

Drifting buoys data denial studies and impact of field campaign data

2026 AR Recon workshop and 2nd
Observational campaigns workshop for better weather forecasts
ECMWF | Reading | June 29 to July 3, 2026

Magnus Lindskog, David Lavers, Bruce Ingleby and Sean Healy

ECMWF, Shinfield Park, Reading, United Kingdom

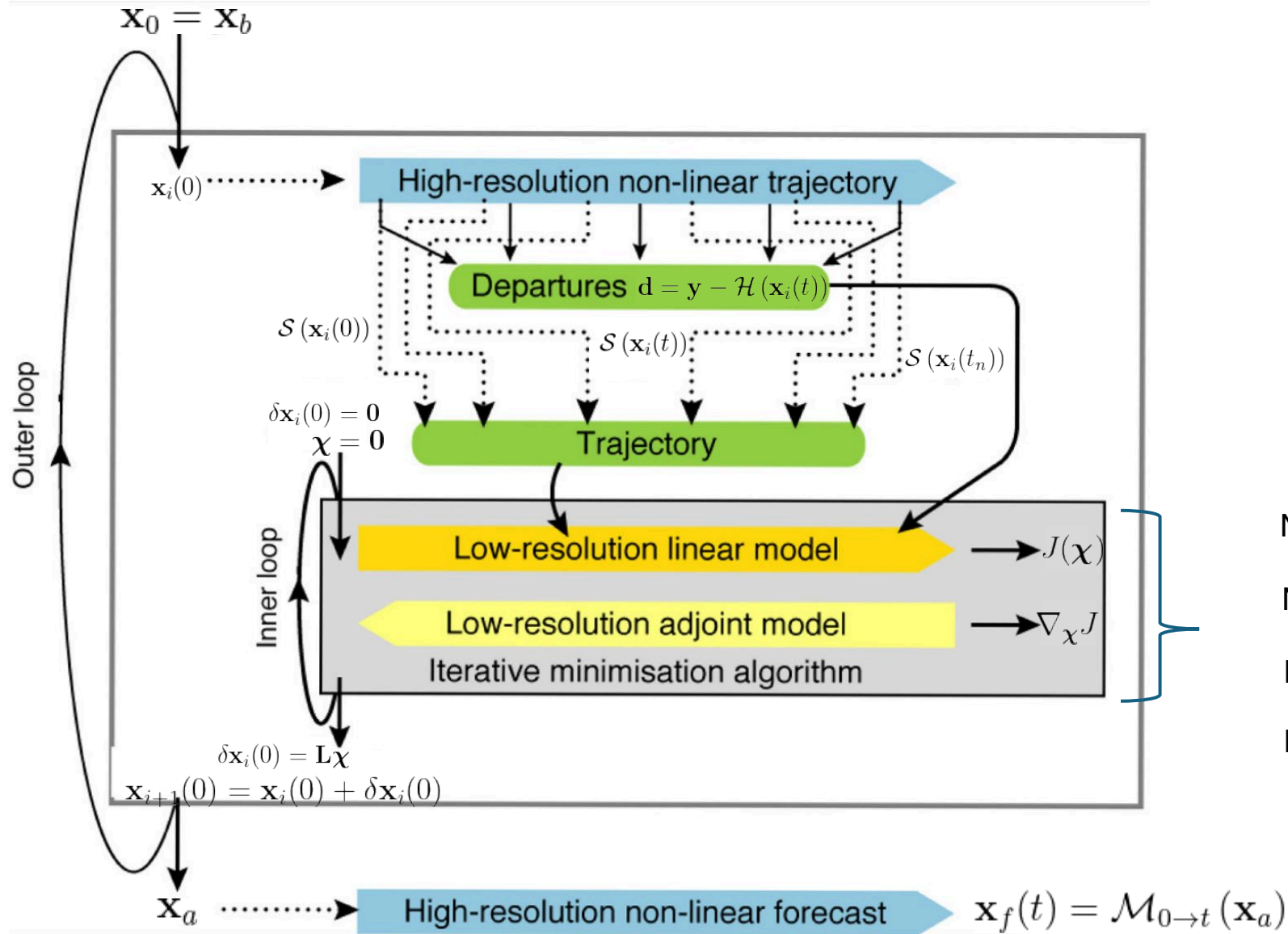
Magnus.Lindskog@ecmwf.int



Structure

- Overview
- Design of observation system impact studies
- Forecast Sensitivity to Observations (FSOI)
- Results
- Summary and Conclusions

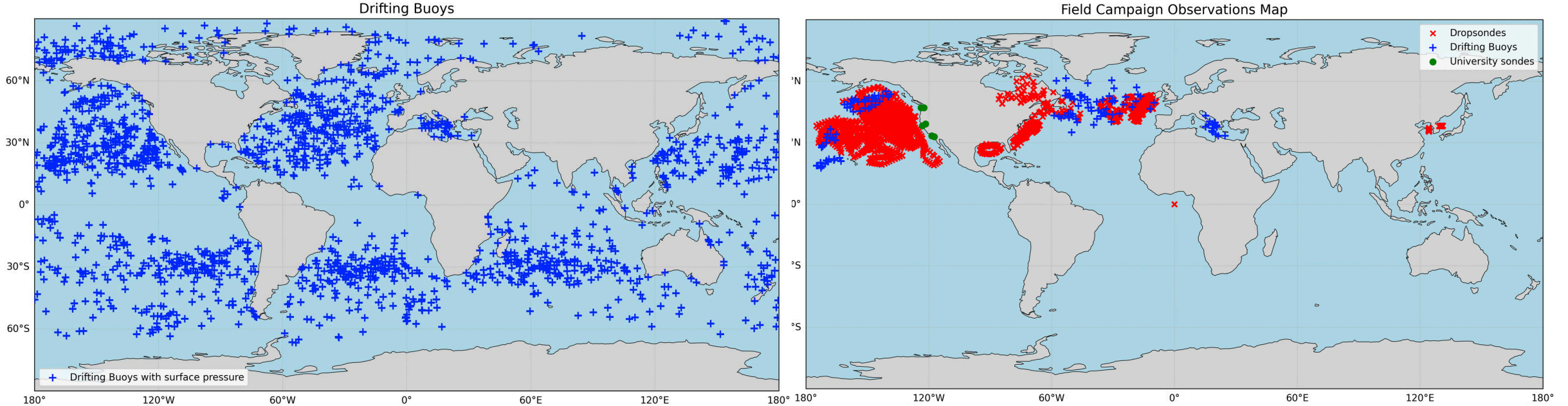
Overview 4D-Var data assimilation procedure in ECMWF IFS



