US CLIVAR High-Latitude Surface Flux Working Group

Co-chairs: Mark Bourassa and Sarah Gille

Ed Andreas, Cecelia Bitz, Dave Carlson, Ivana Cerovecki, Meghan Cronin, Will Drennan, Chris Fairall, Ross Hoffman, Gudrun Magnusdotti, Rachel Pinker, Ian Renfrew, Mark Serreze, Kevin Speer, Lynne Talley, Gary Wick

US CLIVAR Summit, July 2013, Annapolis

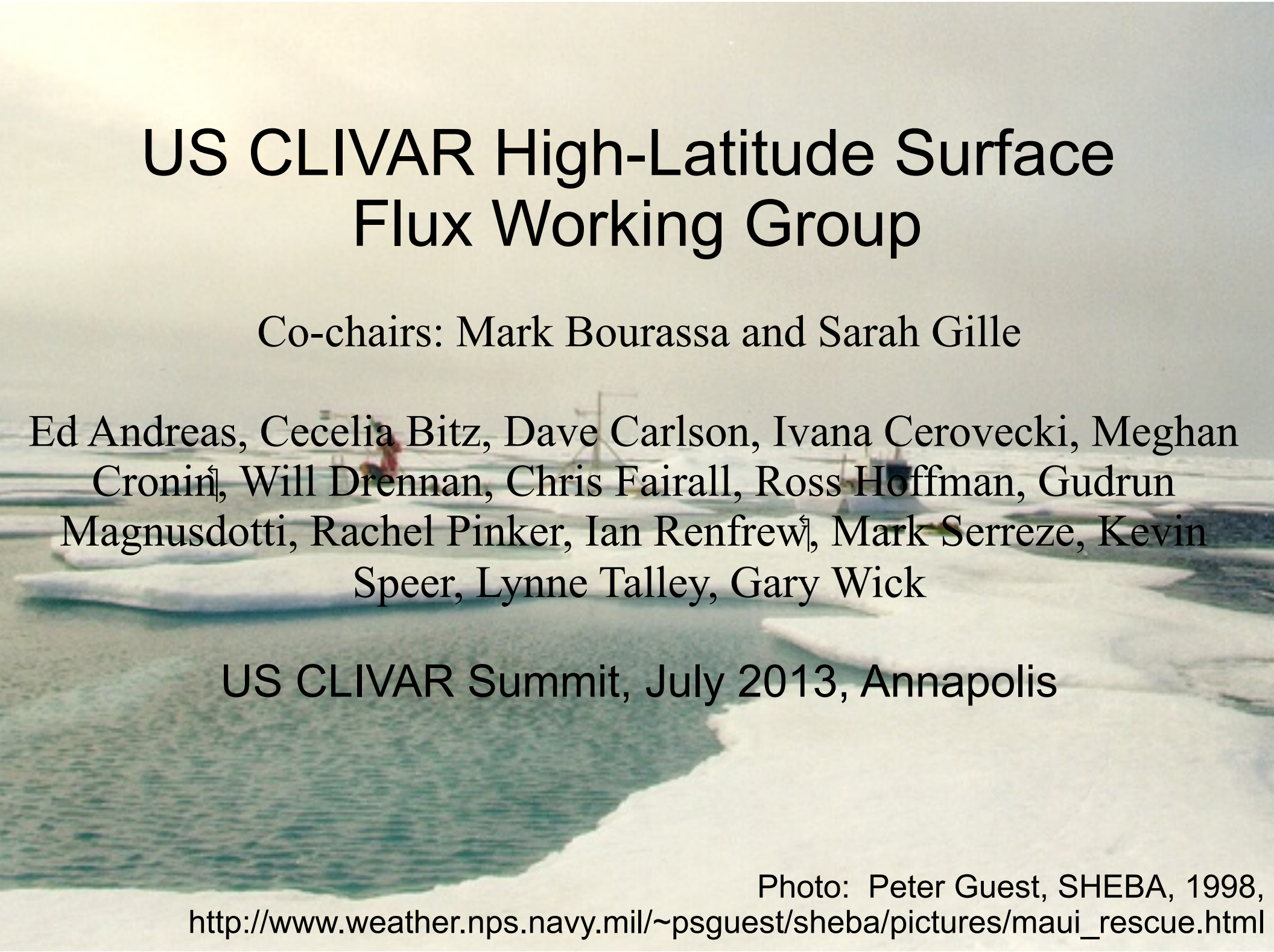


Photo: Peter Guest, SHEBA, 1998, http://www.weather.nps.navy.mil/~psguest/sheba/pictures/maui_rescue.html

Membership

- Ed Andreas (associate)
- Cecelia Bitz
- Mark Bourassa (co-chair)
- Dave Carlson
- Ivana Cerovecki (associate)
- Meghan Cronin (associate)
- Will Drennan
- Chris Fairall
- Sarah Gille (co-chair)
- Ross Hoffman
- Gudrun Magnusdottir
- Rachel Pinker (associate)
- Ian Renfrew (associate)
- Mark Serreze
- Kevin Speer
- Lynne Talley
- Gary Wick

Working Group Started with 2 Objectives

- Document present state of high-latitude fluxes, considering momentum, heat, freshwater, and CO_2. Focus primarily on ocean-atmosphere and ocean-ice-atmosphere fluxes.
- Organize community workshop to coordinate efforts to improve flux estimates at high latitudes.

Photo: Peter Guest, SHEBA
http://www.weather.nps.navy.mil/~psguest/sheba/pictures/artsy.html

Documenting State of Fluxes

- From 2008 to ~ 2010, regular telecons, plus a one-day meeting following AMS meeting in Phoenix in January 2009.
- Workshop (with SeaFlux) in 2010
  - *US CLIVAR Variations* meeting summary.
  - *EOS* workshop summary
- BAMS paper summarizing current state of fluxes (published March 2013)
- OceanObs09 contribution
- *J. Climate/JPO/JTech* (AMS) special collection

Photo: 20 m/s winds as seen from ship. Southern Ocean GasEx (Chris Fairall)

