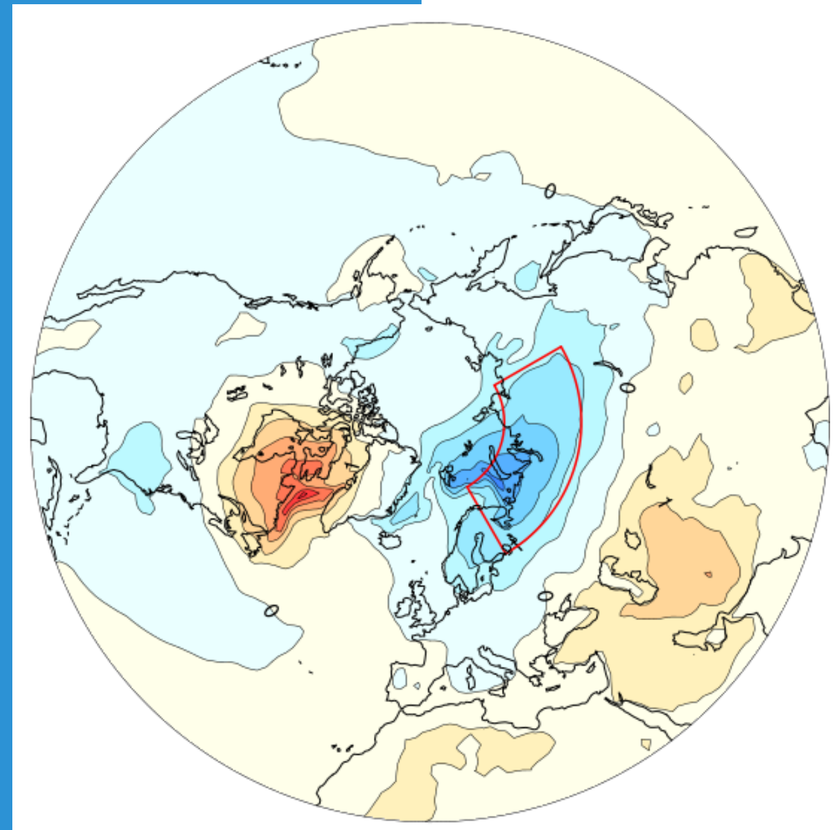
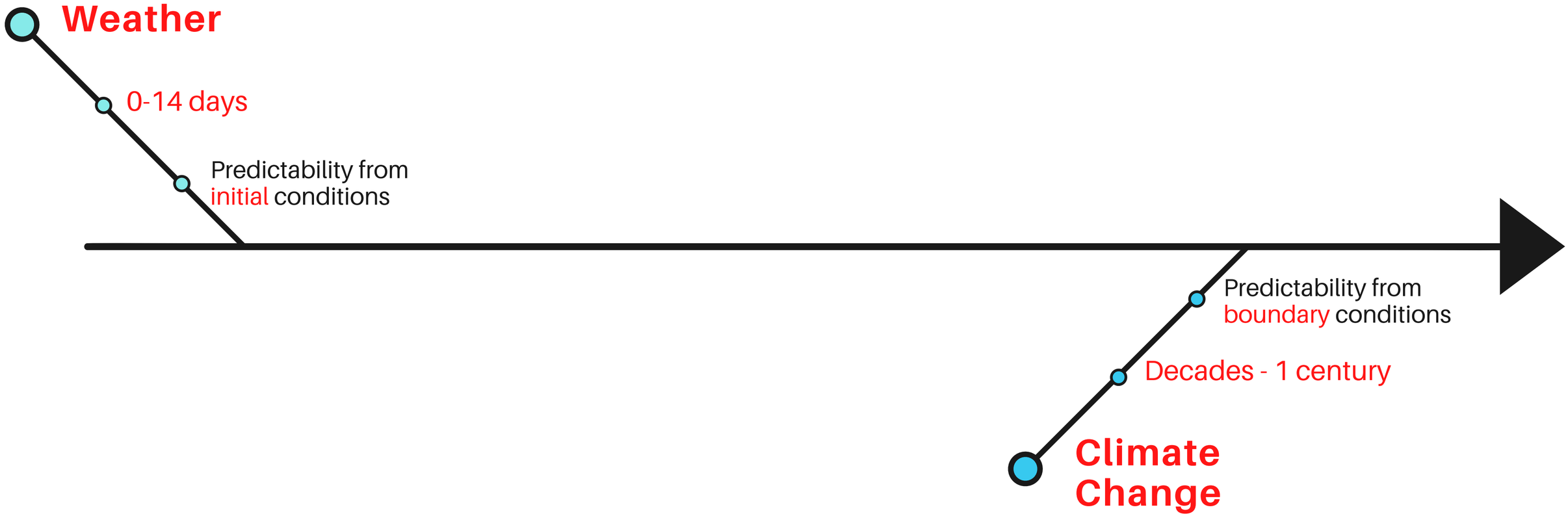


