Observations of Shear-Driven Mixing in Arctic Winter High-Wind Events Using Ice-Tethered Profilers

Sarah Dewey

Advisor: Mary-Louise Timmermans
2nd Reader: Alexey Fedorov

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Abstract

Because the Arctic Ocean has a partial sea ice cover at all times, the region's atmosphere-ocean interaction is dominated by its cryosphere. Wind stress drives sea ice motion, and that motion affects the properties of the water column beneath the ice. The objective of this study is to describe the relationship between sea ice speed and below-ice water properties during periods of anomalously high winter ice speed. Using Ice-Tethered Profilers (ITPs), the speed of multiyear Arctic sea ice is described over time. Seasonal cycles for ice speed and interannual speed variations are established in the Beaufort Gyre (BG) and Transpolar Drift Stream (TDS) using data from the years 2005-2009. Times of high wind stress in winter are inferred from periods of high ice speed during that season. These events are hypothesized to be associated with shear-driven mixing and/or upwelling as a result of horizontal shear in the overlying ice cover. ITP-derived vertical profiles from these winter high-wind events are examined, and support the hypothesis of shear-driven mixing in the upper water column.

Introduction

This study explores a new application of Ice-Tethered Profiler (ITP) data. ITPs provide measurements of physical water-column properties beneath permanent sea-ice cover. This investigation examines the relationship between anomalously large sea-ice speed events in winter (likely induced by winter storms) and changes in the physical properties of the underlying water column.

The ITP program is a joint effort between several international research institutions, including the Woods Hole Oceanographic Institution (WHOI). The first ITP was deployed in the Arctic Ocean's Beaufort Gyre in 2004, and since then 36 ITP systems have been deployed in the Arctic, with 18 presently deployed.[1] While the data set for the ITPs is fairly young, it is extensive enough that several authors have already used it to great effect, both to refine data collection methods and technology (Johnson et. al., 2006) and to gain insight into the upper ocean below the ice. Timmermans et al. (2007), for example, have observed eddies in the Canadian basin, which are ideal for ITP observation because of the instruments' ability to provide vertical ocean profiles that are closely spaced in the horizontal. This spatial resolution is equally helpful in the investigation of winter high-wind events in providing profile information before, during and after a wind event; further, the events' signatures in ITP velocity and vertical profile data are visible across multiple ITPs.

ITP hardware is designed to move with the permanent sea ice into which it is deployed and to provide continuous conductivity-temperature-depth (CTD) profiles, typically twice a day, as the profiler descends and ascends its tether. The ITP is made of a buoy component, a weighted tether (approximately 800 m in length), and a traveling sensor (Figure 1). The surface buoy houses Iridium satellite phone and GPS transmitters, as well as batteries; the profiler is likewise battery-powered, and contains a CTD sensor package similar to an Argo float. This package is connected to the surface unit with an inductive link. ITPs are designed to have a battery lifetime of two to three years.[2]

[1] Statistics as of April 2010.
[2] Additional information and all data at the ITP Program website: http://www.whoi.edu/itp

Winter storms can result in horizontal shear in ice velocity, which induces upwelling by Ekman pumping in the upper water column. Further, shear-driven mixing in the surface ocean can result when the ice moves rapidly over the ocean surface. One cause of increased ice velocities in the Arctic Ocean is high winter wind speeds potentially associated with winter storm events. These high-wind events leave a signature in speed versus time plots for each ITP, and this signature is recognizable across ITPs in similar regions.

For this study, ITP raw position and time information (from hourly GPS fixes) is used to calculate ITP drift speed as a function of time. This information is used to infer winter high-wind events; these events are indicated by spikes in the ice speed during the months of October to March. Vertical profile information from these events could indicate a relationship between energetic ice motion and overturning in the Arctic Ocean; this relationship could also be the basis for a little-explored heat exchange mechanism between the surface and deeper waters.

McPhee (2005) examined this relationship, investigating the connection between large-scale fracture zones and atmosphere-ocean heat exchange using CTD casts. His ice velocity information was satellite-derived, and therefore, unlike for ITPs, it is possible to spatially map zones of ice shear. McPhee proposes that the horizontal shear from ice motion does create this heat exchange, but his data are partially obscured by the presence of eddies under the ice. This study will be the first look at the same kinds of questions tackled by McPhee, using the unique tool of the ITPs.

Background

The Arctic Ocean has two main areas of circulation: the Beaufort Gyre system, running anti-cyclonic (clockwise) north of Alaska, and the Transpolar Drift Stream, flowing north of eastern Siberia across the center of the Arctic Ocean to the North Atlantic (Figure 2). This circulation is important as it influences climate dynamics within the Arctic Ocean and the formation of the North Atlantic Deep Water (NADW).

Arctic sea ice experiences a seasonal cycle of growth and retreat, while maintaining an area of multiyear sea ice in the vicinity of the pole. Ice tends to be at its most densely packed in the Canadian archipelago and north of Greenland, in part due to the lack of open water and atmospheric circulation patterns pushing the ice against the land. The ice reaches its minimal extent during August and September, lagging after the annual period of maximal insolation in the summer; maximal ice extent occurs anywhere from early February to late March (National Snow and Ice Data Center, NSIDC).[3]

A looser icepack is associated with increased ice velocity; data from the ITPs should demonstrate higher ice speeds (given comparable winds) during months of typically minimal ice extent.[4] In addition, 2007 broke all previous records (based on satellite measurements of ice extent beginning in 1979) for minimal ice extent by August of that year; 2008, 2009, and 2005 followed close behind.[5] Therefore, in

[3] http://www.nsidc.org
[4] Mean wind strengths are typically two times larger in winter than in summer (e.g. Toole et al., 2010). The exact relationship between wind speed and ice speed for a given sea-ice cover is complicated, and beyond the scope of this study.
[5] NSIDC.

addition to a seasonal cycle of ice speeds, there may be an interannual variability signal in the ITP speed data.

In addition to influencing deep water formation, the Arctic is an important region of atmosphere-ocean heat exchange. The albedo of sea ice is high and resultant reflected heat plays a part in the cooling of the region. However, the main means of ocean-atmosphere heat exchange and mixing in the water column is through open water and leads (long fractures in the sea ice) in sea ice. As ice extent increases seasonally, these leads are minimized. Other mechanisms for heat exchange are less understood, especially during the winter months. This study proposes and examines ice shear as another means of atmosphere-ocean interaction and impetus for vertical ocean mixing.

The Arctic Ocean's stratification is distinct and strong. Because of the presence of ice, the water underneath typically demonstrates a temperature inversion, where the coldest water lies at the top. The water then warms below a surface-ocean mixed layer before cooling with depth. The profiles of ITPs 1 and 3 (Figure 12a) demonstrate this temperature change. In this sub-mixed layer region, salinity increases with depth: beneath this cool halocline lies warm, salty water from the North Atlantic (Figure 3). Surface polar mixed layer properties deviate from freezing temperature (dependent on the salinity of the mixed layer) only in summer months, when open water and leads increase insolation and consequent warming. This change is visible in Figure 4, when the ITP-observed temperature-freezing temperature difference at 10m depth peaks in the 2006 summer months.

In addition to affecting the water below through its insulation, sea ice has a direct effect on the upper water column through its motion. Ocean upwelling occurs beneath an open lead when ice floes move in opposite directions. Because of the Coriolis effect, this movement causes Ekman transport in the surface ocean mixed layer away from the lead and can bring deeper, warmer water to the surface. This horizontal-shear-induced upwelling may be associated with local periods of intense wind and consequent increased ice speed. However, if the ice all moves uniformly (i.e., there is no horizontal shear) during these episodes, upwelling will not occur. Therefore, the impact to the upper water column of winter "storm" episodes depends not only on their intensity, but on whether there is horizontal shear in the ice pack. This process differs from shear-driven mixing, in which friction at the ice-water interface causes vertical overturning.

Objectives

- To build a coherent record of winter high-wind events for the last several years in the Arctic
- To use this record to examine the relationship between these anomalous events and changes in the physical properties of the underlying water column

Methods

Raw location and time data were downloaded from the WHOI ITP website for ITPs 1 through 29. These data were useful both for plotting the locations of the ITPs by region and for calculating ITP speeds. All data were processed in Matlab. Zonal and meridional ITP velocities were calculated from hourly GPS position information. These component velocities were then used to calculate a speed value for each ITP.

These speed values were plotted to examine seasonal trends in both ice speed time series and normalized histogram formats. A seasonal cycle of ITPs 8 and 13 was plotted for September 2007 through September 2008 to demonstrate the seasonal cycle in the Beaufort Gyre; a similar plot on that same time scale was overlaid for ITP 9 in the Transpolar Drift Stream (Figure 5). A plot of BG ITPs was generated for several years, 2005 to 2009, to describe interannual variability in seasonal cycles (Figure 6). ITPs 6, 8, 11, and 13 were chosen to provide slightly overlapping records (both spatially and temporally) through the time period and to provide records within the central BG through time. These plots were generated using a moving average function,[6] in which the bin length was set to five days to show longer-term data trends.

Normalized histogram plots were also generated to describe this seasonal variability in ice speed (Figure 7). These were compiled over the entire profilers' life spans, with speeds binned in increments of 0.02 m/s. Winter speeds were defined as those recorded before Julian day 61 (March 1/2) and after Julian day 274 (September 30/October 1); leap years were not accounted for because data was sampled every two hours for ITPs 1 through 4 and every hour for ITPs 5 through 29. These twelve to twenty-four data points represent a comparably negligible fraction of the data points over an ITP's typically several-year lifespan. Sample plots were generated for each region: ITP 8 for the BG, and ITP 9 for the TDS. In addition, plots of the difference

[6] Moving average function written by Carlos Adrián Vargas Aguilera, CICESE (Mexico).

in temperature and freezing temperature as a function of time were overlaid on plots of speed versus time for ITPs 1 and 3 to show upper-ocean warming. A moving average function was used for the speed plot, as it later was for all ITP speed plots.

The calculated ITP speed values were then plotted as a function of time for each ITP, with a moving average function superimposed. Speed values in excess of 1 m/s were assigned NaN values when calculating the moving average, because these values were associated with brief, episodic spikes rather than consistently high speeds (speeds rarely exceeded 0.5 m/s, even during identified high-wind events). The moving average for ITPs 1 through 4 was calculated over increments of 24 data points, and the data for ITPs 5 through 29 over 48 data points. This amounted to daily averages for all of the ITPs, because of the sampling frequency differences between the two groups.

These ITP speed versus time graphs were organized geographically and by year, to compare events of anomalously large ice speeds across multiple profilers. In addition, ITP drift paths for each region were plotted in a stereographic projection to indicate which ITPs might be impacted by which of the same winter events. Winter high-wind events were selected through qualitative comparison of the ITP graphs. They appeared as sharp spikes in the speed versus time graphs, with intensities of up to 0.4 m/s and with durations ranging from two to five days. These spikes were isolated, and often surrounded by periods of nearly zero speed values. Except in 2005 and 2006, these episodes were visible over a minimum of three ITP plots. These events were catalogued in a table (Table 2), and four were selected for study (Figures 8-11).

Vertical potential temperature and salinity profiles were plotted for these high-speed anomalies, with geographically-relevant ITPs shown in the same plot. ITP data for comparison (Figures 12-14). The Level III processed vertical profile data are sourced from WHOI's ITP website. "Before" and "After" plots were generated for each ITP, and superimposed in graphs of each event. The "During" plot was centered on the event's date. A "duration range" variable was established, the sum of half the event's inputted duration (in days) and 2 days. This variable was used to situate the Before and After plots, such that the After plot describes the state of the water column 3 to 4.5 days after the conclusion of the event, and the Before plot the same number of days beforehand. Potential temperatures (and freezing temperature for a given salinity) referenced to the surface were calculated using CSIRO's 2006 Seawater v3.2 routines.

Four periods of anomalously high ice speeds were chosen to plot, one occurring each winter. Table 1 details storm event dates, region, duration, and relevant ITPs:

Table 1. Event characteristics for wind events from 2005-2008.

Year	Region	Date	Duration (days)	Intensity (m/s)	ITPs
2005	BG	Oct 21	5	0.2	1,3
2006	BG	Oct 10	2	0.25	4,5[7],6
2007	TDS	Dec 4	4	0.25	9,10,12,16
2008[8]	TDS	Dec 10	5	0.4	24,26,27

The Before, During and After plots of each ITP were superimposed in order to compare the shape of each vertical profile within a specific region, and in order to

[7] ITP 5 is not plotted because the behavior of the profiler becomes slightly erratic during this time.
[8] The December 10, 2008 storm was not plotted because the vertical profile data from WHOI for ITPs 24, 26, and 27 have not yet been processed (April 2010).

gauge change in each vertical profile over the course of the wind event. Salinity and potential temperature were plotted in each vertical profile (note that the strong stratification at the base of the mixed layer is referred to here as the halocline).

Results and Discussion

The speed versus time graphs for both the Beaufort Gyre (BG) and the Transpolar Drift Stream (TDS) share several characteristics: their moving averages rarely exceed 0.2 m/s, and they demonstrate minimal speeds in the winter months (October to March). These trends are indicative of seasonal ice formation: with a more concentrated icepack in the winter, the ITPs naturally move less. Plots from the two representative seasonal cycles demonstrate this pattern, with speeds reaching a maximum in September and October, when the icepack is at its minimum extent (Figures 5 & 6). The surface ocean is at its warmest during these months.

A plot of seasonal cycles across several years in the Beaufort Gyre shows this same trend of maximum speed in early autumn (Figure 6). This plot also demonstrates the interannual variation in ice speeds: the maximum occurs in 2008, a year of extremely low ice extent, and the year after the lowest ice extent on record. This result is not surprising, given the behavior of the thinner, looser icepack in summer. While the TDS speeds from ITP 9 are less than the BG speeds from ITPs 8 and 13 (Figure 5), all three plots demonstrate this seasonal cycle.

This regional dependence of the ice speeds is expected and observed; ice in the TDS tends to move slowly across the central Arctic and then shoot quickly out of the Fram Strait, whereas ice in the Beaufort Gyre generally stays in the region.

Depending on both icepacks' proximity to the Canadian archipelago, ice velocity may be greatly diminished. This is likely the case with ITP 9, starting at the beginning of 2008 (Figure 5).

In addition to seasonality, times of minimum to no movement can be linked to ITP position in the icepack (e.g., an ITP is stuck against landfast ice—or an ITP with a sudden increase in movement exits the TDS into the Greenland Sea); here, the maps provide a useful companion to the speed versus time plots. For example, ITP 9 in July and August 2008 exhibited comparatively low speeds after it drifted up against the Archipelago. In addition, the 0.2 m/s "maximum" speed (c.f. Figure 5) sets a baseline for the identification of winter speed spikes.

Winter speed spikes are also identifiable using normalized histogram plots of seasonal and yearly speed frequencies (Figure 7). These histograms show a clear seasonality in icepack speeds. In ITPs 8 and 9, for example, winter speeds most frequently hover around 0 m/s. 0-2 cm/s was the most-frequently occurring summer speed for ITP 9, while for ITP8, the most frequently-occurring summer speed was 4-6 cm/s. In ITP 8, this seasonal distinction might indicate a denser, less mobile winter icepack and a looser, faster summer icepack, as would be expected with seasonal heating and cycles of ice formation and retreat.

Noticeable in the seasonal histogram, however, is that while summer speeds generally exceed winter speeds in frequency, once speeds reach 0.275 m/s, winter speeds suddenly dominate in frequency. For ITP 9, this same switch occurs at about 0.14 m/s. This shift indicates that whereas the summer icepack moves almost constantly at a higher speed than the winter icepack, the winter icepack's high-speed movement is more episodic. These episodic instances of high-speed movements are potentially related to winter storm events; they may also be related to horizontal ice shear, which might then lead to ocean upwelling as is the case described by McPhee.

In addition to these episodes of increased winter ice speed, the difference in recorded temperature and freezing temperature as a function of time is plotted for ITPs 1 and 3. (Figure 4). If this difference is high, it contributes to the melting of ice floes from below (see Perovich, 2008). This difference is expected to be higher in the summer than in the winter, because of the increased opportunity for the sun to shine directly on the upper ocean between parts of the looser icepack.

In order to examine the below-ice influence of anomalously high winter ice speeds, vertical profiles for several events were plotted. As stated earlier, four primary high-wind events were selected for study. These events were an October 2005 storm in the BG (this is the event for which the temperature and freezing temperature differences were plotted in Figure 4), an October 2006 storm in the BG, a December 2007 storm in the TDS, and a December 2008 storm in the TDS. These storms' durations and magnitudes ranged from two to five days and an estimated 0.2 to 0.4 m/s. Speed versus time plots for each event are shown in Figures 8-11.

The vertical profiles for these high-wind events (Figures 12-14) show varying temperature and salinity shifts for each event. However, each describes a change in the depth of the polar mixed layer, independent of whether the ITPs are in the BG or TDS. All instances of mixed layer "deepening" are described relative to pre-event conditions. In general, the mixed-layer depth (MLD) shows an increase during wind events that remains after the event has passed. However, upwelling is not observed.

In the profiles for the 2005 “storm” event, the data from ITPs 1 and 3 show a deepening of the mixed layer (ML) (Figure 12). Both profiles show a 5m deepening of the ML during the event, with a 10m total deepening after, as evidenced in both the temperature and salinity profiles. ITP 1 shows an increase in ML salinity of about 0.3, during the event; ITP 3 shows a 10m deepening of the ML, with a freshening of 0.2 both during and after October 21. This freshening is not what would be expected for a shear-driven mixing event: a shear-driven mixing event entrains water up into the ML from saltier water below it. This unexpected freshening may be due to spatial variability in the water column. While ITPs 1 and 3 show coherence in the direction and distance of ice movement, that coherence and the possibility that ITP 3 may have moved on top of a fresher water parcel are not mutually exclusive.

The temperature-freezing temperature (“T-Tf”) plots of ITPs 1 and 3 (Figure 4) show more variability in T-Tf values around the time of this winter wind event. This variability is consistent with the shifts in MLD visible in their vertical profiles, though the T-Tf plots are drawn for 10m depths and so they might not be picking up the deeper signal of MLD change (occurring at 20m to 30m). This T-Tf value can only increase if there is heat being transferred to the ocean, as in the summer through insolation between ice floes. If there is variability in the T-Tf value during the winter, then it implies heat is being imparted to the surface water from below. This transfer likely occurs from the shear associated with winter high ice speed events, though more data is necessary to draw a definitive conclusion about heat transfer during these times.

ITPs 4 and 6 do not show the same kind of agreement that 1 and 3 did during their event (Figure 13). There is minimal change in the MLD over the October 10, 2006 event, and the ITPs show completely opposite behavior of the MLD during the time surrounding the event. The ML becomes shallower in ITP 4's profile, and deeper in ITP 6's. The magnitude of this change is 5m each time, but it is unclear what might explain these contradictory pictures of MLD change; it is also unclear whether the MLD is changing overall in the region, since only two profiles are available for the wind event.

