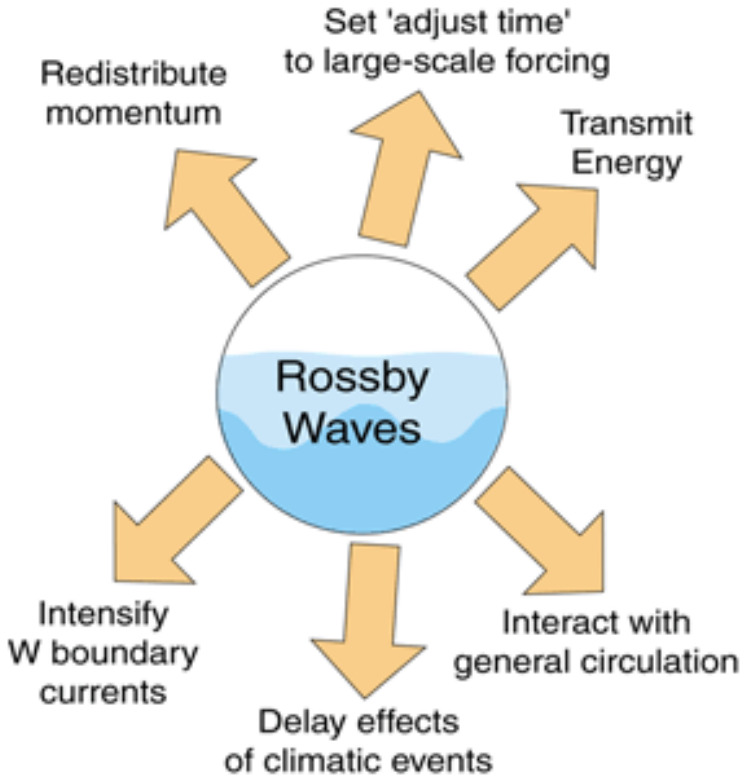
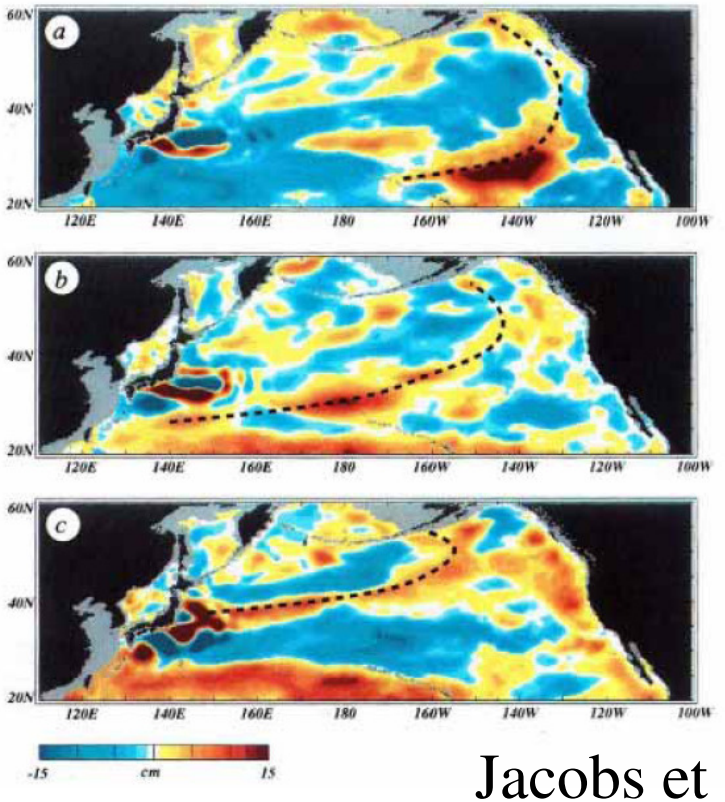
Rossby Waves and the North Pacific Current





Jacobs et al. (2004)

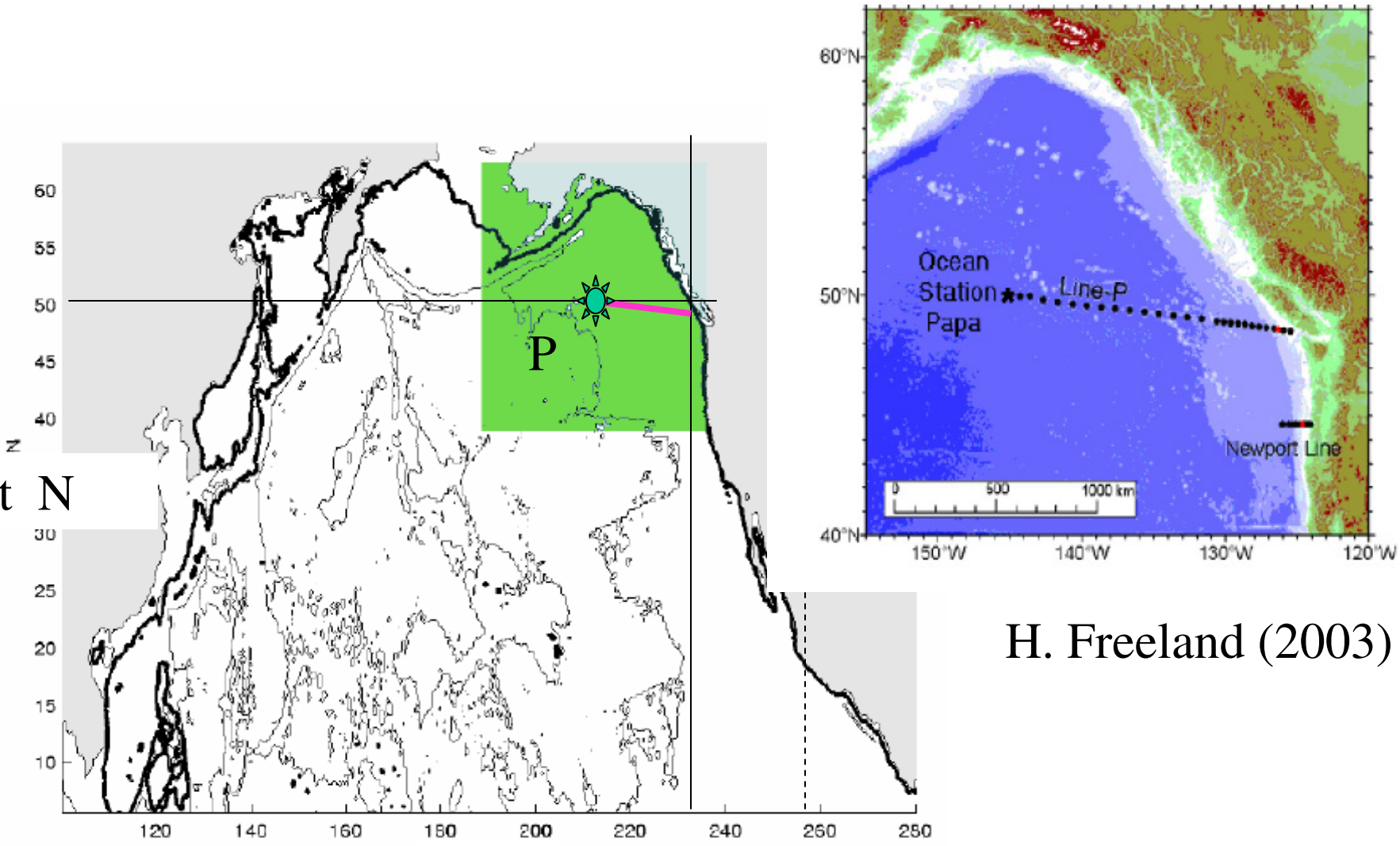
OUTLINE

- BACKGROUND OF REGION
- PARALLEL OCEAN PROGRAM (POP)
- ROSSBY WAVES
- NORTH PACIFIC CURRENT DEVIATION
- SUMMARY

HYPOTHESIS

REMOTELY FORCED ROSSBY WAVES EXIST AND CAN SIGNIFICANTLY INFLUENCE THE NORTH PACIFIC CURRENT (NPC)

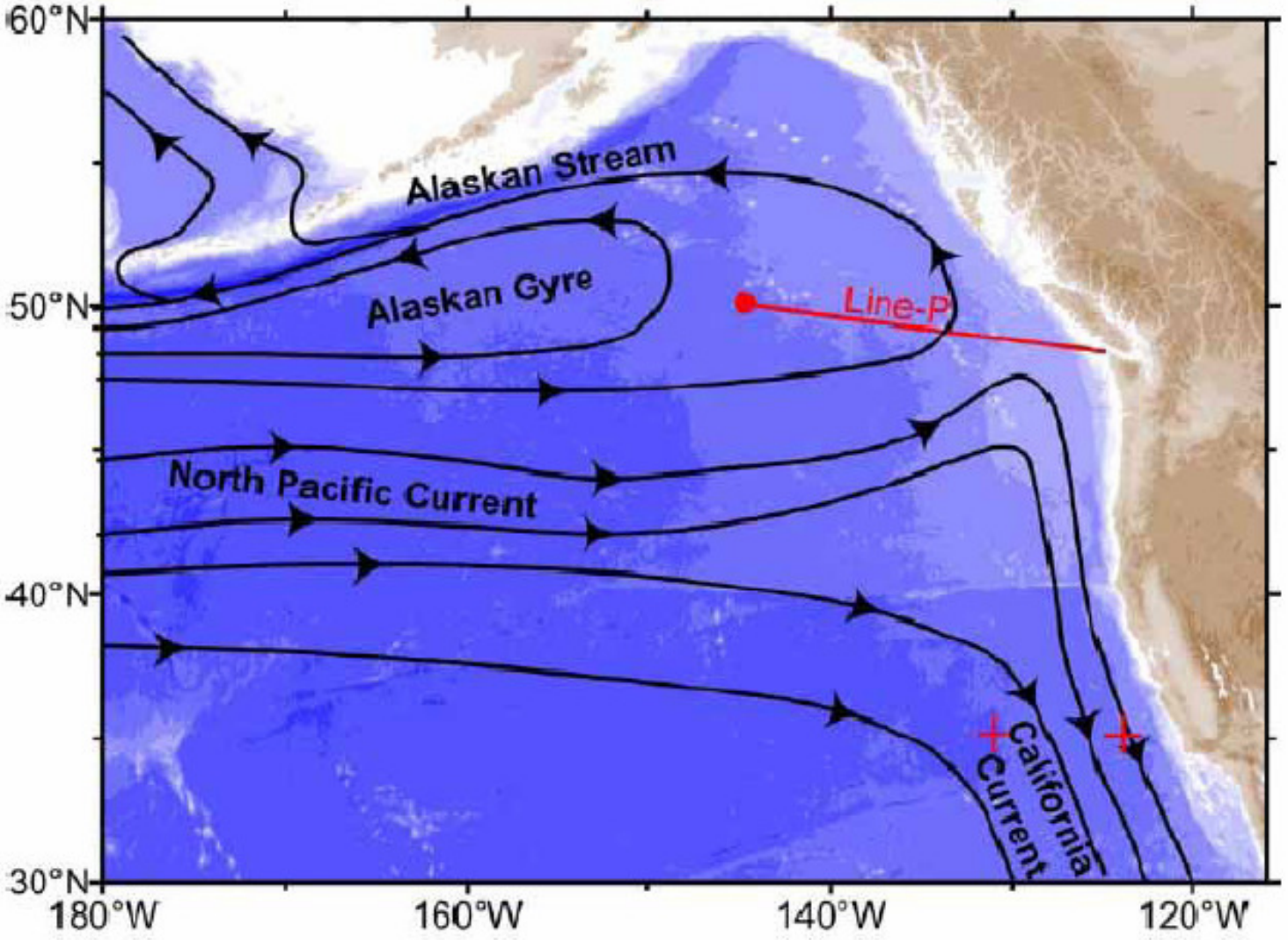
MODEL DOMAIN



H. Freeland (2003)

GRID: 741 x 319

Northeast Pacific



H. Freeland (2006)

PARALLEL OCEAN PROGRAM(POP)