The Other Polar Vortex: Stratospheric Impacts on North Atlantic Winter

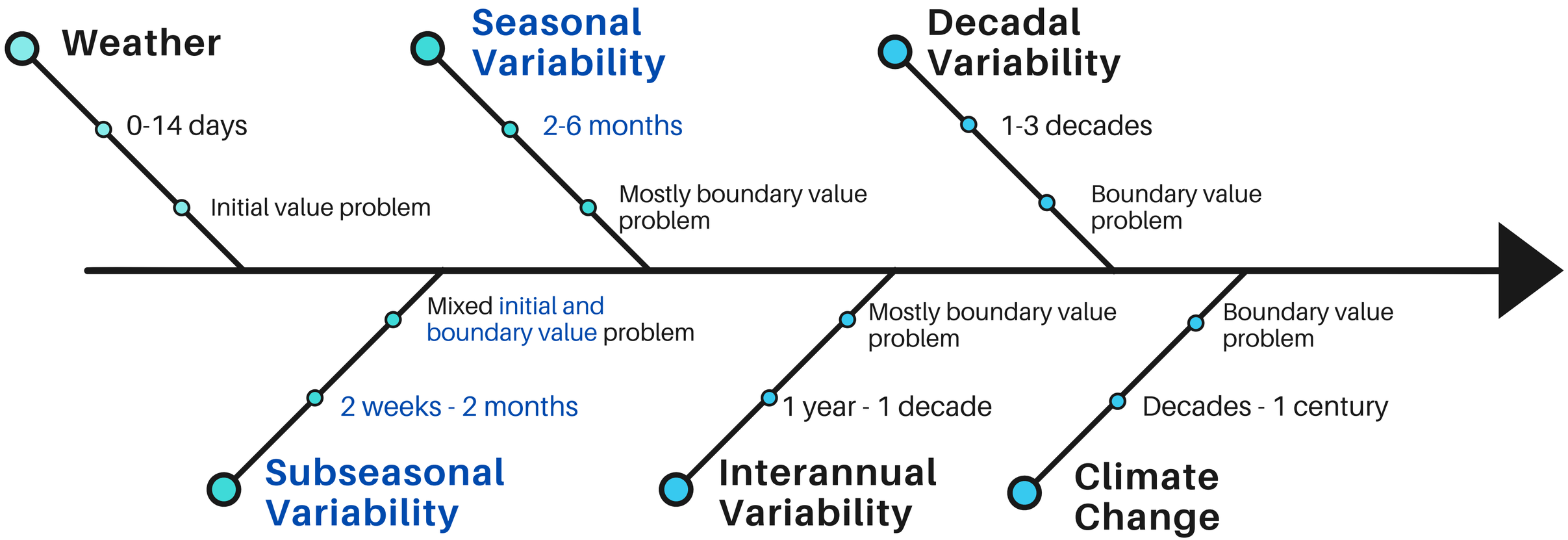
JESSICA OEHRLEIN

Joint work with Gabriel Chiodo and Lorenzo Polvani

TIMESCALES IN ATMOSPHERIC SCIENCE



TIMESCALES IN ATMOSPHERIC SCIENCE



SOME SOURCES OF SUBSEASONAL VARIABILITY

Images from the Noun Project: Nibras@design, Made by Made, Quan Do

Land/Ice Boundary Conditions

Soil moisture, vegetation cycles, snow cover, sea ice

Ocean Boundary Conditions

El Niño-Southern Oscillation: tropical Pacific sea surface temperatures

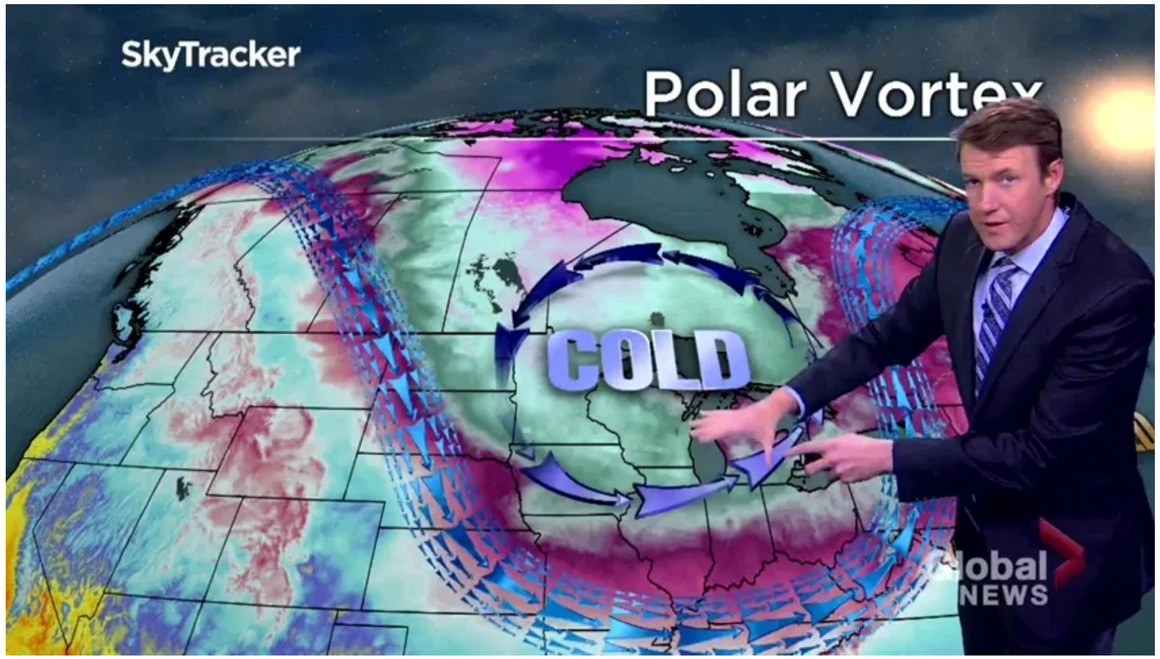
Semi-Regular Oscillations

Madden-Julian Oscillation (tropical convection), Quasi-Biennial Oscillation (tropical stratosphere)

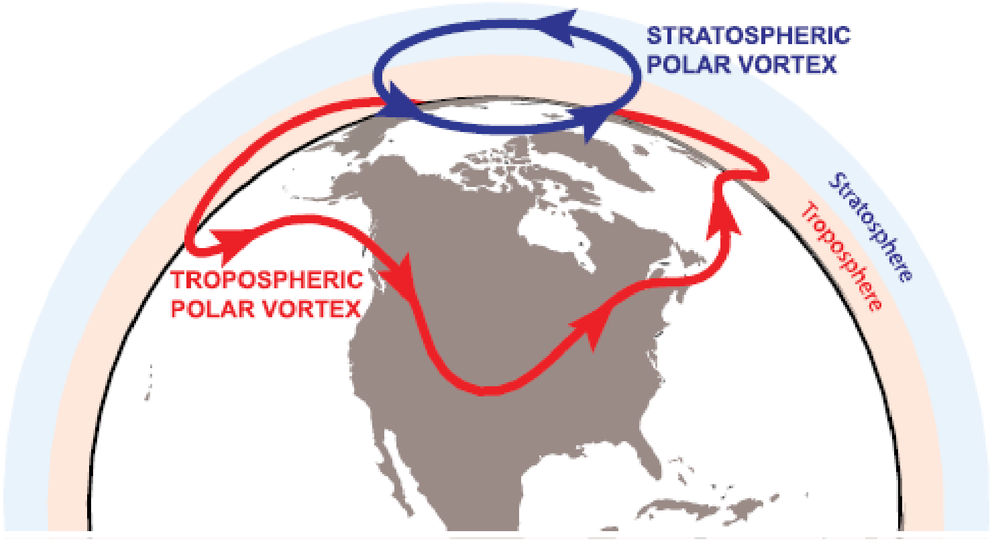
Polar Stratosphere

State of the polar vortex interacts with surface climate

POLAR VORTEX?



THE OTHER POLAR VORTEX



STRATOSPHERIC POLAR VORTEX

East/west wind averaged around latitude circles in December-February

Stratosphere:
~ 10-50 km

Troposphere:
~ 0-10 km

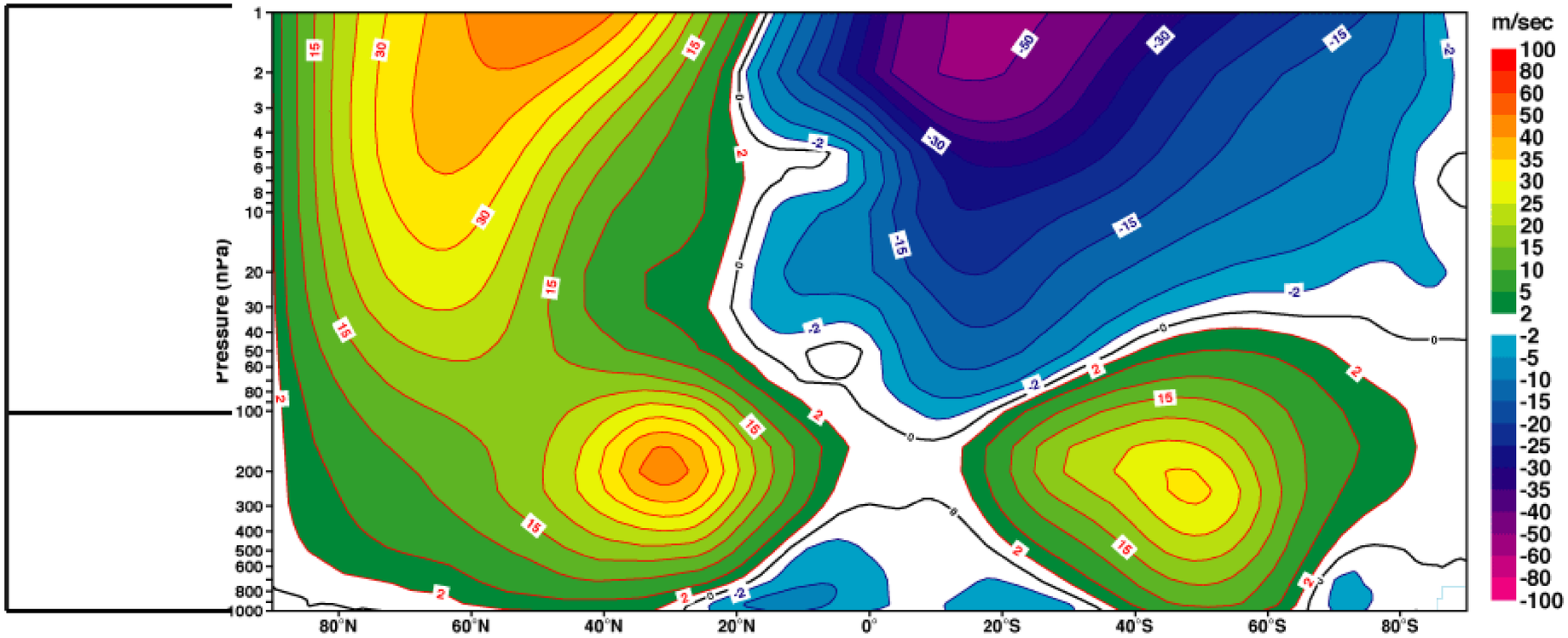


Image from ECMWF

Positive: west-to-east (westerly)
Negative: east-to-west (easterly)

