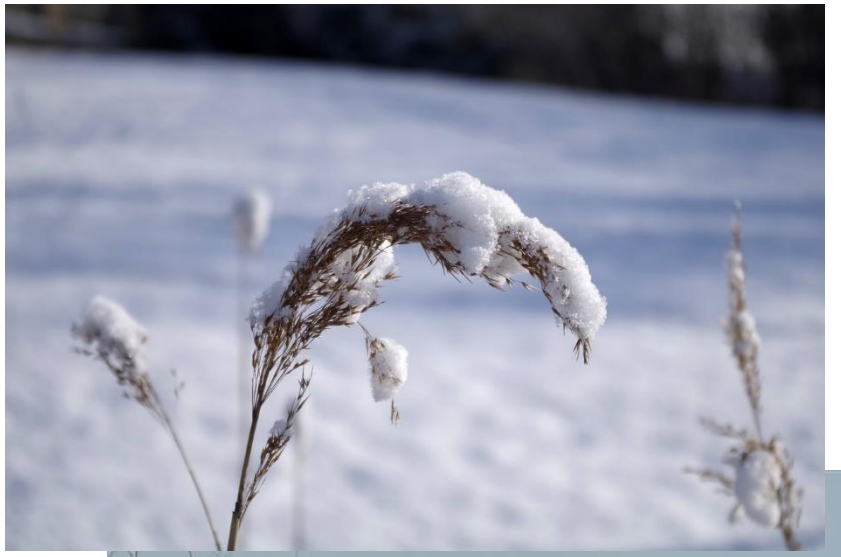
Extreme Low Thicknesses during the 'Beast from the East' of 2018

Edward Graham (University of the Highlands and Islands); **Jonathan Webb** (Oxford)



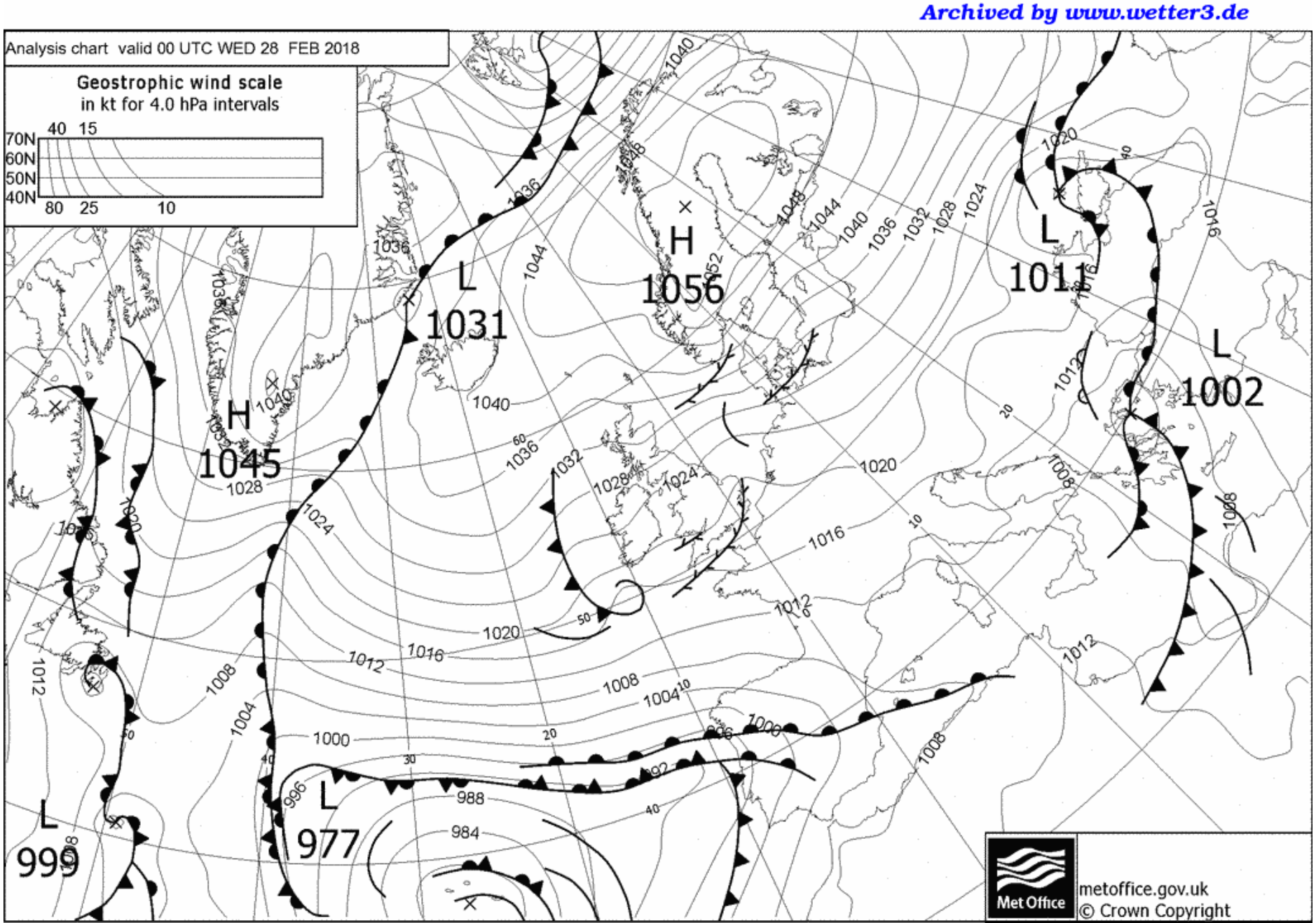
Back to Basics – The Ideal Gas Law

$$P = \rho \, . \, R. \, T$$

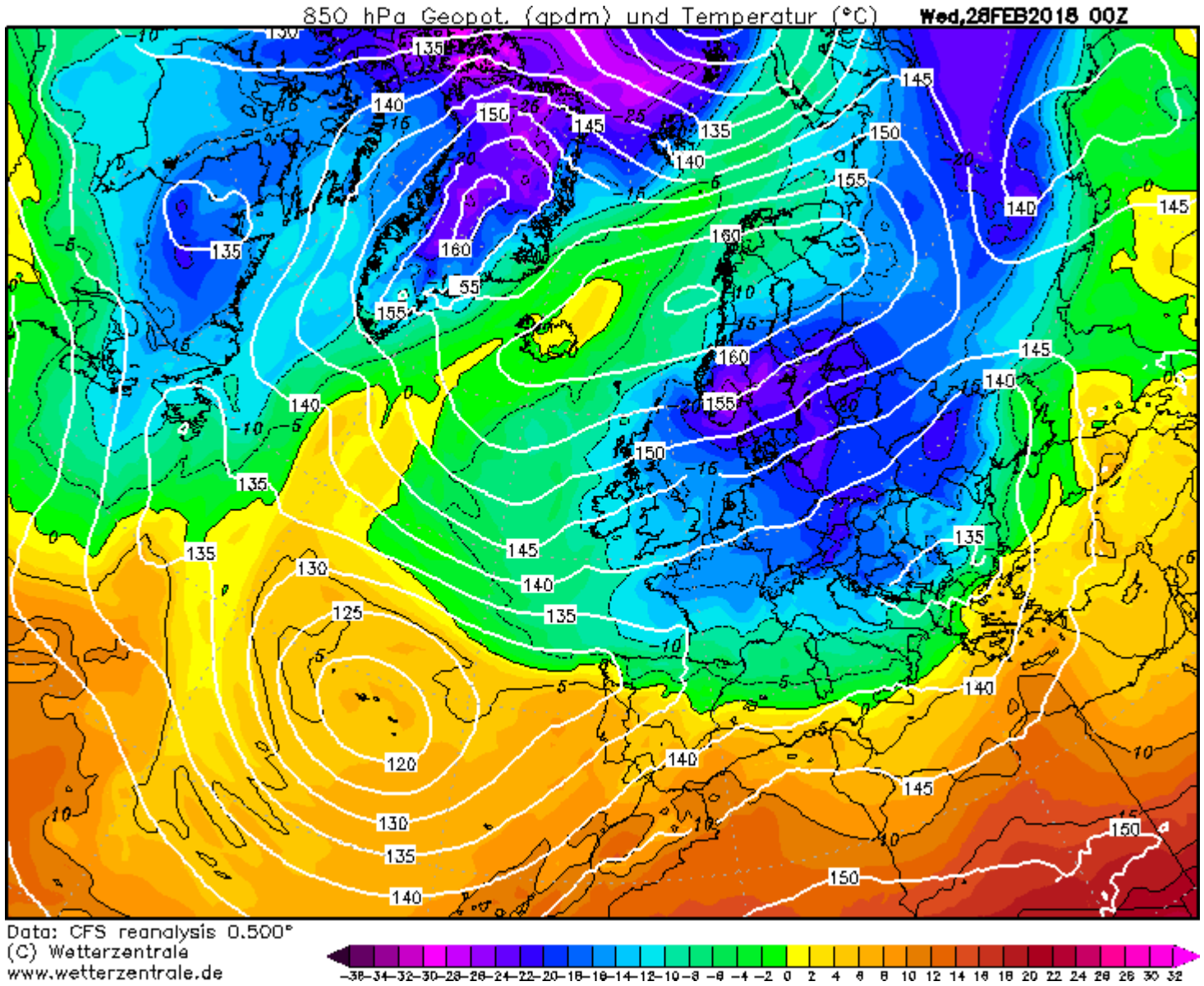
P = pressure
ρ = density
R = Universal Gas Constant
T = Temperature

-> **Pressure ∝ Temperature** (given fixed density)
-> **Density ∝ Temperature** (given fixed pressure)
-> **Temperature ∝ Density** (given fixed pressure)

Back to Basics – The Cold High (formed predominantly by radiational cooling)

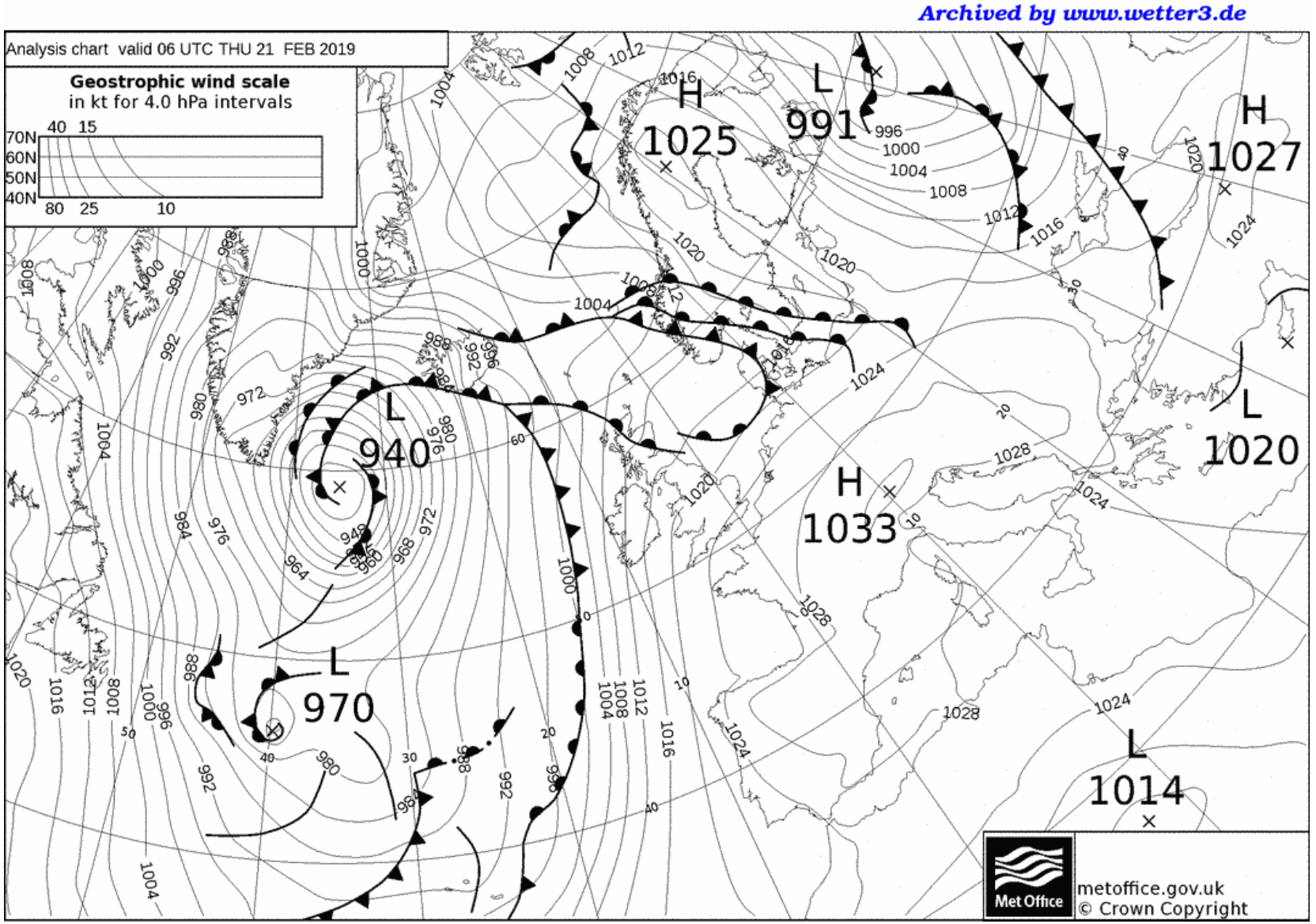


Back to Basics – The Cold High (formed predominantly by radiational cooling)

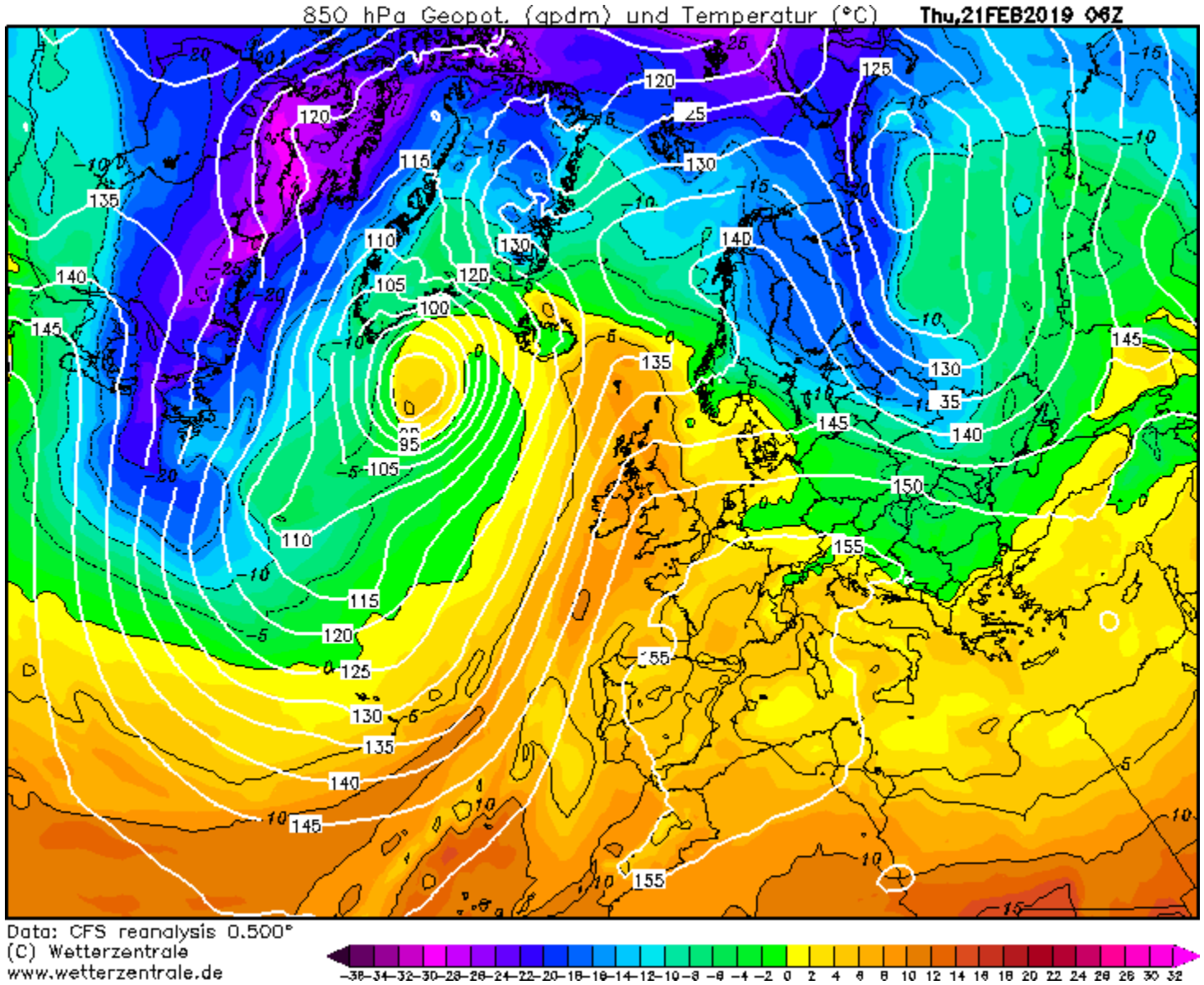


Back to Basics – The Warm High (formed predominantly by compressional warming in adiabatic descent)