12 h assimilation window
 00 UTC cycle 21-09 UTC
 12 UTC cycle: 09-21 UTC

- Min 1: TL255
- Min 2: TL319
- Min 3: TL399
- Min 4: TL511

Drifting buoys denial study and Field campaign observation denial study



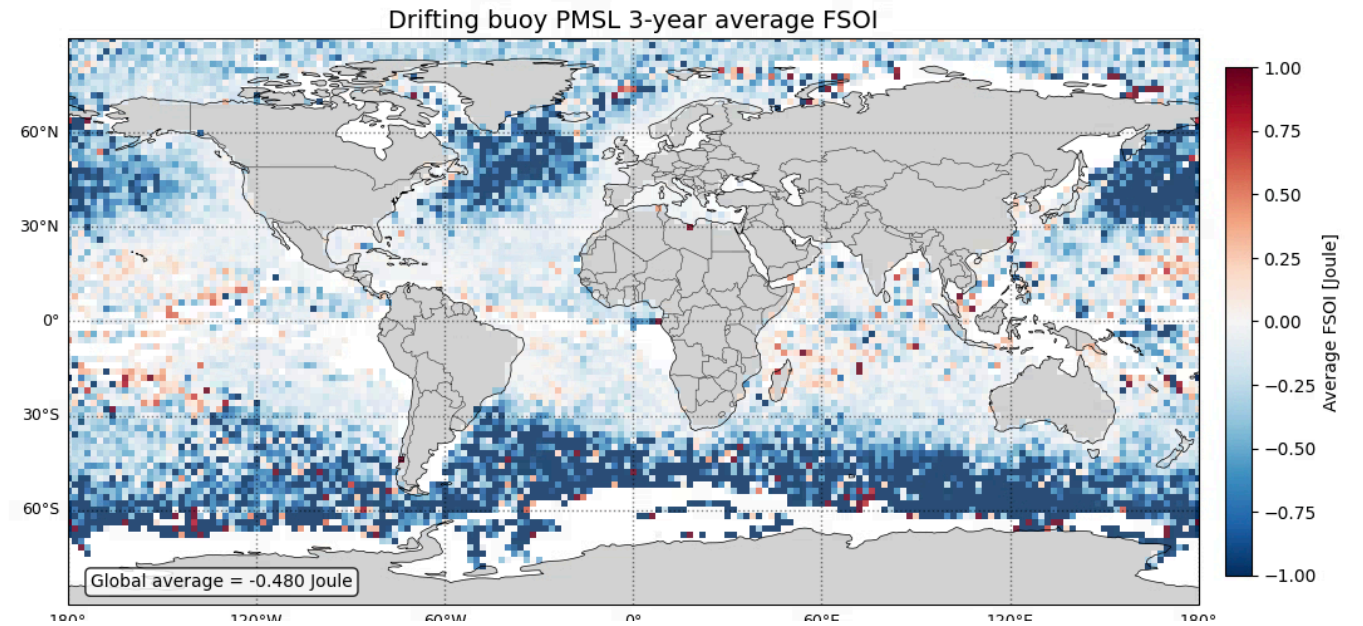
- 3 months (1 Dec 2025 to 28 Feb 2026) Drifting Buoy observations denial parallel experiment.
- 3 months (1 Dec 2025 to 28 Feb 2026) Field campaign data denial parallel experiment (all Dropsondes, one university sonde site, and newly-deployed drifting buoys).

(from Drifting Buoys only surface pressure assimilated, from sondes T,w,q, and low-level geopotential (Dropsondes))

Drifting buoys

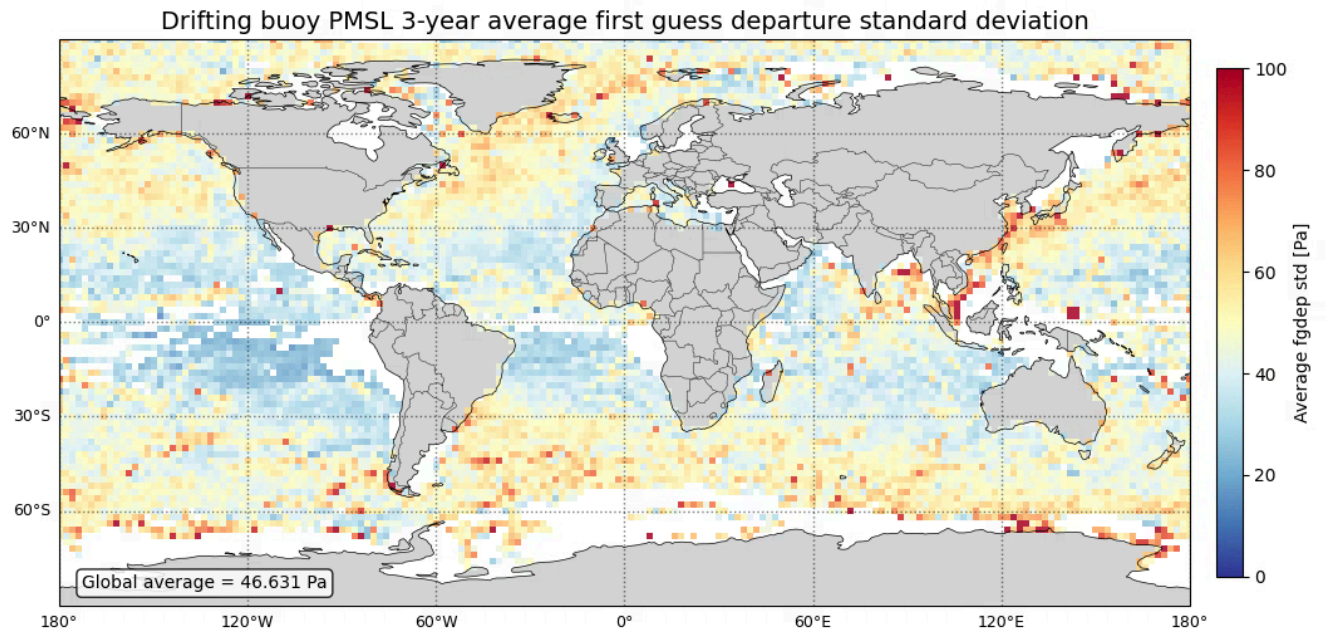
3-year average FSOI
(2023-05-01 to 2026-04-30)

Note that largest negative FSOI means biggest positive impact!
There is a clear latitudinal dependence of FSOI with minima at midlatitude storm tracks and maxima around the Equator.



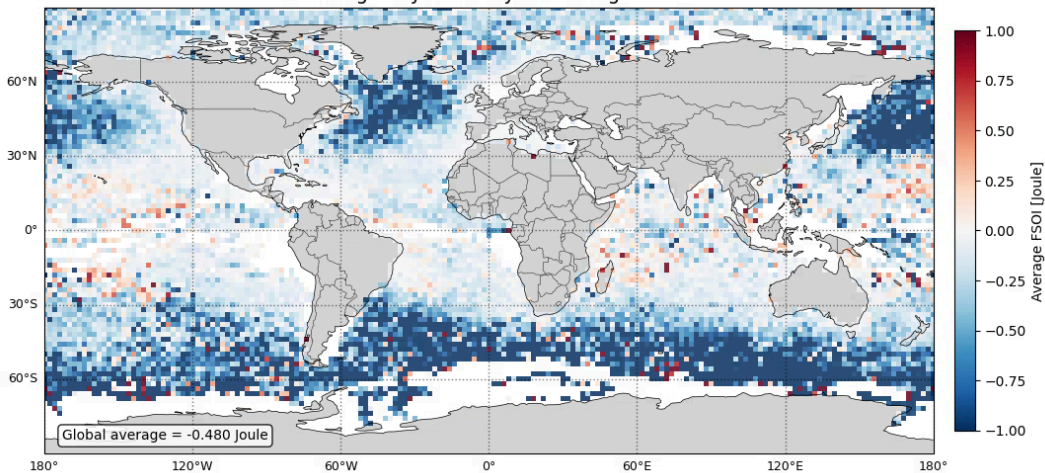
3-year average first-guess departure standard deviation
(2023-05-01 to 2026-04-30)

