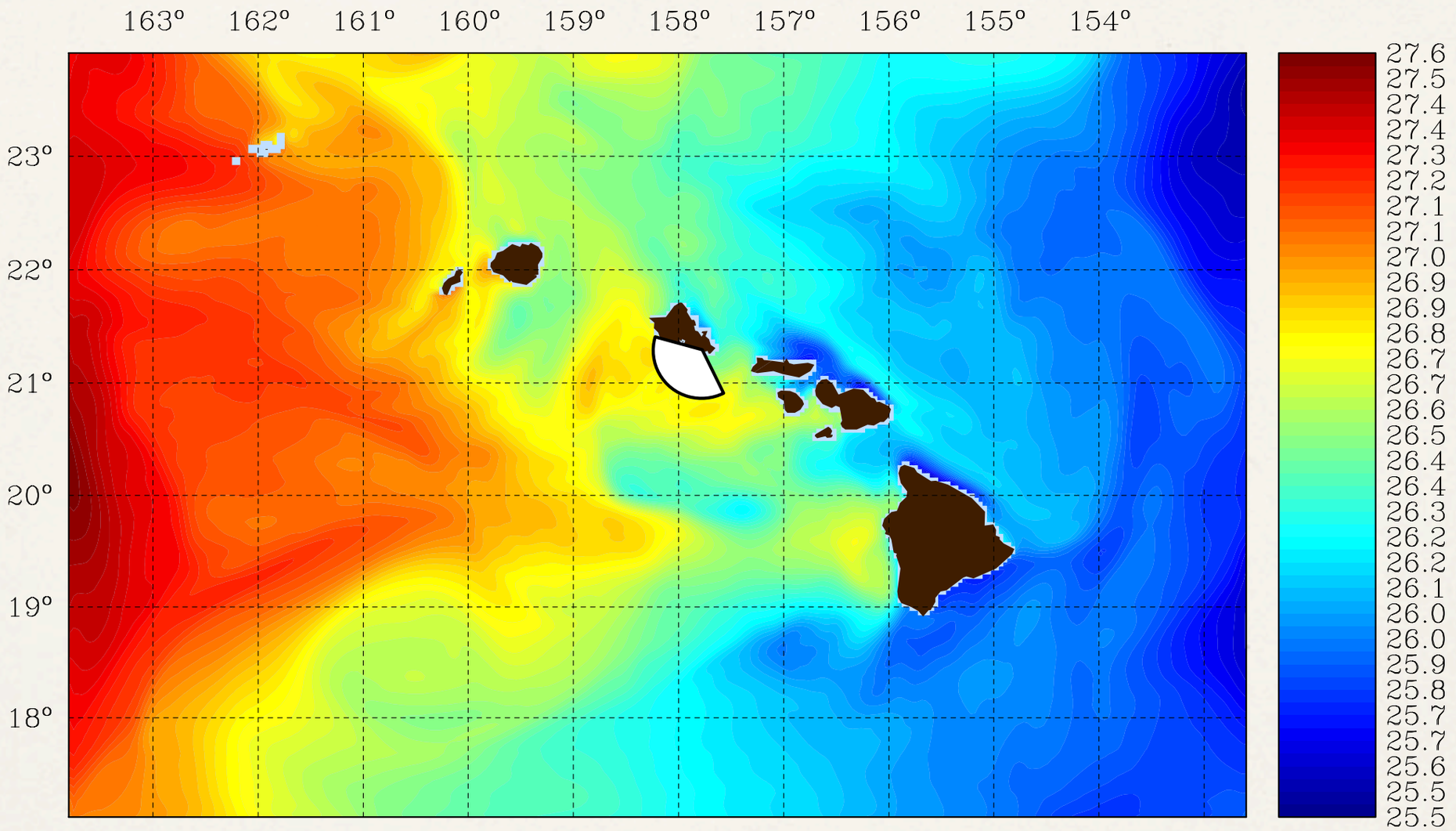
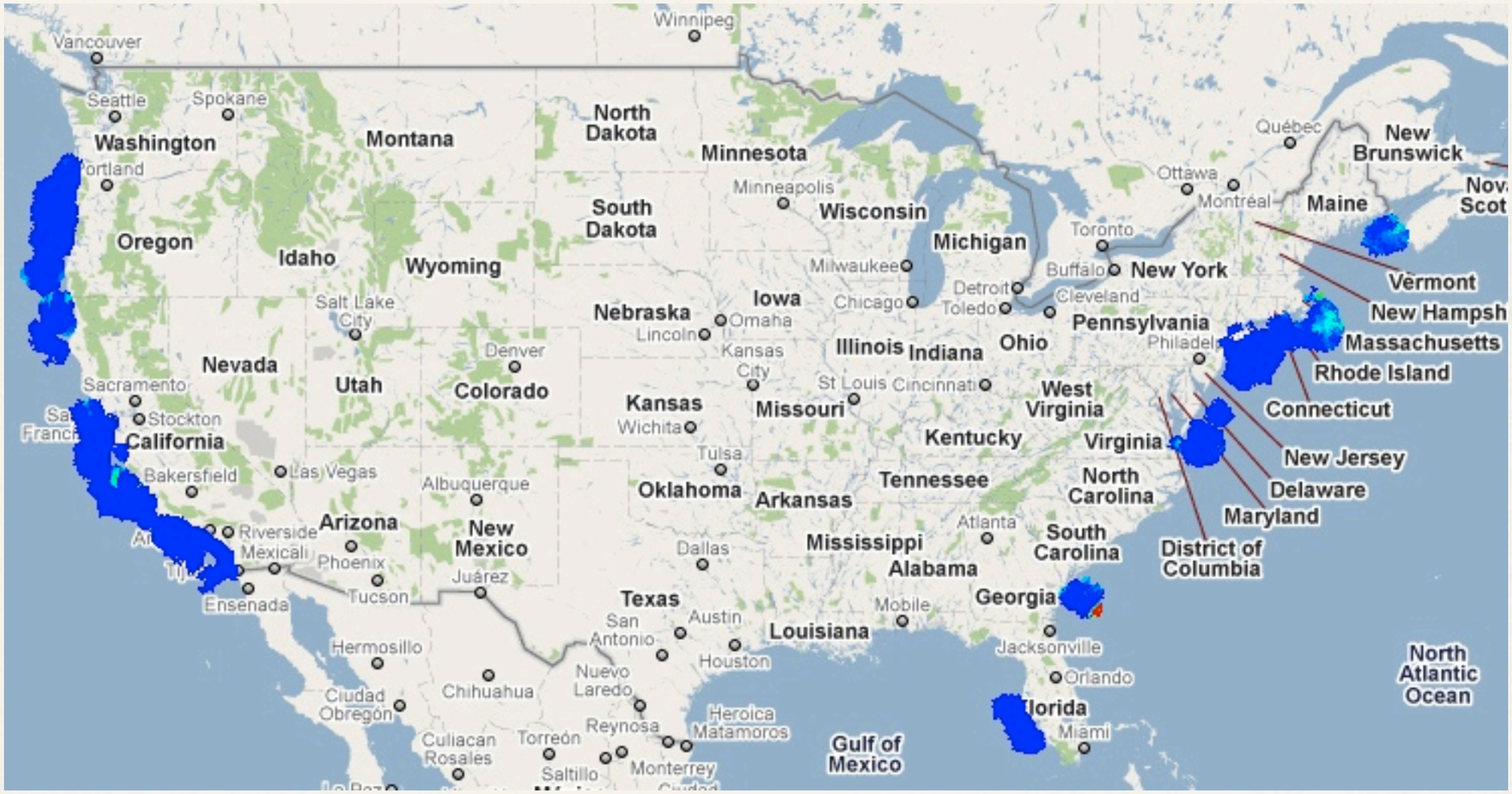
Assimilation of HF-Radar: Raw or Cooked?

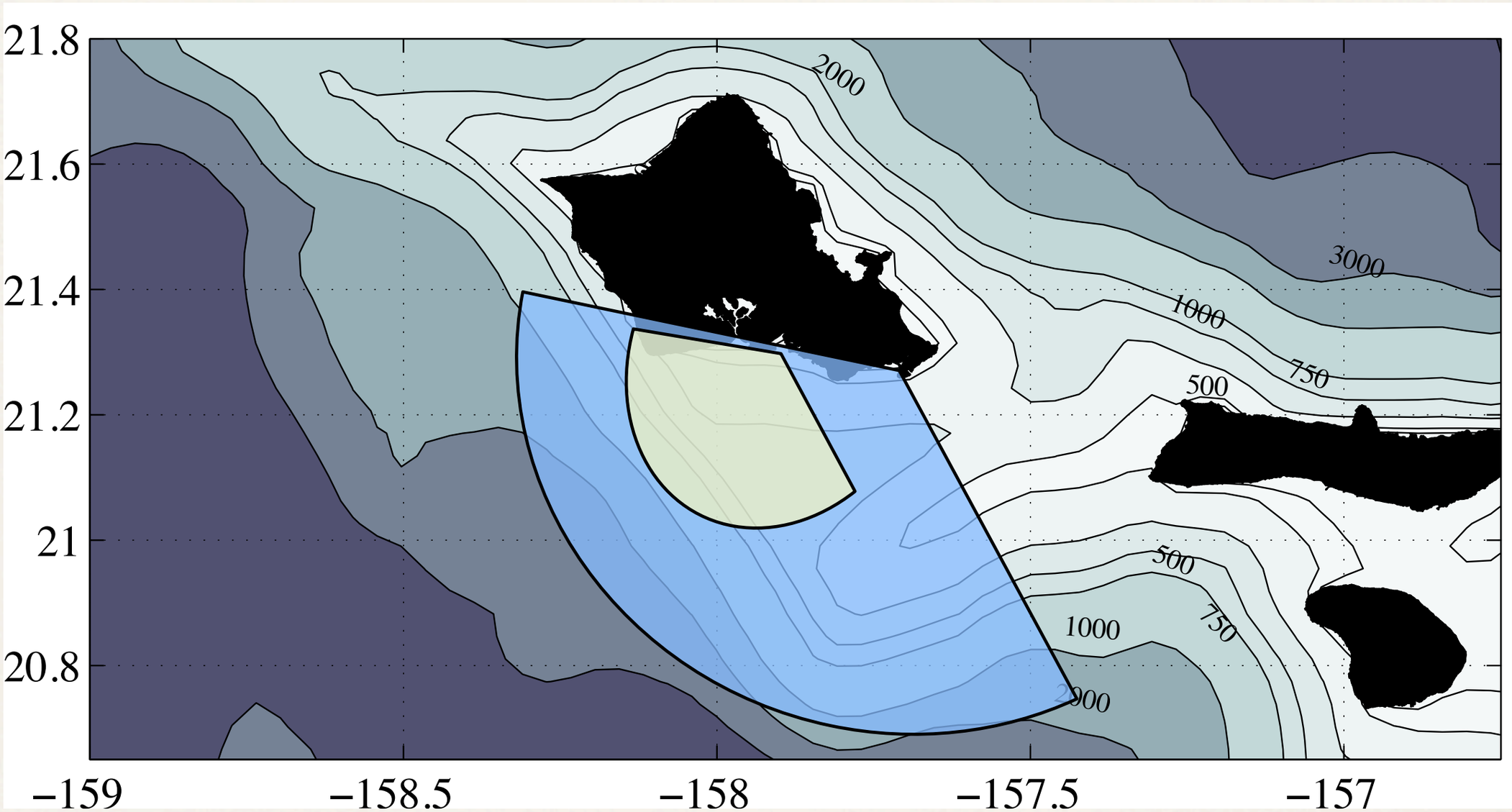
Brian Powell
Thanks: Pierre Flament, Marcia Hsu, Ivica Janeković, Dax Matthews, Andrew Moore

