Intra-seasonal and Seasonal Variability of the Northern Hemisphere Extra-tropics

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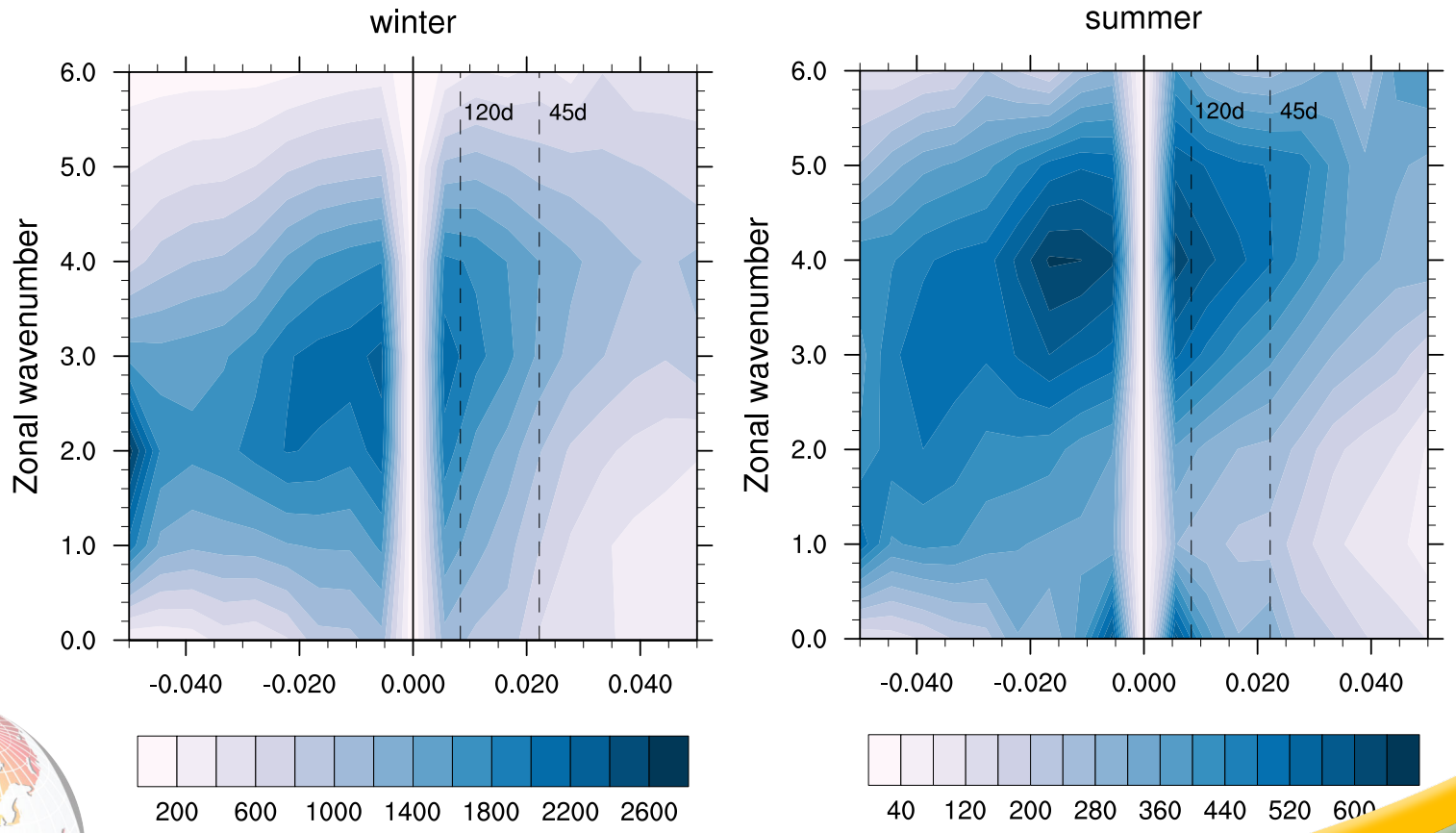
Sub-seasonal to Seasonal variability of the NH Extra-tropics (30-70°N)



