AI Weather Quest

ECMWF

Enhancing sub-seasonal predictions with AI/ML: A competition by ECMWF, endorsed by WMO

What's next? Webinar

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AI Weather Quest

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Enhancing sub-seasonal predictions with AI/ML: A competition by ECMWF, endorsed by WMO

Updated Python Package
Step by step guide

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Agenda

- ✓ The AI Weather Quest in a nutshell
- ✓ The extended framework
- ✓ Zoom in on new variables
- ✓ Step-by-step guide to participate
- ✓ How to engage with the community
- ✓ Question and answers

This session is being recorded.
The recording will be made available online after the webinar. If you do not wish to appear, please turn off your camera.

Please mute your microphone.
Please keep yourselves muted during presentations. You are welcome to ask questions during the Q&As.

The AI Weather Quest in a nutshell

The **ECMWF AI Weather Quest** is a **global benchmark and learning framework** launched in August 2025 to compare ML models for sub-seasonal weather prediction. It is open to all (researchers, tech companies, forecasting institutions, etc.).

Participants currently produce global weekly forecasts for **weeks 3–4** ahead for the following variables:

- Near-surface (2m) temperature (tas)
- Mean sea level pressure (mslp)
- Precipitation (pr)

Forecasts are **evaluated weekly** against reference observational datasets, and results are published live:

The Quest has established a global community fostering evidence and exchange on ML-based S2S skill

Strong participation

250+ Competitors

55+ Teams

100+ Models

Broad usability & uptake

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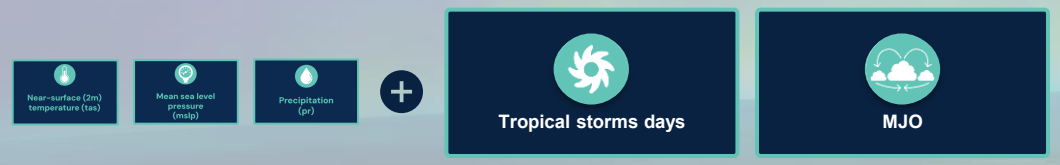
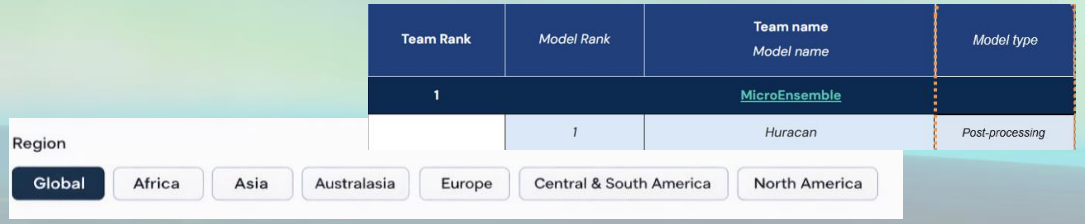
The extended framework - Overview

Building on the success of the first forecasting year, the Quest will continue beyond August 2026 as a long-term benchmarking and learning infrastructure, with an expanded scientific framework and new improvements.

Participants will be able to produce weekly forecasts for weeks 3–4 for **two additional variables**:



Continental evaluation views and clear **information on model types** will be provided on the leaderboards:

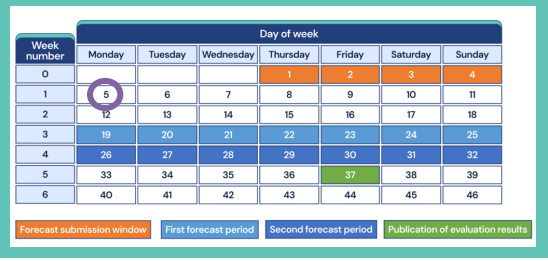


Strong participation

Where capacity exists, **participation by African institutions** will be supported through targeted outreach **aligned with ArcX-linked initiatives and WMO networks**.

Broad usability & uptake

Access to submitted data will be granted on day 5:



Zoom in on new variables: Tropical storm days

Tropical storms days

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What is it?

Tropical storms (TSs) are intense low-pressure systems.

On sub-seasonal timescales, predicting precise TS characteristics is challenging, hence we focus on the number of tropical storm days within a given oceanic basin.

