ECMWF update

WGSIP 24

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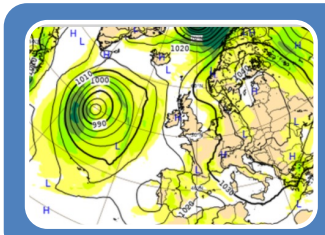
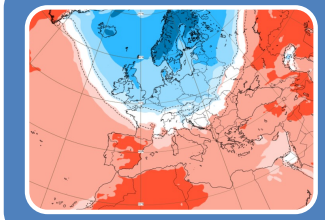
Ensemble forecast systems at ECMWF



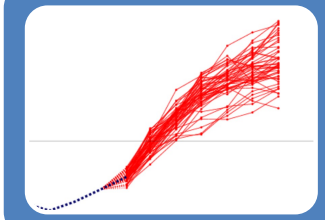
Medium range

- 0-15 days
- 18 km resolution (in Cy48r1 will upgrade to 9 km)
- 51 ensemble members
- Upgraded approximately once a year



Extended range

- Currently an extension of the medium range
- 16-46 days
- 36 km
- 51 ensemble members, twice a week
- Upgraded approximately once a year



Long range: SEAS5

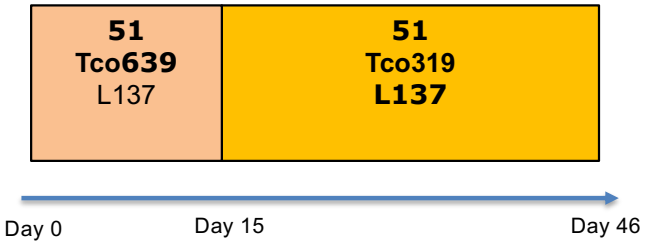
- 0-7 months
- 36 km
- 51 ensemble members, once a month
- Four times a year, the forecast is run out to 13 months
- Last upgraded in 2017 (Cy43r1), next upgrade in 2024/2025

A seamless forecast model underpins all systems (at implementation).

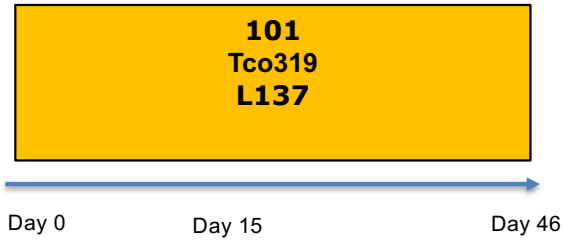
Upgrades to operational systems: extended range configuration

- Extended range configuration will change with Cy48r1 (June 2023)
  - Separate extended and medium range forecast - extended range initialized from day 0 rather than as an extension of the ENS
  - Real-time forecast ensemble size increased to 101 members and issued daily
- In 2024, re-forecasts also expected to be run daily (Cy49r1)
  - Details still to be determined.

