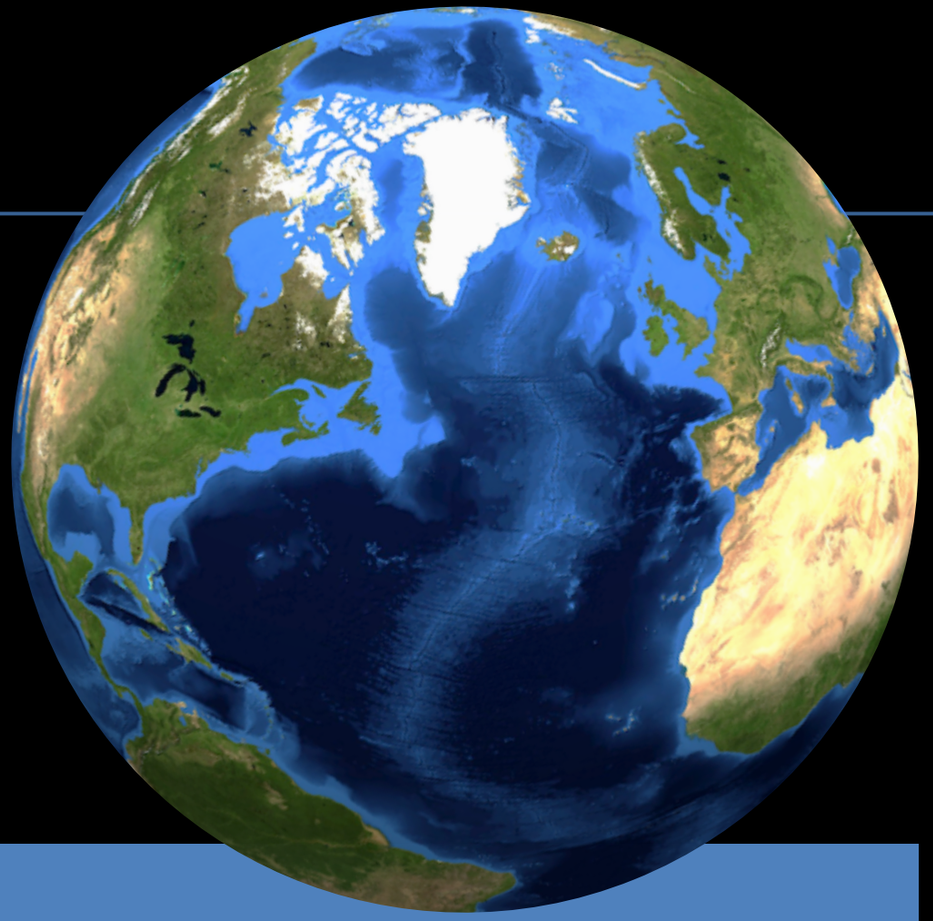
Origins of variability and predictability in the North Atlantic region



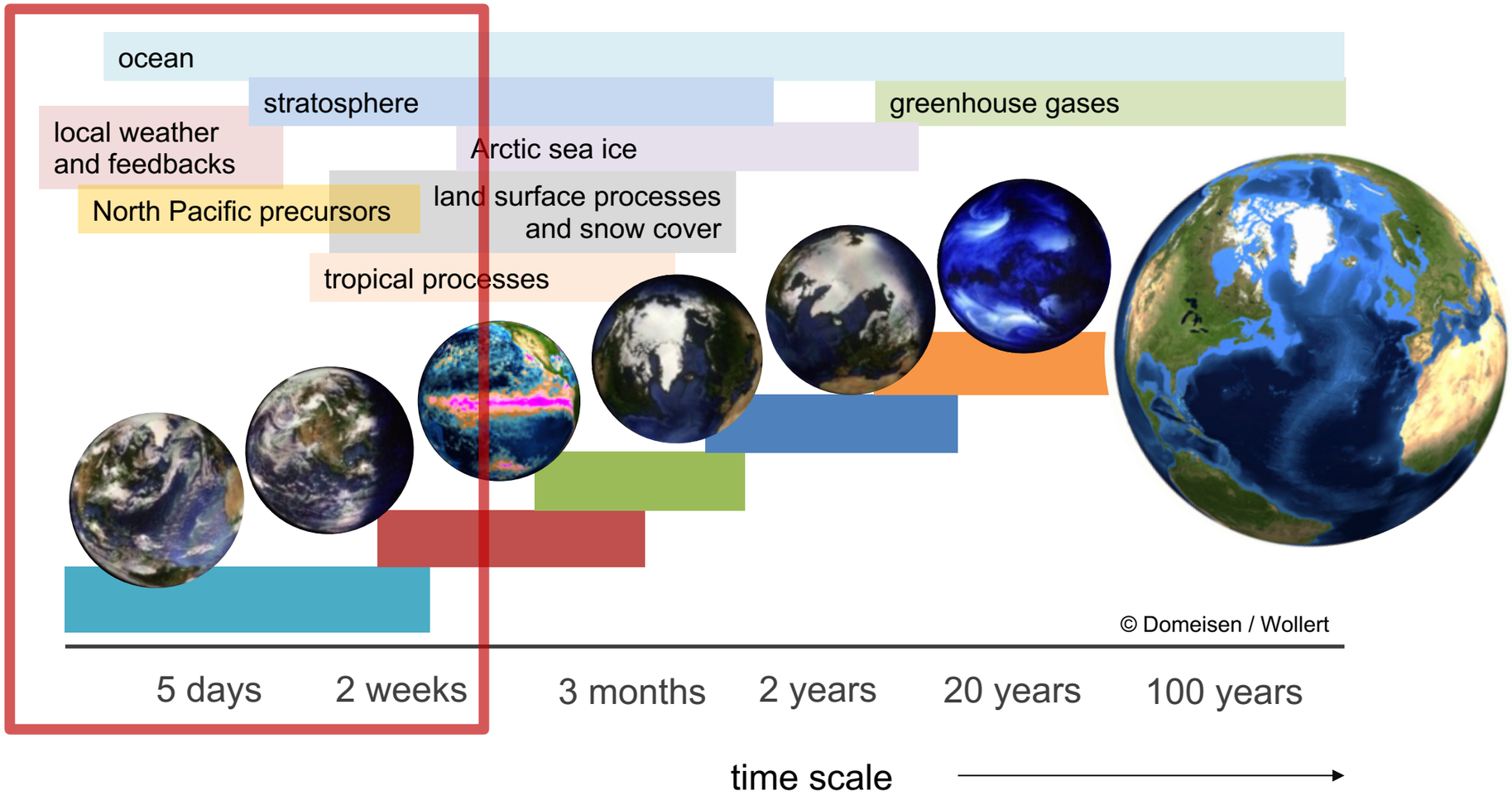
The North Atlantic region remains one of the most challenging regions on the globe for long-range predictions, likely due to the superposition of a wide range of non-stationary remote influences and local variability. Progress in understanding the interplay of these factors promises to lead to improved predictability. This contribution provides an overview of recent North Atlantic predictability research.

Daniela Domeisen

Atmospheric Predictability, ETH Zurich

ETH zürich

WHICH FACTORS DETERMINE VARIABILITY AND PREDICTABILITY OVER THE NORTH ATLANTIC REGION?