Joint US CLIVAR/SeaFlux Workshop

Workshop participants, Day 3

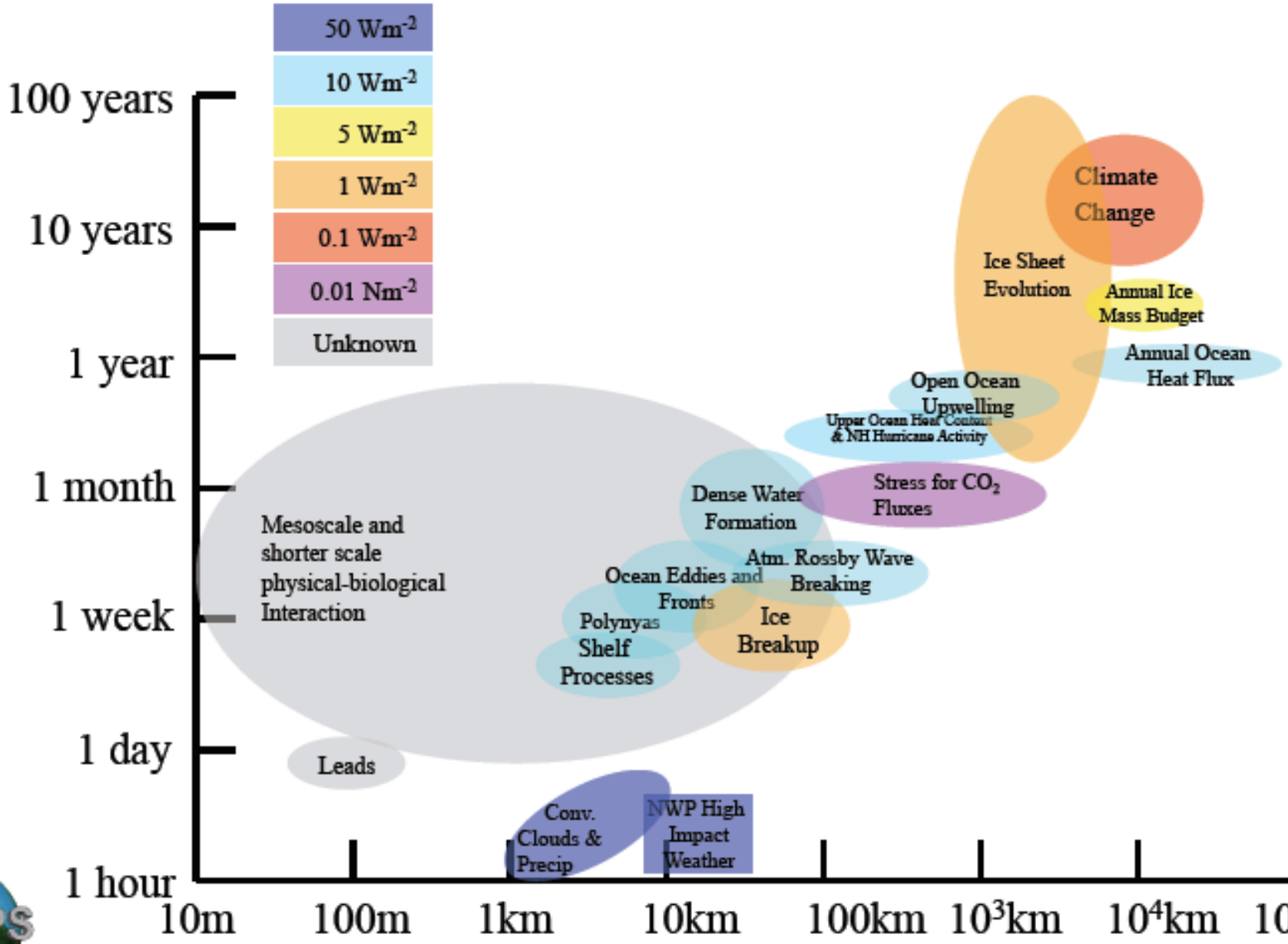
- Disseminate findings.
- Articulate a prioritized plan for improved fluxes.

- Open community workshop held in Boulder, Colorado, 17-19 March 2010, NCAR Center Green
- Capacity crowd (70 participants).

Workshop Objectives

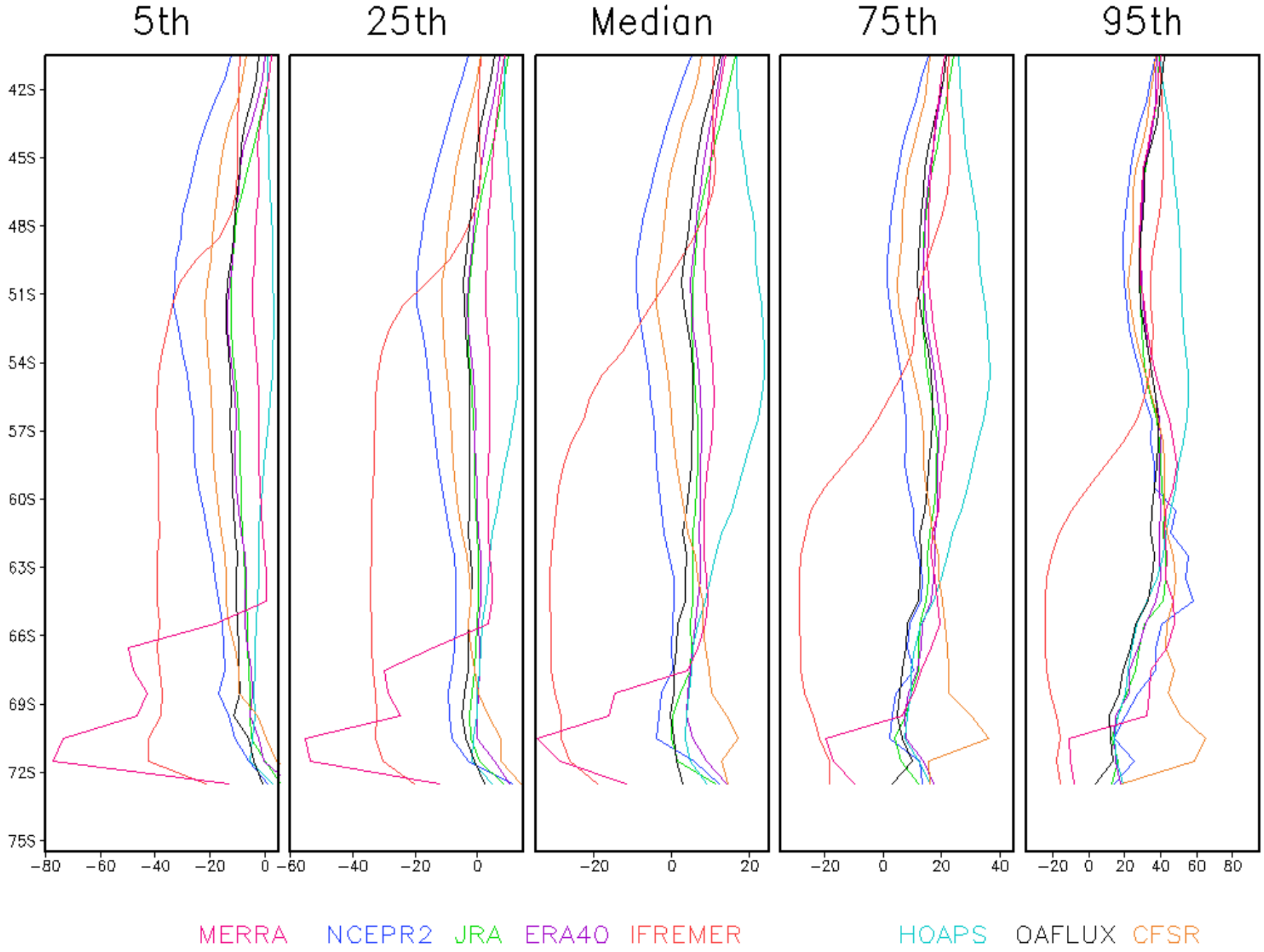
- Share results on applications that rely on fluxes, and look at flux requirements implied by applications.
- Share results on gridded flux products and regional observational (process) studies.

