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**BONUS  
INTEGRAL**



integrated  
carbon  
observation  
system



**Baltic Earth**  
Earth System Science for the Baltic Sea Region

# Using land-based stations for air-sea interaction studies

**Anna Rutgersson<sup>1</sup>, Heidi Pettersson<sup>2</sup>, Erik Nilsson<sup>1</sup>, Marcus Wallin<sup>1</sup>, Erik Sahlée<sup>1</sup>, Hans Bergström<sup>1</sup>, Lichuan Wu<sup>1</sup> et al.**

<sup>1</sup>Air-Water Exchange Platform, Uppsala University,  
[anna.rutgersson@met.uu.se](mailto:anna.rutgersson@met.uu.se)

<sup>2</sup>FMI, Finnish Meteorological Institute



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# Marine micrometeorological sites

- Ships
- Buoys
- Off-shore platforms
- Land-based sites



- Limited flow distortion
- No motion correction
- Relatively easy to access



- Possible land influence

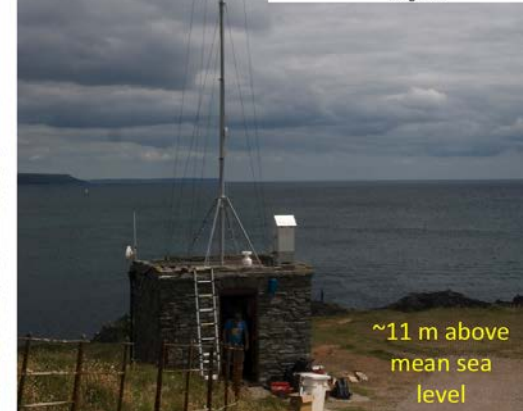
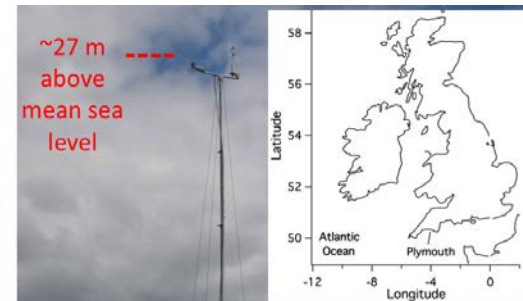
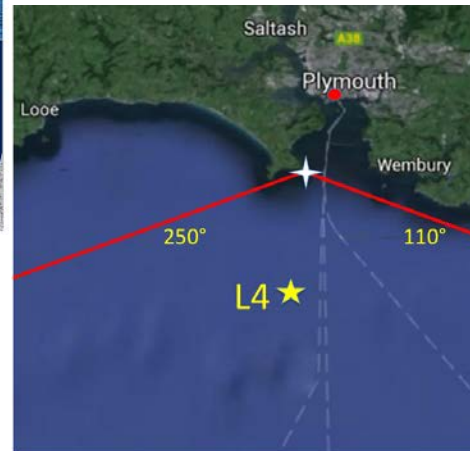
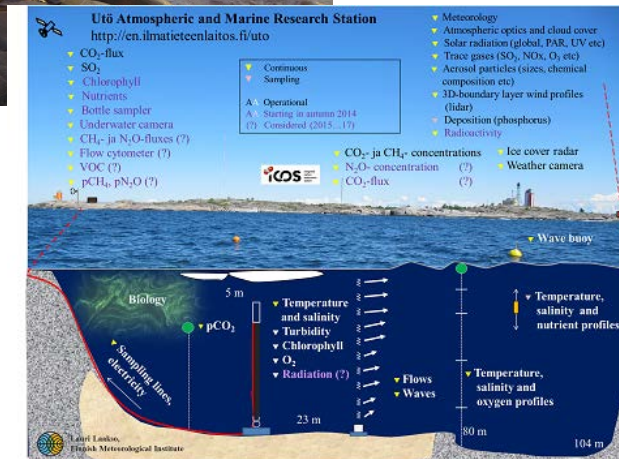




# Land-based marine micrometeorological sites

Examples:

Östergarnsholm, Baltic Sea  
Utö site, Finnish archipelago  
Penlee Point observatory, Plymouth



Key question – what do the fluxes represent?

# Suggestion: define the data based on how much land-influence we have.

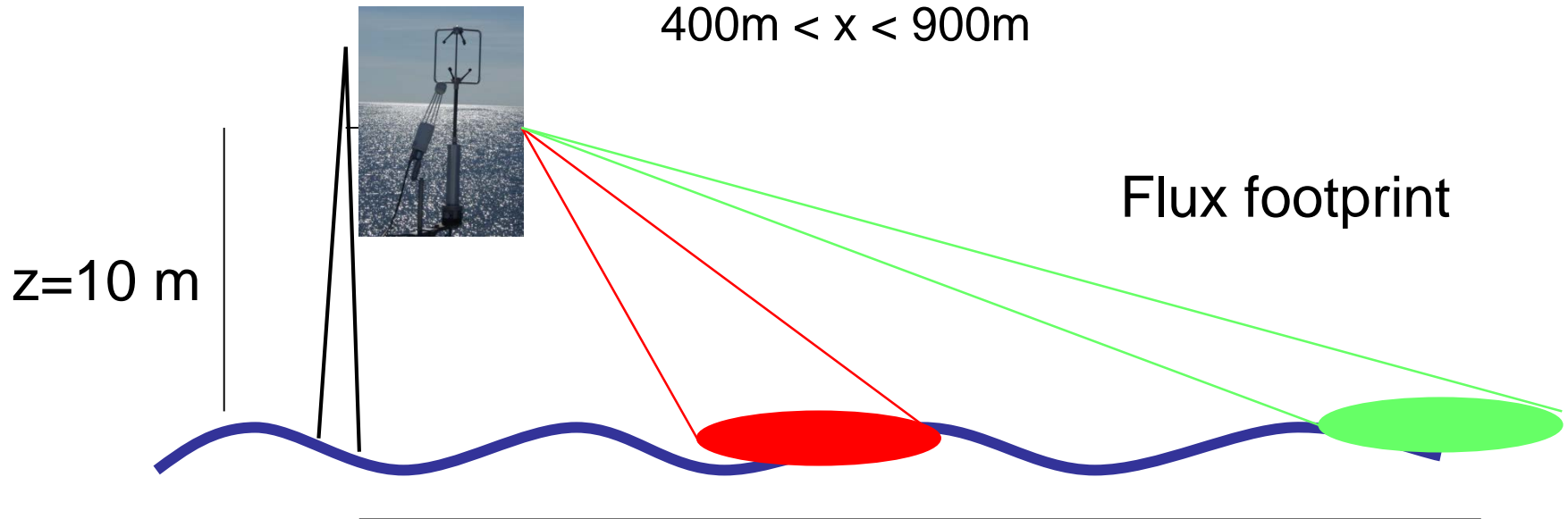
Disturbances:

