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Predicting Sudden Stratospheric Warming 2018 and its climate impacts with S2S models

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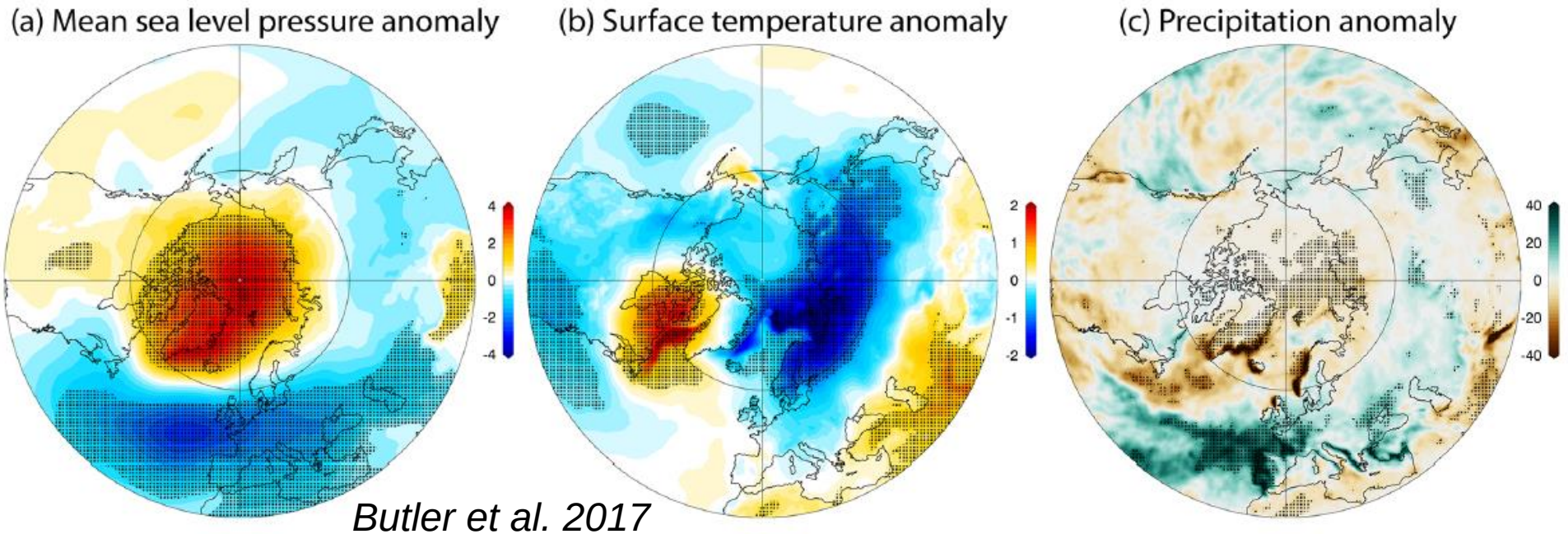
with contributions from A. Charlton-Perez, N. Tyrrell, M. Balmaseda, F. Vitart

SSWs and surface weather



Butler et al. 2017

- Many SSWs are followed by anomalies in surface weather lasting for up to two months:
  - Negative phase of the North Atlantic Oscillation
  - Cold spells across northern Eurasia and eastern US
  - Precipitation anomalies over Atlantic and western Europe