Flux Accuracies and Applications



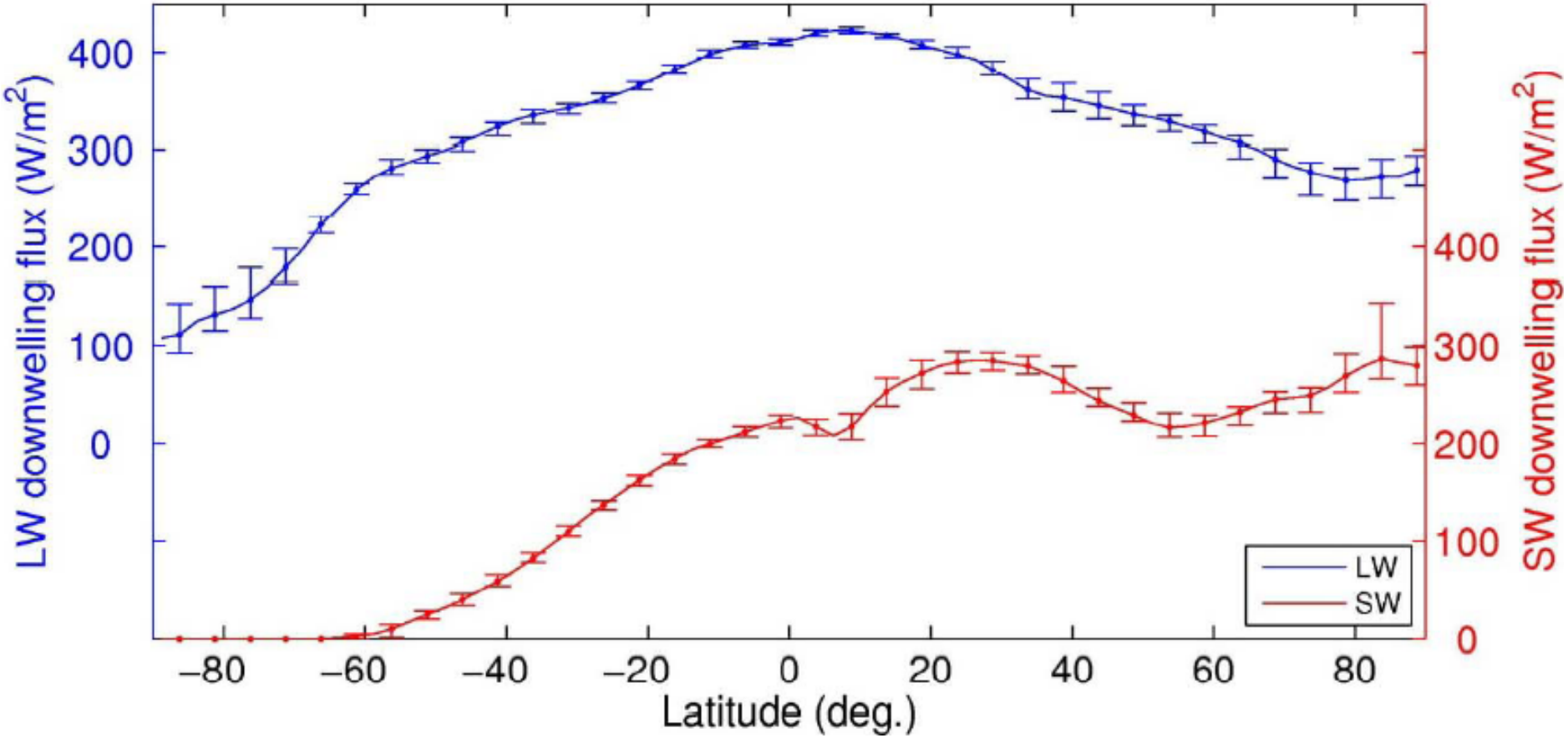
Graphic from Bourassa et al. 2013, BAMS

Distribution of SHF is Inconsistent Among Products



Graphic from Bourassa et al. 2013, BAMS

July Shortwave and Longwave Downwelling Fluxes

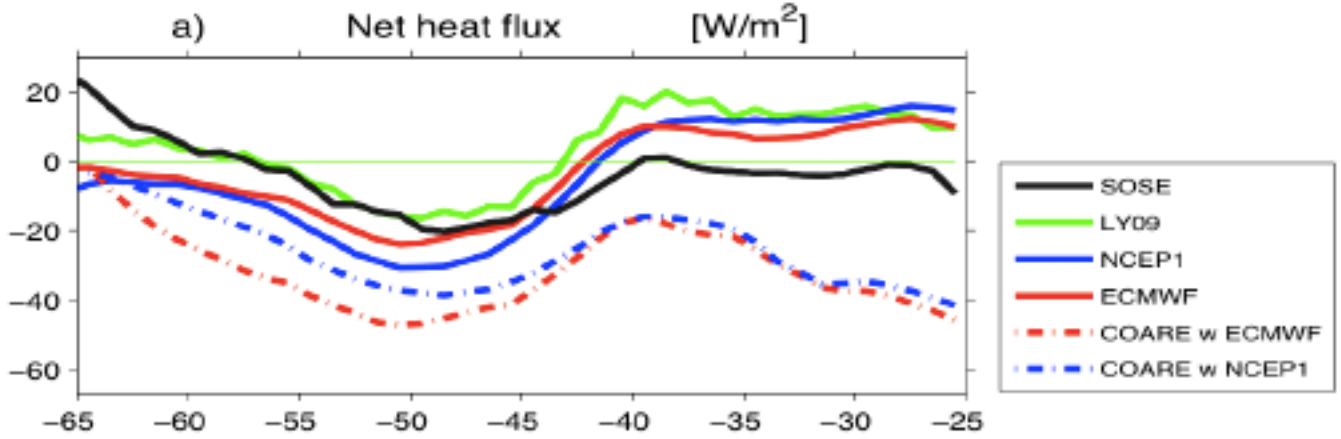


- Radiative fluxes in high latitudes are relatively uncertain. Error bars are one standard deviation, including differences between products and natural variability.

Graphic from Bourassa et al. 2013, BAMS

