The timescale-dependent response to increased ocean model resolution in IFS

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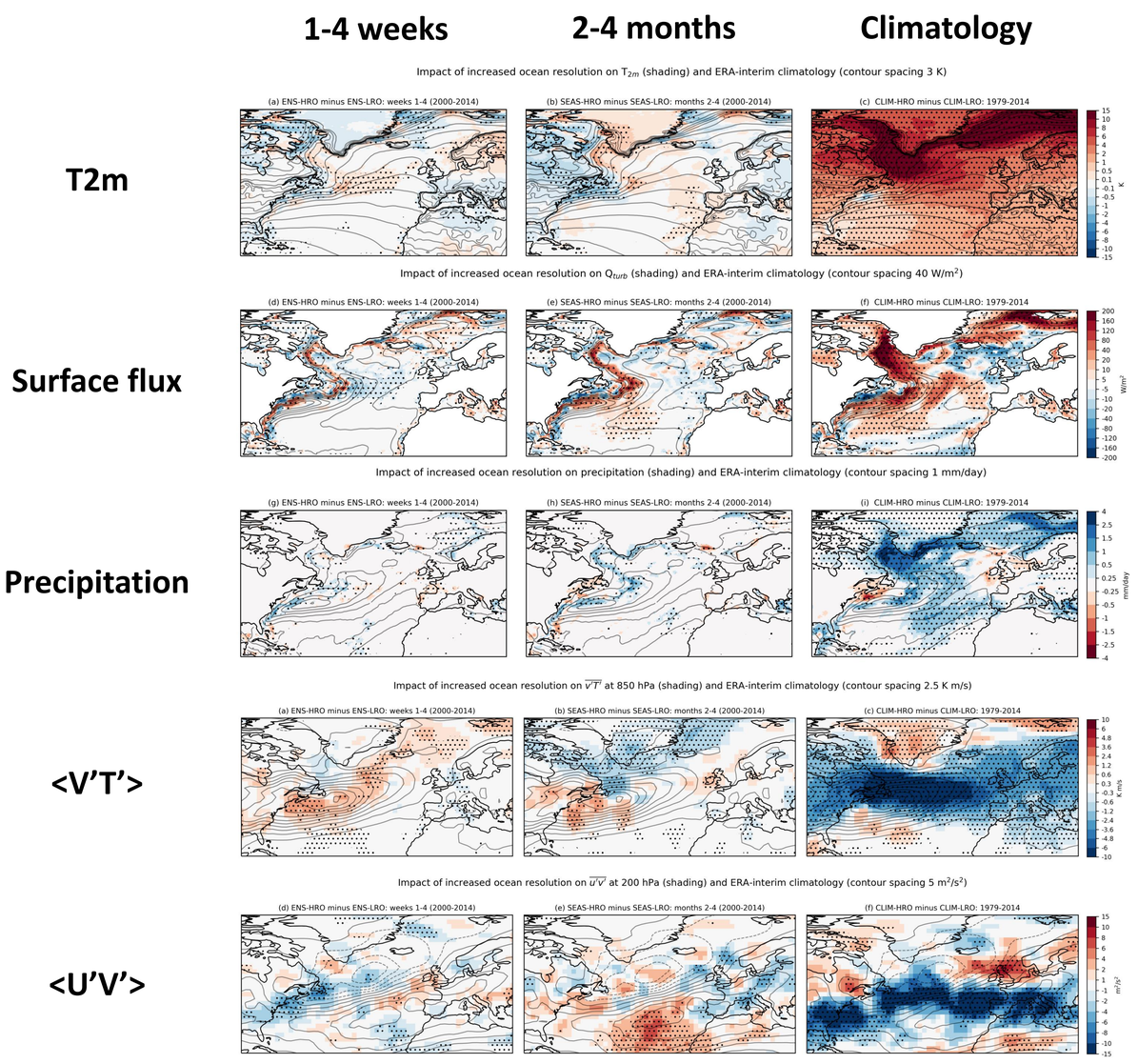
Summary

This study uses initialized forecasts and climate integrations to evaluate the wintertime North Atlantic response to an increase of ocean model resolution from ~100 km (LRO) to ~25 km (HRO) in the European Centre for Medium-Range Weather Forecasts Integrated Forecasting System (ECMWF-IFS).

