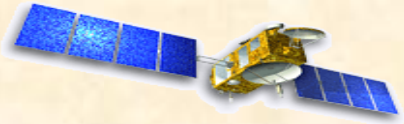

Spatiotemporal variability in ocean circulation observed by altimetry on the northwest Atlantic shelf and the Gulf of Maine

H. Feng[1] and D. Vandemark[1]

[1]Ocean Process Analysis Lab ,University of New Hampshire, NH, USA ;

In collaboration with

J. Wilkin[2] and R. Scharroo[3]
[2]Institute of Marine and Coastal Sciences, Rutgers University, NJ, USA
[3]EUMETSAT, Darmstadt, Germany

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Outline

- Motivation/Objectives
- NW Atlantic shelf/Gulf Maine:
- Coastal altimeter data reprocessing scheme:
- Validation: altimeter-derived across-track geostrophic current anomaly (Vg) using in situ current measurements
- Altimeter Vg temporal / spatial variability
- Summary

Motivation/objectives

Motivation

Improve satellite altimeter sea surface height anomaly (SSHA) data quality and interpretation to foster enhanced use of altimeter SSHA in the GoM/MAB coast/shelf region (e.g. for sea level, circulation modeling, etc..)

Objectives

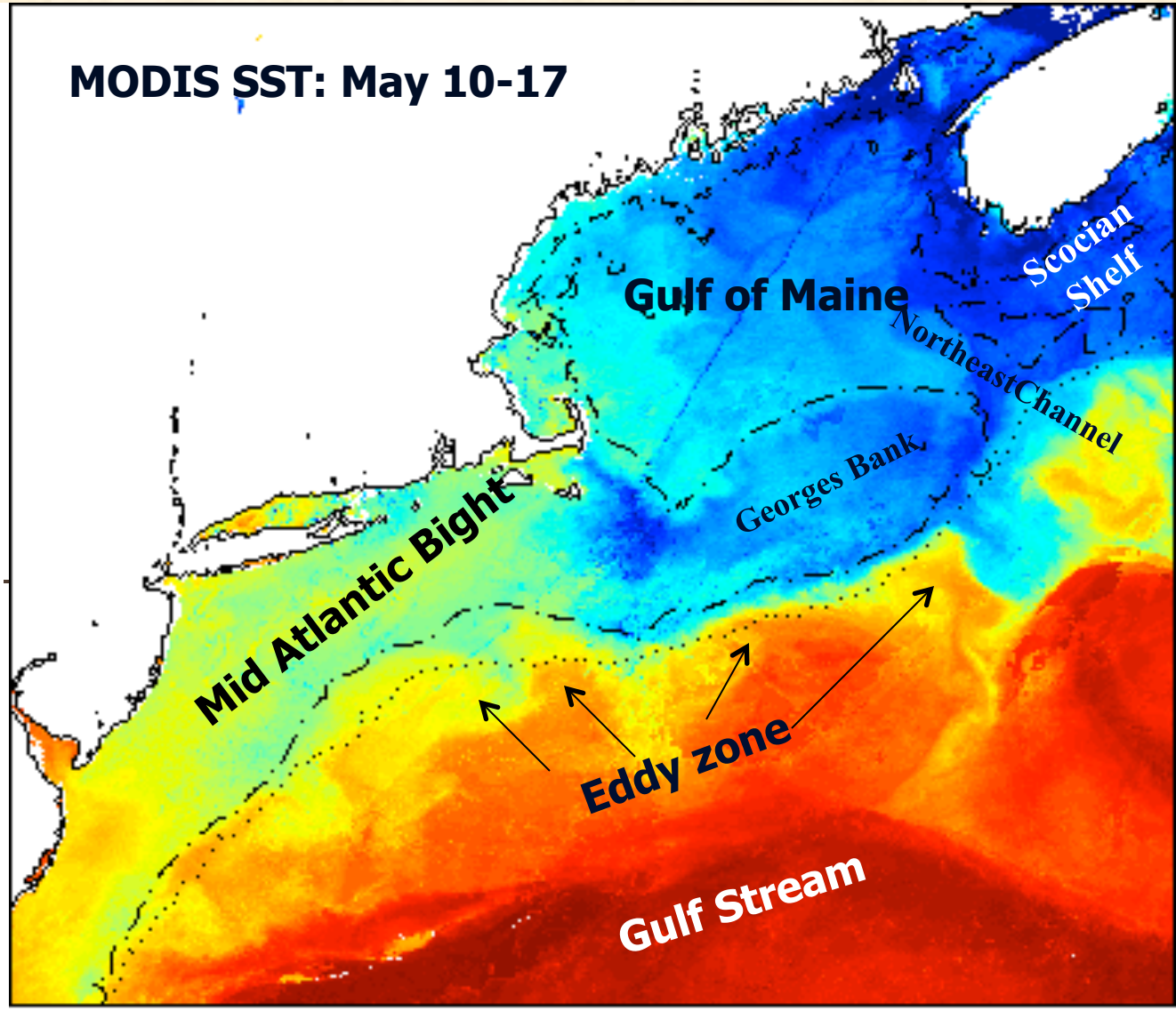
- Develop an altimeter SSHA reprocessing methodology dedicated to the US northeast GoM-MAB coastal and shelf region with improved SSHA quality
- Evaluate the along-track SSHA using coastal tide gauge data
- Evaluate the altimeter estimated across-track surface geostrophic velocity anomalies in terms of in situ buoy-measured currents
- Explore potential applications of altimeter observations of Vg in this coast-shelf region.

NW Atlantic shelf/Gulf Maine: complex/dynamic coastal system

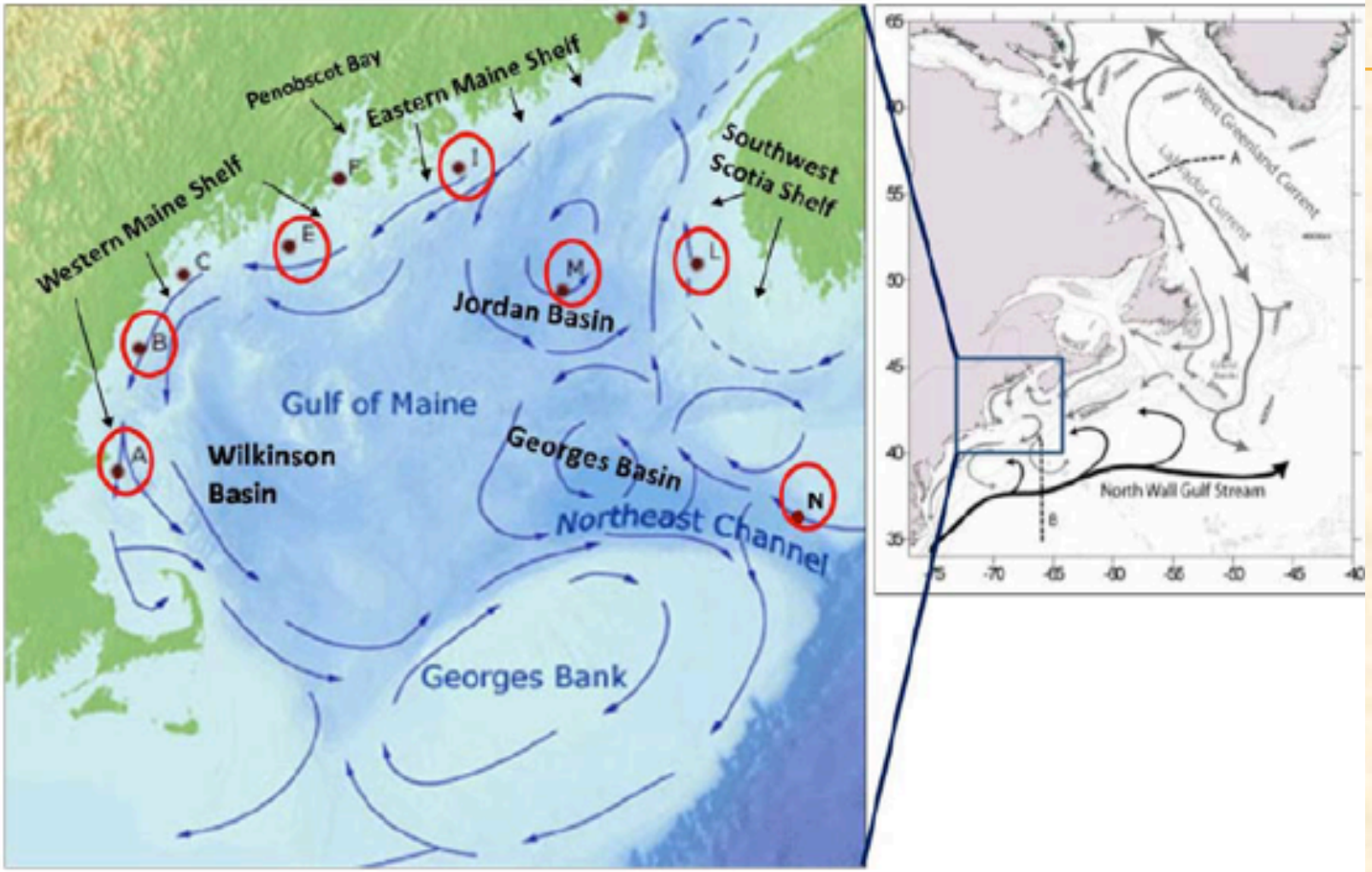
Influenced by:

- **Local:** Winds/River Runoff/Tides/Shelf break
- **Remote:** Cold-fresh Scotian Shelf Water inflow
- **Offshore:** Gulf Stream induced meso- to submeso-scale eddies

Complexity: all forcings vary significantly in space and time



Schematic ocean circulation in the NWA shelf and Gulf of Maine



Main features : a semi-enclosed marginal sea with depth to 370m, 3 basins, CCW gyre, large M2 tidal currents, incoming transport is through Northeast channel and along Scotia Shelf. Offshore warm-salty Gulf Stream induced meso- to submeso-scale eddies near shelf breaks. Several persistent topographically controlled gyres and a strong seasonal change in stratification that potentially impacts circulation features.

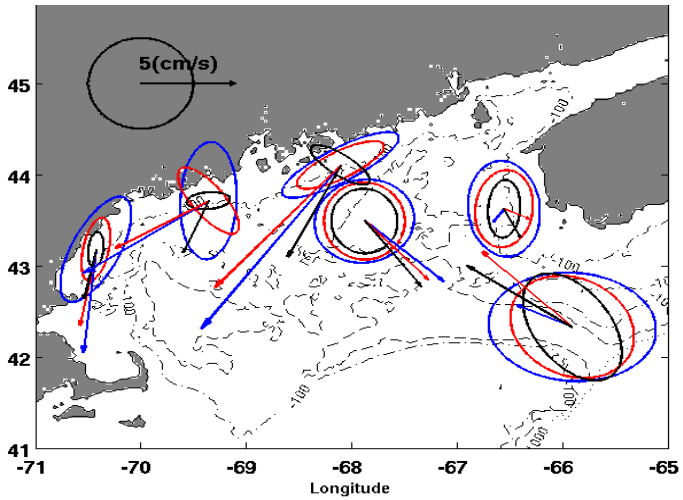
Observational circulation variation patterns: climatology

(On sub-tidal time scales: Blue 0-20m; Red:20-50m; Black:>50m)

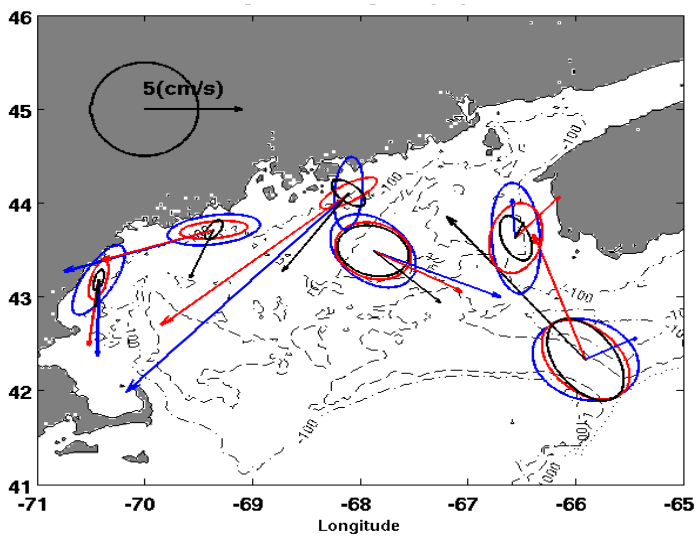
Based on 2001-to-present Gomoos buoy ADCP data http://oceandata.gmri.org/data/recent.html.

-Mean current pattern: a CCW gyre
-Principal axes of the currents align with the isobaths in the GoM coastal stations ; major/minor axes are more or less equal in the deeper stations
- Seasonal patterns differ; W is more energetic than S.

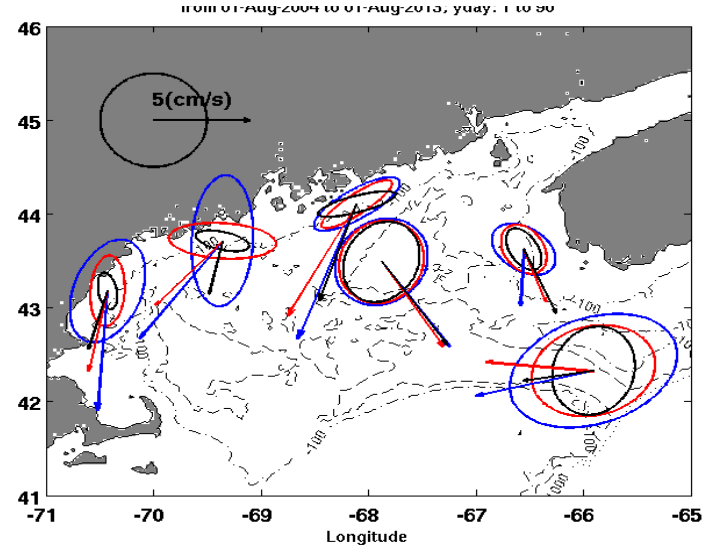
All seasons



Summer



Winter



Overview of altimeter reprocessing

Approach (Feng and Vandemark, 2011)

- Perform evaluation of geophysical corrections to select a set of optimal corrections for the region
- Determine missing data causes and attempt recovery :
  - Deflagging and editing criteria altered (less conservative)
  - Review each correction and flag to understand issues
  - Apply potential recovery algorithms to some corrections if possible

- Data recovery algorithms include
  - Replace MWR-based wet-tropospheric corr at the coast contaminated observations by ECMWF model
  - Lift rain-flags but apply the range error editing
  - Smooth Sea State Bias correction
  - Interpolation and extrapolation
  - ..

