Lagrangian sampling of the Atlantic Water pathways in the Nordic Seas: Surface drifters and RAFOS floats

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Three-dimensional Lagrangian view of the NwAc system

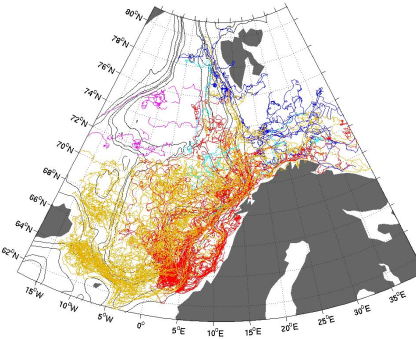
Surface drifters and rafos floats

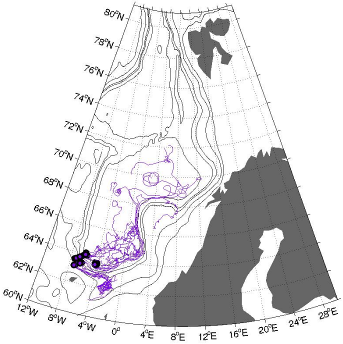
- 306 surface drifters (15m, SVP), satellite positioning, 1990-2009 Global Drifter Programme + POLEWARD=118
- 22 intermediate-depth, acoustic positioning, isobaric RAFOS floats (ca. 800m), 2004-2005 (PATHMIX, Søiland et. al. 2008)
- 23 subsurface RAFOS floats (ca. 200m, IFF, Rossby et. al. 2009) - not yet implemented

Analysis

- Lagrangian signal at different depths - compare the flow statistics: dispersion, travel times, speeds, topographic steering
- data-related problems and conceptual difficulties...

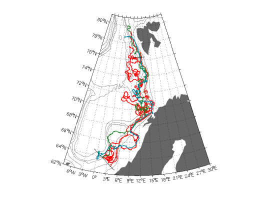
306 SVP (15m) + 22 RAFOS (800m)





3 challenging problems within Lagrangian analysis

1. limited data coverage
2. inherent flow inhomogeneities
3. non-stationarity

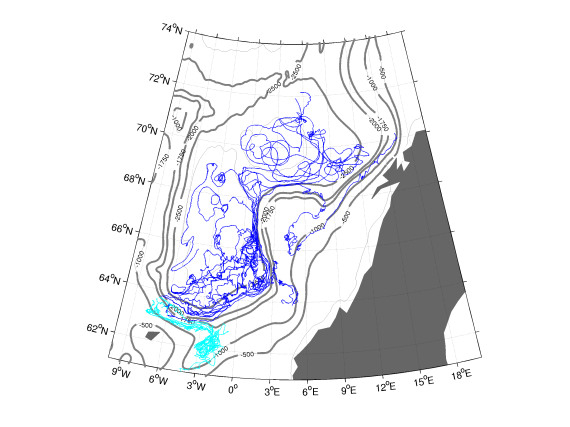


3 approaches within Lagrangian analysis of SVP/RAFOS

1. compare buoys passing through a location at any given time (nonstationarity, data paucity)
2. compare the statistics on buoy in certain regions (inhomogeneity)
3. bin (spatially-average) data over certain regions

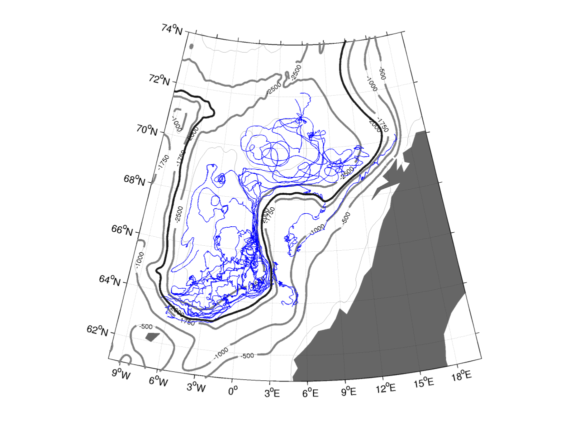
The story begins in the Iceland Faroe Ridge....

