# 2015 Summer Course

# on Optical Oceanography and Ocean Color Remote Sensing

## Overview of the Course

Curtis Mobley

Darling Marine Center, University of Maine
July 2015

# In General...

- Lectures in the mornings
- Labs in the afternoons
- Saturday mornings (as needed): Lab reports, tie up loose ends, critiques, special requests, ...
- Saturday afternoon & Sunday: party, sleep, explore Maine, kayak with Curt

# Topical Organization

**Week 1:** ***Optical Properties of Matter (Inherent Optical Properties, IOPs)***

- Basic definitions
- How light is described
- How light interacts with matter: Theory and measurement of absorption and scattering by particles and dissolved substances

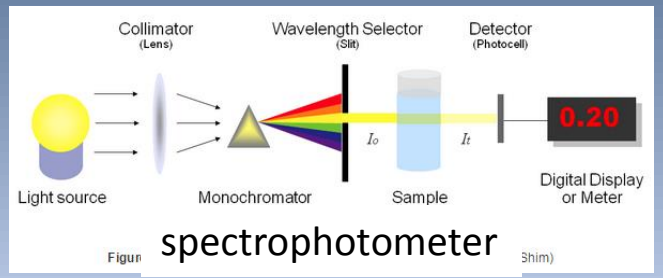
# Week 1 Labs

*Afternoons 2-5: 4 different labs to learn how to use different instruments*

Measurements

Instruments

Absorption by dissolved substances

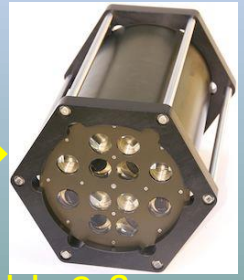



spectrophotometer

Absorption by particles

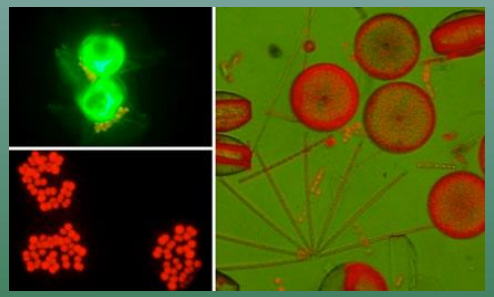
Scattering by particles

ac-9 & ac-s



bb-9 & Hydroscat-6

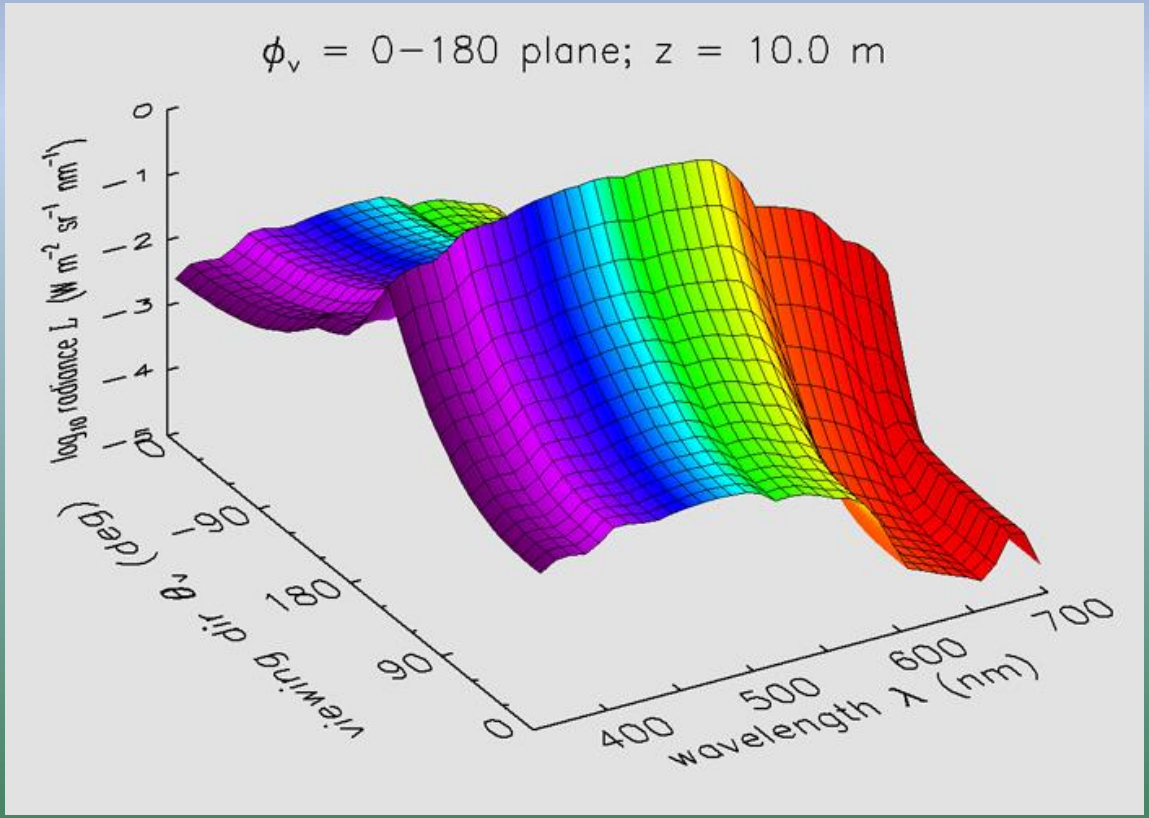
Fluorescence by chlorophyll and CDOM



## Week 2: *Radiometry*

- Radiometric (light) quantities and their measurement
- Other measures of light (Apparent Optical Properties, AOPs)
- Linking material properties to optical properties
- The radiative transfer equation

The labs will be measuring light and learning to run HydroLight and Mie codes



**Week 3:** ***Data Collection and Remote Sensing***

- Field data collection on the R/V Ira C
- Remote sensing
- Data analysis: atmospheric correction for ocean color remote sensing; QA/QC; error estimation

The labs will be field data collection and learning how to use NASA's SeaDAS and SeaBASS software

**Week 4:** ***Synthesis***

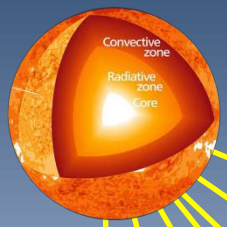
- Design of field campaigns
- Guest lectures
- Work on Student Projects
- Final presentations of student projects

# The Lives of the Photons




Much of the class will be spent discussing all of the things that can happen to solar photons after they arrive at earth….

