

Keeping time in a warming world: Lessons from the Alaskan Arctic

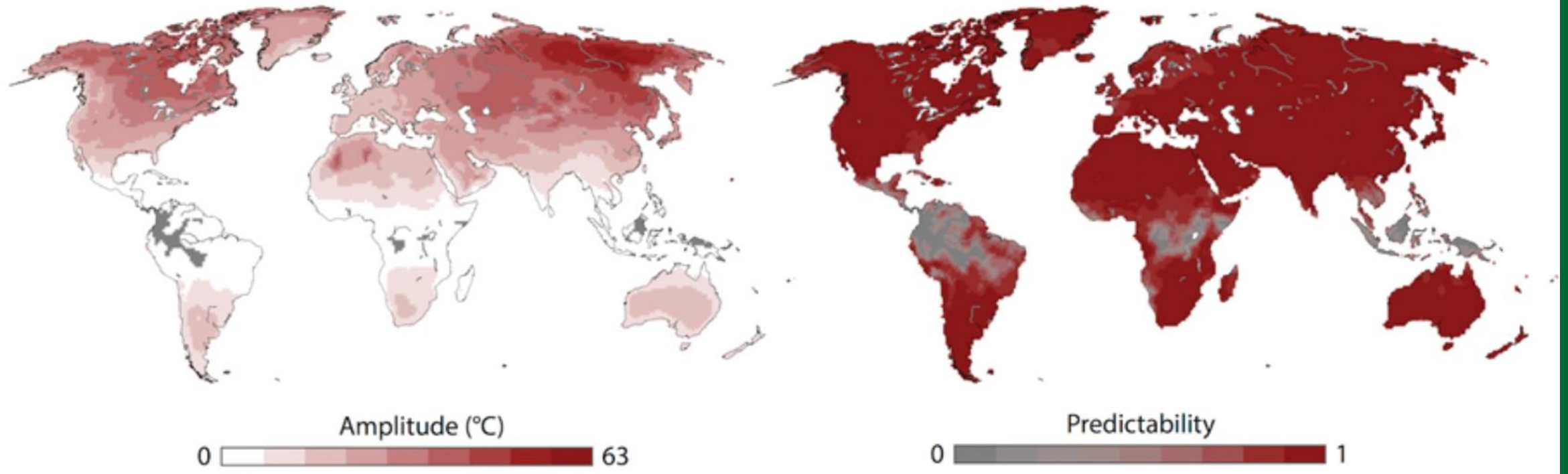
Helen Chmura
University of Alaska Fairbanks



