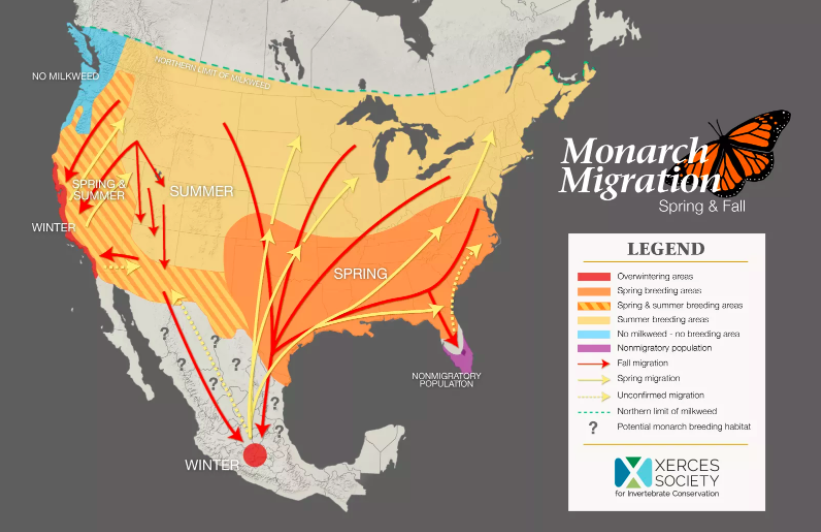
<https://monarchjointventure.org/news-events/news/eastern-monarch-overwintering-population-numbers-announced>

Using KNMI Climate Explorer: <https://climexp.knmi.nl/>

Field Correlations between Monarch Overwintering Acreage and 1) Temperature, 2) Zonal Wind Speed, 3) Meridional Wind Speed, and

4) Regional Correlations with Jet Stream Indices based on maximum Zonal Wind Speed and split into regions and seasons.

(Overwintering and field data was detrended)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month | Temperature | GPH | Zonal-300 u | Zonal-500 | Zonal-850 | Meridional-300 | Meridional-500 v | Meridional-850 |  |
| Feb | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.50.18 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.51.16 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.52.09 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.52.46 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.53.22 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.53.58 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.54.24 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.54.54 AM.png |  |
| August | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-14 at 1.41.16 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.50.32 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.52.31 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.11.41 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.03.33 PM.png |  | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.14.12 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.05.28 PM.png |  |
| September | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-14 at 1.41.31 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.50.40 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.52.14 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.11.47 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.03.41 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.54.59 AM.png |  | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.05.40 PM.png |  |
| October | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.46.34 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.50.56 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.52.41 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.11.57 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.04.21 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.55.11 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.14.28 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.05.57 PM.png |  |
| October-Nov | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-14 at 1.36.18 PM.png |  |  | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.13.07 PM.png |  |  |  |  |  |
| Nov |  | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.51.05 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 11.52.56 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.12.13 PM.pngMacintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.13.17 PM.png |  |  |  |  |  |
| Dec. |  |  |  | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.12.19 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.04.50 PM.png |  |  |  |  |

JulyAugust Reg5 is 104W to 58W, 49.5+-2.2N r = 0.287, p = 0.233

September (No jet Indices for September)

October November Jet stream Indices Region 6 (146W-98W; 47.1N +- 3.4N)(r = 0.373, p = 0.115) Showing a positive correlation with Jet stream position and Temperature in that region and Monarch overwintering numbers.

ToDo: (From meeting on 4/16/18, For meeting on 4/30)

Extract regional averages of: Mean, Tmax, Tmin for August, September, October regions.

Look into correlations of spring climate on following year overwintering acreage? February.

JF Reg 8 p = 0.034, r = -0.488; Jan Feb Reg 8 is over Atlantic ocean

JF Reg 3 p = 0.130, r = 0.360; Jan Feb Reg 3 is over Pacific ocean

May be getting at predictability of overwintering via SSTs, but since not directly over migration paths, should look at other lines of evidence.

Negative correlation of jet over atlantic and overwintering acreage- the lower the jet stream over the atlantic in JF, the larger acreage that following year.

Set up git repo

Figure out vertical transfer of energy for these regions of higher/lower wind speed- uplift created?

