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Omega Oracle: forecasting estuarine carbonate weather

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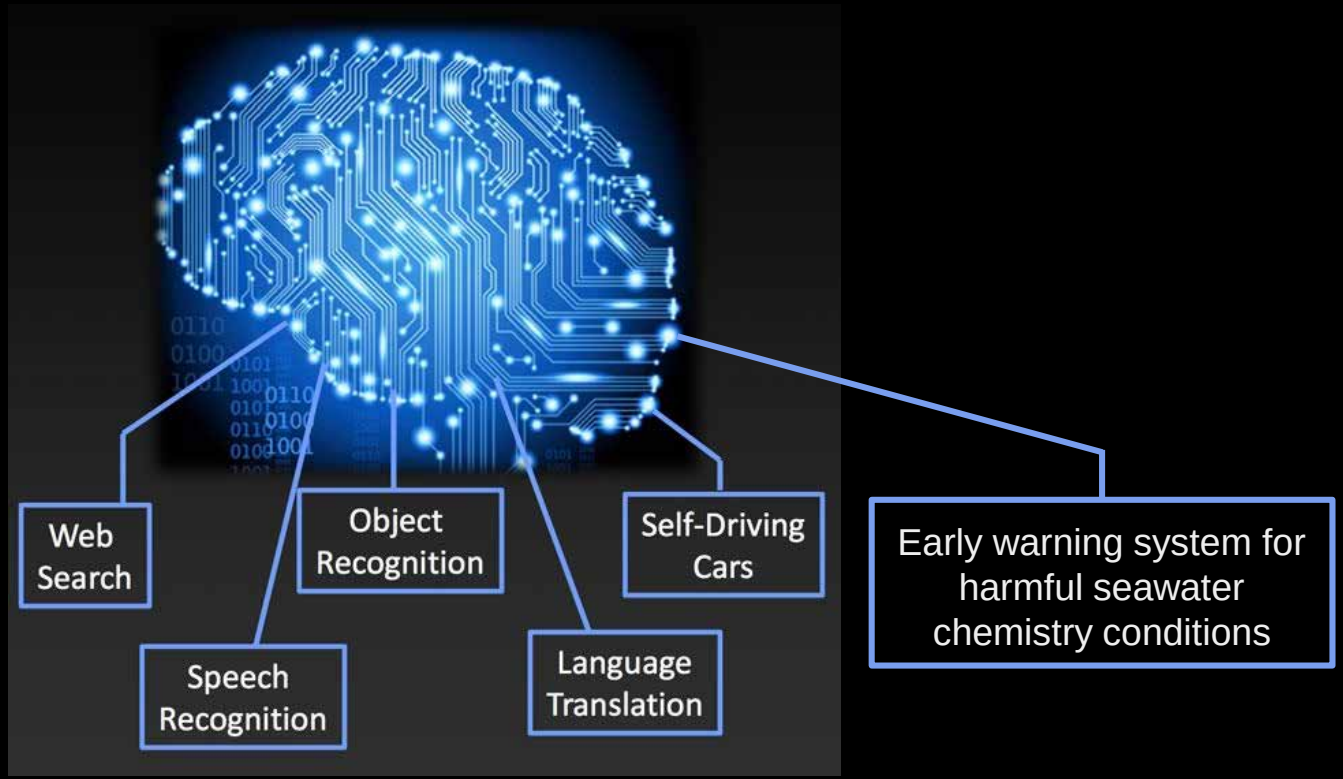
Omega Oracle: Forecasting estuarine carbonate weather

Cameron Allen[1]; George Waldbusser[1], Burke Hales[1]

[1]

Forecasting Ocean Carbonate Weather

Artificial Neural Networks



Model Design

Forecast of:
- Wind driven upwelling,
- Cloud-cover

And,
- Tide Tables
- Time of year

“Learns” about, for example:
tidal transport of upwelled water;
biological modification of water chemistry
(which depends on biomass present,
light + nutrient availability, etc.).

Prediction of Ω time-series

- Following the oyster seed crisis, monitoring of carbonate chemistry at Whiskey Creek Shellfish Hatchery, throughout Pacific coast.
- Mean aragonite saturation state (Ω) exposure matters, but so does variability.