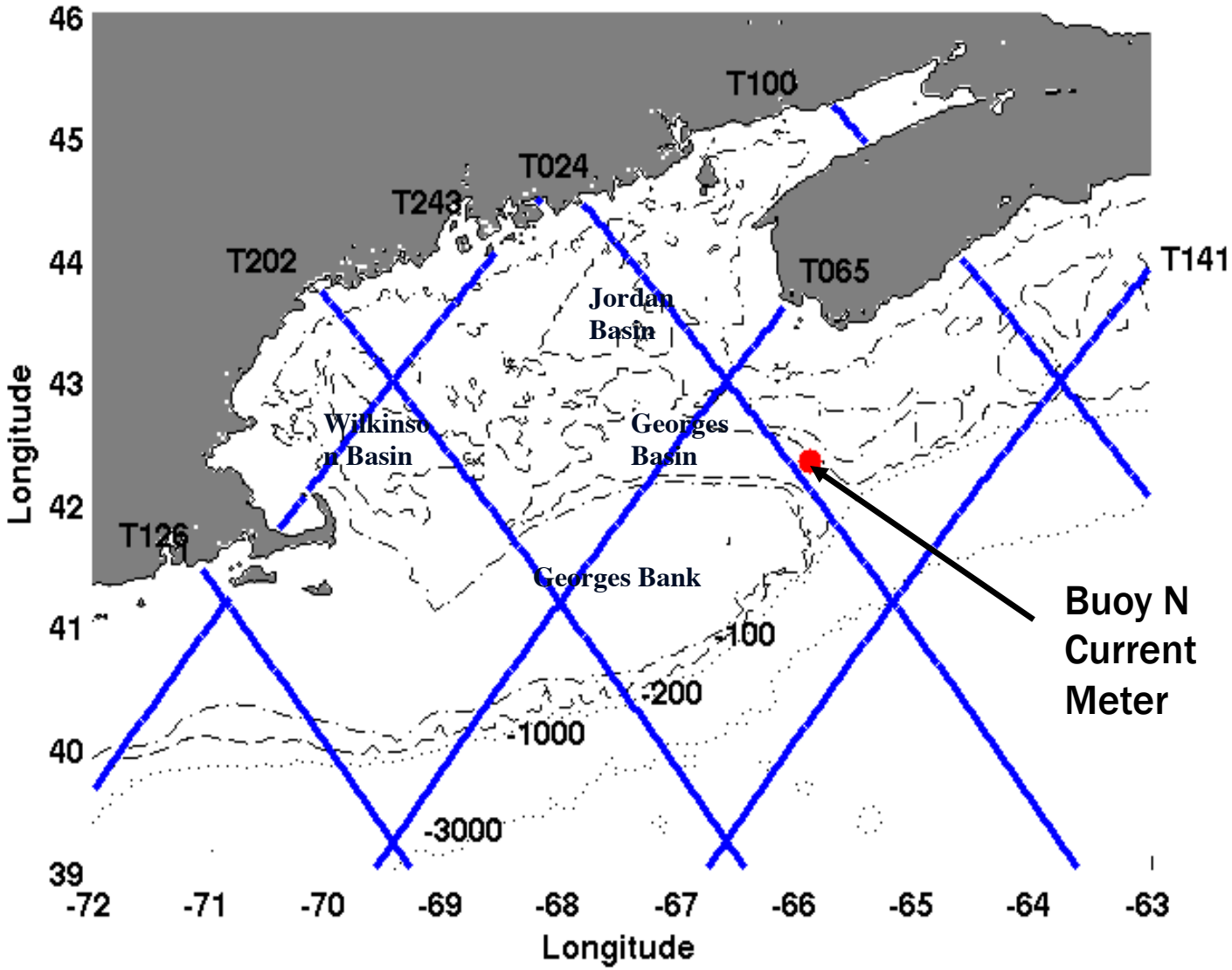
Overview of reprocessing (cont.)

With the 1Hz data (GDR-D), we apply the following now,

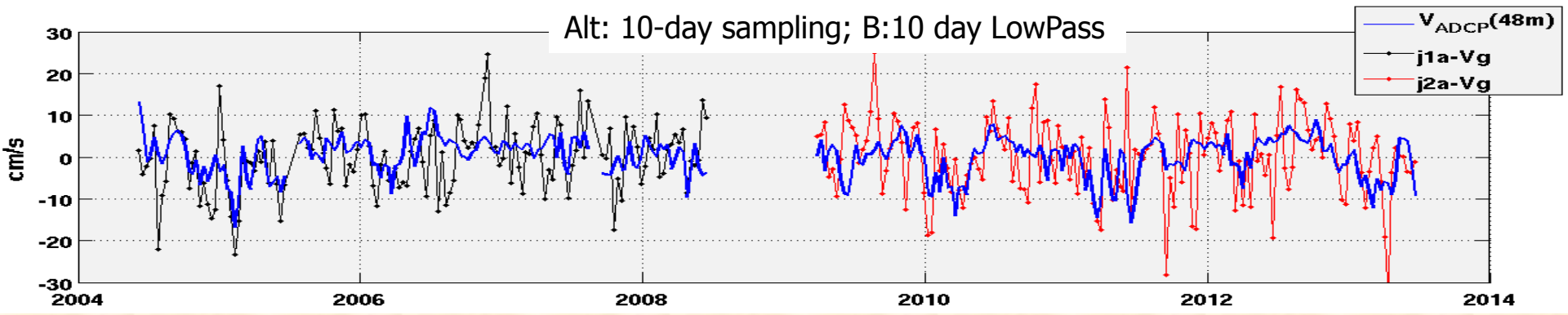
- Corrections for sea surface height anomaly SSHA
  - GOT4.8 ocean tide
  - JMR/TMR + ECMWF model for wet-tropospheric delay
  - Sea State Bias (CLS: 2D nonparametric solution)
  - MOG2D model for high freq sea level variation
  - Mean sea surface (DTU10)

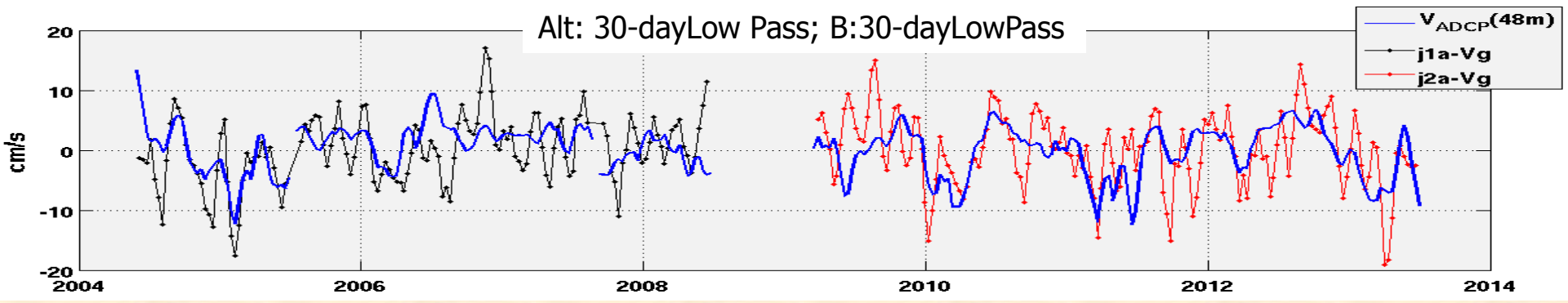
- Along-track SSHA/ geostrophic current data filtering
  - A 30 km LP filter is applied to each track SSHA to reduce the high-frequency gravity waves before alongtrack SSHA is used for Vg.
  - A span of 6 along-track interval (~40km) is used to calculate Vg and then a simple 5-point along-track running mean LP is applied to Vg
  -

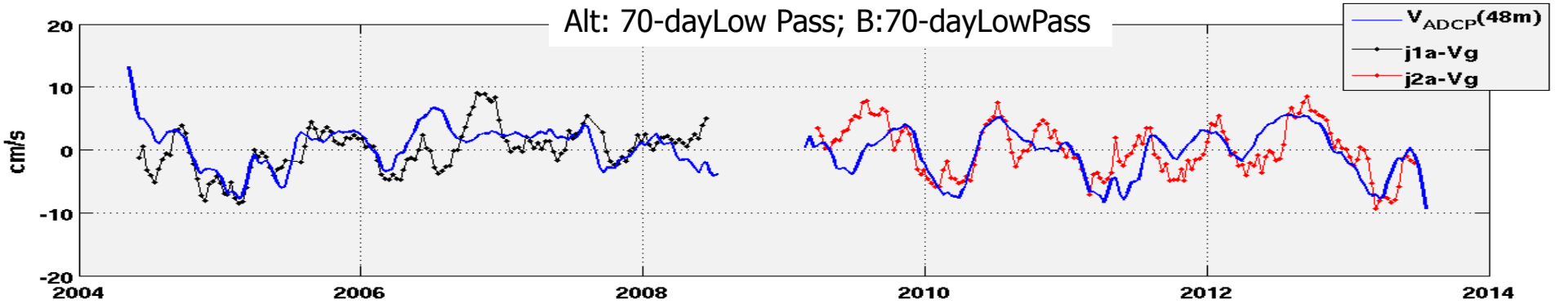
Long-term altimetric (TOPEX, Jason1 and 2) observations in the region



