- Includes tropical cyclone track forecasts

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>

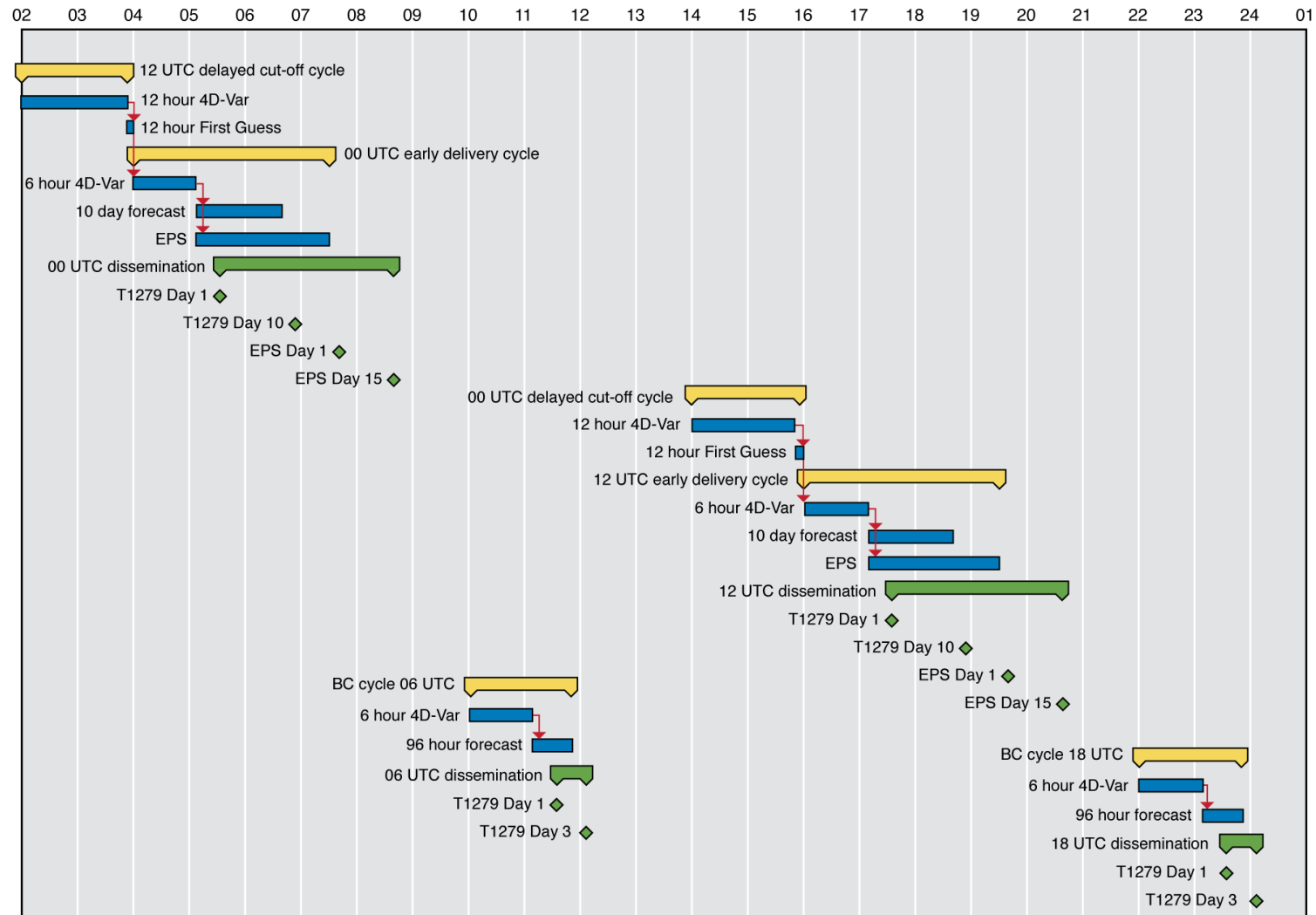
- CAMS global forecasts

- <https://confluence.ecmwf.int/display/COPSRV/CAMS+Global>

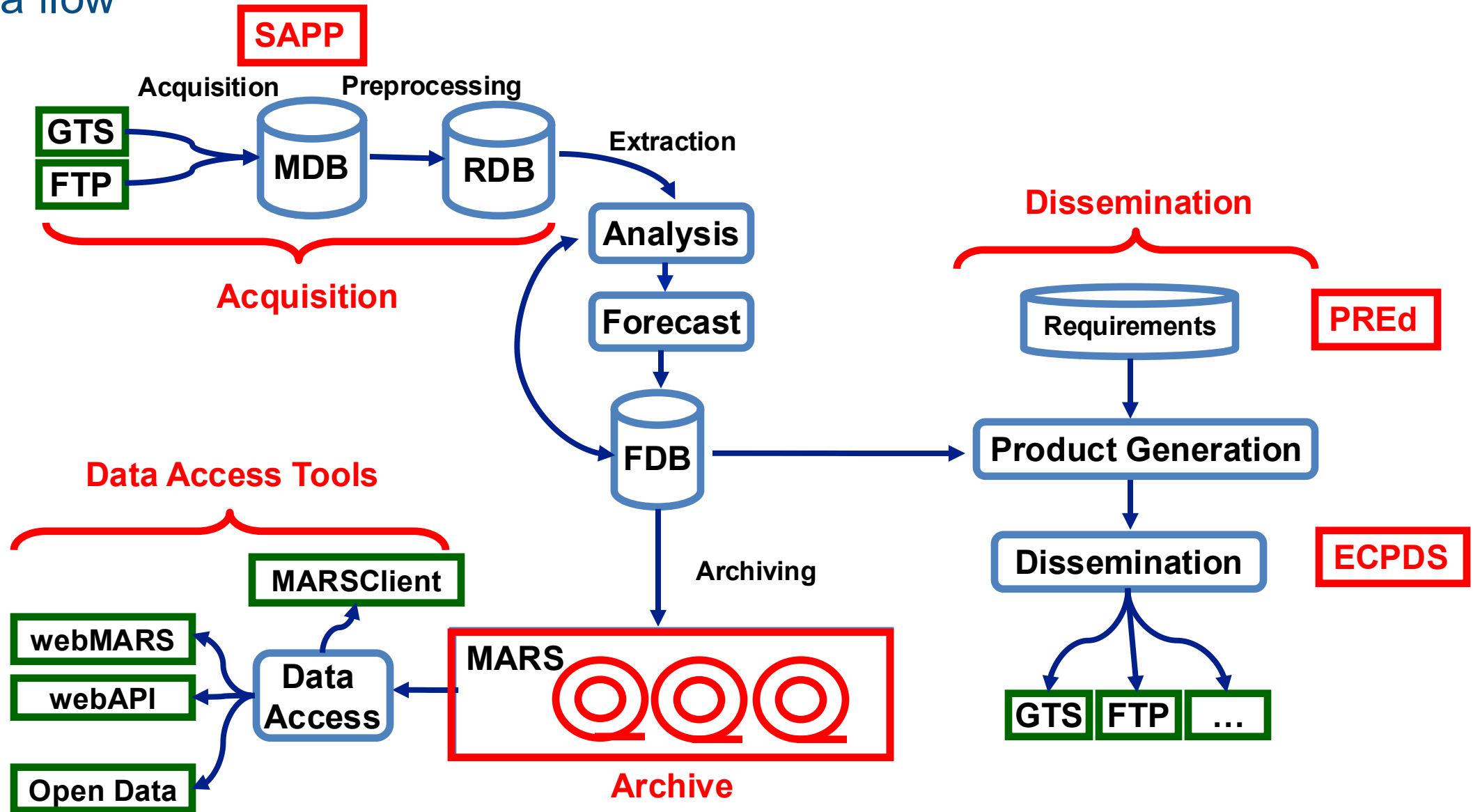
The screenshot shows the ECMWF Confluence page for 'Changes to the forecasting system'. The page is part of the 'Forecast User Portal' and was created by Umberto Modigliani, last modified by Helen Setchell on Jul 26, 2023. The main content area includes a 'Mailing list' section with instructions on how to subscribe or unsubscribe via email, and two lists of changes: 'Planned changes' (Implementation of IFS Cycle 49r1 - Scheduled for Q2 2024 (TBC)) and 'Past changes' (a detailed list of previous cycle implementations from 2016 to 2023). A sidebar on the left contains a 'PAGE TREE' with links to various forecasting issues and configurations.