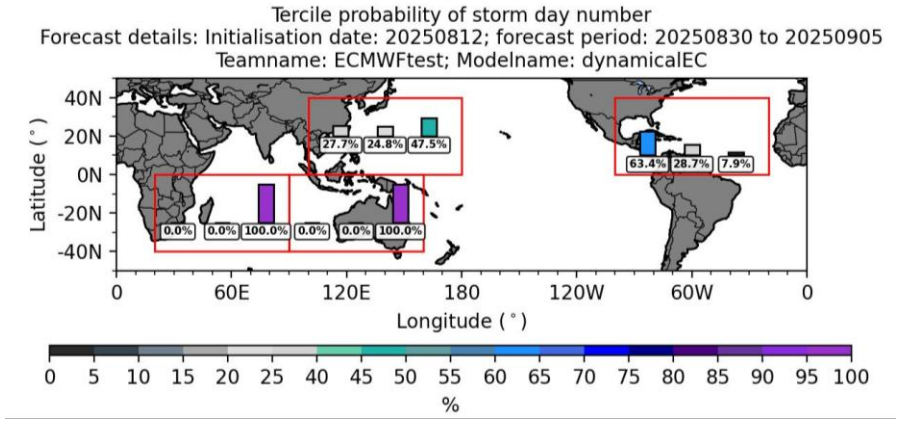
A tropical storm day is defined as a day on which a tropical storm (> 17 m s^{-1}) is present within a given ocean basin.

What are we asking for?

Probability that the weekly sum of storm day count sits within tercile bins of historical conditions.

Basins only forecasted during active periods.

Week number	Day of week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0				1	2	3	4
1	5	6	7	8	9	10	11
2	12	13	14	15	16	17	18
3	19	20	21	22	23	24	25
4	26	27	28	29	30	31	32
5	33	34	35	36	37	38	39
6	40	41	42	43	44	45	46



How will we evaluate?

- Observed TS days taken from latest release of IBTrACS.
- Similar to global metrics, Ranked Probability Skill Scores (RPSSs) will be computed.
- Tercile bounds computed using IBTrACS-derived 20-year historical climatology, +/- 4 days at two-day intervals.

Available training data

- IBTrACS weekly-total of tropical storm days per basin.
- Available from 1979 to one year behind present day.

Detailed description of evaluation and training in **ReadtheDocs**.

Zoom in on new variables : Madden-Julian Oscillation

MJO

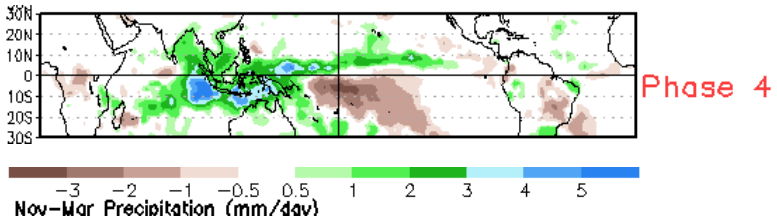
AI Weather Quest ECMWF

What is it?

The Madden-Julian Oscillation (MJO) is a:

- large-scale mode of sub-seasonal variability;
- enhancement and suppression of tropical deep convection.
- influence tropical and extra-tropical weather conditions.

MJO state is defined using a real-time multivariate (RMM) index (WH04) which is then classified into eight phases, each corresponding to the approximate location of the MJO state.

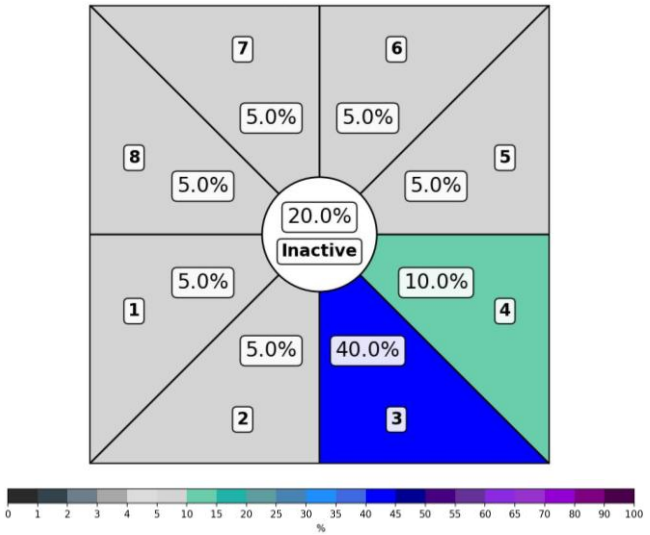


NOAA, accessed 2026

What are we asking for?