- The simulated impacts are timescale-dependent such that impacts in subseasonal and seasonal forecasts cannot be extrapolated to climate timescales.
- In general, mean biases are reduced in HRO relative to LRO configurations and the impact is increased at longer lead times.
- At subseasonal to seasonal lead times, surface heating anomalies over the Gulf Stream are associated with local increases to the poleward heat flux associated with transient eddies.
- In contrast, surface heating anomalies in climate experiments are balanced by changes to the time-mean surface winds that resemble the steady response under linear dynamics (see references for details).
- Some aspects of air-sea interaction exhibit a clear improvement with increased resolution at all lead times. However, it is difficult to identify the impact of increased ocean eddy activity in the variability of the overlying atmosphere (see references for details).
- In particular, atmospheric blocking and the intensity of the storm track respond more strongly to mean biases and thus have a larger response at longer lead times (see references for details).
- Increased ocean resolution drives improvements to subseasonal predictability over Europe. Increase in skill is a result of improvements to the Madden Julian Oscillation and its associated teleconnections rather than changes to air-sea interaction in the North Atlantic region.

Mean atmospheric response (DJF)

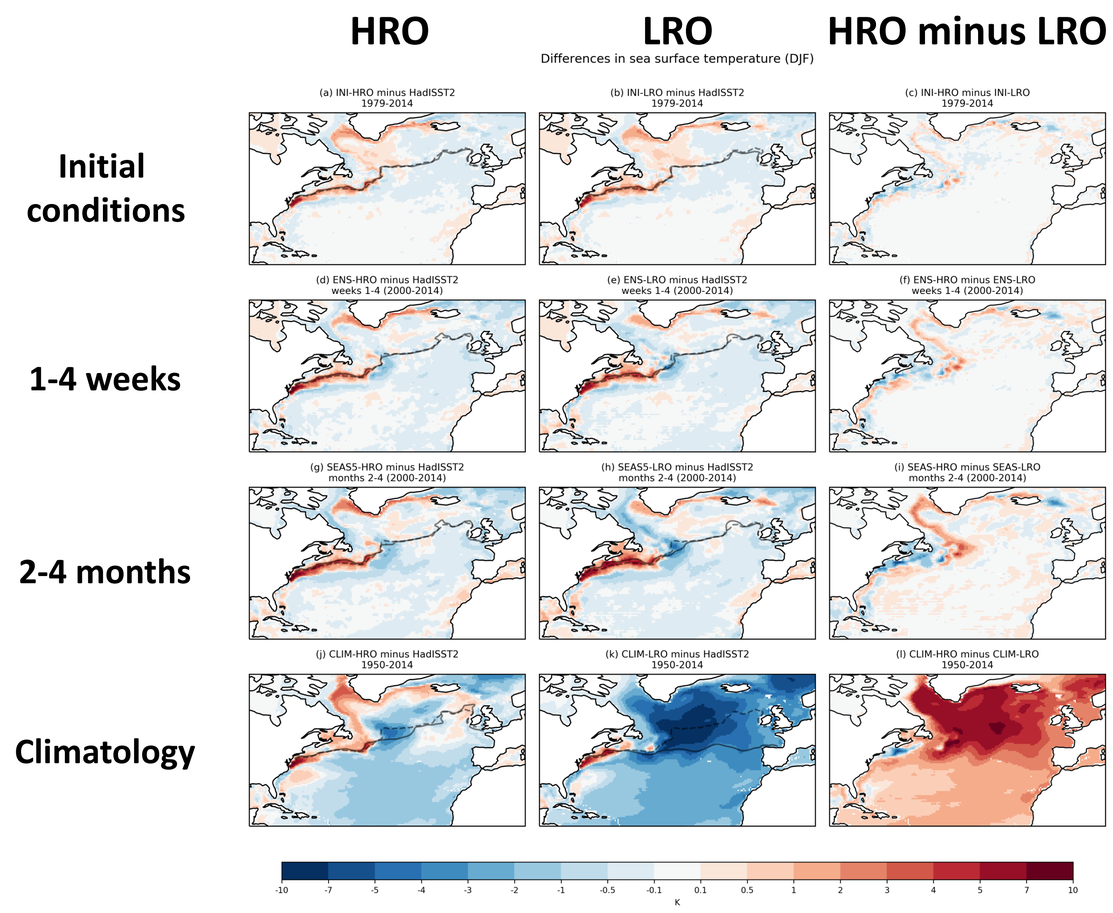


Coupled IFS configurations