Because there is a large spatial variability in MLD it is possible that the anomalous wind event affecting ITPs 4 and 6 may have pushed the ITP-containing ice floe into regions of a shallower mixed layer. (This variability is also larger in the BG, where ITPs 4 and 6 lie, than in the TDS.)[9] The maps (Figures 15-17) accompanying each storm's vertical profile plots show how geographic distance may have come into play. ITPs 4 and 6 (Figure 16) followed a similar trajectory, reinforcing the earlier observation that the wind influencing their respective ice floes was from the same source, but remained separated. Thus, while they both show changes in the MLD over the course of the 2006 wind event, they may have been in areas of differing MLDs.

Unlike the 2005 and 2006 events, the 2007 high-wind event generates a signature over four ITPs. These ITPs show spatially-coherent movement in the TDS north of the Canadian archipelago (Figure 17). Their temperature profiles are accordingly very similar, though ITP 10 demonstrates a cold, sub-surface eddy at

[9] Mary-Louise Timmermans, personal communication, April 16 2010.

approximately 20 m depth, of the type observed by Timmermans et al. (2007). ITP 16 demonstrates similar behavior, but its profile has been excluded from the plot.

In ITP 10, the ML deepened during the winter event by about 7m overall, becoming warmer. ITP 9's ML deepened as well, though it showed a freshening of about 0.5. ITP 12, however, showed little change and in fact a slight shoaling and freshening (of about 0.5) of the ML through the event. This freshening, as observed in ITP 3, may be due to spatial differences in the water columns underlying the ITP. The ITP drift tracks for this 2007 storm show spatial coherence, so the elements influencing the ITP movement and likely the under-ice processes are the same. Given ITP 9's weak stratification before the event compared to the other ITPs, it is very possible that the ITPs overlay very different surface waters.

Overall, the results from the 2005 and 2007 winter high-speed events point to a deepening of the ML (although not a consistent warming and increase in salinity as might be expected) during episodes of intense ice movement. While the 2006 event profile is inconclusive on whether or not the MLD increases or decreases, the MLD does change during the event, and differing MLDs with differing geography may come into play. Yet, something about the ice motion is driving vertical mixing. Because the only observable trend is a deepening of the ML, it may be inferred that these winter high-wind events are more likely associated with vertical-shear-driven mixing than with horizontal-shear-induced upwelling. It remains to be seen whether this hypothesis holds for additional episodes of high winter ice speed.

Conclusions and Directions for Further Research

Using ITP data, a fairly complete picture of ice speeds in the Beaufort Gyre and Transpolar Drift Stream has been constructed for the years 2005-2009. Seasonal cycles of ice speeds have been described for the two main circulation systems. Using plots of speed over time, instances of anomalously high winter ice speeds were identified. These speed spurts are assumed to have been associated with high winds, potentially from winter storm events.

The water column signature of these winter high-wind events shows a changing mixed-layer depth (MLD). During events in 2005 and 2007, the MLD deepened. During an event in 2006, the MLD changed, though results are inconclusive about whether it deepened or shallowed overall. It may be concluded, however, that there is a relationship between winter high-speed events and a changing—likely deepening—MLD.

While these results have been unable to support the hypothesis of horizontal shear-driven upwelling during events of anomalously high ice speeds, they still describe vertical mixing. This mixing, indicated by the changing MLD, is likely associated with vertical shear from the sudden motion of the ice over the water column.

While these ITP records demonstrating MLD changes span the BG and the TDS, further research is needed to examine this trend across broader spatial and time scales: an inherent difficulty in working with ITP data is determining the extent to which the surface-ocean variability observed is spatial versus temporal. As well, additional examples of such events may help to characterize the full extent and nature of MLD change during winter high-wind episodes.

Other directions include expanding on McPhee's investigation by combining future ITP observations with data from ESA's nascent Cryosat mission. This new mission uses laser altimetry, as NASA's IceSat did until October 2009. Altimetry data, combined with ITP data, will contribute to a better understanding of the dynamic cryosphere.

A multi-sensor approach is advisable in future research, regardless of the role of Cryosat. Because ITP speed data has been used as a direct proxy for wind magnitude in this study, without a direct measure of the wind, future studies will benefit from wind data. These data are available from satellite scatterometers, as well as from in-situ barometers on ice mass-balance buoys.

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Figure Index:

Appendix:

Table 2. Observed winter ice speed spikes for all years.

	dates	duration (days, approximate)	intensity (magnitude, m/s)	extent (ITP #s)
2005				
BG	late October	4.5	0.2	1,3
2006				
BG	10/10/06	2	0.25	4,5,6
	Mid-December	4.5	0.2	4,5,6
	Mid-February	13	0.15	1,3
2007				
BG	end of January	4	0.15	4,5,6
	beginning of April	4	0.15	4,5,6
	start of December	3.5	0.25	6,8,11,13,18
TDS	start of December	3.5	0.25	9,10,12,16
	Christmas	5	0.35	7,14,17
2008				
BG	01/20/08	4	0.25	6,8,11,13,18
	Mid-March	5	0.15	8,11,13,18
	12/08/08	2	0.25	8,11,20,21,22,23,25
TDS	12/10/08	5	0.4	24,26,27
	12/18/08	5	0.5	24,26,27,28,29
	start of February	5	0.15	9,10,16
	Mid-March	5	0.1	9,10,16
2009				
BG	New Year's	3.5	0.2	8,11,20,21,23,25
	start of March	5	0.225	8,11,21,23,25
TDS	Mid-January	5	0.23	9,16,28,29
	01/30/09	6	0.25	17,24,26,27

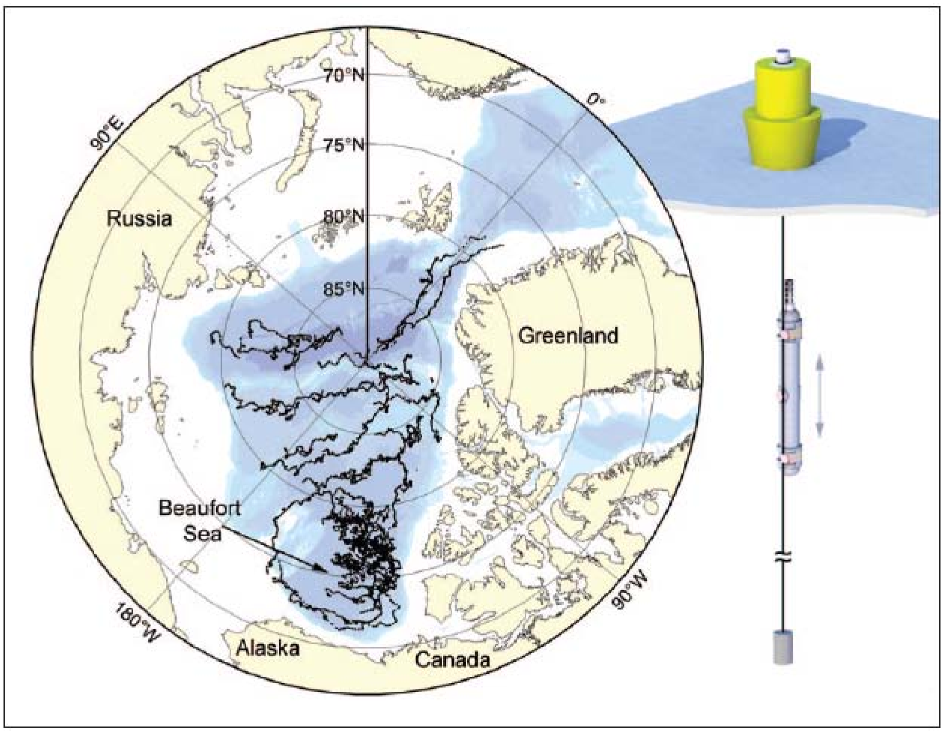

Figure 1. ITP setup and plot of drift tracks for all ITPs. (Mary-Louise Timmermans)

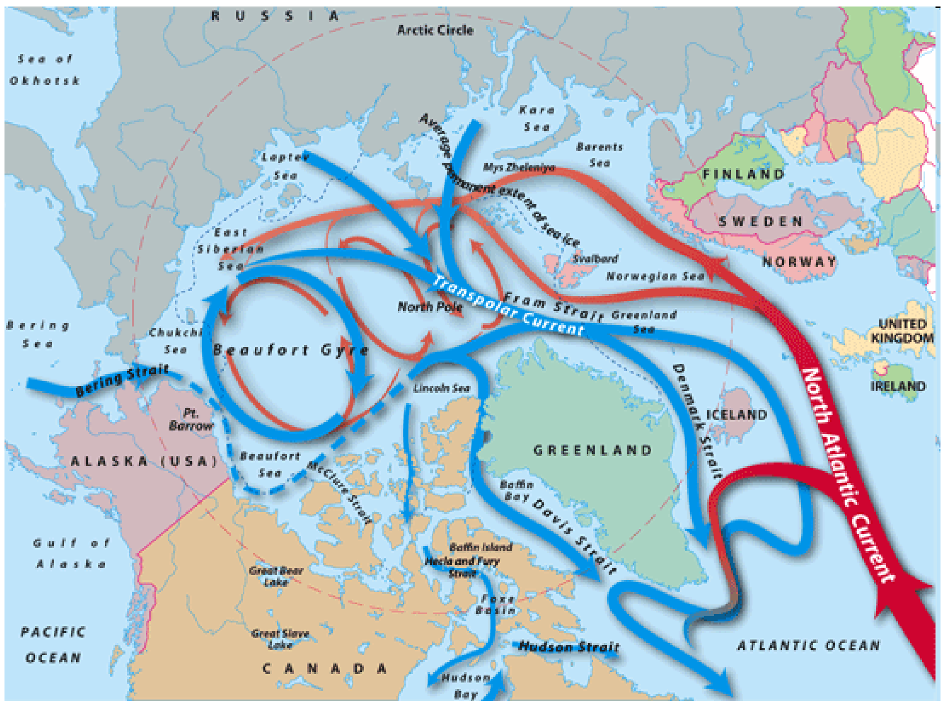

Figure 2. Arctic Ocean currents. (WHOI)

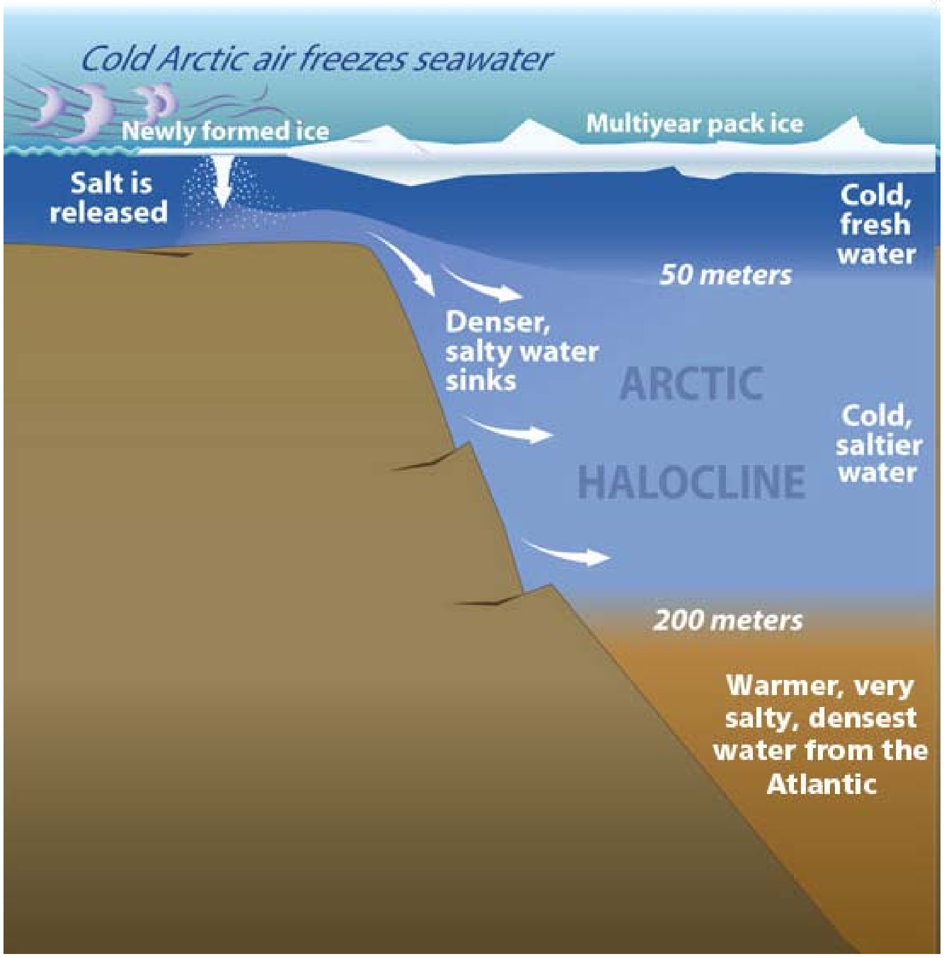

Figure 3. Schematic of Arctic Ocean vertical stratification. (Jayne Doucette, WHOI)

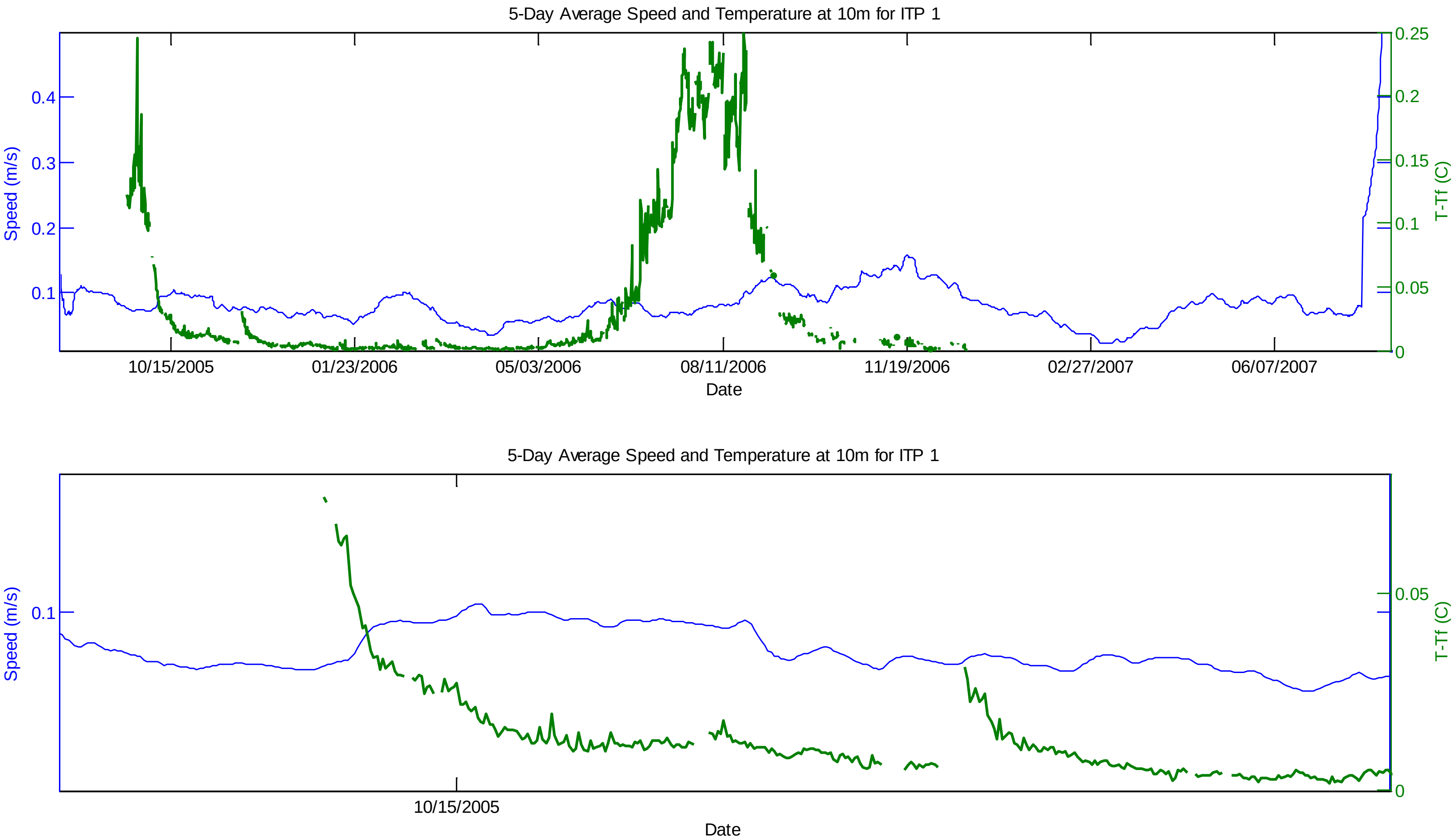

Figure 4a. Plot of 5-day running average speed vs. time and temperature-freezing temperature difference for ITP1. The top plot shows the entire record for ITP1; the bottom plot shows the record at and around the October 21, 2005 high ice speed event.

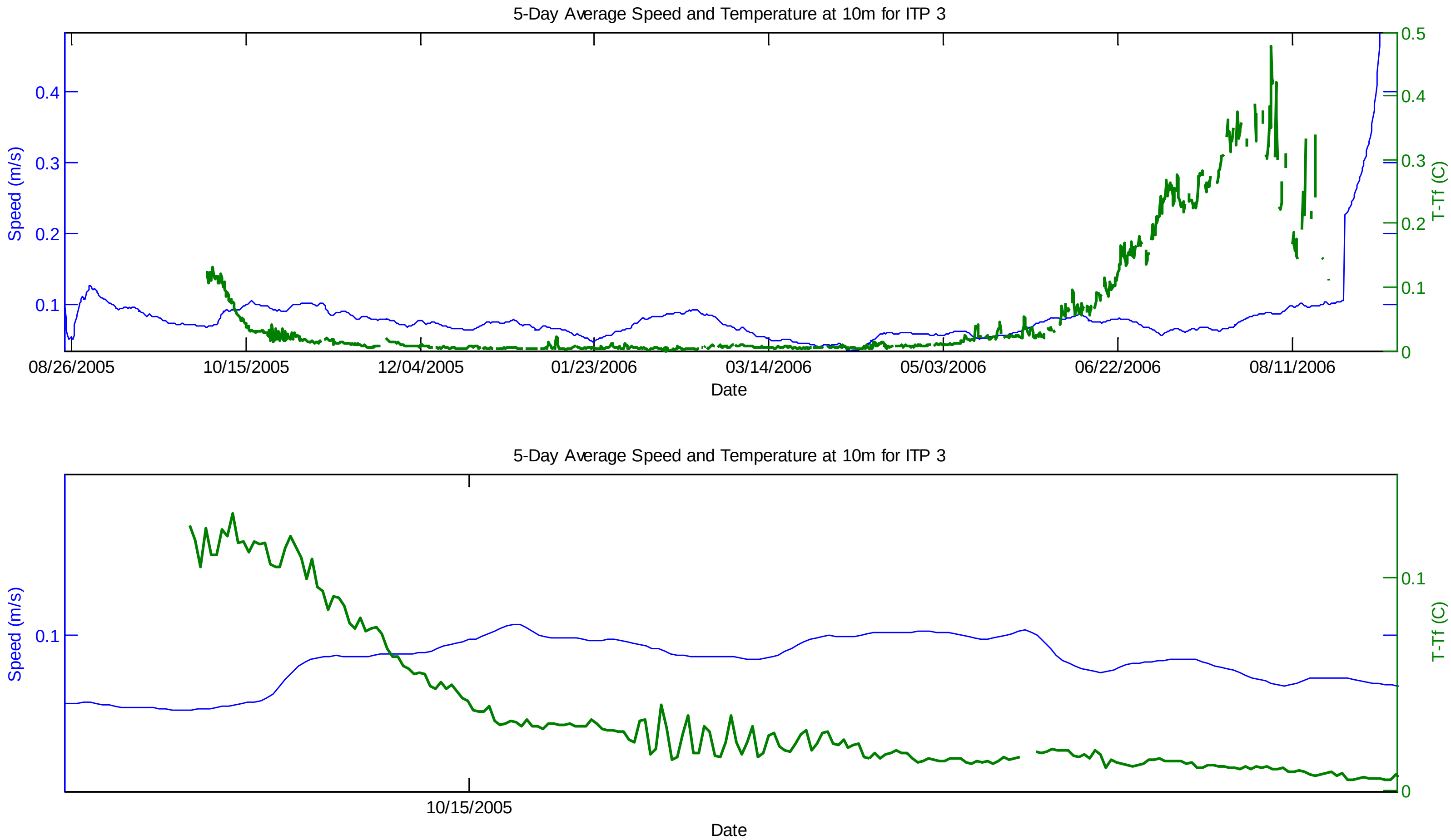

Figure 4b. Plot of 5-day running average speed vs. time and temperature-freezing temperature difference for ITP3. The top plot shows the entire record for ITP3; the bottom plot shows the record at and around the October 21, 2005 high ice speed event.

