HiWinGS
High Wind Gas Exchange Study

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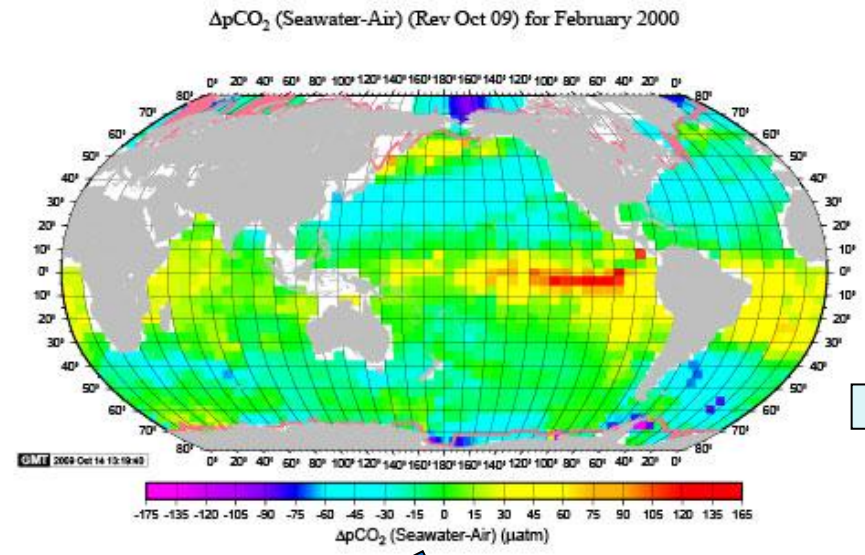
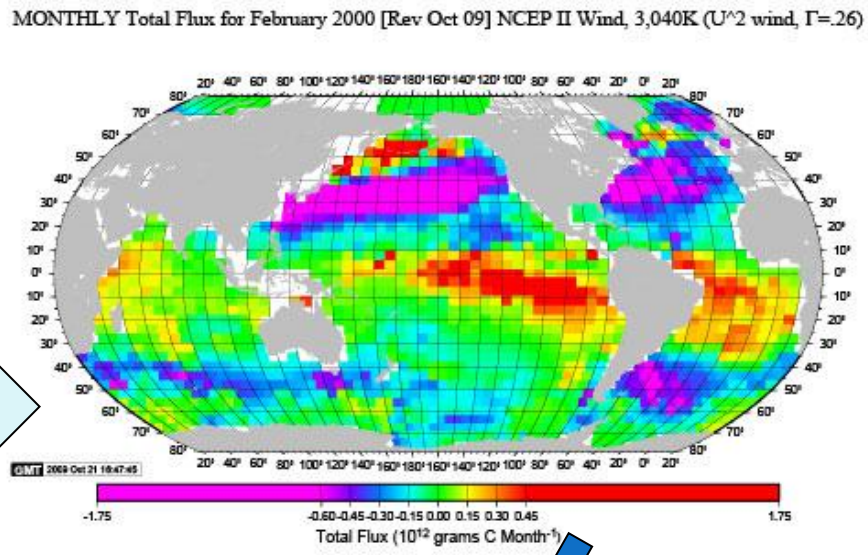
Outline

- Motivations and current state of gas exchange parameterization
- Considerations for HiWinGS
- Status of the ongoing project