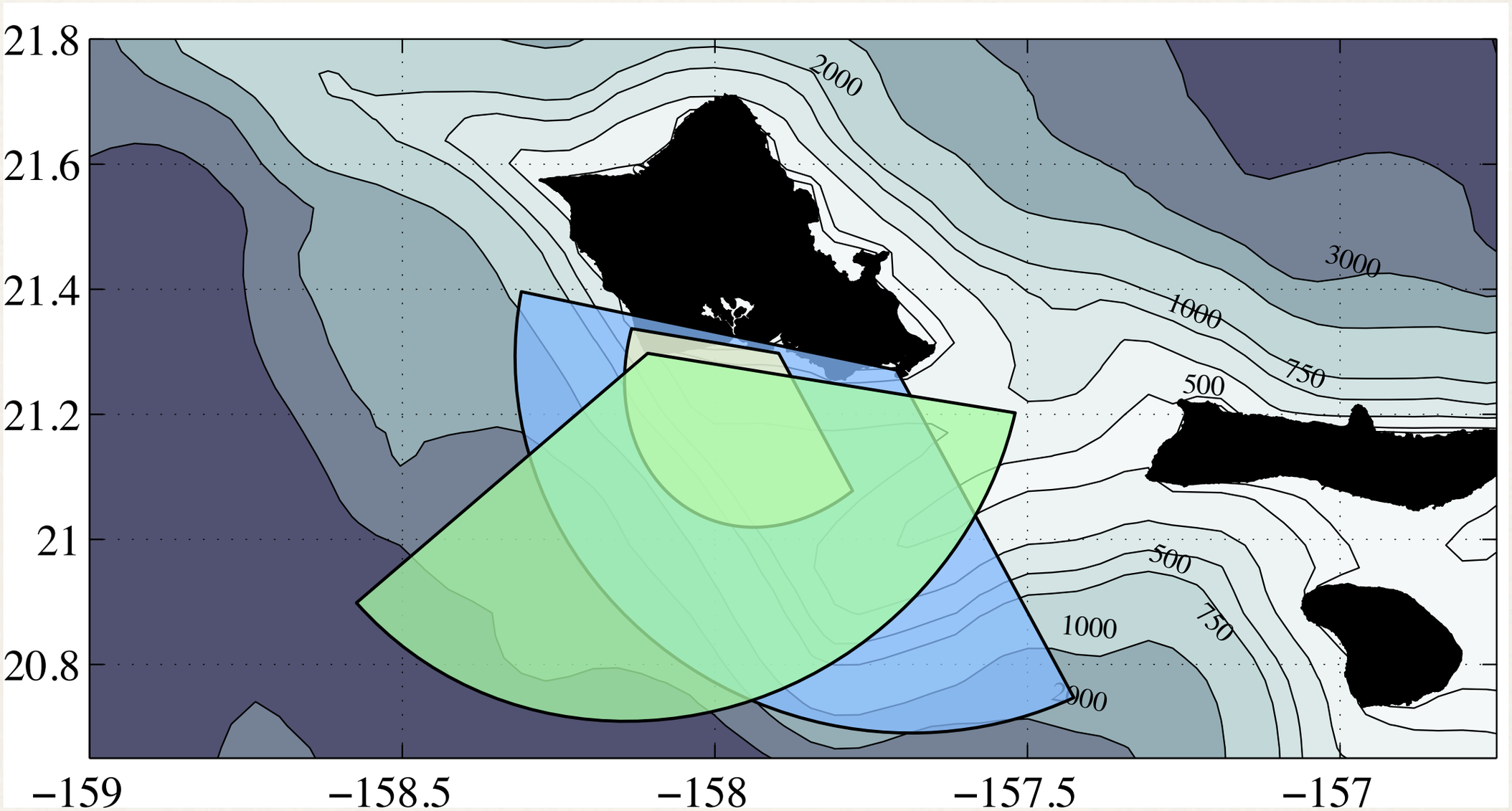
HiOOS Region



US Coastal HF Network




21.8
21.6
21.4
21.2
21
20.8
−159
−158.5
−158
−157.5
−157
2000
3000
1000
750
500
500
750
1000
2000


21.8
21.6
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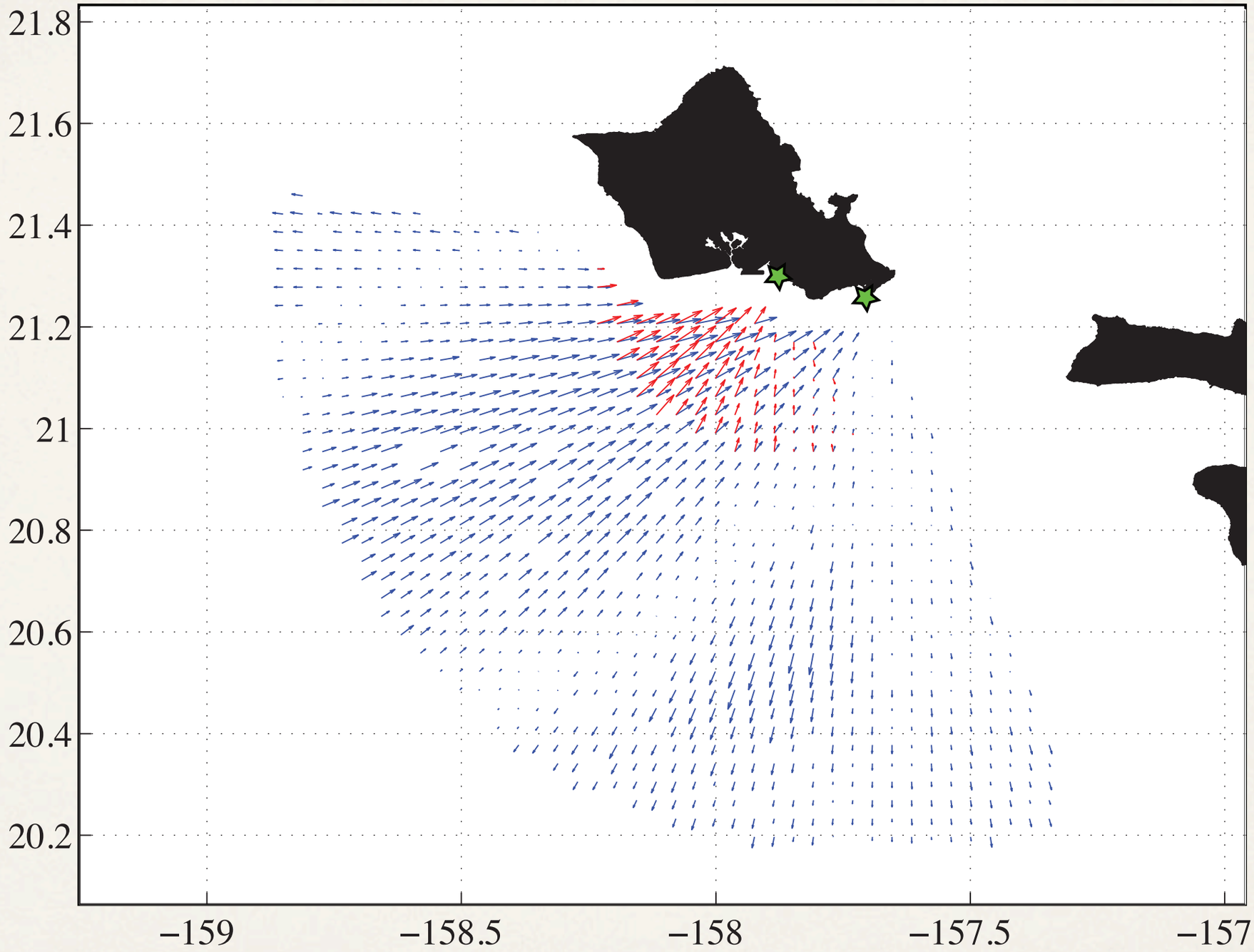
20.8
−159
−158.5
−158
−157.5
−157
2000
3000
1000
750
500
500
1000
750
2000

HF Radar

- Returned pulse amplified via Bragg scattering
- Doppler shift measurement gives velocity of travel away / toward receiver (radial)
- With two, orthogonal measurements, we have the total **u** current.
  - Statistical inverse problem creates correlated errors


21.8
21.6
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20.8
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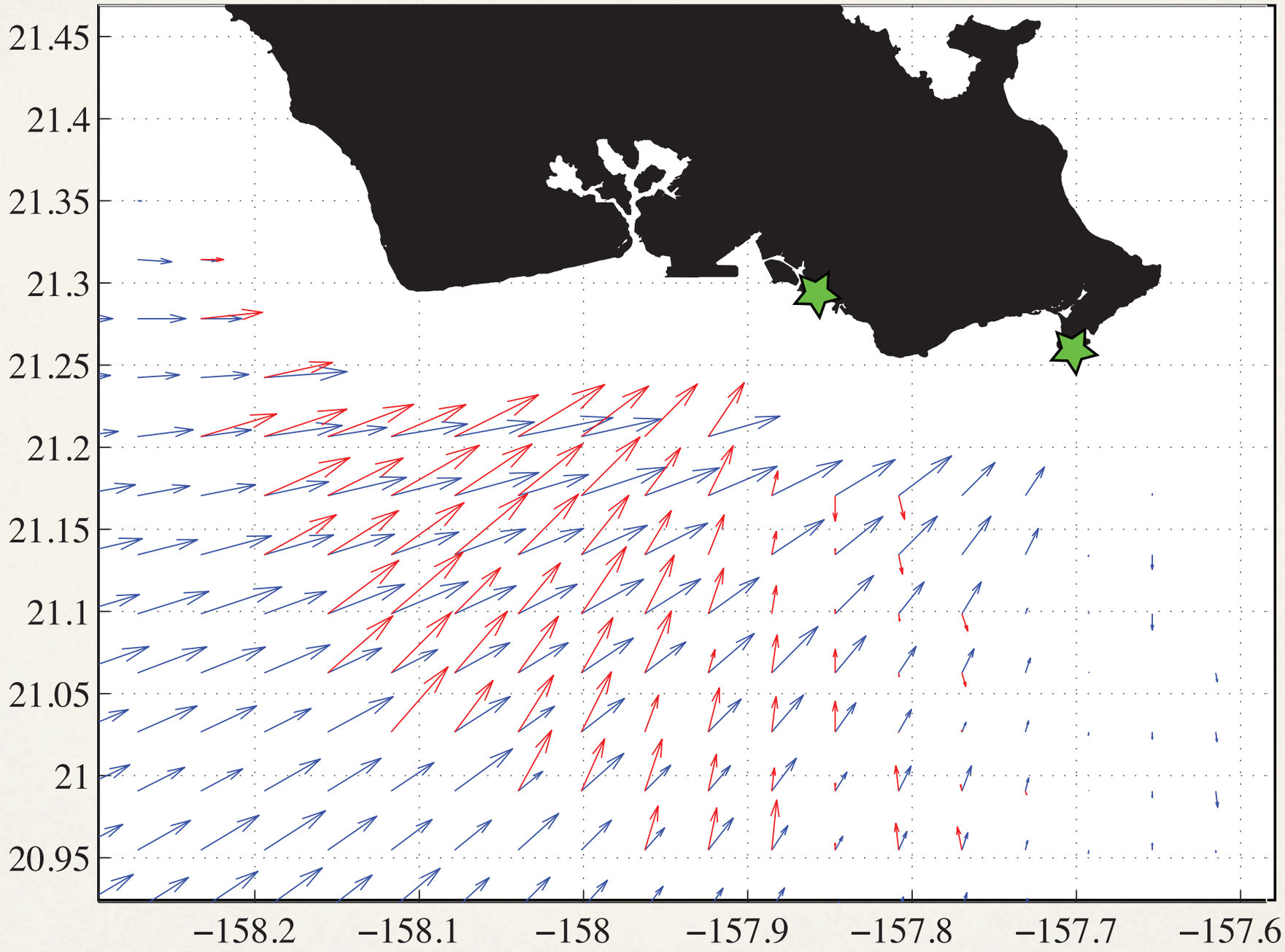
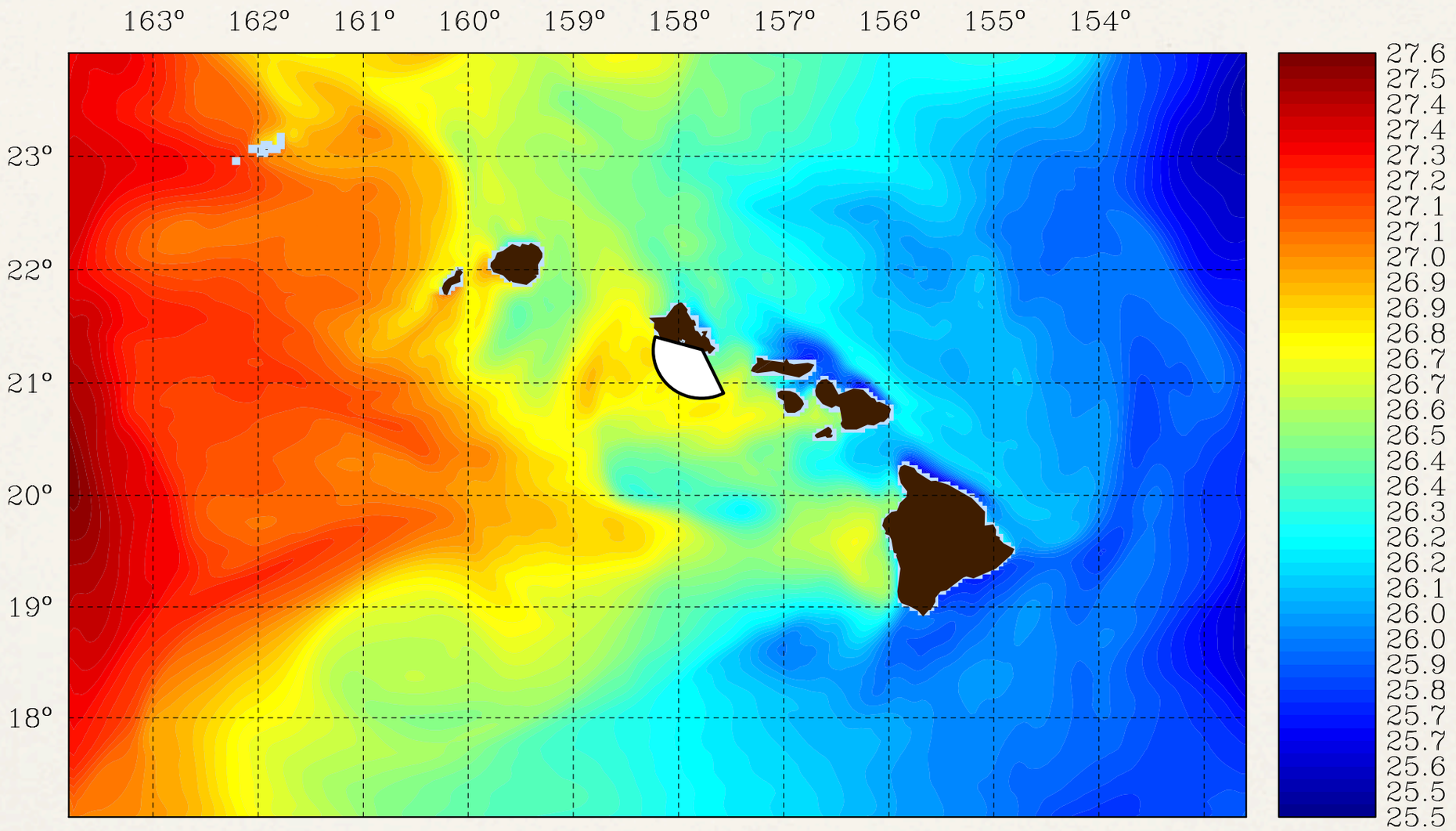