There's a difference in "thickness" (or density) of air by order or 10-20% between warm and cold Highs



Back to Basics – The Warm High (formed predominantly by compressional warming in adiabatic descent)



The very deep cold pool of 27 February–1 March 2018 – historical precedents and perspective

Edward Graham[1] and Jonathan D. C. Webb[2]

[1]*University of the Highlands and Islands, Stornoway*

[2]*TORRO, Oxford*

Introduction

In this investigation, plotted surface (M3) and upper air charts, available actual radiosonde observations and the NCEP-DOE Reanalysis 2 (Kanamitsu *et al.*, 2002) were used to document and analyse the extreme easterly cold pool event which affected much of north-western Europe during late February and early March 2018. Furthermore, the three reanalyses, namely the NCEP/NCAR Reanalysis (Kalnay *et al.*, 1996), the NCEP-DOE Reanalysis 2 (Kanamitsu *et al.*, 2002), and the NOAA-CIRES Twentieth Century Reanalysis ('20CR'; Compo *et al.*, 2011) were collectively used, together with any available upper air observations (chiefly from 1945), to determine the severity of this event within the historical context of all previous cold pool events over Great Britain and Ireland during the past 70–102 years.

This paper focuses on the first phase of the late-winter cold spell, when the cold pool crossed these islands and snowfall was convective in origin (Pike and Webb, 2019). This snow was principally associated with the interaction between deep, exceptionally cold air and relatively warm seas, enhanced and extended inland by coastal convergence

Graham and Webb (2019) in *Weather* (March 2019)

RMetS Royal Meteorological Society

What we did in Graham and Webb (2019)

We used the following reanalyses:

- **NOAA-CIRES 20CR** (Compo et al. 2011) up to 1947
- **NCEP-NCAR** (Kalnay et al. 1996) from 1948-1978
- **NCEP-DOE Reanalysis 2** (Kanamitsu et al. 2002) from 1979-2018

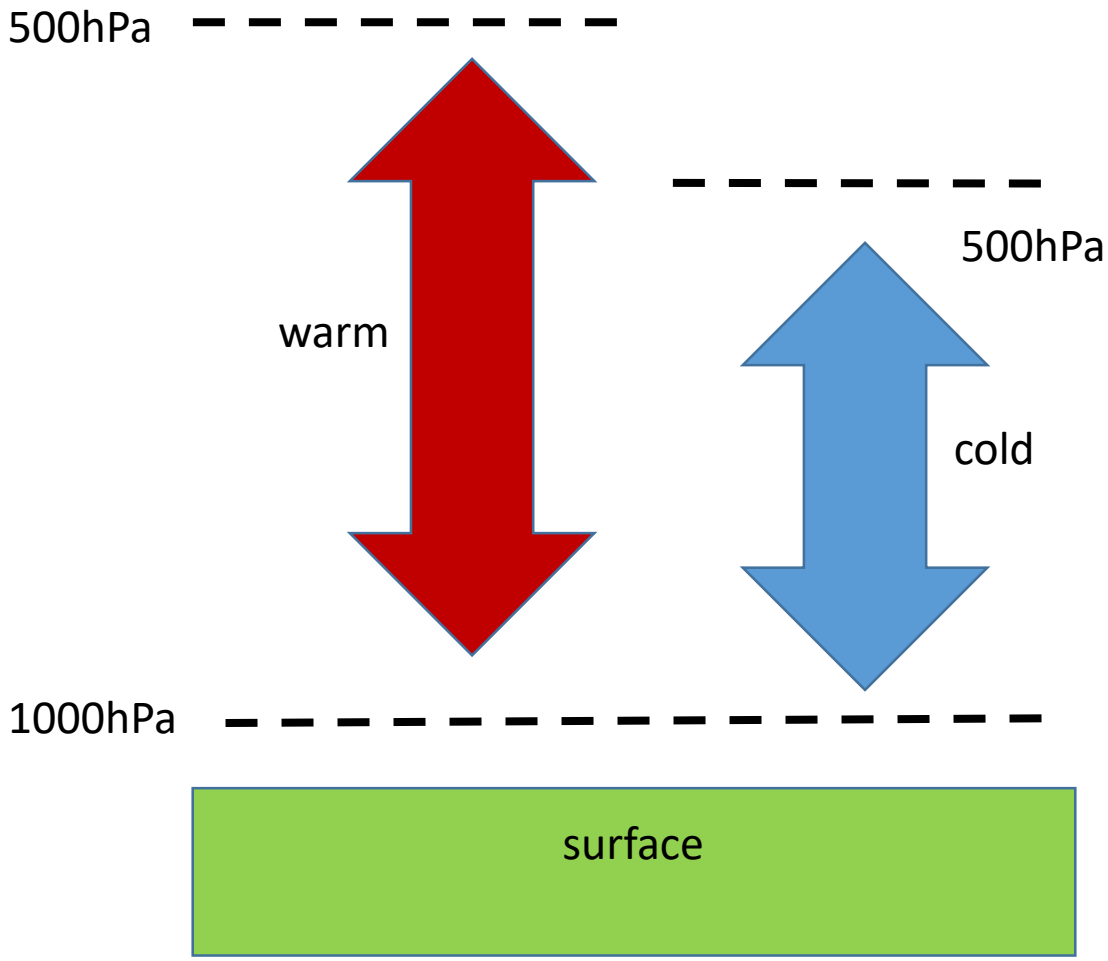
to document all “Beasts from the East” plus other cold pools, 1916-2018

We used the following criteria for cold pools:

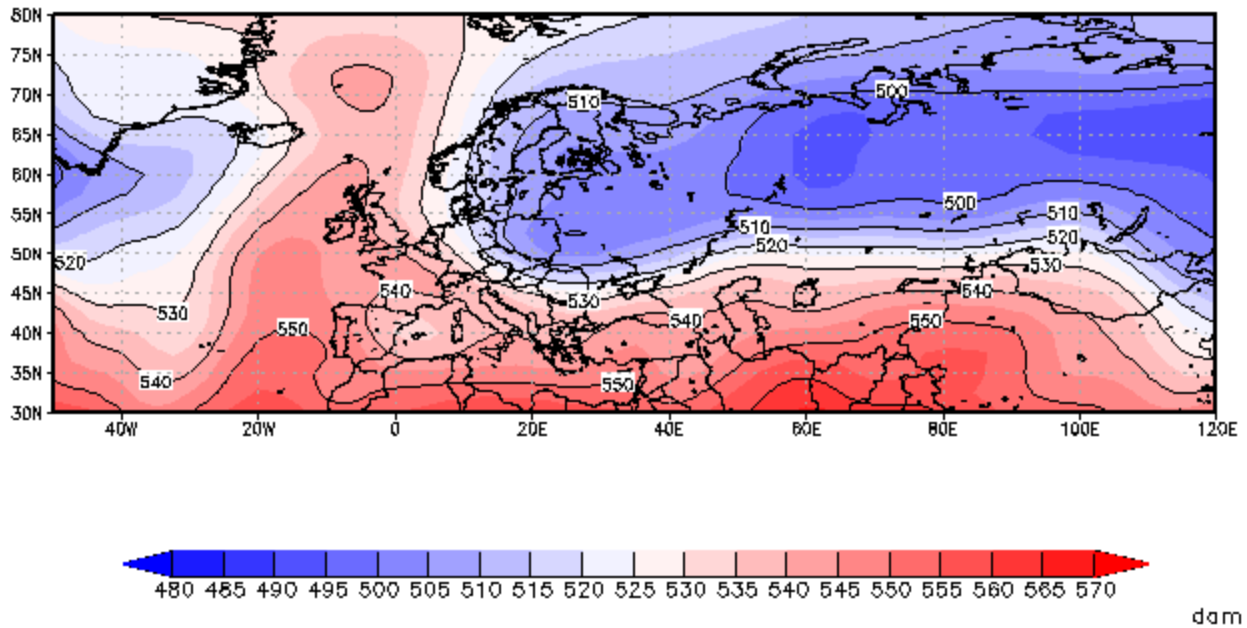
- **850hPa temp** (-14 to -20C)
- **500hPa temp** (-37 to -46C)
- **Thickness of 1000-500hPa layer** (less than 5080m, or **<508 dam**)

- Lots of animations of cold pool advection

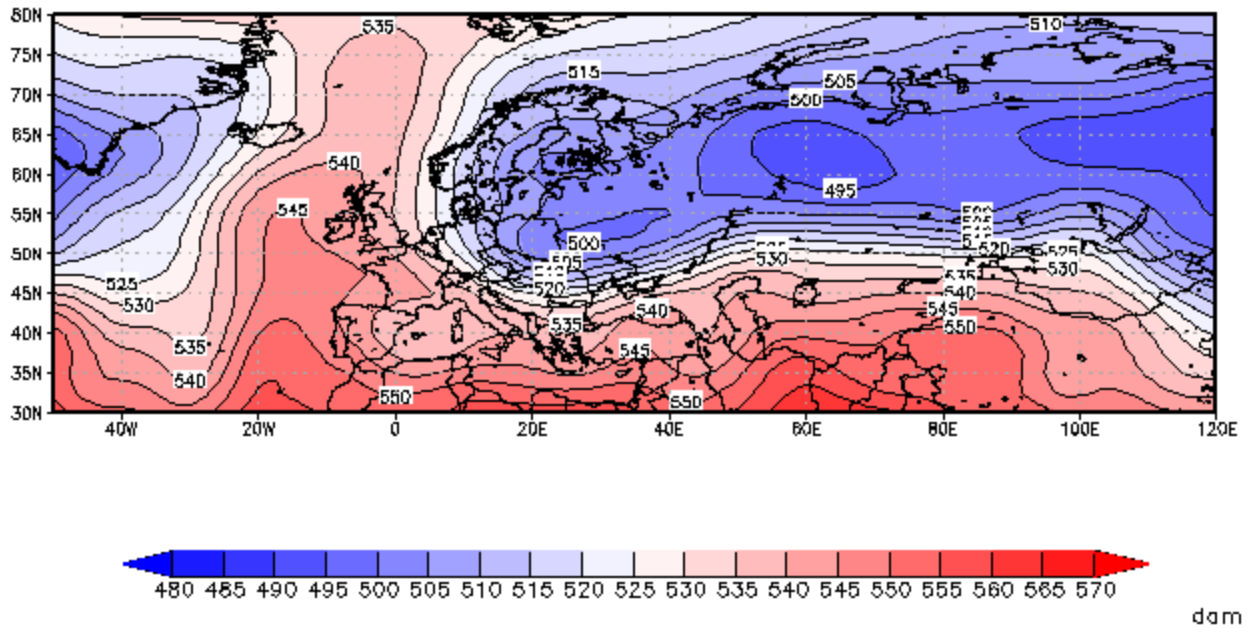
What is Thickness?



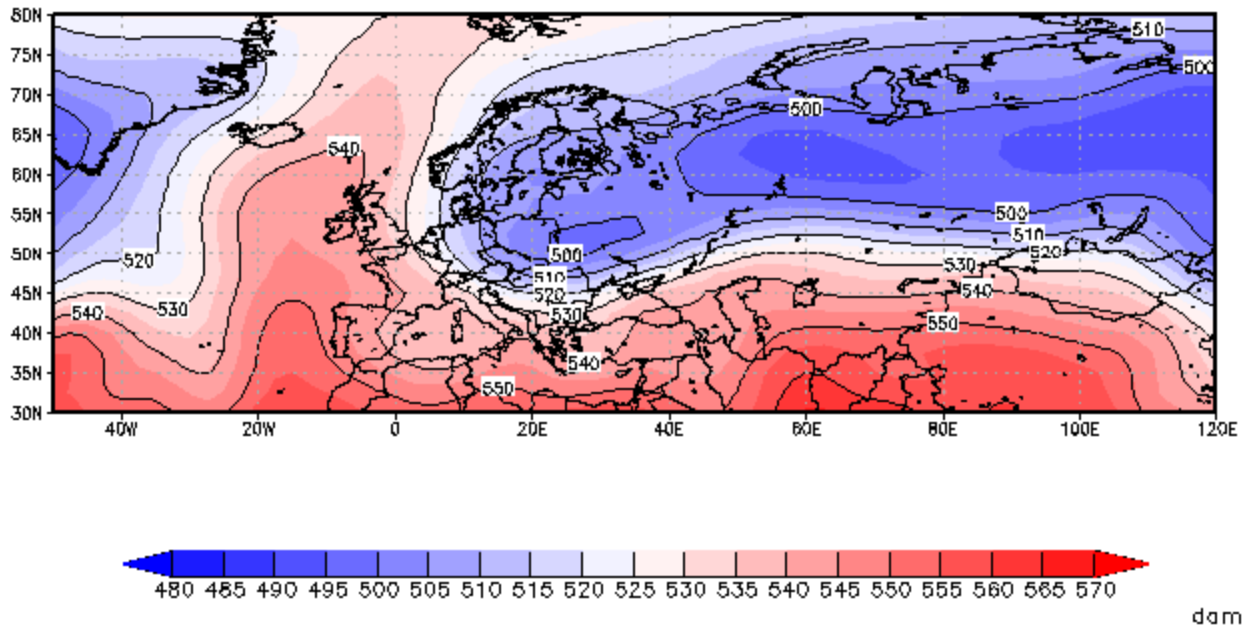
NCEP–NCAR Reanalysis II Thickness 1000–500hPa 18Z 24 FEB 2018



