New visualisation of forecast system diagnostics

Mark Rodwell, Rebecca Emerton

Using ECMWF's Forecasts (UEF2022)

ECMWF

8 June 2022

Thanks to: Sylvie Lamy-Thépaut, Cihan Sahin, Carlos Valiente, Peter Bechtold, Fernando Prates

The Diagnostics Explorer – Now available to users

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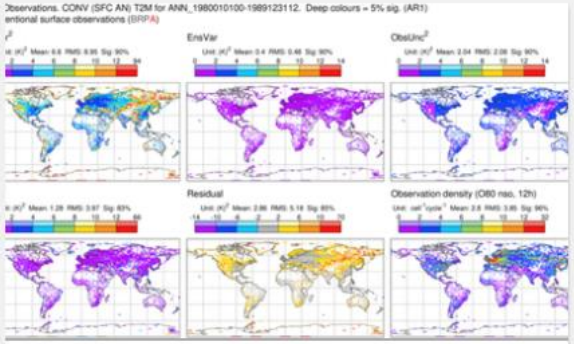

Era5 Eda Observations

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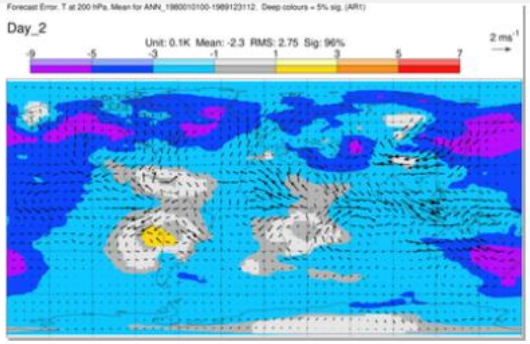
ADD TO CHARTSET



Era5 Forecast Error

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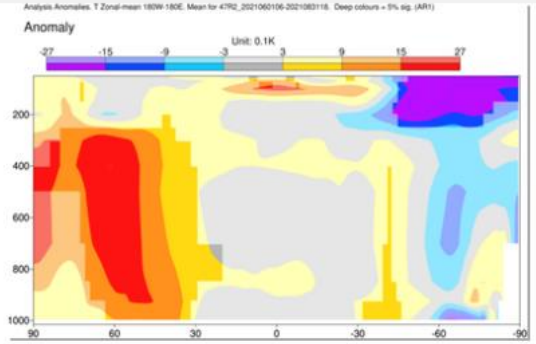

Esuite Analysis Anomalies

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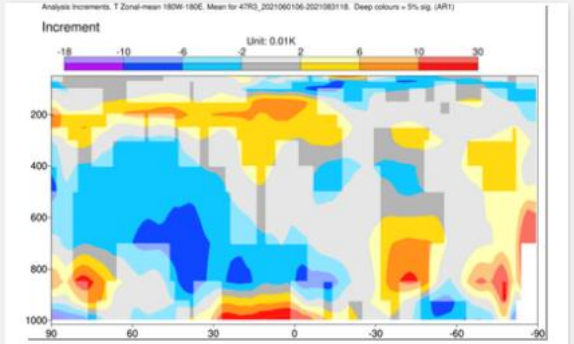
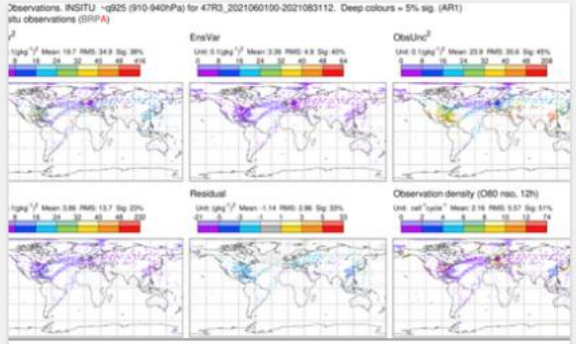


Esuite Analysis Increments

Esuite Analysis Increments



Esuite Eda Observations

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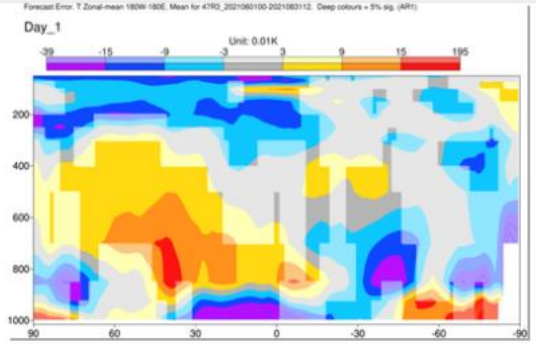
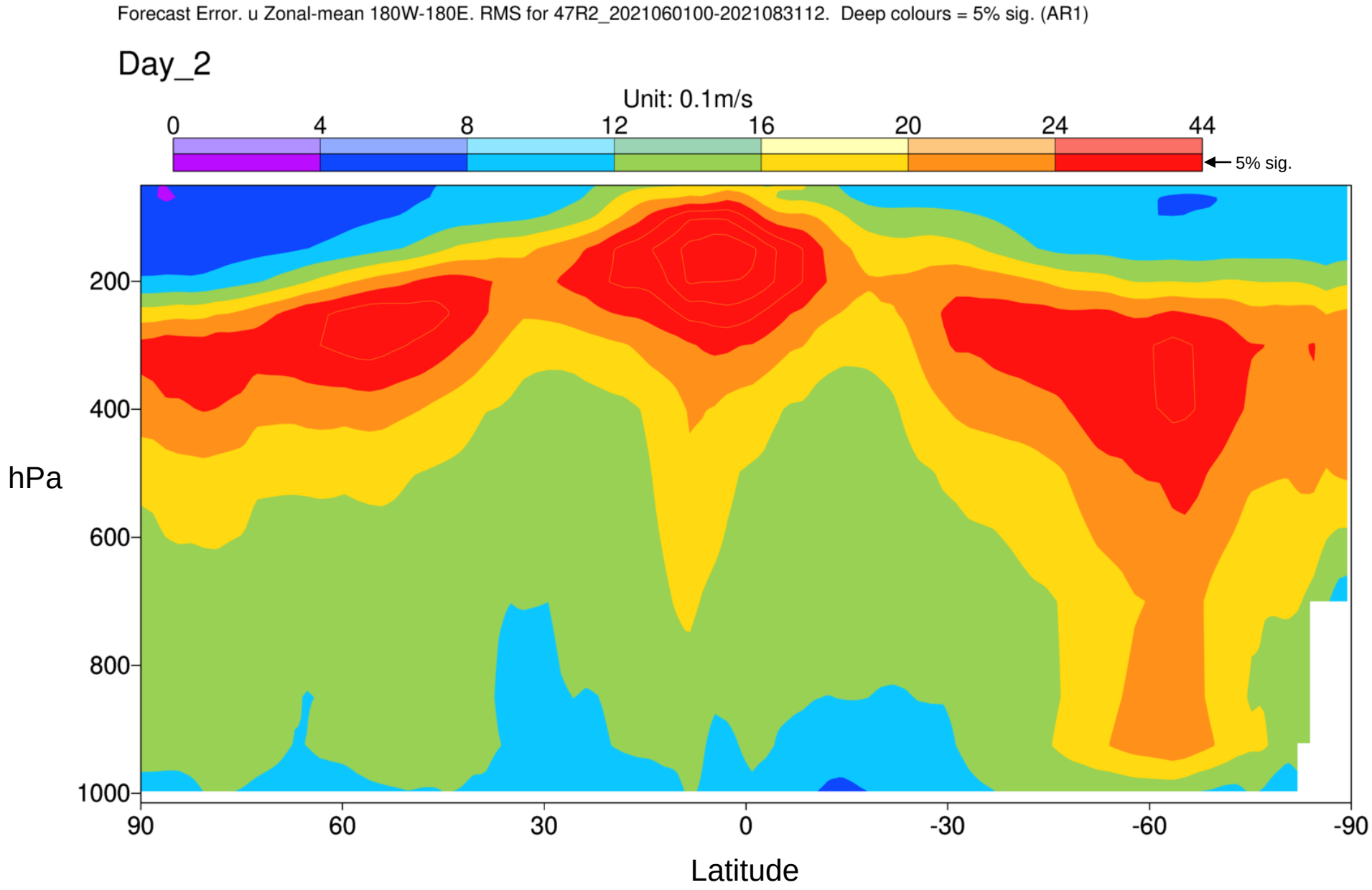


