A Combination of Measurement Strategies Elucidates Rare Events along Line P

Roberta Hamme
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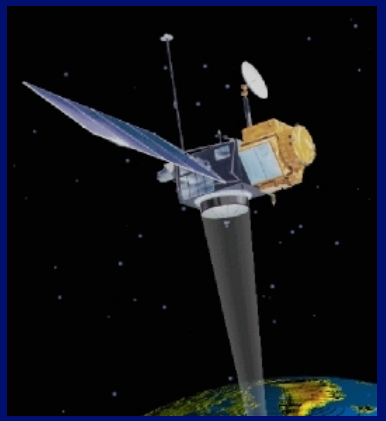
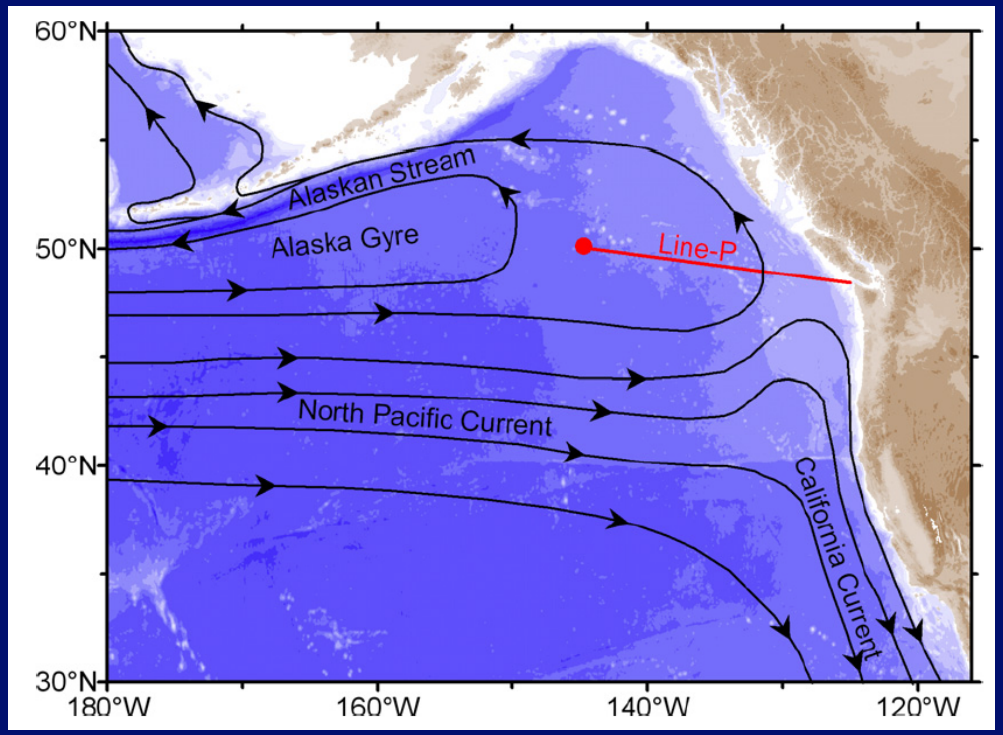