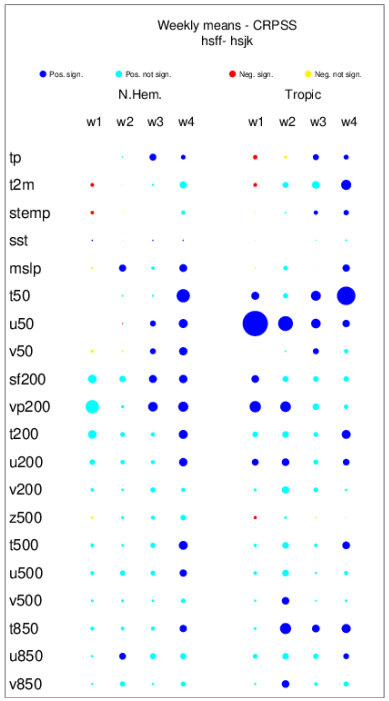
Current configuration



Next configuration



Impact of increasing ensemble size



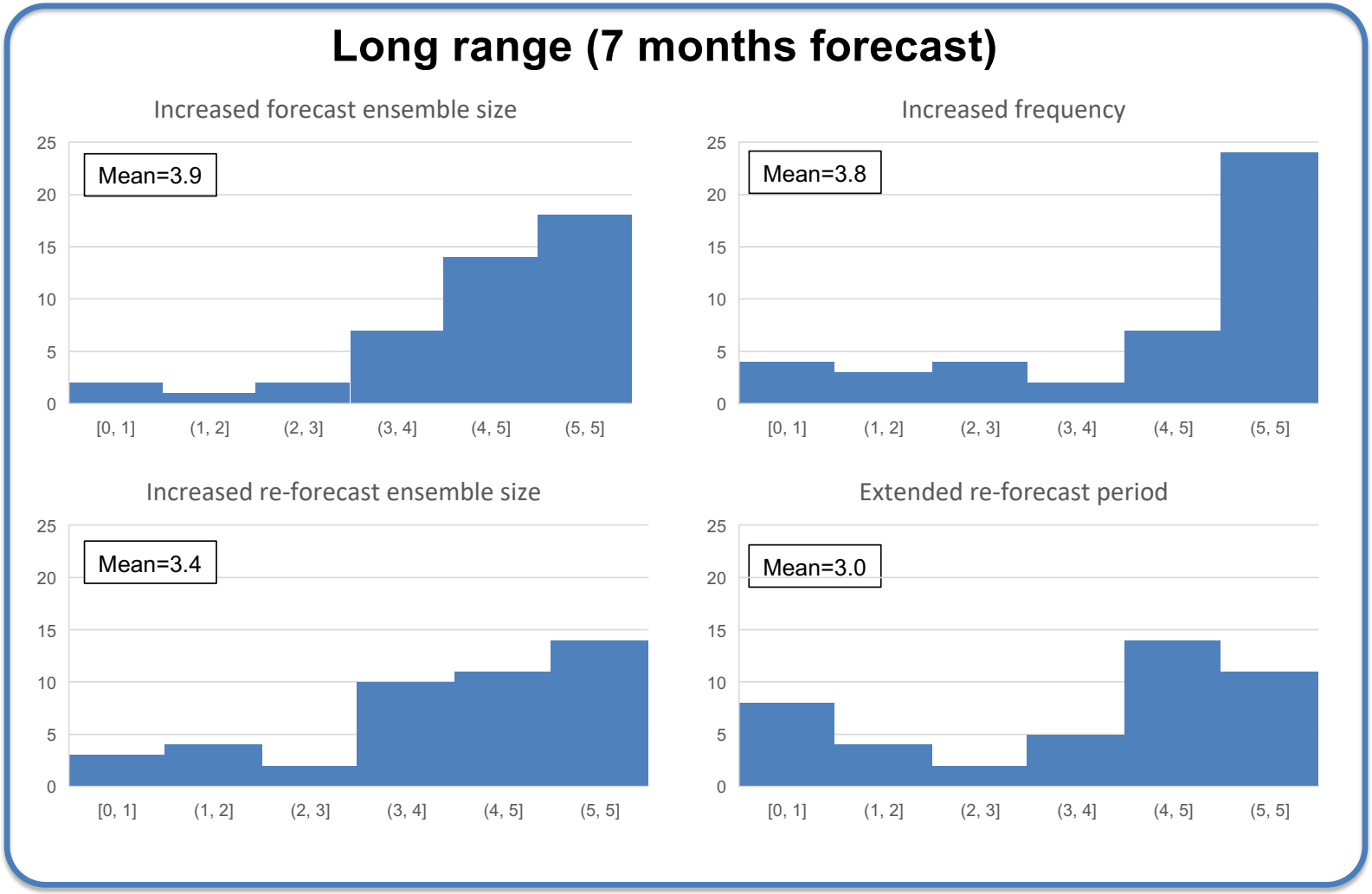
47r3: 101m Tco319 vs 51m Tco639/Tco319

F. Vitart

SEAS6 configuration: User survey

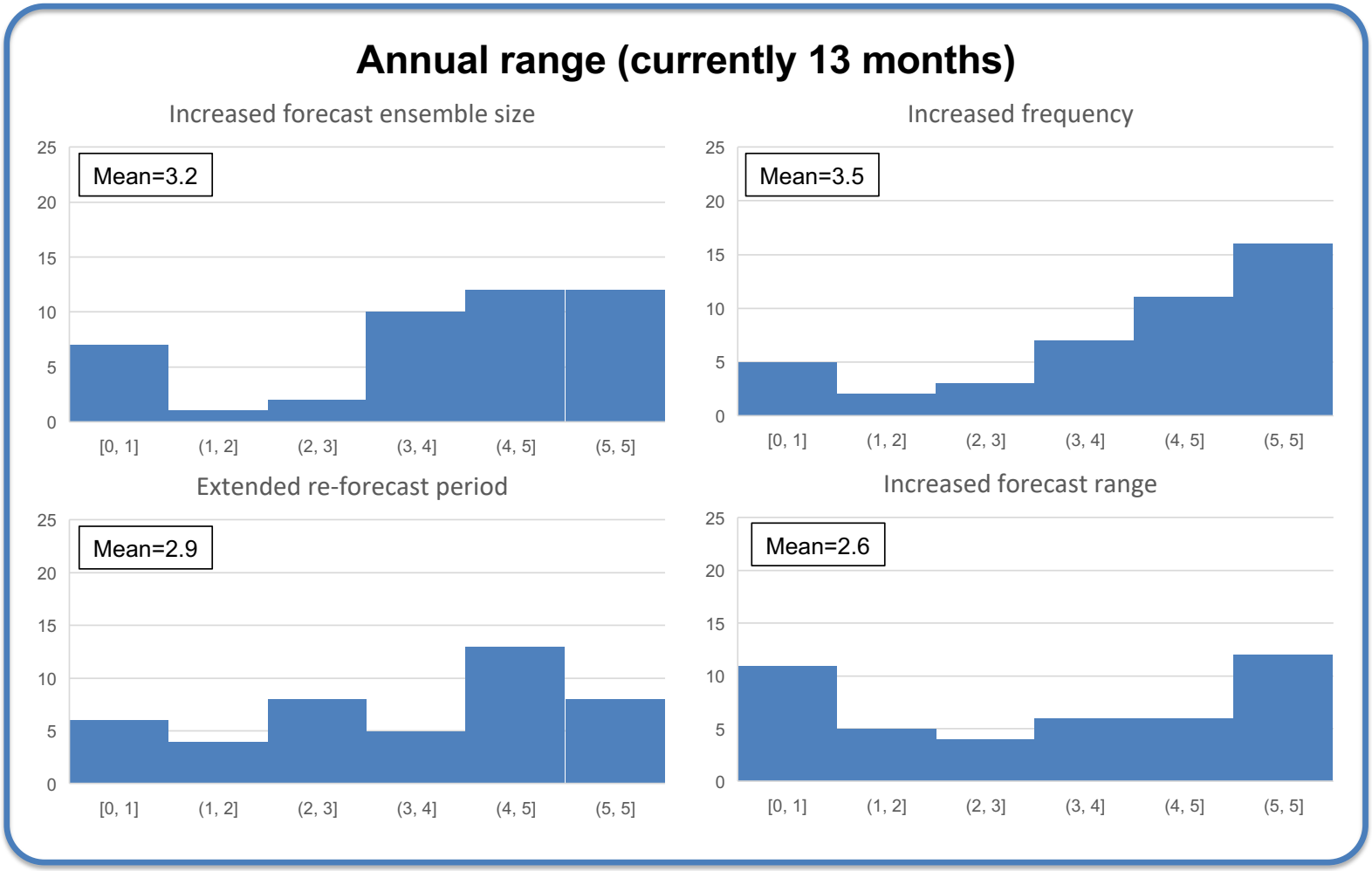
ECMWF's new ATOS supercomputer and a move to single precision computation enable us to expand the configuration of forecasts and reforecasts for SEAS6.

To inform choices, users were asked to rank from 0 to 5 the **importance** of increasing forecast frequency, forecast range, number of ensemble members and reforecast years.



