MTS/IEEE Oceans 2002

(Proceedings 2014-2024.pdf)

Observing Sea Surface Salinity in Coastal Domains Using an Airborne Surface Salinity Mapper

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Acknowledgements

- NOAA (Funded SLFMR development in collaboration with NRL & ProSensing Inc.)
- NRL (CoJet funding & Support for J. Miller, J. Wesson, D. Johnson)
- USM (D. Burrage, J. Johnson)
- Mississippi Space Commerce Initiative (J. Johnson)
- South Florida Water Management District (Surface Salinity data)

Presentation Purpose

Present novel method of field calibrating SLFMR and show examples of CoJet results.

Outline

- Instrument system
- Field calibration
- CoJet surface salinity maps
- Summarize results
- Recent developments

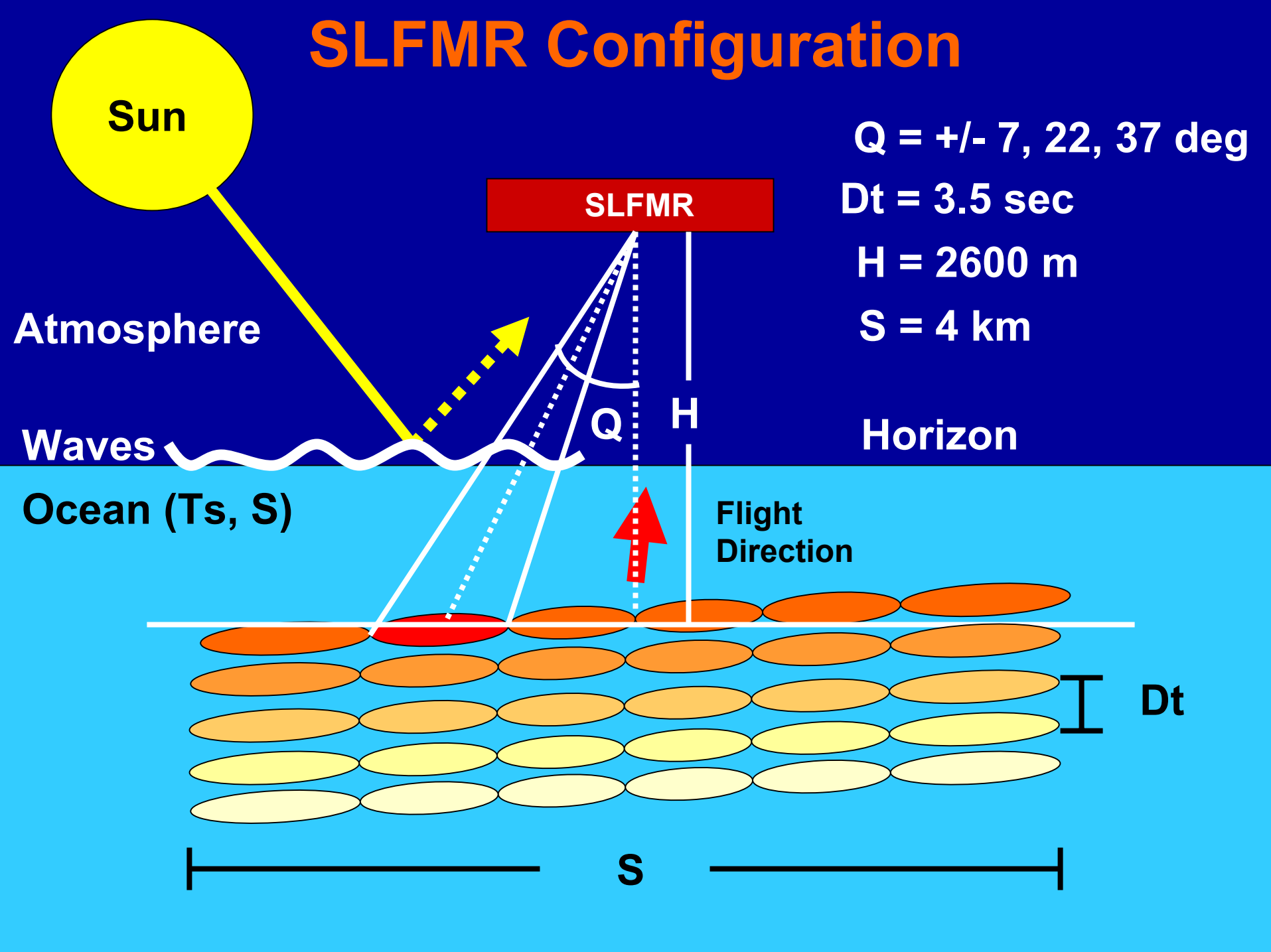
PC & Data Acquisition Rack

Salinity Mapper SLFMR & IR

SLFMR Specifications

- Pulsed noise injection Dicke radiometer (1.4 GHz)
- Multi-beam antenna with 6 beams of 15 deg FOV
- Beams point downward to either side at 7, 22 & 37deg
- Single radiometer samples beams sequentially at 0.5s
- A 6-beam scan is completed in 3.5 s =>
- At 2600 m maps a 60 x 60 km area in about 4 hours
- Nominal resolution across a 4 km swath is 1 km.

SLFMR Configuration



SLFMR Calibration

- The need for frequent instrument calibration was not fully appreciated during the earlier CoJet campaigns.

