Upgrades to medium/extended range reforecasts and the SEAS6 configuration: an update

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49r1 Reforecast Configuration for Medium and Extended-range

Motivation:

In 48r1 there will be changes to the real time ensemble in addition of increased resolution (medium range) and increased ensemble size (extended range)

- Medium and extended range ensemble decoupled from day zero
- Extended range will run daily (as opposed of twice a week)

The current reforecast configuration needs revisiting

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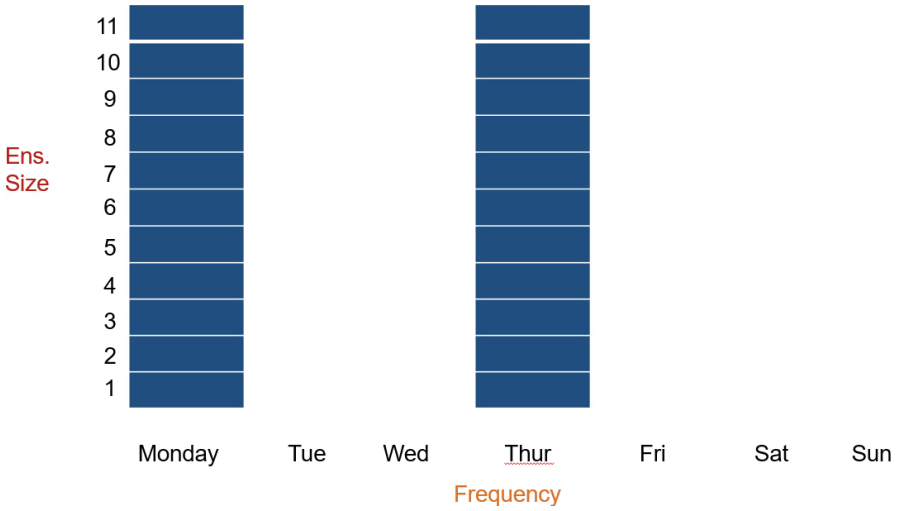
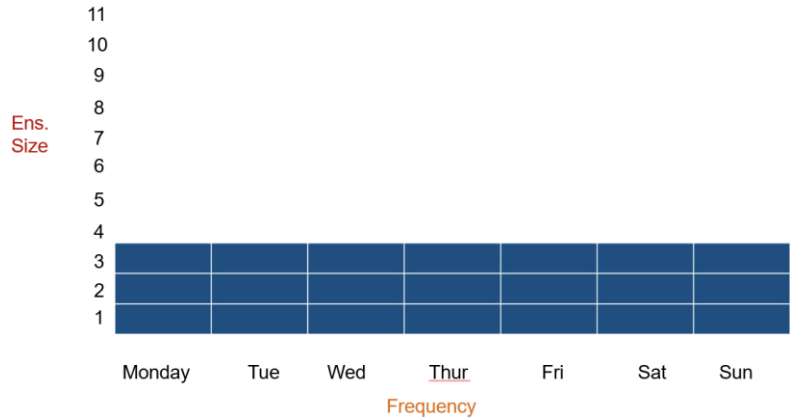
Re-forecast configuration

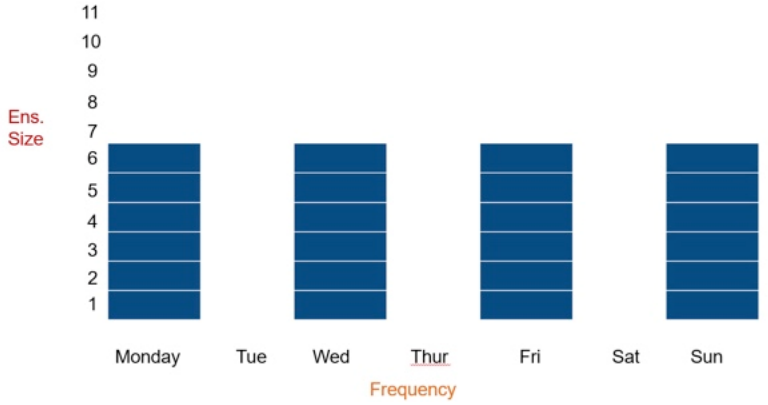
Current Configuration



New Configuration for 49R1?



Or?

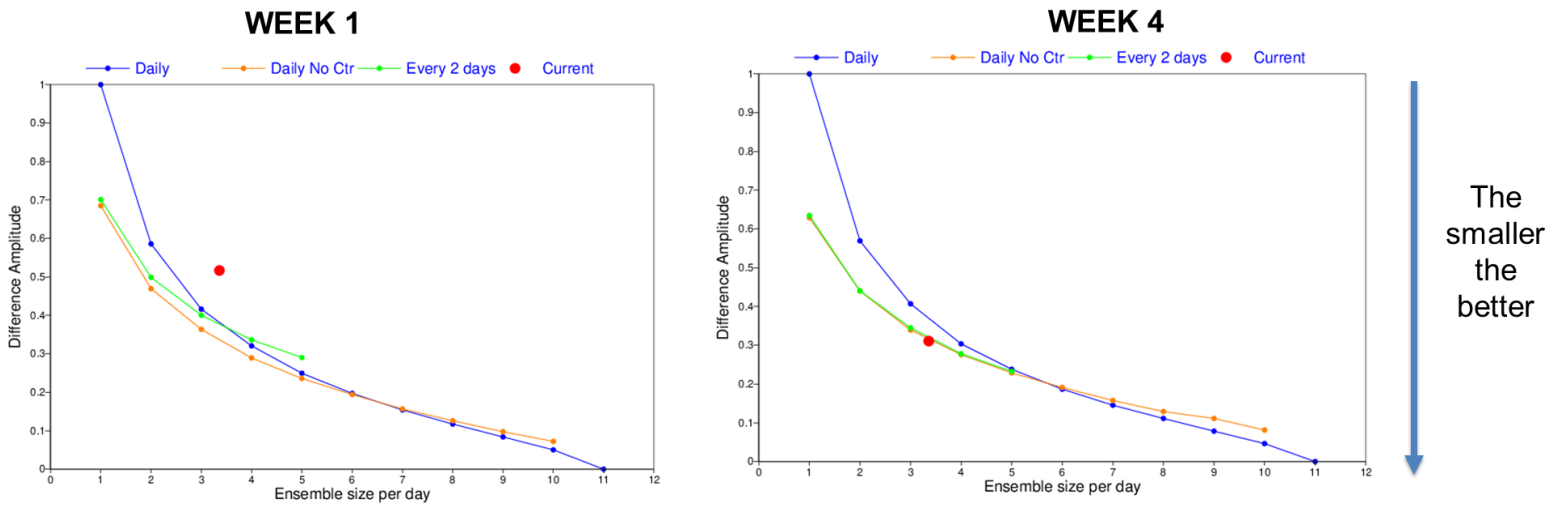


The impact of different options on climate and skill scores were tested with a set of 11-member daily reforecasts, with different ways of sampling.