Søiland et. al. (2008) - fate determined by the topography:
Deep Group (13, deployed < -1750m) & Shallow Group (9, deployed > -1750m)



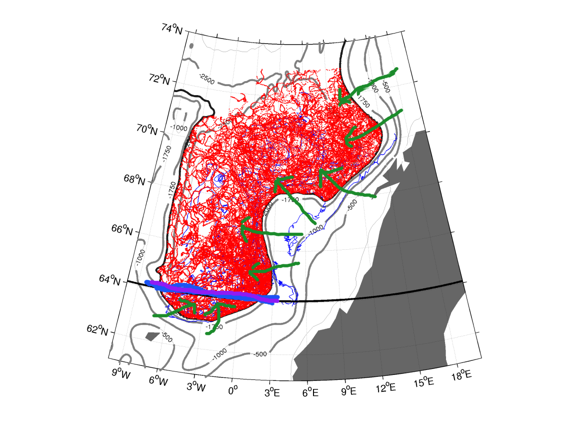
Deep Group extended: 13 Deep Group + 1 = 14.

Restrict area: NOR + LOF (2000m isobath)

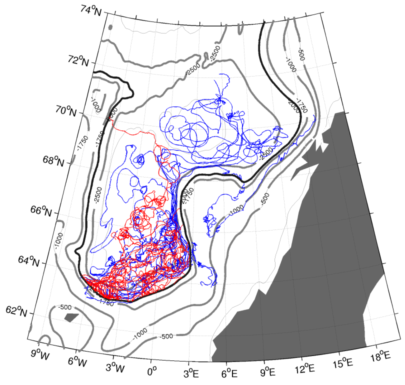


126 surface drifters - different enter site (NwAC-EB!) - not Lagrangian-comparable

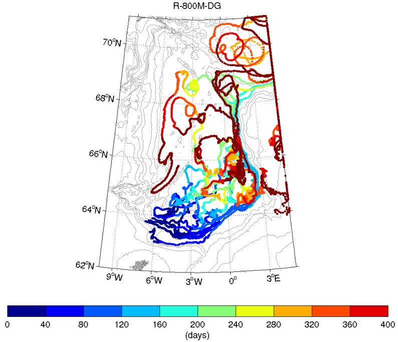
Restrict SVP entrance site: < 64N

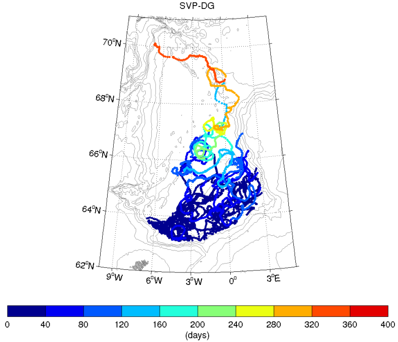


48 surface drifters & 14 rafos floats

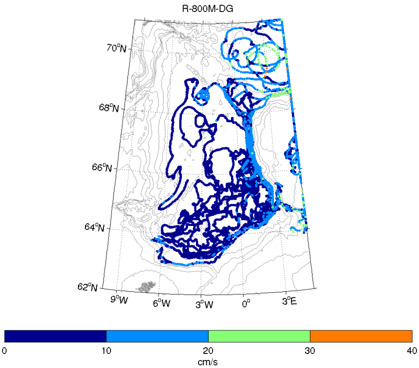


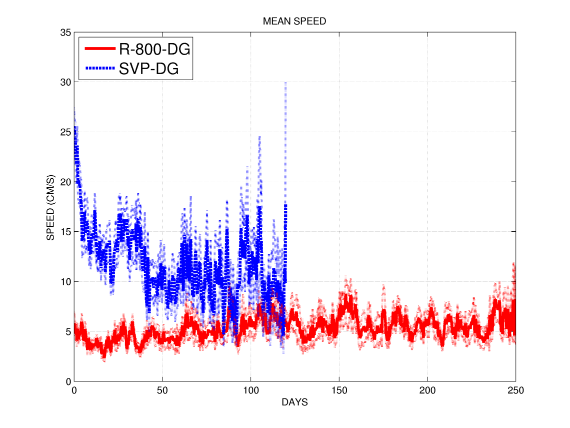
The Norwegian Basin: Pathways and time scales



