Atmosphere-Ocean Interaction in Mid-latitude Western Boundary Currents

CLIVAR Working Group

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Co-chairs

Goals

- ***Bring together KESS, CLIMODE, and other western boundary current groups for synthesis of results***
- ***Identify shortcomings in atmosphere, ocean, and coupled models***
- ***Identify observational gaps and modeling experiments***

Science Issues

• How does air-sea interaction compare in North Atlantic and North Pacific?
• What is the nature of atmosphere-ocean interaction over western boundary currents? Is it coupled?
• To what extent are coupled models getting the interaction right?
• Does the air-sea interaction extend beyond the boundary layer and influence climate?

Tasks

- ***Year 1: Review available research on WBCs; define and coordinate syntheses of KESS and CLIMODE***
- ***Year 2: Convene larger conference to frame science issues, evaluate models, and foster model improvements***
- ***Deliverables:***
    - ***Foster parallel KESS/CLIMODE analyses***
    - ***White paper on outstanding issues (BAMS or US CLIVAR Variations)***

Membership

Bo Qiu (U of Hawaii, co-chair)
Mike Alexander (NOAA CDC, co-chair)
Kathie Kelly (U of Washington, co-chair)
Nick Bond (NOAA/PMEL)
Meghan Cronin (NOAA/PMEL)
Claude Frankignoul (LOCEAN, Paris)
Terry Joyce (WHOI)
Young-Oh Kwon (WHOI)
Hisashi Nakamura (U of Tokyo)
Roger Samelson (Oregon State U)
Justin Small (U of Hawaii)
LuAnne Thompson (U of Washington)

Activities

Review of existing research by topic conducted by teleconferences

- *KESS and CLIMODE*
- *Ocean front air-sea interaction*
- *Large-scale air-sea interaction*

Scheduled working meeting at the AMS meeting in Portland, 23-24 August

What is CLIMODE?

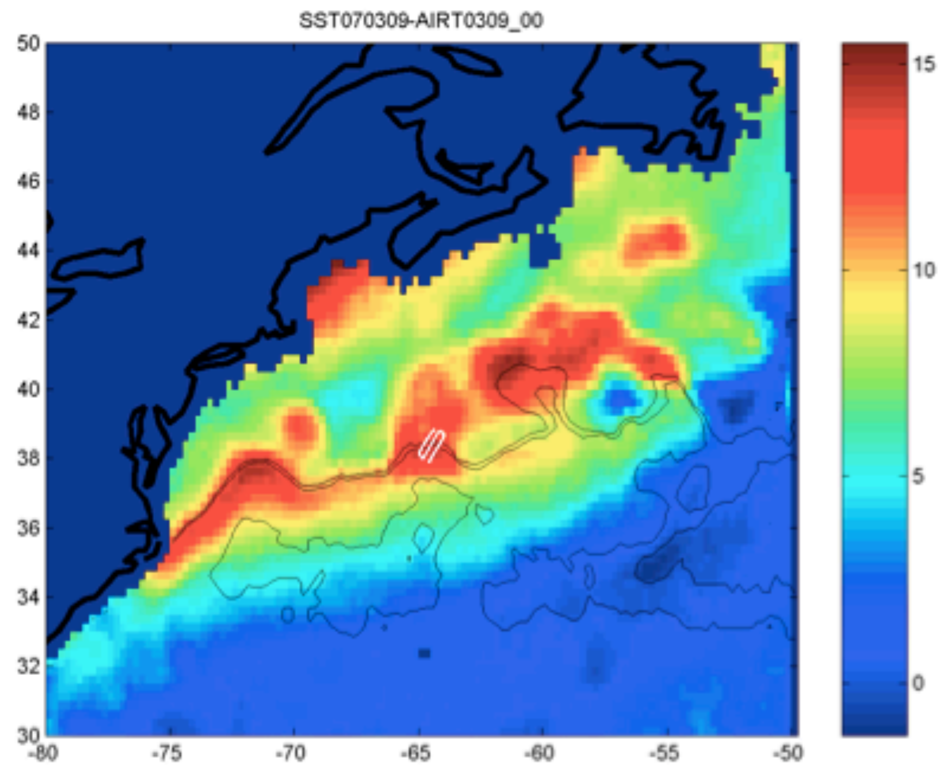
CLIvar
MOde water
Dynamics
Experiment

CLIMODE is a major, ongoing process study (2005- 2009) of the formation, subduction, & dispersal of Eighteen Degree Water (EDW), the principal water mass of the subtropical North Atlantic Ocean – one of the Subtropical Mode Waters that are invariably found equatorward of major zonal currents, like the Antarctic Circumpolar Current, Kuroshio, and Gulf Stream.

