Atlas of Antarctic Sea Ice Drift

Data Quality Check

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1. Overview

The Atlas of Ice Motion in the Antarctic combines ice drift data from two complementary measurement principles to get an overview of the variability of ice motion over the entire Southern Ocean.

Drifting buoy data has a good temporal resolution and position accuracies from 350m for ARGOS buoys to about 50m for GPS buoys, but does not cover all regions and temporal seasons in the southern ocean homogeneously.
In contrast, an overview of all time and regions ice motion can be gained from satellite data from polar-orbiting satellites, crossing the region of interest several times a day and so providing daily composite images. Various schemes and algorithms have been developed and tested to determine ice motion out of pairs of sequential radar or passive microwave radiometer images. *(see Kwok et al., 1990; Kwok et al., 1998; Maslanik et al., 1998; Liu and Cavalieri, 1998).*

In the Ice Motion Atlas, an advanced satellite product is used, called the **SSMI optimal interpolated** data (hereafter called simply OI data). This dataset derives ice motion out of an optimally analysed combination of results from the SSMI 37GHz and 85GHz passive microwave radiometer channels and combines it with buoy motion as/when geographically and temporally available in the following way:

$$\vec{u} = \sum_{i}^{85GHz} \alpha_i * u_i + \sum_{j}^{37GHz} \beta_j * u_j + \sum_{k}^{buoy} \gamma_k * u_k$$

The weighting coefficients alpha, beta and gamma are determined after C*olony and Thorndike (1984)*. Solutions for Alpha, beta and gamma are obtained at each point based on the uncertainties, the expected variance of the motion, and distance to available observations. The correlation lengthscale varies between 300km near the coast up to 800 km within the pack. *(Kwok, personal communications, 2003)*

Providing these two different kinds of data together in the Ice Motion Atlas database allows an extensive comparison, which will act as quality test for the OI motion data, looking at the buoys velocity as reference.

2. Comparisons for 1992

The broad collection of buoy data in the Ice Motion Atlas gives the possibility to treat buoys from different sea-ice regimes to investigate differences in seasonal bias and root-mean-square error (rms-error) of the satellite data. The uncertainty for these different conditions will be revealed and so the database can be added with a quality flag for different seasons and regions of OI satellite drift data.
Detailed studies on comparisons of satellite drift data with drifting buoy measurement *(Maslanik et al., 1998; Kwok et al., 1998; Geiger et al., 2000)* show, that it is not sufficient, to just compare a speed value at a certain buoys position and time to the nearest gridpoint on SSMI grid. So a method is used and tested for best temporal and spatial scales for a comparison.

As done in the above mentioned literature, velocity out of the OI data, which exist on a regular 100km spaced grid, will be interpolated to the buoys position via radial search. All grid values within a given search radius ***r*** around the actual buoy position will be distance-weighted and combined averaged into a single mean comparison value.
Studies in the Arctic for the SSMI 85 GHz data indicate the best results, i.e. smallest rms differences between buoy and satellite drift values for a search radius around 600km *(Geiger et al., 2000)*, which is in agreement with a lengthscale of ~1000km for the dominant wind forcing.
Satellite drift data used here was sampled every 1 or 2 days and buoy data is filtered with sliding means to get comparable values. So in the first step, it was investigated whether the optimal 600km search radius of the Arctic is applicable in the Southern ocean, or if there are some fundamental differences that require a different approach. The sampling timescales for the SSMI_OI data are 1day and 2day, and so the time averaging of buoys should be adapted to this sampling interval.
Furthermore, it should be concerned, that the OI data is already an interpolation product, and there maybe include some artefacts when performing the radial search, which will not be seen in simple 85GHz data.
To start, OI and 85GHz data is compared with different time averaged buoy data to find out the best combination. The comparisons are first done for the year 1992, where two buoy clusters, one close to the coast at the Antarctic peninsular and the other in the central Weddell gyre, allow also to look at regional effects.
In the coastal regions of the western Weddell Sea, more perennial ice is expected and the buoy motion is constrained with the ice being compressed against the coastal barrier. In the central region, there is predominantly seasonal ice with relatively free drift and divergent motion. *(Kottmeier and Sellman, 1996; Drinkwater, 1998; Drinkwater and Liu, 1999).*

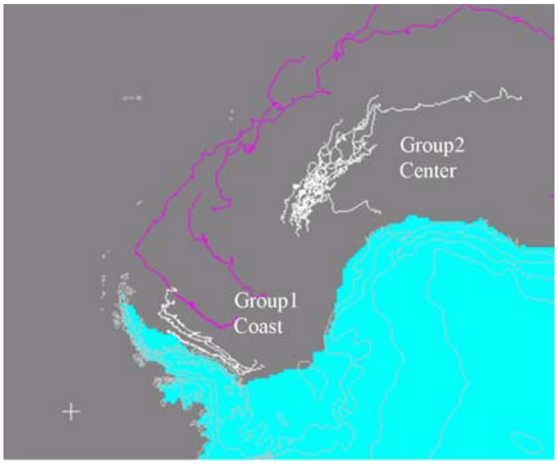

Fig.1 : *All available buoys 1992*

2.1 Data Sets and Preparation

All datasets are included in a Geographic Information System (GIS), which makes the overlaying of georeferenced data from different sources, as well as the calculation of combinated products, possible.

