



# A MOORED DESCRIPTION OF THE ANNUAL SPRING BLOOM IN THE NORTHWEST MEDITERRANEAN SEA

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## BOUSSOLE Mooring



BOUSSOLE is a optical mooring and field campaign in Ligurian Sea subbasin of the Mediterranean Sea. The radiometers are highlighted with red arrows in both schematics and are separated by approximately 9m of water.

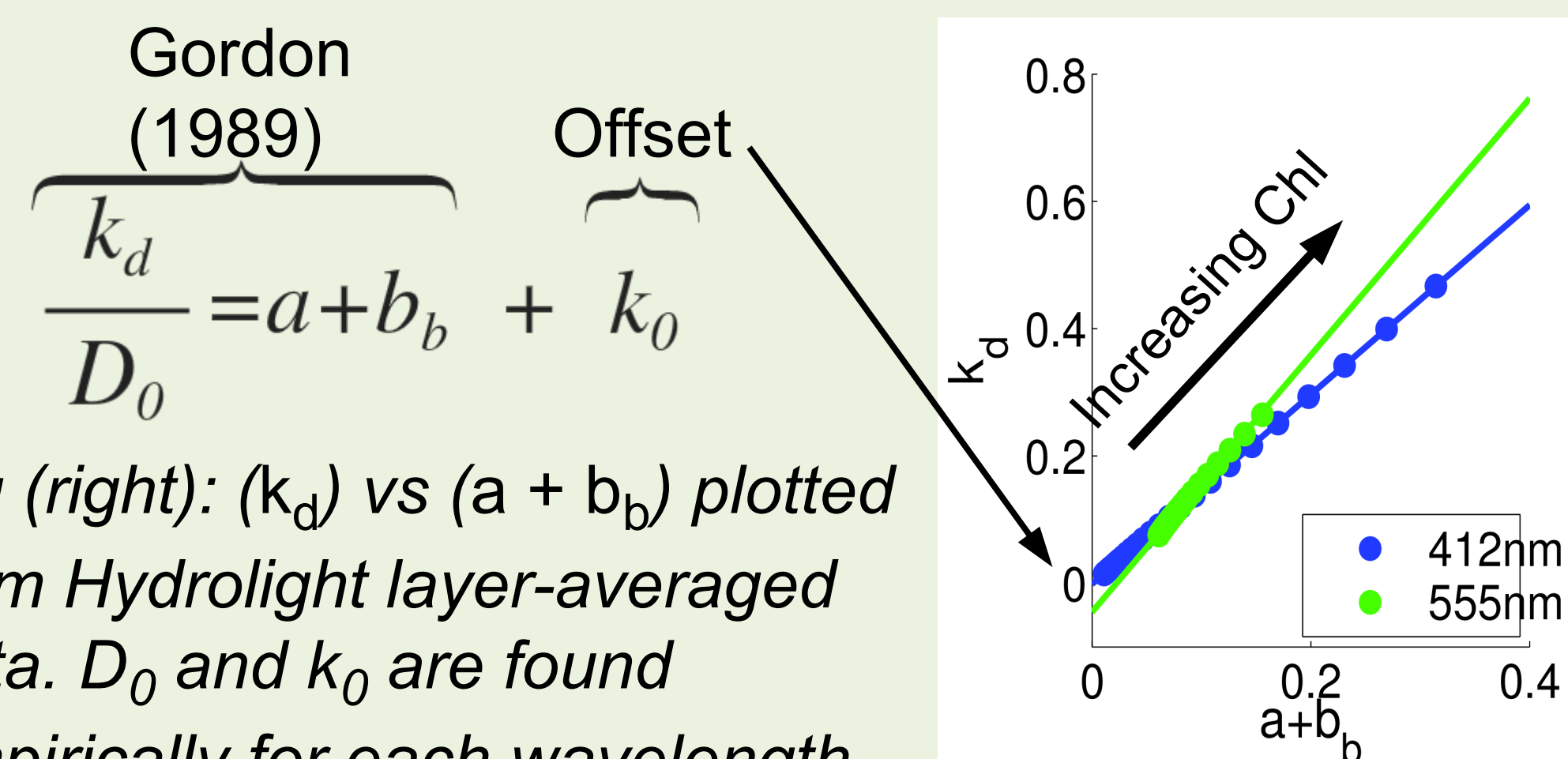
## Scientific Objective

Understanding primary production is essential in a physically and biologically dynamic system. Moorings provide a stable, multi-measurement platform to give biological measurements in the context of other variables.