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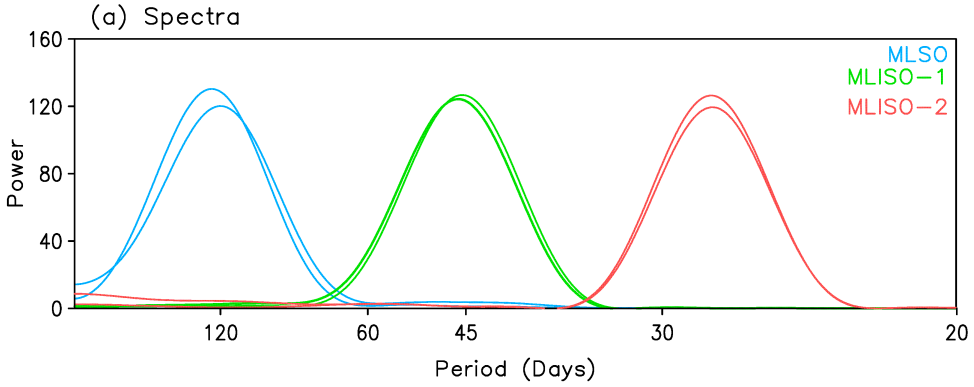


Plaut and Vautard, 1993 (MSSA):
122-day: 3rd harmonic of the annual cycle
70-day: fluctuations of Atlantic jet
40-45 days: Pacific sector
30-35 days: a harmonic of 70-day mode

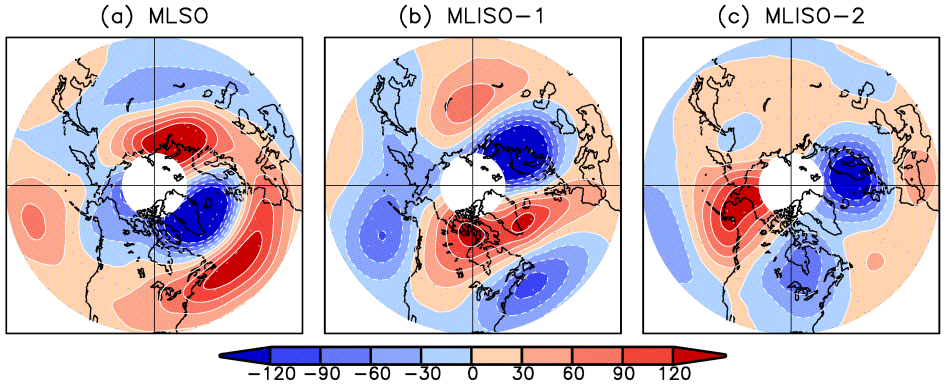
Data adaptive method, **M**ulti-channel **S**ingular **S**pectral **A**nalysis (MSSA; e.g., Ghil et al. 2002) applied to 500-hPa geopotential height daily anomalies between 1979-2012:

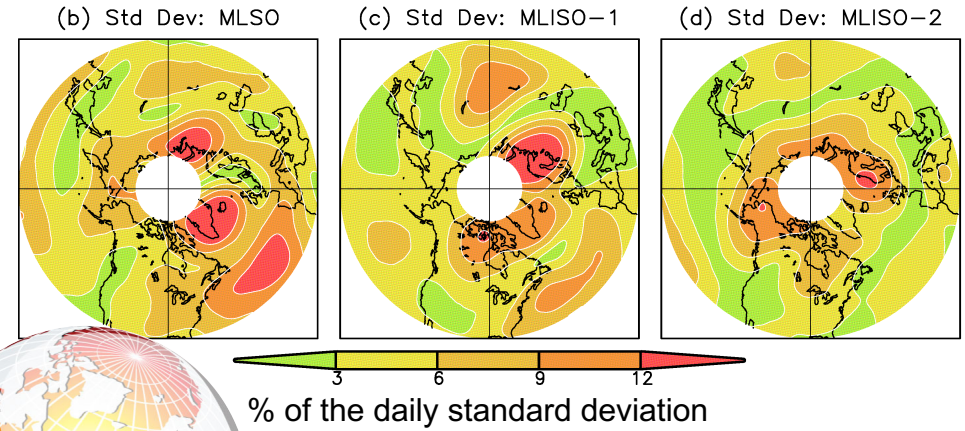
- MLSO – 120 days
- MLISO-1 – 45 days
- MLISO-2 – 28 days

Stan and Krishnamurthy, 2019

Ghil and Mo, 1991 (SSA):
48-day and 23-day global modes

Oscillation Patterns





Global patterns with regional center of action:

MLSO

- Zonally elongated North Atlantic dipole -> anom over Eurasia and N Pacific

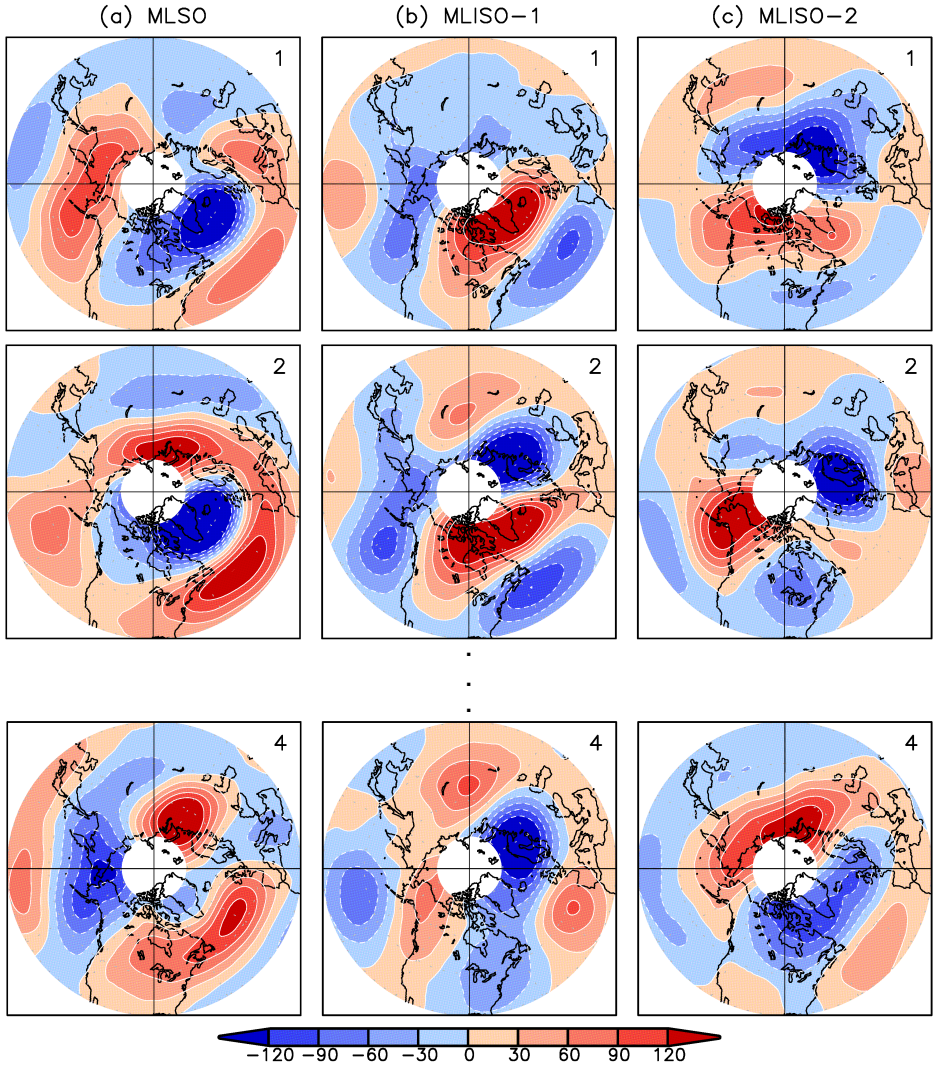
MLISO-1

- N Pacific and N Atlantic oriented in NW-SE direction

MLISO-2

- Tripole pattern with same sign centers over N Europe and E Canada and opposite sign over Alaska

Propagation Characteristics



Oscillation	Phase speed E-W direction	N-S direction
MLSO	• 3-4m/s westward of 120°W mid-lat • standing high-lats	• northward over N Atl and N America
MLISO-1	• 3m/s mid-lats • 10-12m/s high-lats	• standing
MLISO-2	• 20m/s high-lats • standing mid-lats	• northward over N Atlantic • standing over N America

Potential Predictability of Mid-latitude Oscillations

- Linear regression model (Rodney et al. 2013):

Predictors:
- RMM1(0), RMM1(0)
- RMM1(-1), RMM2(-1)
- T2m(0)

