

## ***Interactive comment on “Daily scale winter-time sea surface temperature variability and the Iberian Poleward Current in the southern Bay of Biscay from 1981 to 2010” by G. Esnaola et al.***

### **Anonymous Referee #2**

Received and published: 28 February 2013

The is an excellent paper on the poleward flow on the slopes (and shelf) around Northern Spain. It captures a reconstructed SST structure of the winter flow as an anomaly time series from 1981 to 2010 and derives the meteorological variables that force years with enhanced flow. The main driver for the SST positive anomalies is shown to be a low atmospheric pressure anomaly in the N Atlantic to the west of Europe with a centre near 25W, 50N. The associated wind stress and heat flux patterns are given. The wind stress will force a flow pattern directly or indirectly (through density re- adjustment) and altimeter data are used to show the slope currents off Portugal and in the southern Bay of Biscay that correspond with the SST winter warming pattern. Excellent, I strongly recommend publication of Esnaola et al, subject to reference to some papers outlined

C1638

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Interactive  
Comment

below, some inserts in Table 2, a few minor oceanography corrections, a few incorrect sentences removed, and that the authors show that they know the difference between SST / PIC (particular at page 3813). The paper is very well written. In terms of balance, although I liked the reconstruction analysis and the SST result, fig 7, I would have preferred relatively more words and appraisal of the scientific findings or deductions and have made some suggestions under CONCLUSIONS. Overall rating, very good.

Many points are listed below. Most can be taken care of with an appropriately placed reference. Some are just information which may help interpretation of data. These are largely put under **Figures** below as that is where the results can be seen and appraise more critically. The comments are intended to be helpful, showing sometimes an alternative view or giving a bit of extra information that is not easy to glean from the literature, or something that is clearly incorrect.

Title. The definition of the Navidad is “the extent of winter SST warming that results from the slope current in the Bay of Biscay along Northern Spain”. This SST anomaly comes near New Year and ‘belongs’ (is attached to) to Spain, hence the convenient shortened name ‘Navidad’. A shortened title might read .. “Navidad variability from 1981-2010”. Making everything Iberian (PC) can lead to some misinterpretations (and some don’t know where it is). For example, Navidad refers to SST and this is not quite the same ‘thing’ as the slope current. The temperature can result from displacement, or current integration, so SST maximum will not be coincident with flow maximum. In general the SST will lag the poleward current and near maximum temperatures can be sometimes observed when the flow has stopped. If it is IPC along Spain at what point does it stop being IPC in French Waters on the Armorican slopes? Isn’t a lot of the ‘real’ IPC already lost off NW Spain? Give an estimate for the IPC slope transport (and ref if already in literature), it is not difficult. See satellite images (fig 17) shown in Pingree and Le Cann 1989 showing loss off NW Spain for example (put in Table 2). These authors also gave the increasing (collected with latitude, with wind stress and dynamic height) poleward slope transport off northern France as ~2Sv and ~7Sv as

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

far north as 60N as early as 1989. Inertial Overshoot occurs off other promontories, Goban Spur, Cape St Vincent, as well as NW Spain.

Abstract. An oceanographer likes to think the surface conditions drive the ocean, of 500hPa.

Introduction. -Page 3798 Line 29. These references, Garcia-Soto & Pingree (2012) (which extends the AVHRR satellite observations of the IPC to 2010) and the earlier one by Garcia-Soto, Pingree & Valdés (20002) (covering 30 years of high resolution AVHRR satellite observations (1979-2010)) should be mentioned early in the INTRODUCTION. They cover and analyse the same oceanographic structure (SST/IPC) for the same period of time (1981-2010) as in this Esnaola manuscript. I suggest with a sentence added after line 15 page 3797 saying ... This paper (Esnaola) examines the meteorological forcing for the SST variability for the period ... analysed earlier ... insert refs 2002 and 2012.

3796 25 after oceanic area give ref for anticyclonic from direct current measurement (eg Deep-Sea Research 1993, vol 40 369-388)

3797 1 after wind-induced currents give Prog Oceanogr 1989 vol 23 303-338 ref otherwise it looks like everything was done by Koutsikopoulos and Le Cann in 1996.