Time series of Jason1 (black) and Jason2 (red) across –track geostrophic current anomaly Vg (positive values for northeastward anomaly) from **Track 24,** and the 10-day/30day/ 70day/ LP filtered Buoy-N measured across-track current V_{ADCP} from the **48m** depth



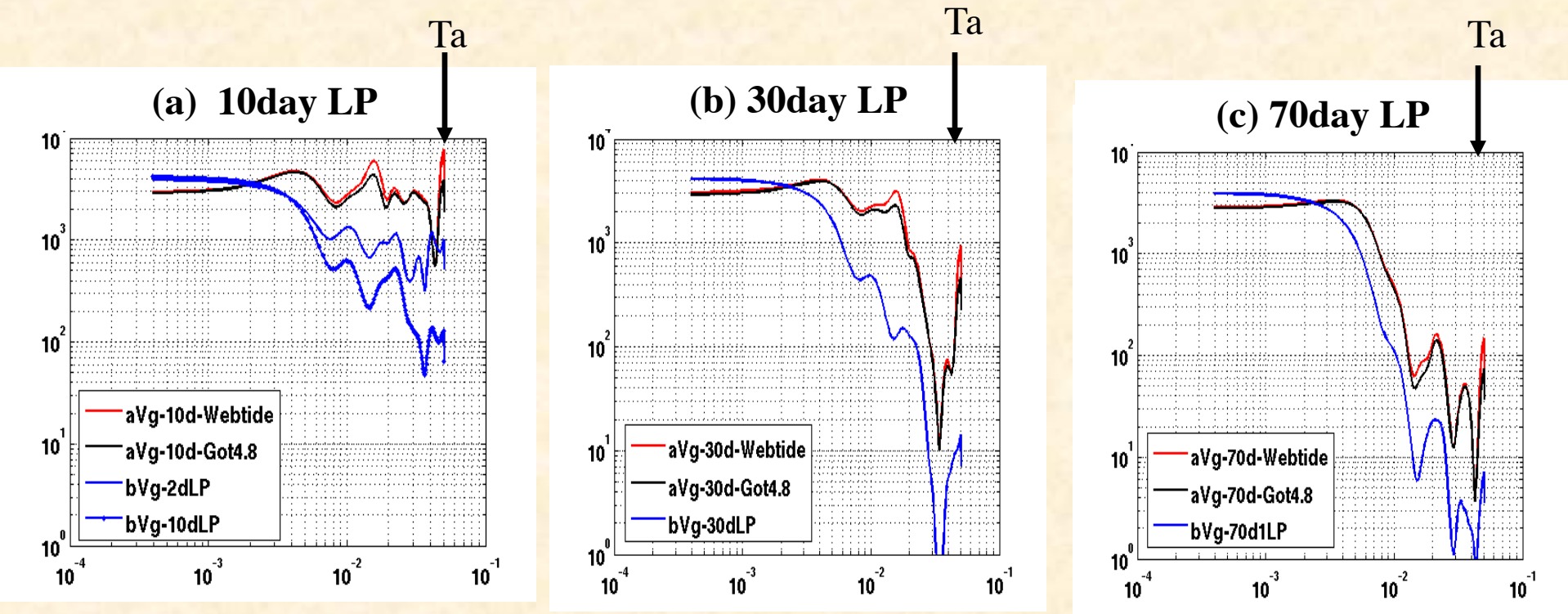




Auto-spectra of altimeter Jason 2 derived across-track geostrophic current anomaly Vg as well as buoy N

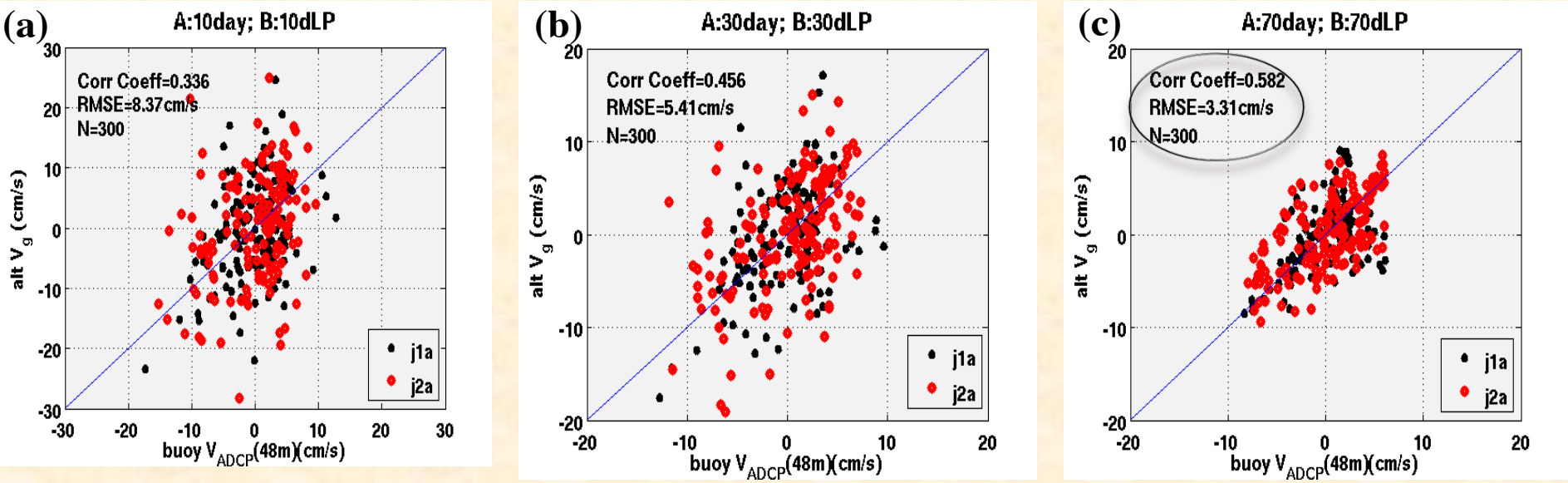
(a) 10-day (b) 30 day and (c) 70day Low Pass filtered $V_{ADCP}$from depth at 48m.

Ta =62.1 days ; TOPEX/Jason M2 tide alias period (Schlax and CheltonN, 1994)