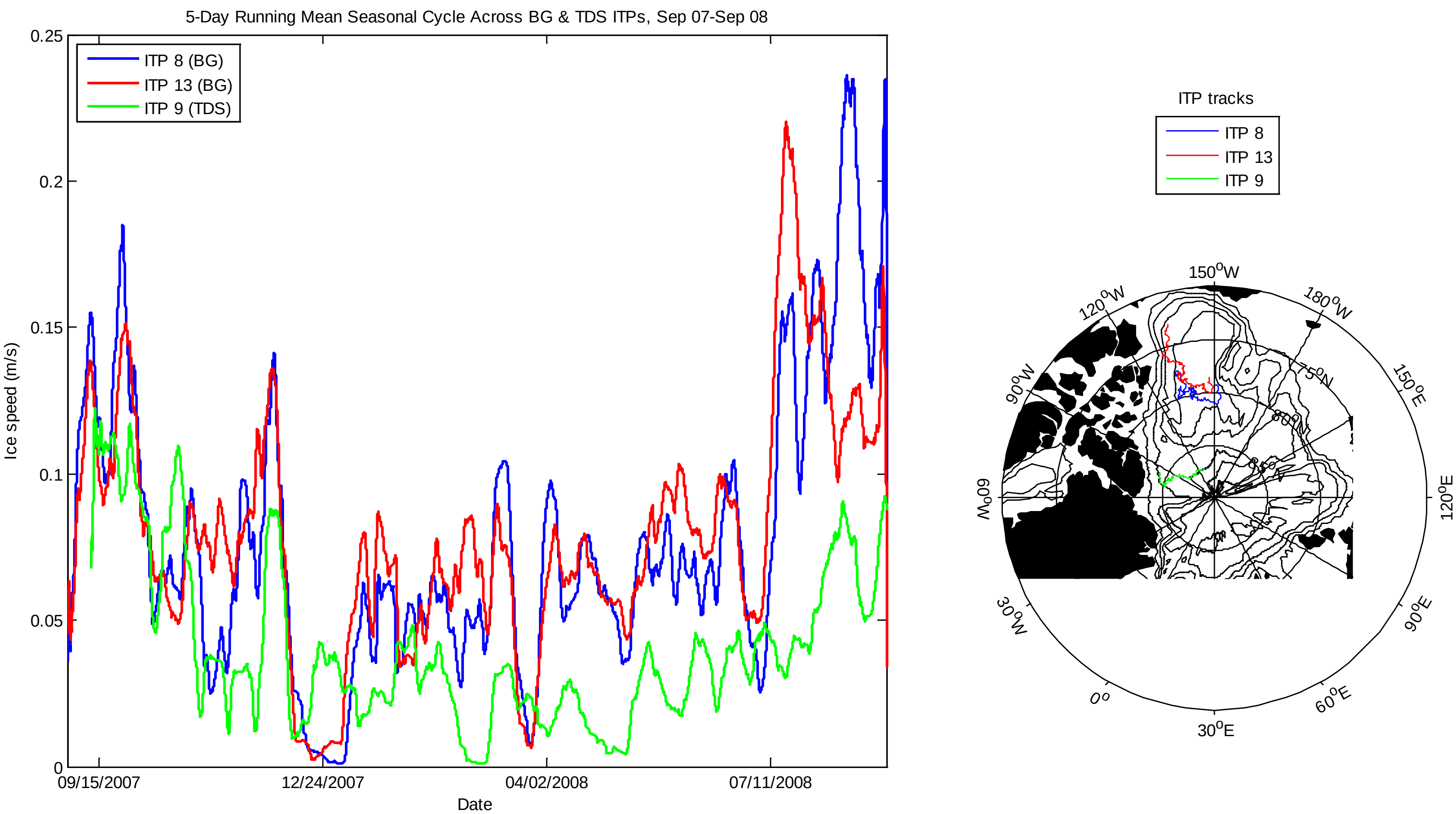

Figure 5. Seasonal Cycle of Ice Speeds for the Beaufort Gyre and Transpolar Drift Stream plotted from September 2007 to September 2008 (5-day running average). ITP locations during this year are shown in the map to the right.

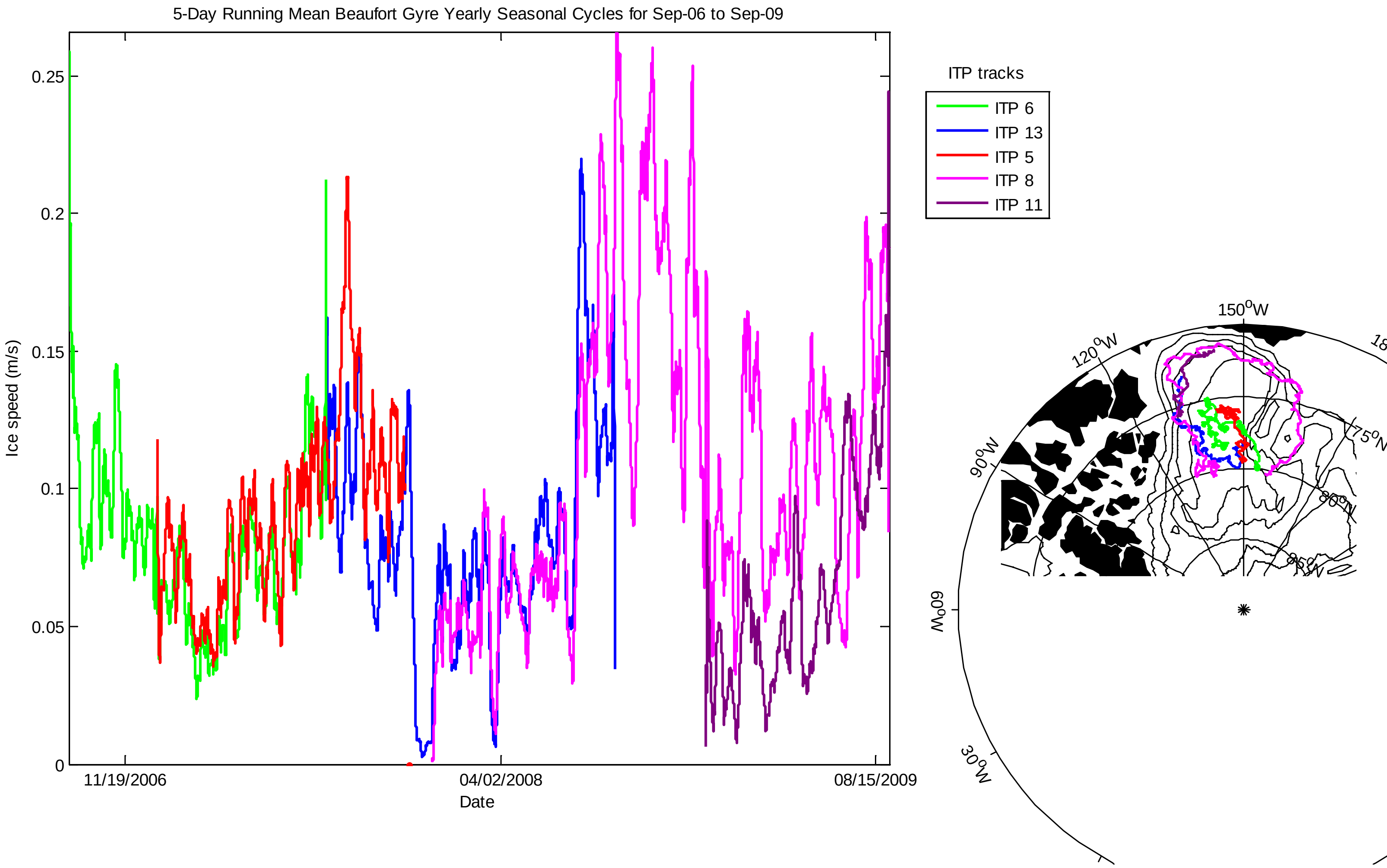

Figure 6. Seasonal Cycle of Ice Speeds for the Beaufort Gyre, plotted from September 2006 to September 2009, across ITPs 6, 5, 13, 8, & 11 (5-day running average). The track of each ITP's movement during the time for which it is plotted is represented on the map to the right.

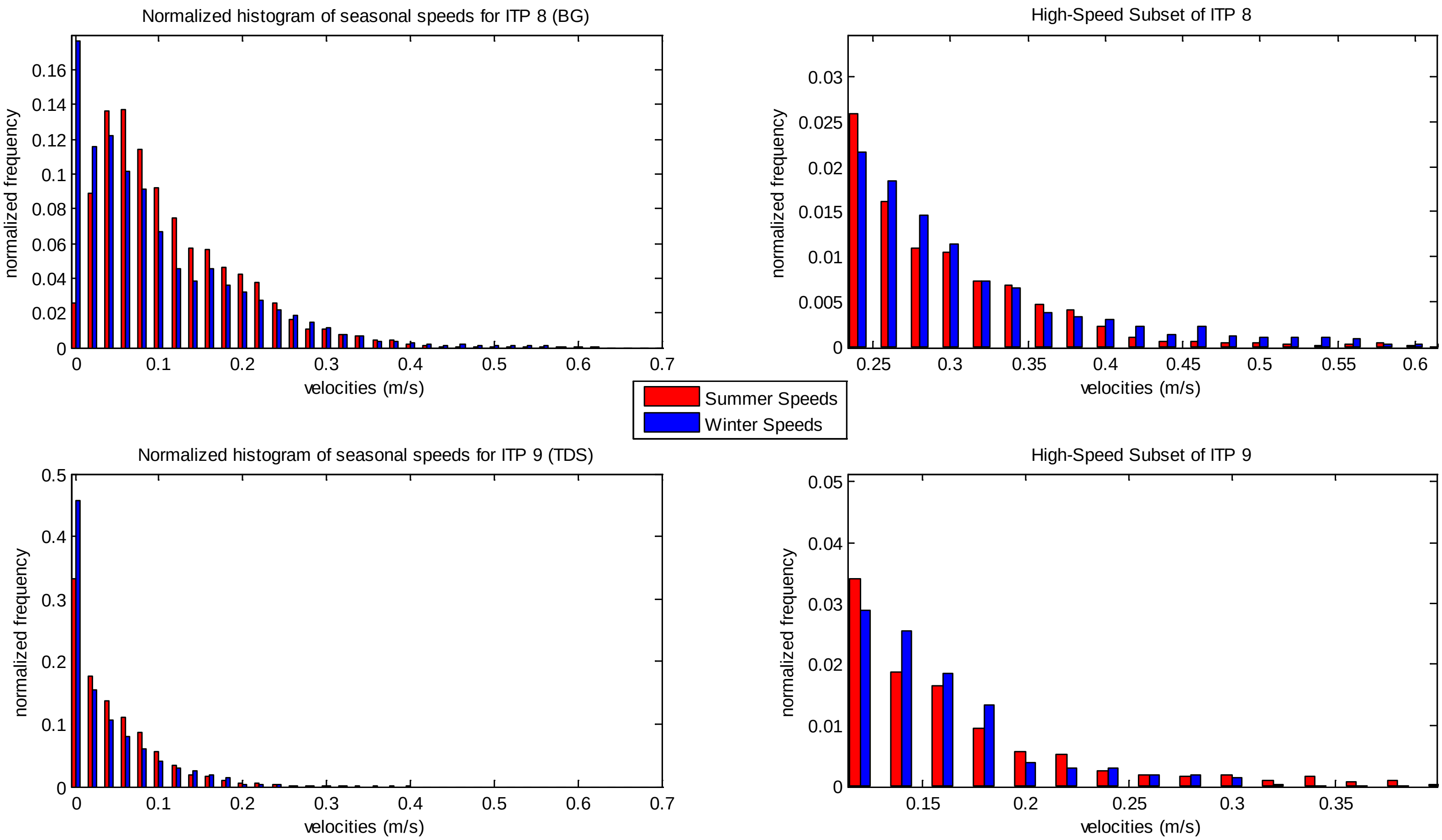

Figure 7. Normalized histograms of seasonal ice speeds in the Beaufort Gyre and Transpolar Drift Stream. High-zoom portions show higher frequency of high speeds during winter months.

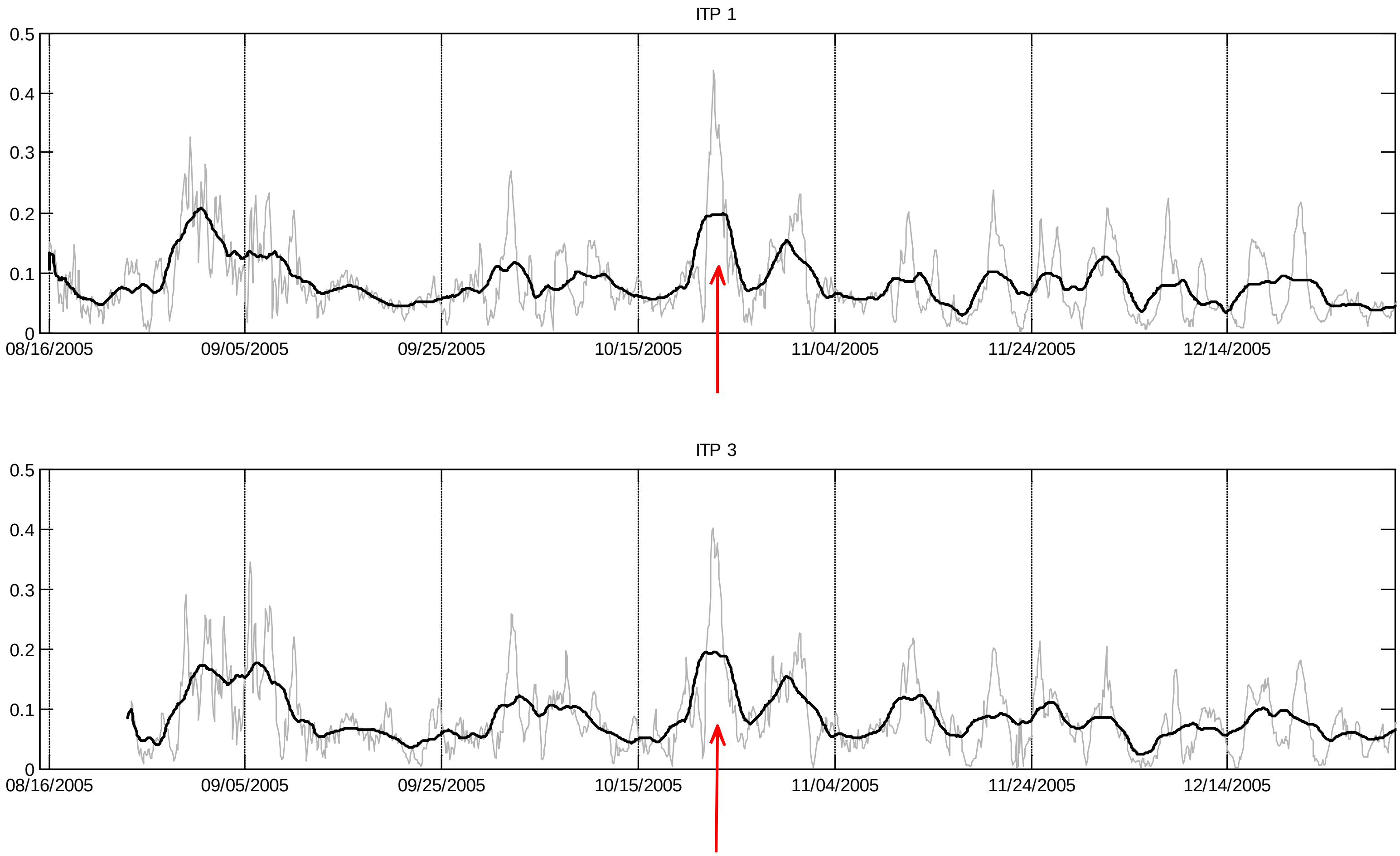

Figure 8. Winter 2005 high ice speed event, observed in the Beaufort Gyre across ITPs 1 & 3. Ice speeds are plotted as a function of time. Grey lines indicate raw speed data; black lines indicate daily moving average. Red arrows indicate peak of wind event.

