Climatic drivers and constraints of phenological change

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Annual temperature cycle
Upper troposphere dynamics – Pressure Levels

01-Sep

200hpa Height (Km)

200hpa Height (Km)

Degrees West

Degrees North
Upper troposphere dynamics – Jet Stream
Modes of variability – PNA (Pacific/North America)

(positive phase)

JISAO, Univ. of Washington
Modes of variability – NAM (Northern Annular Mode) (positive phase)

JISAO, Univ. of Washington
PNA impacts on warm-day frequency

From Ault et al., 2011 (JCLIM)
NAM impacts on warm-day frequency

From Ault et al., 2011 (JCLIM)
Implications for spring onset
Implications for spring onset
Spring Indices

Do “plants” care?

From Ault et al., 2011 (JCLIM)
Spring Indices

From Ault et al., 2011 (JCLIM)
Spring Indices

Mean Leaf Index Date

From Ault et al., 2011 (JCLIM)
Spring Indices

Regressions against NAM/PNA

From Ault et al., 2011 (JCLIM)
Do actual plants care?
Interannual variability

From Schwartz et al., in review.
Southeastern US “warming hole”

From Schwartz et al., in review.
Southeastern US “warming hole”

From Schwartz et al., in review.
Southeastern US “warming hole”

From Portman et al., 2009 (PNA...
Southeastern US “warming hole”

CCSM3 20th Century Ensemble: 1 member with similar pattern to obs.

From Meehl et al., 2012 (JCLIM)
Southeastern US “warming hole”

From Meehl et al., 2012 (JCLI)
Southeastern US “warming hole”

Substantial role for natural variability…
CCSM4 Large Ensemble (30 Members)

State-of-the art model

Identical boundary conditions

Run from 1970-2005

*Slightly* different initial conditions

Investigate role of natural variability

Deser et al., in preparation
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

![Map showing temperature trends](image)

-3  -2  -1  0  1  2  3 (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

-3 -2 -1 0 1 2 3
(degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

-3  -2  -1  0  1  2  3
(degC)

Obs.  Run 1  Run 2
Run 3
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

Run 1

Run 2

Run 3

Run 4

Run 5

Run 6

1970-2005 Temperature Trends

-3 -2 -1 0 1 2 3 (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

Obs.  Run 1  Run 2
Run 3  Run 4  Run 5
Run 6  Run 7

1970-2005 Temperature Trends

-3  -2  -1  0  1  2  3 (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

Obs.  Run 1  Run 2
Run 3  Run 4  Run 5
Run 6  Run 7  Run 8
Run 9

1970-2005 Temperature Trends

-3  -2  -1  0  1  2  3
(degC)
1970-2005 Temperature Trends

CCSM4 Large Ensemble (30 Members)
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1970-2005 Temperature Trends

(degC)

-3 -2 -1 0 1 2 3
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(degC)

-3 -2 -1 0 1 2 3
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

-3  -2  -1  0  1  2  3 (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(degC)

-3  -2  -1  0  1  2  3
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(degC)

Obs.  Run 1  Run 2  Run 12  Run 13  Run 14  Run 3  Run 4  Run 5  Run 15  Run 6  Run 7  Run 8  Run 9  Run 10  Run 11

1970-2005 Temperature Trends

(degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

-3 -2 -1 0 1 2 3 (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

Obs., Run 1, Run 2, Run 12, Run 13, Run 14, Run 3, Run 4, Run 5, Run 15, Run 16, Run 17, Run 6, Run 7, Run 8, Run 18, Run 19, Run 9, Run 10, Run 11

1970-2005 Temperature Trends

-3 -2 -1 0 1 2 3 (degC)
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(degC)

-3  -2  -1  0  1  2  3

Run 1  Run 2  Run 12  Run 13  Run 14
Run 3  Run 4  Run 5  Run 15  Run 16
Run 17
Run 6  Run 7  Run 8  Run 18  Run 19
Run 20
Run 9  Run 10  Run 11

Map showing temperature trends from 1970-2005 for different ensemble runs.
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(degC)

-3  -2  -1  0  1  2  3
CCSM4 Large Ensemble (30 Members)

1970-2005 Temperature Trends

(ddegC)
Recap.

Large-scale coherence + interannual variability $\rightarrow$ important role for **atmospheric dynamics**.

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Advection of **warm subtropical air masses** is key to start of spring.

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Position and “waviness” of jetstream govern different flavors of **spring warming**.

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Natural variability likely masks regional trends driven by warming on **interannual to decadal timescales**.
2012 – “warm event” or early spring?
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Future work…

- Upper-level dynamics (Arctic ozone, troposphere height, etc)
- Near-surface dynamics (wind speed, SLP, etc)
- Seasonality (annual phasing, stratospheric warming, etc)
- Spring indices
- Satellite measures of greenup & snow
- Phenological observations
Acknowledgments

Mark Schwartz and the Phenology 2012 conference organizers, NCAR-ASP, Clara Deser, John Fasullo, Jerry Meehl, and Adam Phillips.

Thanks!