Wind-driven transport of the Apalachicola River plume as a connectivity mechanism between terrestrial precipitation variability and offshore oceanic properties

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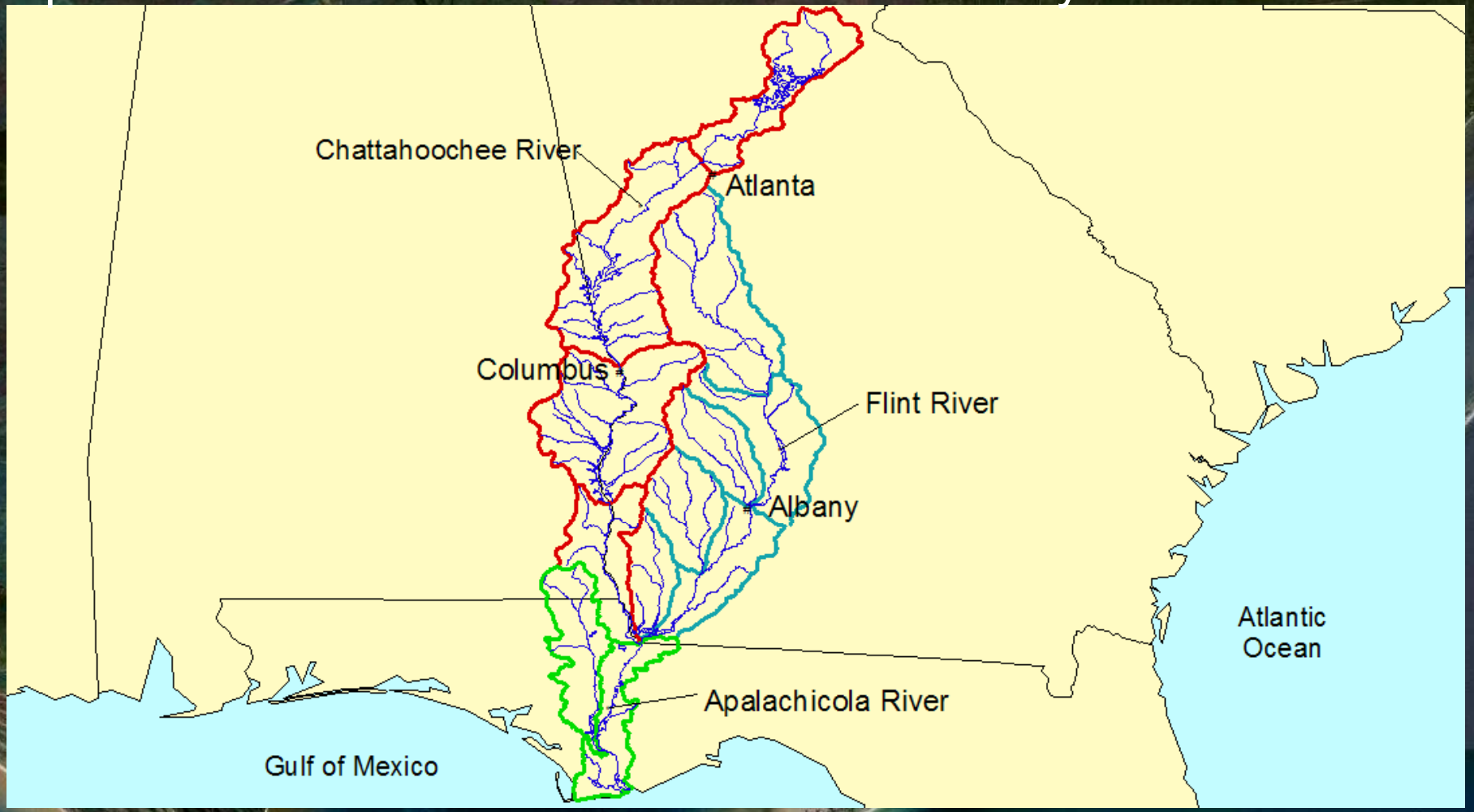
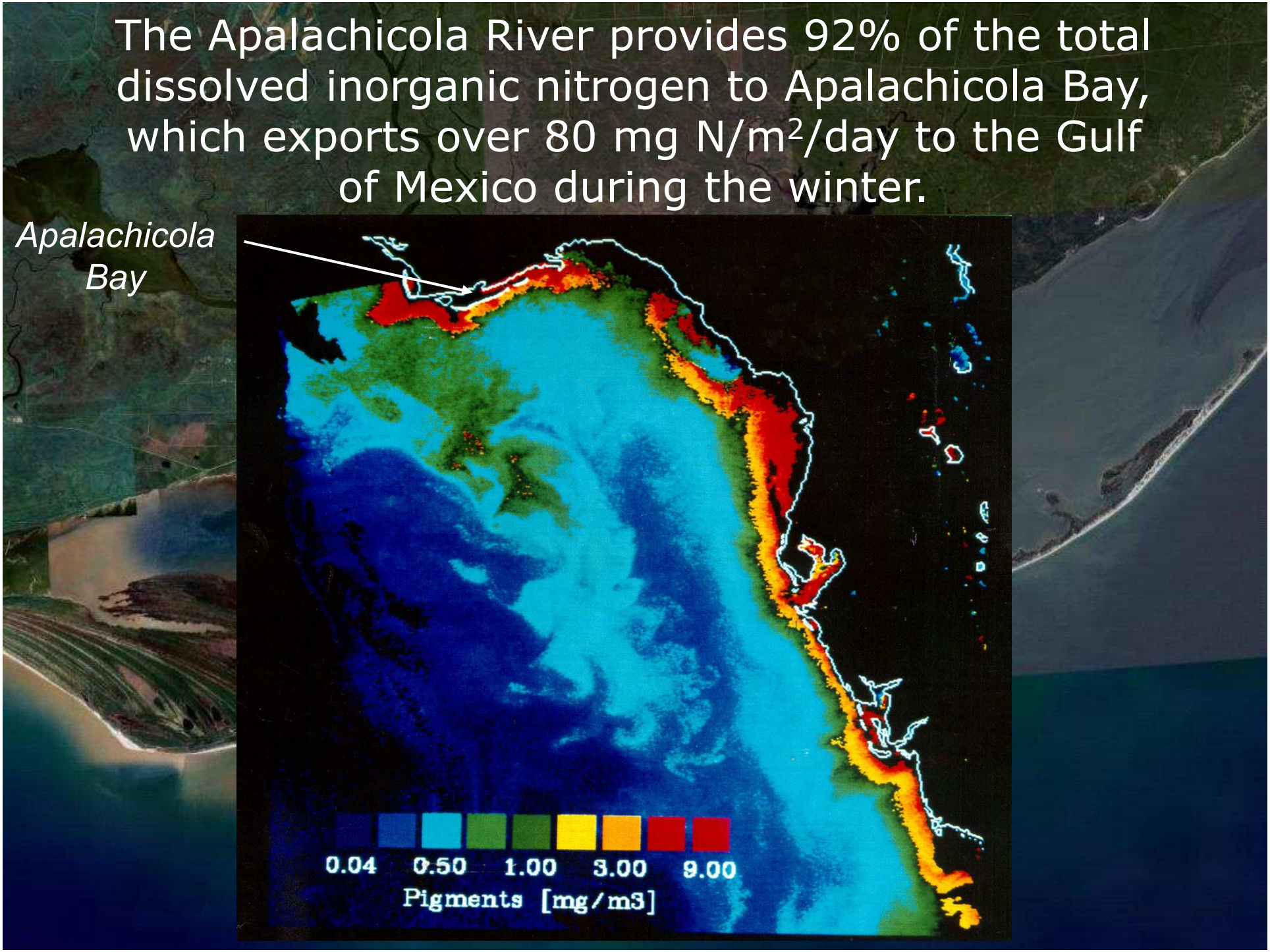
Apalachicola – Chattahoochee – Flint River System Watershed

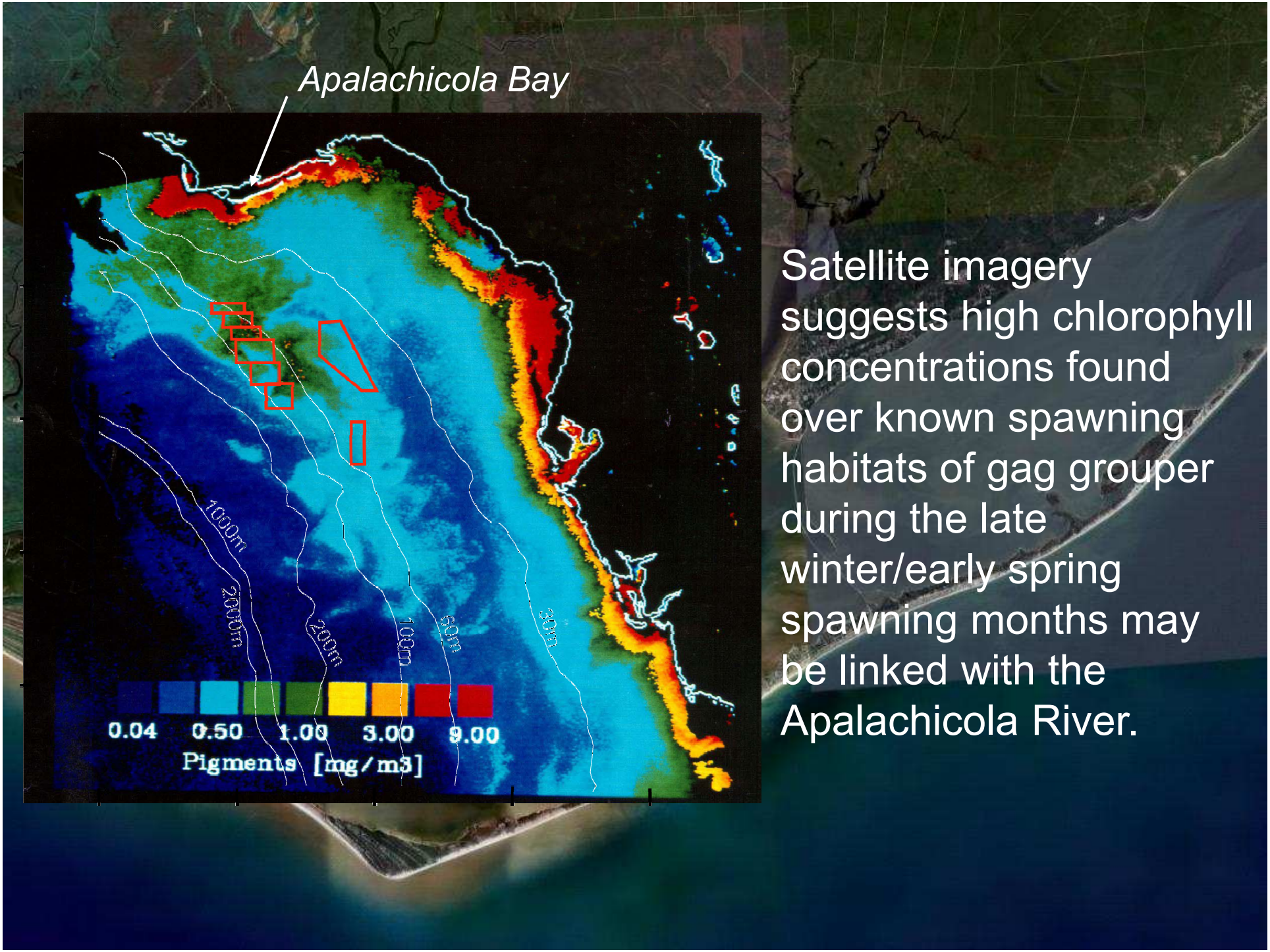


Drainage area = 50,000 km^2 Average discharge rate = 736 m^3/s

Largest source of freshwater in Gulf of Mexico east of Mobile Bay

The Apalachicola River provides 92% of the total dissolved inorganic nitrogen to Apalachicola Bay, which exports over 80 mg N/m^2/day to the Gulf of Mexico during the winter.