The need for *k*

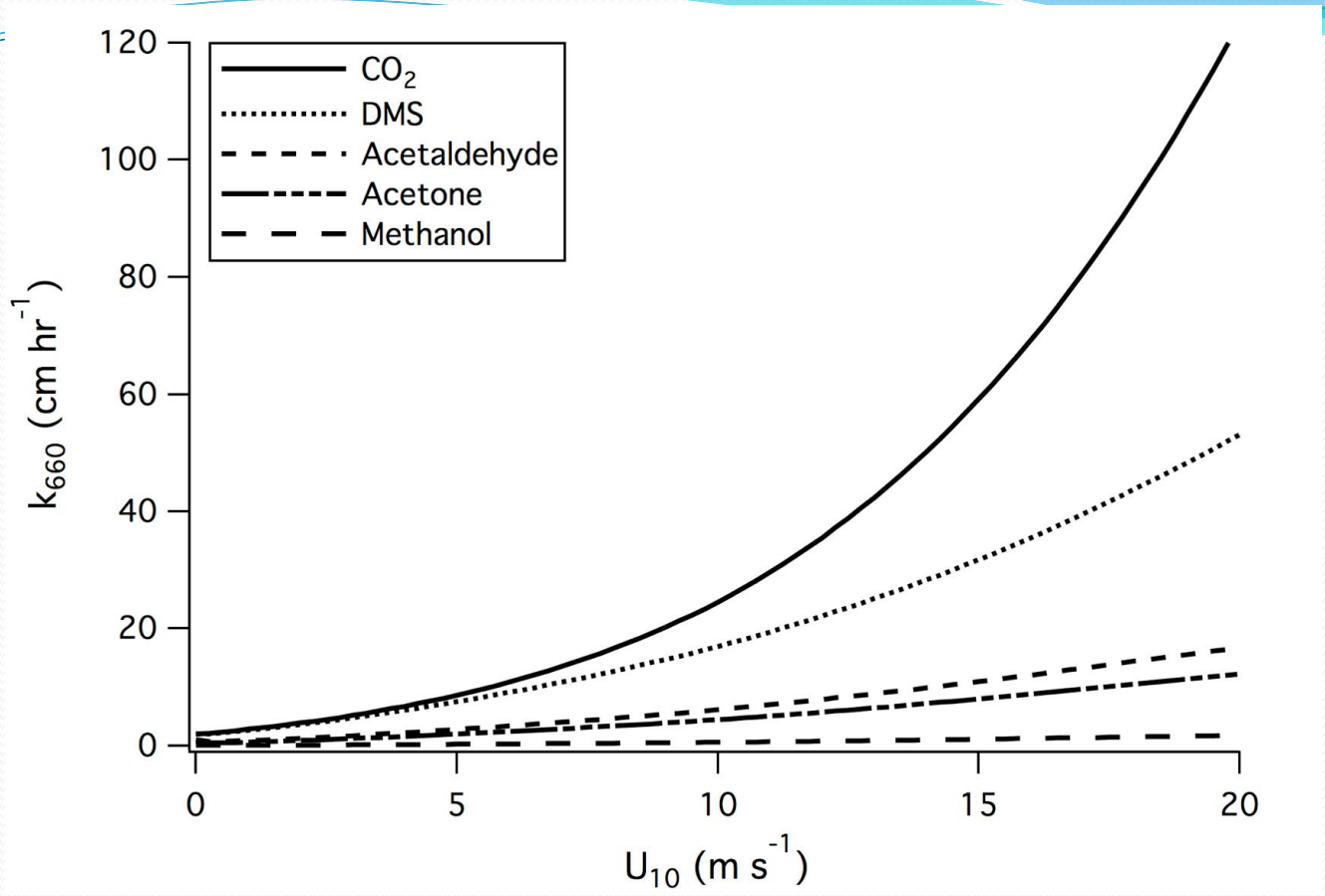


k



$$\Delta pCO_2 * k = Flux$$

Takahashi, et al. (2009), *DSR II*, **56**, pp 554-577



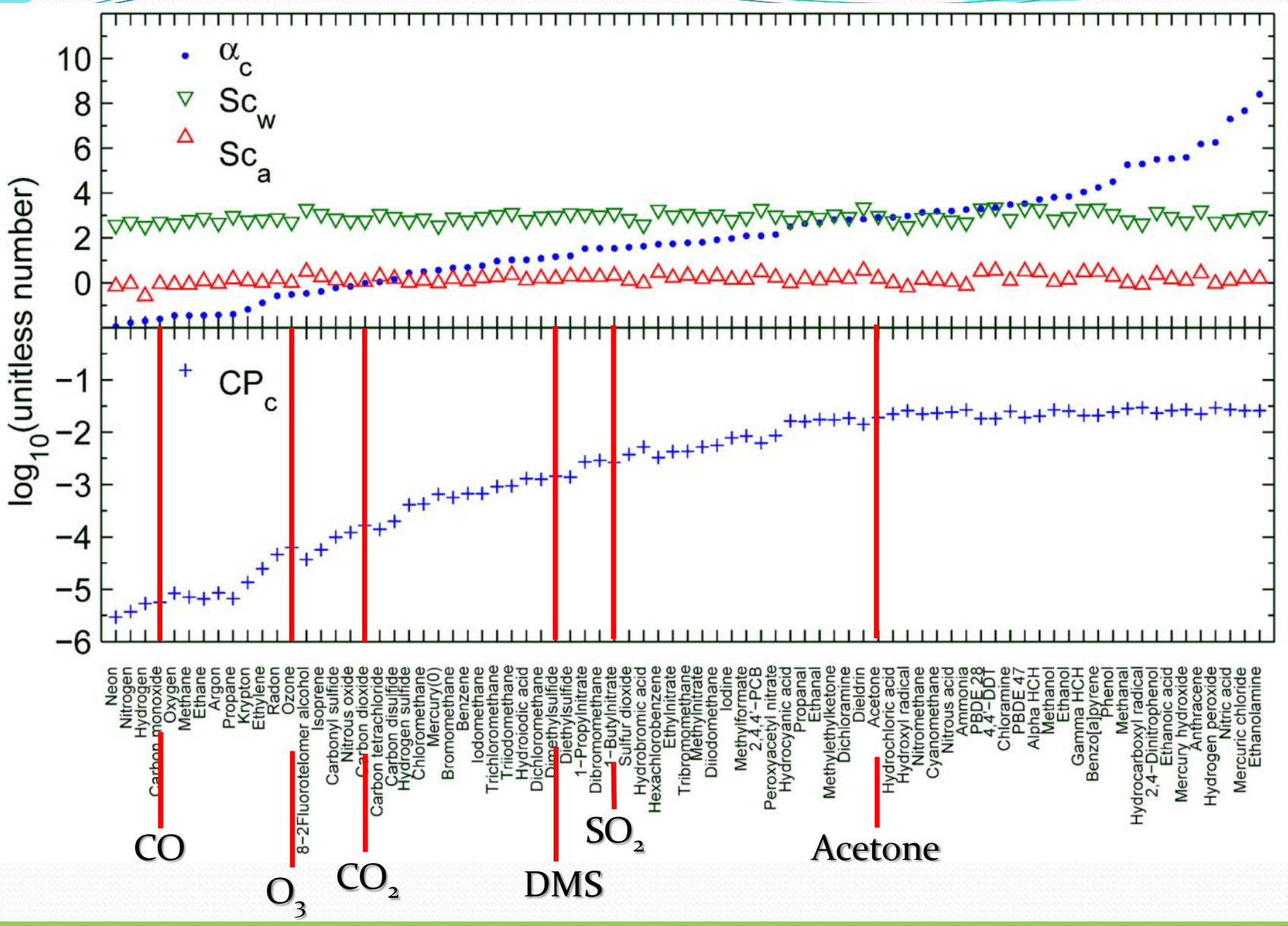
***k* predicted by the NOAA COARE gas transfer model**

