Global Ocean Monitoring: Recent Evolution, Current Status, and Predictions

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http://www.cpc.ncep.noaa.gov/products/GODAS/

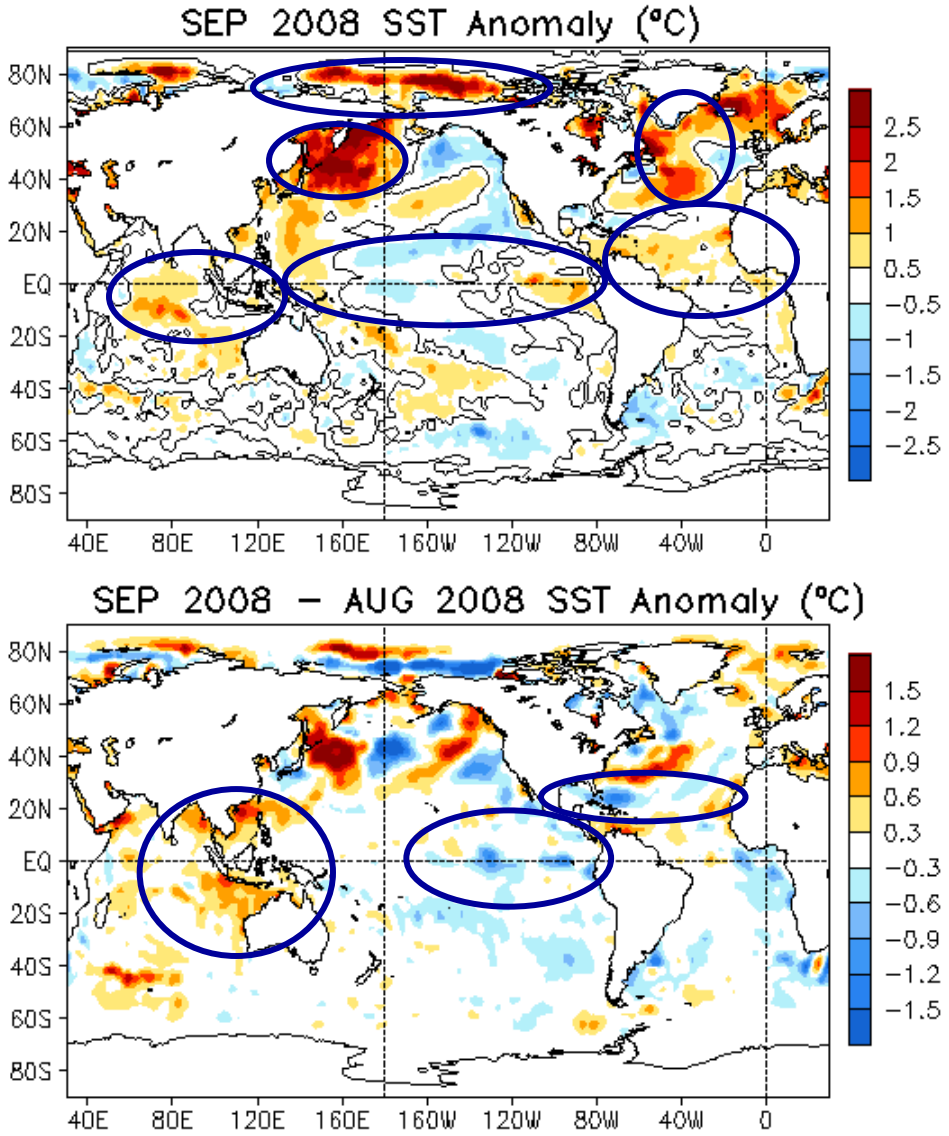
Outline

- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- CFS SST Predictions

Overview

- **Global Ocean**
  - Above normal global mean SST anomaly persisted.
- **Pacific Ocean**
  - ENSO-neutral conditions will continue through winter.
  - Tropical SSTA have cooled from the previous month.
- **Indian Ocean**
  - Dipole Mode Index decreased last month.
  - Most of the Indian ocean has above normal temperatures.
- **Atlantic Ocean**
  - Tropical North Atlantic continued to warm up, favorable for hurricane development.
- **Arctic Ocean**
  - Sea ice extent bottomed out at 2nd lowest level.

Global SST Anomaly (⁰C) and Anomaly Tendency

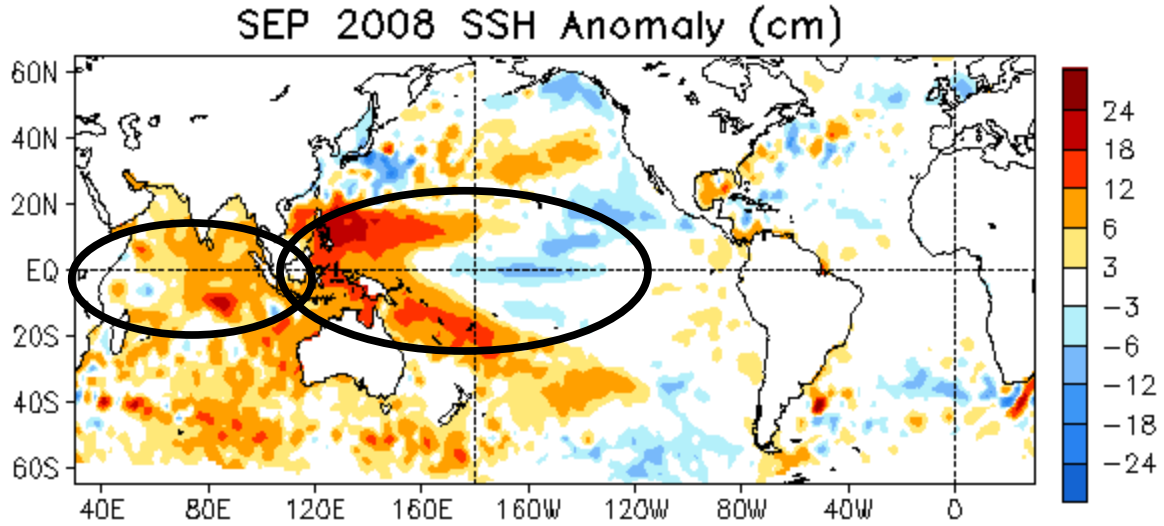


- Positive SSTA in W. North Pacific and W. North Atlantic.
- Positive SSTA in Arctic Ocean due to ice melt.
- Weak anomalies in the tropical Pacific.
- Positive SSTA in tropical Atlantic and Indian Oceans

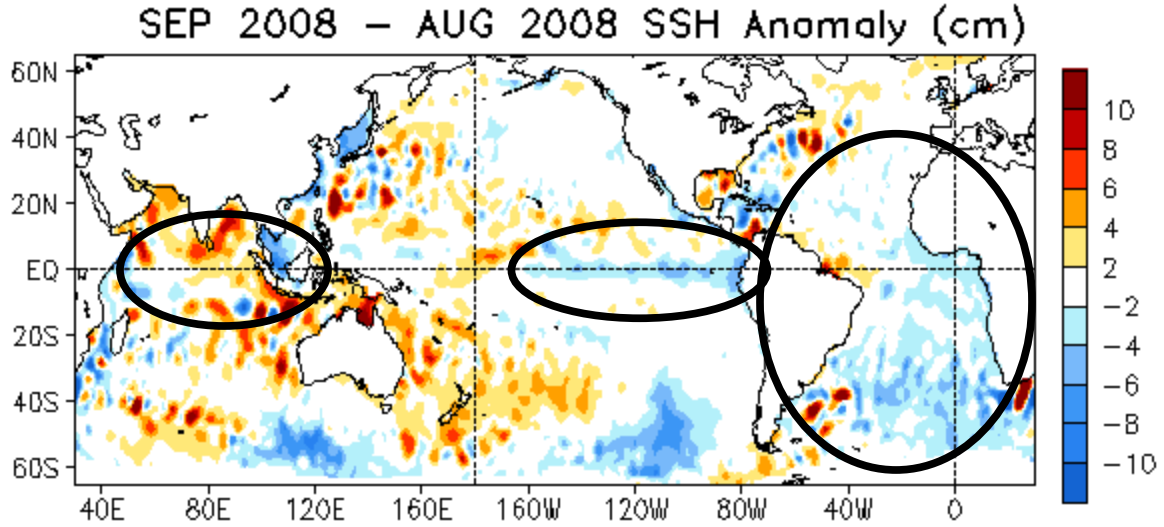
- SSTA cooled in E. Tropical Pacific.
- SSTA warmed in Eastern Indian Ocean.
- SSTA in tropical Atlantic warmed except where hurricane Ike traversed

Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Global SSH Anomaly (cm) and Anomaly Tendency



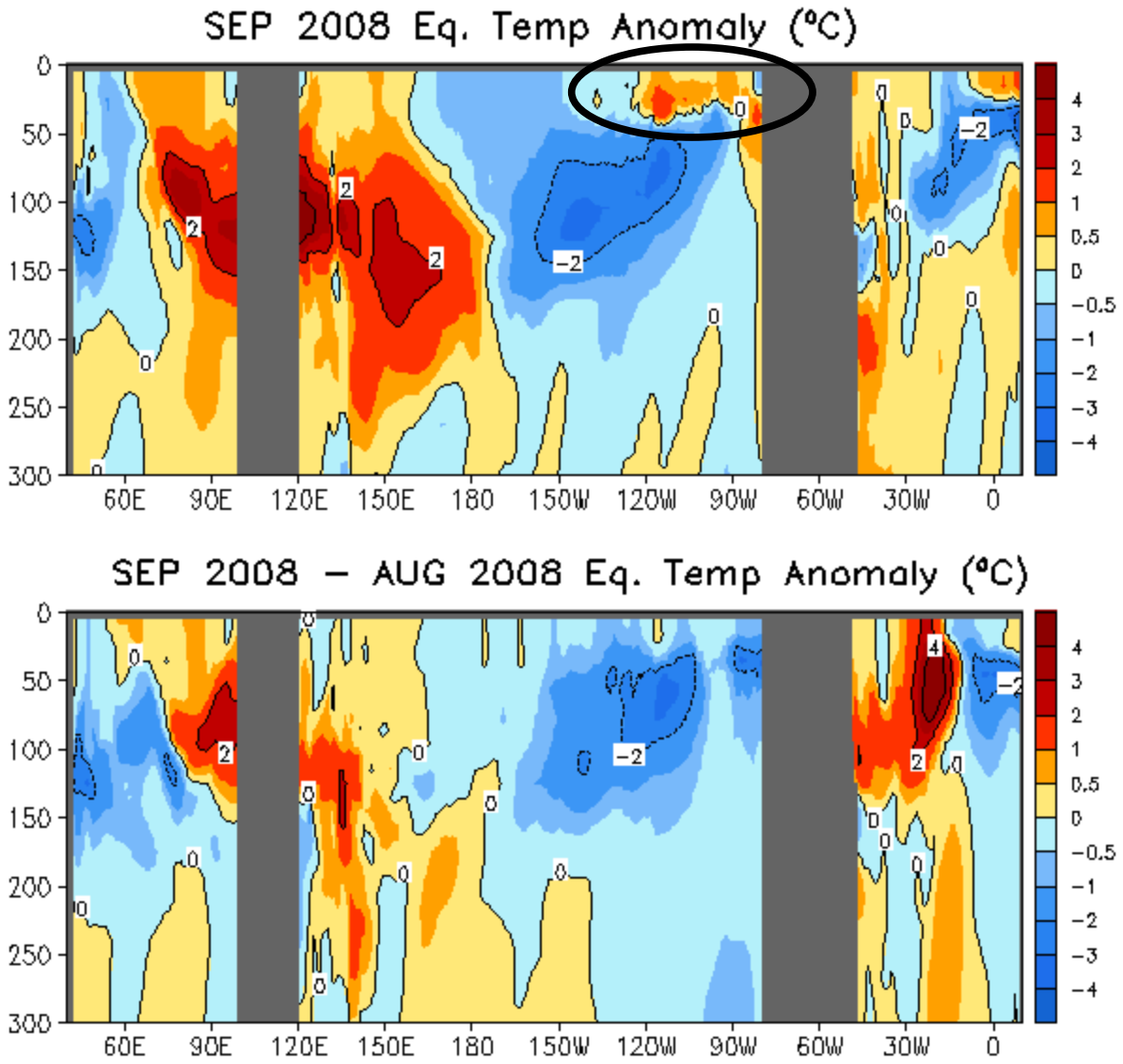
- Horseshoe pattern in Pacific, with positive anomalies in the warm pool region and negative anomlies in central Pacific
- Positive SSHA in most of Eastern Hemisphere.



- SSH decreased in most of the South Atlantic Ocean.
- SSH decreased in equatorial Eastern Pacific.
- SSH increased in Indian Ocean.

Fig. G2. Sea surface height anomalies (top) and anomaly tendency (bottom). Data are derived from http://www.aviso.oceanobs.com . Anomalies are departures from the 1993-2005 base period means.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2ºS-2ºN



- Warm temperature anomalies surround the Maritime Continent. Cool anomalies east of the dateline.

-Warm temperatures in far eastern Pacific now confined to top 25m.

