COASTAL OCEAN MODELING
GORDON RESEARCH CONFERENCE
17-22 JUNE 2007
COLBY-SAWYER COLLEGE
NEW LONDON, NH, USA

Francisco E. Werner, Chair; Richard P. Signell, Vice-Chair
Organizing Committee: John Allen, Julie Pullen, Mark Stacey and John Wilkin

INTEGRATION OF MODELING AND OBSERVING SYSTEMS

BIO-PHYSICAL MODELING

ATMOSPHERE-OCEAN INTERACTION

DATA ASSIMILATION

MODEL COUPLING AND ADAPTIVE GRIDS

HURRICANE/SEVERE STORM MODELING

SKILL ASSESSMENT

COASTAL SEDIMENT TRANSPORT & GEOMORPHOLOGY MODELING

STRATIFIED FLOW & TOPOGRAPHY

http://www.grc.org > Current 2007 > Coastal Ocean Modeling

http://www.grc.org/programs.aspx?year=2007&program=coastal

Nitrogen and carbon cycle modeling of the Northeast North American shelf: Nesting ROMS within HYCOM

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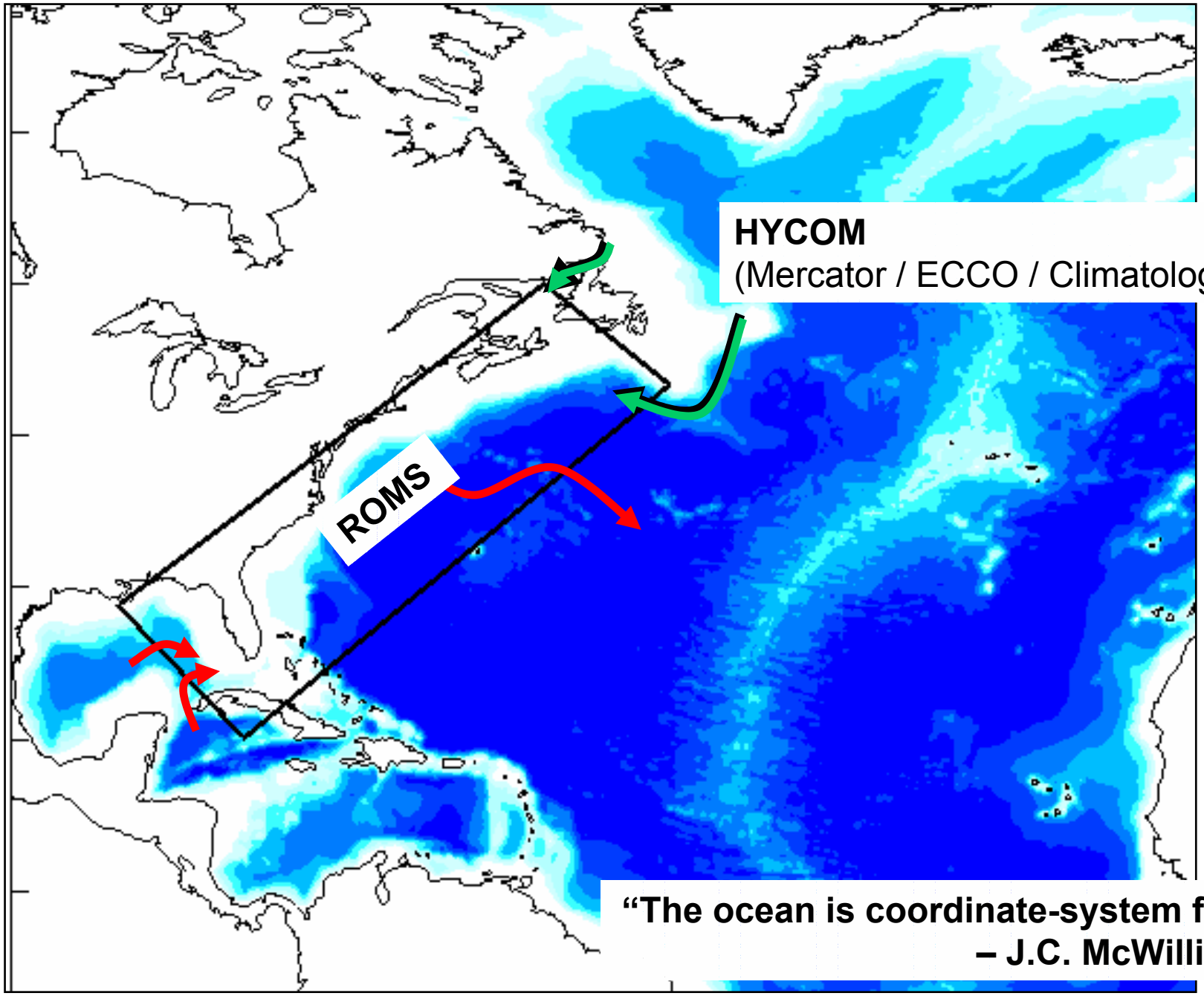
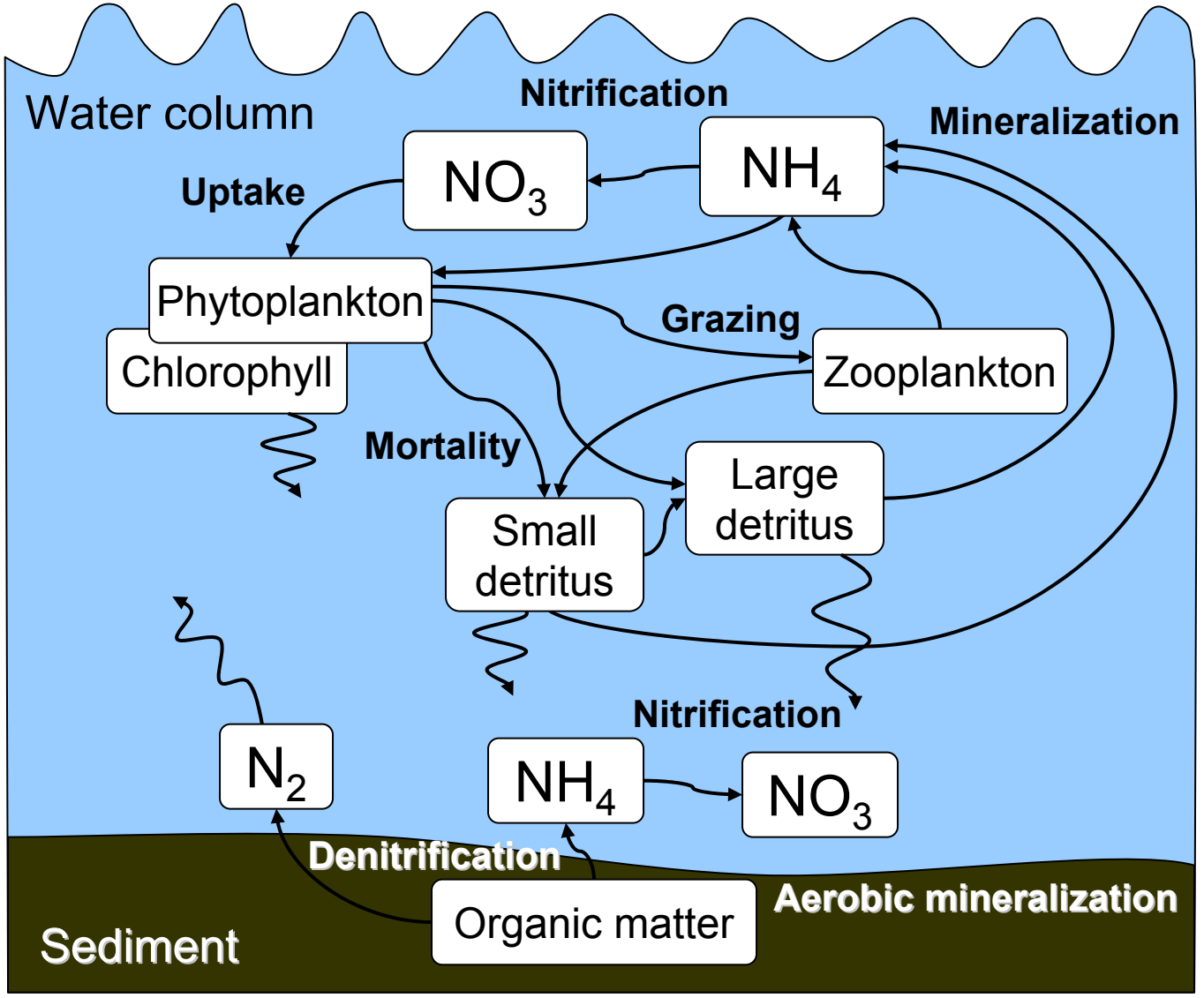
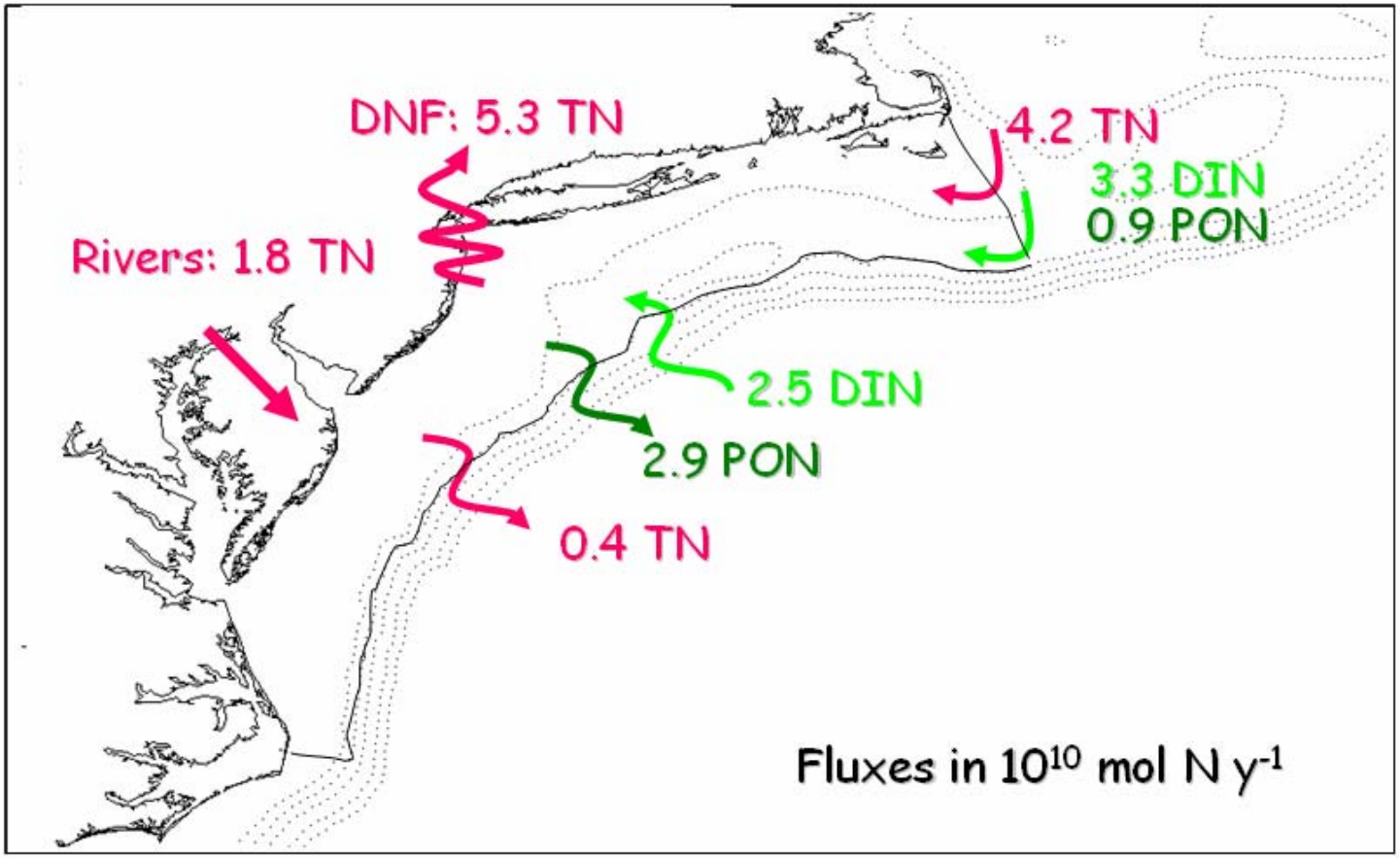

HYCOM
(Mercator / ECCO / Climatology)
ROMS
“The ocean is coordinate-system free”
– J.C. McWilliams

Circulation and biogeochemical modeling



Fennel, K., et al 2006: Nitrogen cycling in the Middle Atlantic Bight: Results from a three-dimensional model and implications for the North Atlantic nitrogen budget. Glob. Biogeochem. Cyc., 20, doi:10.1029/2005GB002456.

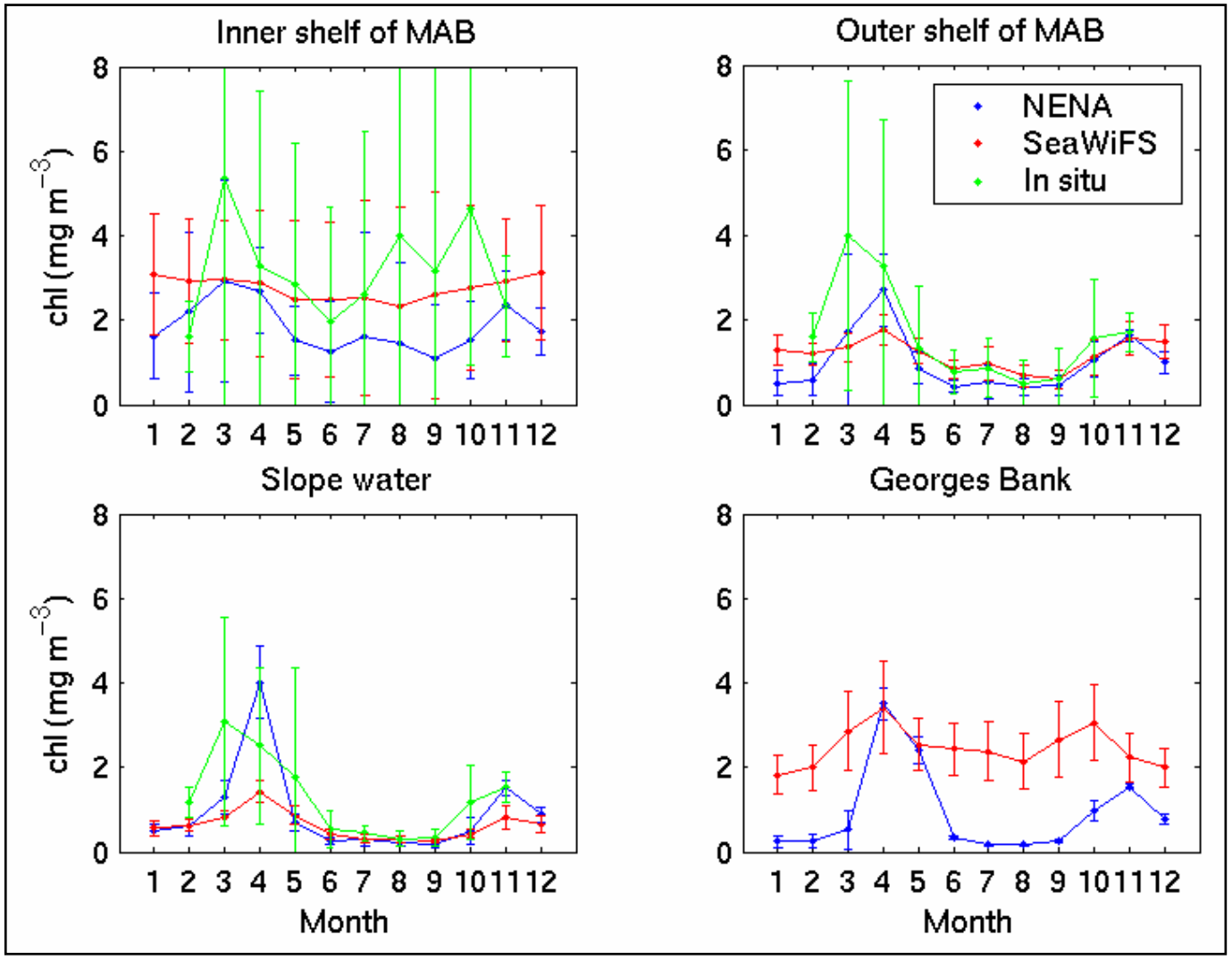
Nitrogen cycle modeling for wide shelves



Sources and sinks of nitrogen

Role of shelf denitrification

Fennel, K., et al 2006: Nitrogen cycling in the Middle Atlantic Bight: Results from a three-dimensional model and implications for the North Atlantic nitrogen budget. Glob. Biogeochem. Cyc., 20, doi:10.1029/2005GB002456.