3797 5 bay >Bay

3797 10 the poleward flow in the Bay of Biscay (called here IPC) and Navidad (this paper) was first measured by Pingree and Le Cann 1990

3797 24 but the wind stress causes the ocean density structure change, the balance is upset ( a weakened Gyre for example, see your fig 10). Also the local wind at a point does not produce the current at that point. So say how this 1/5 quantitative current value of IPC was scientifically derived or remove this sentence.

3798 23 the decay is derived analytically in Pingree and Le Cann 1990 and even more thoroughly in Cont Shelf Research 1999 19 929-975 (insert a ref with Peliz). This paper

C1640

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



also discusses SOMA, the seasonality response shown with ~year long measurements eg Pingree and Le Cann 1990. Give a ref for IPC seasonality off Portugal from current measurement.

3798 28 see also JMBAUK 1994 74 107-128 shows Navidad time series from 1967-1993.

3799 19-21 remove this sentence, not correct.

3800 5 satellite images of complete Navidad first shown in Pingree and Le Cann 1989?

3800 20 you are analysing the SST or Navidad not the IPC which is not the same if you examine lonterm records. Give or a ref for longterm IPC mooring showing that SST and IPC are completely in phase, what did the first IPC defining observations say about this?

3801 5 really it is atmospheric , the ocean conditions eg SLA are a response.

3803 18 spell out

3803 27 removing the daily climatology. Explain more fully with another esentence.

3807 16 worsen?

3808 14 westernmost? Give boxes I II III IV V for a location clue.

3810 8 mean climatology, add another sentence

3809 25 resemble well >match

3810 18 actually NE winds . This is expected as there is more Spanish than Portuguese slope in

boxed regions.

3810 27 1987 Jan (~12.5C in BoB) without a surface signature of Navidad (it is temp not current IPC) and other earlier years (compares well with your fig 7) shown plotted

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

in Fig 2 of JMBAUK 1994 94 107-128, see also 1990 (~14C), max of the 1967-1993 period plotted.

3811 4 remove yr

3811 14 see fig 5 caption date error

3812 9 on>of 3812 10 on>in 3812 13 in>near

3813 First para see comments on Table 2 below.

3813 15 1991 is measured ~15 month record! rig 129, weak (the in situ measurements exist) but comes mid Jan (see JMBAUK 1994), min Sept Oct (SO) and min again Mar April (MA). This is the **SOMA** signal also very evident for 1989 (rig 118), a strong Navidad. Does the IPC/Temp off Iberia show SOMA?

3813 15-25 rewrite. IPC/SST are not the same thing. A weak Navidad can have a strong signal SST at NW Spain ONLY; in a strong Navidad year the SST signal reaches 4W. So does a strong SST at NW Spain mean a weak IPC or a strong IPC? What is the definition for the IPC at NW Spain? When was the term first defined and used? Give reference. Where are the first current measurements in the BoB, see Title of manuscript. At line 16, January 1999, Give date for SST satellite image showing structure along the Spanish slope to say 4W, G-S&P (2012) say no marked SST along Spanish Slope. At line 19 does this mean Torres and Barton also confused SST development along the Cantabrian shelf with IPC SST only well marked off NW Spain? At line 22, noisiest, give standard deviation (Fig 7). Give mean standard deviation of other years. At line 24, it is more than a null value? What has gone wrong?, images for 12 Jan 2001, and 21 Dec 2000 show structure (Table 2, G-S&P, 2012). Remove offending sentence or rewrite.

3814 9 entering the BoB where it is called NAVIDAD.

3814 (line 11) to page 3815 (line 15) Esnaola reviews the interannual variability of the IPC described in previous studies but again the most recent work by GS-&P (2012)

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

with satellite and in situ observations up to 2010 is not mentioned. The authors should correct this. GS&P (2012) mentioned the following years of strong Navidad: 1979, 1982, 1984, 1988, 1989, 1990, 1996, 1998, 2001, 2003, 2007 and 2010 (January years). This makes the sentence at (page 3815 Lines 3-4) look very odd! Rewrite this section as others knew about these years, also check your Table 2 for consistency.