See **www.climode.org**

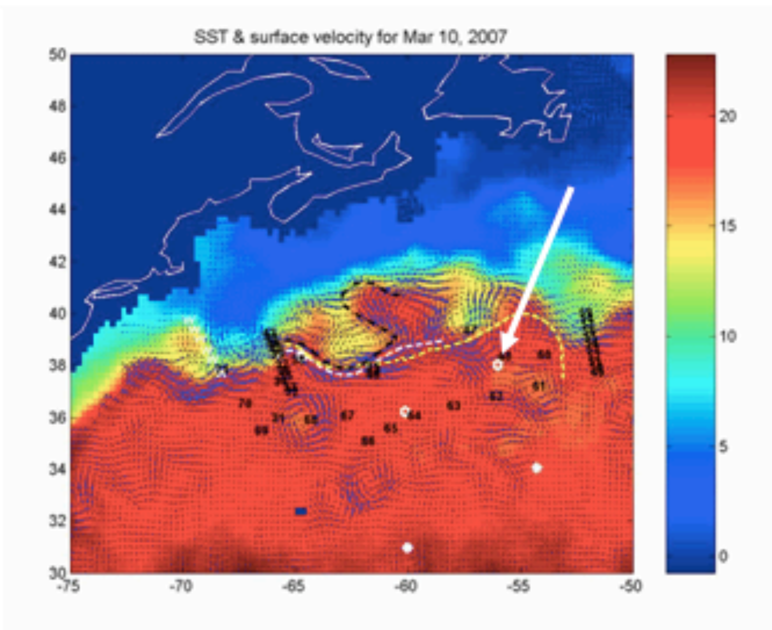
8-9 March High HF Event – 3

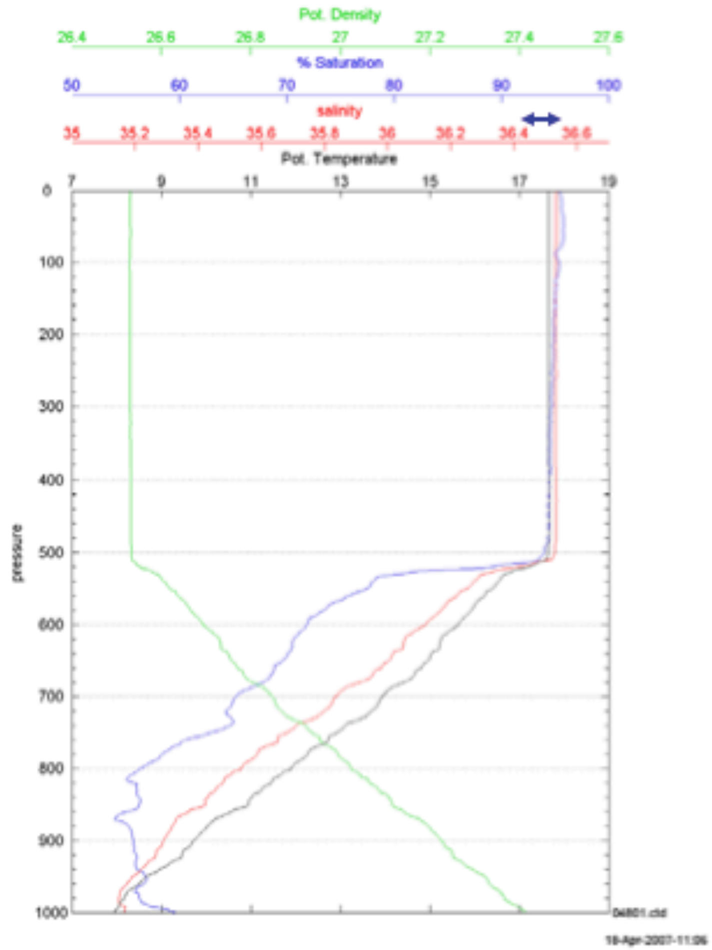
Regional map of SST – Air Temp ***difference***, with SST contours of the 17.5 & 18.5 °C isotherms during cold air outbreak on 9 March. Note how large ***ΔT*** can be found over the warm core of the GS and over its northward meanders.



CLIMODE

EDW, was it formed in the late winter of 2007?

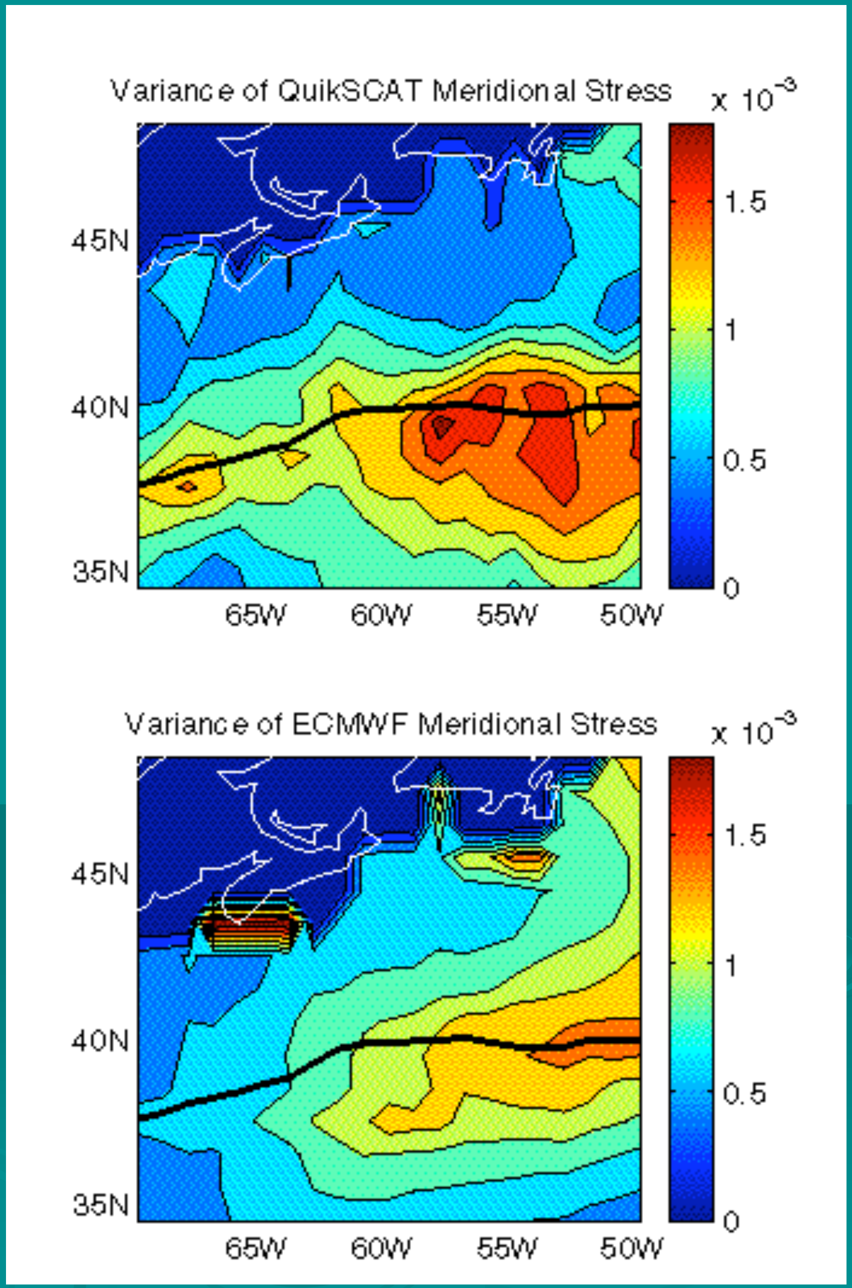




Yes! Of the CTD stations on Leg 2, one of the deepest layers of newly ventilated EDW was found at station 48, just south of the Gulf Stream (see white arrow at left). The ML depth (right) was about 500m at this station.