Next generation gridded products: SeaFlux

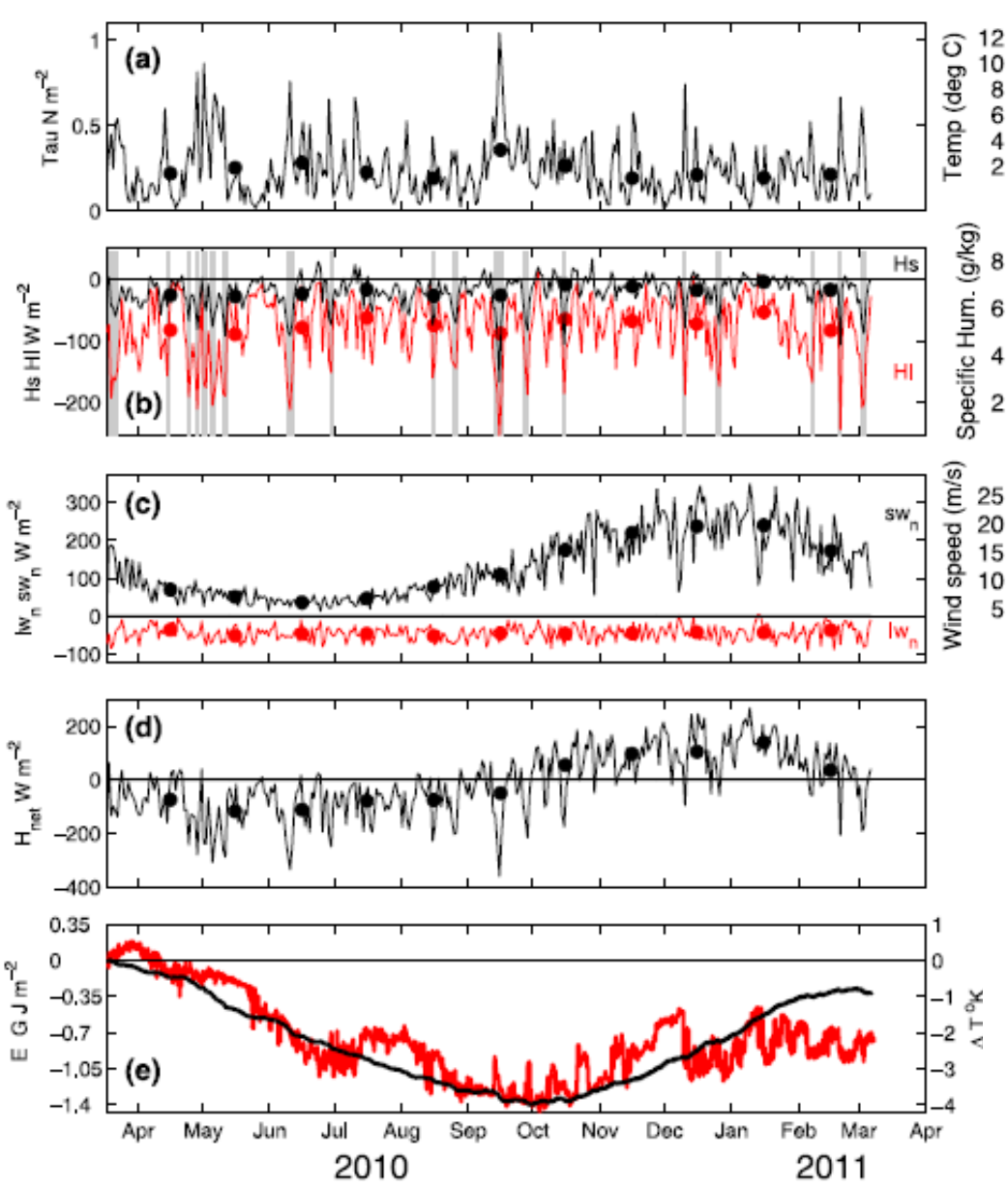
- SeaFlux focused on gridded products, with substantial contributions from satellite observations and reanalysis.
- Assessment crucial. US CLIVAR may be able to help with flux assessment (e.g. a Flux Intercomparison Project or a flux component in a future Model Intercomparison Project).
- All users can help make sure flux products are put through tests with a variety of applications.