1. Mesoscale systems (sea-breeze, Low-level jets, upwelling,...)
2. Heterogeneous footprint
3. Disturbed wave field
4. Limited fetch
5. Shore zone (combined land-sea footprint)
6. Downwind topography

# Concept of foot-print, measurements "see" some distance upwind

Unstable atmospheric conditions:

60% of fluxes originates at  
 $400\text{m} < x < 900\text{m}$



Stable atmospheric conditions: 60%  
of fluxes originates at  
 $1.5\text{km} < x < 5\text{km}$



x=?



# Define categories

CAT1. Open sea, undisturbed wave field, water side measuring system representative of the flux footprint of the tower. Meso-scale circulation systems might influence the station, but the data can be considered stationary and homogeneous.

CAT2. Disturbed wave field resulting in physical properties different from open sea conditions and likely also heterogeneity of water properties in the foot-print region. In a near surface region the biogeochemical properties can vary even if the physical does not (run-off, biological activity).

CAT3. Mixed land/sea footprint of the data, very heterogeneous conditions, not possible with few water-side measurements to fully represent water-side conditions.



# Define categories

CAT1. Marine station, undisturbed wave field, water side measuring system, 1. Open sea conditions, 100 m distance from the tower. Meso-scale circulation, but the station, but the data can be considered stationary and homogeneous.

CAT2. Disturbed conditions, different from open sea, 2. Coastal sea conditions, also heterogeneity of water properties near surface region, the biogeochemical properties can vary even if the physical does not.

CAT3. Mixed conditions, not representative of open sea, 3. Shore conditions, very heterogeneous measurements to fully represent water-side conditions.

# Quality control

Marine fluxes generally small give often limited signal-to-noise ratio:

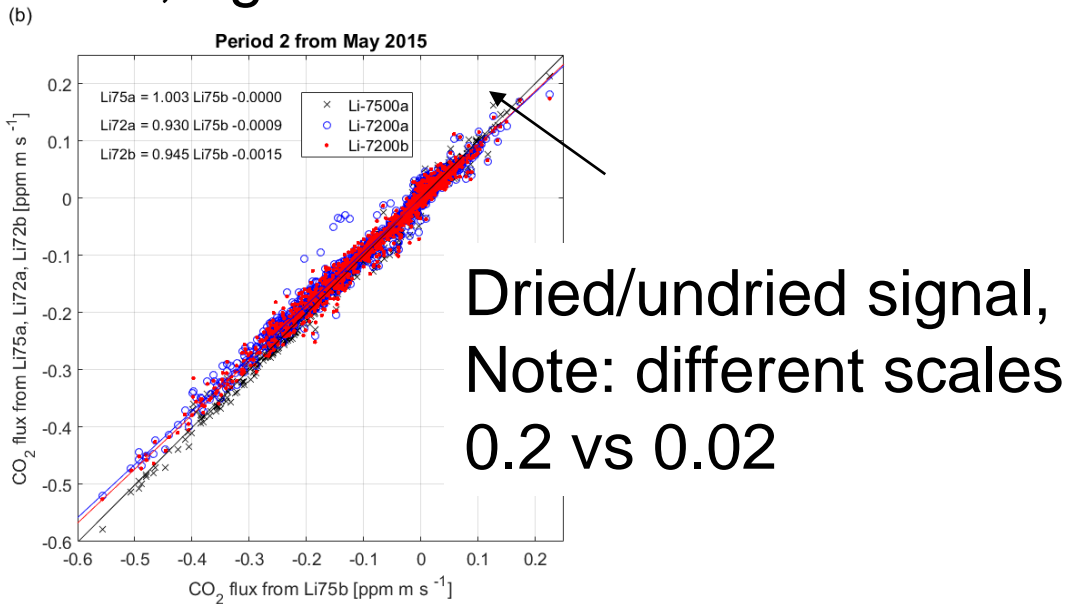
- **Salt contamination** on windows requires frequent cleaning or drying of signal (Nilsson et al., 2018, Honkanen et al., 2018).
- Webb correction significant.
- Up-wind disturbances



