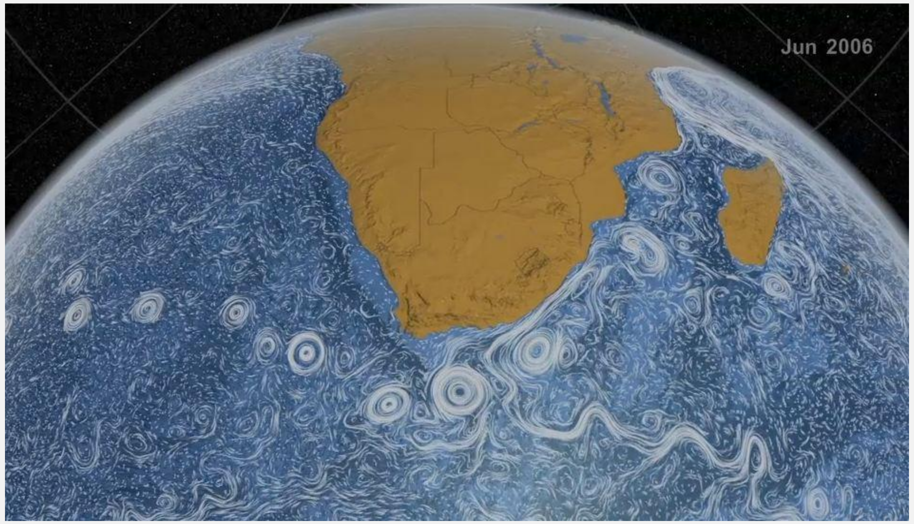
Spatial and temporal scales of chl-a variability in the SAZ using a glider

Hazel Little
Supervisors: Sandy Thomalla, Sebastiaan Swart, Marcello Vichi
University of Cape Town

Introduction

- Southern Ocean is important zone for the biological carbon pump.
- Phytoplankton have high temporal and spatial variability in the SAZ.
- Patchy as a result of small scale drivers.
- High-resolution sampling is required to understand phytoplankton variability and estimate primary production.
- Issues with gliders and their quasi-Lagrangian sampling.
- Mesoscale = 11 – 25 days, 10 – 100 km
- Submesoscales = 2 – 10 days, 1 – 10 km



Aims

Temporal Analysis

1. How much of the observed variability is seasonal, mesoscale and submesoscale?
2. Does the variability change seasonally?
3. How do they relate to the physical drivers (wind and MLD)?
4. What scales must you sample at in order to resolve the variability of the seasonal cycle?

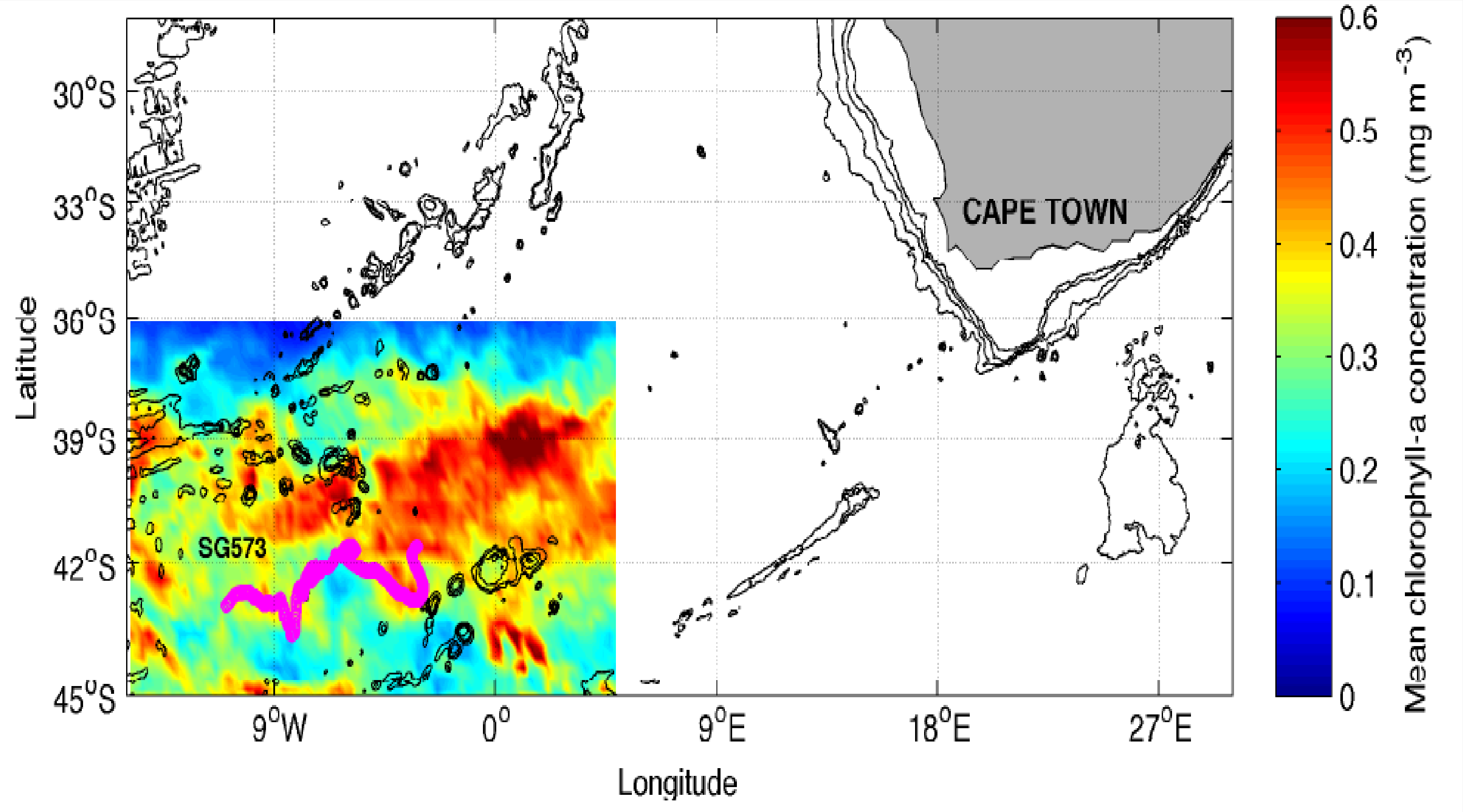
Spatial Analysis

1. How does the observed variation change with length scales in the SAZ?
2. Does the variability change seasonally?
3. To what extent is the variability that gliders measure due to spatial patchiness?