3814 26 IPC (=Navidad) not really correct as stated again, Navidad is temp and IPC is poleward current, the PC bit of IPC by definition.

3815 1988/1989 measured at rig 118, 9 month record, data show only strong events only in Nov/Dec and Jan/Feb at 7W.

3815 27 sentence starting AsTorres ... doesn't read quite

3816 11 Spanish coast

3817 2 nevertheless Area I is just warmer and saltier than Area V? so no too good as a source región? You would need a Lagrangian track for this conclusion based on profiles.

3817 10 I have put my comment below under Fig. 9. Conclusions should be based on direct measurements, I have given some refs. Alternatively give position and ref of a winter mode water with  $T \sim 11\text{C}$  and  $S \sim 35.6\text{psu}$  (ENAWp) in any subpolar region. What latitude do you consider subpolar?

3817 24 is this convincing? the broad 14C to 16C distribution is saltier in Area 1? Why would properties mix along the ENAWt –ENAWp line?

3819 Actual atmospheric pressure is not single valued wrt NAO etc or the same NAO can have different pressure distributions so correlations are never going to be perfect. Monthly NAO is variable and can miss situations between months or at 15 day intervals? In JMBAUK 2005 85 1301-1315 NAO was correlated with N Atlantic circulation based on large scale SLA gradients like the ones seen in your fig 10 and the results gave values as high as  $r \sim 0.8$  (for flow SLA difference between the subtropical and sub-

polar gyres (~a broad NA Current) lagging the NAO by as much as 6 months. So as is obvious NAO is going to correlate differently depending on spatial scale and temporal scale situations. We could use the daily met variables over the N Atlantic but then a lot of time series analysis.

3819 19 'complex' . . . change sentence to show that others already have some understanding of the situation, see above.

3819 20 daily? See above

3820 6 The subtraction means that you might have found the situation (-ve) for the occurrence of the P20, an upwelling situation perhaps. Also how linear is the system?

3820 16 Figure 10. I have put my comments under Fig.10 below.

3820 28 you have to give values/units for wind stress curl

3821 It seems to me that the pressure anomaly explains most of the SST.

3822 10 If you analyse the mean seasonal set up across the NW European margin you will find it is a maximum in Nov.

3822 15 Cape Penas . . . this is Aviles Canyon region and slope flow is disrupted as off Lisbon, Setubal and Lisbon Canyons. At Cap Breton and Cap Ferret it's the same? With the production of Swoddies.

3823 2 slope is given a unit 'rad'? These values are 10x smaller than annual means towards the slopes off Cape St Vincent. 2 year record here with 400 day slope current mean at 480m (Rig 149) shown in Pingree 2002 (fig 13). This record also shows continuous slope current overshoot with flow not able to make the corner of the promontory.

3823 5 their Fig 9?

3823 4 make clear whether this is about topographic beta or planetary coriolis variation. If the latter can we expect a balance? What about curl and Ekman up-

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

welling/downwelling?

3823 24 add? but the wind driven response in other areas may not necessary be the maximum responses for those regions

3824 29 show >shows

3825 5 in G-S&P 2012 page 200 1st para it states the 1996 (Jan) and 1998 (Nov 1997) comes in 2 SLA pulses . Also that the ocean response to a low pressure like your fig 10 takes much longer.

3825 15 you would need to firm up wind stress curl for this statement. As already mentioned the topography does it, Aviles Canyon etc. This should come before wind stress curl. Also loss off NW Spain, this is called Inertial Overshoot, see 1999 Continental Shelf Research 19 929-975.

3825 25 and slope current helped along locally with west wind or easterly stress component. The source then is not from Portugal.

3826 13 see comment already given at 3825 5 above

3826 18 1997/1998 found to be Nov in SLA see previous comment and at 3825 5

3826 22 the averaged IPC/SST shows SOMA (rigs 118 and rig 129) which says it 'starts' in SO (September/ October) and 'finishes' in MA (March April) this was done from 1988 to 1991. It's all a question of definitions of IPC, what did the early observations show?