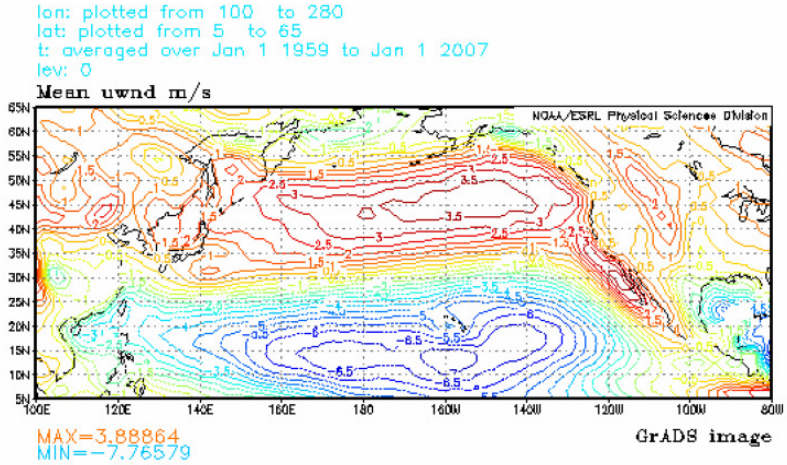
- ***HIGH PERFORMANCE COMPUTING VIRTUAL LABORATORY [HPCVL]***

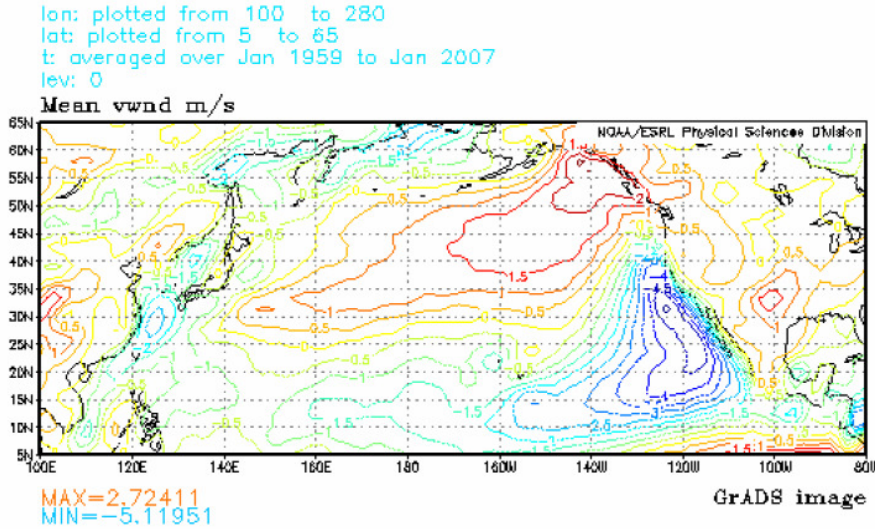
  46 YEAR RUN, "SPUN UP" USING LEVITUS CLIMATOLOGY OF **T**, AND **S.**
- MODEL HAS HORIZONTAL RESOLUTION OF 0.25 DEGREES
- 28 VERTICAL LEVELS WITH 10M RESOLUTION IN UPPER LAYERS
- SPECTRAL NUDGING WAS VITAL FOR REPRODUCING OBSERVATIONS

SPECTRAL NUDGING:

- *ONLY SPECIFIED FREQUENCY BANDS ARE NUDGED TOWARD THE CLIMATOLOGY, AVOIDING DRIFT OVER LONG SIMULATIONS AND ALLOWING THE HIGHER FREQUENCY DYNAMICS TO EVOLVE ACCORDING TO THE MODEL DYNAMICS*

MODEL FORCING

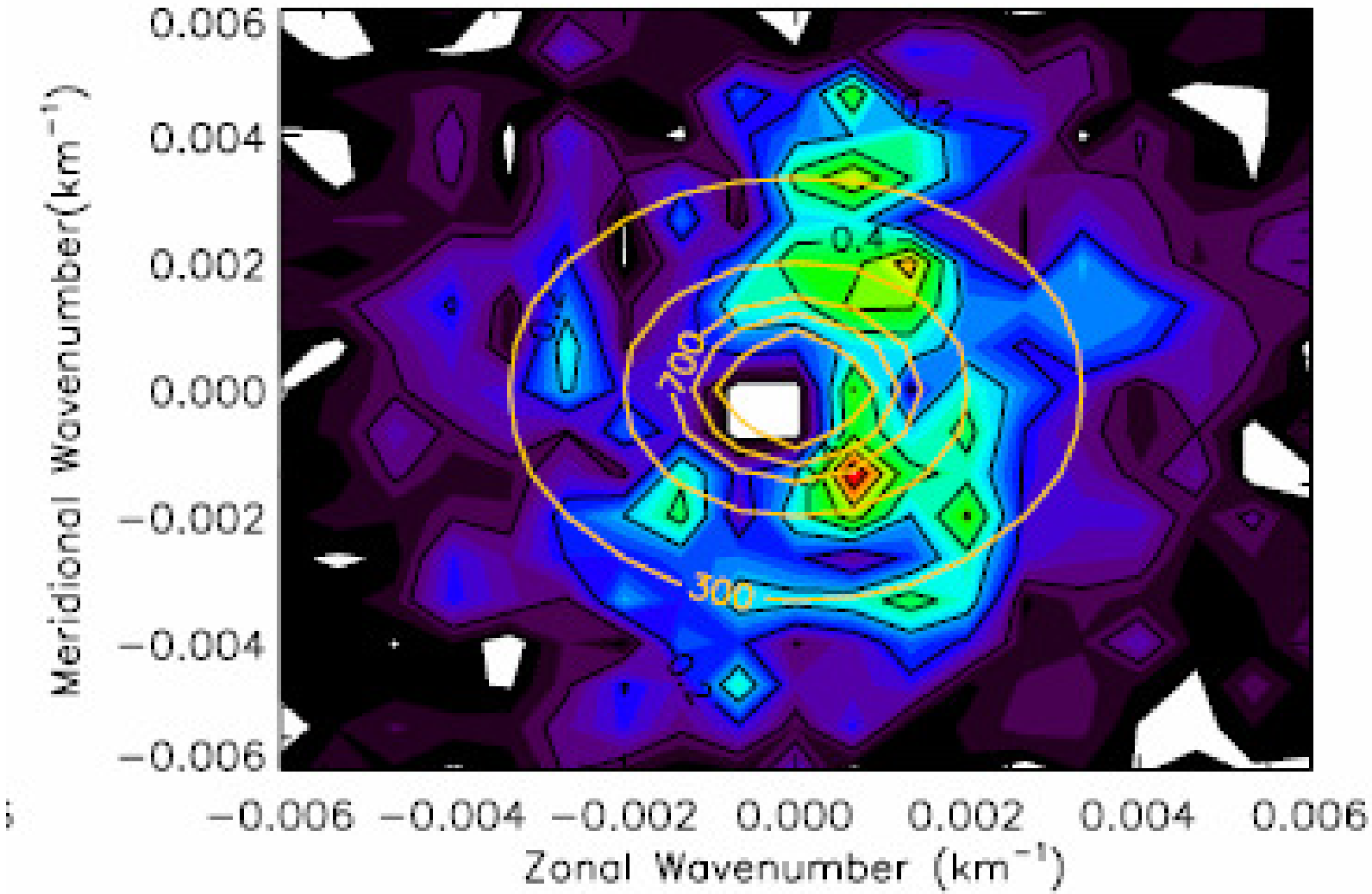




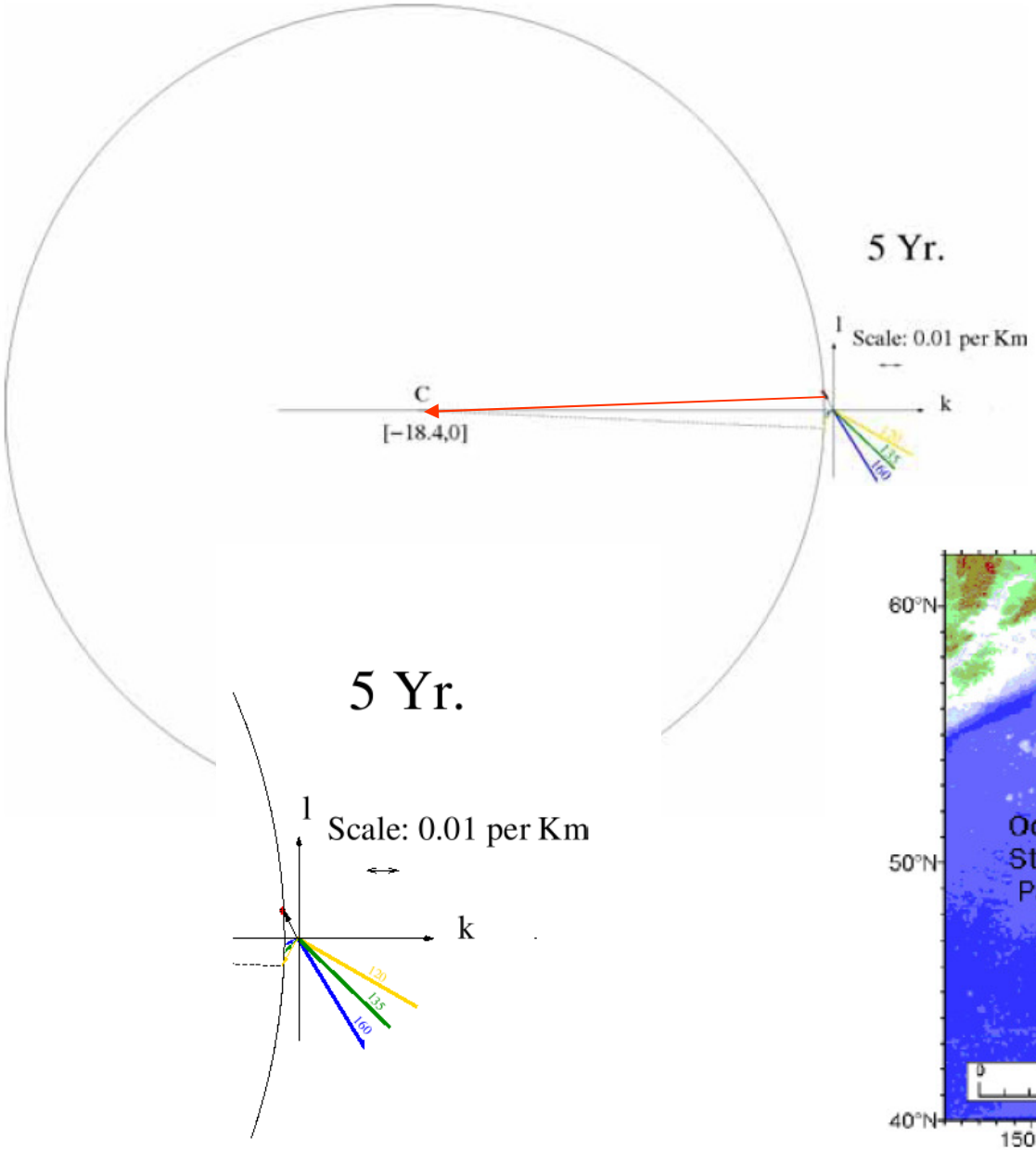
- NCEP [NATIONAL CENTER FOR ENVIRONMENTAL PREDICTION]
- MONTHY MEAN "OBSERVED" VALUES OF:
  - ***ZONAL AND MERIDIONAL WINDSTRESS***
  - ***NET HEAT FLUX***
  - ***RAIN RATE***
  - ***SEA-LEVEL PRESSURE***