SEAS6 configuration: User survey

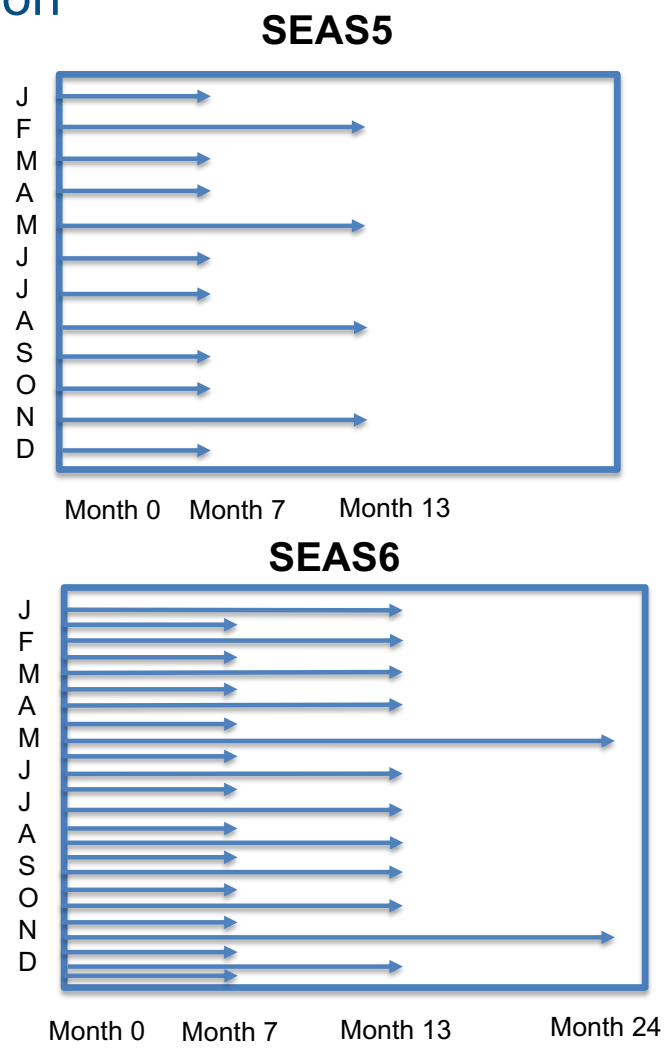
There was less of a clear preference in the annual range, but increasing forecast frequency was preferred over other options.



Upgrades to operational systems: long range configuration

Expected SEAS6 configuration:

- Seven month forecasts issued twice a month,101 ensemble members
  - 1st of the month reforecast size of 33, 1981-2022
  - 16th of the month reforecast size of 11, 1993-2022
  - Every quarter 55 members will be run for a longer hindcast period (1961-2022), for a more complete estimation of skill
- Thirteen month forecasts issued once a month, 33 ensemble members
  - Reforecast size of 11 members, 1993-2022
- Twenty-four month forecasts issued twice a year, 33 ensemble members
  - Reforecast size of 20 members, 1961-2022
- Bias correction of products will use 1993-2022
  - Consistent with C3S
  - More recent period



Strands of forecast system development

- **Ocean and atmosphere model upgrades:** IFS, NEMO4, SI3
  - Clear improvement in the stratosphere since SEAS5 from increase in vertical levels, hybrid linear ozone scheme…
  - New stochastic physics scheme to be implemented in Cy49r1 (Lang et al. 2021, QJRMS)
  - NEMO4/SI3 – New version of the ocean model and an upgrade to the SI3 multi-category sea ice model
- **New initialization datasets:**
  - OCEAN6 - New version of the ocean reanalysis system including SST assimilation using an ensemble data assimilation approach. See talk by Hao Zuo.
  - New land surface initialization including data assimilation of soil moisture and snow
- **Improved forcings:** CMIP6 GHG, volcanic aerosol, tropospheric aerosol
  - See talk by Lauriane Batte on Confess
- **Addressing known model errors (UGROW):**
  - decadal variability in the NW Atlantic, Eastern Indian ocean, DJF Pacific jet extension

Seamlessness is a priority: Developments are contributed to IFS cycles and tested at all timescales.