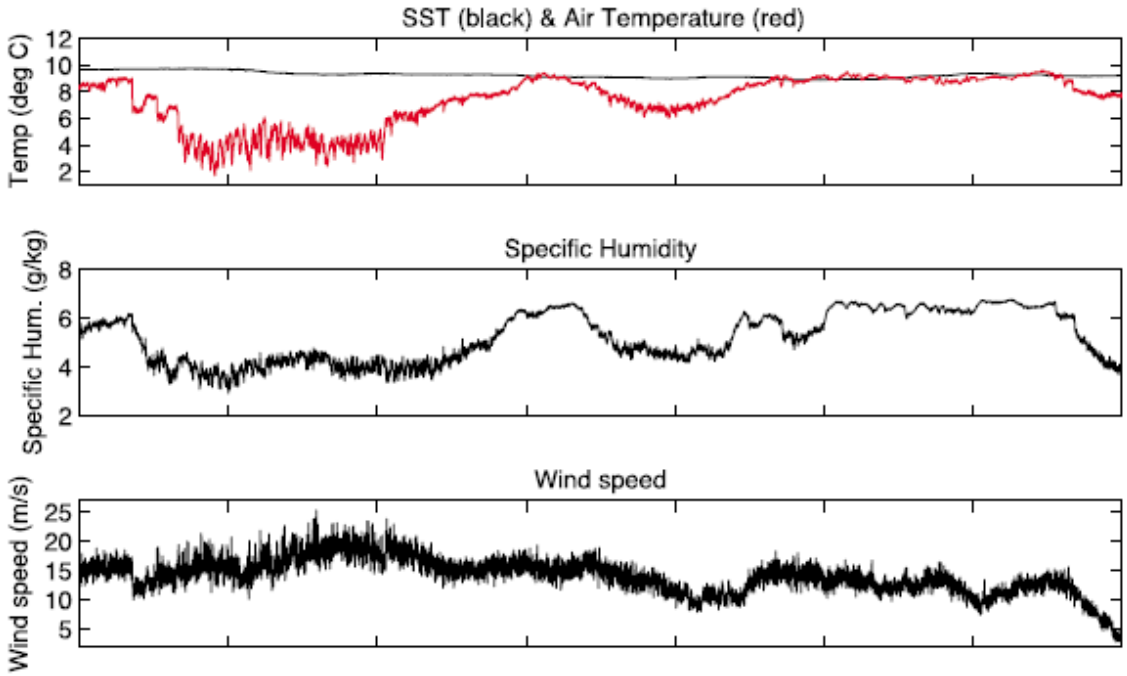


Example flux comparison: Zonal average, 2005-07 (Cerovecki et al., 2010)

SOSE (Southern Ocean State Estimate); LY09 (Large and Yeager, 2009)

Observations from Southern Ocean Flux Station

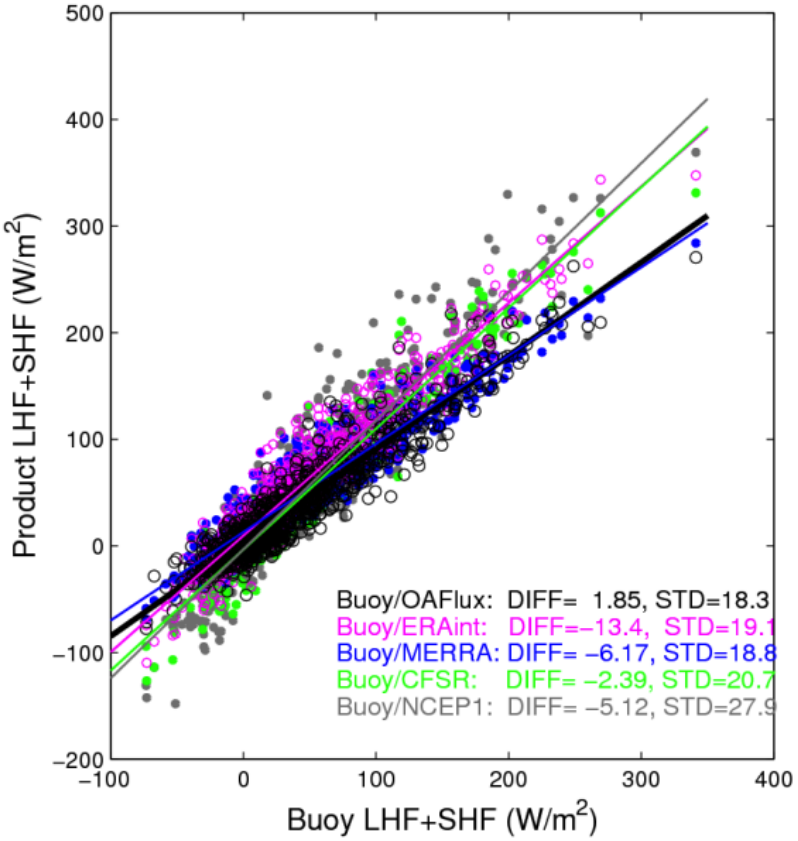




- High-quality high-latitude observations must be maintained to provide
  - Surface truth for satellite observations and NWP
  - Ensure stability of satellite time series
  - Observations for process studies