Data and Methods

Data

- A Seaglider (SG573) was deployed in the SAZ from spring 2012 to summer 2013 (5.5 months).
- Chl-a, particular organic carbon (POC) and mixed layer depth (MLD) all collect by the glider.
- Wind stress obtained from SeaWinds from QuickSCAT satellite.
- Ocean colour and sea surface temperature (SST) from MODIS Aqua.



Data and Methods

Methods

- Temporal variability was investigated with Empirical Mode Decomposition (EMD).
- Spatial variance was calculated at different length scales (Mahadevan and Campbell, 2002).

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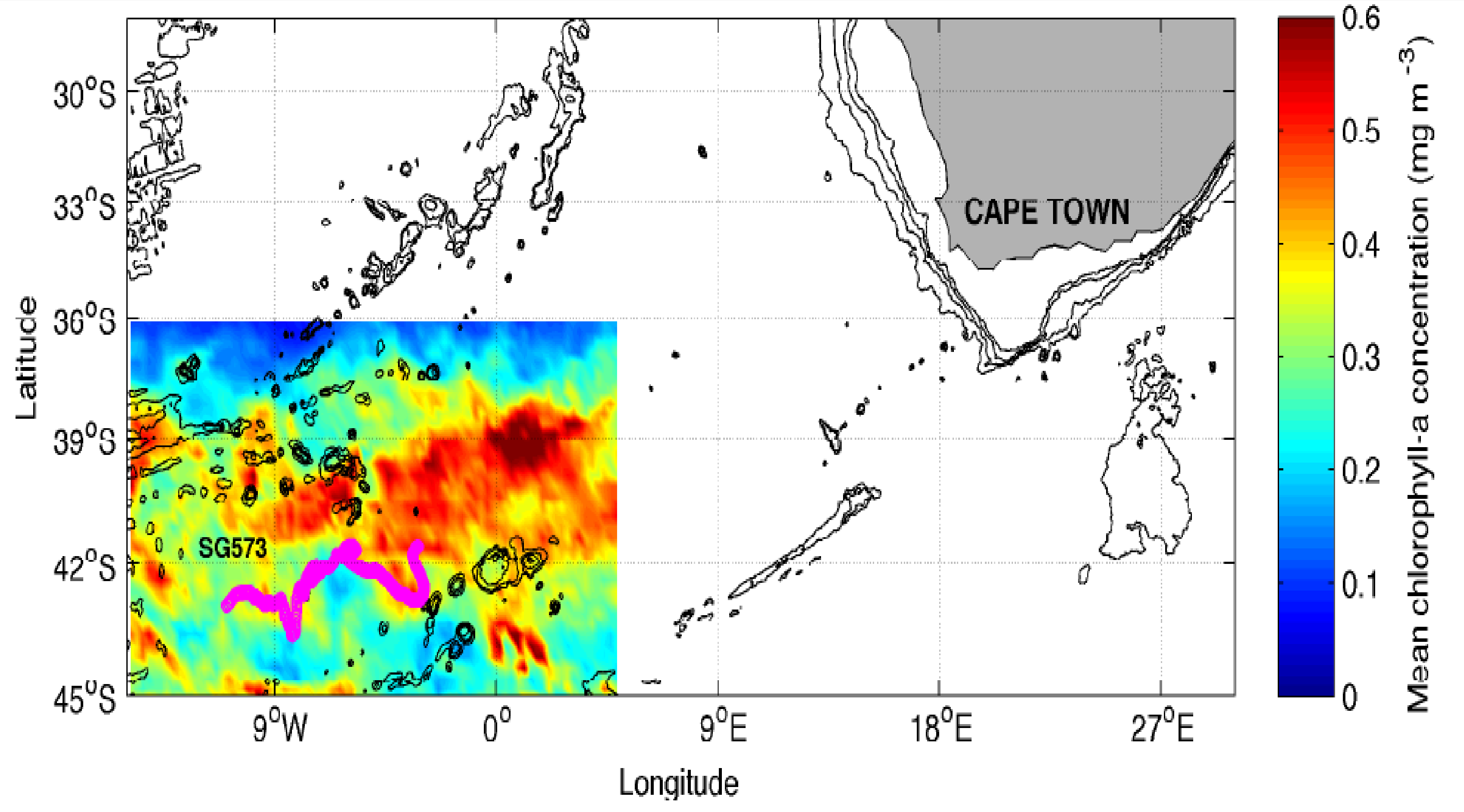
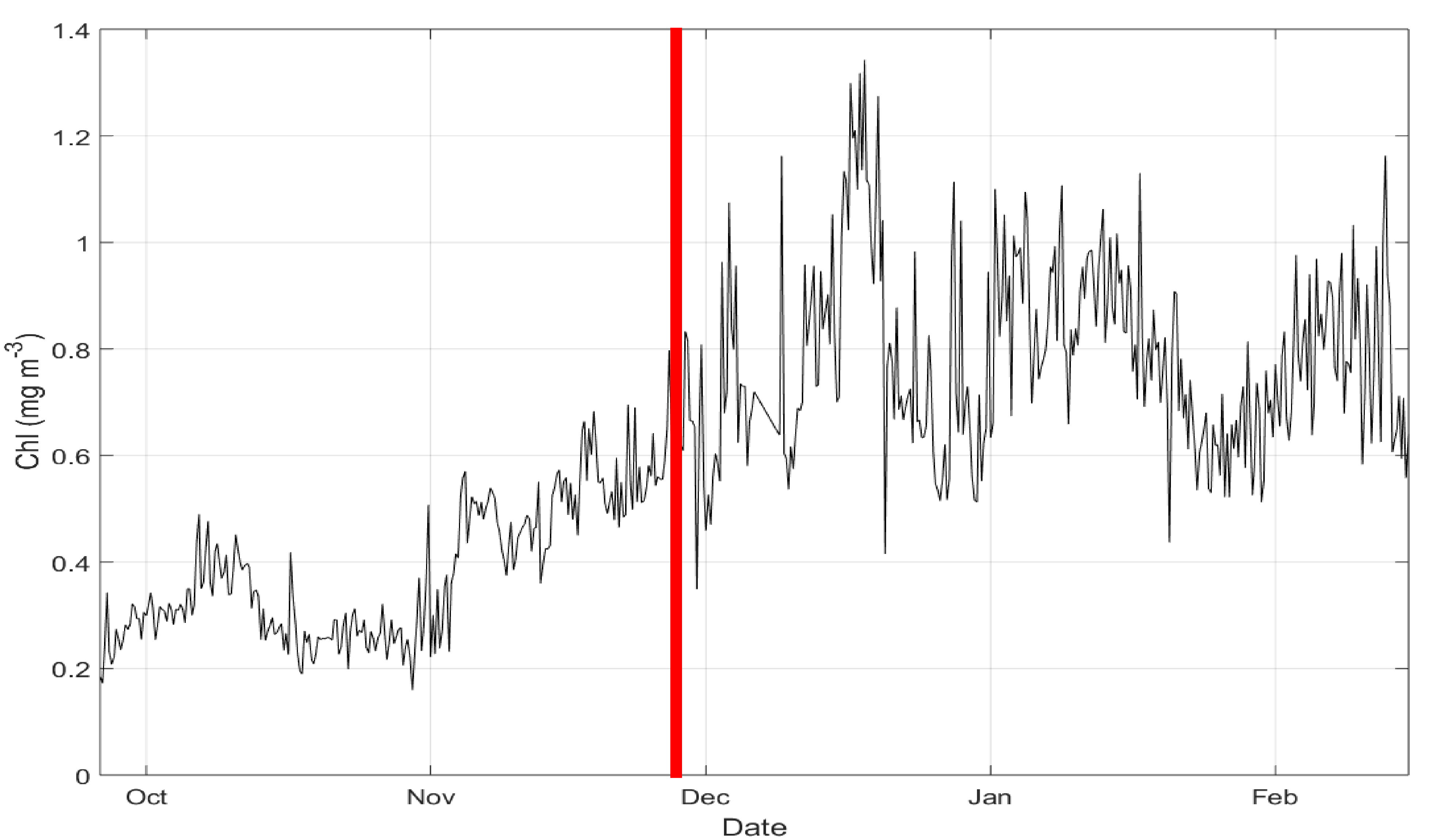
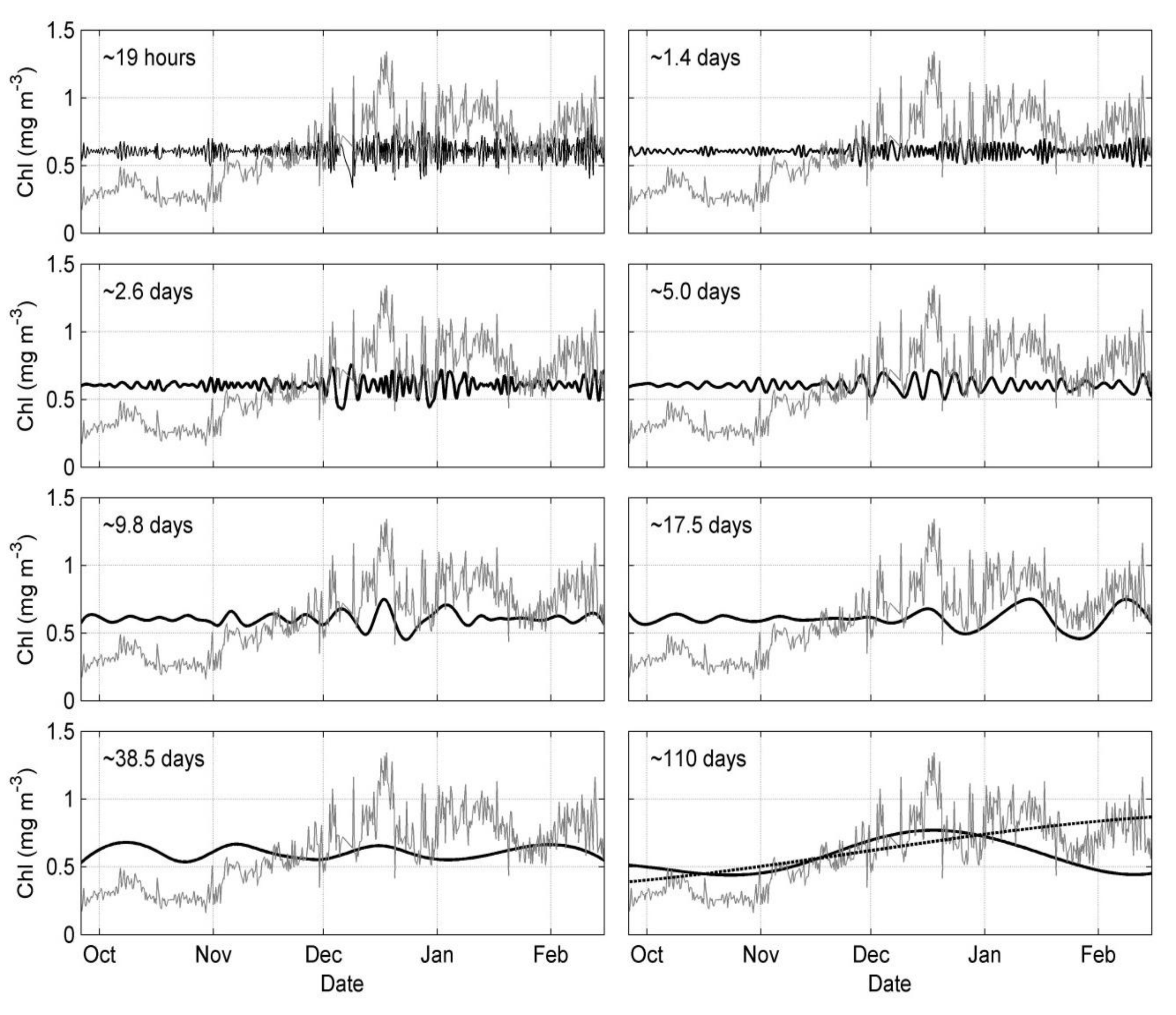