Satellite data (OI and non-OI Products)

Satellite drift data is available as optimal interpolated and not interpolated 85GHz values for the month March-November from 1979 to 1997 with a spatial resolution of 100 km. Drift calculated every second day is available from 1979 to 1997, while one day calculations exist only in the time after 1992 (since the 85GHz channel was only available more recently on SSM/I).
Because the Ice Motion Atlas is used to investigate long timeseries and statistics to detect interannual variability and change, the two-day data (further called 2d) are mainly used here. This avoids problems of non-uniformity and differences in data sets resulting from different channels, sampling intervals, and dataset duration. The choice of 2d drift also is due to the improved tracking accuracy of these products

Name conversion for satellite data:
1day: displacement vectors for dd to dd+1, every day
2day: displacement vectors for dd to dd+2, every second day

Buoy data

The basic buoy data is already preprocessed and error corrected and contains the 3 -12 hourly position, calculated drift and additional measured values, according to the buoy's equipment. To fit to the satellite data and other daily data, daily fixed means are calculated (from the daily fixed interval 00:00 – 24:00 hrs, centered on 12:00 hrs).
From the background, that the satellite 2day drift is computed by using the *day* to *day+2* displacement, it is useful to calculate 3-day sliding means for the buoy velocities, to be comparable to the satellite time interval (spanned by the satellite drift products), and such that tidal and inertial loops are filtered out of the buoy records.

Name conversion for buoy data:

b1: fixed 1 day mean, containing of all 8 values per day

```
d1d1d1d1d1d1d1d1 d2d2d2d2d2d2d2d2 d3d3d3d3d3d3d3d3 d4d4d4d4d4d4d4d4
|---mean d1---------|--------mean d2-------|--------mean d3------|--------mean d4----- |
```

b3: sliding mean over 3 days to filter high frequencies out and to match the time span of the satellite 2day data.

```
d1d1d1d1d1d1d1d1 d2d2d2d2d2d2d2d2 d3d3d3d3d3d3d3d3 d4d4d4d4d4d4d4d4
|-------------------------- mean d1 ---------------------------------|
                 |---------------------------- mean d2 ---------------------------------|
```

2.2 Interpolation and RMS Calculation

For each day and buoy, the nearest gridded satellite drift vectors are interpolated to a specific buoy location within a fixed search radius using a weighted distance method.

Search radii vary between 600/800 km (from literature) to 200 km (the range which comes close to the GIS borders of calculating gridded fields out of the 12 nearest neighbours).

For each day and buoy the velocity difference between satellite and buoy for different dataset combinations is calculated. To get an overview of how different conditions (season/regions) influence the magnitude of the rms error, separate regional investigations are performed.

Name conversion for seasons:

Seasons: (there are only three because of the availability of SSMI products)
A (March, April, May)
B (June, July, August)
C (September, October, November)

Name conversion for regions:

Regions: (to investigate different sea ice regimes)
Coast   (close to the Antarctic peninsula) → Group1
Center (Central Weddell Sea) → Group2
All   (all buoy data of the year) → Group1 + Group2 + Others

2.3 Comparison scheme

For the radius range between 200 and 600 km, rms differences are calculated out of the dataset-combinations. The satellite-buoy data combinations and output file naming convention is as below:

2day SSMI_OI data + b1 buoy data → OI2_b1_…
2day SSMI_OI data + b3 buoy data → OI2_b3_…
2day SSMI_85V data + b1 buoy data → 85V2_b1_…
2day SSMI_85V data + b3 buoy data → 85V2_b3_…

For the OI2 – b3 combination, the search radius was increased up to 1000 km to see if any changes appear beyond the standard search radius value.