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DAYS TO WEEKS:
NAO: DETERMINISTIC PREDICTABILITY OF 2-3 WEEKS

Limited operational predictability beyond about 1 week

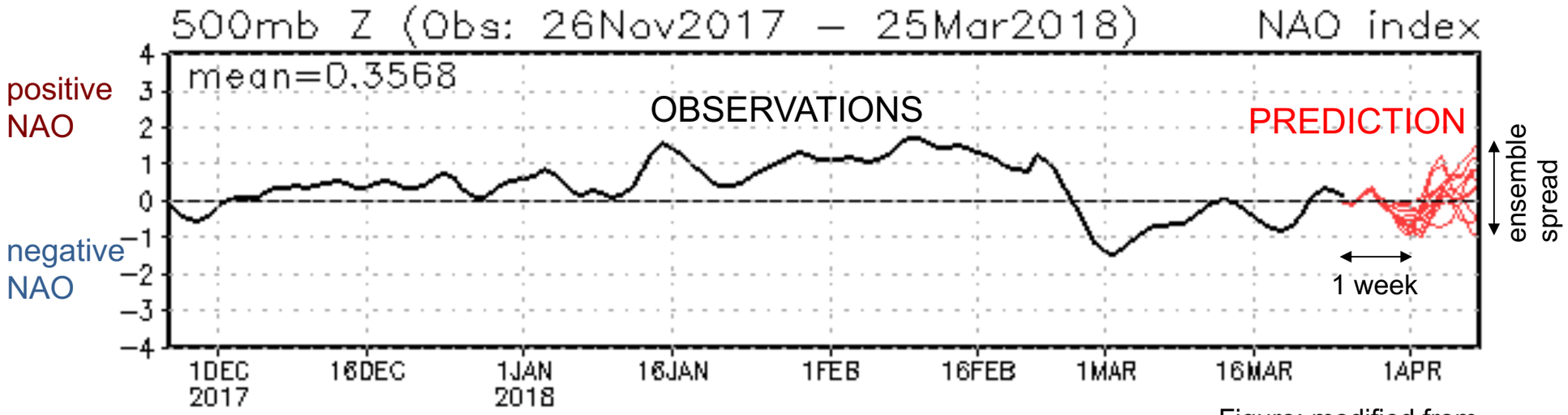

Figure: modified from cpc.ncep.noaa.gov

The theoretical prediction limit of the North Atlantic Oscillation lies at 2-3 weeks.
This is more predictable than numerical models tell us and reaches into sub-seasonal timescales.

Domeisen et al., 2018, JClim. http://doi.org/10.1175/JCLI-D-17-0226.1

also of interest: Zhang et al. (2019) JAS. https://doi.org/10.1175/JAS-D-18-0269.1

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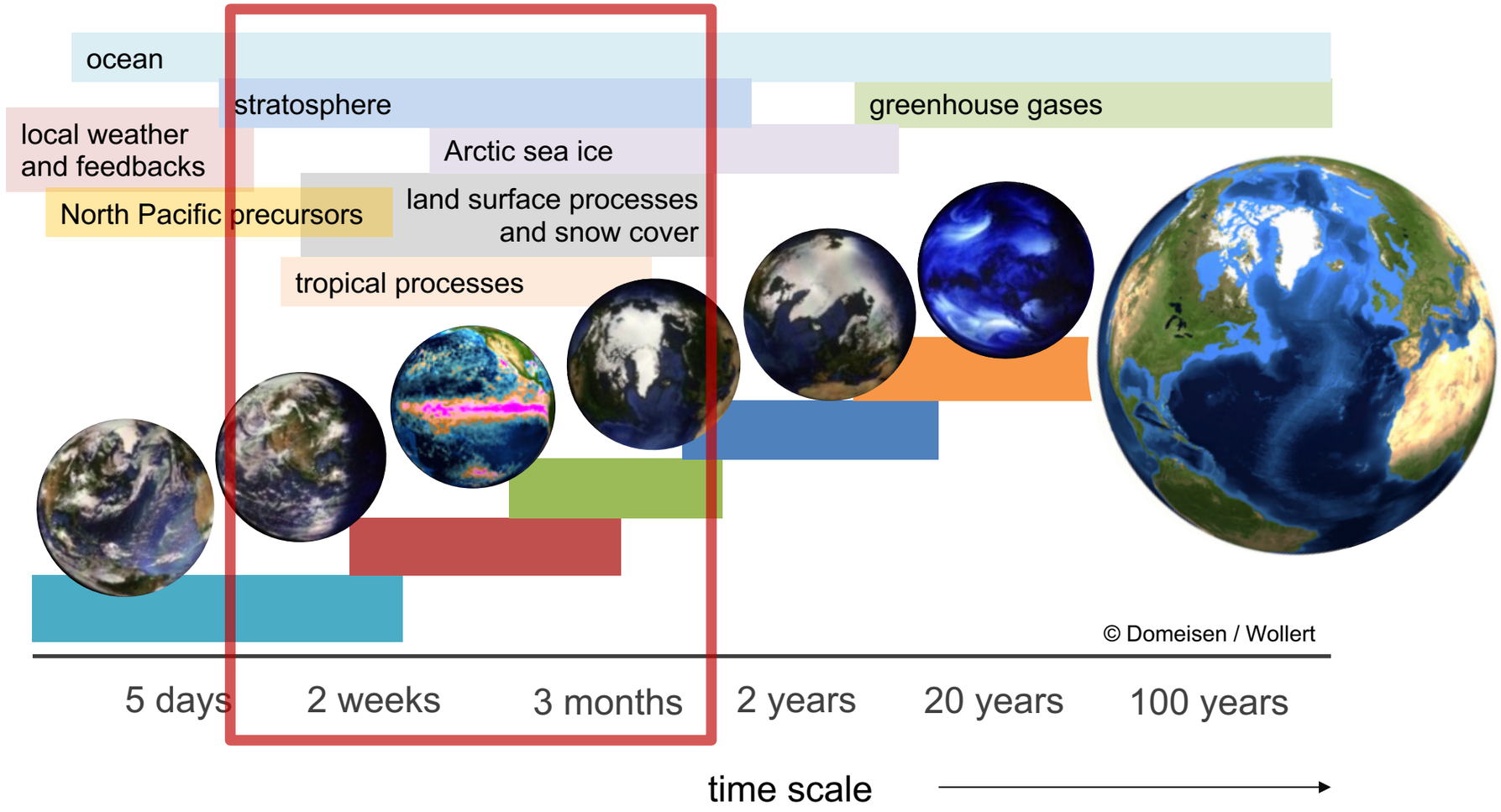

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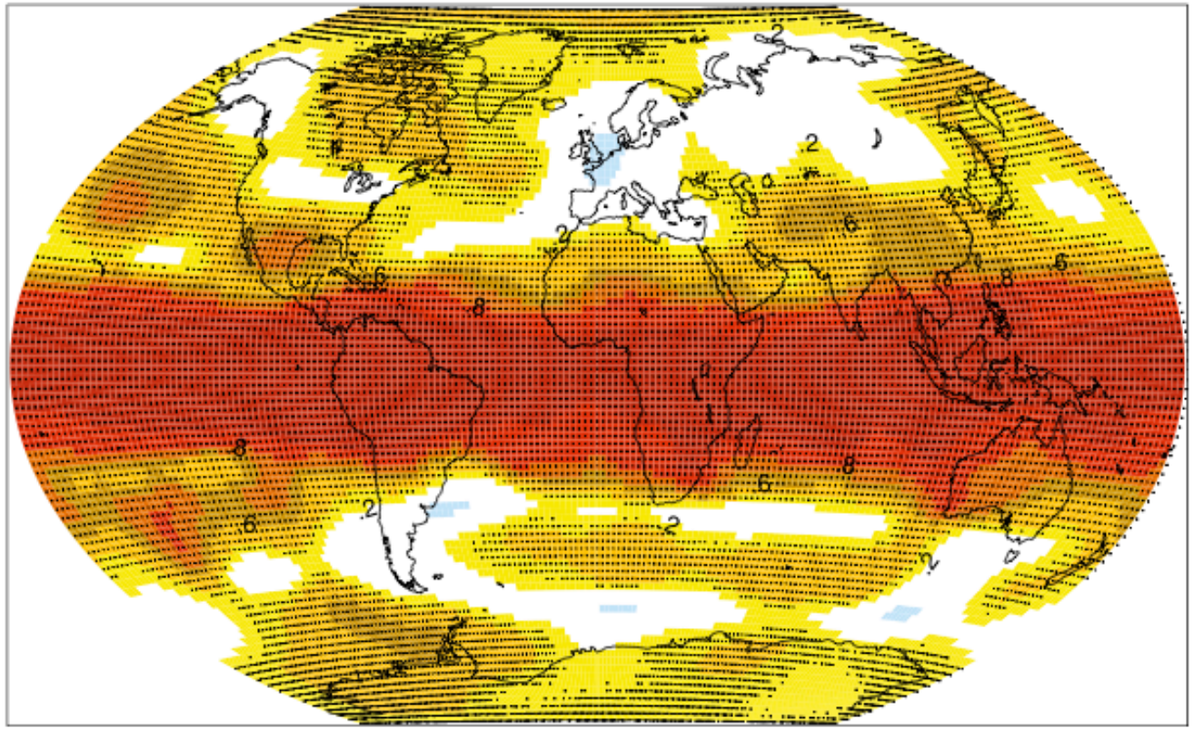
WEEKS TO MONTHS: LIMITED SEASONAL PREDICTABILITY OVER LARGE PARTS OF THE NORTH ATLANTIC / EUROPE