STRATOSPHERIC POLAR VORTEX

East/west wind averaged around latitude circles in December-February

Stratosphere:
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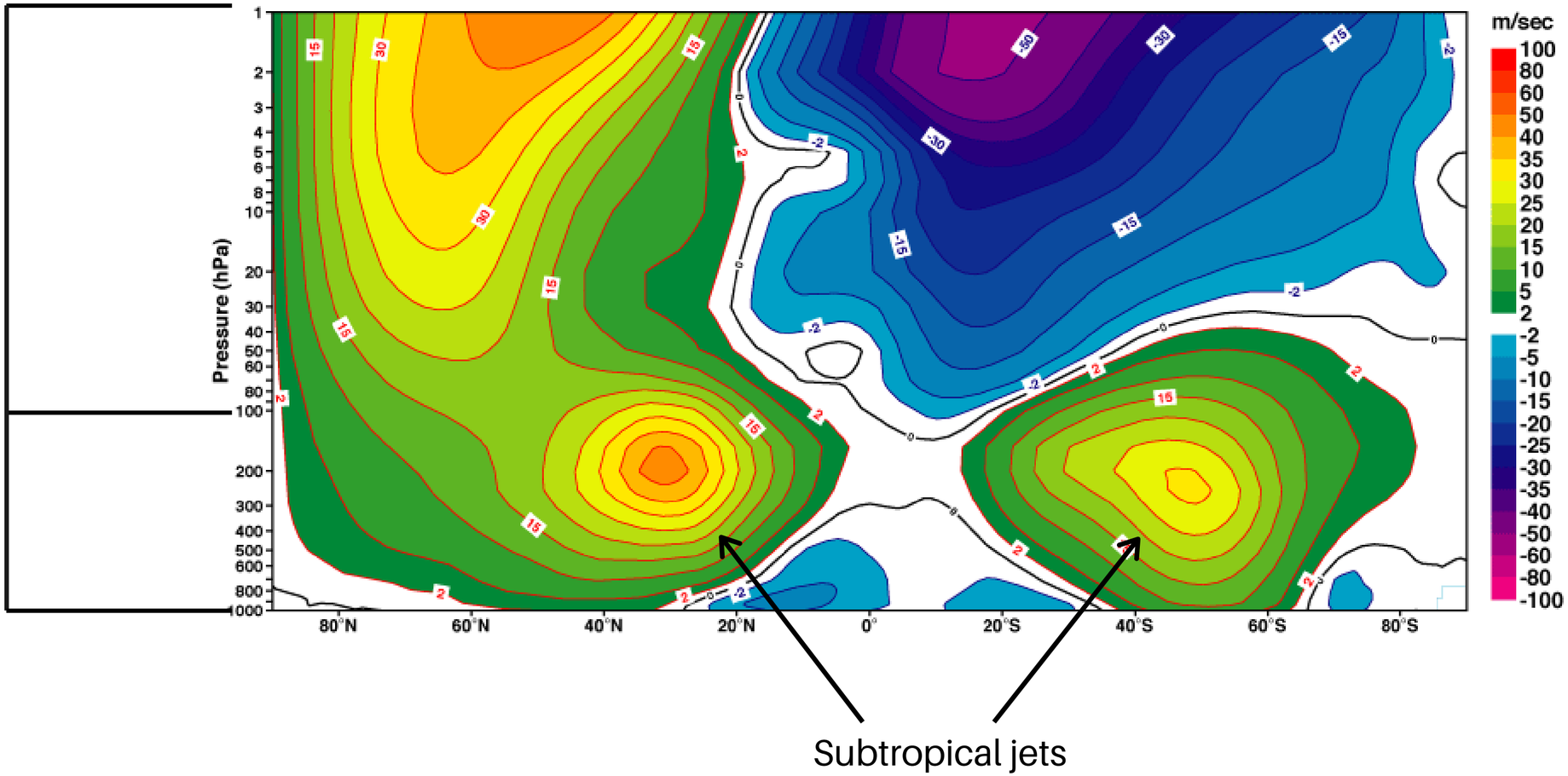
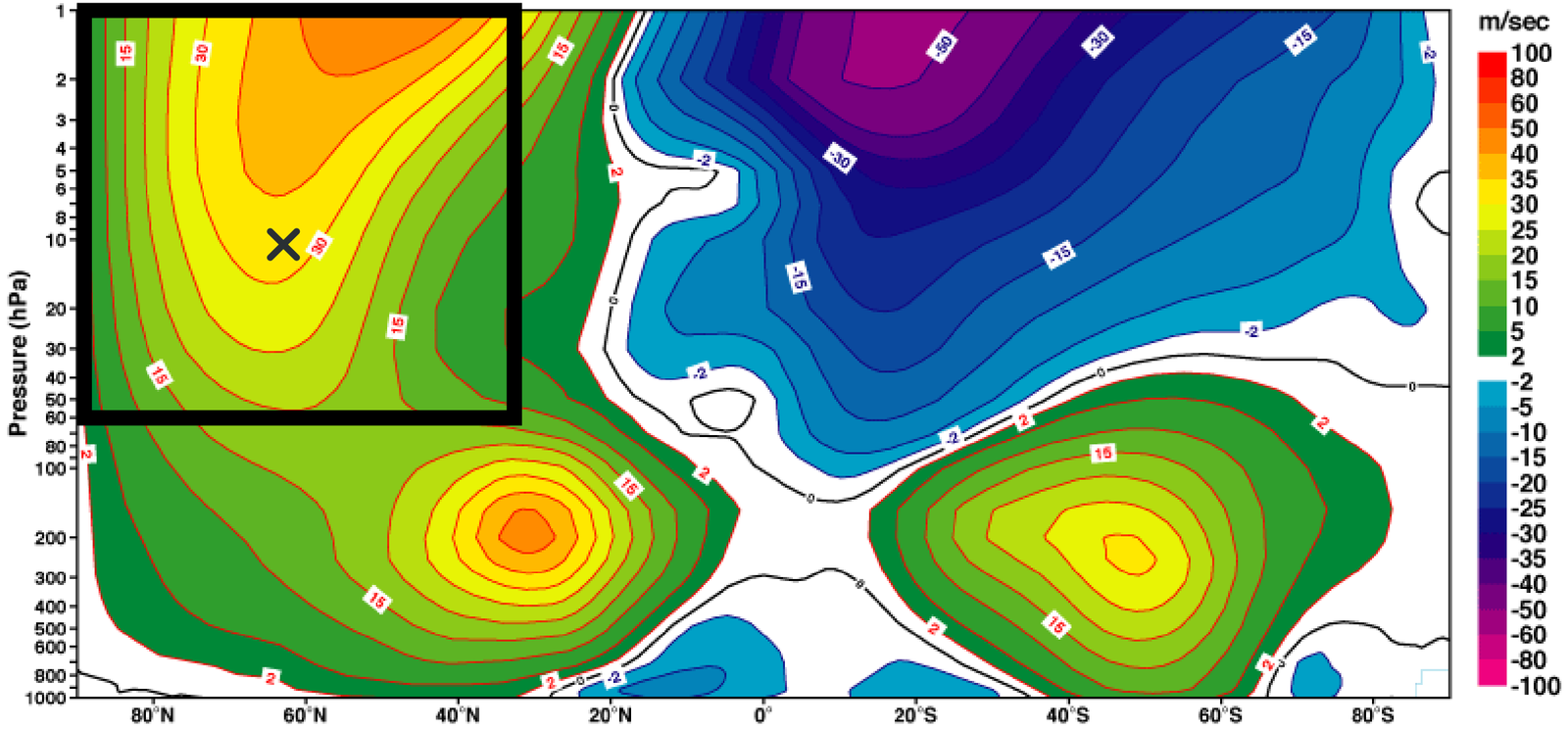