Probabilistic forecasts for each MJO phase (including inactive) for every Thursday.

Week number	Day of week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0				1	2	3	4
1	5	6	7	8	9	10	11
2	12	13	14	15	16	17	18
3	19	20	21	22	23	24	25
4	26	27	28	29	30	31	32
5	33	34	35	36	37	38	39
6	40	41	42	43	44	45	46



How will we evaluate?

- Observed MJO computed for ERA5T.
- Forecasts skill will be assessed relative to a seasonally-varying climatology (20-years ERA5, +/- 4 days at two-day intervals).
- Brier Skill Score will be leaderboard metric.

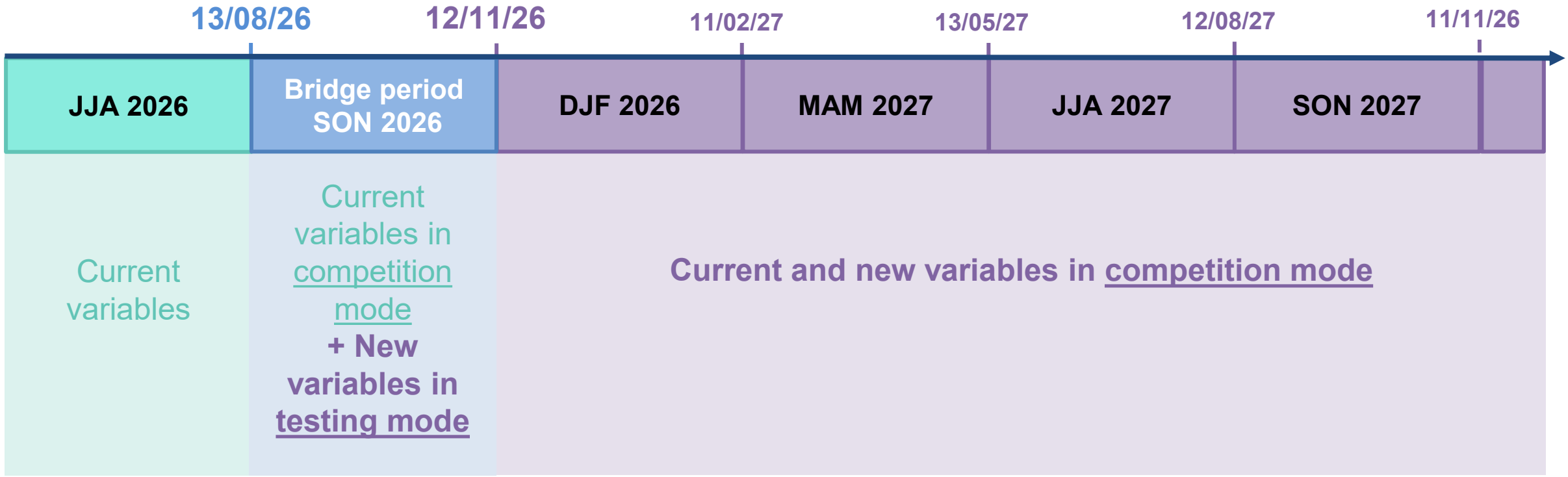
$$BSS = 1 - \frac{BS_{fc}}{BS_{clim}} \; where \; BS_x = \overline{(x-o)^2}$$

Available training data

- Pre-computed ERA5-derived MJO characteristics.
- Available from 1979 to 4 months behind present day.

Detailed description of evaluation and training in **ReadtheDocs**.