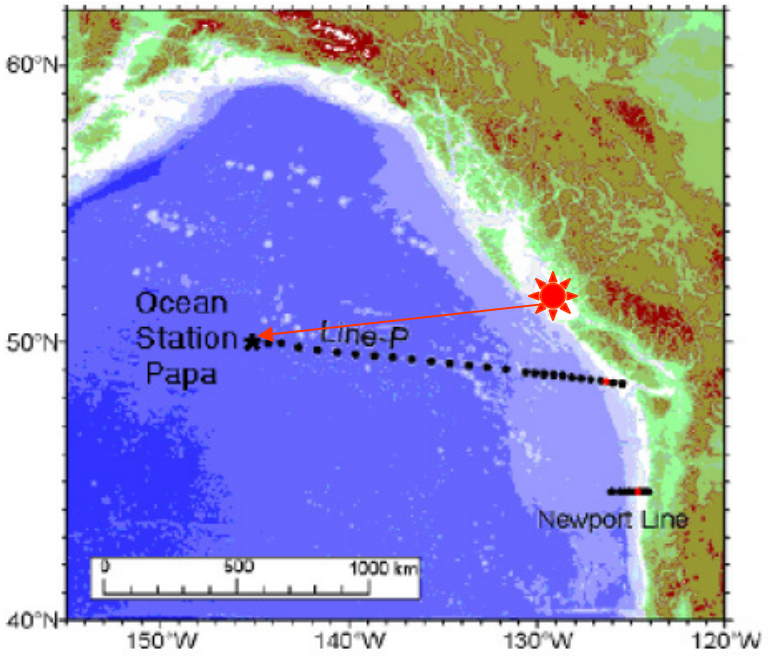
  FROM 1960 THROUGH 2006 [46 YEAR SIMULATION]

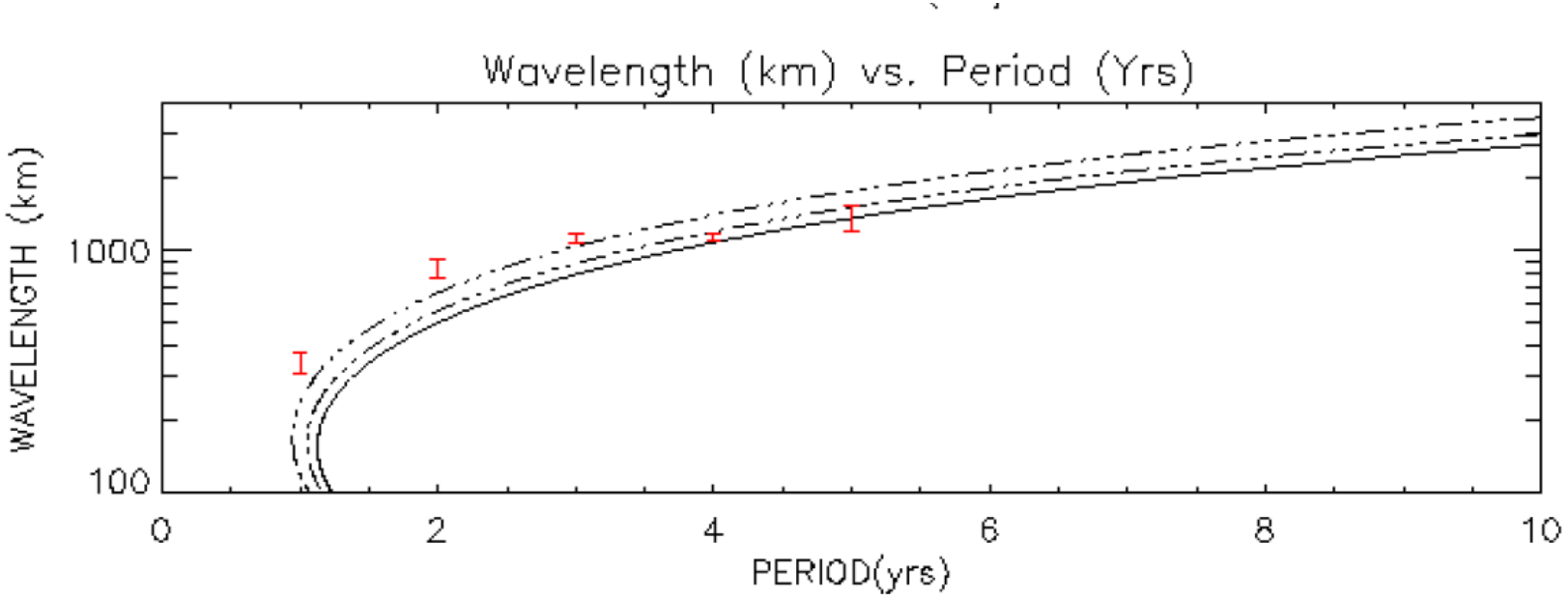
5 YEAR PERIOD SPECTRAL WAVENUMBER POWER DENSITY



Scaled
Dispersion curve for 5 year Rossby Wave



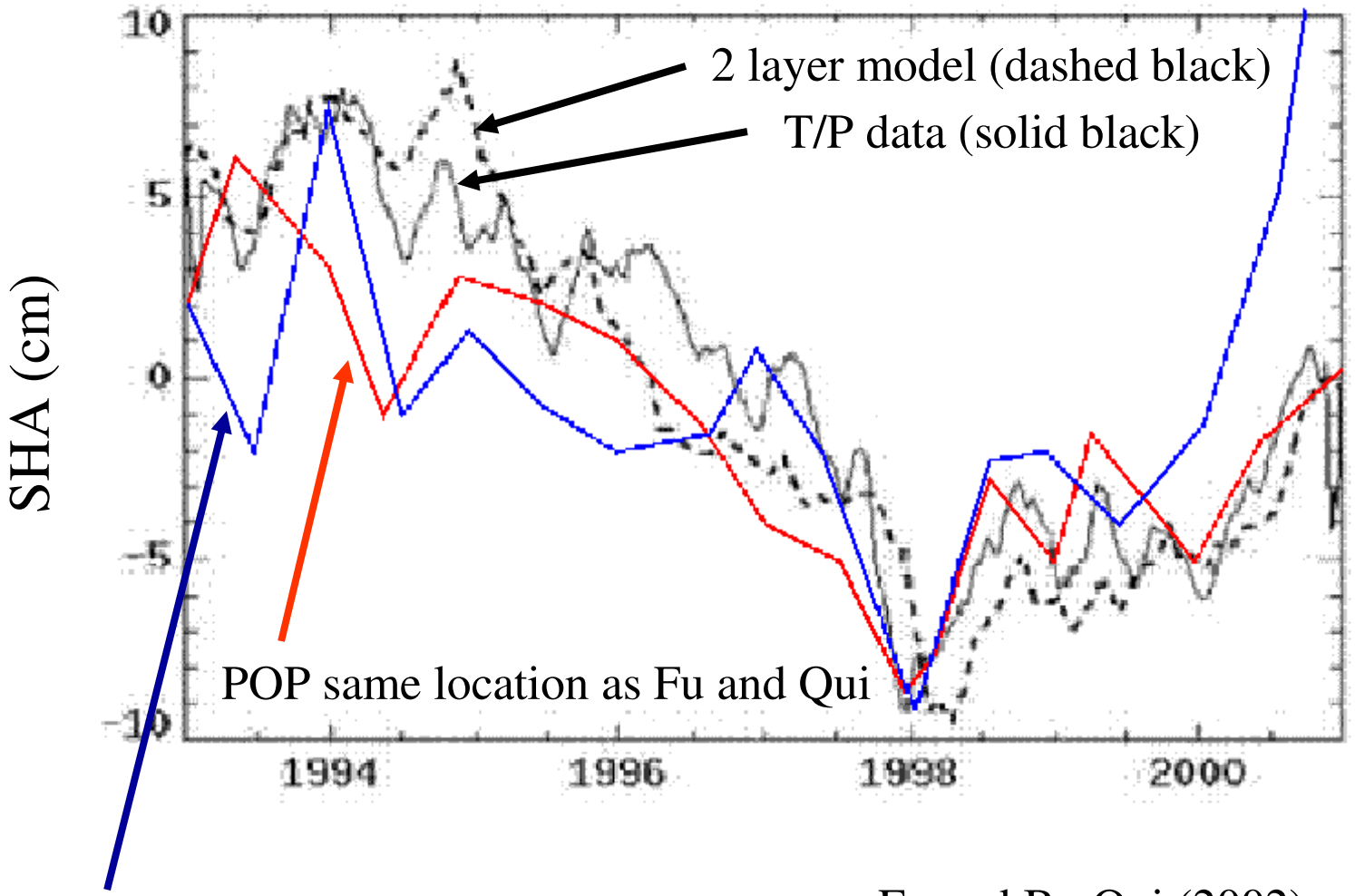




Values (in red) are from the spectral analysis, plotted over the theoretical, longwave dispersion curves for 45,48 and 50^0 N.

- C_1=2.4 m/s [MODE 1]
- a_{50N}=22km [0.71cm/s]
- a_{45N}=24km [0.92 cm/s]
- a_{40N}=26km [1.18 cm/s]

RRD, and phase speed in good agreement with results of Chelton et al. (1998) for global 1^o grid.

