MER Data Processing at SPG

(MER = Marine Environmental Radiometer)

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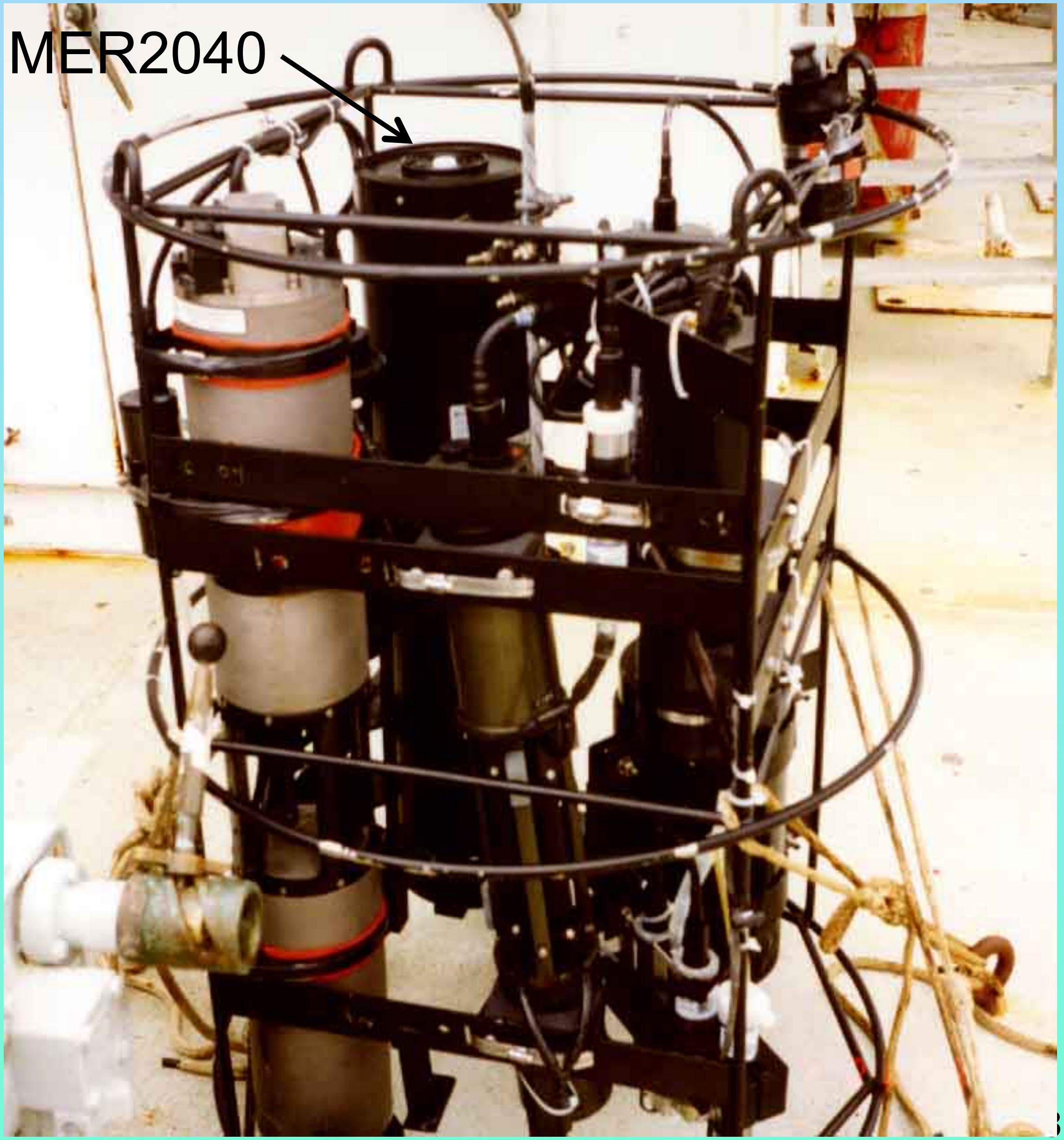
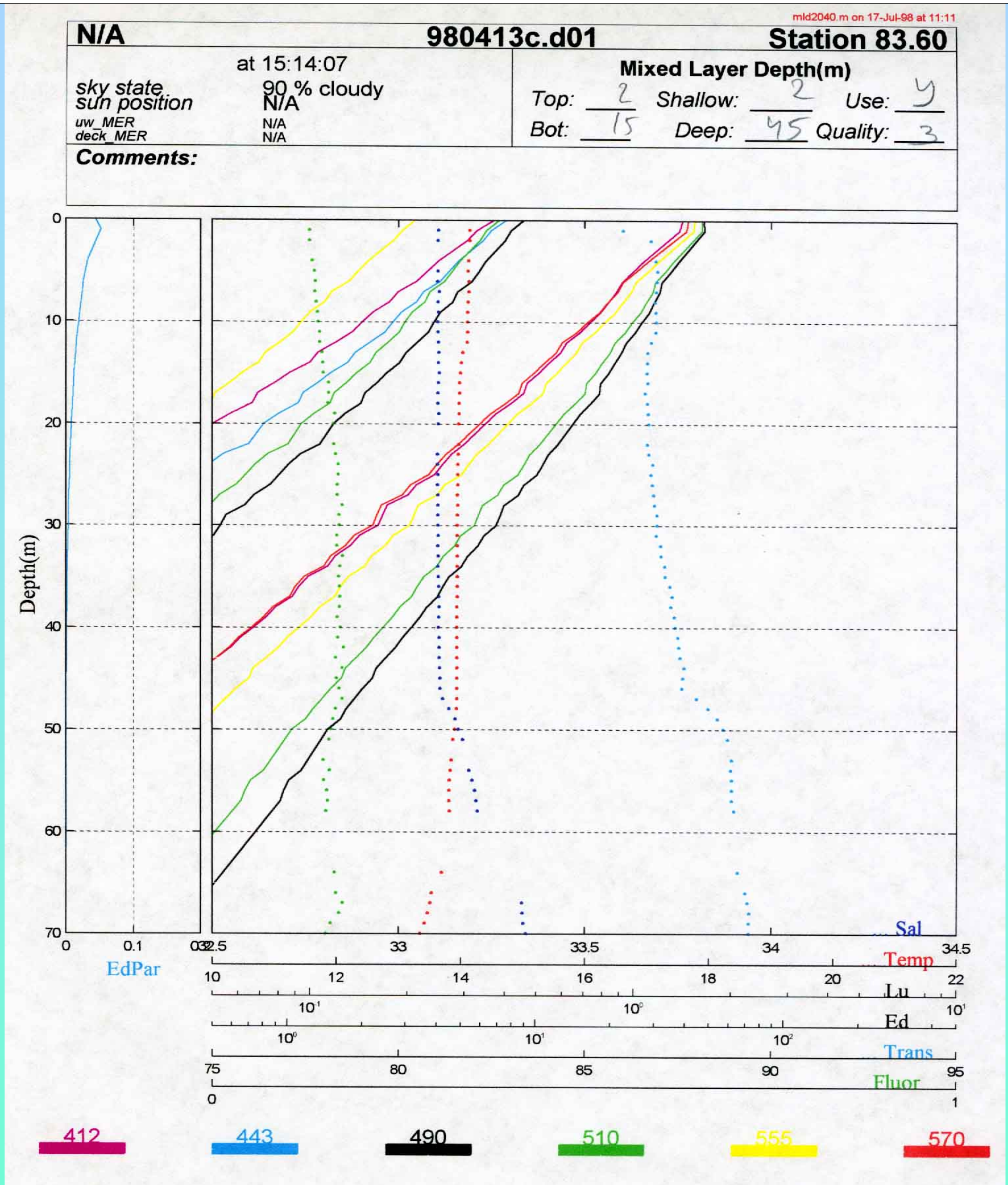
Original (~199X) deployment from A-frame