- We thus adjust Tb gain and/or offset (c, d) for each beam, so that retrieved Salinity matches *in situ* Salinity.

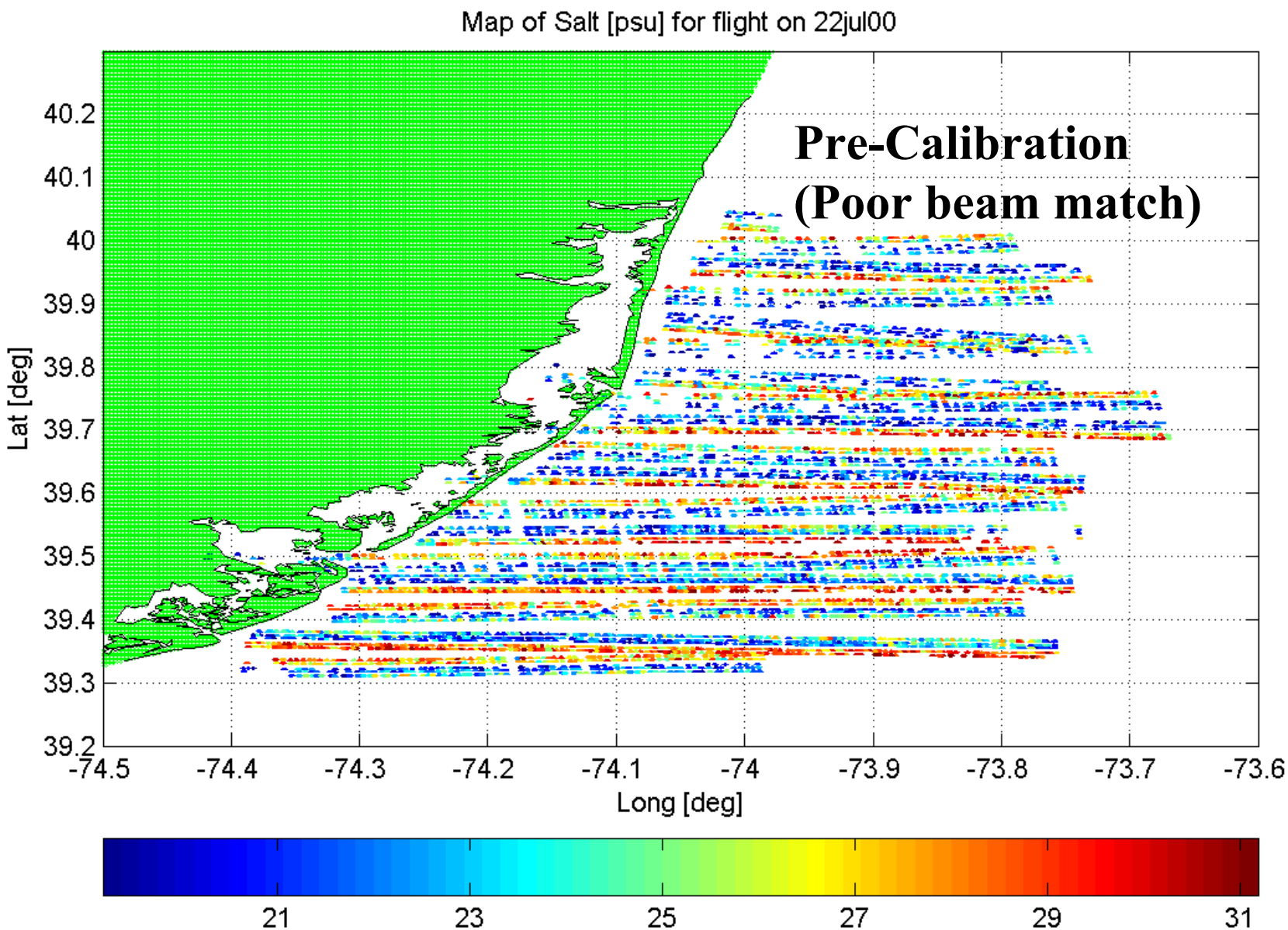
Instrument Calibration: $Ta = G(Vo, T_1, T2, T3, \ldots)$
(Possibly non-linear)

Salinity Retrieval: $S = F(Ts, Tb, \ldots Pj)$
(Non-linear)