More soluble gases have lower *k*

- airside control

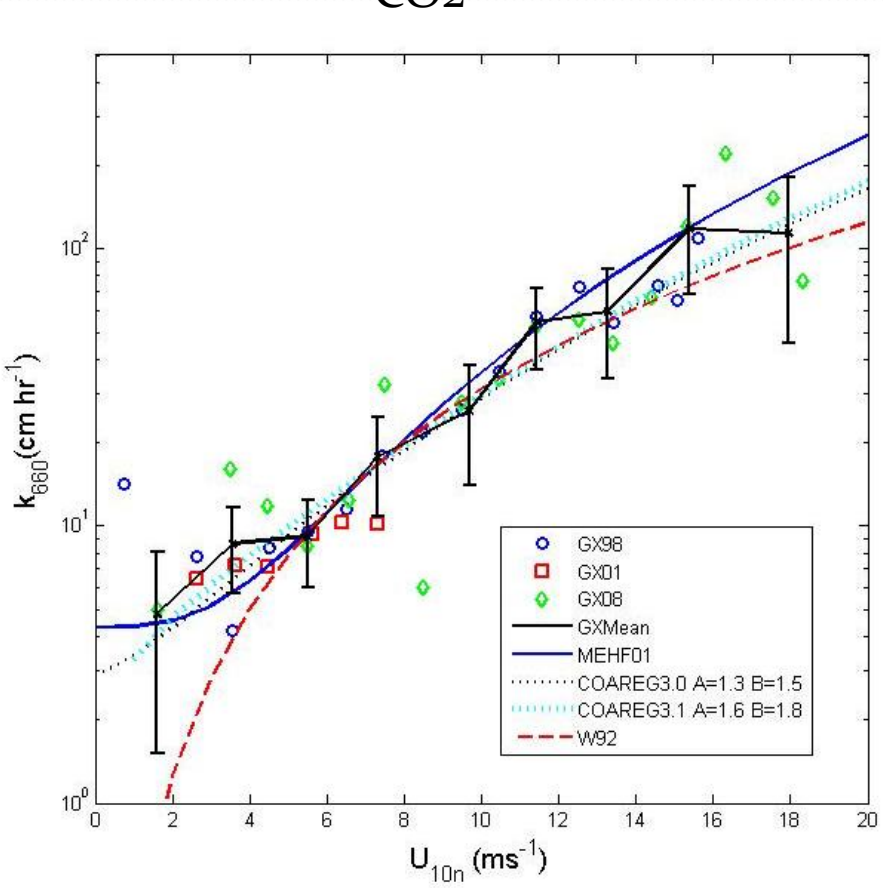
- less partition in air bubbles

Gas Solubilities

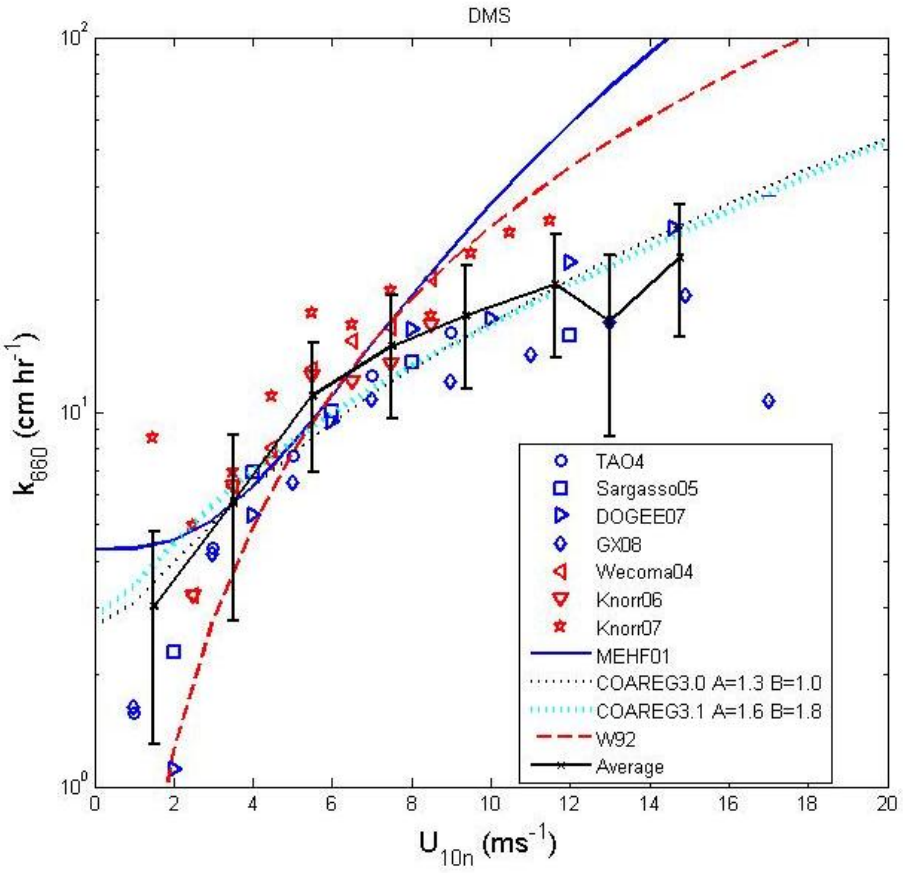


Eddy Covariance Observations as of 2010

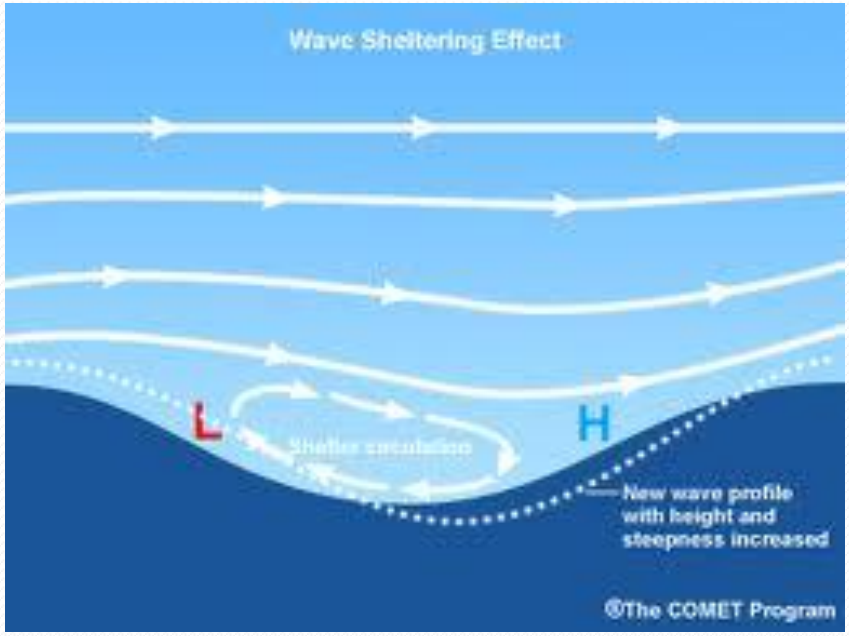
CO_2

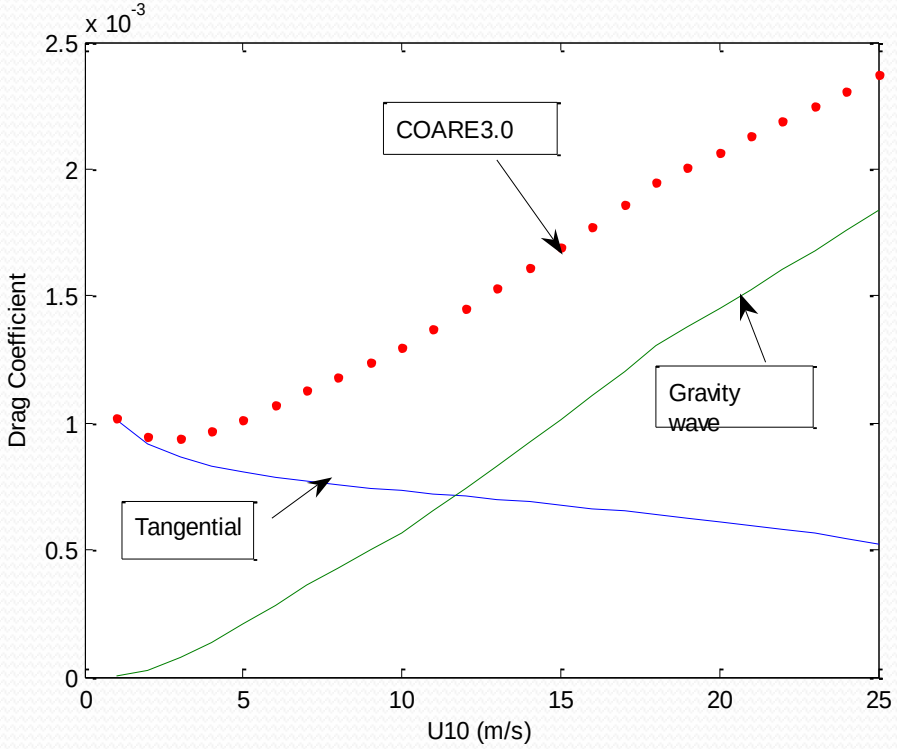


DMS



Major Non-Bubble Question:
Partitioning of wind stress into tangential / form drag?

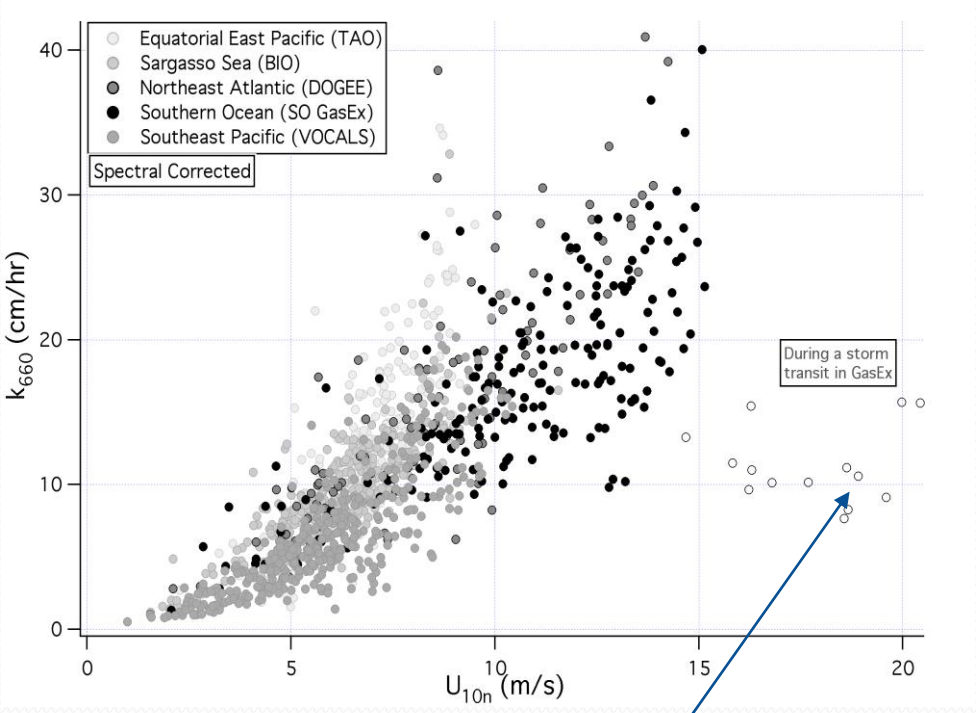




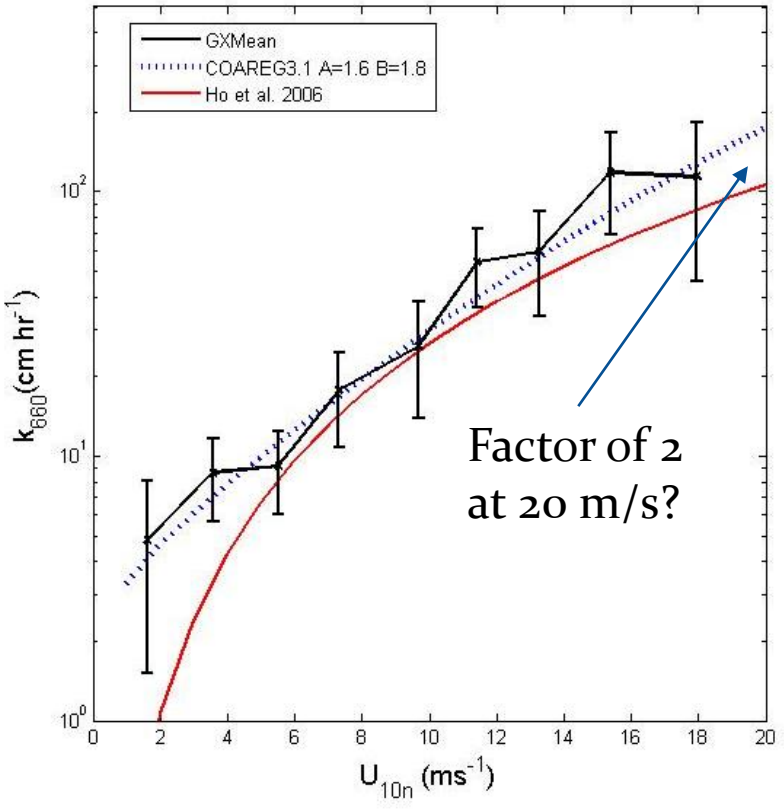
OTHER ISSUES:

Left - Drop in k for DMS at high winds?

Right - Disagreement tracer and eddy covariance?



DMS transfer velocity – Drop at high winds?



