Why the UK forecast flipped: a storyboard, working backwards

Over the 14–17 Oct runs, the week of 19–26 October went from high pressure and dry to low pressure and wet. The flip was right. This follows the forecast error from the UK back through the North Atlantic and North America to its likely origin, and says how strong the evidence is at each step.

READ THIS FIRST

- **The flip was correct.** Analyses to 21 Oct show the UK high collapsing on 20 Oct, as the 16 Oct run forecast. The 13 Oct run kept it.
- **The error was a block that never happened.** Early runs held a Greenland/Iceland ridge. In reality the Atlantic trough came in and the ridge moved on to Scandinavia.
- **Why:** a Rossby wave packet crossing North America **weakened** on 17–18 Oct. Its trough dug further south than forecast (to 36°N), tapped Gulf moisture, then **split and lifted out** on a 90 m/s jet. The 13 Oct run kept the trough whole and over-strong near Nova Scotia, which built the block.
- **Origin:** a short wave that came ashore in British Columbia on 14 Oct. The 13 Oct run sent it too far north after it crossed the Rockies; the 14 Oct run had its track but not its deepening. That two-step error is why the flip was gradual.
- **Observations:** the wave was invisible to balloons until it came ashore on 14 Oct, when the 13 Oct run was still only about 25 m off. The error then grew over land: the ridge right behind the wave was sharper than forecast, with stronger northerlies that steered it south. That explains roughly half the track error; the rest is the wave's own development.
- **Phasing:** in reality the wave merged with a small upper low over the Four Corners, which probably helped the trough extend south. The low itself was well forecast; the forecasts' problem was whether the wave reached it.
- **Not the cause:** Typhoon Koguma's packet crossed the Pacific and was forecast well. Tropical convection and the MJO barely changed between runs. No Atlantic or Caribbean tropical cyclone was active. Latent heating in the rain band did not drive the short wave's deepening (tested across the 14 Oct members).
- **Cross-check:** AIFS-ENS, ECMWF's machine-learnt ensemble, made the same error from the same analyses. That points to the starting state of the short wave, or limited predictability, rather than model physics.

1 **The UK forecast flips from high to low** — ESTABLISHED

Runs of 14–17 Oct · UK pressure anomaly +15 → −7 hPa

2 **And the flip was right** — ESTABLISHED

Valid 19–21 Oct · the UK high collapses on 20 Oct as the 16 Oct run forecast

3 **A Greenland/Iceland block that never happened** — ESTABLISHED

Valid 18–20 Oct · 13 Oct run errors of +380 to +500 m near Iceland; no member close

4 **A wave packet weakened over North America, but not in the forecast** — ESTABLISHED

17–18 Oct · real envelope 38 → 27 m/s; 13 Oct run 44 → 48 m/s

5 **The trough dug south, split and lifted out** — ESTABLISHED

16–18 Oct · reached 36°N (forecast 39°N; only 4 of 50 members got that far), then ejected on a 90 m/s jet

6 **A long Gulf-to-Newfoundland rain band: a sign of the trough's path, not its driver** — TESTED · NOT THE DRIVER

17–19 Oct · 40–60% underplayed in the 13 Oct run; a latent-heating test finds no driving role

7 **A short wave from the NE Pacific dug further south and deeper than forecast** — TRACED

14–17 Oct · 13 Oct run: wrong track after the Rockies; 14 Oct run: right track, too weak

8 **The ridge right behind the wave was sharper than forecast, steering it south** — SUPPORTED · ABOUT HALF THE TRACK ERROR

14–16 Oct · radiosondes saw the wave from landfall; the error then grew over land

9 **A small upper low over the Four Corners: the trough's phasing partner** — REAL · NOT THE ERROR

14–16 Oct · well forecast; the wave merged with it in reality, but rarely came close enough in the forecasts

10 **AIFS-ENS, ECMWF's machine-learnt ensemble, made the same mistake** — ESTABLISHED

Runs of 13–17 Oct · same short-wave track error, same over-strong packet, flipped no earlier

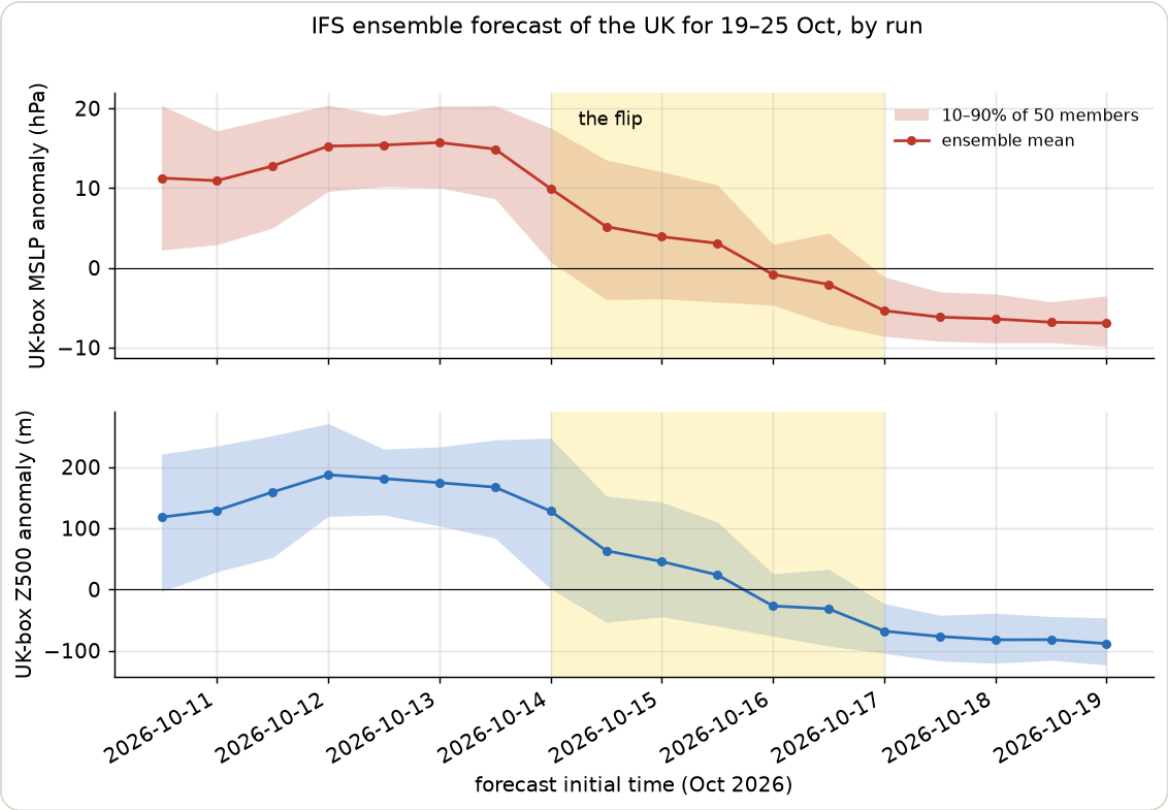
11 **Typhoon Koguma seeded the packet over the Pacific** — CONTEXT

13–16 Oct · its packet was forecast well, so it isn't where the forecast went wrong

1 The UK week flipped from +15 hPa to −7 hPa over four runs

A steady slide across the 14–17 Oct runs, not one bad run.

ESTABLISHED



UK box 50–59°N, 6°W–2°E, mean of 19–25 Oct (12 UTC). Anomalies against the ERA5 1991–2020 October mean. Shading is the 10–90% range of the 50 members.

THE NUMBERS

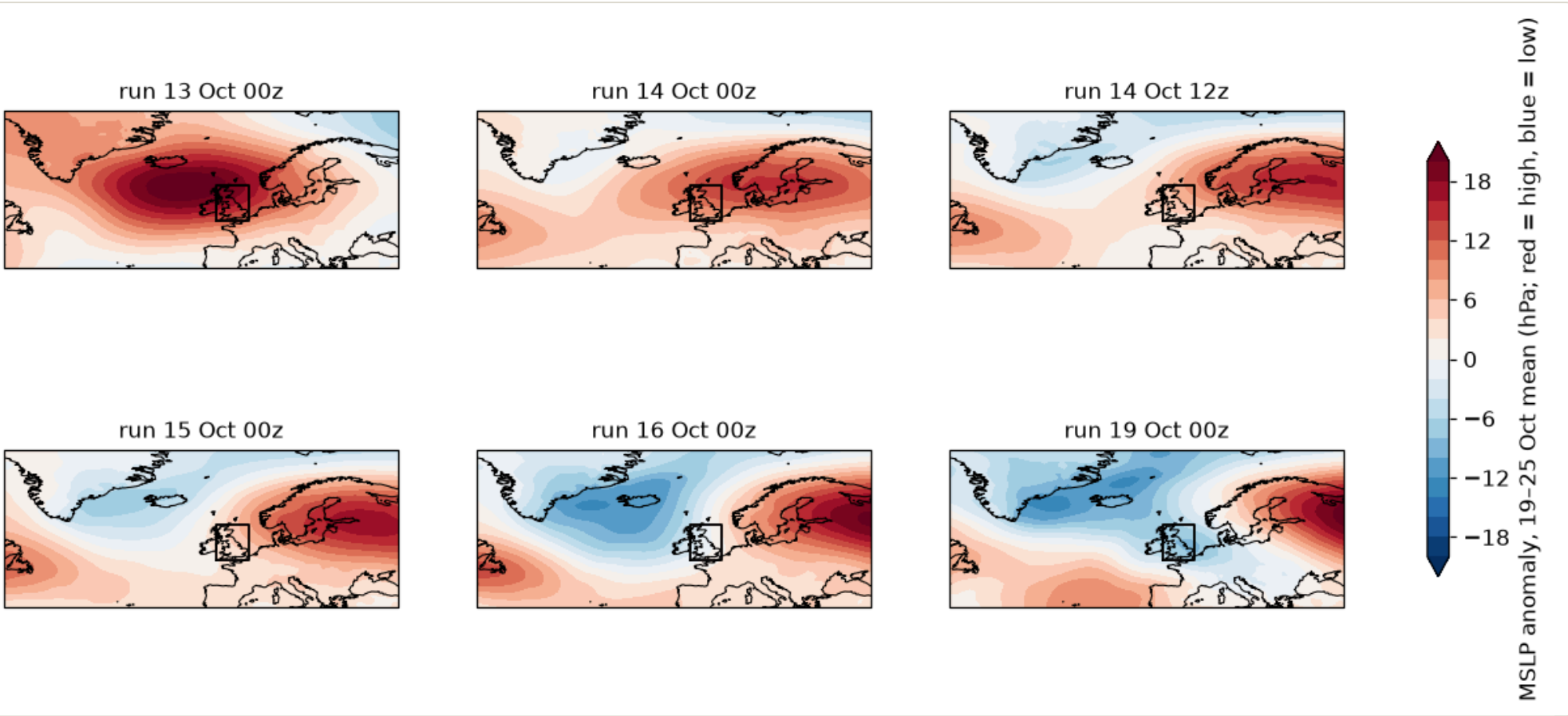
12–13 Oct runs: MSLP **+15 hPa**, Z500 **+170 to +190 m**, **100%** of members high.

14 Oct 00z → 12z: +10 → +5 hPa; members high 94% → 78%.

15 Oct: +3 to +4 hPa (70% high). **16 Oct 00z:** −1 hPa (42% high).

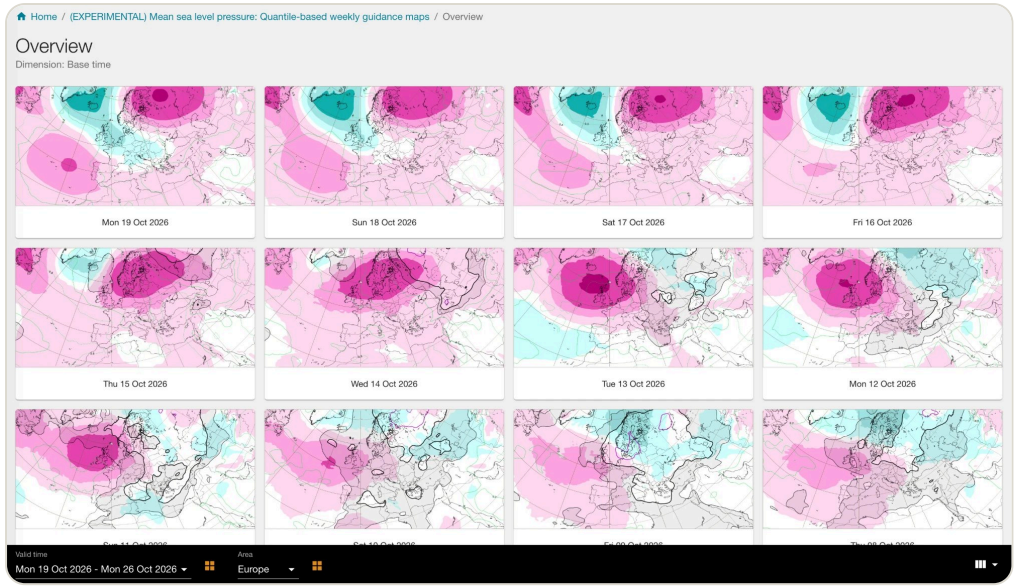
From 17 Oct: −5 to −7 hPa, Z500 −70 to −90 m, 0–6% of members high.