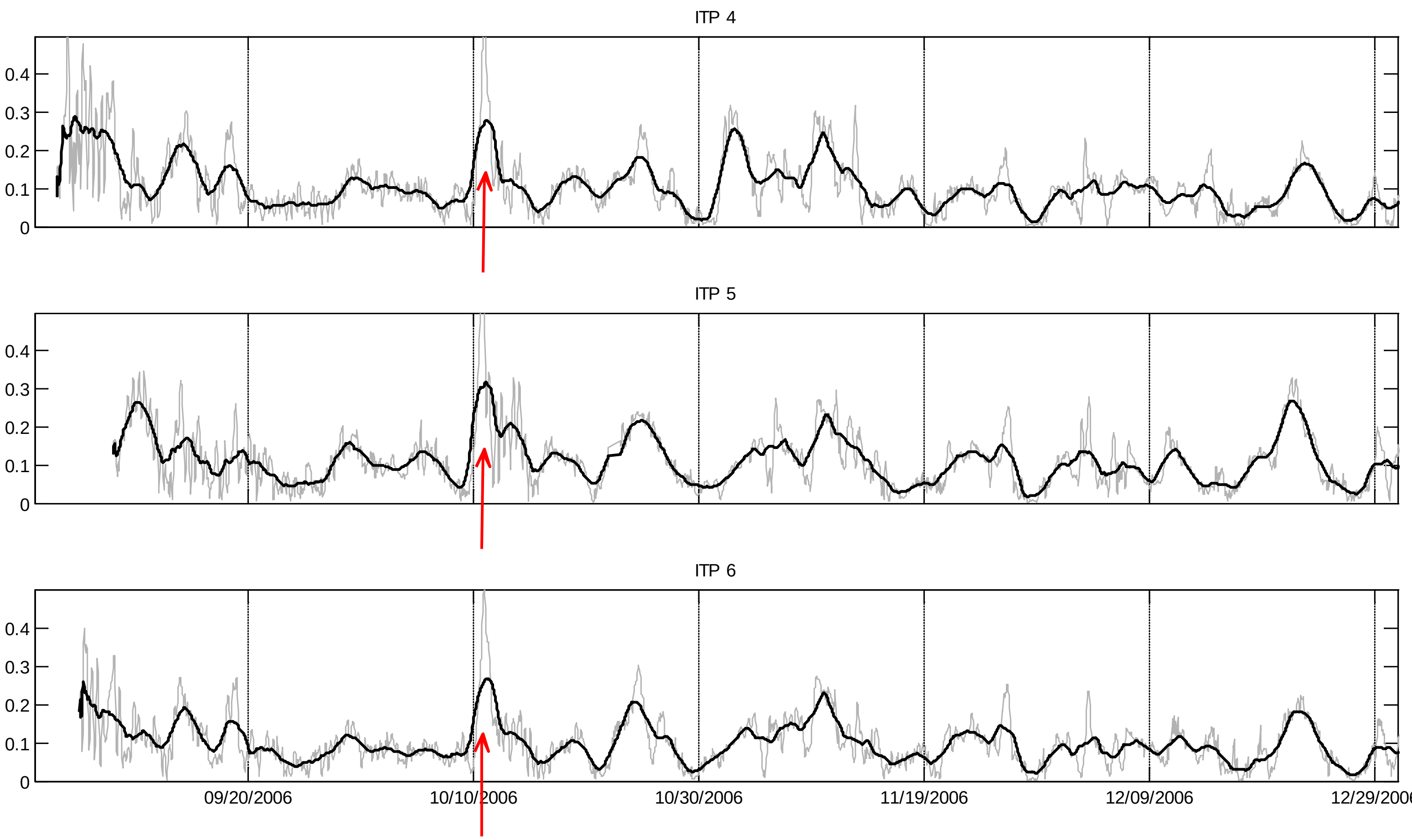

Figure 9. Winter 2006 high ice speed event, observed in the Beaufort Gyre across ITPs 4, 5, & 6. Ice speeds are plotted as a function of time. Grey lines indicate raw data; black lines indicate daily moving average. Red arrows indicate peak of wind event.

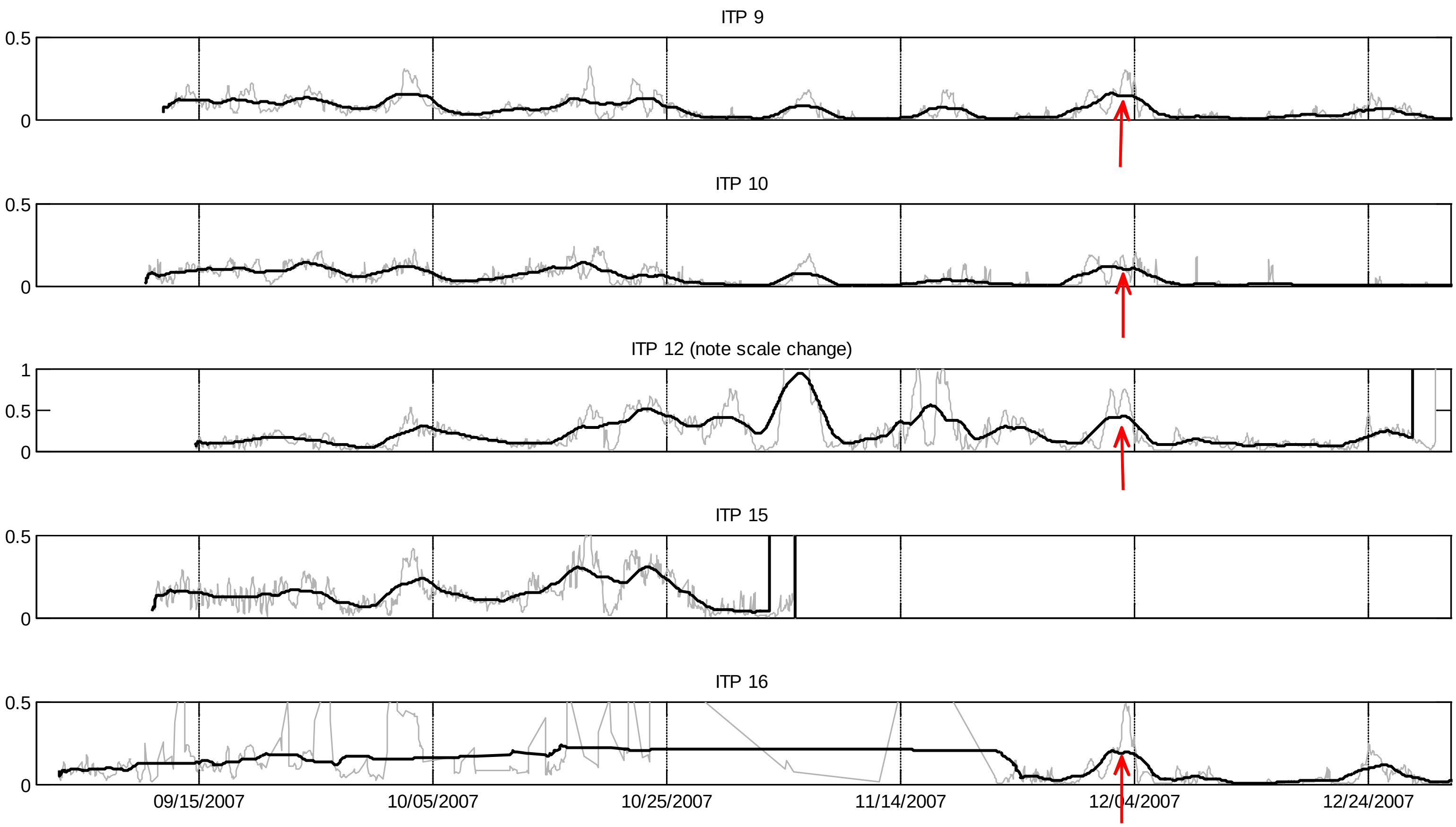

Figure 10. Winter 2007 high ice speed event, observed in the Transpolar Drift Stream across ITPs 9, 10, 12, & 16. ITP 15 is plotted to show spatial coherence across ITPs in this region. Ice speeds are plotted as a function of time. Grey lines indicate raw data; black lines indicate daily moving average. Red arrows indicate peak of wind event.

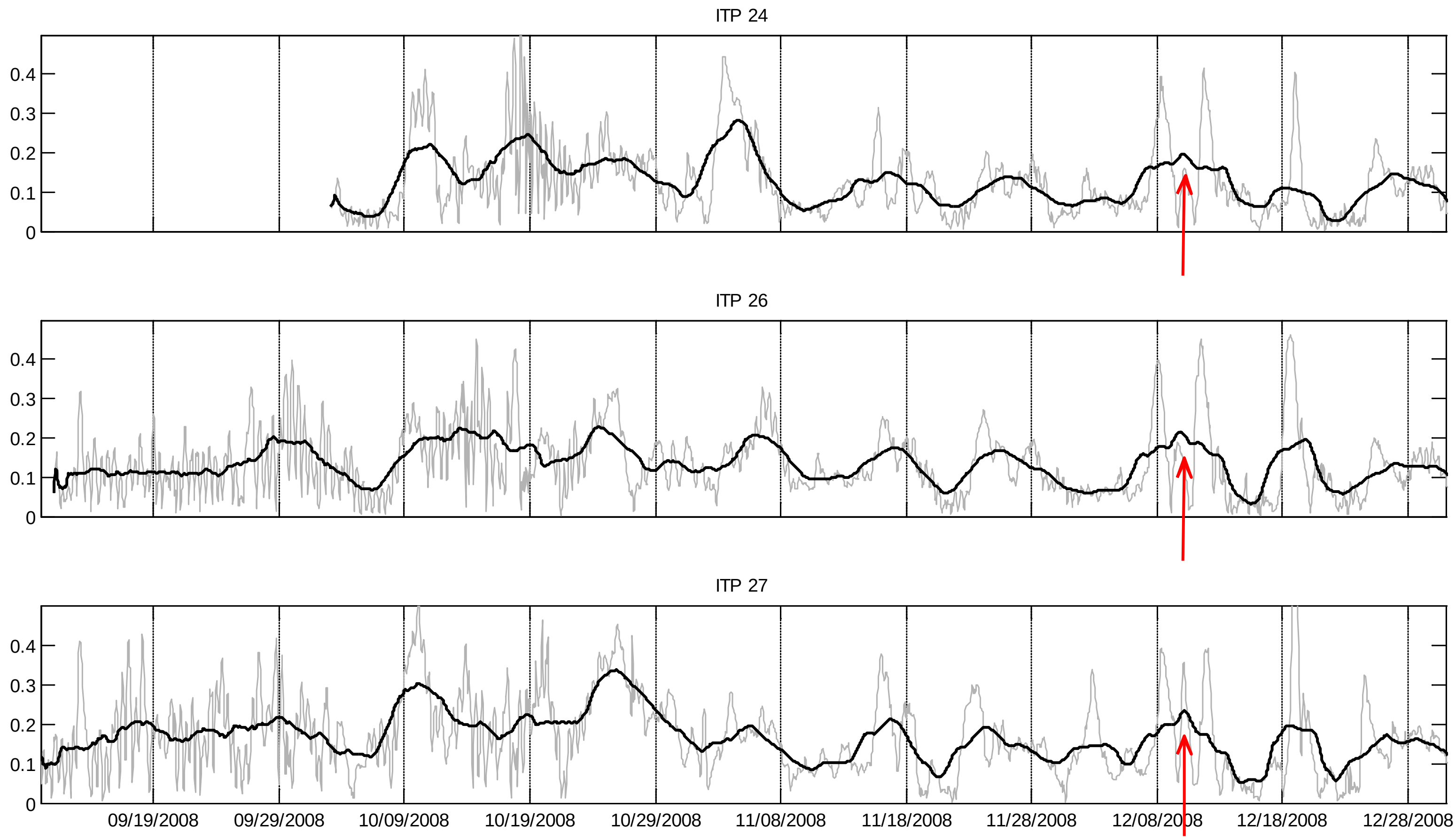

Figure 11. Winter 2008 high ice speed event, observed in the Transpolar Drift Stream across ITPs 24, 26, & 27. Ice speeds are plotted as a function of time. Grey lines indicate raw data; black lines indicate daily moving average. Red arrows indicate peak of wind event.

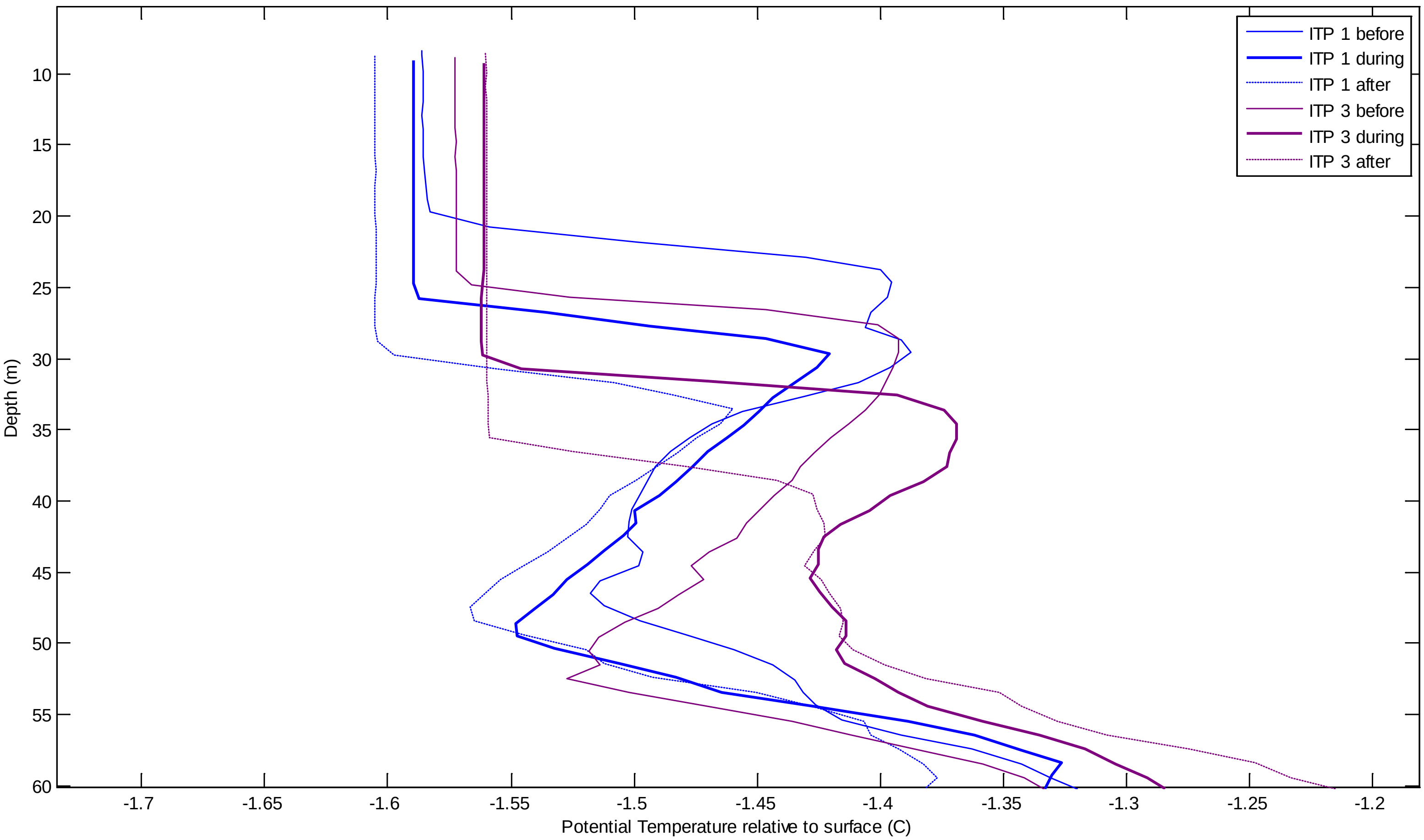

Figure 12a. Potential temperature plotted with depth for ITPs 1 & 3 in the Beaufort Gyre during the October 21, 2005 high ice speed event.

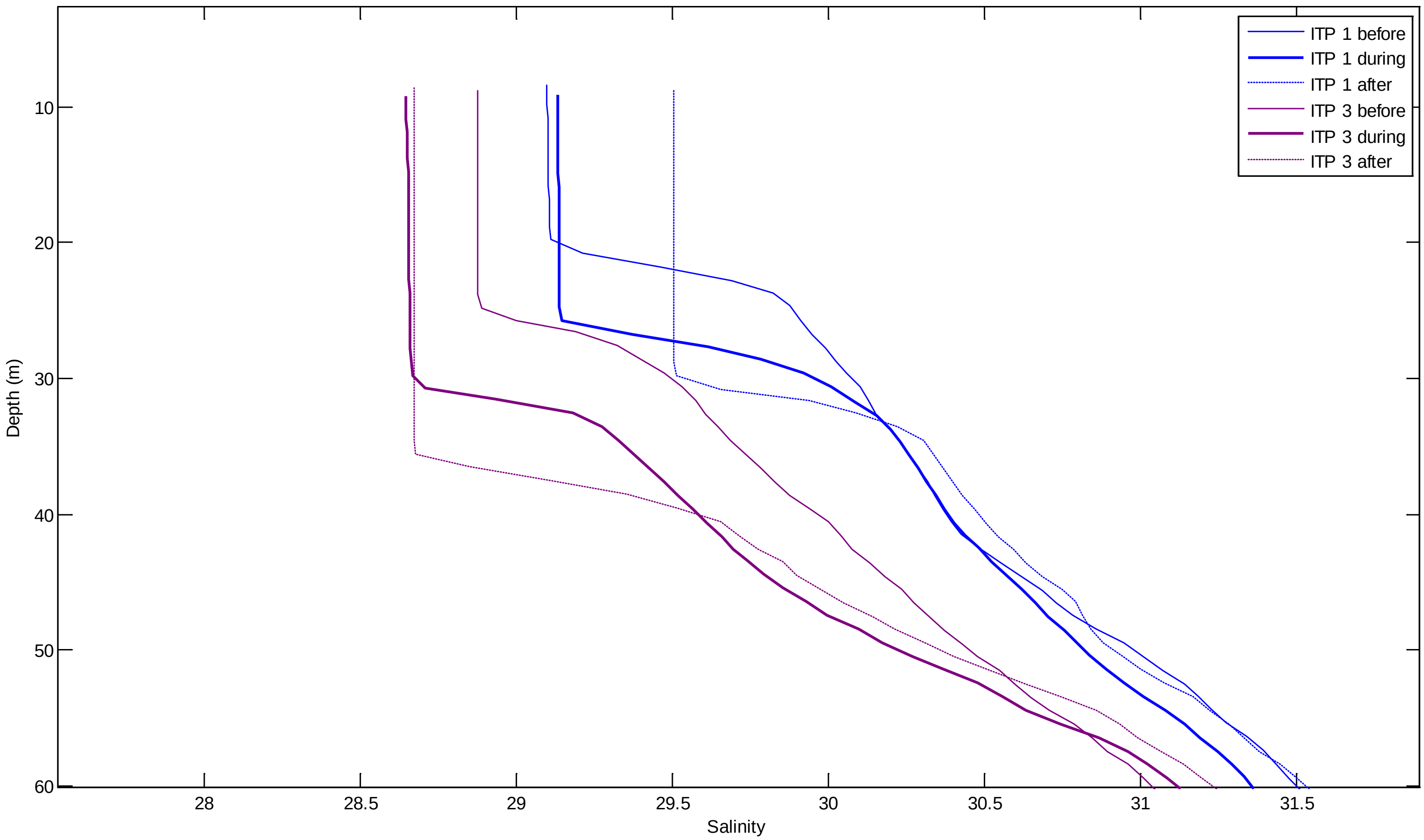

Figure 12b. Salinity plotted with depth for ITPs 1 & 3 in the Beaufort Gyre during the October 21, 2005 high ice speed event.

