SMS-618, Particle Dynamics
Assignment week 1 (please return ASAP) – compilation of answers from the group.

Suppose for a moment that NASA asked you to design a sensor to send to Europa (Jupiter's satellite) and probe the vast water reservoirs found under ice on its surface (see: http://nssdc.gsfc.nasa.gov/planetary/ice/ice_europa.html).
Questions for us to solve as a group (spend 5minutes on each of them individually, and we will then discuss them in a group):

• What properties would you want to sense?
(What questions do I have? 1) Is there life? 2) If so, what is/are the autotrophic metabolism(s)? 3) If no life, why not?)

Physical properties:
Salinity, temperature, pressure, density, Currents (tides), turbulence, depth (and bottom type), Scatter, attenuation, absorption (spectral)

Particulate properties:
Organic Carbon (concentration), Particle size distribution, Particle shape/density, pigments

Dissolved properties:
Nitrate concentration, pH, redox potential, O2, Dissolved gases

• What sensors would you use to sense those properties?
Physics: CTD, ADCP, Radiometers, SONAR (depth, distances below ice), Optical scattering, attenuation, absorption meters, acoustical scattering. Mechanical system for breaking ice, Mechanical system for taking samples

Biogeochemistry: Camera (still/video), LISST, Flow cytometer, ISUS, a high-resolution in-situ spectrophotometer detecting deep UV-near IR wavelengths. IR is included because this might be the only kind of "light" available, perhaps at depth, and if life is present I would expect its associated absorbing compounds to be sensitive at these wavelengths. Visible and UV wavelengths will help to identify and quantify elements detected with the mass spectrometer, fliter banks for size fractionated measurements.

Suggested systems:

1) An AUV with the following:
   a) a CTD
   b) a pH meter
   c) an O_2 sensor
   d) an underwater mass spectrometer for qualitative elemental composition (prototypes now exist!

http://www.monitorinstruments.com/061201%20Petroleum%20Exploration%20by %20Undersea%20Mass%20Spectrometry.pdf)

2) A "bottom lander" with:

a) an upward looking ADCP

b) CTD and pH meter

c) In situ Laser-Induced Breakdown Spectrometer ("LIBS", still in the lab-testing phase in real life, but will allow in-situ measurements of vent fluid composition and perhaps pore water composition with sampler modification)
http://www.oceans06mtsieeeboston.org/docs/poster.pdf

Please answer the following questions (after reviewing the tentative syllabus):

• Why have you signed up for this class? What do you hope to learn from it?

Topics of interest:

- *How/why particles are created, aggregate, and sink in the open ocean.*
- *Settling, aggregation, and transport of particles.*
- *Optical properties of particles.*
- *Conservation equations.*
- *Theoretical understanding of transport and resuspension of sediments between delivery and burial.*
- *Chemical processes occurring on particles in the water column of the coastal ocean.*
- *Interaction of particles with turbulence.*
- *Why should we care about particles?*
- *Stuff I know nothing about…*

• Which topics would you like to see us spend most time on?

Particle aggregation and sinking, particle IOPs
Physical laws governing particle dynamics.
Bottom boundary layer dynamics.
What are the options for measuring relevant quantities in particle dynamics?
Physics of sediment resuspension in coastal areas as a function of sediment type
Mechanisms, temporal- and spatial-scales of flocculation and disaggregation of particles in the water column (with emphasis on both bottom and surface boundary layers)
Connections between sediment source and resuspension dynamics ("source" = biogenic/lithogenic, latitude, residence time on bottom)
Methods of numerically modeling resuspension and particle fluxes (given inputs like wind stress, salinity, tides)
Sources and transport fluxes of lithogenic particles to the gyres (eg atmospheric dust, sediments advected from continental slopes along isopycnals)

Fate of lithogenic particles (via physical and biogeochemical mechanisms) in the open ocean
Particles as microenvironments for biology and chemistry
Measurement methods of particle flux, concentration, and composition (direct and proxy)
For all the above: What are the current gaps between hypotheses and actual observations?

• How much emphasis would you want to see applied to:

1. Methods to sense particles and their properties (including labs with instruments).
YES. Very interested. Also, methods to sense particles (instrumentation) is a topic I don't have much hands-on experience with, so that would be useful.
Quite a bit! I would like to see an emphasis on the principles these methods are based on, and only the really important empirical relationships found (that may be used to develop new methods).

2. Quantitative modeling of particle dynamics:
Possibly interesting, especially if it is well tied to the theoretical physical description (could we come up with models, based on what we learn in the course? Can we figure out where our models would fail?).
Strongly interested in bio-physical modeling.

1. Coastal and estuarine sediment transport.
Introductory level is enough for me.
2. Particles and their dynamics in the open ocean (e.g. the biological pump).
Very interested. Particles and their dynamics in the open ocean is a topic I would like to see emphasis on.
I don't have a preference for one or the other environments. What I would like to see is a practical question leading to our investigation of possible models, with an emphasis on the relevance of the question to begin with.

3. Overview of other phenomena where particles are observed to play a role.
Introductory level is good. Overview of other phenomena is also interesting to me – as much of this as can be fit in would be nice. Short discussion
Larval transport and dynamics.

4. Class discussions of pertinent material (e.g. papers) vs. frontal presentation?
I would like a mix of presentations by one student and discussions. Both have their benefits for me. I think about 50/ 50 class discussion/ frontal presentation would be ideal. Frontal presentation and discussion. I like paper discussions, but prefer lectures. I think often paper discussions drag on and can be an inefficient way to glean information.

My ideal distribution of time across the listed topics:

Methods: 25%
Quantitative modeling: 60% (subdivided below)
- *Coastal: 65% (39% of total)*
- *Open ocean: 35% (21% of total)*

Overview of phenomena: 15%

In general, discussion is more useful than traditional lecture; however, when the material is very quantitative in nature (ie, the associated "traditional" lecture would consist mostly of derivation), I need to work through the math either on my own or with the class before I can contribute much to, or realize all the benefits of, a class discussion. From a practical standpoint, I'd like to see discussions of quantitative modeling techniques preceded by a problem set (optional is okay, if others in the class don't need to work through equations before talking about them), or accompanied by an in-class "modeling lab".