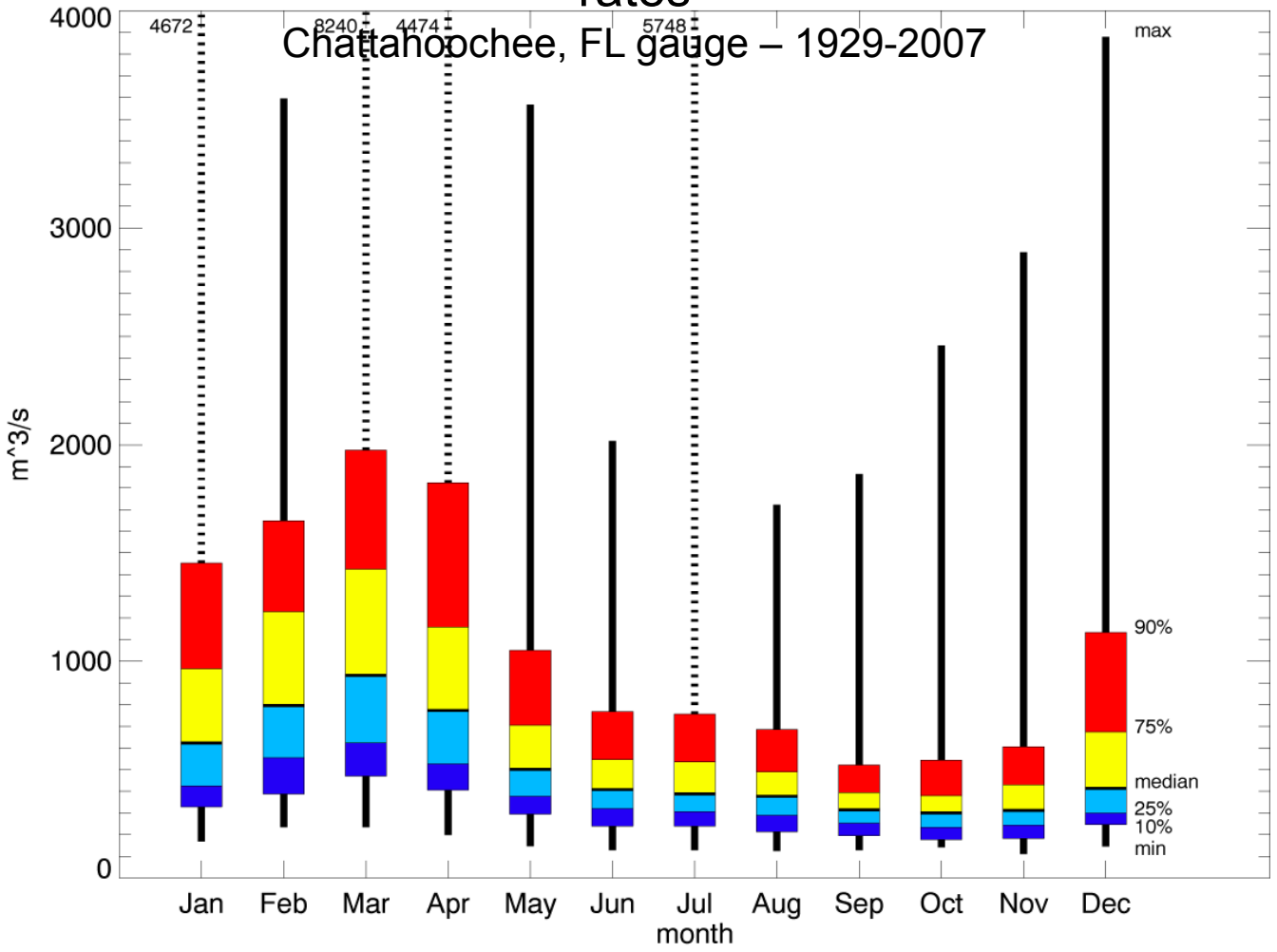


Satellite imagery suggests high chlorophyll concentrations found over known spawning habitats of gag grouper during the late winter/early spring spawning months may be linked with the Apalachicola River.

Seasonal Variability

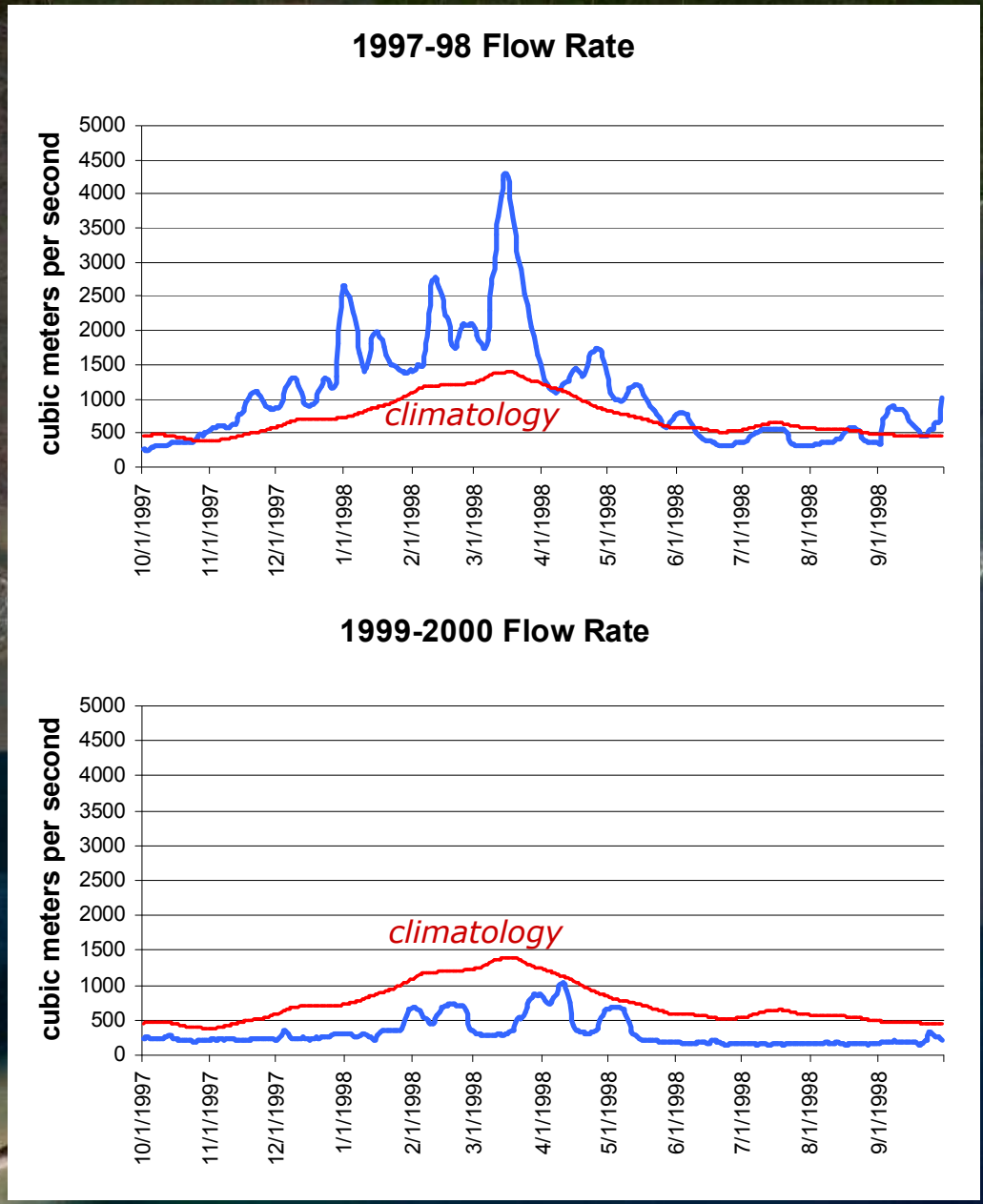
Monthly distributions of Apalachicola River daily flow rates

