Polynya Project log

16/11/2023 - I already have the raw data for WRS,EWS,CWS. Now, just do the other regions.

21/11/2023 - Now calculated polynya statistics for all regions around the Antarctic and included the Zonal Wavenumber 3 index. When performing PCA earlier, the number of PCA components kept was 10, which corresponded to about 90% of the variation being explained. Now, the number of features has increased from 18 to 38, features being the climate indices and polynya data, so necessarily, we have to use more PCA components to use explain the same variance in the data. I am debating whether to use 14 components, which explains 80% of the variance, or 18 components, which represents about 90%, or 10 components, which represents about 70%. Using more PCA components complicates things, but we must to make sure we are accounting for as much of the variance of the data as we need to. What is this number?

The rows of the data matrix are times (months) and the columns are features (climate indices and polynya stats). Think of data matrix as a matrix of row vectors. Each row vector represents one time, and it represents the 'state of the system' at that time, so call these row vectors state vectors. The principal component vectors are a basis in which I can write these state vectors. The earlier principal components are more important than the later ones, i.e the first principal component is the most representative state of the system.

The PCA component vectors can be written in the usual 'feature' basis, i.e with 38 components. These components of each PCA vector can tell you about what the PCA vector physically means.

10/12/2023 - Polynya monthly scaled anomalies. Repeat for 30 and 65 % SIC thresholds. There are Nan values in anomaly time series - this is because for all the points for that month, say July, in that region, there were no polynyas, so std is 0.

24/01/2024 - Trying to answer the question of why there are months for which no coastal polynya area is observed for all years in certain regions. The question is what happens to the polynyas? Do they open out into the open ocean, or does sea ice simply cover the polynya?

For each region and day, land area + sea ice area + open ocean area + total polynya area = region total area. If region total area and land area are constant, then sea ice area + open ocean area + total polynya area = constant. Thankfully, we find this to be the case in the raw data and the daily interpolated data (didn't check this rigorously, just checked a large number of days in EBS in excel).

Unfortunately, I didn't save monthly sea ice areas and open ocean areas, only polynya areas. So I am going to save monthly sea ice areas and open ocean areas.

Note, monthly polynya data is actually monthly sums, not average over all days for that month. Now for each day, the above sum is a constant, but if we are comparing monthly sums to each other, the sum will NOT be a constant, because the months have different numbers of days. However, if we do the above sum but instead of using monthly totals, we use the average for all days over a month, then this value should be constant for different months, i.e <sea ice area> + <open ocean area> + <total polynya area> = constant across different months, where the angle brackets indicate the average over all the days in one particular month of one particular year.

Noting the above, I think its best to calculate the results we obtained earlier (30,65 and 30+65 graphs of e.g anomalies away from monthly means) but using averages over a month instead of monthly totals.

The confusing rolling average thing actually calculates monthly average. A naive method of just dividing by the number of days instead of the fancy pandas rolling average method actually gives 0 nan values I think.

Results from this:

The only regions that have an incomplete coastal polynya anomalies timeseries are EBS and EIS.

EBS coastal polynyas: no EBS coastal polynyas for the months Jul,Aug,Sep, causing nan values in anomalies time series. In these same months, the sea ice is rising dramatically, and the open ocean area is falling dramatically, and is close to 0. This indicates that the EBS coastal polynya is being converted to sea ice in these months, which makes sense, since these months are the austral winter.

EIS coastal polynyas: no EIS coastal polynyas for the months May-Sep. Again, sea ice area is increasing in these months and open ocean area is decreasing in these months, indicating that the EIS coastal polynyas are being converted to sea ice, which makes sense, since these months are the austral summer.

Actually, these conclusions are not 100% definite. Take the case of EBS coastal polynyas. Open ocean area actually decreases to 0 in Jul,Aug,Sep. We are concluding that coastal polynyas do not connect to the open ocean, but freeze over. They could in fact be lost because they initially connect to the open ocean, then the open ocean completely freezes over. We also need to disentangle the increase of sea ice area due to the freezing over of the polynyas from the increase of sea ice area due to the freezing over of the open ocean.

To definitively track what happens to the coastal polynyas in these months, need to track what happens to the individual pixels of the coastal polynya.

Note, actually tracking the pixels in the EBS, there is are some interesting events in 2010 Dec. From 2010/12/01 to 2010/12/02, coastal polynya and offshore polynyas in EBS grow and merge with each other, becoming one big coastal polynya. In December 2010/12/14 to 2010/12/15 coastal polynya opens out into the sea.

26/01/2024 - Note, in matshow plots, major grid lines have separation 50 ticks, where 1 tick corresponds to 5km?

Meeting: Around summer time, there is a sharp drop off in polynya area, due to polynyas opening out into the open ocean. Our classification method means that the polynya is now instantly classified as open ocean. This is unphysical, since the area that used to be the polynya is still governed to a large extent by polynya dynamics, so an effective polynya area should be prescribed, instead of classifying the whole area as open ocean. In other words, a smoothing needs to be applied to this sharp drop-off. The way in which this is done needs to be determined and will depend on the specifics of the polynya dynamics and how they differ from the dynamics of the open ocean. This may differ from region to region and possibly from decade to decade.

Initially, since we want to focus on the polynyas and not the open ocean, we will ignore months where there is significant polynya opening out into the open ocean, i.e some summer months. What months these are needs to be determined for the different regions. The method I will pursue is to first do a sphagetti plot of the actual raw time series of polynya extent against month for all the years without any statistical analysis, so I can identify the rough timeframe in which sharp drop off in polynya extent occurs. I will then visualise this region to pinpoint more exactly if opening out is actually what is responsible for this sharp drop off (likely) and the exact date which this occurs for all years. I will get exact drop-off dates for all years in a particular region, then pick a sensible timeframe over which I ignore the data in that region. I will then repeat this for all regions.