Large negative FSOI in areas with high background error standard deviations (large uncertainties, not so many other observations and dynamically active areas)

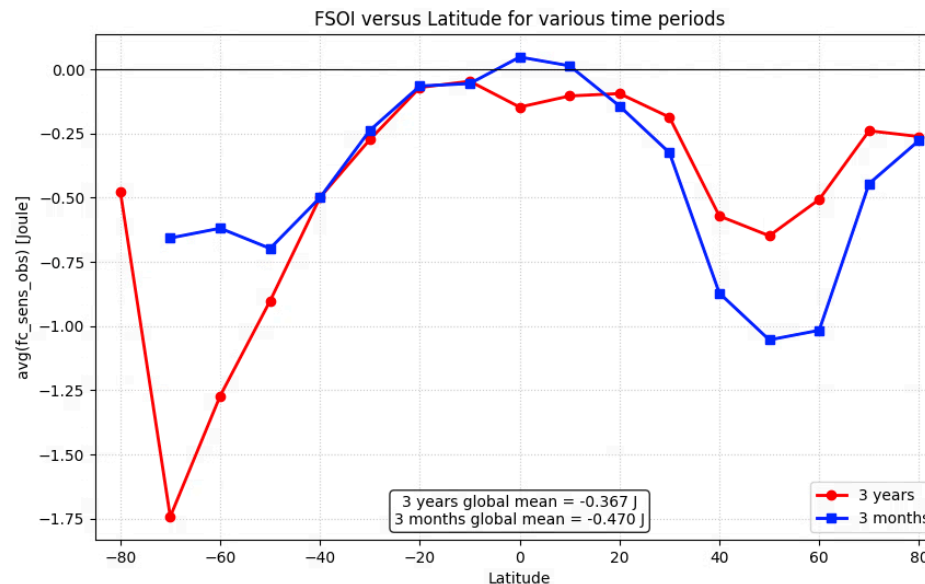


Drifting buoys

3-year average FSOI
(2023-05-01 to 2026-04-30)
Drifting buoy PMSL 3-year average FSOI

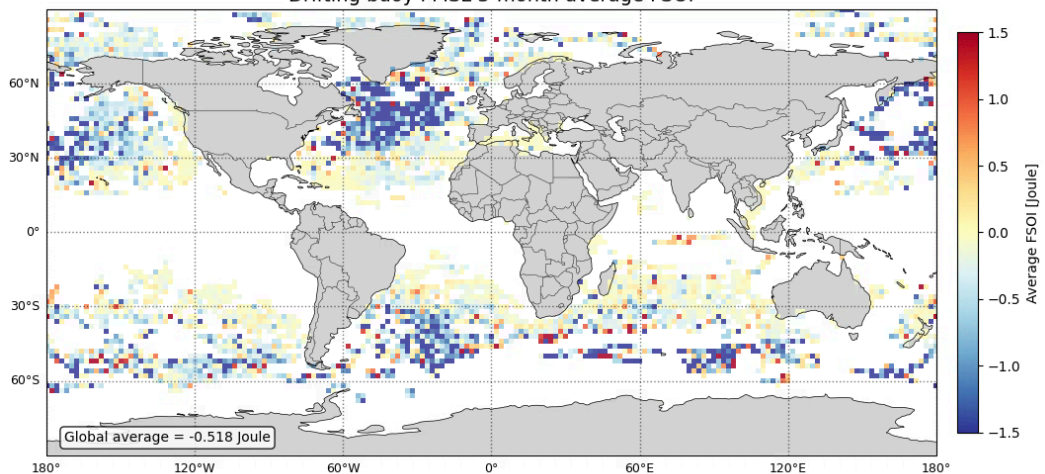


3-year average FSOI
(2023-05-01 to 2026-04-30)



3-month average FSOI
(2025-12-01 to 2026-02-28)

Drifting buoy PMSL 3-month average FSOI



There is a clear latitudinal dependence of FSOI with minima at midlatitude storm tracks and maxima around the Equator. For the 3-month period drifting buoys on Northern Hemisphere more important than for the Southern Hemisphere. The opposite apply for the 3-year average.

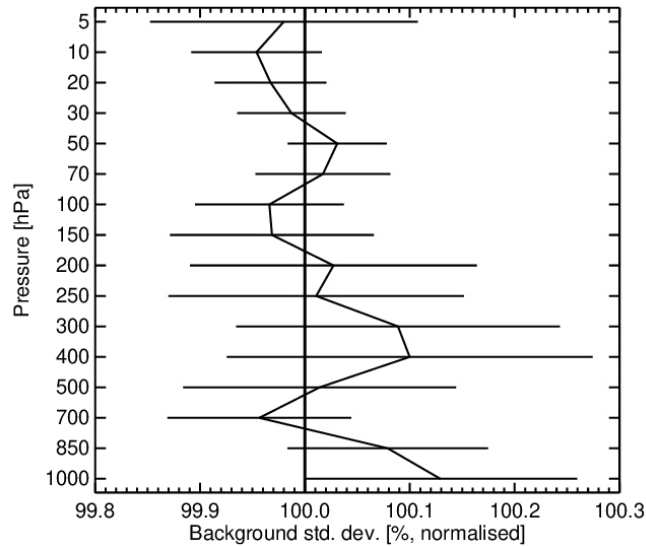
Drifting buoys

Verification against other observations

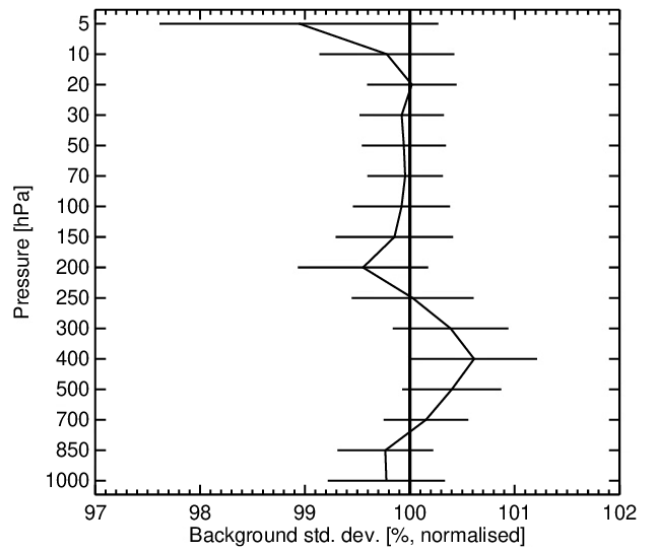
Normalized difference in ob-fg departures

Values larger than 100% indicate degradation brought by denying buoys.

