Lake Street
CONSULTING
working with the weather

Perspective. Imagination.
Key ingredients for happy users?

Using ECMWF Forecasts meeting 2018

Isla Finney

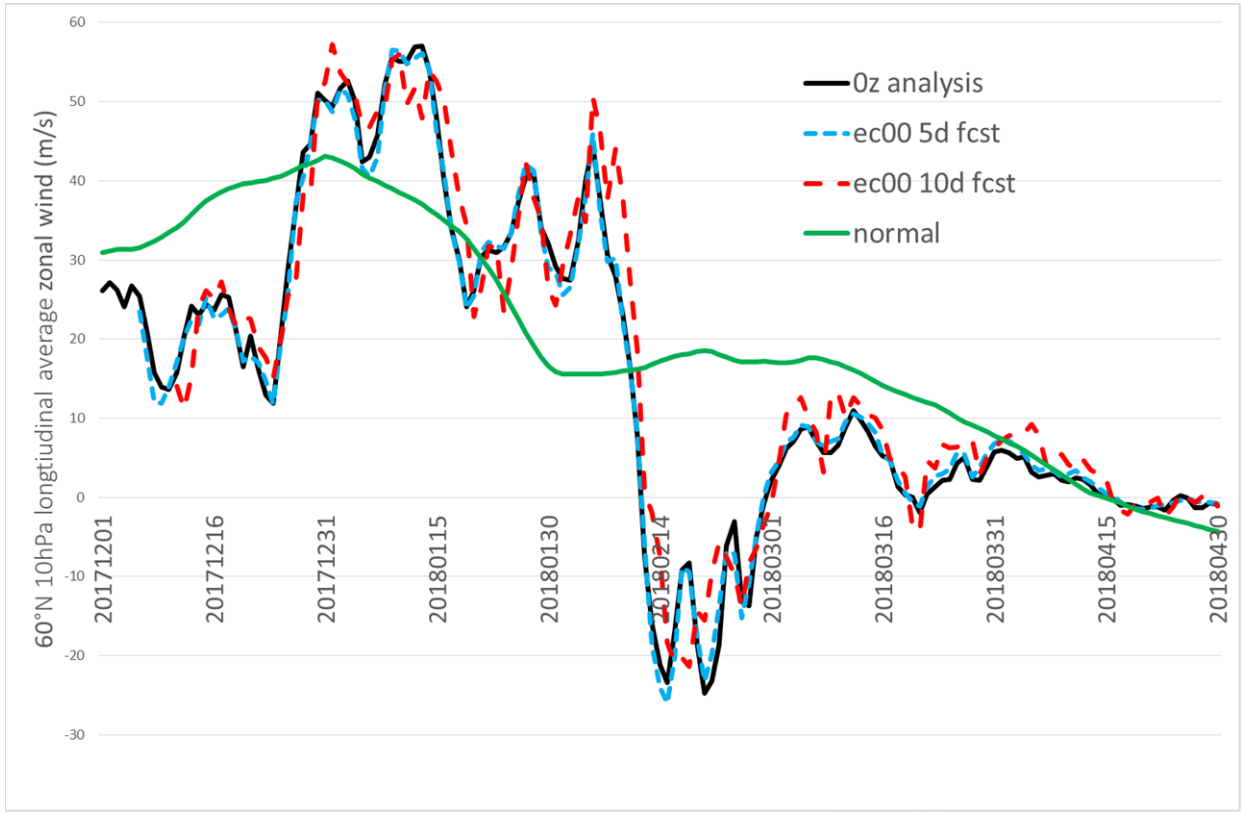
Outline

- UEF 2018 tagline *ECMWF model outputs: the only limit is your imagination*
- Ensemble forecasts aim to explore
  - initial condition error
  - and model error

    using perturbations at initialisation + stochastic perturbations during evolution
- Operationally, see structural model error again and again
  - Winter 2017/2018 and the stratosphere
  - April 2018 European 'heatwave'
- Users continue to express uneasiness with ensemble construction
  - Observations from EC45 day ensembles
- So, given a blank sheet,

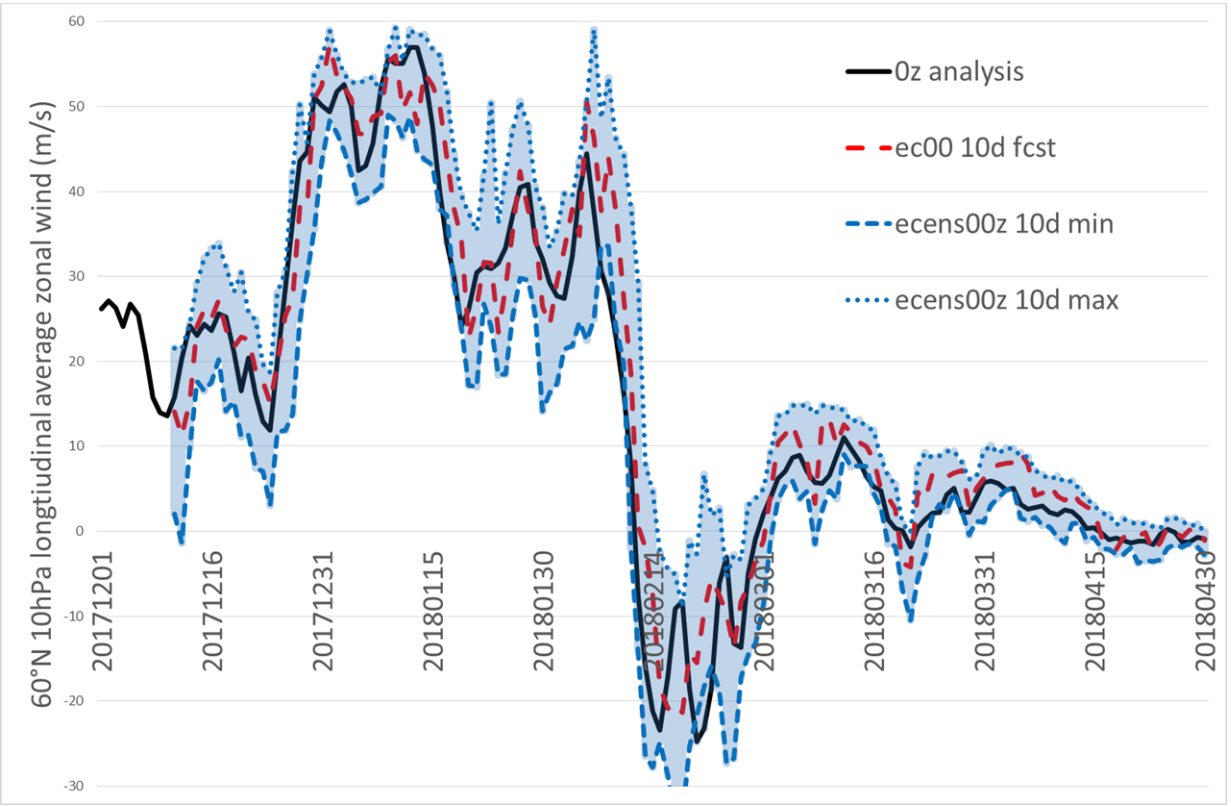
  can we imagine an ensemble construction which would satisfy users?
- Coffee break challenge