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Season | Region | Longitudinal boundaries | Mean±SD | | Temperature | Precipitation |
| January-February | REG 1 | 18-40 E | 27.5± | 1.8 | 42.94 | 21.88 |
| REG 2 | 40-80 E | 27.7± | 1.2 | 37.96 | 20.99 |
| REG 3 | 80-146 E | 28.9± | 0.9 | 33.57 | 18.60 |
| REG 4 | 146-172 E | 33.4± | 1.6 | 15.11 | 10.91 |
| REG 5 | 172E-100W | 37.0± | 3.6 | 48.04 | 24.69 |
| REG 6 | 100-72 W | 35.4± | 3.0 | 43.48 | 24.30 |
| REG 7 | 72-28 W | 41.5± | 3.8 | 51.09 | 25.69 |
| REG 8 | 28W-8E | 34.2± | 5.9 | 35.36 | 18.99 |
| April-May | REG 1 | 24-74E | 37.0± | 4.3 | 21.12 | 16.66 |
| REG 2 | 74-116E | 44.6± | 4.7 | 17.78 | 15.36 |
| REG 3 | 116-152E | 37.0± | 2.8 | 28.52 | 16.76 |
| REG 4 | 152E-150W | 41.9± | 2.3 | 37.50 | 14.66 |
| REG 5 | 150-120W | 40.9± | 4.7 | 20.98 | 19.37 |
| REG 6 | 120-94W | 38.3± | 5.6 | 21.47 | 14.59 |
| REG 7 | 94-56W | 42.2± | 2.9 | 11.79 | 10.43 |
| REG 8 | 10W -8E | 35.3± | 6.6 | 22.90 | 15.24 |
| July-August | REG 1 | 20-54E | 44.5± | 4.6 | 15.96 | 11.32 |
| REG 2 | 54-86E | 44.1± | 2.3 | 15.88 | 14.86 |
| REG 3 | 86E-160W | 47.2± | 2.7 | 18.15 | 14.70 |
| REG 4 | 160-104W | 54.4± | 4.5 | 16.92 | 12.56 |
| REG 5 | 104-58W | 49.5± | 2.2 | 26.04 | 14.79 |
| REG 6 | 58-16W | 50.3± | 1.9 | 21.05 | 15.94 |
| REG 7 | 16W-8E | 51.1± | 4.6 | 12.88 | 12.97 |
| October-November | REG 1 | 10E-26E | 37.2± | 7.6 | 8.67 | 9.67 |
| REG 2 | 26-56E | 38.4± | 6.7 | 14.75 | 14.82 |
| REG 3 | 56-104E | 39.0± | 5.5 | 26.38 | 14.03 |
| REG 4 | 104-148E | 36.7± | 2.0 | 25.73 | 8.8 |
| REG 5 | 148E-146W | 42.9± | 1.9 | 14.99 | 11.50 |
| REG 6 | 146-98W | 47.1± | 3.4 | 22.19 | 16.60 |
| REG 7 | 98-66W | 41.9± | 3.1 | 24.98 | 12.75 |
| REG 8 | 66-34W | 47.4± | 3.1 | 16.38 | 12.52 |
| REG 9 | 34-10W | 50.4± | 5.1 | 8.53 | 11.10 |

**Supplementary Table 1: Spatial correlation of seasonal NHJ indices with temperature and precipitation from 1930-2012 CE.** The longitudinal boundaries of each NHJ index (labelled as REG-followed by the number of the index) for each season. The mean latitudinal position and standard deviation, the fraction of the map (%) with significant correlations (*P<0.1*) with corresponding seasonal temperature and precipitation. The Precipitation and Temperature data are from gridded 0.5º CRU TS3.23 data [Harris et al. 2014].

|  |  |  |  |
| --- | --- | --- | --- |
| Month | Temperature Mean | Tmax (CRU 0.5d, 1994-2016) | Tmin (CRU 0.5d, 1994-2016) |
| Feb | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 7.50.18 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.08.55 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.14.08 AM.png |
| March | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.24.49 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.29.52 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.14.46 AM.png |
| August | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-14 at 1.41.16 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.09.08 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.15.07 AM.png |
| September | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-14 at 1.41.31 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.09.16 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.15.16 AM.png |
| October | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-16 at 12.46.34 PM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.09.26 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.15.24 AM.png |
| Nov | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.28.02 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.09.37 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.15.31 AM.png |
| Dec. | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.25.38 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 9.09.42 AM.png | Macintosh HD:Users:amyhudson:Desktop:Screen Shot 2018-04-30 at 11.43.24 AM.png |

Methods: I used the knmi Climate Explorer to run Pearson correlations with multiple climate fields (Tmean- GCHC, Tmax, Tmin) I detrended the climate field, jet stream indices, and the monarch overwintering area with a linear regression before making the correlations.

With the temperature mean, max, and min columns, we see where the max and min temps may be dominating the mean and the correlation signal with monarch overwintering.

We have the time series of the actual temperature data for the grid cell for August September.

Write up those results from R

Rerun February covering Mexico

Read the proposal.

Update TO DO list – GIT HUB!

Correlations with October temperatures in the South west may imply that butterflies that are west of the rockies may be coming down to mexico, possibly dependent on the CA climate.

Composite analyses may help a bit more with these hypotheses vs just correlation, however composite analyses are best with at least 8 years/ events (SEA analysis)

Do the butterflies migrating from southern British Columbia get down to California in October, find warmer weather, and then decide to keep going down to Mexico? Is this correlation an artifact of the

Wind speed: Meridional m/s negative if blowing from north to south (north wind) and positive if blowing south to north (south wind)

We would expect a south to north wind in February to lead to an increase in overwintering population the following year, because butterflies would get more support going north. That would be a positive correlation. We see a negative correlation.

Instead a strong south to north wind

Zonal wind is positive if it flows west to east and negative if it flows east to west

This may suggest instead that a strong ridging jet stream the February before (strong westerlies, strong northerlies) leads to warmer, (and dryer) conditions in California and wetter and colder conditions in February in eastern Canada.

August: Monarchs are expected to be observed most in Ontario (via the predictive model)