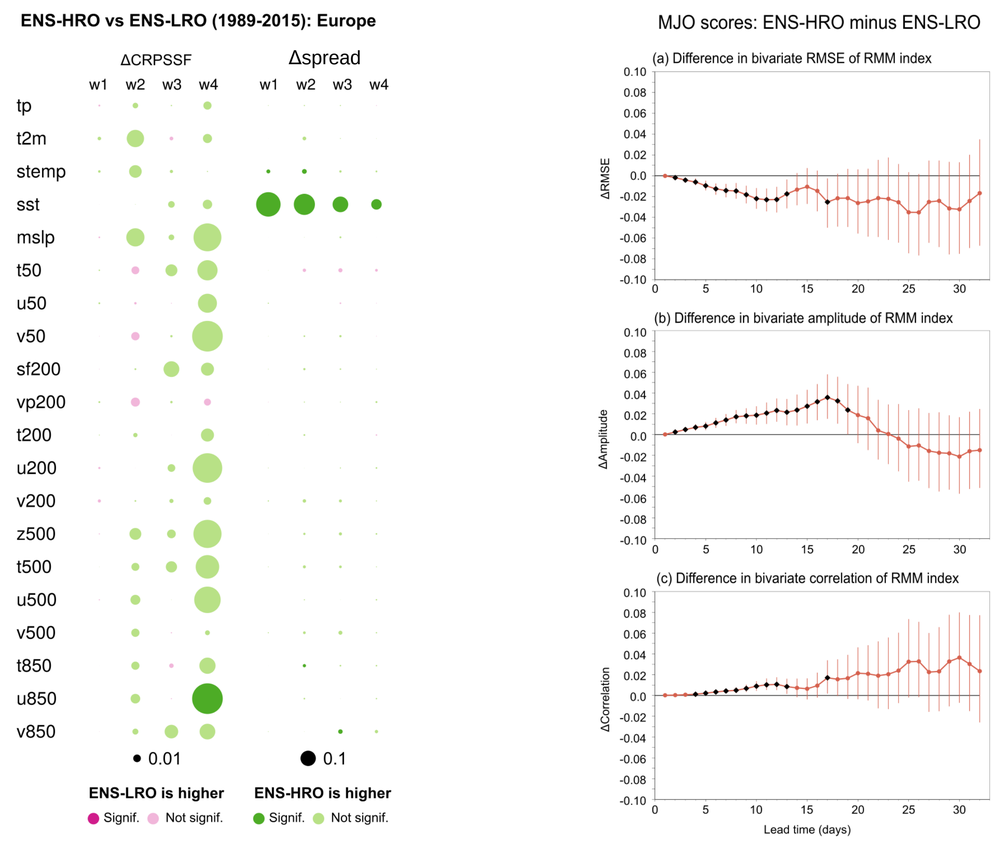
Name	Type	Members	Period	Reforecasts per year	Atm. res.	Ocean res.
INI-LRO	Ocean/sea-ice analysis	5	1979-2016			~100 km
INI-HRO	Ocean/sea-ice analysis	5	1979-2016			~25 km
CLIM-LRO	Climate simulation	1	1950-2014		~50 km	~100 km
CLIM-HRO	Climate simulation	1	1950-2014		~50 km	~25 km
CLIM-HRO-HRA	Climate simulation	1	1950-2014		~25 km	~25 km
ENS-LRO	Subseasonal ensemble reforecast	5	1989-2016	12 × 32 days	~31 km	~100 km
ENS-HRO	Subseasonal ensemble reforecast	5	1989-2016	12 × 32 days	~31 km	~25 km
SEAS-LRO	Seasonal ensemble reforecast	5	1981-2016	2 × 7 months	~31 km	~100 km
SEAS-HRO	Seasonal ensemble reforecast	5	1981-2016	2 × 7 months	~31 km	~25 km

North Atlantic SST biases vs lead time

- HRO and LRO configurations have very different climatological SST biases in the North Atlantic.
- However, at subseasonal lead times, SST biases are very similar and in part inherited from the ocean initial conditions.
- Improved ocean initial conditions with reduced SST biases and more realistic Gulf Stream will have a direct impact on subseasonal forecasts.



Subseasonal predictability over Europe



References

- Roberts et al (2018). Climate model configurations of the ECMWF Integrated Forecasting System (ECMWF-IFS cycle 43r1) for HighResMIP. Geoscientific model development, 11(9), 3681-3712.
- Roberts et al. (in review). The timescale-dependent response of the wintertime North Atlantic to increased ocean model resolution in a coupled forecast model. *Submitted to* Journal of Climate.