

JAMES GIRTON, APL-UW

# PROFILING FLOATS FOR SWOT CAL/VAL

# EM-APEX Velocity and CTD profiler



Now there is a profiling float with Iridium and GPS plus:

- Electrodes for sensing horizontal electric currents—*proportional to horizontal water velocity via motional induction*
- Low-noise, low-power pre-amplifiers and microprocessor
- Vanes for rotation (to remove electrode drift)
- 3-axis magnetometer and accelerometer

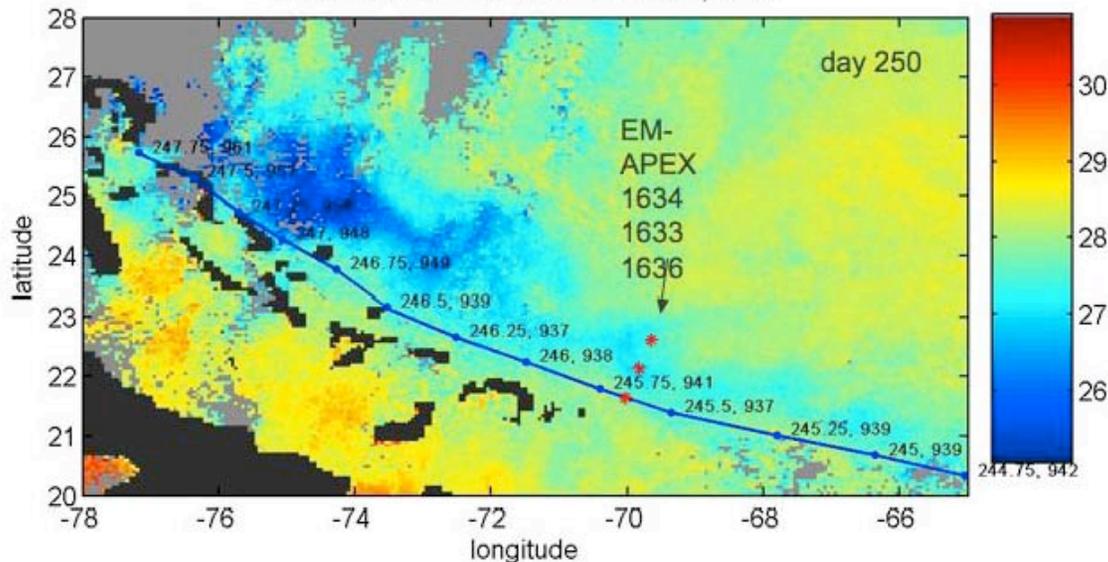
(thanks to Tom Sanford, Doug Webb, John Dunlap, and Jim Carlson)

Webb APEX

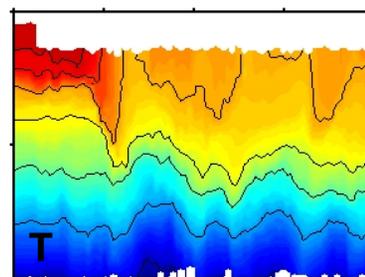
EM-APEX

# Hurricane Frances Measurements (comparison with Price model)

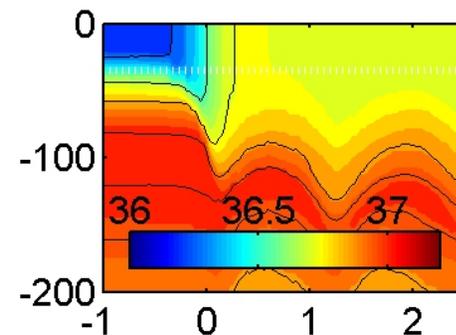
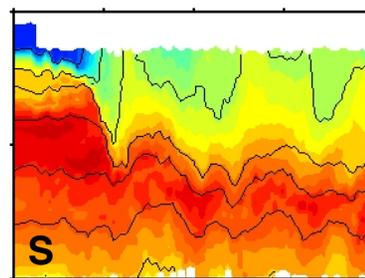
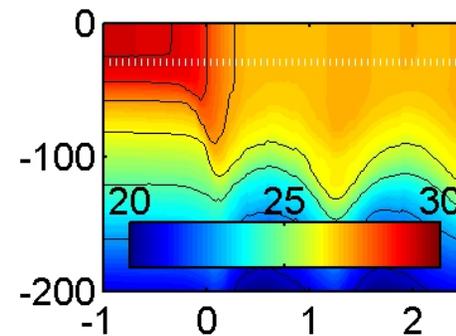
GOES SST and the track of Frances; 2004



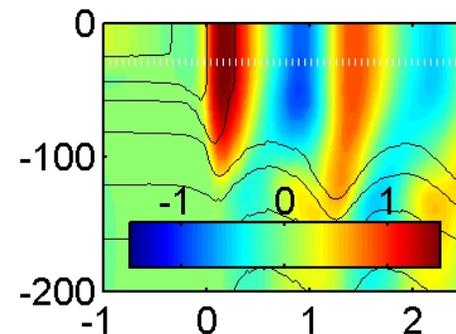
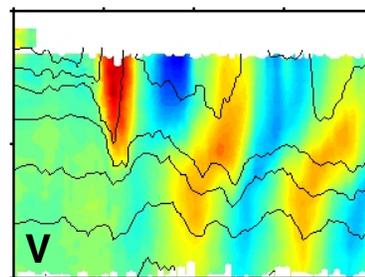
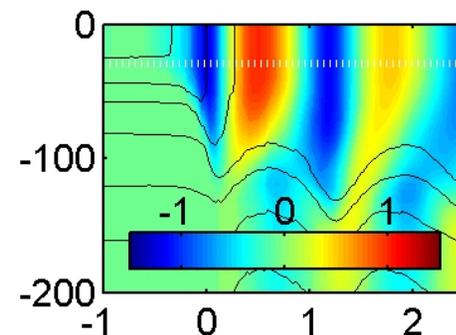
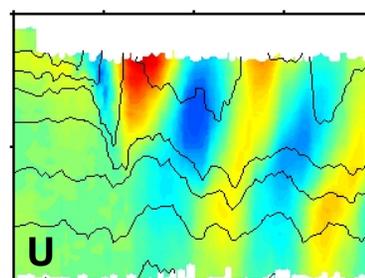
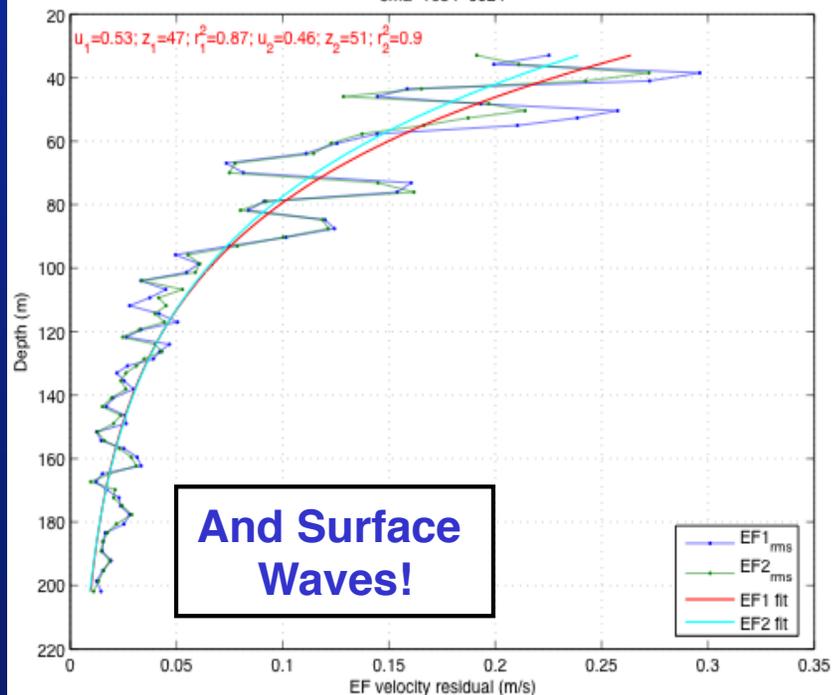
EM-Apex 1633



3DPWP,  $X_o = 55$  km



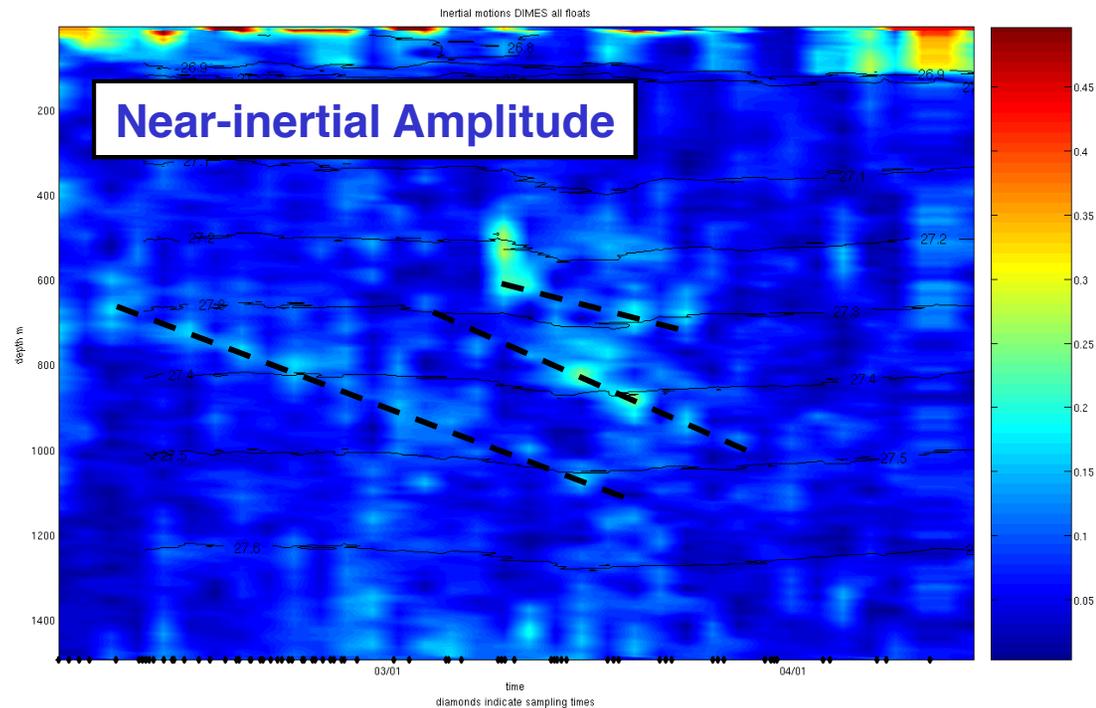
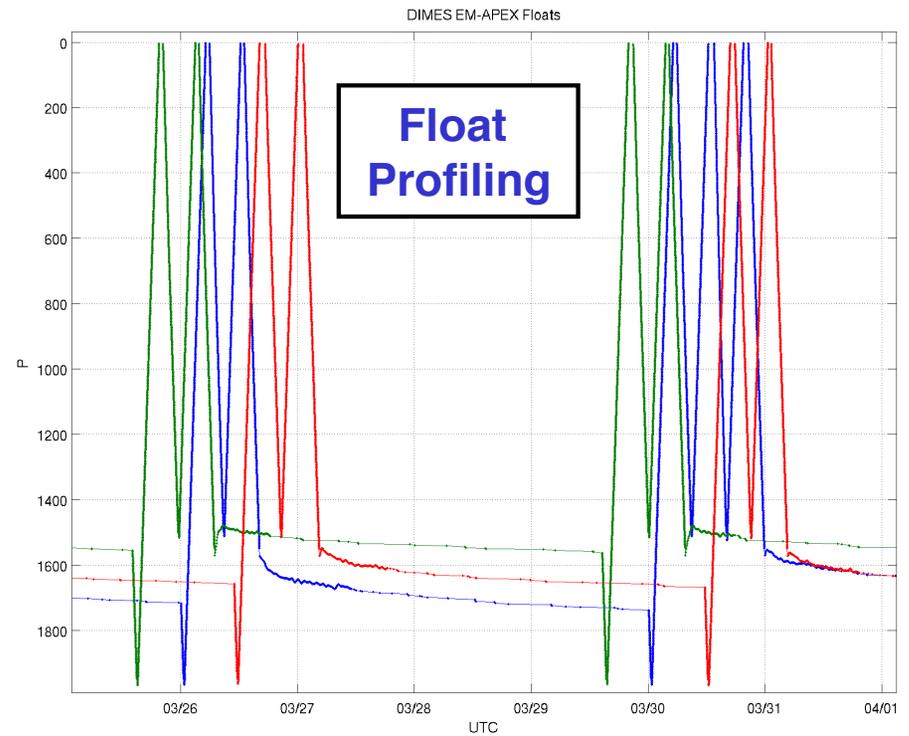
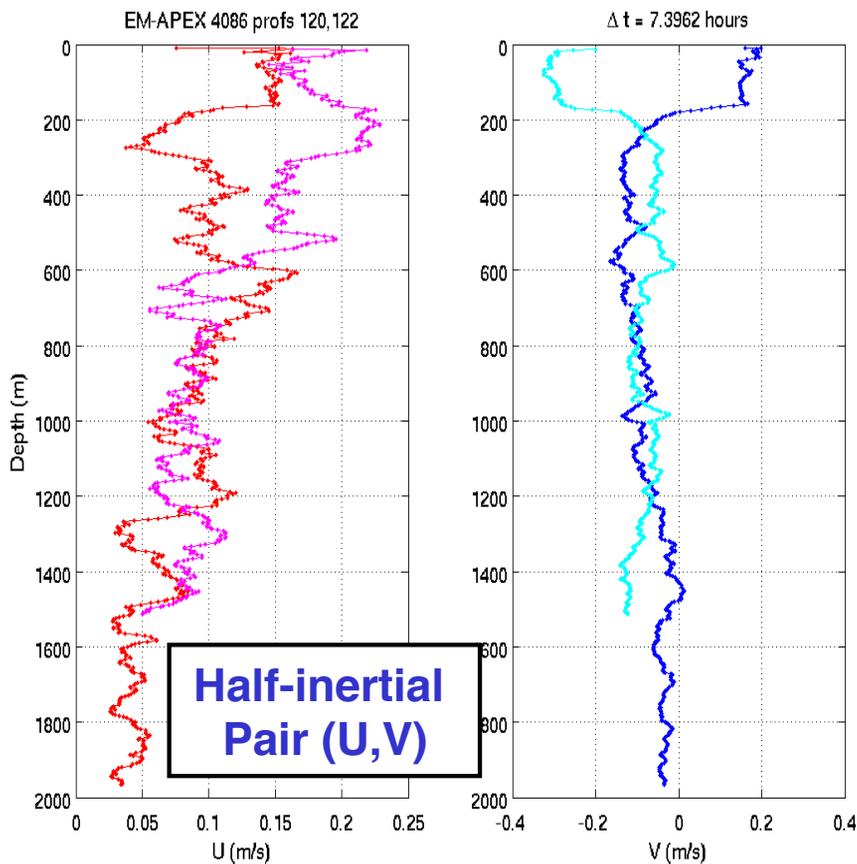
ema-1634-0024



# Half Inertial Period Profiling (Southern Ocean)

- *Average* gives estimate of sub-inertial (geostrophic) current
- *Difference* gives inertial current

Caveat: Valid only if inertial and mean are the dominant velocity components.



