Ocean Color Climate Records
NASA REASoN CAN

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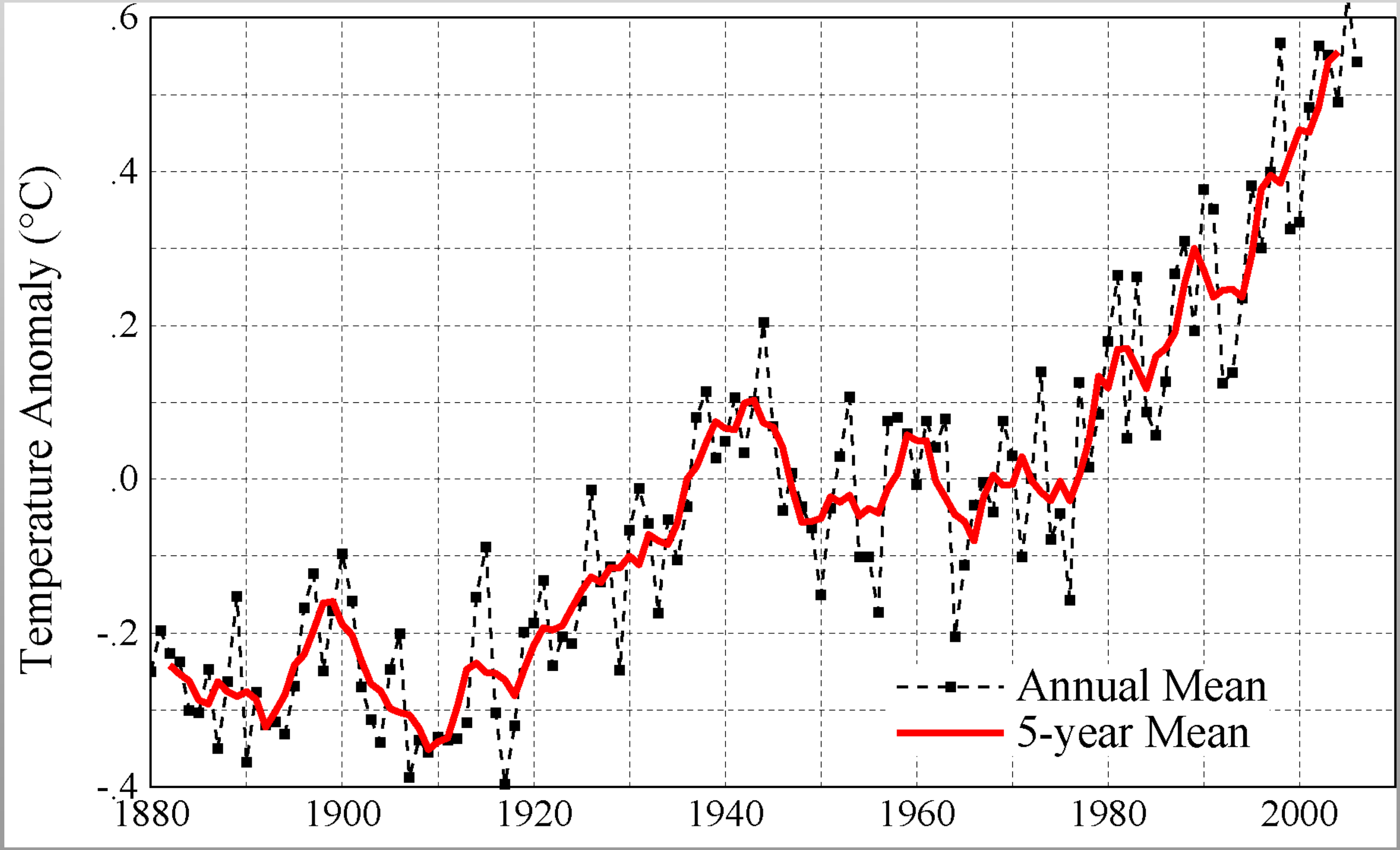
Ocean Color Climate Records

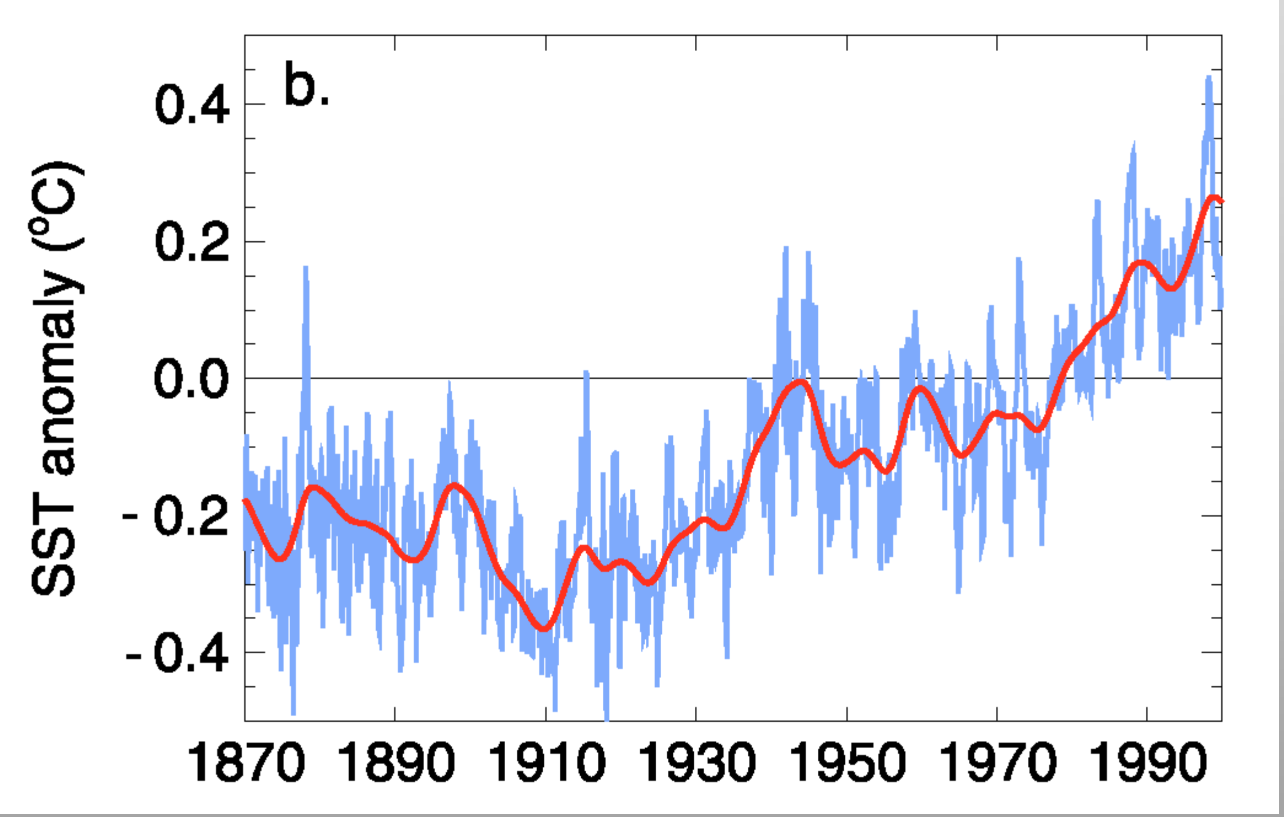
Global Mean Air Temperature:
0.74^{o} increase 1906-2005 (IPCC 2007)



From Hansen et al. 2006, PNAS

SST:

0.2^oC increase 1980-2003 (OISST)



(from Rayner et al 192, JGR)

Does ocean chlorophyll respond?