Here, the Spring Bloom for the Northwestern Mediterranean Sea is described in timeseries of chlorophyll, temperature, and heat exchange.

## New Chlorophyll Bio-optical Model

Gordon (1989) is adjusted by geometric terms found with the Hydrolight Modeling Software.



Backscattering ( $b_b$ ) is assumed due to water ( $b_{bw}$ ) and particles ( $b_{bp}$ ). Absorption ( $a$ ) is assumed due to water ( $a_w$ ), particles ( $a_p$ ), and solubles ( $a_s$ ).

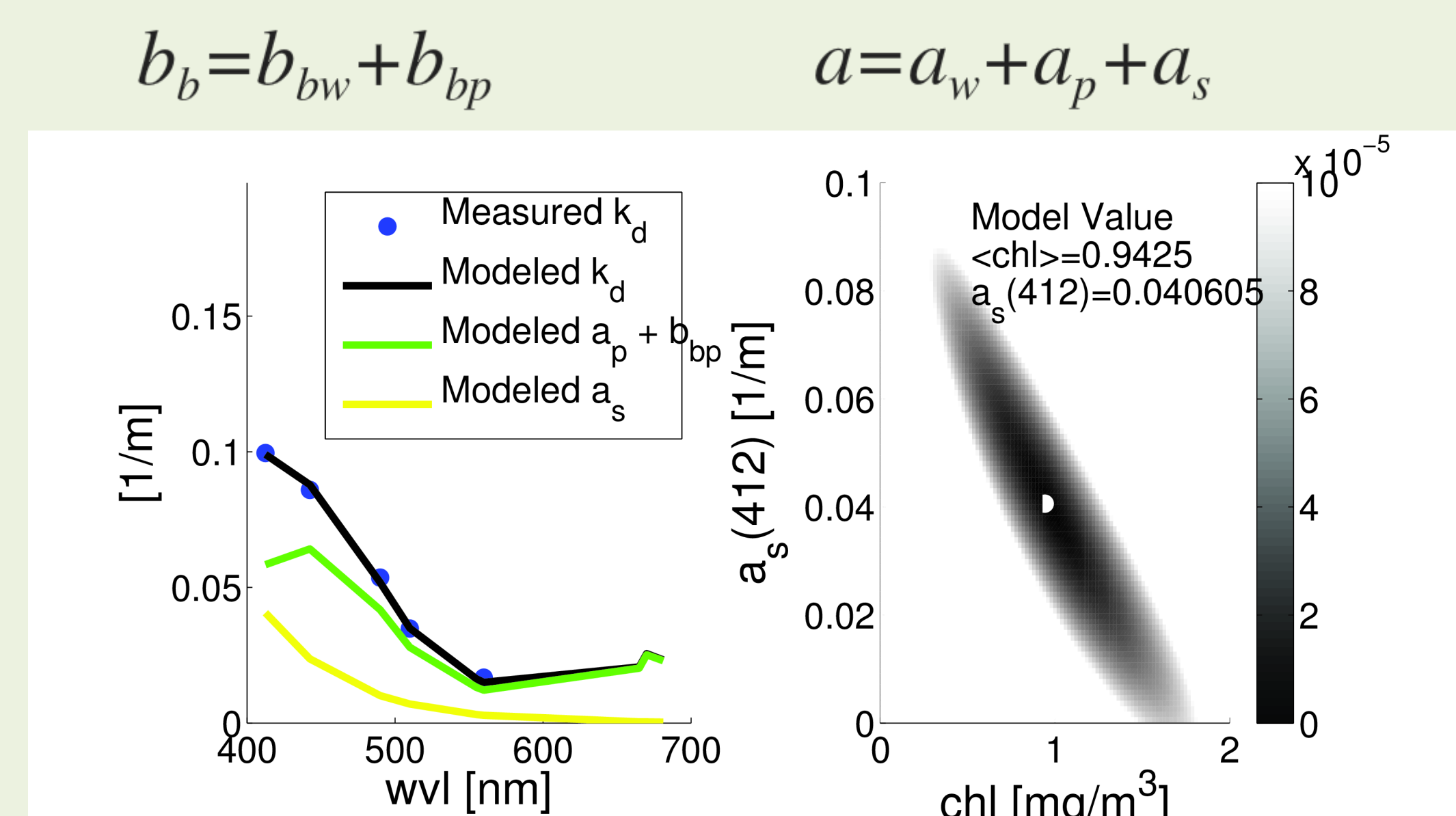


Fig (above): Data from 5-April-2012. Least squares minimization between observed and modeled  $k_d$  finds the unknowns  $a_s(412)$  and  $\langle chl \rangle$ .

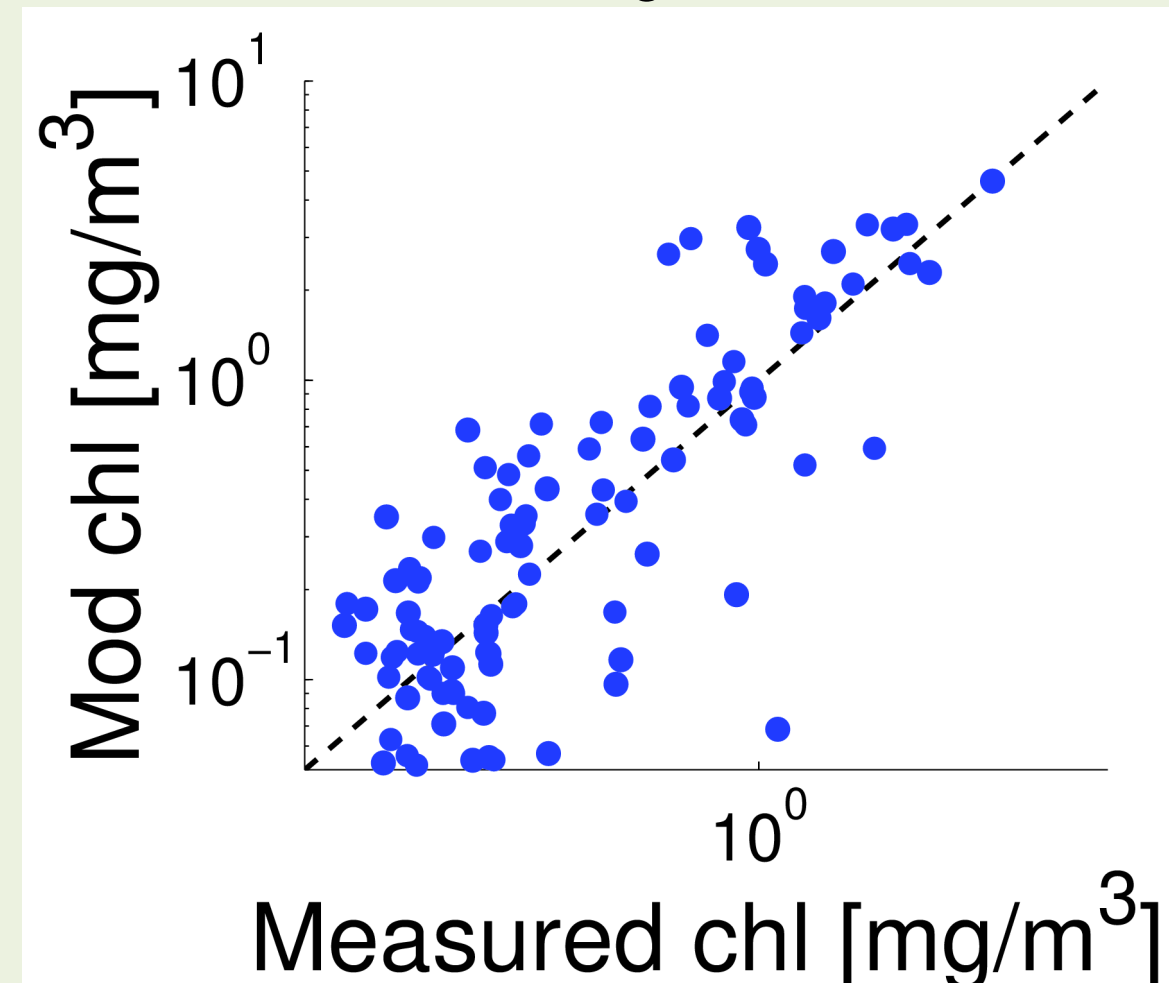
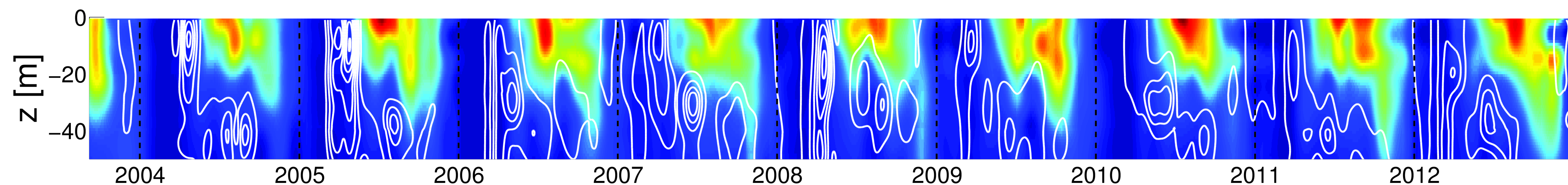