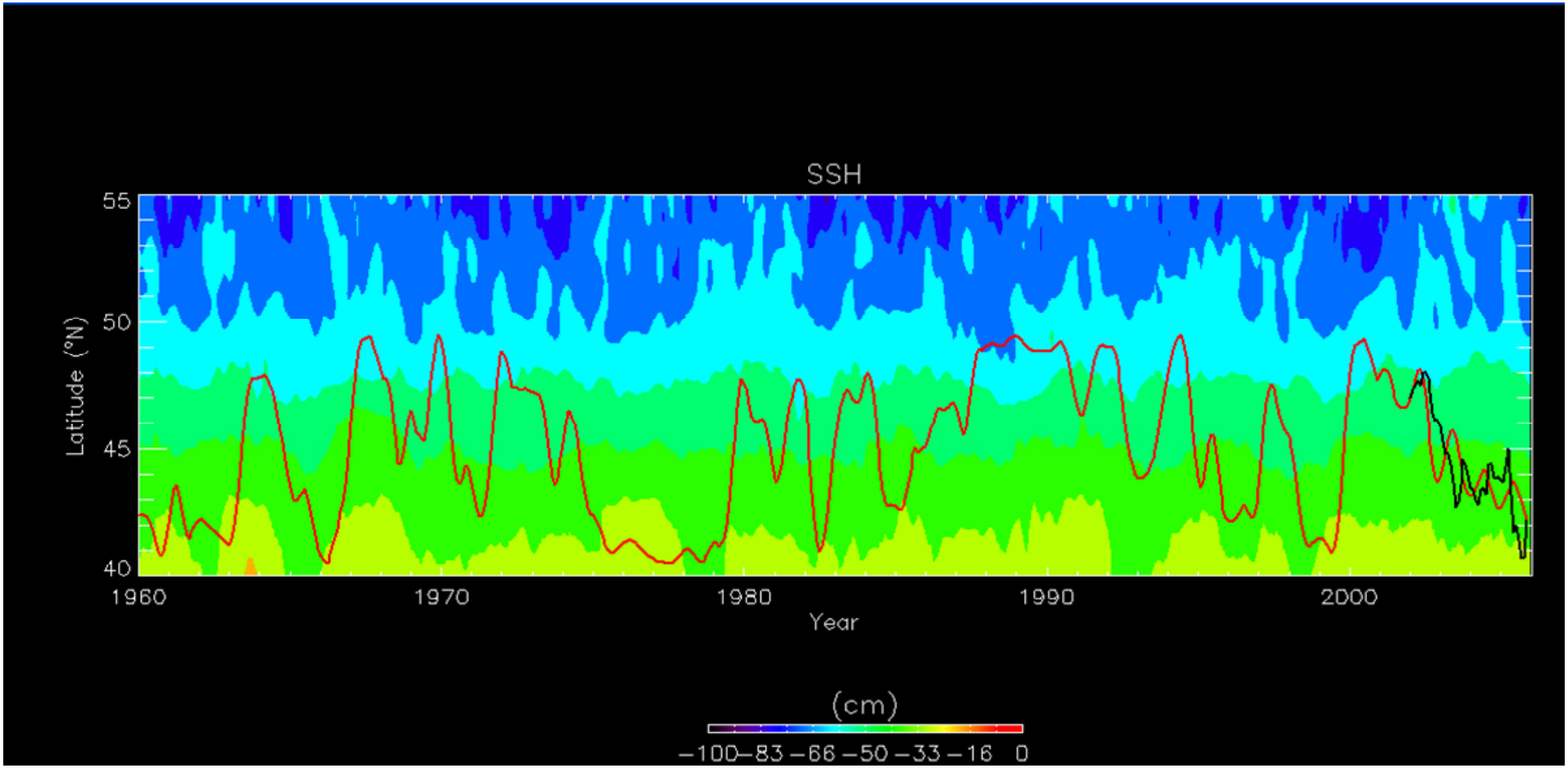


POP @ OWS Papa
Position. 145W-50N

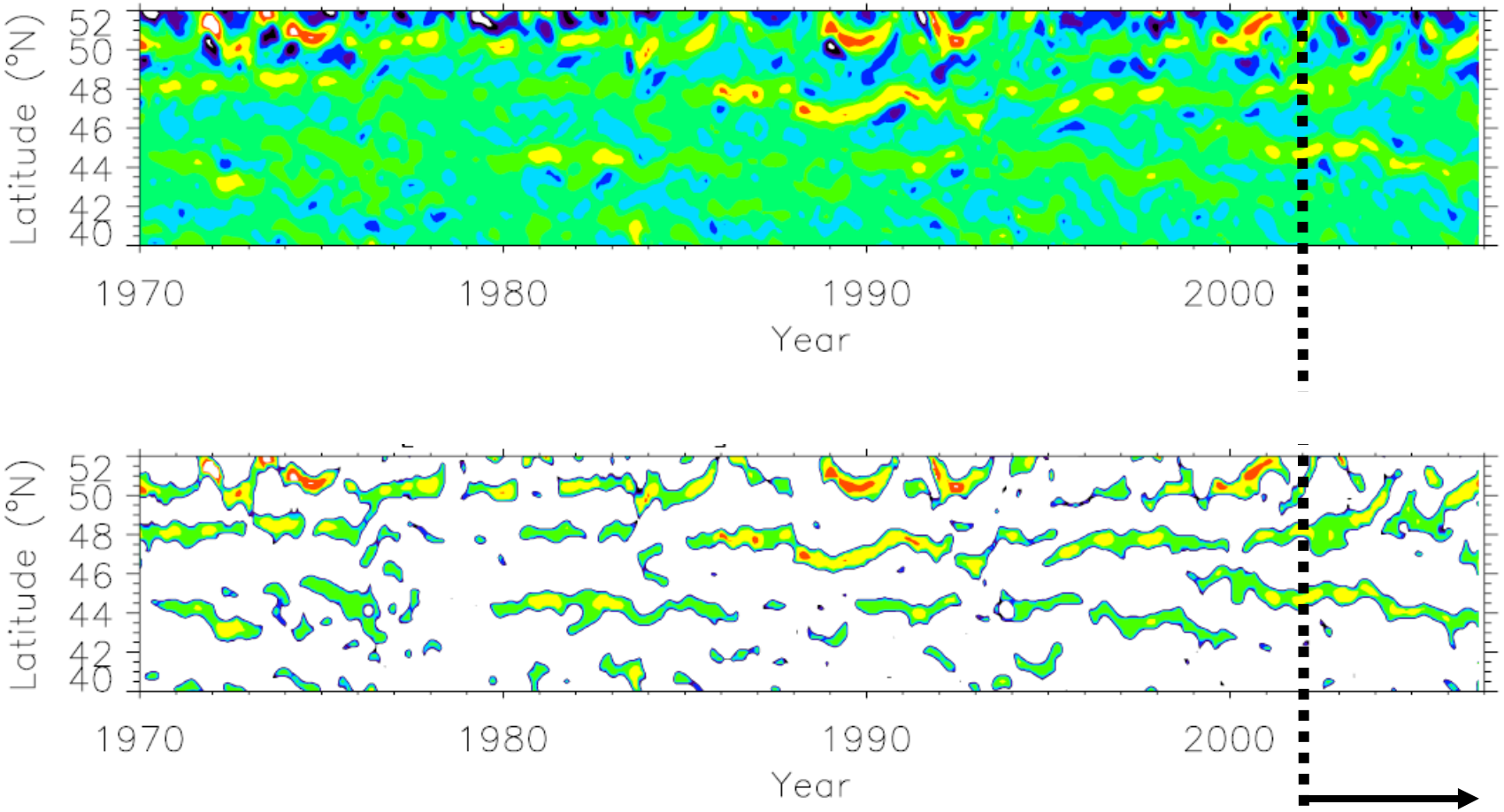
Fu and Bo Qui (2002)
Position. 144W-49N

ESITMATED POSITION OF NPC AT 145W MERIDIAN FROM 1970- 2006

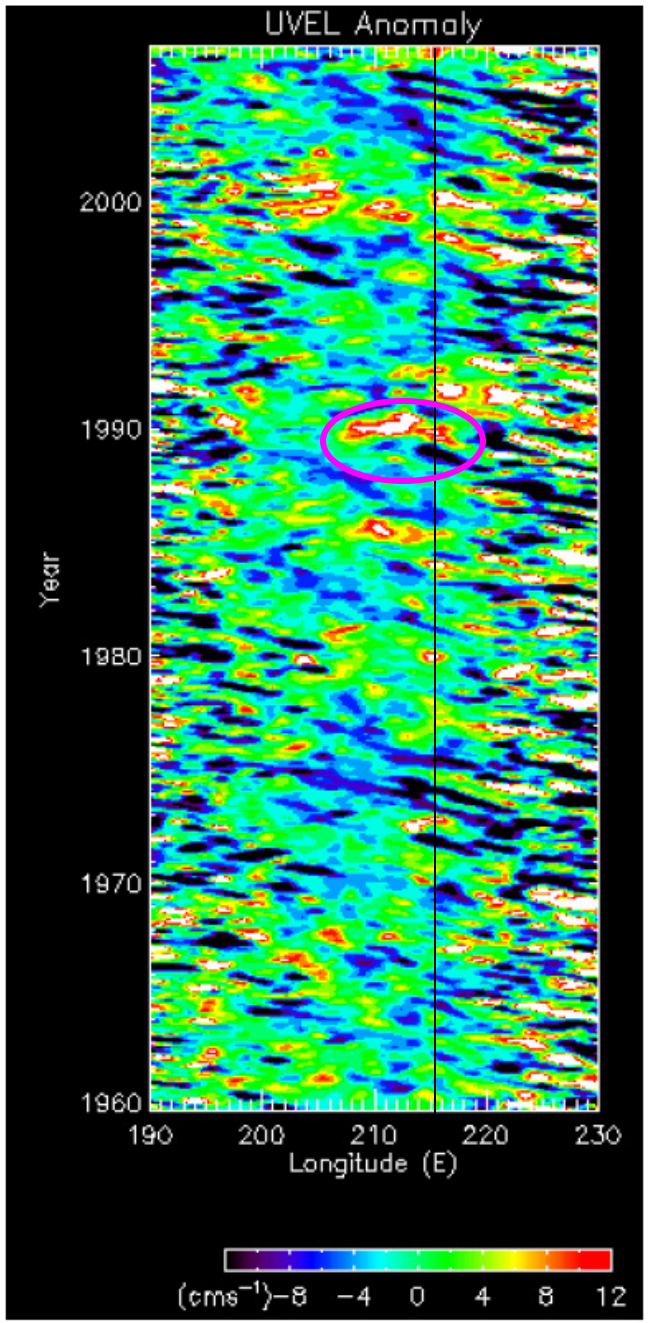
RED SOLID LINE REPRESENTS SIMULATED LOCATION OF NPC AXIS

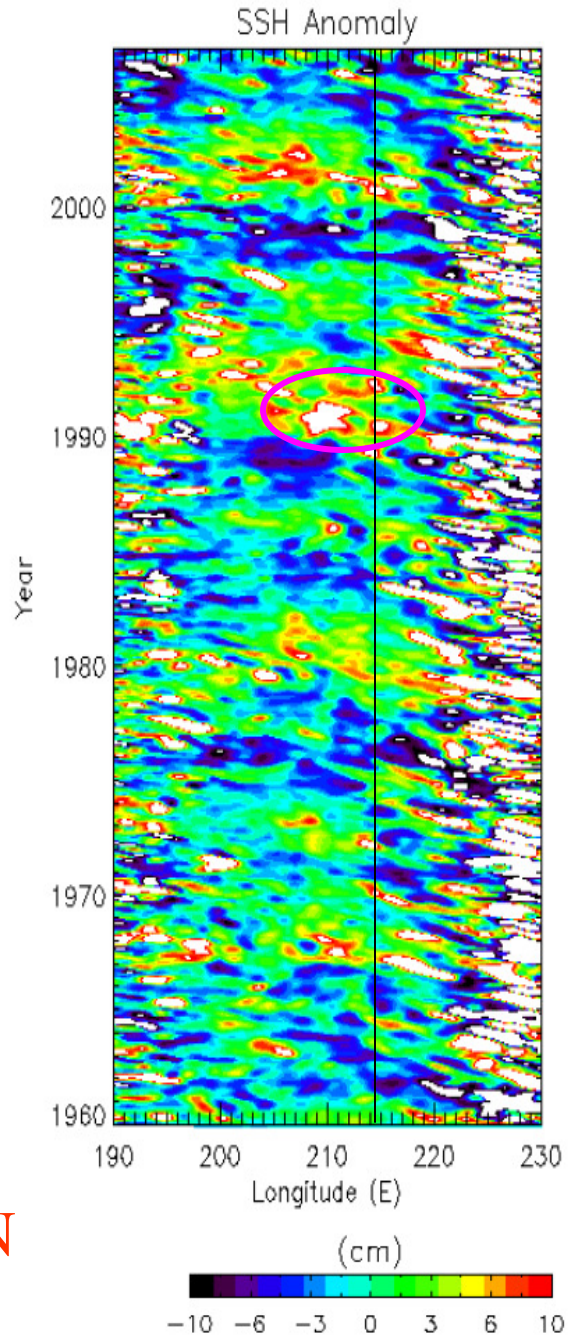


DEPTH AVERAGED SPEED (0-100M) ALONG 145°W

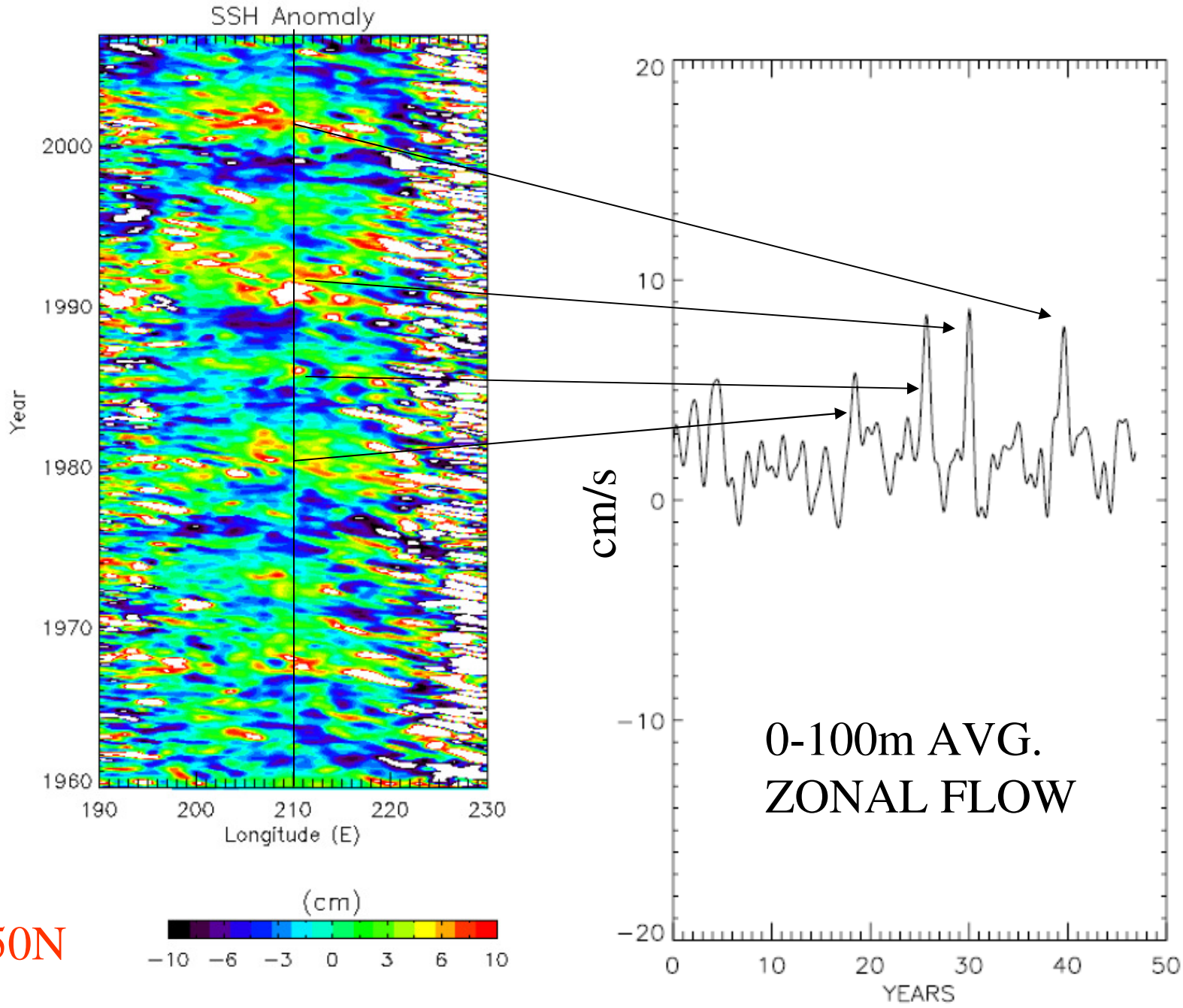