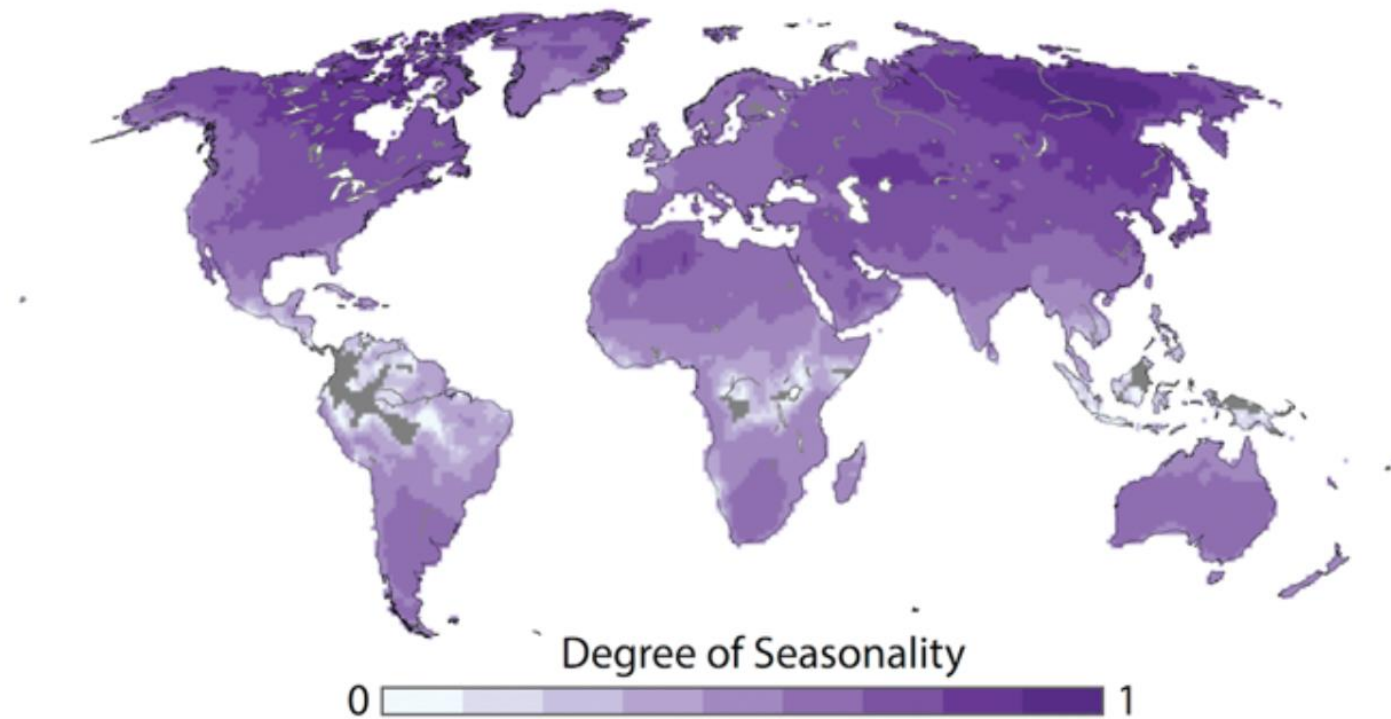




Seasonality in temperature



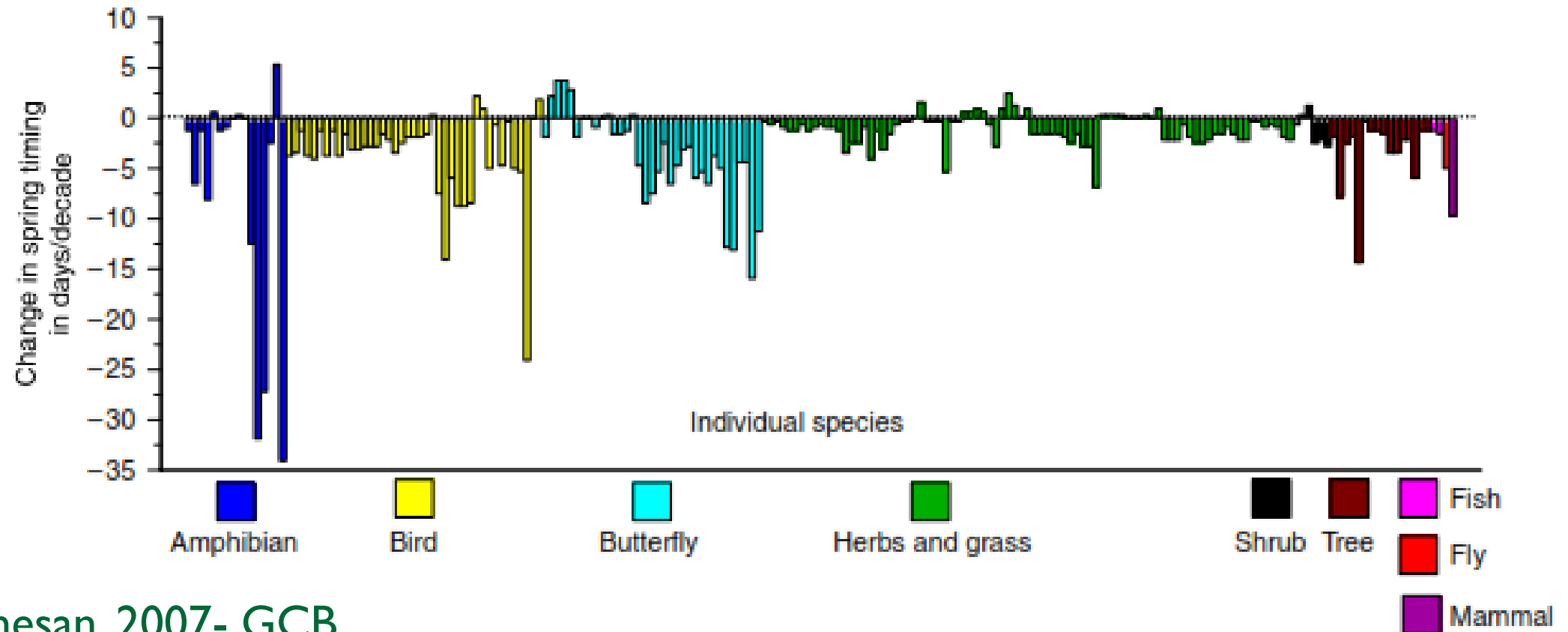
Seasonality in temperature



Strategies to cope with seasons



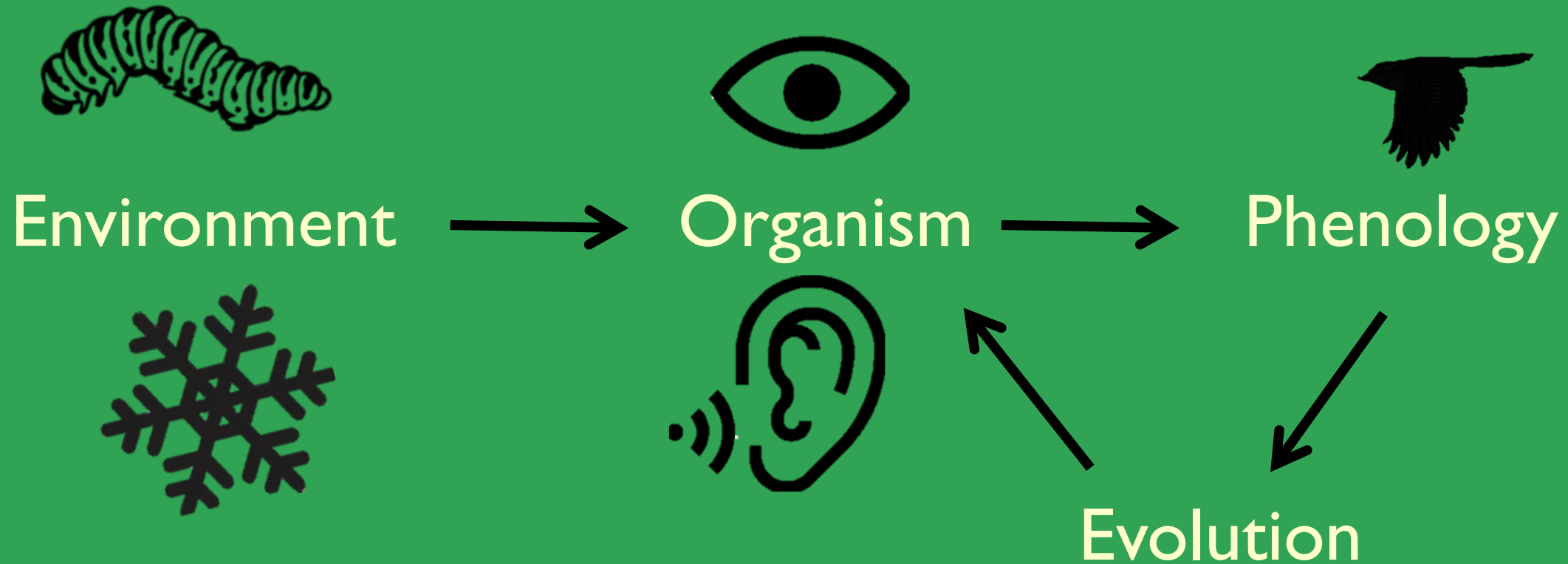
Climate change alters phenology



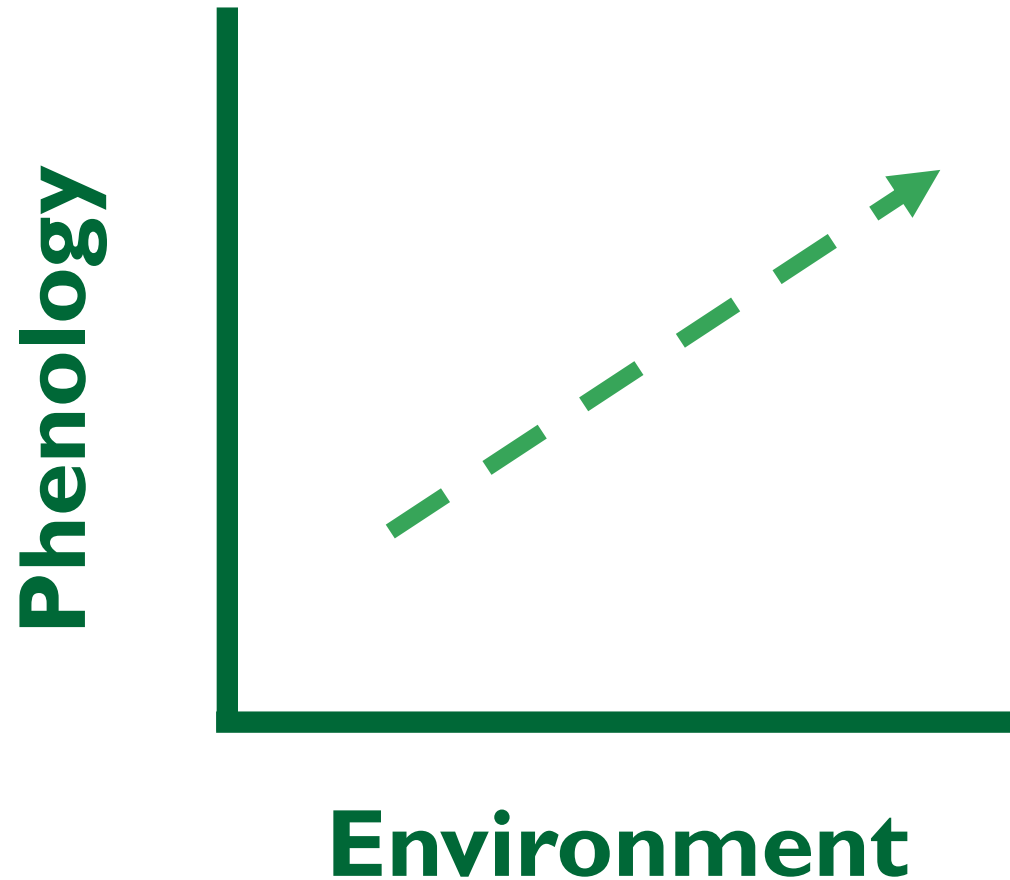
Parmesan, 2007- GCB

**Where does this variation
come from?**

Mechanisms driving variation in phenology