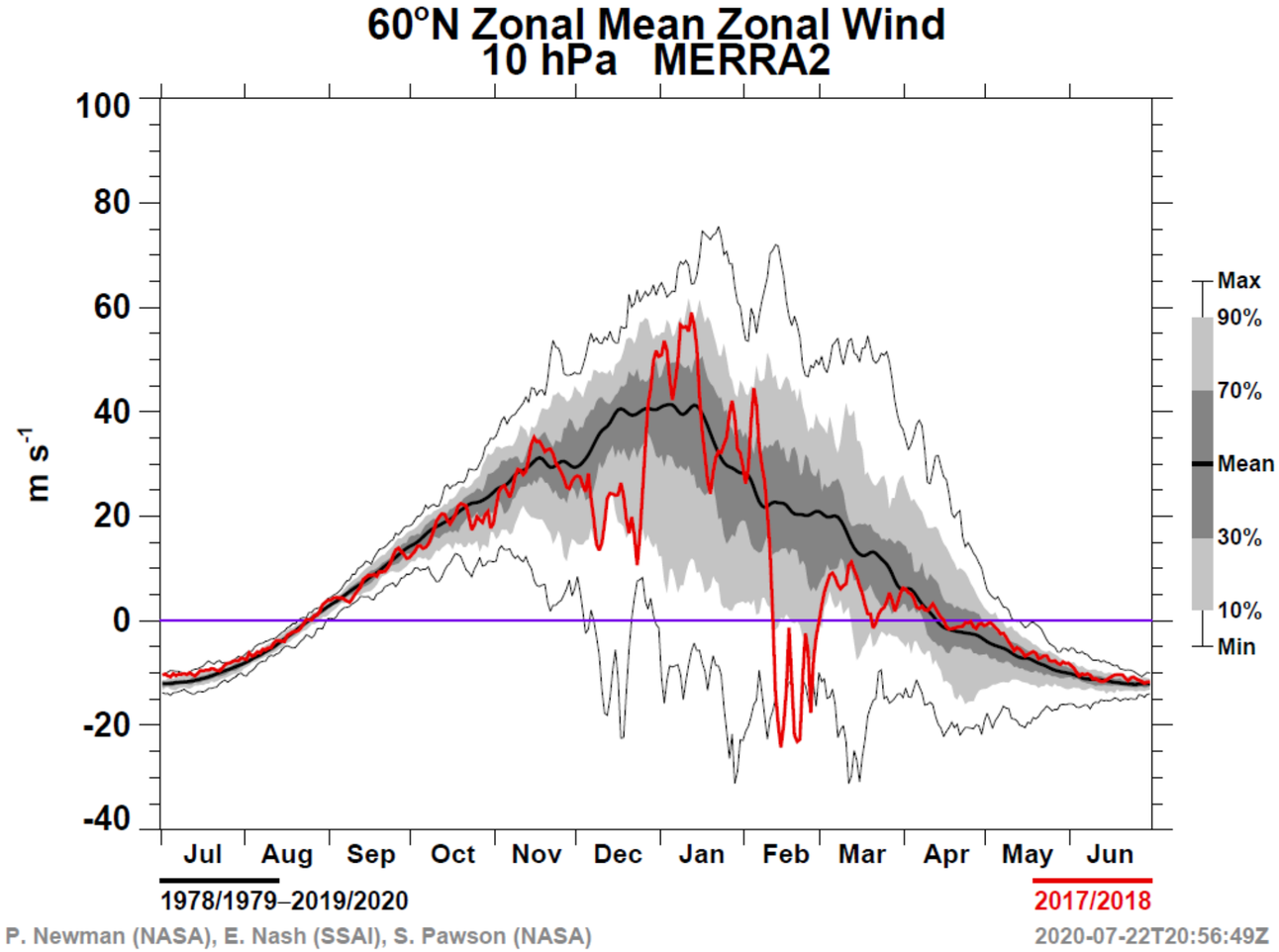
STRATOSPHERIC POLAR VORTEX

Stratospheric polar vortex: Region of strong westerly winds over the winter pole

East/west wind averaged around latitude circles in December-February

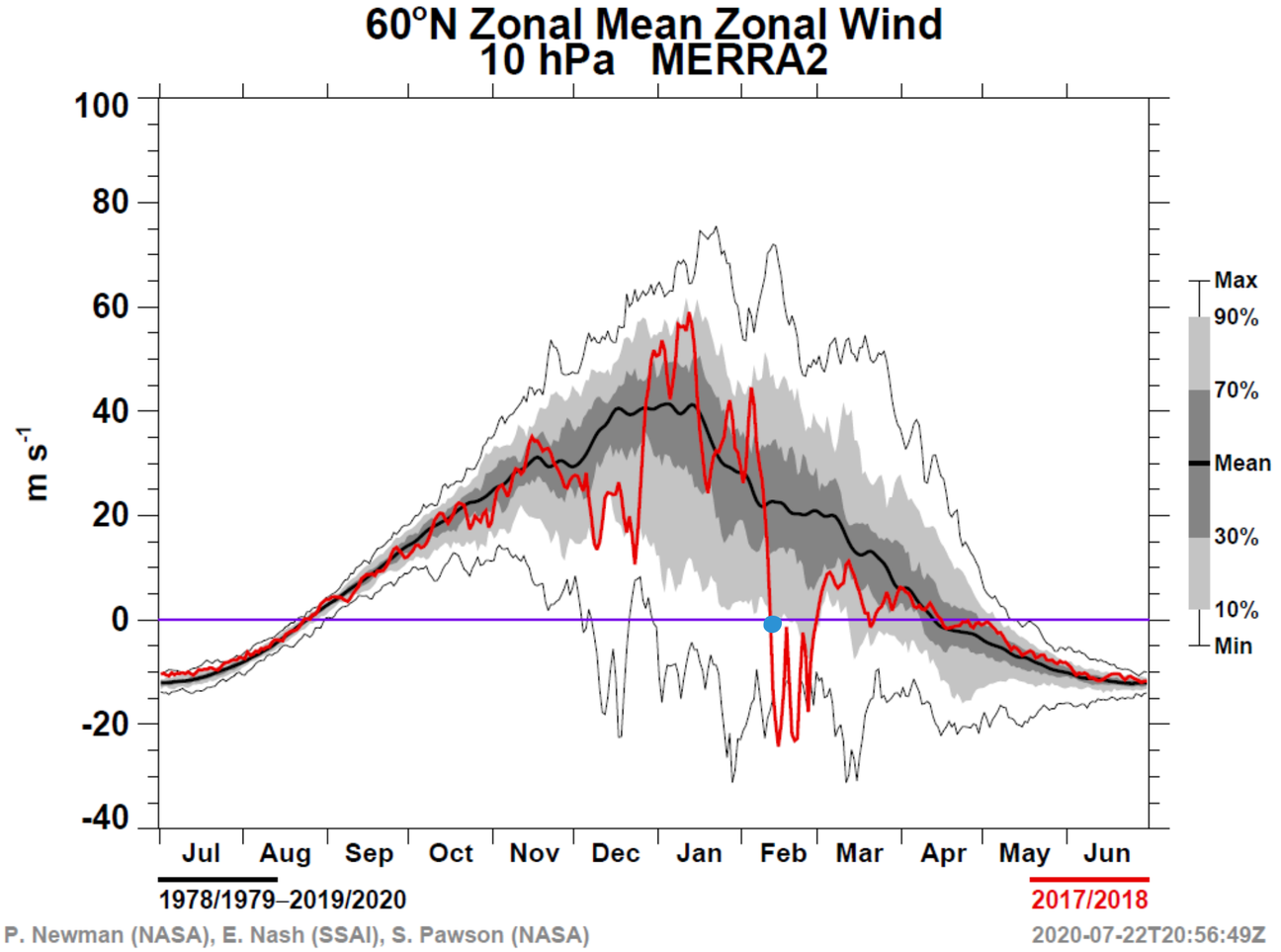


POLAR VORTEX EVOLUTION

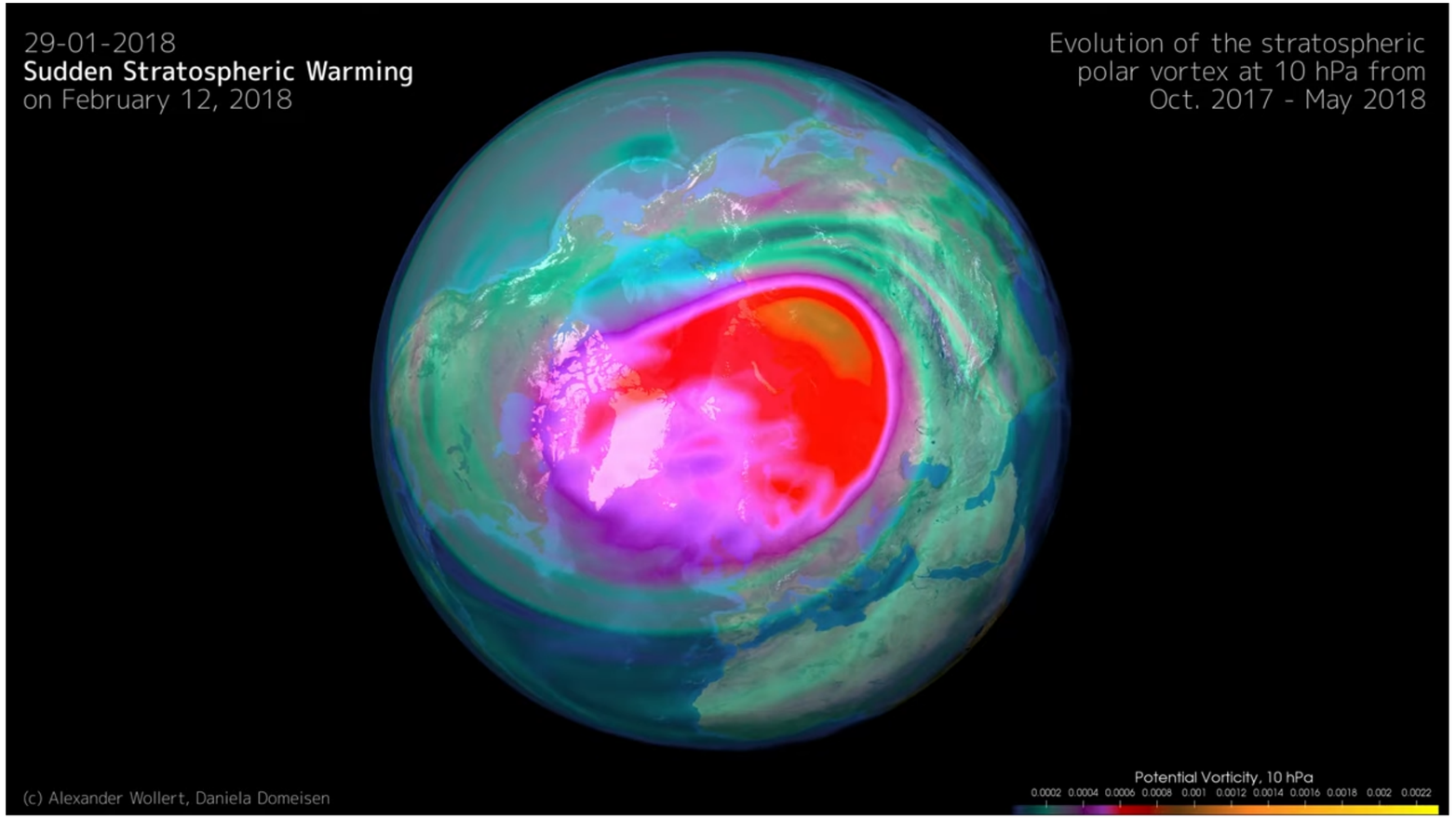


SUDDEN STRATOSPHERIC WARMING (SSW)

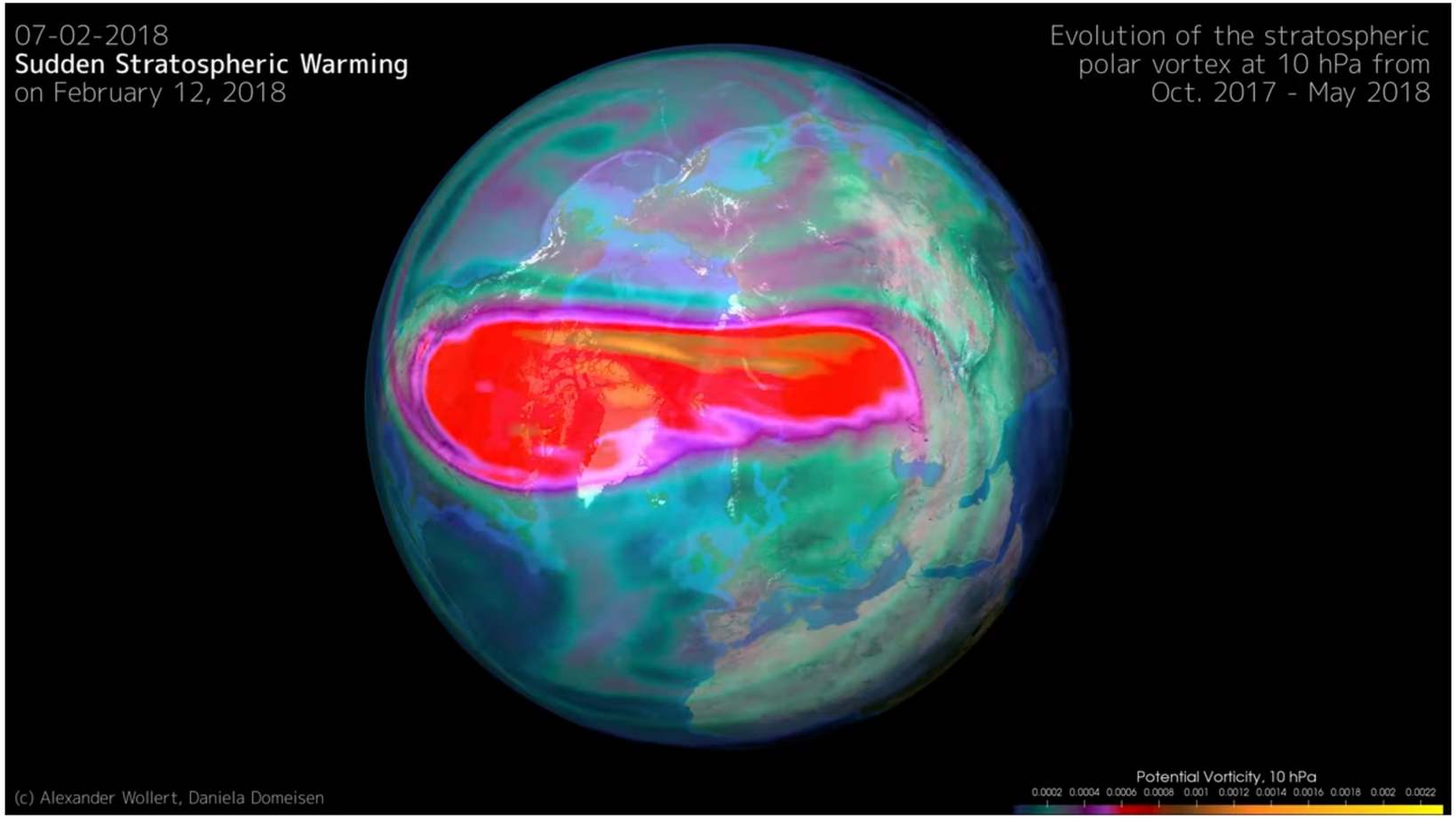
Sudden Stratospheric Warming:
A reversal in the direction of winds (from west to east) averaged at 60 N and 10 hPa before the seasonal breakdown of the vortex