Esuite Forecast Error

Esuite Forecast Error

Diagnostics Explorer: https://apps.ecmwf.int/webapps/intraplots/packages/diagnostics/

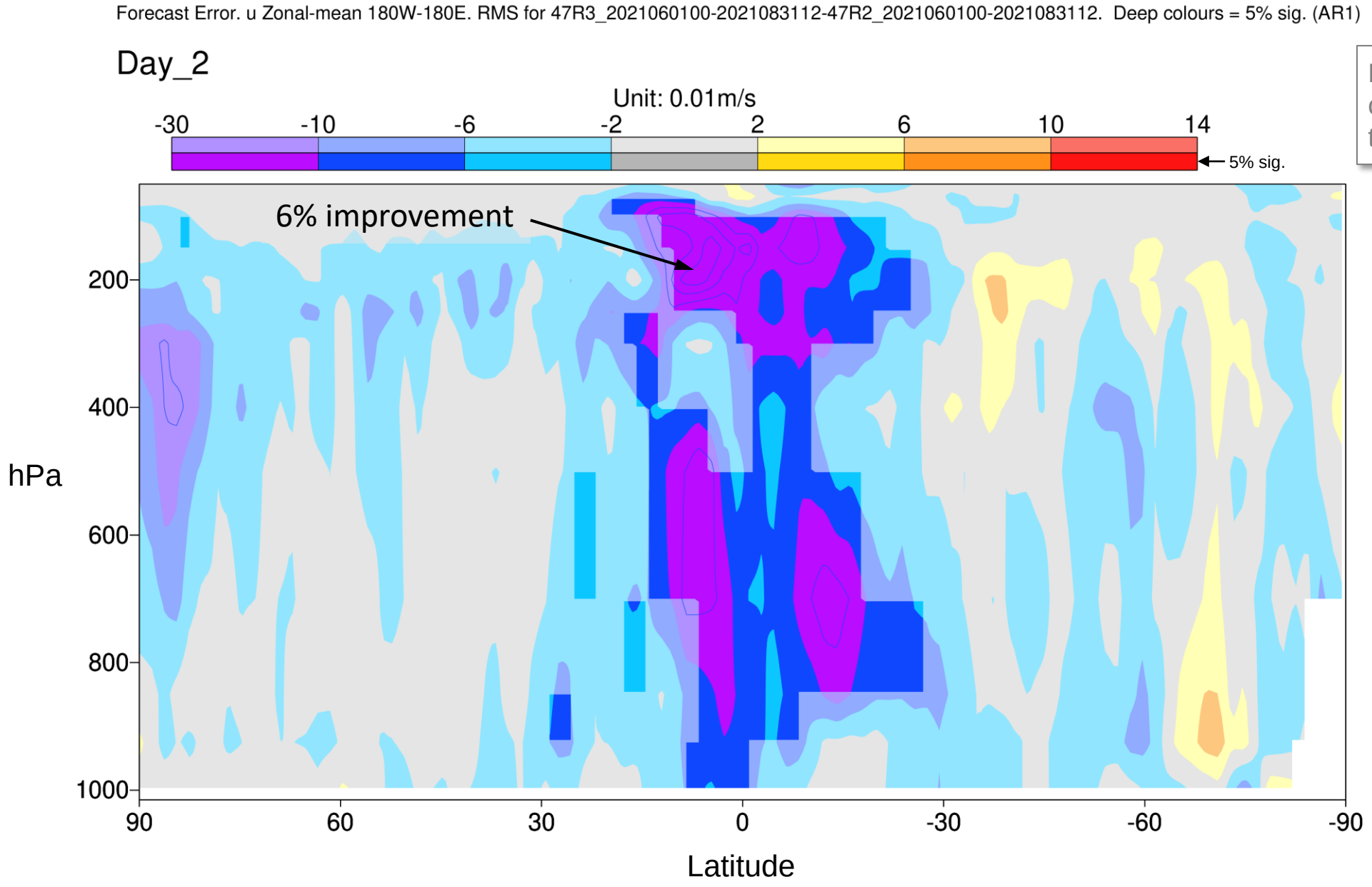
Errors for west-east (U) wind component at day-2 (previous operational cycle 47r2)



JJA 2021. Root of temporal and longitudinal-mean squared errors

Errors prominent in the upper troposphere – Does the new cycle improve these?

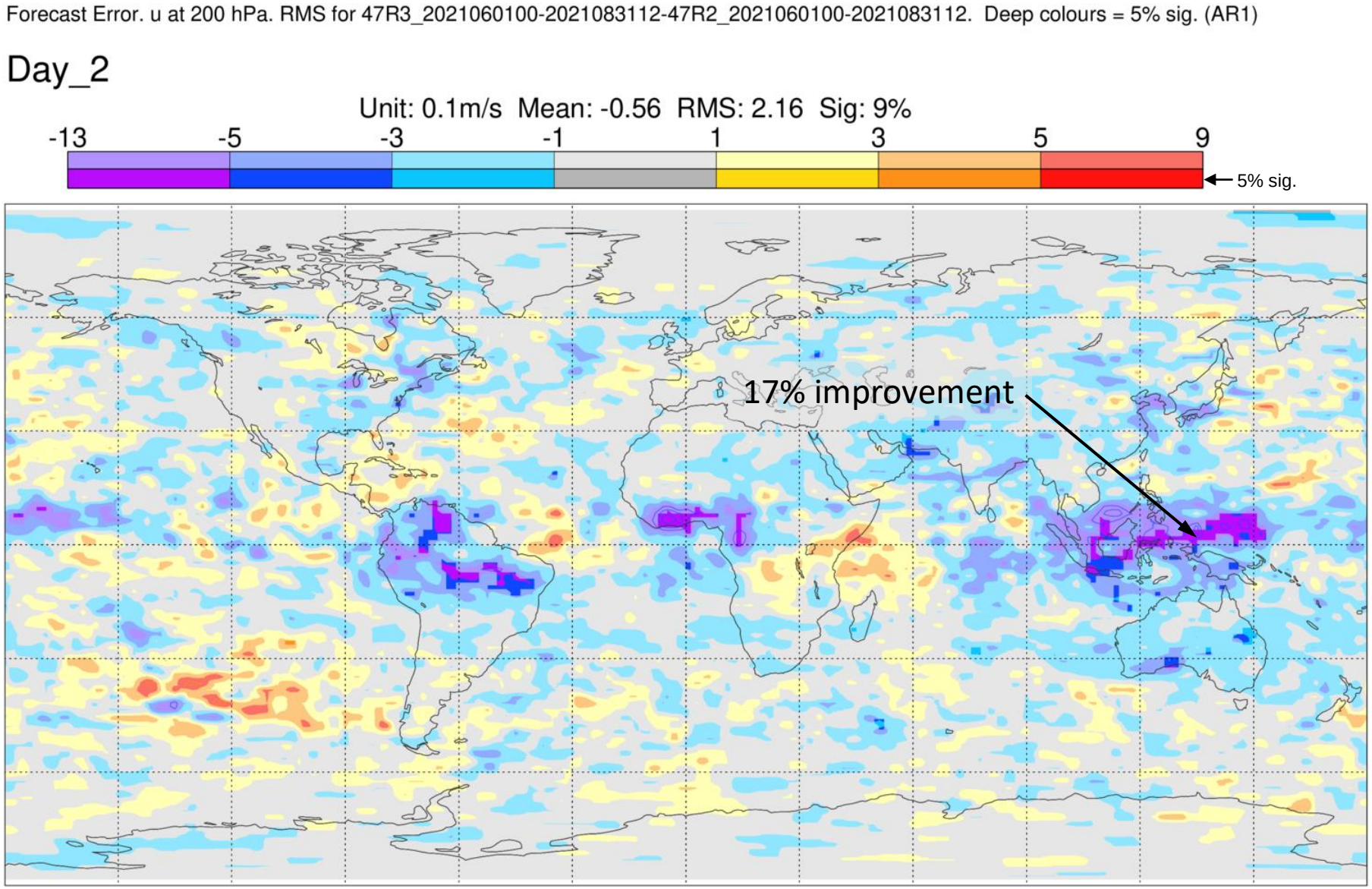
Change in U errors at Day-2 (current - previous operational cycle)