# EM-APEX in EDDIES: Summary

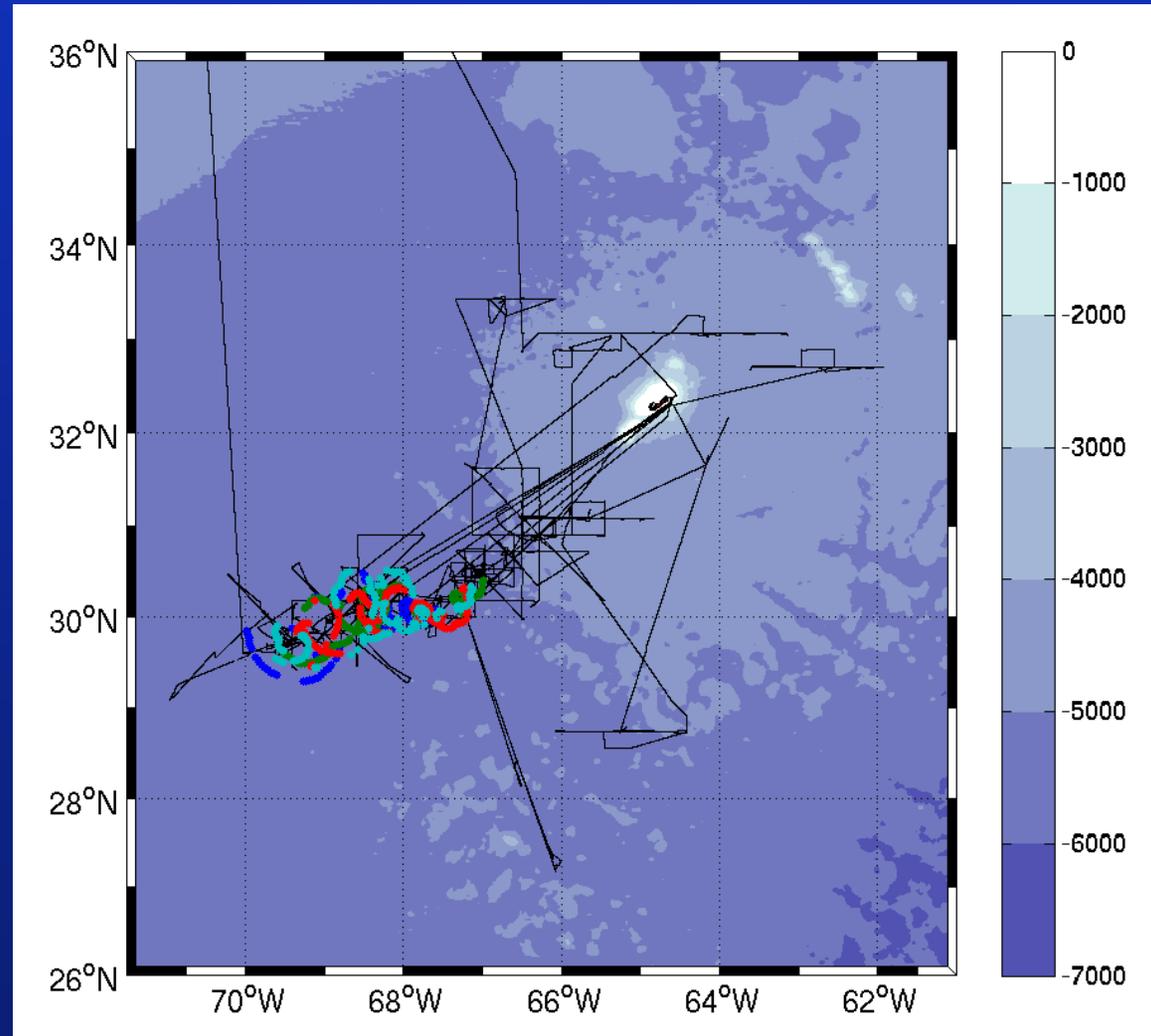
**6 week deployment** in an anticyclonic mode-water eddy southwest of Bermuda.

**Primary mission:** to characterize the internal wave shear and strain climate for comparison with tracer spreading

**Profiling strategy:** 3-hour intervals for a two day period, followed by 2 days “parked” at the depth of the **tracer isopycnal** (generally 80-100m)

**Reasoning:** (a) resolve semidiurnal tides, (b) save battery life and (c) minimize **drift** away from the tracer patch. Also used a “yoyo” mode near the end of the deployment for rapid sampling.

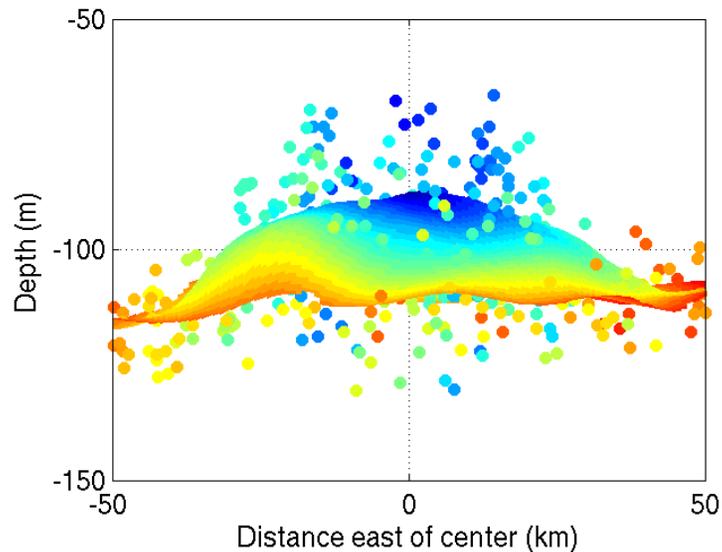
**3 out of 4 EM-APEX recovered.**



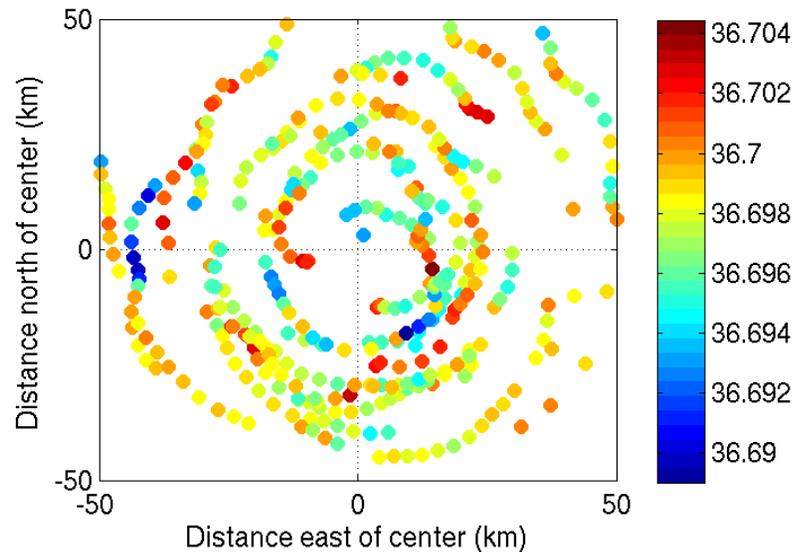
Black line: cruise tracks of all 4 Oceanus legs  
Colored dots: EM-APEX profiles

# Mapping the eddy

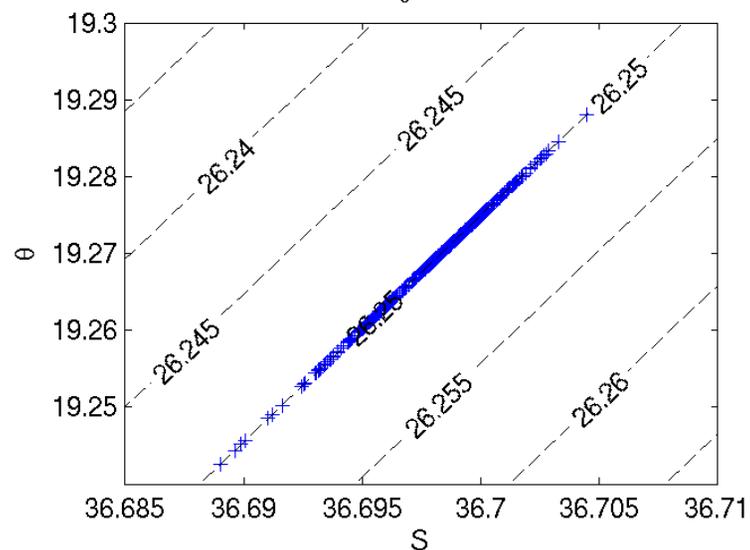
Depth of the  $\sigma_\theta=26.25$  isopycnal (shaded by radius)



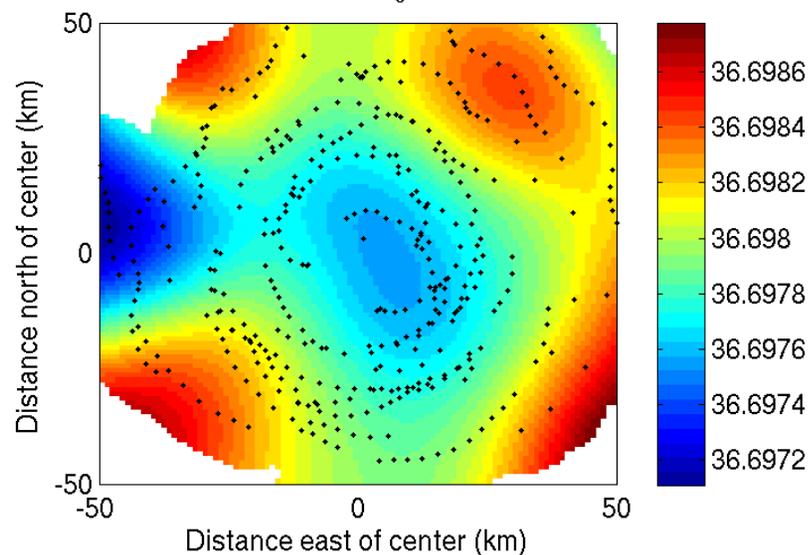
Salinity on  $\sigma_\theta=26.25$  isopycnal



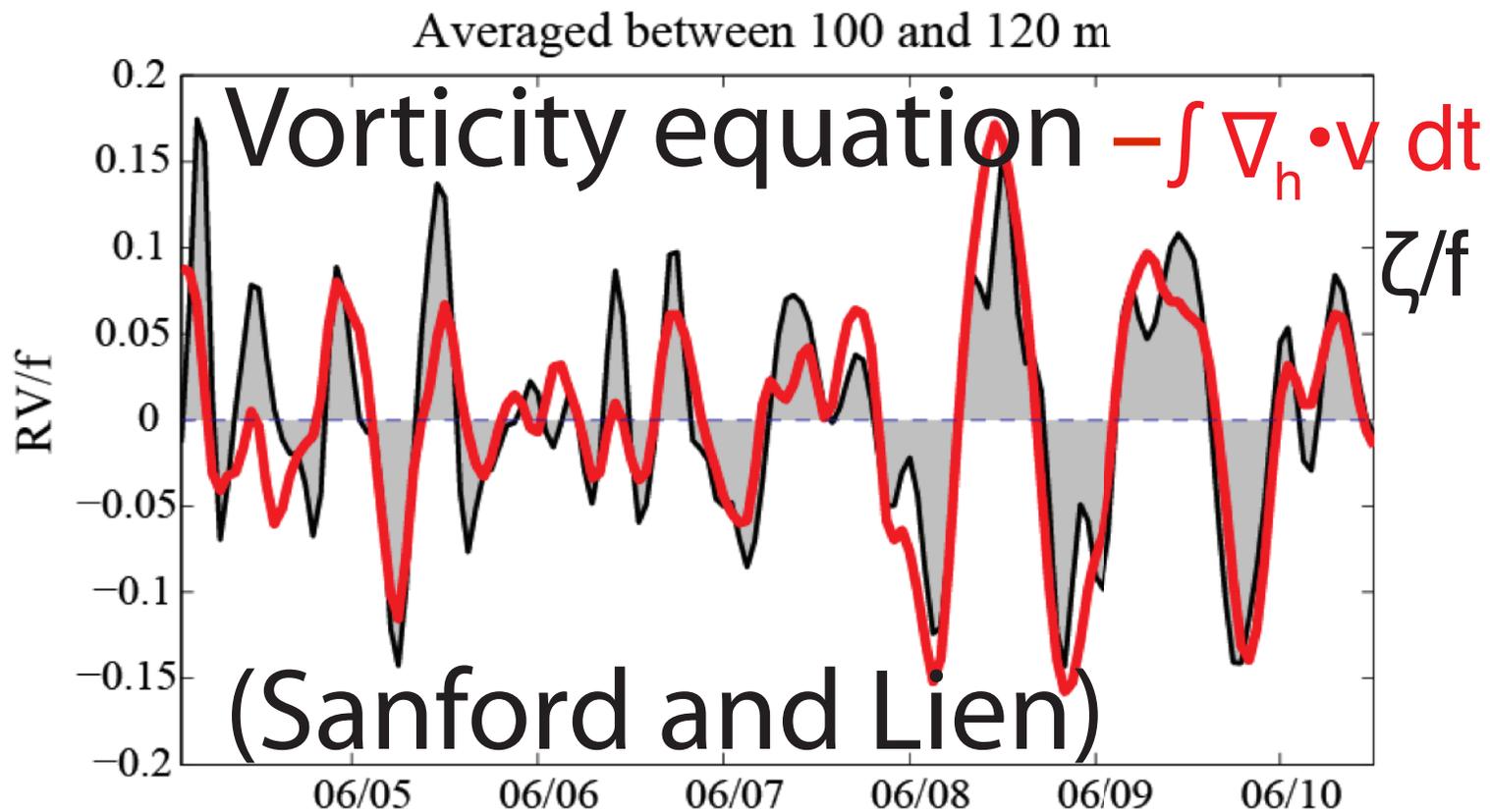
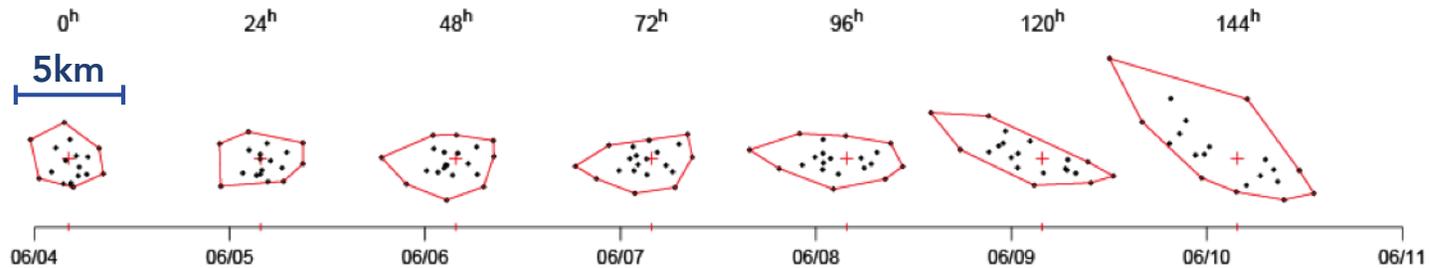
$\theta$ -S range on  $\sigma_\theta=26.25$  isopycnal