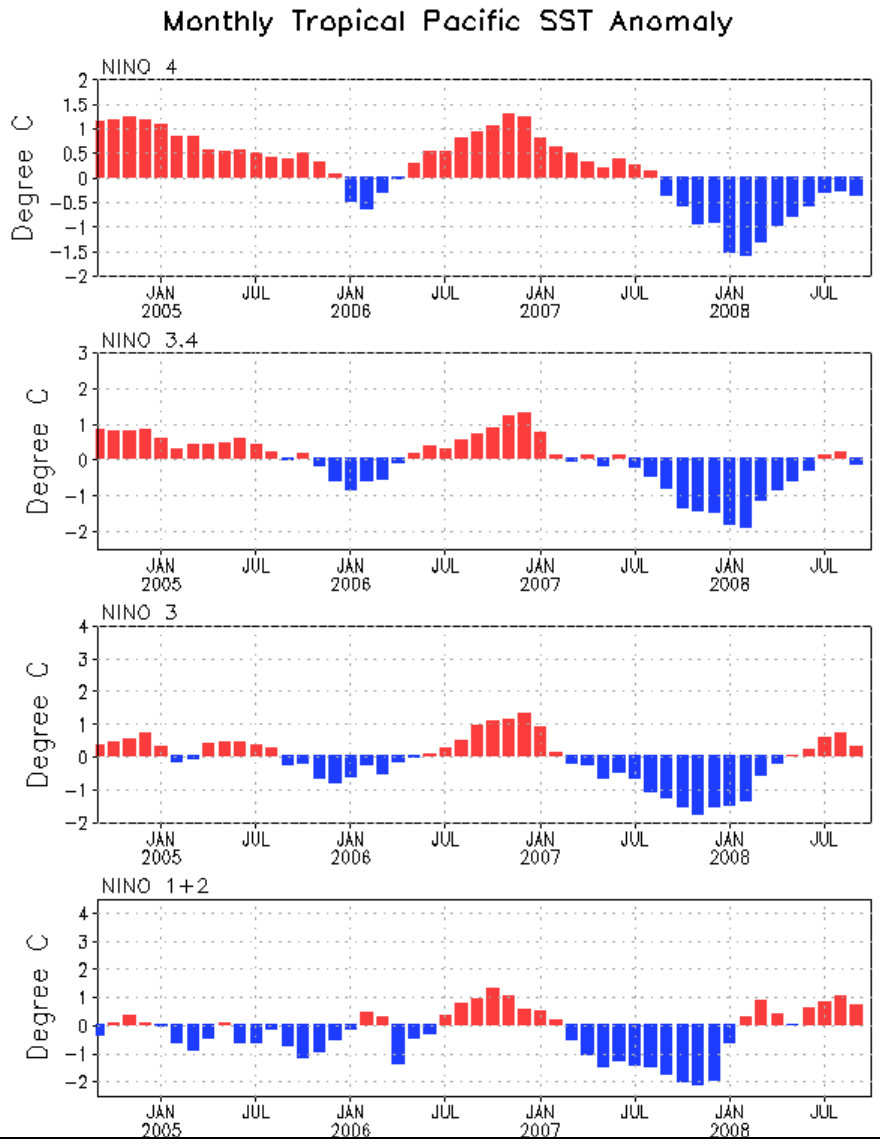
-Cool temperatures at thermocline depth in Atlantic

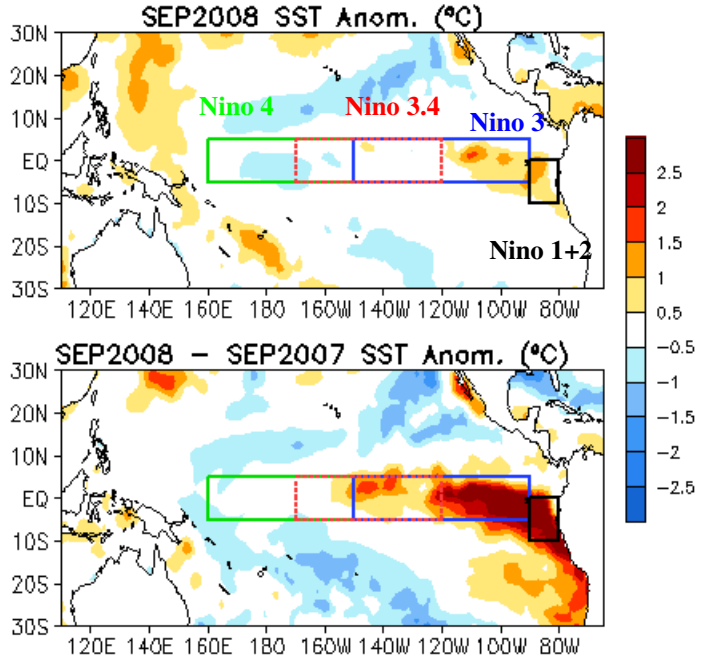
- Temperature decreased in C.-E. Pacific.
- Temperature continued to increase (decreased) in E. (W.) Indian Ocean near the thermocline.

Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1982-2004 base period means.

Tropical Pacific Ocean

Evolution of Pacific NINO SST Indices



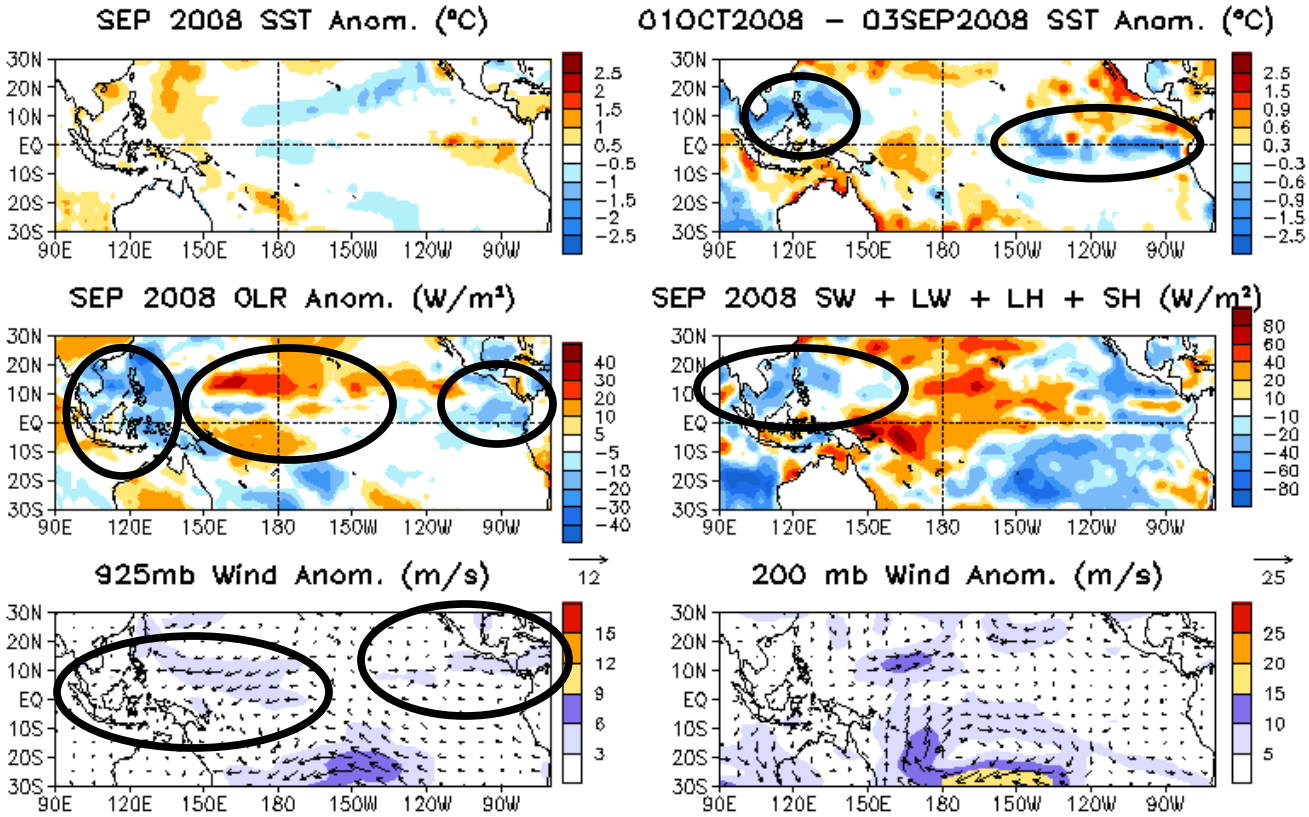


- ENSO-neutral conditions will continue into early 2009 – NOAA's "ENSO Diagnostic Discussion."

- Tripole SSTA pattern in tropical Pacific (negative in C. Pacific and positive in W. and E. Pacific).

Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds



- Convection suppressed (enhanced) in C. Pacific (Maritime Continent and far E. Pacific).
- Low-level easterly (westerly) wind anomalies presented in tropical W. Pacific (north-eastern Pacific).
- SST decreased in South China Sea and N.-W. Pacific due to persistent convection in that region.

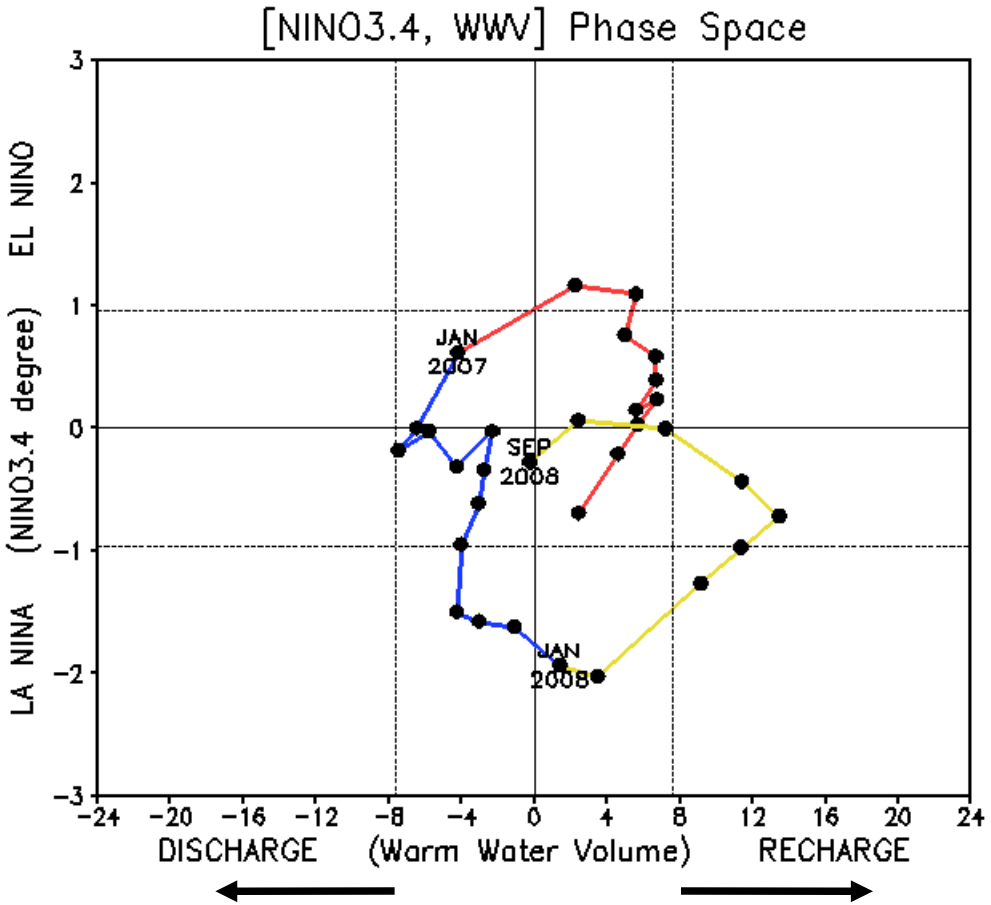
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

Warm Water Volume (WWV) and NINO3.4 Anomalies

-WWV is defined as average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] (Meinen and McPhaden, 2000).

-Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4.

- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.

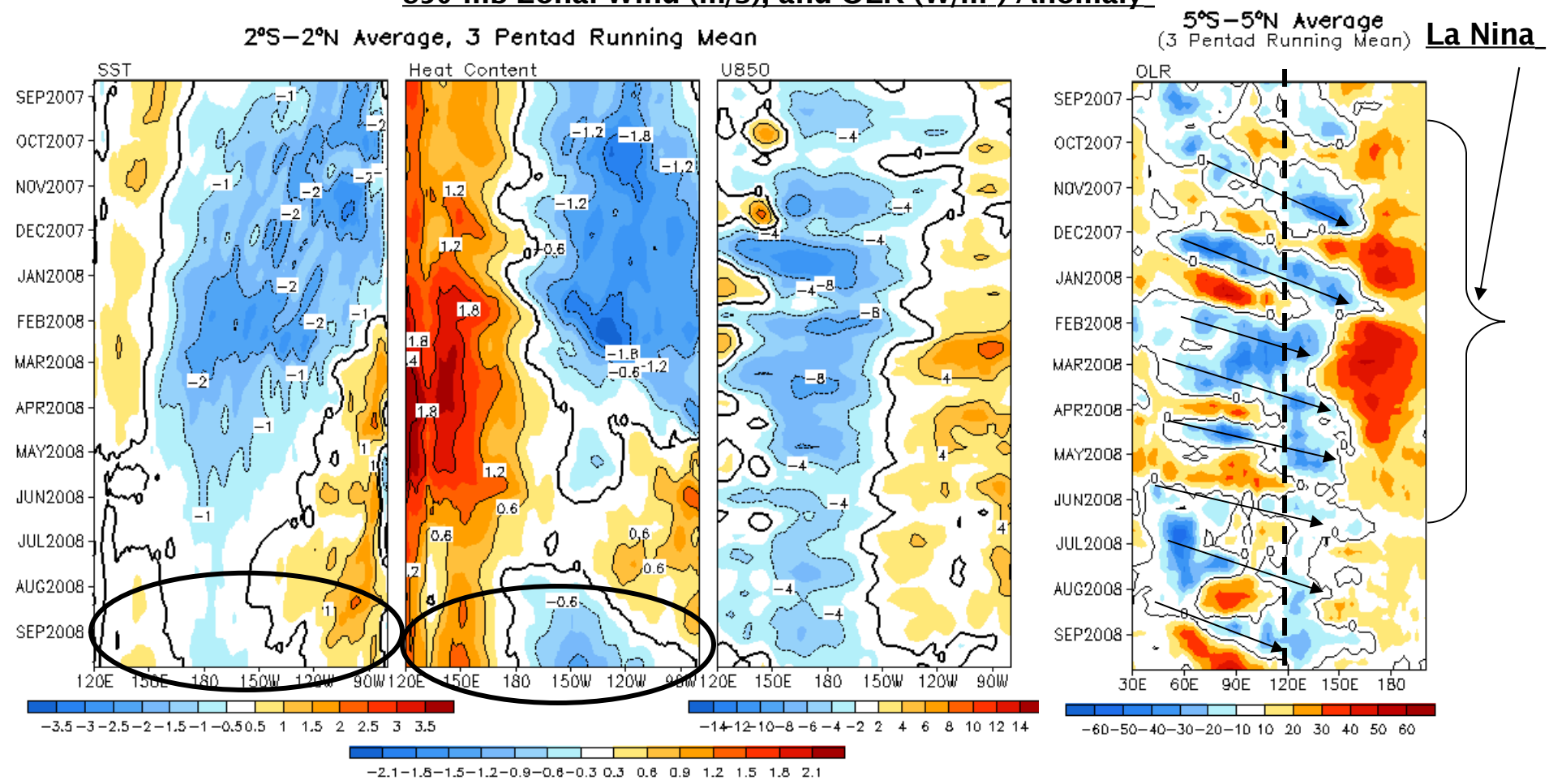


- Warm Water Volume(WWV) has increased rapidly from February to May, but has decreased since then.