Winter 2017/2018



- Stratosphere a strong influence
- Operationally, noticed changes in forecasts every time zonal wind decreased
- 5d zonal wind forecast good
- 10d forecast suffers lag, but reasonable

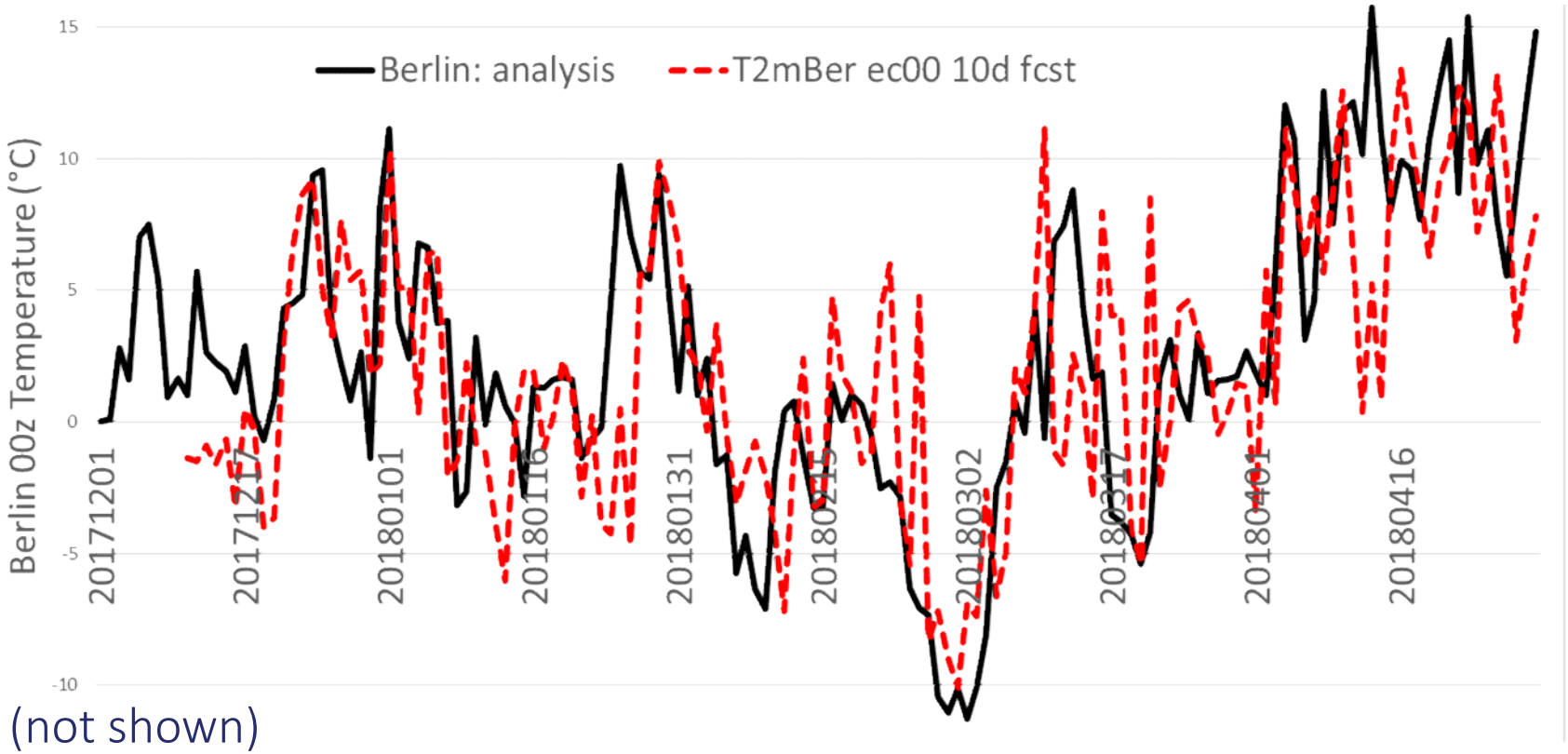
June 6th 2018



Winter 2017/2018

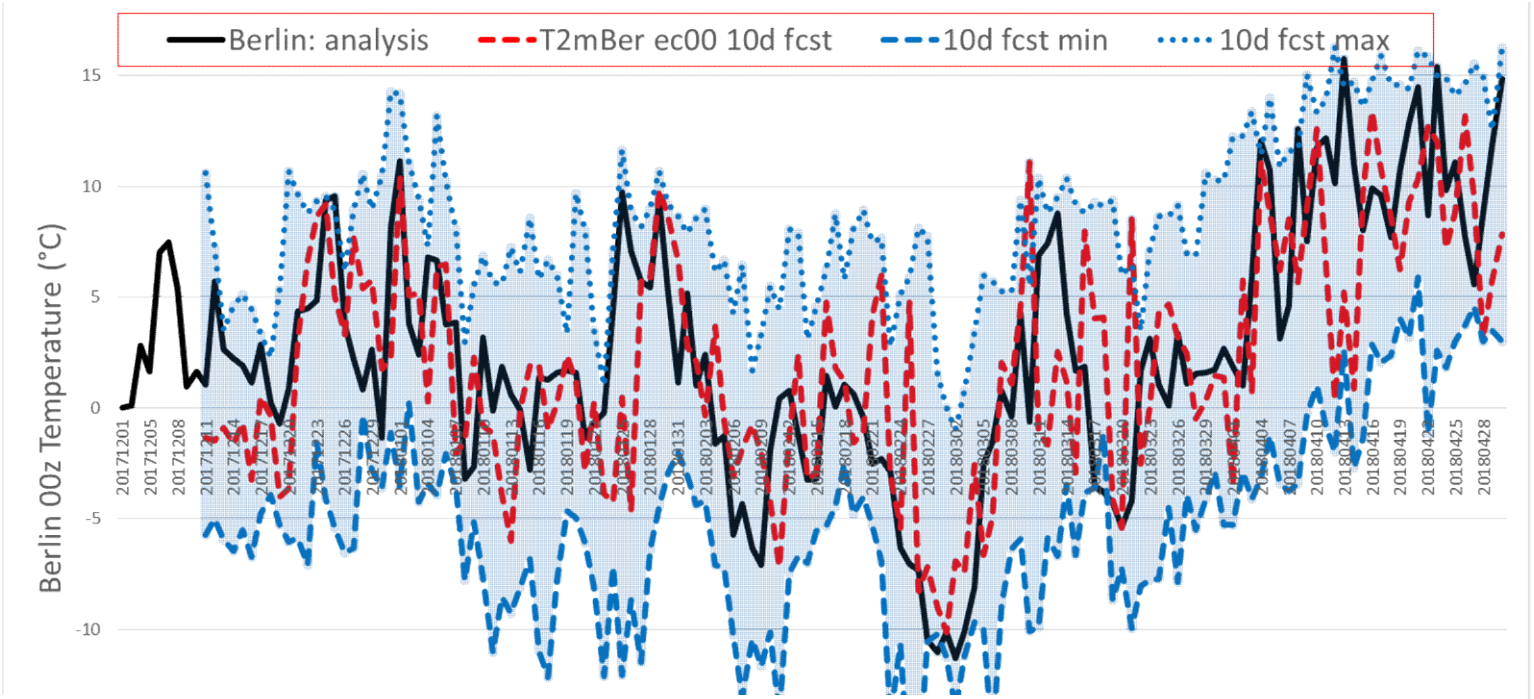
- Stratosphere a strong influence
- Operationally, noticed changes in forecasts every time zonal wind decreased
- 5d zonal wind forecast good
- 10d forecast suffers lag, but reasonable...
- ...and verification lies within 10d ensemble spread