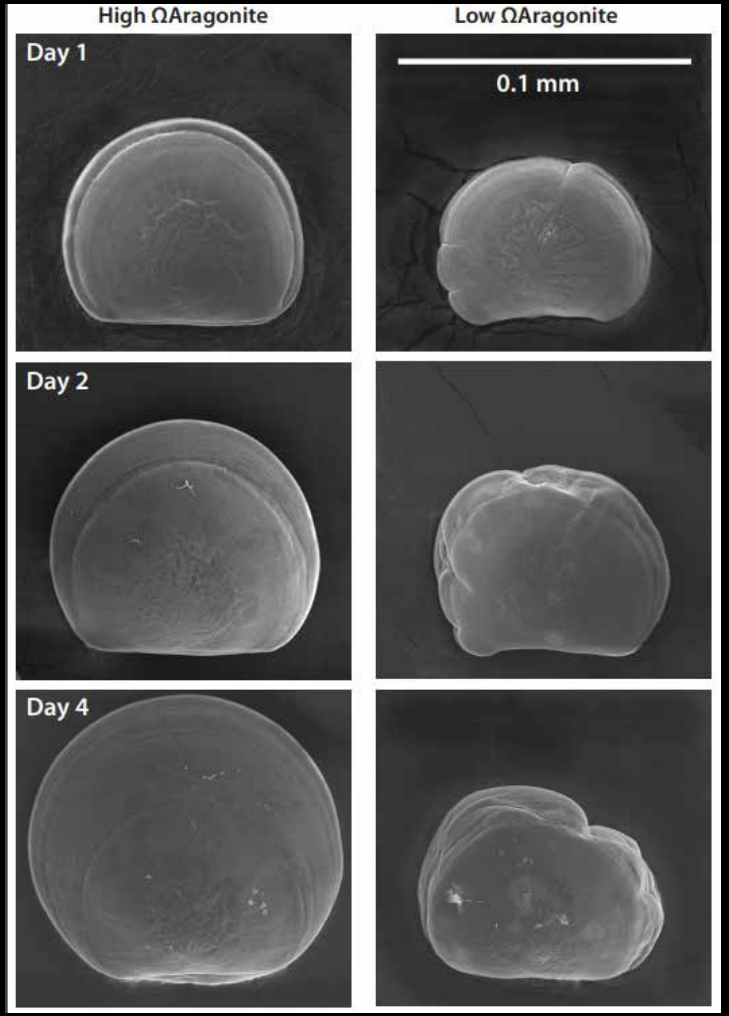
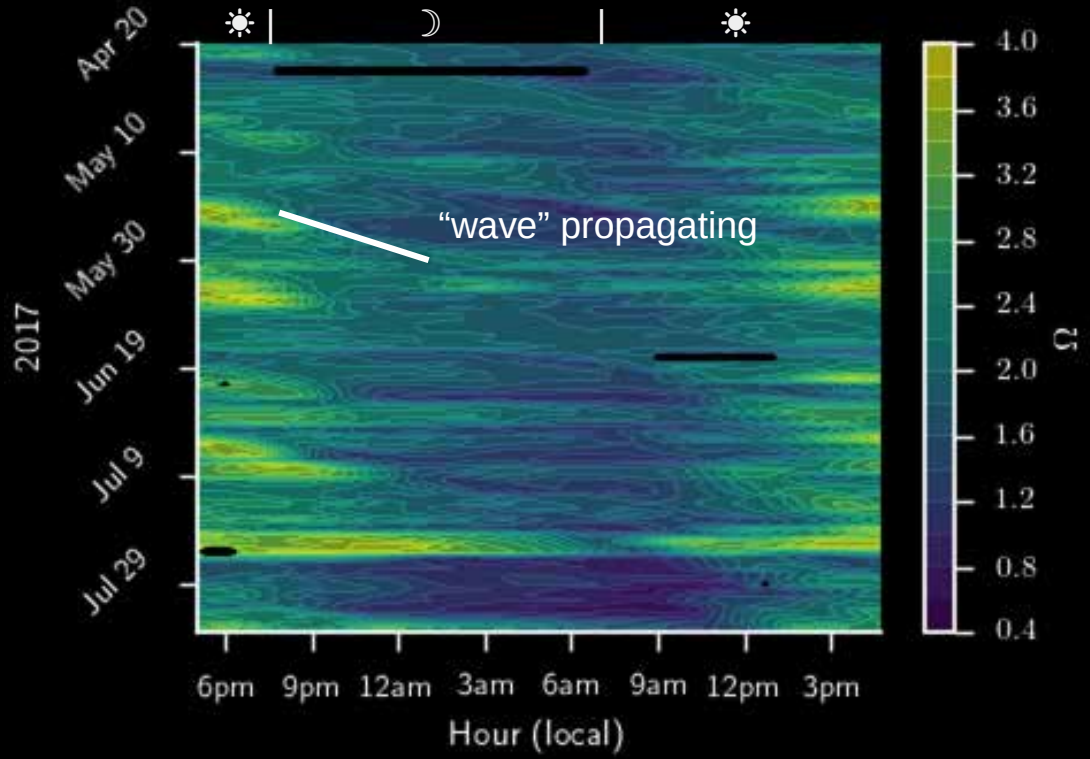


Photo credit-
E Brunner, G Waldbusser.

Carbonate chemistry record in Netarts Bay, Oregon

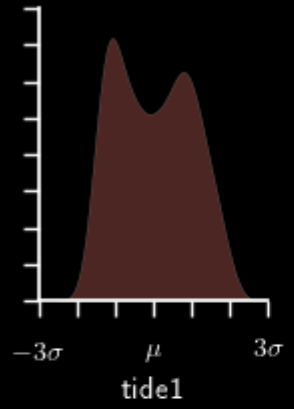


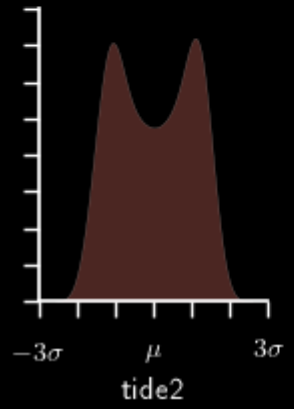
Note wave-like structures which appear to be tidal.

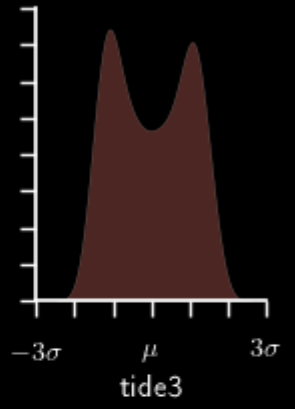
Due to the very regular daily structure this data can be well expressed in terms of only a few principal components.

So, regress how this structure reacts to physical, biological forcing using four years of monitoring record.