Prediction skill averaged for December – February 1981 - 2011

Model: Max-Planck-Institute Earth System Model (MPI-ESM-LR) [Baehr et al (2015). *Climate Dynamics*. http://doi.org/10.1007/s00382-014-2399-7]

Initialization: November



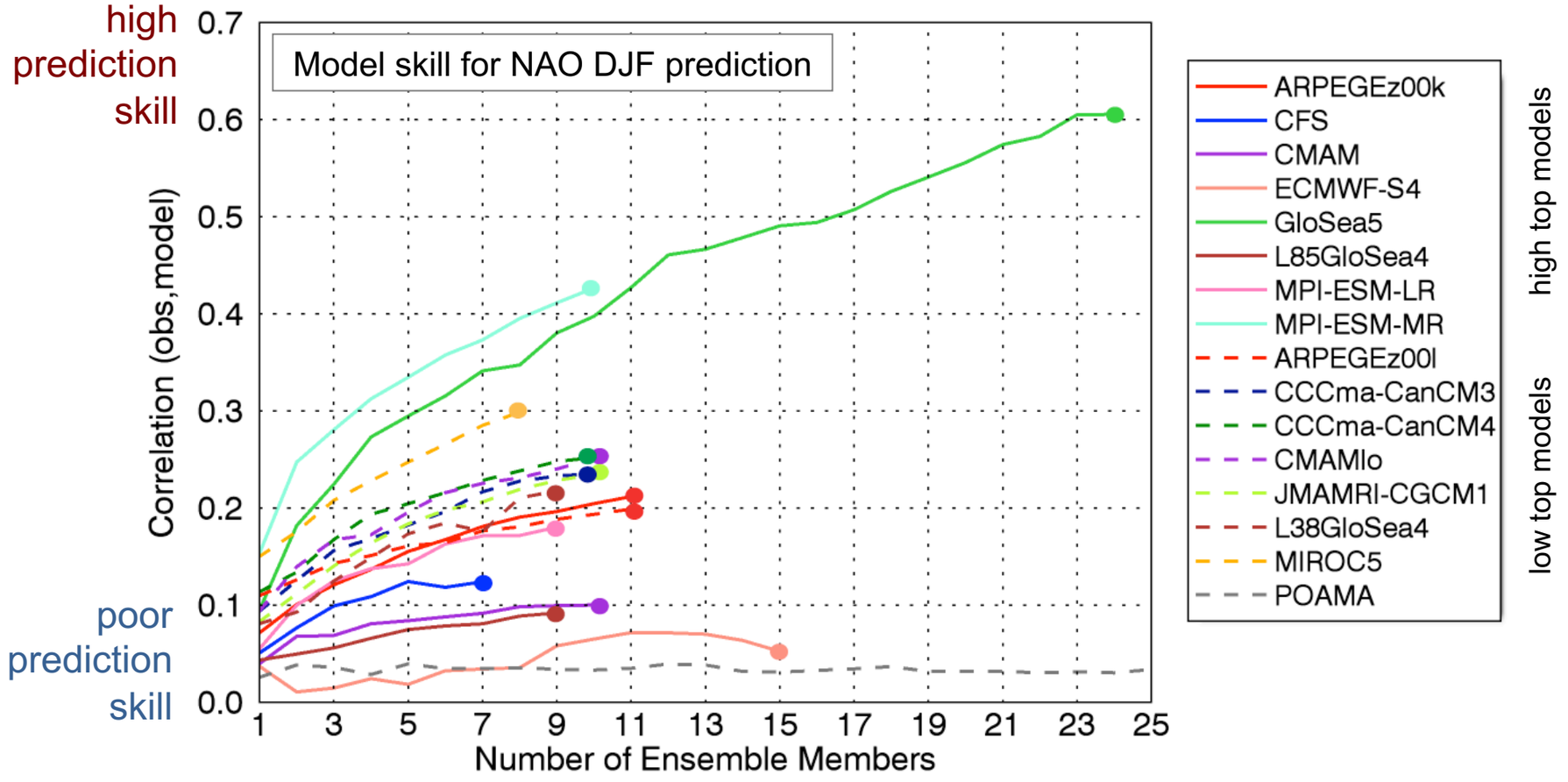
anomaly correlation coefficient

poor prediction skill

high prediction skill

Figure:
Domeisen et al., 2015, J.Climate
https://doi.org/10.1175/JCLI-D-14-00207.1

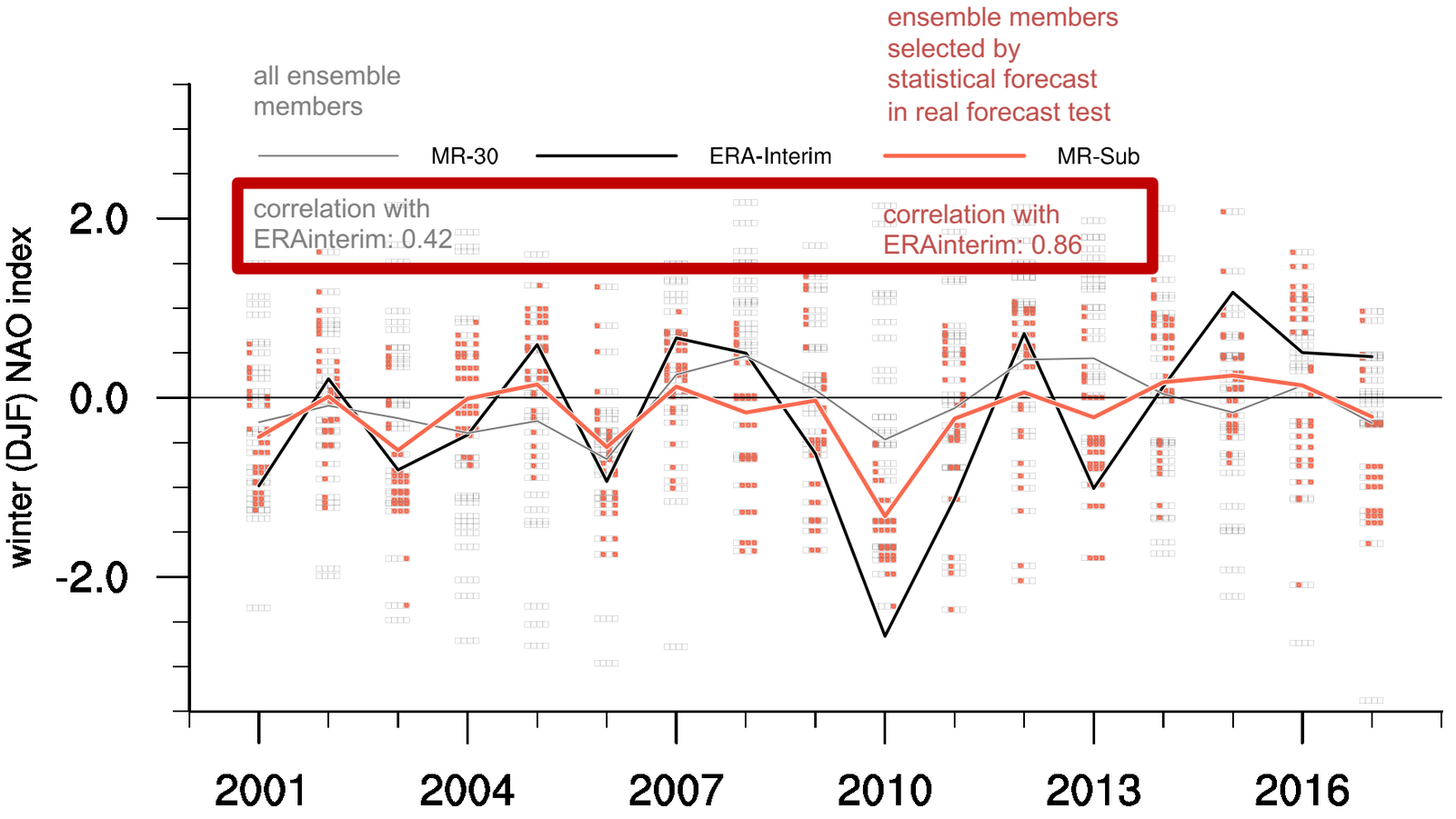
HOW PREDICTABLE IS THE NAO ON SEASONAL TIMESCALES?