Instrument(s): DROP TEMP TEMP-DESCENT - T Area(s): NH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

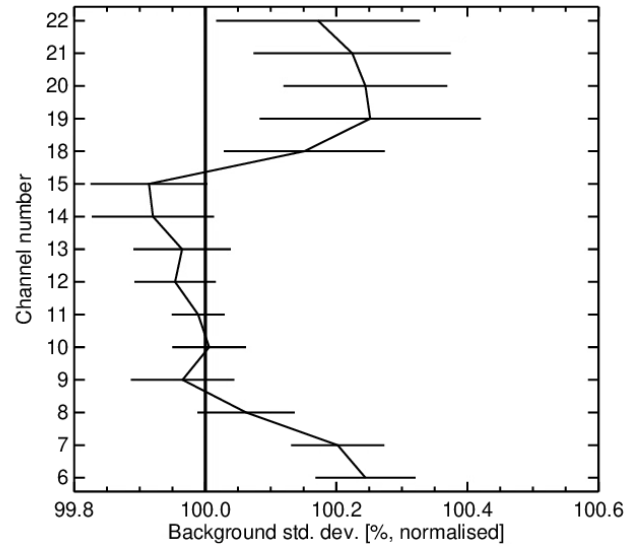


Instrument(s): DROP TEMP TEMP-DESCENT - T Area(s): SH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

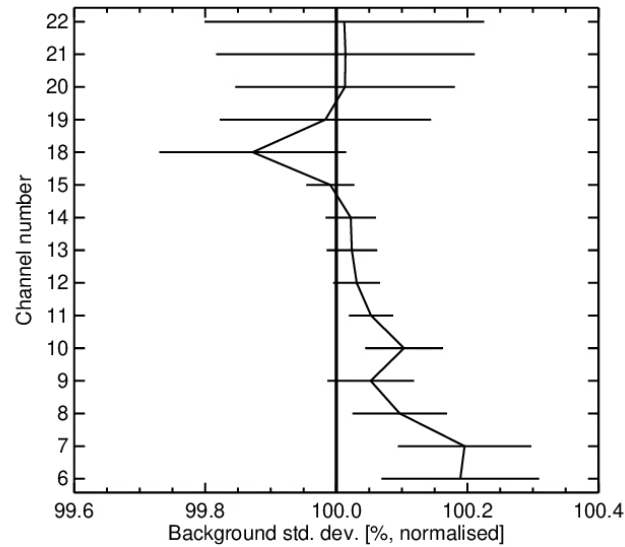


— Drifter denial
100% = Control

Instrument(s): NOAA-20,21; NPP - ATMS - TB Area(s): NH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

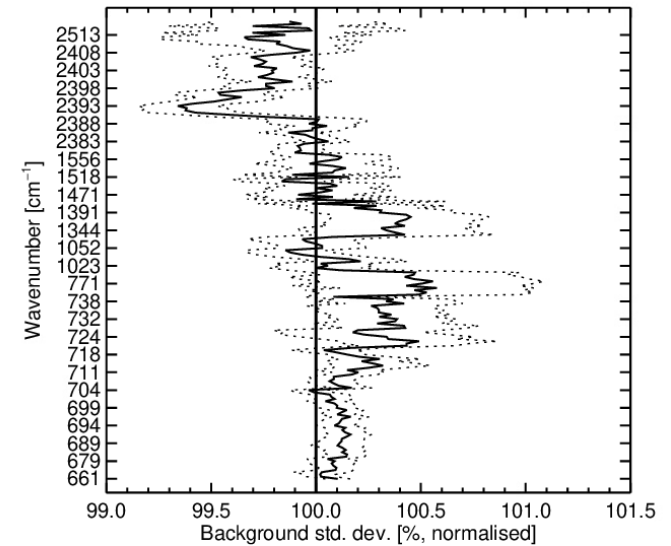


Instrument(s): NOAA-20,21; NPP - ATMS - TB Area(s): SH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

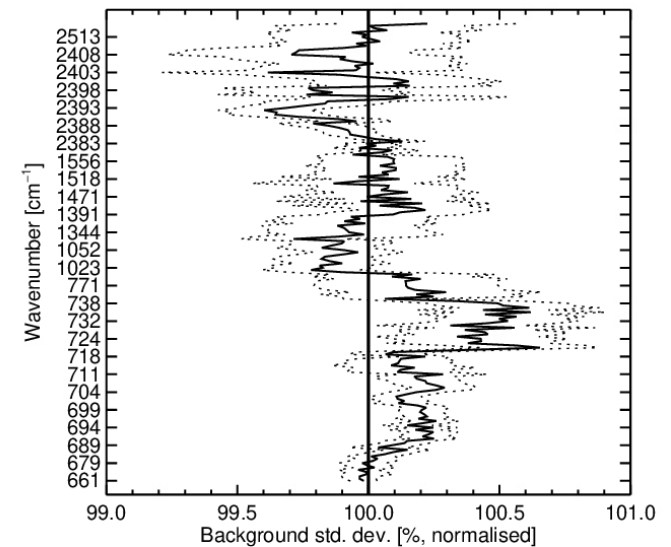


— Drifter denial
100% = Control

Instrument(s): NOAA-20,21 - CRIS - TB Area(s): NH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026



Instrument(s): NOAA-20,21 - CRIS - TB Area(s): SH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026



— Drifter denial
100% = Control

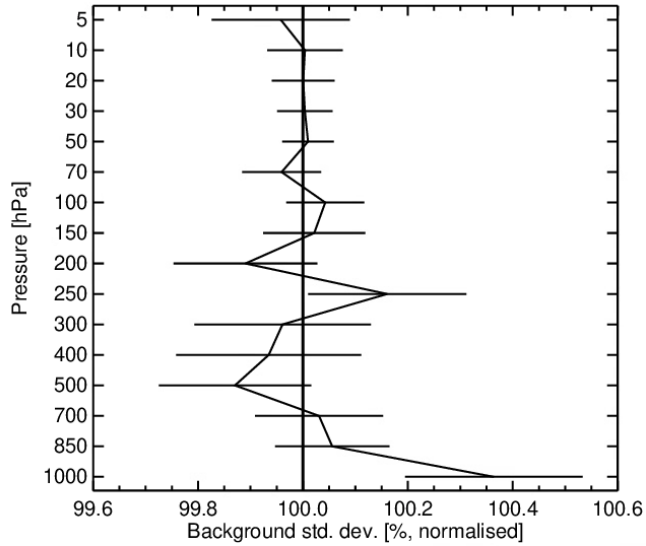
Field
campaign
observations

Verification
against other
observations

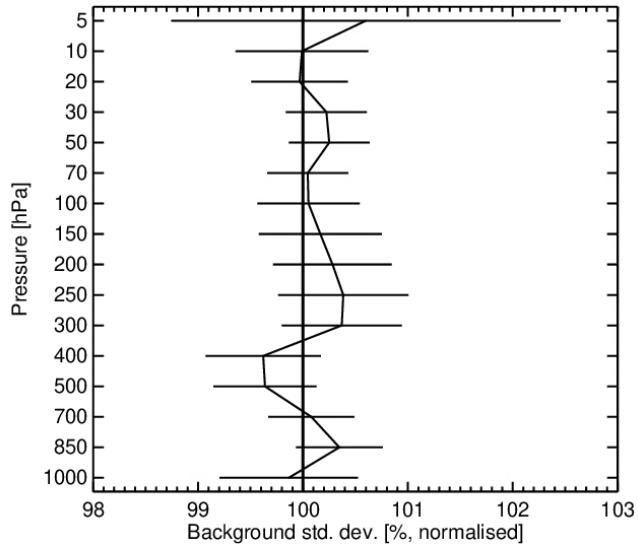
Normalized
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Values larger than
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Instrument(s): DROP TEMP TEMP-DESCENT - T Area(s): NH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