Observations Start in 2002


UVEL Anomaly
Year
2000
1990
1980
1970
1960
190
200
210
220
230
Longitude (E)
(cms^{-1})
−8
−4
0
4
8
12


SSH Anomaly
Year
2000
1990
1980
1970
1960
190
200
210
220
230
Longitude (E)
(cm)
−10
−6
−3
0
3
6
10

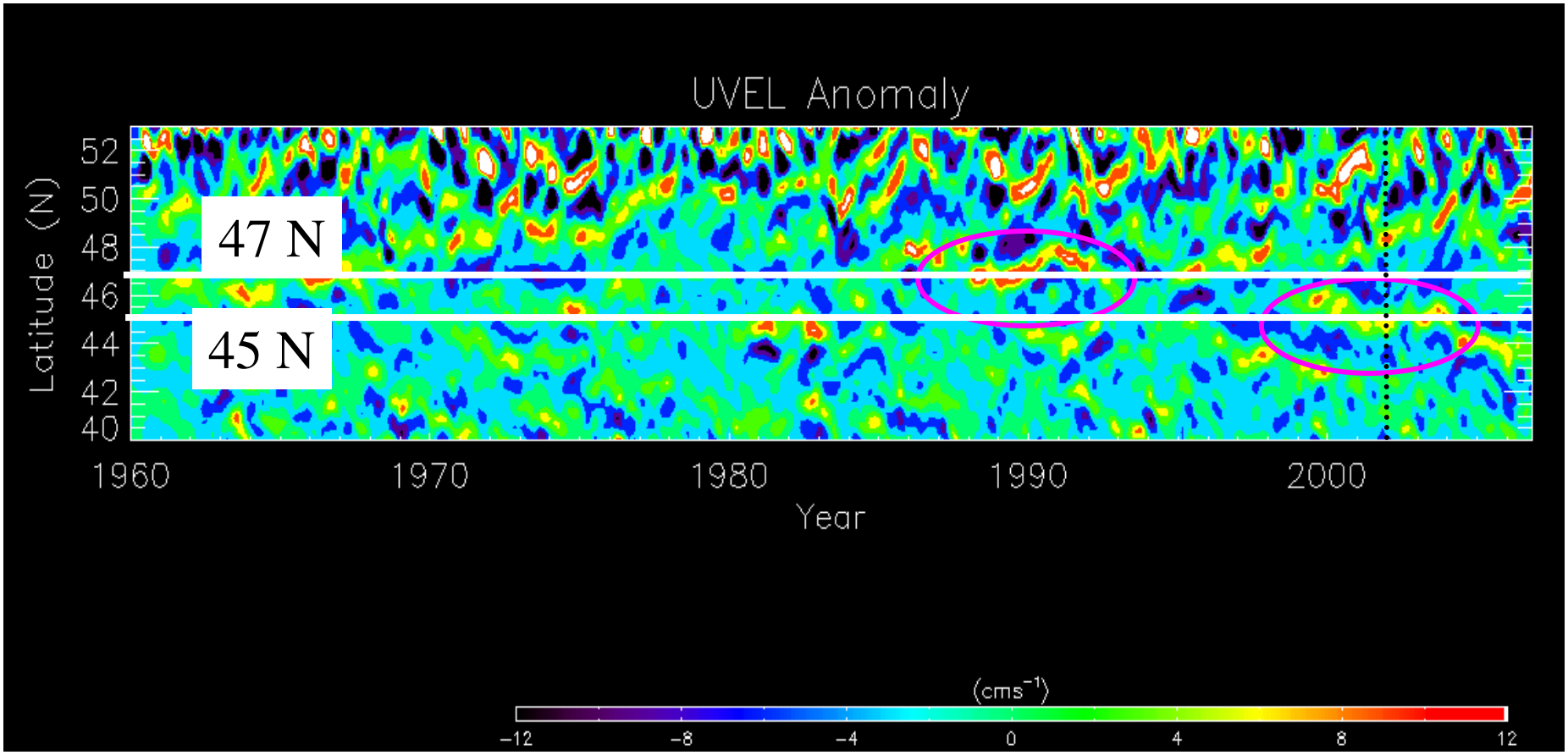
50N


SSH Anomaly
Year
2000
1990
1980
1970
1960
190
200
210
220
230
Longitude (E)
(cm)
−10 −6 −3 0 3 6 10
50N
cm/s
20
10
0
−10
−20
0
10
20
30
40
50
YEARS
0-100m AVG.
ZONAL FLOW