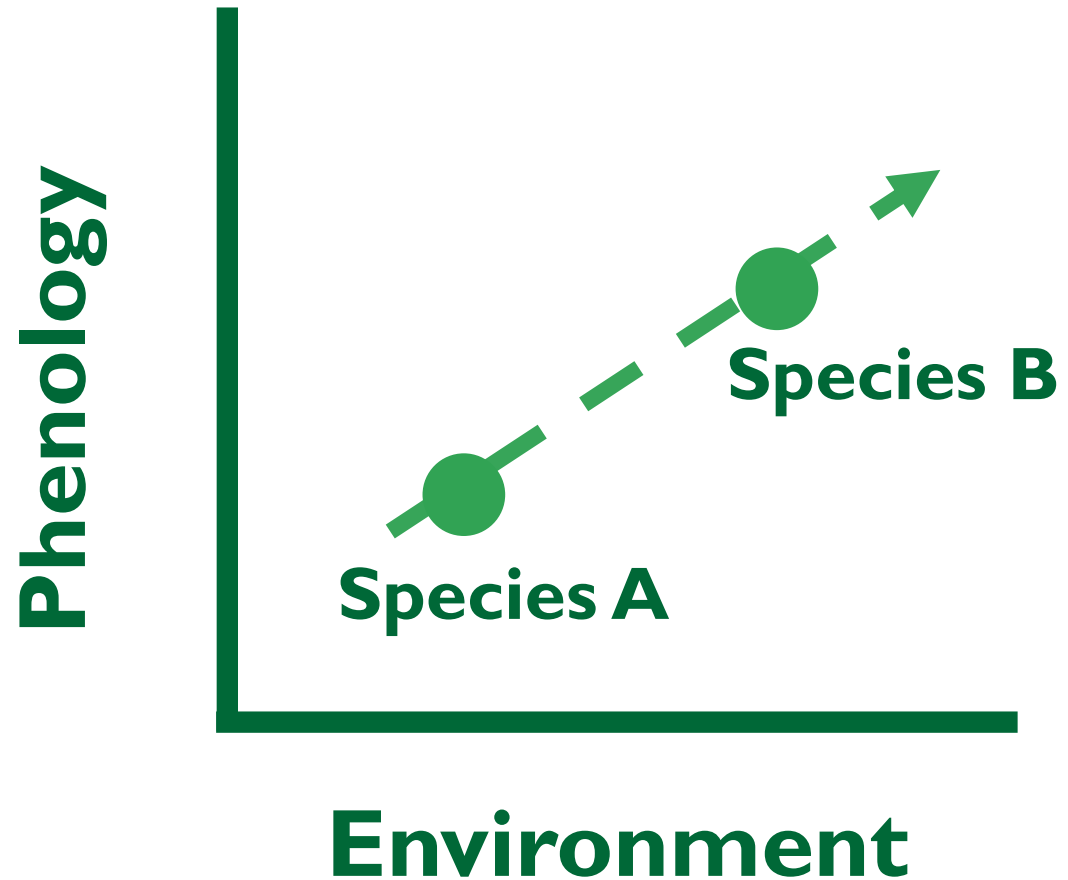


Variation in environment drives phenology



Chmura et al., 2018-
Ecological Monographs

Variation in environment drives phenology

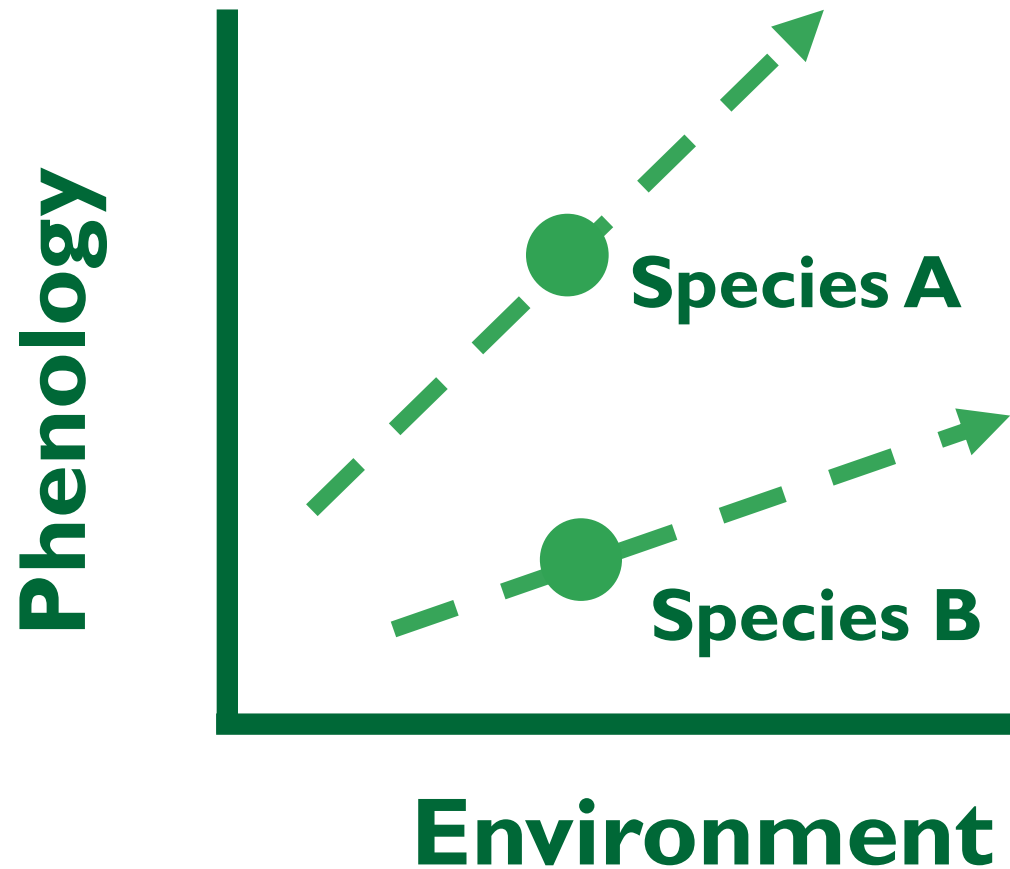


Variation in organismal physiology drives phenology



Chmura et al., 2018-
Ecological Monographs

Variation in organismal physiology drives phenology



Chmura et al., 2018-
Ecological Monographs

Question

**What
mechanisms
