# Sustained Lagrangian Observations of Upper-Ocean Currents, Stratification & Turbulence

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&

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# Surface currents are…

… not well-defined

… strongly forced

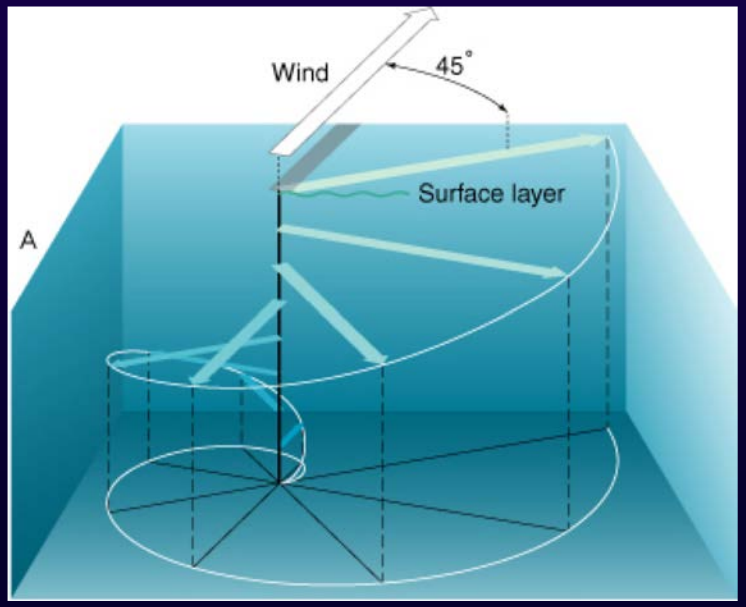
… sheared

… turbulent and wavy – on all scales

… 3D (horizontally convergent)