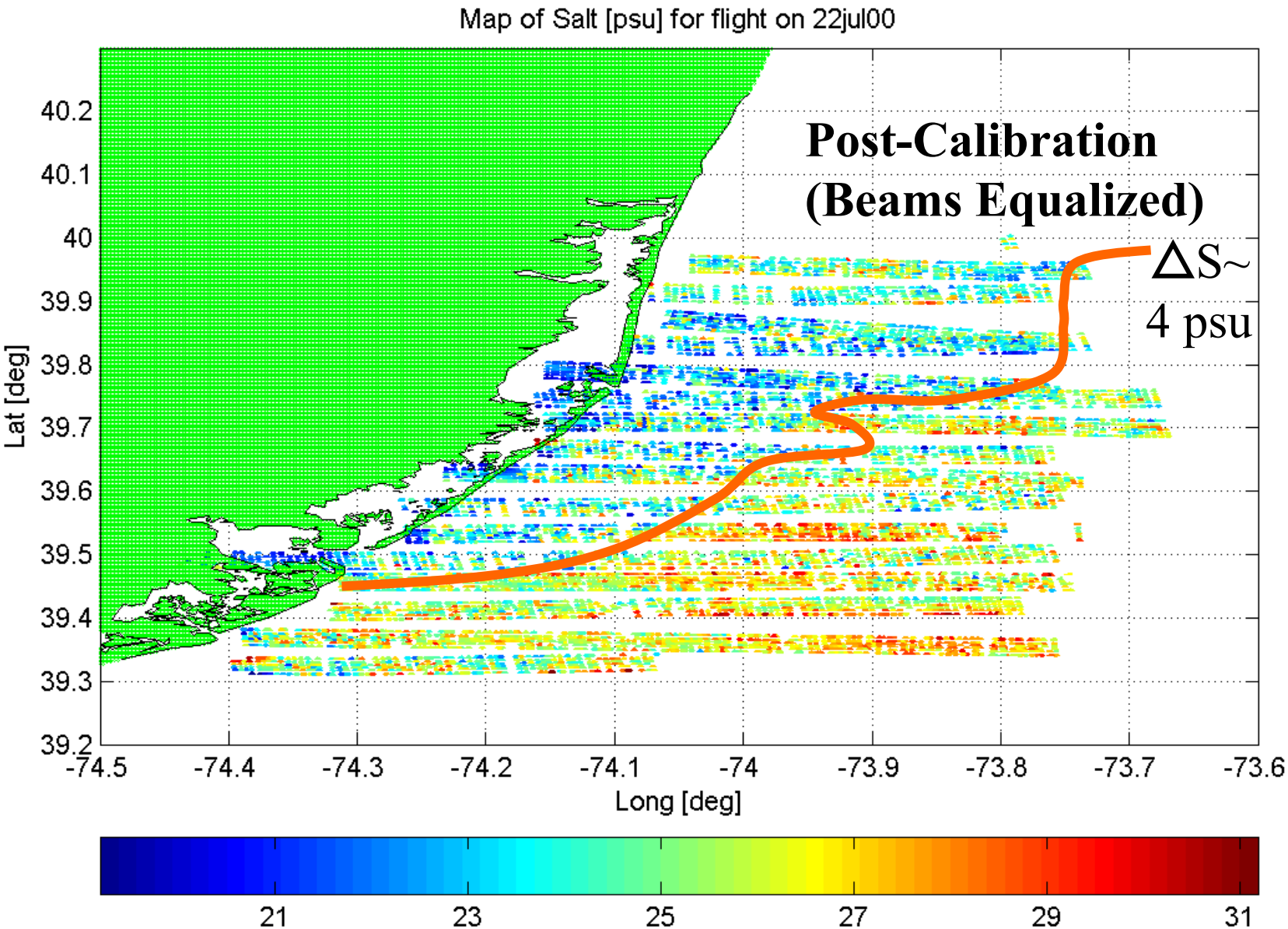
Field Calibration: $\boxed{Tb = c\,Ta + d}$

(Previously we used: $S = c\,Sa + d$ **)**

CoJet_I Sea Surface Salinity Before Screening



CoJet_I Sea Surface Salinity After Screening



<S> =25 psu

Novel Field Calibration Methods

Sea Surface Temperature: Ts

In situ and mean Salinity: S (observed), $\langle S \rangle$ (guess?)

Ocean Brightness Temp: Tb_k, for the k'th beam

Apparent Brightness Temp: Ta_k, for the k'th beam

Retrieved Salinity(non-linear): $S_k = F(Ts, Tb_{k,}, \ldots P_{j,k})$

Beam Calibration Equation: $Tb_k = c_k\, Ta_k + d_k$

Inferred Brightness Temp: $[Tb_k] = F^{-1}(Ts, S, \ldots P_{j,k})$

Inferred Mean Br. Temp: $\{Tb_k\} = F^{-1}(Ts, \langle S \rangle)$

<u>Preliminary Calibration</u>:

Choose d_k so that

$\langle Tb_k \rangle = \{Tb_k\}$

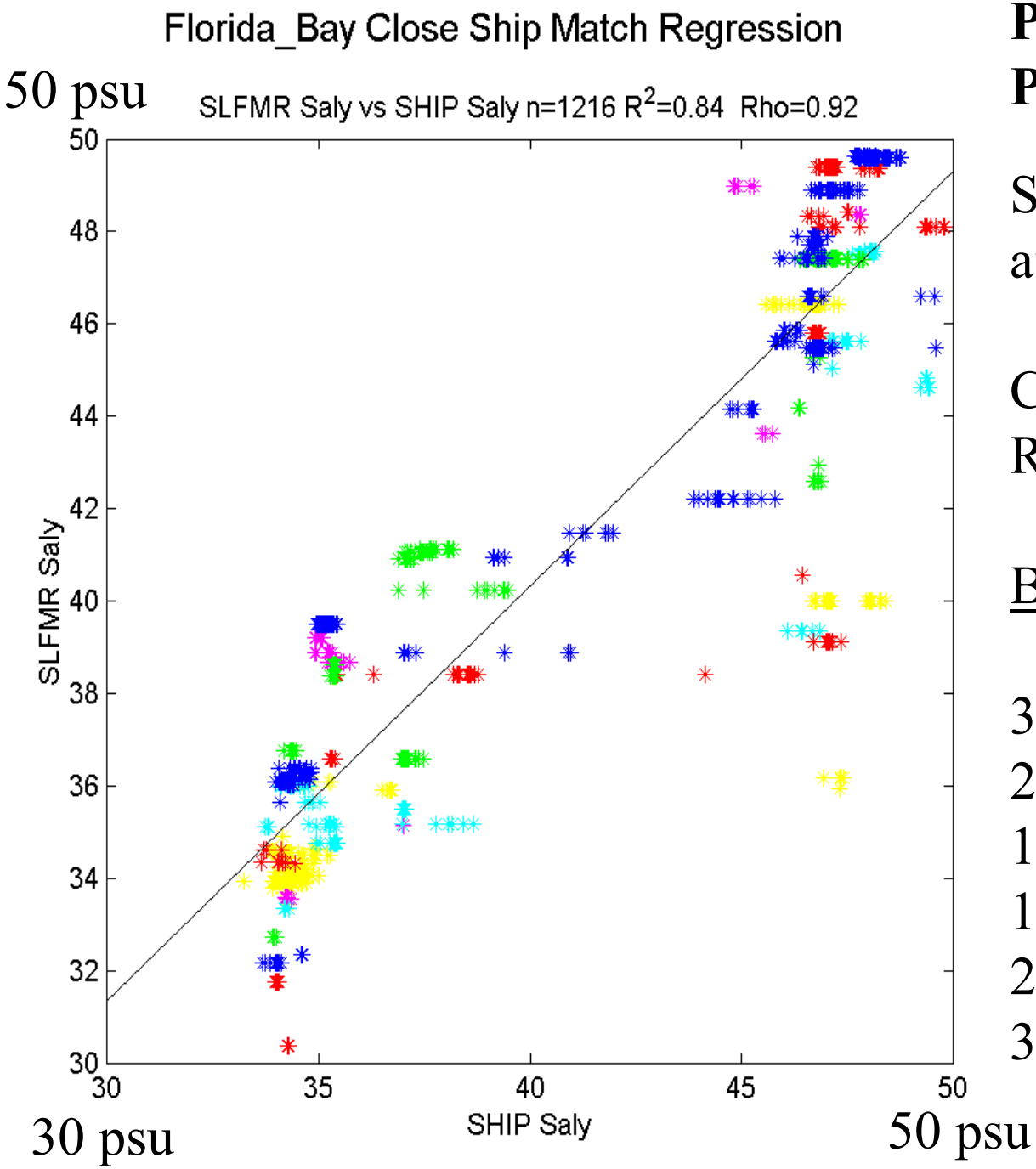
for guesstimated $\langle S \rangle$

<u>Final Calibration</u>:

Estimate c_k, d_k by

regressing Ta_k v's [Tbk]

for various in situ S



Preliminary-Calibration Performance

SLFMR V's in situ SSS after Preliminary Cal.

Correlation Coef.= 0.92
Resid. Stdev. = 2.5 psu

<u>Beams:</u>

3L (Yellow)
2L (Magenta),
1L (Cyan)
1R (Red)
2R (Green),
3R (Blue).

Calibration Methods

- Previously field calibration matched observed and *in situ* salinities, but ignored non-linearities in the salinity retrieval relationship.

- Now preliminary calibration performs beam equalization by inverting this relationship to compute brightness temperature offsets referenced to assumed, or spatially-averaged, salinity values.

- Alternatively, final calibration matches observed brightness temperatures with those inferred from *in situ* salinity, to deduce beam calibration offsets.