Winter Berlin T2m forecast:10 d



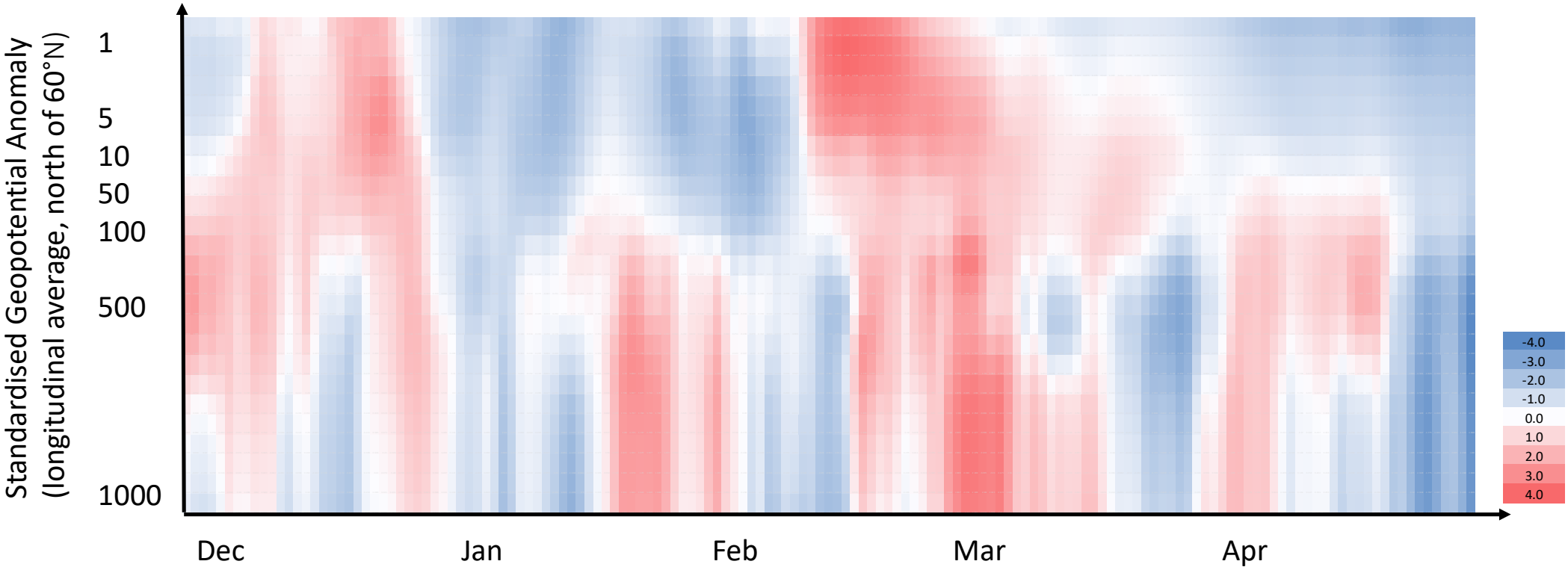
- 5d forecast ok (not shown)
- 10d forecast not great! Bias to shift back warm through late Feb and late Mar

Winter Berlin T2m forecast:10 d



- Verification lies within ensemble spread, but this is large
- And little correlation between spread and skill (r^2 ~ 0.25)
- Where is breakdown in forecast skill? Is it stratospheric/tropospheric coupling?

‘Drip map’, 00z analysis



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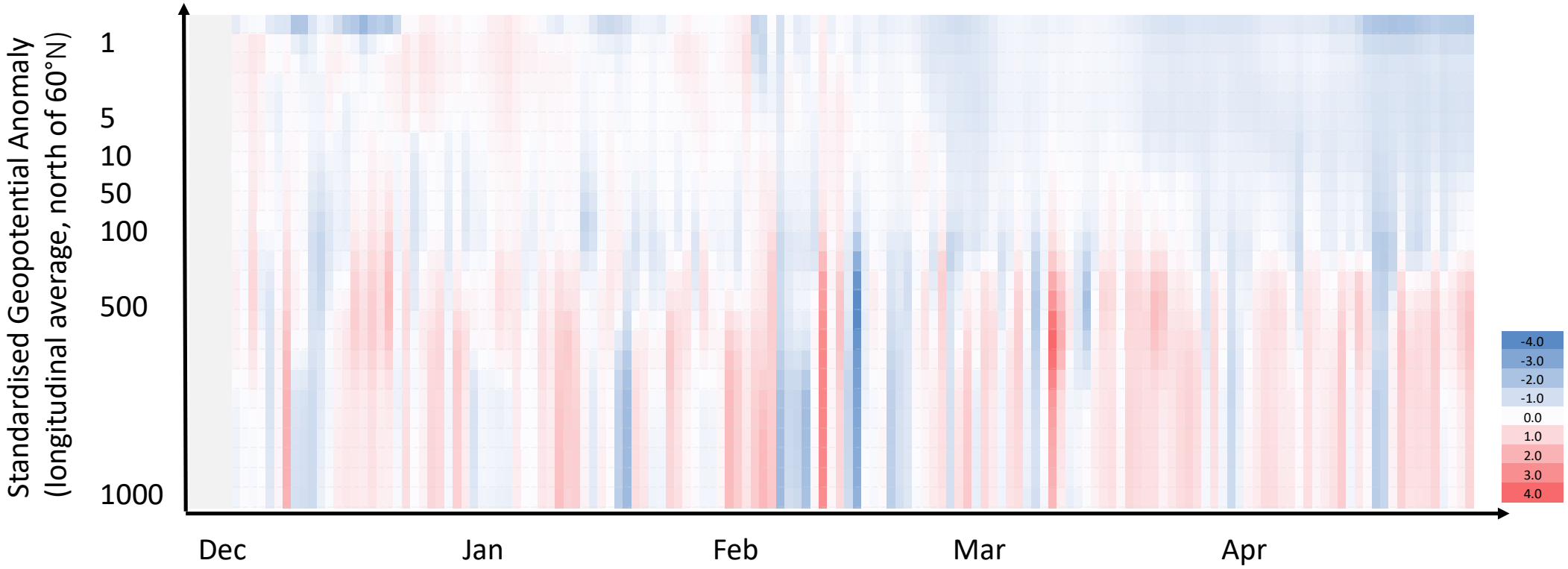
‘Drip map’, 5d forecast error

Small errors in stratosphere, and a negative bias.
Larger errors in troposphere, which seem to impact entire column and be somewhat random