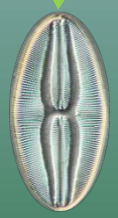
# The Lives of the Photons

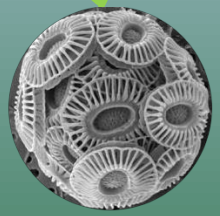


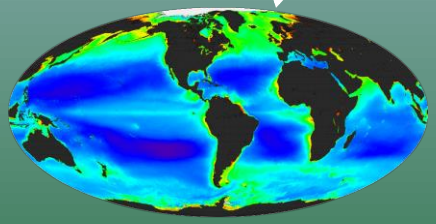

$O_3$

$N_2$

$H_2O$





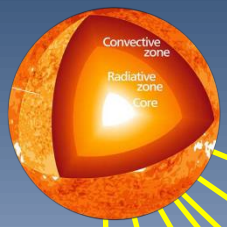
Some photons are absorbed by atmospheric gases such as ozone.

Others are scattered by non-absorbing gases such as nitrogen.

Some are absorbed or scattered by aerosols.

Photons that reach the sea surface are either reflected or transmitted into the water.

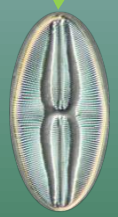
# The Lives of the Photons

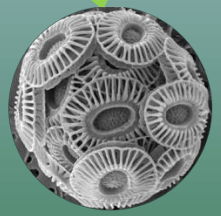


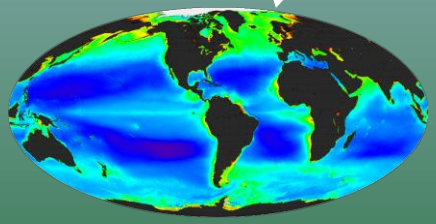

$O_3$

$N_2$

$H_2O$





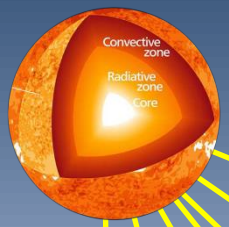
Some of the light that gets into the water is absorbed by phytoplankton, water, CDOM, or mineral particles.

Some of the light absorbed by chlorophyll and CDOM is re-emitted at longer wavelengths (fluorescence).

Light can be scattered by phytoplankton and other particles.

Water molecules themselves absorb and scatter light, and can change one wavelength into another.

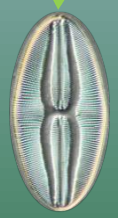
# The Lives of the Photons

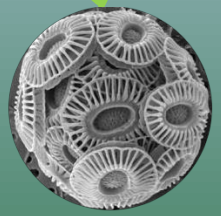


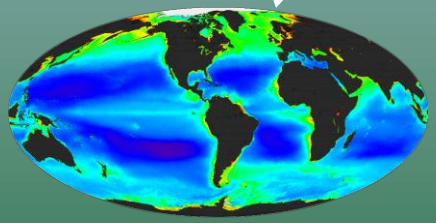

$O_3$

$N_2$

$H_2O$





Some of the light scattered upward by the atmosphere, sea surface, and water column reaches satellite sensors, where the photon energy is converted to a digital signal.

The NASA satellite data are sent to the Ocean Biology Processing Group…

…where enormous amounts of science and computer power are required to convert the raw satellite data to products of scientific interest

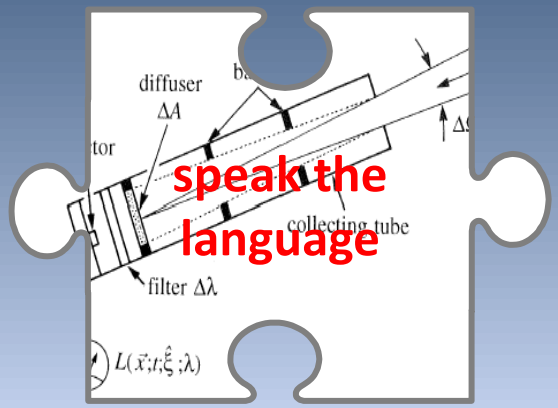
# The Promise of the Class

Four weeks are not sufficient to make you experts, but...

...by the end of the class you should have sufficient knowledge to

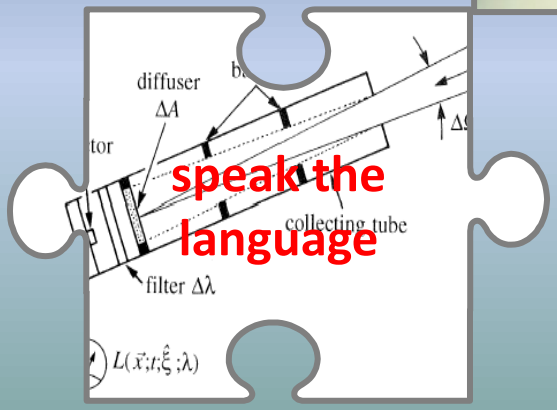
- read papers on optical oceanography, bio-optics, and ocean color remote sensing
- feel semi-comfortable operating  various lab and field instruments
- download ocean color imagery from NASA and upload your data
- be able to run HydroLight and Mie codes

