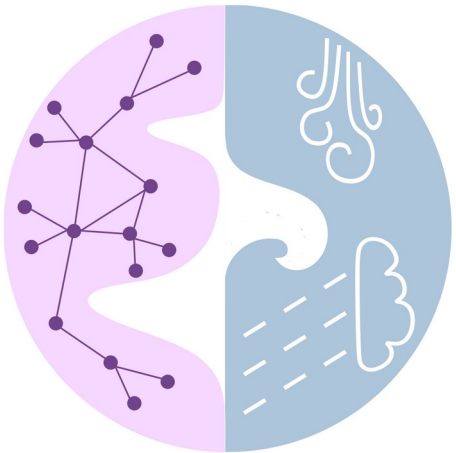
# Journal Club

19 Jan 2021



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Geoscientific Model Development
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# SEAS5: the new ECMWF seasonal forecast system

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# SEAS5

- 5th gen seasonal forecast system from ECMWF
- Follows SEAS4 (2011-2017)
- In operation since 2017
- Necessary because:
  - Integrated Forecast System (IFS) has improved
    - Improved tropical convection
    - Higher resolution
    - Improved ocean physics
    - Prognostic sea-ice model

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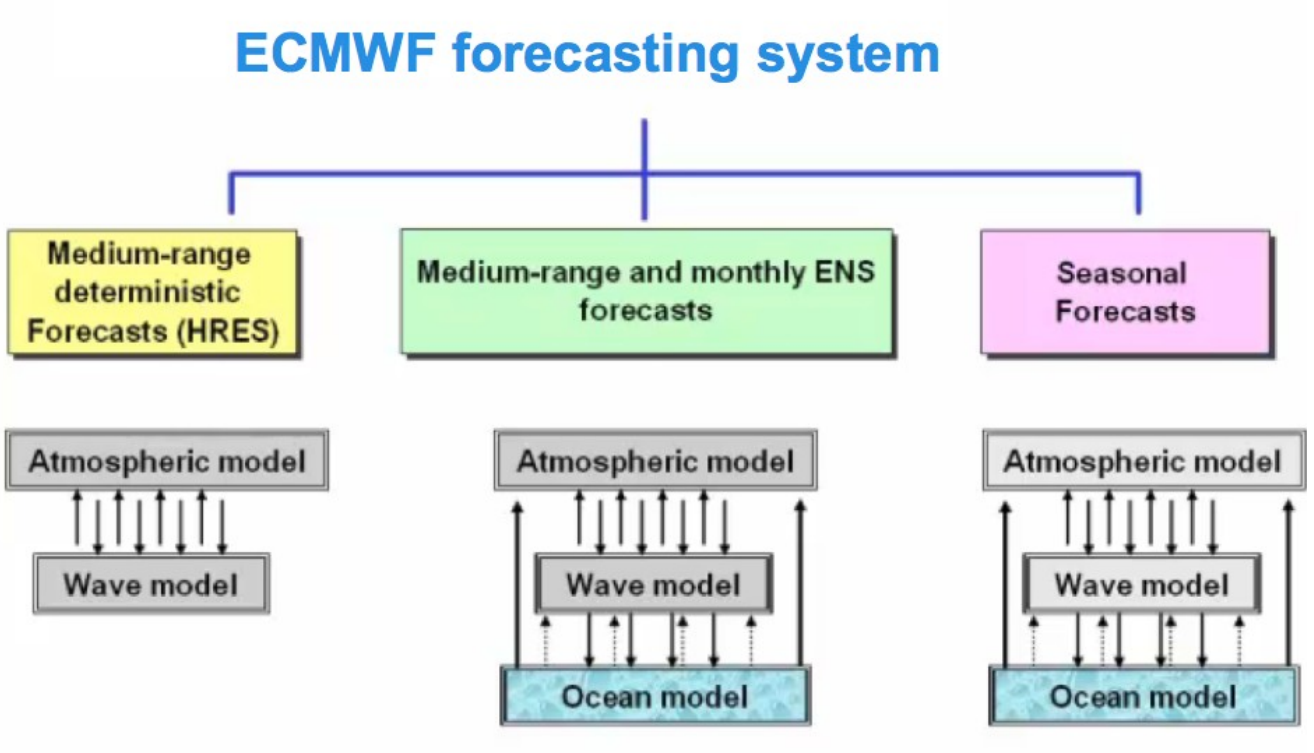
# IFS

- Forecast system (not a single model) composed of
  - Atmospheric model
  - Ocean wave model
  - Ocean model
  - Land surface model
  - Data analysis system
  - Preturbation system (for ensemble generation)

# IFS


ECMWF forecasting system
Medium-range deterministic Forecasts (HRES)
Medium-range and monthly ENS forecasts
Seasonal Forecasts
Atmospheric model
Wave model
Atmospheric model
Wave model
Ocean model
Atmospheric model
Wave model
Ocean model

# Description of SEAS5

- **Forecast and re-forecast**
- **Model configuration**
- **Model initialisation**
- **Ensemble generation**

# Description of SEAS5

- **Forecast and re-forecast**
  - *Forecasts*
    - “long range” forecasts include
    - 51 ensemble members
    - Initialised on 1st of every month
    - Integrated for 7 months
    - 15 are selected on 1st of Feb, May, Aug & Nov for a further 6 month integration
      - These provide ENSO “outlooks”

# Description of SEAS5

- **Forecast and re-forecast**
  - *Re-Forecasts*
    - i.e. retrospective forecasts (aka hindcasts)
    - 25 ensemble members
    - Initialised 1$^{st}$ of every month (1981-2016)
    - 15 are initialised on 1$^{st}$ Feb, May, Aug, & Nov for longer integration
    - Only data from 1993 to 2016 are used to calculate forecast anomalies (due to warming)