Does ocean chlorophyll play a role?

Global Trend Analyses

Gregg et al. (2005, GRL): 4% increase 1998-2003 ($P<0.05$)
10% increase on coasts (<200m bottom depth)
No change open ocean

Behrenfeld et al. (2006, Nature): 0.01 Tg integrated chl decrease per year 40^oS to 40^oN, 1999-mid-2006 ($P<0.0001$)
No change poleward of 40^o

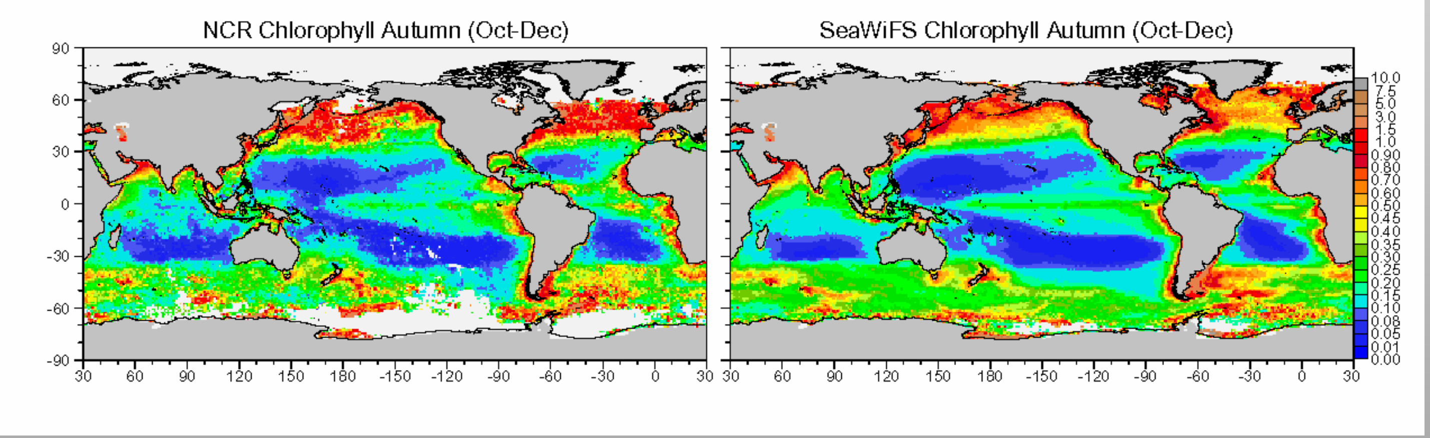
Both used SeaWiFS and matched changes to changes in other climate variables

Longer-Term Global Analyses

Gregg and Conkright (2002, GRL): 6% decline 1980's (CZCS) to 2000's (SeaWiFS)

Entire CZCS record (1979-1986), SeaWiFS (1997-2000)

Open ocean only



Antoine et al. (2005, JGR): 22% increase

CZCS record (1979-1983), SeaWiFS (1998-2002)

Case 1 waters, open ocean only; Maximum 1.5 mg m^{-3}

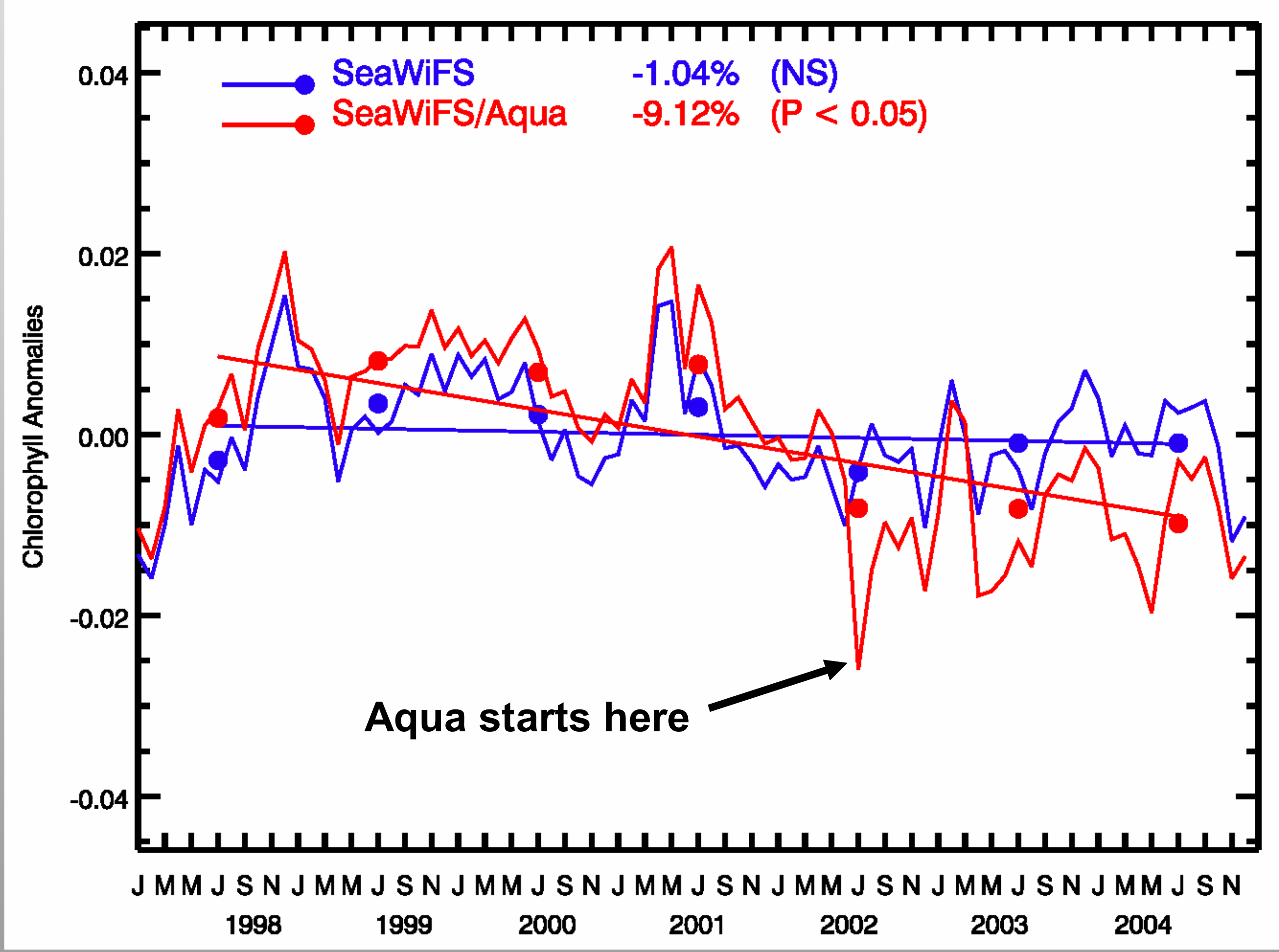
Both used consistent algorithms for CZCS and SeaWiFS

