NOMAD: the NASA bio-Optical Marine Algorithm Data set

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Ocean Color Bio-optical Algorithm Mini-workshop
27-29 September 2005, University of New Hampshire

The punchline

the NASA OBPG has compiled, through generous contributions from the ocean color research community, a global, high-quality, *in situ* data set for bio-optical algorithm development & ocean color satellite validation activities

this data set has been named NOMAD

SeaBAM

a remarkable achievement

SeaBAM: SeaWiFS Bio-optical Algorithm Mini-workshop

coincident observations of $R_{\mathrm{rs}}(\lambda)$ & C_a

919 original stations in 1997; expanded to 2,853 by 2000

source of most empirical, operational satellite C_a algorithms

but ...

current limitations

no metadata, such as date, location, or cruise names

no operational mechanism for updating or extending data set

SeaBASS

where to start?

SeaBASS: SeaWiFS Bio-optical Archive & Storage System

local repository of *in situ* data for community research & validation activities

includes most data considered in SeaBAM

significantly extended during SIMBIOS-era

logical source & location for continued evolution of a SeaBAM-like data set

begin process by compiling coincident *AOP*'s and C_a

extend data set with *IOP*'s and *AOT*'s

NOMAD-specific acknowledgements

NASA Ocean Biology Processing Group

T. Moore, J. Campbell (UNH)
S. Maritorena, D. Court (UCSB)
J. O'Reilly (NOAA)
S. Hooker (NASA)

<u>early release of data to public</u>
R. Arnone, W. Balch, F. Chavez, L. Harding, S. Hooker, G. Mitchell, R. Morrison, F. Muller-Karger, N. Nelson, D. Siegel, A. Subramaniam, & R. Stumpf

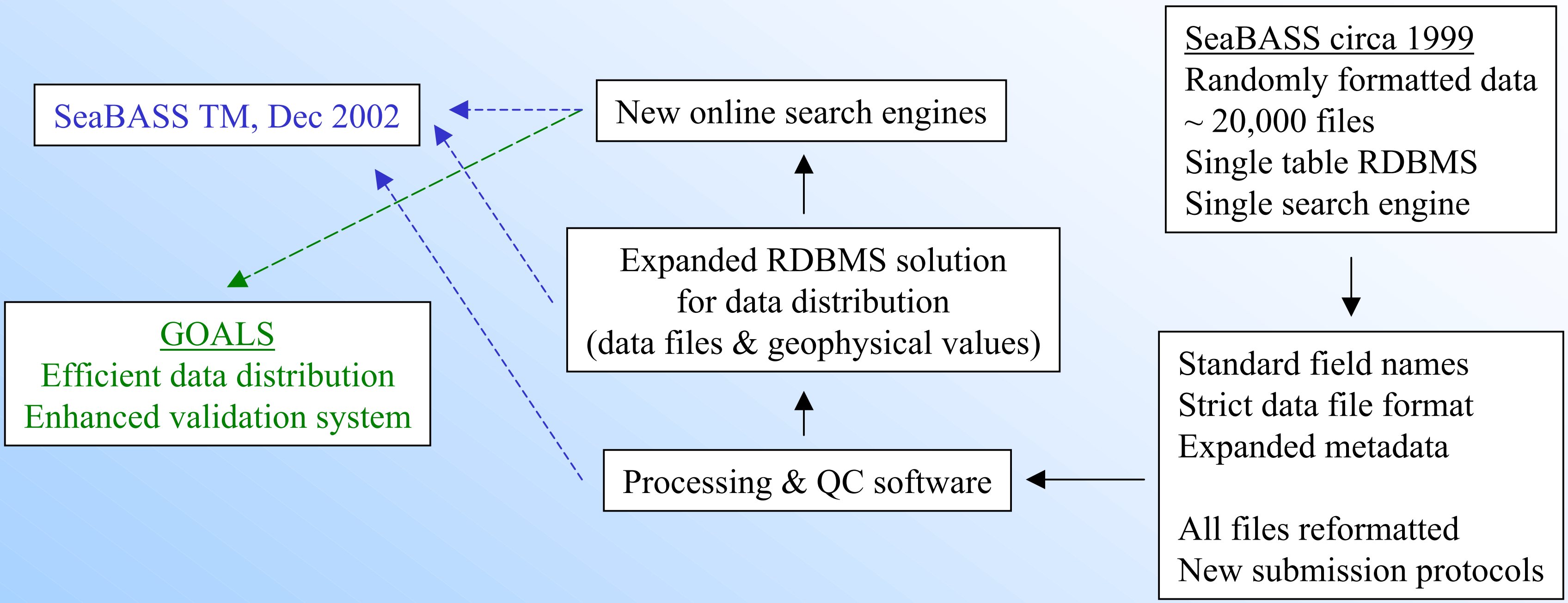
SIMBIOS NRA-96 & NRA-99 participants
voluntary data contributors