Outcomes of experimentation: brief reminder

- **Criteria**: estimation of climatology for calibration and impact on skill assessment.
- **For MR,** more frequent start dates is more beneficial than increasing ensemble size.
- **For ER**, all configurations at same computational cost are equal**.**
- If few number of ensemble members are used, it is recommended to exclude CF.

Impact of reforecast sampling on precipitation climatology



Proposed configuration sent for consultation

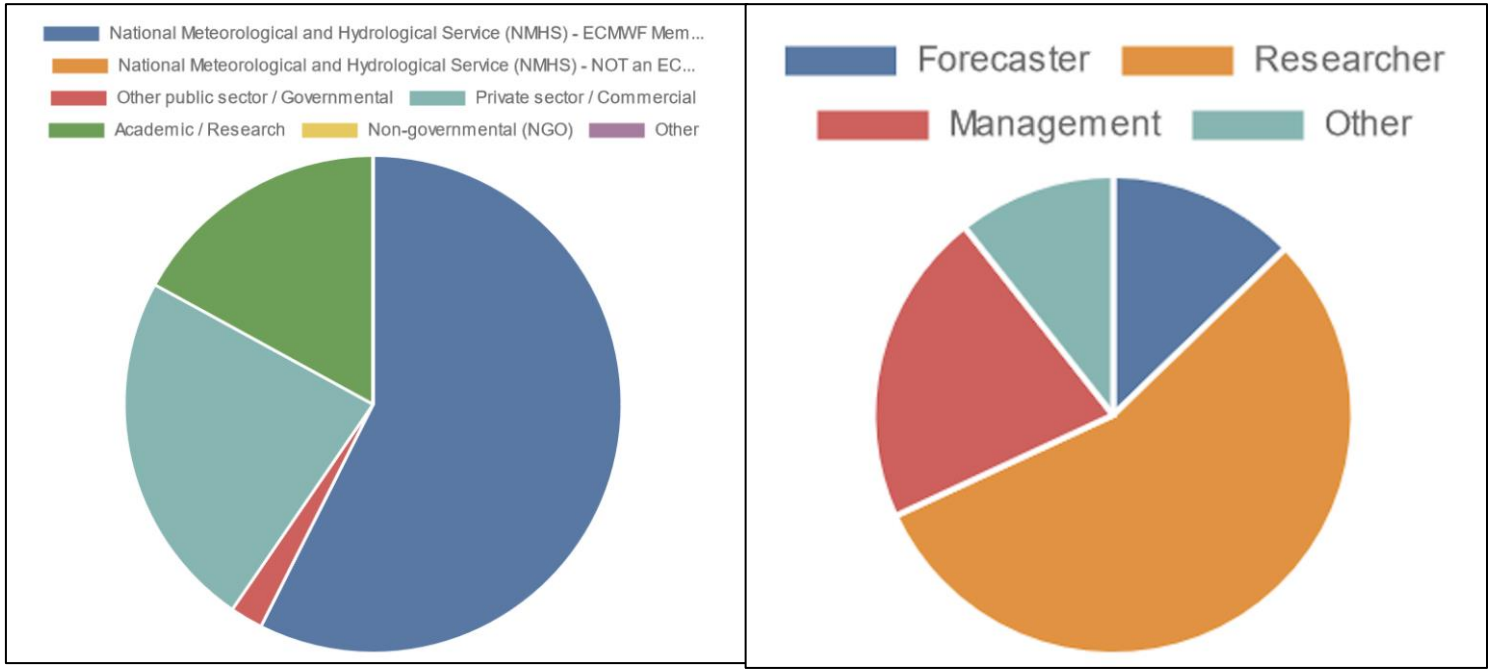
Extended-range: 10 members every 2 days, only pf?

Medium-range: 4-members every 2 days or 2 members daily, only pf?

(presented by Frederic Vitart UEF 2022)

Outcomes from user's consultation

- Good response. Mix of research,services and commercial applications – wide range of uses (case studies…calibration)
- General satisfaction, but two concerns:
  - **10-15% wanted to keep the Control runs** (e.g. because Control has better climate than perturbed)
  - **Number of members more valued than temporal frequency**: no desire to reduce ensemble size for a given date - Calibration and handling extremes.



Final reforecast configuration for Medium and Extended range in 49r1

- **Extended range**: 10 perturbed + 1 control fc on fixed days of the month, every 2 days, over past 20 years

  1/3/5/7/9/11/13/15/17/19/21/23/25/27/29 (excluding 29 February)
- **Medium Range**: 10 perturbed + 1 control fc on fixed days of the month every 4 days, over past 20 years

  1/5/9/13/17/21/25/29 (excluding 29 February)

The main advantages of this new configuration are:

• Increased extended-range frequency will benefit skill assessment and calibration

• Running fixed days of the month will allow for direct comparisons between re-forecasts produced in different years, and direct comparisons with seasonal re-forecasts.