SSWs provide source of enhanced subseasonal predictability

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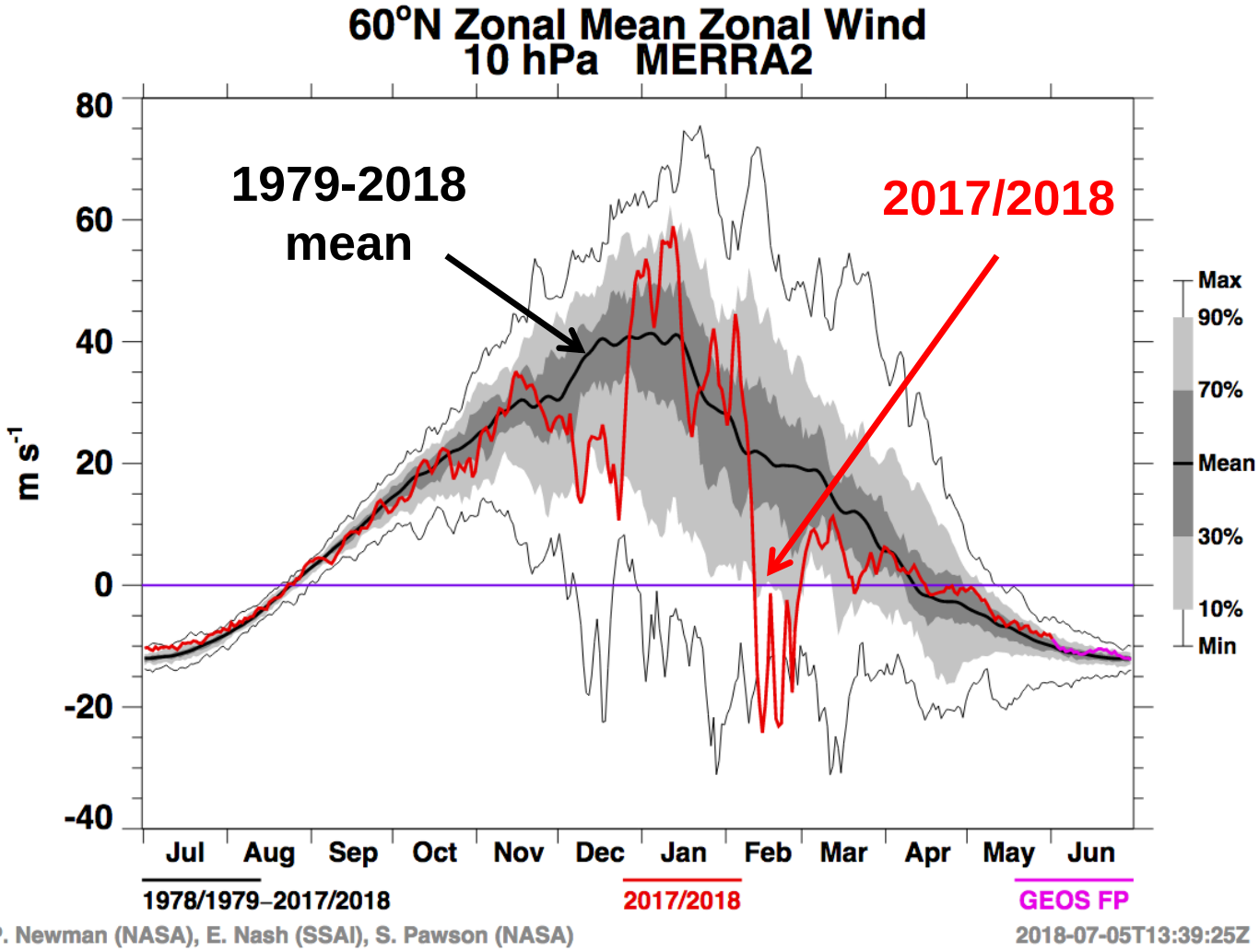
Sudden Stratospheric Warming 2018



The New York Times

Europe Was Colder Than the North Pole This Week. How Could That Be?

By Kendra Pierre-Louis

March 1, 2018

A gondolier cleared snow this week in Venice. Manuel Silvestri/Reuters

Subfreezing temperatures have spread acros
the past week, stretching from Poland to Spa

What's behind the UK's freezing weather?