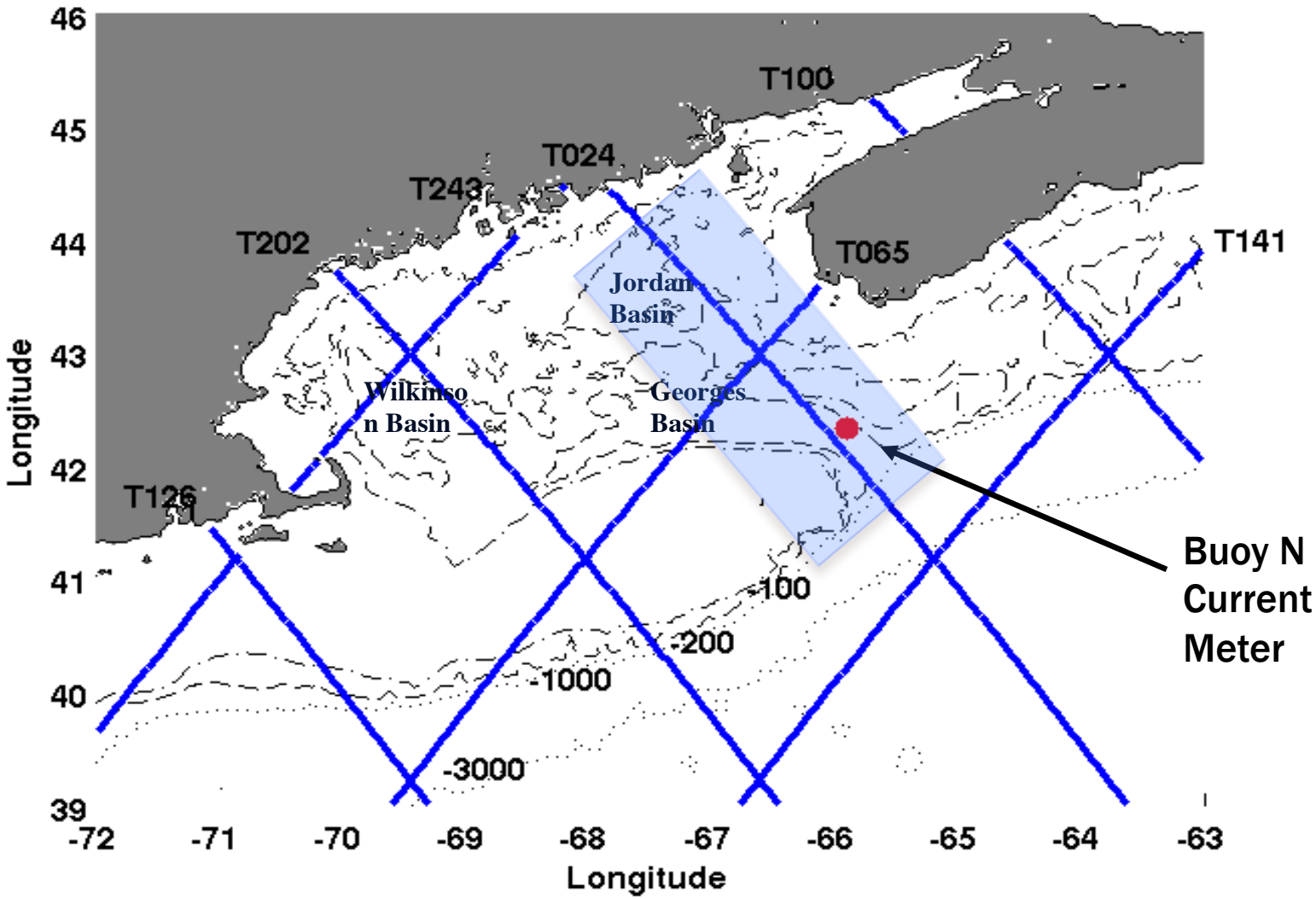
(Jason2: 190 cycles from Jul 2008 to Aug 2013)

Scatter plot of Jason 1 and Jason 2 derived Vg against the buoy N V_{ADCP} (a) 10-day LP (b) 30-day LP and (c) 70-day LP.



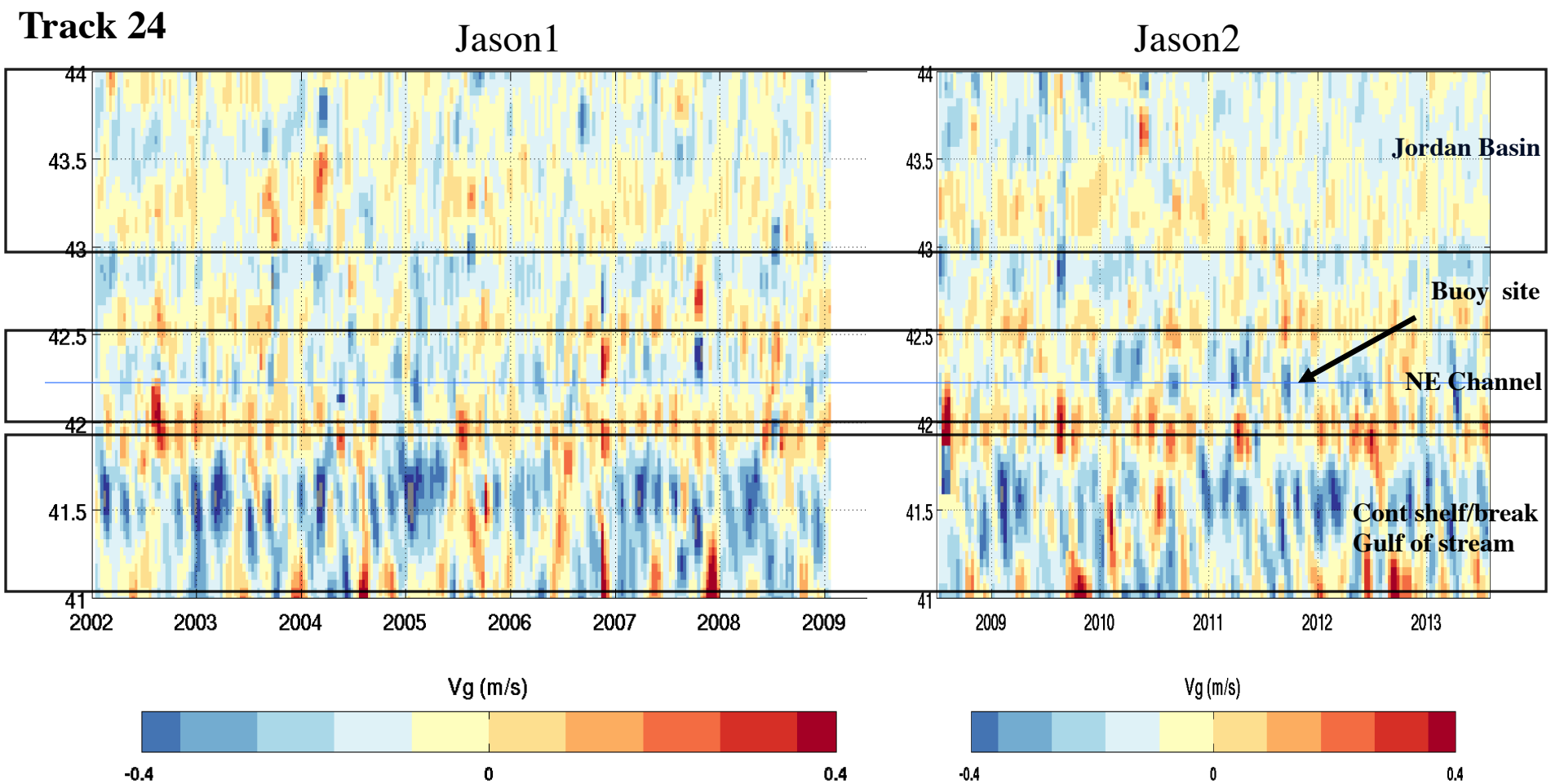
Corr. Coef: Correlation coefficient (Corr. Coef) ,
RMSE: Difference RMSE
N: number of instantaneous observations of altimeters and buoy.

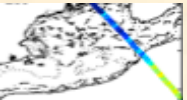
Altimeter Vg on Track 24 is the focus in the next 2 slides