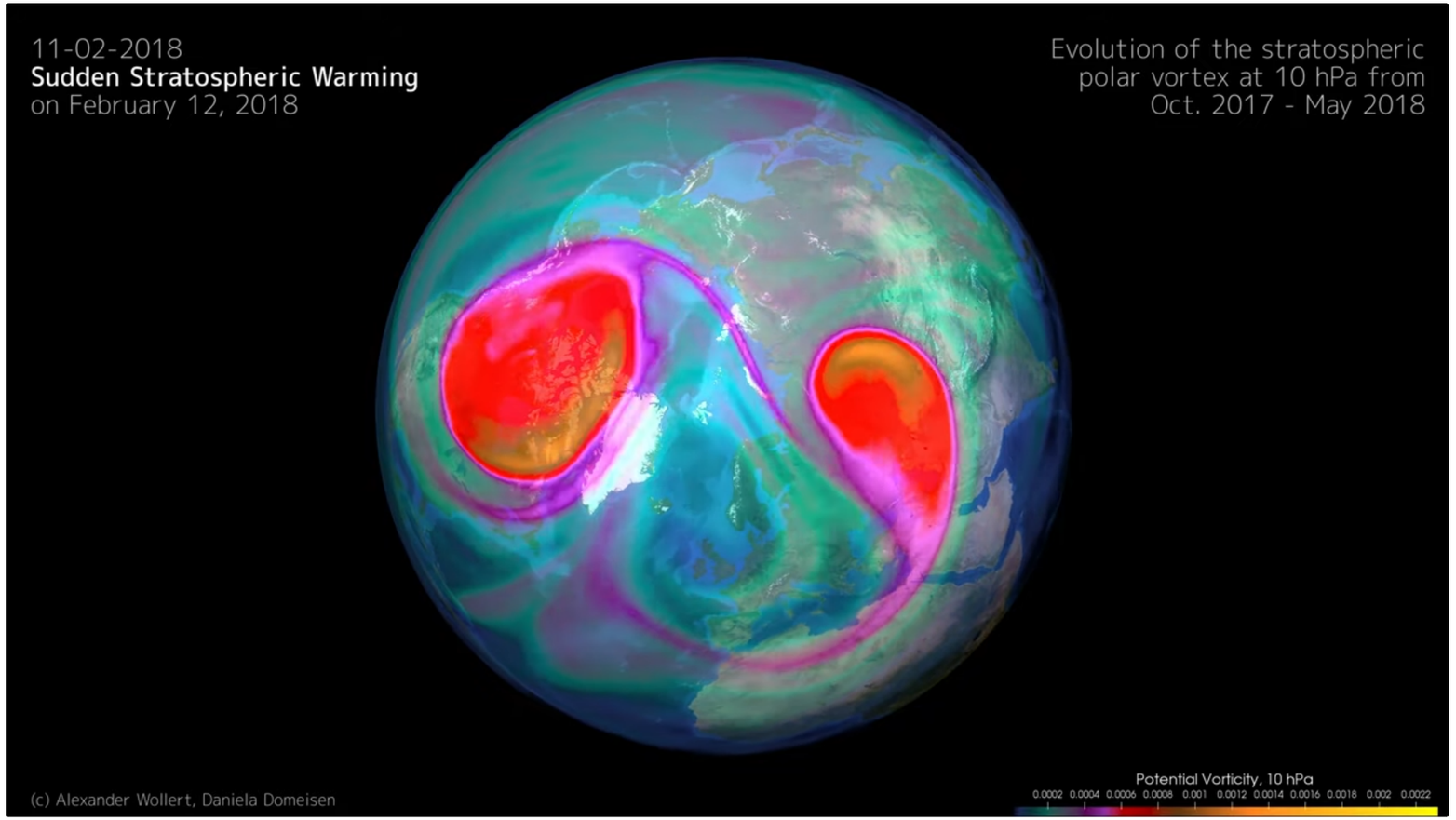
STRONG POLAR VORTEX



A FEW DAYS BEFORE SSW



SUDDEN STRATOSPHERIC WARMING



SURFACE EFFECTS OF AN SSW

In the two months following an SSW:

- Anomalously high pressure (weak low) near Iceland
- Anomalously low pressure (weak high) near the Azores
- Temperature and precipitation dipole in Eurasia
- *Sometimes* a cold and snowy eastern US and warm Labrador/Greenland

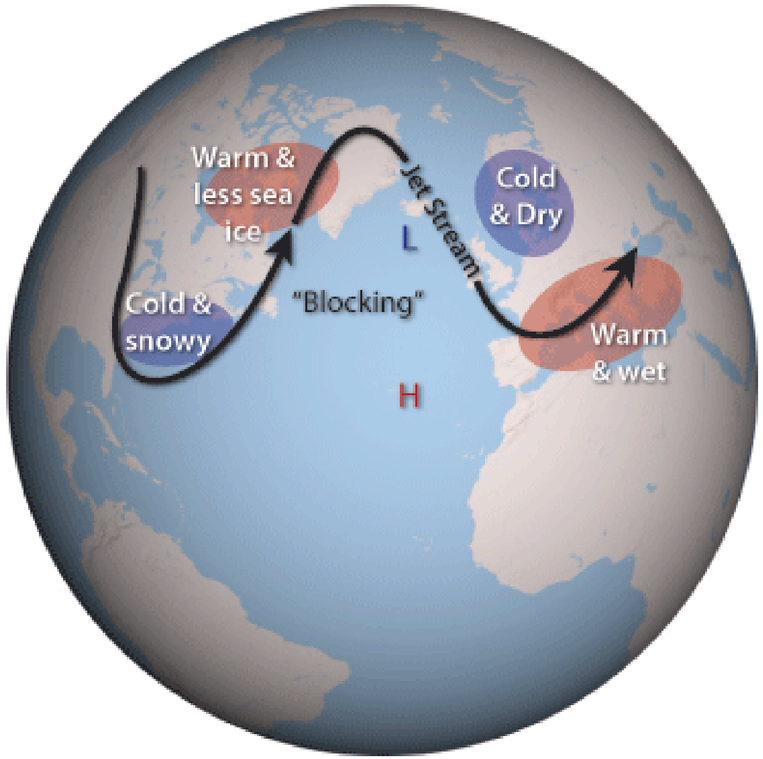


Image from NOAA

Typical pattern following SSWs

SSW AREAS OF STUDY

Prediction	How do we predict SSWs? What features tend to precede them?
Impacts	How do the effects of SSWs descend to the surface, and what affects that descent?
Change	How will SSWs and their effects change in the future?
Interactions	What other atmospheric features or phenomena interact with SSWs or their effects, and how?
Models	How well do different models represent processes related to SSWs and their impacts?