# The Pieces Will All Come Together, and You Will Learn to

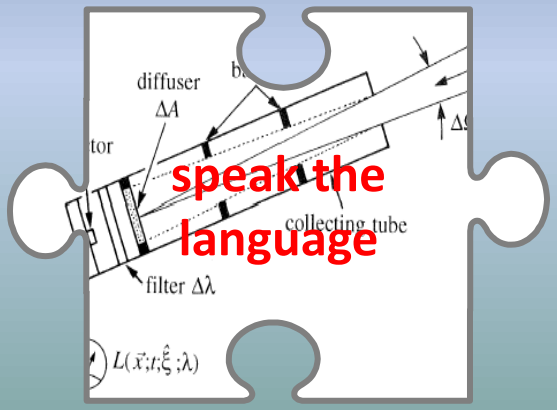



**speak the language**

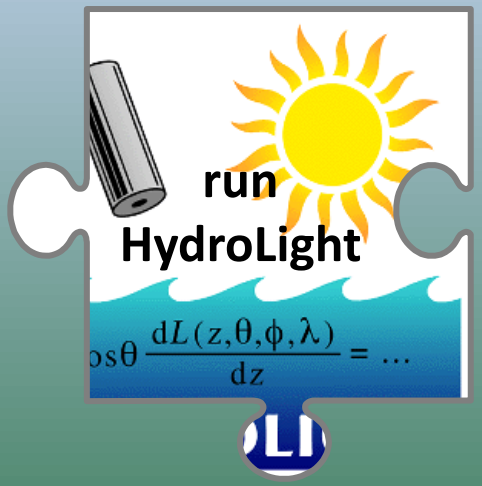

measure
absorption
& scattering

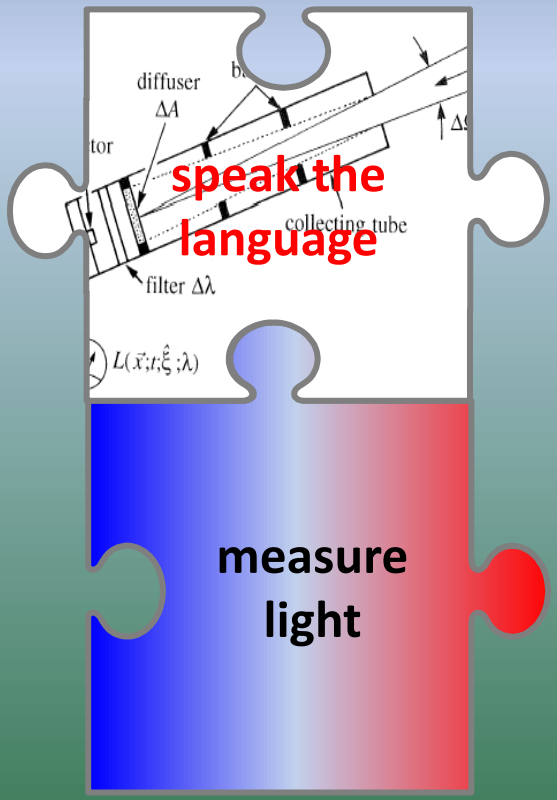

diffuser
ΔA
tor
collecting tube
filter Δλ
$L(\vec{x};t;\hat{\xi};\lambda)$
speak the
language