21.45
21.4
21.35
21.3
21.25
21.2
21.15
21.1
21.05
21
20.95
−158.2
−158.1
−158
−157.9
−157.8
−157.7
−157.6

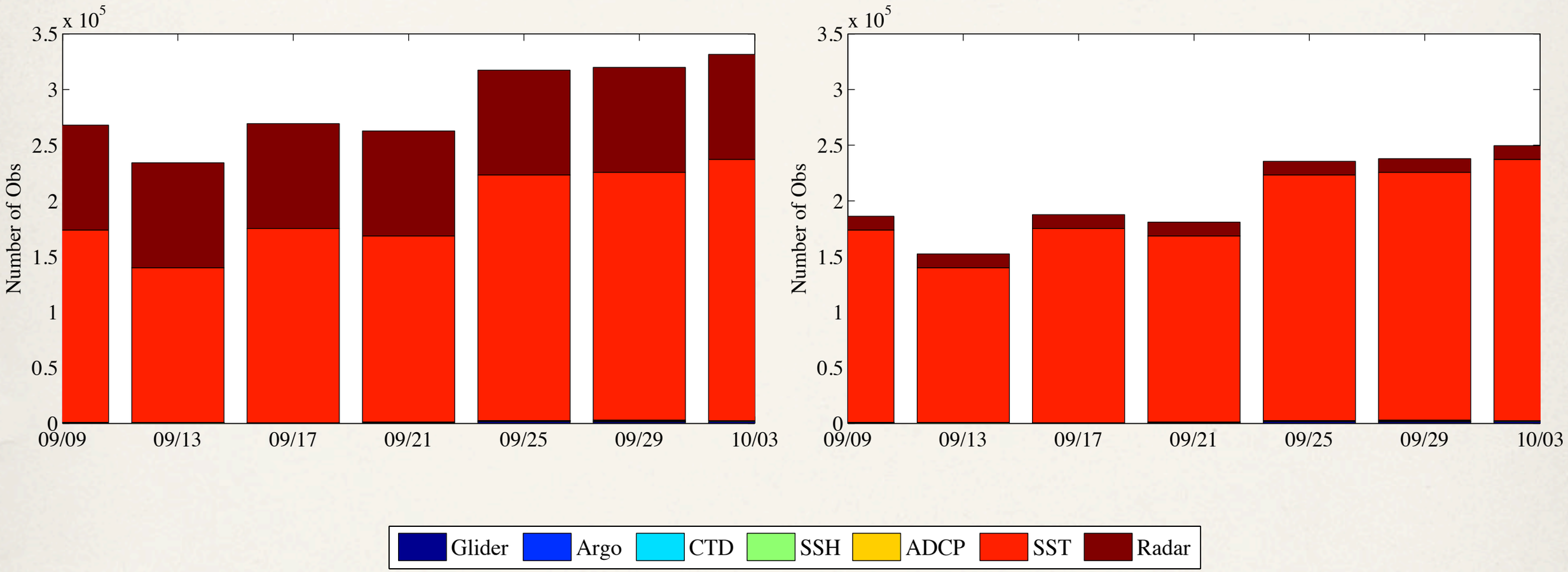
Twin Experiment

- Using Model-Space 4D-Var spinup from HiOOS
- Period with many available observations
  - Velocity alone can be very sensitive
  - Typical usage scenario: Satellite, Sea Glider, Argo, etc.
- Took the output from the assimilation system over 28 days and sampled the field to generate radials
  - Use community standard vector routines
- Took a state from 2 months prior, and integrated forward as my initial guess