… broadly important

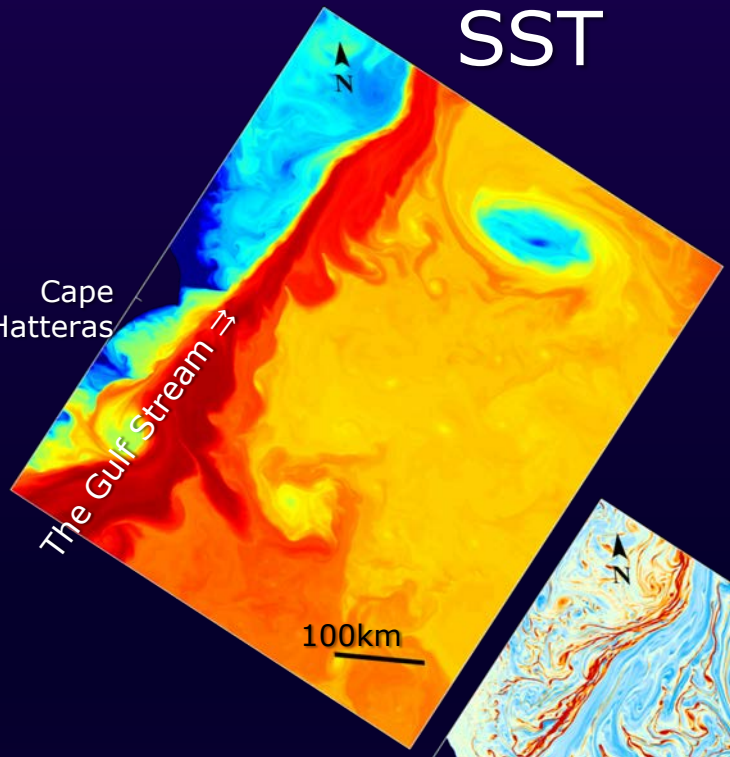
# Changing views on surface currents



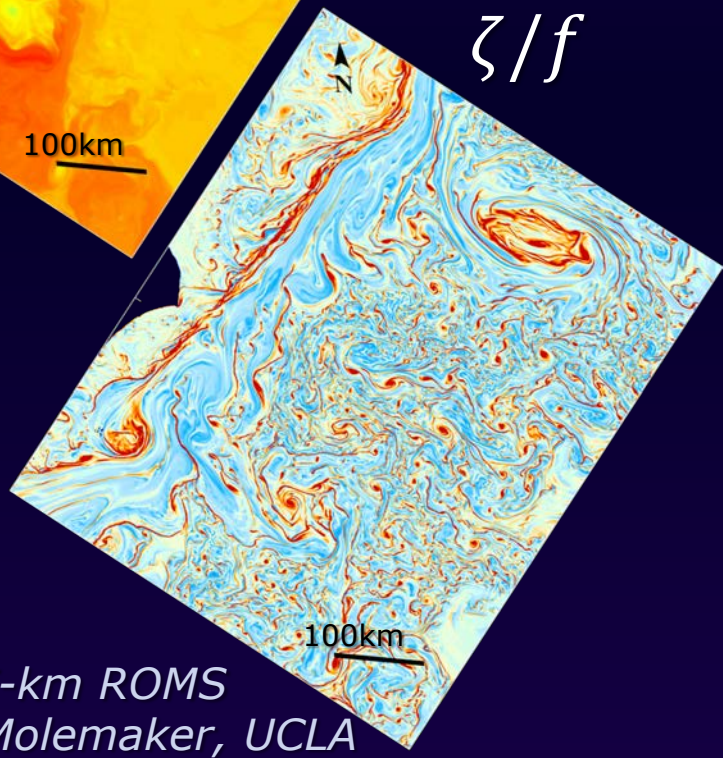


*NASA Ocean Motion*

SST




$\zeta/f$

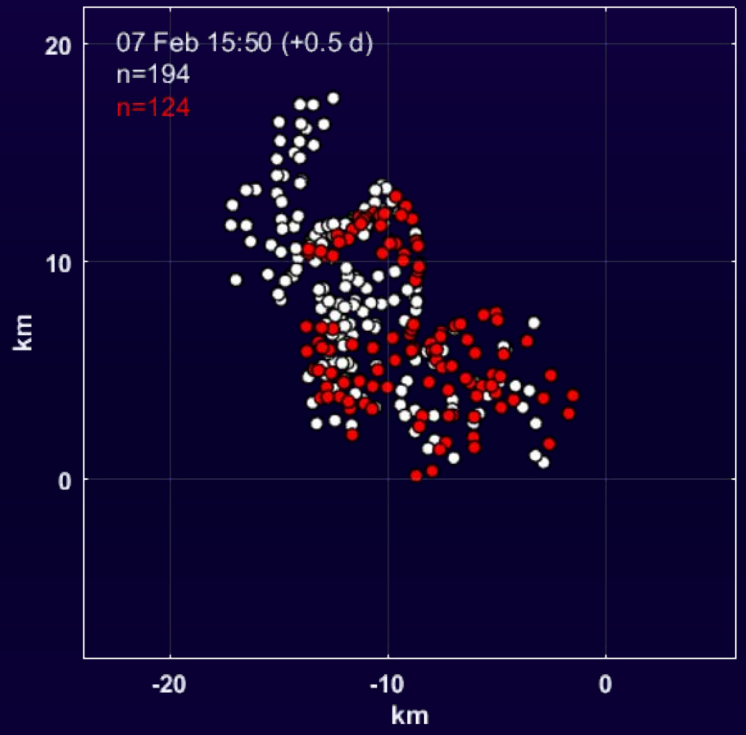



*0.5-km ROMS*
*J. Molemaker, UCLA*

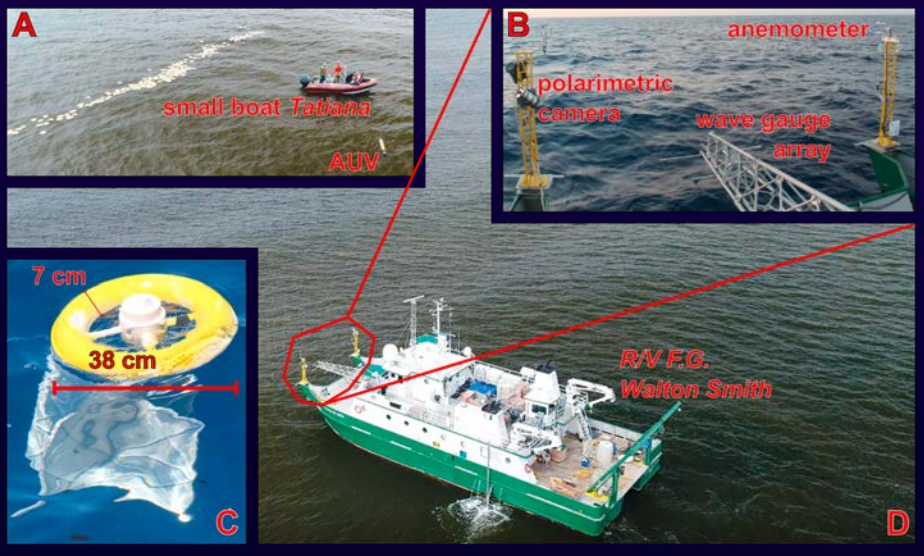
# Changing observational strategies

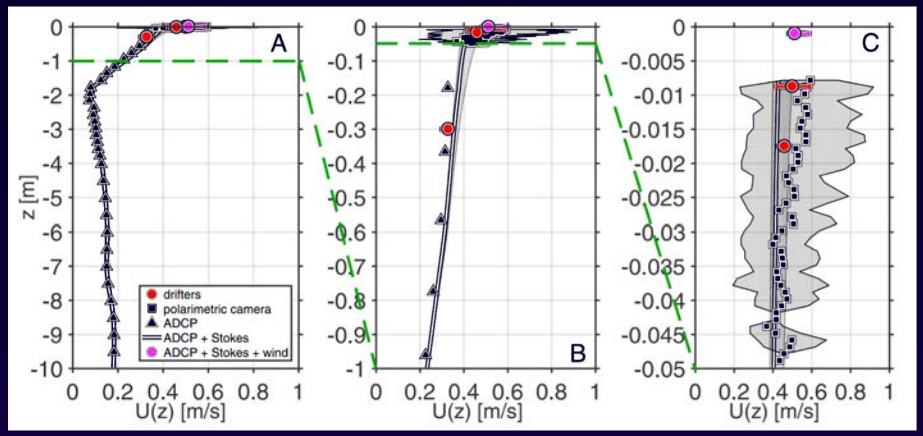
Multi-scale, multi-modal, multi-platform…