Need to include solubility, temperature, understand high wind / wave effects

HiWinGS
High Wind Gas Exchange Study

***Objective*:**

• Gather exchange data (fluxes, surface concentrations, physical forcings) in high winds

• Develop NOAA/COARE gas transfer model across solubility range and improve wave/whitecap/turbulence characterization

• Develop understanding of implications of surface renewal vs. form drag on gas exchange

HiWinGS
High Wind Gas Exchange Study

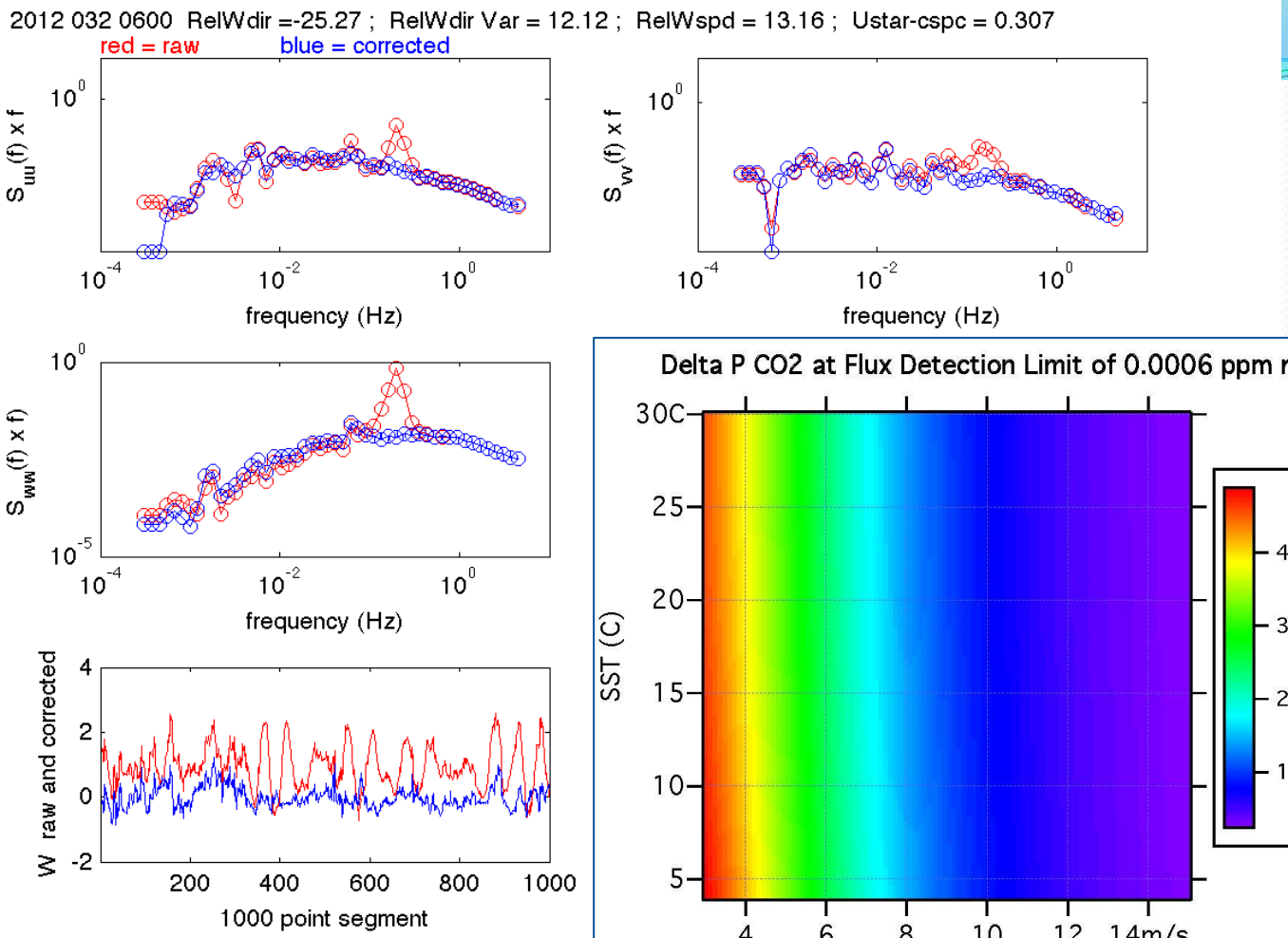
***Key observations*:**

• Gas fluxes and sea surface concentrations across solubility span (CO_2, DMS, Methanol, etc) with a variety of instruments

• Characterization of wave spectra, breaking, whitecaps, bubbles

• Methanol fluxes to characterize air-side transfer velocity contribution

• Recent advances in fast CO2 measurements permit extending observational capabilities



$$w(t) = w_m - \mu \bullet z(t)$$

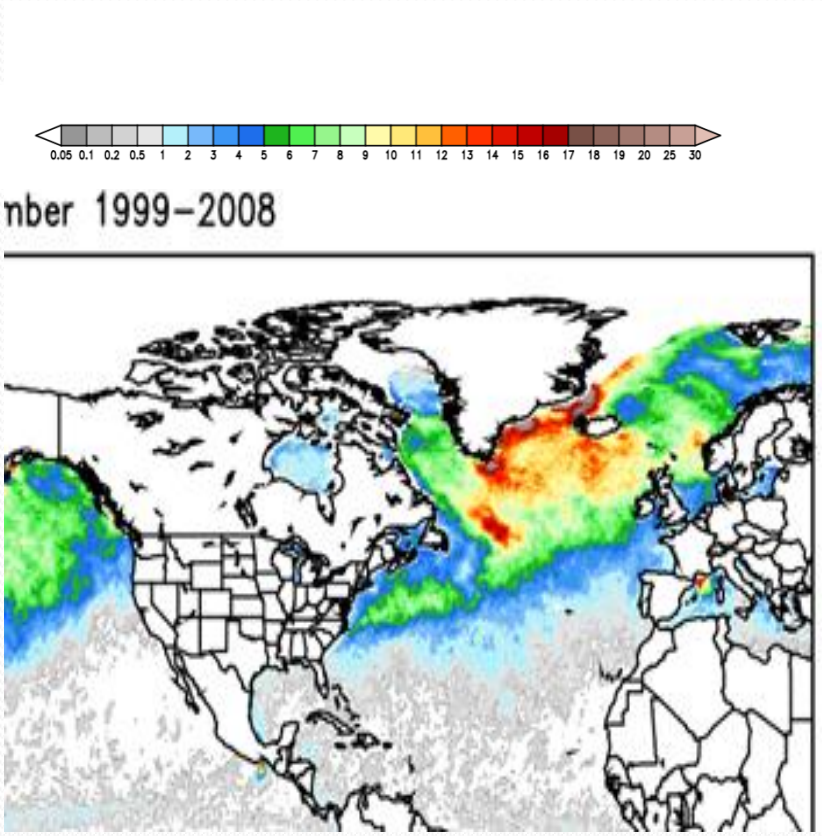
$$\mu = \langle wz \rangle / \sigma^2(z)$$

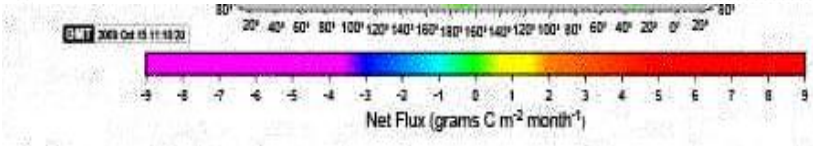
Significant improvement to motion correction results in better detection limit for CO_2 observations

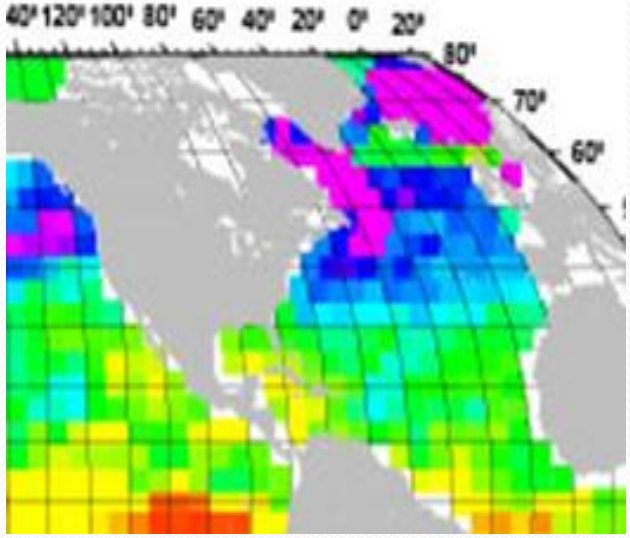
Site Considerations for the HiWinGS Cruise

- High wind speed (U>17 m/s)
- Significant DPCO2 (abs(dpco2)>40 ppm)
- Significant PDMSw
- Logistically attractive
- Sites considered
  - Gulf Tehuanepec
  - GASEX-3 Region
  - CLIMODE (N Atlantic)
  - SW. of New Zealand
  - **S. of Greenland – THE CHOICE**

Winds >17 m/s and CO2 flux November







Quikscat wind climatology:
M. Bourassa, FSU

Takahashi et al. CO_2 data base

Participants & Instrumentation

Huebert/Blomquist UH: Eddy fluxes of DMS, CO_2, stress, Continuous SW concs of DMS, CO_2