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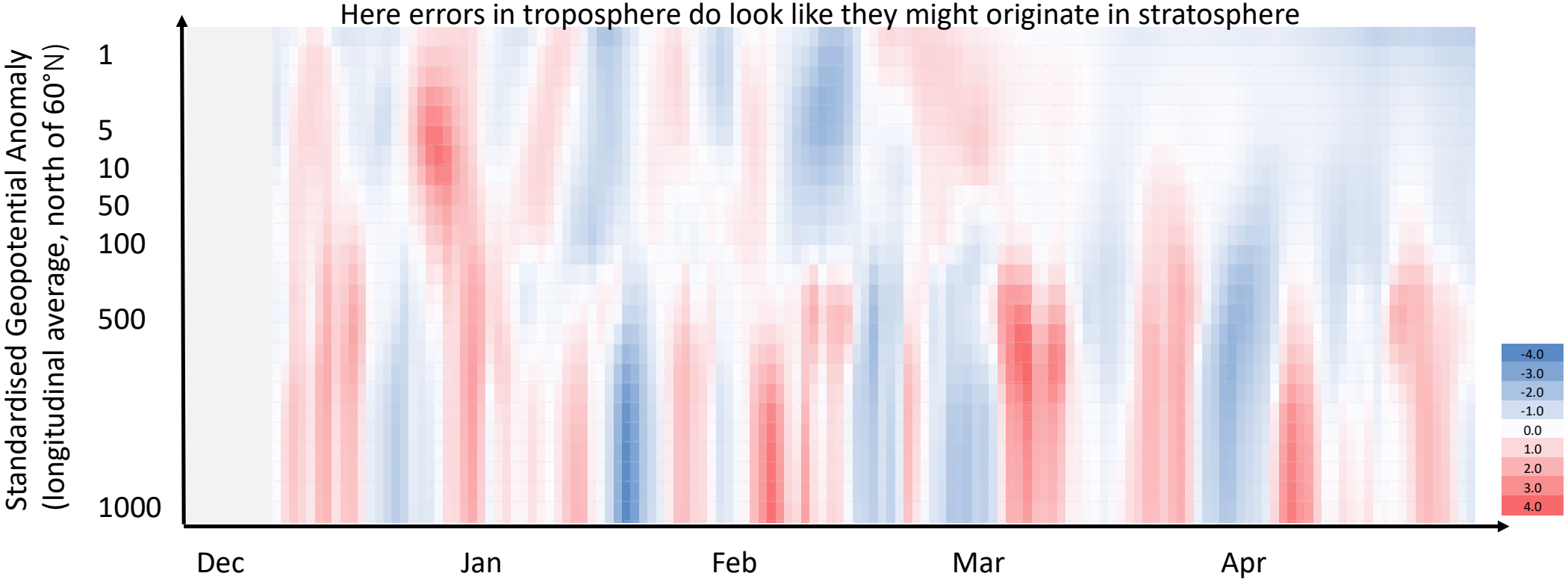
‘Drip map’, 10d forecast error

Significant errors in stratosphere late Dec through March.
Questionable whether validation lies within ensemble spread (not checked)
Here errors in troposphere do look like they might originate in stratosphere



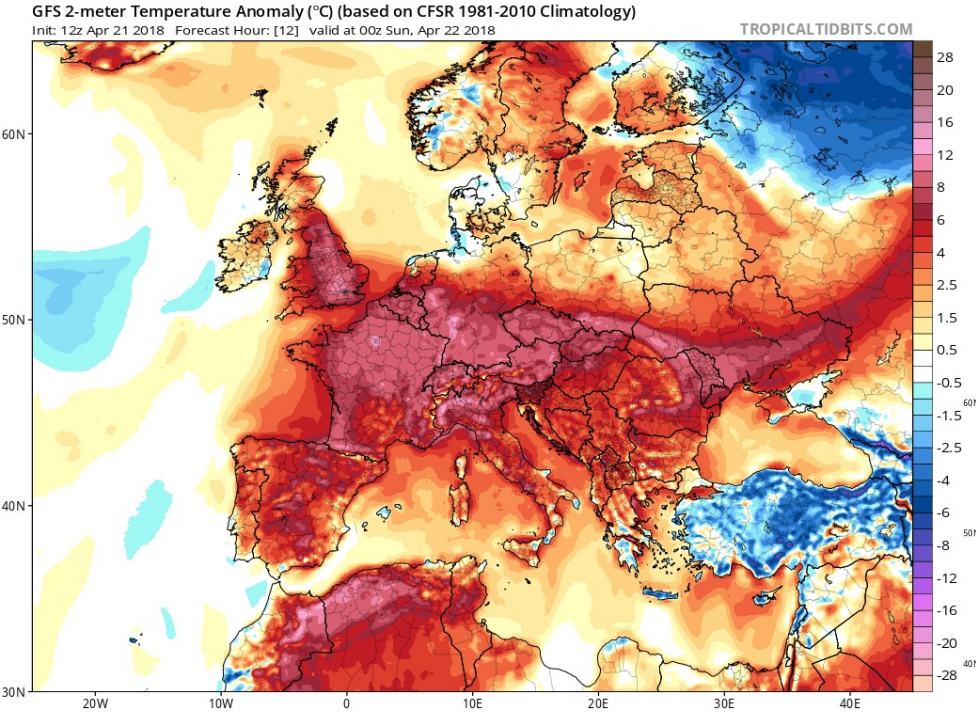
Winter 2017/18 stratosphere

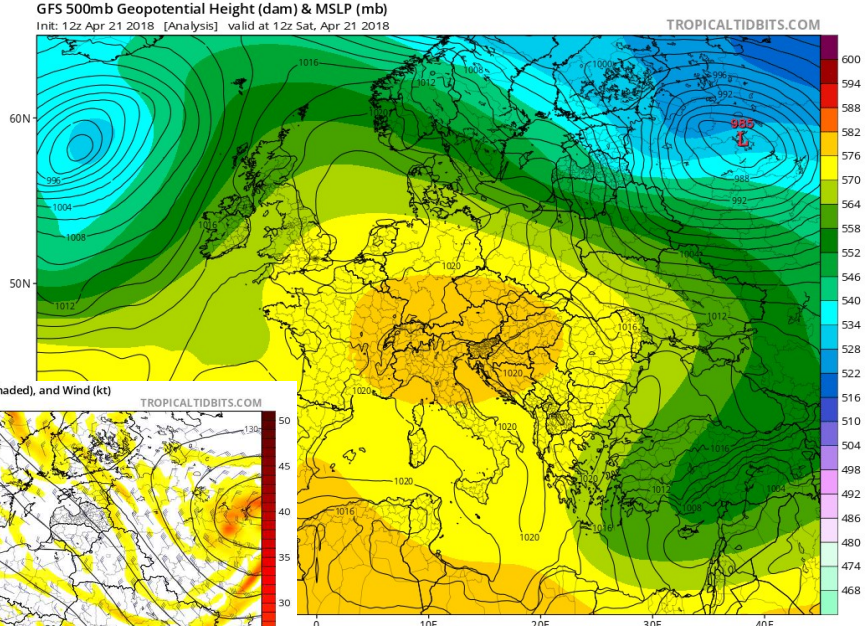
- 5 day forecasts reasonable
  - Drip maps suggest main source of error arises in troposphere
- 10 day forecasts poor for T2m
  - Berlin T2m temperature forecast biased warm during key periods
  - Drip maps suggest significant stratospheric error of similar magnitude to actual signal
- Possible some ensembles capture the correct behaviour, but looks unlikely
- Any ECMWF insights? Nothing on known IFS issues webpage.