CoJet Airborne Salinity Mapping

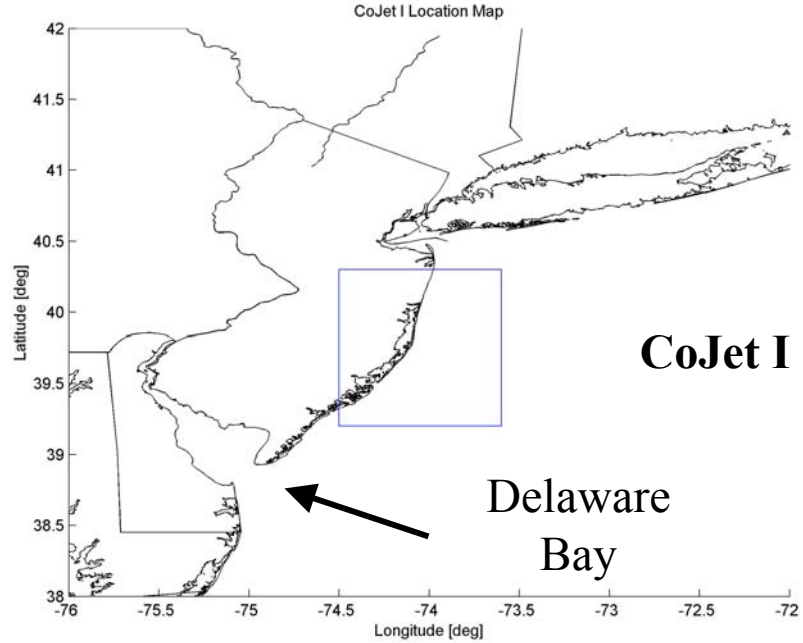
CoJet GOALS

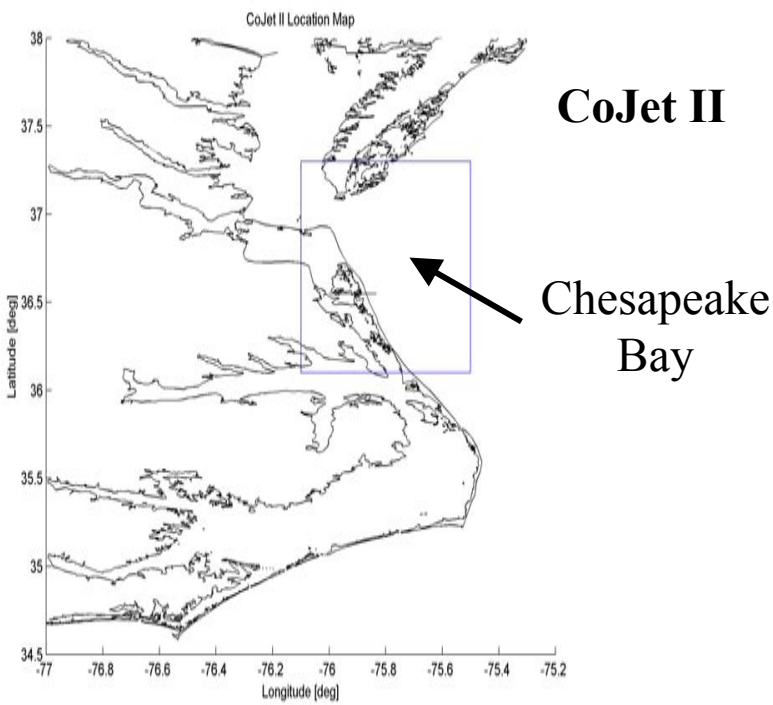
- To assess the performance of the SLFMR as an airborne salinity mapper.

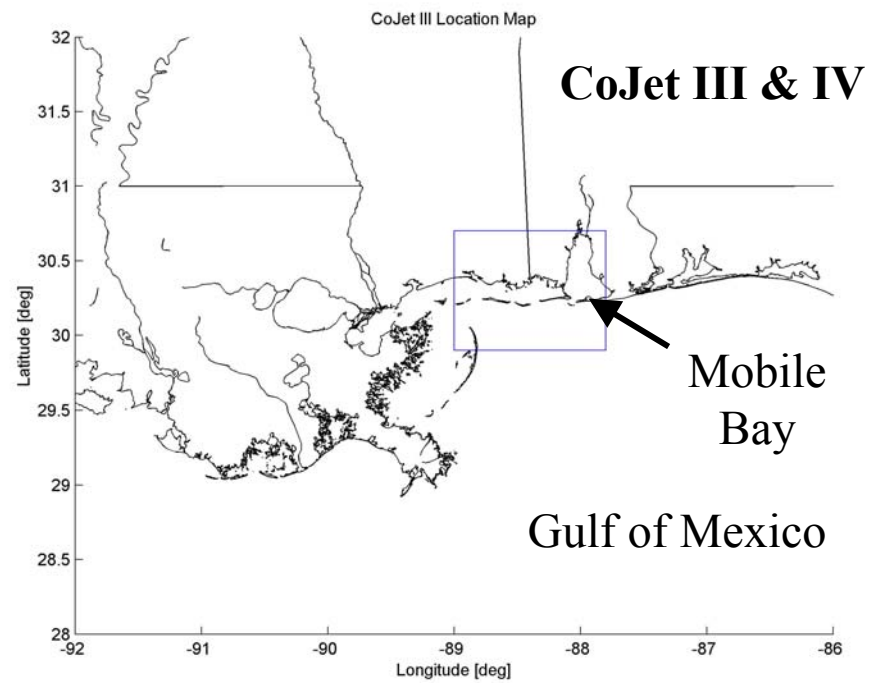
- Use the SLFMR to help describe the structure and dynamics of coastal plumes and buoyancy jets.

- Provide sea surface salinity maps for assimilation into numerical hydrodynamic models.

CoJet Location Maps:







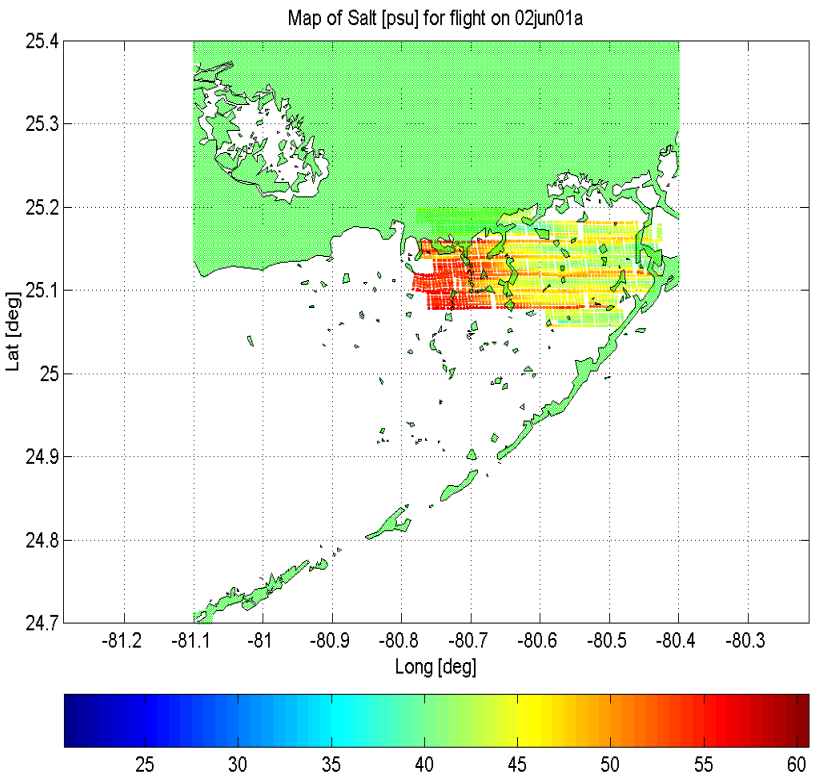
CoJet Campaigns

Date	Experiment	Location
18-24 Jul 2000	**CoJet-I**	New Jersey Coast and Continental Shelf
12-22 Sep 2000	**CoJet-II**	Chesapeake Bay entrance and Continental Shelf
16-30 May 2001	**CoJet-III-MS**	Mobile Bay, Mississippi Sound and Northern Gulf of Mexico
02-05 Jun 2001	**CoJet-III-FB**	Florida Bay

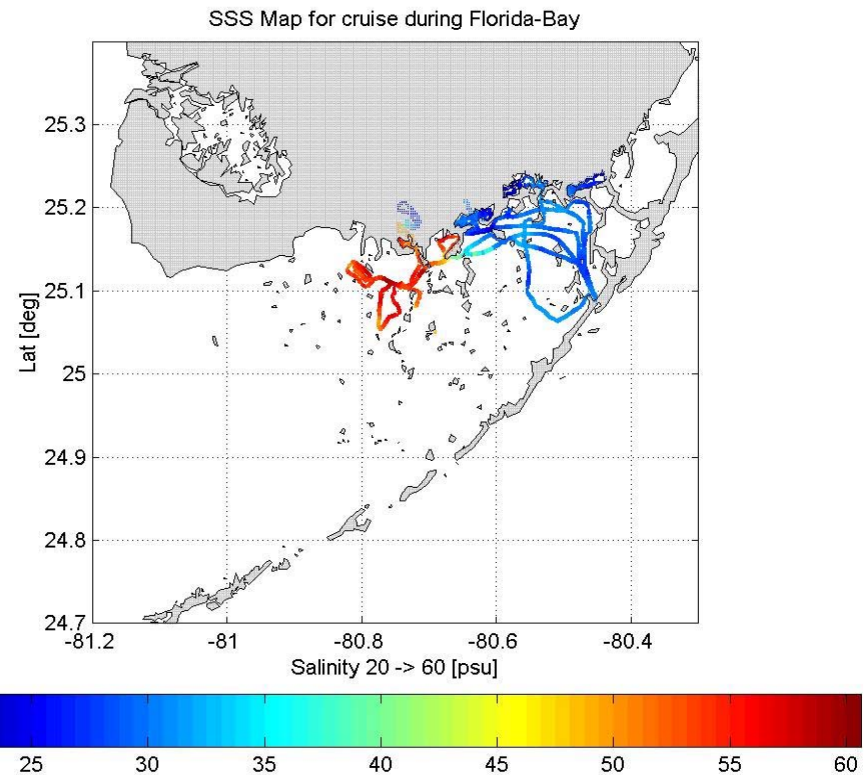
Shipboard SSS Map Showing Hypersaline Conditions in Florida Bay. Observed Salinties Exceed 50 psu west of Long. 80.65deg W.

[NASA has recently validated the K&S algorithm up to 40 psu]

SLFMR SSS map.



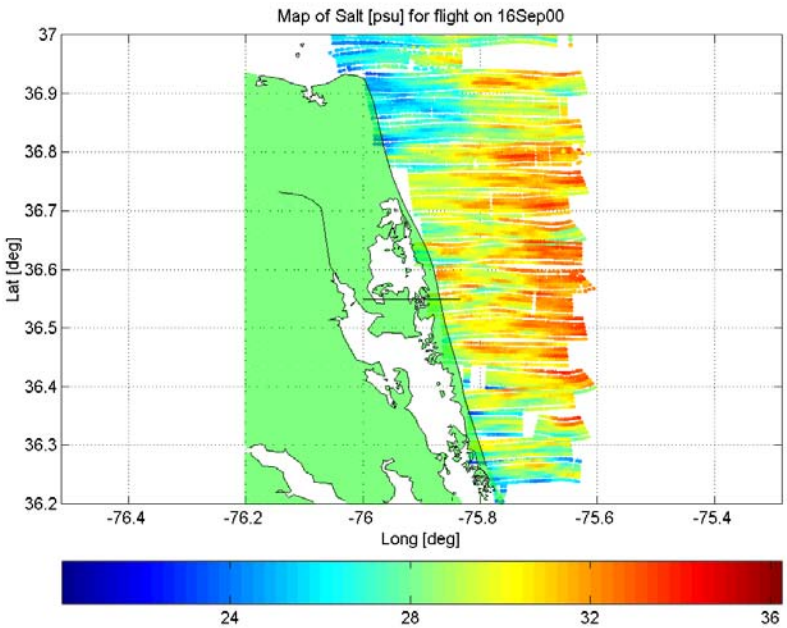
Shipboard SSS map.