Smoothed salinity on  $\sigma_\theta=26.25$  isopycnal

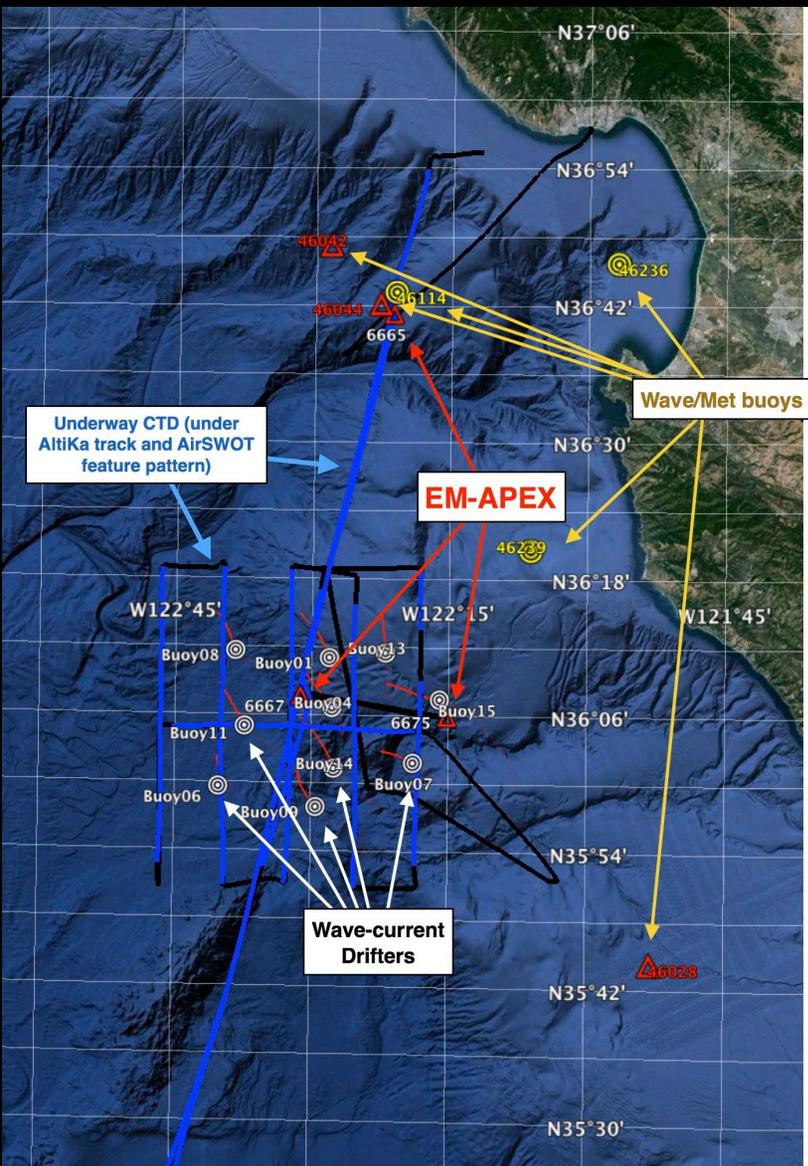


# LatMix: *Sampling of submesoscale dynamics with a synchronous profiling array*

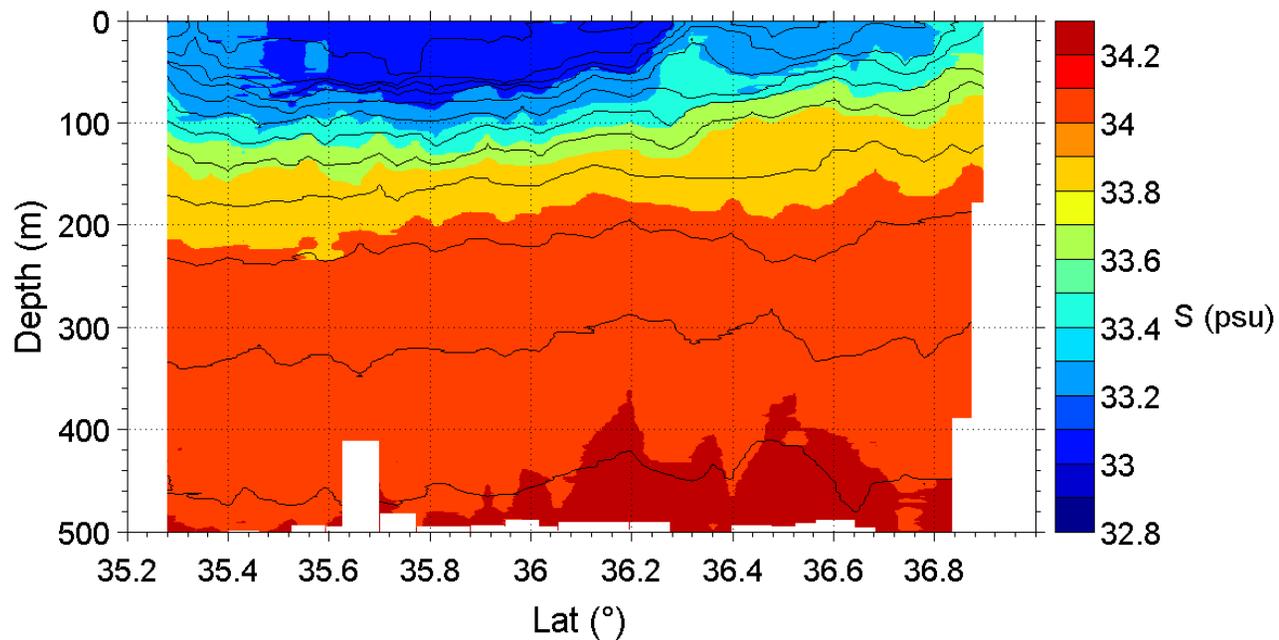
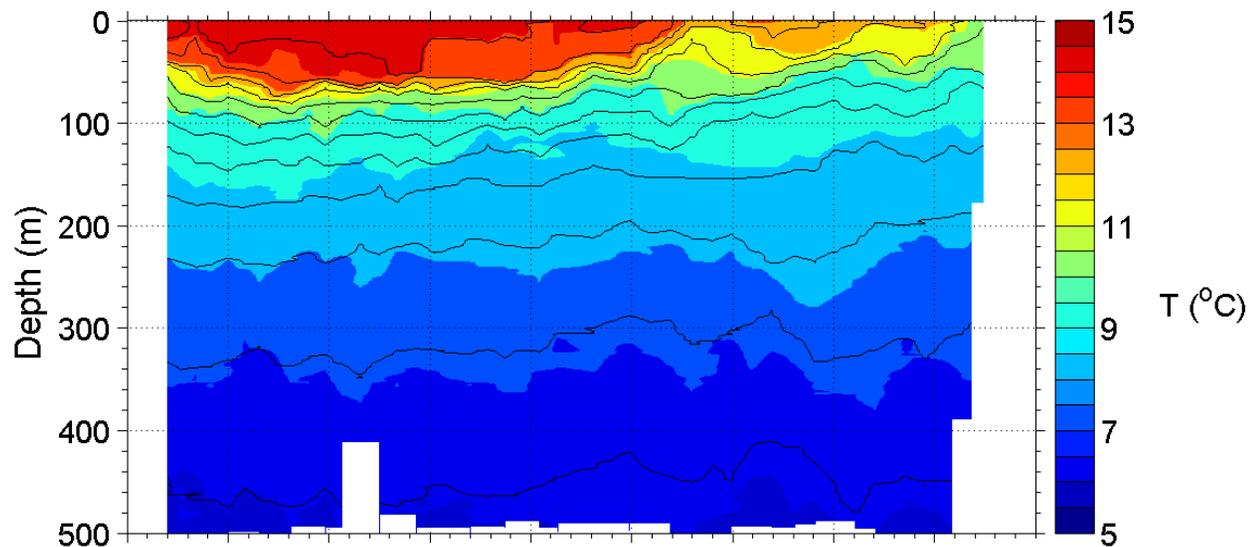
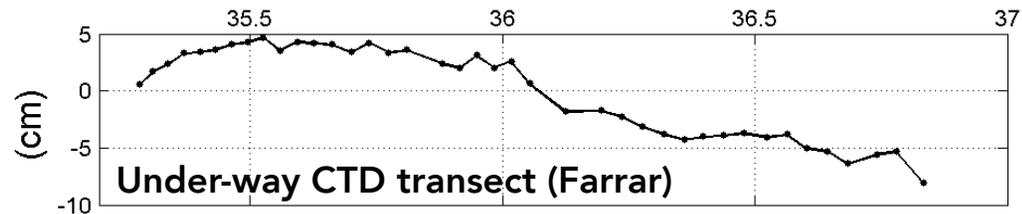


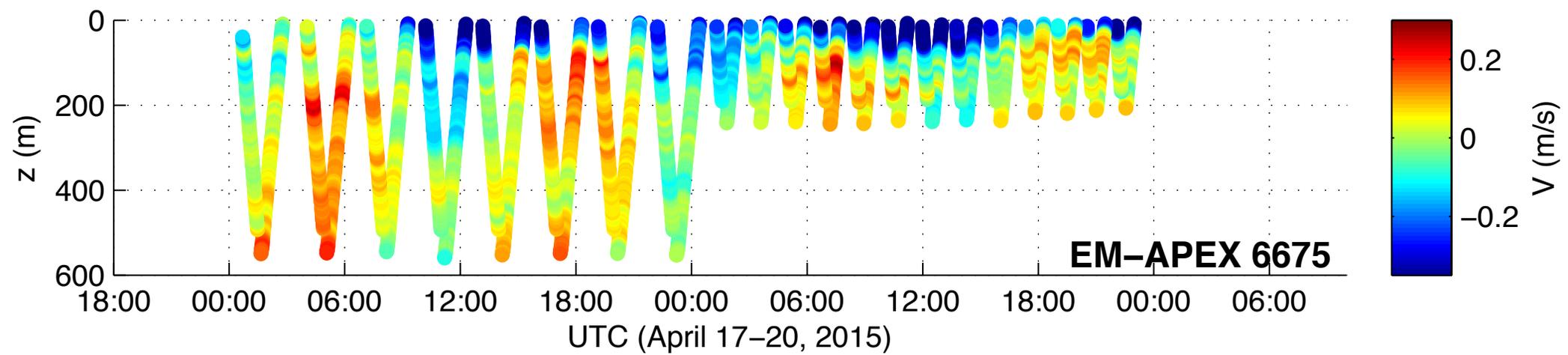
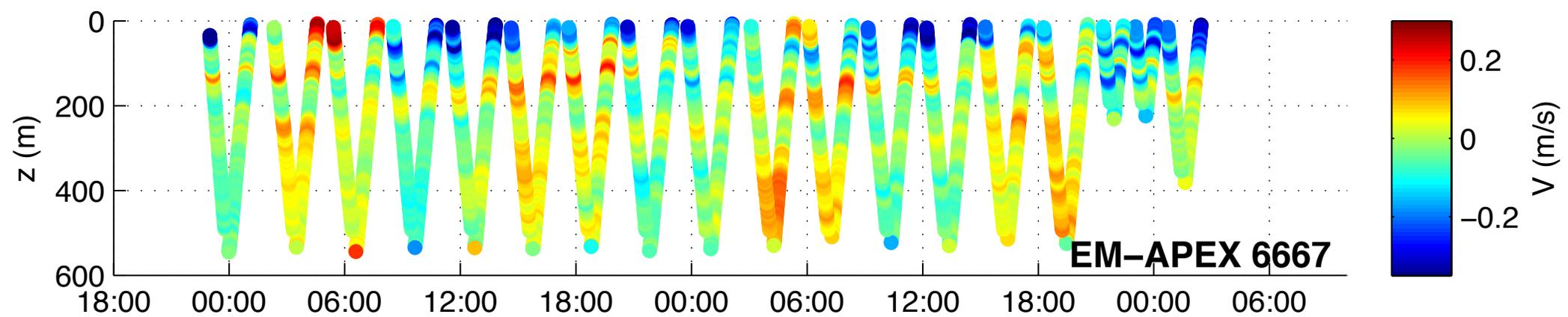
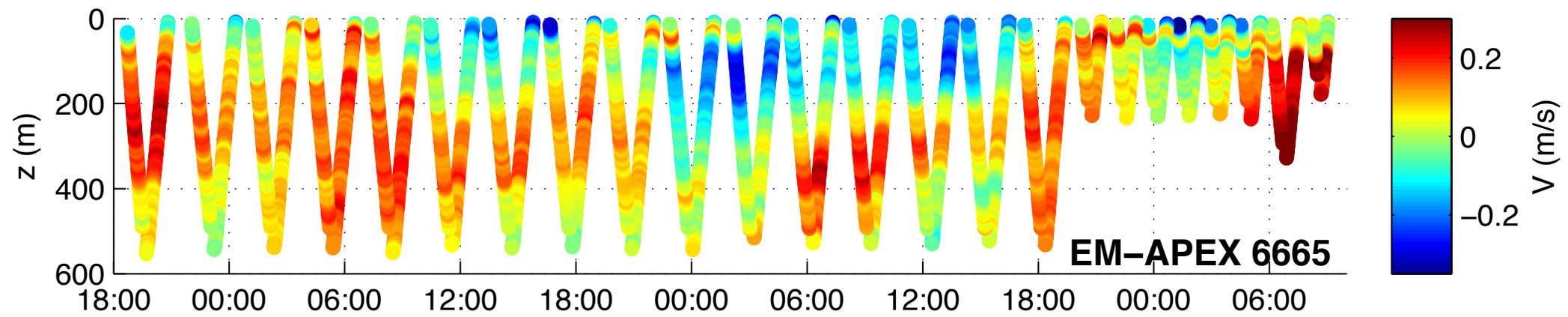
# AirSWOT (April 2015)

field experiment off  
Monterey



Dynamic height along section 1

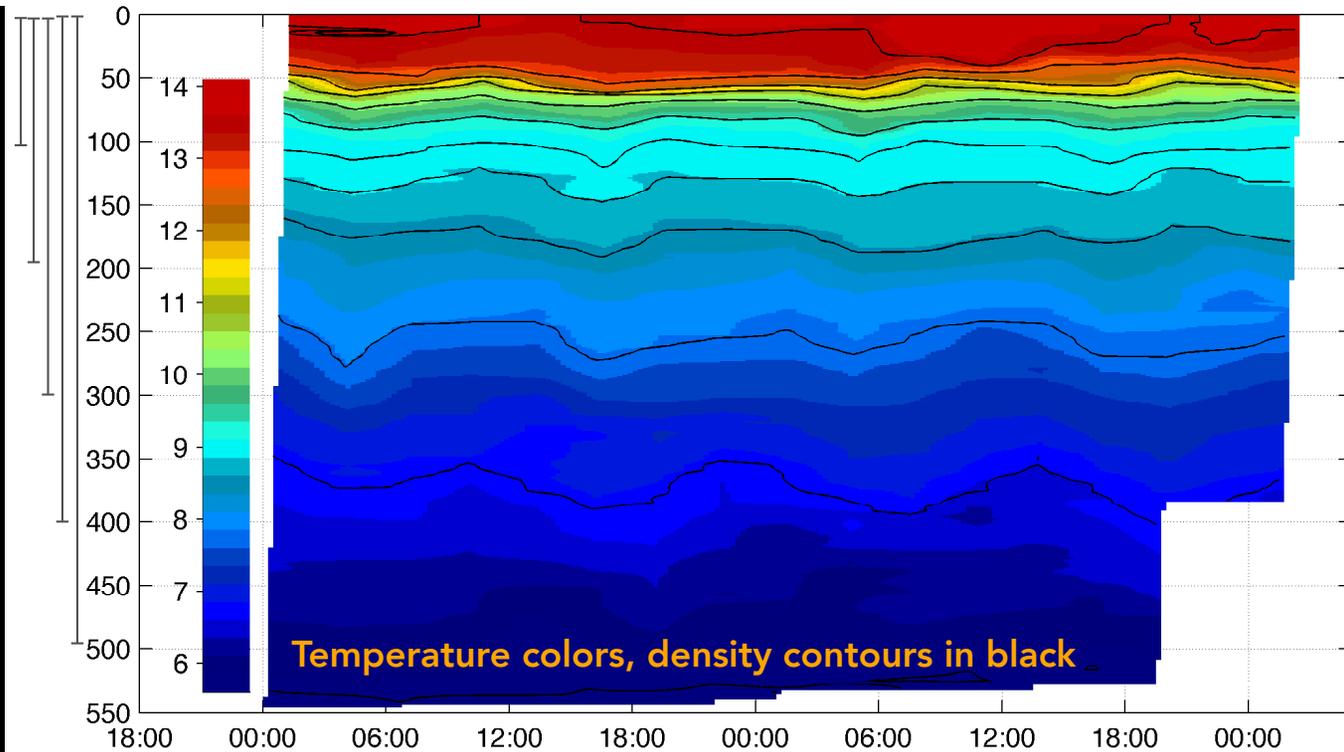
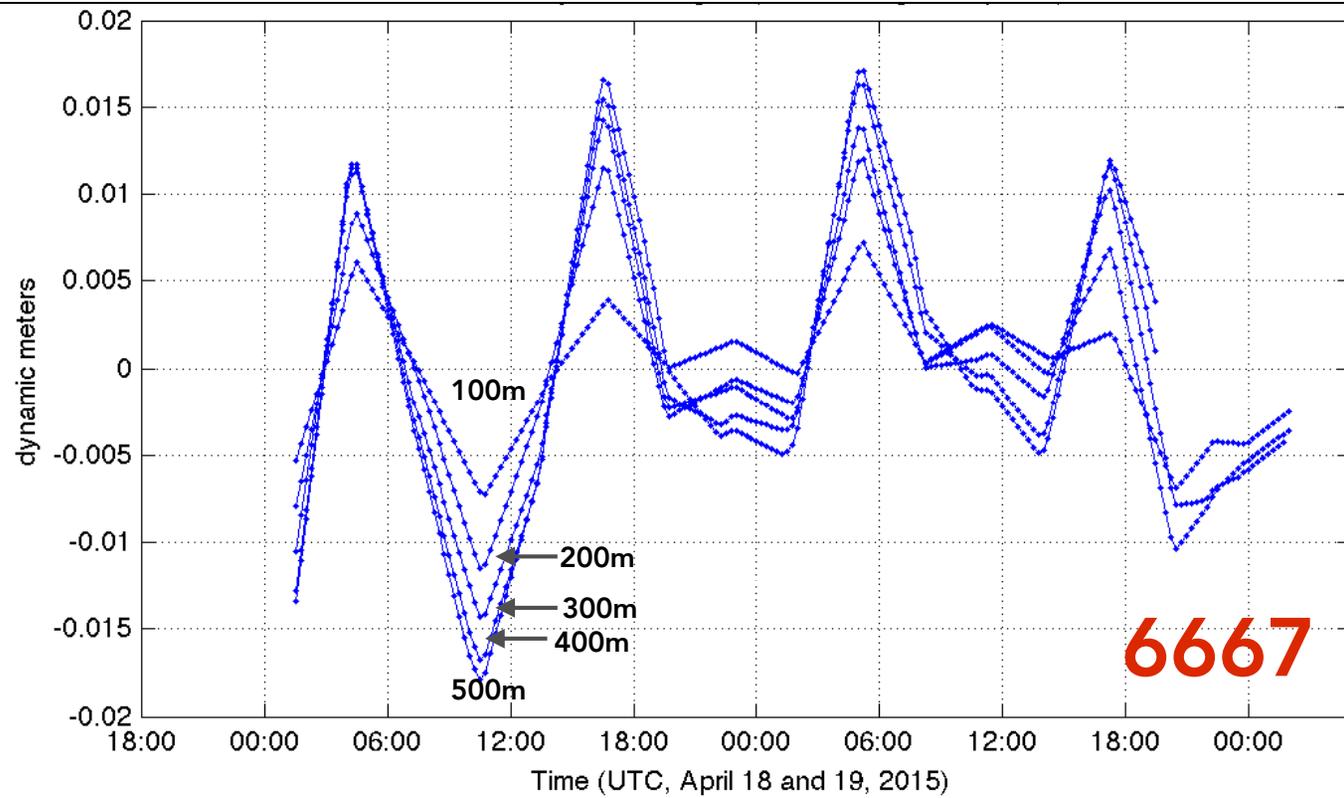