There are large negative anomalies in sea ice concentration from 1985-1990 in some regions - this is some quirk of the data, since this was not actually observed - identify the cause of this. Is the cause a lot of missing data in this time? Can investigate this by plotting number of nan values per year in every region.

Potentially get started on frequency/wavelet coherence analysis done by Swathi. We are interested in periods > 1year, which may indicate a link to the major climate indices outside of the simple annual cycle.

27/01/2024 - Looking at the total Jun-Jun raw polynya area for years between 1991 and 2022 (1985-1990 has some problem, need to check It out) EBS, drop-off always occurs between Nov and Feb, so plot flood_map for these months.

Note, another way that offshore polynyas can form is not only through melting of a pocket of sea ice, but also through connecting of sea ice around a section of open ocean at the start of winter - this is the opposite of polynyas opening out into the open ocean, and again in this way, that new polynya area shouldn't be ascribed as all polynya, but some effective polynya area should be given, since its still largely governed by open ocean dynamics. But we can consider this matter later. An example of this is EBS 1998 May

Note, interesting phenomenon in EBS 2003 Dec 30% - two offshore polynyas grow and merge with each other enclosing a little bit of ice - is there something taking heat away from that small region preventing it from melting and becoming polynya?

Disadvantage with ignoring summer polynyas - looking at the jun-jun plots, these are actually the largest polynyas.

29/01/2024 - It is quite clear from looking at the jun-jun plots and flood maps for the EBS with 30% SIC threshold that December is almost always the month in which opening out of polynyas into the open ocean occurs. There were polynya opening events in November and January for some years (1993 Jan, 1995 Jan, 2012 Jan, 1998 Nov), but these were in general of much smaller magnitude than the events in December, i.e the polynya areas in the EBS that opened were in general smaller.

For 65% threshold EBS, see a major polynya opening event a bit earlier than Dec in 1996 Nov, smaller polynya opening events in Dec.

Something strange happening for EBS 65% 2000/12/01 - seems like whole Antarctic land mass is classified as polynya, and there is no sea ice around Antarctic land mass?

I am classifying polynyas as areas which have SIC below a certain threshold (30% or 65%) surrounded by sea ice, which are defined as areas above this threshold. However, this delineation should ideally not be so sharp: for example, at the edge of a region classed as an offshore polynya, SIC might be 29%, and then transition to 31% in the surrounding region classified as sea ice - however, the region of sea ice close to this artificial boundary I have defined probably has similar dynamics to the so-called polynya. I think that for now, this simplistic representation of polynyas is not bad, but in the future, I would need to devise a scheme that better represents polynya areas. This would probably involve plotting a colormap of the sea ice concentration itself and use of a more sophisticated physically motivated condition to delineate polynya area.

EBS 65% 2012/11/27-30, there is polynya opening, but also the opposite phenomenon of polynya closing as described above for the summer months, I.e the apparent sudden formation of an open ocean polynya due to our on-off style classification - again, this is artificial , and is a disadvantage of our classification method.

EBS 65% 2017/09/12-13, sudden appearance of large offshore polynya - consequence of faulty classification system, or due to some large scale oceanic/atmospheric heat transfer to that region - probably there is some excess of heat that explains this, it is just not as pronounced as what the data implies due to the limitations of the on-off classification scheme.

EWS 30% 1991/07/18-20 - there is a minor polynya opening-closing event here - openings may happen as early as Jul.

EWS 30% 1993/03/01-02: there is actually a polynya opening here in March. But this month is generally when sea ice recovers.

In general, the polynya openings in Feb and later, or October or earlier, are of far smaller magnitude and are far less frequent than the openings in Nov,Dec,Jan.

Should I classify the 'importance' of the opening events, i.e the size of the polynya that opened and the subsequent size of the jump in the polynya record? If a very small polynya opened out and the jump is very small, does it really matter? In addition, should the importance of the opening events be judged in terms of the absolute jump, or the size of the jump relative to the typical polynya areas for that region. As an example, the polynya areas in the EWS, are typically smaller than those in the EBS (according to our classification scheme), and as a result, the absolute size of the jumps is smaller for the EWS than for the EBS.

Whatever the size of these jumps, significant numbers of openings only occur in the same sorts of months (the summer months of Nov-Feb) from looking at jun-jun plots, and I'm trying to identify months to ignore, so probably don't need to do extra analysis to consider the importance of the polynya openings.

Note, large inaccuracies occurring at 2000/03/02 and 2000/03/22 and 2002/03/24 and 2002/03/30 and 2002/03/31 and 2003/03/24 - suddenly, a large section of sea ice gets classified as polynya.

From the above recent considerations, it is of high priority to devise a better polynya classification scheme to prevent these large 'discontinuities' (they aren't strictly discontinuities, just sudden changes that aren't due to a physical reason, only due to the drawback of the on-off classification scheme).

30/01/2024 - Could be beneficial to include consideration of SIC spatial gradients when classifying polynyas - a very steep SIC gradient at the boundaries of the polynya makes it easy to classify, but how are we to classify it when there is a very shallow gradient? The naive threshold method we are using seems unsatisfactory, since we set a sharp boundary where there may not be one.

2017/09/12-13 EBS 65% Flagged this yesterday - sudden appearance of a large offshore polynya. Now if SIC is initially far higher on average in this region than the threshold of 65%, and then over the course of 1 day, it becomes far lower on average than the threshold, then can confidently say that this polynya has formed over the timescale of 1 day. However, if the SIC in this region had been steadily decreasing for multiple days, it would be too simplistic to say that the polynya just appeared overnight, resulting in a spike in the offshore polynya area. Ideally, in this situation, polynya area should increase smoothly over some timescale which needs to be determined from the SIC data and from physical justifications. Need to research polynya timescales.