Chattahoochee, FL gauge – 1929-2007

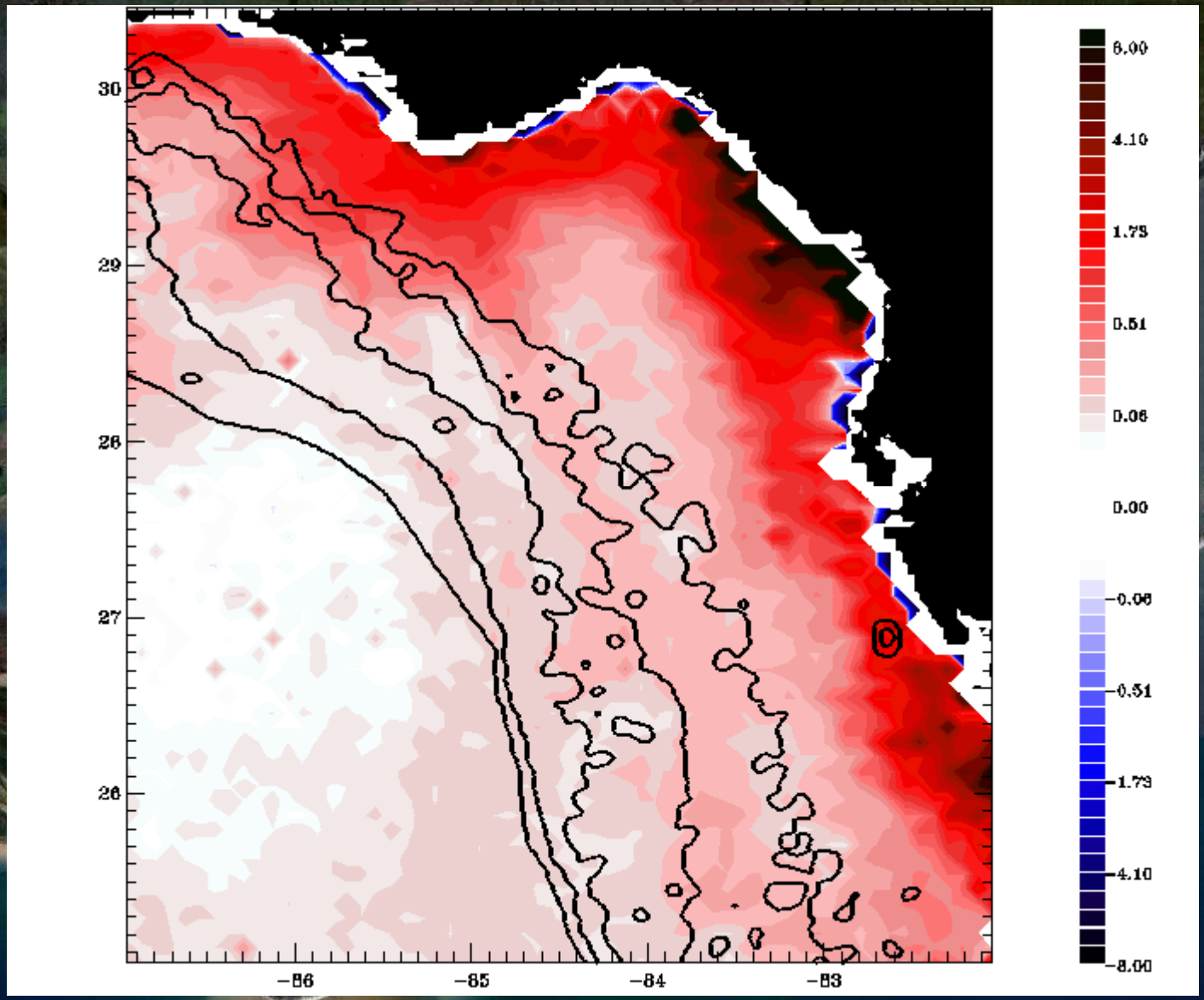


How does this discharge variability impact the regional oceanography?

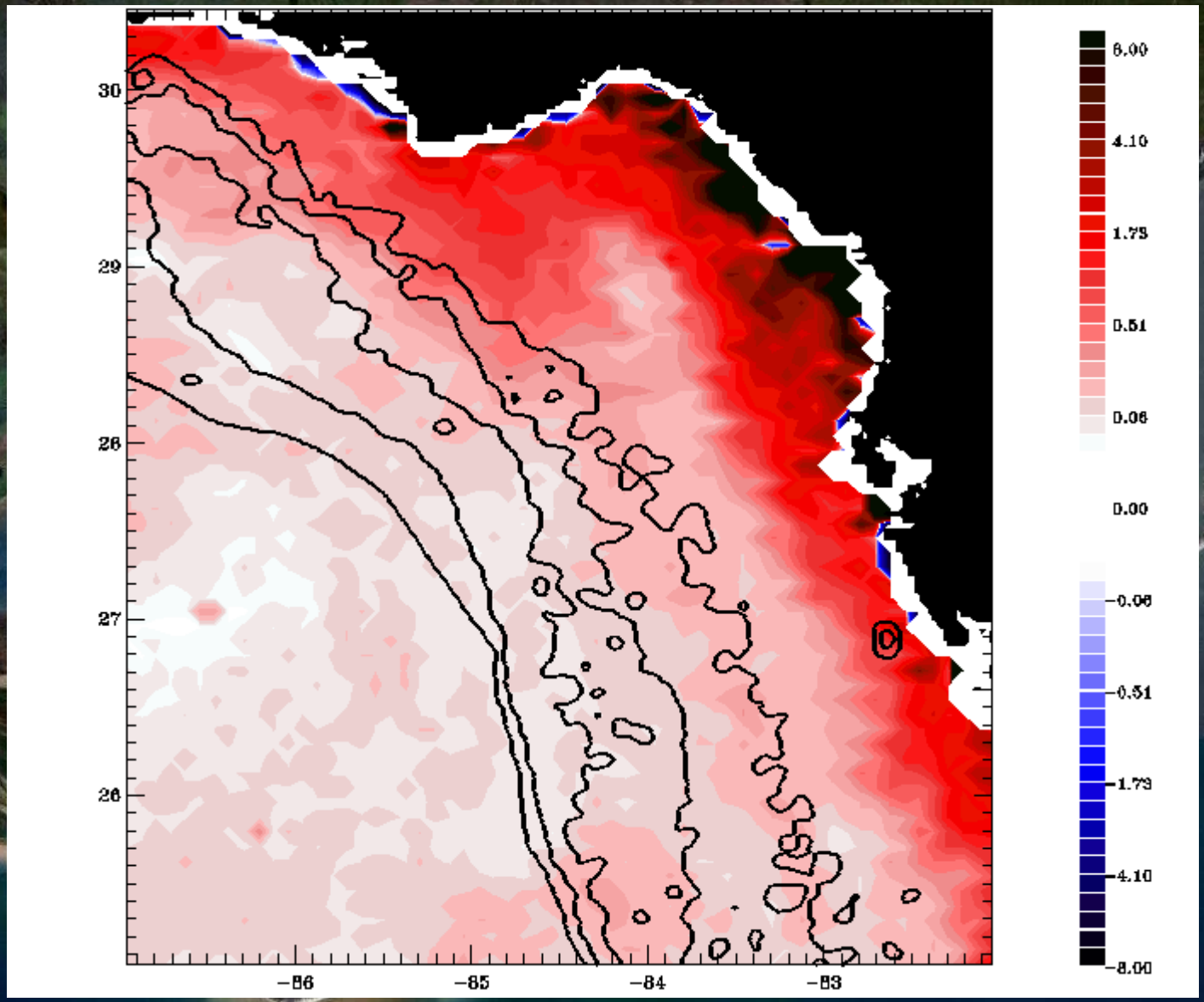
What is the geographic scope of the river's influence?



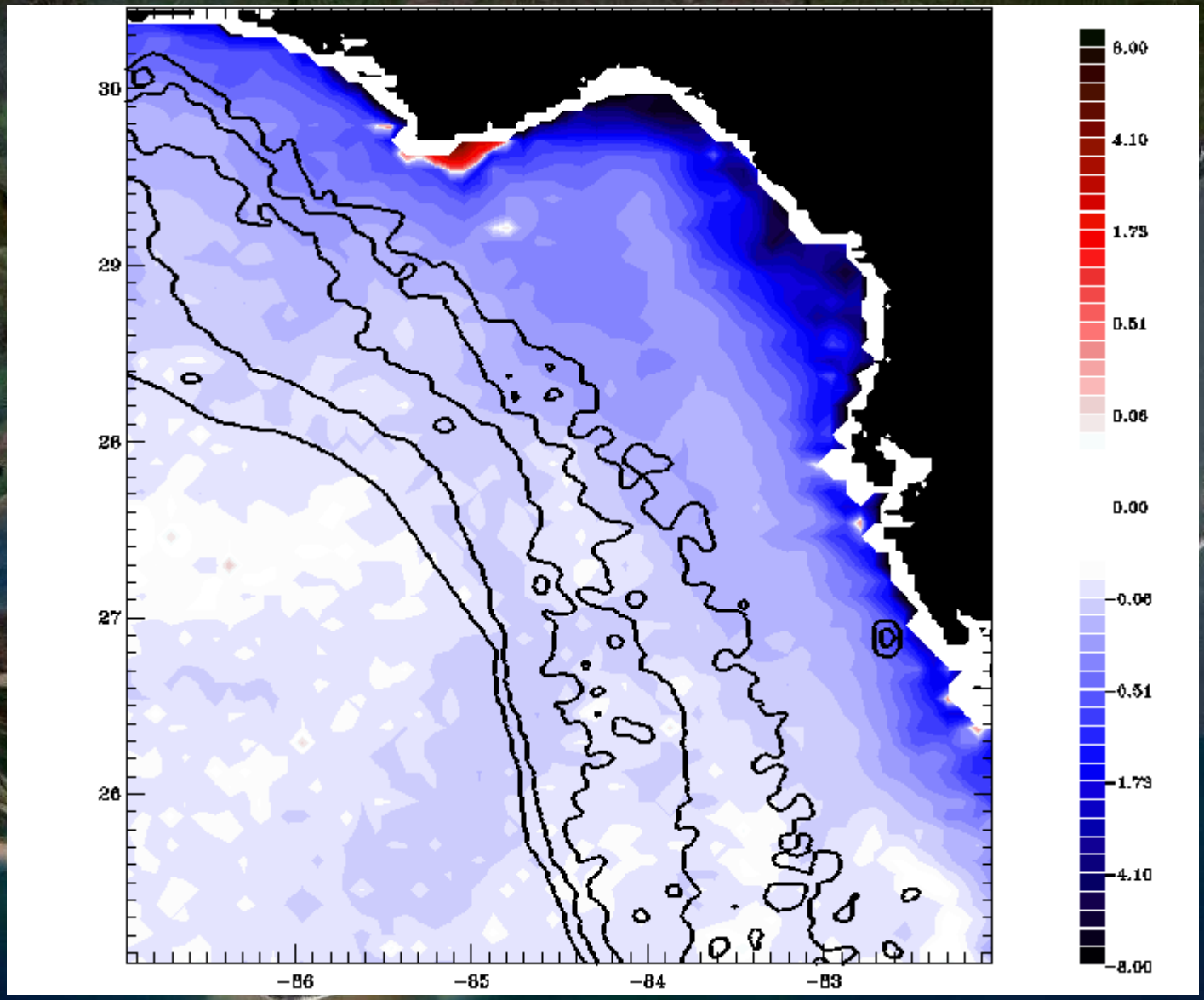
SeaWiFS Chl *a* Monthly Anomaly (mg/m^3) Feb 1998



