The Ocean Surface Wind-Driven Currents

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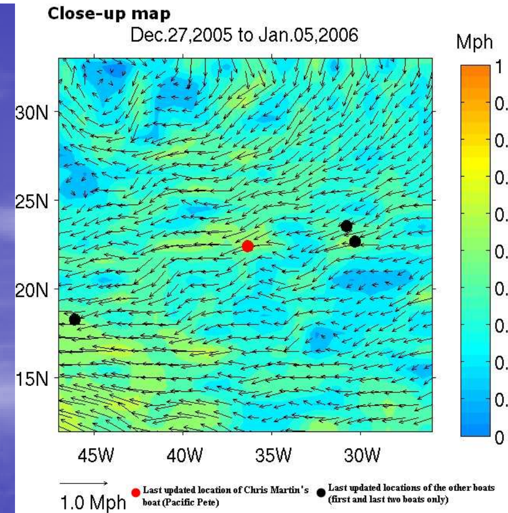
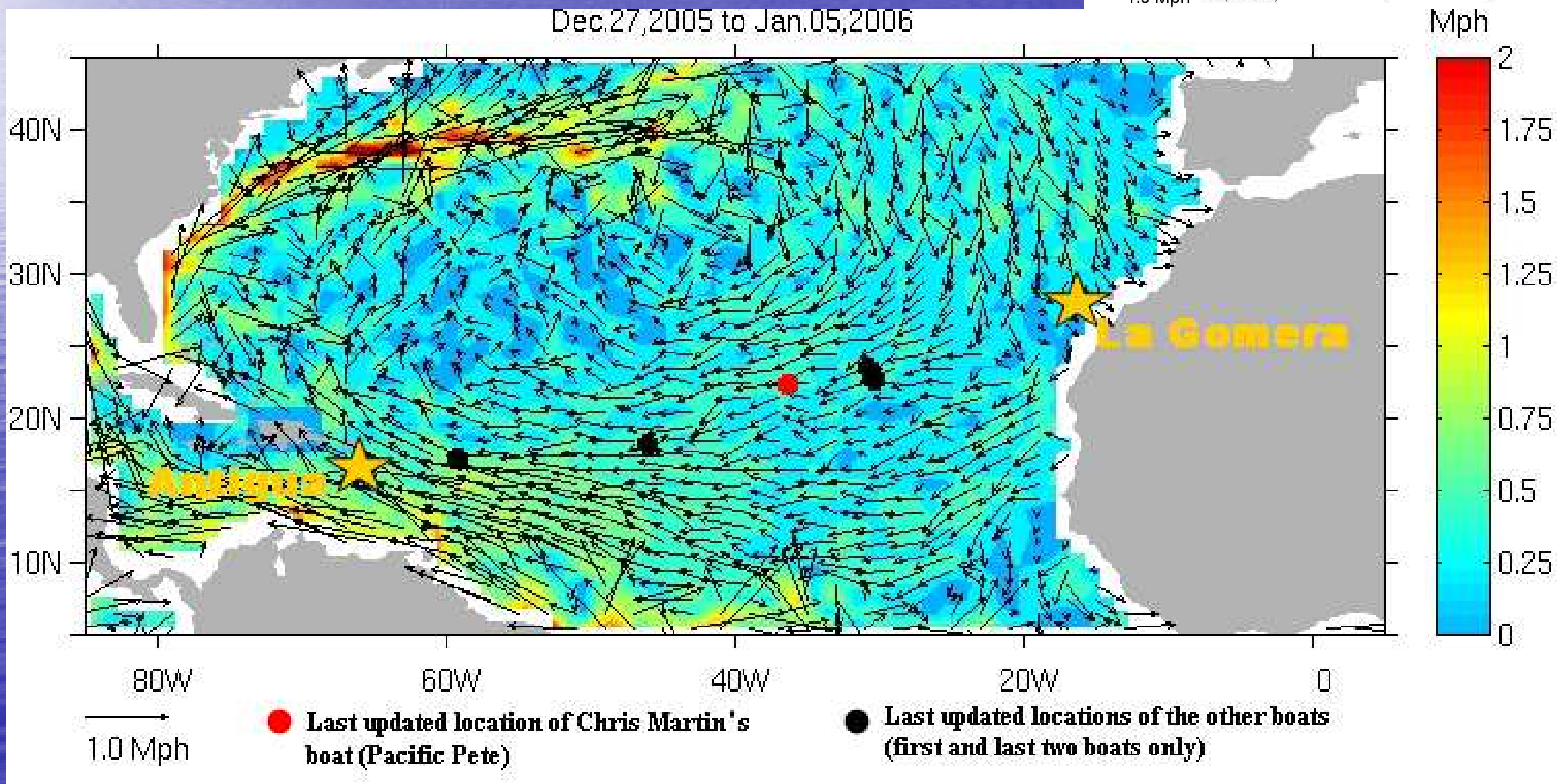
Presentation outline