Our threshold method indicates a sudden offshore polynya formation, and this is in fact validated by looking at the mean SIC in this area. Around the polynya formation time, mean SIC slope is large and negative, and final mean value after the sharp decline is <40% , indicating that there is some physical mechanism driving this and its not just a consequence of our threshold method. The timescale over which the steep drop in SIC occurs is roughly 4 days, from the 10th to the 14th. Therefore, concluding that the polynya forms over 1 day from the 12th to the 13th, which is what we get from our threshold method, isn't a terrible approximation in this particular case, but demonstrates that the polynya should probably be formed over a slightly longer period than 1 day, somewhere between 1 day to 1 week.

There may be other instances in which a large polynya area forms according to our threshold method, however the decline in mean SIC around polynya formation time is slow. Then, our threshold method will show a large sudden spike in polynya area, when in reality, increase should have been MUCH smoother.

31/01/2024 - There is some mention of the PSSM method in the literature (see some of the papers in my 'Papers' folder). This method relies on characterising polynya area using a variable called the polarisation ratio, which is derived from brightness temperatures at different frequencies and polarisations (V=Vertical, H=Horizontal). It relies on iteratively improving a simulation polynya image as compared to a measured polynya image - an iteration is chosen which maximises correlation between simulated and measured images and minimises absolute differences in brightness temperatures.

There is also a paper on the use of thermal infrared sensors, such as MODIS, as compared to passive microwave sensors when classifying a certain Greenland Polynya called the North Water Polynya. The upside of the thermal infrared sensor is the increased spatial resolution compared to passive microwave sensing, however passive microwave sensing is relatively insensitive to cloud cover compared to thermal infrared sensors.

This paper details a method to calculate polynya area from retrieved MODIS variable, which is ice surface temperature (IST). IST is first converted to a quantity called thin-ice thickness (TIT) using a thermodynamic model, and TIT values below 0.2m are classified as polynya.

01-03/02/2024 - Earlier identified a problem, either in the data or our flood-fill algorithm, in the years 1985-1990. Subsequently plotted flood maps for these years for whole of Antarctica to identify problem. Can see that some days, the whole of Antarctica is classed as a polynya. Looking at the raw arrays, can see that there are two types of problem days:

1. All pixels have 0 SIC. Most of the problem days are these.
2. It is not the case that all pixels have 0 SIC, however all the sea ice is classified as a polynya. This kind of problem only occurs for 30% threshold, not 65% threshold (e.g 1985 Jul 3 30%)

Need to check how regional interpolation handles these days. Looking at missing_days.csv, it looks like some of the days that do have missing data have not been included in this csv, e.g compare the flood maps for 1985 Sep to reported missing days in missing_days.csv. But, maybe this is an old csv.

We are using polynya extent, and not polynya area, i.e we are taking the whole pixel as polynya if it has SIC below the threshold, not just the part of the pixel that is open water, which would involve multiplying SIC by the area of the grid cell.

Meeting: M Rogers and J Rosser came up with a strategy for handling polynyas around Nov-Feb where the vast majority of the polynya opening events occur. The strategy is as follows:

1. In the whole winter period, before opening events occur, all pixels are classified into 5 categories: 2 polynya categories (coastal and offshore), sea ice, open ocean, land.
2. When opening occurs, we create 2 new categories: ‘Polynya formed at or after t = 0’ and ‘open ocean formed at or after t = 0’.
3. The Pixels that formed the ‘ice bridge’ between the polynya and the open ocean prior to opening are classified as polynya once opening out occurs
4. We then classify the relevant pixels into the 2 new categories.

Also, problem in early years where classification is incorrect for 30% could just be a consequence of not standardising colours for the flood maps, and one category might be missing. Need to check this.

NOTE - CHANGE TO CODE THAT CREATES INITIAL POLYNYA AREA ETC. CSV FILES - regional_polynyas_data_to_csv_download_copy.ipynb. region_mask1 is the same as region_mask2, so no point in creating region_mask2, so delete code that creates region_mask2.

Possible method of implementation:

Say there is an opening event. For the pixels of the ice bridge, pixels closer to Antarctica than the ice bridge pixels are polynya, pixels further from Antarctica are open ocean. Then, the pixels of the ice bridge become open ocean, along with all the polynya pixels behind the ice bridge. To identify the locations of opening events, we want to find ice bridges. To identify the opening time, want to find the time at which pixels of the ice bridge transition to open ocean.

Want to mask ice pixels on the borders of polynyas differently.

05/02/2024 - I devised a method of identifying all polynya pixels which border sea ice. :

1. Run the initial algorithm until step 5 (see word document Polynya_algorithm.docx), where we produce the image flood_map. The classifications used are S=0,L=1,O=3,P=5
2. Each pixel has 8 neighbours (periodic B.Cs at the edges of the image, which are unimportant anyway because they are always ice free). Consider an arbitrary pixel and call this the central pixel. Use np.roll on flood_map to create 8 images which are shifts of flood_map in each of the 8 neighbouring directions. In each image, one of the neighbouring pixels is now in the position of the initial central pixel
3. Take the difference between flood map and each of these 8 images, so that each pixel has 8 associated values, which are the differences between it and its neighbours
4. Create an image where every pixel is assigned the value of the maximum of the 8 neighbouring differences for that pixel.
5. The polynya-seaice borders are the pixels in this array of maximum differences which have a value of 5 (remember, P=5,S=0 so P-S = 5, and the values for the other 4 borders are different from 5).
6. Identify the open ocean pixels that border sea ice on day t=-1 - call this the 'old ice boundary'
7. Identify pixels that are 'contained' by the border sea ice pixels, i.e between border ice and Antarctic land mass. Can't simply use inverse of the border masks, because then pixels that are further away from Antarctica but still not border pixels are included.