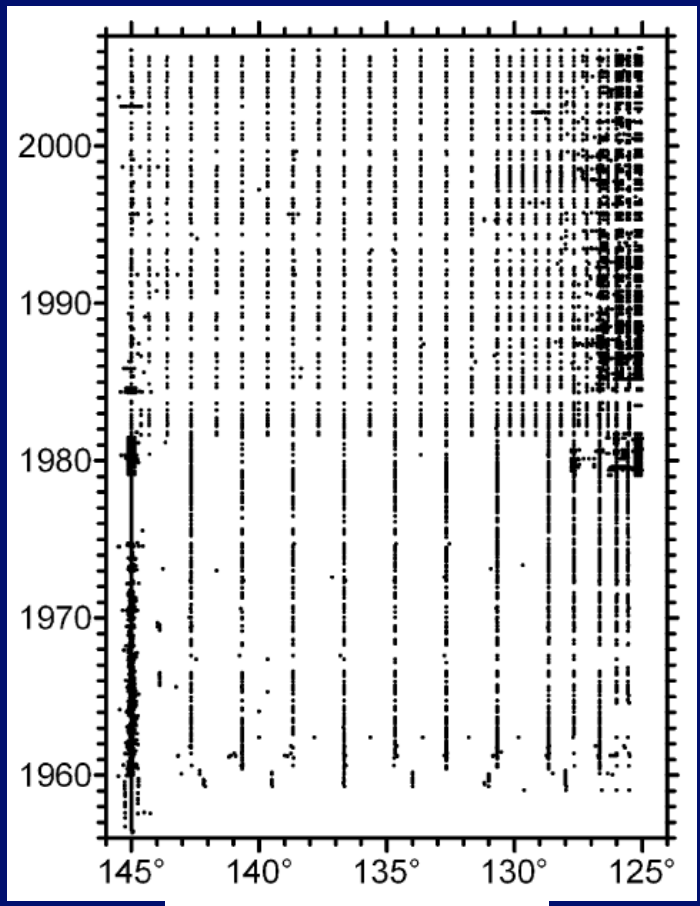
Line P / Station Papa

1949 – Bathythermograph obs begin, 1956 - hydrography

Mooring – 2007 to present

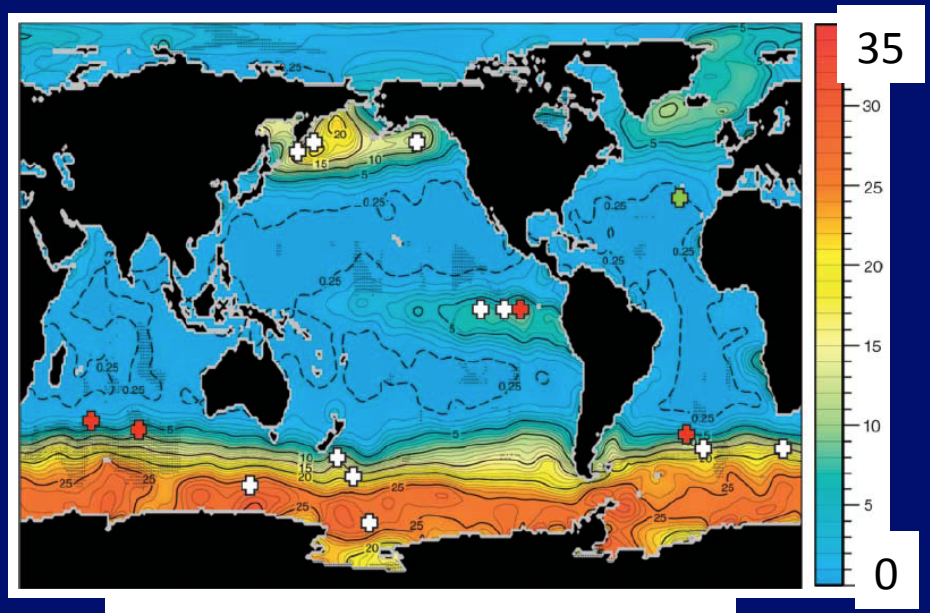


(Freeland 2007 Prog. Oceanogr.)