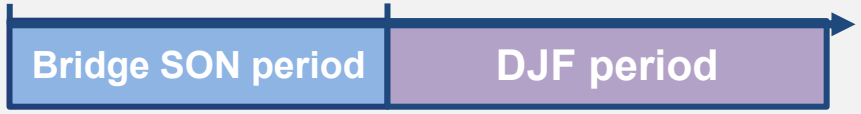
The extended framework - Timeline



Zoom on the new variables : The Bridge Period structure

AI Weather Quest ECMWF

13/08/26 12/11/26



Bridge Period: **Trial forecast submission, visualisation and self-evaluation** of new variables in a non-competitive environment.

Week number	Day of week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0				1	2	3	4
1	5	6	7	8	9	10	11
2	12	13	14	15	16	17	18
3	19	20	21	22	23	24	25
4	26	27	28	29	30	31	32
5	33	34	35	36	37	38	39
6	40	41	42	43	44	45	46

Forecast submission window | First forecast period | Second forecast period | Publication of evaluation results

Key dates:
Submission window: **Days 1 to 4**
Publish successful submissions: **Day 5**
Publish forecast scores: **Day 37**

Week	Initialisation date (Day 1)	Submission closes (Day 4)	Publication of submitted model names (Day 5)	Week 3 commencing date (Day 19)	Week 4 commencing date (Day 26)	Self-evaluate (Day 37)
-13	Thursday 13-Aug	Sunday 16-Aug	Monday 17-Aug	Monday 31-Aug	Monday 7-Sep	Friday 18-Sep
... 8 weeks ...						
-5	Thursday 8-Oct	Sunday 11-Oct	Monday 12-Oct	Monday 26-Oct	Monday 2-Nov	**Friday 13-Nov**
-1	Thursday 5-Nov	Sunday 8-Nov	Monday 9-Nov	Monday 23-Nov	Monday 30-Nov	Friday 11-Dec
1	**Thursday 12-Nov**	Sunday 15-Nov	N/A (data published!)	Monday 30-Nov	Monday 7-Dec	Friday 18-Dec

13 weeks to check new variables forecast submission is successful.

Every Monday An excel file will be updated on the forum to include the **model names of all successful submissions** for new variables.

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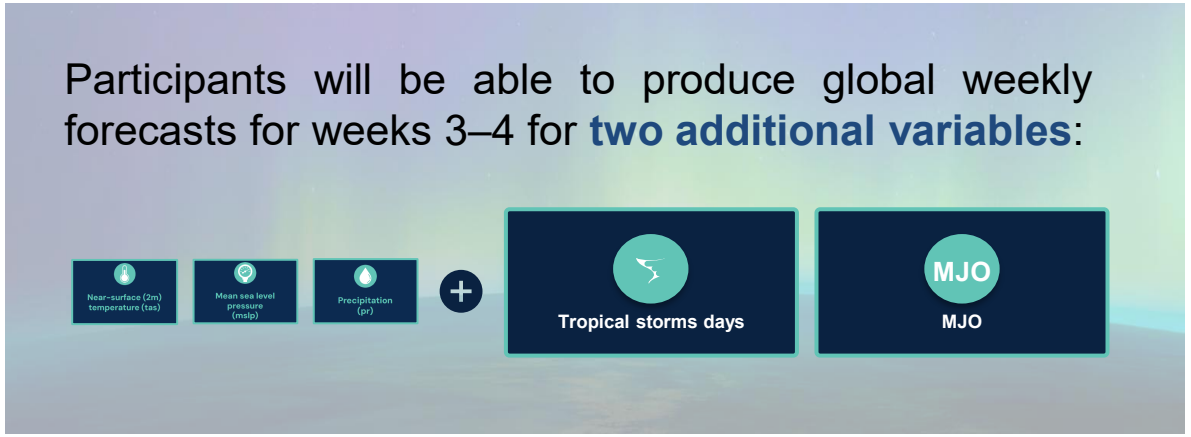
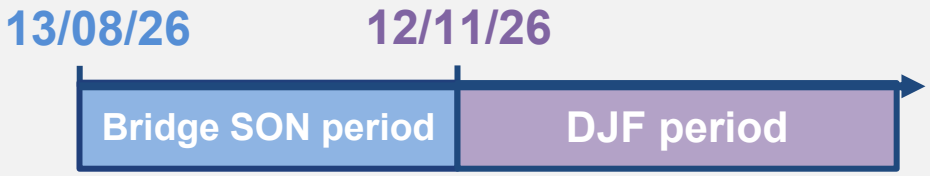
Poll time!