By Jonathan Amos
BBC Science Correspondent

1 March 2018

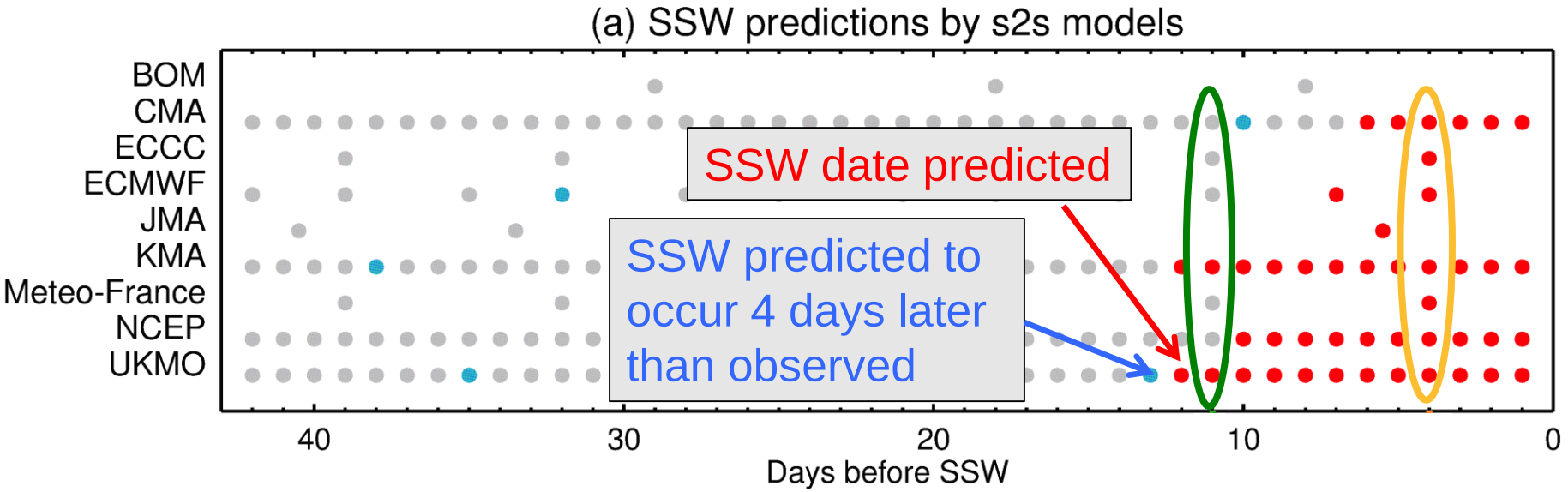
Share

UK snow

The main airport in Geneva was closed for several hours on Thursday. Hundreds of flights were canceled across Europe. Martial Trezzini/Keystone, via Associated Press