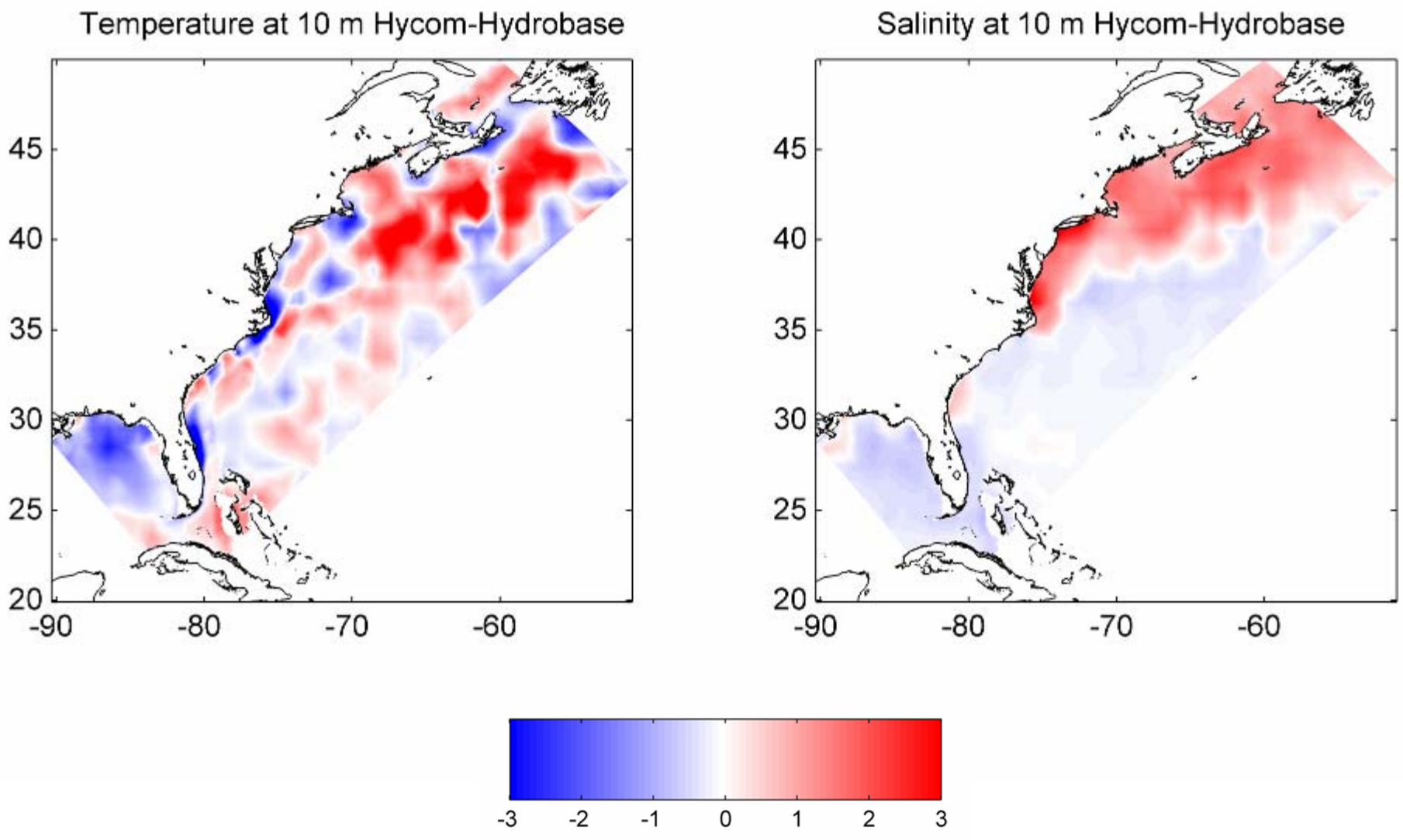
Model-data comparisons

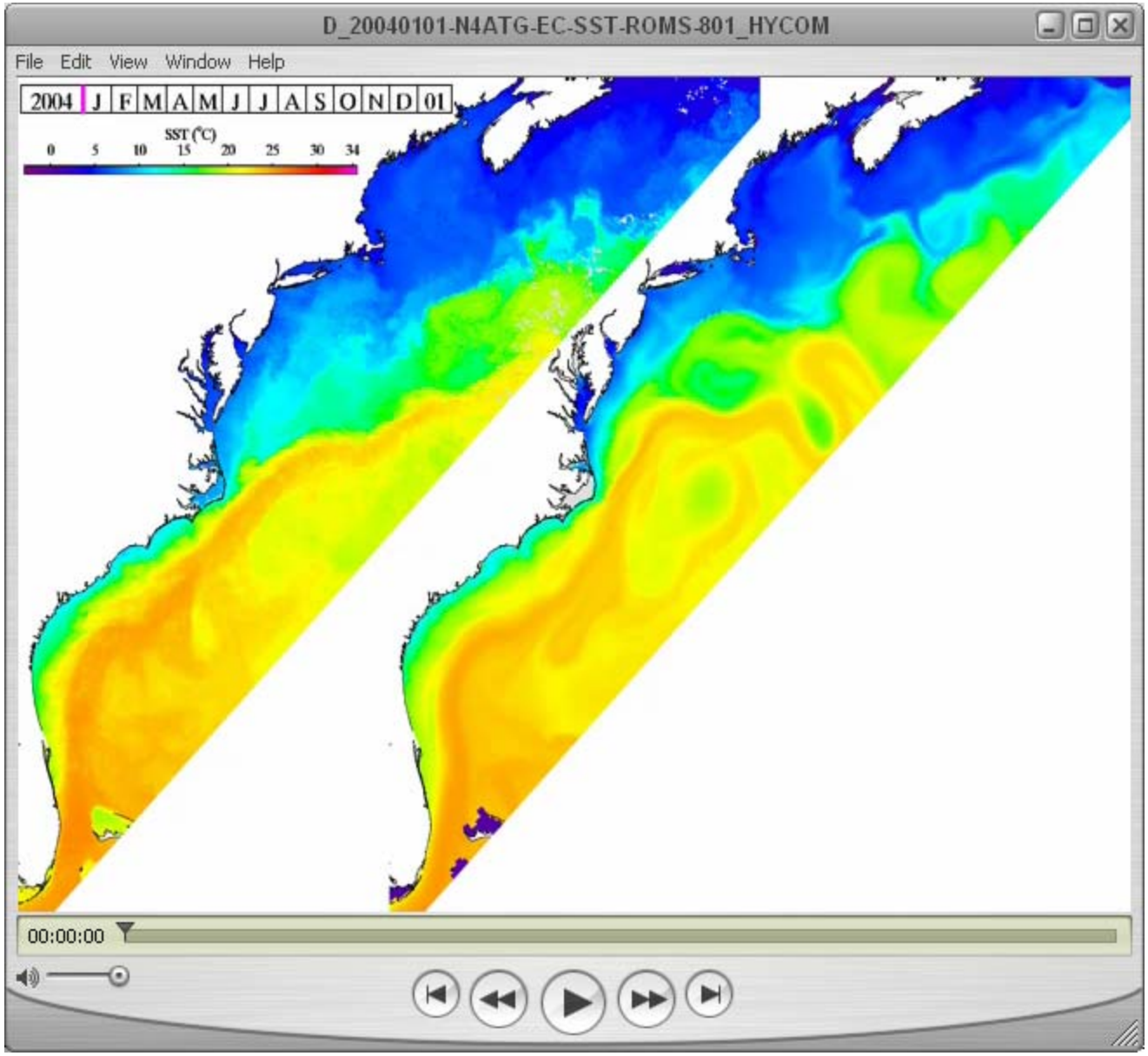
← Model crashes in summer (no tides)

Fennel, Wilkin, O'Reilly

ROMS in Hycom NENA configuration

- 10 km horizontal, 30 s-levels terrain-following
- NCEP daily surface atmospheric reanalysis
  - *Fairall et al. 2003 bulk flux air-sea exchange parameterization*
  - *daily shortwave modulated for diurnal cycle*
  - *evaporation from latent heat minus NCEP precip*
- embedded in Hycom North Atlantic best-estimate daily
  - *Hycom T,S bias w.r.t. Hydrobase annual mean is removed*
  - *radiation/nudging to Hbase+Hycom' T,S and **u** at perimeter*
  - *200 km linear taper nudging region 0 to 2 day^{-1} at perimeter*
  - *OTPS/TPX03 tides and Flather condition with Hycom ζ, $\overline{u}$*
- Monthly climatological rivers (Seitzinger)
- Mellor-Yamada 2½ vertical turbulence closure
- Start physics in June 2003
  - *start BGC in January 2004*
  - *BGC boundary conditions from regressions of tracer on T,S data*