HiOOS Region

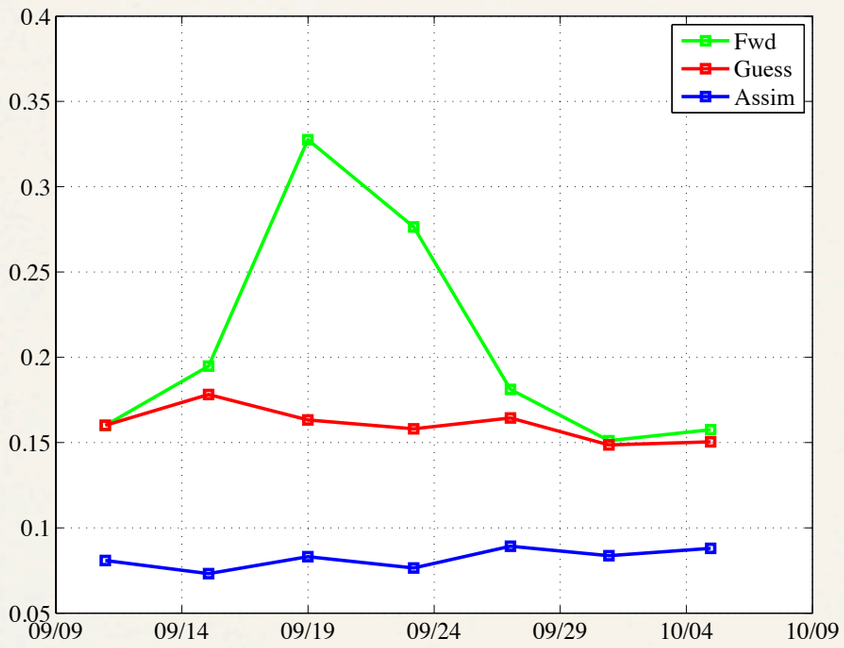


Observation Counts

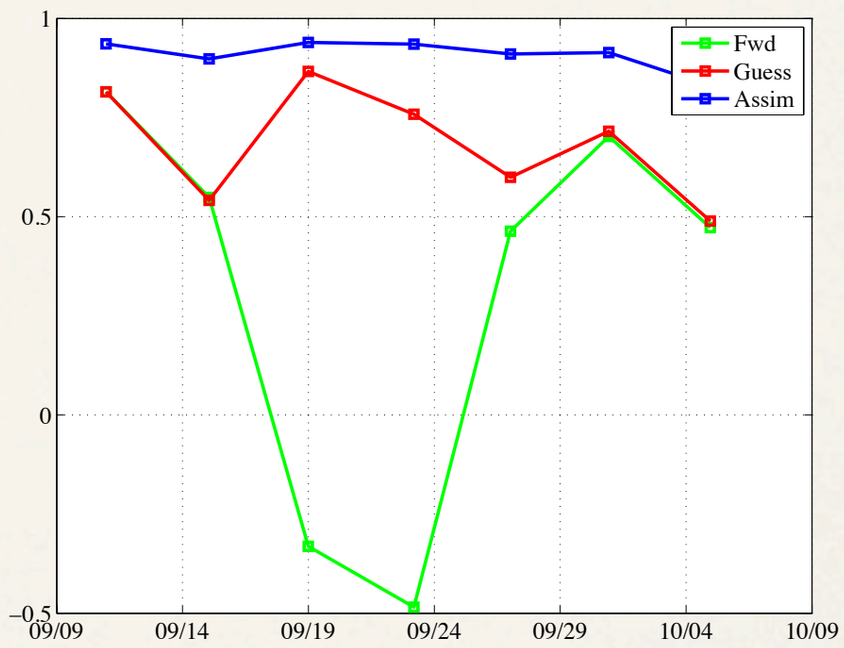


Radial Assimilation

RMS



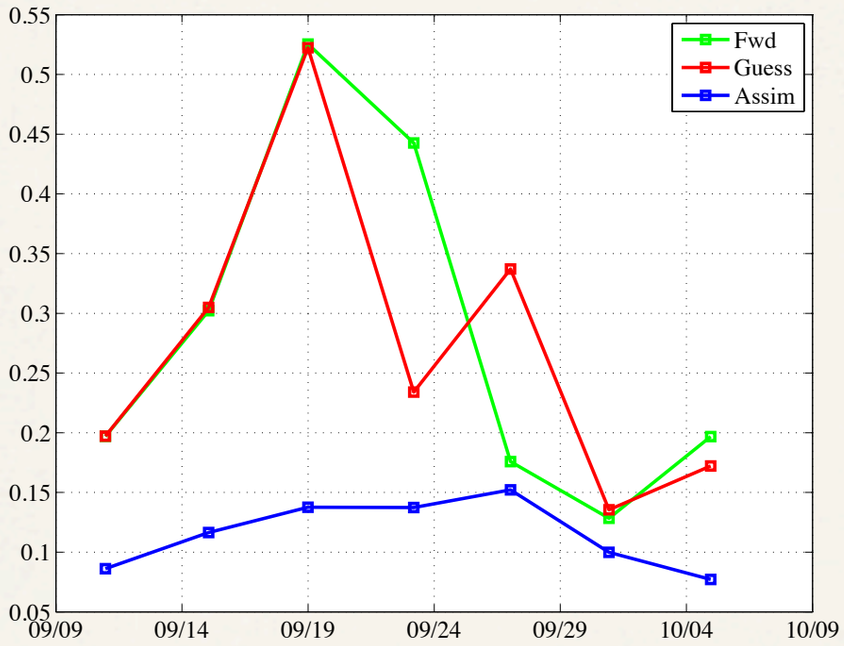
Correlation



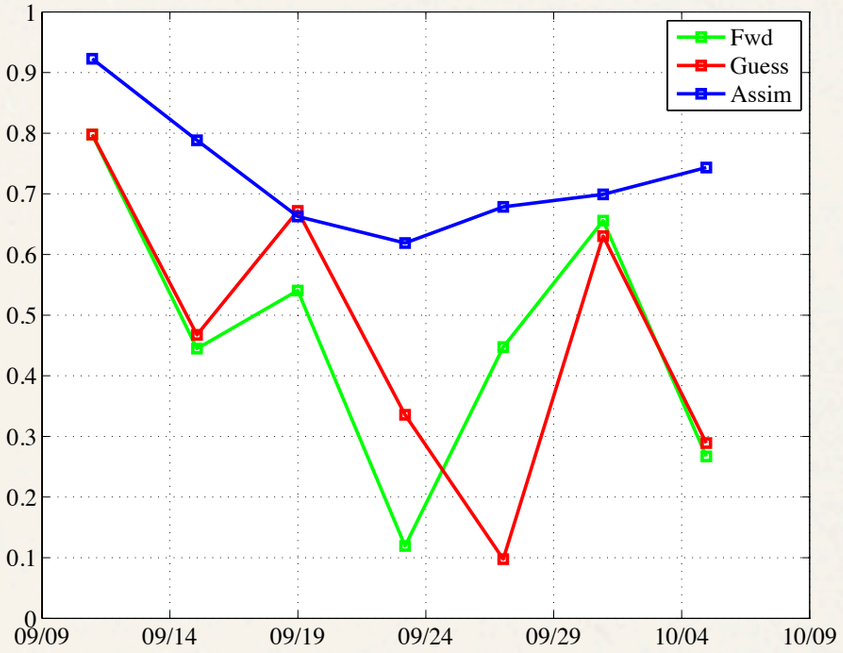
Vector Assimilation

U-Velocity

RMS

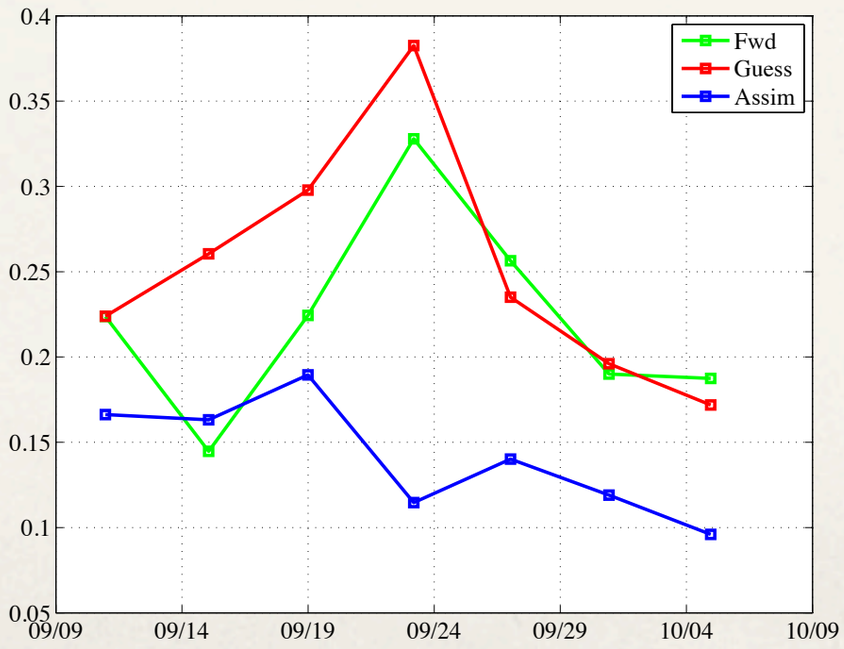


Correlation

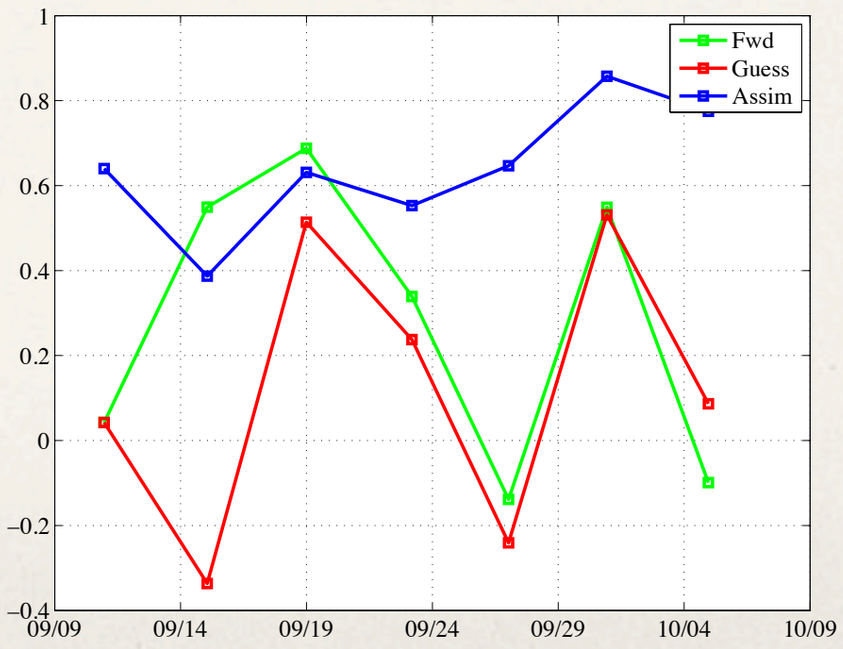


V-Velocity

RMS



Correlation

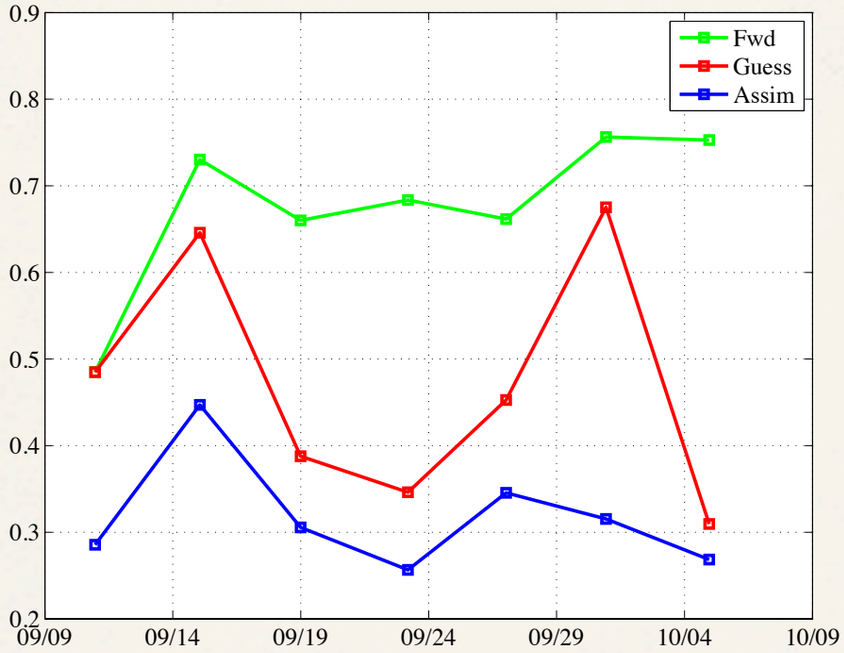


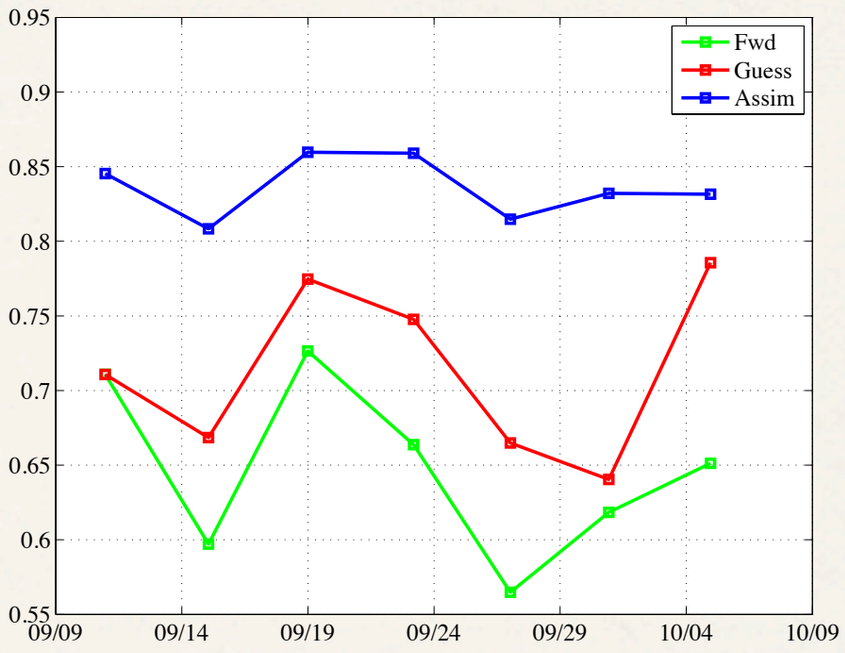
Temperature?

RMS

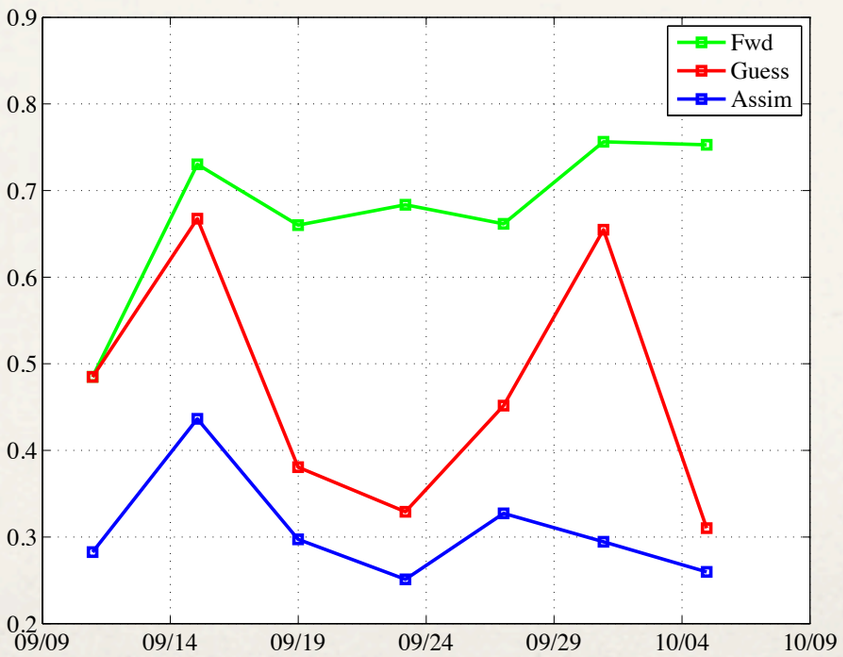
Correlation

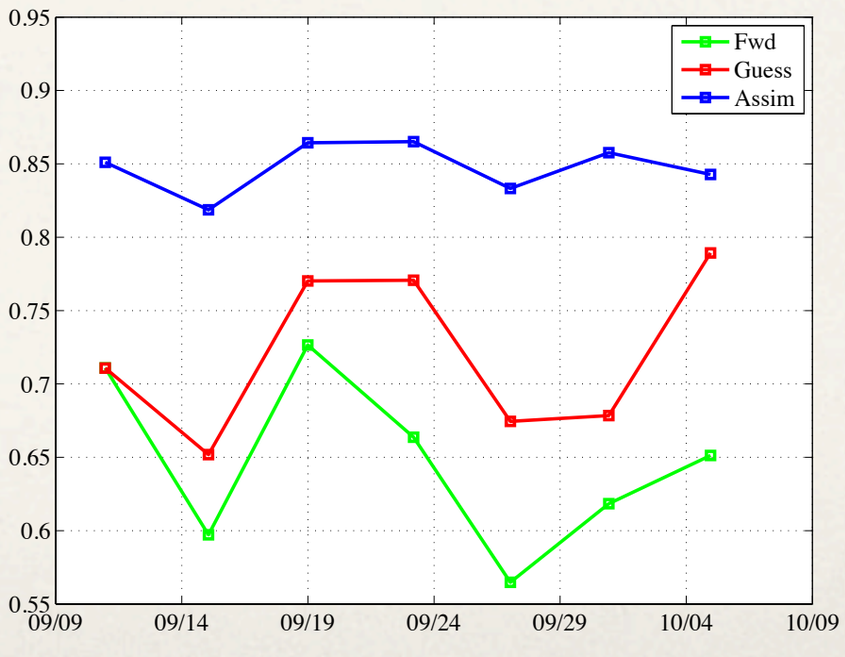
Radial Assim





Vector Assim



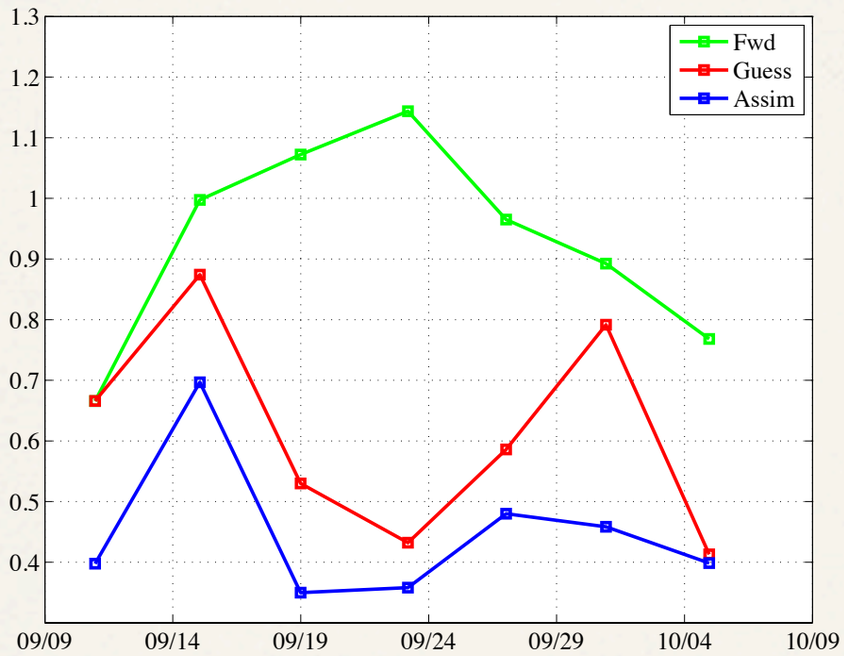


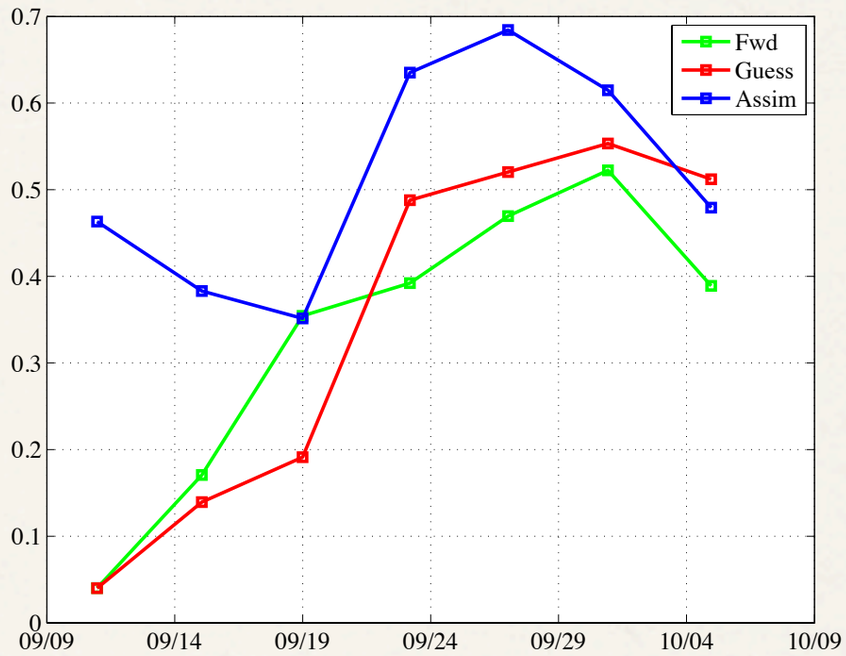
Temperature in Region?