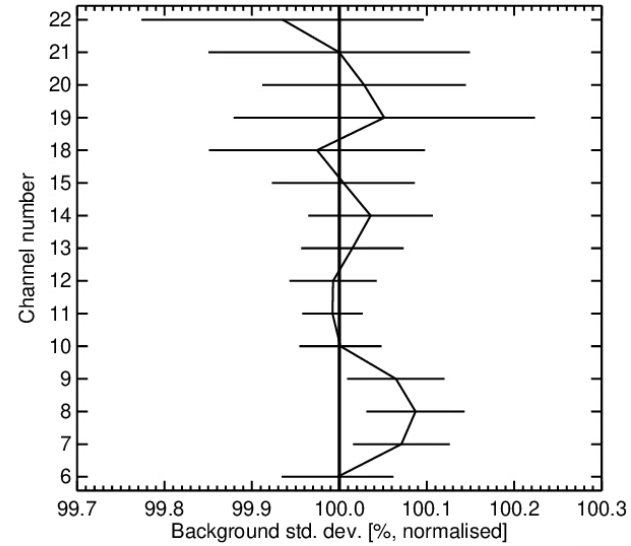


Instrument(s): DROP TEMP TEMP-DESCENT - T Area(s): SH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

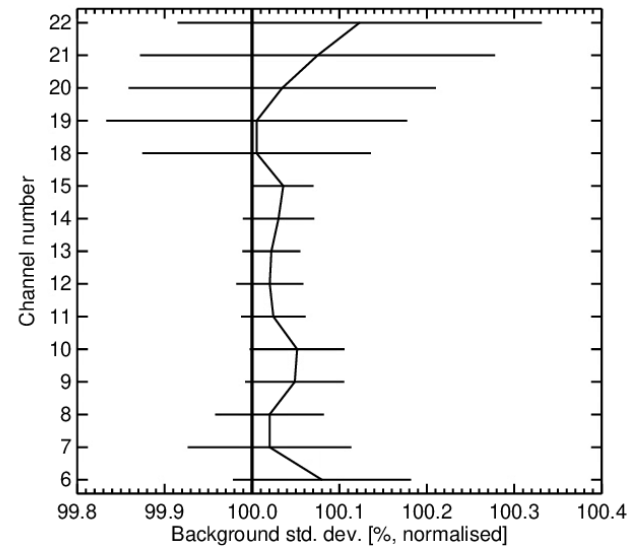


— NO_FLD_OBS
- - - 100% = CTL

Instrument(s): NOAA-20,21; NPP - ATMS - TB Area(s): NH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026

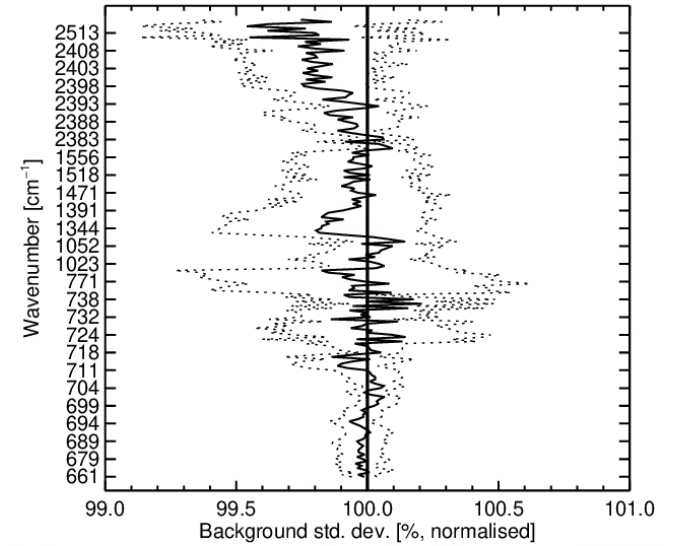


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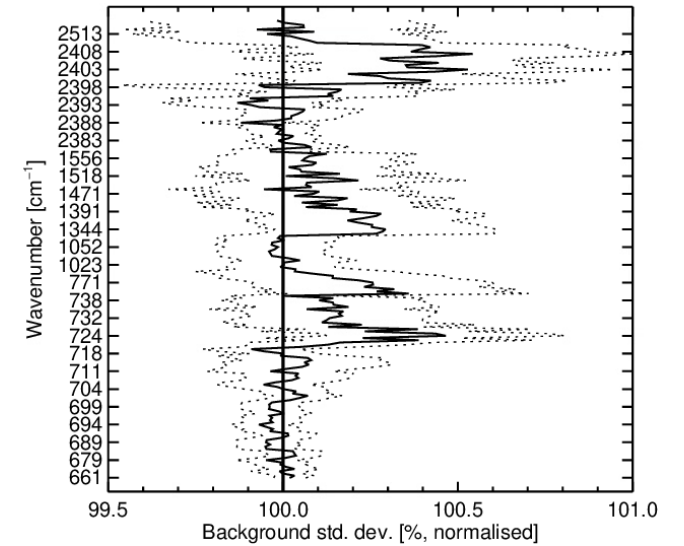


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Instrument(s): NOAA-20,21 - CRIS - TB Area(s): NH
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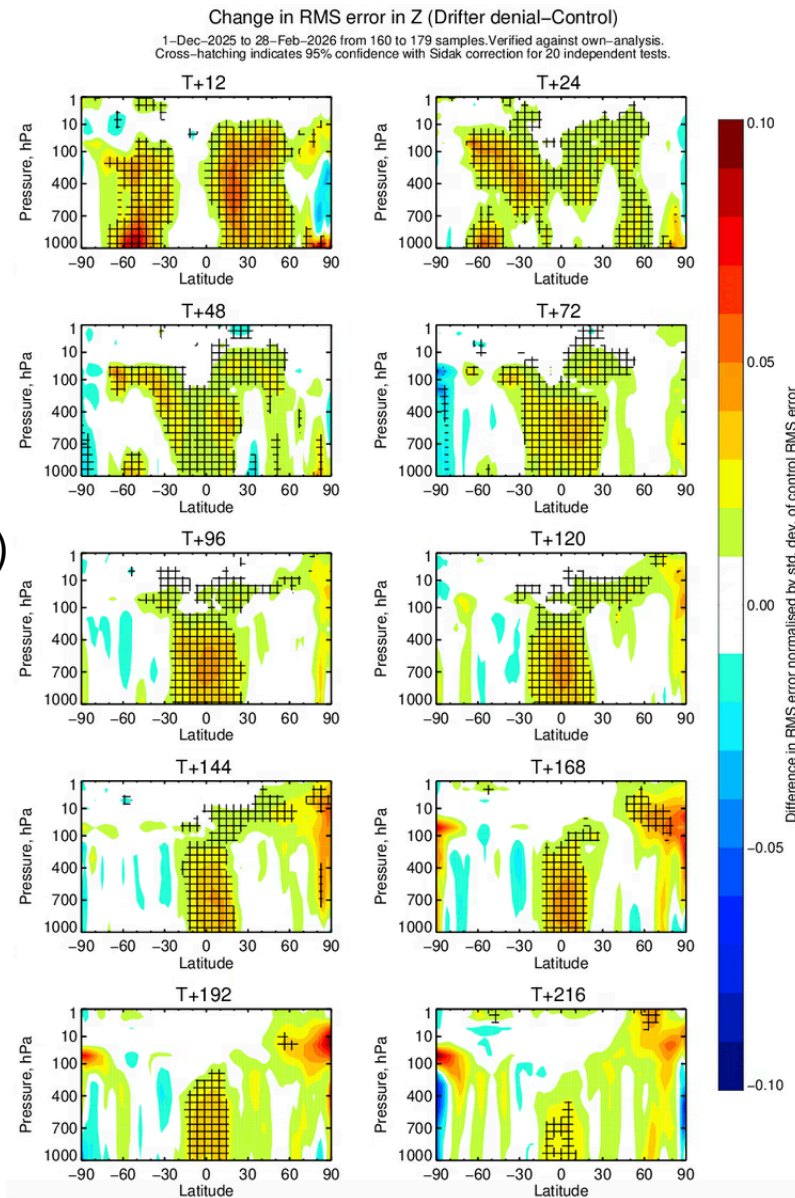
Instrument(s): NOAA-20,21 - CRIS - TB Area(s): SH
From 00Z 1-Dec-2025 to 12Z 28-Feb-2026