measure light

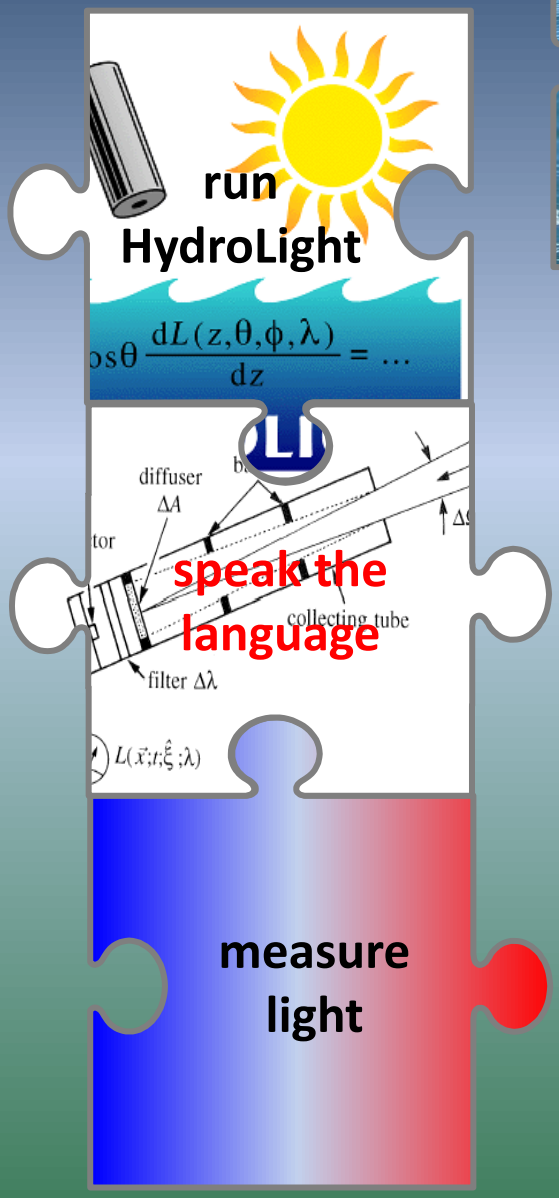



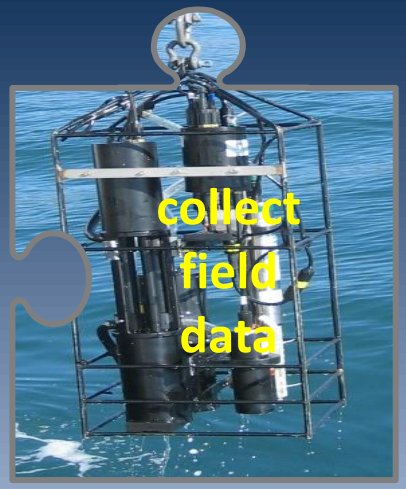

measure
absorption
& scattering


run
HydroLight
$\cos\theta \frac{dL(z,\theta,\phi,\lambda)}{dz} = \ldots$

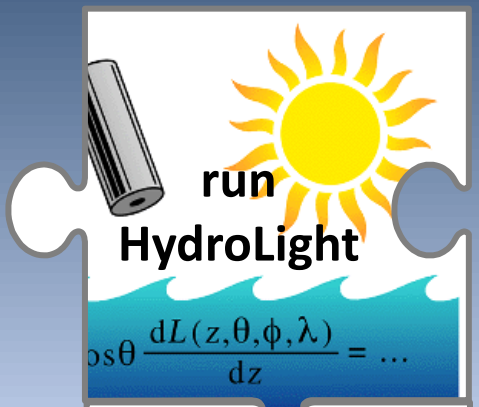

diffuser
$\Delta A$
filter $\Delta\lambda$
$L(\vec{x};t;\hat{\xi};\lambda)$
speak the
language
measure
light

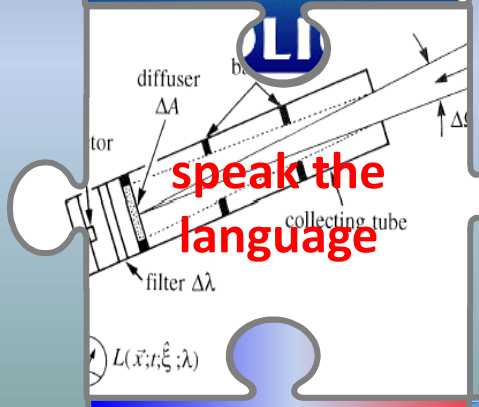

measure
absorption
& scattering

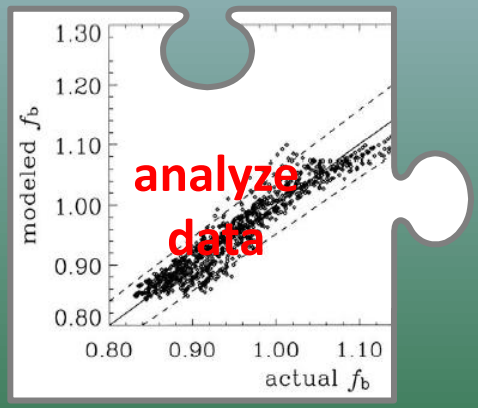

run
HydroLight
$\cos\theta \frac{dL(z,\theta,\phi,\lambda)}{dz} = \ldots$
diffuser
$\Delta A$
collecting tube
filter $\Delta\lambda$
$L(\vec{x};t;\hat{\xi};\lambda)$
speak the
language
measure
light

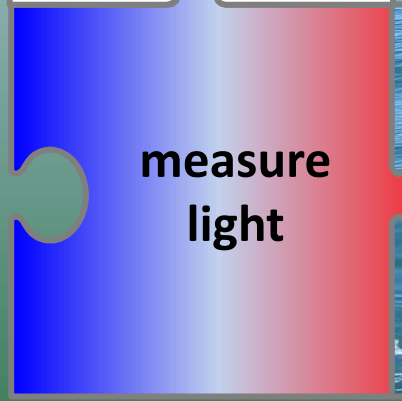

collect
field
data

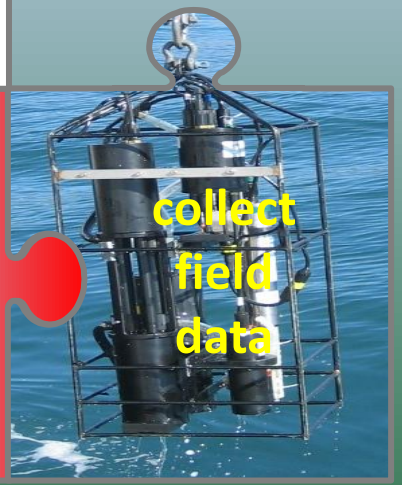

measure
absorption
& scattering


run
HydroLight
$\cos\theta \frac{dL(z,\theta,\phi,\lambda)}{dz} = \ldots$


diffuser
ΔA
collecting tube
filter Δλ
$L(\vec{x};t;\hat{\xi};\lambda)$
speak the
language


1.30
1.20
1.10
1.00
0.90
0.80
modeled $f_b$
0.80
0.90
1.00
1.10
actual $f_b$
analyze
data