- Both NINO3.4 and WWV are close to normal conditions.

Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies for WWV (NINO 3.4) are departures from the 1982-2004 (1971-2000) base period means.

Evolution of Equatorial Pacific SST (ºC), 0-300m Heat Content (ºC), 850-mb Zonal Wind (m/s), and OLR (W/m²) Anomaly

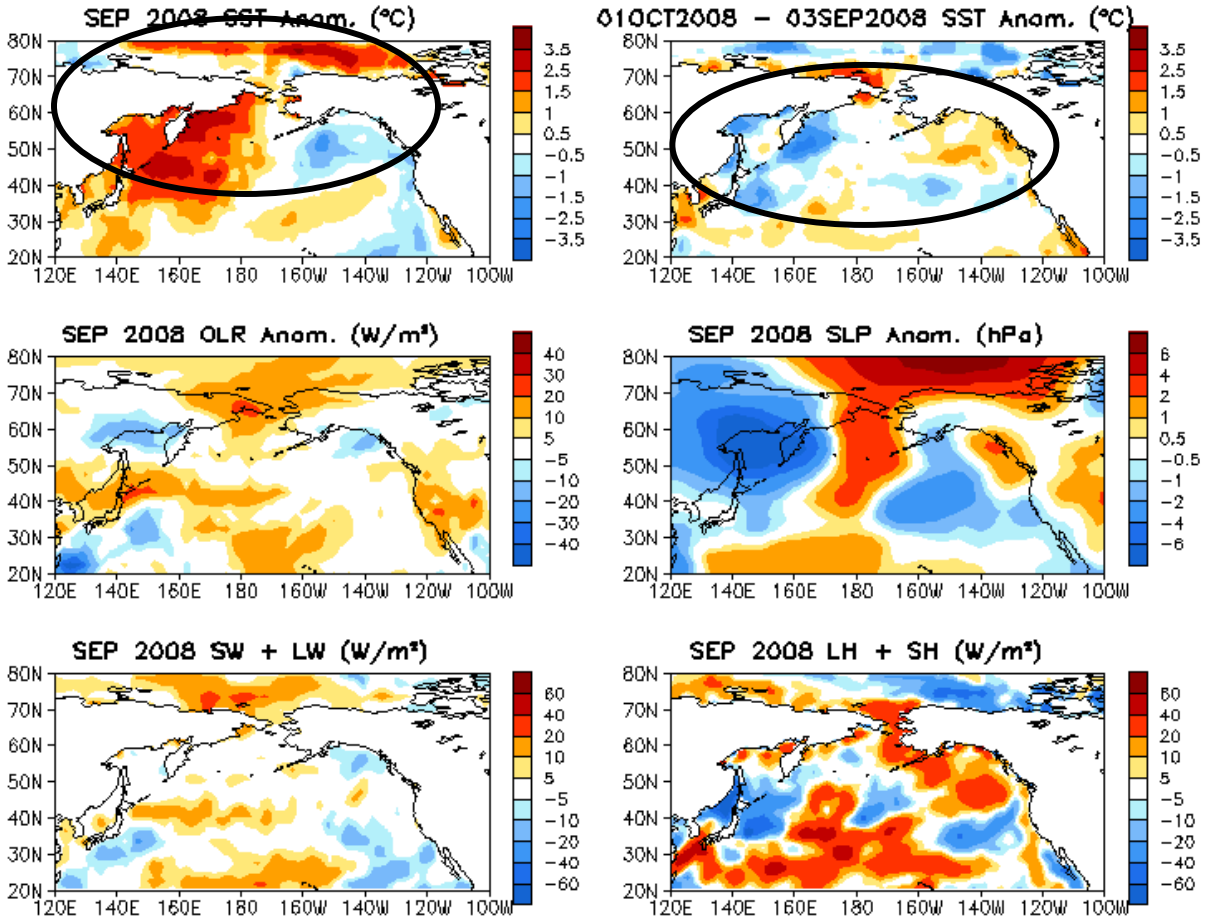


- Tripole SSTA patterns in tropical Pacific.
- Continued eastward propagation of negative heat content anomalies.
- Subseaonal variability is dominant in OLR for recent months.

Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. SST is derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

North Pacific & Arctic Ocean

North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx



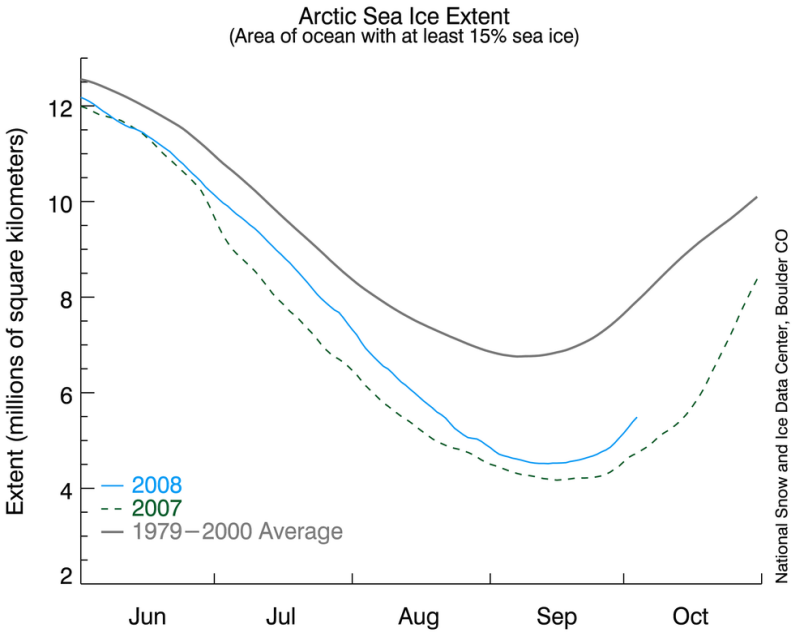
- Negative anomalies south of Alaska, and positive anomalies east of Asia.
- Warm SSTA in artic ocean associated with anomalous ice melt.
- SSTA tendency had damped the anomalies over most of the north Pacific

Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

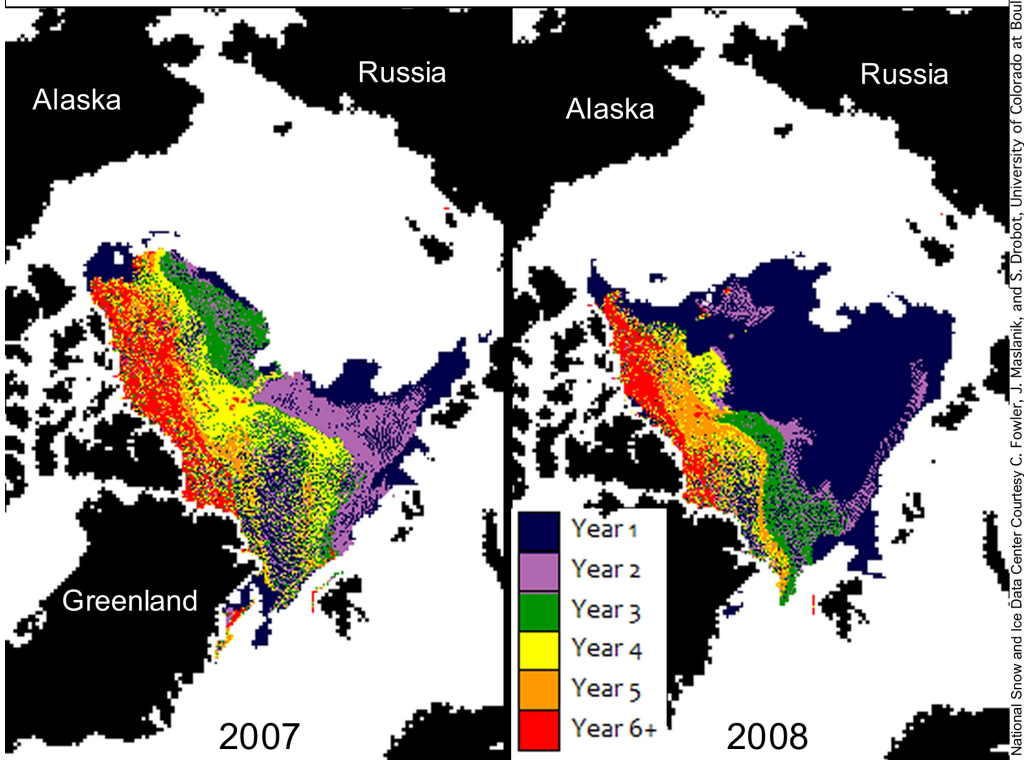
Arctic Sea Ice

National Snow and Ice Data Center

http://nsidc.org/arcticseaicenews/index.html

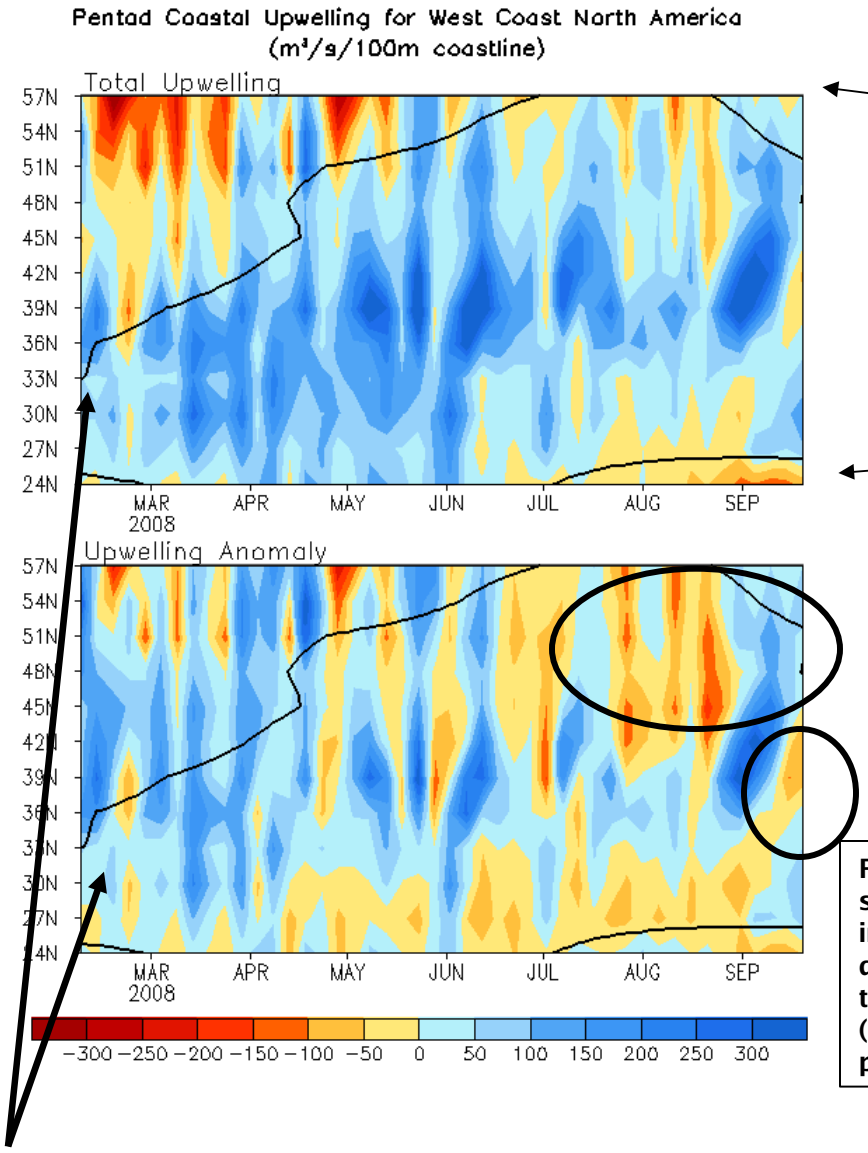


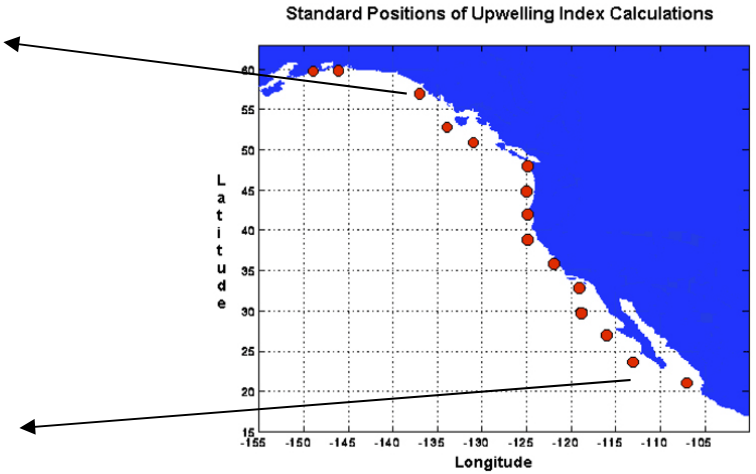
Ice age at the end of the 2007 and 2008 melt seasons



- 2nd smallest ice pack on record
- Large reduction in multi-year ice
- Most of ice pack is thin first year ice susceptible to melting

North America Western Coastal Upwelling





-Strong upwelling event in early September.