Massive drifter release




*CARTHE LASER experiment*
*Gulf of Mexico, 2016*

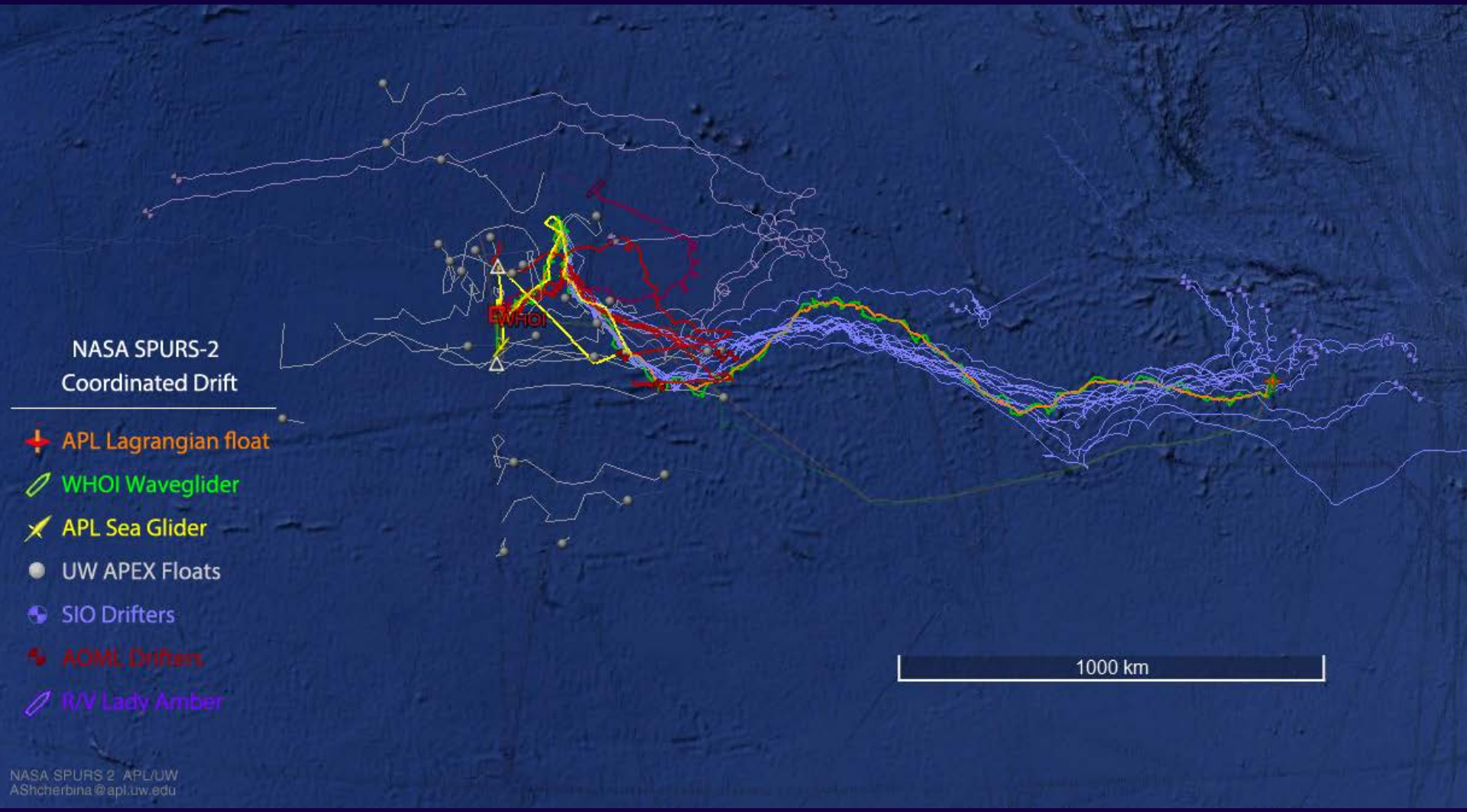



Laxague et al., JRL 2017

# NASA SPURS-2
# Cooperative Autonomous Sampling

26 Aug – 12 Dec 2016, 100 days,  2 550 km



# SPURS-2 Coordinated Autonomous Deployment

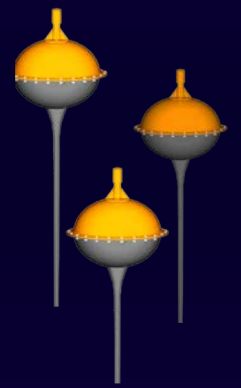
A mix of >20 instruments, fully-Lagrangian and driveable

**Lagrangian float**
2xCTD, Surface TS, PAL, ADCP
0 – 100m
*A. Shcherbina et al.*

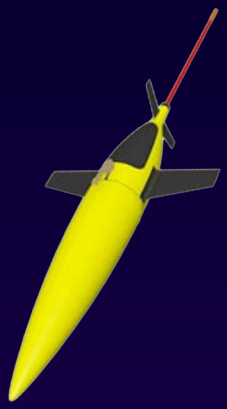
**APEX ARGO float**
CTD, Surface TS, PAL
0 – 2,000m
*S. Riser et al.*