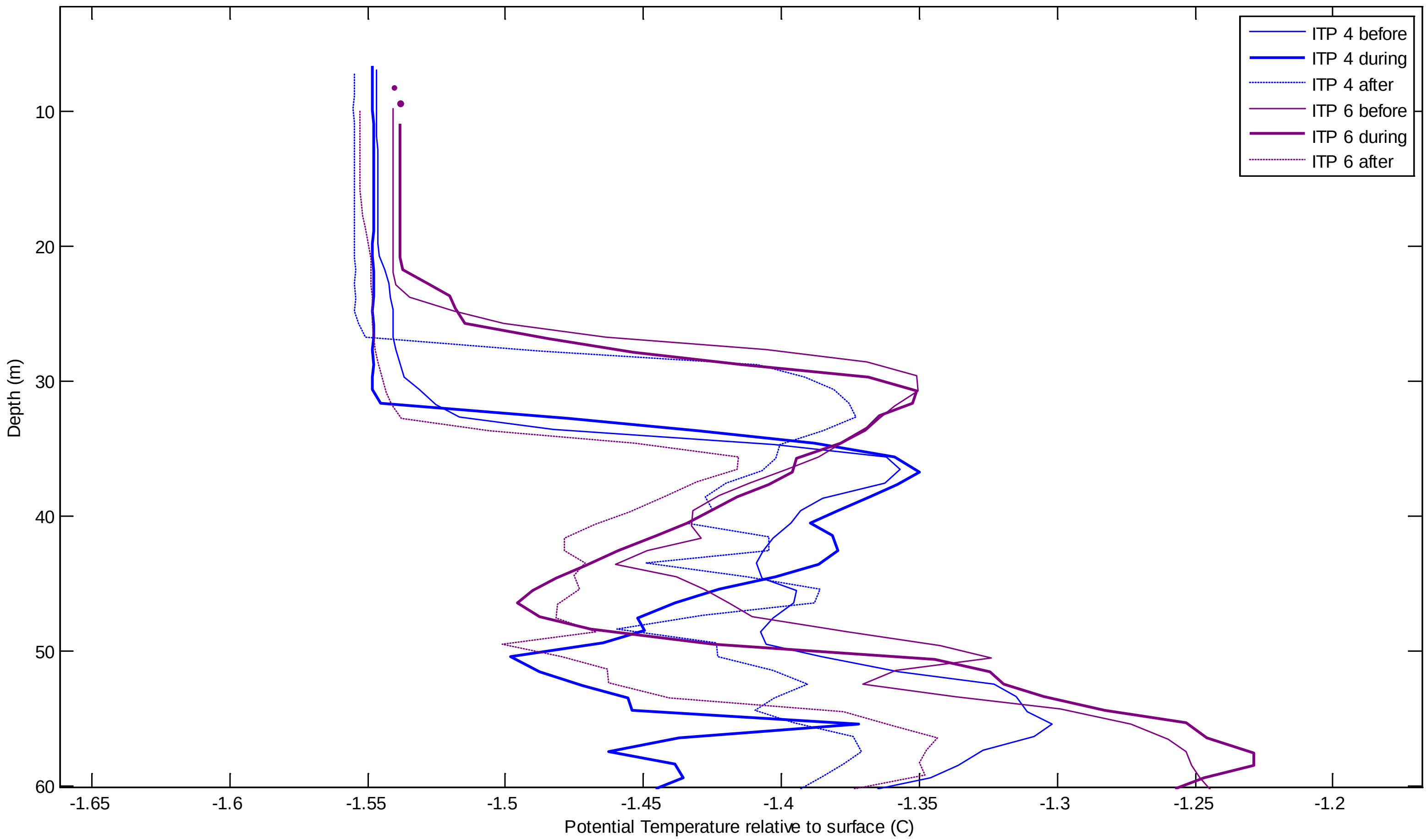

Figure 13a. Potential temperature plotted with depth for ITPs 4 & 6 in the Beaufort Gyre during the October 10, 2006 high ice speed event.

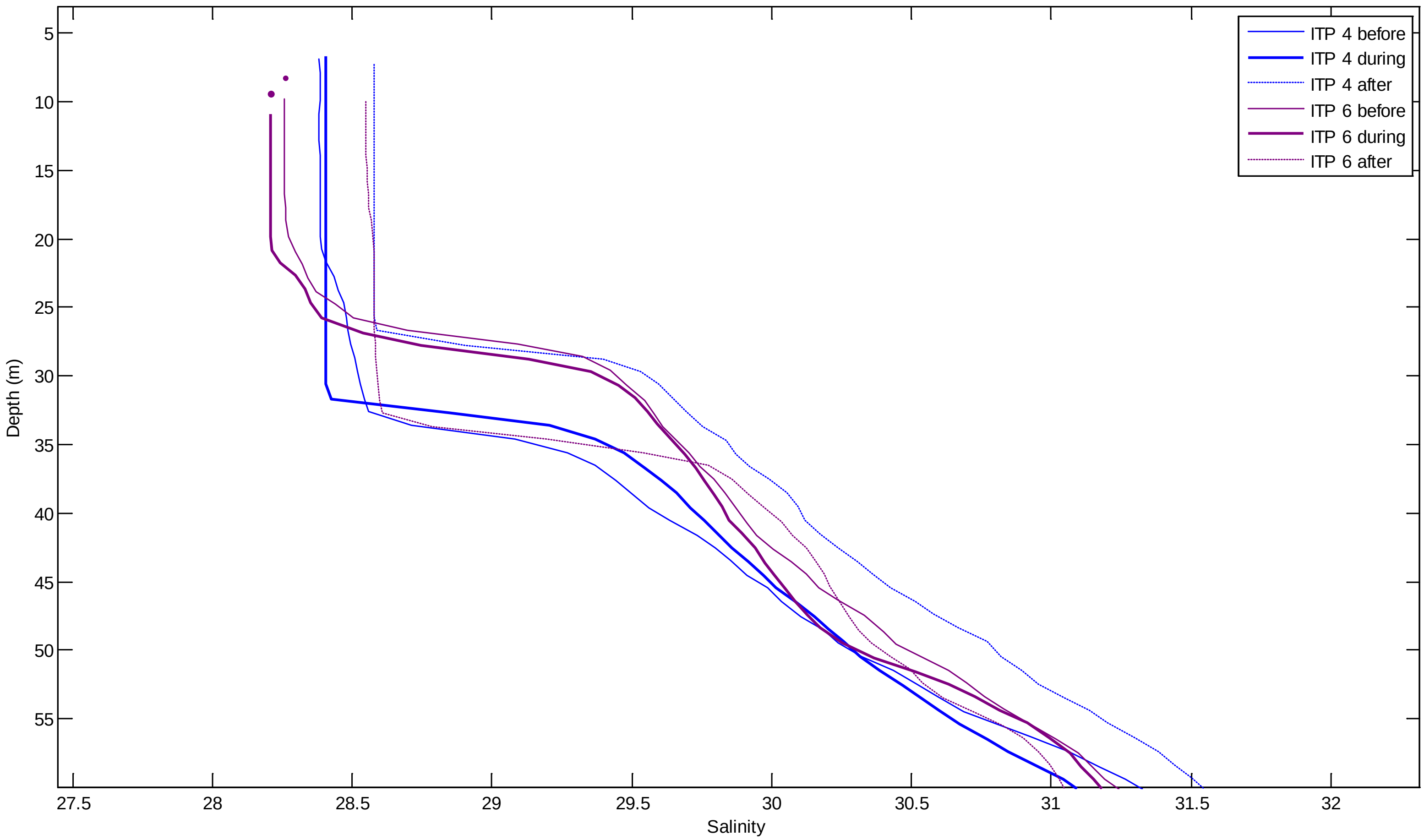

Figure 13b. Salinity plotted with depth for ITPs 4 & 6 in the Beaufort Gyre during the October 10, 2006 high ice speed event.

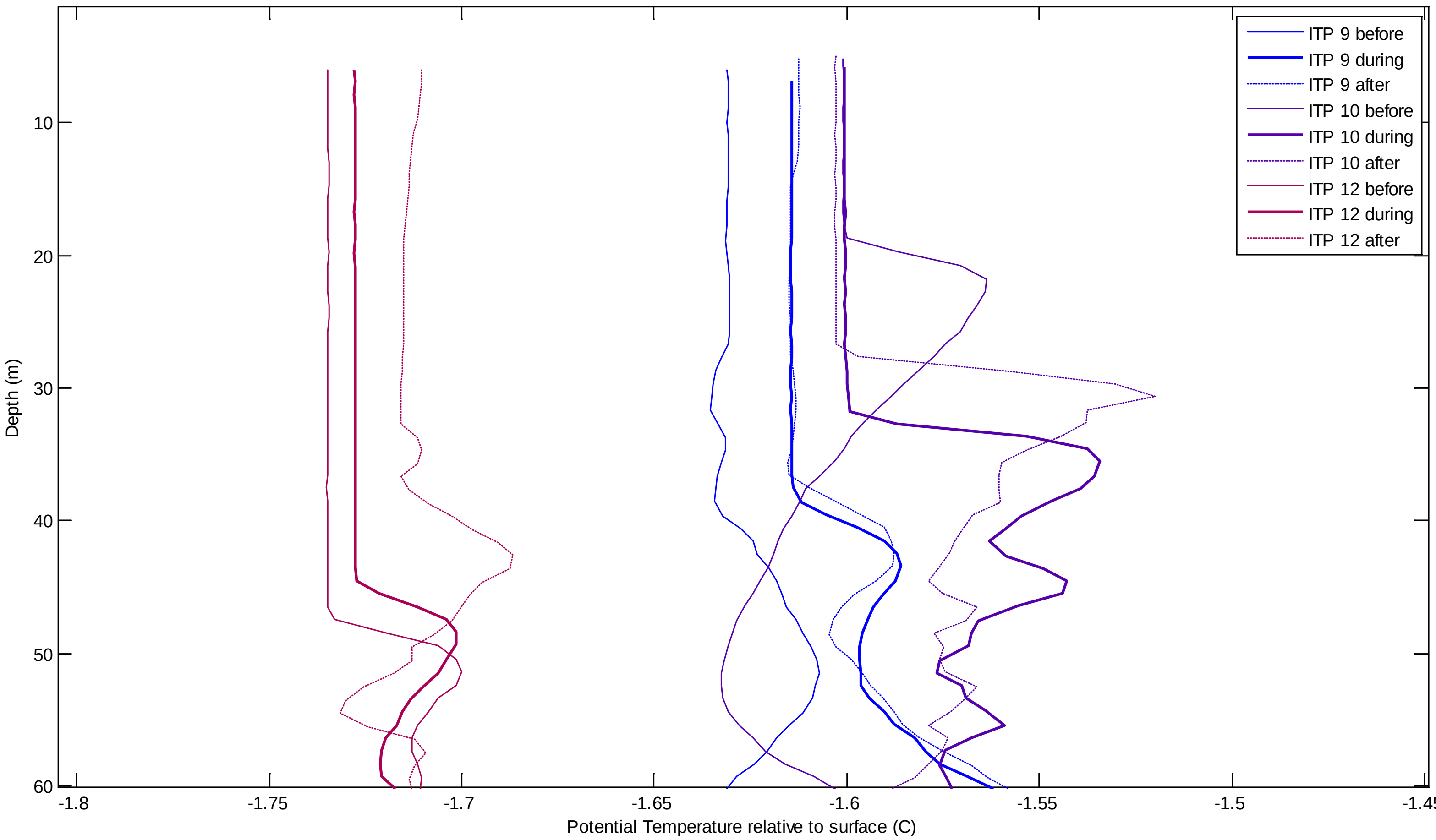

Figure 14a. Potential temperature plotted with depth for ITPs 9, 10, & 12 in the Transpolar Drift Stream during the December 4, 2007 high ice speed event.

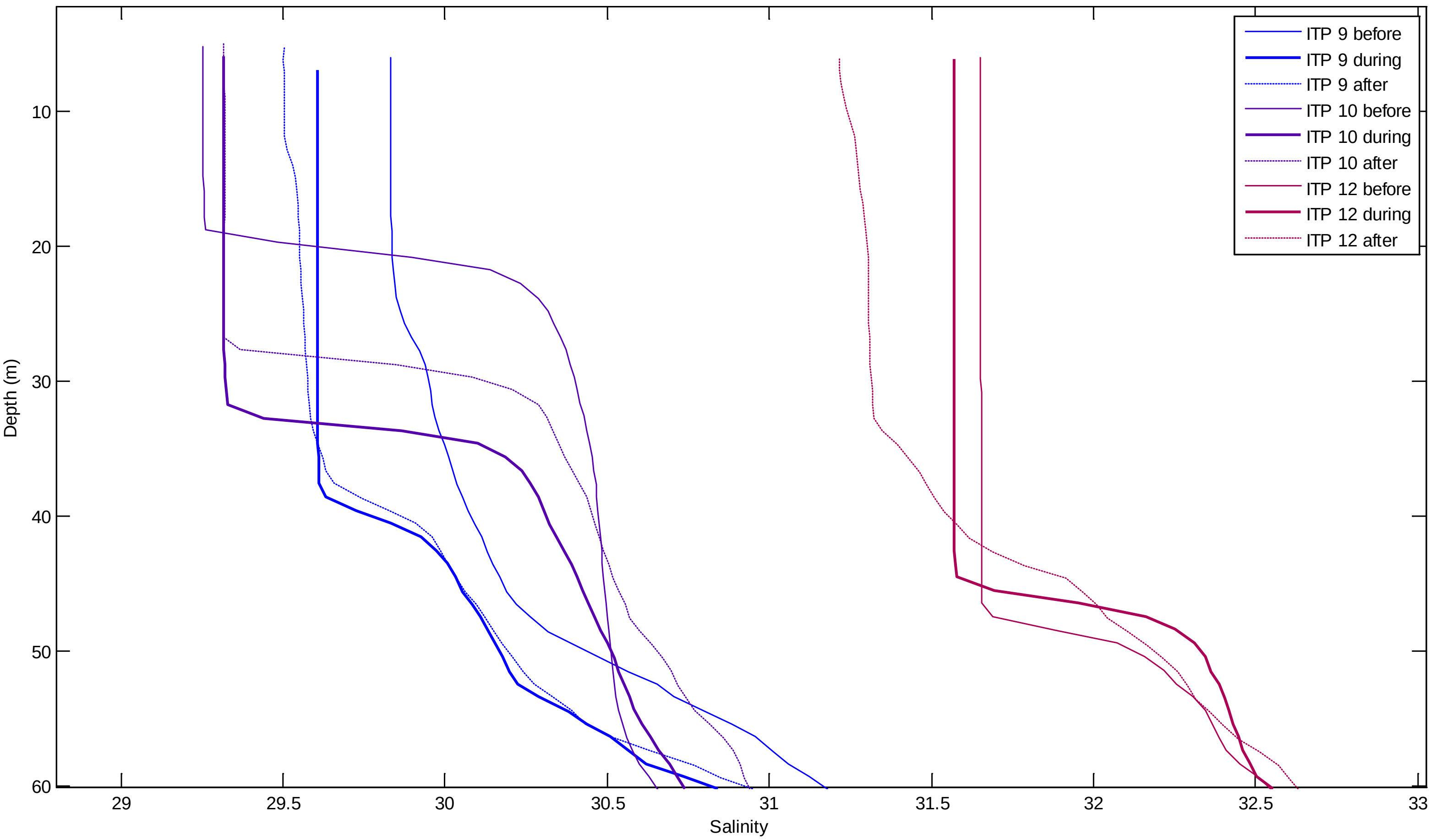

Figure 14b. Salinity plotted with depth for ITPs 9, 10, & 12 in the Transpolar Drift Stream during the December 4, 2007 high ice speed event.

ITP Paths During Event

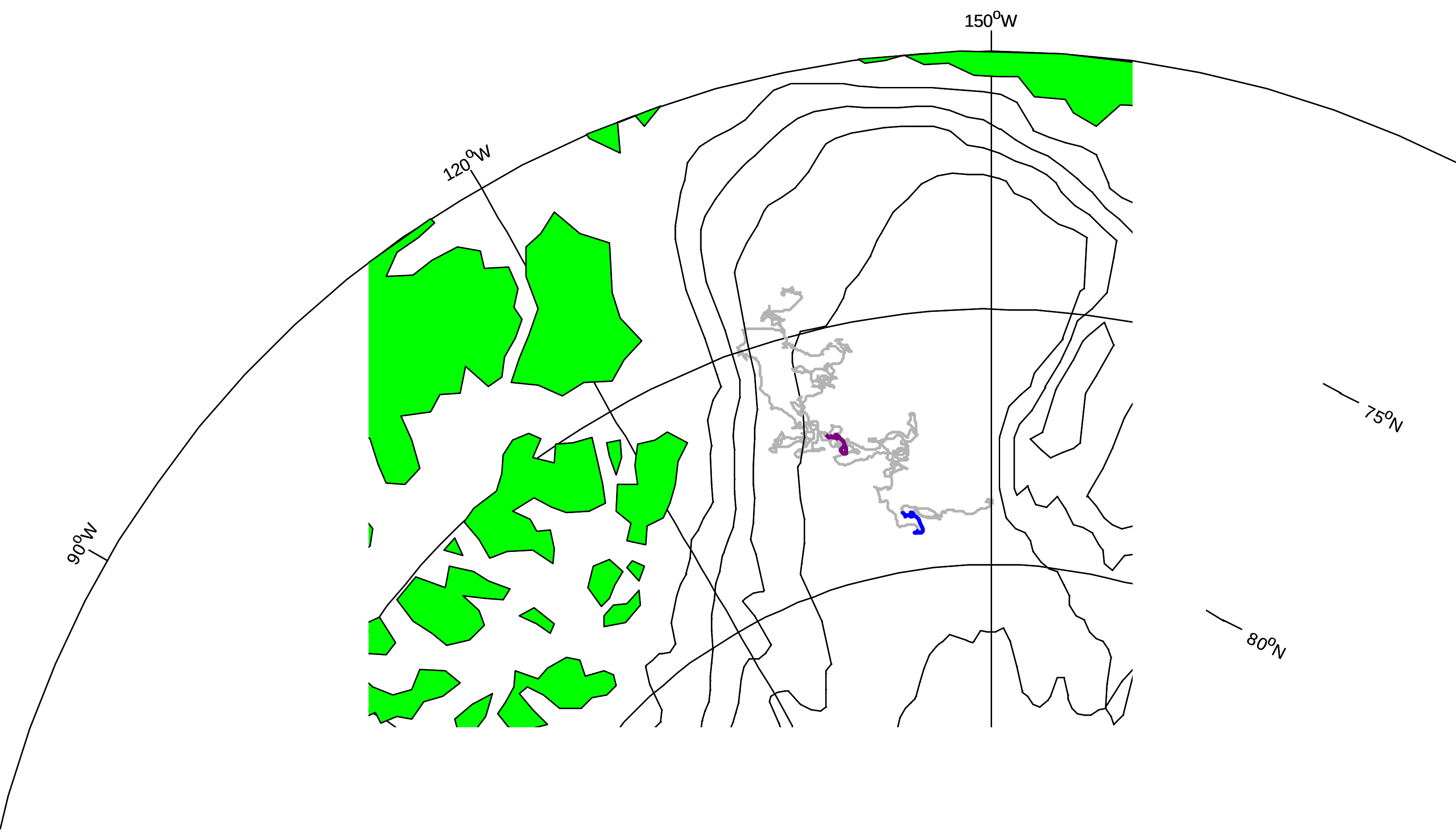

Figure 15. Drift tracks plotted for ITPs 1 & 3 in the Beaufort Gyre. Grey indicates the complete record for the life of the ITP; each ITP is color-coded according to its potential temperature and salinity plots for the duration of the high-wind event. Notable is the spatial coherence of the drift tracks during the event.

ITP Paths During Event

Figure 16. Drift tracks plotted for ITPs 4 & 6 in the Beaufort Gyre. Grey indicates the complete record for the life of the ITP; each ITP is color-coded according to its potential temperature and salinity plots for the duration of the high-wind event. Notable is the spatial coherence of the drift tracks during the event.