Note: smaller contour interval for the differences

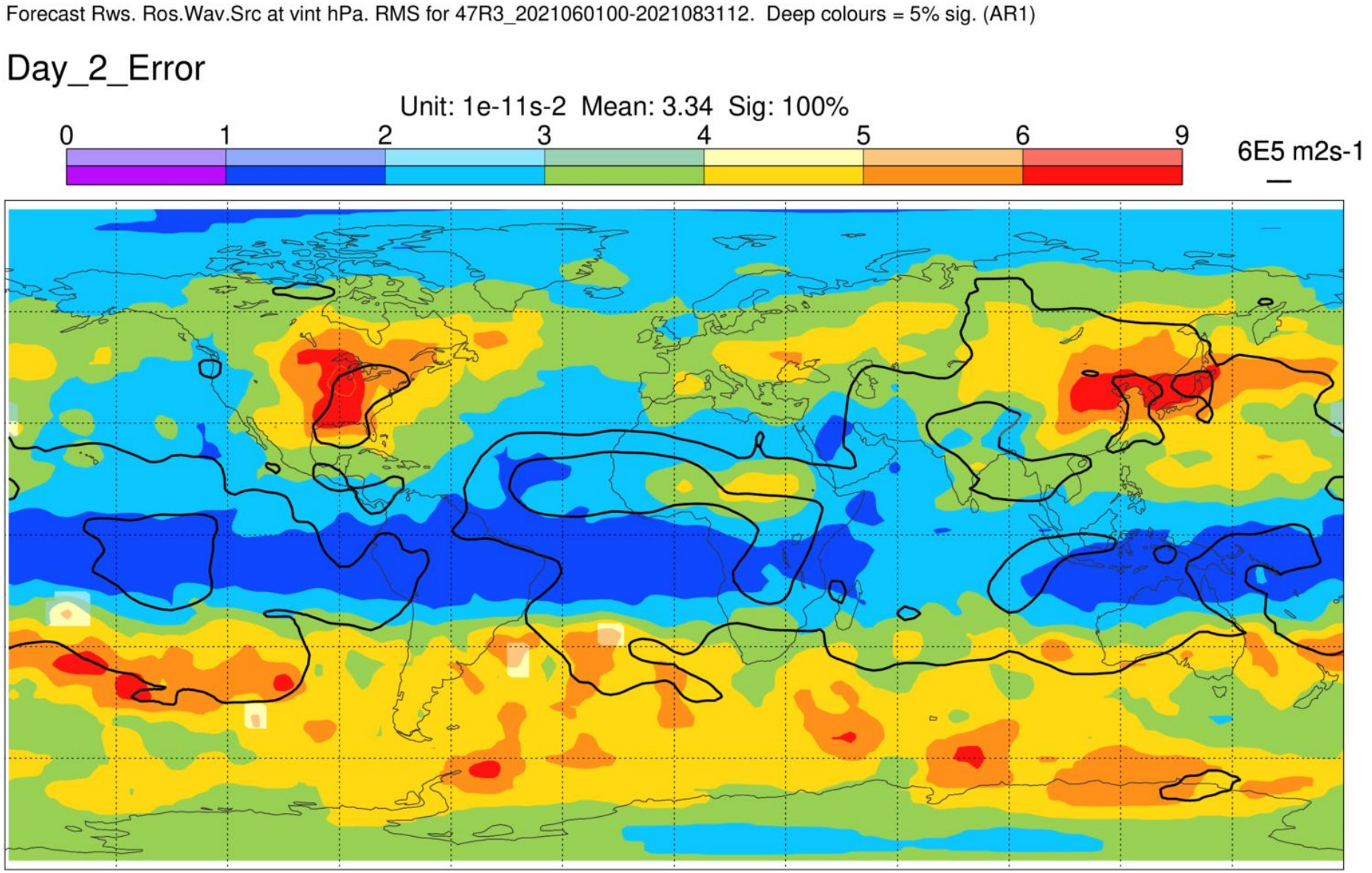
Zonal-mean improvements are focused in the tropics – Where in the tropics?

Change in U errors at Day-2 (current - previous operational cycle)



Reduced errors over the West Pacific Warm Pool – Indicating improved modelling of the MJO in this difficult region

“Rossby Wave Source” errors in 47r3 Esuite tests



Set of plots showing terms in the Barotropic Vorticity Equation

Here, short lead-time errors in the Rossby Wave Source over North America, due to predicting mesoscale convection, can lead to poor/uncertain medium-range forecasts for Europe

JJA 2021. RWS $= \underline{\nabla} \cdot \left(\underline{v}_\chi \zeta\right)$
Integrated 100-300hPa

The Rossby Wave Source is also useful for identifying deficiencies and improvements in tropical - extratropical teleconnections

Shadowing the truth trajectory. Shading shows sources of ensemble divergence

EDA background "Langrangian" growth-rate" (following the horizontal flow) for PV_{330K} (shaded).
CF PV_{330K} (contours) and 850hPa winds and humidity fluxes (vectors). EM precipitation (dots).