Using these identified borders between polynya and sea ice, I want to identify opening events and handle accordingly

1. Want to identify days when there are opening events AND the border polynya pixels that open into the ocean.
2. For a particular day t=-1, once you get the borders, check all border pixels to see if they have turned into open ocean or not on day t=0. If they have, assume that identified pixels have opened out on day t=0. If they haven't, pixel hasn't opened out.
3. For pixels identified as opening out on t=0, run the 'flood' function on day t=-1 to create a mask which identifies all pixels of the polynya which the opening pixel is a part of.
4. Assign the opening pixels and all polynya pixels in the t=-1 flood mask the polynya value on day t = 0 (since the initial algorithm classifies it as open ocean on day t = 0).
5. Identify all interior pixels on day t = 0 that are open ocean
6. Identify the interior pixels on day t = 0 that are open ocean and border polynya pixels - these are 'new polynya' (new classification)
7. Want to then flood fill from one of the interior ocean pixels that border polynya and classify these also as 'new polynya'
8. The interior pixels on day t = 0 that are open ocean and do NOT border polynya pixels are 'new open ocean'

Need to identify polynyas that ARE open currently and other polynyas that WILL open the next day.
Already created the criteria to identify polynyas that will open the next day.
Polynyas that are open currently have a border with the old sea ice border.

Between step 10 and 11, when we reconvert the newly formed polynya classifcation back to the old polynya classification to return step 11 to step 5, we count new polynya pixels. Then, when we repeat for subsequent days, we only get the new polynya pixels FOR THAT DAY, so to get total new polynya pixels, need to take cumulative sum.

In step 7, where we identify all polynyas that opened out the next day, if there are none, replace the extra classifications of PSB and OSB with the old P and O, returning us back to the end of step 5 (where we have flood map).

06/02/2024 - Europe polynya meeting -

1. Use both SIC and SIT data to identify polynyas and compare results - maybe if there is no opening in one type of data, can use that data for that day etc.
2. No thresholding - just investigate SIC distribution link to climate indices
3. What is a polynya? Need some external data - area of upwelling etc.
4. Use multiple thresholds

07/02/2024 - Problem - new algorithm works for initial opening event, but there is a problem when you try and run the algorithm on the output, where the polynya that has opened out is classified as polynya, all the new polynya pixels are reset to polynya, all the new ocean pixels are reset to ocean. What happens is it identifies.

The thing is, the image that is produced from the initial image, which is the image for just before opening, has polynya bordering open ocean.
We want to identify this and cap it off with a different mask, so that when we do the flood fill to obtain new coastal polynya in the next iteration, we don't flood fill the whole open ocean.
The thing is, some of these polynya pixels that border open ocean also border sea ice on the other side, so the max method doesn't work, (just see values for the pixels and will easily see why) - the polynya pixels that border open ocean and ice are not included in the cap.
So, just need a new way of identifying polynya pixels that have at least one neighbouring pixel which is open ocean.
Need to carry through the boundary from step 7 to step 8, but for open polynyas, this is not currently working.
Check steps 8 to 9

10/02/2024 - New algo takes about twice as long? Not bad.

Slight problem with NO calculation. Only calculates NP when and where opening occurs. But NO is calculated at every step and everywhere interior to the sea ice boundary where new ocean forms regardless of whether opening occurred or not.

If there is an opening event IN THE REGION or there are currently open polynyas, we want to count NO in that region alone.

Flood fill from O pixels which border NP? - No, because these pixels don't exist - would have been flooded as NP.

NP calculation is fine, so leave algo for now. NO is also a very small error, because we recalculate the OSB each time and NO is open ocean INSIDE the OSB (which doesn't border NP), so value of O has very small error.

What you want to do is delay the step of getting areas. First clear off the classifications, calculate POSB boundary.
Then determine if the region has any POSB boundary.
If it doesn't, we still have the map with the new classifications NOT cleared away. In this map, classify all the NO as O.
THEN only calculate areas.

Storm going over - get polynyas.

15/02/2024 - Algorithm UNINTENTIONALLY gets polynyas which are currently open on day t = -1 BECAUSE, to get polynyas that open the next day in step 7, take the intersection between PSB from t = -1 and O from t = 0 - polynyas which are currently open probably have some sea ice border, I.e some PSB pixels and because ice retreats in the summer, it is very likely that the next day, using the OLD algorithm, those PSB pixels are ice free. HOWEVER, in the winter, when sea ice is ADVANCING, there will be no opening events. The currently open polynyas may have sea ice borders, BUT, because ice is advancing, very unlikely that those PSB pixels will be O the next day, they are more likely to be S. SO, as a result of not counting currently open polynyas separately, get SHARP DROP in polynya area when suddenly it seems like no polynya is detected.

Identified the problem - algorithm only works when ice is RETREATING. This is because we carry over polynyas that open or are currently open (albeit in a non-ideal way as described in above paragraph) to the next day - this works if there is open ocean around these polynyas the next day during the period when ice is retreating. But when ice is ADVANCING, carrying over opening or open polynyas to the next day actually HIDES the newly formed ice as Polynya, which is not what we want.

SOLUTION - Only carry over the part of open or opening polynyas that is NOT sea ice the next day

Now that I implemented these changes, don't get huge sharp drop in polynya area anymore

Took 8.5 minutes to run a whole year for one region, BUT, I think my computer was quite slow. Nevertheless, at this rate, with 10 regions and 38 years between 1985 and 2023, will expect to take.

18/02/2024 - Now when I compare flood maps produced by initial algorithm to those produced by updated algorithm, when ice is advancing in the winter, there seem to be these regions where the ice grows back in 'specks' . Specks don't occur in EBS, so maybe that's why updated and initial seem to align in winter. This speckling is on the borders of sea ice and open ocean and doesn't extend too far into ice sheet, although it's noticeable. It shouldn't affect polynya area counts as long as polynyas don't extend into this speckling region.