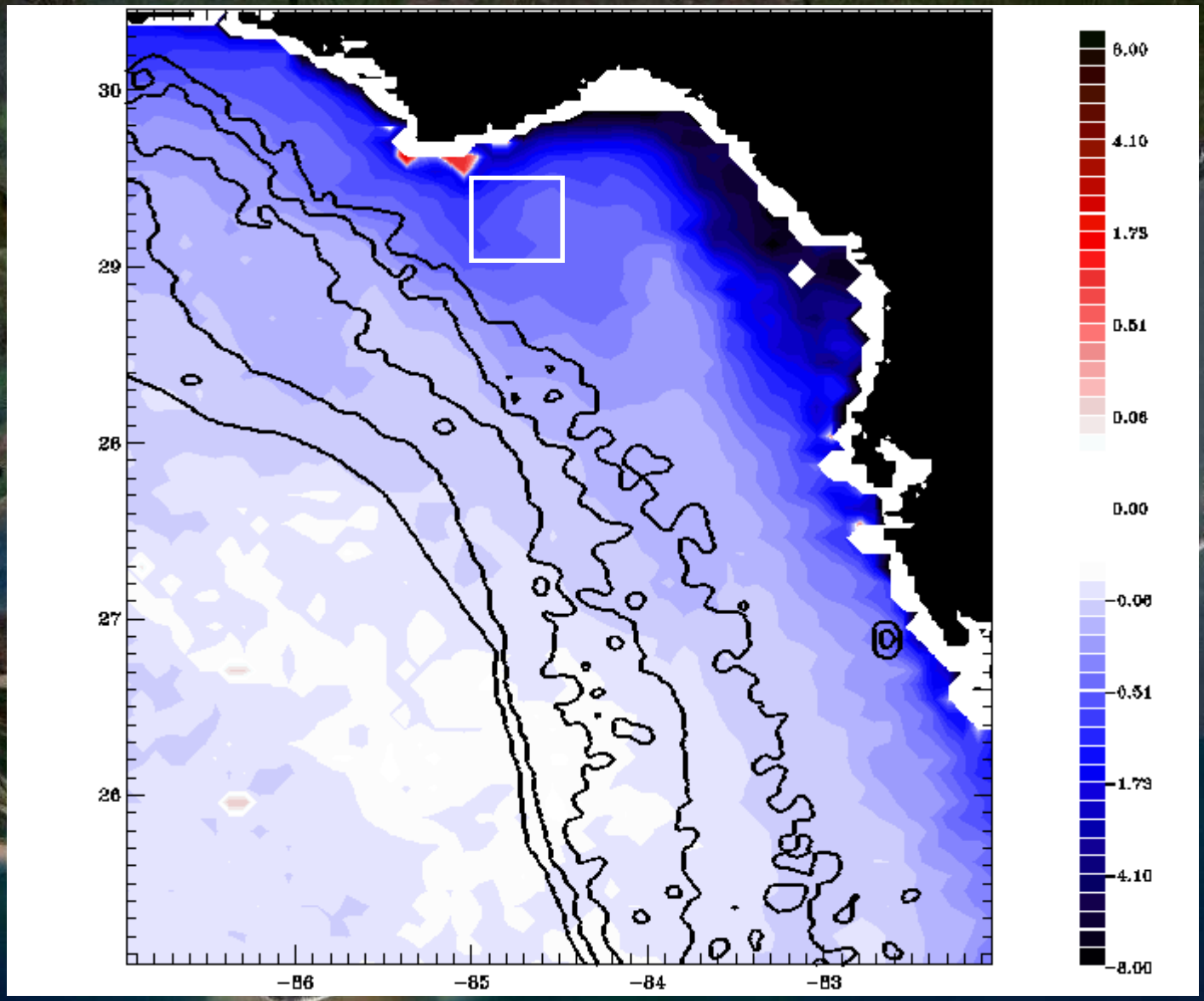
SeaWiFS Chl *a* Monthly Anomaly (mg/m^3) Mar 1998

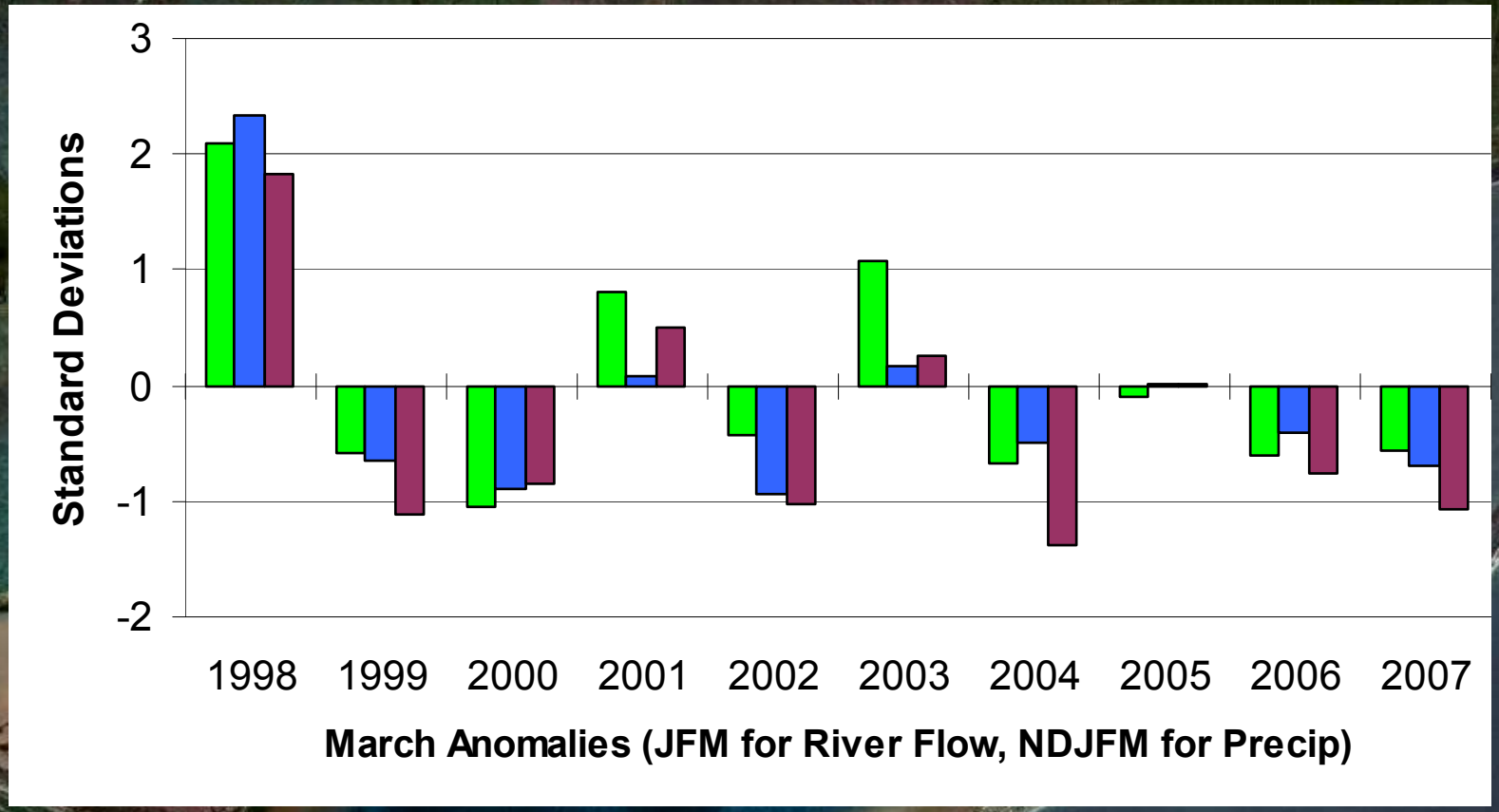


SeaWiFS Chl *a* Monthly Anomaly (mg/m^3) Feb 2000



SeaWiFS Chl *a* Monthly Anomaly (mg/m^3) Mar 2000

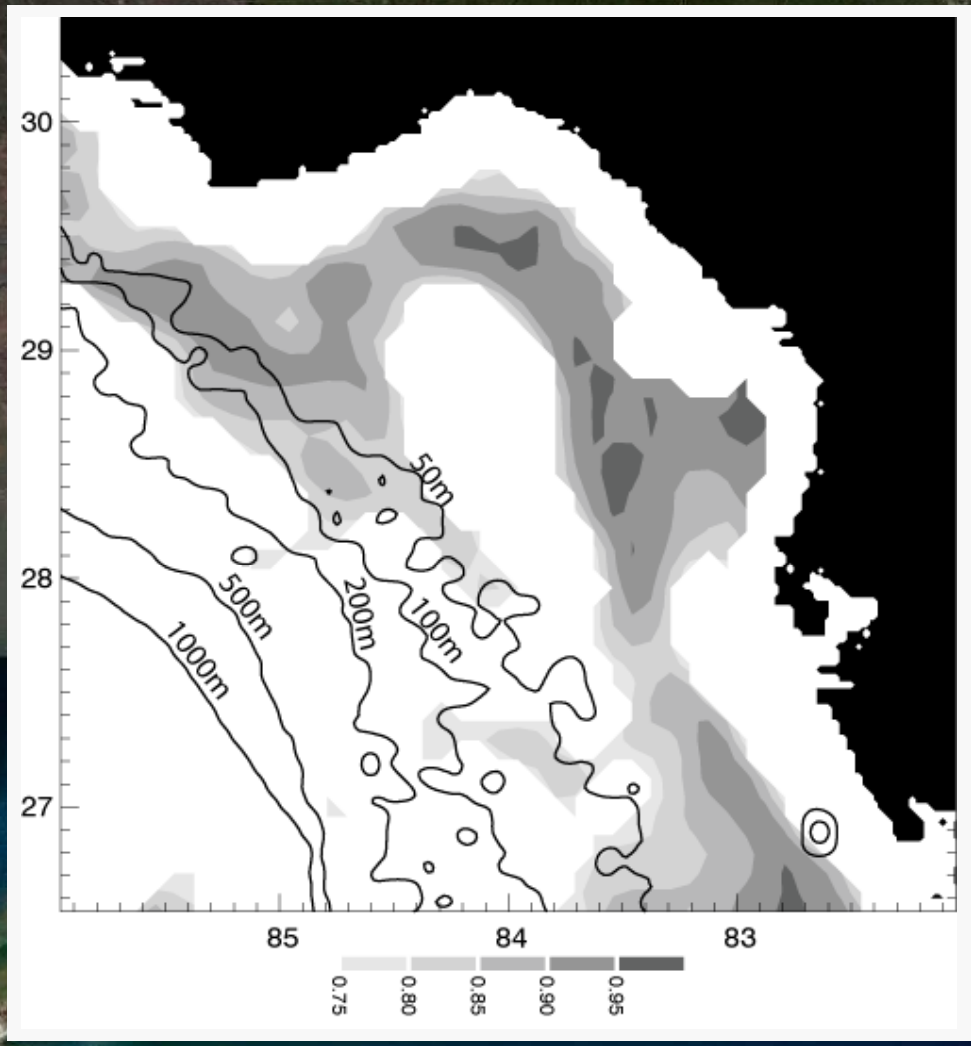




Interannual variability in chlorophyll offshore of Apalachicola Bay seems to be linked to variability in the Apalachicola River discharge and the regional precipitation.