Original data processing was based on BBOP – Thanks, Dave!

Self-shading of Lu sensors can be a problem (MER2040)

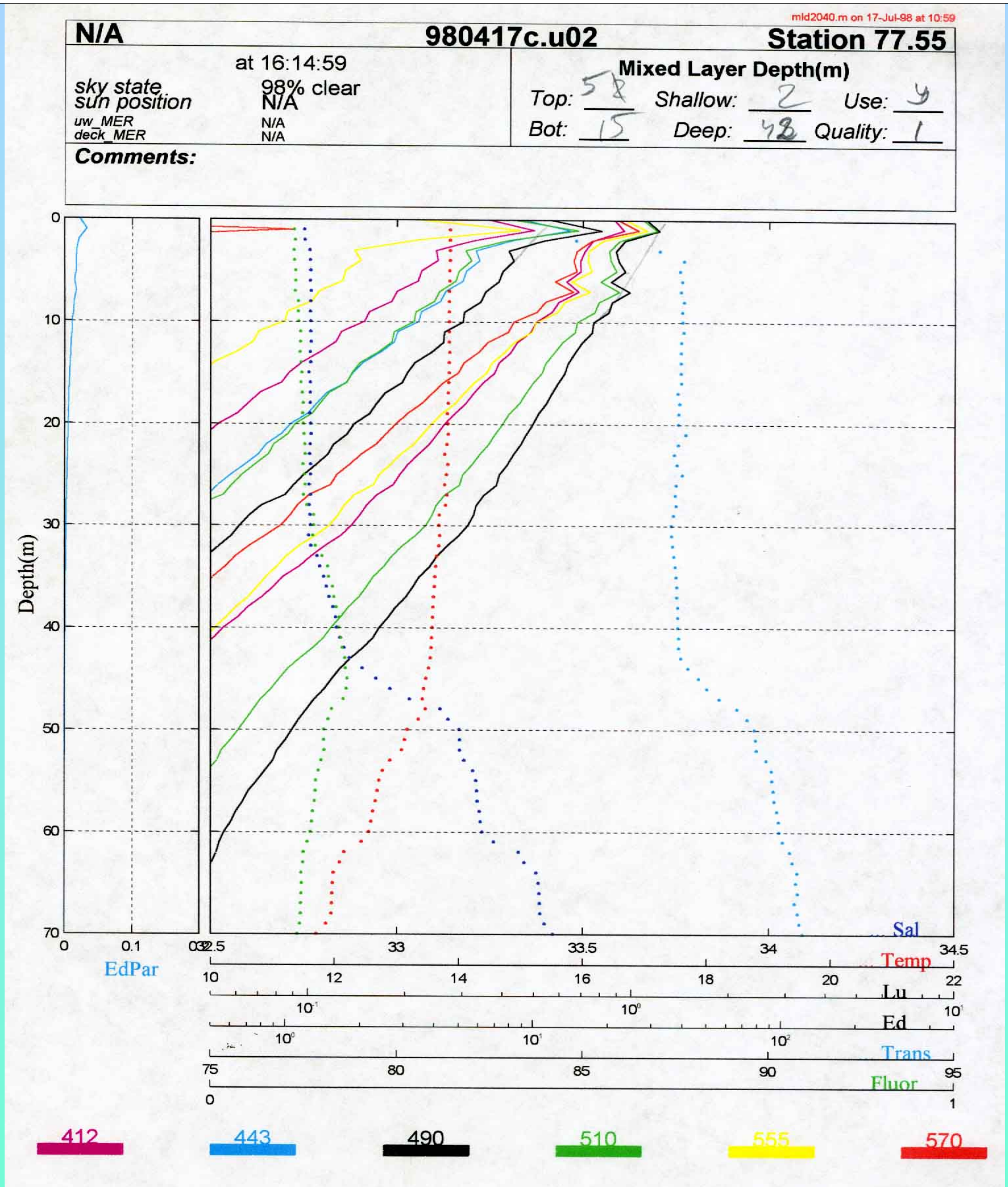


Kahru, M, Mitchell, B.G, 1998. Evaluation of instrument self-shading and environmental errors on ocean color algorithms. Proc. Ocean Optics XIV CD-ROM, Kona Hawaii.



Original processing with C-code executables, MatLab plots

Near-surface effects due to ship shadow; this is a "good" profile



Near-surface effects due to ship shadow; this is a more "common" profile: strong ship shadow

Using free-fall radiometers (e.g. PRR800) since 2001:

Improved profile quality; self-shading no significant problem

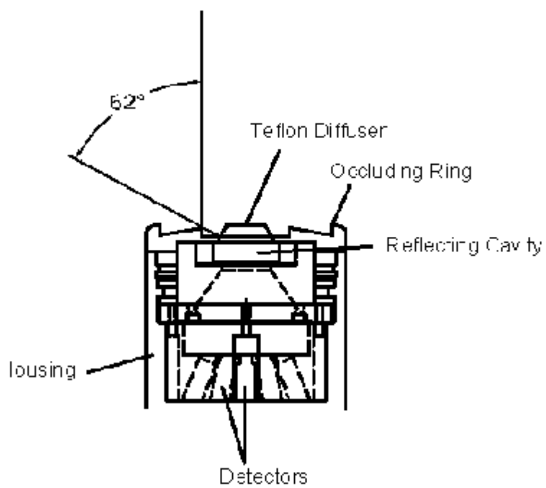
Radiance

Biospherical Instruments Inc.

Leaders in Optical Sensing and Profiling Technology

Abbreviated "L," **Radiance** sensors are easy to inspect because they do not typically have a diffuser. In our systems, filter-photodetectors are positioned at the bottom of individual Gershun-style tubes. An endplate restricts the field-of-view to the desired solid angle (PRR-2800 photo at right).

Cosine Irradiance (E_d or E_u)