Atlimeter Vg temporal/spatial variability

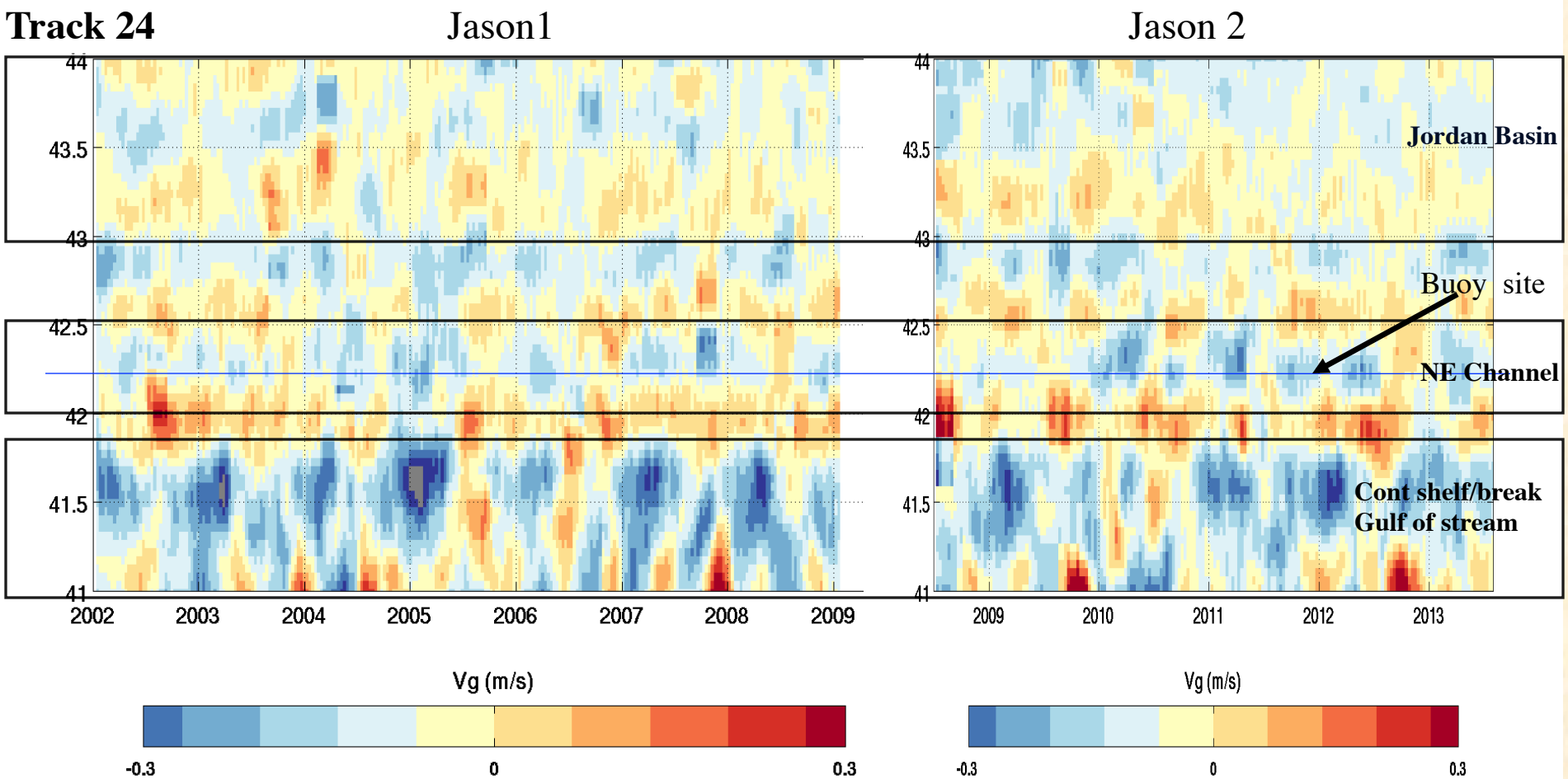
Time–space diagrams of 30-day LowPass filtered Jason1a and Jason 2a derived across-track geostrophic current anomaly Vg (**positive for northeastward**)





Atlimeter Vg temporal/spatial variability

Time–space diagrams of 70-day LowPass filtered Jason1a and Jason 2a derived across-track geostrophic current anomaly Vg (**positive for northeastward**)



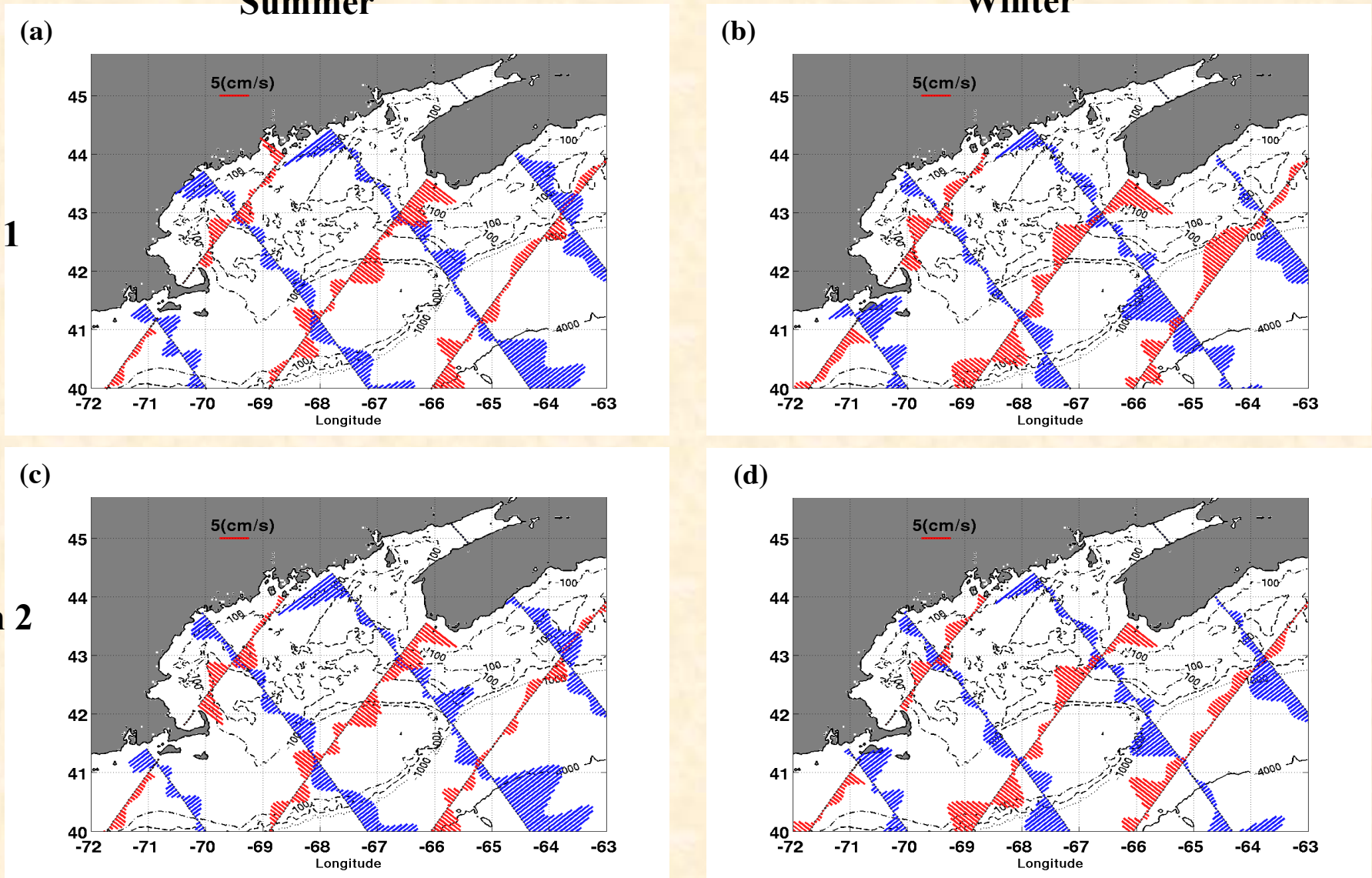
Altimeter Vg Anomaly Spatial Pattern Climatology (30day LP)

(a)/(c) Summer (Jul-Aug-Sept) and (b)/(d) winter (Jan-Feb-Mar) climatology maps of across-track geostrophic current anomalies derived from altimeter Jason 1 (2002.1-2009.1) and Jason2 (2008.7-2013.8) . Blue/red lines indicate descending and ascending tracks, respectively.