- Introduction
- Past and current work
- Future research and tasks


Rowing 2550 Nautic Miles, 2930 Miles, or 4720 Kilometers!
The race will start in the harbor of San Sebastian, La Gomera (Canary Islands), and finish in Antigua, in the Caribbean Islands.
Atlantic
La Gomera
Antigua
Ocean
Image © 2005 MDA EarthSat


Stappard Howes


Close-up map
Dec.27,2005 to Jan.05,2006
Mph
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
30N
25N
20N
15N
45W
40W
35W
30W
1.0 Mph


Dec.27,2005 to Jan.05,2006
Mph
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
40N
30N
20N
10N
80W
60W
40W
20W
0
La Gomera
Antigua
1.0 Mph
Last updated location of Chris Martin's boat (Pacific Pete)
Last updated locations of the other boats (first and last two boats only)

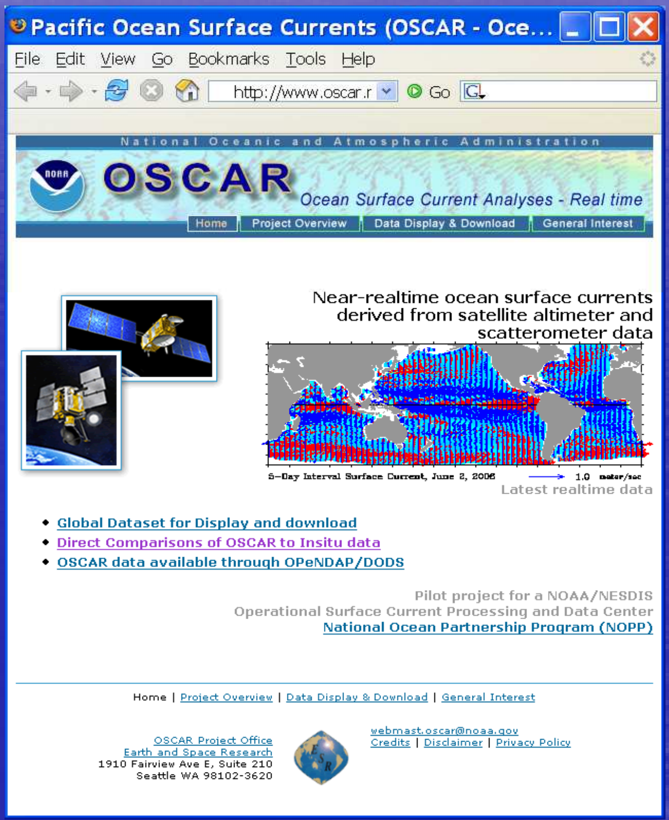
Turbulence in upper ocean boundary layer, restricted scope of study

- Turbulence produced by external and internal processes
- by wind stress, air-sea heat flux
- locally or remotely; "instantaneously" or delayed
- within or below wave-breaking layer

Ocean Surface Current Analyses Real-time (OSCAR)

http://www.oscar.noaa.gov

- Global/Updated ~5 days
- Display/Download
- Direct comparisons with *in situ* data (and in near real-time)



Main objectives…

- Investigation of dynamics of local wind-driven surface currents
- Daily to monthly timescales
- Direct wind-forcing models

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- Daily to monthly timescales
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…and expected outcome:

- Better understanding of direct wind-driven surface ocean circulation
- Synthesis of wind-forcing models for operational applications

Present OSCAR wind-driven velocity:

Low-frequency, local impact of surface wind on surface currents (T≥10-20 days)

$$\mathbf{i}f\bar{\mathbf{U}} = -g\nabla\zeta + \frac{h}{2}\nabla\theta + \frac{\boldsymbol{\tau} - A\mathbf{U}_z(-h)}{h}$$

Complex notation:

$\mathbf{U} = u + \mathbf{i}v$

$\nabla = \frac{\partial}{\partial x} + \mathbf{i}\frac{\partial}{\partial y}$

Vertical Shear

$A\mathbf{U}_{zzz} = \mathbf{i}f\mathbf{U}_z + \nabla\theta$

$\mathbf{U}_z(z=0) = \frac{\boldsymbol{\tau}}{A}$

$\mathbf{U}_z(z=-H) = \mathbf{0}$

→

$$\bar{\mathbf{U}} = \bar{\mathbf{U}}_{Wh} + \mathbf{U}_G + \bar{\mathbf{U}}_{Bh}$$

Stommel velocity averaged between z=0 and z=-h

(Bonjean & Lagerloef 2002)

Key parameterization:

$$A = a \times \left(\frac{|W|}{W_0} \right)^2 \qquad (W = \text{wind speed})$$

(Santiago-Mandujano & Firing, 1991)

Analysis/calibration of the OSCAR wind-driven velocity $\bar{\mathbf{U}}_{Wh}(a,H)$ using satellite wind and drifting buoy data

$$\mathbf{U}_{Buoy} \leftrightarrow \mathbf{U}_G + \bar{\mathbf{U}}_{Wh}(a,H)$$

($\bar{\mathbf{U}}_{Bh}$ neglected for now)

Data:

- Gridded QuikScat wind data from COAPS
- World wide buoy drifter deployment (AOML) data
- AVISO merged gridded SSH data

January 2000-December 2004

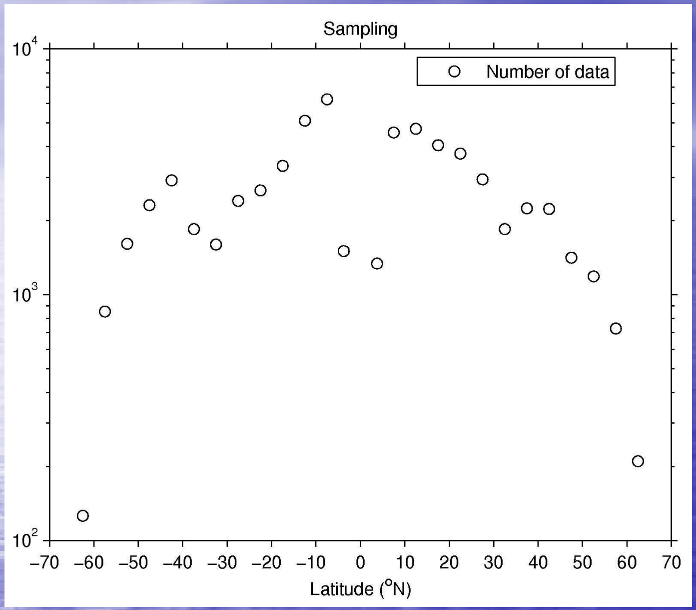
In a geographical domain D:

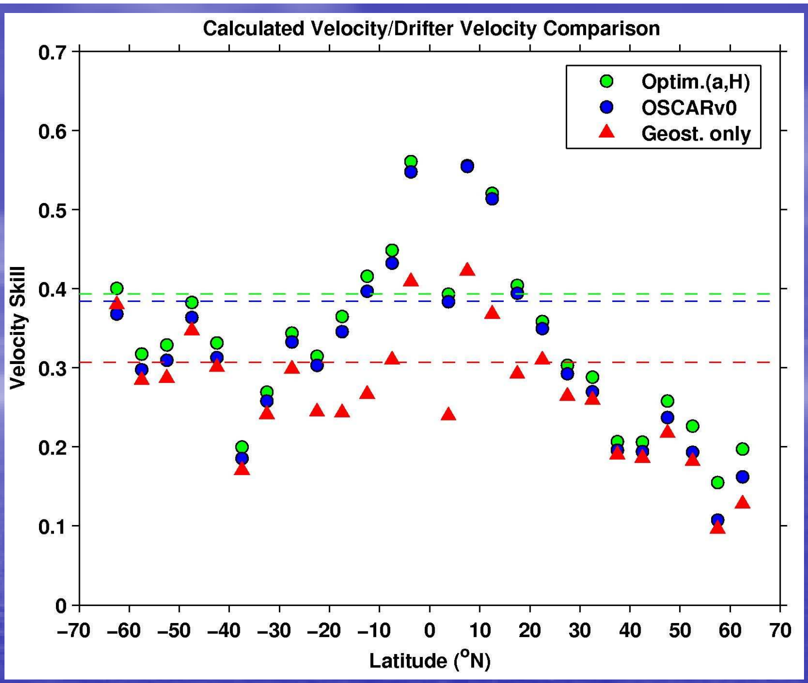
Minimizing

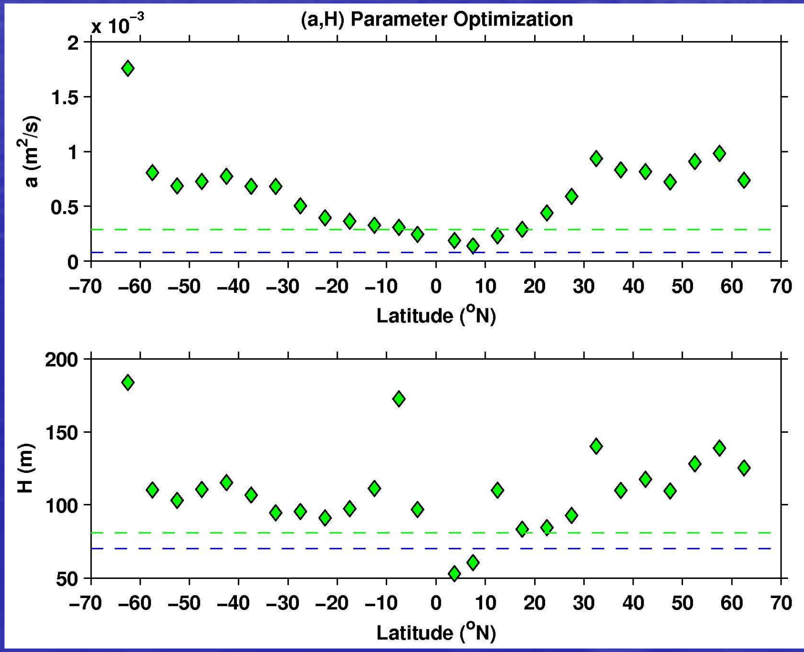
$$\mathrm{RMS}\left(\left|\mathbf{U}_{Buoy} - \mathbf{U}_G - \bar{\mathbf{U}}_{Wh}(a,H)\right|\right)$$