**Wave Glider**
2xCTD, Wind, $T_{air}$
*B. Hodges et al.*

**AOML Drifters**
2xCTD
*D. Volkov et al.*



**SIO Drifters**
CTD, Waves (some)
*L. Centurioni et al.*



**Seaglider**
CTD, PAL, Micro-structure
0 – 1,000m
*L. Rainville et al.*

**R/V Lady Amber**
Underway CTD&MET
*L. Rainville et al.*

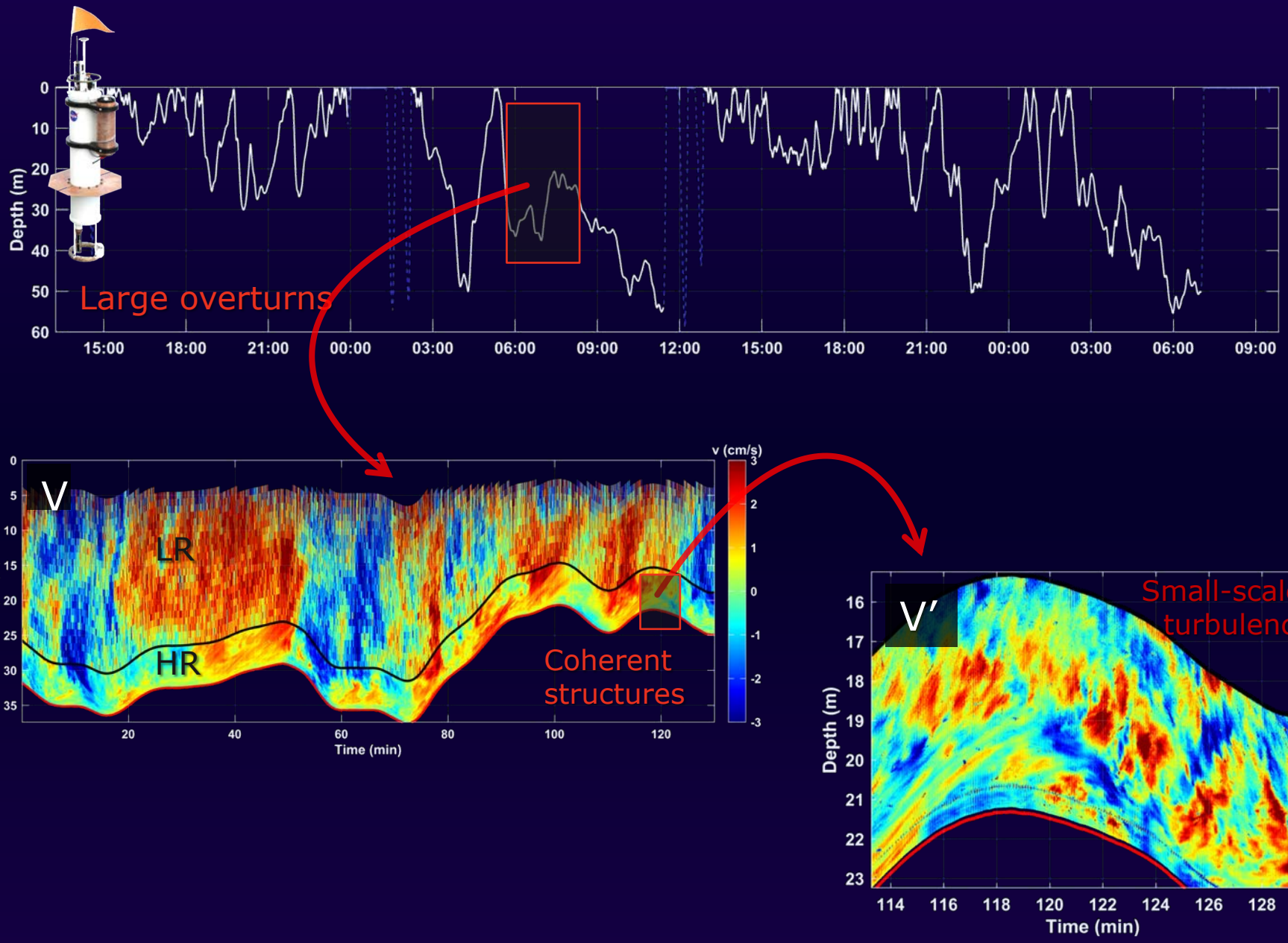
# Mixed Layer Lagrangian Float

## With the new ADCP payload

- Versatile fully-Lagrangian or profiling platform
- 2× CTDs
- 5-beam Nortek Signature1000 ADCP
  - Broadband
    (30m range, 1m resolution)
  - Pulse-coherent
    (6m range, 2cm resolution)