Storm Track Steering by Strong Currents

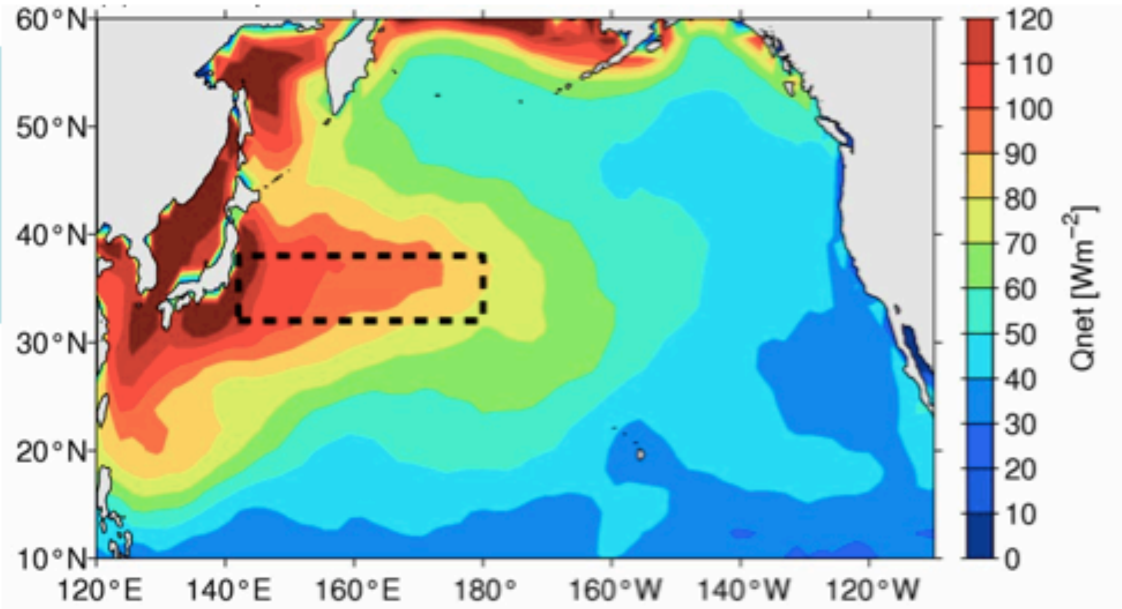
• Meridional QuikSCAT wind stress variance (proxy for cyclone activity)
• Maximum along Gulf Stream path (black)
• Similar for major current systems *(Nakamura et al., 2004)*
• Gulf Stream currents evident in QuikSCAT winds *(Chelton et al., 2004)*



KESS/KEO

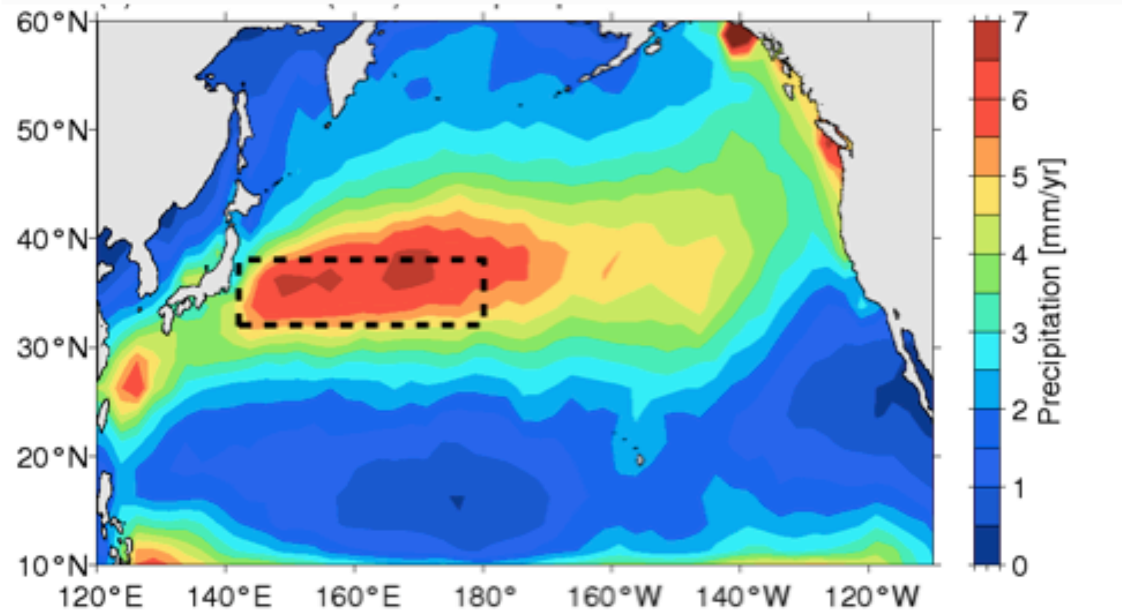
Wintertime (JFM) rms net surface heat flux variability

(NCEP reanalysis)