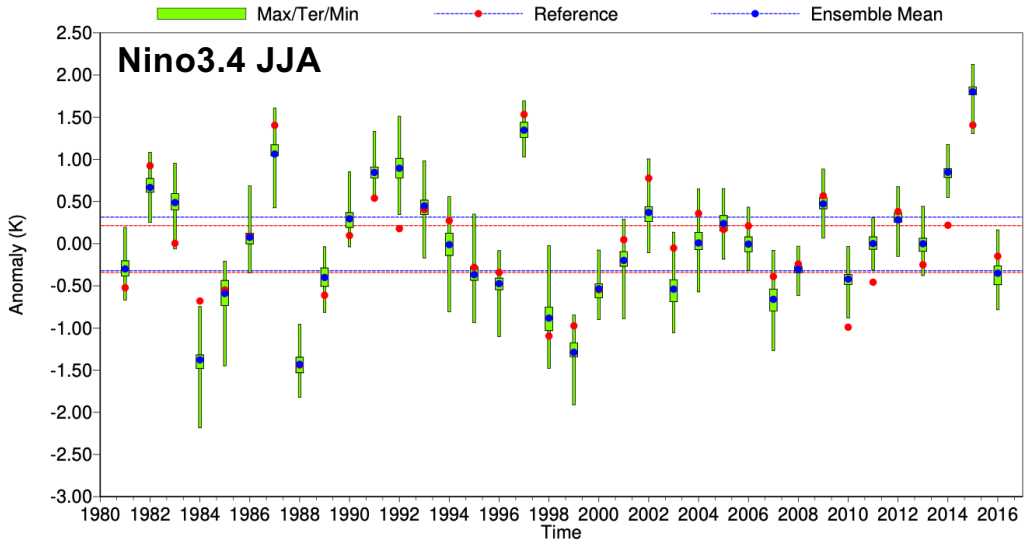
Some research highlights

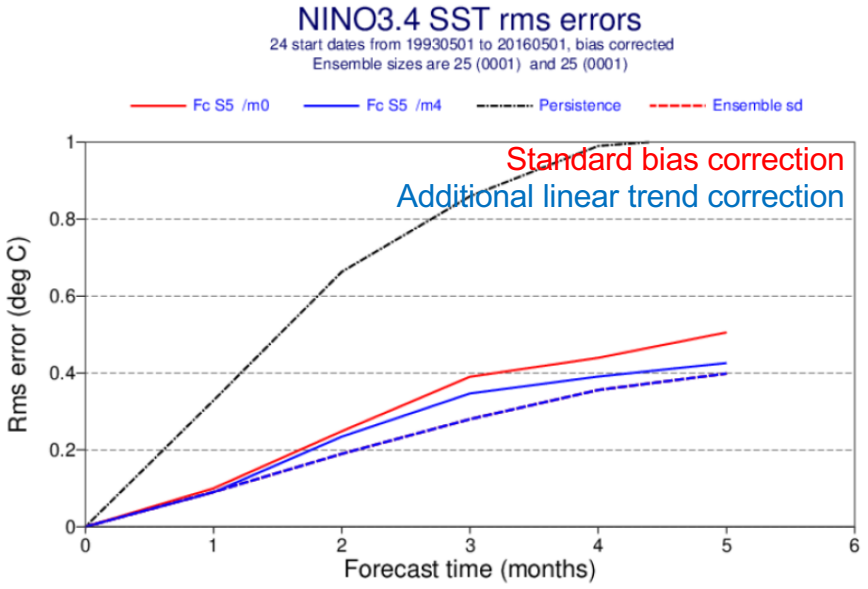
- Exploration of model errors
  - DJF northern hemisphere jet biases, common to S2S models (F. Vitart)
  - JJA eastern Indian Ocean biases (M. Mayer et al. submitted to JClimate)
  - UGROW Trends – Arctic Warming (S. Tietsche), tropical oceans (M. Mayer), tropical cyclones (F. Vitart)
- Evaluation of forecast models
  - MJO-regime interactions at the subseasonal timescale (C. Roberts)
  - Impact of ocean observations (B. Balan Sarojini & M. Balmaseda)
  - Attribution case studies of seasonal climate extremes (R. Senan & A. Weisheimer)
  - Non-stationarity in mean state and variability from 63 year hindcasts (A. Weisheimer)
  - ENSO predictability at the 1-2 year timescale (A. Weisheimer & M. Balmaseda)
- Many projects in progress or spinning up (several will be discussed in coming talks):
  - Aspect – Seasonal-to-decadal prediction for seamless climate information
  - Cerise – Developing innovative coupled land-atmosphere data assimilation and land surface initialization
  - EERIE – Impact of ocean mesoscale on weather and climate
  - ACCIBERG – Arctic and ice-berg forecasting