measure
light


collect
field
data

relate optics to physics & biology

measure absorption & scattering

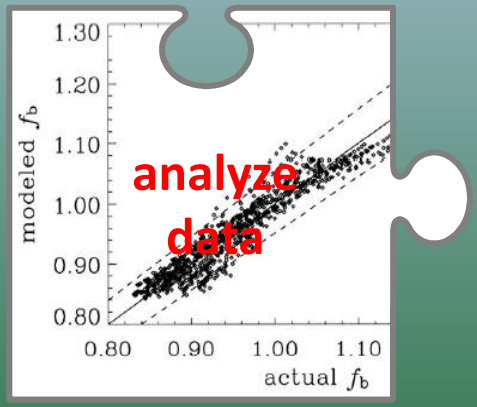
run HydroLight

$$\cos\theta \frac{dL(z,\theta,\phi,\lambda)}{dz} = \ldots$$

speak the language

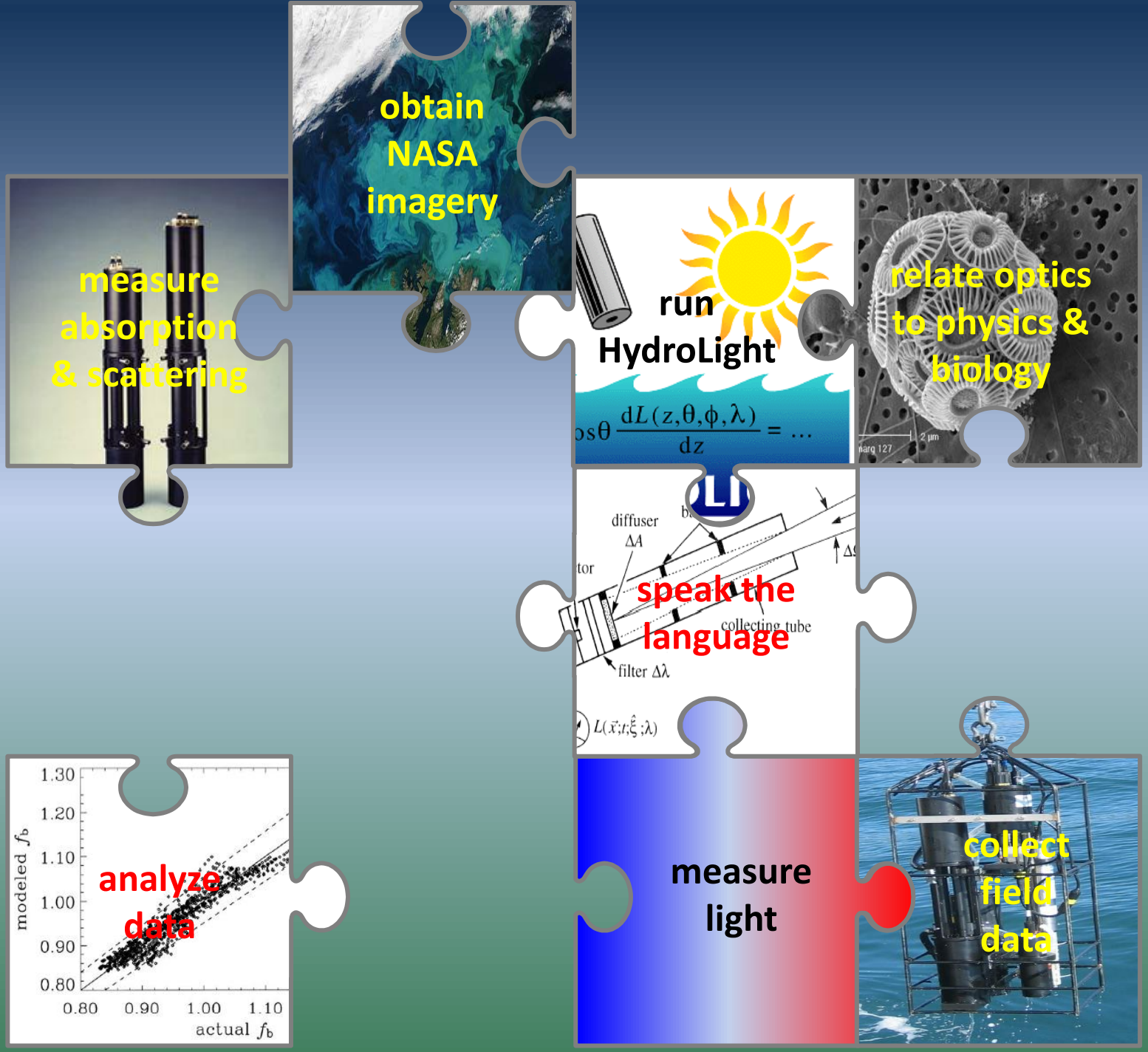
diffuser
$\Delta A$
collecting tube
filter $\Delta\lambda$
$L(\vec{x};t;\hat{\xi};\lambda)$