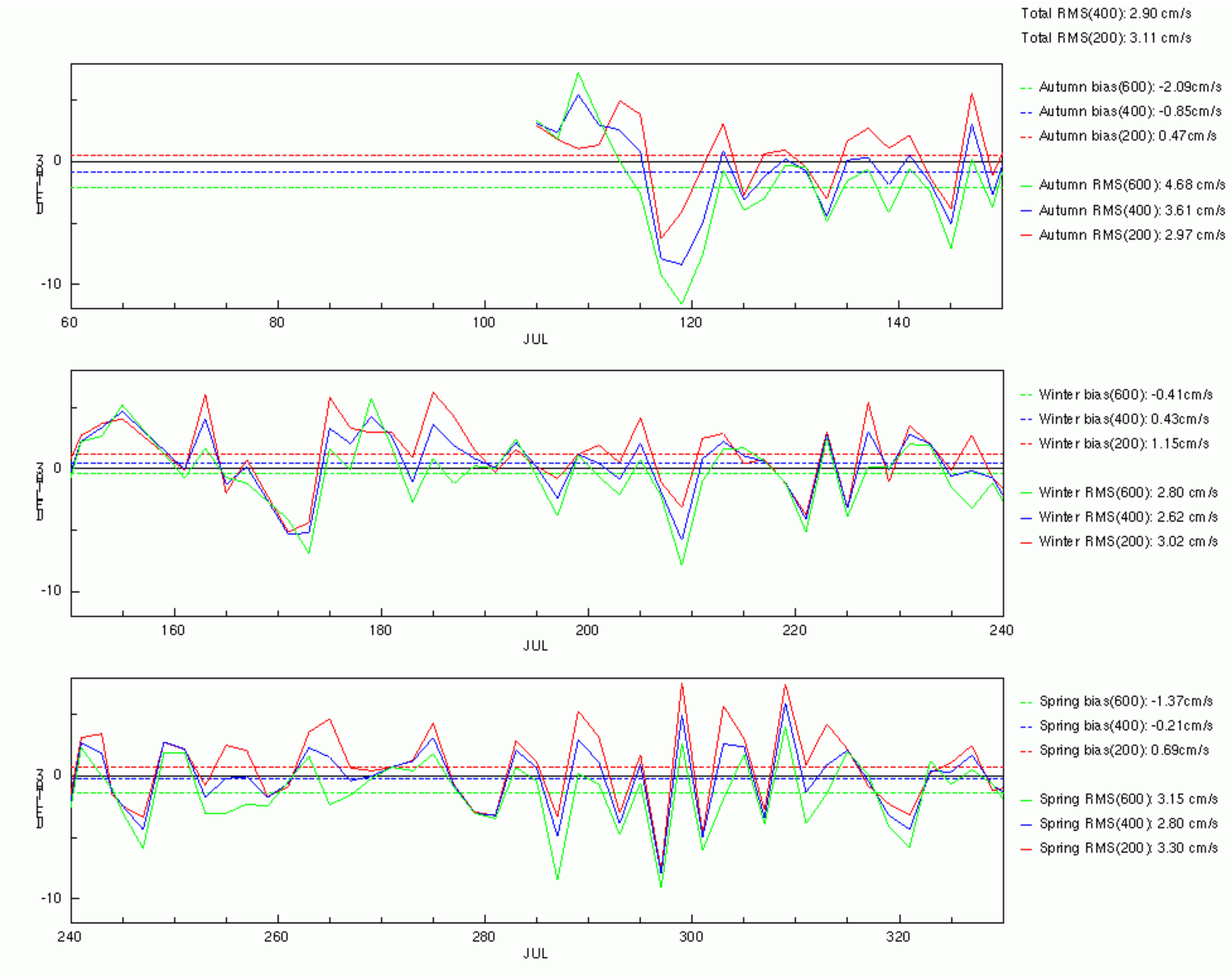

Fig.:2 *Example for 1992 comparison of rms error and bias (in cm/s) for different buoy groups at each day of year*

2.4 Comparison results for 1992

In all cases, the error magnitude gets its lowest values (red and pink marked) for the combination.OI2_b3, which implies that the OI-data describe the motion field better than the non-interpolated data, and that the 3-d moving window averaging method for sampling the buoy data minimizes the rms difference between satellite and buoy drift, and is judged better than the comparison performed using 1day buoy means. This result is consistent with some of the findings of *Geiger and Drinkwater (2001).*

	All oi_b1	**All oi_b3**	**All 85_b1**	**All 85_b3**		**Coast oi_b1**	**Coast oi_b3**	**Coast 85_b1**	**Coast 85_b3**		**Center oi_b1**	**Center oi_b3**	**Center 85_b1**	**Center 85_b3**
R1000		3.42		3.86			4.29		4.43			5.31		6.58
R800		3.26		3.75			4.43		4.59			4.81		6.43
R600	4.83	2.49	5.18	3.75		4.45	4.22	4.60	4.77		9.46	3.19	10.59	6.37
R400	4.45	2.54	4.95	3.99		4.31	4.13	4.70	4.97		8.88	2.93	9.93	6.60
R200	4.16	2.60	4.94	4.42		3.94	3.66	4.97	5.28		8.42	3.40	9.53	7.06
R1000		2.94		3.09			3.89		3.83					
R800a		2.93		2.96			3.98		3.74					
R600a	3.59	2.32	3.60	2.91		4.61	3.83	4.35	3.77		-	-	-	-
R400a	3.50	2.32	3.53	2.95		4.52	3.81	4.30	3.86		-	-	-	-
R200a	3.32	2.38	3.62	3.24		4.32	3.73	4.47	4.27		-	-	-	-
R1000		3.19		3.60			4.45		4.33			4.97		6.12
R800b		3.19		3.62			4.50		4.40			4.43		6.18
R600b	3.99	2.86	4.47	3.70		4.60	4.78	4.41	4.53		7.95	2.82	9.03	6.17
R400b	3.70	2.86	4.31	3.82		4.40	4.75	4.48	4.63		7.45	**2.39**	8.62	6.10
R200b	3.36	2.58	4.21	3.85		3.80	3.96	4.44	4.49		7.21	2.62	8.47	5.95
R1000		4.02		4.71			4.46		4.72			5.55		6.83
R800c		3.66		4.49			4.66		5.39			5.05		6.59
R600c	6.42	**2.31**	6.88	4.46		4.21	4.15	5.04	5.76		10.51	3.43	11.46	6.52
R400c	5.79	2.47	6.48	4.89		4.09	4.10	5.29	6.11		9.63	3.23	10.66	6.90
R200c	5.45	2.88	6.41	5.64		3.76	**3.60**	5.81	6.58		3.70	5.50	10.09	7.59

Tab.1: *Rms difference in cm/s for the different data combinations as declared above*

Total Minima

Total minima for the region in different seasons

Radius dependant minima for each datasets combination

2.4.1 On the search radius

For the investigated data it is in most cases of the 85V2/b3 comparisons, that the best results (i.e. minimum rms differences) occur at a search radius of 600 km, with typically a fairly continuous decrease in rms difference between 200 and 600km. Further examinations with increasing the radius up to 800 and 1000 km show the reverse with an increase once more of the rms difference. Consequently, the search radius was set at 600 km. In the OI data, the minimum in rms difference shows the r600 minimum only when looking at the total dataset, but the way the minima differ between the different search ranges is quite smaller than in the non-OI case.

In the coastal region, the minimum for the OI date is clearly found at the smallest search radius of 200km, with a slight decrease in rms error again for search radius going beyond 800km. In contrast to this, for the same region but not interpolated data, the minimum is still decreasing with increasing the radius.

Apparently the smaller search radius for optimal interpolation, which was used in the vicinity of the coast, affects the consistency between buoy and satellite data to be best at the r200 comparisons. In the central Weddell region, longer correlations scales were used for optimal interpolation, so smallest error values here occur at 400 km. However, long correlation length scales can be found due to stress transfer, and so it is probably because the correlation length scale in certain configurations is larger.

Despite this regional effect, the error values show, that for non-interpolated data, an optimal search radius of around 600km, (as was used in the Arctic studies by Geiger et al. 2001) can also be used in the Antarctic region.
Interpolated data show quite smaller rms differences than not interpolated ones, but the effect of dependence on the search radius is superposed by the effect of the interpolation radius which was used to calculate the OI data.

2.4.2 On the temporal windowing for buoy data

As described above (in section 2.4), the best temporal window for comparing the buoy data with the satellite 2d ice drift velocity data seems to be the 3day sliding means. In most of the cases, the rms-errors decreases considerably.

In the central Weddell region, the improvement is the strongest, because the higher frequency variations in buoy drift data caused by tidal and inertial oscillations is removed by this smoothing.