Large inter-model spread in the seasonal predictability of the NAO. Strong dependence on the number of ensemble members of the prediction system.

Figure: modified from Butler et al (2016), QJRMS. http://doi.org/10.1002/qj.2743

COMBINING A STATISTICAL AND A DYNAMICAL FORECAST CAN DOUBLE PREDICTION SKILL



"Real" forecast test of the winter North Atlantic Oscillation (NAO) for the period from 2001 to 2017.
The correlations between the MR-30 (gray line), the MR-Sub ensemble mean NAO (red line), and the ERA-Interim NAO (black line) are 0.42 and 0.86, respectively (significant at the 99% confidence level).

The statistical forecast uses remote connections to improve predictability of the NAO.

Figure: Dobrynin et al (2018), GRL, http://doi.org/10.1002/2018GL077209

MPI-ESM prediction system: Baehr et al (2015). Climate Dynamics. http://doi.org/10.1007/s00382-014-2399-7

EXAMPLE FOR A REMOTE IMPACT ON THE NORTH ATLANTIC: EL NINO SOUTHERN OSCILLATION

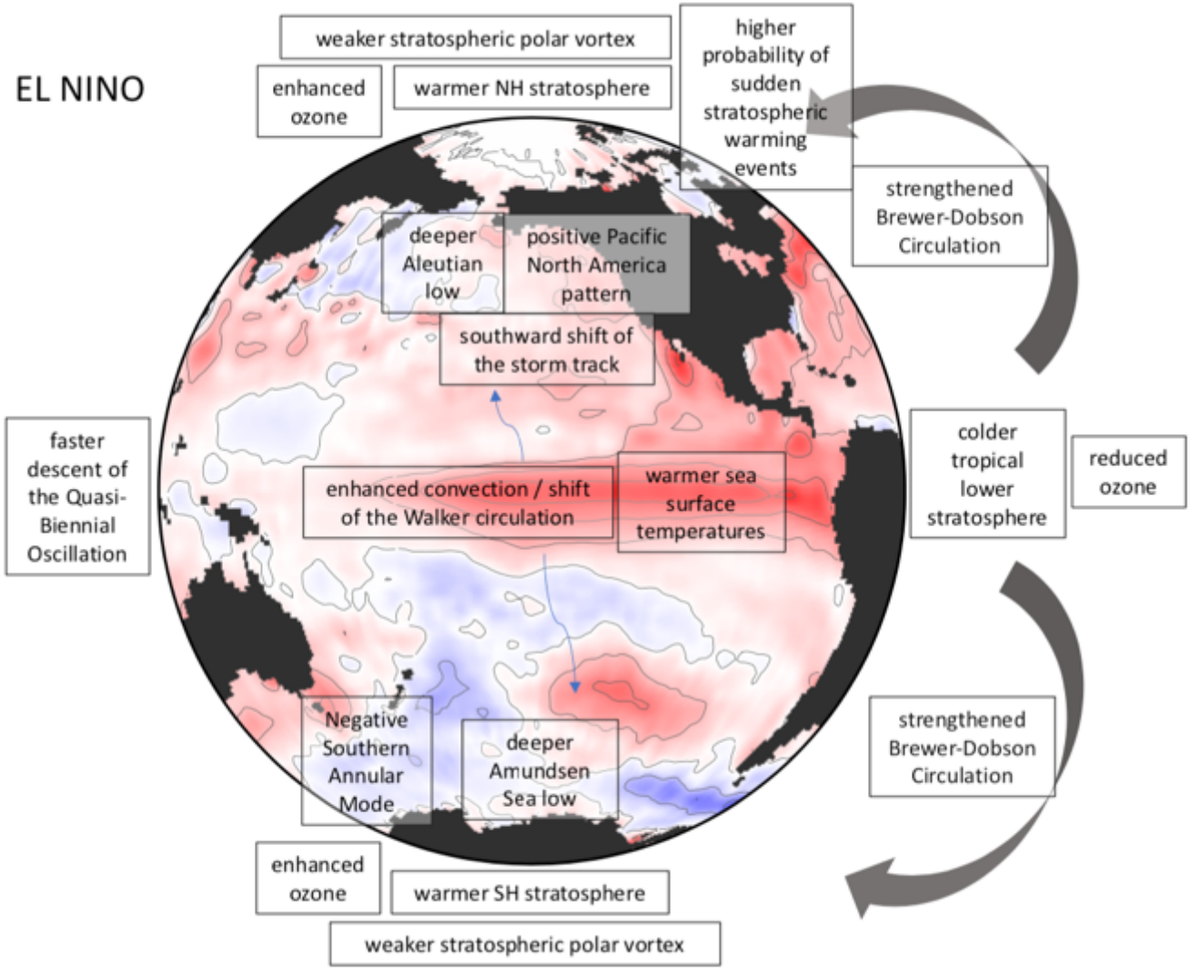
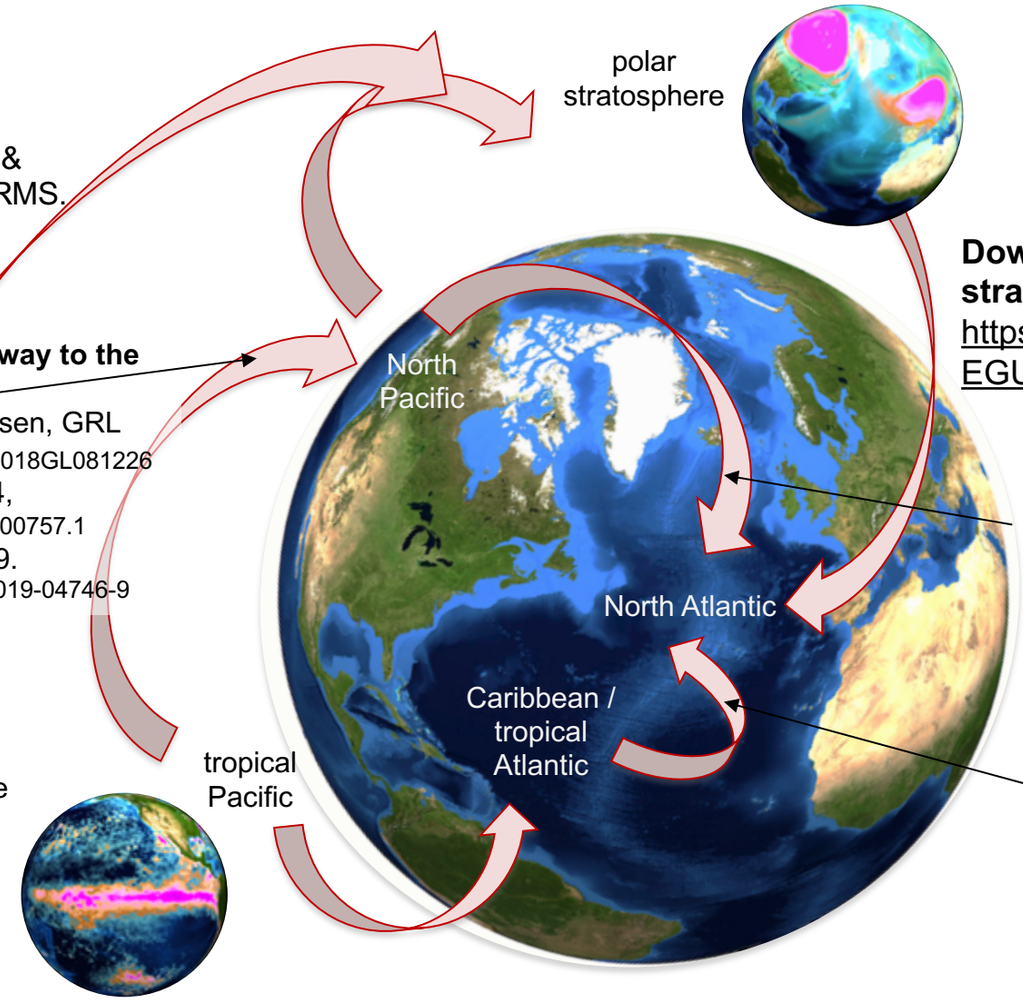


Fig.: Domeisen, Garfinkel, and Butler, Rev. Geophys., 2019. http://doi.org/10.1029/2018RG000596

HOW CAN REMOTE CONNECTIONS HELP WITH LONG-RANGE PREDICTION? DIFFERENT ENSO PATHWAYS

ENSO teleconnections to the North Atlantic exhibit many pathways that are superpositioned on each other.