Europe's weather usually approaches from the Atlantic, to the west,

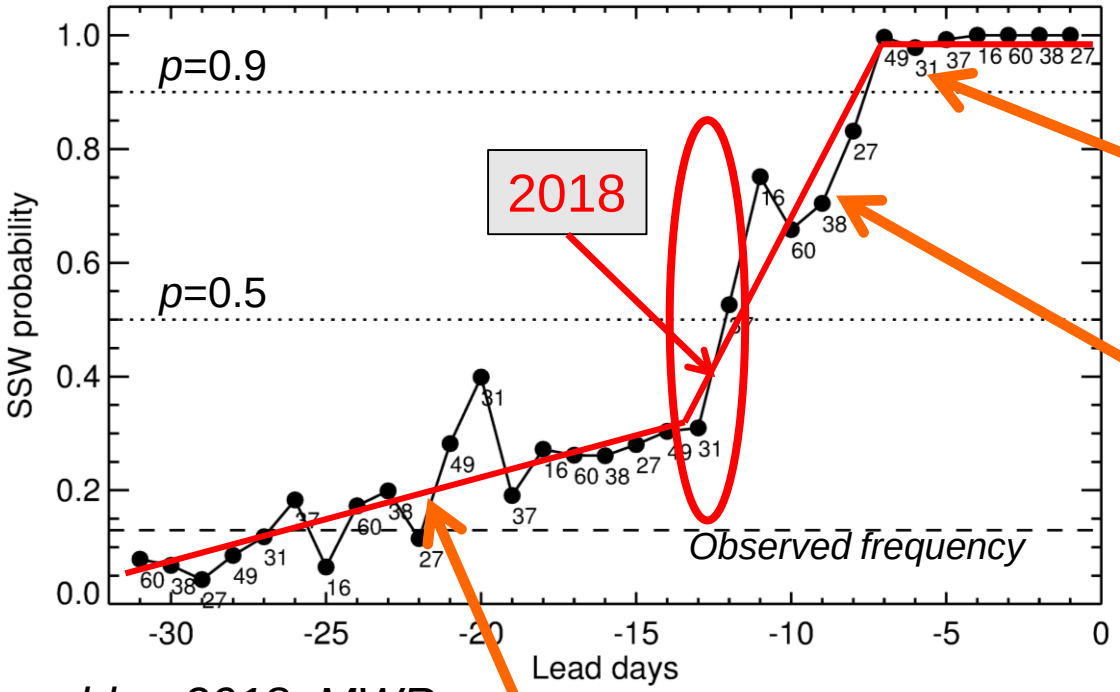
S2S predictions of SSW 2018



- SSW occurred on 12 February 2018
- Earliest ensemble mean forecasts by some models from 30-31 January (lead time 12-13 days)
- Forecasts from 1 February (lead time 11 days): predicted SSW probability by S2S models (151 members in total) is ~0.3
- Forecasts from 8 February (lead time 4 days): predicted SSW probability by S2S models (151 members in total) is 1.0