Bridge Period: **Trial forecast submission, visualisation and self-evaluation** of new variables in a non-competitive environment.

Interested in the new variables?

Tell us in the Teams poll.

Are you interested in submitting forecasts for the new variables?

- ◯ Yes, for MJO
- ◯ Yes, for tropical storm days
- ◯ Possibly, but we need more information first
- ◯ No
- ◯ I do not plan on participating to the Quest

Participating in the AI Weather Quest: **Required updates**

A Python Package named **AI-WQ-package** has been created to support forecast submission, visualization and evaluation.

From August 10th 2026, the AI Weather Quest will be transitioning from an FTP service to an ECMWF file-sharing site service called ECBox.

Steps (1) and (2) must be conducted before start of SON 2026 period.
Step (3) needed from August 10th 2026.

- You can upgrade the package today!
- For submissions from August 13th 2026, all three steps will need to be conducted.

Three necessary steps:

(1) Upgrade of **AI-WQ-package** (or install version >= 3.26)

```
python3 -m pip install --upgrade AI-WQ-package
```

(2) Install **sites-toolkit** from ECMWF repository

```
python3 -m pip install sites-toolkit -i
https://get.ecmwf.int/repository/pypi-all/simple
```

(3) Update password from August 10th 2026

New password will be sent to all registrants on August 10th 2026.

Detailed **ReadtheDocs** documentation.

Participating in the AI Weather Quest: **Step-by-step guide**

Forecast submission

```
1 from AI_WQ_package import forecast_submission
2 forecast = forecast_submission.AI_WQ_create_empty_dataarray(variable, fc_start_date, fc_period,
                                                              teamname, modelname, password)
3 forecast.values = saved_forecast_values
4 forecast_submit = forecast_submission.AI_WQ_forecast_submission(forecast, variable, fc_start_date,
                                                                  fc_period, teamname, modelname, password)
```

1. Import module.
2. Create an empty *xarray.DataArray*.
3. Populate empty *xarray.DataArray* with forecast probabilities.
4. Submit your forecast to the AI Weather Quest.

Several checks are made before submission including:

- Forecast initialisation date is a Thursday and within **days 1 to 4** of the forecast workflow.
- Coordinates have the correct shape and values.
- Summed probabilities are equal to 1.0±0.2.

Function parameter	Description
variable	Forecast variable (*tas*, *mslp*, *pr*, ***MJO*** or ***TS***)
fc_start_date	Forecast initialisation date (*YYYYMMDD*)
fc_period	The selected forecasting window (*1* or *2*)
teamname	Registered team name
modelname	Registered model name
password	Forecast submission password

Participating in the AI Weather Quest: **Step-by-step guide**

AI Weather Quest ECMWF

Tropical storms

2 `forecast = forecast_submission.AI_WQ_create_empty_dataarray(`***`TS`***`, fc_start_date, fc_period, teamname, modelname, password)`

```
<xarray.DataArray (tercile: 3, basin: 4)> Size: 96B
array([[2.7469223e-316, 0.0000000e+000, 0.0000000e+000, 0.0000000e+000],
       [0.0000000e+000, 0.0000000e+000, 0.0000000e+000, 0.0000000e+000],
       [0.0000000e+000, 0.0000000e+000, 0.0000000e+000, 0.0000000e+000]])
Coordinates:
  * tercile              (tercile) float64 24B 0.3333 0.6667 1.0
  * basin                (basin) <U4 64B 'ATL' 'NWP' 'SWIO' 'SEIO'
    forecast_issue_date  datetime64[s] 8B 2026-05-28
    forecast_period_start datetime64[s] 8B 2026-06-15
    forecast_period_end  datetime64[s] 8B 2026-06-21
```

Dimension	Description
tercile	Below-normal, near-normal and above-normal terciles.
basin	Four basins are defined: - North Atlantic (ATL): 0° to 40°N, 100° to 20°W - North-West Pacific (NWP): 0° to 40°N, 100° to 180°E - South-West Indian Ocean (SWIO): 0° to 40°S, 20° to 90°E - South-East Indian Ocean (SEIO): 0° to 40°S, 90° to 160°E