QBO effects on extratropics: Anstey & Shepherd (2014), QJRMS. Gray et al., 2018

Nonlinearity in the pathway to the North Pacific:
Jiménez-Esteve & Domeisen, GRL 2019, http://doi.org/10.1029/2018GL081226
Frauen et al., JClim, 2014, http://doi.org/10.1175/jcli-d-13-00757.1
Bayr et al, Clim Dyn, 2019. http://doi.org/10.1007/s00382-019-04746-9

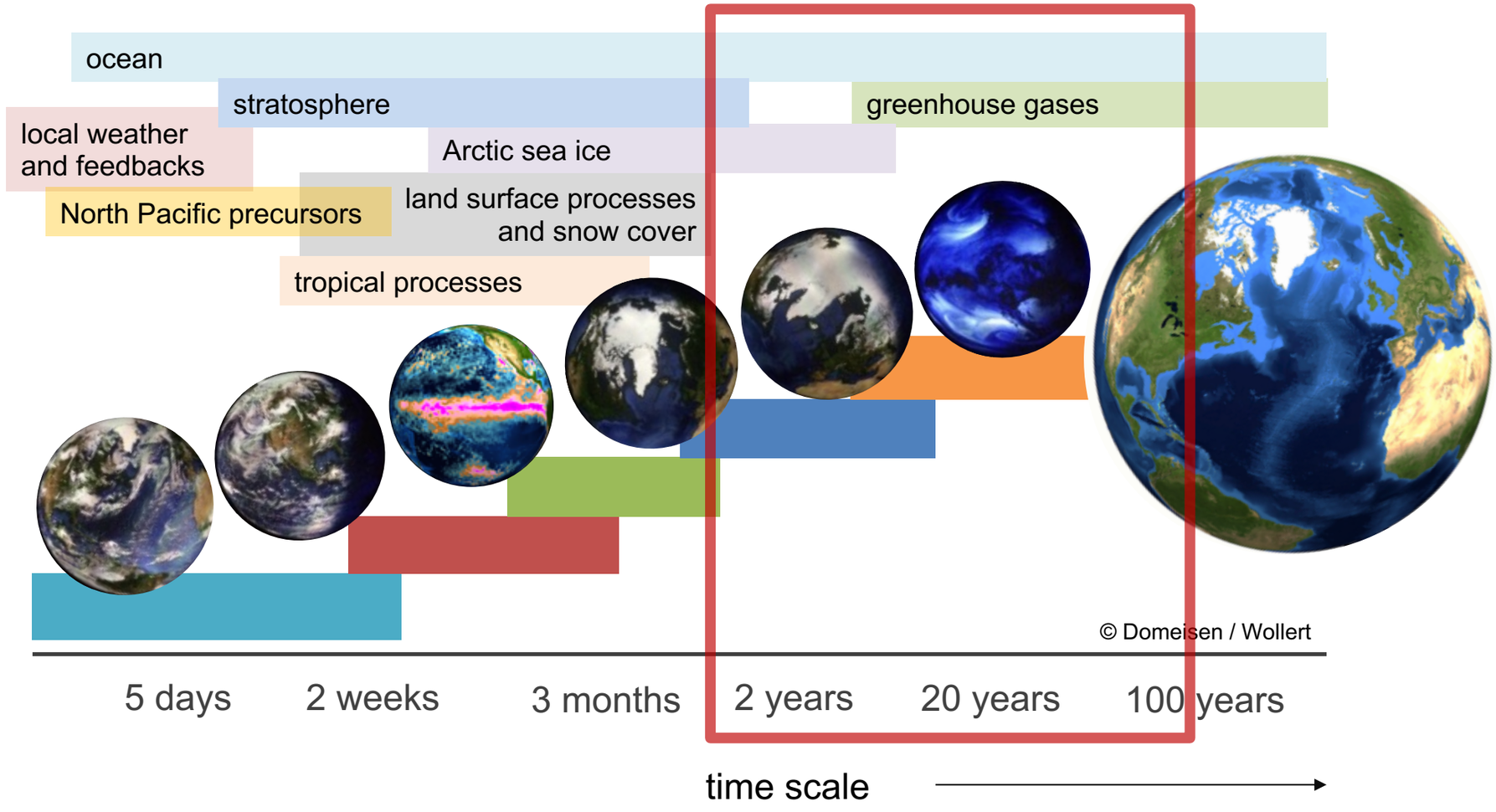
Downward impact from the stratosphere: EGU presentation https://meetingorganizer.copernicus.org/EGU2020/EGU2020-7862.html

The tropospheric pathway of ENSO to the North Atlantic:
Jiménez-Esteve & Domeisen, JClim 2018, http://doi.org/10.1175/JCLI-D-17-0716.1
Jiménez-Esteve & Domeisen, WCD, 2020, http://doi.org/10.5194/wcd-2019-18

Pathway through the tropical Atlantic:
Wulff et al, GRL 2017, http://doi.org/10.1002/2017GL075493
Lopez-Parages et al, Clim Dyn, 2015a,b http://doi.org/10.1007/s00382-015-2951-0
Neddermann et al, Clim Dyn, 2019, http://doi.org/10.1007/s00382-019-04678-4

See also:
Ineson & Scaife, 2009
Butler & Polvani, 2011 GRL
Garfinkel & Hartmann, 2010
Garfinkel et al., 2018
Gray et al., ACP, 2018
Bell et al. 2009
Li & Lau, 2013
Domeisen et al. 2015
Butler et al. 2016
Iza et al. 2016

WHICH FACTORS DETERMINE VARIABILITY AND PREDICTABILITY OVER THE NORTH ATLANTIC REGION?



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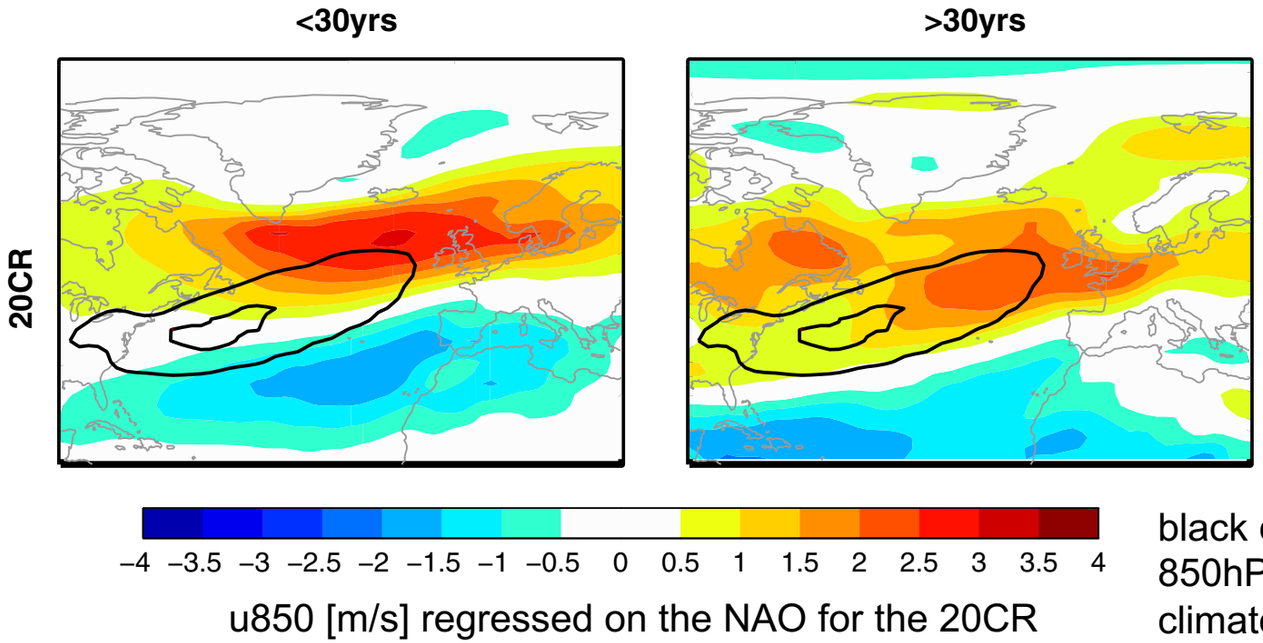
YEARS TO DECADES: DECADAL VARIABILITY