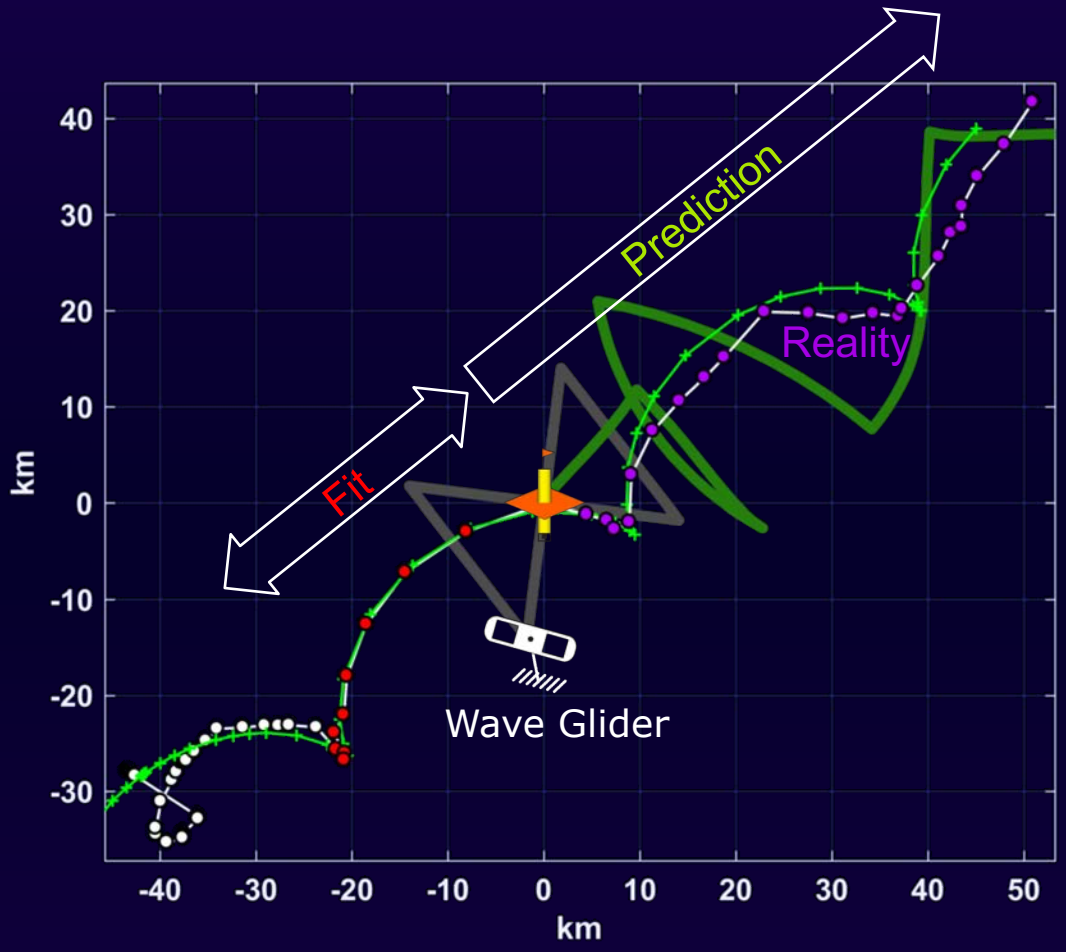
interleaved

# Visualizing boundary-layer shear and turbulence

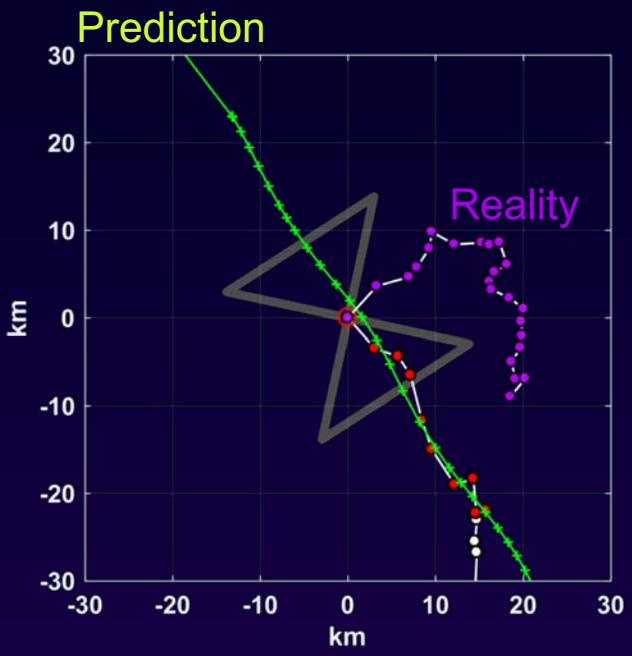


# Coordinating autonomous platforms

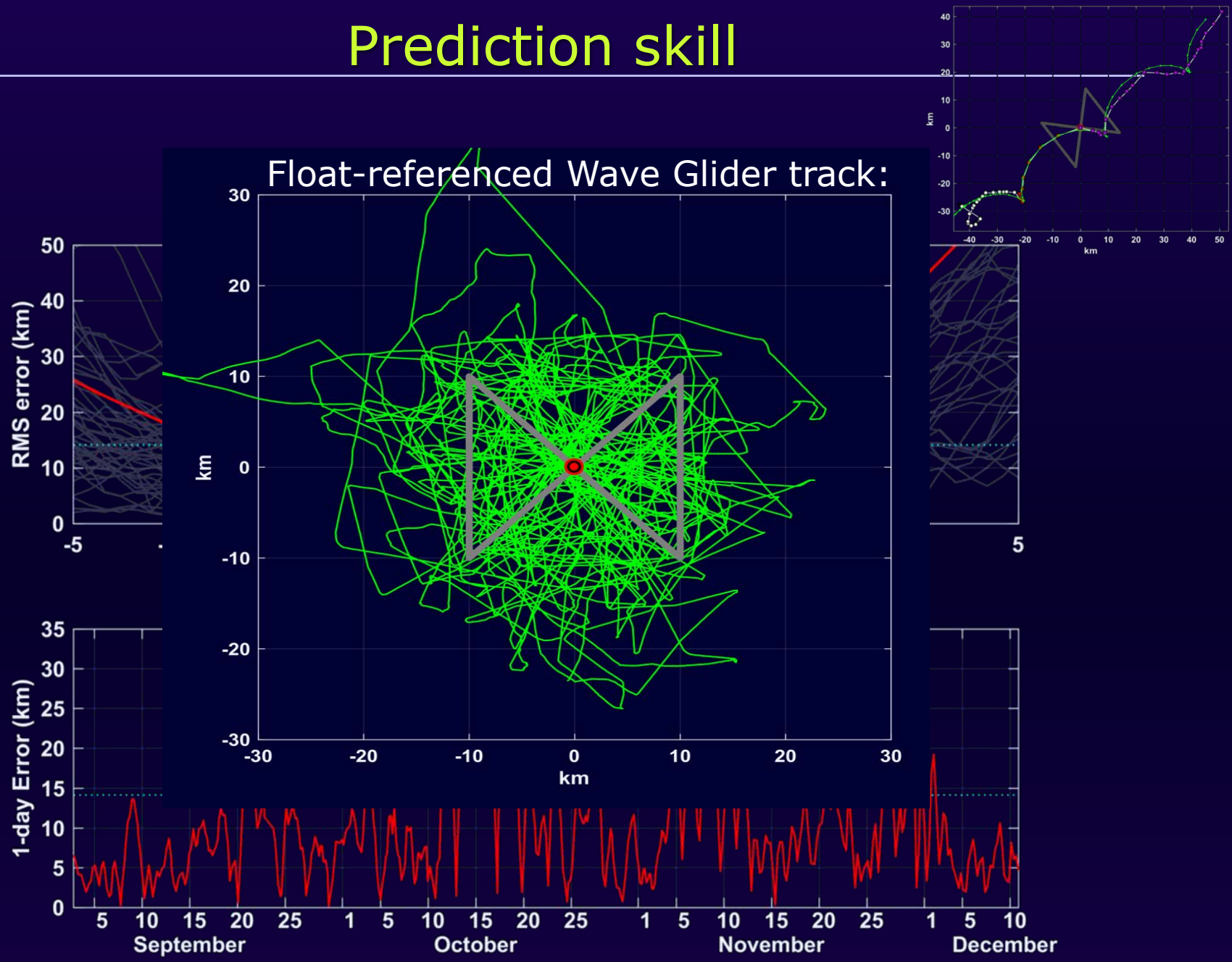
## Semi-automatic prediction and planning