Glider chlorophyll-a time series



Empirical Mode Decomposition



Results - Temporal Analysis

Scales of variability : Spring

EMD	Chl-a	MLD	Wind Stress
1	0.8 (2%)	0.9 (1%)	1.0 (2%)
2	2.1 (4%)	2.1 (10%)	2.5 (7%)
3	4.8 (33%)	4.2 (17%)	4.4 (12%)
4	***9.9 (51%)***	7.0 (26%)	8.2 (15%)
5	14.8 (2%)	***19.5 (34%)***	***22.3 (21%)***
6	22.0 (0%)	30.5 (7%)	Residual (3%)
7	Residual (0%)	Residual (6%)	

- Submesoscales (2, 5 and 10 days) account for 88% of chl-a variability.
- MLD and wind stress vary at similar submesoscales as chl-a.
- Chl-a variability is driven by submesoscale eddies that alter the light environment (Mahadevan 2012).

Results – Temporal Analysis

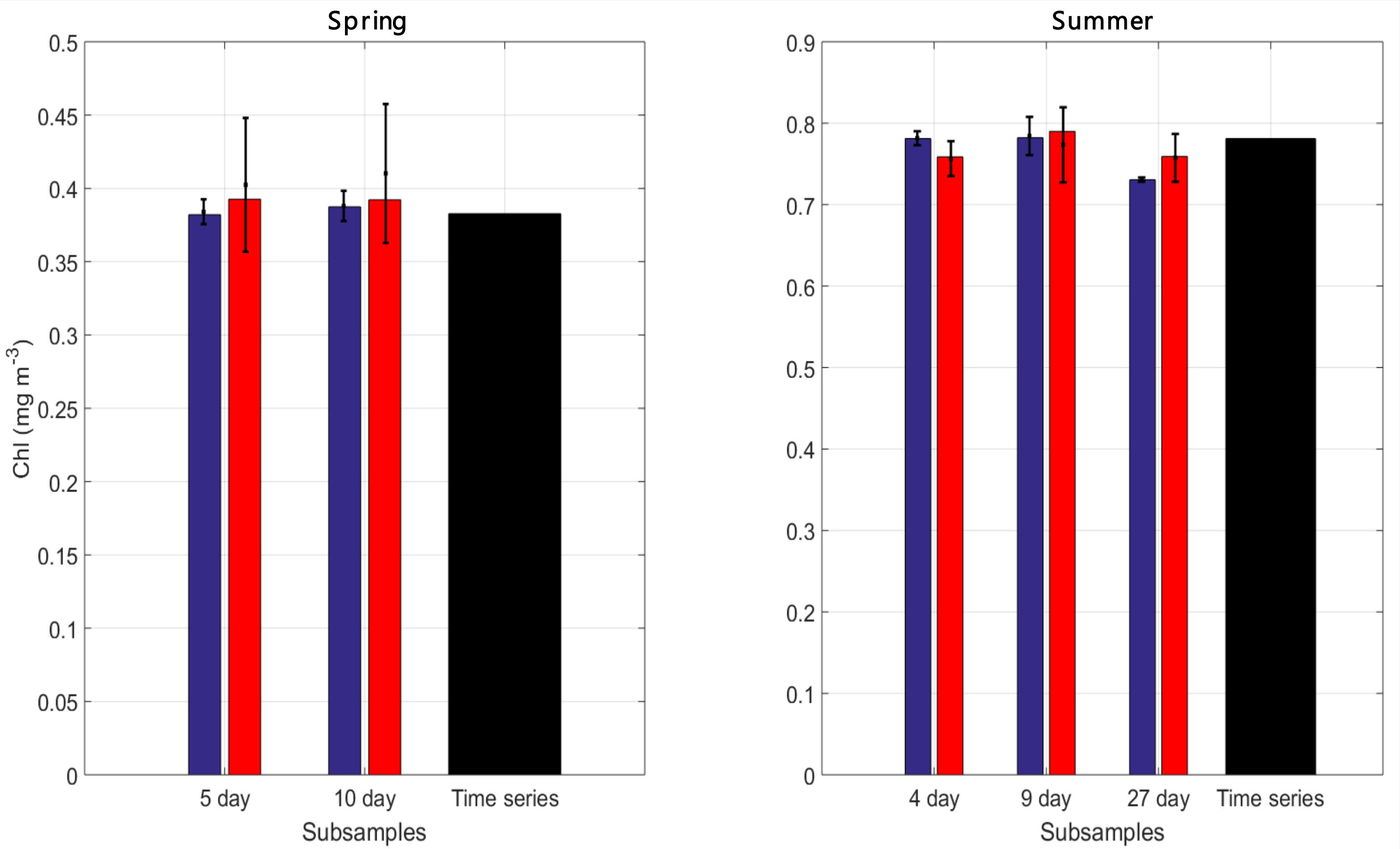
Scales of variability : Summer

EMD	Chl-a	MLD	Wind Stress
1	0.8 (1%)	0.8 (2%)	1.0 (1%)
2	2.2 (10%)	2.3 (21%)	3.0 (32%)
3	4.2 (19%)	***6.1 (41%)***	***5.6 (45%)***
4	8.9 (6%)	13.9 (39%)	10.2 (28%)
5	***27.1 (54%)***	45.5 (8%)	19.5 (9%)
6	62.5 (0%)	Residual (0%)	38.8 (30%)
7	Residual (4%)		Residual (0%)