Temperature at 10 m Hycom-Hydrobase
Salinity at 10 m Hycom-Hydrobase
45
40
35
30
25
20
-90
-80
-70
-60
-3
-2
-1
0
1
2
3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SST (°C)
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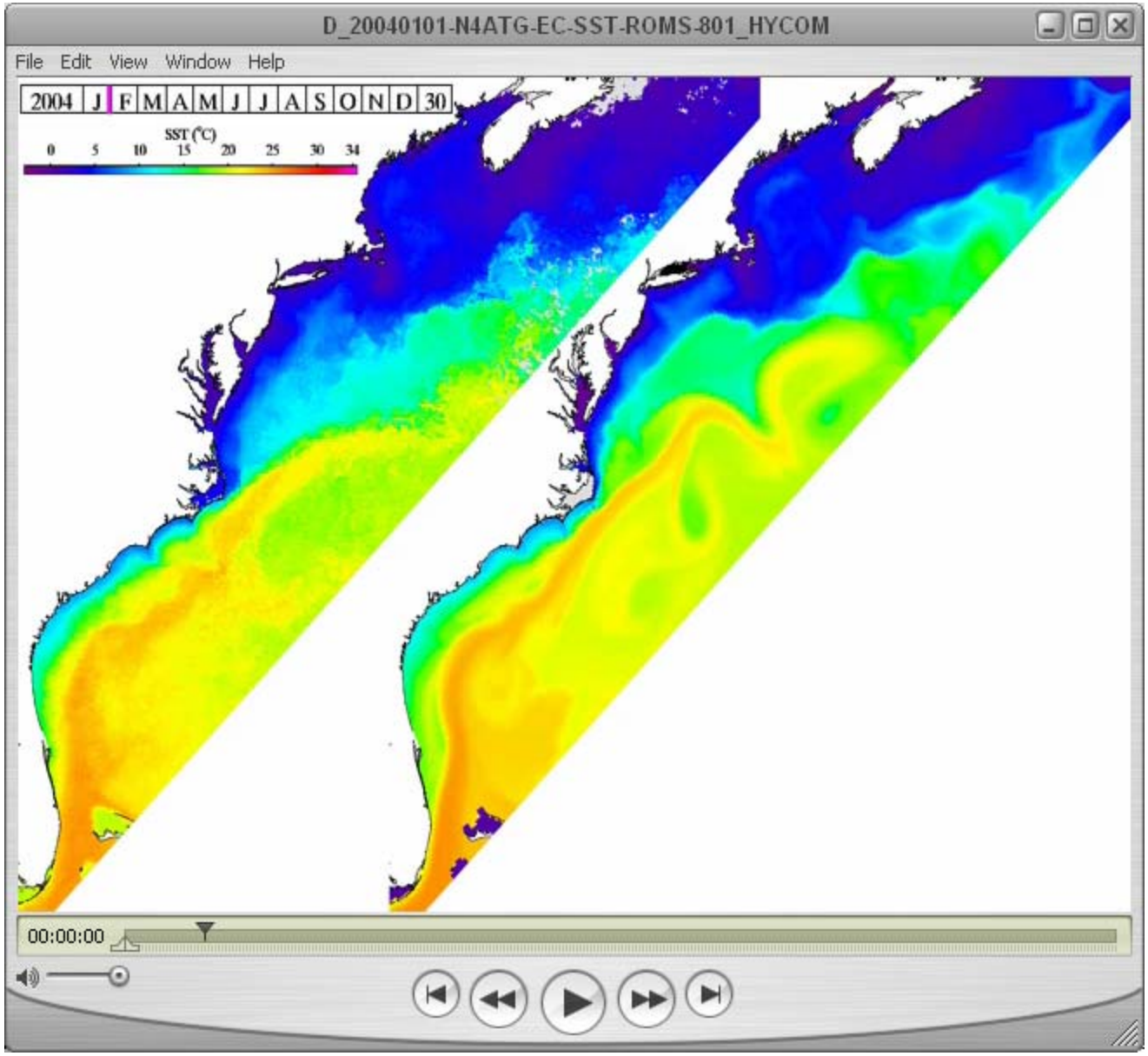
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SST (°C)
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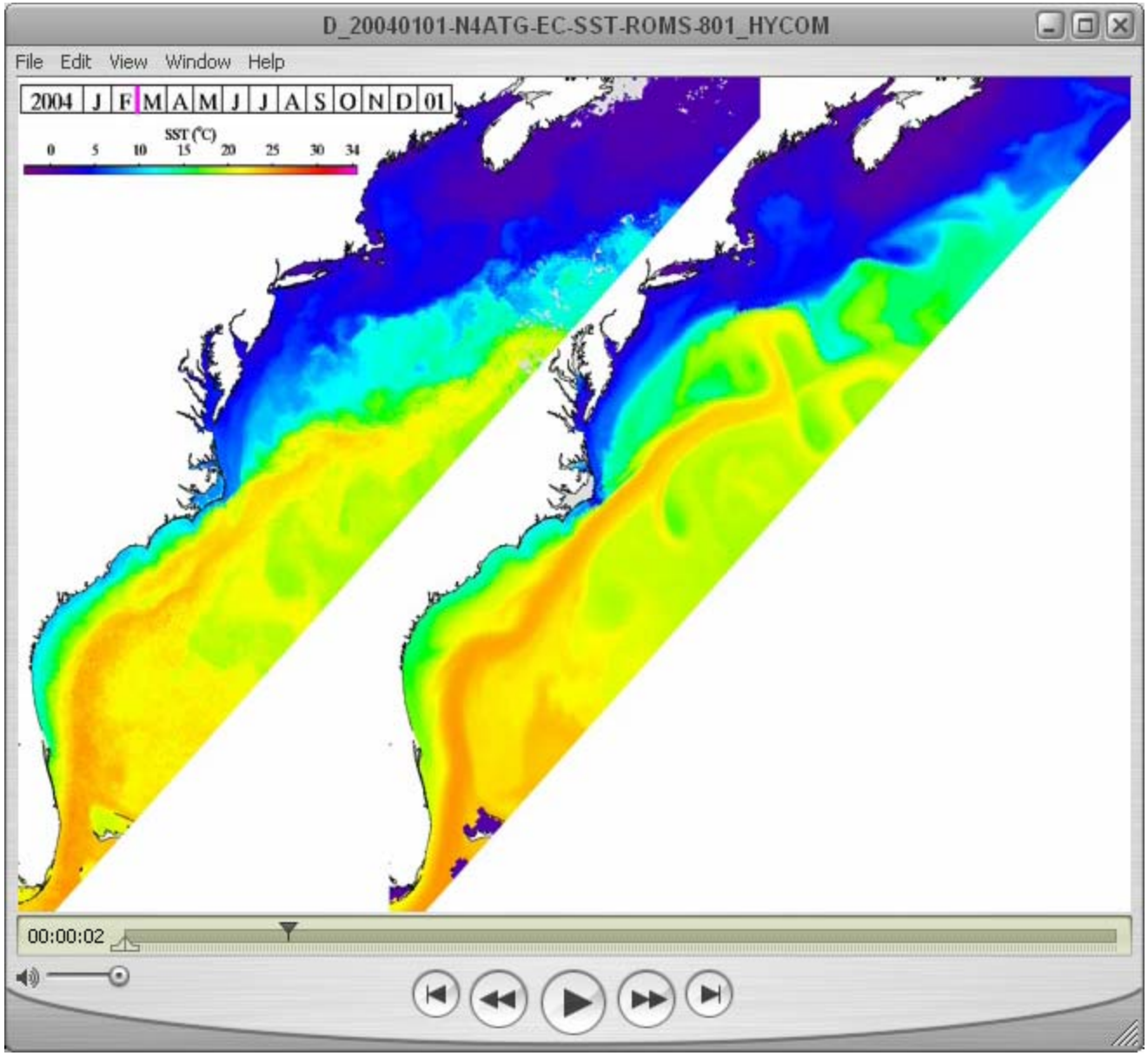
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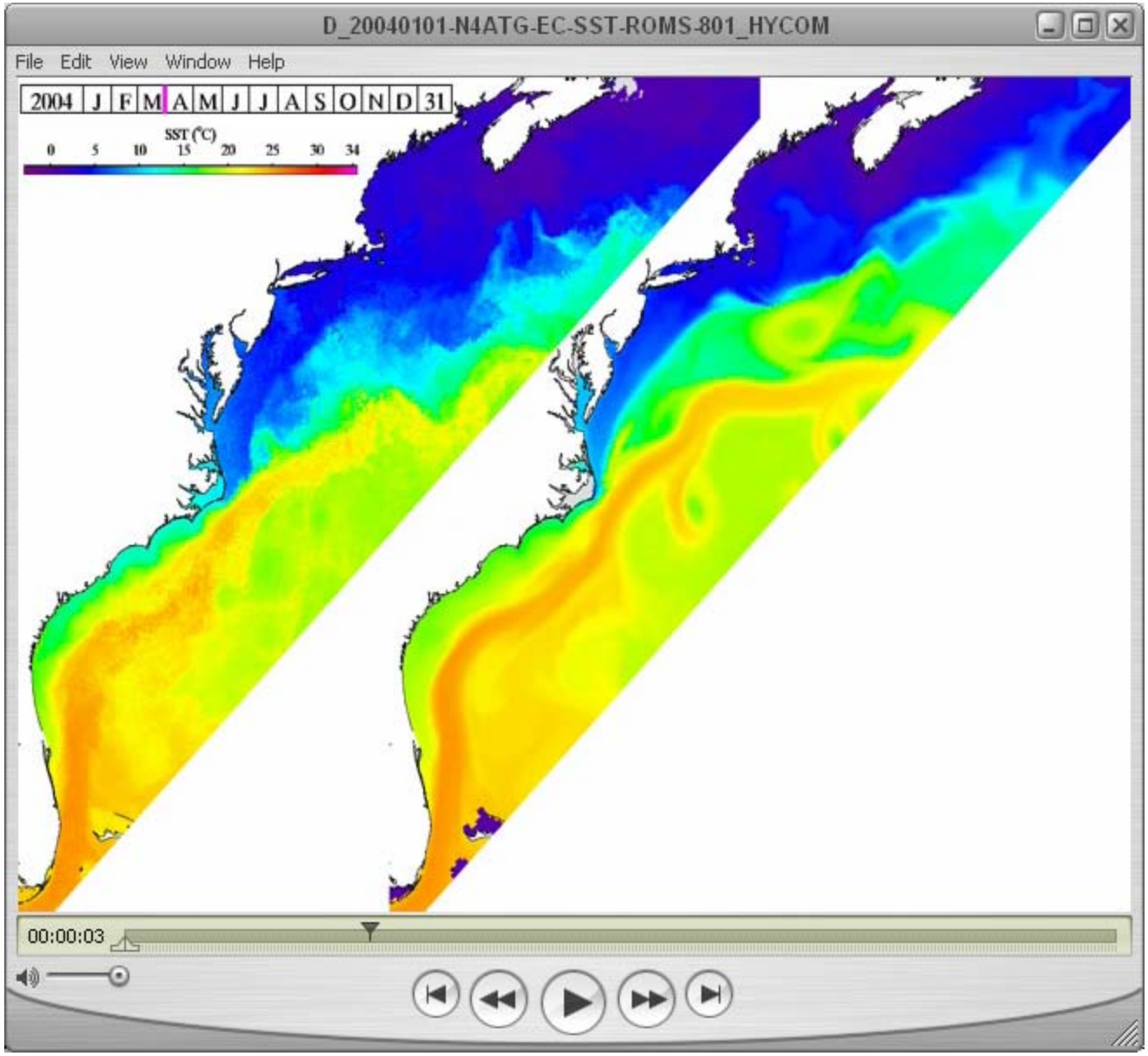
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SST (°C)
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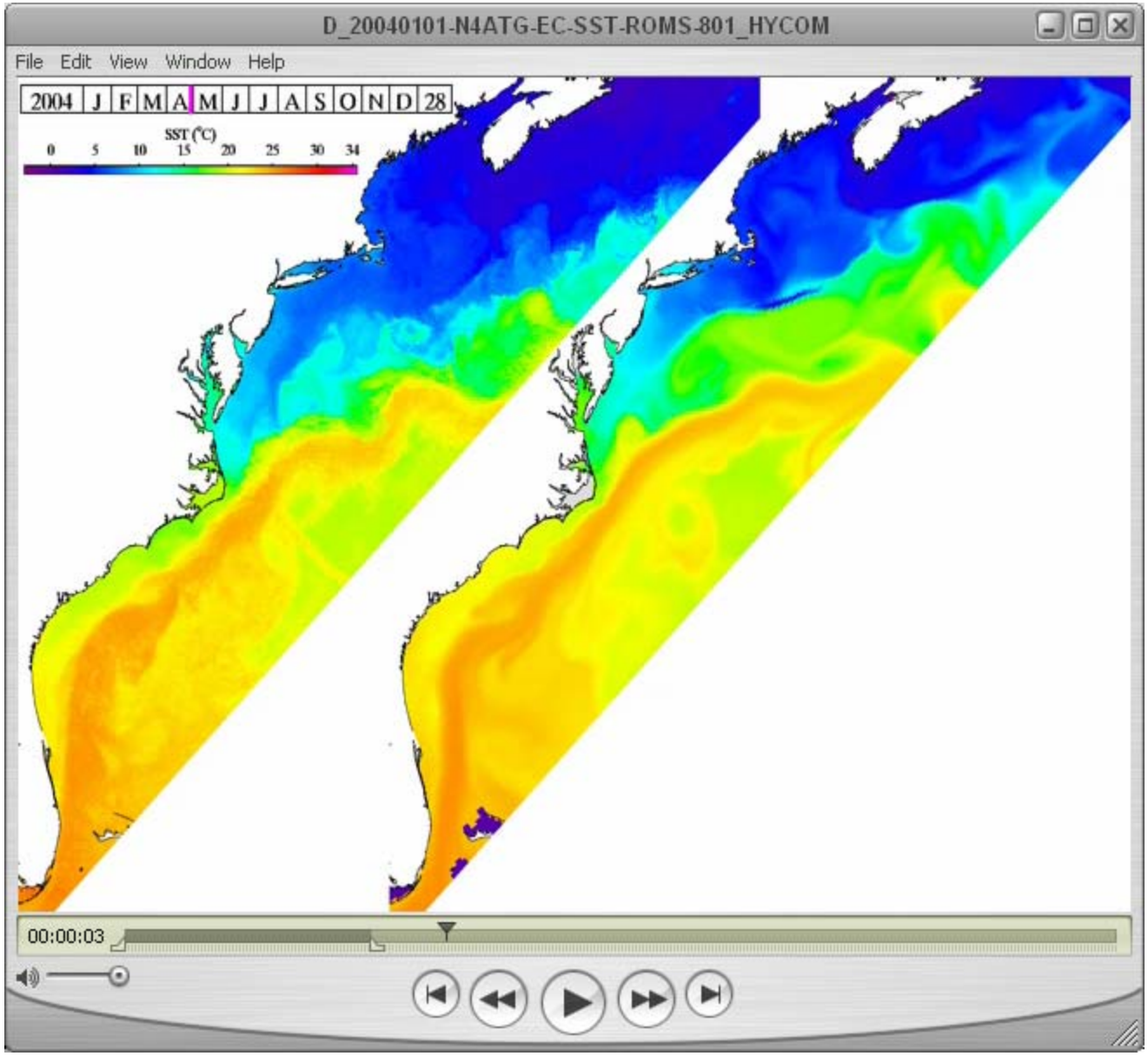
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SST (°C)
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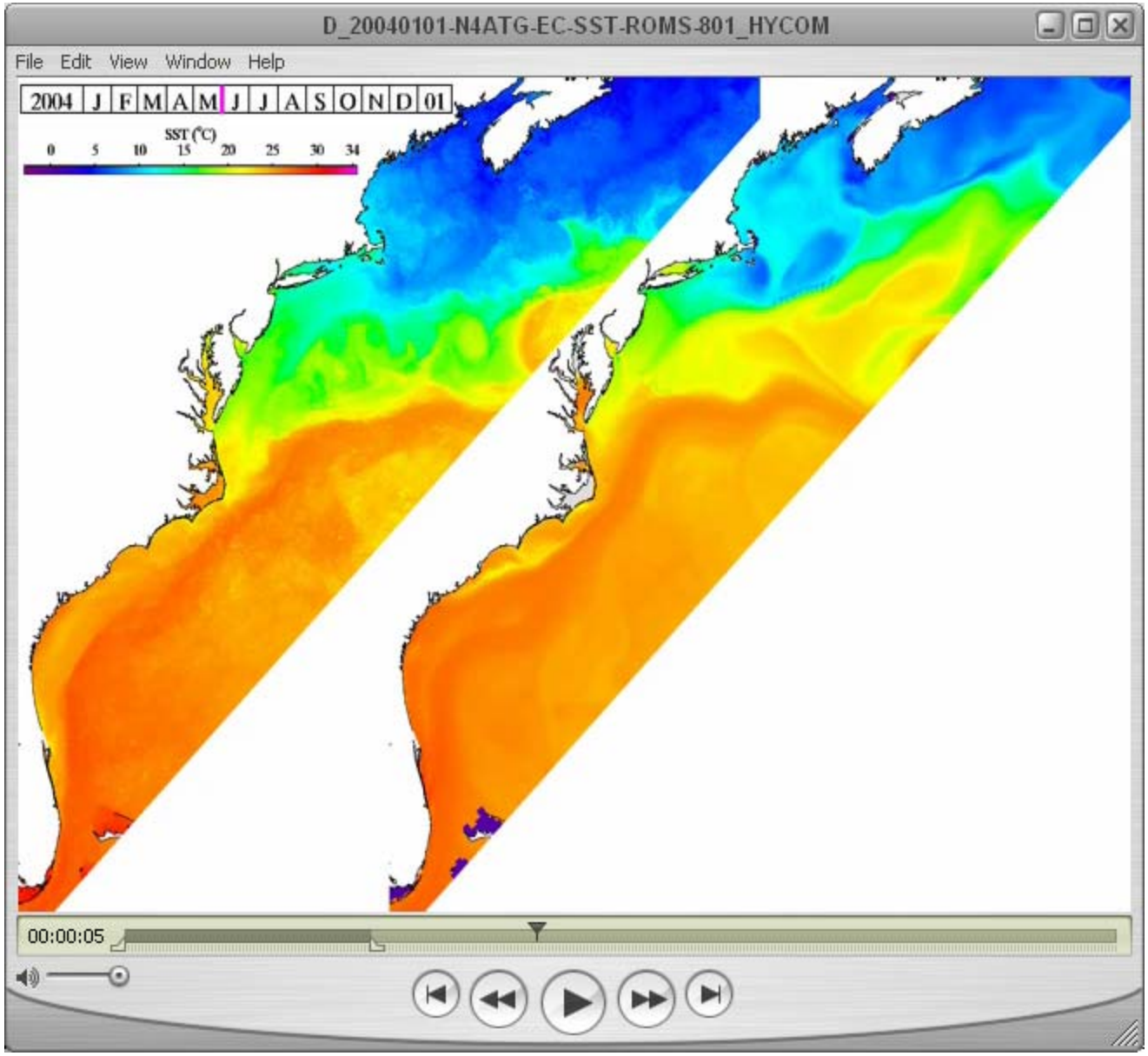
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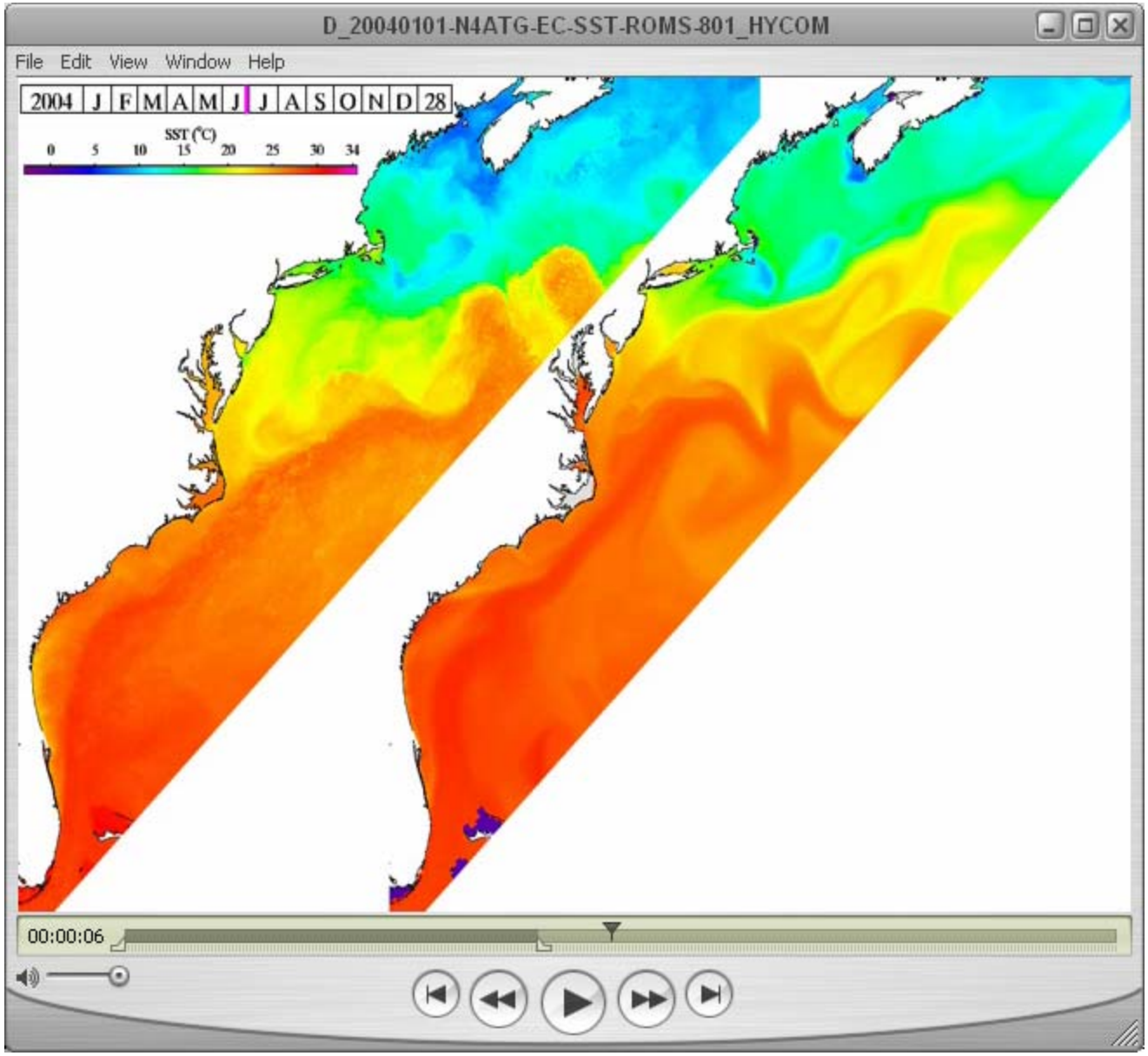