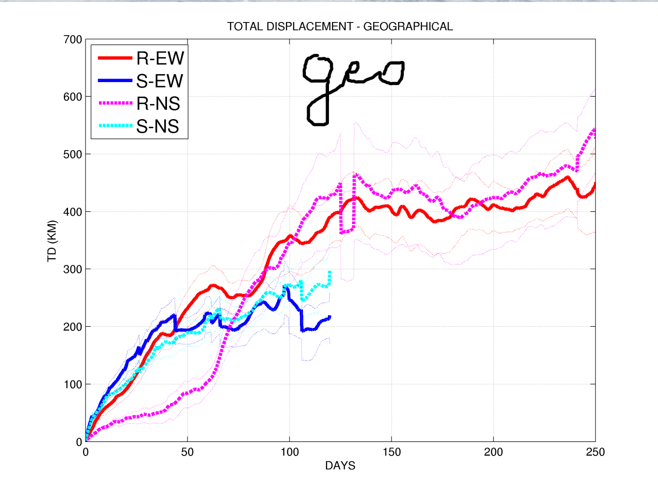


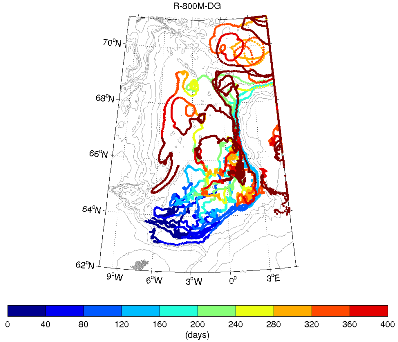
The Norwegian Basin: Speeds

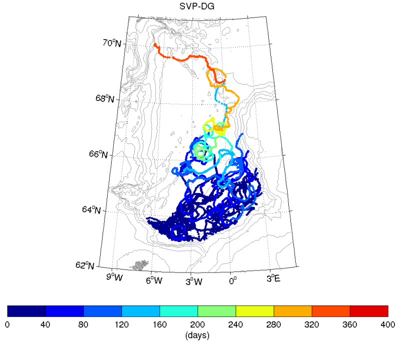



MEAN SPEED
R-800-DG
SVP-DG
SPEED (CM/S)
DAYS
0
5
10
15
20
25
30
35
0
50
100
150
200
250

The Norwegian Basin: Total displacement




R-800M-DG
70°N
68°N
66°N
64°N
62°N
9°W
6°W
3°W
0°
3°E
0
40
80
120
160
200
240
280
320
360
400
(days)


SVP-DG
70°N
68°N
66°N
64°N
62°N
9°W
6°W
3°W
0°
3°E
0
40
80
120
160
200
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f/H analysis

- Nordic Seas - weakly stratified
- barotropic potential vorticity $PV \approx f/H$ flows tend to conserve it
- contribution of f one order smaller
- principle: project the velocities on f/H contours

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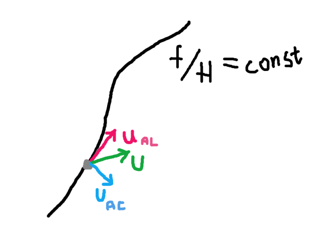

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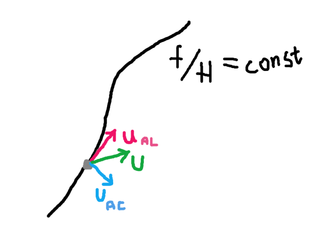
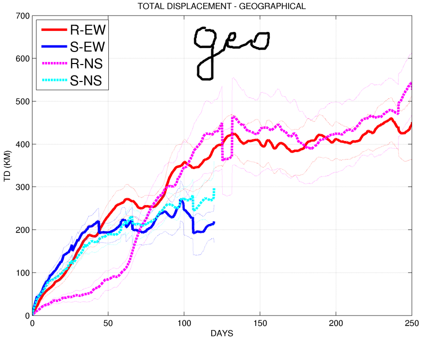
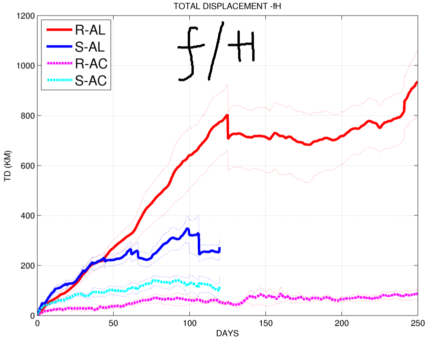


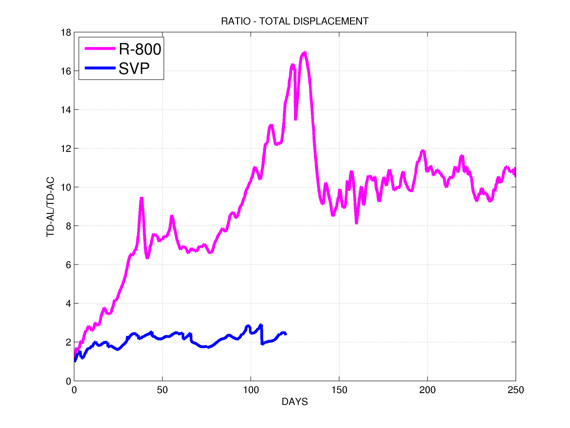
- integrate displacements
- scrutinize the anisotropy