History of the effort

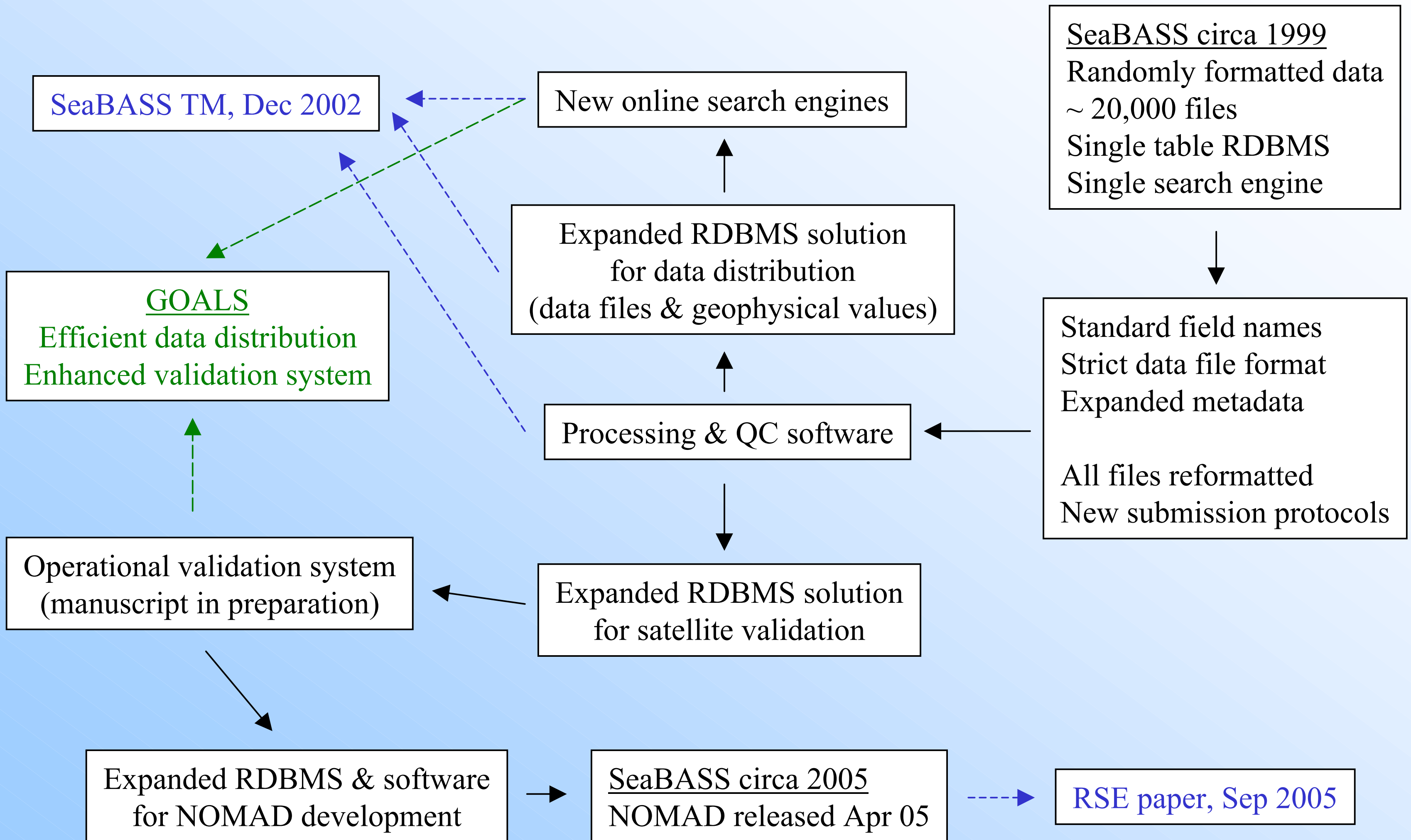
SeaBASS circa 1999
Randomly formatted data
~ 20,000 files
Single table RDBMS
Single search engine