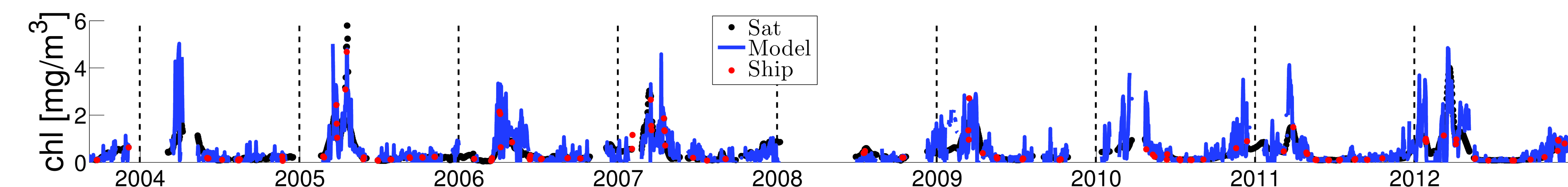
Fig (left): Comparison of model chlorophyll with directly measured chlorophyll layer.  $r^2 = 0.69$ . This is the average chlorophyll value for the upper 9m.

## Timeseries

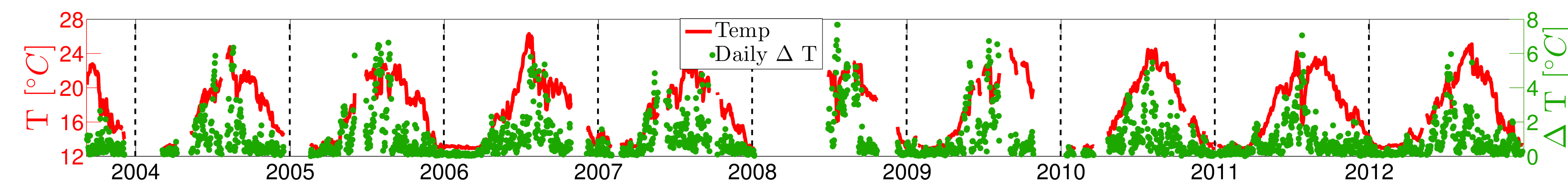
Ship-measured Temp (shaded) Chl (contour)