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Participating in the AI Weather Quest: **Step-by-step guide**

Madden-Julian Oscillation

2

```
forecast = forecast_submission.AI_WQ_create_empty_dataarray(MJO, fc_start_date, fc_period,
                                                           teamname, modelname, password)
```

```
<xarray.DataArray (MJO_phase: 9, valid_time: 4)> Size: 288B
array([[3.61227713e-316, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000],
       [0.00000000e+000, 0.00000000e+000, 0.00000000e+000,
        0.00000000e+000]])
Coordinates:
  * MJO_phase           (MJO_phase) int64 72B 0 1 2 3 4 5 6 7 8
  * valid_time          (valid_time) datetime64[s] 32B 2026-06-04 ... 2026-0...
    forecast_issue_date  datetime64[s] 8B 2026-05-28
```

?

- For MJO, fc_period option is redundant but will only accept ‘1’ or ‘2’.

Dimension	Description
MJO_phase	MJO phase with 0 denoting inactive MJO.
valid_time	Forecast days aligned with Thursdays within forecasted week (only 3rd and 4th weeks evaluated for leaderboards).

Participating in the AI Weather Quest: **Step-by-step guide**

Forecast visualisation

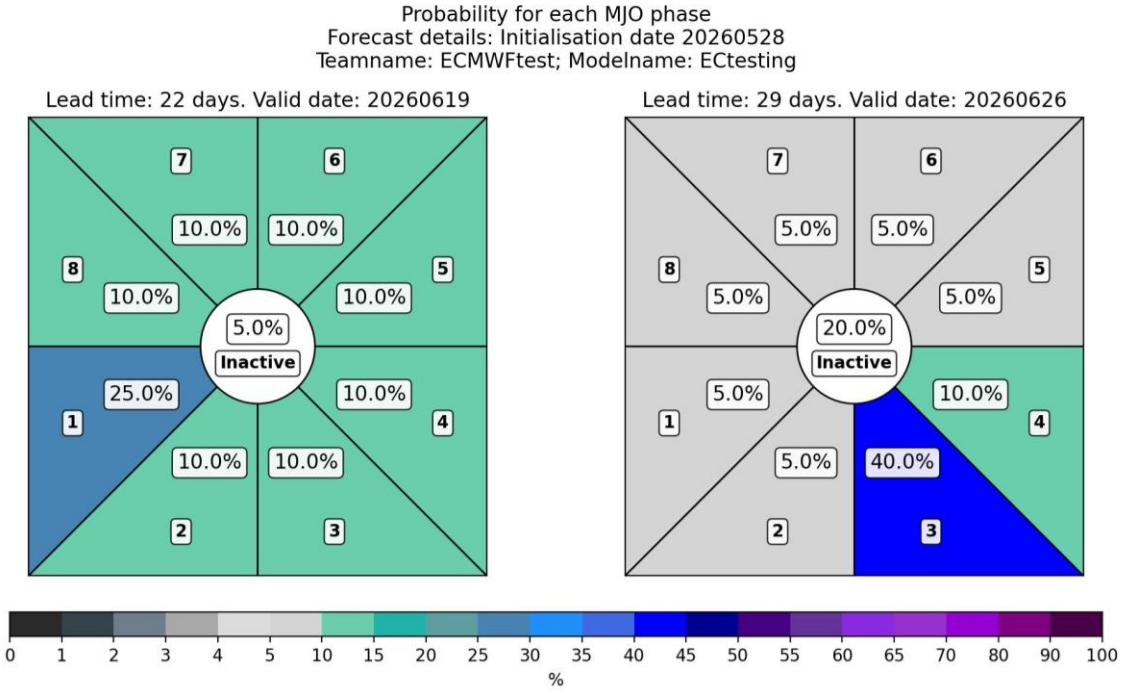
1 `from AI_WQ_package import plotting_forecast`