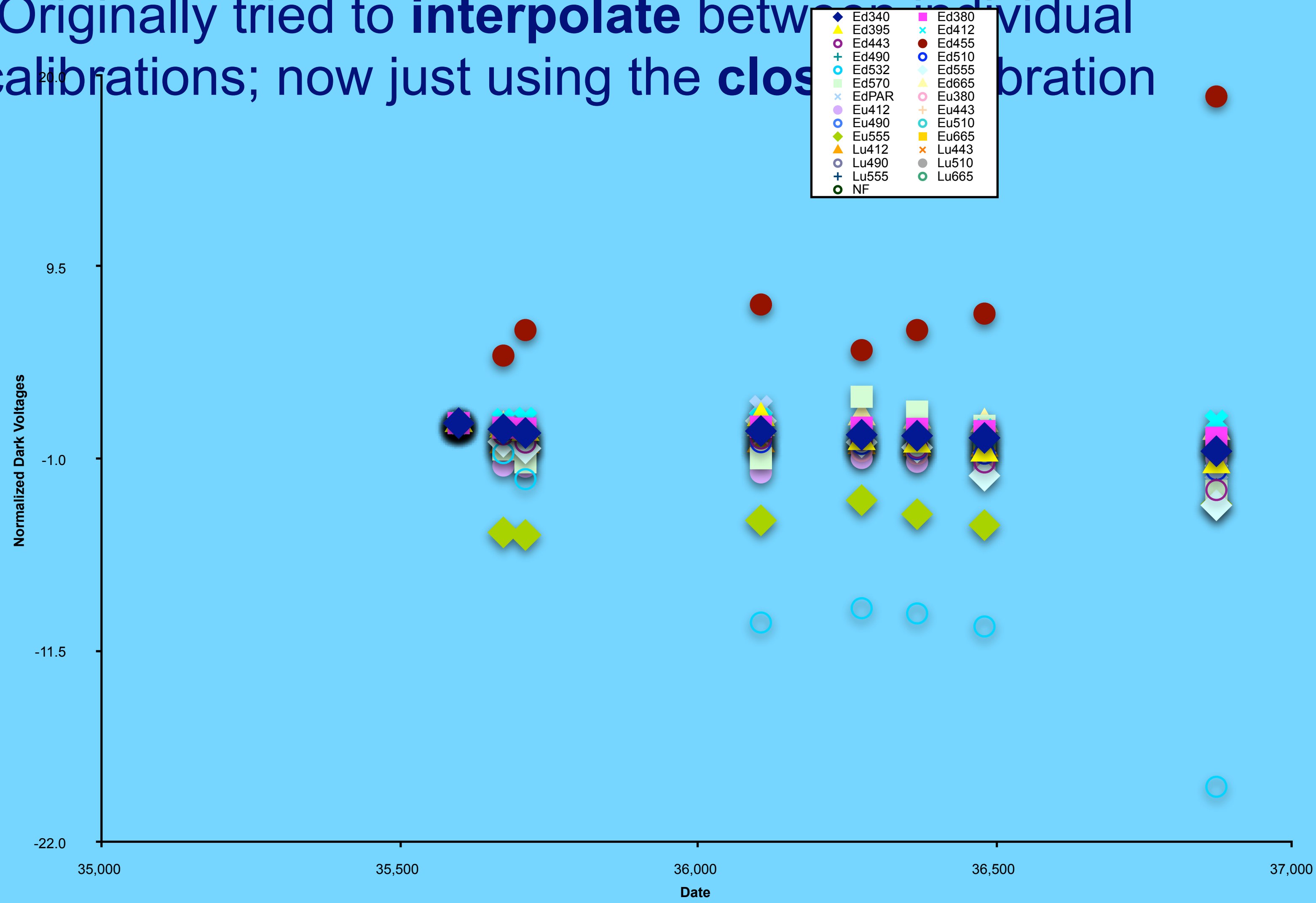


Used for measuring upwelling or downwelling sunlight, a properly designed cosine collector, will report irradiances that are proportional to the cosine of the angle of incidence.

This diagram is a side view of a cosine collector, showing the relationship between the collector, occluding rings, and photodetectors. For designs using multiple photodetectors such as this, wavelength detuning as the view angle of the photodetector moves off-axis must be controlled.

•**1) Calibrate or re-calibrate** all files with the latest (best) calibration file with a batch command using BSI *Profiler* (*C:\Program Files\Biospherical\Profiler\Profiler.exe*).