Graphics from Schulz et al. 2012, JGR

Daily mean, N=945

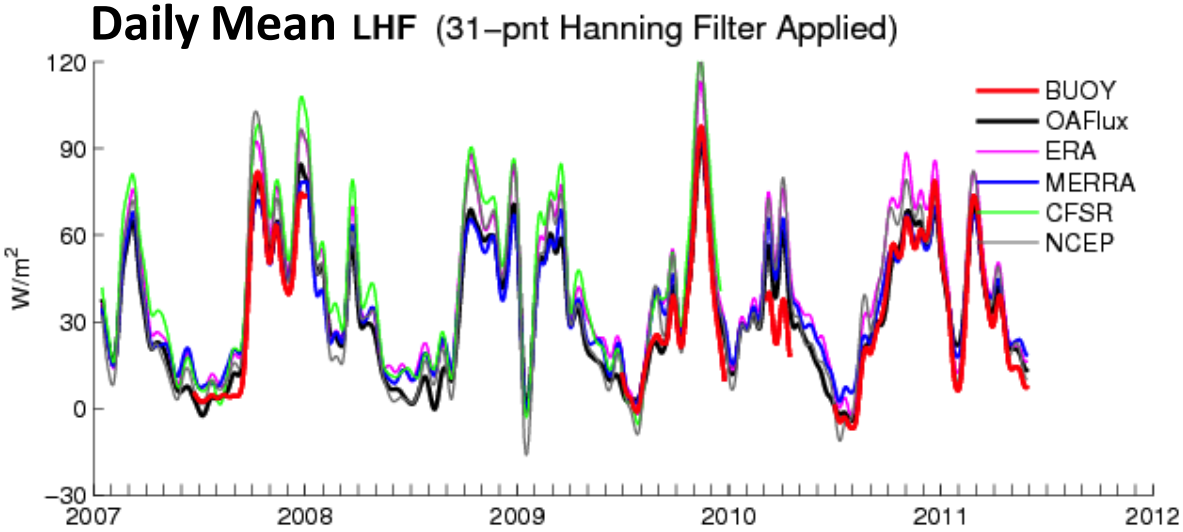


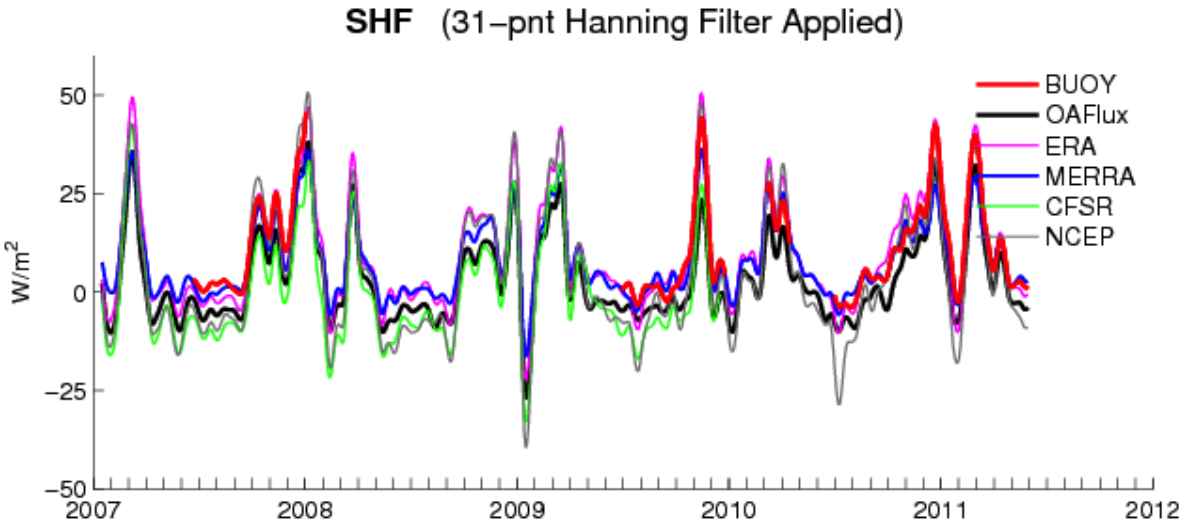
station map is from
http://www.pmel.noaa.gov/ocs/disdel/disdel.html

WHOI OAFlux Project
PI: Lisan Yu

Flux product comparison with Buoy

Station Papa (50N, 145W)

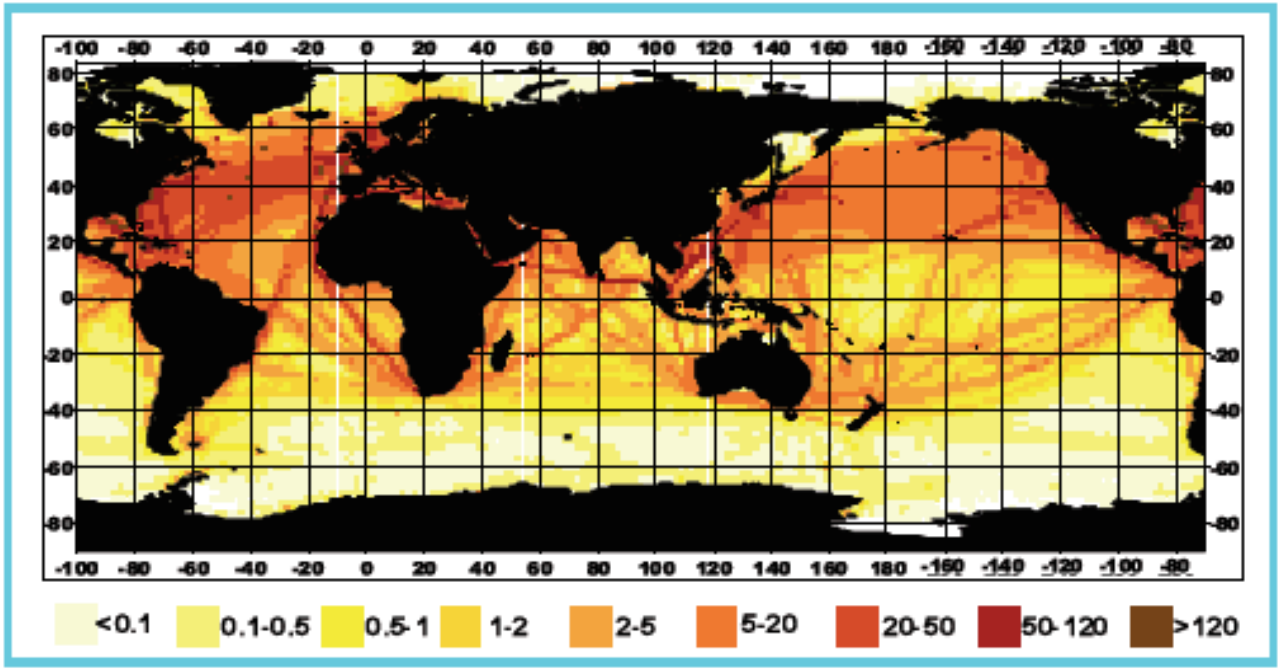




Need for observations

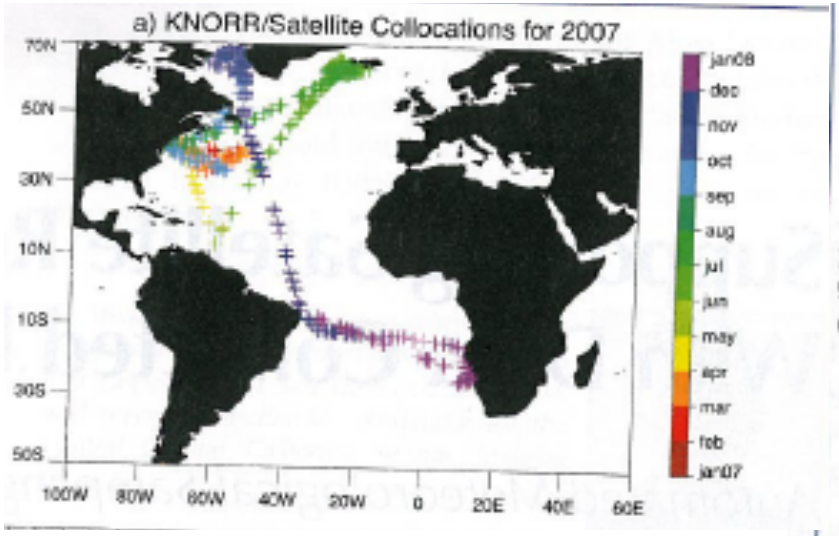
- Historic observations sparse, but it will be crucial to analyze historical data carefully and to make use of new data as it becomes available
- New buoy observations (longest record is south of Tasmania)
- Since workshop, Fairall et al. have instrumented a NOAA ship operating in Bering Sea.