SSWs predictability in ECMWF system

SSW predictability averaged across 6 past SSWs with strong tropospheric impacts



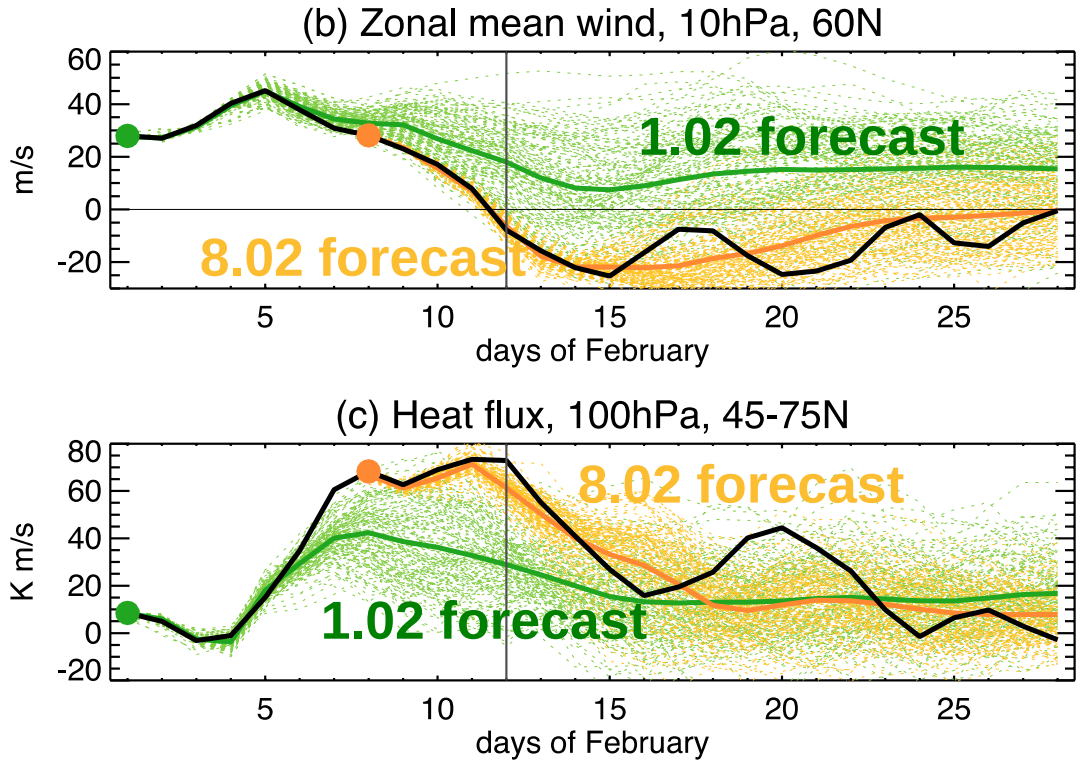
Karpechko, 2018, MWR

days 7-0: Deterministic limit

days 13-7: Fast increase in predictability

days 32-13: Slow increase in predictability

Planetary wave propagation

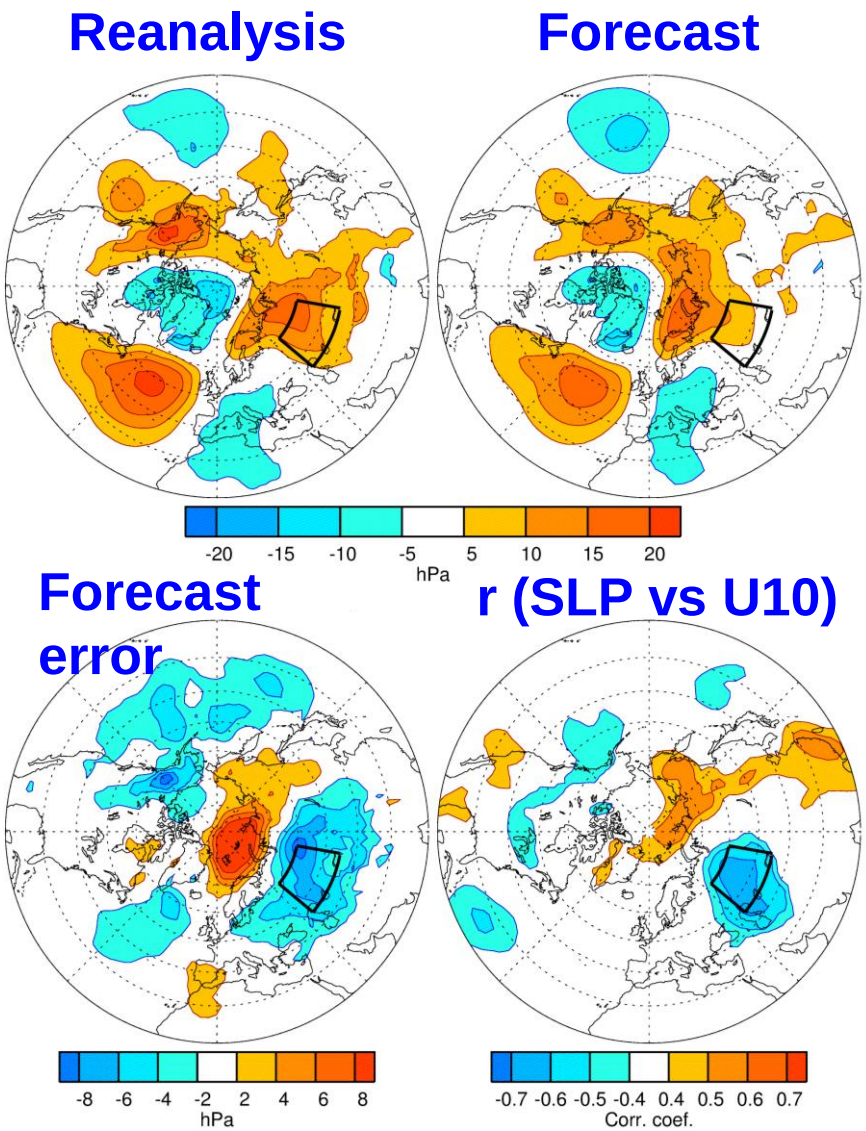


Stratospheric winds

Eddy heat flux 100hPa

- Wind forecasts from 1 February strongly correlate with eddy heat flux forecasts across ensemble members (r=0.94) which is underestimated by most members (*see also Taguchi 2016*)
- Forecasts from 8 February correctly predicted the magnitude of the heat flux. Consequently, SSW was also well predicted