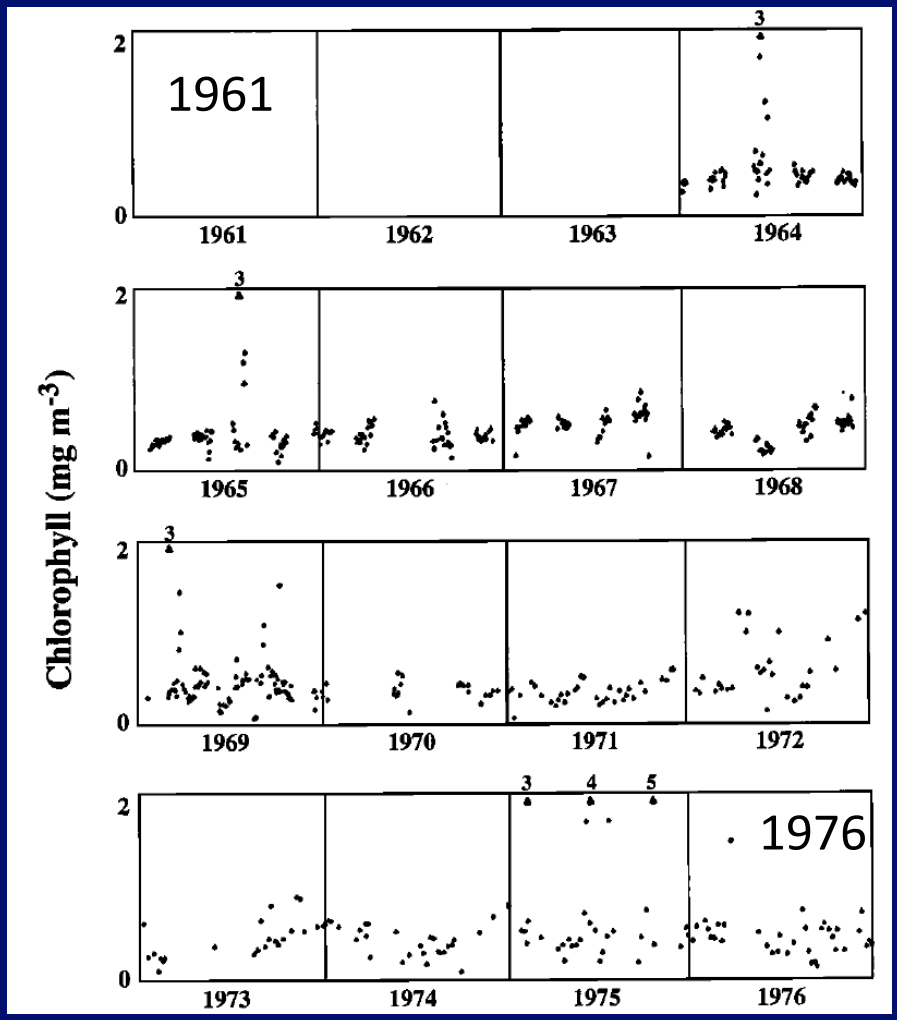
HNLC Region

Large phytoplankton iron limited, periodic bloom events



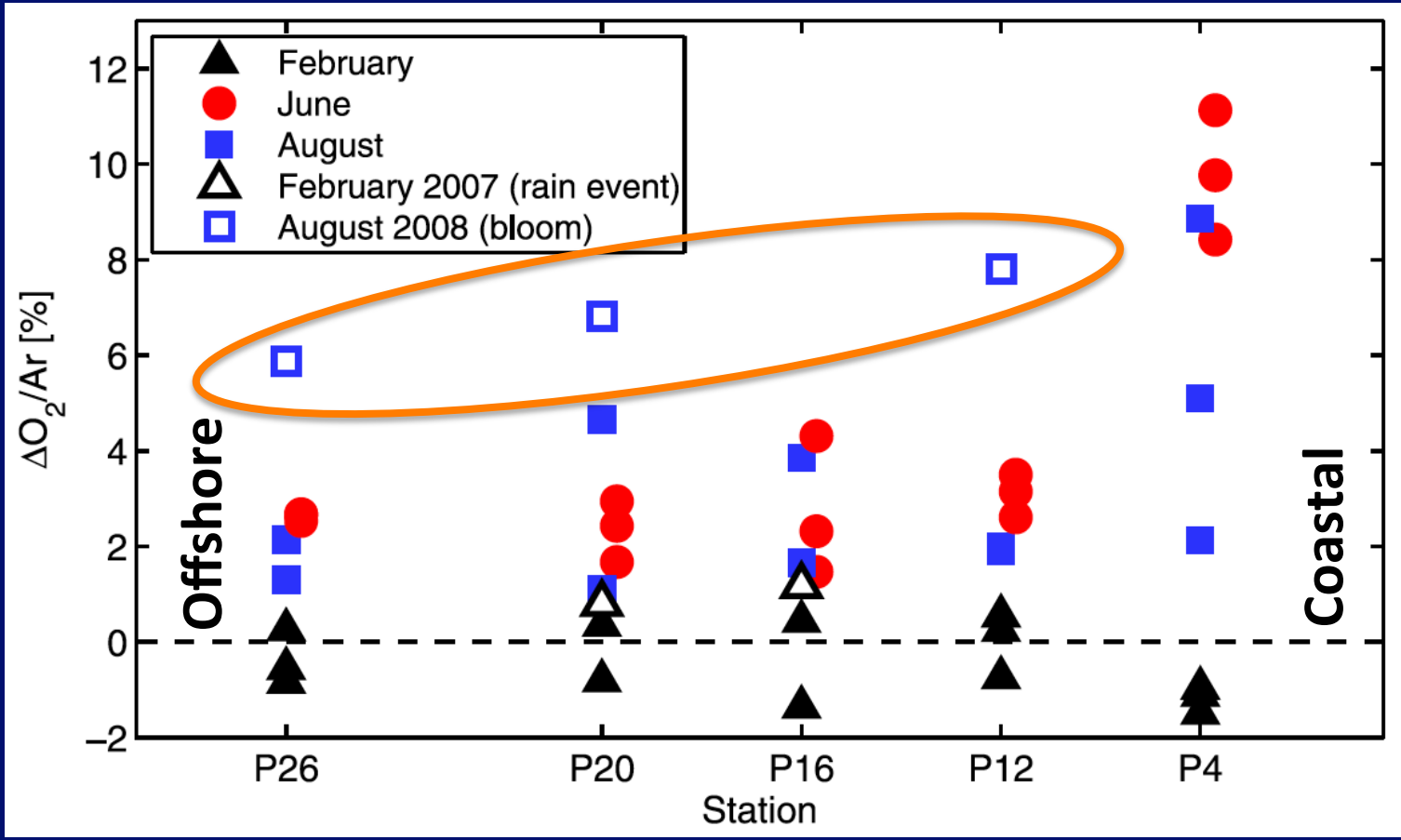
Annual mean Nitrate (umol/L)

Boyd et al. 2007 Science



Boyd et al. 1998 Global Biogeochem. Cycles
Reprinted from Parslow 1981 PhD thesis

Biological oxygen supersaturation (2007-2009) - high Aug 2008



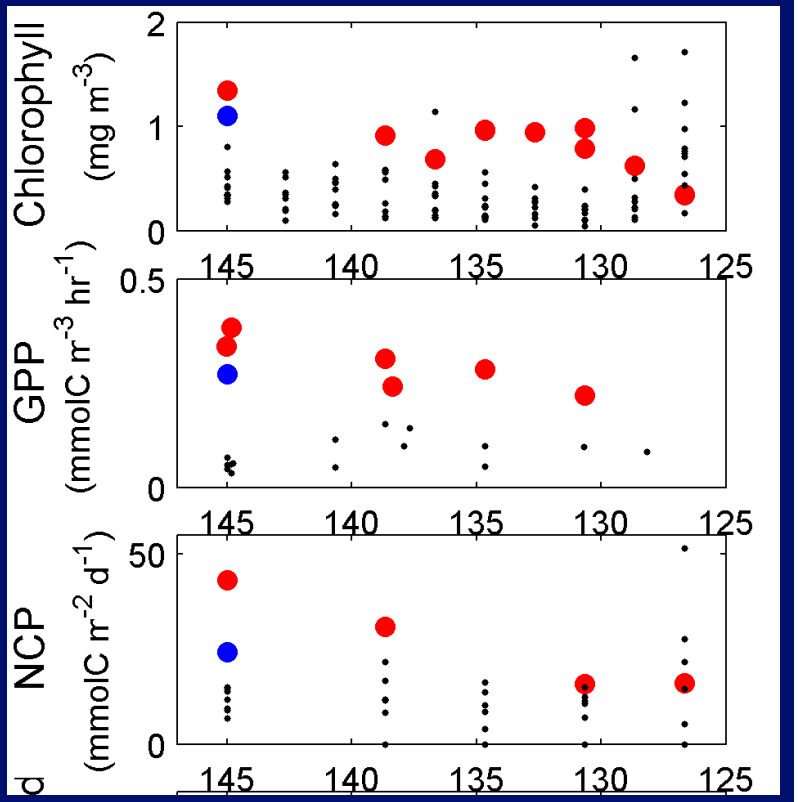
(Giesbrecht et al. 2012 Global Biogeochem. Cycles)

Shipboard observations demonstrate bloom conditions in Aug 2008

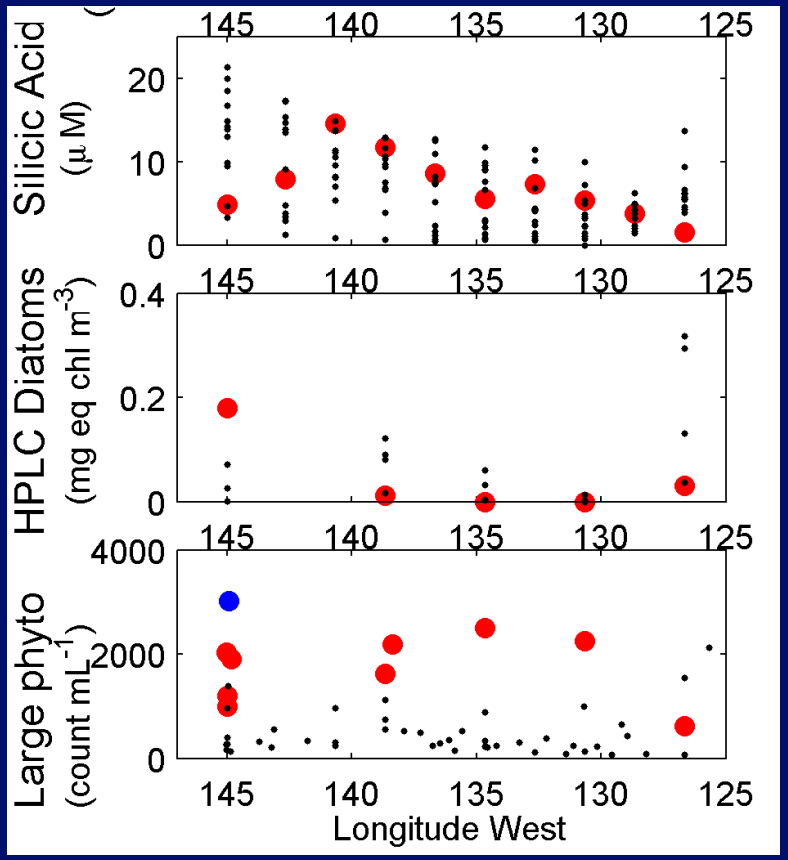
R. Hamme
K. Giesbrecht
D. Lockwood

M. Kavanaugh

Line P
F. Whitney



(Hamme et al. Geophys. Res. Lett.)