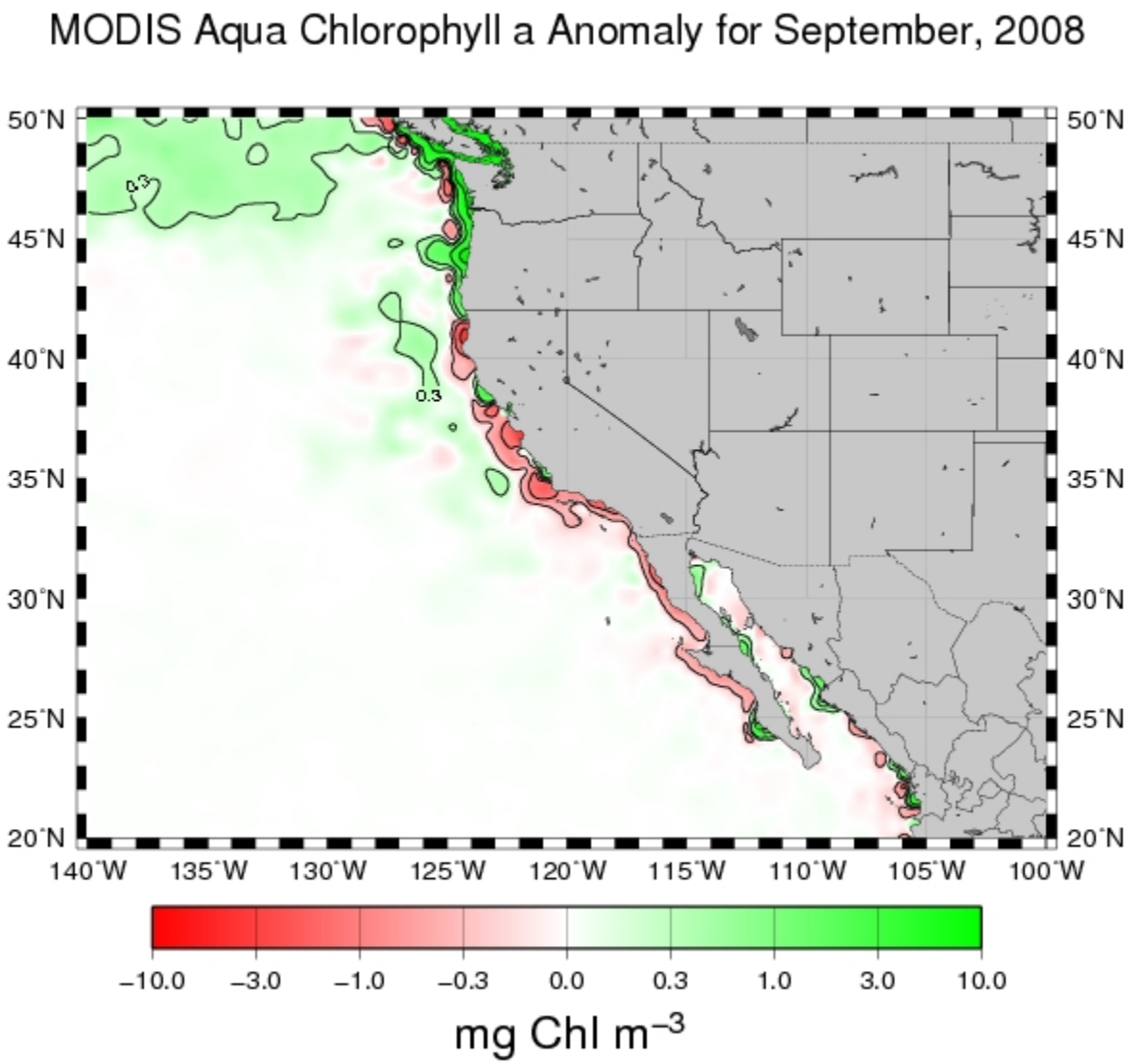
-More recently, negative anomalies south of 42N

Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point (m³/s/100m coastline). Anomalies are departures from the 1982-2004 base period pentad means.

- Area below (above) black line indicates climatological upwelling (downwelling) season.
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36ºN to 57ºN.

Monthly Chlorophyll Anomaly

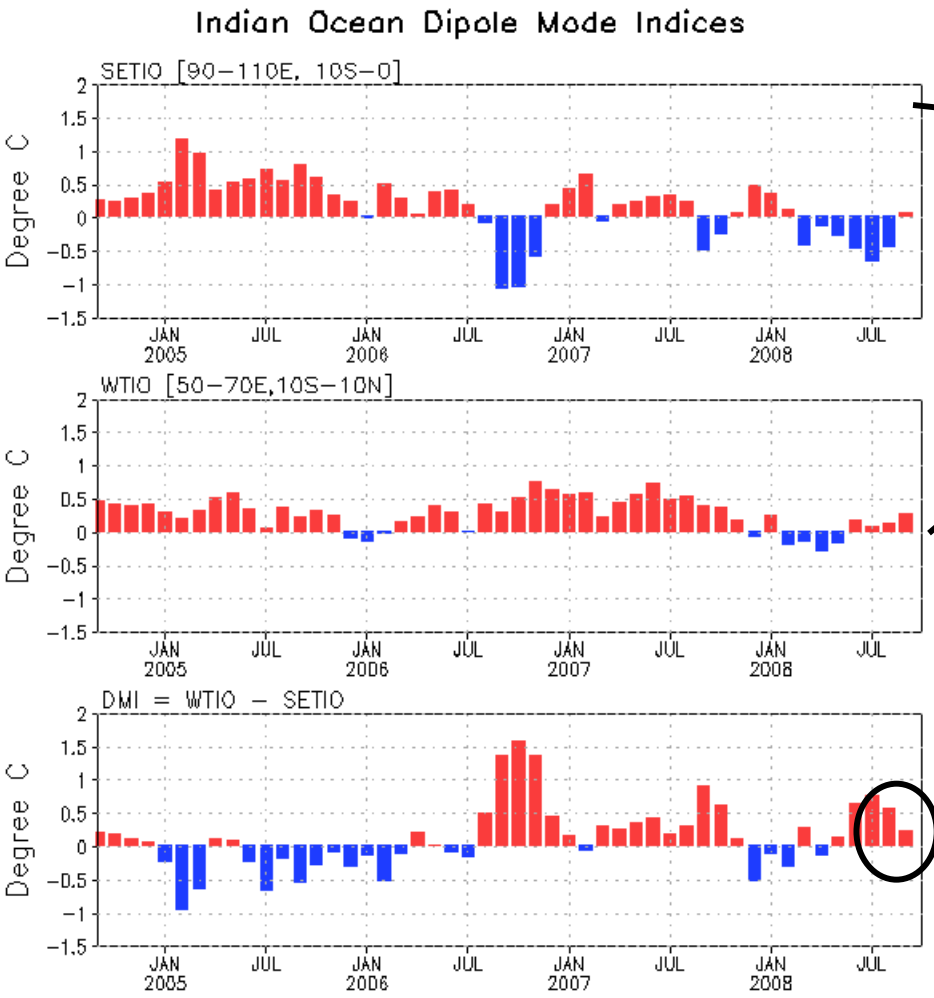
http://coastwatch.pfel.noaa.gov/FAST

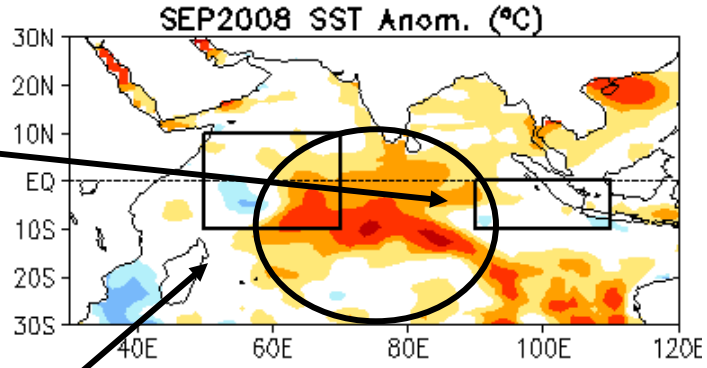


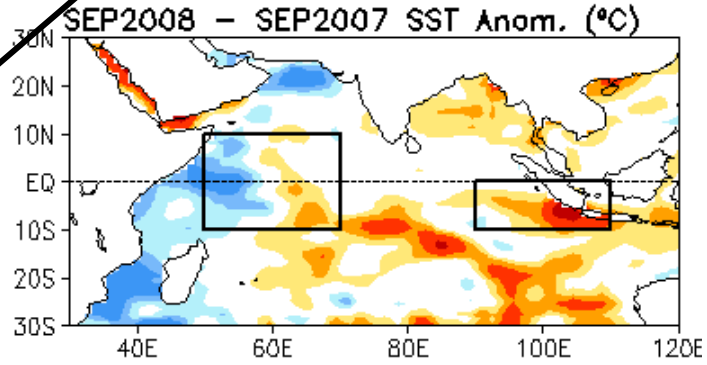
Negative Chlorophyll anomalies were consistent with suppressed upwelling south of 42N and positive anomalies north of California

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices



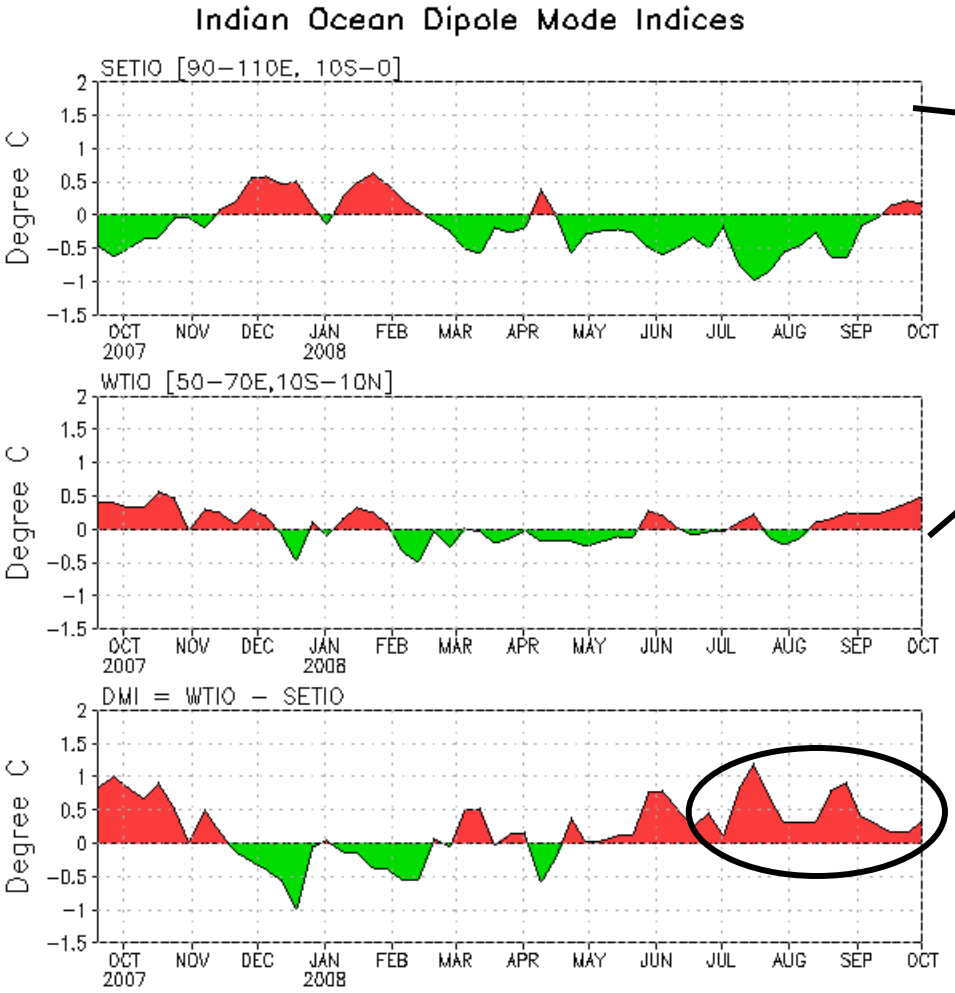


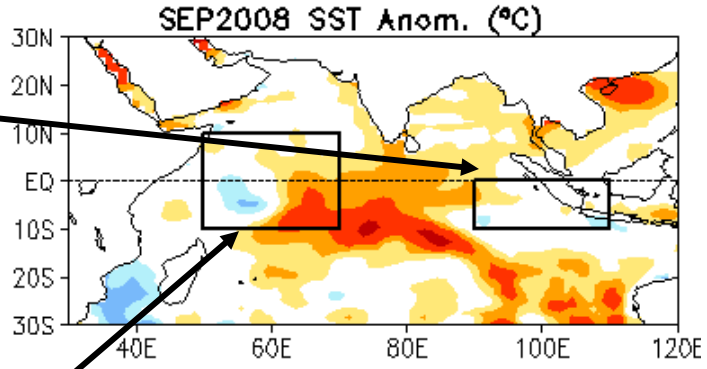


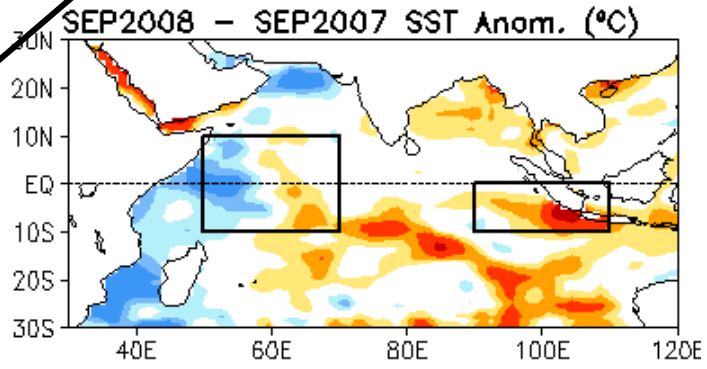
- Dipole Mode Index (DMI) retreated close to zero in September.
- Warm Anomalies in central Indian Ocean.
- Tropical Indian Ocean SST is cooler in west and warmer in the east compared to last August.