# Description of SEAS5

- **Model configuration**

| | SEAS4 | SEAS5 |
|---|---|---|
| IFS cycle | 36r4 | 43r1 |
| IFS horizontal resolution (dynamics) | T255 | T319 |
| IFS horizontal grid | linear | cubic octahedral |
| IFS horizontal resolution (physics) | N128 (80 km) | O320 (36 km) |
| IFS vertical resolution (Top of atmosphere) | L91 (0.01 hPa) | L91 (0.01 hPa) |
| IFS model stochastic physics | 3-scale SPPT and SKEB | 3-scale SPPT and SKEB |
| Coupling | OASIS3 | single executable |
| Ocean model | NEMO v3.0 | NEMO v3.4.1 |
| Ocean horizontal resolution | ORCA 1.0 | ORCA 0.25 |
| Ocean vertical resolution | L42 | L75 |
| Sea-ice model | sampled climatology | LIM2 |
| Wave model resolution | 1.0° | 0.5° |

# Description of SEAS5

- **Model initialisation**

| | SEAS4<br>re-forecast/forecast | SEAS5<br>re-forecast/forecast |
|---|---|---|
| Atmosphere initialisation | ERA-Interim/operations | ERA-Interim/operations |
| Land initialisation | ERA-Interim land (36r4)/operations | ERA-Interim land (43r1)/operations |
| Ocean initialisation | ORA-S4/ORTA4 | ORA-S5/OCEAN5-RT |

# Description of SEAS5

- **Ensemble generation**
  - *Initial condition perturbations*
  - *Stochastic model perturbations*

# Description of SEAS5

- **Ensemble generation**
  - *Initial condition perturbations*
    - Represent uncertainty in data
    - Atmosphere:
      - from ensemble of data assimilation and from leading singular vectors
    - Ocean:
      - From assimilated observations and from forcing fields at the surface

# Description of SEAS5

- **Ensemble generation**
  - *Stochastic model perturbations*
    - Flow dependent multiplicative noise
    - Spatially and temporally correlated
    - Three scales
      - Small-scale (fast)
      - Large-scale (slow)
      - Intermediate

# Assessment and evalution

- **Note on terminology**
  - *Forecast lead time*
    - Months elapsed since initialisation
  - *Forecast month*
    - Month being discussed
  - Example:
    - “*if a forecast is initialised on 1 January, February has 1-month forecast lead time and is month 2 of the forecast*”

# Assessment and evalution

- **Evaluation metrics**
  - *Anomaly correlation*
  - *Amplitude ratio*
  - *Root mean square error*
  - *Continuous ranked probability skill score (CRPSS)*
  - *Reliability diagrams*

# Assessment and evalution

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# Assessment and evalution

- **Evaluation metrics**
  - *Anomaly correlation*
  - *Amplitude ratio*
  - *Root mean square error*
  - ***Continuous ranked probability skill score (CRPSS)***

***CRPSS = 1 – CRPS_fs / CRPS_cl***

where *CRPS_fs* and *CRPS_cl* are continuous ranked probablity scores (*CRPS*) of model & climatology forecasts

$$CRPS = \int_{-\infty}^{\infty} \left(P_{fcst}(x) - P_{obs}(x)\right)^2 dx$$

# SEAS5 Diagnostics: Tropics

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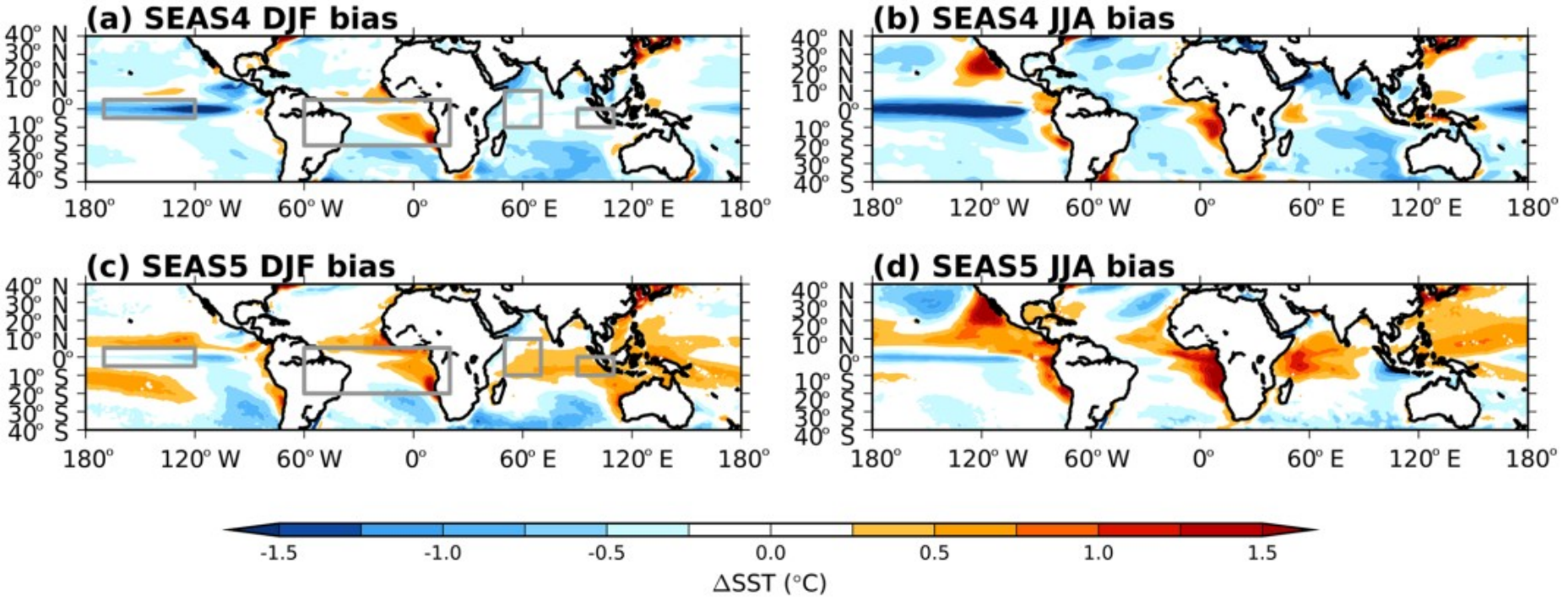