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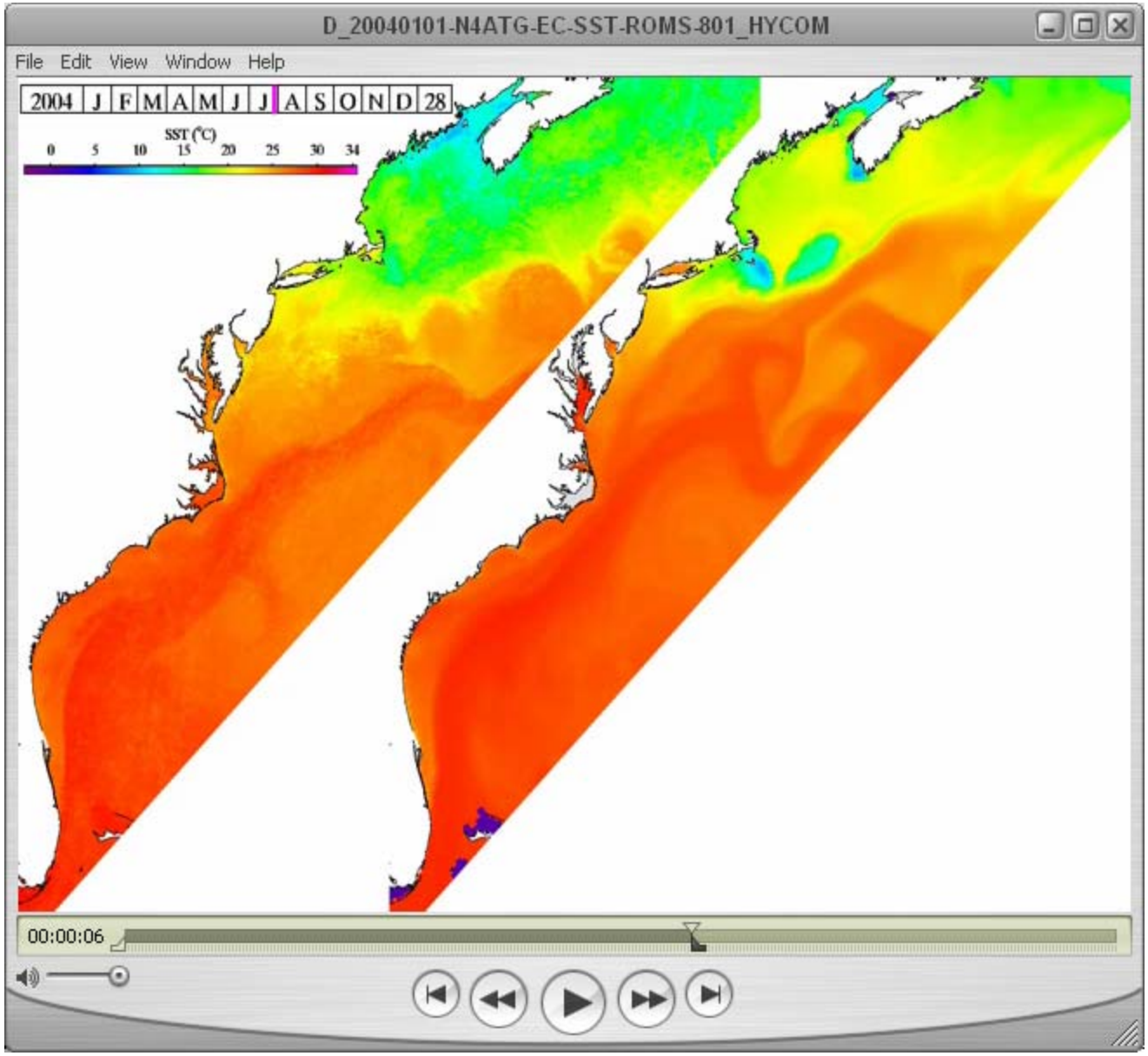
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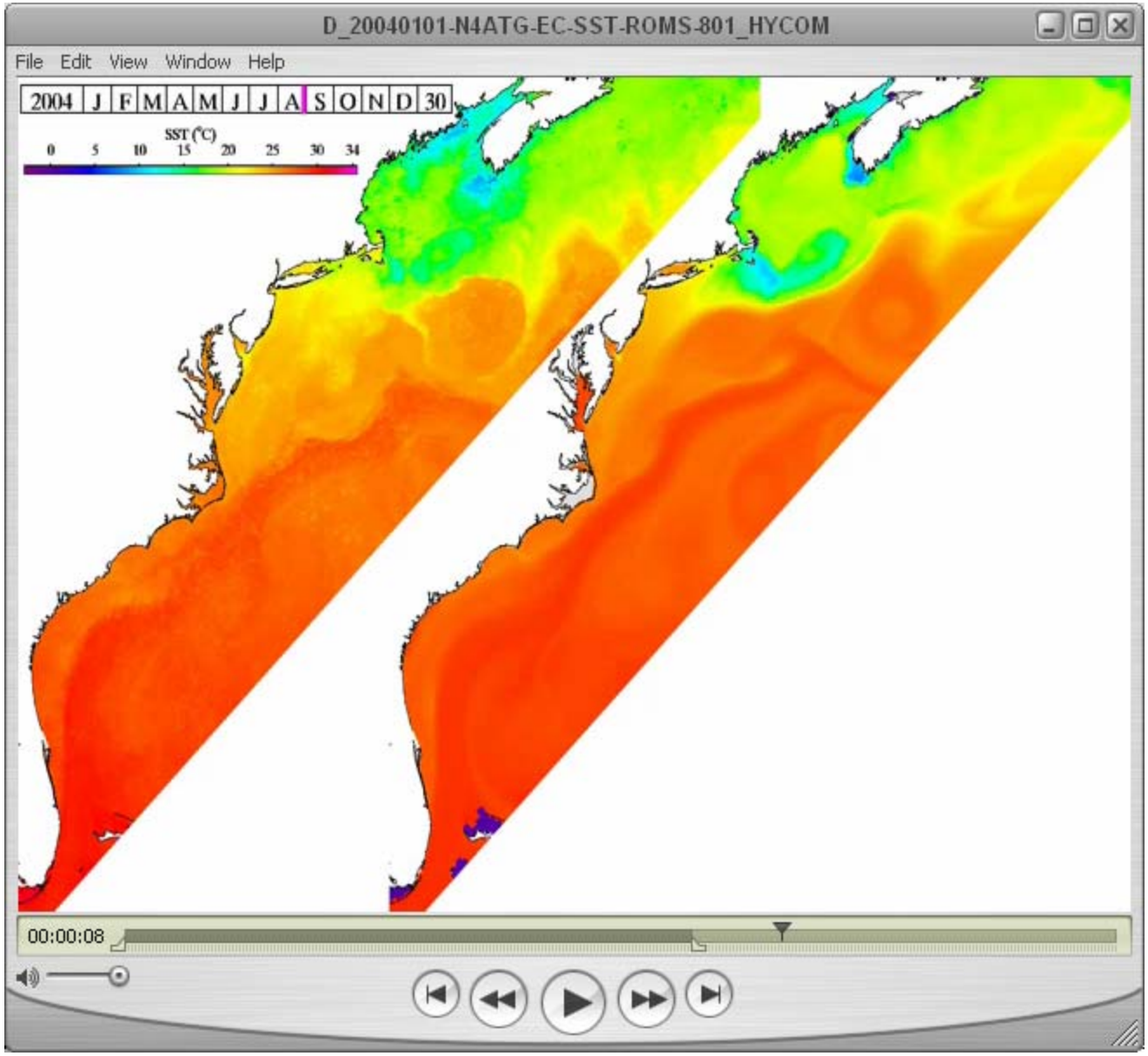
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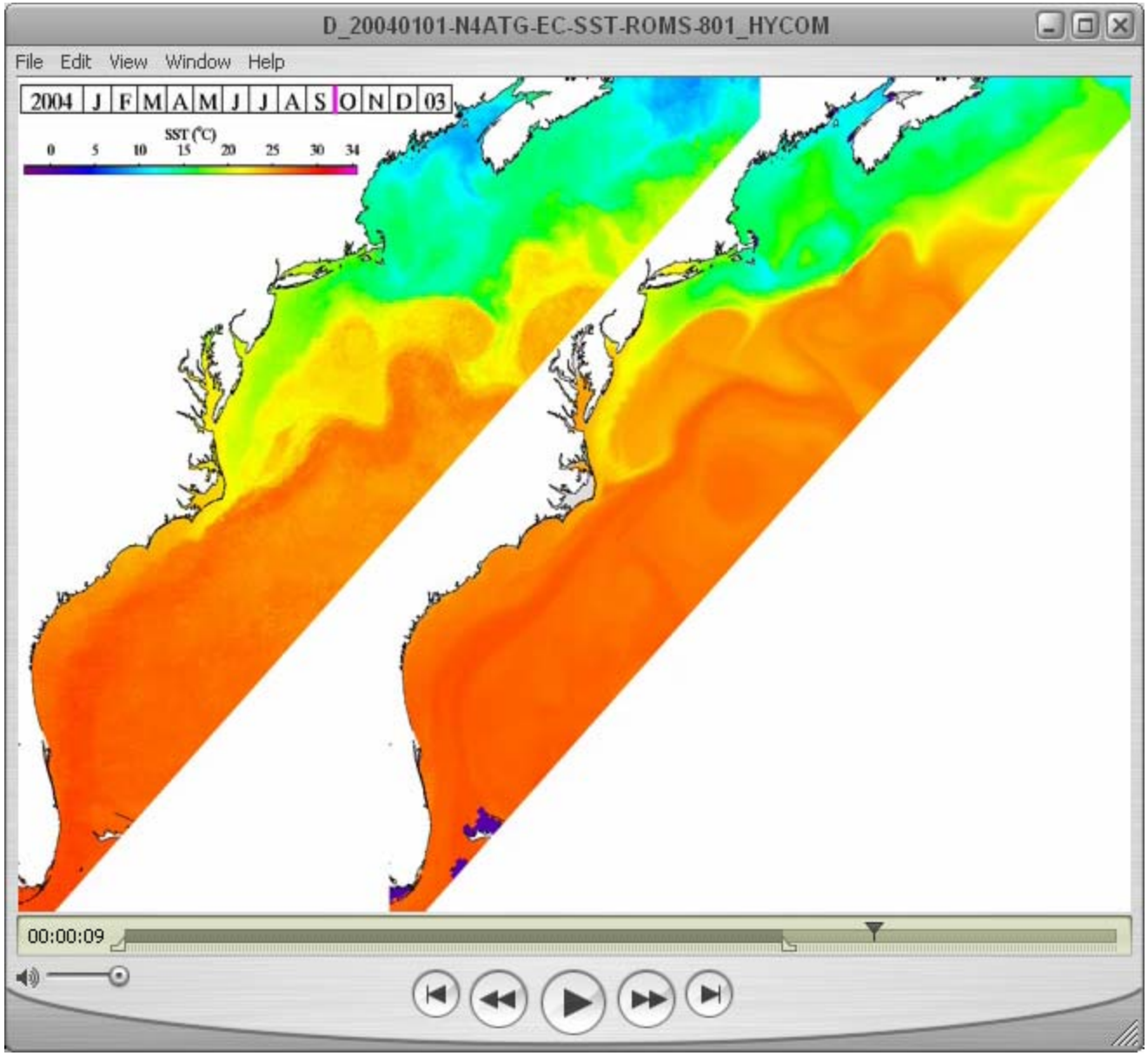
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SST (°C)
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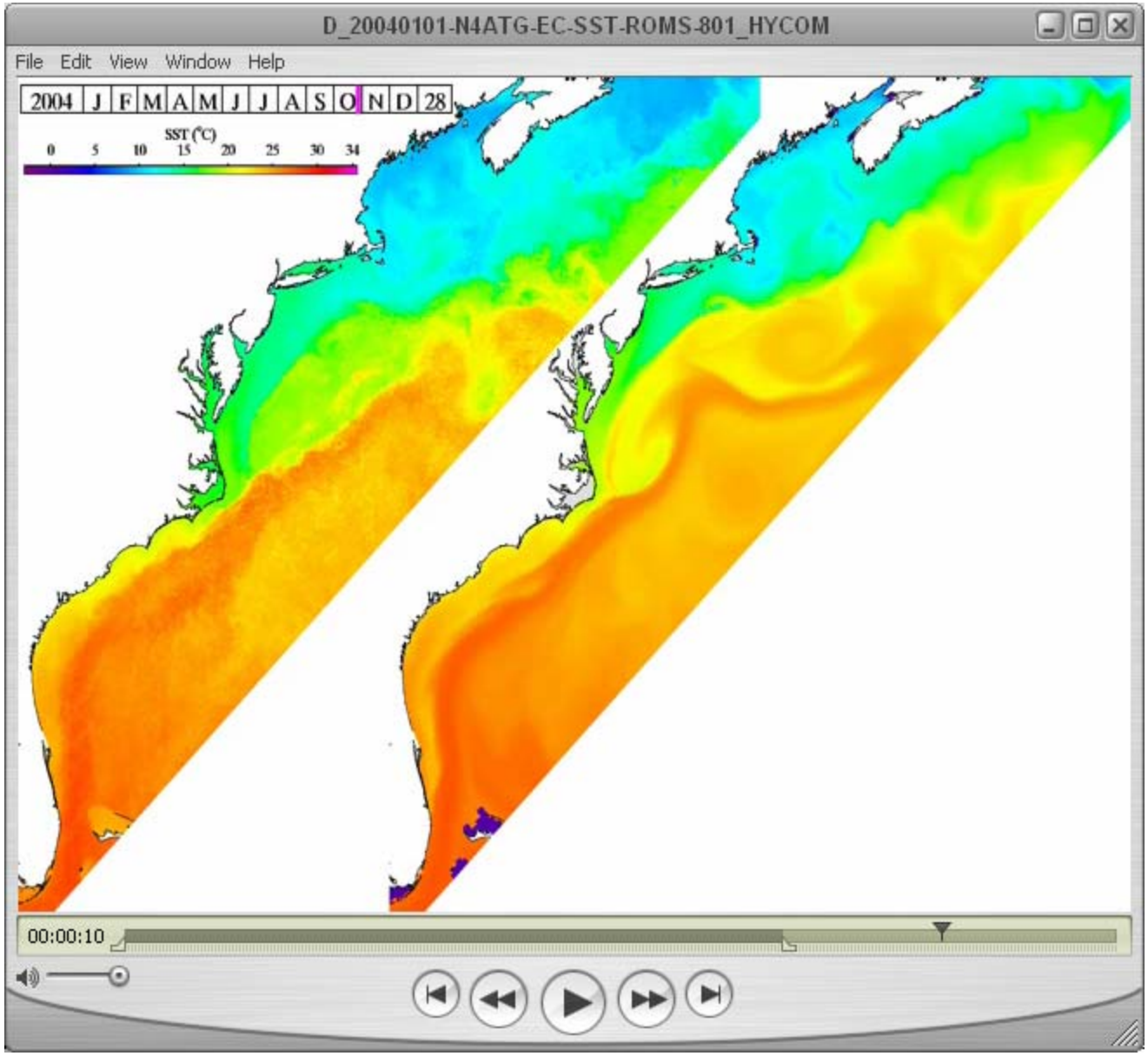
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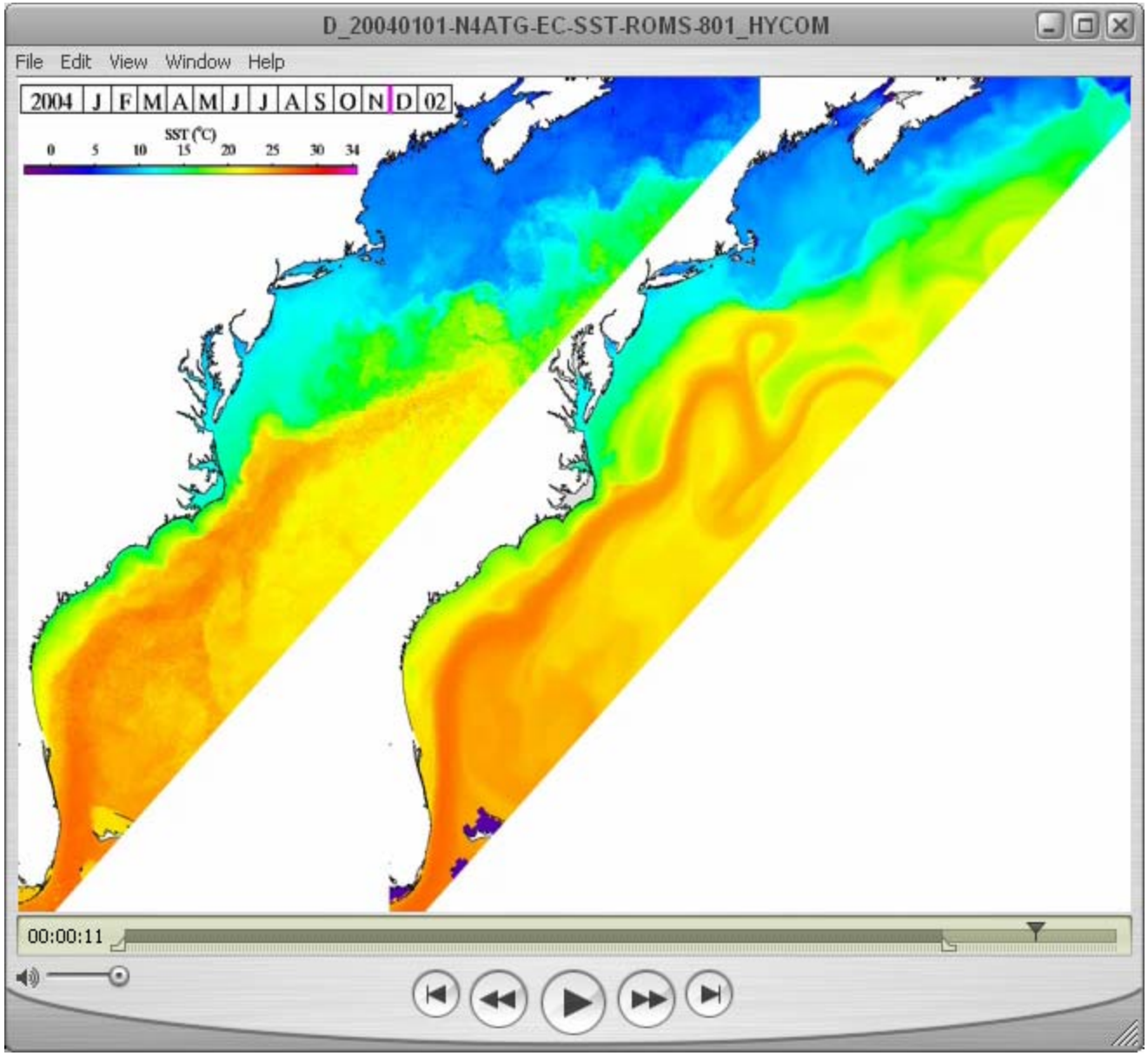
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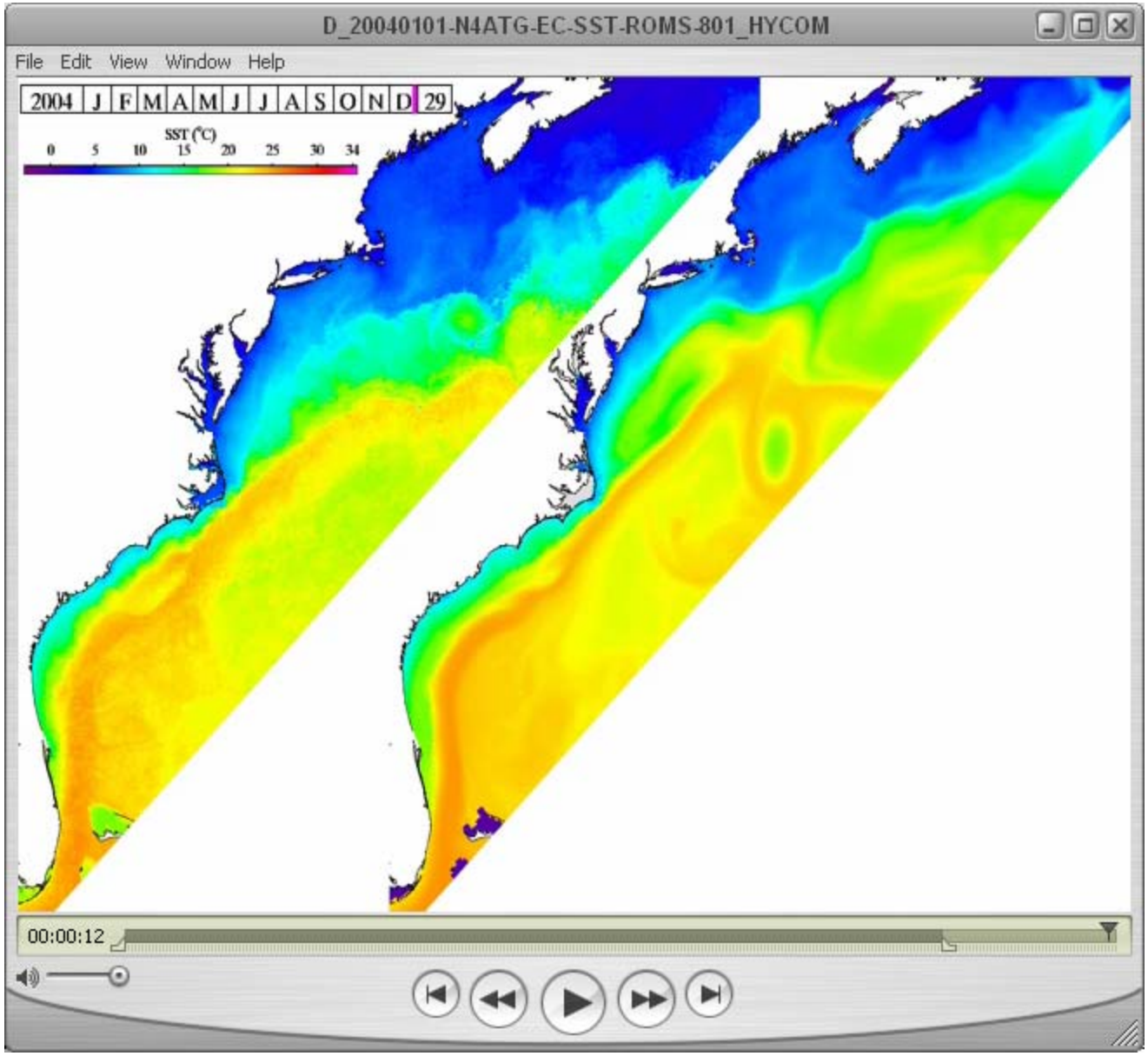
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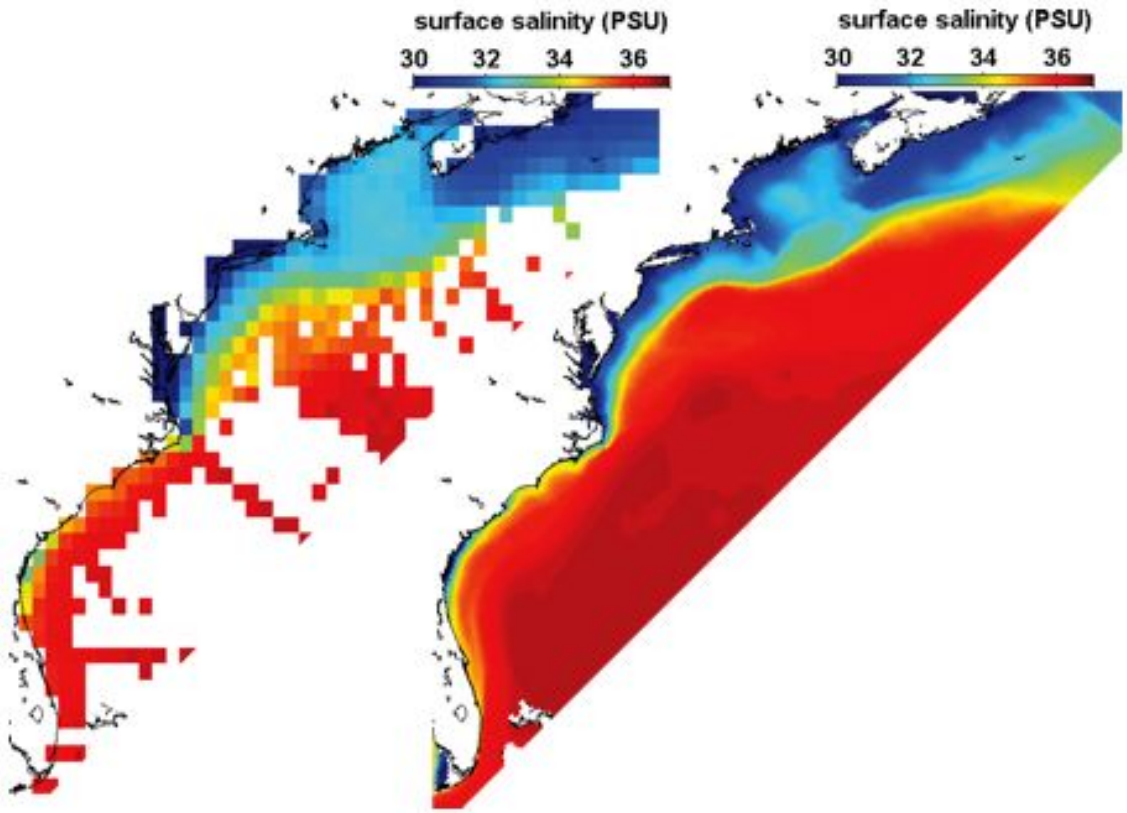
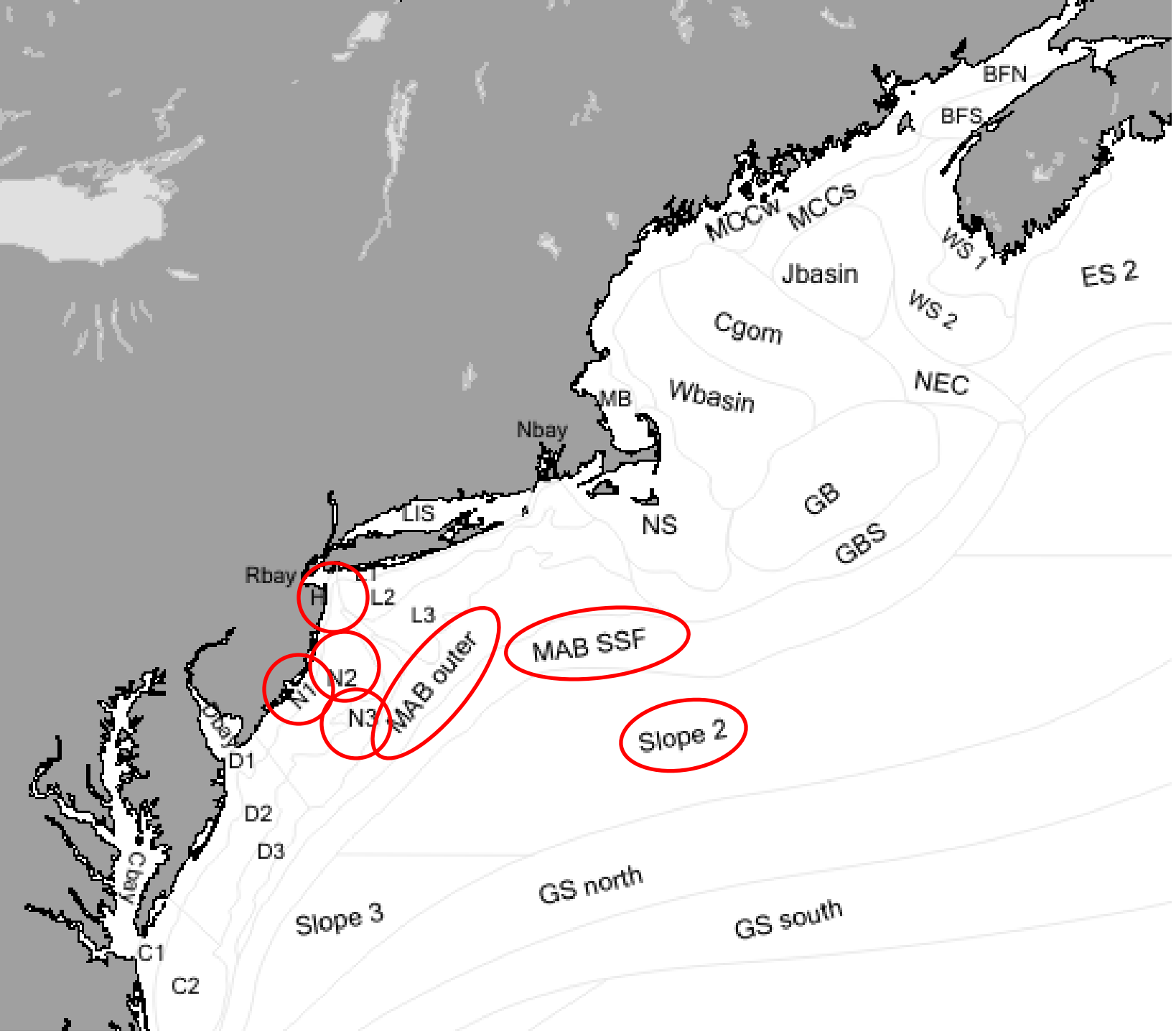
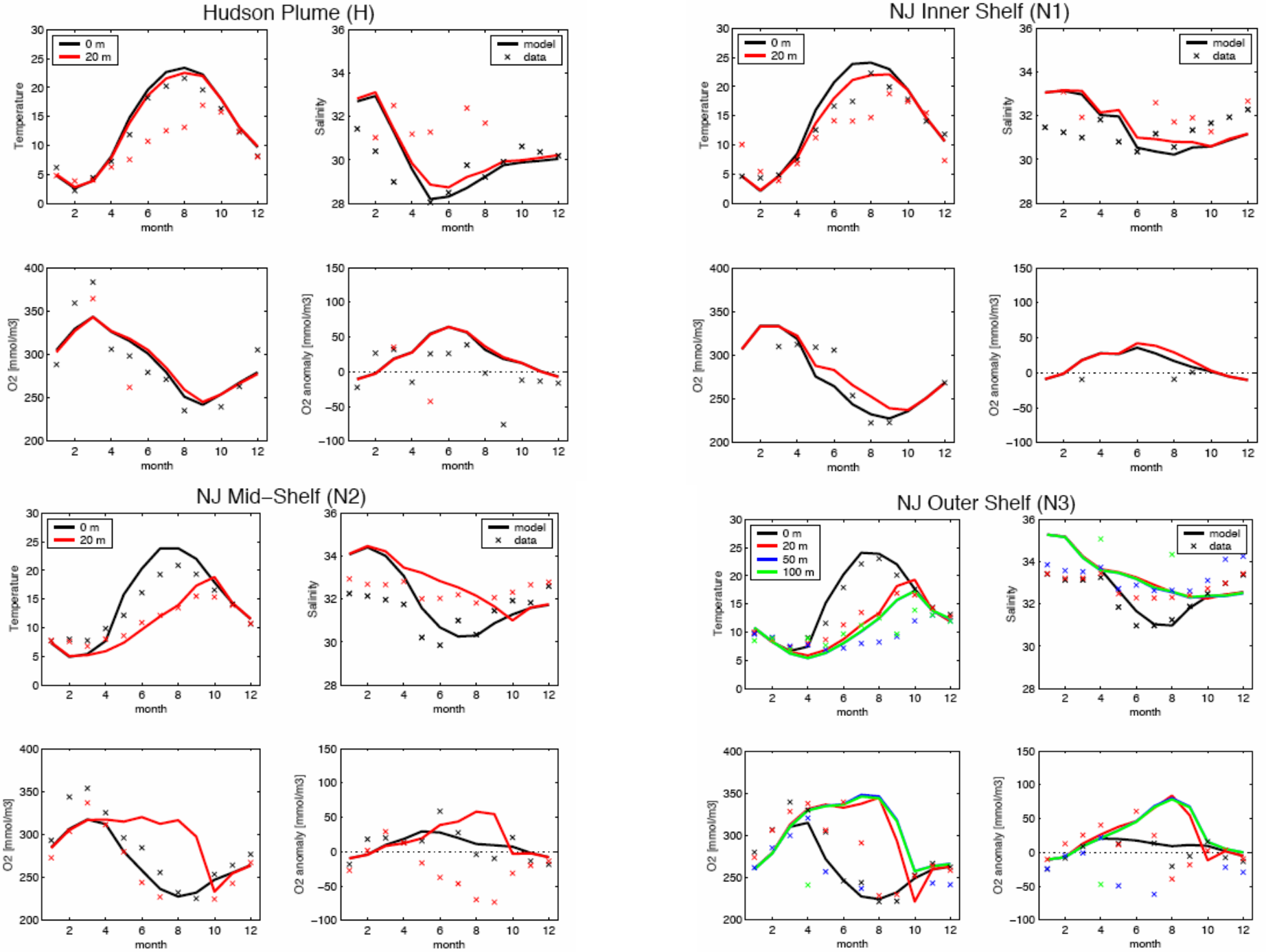
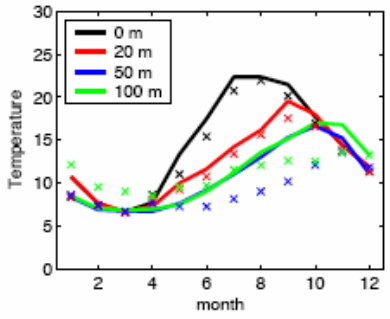
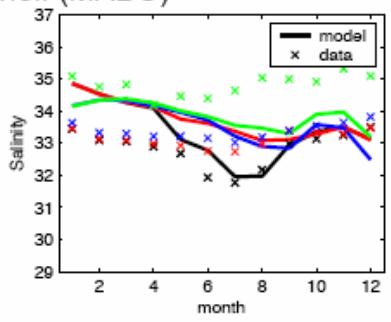