Need to identify where this speckling comes from. Speckling occurs during winter at the borders between sea ice and ocean only - can't represent growing sea ice properly - sea ice interspersed with open ocean for some reason.

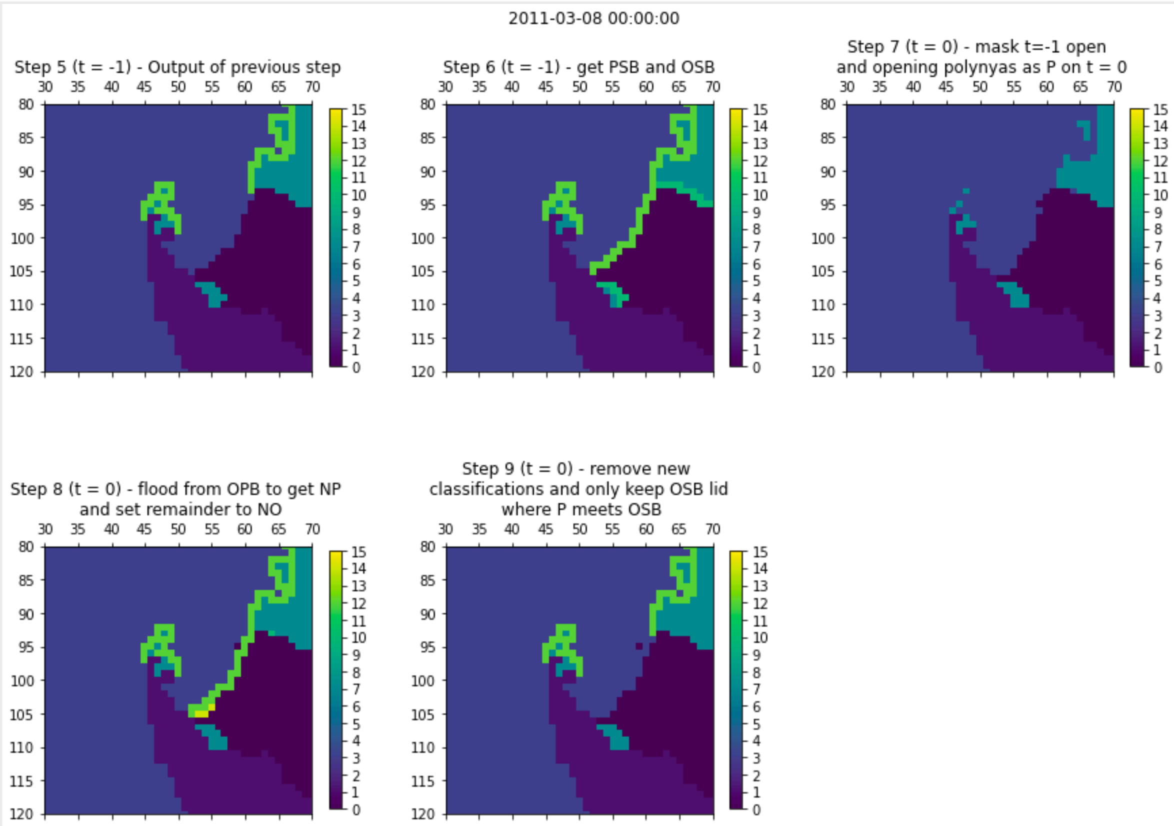
Reason - sometimes, sea ice is getting entrapped within the OSB as it grows in winter - some of these ice pixels then get classed as NO.

Problem seems to be POSB and OSB (both masked as OSB) go through pixels where there is newly forming ice.

Remove OSB around step 7/8? Or move around which particular place I install it in these steps?

Problem - Step 8 involves flood filling up to the OSB from open ocean that borders polynyas to identify NP. Now this works when the ice is retreating, but when the ice is advancing past the OSB, get this speckling problem.

We don't want the OSB in locations where ocean borders sea ice - call this pure OSB (remember that OSB bordering polynya is also masked as OSB) - when the ice is advancing. How to check if the ice is advancing? Get locations of all pure OSB pixels on t = -1, and replace pure OSB with O in the locations where they turn into sea ice the next day - remember, don't want OSB in these locations because it will cause speckling.



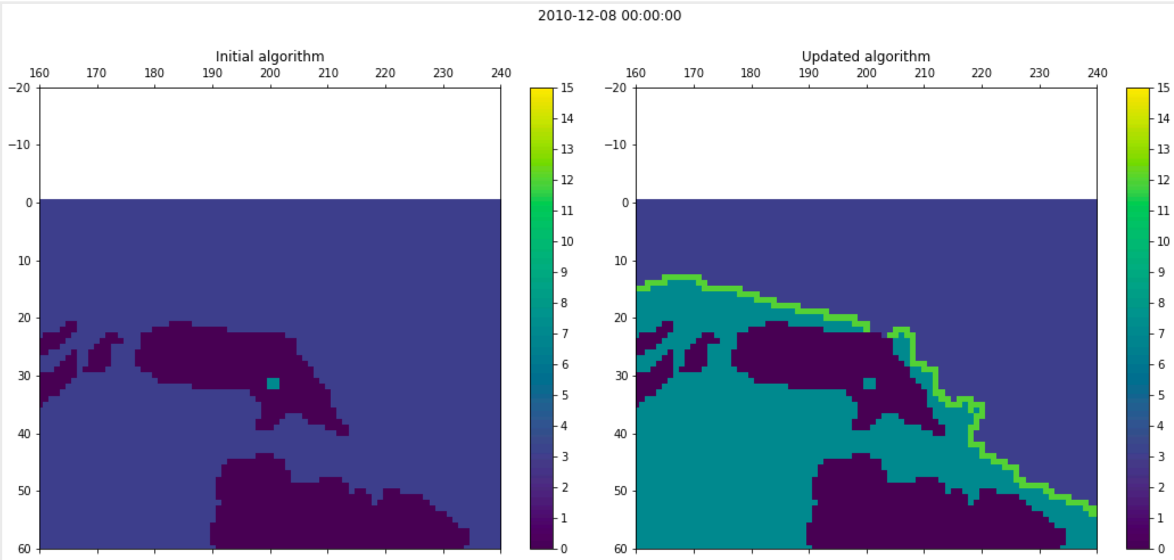
By implementing the above, the speckling problem is solved.