The screenshot shows the ECMWF Confluence page for 'CAMS Global'. The page is part of the 'Production' space and was created by Miha Razinger, last modified by Richard Engelen on Apr 30, 2019. The main content area lists several key updates, including the implementation of IFS cycle 48r1 for CAMS, the porting of IFS cycle 47r3 to ATOS, and the implementation of IFS cycle 47r2. It also lists the implementation of IFS cycle 47r1, IFS cycle 46r1, and the current global production log files. A sidebar on the left contains a 'PAGE TREE' with links to various CAMS Global updates and products.

The main operational suites on ECMWF's HPCF



Data flow



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

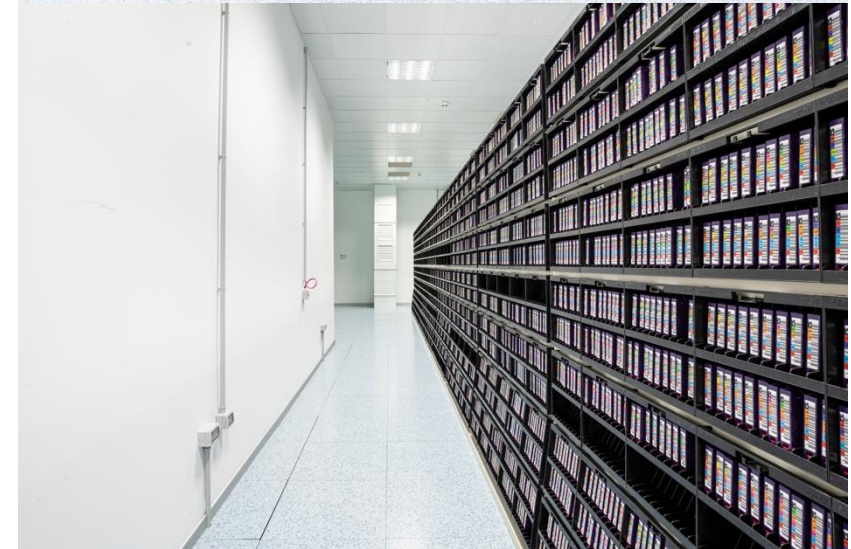


Running meteorological models

- 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



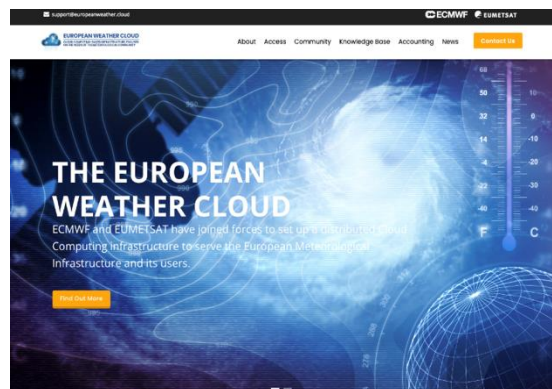
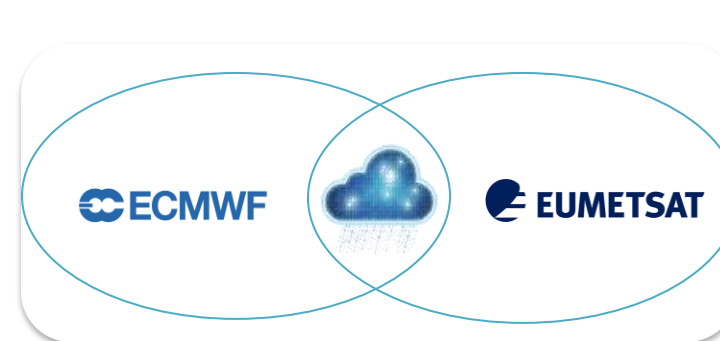
Data Handling Services

- 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

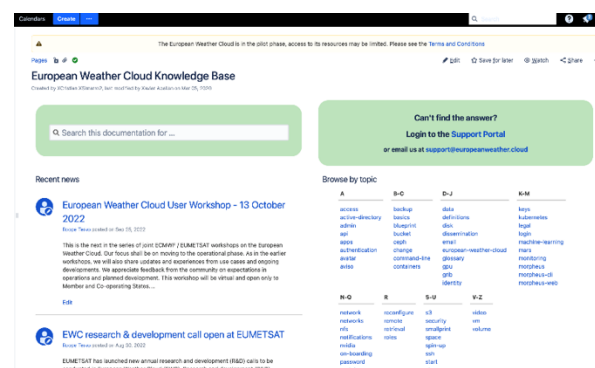


European Weather Cloud

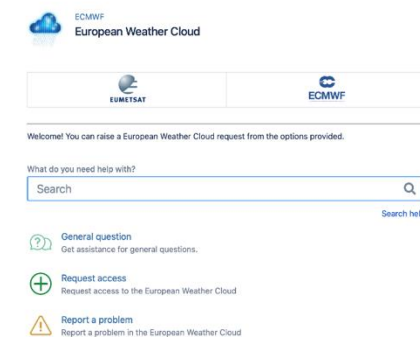
- Pilot project started in 2019 by ECMWF and EUMETSAT
- Operational since 26 September 2023



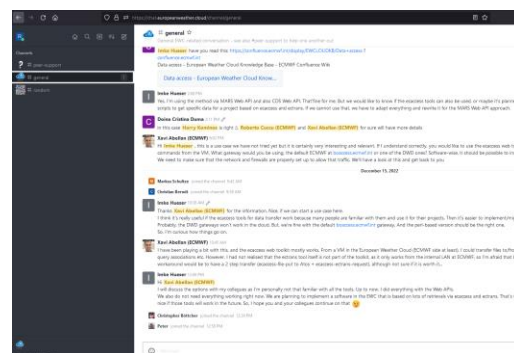
[Main Website](#)



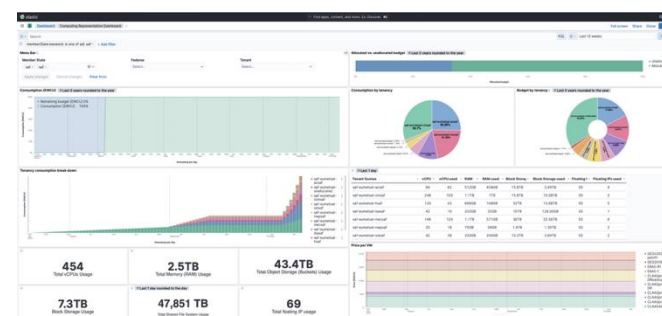
[Knowledge Base](#)



[User Support Portal](#)



[Discussion Platform](#)



[Accounting Platform](#)



EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

www.europeanweather.cloud



EWC – Operational Infrastructure



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

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

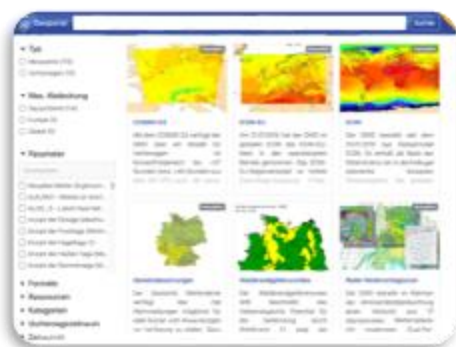
- Hosted externally with 10 Gbps link to EUM
- Sizing may increase in future based on demand
- New Cloud Infrastructure ready in Bologna
- 2 Production clouds - one on each computer hall

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





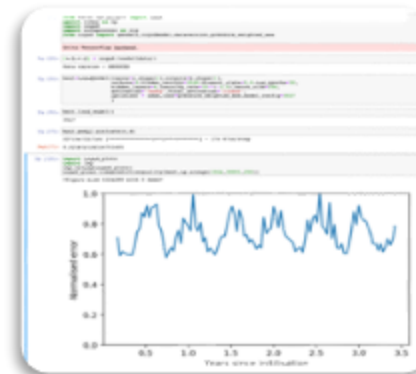
EWC: What could you do with it ?