This is the **medium-range** IFS ensemble, not the extended-range product behind the ECMWF weekly charts. It reproduces the same flip.

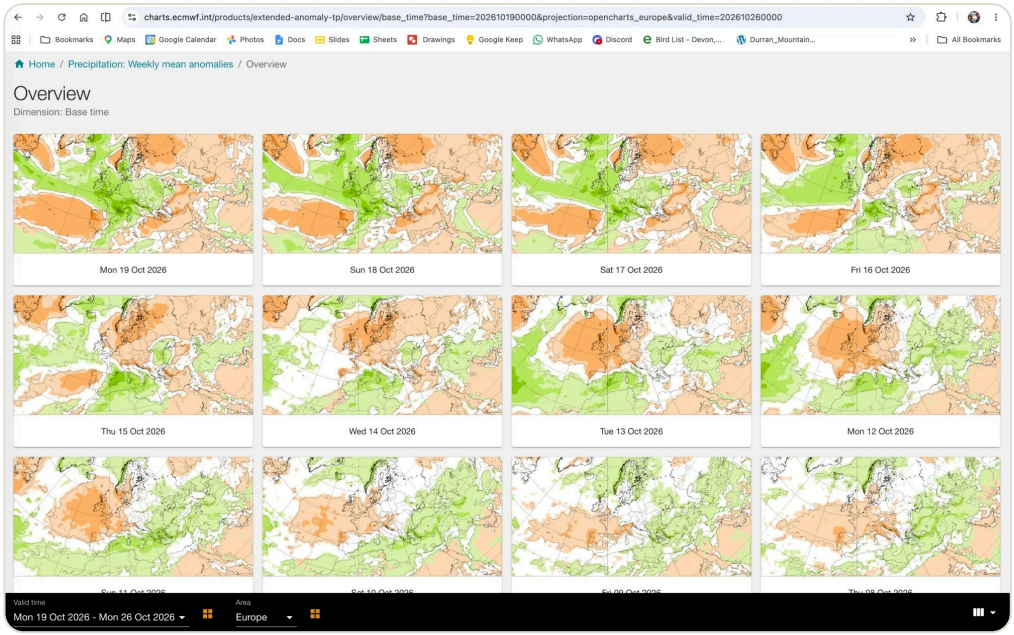


Weekly-mean MSLP anomaly for 19–25 Oct from successive runs (black box: UK). The high over the UK is pushed into Scandinavia as a low develops near Iceland.

THE ECMWF EXTENDED-RANGE CHARTS THAT SHOWED THE FLIP



Quantile-based weekly MSLP guidance for 19–26 Oct, by base time.

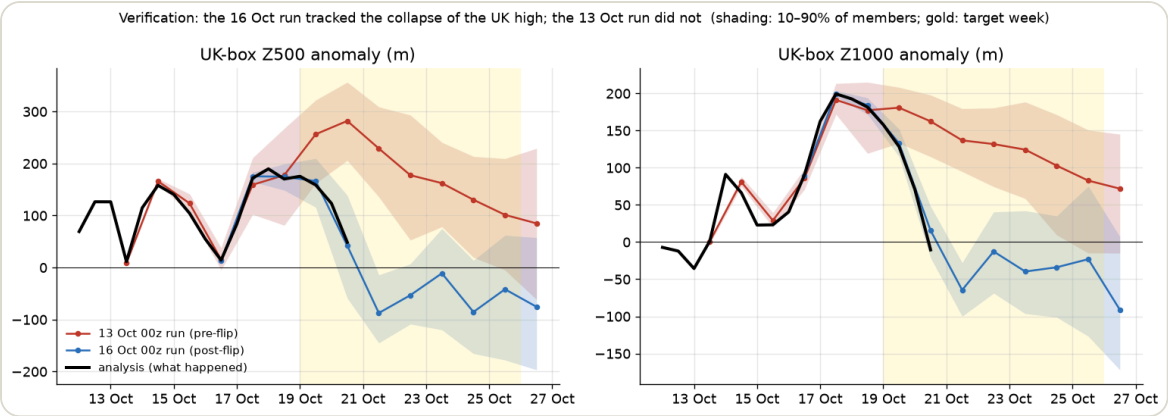


Weekly mean precipitation anomalies for the same week.

2 The flip was right: the UK high collapsed on 20 October

Checked against ECMWF analyses up to 21 Oct 00z.

ESTABLISHED



UK-box Z500 and Z1000 anomaly. Black: analysis. Red: 13 Oct run. Blue: 16 Oct run. Both runs match the analysis up to 19 Oct; only the 16 Oct run follows the collapse.

UK BOX, 12 UTC

	ANALYSIS	13 OCT RUN	16 OCT RUN
Z500, 19 Oct	**5713 m**	5811	5721
Z500, 20 Oct	**5601 m**	5834	5594
Z1000, 19 Oct	**222 m**	275	227
Z1000, 20 Oct	**83 m**	256	109

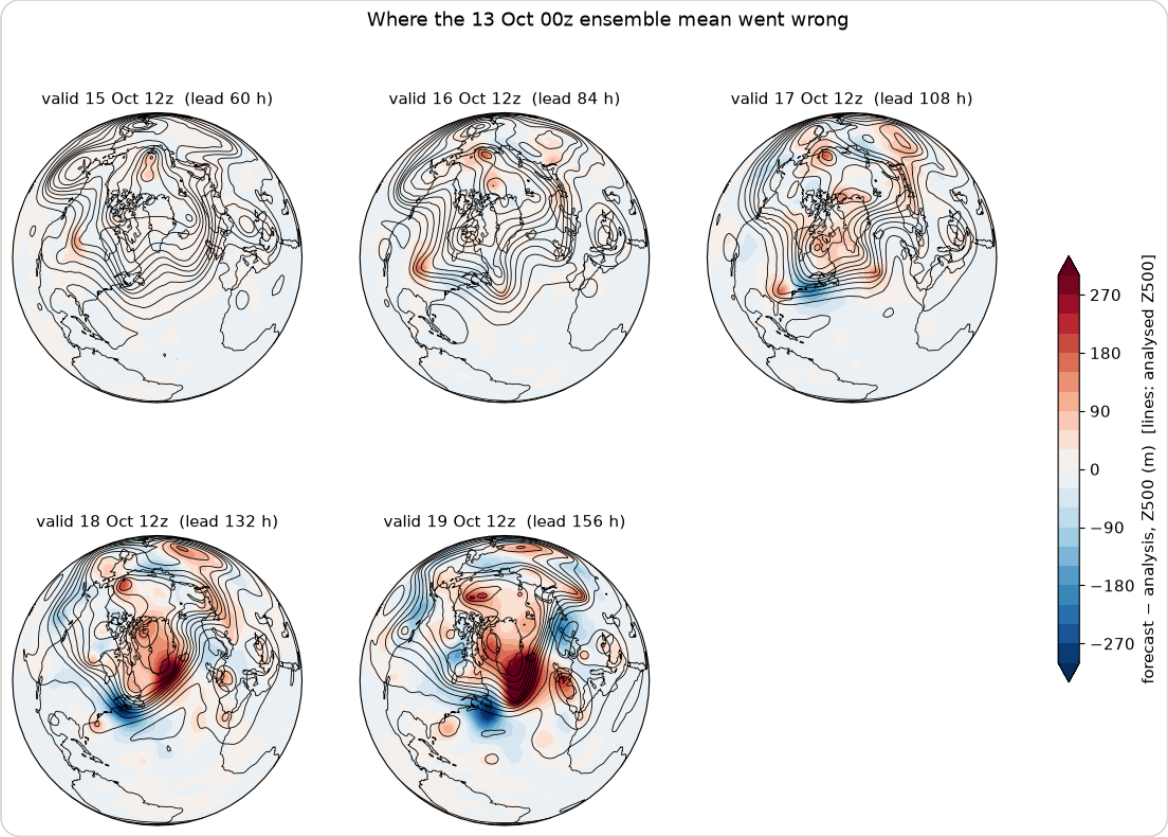
Z1000 of 222 m is roughly 1028 hPa; 83 m is roughly 1010 hPa.

The high was still over the UK on 19 Oct. Within 24 hours it had gone, exactly as the 16 Oct run said.

3 The early runs built a Greenland/Iceland block that never happened

The error is a dipole: heights far too high near Iceland and too low off Nova Scotia.

ESTABLISHED



13 Oct 00z ensemble mean minus analysis, Z500 (lines: analysed Z500). Small until 16 Oct, then explosive growth over the Atlantic.

HOW BIG, AND WHERE FIRST

By 18–19 Oct: **+380 to +500 m** too high near 60°N, 33°W and **−230 to −310 m** too low near 40–43°N, 55–64°W.

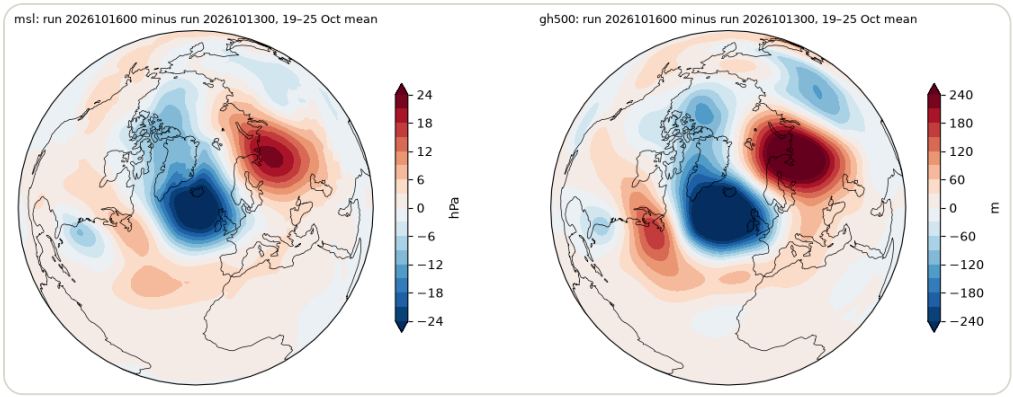
Observed Iceland-minus-SW-Atlantic height difference on 19 Oct: **−192 m**. The 13 Oct run's 10th percentile was −26 m, so essentially **no member** got there.

16 Oct run minus 13 Oct run: down to **−32 hPa / −420 m** south-west of Iceland, up to **+22 hPa / +360 m** over northern Scandinavia and north-west Russia.