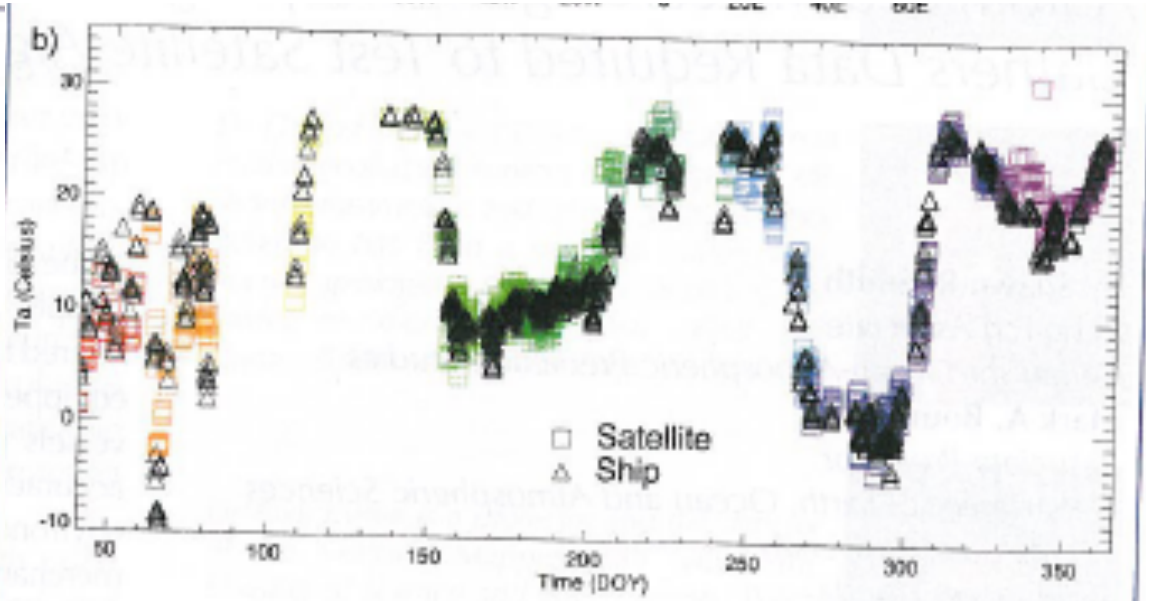
ICOADS VOS data: 1880-2007

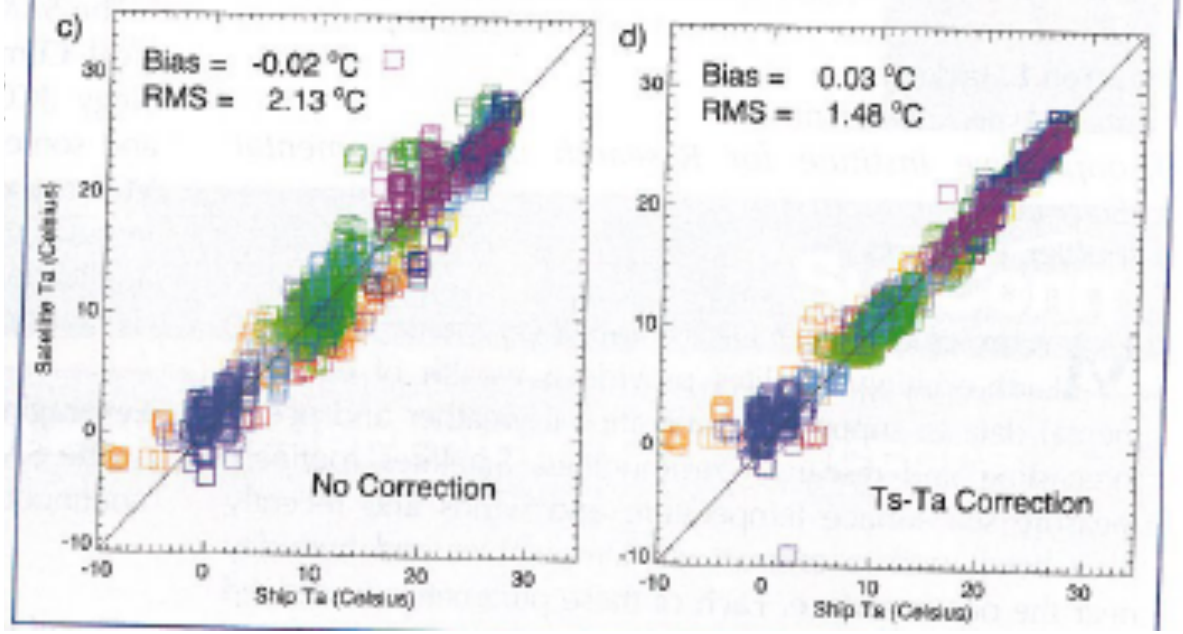


Sampling is inhomogeneous in space and in time!