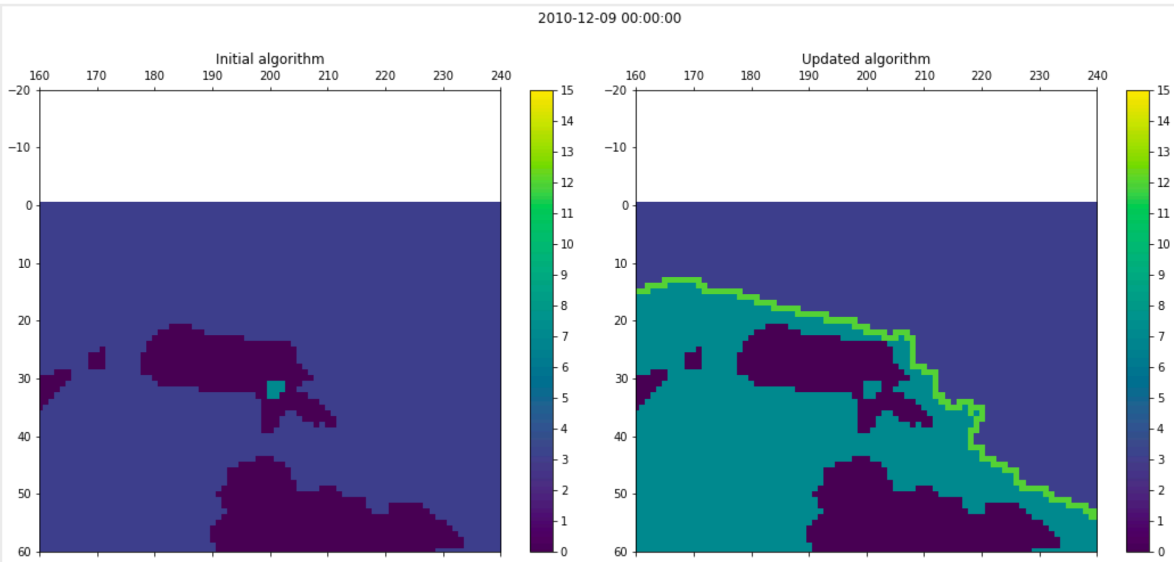
25/02/2024 - New problem - in various sectors (not really EBS), polynya remains long after all ice has retreated and WELL into ice advancing winter period AND next ice retreating summer period.

Ideally, what we want is peak polynya area in peak summer (December) when ice has finished retreating. After December, ice probably advances, so slowly want to reduce polynya extent from its edges.

For this, need to identify a safe day to say that this is peak summer. Then, for each polynya pixel of the polynya open ocean border, want to set it as ocean the next day if in the initial algorithm, that pixel is ocean the next day.

Could define peak summer as the first day when there is one big continuous polynya open ocean boundary. An example is given below:





As we can see, the polynya open ocean border is not continuous on the 8th Dec, but becomes continuous on the 9th. Therefore, from the 9th, can start outwards-in polynya reduction process.

However, I don't think it will be as easy as this, because even if there is one continuous border around the outside, there could be small borders on the inside or perhaps outside of the main border. So, probably need to decide on a date.

Actually, in 2011, main continuous border actually forms very early around late October, but it's quite close to sea ice, so probably set a date of 21 Dec (southern summer solstice) to start outwards-in polynya reduction process.

OR, as soon as POSB forms, if that pixel is O the next day from initial algo, set it to O.

Use this latest trick of open ocean eating neighbouring polynya by layers of thickness 1 pixel at a time. Arbitrary - 1 pixel layer thickness not determined through physical reasoning, just an ad hoc method to reset the flood map by the next winter so that we don't have large polynya areas surrounding the ice sheet come winter time.

FINAL thing - how do I want NP to behave? Get bl of current NP, take union with bl of previous NP and intersect it with f_t0 not S.

Don't care about NO, so comment out lines that calculate NO to potentially save a bit of time in the also.

Is it a problem that NP seems so much larger than P? No, because the way we are calculating P is P on that day, but the way we calculate NP is cumulative.

06/03/2024 - Meeting: Do runs with and without ocean eating polynya - ocean eating polynya is quite arbitrary and the way in which we do this is arbitrary too. Also, instead of the polynya pixels that contact open ocean upon opening being polynya, make them open ocean - hope this will prevent excessively large polynyas from forming.

Looking at Jun-Jun plots for all regions for all years, run the original algorithm between April 1st and October 31st and the updated algorithm between November 1st and March 31st.

i.e, if date.month = Apr to Oct, run initial algorithm, if date.month = Nov to Mar, use updated algorithm.

Don't need to store the NP category, but need it in the algorithm for the flood fill step.

Want to try to reduce max size of polynyas in summer, because they are unrealistically big. I think the ice bridge method amounts to the following implementation in the code: carry over the opening polynyas to the next day. But we need to then alter the flood fill step. It is the flood fill step that creates a large initial polynya, because we flood fill to the old OSB. I think we should set the OSB in the region of opening as the ocean pixels that border the opening polynya pixels. Would this prevent the formation of new polynya? No, because the polynya-sea ice border is not masked with this OSB lid, so the polynya can grow through this border. We are just prohibiting the polynya from expanding through the PSB pixels that open out the next day.