Summer **Winter**

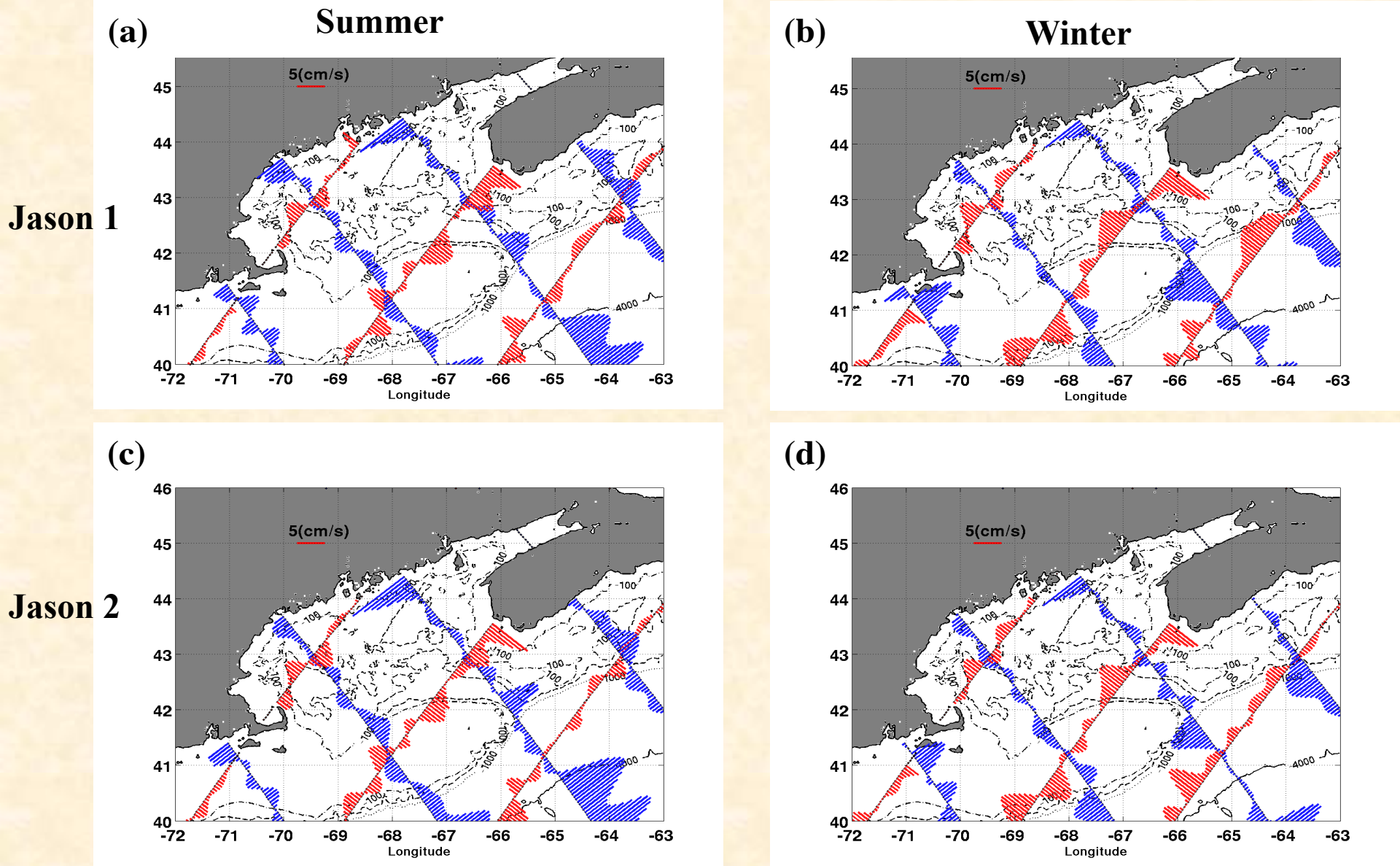
Jason 1

Jason 2



Altimeter Vg Anomaly Spatial Pattern Climatology (70day LP)

(a)/(c) Summer (Jul-Aug-Sept) and (b)/(d) winter (Jan-Feb-Mar) climatology maps of across-track geostrophic current anomalies derived from altimeter Jason 1 (2002.1-2009.1) and Jason2 (2008.7-2013.8) . Blue/red lines indicate descending and ascending tracks, respectively.



Summary

- Buoy current validation results are encouraging, showing that altimetry appears to be reliable and useful for characterizing synoptic geostrophic current variation with a correlation coefficient of 0.58 and difference RMSE of 3.3cm/s, particularly for the seasonal, annual and interannual scales (>70dayLP).

- Discrepancies still exist between altimeter-based and in-situ Vg, most likely related to
  - remaining/significant high-frequency aliasing M2 tide errors (and mayby other tide constituent aliasing) ,
  - ageostrophic components (e.g. wind driven Ekman and baroclinic currents),
  -
- We have characterized spatial and temporal variability of surface geostrophic anomaly current Vg from Jason1 and Jason 2, both showing fairly consistent pattern. Some key **spatial - temporal features** are generally consistent with previous knowledge, particularly in the shelf/slope and some deeper basins.

- Future improvements:

Acknowledgements

- NASA's Science Directorate Physical Oceanography Program

- University of Maine Buoy measurement program and Northeast Regional Assoc. Coastal Ocean Observing System (NERACOOS)

- Radar Altimeter Database System (RADS)

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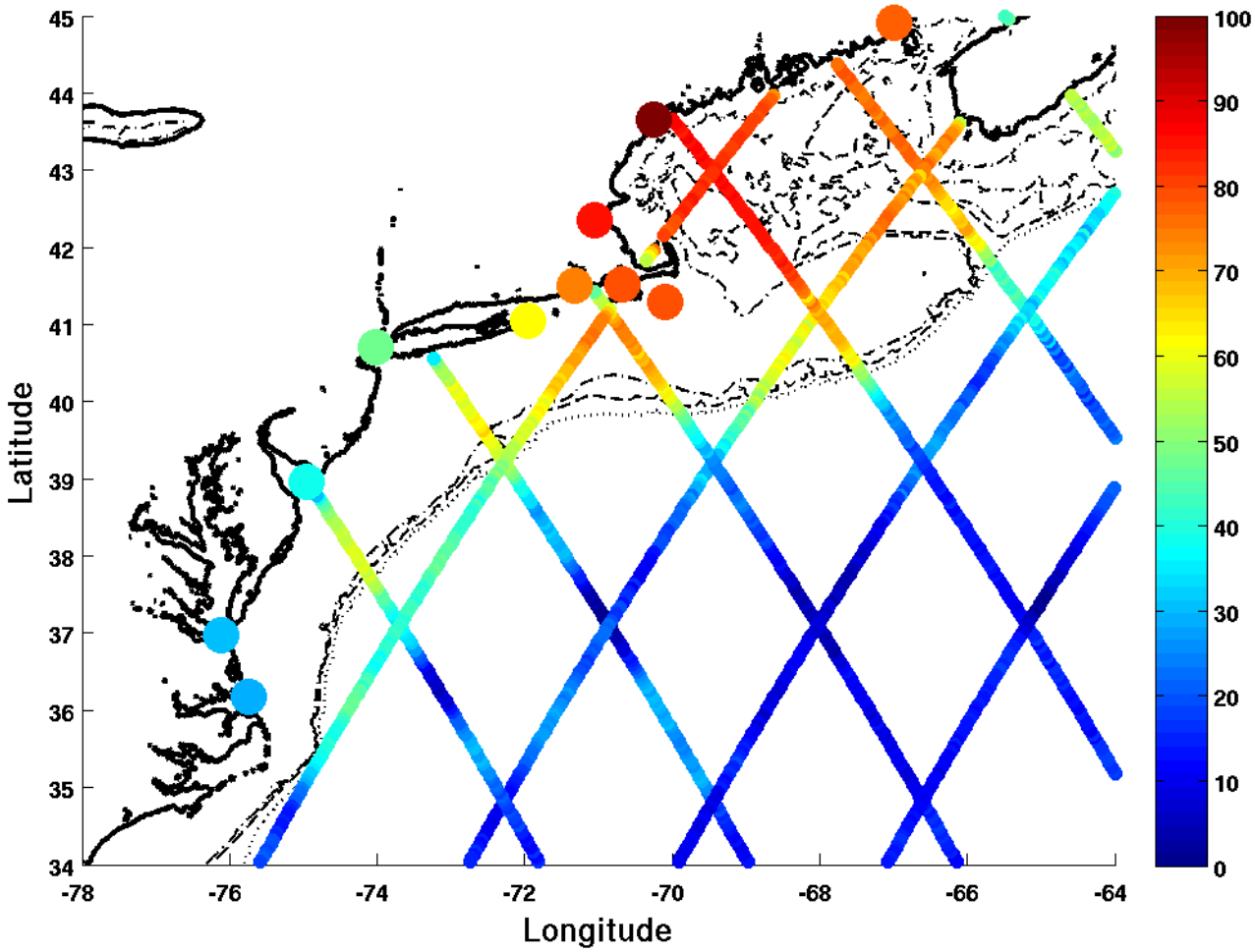
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-72
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-66
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Longitude
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Schematic of ocean circulation in the NWA shelf and Gulf of Maine