GOALS
Efficient data distribution
Enhanced validation system

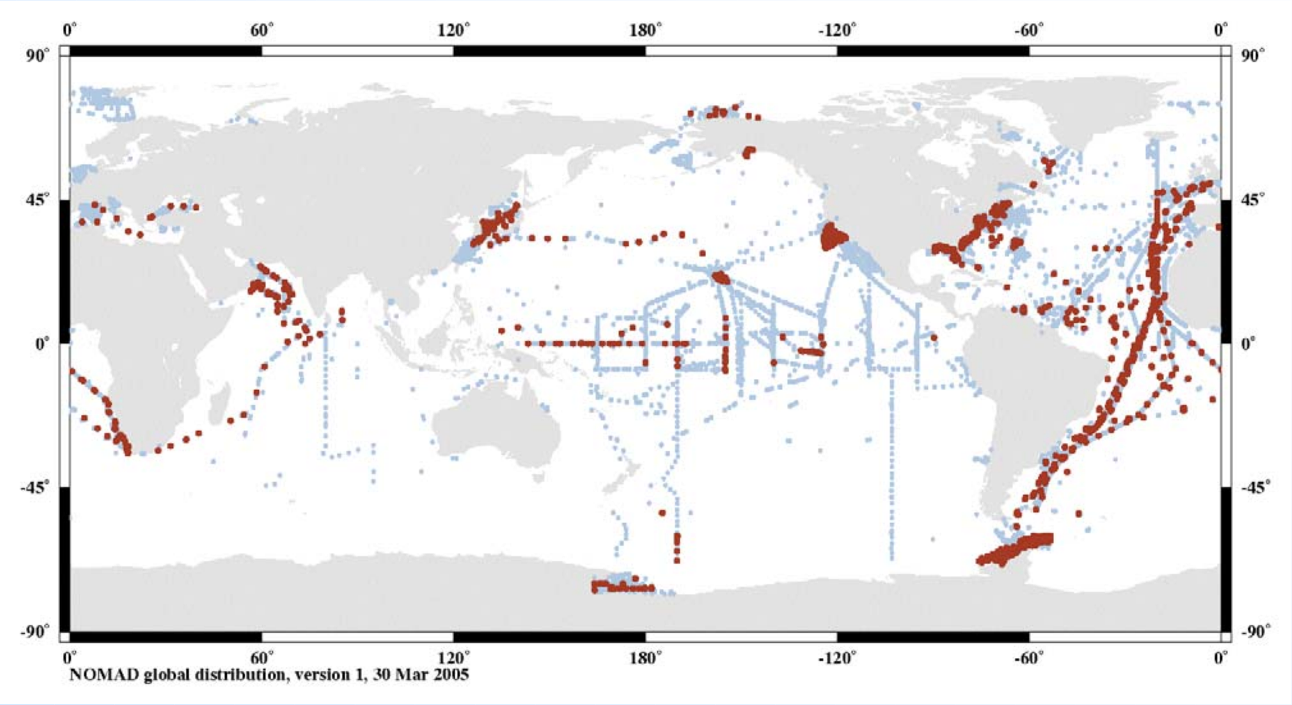
History of the effort



History of the effort



NOMAD



3,467 coincident observations of $L_w(\lambda)$, $E_s(\lambda)$, $K_d(\lambda)$, & C_a

metadata includes date, location, & cruise name
plus, NCDC OISST, NGDC ETOPO2, & processing flags

compilation described in Werdell & Bailey (2005, *Rem. Sens. Environ.*, 98, 122-140)

Features & distribution

bit	abbreviaton	usage	description
0	AOP	D	radiometry, $L_w(\lambda)$ or $R_{rs}(\lambda)$, available (*always set*)
1	CHL	D	fluorometrically-derived C_a available
2	HPLC	D	HPLC-derived C_a available
3	AOT	D	aerosol optical depths, $\tau_a(\lambda)$, available
4	A	D	absorption coefficients, $a(\lambda)$, available
5	BB	D	backscattering coefficients, $b_b(\lambda)$, available
6	KD	D	diffuse downwelling attenuation coefficient, $K_{rs}(\lambda)$, available
7	CAST	I	data from radiometric or pigment depth profile
8	SPEC	I	data from laboratory spectrophotometry
9	VSB	P	$L_w(\lambda)$ processed using OBPG software
10	INT_CHL	P	depth-integrated (optically weighted) fluorometric C_a
11	INT_HPLC	P	depth-integrated (optically weighted) HPLC-derived C_a
12	SHADE	P	instrument self-shading correction applied to $L_u(\lambda,0^-)$
13	FQ	P	f/Q correction applied to $L_w(\lambda)$
14	ES	I	$E_s(\lambda)$ available from reference instrument
15	RRS	I	$L_w(\lambda)$ estimated from $R_{rs}(\lambda)$
16	HYPER	I	hyperspectral observation of $L_w(\lambda)$ or $R_{rs}(\lambda)$

20 INT_A optically-weighted a_p, a_d, and a_g,
21 INT_BB optically-weighted b_b

binary processing flag provided for every NOMAD data record

permit discrimination between instrumentation, processing methods, & data availability

currently used by validation system to separate fluorometric & HPLC pigments, in-water & above-water radiometry, etc.

http://seabass.gsfc.nasa.gov/cgi-bin/nomad.cgi

Looking forward

it's not only about C_a anymore …

continued evolution of NOMAD required as

community knowledge grows,
as new science questions arise,
& as the *state of the art* progresses

OBPG acts as the steward of NOMAD,
in collaborative partnership with the research community,
working together to direct its evolution

Looking forward

bulk CTD water temperature and salinity added (Jul 2005)

spectrophotometric absorption coefficients added (Aug 2005)

backscattering coefficients added (Sep 2005)

processing and evaluation details are available:
http://seabass.gsfc.nasa.gov/data/werdell_nomad_iop_qc.pdf

expanded IOP evaluation data sets are available:
http://seabass.gsfc.nasa.gov/data/nomad_iopeval_v1.3_2005262.txt
http://seabass.gsfc.nasa.gov/data/nomad_bbeval_v1.3_2005262.txt

New IOPs and semi-analytic algorithms

a_p, a_d, a_g, and b_b selected for addition to NOMAD

note, also, a_ϕ (= a_p - a_d) and b_{bp} (= b_b - b_{bw})

why these?