In coastal regions, it is not so obvious what the best method of comparison should be because the buoy movement there is always constricted as a result of compact ice conditions, and exhibits lower high frequency variance. So here in the limited cases that are considered, there is a chance that the rms difference becomes larger as a consequence of buoy smoothing, particularly during the winter months.

2.4.3 On the different regions

In general, rms differences in the coastal area are larger than in other locations, and data from this region seems not to show a clear dependences on averaging interval, search radius or temporal season, like the other data does. Measuring in the region of perennial ice, the buoy data appears less influenced by the seasonal cycles.

One effect which is evident is that, for the OI data and 3day smoother buoy comparison, the error is always the smallest when data within a 200km search radius were compared. The ice motion here is limited with ice being compressed and ridged near the coast. So in this areas, the correlation length scales even become smaller, which would explain the best values from the nearest positions around. An other effect already mentioned is for OI and 85GHz, the error continues to decrease with bigger search radius. For buoys positioned near the Antarctic peninsular, a big search radius could even include data from the western side. The errors for the data from the central Weddell Sea show a similar behaviour like the data of the complete set , but with the r400 error to be the smallest for OI data.

2.4.4 On the different seasons

With the satellite motion products only available for the months 3 – 11 (Mar – Nov), seasonal rms and bias were computed for the seasons autumn (months 3,4,5) winter (months 6,7,8) and spring (months 9,10,11) .

For the total area as well as for the coastal one, the OI rms differences generally reached their smallest values in the spring period, when the ice melts. Here, the smallest error for all comparisons was reached..

For the examination period 1992 there was no autumn data in the central Weddell region but for the next two periods it is to see, rms differences is smaller for winter season and get real bigger amounts in spring, where the melting onsets, which has more effect in this region than in the coastal one.

2.4.5 On the bias

Determining the OI2_b3 data combination as overall best for comparisons, the seasonal bias for these data was examinated.

	All	**Coast**	**Center**
Season A (Mar-May)	1.26	2.86	-2.09
Season B (Jun-Aug)	1.61	4.65	-0.41
Season C (Sep-Nov)	-0.05	4.55	-1.37

Tab.2: *Seasonal bias in cm/s for r600 interpolation on OI2_b3 data combination*

The differences are always calculated by subtracting the buoy velocity from the satellite value *(Vs – Vb)*, and so positive bias values mean the satellite velocity is greater than that of the buoys, while negative values show the satellite data to underestimate the buoy drift.

Values have a large seasonal and regional range, and it is difficult to make some clear conclusions from that.

Coastal regions always have positive bias which means the drift to be overestimated by the satellites. This is shown for the total area ,too.
In the central Weddell region, all seasons negative bias indicates that drift is underestimated by satellite data. A clear seasonal dependancy is not easy to see from this, and further investigations with more buoy comparison sets seem to be necessary.

2.5. Results of 1992 Comparisons

To give a quality comment on the OI data out of this examination, then a rms-error of **2.49 cm/s** would be provided for the complete area and the year, when looked at with the 600km search radius
For seasonal distinctions, we can guess an error of **2.32 cm/s** for autumn, **2.58 cm/s** for winter and **2.31 cm/s** for spring.
For coastal regions, with better comparisons at 200km search radius an all-year error of about **3.66 cm/s** is calculated. Seasonal values range from **3.73cm/s** (autumn), **3.96 cm/s** (winter) to **3.60 cm/s** spring
The central Weddell region shows an r600 average rms of **3.19 cm/s**, with **2.82** cm/s winter values and **3.42 cm/s** spring values.

3. Examination Extension

Examinations like this are carried out for the whole dataset with a 600km search radius (r600) to see if the rms differences are comparable. This exercise must also take into account the coastal areas, in which it was observed that the rms differences are smaller by using a smaller interpolation radius. According to the availability of buoys, 9 different examination areas from different ice or circulation regimes were defined . Values for the year 1992 could slightly differ from above, because now, all buoys of the year, and not only the selected groups were involved.

3.1 Investigation Areas

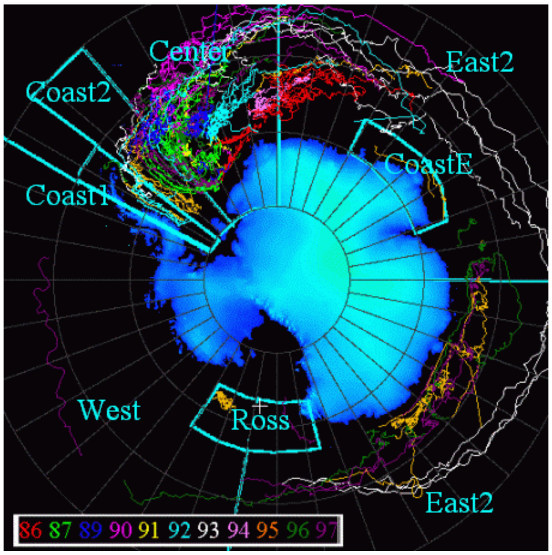

Fig.2: *Different examination areas, according to buoy position and tracks*

Coast1:	lon = 295 – 305 °E	lat = 80 – 50 °S
Coast2:	lon = 305 – 320 °E	lat = 80 – 50 °S
Center:	lon = 320 – 360 °E	lat = 80 – 50 °S
East1:	lon = 0 – 90 °E	lat = 65 – 60 °S
Ecoast:	lon = 30 – 70 °E	lat = 70 – 65 °S
East2:	lon = 90 – 190 °E	lat = 67 – 60 °S
Ross:	lon = 160 – 210 °E	lat = 80 – 67 °S
West:	lon = 190 – 295 °E	lat = 80 – 67 °S
East1out:	lon = 0 – 90 °E	lat = 60 – 50 °S
East2out:	lon = 90 – 190 °E	lat = 60 – 50 °S
Westout:	lon = 190 – 295 °E	lat = 67 – 50 °S

3.2 Comparison results 1985 – 1997

Looking at the total rms differences and bias for all the seasons and regions, the first thing to recognize is that the 1992 data, which were investigated in more detail, are among the ones with the best error fits and smallest bias.