Using a single sensor (SeaWiFS) trends can be reconciled between different approaches/investigators; trends are consistent with climate changes

Changes determined from different sensors are not in agreement, despite consistent processing methodologies across sensors, but reconciliation is possible (confirmation is more difficult)

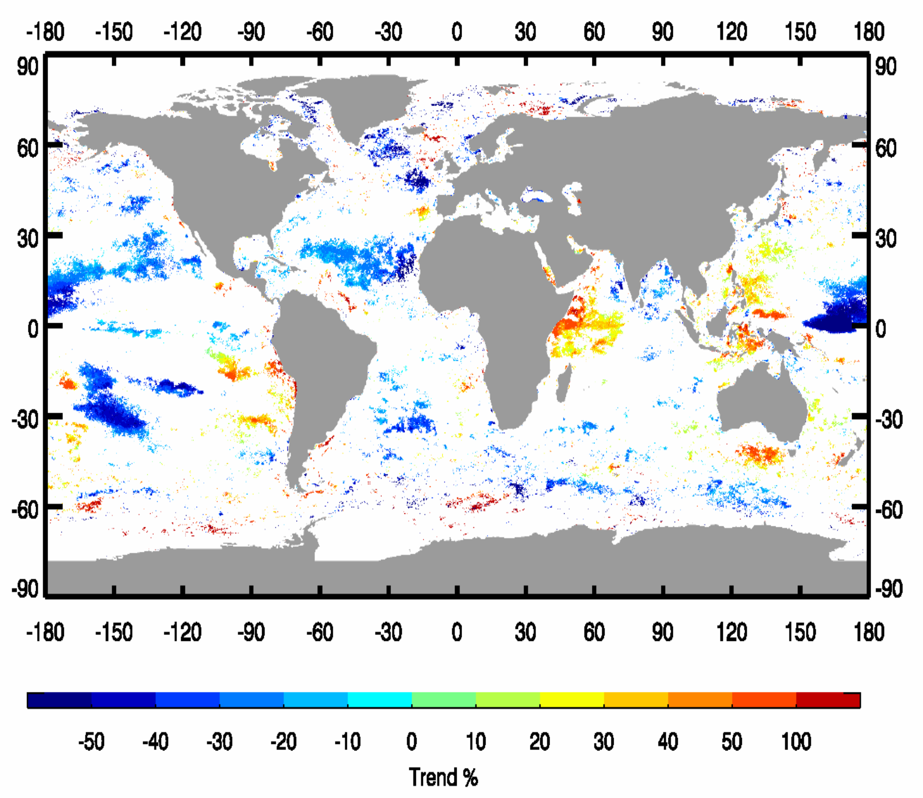
MODIS-Aqua provides a test of the consistent processing/ consistent data assumption: coincident with SeaWiFS

Global Annual Trends using SeaWiFS, and SeaWiFS/Aqua

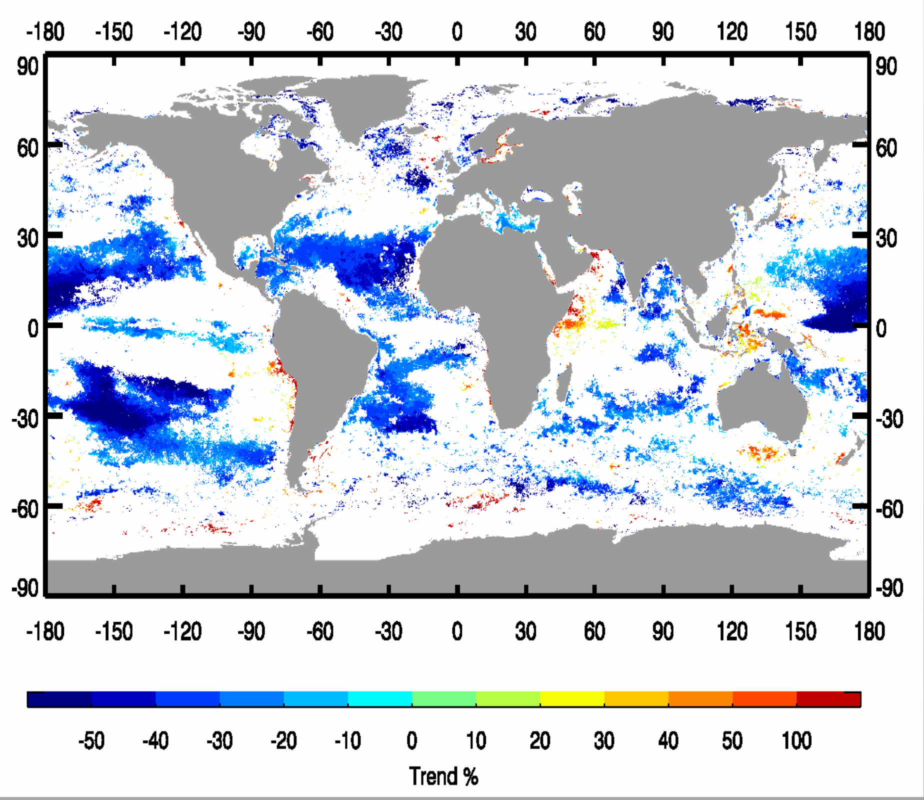


Regional Annual Trends

SeaWiFS



SeaWiFS/Aqua



Linear trends using 7-year average/composite images were calculated, and when significant ($P < 0.05$), shown here.

Maybe there is something different between SeaWiFS and MODIS that is not corrected by consistent processing.

Or maybe consistent processing is not enough.