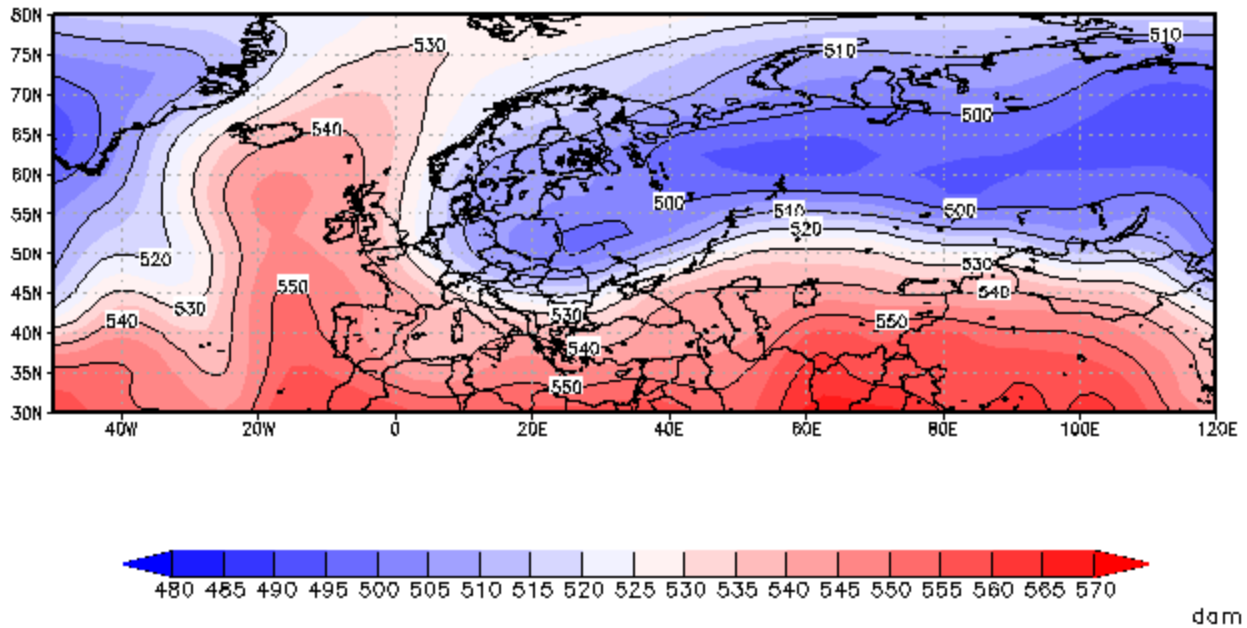
NCEP—NCAR Reanalysis II Thickness 1000—500hPa 00Z 25 FEB 2018



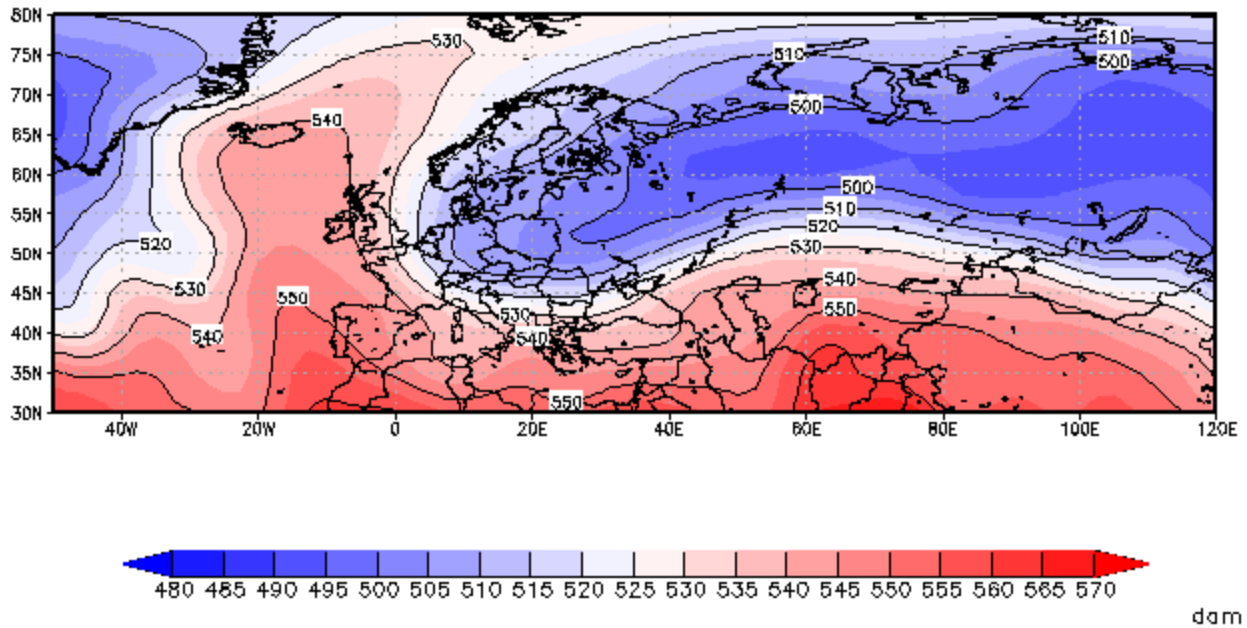
NCEP—NCAR Reanalysis II Thickness 1000—500hPa 06Z 25 FEB 2018



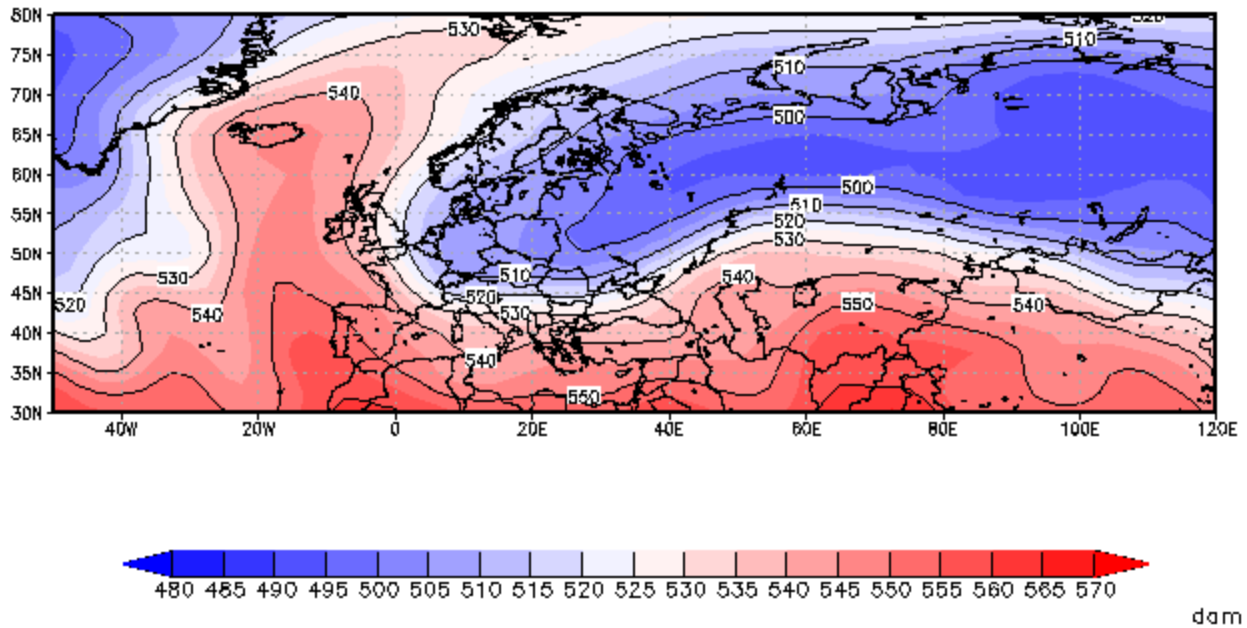
NCEP—NCAR Reanalysis II Thickness 1000—500hPa 12Z 25 FEB 2018



NCEP—NCAR Reanalysis II Thickness 1000—500hPa 18Z 25 FEB 2018



NCEP—NCAR Reanalysis II Thickness 1000—500hPa 00Z 26 FEB 2018



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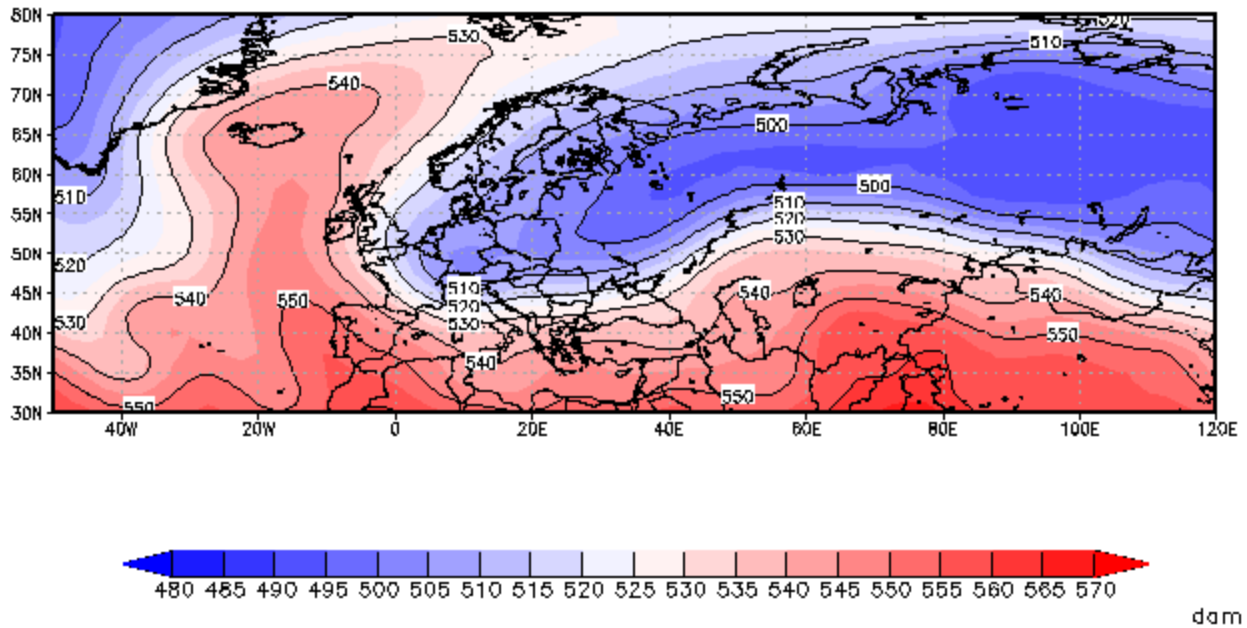
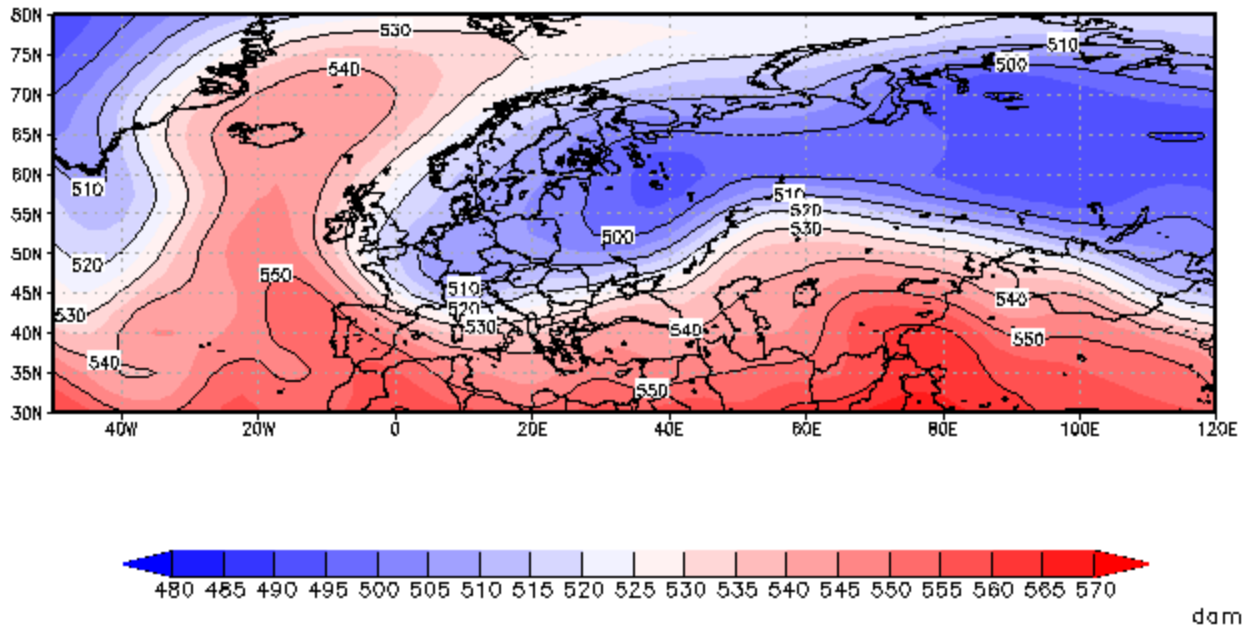


NCEP—NCAR Reanalysis II Thickness 1000—500hPa 12Z 26 FEB 2018



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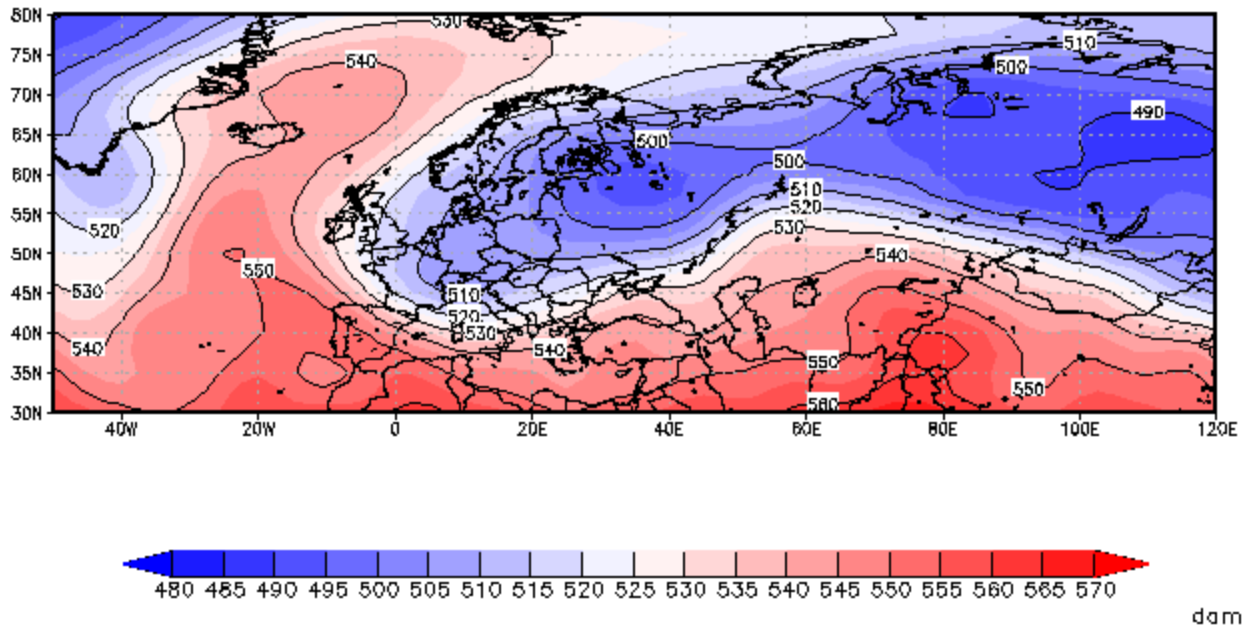
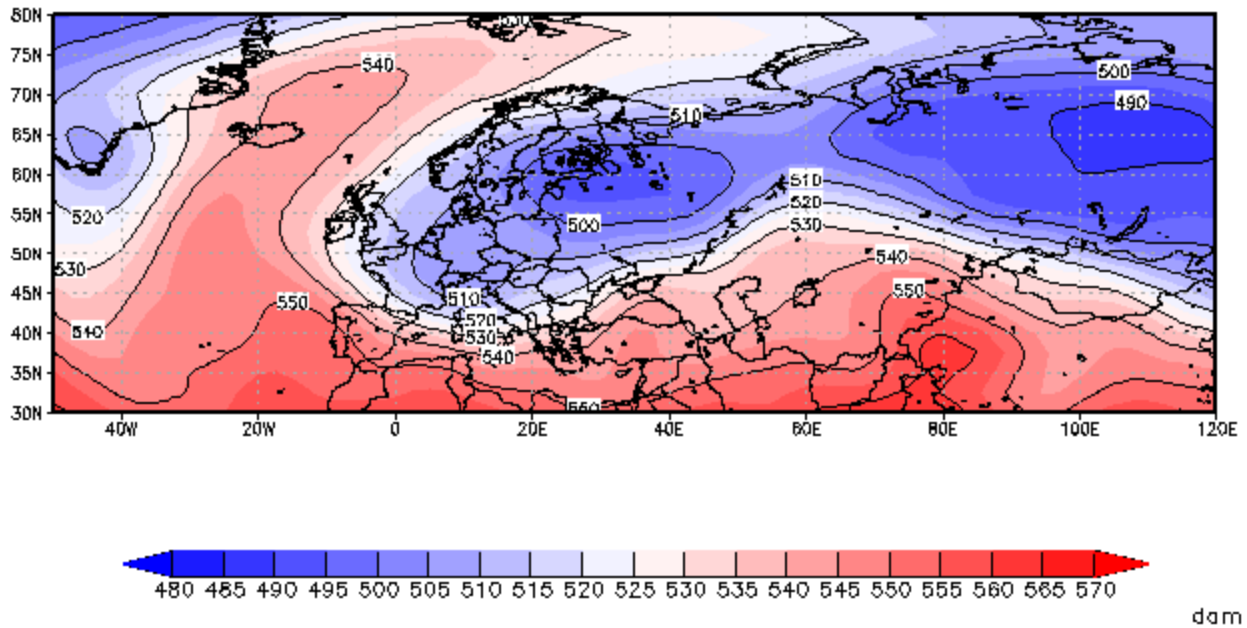