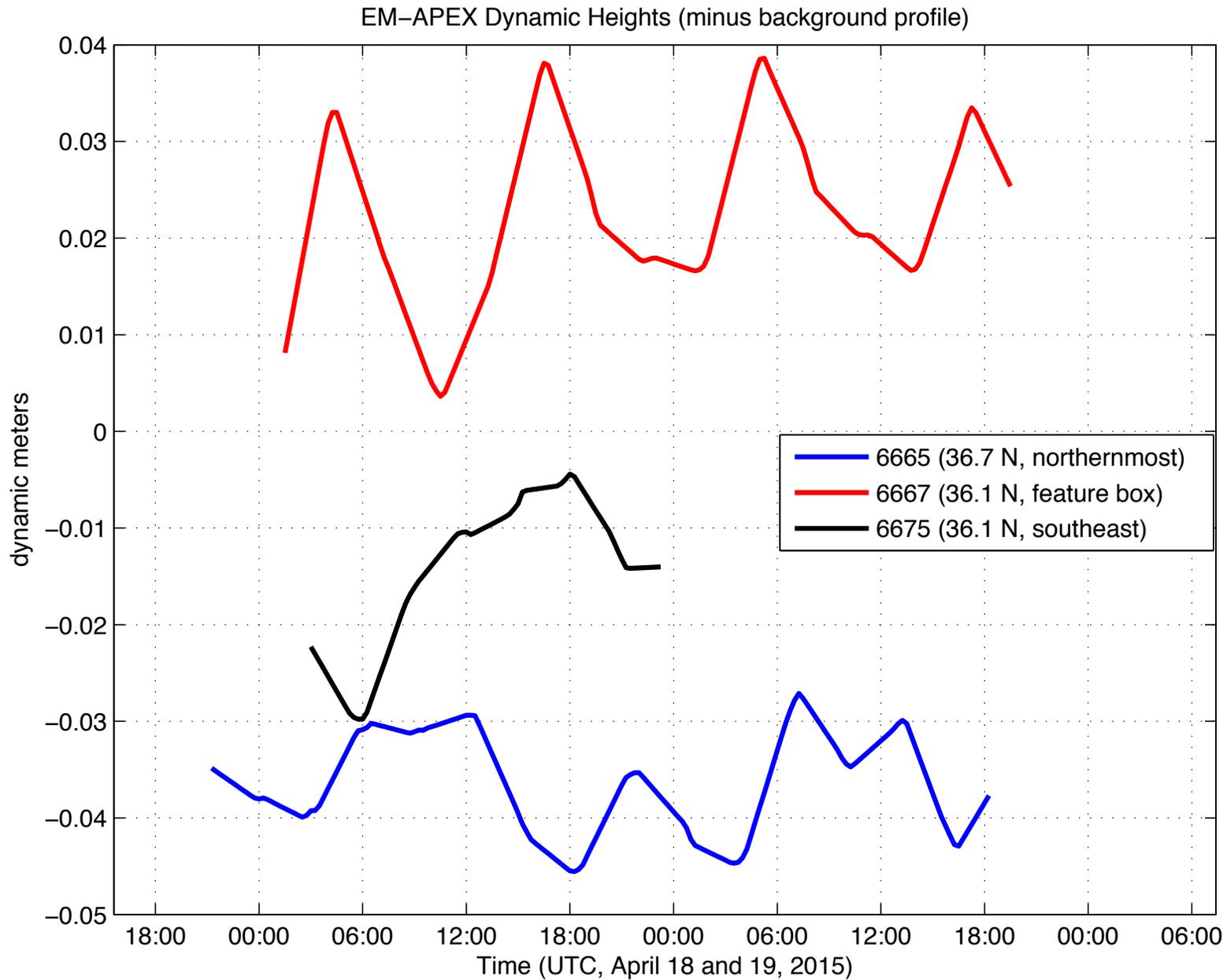
# EM-APEX

## Dynamic Height Amplitude vs. Integration Depth

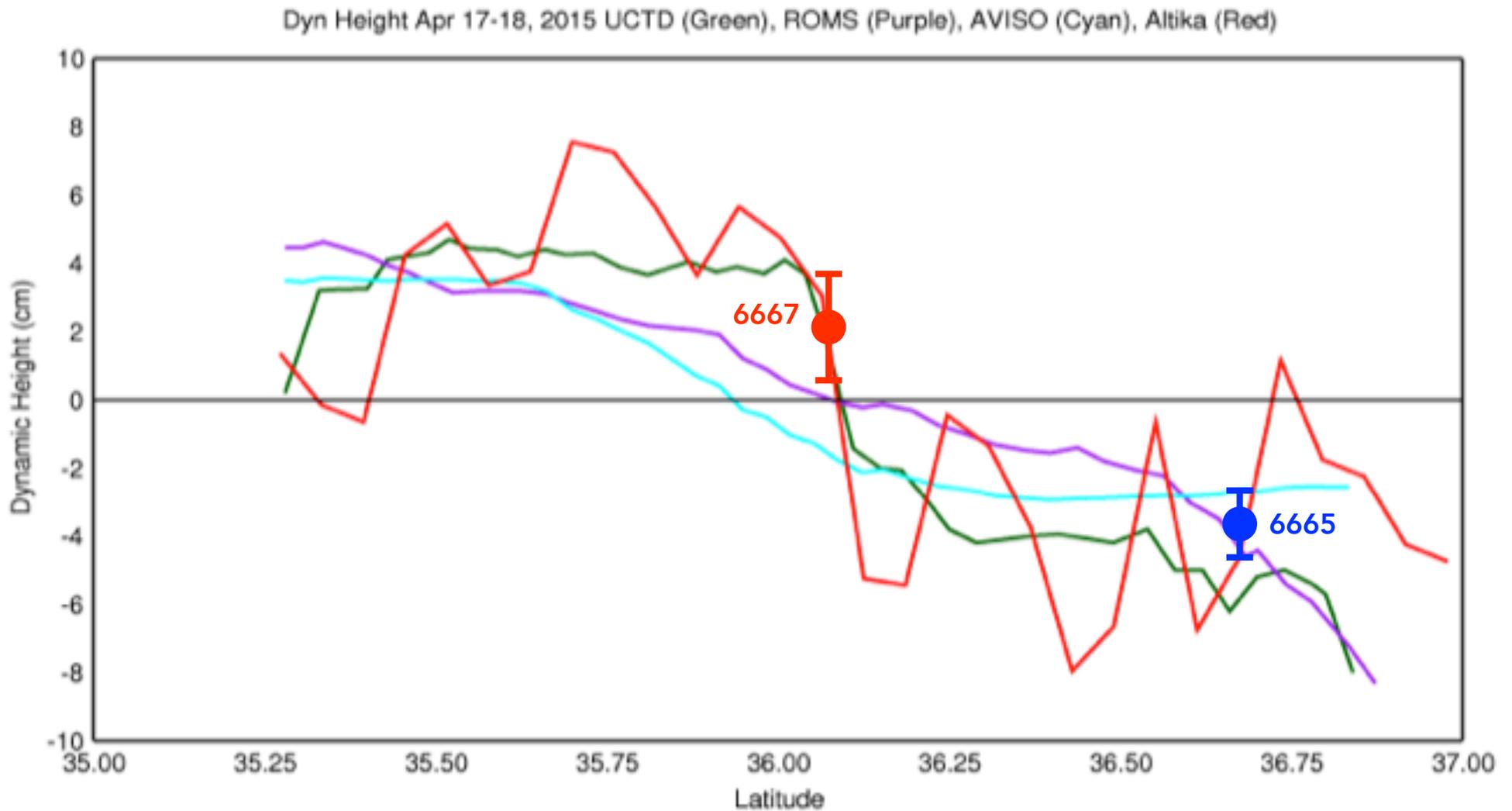
*(550m is max for  
resolving  
semidiurnal  
internal tides with  
3-hour sampling)*



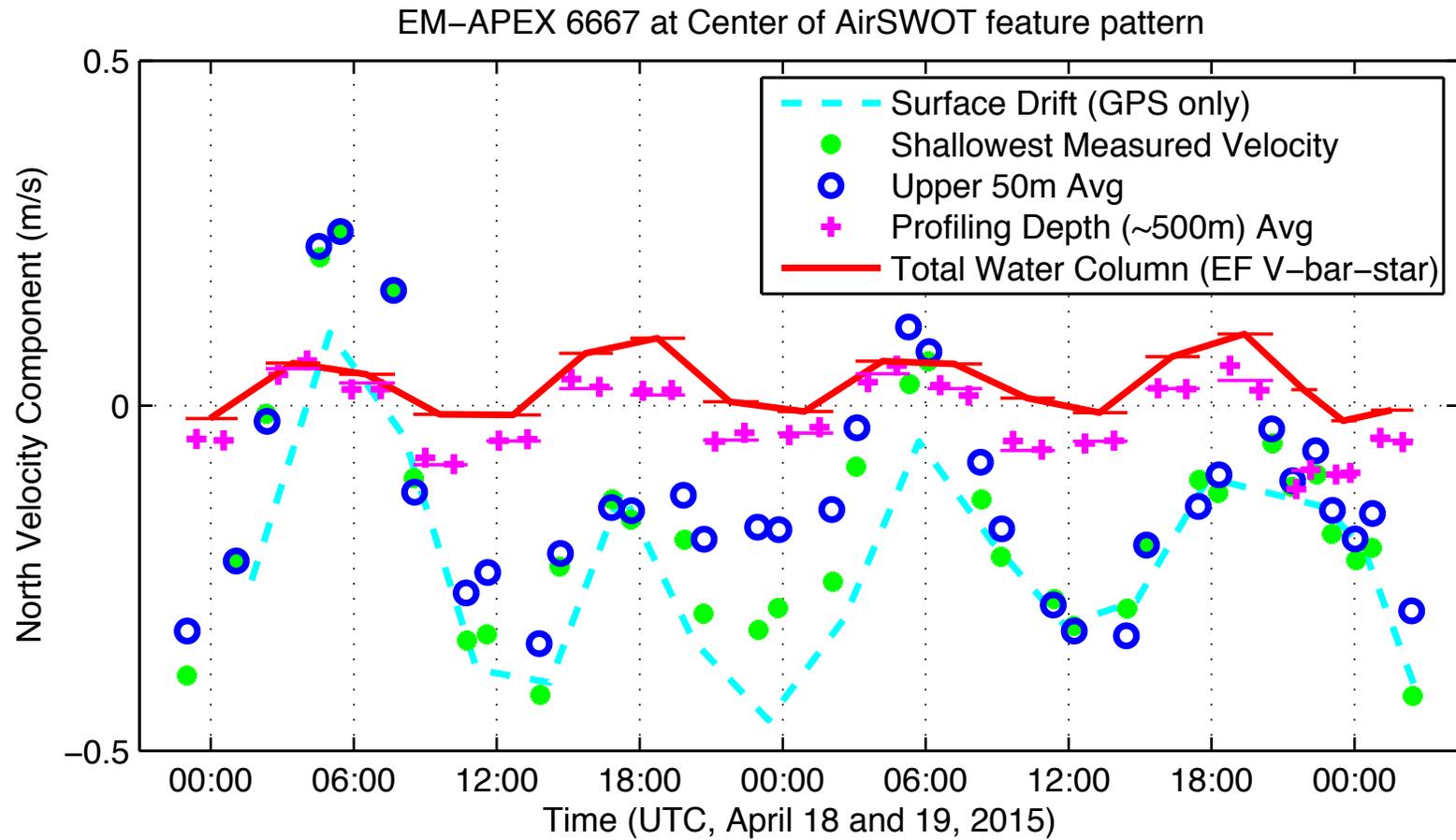
# EM-APEX Dynamic Height Timeseries



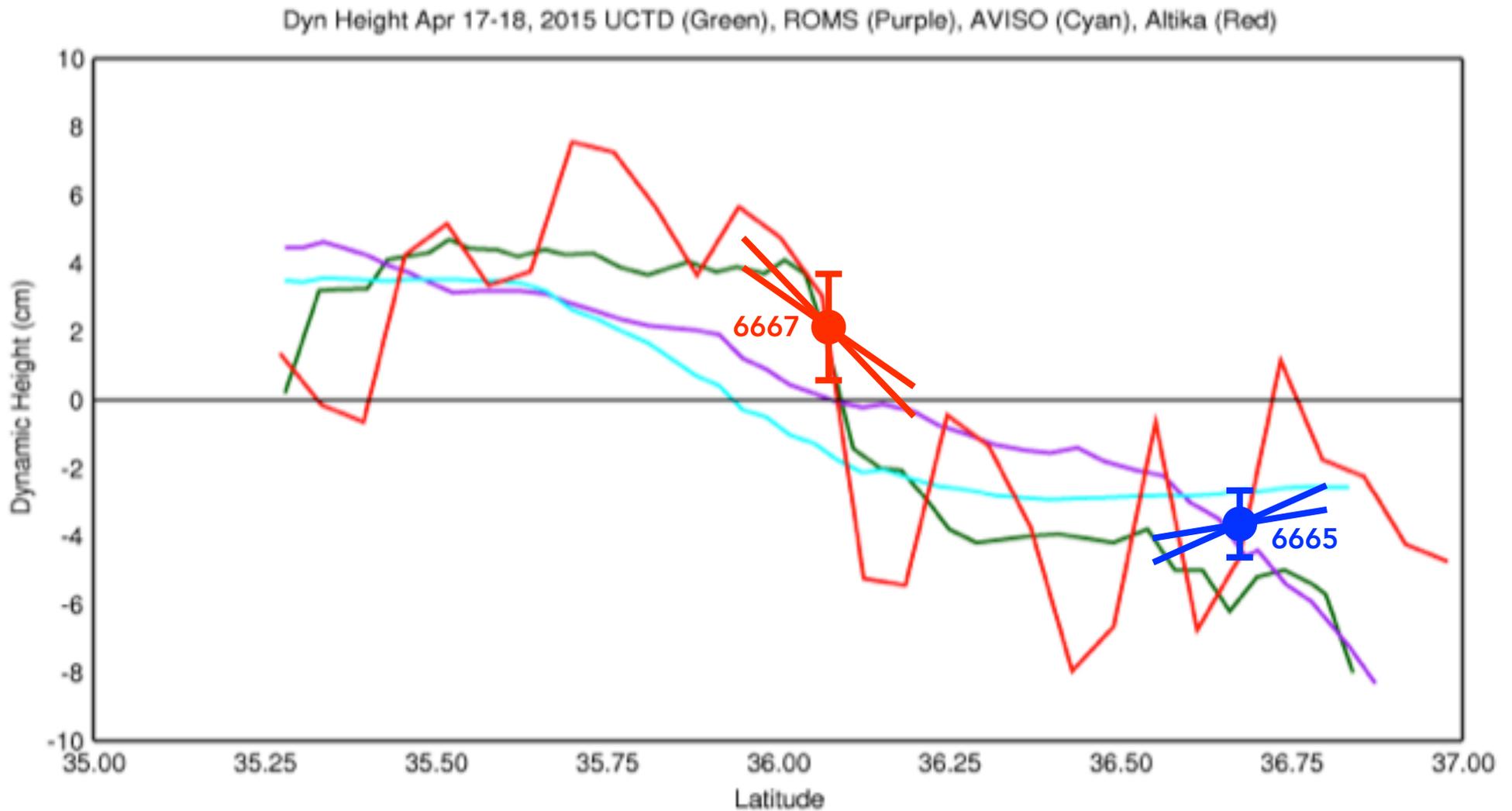
# Spatial transects plus *EM-APEX* timeseries range