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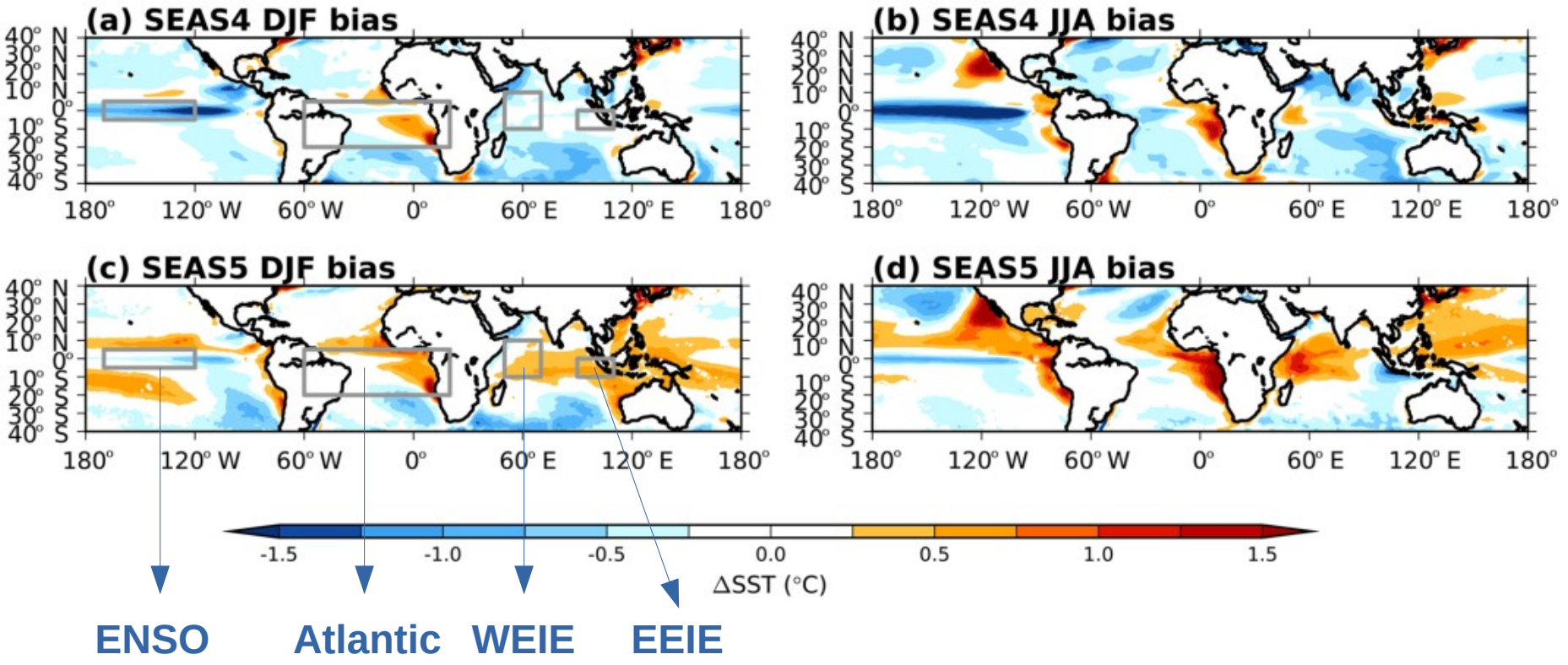