NCEP—NCAR Reanalysis II Thickness 1000—500hPa 00Z 27 FEB 2018



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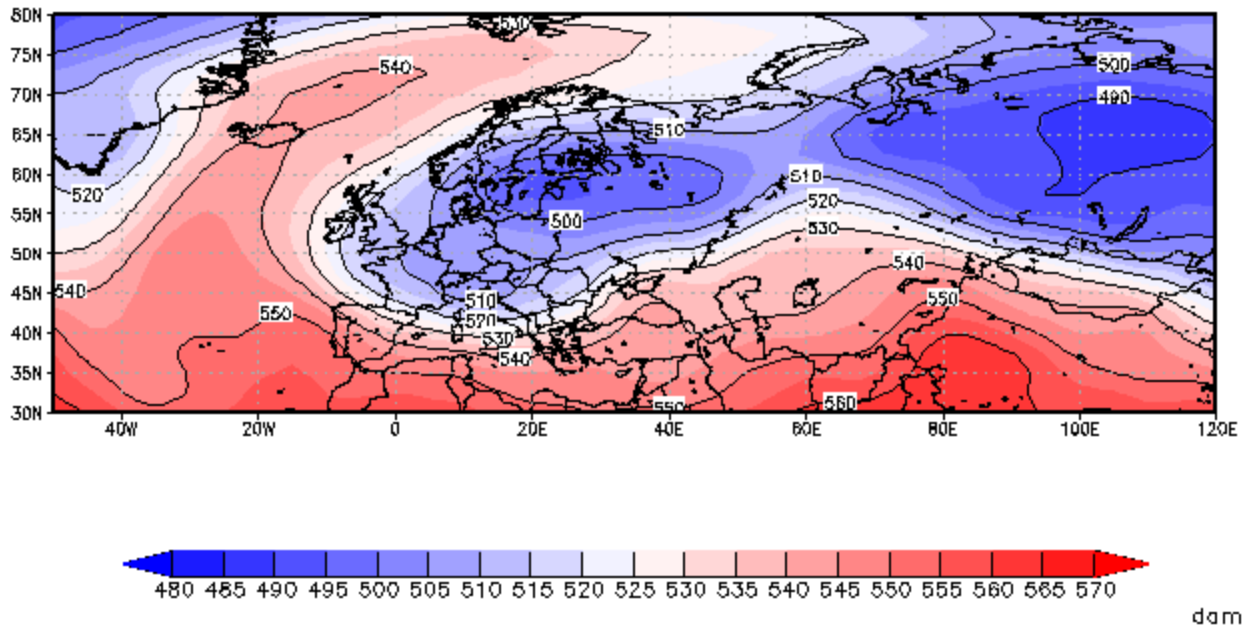
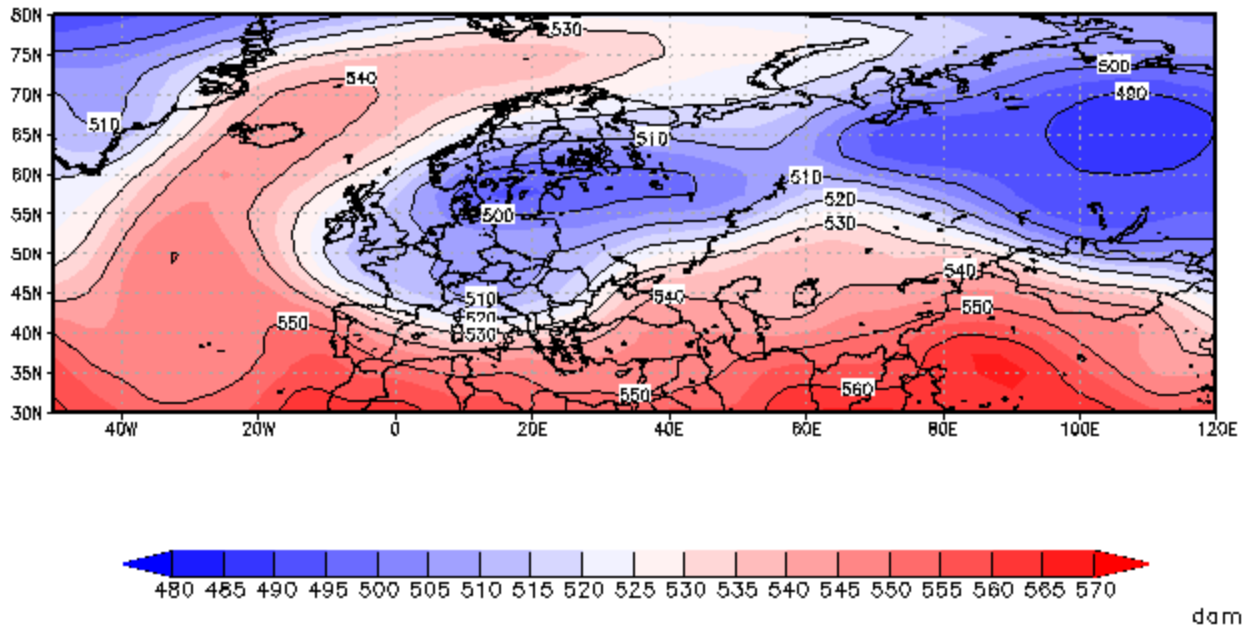


NCEP—NCAR Reanalysis II Thickness 1000—500hPa 12Z 27 FEB 2018



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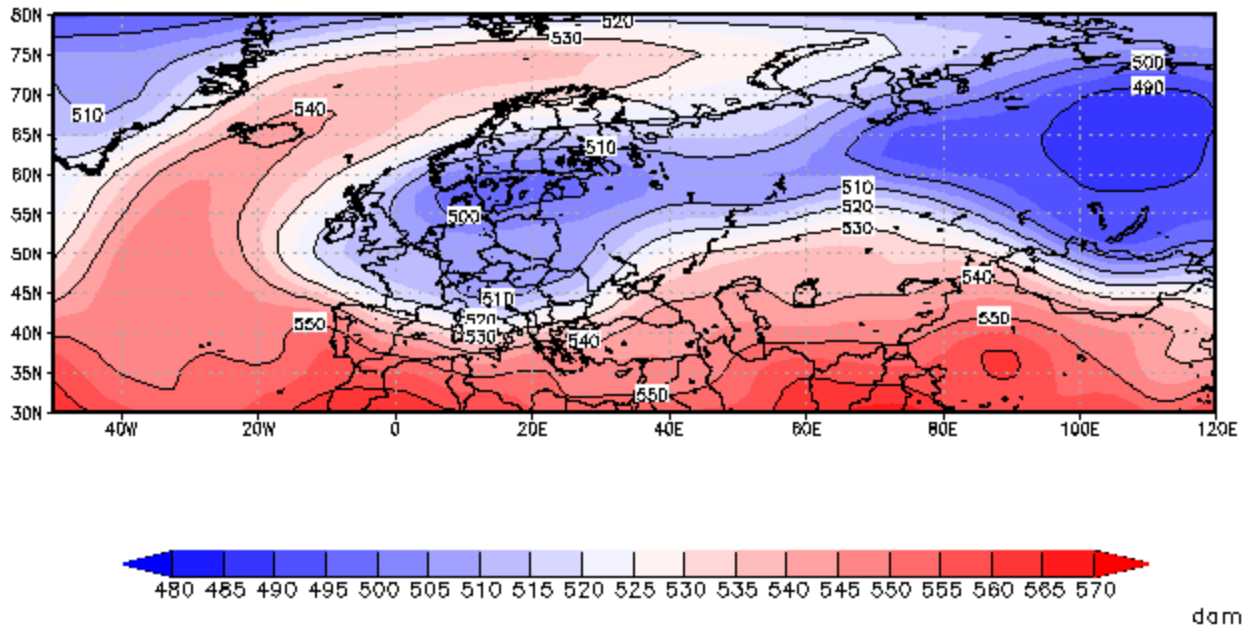

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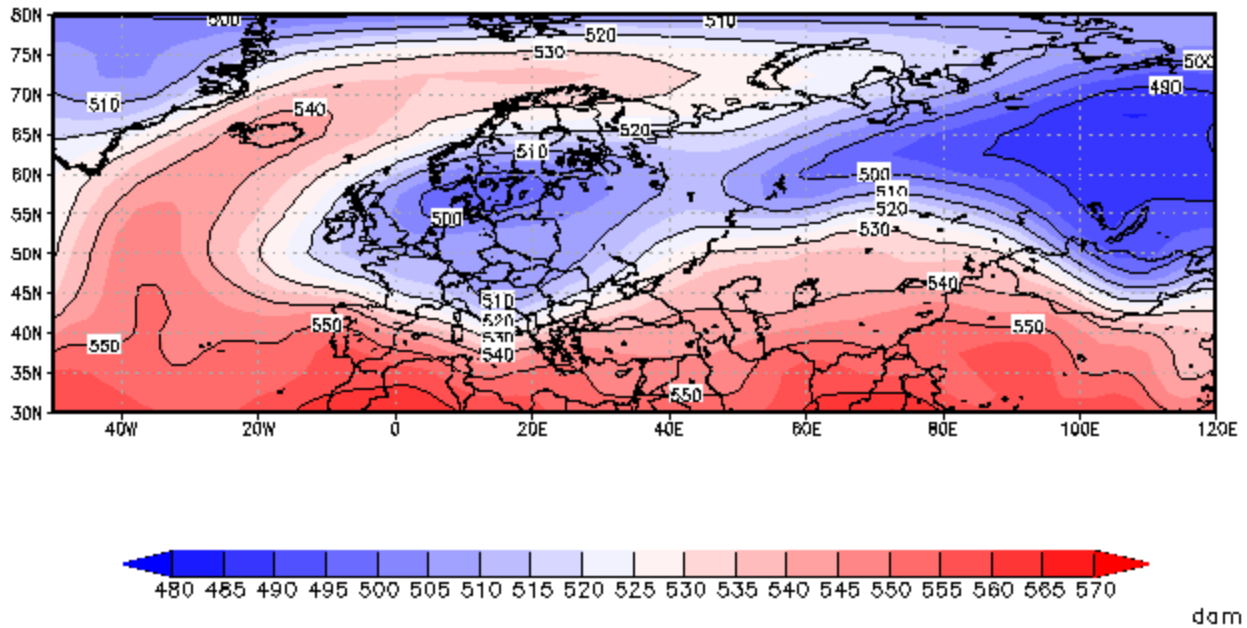

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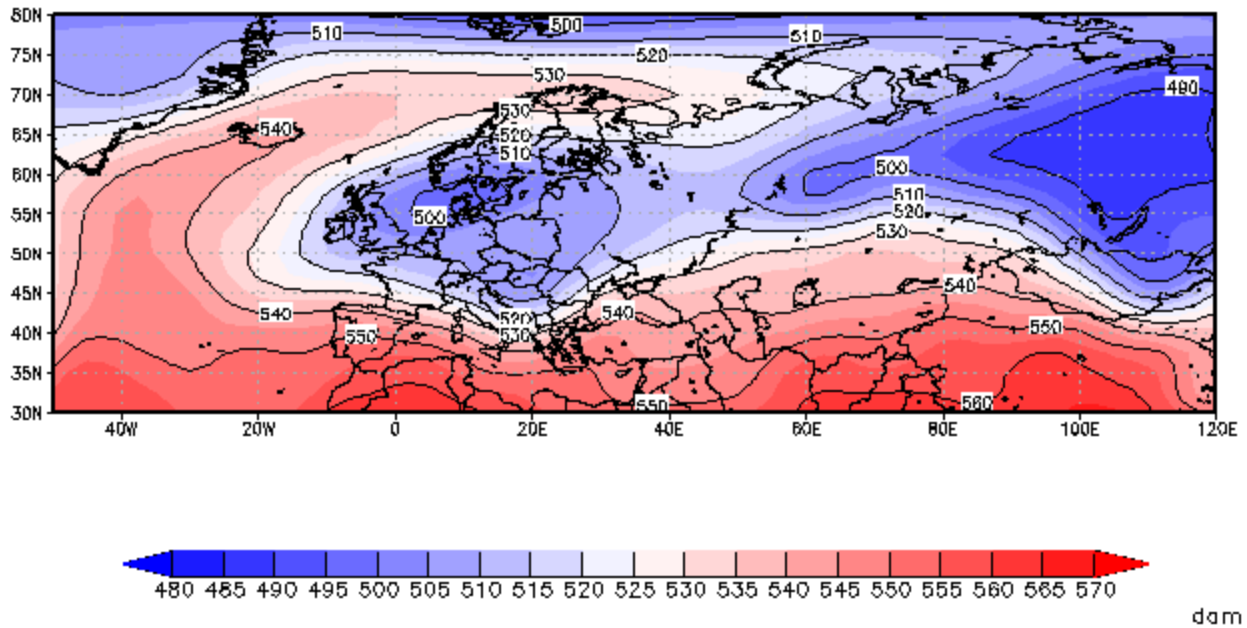