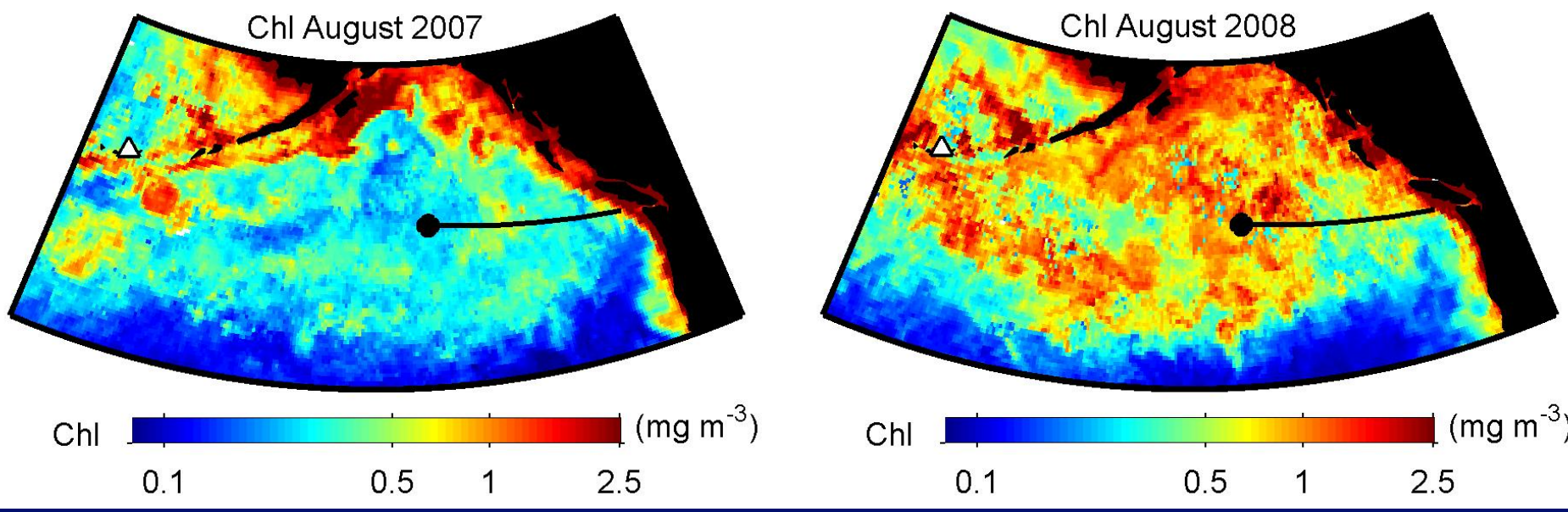


Line P
F. Whitney

M.A. Peña

M. Kavanaugh

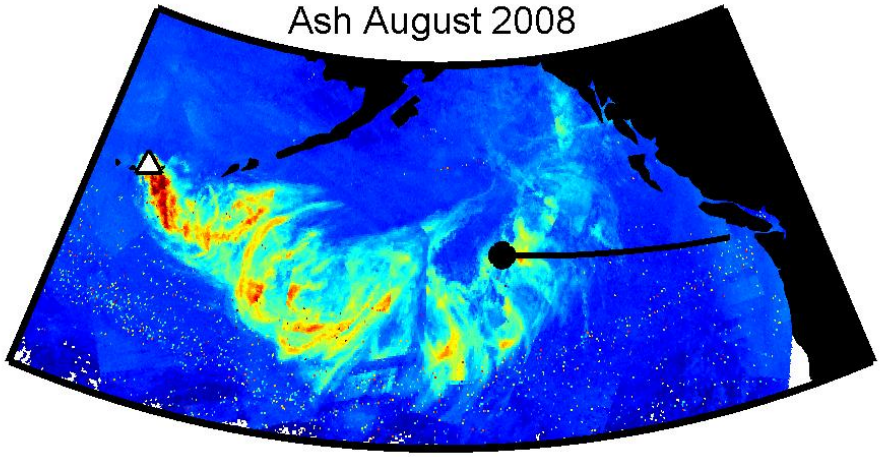
Satellite chlorophyll demonstrates Aug 2008 bloom widespread

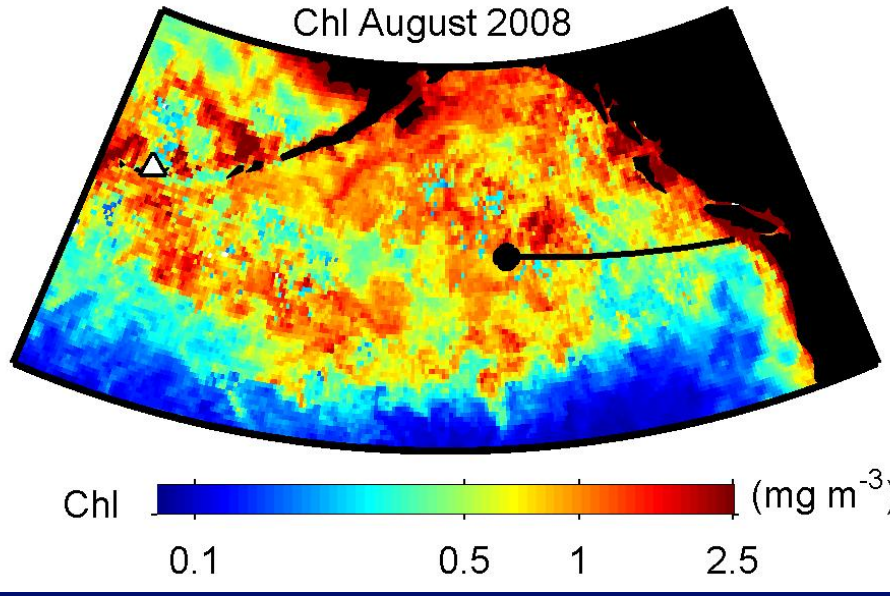


MODIS Aqua chlorophyll
(modified from Hamme et al. Geophys. Res. Lett.)