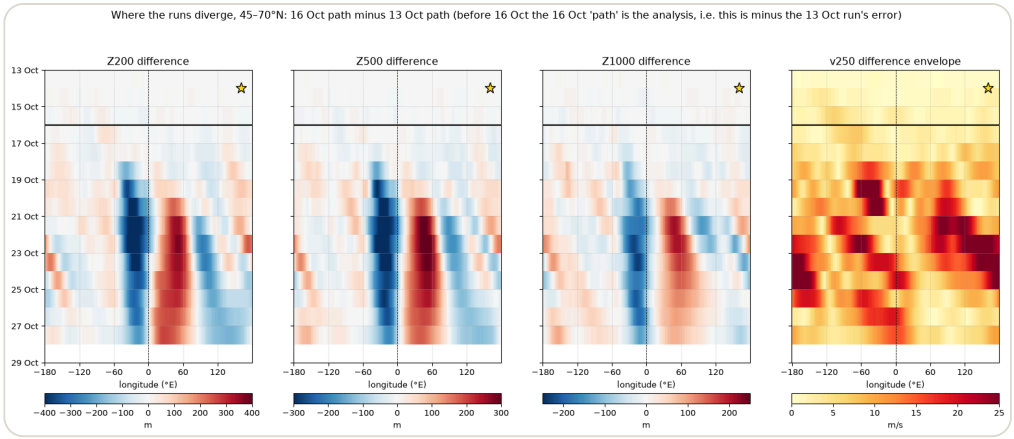
13 OCT RUN, Z500 RMS ERROR (M), 35–70°N	N AMERICA	ATLANTIC	EUROPE
15 Oct (+60 h)	**20**	11	8
16 Oct (+84 h)	**33**	19	17
17 Oct (+108 h)	43	**51**	22
18 Oct (+132 h)	42	**116**	39
19 Oct (+156 h)	48	**180**	63
20 Oct (+180 h)	69	**205**	160

The error appears first over **North America**, then explodes over the Atlantic and reaches Europe last. At the same lead time the 16 Oct run's errors are just as large (about 30 m over North America at +84 h). It wasn't more skilful; its starting conditions already contained what happened over North America.

SHOW THE OVERALL DIFFERENCE MAPS AND THE "WHERE THE RUNS DIVERGE" HOVMÖLLER



16 Oct run minus 13 Oct run, 19–25 Oct mean. MSLP left, Z500 right; the colour scale saturates at ±24 hPa / ±240 m.

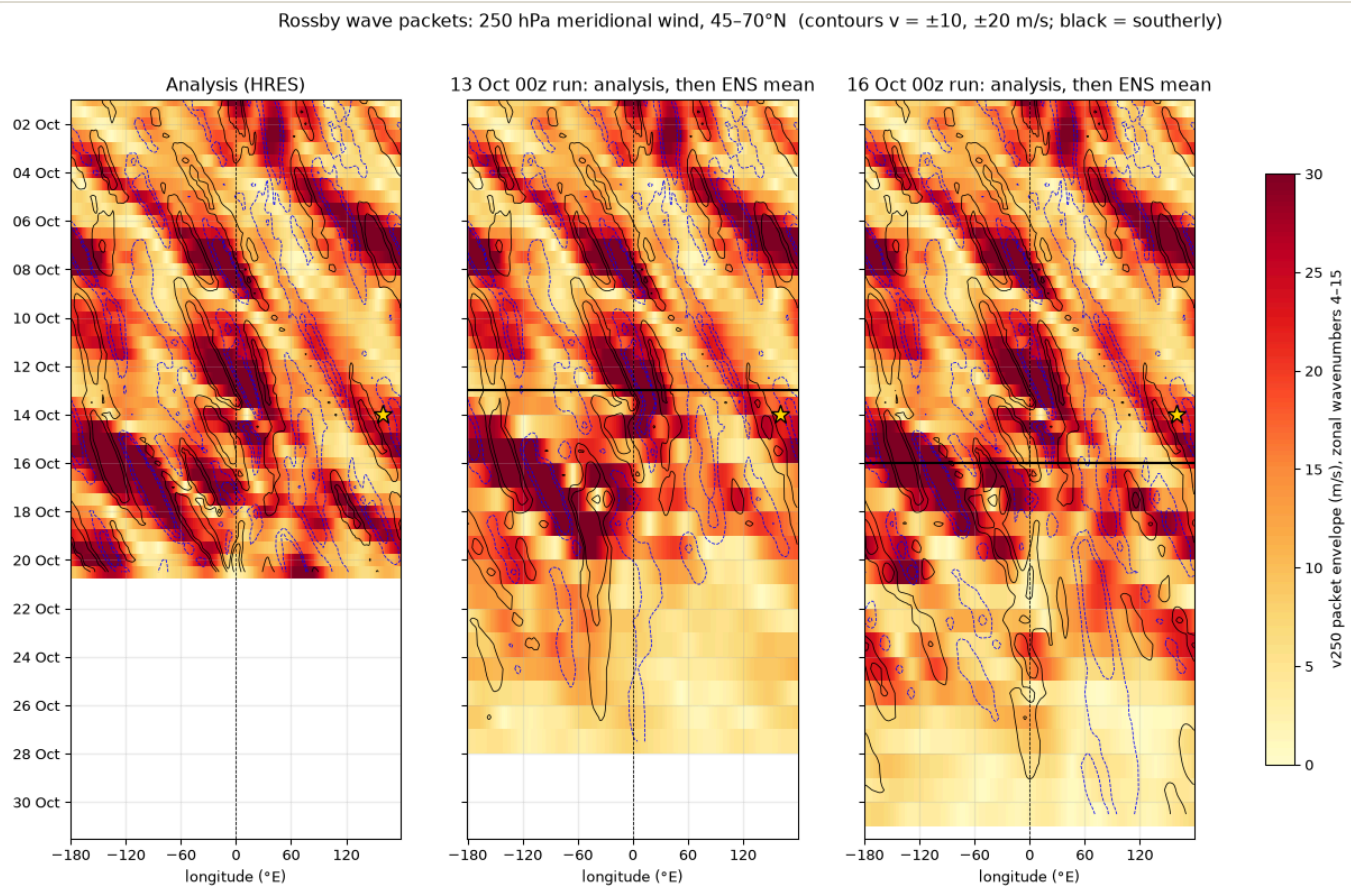


16 Oct path minus 13 Oct path, 45–70°N. Before 16 Oct the "16 Oct path" is the analysis, so the top rows show minus the 13 Oct run's error. The difference grows near 60–30°W from 17 Oct, then spreads up- and downstream.

4 A Rossby wave packet weakened over North America, but not in the forecast

The same packet, forecast correctly over the Pacific, stayed far too strong once it reached eastern North America.

ESTABLISHED



250 hPa meridional wind, 45–70°N. Shading is the packet **envelope** (zonal wavenumbers 4–15); contours are the wind itself. Each diagonal band is a packet. The individual troughs and ridges (contours) move east more slowly than the bands; that difference is the hallmark of a packet. ★ marks Koguma's extratropical transition.

HOW TO READ A HOVMÖLLER FOR PACKETS

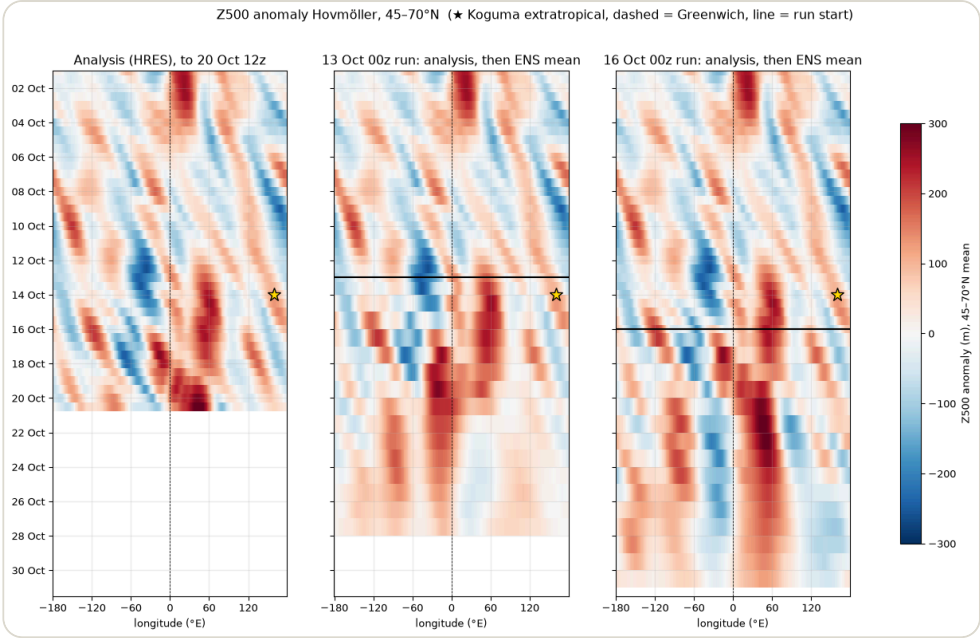
Individual troughs and ridges move east slowly; here the **phase speed** is about **7–8 m/s**.

Energy moves along the packet at the **group speed**, here about **25 m/s**, building new troughs and ridges downstream.

In a Z Hovmöller that looks like a stepped, diagonal band of strong anomalies. The v250 envelope shows it as one band.

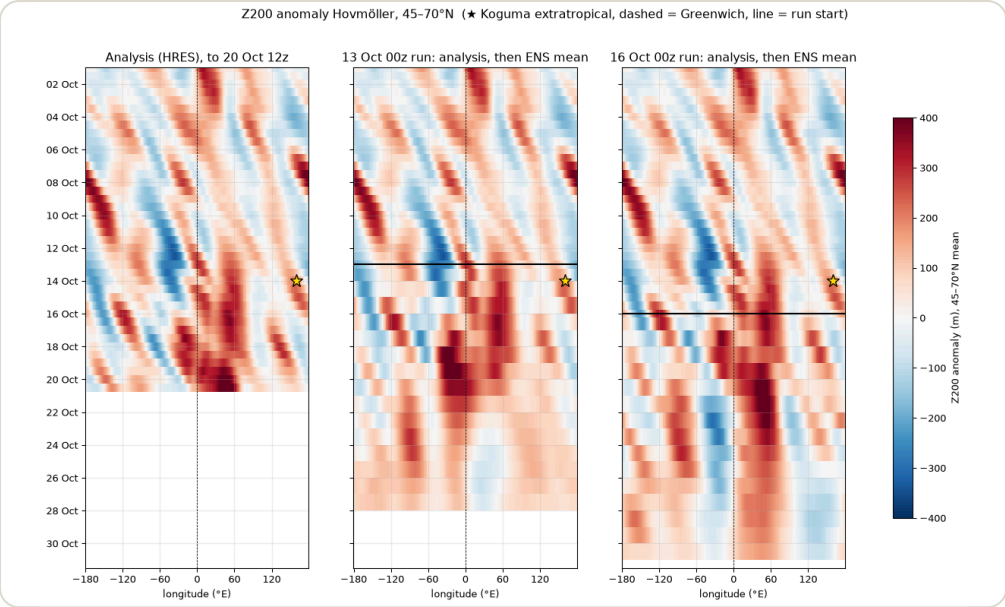
PACKET PEAK (35–60°N)	ANALYSIS	13 OCT RUN, MEMBER MEAN
14 Oct, ~162°W	42 m/s	42
15 Oct, ~146°W	42	43
16 Oct, ~140°W	35	37
17 Oct, ~83°W	38	44
18 Oct, ~71°W	**27**	**48 (10–90%: 43–54)**
19 Oct, ~14°W	22	26

The packet started near 170°E on 13 Oct, peaked at 45 m/s near 152°W on 15 Oct and reached the UK on 19 Oct.

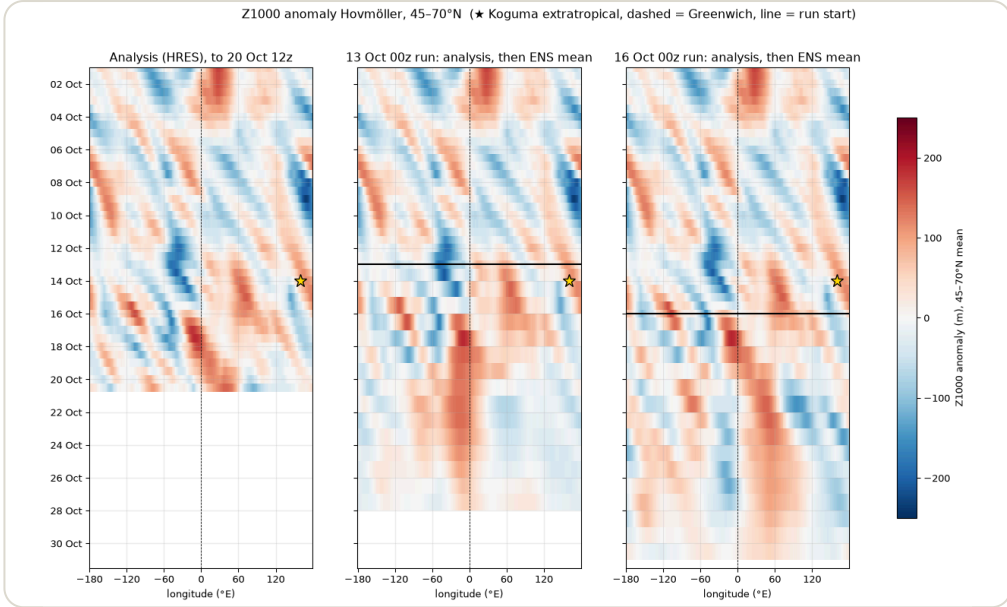


Z500 anomaly, 45–70°N, as in the ECMWF chart. Analysis (left) and each run's analysis-then-forecast. After 17 Oct the 13 Oct run holds a stationary ridge near 30°W–0° (the block); in reality the ridge moved east to 20–60°E.