ZONAL VELOCITY ANOMALIES

4-5 YR

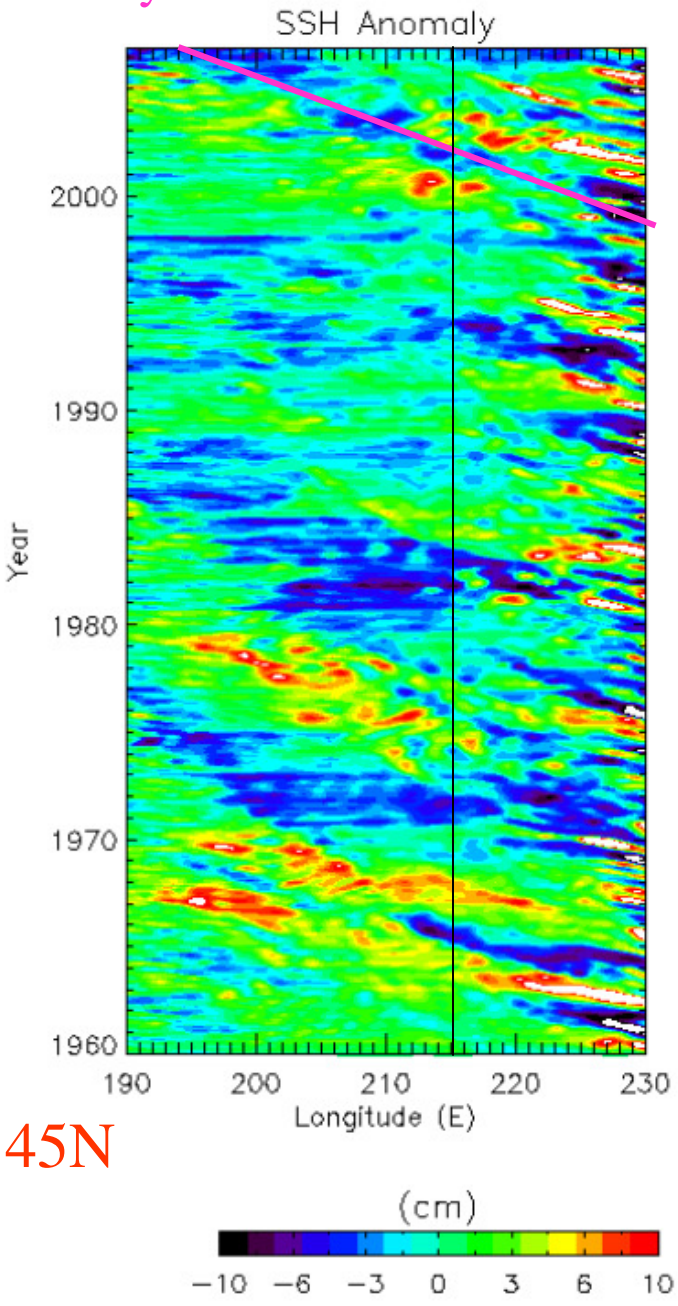
3-4 YR

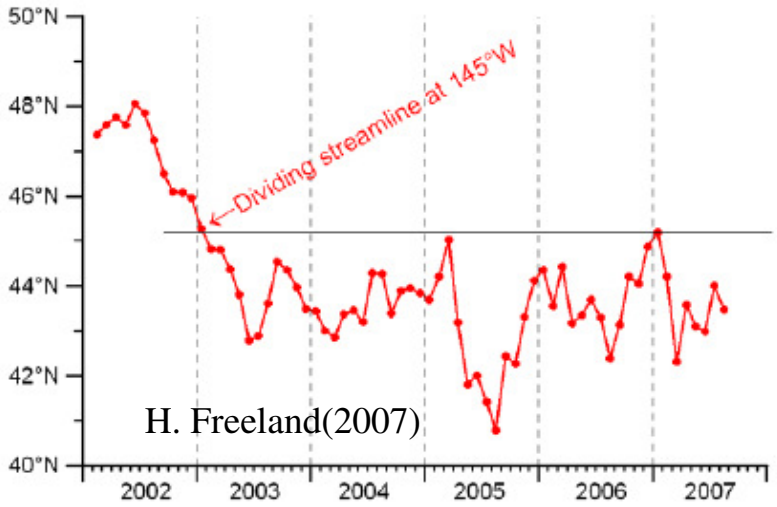


1.1cm/s
316km/yr

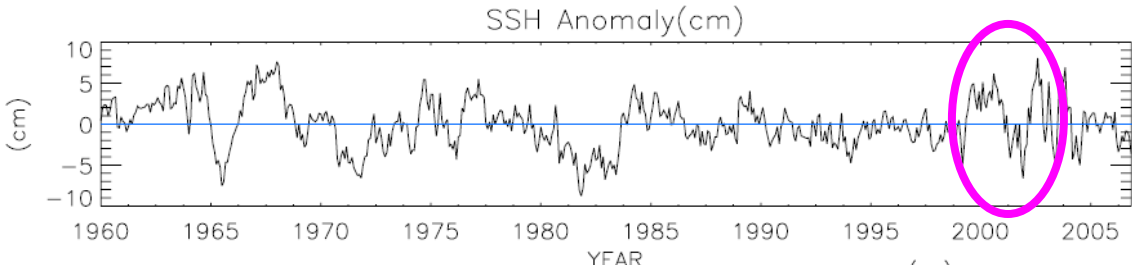
[Median OBS ~1.3 cm/s] Challenor et al. (1998)