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



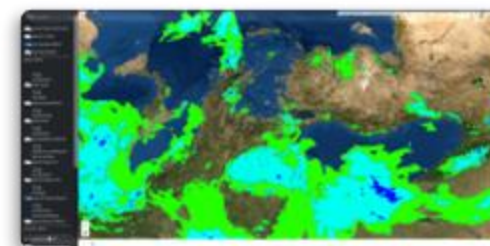
KNMI Climate Explorer setup on EWC



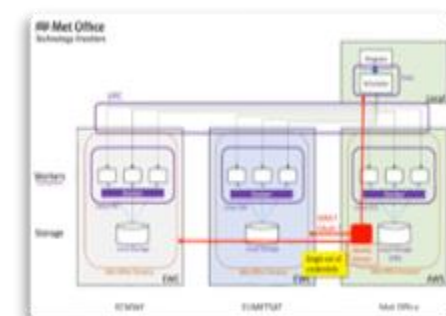
Atmospheric dispersion modelling from RMI



NordSat developing imagery generation tools for satellite products



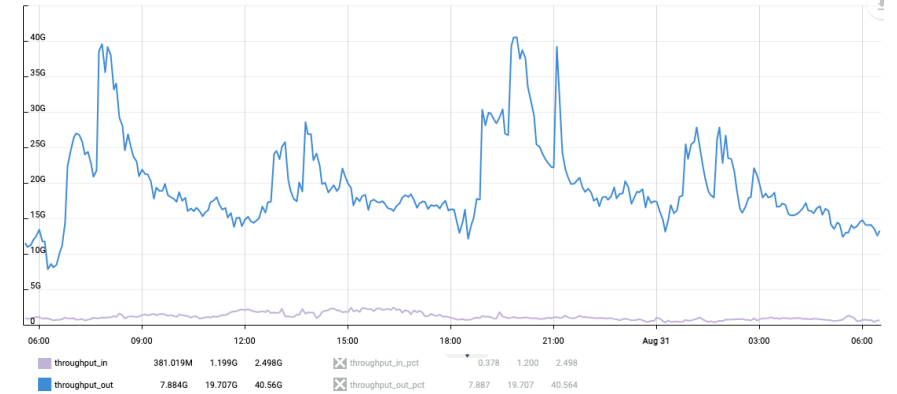
South-East European Multi-Hazard Early Warning Advisory System Common Interface Platform



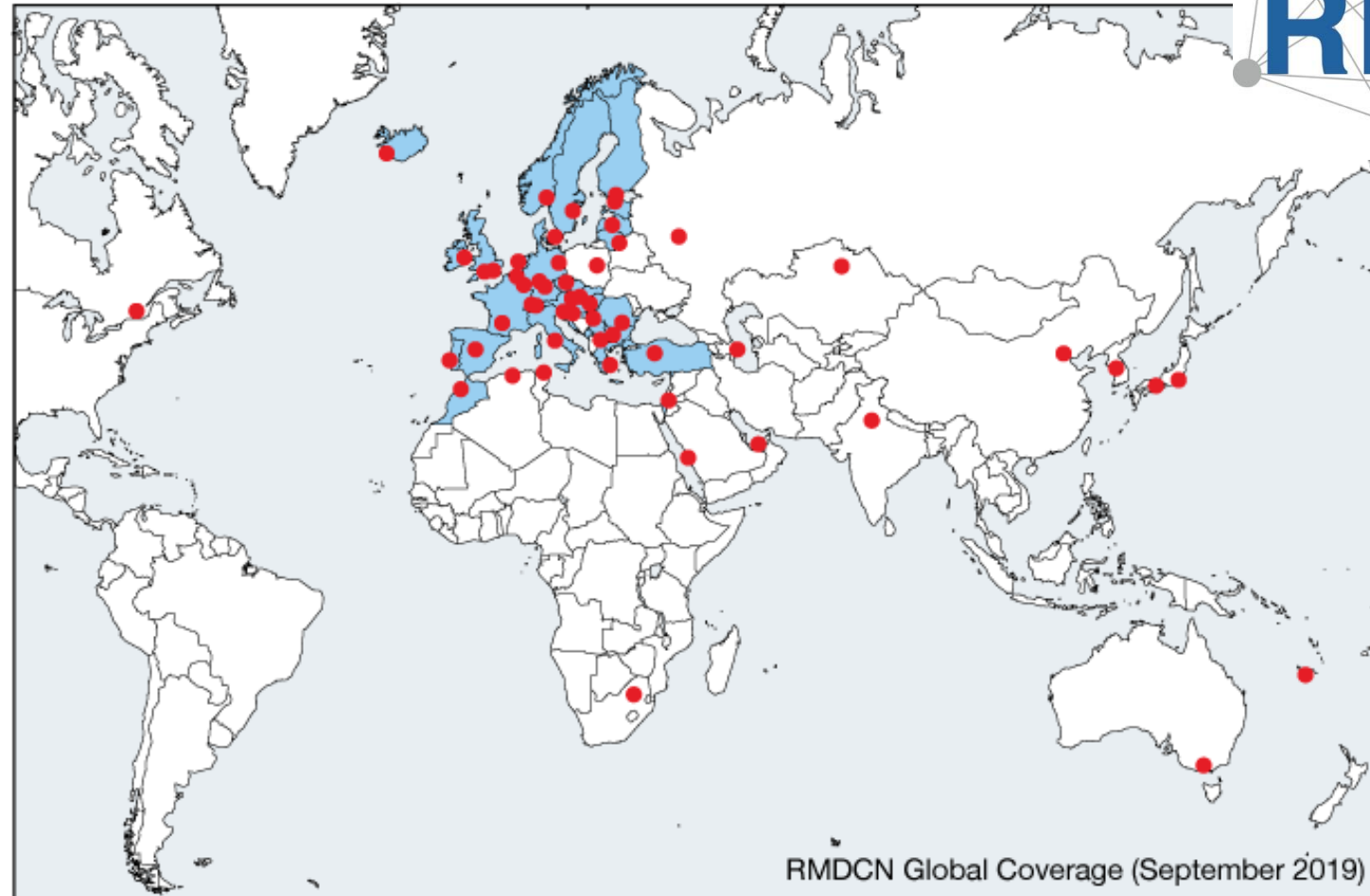
UK Met Office demonstrates Data Proximate Compute use case

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 MPLS (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

ECMWF

Log in to your account

Username or Email
mickey.mouse@disney.com

Password

☐ Remember me

Log in

New user? Register

New user?
An ECMWF account enables you to:

- access open data more quickly
- register for events
- enrol on online courses
- access training resources
- create and track service requests

To check if you are eligible for more features you can read about access to our computing facilities

mickey.mouse@disney.com

☐ MySmartPhone ☐ MyLaptop

One-time code

Log in

Select the device to provide the One-time code

mickey.mouse@disney.com

☐ MySmartPhone ☐ MyLaptop

One-time code
123456

Log in

Enter the 6-digit One-time code provided by the selected device

New user?
An ECMWF account enables you to:

- access open data more quickly
- register for events
- enrol on online courses
- access training resources
- create and track service requests

To check if you are eligible for more features you can read about access to our computing facilities

Accounts

- 825842 john@gmail.com Google
- 720242 john@facebook.com Facebook
- 109764 john@linkedin.com LinkedIn
- 073470 john@dropbox.com Dropbox
- 308005 john@amazon.com Amazon
- 567744 john@yahoo.com Yahoo



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!