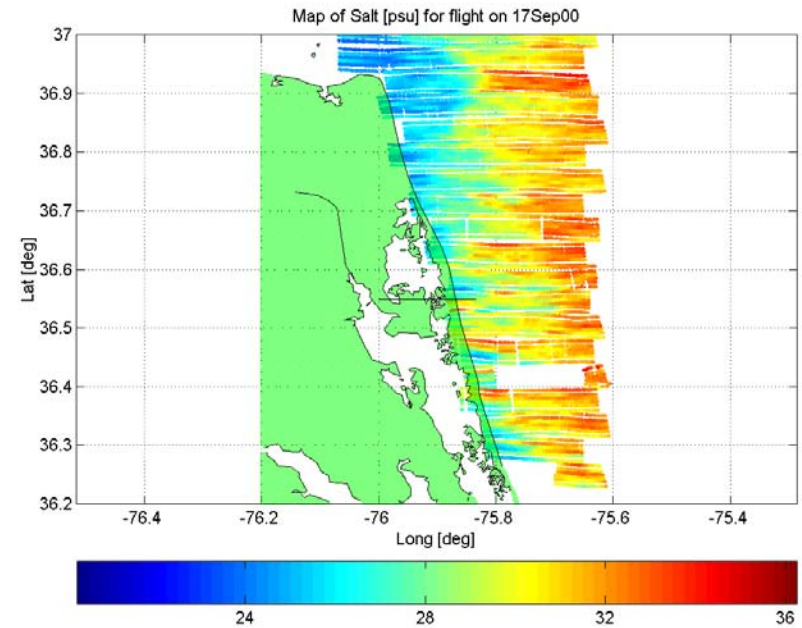


June 2000 (End of Dry Season) <S>=42.9 psu

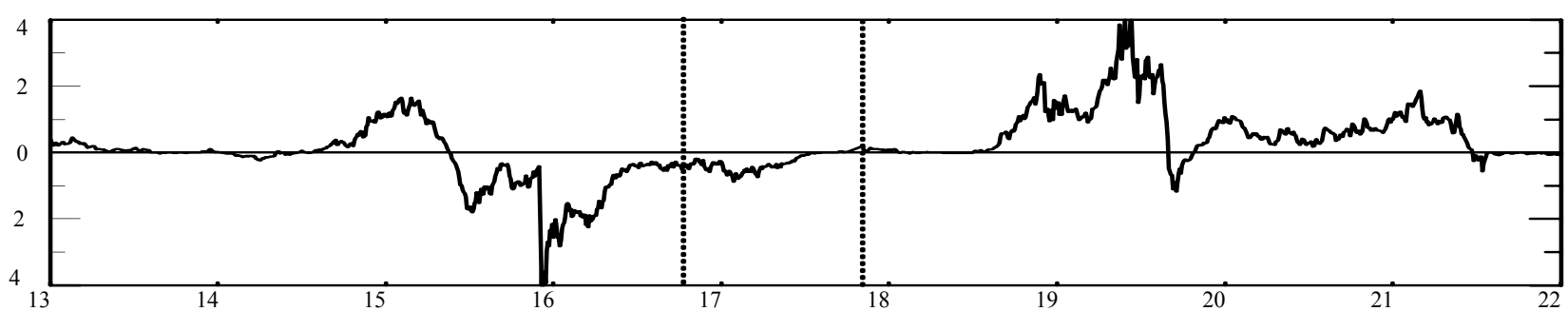
CoJet-II SLFMR SSS Maps Showing Chesapeake Bay Outflow Plume Response to Relaxation of Down-Welling Favorable Winds

16 Sep, 2000 <S> =29 psu 17 Sep, 2000





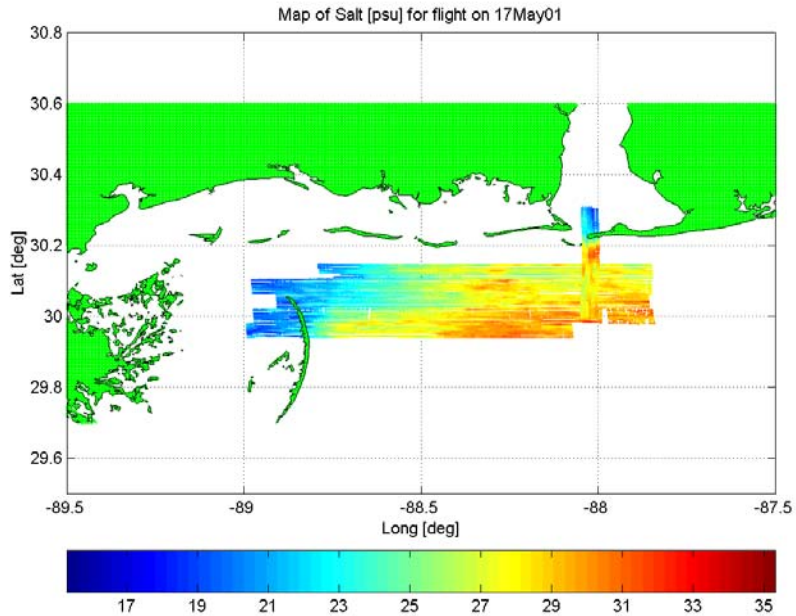
Restricted plume, down-welling Expanded plume after relaxation.