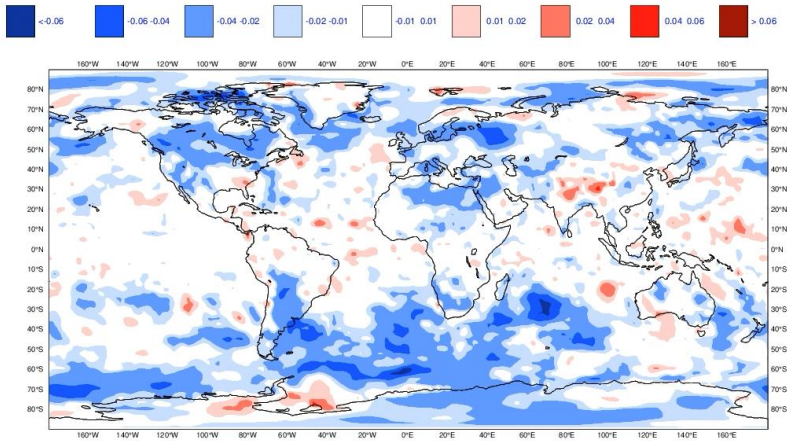
• Common dates for medium-range and extended-range reforecasts provide opportunities for generation of calibrated dual-resolution ensemble products

• Common dates for the two reforecast sets also facilitate an assessment of the impact of resolution

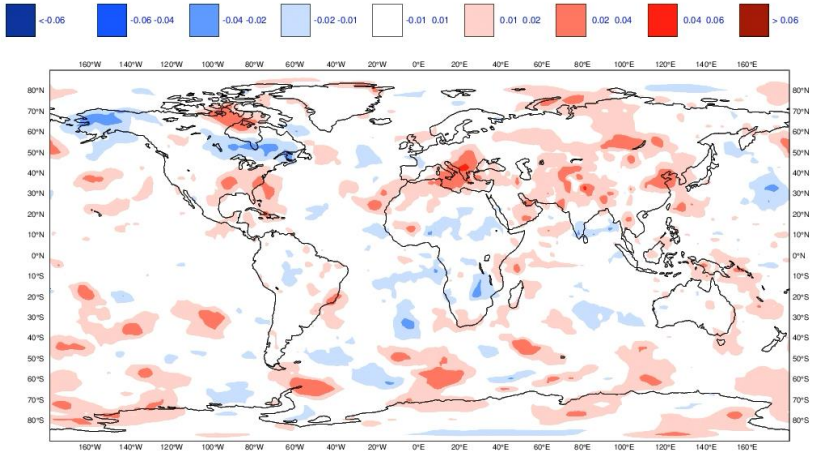
Lagged ensemble Experiments

- 15 members starting on 1st Feb/May/August/November 1989-2020 -101 members
- Same but starting 1 day earlier.
- Weekly means combined to get 202-member ensemble (e.g. day 5-11 starting on 1st Feb combined with day 6-12 starting on 31 Jan.)

Lagged 202 members v Non-Lagged 101 members
2m-temperature CRPSS difference
Day 5-11

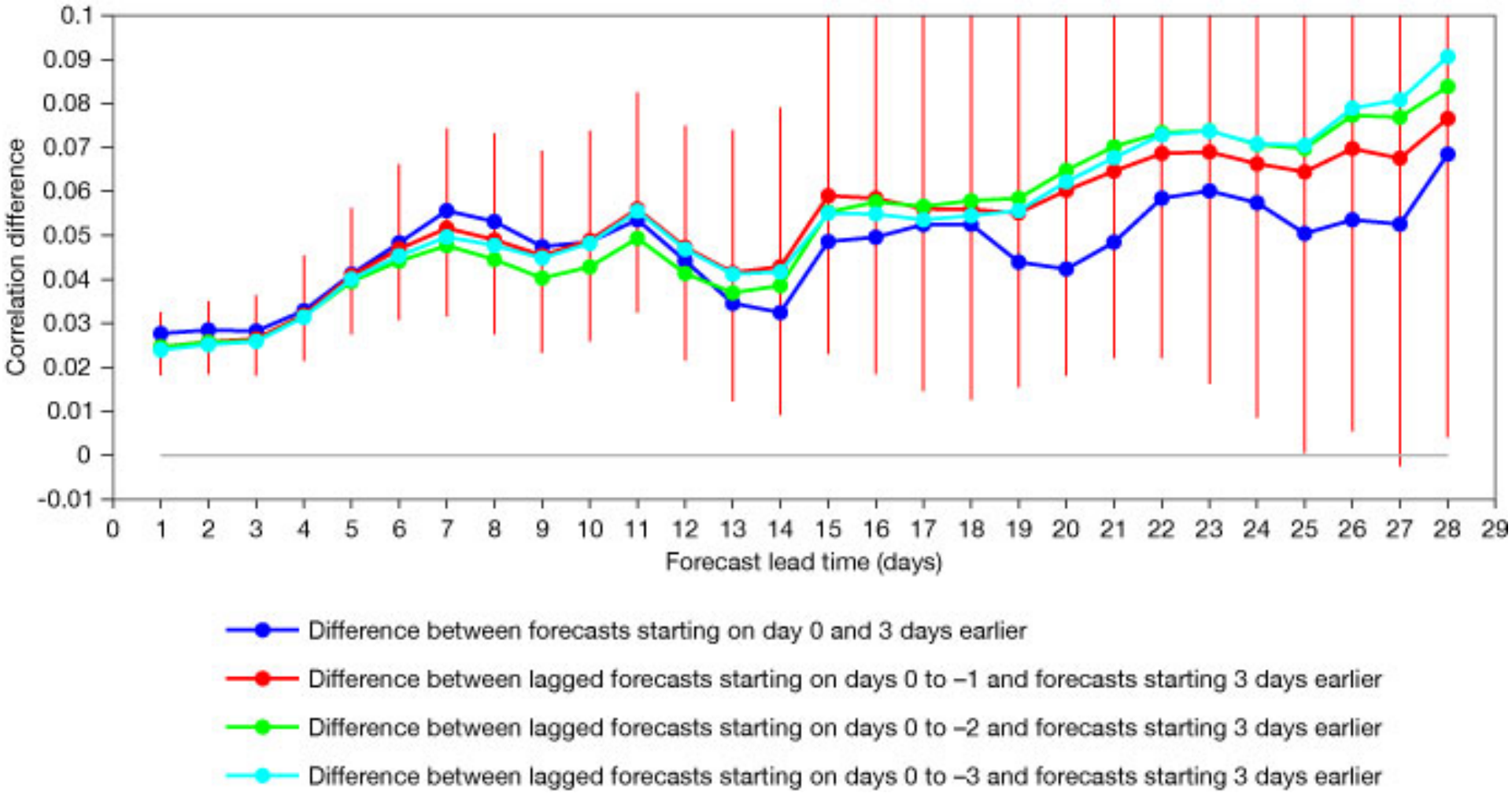


Day 26-32



By Frederic Vitart

Impact of Lagged ensembles on MJO skill



Lagged ensembles take home messages

- Lagged ensemble can provide a slight, but statistically significant improvement in forecast skill at weeks 3 and 4
- Significant degradation at week 1, except for tropical precipitation
- Improvement depends on the variables and geographical location
- No benefit of lagged ensemble for polar stratospheric circulation up to week 4.

