PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

Climate Change Service climate.copernicus.eu

IMPLEMENTED BY ECMWF

#EUSpace

C3S Seasonal forecasts from ECMWF

Christopher Goddard, Eduardo Penabad, Anca Brookshaw, Tim Stockdale, SWIOCOF, 17th June 2025

Overview

- Introduction to C3S seasonal forecasts
  - Data products
  - Graphical products
  - User tools
- Tropical Cyclone products
- Seasonal system upgrades
  - ECMWF SEAS6


opernicus
CLIMATE CHANGE
MARINE MONITORING
ATMOSPHERE MONITORING
LAND MONITORING
SECURITY
EMERGENCY MANAGEMENT

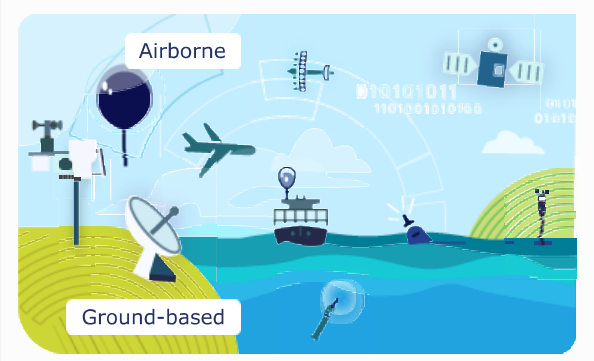
PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

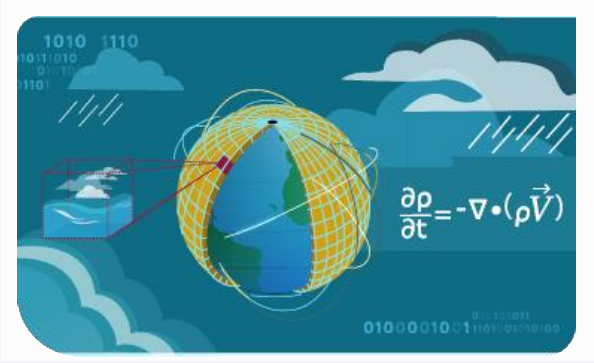
Climate Change Service climate.copernicus.eu

IMPLEMENTED BY ECMWF

EARTH OBSERVATIONS



MODELLING



OUTPUTS: EUROPEAN AND GLOBAL

1. Products

- Historical observations
- Reanalyses
- Seasonal forecasts
- Climate projections

2. Tools to explore further

- Making climate data more directly usable for further exploration and analysis

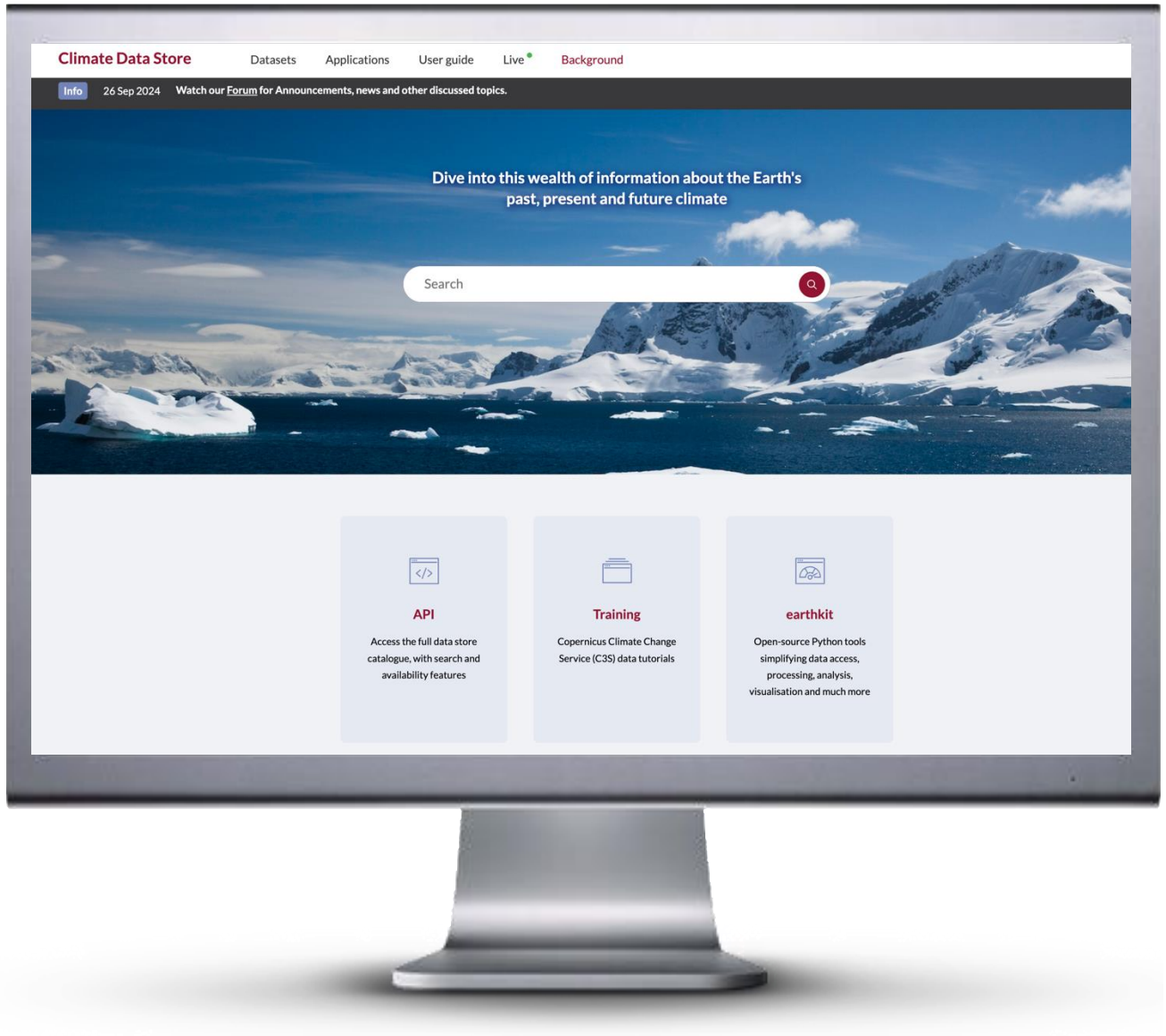
3. Supporting practical use of data

- Applications
- Case studies
- Regular bulletins

USERS

- Industry
- Businesses
- Government and policymakers
- Scientific community
- Media and the public