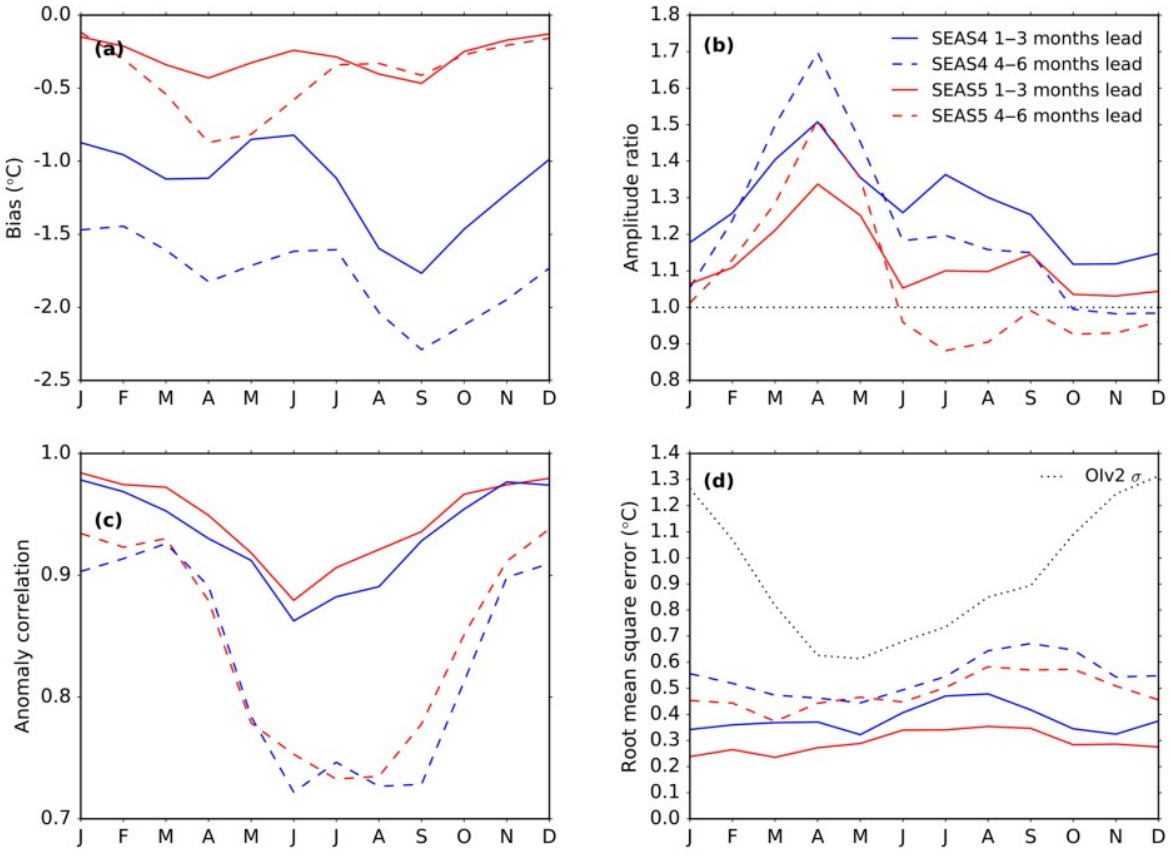
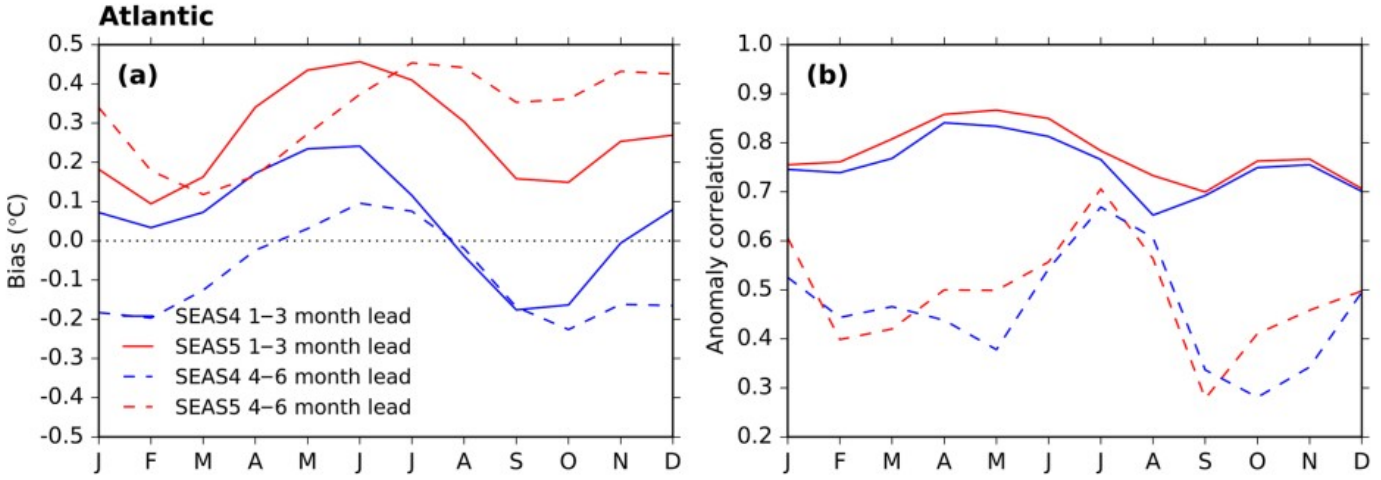