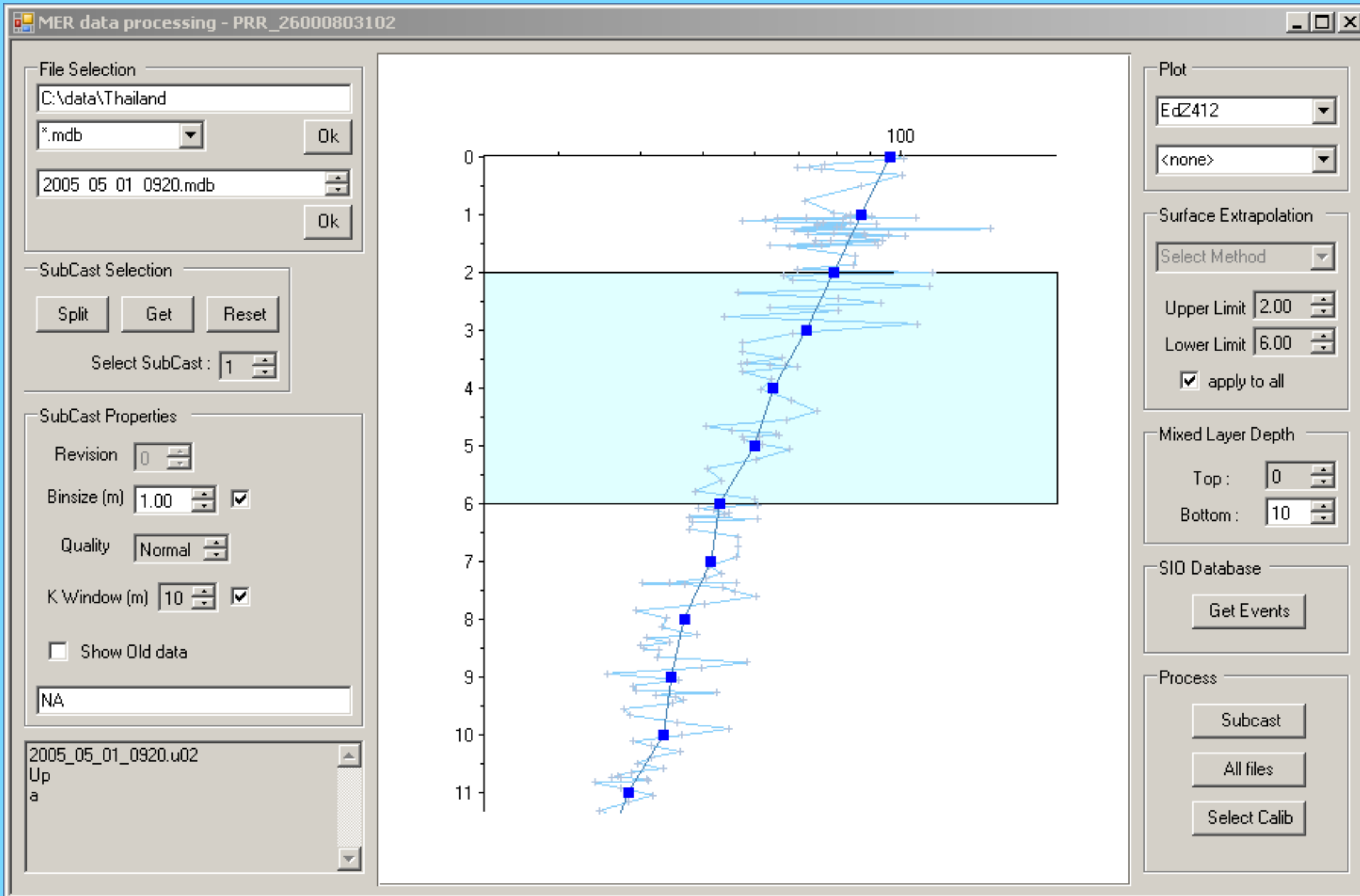
•Originally tried to **interpolate** between individual calibrations; now just using the **closest** calibration



New processing software

- Moved from ASCII to databases (Access, SQL Server, etc)
- Can ingest data from legacy formats (BBOP LCD, CSV, etc, different instruments, e.g. BSI, Satlantic)
- All processing done using data in databases, output dumped to databases

2) Process all files with ***MER_Processing.exe***



•2) Process all files with MER_Processing.exe

•**Split** into one or more down- and/or up-casts

•**Bin** into regular vertical bins with flexible interval (typically 1 m but smaller for shallow and/or turbid waters)

•Select depth interval for **surface extrapolation**

•Assign **quality** values (poor=1, normal=2, good=3)

•Depth interval & quality parameters are for **each individual band** (e.g. 18 bands of *Ed*, *Lu*, *Eu* = 54 bands); (in practice duplicated)

•**Record all** (binned data as well as processing parameters) into an *Access* database, e.g. *Prr800Cast_CCE-P0810.mdb*

3) Copy data tables from individual (cruise) *Access* file to **combined *Access*** files

Transfer data from *Access* to ***SQL Server***

Further **analysis** using combined *Access* files and *SQL Server*

Thank you

Ocean Color: Basic Relationships

Remote sensing reflectance, Rrs(λ)

$Rrs(\lambda) = L_u(\lambda) / E_d(\lambda)$ (just above water or depth 0+)

$E_d(\lambda)$ = downwelling irradiance

$L_u(\lambda)$ = upwelling radiance

In practice, 3 ways of calculating Rrs:

1) $Rrs1(\lambda) = 0.519 * L_u(\lambda, 0-) / E_d(\lambda, 0-)$

$L_u(\lambda)$ and $E_d(\lambda)$ are measured just below surface or depth 0-

2) $Rrs2(\lambda) = 0.54 * L_u(\lambda, 0-) / E_s(\lambda)$ *- NASA protocols*

$L_u(\lambda)$ measured at depth 0- , E_s measured above surface

3) Rrs3(λ) = mean [Lu/Ed] for top 2 samples between Shallow and Deep depths of the vertical profiles

Normalized water-leaving radiance, Lwn

$Lwn = Rrs*F^o(\lambda)$ (Neckel & Labs, 1984)