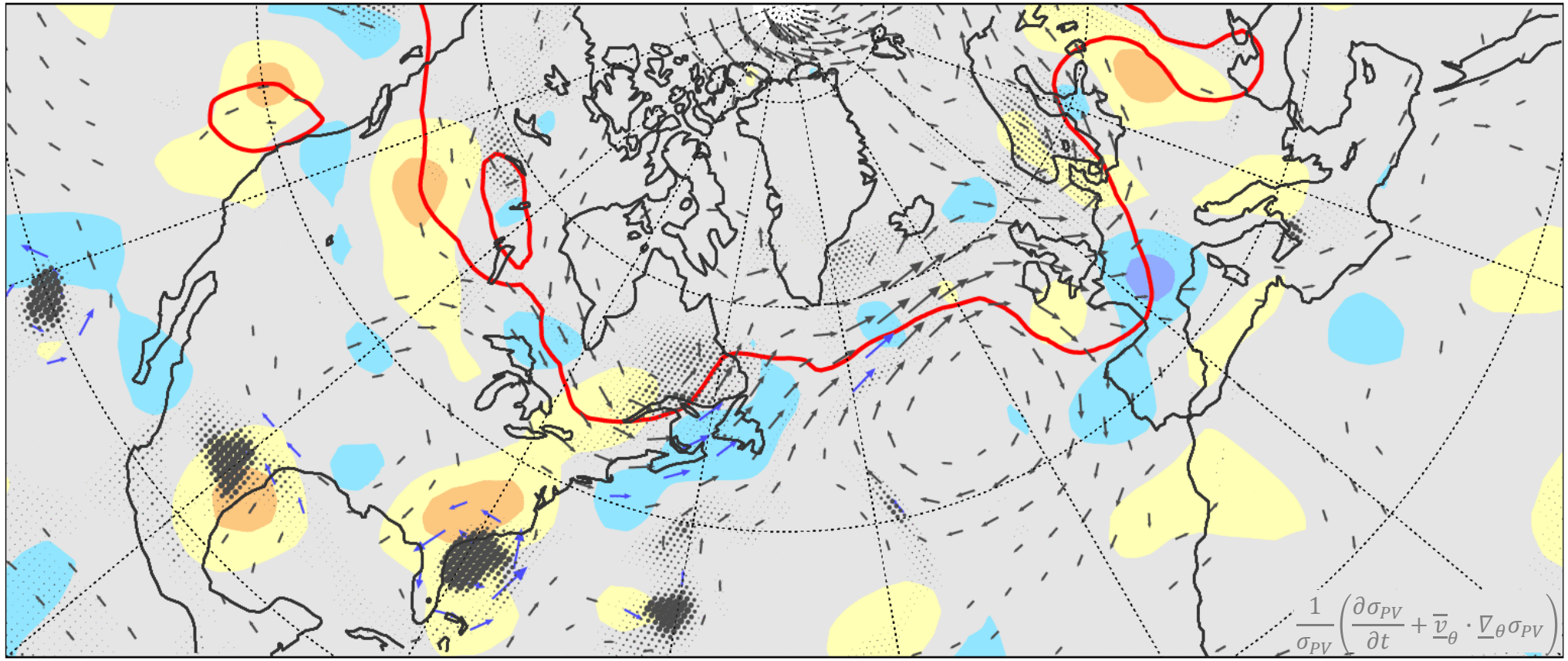
ECMWF 20190905 00Z

Unit: $0.01h^{-1}$

-21 -15 -9 -3 3 9 15 21

Precipitation
• 2 mmh^{-1}

Wind (& moisture flux)
30 ms^{-1} $100gkg^{-1}ms^{-1}$
2 PVU

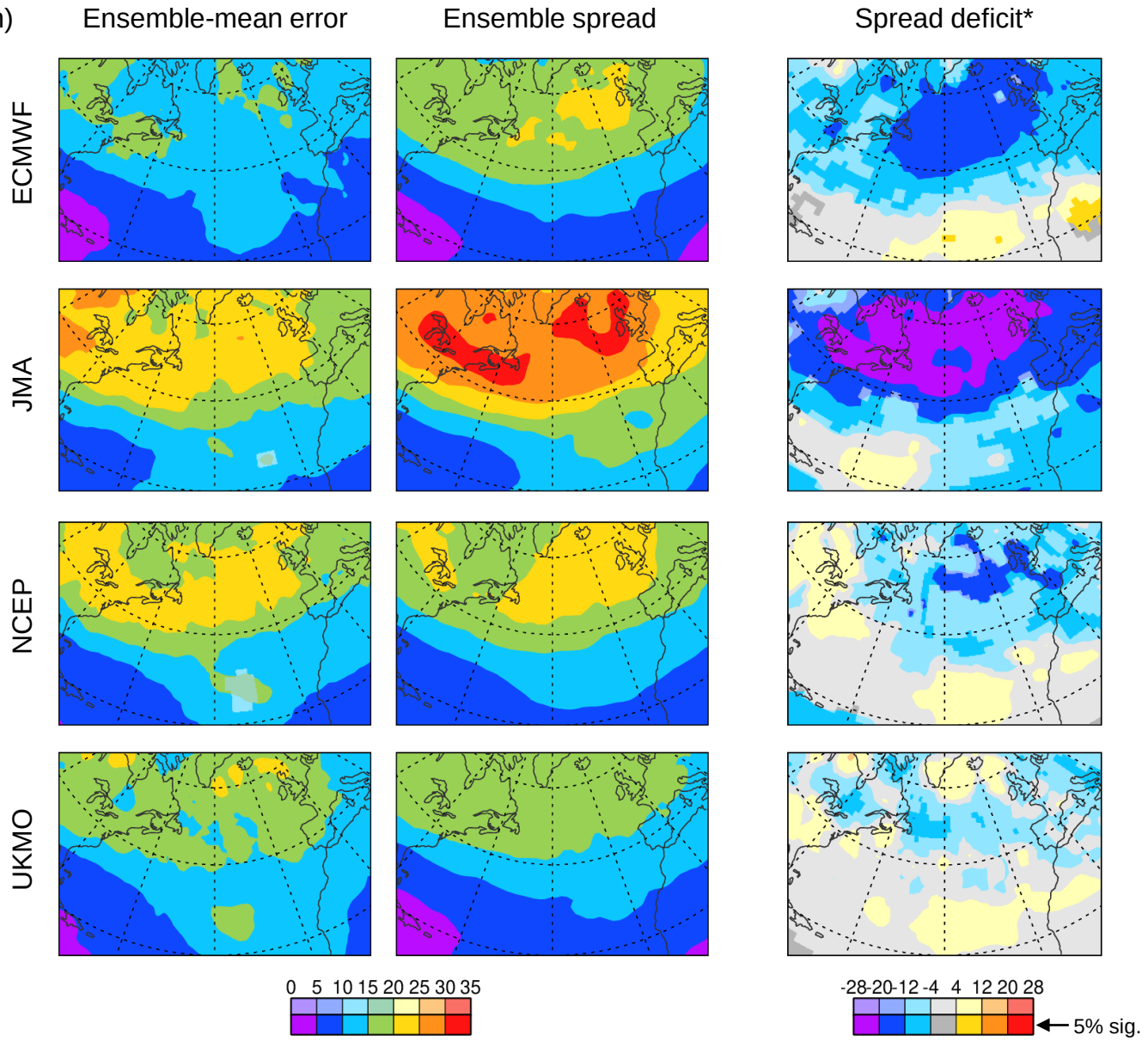


Fields filtered to scales ≥ 1000km

Issues include: tropical cyclone initialisation, its migration North, interaction uncertainties with upper-level trough – How is Stormtrack reliability?

Reliability assessment at Day-2 over the Atlantic for models in the ‘TIGGE’ archive

DJF 2020/21 Z250 (m)