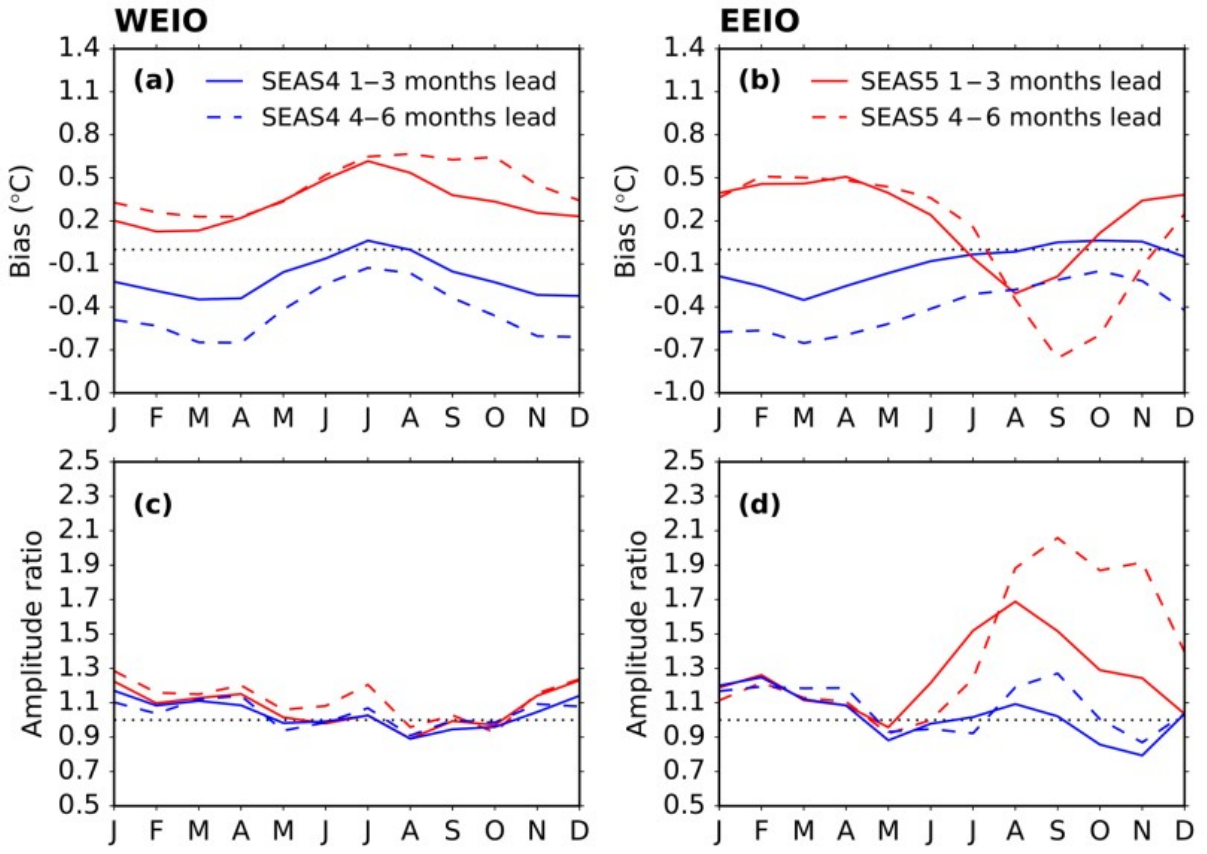
# SEAS5 Diagnostics: Tropics - ENSO



# SEAS5 Diagnostics: Tropics - Atlantic



# SEAS5 Diagnostics: Tropics – Indian Ocean