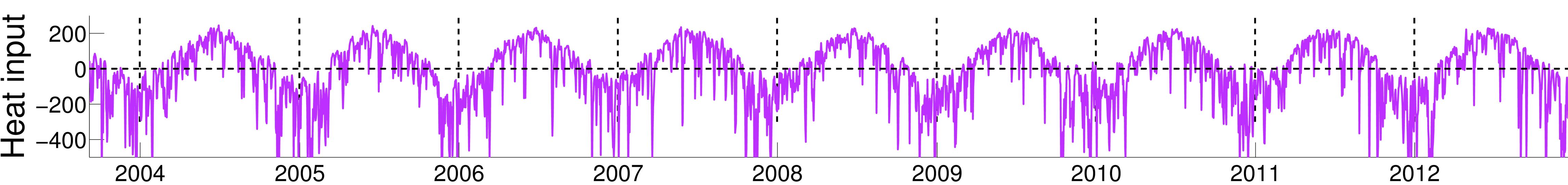
Surface Chl



Buoy Surface Temp daily Mean and Cycle



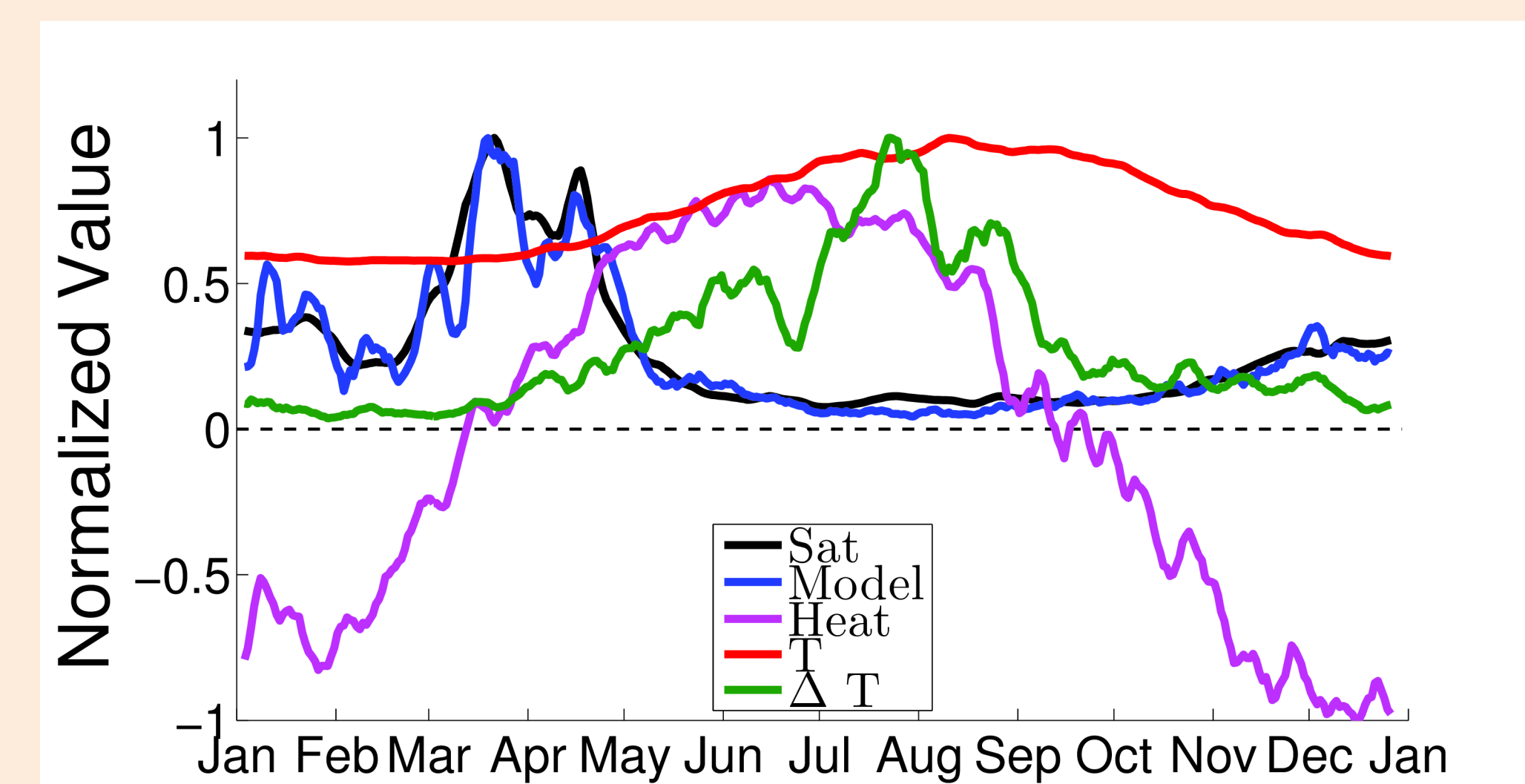
NCEP Bulk Heat input  $[W/m^2]$



1589 days of chlorophyll measurements over 10 years along with other timeseries at the BOUSSOLE location give an understanding of the annual Spring Bloom cycle. Ship-board measurements (top) describe the chlorophyll bloom at the surface, and then deepening immediately below the mixed layer.