Ash dispersal matches chlorophyll extent fairly well

Kasatochi erupted directly into a forming storm system





Kasatochi Aug 10, 2008

NOAA AVHRR Brightness Temp Diff
Ash: Peter Webley (University of Alaska Fairbanks)

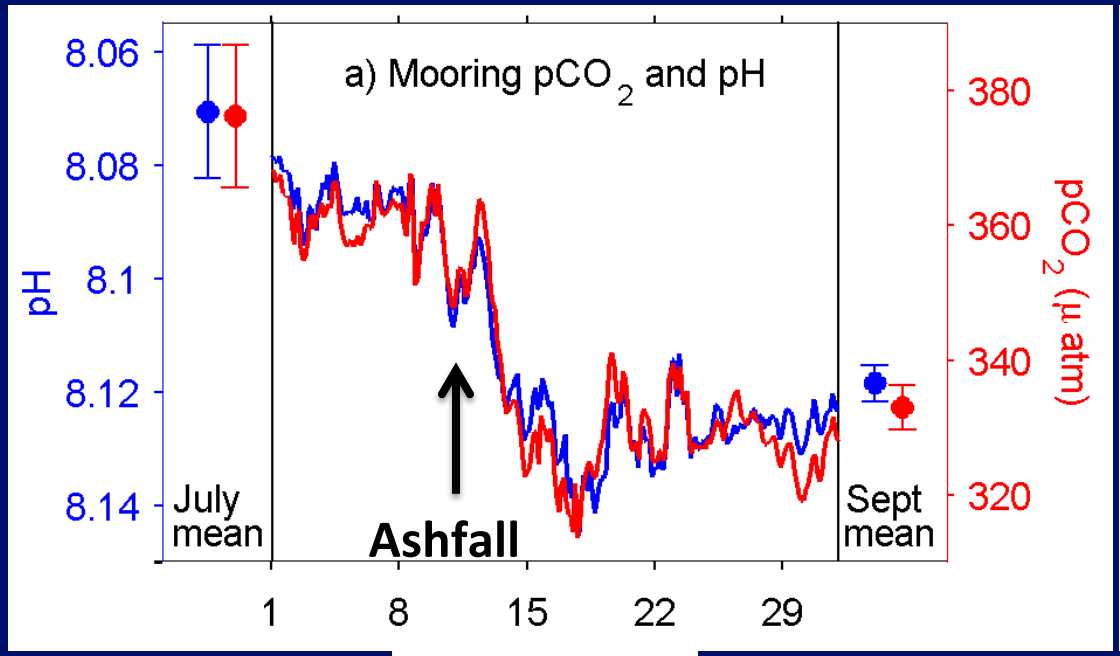
NASA MODIS Aqua chlorophyll

(modified from Hamme et al. Geophys. Res. Lett.)

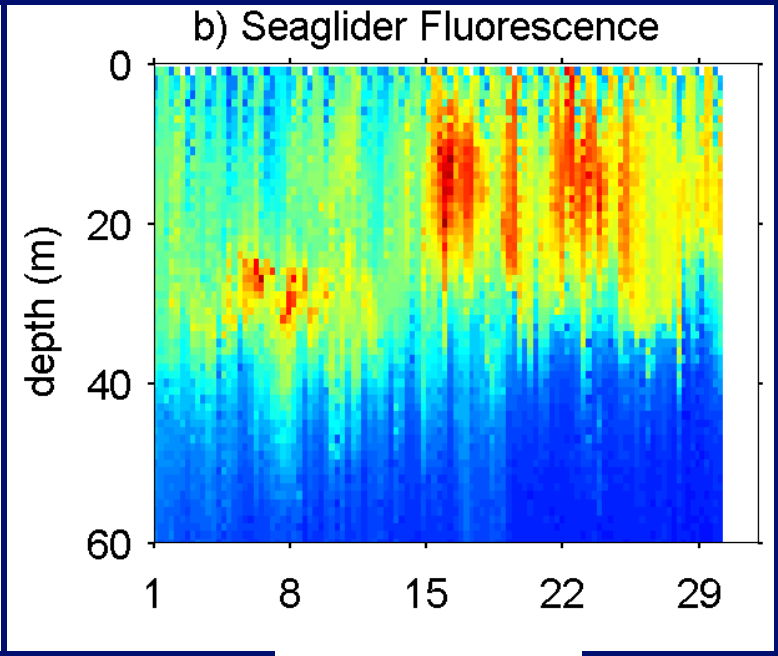
Mooring and glider data demonstrate timing of bloom