surface salinity (PSU)
30 32 34 36
surface salinity (PSU)
30 32 34 36

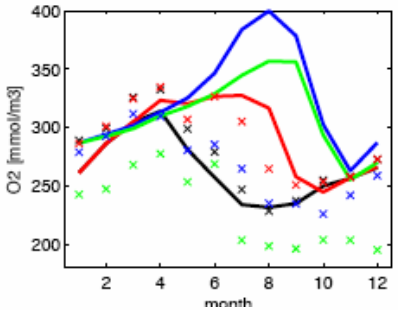

BFN
BFS
MCCw
MCCs
WS 1
ES 2
Jbasin
WS 2
Cgom
NEC
MB
Wbasin
Nbay
LIS
NS
GB
GBS
Rbay
H
L1
L2
L3
MAB SSF
MAB outer
N1
N2
N3
Slope 2
Cbay
D1
D2
D3
C bay
Slope 3
GS north
GS south
C1
C2

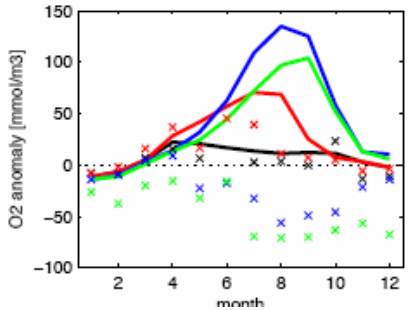

Hudson Plume (H)
NJ Inner Shelf (N1)
NJ Mid–Shelf (N2)
NJ Outer Shelf (N3)
0 m
20 m
50 m
100 m
model
data
Temperature
Salinity
O2 [mmol/m3]
O2 anomaly [mmol/m3]
month

MAB Outer Shelf (MABO)

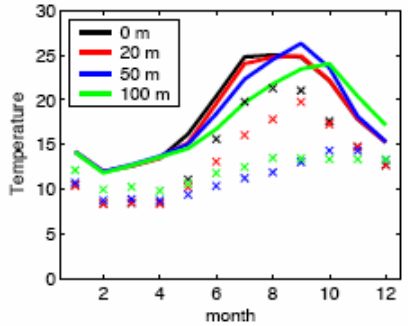


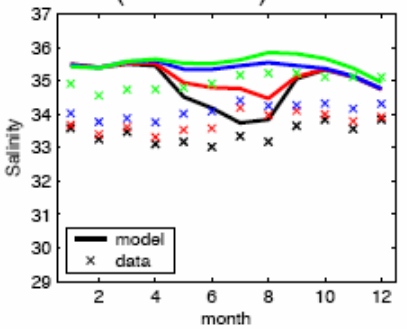


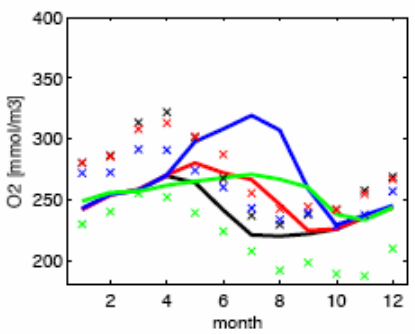


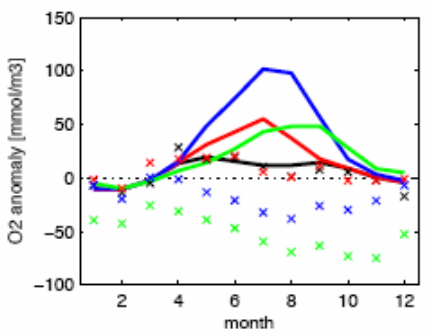


MAB Shelf Slope Front (MABSSF)

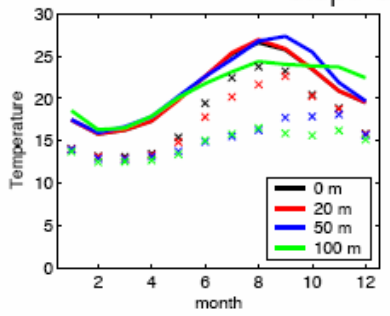


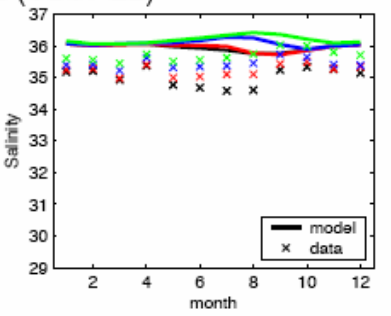


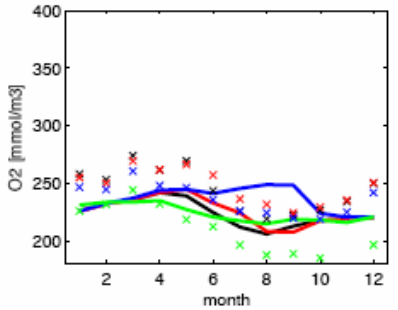


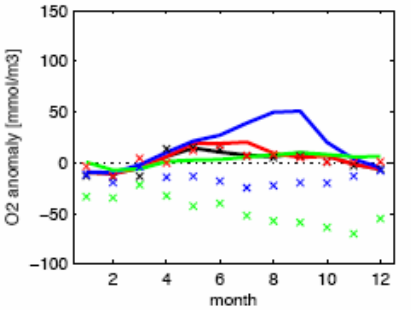


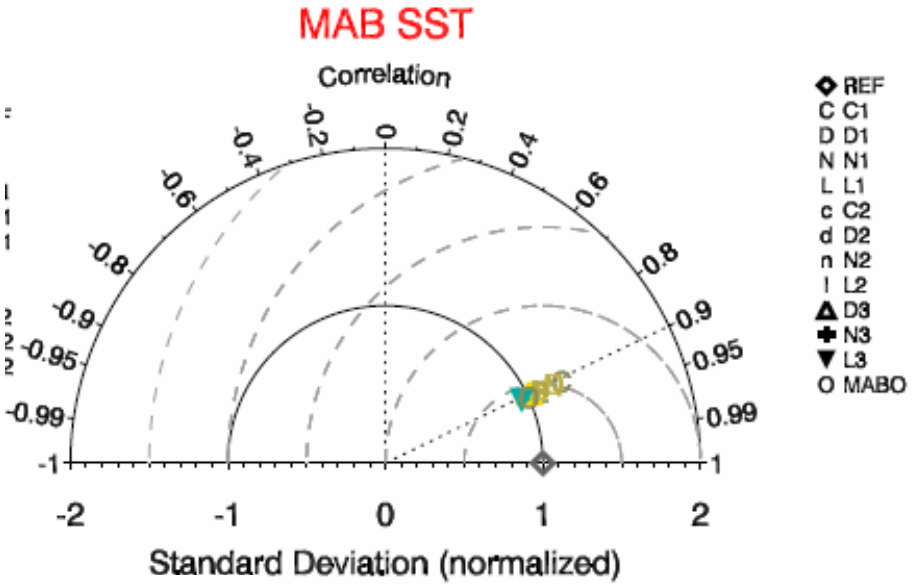
Slope Sea 2 (SLOPE2)