Zappa, Lamont: wave measurement imaging systems

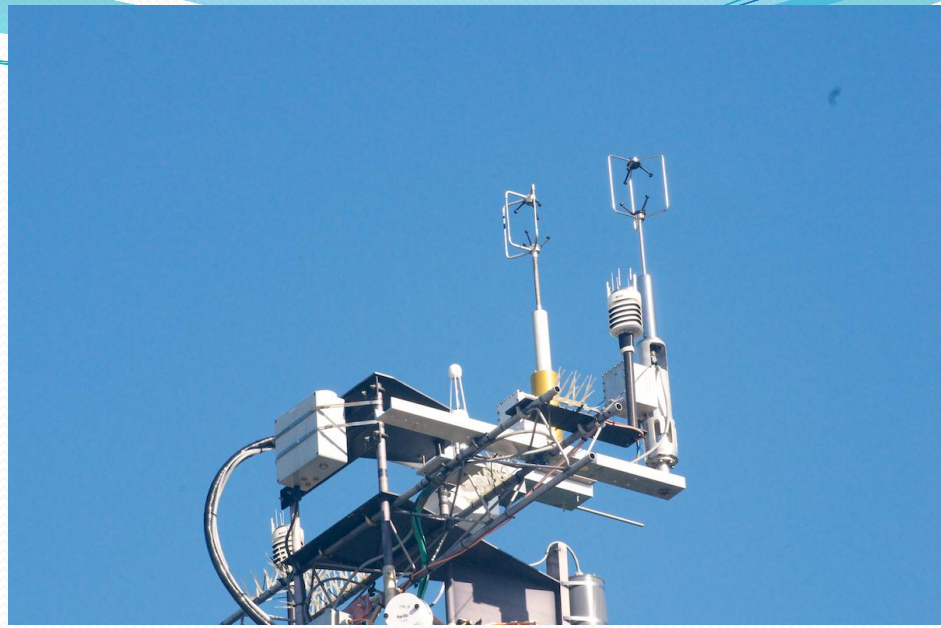
Brooks/Yelland, UK: CLASP aerosol spectrometer, Whitecaps from cameras, Radar for waves, Small spar buoy for wave measurement, bubble measurement strategies

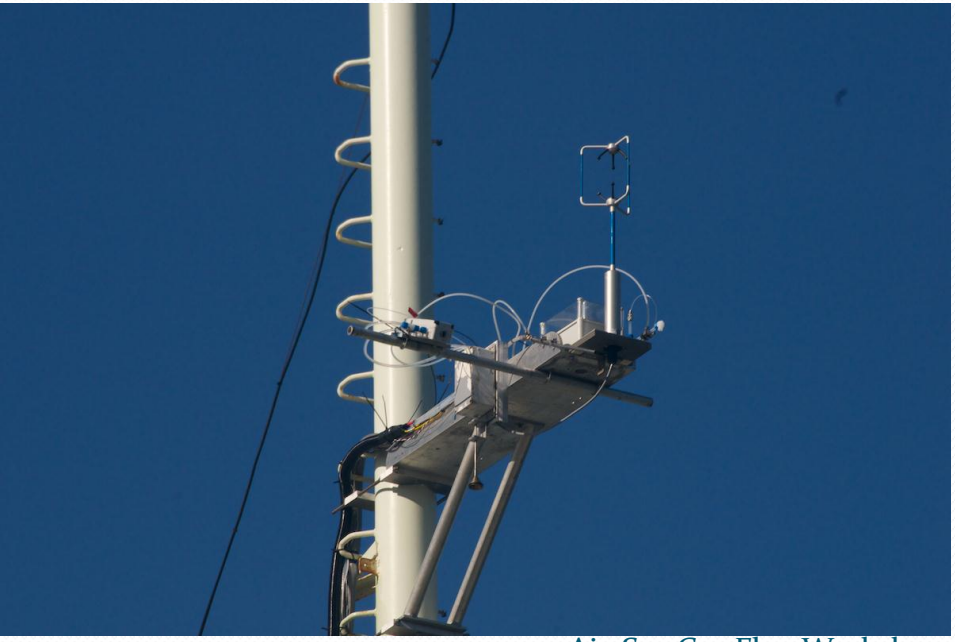
Fairall/Hare, NOAA: Theoretical and analytical arguments on measurement and parameterization approaches, lab work on sensor development, stress, water vapor, and CO_2 flux measurements

Bertram, UCSD: Fluxes of organics such as isoprene and monoterpenes

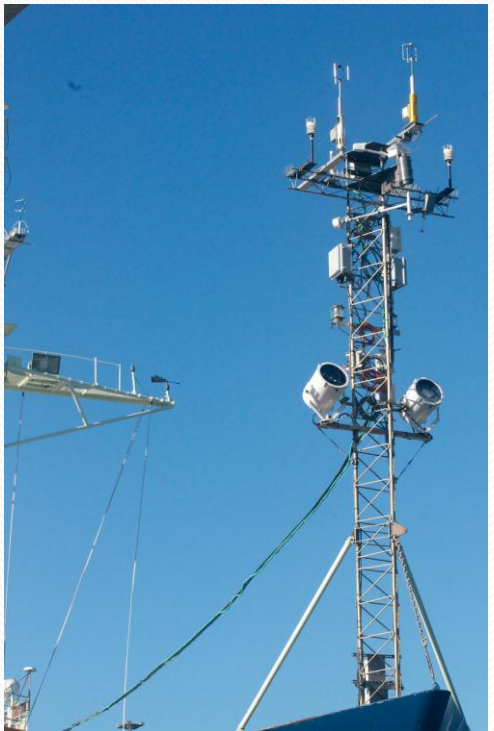
Yang, *Plymouth Marine Laboratory, UK*: Proton Transfer Reaction Mass Spectrometer (PTR-MS) of methanol and acetone (atmospheric and seawater), Sonic anemometer.

All: Bow tower to support multiple sonic anemometers, chemical sensors, and inlet systems for lab instruments; clean seawater supply; possibly a fish for near-surface profiling;