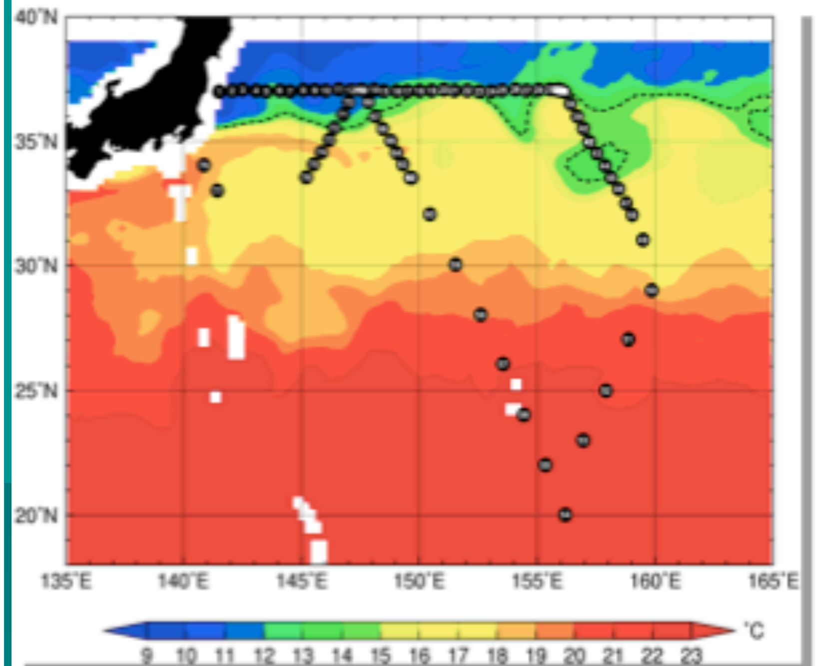
Wintertime (JFM) precipitation

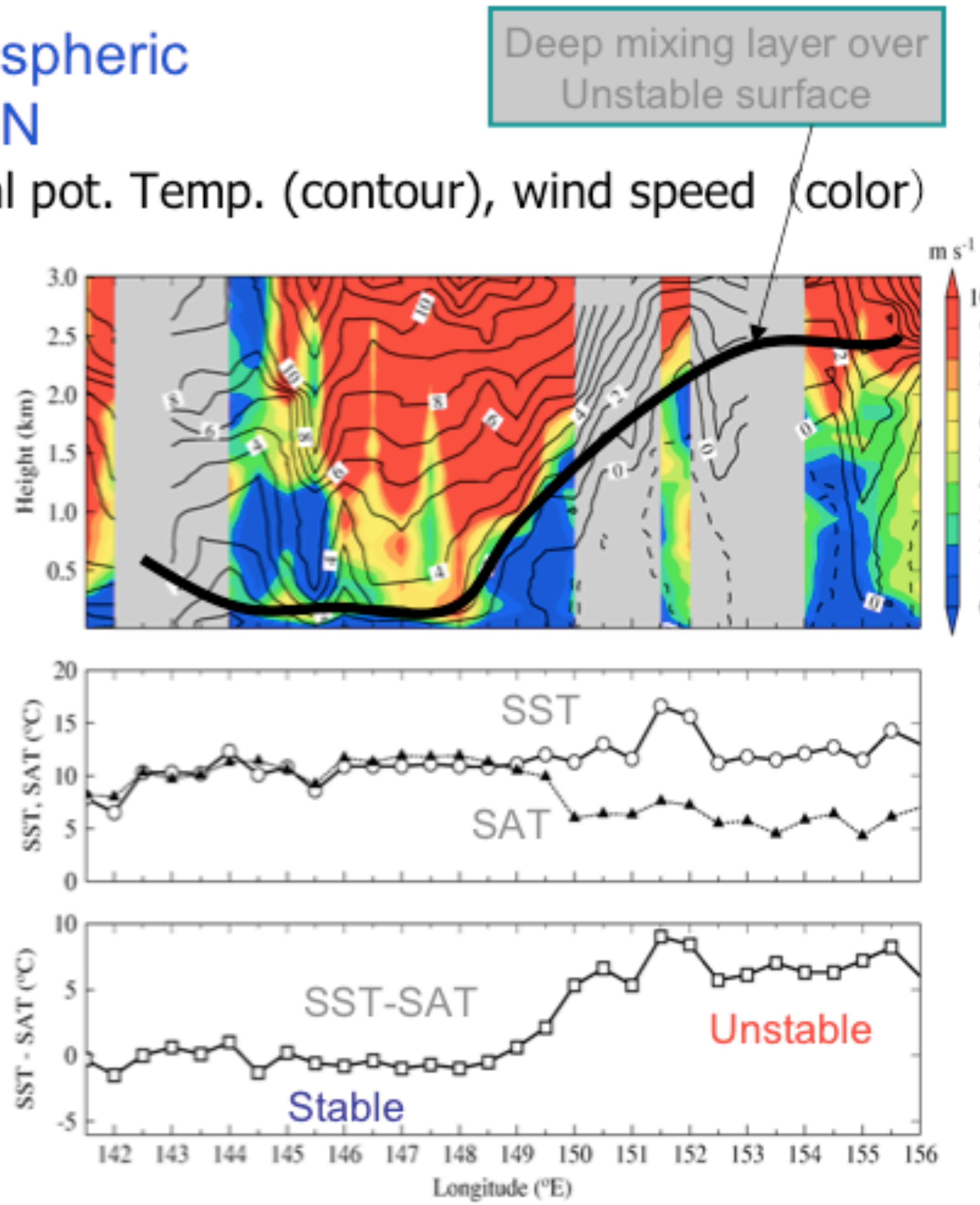
(proxy for winter stormtracks)



Pre-KESS wintertime atmospheric sounding results along 37°N

Virtual pot. Temp. (contour), wind speed (color)