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Goal:

Provide consistent, seamless time series of Level-3 ocean color data from 1979, with a 9-year gap (1987-1996)

Produce Climate/Earth Science Data Records (CDR/ESDR) of ocean color

Make CDR's available to the public

CDR: A time series of sufficient length, consistency, and continuity to determine climate variability and change
National Research Council, 2004

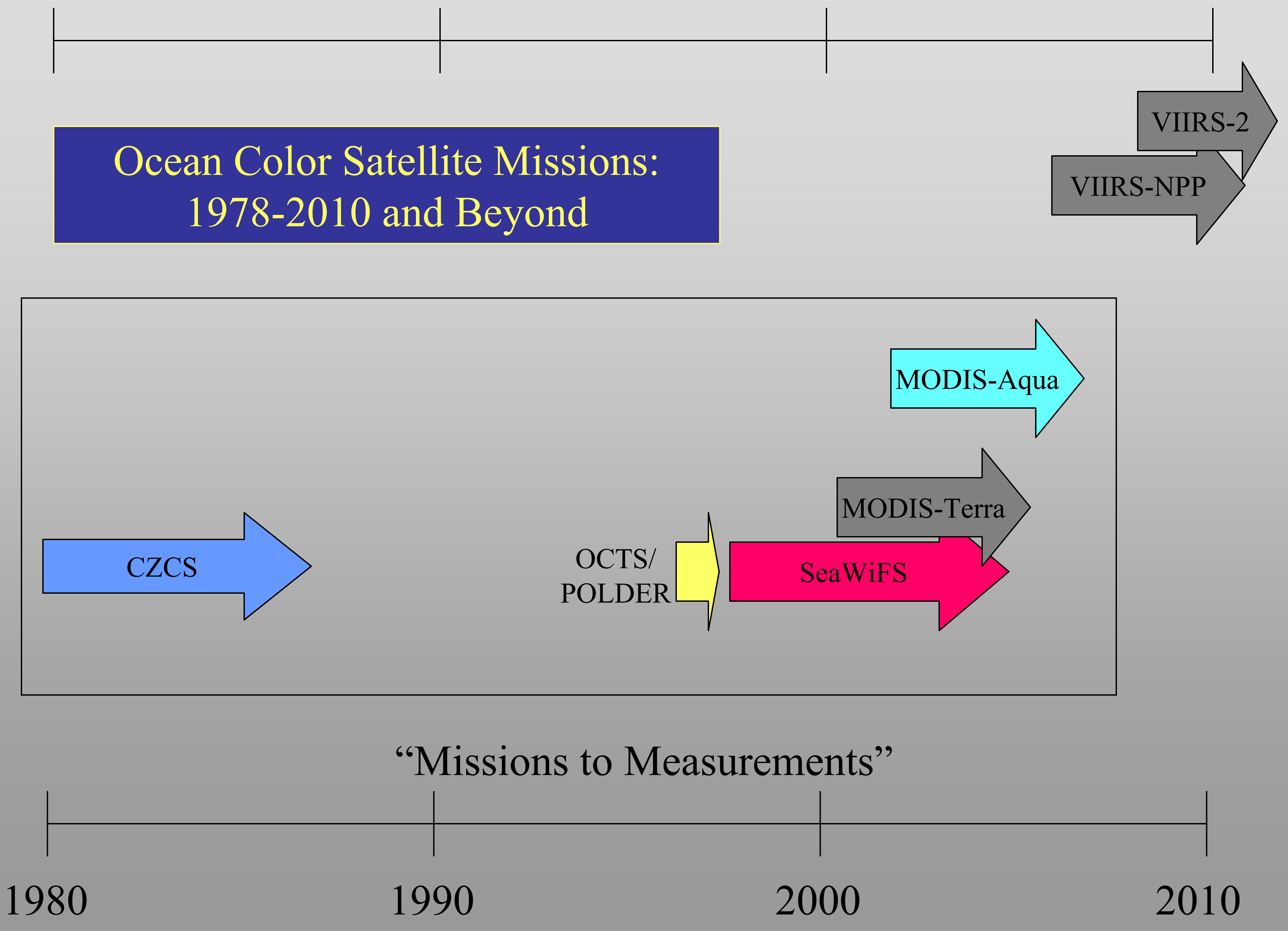
Technical Definition of Consistent/Seamless:

all temporal sensor artifacts removed

no obvious interannual discontinuities unattributable to natural variability

all known mission-dependent biases removed or quantified

similar data quality and structure


Ocean Color Satellite Missions:
1978-2010 and Beyond
VIIRS-2
VIIRS-NPP
MODIS-Aqua
MODIS-Terra
CZCS
OCTS/
POLDER
SeaWiFS
"Missions to Measurements"
1980
1990
2000
2010