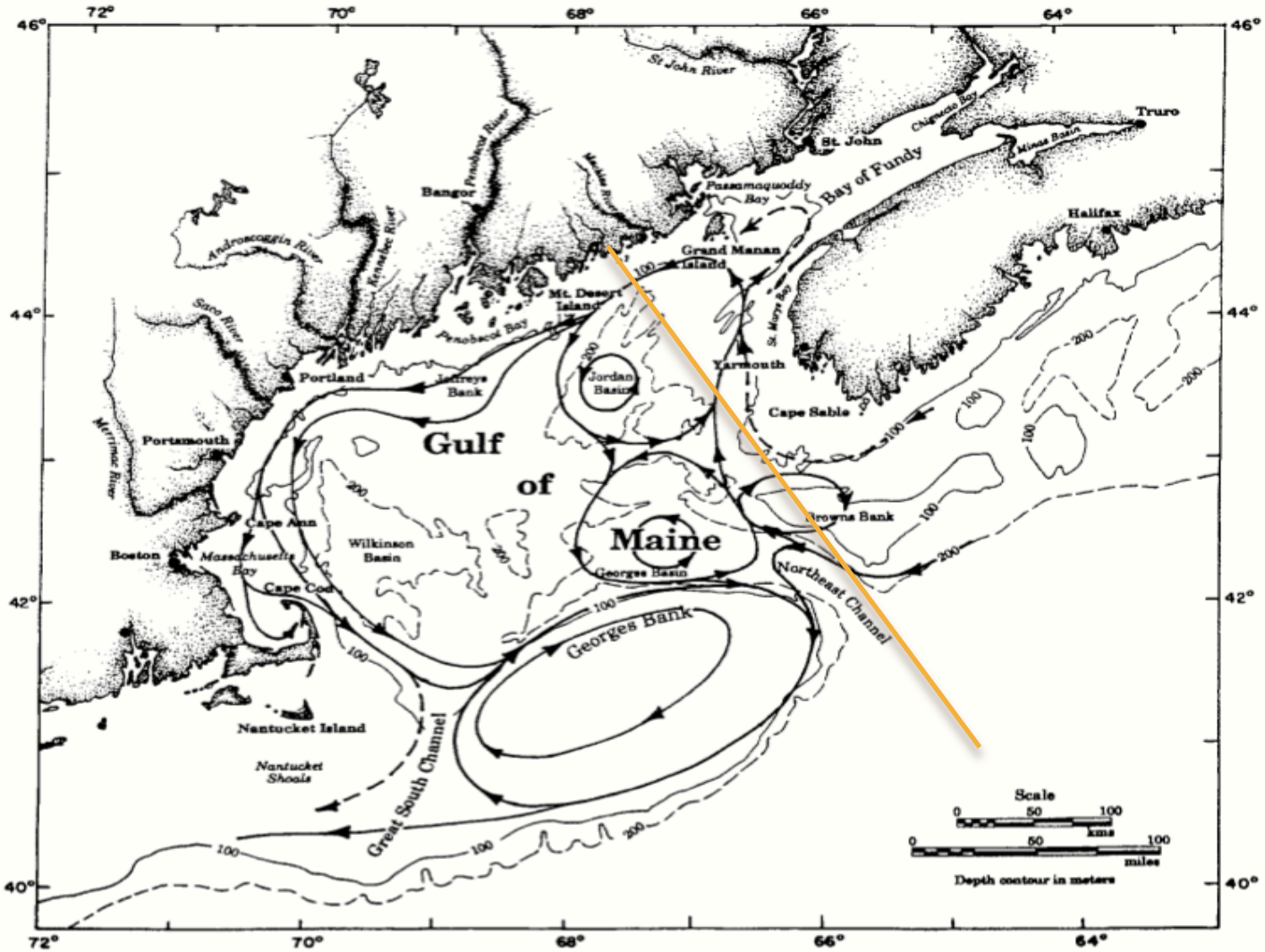

FIG. 2. Schematic of the vernal circulation in the Gulf of Maine. Based on the drifter (drogued at 10 and 40 m) and hydrographic observations in the spring of 1994 (N. R. Pettigrew, unpublished manuscript).

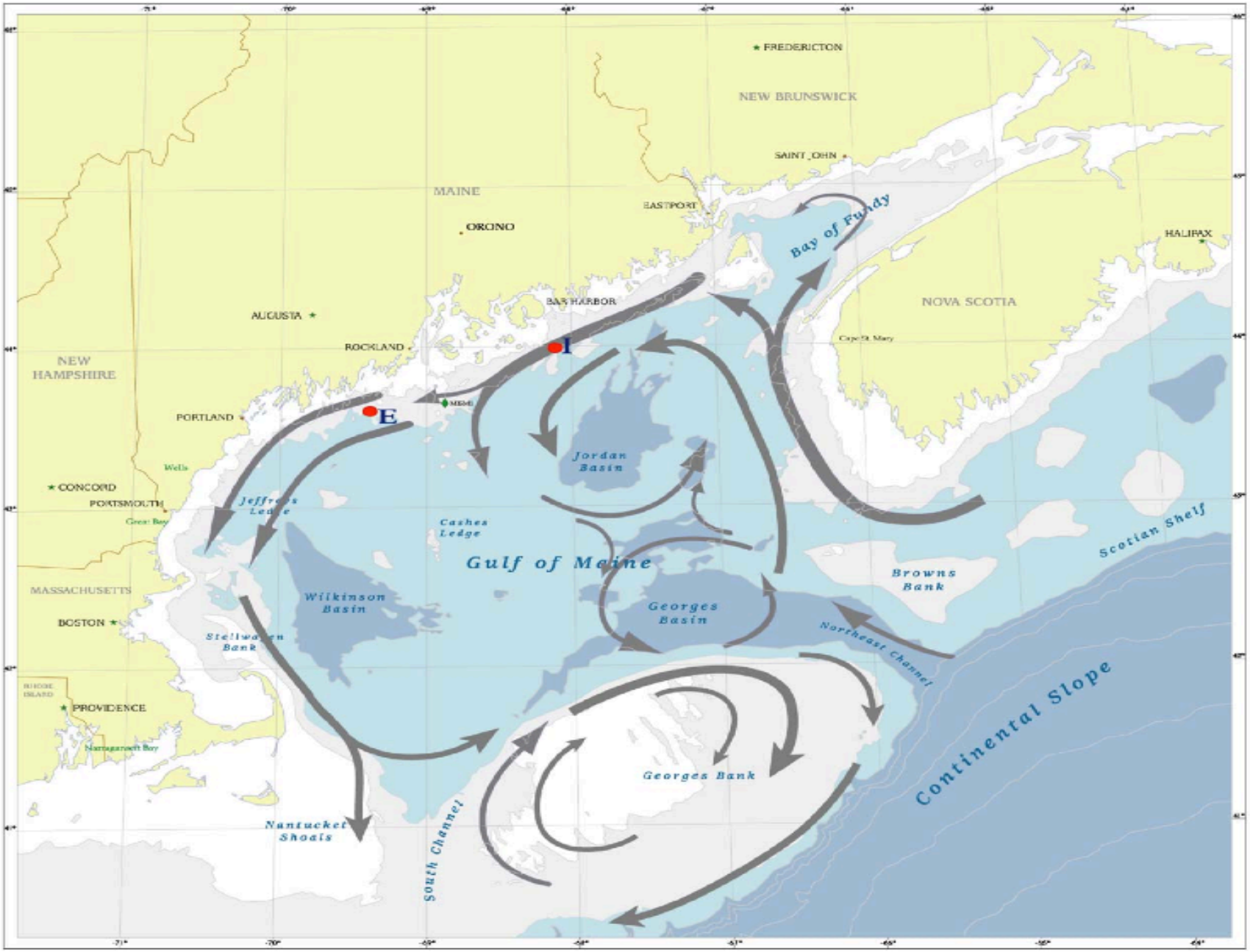

Fig. 3. Summer schematic circulation diagram of for the upper 40 m in the Gulf of Maine. The red dots marked E and I indicate the locations of real-time GoMOOS buoys that have been measuring currents since the summer of 2001.