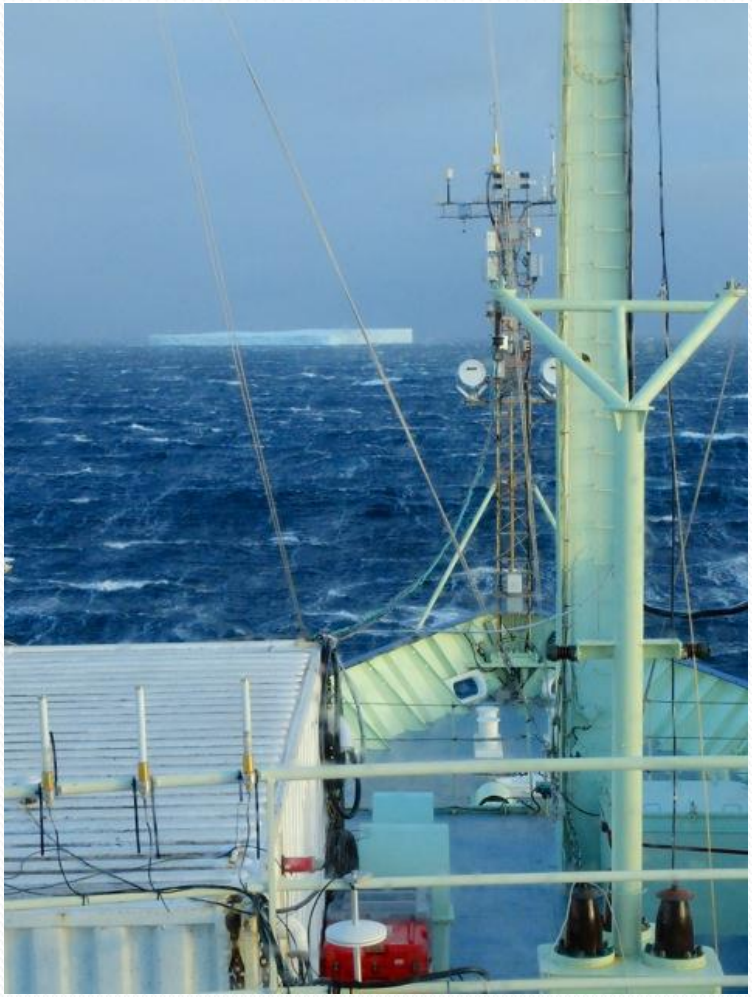
Meteoro logical sensors on R/V Knorr

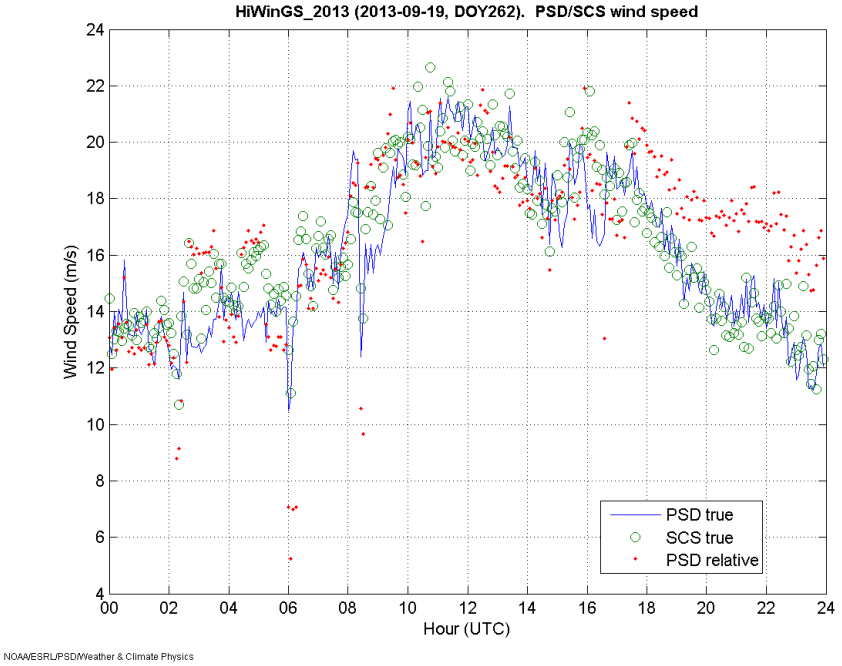


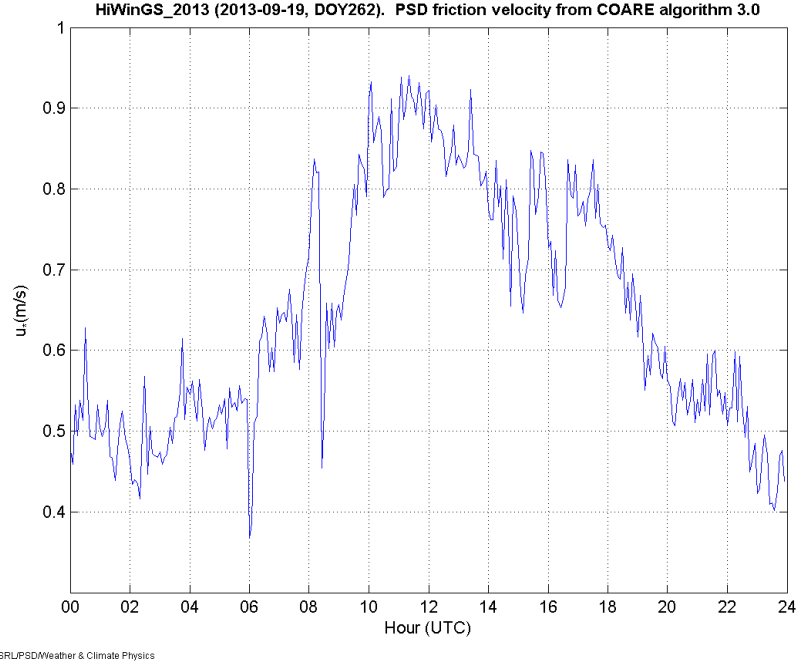
R/V Knorr early in HIWINGS

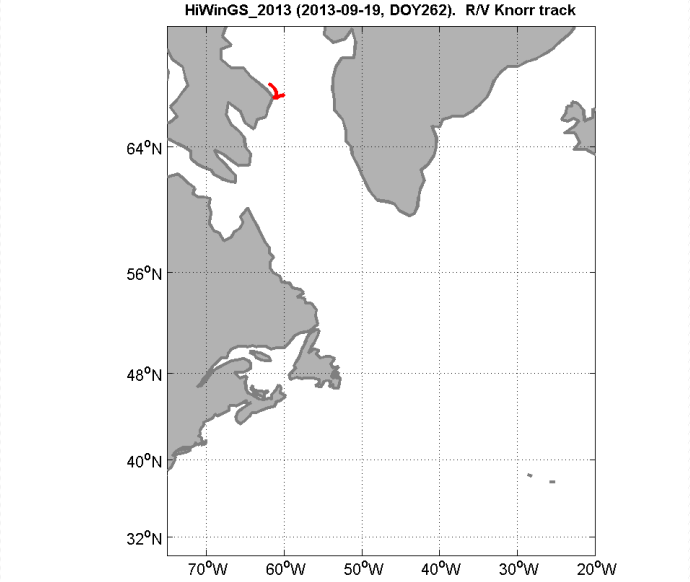
Port call in Nuuk, Greeland
Sept 11 2013