The Norwegian Basin: Total displacement anisotropy





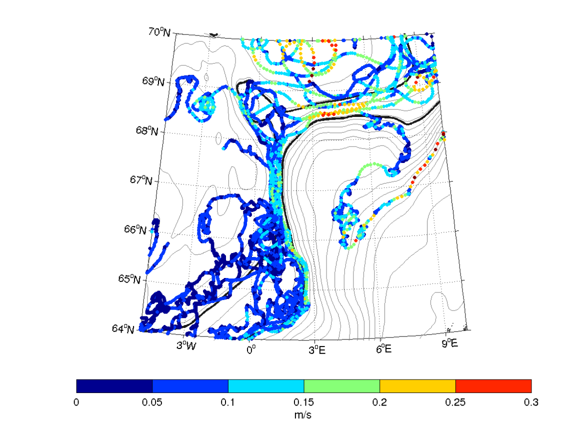
Degree of anisotropy - calculate the ratios



Unreliable statistics?
Idea: angle between the f/H-contours and drifter/float tracks

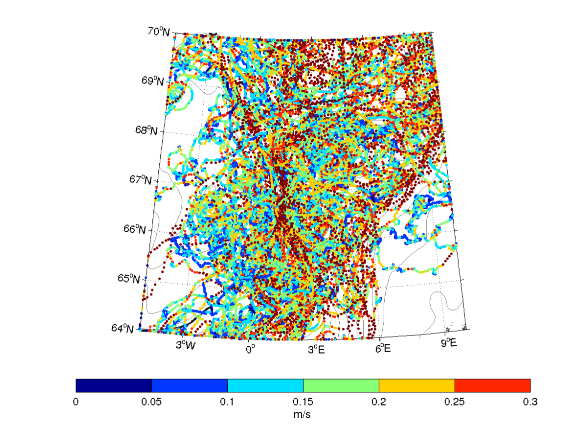
Rafos at VM (11)

Rafos: strong topographic steering at the Voring Margin (66-68 N, 0.2.5 E)
Søiland et. al. (2008)

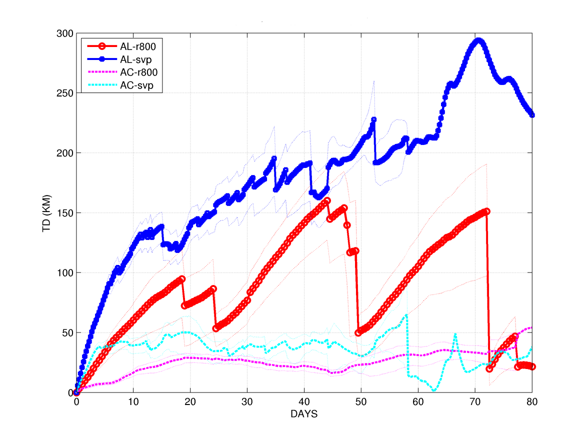


Surface drifters at VM

Steering av SVP: mentioned by Orvik and Niiler (2002)
All surface drifters recorded at the VM (58)



fH-anisotropy:



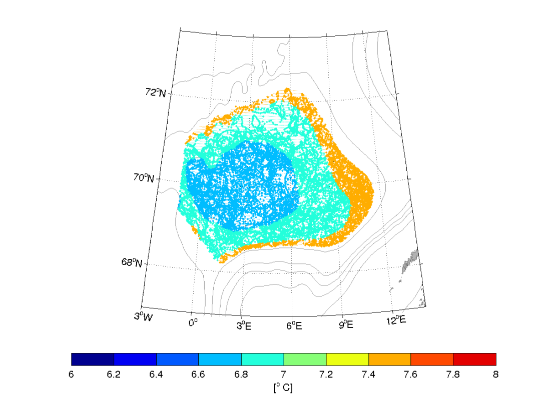
Ratio: 3.8 (rafos), 2.6 (surface drifters)