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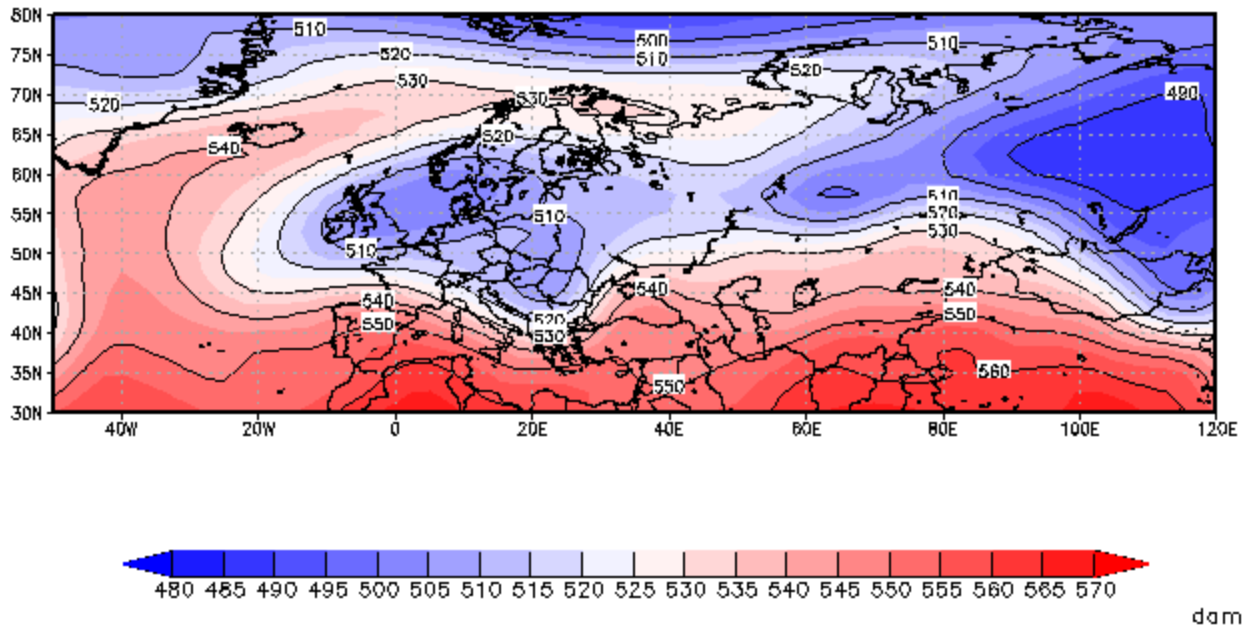
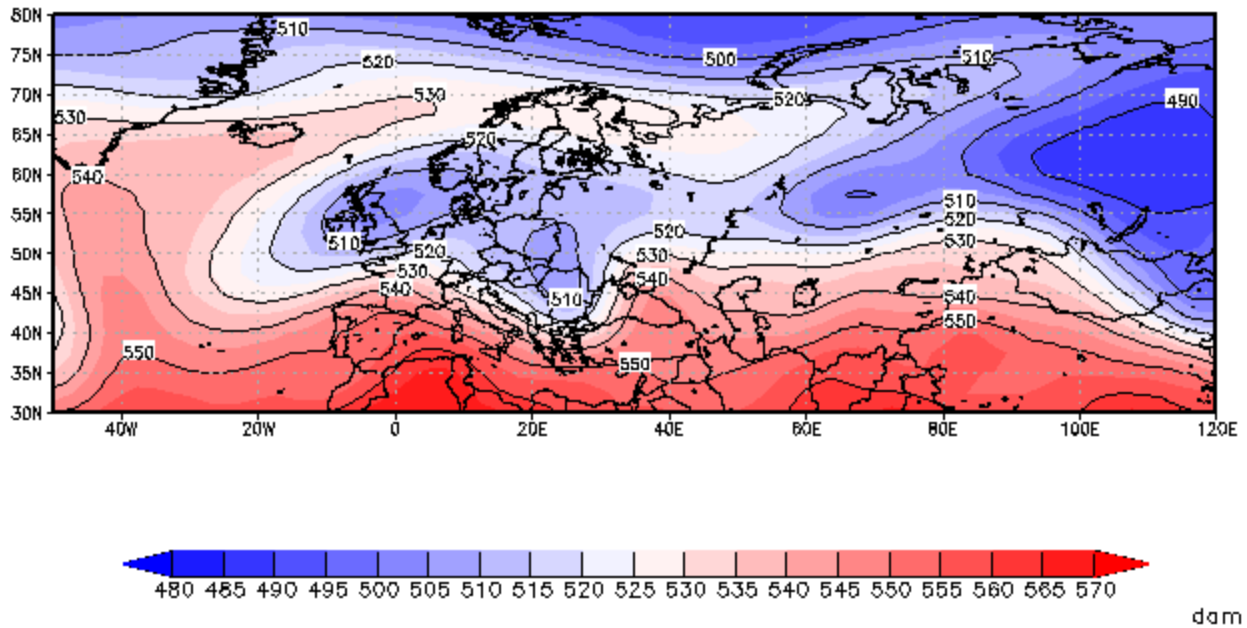
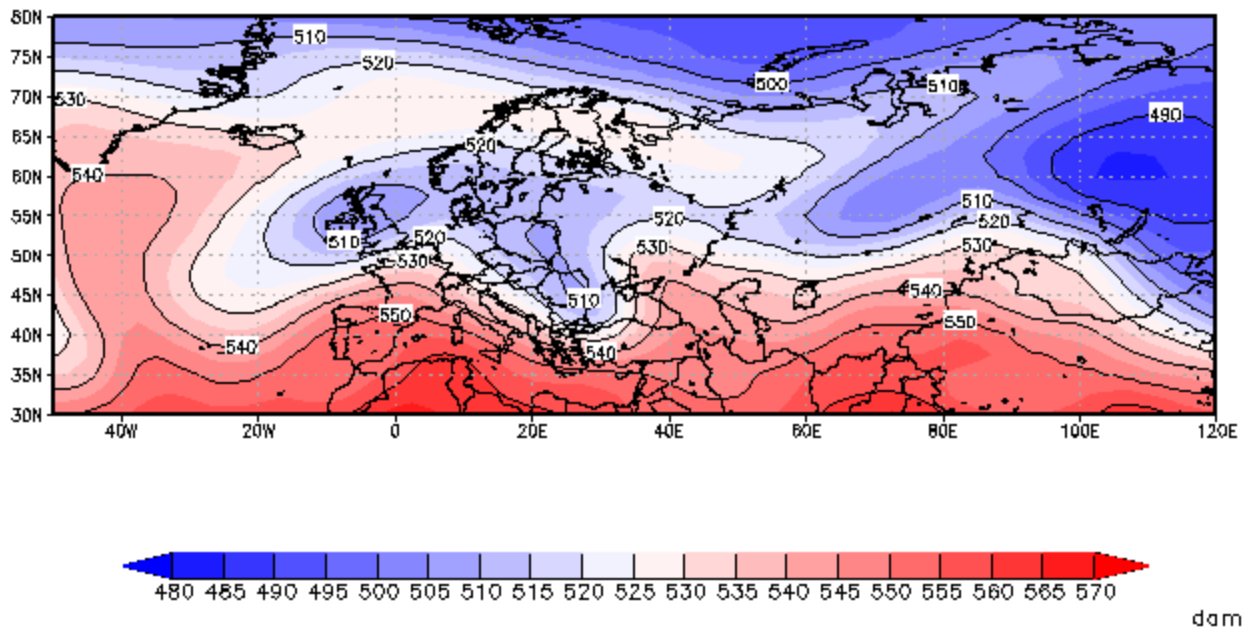


NCEP—NCAR Reanalysis II Thickness 1000—500hPa 18Z 28 FEB 2018



NCEP–NCAR Reanalysis II Thickness 1000–500hPa 00Z 01 MAR 2018



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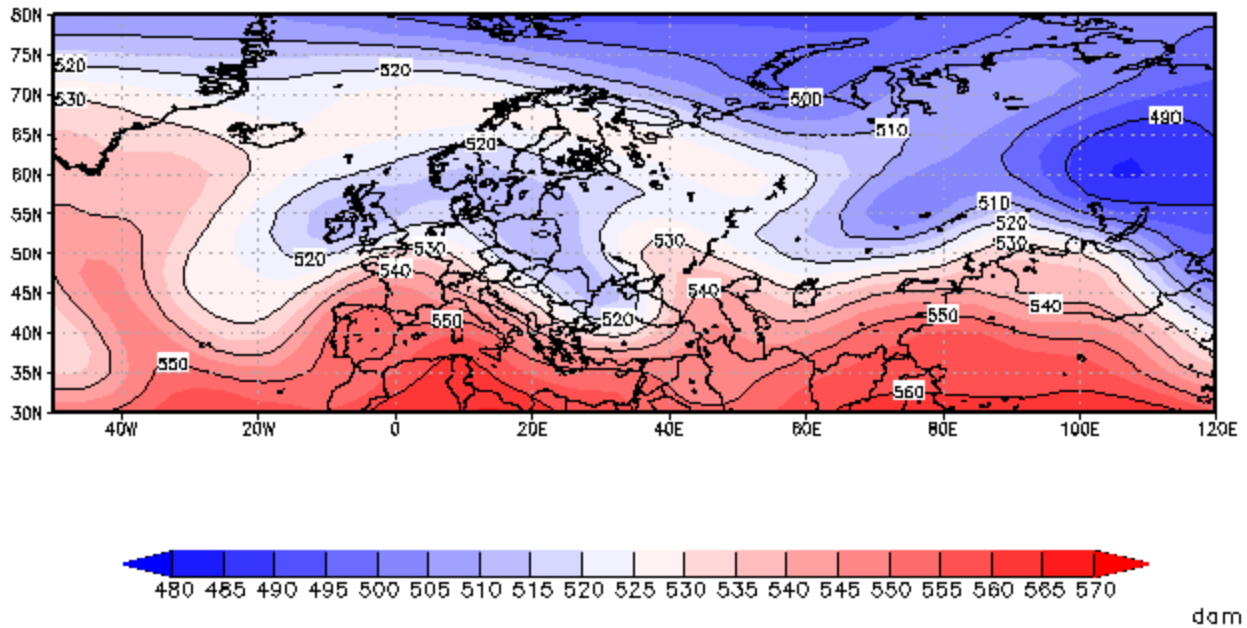
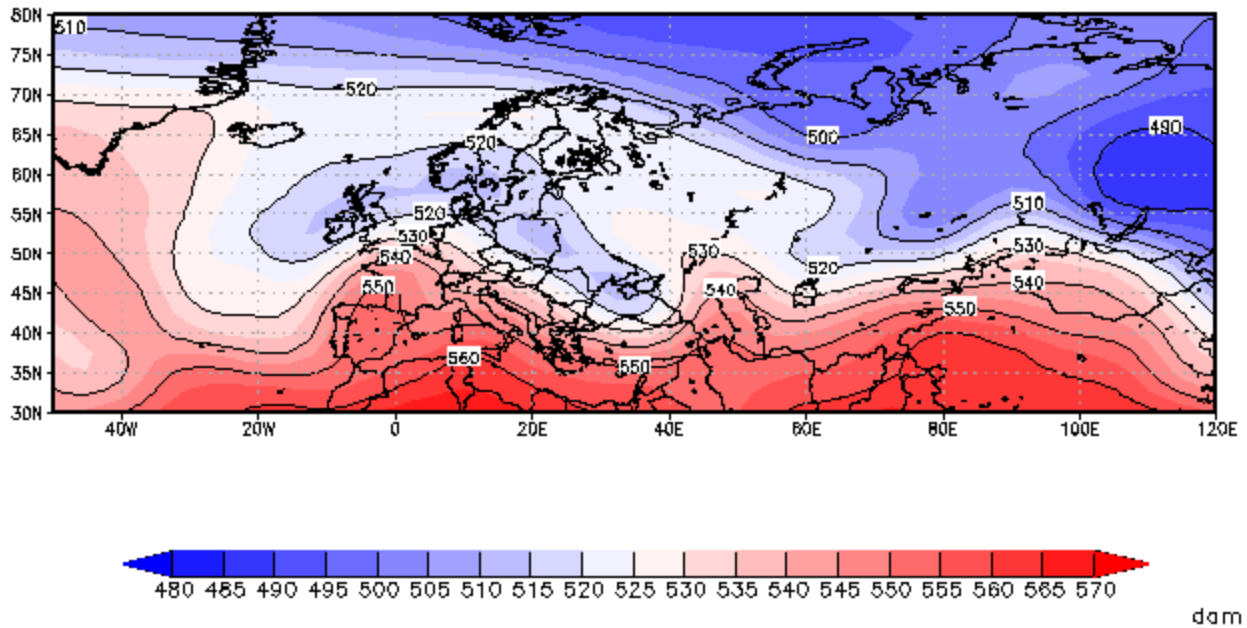


NCEP–NCAR Reanalysis II Thickness 1000–500hPa 12Z 01 MAR 2018



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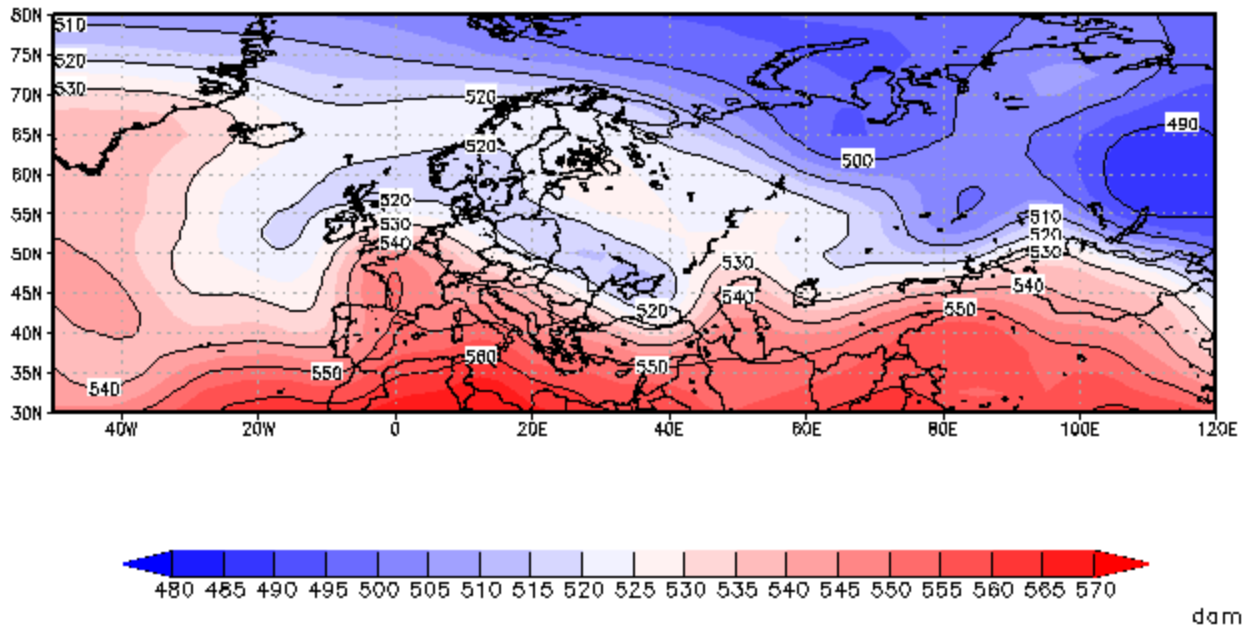


Results: Chronology and climatology of cold pools**;** most were **easterly**; some were **northerly** (Feb 1969); A few were **westerly** (Jan 1993, Jan / Feb 2018) – "**Pests from the West**"!

Table 1.

Total thicknesses of 504dam or below for the period 1947–2018 across Great Britain and Ireland measured by radiosonde stations, with reanalysis data for comparison.