3827 ENAWp? Sub Polar water is usually considered to be in area A of fig 1 of Pingree 2002 the otherside of the of the N Atlantic Current, ie the Sub Polar Gyre. You have already given a good name for your region of interest in 'Introduction', 'Intergyre'? Changes of temperature for the region will follow AMO well? The less saline water in Area III ~300-500m comes from the Bay of Biscay itself refs already given. The BoB water property hasn't changed changed significantly since Nov Dec 1967? See fig 1 of

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Deep-Sea Research 1969 vol 16 275-295 near sigma 27.1-27.2. This CTD profile at Sta Cavall (6534) central BoB is the first high resolution CTD (called STD then) profile in the NE Atlantic with values every m with resolution 0.001C and 0.002 psu.

3827 20 the time series is fine. The conclusion of this para wrt to salty water (ENAWt of ENAWp wrt to fresher comment above) is that the water is saltier equatorially (as opposed to poleward) pointing to an origin for a component of the IPC to the south, even south of Area I?

3827 24 this needs rewriting, ENAW definition line defines what? Give ref showing water actually mixes/ moves along this line. Say instead? That this water is colder than 12C (fig 9) and not in the Area I profile fig 8? Alternatively draw deeper water properties on a sigma theta surface and insert new diagram to show influence.

3828 2 Fig 10 is good, do you want to introduce doubt, with speculative explanation? Is it hard to understand what you are saying, quantify how much evaporation for a 200m water column. eg Area I, S~35.9psu, Area III, S~35.6psu~this requires ~2m of rain for this particular journey?

3828 11 500 hPa, the low pressure anomaly is still present at SLP which is where the wind stress is?

3828 19 complex may be but still a low pressure anomaly Index.

3828 but actually related to north component of wind stress to south off Portugal 1993 Deep-Sea Research II vol 40 369-388.

3828 29 advection of what?

3829 top sentence give a reference for such a statement. Or do you just mean that a cyclone has lower SST than an anticyclone near the centre?

3829 4 this is actually a tripole NS for the Ocean with warmer subpolar and subtropical regions? As is the Ocean NAO SST anomaly?

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



Interactive  
Comment

3829 6 steric sea level, point to it in the figures, I don't see it just SLA elevations along the Ocean Margin or Eastern Boundary Flow.

3829 10 how deep do you think the wind stress (Ekman) goes to feel the slope topography? Give values and units and associated errors for wind stress curl.

3829 13 unison? Remove this statement. The slope current is usually present there but also seasonal see many refs but in particular 1999 Continental Shelf Research 19 929-975 with ~500 day records from 3 different current meters off Goban Spur (promontory) showing seasonal repeat, and overshoot at rig 154. Clearly favourable wind stress with winds from say the SW are going to enhance the shallower slope current in the winter where the slope takes that orientation, eg Ireland to Shetland. Just as a west wind will enhance flow along the north coast of Spain and a SW wind will help both Portugal and Spain (as in your fig 10). These wind effects can all be done with a slightly different low pressure anomaly, a cyclone as shown in G-S&P 2012 fig 11 and strikingly in fig 12 with satellite images. Dec 1989 is just right for a bit of increased flow off Goban spur and in the Bay of Biscay, see fig 13 Pathfinder SST anomalies. Of course the depression won't stay still so effects have to be integrated. That's why the ocean needs a few months of winter NAO negative to get a significant subsequent response. Force magnitude and full response are generally not in phase. These authors (Garcia-Soto et al 2002 and Garcia-Soto and Pingree (2012) did not suggest unison but demonstrated using monthly thermal satellite observations that the poleward current can extend from Portugal to Scotland in particular years (see their figs for Jan 1990 and 1998) that patches of poleward SST can occur extensively with variable meteorological conditions with a large extent of development. Make this quite clear here and again in 'conclusions points 7 and 10'.