New and Post-Processing Enhancements

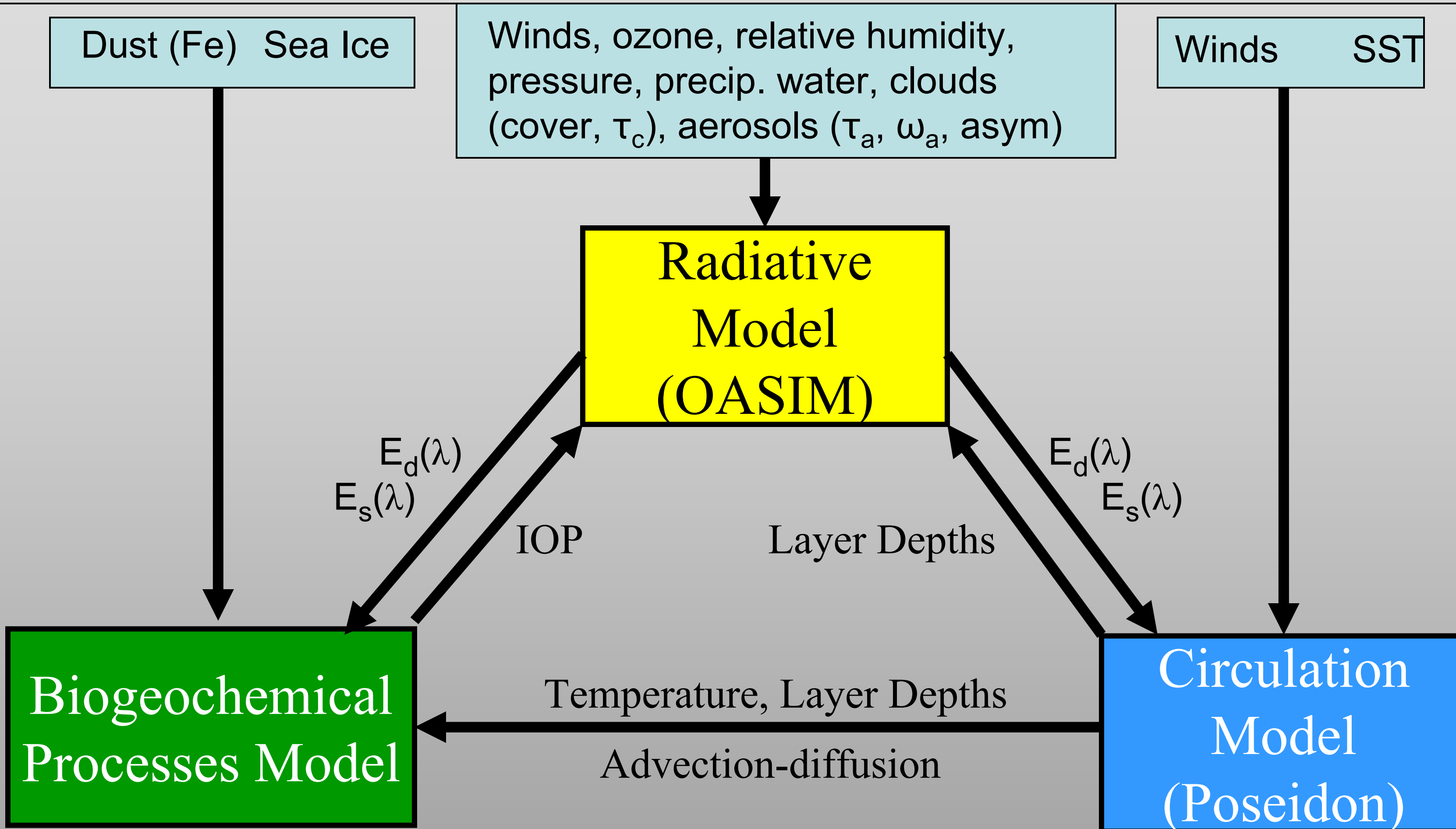
Fine-tune radiance-chlorophyll relationships post-processing
- Correct for residual biases

In situ data blending

Integrate Models
- Aerosols
- Data assimilation

All of the above

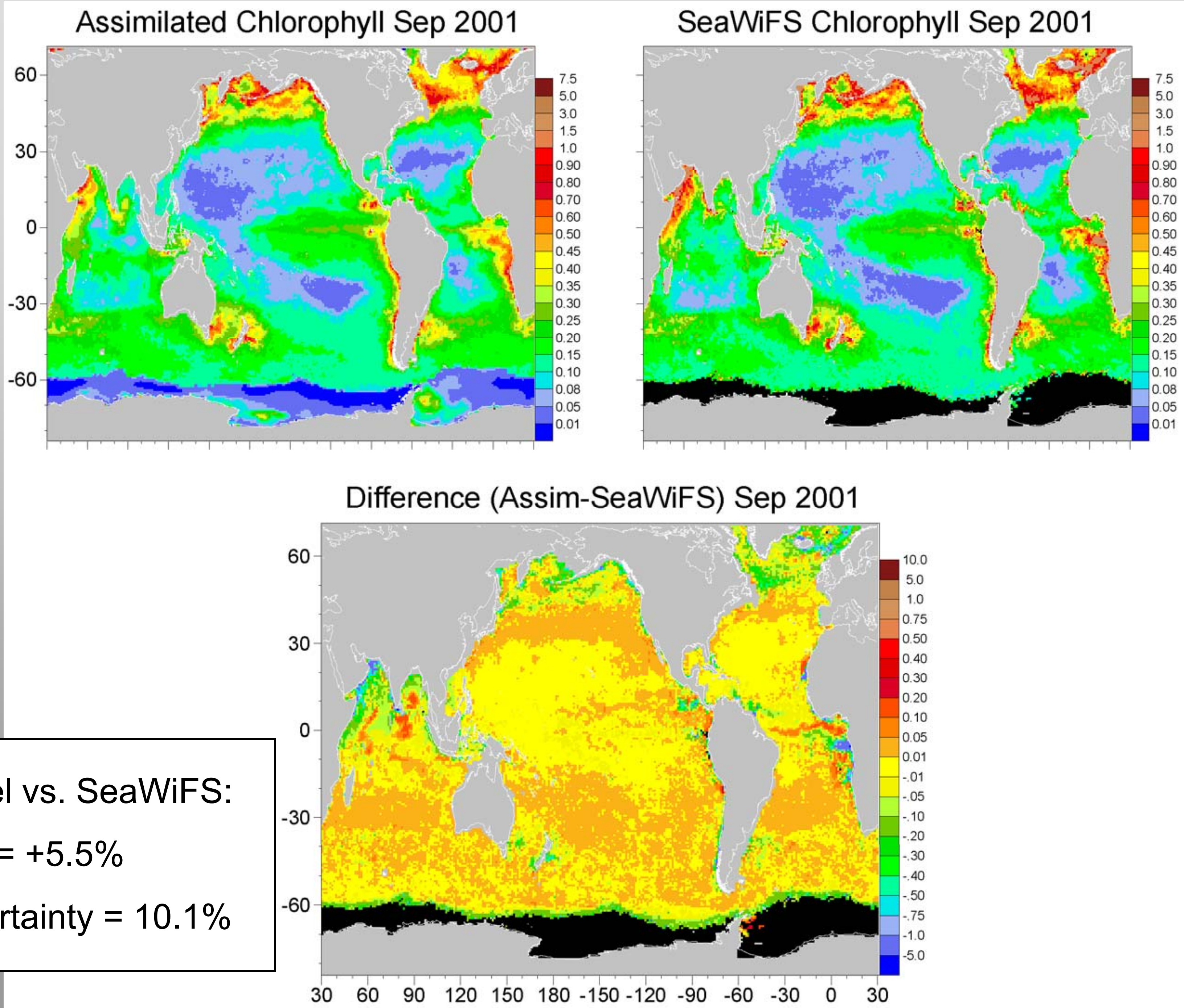
NASA Ocean Biogeochemical Model (NOBM)



Outputs:

Chlorophyll, Phytoplankton Groups
Primary Production
Nutrients
DOC, DIC, pCO_2
Spectral Irradiance/Radiance