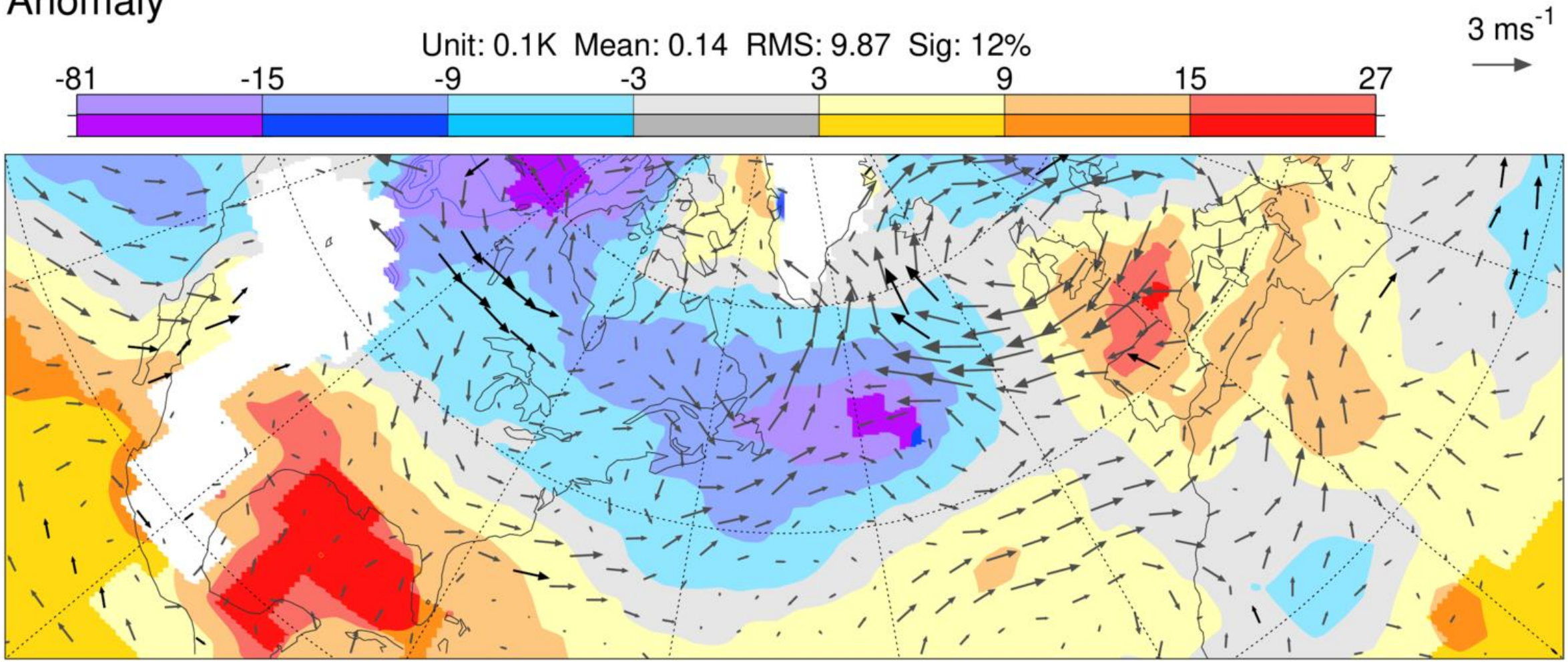


Assessment of the ensemble ‘spread-error’ agreement (*taking into account bias and analysis uncertainty)

ECMWF’s smallest errors demonstrate what is possible for spread too

The ensemble is too uncertain in it’s prediction of storm formation – We have ideas of how to improve this

Analysis Anomalies. T at 850 hPa. Mean for MAM 2020. Deep colours = 5% sig. (AR1)



Western European blocking, and corresponding temperatures anomalies, during the start of “Lock-down”

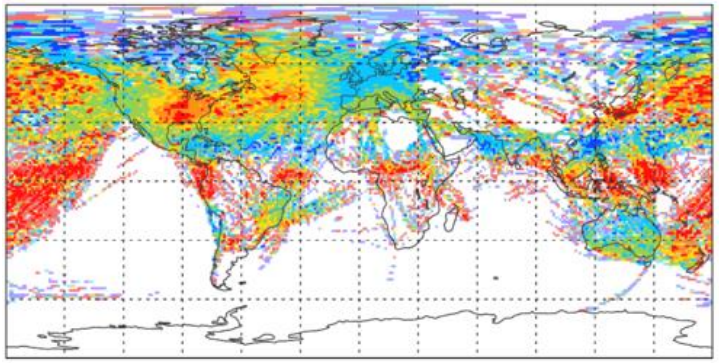
Observational information used by the data assimilation: Aircraft winds

Eda Observations. AIREP ~u200 (185-215hPa) for MAM 2021. Deep colours = 5% sig. (AR1)
Aircraft observations (BRPA)

Depar^2

Unit: $(ms^{-1})^2$ Mean: 9.85 RMS: 14.8 Sig: 56%

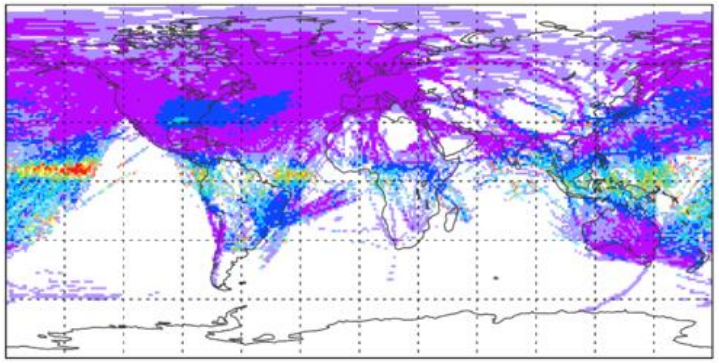
0 2 4 6 8 10 12 276



EnsVar

Unit: $(ms^{-1})^2$ Mean: 2.42 RMS: 3.52 Sig: 57%

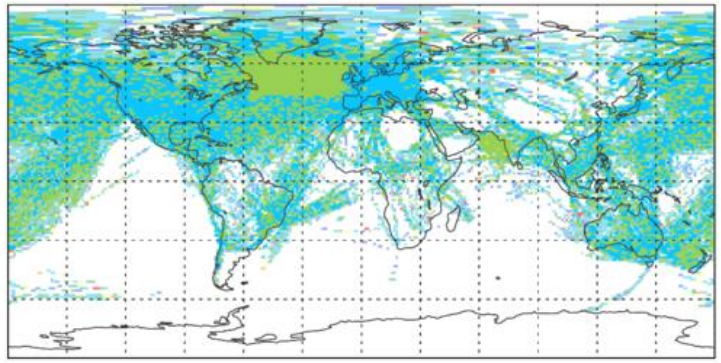
0 2 4 6 8 10 12 42



ObsUnc^2

Unit: $(ms^{-1})^2$ Mean: 5.99 RMS: 6.09 Sig: 62%

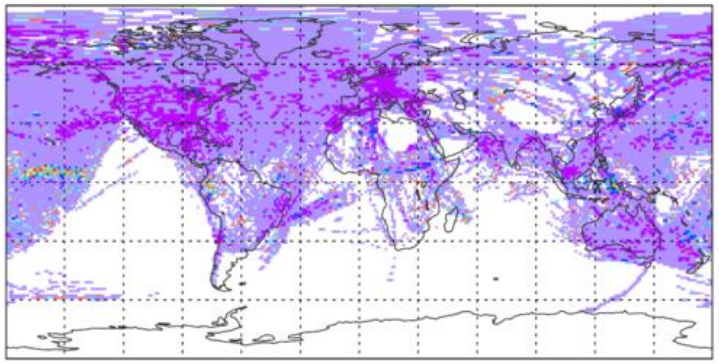
0 2 4 6 8 10 12 20



Bias^2

Unit: $(ms^{-1})^2$ Mean: 1.33 RMS: 5.26 Sig: 16%

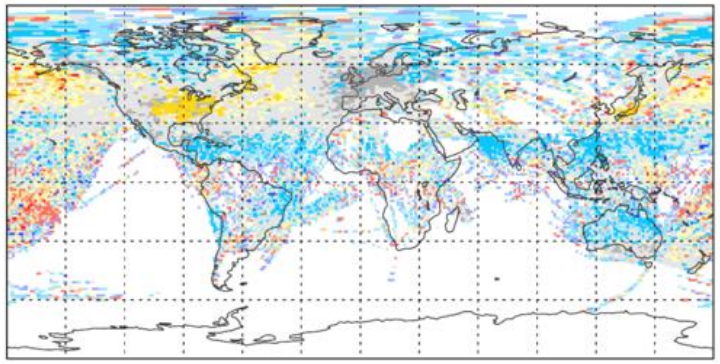
0 2 4 6 8 10 12 236



Residual

Unit: $(ms^{-1})^2$ Mean: 0.09 RMS: 8.54 Sig: 15%

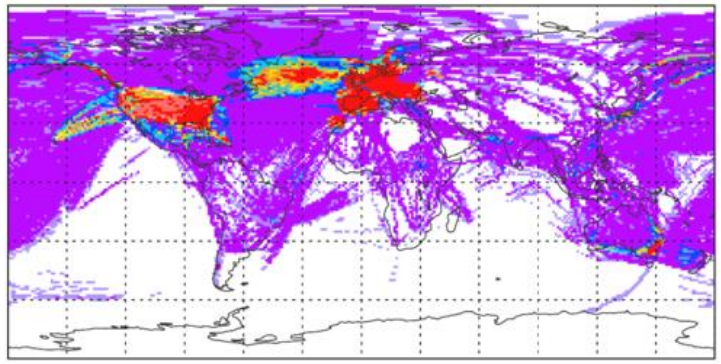
-50 -10 -6 -2 2 6 10 258



Observation density (O80 nso, 12h)