Changes begin ~2 days after ashfall, largest change within 7 days

Ocean Carbon uptake ~ 0.01 Pg C



Chris Sabine, Mike DeGrandpre, Steve Emerson



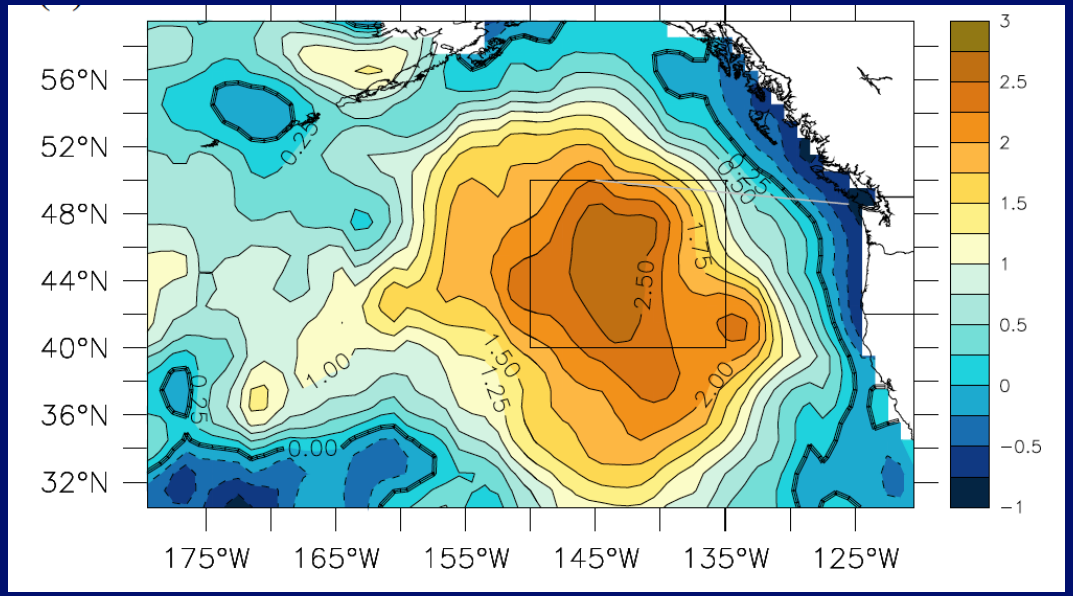
Charlie Eriksen

(Hamme et al. Geophys. Res. Lett.)

“The Blob” – Anomalously warm N Pacific SST

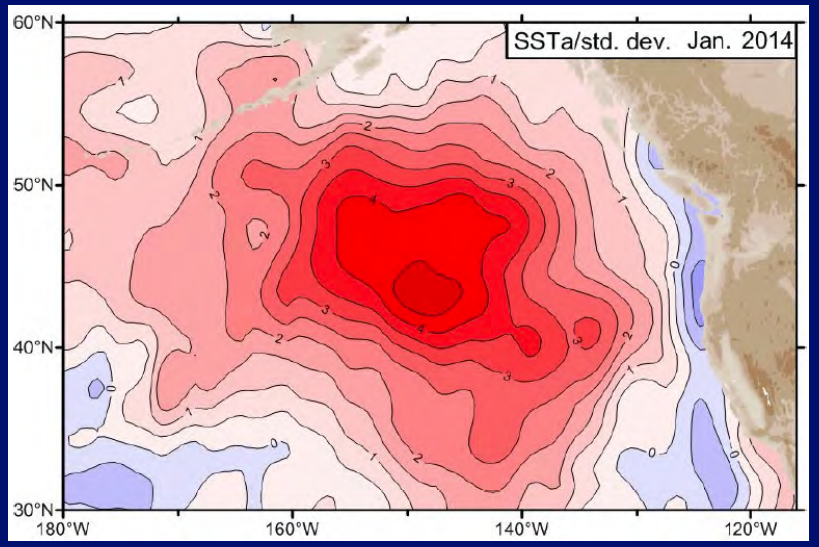
High SLP suppressed wind stress and winter heat loss

Feb 2014 SST anomaly (°C) from NCEP GODAS relative to 1981-2010 mean



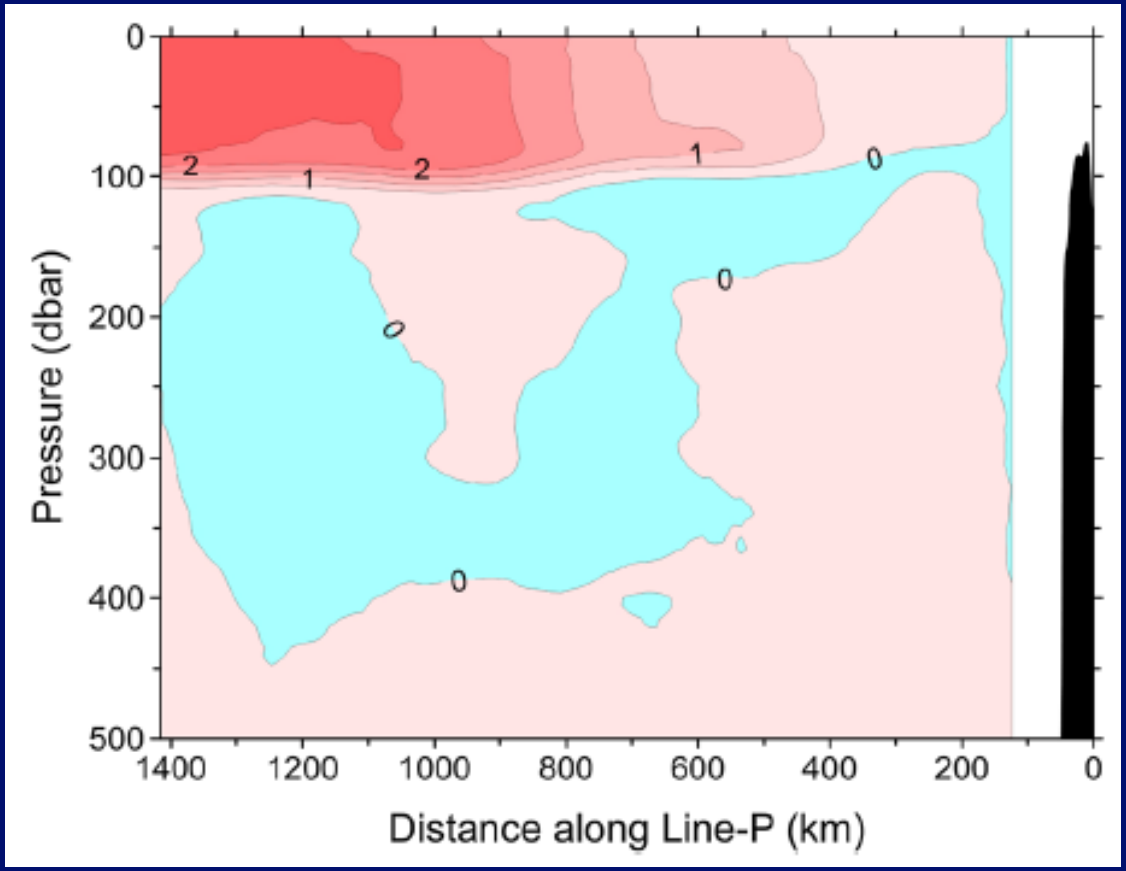
(Bond, Cronin, Freeland, Mantua (2015) Geophys. Res. Lett.)