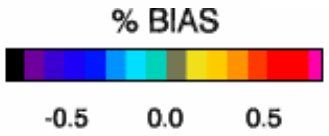


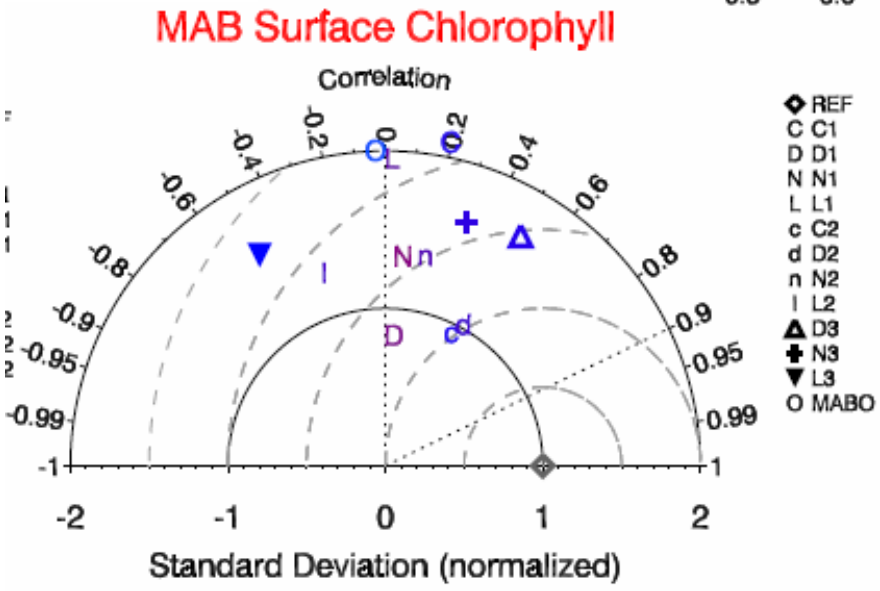


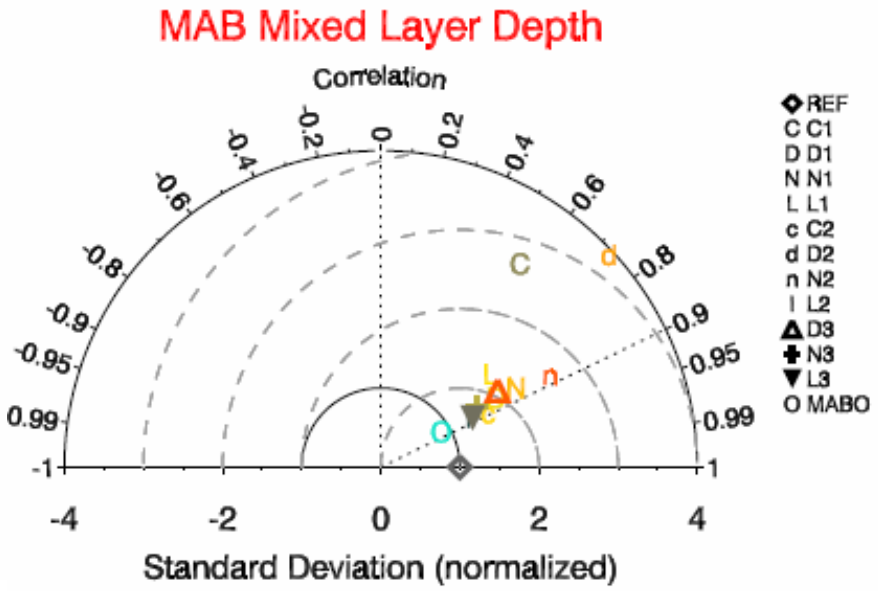




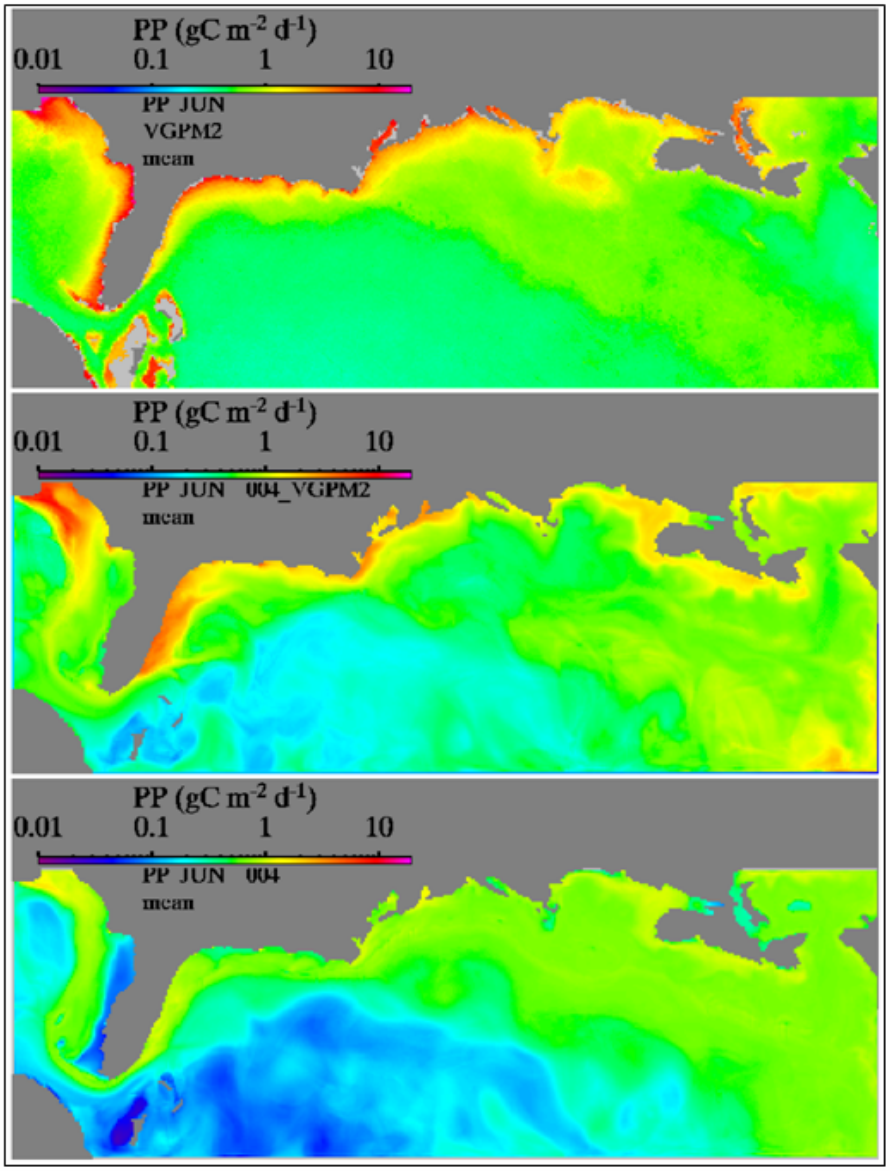
Taylor diagrams for model skill assessment







Model, satellite and ecosystem algorithm comparison

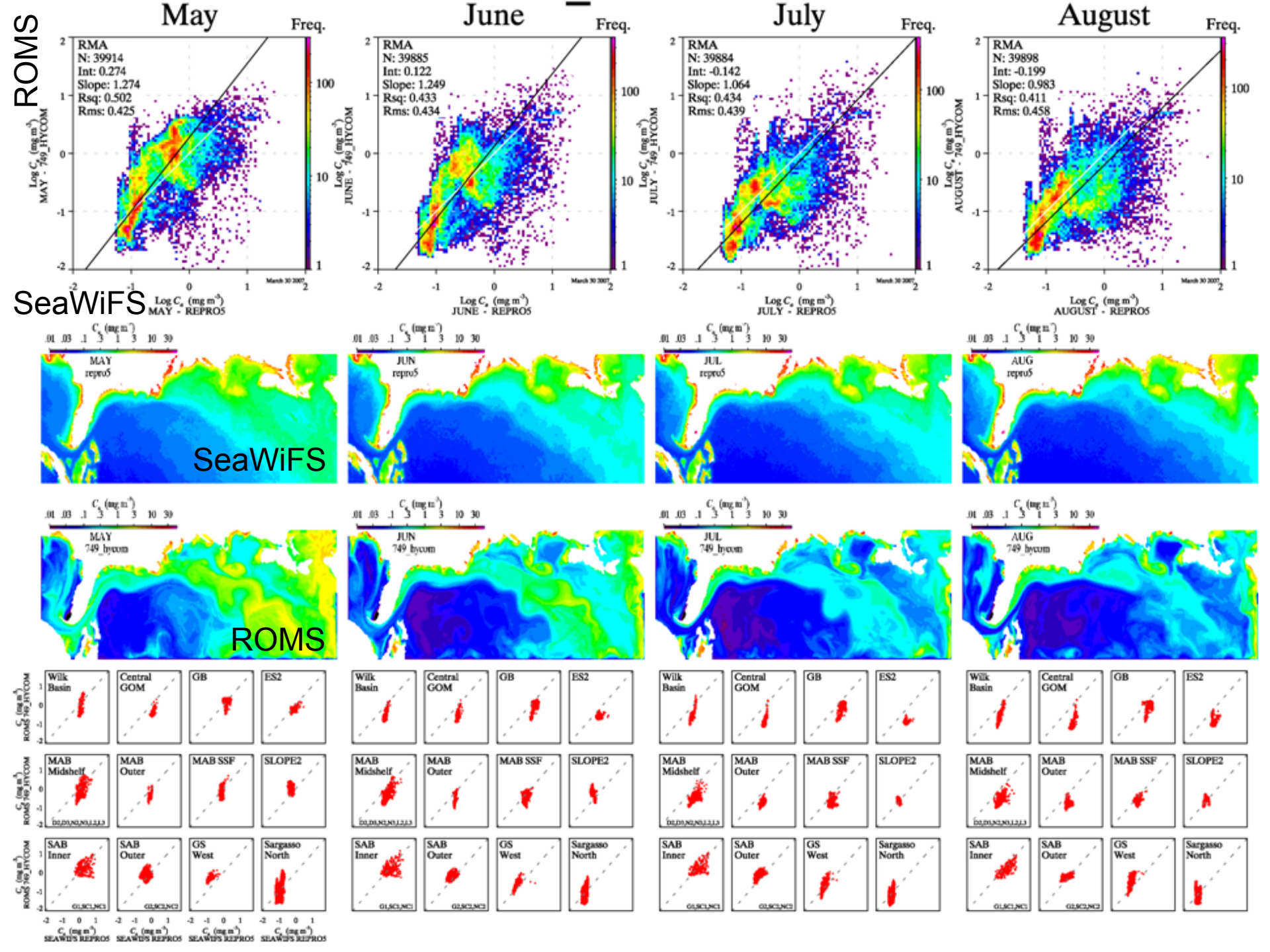


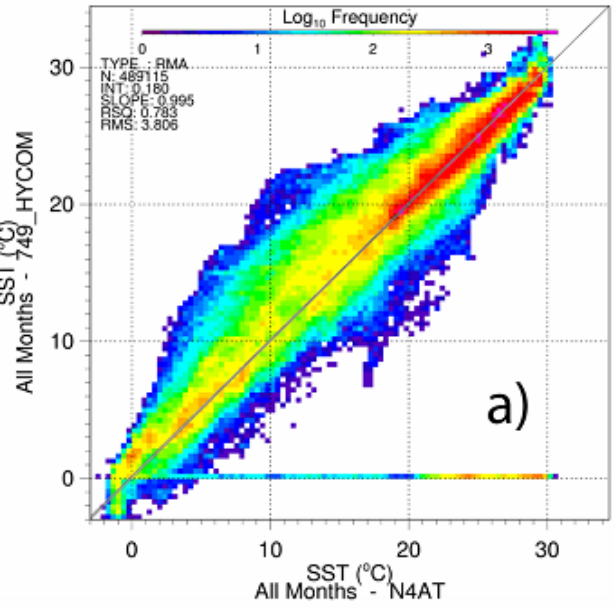
Satellite-derived primary production (PP) using VGPM2

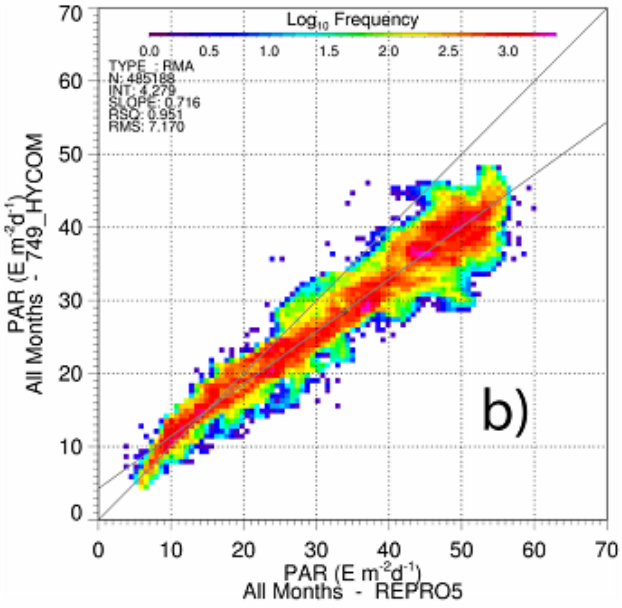
VGPM2 applied to NENA-simulated fields

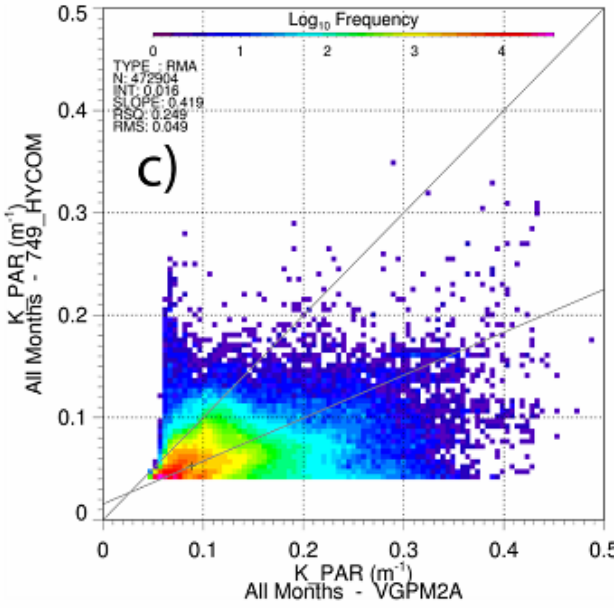
Modeled PP using NENA

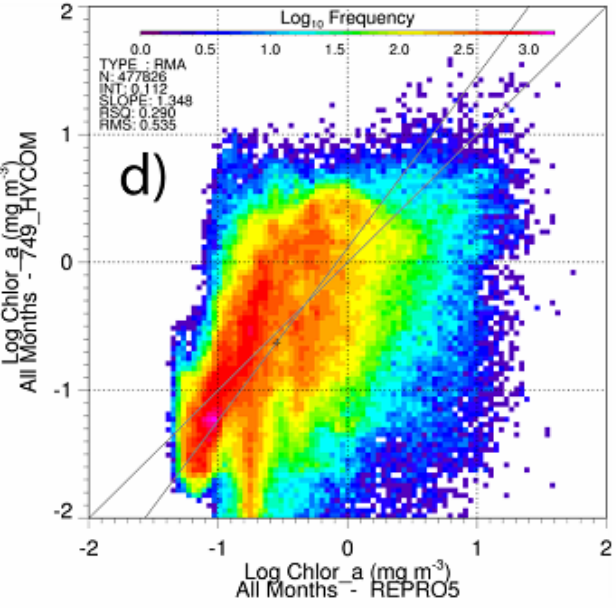
Fennel, Wilkin, O'Reilly

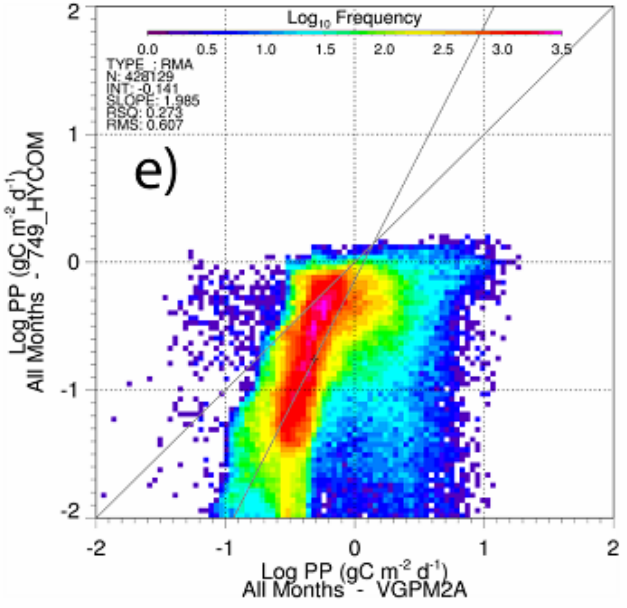

May
June
July
August
Freq.
ROMS
RMA
N: 39914
Int: 0.274
Slope: 1.274
Rsq: 0.502
Rms: 0.425
N: 39885
Int: 0.122
Slope: 1.249
Rsq: 0.433
Rms: 0.434
N: 39884
Int: -0.142
Slope: 1.064
Rsq: 0.434
Rms: 0.439
N: 39898
Int: -0.199
Slope: 0.983
Rsq: 0.411
Rms: 0.458
SeaWiFS
MAY - REPRO5
JUNE - REPRO5
JULY - REPRO5
AUGUST - REPRO5
MAY repro5
JUN repro5
JUL repro5
AUG repro5
MAY 749_hycom
JUN 749_hycom
JUL 749_hycom
AUG 749_hycom
Wilk Basin
Central GOM
GB
ES2
MAB Midshelf
MAB Outer
MAB SSF
SLOPE2
SAB Inner
SAB Outer
GS West
Sargasso North