UGROW-trend: Errors in long-term SST trends affect ENSO skill

- ENSO skill is increased when we apply a linear trend correction to SST forecasts
- Similar results are obtained for other regions (e.g. northern extratropics) and variables (OHC etc)

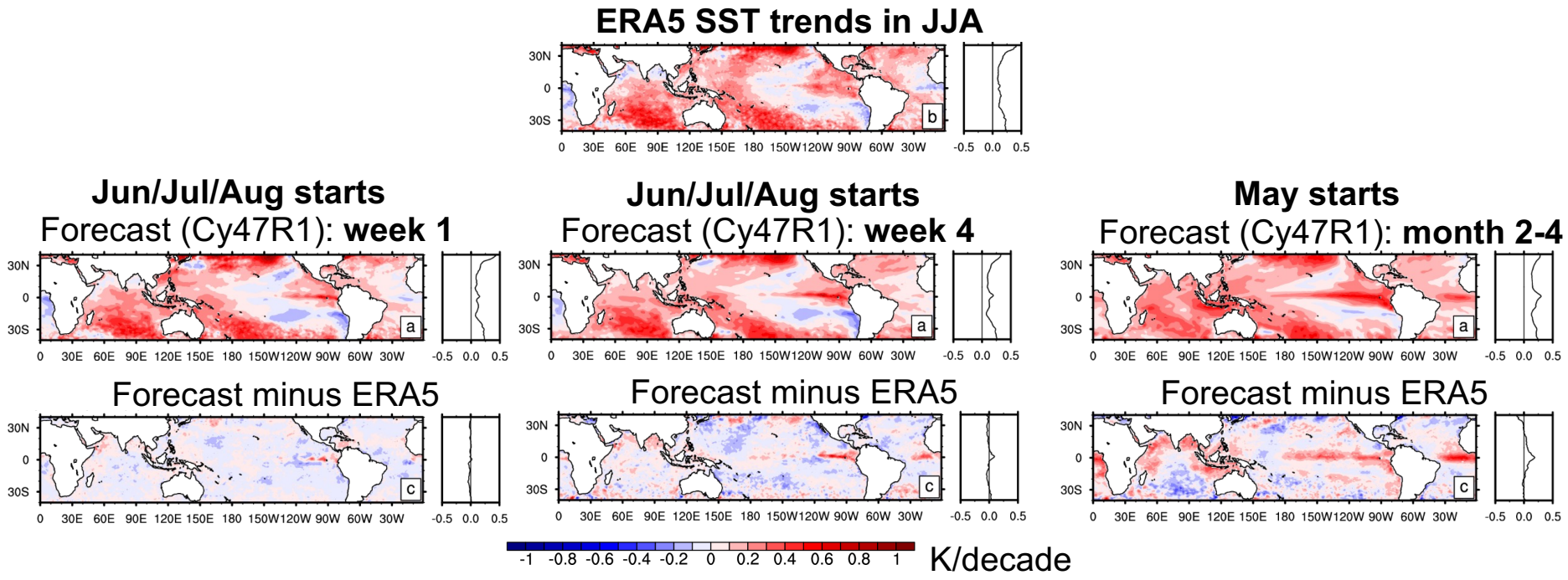
SEAS5 May starts 1993-2016





UGROW-trend: SST trends in extended and long-range forecasts (1993-2016)

- Characterize errors in SST trends and related fields (as a function of lead time, season, resolution, etc)
- Some SST trend errors on seasonal scale become visible already in week 1 (e.g. eastern eq. Pacific)