- Submesoscales (2, 4 and 9 days) account for 27% of chl-a variability .
- MLD and wind stress vary at similar submesoscales as chl-a.
- Storm interaction alter the MLD, nutrient and light environment, driving chl-a variability.

Results – Temporal Analysis

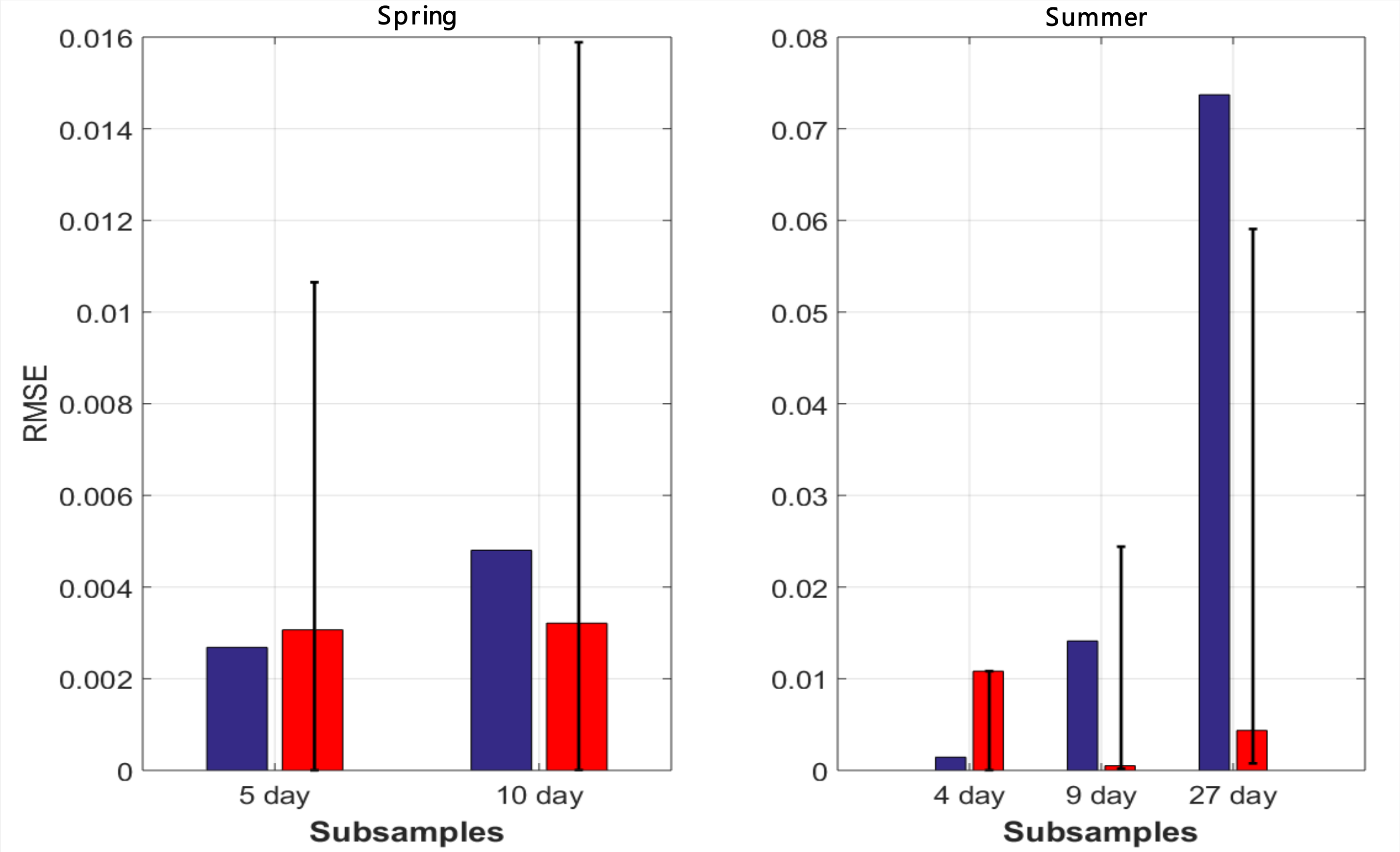
Subsampling at dominate scales of variability



- Mean of set and random subsampling captured the time series mean.
- Standard deviation of set subsampling captured the time series standard deviation.