Rrs calculation using in-water instruments

$Rrs1(\lambda) = 0.519 * L_u(\lambda, 0\text{-}) / E_d(\lambda, 0\text{-})$

Advantages: Using single instrument

Disadvantages: "Surface extrapolation" (extrapolation to 0- depth) has large errors; Subjectively used depth bins used for surface extrapolation

$Rrs2(\lambda) = 0.54 * L_u(\lambda, 0\text{-}) / E_s(\lambda)$ *- in NASA protocols*

Advantages: Es not affected by fluctuations like Ed (wave focusing, vertical tilt)

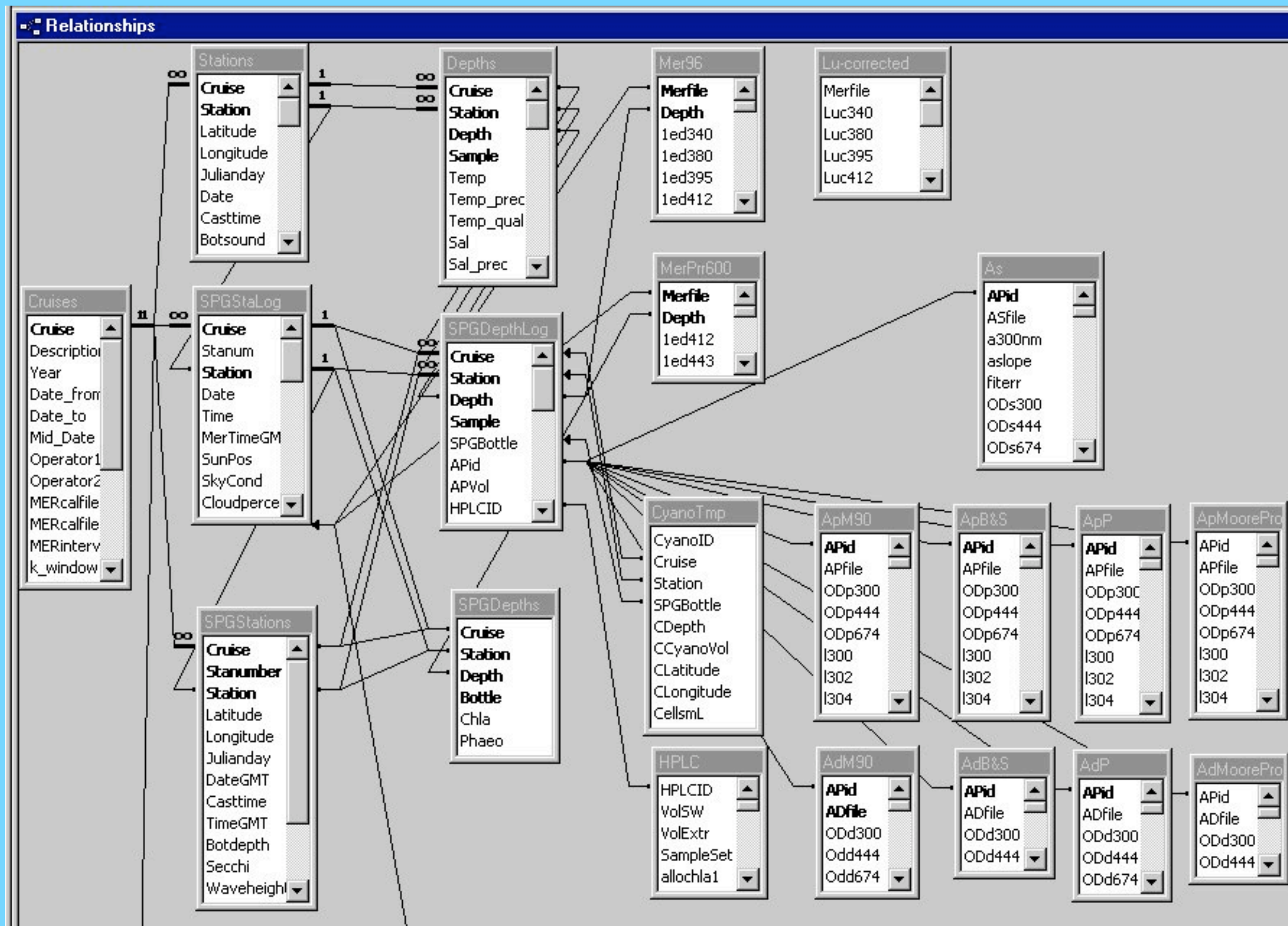
Disadvantages: Using 2 instruments that are spatially separated; that may introduce bias, e.g. due to moving cloud and ship shadows

$Rrs3(\lambda)$ = mean [Lu/Ed] *(using binned Lu and Ed values)*

Advantages: No "vertical extrapolation" error; less dependent on relative depth error that is significant in turbid waters

Disadvantages: not standard, subjectively selected depth bins used

•The following programs use a SQL database with station information and an Access database with surface extrapolated data –RrsTop.mdb



4) Run ***GetMerMatchesConsole.exe*** for a new cruise: finds the station info from SQL database, updates the *StationEvent* table in *RrsTop.mdb*

C:\Access>GetMerMatchesConsole

Usage: GetMerMatchesConsole cruise

Example: GetMerMatchesConsole CAL03

This means ALL matching to CAL03*, e.g. CAL0301, CAL0304, etc.