Tropospheric forcing of SSW 2018

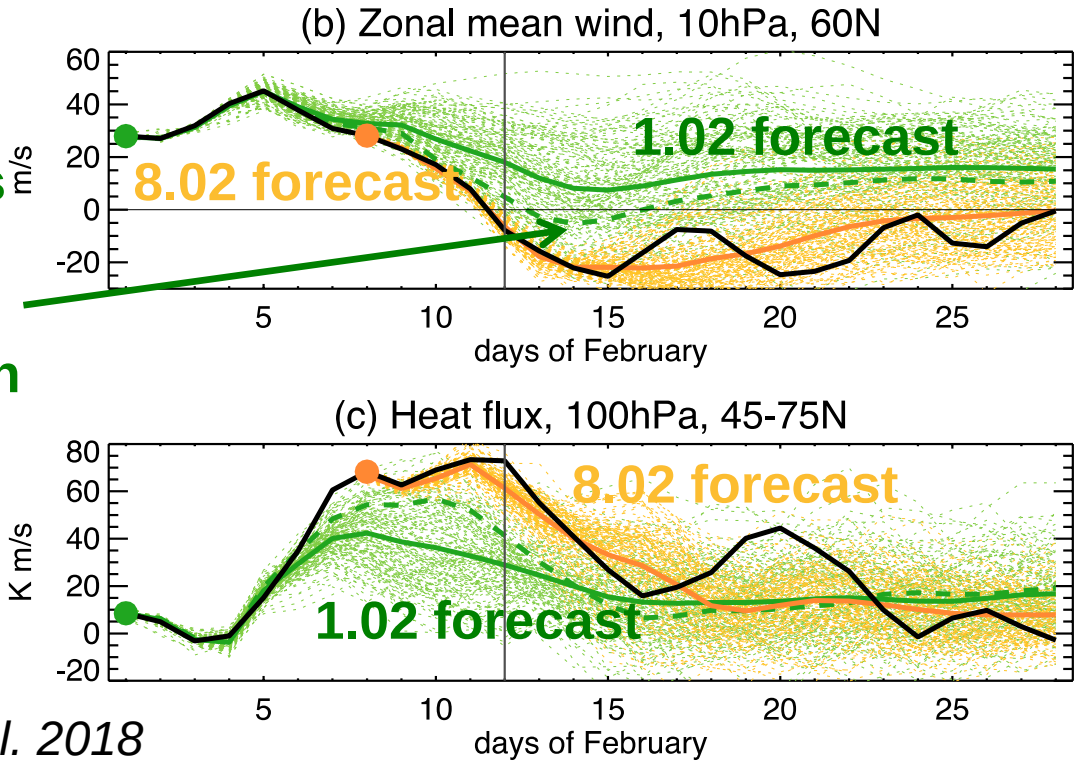


- **SLP** anomaly field **averaged over 1-11 February** in reanalysis and forecast from 1 February shows several anomalous anticyclones
- Anticyclones, in particular over northern Europe, are often associated with SSW forcing (e.g. Martius et al. 2009; Woollings et al. 2010)
- For the SSW 2018, errors in the forecasted location of the high over Ural strongly correlate with the errors in stratospheric winds