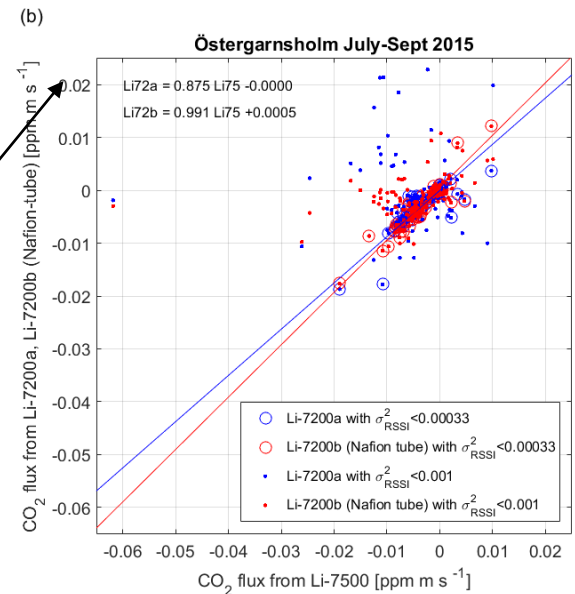
# Salt contamination

Comparison of dired/undried signal, results inconclusive (no impact at the agricultural site):

## Land, agricultural site

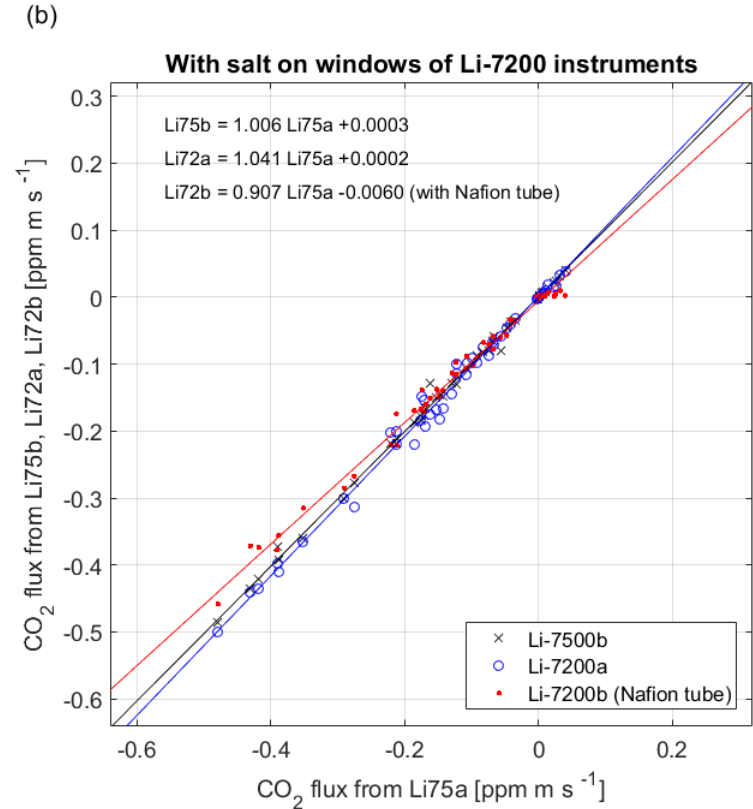
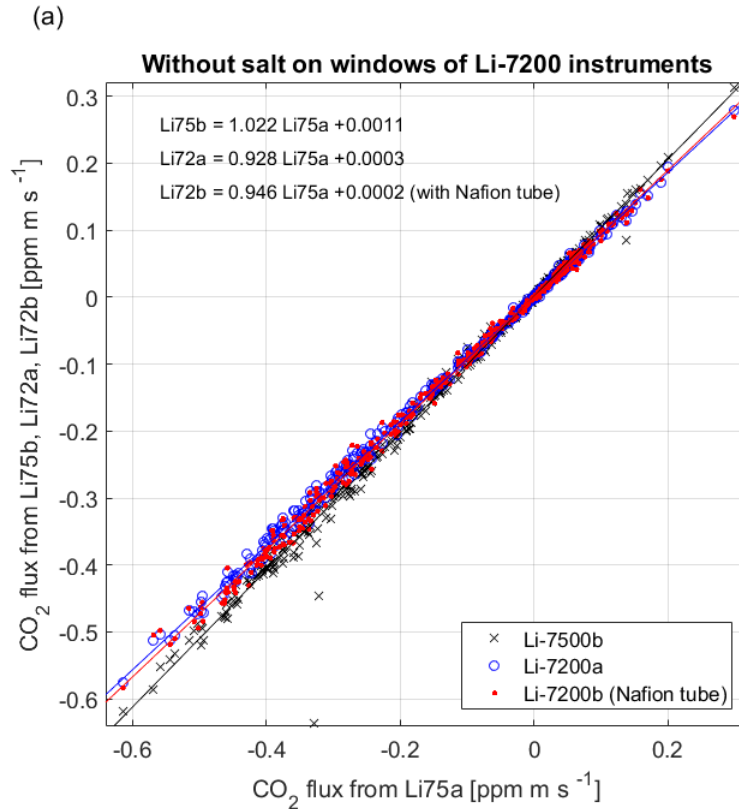


## Sea, Östergarnsholm



# Agricultural site: Salinity artificially added

- **CO<sub>2</sub> flux: Li-7200b 'dried'**  
Indications of a significant difference between the 'dry' and 'wet'



13% enhanced flux due to salt contamination (in the undried system).



# Define categories

CAT1. Marine station, undisturbed wave field, water side measuring system, 1. Open sea conditions, 100 m distance from the tower. Meso-scale circulation, but the station, but the data can be considered stationary and homogeneous.

CAT2. Disturbed conditions, physical properties different from open sea, 2. Coastal sea conditions, also heterogeneity of water properties near surface region, the biogeochemical properties can vary even if the physical does not.