SHOW Z200 AND Z1000 HOVMÖLLERS



Z200 anomaly, 45–70°N.

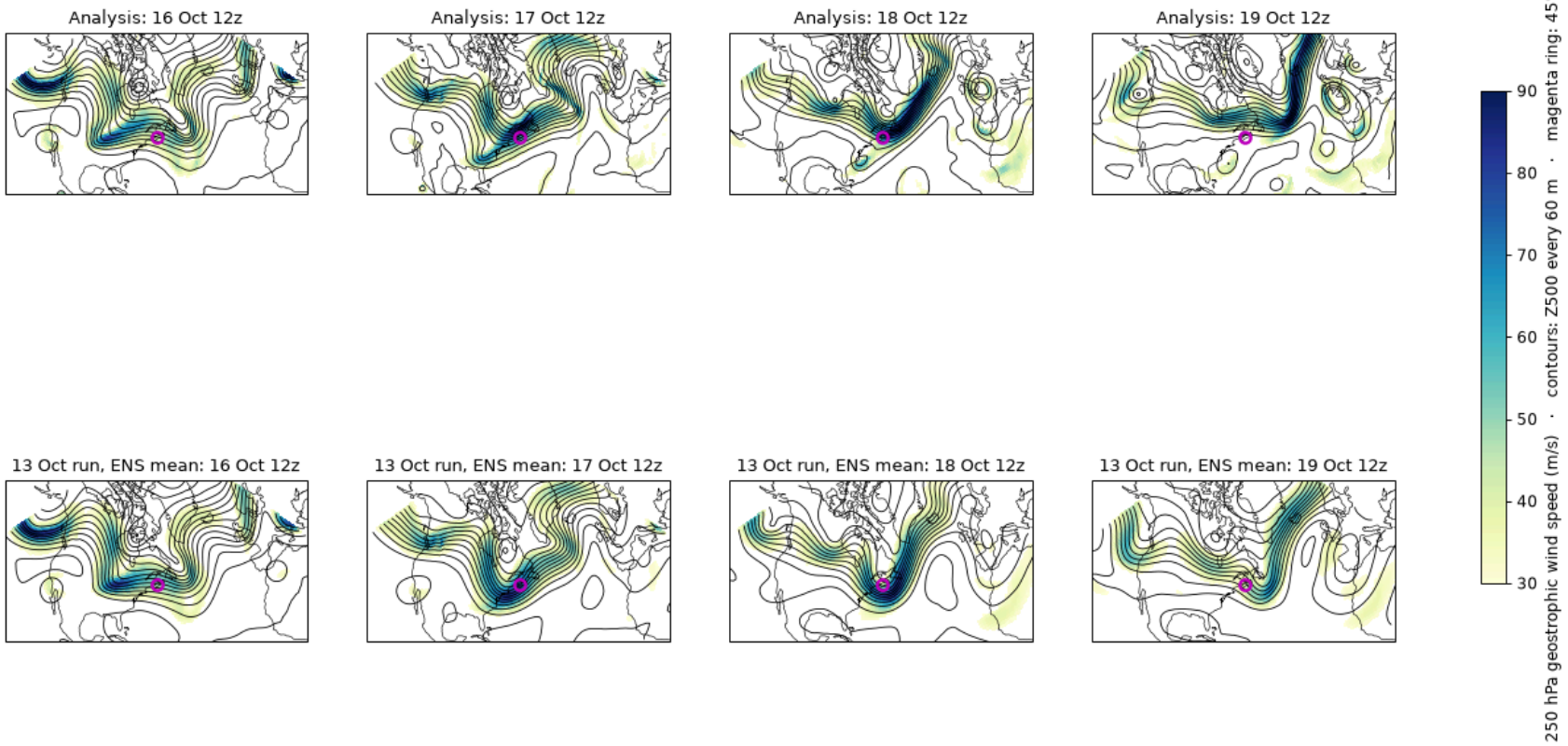


Z1000 anomaly, 45–70°N. The 13 Oct run's surface high stalls over 30°W–0° from 18 to 23 Oct. The block is aligned from the surface to 200 hPa.

5 The trough dug further south, then split and lifted out

Why the packet weakened: the trough broke up instead of staying whole.

ESTABLISHED



250 hPa geostrophic wind (shading, the jet) and Z500 (contours). Top: analysis. Bottom: 13 Oct run (member-mean jet speed). The magenta ring is 45°N, 64°W. In reality the trough stretched south-west to north-east on 18 Oct, with a 90 m/s jet from the US east coast towards Greenland and a small cut-off left near the south-east US. The forecast kept one deep trough on the ring.

TROUGH ALONG 75–90°W

	ANALYSIS	13 OCT RUN
17 Oct: reaches south to	**36°N**	39°N (10–90%: 37–40°N; 4 of 50 members reach 36°N)
17 Oct: deepest Z500	5039 m	5097 m (no member deeper than 5039 m)
18 Oct: reaches south to	**gone (north of 49°N)**	45°N (42–47°N)

The real trough reached further south than 46 of the 50 members of the 13 Oct run, was deeper than all of them, and then lifted out a day sooner.

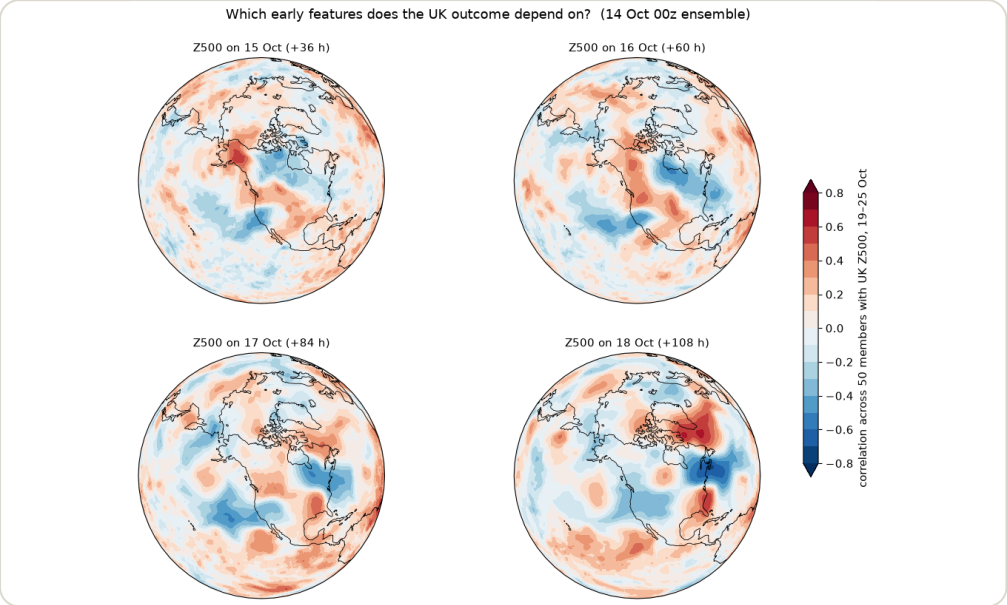
DOES THE UK OUTCOME DEPEND ON THIS? (14 OCT RUN, MEMBERS SPLIT)

Z500 at 45°N, 64°W on 18 Oct: **r = −0.73**. A trough parked there means a UK high.

Packet strength over 90–50°W on 18 Oct: **r = +0.65**. A stronger packet means a UK high.

A shuffle test puts the 5% significance threshold at about |r| = 0.28 for a single pre-chosen box, and 0.56 for the strongest point anywhere in the hemisphere. Both values clear both.

SHOW THE HEMISPHERIC SENSITIVITY MAPS (14 OCT RUN)

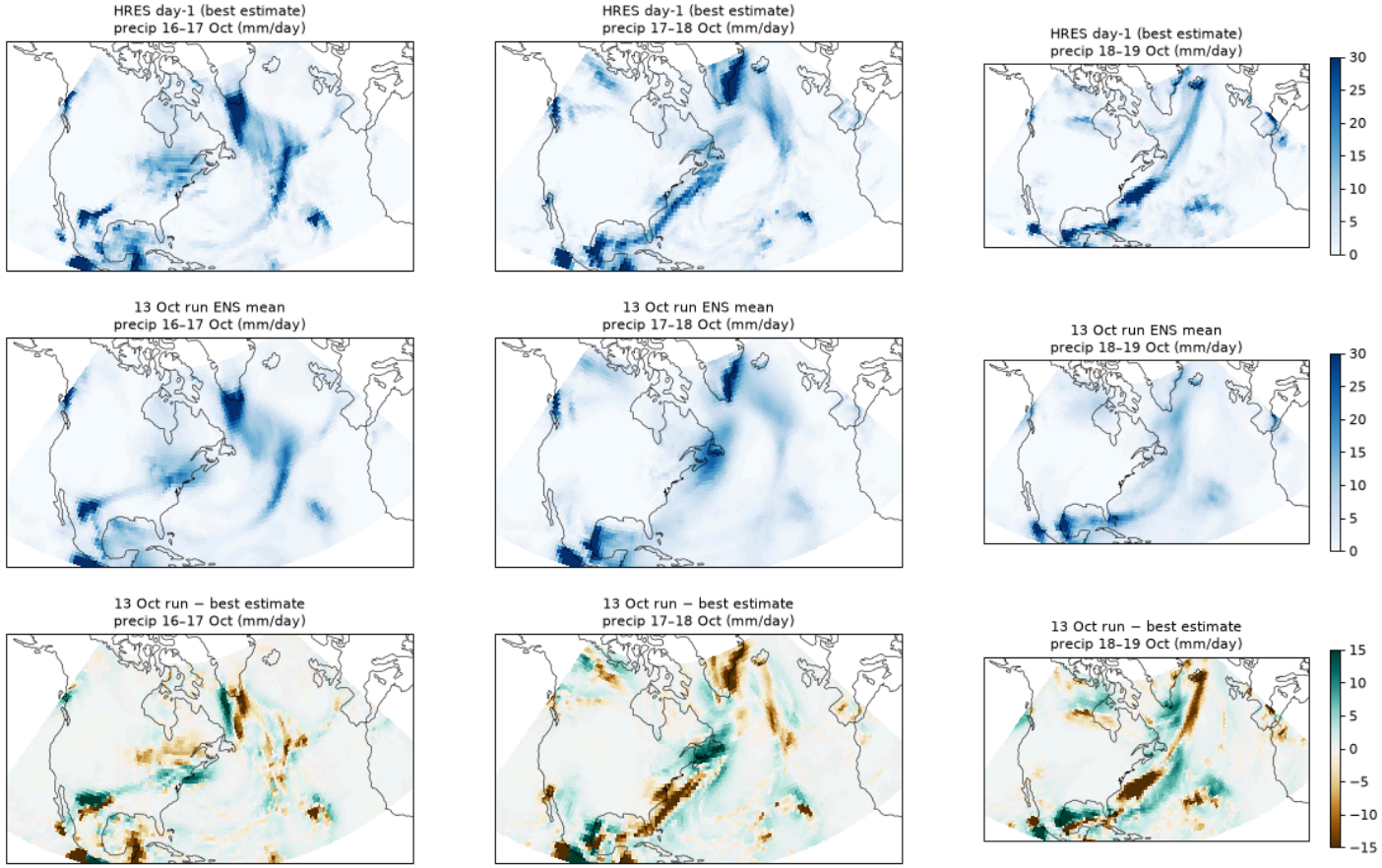


Correlation across 50 members between Z500 at each point and the UK weekly Z500. The 18 Oct Nova Scotia signal stands out; the 15–17 Oct upstream values are at the edge of chance individually.