*EM-APEX meridional velocity:  
Tidal and mean*



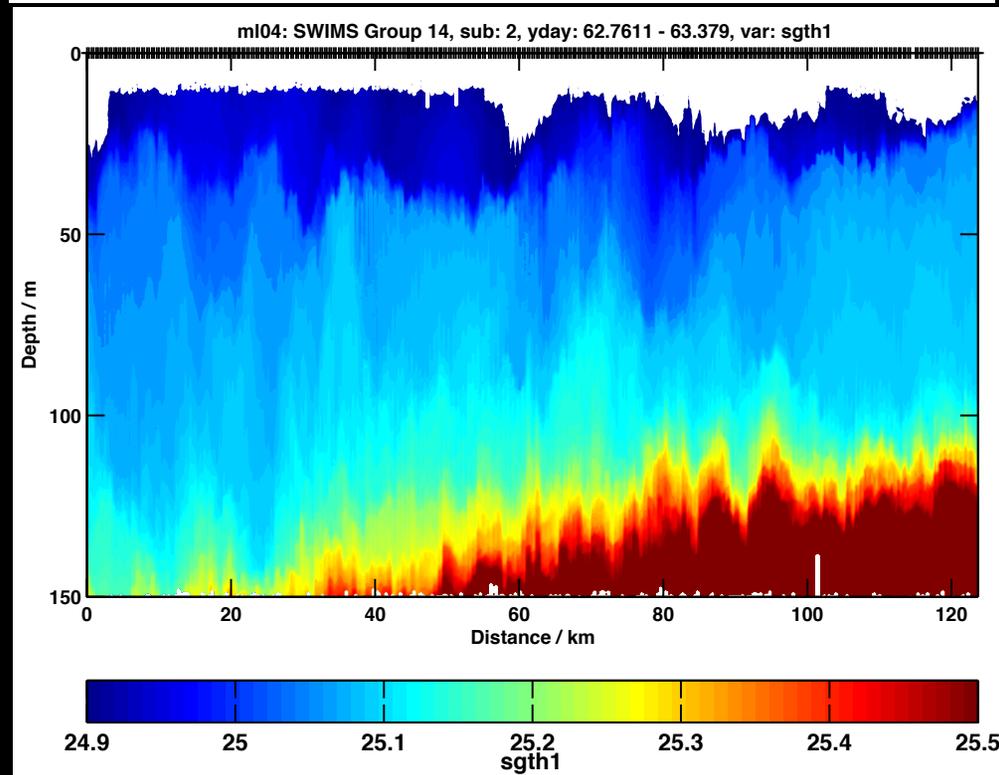
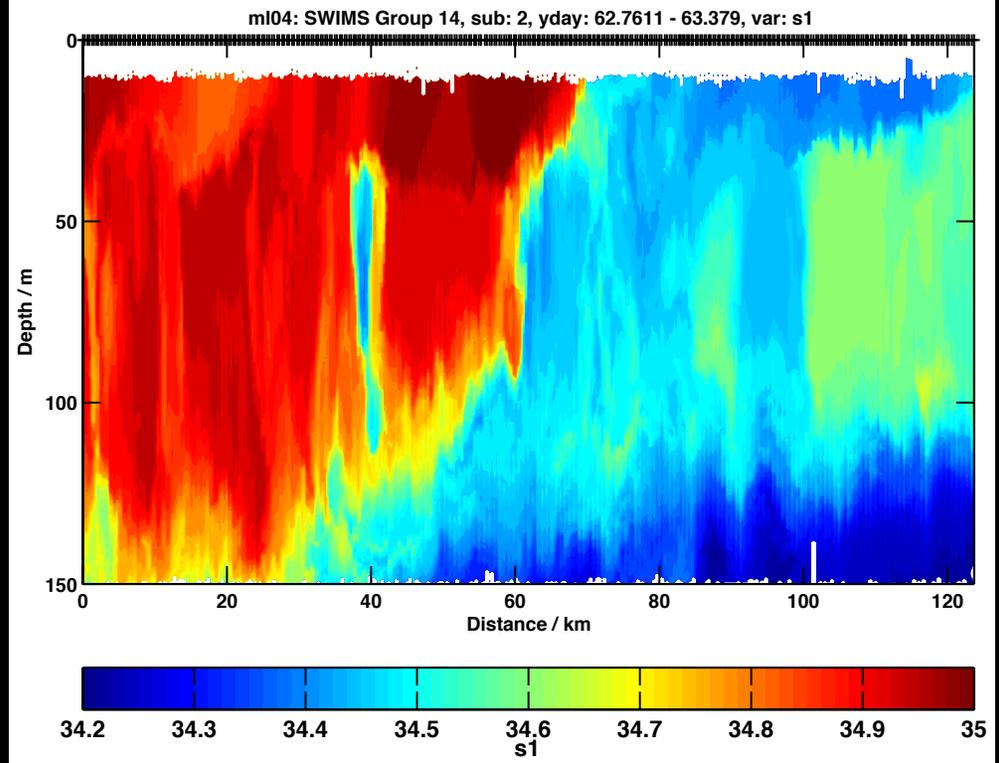
*EM-APEX surface slope from 2-day averaged perpendicular velocity component  
(range from surface drift, 5m, 50m average)*



# March 2017: Submesoscale Mixed-Layer Eddies experiment (SMILE)

*Girton, Kunze, Farrar, Mickett*

Tools: SWIMS towed profiler



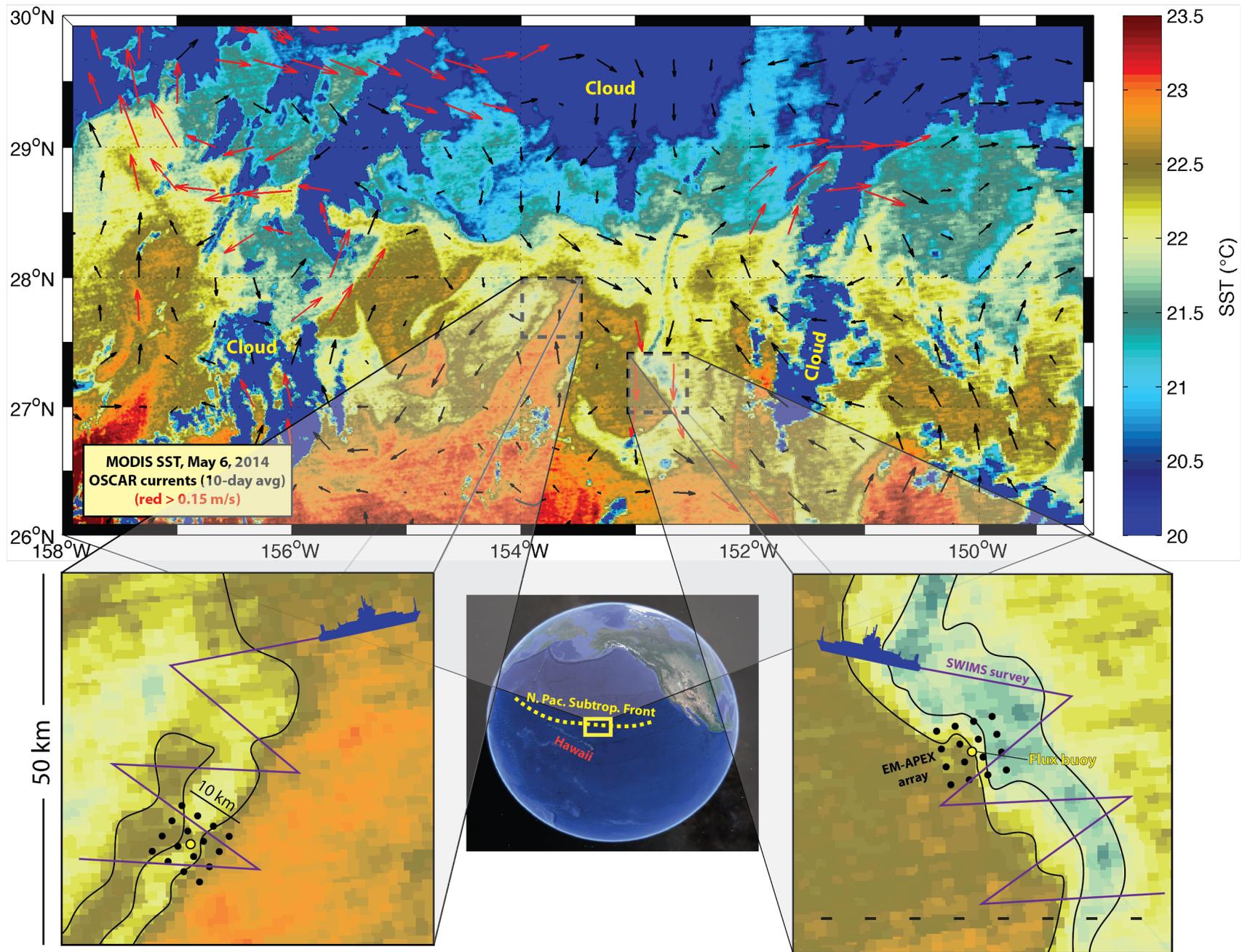
EM-APEX



Surface buoy



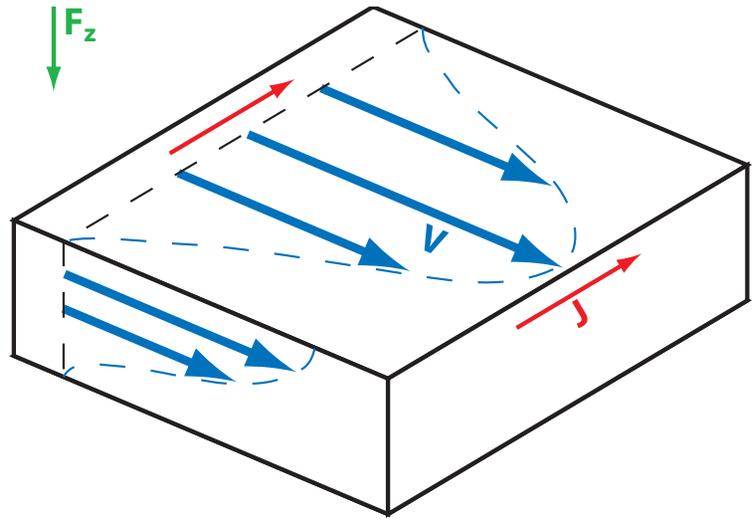
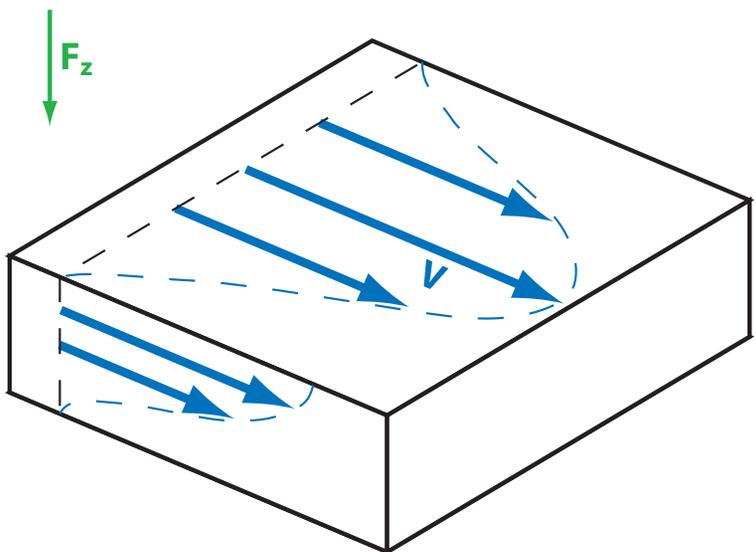
# SMILE Location: North Pacific Subtropical Front



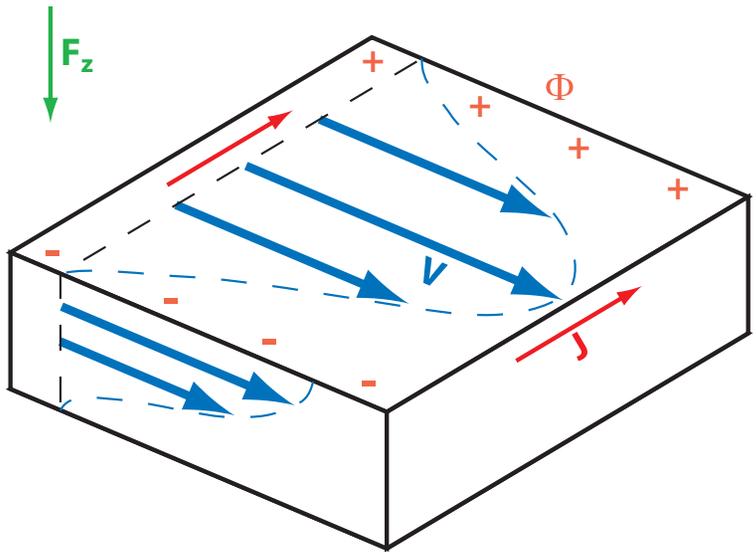
THANKS!

ADDITIONAL SLIDES...

Measuring Ocean Currents through Motional Electromagnetic Induction (thanks to Tom Sanford!)