Model Design



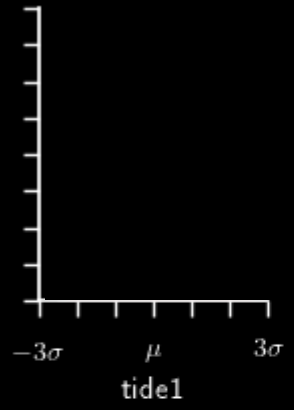


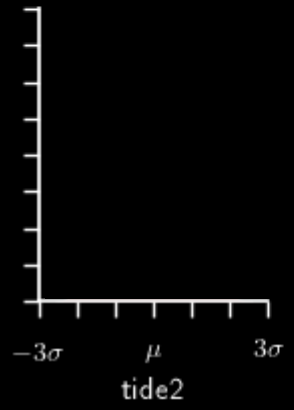


The tides are represented by the magnitude of the first three principal components of the days tide.

This contributes three scalar values per day. Over the four year dataset they have these normalized distributions.

Model Design



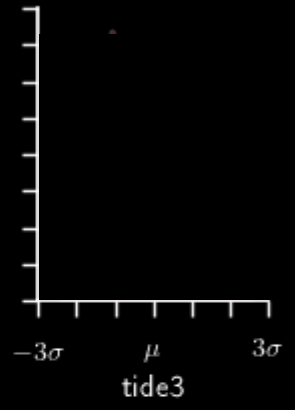


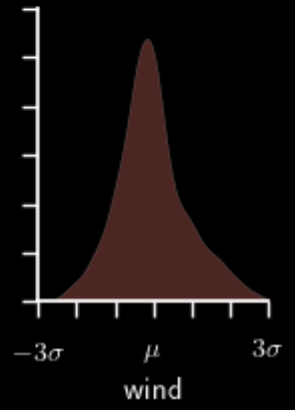
Now, add our upwelling index term.

This is represented by the daily northward wind-stress of the day of the forecast in a weighted sum with the preceding days.

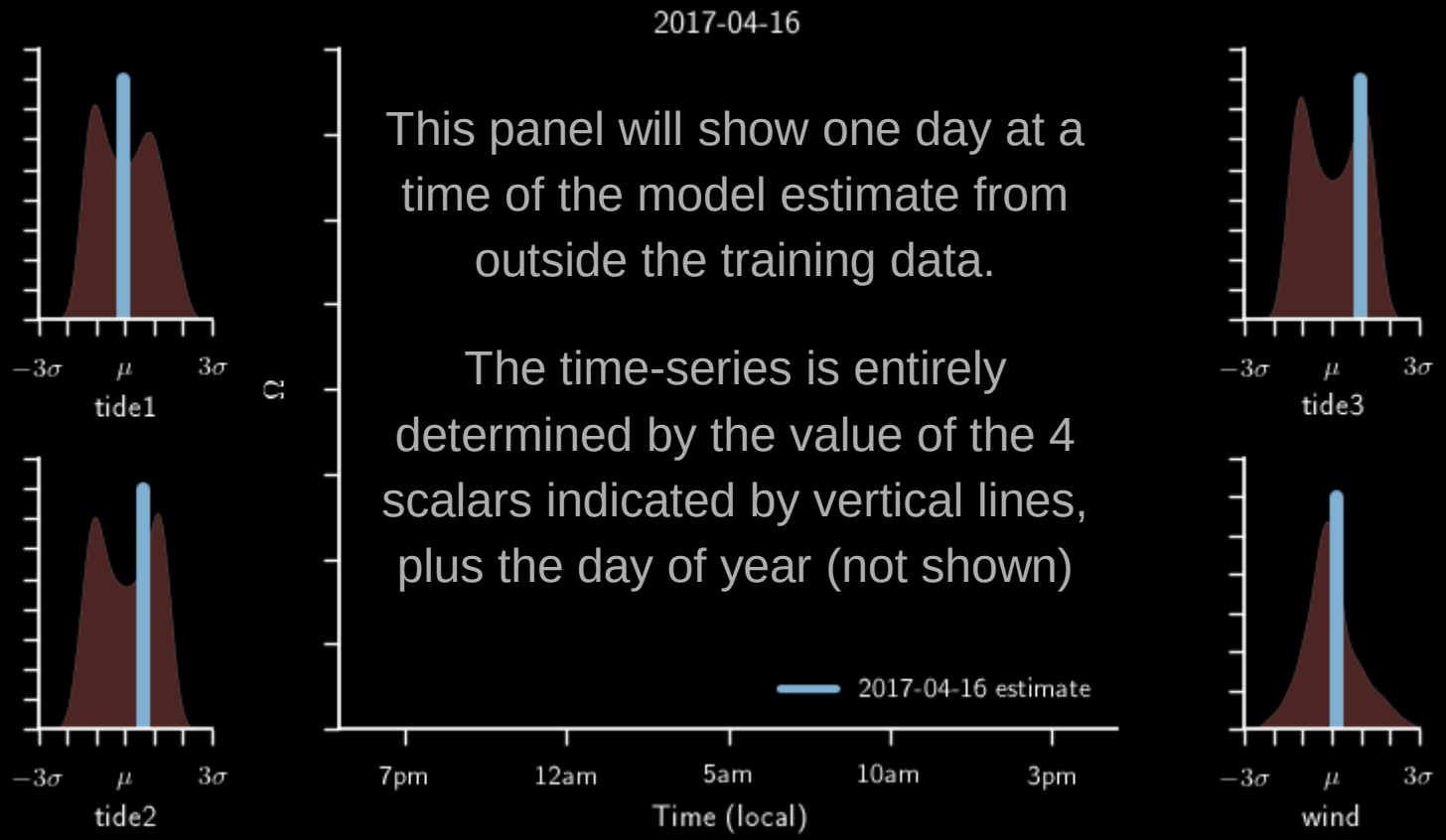
The weighting emphasizes the forecast day most, and each day prior exponentially less significantly.