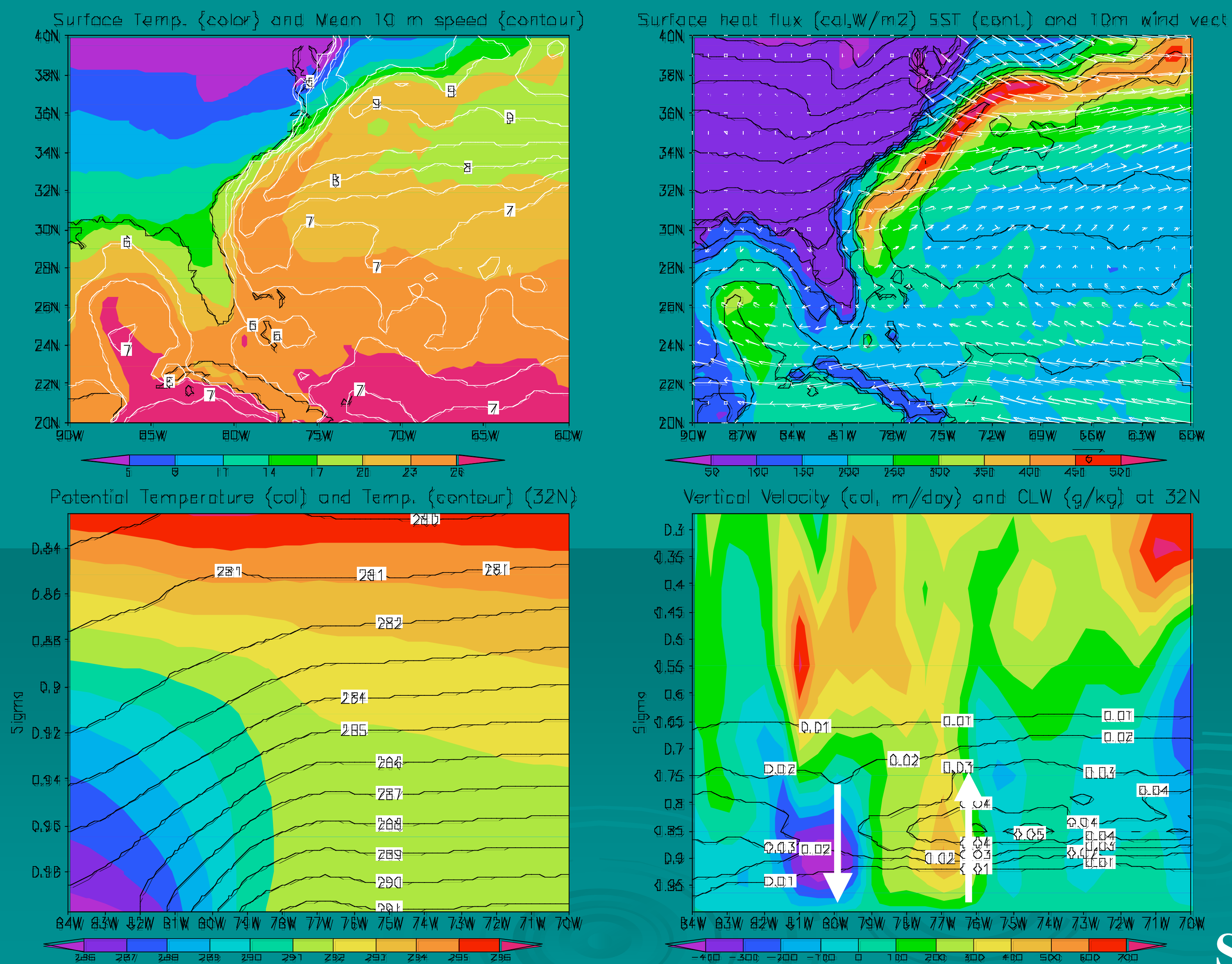
Feb. 24, 2004 – Mar. 17

(78 soundings)

Courtesy of Y. Tanimoto

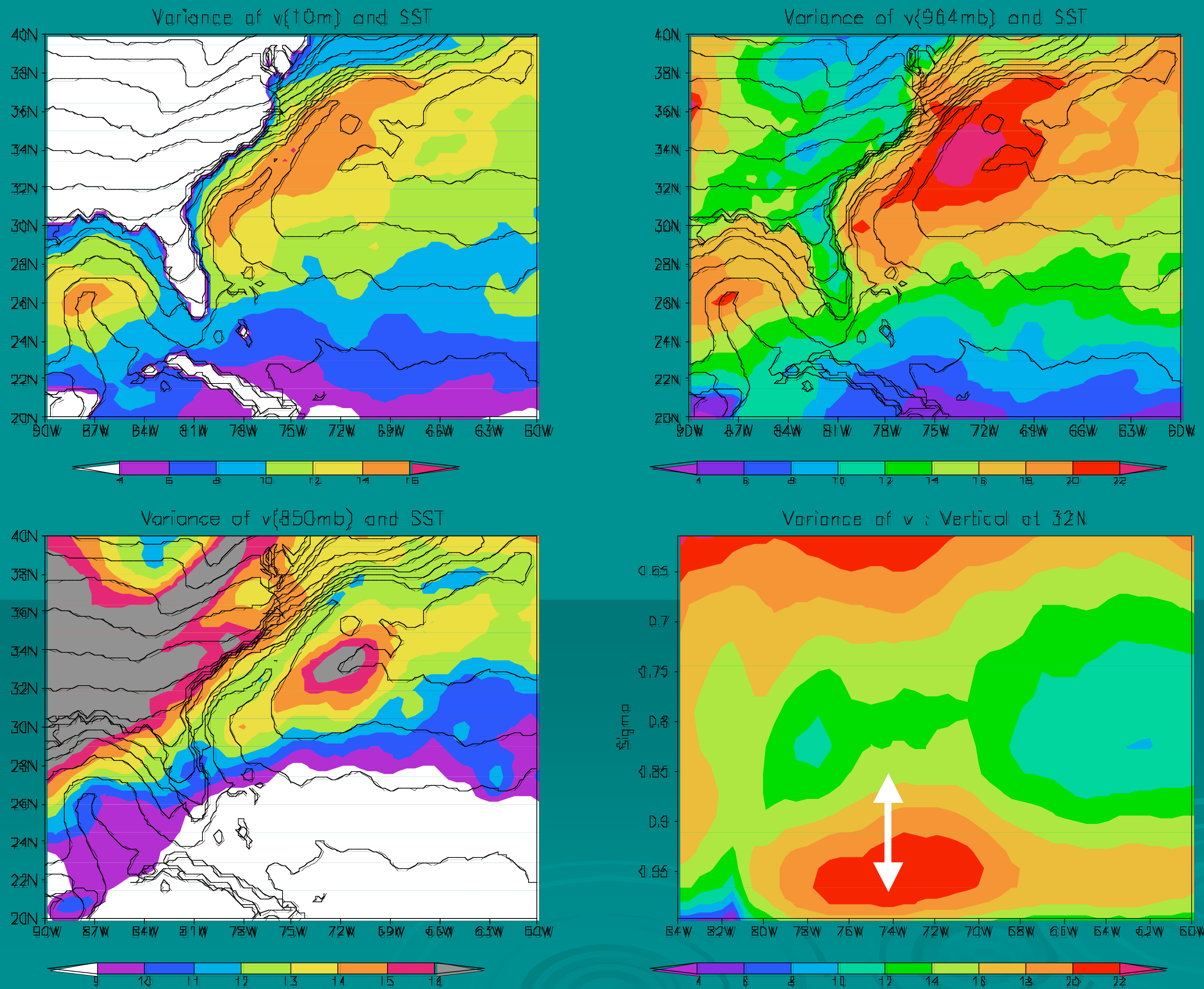
Ocean front air-sea interaction

Regional Atmospheric Model
Jan-Apr Mean



Small et al.