Jan 2014 SST anomaly (std dev) from NOAA OIv2 relative to 1981-2013 mean



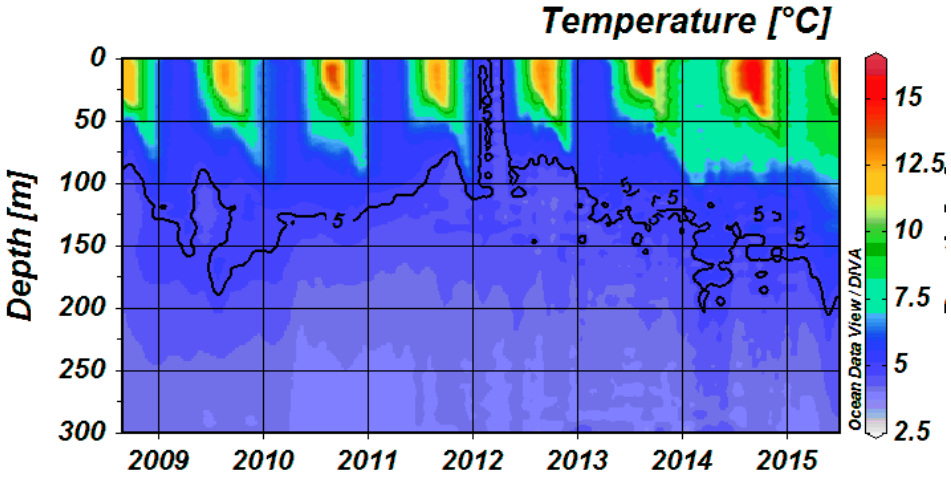
(Freeland (2014) CMOS Bulletin)

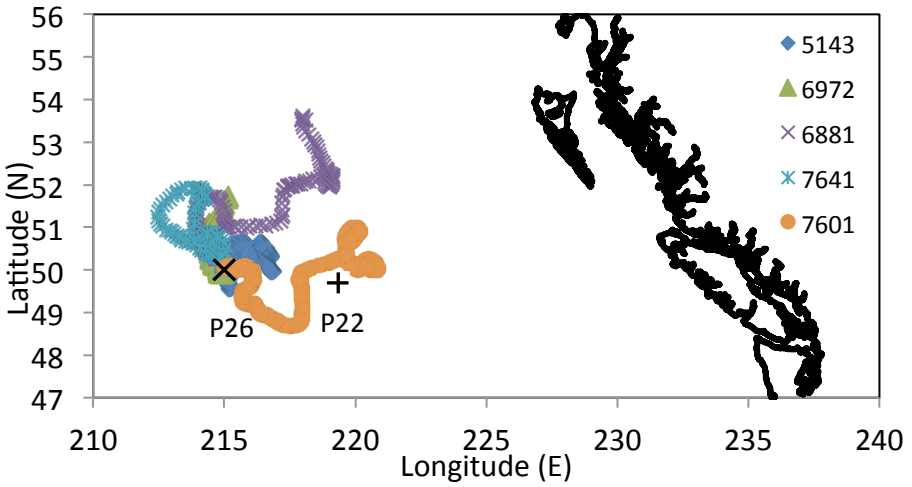
February 2014 Argo temperature interpolated onto Line P minus Line P 1956-1991 mean



(Bond, Cronin, Freeland, Mantua (2015) Geophys. Res. Lett.)