Radiosonde station	*Date*	*Time (UTC)*	*Actual radiosonde*			*Reanalysis*		
			850hPa temperature (°C)	*500hPa temperature (°C)*	*Radiosonde total thickness (dam)*	*850hPa temperature (°C)*	*500hPa temperature (°C)*	*Reanalysis thickness (dam)*
Hemsby	1 February 1956	1400	−20	−40	497	−19	−40	498 (1800 UTC)
Hemsby	12 January 1987	1200	−18	−42	497	−19	−43	494
Crawley	12 January 1987	1200	−20	−40	499	−19	−40	497
Stornoway	7 February 1969	1100	−16	−42	500	−19	−35[a]	504[a]
Aughton	13 January 1987	0000	−17	−42	500	−18	−41	501
Crawley	13 January 1987	0000	−18	−39	501	−19	−37	503
Crawley	2 February 1956	0200	−18	−39	501	−19	−38	501 (0000 UTC)
Albemarle	28 February 2018	1200	−15	−46	502	−15	−44	502
Crawley	7 February 1991	0600	−18	−37	502	−18	−36	506
Albemarle	28 February 2018	0517	−14	−42	503	−15	−43	503 (0600 UTC)
Albemarle	28 February 2018	1715	−15	−43	503	−15	−44	503 (1800 UTC)
Hemsby	2 February 1956	0200	−19	−39	503	−19	−39	502 (0000 UTC)
Larkhill	29 January 1947	0600	−17	−38	504	−15	−33	514[b]

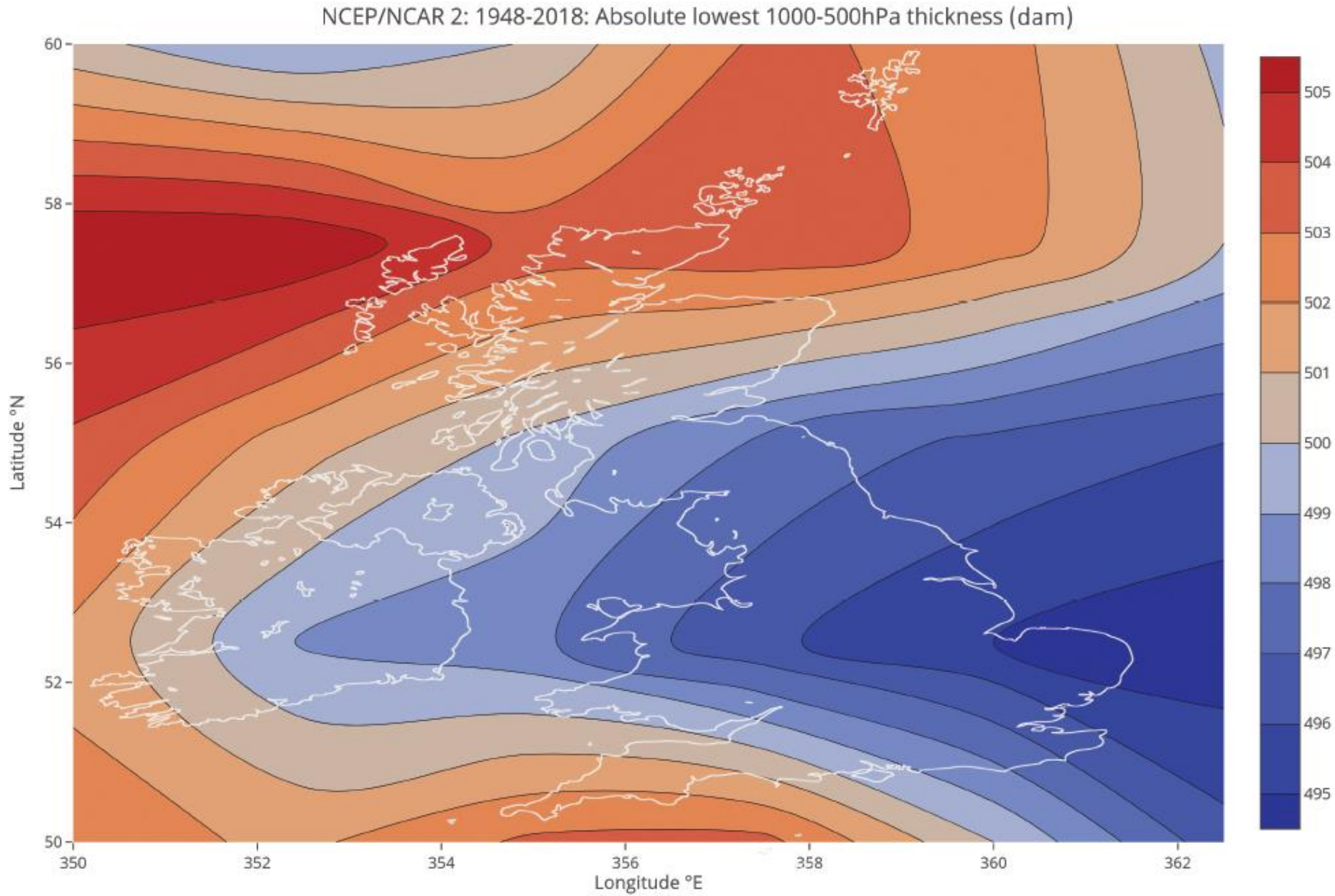
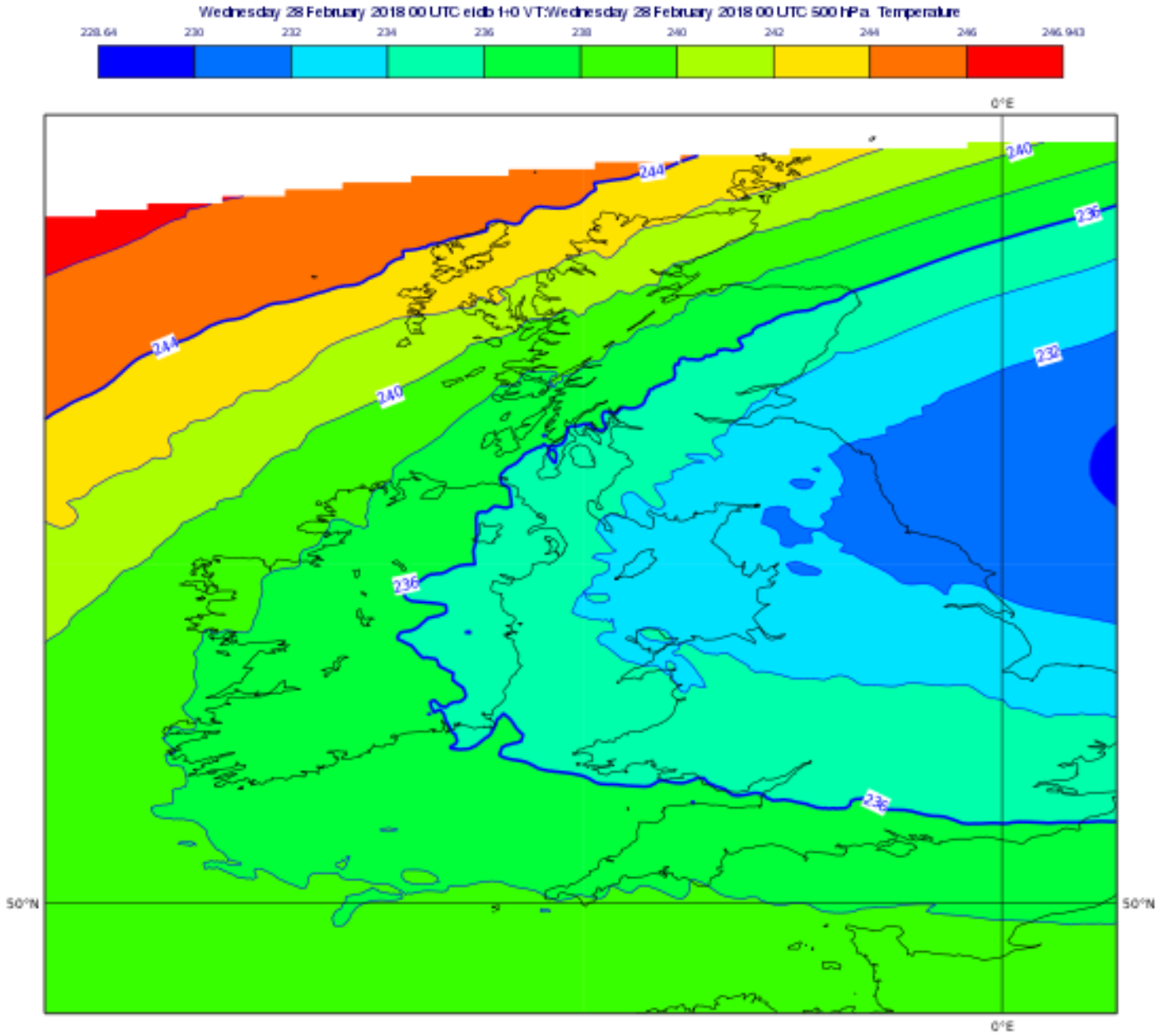


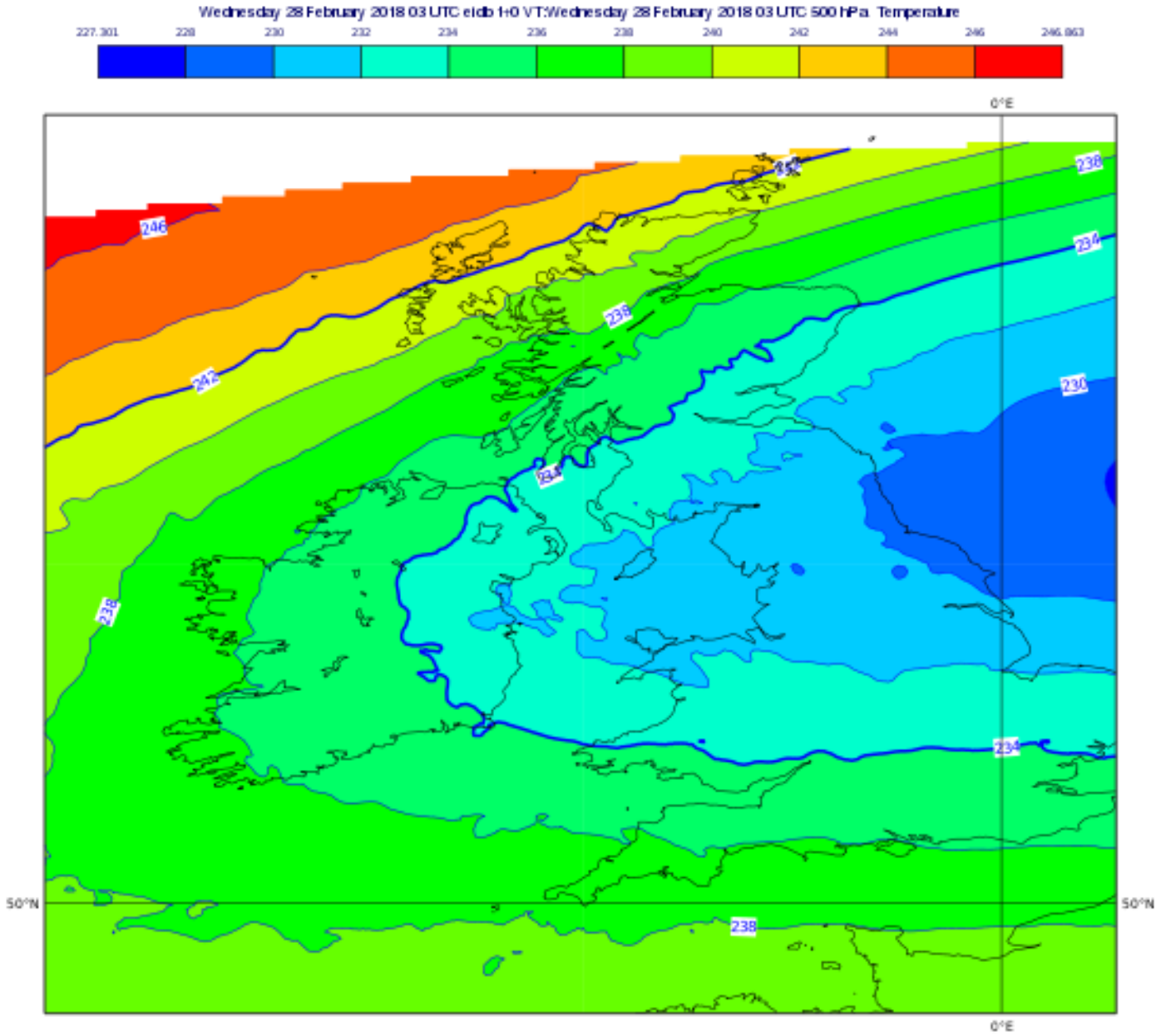
Figure 3. The absolute lowest thickness in the reanalyses from 1948–2018, plotted as a contour map (see text for more details).