Vertical structure of variance (MODEL)



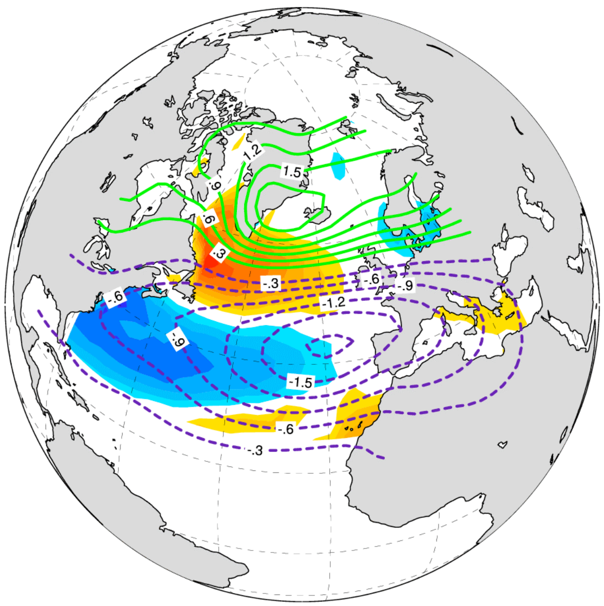
$$\overline{v'v'}$$

Small et al.

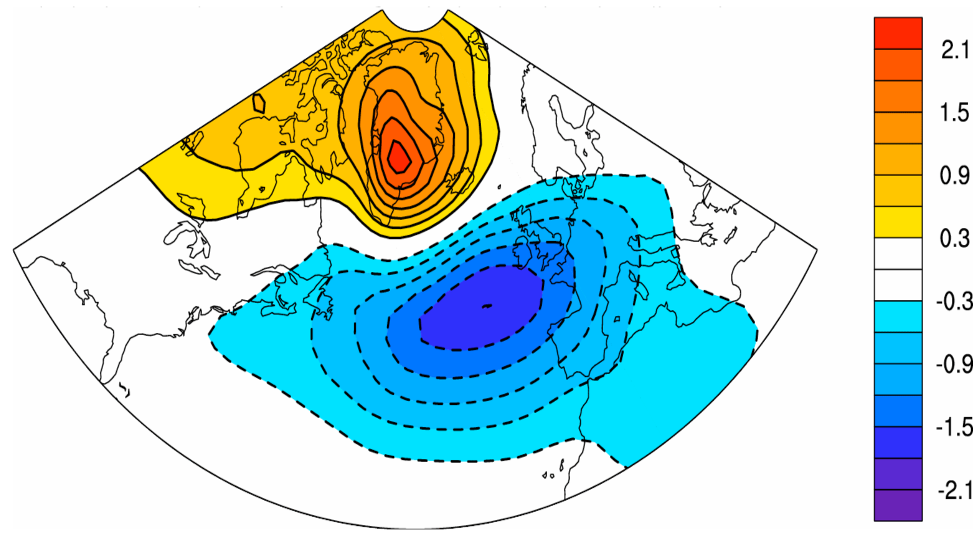
Large-scale air-sea interaction

Winter (NDJFM) Sea Level Pressure Response

Forcing



SLP Response

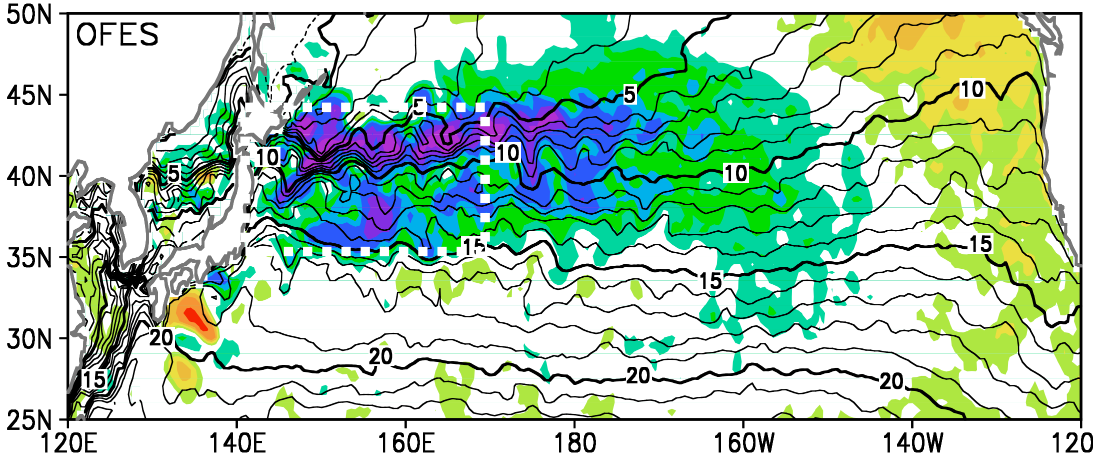


Modest (~20%) but significant SLP response that acts as a positive feedback (e.g., in this model, reemergence enhances the winter-to-winter persistence of the North Atlantic Oscillation).