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

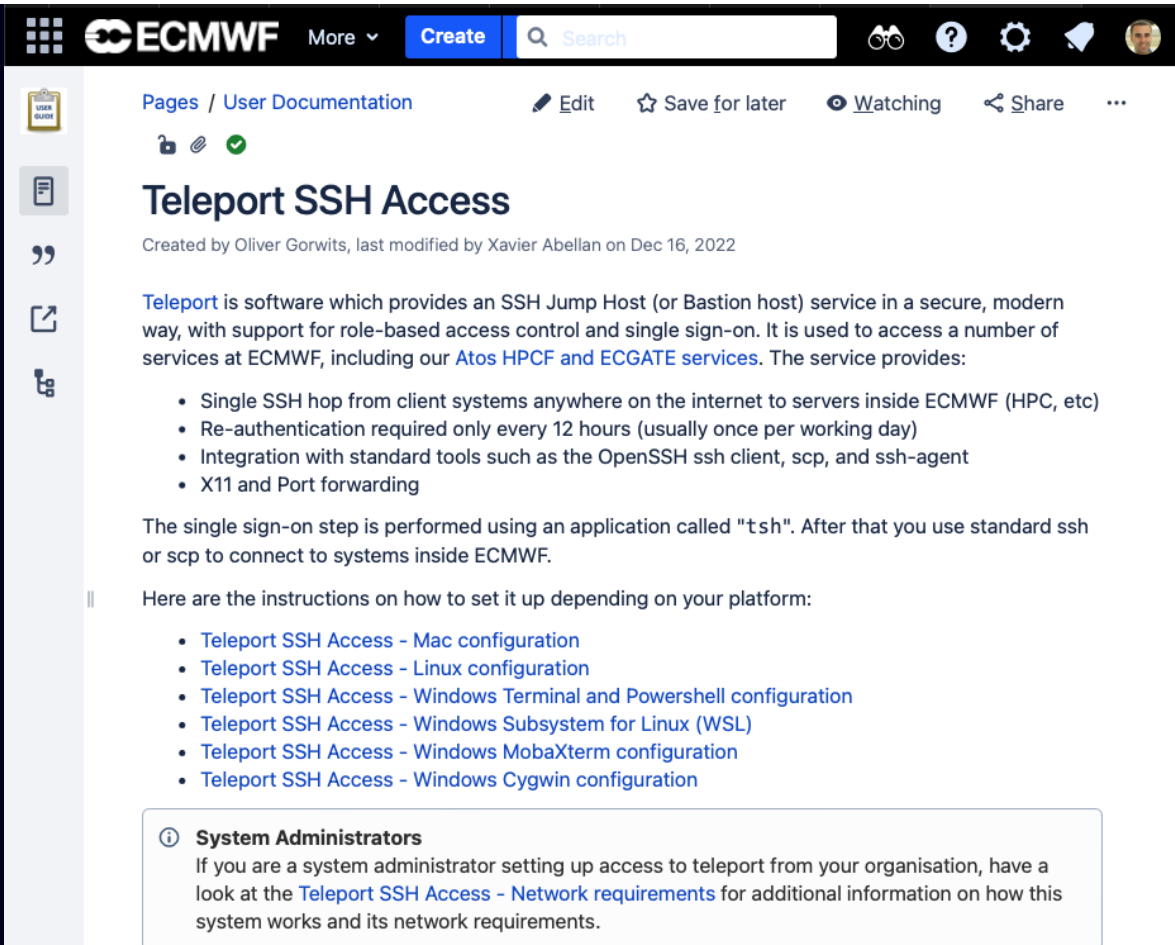
[IMPORTANT] Read carefully the following documentation:

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](#)

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](#)

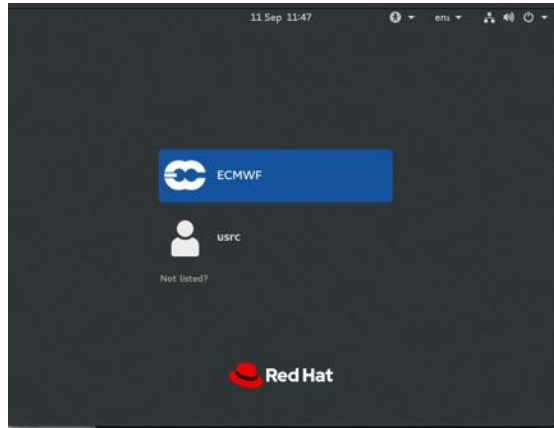
System Administrators
If you are a system administrator setting up access to teleport from your organisation, have a look at the [Teleport SSH Access - Network requirements](#) for additional information on how this system works and its network requirements.



See [Teleport SSH Access](#) documentation

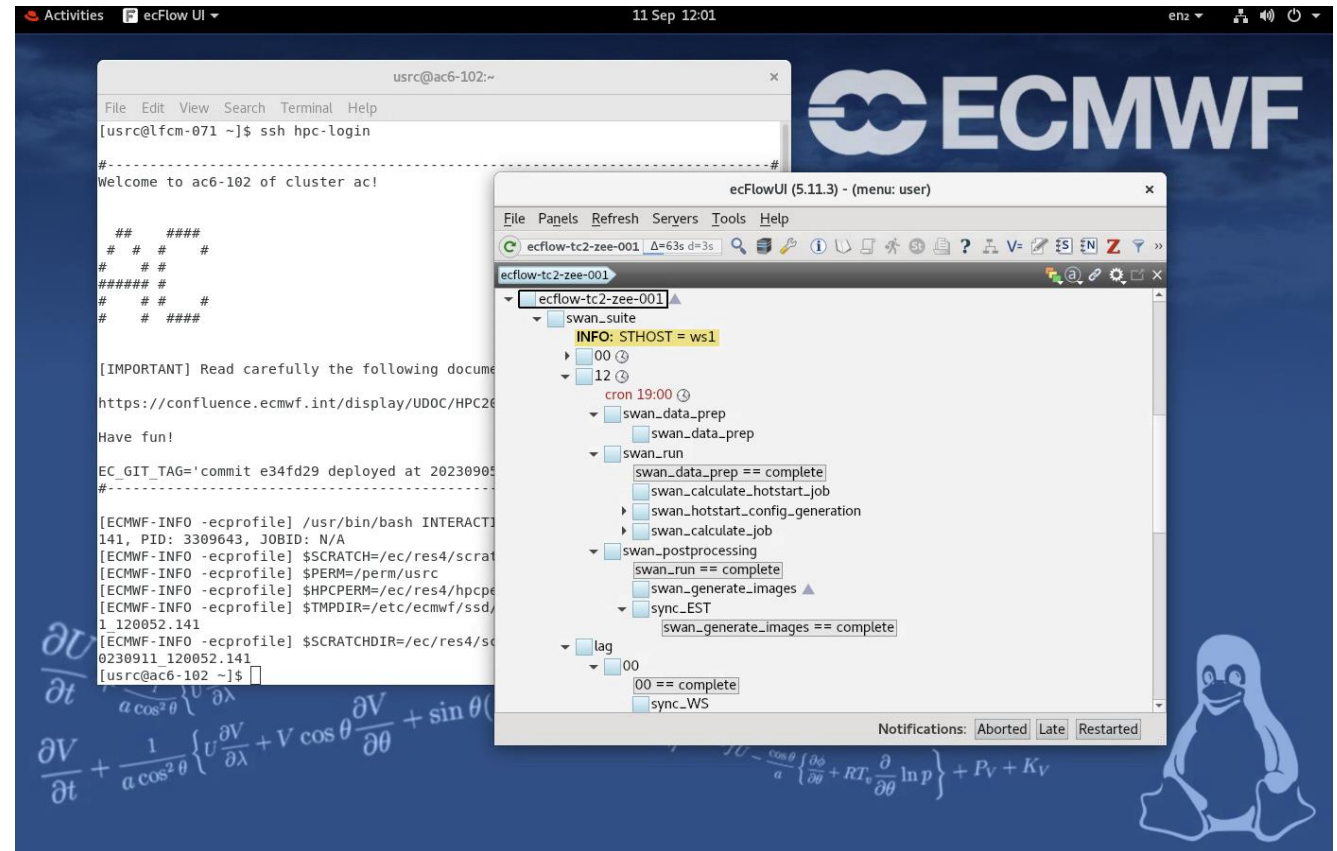
Remote access: the Linux VDI service

<https://desktop.ecmwf.int/>



Limited software installed

- No MARS
- No ECMWF software
- No 3rd party software
- No additional Python packages