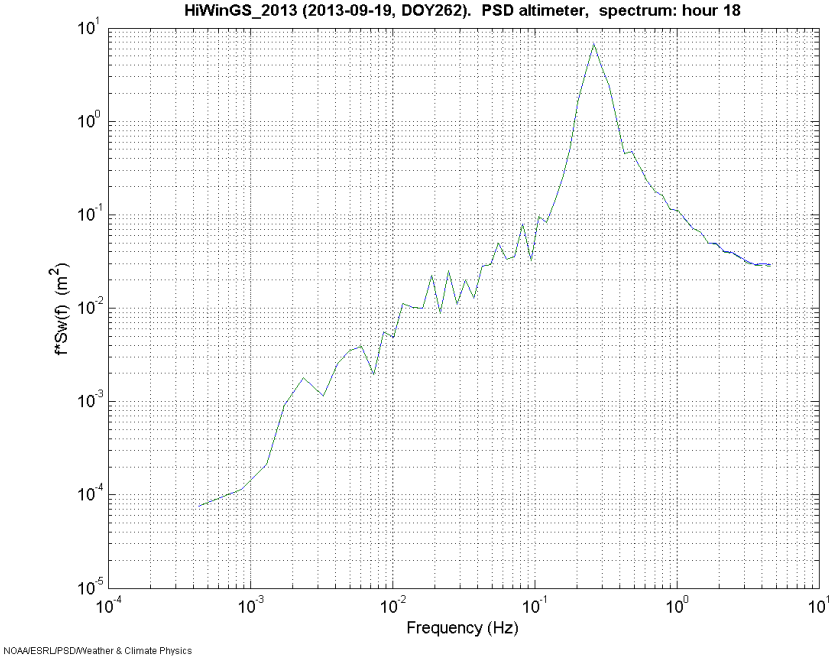
20 m/s winds near Baffin Island









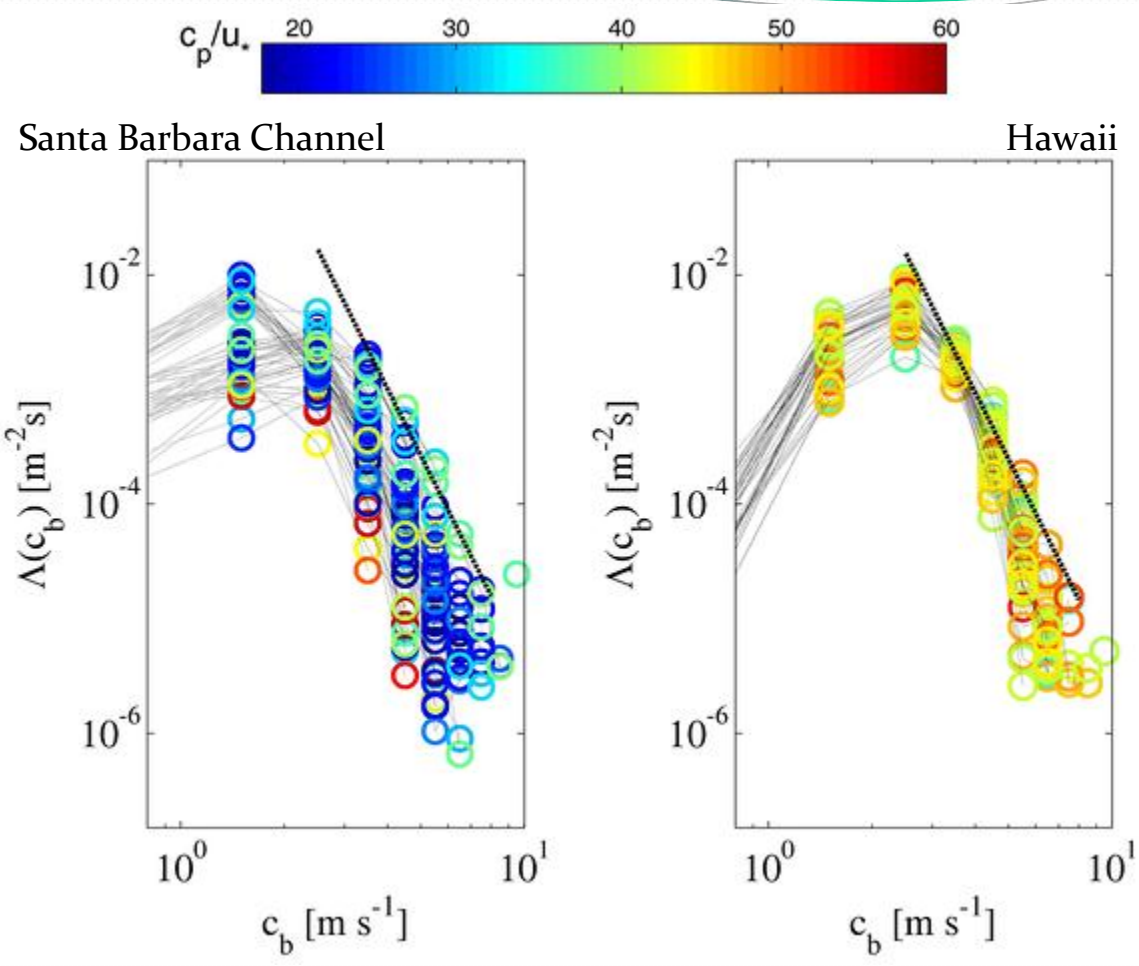


ftp://ftp1.esrl.noaa.gov/psd3/cruises/HIWINGS_2013/Knorr/flux/Raw_Images/

Examples of Planned Observations

Breaking Crest Length Distribution using video and IR

LDEO

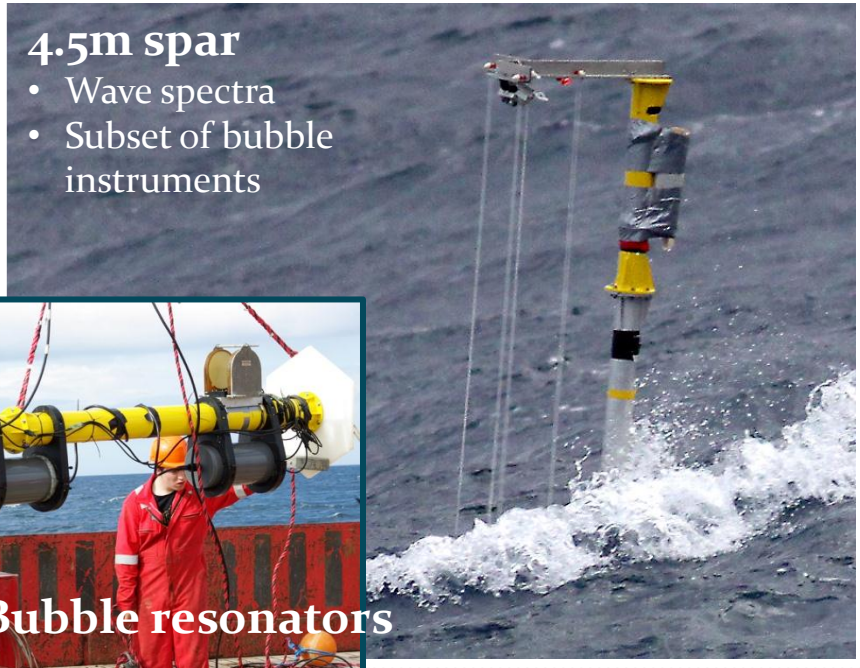


Young wind seas on left vs old wind seas on the right;
Breaking crest speed at peak is lower for SBC;
Variance in breaking crest length magnitude is higher for SBC.

SPAR Buoys – wave spectra, breaking, and bubbles

LEEDS

- Optical bubble camera
- Acoustic bubble sensors
- Upward pointing sonar – bubble plume imaging
- Wave wires + heave sensor
- Nortek ADV for turbulence
- Whitecap imaging camera in dome



Measurement of VOC fluxes

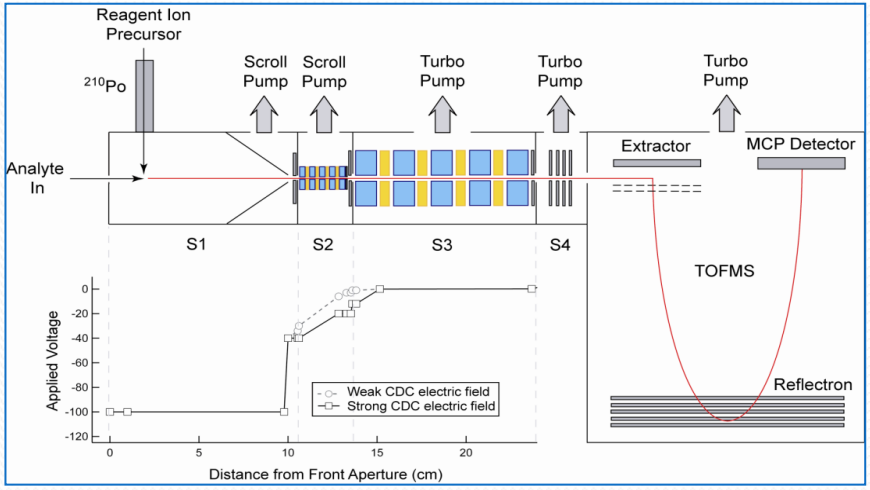
UCSD

Marine Volatile Organic Compounds (VOC):

1) **Impact oxidant loadings in the MBL**
2) **Contribute to secondary organic aerosol production**
3) **Affect size and µ-physical properties of marine CCN**

Chemical Ionization Time-of-Flight Mass Spectrometry (CI-TOFMS) (DMSO, isoprene, acetone, methanol, dimethylamine)