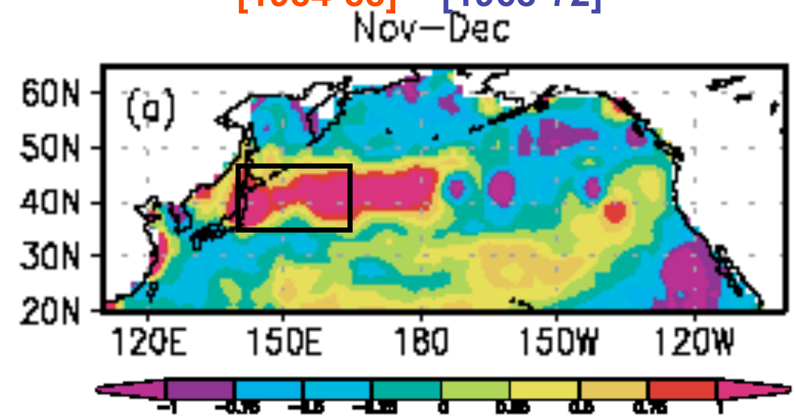
Decadal SST anomalies along the Oyashio front and associated anomalous heat release into the atmosphere

Nonaka, Nakamura, Tanimoto, Kagimoto, Sasaki (2006, J.Clim)

OFES-**simulated** JFM SST for 1984-88 (contour);
SST difference [1984-88] – [1968-72] (color)



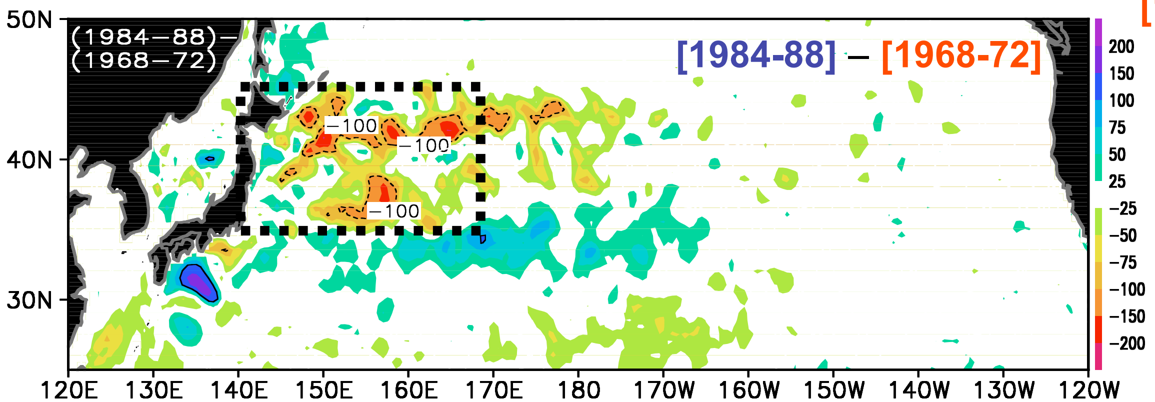
Observed SST difference
[1984-88] – [1968-72]



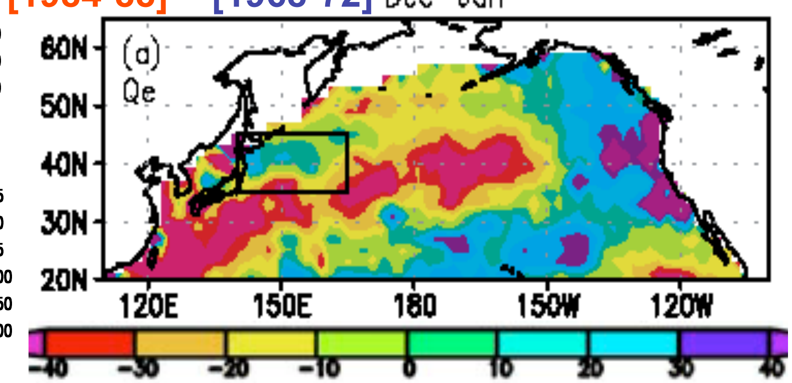
Reduced **(enhanced) surface heat release from the *cooler* (warmer) frontal zone !**

Oceanic thermal forcing on the atmosphere in the mid-latitude frontal zone !