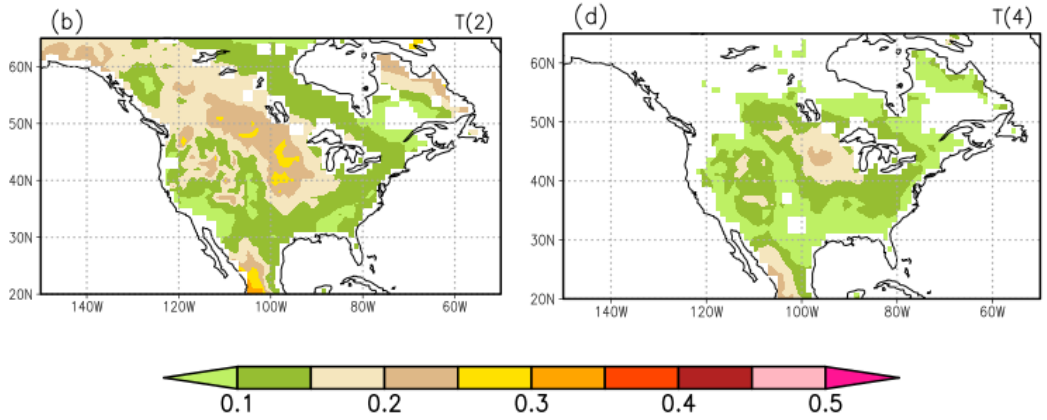
Predictand:
- T2m(t), t = 1,2, 3, 4 pentads

Predictors:
- RMM1(0), RMM1(0)
- RMM1(-1), RMM2(-1)
- T2m(0)
- **ML Oscillation(0)**

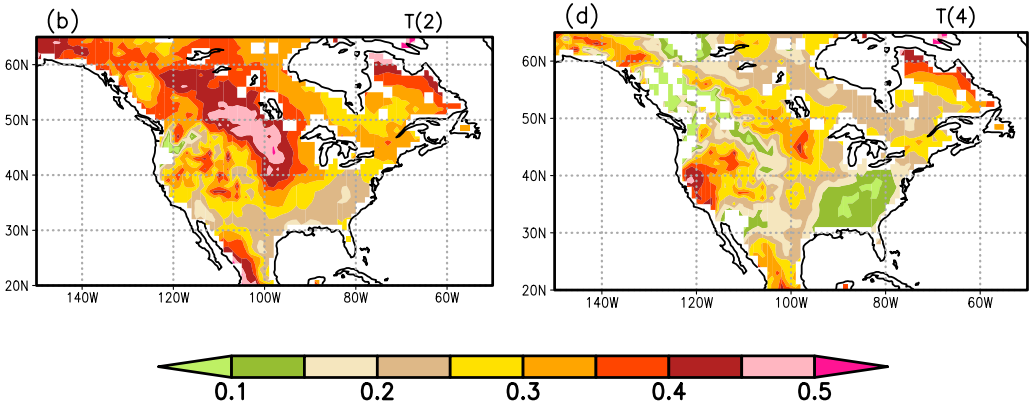
Predictand:
- T2m(t), t = 1,2, 3, 4 pentads