$\Rightarrow$ Optimized values of a and H

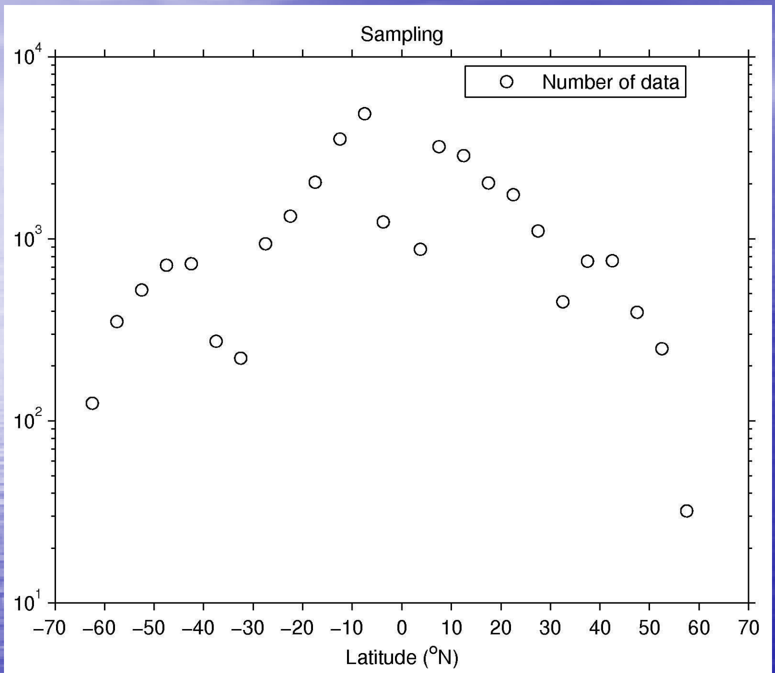
GLOBAL OCEAN ADJUSTMENT 2000-2004

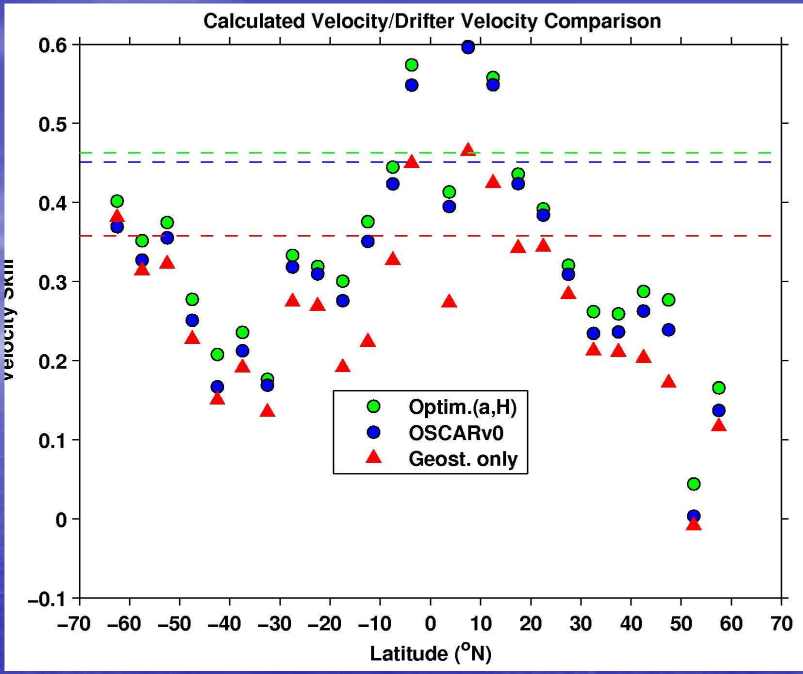


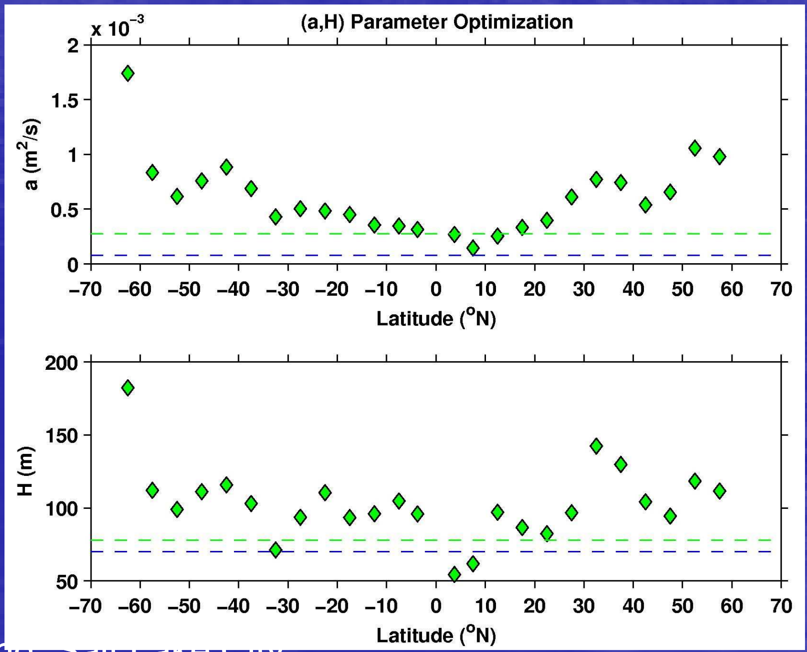




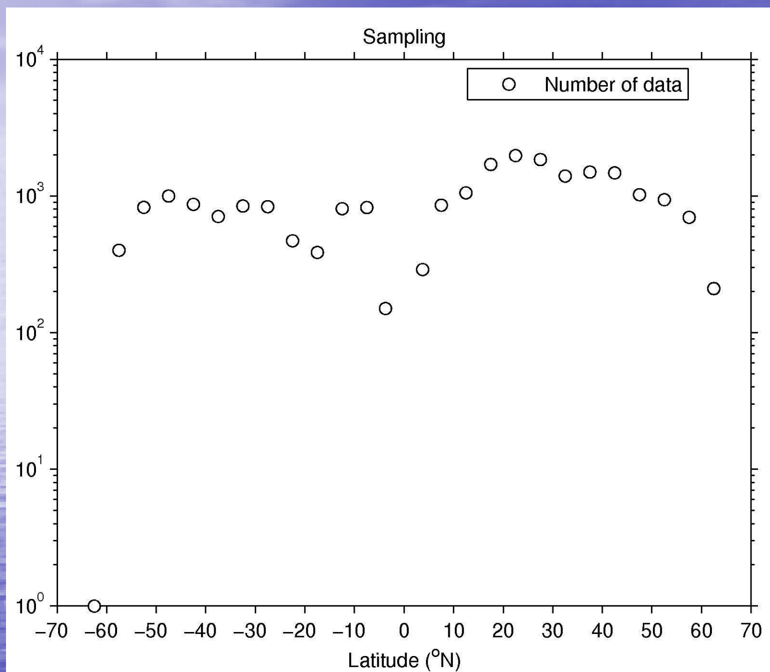
PACIFIC OCEAN ADJUSTMENT 2000-2004

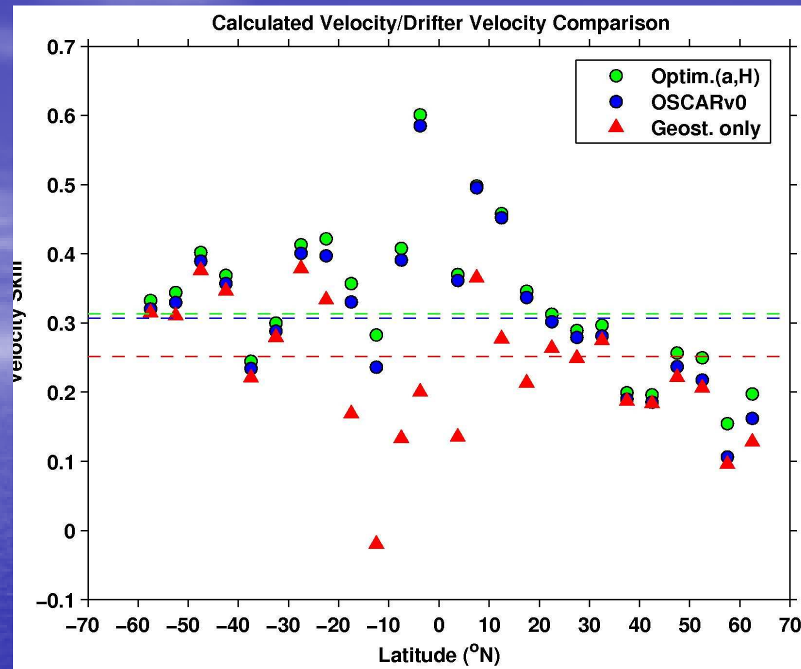


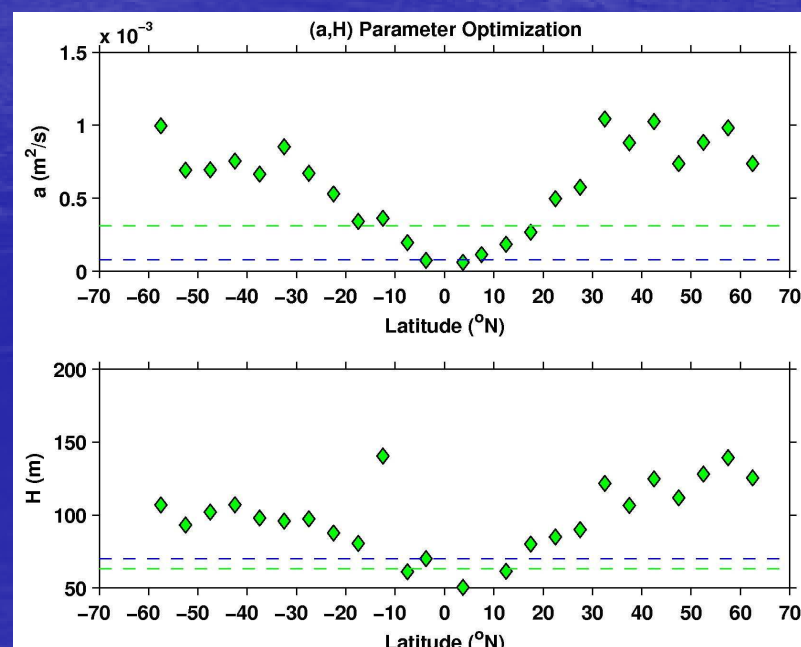




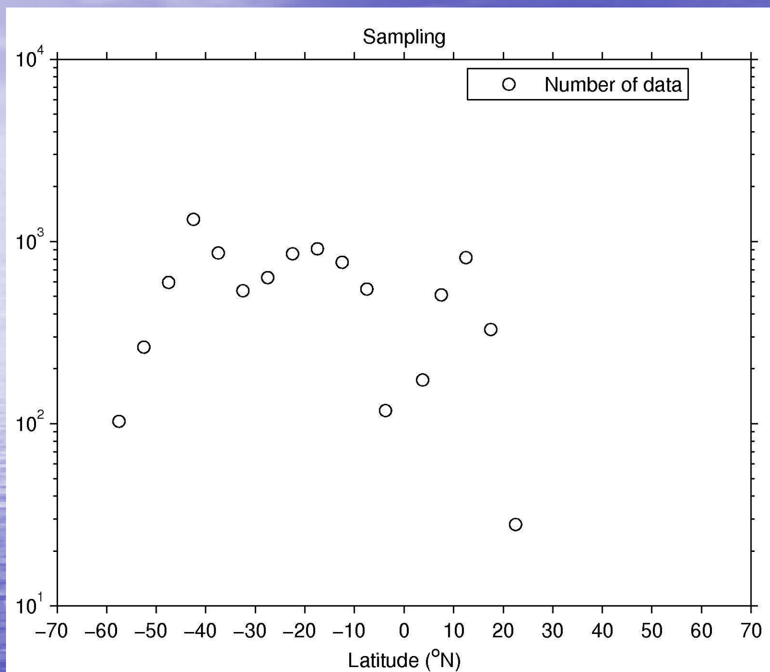
ATLANTIC OCEAN ADJUSTMENT 2000-2004

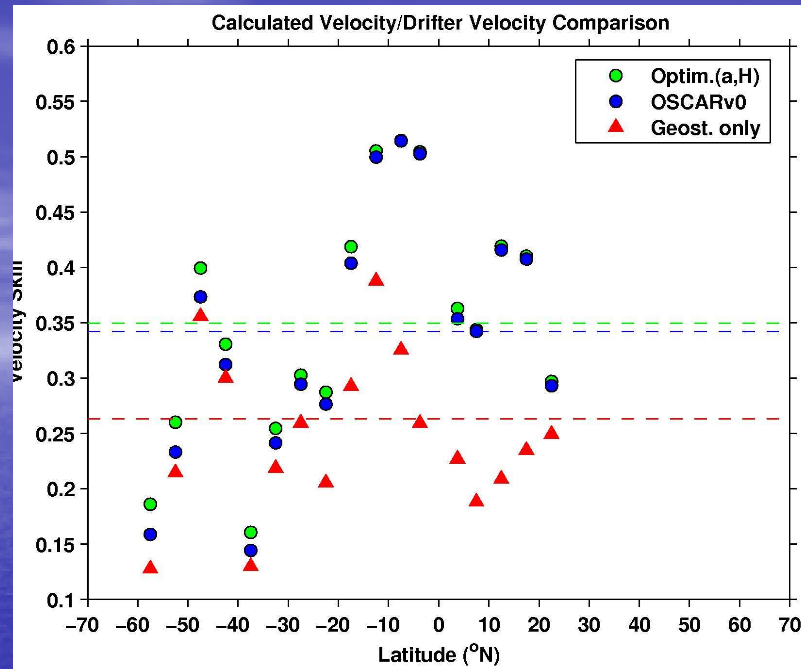