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Evolution of Indian Ocean SST Indices







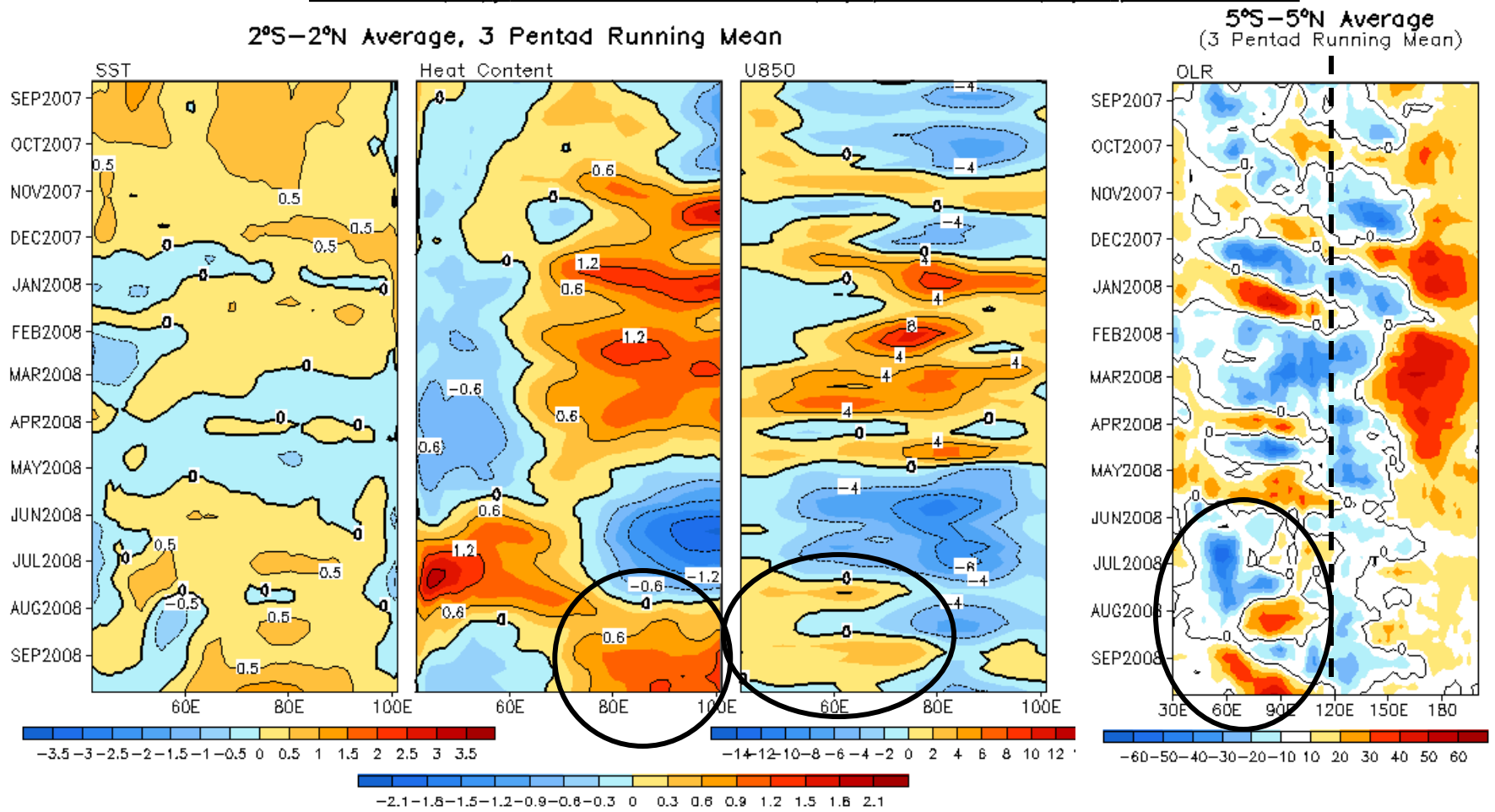
- Dipole Mode Index (DMI) was significantly modulated by intraseasonal variability, with more of the variability coming from the east.

DMI peaked in early June, mid-July and late August.

Western Indian Ocean SSTA steadly increased since early August

Fig. I1b. Indian Ocean Dipole region indices, calculated as the area-averaged weekly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

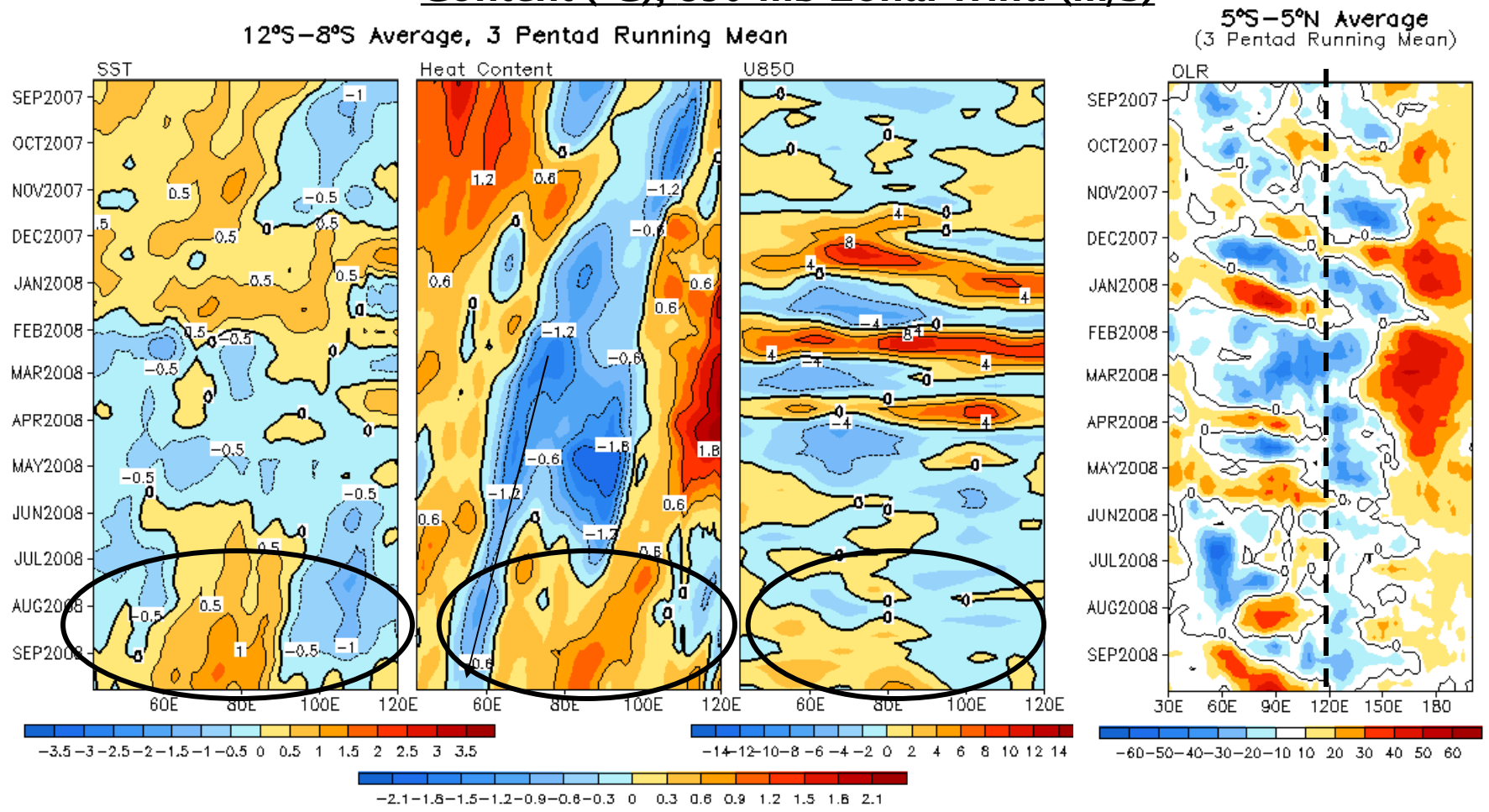
Recent Evolution of Equatorial Indian SST (ºC), 0-300m Heat Content (ºC), 850-mb Zonal Wind (m/s) and OLR (W/m²) Anomalies



- Westely wind anomalies in the western Indian Ocean have persisted since mid July.
- Heat content anomalies in the east have increased since early summer, with a switch in polarity in June.
- Convection is dominated by intraseasonal oscillations in recent months.

Fig. I3. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2ºS-2ºN and Outgoing Long-wave Radiation (OLR, right) averaged in 5ºS-5ºN. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

Recent Evolution of 10°S Indian SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s)



- SST anomalies continue to warm up along 10°S.

-Negative heat content anomalies near 60E continues to shift westward.

Fig. I4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 12°S-8°S and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

-Warm Anomalies in Central Indian Ocean

- Suppressed Convection south of India and enhanced convection near the Phillipines is associated wit the MJO