And how does MÉRA compare? 28 Feb 2018 00z 850hPa air temp

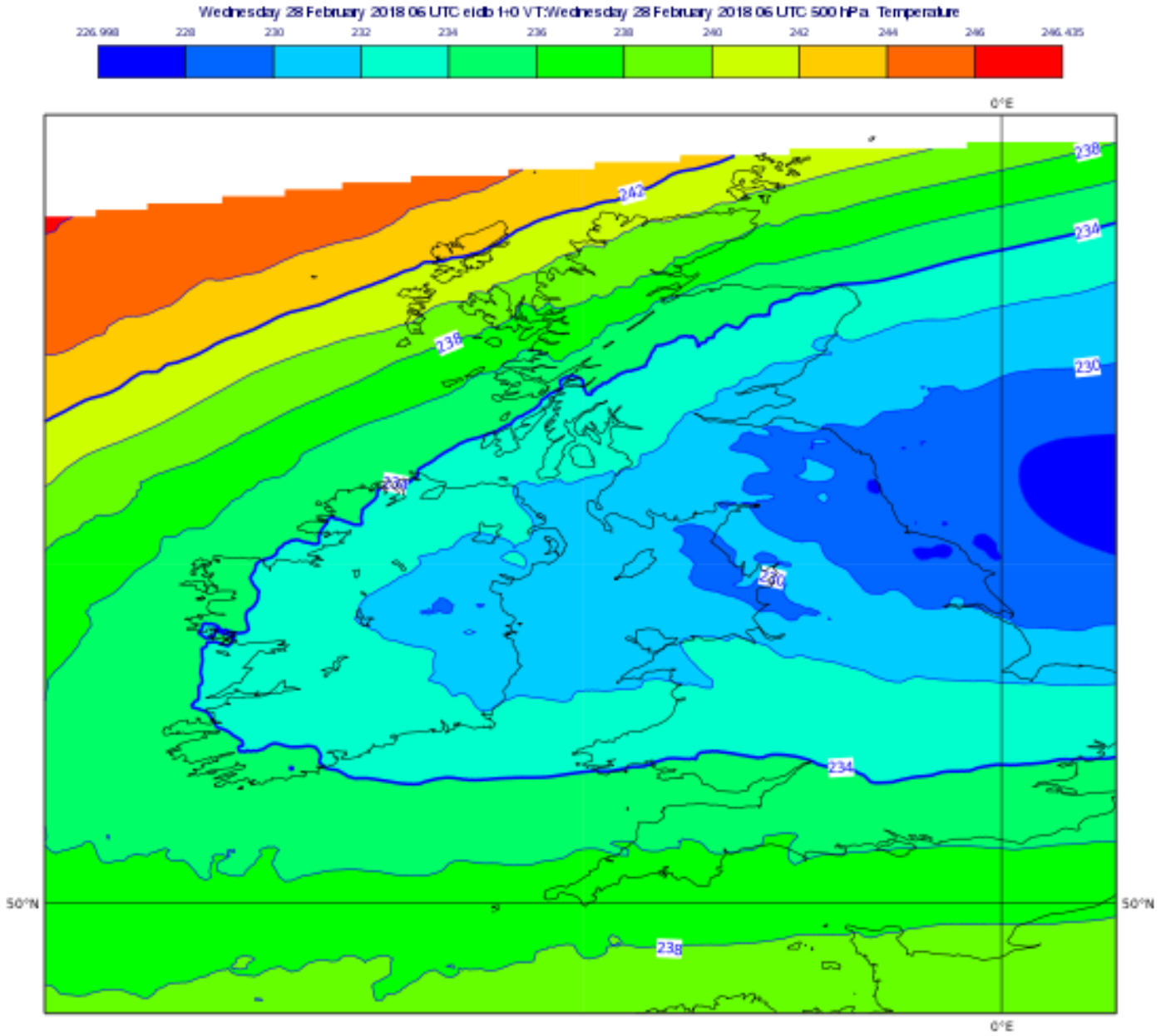


A quick qualitative comparison…

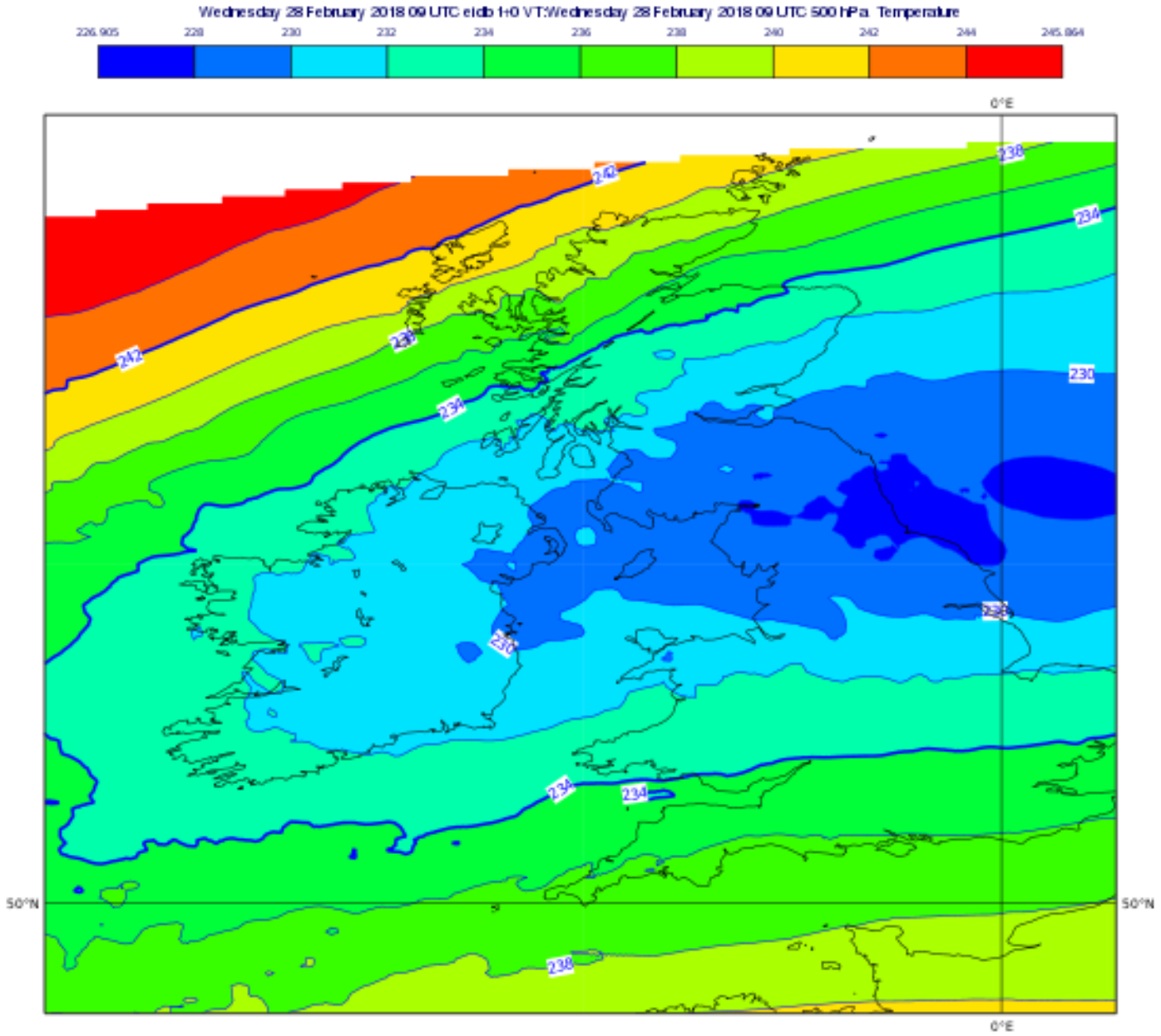
And how does MÉRA compare? 28 Feb 2018 03z 850hPa air temp



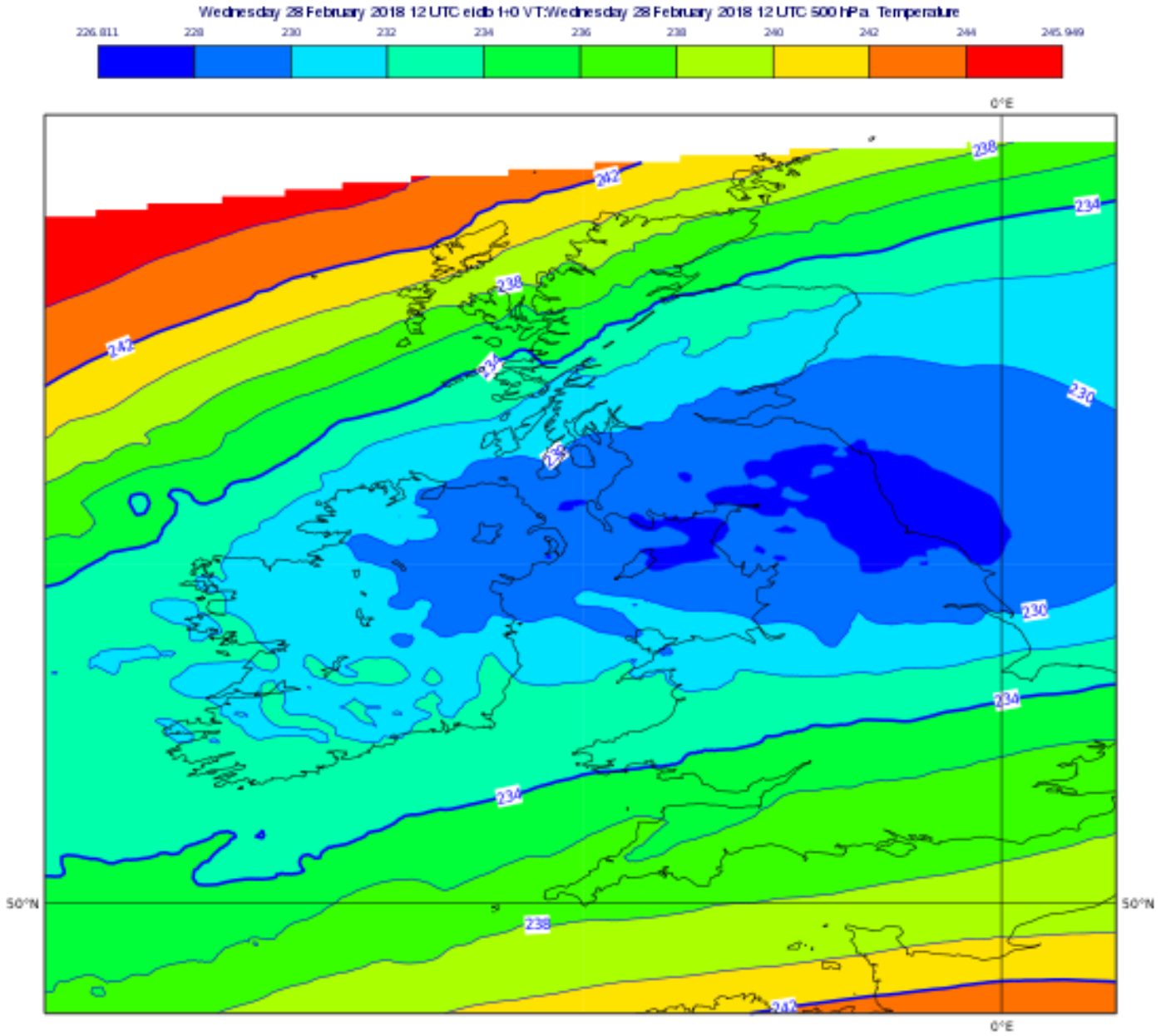
And how does MÉRA compare? 28 Feb 2018 06z 850hPa air temp



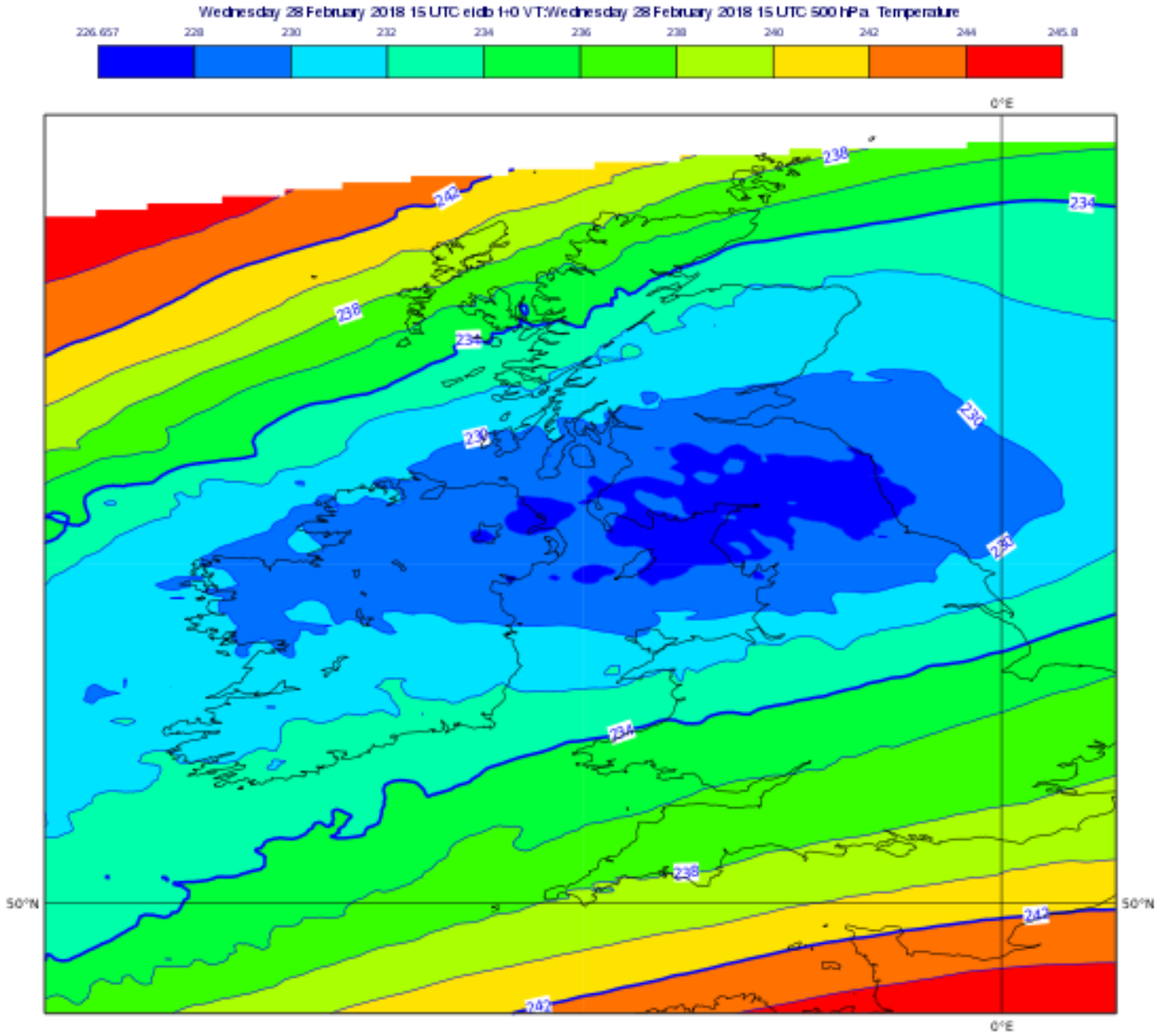
And how does MÉRA compare? 28 Feb 2018 09z 850hPa air temp



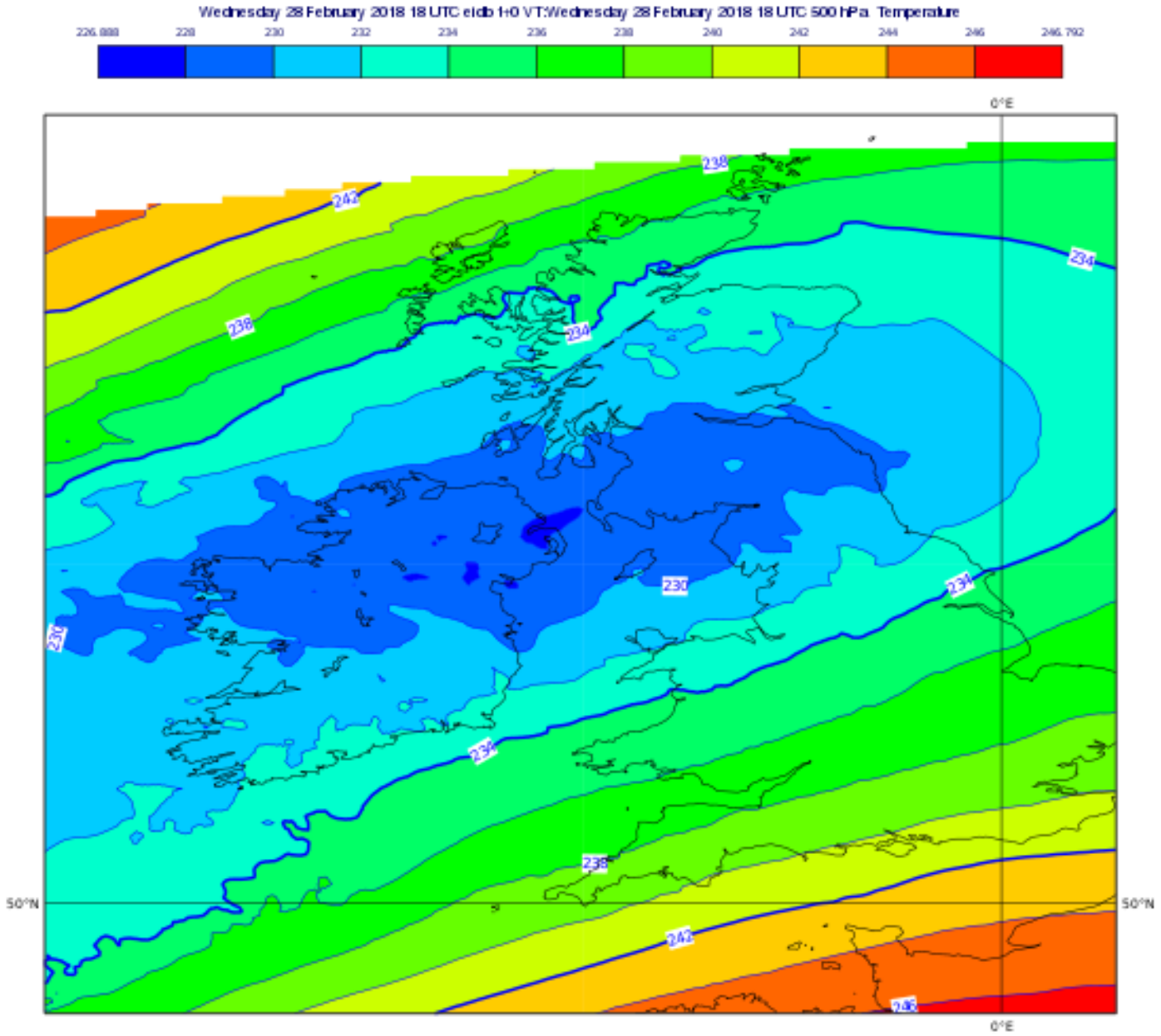
And how does MÉRA compare? 28 Feb 2018 12z 850hPa air temp