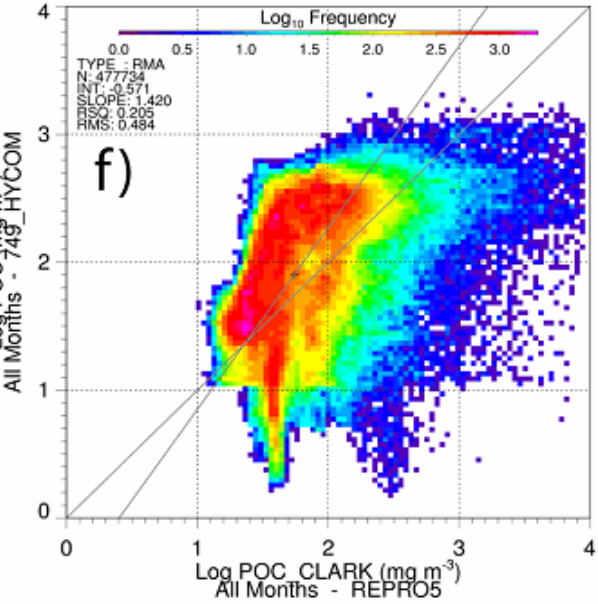

Log10 Frequency
TYPE : RMA
N: 489115
INT: 0.180
SLOPE: 0.995
RSQ: 0.783
RMS: 3.806
a)
SST (°C) All Months - 749_HYCOM
SST (°C) All Months - N4AT


Log10 Frequency
TYPE : RMA
N: 485188
INT: 4.279
SLOPE: 0.716
RSQ: 0.951
RMS: 7.170
b)
PAR (E m-2d-1) All Months - 749_HYCOM
PAR (E m-2d-1) All Months - REPRO5

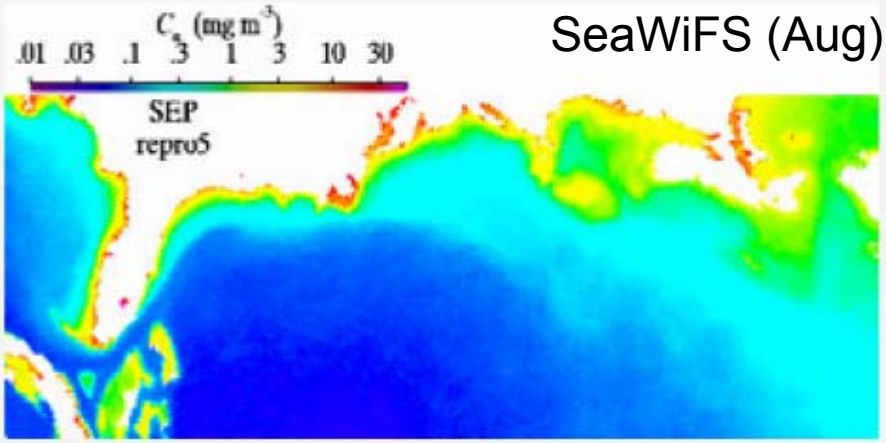

Log10 Frequency
TYPE : RMA
N: 472904
INT: 0.016
SLOPE: 0.419
RSQ: 0.249
RMS: 0.049
c)
K_PAR (m-1) All Months - 749_HYCOM
K_PAR (m-1) All Months - VGPM2A


Log10 Frequency
TYPE : RMA
N: 477826
INT: 0.112
SLOPE: 1.348
RSQ: 0.290
RMS: 0.535
d)
Log Chlor_a (mg m-3) All Months - 749_HYCOM
Log Chlor_a (mg m-3) All Months - REPRO5

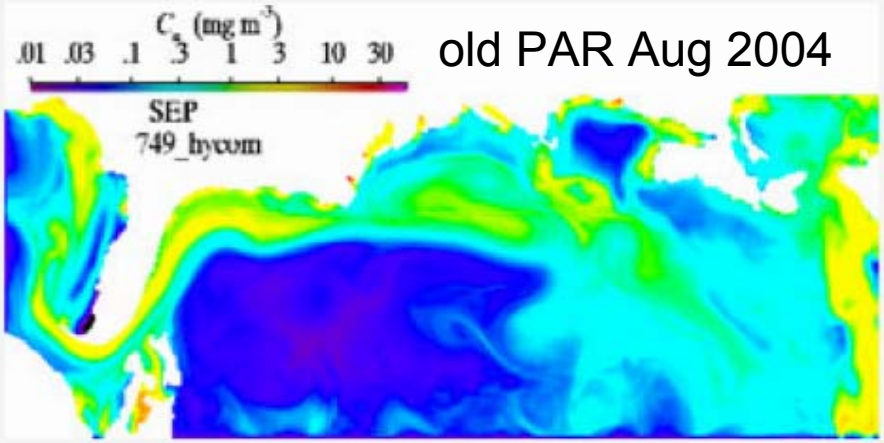

Log10 Frequency
TYPE : RMA
N: 428129
INT: -0.141
SLOPE: 1.985
RSQ: 0.273
RMS: 0.607
e)
Log PP (gC m-2 d-1) All Months - 749_HYCOM
Log PP (gC m-2 d-1) All Months - VGPM2A


Log10 Frequency
TYPE : RMA
N: 477734
INT: -0.571
SLOPE: 1.420
RSQ: 0.205
RMS: 0.484
f)
Log POC (mg m-3) All Months - 749_HYCOM
Log POC_CLARK (mg m-3) All Months - REPRO5

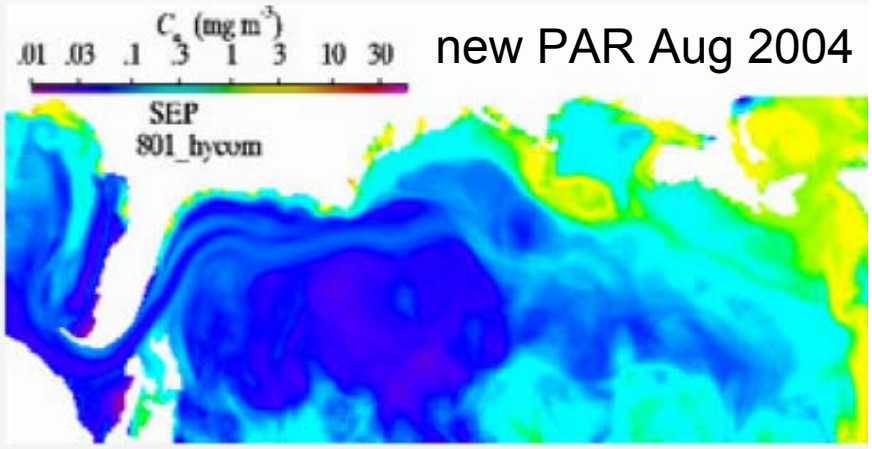
Shallower euphotic depth gives more realistic chlorophyll distribution on Georges Bank, the Gulf of Maine and the Slope Sea.



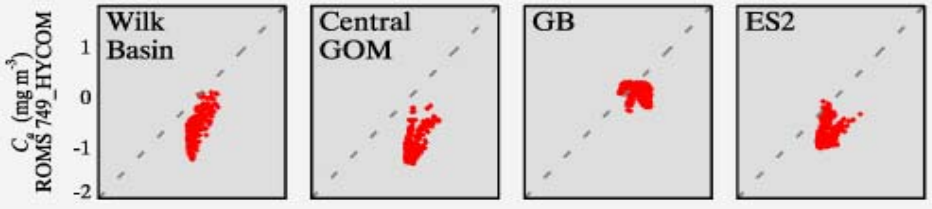
SeaWiFS (Aug)

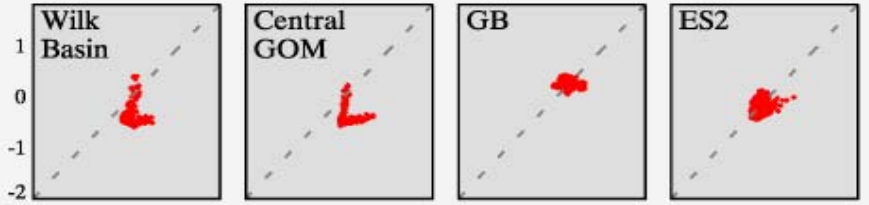


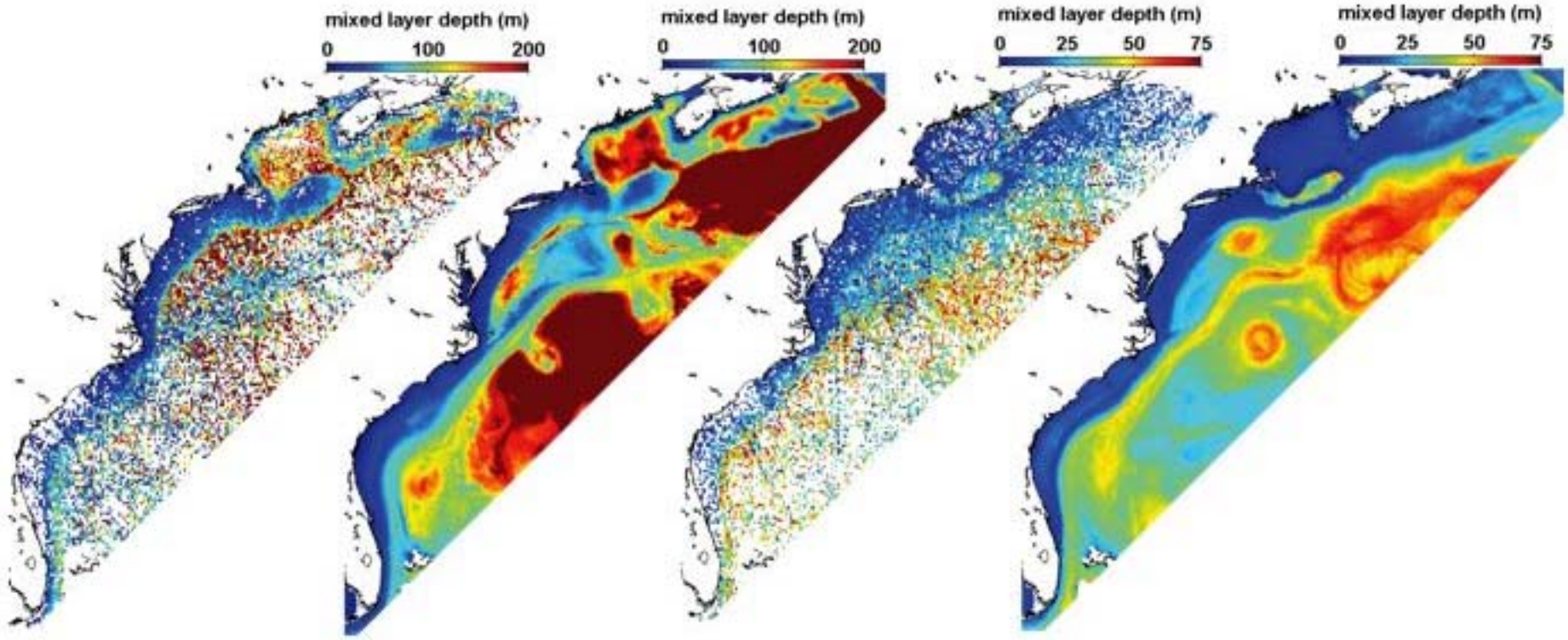
old PAR Aug 2004



new PAR Aug 2004





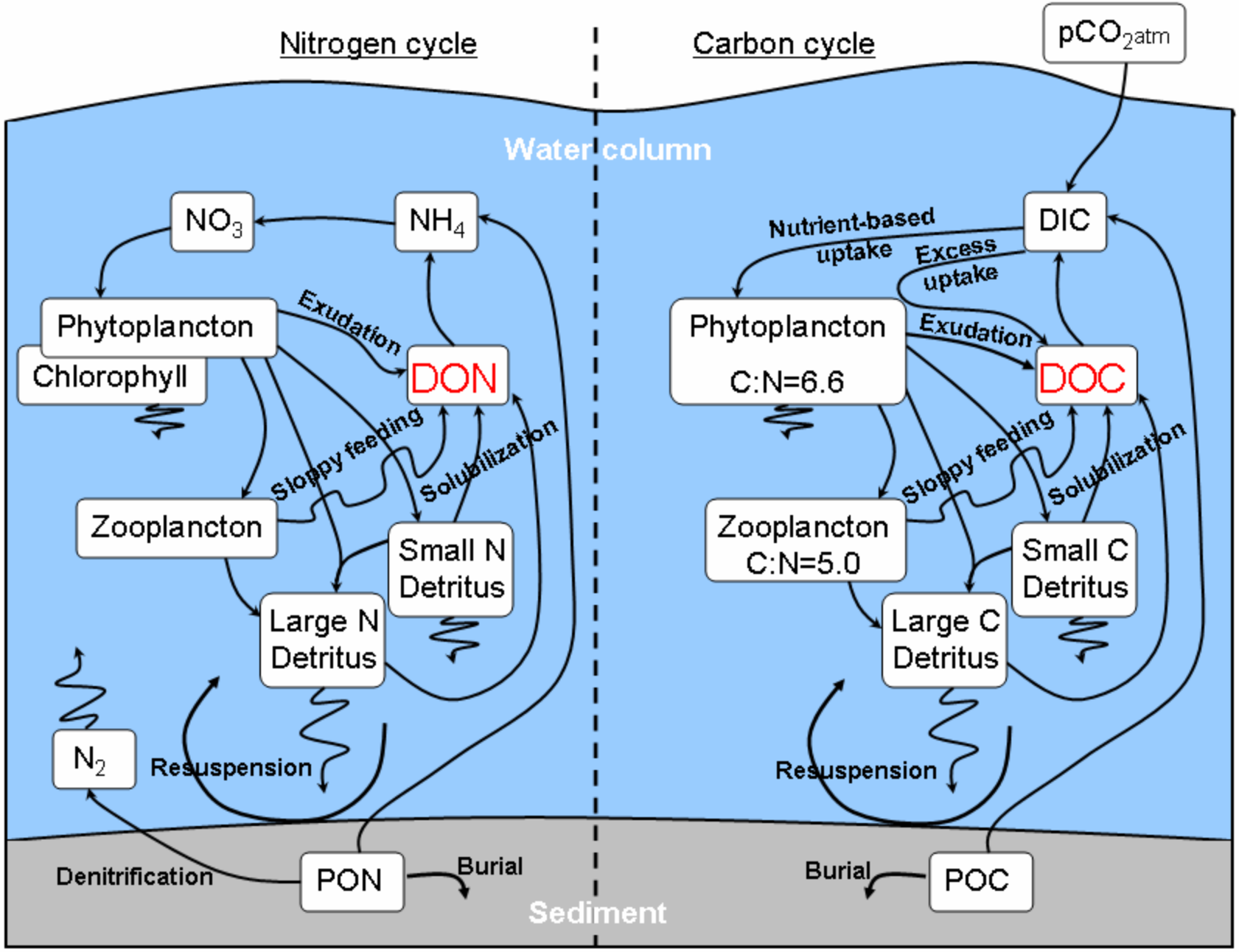


March climatology

March model

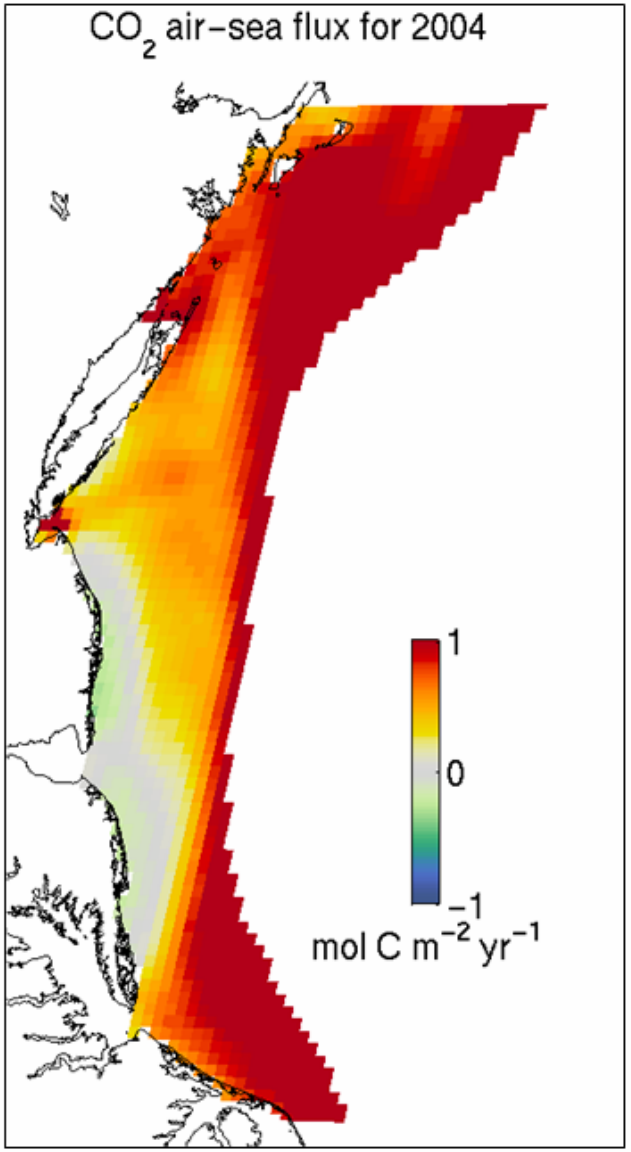
September climatology

September model



Semilabile DON and DOC with degradation rates from weeks to months

Continental shelf carbon cycle



Simulated annual air-sea flux of CO_2
Explicit inorganic carbon cycling

Positive values indicate uptake by ocean

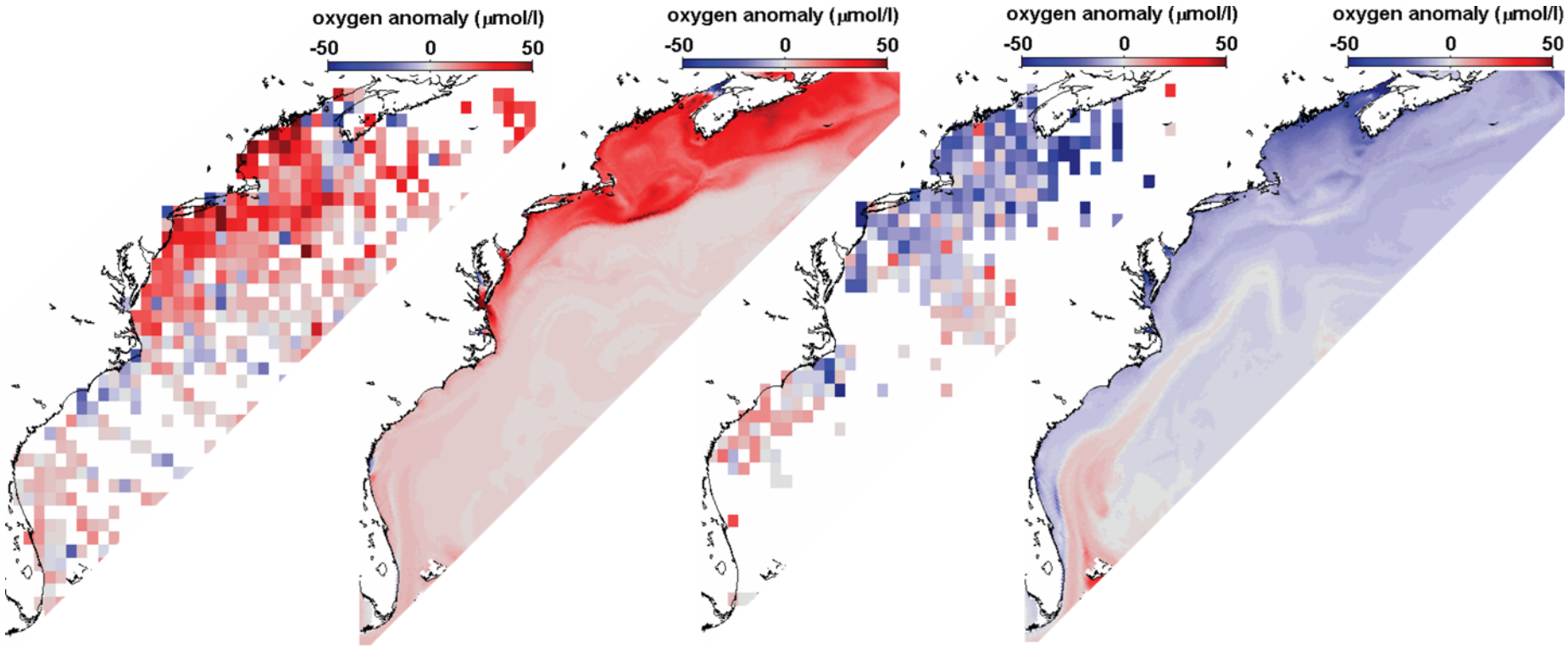
Outer Mid-Atlantic Bight continental shelf is a sink for atmospheric CO_2