3830 1st sentence I don't think this makes sense rewrite or remove and sentence before . A force, wind stress say, gets a response, how long it takes depends on many factors even whether we are talking about SST (eg upwelling off Africa) or currents (the development of the Subtropical Gyre) , size of region considered etc.

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

3830 8 or just the geosophic adjustment without any heat flux

3830 20 give the grid scale for the SLA data and the separation of ascending and descending tracks somewhere off Portugal. Also state that the anomalies anomalies in the ocean result from eddies and could be removed with 5 deg averaging.

3831 5 The G-S& P 2012 response largely results from the NAO change between 1995 and 1996, or atmospheric pressure change, a low pressure anomaly develops. The Winter NAO change is shown in JMBAUK 2005 85 1301-1315, the largest positive to negative Winter Index change on record? Anyway figs 3 and 5 of that paper show the NA circulation (between the Sub polar and Subtropical) depicted as NAC Index lags the the driving wind stress by about half a year (look near 96, 1996).

CONCLUSIONS 3831-3832 very briefly here or in DISCUSSION

1. What is % variance accounted for by PCA?
2. To what depth can topographic beta be expected to work. Is this realistic (slope goes to >2000m and with stratification)?
3. Give the heating required to expand the surface (slope/shelf region) by say 4 cm. Is this realistic?
4. Give the fresh water transfer for considering salinity decrease from Area south to Area III. Does this just not stongly indicate vertical tranfer is not significant overall wrt to advection of properties?
5. Give a Slope Transport estimate in Sv (need only fig 11 and 8)
6. Give a reference for a buoy track coming on slope from say more than 14W, at 41N.
7. Say the winter –NAO and the EA+ do show a low pressure anomaly in the N Atlantic (it's in the definition for the Jan NAO dipole, which is north south, ) and that a low pressure centred somewhere between Iceland and the Azores will tend to have SW winds off Spain (and S winds off UK , see G-S&P 2012) as it passes? If the anomaly

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

is centred further south we could even get a north stress off Iberia (from a south wind). Would this pattern be better for making the IPC? It is interesting that a south wind still produces a shelf flow along the N Spanish Coast (Pingree and Le Cann 1993). That is because of Ekman transport and that flow can be caused by wind set up in other regions, a low in Area III in this case. Finally if we move the low even further south we get SE winds (north stress) off Iberia with a high SLP to the north. It may not happen very often and it is hardly surprising that NAO –ve cannot work too well as high pressure to the north becomes NAO + correlating with Navidad/IPC. But such events do happen and occurs in the 1988-1991 mooring data shown in JMBAUK 74 107-128. It also happens (S-SE winds) in the SST P80 time series?

8. Is there a positive SLP anomaly centre (fig 10) north of 65N, between here and the N Pole as in NAO? Or is the positive anomaly to the south as in EA? Or do you have both or none?

9. Is you SLA pattern much the same as NAO but displaced / intensified to the east and therefore more effective in the Bay of Biscay.

10. If this analysis was done elsewhere would we just get a concentration of isobars (with favourable direction) near the region of interest? Have we discovered wind stress is important in our region of interest or generally locally if considering a fixed point? The more the forcing is local the shorter time for adjustment. The adjustment time scale for currents on the shelf/shelf break is only a few days.

## Figures

Fig. 1 caption, Word, 200m depth also shown, depths should not be labelled with minus sign

Fig, 2 non-mising

Fig. 3 like >as

Fig. 4 1990 and 1996 do not show warm water coming on slope from region V. Im-

ages for January 1990 show poleward flow from much further south, south of Cape St Vincent even, so from the subtropical front region where there is a maximum dynamic height gradient ( $\sim 2 \times 10^{-7}$  rad, see for example fig 2 of JMBAUK 1999 79 769-792). 1987 and 2005 show temperature gradients in region V but no slope current? Comment? In 1990 and 1996 it's hot at/along the French coast, near Cap Breton, this is reconstructed, should we believe these coastal anomalies?

Fig. 5 caption says January of XII in fig. Could one say the anomaly is leaving the slope near region V rather than sourcing the Navidad?