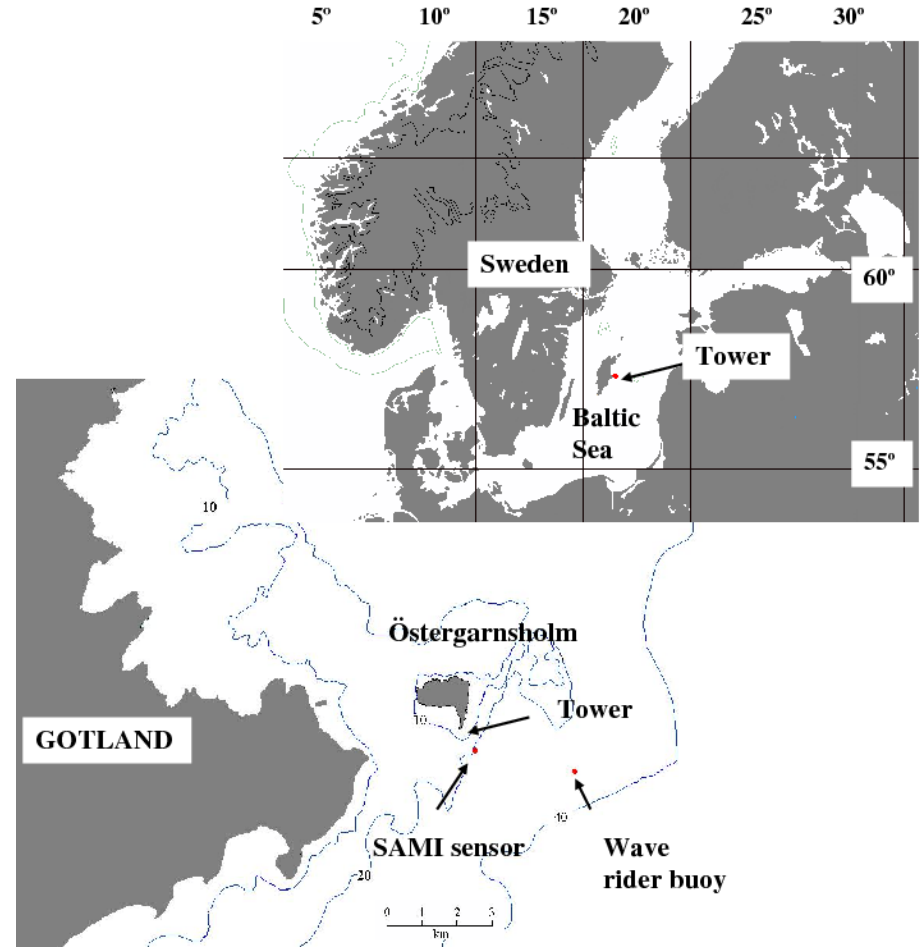
CAT3. Mixed conditions, not representative of water-side conditions, 3. Shore conditions, very heterogeneous measurements to fully



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# Use Östergarnsholm site to test criteria

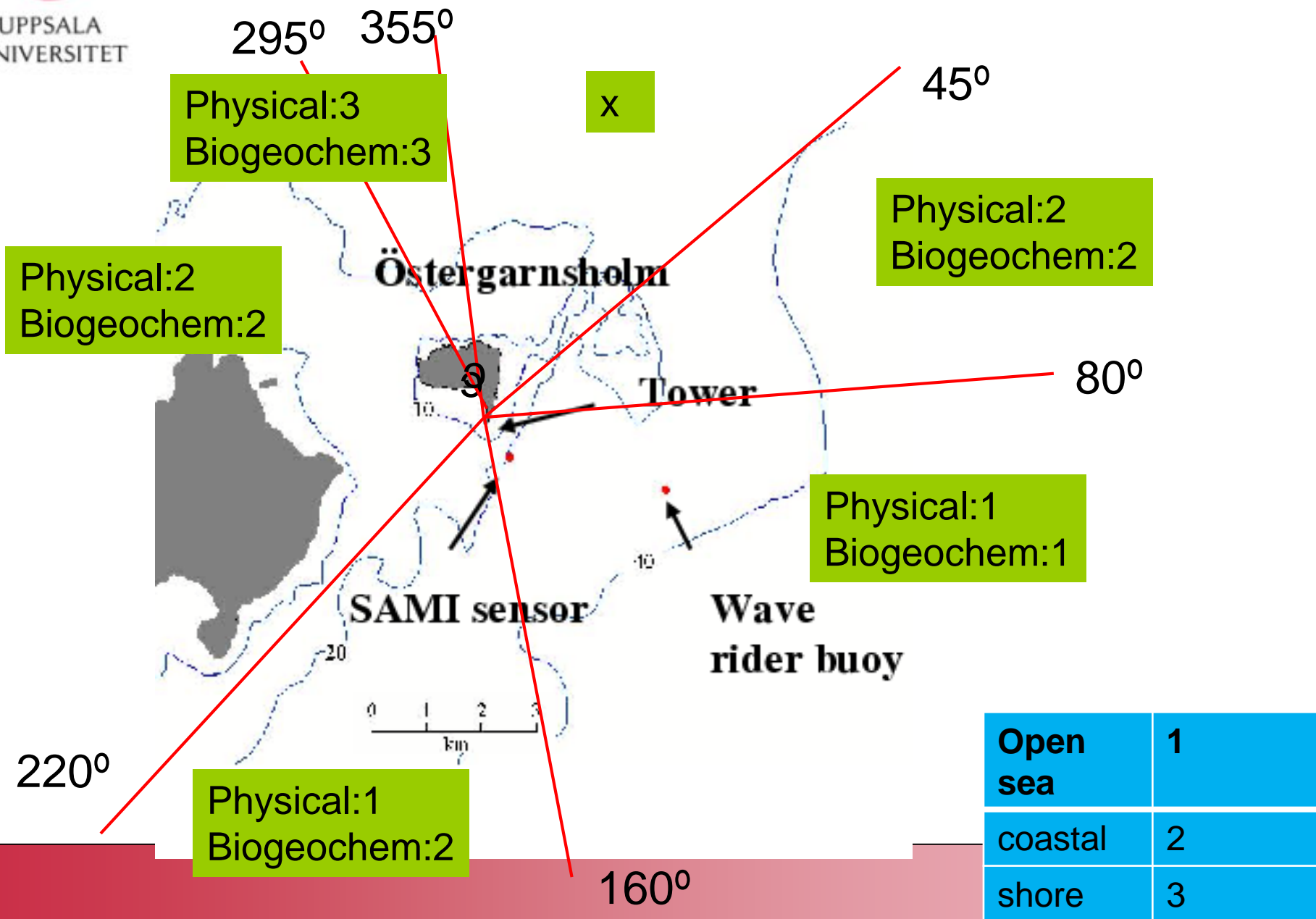
- No archipelago.
- Ideal bottom topography.
- Shallow island.
- Relatively undisturbed site.