The type of North Atlantic variability varies depending on the considered timescale.

black contours: 850hPa wind climatology

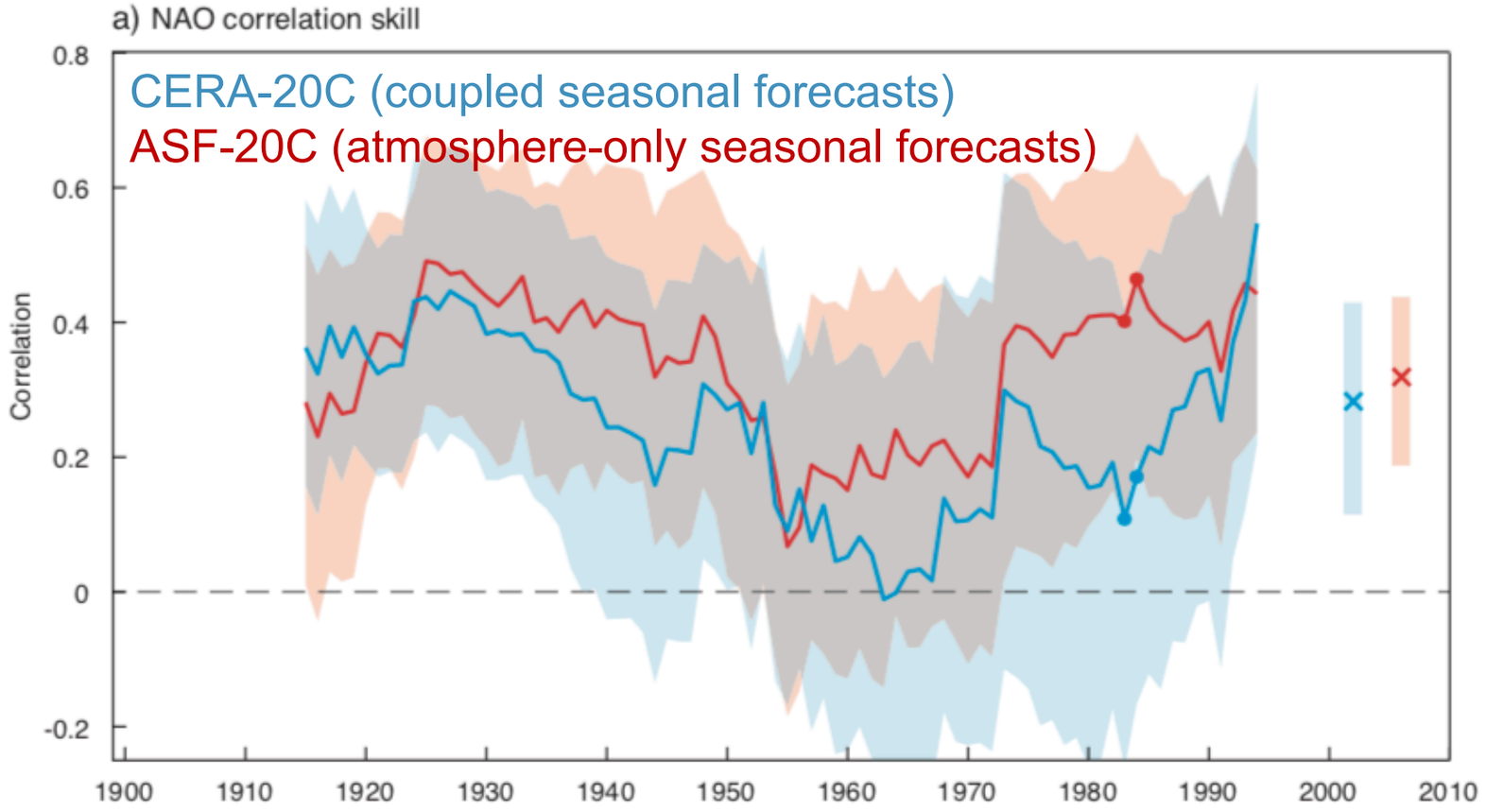
interannual-decadal timescale:
variations in latitude of storm track / jet

multi-decadal timescale:
variations in strength of the storm track / jet

Figure: Woollings et al, 2014, ClimDyn. http://doi.org/10.1007/s00382-014-2237-y

see also: Woollings et al., 2018, JClim

THERE IS STRONG DECADAL VARIABILITY IN NAO PREDICTION SKILL



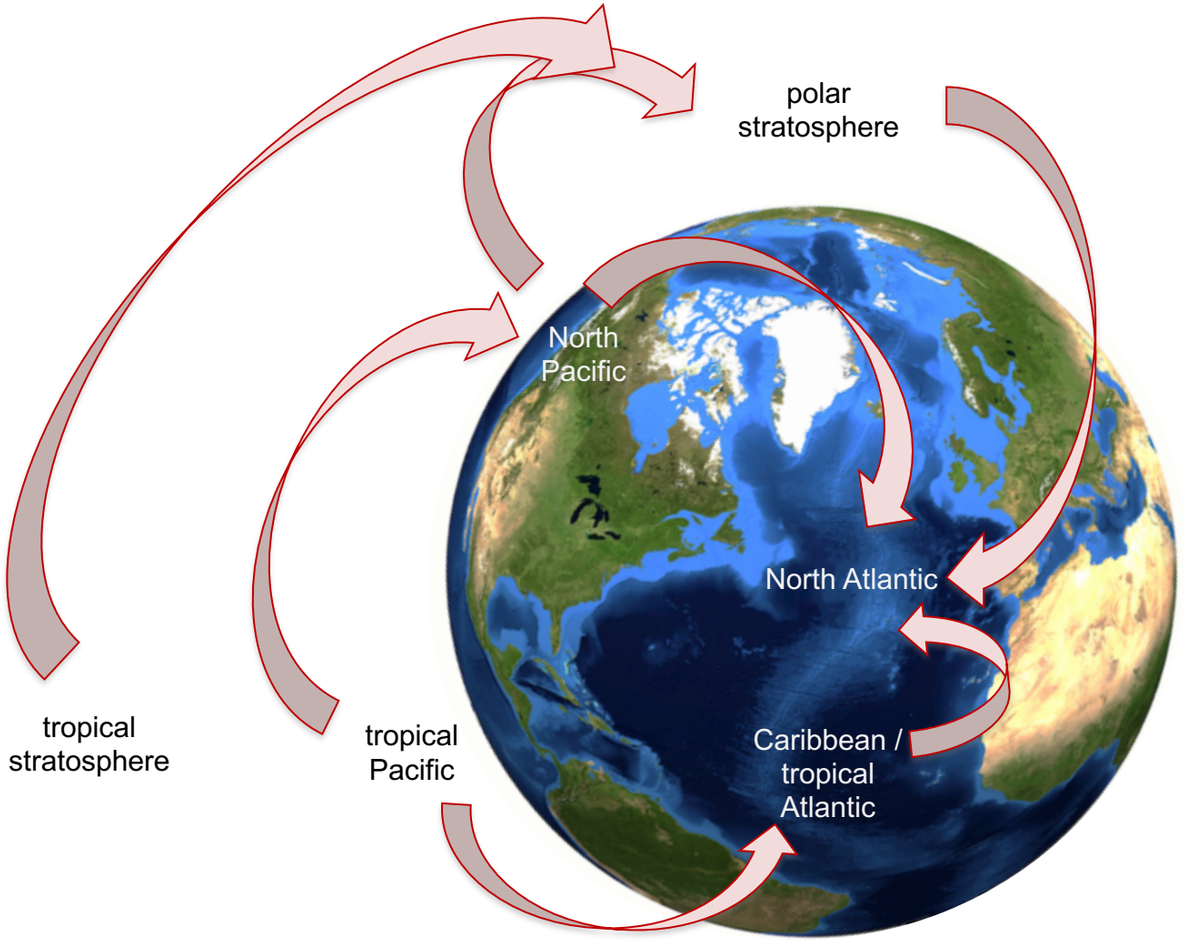
Forecast skill of the DJF NAO. Forecasts initialised in November. 30-year moving window correlation coefficients of the hindcast ensemble mean with CERA-20C. Shading indicates the 5-95% confidence intervals. Correlations for each 30- year window are plotted at the central year. Bars on the right show correlations and confidence intervals over the full hindcast period 1901-2009.