6 Convection: the rain band followed the trough, but did not drive it

Underplayed in the 13 Oct run because its trough was in the wrong place. A latent-heating test on the 14 Oct members finds no sign that the heating deepened the short wave.

TESTED · A SIGN, NOT A DRIVER



24 h precipitation: HRES day-1 forecast as best estimate (top), 13 Oct run (middle), and the difference (bottom; brown = forecast too dry). On 17–19 Oct the real rain band ran along the trough's south-east flank from the Gulf coast to Newfoundland. The 13 Oct run had it weak and out of place, with rain concentrated over the Maritimes instead.

BOX MEANS (MM/DAY): BEST ESTIMATE · 13 OCT RUN · 16 OCT RUN

REGION, WINDOW	BEST	13 OCT	16 OCT
SE US / Gulf, 17–18 Oct	6.0	**3.5**	6.4
US east coast + NW Atlantic, 18–19 Oct	6.4	**2.7**	7.2
US east coast + NW Atlantic, 16–17 Oct	4.1	4.7	4.2

250 hPa outflow on 18 Oct 00z was about 30% weaker in the 13 Oct run: 6.1 against 9.4 (SE US) and 8.9 against 12.1 (east coast), in 10^{-6} s^{-1}.

A fingerprint of the trough (14 Oct members): a coastal rain band on 18–19 Oct goes with the flip (r = −0.52); rain concentrated over the Maritimes on 17–18 Oct goes with the block (r = +0.55).

Timing points to the trough first: the 13 Oct run's height errors over North America were already growing on 15–16 Oct, while its rainfall was still about right on 16–17 Oct.

LATENT-HEATING TEST, 14 OCT RUN (50 MEMBERS)

TEST	RESULT
Rain ahead of each member's short wave → its **next** deepening, allowing for the wave's strength and latitude	**partial r −0.08 to +0.10: none**
Gulf / SE US moisture and CAPE on 15–16 Oct, before the wave arrived	|r| ≤ 0.18: none
Rain ahead of the **real** wave, 16 Oct (24 h)	5.6 mm against a best estimate of 5.3 (38 of 50 members at or above): not underdone, yet wave strength on 17 Oct 12z was 22.9 against 28.4
700 hPa ascent ahead of the trough → UK week	**r +0.30 to +0.47; +0.32 to +0.40 after allowing for the wave: favours the block**
700 hPa ascent ahead of the trough → the wave's next deepening	r −0.15 to −0.43: slightly **less** deepening

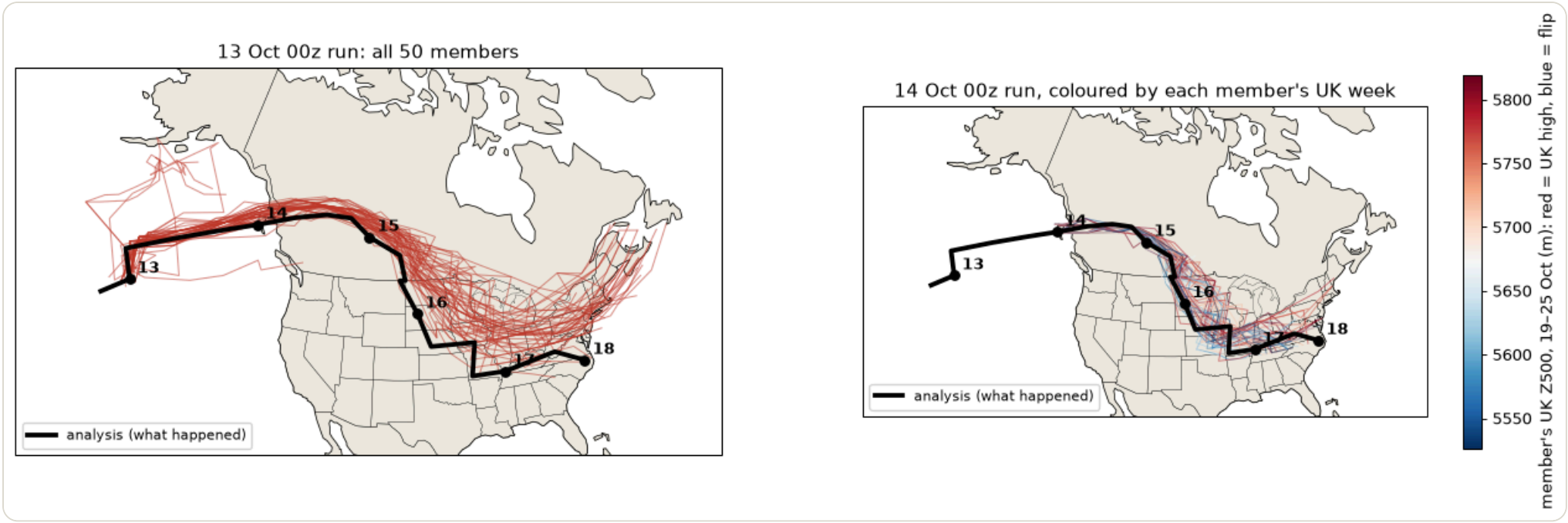
"Ahead" = the downstream half of a disc around each member's wave; results hold for radii of 1,000, 1,500 and 2,000 km and for both 12 h windows tested. Shuffle-test 5% threshold about |r| = 0.28.

Verdict. The heavier coastal rain band in reality was a **sign** of the trough's southern path and split, not its cause. In this ensemble latent heating did not deepen the short wave. Rising, raining air ahead of the trough instead leaned towards building the downstream ridge, the block, which is the known warm-conveyor-belt ridge-building effect.

7 Origin: a short wave that came ashore in British Columbia, then dug further south and deeper than forecast

Traced as a 500 hPa vorticity maximum in 6-hourly analyses, then followed in every ensemble member.

TRACED · TWO-STEP FORECAST ERROR



Black: the real short wave (dots at 00 UTC, labelled with the day of October). Left: the 13 Oct run's 50 members, which carry it east across the border and out through New England and the Maritimes. Right: the 14 Oct run's members, coloured by what each gave the UK for 19–25 Oct (blue = the flip, red = the high). A few 13 Oct members wander near Alaska in the first hours; that is the tracker briefly picking up a neighbouring feature.

THE REAL TRACK

13 Oct: a weak feature in the NE Pacific (44°N, 153°W) strengthens through the Gulf of Alaska.

14 Oct: comes ashore on the BC coast (53°N, 133°W at 00z) and crosses the Rockies into north-east BC and Alberta.

15 Oct: turns south-east over Saskatchewan (49°N, 104°W at 12z).

16 Oct: digs through the Dakotas, Iowa and Missouri.

17–18 Oct: reaches Tennessee and North Carolina (36–38°N), strengthening from about 14 to **28 ×10⁻⁵ s⁻¹**. This is the trough of frame 5.

Before 13 Oct the trace leads back, tentatively, to an upper low north-east of Hawaii (26–29°N, 165–170°W) on 10–11 Oct. The feature nearly vanished on 12 Oct, so that link is uncertain.

STEP 1 · 13 OCT RUN: RIGHT FOR TWO DAYS, THEN THE WRONG TRACK

VALID (LEAD)	REAL	MEMBERS (MEAN)	ERROR
15 Oct 00z (+48 h)	54°N 111°W	55.1°N 112.5°W	230 km
15 Oct 12z (+60 h)	49°N 104°W	51.9°N 106.2°W	420 km
16 Oct 06z (+78 h)	41°N 100°W	45.4°N 98.1°W	660 km
17 Oct 00z (+96 h)	37°N 89°W	41.7°N 85.3°W	890 km
17 Oct 12z (+108 h)	**38°N 81°W**	**44.1°N 74.6°W**	**1,450 km**

Within 110–230 km up to 15 Oct 00z. After the Rockies crossing the forecast wave stays 3–6° too far north and lifts out north-east. The error sits on the wave and the ridge immediately behind it (frame 8).

STEP 2 · 14 OCT RUN: RIGHT TRACK, NOT DEEP ENOUGH

Its members follow the real path closely (16 Oct 00z: 45.8°N against a real 45°N).

At the trough base on **17 Oct 12z** they average **22.9** against a real **28.4 ×10⁻⁵ s⁻¹**; only one member reaches 29.1.

14 OCT MEMBERS, WAVE STRENGTH ON 17 OCT 12Z	UK Z500, 19–25 OCT
Stronger half	**5648 m (the flip)**
Weaker half	**5736 m (the high)**

r = –0.50 between strength and the UK week (5% threshold about 0.27). The latent-heating test in frame 6 finds no sign that rain drove this deepening, so the missing strength looks dynamical: the upper-level jet and wave structure, which 1° open-data fields cannot resolve well.

WHY THE FLIP WAS GRADUAL

13 Oct and earlier: wrong track → no dig → Greenland block → dry UK.

14 Oct: right track, too weak → partial flip (UK +10 → +5 hPa).

16–17 Oct: the dug, deepened wave is in the analysis itself → full flip.

Short waves crossing the Rockies after a long trip over the thinly observed NE Pacific are a classic source of forecast trouble. Frame 8 looks at what the radiosondes saw as it came ashore, and why it turned south.

SHOW THE REGIONAL HEIGHT ERRORS (13 OCT RUN)

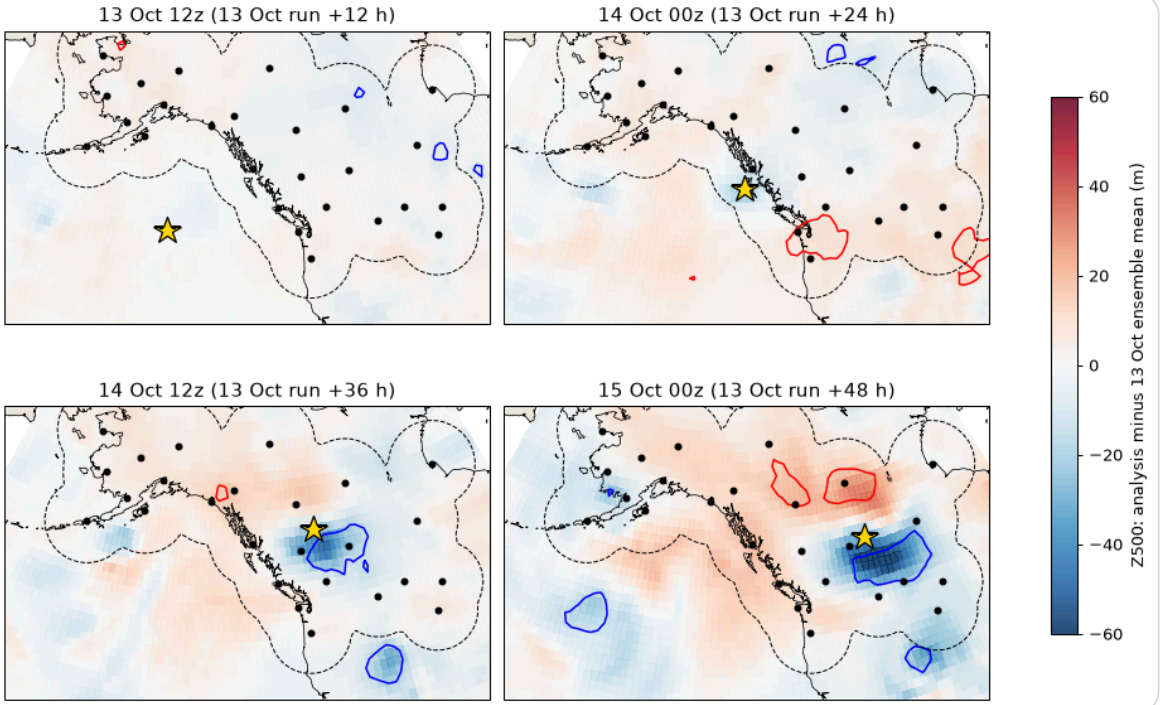
VALID	CANADIAN PRAIRIES 45–58°N 115–95°W	CENTRAL US 32–45°N 105–85°W	SE US 25–35°N 90–75°W
14 Oct (+36 h)	+4	+1	−2
15 Oct (+60 h)	**+27**	+12	−1
16 Oct (+84 h)	+21	**+44**	−2
17 Oct (+108 h)	+9	+17	**+21**

Mean Z500 error in metres; positive means forecast heights too high, so the trough is too weak or misplaced. The error moves south-east with the short wave.