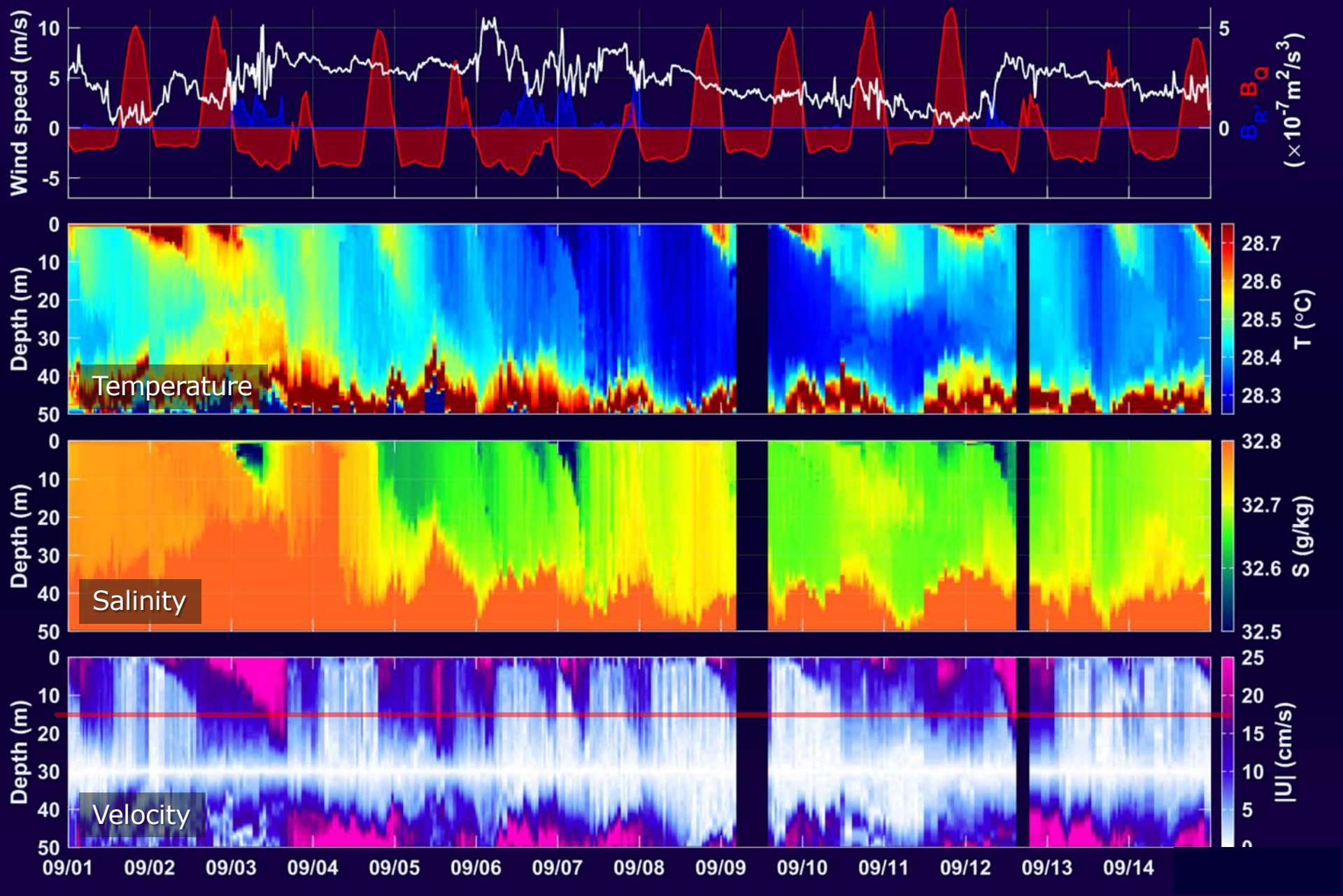

- $V_0 + V_{Inertial}$
- 2.5-day fit
- 5-day prediction
- Pattern distorted



# Prediction skill

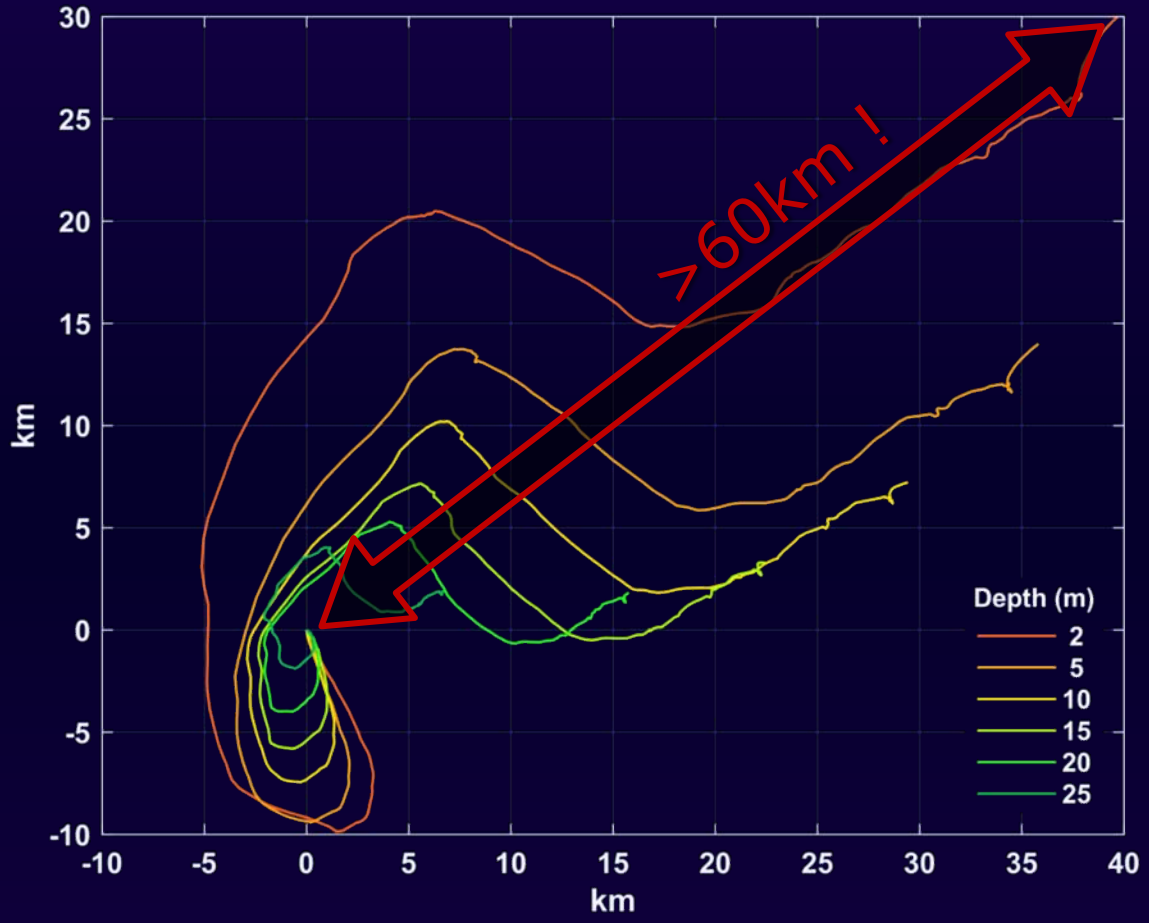