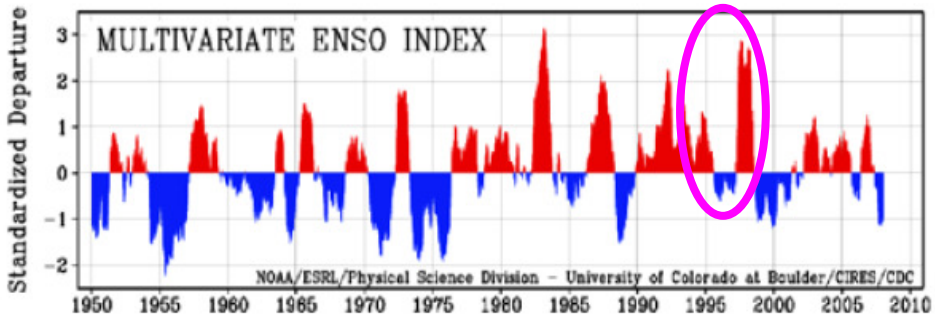
Rossby Wave passes





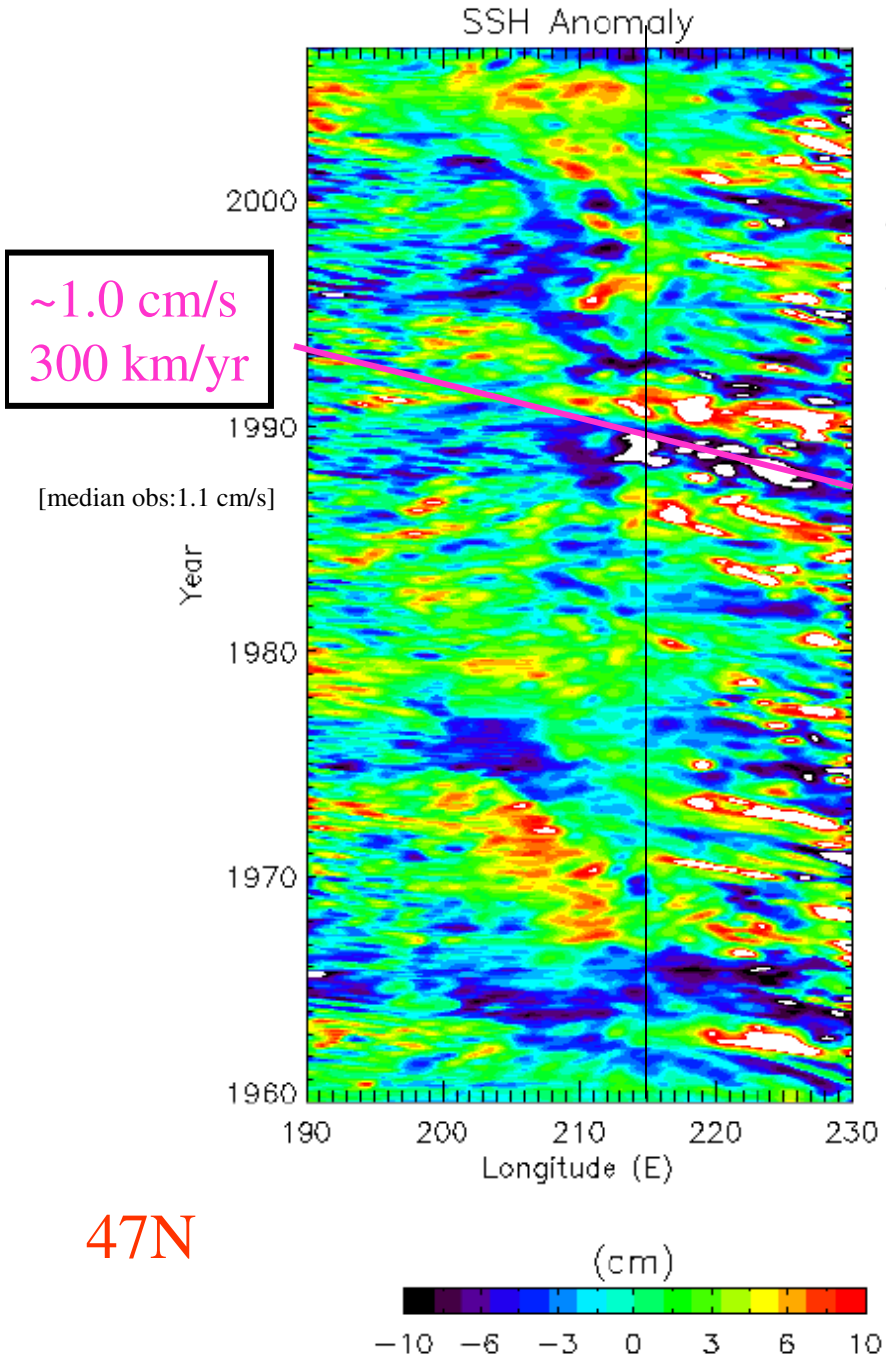
3 YR PERIOD

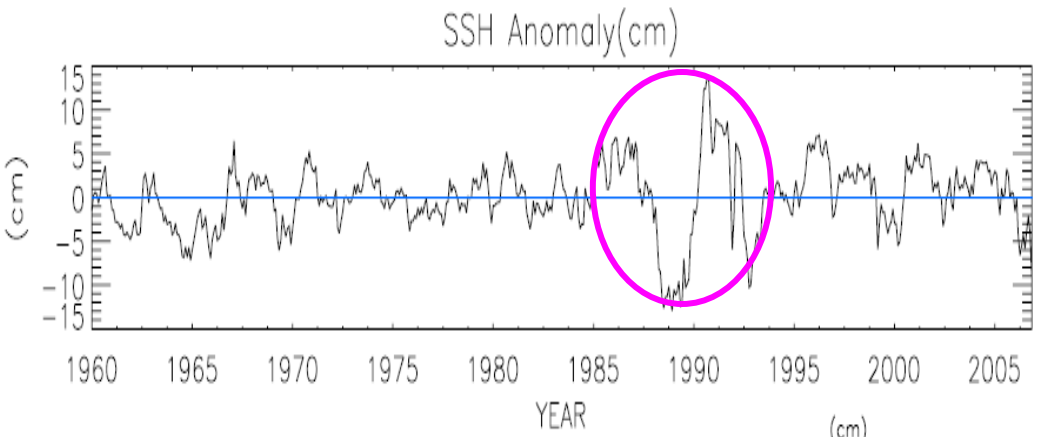




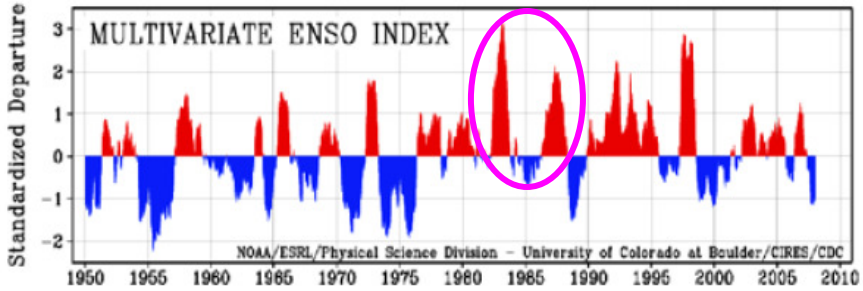
1994-1997

[arrive: 1999/2000-2002/2003];
4-5 yr travel time





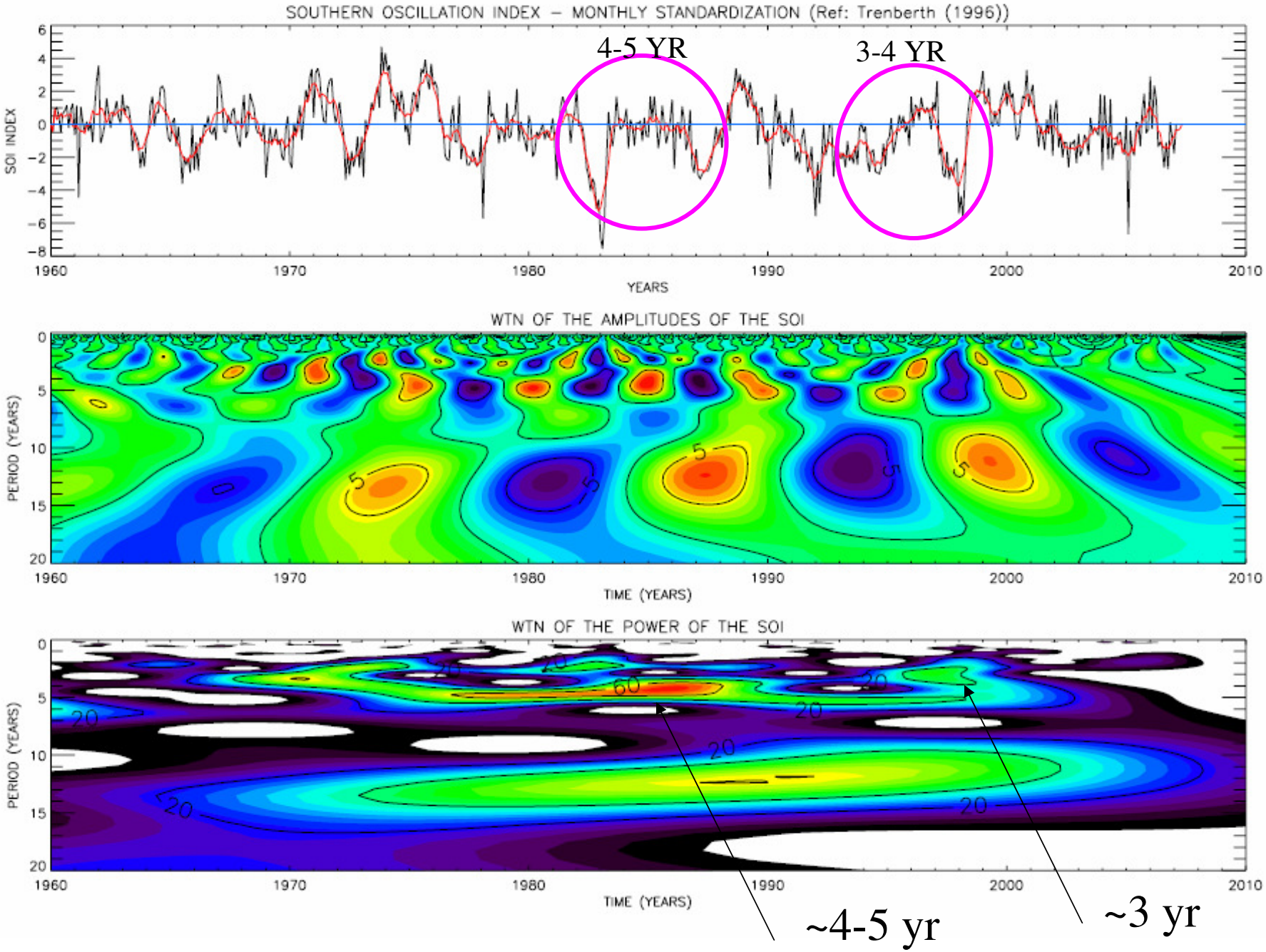
4-5 YR PERIOD



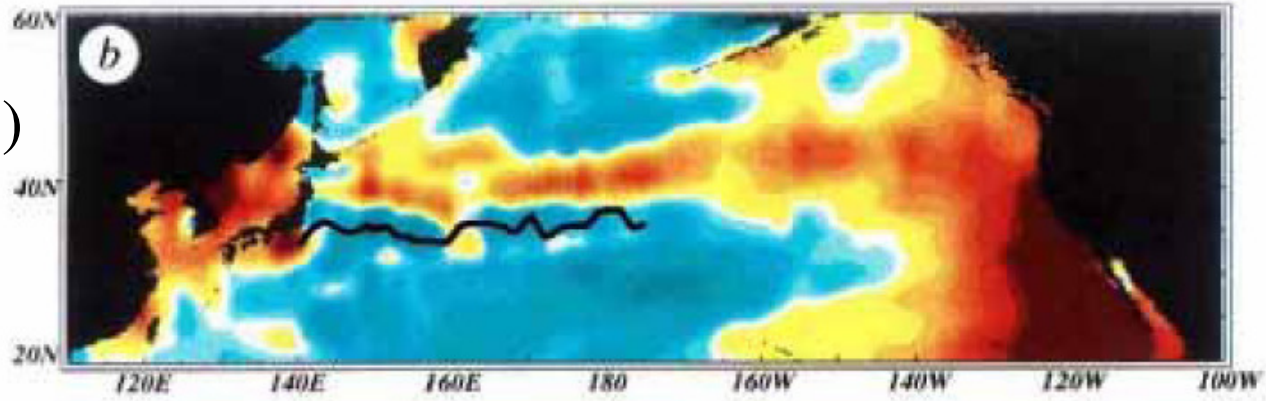
1983/84-1987/88

[Arrive: 1986/87-1990/92]; approx. 4 year travel time

Southern Oscillation Index (SOI)

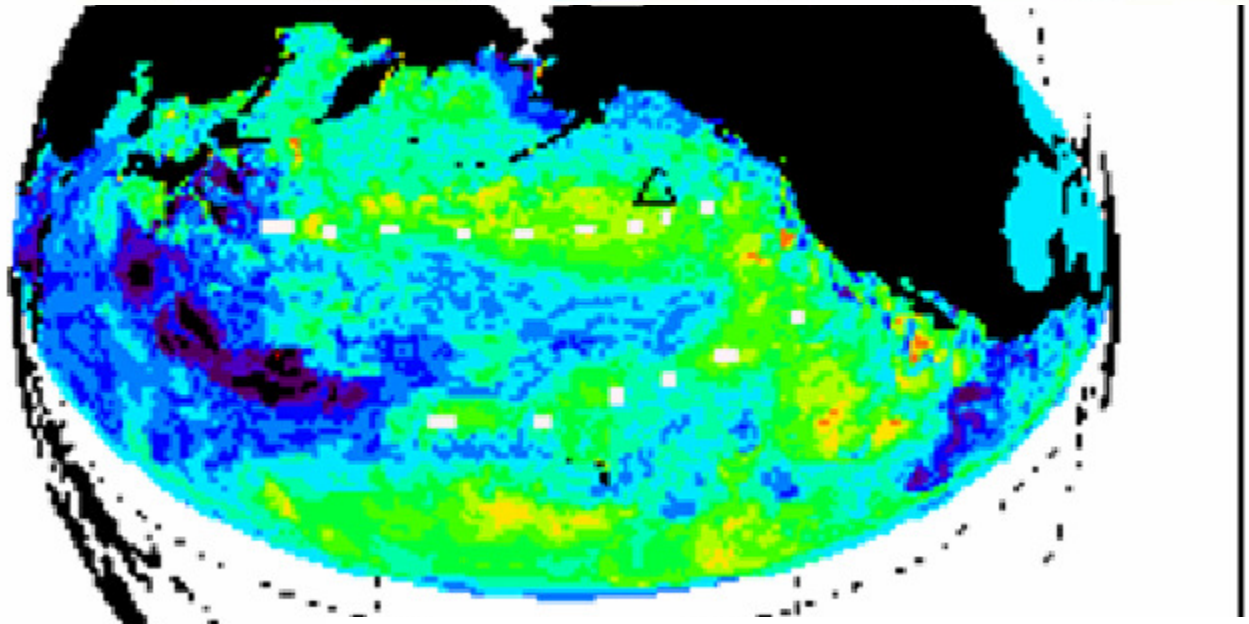


Jacobs
et al. (2004)



(1991)

SST
ANOM.