8 Observations and steering: why the short wave turned south

The wave reached the radiosonde network only at landfall. The 13 Oct run was close then; the error grew over land as the ridge right behind the wave sharpened more than forecast.

SUPPORTED · ABOUT HALF THE TRACK ERROR



Z500 analysis minus the 13 Oct run's ensemble mean for the same time. Black dots: radiosonde stations; dashed line: 500 km from the nearest station; solid lines: differences beyond two ensemble spreads (red above, blue below); star: the short wave. Until landfall the wave was far outside the network and the two agree; afterwards the difference grows on the wave itself.

WHEN THE BALLOONS FIRST SAW THE WAVE

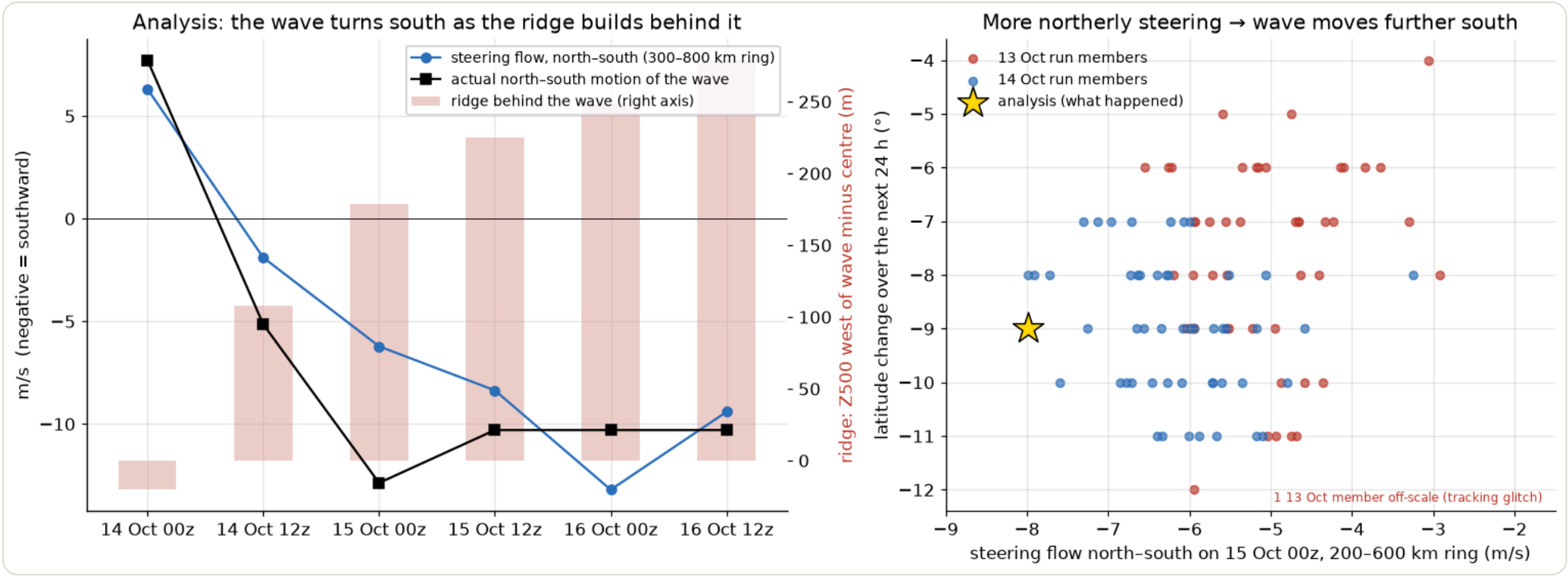
TIME	WAVE	NEAREST RADIOSONDE	STATIONS ≤800 KM
13 Oct 00z	41°N 150°W	Cold Bay, 1,833 km	0
13 Oct 12z	48°N 146°W	Kodiak, 1,166 km	0
14 Oct 00z	**53°N 133°W**	**Annette Island, 245 km**	**3**
14 Oct 12z	56°N 120°W	Prince George, 294 km	7

ANALYSIS MINUS 13 OCT FORECAST, ON THE WAVE

14 Oct 00z (landfall, +24 h): largest difference −25 m, on the wave; within the ensemble spread almost everywhere.

14 Oct 12z: −50 m at 54°N 118°W. **15 Oct 00z:** −66 m at 51°N 109°W, with 20% of nearby points beyond two spreads.

Balloons then recorded the gap: Stony Plain −41 m below the 13 Oct forecast (15 Oct), Rapid City −100 m and Bismarck −114 m (16 Oct), at or below the lowest members.



Left: on the analyses the wave turns south as the ridge behind it builds from nothing to about 250 m, and the steering flow (500 hPa geostrophic wind averaged 300–800 km around the wave) turns southward with it. Right: across members, more northerly steering on 15 Oct 00z goes with a larger southward move over the next 24 h; the analysed value (star) is more northerly than every 13 Oct member.

THE MECHANISM IN THE 13 OCT MEMBERS

Stronger ridge behind the wave → stronger northerly steering: **r = −0.43 to −0.68**.

Stronger northerly steering → further south 24 h later, allowing for starting latitude: **partial r +0.39 to +0.68**; +0.44 to +0.81 across three ring sizes.

The run's ridge was 8–20 m weaker than analysed and its steering 0.5–3 m/s less northerly. The 14 Oct run had both about right, and its track was right.

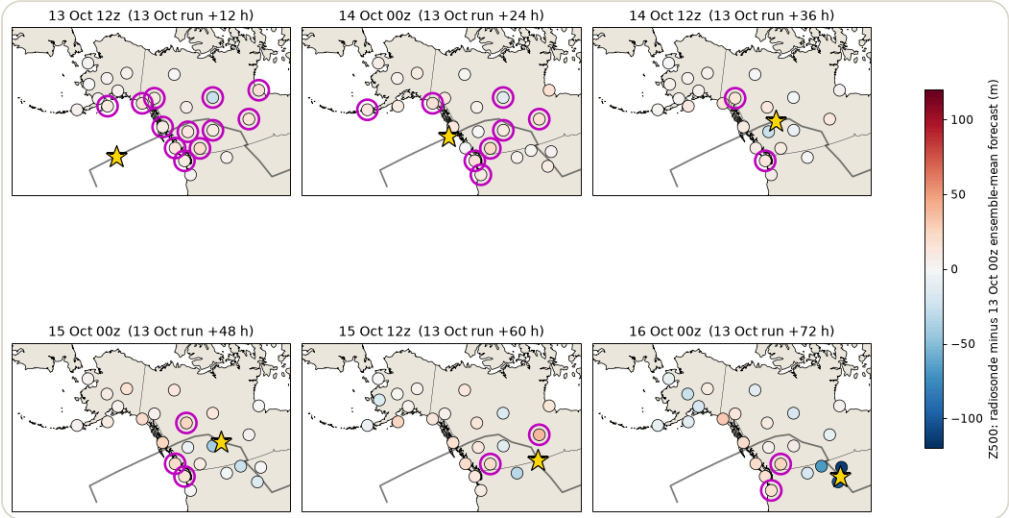
Balloons on 15 Oct 12z: 250 hPa northerlies of −52 m/s at Stony Plain and −47 m/s at Great Falls, against −44 and −38 m/s in the 13 Oct forecast.

THE MISSING NORTHERLIES WERE CLOSE TO THE WAVE

STEERING ON 15 OCT 00Z	13 OCT MEMBERS	ANALYSIS	MEMBERS AS NORTHERLY
200–600 km ring	−4.7 m/s	**−8.0 m/s**	**0 of 50**
300–800 km ring	−5.0	−6.2	4 of 50
400–1,000 km ring	−5.1	−5.1	36 of 50

Verdict. The ridge–trough couplet right around the wave was tighter than forecast, with stronger flow on its back side, rather than the large-scale steering being wrong. Accumulated over time, the steering error accounts for roughly half the 13 Oct run's latitude error; the rest is the wave's own development, which also moved it south faster than its steering early on. A link from stronger northerlies to **deepening** is not supported (inconsistent signs between runs).

SHOW BALLOON-MINUS-FORECAST AT EACH STATION

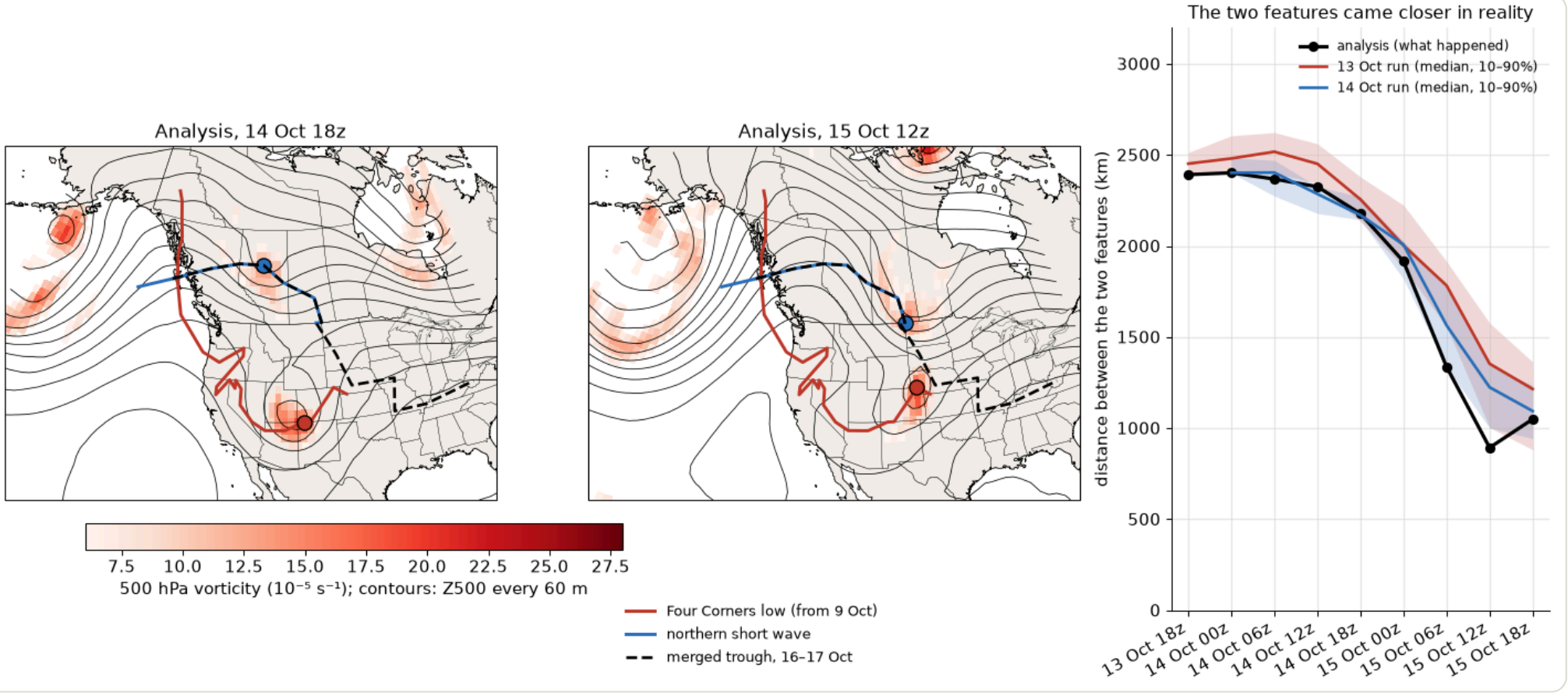


Z500 radiosonde minus the 13 Oct run's ensemble-mean forecast at each station; magenta rings: observation outside all 50 members (partly a point-versus-grid effect). Star: the short wave. Interpolating smoothed 1° fields to a point leaves offsets of about 10–20 m even for the analysis.

9 The Four Corners upper low: a phasing partner, not the source of the error

Hypothesis raised by Nick Silkstone from the ERA5 500 hPa map for 14 Oct 21 UTC: did this small upper low give the northern trough lower heights to drop into?