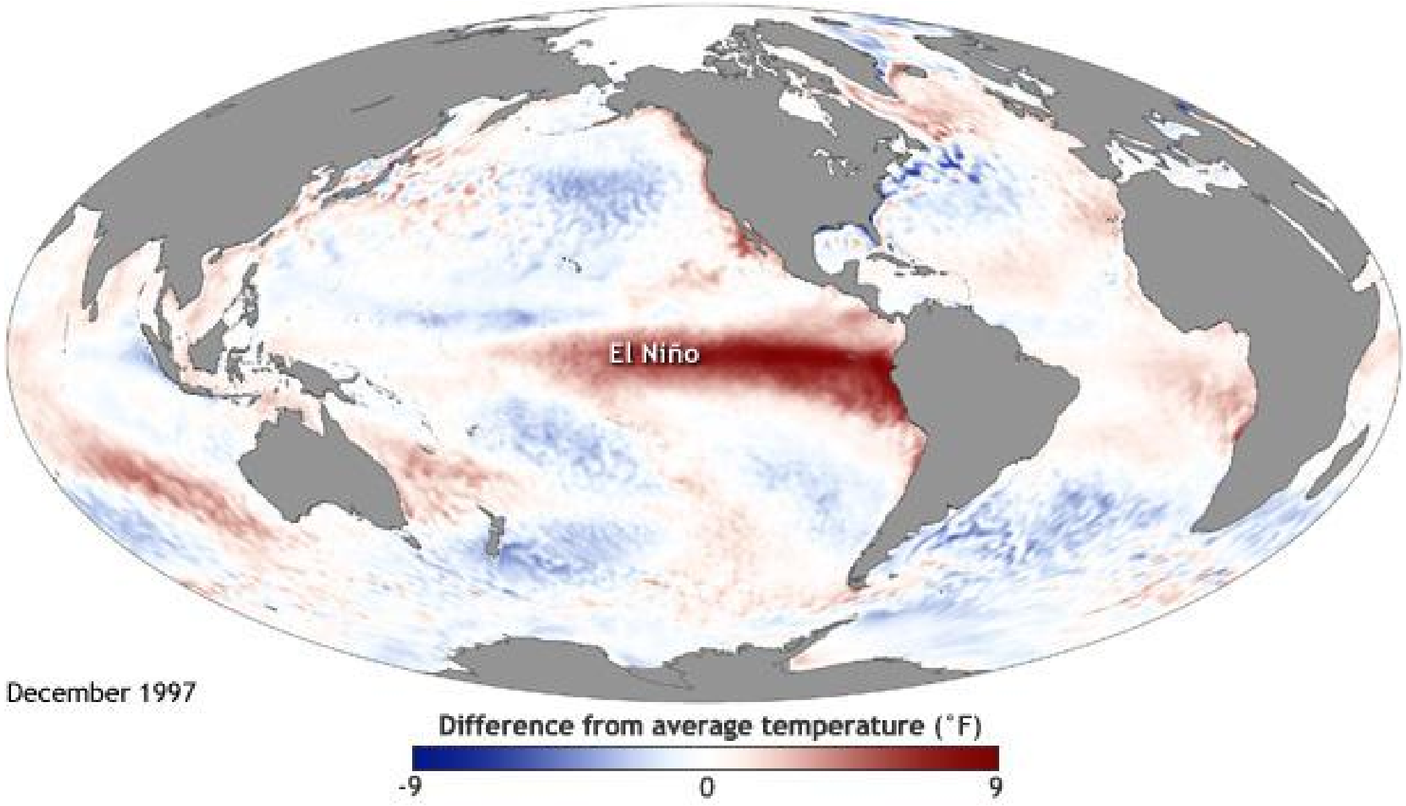
How do ozone chemistry and transport affect SSWs and their surface impacts?

Prediction	How do we predict SSWs? What features tend to precede them?
→ *Impacts*	How do the effects of SSWs descend to the surface, and what affects that descent?
Change	How will SSWs and their effects change in the future?
→ *Interactions*	What other atmospheric features or phenomena interact with SSWs or their effects, and how?
→ *Models*	How well do different models represent processes related to SSWs and their impacts?

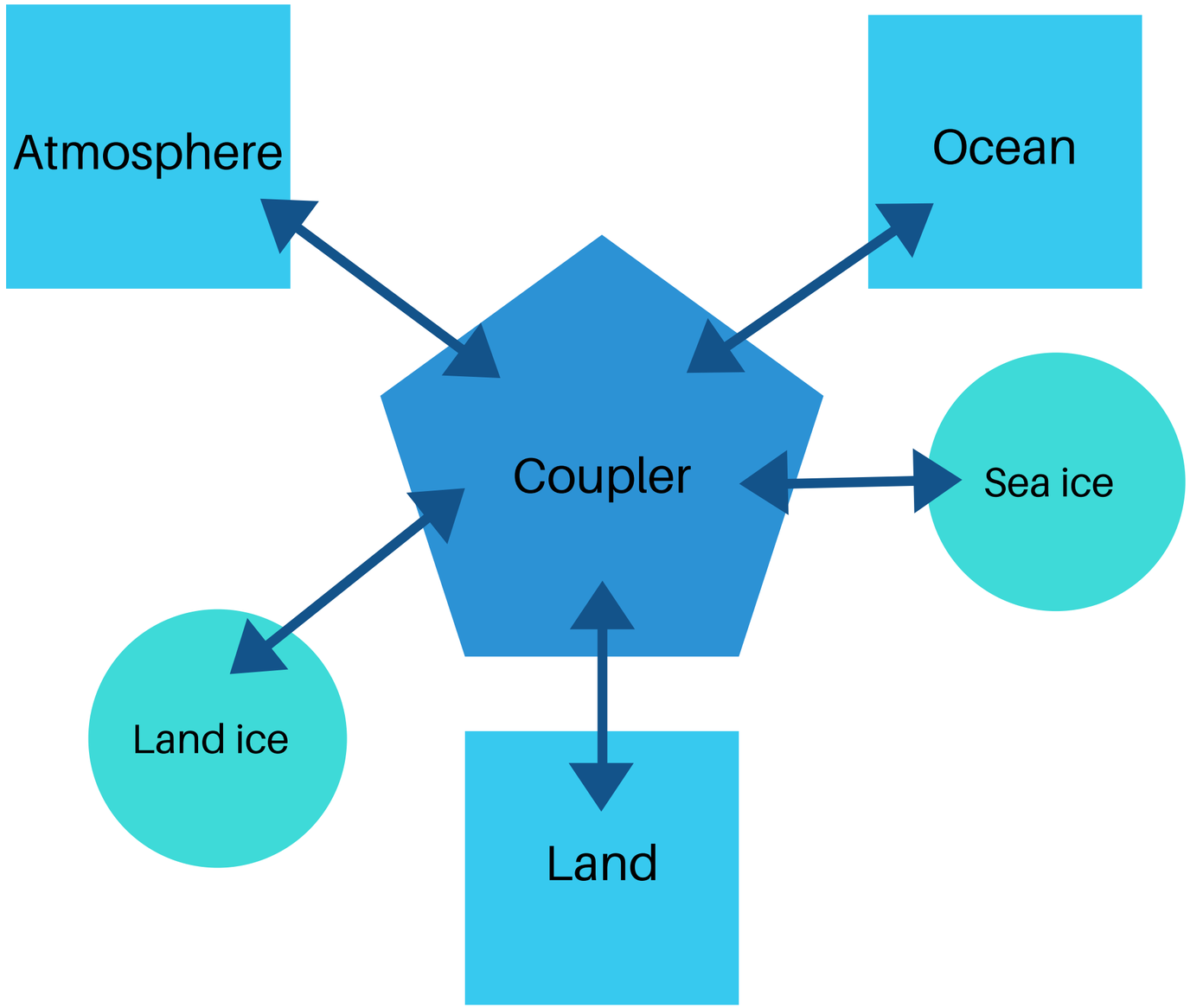
How do the surface impacts of SSWs change with El Niño-Southern Oscillation (ENSO) phase?

Prediction	How do we predict SSWs? What features tend to precede them?
→ *Impacts*	How do the effects of SSWs descend to the surface, and what affects that descent?
Change	How will SSWs and their effects change in the future?
→ *Interactions*	What other atmospheric features or phenomena interact with SSWs or their effects, and how?
Models	How well do different models represent processes related to SSWs and their impacts?