Raw upwelling index from Pierce and Barth
http://damp.coas.oregonstate.edu/windstress/index.html

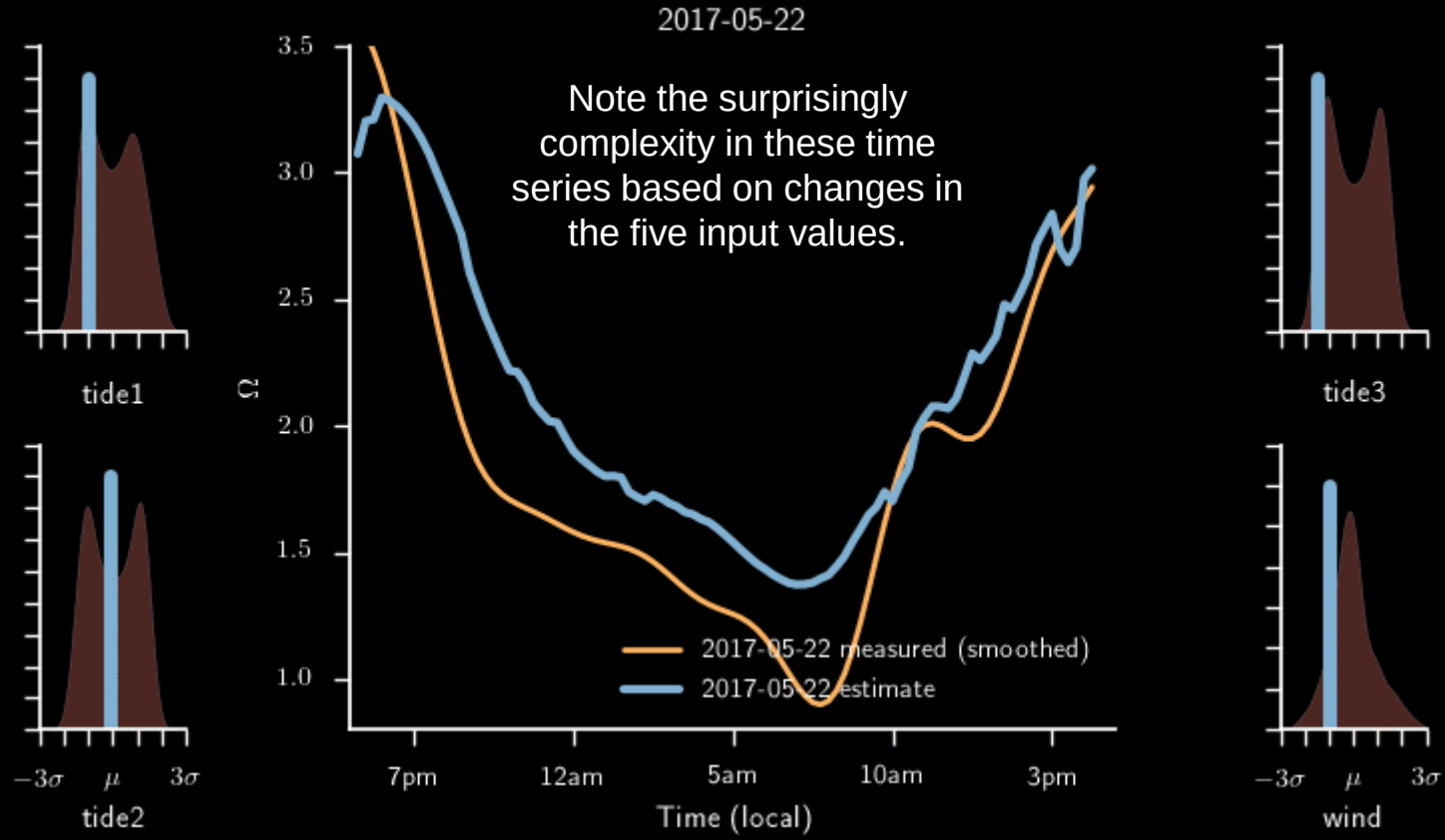