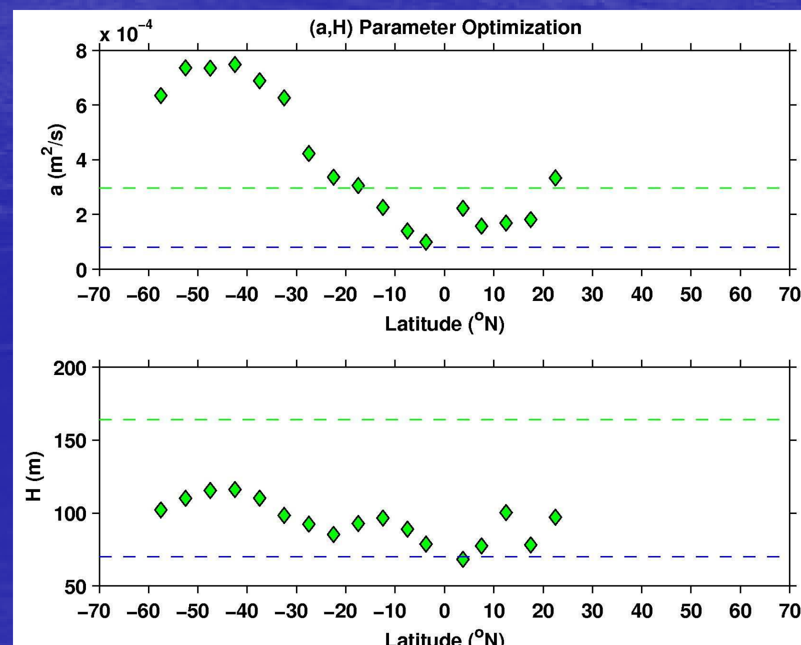




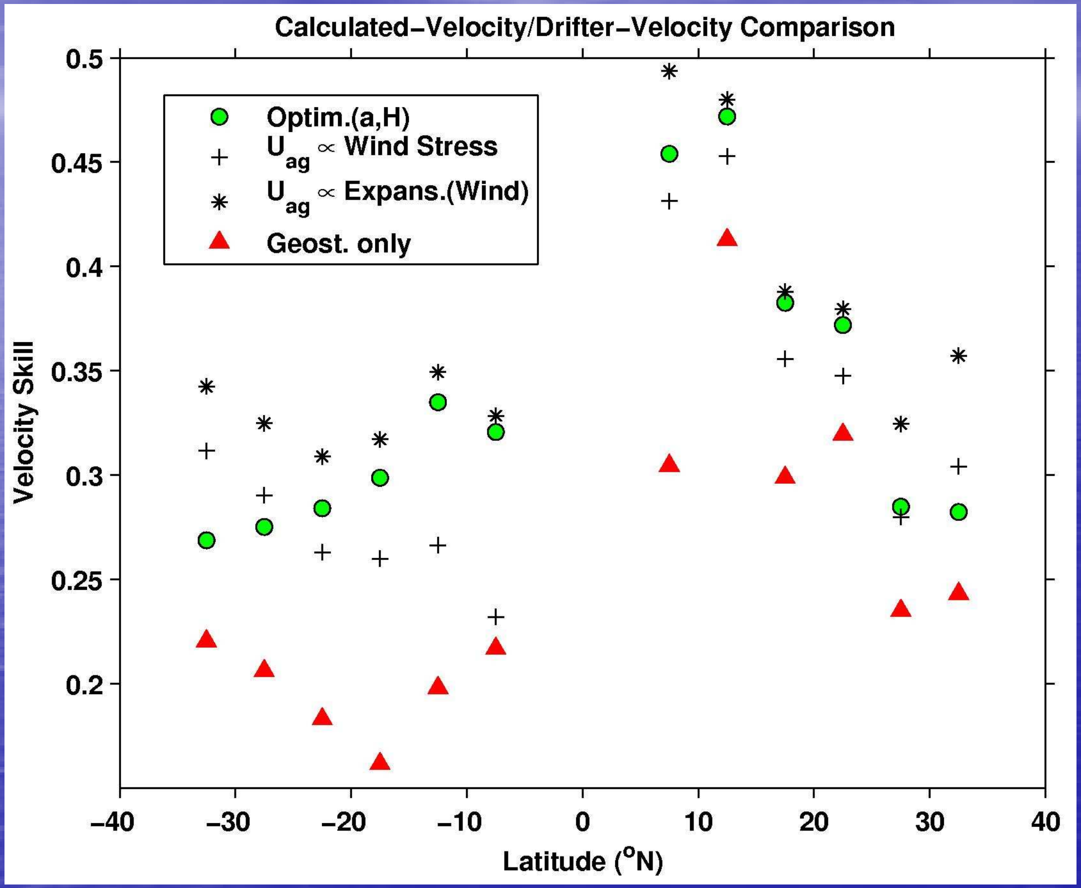
INDIAN OCEAN ADJUSTMENT 2000-2004







Empirical vs. theoretically derived models



Direct (locally) wind-driven models

- Ekman-type models (e.g. OSCAR=bonjean and Lagerloef, 2002)
- Slab model
- Lagerloef et al. (1999) “Ekman” model
- Empirical models (Ralph and Niiler, 1999; Rio and Hernandez, 2003)
- High-frequency wind-driven model (e.g. Rudnick and Weller, 1993)

Central question …

What is (are) the model(s) that best describe the direct wind-driven circulation on subinertial to superinertial timescales?

… and objective

Intercomparison of empirical/theoretical models, from low to high frequencies, using common and consistent database:

all presently available satellite observations including **<u>QuikScat data,</u>**

and in situ data including drifting buoy data.

Project strategies

- Fundamental research: wind-driven surface current dynamics, subinertial to superinertial timescales
  - Wind-driven models
  - Coherence study winds/ageostrophic currents
  - Extraction of high-frequency signal
  - Model analysis
  - Equatorial wind-driven dynamics
- Direct applications
  - Composite wind-driven model
  - Predictability study of wind-driven currents using NCEP and ECMWF forecast winds

    (toward operational nowcast and short-range forecast)
- Open to collaboration/synergy (OGCMs, ocean predictive systems)