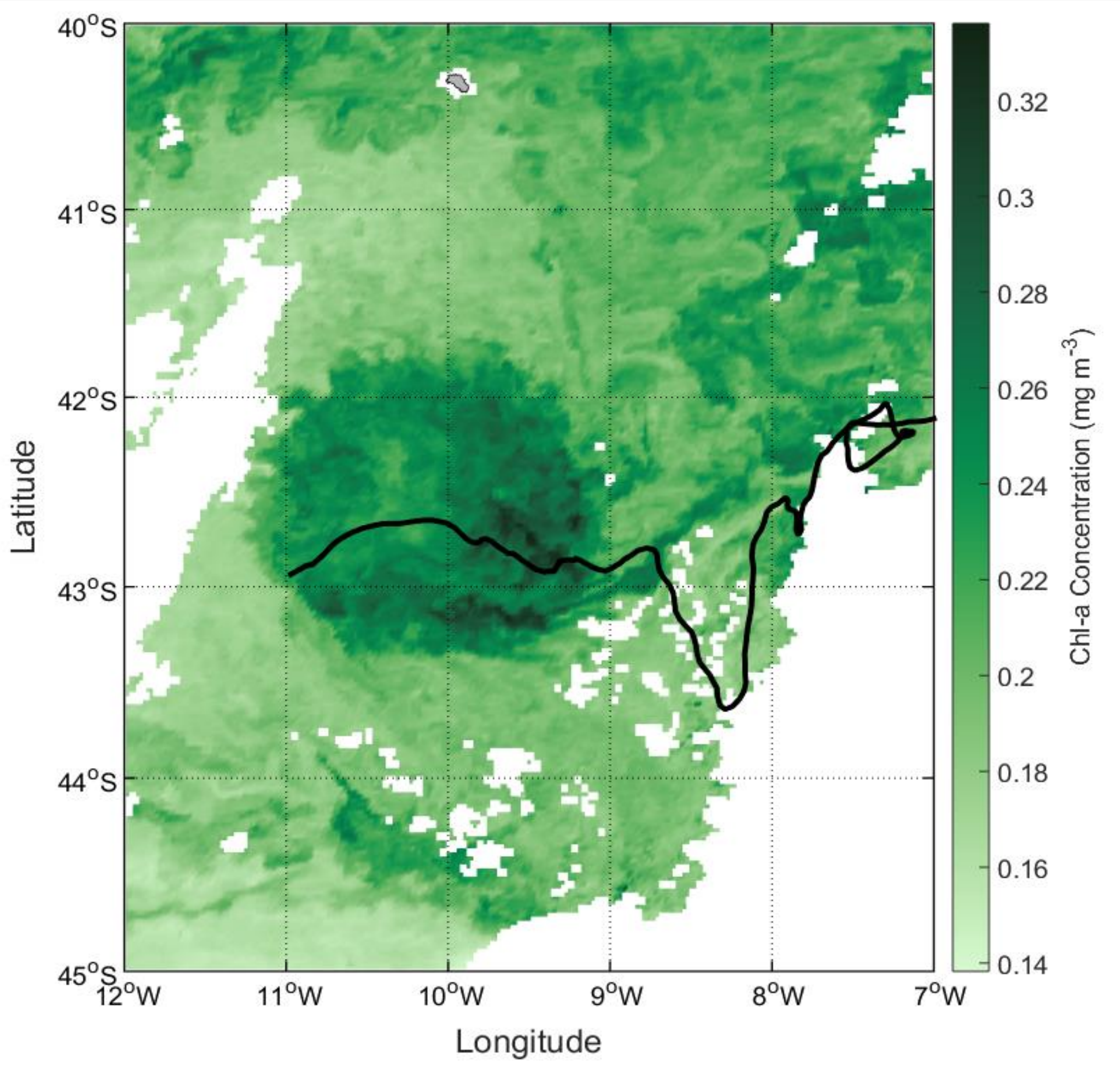
Results – Temporal Analysis

Subsampling at dominate scales of variability



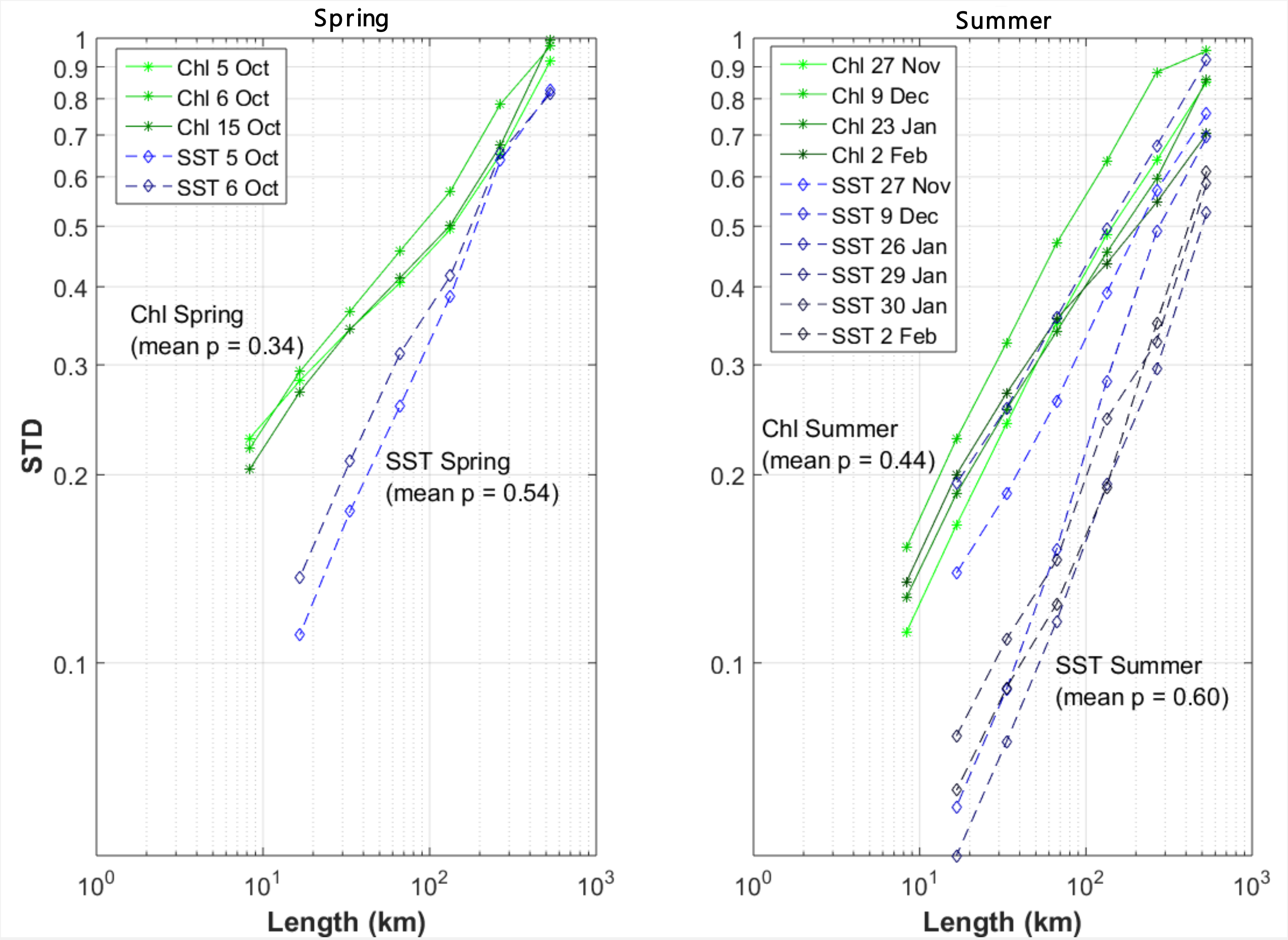
- Need to sample periodically.
- Subsample at frequencies (less than 10 days) in both spring and summer to resolve to chl-a variability.