RMS

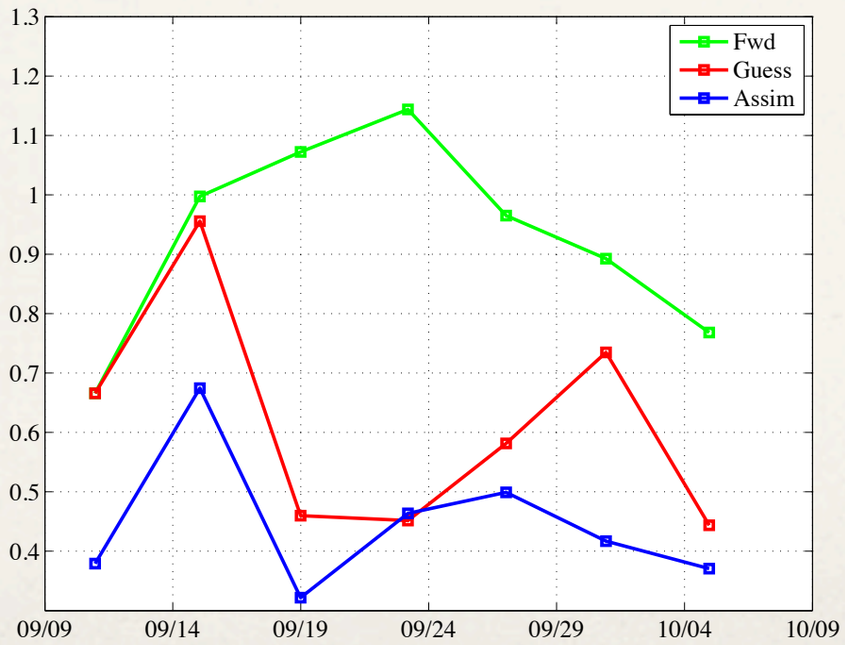
Correlation

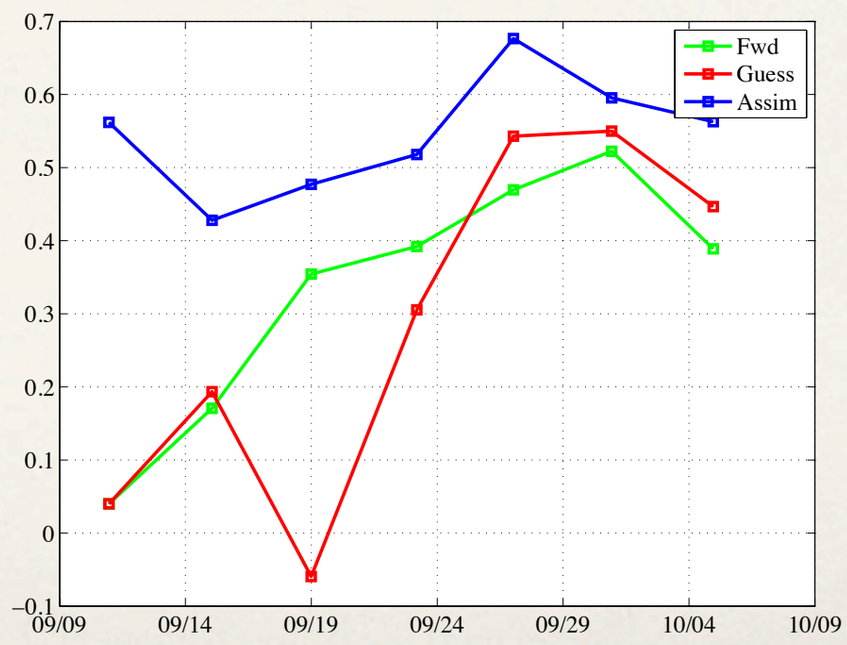
Radial Assim





Vector Assim

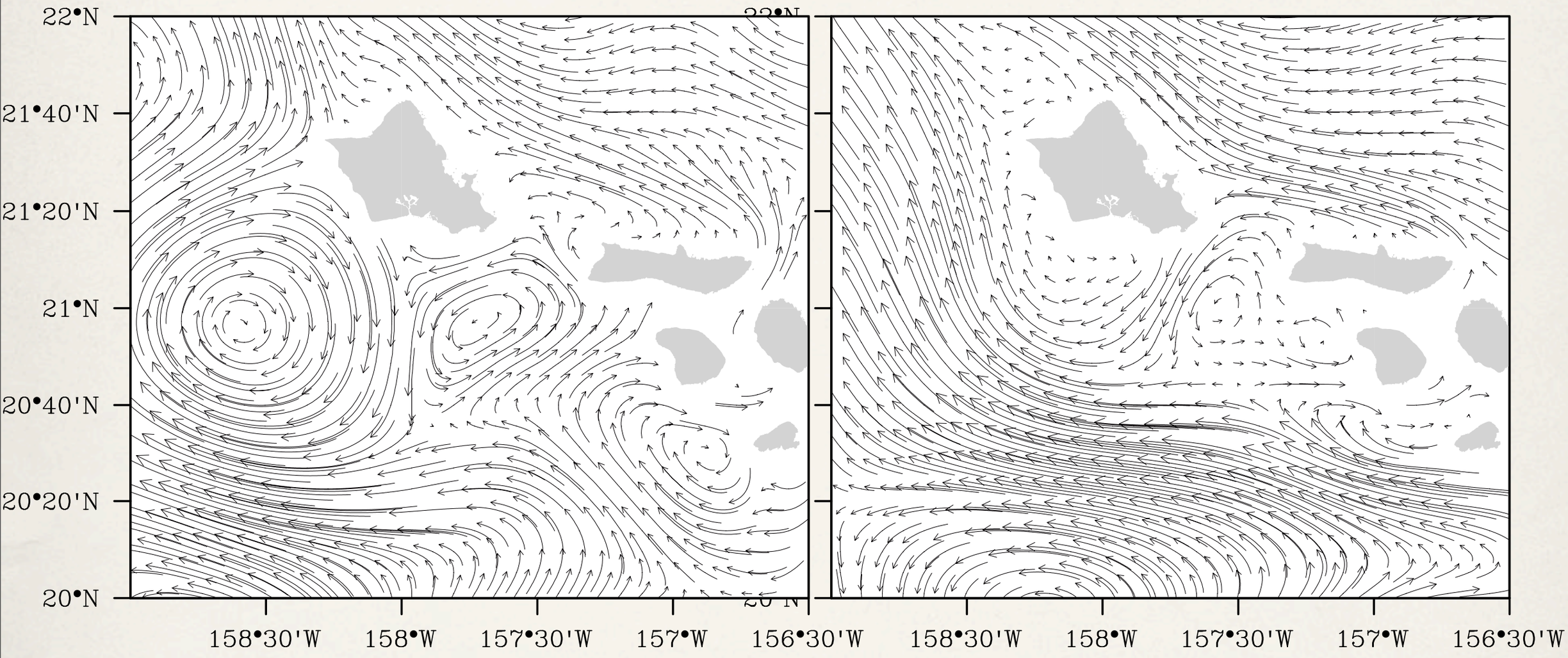




Surface Currents

Truth

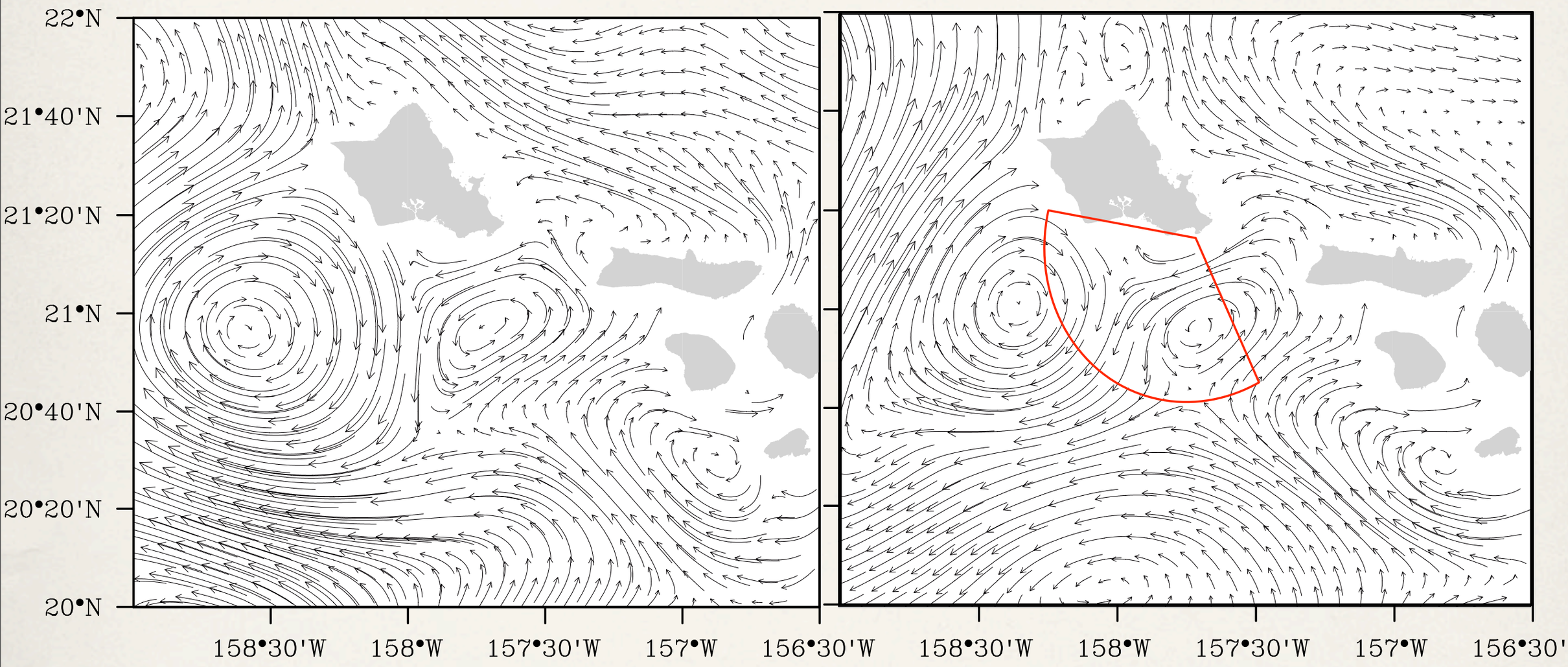
Forward Guess



Surface Currents

Truth

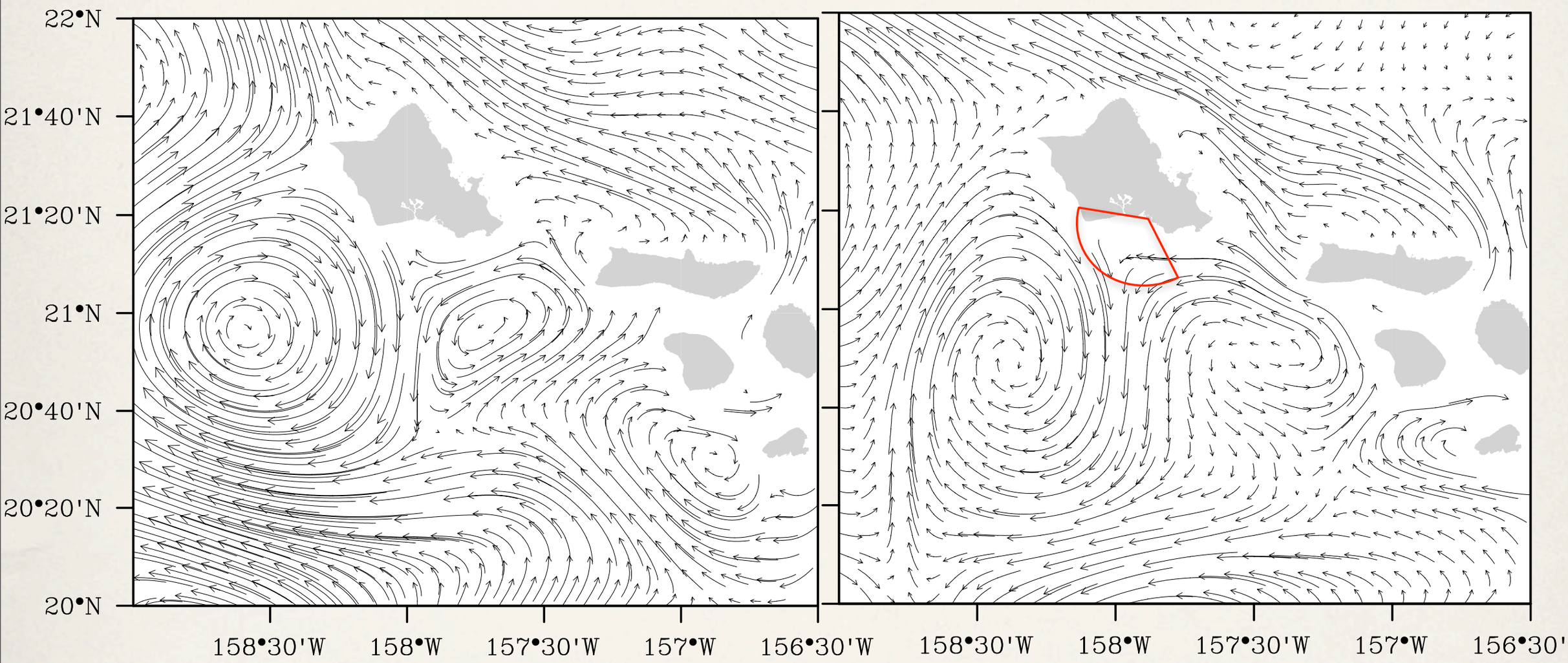
Radial Assim