See [Linux Virtual Desktop – VDI](#) documentation

Web Services

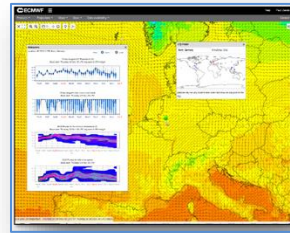


Web services – overview

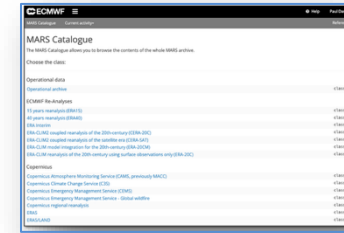
Key service areas



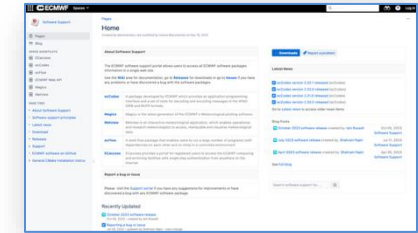
www
Everyone



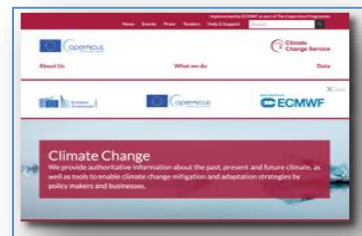
ecCharts
Forecasters



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

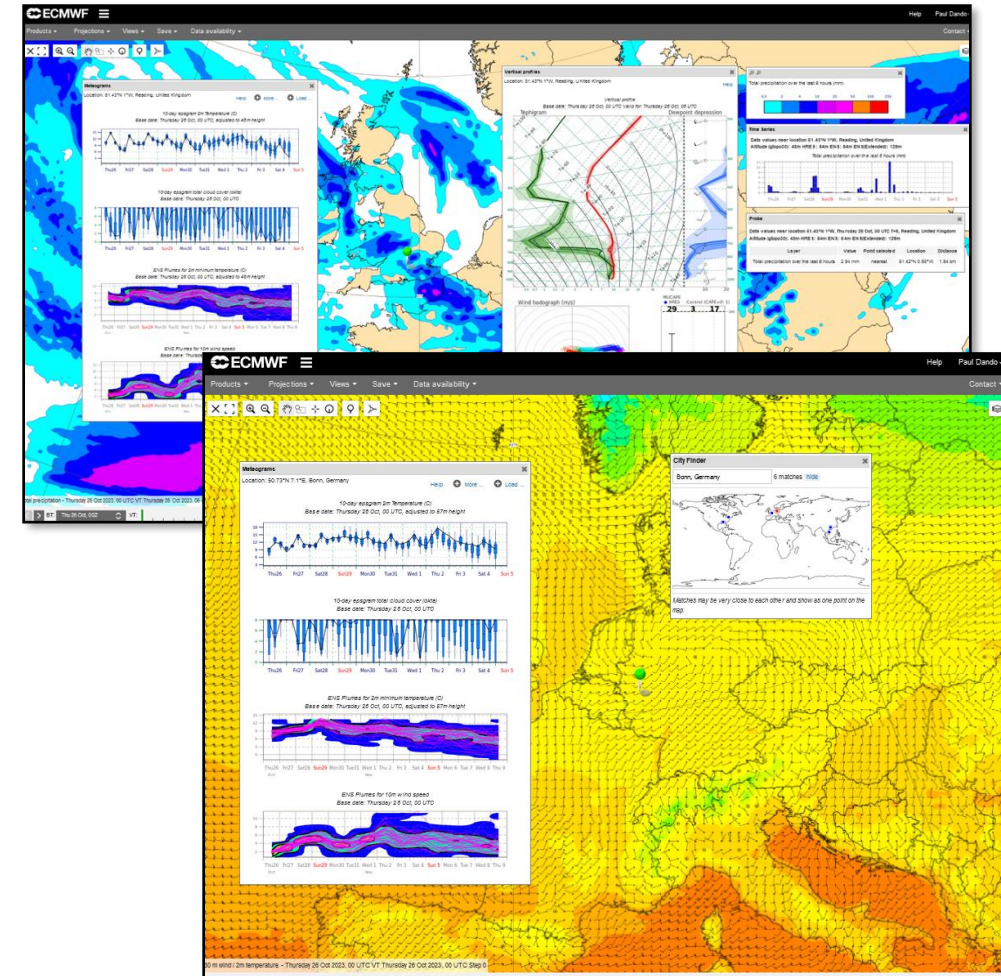
The screenshot displays the ECMWF Open Charts website. The top navigation bar includes links for Home, About, Forecasts, Computing, Research, Learning, and Publications. Below this, a secondary navigation bar lists Charts, Datasets, Quality of our forecasts, About our forecasts, and Access to forecasts. The main content area features a search bar for 'Search ECMWF open charts' and a section titled 'Our Integrated Forecasting System (IFS)' which describes the system's capabilities and provides a link to the quality of the forecasting system. A 'Quick links' section on the left offers shortcuts to the Chart Browser, Chart Dashboard, and ecCharts. The central part of the page shows a 'Charts catalogue' with a search bar and filters for Range (Medium (15 days), Extended (42 days), Long (Months)), Type (Forecasts, Verification), Component (Surface, Atmosphere), and Product type (High resolution forecast (HRES), Ensemble forecast (ENS), Combined (ENS + HRES), Extreme forecast index, Point-based products, Experimental: AIFS). The right side of the page displays four featured charts: 'Mean sea level pressure and 850 hPa wind speed', '500 hPa geopotential height and 850 hPa temperature', and two others showing wind speed and geopotential height. Each chart includes a description and a 'Latest forecast' link.



See [Changes on web charts application](#)

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

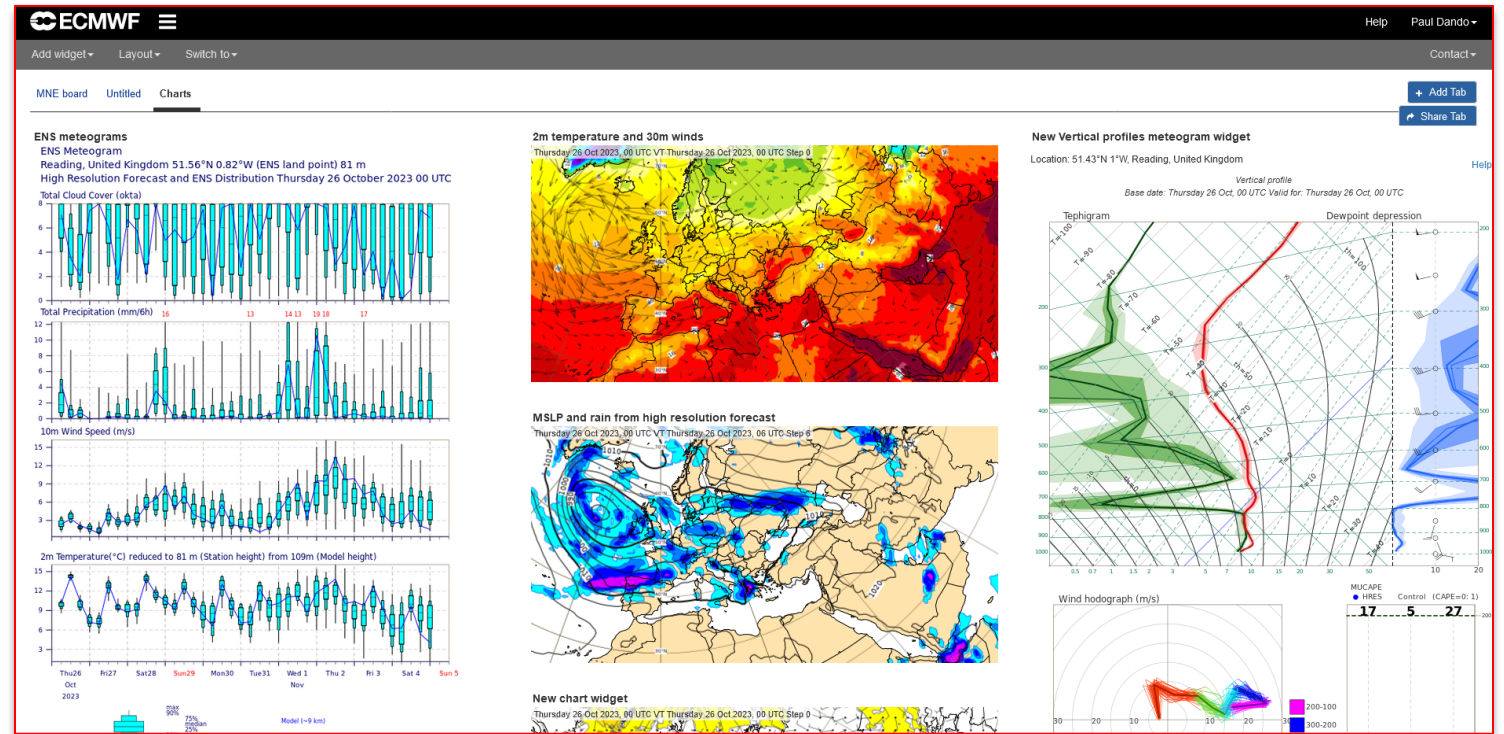
- Highly interactive (products created on-demand)
 - Interactivity (zoom-pan) and animation
 - Layer customisation (e.g. thresholds)
 - Charts with bespoke layers and optional styles
 - HRES, ENS, WAM products
 - Standard and bespoke ENS meteograms
 - Extreme Forecast Indices (EFI)
 - Point probing to 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