What is the origin of this decadal variability? Might remote connections be involved?

Figure: Weisheimer et al (2020). *BAMS*. http://doi.org/10.1175/BAMS-D-19-0019.1

Also of interest: Weisheimer et al (2018). *QJRMS.* http://doi.org/10.1002/qj.3446

SUMMARY

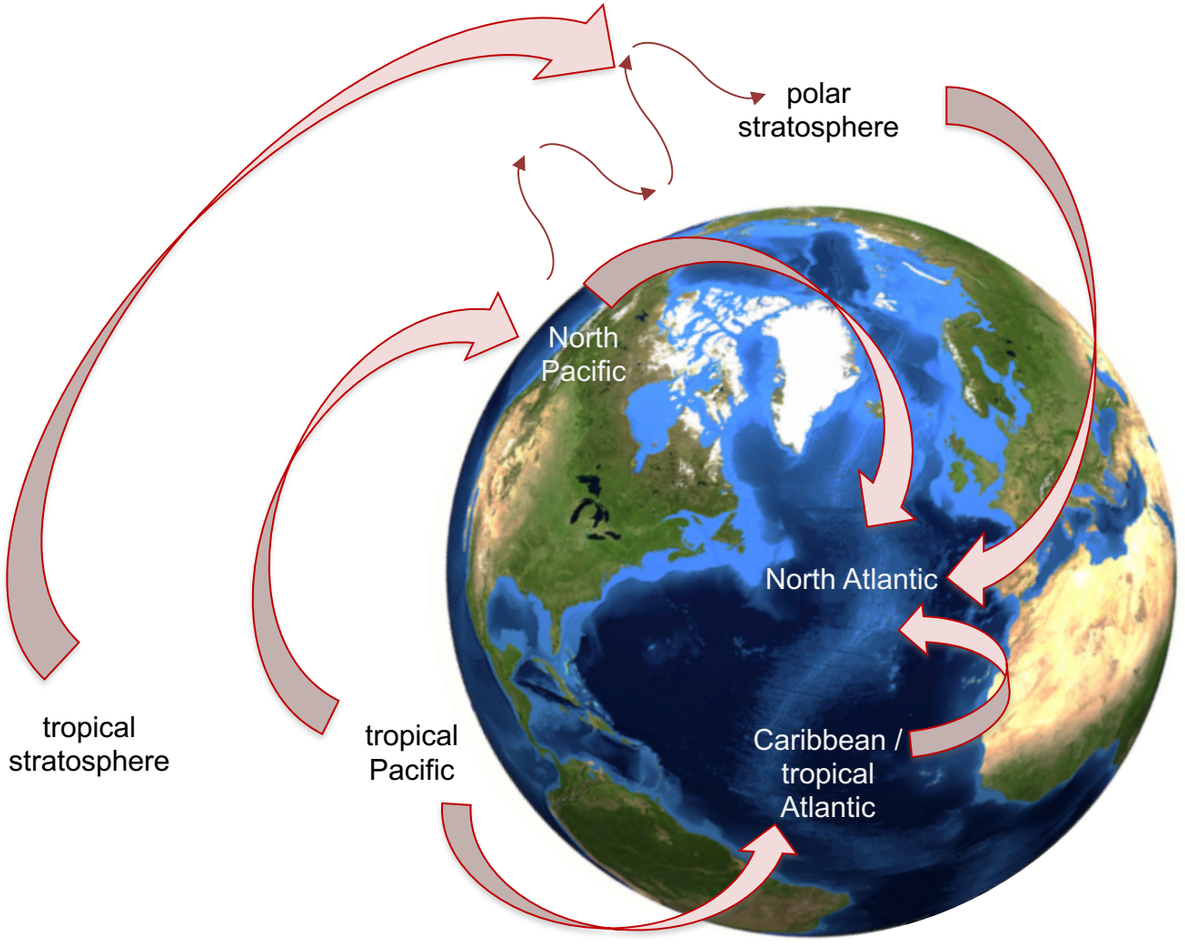


The remote connections in the climate system can be used for long-range prediction.

There are however some challenges:

a range of different drivers and remote effects

SUMMARY



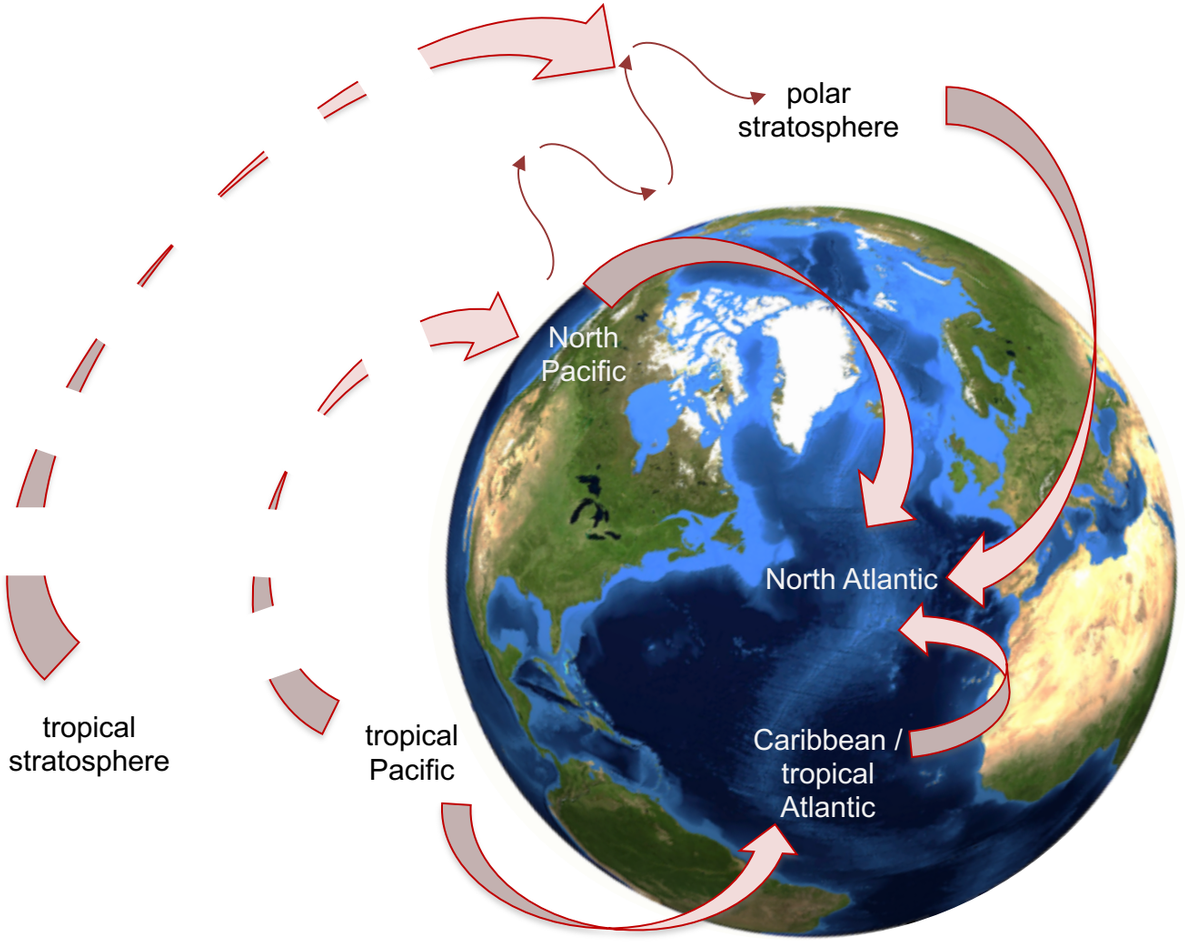
The remote connections in the climate system can be used for long-range prediction.

There are however some challenges:

a range of different drivers and remote effects

non-linearity: a stronger forcing does not necessarily yield a stronger impact, and vice versa

SUMMARY



The remote connections in the climate system can be used for long-range prediction.