Unit: $cell^{-1}cycle^{-1}$ Mean: 3.58 RMS: 19.7 Sig: 80%

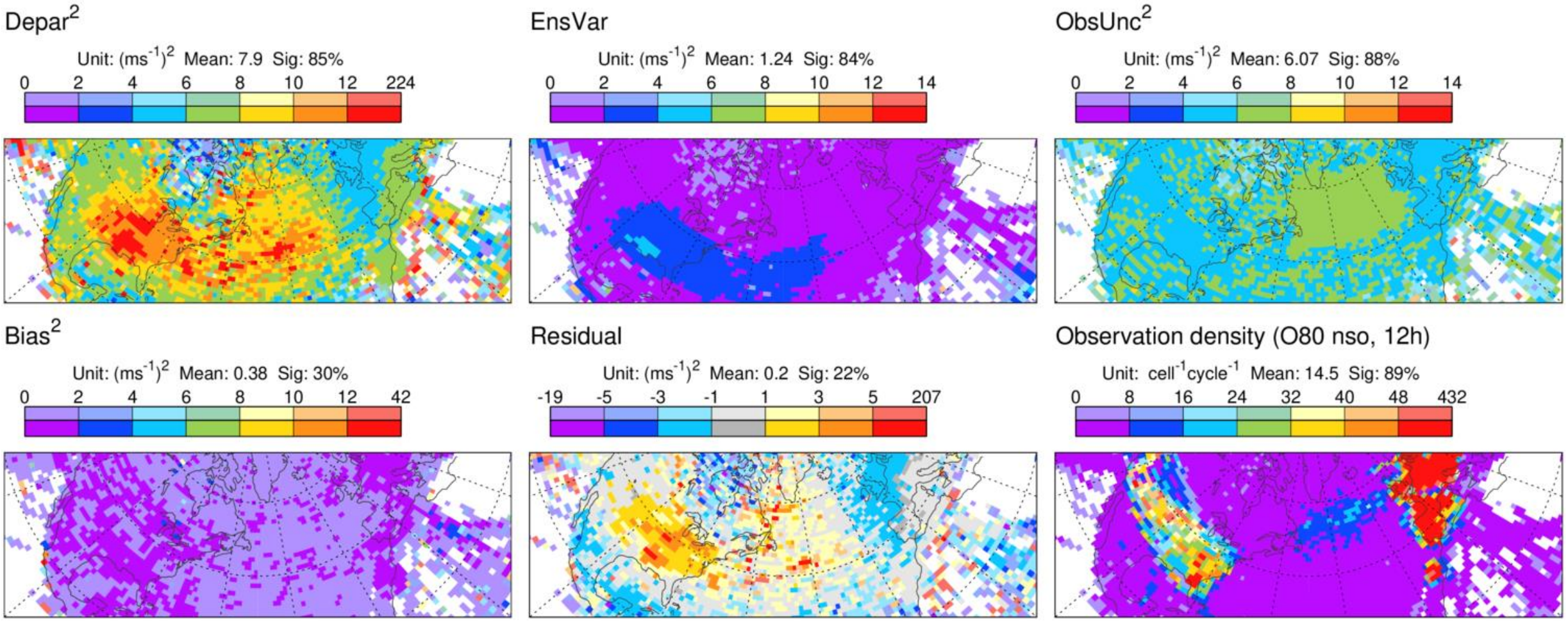
0 2 4 6 8 10 12 430



Information from aircraft observations at cruising altitude

Zoom into North Atlantic region

Eda Observations. AIREP ~u200 (185-215hPa) for MAM 2021. Deep colours = 5% sig. (AR1)
Aircraft observations (BRPA)



Under-spread in Spring-time convective region of North America

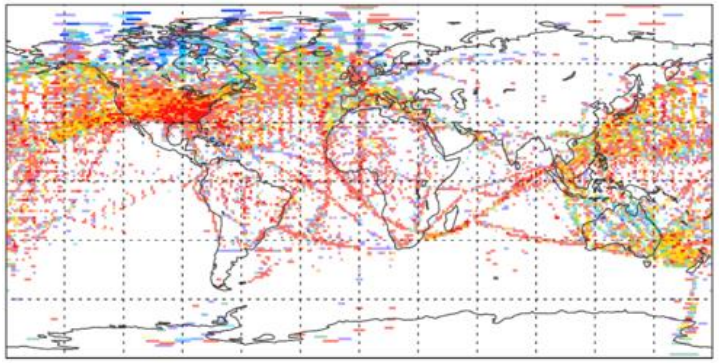
Look back to the 1980s in the ERA5 re-analysis

Eda Observations. AIREP ~u200 (185-215hPa) for ANN_1980010100-1989123112. Deep colours = 5% sig. (AR1)
Aircraft observations (BRPA)