# Lagrangian Float record of upper-ocean evolution



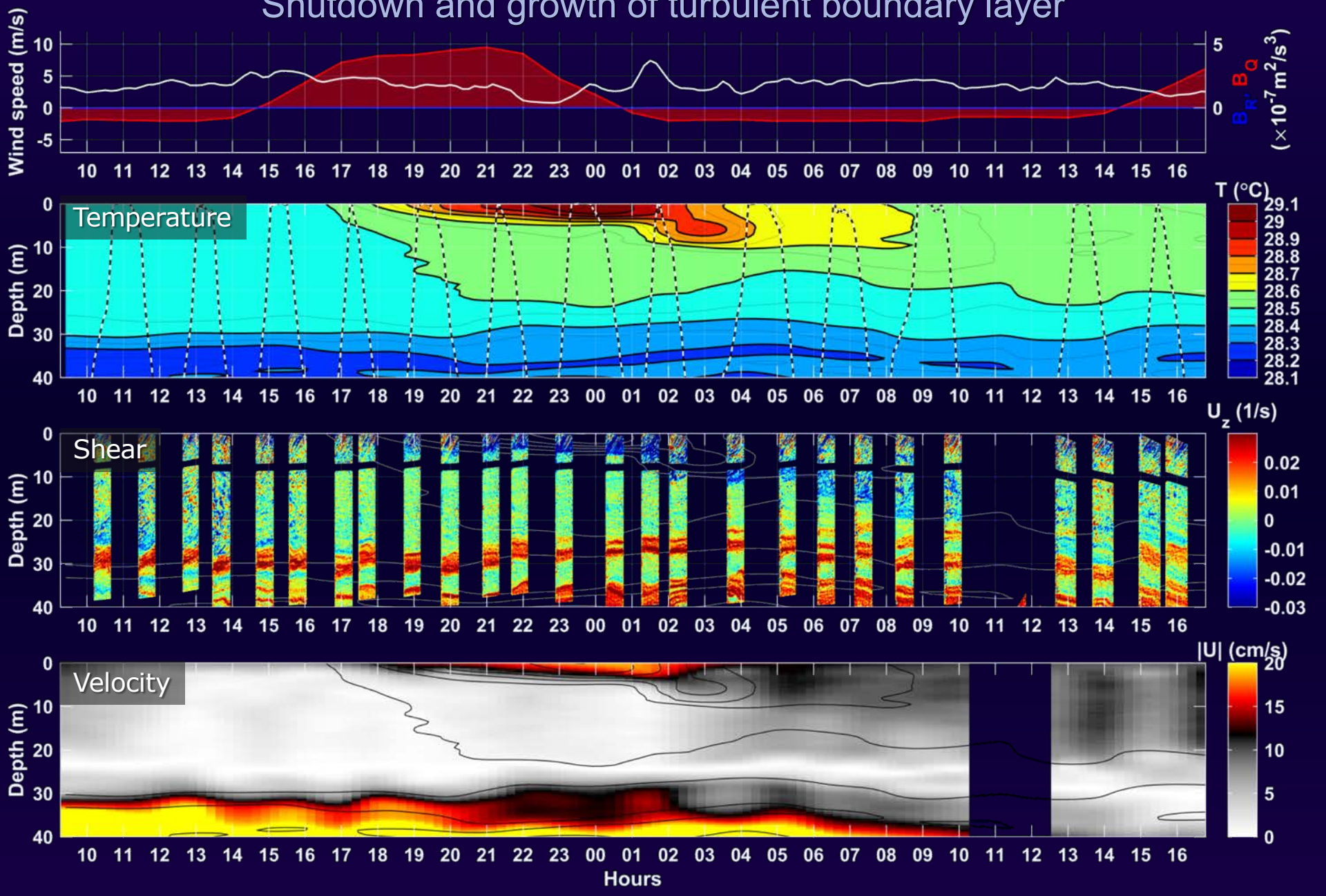
# Cumulative advection over 2-week period