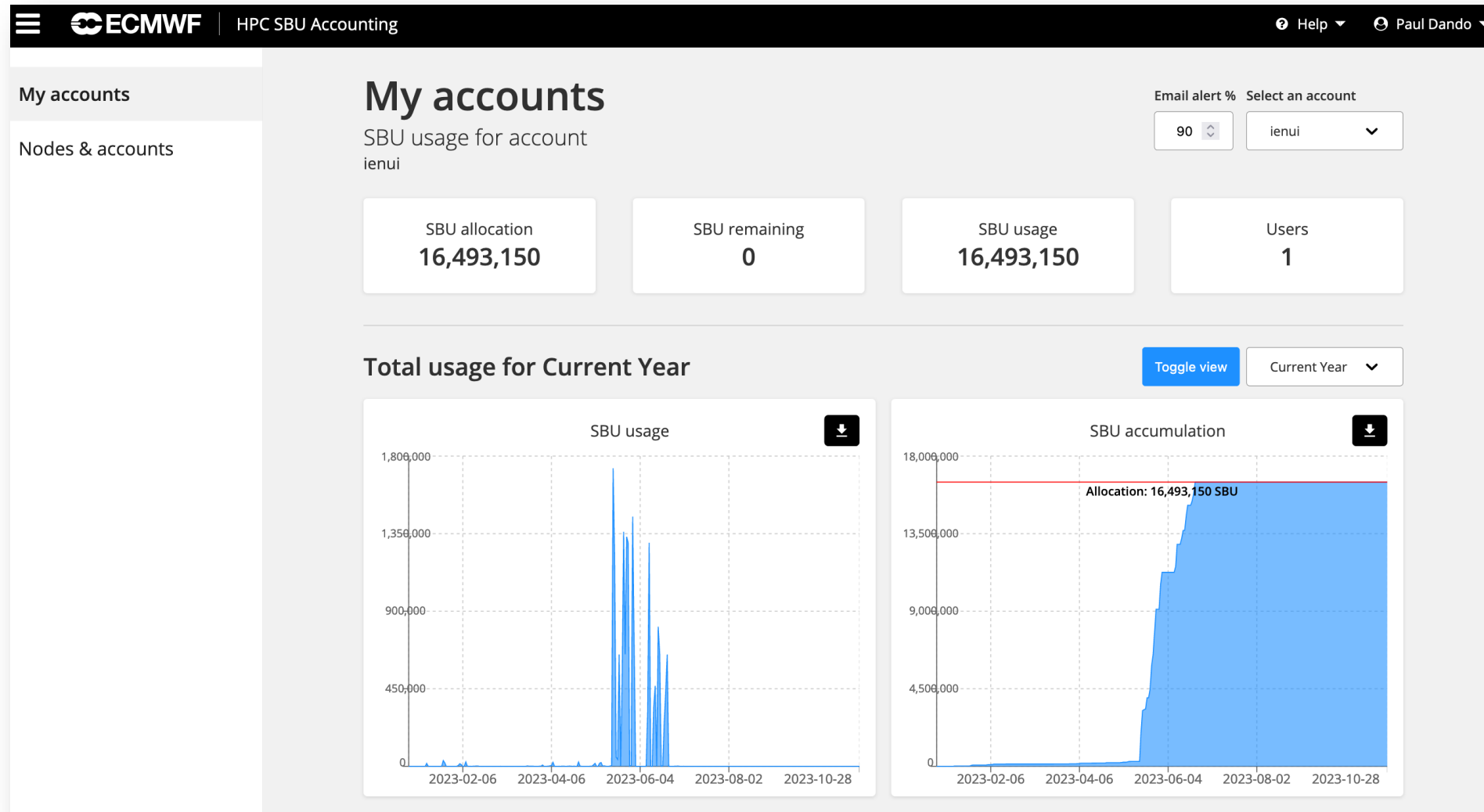


Web Services – MARS <http://apps.ecmwf.int/services/mars/catalogue/>

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

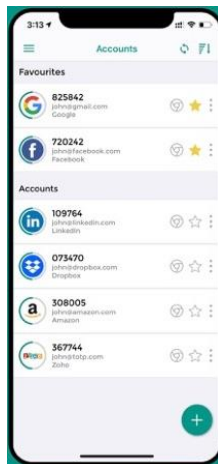
The image shows two overlapping screenshots of the ECMWF website. The background screenshot is the 'MARS Catalogue' page, which provides an overview of the MARS archive and lists various data classes such as 'Operational data', 'Operational archive', 'ECMWF Re-Analyses', and 'Copernicus'. The foreground screenshot is the 'Access MARS' page, which serves as a guide for users to retrieve MARS data via the Web API. It includes an introduction, contact information, useful links, and a step-by-step guide for installation and usage. The step-by-step guide lists eight steps: 1. Download mars, 2. Install ECMWF API client library, 3. Install ECMWF KEY, 4. Test installation, 5. Check availability, 6. MARS examples, 7. Brief MARS request syntax, and 8. Documentation.