Proposed configuration for SEAS6

- SEAS5 was implemented in operations in 2017
  - Atmosphere: Tco319 L91, IFS 43r1
  - Ocean ORCA025, NEMO3.4 LIM2

- SEAS6 is expected to be implemented in 2024 (7 years later)
  - Atmosphere: Tco319 L137, IFS 49r2. Single precision
  - Ocean: eORCA025, NEMO4-SI3, single precision

- Computational cost per month is about the same (single precision balancing cost of increased vertical resolution), so extra HPC resource can be used for increased number of integrations

- Main enhancements were agreed in late 2021 and presented at UEF2022 (see next slide), but some decisions were left for later

- This is the proposal for the complete “shape” of the forecasts and reforecasts

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SEAS6 configuration summary

- **Enhancement 1: Real-time forecasts with 100/101 member ensembles**
- **Enhancement 2: Issue SEAS twice per month**
  - Initial date 1st and 16th of each month
- **Enhancement 3: More comprehensive reforecasts**
  - Larger ensemble size and/or larger set of years
- **Enhancement 4: Expand annual-range ENSO forecasts**
  - Option 1: Issue forecast monthly not quarterly
  - Option 2: Remain quarterly, but increase range to 18-24 months

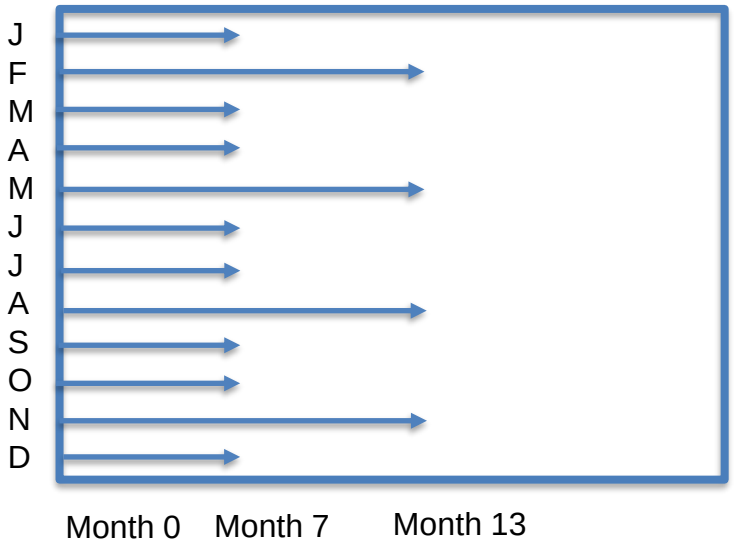
As presented at UEF 2022

- **(Enhancement 5: shorter lifetime of SEAS6, keep closer to operational cycle)**

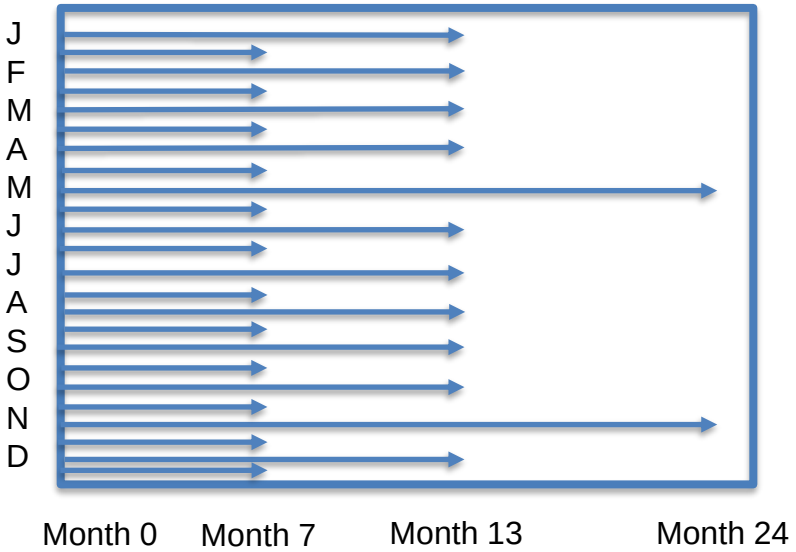
Final decisions on (3) and (4) will be made in due course
Still time for feedback!

Real-time forecast enhancements at a glance:

SEAS5



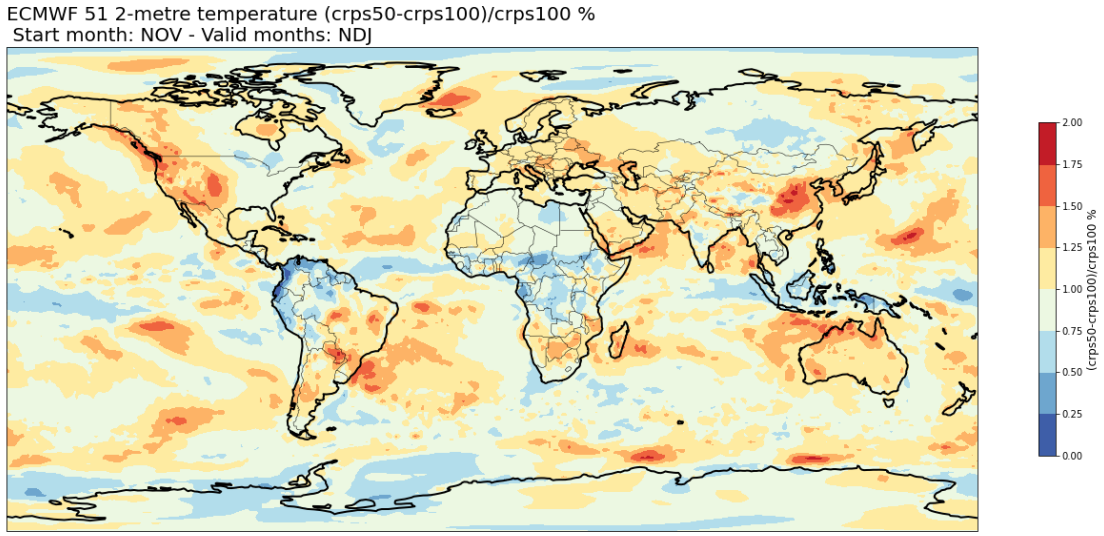
SEAS6

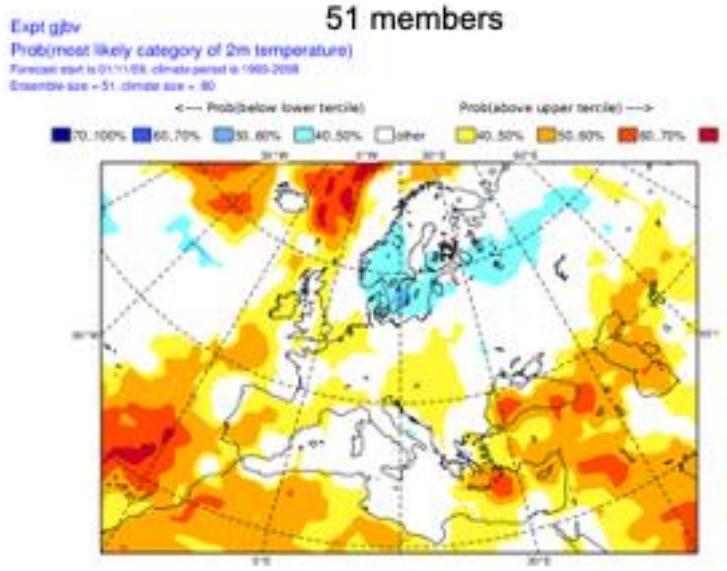


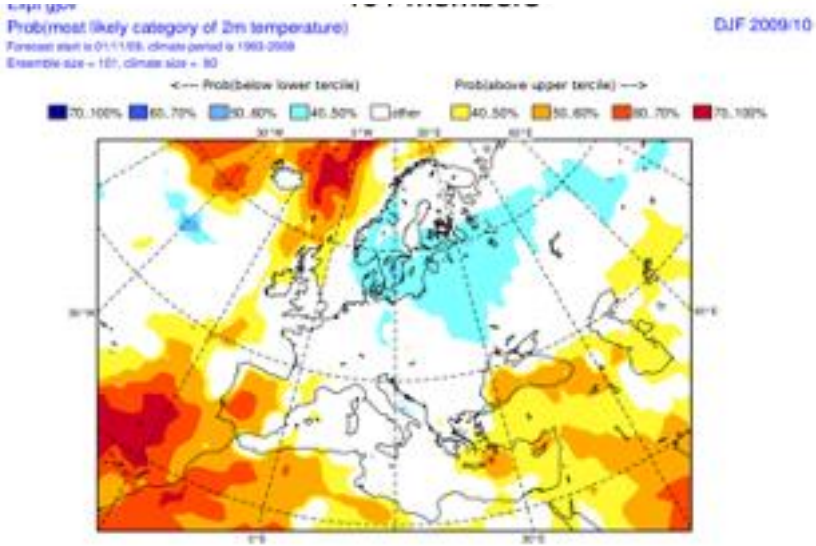
- 7m twice a month (101 members)
- 13m every month (33 members)
- 24m twice a year (33 members)

SEAS6 enhancement 1: 101 member ensembles

- Reduced noise and improved accuracy in forecasts,
- Shown (right) are seasonal forecasts of T2m
- Consistent with planned increase in EXT







Estimated reduction in CRPS (hence increase in skill).
This is positive everywhere (by definition), with strongest gains in areas of weakest signal, including over Europe in winter.

SEAS6 enhancement 2: Issue forecasts twice per month

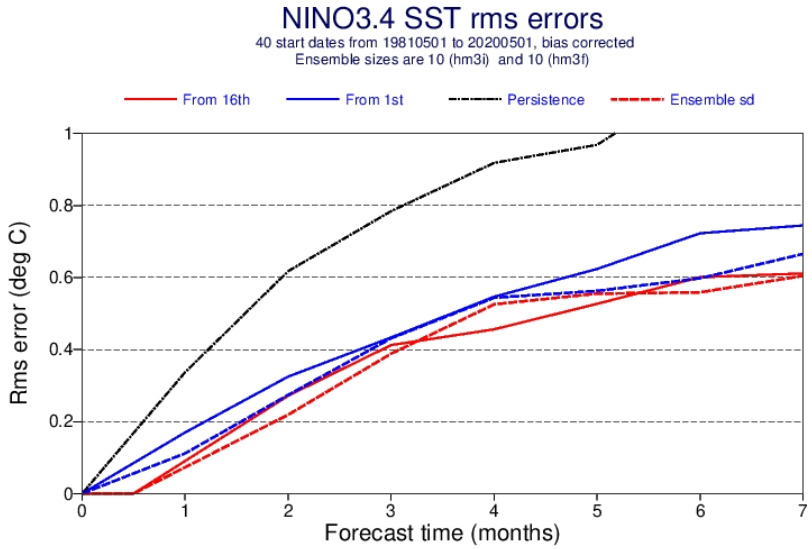
Rationale:

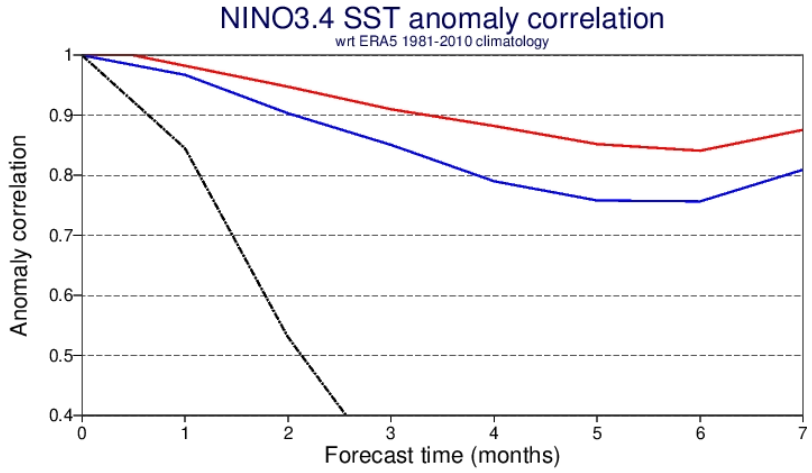
- Provide more timely updates to users, particularly for months 2-4
- Slightly improved effective skill levels due to reduced average lead time
- More credibility when things change, e.g. due to MJO activity or an SSW

Cost:

- Cost is somewhat moderated by restricting resmain re-forecast sets for both 1st and 16th to 1993-2022
- Additional skill estimates will continue to be available at quarterly intervals, with bigger ensembles, and extending further back in time.