New IOPs and semi-analytic algorithms

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note, also, a_ϕ (= a_p - a_d) and b_{bp} (= b_b - b_{bw})

why these?

in general, subsurface reflectance described via:

$$r_{rs} = g_1 x + g_2 x^2 \text{, where } x = \frac{b_b}{a + b_b} \text{ and}$$

(1) $b_b = b_{bw}(\lambda) + M_{bp}\lambda^{v_{bp}}$ (or, $= b_{bw}(\lambda) + M_L \lambda^{v_L} + M_S \lambda^{v_S}$)

(2) $a = a_w(\lambda) + M_{dg} \exp[-S(\lambda - 400)] + M_\phi \hat{a}_\phi$

New IOPs and semi-analytic algorithms

traditionally, three unknowns, a_{dg}, a_ϕ, and b_{bp}, described as a function of their magnitude, M, and spectral shape basis vector

parameter	*magnitude*	*basis vector*	*input*
a_{dg}	M_{dg}	$\exp[-S(\lambda-400)]$	S
a_ϕ	M_ϕ	$\hat{a}_\phi$	$\hat{a}_\phi$
b_{bp}	M_{bp}	$\lambda^{v_{bp}}$	v_{bp}

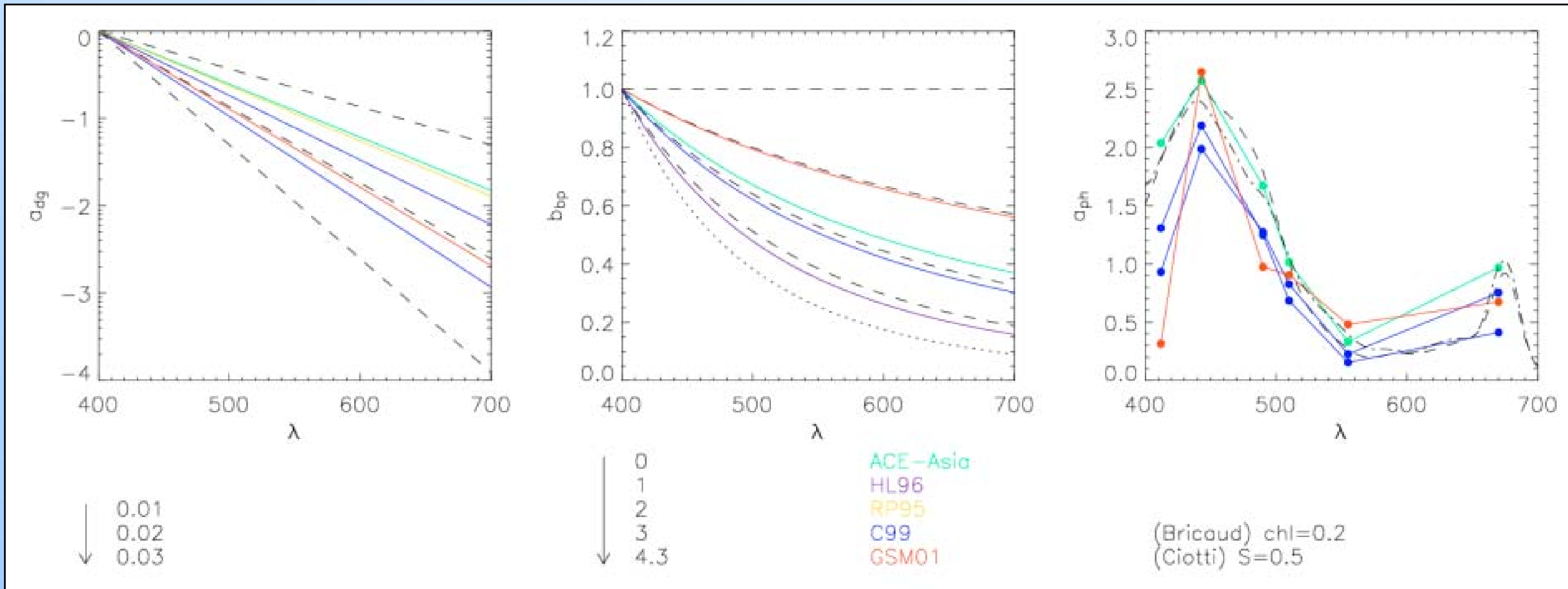
literature review suggests that almost all semi-analytic algorithms adopt such a formulation, with minor variation

Roesler and Perry (1995), Hoge and Lyon (1996), Garver and Siegel (1997), Carder et al. (1999), Reynolds et al. (2001), Lee et al. (2002), Maritorena et al. (2002), Roesler and Boss (2003)

fourth "input" is inversion method:
e.g., matrix, nonlinear minimization, linear solution

$\hat{a}_\phi$

Looking forward



Looking forward

reiterate the need for future studies and sensitivity analyses to focus on basis vectors and inputs: S, $\hat{a}_{\phi}$, v_{bp}, and inversion choice