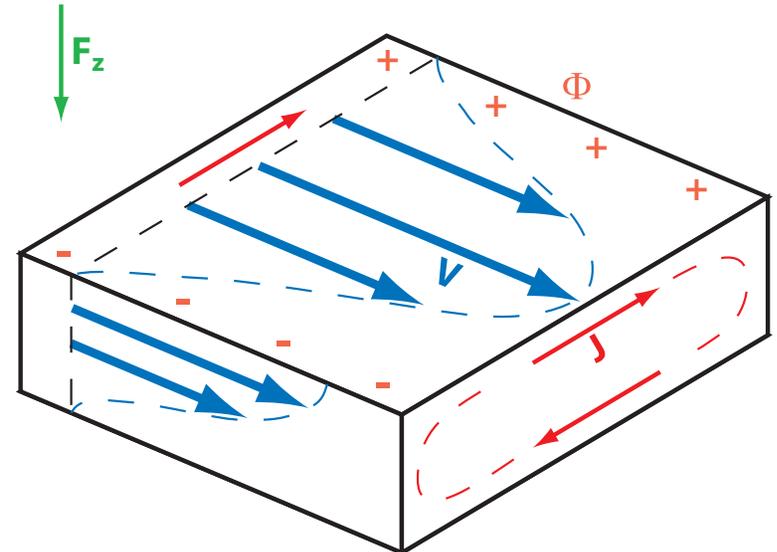


$$\mathbf{J} = \sigma(\mathbf{v} \times \mathbf{F})$$



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$$\nabla_h \Phi = F_z \bar{v}^*$$



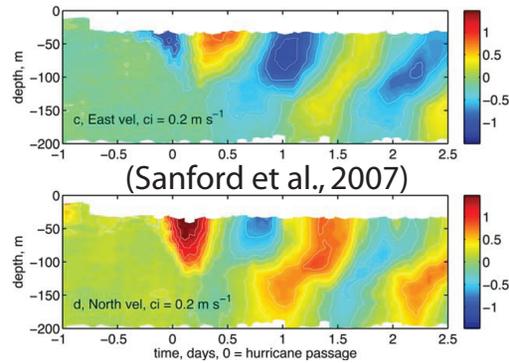
$$\mathbf{J} = \sigma(\mathbf{v} \times \mathbf{F} - \nabla \Phi)$$

$$\nabla_h \Phi = F_z \bar{v}^*$$

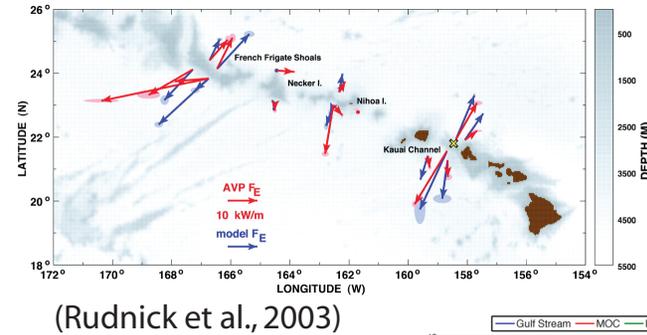
# EF velocity has unique sampling capabilities

Fast deployments/surveys, harsh conditions, sustained measurements

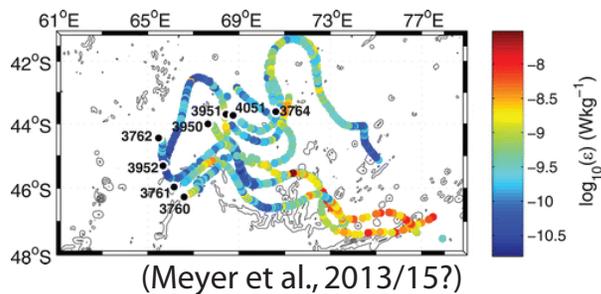
## Inertial waves from hurricanes



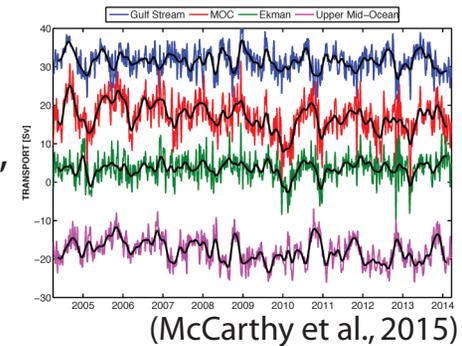
## Generation of internal tides



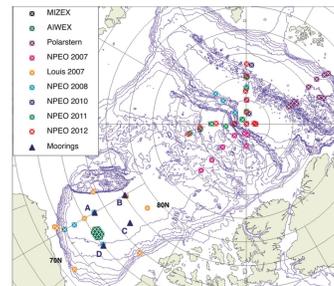
## Mixing timeseries in Southern Ocean



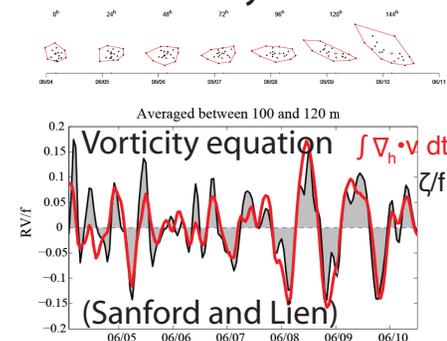
30+ years of Florida Current, AMOC studies



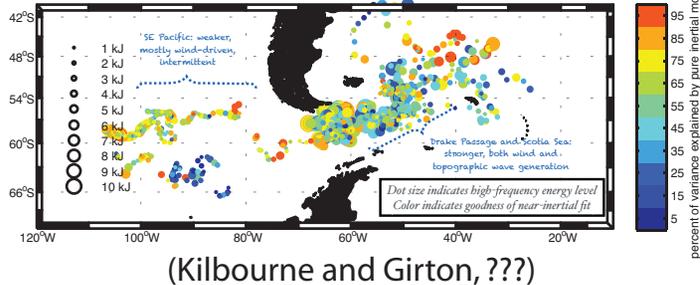
## Under ice sampling



## Synchronous array, submesoscale dynamics

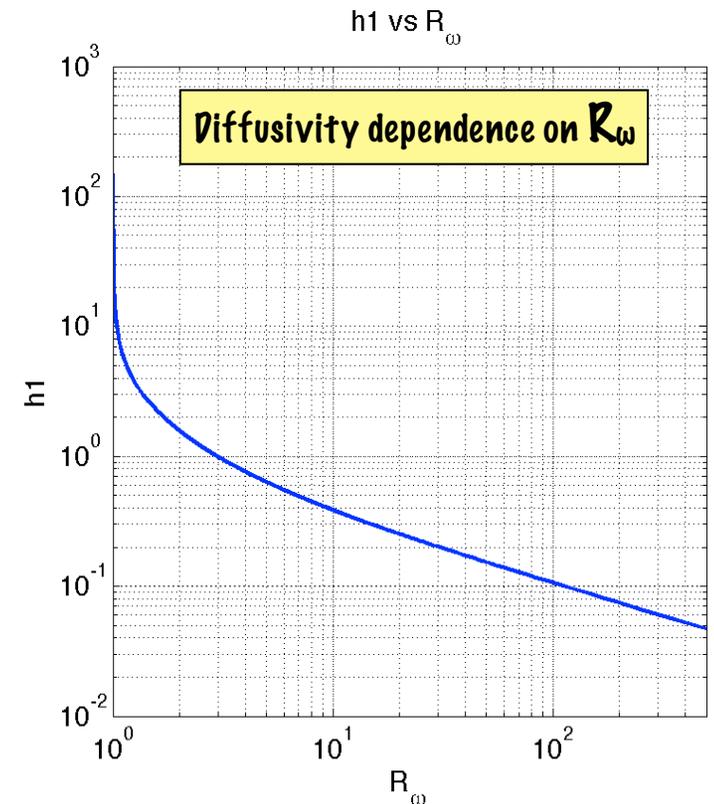
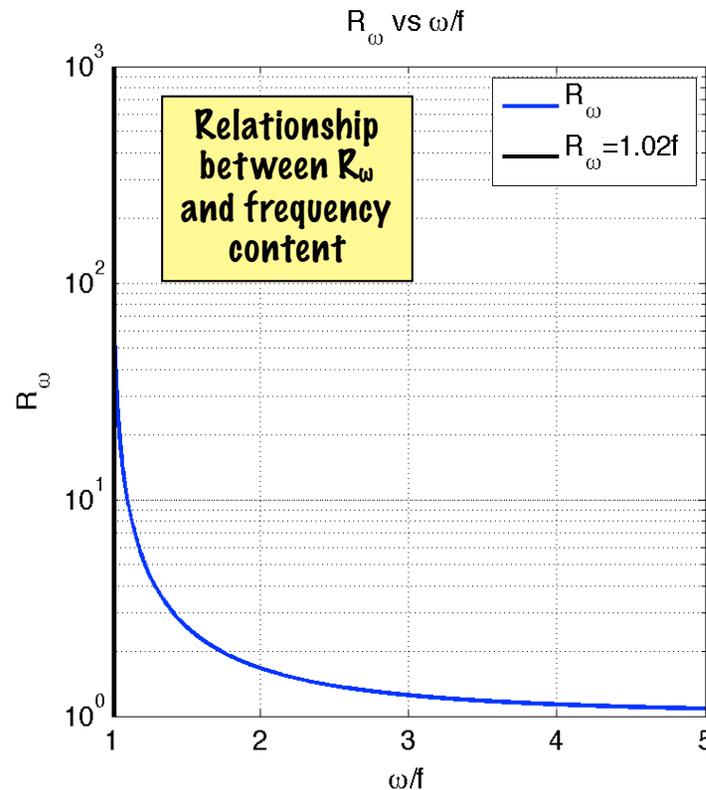
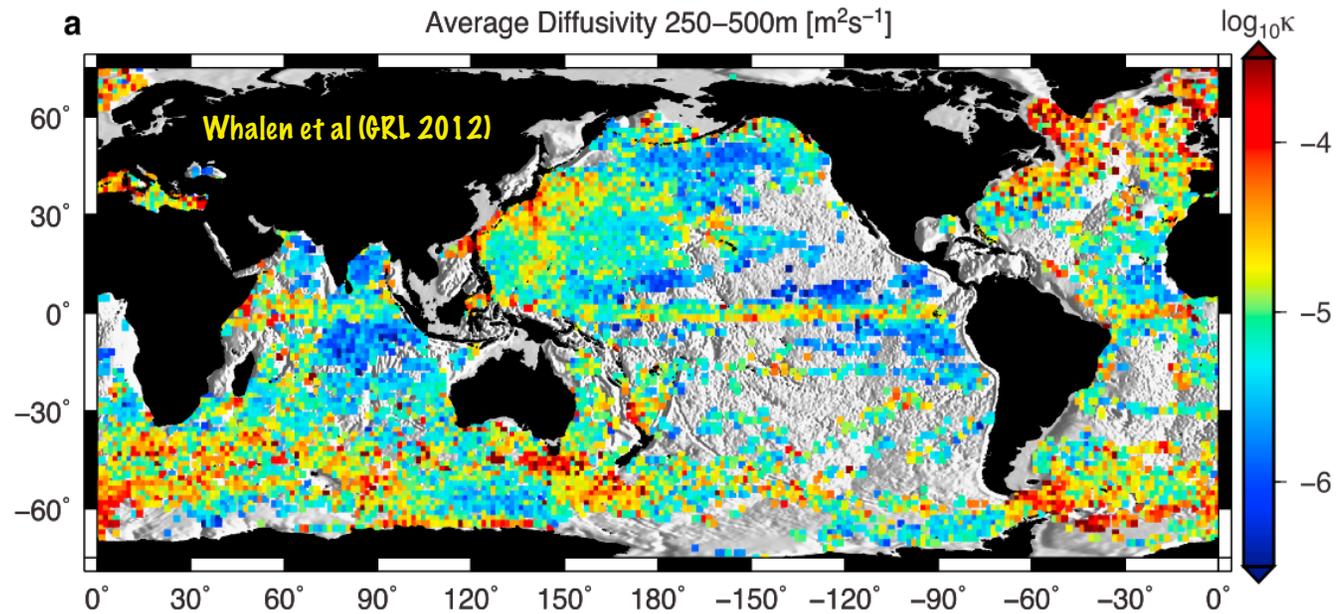


## NEAR-INERTIAL VELOCITY VARIABILITY (UPPER 1500 M AVERAGE) FROM ALL EM-APEX PROFILE PAIRS IN DIMES



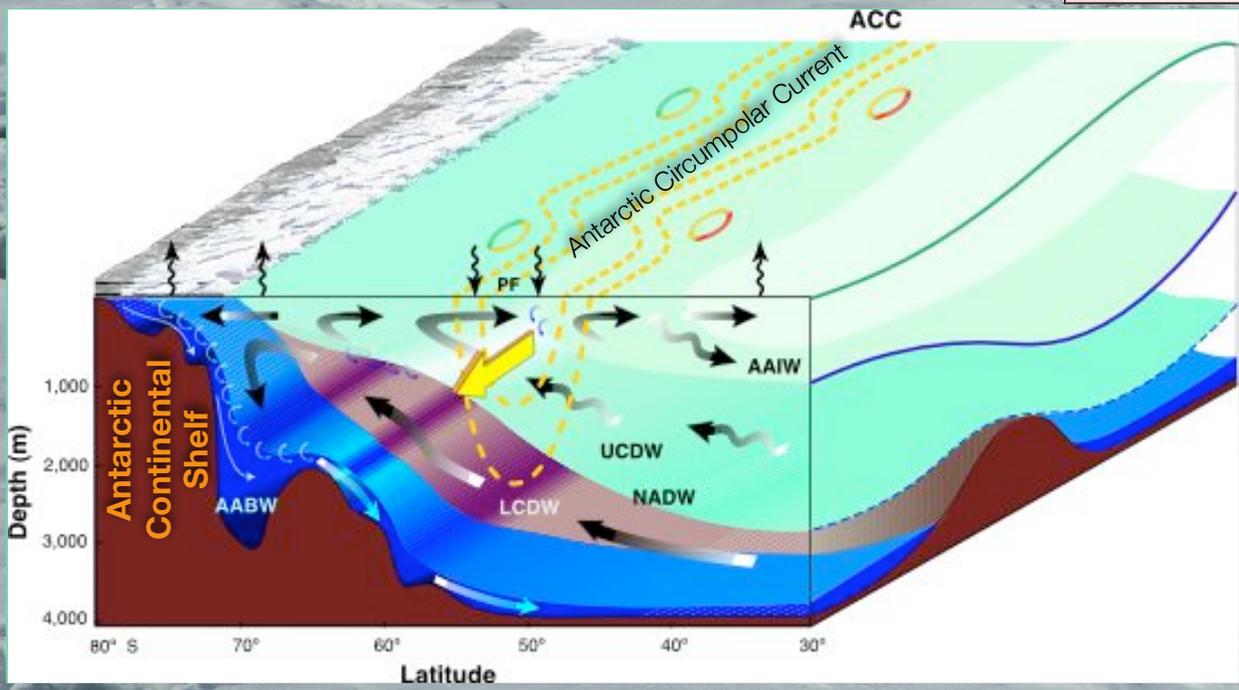
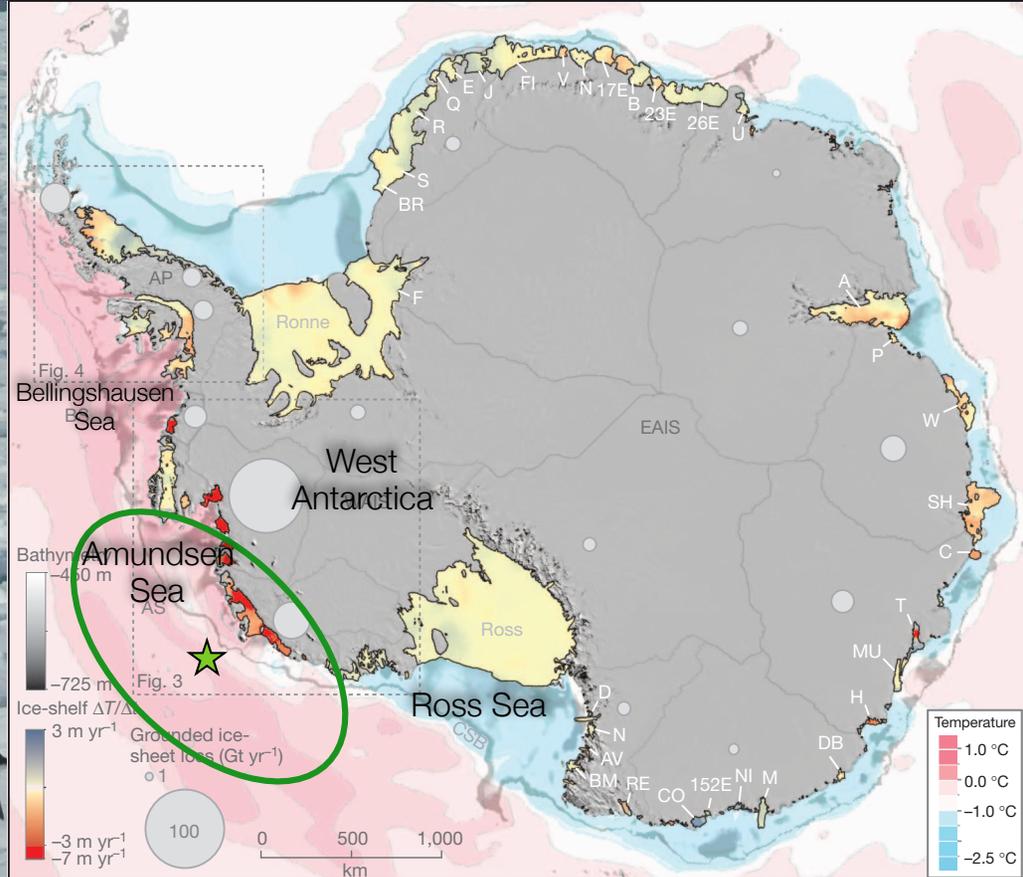
# Finestructure Diffusivity Sensitivity

- Often substantial shear comes from near-inertial waves (low frequency)
- Shear-to-strain ratio ( $R_\omega$ ) likely varies on multiple time and space scales (e.g., seasonally or pulses linked to individual storms)
- Finestructure diffusivity depends on the frequency content of the wavefield through the function  $h1$  (plotted at right)