EL NIÑO


El Niño
December 1997
Difference from average temperature (˚F)
-9
0
9

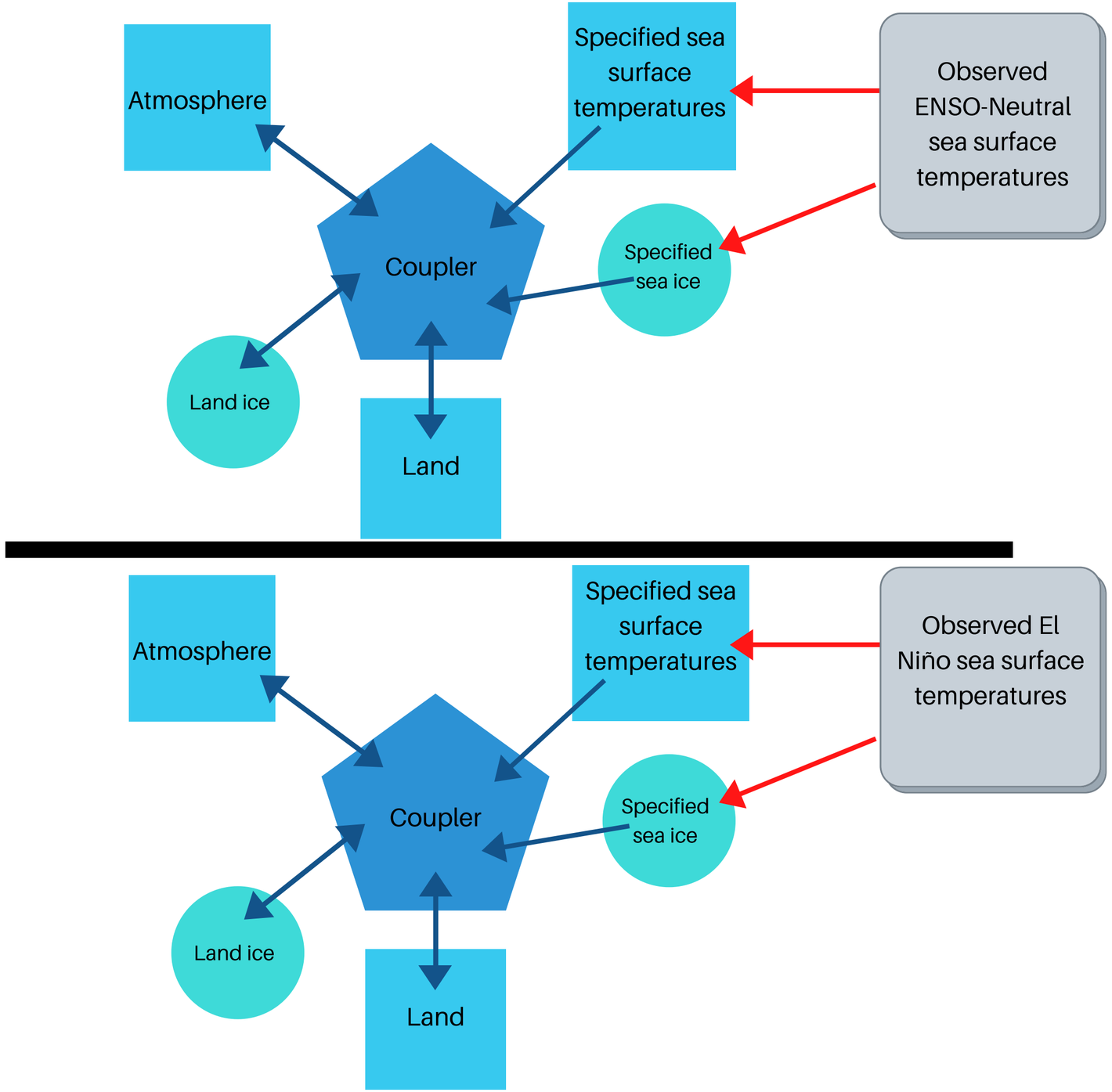
EARTH SYSTEM MODELS



EL NIÑO AND SSWS

How do the surface impacts of SSWs change with El Niño-Southern Oscillation (ENSO) phase?

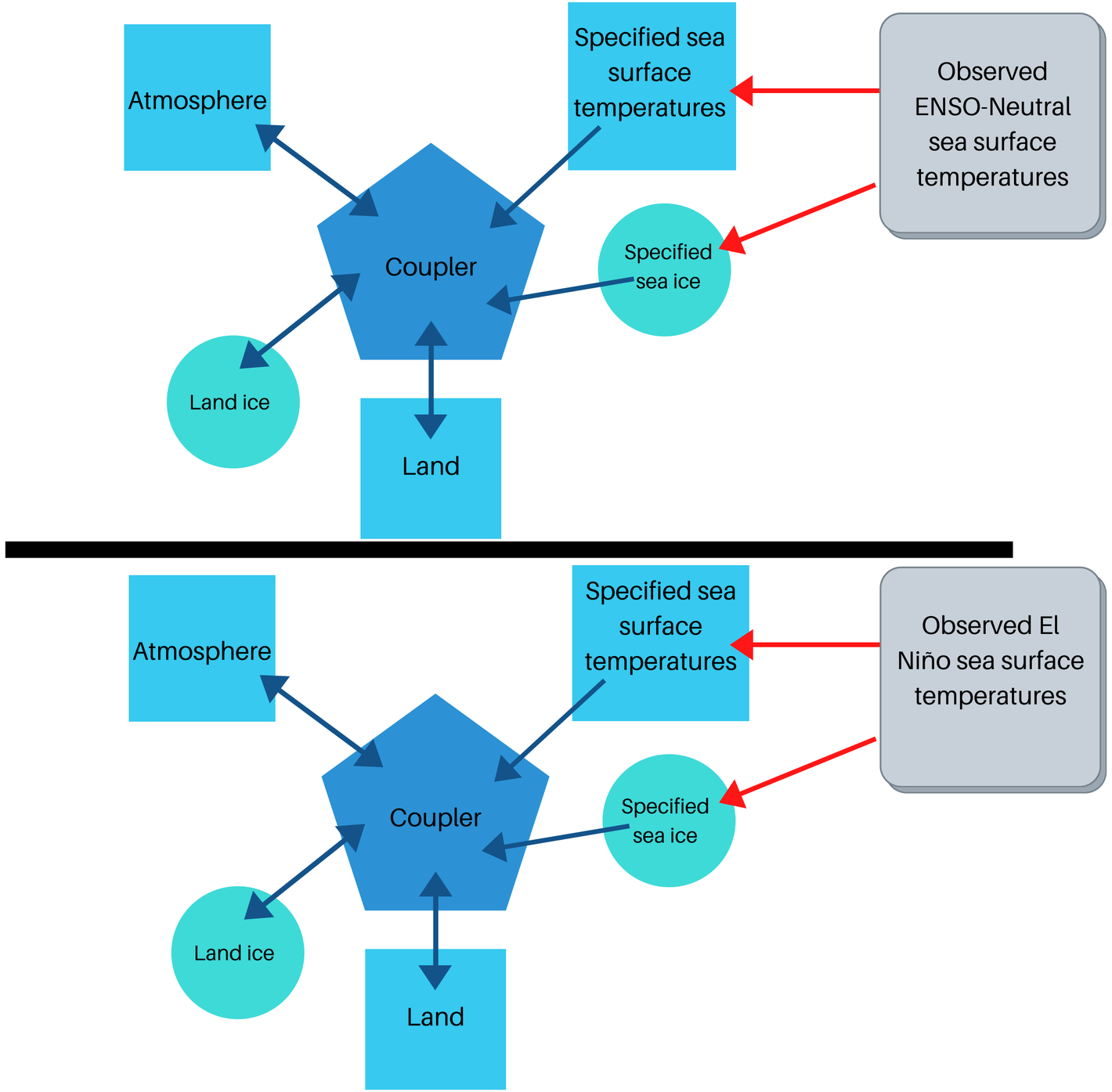
- Two sets of 200 year model runs with different specified sea surface temperatures
- We use simulation because
  - few events in observations;
  - isolates role of ENSO.



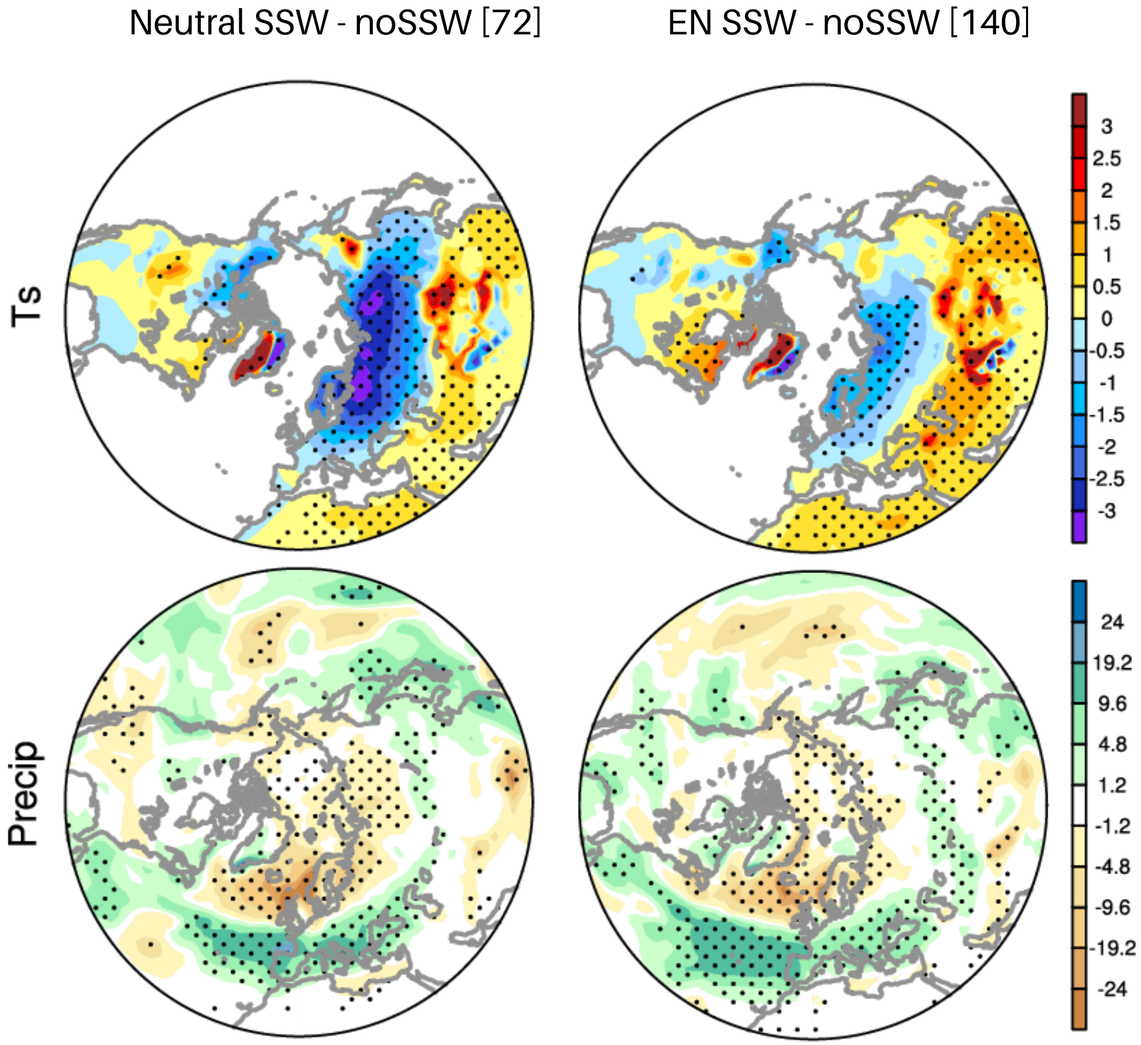
EL NIÑO AND SSWS

How do the surface impacts of SSWs change with El Niño-Southern Oscillation (ENSO) phase?