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

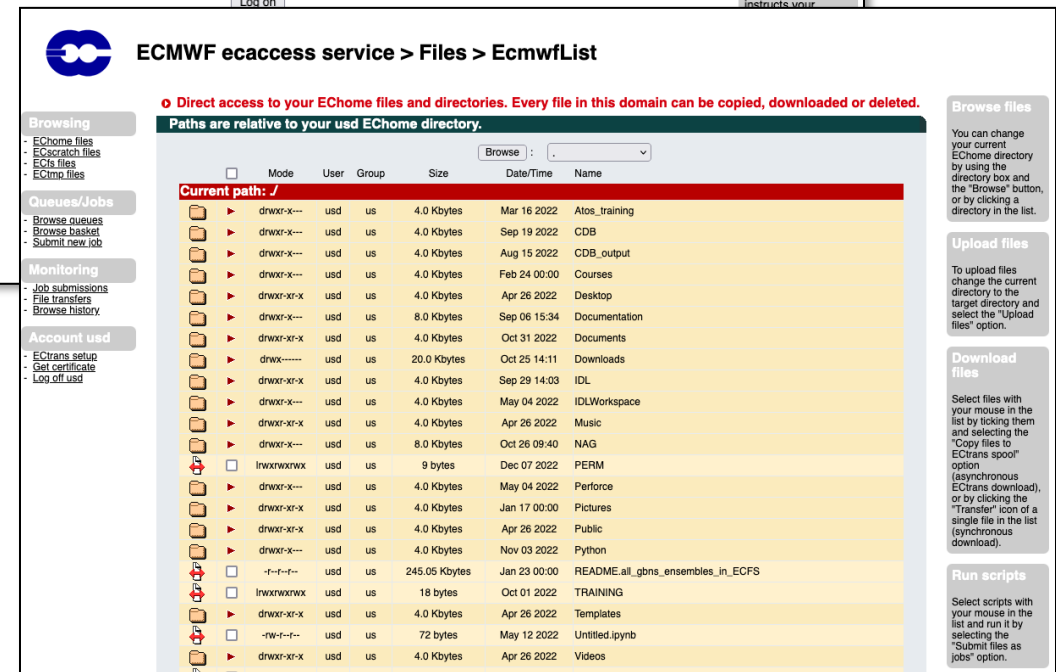
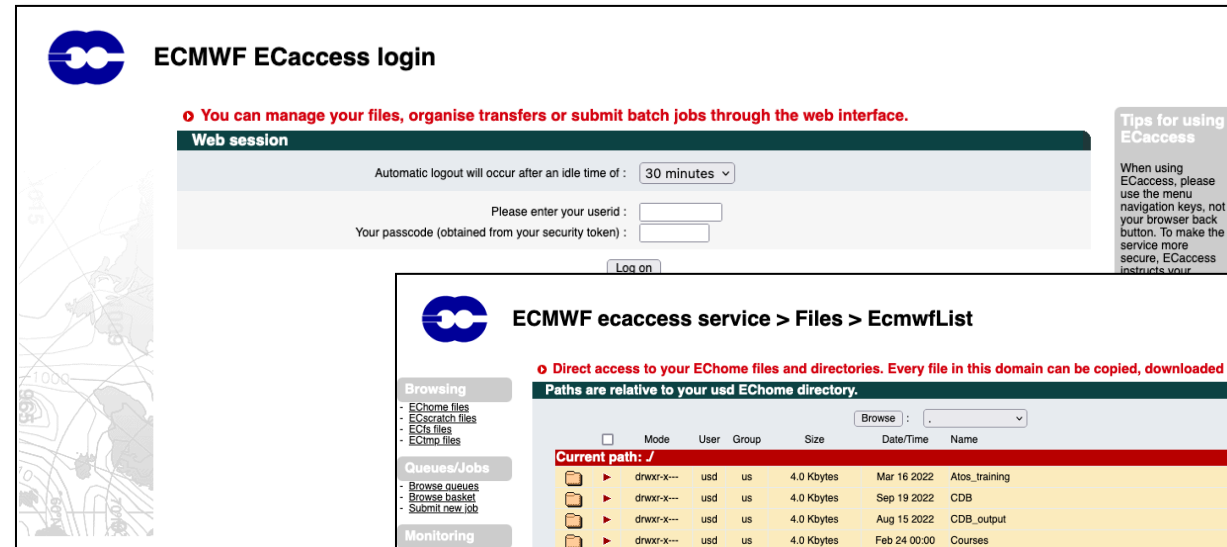


Web Services – <https://boaccess.ecmwf.int>

- 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>

The screenshot shows the ECMWF User Documentation page in Confluence. The page title is "User Documentation" and it includes a welcome message. The left sidebar contains a "Pages" section with a "Browse by content" annotation. The main content area has a "Browse by content" section (annotated with a red box), a "Browse by topic" section (annotated with a blue box), and a "Recent news" section. A search bar is located at the top right, with a "Search" annotation. A "Search this documentation for ..." input field is also present. The "Browse by content" section lists various topics such as "Support portal", "Teleport SSH Access", "Atos HPCF and ECGATE services", "Linux Virtual Desktop - VDI Docu", "MARS user documentation", "ECFS user documentation", "Atlassian suite: JIRA, Confluence, E", "Internal User Documentation", "Time Critical applications", "Model level definitions", "Gaussian grids", "ECMWF software packages - FAQ:", "Machine Learning infrastructure @", "Login and authentication informat", "How-to articles", "Troubleshooting articles", "Obsolete", "Users Multi Factor Authentication", and "Getting started with ECMWF Serv". The "Browse by topic" section lists topics like "Recent", "slurm, batch, job, binding", "Popular", "access atos batch bitbucket bufr cms-publishing computation", "confluence data decode dissemination eccbufr-faqs", "eccodes-faqs ecflow-faqs efficiency encode error faq", "going-further grib hpc hpc2020 job kb-how-to-article kb-information-article kb-troubleshooting-article keys keyword", "leap42 limits linux login magics-faqs mars metview-faqs missing-values packing password performance plots", "python queue server slurm troubleshooting vdi web-publishing webapi webapi-faqs zimbra". The "Recent news" section includes two articles: "Change of default versions of ECMWF software packages - November 2023" and "Change of default versions of ECMWF and third-party software packages - May 2023".

Browse by content

Browse by topic

Search

Search this documentation for ...

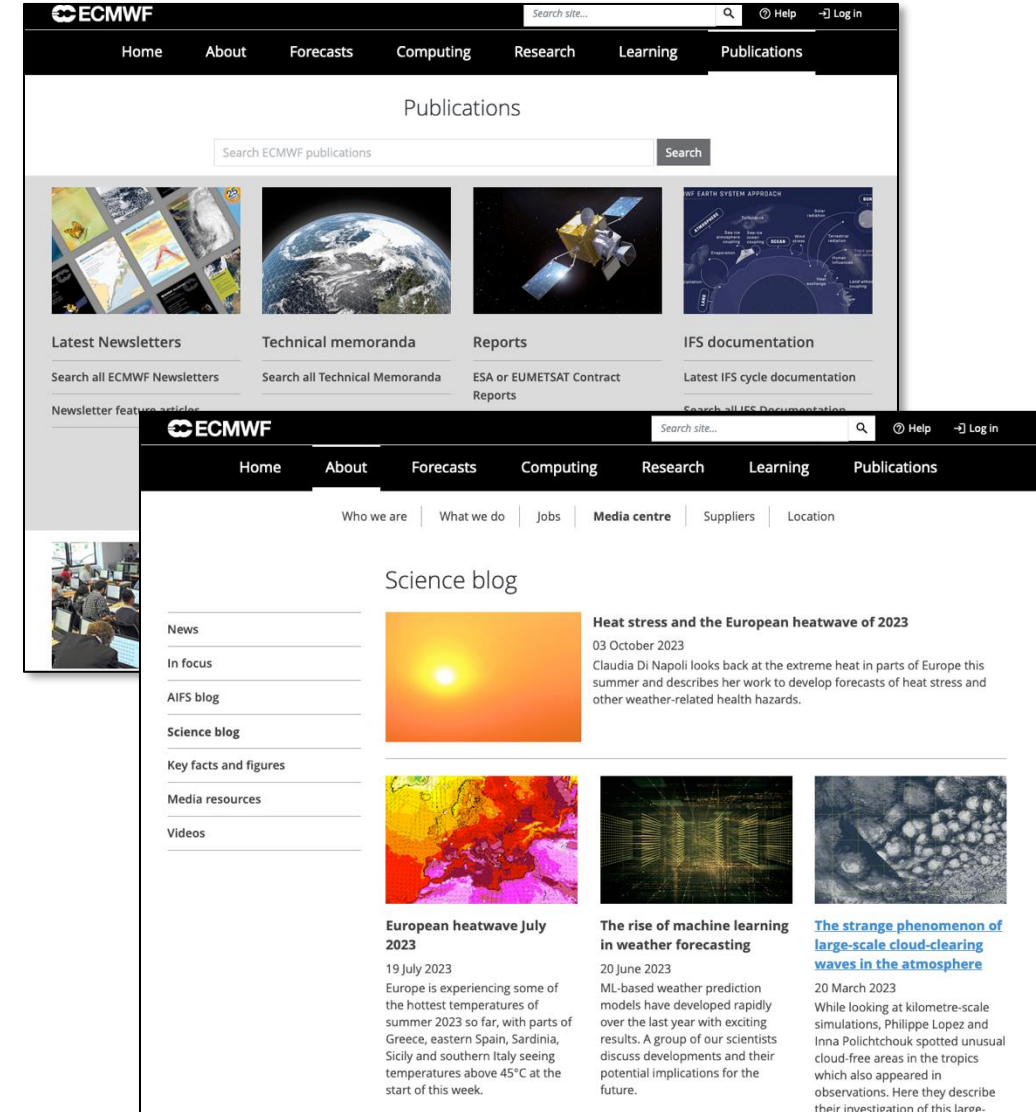
Recent news

Change of default versions of ECMWF software packages - November 2023

Change of default versions of ECMWF and third-party software packages - May 2023

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

ECMWF

Search site... Help Log in

Home About Forecasts Computing Research Learning Publications

Our facilities | Access to computing facilities | Software | **Service status**

Service status

● ACQUISITION	● ATOS	● CADS	● CONNECTIVITY	● DISSEMINATION	● ECACCESS
● ECFS	● EFAS	● EMAIL	● ENVIRONMENT	● European Weather Cloud	● INTERNET
● MARS	● MSACCESS	● prepIFS	● Product Requirements	● RMDCN	● Support Portal
● TELEPHONY	● WEB-SERVICES				