Similar small values appear for the years 1991 and 1995/1996. These are years with a good number of buoy deployments, and so it is reasonable that the OI drift, involving this data, is quite close to reality.

Further extreme large rms differences appear in 1985, the autumn 1989, winter and spring 1990 and autumn and winter in 1993. Most of them show large negative bias, too. This error comes from certain days with sudden high buoy velocity, even in the 3day averaged data during which time the ice drift velocity is significantly underestimated by satellites.

It should be checked out as to whether this data is not included in the optimal interpolation, since the number of buoys concerned when calculating the OI data differed from the current version of the IPAB buoy database used for the Sea Ice Motion Atlas.

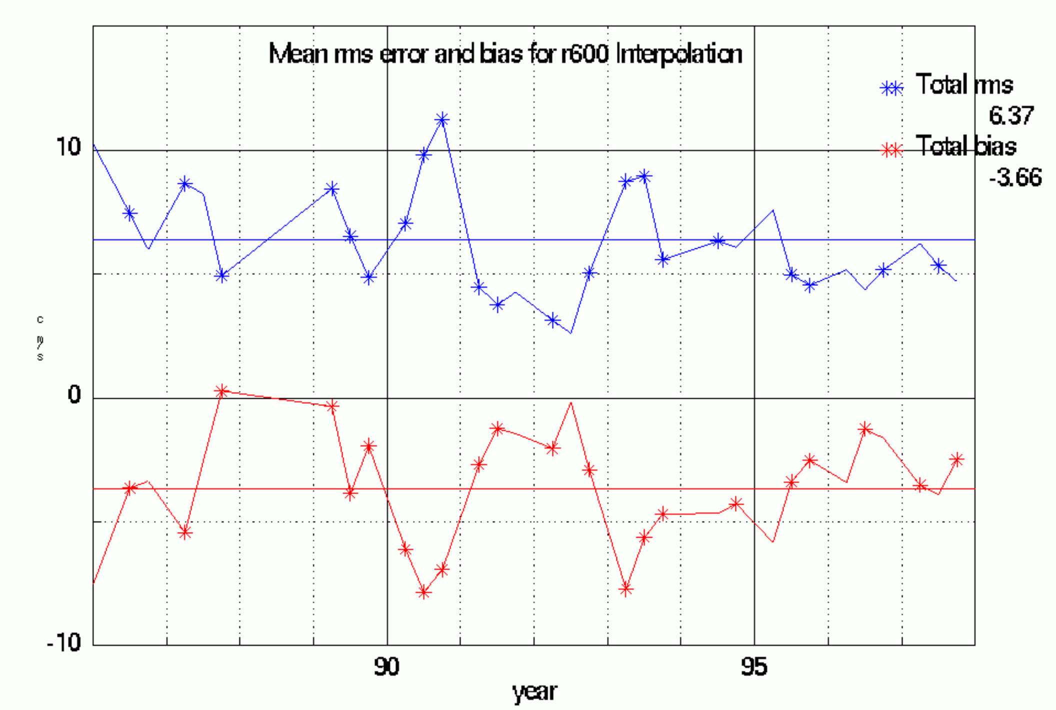

Fig.4: *All seasons and regions RMS error and bias*

When we include these strongly varying values from problematic seasons, the total mean RMS error becomes relatively higher at **6.37 cm/s**. The total mean bias is **-3.66 cm/s**, indicating on average an underestimation of true drift values in the examination period.

After checking out the error peak values with the corresponding buoy data and detecting these one-day velocity peaks these data were filtered out, to get a better view on the usual error distribution.

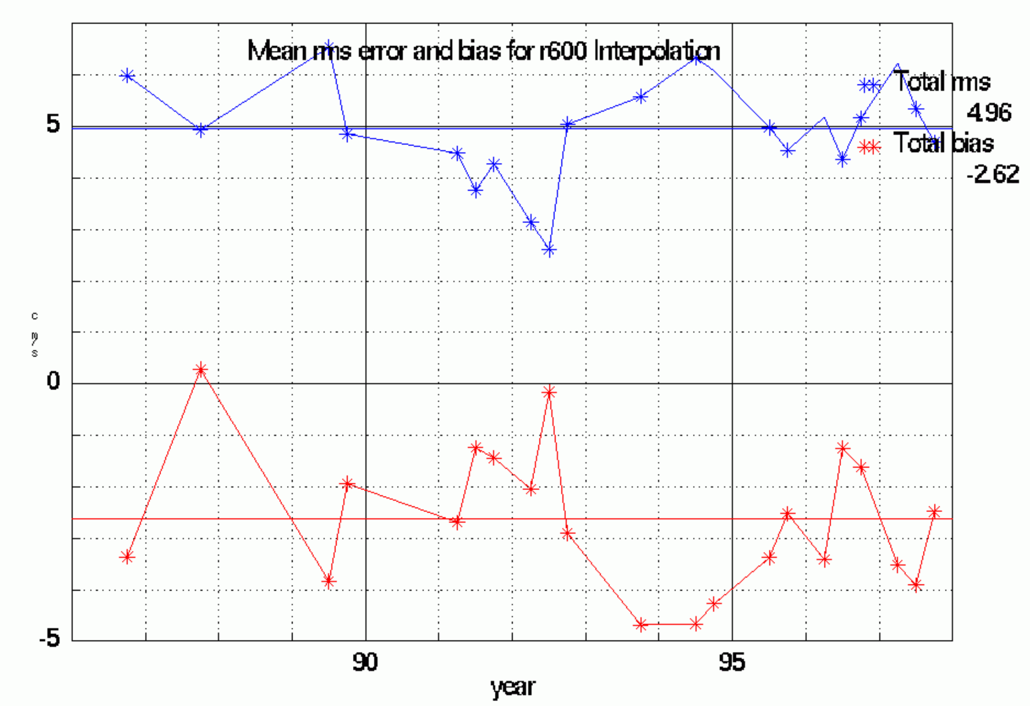

Fig.5: All seasons and regions RMS error and bias, spike corrected

With neglecting the above mentioned problem areas/seasons, the total mean RMS error reduces to **4.96 cm/s**, with a mean bias of **–2.62 cm/s**. This means, the tendency of underestimation is still there.