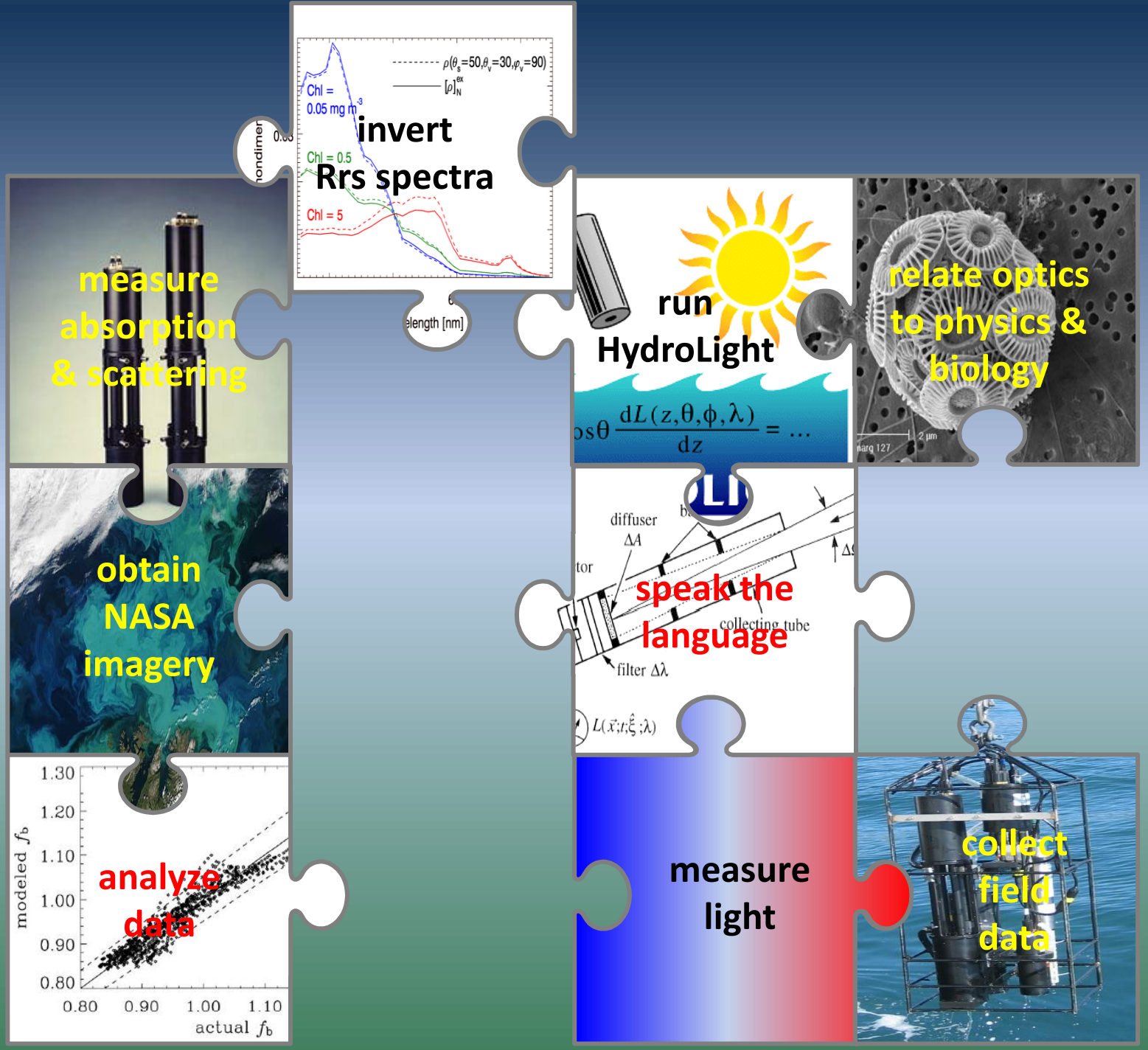
analyze data

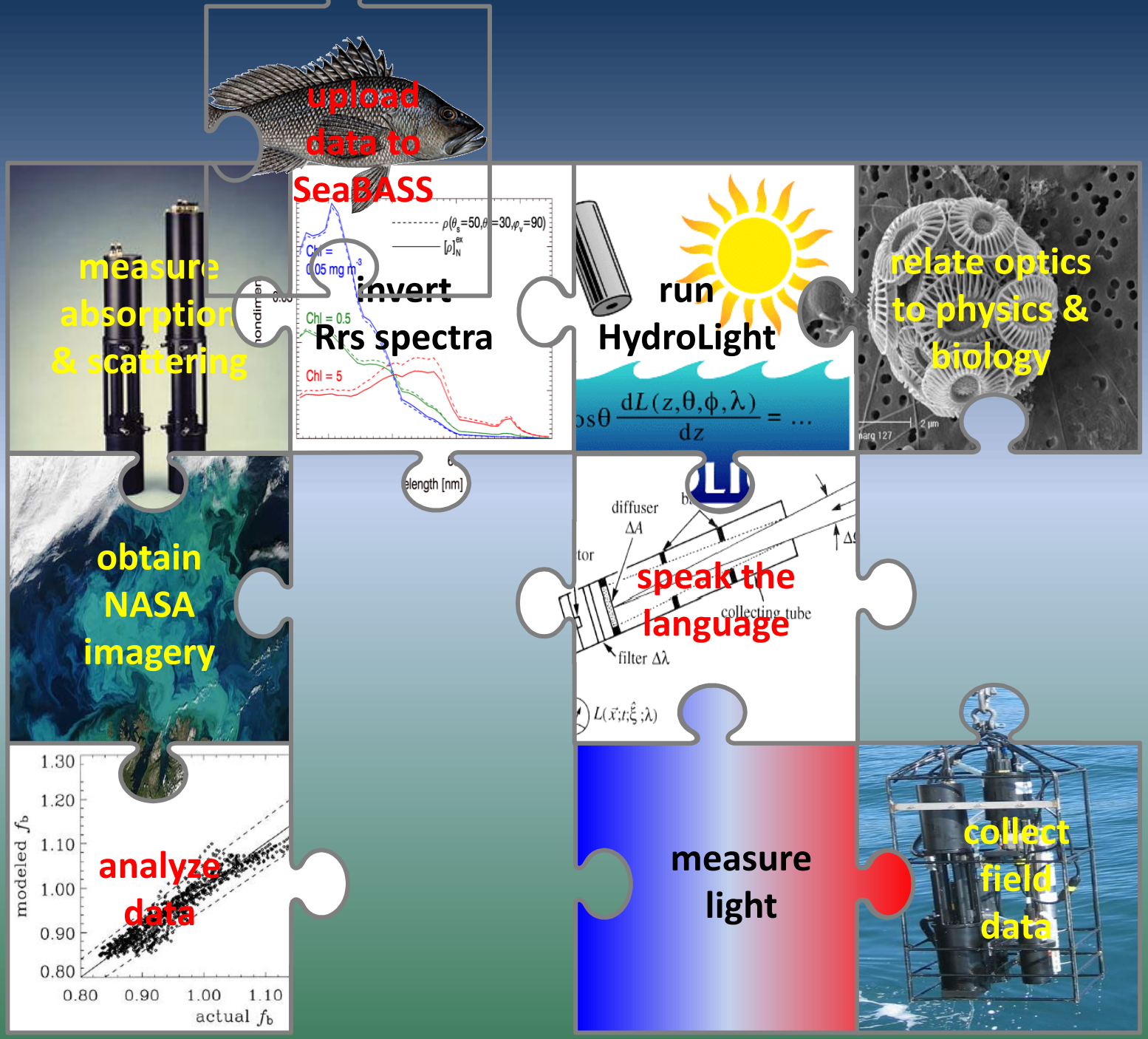


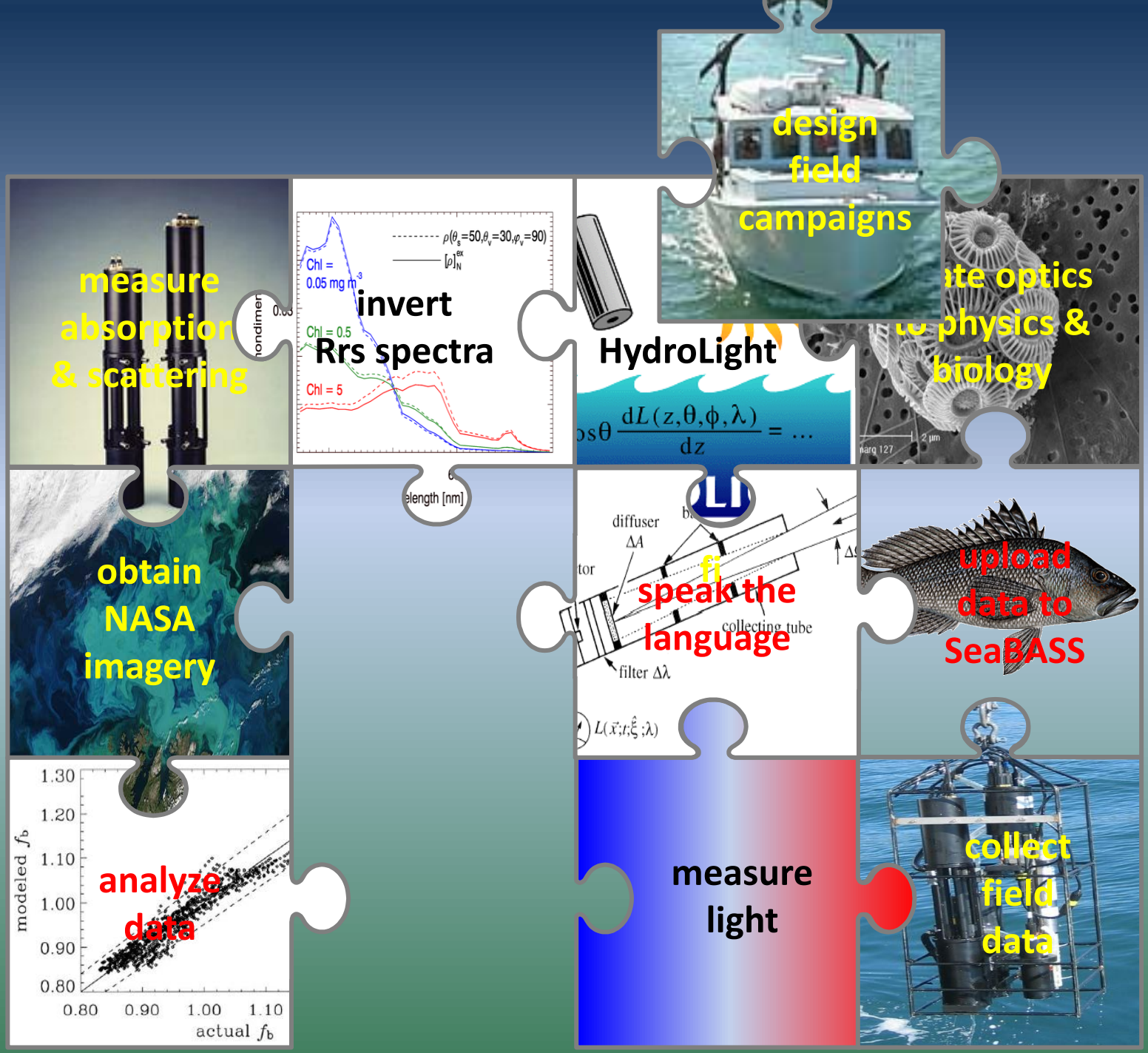

measure light

collect field data


obtain NASA imagery
measure absorption & scattering
run HydroLight
relate optics to physics & biology
speak the language
diffuser
collecting tube
filter Δλ
analyze data
modeled $f_b$
actual $f_b$
1.30
1.20
1.10
1.00
0.90
0.80
measure light
collect field data

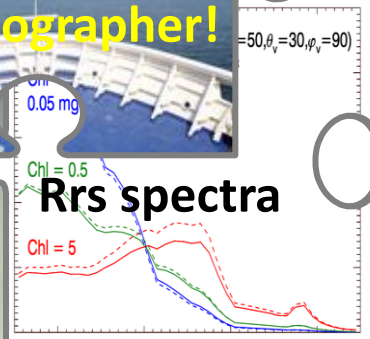

measure absorption & scattering
invert Rrs spectra
Chl = 0.05 mg m-3
Chl = 0.5
Chl = 5
run HydroLight
relate optics to physics & biology
obtain NASA imagery
speak the language
diffuser
collecting tube
filter Δλ
analyze data
modeled $f_b$
actual $f_b$
measure light
collect field data


upload data to SeaBASS
measure absorption & scattering
invert Rrs spectra
Chl = 0.05 mg m-3
Chl = 0.5
Chl = 5
run HydroLight
relate optics to physics & biology
obtain NASA imagery
diffuser
collecting tube
filter Δλ
speak the language
analyze data
modeled $f_b$
actual $f_b$
measure light
collect field data


design field campaigns
measure absorption & scattering
invert Rrs spectra
HydroLight
ate optics to physics & biology
obtain NASA imagery
speak the language
upload data to SeaBASS
analyze data
measure light
collect field data

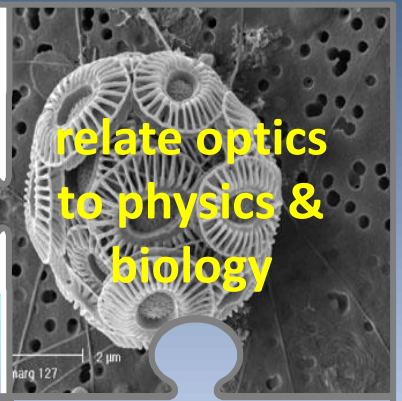
be an *Optical* oceanographer!