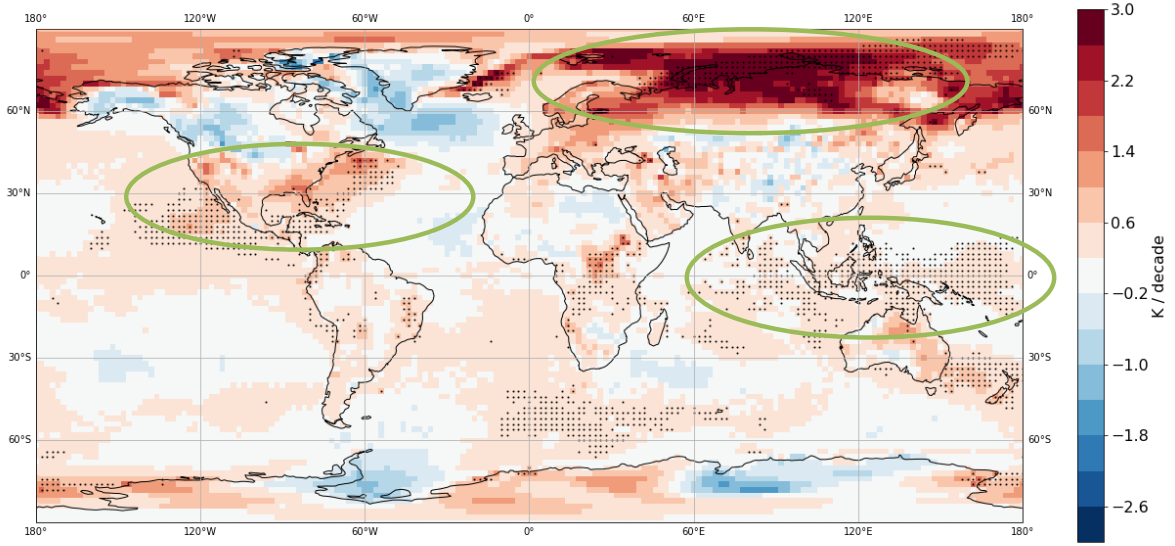


M. Mayer

UGROW-trend: Arctic temperature trends

20-year trends of Jan/Feb 2m temperature in ERA5

ERA5 t2m trend Jan/Feb 2000 – 2019



Stippling where trend is robust and important

Cp. Simmons, A. J.: Trends in the tropospheric general circulation from 1979 to 2022, Weather Clim. Dynam., 3, 777–809

Trend criterion:

- ***Robustness*** *I: statistical significance of non-zero trend (Wilcoxon signed-rank test of week-by-week trends)*

- *Robustness II: sensitivity to leaving out single years < 10%*

- ***Importance****: total variance explained by trend > 10%*

There are three coherent large-scale regions with robust and important trends:

- *Tropical warm pool*

- *Subtropical Atlantic and Pacific near North America*

- ***Eurasian Arctic***

S. Tietsche

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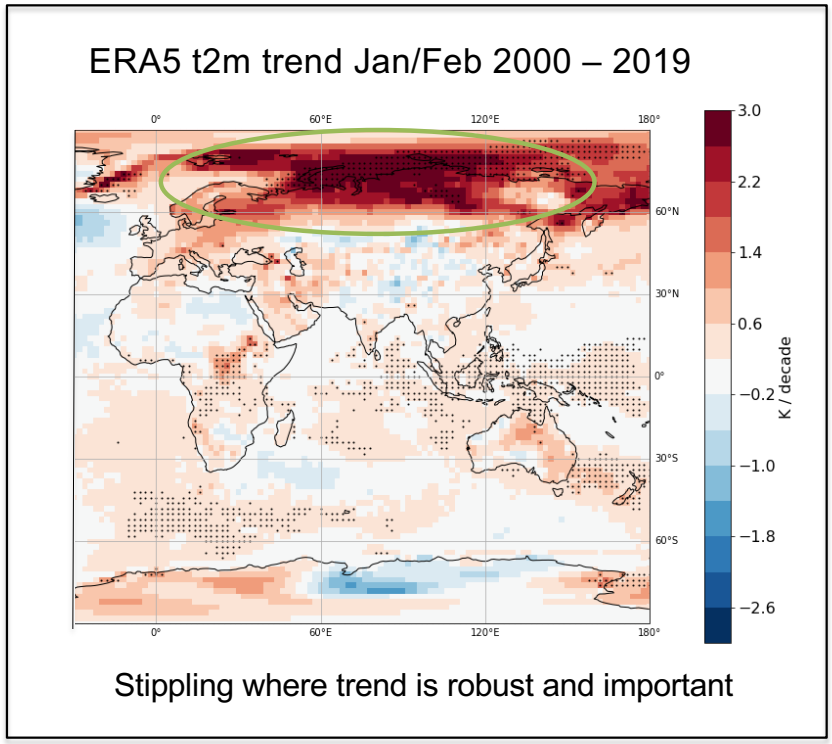
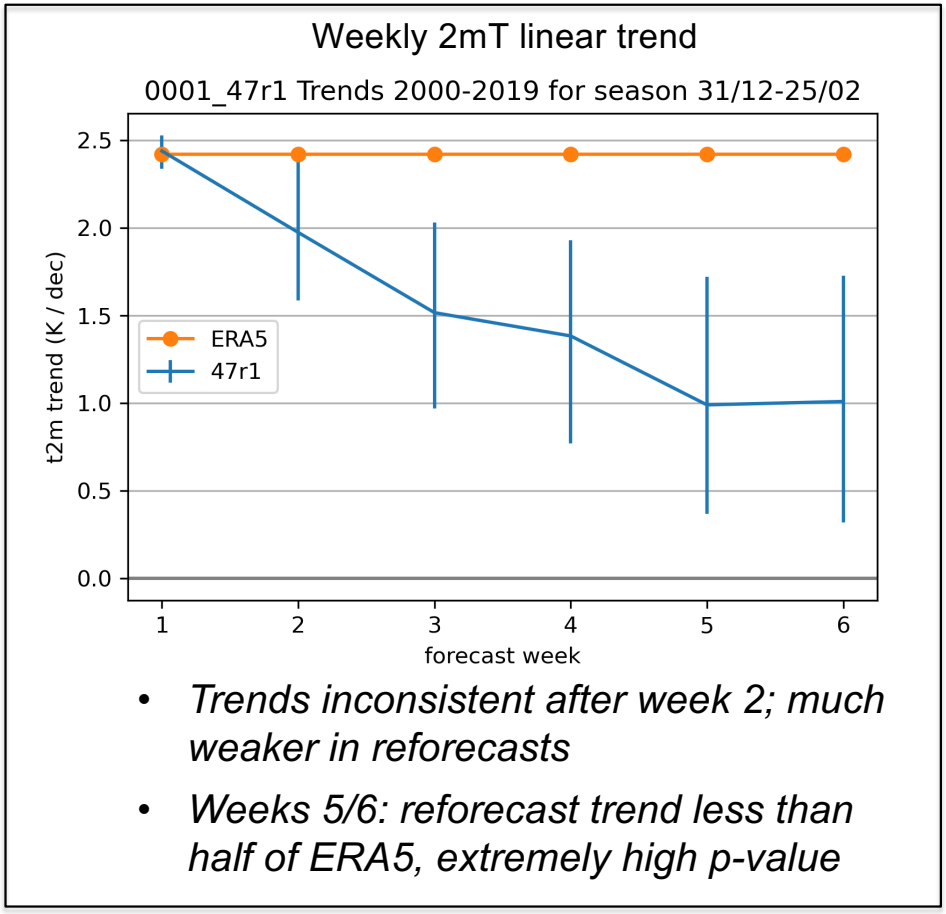
Eurasian Arctic t2m trend in ERA5 / 47r1 reforecasts





- *Trends inconsistent after week 2; much weaker in reforecasts*
- *Weeks 5/6: reforecast trend less than half of ERA5, extremely high p-value*

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S. Tietsche