create
phenological
variation?**

Mechanism 1

Environmental variation

Mechanism 2

Physiological variation



Environmental mechanisms at high latitudes

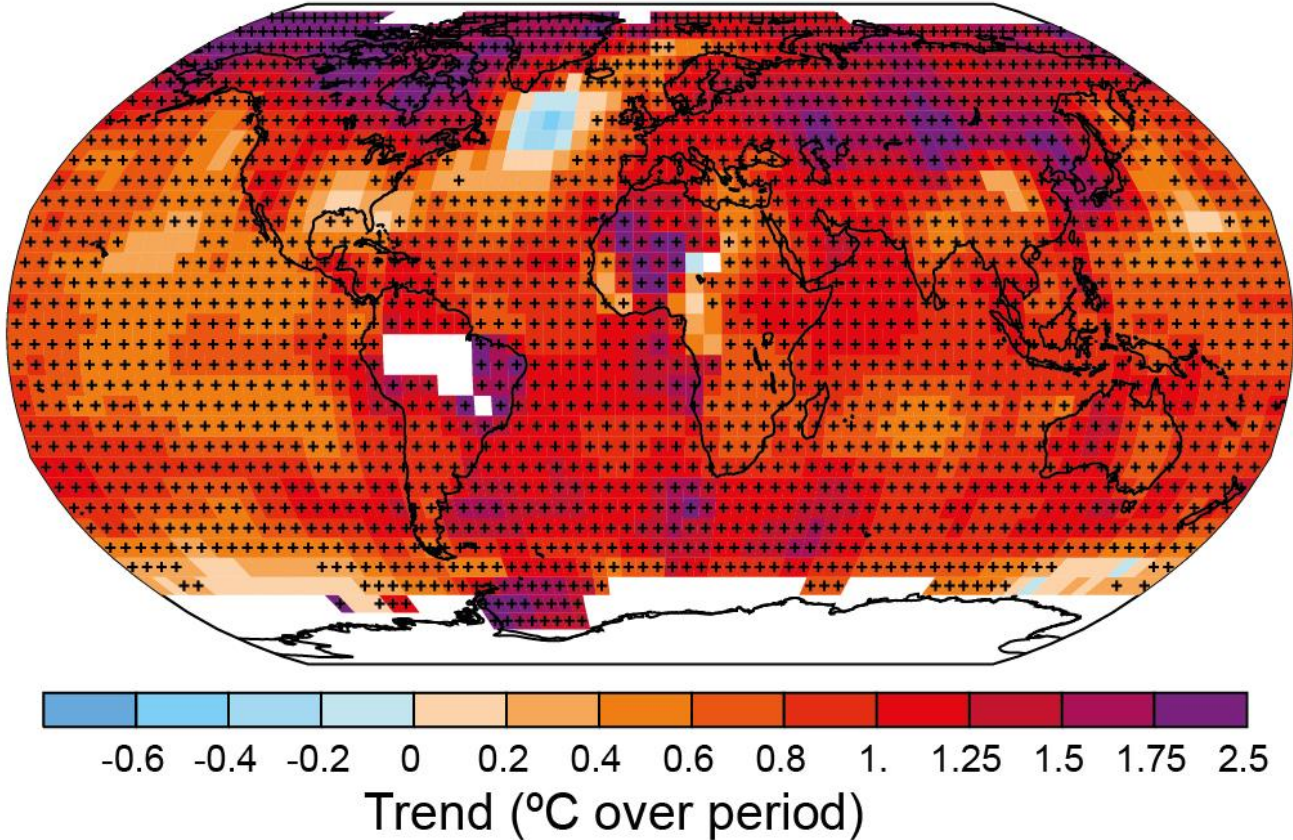


Environmental mechanisms at high latitudes

Hypotheses

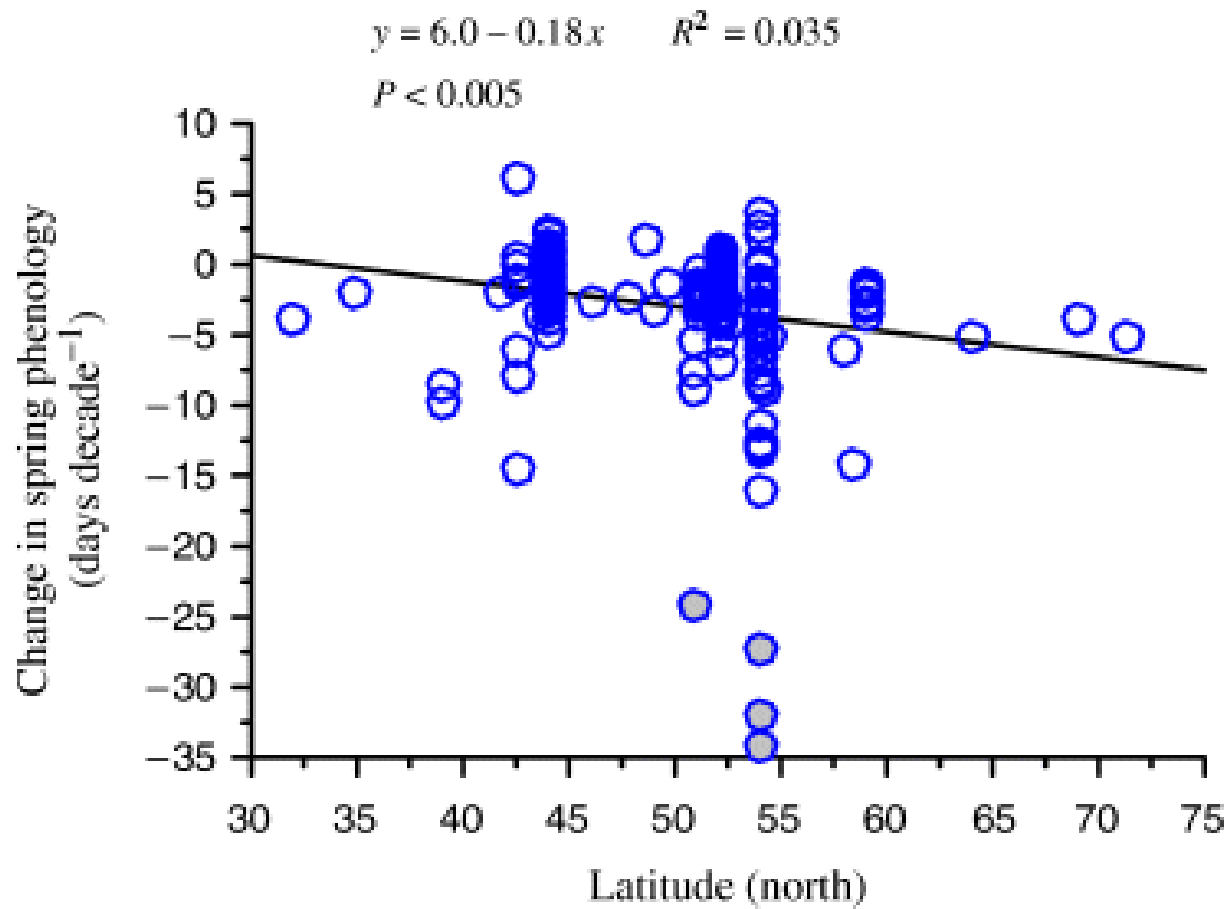
- Greatest temperature changes predicted at high latitudes.
- Globally reduced period of snow cover at high latitudes.