— NO_FLD_OBS
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Drifting buoys

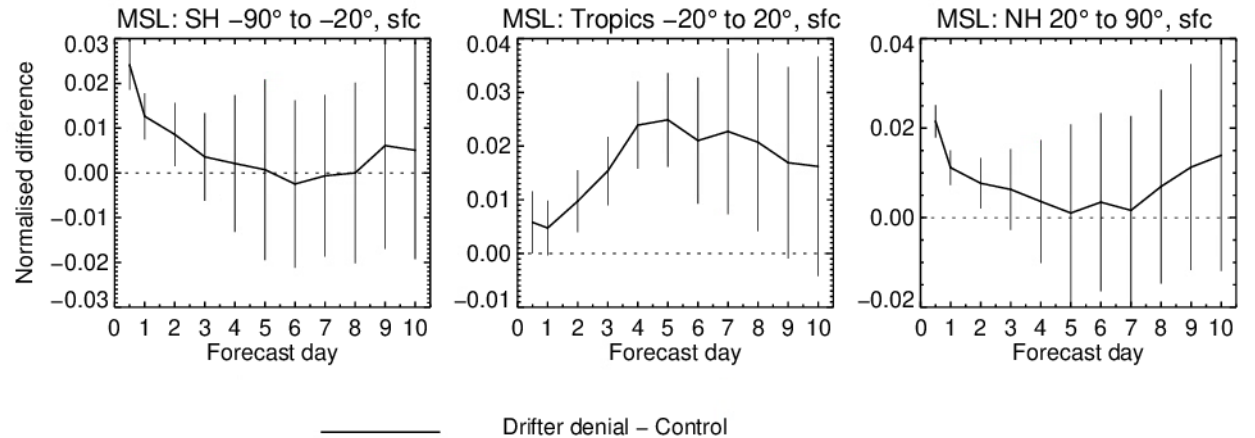
Geopotential
(red degradation)



Verification against own analyses Experiment denying buoys minus control

Surface pressure
(positive indicate degradation)

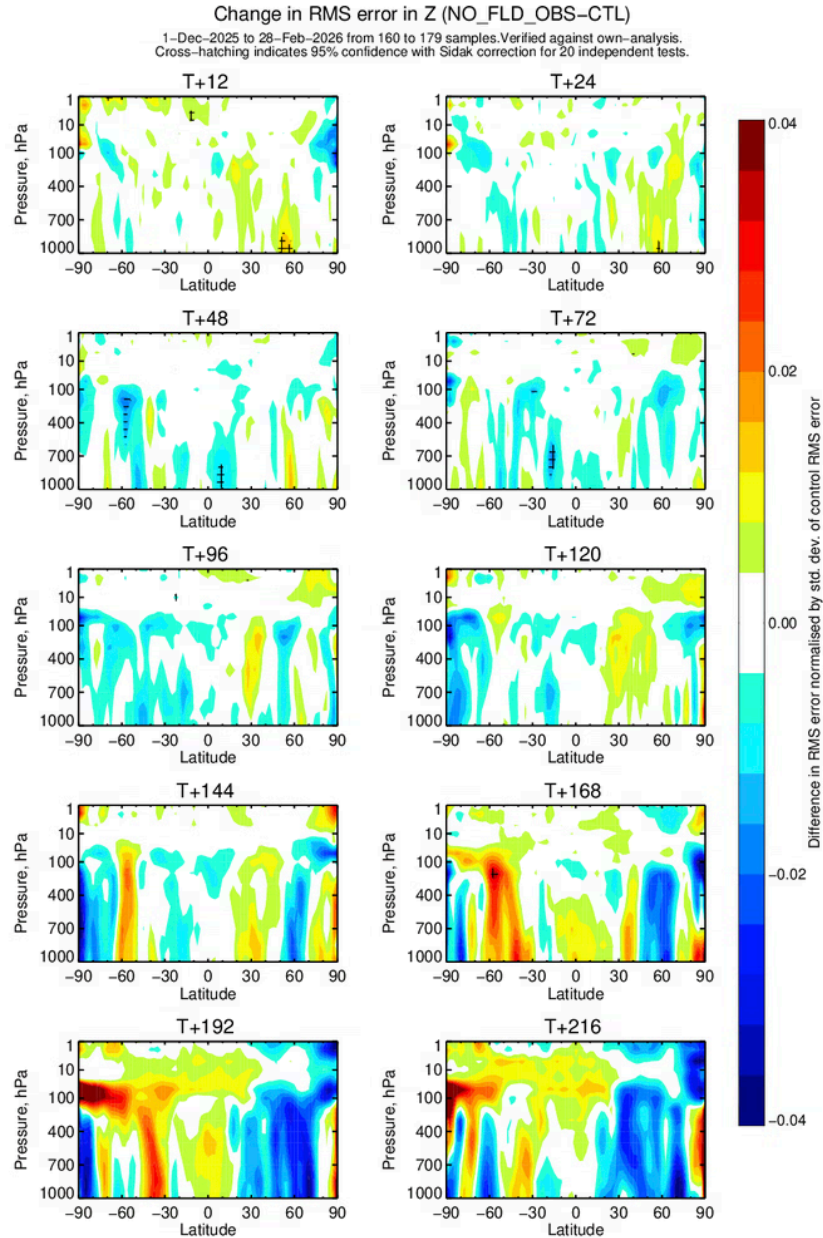
1-Dec-2025 to 28-Feb-2026 from 160 to 179 samples. Verified against own-analysis.
Confidence range 95% with AR(2) inflation and Sidak correction for 4 independent tests.



Clear degradation from removing all drifting buoy observations.
Also seen for temperature and wind forecast (not shown).
More degradation on the Northern than on the Southern Hemisphere.