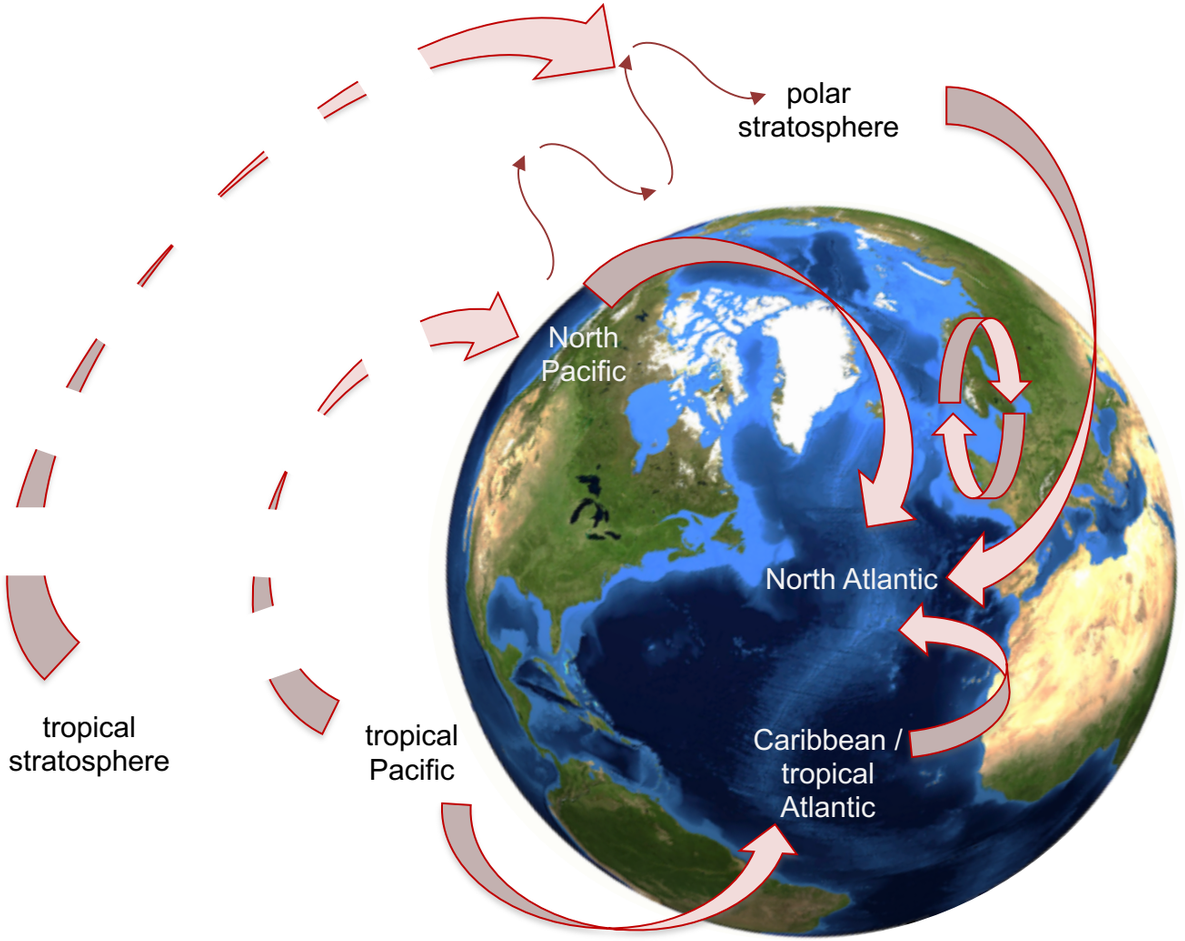
There are however some challenges:

a range of different drivers and remote effects

non-linearity

non-stationarity: not all pathways are always active

SUMMARY



The remote connections in the climate system can be used for long-range prediction.

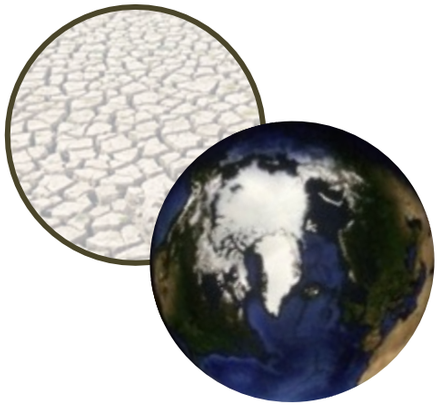
There are however some challenges:

a range of different drivers and remote effects

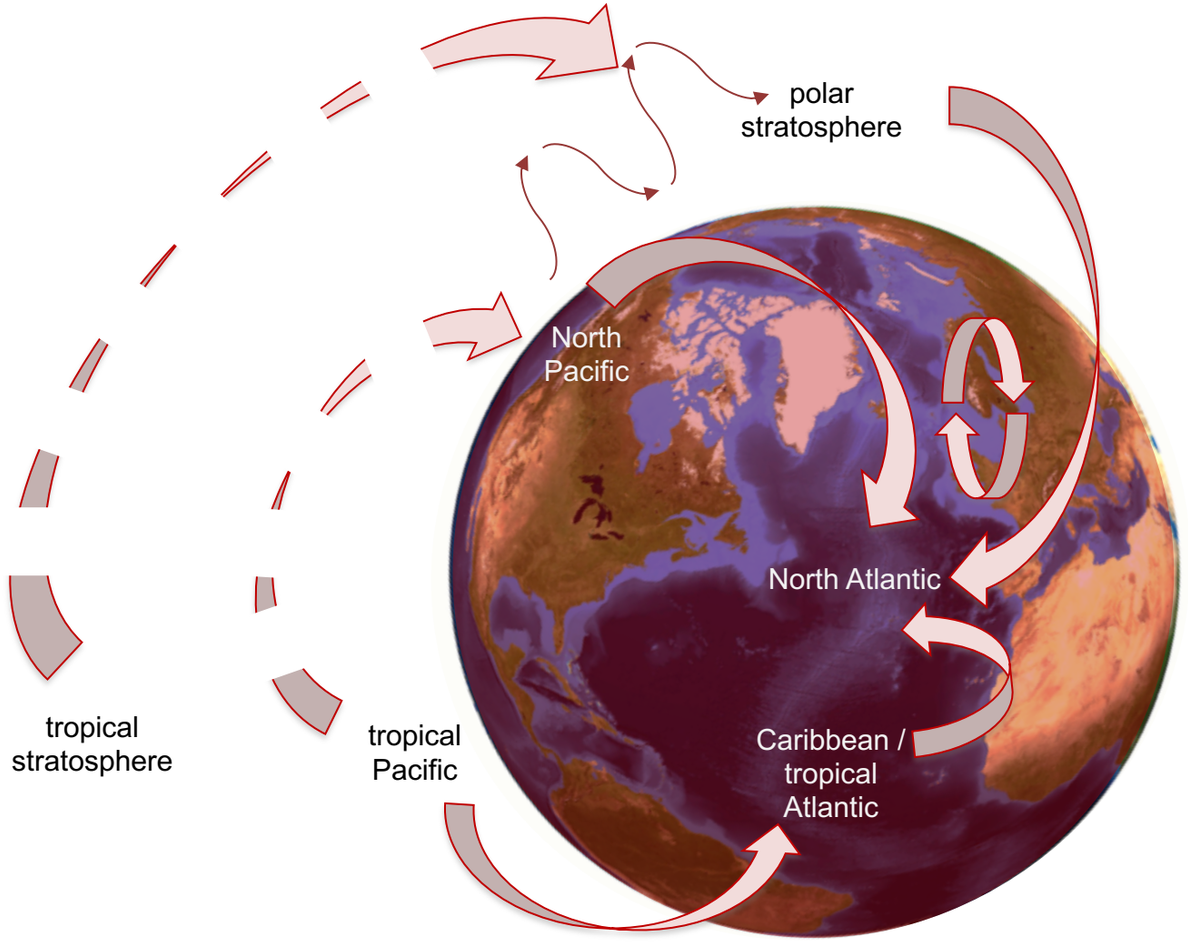
non-linearity

non-stationarity

local feedbacks



SUMMARY



The remote connections in the climate system can be used for long-range prediction.

There are however some challenges:

a range of different drivers and remote effects

non-linearity

non-stationarity

local feedbacks

climate change