GISS 1901-2012



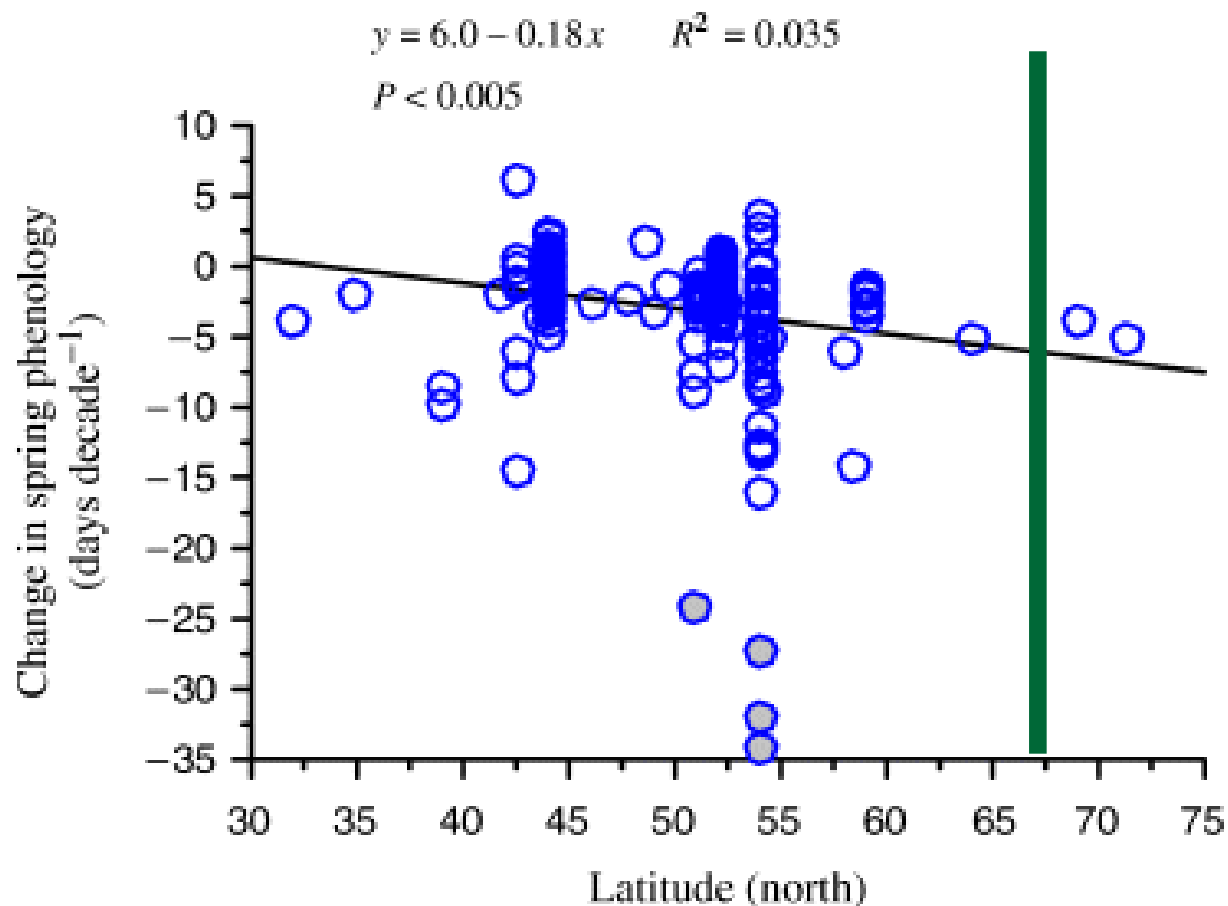
**Latitudinal
variation in
temperature
change**

IPCC, AR5, Working Group I, Fig. 2.2



**Latitude is a
weak
predictor of
phenological
shift**

Paucity of data in
the Arctic



**Latitude is a
weak
predictor of
phenological
shift**



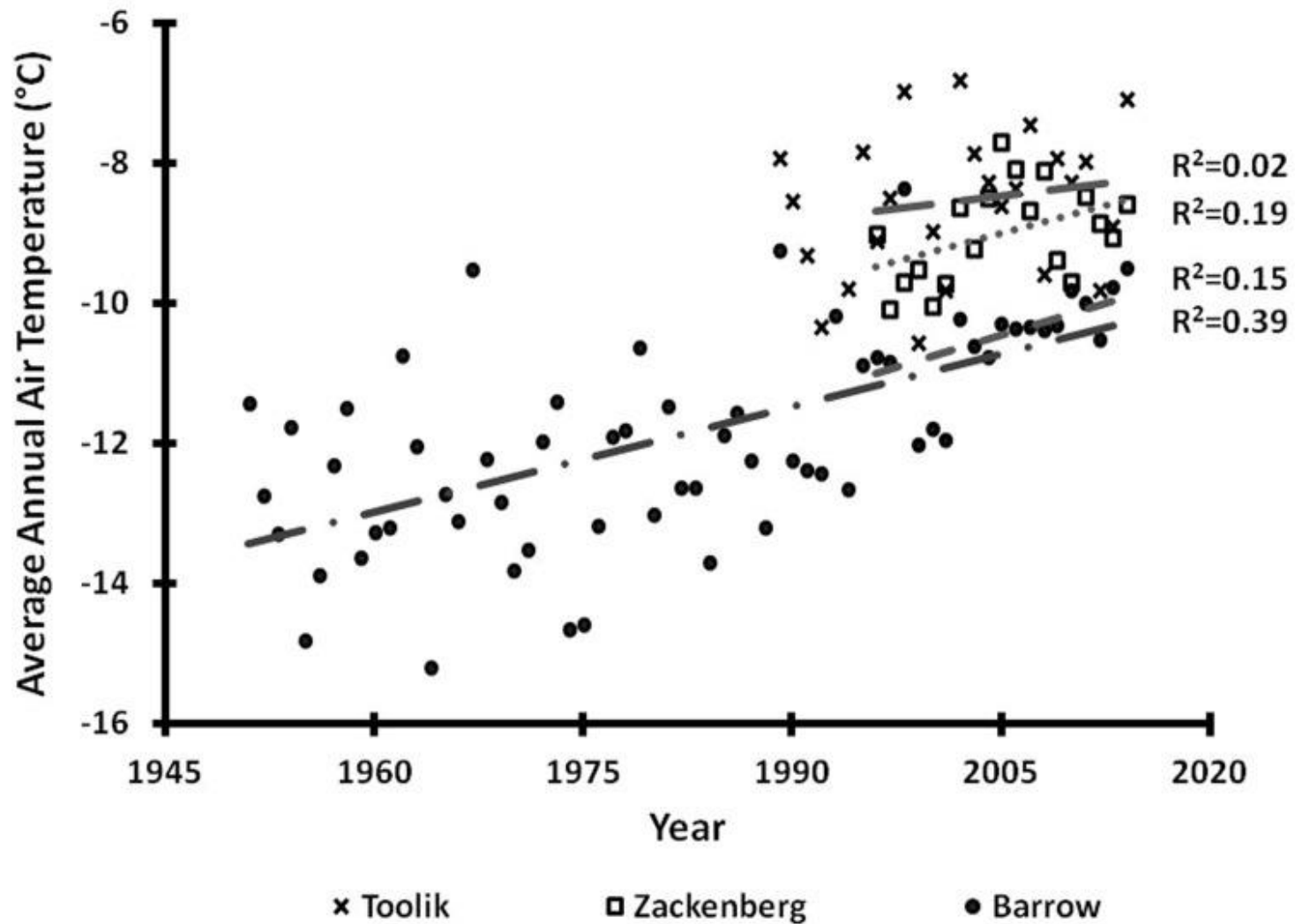
1992-1996 vs 2012-2016
Coming soon!