Implemented by ECMWF, C3S is the climate change information service of Copernicus, the EU's Earth observation programme



Climate data store (CDS)

- Data catalogue (with open data policy)
- API
- Tools
- Web applications
- User support

https://cds.climate.copernicus.eu

Overview of (global) C3S datasets

Observations:

- Approximately 30 satellite essential climate variables (ECVs)
- In-situ observations

Reanalysis:

- ERA5 and ERA5-Land
- ERA5 ARCO-format for sub-regions and temporal aggregations
- ORAS5

Seasonal forecasts:

- daily/monthly/anomalies on single levels
- daily/monthly/anomalies on pressure levels
- monthly data for ocean variables

Climate projections:

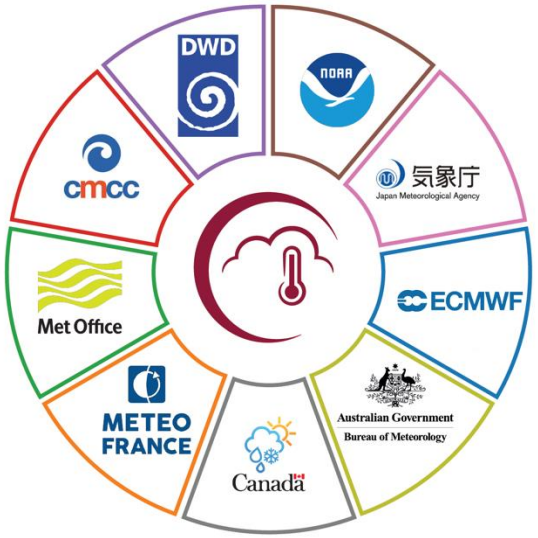
- CMIP5 and CMIP6 global climate projections
- CORDEX-CMIP5 regional climate projections (all domains)

- Dataset underpinning **C3S Atlas** (and IPCC Atlas)
  - Observations/reanalysis/projections
  - Harmonised set of regular grids
  - Pre-computed monthly indices (bias corrected for threshold-based indices)

Data products

cds.climate.copernicus.eu

- Datasets available in the Climate Data Store
  - Atmosphere (38 variables)
    - daily and subdaily data (6h, 12h, 24h)
    - monthly statistics (mean, max, min, standard deviation)
    - bias corrected data (monthly anomalies)
  - Ocean monthly means (12 variables)
- Multi-system retrospective forecasts and real-time forecasts, the latter published on 6th (ECMWF) and 10th day of month (the rest)



CDS API

```
import cdsapi

c = cdsapi.Client()

c.retrieve(
    'seasonal-monthly-single-levels',
    {   'format':'grib',
        'originating_centre':'meteo_france',
        'variable':'total_precipitation',
        'product_type':[
            'ensemble_mean','hindcast_climate_mean'
        ],
        'year':'2018',
        'month':'09',
        'leadtime_month':['1','2','3','4','5','6'] },
    'cds_seasonal_output.grib')
```

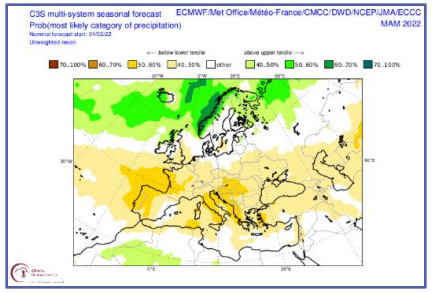
Python workflows

jupyter

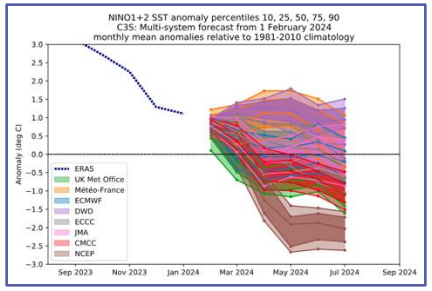
Graphical products

climate.copernicus.eu/charts/packages/c3s_seasonal/

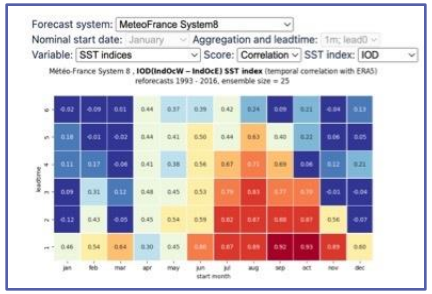
Products for individual contributing systems and multi-system combination



Total precipitation
Near-surface temperature and wind
Mean sea-level pressure
Sea surface temperature
Sea ice concentration
Geopotential height at 500 hPa
Temperature at 850 hPa



Sea surface temperature NINO regions
Sea surface temperature Indian Ocean (IOD)
Zonal mean wind at 10hPa



Temporal correlation
Relative Operating Characteristic (ROC) score
Ranked Probability Score (RPS)

C3S Seasonal user tools: summary

C3S data tutorials:

- Seasonal forecast anomalies
- Seasonal forecast verification
- Installed on CDS Jupyter Hub (in beta status)

ecmwf-projects.github.io/copernicus-training-c3s/

C3S Seasonal workflows:

- Additional examples for user adaptation
- In progress:
  - Reproducing the graphical products
  - Reproducing the NINO indices and verification
  - *More to come…*

ecmwf-projects.github.io/c3s-seasonal-forecasts/

C3S external EQC :

- Quality assessments in response to user questions can serve as further examples
  - Multi-model probabilistic forecast
  - Bias assessment
  - Hit rate for tercile categories

ecmwf-projects.github.io/c3s2-eqc-quality-assessment/

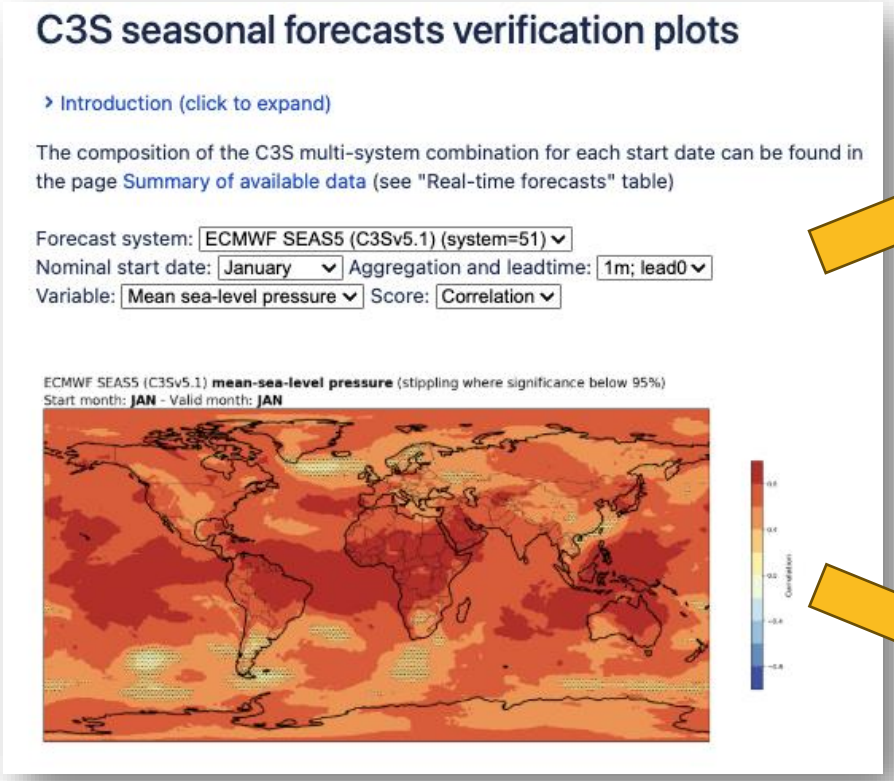
C3S Jupyter Hub:

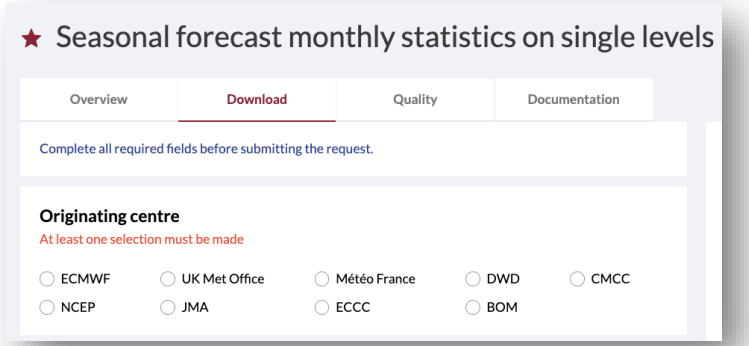
earthkit.readthedocs.io/en/latest/

Earthkit:

jupyterhub.ecmwf.int/

Verification example





Ingredients available to reproduce this for other variables

CDS datasets

- Daily/monthly/anomaly data for single and pressure levels
- Monthly data available for ocean variables

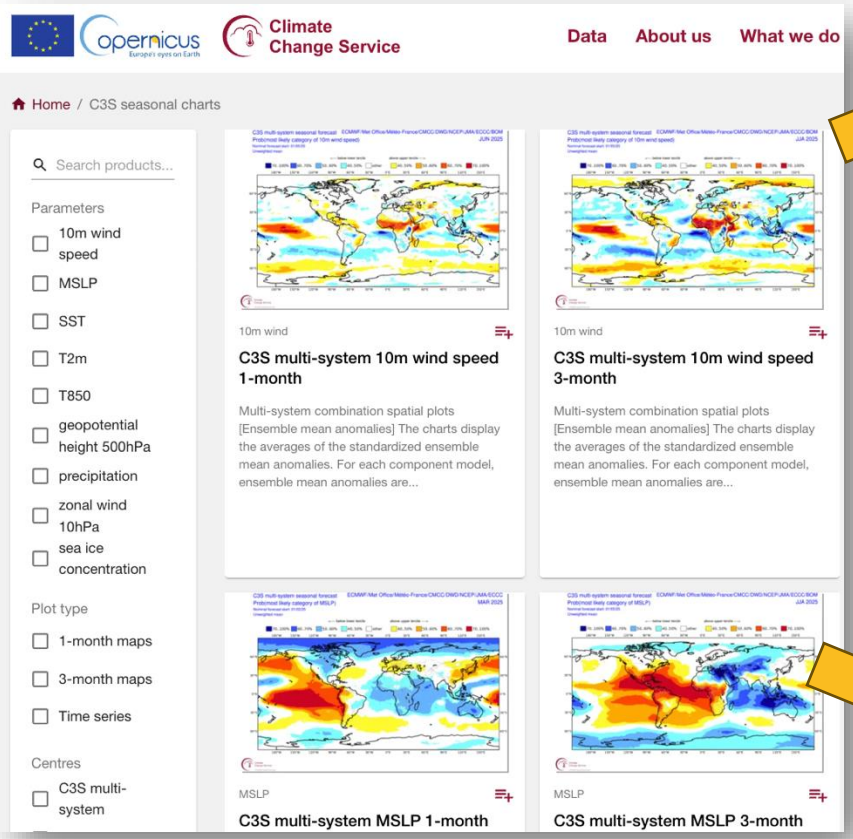
Code:

- Training Notebook on verification

confluence.ecmwf.int/display/CKB/C3S+seasonal+forecasts+verification+plots

Products example

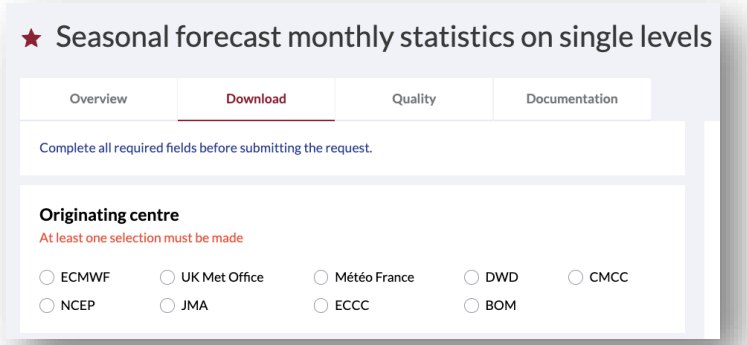
C3S seasonal example on reproducing graphical products:

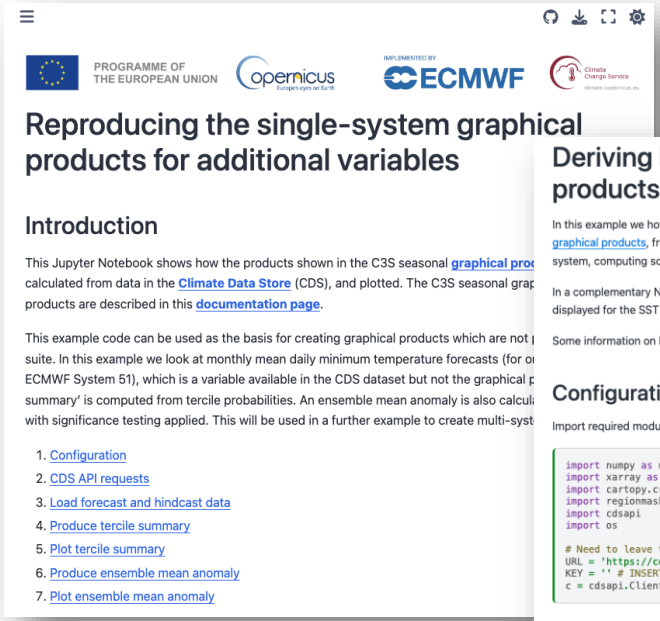


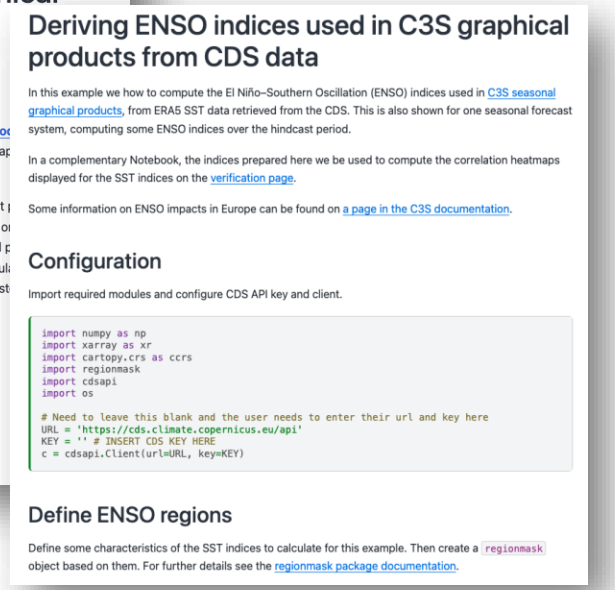
Ingredients available to reproduce this for other variables

CDS data:

- Daily/monthly/anomaly data for single and pressure levels
- Monthly data available for ocean variables







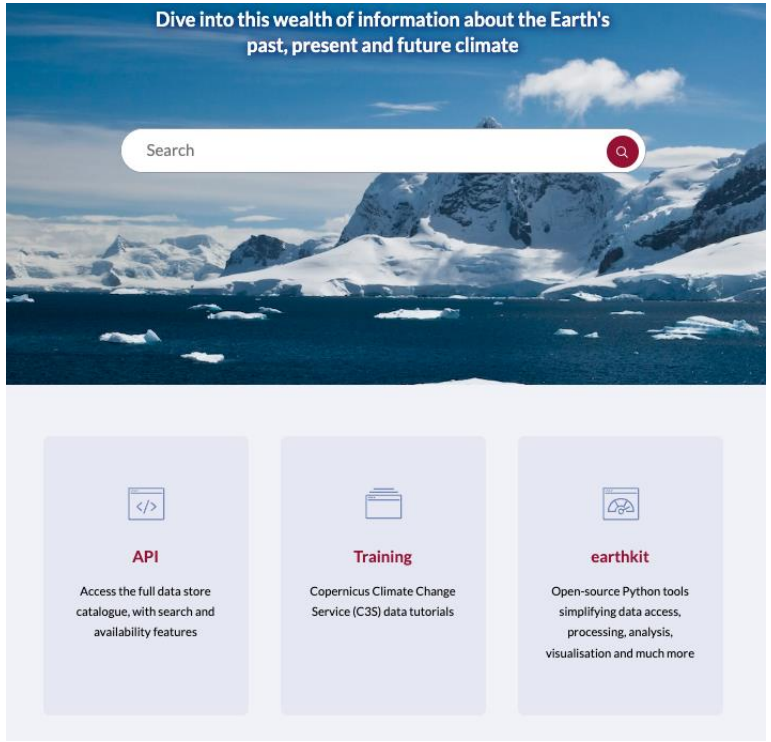
Code:

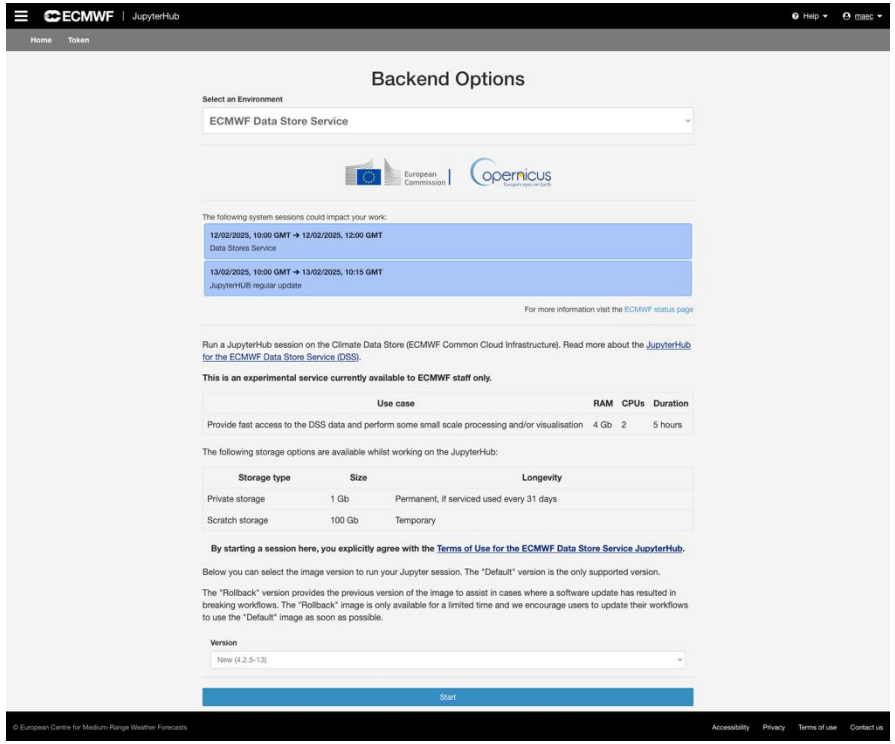
- Notebooks related to graphical products

climate.copernicus.eu/charts/packages/c3s_seasonal/

C3S data store Jupyter Hub service

- C3S Data Store Service (DSS) Jupyter Hub (experimental/beta status)
  - Documentation: *confluence.ecmwf.int/pages/viewpage.action?pageId=462526111*
  - Jupyter Hub (Select Data Store Service): *jupyterhub.ecmwf.int/*





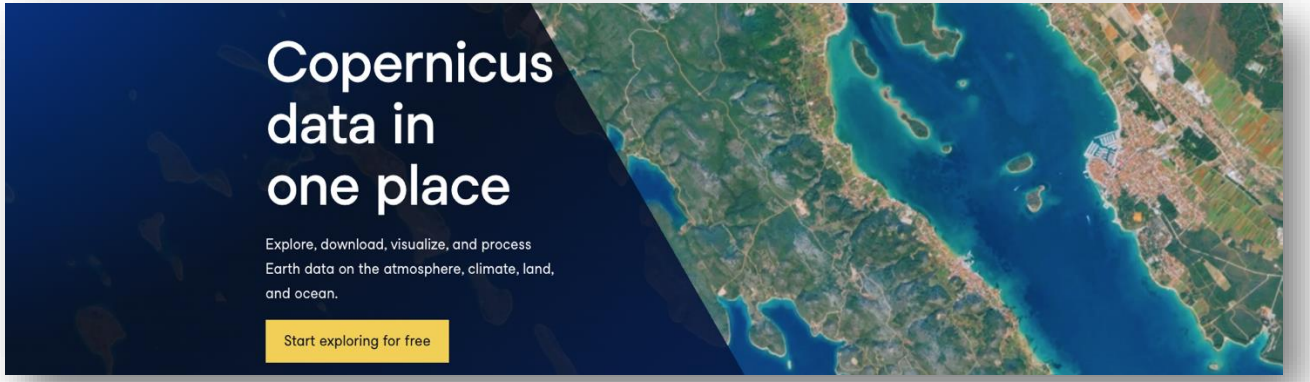
Other cloud platforms

Binder: *mybinder.org/*

Kaggle: *www.kaggle.com/*

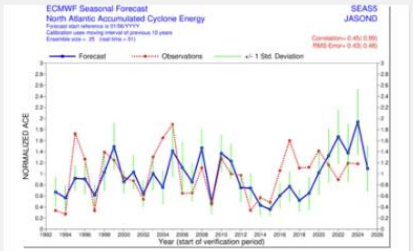
Colab: *colab.google/*

Wekeo: *wekeo.copernicus.eu/*



SEAS5 tropical cyclone products

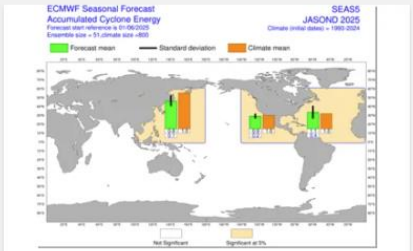
charts.ecmwf.int/



Seasonal forecast verification

Accumulated Cyclone Energy (Verification) – Long Range Forecast – SEAS5

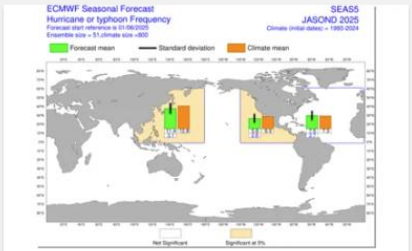
This chart provides information on the verification of forecasts of Accumulated Cyclone Energy ...