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# Sectors, suggestion



# Define categories Ö-holm

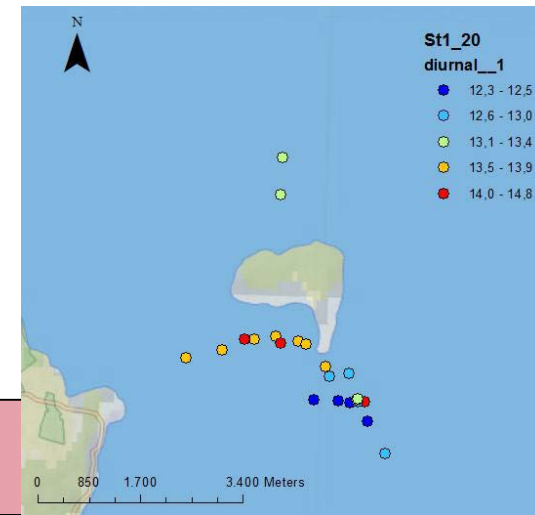
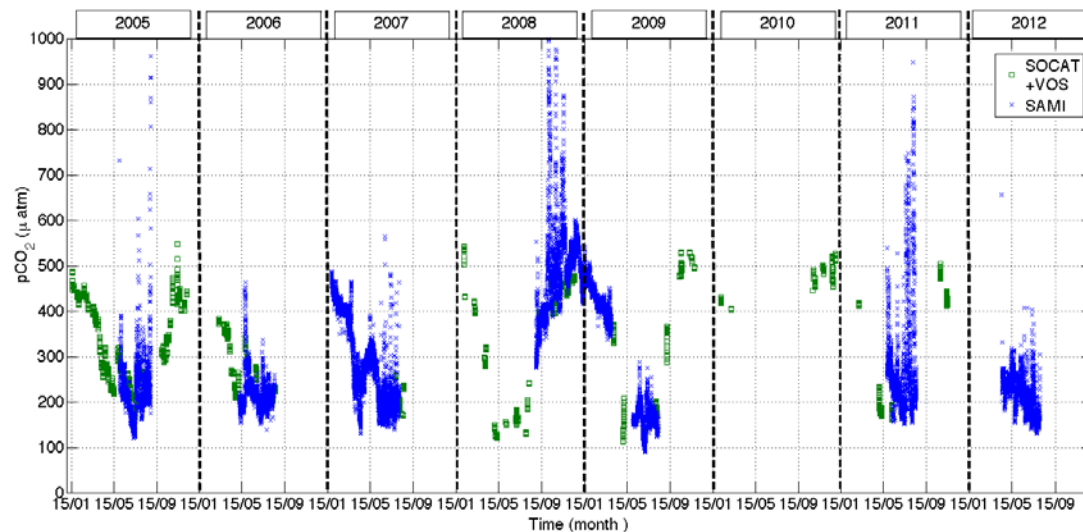
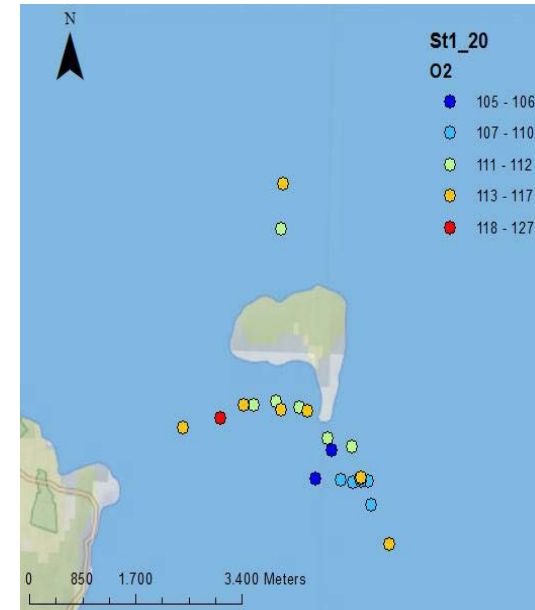
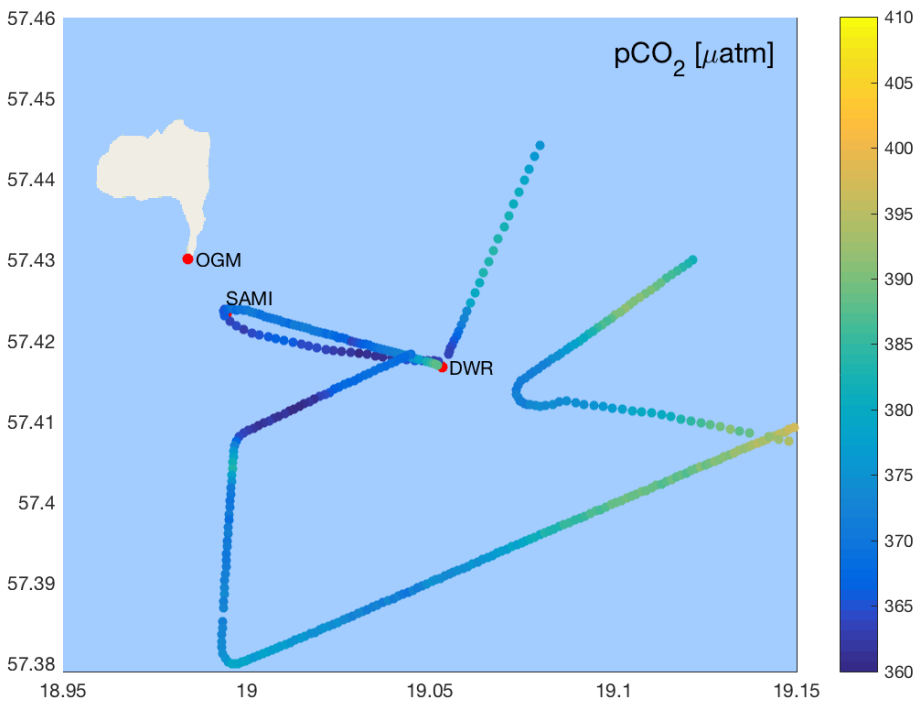
1. Physical (stress, heat and humidity fluxes; waves, SST)
2. Biogeochemical (carbon; runoff, biological activities)