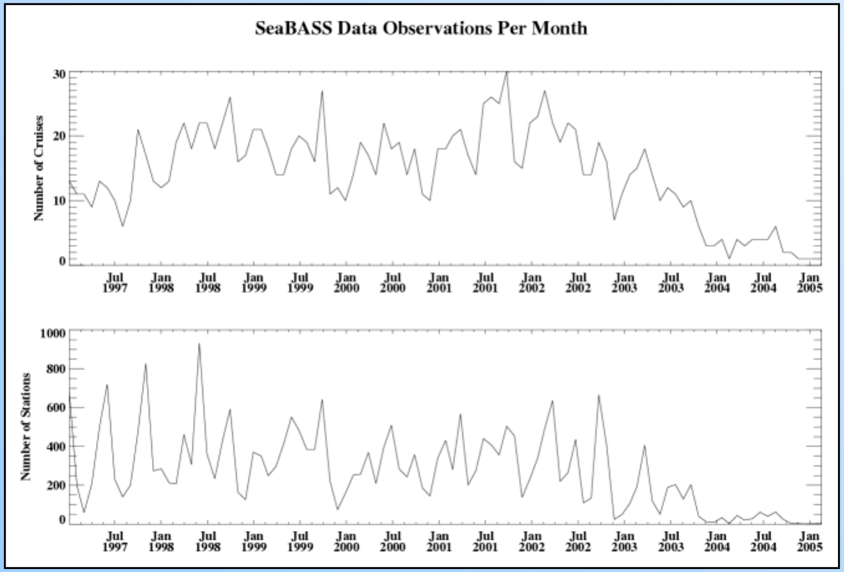
to that end, the OBPG has:

several preliminary sensitivity analyses to share,
despite “few” complete data set within NOMAD

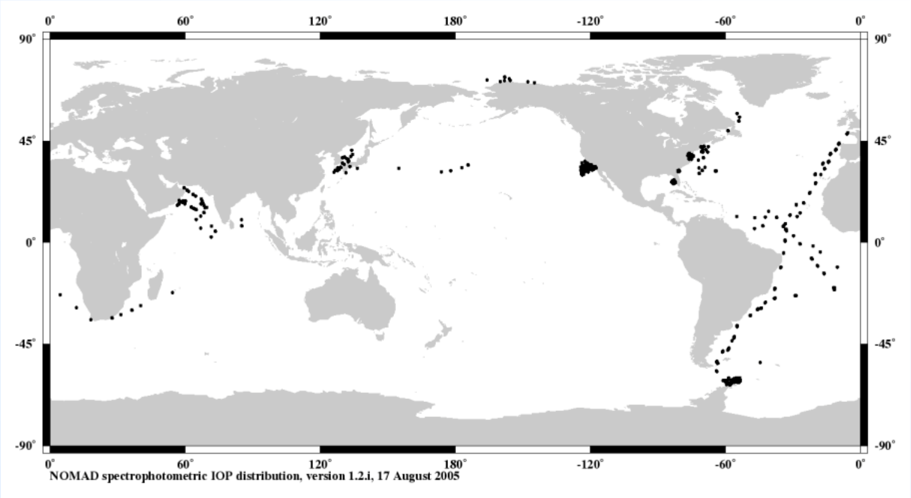
plans to update *msl12* with the ability to generalize semi-analytic model selection (think “build your own”) for IOP retrievals

Expanding NOMAD

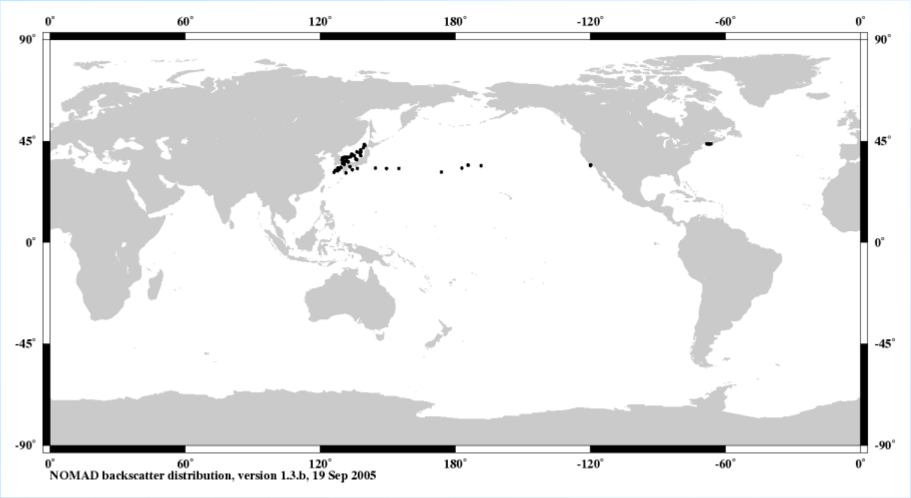
1. limited number of IOP's
2. declining rate of data submission