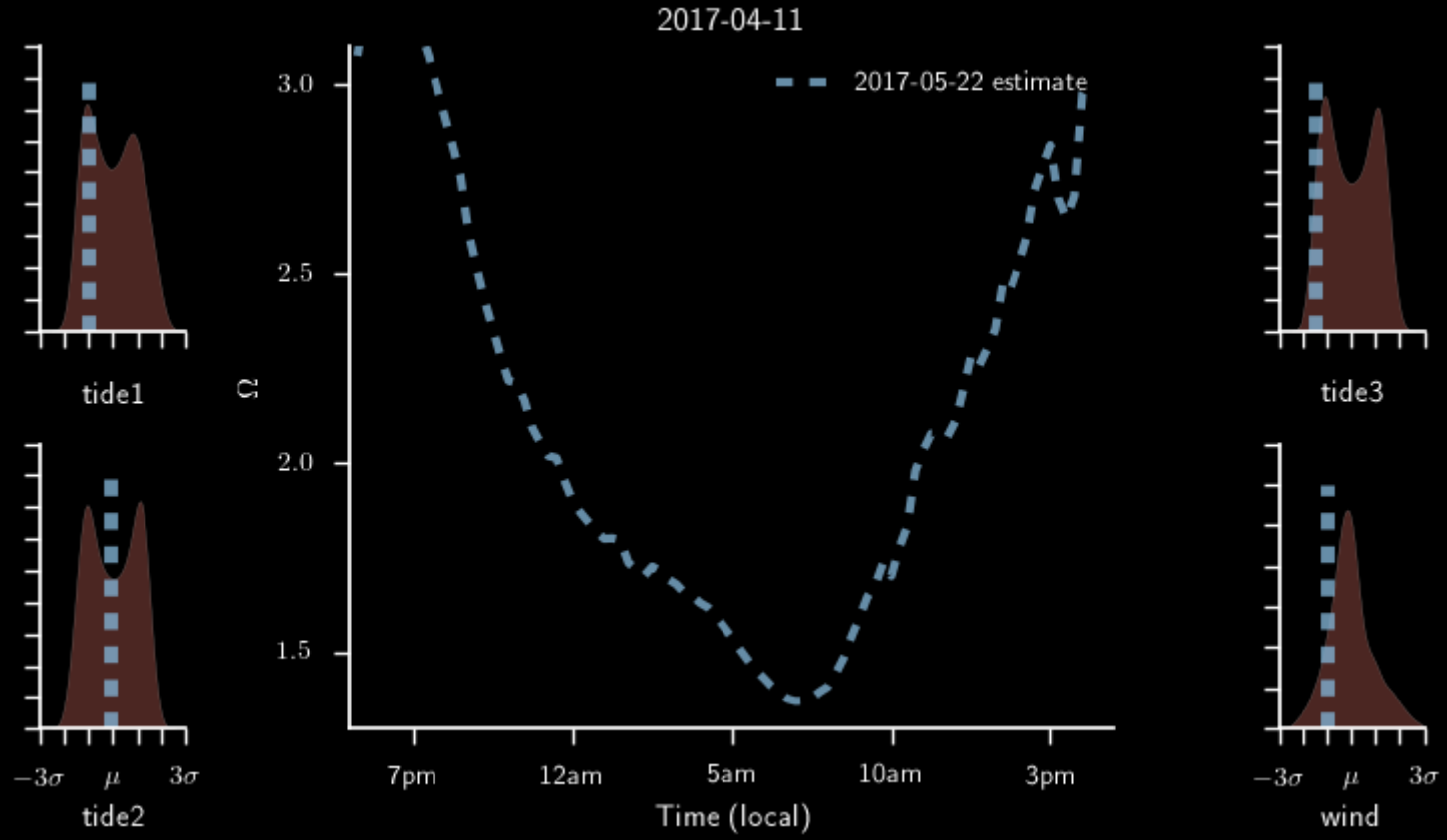
Model Design



Model Results



Emergent character of daily dynamics