Correlation between March chl *a* anomaly and Apalachicola River discharge (Jan – Mar) anomaly (1998-2007)

What are the physical mechanisms responsible for this connectivity?

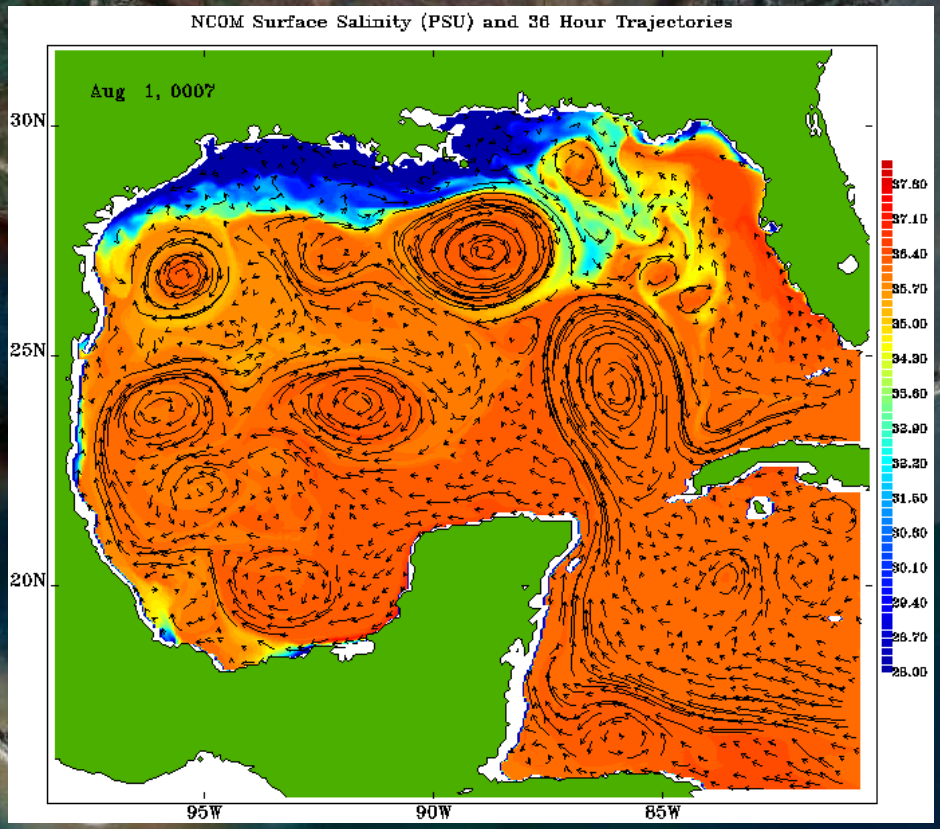


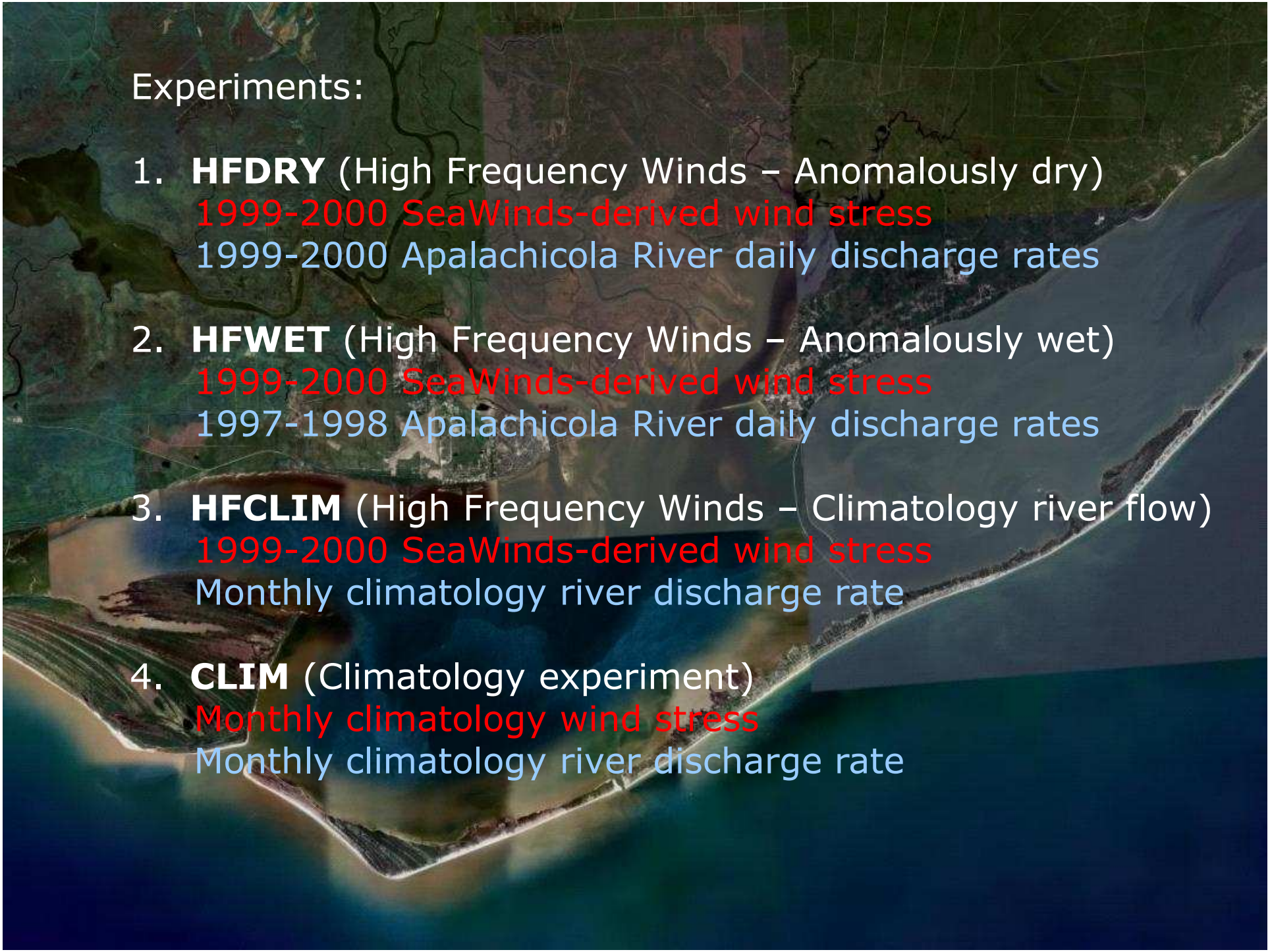
Numerical model experiments

Navy Coastal Ocean Model : Gulf of Mexico – 1/20° resolution

Initialized from a data assimilative hindcast on 9/22/99 and run for one year (analysis focuses on Dec-Apr)

Forcing: climatology surface heat flux; 30 river sources; climatology or 12-hourly (scatterometer-derived) wind stress





Experiments:

1. **HFDRY** (High Frequency Winds – Anomalously dry)
   1999-2000 SeaWinds-derived wind stress
   1999-2000 Apalachicola River daily discharge rates

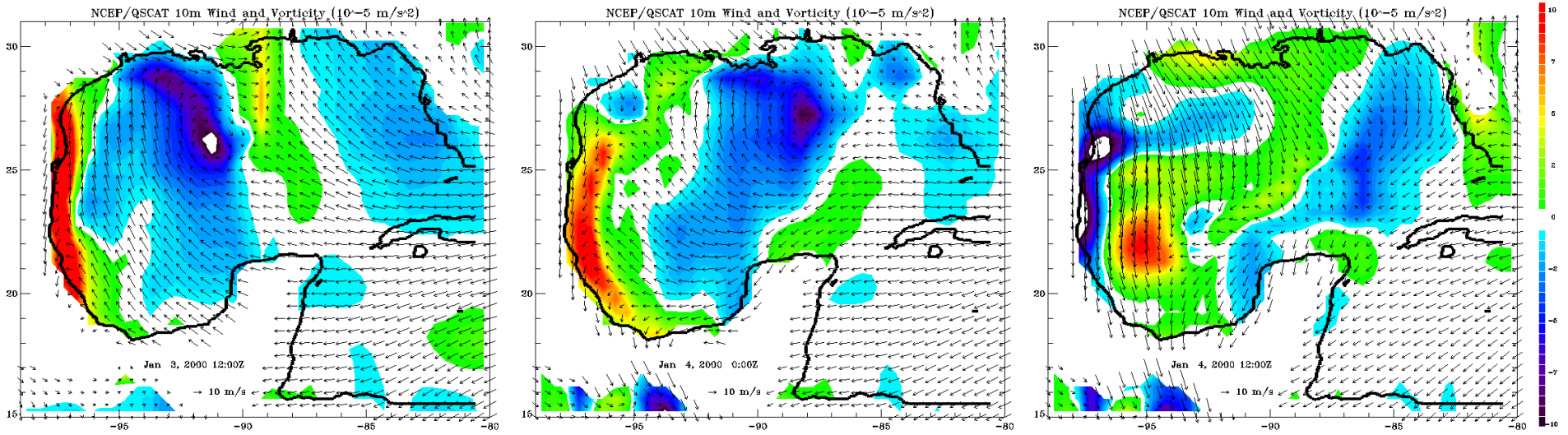
2. **HFWET** (High Frequency Winds – Anomalously wet)
   1999-2000 SeaWinds-derived wind stress
   1997-1998 Apalachicola River daily discharge rates

3. **HFCLIM** (High Frequency Winds – Climatology river flow)
   1999-2000 SeaWinds-derived wind stress
   Monthly climatology river discharge rate

4. **CLIM** (Climatology experiment)
   Monthly climatology wind stress
   Monthly climatology river discharge rate