No net uptake off NJ due to outgassing during summer from upwelling

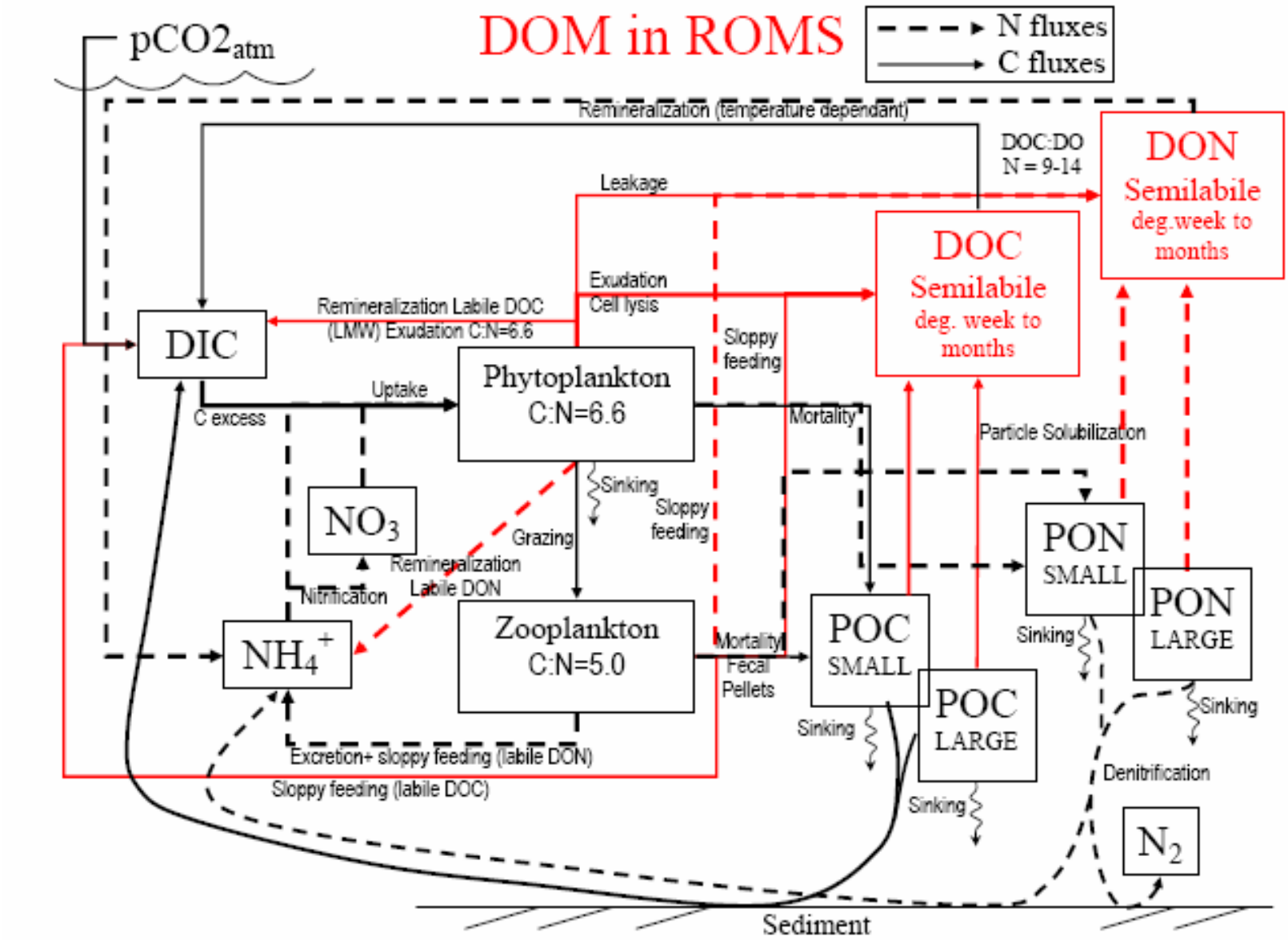
Katja Fennel

MAB atmospheric CO_2 uptake estimates

	DeGrandpre *et al.* (2002)	Model	Model w/o DNF
Total (**Mt C yr^{-1}**)	**1.0 ± 0.6**	**0.9**	**1.62**
Inner Shelf (0-20 m) (**mol C m^{-2} yr^{-1}**)	**0.9 ± 0.63**	**0.38**	**1.1**
Mid-shelf (20-50 m) (**mol C m^{-2} yr^{-1}**)	**1.6 ± 1.28**	**0.57**	**1.2**
Outer Shelf (50-200 m) (**mol C m^{-2} yr^{-1}**)	**0.7 ± 0.07**	**0.91**	**1.2**

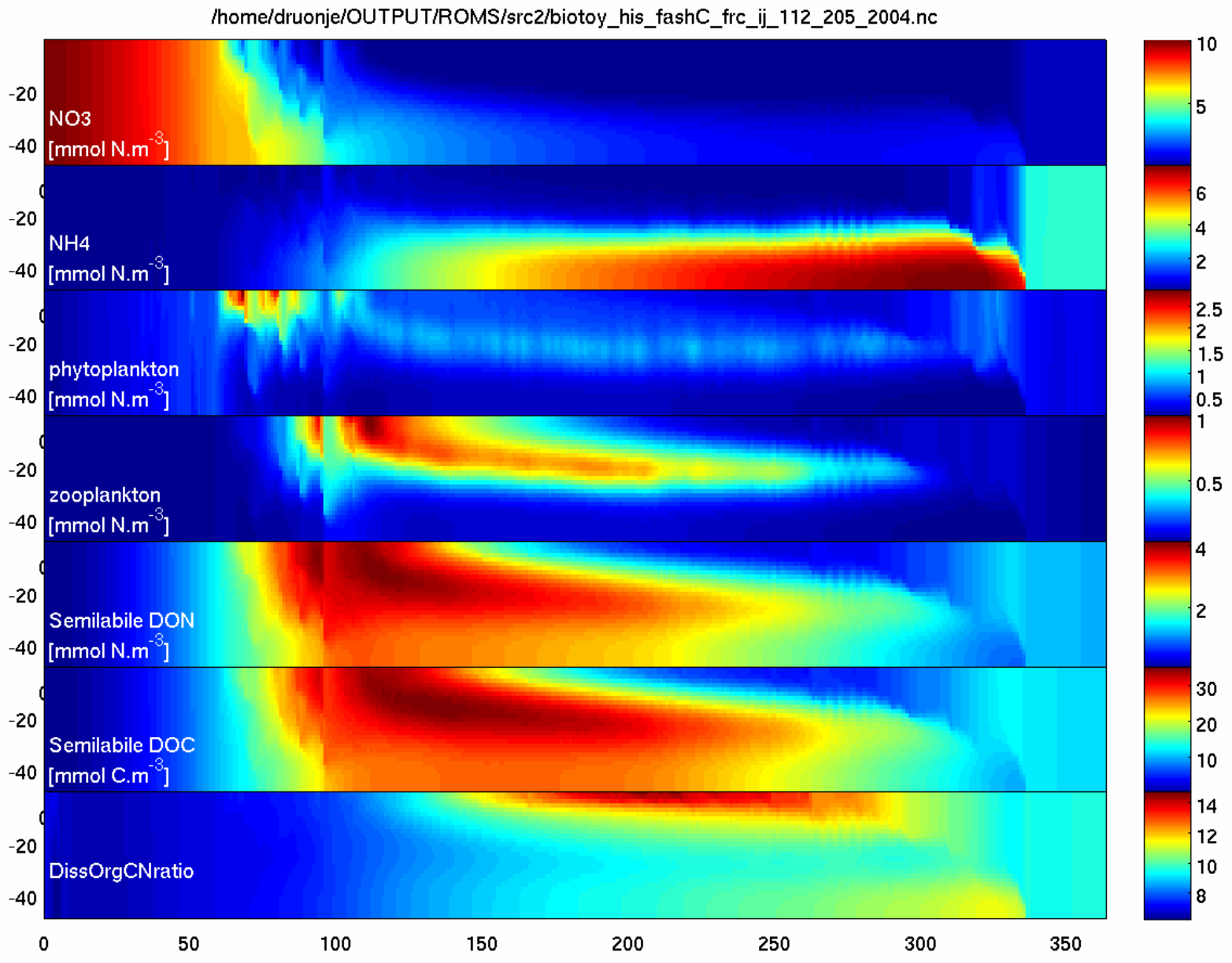

oxygen anomaly (µmol/l)
-50
0
50
oxygen anomaly (µmol/l)
-50
0
50
oxygen anomaly (µmol/l)
-50
0
50
oxygen anomaly (µmol/l)
-50
0
50

DOM modeling



Jean-Noel Druon

1-D Mid Atlantic Bight results



Summary: Status/Future

- ROMS-in-HYCOM for NENA works
  - but requires that the salinity bias is corrected
    - increasing resolution will not solve bias
  - ROMS biases:
    - South Atlantic Bight bottom temperatures too cold
    - shelf stratification too strong
    - MAB shelf/slope front under-resolved
  - ROMS/BGC:
    - sensitivity to vertical mixing, k_{PAR} being pursued
    - must consider benthic processes (semi-labile constituents, diagenesis, denitrification, export, benthic primary productivity)
    - DOC model running now

**Experimental System for Predicting Shelf and Slope Optics*

jwilkin@rutgers.edu
http://marine.rutgers.edu

Summary: Status/Future

- Needs
  - explore improved open boundary condition schemes
  - better process for data transfer and coordinate remapping (presently ad hoc extrapolation and land/sea/bathy mis-match)
    - especially for future operational applications (MURI-ESPreSSO*) unbiased Hycom (on shelf) preferred
    - but possibly corrected via shelf assimilation
  - should use inter-annual river flow variability (in both models but especially in ROMS)

- Future
  - Operational MAB
  - 4DVar assimilation of Coastal Observing System data
    - gliders, CODAR, cabled observatory
  - Optics model for ESPreSSO
  - multiple nesting within ROMS

**Experimental System for Predicting Shelf and Slope Optics*

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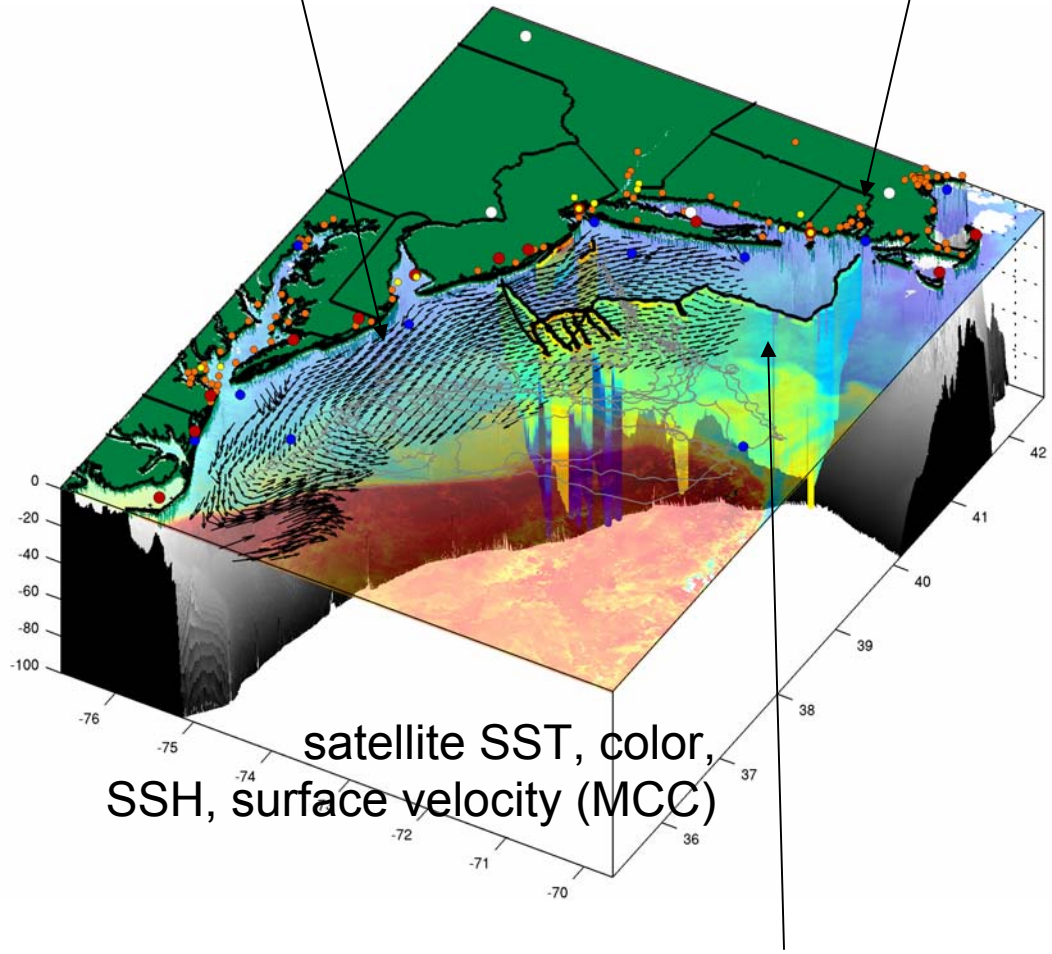
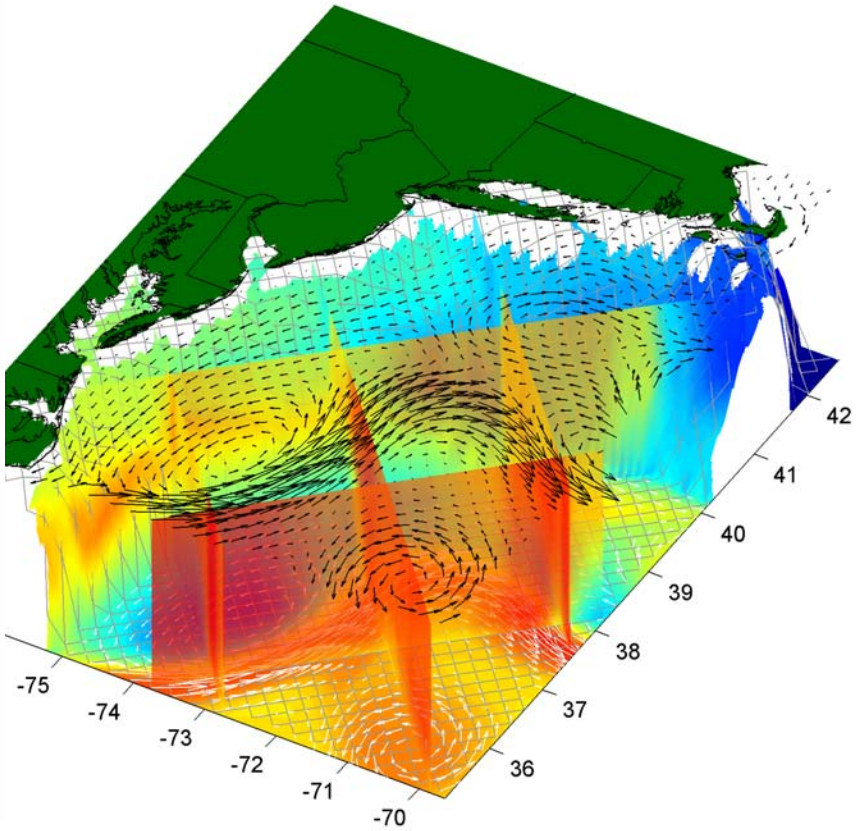
CODAR surface currents

coastal meteorology

ROMS in HYCOM



satellite SST, color,
SSH, surface velocity (MCC)



glider: T,S, optics along paths