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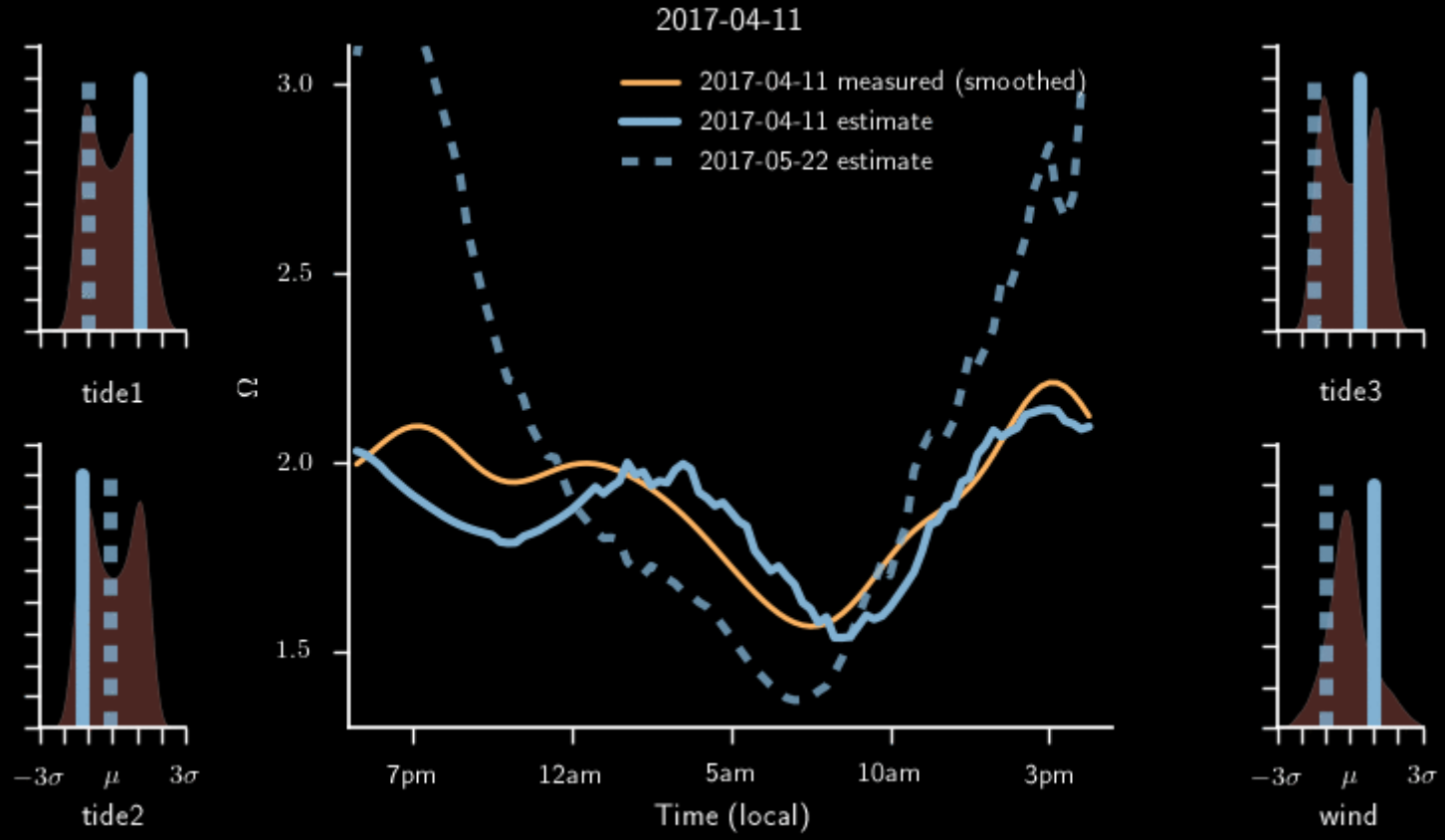
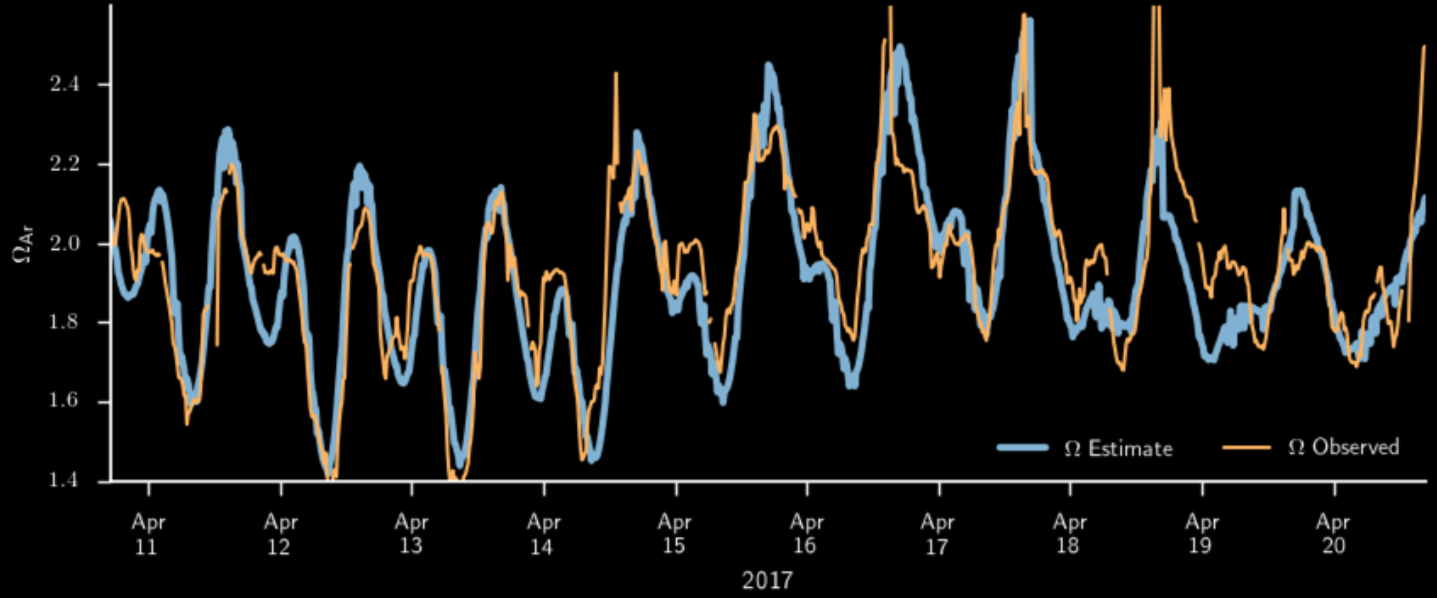