measure absorption & scattering



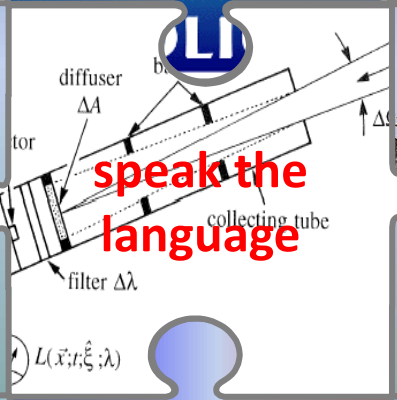

Rrs spectra

run HydroLight



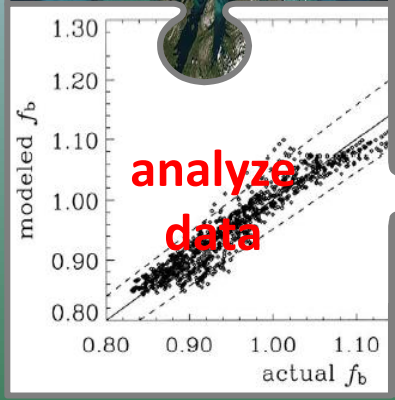
relate optics to physics & biology

obtain NASA imagery




speak the language

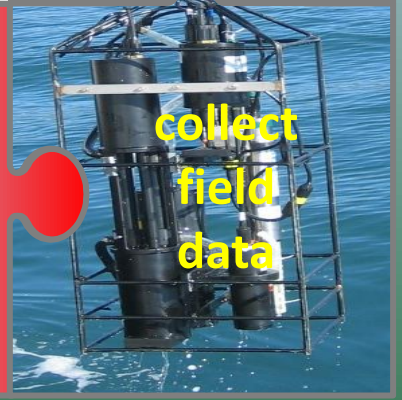
upload data to SeaBASS



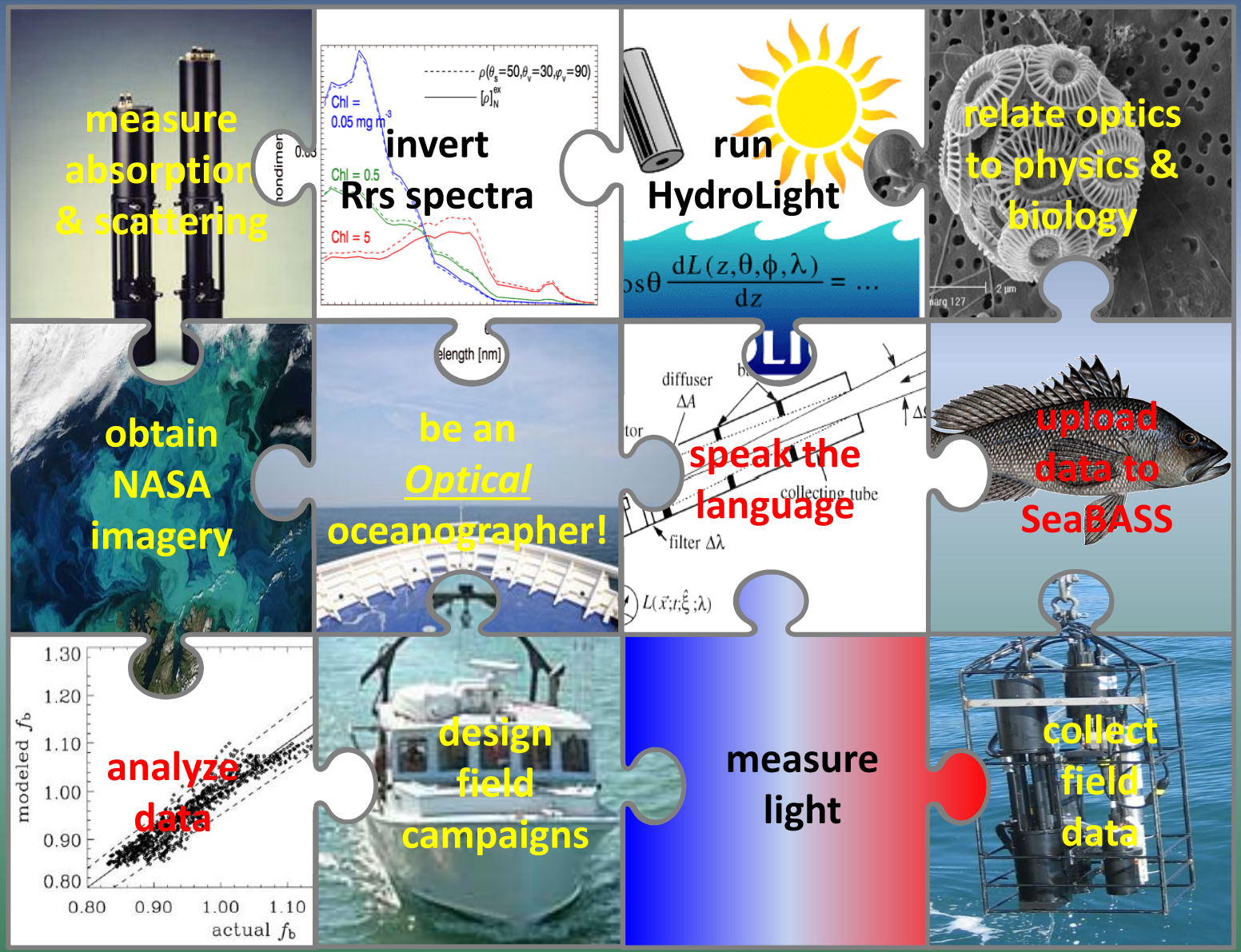

analyze data

design field campaigns

measure light



collect field data


measure absorption & scattering
invert Rrs spectra
Chl = 0.05 mg m-3
Chl = 0.5
Chl = 5
run HydroLight
relate optics to physics & biology
obtain NASA imagery
be an Optical oceanographer!
diffuser
collecting tube
filter Δλ
speak the language
upload data to SeaBASS
analyze data
modeled $f_b$
actual $f_b$
design field campaigns
measure light
collect field data