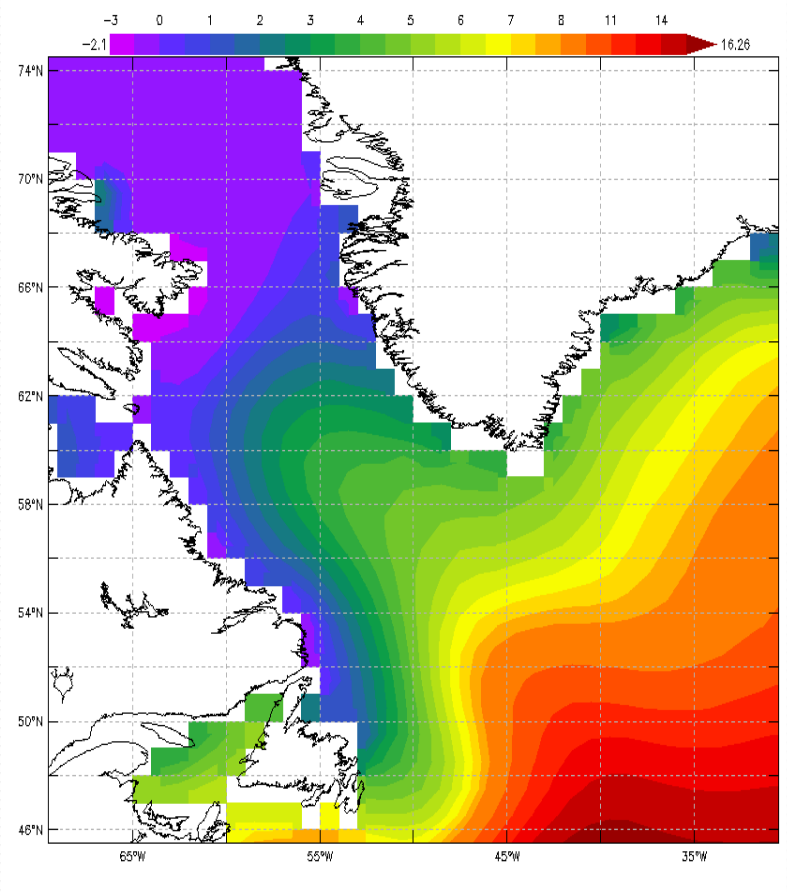
Complete mass spectrum at 20Hz

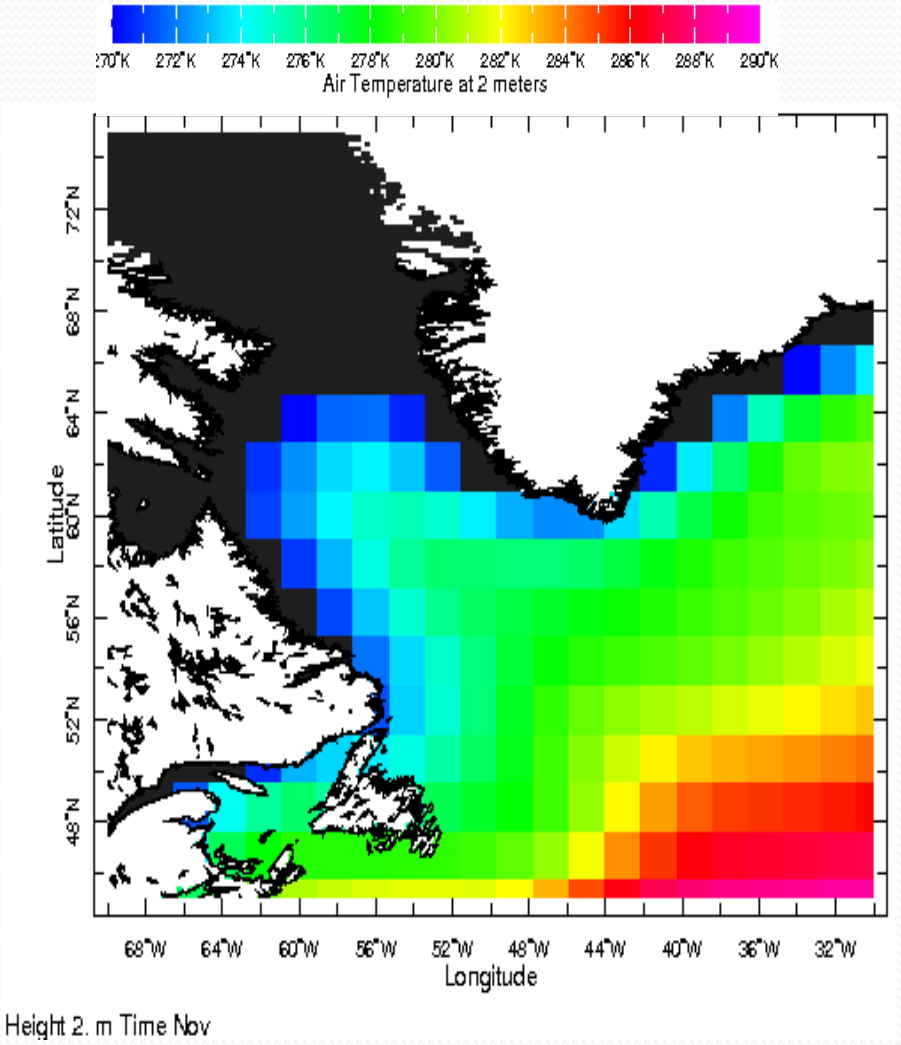


Compound	CO_2	Isoprene	DMS	Dimethyl amine	Methanol	DMSO
K_H [M atm^{-1}]	3.4 x 10^{-2}	1.3 x 10^{-2}	5.5 x 10^{-1}	3.1 x 10^{1}	2.3 x 10^{2}	1.4 x 10^{3}

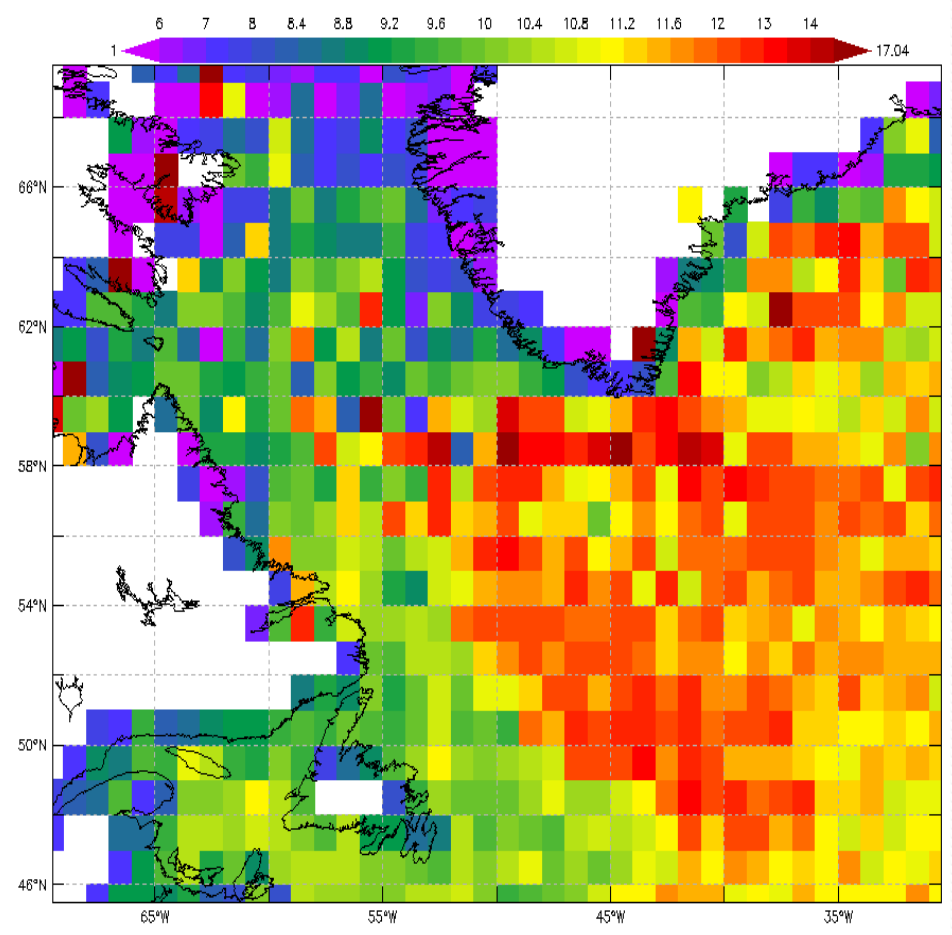
N Atlantic Temperatures November
SOCAT Database, http://www.socat.info/

Sea Surface Temperature

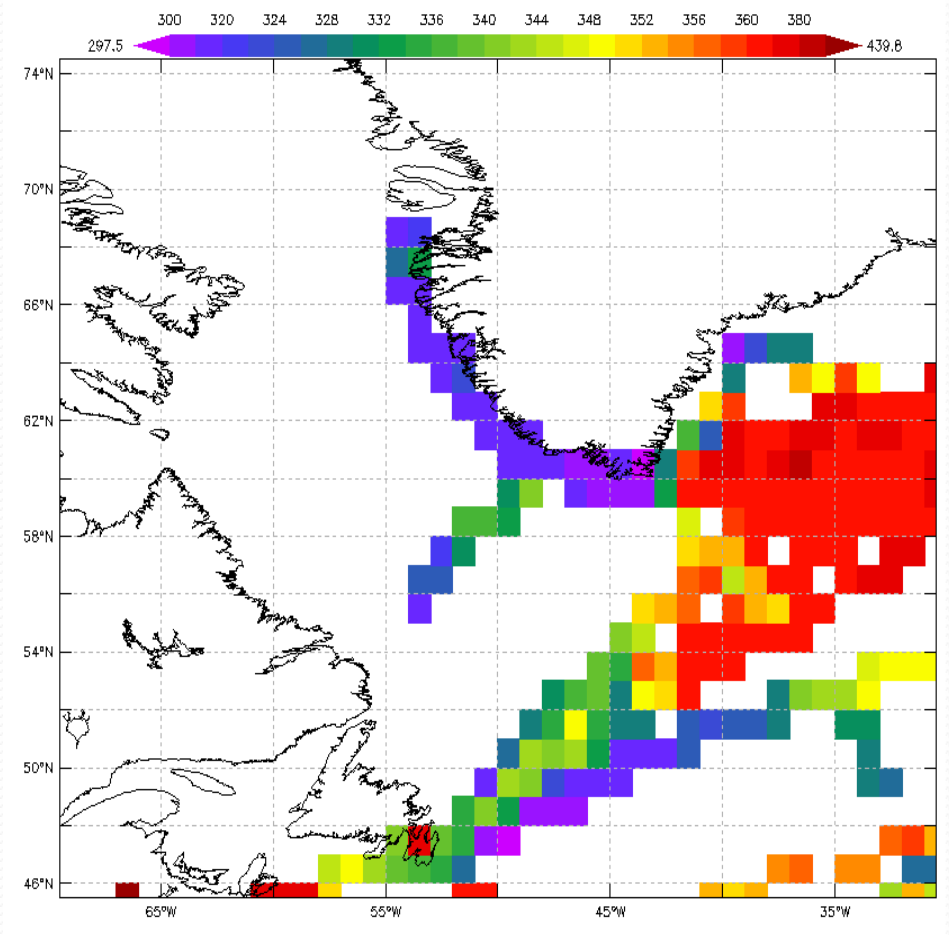




Winds and PCO2 November
SOCAT Database, http://www.socat.info/



U10m (m/s)



PCO2w

Ocean Flux GHG Project Data: http://www.oceanflux-ghg.org/The-Project