10/03/2024 - Problem with new_algo3: whole open ocean is getting flood filled as OSB. I ran algo 1 animation, (without polynya eating step), and this problem isn't there, so it's a problem with the ice bridge step.

Reason is because forgot to specify 'axis = 0' in the sum which is in the step where I obtain booleans.

Now, problem with algo 3 is that whole open ocean gets flooded as polynya. Also get the speckling phenomenon

I think I identified why the open ocean is getting flooded as polynya: I think that removing the t = -1 OSB lid and replacing it with the O pixels that border PSB that open out the next day may in some cases leave open ocean that borders opening polynya that connects out into the open ocean. Probably still have to keep the old t = -1 lid.

Discussions with Martin - It is probably best not to grow the polynya after it opens up to avoid huge, unphysical polynya areas and we can then avoid the arbitrary open ocean eating polynya step, since smaller polynya area will mean that sea ice will probably cover the whole polynya in winter.

Problem - from animations, EBS polynya in 2010 Dec opens out, but is not covered by the time we get to April, leading to huge drop in polynya area as we revert to the original algorithm. This might be just because EBS polynya was especially large, and by this time, most other open polynyas are covered by ice. Check if this is the case, and maybe check some other years. If not, would have to run the updated algorithm for perhaps an extra month (so updated algorithm from Nov to Apr, old algo from May to Oct).

13/03/2024 - Definitely an extra month of the updated algorithm is needed. So now, phases are Nov to Apr for updated algorithm, May to Oct for initial algorithm.

By plotting graph of polynya area vs time, there still seems to be a sudden drop in polynya area, so maybe even April is not late enough and we need to extend the updated algorithm for an extra month again. By looking at the animations, I think ending the updated algorithm at the end of May is fine - most of the old summer polynyas are covered over by ice without needing to use ocean eating polynya, just the abnormally large EBS one isn't, but it would be covered a few days later anyway.

For the year 1985, basically every other day is unavailable, and there are rare occasions where more than one consecutive days are unavailable, but there don't seem to be periods with more than one continuous available day.

Now we are using a linear interpolation, and the interpolation assigns a flood map as missing data if there are 8 consecutive missing days in a row. I think the linear interpolation should be fine - we want to use as long as timeseries as possible.

There is a slight problem here, in that on the missing days, the combined algorithm still has polynyas but no sea ice. The updated algorithm that prevents opening polynyas from being classified as open ocean also doesn't work. This is because it relies on calculating polynya sea ice boundaries, and on missing days, there is no sea ice, only polynya.

Could just accept opening polynyas being classified as open ocean. Or, could do the interpolation in this step itself, without doing it after the raw timeseries have been generated.

What I could do is run the first 5 steps of the initial algorithm, which produces the naive flood map. Then I save that flood map for all days. I then run the regional interpolation for the flood maps - remember, the current regional interpolation is carried out for the calculated areas.

When running the updated algorithm (Nov - May), I then load in these interpolated flood maps at the start, and run the rest of the algorithm. Note that for the algorithms with the polynya eating step, the flood maps from the initial algorithm for t = -1 and t = 0 are required. For algorithms without the polynya eating step, only the flood map from the initial algorithm for t = 0 is required.

Actually, interpolating flood maps won't work, because it will give fractional values. Say a particular pixel was ice one day, then the subsequent day was missing, then the day after that, the pixel was open water. Then, the pixel has 0.5 probability of being ice or water the next day.

Using this probability method, get flood map which looks decent except for speckling, which arises from random choices.

Huge gap from 1986 Apr to 1986 Oct inclusive
1987 Dec is missing, through to a large portion of 1988 Jan

Going to nan out 1986 Apr 1 to 1986 Nov 1
Nan out 1987 Dec 1 to 1988 Jan 12.

There is one particular region where the ice never grows back by the end of may - around the EWS, i.e 'top' of Antarctic

Some open polynyas reform back again as closed polynyas when ice advances - this gives us confidence in our method of characterising open summer polynyas - there is something in that region that is hindering ice formation. I believe these are the coastal polynyas. Sometimes, when ice is advancing the next winter, it advances up to the border of an open polynya from the prior summer and fluctuates here for a few days - more confidence in our method of designating summer polynyas.

One bad thing about algo 3 - once polynyas open in summer, there are disconnected sections of polynya - we would like to grow polynyas but not towards the open ocean - hard to achieve without flood filling up to old OSB, which caused huge polynyas, forcing us to use ocean eating polynya, so stick with this approximation for now - should be fine.

19/03/2024 - Meeting: Extend the date of transition from initial algorithm to updated algorithm from 1st Nov to Mid November. The reason the transition is currently at the 1st Nov is because major opening events occur from Nov to Feb, so to make sure to capture all of them, I was conservative. However, the major opening events in November in fact occur towards the end of November. Therefore, I should change the transition to Mid November to prevent small specks of open water in marginal ice zone being classed as polynya when ice starts to retreat in early November. To balance out marginal ice zone polynyas and early opening out and misclassification of polynyas as open ocean, choose Jul 1st to Nov 20th to run initial algo, and Nov 20th to Jul 1st to run updated one. This decision comes from examining the flood maps and polynya timeseries.

Also, Martin also picked up on the way the ice advances around the open summer polynya - had an idea where I track the date at which the interior pixels of that open polynya turn into ice and the date at which the boundary pixels turn into ice and test for significant differences (e.g using a student t-test). Want boundary pixels to turn into ice significantly earlier than interior pixels. I will probably just do this for one polynya, and will need to designate an area of study for this. Do this after spectral analysis.