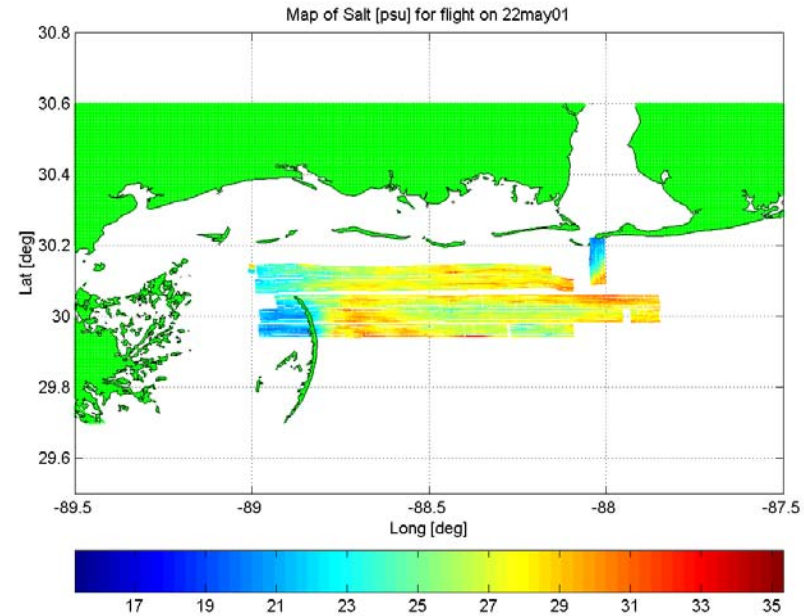
Chesapeake Bay Light Tower- Alongshore Wind Stress (dyne/cm2)

Evolution of Mobile River Plume in Response to Wind During CoJet-III.

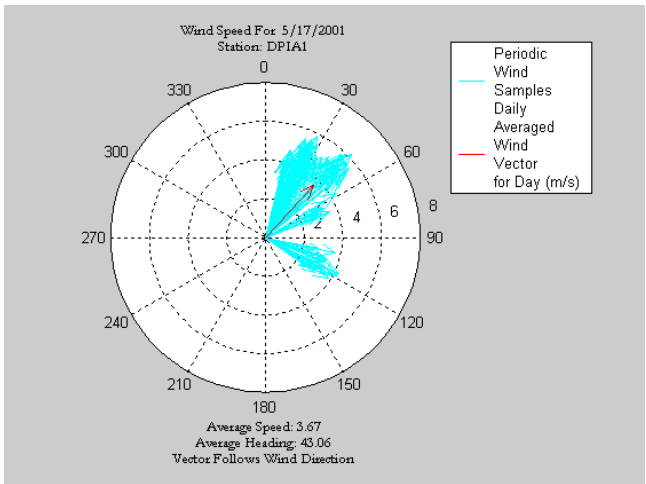
17 May, 2001



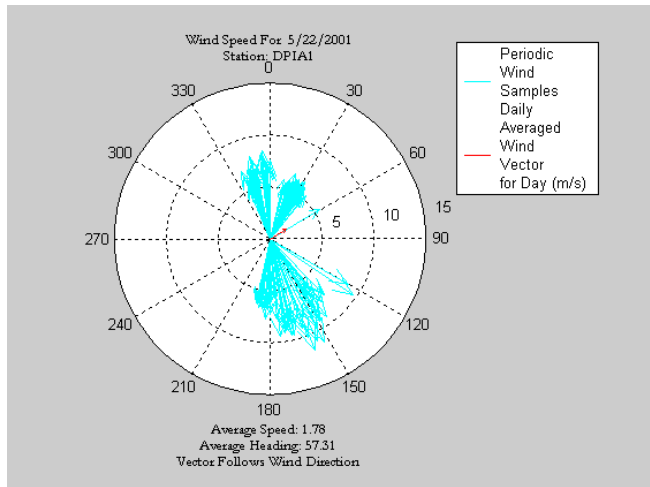
20 May, 2001



Plume extending Eastward.



Plume confined Westward.



CoJet Results

- The mapper was used to determine the spatial extent of the high salinity plume that develops in Florida Bay during warm periods with low rainfall.

- The response of the Chesapeake Bay outflow plume to relaxation of down-welling favorable winds was observed by daily mapping flights.

- The larger-scale response of the Mobile River plume to changes in Ekman forcing was monitored at intervals of several days.

CoJet Airborne Salinity Mapping

Summary

- The SLFMR has been used to repeatedly map sea surface salinity in several US coastal settings.

- Two novel methods for field calibrating the radiometer have been presented.

- Repeated surveys show how coastal plumes of varying size respond to changing wind conditions.

Recent Developments

- We have begun studying the effects of surface roughness, sun and galactic glint, and other environmental influences on salinity retrievals.

- A more sensitive mapper, STARRS, developed for NRL, was tested over Mississippi Sound and the Gulf of Mexico in Oct. 2001 (CoJet-IV).

- STARRS was then flown in Europe for ESA to help design algorithms for SMOS, a salinity mapping satellite due for launch in 2006.

- We also plan to use STARRS to help evaluate the AQUARIUS SSS-mapping satellite which is due for launch by NASA in the same year.

CoJet Airborne Salinity Mapping

Conclusions

- The SLFMR produced surface salinity maps with salinities ranging from quite fresh to hypersaline.

- After preliminary calibration, frontal boundaries were well represented.

- In combination with *in situ* data, the airborne salinity maps helped determine plume evolution.

- The experience gained will aid in validation and regional application of future satellite missions.

CoJet Airborne Salinity Mapping

The End!