coincident $C_a + a(\lambda)$

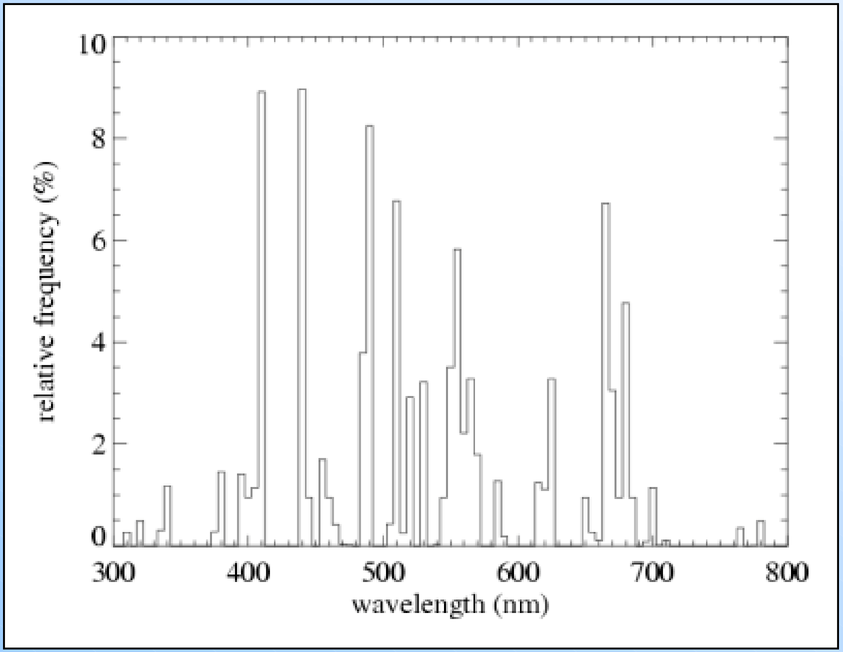


coincident $C_a + b_b(\lambda)$



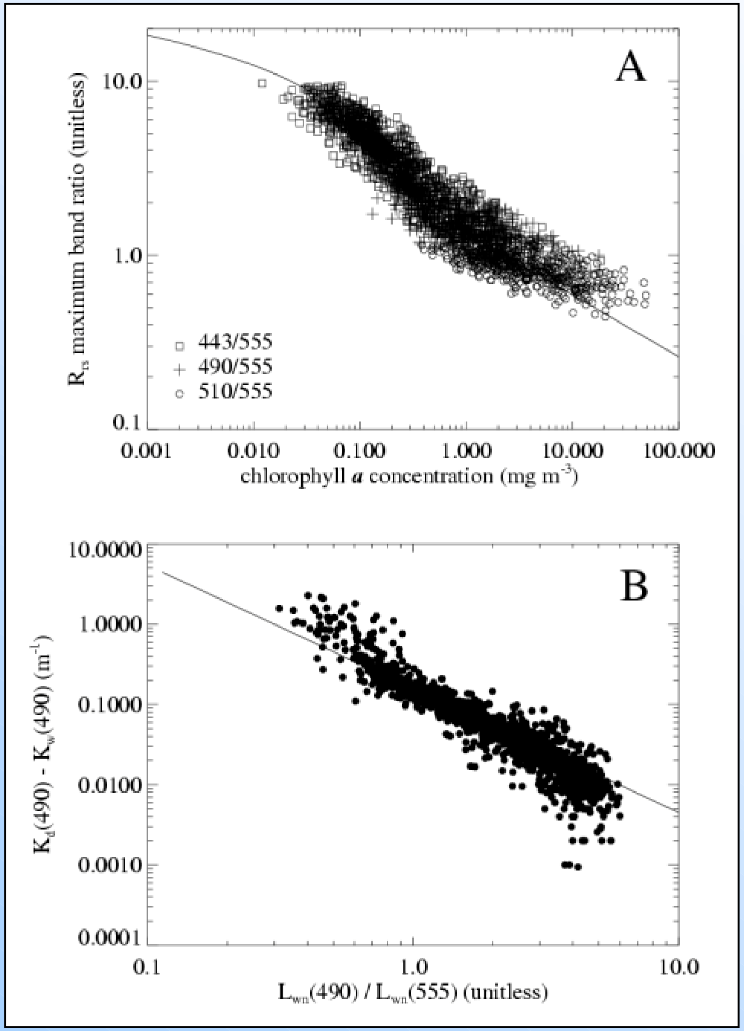
EXTRA SLIDES

Wavelength selection

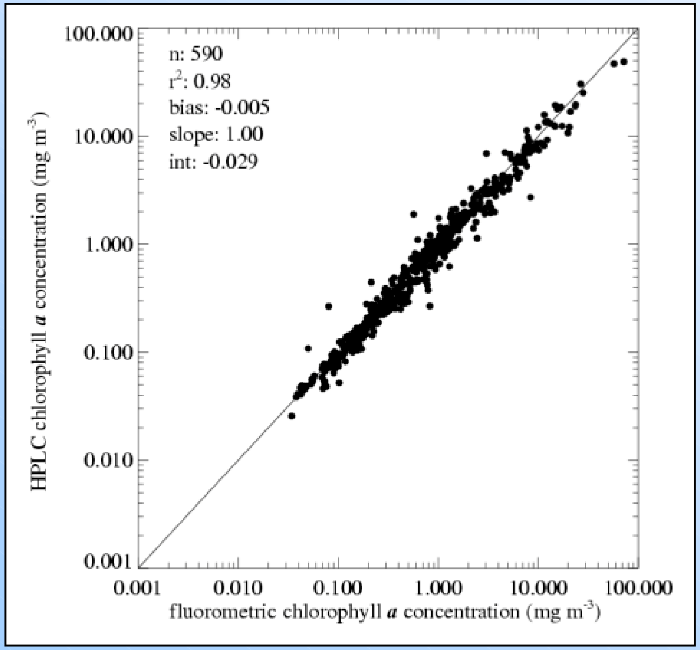


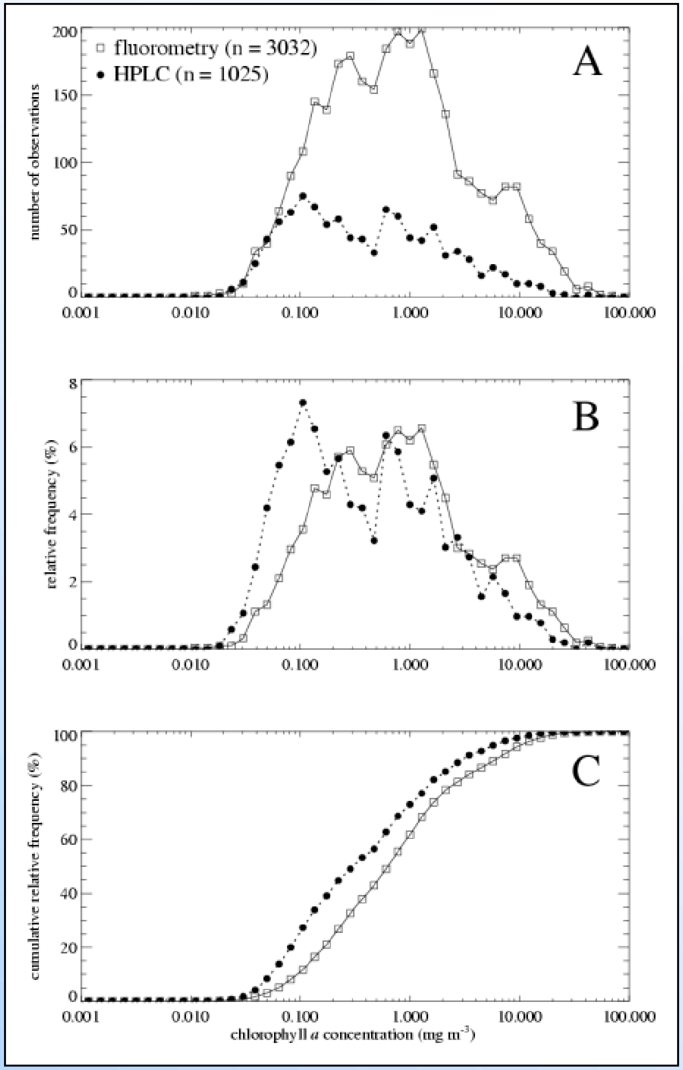
wavelength	frequency	heritage
405	2.5	MOS*
411	99.5	OCTS, SeaWiFS, MODIS, MERIS, VIIRS
443	99.9	CZCS, OCTS, MOS, SeaWiFS, MODIS, MERIS, VIIRS
455	15.8	
465	3.8	
489	100.0	OCTS, MOS*, SeaWiFS, MODIS, MERIS, VIIRS
510	75.8	SeaWiFS, MERIS
520	42.6	CZCS, OCTS, MOS
530	34.9	MODIS
550	21.7	CZCS, MODIS
555	70.0	SeaWiFS, VIIRS
560	21.7	MERIS
565	46.2	OCTS
570	18.9	MOS
590	13.5	
619	17.2	MOS*, MERIS
625	43.5	
665	59.0	MODIS, MERIS
670	27.4	CZCS, OCTS, SeaWiFS, VIIRS
683	45.5	MOS, MERIS