Impact of MLSO on the prediction skill of 2m-T over the North America

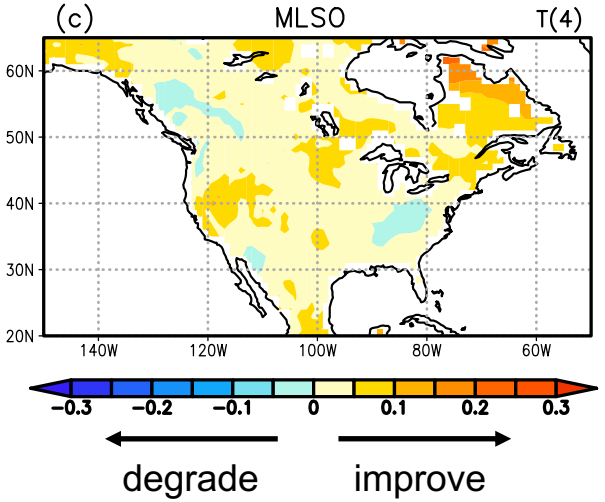
2-Predictor Model



3-Predictor Model



MAE Skill Score



$$SS(f,r,x) = 1 - \frac{MSE(f,x)}{MSE(r,x)}$$

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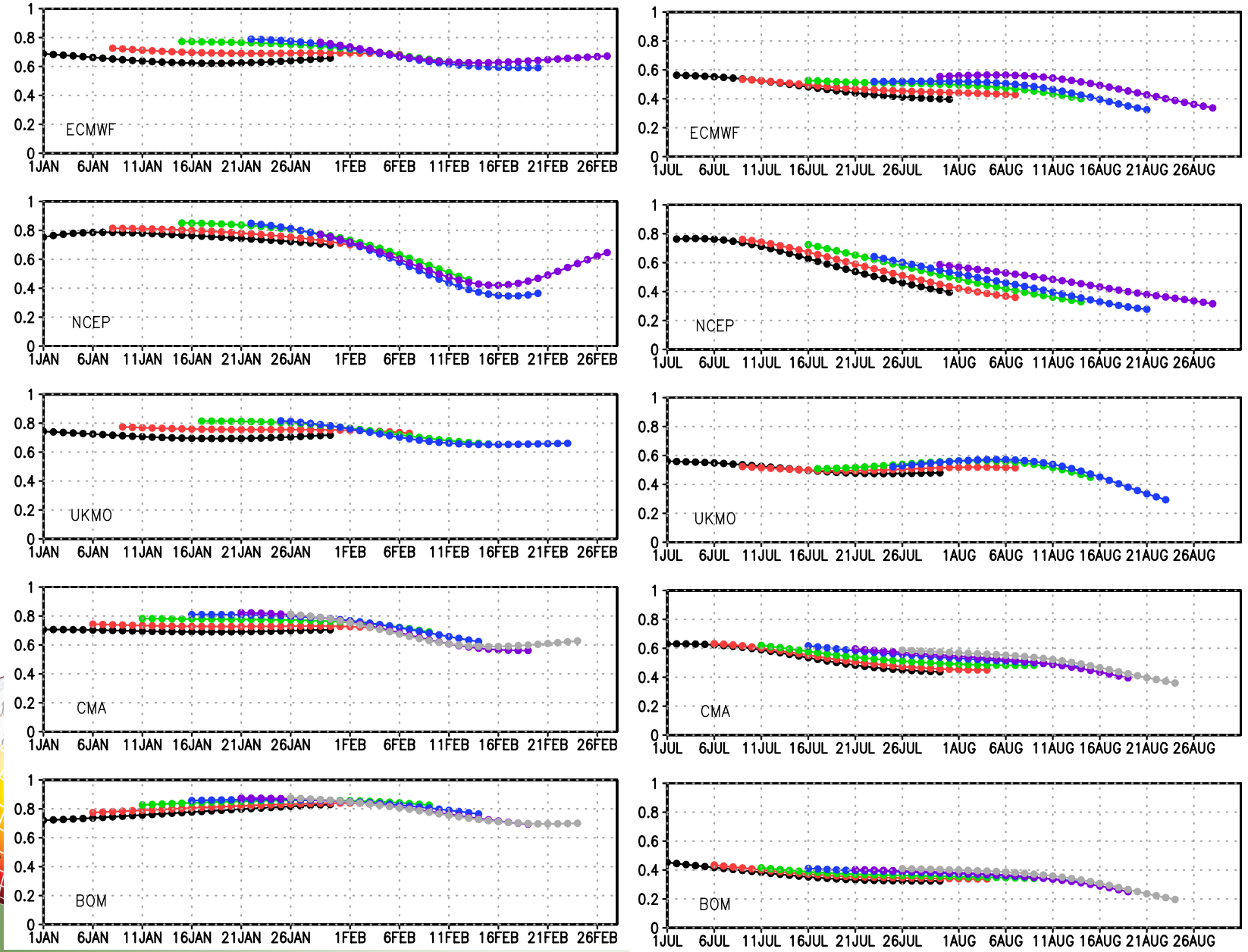
MLSO skill in S2S Models (ACC reforecast)



Conclusions

- On S2S timescales, the atmospheric variability of mid-latitudes is dominated by there oscillatory modes with periods of 120, 45, and 28 days.
- The modes propagate westward around the globe with small northward propagation
- In the peak amplitude phase they project onto the canonical teleconnection patterns of mid-latitudes
- The 120-day mode demonstrated forecast of opportunity, where periods of enhancement of statistical significant forecast skill can occur for week 3.
- For the 120-day mode, the S2S models show consistent high forecast skill for week 3-4, with seasonal dependence; winter AAC is higher than the summer.