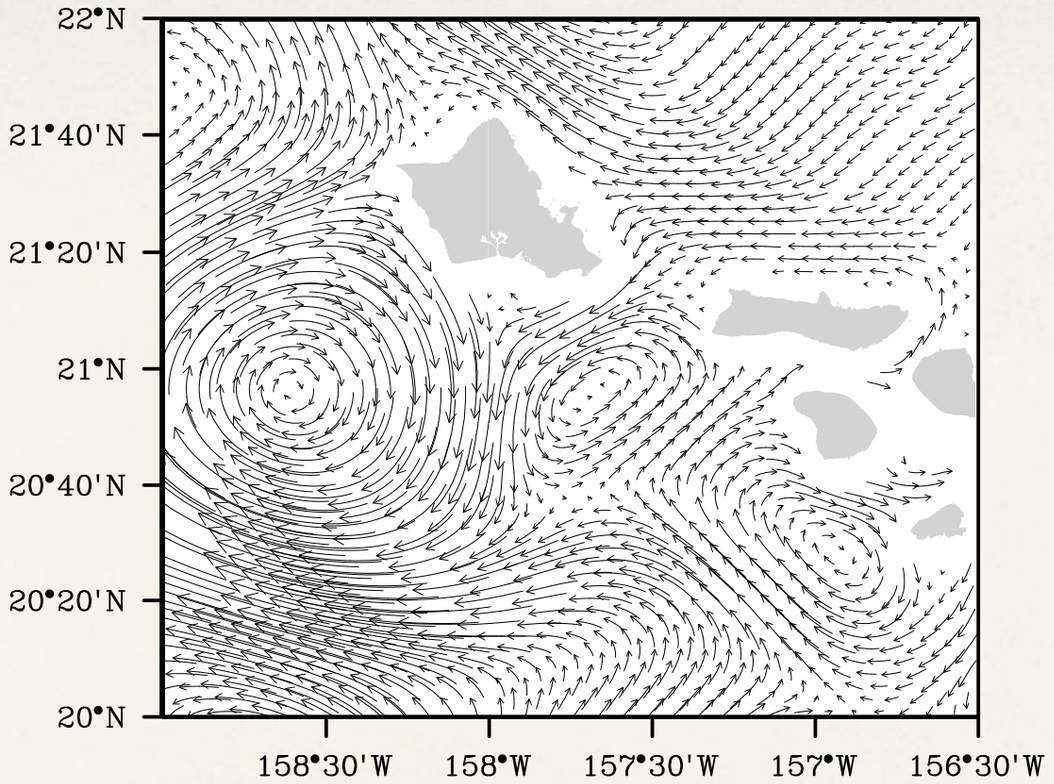
Surface Currents

Truth

Vector Assim



Truth



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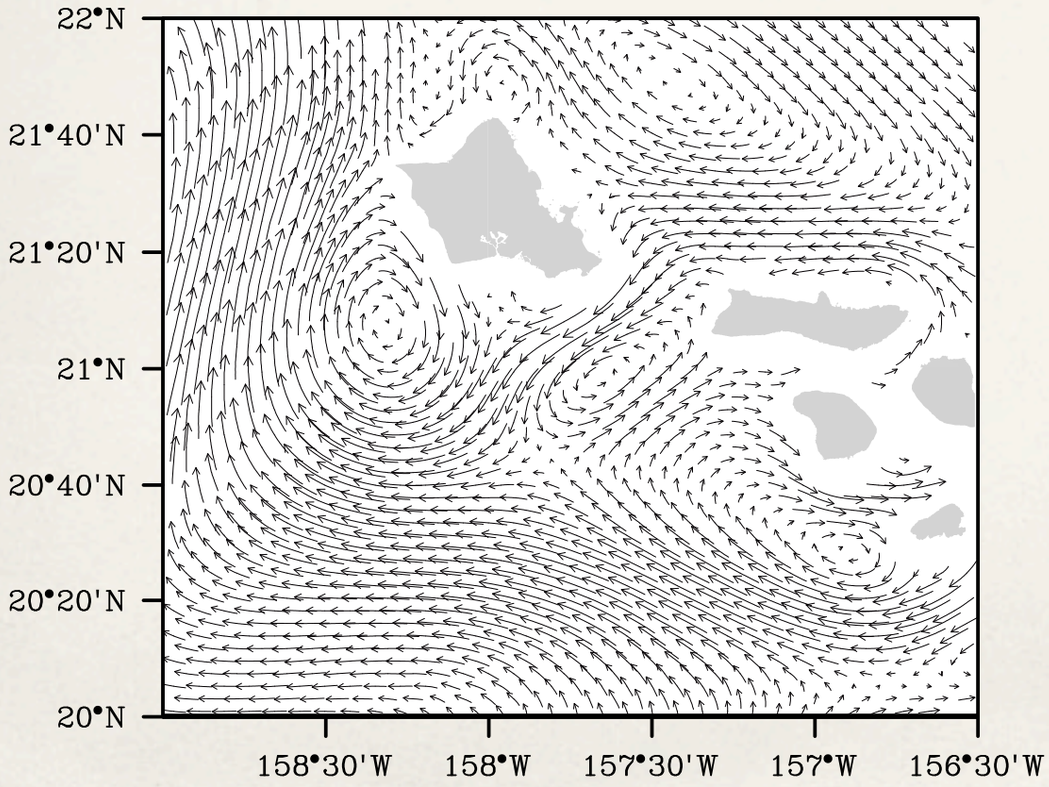

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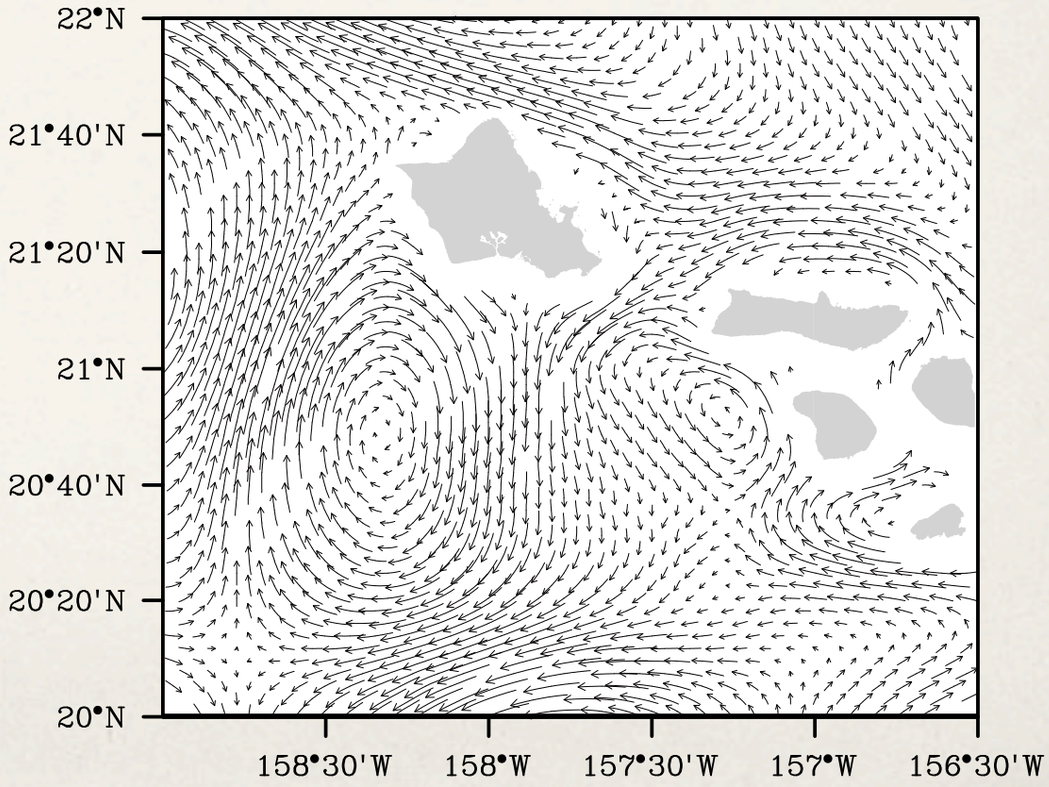
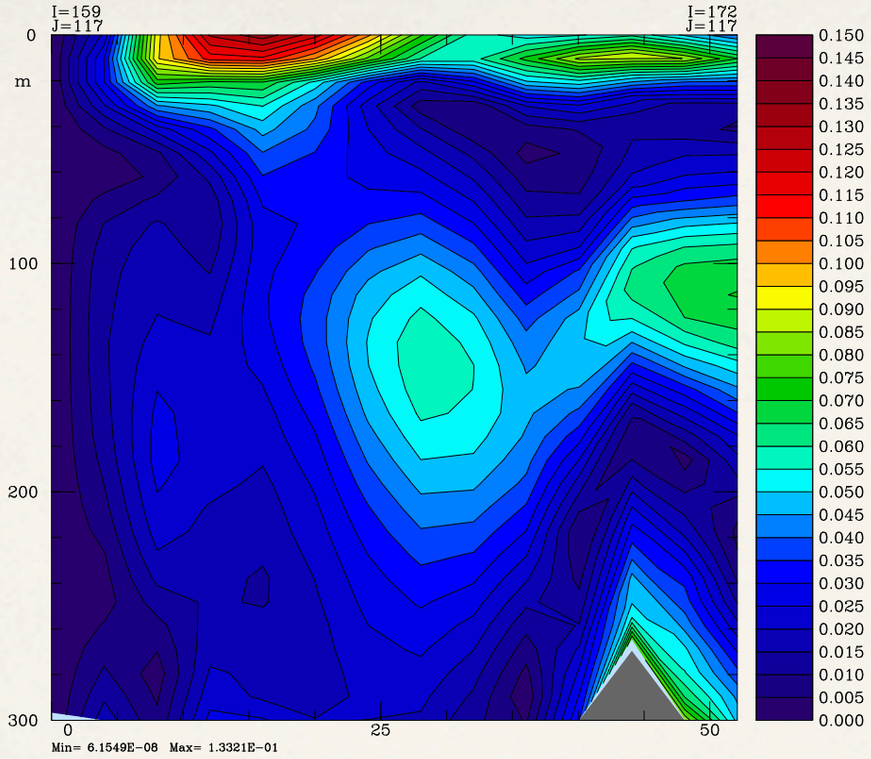
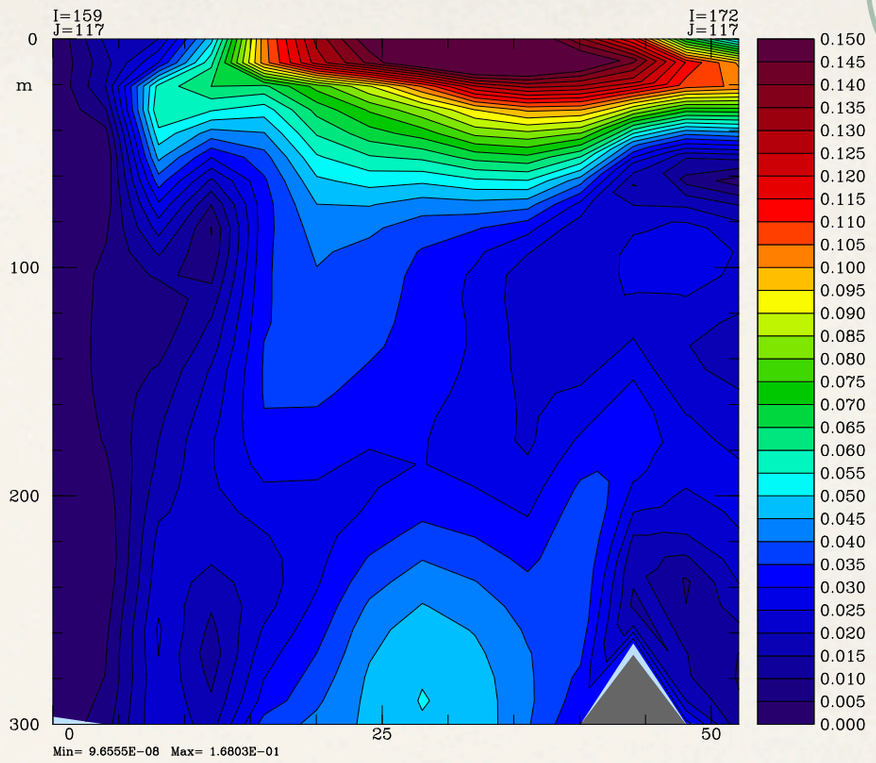