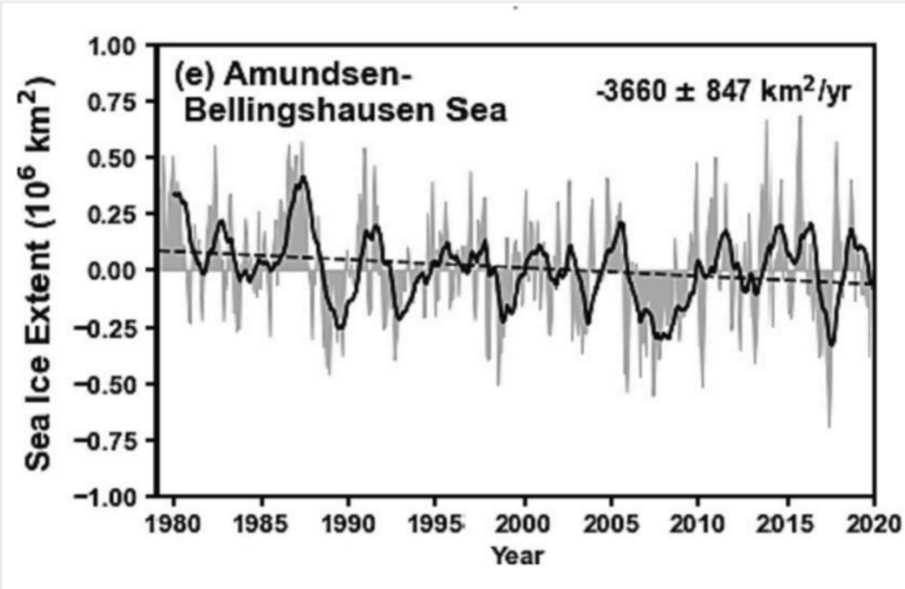
Extended updated polynya phase to June - it is fine, because at this point the ice is still advancing, so don't get marginal polynyas.

20/03/2024 onwards - Perform analysis from 1989 onwards. Now, method is largely clarified, just need to collect results and explain them

Done continuous wavelet transforms for individual timeseries. For the sea ice timeseries, there aren't any regions where there are significant power (95%) for periods longer than a year. Also showing the OPPOSITE trend to Swathi paper - In Swathi paper, power increases with period. Here, power peaks at 1 year, then decreases for all regions.

I think that I may need to calculate the anomalies in a different way, so that the timeseries I put into the wavelet transform doesn't have this big peak at 1 year, i.e we get rid of the 1 year signal. Swathi calculates anomalies against a climatological mean: 'The Antarctic sea ice anomalies were determined on an annual scale by subtracting the mean extent of the climatology year (1981–2010) from the mean values of the total years (1979–2020) (Table S2)'

A graph of SIE from Swathi is shown below: the black line is the 12 month running average. This has high power at longer periods than 1 year. Is it this that they are using in the wavelet transforms?



Actually, it seems like the anomalies that Swathi uses are similar to the anomalies we use. Look at this from https://nsidc.org/data/seaice_index. The only difference is that they don't scale by the std.

Monthly Sea Ice Concentration Anomaly

These images of anomalies in ice concentration show, in percent color-coded in shades of blue (negative anomaly) to red (positive anomaly), how much the ice concentration for a month differs from the mean calculated for that month over the 1981 through 2010 time range. The total anomalous area of sea ice for that month is also shown in the bottom margin of the image. The area around the North Pole that is not imaged by the satellite is left out of the images (light grey circle).

Used MATLAB REDFIT repository by Grinsted to compute wavelet transforms. From the script wave_signif.m and wt.m, it is clear that they run the function wave_signif in wt.m and set the argument siglvl of wave_signif to -1, which automatically sets significance level to 95%.

Problem, because some climate indices don't have the full timeseries.
IPO only has until 2017 Feb. ZW3 both indices have until 2020 Dec.

Fix the problem using a nanbl, but IPO doesn't work - for some reason, the IPO timeseries I have is really smooth, so the rednoise function doesn't work.

Replaced our overly smooth IPO with Swathi 'unfiltered' IPO (IPO timeseries is in My_Polynya_files).

Realised that the regions are actually in the wrong place, e.g WRS in not in the place where ross sea should be. Easy fix - in the csvs data_scaled_anomalies and analysis_information... change the names accordingly.

Sometimes, e.g for the IOD, the wavelet coherence with e.g TP CWS has significant windows at long periods ~8 years, when in the wavelet transforms of IOD and TP CWS, there are no significant windows here. However, there is high power in this window, albeit not significant, in the wavelet transforms, so no contradiction.

For lagged correlations, investigating leading and lagging of climate indices compared to polynya timeseries for period of 5 years (60 months)

Note, the southern oscillation index (SOI) is actually a measure of ENSO

Significant relationships:

Certainly a relationship between TP EIS and ENSO. Overlaying the timeseries, can see that TP EIS is essentially in phase with ENSO and varies like ENSO as well, i.e positive correlation. This is what we see in the lagged correlation plot between the two: Maximum correlation at -2 months, i.e ENSO leads EIS by 2 months.

I'm seeing a few timeseries where the polynya actually leads ENSO - what does this mean? Does this mean that ENSO actually leads polynya on a slightly longer and less obvious timescale? Or is there a change that underlines both the polynya and ENSO?

What is polynya backfill pressure? What does synoptic mean? Does it mean the local weather conditions and not the large scale climate indices?

Note, when calculating p values for correlations in MATLAB, there is option to get lower and upper confidence intervals at 95%.

This CI range gives us a range of possible r values at the 95% significance level. This means if the NULL hypothesis ($r = 0$) is outside of these bounds, we have a significant result.

Regression doesn't work well on ASL quants and polynya variables.

Make sure to add images of ice reforming around polynyas in ice advance season in methods. Briefly describe that it is sea ice advance, but don’t say the physics of it yet. Leave that to a later section, say in the results or discussion.