Fig. 6 Longitudes 3 8 13 W incorrect; also Latitude 43N. Does not this figure suggest we might expect contributions to the slope current from regions south of V (centred  $\sim 41$ N)? Of course we don't expect the poleward current to be only on the slopes further south, shown by buoy tracks, eg fig 3 and fig 24 of JMBAUK 1997 77 573-624. The arrow from the slopes near Lisbon (fig 24) is based on 711 days at 200m on 2000m depth contour and slope flow from the south and meddies (can leave the slopes near Lisbon and Setubal Canyons 'restrictions' (see buoy and sub surface slope tracks in JMBAUK 75 235-252).

Fig. 7 caption remove 'analysis'? Year is better than Years for abscissa? Very fine figure. What about the grey bars in 2002 (Nov Dec 2001)? Red dots don't always appear to give the mean, 1989Feb? Say dashed positive and negative lines are . . . in caption. Certainly in good agreement with Garcia-Soto.

Fig. 8 Easier if temp scale at top and salinity scale below, since paper is more about SST. Should say what numbers are in () in fig caption and change salt to sal. Give error bars on profiles. Give stability profiles BVF (cycles per h, OK) for each area. BVF min (a tracer) is around 200-300m in Bay of Biscay ( $\sim 1$ cph) and BVF appears modified by slope current even at depth of min in these figures.

Fig.9 like in >as, profiles >station data (as just distribution of water properties). The ENAWp ENAWt line does not represent flow or mixing. ENAWp is not Subpolar Water

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

in Area III. Water with these properties (11C, ~35.6psu sigma 27.1-27.2) is formed just to the north in the Bay of Biscay in winter near the slopes at 48N. Deep mixing ~400 m here forms the BVF min. A deep drogued Argos buoy placed in this min moved south across the Bay of Biscay ( buoy 3907, it took 305 days to get to between Area II and III (Deep-Sea Research II 1993 vol 40 369-388, fig 8). Winter mixing is shown in fig 5 of Deep-Sea Research 1989 vol 36 735-758. This ~11C Water (see Area III) is not subpolar water just Biscay Water (could even be called Biscay Mode Water, see also Fig 1 of JMBAUK 1999 79 769-792). The BVF min at sigma ~27.2, ~300m depth is shown in fig 4. The ENAWt is not very helpful; at the limit shown here (this figure) ~36.3psu ~16C this is the Subtropical Front or near surface Azores Current and in the east this water can move poleward towards Cape St Vincent with SST winter (Feb/March) temperatures in the range ~14-17C.

Finding similar properties in Area V does not show only source unless you show an Area VI to the south (eg as seen in 1990 January images, figure 5 shown in Pingree and Le Cann, JMBAUK 1990) that does not have these properties. It would be expected that an Area VI would be somewhat warmer as SST falls along the slope current from Cape St Vincent to Cape Breton. SST to south (Area VI) would be warmer than March 14-17C, range given above in January. This can be firmed up with buoy / sub surface float tracks. Give firm reference for buoy/float coming in from 41N 14 W (Area V) to slope at 41N 9-10W. What is that H and dot on the subtropical subpolar line?

Fig.10 caption should have (a) b c d. Anyway top Z (a), more explanation must be given, give units for the numbers in this fig. Give -50 meaning. Say what -10m storm tracks mean. Next Surface (b), not possible to see what pressure has caused what wind/stress in white regions, change isobars to black here. Similar pressure distributions are given in Garcia-Soto and Pingree 2012 (Figure 11). The low centre is near the atmospheric cyclone centres shown in this same paper (Figure 12). Not clear why wind stress arrows missing in some regions, give also geostrophic wind based on isobars, this is linear and will do qualitatively where wind stress is missing. These will