OFES-**simulated** JFM difference in surface heat flux



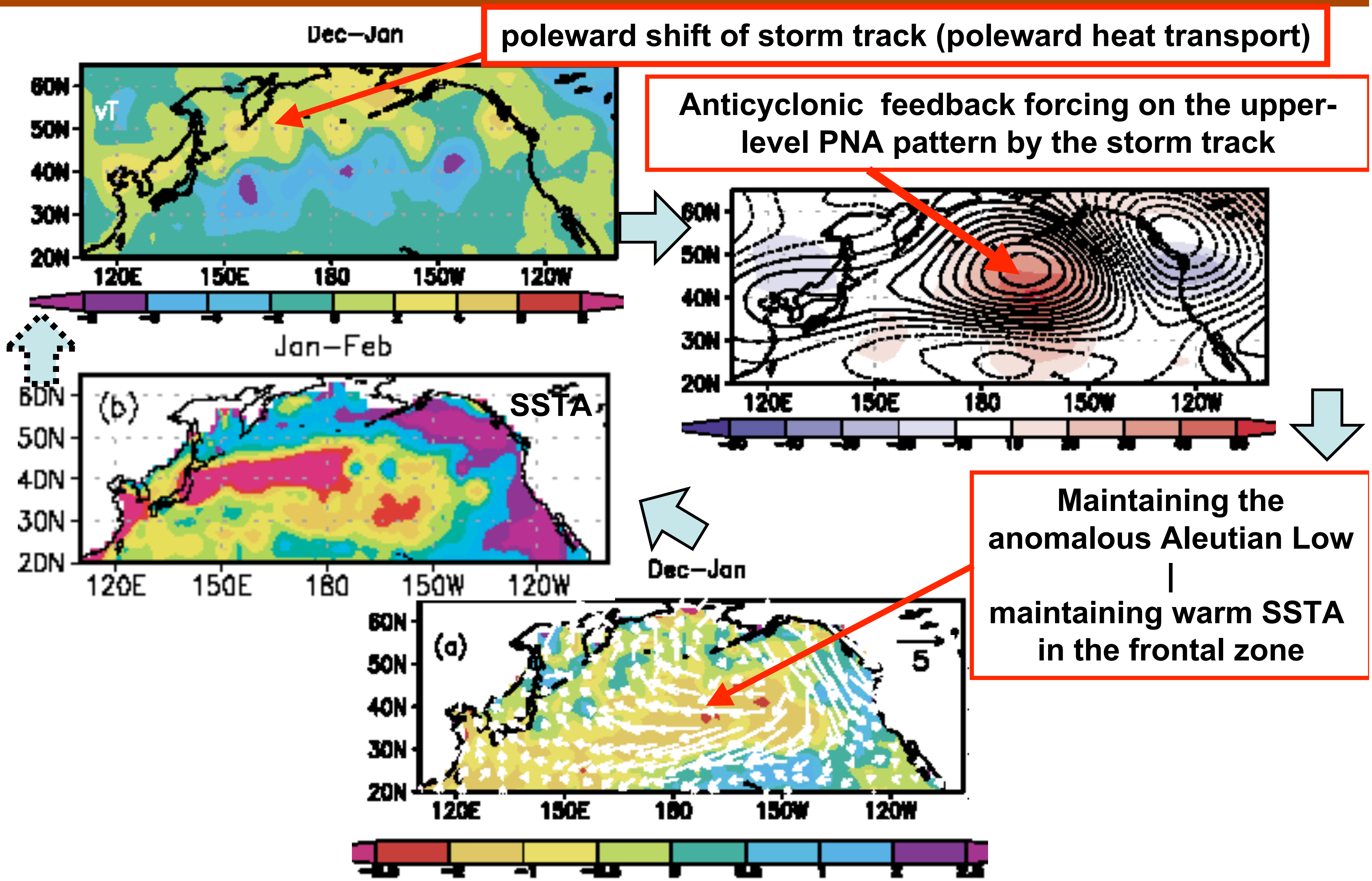
[1984-88] – [1968-72] Dec–Jan



▲ **Observed latent heat flux difference**

Possible feedback by decadal SST anomalies along the Oyashio front onto the atmosphere

Tanimoto, Nakamura, Kagimoto, Yamane (2003, JGR)



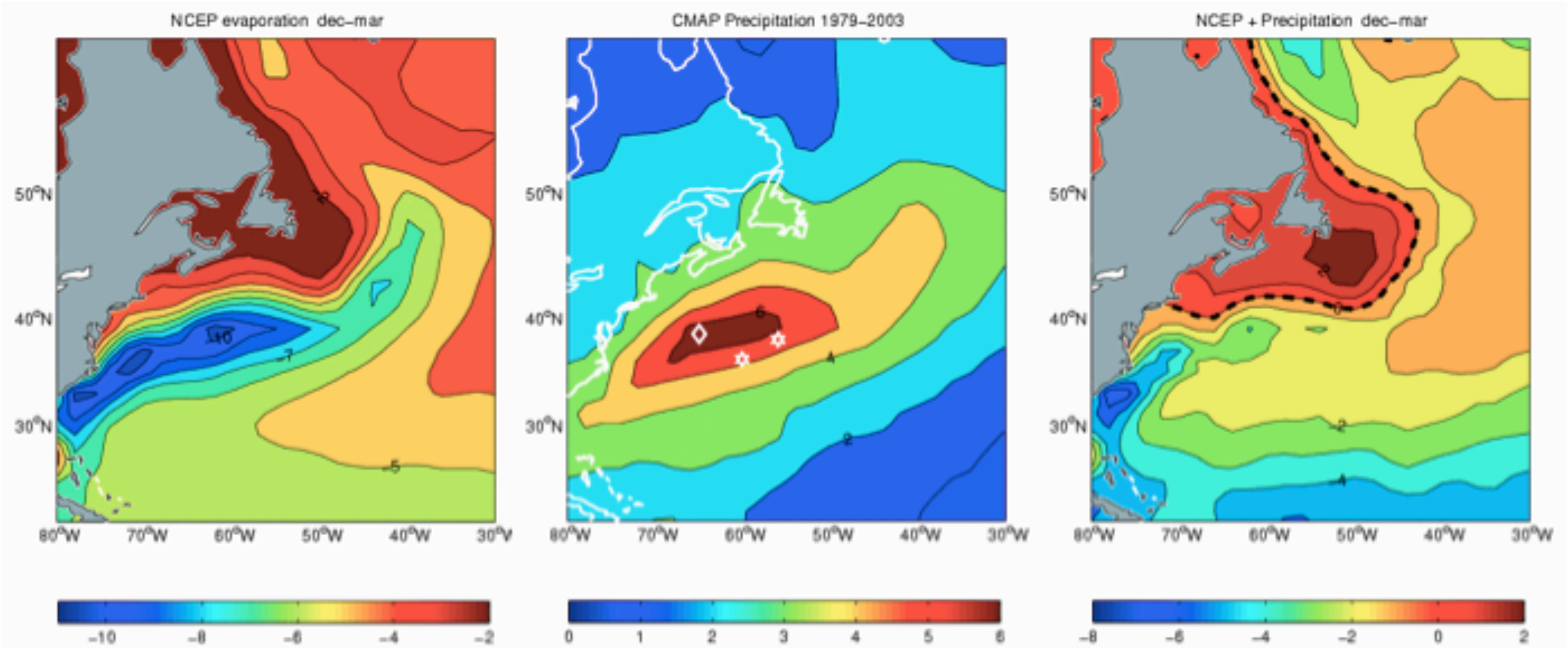
Future Plans

Scheduled working meeting at the AMS meeting in Portland, 23-24 August

Conference in 2008, review papers

CLIMODE

Precip & Evap Compared



While the winter months NCEP Evaporation (left) may be of questionable absolute accuracy, one can see enhanced Evaporation over the Gulf Stream off N. Carolina with increased CMAP Precipitation (middle) somewhat 'downstream' along the storm track, suggesting a rapid but not instantaneous atmospheric response, a decaying E-P signal (right), and efficient 'recycling' of water in the region. Units for both are **mm/day**.

Rain rate and deep response

- Hobbs (GRL, 1987) introduced the 'Gulf Stream Rainband', a quasi-stationary band with associated lightning strikes. Trunk and Bosart (1990) mapped the mean radar echos off Cape Hatteras to confirm.