3.3 Comparisons between different regions

To examine the seasonally varying rms-error and bias in more detail, the same values were calculated for the different investigation areas, mentioned in 3.1

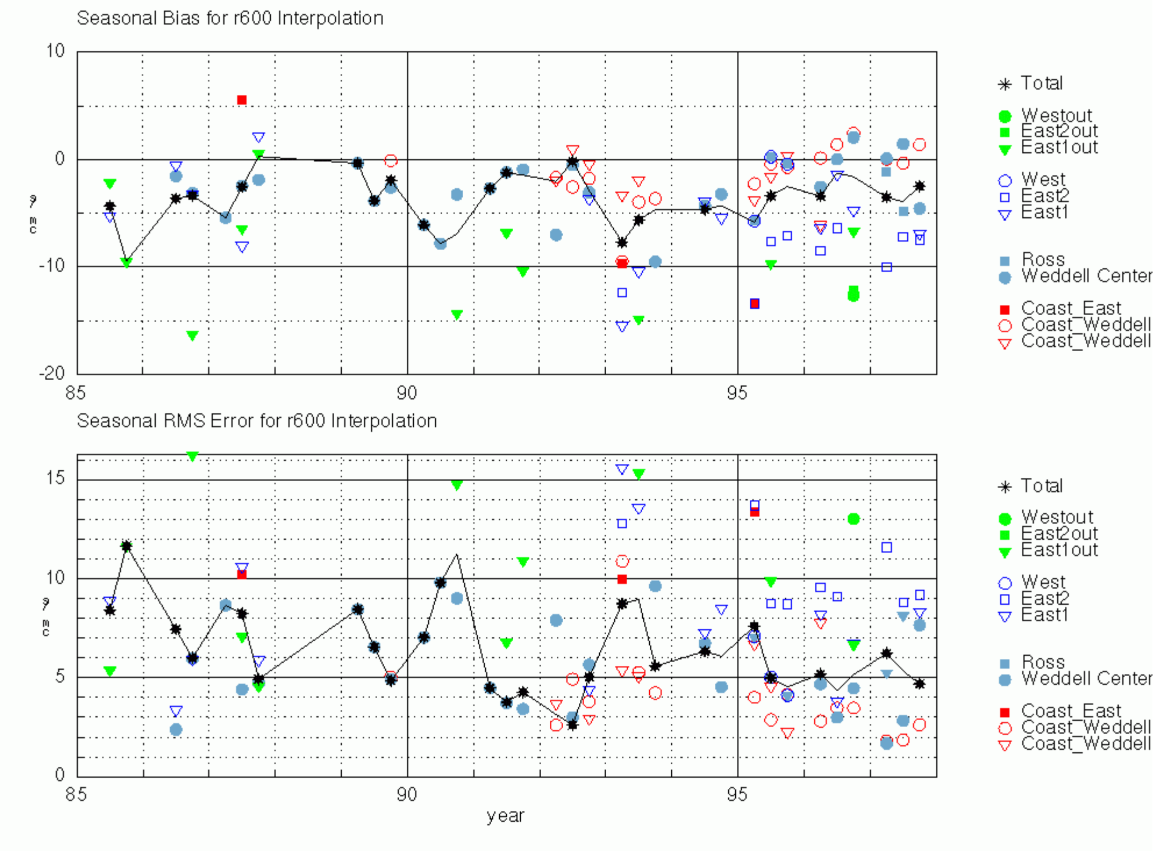

Fig.6: *All regions rms and bias (as black stars) and the seasonal division by regions (red= coastal regions, light blue = central Weddell and Ross Sea, blue=other regions, green=regions like blue but north of 60°S)*

3.3.1 General findings

Looking closer at the singular values shows, that big peaks are often caused by single events lasting a few days and so does not imply the dataset for the whole time is so wrong. The coastal buoys (red) show in most of these cases a similar behaviour and a bias close to zero or positive. This appears not for the coastal buoys which are not in the Weddell Sea but located at the coast of East Antarctica. This result here stands in accordance to findings from *Heil and Allison (1999)* who made comparisons for east Antarctic buoys.

Ross Sea data (light blue sqares) seems not to differ much from the central Weddell data. The largest rms differences occur for the regions where buoys are already entrained within the motion of the ACC (close to the ice margin). This is to see in the behaviour of all green symbols. They show consistent negative bias (perhaps explained from the satellite orbits processing in the other direction, resulting in poorer sampling or smearing of the motion due to the composite image formation). Large rms differences with positive or near zero bias always come from coastal regions. Here, satellite products seem to overestimate the real drift velocities.

	Total rms	Autumn rms	Winter rms	Spring rms	Total bias	Autumn bias	Winter bias	Spring bias
coast1	3.633	4.545	3.550	2.605	-0.993	-2.590	-0.147	0.000
coast2	4.373	5.097	3.944	3.882	-0.900	-3.703	-0.812	-0.397
ecoast	10.085	9.970	10.200	99.000	-2.075	-9.720	5.570	99.000
center	6.295	6.365	4.697	5.998	-3.423	-3.578	-2.283	-3.011
ross	5.210	5.260	5.025	4.110	-1.340	-1.150	-1.725	-0.420
east1	8.200	11.380	8.063	6.645	-5.595	-11.295	-5.218	-3.612
east2	9.848	12.185	8.157	8.950	-8.393	-11.215	-6.537	-7.290
west	9.015	14.290	1.900	4.110	-6.015	-12.010	1.420	-0.420
east1out	10.705	99.000	8.882	10.812	-9.615	99.000	-7.976	-9.412
east2out	13.040	99.000	99.000	13.040	-12.220	99.000	99.000	-12.220
westout	13.225	15.130	9.130	13.020	-12.760	-14.730	-9.130	-12.650

Tab.3: *Summary of all seasons/regions rms and bias in cm/s*
99.00 indicates that no values could be calculated for that region

3.3.2 Detailed look at high error cases

<u>1986 Winter season</u>

In this season, we get a large rms error of about 10 cm/s with a strong negative bias of 6 cm/s, which means that at one time the satellite data significantly underestimate the buoy drift.