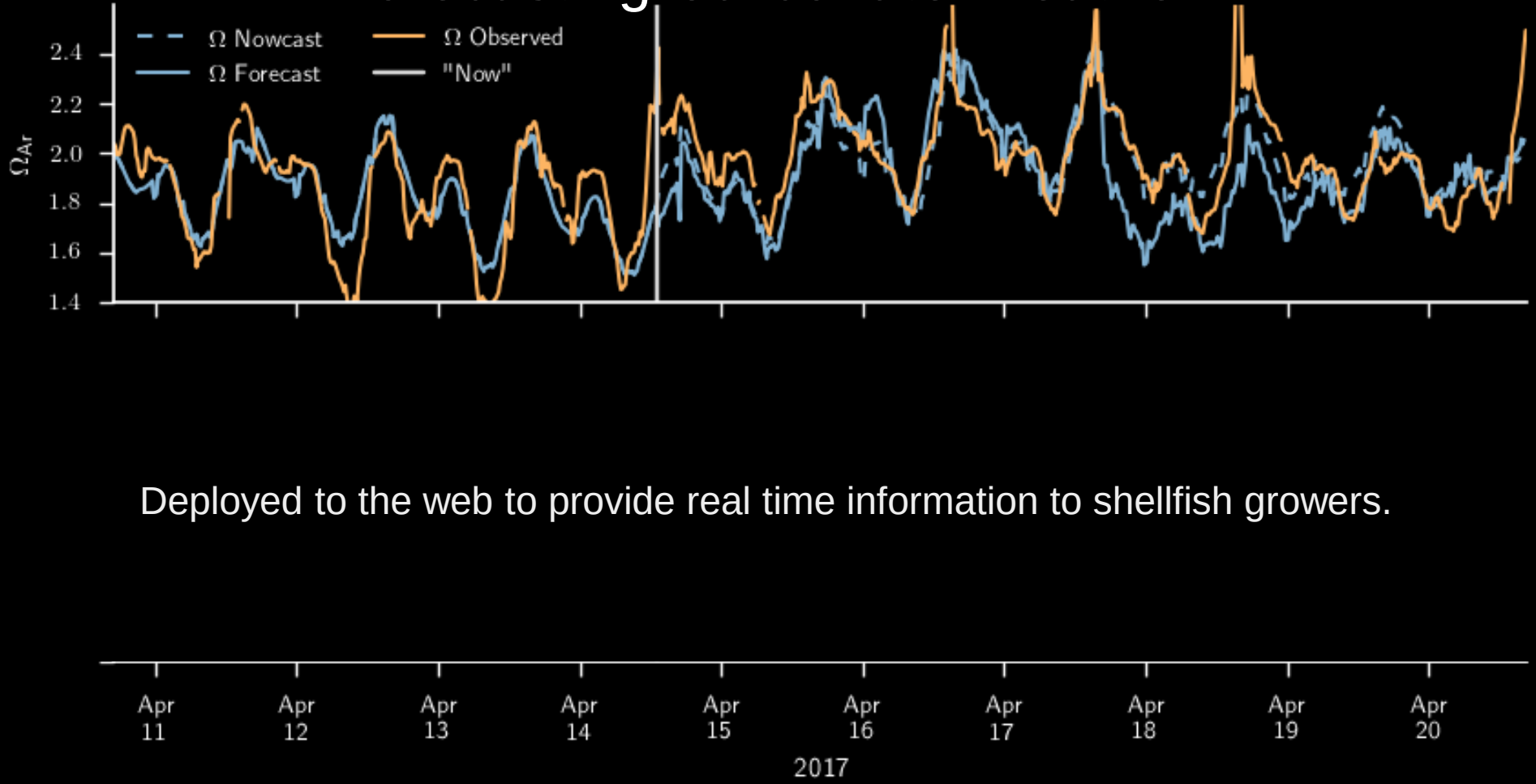
Forecasting Carbonate Weather

Observed value, model estimate of Ω in Netarts Bay, Oregon.



Assuming prediction of inputs are as good as the training data….

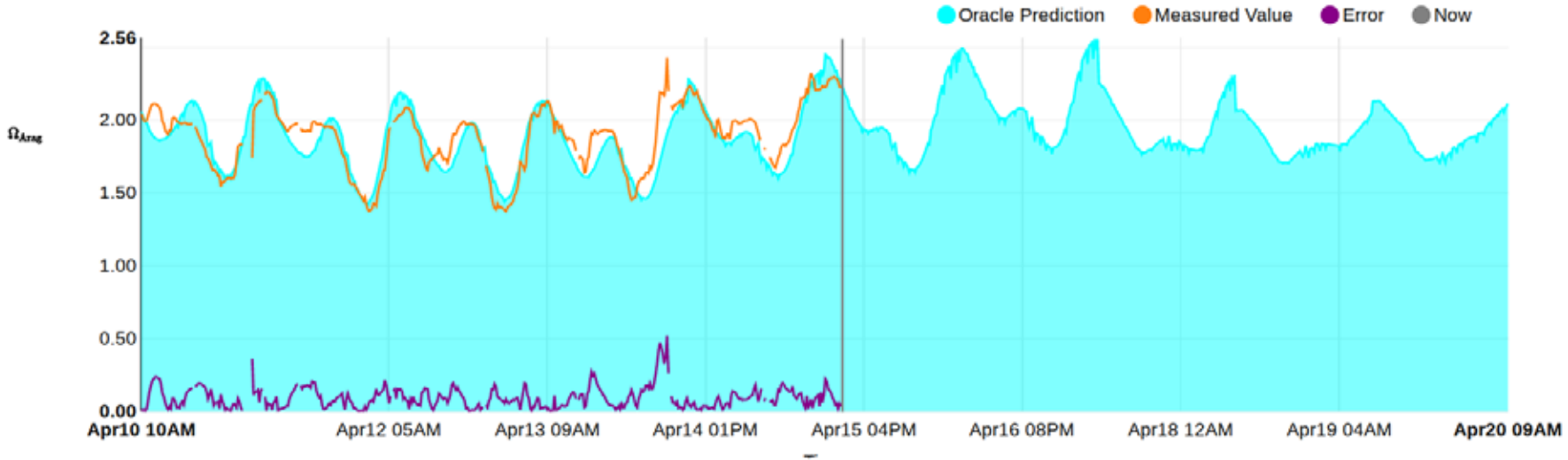
Forecasting Carbonate Weather



Deployed to the web to provide real time information to shellfish growers.

oracle.cameronpallen.com/netarts

Ω Oracle Ω



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Oregon State University
College of Earth, Ocean, and Atmospheric Sciences