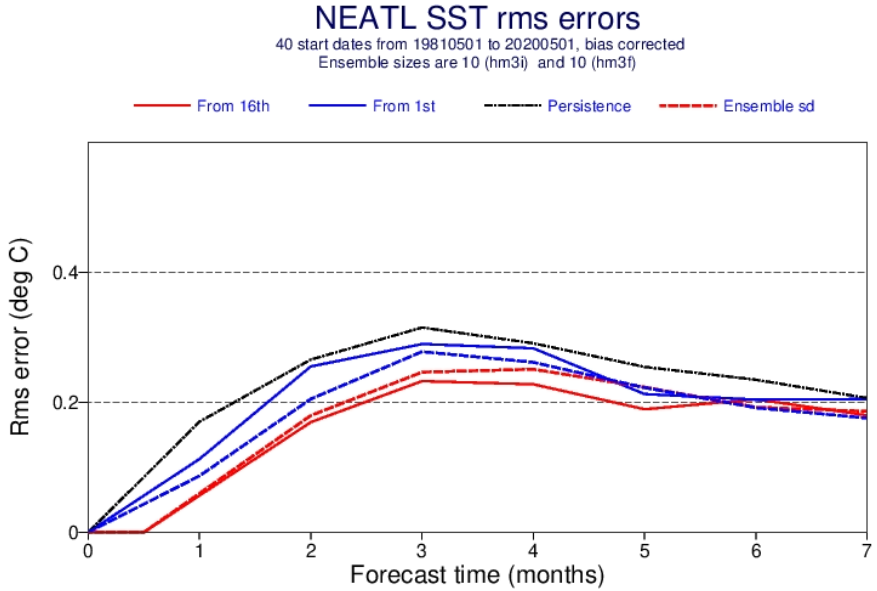
SEAS6 enhancement 2: Issue forecasts twice per month





TCo199 Cy47r3 tests for May starts show strong benefit from starting on the 16th (red) rather than the 1st (blue).

Benefit is not just a uniform shift in lead time, but in some situations a more up-to-date forecast gives access to a more accurate forecast regime.

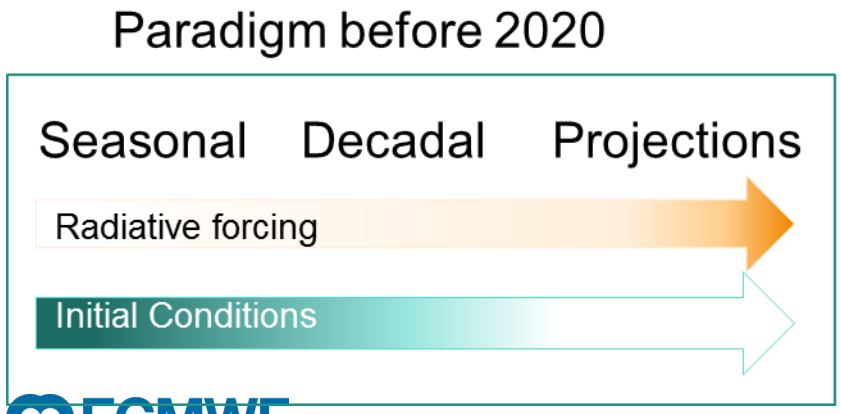


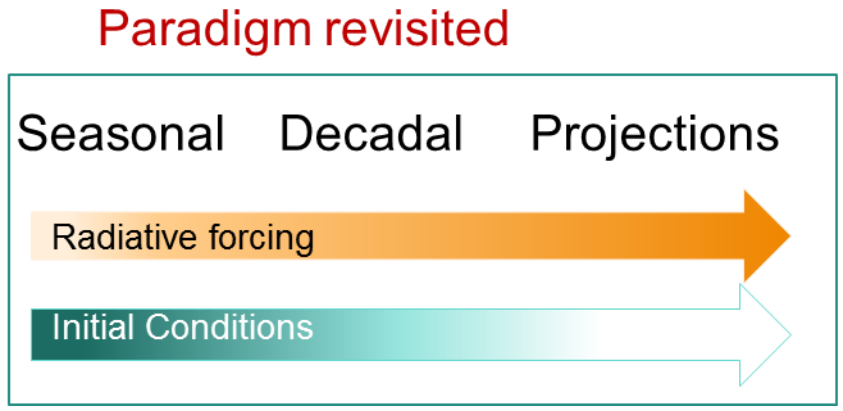
Tim Stockdale

SEAS6 enhancement 4: Extend annual-range forecasts

Rationale:

- The climate is changing. Increased demand of information for adaptation (e.g. water management, agriculture)
- ENSO evolution is affected by noise, and the forecast outlook can change a lot during 3 months. More frequent updates of the now quarterly 13 months ENSO outlooks will be useful
- We have demonstrated forecast skill to 18 months and beyond on windows of opportunity
- WMO definition of long-range forecasting extends to 2 years
- A changing climate does not only make climatology less informative, but can be an additional source of predictability