When looked for details in the buoy data, there is a strong peak of negative u-velocity (which means westward drift) for some days in august 1996, around day 229. This peak is evident in the data of three buoys.

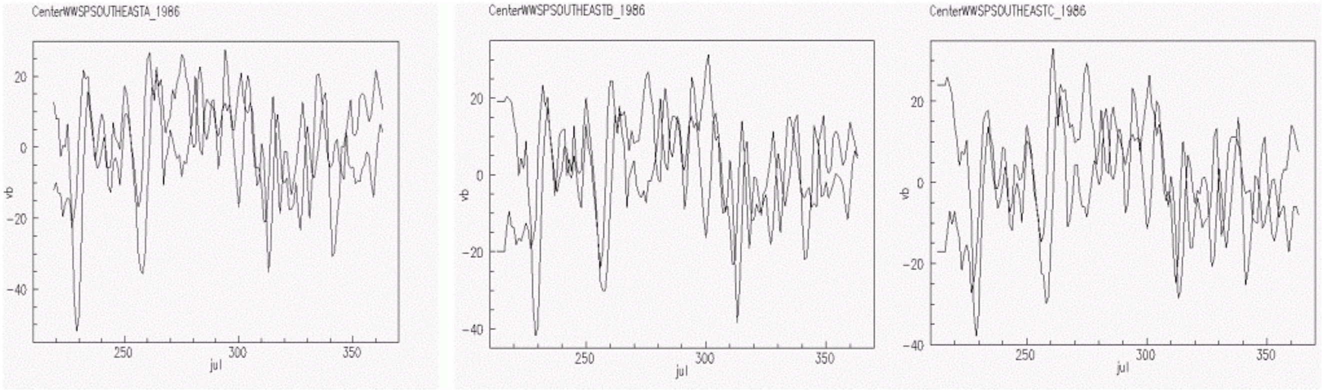

Fig.7: *Drift components u and v for buoys 3291, 3294 and 6574*

From the buoy data, it is possible to see that a short but strong westward drifting event happens at this time and location. To see, if this is evident in the satellite data, the overlay of the OI satellite drift vectors from the GIS is plotted below.

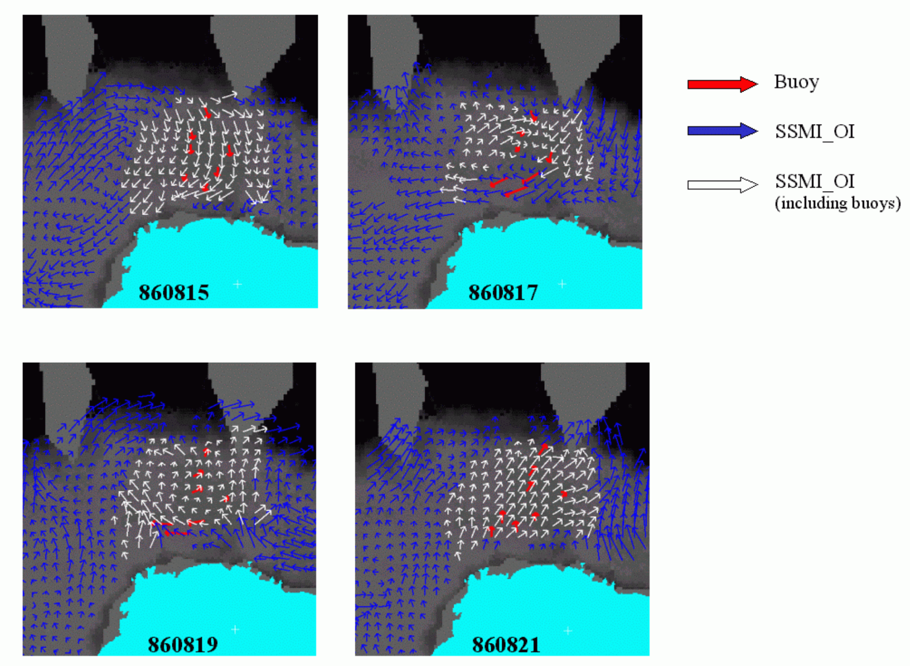

Fig.7: *Comparison of satellite and buoy drift vectors. Satellite data including buoy information in optimal interpolation are highlighted.*

On August 15, 1986 before the velocities grow there is a good fit between satellite and buoy motion. At this point in time the approaching cyclone is pushing ice towards the shore. On August 17 and 19, when the strong motion occurs, there is a large difference between the buoys and satellite vectors closest to the coast. It is possible also to see that for these two days, the optimally interpolated vectors were not calculated by integrating the buoy information, and for some reason the buoy data were filtered or rejected. This kind of example illustrates the discrepancies that can be found between the two datasets, and shows the great impact of buoy data for the quality of satellite products, Provided that the OI scheme can correctly take into account rapid adjustments in the buoy motion (particularly in near-shore regions such as this).

1989 Autumn season

During this year and season, there is a significant mean rms difference but nearly zero bias. Investigations of the plots of rms differences shows that there is a strong daily variation between negative and positive differences in satellite and buoy velocity. This is the reason, why rms error gets larger, while bias stays relatively low.

1990/1993 Central Weddell and Outer Regions

Large rms differences with negative bias originate from the central Weddell Sea marginal ice zone and the Weddell coast2 region for these two years.