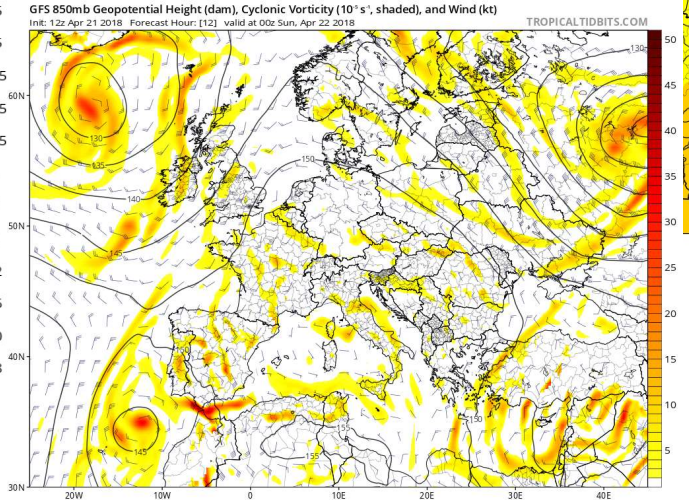
  [Note from post seminar: yes, and Stratospheric Task Force report just published]
- What are ensemble expectations?

  Are stochastic perturbations during evolution enough?

April 20-22nd European ‘heatwave’





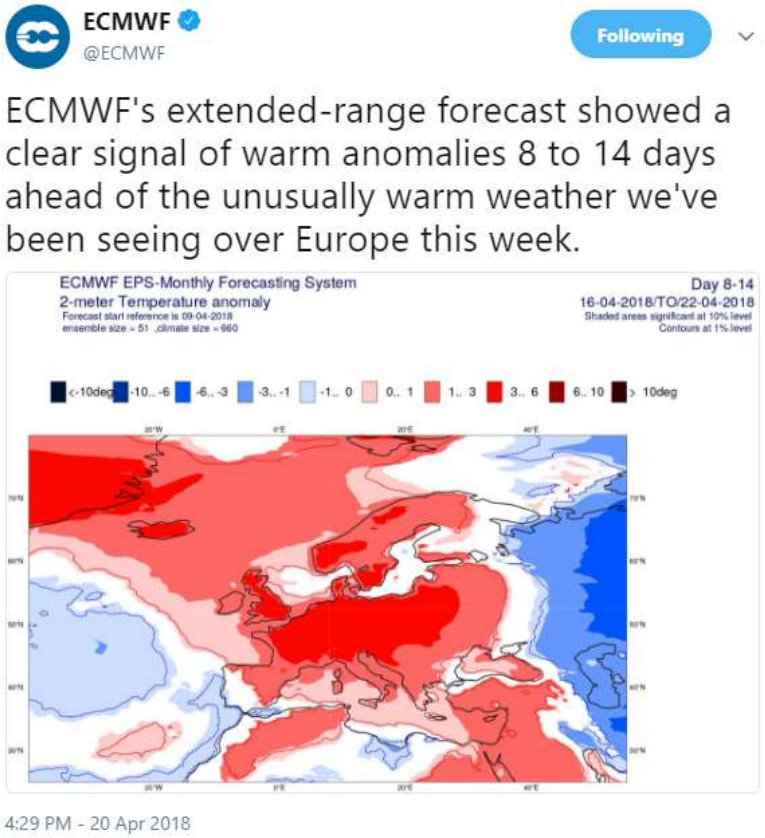


June 6th 2018

Source: GFS data from NOAA via tropicaltidbits.com

Success: a measure defined by the user

- ECMWF tweet suggests the forecast was a success
- T2m maybe, but multivariate?
- … a bust for energy customers
  (renewables incorrect)
- … and for farmers in Oxfordshire
  (drying wind not captured, and critical)

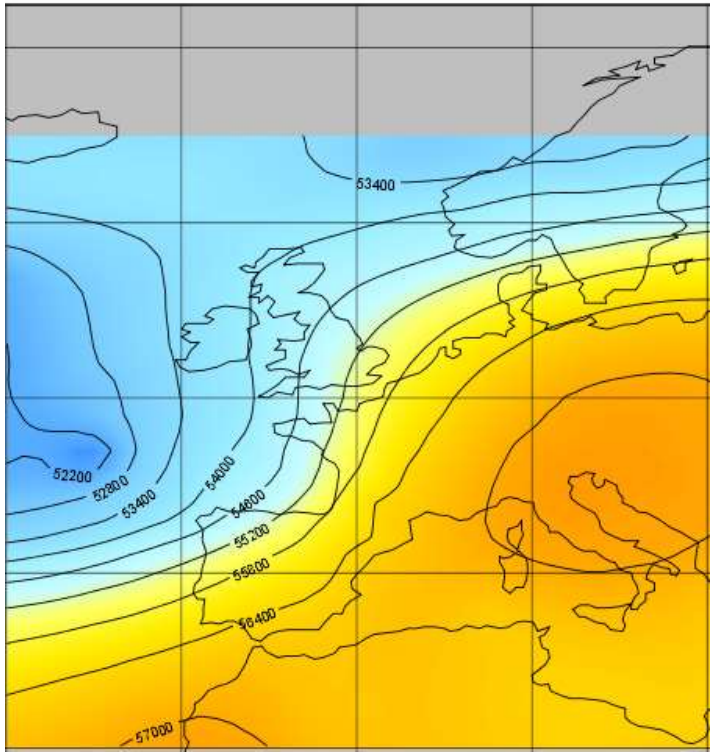


Forecasts for T2m daily average for FR

Forecast	Range (°C)	Warmest pertbn
EC monthly init April 2nd	6.0 - 18.5	#32
EC monthly init April 9th	10.0 – 18.0	#12
EC00z ens init April 16th	15.5 – 19.0	#6 #38 close (18.5) and picks up warmth in UK better
Actual: April 21st	19.8	

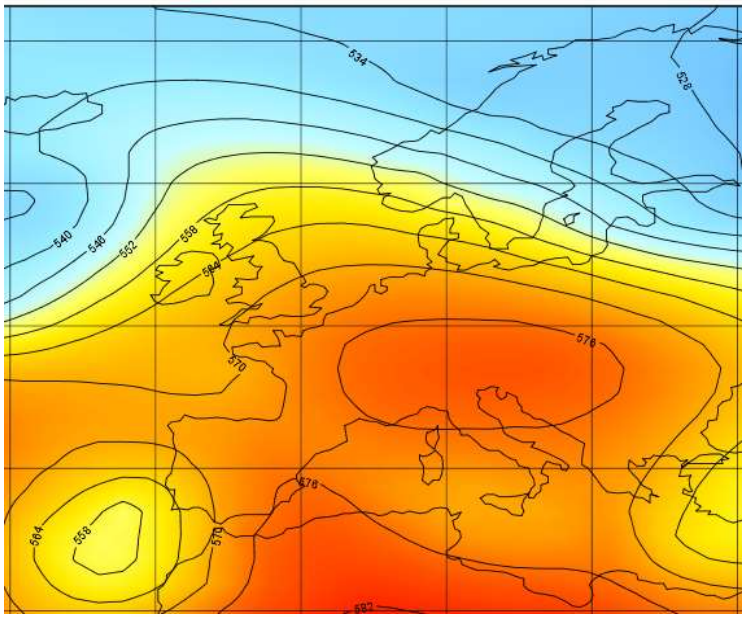
‘Best’ z500 forecasts for April 21st 12z, initialised April 2nd & April 9th 00z