Guess



Truth



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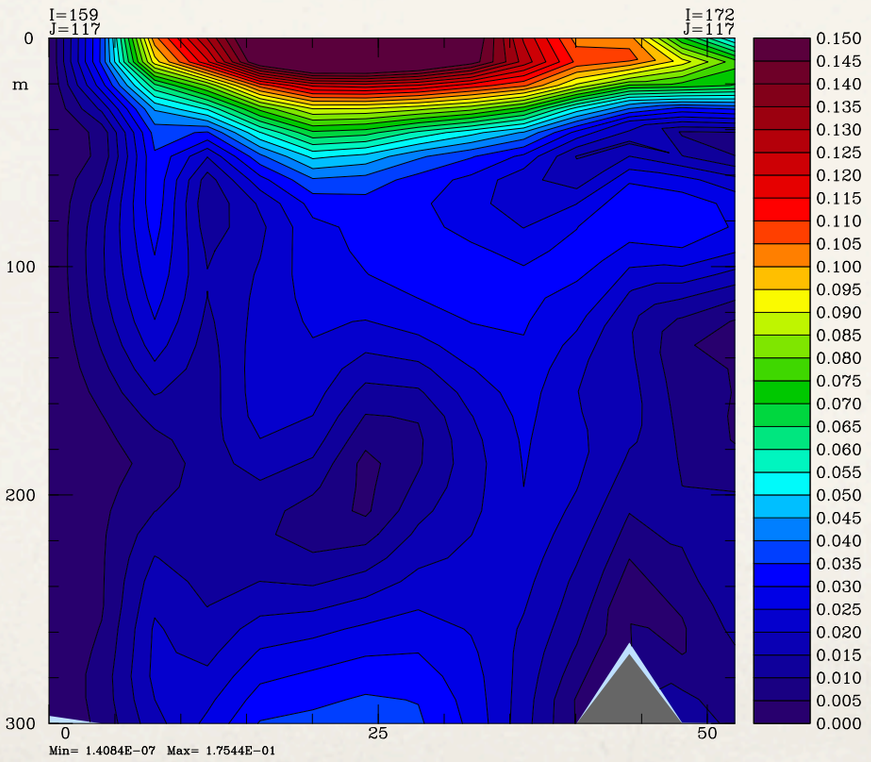

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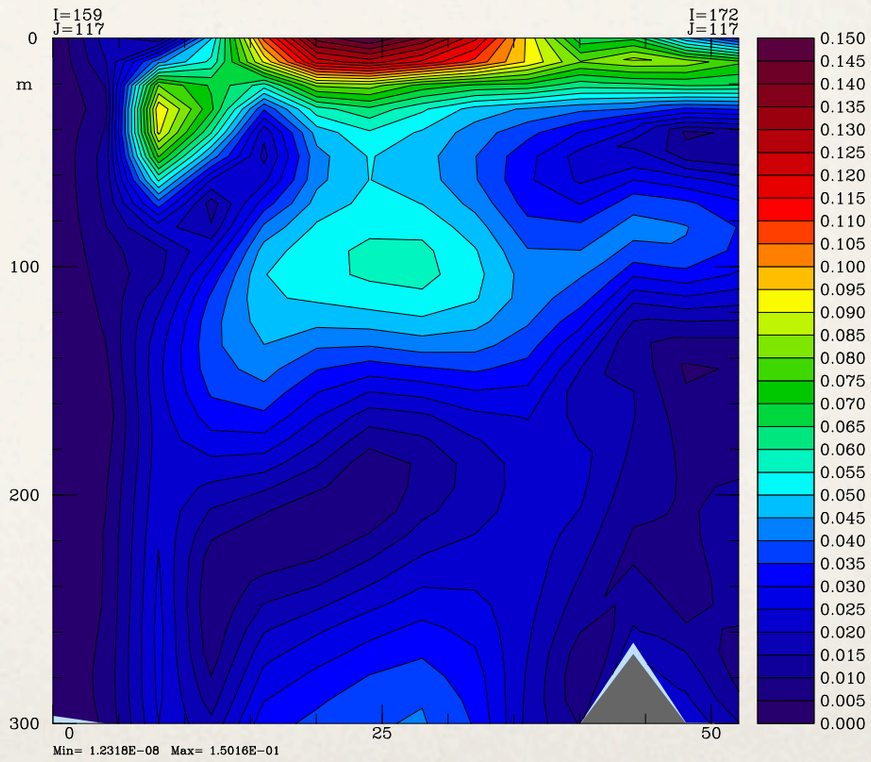

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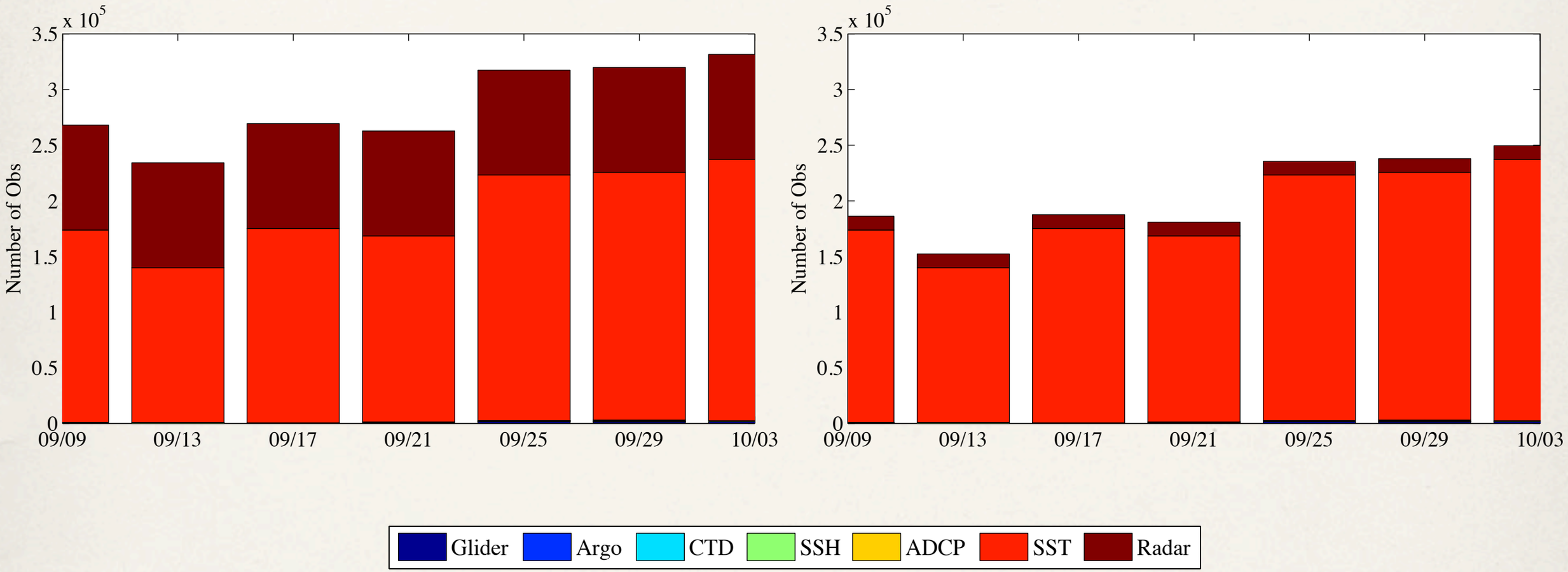
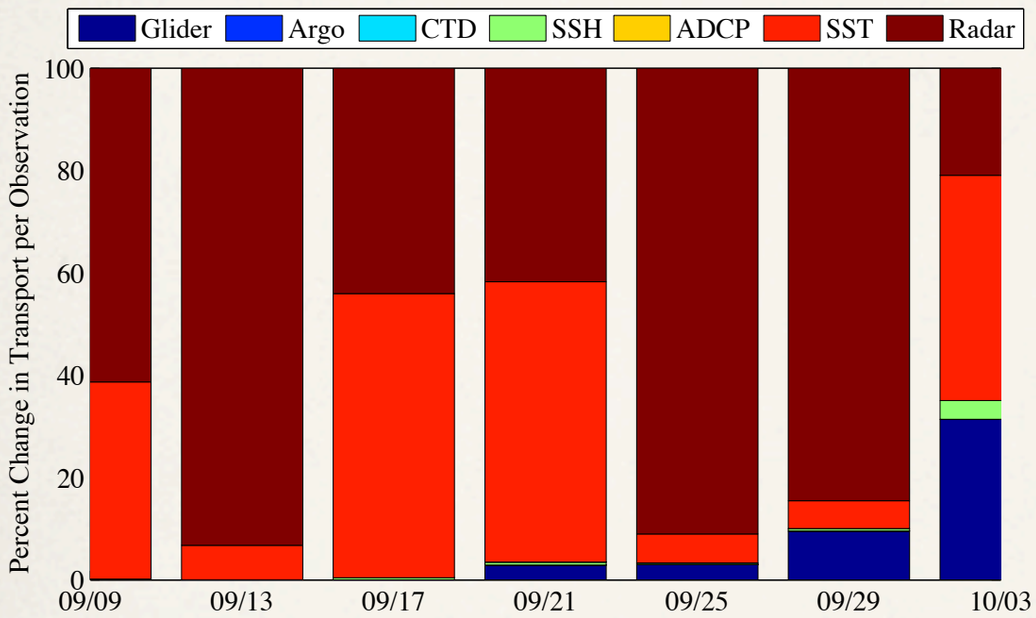
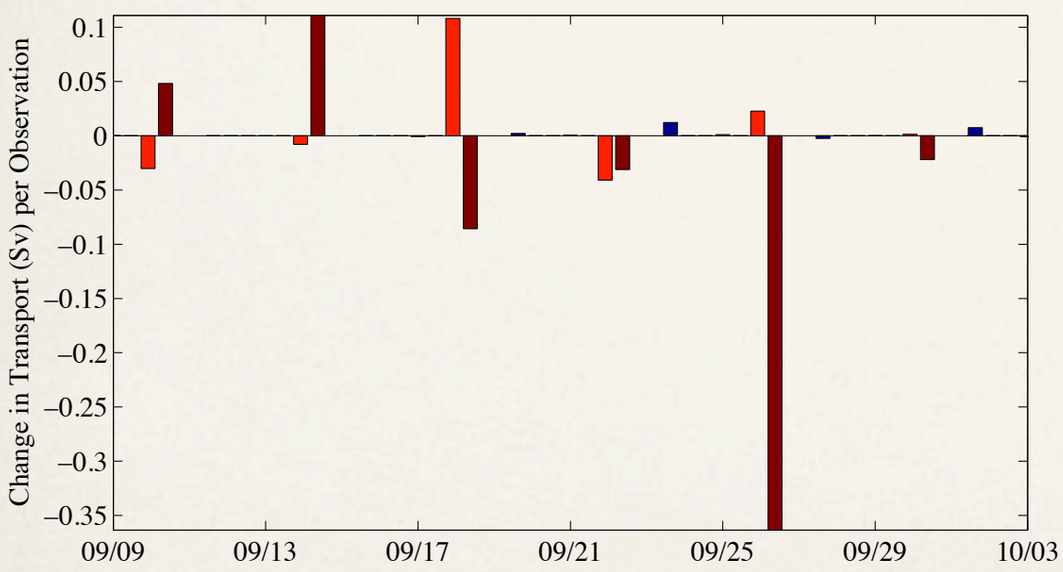
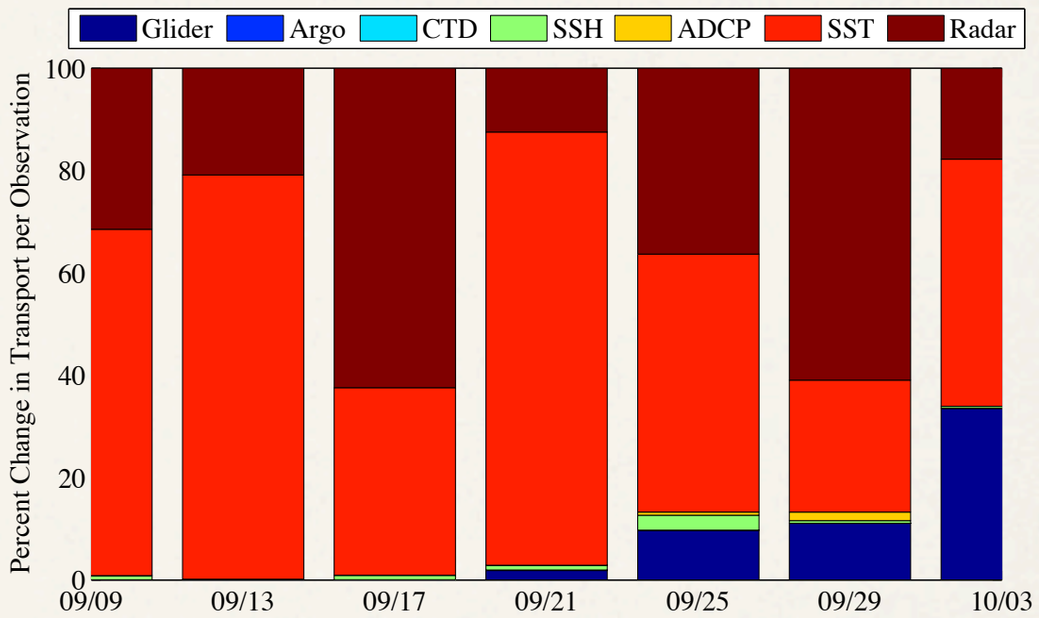