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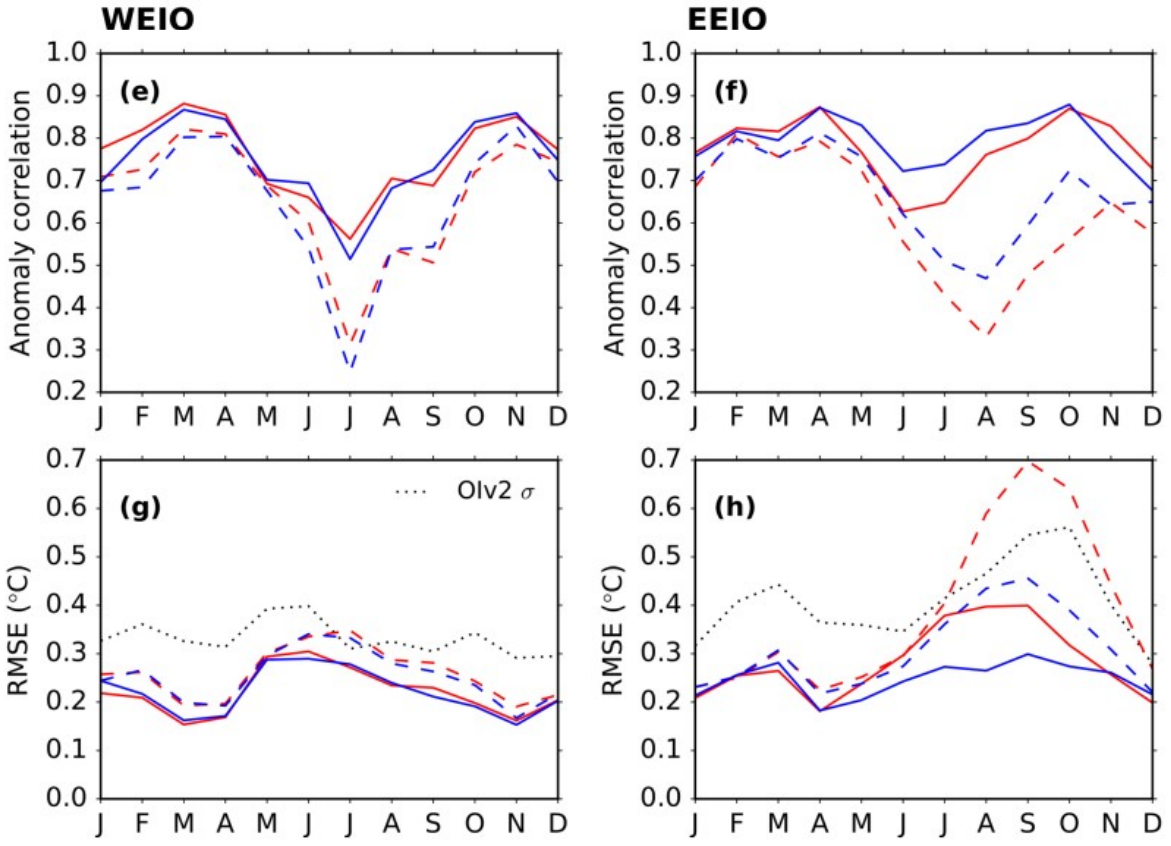
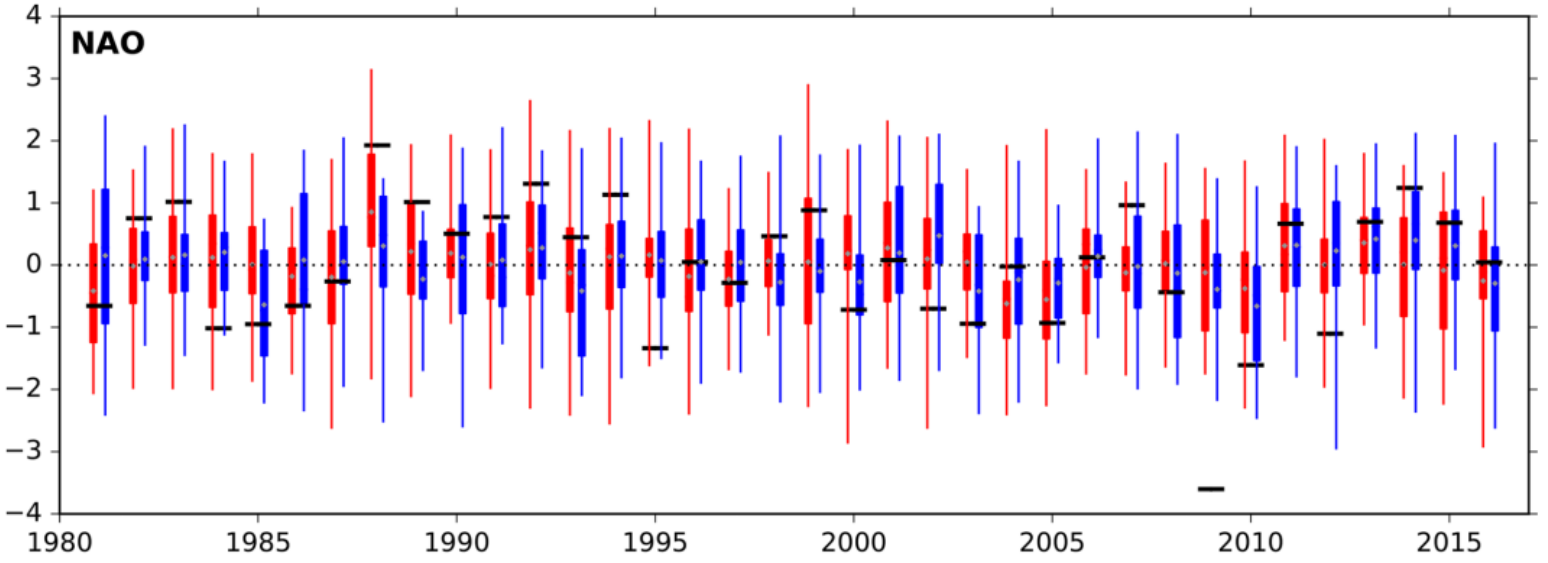
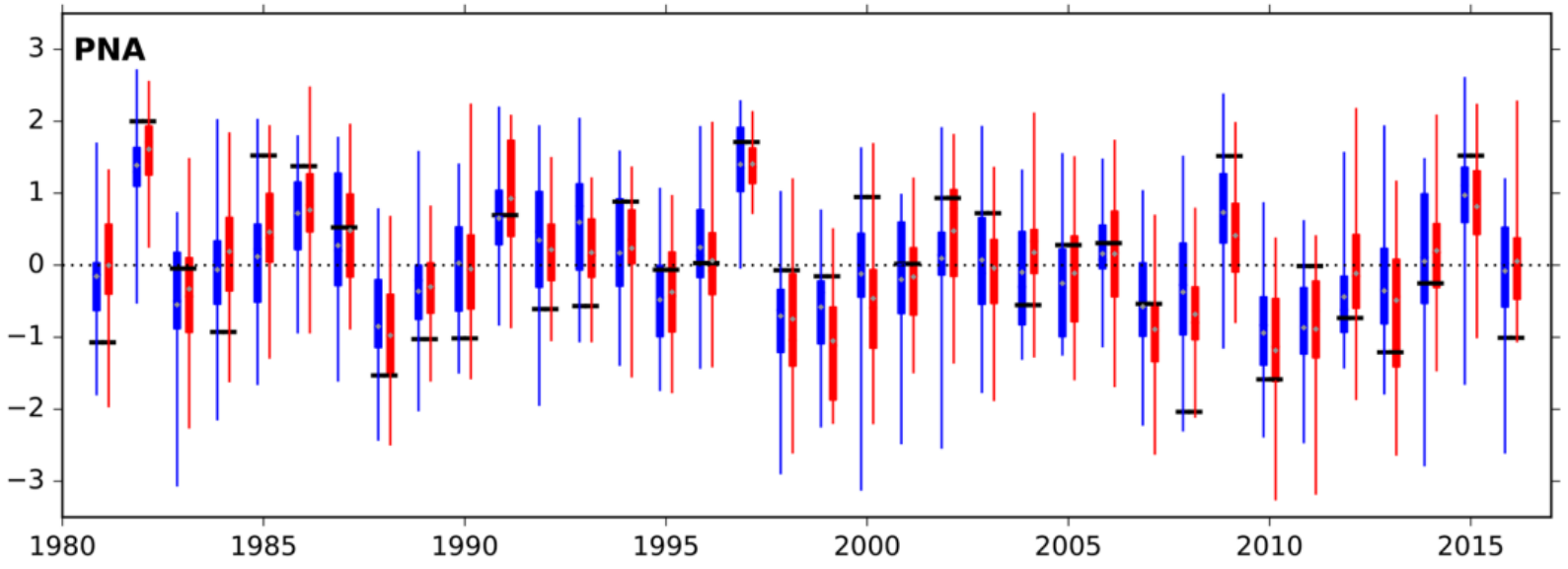