Ocean colour grid



Results – Spatial Analysis

Investigating scales of chl-a and SST patchiness

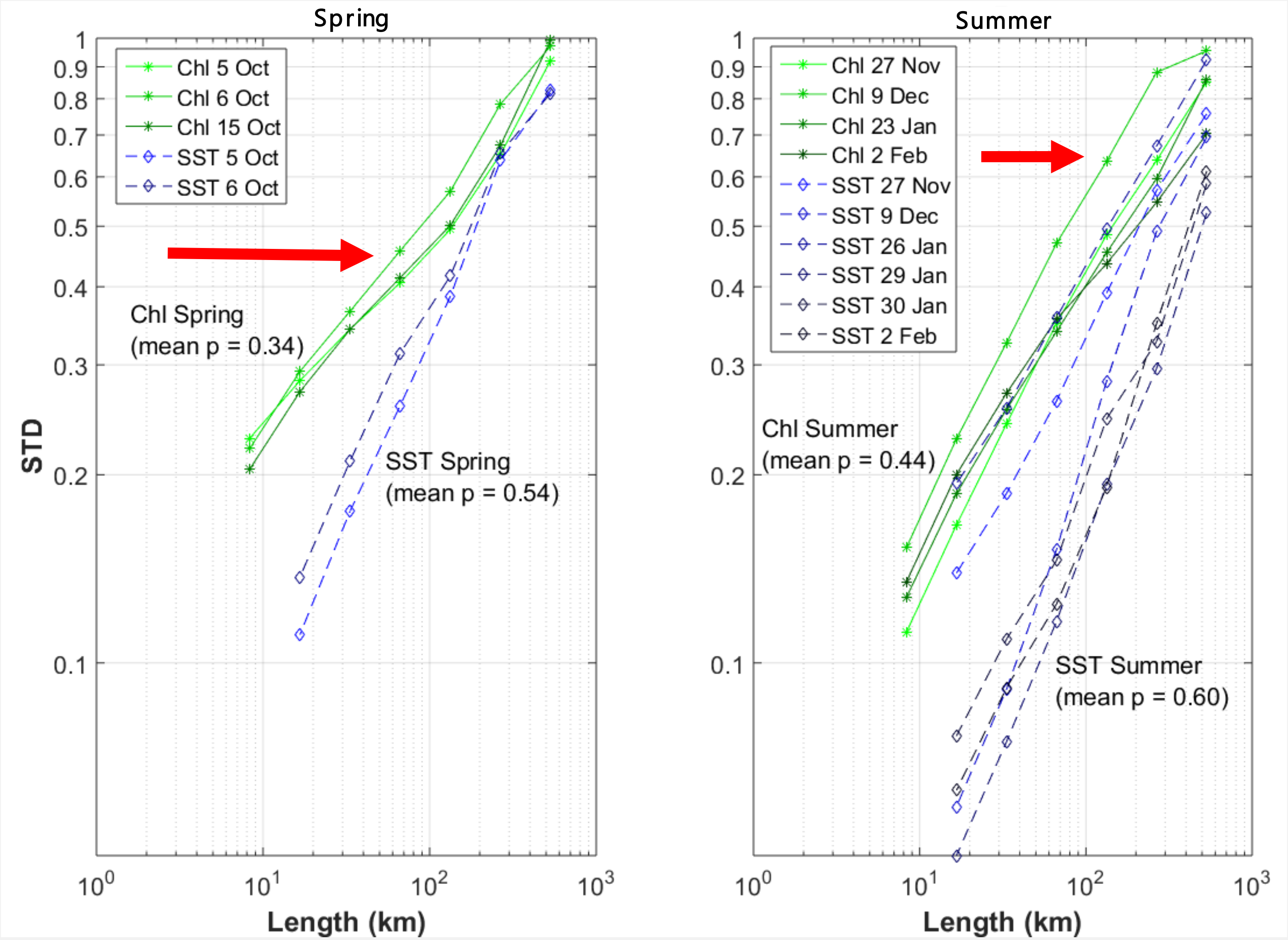


- Slope (p) is the measure of spatial heterogeneity.
- Phytoplankton are equally patchy in spring and summer.
- Higher variance in summer than spring due to higher maximum biomass.
- Phytoplankton are patchier than SST due to growth.