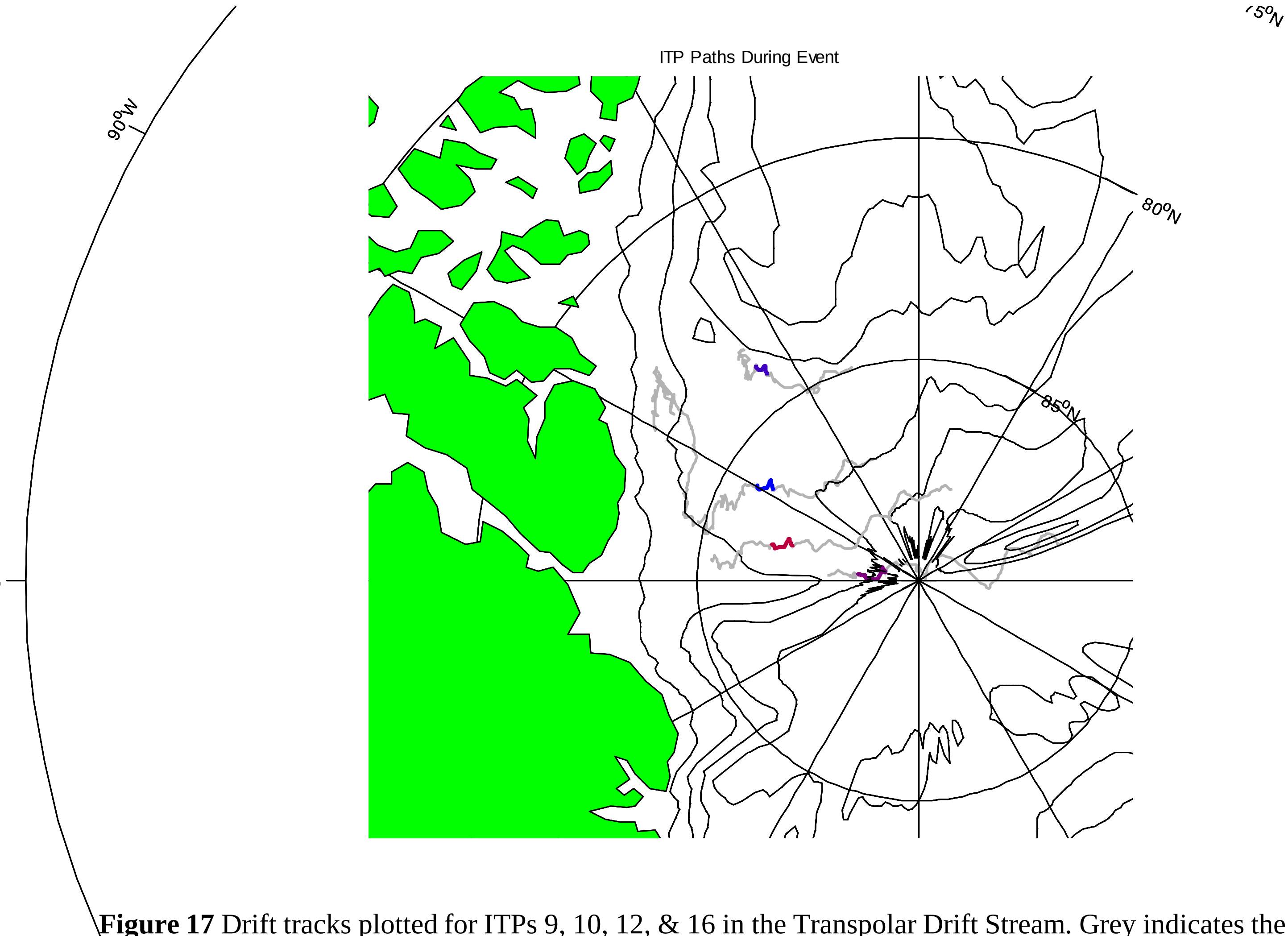

Figure 17 Drift tracks plotted for ITPs 9, 10, 12, & 16 in the Transpolar Drift Stream. Grey indicates the complete record for the life of the ITP; each ITP is color-coded according to its potential temperature and salinity plots for the duration of the high-wind event. Notable is the spatial coherence of the drift tracks during the event. ITP16 is shown in purple to illustrate this coherence, despite not being represented on the vertical profile plots of the wind event.

Appendix: Matlab Code

Index

Outside routines:

Seawater Library v3.2 – Phillip P. Morgan, Lindsay Pender, CSIRO
Contains routines for calculating seawater properties
M_Map v1.4 – Rich Pawlowicz, UBC
Mapping package
moving_average.m – Carlos Adrián Vargas Aguilera, CICESE
Moving average function
tlabel.m – Carlos Adrián Vargas Aguilera, CICESE
converts datenum plot ticks to mm/dd/yyyy format

Principal code:

Rawlocs_plot.m

```
% Program to read in and to plot ITP data from rawlocs files
i=1;
for k=1:29 % loop to read in multiple files
    infile=horzcat('itp',num2str(k),'rawlocs.dat');
    ITP_readin(infile,k);
    ITP_summary(i,1)=ITP;
    i=i+1;
    display(k)
end
```

ITP_readin.m

```
function [ITP]=ITP_readin(infile,k)
% function to read in ITP data

data=load(infile);

tjd=data(:,2); ITP(k,1).tjd=tjd;
year=data(:,1); ITP(k,1).year=year;
time=datenum(data(:,1),1,1)+data(:,2)-1;
ITP(k,1).time=time;

lon=data(:,3);
lat=data(:,4);
ITP(k,1).lon=lon;
ITP(k,1).lat=lat;

for i=1:length(ITP(k,1).time)
[dist(i),bear(i)]=sw_dist([ITP(k,1).lat(1)
ITP(k,1).lat(i)],[ITP(k,1).lon(1) ITP(k,1).lon(i)],'km');
end

x=(dist.*cos(bear*pi/180))'; y=(dist.*sin(bear*pi/180))';
n=numel(ITP(k,1).time); x(n)=0; y(n)=0; % adjust for different-sized
matrices
ITP(k,1).x=x; ITP(k,1).y=y;

%try to identify and filter out the spikes in latitude

 [b,a]=butter(5,.25);
 ylo=filtfilt(b,a,ITP(k,1).y);
 dy=ITP(k,1).y-ylo;

 j=find(dy>0.5);

 yf=ITP(k,1).y;

 yf(j)=(yf(j-1)+yf(j+1))/2;
 ITP(k,1).yf=yf;

uvel=diff(ITP(k,1).x*1e3)./diff(ITP(k,1).time*24*3600);
vvel=diff(ITP(k,1).yf*1e3)./diff(ITP(k,1).time*24*3600);

%apply a triangle convolution filter to the velocities
```

```
 tri=[.25 .5 .25];
 z=conv(uvel,tri);
 uvel=z(2:end-1);
ITP(k,1).uvel=uvel;
 z=conv(vvel,tri);
 vvel=z(2:end-1);
 ITP(k,1).vvel=vvel;

r=numel(ITP(k,1).uvel);
for i=1:r
    ITP(k,1).uvel(i)=ITP(k,1).uvel(i)*ITP(k,1).uvel(i);
    ITP(k,1).vvel(i)=ITP(k,1).vvel(i)*ITP(k,1).vvel(i);
end
n=numel(ITP(k,1).time); ITP(k,1).uvel(n)=NaN; ITP(k,1).vvel(n)=NaN;
speed=sqrt(ITP(k,1).uvel+ITP(k,1).vvel);
n=numel(ITP(k,1).time);
speed(n)=0;
ITP(k,1).speed=speed;

 assignin('caller', 'ITP', ITP(k,1));

end
```

year_eval.m

```
for i=1:29

for k=4:9
yr_eval=strcat(num2str(200),num2str(k));
q=find(ITP_summary(i,1).year==str2num(yr_eval));
exist('q');

if ans==1
    if yr_eval==num2str(2004)
      ITP_yearplot(i,1).ITPtime2004=ITP_summary(i,1).time(q);
      ITP_yearplot(i,1).ITPspeed2004=ITP_summary(i,1).speed(q);
    elseif yr_eval==num2str(2005)
      ITP_yearplot(i,1).ITPtime2005=ITP_summary(i,1).time(q);
      ITP_yearplot(i,1).ITPspeed2005=ITP_summary(i,1).speed(q);
    elseif yr_eval==num2str(2006)
      ITP_yearplot(i,1).ITPtime2006=ITP_summary(i,1).time(q);
      ITP_yearplot(i,1).ITPspeed2006=ITP_summary(i,1).speed(q);
    elseif yr_eval==num2str(2007)
      ITP_yearplot(i,1).ITPtime2007=ITP_summary(i,1).time(q);
      ITP_yearplot(i,1).ITPspeed2007=ITP_summary(i,1).speed(q);
    elseif yr_eval==num2str(2008)
      ITP_yearplot(i,1).ITPtime2008=ITP_summary(i,1).time(q);
      ITP_yearplot(i,1).ITPspeed2008=ITP_summary(i,1).speed(q);
    elseif yr_eval==num2str(2009)
      ITP_yearplot(i,1).ITPtime2009=ITP_summary(i,1).time(q);
      ITP_yearplot(i,1).ITPspeed2009=ITP_summary(i,1).speed(q);
    end
end
end
end
```

```
figure(2005)
tstart=datenum(2005,08,15); tend=datenum(2005,12,31);

subplot(2,1,1)
plot(ITP_yearplot(1,1).ITPtime2005,ITP_yearplot(1,1).ITPspeed2005,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(1,1).ITPtime2005,moving_average(ITP_yearplot(1,1).ITP
speed2005,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 1')

subplot(2,1,2)
plot(ITP_yearplot(3,1).ITPtime2005,ITP_yearplot(3,1).ITPspeed2005,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(3,1).ITPtime2005,moving_average(ITP_yearplot(3,1).ITP
speed2005,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 3')

figure(20061)
tstart=datenum(2006,01,01); tend=datenum(2006,12,31);

subplot(2,1,1)
plot(ITP_yearplot(1,1).ITPtime2006,ITP_yearplot(1,1).ITPspeed2006,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(1,1).ITPtime2006,moving_average(ITP_yearplot(1,1).ITP
speed2006,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 1')

subplot(2,1,2)
plot(ITP_yearplot(3,1).ITPtime2006,ITP_yearplot(3,1).ITPspeed2006,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(3,1).ITPtime2006,moving_average(ITP_yearplot(3,1).ITP
speed2006,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 3')

figure(20062)
tstart=datenum(2006,09,01); tend=datenum(2006,12,31);

subplot(3,1,1)
plot(ITP_yearplot(4,1).ITPtime2006,ITP_yearplot(4,1).ITPspeed2006,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(4,1).ITPtime2006,moving_average(ITP_yearplot(4,1).ITP
speed2006,24),'k-','LineWidth',2), hold on
```

```
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 4')

subplot(3,1,2)
plot(ITP_yearplot(5,1).ITPtime2006,ITP_yearplot(5,1).ITPspeed2006,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(5,1).ITPtime2006,moving_average(ITP_yearplot(5,1).ITP
speed2006,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 5')

subplot(3,1,3)
plot(ITP_yearplot(6,1).ITPtime2006,ITP_yearplot(6,1).ITPspeed2006,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(6,1).ITPtime2006,moving_average(ITP_yearplot(6,1).ITP
speed2006,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 6')

figure(20071)
tstart=datenum(2007,01,01); tend=datenum(2007,12,31);

subplot(4,1,1)
plot(ITP_yearplot(1,1).ITPtime2007,ITP_yearplot(1,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(1,1).ITPtime2007,moving_average(ITP_yearplot(1,1).ITP
speed2007,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 1')

subplot(4,1,2)
plot(ITP_yearplot(4,1).ITPtime2007,ITP_yearplot(4,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(4,1).ITPtime2007,moving_average(ITP_yearplot(4,1).ITP
speed2007,24),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 4')

subplot(4,1,3)
plot(ITP_yearplot(5,1).ITPtime2007,ITP_yearplot(5,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(5,1).ITPtime2007,moving_average(ITP_yearplot(5,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 5')
```

```
subplot(4,1,4)
plot(ITP_yearplot(6,1).ITPtime2007,ITP_yearplot(6,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(6,1).ITPtime2007,moving_average(ITP_yearplot(6,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 6')

figure(20072)
tstart=datenum(2007,08,01); tend=datenum(2007,12,31);

subplot(6,1,1)
plot(ITP_yearplot(5,1).ITPtime2007,ITP_yearplot(5,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(5,1).ITPtime2007,moving_average(ITP_yearplot(5,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02
0.7747 0.1141-0.02]); title('ITP 5')

subplot(6,1,2)
plot(ITP_yearplot(6,1).ITPtime2007,ITP_yearplot(6,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(6,1).ITPtime2007,moving_average(ITP_yearplot(6,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 6')

subplot(6,1,3)
plot(ITP_yearplot(8,1).ITPtime2007,ITP_yearplot(8,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(8,1).ITPtime2007,moving_average(ITP_yearplot(8,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
2*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 8')

subplot(6,1,4)
plot(ITP_yearplot(11,1).ITPtime2007,ITP_yearplot(11,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(11,1).ITPtime2007,moving_average(ITP_yearplot(11,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
3*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 11')
```

```
subplot(6,1,5)
plot(ITP_yearplot(13,1).ITPtime2007,ITP_yearplot(13,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(13,1).ITPtime2007,moving_average(ITP_yearplot(13,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
4*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 13')

subplot(6,1,6)
plot(ITP_yearplot(18,1).ITPtime2007,ITP_yearplot(18,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(18,1).ITPtime2007,moving_average(ITP_yearplot(18,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
5*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]);
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 18')

figure(20073)
% Transpolar Drift
tstart=datenum(2007,09,01); tend=datenum(2007,12,31);

subplot(3,1,1)
plot(ITP_yearplot(7,1).ITPtime2007,ITP_yearplot(7,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(7,1).ITPtime2007,moving_average(ITP_yearplot(7,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 7')

subplot(3,1,2)
plot(ITP_yearplot(14,1).ITPtime2007,ITP_yearplot(14,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(14,1).ITPtime2007,moving_average(ITP_yearplot(14,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 14')

subplot(3,1,3)
plot(ITP_yearplot(17,1).ITPtime2007,ITP_yearplot(17,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(17,1).ITPtime2007,moving_average(ITP_yearplot(17,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 17')
```

```
figure(20074)
% in-betweens
tstart=datenum(2007,09,01); tend=datenum(2007,12,31);

subplot(5,1,1)
plot(ITP_yearplot(9,1).ITPtime2007,ITP_yearplot(9,1).ITPspeed2007,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(9,1).ITPtime2007,moving_average(ITP_yearplot(9,1).ITP
speed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 9')

subplot(5,1,2)
plot(ITP_yearplot(10,1).ITPtime2007,ITP_yearplot(10,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(10,1).ITPtime2007,moving_average(ITP_yearplot(10,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 10')

subplot(5,1,3)
plot(ITP_yearplot(12,1).ITPtime2007,ITP_yearplot(12,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(12,1).ITPtime2007,moving_average(ITP_yearplot(12,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 1]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 12 (note scale
change)')

subplot(5,1,4)
plot(ITP_yearplot(15,1).ITPtime2007,ITP_yearplot(15,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(15,1).ITPtime2007,moving_average(ITP_yearplot(15,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 15')

subplot(5,1,5)
plot(ITP_yearplot(16,1).ITPtime2007,ITP_yearplot(16,1).ITPspeed2007,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(16,1).ITPtime2007,moving_average(ITP_yearplot(16,1).I
TPspeed2007,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 16')
```

```
figure(20081)
% Beaufort Gyre
tstart=datenum(2008,01,01); tend=datenum(2008,08,30);

subplot(5,1,1)
plot(ITP_yearplot(6,1).ITPtime2008,ITP_yearplot(6,1).ITPspeed2008,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(6,1).ITPtime2008,moving_average(ITP_yearplot(6,1).ITP
speed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 6')

subplot(5,1,2)
plot(ITP_yearplot(8,1).ITPtime2008,ITP_yearplot(8,1).ITPspeed2008,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(8,1).ITPtime2008,moving_average(ITP_yearplot(8,1).ITP
speed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 8')

subplot(5,1,3)
plot(ITP_yearplot(11,1).ITPtime2008,ITP_yearplot(11,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(11,1).ITPtime2008,moving_average(ITP_yearplot(11,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 11')

subplot(5,1,4)
plot(ITP_yearplot(13,1).ITPtime2008,ITP_yearplot(13,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(13,1).ITPtime2008,moving_average(ITP_yearplot(13,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 13')

subplot(5,1,5)
plot(ITP_yearplot(18,1).ITPtime2008,ITP_yearplot(18,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(18,1).ITPtime2008,moving_average(ITP_yearplot(18,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 18')

figure(20082)
```

```
tstart=datenum(2008,08,01); tend=datenum(2008,12,31);

subplot(7,1,1)
plot(ITP_yearplot(8,1).ITPtime2008,ITP_yearplot(8,1).ITPspeed2008,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(8,1).ITPtime2008,moving_average(ITP_yearplot(8,1).ITP
speed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.1289 0.8899 0.7784
0.0764]); title('ITP 8')

subplot(7,1,2)
plot(ITP_yearplot(11,1).ITPtime2008,ITP_yearplot(11,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(11,1).ITPtime2008,moving_average(ITP_yearplot(11,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.1289 0.8899-
(0.05+0.0764) 0.7784 0.0764]); title('ITP 11')

subplot(7,1,3)
plot(ITP_yearplot(20,1).ITPtime2008,ITP_yearplot(20,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(20,1).ITPtime2008,moving_average(ITP_yearplot(20,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.1289 0.8899-
2*(0.05+0.0764) 0.7784 0.0764]); title('ITP 20')

subplot(7,1,4)
plot(ITP_yearplot(21,1).ITPtime2008,ITP_yearplot(21,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(21,1).ITPtime2008,moving_average(ITP_yearplot(21,1).I
TPspeed2008,48),'k-','LineWidth',2),  hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.1289 0.8899-
3*(0.05+0.0764) 0.7784 0.0764]); title('ITP 21')

subplot(7,1,5)
plot(ITP_yearplot(22,1).ITPtime2008,ITP_yearplot(22,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(22,1).ITPtime2008,moving_average(ITP_yearplot(22,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.1289 0.8899-
4*(0.05+0.0764) 0.7784 0.0764]); title('ITP 22')
```

```
subplot(7,1,6)
plot(ITP_yearplot(23,1).ITPtime2008,ITP_yearplot(23,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(23,1).ITPtime2008,moving_average(ITP_yearplot(23,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.1289 0.8899-
5*(0.05+0.0764) 0.7784 0.0764]); title('ITP 23')

subplot(7,1,7)
plot(ITP_yearplot(25,1).ITPtime2008,ITP_yearplot(25,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(25,1).ITPtime2008,moving_average(ITP_yearplot(25,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0
0.5],'XGrid','on','Position',[0.1289 0.8899-6*(0.05+0.0764) 0.7784
0.0764]); tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 25')

figure(20083)
% Transpolar Drift
tstart=datenum(2008,09,01); tend=datenum(2008,12,31);

subplot(3,1,1)
plot(ITP_yearplot(14,1).ITPtime2008,ITP_yearplot(14,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(14,1).ITPtime2008,moving_average(ITP_yearplot(14,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 14')

subplot(3,1,2)
plot(ITP_yearplot(17,1).ITPtime2008,ITP_yearplot(17,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(17,1).ITPtime2008,moving_average(ITP_yearplot(17,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 1]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 17 (note scale
change)')

subplot(3,1,3)
plot(ITP_yearplot(19,1).ITPtime2008,ITP_yearplot(19,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(19,1).ITPtime2008,moving_average(ITP_yearplot(19,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 19')

figure(20084)
```

```
tstart=datenum(2008,09,10); tend=datenum(2008,12,31);

subplot(3,1,1)
plot(ITP_yearplot(24,1).ITPtime2008,ITP_yearplot(24,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(24,1).ITPtime2008,moving_average(ITP_yearplot(24,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 24')

subplot(3,1,2)
plot(ITP_yearplot(26,1).ITPtime2008,ITP_yearplot(26,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(26,1).ITPtime2008,moving_average(ITP_yearplot(26,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 26')

subplot(3,1,3)
plot(ITP_yearplot(27,1).ITPtime2008,ITP_yearplot(27,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(27,1).ITPtime2008,moving_average(ITP_yearplot(27,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 27')

% in-betweens
figure(20085)
tstart=datenum(2008,01,01); tend=datenum(2008,12,31);

subplot(3,1,1)
plot(ITP_yearplot(9,1).ITPtime2008,ITP_yearplot(9,1).ITPspeed2008,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(9,1).ITPtime2008,moving_average(ITP_yearplot(9,1).ITP
speed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 9')

subplot(3,1,2)
plot(ITP_yearplot(10,1).ITPtime2008,ITP_yearplot(10,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(10,1).ITPtime2008,moving_average(ITP_yearplot(10,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 10')
```

```
subplot(3,1,3)
plot(ITP_yearplot(16,1).ITPtime2008,ITP_yearplot(16,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(16,1).ITPtime2008,moving_average(ITP_yearplot(16,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 16')

figure(20086)
tstart=datenum(2008,08,30); tend=datenum(2008,12,31);

subplot(2,1,1)
plot(ITP_yearplot(28,1).ITPtime2008,ITP_yearplot(28,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(28,1).ITPtime2008,moving_average(ITP_yearplot(28,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 28')

subplot(2,1,2)
plot(ITP_yearplot(29,1).ITPtime2008,ITP_yearplot(29,1).ITPspeed2008,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(29,1).ITPtime2008,moving_average(ITP_yearplot(29,1).I
TPspeed2008,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 29')

figure(20091)
% Beaufort Gyre
tstart=datenum(2009,01,01); tend=datenum(2009,10,01);

subplot(6,1,1)
plot(ITP_yearplot(8,1).ITPtime2009,ITP_yearplot(8,1).ITPspeed2009,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(8,1).ITPtime2009,moving_average(ITP_yearplot(8,1).ITP
speed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02
0.7747 0.1141-0.02]); title('ITP 8')

subplot(6,1,2)
plot(ITP_yearplot(11,1).ITPtime2009,ITP_yearplot(11,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(11,1).ITPtime2009,moving_average(ITP_yearplot(11,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 11')
```

```
subplot(6,1,3)
plot(ITP_yearplot(20,1).ITPtime2009,ITP_yearplot(20,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(20,1).ITPtime2009,moving_average(ITP_yearplot(20,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
2*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 20')

subplot(6,1,4)
plot(ITP_yearplot(21,1).ITPtime2009,ITP_yearplot(21,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(21,1).ITPtime2009,moving_average(ITP_yearplot(21,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
3*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 21')

subplot(6,1,5)
plot(ITP_yearplot(23,1).ITPtime2009,ITP_yearplot(23,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(23,1).ITPtime2009,moving_average(ITP_yearplot(23,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on','Position',[0.13 0.8565-0.02-
4*(0.1141-0.02+0.05) 0.7747 0.1141-0.02]); title('ITP 23')

subplot(6,1,6)
plot(ITP_yearplot(25,1).ITPtime2009,ITP_yearplot(25,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(25,1).ITPtime2009,moving_average(ITP_yearplot(25,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0
0.5],'XGrid','on','Position',[0.13 0.8565-0.02-5*(0.1141-0.02+0.05)
0.7747 0.1141-0.02]); title('ITP 25'),
tlabel(gca,'x',23,'keeplimits','keepticks');

% Transpolar Drift
figure(20092)
tstart=datenum(2009,01,01); tend=datenum(2009,03,03);

subplot(4,1,1)
plot(ITP_yearplot(17,1).ITPtime2009,ITP_yearplot(17,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(17,1).ITPtime2009,moving_average(ITP_yearplot(17,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 1]);
tlabel(gca,'x',23,'keeplimits','keepticks');
```

```
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 17 (note scale
change)')

subplot(4,1,2)
plot(ITP_yearplot(24,1).ITPtime2009,ITP_yearplot(24,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(24,1).ITPtime2009,moving_average(ITP_yearplot(24,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 24')

subplot(4,1,3)
plot(ITP_yearplot(26,1).ITPtime2009,ITP_yearplot(26,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(26,1).ITPtime2009,moving_average(ITP_yearplot(26,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 26')

subplot(4,1,4)
plot(ITP_yearplot(27,1).ITPtime2009,ITP_yearplot(27,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(27,1).ITPtime2009,moving_average(ITP_yearplot(27,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 27')

% in-betweens
figure(20093)
tstart=datenum(2009,01,01); tend=datenum(2009,10,06);

subplot(4,1,1)
plot(ITP_yearplot(9,1).ITPtime2009,ITP_yearplot(9,1).ITPspeed2009,'Colo
r',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(9,1).ITPtime2009,moving_average(ITP_yearplot(9,1).ITP
speed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 9 (note scale
change)')

subplot(4,1,2)
plot(ITP_yearplot(16,1).ITPtime2009,ITP_yearplot(16,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(16,1).ITPtime2009,moving_average(ITP_yearplot(16,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.25]);
tlabel(gca,'x',23,'keeplimits','keepticks');
```

```
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 16 (note scale
change)')

subplot(4,1,3)
plot(ITP_yearplot(28,1).ITPtime2009,ITP_yearplot(28,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(28,1).ITPtime2009,moving_average(ITP_yearplot(28,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5]);
tlabel(gca,'x',23,'keeplimits','keepticks');
set(gca,'XTickLabel',[],'XGrid','on'); title('ITP 28')

subplot(4,1,4)
plot(ITP_yearplot(29,1).ITPtime2009,ITP_yearplot(29,1).ITPspeed2009,'Co
lor',[0.7 0.7 0.7],'LineWidth',1), hold on

plot(ITP_yearplot(29,1).ITPtime2009,moving_average(ITP_yearplot(29,1).I
TPspeed2009,48),'k-','LineWidth',2), hold on
set(gca,'XLim',[tstart,tend],'Ylim',[0 0.5],'XGrid','on');
tlabel(gca,'x',23,'keeplimits','keepticks'); title('ITP 29')
```