- Westerly Anomalies along equator, slightly weakened Somali jet

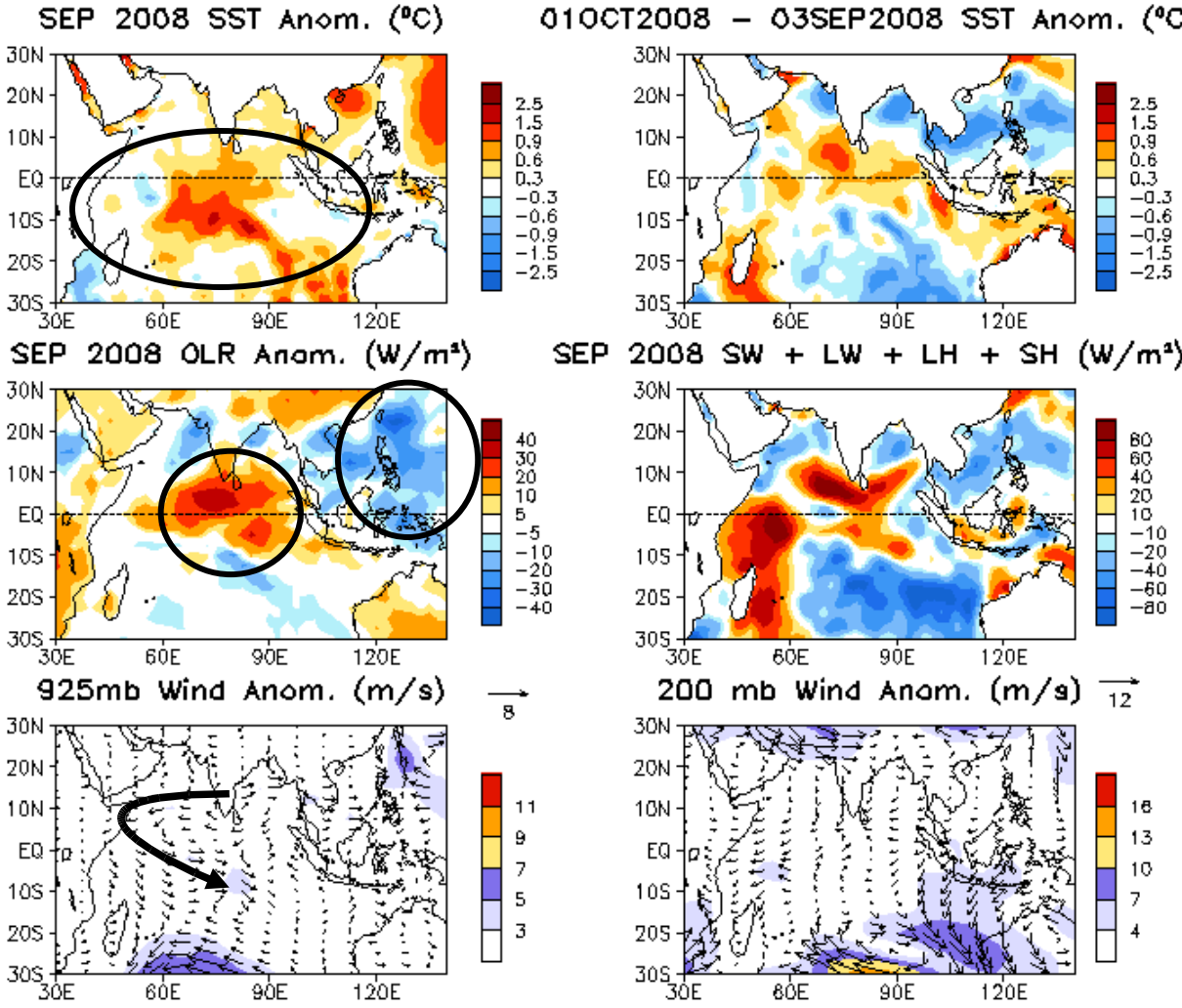
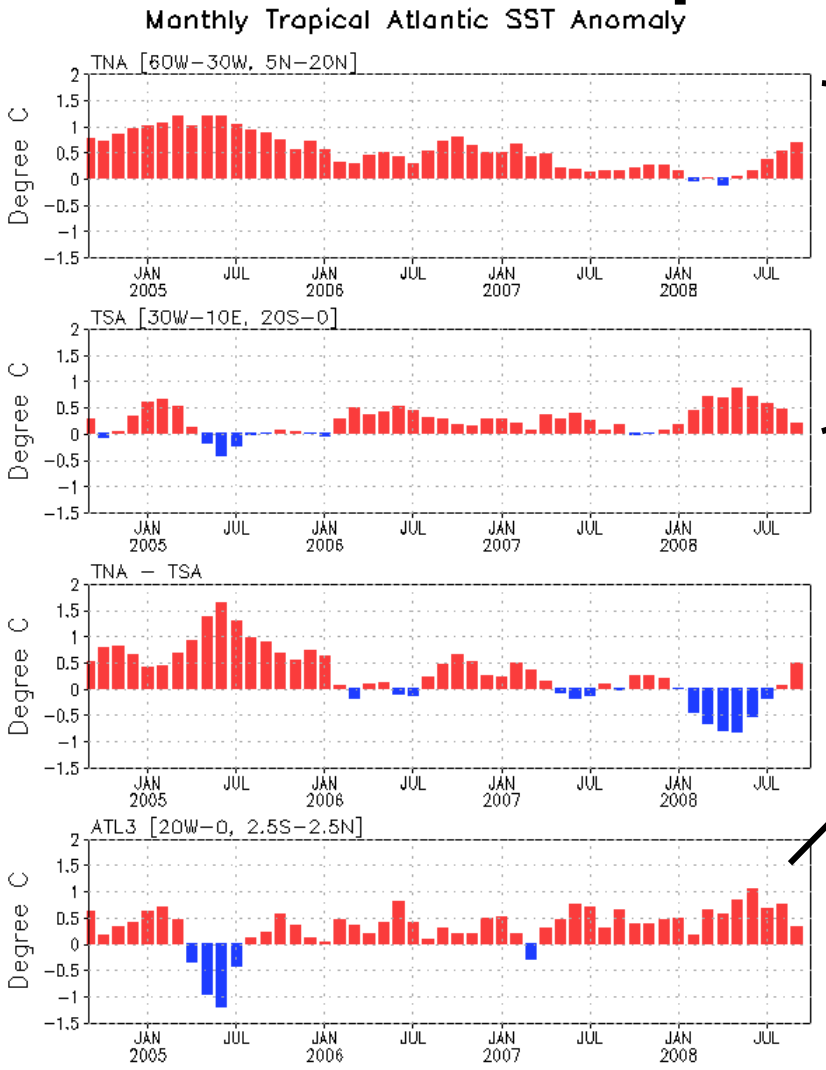
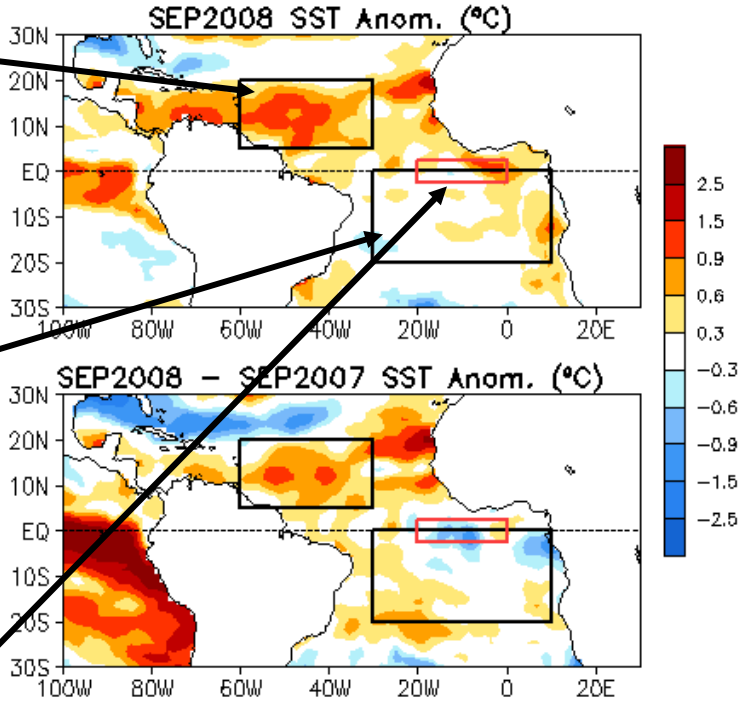


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices



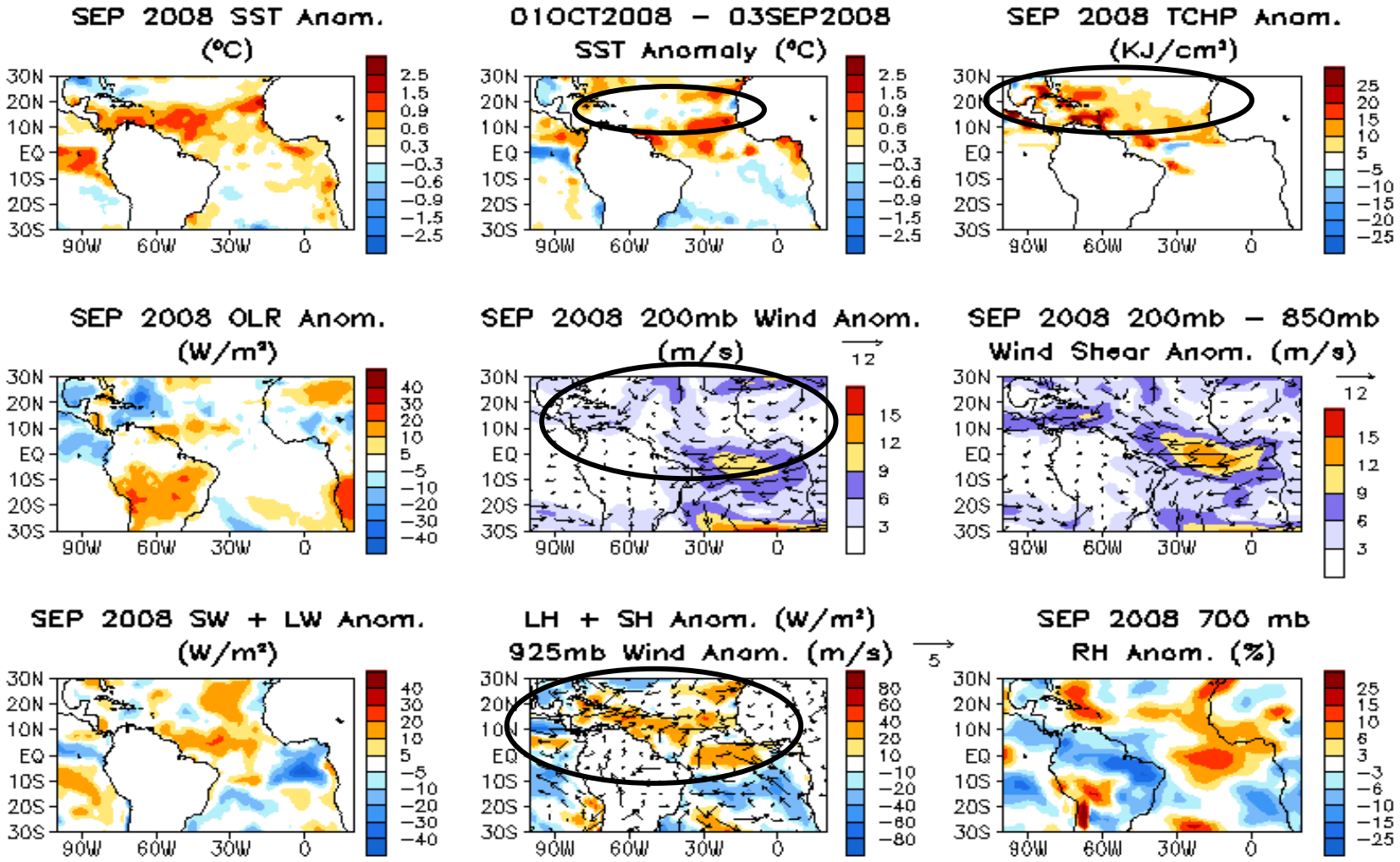


- Tropical North Atlantic SST has been steadily increasing since April, and reached near 0.7°C in September 08.

- Tropical Atlantic SST was much warmer than that last August except near the track of hurricane Ike and near equatorial Africa.

Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Tropical Atlantic: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb/200-mb Winds, Windshear, TCHP, RH Anomaly



- SSTs increased in the hurricane Main Development Region (MDR).
- Upper level easterly anomalies and lower level westerly anomalies have both contributed to reduced wind shear over the Atlantic basin
- Tropical Cyclone Heat Potential (TCHP) continues to be above average.

North Atlantic Ocean

North Atlantic: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

-North Atlantic SST remains above normal

-Change in SSTA are a result of large latent and sensible heat flux anomalies.