)0_ECENS_00z_initi2018040200_valid042100_



Temperature may be reasonable, but wind, solar, rainfall?

z500_ECOPER_12z_20180421_analysis



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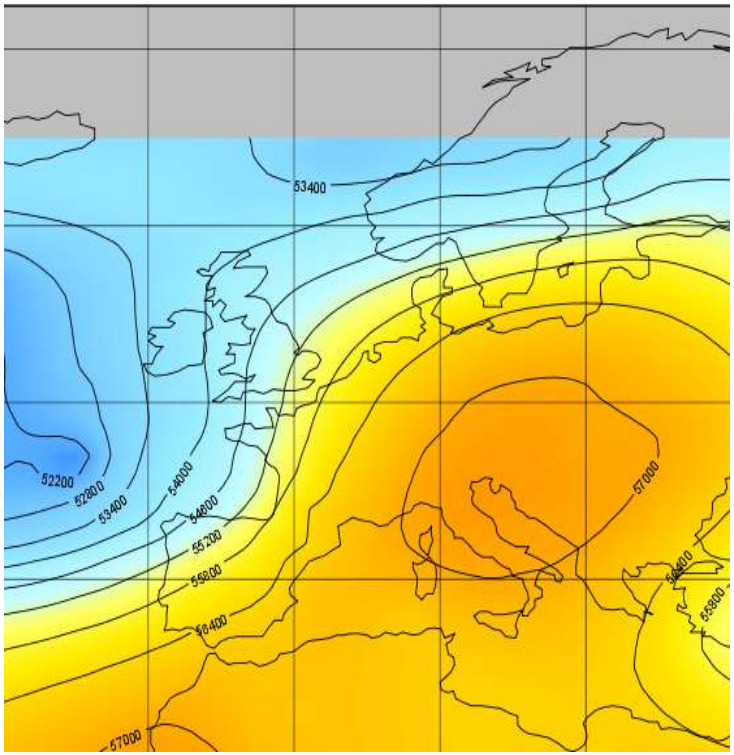

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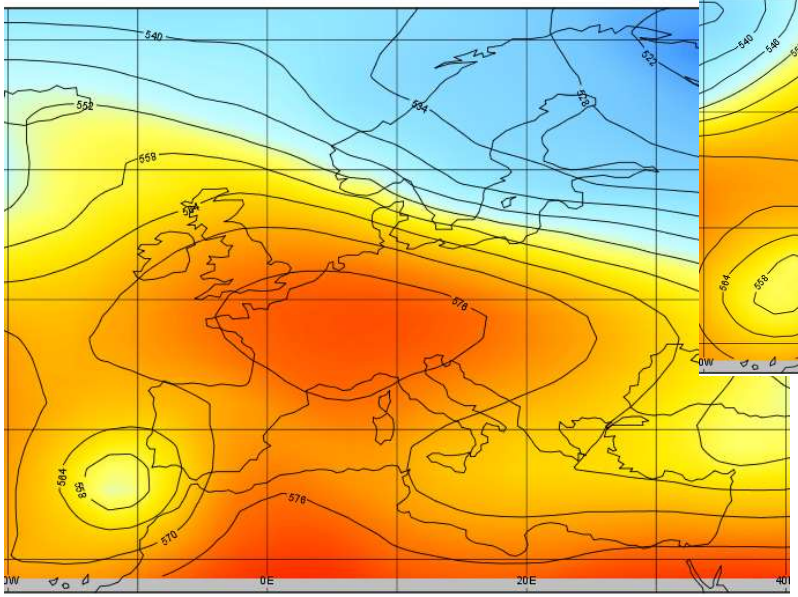
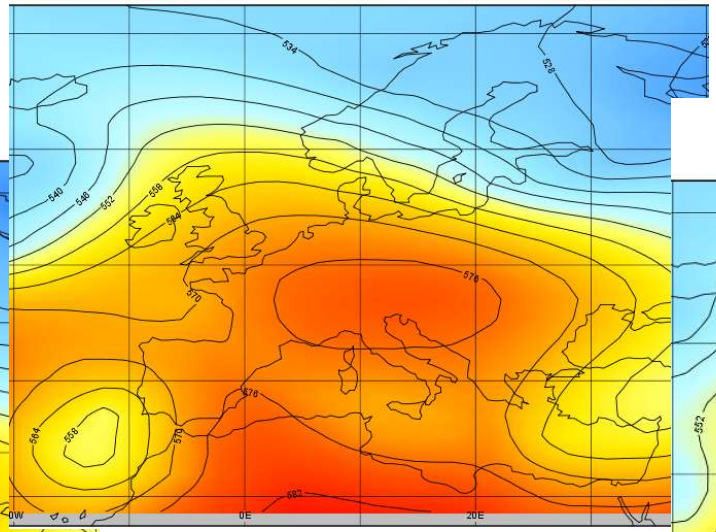
Source: ECMWF data plotted using Panoply

z500 forecasts for April 21st 12z, initialised April 16th, 00z

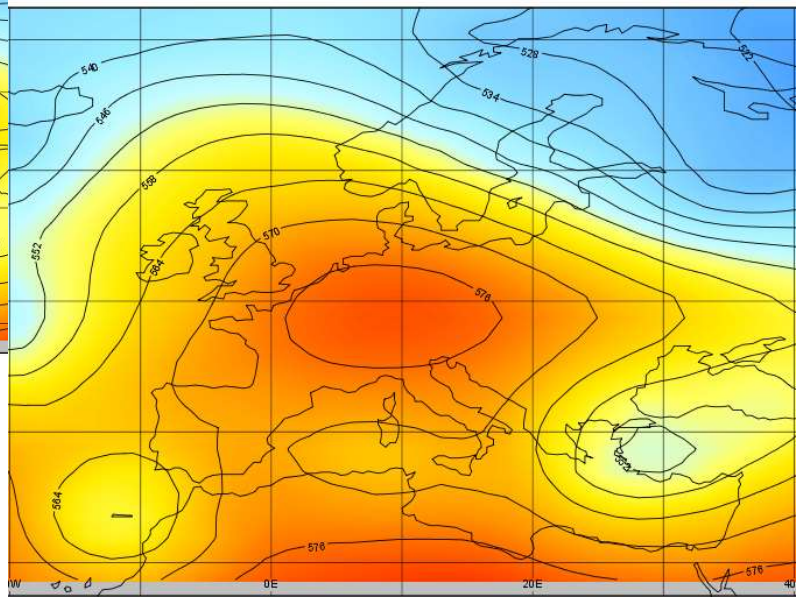
z500_ECENS_00z_init2018041600_valid042112_6