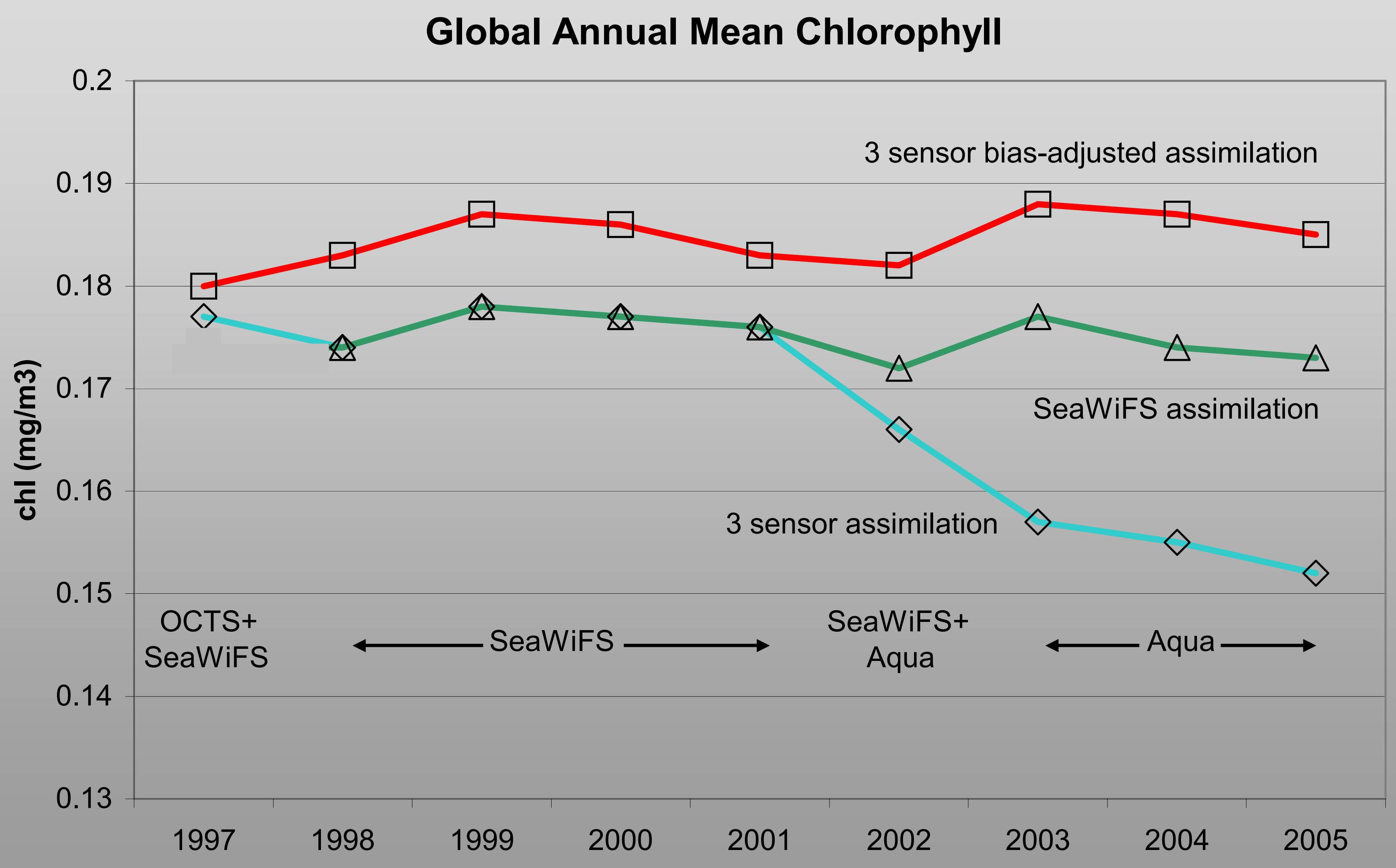
Global model grid:
domain: 84°S to 72°N
1.25° lon., 2/3° lat.
14 layers



Model vs. SeaWiFS:

Bias = +5.5%

Uncertainty = 10.1%



Global Annual Mean Chlorophyll
chl (mg/m3)
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
1997
1998
1999
2000
2001
2002
2003
2004
2005
3 sensor bias-adjusted assimilation
SeaWiFS assimilation
3 sensor assimilation
OCTS+ SeaWiFS
SeaWiFS
SeaWiFS+ Aqua
Aqua

Advantages of Data Assimilation

- Achieves desired consistency, with low bias
- Responds properly to climatic influences
- Full daily coverage – no sampling error
- Effective use of data to keep model on track
- Only spatial variability required from sensors

Disadvantages of Data Assimilation

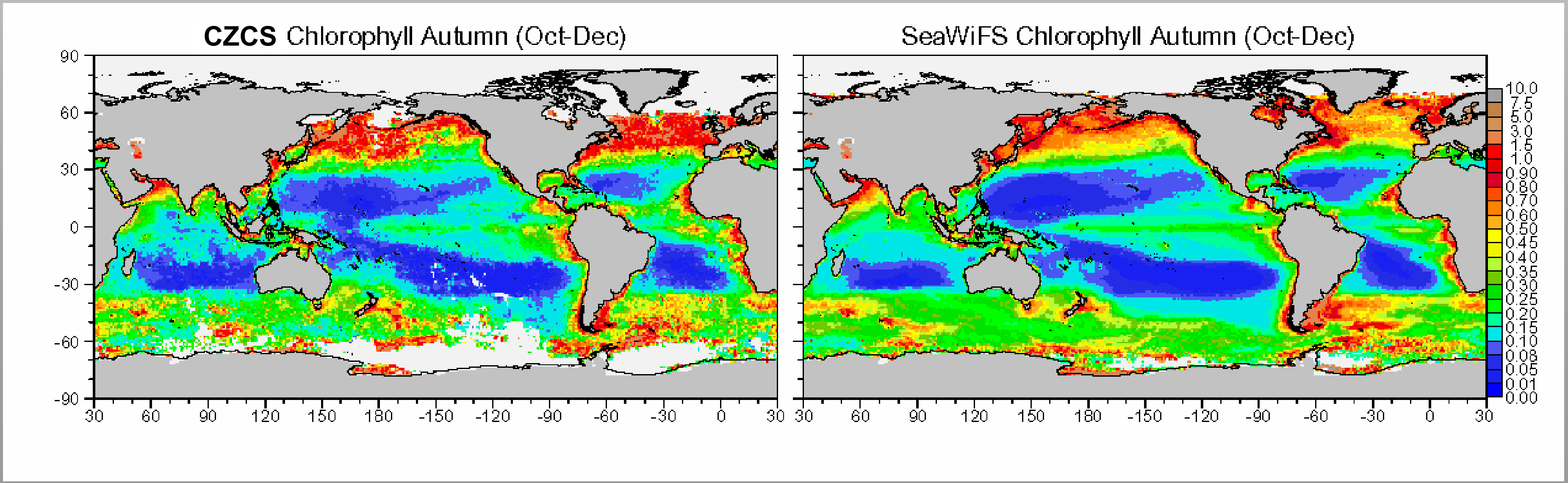
- Low resolution (for now)
- No coasts (for now)
- Excessive reliance on model biases
- Cannot validate model trends with sensor data