Biogeochemical floats show anomalously low nitrate in Blob

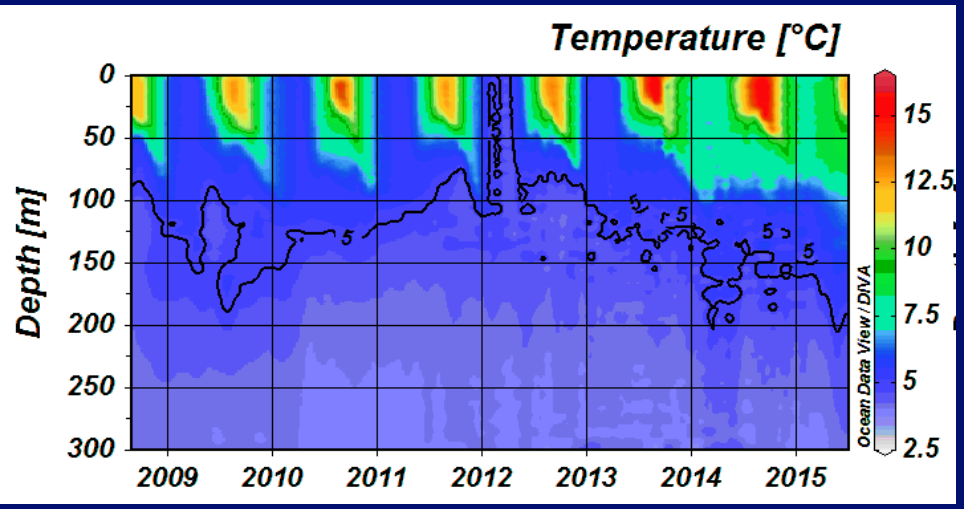


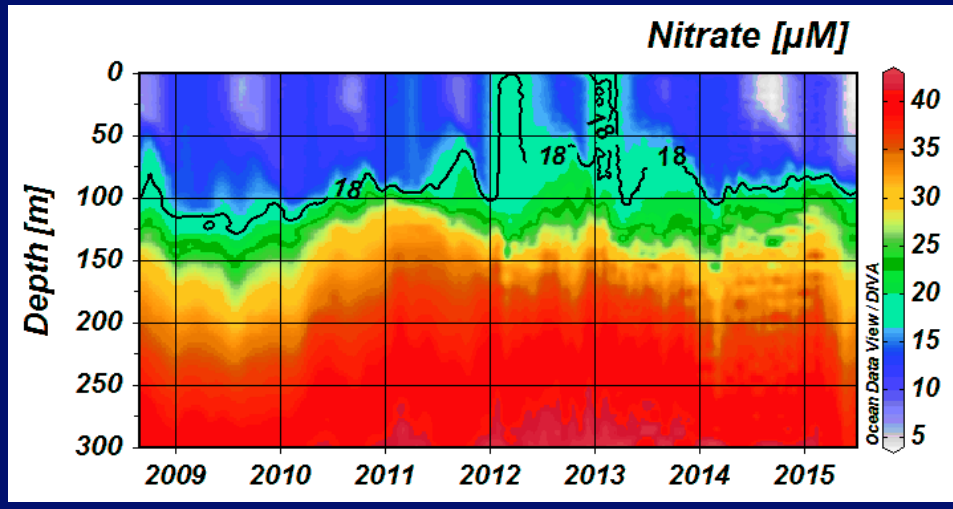


Data figures from Ken Johnson (MBARI) extended from Johnson, Coletti, Jannasch, Sakamoto, Swift, Riser (2013) JTECH

Map by Frank Whitney (IOS-DFO)

Biogeochemical floats show anomalously low nitrate in Blob

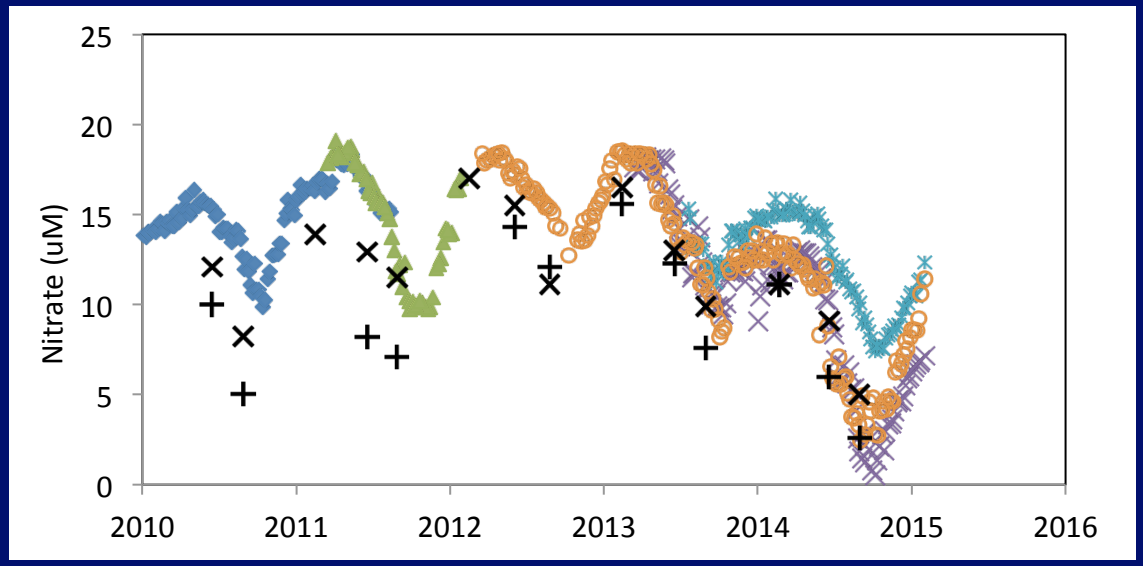




Data figures from Ken Johnson (MBARI) extended from Johnson, Coletti, Jannasch, Sakamoto, Swift, Riser (2013) JTECH

Biogeochemical floats show anomalously low nitrate in Blob

Must calibrate float nitrate to shipboard measurements
Also shipboard nitrate provides longer timescale context



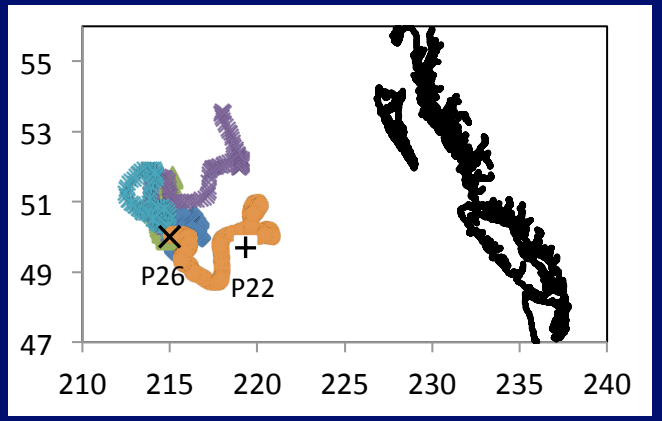


Figure / compilation by Frank Whitney (IOS-DFO) from data by Ken Johnson (MBARI) and Marie Robert (LineP, IOS-DFO)

Papa mooring: 7 years surface pCO_2 and pH measurements

Fassbender, Sabine, Cronin (2015) submitted to Global Biogeochem. Cycles
Fassbender (2014) PhD thesis

Alkalinity – Salinity Relationship based on CLIVAR

Fassbender, Sabine, Cronin (2015) submitted to Global Biogeochem. Cycles
Fassbender (2014) PhD thesis

Alk–S Relationship performs better than Lee algorithm
Calculated DIC matches in situ samples well

Fassbender, Sabine, Cronin (2015) submitted to Global Biogeochem. Cycles
Fassbender (2014) PhD thesis

Productivity derived from carbon mass balance

Fassbender, Sabine, Cronin (2015) submitted to Global Biogeochem. Cycles
Fassbender (2014) PhD thesis

Conclusions

- Autonomous and Shipboard measurements build on each other synergistically
- Shipboard Line P meas provide measurements that cannot be made by autonomous sensors, long time history for comparison, calibration of deployed sensors, and proxy relationships for interpretation
- Autonomous sensors provide high frequency data (timing, event detection, full annual cycle), broader spatial sampling, and independent realizations of phenomena