Powered by NANOOS-NVS, Dark Sky, and XTide

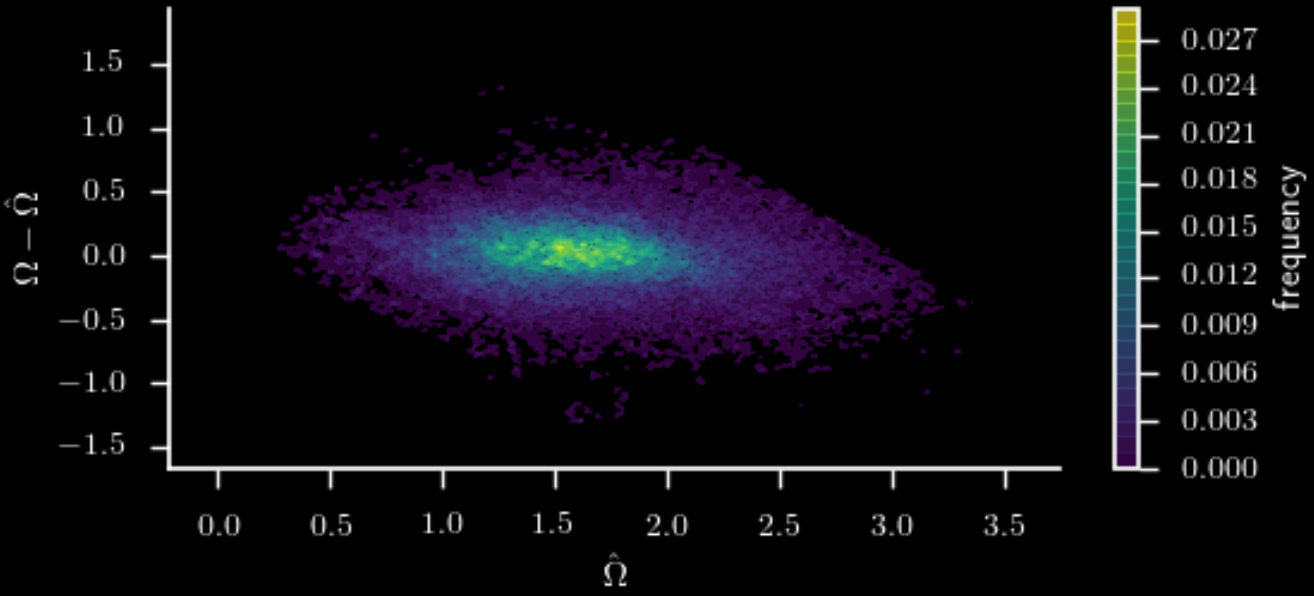
Thanks to Whiskey Creek Shellfish Hatchery, pandas, NumPy, SciPy, Keras, aiohttp, and D3.js

Summary

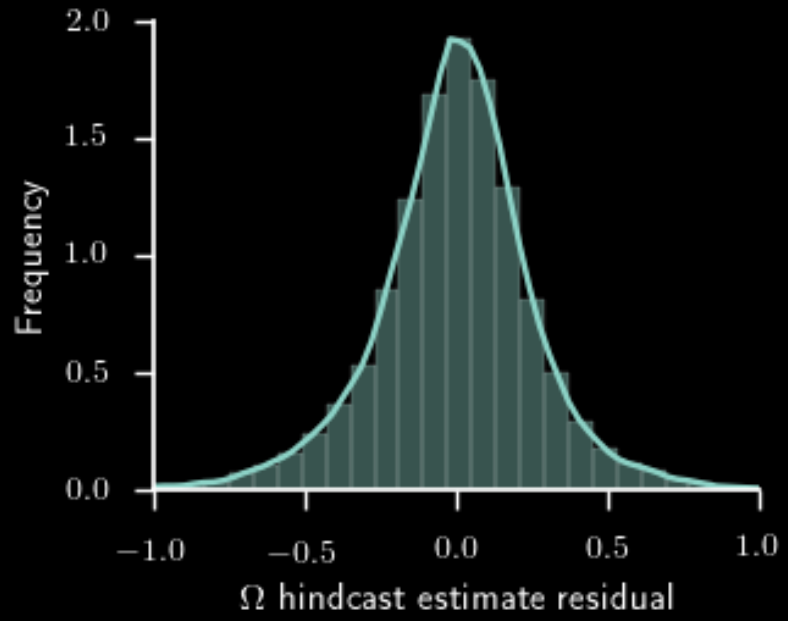
- We can build a skillful model of complex estuarine carbonate chemistry from atmospheric and tidal forcing. Given sufficient training data.
- The resulting regression model demonstrates emergent characteristics. Simple controls are able to describe seemingly more complex temporal dynamics.
- Capability to provide real-time forecasting to shellfish growers to help them make operational decisions.

Questions?

Model Skill

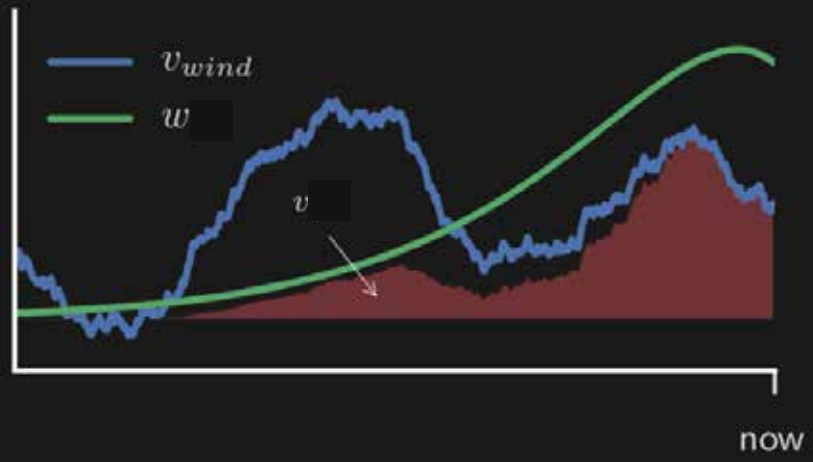

1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
$\Omega - \hat{\Omega}$
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
$\hat{\Omega}$
0.027
0.024
0.021
0.018
0.015
0.012
0.009
0.006
0.003
0.000
frequency

Model Skill



64 percent of observations within 0.2 units of model hindcast estimate.

$$v = \int_{-\infty}^{\text{now}} v_{\text{wind}}(t) \cdot w(t)dt$$



THIS IS YOUR MACHINE LEARNING SYSTEM?
YUP! YOU POUR THE DATA INTO THIS BIG PILE OF LINEAR ALGEBRA, THEN COLLECT THE ANSWERS ON THE OTHER SIDE.
WHAT IF THE ANSWERS ARE WRONG?
JUST STIR THE PILE UNTIL THEY START LOOKING RIGHT.
DATA
ANSWERS