Compared to In situ Data

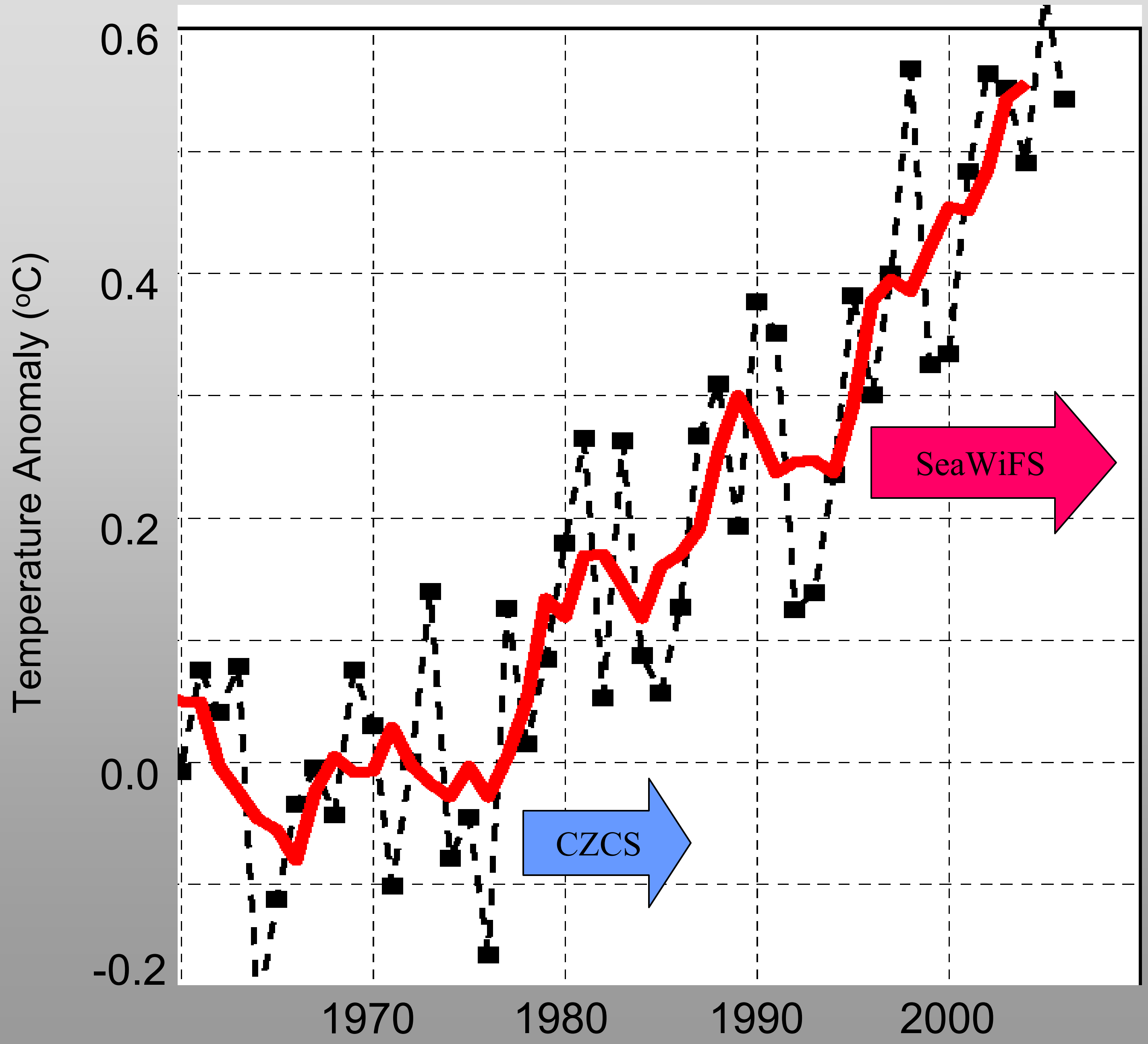
	Bias	Uncertainty	N
SeaWiFS	-1.3%	32.7%	2086
Free-run Model	-1.4%	61.8%	4465
Assimilation Model	0.1%	33.4%	4465

Can the CZCS provide a Climate Data Record?

CDR: A time series of sufficient length, consistency, and continuity to determine climate variability and change
National Research Council, 2004



(from Gregg and Conkright, 2002 GRL)



0.6
0.4
0.2
0.0
-0.2
Temperature Anomaly (oC)
1970
1980
1990
2000
SeaWiFS
CZCS

CZCS Deficiencies

1) Low SNR
Solution: Take mean over 25km

2) 5 bands, only 4 of which quantitatively useful
-- limits aerosol detection capability
Solution: Innovative approaches for aerosols

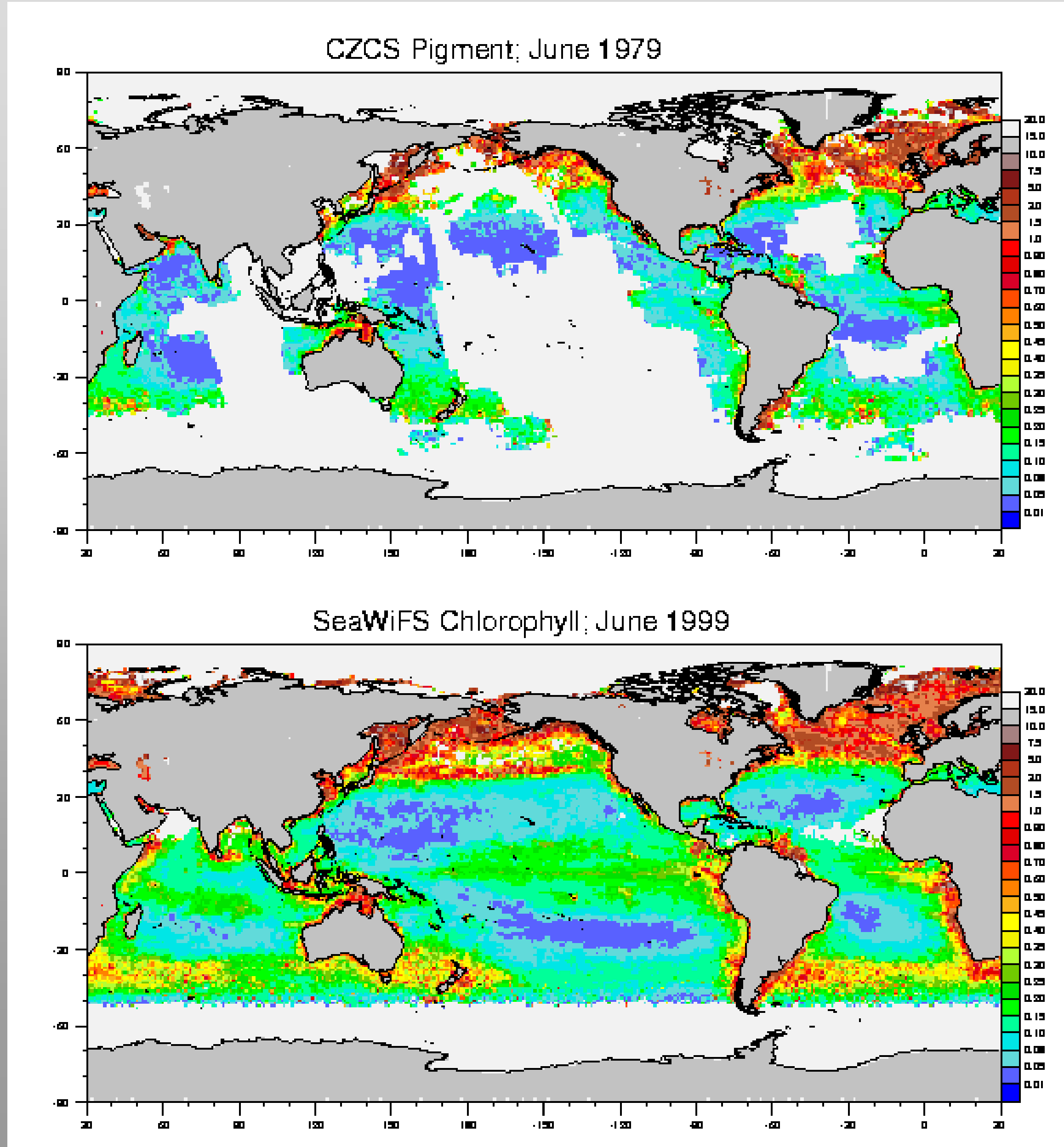
3) Navigation
Solution: Bias corrected, orbit vectors obtained, reconstructing viewing angles