No directional effect of year
(1997-2010)
Sheriff et al., 2011 - Proc Roy. Soc.



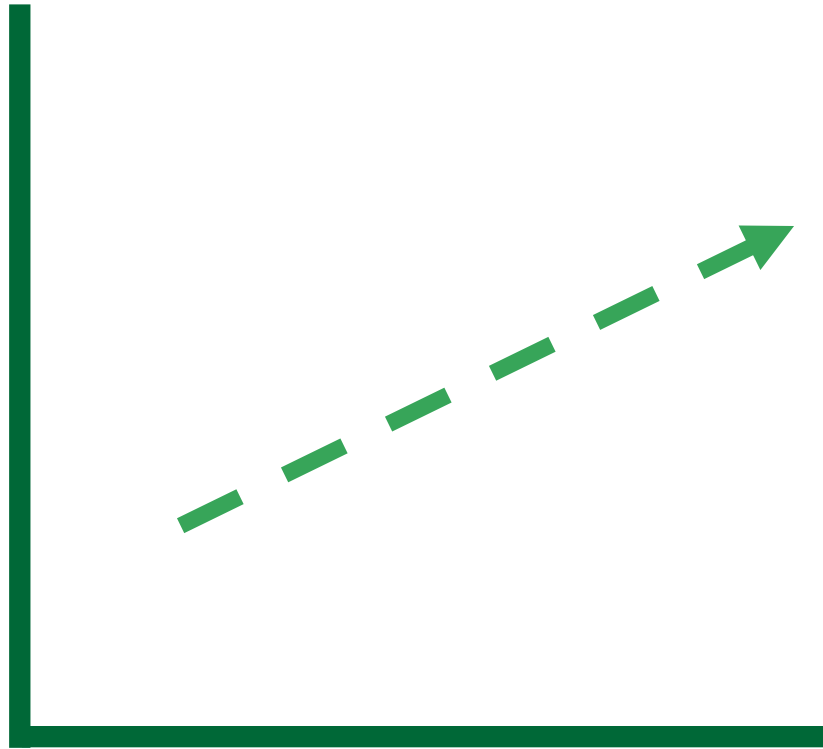
Vertebrate
phenology at
Toolik

Why is latitude a weak predictor of phenological shift?