Latest seasonal forecast

Accumulated Cyclone Energy – Long Range Forecast – SEAS5

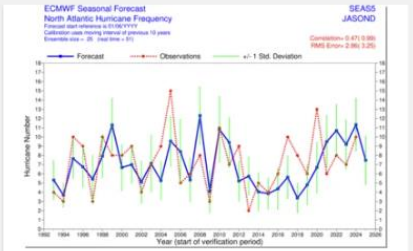
The ECMWF seasonal forecasts (SEAS5) are produced every month with a 51-member ensemble at a ...



Latest seasonal forecast

Hurricane/Typhoon Frequency – Long Range Forecast – SEAS5

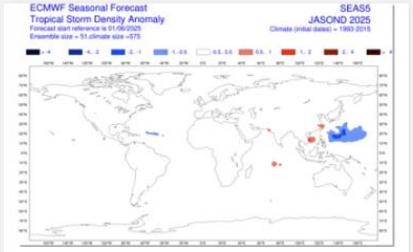
The ECMWF seasonal forecasts (SEAS5) are produced every month with a 51-member ensemble at a ...



Seasonal forecast verification

Hurricane/Typhoon Number (Verification) – Long Range Forecast – SEAS5

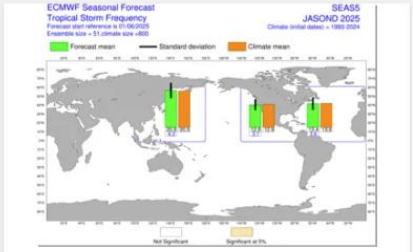
This chart provides information on the verification of forecasts of the number of tropical ...



Latest seasonal forecast

Tropical Storm Density Anomaly – Long Range Forecast – SEAS5

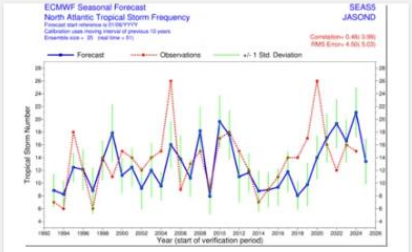
The ECMWF seasonal forecasts (SEAS5) are produced every month with a 51-member ensemble at a ...



Latest seasonal forecast

Tropical Storm Frequency – Long Range Forecast – SEAS5

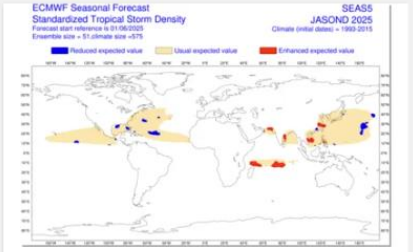
The ECMWF seasonal forecasts (SEAS5) are produced every month with a 51-member ensemble at a ...



Seasonal forecast verification

Tropical Storm Number (Verification) – Long Range Forecast – SEAS5

This chart provides information on the verification of forecasts of the expected number of ...



Deterministic verification

Tropical Storm Standardised Density – Long Range Forecast – SEAS5

The ECMWF seasonal forecasts (SEAS5) are produced every month with a 51-member ensemble at a ...

- Accumulated cyclone energy (and verification)
- Tropical storm frequency (and verification)
- Hurricane/Typhoon frequency (and verification)
- Tropical storm density (anomaly)

Tracks are not published!

Future C3S Seasonal tropical cyclone products

- Follow WMO guidance on encoding cyclone tracks (BUFR format)
- Plan to track TCs in SEAS6 (for 13-month integrations) and publish the tracks
- In the longer term the same tracking will be deployed for other C3S seasonal systems

For medium range (up to 10 days):

www.ecmwf.int/en/forecasts/datasets/wmo-essential#Essential_Tropical

WMO Essential

These products are available to the public and their use is governed by the Creative Commons CC-4.0-BY licence. This means WMO Essential data may be redistributed and used commercially, subject to attribution.

These products are only available with a 0.5° by 0.5°grid.

- Based on HRES
- Based on ENS
- Tropical cyclones

New:Tropical cyclones for 06/18 cycles are available

Access the data files (permission may be required) ›

Licence:

View licence

```
Filenames follow the WMO standards
The list of products that you see is based on your login credentials
```

```
A_JSXX06ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70E_-90p9degW_10p7degN_bufr4.bin     17-05-2025 07:41        25301    597396337
A_JSXX07ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71E_-106p5degW_9p8degN_bufr4.bin     17-05-2025 07:41        16102    597396339
A_JSXX08ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72E_-108p5degW_13p1degN_bufr4.bin    17-05-2025 07:41         9329    597396341
A_JSXX09ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_73E_-101p3degW_13p1degN_bufr4.bin    17-05-2025 07:41         6433    597396343
A_JSXX10ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_74E_-89p8degW_9p8degN_bufr4.bin      17-05-2025 07:41         5527    597396345
A_JSXX11ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70L_-40p2degW_54p1degN_bufr4.bin     17-05-2025 07:41        15596    597396347
A_JSXX12ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71L_-75p5degW_11degN_bufr4.bin      17-05-2025 07:41        14141    597396349
A_JSXX13ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72L_-40degW_54degN_bufr4.bin        17-05-2025 07:41         8697    597396351
A_JSXX14ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_73L_-19p2degW_5p6degN_bufr4.bin     17-05-2025 07:41         6555    597396353
A_JSXX15ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_74L_-69p7degW_11p4degN_bufr4.bin    17-05-2025 07:41         5638    597396355
A_JSXX16ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70C_-142p7degW_4p5degN_bufr4.bin    17-05-2025 07:41         5888    597396357
A_JSXX17ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71C_-177p9degW_3p9degN_bufr4.bin    17-05-2025 07:41         5256    597396359
A_JSXX18ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70A_73p4degE_18p1degN_bufr4.bin     17-05-2025 07:41         5992    597396361
A_JSXX19ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71A_67degE_14p4degN_bufr4.bin       17-05-2025 07:41        24812    597396363
A_JSXX20ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72A_74degE_14p3degN_bufr4.bin       17-05-2025 07:41        14464    597396365
A_JSXX21ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_73A_66p7degE_13p8degN_bufr4.bin     17-05-2025 07:41         8137    597396367
A_JSXX22ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_74A_65p5degE_16p7degN_bufr4.bin     17-05-2025 07:41         5347    597396369
A_JSXX23ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_75A_71p4degE_17p8degN_bufr4.bin     17-05-2025 07:41         3719    597396371
A_JSXX24ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_76A_59p4degE_22p6degN_bufr4.bin     17-05-2025 07:41         3543    597396373
A_JSXX25ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70B_83p8degE_13p5degN_bufr4.bin     17-05-2025 07:41        25947    597396375
A_JSXX26ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71B_83p6degE_12p7degN_bufr4.bin     17-05-2025 07:41         8804    597396377
A_JSXX27ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72B_86p2degE_12p7degN_bufr4.bin     17-05-2025 07:41         9279    597396379
A_JSXX28ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_73B_87p3degE_17degN_bufr4.bin       17-05-2025 07:41         5977    597396381
A_JSXX29ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_74B_82p1degE_14degN_bufr4.bin       17-05-2025 07:41         6332    597396383
A_JSXX30ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70S_57degE_-6p6degS_bufr4.bin       17-05-2025 07:41        10118    597396385
A_JSXX31ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71S_86p6degE_-11p2degS_bufr4.bin    17-05-2025 07:41         6130    597396387
A_JSXX32ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72S_68p2degE_-17p8degS_bufr4.bin    17-05-2025 07:41         2842    597396389
A_JSXX33ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70U_95p3degE_-11degS_bufr4.bin      17-05-2025 07:41        23951    597396391
A_JSXX34ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71U_128p8degE_-6p2degS_bufr4.bin    17-05-2025 07:41        19836    597396393
A_JSXX35ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72U_107p5degE_-12p6degS_bufr4.bin   17-05-2025 07:41        13370    597396395
A_JSXX36ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_73U_147p2degE_-10degS_bufr4.bin     17-05-2025 07:41         8604    597396397
A_JSXX37ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_74U_103p1degE_-6p9degS_bufr4.bin    17-05-2025 07:41         6315    597396399
A_JSXX38ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_75U_100p6degE_-6p9degS_bufr4.bin    17-05-2025 07:41         5804    597396401
A_JSXX39ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_70P_175p3degE_-6p5degS_bufr4.bin    17-05-2025 07:41        12246    597396403
A_JSXX40ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_71P_162degE_-9degS_bufr4.bin        17-05-2025 07:41         6286    597396405
A_JSXX41ECEP170000_C_ECMP_20250517000000_tropical_cyclone_track_72P_161p4degE_-11degS_bufr4.bin     17-05-2025 07:41         5292    597396407
```

Tropical cyclone

Tropical cyclone activity (including genesis)

Time

Mon 16 Jun 2025 00 UTC

Cyclone product

Strike probability

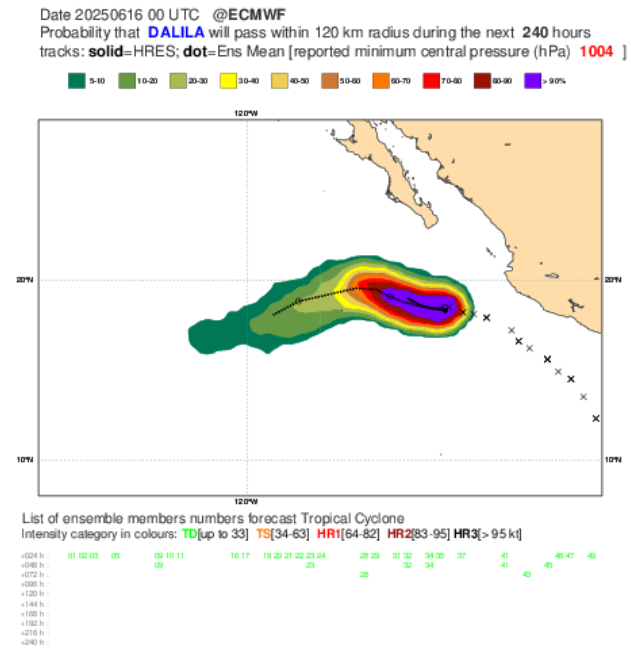
Latest cyclones

- DALILA (04E) - Region 02
- WUTIP (01W) - Region 04
- 02W (02W) - Region 04
- 04E (04E) - Region 01
- COSME (03E) - Region 02
- BARBARA (02E) - Region 01
- 01W (01W) - Region 04
- 03E (03E) - Region 02
- ALVIN (01E) - Region 01
- 01E (01E) - Region 02