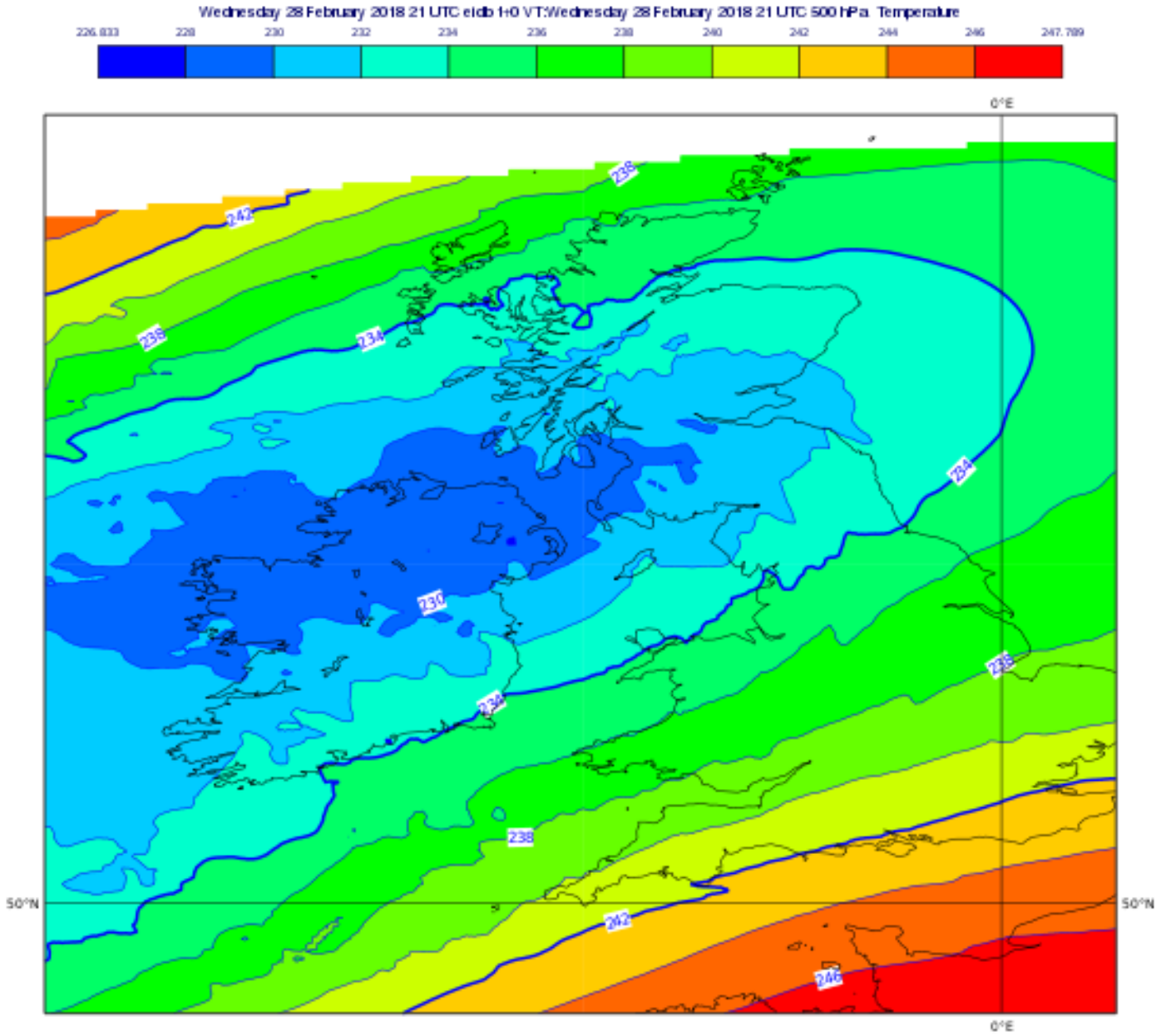
And how does MÉRA compare? 28 Feb 2018 15z 850hPa air temp



And how does MÉRA compare? 28 Feb 2018 18z 850hPa air temp



And how does MÉRA compare? 28 Feb 2018 21z 850hPa air temp



THANK YOU FOR YOUR ATTENTION!

puno hvala!
doviđenja!

¡muchas gracias!
Adios!

Tapadh leibh
Tioradh!

Danke vielmals! Tschüss

a plus!

Auf wiederluege!

Merci et au revoir!

SLÁINTE MHATH!

Cheerio!

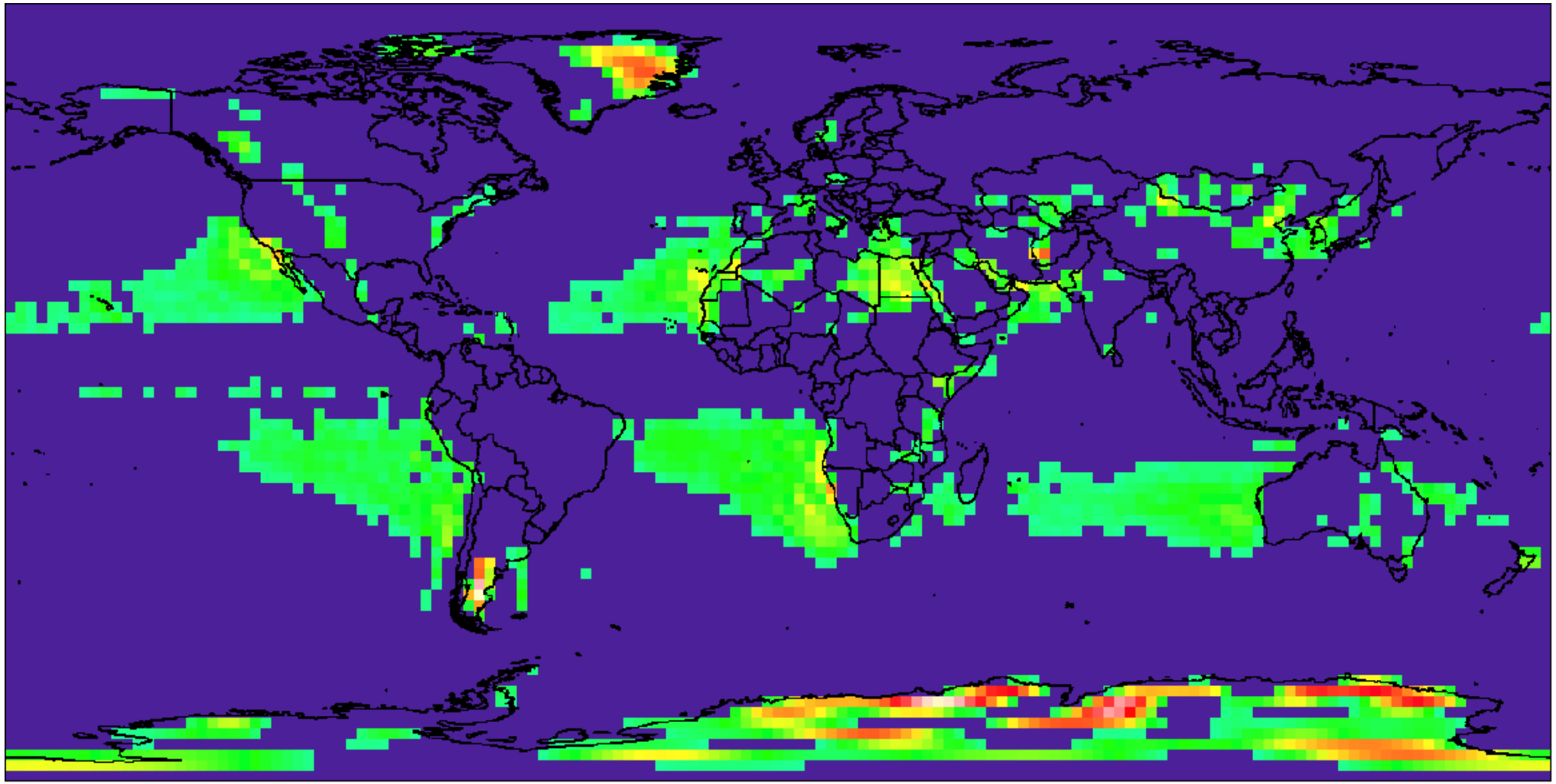
A bientot!

Thenk ye
See you!

Ciao!

Appendix 1: Back to Basics – The Warm High (formed predominantly by compressional warming in adiabatic descent)

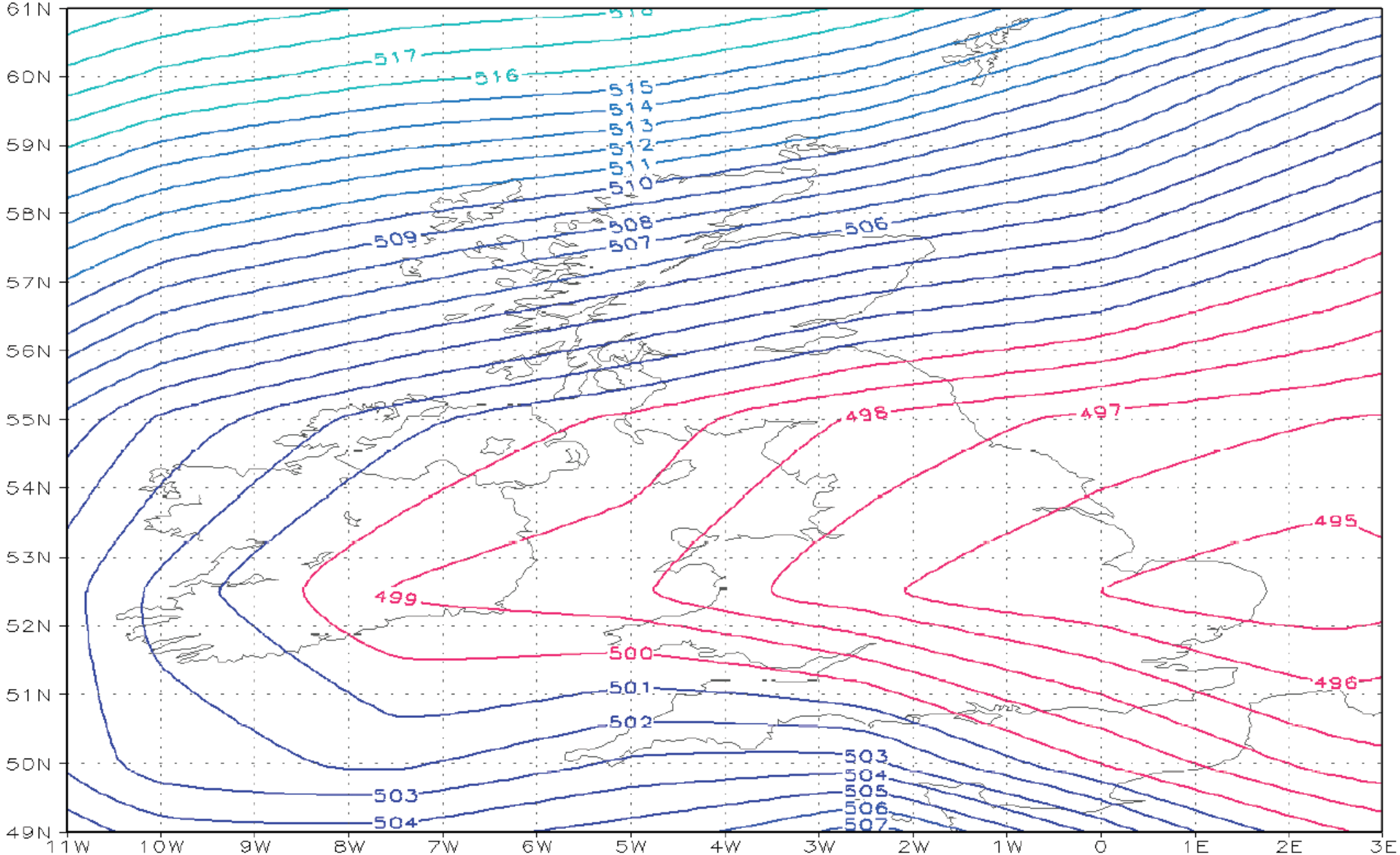
Adiabatic warming at a few mm/sec -> No Kolmogorov turbulence



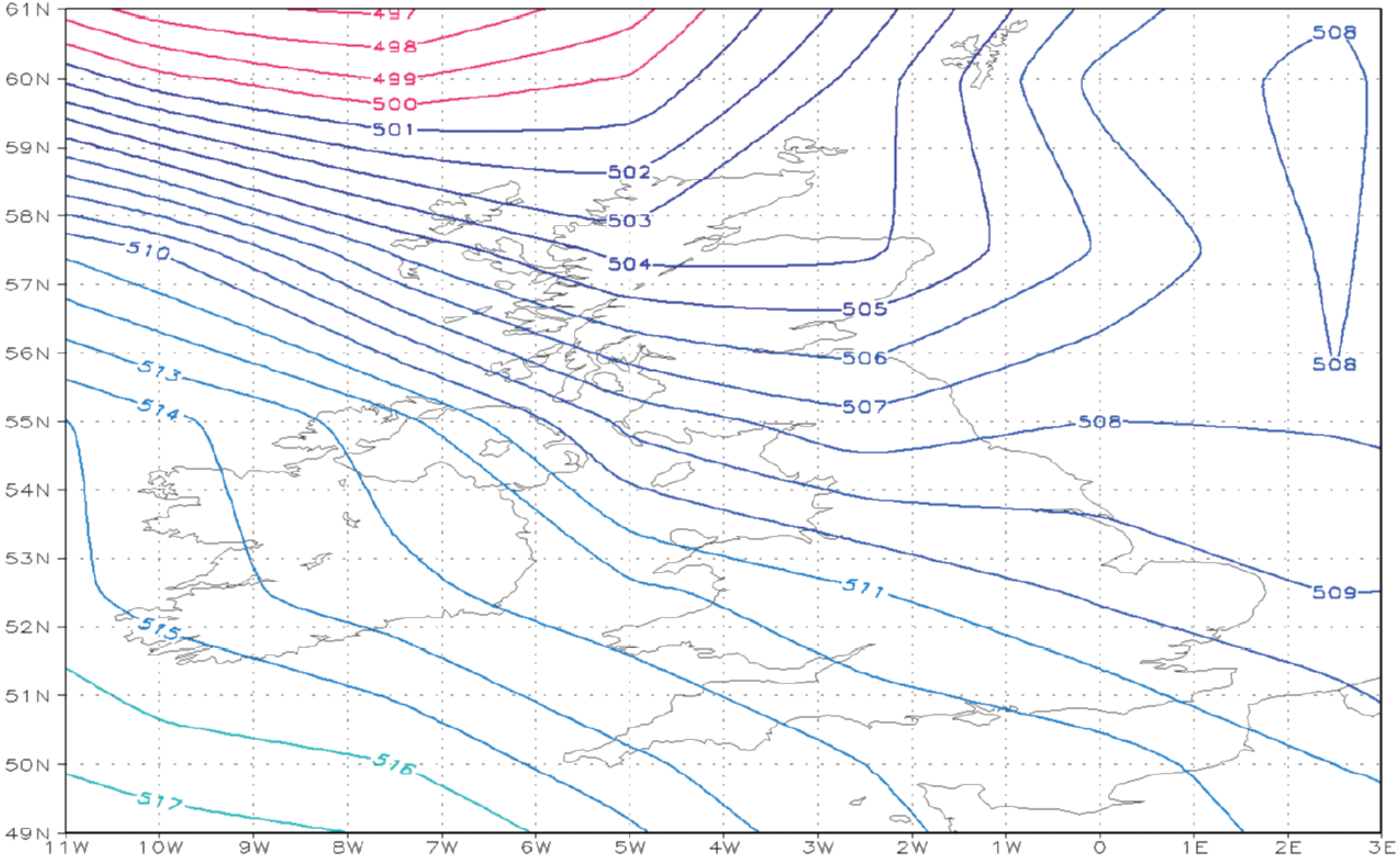
(a) vertical velocities of 0.025 to 0.045 Pa/sec (yellow)

Graham (2008)

Appendix 2: Jan 1987 – Lowest thicknesses



Appendix 3: Feb 1969 – Lowest thicknesses



Appendix 4: Late Feb / early March 2018