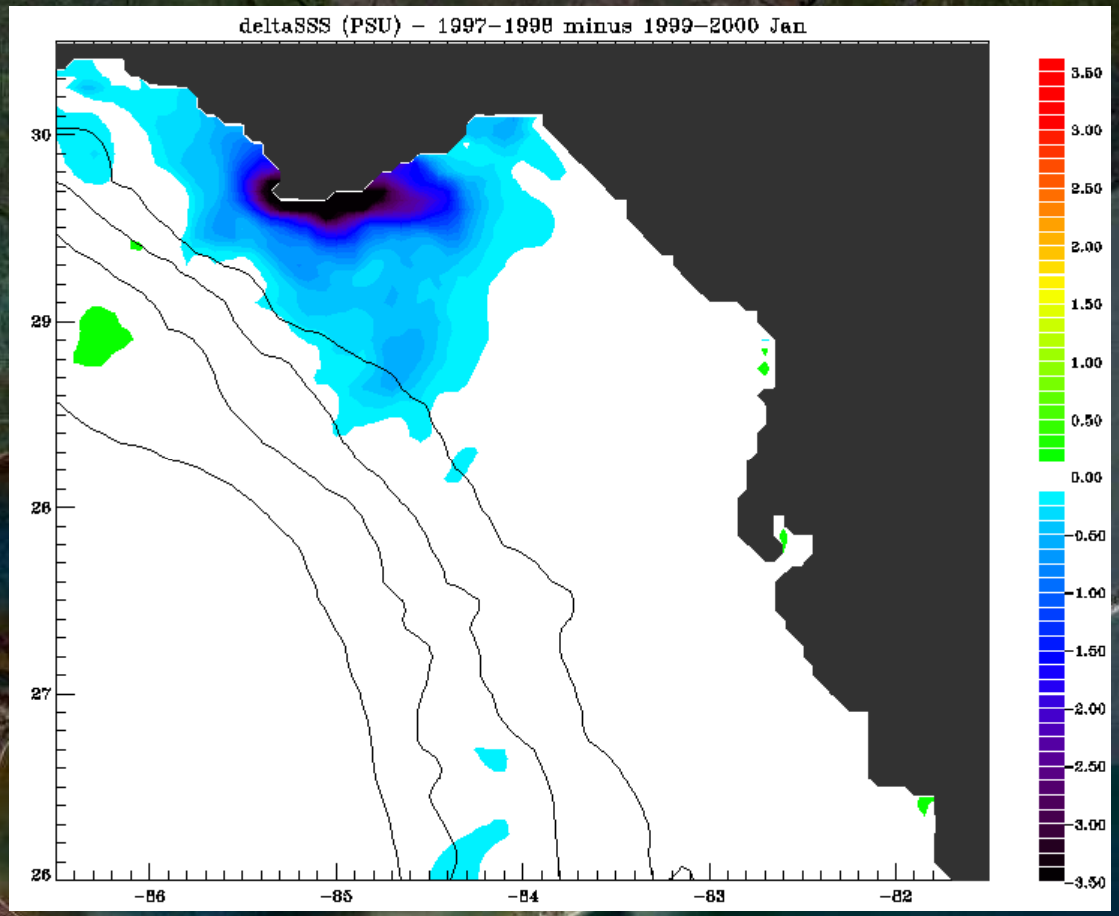
SeaWinds-derived Wind Stress Fields:

- SeaWinds (QuikSCAT) winds are objectively mapped to a ½° grid every 12 hours
- NCEP Reanalysis II used as a background field for the objective gridding
- Method shown to produce complete fields representing frontal features and cyclones (Morey et al., Ocean Dynamics, 2007)
- Stresses computed using Large et al. (1994) drag coefficient

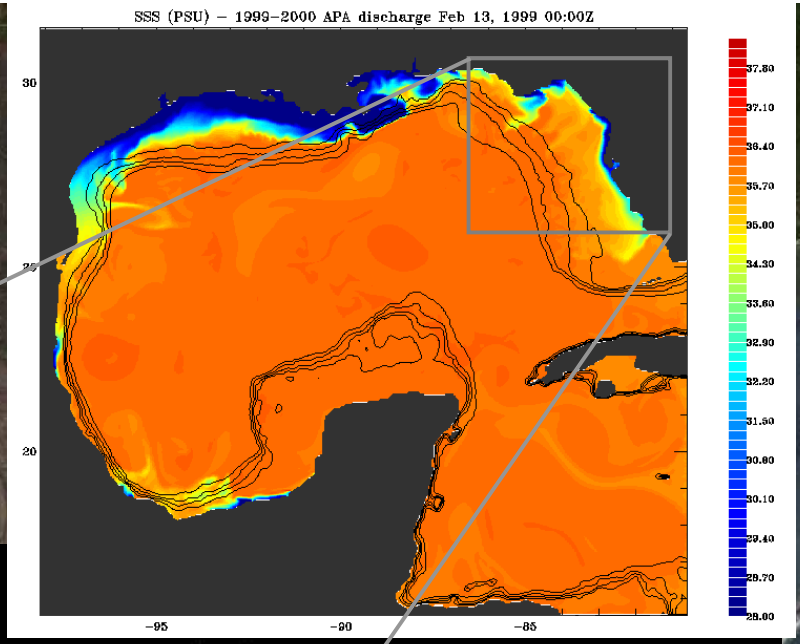


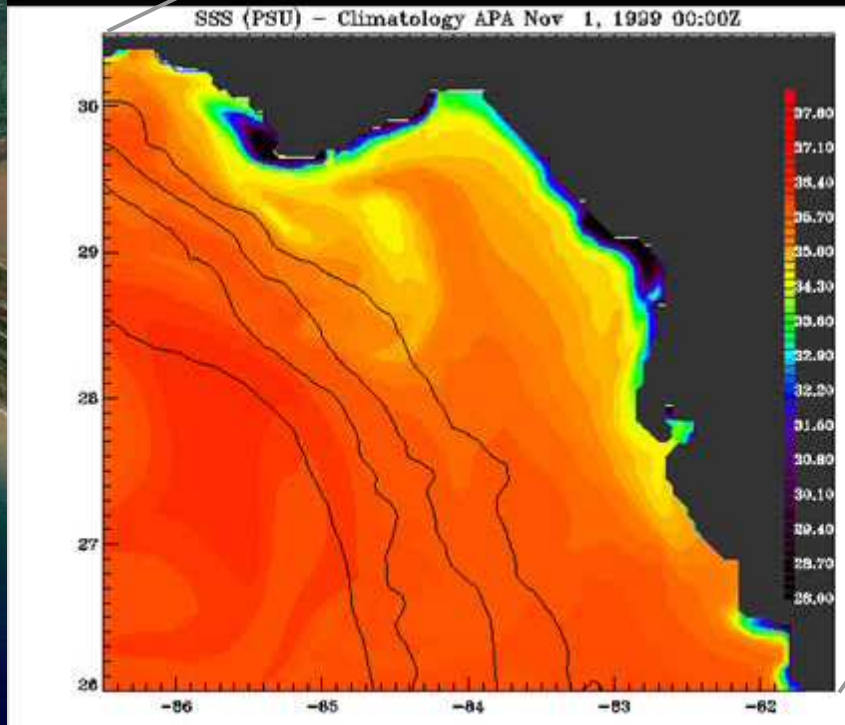
Difference in monthly-averaged salinity fields

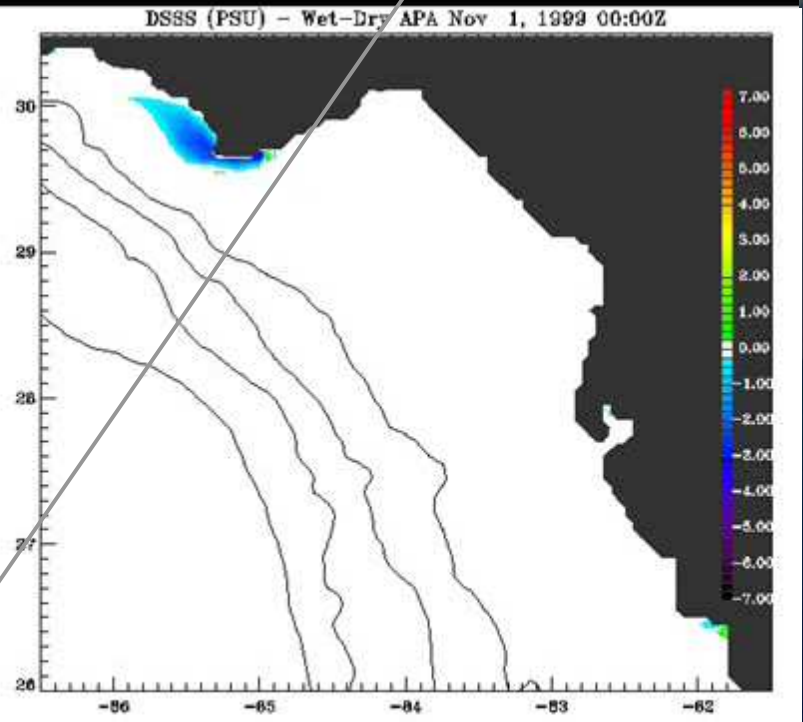
HFWET-HFDRY



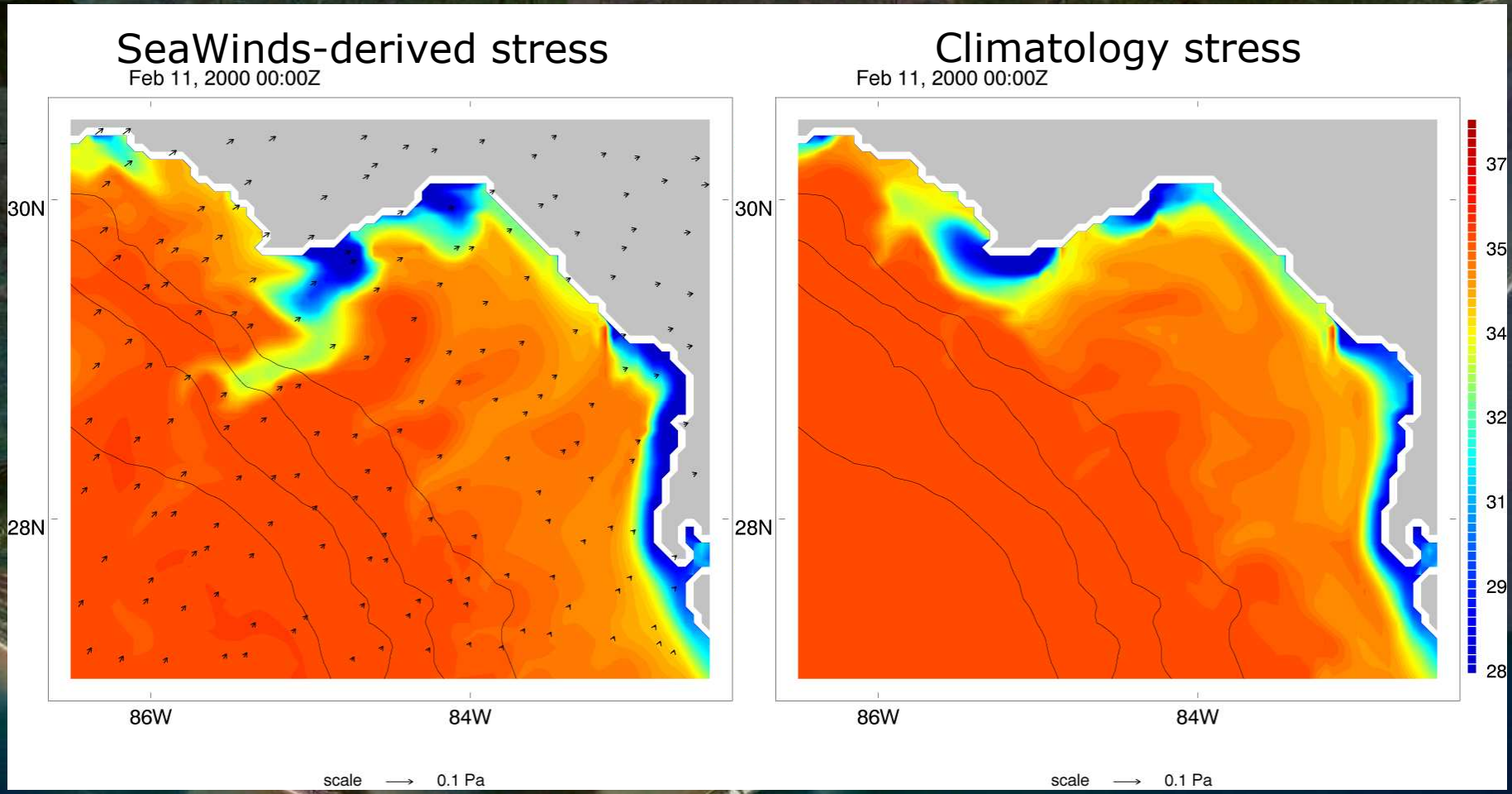
The difference between the surface salinity fields of the model experiments differing only in the prescribed Apalachicola River flow rate (HFWET and HFDRY) approximately shows the region influenced by the river.