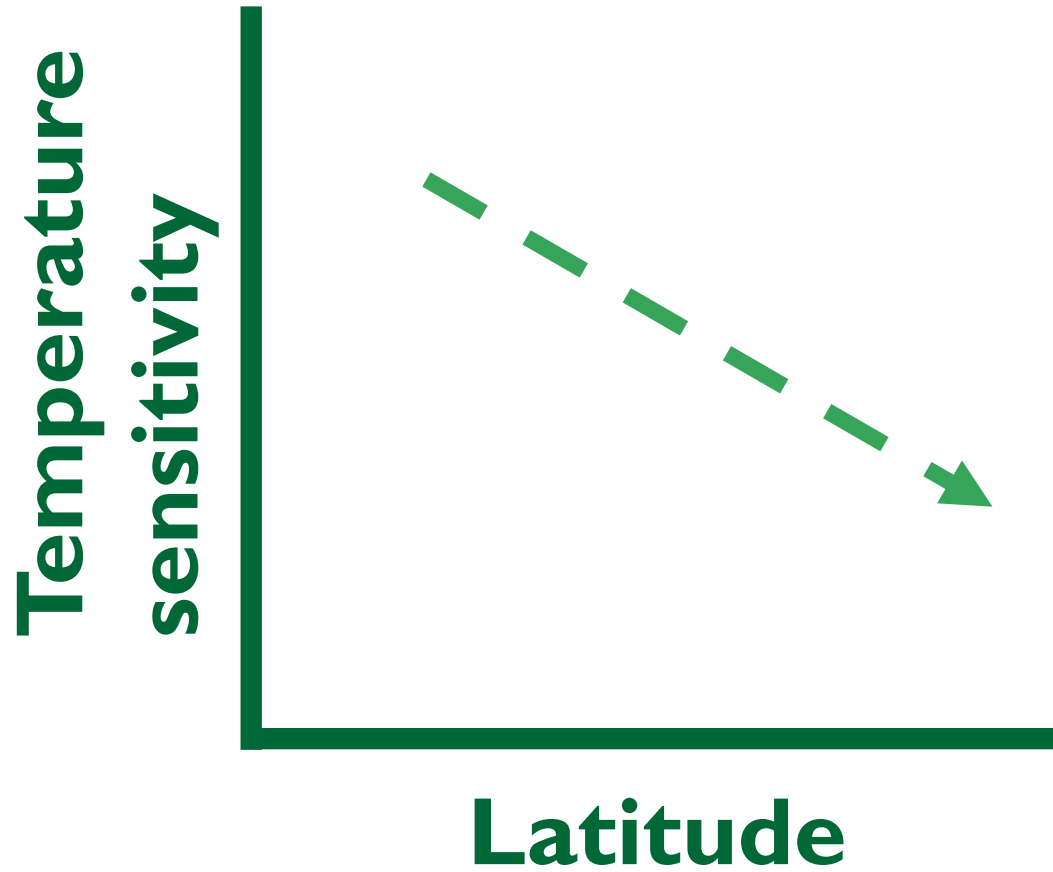
Scale and time-series length

Temperature change



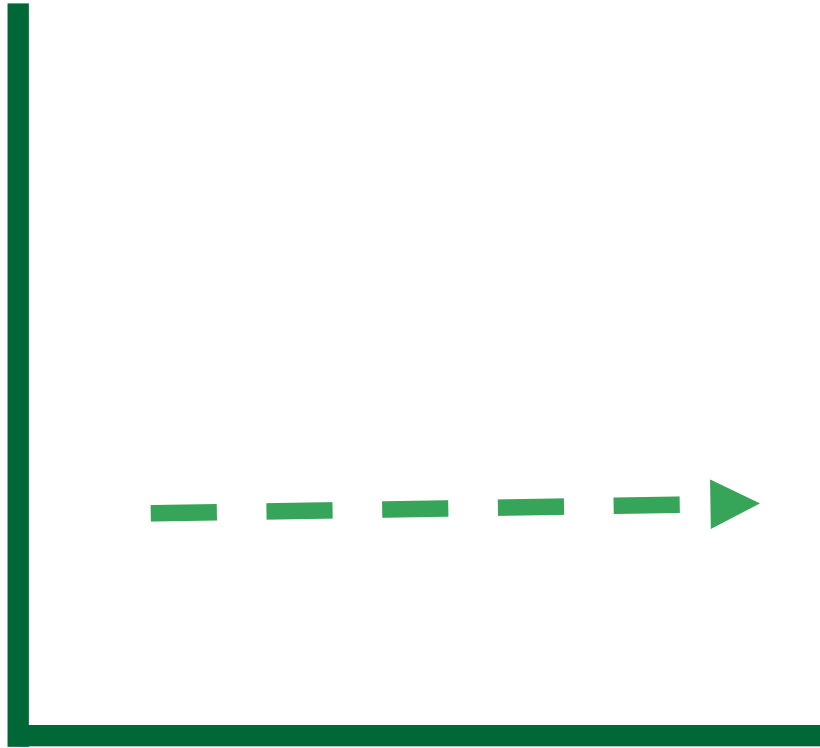
Latitude

**A role for
temperature
sensitivity**



**A role for
temperature
sensitivity**

Phenological shift



Latitude

**A role for
temperature
sensitivity**



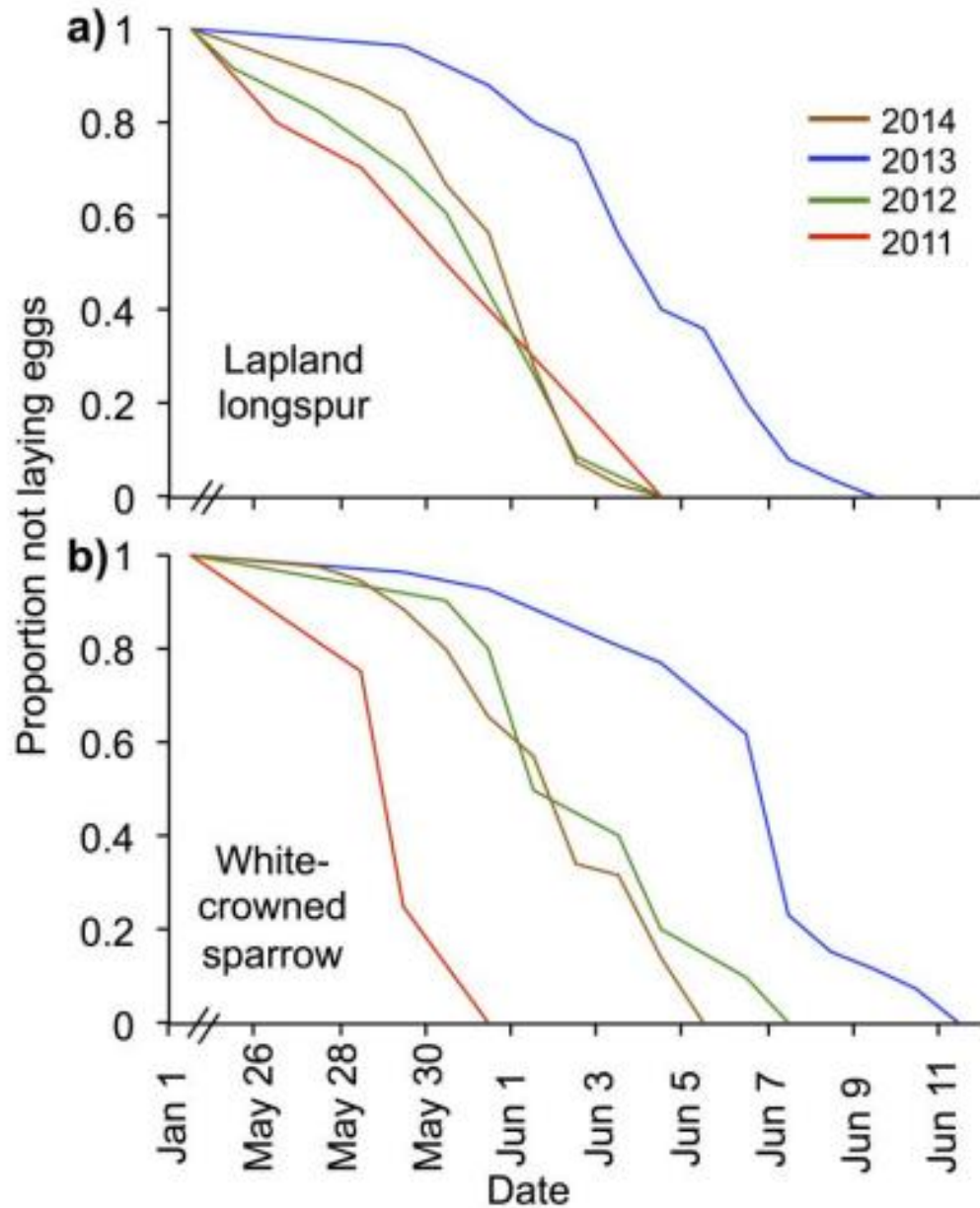
Organismal mechanisms at high latitudes



Organismal mechanisms at high latitudes

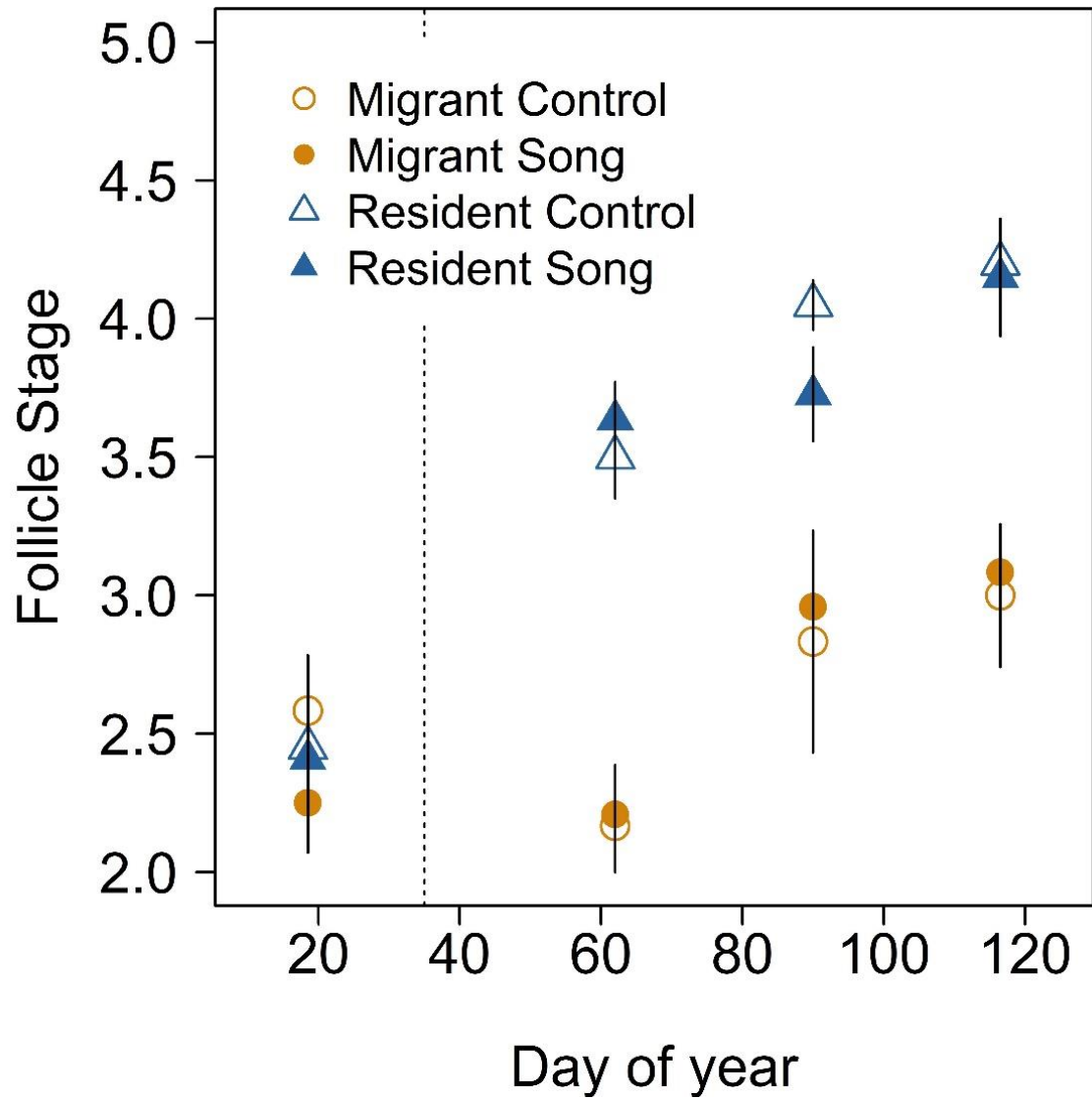
Hypotheses

- Driven by photoperiod and endogenous circannual rhythms
- Relatively insensitive to temperature and other environmental cues



Interannual variation in clutch initiation

Boelman et al. 2017, *Oecologia*



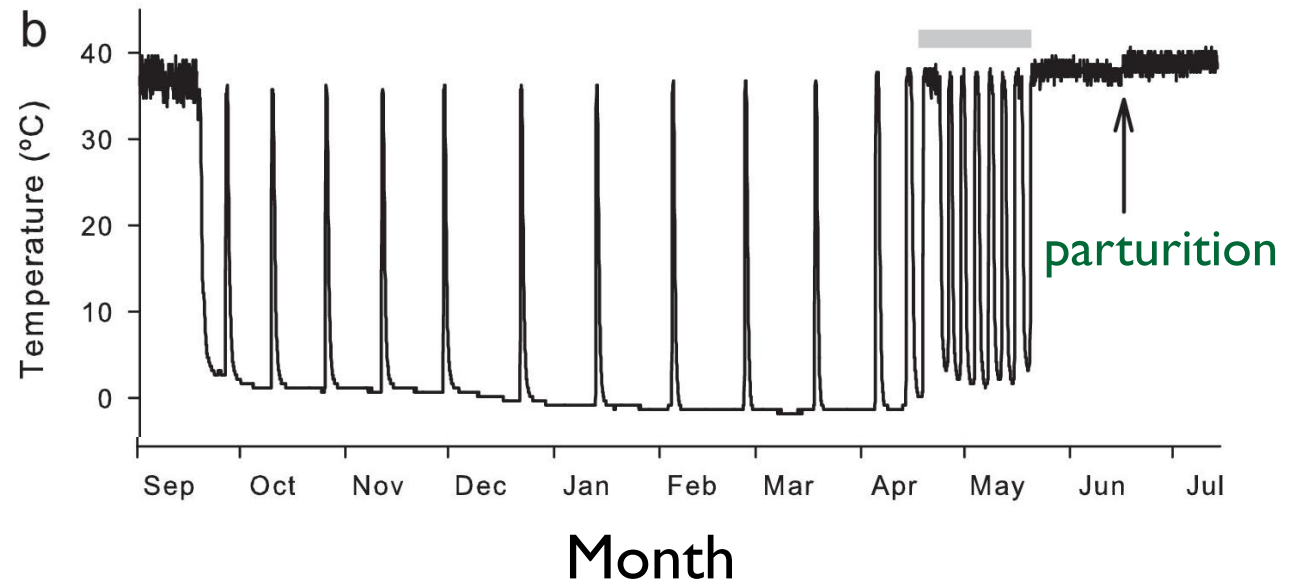
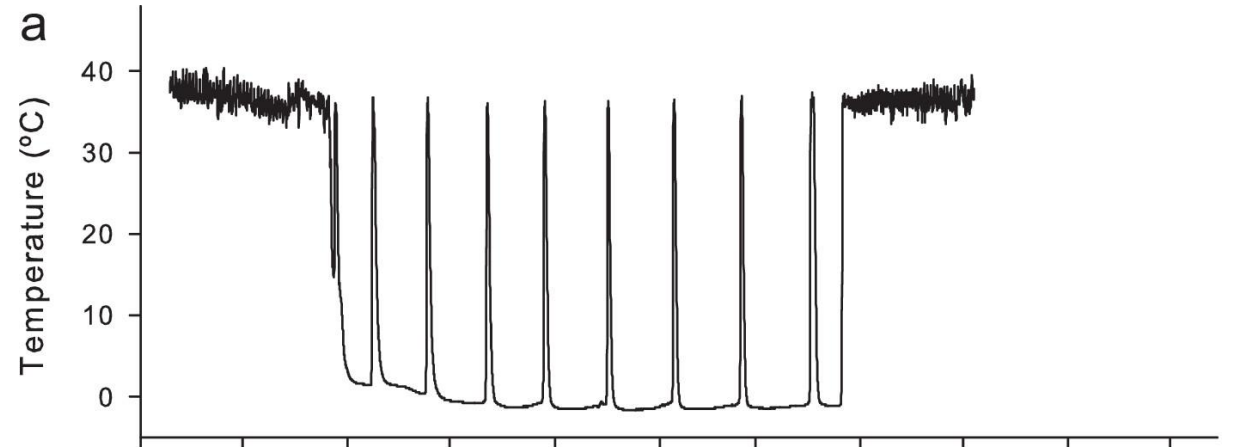
No latitudinal differences in reproductive sensitivity to song

Chmura et al. 2017, JEB

Sex-dependent plasticity in hibernation



Williams et al. 2017- Am Nat.



Sex- dependent plasticity in hibernation



-6 ° C



-6 ° C



-2 ° C

What have we learned?

Environmental variation

- Despite latitudinal patterns in temperature change, hemispheric phenological shifts do not always show latitudinal patterns.
- Data gaps persist in the Arctic.
- Consider regional environmental changes and regional phenological responses within the Arctic.

What have we learned?

Physiological variation

- Animals at high latitudes show phenological flexibility.
- Phenological flexibility may vary across sexes, trophic levels etc.
- Physiological pathways still under study.



Research at Toolik

Opportunities

- Maturing long-term data sets
- Opportunities to connect across study systems
- 2013 !



Thank You!

Team Bird
Team Squirrel
NSF IOS and OPP
Toolik Station Staff