REAL AND RELEVANT · NOT THE ERROR



Left and middle: analysed 500 hPa vorticity and heights on 14 Oct 18z and 15 Oct 12z, with the tracks of the Four Corners low (red, from 9 Oct), the northern short wave (blue) and the merged trough after 16 Oct (dashed). Right: distance between the two features, analysis against the 13 and 14 Oct ensembles. In reality they closed to 893 km by 15 Oct 12z and merged by 16 Oct 06z.

WHAT THE LOW WAS

A cut-off low from the north, not the subtropics: a short wave over the Yukon and SE Alaska on 9 Oct that dropped down the BC and Oregon coast (10–11 Oct), cut off over the Great Basin (12–13 Oct), crossed Arizona and the Four Corners on 14 Oct and reached Colorado and Nebraska on 15 Oct.

Compact and strong: vorticity about 25 $\times 10^{-5}$ s^{-1}, closed 500 hPa low near 5,620 m on 14 Oct.

It phased with the northern wave: the gap closed from 2,400 km (14 Oct) to 893 km (15 Oct 12z); one merged feature by 16 Oct 06z, which then deepened from about 16 to 28 $\times 10^{-5}$ s^{-1} as it dug into the south-east US. Phasing combines the two troughs' vorticity into one larger, deeper trough, which fits the trough extending further south.

SENSITIVITY TESTS ACROSS MEMBERS

TEST	RESULT
The low in the 13 and 14 Oct forecasts, 14–15 Oct	Position within 0–178 km; lowest Z500 within 4–16 m; similar strength: **well forecast**
Its strength, depth and position on 15 Oct → later dig, trough reach, UK week	$\|r\| \leq 0.29$: **no significant link**, though members varied about as much as in the northern wave's latitude, which did show links
Members bringing the two features within 1,000 km by 15 Oct 12z (real: 893 km)	**2 of 50 (13 Oct run), 4 of 50 (14 Oct run)**
Closer half against further half of 14 Oct members: UK week Z500	5669 against 5715 m: right direction, not significant ($r = +0.19$)

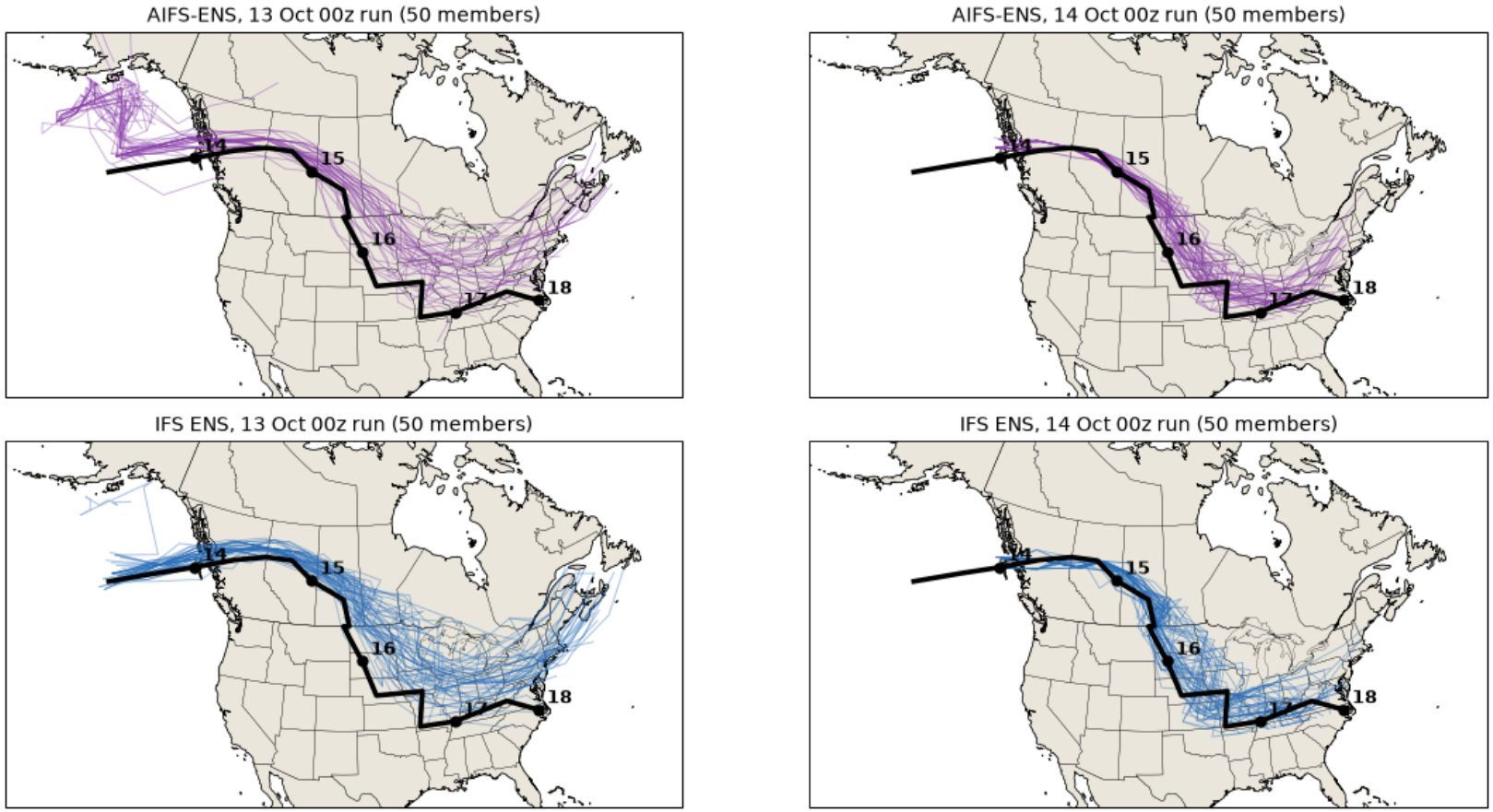
Verdict. The low was a well-forecast target that the northern wave merged with, and the merger very likely helped the trough extend south and deepen. Whether the two met depended on the northern wave's track (frame 8), which is where the forecasts went wrong. An ensemble can only test sensitivity within the variations its members explored; it cannot say what would have happened without the low.

Future work: a model experiment. ECMWF's AIFS model has open weights, so it can be re-run from the 13 Oct 00z analysis with the Four Corners low weakened or removed, and separately with the northern short wave or the ridge behind it adjusted. Comparing those runs would test directly whether phasing, and which feature, changed the UK outcome. This needs the model installed (a few GB) and a GPU for practical run times; on a laptop CPU, several hours per forecast. See frame 13.

10 Cross-check: AIFS-ENS made the same mistake

ECMWF's machine-learnt ensemble, started from the same analyses, shows the same short-wave and trough errors and flipped no earlier.

ESTABLISHED · SAME ERROR



The short wave in 50 members of each system (purple: AIFS-ENS; blue: IFS ENS) against the real track (black, dots at 00 UTC labelled with the day). Left: 13 Oct 00z runs, both carrying the wave too far north and out through New England. Right: 14 Oct 00z runs, both close to the real path. AIFS has no vorticity output, so its short wave is tracked with vorticity derived from 500 hPa heights; that method stays within a median 170 km of the true-vorticity track on the analyses.

13 OCT 00Z RUN: THE SHORT WAVE

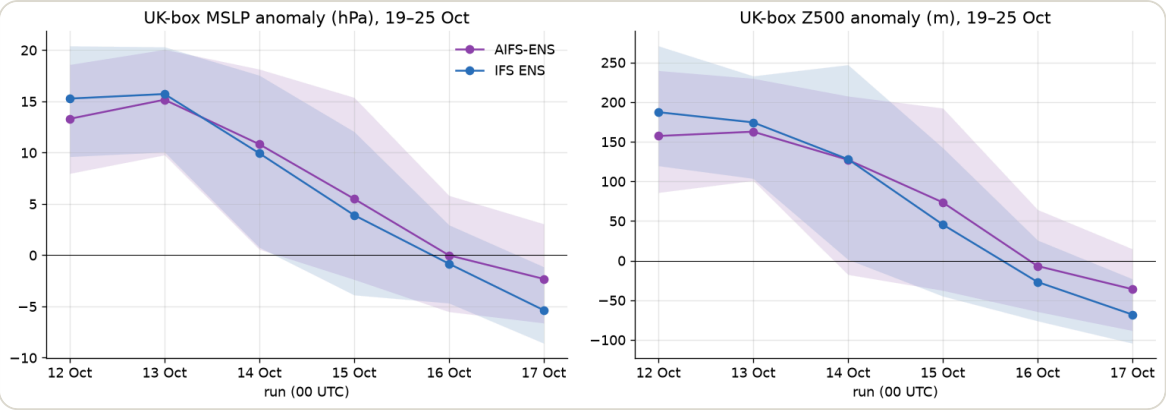
VALID	REAL	AIFS (ERROR)	IFS (ERROR)	STRENGTH AIFS / IFS
15 Oct 12z	49°N	52.2°N (295 km)	51.7°N (395 km)	1.03 / 1.03
16 Oct 12z	41°N	46.5°N (671 km)	42.6°N (333 km)	0.92 / 1.08
17 Oct 00z	37°N	45.2°N (1,327 km)	41.0°N (851 km)	0.71 / 0.91
17 Oct 12z	**38°N**	**45.8°N (1,748 km)**	**43.6°N (1,375 km)**	0.73 / 0.79

Strength is relative to each method's own analysis value (1.00 = as analysed). Tracking starts at 13 Oct 12z for both systems, because at 13 Oct 00z the wave was too weak in height-derived vorticity to track.

14 Oct 00z run: both systems follow the real path (AIFS 111 km off on 15 Oct 12z, IFS 264 km), and both under-deepen the wave by 17 Oct 12z (0.79 and 0.80 of the analysed strength).

TROUGH, PACKET AND VERIFICATION

	ANALYSIS	AIFS	IFS
Trough reach along 75–90°W, 17 Oct 12z: 13 Oct run	36°N	38.8°N (4/50 reach 36°N)	38.6°N (4/50)
Same, 14 Oct run	36°N	37.7°N (10/50)	37.6°N (12/50)
Packet near 71°W, 18 Oct 12z: 13 Oct run	27 m/s	**47 (10–90%: 38–56)**	**48 (43–54)**
Same, 14 Oct run	27 m/s	46 (30–57)	40 (22–54)
UK-box Z500, 20 Oct 12z, from the 16 Oct run	5601 m	5641	5594



UK-box anomalies for 19–25 Oct by run: AIFS-ENS (purple) against IFS ENS (blue); shading is the 10–90% range of members. AIFS flips in step with IFS but commits later.