Sector	Physical	Biogeo-chemical
45<WD<80	2	2
80<WD<160	1	1
160<WD<220	1	2
220<WD<295	2	2
295<WD<355	3	3
355 over 45	X	X



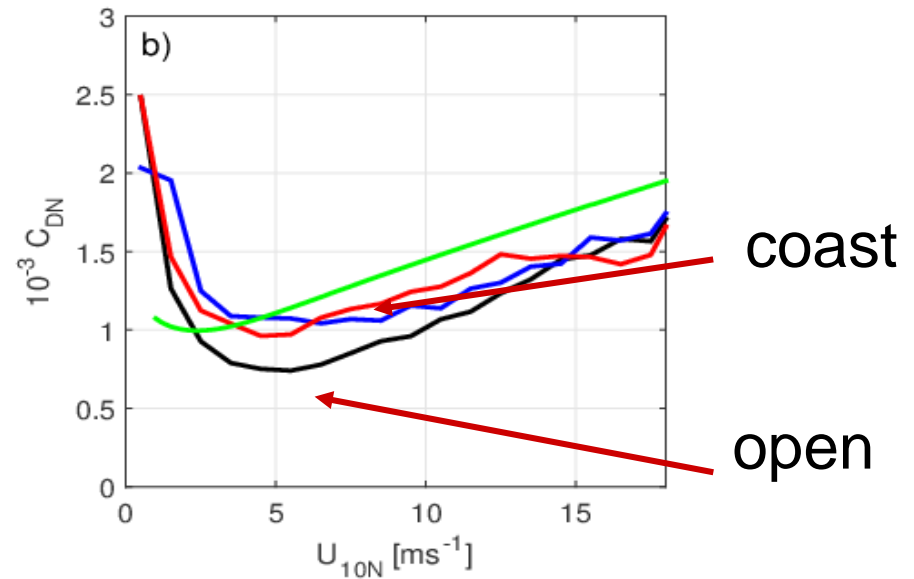
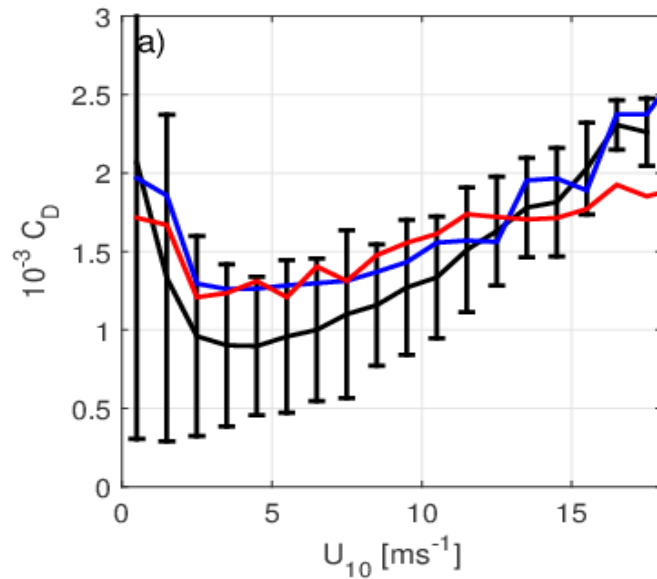
# Use Östergarnsholm, data

## Water-side homogeneity



# Use Östergarnsholm, data

## Drag coefficient



Below 10m/s:

Higher drag coefficient in the coastal sector – younger waves giver larger drag



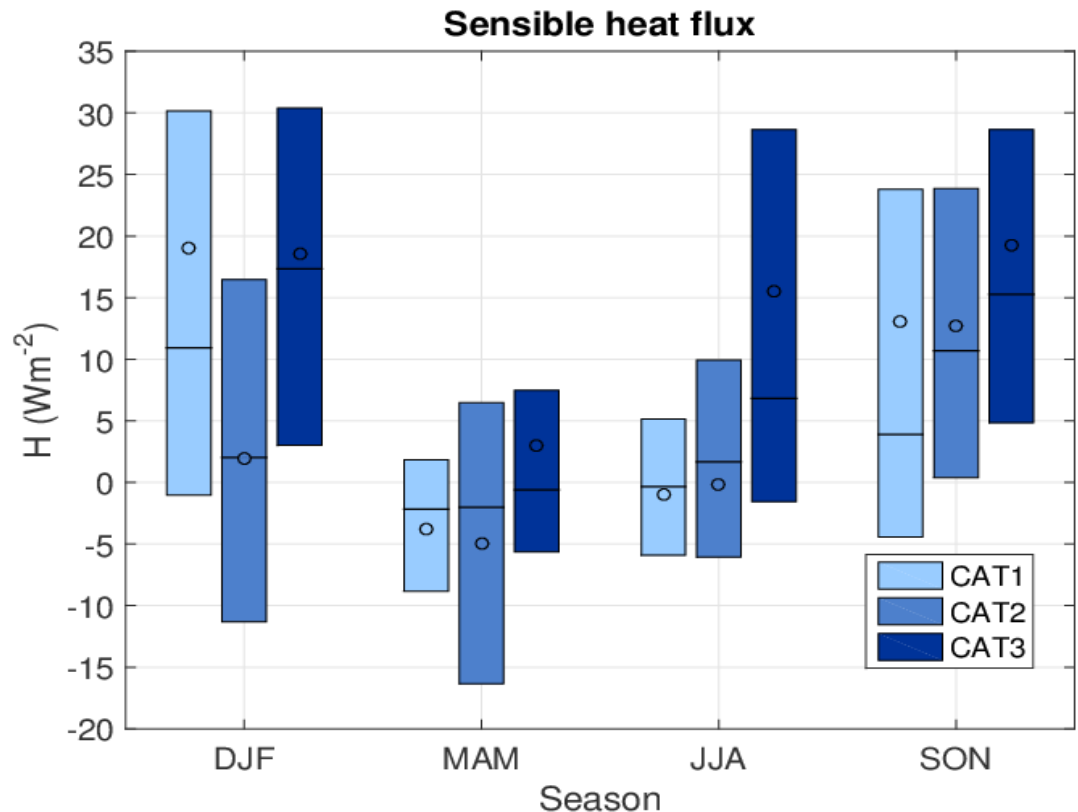


# Use Östergarnsholm, data, sensible heat flux

Upward fall and winter

Downward spring and summer.

Differences in seasonal cycle between coastal  
and open sea



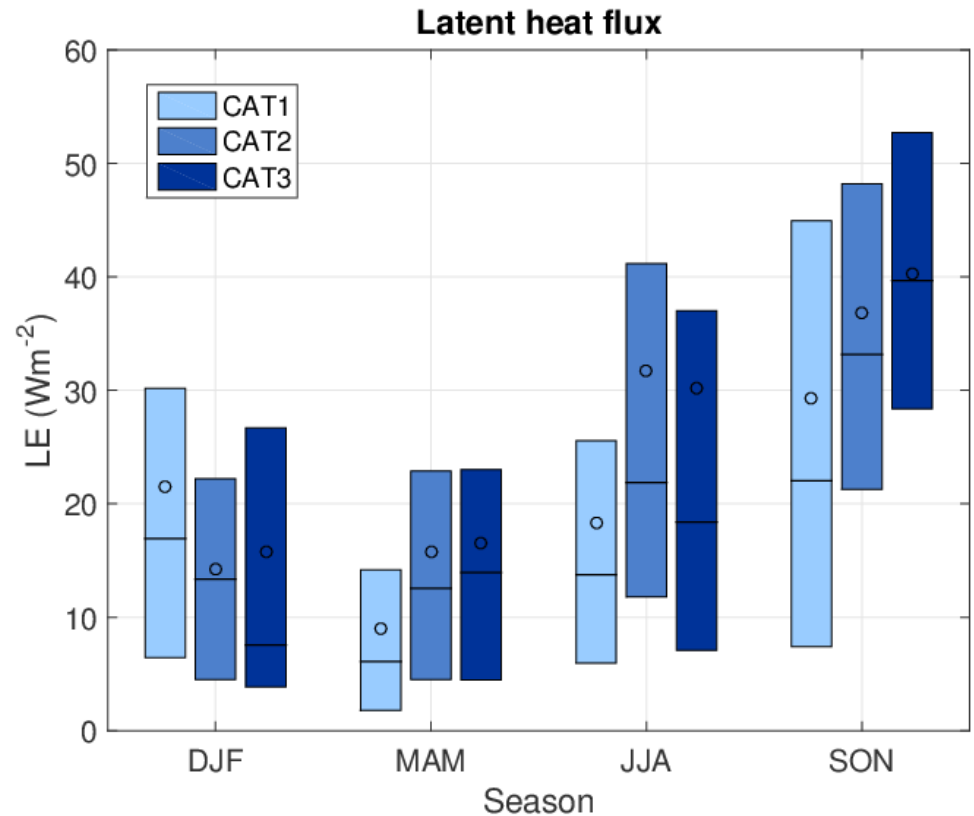


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# Use Östergarnsholm, data, latent heat flux (evaporation)

Larger over coastal zone.

Different seasonal cycle for coastal and open sea.