z500_ECOPER_12z_20180421_analysis



z500_ECENS_00z_init2018041600_valid042112_38



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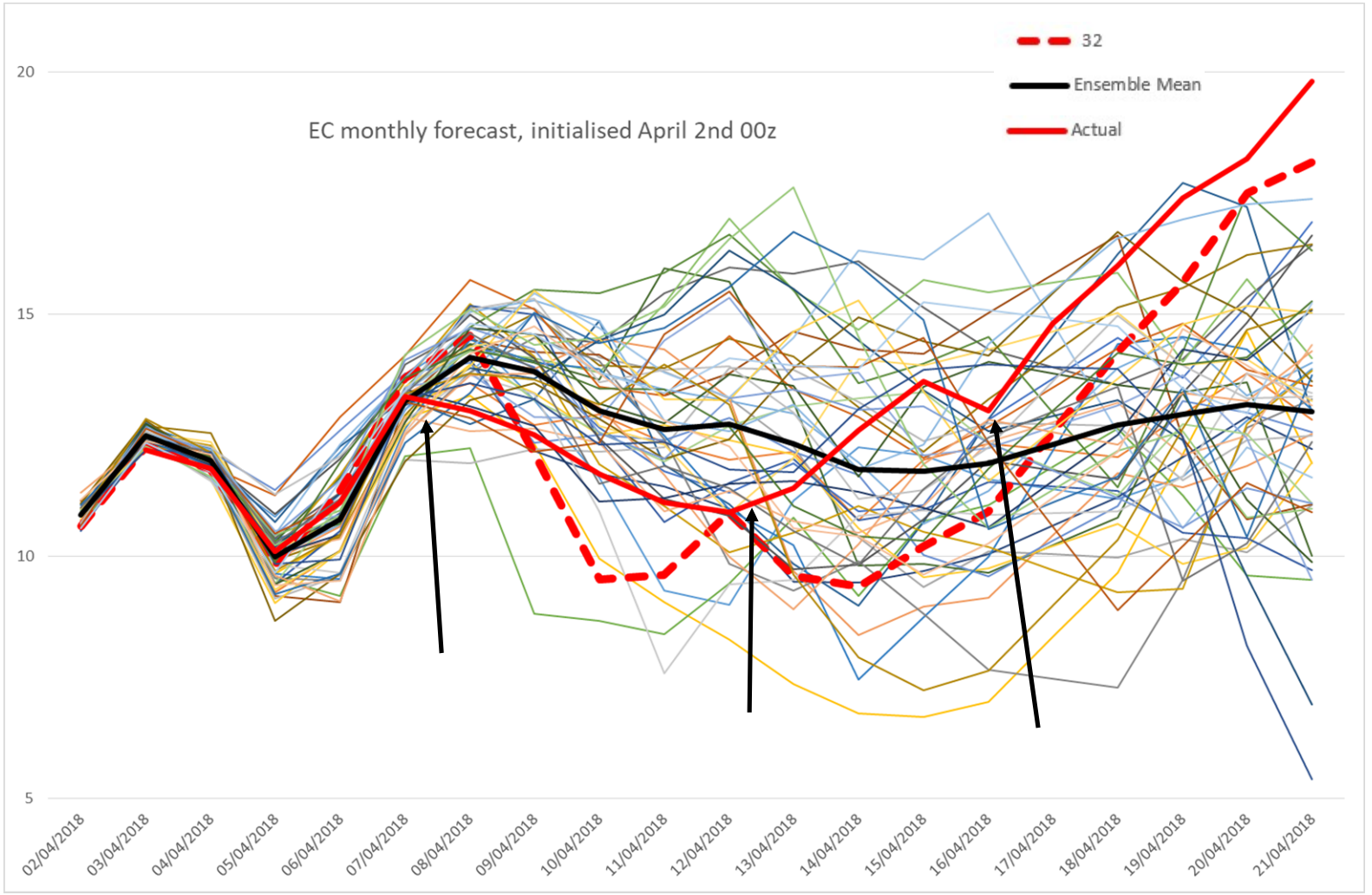
Source: ECMWF data plotted using Panoply



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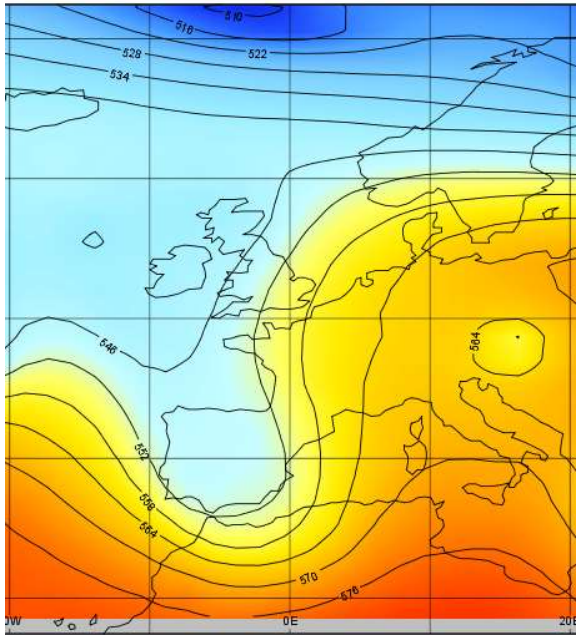
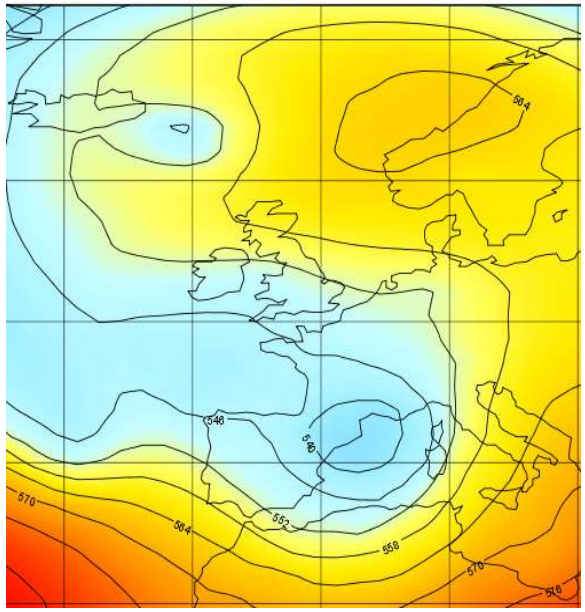
Sensitivities

High builds => colder set up
Low in mid-Atlantic stronger => warm set up sooner
Actual pattern in-between balance

z500_ECOPER_12z_20180408_analysis



z500_ECOPER_12z_20180412_analysis

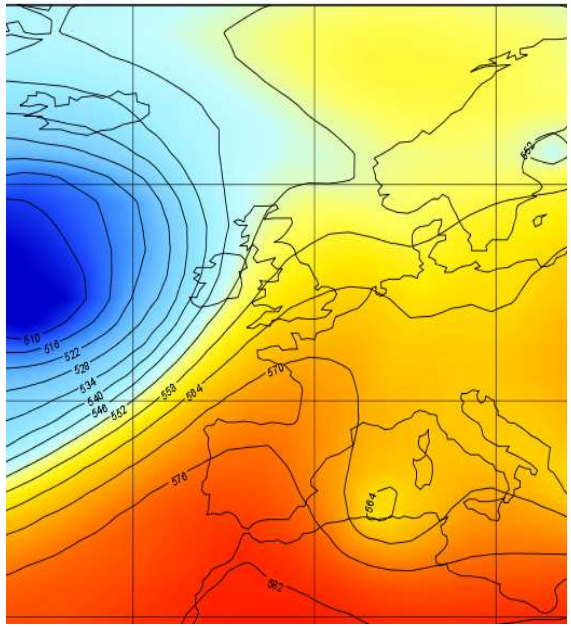


Location of low key.
Further south => cold scenario, low dominates over Scandi
Further north (actual) => warm as ridge Morocco builds