- Two sets of 200 year model runs with different specified sea surface temperatures
- Find SSWs in each set
- Compare surface climate in the two months following SSWs to non-SSW years under each condition



EL NIÑO AND SSWS



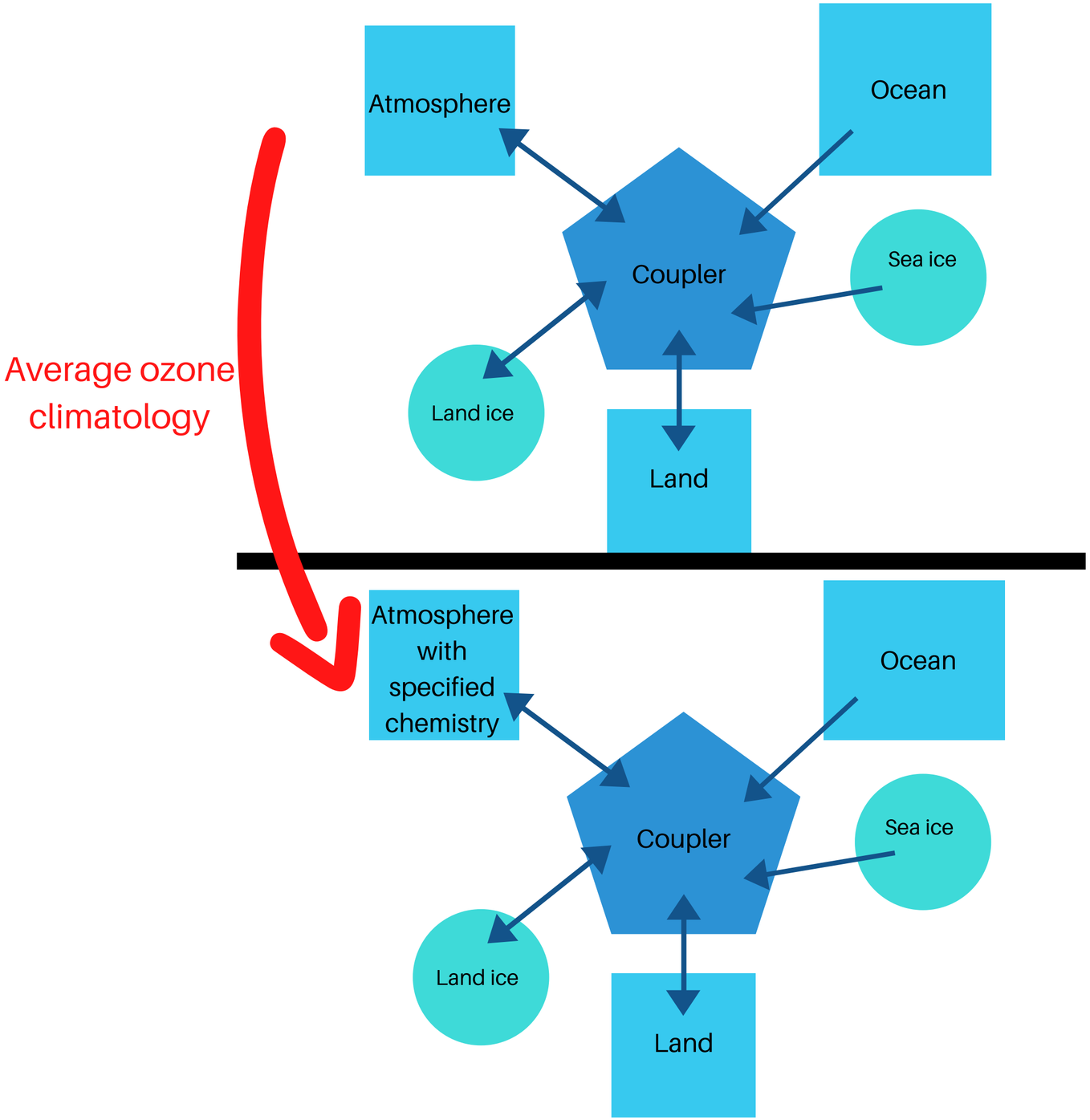
CONCLUSIONS

- Atmospheric variability occurs (and matters) on a wide range of timescales.
- The sources of that variability change with the timescale.
- The polar stratosphere is a key source of winter surface climate variability in the North Atlantic region.
- Climate models are helpful not only for prediction but also for understanding physical processes
  - in the absence of observed data;
  - through nonphysical experiments.

OZONE AND SSWS

How do ozone chemistry and transport affect SSWs and their surface impacts?

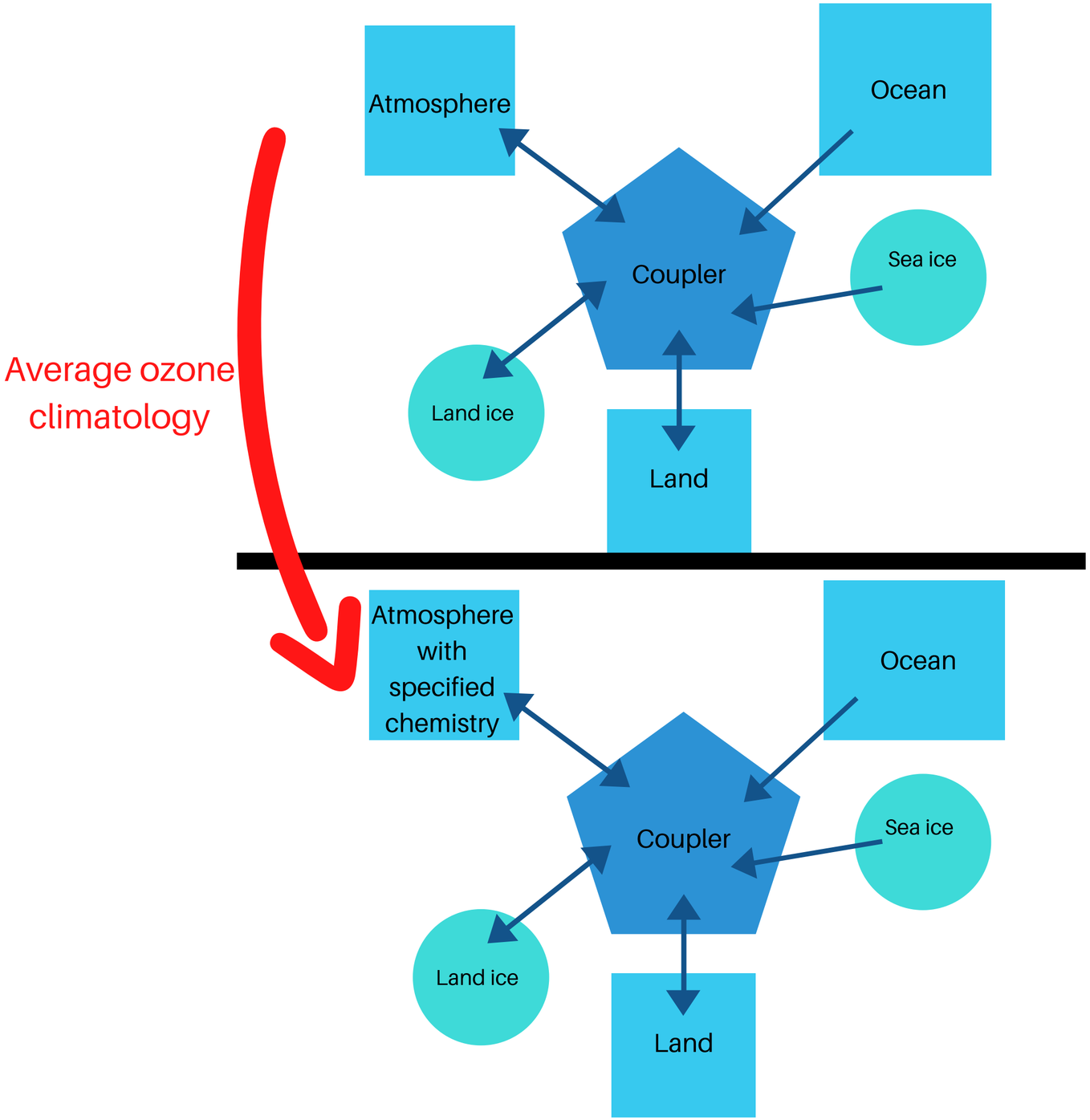
- Two sets of 200 year model runs, one that includes chemistry
- The second has specified ozone based on the average for each day in first simulation
- Simulation because this question is hard to answer observationally



OZONE AND SSWS

How does the inclusion of interactive ozone chemistry affect modeled surface impacts of SSWs?

- Two sets of 200 year model runs, one that includes chemistry
- The second has specified ozone based on the average for each day in first simulation
- Find SSWs in each set
- Compare surface climate following SSWs under each condition



OZONE AND SSWS