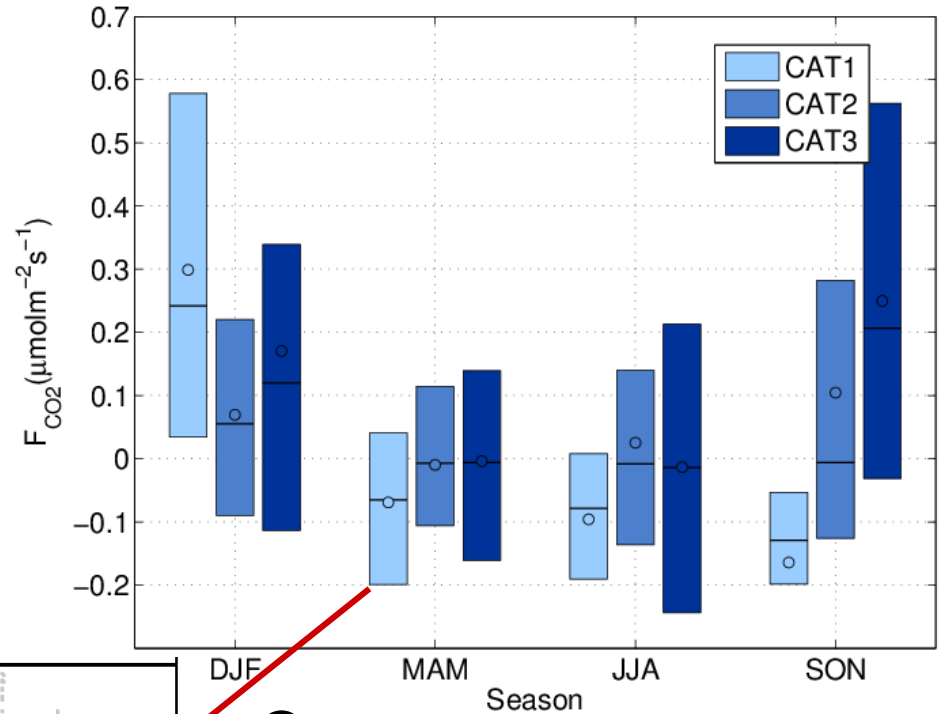




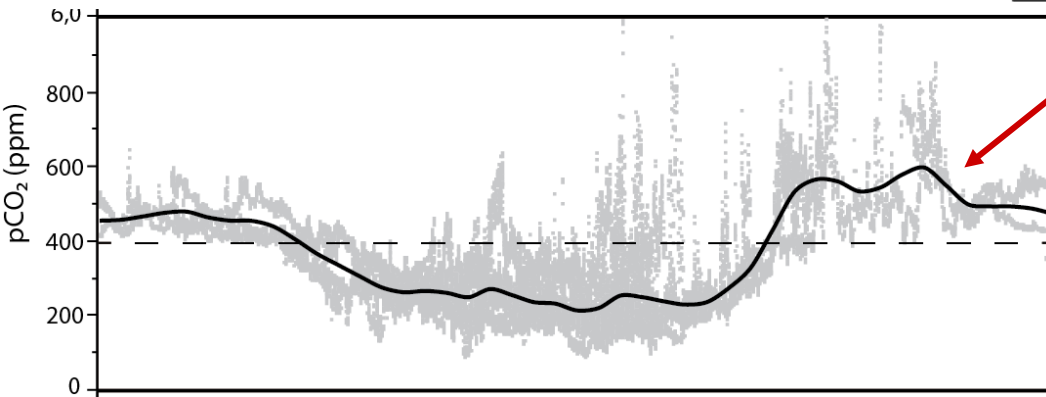
# Use Östergarnsholm, data

Flux of carbon dioxide

Different seasonal cycle,  
for different sectors

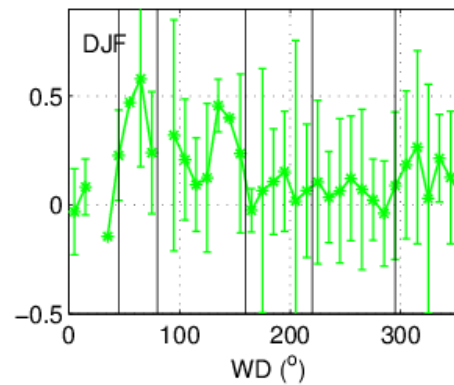
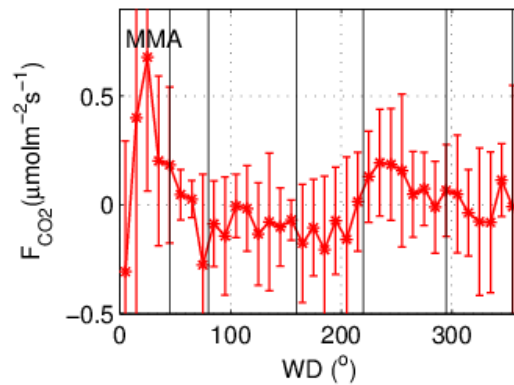
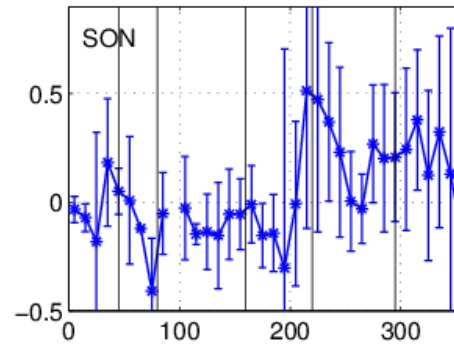
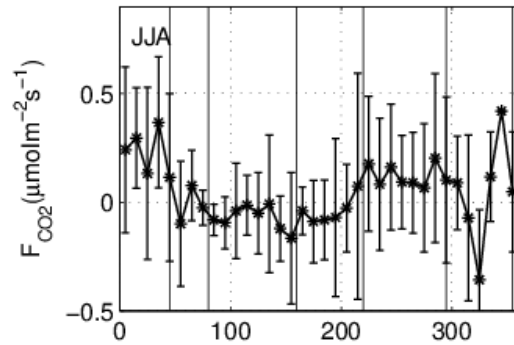


Open sea





# Use Östergarnsholm, data



Choice of sectors - reasonable



# Conclusions

- Land-based marine micrometeorological data should be defined based on magnitude of land disturbance:
  - Open sea
  - Coastal
  - Shore area
- For marine data caution is needed regarding:
  - Salt contamination
  - Upwind disturbances
- At Östergarnsholm clear differences in fluxes are seen between coastal and open sea data.



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# Thank you!