Mahadevan and Campbell (2002)

Results – Spatial Analysis

Investigating scales of chl-a and SST patchiness



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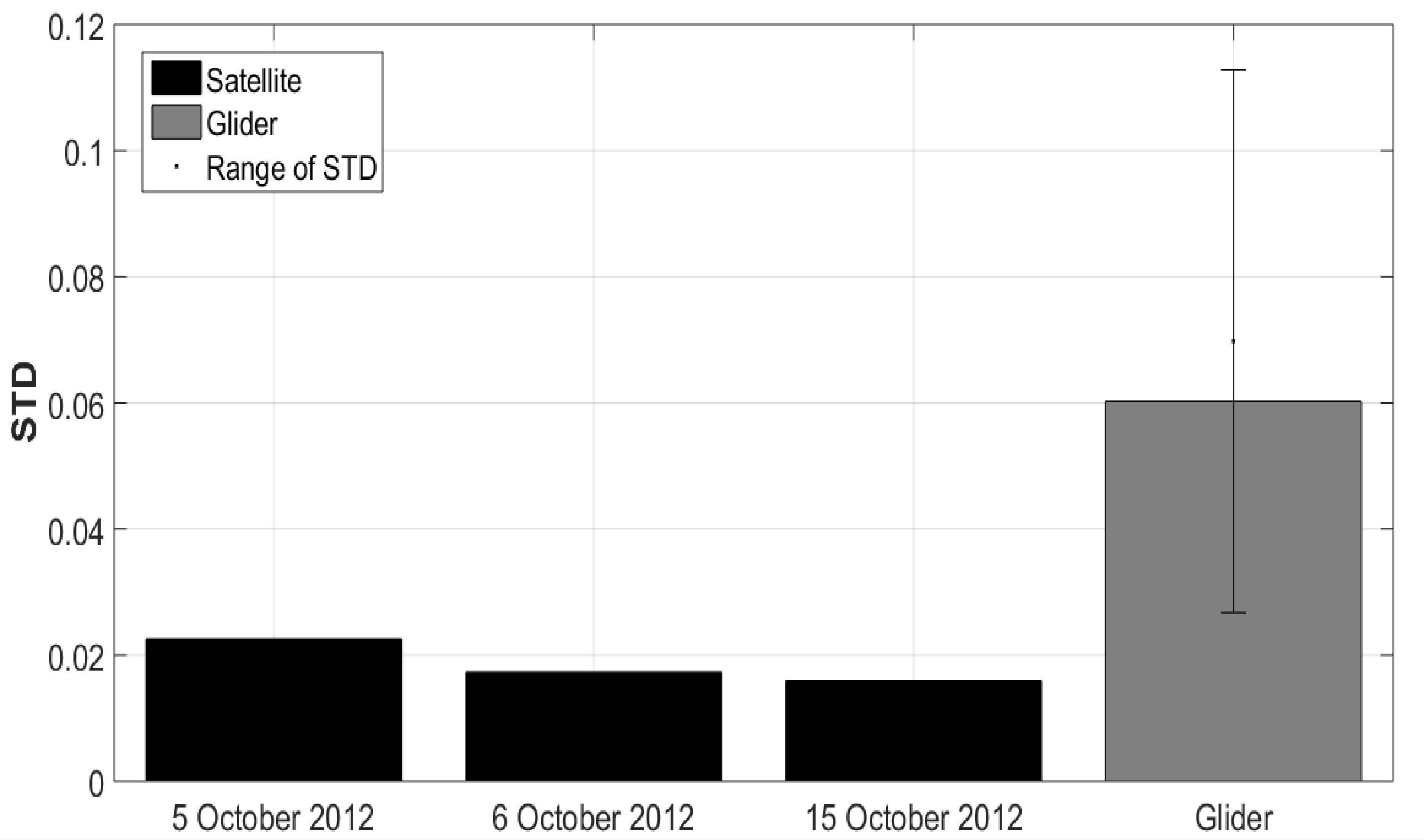
Results – Spatial Analysis

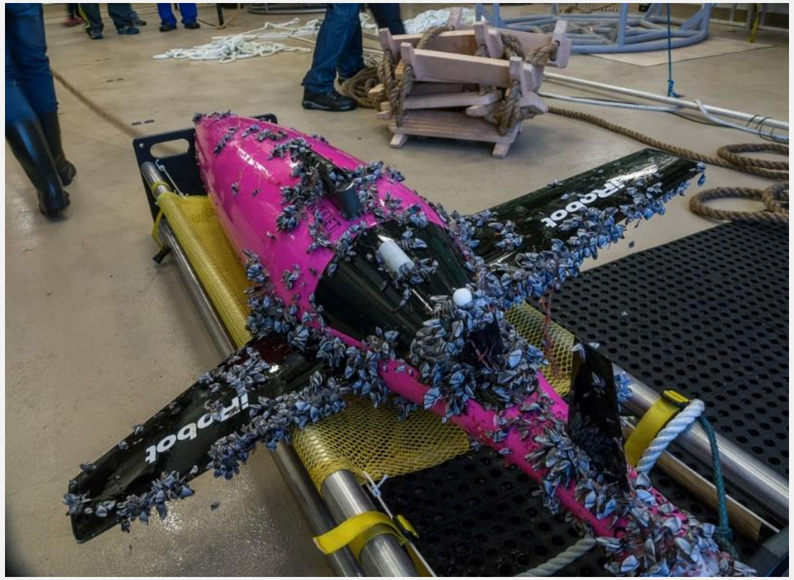
Comparison of satellite and glider patchiness



- The glider captured more variability than the satellite in spring.
- If gliders were not behaving in a quasi-Lagrangian manner, the glider data would look similar to the satellite.
- A 1/3 of the glider variability is caused by spatial variability, the remainder occurs from local adjustments in time.

CONCLUSION

- Chl-a temporal variability occurs at submesoscales for spring and summer, however they are caused by different forcing mechanisms.
- Chl-a needs to be subsampled at set frequencies (less than 10 days) in both spring and summer to resolve to chl-a variability.
- Chl-a is patchier at small length scales for spring and summer.
- Chl-a is more patchy than SST.
- The glider is mainly measuring chl-a adjustments in time rather than in space.



Thank You

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