Evaluation of Satellite Retrievals of 10m Ta and Qa



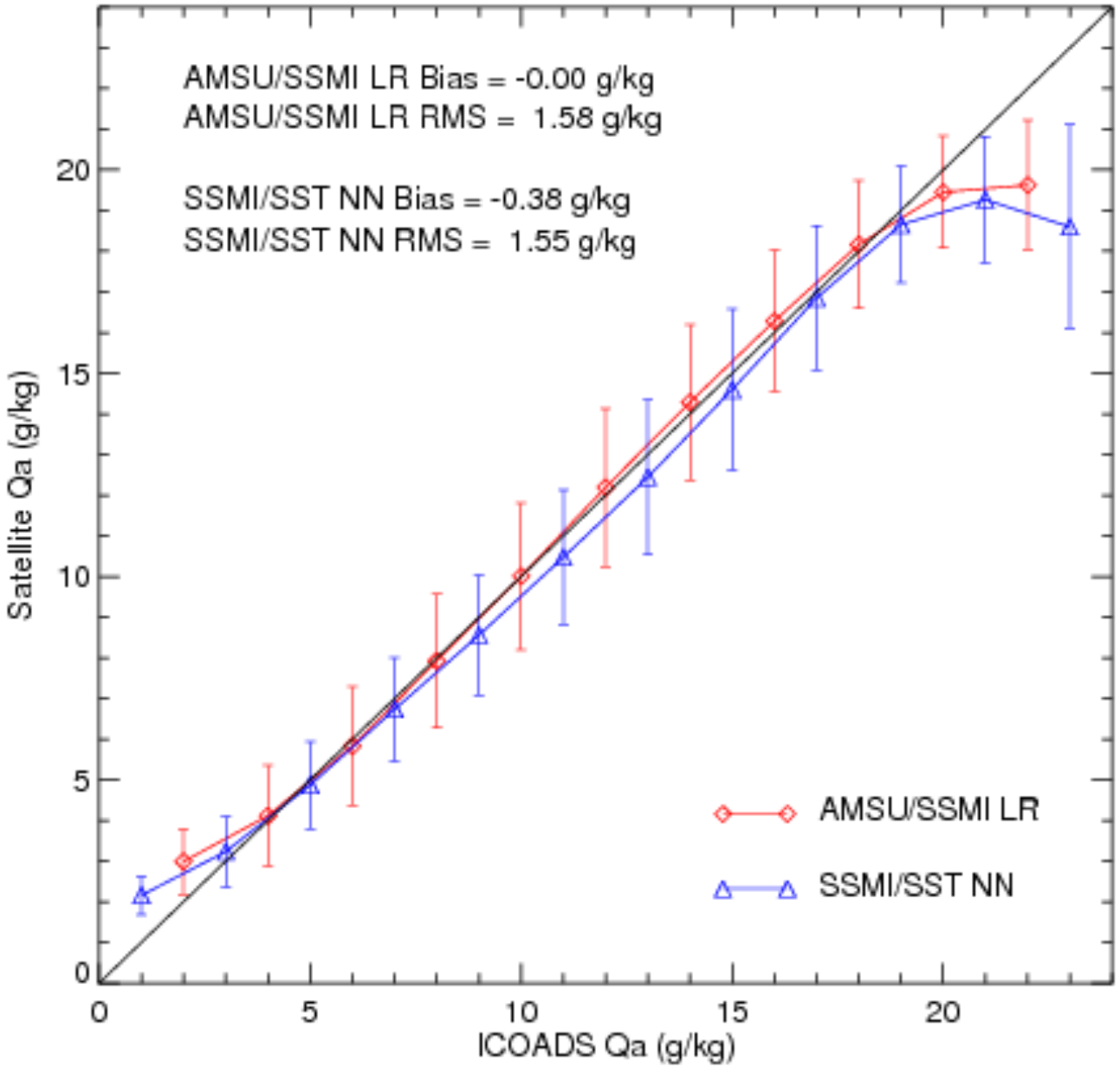




- Comparison to research vessel observations from SAMOS
- Metadata are used to make systematic (but not uniform) adjustments to the data
- Archiving of metadata is essential

Gaphics from Smith, et al., 2012Sea Tech., June 2012, 21 – 24.

Comparison of Two Retrieval Techniques



- Blue – Roberts et al. (SeaFlux)
- Red – Jackson and Wick
- Need more surface data from extreme conditions to improve satellite retievals for these extremes

Graphic from Bourassa et al. 2013, BAMS

USCLIVAR Working Group Recommendations

- *Acquire more in situ observations*
  - Direct observations of fluxes; input data for bulk turbulent flux algorithms; and input for estimation of radiative fluxes
    - E.g., R/V observations, Antarctic support vessels, moored buoys, instrumentation of merchant ships working high latitude routes, and UAVs
    - Metadata must also be recorded
  - Process studies including on ice field campaigns
  - Always needed for satellite validation!
- *Make observations and flux products more accessible*
  - Easier to find
    - We are working with several groups to achieve this goal
  - Include uncertainties
  - With easily accessible information on strengths and weaknesses

Recommendations Continued

- *Develop improved satellite observing capabilities*
  - Improve upon existing algorithms for high-lat conditions
  - Energy fluxes have many issues that can be partially addressed better observations of related variables.
  - Stress from scatterometers
  - CO_2 fluxes
  - For time scales typical of the synoptic scale in the atmosphere, an accuracy of 5 Wm^{-2} in net energy fluxes is considered a desirable, albeit challenging.
  - Likely will require
    - Closely collocated satellite observations (either on a single satellite or an A-Train like arrangement)
    - Coordinated satellite orbits

Additional Suggested Ways Forward

- Continue to assess accuracy requirements
  - Test the observing system and models with selected processes
- Improve the physics for assimilation of satellite winds
  - Treat them as equivalent neutral winds or perhaps stress
    - Related to trend in long-term gridded products
  - Include waves and currents in assimilation & flux models
    - Downside – more approaches than researchers
  - Requires more comparison and assessment
- Determine what satellite sampling is needed
  - Work to achieve that sampling
  - In situ data will ALWAYS be needed to test satellite calibration
  - Finer spatial/temporal sampling
    - E.g, 5km resolution or better has been suggested for a scatterometer on GCOM-W2; 1km to 100m has been suggested for coastal regions

Photo: Chris Fairall, Southern Ocean GasEx

Workshop Consensus Strategies for Improving Fluxes

- ***More routine observations***: Moorings, or routine ship-board observations of momentum and turbulent heat fluxes.
- ***More process studies***: Arctic and Antarctic observations desirable.
- ***New satellites***: Prospect of obtaining momentum, latent heat, sensible heat, radiative fluxes through a well-defined set of sensors, possibly in multi-satellite formation ("Flux Train").
- ***Improved access to observations and reanalyses***: Good meta-data, quality control and uncertainty information.
- Data providers suggested need for ***improved data users***. More caution urged on selecting data products appropriate for application and testing multiple data products (rather than using first one located.)