cf. Tripathi et al. 2016

Planetary wave propagation

15 members with best forecast of the Ural high



Stratospheric winds

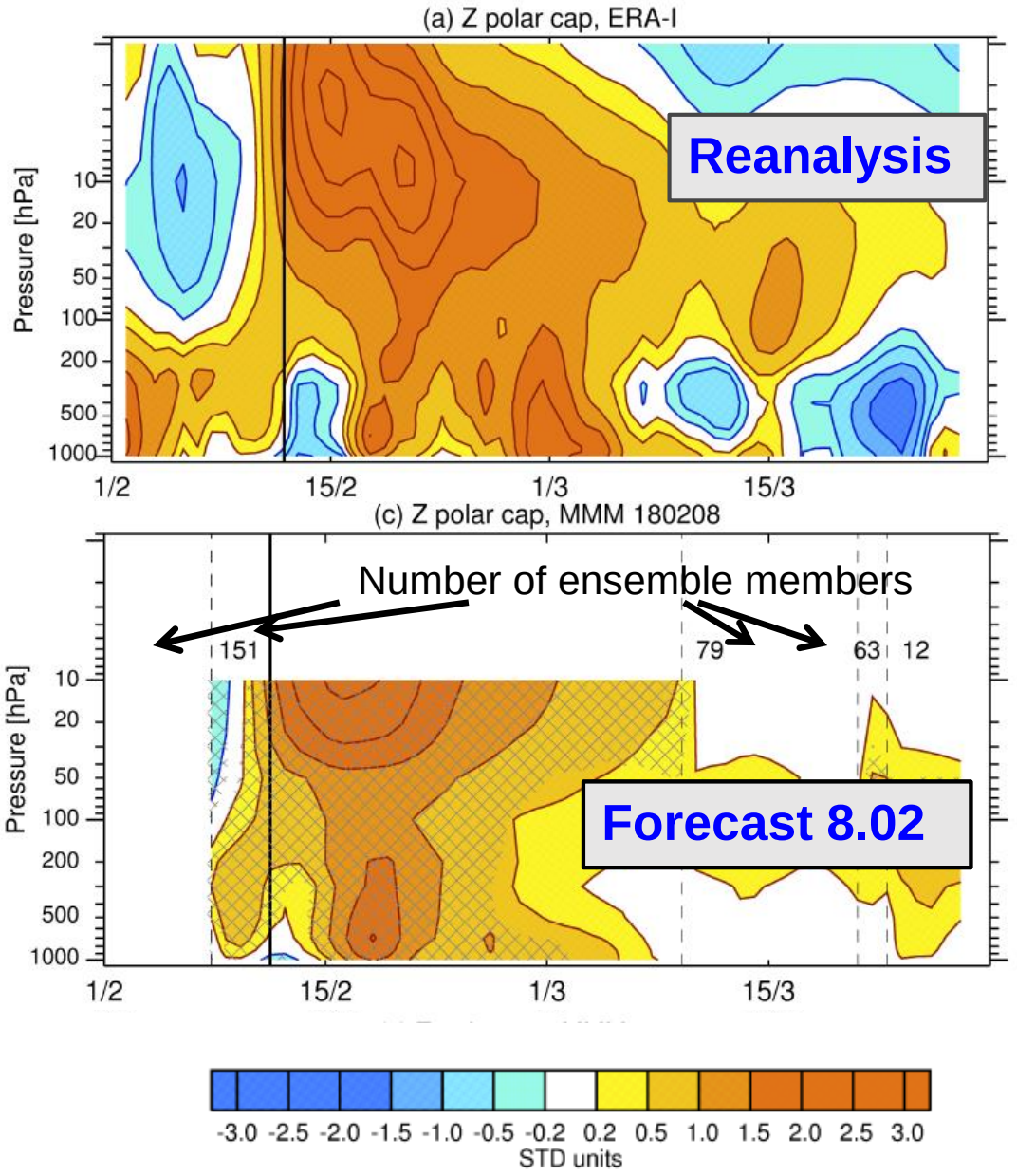
Eddy heat flux 100hPa

Karpechko et al. 2018

- The subgroup of forecast ensemble members from 1 February with best forecasts of the Ural high predicts stronger eddy heat flux to the stratosphere; it also predicts an SSW

Downward propagation

- Strat.-trop. coupling of Northern Annular Mode (NAM) anomalies was not forecast from 1.02 but was forecast from 8.02
- In both 1.02 and 8.02 forecasts, ensemble means predicted a negative NAM in the troposphere continuing into early March, as observed, with ~70% members forecasting NAM signal into week 3.