Depar^2

Unit: $(ms^{-1})^2$ Mean: 30.5 RMS: 51.2 Sig: 21%

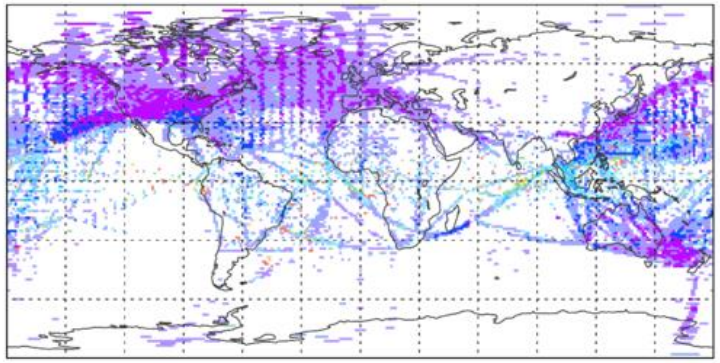
0 4 8 12 16 20 24 980



EnsVar

Unit: $(ms^{-1})^2$ Mean: 4.87 RMS: 6.84 Sig: 21%

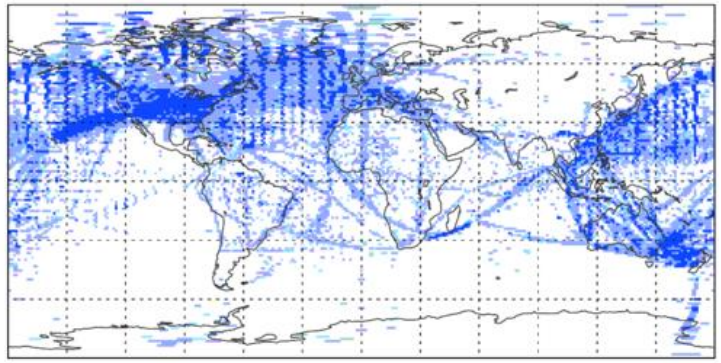
0 4 8 12 16 20 24 92



ObsUnc^2

Unit: $(ms^{-1})^2$ Mean: 6.39 RMS: 6.63 Sig: 22%

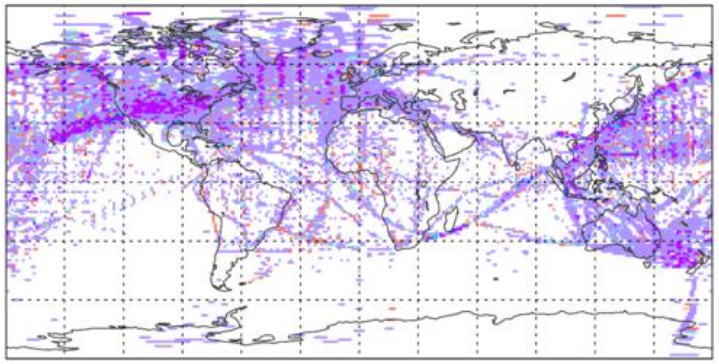
0 4 8 12 16 20 24 28



Bias^2

Unit: $(ms^{-1})^2$ Mean: 5.89 RMS: 23.8 Sig: 8%

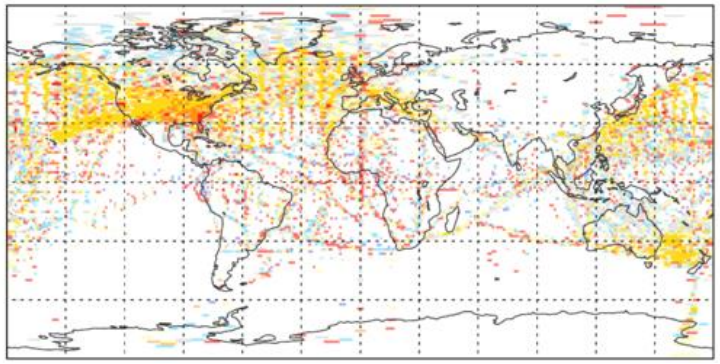
0 4 8 12 16 20 24 980



Residual

Unit: $(ms^{-1})^2$ Mean: 13.3 RMS: 35.3 Sig: 15%

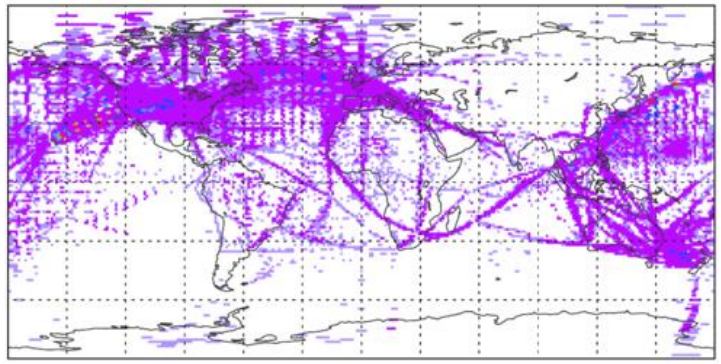
-95 -25 -15 -5 5 15 25 755



Observation density (O80 nso, 12h)