Field
campaign
observations

Geopotential
(red degradation)

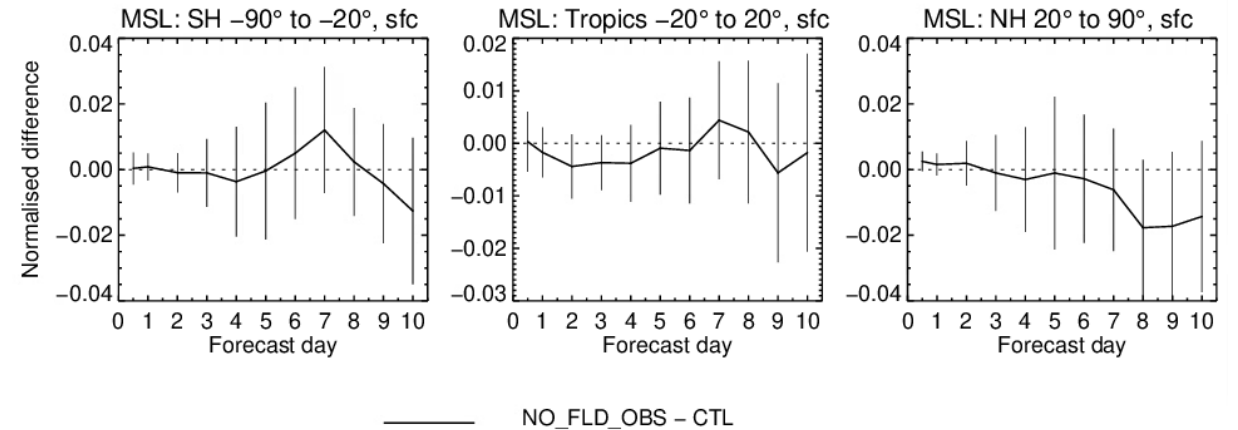


Verification against own analyses
Experiment denying field campaign
observations minus control

Surface pressure

(positive indicate degradation)

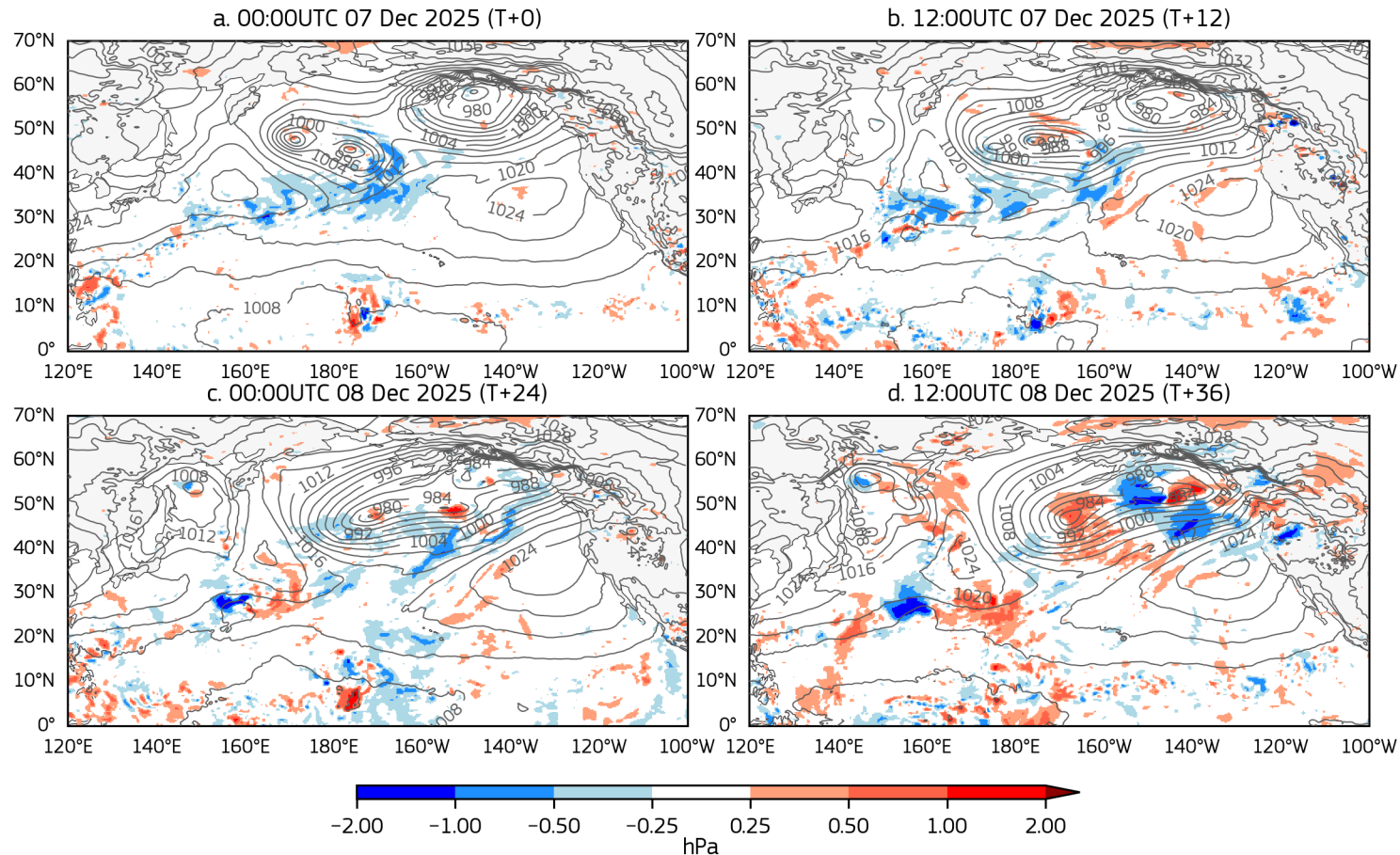
1-Dec-2025 to 28-Feb-2026 from 160 to 179 samples. Verified against own-analysis.
Confidence range 95% with AR(2) inflation and Sidak correction for 4 independent tests.



Not so clear degradation on average scores from removing field
campaign observations (only minor at short ranges on
Northern Hemisphere). Investigation of impact on case studies
remains to be done.

Case study from drifting buoy denial experiment

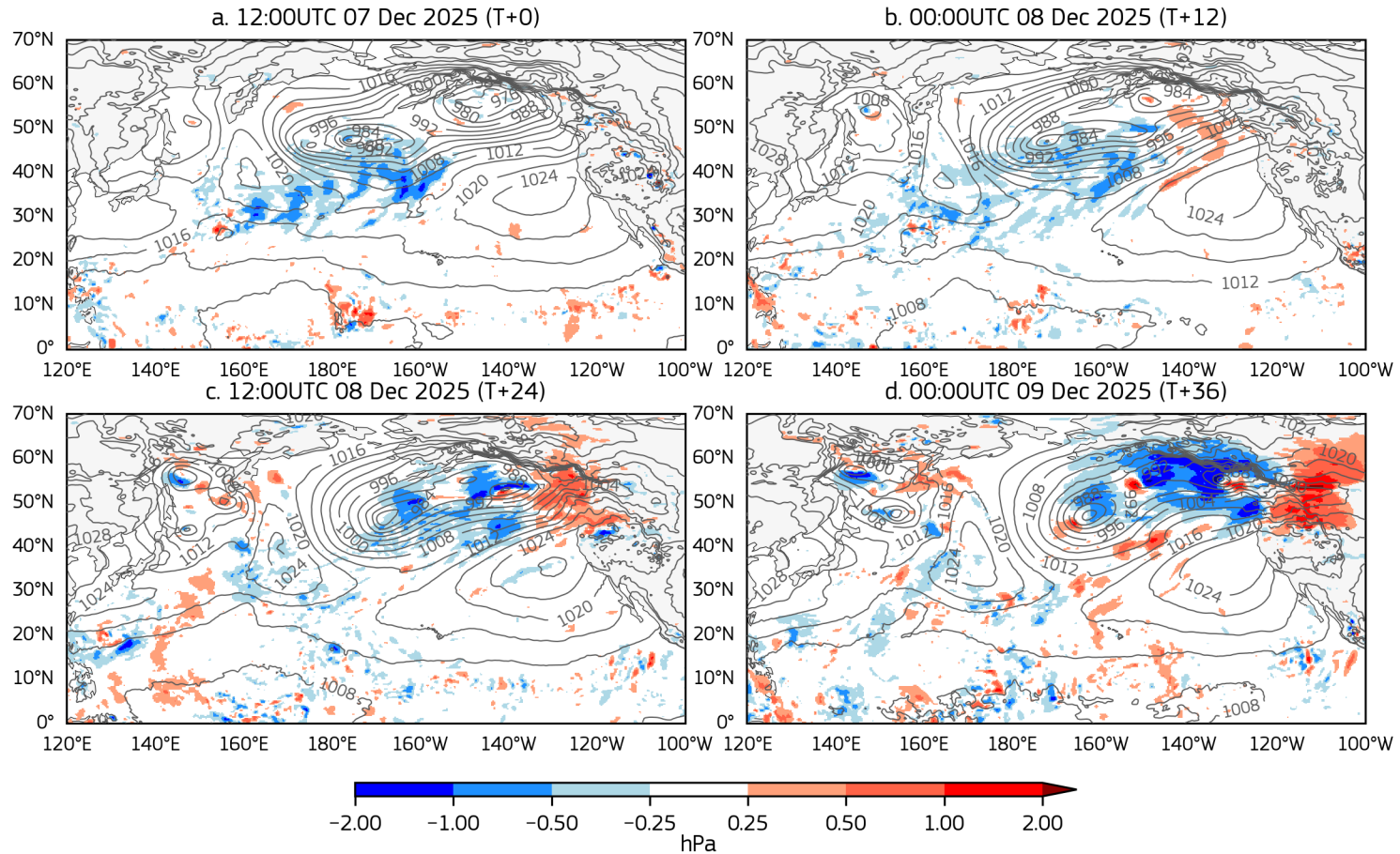
Preliminary analysis on December 2025 storm in Pacific Northwest