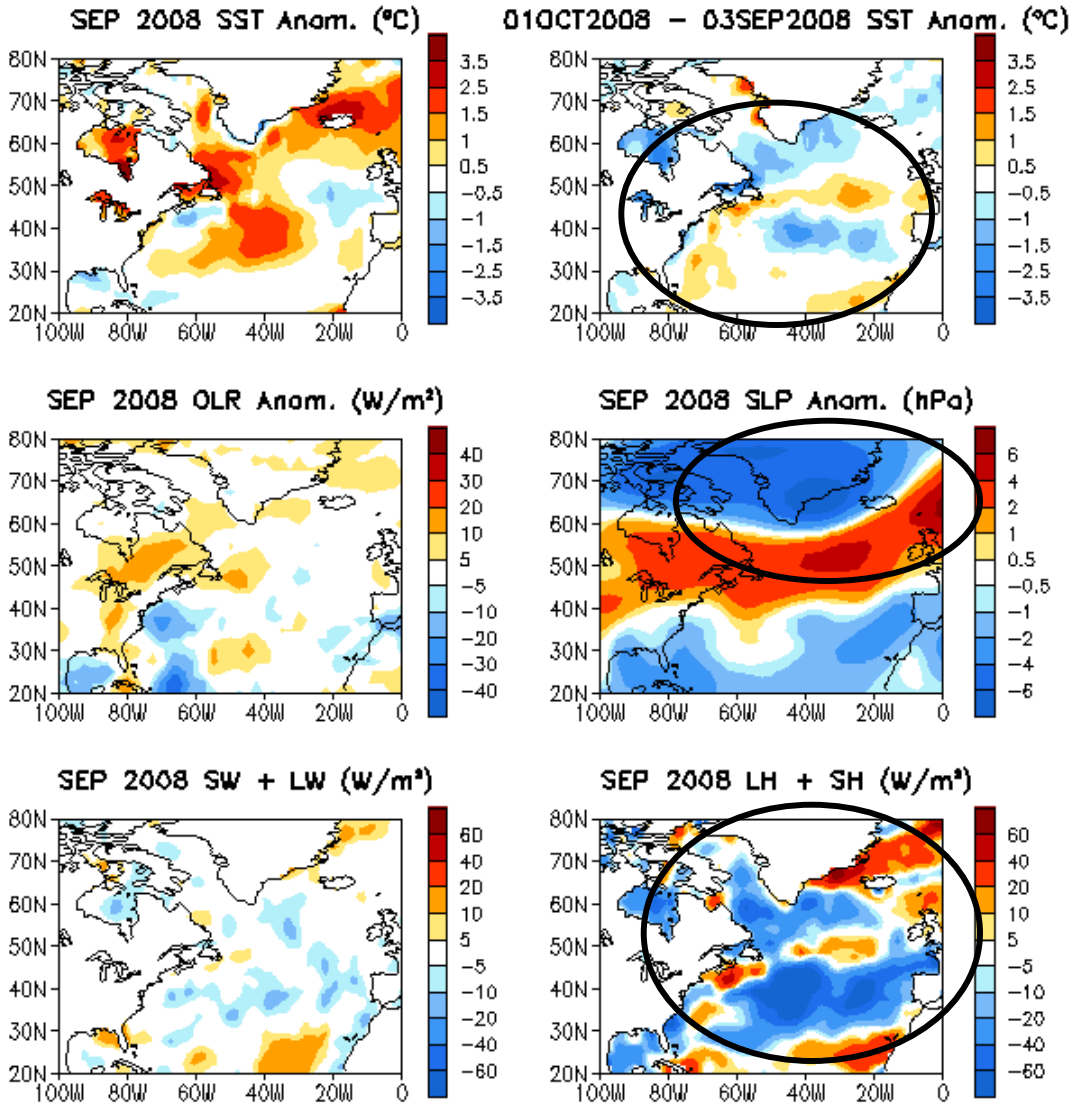
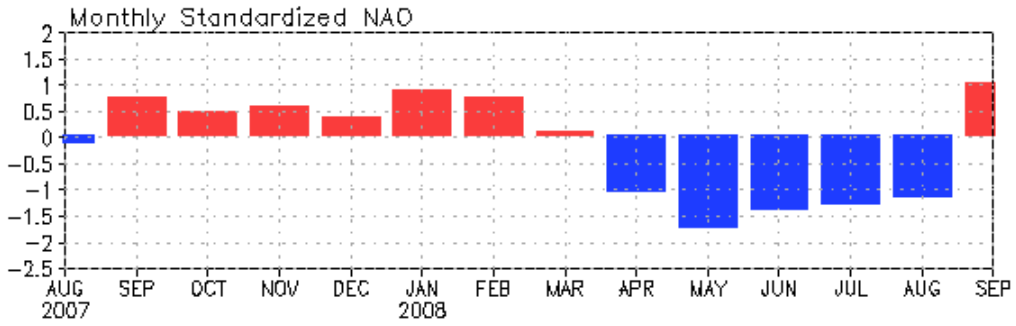
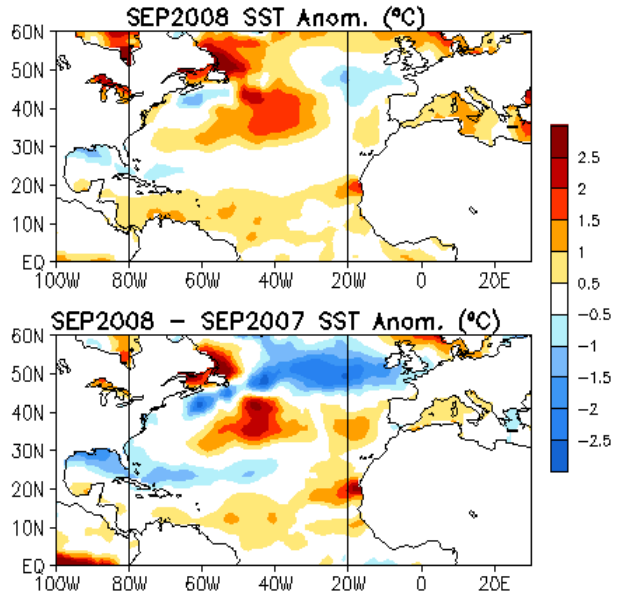
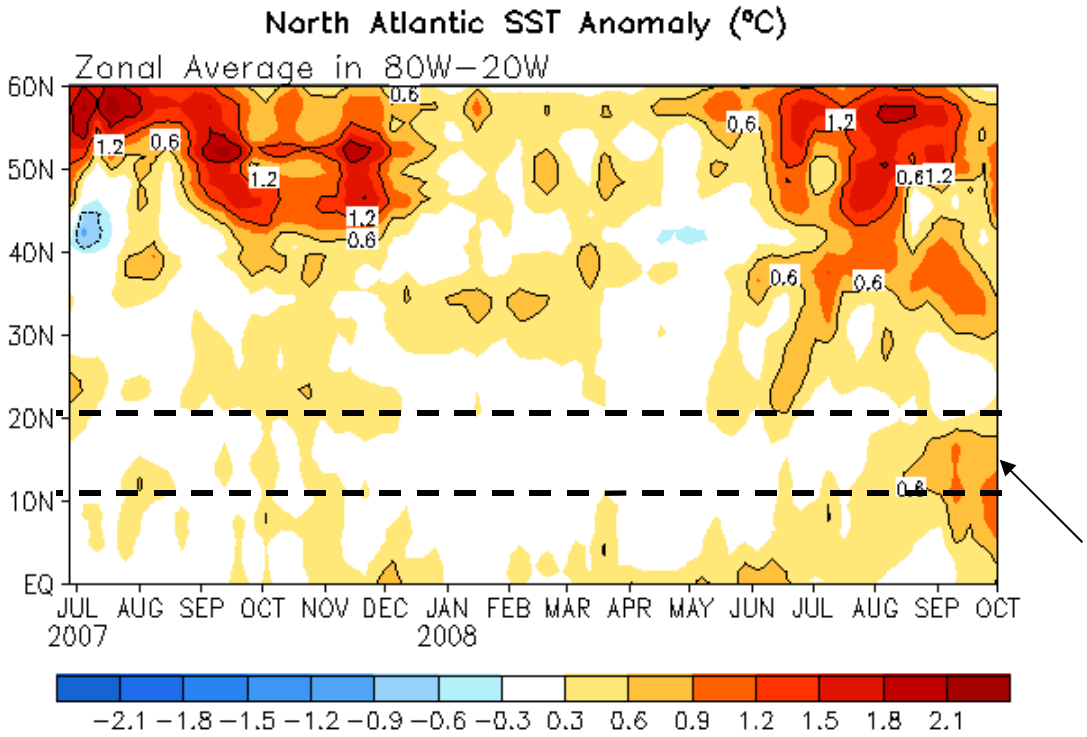


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

NAO and SST Anomaly in North Atlantic







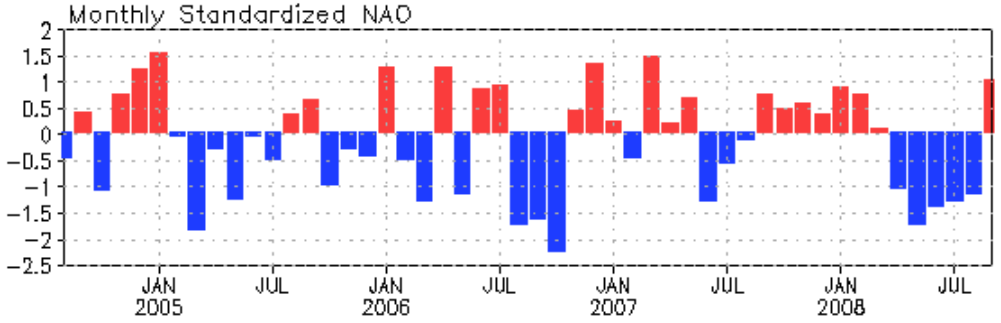
- High-latitude North Atlantic SSTA are closely related to NAO index – negative (positive) NAO leads to SST warming (cooling).

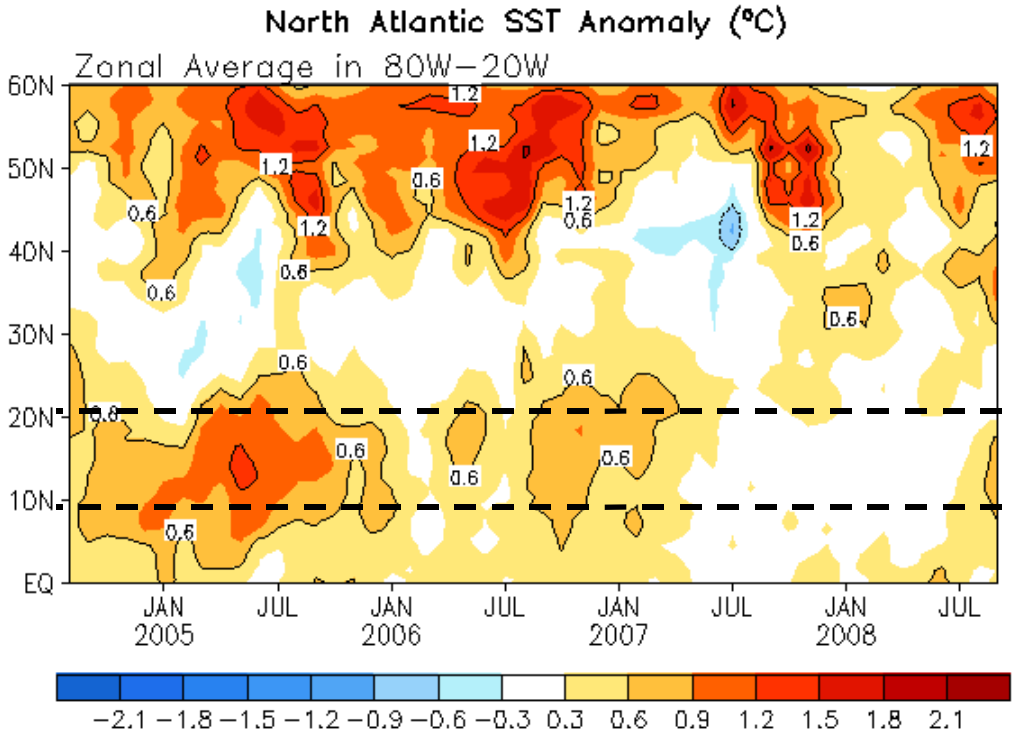
- NAO has finally switched sign, ending a 5 month run of below normal.

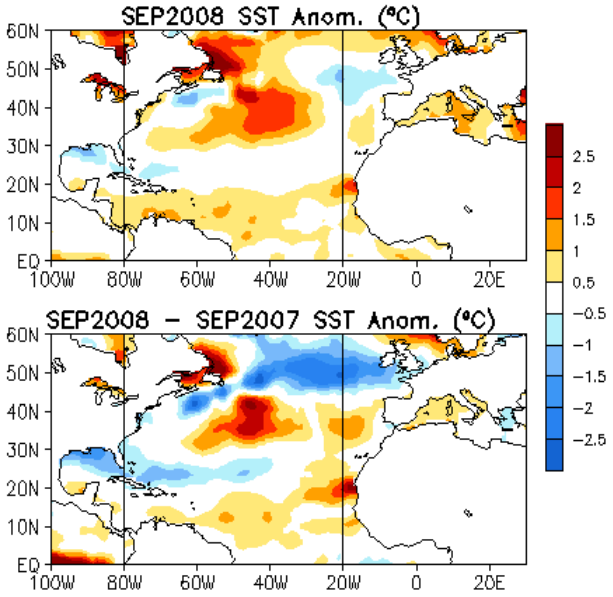
-SSTA in Main Development Region continues to warm.

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80°W and 20°W (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

NAO and SST Anomaly in North Atlantic





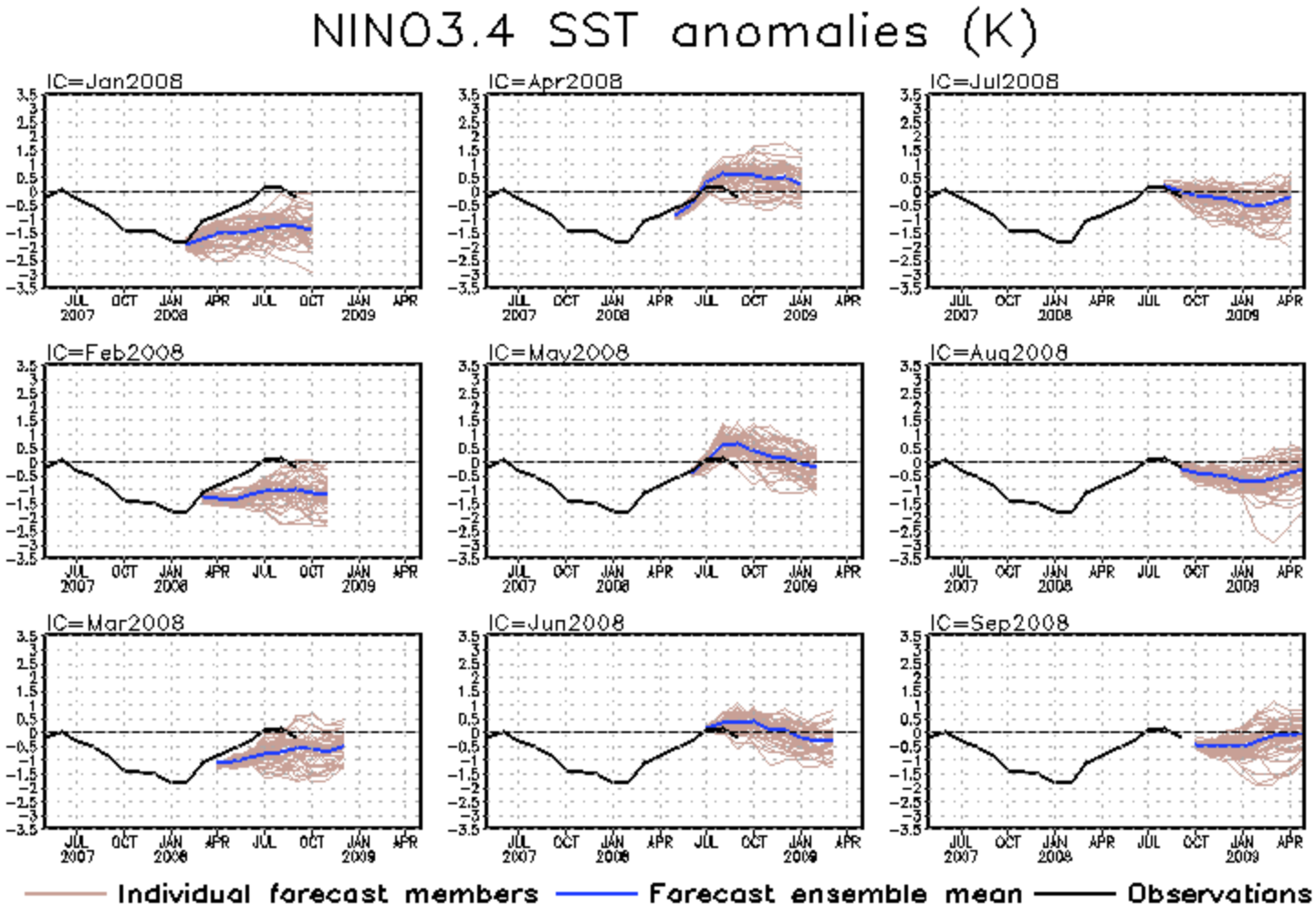


- SSTA in hurricane main development region is now at the 2006 level.

Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80°W and 20°W (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

CFS SST Predictions and Ocean Initial Conditions

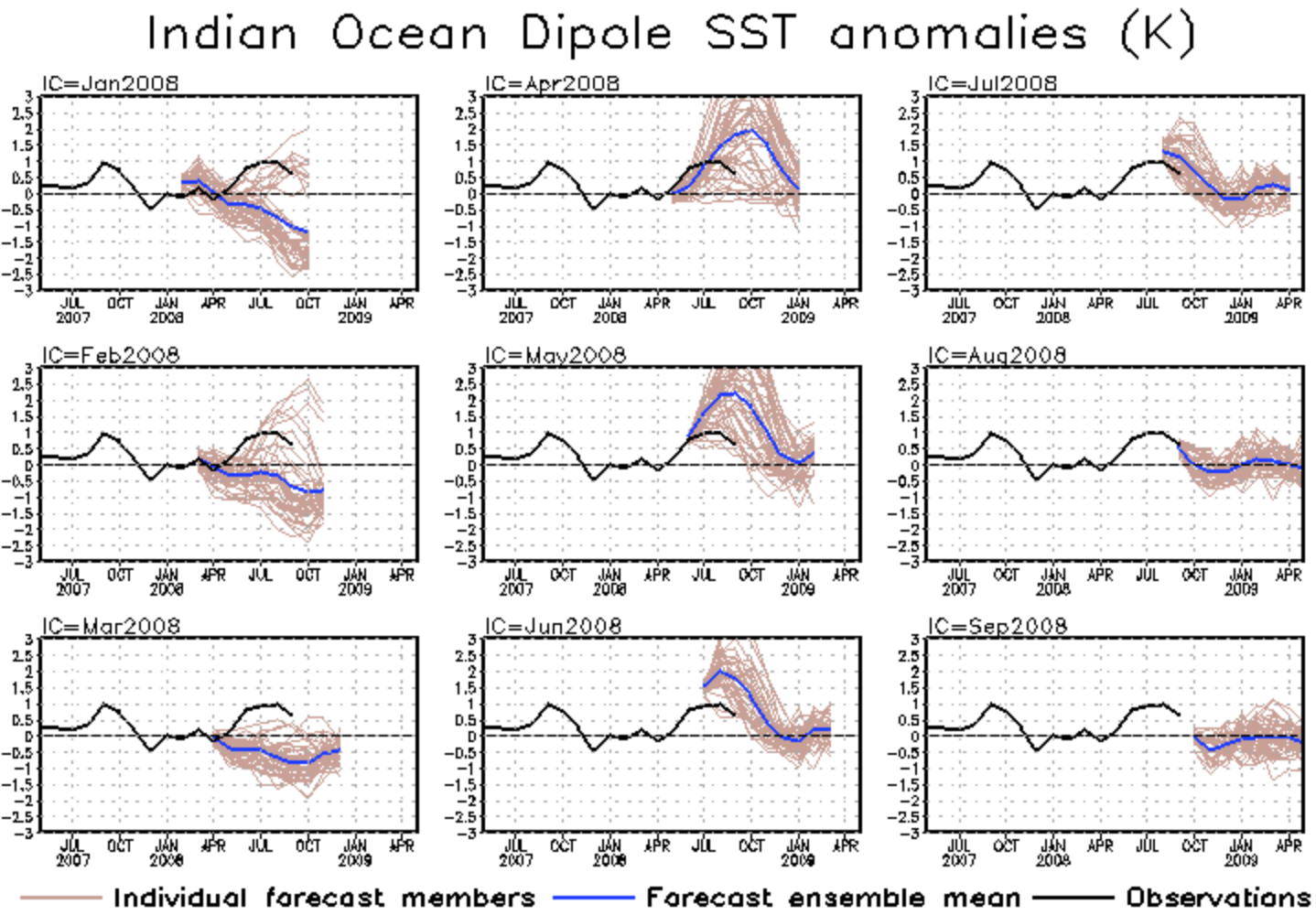
CFS Niño3.4 SST Predictions from Different Initial Months



- Latest forecasts are calling for ENSO-neutral to weak La Nina conditions.

Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labeled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

SETIO = SST anomaly in [90°E-110°E, 10°S-0]

WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

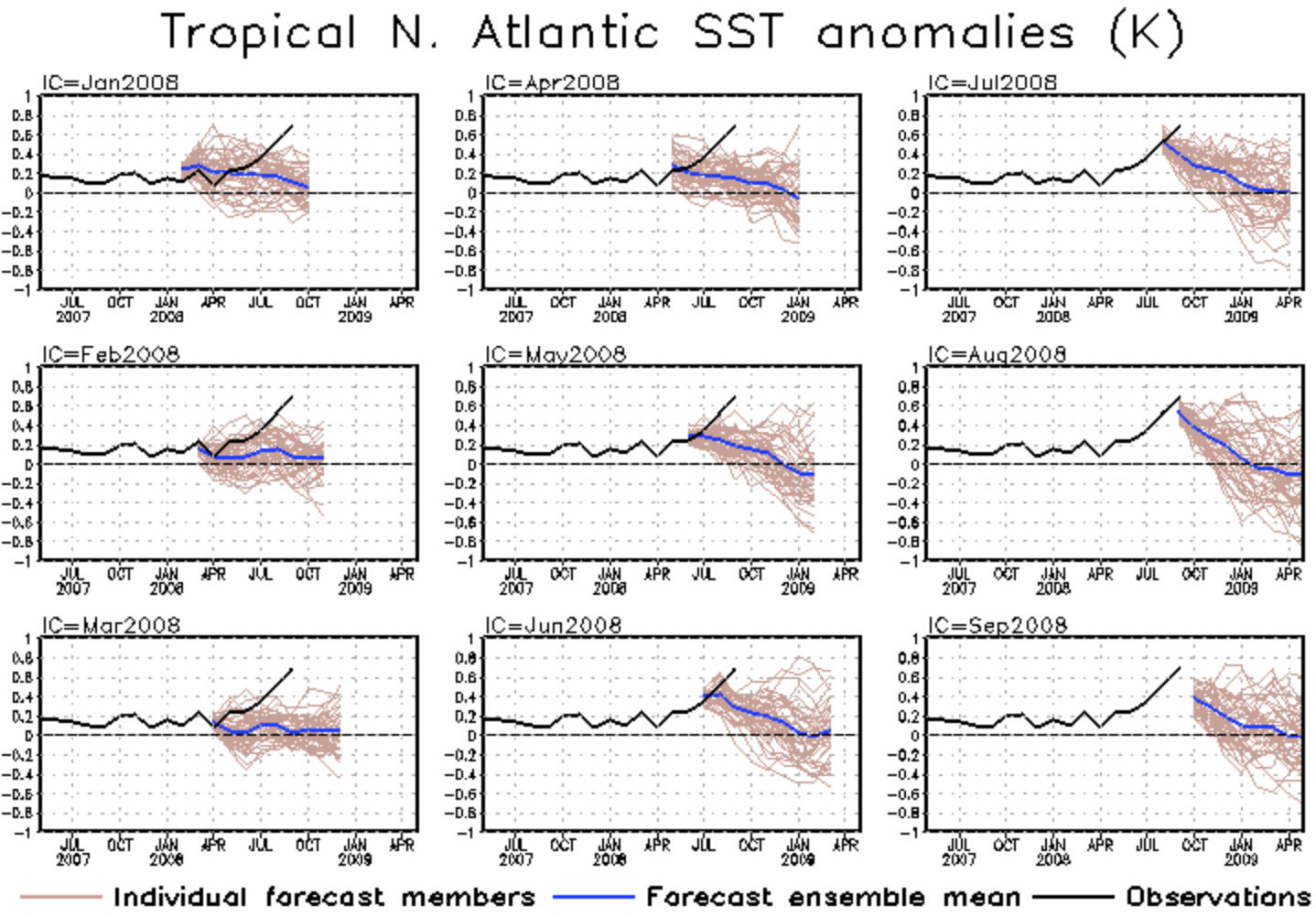
- **CFS overestimated the amplitude of IOD.**

- **CFS called for a strong negative IOD event from Jan-Apr I.C., suggesting that IOD has a low predictability of about 1-2 month lead times.**

-**Latest forecasts call for neutral conditions**

Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labeled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].

- CFS always damps SSTA in I.C., suggesting either the SSTA is unpredictable or the model has systematic errors in predicting SSTA in hurricane main development region.

This is a region that shows skill in the hindcasts. Perhaps that skill is only an ENSO teleconnection?

Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labeled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

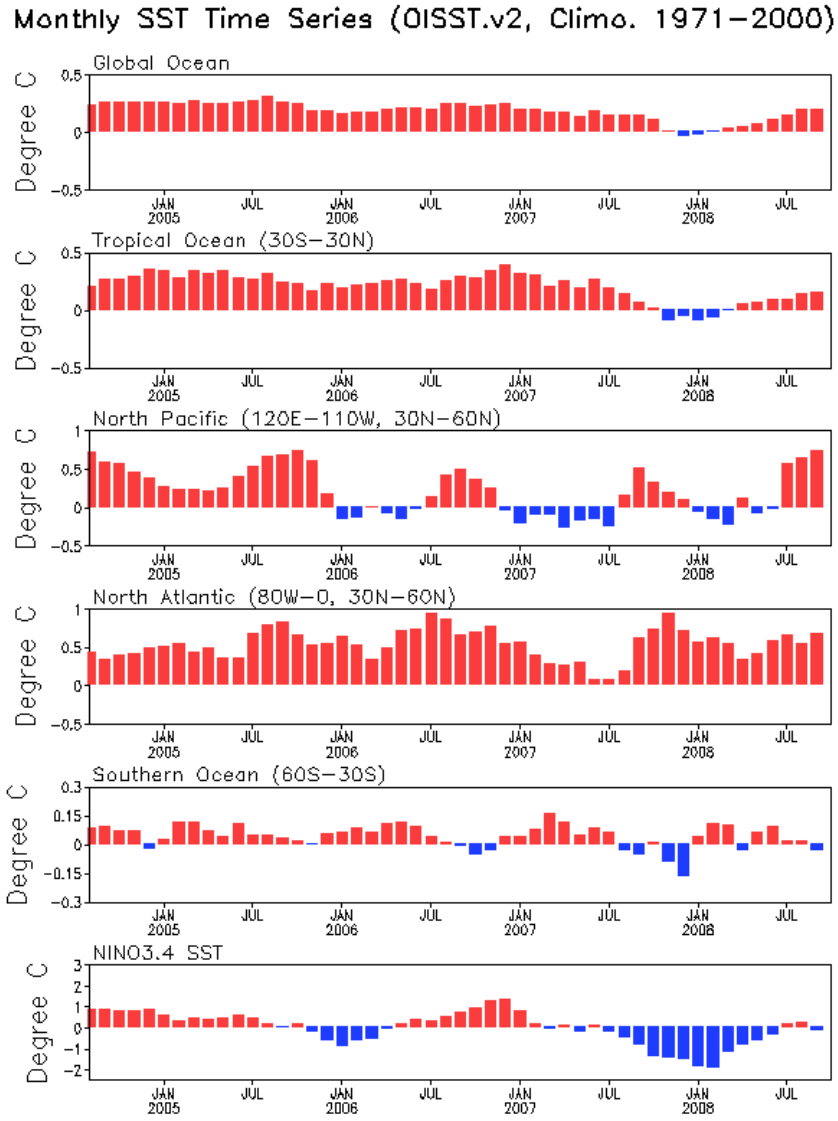
Summary

- **Global Ocean**
  - Above normal global mean SST anomaly persisted.
- **Pacific Ocean**
  - ENSO-neutral conditions will continue through winter.
  - Tropical SSTA have cooled since August.
- **Indian Ocean**
  - Dipole Mode Index decreased last month.
  - Most of the Indian ocean has above normal temperatures
- **Atlantic Ocean**
  - Tropical North Atlantic continued to warm up, favorable for hurricane development.
- **Active Ocean**
  - Sea ice extent bottomed out at 2nd lowest level.

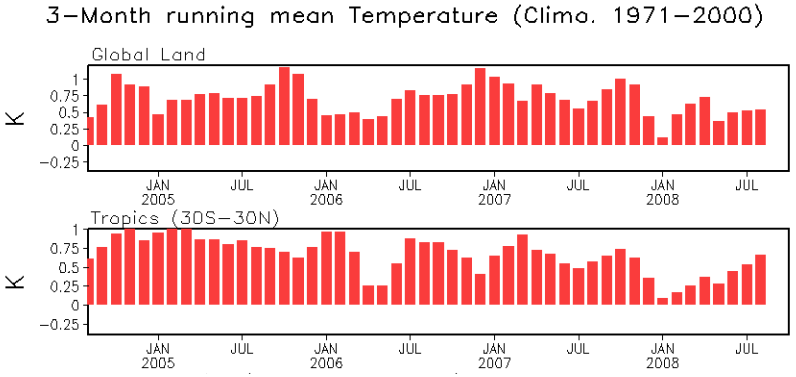
Backup Slides

Monthly Time Series

Sea Surface Temperature



CAMS Land Temperature



- **Tropical land temperature tracks the tropical ocean temperature well.**
- **Land temperature variability is larger than SST variability.**

Fig. BU. Sea surface temperature (SST) anomalies (left) and surface air temperature anomalies (right) average for selected regions. Due to larger variability, the surface air temperature anomalies have a 3-month running mean applied. Anomalies were computed with respect to the 1971-2000 base period means.

Data Sources and References

- Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)
- SST 1971-2000 base period means (Xue et al. 2003)
- NCEP CDAS winds, surface radiation and heat fluxes
- NESDIS Outgoing Long-wave Radiation
- PMEL TAO equatorial temperature analysis
- NCEP's Global Ocean Data Assimilation System temperature, heat content, currents (Behringer and Xue 2004)
- Aviso Altimetry Sea Surface Height
- Ocean Surface Current Analyses –Realtime (OSCAR)

Please send your comments and suggestions to Yan.Xue@noaa.gov. Thanks!