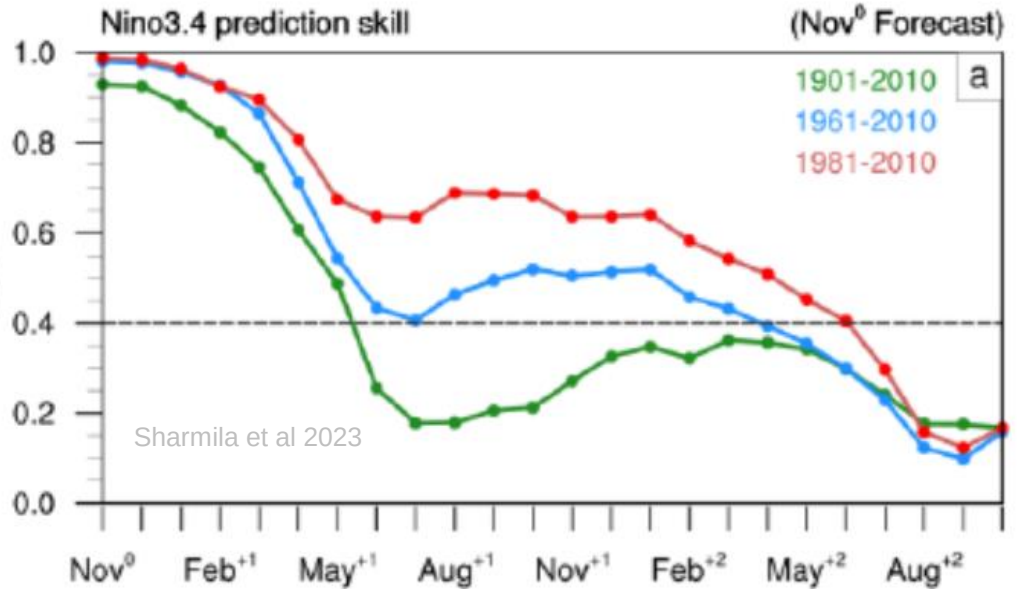


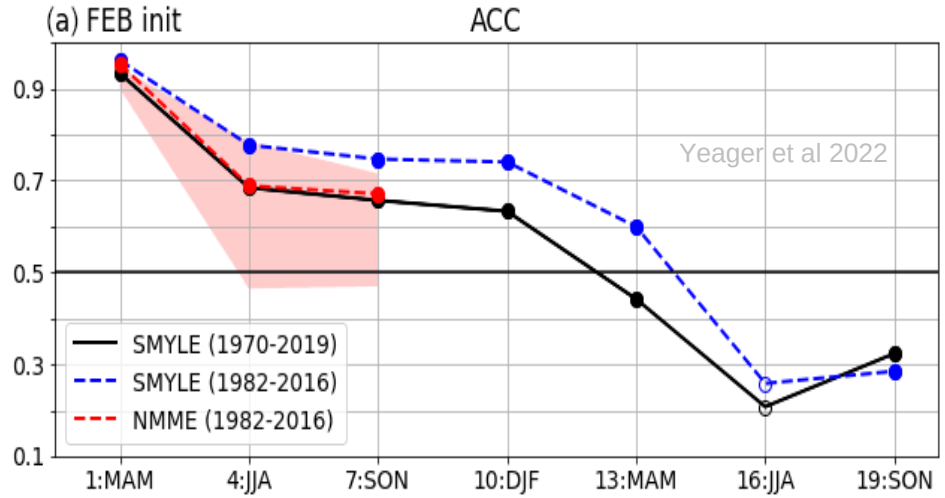
24-month forecasts

Evidence of ENSO predictability beyond year 1

- Several systems show skill beyond 18 months for ENSO prediction.(Yeager et al 2022, Dunstone et al 2022, Sharmila et al 2023)
- In certain occasions –windows of opportunity- that skill can go beyond (eg from El Nino to La Nina)
- There are other predictability drivers beyond ENSO: radiative forcing, stratosphere, upper ocean heat content worldwide

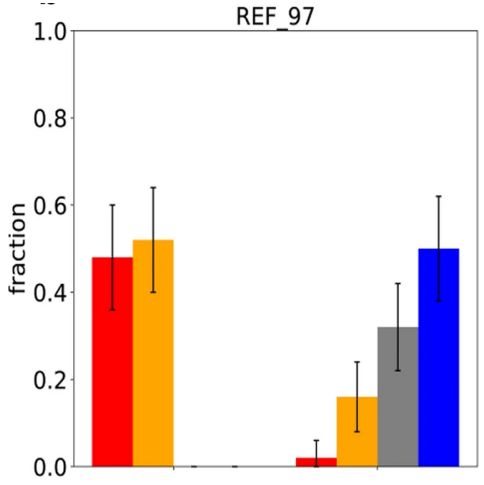
Skill beyond 1-years on ENSO forecasts





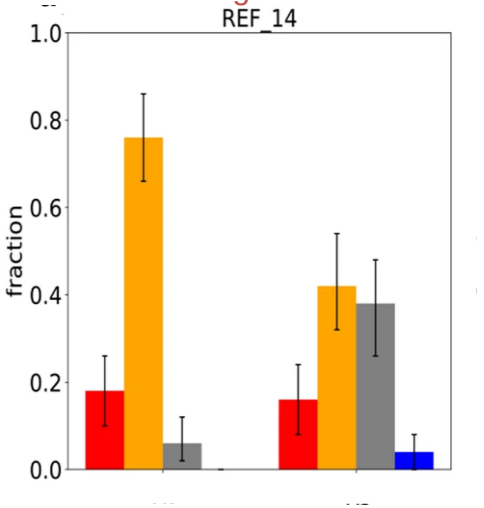
Predicting ENSO 2-years ahead: two case studies