Recent searches

SEARCH

charts.ecmwf.int/products/cyclone



C3S Seasonal: new features

System upgrades

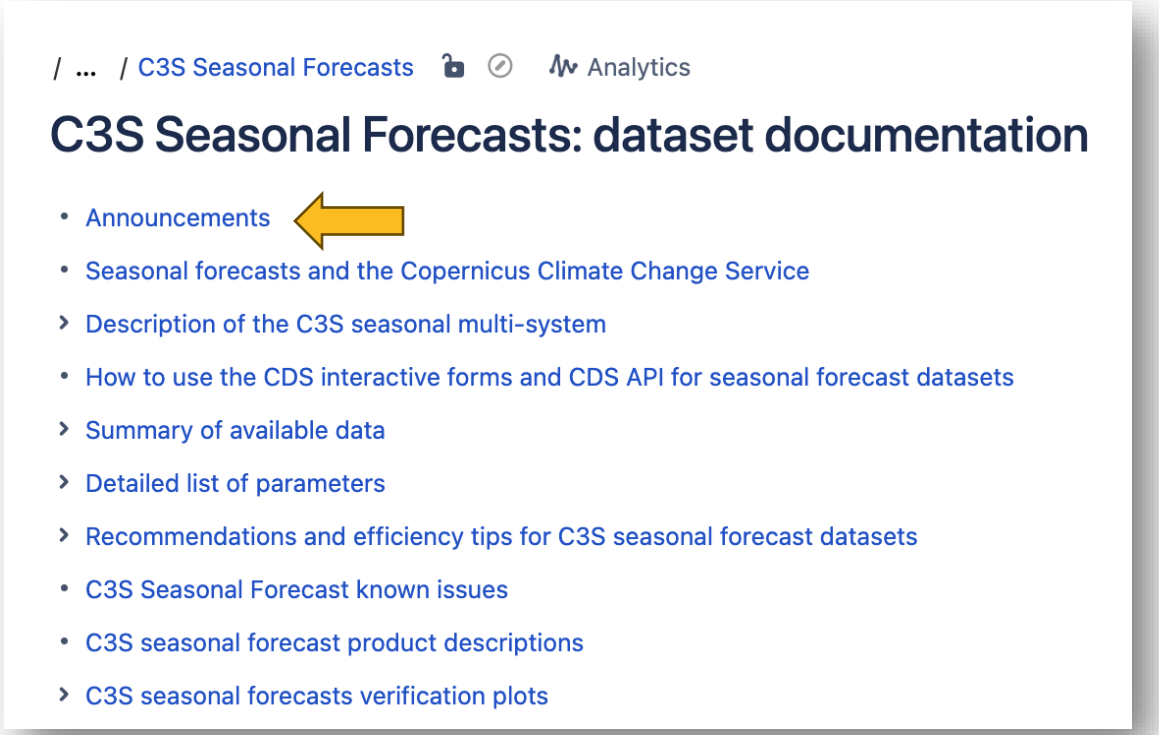
- Recently in production
  - DWD GCFS2.2
  - MF System9
  - BOM ACCESS-S2 (new contributing centre)

- Coming soon
  - CMCC SPS4
  - ECMWF SEAS6

Other incoming features

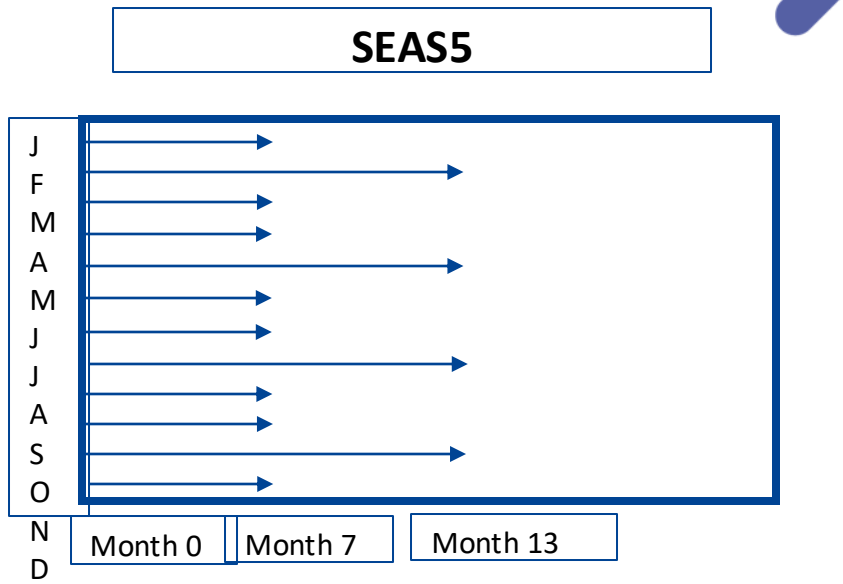
- Graphical products as data
- Working towards an updated hindcast period
- GRIB2 encoding

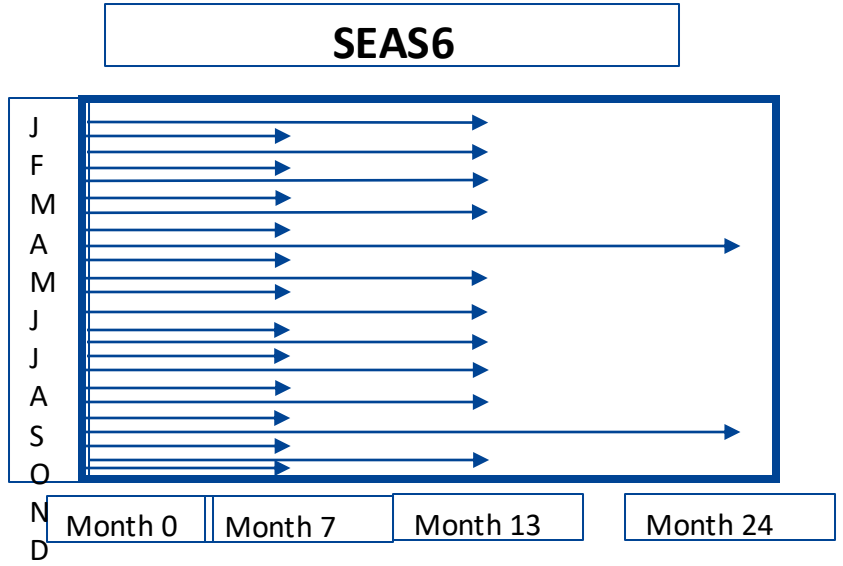
https://confluence.ecmwf.int/display/CKB/C3S+Seasonal+Forecasts



SEAS6 configuration summary

- **Enhancement 1: Real-time 101-member ensemble**
- **Enhancement 2: Issue SEAS twice per month**
  - Initial date 1st and 16th of each month
- **Enhancement 3: More comprehensive reforecasts**
  - Larger ensemble sizes and larger set of years
- **Enhancement 4: Expand annual-range ENSO forecasts**
  - Issue forecast monthly not quarterly
  - Twice per year, increase range to 24 months





Slide courtesy of Tim Stockdale (ECMWF)

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

Climate Change Service climate.copernicus.eu

IMPLEMENTED BY ECMWF

#EUSpace

Thank you