Transport at VM

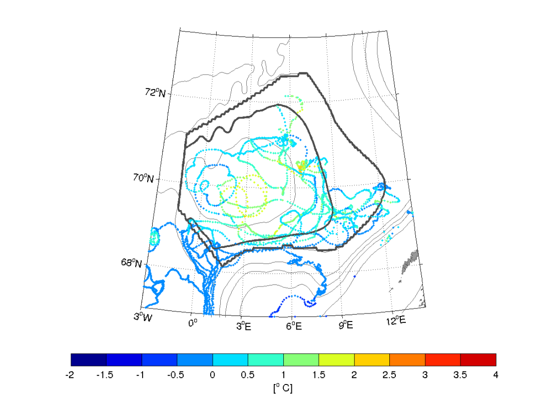
- Rafos, 500-2500m: z=2000m, $u \approx 0.1$ m/s x 30km –> 6 sv (Søiland et. al., 2008)
- more complicated for surface drifters (spread around the VM)
- mean speed ($\sqrt{u^2+v^2} \approx 0.25$ m/s) and mean along-fH speed (u_L)
- u_L constitutes ca. 90% $|u|$
- between 2200 and 2900 isobath (ca. 18km): (uv=3.6 + 1.4=5sv/uL=3.6 +0.9=4.5 sv)
- between 2000 and 3000 isobath (ca. 35km): (uv=6.3 + 2.3 = 8.6/uL=6.3 +1.75=8.1 sv)
- depends on smoothness of topography/distribution of data - needs more carefull calculations

Lofoten Basin - temperature signal

Surface signal - binned in f/H contours



Rafos signal at 800m



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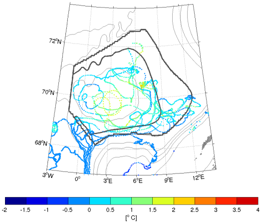
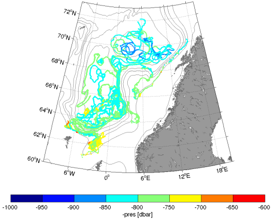
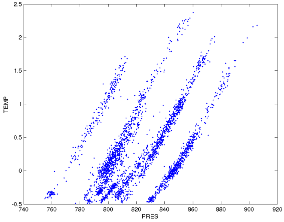






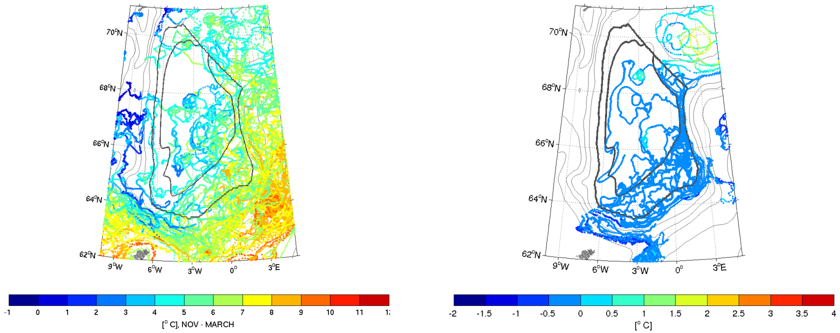
AW-layer deepening (Orvik, 2004) + MLD deepening in winter (Nilsen and Falck, 2006)

The role of eddies in cooling (lateral mixing)

Vertical mixing (deep eddies/MLD - Nilsen and Falck, 2006)

The Norwegian Basin

Binning of temperature in fH-contours does not work in the Norwegian Basin the Arctic Front!



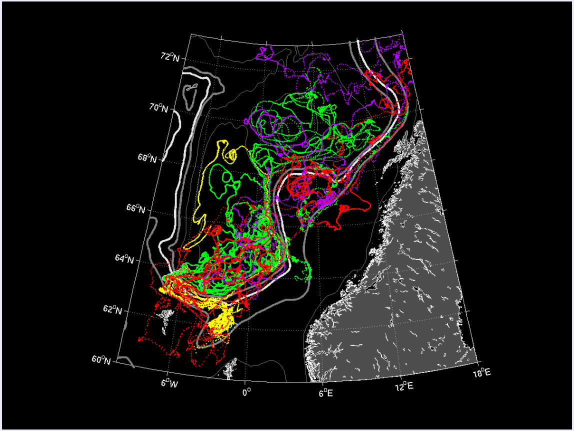
The role of eddies!

Initial conclusions

- SVP + RAFOS data sets offer a powerfull possibility to obtain a 3d-Lagrangian view of the circulation in the NS
- First attempt to quantify the evident topographic steering in the NwAC WB-EB-NCC system has been made made (displacement anisotropy, binning of temperature signal in f/H-contours)
- The topographic steering in the SE Norwegian Basin appears stronger at depths than at the surface
- Strong topographic control at the VM at all depths (barotropic flow) - high transports?
- Further evidence on AW deepening in the Lofoten Basin, horizontal eddy mixing and vertical mixing (to be explored in more detail..)
- a reliable statistics to assess the differences is still to be found (work in progress)
- try to integrate the RAFOS data from 200m depth into the analysis

RAFOS: DG (13, deployed < -1750m) & SG (9, deployed > -1750m)

SVP "deployed" $dr = (+/-0.02^o)$: "DG" (12) & SG (4)



Idea: increase *dr*, check destinations.