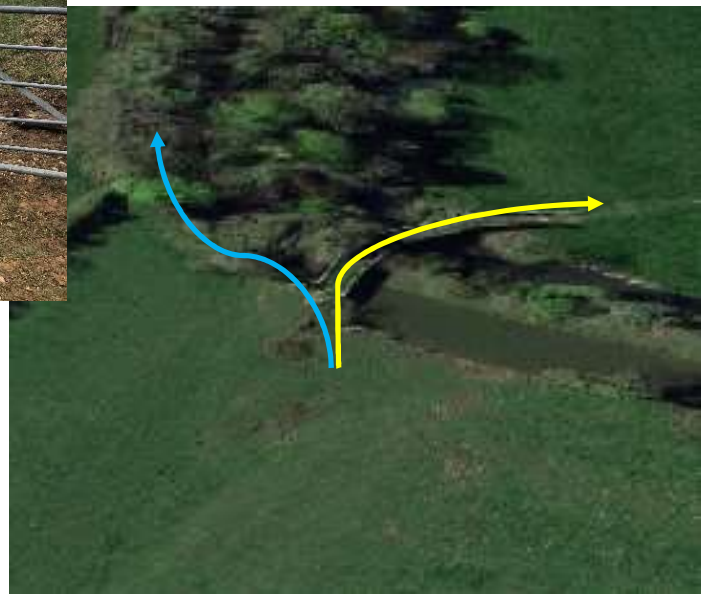
Source: ECMWF data plotted using Panoply

Strength of low key
Low needs to weaken (=> shift north) if low off of Iberian Peninsula is to form and intensify heat
Errors at play: US storms and final stratospheric warming

z500_ECOPER_00z_20180417_analysis



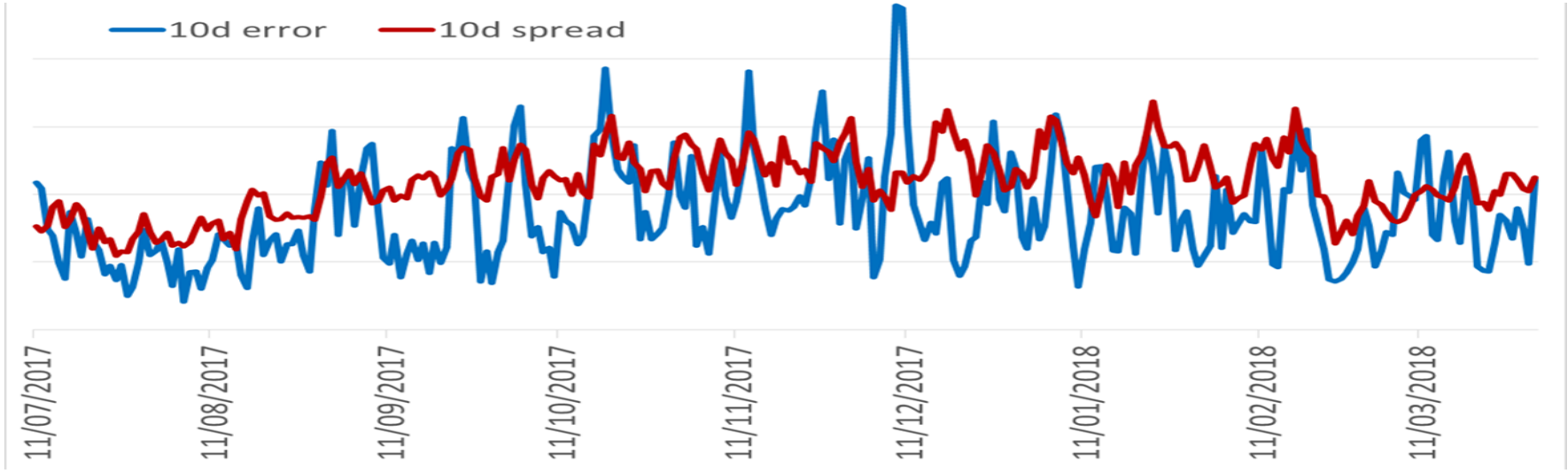
Model error: ‘bridges’ indicate alternative routes!



Source: Isla Finney, Google

Spread and flow

- At present, spread is very flow dependent. Not surprising
  - z500 over Europe, 7/7/17 – 31/3/2018 (all c43r3), 00z cycle only
  - 10d and 30d ensemble spread correlated (by initialisation date), r^2=0.7
  - Average shift in ensemble mean at a given validation time from 10d to 7d forecast is **37%** the average (10d) ensemble spread



Ensemble construction now

- Initialisation (data assimilation and perturbations) at t=0
  - Good data assimilation key: Panasonic/AirDat Real time 4dVAR results
  - SV perturbations good for sampling sensitivity in *initial* flow
- Stochastic perturbations throughout the evolution
  - SPPT look to address under-resolved processes in parameterisations
    - Excludes boundary layer
    - Not dependent on current synoptic pattern
  - SKEB… Turned off in c45r1
- SPPT not enough to explore the alternatives when we reach a 'bridge'.

Believe spread/flow issues, jumpiness, ensemble slave behaviour to op are all manifestations of not sufficiently exploring model error.

Ensemble construction evolution: adaptive scheme at all time steps?

- Adds perturbations when required, not only at initialisation
- Make a list of top 10 (or 3, or 5...) processes known to be modelled imperfectly
  - Or 'bridges' where the model repeatedly fails to see the alternative routes
  - May include
    - certain regime transitions (*e.g.* Laura Ferranti's work)
    - convective processes (input from ETH Zurich collaboration?)
    - stratospheric processes or strat->trop coupling
    - ... (numerous contenders, with expertise often already existing within ECMWF)
- Add additional perturbations as required at each 'bridge' *e.g.* day 3, 5, 8...
- The only limit (should be) your imagination.
- Not only ensemble size vs model resolution!

Key points

- User requirements are multivariate

  and traditional statistics can give a poor performance summary

- Feedback from users to ECMWF is good.

  Two – way communication is better.

- Imagination is required for the next significant step in NWP.

  Here is only one idea. What other ideas are out there?

Coffee break challenge

- Easy to catch up with familiar faces
  - ⇒ Tends to alienate newcomers...
  - ... and the many of us who find joining an existing conversation awkward

- With a little effort, it can be an opportunity to network
  - ⇒ Insight into different fields with potential for new ideas and cross-pollination
  - ⇒ Grows and nutures our community

The challenge

- ***Either*** speak to someone you don't know
- ***Or*** actively draw into your group/conversation someone standing alone

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Forecast data changes, sometimes rapidly.

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info@lakestreetconsulting.co.uk

www.lakestreetconsulting.co.uk

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