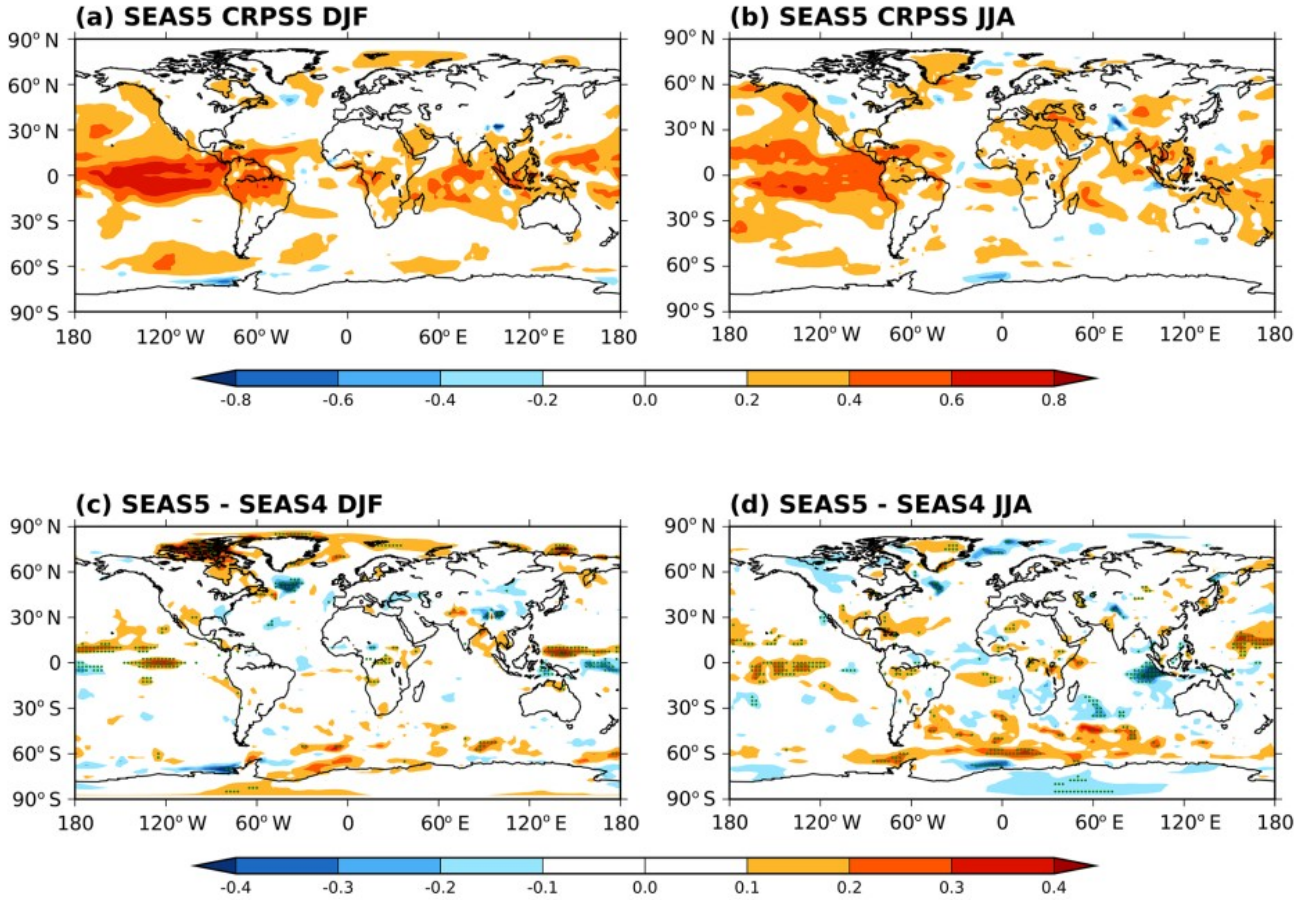
# SEAS5 Diagnostics: Extratropics - NAO



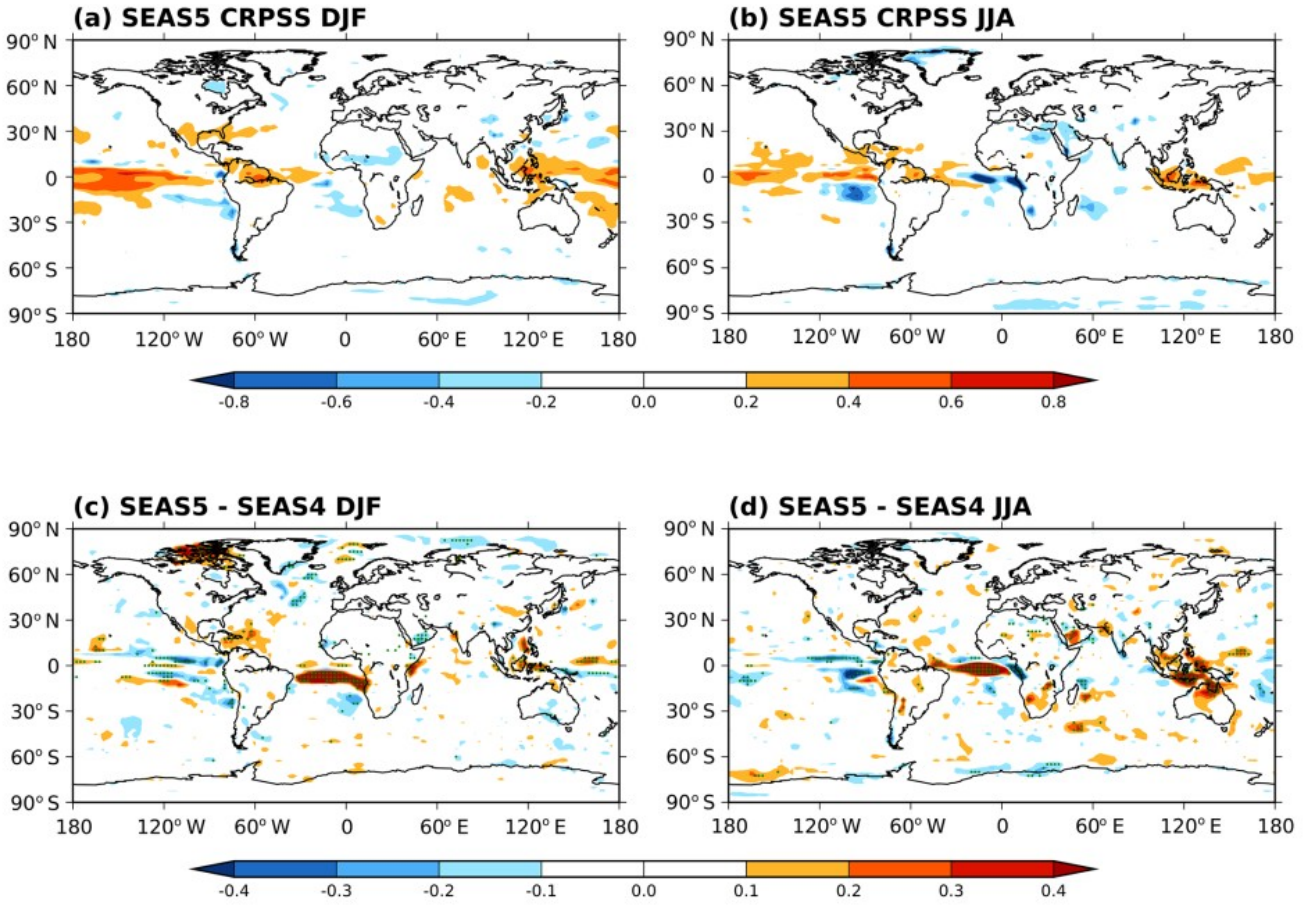
# SEAS5 Diagnostics: Extratropics - PNA



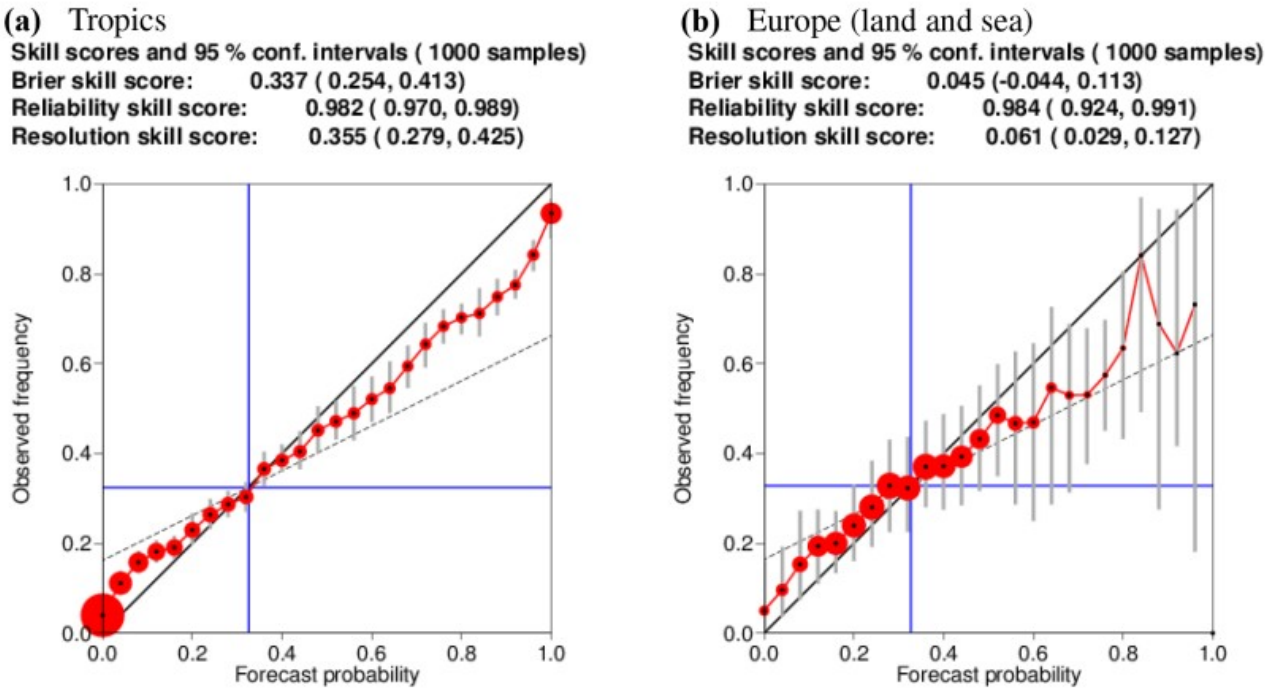
# SEAS5 Verification: CRPSS – 2m Temp



# SEAS5 Verification: CRPSS – Precip



# SEAS5 Verification: Reliability diagrams



# Conclusions

- Improvement in equatorial Pacific (ENSO)
- Sea-ice model → improvement in 2m temp
- EEIO variability is more than observed
  - Impacts teleconnections to this part
- Low skill for in IO in NH summer monsoon
- No decadal variability in the Atlantic
- Temperature biases in lwoer stratosphere
  - Could also impact teleconnections