5) Run ***Fill_Sun_Elevation.exe*** - fills *Sun_Elevation* field in table *StationEvent* of *RrsTop.mdb* with calculated sun elevation in degrees (using the date/time and latitude/longitude)

C:\Access>Fill_Sun_Elevation

Usage: Fill_Sun_Elevation cruise

NOTE! Expects C:\Access\RrsTop.mdb !!!

Example: Fill_Sun_Elevation CAL0304

Note that CAL03 will match CAL03*, e.g. CAL0301, CAL0304, etc

6) *Run* ***GetRrsTop.exe****: calculates surface Rrs estimates (Rrs1, Rrs2, Rrs3), updates tables Rrs1, Rrs2, Rrs3 in RrsFile (RrsTop.mdb).*

Usage: GetRrsTop MerCastFile RrsFile

Example:

C:\Access>GetRrsTop Prr800Cast_CCE-P0704.mdb RrsTop_test.mdb

29 Merfiles read from table FilesLog

172 columns (bands) in table Processed

29 Lu bands found

==

CCE-P0704, PRR800_0900111

==

29, 29, 29 Rrs1, Rrs2, and Rrs3 records updated in file RrsTop_test.mdb

7) Run ***GetSurfChl.exe***: finds matching surface Chl-a (both fluorometric and HPLC) from SIO SQL database, updates the *ChlSurfaceFluor* and *ChlSurfaceHPLC* tables in *RrsTop.mdb*

C:\Access>GetSurfChl

Usage: GetSurfChl cruise

Example: GetSurfChl AMLR2001

Note: AMLR2 will match AMLR2000, AMLR2001, etc.

Don't use * to match multiple cruises!

Note: excluding all cruisenames with INC = incubation!

Cannot use cruises with names like INC* !

8) Run ***MeanRrsTop.exe***: calculates mean *Rrs* top values for all the **best** casts (including all down- and up-casts) for each station; run separately for *Rrs1*, *Rrs2* and *Rrs3*

// Uses only casts with quality of 2 and 3 (>= QualityAcceptable)

/// Picks casts with MAX quality only, averages those and saves a composite or mean cast

// For example, if 2 casts with quality 2 and 3 exist, will use only the quality=3 cast and copy that;

// if 2 casts of quality 2 exist, will average those

Run 3 times, for each Rrs type:

MeanRrsTop RrsTop.mdb CCE-P0810 Rrs1

MeanRrsTop RrsTop.mdb CCE-P0810 Rrs2

MeanRrsTop RrsTop.mdb CCE-P0810 Rrs3

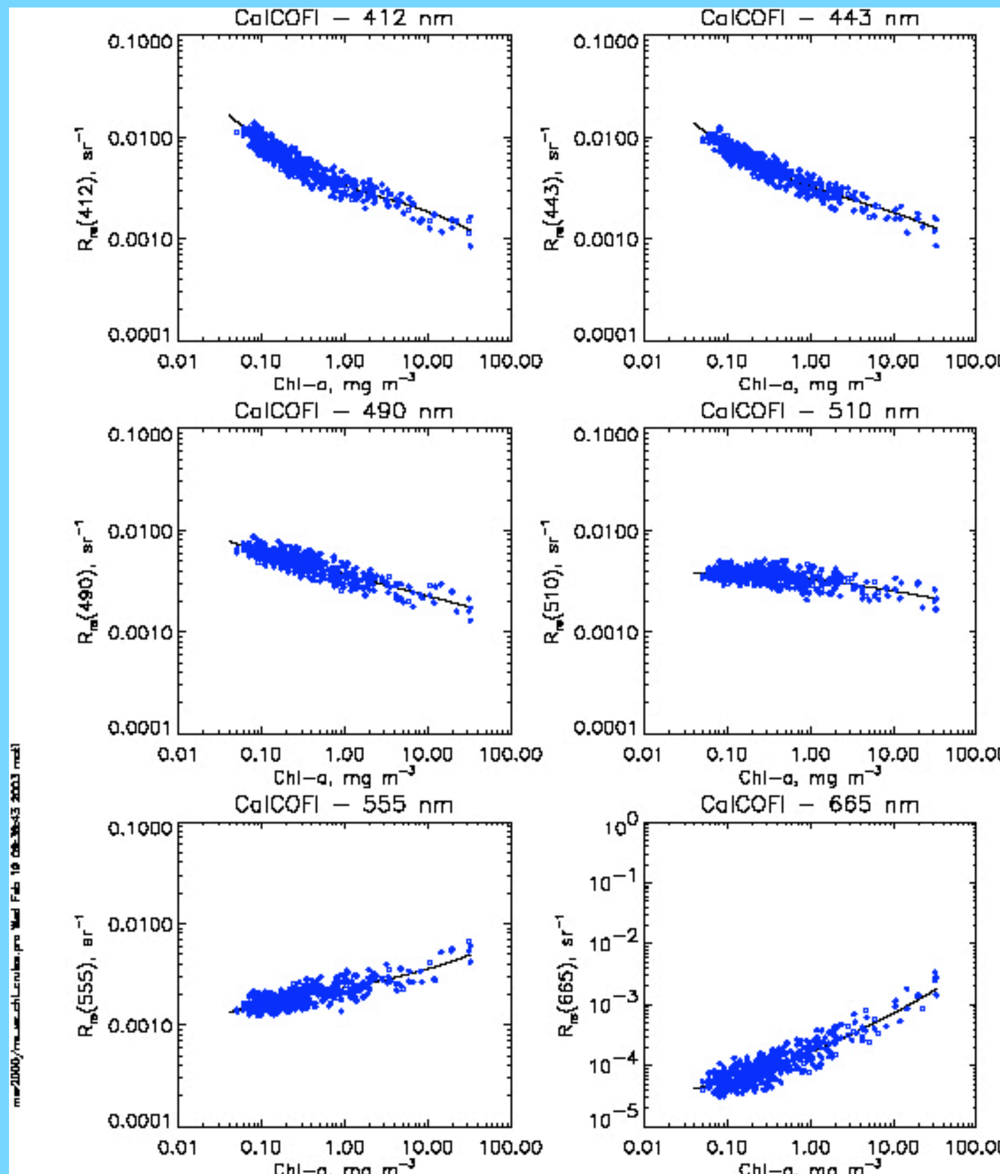
!!! Needs ***Mer2003.mdb*** with all the individual casts AND filled ***StationEvent*** table in ***RrsTop.mdb***

Summary of processing in-water radiometry

- **Calibrate** or re-calibrate all files with the latest (best) calibration file
- **Process all files with MER_Processing.exe**: split the down- and up-casts, record all binned values into an Access database
- Fill the **station info** (*StationEvent* table in *RrsTop.mdb using GetMerMatchesConsole.exe*)
- Calculate **sun elevation** for each station using the date/time and latitude/longitude)
- Calculate **surface Rrs** estimates (*Rrs1*, *Rrs2*, *Rrs3*) in *RrsTop.mdb*
- Find **matching surface Chl-a** (both fluorometric and HPLC), fill *ChlSurfaceFluor* and *ChlSurfaceHPLC* tables in *RrsTop.mdb*
- Calculate **mean Rrs** top values for all the best casts (including all down- and up-casts) for each station; for *Rrs1*, *Rrs2* and *Rrs3*
- **Plot Rrs versus Chl-a** for all casts and for all stations (means per casts)
- **Plot Rrs ratios versus Chl-a**; fit a new nonlinear model or compare with old models
- Generate SeaBASS format text files with ***MerCastToSeaBASS***

Rrs vs Chl-a at SeaWiFS wavelengths

- *Rrs (λ) =*
- *Lu(λ) / Es(λ)*
- *Rrs ~ b_b/(a + b_b)*
- *Rrs ~ b_b/a*



Case-1 waters off California

Quality-control using plots vs Chl-a

Plot Rrs versus Chl-a *(run query qRrs3_Cast_Chl) – for all casts and for stations (means per casts)*

Plot Rrs ratios versus Chl-a*; fit a new nonlinear model or compare with old models*

Remote Sensing Reflectance (Rrs)

- *The ratio of radiance leaving the water (upwelling) to irradiance incident on the water (downwelling). So-named because it indicates the effective reflectance of a body of water when viewed by a remote sensor such as an airborne or satellite radiometer.*
- *Rrs = Lu/Ed (at depth 0+)* *Units?*

Radiance (*L*), upwelling radiance, *Lu*

Radiant flux per unit area per unit solid angle per unit wavelength interval, i.e. **$W/m^2/sr/nm$**.

In intuitive terms, it is the quantity we humans perceive as brightness. Radiance may also be measured with a non-imaging radiance collector.

Radiance is a function of viewing angle, and other radiometric quantities such as irradiance can be calculated by integrating the radiance over a range of angles.

Irradiance (*E*), downwelling irradiance, *Ed*

Power per unit area incident on a surface, expressed in W/m^2 (**$W/m^2/nm$** if measured spectrally). Different irradiance quantities may be defined with reference to different collecting surfaces, for example plane irradiance and scalar irradiance. If not otherwise qualified, plane irradiance is assumed.

•*http://www.hobilabs.com*