FC Starting Feb 1997



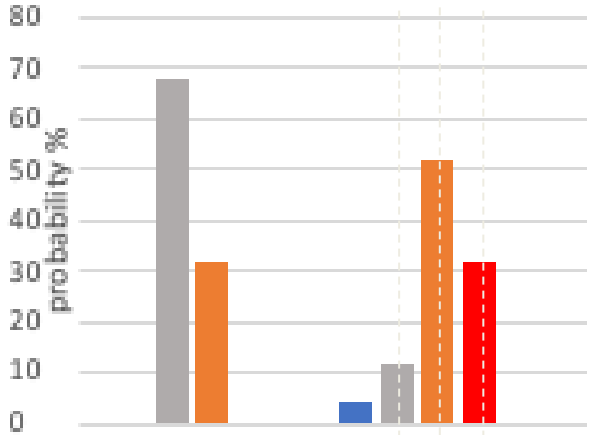
DJF 1997/8 DJF 1998/99

FC Starting Feb 2014



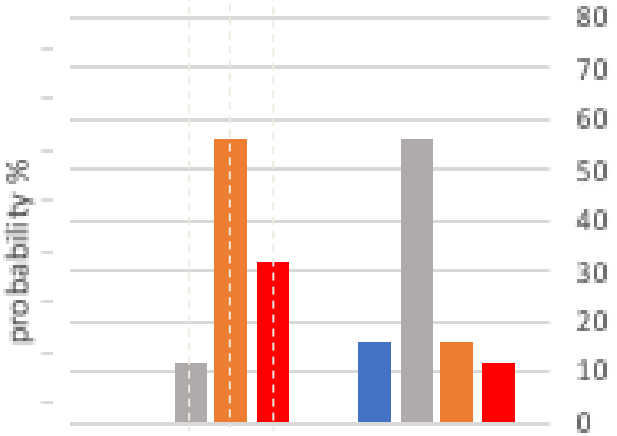
DJF 2014/15 DJF 2015/16

Feb 2022



DJF 2022/3 DJF 2023/4

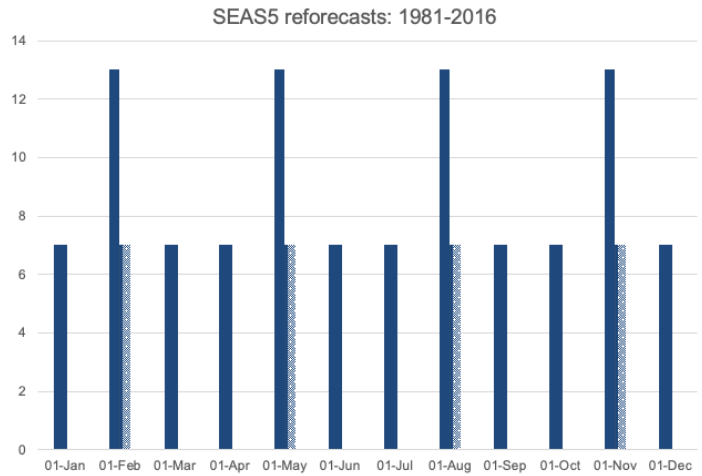
Feb 2023



DJF 2023/4 DJF 2024/25

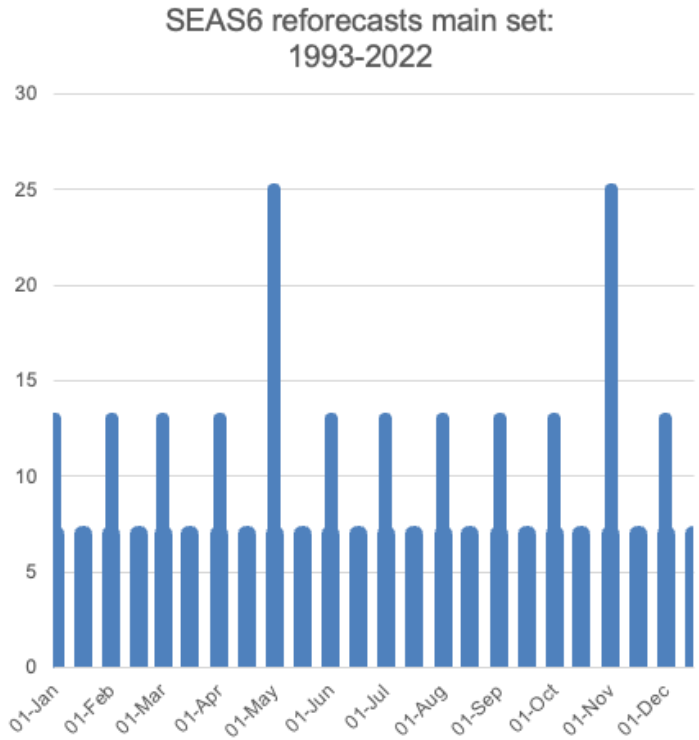
From Mayer and Balmaseda 2021

Reforecasts



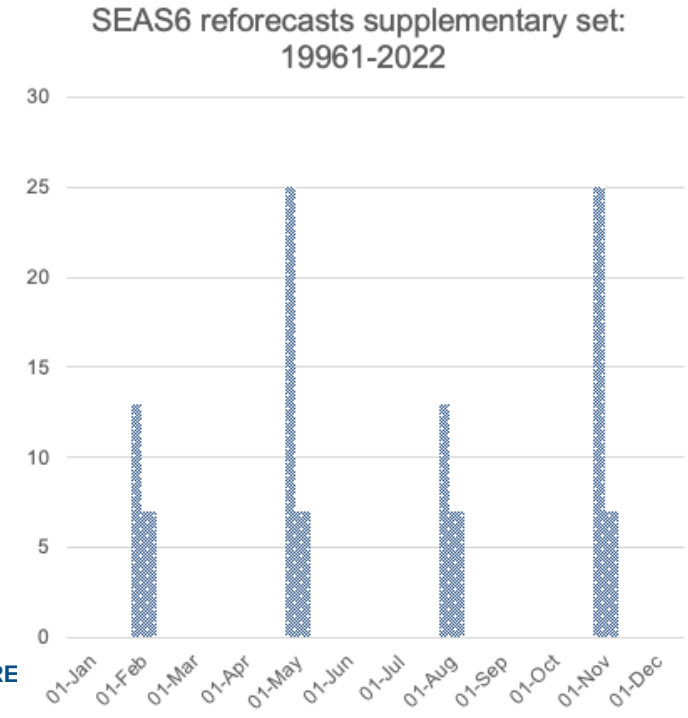
Seas5 main set:
7m fc: 25 members monthly
13m fc: 15 members monthly

Seas5 supplementary (dashed):
7m fc: up-to 50 members quarterly (Feb/May/Aug/Nov



Seas6 main set (left): 1993-2022)
7m fc: 33 members twice a month
13m fc: 22 members monthly
24m fc: 22 members twice a year

Seas6 supplementary set (right)
Back extension to 1961
+ 7m: up-to 55 ens quarterly



Summary

New reforecast configuration for MR-ER in 49r1

- **Extended range**: 10 perturbed + 1 control fc on fixed days of the month, every 2 days, over past 20 years
  1/3/5/7/9/11/13/15/17/19/21/23/25/27/29 (excluding 29 February)
- **Medium Range**: 10 perturbed + 1 control fc on fixed days of the month every 4 days, over past 20 years
  1/5/9/13/17/21/25/29 (excluding 29 February)

This should allow lagged-ensembles, dual-resolution ensemble, assessment of impact of high-res

SEAS6 configuration in 49r2

Real time forecasts

- 7m twice a monthly, 101 members
- 13m monthly, 22 members
- 14m twice a year 22 members

Reforecasts

A) Main set: 1993-2022

- 7m twice a monthly, 33 members
- 13m monthly, 22 members
- 24m twice a year 22 members

B) Supplementary set: back extension to 1961

- 7m quarterly: 55 members
- 13m, quarterly: 22 members
- 24m, twice a year: 22 members