Unit: 0.1 $cell^{-1}cycle^{-1}$ Mean: 0.17 RMS: 0.883 Sig: 59%

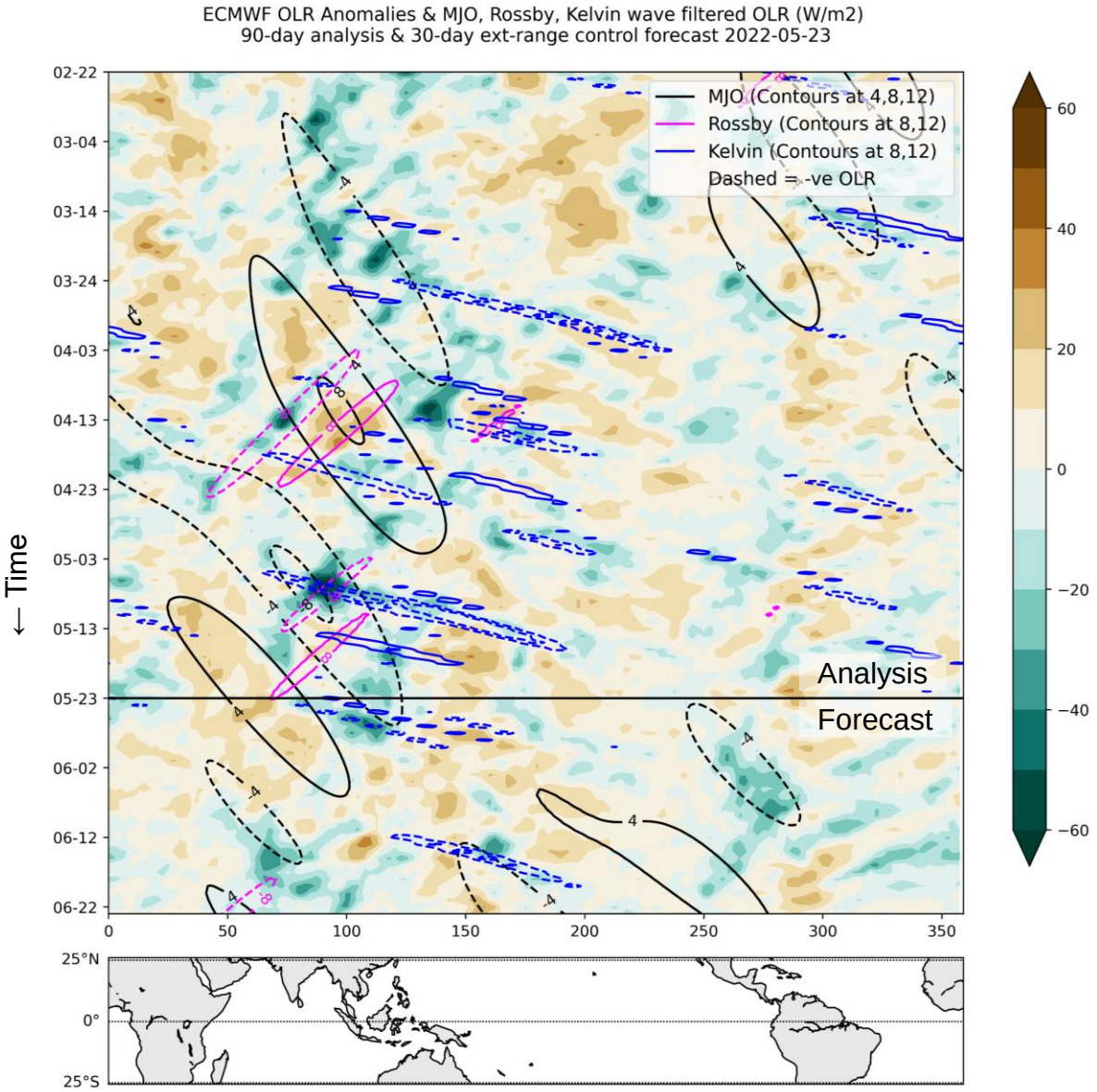
0 2 4 6 8 10 12 28

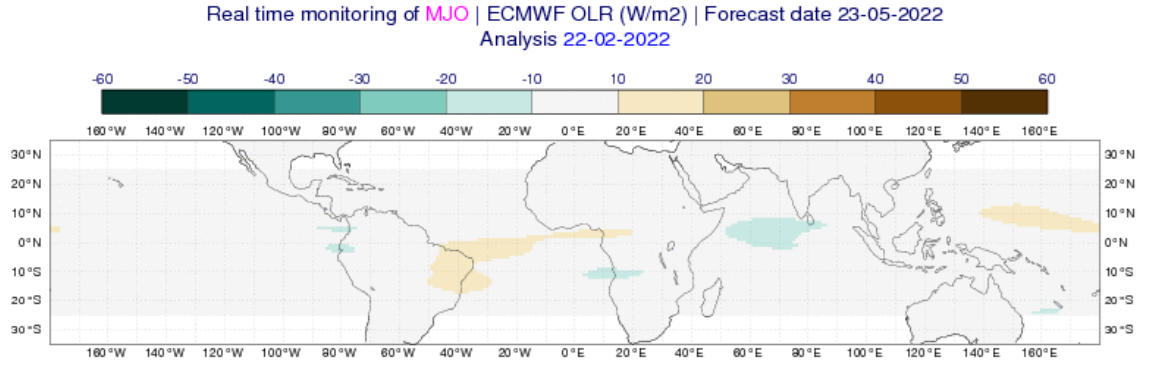


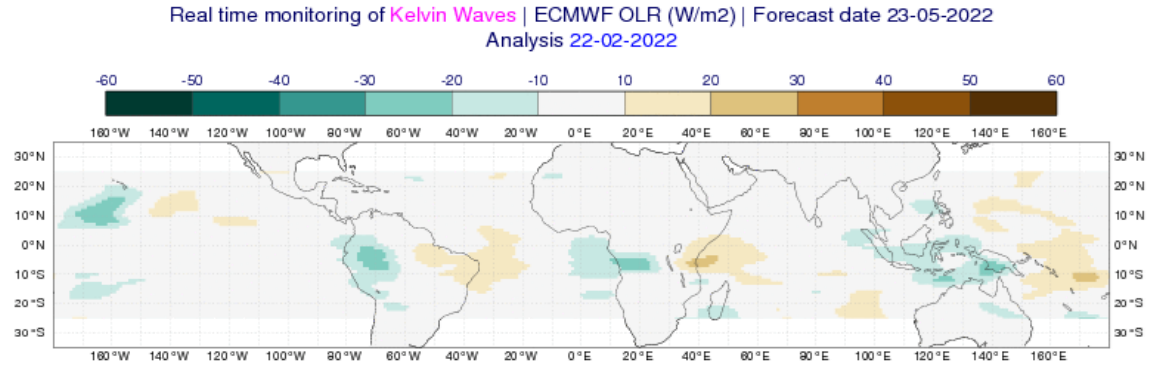
Consistent diagnostics of ERA5 help put progress into perspective, and allow detailed study of trends

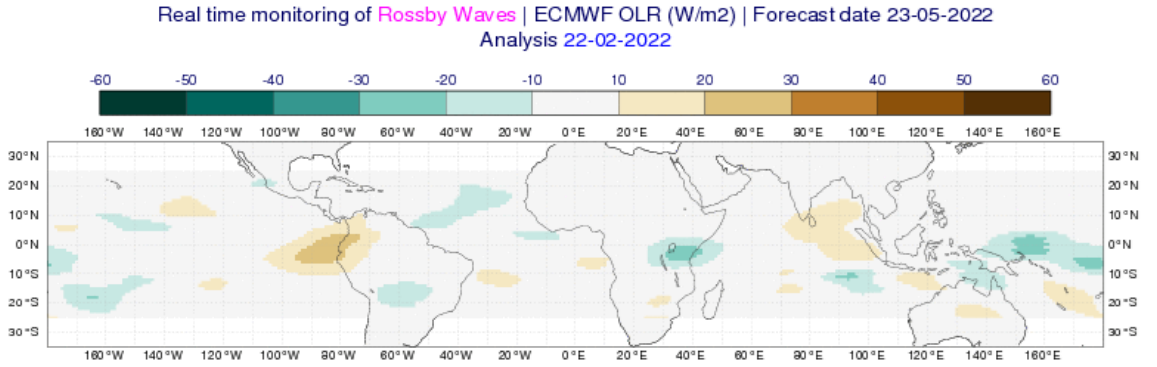
Tropical Wave Diagnostics – Madden Julian Oscillation (MJO), Kelvin, Rossby

Rebecca Emerton









Real-time monitoring of tropical waves – helps diagnose errors and uncertainties in extreme precipitation and teleconnections to the midlatitudes

The Diagnostics Explorer – Summary

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Soon: TIGGE/ENS

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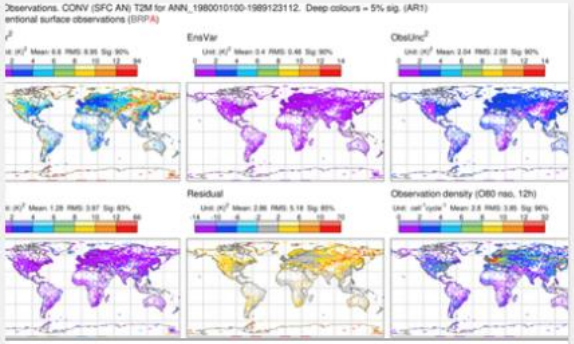

Era5 Eda Observations

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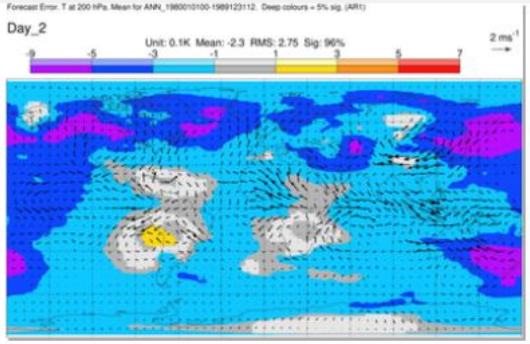

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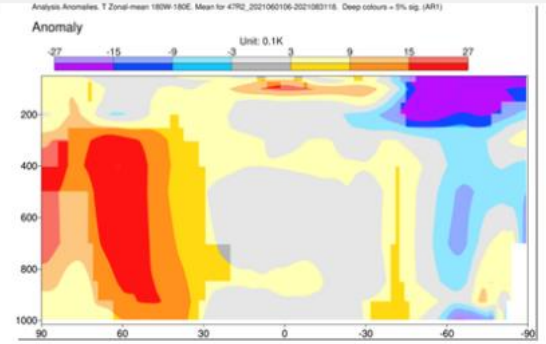

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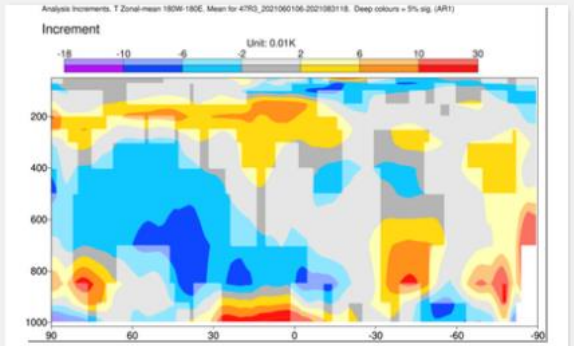
Feedback welcome on Forecast User Forum – https://confluence.ecmwf.int/display/FUF



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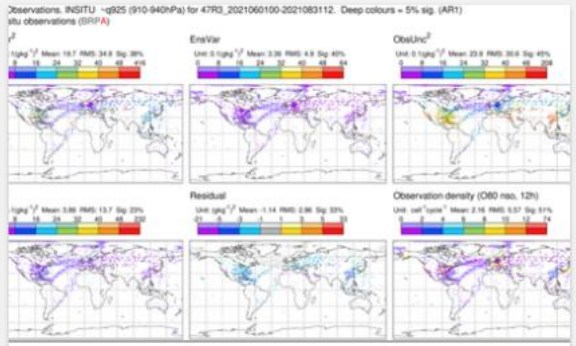

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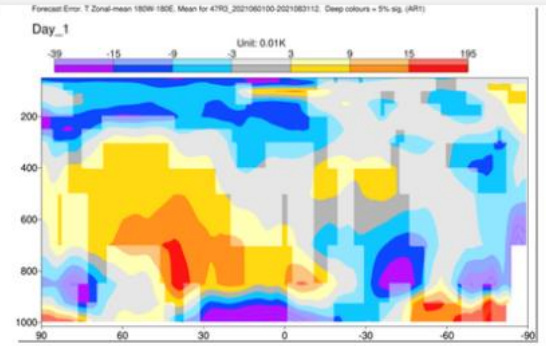

Esuite Forecast Error

Esuite Forecast Error

Thank you