## Annual Cycle

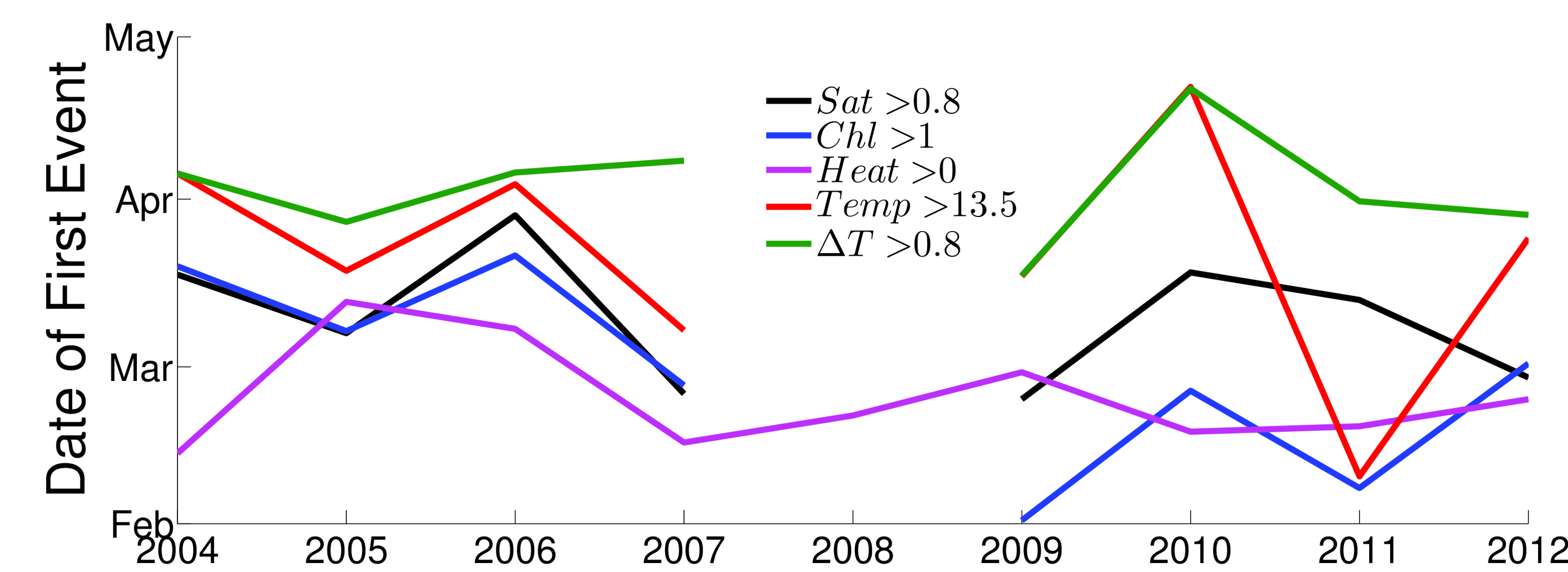
The average annual cycle shows the order of events; (1) the bloom initiates, (2) heat begins to transfer to the ocean, (3) both the temperature and diurnal temperature cycle begin to rise.



## Annual Events

For each timeseries above, a value was chosen which signifies a stage in the annual cycle. The timeseries below gives the first instance of this value between February and June of each year. The order can help determine relative importance in the Spring Bloom cycle.

Note that the event order can be different than the average annual cycle.



## Hypotheses

- The Mixed Layer Depth shallows when the diurnal temperature change begins to rise because the volume of water which is heated over the day is shrinking. This occurs after the bloom has initiated.
- The Price-Weller-Pinkel Model can be used to estimate the Mixed Layer Dynamics, and specifically Mixed Layer Depth, between cruises at the mooring.
- The in situ irradiance and other sensors can more appropriately estimate the heat exchange at BOUSSOLE.
- Ecosystem modeling will be improved with bulk chlorophyll concentrations of the surface layer.

## References/Acknowledgements

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