Bio-optical relationships

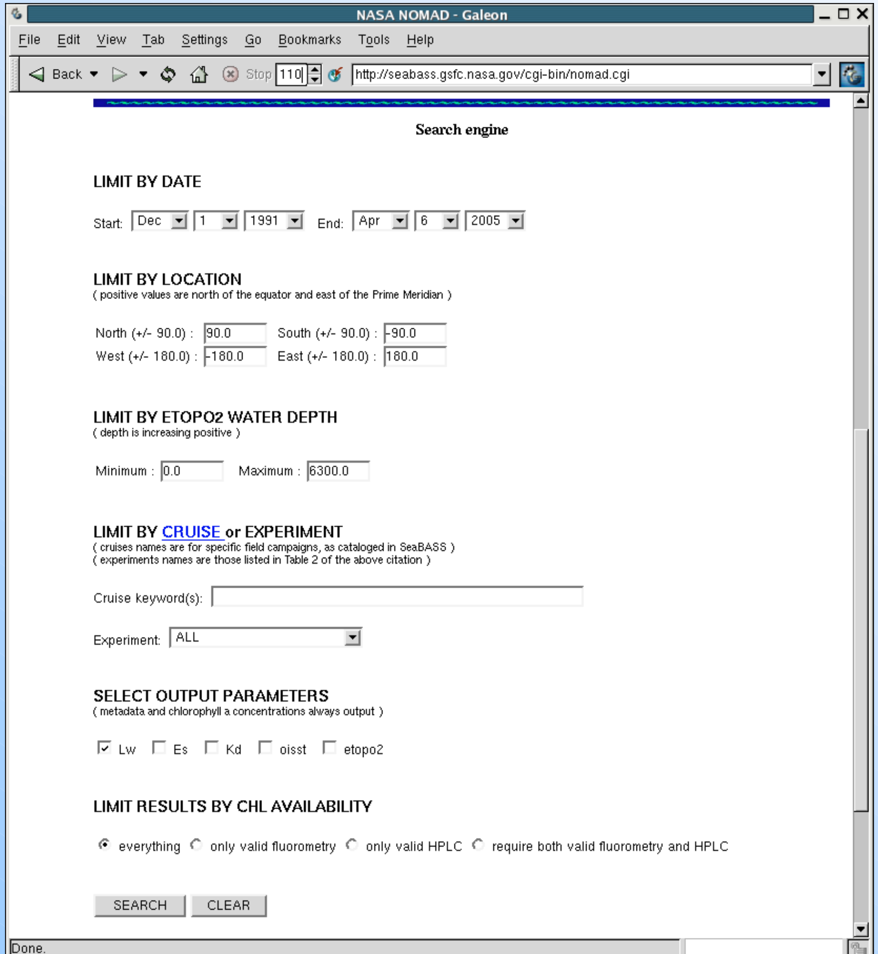


C_a distribution





Features & distribution



<u>provides access to:</u>

full data set in a single file
search engine
recommended acknowledgements
pre-print of *RSE* manuscript

<u>limit queries by:</u>

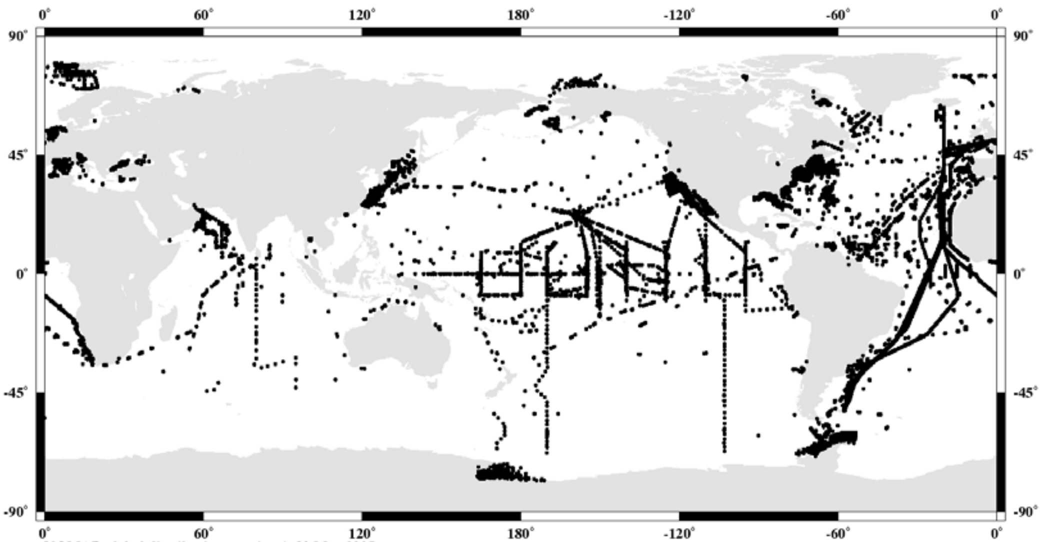
date
location
water depth
cruise & experiment
C_a availability

<u>user-defined output products:</u>

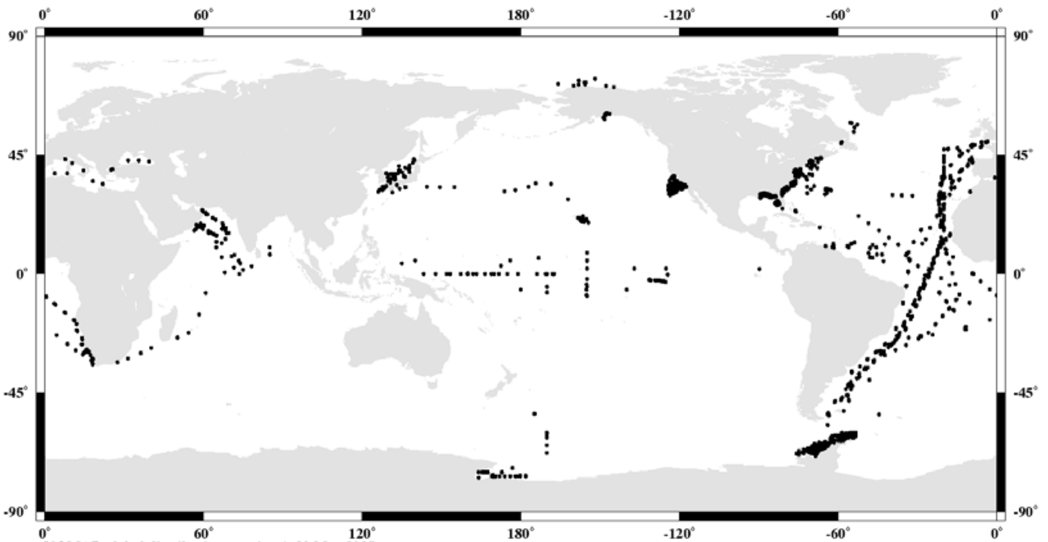
$L_w(\lambda)$, $E_s(\lambda)$, $K_d(\lambda)$, oisst, etopo2
C_a always output

http://seabass.gsfc.nasa.gov/cgi-bin/nomad.cgi

Maps



NOMAD global distribution, version 1, 30 Mar 2005



NOMAD global distribution, version 1, 30 Mar 2005