Global variables

2 `plotting_forecast.plot_forecast(`*`forecast,quintile_num`*`)`

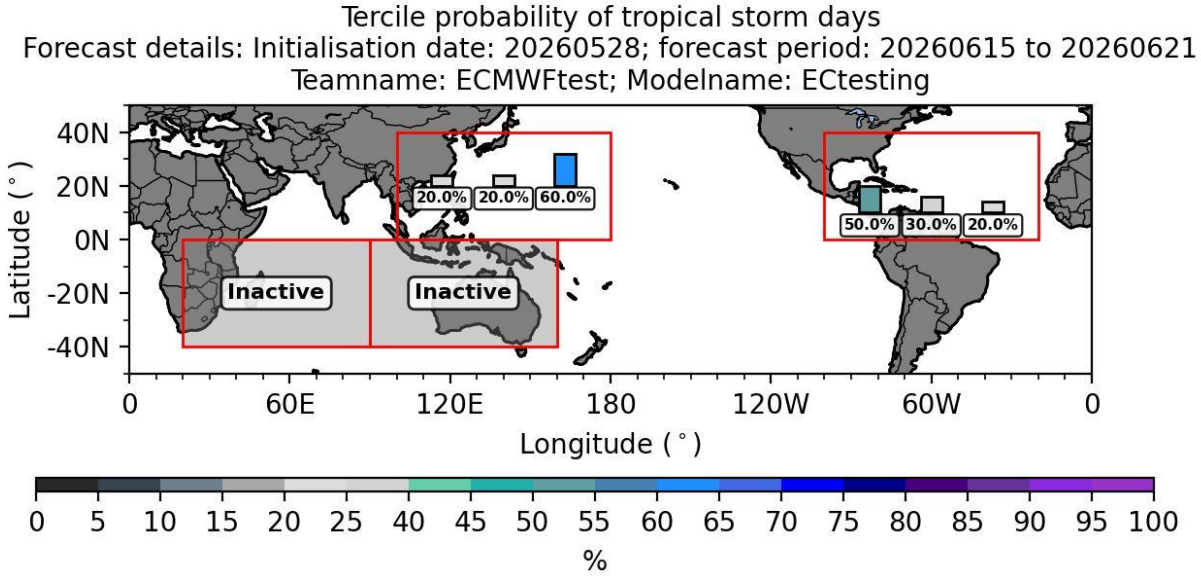
Madden-Julian Oscillation

2 `plotting_forecast.`**`plot_MJO_forecast`**`(`*`forecast`*`)`



Tropical storms

2 `plotting_forecast.`**`plot_TS_forecast`**`(`*`forecast`*`)`



Same format as **ECMWF-hosted** forecasting portal

Participating in the AI Weather Quest: **Step-by-step guide**

AI Weather Quest ECMWF

Forecast evaluation: MJO

$$BSS = 1 - \frac{BS_{fc}}{BS_{clim}} \; where \; BS_x = \overline{(x-o)^2}$$

```
1  from AI_WQ_package import retrieve_evaluation_data, forecast_evaluation
2a obs = retrieve_evaluation_data.retrieve_daily_MJO_obs(date,password)
2b MJO_clim = retrieve_evaluation_data.retrieve_20yr_MJO_clim(date,password)
3  MJO_pred = submitted_forecast.sel(valid_time=date)
4a BS_fc = forecast_evaluation.calculate_MJO_brier_score(submitted_forecast,MJO_obs)
4b BS_clim = forecast_evaluation.calculate_MJO_brier_score(MJO_clim,MJO_obs)
4  BSS = 1 - BS_fc/BS_clim
```

1. Import modules.
2. Download data including (a) observations and (b) MJO climatology.
3. Select correct forecasted valid time.
4. Compute brier scores for (a) forecast and (b) climatology.
5. Derive the BSS.

Function parameter	Description
date	Forecasted week 3 or week 4 start date (*YYYYMMDD*).
password	Forecast submission password.
submitted_forecast	Forecast submitted to the AI WQ.

Read the Docs Period-aggregated BSSs is computed as an average of BSs across initialisations.