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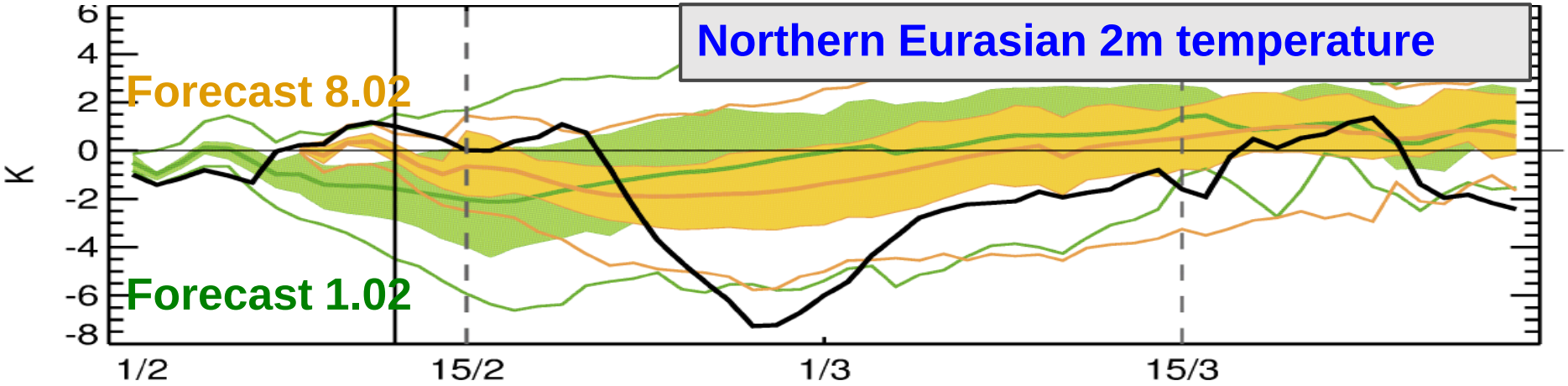
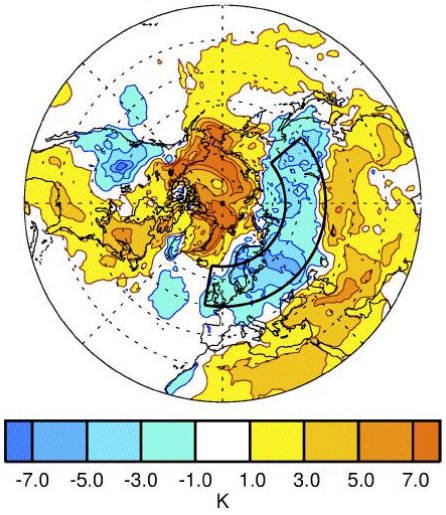
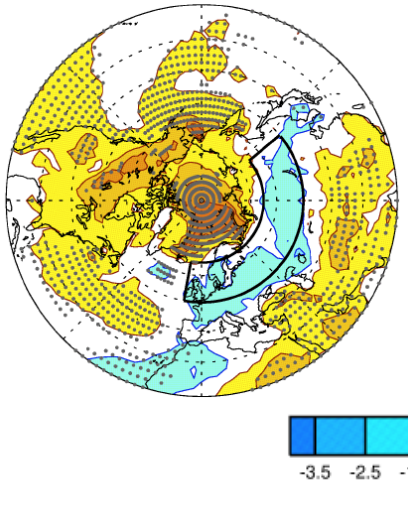
Predicting cold spell 2018



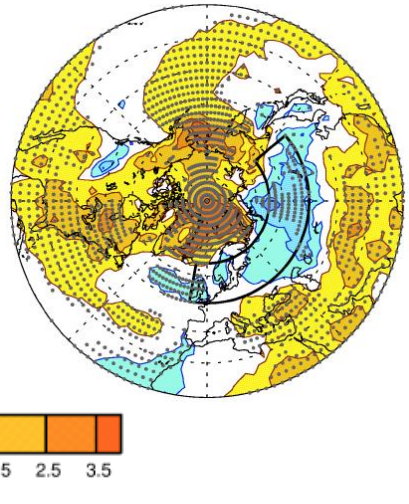
Reanalysis 15.02-15.03



Forecast 1.02



Forecast 8.02



- Long duration of the cold signal is captured well but the magnitude of the signal is underestimated

SUMMARY

- The 2018 SSW was predicted by some models at lead times 12-13 days
  - not unusual when compared to previous events
- The predictability of the 2018 SSW was limited by errors in the forecasted location of weather system (Ural high) and underestimated magnitude of the stratospheric wave forcing
- Cold period was captured at lead times 3-4 weeks qualitatively, but not its magnitude
- Stratosphere has likely played a role in extended predictability in Feb-Mar 2018