Vert_prof.m

```
% plots depth profile before, during, and after winter storm event

clear fid
% ask for variable input for date of event center and duration
event_year=input('Please enter the year of the event  ');
event_month=input('Please enter the month of the event  ');
event_day=input('Please enter the day of the event  ');
    event_date=datenum(event_year,event_month,event_day);
event_duration=input('What was the total duration of this event (in
days)?  ');

% ask for which ITP profiles to plot
ITP_number(1,1)=input('Please enter the first ITP number for which you
need a profile  ');
for r=2:7
repeat_val(1,r)=input('Would you like to plot an additional ITP
profile? (Y/N)  ','s');
    if repeat_val(1,r)=='Y'
        ITP_number(1,r)=input('Please enter the next ITP number for
which you need a profile  ');
    else
        break
    end
end

% find values just outside of range, on either side
dur_range=event_duration+2;
before_date=event_date-dur_range; after_date=event_date+dur_range;

% generate 3 profiles: "Before", "During", "After"
% open seawater routines
```

```
cd ../../
cd seawater_ver3_2

n=numel(ITP_number);

% Set up plot colors so each ITP is different
grph_color_int=1/n;
grph_color=[0 0 1]; % initialize graph color

for m=1:n
    if ITP_number(1,m) <= 5
        fname=horzcat('itp',num2str(ITP_number(1,m)),'final.mat');
    else
        fname=horzcat('itp',num2str(ITP_number(1,m)),'final-beta.mat');
    end

    fid(1,m)=open(fname);

% find array indexes for three dates

event_ind=find(floor(datenum(fid(1,m).date(:,1),fid(1,m).date(:,2),fid(
1,m).date(:,3)))==event_date);
        event_index(1,m)=round(mean(event_ind));

before_ind=find(floor(datenum(fid(1,m).date(:,1),fid(1,m).date(:,2),fid
(1,m).date(:,3)))==before_date);
        before_index(1,m)=round(mean(before_ind));

after_ind=find(floor(datenum(fid(1,m).date(:,1),fid(1,m).date(:,2),fid(
1,m).date(:,3)))==after_date);
        after_index(1,m)=round(mean(after_ind));

% POTENTIAL TEMPERATURE
figure(1)

PR=[0];

    PT=sw_ptmp(fid(1,m).S,fid(1,m).T,fid(1,m).P,PR);
    fid(1,m).Tf=sw_fp(fid(1,m).S,fid(1,m).P);
    temp=fid(1,m).T-fid(1,m).Tf;

dpth_calc=sw_dpth(fid(1,m).P(:,before_index(1,m)),fid(1,m).lat(before_i
ndex(1,m),:));
    leg_name=horzcat('ITP ',num2str(ITP_number(1,m)),' before');

plot(PT(:,before_index(1,m)),dpth_calc,'color',grph_color,'LineWidth',1
,'DisplayName',leg_name), hold on

PR=[0];
    PT=sw_ptmp(fid(1,m).S,fid(1,m).T,fid(1,m).P,PR);
    fid(1,m).Tf=sw_fp(fid(1,m).S,fid(1,m).P);
    temp=fid(1,m).T-fid(1,m).Tf;

dpth_calc=sw_dpth(fid(1,m).P(:,event_index(1,m)),fid(1,m).lat(event_ind
ex(1,m),:));
```

```
    leg_name=horzcat('ITP ',num2str(ITP_number(1,m)),' during');

plot(PT(:,event_index(1,m)),dpth_calc,'color',grph_color,'LineWidth',2,
'DisplayName',leg_name), hold on

PR=[0];
    PT=sw_ptmp(fid(1,m).S,fid(1,m).T,fid(1,m).P,PR);
    fid(1,m).Tf=sw_fp(fid(1,m).S,fid(1,m).P);
    temp=fid(1,m).T-fid(1,m).Tf;

dpth_calc=sw_dpth(fid(1,m).P(:,after_index(1,m)),fid(1,m).lat(after_ind
ex(1,m),:));
    leg_name=horzcat('ITP ',num2str(ITP_number(1,m)),' after');

plot(PT(:,after_index(1,m)),dpth_calc,'color',grph_color,'LineStyle',':
','DisplayName',leg_name), hold on

set(gca,'YDir','reverse'),
axis([-2 -1 0 60])
xlabel('Potential Temperature relative to surface (C)'), ylabel('Depth
(m)')

figure(3)
    title('ITP Paths During Event')
    m_proj('stereographic','lat',90,'long',30,'radius',20);
    m_elev('contour',[-3500:1000:-500],'edgecolor','k');
    m_grid('xtick',12,'tickdir','out','ytick',[75 80 85 90],'linest','-
');
    m_coast('patch',[0 1 0]);
map_leg=horzcat('ITP ',num2str(ITP_number(1,m)));
    m_line(fid(1,m).lon,fid(1,m).lat,'LineWidth',2,'color',[0.7 0.7
0.7]);

m_line(fid(1,m).lon(before_index(1,m):after_index(1,m)),fid(1,m).lat(be
fore_index(1,m):after_index(1,m)),...
        'color',grph_color,'LineStyle','-
','LineWidth',2.5,'DisplayName',map_leg);

    hold on

% SALINITY NOW

figure(2)

dpth_calc=sw_dpth(fid(1,m).P(:,before_index(1,m)),fid(1,m).lat(before_i
ndex(1,m),:));
    leg_name=horzcat('ITP ',num2str(ITP_number(1,m)),' before');

plot(fid(1,m).S(:,before_index(1,m)),dpth_calc,'color',grph_color,'Line
Width',1,'DisplayName',leg_name), hold on

dpth_calc=sw_dpth(fid(1,m).P(:,event_index(1,m)),fid(1,m).lat(event_ind
ex(1,m),:));
    leg_name=horzcat('ITP ',num2str(ITP_number(1,m)),' during');
```

```
plot(fid(1,m).S(:,event_index(1,m)),dpth_calc,'color',grph_color,'LineW
idth',2,'DisplayName',leg_name), hold on

dpth_calc=sw_dpth(fid(1,m).P(:,after_index(1,m)),fid(1,m).lat(after_ind
ex(1,m),:));
    leg_name=horzcat('ITP ',num2str(ITP_number(1,m)),' after');

plot(fid(1,m).S(:,after_index(1,m)),dpth_calc,'color',grph_color,'LineS
tyle',':','DisplayName',leg_name), hold on

set(gca,'YDir','reverse'),
axis([27 35 0 60])
xlabel('Salinity'), ylabel('Depth (m)')

grph_color=grph_color+[grph_color_int 0 -grph_color_int];

clear fid
end
```

comp_vel.m

```
function [ITP_yearplot]=comp_vel(i,ITP_summary)
% Superimposes plots of uvel and vvel for each ITP

    ITP_summary(i,1).uvelplot=ITP_summary(i,1).uvel;
    ITP_summary(i,1).vvelplot=ITP_summary(i,1).vvel;
        n= ITP_summary(i,1).uvel > 1.;
        ITP_summary(i,1).uvelplot(n)=NaN;
        n= ITP_summary(i,1).vvel > 1.;
        ITP_summary(i,1).vvelplot(n)=NaN;
    plot(ITP_summary(i,1).time,ITP_summary(i,1).uvelplot,'b-'), hold on
    plot(ITP_summary(i,1).time,ITP_summary(i,1).vvelplot,'r-'), hold on
        ylabel('Ice velocities (m/s)'), tlabel(gca,'x',23);
        legend('zonal velocity','meridional velocity'), axis tight

end
```

ice_hist.m

```
% Creates histograms of cm/s ice speeds by a) year and b) season for
% multiple ITPs

% histc usage stub from Andrew Stevens, astevens@junkusgs.gov, on
Google
% groups. Lifesaver.

% get speeds by year for each ITP, convert speeds to cm/s
% RUN YEAR_EVAL.M FIRST!

figure % Seasonal histograms!
i=input('Which ITP to plot across the seasons?   ');
summer=find(ITP_summary(i,1).tjd<=274 & ITP_summary(i,1).tjd>=61);
winter=find(ITP_summary(i,1).tjd>=274 | ITP_summary(i,1).tjd<=61);

summer_var=ITP_summary(i,1).speed(summer);
```

```
winter_var=ITP_summary(i,1).speed(winter);
max_comp1=numel(summer_var);
max_comp2=numel(winter_var);

m=max(max_comp1,max_comp2);
for j=1:m
    summer_plot(j,1)=NaN;
    winter_plot(j,1)=NaN;
end
for k=1:max_comp1
    summer_plot(k,1)=summer_var(k);
end
for k=1:max_comp2
    winter_plot(k,1)=winter_var(k);
end

data=[summer_plot]; xint=0.020; edges=(-0.0025:xint:1);
[s,bin]=hist(data,edges);
     h=bar(bin,s./sum(s),.25,'hist'); set(h(1),'facecolor','red');
     ylabel('normalized histogram'); hold on
     data=[winter_plot]; edges=(0.0025:xint:1);
     [s,bin]=hist(data,edges);
     h=bar(bin,s./sum(s),.25,'hist'); set(h(1),'facecolor','blue');

axis tight, xlabel('velocities (m/s)'), ylabel('normalized frequency')
title(['Normalized histogram of seasonal speeds for ITP ',num2str(i)])
legend('Summer Speeds','Winter Speeds')
```

Seasonal_avg.m

```
function[ITP_yearplot]=seasonal_avg(i,ITP_summary)

% plot speed vs. time for full range
% NaN for certain parameters
n=ITP_summary(i,1).speed>=1.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities above 1 m/s
if i==7
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end
if i==14
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end
if i==17
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end
if i==19
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end
if i==24
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end
if i==26
```

```
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end
if i==27
    n=ITP_summary(i,1).lat<80.; ITP_summary(i,1).speed(n)=NaN; % NaN
velocities for latitudes below 80N for TDS ITPs
end

m=numel(ITP_summary(i,1).speed);
plot(ITP_summary(i,1).time,ITP_summary(i,1).speed,'Color',[0.7 0.7
0.7],'LineWidth',1)
hold on

% plot moving average over data
    if (i<=4)

plot(ITP_summary(i,1).time,moving_average(ITP_summary(i,1).speed,24),'k
-','LineWidth',2)
    end

    if (i==6)
    elseif (i==14)
            ITP_summary(i,1).time1=ITP_summary(i,1).time(1:3648,1);
            ITP_summary(i,1).time2=ITP_summary(i,1).time(3649:m,1);
            ITP_summary(i,1).speed1=ITP_summary(i,1).speed(1:3648,1);
            ITP_summary(i,1).speed2=ITP_summary(i,1).speed(3649:m,1);

plot(ITP_summary(i,1).time1,moving_average(ITP_summary(i,1).speed1,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time2,moving_average(ITP_summary(i,1).speed2,48),
'k-','LineWidth',2)
    elseif (i==16)
            ITP_summary(i,1).time1=ITP_summary(i,1).time(1:583,1);
            ITP_summary(i,1).time2=ITP_summary(i,1).time(584:7616,1);
            ITP_summary(i,1).time3=ITP_summary(i,1).time(7617:8614,1);
            ITP_summary(i,1).time4=ITP_summary(i,1).time(8615:m,1);
            ITP_summary(i,1).speed1=ITP_summary(i,1).speed(1:583,1);
            ITP_summary(i,1).speed2=ITP_summary(i,1).speed(584:7616,1);

ITP_summary(i,1).speed3=ITP_summary(i,1).speed(7617:8614,1);
            ITP_summary(i,1).speed4=ITP_summary(i,1).speed(8615:m,1);

plot(ITP_summary(i,1).time1,moving_average(ITP_summary(i,1).speed1,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time2,moving_average(ITP_summary(i,1).speed2,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time3,moving_average(ITP_summary(i,1).speed3,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time4,moving_average(ITP_summary(i,1).speed4,48),
'k-','LineWidth',2)
    elseif (i==17) % doesn't work
            ITP_summary(i,1).time1=ITP_summary(i,1).time(1:1951,1);
```

```
            ITP_summary(i,1).time2=ITP_summary(i,1).time(2566:m,1);
            ITP_summary(i,1).speed1=ITP_summary(i,1).speed(1:1951,1);
            ITP_summary(i,1).speed2=ITP_summary(i,1).speed(2566:m,1);

plot(ITP_summary(i,1).time1,moving_average(ITP_summary(i,1).speed1,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time2,moving_average(ITP_summary(i,1).speed2,48),
'k-','LineWidth',2)
    elseif (i==22) % works
            ITP_summary(i,1).time1=ITP_summary(i,1).time(1:3849,1);
            ITP_summary(i,1).time2=ITP_summary(i,1).time(3872:m,1);
            ITP_summary(i,1).speed1=ITP_summary(i,1).speed(1:3849,1);
            ITP_summary(i,1).speed2=ITP_summary(i,1).speed(3872:m,1);

plot(ITP_summary(i,1).time1,moving_average(ITP_summary(i,1).speed1,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time2,moving_average(ITP_summary(i,1).speed2,48),
'k-','LineWidth',2)
    elseif (i==28)
            ITP_summary(i,1).time1=ITP_summary(i,1).time(1:4122,1);
            ITP_summary(i,1).time2=ITP_summary(i,1).time(4192:m,1);
            ITP_summary(i,1).speed1=ITP_summary(i,1).speed(1:4122,1);
            ITP_summary(i,1).speed2=ITP_summary(i,1).speed(4192:m,1);

plot(ITP_summary(i,1).time1,moving_average(ITP_summary(i,1).speed1,48),
'k-','LineWidth',2), hold on

plot(ITP_summary(i,1).time2,moving_average(ITP_summary(i,1).speed2,48),
'k-','LineWidth',2)
    else




plot(ITP_summary(i,1).time,moving_average(ITP_summary(i,1).speed,48),'k
-','LineWidth',2)
    end

    tlabel(gca,'x',23);
 end
```