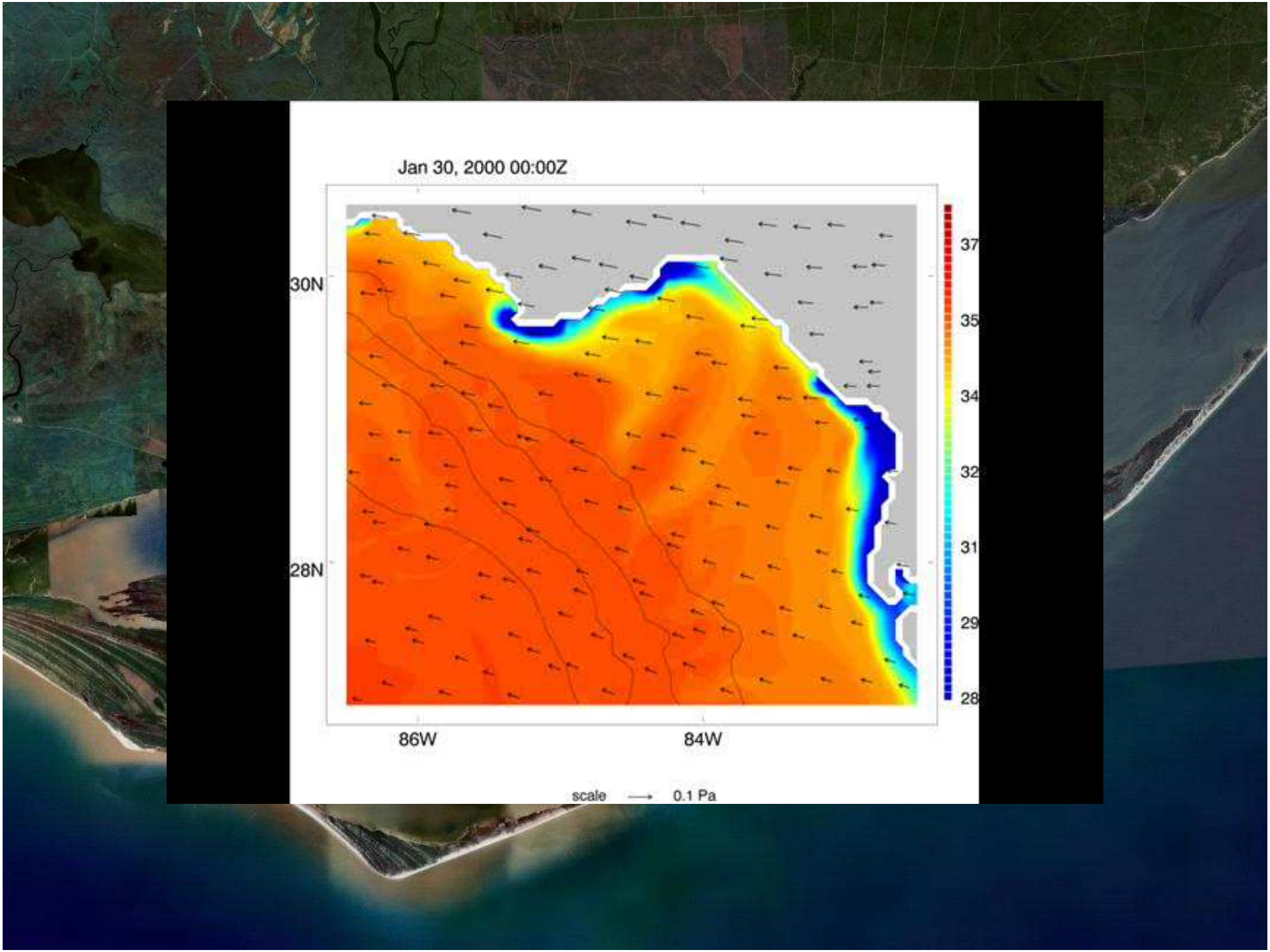






No offshore penetration of the plume without synoptic-scale wind variability




Jan 30, 2000 00:00Z
30N
28N
86W
84W
37
35
34
32
31
29
28
scale
0.1 Pa

Episodic upwelling winds (typically associated with cold fronts) are necessary for intermittently directing the plume offshore

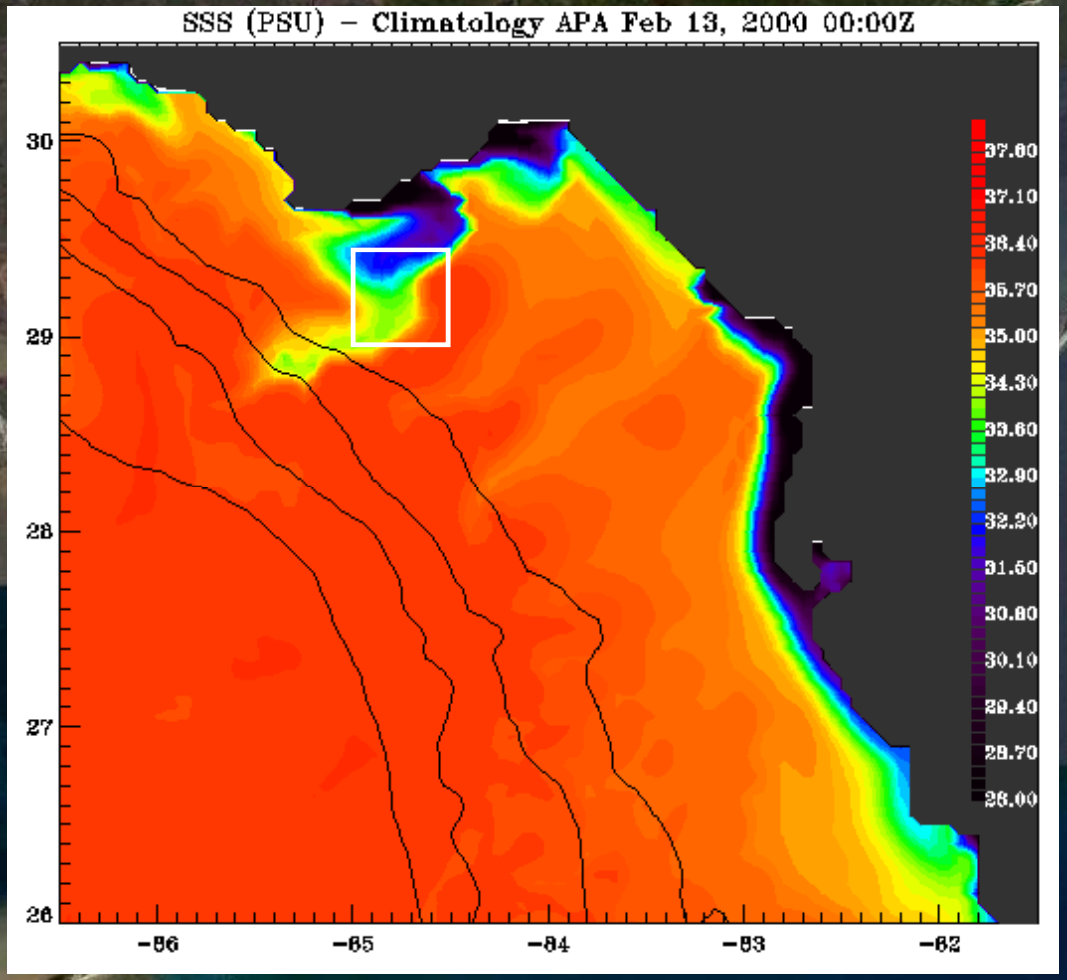
Objective definition for an offshore-directed plume:

$$\frac{d\overline{S}}{dt} \leq -0.2\,\mathrm{PSU\,day^{-1}}$$

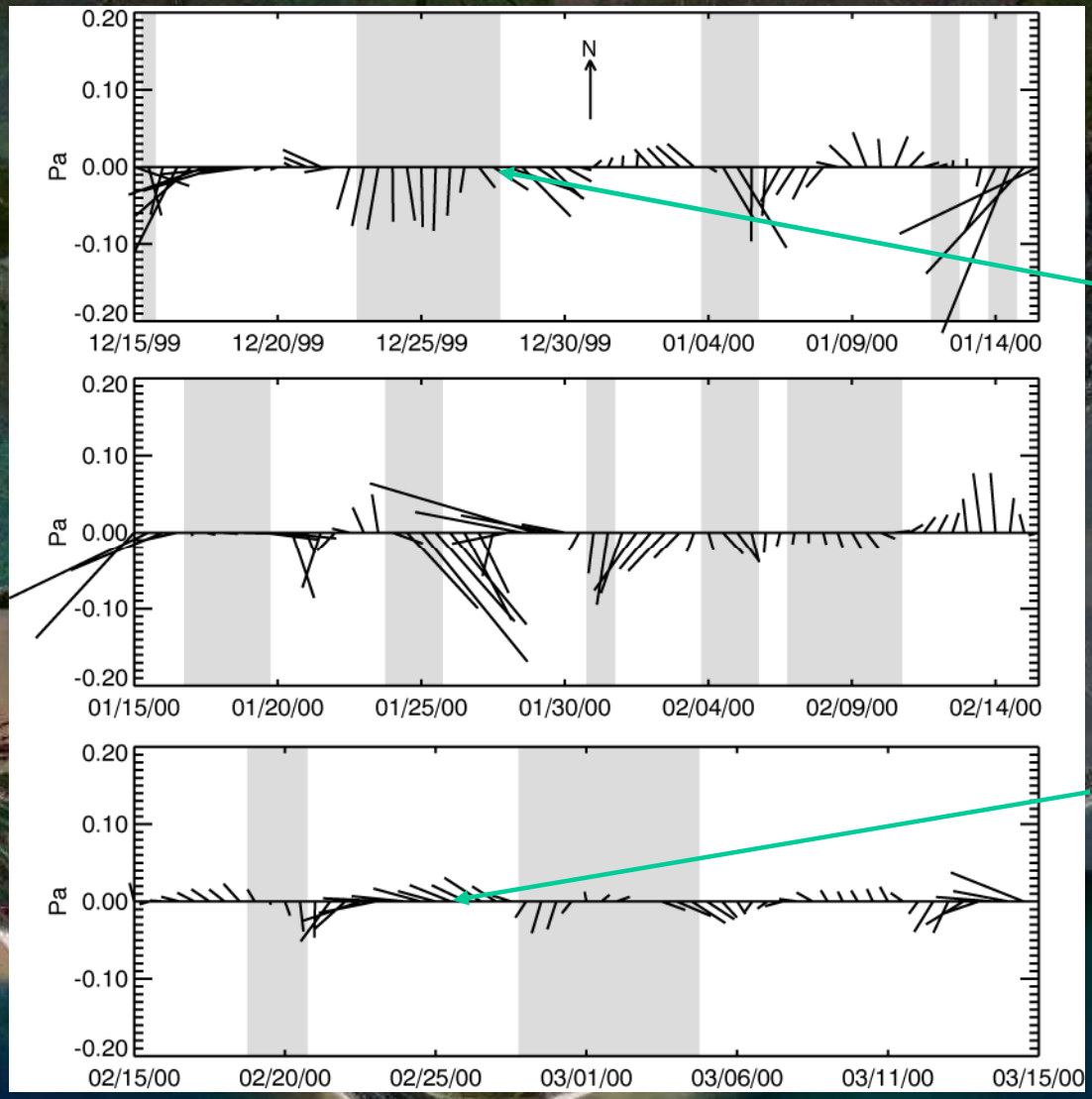
or

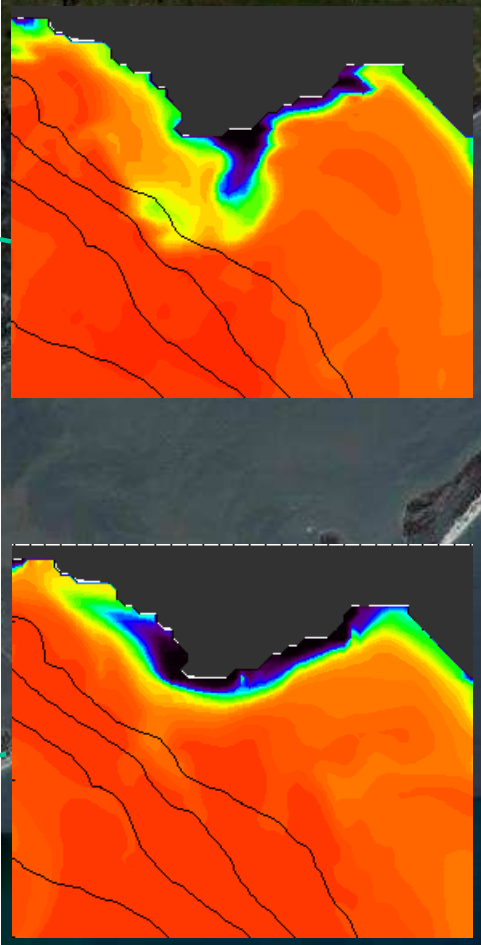
$$\frac{d\,\min(S(x,y))}{dt} \leq -0.2\,\mathrm{PSU\,day^{-1}}$$

where $\overline{S}$ and min($S(x,y)$) are the average and minimum salinity within the boxed region



Wind stress time series from 84.75W, 29.25N

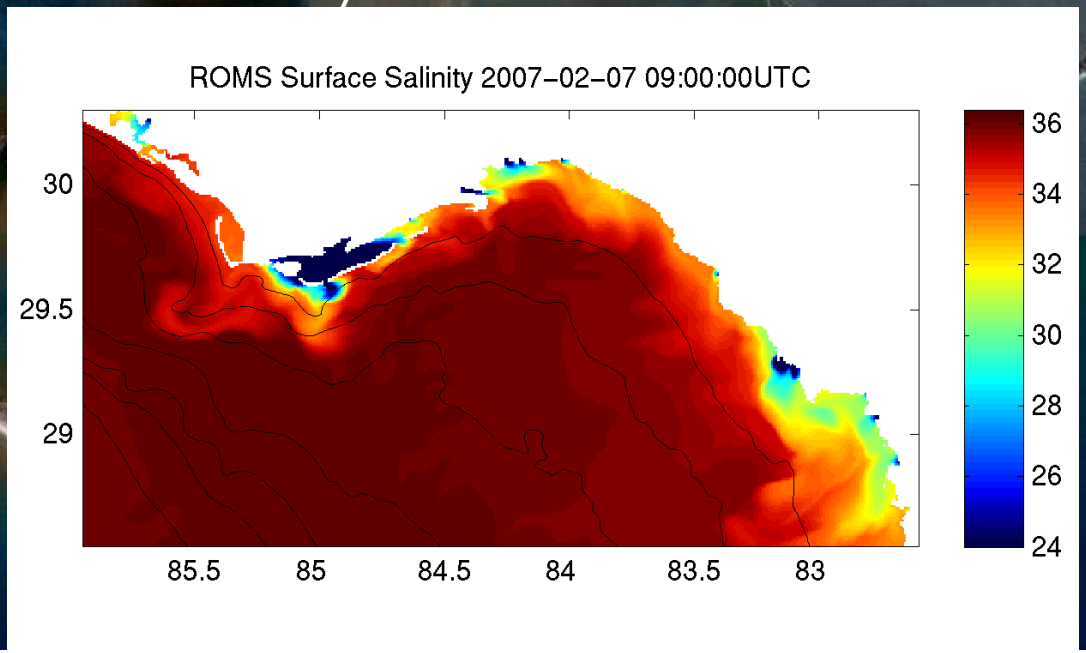




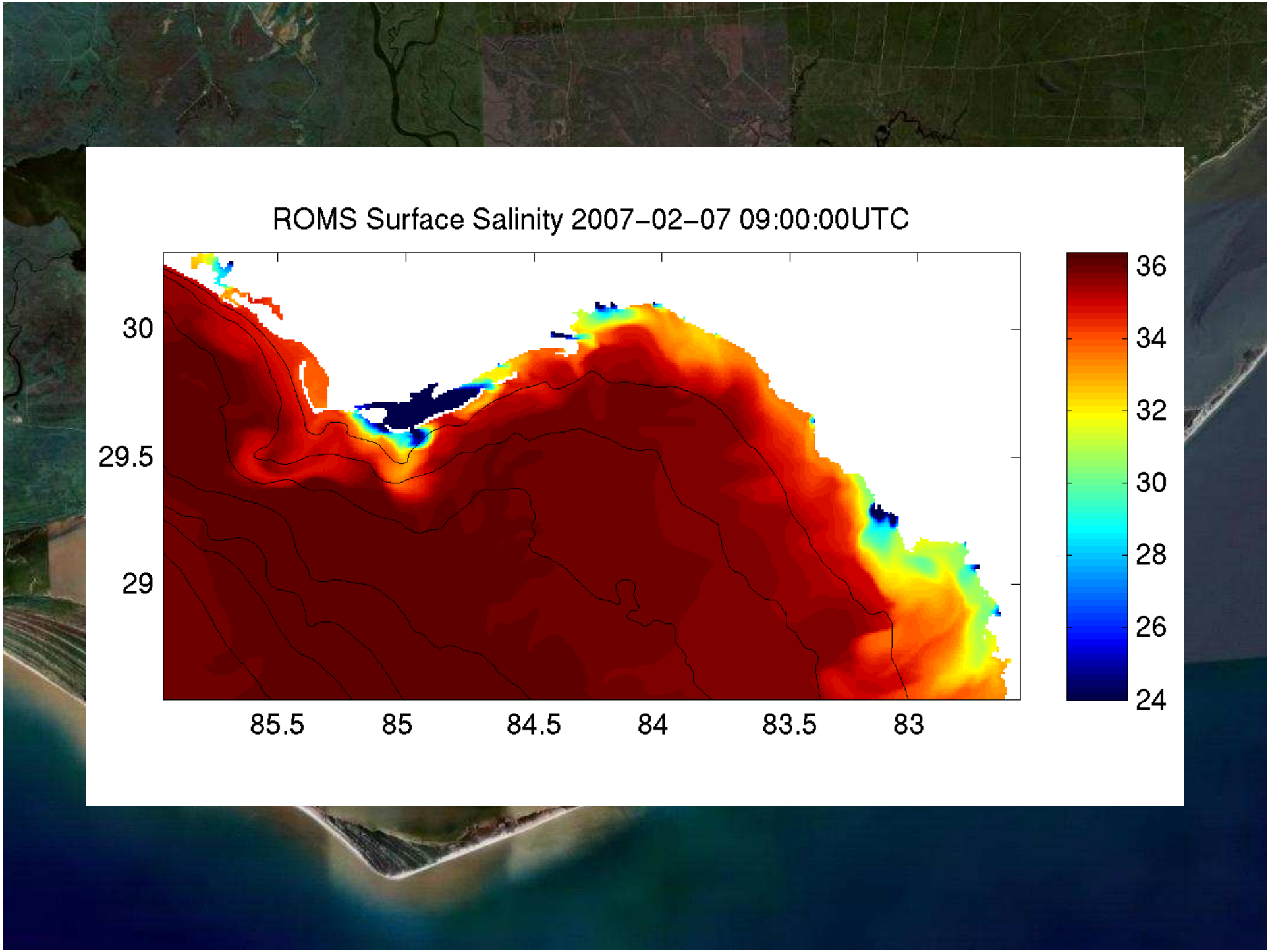
Objectively defined plume events shown by gray shading

Summary

- Episodic upwelling events (associated with cold frontal passages) direct the Apalachicola River plume offshore.
- The intermittent offshore extensions of the plume transport anomalies of salinity and bio-optical properties offshore
- The connectivity region between the coastal anomalies (produced by precipitation/river discharge variability) and the offshore water properties is a tongue-like pattern as seen from satellite ocean color.
- The 10-year record of scatterometer-derived wind fields will enable further investigation of the interannual variability and connections with regional marine ecosystems.



800m resolution ROMS


ROMS Surface Salinity 2007−02−07 09:00:00UTC
30
29.5
29
85.5
85
84.5
84
83.5
83
36
34
32
30
28
26
24