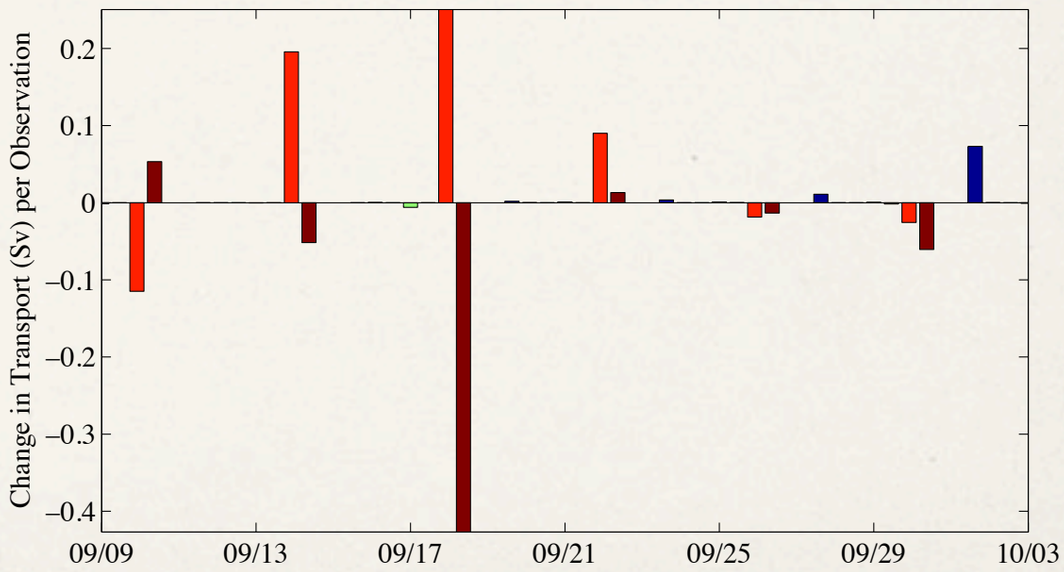
Radials





Vectors





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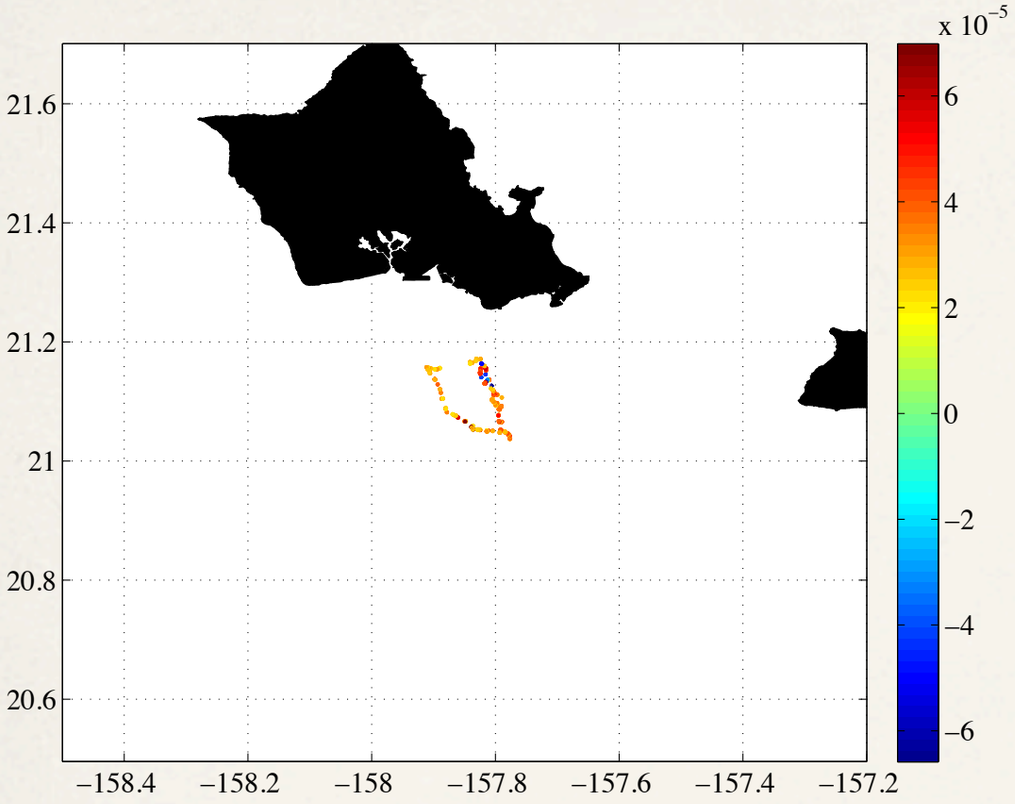
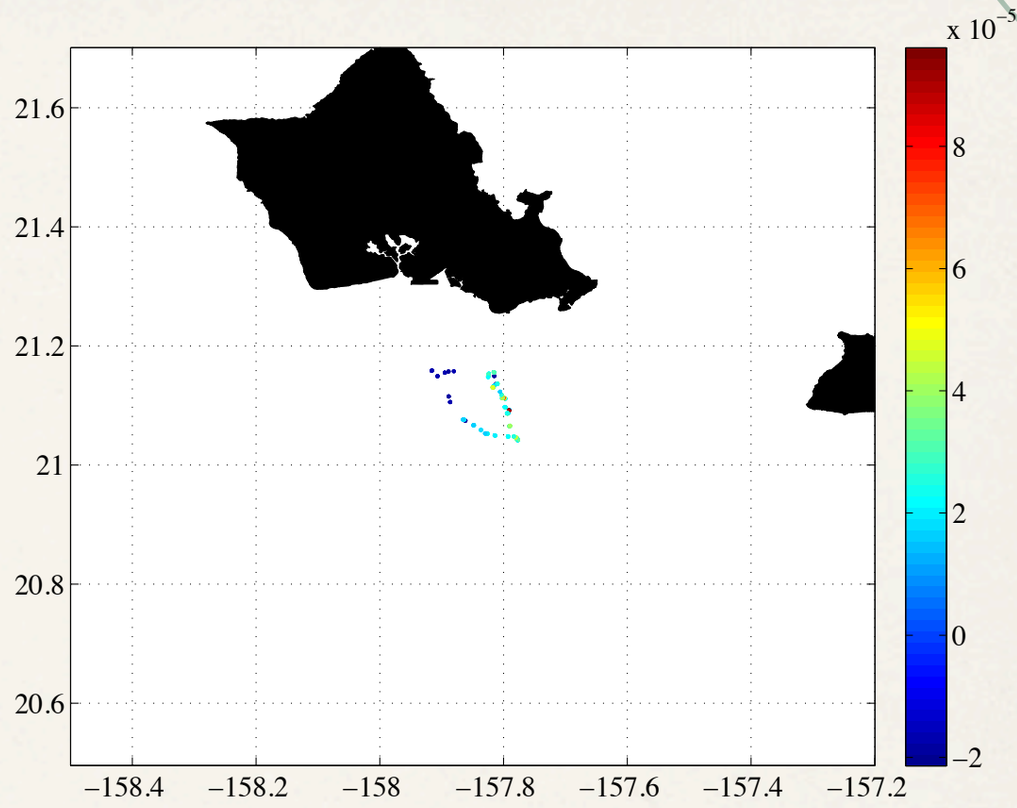
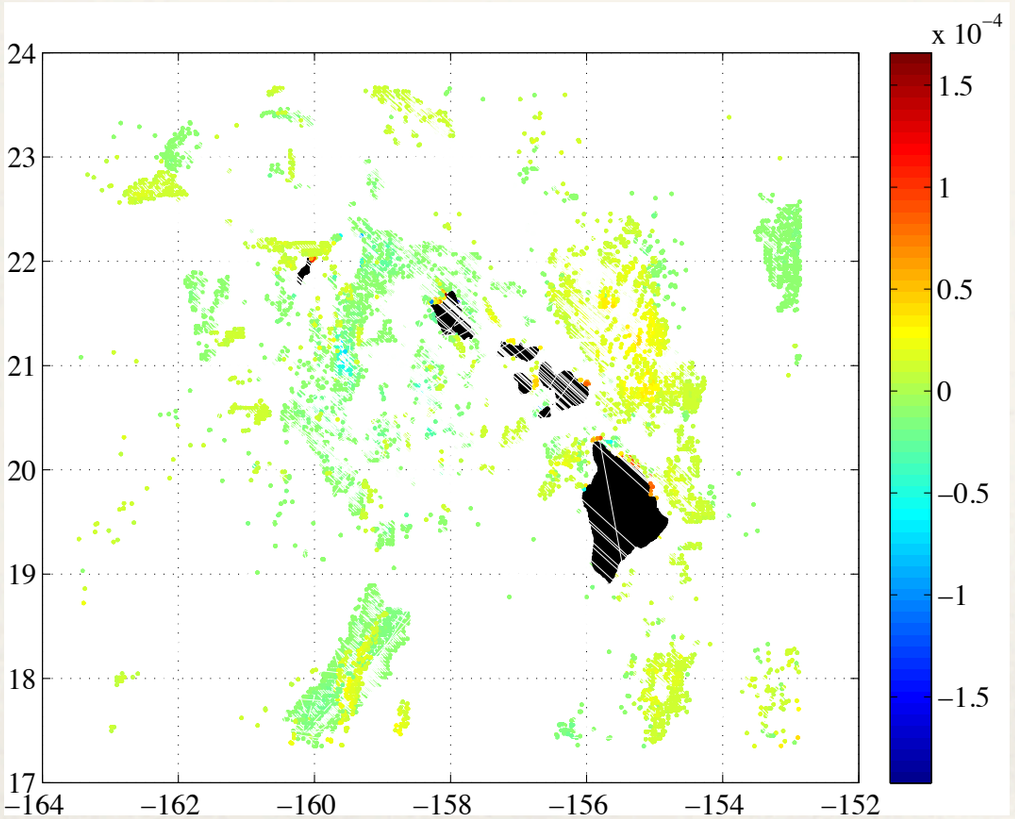
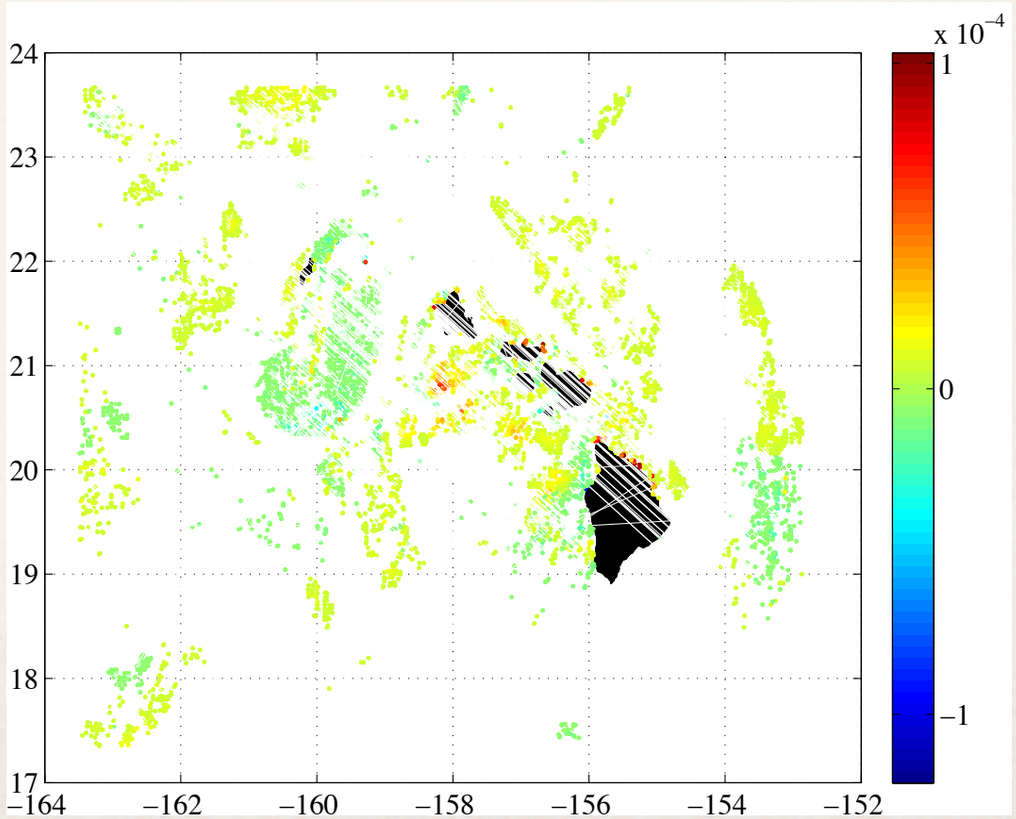


Vectors







Future

- Observation Space Methods
  - Array Modes (processing in-progress)

Array Modes

Innovation Vector: $$\mathbf{d} = \mathbf{y}^o - \mathcal{H}\mathbf{x}^b \quad ,$$

where, $\mathbf{y}^o$ are observations, $\mathbf{x}^b$ is background circulation, $\mathbf{x}^t$ truth

Given errors of: $$\epsilon^b = \mathbf{x}^b(0) - \mathbf{x}^t(0)$$

$$\epsilon^o = \mathbf{y}^o - \mathcal{H}\mathbf{x}^t$$

Then, $$\left\langle \mathbf{d}\mathbf{d}^T \right\rangle = \left\langle \left(\epsilon^o - \mathbf{G}\epsilon^b\right)\left(\epsilon^o - \mathbf{G}\epsilon^b\right)^T \right\rangle$$

$$= \mathbf{R} + \mathbf{G}\mathbf{D}\mathbf{G}^T$$

where $\mathbf{G} = \mathbf{H}\mathbf{M}$

Future

- High-Resolution Inner Model
- Tides are of great concern
  - Rutgers de-tides the HF vectors and adds in their own tides.
  - Balance between density (PE) and velocity (KE) measurements