Varies strongly with depth

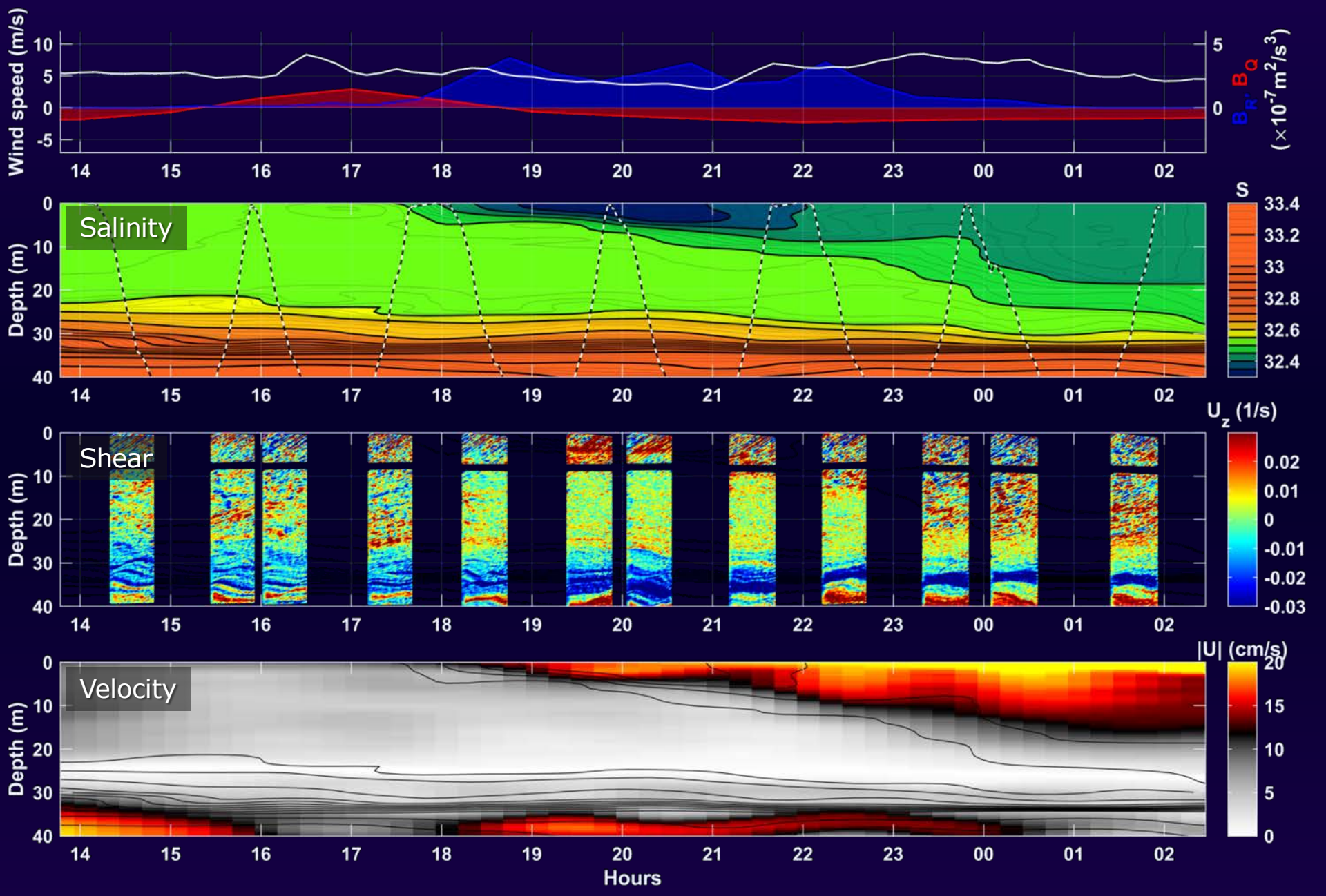


# Diurnal Warm Layer upper-ocean response

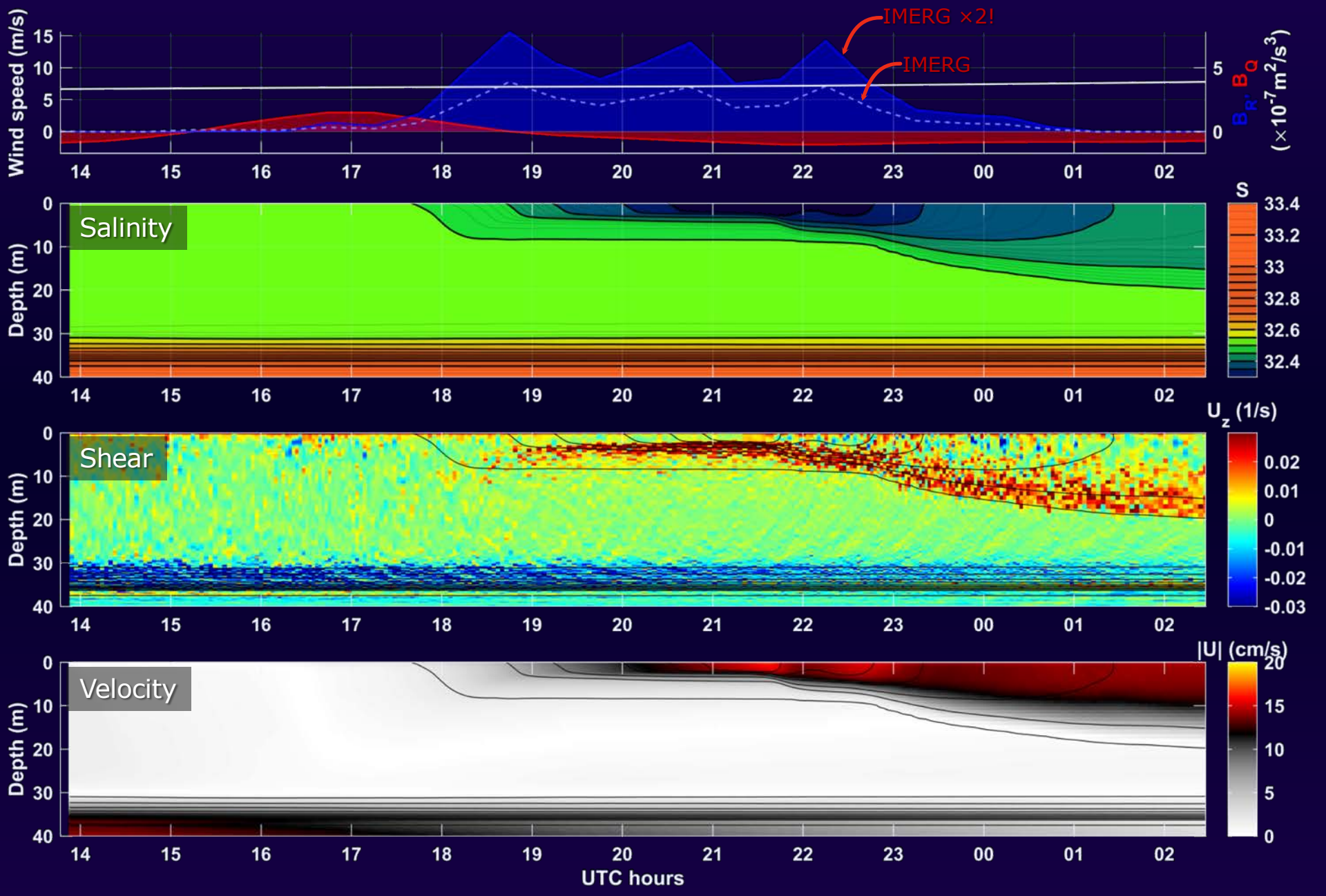
## Shutdown and growth of turbulent boundary layer



# Rain puddle response



# Large Eddy simulation of upper-ocean response



# Sustained Lagrangian Observations of Upper-Ocean Currents, Stratification & Turbulence

conclusions

Sustained Lagrangian observations reveal the details of upper-ocean response

Prediction remains a challenge

Models can reproduce upper-ocean response …

… but only if supplied with accurate full forcing