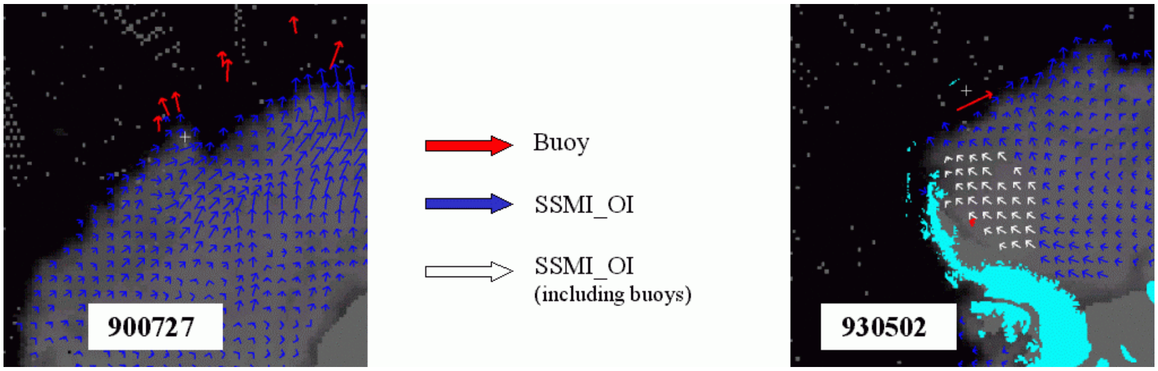

Fig.8: *Comparison of satellite and buoy drift vectors. Satellite data including buoy information in optimal interpolation are highlighted.*

In both cases, the buoy data is very close to the ice edge, in the year 1990, it is even not included in the satellite interpolation, perhaps as a consequence of a combination of rapid ice edge growth and northward ice margin advection. Since these buoy data are not flagged as outside the ice these cases go into the comparisons and make the error values larger. As is evident in the plot of 1993, particularly in the regions near the coast, there is good fit between the data and buoy drift.

Ice margin problems

Like in the previously examined case (above), the comparison always encounters problems (i.e. large rms differences) in cases where buoys are close to the ice edge. Though sometimes in ice, so that they are often not flagged as being outside of the comparison. In these cases, the method using a search radius large enough to capture these buoys produces large errors. The buoys of 1993, that nearly circumnavigated half of the Antarctic continent illustrate this problem very well.

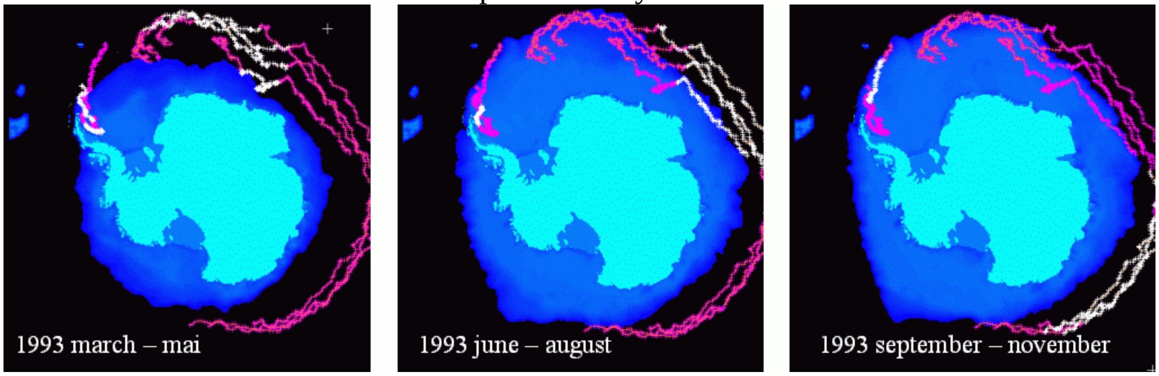

Fig9: *Track of 1993 buoys (red) and ice concentration for different seasons. The path of the buoys while these seasons is marked in white.*

4.Conclusions and summary

The main findings from this investigation were

- The optimal interpolated OI data show smaller errors than the 85 GHz data when compared to buoys
- A slighting mean for buoy data, adapted to the time interval of the satellite pictures is better for comparison of the two datasets
- Search radii around 600km like used in the Arctic are appropriate for the Antarctic too, except for coastal regions with more compressed, perannial ice.
- Coastal regions generally show smaller rms errors and a positive or close to zero bias. Values there are not so season dependant than from other regions.
- A general dependence from the different seasons is not clearly to see from the data. In most of the cases, except for the outer areas, there are decreasing errors and smaller negative bias in the spring seasons.
- The division of the investigation areas in the parts south and north of 60°S shows great differences of the values and even the strong negative bias for this regions near the ice margin zone and already influenced by the ACC.

This comparison clearly invalidates some former results, and indicates quite conclusively that where buoy data are exploited in the OI scheme, that the satellite products are extremely good representation of the spatio-temporal patterns in sea-ice drift. Furthermore, the optimal merging of satellite and IPAB data gives the opportunity to provide modellers with a dataset of practical value, accompanied by uncertainty estimates with regional and seasonally varying values.

Such comparisons clearly illustrate that the satellite buoy comparisons must be carefully made, such that the correct rms differences are found between the two datasets. Former comparisons have clearly encountered difficulties in this regard. Early point-to-point comparisons with buoys were rather crude, and under some circumstances give the impression that the satellite products are actually worse than they really are. This is a consequence of non-optimal schemes to compare the Lagrangian drift track data with an Eulerian gridded product. It should be even kept in mind, that the buoy data was smoothened to the satellites temporal resolution, and so much of the high frequency changes were not considered.

Furthermore, our results show that the method should carefully consider the seasonal and regional uncertainties/biases that result from variations in ice conditions, the length-scale and time-scale inherent to sea-ice variability

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