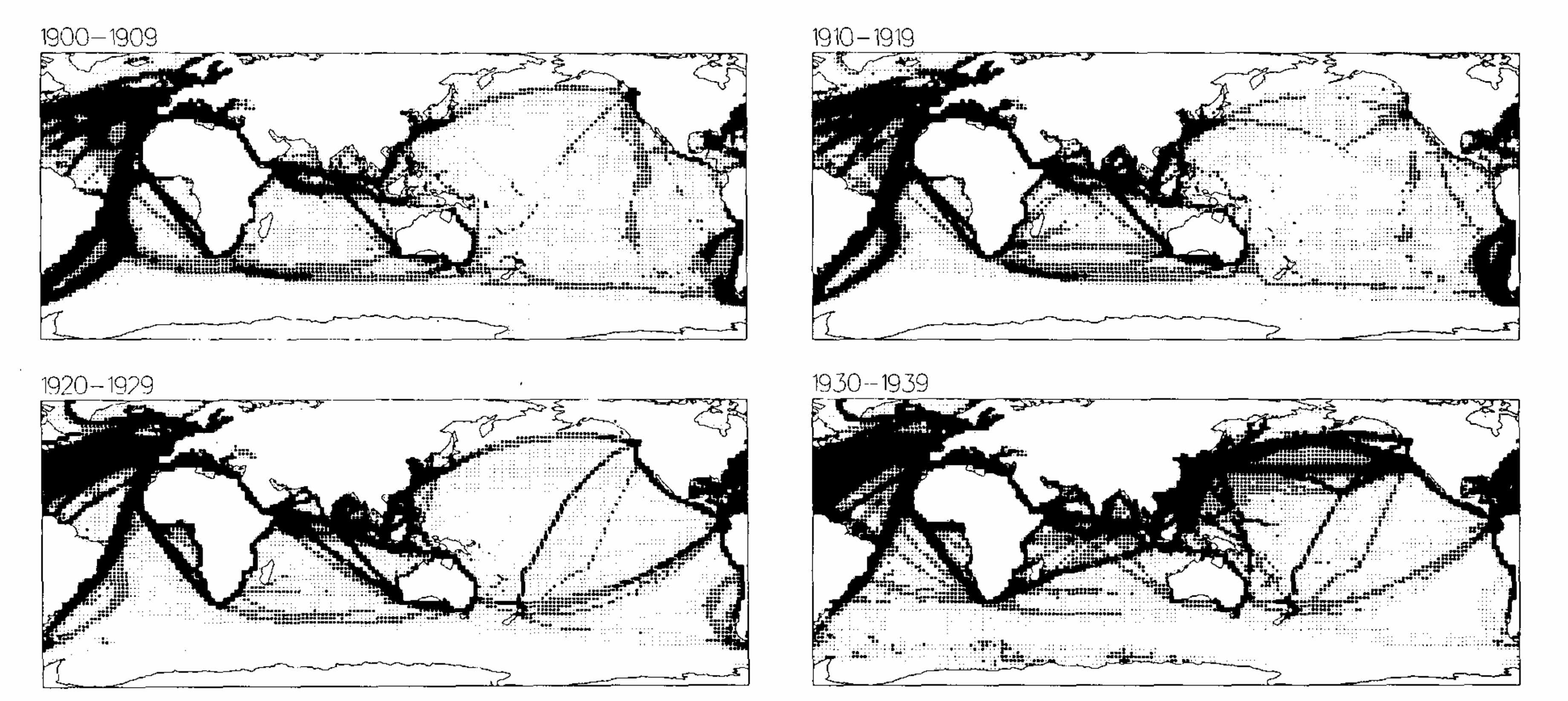
4) El Chichon
Solution: Tighter restriction on reflectance

5) Anomalous behavior post-1981
Solution: Don’t use Band 2

6) Sampling

CZCS Sampling





Ship observations per decade: light symbol=10, medium=100, dark=400

from Rayner etal 1993, JGR

Ocean Color Climate Records

Distinct from Operations Data Sets managed by OGBP

Stored at GES-DAAC, access using Giovanni

L3 format, 25-km, monthly, consistent with other climate data sets

Includes discontinuous time series
  1978-1986; 1996-2005
  chlorophyll only for now
mission names not mentioned except under detailed information

Facilitates new and post-processing advances to ensure CDR consistency

Does not interfere with operations requirements and community

Climate Records Issues

1) How calibrate historical and future sensors, maintaining consistency?

2) Is BRDF a good idea?

3) Can we define more rigorous metrics than in situ comparisons, that constrain global mean estimates?

4) Is it acceptable to have two data streams:
   - operational (best available methods; mission-dependent, high resolution)
   - climate (maximum commonality/consistency of methods, low resolution)?

5) How much consistency can we achieve without resorting to post-processing methods (blending of in situ data, assimilation)?