# Motivation: Antarctic ice sheets in jeopardy

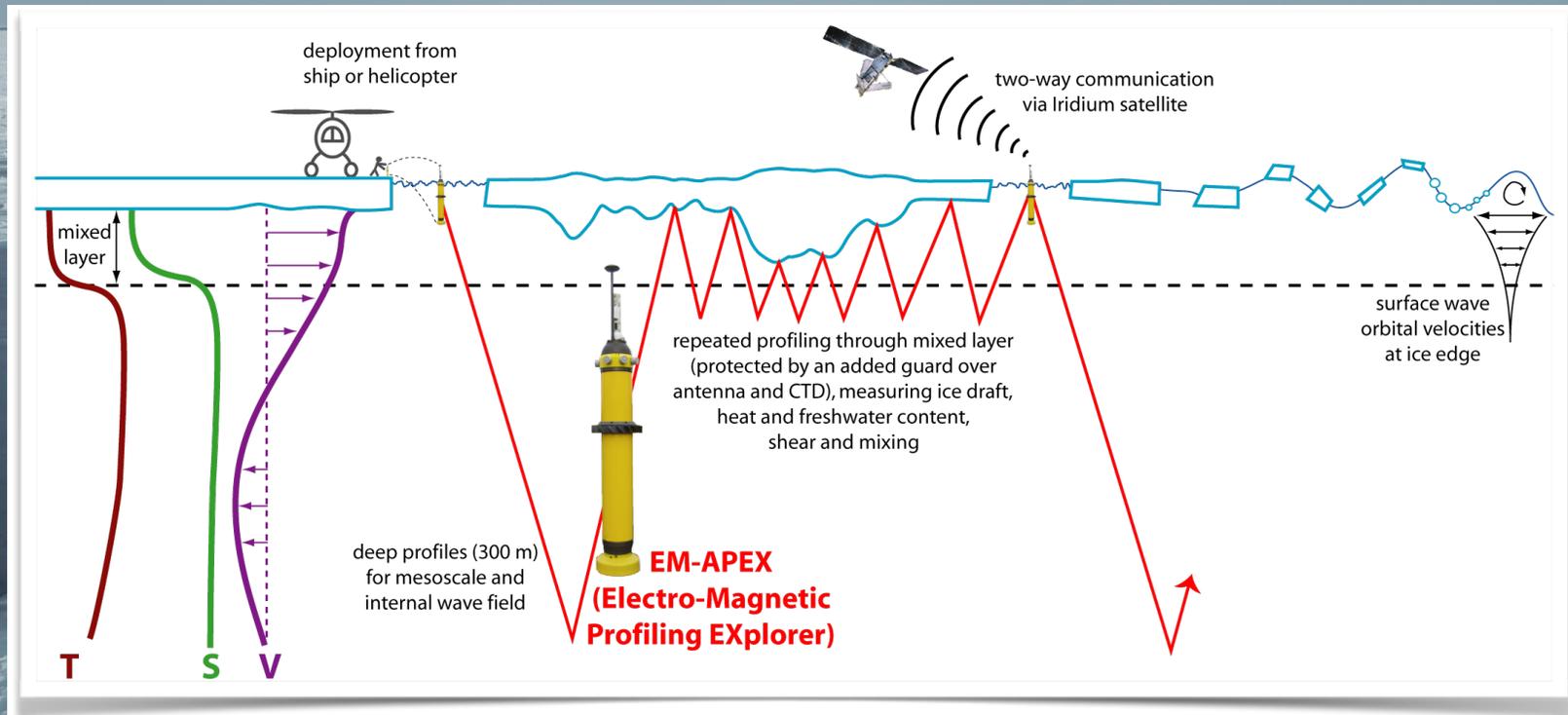
- Amount of warm Circumpolar Deep Water (CDW) on the continental shelf influences ice shelf melting rate
- Ocean-Shelf exchange has elements of the classical Eastern Boundary Upwelling problem



- Regional (West Antarctic) sea-ice reduction contrasts with overall Antarctic sea-ice extent
- Bottom limb of the Meridional Overturning Circulation (MOC) depends on shelf circulation and mixing processes

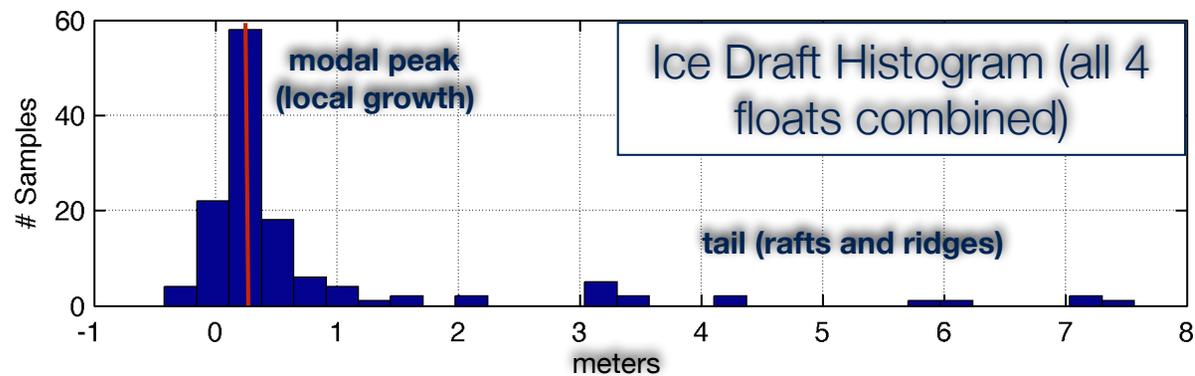
# Autonomous Measurements in the Seasonal Ice Zone

- Need for an economical approach to sustained timeseries and trajectory measurements
- Profiling floats are easily added to other work (station turnovers, surveys) and are robust enough for ice.
- EM-APEX adds velocity measurement (and now Temperature Microstructure) and magnetometer.



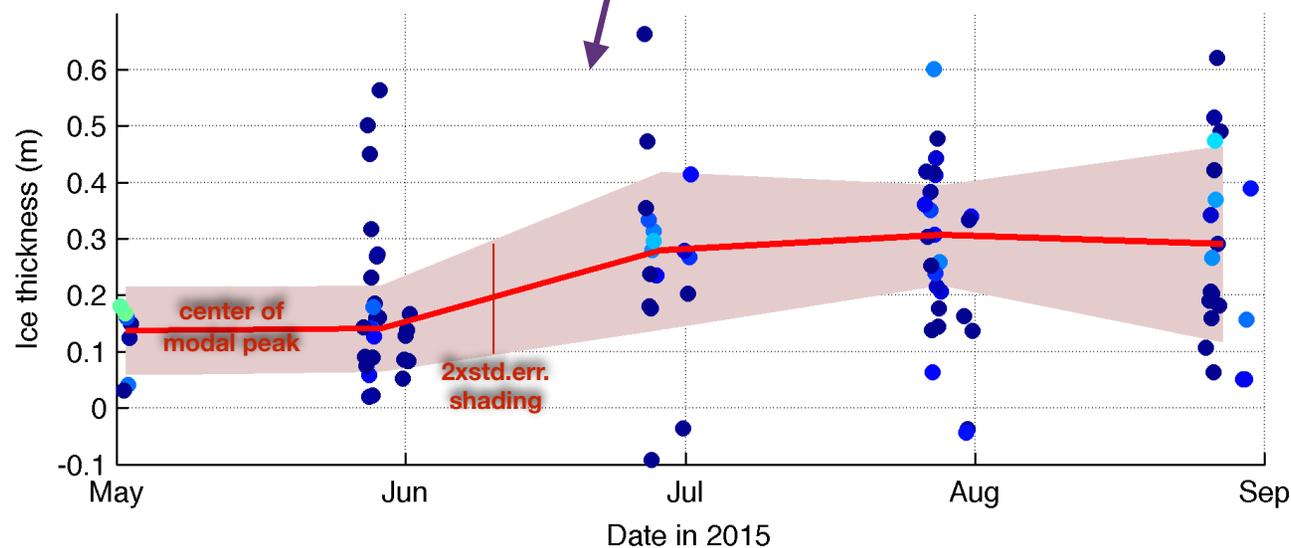
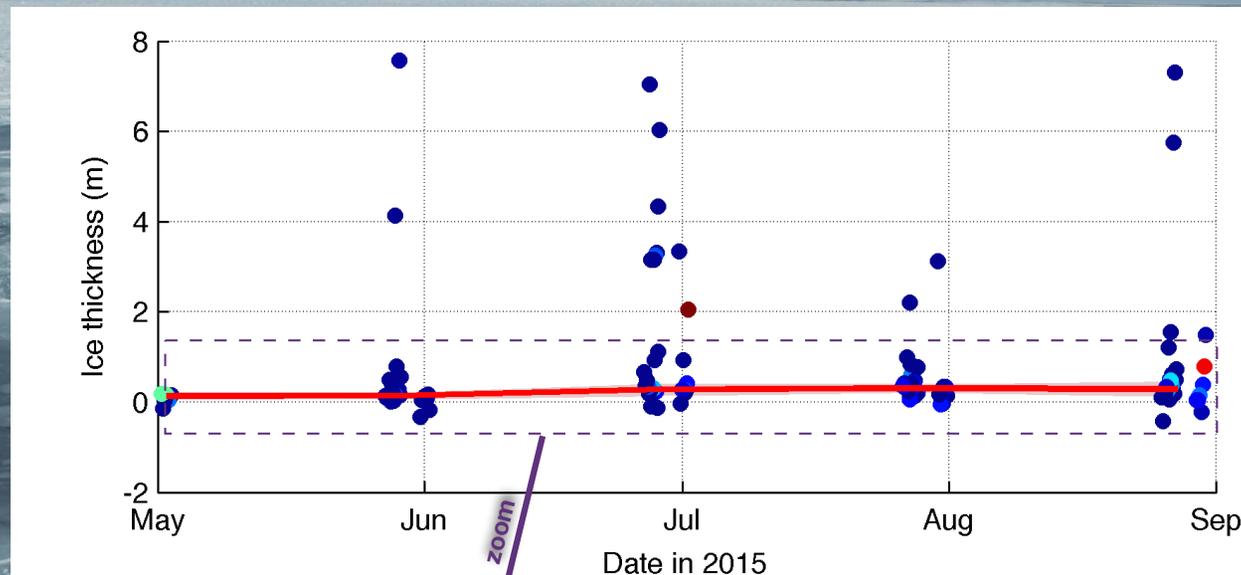
# Sea-ice Results

(wintertime, aggregate of 4 floats north of Antarctic slope)



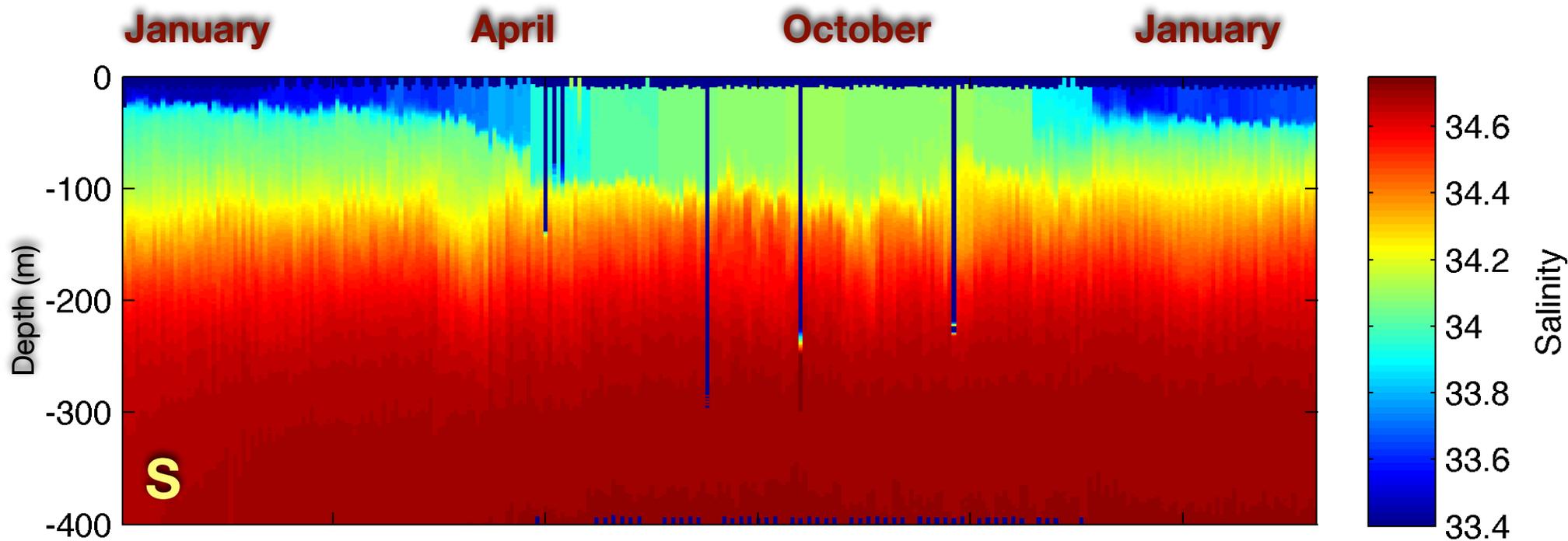
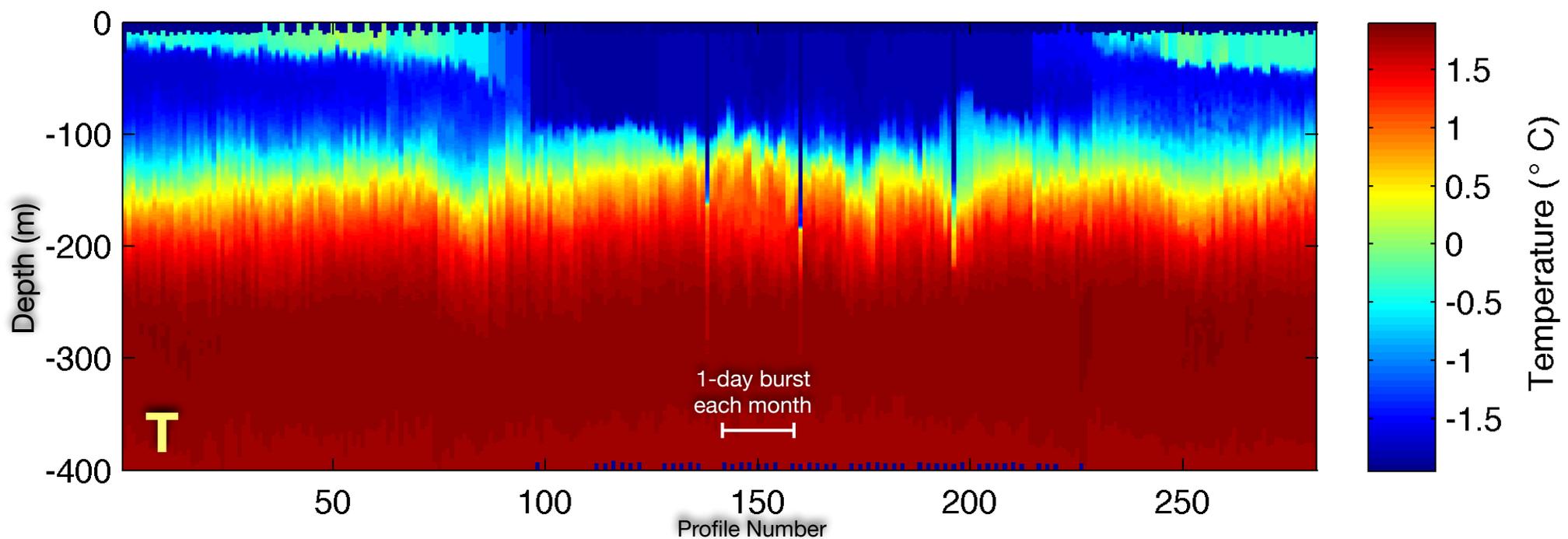
## Ice thickness distribution

contains a mode around 10-30cm (local growth) and a long tail out to 8m (rafts and pressure ridges)

