Van Gogh’ “Starry Night” and turbulence scaling
IcySeas.org blog post, Labrador Current

http://icyseas.org/2013/05/08/the-turbulence-of-van-gogh-and-the-labrador-shelf-current/

Mixing without and with rotation
MIT Geophysical Fluid Dynamics Lab

http://paoc.mit.edu/labweb/lab1/nonrot.mpg

http://paoc.mit.edu/labweb/lab1/taylorclip.mpg
The American Passage to the North Pole:

Ice, Oceans, and Climates of Nares Strait

Andreas Münchow
University of Delaware
http://IcySeas.org

Collaborators: Drs. Melling (Canada), Johnson, Nicholls (England), Falkner, Mix, Samelson, Padman (Oregon), Fricker (California), Rabe (Scotland), Wahlin, Heuze (Sweden), Gudmansen (Denmark), Song, Badiey, Huntley and Ms. Ryan (Delaware)
What happens in Greenland stays in Greenland ... NOT
Track and Locations of Petermann Ice Islands

Petermann Ice Island 2010/11
1928 Marion Expedition

Labrador Shelf Current

Smith (1931)
Summer 2012 Undergraduate Interns Julie Jones (Ice) and Allison Einolf (Ocean)
Petermann Gletscher and environs in transition

**AIR**
+0.12 ± 0.04 °C/year

cold

**ICE**
-5 m/year

**OCEAN**
+0.06 ± 0.02 °C/year
+0.01 °C/year

**ROCK**

warm
Dynamic Equilibria:

Single states:

Multiple states:

Globally unstable

Globally stable

Adapted from Dr. Berryman, WSU-529 “Population Theory”
Hysteresis Loop of Climate Change

Stommel (1961)

Nonlinear response of thermohaline circulation to freshwater perturbations

Caveats:
- Location of current climate?
- 100-500 year duration
- Distance to convection sites

Rahmstorf (2000)
Hysteresis Loop of Climate Change

Stommel (1961)

Rahmstorf (2000)

Alley (2001)
Greenland Ice Core Data:

Oxygen isotopes $\delta^{18}O \sim \Delta T$ temperature

from Alley et al. (2001)
USCGC Healy ADCP system:

1. Healy in snowy Seattle dry-dock

2. Well of the 75-kHz phased array ADCP

3. Bilge rat in the back

4. Command and Control
Flux vs. Wind:

-0.77 Sv
-0.92 Sv
-0.91 Sv
-1.03 Sv

USGSC Healy 2003 ADCP surveys

{ 0.9±0.10 Sv

-3.8 +/- 0.3 Sv
5.1 +/- 0.2 Sv

Greenland
Velocity Surveys

Volume Flux: $0.77 \pm 0.10$ Sv
Fresh Water Flux: $28 \pm 4$ mSv

$L_D \sim 10$ km internal Rossby Radius
Velocity Moorings

Magnetic Compass not always reliable:

- Nares Strait (2003-12): ~ 3800 nT
- Fram Strait (2014-16): ~ 6700 nT
- Required: >10,000 nT

horizontal magnetic field strength.

Rigid Backbone allows Pitch and Roll, but NO Heading Change

- 2003-06  Nares Strait  US-ASOF
- 2007-09  Nares Strait  CA-IPY
- 2009-12  Nares Strait  private
- 2014-16  Fram Strait  with AWI
- 2017-?  Fram Strait  with AWI
75 kHz ADCP Mooring Deployment from CCGS Henry Larsen
Discovery Harbor
Tide Gauge at 30-m depth:

Recovered 2012 after
4 failed prior attempts

Photo Credits: Derrick Stone
Conclusions:

Arctic velocity measurements challenging:
Careful experimental design essential.

Nares Strait 2003-09 freshwater flux 59 mSv:
Half reside unmeasured in surface 30-m.

Nares Strait dynamics largely linear:
Driven by along-channel pressure gradient.

Challenges:

Long time scales of climate variability:
How to maintain climate time series?

Nonlinear physics within Complex Systems:
Equilibria, Tipping Points, Turbulence;

Under ice/water data communication:
Acoustic “cell phone” towers;

Envisioning Information (Edward Tufte):
How to escape Flatland?