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Interactive  
Comment

show SW winds off NW Spain as in Garcia-Soto and Pingree? Say why wind stress arrows are missing in the Bay of Biscay (lag 15-30). Wind STRESS anomaly is NE as in Garcia-Soto and Pingree (G-S&P). Of course you cannot compare the position of the lows in G-S&P with that here directly as that would be like comparing anomaly with the actual situation but the interpretation is much the same, namely a north component of stress (a SW wind gives a north component of wind stress) from the Subtropical Front/ Azores Current region to Ireland is the driver, with local variations depending on the slope orientation. Pingree 1993 Deep-Sea Research vol 40 369 -388 (Figure 11) shows the wind stress at 40N 10W and concludes seasonality of the slope current with max tendency change in December is responsible for the timing of the poleward flow on the Portuguese slopes (IPC) and Navidad follows in the Bay of Biscay, enhanced with the east component of wind stress (SW wind) here, see Pingree and Le Cann 1989 wind response. SLA (c) spell out SLA in caption. All the SLA values in the white region /ocean could be derived with say a running mean of 5deg (averaging as in JMBAUK 2012, 92 213-234). Say in text the OCEAN structure SST and SLA is a tripole for low atmospheric pressure anomaly. SLA v (d) SLA averaging of gridded data should be done to remove white bits? How convincing is this wind stress curl, AGAIN (see a) must give units for these number. Slope current does not appear to come from Area V, comment? Figure should be extended south to show where water south of 40N is coming from, an Area VI? In Pingree and Le Cann 1989, the modelled (from 40 N to 64 N, but only shown from 45N, their Fig 14) slope current did not significantly come on shelf in the Celtic Sea and English Channel, comment? ...but there is shelf flow with south and SW winds (see responses and (b) above), so wind and slope current not truly resolved which is why models are so important. These figures (a) (b) (c) (d) are important so it is worth taking a bit more trouble with them, making them larger at least. Suggest 2 figures.

Fig. 11 Similar to? Say in text the anomalies in other regions may not be representative of the most significant/sensitive anomalies (seasonal/interannual) found (known to occur) in other regions since the analysis here was for IPC region. How does -15-0

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Interactive  
Comment[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

compare with in principle (large scale) with temperature anomaly SST tripole resulting from Sea Level Pressure (low pressure anomaly, NAO -ve) described and shown in G-S& P (figure 7A)?

TABLE 2 needs a few entries/corrections

At line 5 page 3839 after Iberian Coasts insert 'or NW Spain'. Line 6, ZG not in Table. In the Table include this information. GS& P (2012) analyzed the poleward current off northern Spain from 1979 to 2010 (ieTime-evolution) using ERSST v3b. SST anomaly data (their figure 8). Also AVHRR Pathfinder data (monthly) presenting the important Jan 1990 SST anomalies from Portugal to Norway (figure 13), see comment at 3829 13. At Garcia-Soto, Pingree & Valdés (2002) indicate January monthly (their fig 3B, 1967-2000). Also Garcia-Soto (2004) 18/12/2002 Altimetry. Pingree and Le Cann 1989 Prog Oceanogr vol 23 303-338, Figure 17 shows Navidad around NW Spain and to Cap Breton Dec 83 and Jan 89. Pingree 1994 JMBAUK 74 107 -128, in situ measurements (hourly data, daily running mean) from 1988 to 1991 on moorings 118 and 129 on 1000m contour. Also time series of Navidad SST (January) from 1967 to 1993 together with mooring data (ringed), showing Navidad can penetrate to 210m depth with poleward flow (Rig 118) reaching 30cm/s in Dec 1988 and Jan 1989, broadly comparable with your figure 10 values. The mooring results described 'Navidad' evolution and events and showed the seasonal maximum temperature lags the alongslope current by almost a month (the temperature will persist as the current decays). These measurements were for the 1989 Navidad (see your figure 7 and Area II). Again your result fig 7 works fine with a month of 1989 daily data (January) from the NW Spanish slope. When was the term IPC first used? Give date in text (in Introduction). The Jan SST series also shows the cooling trend in 1970s and increasing temperatures from mid 1970s to 1993 as seen in AMO and Bay of Biscay SST (G-S&P 2012) so longterm changes in winter mixing temp are know, put ref and confirm or contrast near Perez and Pollard ref 3827 7.

Interactive comment on Ocean Sci. Discuss., 9, 3795, 2012.

C1653