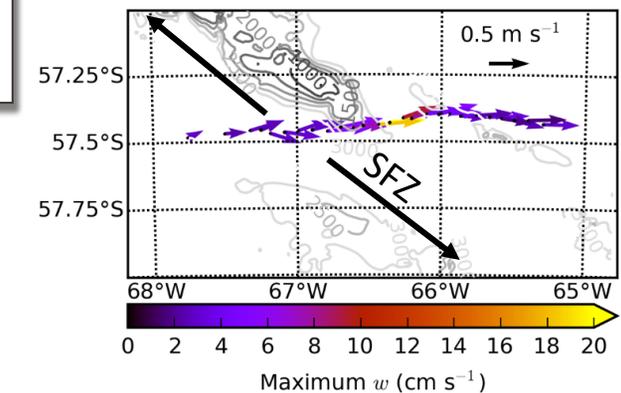
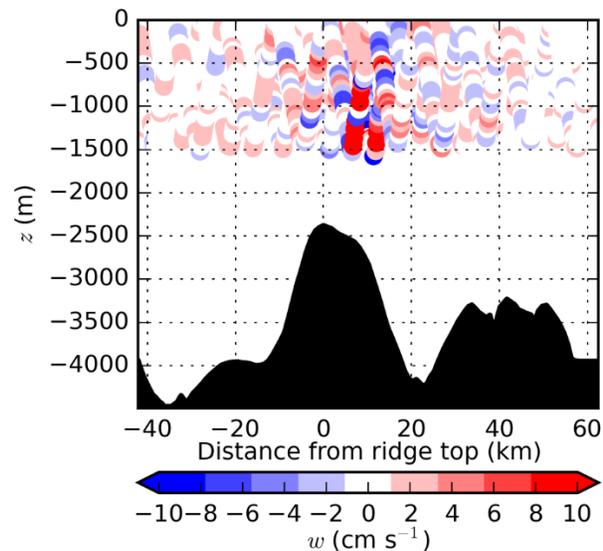
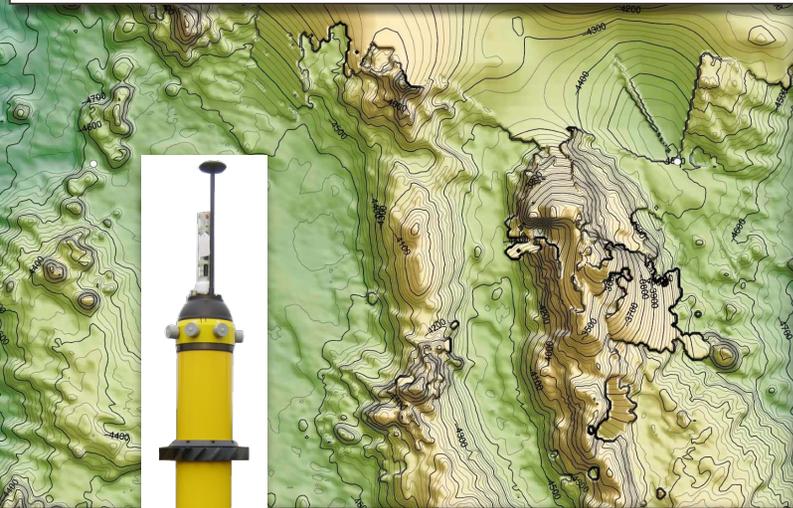


Seasonal growth is apparent in the modal peak

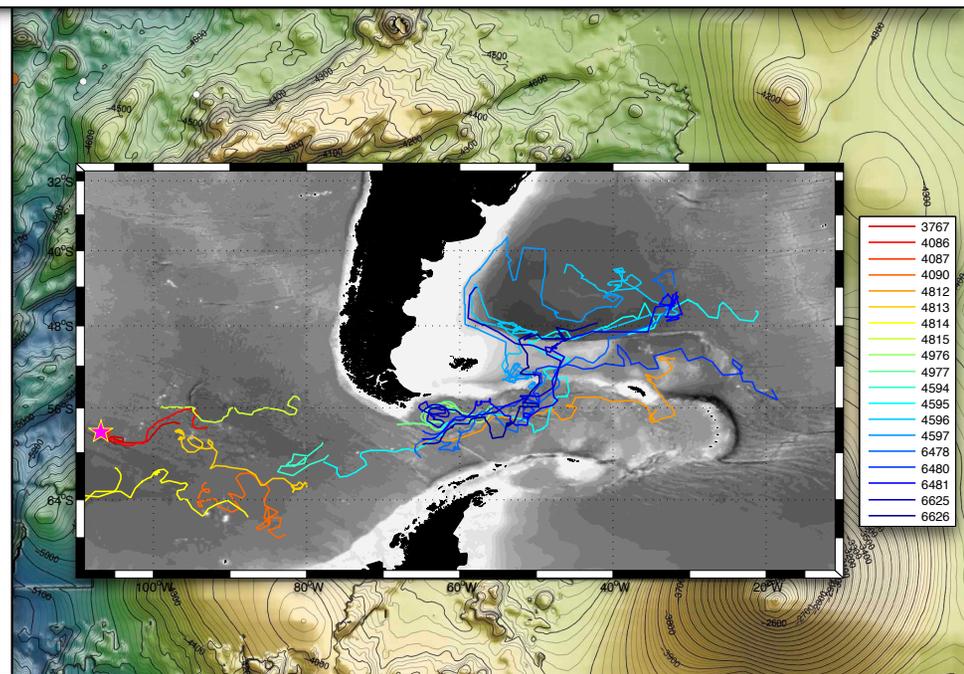
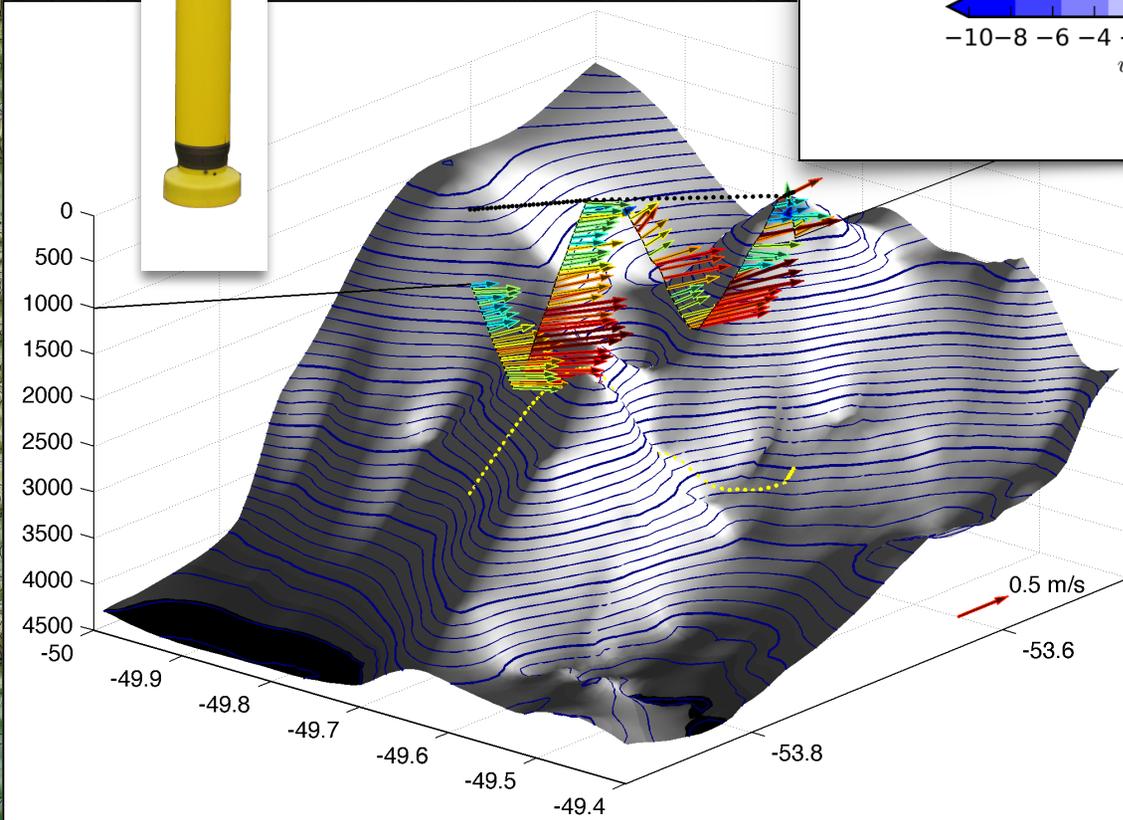
# Year-Round T and S



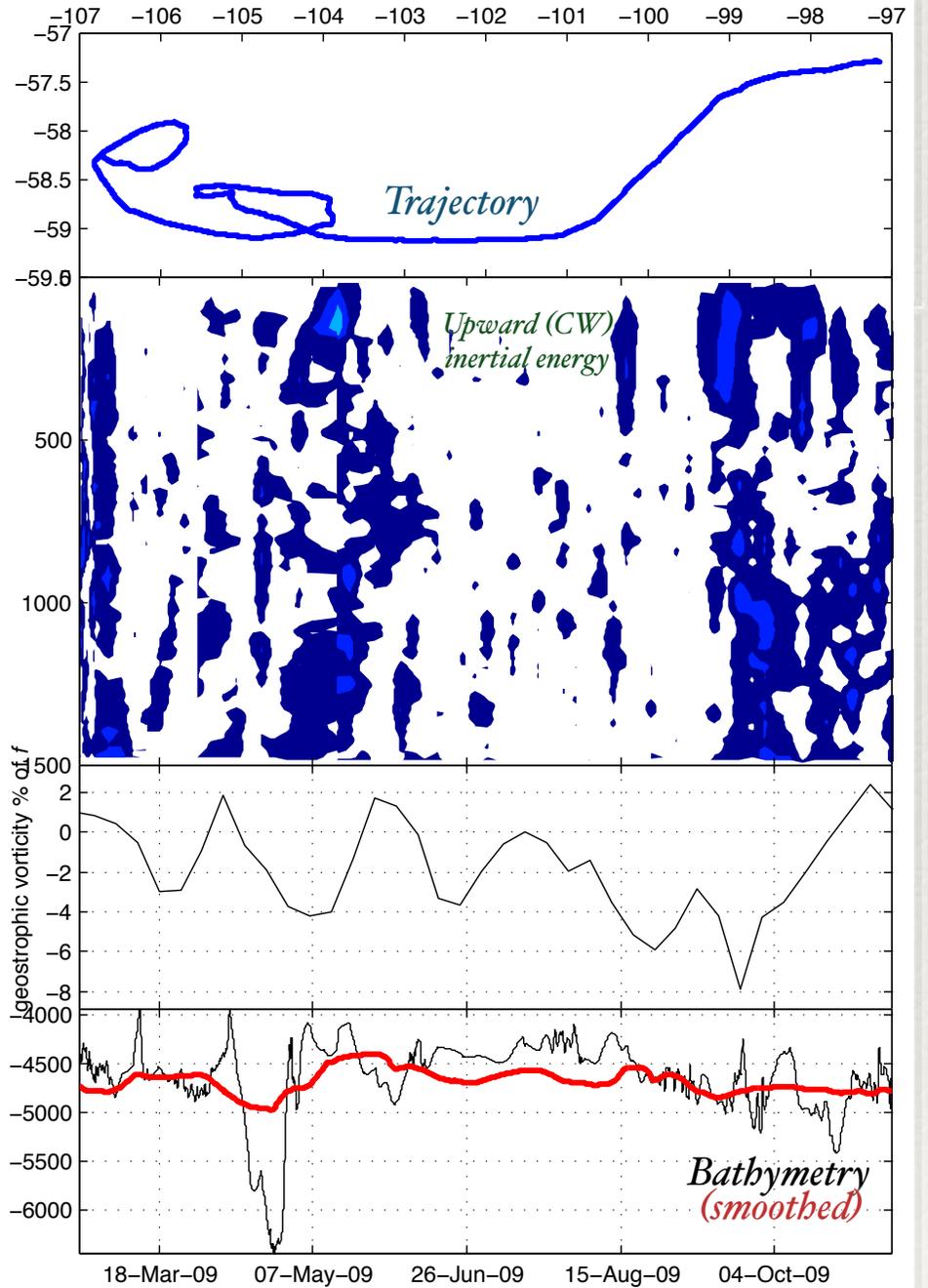
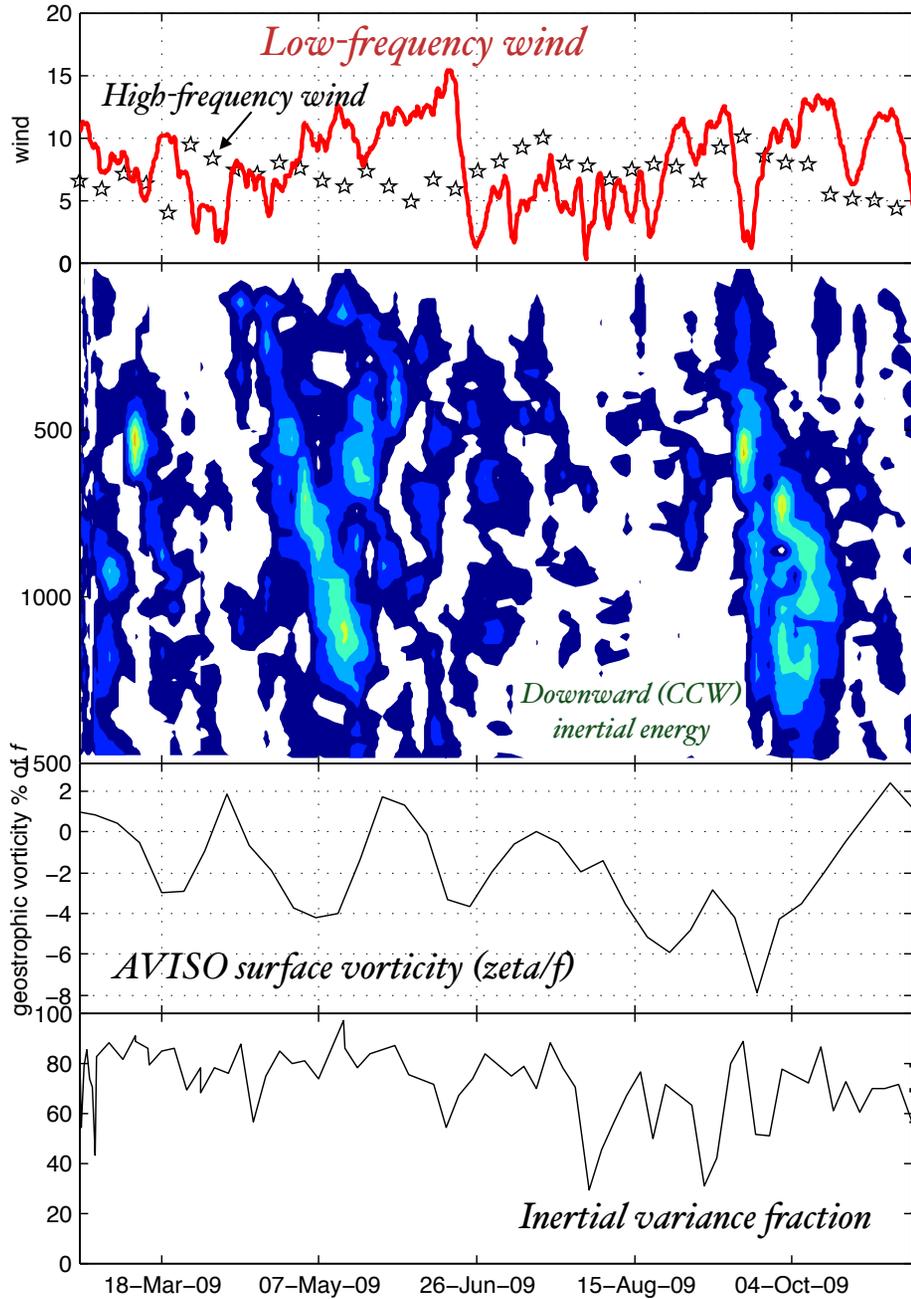
# TOPOGRAPHIC LEE WAVES OBSERVED BY EM-APEX PROFILING FLOATS IN THE SOUTHERN OCEAN



- Vertical water motion reversed the direction of float motion on several occasions.
- Maxima occur in the lee of a Shackleton Fracture Zone ridge.



3767



# NEAR-INERTIAL VELOCITY VARIABILITY FROM ALL EM-APEX PROFILE PAIRS IN DIMES (UPPER 1500 M INTEGRAL)