Seasonal_cycle_eg.m

```
% Graphs seasonal cycle of speed vs. time for sample ITPs in the BG and
TDS
% Run YEAR EVAL first!

% BG: ITP 21. Cycle for Sep 1 2008-Sep 1 2009
figure(1)
subplot(2,3,[1 2 4 5])

start=floor(datenum(2007,9,1,12,00,00));
start_ind=floor(mean(find(floor(ITP_yearplot(8,1).ITPtime2007)==start))
);
```

```
finish=max(ITP_yearplot(8,1).ITPtime2007);
finish_ind=find(ITP_yearplot(8,1).ITPtime2007==finish);
k=0;
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(8,1).ITPspeed2007(i,1);
    time_sample(k,1)=ITP_yearplot(8,1).ITPtime2007(i,1);
end
start=min(ITP_yearplot(8,1).ITPtime2008);
start_ind=find(ITP_yearplot(8,1).ITPtime2008==start);
finish=floor(datenum(2008,9,1,12,00,00));
finish_ind=floor(mean(find(floor(ITP_yearplot(8,1).ITPtime2008)==finish
)));
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(8,1).ITPspeed2008(i,1);
    time_sample(k,1)=ITP_yearplot(8,1).ITPtime2008(i,1);
end
plot(time_sample,moving_average(speed_sample,96),'b-','LineWidth',2),
hold on
clear speed_sample, clear time_sample, k=0;
start=floor(datenum(2007,9,1,12,00,00));
start_ind=floor(mean(find(floor(ITP_yearplot(13,1).ITPtime2007)==start)
));
finish=max(ITP_yearplot(13,1).ITPtime2007);
finish_ind=find(ITP_yearplot(13,1).ITPtime2007==finish);
k=0;
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(13,1).ITPspeed2007(i,1);
    time_sample(k,1)=ITP_yearplot(13,1).ITPtime2007(i,1);
end
start=min(ITP_yearplot(13,1).ITPtime2008);
start_ind=find(ITP_yearplot(13,1).ITPtime2008==start);
finish=floor(datenum(2008,9,1,12,00,00));
finish_ind=floor(mean(find(floor(ITP_yearplot(13,1).ITPtime2008)==finis
h)));
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(13,1).ITPspeed2008(i,1);
    time_sample(k,1)=ITP_yearplot(13,1).ITPtime2008(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'r-','LineWidth',2),
hold on
% TDS: ITP 9. Cycle for Sep 11 2007-Sep 11 2008
start=floor(datenum(2007,9,11,12,00,00));
start_ind=floor(mean(find(floor(ITP_yearplot(9,1).ITPtime2007)==start))
);
finish=max(ITP_yearplot(9,1).ITPtime2007);
finish_ind=find(ITP_yearplot(9,1).ITPtime2007==finish);
k=0;
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(9,1).ITPspeed2007(i,1);
    time_sample(k,1)=ITP_yearplot(9,1).ITPtime2007(i,1);
end
start=min(ITP_yearplot(9,1).ITPtime2008);
```

```
start_ind=find(ITP_yearplot(9,1).ITPtime2008==start);
finish=floor(datenum(2008,9,11,12,00,00));
finish_ind=floor(mean(find(floor(ITP_yearplot(9,1).ITPtime2008)==finish
)));
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(9,1).ITPspeed2008(i,1);
    time_sample(k,1)=ITP_yearplot(9,1).ITPtime2008(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'g-','LineWidth',2),
hold on %48
tlabel(gca,'x',23,'keeplimits','keepticks');
axis ([datenum(2007,9,1) datenum(2008,9,1) 0 0.25])
xlabel('Date'), ylabel('Ice speed (m/s)')
legend('ITP 8 (BG)','ITP 13 (BG)','ITP 9 (TDS)','Location','NorthWest')
title('5-Day Running Mean Seasonal Cycle Across BG & TDS ITPs, Sep 07-
Sep 08')

subplot(2,3,[3 6])
    m_proj('stereographic','lat',90,'long',30,'radius',20);
    m_elev('contour',[-3500:1000:-500],'edgecolor','k');
    m_grid('xtick',12,'tickdir','out','ytick',[75 80 85 90],'linest','-
');
    m_coast('patch',[0 0 0]);
% Isolate positions during 2007-08 season for 8,13,9

eight_time_start=find(floor(ITP_summary(8,1).time)==datenum(2007,9,1),
1 );

eight_time_end=find(floor(ITP_summary(8,1).time)==datenum(2008,9,1), 1
);

tteen_time_start=find(floor(ITP_summary(13,1).time)==datenum(2007,9,1),
1 );

tteen_time_end=find(floor(ITP_summary(13,1).time)==datenum(2008,9,1), 1
);

nine_time_start=find(floor(ITP_summary(9,1).time)==datenum(2007,9,12),
1 );
    nine_time_end=find(floor(ITP_summary(9,1).time)==datenum(2008,9,1),
1 );
% Plot ITP tracks for buoys 8,13,9

p1=m_line(ITP_summary(8,1).lon(eight_time_start:eight_time_end),ITP_sum
mary(8,1).lat(eight_time_start:eight_time_end),'color',[0 0
1],'LineWidth',1.5);

p2=m_line(ITP_summary(13,1).lon(tteen_time_start:tteen_time_end),ITP_su
mmary(13,1).lat(tteen_time_start:tteen_time_end),'color',[1 0
0],'LineWidth',1.5);

p3=m_line(ITP_summary(9,1).lon(nine_time_start:nine_time_end),ITP_summa
ry(9,1).lat(nine_time_start:nine_time_end),'color',[0 1
0],'LineWidth',1.5);
    h=legend([p1,p2,p3],'ITP 8','ITP 13','ITP 9');
    set(get(h,'title'),'string','ITP tracks');
```

```
    hold on

% several years in the BG: ITP 8. Yearly seasonal cycles for Sep07-
Sep09
figure3 = figure;
axes3 = axes('Parent',figure3);
subplot(2,3,[1 2 4 5])

clear time_sample, clear speed_sample

start=floor(min(ITP_yearplot(13,1).ITPtime2007));
start_ind=floor(mean(find(floor(ITP_yearplot(13,1).ITPtime2007)==start)
));
finish=floor(max(ITP_yearplot(13,1).ITPtime2007));
finish_ind=find(floor(ITP_yearplot(13,1).ITPtime2007)==finish, 1);
k=0;
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(13,1).ITPspeed2007(i,1);
    time_sample(k,1)=ITP_yearplot(13,1).ITPtime2007(i,1);
end
start=min(ITP_yearplot(13,1).ITPtime2008);
start_ind=find(ITP_yearplot(13,1).ITPtime2008==start);
finish=floor(datenum(2008,9,1,12,00,00));
finish_ind=floor(mean(find(floor(ITP_yearplot(13,1).ITPtime2008)==finis
h)));
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(13,1).ITPspeed2008(i,1);
    time_sample(k,1)=ITP_yearplot(13,1).ITPtime2008(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'b-
','LineWidth',2,'DisplayName','ITP 13'), hold on
tstart=datenum(2007,09,01); tend=datenum(2008,09,01);
title('5-Day Running Mean Beaufort Gyre Yearly Seasonal Cycles for Sep-
06 to Sep-09')

clear time_sample, clear speed_sample, k=0;
start=min(ITP_yearplot(6,1).ITPtime2006);
start_ind=find(ITP_yearplot(6,1).ITPtime2006==start);
finish=max(ITP_yearplot(6,1).ITPtime2006);
finish_ind=find(ITP_yearplot(6,1).ITPtime2006==finish);
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(6,1).ITPspeed2006(i,1);
    time_sample(k,1)=ITP_yearplot(6,1).ITPtime2006(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'g-
','LineWidth',2,'DisplayName','ITP 6'), hold on

clear time_sample, clear speed_sample, k=0;
start=min(ITP_yearplot(6,1).ITPtime2007);
start_ind=find(ITP_yearplot(6,1).ITPtime2007==start);
finish=min(ITP_yearplot(13,1).ITPtime2007);
finish_ind=mean(find(round(ITP_yearplot(6,1).ITPtime2007)==round(finish
)));
```

```
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(6,1).ITPspeed2007(i,1);
    time_sample(k,1)=ITP_yearplot(6,1).ITPtime2007(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'g-
','LineWidth',2,'DisplayName',[]), hold on

clear time_sample, clear speed_sample, k=0;
start=min(ITP_yearplot(5,1).ITPtime2007);
start_ind=find(ITP_yearplot(5,1).ITPtime2007==start);
finish=max(ITP_yearplot(5,1).ITPtime2007);
finish_ind=find(ITP_yearplot(5,1).ITPtime2007==finish);
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(5,1).ITPspeed2007(i,1);
    time_sample(k,1)=ITP_yearplot(5,1).ITPtime2007(i,1);
    if speed_sample(k,1) >= 1.
        speed_sample(k,1)=NaN;
    end
end
plot(time_sample,moving_average(speed_sample,120),'r-
','LineWidth',2,'DisplayName',[]), hold on

clear time_sample, clear speed_sample, k=0;
start=min(ITP_yearplot(8,1).ITPtime2008);
start_ind=find(ITP_yearplot(8,1).ITPtime2008==start);
finish=max(ITP_yearplot(8,1).ITPtime2008);
finish_ind=find(ITP_yearplot(8,1).ITPtime2008==finish);
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(8,1).ITPspeed2008(i,1);
    time_sample(k,1)=ITP_yearplot(8,1).ITPtime2008(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'m-
','LineWidth',2,'DisplayName','ITP 8'), hold on
clear time_sample, clear speed_sample, k=0;
start=min(ITP_yearplot(8,1).ITPtime2009);
start_ind=find(ITP_yearplot(8,1).ITPtime2009==start);
finish=floor(datenum(2009,9,1,12,00,00));
finish_ind=floor(mean(find(floor(ITP_yearplot(8,1).ITPtime2009)==finish
)));
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(8,1).ITPspeed2009(i,1);
    time_sample(k,1)=ITP_yearplot(8,1).ITPtime2009(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'m-
','LineWidth',2,'DisplayName',[]), hold on

clear time_sample, clear speed_sample, k=0;
start=min(ITP_yearplot(11,1).ITPtime2009);
start_ind=find(ITP_yearplot(11,1).ITPtime2009==start);
finish=floor(datenum(2009,9,1,12,00,00));
finish_ind=floor(mean(find(floor(ITP_yearplot(11,1).ITPtime2009)==finis
h)));
```

```
for i=start_ind:finish_ind
    k=k+1;
    speed_sample(k,1)=ITP_yearplot(11,1).ITPspeed2009(i,1);
    time_sample(k,1)=ITP_yearplot(11,1).ITPtime2009(i,1);
end
plot(time_sample,moving_average(speed_sample,120),'color',[0.5 0
0.5],'LineWidth',2,'DisplayName',[]), hold on

tlabel(gca,'x',23,'keeplimits','keepticks'), axis tight
xlabel('Date'), ylabel('Ice speed (m/s)')

subplot(2,3,[3 6])
    m_proj('stereographic','lat',90,'long',30,'radius',20);
    m_elev('contour',[-3500:1000:-500],'edgecolor','k');
    m_grid('xtick',12,'tickdir','out','ytick',[75 80 85 90],'linest','-
');
    m_coast('patch',[0 0 0]);
% Plot tracks corresponding to times on other subplot

six_start=find(floor(ITP_summary(6,1).time)==floor(min(ITP_yearplot(6,1
).ITPtime2006)), 1);

six_end=find(floor(ITP_summary(6,1).time)==floor(max(ITP_yearplot(6,1).
ITPtime2007)), 1);

tteen_start=find(floor(ITP_summary(13,1).time)==floor(min(ITP_yearplot(
13,1).ITPtime2007)), 1);

tteen_end=find(floor(ITP_summary(13,1).time)==floor(datenum(2008,9,1)),
1);

five_start=find(floor(ITP_summary(5,1).time)==floor(min(ITP_yearplot(5,
1).ITPtime2007)), 1);

five_end=find(floor(ITP_summary(5,1).time)==floor(max(ITP_yearplot(5,1)
.ITPtime2007)), 1);

eight_start=find(floor(ITP_summary(8,1).time)==floor(min(ITP_yearplot(8
,1).ITPtime2008)), 1);

eight_end=find(floor(ITP_summary(8,1).time)==floor(datenum(2009,9,1)),
1);

elvn_start=find(floor(ITP_summary(11,1).time)==floor(min(ITP_yearplot(1
1,1).ITPtime2009)), 1);

elvn_end=find(floor(ITP_summary(11,1).time)==floor(datenum(2009,9,1)),
1);
% Plot ITP tracks for buoys 8,13,9

p1=m_line(ITP_summary(6,1).lon(six_start:six_end),ITP_summary(6,1).lat(
six_start:six_end),'color',[0 1
0],'LineWidth',1.5);%,'DisplayName','ITP 6');

p2=m_line(ITP_summary(13,1).lon(tteen_start:tteen_end),ITP_summary(13,1
```

```
).lat(tteen_start:tteen_end),'color',[0 0
1],'LineWidth',1.5);%,'DisplayName','ITP 13');

p3=m_line(ITP_summary(5,1).lon(five_start:five_end),ITP_summary(5,1).la
t(five_start:five_end),'color',[1 0
0],'LineWidth',1.5);%,'DisplayName','ITP 3');

p4=m_line(ITP_summary(8,1).lon(eight_start:eight_end),ITP_summary(8,1).
lat(eight_start:eight_end),'color',[1 0
1],'LineWidth',1.5);%,'DisplayName','ITP 4');

p5=m_line(ITP_summary(11,1).lon(elvn_start:elvn_end),ITP_summary(11,1).
lat(elvn_start:elvn_end),'color',[0.5 0
0.5],'LineWidth',1.5);%,'DisplayName','ITP 5');
    %h=[p1,p2,p3,p4,p5]; legend=(h);
    h=legend([p1,p2,p3,p4,p5],'ITP 6','ITP 13','ITP 5','ITP 8','ITP
11');
    set(get(h,'title'),'string','ITP tracks');
    hold on
```

t_v_comp.m

```
% interpolates temperature and velocity data from ITPs onto same time
grid;
% plots these comparisons

% Calculate freezing temp using seawater files
cd ../../
cd seawater_ver3_2


for m=1:29
    ITP_number(1,m)=m;
    clear fname, clear fid
    if ITP_number(1,m) <= 5
        fname=horzcat('itp',num2str(ITP_number(1,m)),'final.mat');
    else
        fname=horzcat('itp',num2str(ITP_number(1,m)),'final-beta.mat');
    end
exist(fname,'file');
if ans==2
    fid(1,m)=open(fname);
    fid(1,m).Tf=sw_fp(fid(1,m).S,fid(1,m).P);

% Calculate "temp" using T = T - Tf
fid(1,m).temp=fid(1,m).T-fid(1,m).Tf;

% Convert fid dates to datenums (used for interpolation step)
d=numel(fid(1,m).date(:,1));
for i=1:d
    fid(1,m).dnum(i,1)=datenum(fid(1,m).date(i,:));
end

% speed data

mint=min(ITP_summary(ITP_number(1,m),1).time);
maxt=max(ITP_summary(ITP_number(1,m),1).time);
```

```
xi=mint:0.25:maxt;
x=ITP_summary(ITP_number(1,m),1).time;
y=ITP_summary(ITP_number(1,m),1).speed;

% temperature data at 10 m
depth_temp=sw_dpth(fid(1,m).P,fid(1,m).lat');
depth_round=round(depth_temp);
for n=1:20
    for l=1:10
        a=isnan(depth_round(l,n));
        if (uint8(a) ~= 1)
            if (depth_round(l,n)==10)
            depth_ind=l;
            break
            end
        end
    end
end
x2=fid(1,m).dnum; y2=fid(1,m).temp(depth_ind,:);

% interpolate each to speed-defined time grid
if (m~=9)
if (m~=17)
if (m~=11)
    yi=interp1(x,y,xi);
    yi2=interp1(x2,y2,xi);
    if m <= 4
        yi=moving_average(yi,60);
    else
        yi=moving_average(yi,120);
    end
    title_struct(1,m).title_name=horzcat('5-Day Average Speed and
Temperature at 10m for ITP ',num2str(m));
    title_name{1,m}=title_struct(1,m).title_name;

    % NaN speeds above 0.5 m/s
    n=numel(yi);
    for k=1:n
        if yi(1,k) > 0.5
            yi(1,k)=NaN;
        end
    end
    % NaN temps below 0 degC
    n=numel(yi2);
    for k=1:n
        if yi2(1,k) <0.
            yi2(1,k)=NaN;
        end
    end
% plot on same figure
    figure(m)
    subplot(2,1,1)
    [ax,h1,h2]=plotyy(xi,yi,xi,yi2);
    set(h2,'linewidth',2), set(h1,'linewidth',0.5)
    set(ax(2),'XTick',[]); set(ax(2),'XTickLabel',[]);
    set(get(ax(1),'Ylabel'),'String','Speed (m/s)')
```

```
    set(get(ax(2),'Ylabel'),'String','T-Tf (C)')
    datetick('x',23,'keepticks'); axis tight
    title(title_name{1,m}), xlabel('Date')
    subplot(2,1,2)
    [ax,h1,h2]=plotyy(xi,yi,xi,yi2);
    set(h2,'linewidth',2), set(h1,'linewidth',0.5)
    set(ax(2),'XTick',[]); set(ax(2),'XTickLabel',[]);
    set(get(ax(1),'Ylabel'),'String','Speed (m/s)')
    set(get(ax(2),'Ylabel'),'String','T-Tf (C)')
    datetick('x',23,'keepticks'); axis tight
    title(title_name{1,m}), xlabel('Date')
    end
end
end
else
    fprintf('File does not exist'), fprintf('\n')
end

end
```