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Participating in the AI Weather Quest: **Step-by-step guide**

Forecast evaluation: TS

```
1  from AI_WQ_package import retrieve_evaluation_data, forecast_evaluation
2a obs = retrieve_evaluation_data.retrieve_weekly_obs(date,variable,password)
2b tercile_clim = retrieve_evaluation_data.retrieve_20yr_quantile_clim(date,variable,password)
3  obs_pbs = forecast_evaluation.conditional_obs_probs(obs,tercile_clim)
4  RPSS = forecast_evaluation.calculate_RPSS_TS(submitted_forecast,obs_pbs)
```

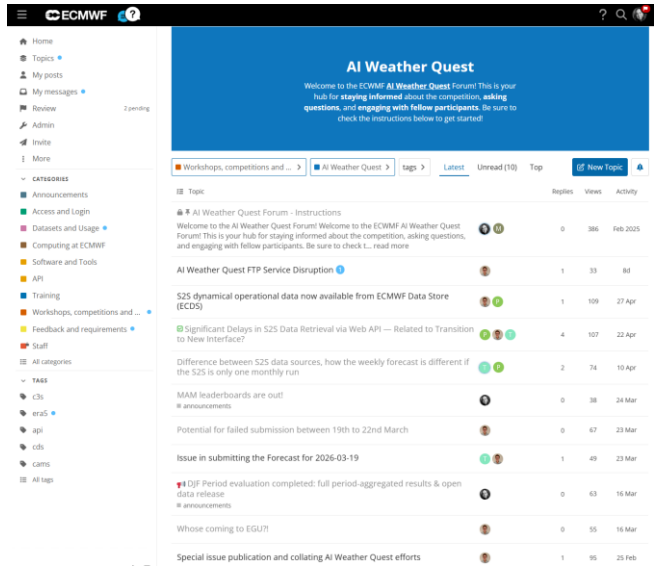
1. Import modules.
2. Download data including (a) observations and (b) tercile-based climatology (IBTrACS).
3. Compute observed probabilities.
4. Derive the RPSS.

RPSS given for each basin.

Function parameter	Description
date	Forecasted week 3 or week 4 start date (*YYYYMMDD*).
variable	Forecasted variable (*tas*, *mslp*, *pr*, ***TS***).
password	Forecast submission password.
submitted_forecast	Forecast submitted to the AI WQ.

How to engage with the community

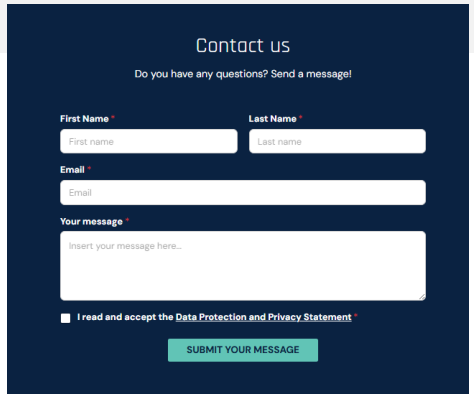
+ For any questions / comments relevant to the whole community, **participants** can use the **forum**.



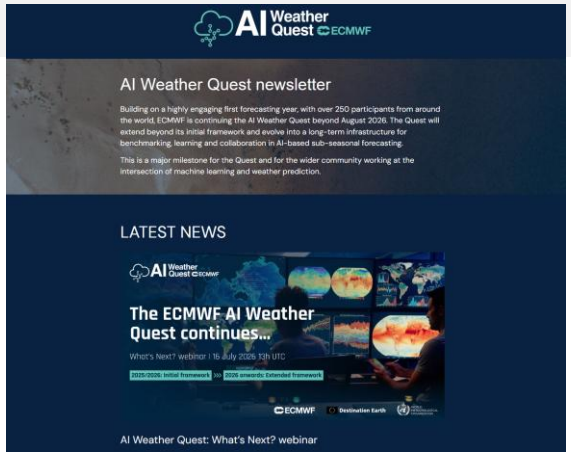
During the Bridge Period

Check via the ***Successful MJO & TS submissions*** topic (on Mondays) for the **names of the teams & models for which new variables forecasts have been successfully submitted.**

+ For individual matters, **participants** can reach out through the **contact form**.



+ For keeping up with the Quest, **observers** can subscribe to the **Newsletter**.



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Q&A

Feel free to ask your questions!

- *Raise your hand to speak*
- *Type your questions in the chat*

Thanks!

To everyone involved in the organisation of the AI Weather Quest and everyone involved in its journey!