RUN (00Z)	AIFS MSLP	IFS MSLP
13 Oct	+15.2 (100% high)	+15.7 (100%)
14 Oct	+10.8 (90%)	+9.9 (94%)
15 Oct	+5.5 (82%)	+3.9 (70%)
16 Oct	−0.0 (46%)	−0.8 (42%)
17 Oct	**−2.3 (26%)**	**−5.4 (6%)**

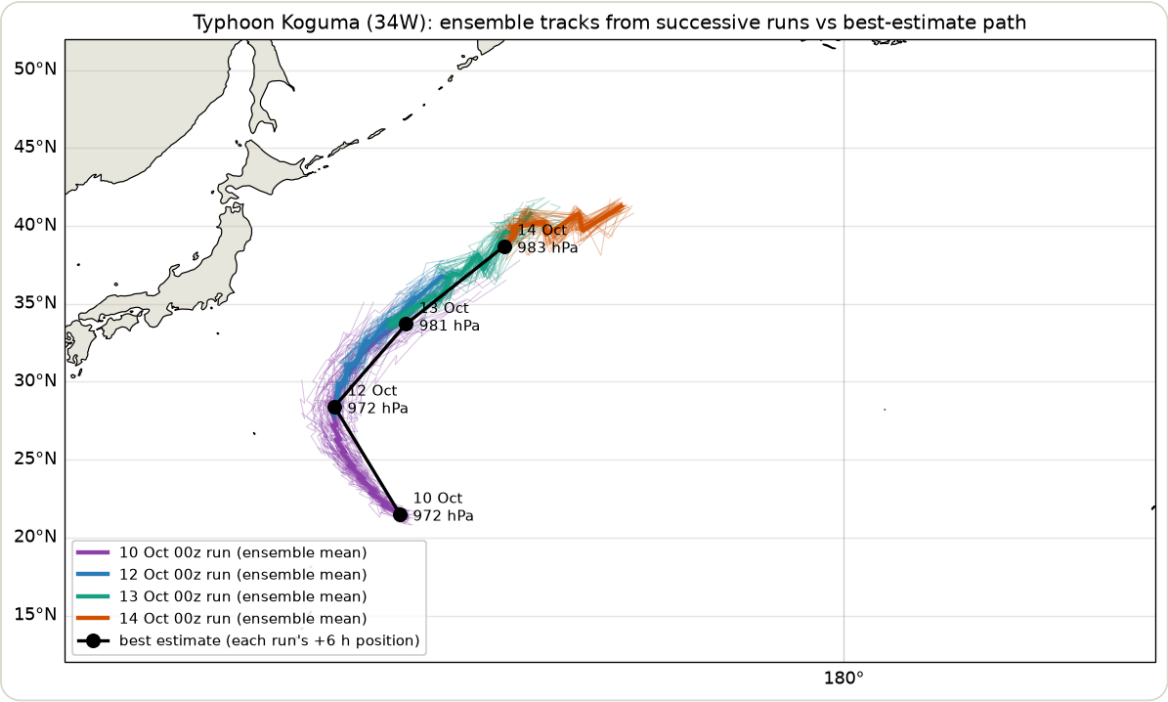
UK-box MSLP anomaly (hPa), 19–25 Oct, with the share of members above normal.

What this suggests. Two very different models, one physics-based and one machine-learnt with no convection scheme at all, started from the same analyses and made the same error. That points away from model physics such as convection or latent heating, in line with frame 6, and towards the starting analysis of the short wave or the flow's own limited predictability. It is an inference, not a proof: AIFS learned from ERA5, so it can share IFS-like behaviour.

11 Typhoon Koguma: it seeded the packet, but it isn't where the forecast went wrong

Revised from the first storyboard.

CONTEXT



ECMWF ensemble tracks for Koguma (34W) from successive runs against a best-estimate path (each run's +6 h position).

Koguma recurved and went extratropical on about **14 Oct** near 39°N, 158°E. The packet in frame 4 starts at that longitude and time.

The early runs had its **track** too slow and too far south-west, by 550–1,630 km. Intensity error was small (−8 to +2 hPa on the ensemble mean).

But the 13 Oct run forecast the resulting packet over the Pacific almost exactly (42/42, 43/42, 37/35 m/s on 14–16 Oct). The Gulf of Alaska low's depth was also right (973.6 against 975.2 hPa).

So Koguma helped create the situation, but its forecast errors did not cause the flip.

12 Checked and ruled out

TROPICAL CYCLONES NEAR NORTH AMERICA **RULED OUT**

Atlantic / Caribbean: the only storm was **Isaias (09L)**, at 976 hPa on the northern Gulf coast on 10 Oct. It was inland and decaying by 11 Oct. No run from 11 to 17 Oct tracks any Atlantic system.

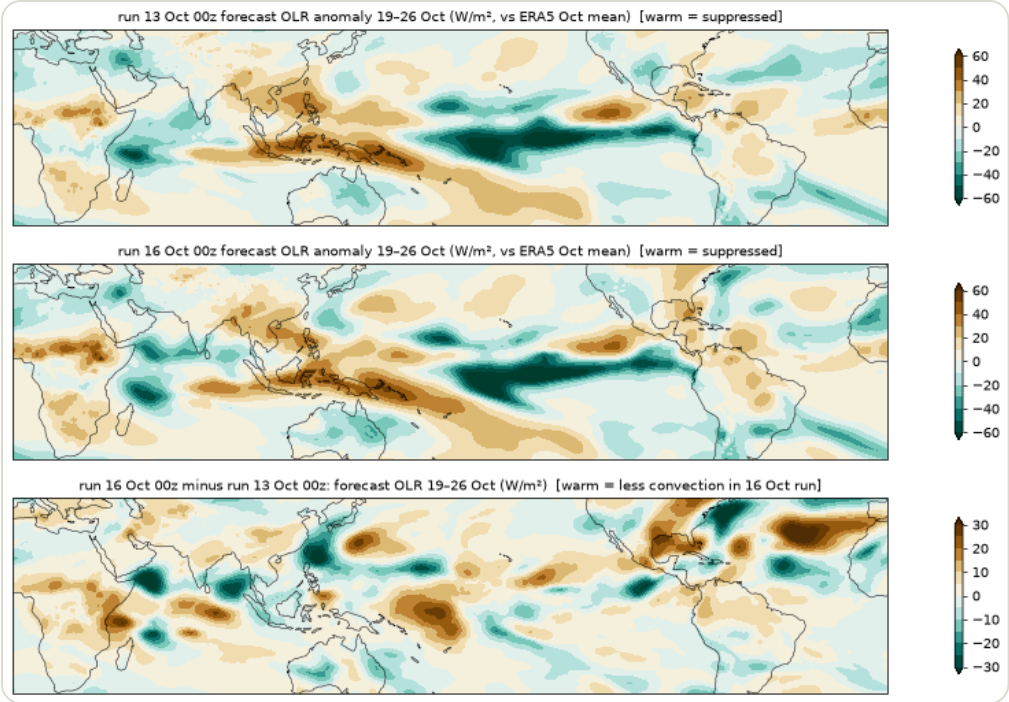
Eastern Pacific: Simon weakened off western Mexico; Trudy deepened to about 977 hPa off southern Mexico on 16–18 Oct and moved north-west along the coast. There is no sign either was involved.

TROPICAL CONVECTION AND MJO **RULED OUT AS THE TRIGGER**

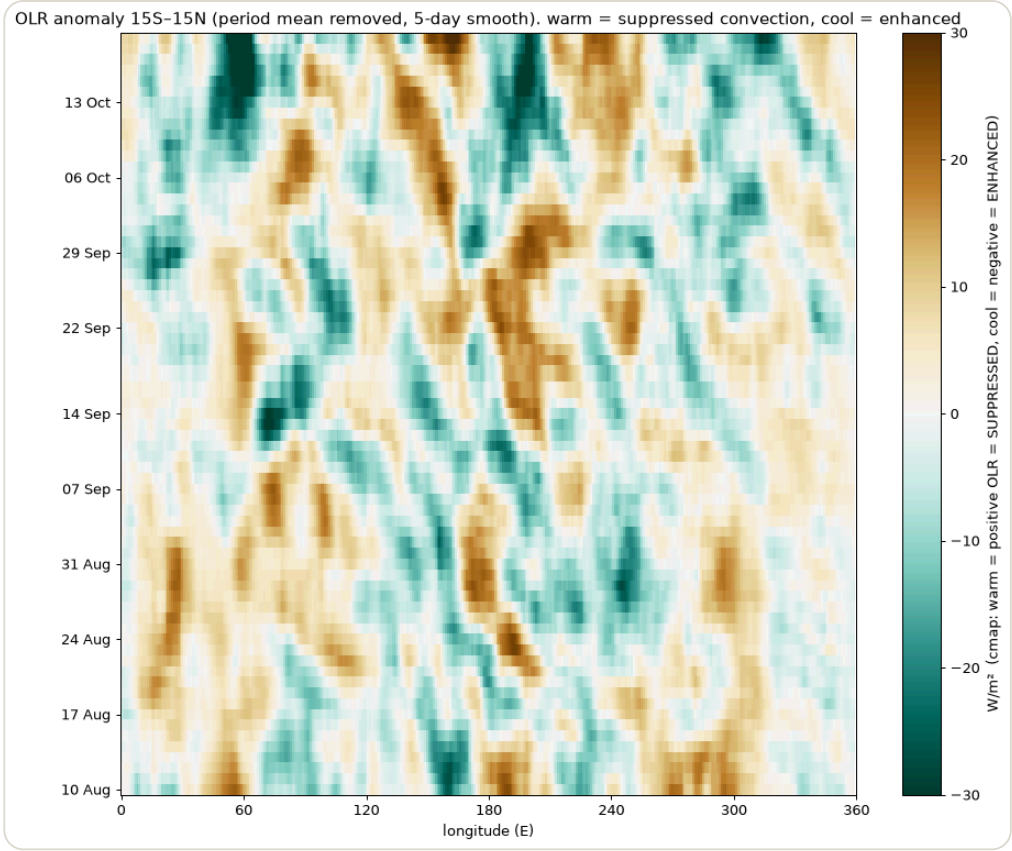
Forecast tropical OLR for 19–26 Oct barely changed between runs (3–6 W/m² by sector, against an El Niño-like background of ±30).

An MJO-like eastward signal is visible, with a new phase over the western Indian Ocean around 13–19 Oct. This is a visual read only; the RMM index was not computed.

SHOW THE OLR FIGURES



Forecast OLR anomaly for 19–26 Oct, 13 vs 16 Oct runs, and their difference.



Tropical OLR anomaly, 15°S–15°N, 10 Aug–19 Oct.

13 Caveats, corrections and future work

CAVEATS

The analysis uses the **medium-range ensemble** (0.25°, thinned to 1°), not the extended-range product. They agree on the flip.

"Best estimate" rainfall is the HRES day-1 forecast, not observations. Jet speeds are geostrophic.

The data show where analyses and forecasts diverged, but not which observations fed each analysis.

Correlations across members show association, not cause. Rain and 700 hPa ascent stand in for latent heating.

AIFS short-wave tracking uses vorticity derived from 500 hPa heights (checked against the true-vorticity track on the analyses).

Observations are radiosondes only (IGRA2, quality flags not applied); aircraft and satellite data are not in the open record. Steering uses the 500 hPa geostrophic wind at a single level.

CHANGED SINCE THE FIRST VERSION

Koguma demoted from "possible root cause" to context: the packet it seeded was forecast well.

The chance level for hemisphere-wide correlations is about 0.46–0.56, not 0.4. Only the strongest links are kept.

Koguma's pressure is quoted as the ensemble mean (about 972 hPa), not the deepest member (953 hPa).

Short wave traced (frame 7): the "northern stream" origin is now a tracked feature with a two-step forecast error.

Latent-heating check (frame 6): heating did not drive the deepening. This replaces the earlier "very likely reinforced the split".

AIFS-ENS cross-check (frame 10): the machine-learnt ensemble made the same error.

Observations and steering (frame 8): no large missed feature at landfall; the error grew over land around the wave.

Four Corners low (frame 9): real, well forecast, and a phasing partner for the northern wave; not the source of the error.

POSSIBLE NEXT STEPS

AIFS initial-condition experiment (priority). Re-run ECMWF's open-weights AIFS model from the 13 Oct 00z analysis in several versions: unchanged; with the Four Corners low weakened or removed; with the northern short wave deepened; and with the ridge behind it sharpened. If the "sharper ridge" or "deeper wave" versions flip the UK week and the "no low" version blocks it, that would turn the associations in frames 7–9 into tested cause and effect. Practical on a GPU workstation; several hours per forecast on a laptop CPU.

Deep-layer steering and potential-vorticity diagnostics around the short wave on 14–16 Oct with full-resolution data, to separate steering from the wave's own

development.

Examine the jet streak and upper-level wave structure around the short wave on 16–17 Oct with full-resolution data, to find what the 14 Oct run missed.

Compare the ECMWF MJO (RMM) forecast between the 13 and 16 Oct runs.

Data: ECMWF open data (IFS and AIFS ensembles 0.25°, HRES analyses and day-1 forecasts, tropical cyclone tracks; fields thinned to 1°) and ERA5 monthly means 1991–2020 from the Copernicus Climate Data Store. Packet envelope after Zimin et al. (2003). Analysis by Claude (Anthropic) and Nick Silkstone, 20–21 Oct 2026.

Radiosonde data: NOAA NCEI Integrated Global Radiosonde Archive, version 2 (IGRA2). Contains ECMWF open data (© ECMWF, licensed under CC BY 4.0) and modified Copernicus Climate Change Service information (2026); neither ECMWF nor the European Commission is responsible for any use of this information. The extended-range chart screenshots are © ECMWF (charts.ecmwf.int), CC BY 4.0.