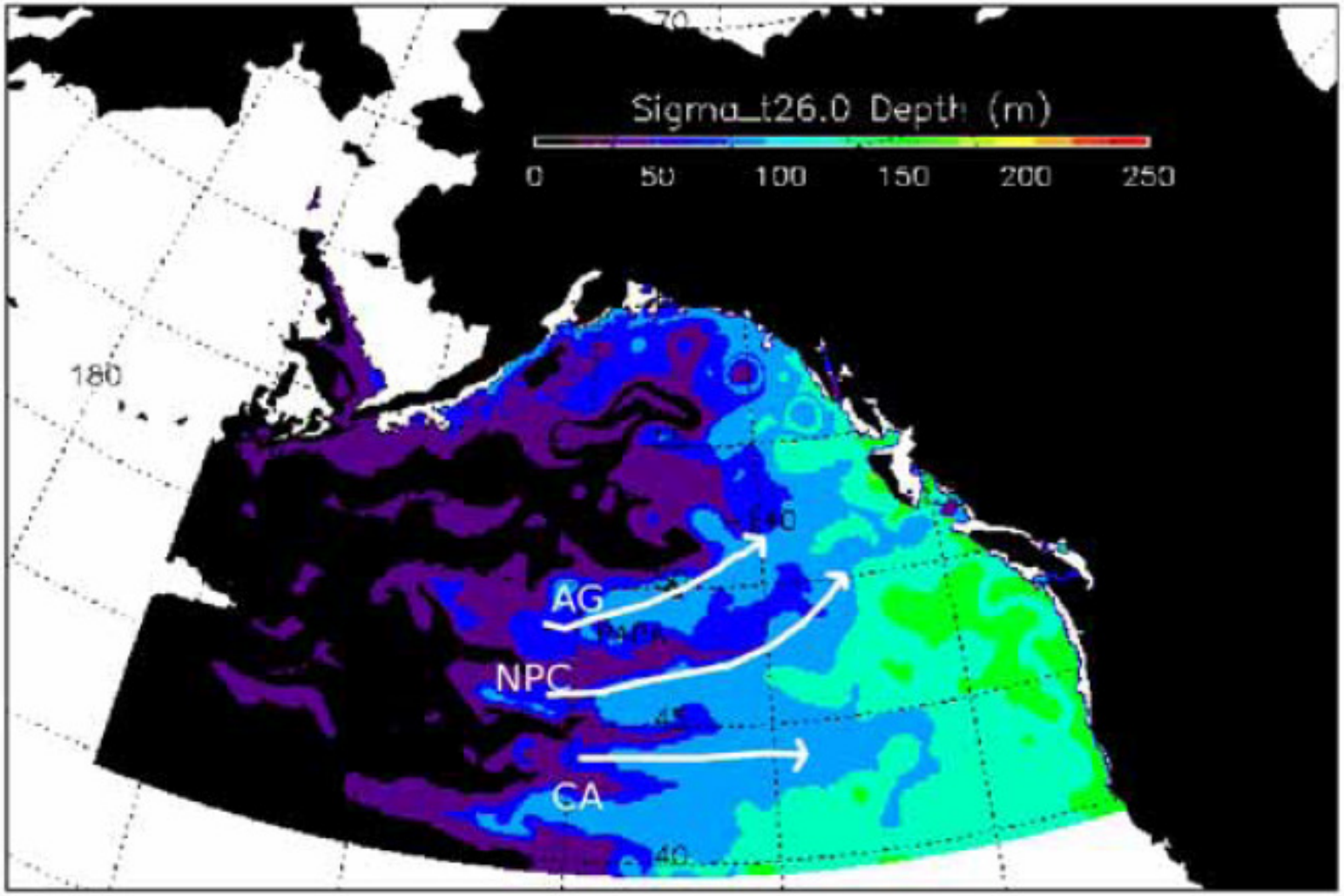
(2001)

2001, large ridge of SSTA extended all across Pacific – similar to Jacobs et al.(2004) for passing RW in 1991.

SUMMARY AND SPECULATION

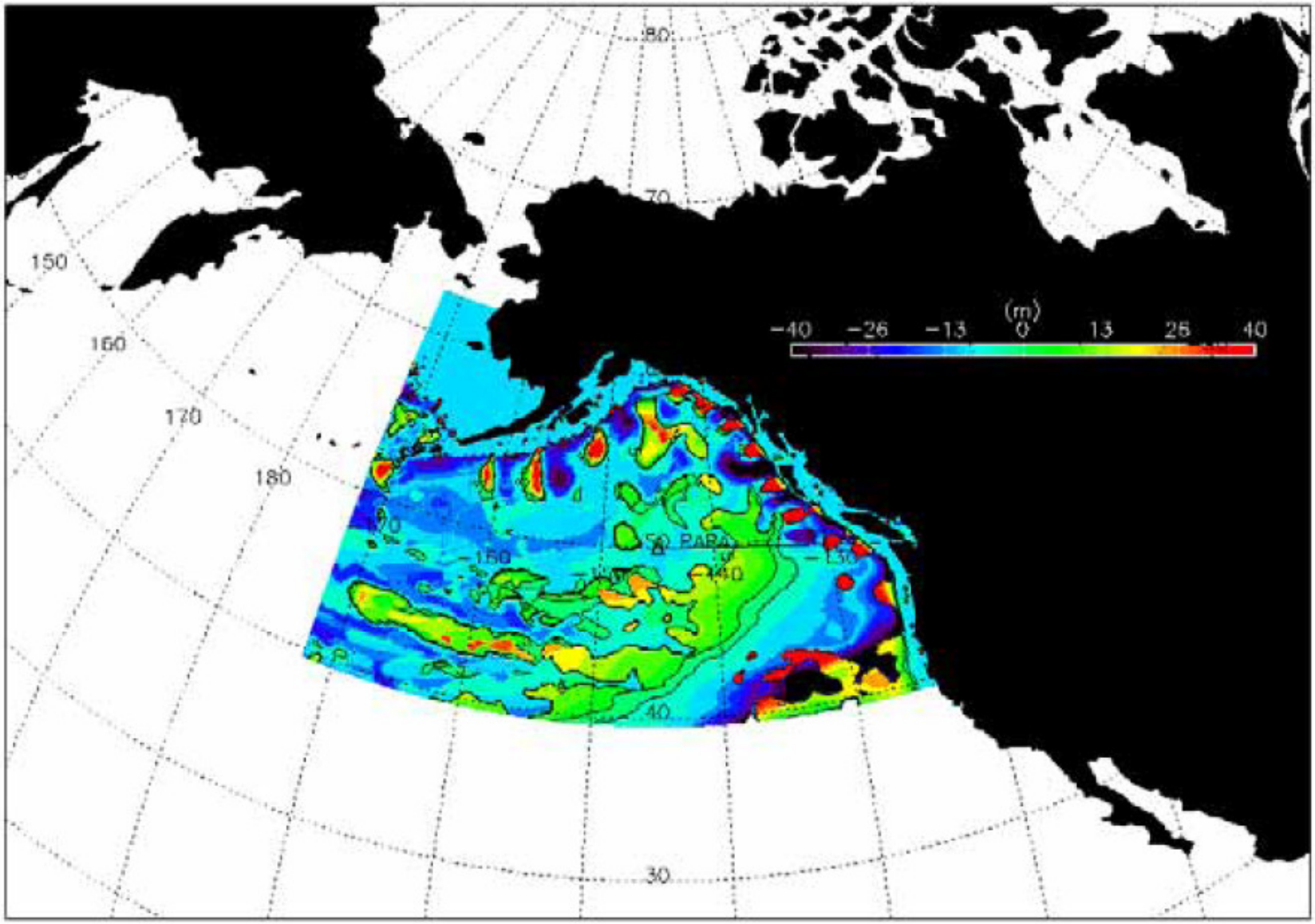
- NORTH PACIFIC CURRENT (NPC) POSITION CAN BE SIMULATED SUCESSFULLY BY POP AT MODEL RESOLUTION AS LONG AS SPECTRAL NUDGING IS USED.
- LATITUDE AND FLOW OF NPC CAN BE MODULATED BY ROSSBY WAVES ARRIVING FROM THE COAST APPROXIMATELY 3-4 YRS AFTER THEIR FORMATION.
- THEY TRAVEL AT 1-2CM/S
- THESE ROSSBY WAVES ARE FORCED BY GLOBAL CLIMATE VARIABILITY, SUCH AS ENSO.
- THE MODEL SUGGESTS THAT THE NPC CAN BE MODULATED UP TO ABOUT 5 YEARS AFTER LARGE CLIMATIC EVENTS.

WHAT MAINTAINS THESE SYSTEMS?



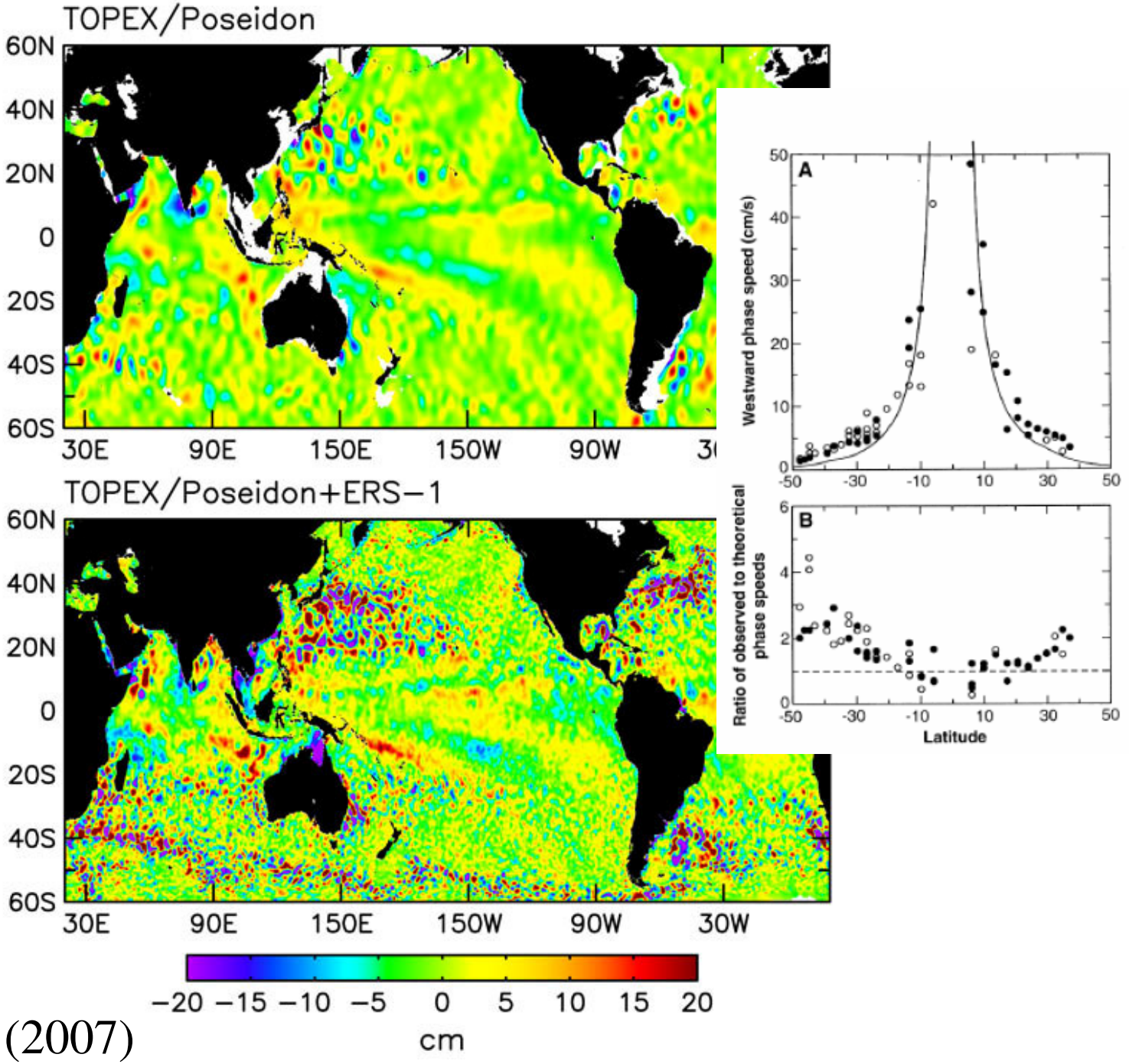
SIGMA_t 26.0 SURFACE DEPTH ANOMALIES

ARE PREDICTIONS POSSIBLE?



Sigma-t 26.8 surface depth anomaly October, 2005. [from 2003 ENSO ?]

Major
Improvement
In resolution



Chelton et al. (2007)

THANK-YOU