MSLP (hPa) of control (black isolines) and difference control minus Buoy denial exp (shaded blue and red).

Case study from drifting buoy denial experiment

Preliminary analysis on December 2025 storm in Pacific Northwest



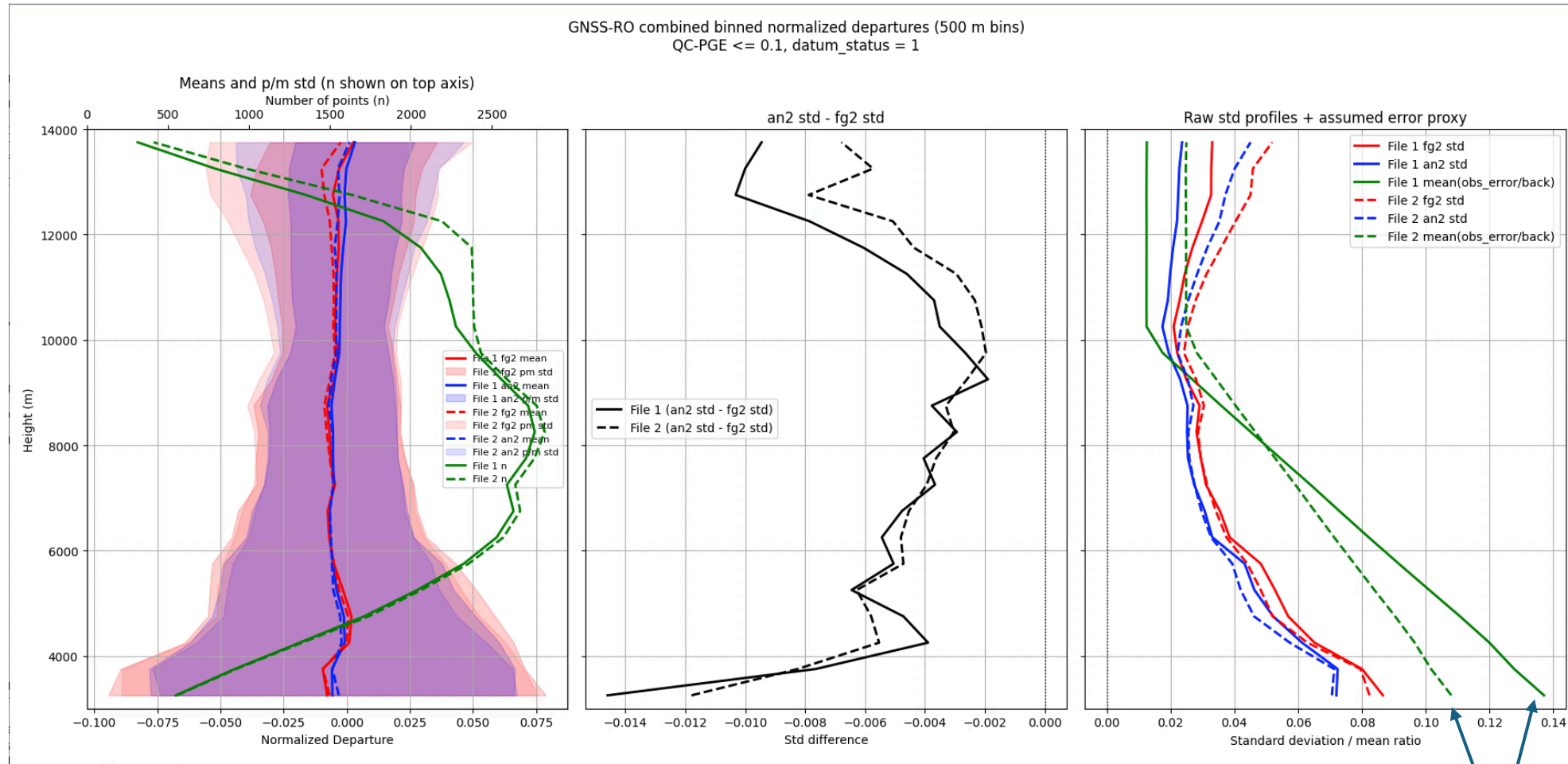
There appears to be sensitivity in the vicinity of the storm

MSLP (hPa) of control (black isolines) and difference control minus Bouy denial exp (shaded blue and red).

Summary and conclusions

- Results from recent ECMWF data denial studies concerning drifting buoys and field campaign observations were presented.
- The averaged verification scores of ECMWF IFS forecasts are clearly degraded if not using drifting buoy surface pressure observations in the data assimilation.
- The importance of using drifting buoy surface pressure observations for reducing errors of ECMWF IFS forecasts is supported also by the FSOI metric.
- Impact of the buoy observations are larger in the midlatitudes than in the tropics.
- Denial of observations that are attributed to be due to field campaigns does not result in a clear degradation on average verification scores.
- A preliminary first case study analysis indicated a clear sensitivity of the drifting buoy surface pressure observations in the vicinity of a storm over the Northern Pacific. However, individual case studies will be looked further into both for the buoy denial study and the observation field campaign denial study.
- Further observation impact/denial studies are being discussed with EUMETNET.
- First work on ARO assimilation for Jan-Feb, 2026 – sharing results with Scripps

ARO departure statistics from Jan-Feb, 2026



- ARO bending angle departures look good. Testing the impact of ARO bending angle uncertainty model

Thank You!

Magnus Lindskog et al.

ECMWF, Shinfield Park, Reading, United Kingdom

Magnus.Lindskog@ecmwf.int