Notifications

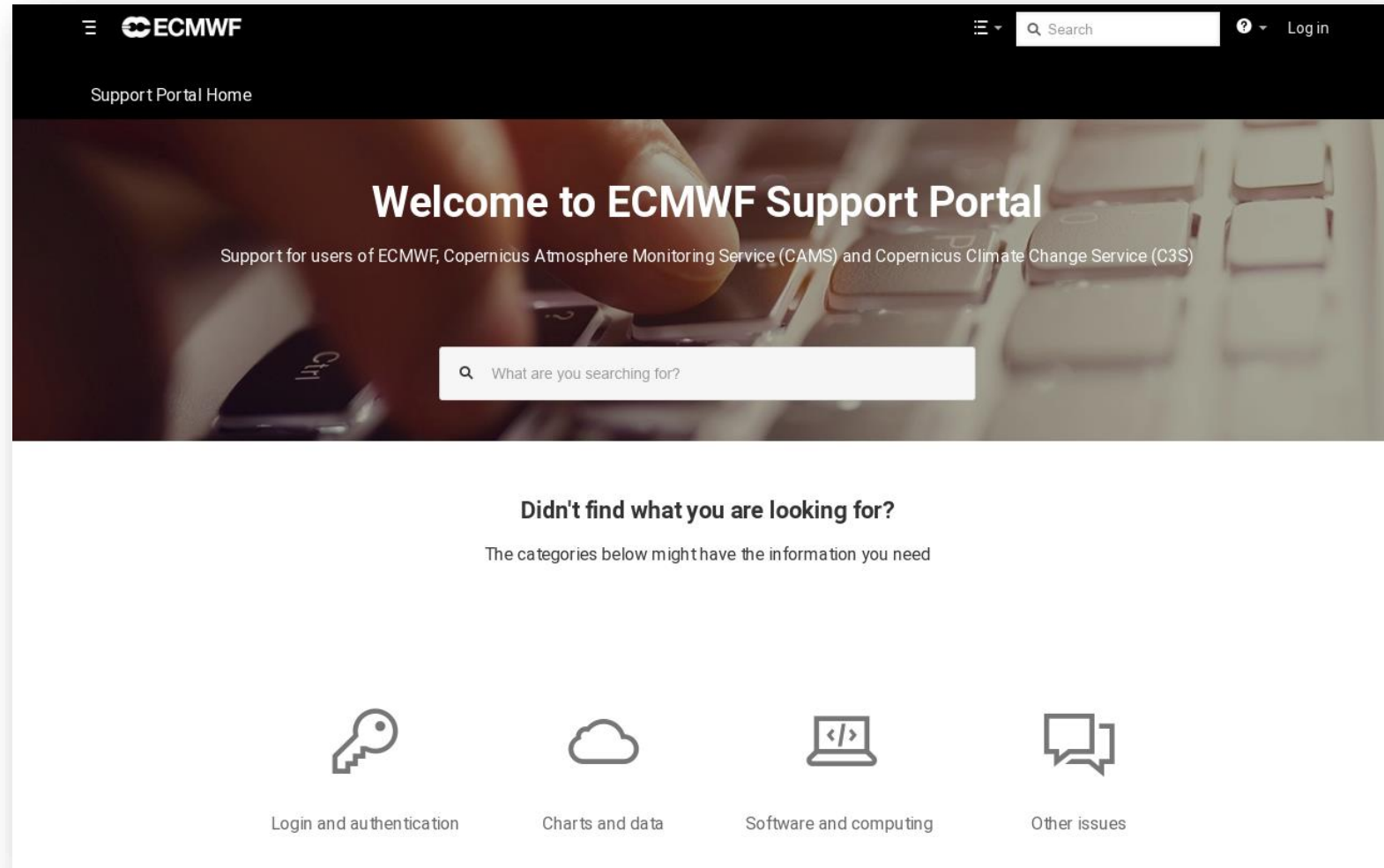
Date range: Last 24h **Last 7 days** Last 30 days All

Show 10 entries Search:

Date created	Service	Notification type	Title	User action required
Thu 26/Oct/2023 13:30:02 UTC	WEB-SERVICES	Start	System Session Starts: eccharts, opencharts, intraplots: Routine update	✓
Thu 26/Oct/2023 12:54:19 UTC	WEB-SERVICES	End	System Session Ends: WebMARS: Redeploy frontend	
Thu 26/Oct/2023 12:30:08 UTC	WEB-SERVICES	Start	System Session Starts: WebMARS: Redeploy frontend	✓
Thu 26/Oct/2023 12:18:51 UTC	ATOS	In Progress	Atos HPCF - filesystem /lus/h2resw01 supporting \$HPCPERM and \$SCRATCH and /ec/fws4	
Thu 26/Oct/2023 10:17:46 UTC	ATOS	Start	\$SCRATCH/\$HPCPERM hanging on Atos HPCF	
Thu 26/Oct/2023 08:00:01 UTC	ECFS, MARS	Start	System Session Starts: Spectralib05 -Control path reconfiguration	✓
Thu 26/Oct/2023 00:21:10 UTC	RMDCN	End	RMDCN Acquisition and Dissemination service back to normal.	
Thu 26/Oct/2023 00:20:05 UTC	CONNECTIVITY	End	Instabilities on the RMDCN network resolved.	

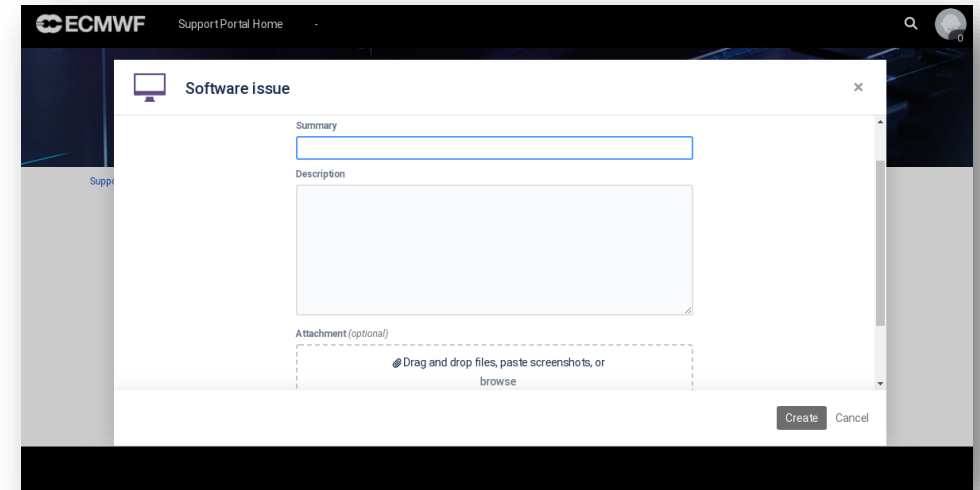
Getting help and reporting problems

<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

A screenshot of the ECMWF Support Portal interface. The page is titled 'Software issue' and contains a form with three main sections: 'Summary' with a text input field, 'Description' with a larger text area, and 'Attachment (optional)' with a dashed box containing the text 'Drag and drop files, paste screenshots, or browse'. At the bottom right of the form are 'Create' and 'Cancel' buttons. The background shows the ECMWF logo and 'Support Portal Home' text.

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

Questions ?

